TESLA - COLLABORATION

Transparencies from the

TESLA Meeting, March 1-3, 1999 at DESY

DESY

April 1999, TESLA 99-06

TESLA Meeting March 1 - 3, 1999 at DESY

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TESLA Report 99-06

) [illegible]

Proposal
for Time Table of
TTF II and FEL

Status of present Linac operations will be given in several presentations this morning

Cavities of module #3 are ready to be combined to string
6 out 8 couplers have been preconditioned with RF

Proposal: Spend 1 more week to condition
couplers #7 and #8

Proposal for Linac operation:

End run as planned March 15th

Schedule for installation will be presented by G.Schmidt

Stay with start-up date for proof of principle experiment for FEL
July 15th

Module #1 will be replaced by Module #3

Module #1 will equipped with better cavities and cryostat will be modified.

ready as #1* for reinstallation

end October 99

Proposal: Linac operation

from July 15th
to end October

Install module #1*

resume Linac operation February 1st 2000

Linac operation until end of
November 2000
End of TTF stage I

!!! need 10 MW klystron plus modulator
to operate three modules

EXPO 2000 at DESY runs from
beginning of JUNE to end OCTOBER

Module #4 (NEW CRYOSTAT!!!) will be ready
mid December 99
will be used as exhibition part for EXPO 2000

Material for 32 standard cavities is being ordered

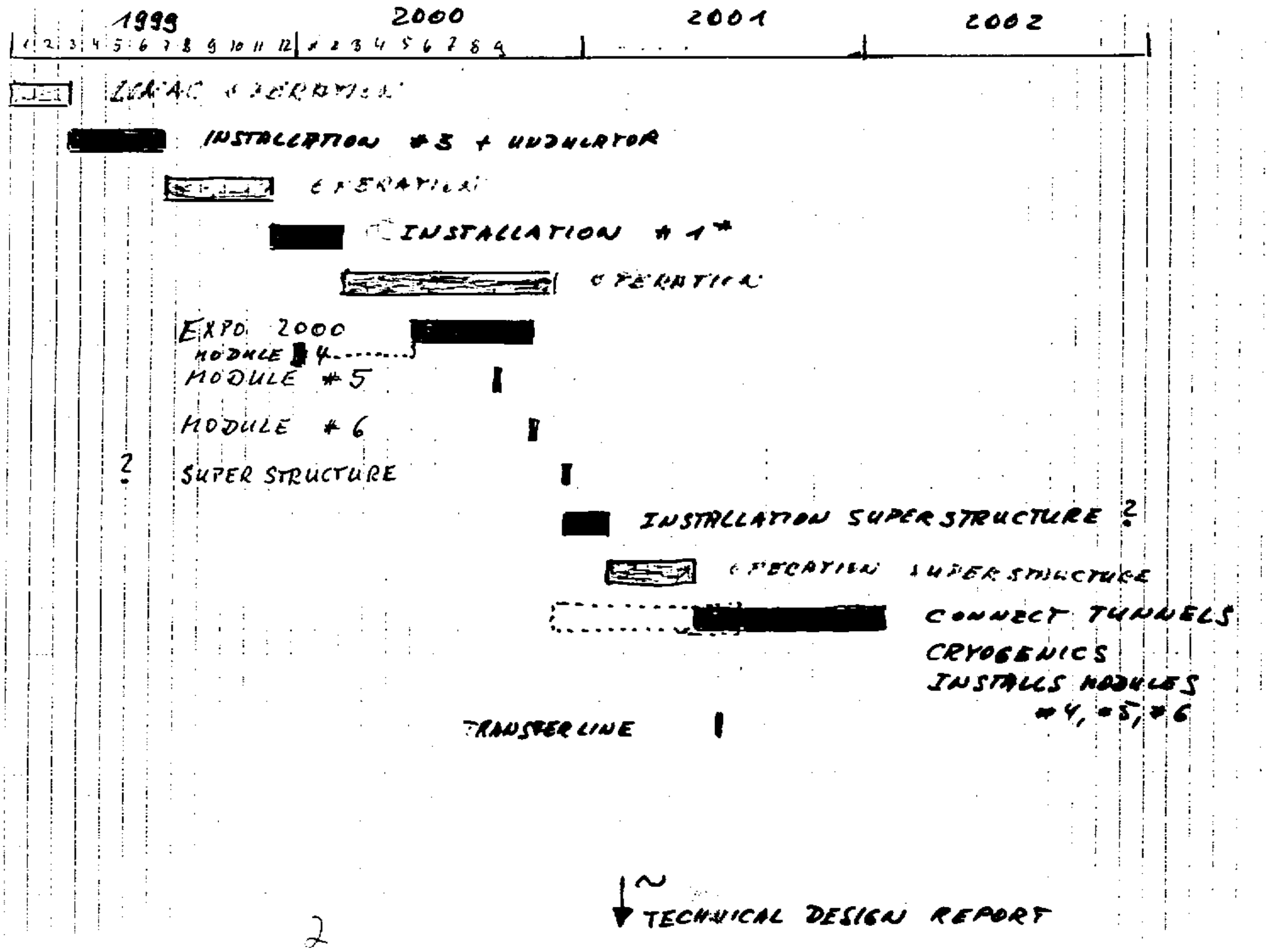
Fabrication order for 24 + 8 cavities is on call for tender

Earliest dates for completion of
module #5 end of May 2000
module #6 end of July 2000
module #7 mid September 2000 ?????

Problem superstructure

If design report based on superstructure beam test would be important

↓ has to be done in phase I



Summary of cavity tests

Michael Pekeler
TTF Collaboration Meeting
DESY, 1st - 3rd March 1999

- Overview above tested TESLA 9-cell cavities
- Performance of cavities installed in module 2
- Test results of new cavity production
- Cavities for module 3
- Field emission
- Test result of Rossendorf gun

Overview above tested TESLA 9-cell cavities

50 cavities arrived at TTF
(+ 5 cavities for Schwettman
+ 6 cavities for Rossendorf)

44 cavities got HT 1400 C
(+ 6 cavities for Rossendorf)

42 cavities tested in vertical cryostat
(+ 5 cavities for Schwettman
+ 2 cavities for Rossendorf)

28 cavities equipped with He vessel

18 cavities tested in horizontal cryostat CHECHIA

13 cavities installed in the linac
(+ 8 cavities will be installed now)

In addition 4 single cell cavities, one 2-cell cavity, one 4-cell cavity, one 5 cell cavity and one 1/2 cell (gun)-cavity have been treated.

How much have we done in one year

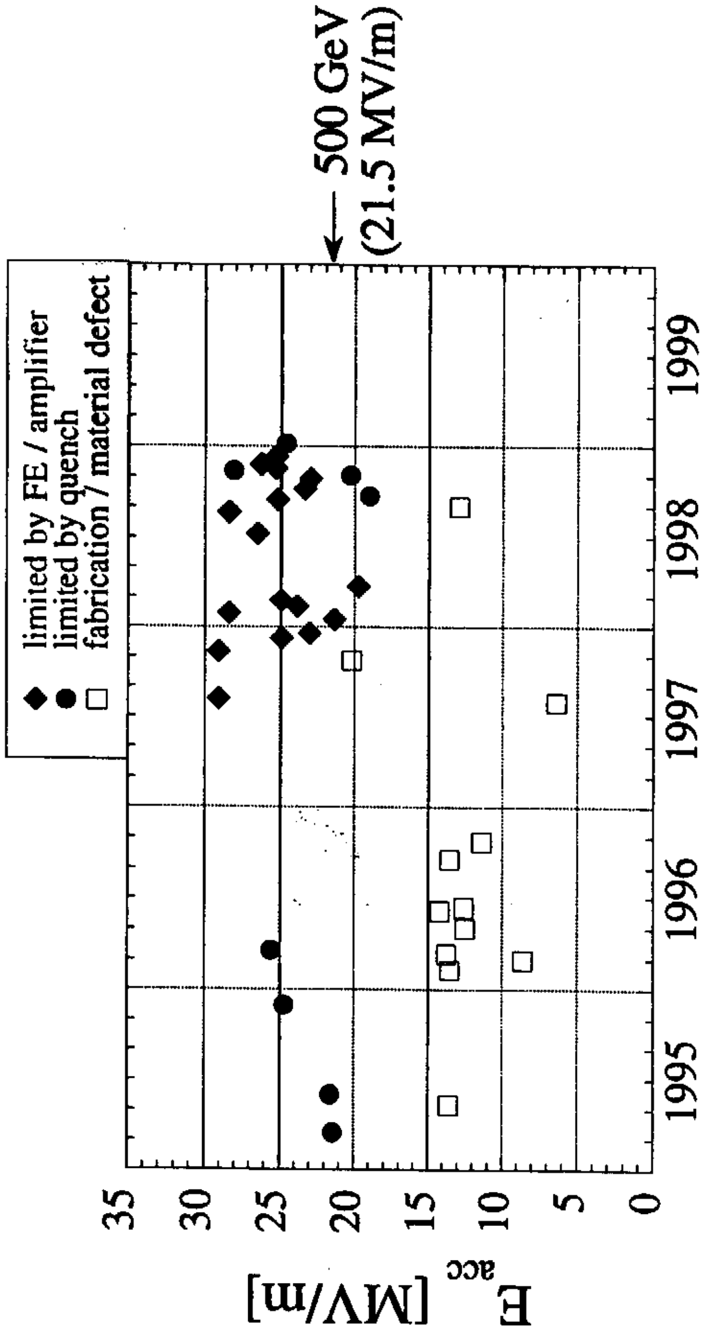
activity	**1996**	**1997**	**1998**	**9 weeks 1999**
cavities arrived	7	12	27	3
inner surface removal [mm]	1.2	1.7	4.0	1.3
cavities HT 1400	8	5	24	8
cavities got first vertical test	10	8	20	4
total number of vertical tests	29	45	46	7
He vessel welded	8	3	14	2
CHECHIA tests	8	1	5	4

How much time do we need now for cavity test and preparation

activity	now [days]	personal estimation for mass production [days]
mech. + RF check	3	1
BCP before HT	3	1
HT 800 C	4	2
HT 1400 C	5	5
BCP after HT	3	1
tuning	1	1
preparation vert. test	5	3
vertical test	4	3
He vessel welding	12	4
preparation for CHECHIA	7	3
CHECHIA test	9	5
total	59	29

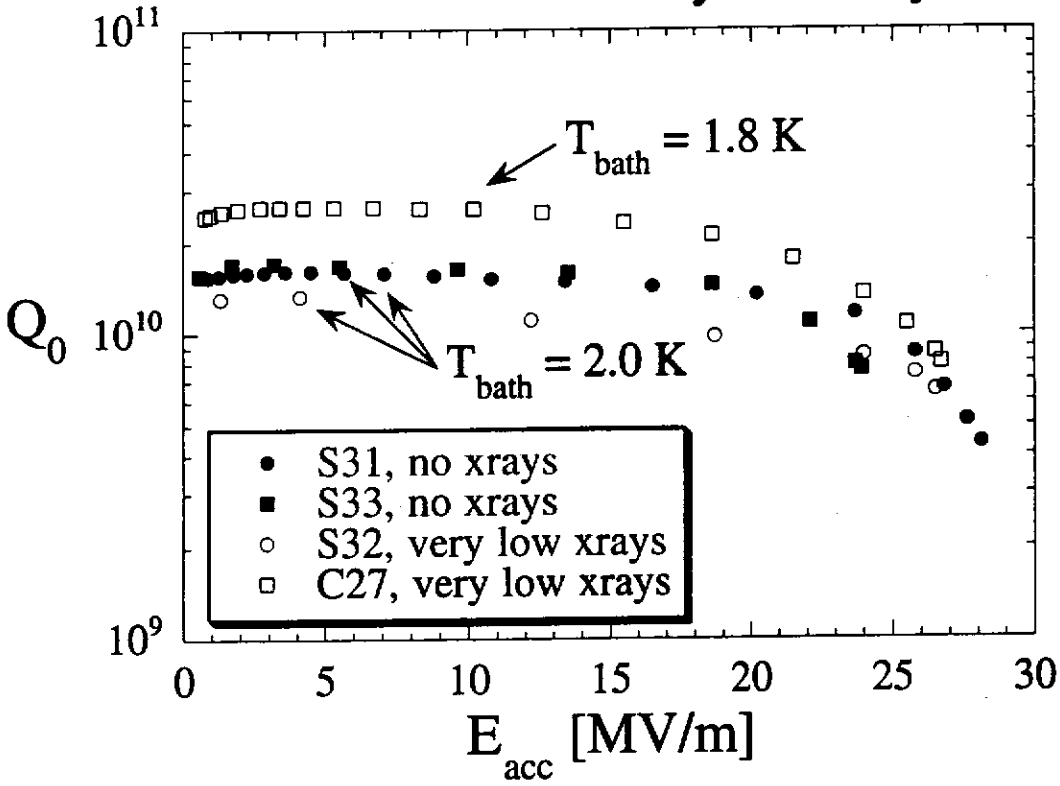
only working days were counted

Maximum gradients reached in 9-cell cavities



1998: we normally reach gradients between 20 and 30 MV/m.
But there are also cavities with quenches in that region.
We need to find the quench locations, reduce field emission and study the Qdrop without xrays

We have observed now the Qdrop without or with very low xrays.



1. Cavity production

cavity	Eacc [MV/m]	Q0 [10^9]	used in/as	comment
P1	>29.1	6	EP at KEK	Prototype
P2	16.3	22	stored	Prototype
C19	22.1	2	capture cy	
D1	24.7	17	module 1	
D2	21.9	4	module 1	
D3	25.6	29	module 1	
D4	13.5	16	module 1	defect
S7	13.8	8	module 1	weld defect
S8	12.5	12	module 1	weld defect
S10	14.2	16	module 1	weld defect
S11	13.5	13	module 1	weld defect
A15	>23.0	4	module 2	
C21	>29.3	8	module 2	
C22	20.2	21	module 2	weld defect
C23	>25.3	8	module 2	
C24	>19.7	5	module 2	
C25	>28.4	9	module 2	
C26	>21.4	4	module 2	
C27	>26.7	8	module 2	
S12	12.6	13	cap. cy (FNAL)	weld defect
D5	8.6	24	cy 4 tuner test	defect
D6	13.6	12	cut	defect
S9	11.4	11	stored	weld defect
A13	3.4	10	museum	strong weld defects
A14	6.4	11	stored	weld defect
A16	20.8	6		needs new test
A17				not tested yet
A18				not tested yet
avg.	18.9			

2. Cavity production (scanned material)

cavity	Eacc [MV/m]	Q0 [10^9]	will be used in	comment
S28	>25.3	6	-> module 3	
S29	>26.7	6	-> module 3	
S30	>28.4	7	-> module 3	
S32	>26.5	7	-> module 3	
D39	>25.2	7	-> module 3	
D40	>22.8	5	-> module 3	
D41	>23.3	5	-> module 3	
D42	24.6	7	-> module 3	
S31	(28.1)	4	(-> module 4)	new test necessary
C44	>25.5	6	-> module 4	He vessel welded
S33	23.9	7		Q_{drop} without xrays
S34	>14.4	2		field emission
Z49	>18.0	4		field emission
D37	20.3	5		BD
D38	19.5	3		BD
C43	12.9	20		BD, weld defect
S35				HT 1400 done
S36				HT 1400 done
C45				HT 1400 done
C46				HT 800 done
C47				HT 800 done
C48				just arrived
Z50 - Z54				under production at Zanon
avg.	**22.9**			

Performance of cavities installed in module 2

cavity	vert. test [MV/m]	hor. test [MV/m]	comment
C21	29.3*	18.3	new HPR after hor. test
C22	20.2	18.1	new HPR after hor. test
C23	25.3*	33.0	
C25	28.4*	24.0**	
A15	23.0*	26.4**	
C24	19.7*		no hor. test
C26	21.4*		no hor. test
C27	26.7*		no hor. test
avg.:	**24.3**	**23.4**	

* limited by field emission and available cw RF power

** limited by coupler in horizontal test

2 cavities had problem:

- C22 quench @ 20.2 MV/m, quench at repaired whole in equator weld
- C24 had accident during HPR, nozzle of HPR system scratched inner surface, no grinding was applied, only 20 µm BCP.

What did we reach with module 2 ?

All cavities get the same incident power, **the Qext of the input coupler vary by ±10%**

Without beam **up to now** 20.8 MV/m **were reached with** 1 Hz operation and 500 µs rise + 500 µs flat-top time.

In addition cryo losses were measured with 10 Hz and 500 µs rise time, 800 µs flat-top time operation.

18.8 MV/m, Pcryo=14.2 W -> Q = 2.7 E9
19.7 MV/m, Pcryo=20.8 W -> Q = 2.0 E9

With beam up to now 18.5 MV/m **were reached with** 500 µs rise + 100 µs flat-top time.

The warm part of the coupler is the limiting factor --> **still needs more processing time.**

Test results of new cavity production

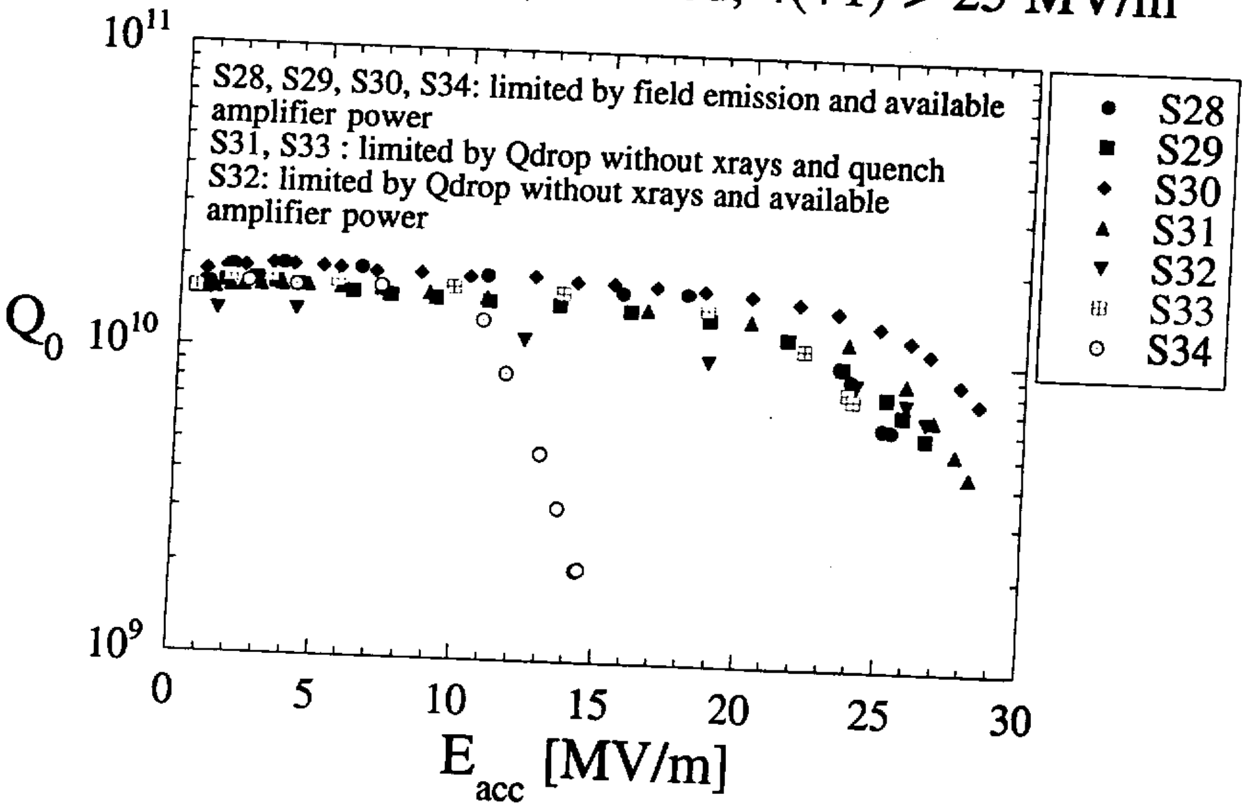
3 cavities showed quench below or close to 20 MV/m:

- D37 @ 20.3 MV/m, **reason not known**
- D38 @ 19.5 MV/m, **suspicion: bad weld preparation**
- C43 @ 12.9 MV/m, **quench at repaired whole in equator weld**

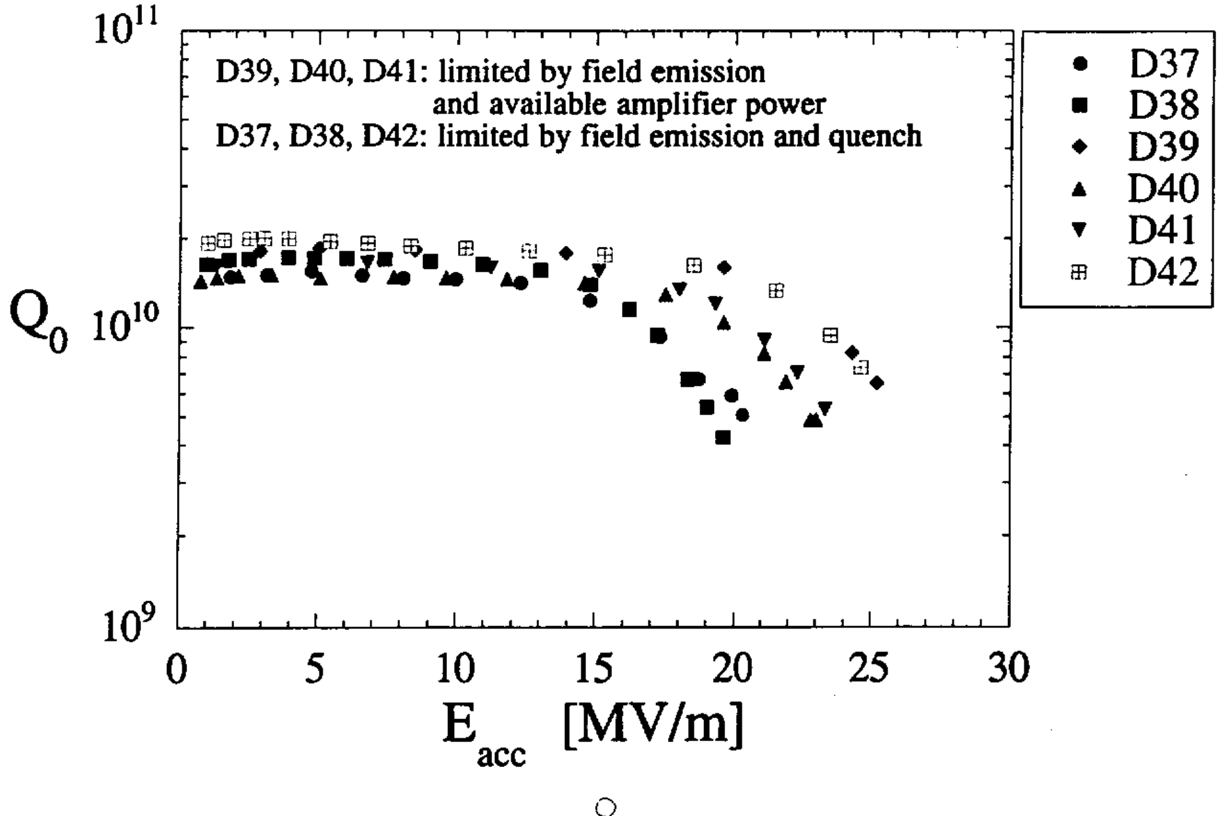
cavity D42 shows quench @ 24.6 MV/m, reason not known.
cavity S33 shows quench @23.9 MV/m, reason not known

All other cavities are limited by field emission and available amplifier power

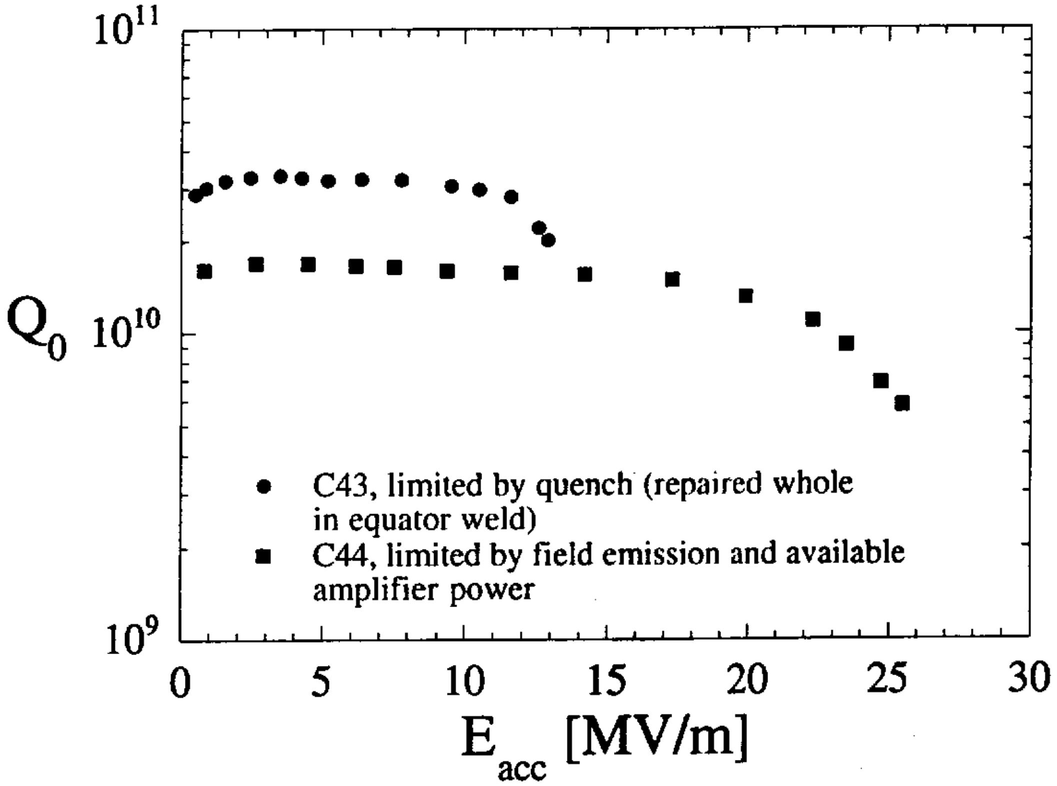
2. cavity production from ACCEL:
9 ordered, 9 arrived, 7 tested, 4(+1) > 25 MV/m


S28, S29, S30, S34: limited by field emission and available amplifier power
S31, S33 : limited by Qdrop without xrays and quench
S32: limited by Qdrop without xrays and available amplifier power

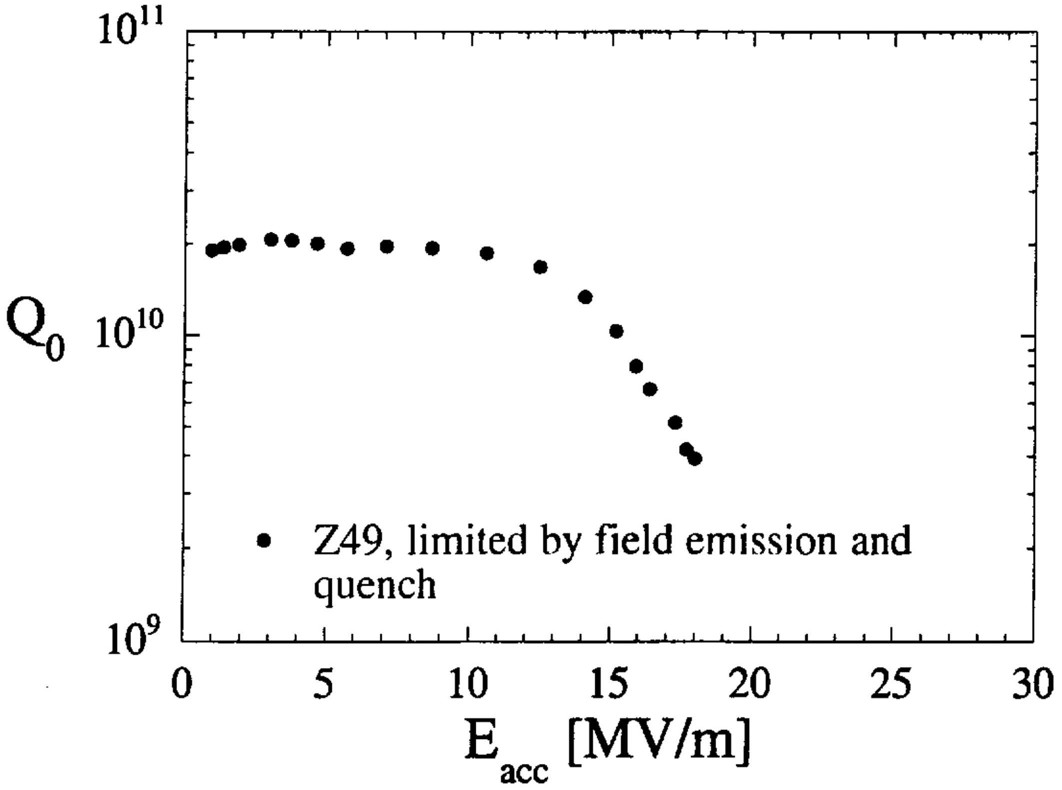
2. cavity production from DORNIER:
6 ordered, 6 arrived, 6 tested, 4 >~ 25 MV/m


D39, D40, D41: limited by field emission and available amplifier power
D37, D38, D42: limited by field emission and quench

2. cavity production from CERCA: 6 ordered, 6 arrived, 2 tested, 1 > 25 MV/m



2. cavity production from ZANON: 6 ordered, 1 arrived, 1 tested



Cavities for module 3

4 cavities from ACCEL (S28, S29, S30, S32) and 4 cavities from Dornier (D39, D40, D41, D42) selected for module 3.

Average gradient in the vertical test was: 25.4 MV/m

All cavities are equipped with He vessel

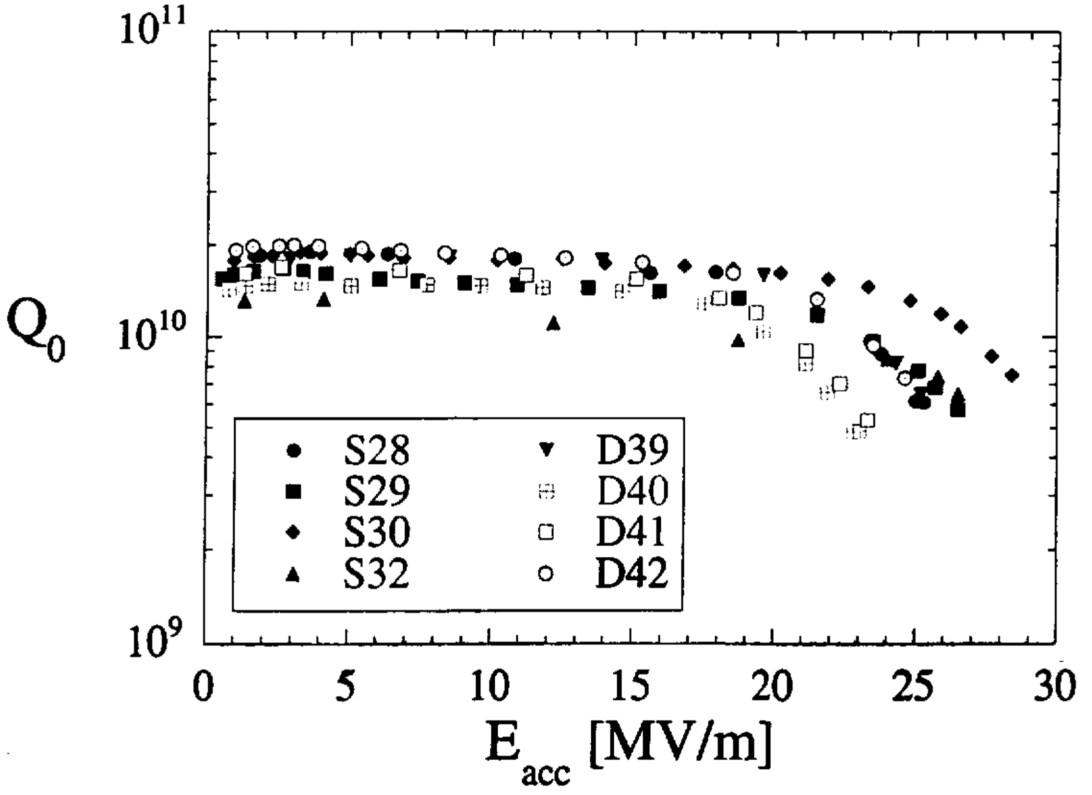
4 cavities are equipped with processed cold part of main coupler

3 (+1) cavities have been tested in CHECHIA

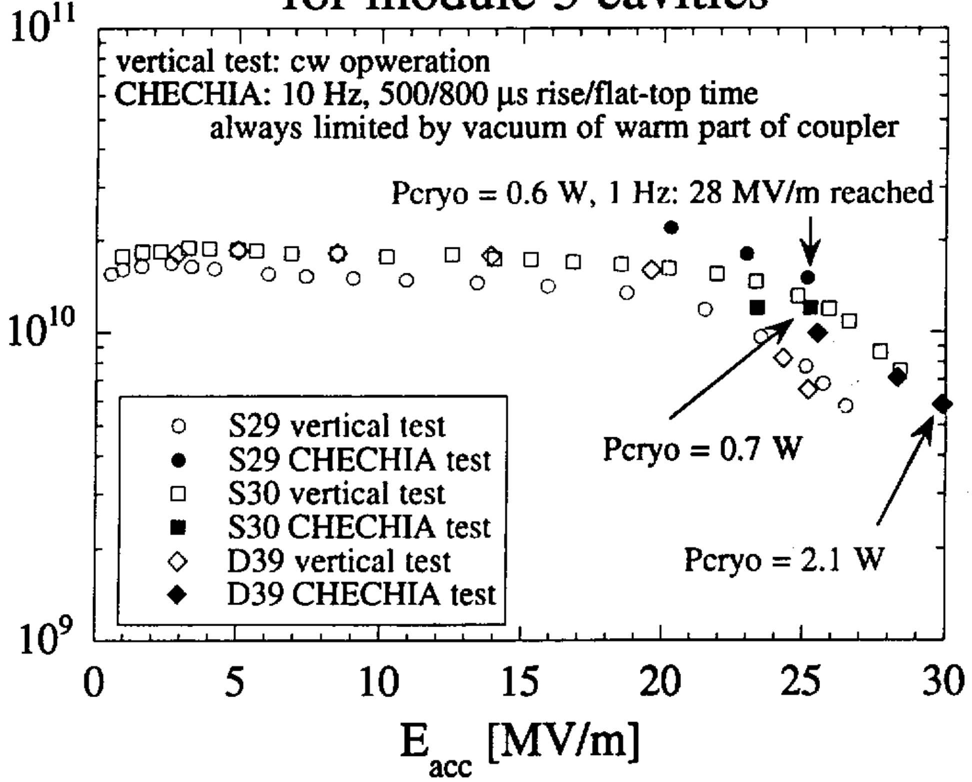
2 additional main coupler are processed and 2 more additional main coupler are under processing -> all cavities will be equipped with a processed cold window

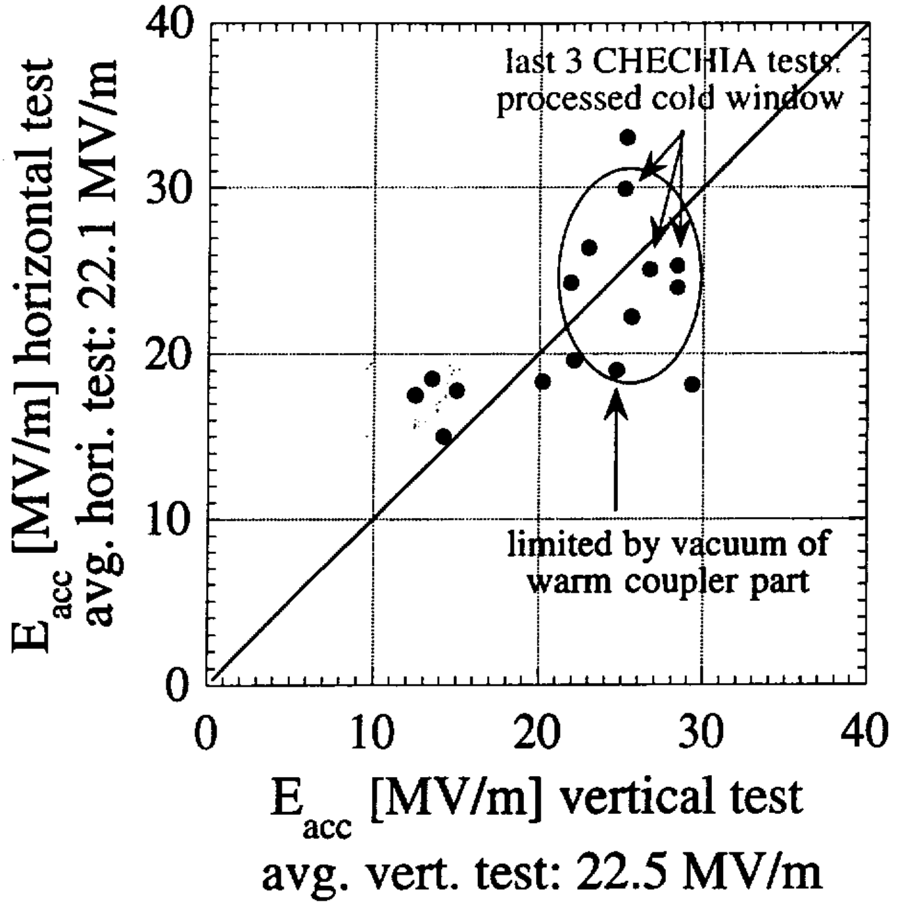
---

vertical test of cavities selected for module 3



Comparison of vertical to CHECHIA test for module 3 cavities





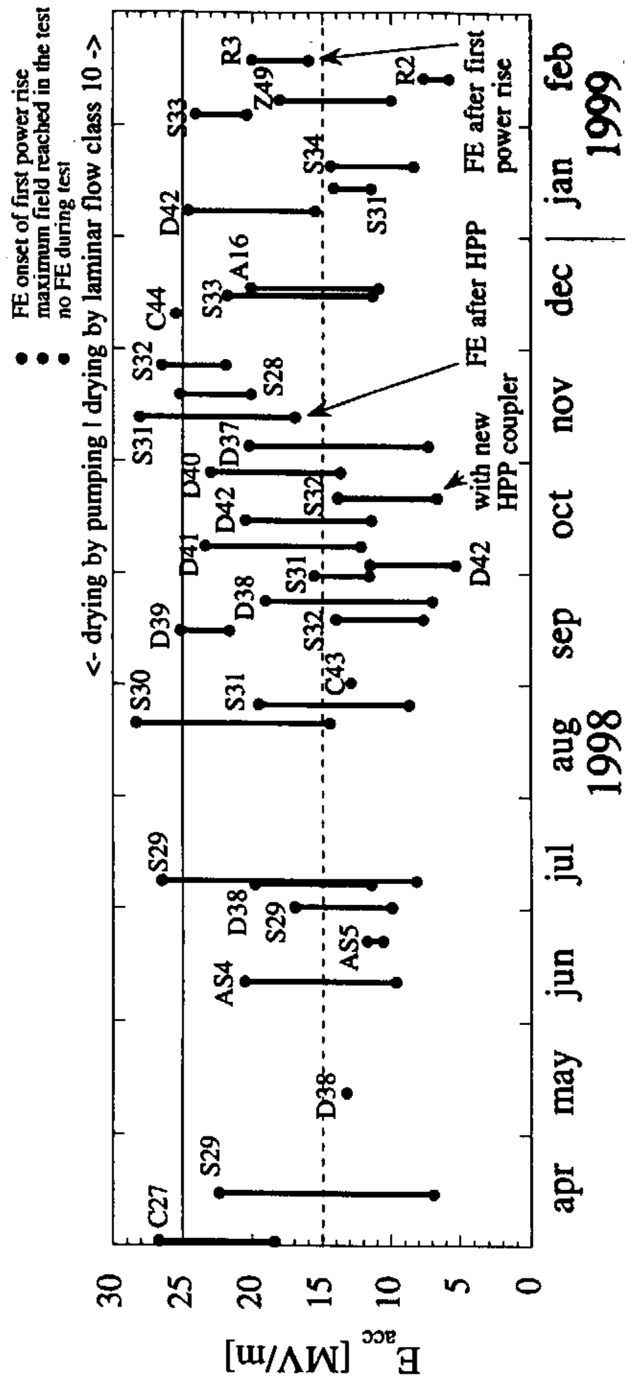
Field emission

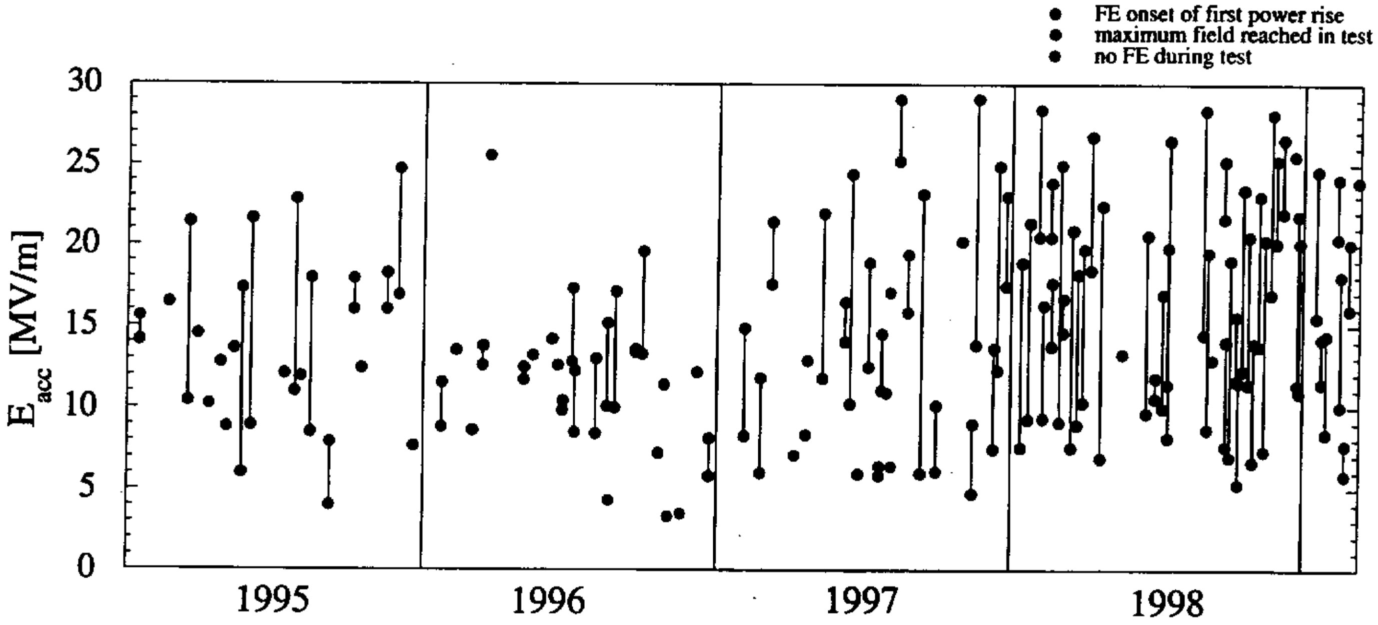
Still the vertical test results suffer a lot from field emission

There was a hint that drying by laminar flow gives better results than drying by pumping. In the moment, we use drying by laminar flow.

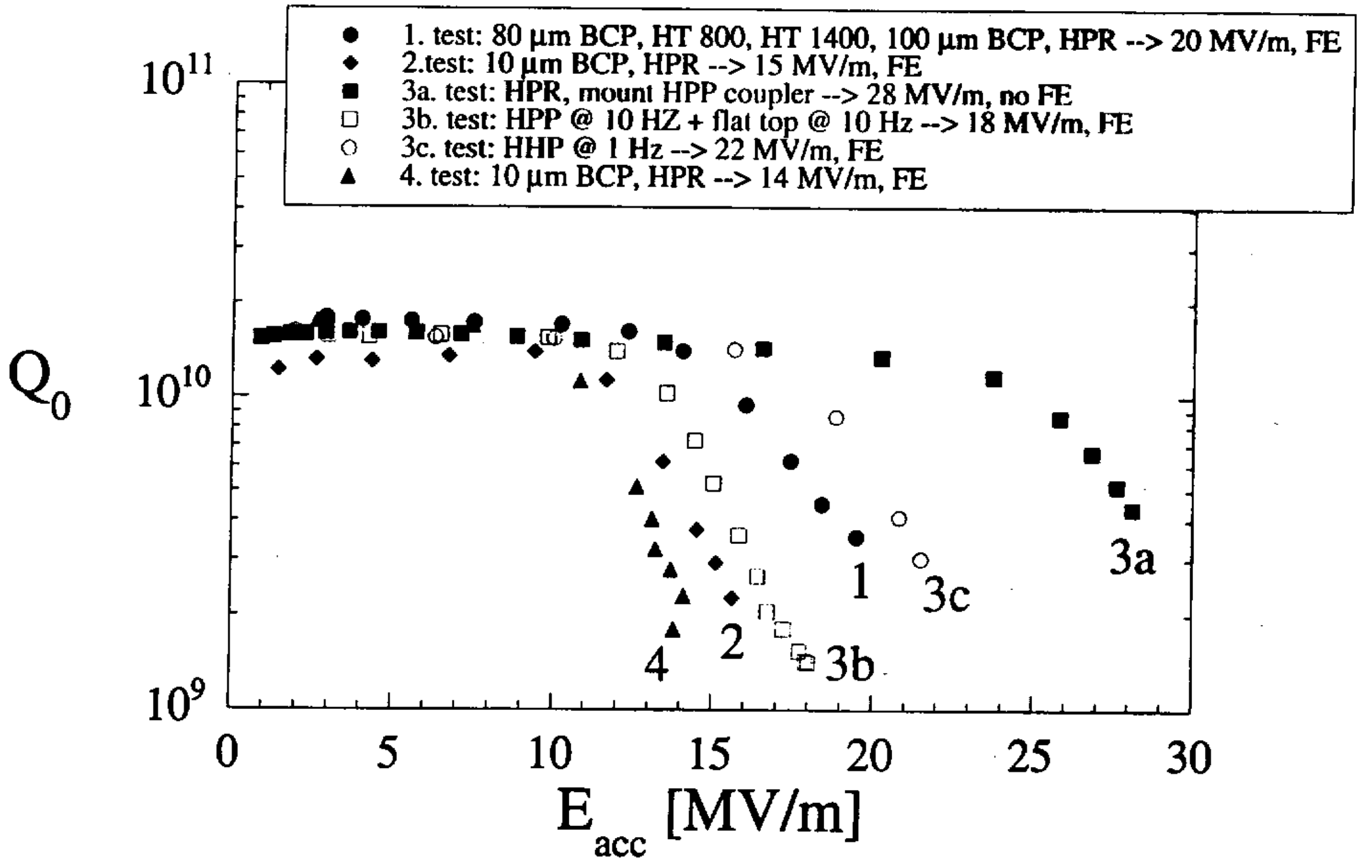
We have a new HPP coupler to fight field emission, but we have no klystron to use it in the moment.

We reduced a cavity by applying HPP with 10 Hz without having a good interlock system ---> We did not do HPP for a long time, so we partially forgot how to do it right





History of cavity S31



Test result of Rossendorf gun

Idea to use a superconducting cavity as a photo injector

We have tested this cavity called RG1 with and without cathode

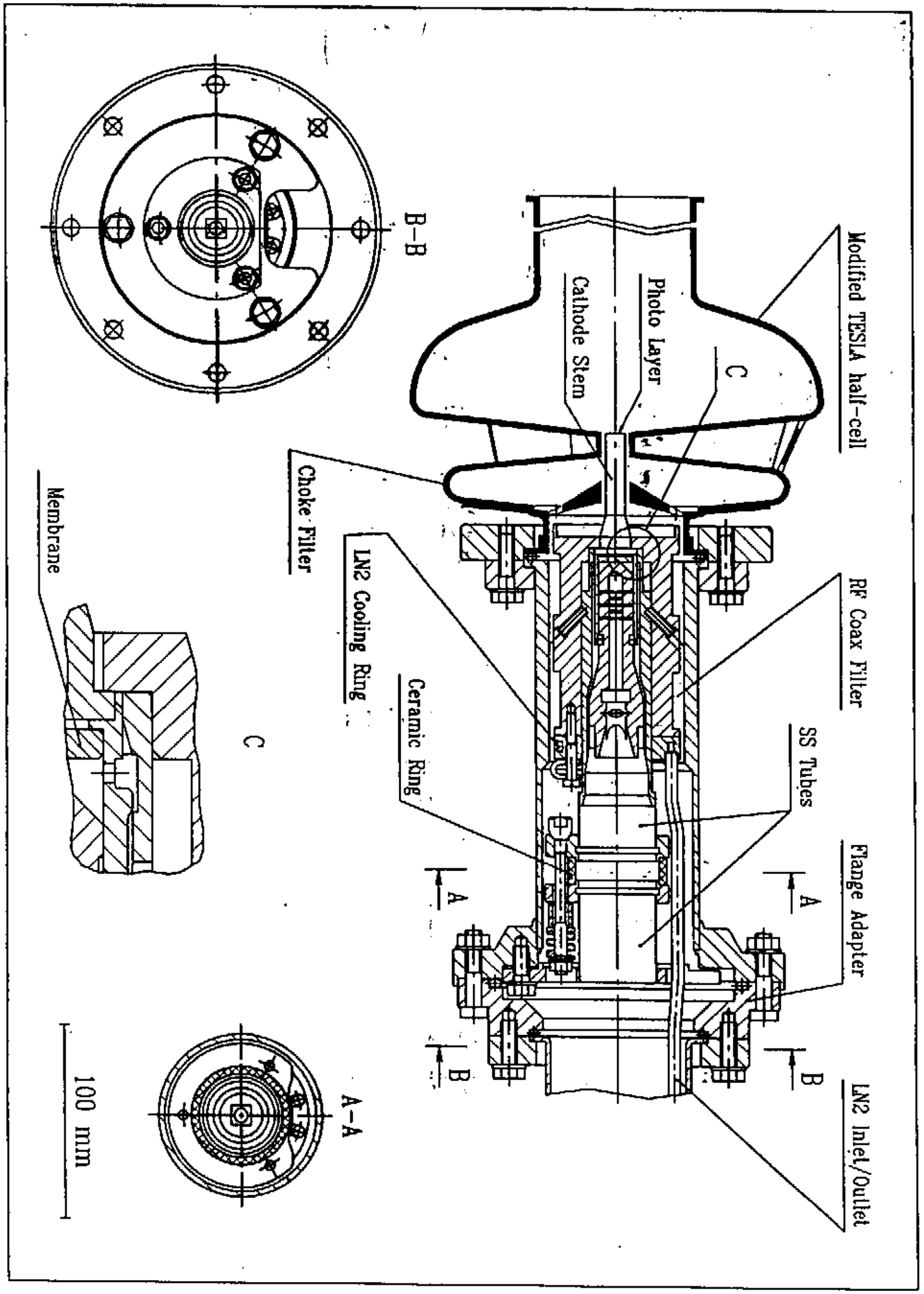
Parameters:

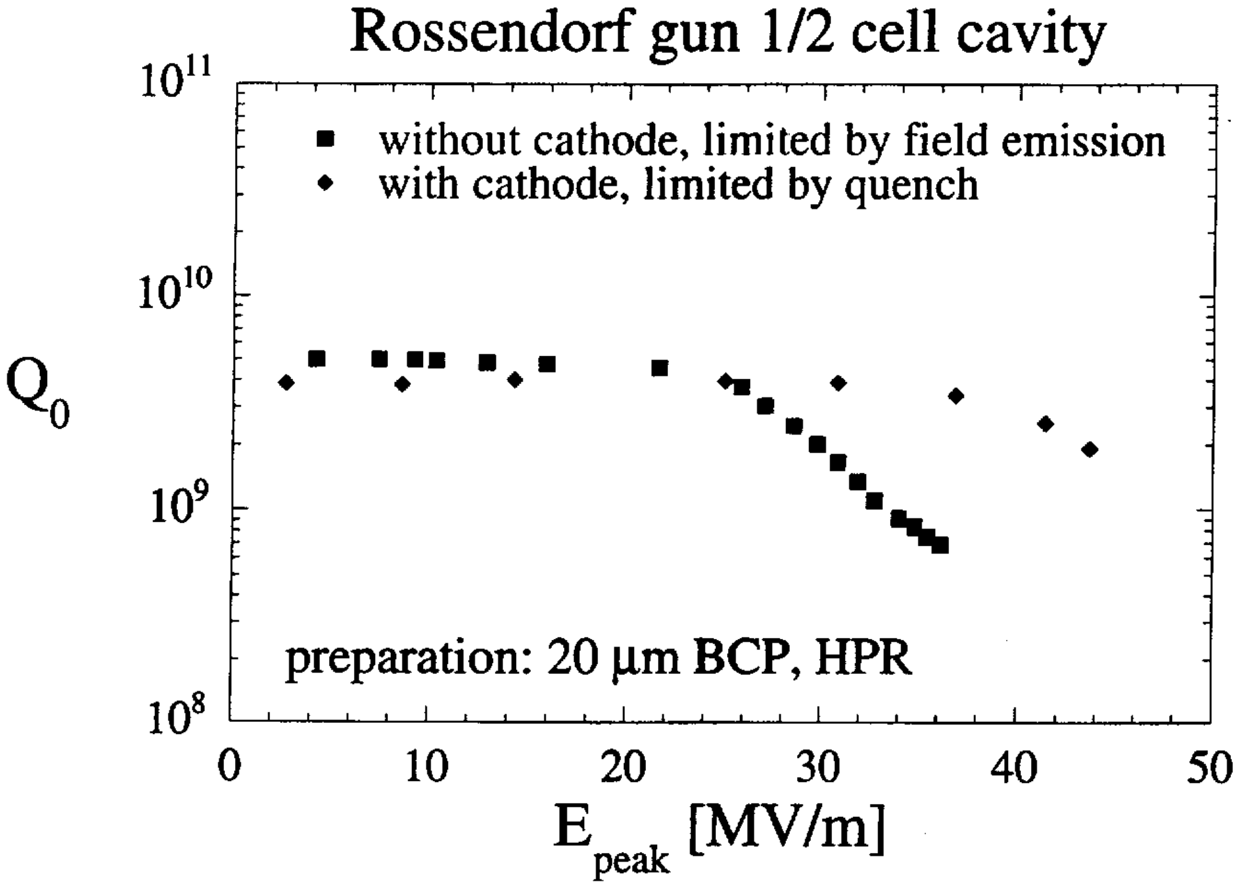
	TESLA 9cell	RG1 without cathode	RG1 with cathode
R/Q [Ω]	1036	67.9	68.3
Hpeak/Eacc [mT/MV/m]	4.26	3.17	3.17
Epeak/Eacc	2.0	2.0	1.5

Results:

	RG1 without cathode	RG1 with cathode
Eacc [MV/m]	18.2	28.5
Hpeak [mT]	57.7	90.3
Epeak [MV/m]	36.1	43.6
Ecathode [MV/m]		31.8

Hpeak = 90.3 mT in a TESLA 9cell cavity would correspond to an accelerating gradient of 21 MV/m.




Rossendorf gun 1/2 cell cavity
■ without cathode, limited by field emission
◆ with cathode, limited by quench
preparation: 20 µm BCP, HPR
Q_0
10^{11}
10^{10}
10^{9}
10^{8}
0
10
20
30
40
50
E_{peak} [MV/m]

H. Edwards

The Lasersystem

Performance

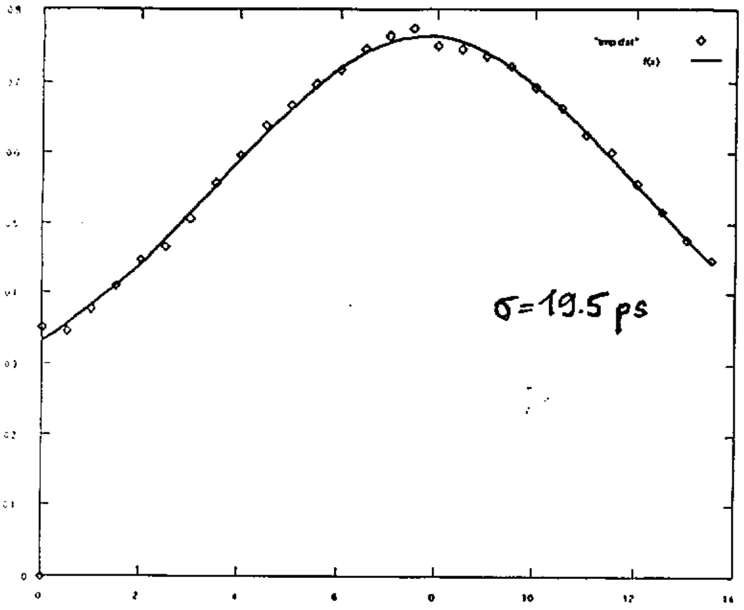
- Energy:
  - up to 30 μJ per Micropulse, largely sufficient for 8 nC
  - stability (shot to shot/within train) better than 5 % rms
- Phase:
  - stability better than 1 ps
  - drift seen with short pulses, fixed by forcing laser phase to 0 using the phase feedback system
  - occasional drift of resonator length
- Transverse profile:
  - flat top, uniformity not satisfactory yet
  - spatial filter in UV to be included, conversion green to UV to be optimized
- μ Pulse length:
  - phase scans suggested a long pulse, confirmed by streak camera and autocorrelation measurements ($\sigma = 15$ ps in UV)
  - fixed by replacing the oscillator laser head
  - now: $\sigma = 9$ ps in IR, estimate 5 to 8 ps in UV

The Lasersystem II: Reliability

- Uptime:
  - is running since mid December (except Xmas)
  - in total 1600 hours with 1 Hz or $5.8 \cdot 10^6$ shots
  - uptime 99 %, available for beam 97.5 %
- Failures
  - flashlamps of pulse train oscillator (PTO) exchanged after $8 \cdot 10^6$ shots
  - lost 4 hours + 2 shifts with very unstable conditions
  - complete PTO laser head exchanged to cure pulse length
  - Sparc cpu in laser VME had to be replaced
- Server
  - laser server and control program is running smoothly and stable
  - laser cpu was heavily effected once by Desy network problems, reboot was required
- Interlocks
  - no failure of personal laser safety interlock
  - access to tunnel with laser beam on is not yet established in a way, that operators could make use of it.
  - no failure of technical laser safety this time (we had one failure in May 1998), SPS is working fine

Autocorrelation trace (λ=1047nm)

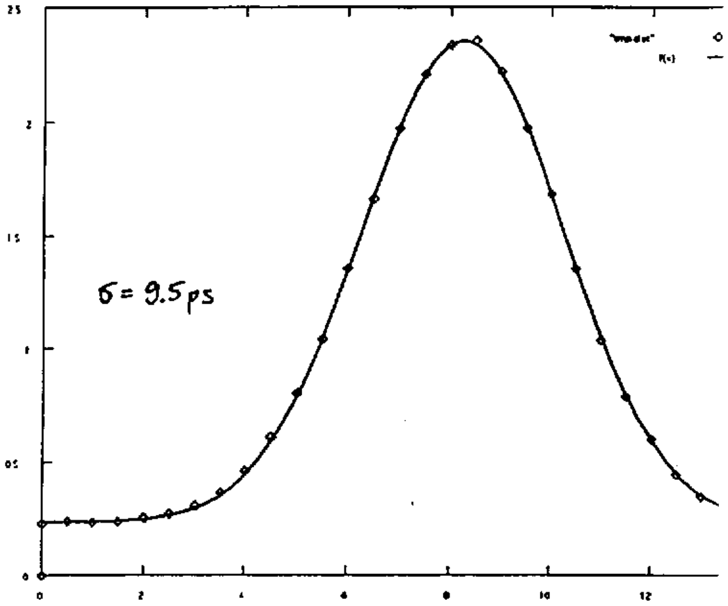
before



σ=19.5 ps

time

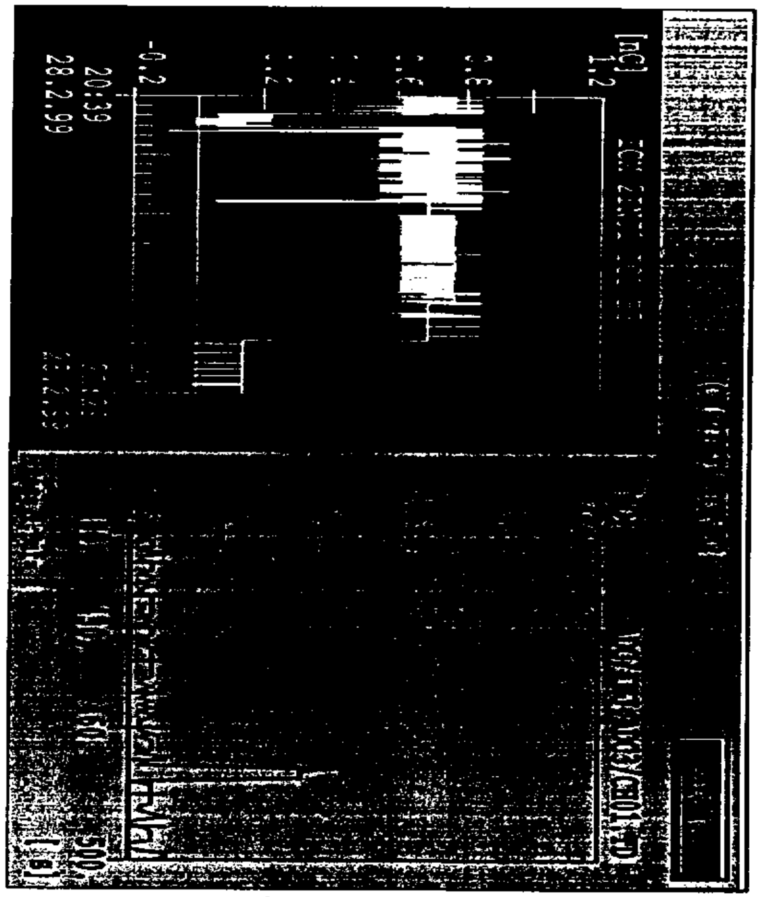
after exchange of Laser head



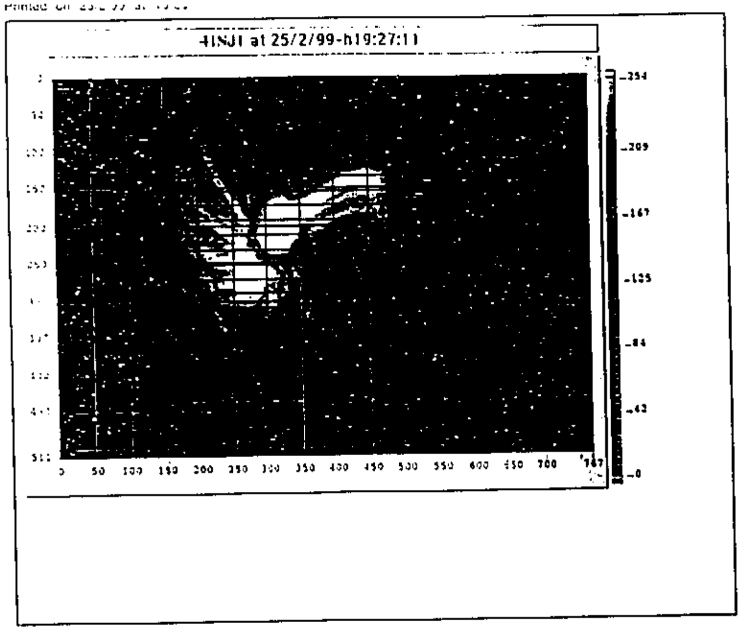
σ = 9.5ps

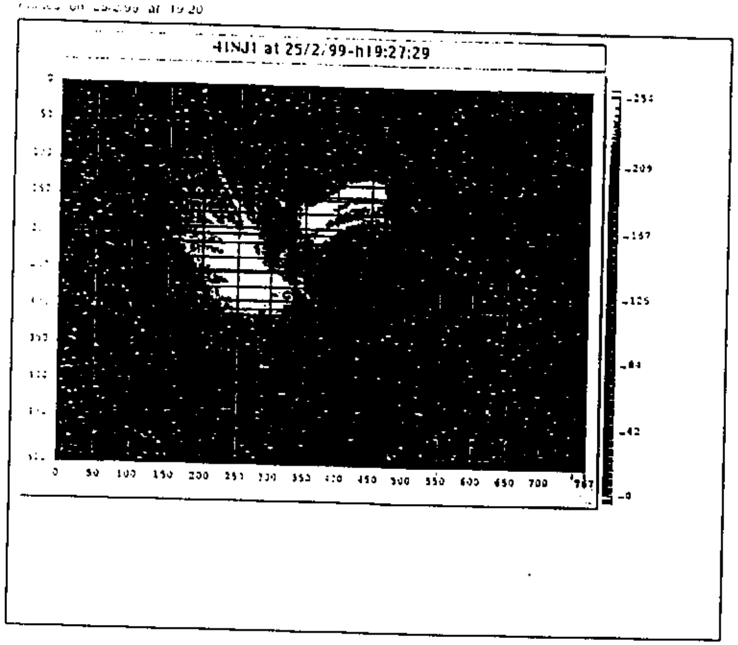
time

28.Feb.99 23:33.01



17



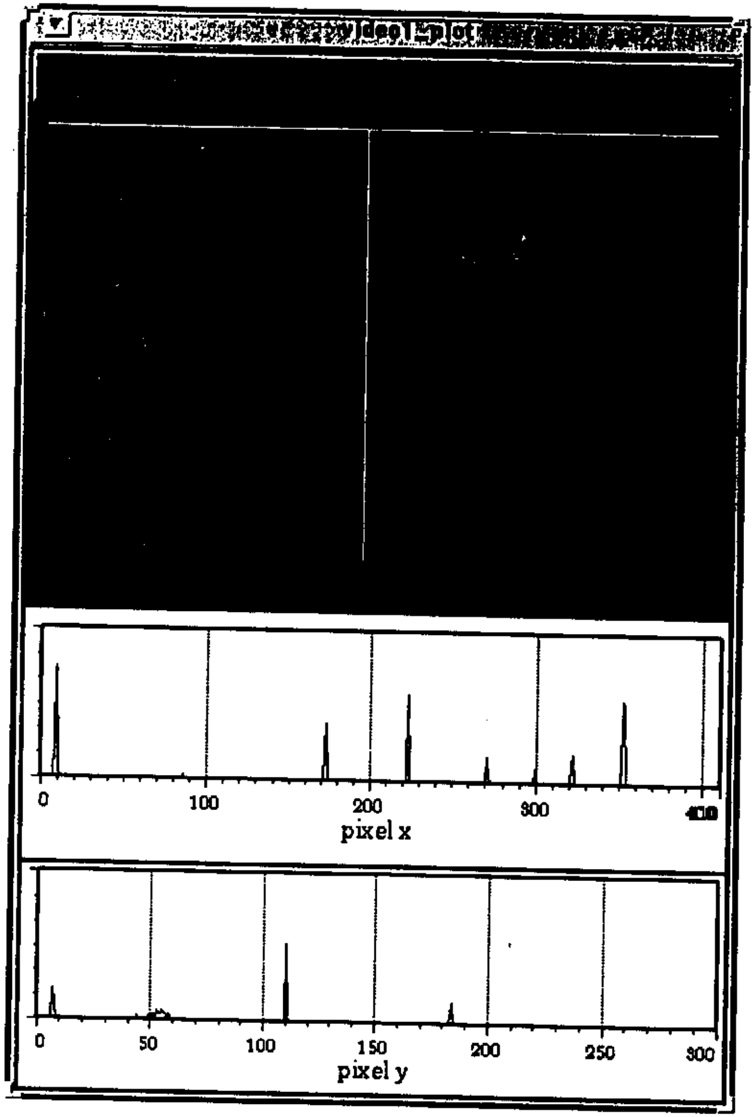


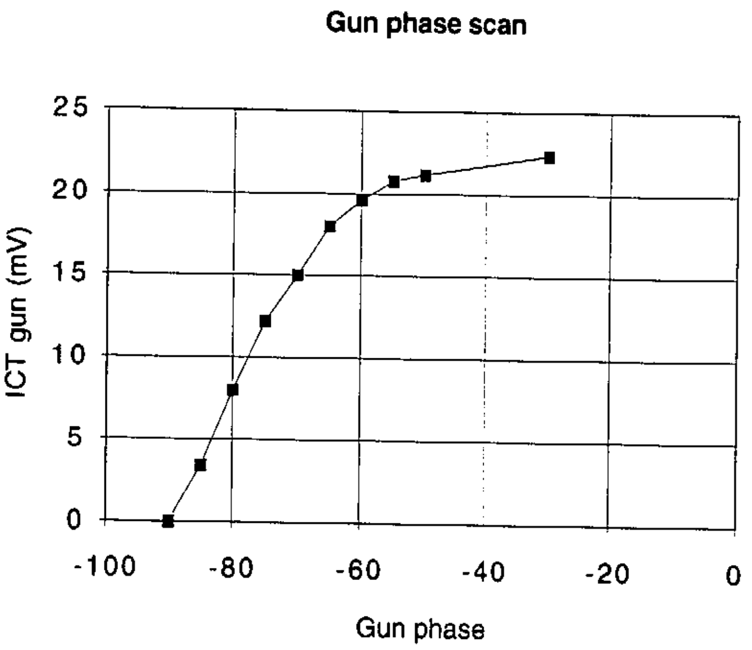
gun Power to > 3 MW

2.2MW ⇒ 35MV/m cathode.

operates to 2.7MW. some trips

(needs console reset)

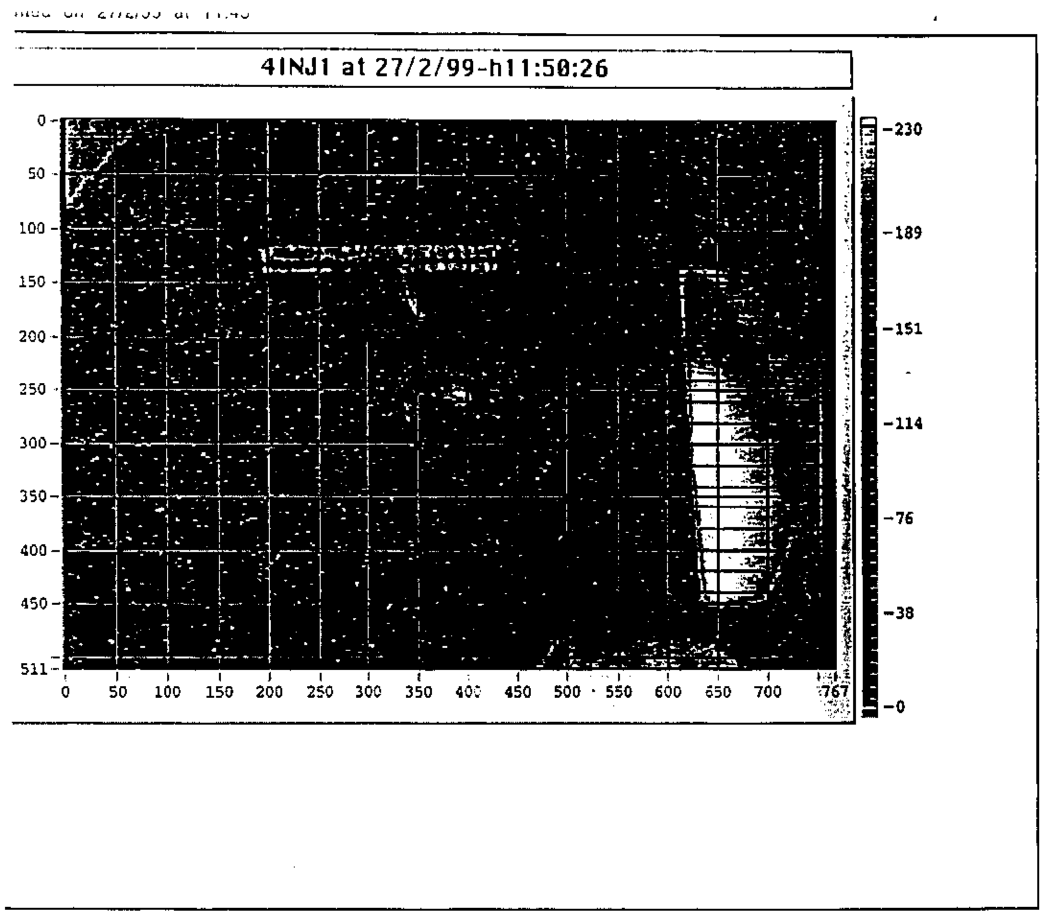

video1_plot
0
100
200
300
400
pixel x
0
50
100
150
200
250
300
pixel y


Gun phase scan
ICT gun (mV)
25
20
15
10
5
0
-100
-80
-60
-40
-20
0
Gun phase

Gun Phase Scan.

16 deg FWHM.
2.14 ps/deg
0.3 mm/ps

34ps FWHM 14.6ps σ
4.3 mm σ



Laser-measurement.

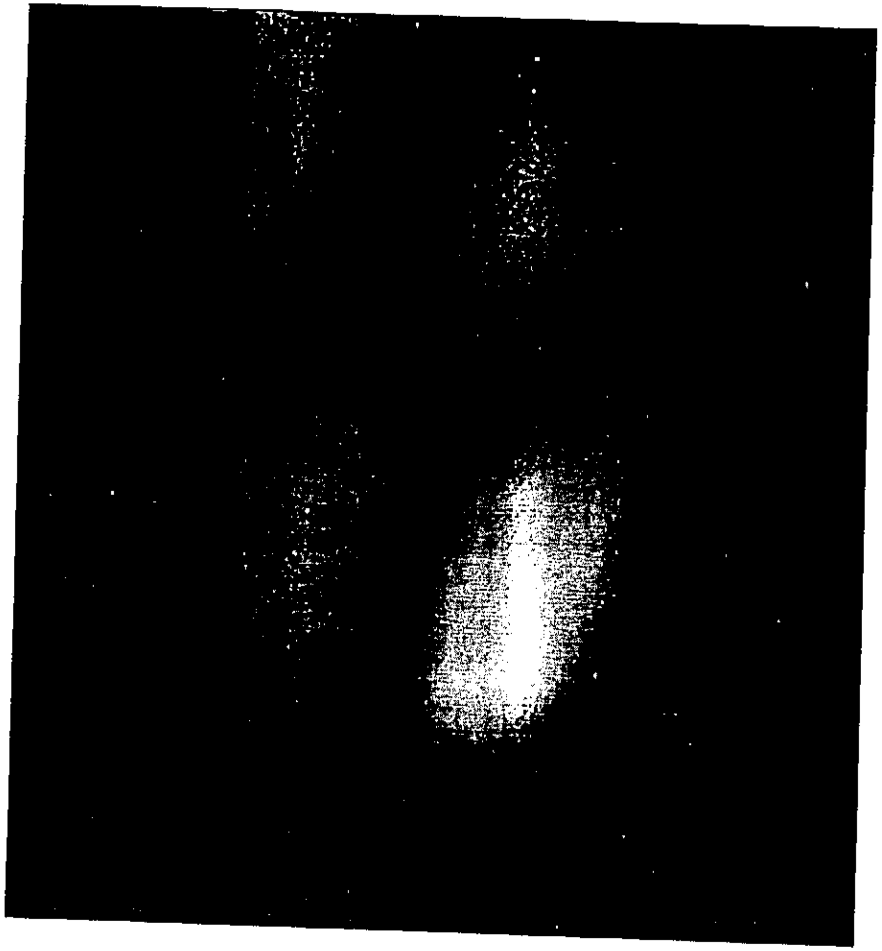
now
IR σ = 9.5ps was 18.5 σ
UV (exp. 5-8ps) was 15.

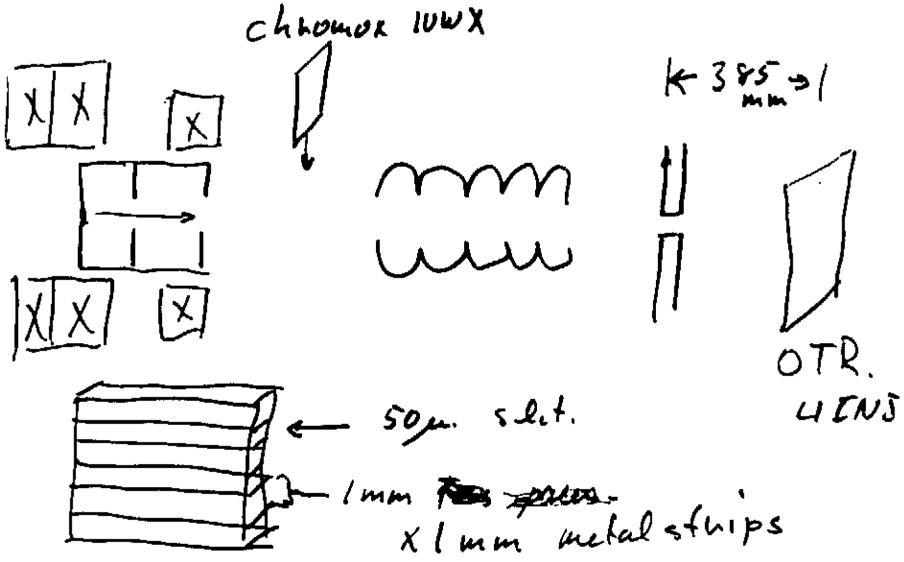
Design

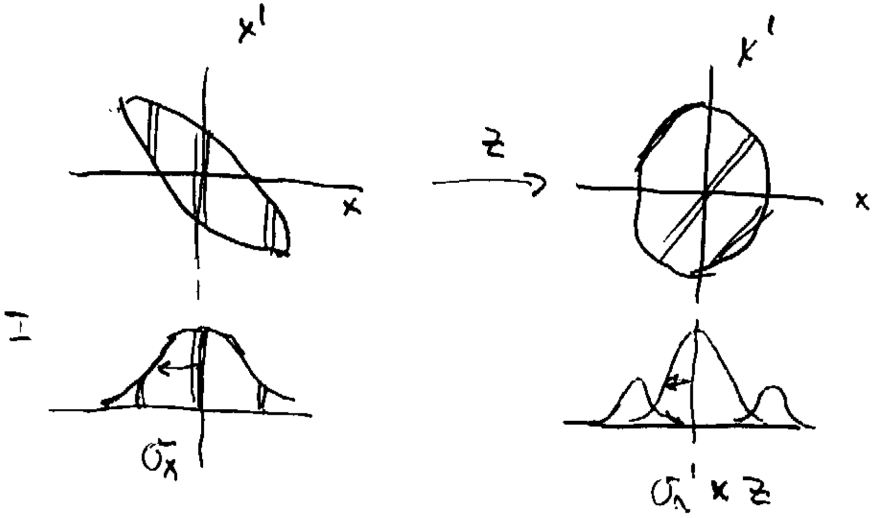
Colby - TTF report. 13-28 ps FWHM.
thesis 8-10 ps FWHM.

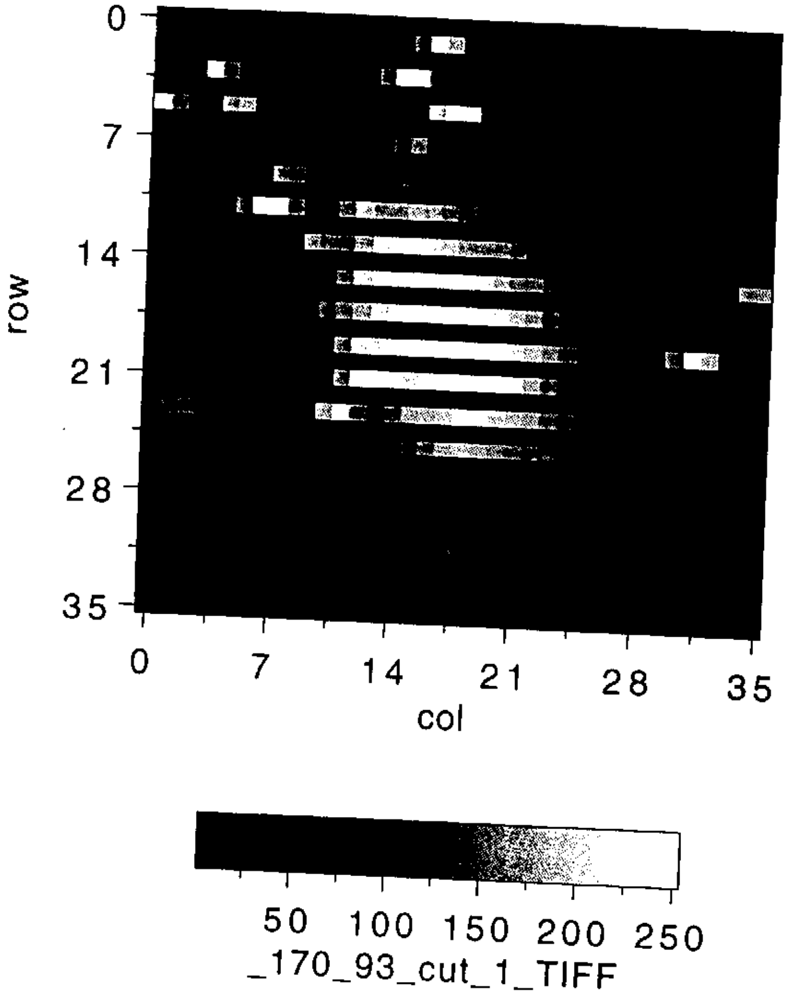
Best Effort Request? 5-10ps σ
≈ 12-23 ps FWHM.

Slit Emittance Data.

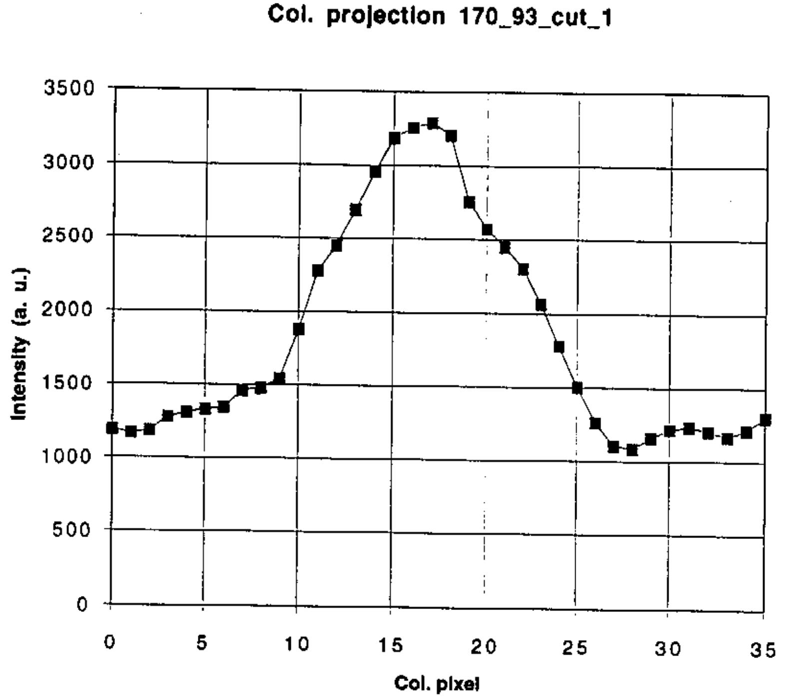








TTFOTR2@MAC, FEB26/11:13



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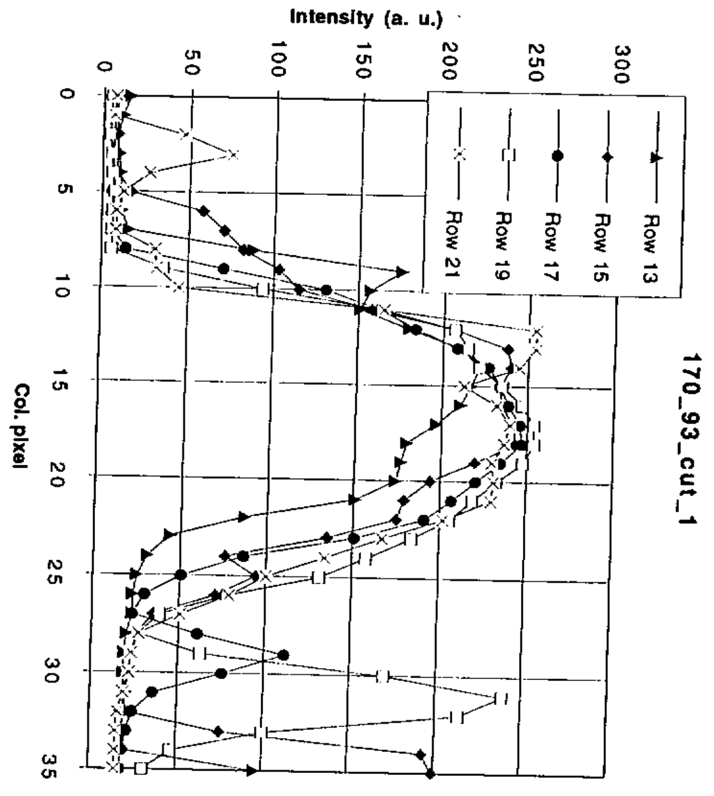

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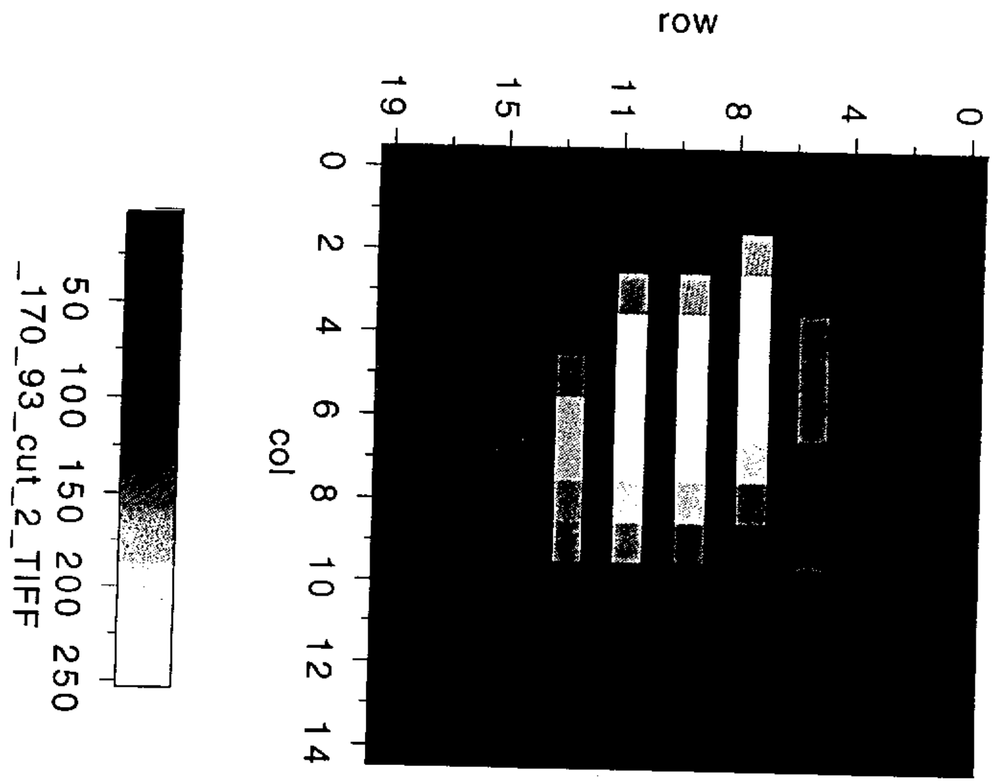
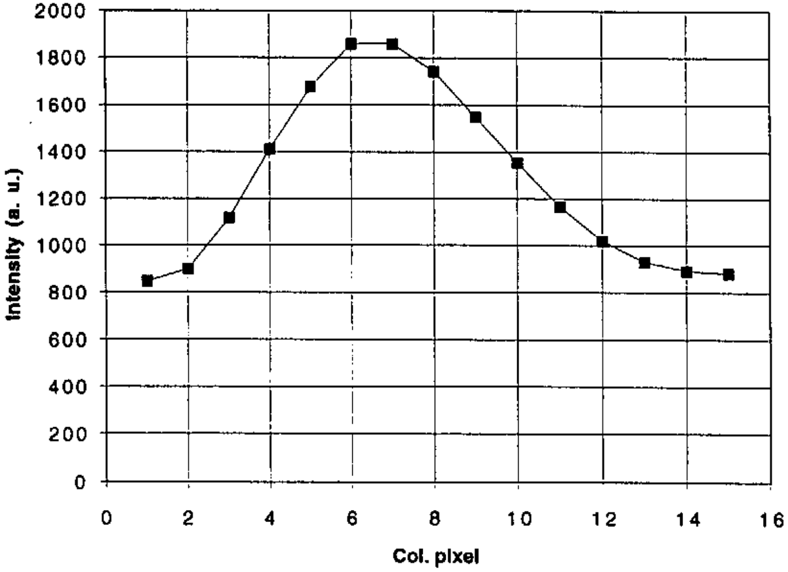
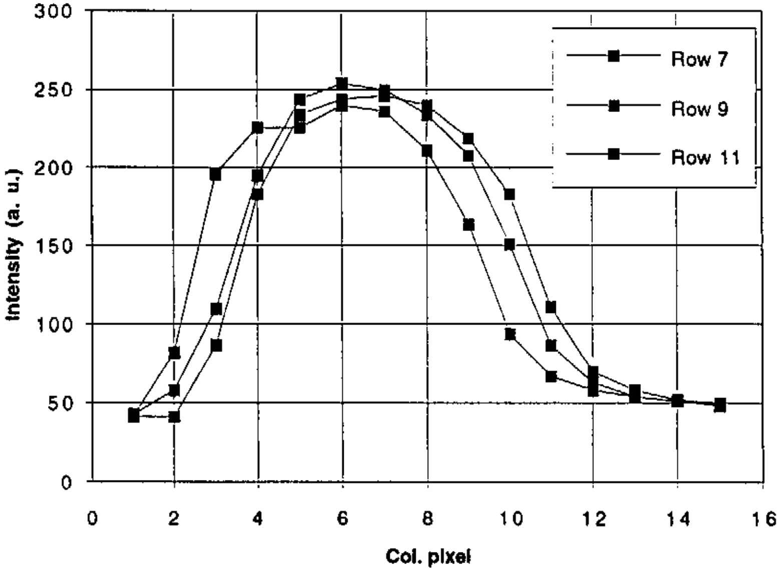


TTFOTR2@MAC, FEB26/11:03



Col. projection 170_93_cut_2

TTFOTR2@MAC, FEB26/14:52



170_93_cut_2

TTFOTR2@MAC, FEB26/13:40

Data plots 1 NE

Spot FWHM 12 p (5.1 p σ)

Slit FWHM 6.3 p (2.7 p σ)

$$x x' = 12 \times \frac{6.3}{385} \times \frac{(.06)^2}{(2.35)^2} = 0.125$$

$z = 385$ mm p ~~ck~~ = p = 0.06 mm

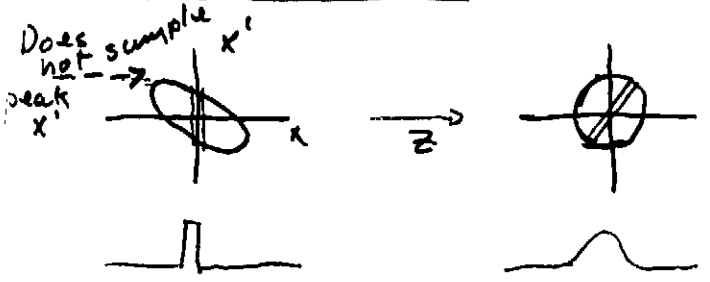
log book

Spot σ 8.9 p

Slit σ 3.6 p

$$x x' = 8.9 \times \frac{3.6}{385} \times (06)^2 = 0.3$$

Correction for beam convergence?



correction ~ $\frac{1}{0.7}$ from slit spacing we think

$$\varepsilon_N \approx \nearrow \frac{0.125}{0.7} \times 33 = 5.9\ \pi \text{ mmmr}$$

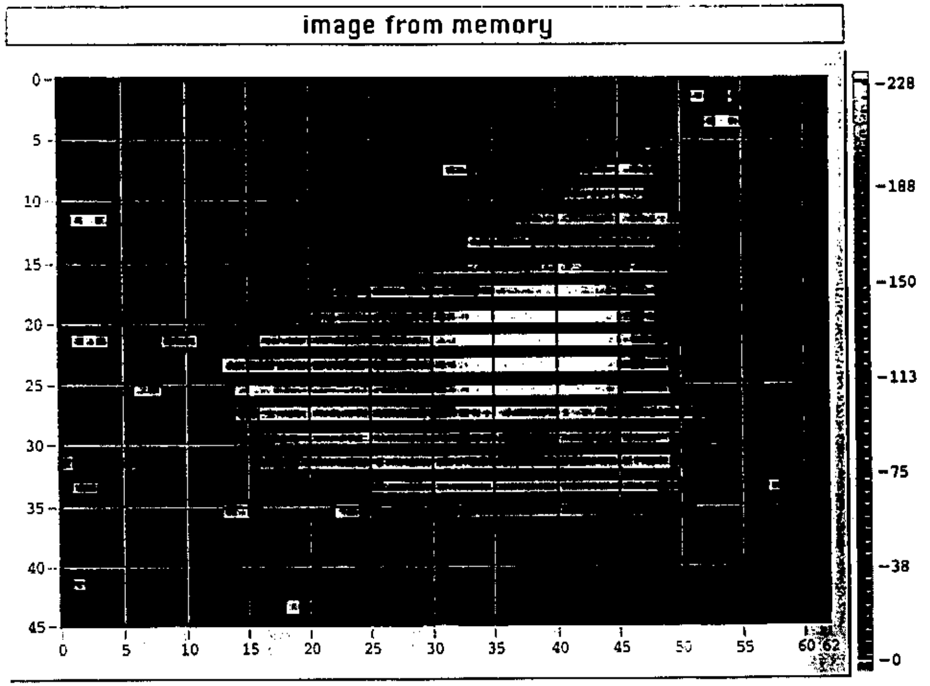
$$\searrow \frac{0.3}{0.7} \times 33 = 14\ \pi \text{ mmmr}$$

$pc = 16.5$ MeV. $\overset{\uparrow}{\gamma}$

To Do - -(this, next week)

- Try to see beam through slit as move focus forward.
- Set up and measure 8 nC.
- Compare with Mark.
- Get Energy spectrum vs φ
- See how E changes with focus.
- Dark current check

nted on 27/2/99 at 16.04 [illegible]



27/2/99 at 15:56 AMC Slits.

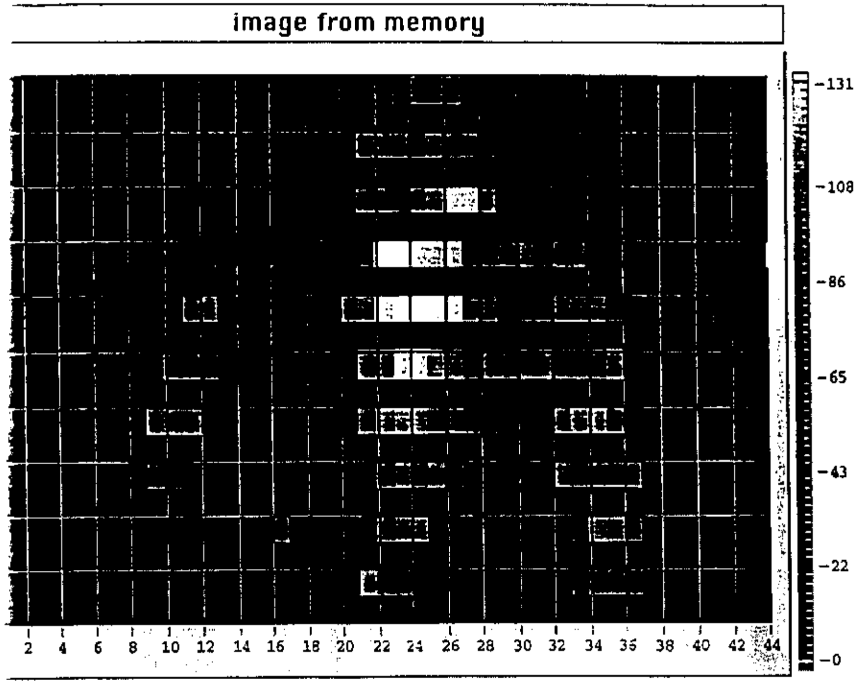
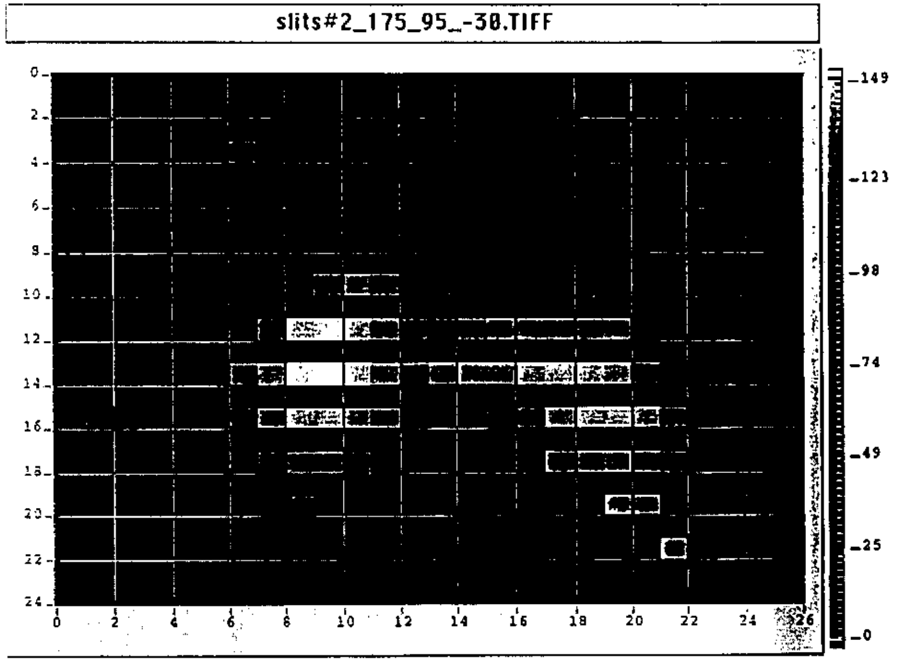


image from memory

Last modified on 18/12/97 at 8:13
Printed on 28/2/99 at 11:32

3



slits#2_175_95_-30.TIFF

27

M. Geitz

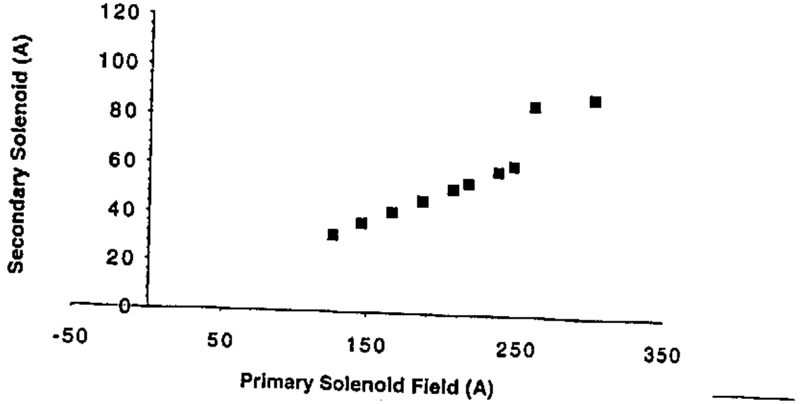
LINAC OPERATION JAN/FEB 99

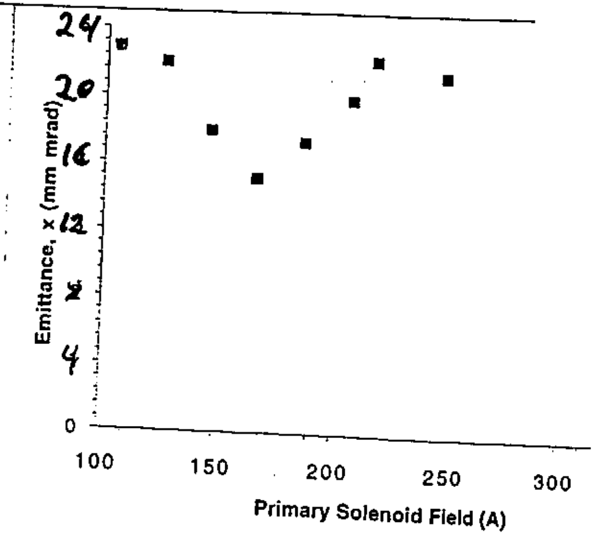
MAIN GOAL:

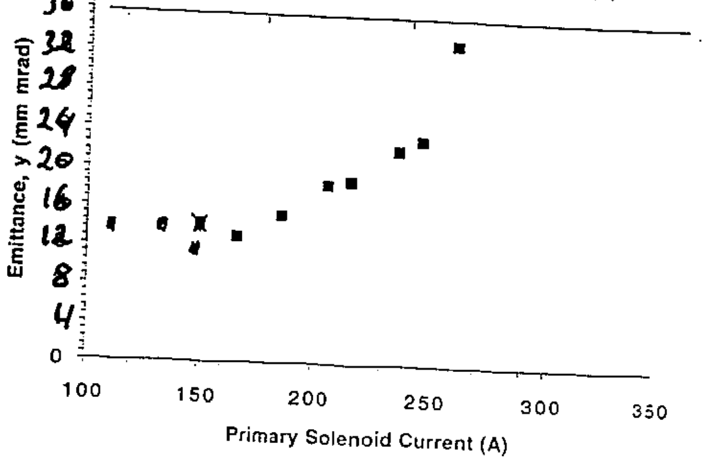
- PREPARATION OF THE LINAC FOR THE INSTALLATION OF THE FEL
  - COMMISSIONING OF NEW BEAMLINE ELEMENTS
    - (i) FINAL RF GUN
    - (ii) BUNCH COMPRESSOR II
    - (iii) CRYO MODULE II
  - COMMISSIONING OF DIAGNOSTICS
  - " " OPTICS
- MEASUREMENTS IMPORTANT FOR THE HIGH ENERGY COLLIDER
  - HOM
  - RF STEERING

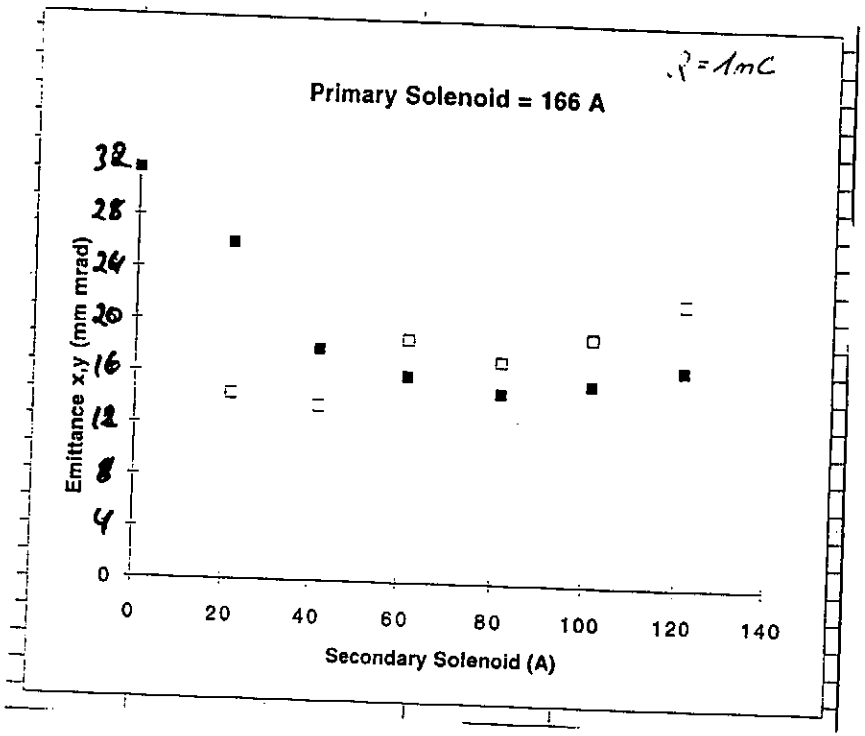
1) INJECTOR STATUS

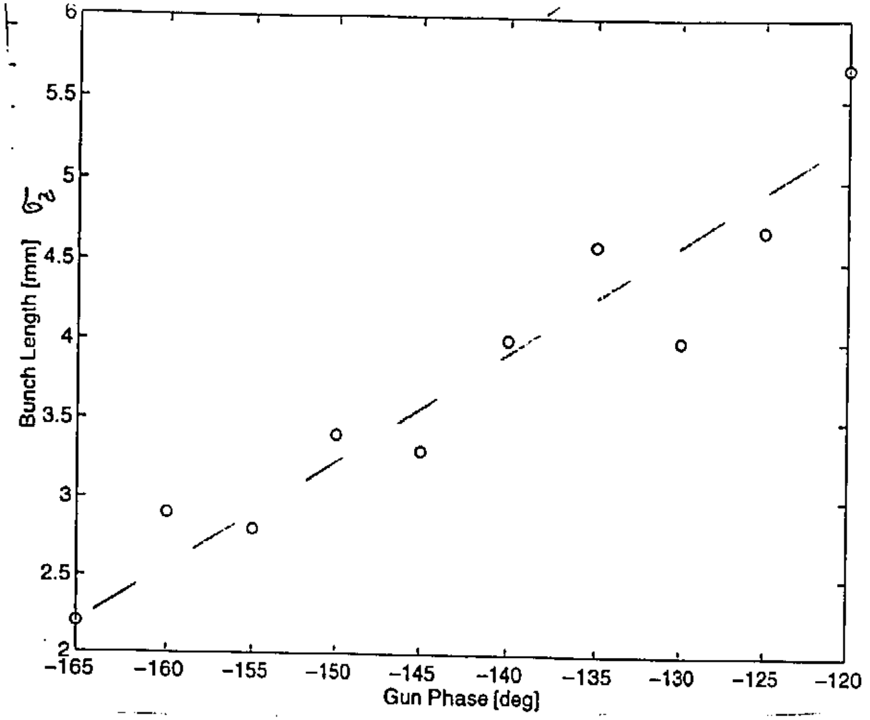
- ENERGY WITHOUT CAPTURE CAVITY
  $E \approx 4{,}5\,\mathrm{MeV}$
- INJECTOR ENERGY $E > 16{,}5\,\mathrm{MeV}$
- ENERGY SPREAD $Q = 1\,\mathrm{nC} \rightarrow \frac{\Delta E}{E} \approx 0{,}3$
  $Q = 8\,\mathrm{nC} \rightarrow \Delta E/E \approx 1\%$
  (UPPER ESTIMATE → SCREENS)
- EMITTANCE: $1\,\mathrm{nC} \rightarrow (12 \pm 6) \cdot 10^{-6}$
  (TOMOGRAPHY) $8\,\mathrm{nC} \rightarrow (50 \pm 10) \cdot 10^{-6}$
  (PEPPER POT): $1\,\mathrm{nC} \rightarrow (9 \pm 4) \cdot 10^{-6}$
  ↳ GUN SOLENOIDS MUCH SMALLER THAN EXPECTED.
- DARK CURRENT: 7-14 μA
- CATHODE LIFETIME: ≥ 1 month
- LASER PULSE LENGTH:
  $\tau_2 \approx 20\,\mathrm{ps} \longrightarrow \tau_2 \approx 10\,\mathrm{ps}$
- ELECTRON PULSE LENGTH
  $6\,\mathrm{ps} \leq \tau_e \leq 15\,\mathrm{ps}$.

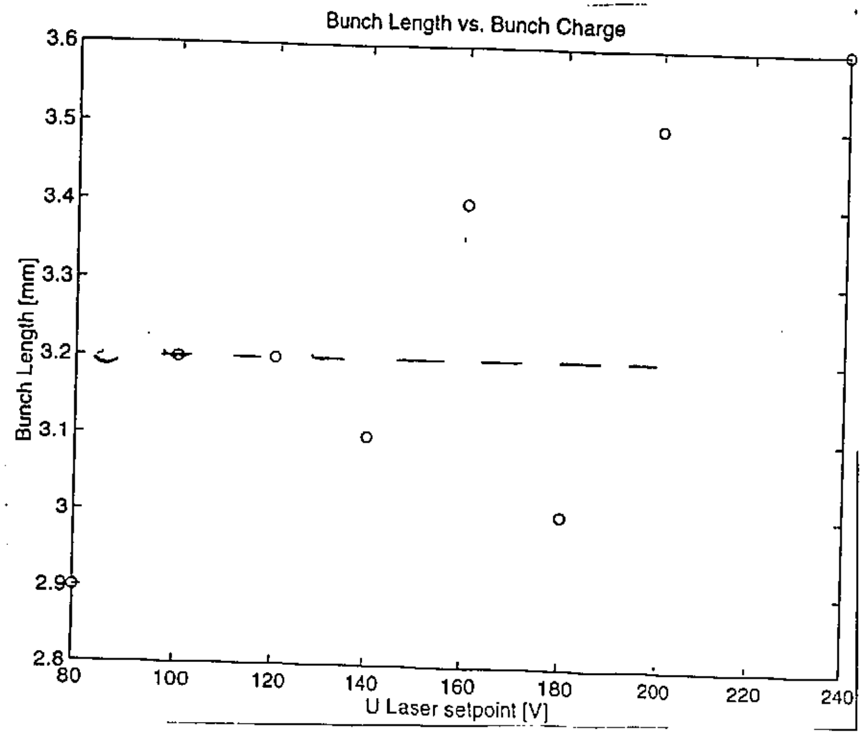

Secondary Solenoid (A)
120
100
80
60
40
20
0
-50
50
150
250
350
Primary Solenoid Field (A)


Emittance, x (mm mrad)
24
20
16
12
8
4
0
100
150
200
250
300
Primary Solenoid Field (A)

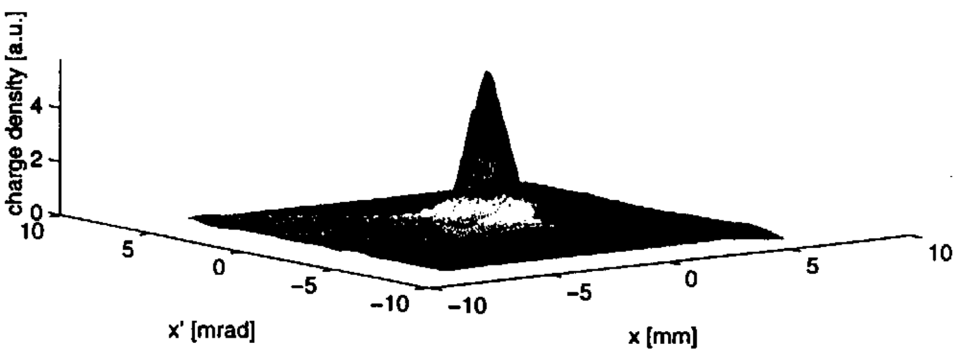

Emittance, y (mm mrad)
40
36
32
28
24
20
16
12
8
4
0
100
150
200
250
300
350
Primary Solenoid Current (A)

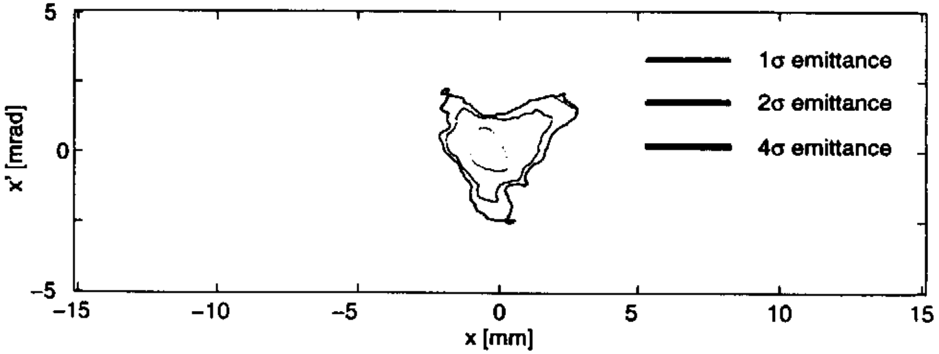

Q = 1nC
Primary Solenoid = 166 A
Emittance x,y (mm mrad)
32
28
24
20
16
12
8
4
0
0
20
40
60
80
100
120
140
Secondary Solenoid (A)





Transverse phase space distribution at the TTFL Injector II





Normalized emittance: (12 ± 6) mm mrad

Twiss parameters: $\beta = (1.2 \pm 0.3)$ m
$\alpha = (0.1 \pm 0.3)$

TTFL, January 1999

99

H. Edwards
D. Sertore

↓ J. Kossatz 15.6.

distance ⑥ − ① = 81 − 35 = 46 Pixels (±2)

assume 60μm/Pixel → ⑥ − ① = 0.06mm · 46 = 2.76 ± 0.1mm

→ distance of slit images on screen: 0,55 ± 0.02 mm

→ reasonable to <u>assume</u> slit distance of 0.5 mm

196, 64, 2.7 MW
φ_{gun} 110, φ_{ec} 101

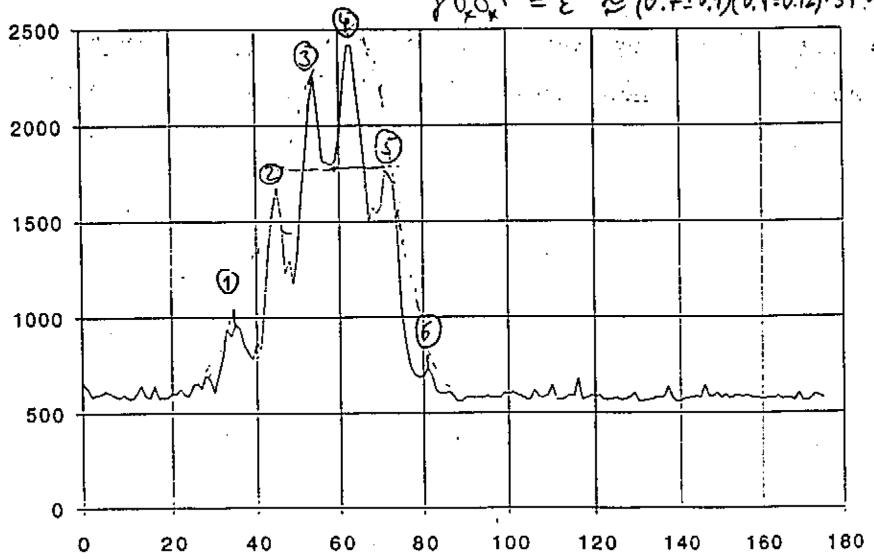
↳ beam width at slit:
$\sigma_x \approx \frac{0.5}{0.55} \cdot (13 \pm 2) \cdot 0.06 \frac{mm}{Pix} = (0.70 \pm 0.1)$ mm

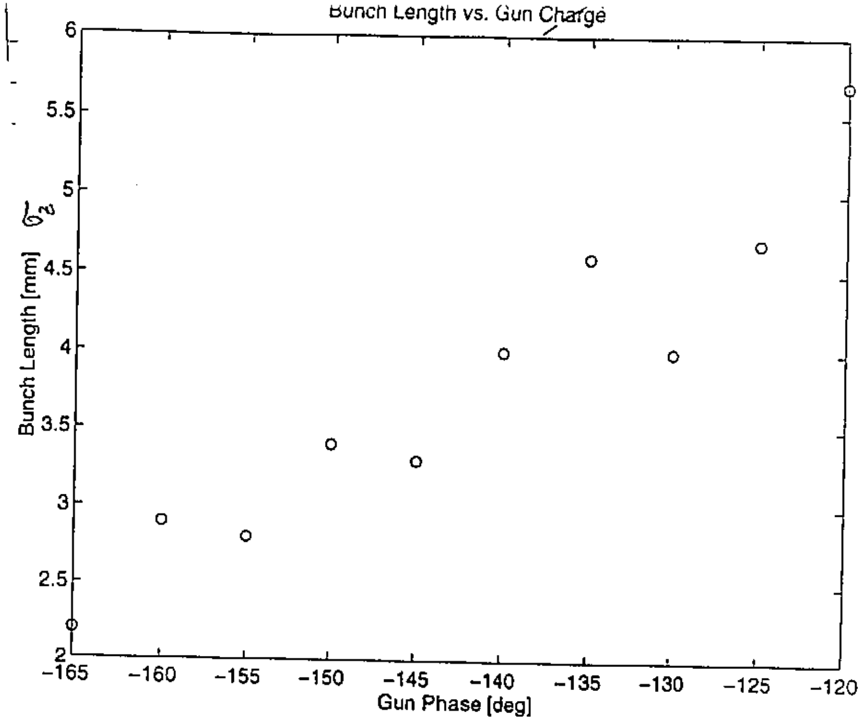
beam divergence at slit: $\frac{\sigma_x}{Dist} = \sigma_{x'} = \frac{(0.15 \pm 0.5)mm}{385 mm} \approx (0.4 \pm 0.12)$ mr
slit (2.6 ± 1) Pixel

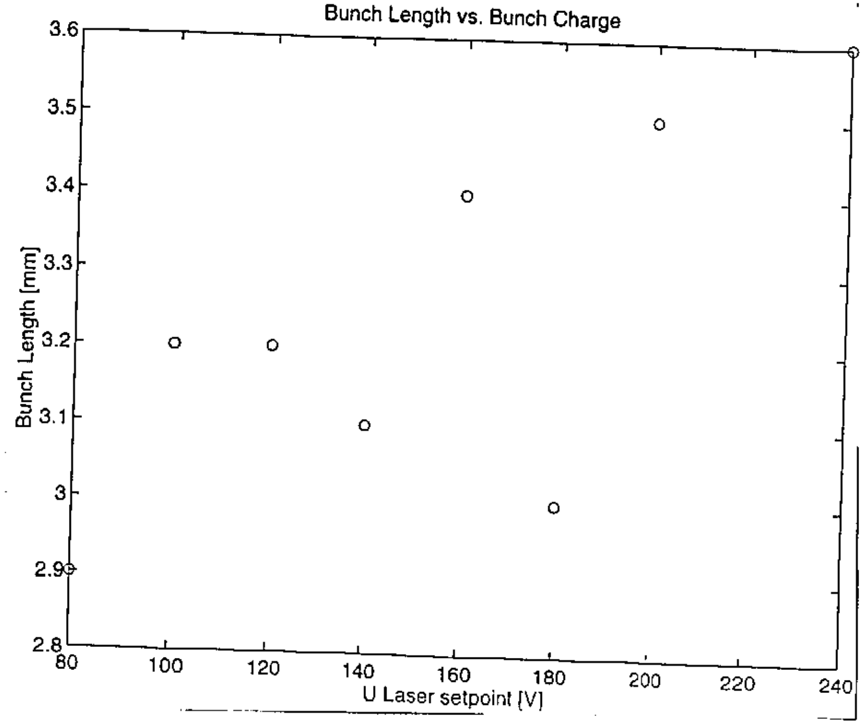
$\gamma \approx 34$

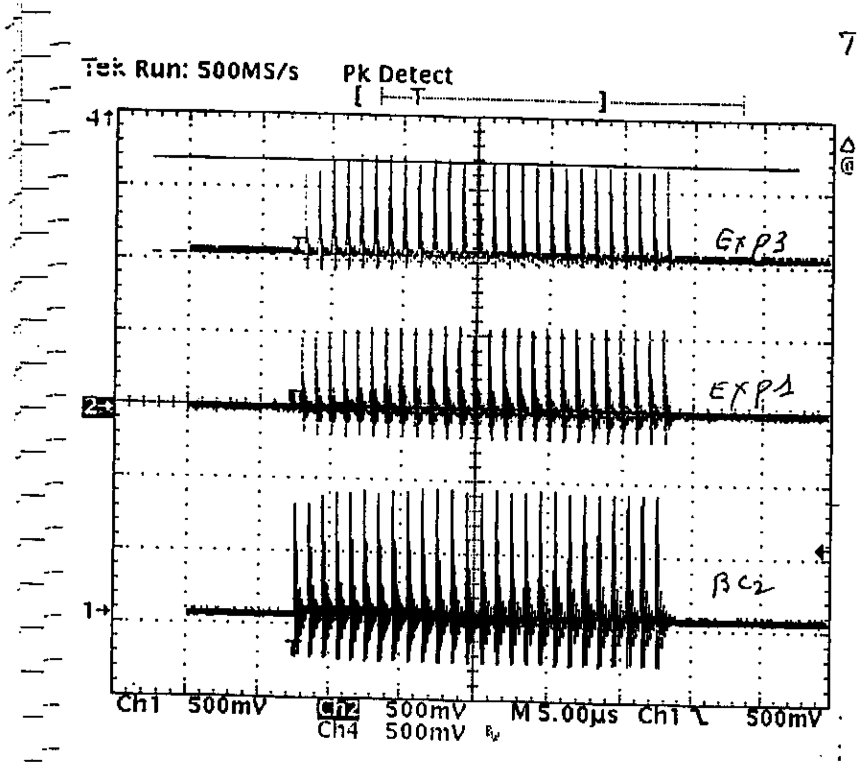
$\gamma \sigma_x \sigma_{x'} = \varepsilon^n \approx (0.7 \pm 0.1)(0.4 \pm 0.12) \cdot 34$ mm mrad
$= (9.5 \pm 4)$ mrad mm

prof_20 Chart 1









2) LINAC

- ENERGY DURING STABLE OPERATION WITH KLYSTRON II : $E \approx 160-180$ MeV
- ENERGY SPREAD : $\Delta E/E \approx 0{,}3\%$ (1nC) (OTR SCREEN EXP3)
- EMITTANCE : (EXP1, BC2)

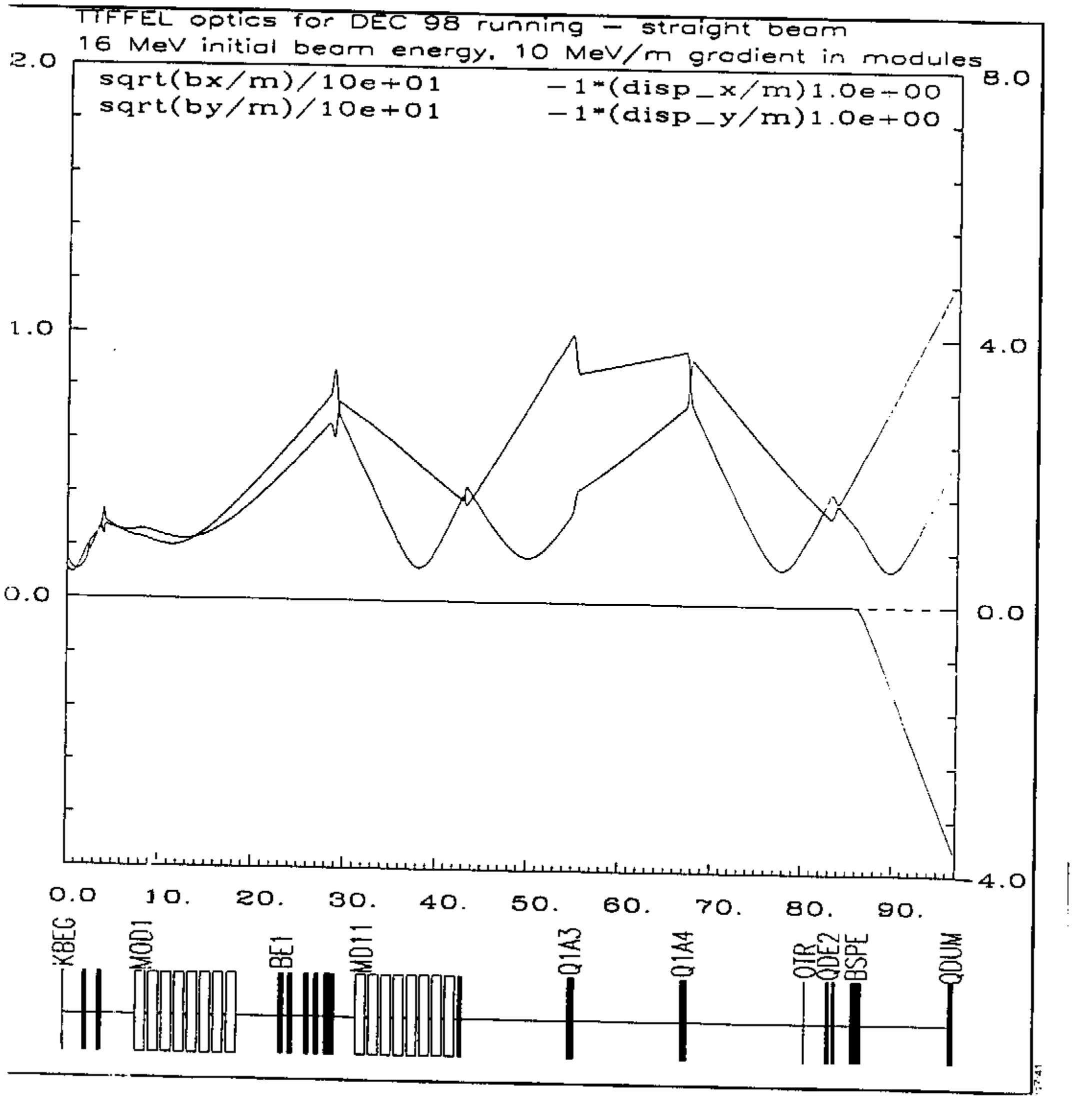
  $\varepsilon_x \approx 8 \cdot 10^{-6}$ $\varepsilon_y \approx 30 \cdot 10^{-6}$

  (ERROR ESTIMATE ≈ 50%)

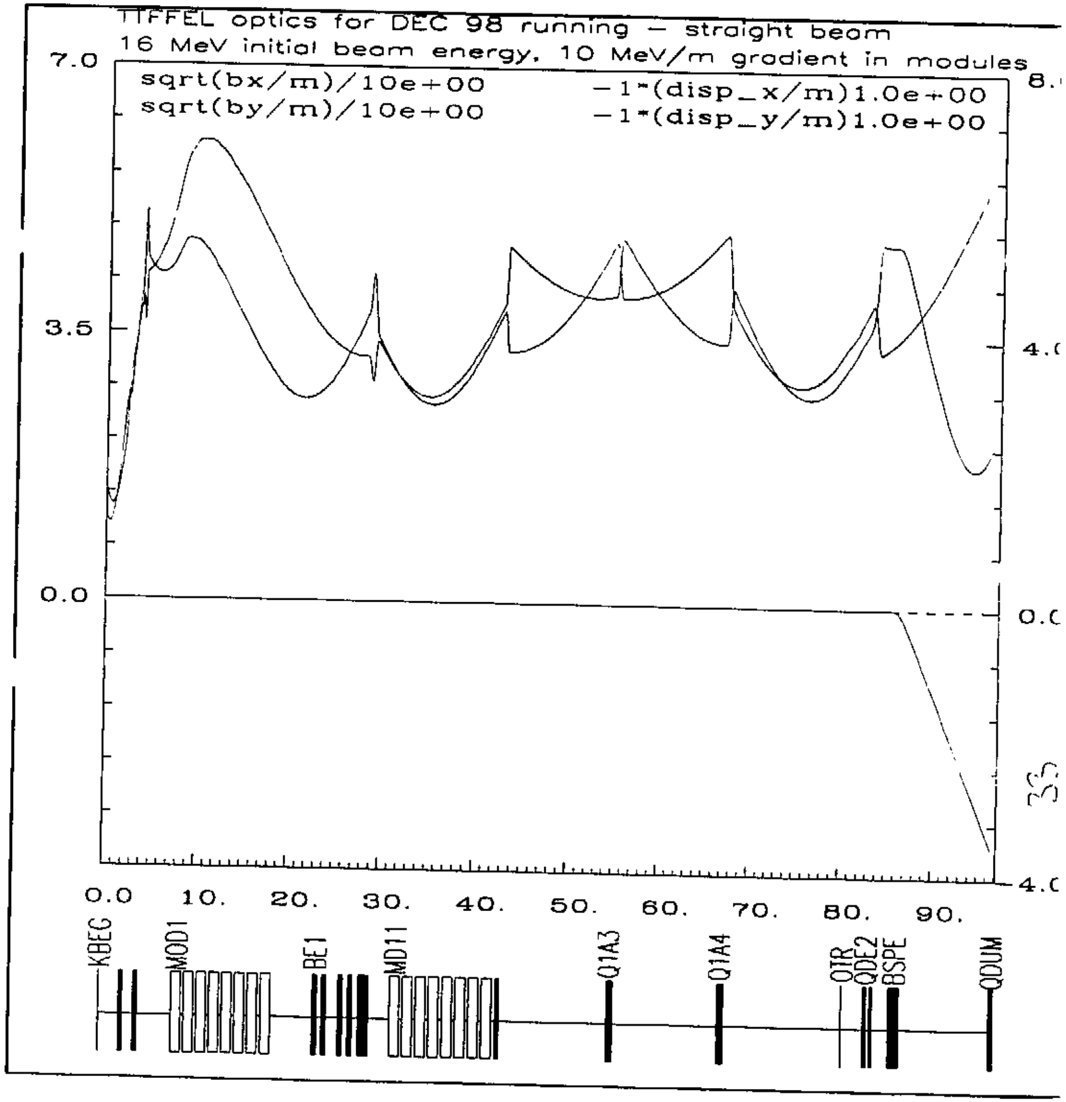
  ↳ HAS TO BE CONFIRMED BY DIFFERENT ANALYSIS.
- BEST "OPTICS APPROXIMATION"
  - → SO-CALLED "LIMBERG" OPTICS
- MUCH HIGHER DARK CURRENT FROM MODULE 2 THAN MODULE 1
  - → SOURCE 8.1 CAVITY
- DIAGNOSTICS :
  - TOROIDS NOW OPERATIONAL
  - BPMS NOW OPERATIONAL

    ~~[illegible]~~
  - SYNCHROTRON LIGHT EXP3 AVAILABLE

Straight-through-optics for 1nC
with space-charge effects switched off



TTF-FEL optics straight through 27.1.99
for q = 1nC (bc2 and S-band triplett off)



SPECIFIC EXPERIMENTS

1) HIGHEST GRADIENT MODULE II

- "FORWARD POWER" MEASUREMENTS

  $E^L = \frac{R}{Q} \cdot 4 \cdot Q_L \cdot P_f \left(1 - e^{-t/T}\right)$

  ↳ 20.8 MV/m = E_{ACC}
  ↳ PARTY

- BEAM MEASUREMENT (2 KLYSTRONS)
  - → MODULE I $E \approx 85$ MeV
  - MODULE II $E_{ACC} \approx 15$ MV/m, LIMITED BY COUPLER VACUUM

→ 1 WEEK-END OPERATION TO OBTAIN HIGHER VALUES

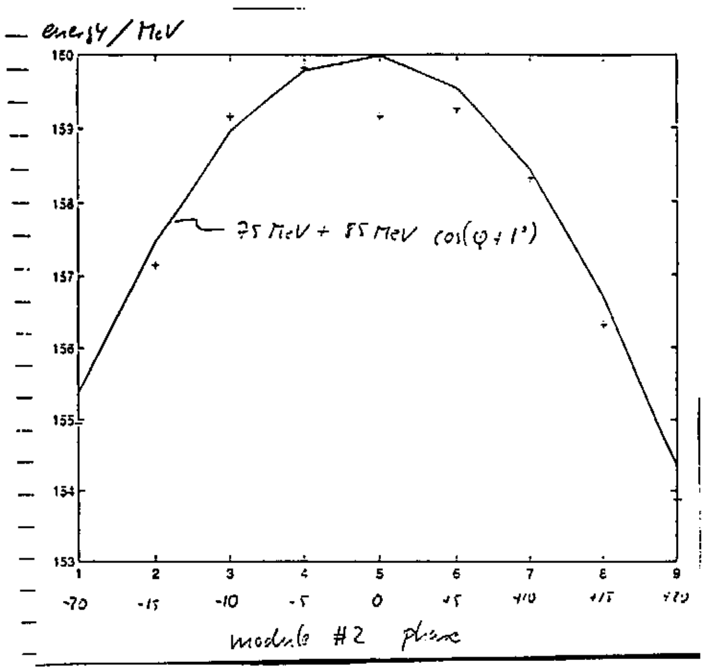
→ ACHIEVED GRADIENT CONSTANTLY GROWING TO:

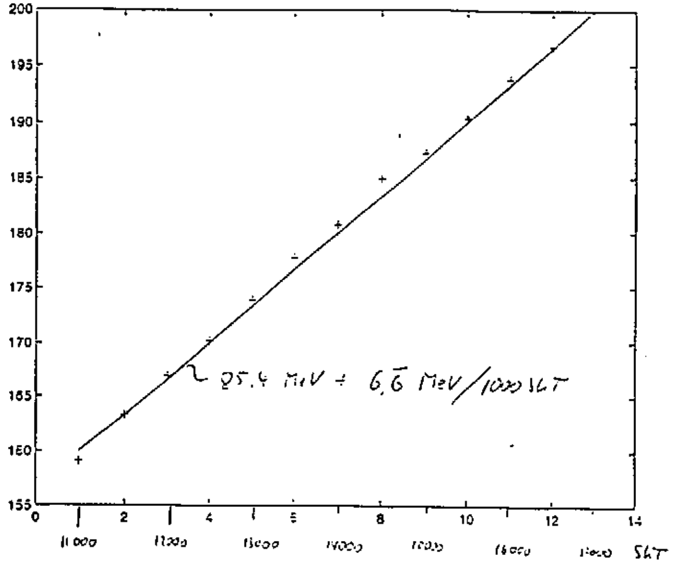
E_{ACC} = 18,1 MV/m
τ = 600 μs

WITH FULL TRANSM.

STILL LIMITED BY COUPLER VACUUM

↳ CONSISTENT NOW WITH RF CALIB.





13.1.99

12⁴⁵ ~~Extra~~ We want to do cryo-loss measurements on CHECHIA

Therefore in order to have low losses from the module, I reduce the power to 80 kW

21⁰⁰ we start now with FT: 400 + 100 µs /1 Hz

→ goal: find Eacc max at this pulse form.

22⁰⁰	150 kW	= 18.4 MV/m	
	155 kW	=	
22⁰⁵	160	19.0 MV/m	
22⁰⁷	170	19.56 MV/m	
22¹²	178	20.0 MV/m	IL e⁻ 70k/#10

pulse 500 + 100 µs /1 Hz

22²⁵

	100 kW	17.4 ~~kW~~ MV/m	
22²⁶	120 kW	19.0 "	
22³⁰	130	19.85 "	
	137.5	19.96 MV/m	
22³³	140	20.0	IL e⁻/#10
22⁴⁷	143 kW	20.8 MV/m	fürs Telegramm
22⁵⁶	160 kW		IL e⁻/#15

500 + 300 µs /1 Hz

100 kW	17.4 MV/m	IL e⁻ /#75

All e⁻ koincidence IL thresholds to 3V

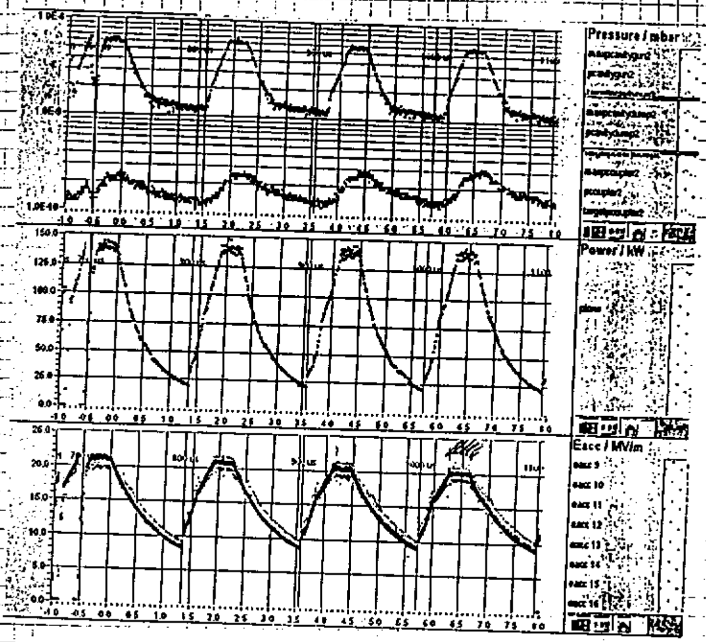
now script : module_ET_20MV.scr

Pmax 140 kW, 500 µs rise time ≙ 20 MV/m

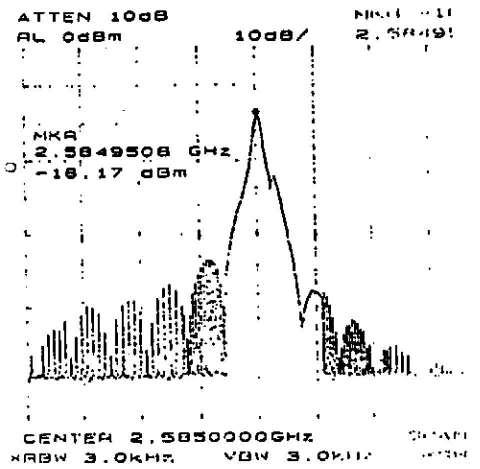
for 500 + 200 µs
500 + 300 µs
500 + 500 µs

Programm worked up to a pulse length of 500 + 500 µs at a repetition rate of 1 Hz up to a power of 140 kW

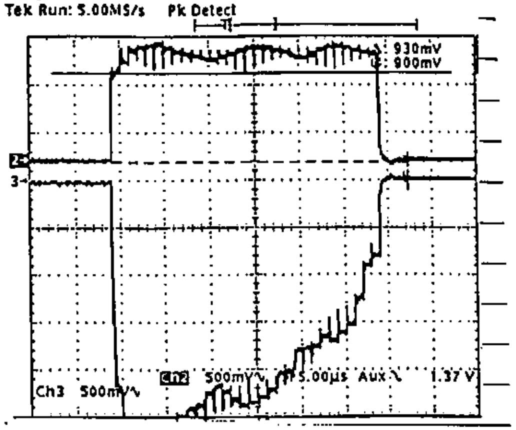
This is 20.6 MV/m at Qext = 2.4·10⁶ and 500 µs rise time

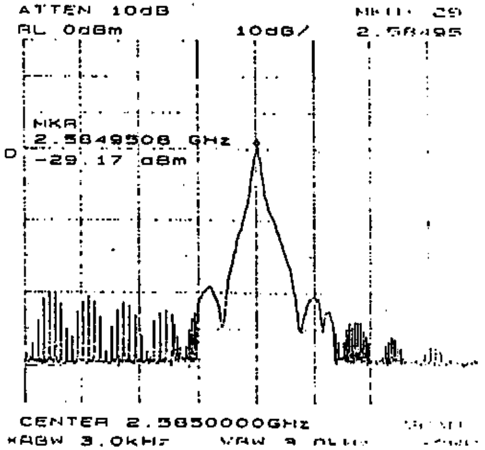


2) HIGHER ORDER MODES
- FOUND THE SAME "TRAPPED MODE" THAN LAST YEAR (2,5845 GHz)
- OBSERVATION OF HOM INSTABILITY
  → SEE SPECIAL WORKING GROUP PRESENTATION.

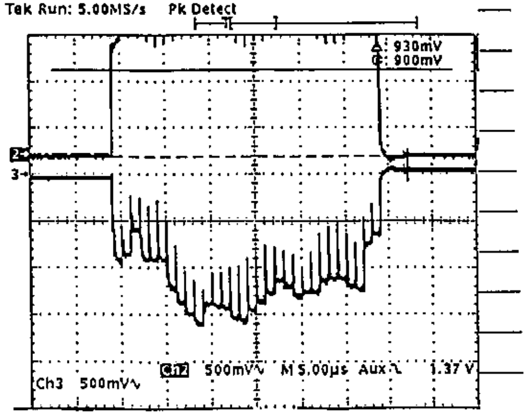


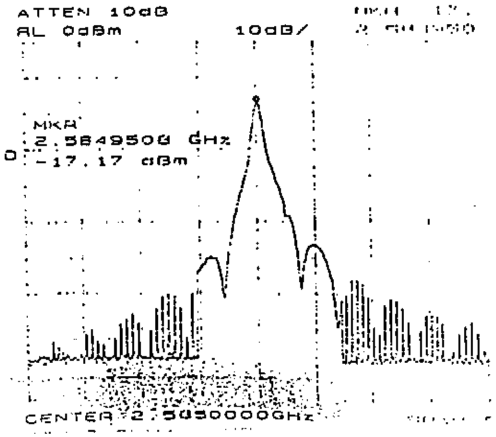
dogleg - 3A restart DM



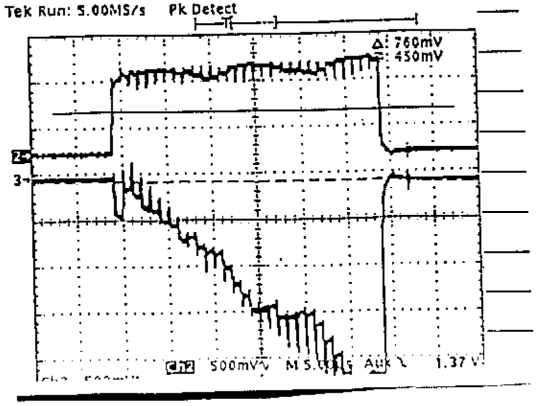


dogleg = 0





dogleg + 3A



3) BUNCH COMPRESSOR II

- COMPRESSION OBSERVED
- BUNCH LENGTH MEASURED

  $\sigma_t \gtrsim 2,3$ ps (BEFORE LASER MANIP.,

  $\sigma_t \geq 1,6$ ps (AFTER ")

  (REMEMBER + 50% ERROR)

- QUALITIVE SCAN OF MODULE I PHASE TO OPTIMIZE COMPRESSION

4) PROBLEMS DURING OPERATION (LAST 2 WEEK

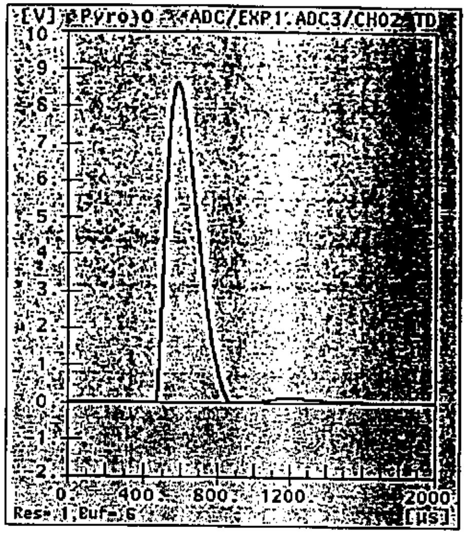
(i) TRANSVERSE INSTABILITY IN THE INJECTOR, PERHAPS CHARGING

(ii) STRONG FLUCTUATIONS IN ENERGY APPEARED → VISIBLE IN BC2

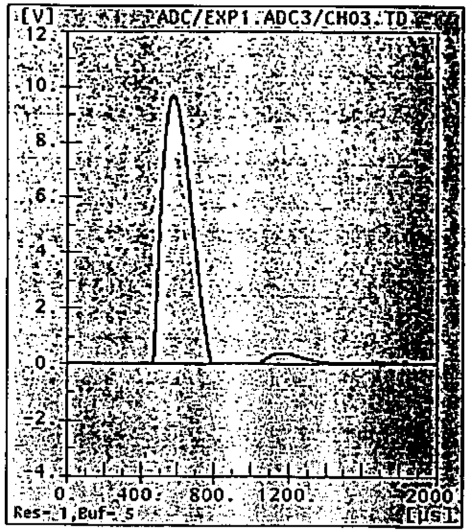
(NEW EFFECT, NEED TO BE INVESTIGATE

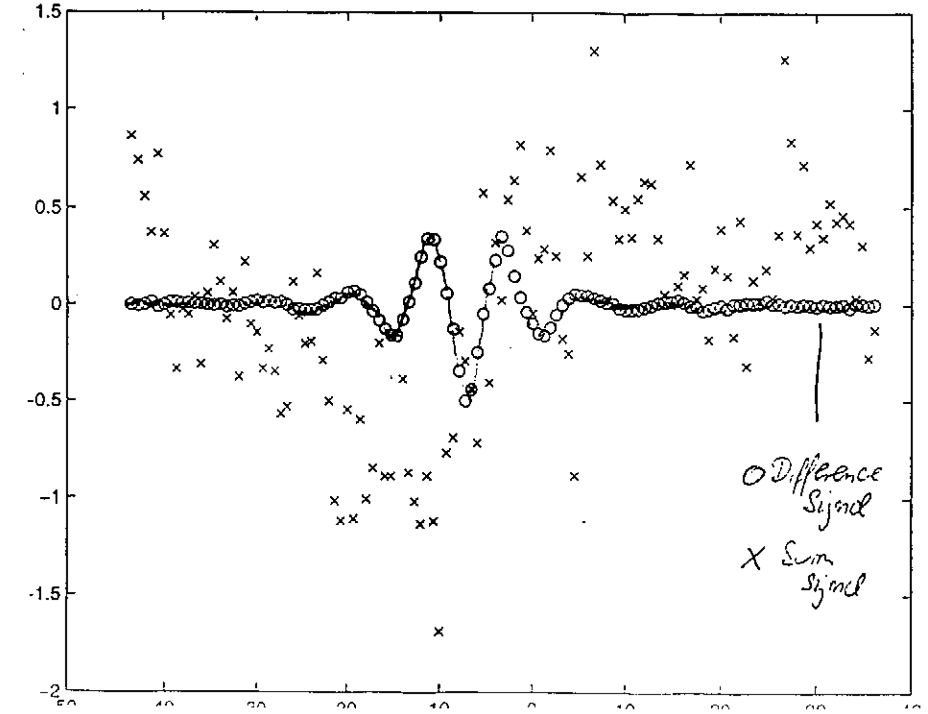
1st Sund compression bc2

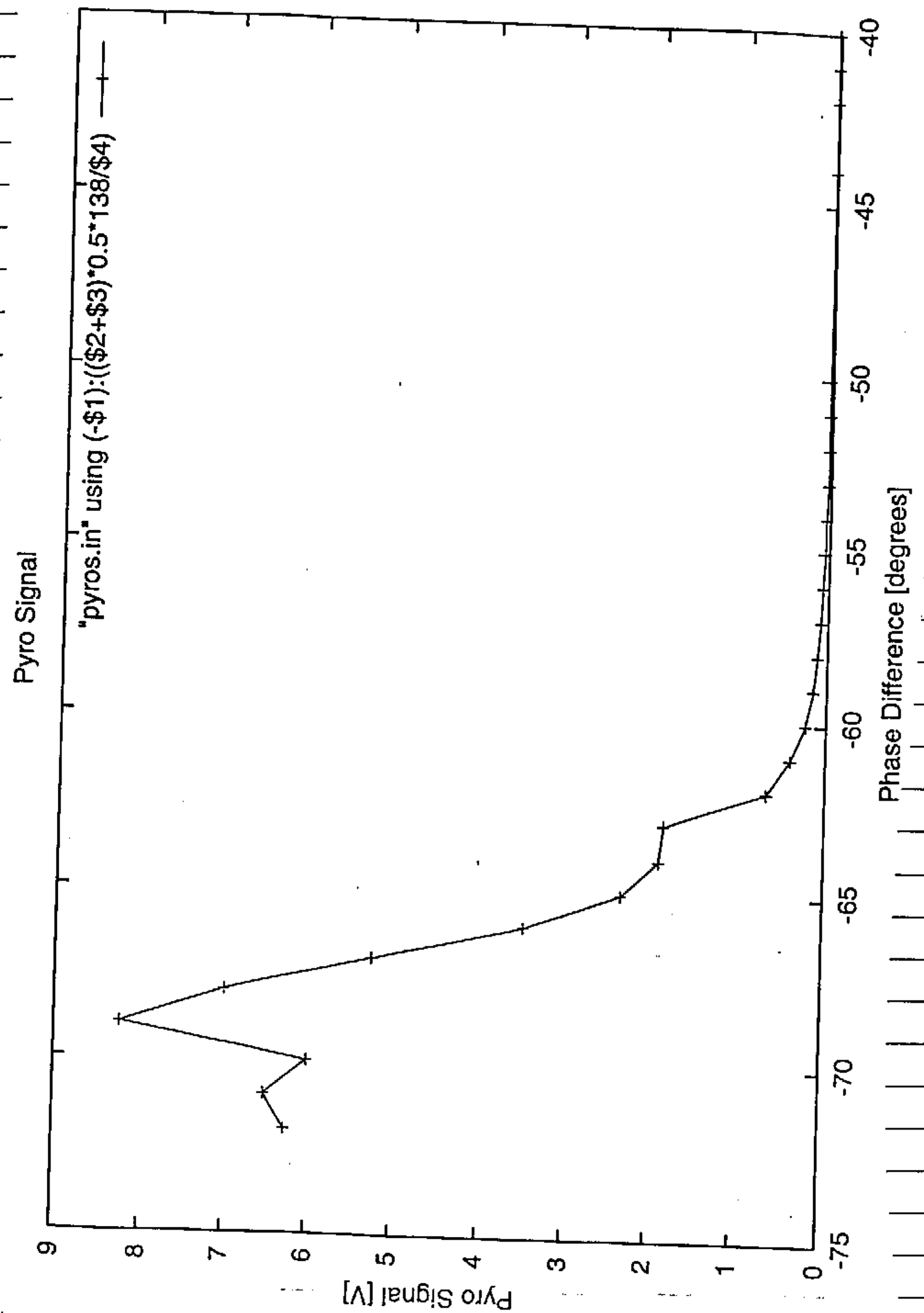
Pyro. Detector 0



Pyro. Detector 1







CONCLUSION

- RFGUN OPERATIONAL
- MODULE II $\Delta E = 18,1\ MV/m$ COUPLER LIMITED
- COMPRESSOR II SHOWED COMPRESSION
- DIAGNOSTICS FINALLY WORKING

STEPS TO GO

- OPTIMIZE EMITTANCE OF RFGUN FOR FEL OPERATION
- CONDITIONING OF MODULE COUPLERS
- MORE WORK ON BC2 NEEDED TO OBTAIN $\sigma_z = 250\,\mu m$.

RF Operation

Two Cryomodules and the RF Gun
Run 1/99

Guido von Walter

- The Linac LLRF System
- Module 2 RF commissioning
- The RF Gun
- Conclusion and Outlook

LLRF Team

Valeri Ayvazyan
Alex Gamp
Serguei Goloborodko
Henning Imsieke
Andrei Kholodnyi
Tomasz Plawski
Kay Rehlich
Stefan Simrock
Yurij Tchernoousko
Guido von Walter

with support of
MHF-P
MHF-SL
FDET
TTF Collaboration

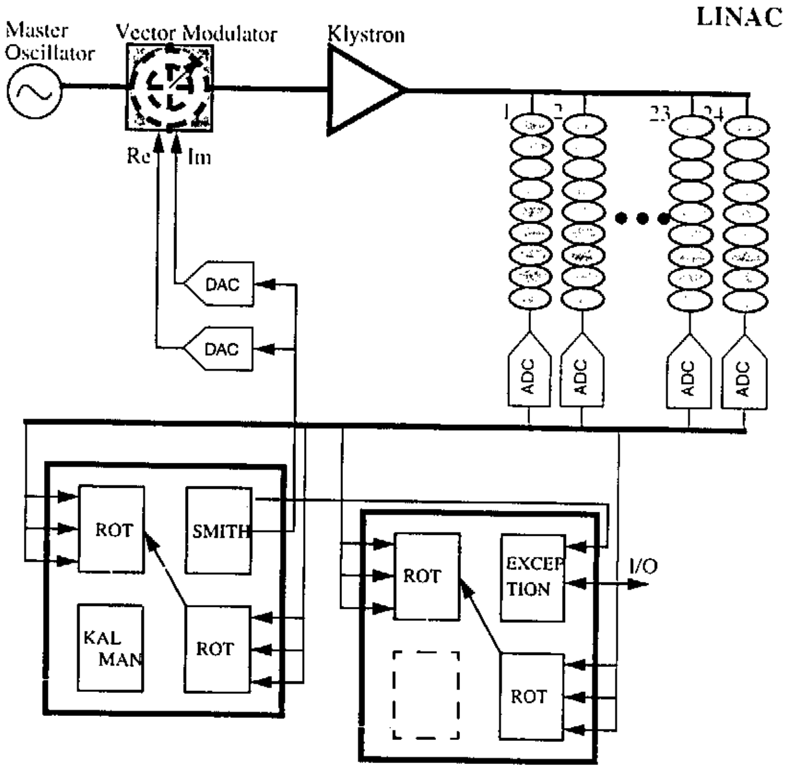
The Linac LLRF System

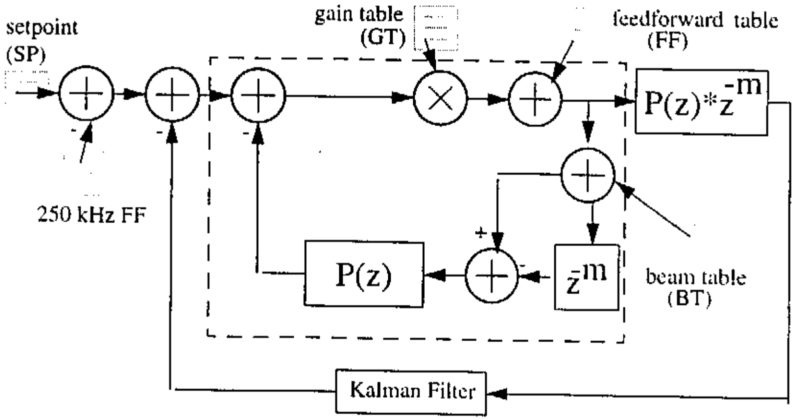
New DSP System

- New hardware, faster DSPs, input channels for the control of 24 cavities
- Features Kalman Filter and Smith Predictor
- Exception handling DSP
- Ready for three module operation

New DSP server software

- Parameter based operation, tables calculated by server
- Operator interface integrated into DOOCS control system





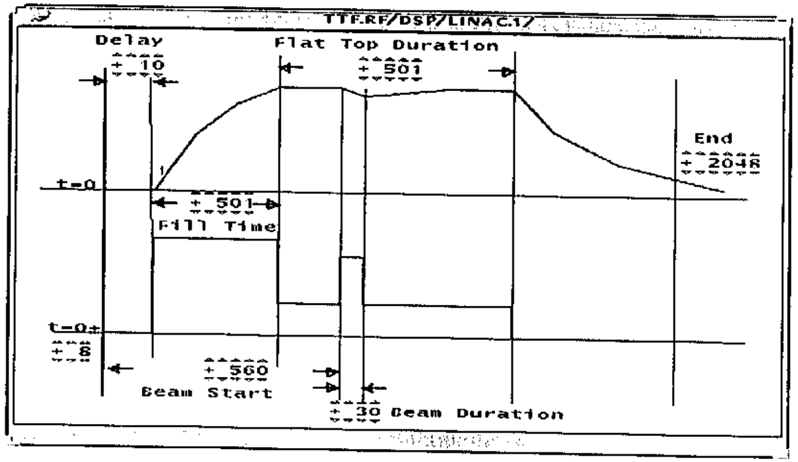
Andrei Kholodnyi

DSP server features

Parameter driven table generator

Tables and feedback operation data are derived from the RF operational parameters:

- Setpoint:
  Voltage (calibrated)
  Phase (relative to beam)
  Fill time
  Delay time
  Flat top duration



DSP server features (2)

- Feedforward:
  derived from setpoint table
  Fill to flat top ratio
  Amplitude scaling } cal. parameters
  Phase offset

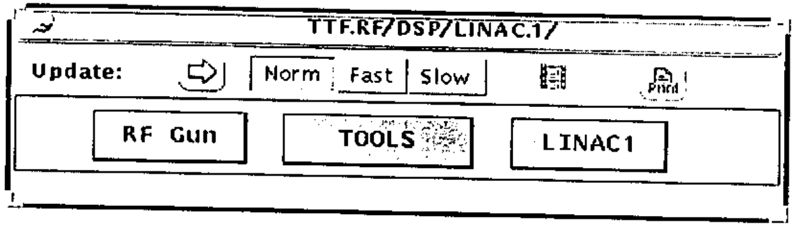
- Beam compensation:
  Beam current
  Beam phase
  Beam start time
  Beam duration

- System Gain

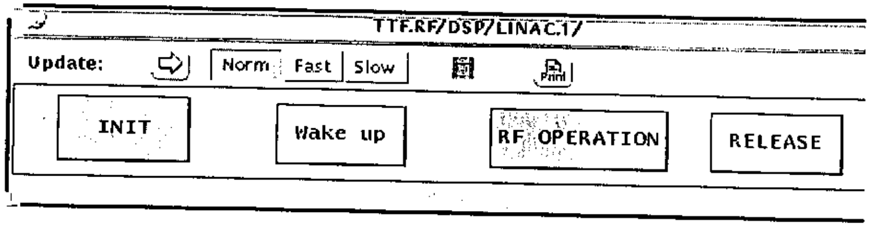
Loop Gain

DOOCS Operator interface

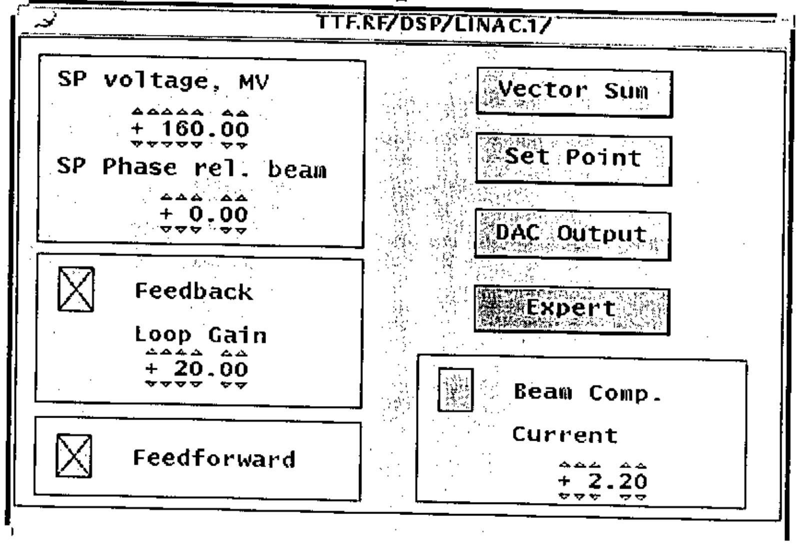
System selection:



Startup:

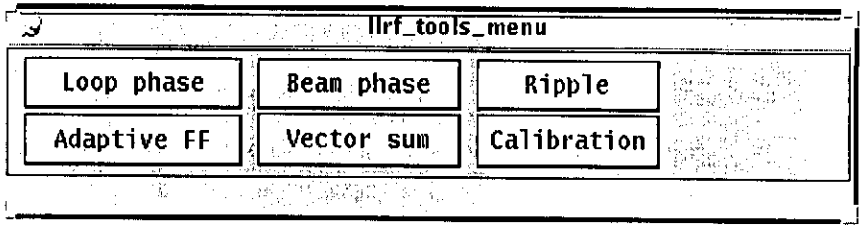


Linac LLRF operation panel:



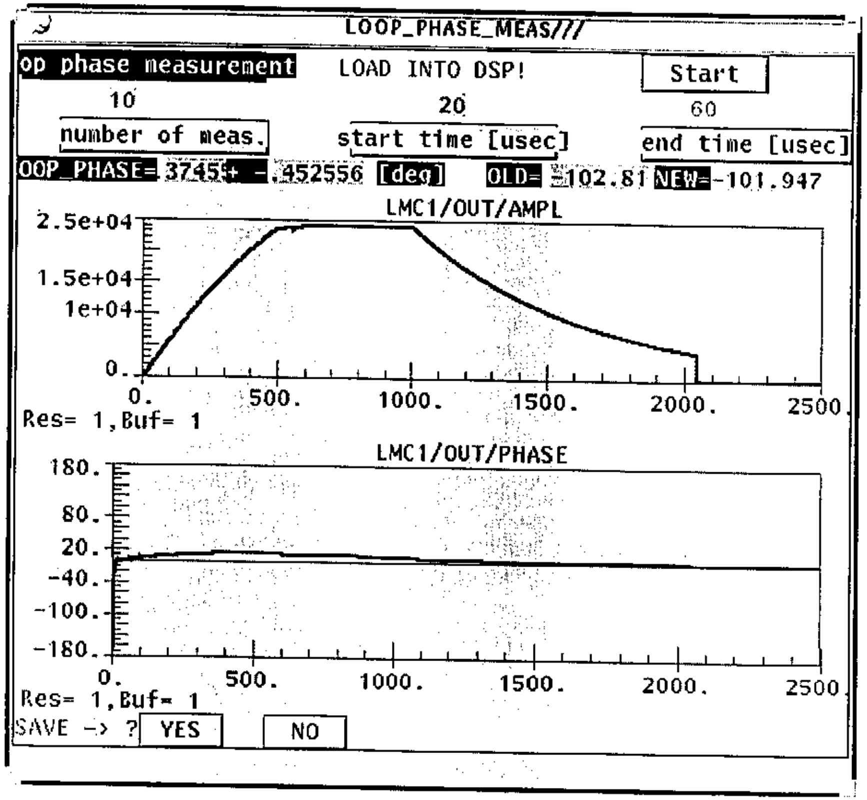
LLRF Utility software

Support applications integrated into DOOCS environment:



Loop phase

-compensates phase offsets from klystron and phase shifter (in BC operation)
- required for stable feedback operation



10 number of meas.

20 start time [usec]

60 end time [usec]

OOP_PHASE= 37455+ -.452556 [deg] OLD= -102.81 NEW= -101.947

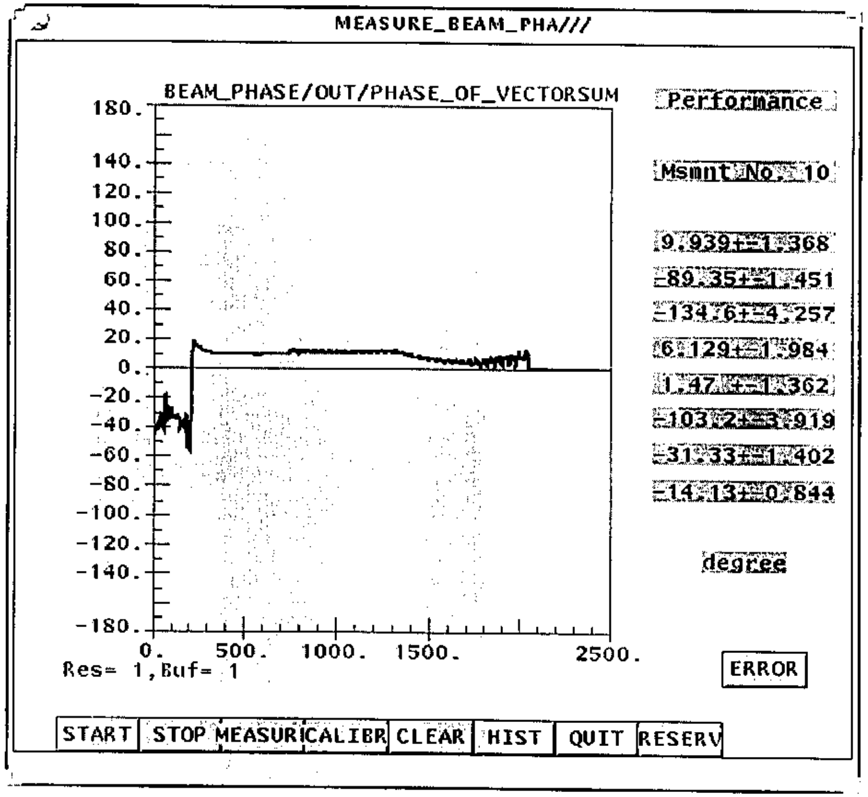
Res= 1,Buf= 1

Res= 1,Buf= 1

SAVE -> ?

Beam phase

- measures phase of beam with respect to RF
- allows simple adjustment for ‘on crest’ acceleration



Performance

Msmnt No. 10

9.939+-1.368
-89.35+-1.451
-134.6+-4.257
6.129+-1.984
1.47 +-1.362
-103.2+-3.919
-31.33+-1.402
-14.13+-0.844

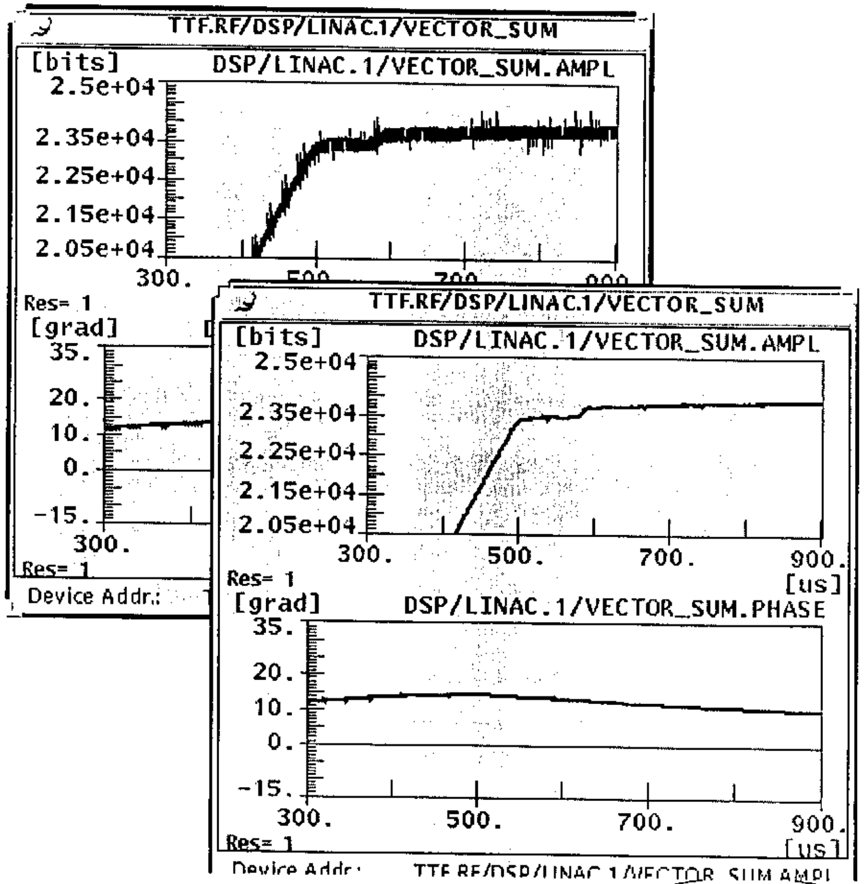
degree

Res= 1,Buf= 1

→ System identification, Dipl. Thesis M. Hüning

Ripple table

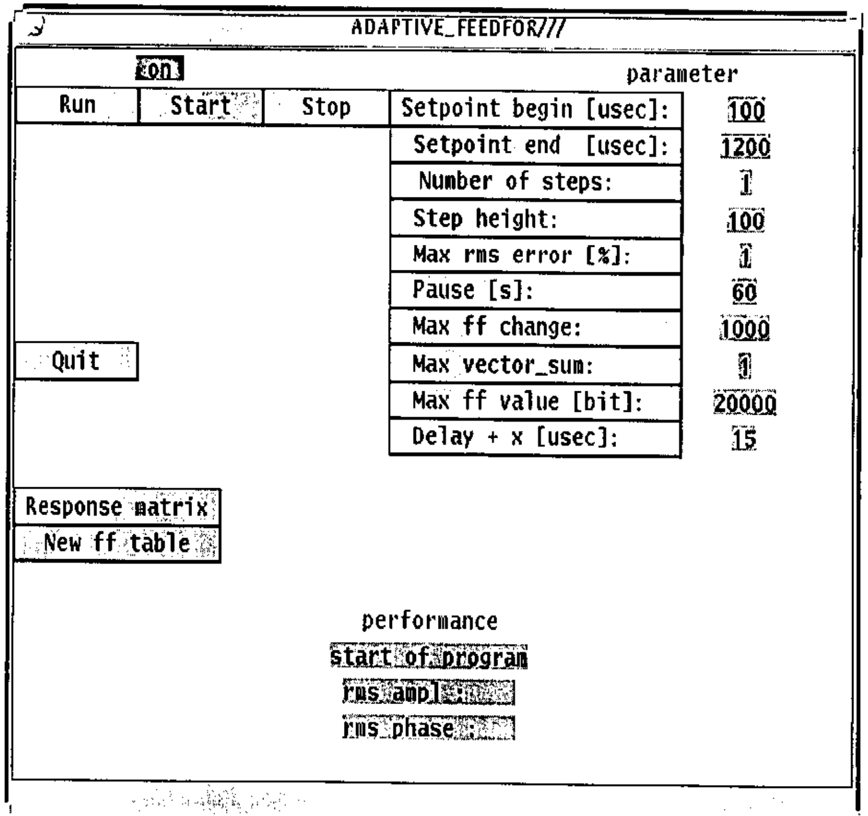
- enables a correction scheme for the systematic error from down conversion to 250kHz IF
- replaces simpler filtering schemes and allows feedback with higher gain



1 % noise is amplified by feedback loop

Adaptive Feedforward

- controls the calculation of FF tables with correction for pulse-to-pulse repetitive errors



parameter

Setpoint begin [usec]: 100
Setpoint end [usec]: 1200
Number of steps: 1
Step height: 100
Max rms error [%]: 1
Pause [s]: 60
Max ff change: 1000
Max vector_sum: 1
Max ff value [bit]: 20000
Delay + x [usec]: 15

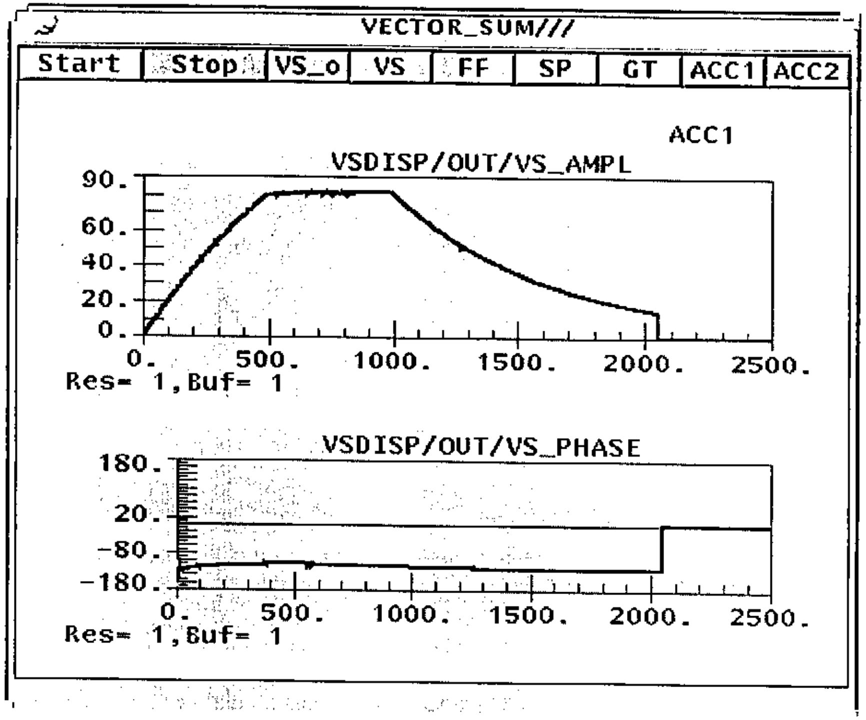
performance

start of program
rms ampl :
rms phase :

Dipl. Thesis M. Liepe
adaptive FF improves fieldstability by a factor of 10

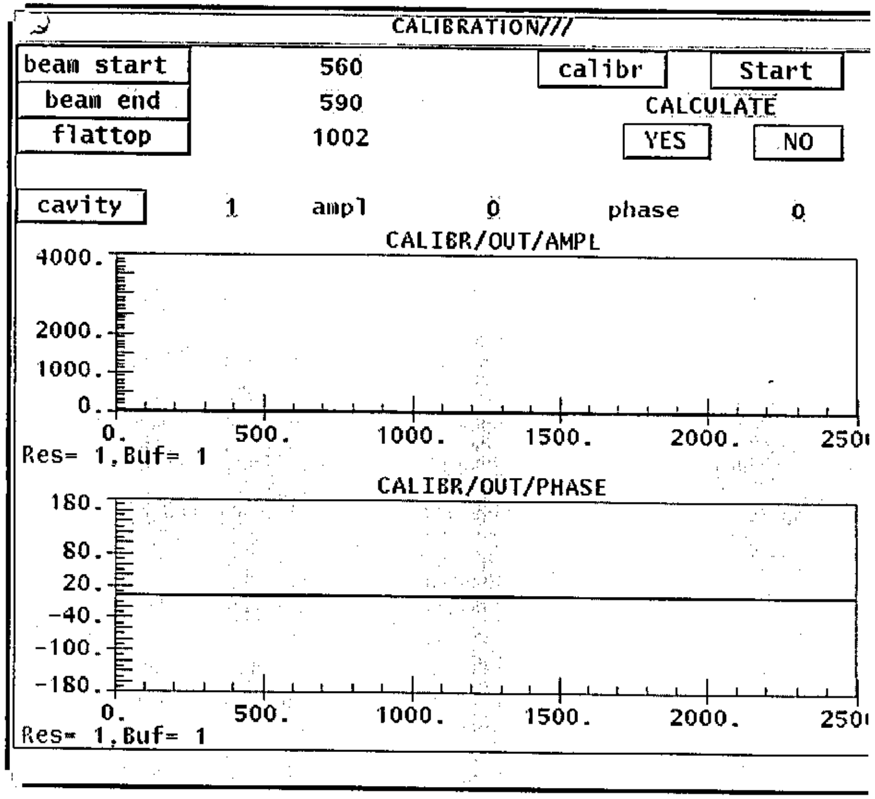
Vector sum display

- monitors vector sum of modules separately



Calibration

- assists in beam based calibration of gradients



beam start 560

beam end 590

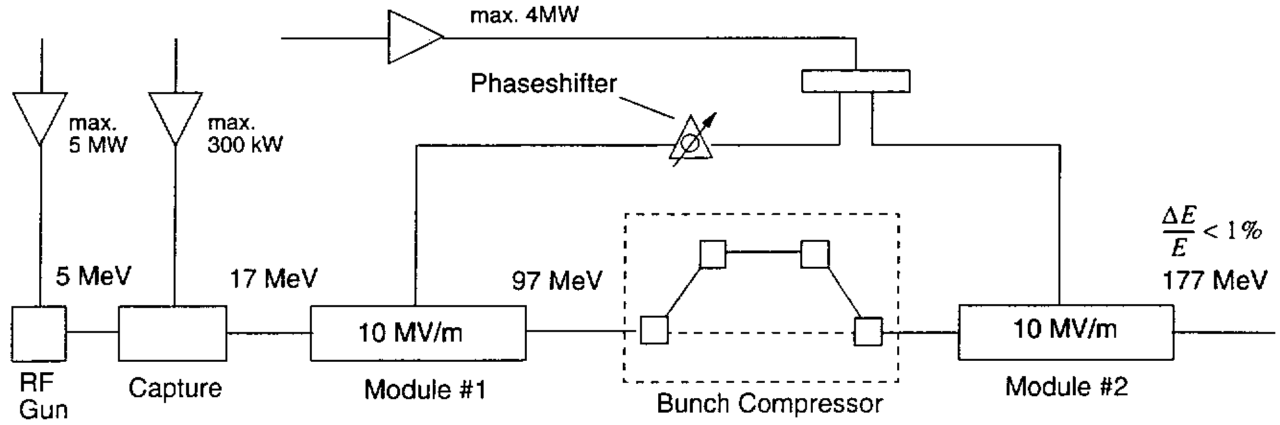
flattop 1002

cavity 1 ampl 0 phase 0

Res= 1,Buf= 1

Res= 1,Buf= 1

RF System Diagram with Bunch Compressor



Module RF commissioning

1. Phase adjustment
- Three stub tuners used to adjust phases and loaded Q
- improvement from ±50° to ±3°
- one tuner (cavity 8 of module 1) fitted with motor drive

2. Beam based calibration
- good beam required to get sufficient signal/ noise ratio (8nC, 30us for 1MV/m gradient)

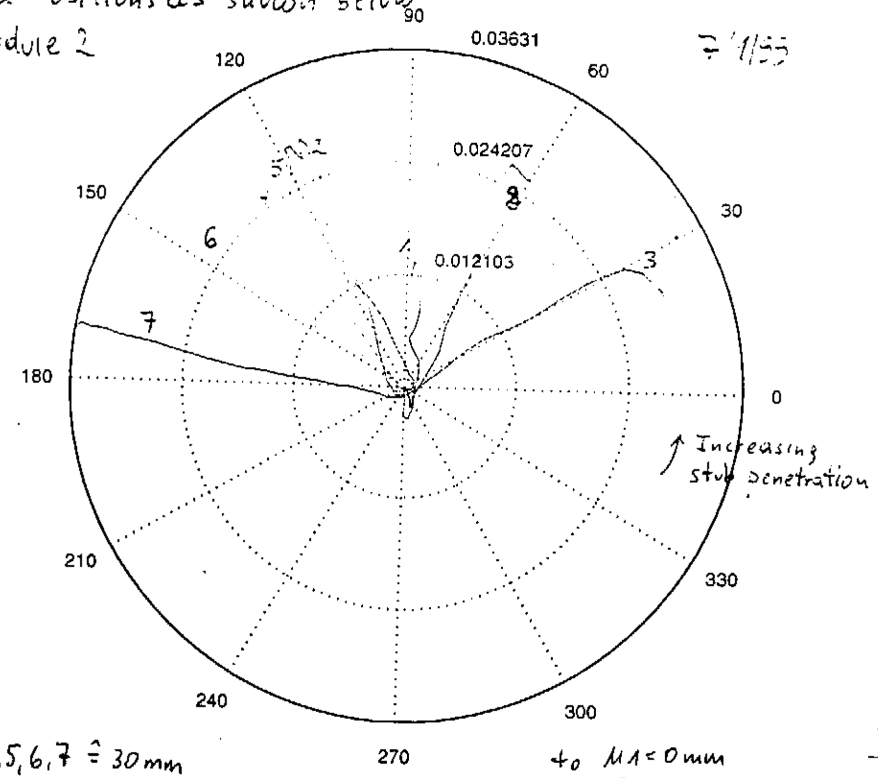
3. Gradient calibration
- preliminary calibration (to 10%)
- used as current measurement to improve transmission between modules

WG (M1.C1) = 30mm
(M1.C2 … C8) = 0mm (all Stubs)
(M2.C1 … C8) = 30mm (all Stubs)

Changed positions as shown below:

Module 2

7/1/99



2,4,5,6,7 ≙ 30mm
1,3,8 ≙ 0mm

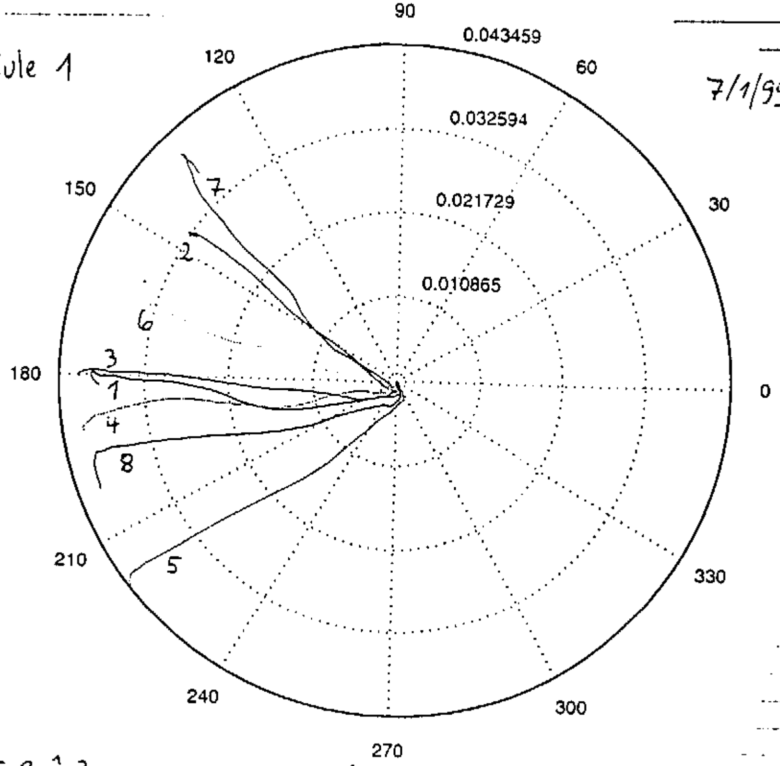
to M1 = 0mm
to M2 = 0mm

1,3,8 → 30 mm to M2 ≙ (10,15,10)

Stub positions for measurement
M1 (C2,3,6,7) ≙ 0mm … M1 (C1,4,5,8) ≙ 30mm
M2 (C1,3,8) ≙ 0mm M2 (C2,4,5,6,7) ≙ 30mm
M1 = 0mm (WG to Module 1)
M2 = 0mm (WG to Module 2)

Module 1

7/1/99



1,4,5,8 ≙ 30 mm 2,3,6,7 ≙ 0mm

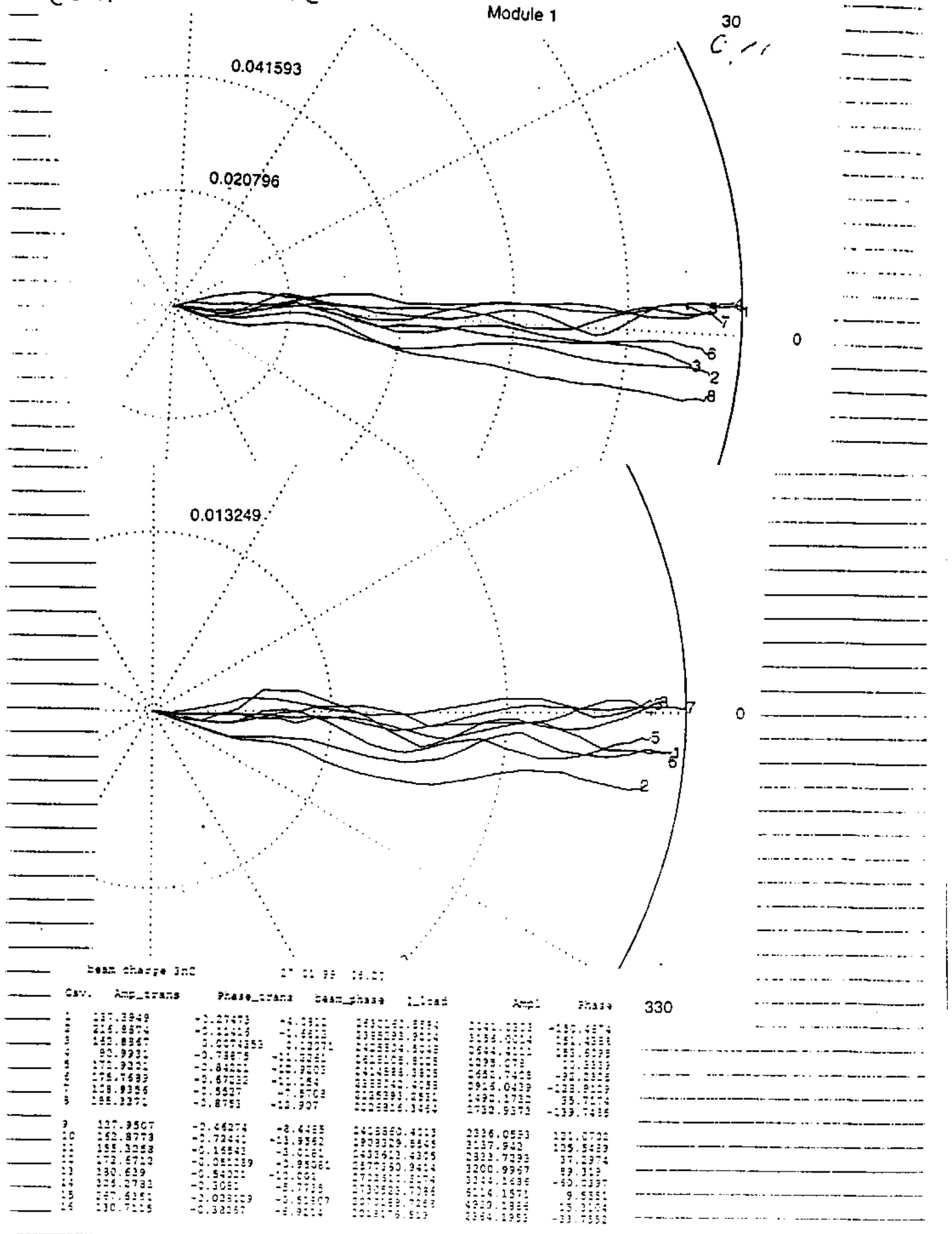
to M1 = 0mm
to M2 = 0mm

17^{30} Change stub positions to

M2 (C1,3,8) → 30 mm
to M2 = (10,15,10)

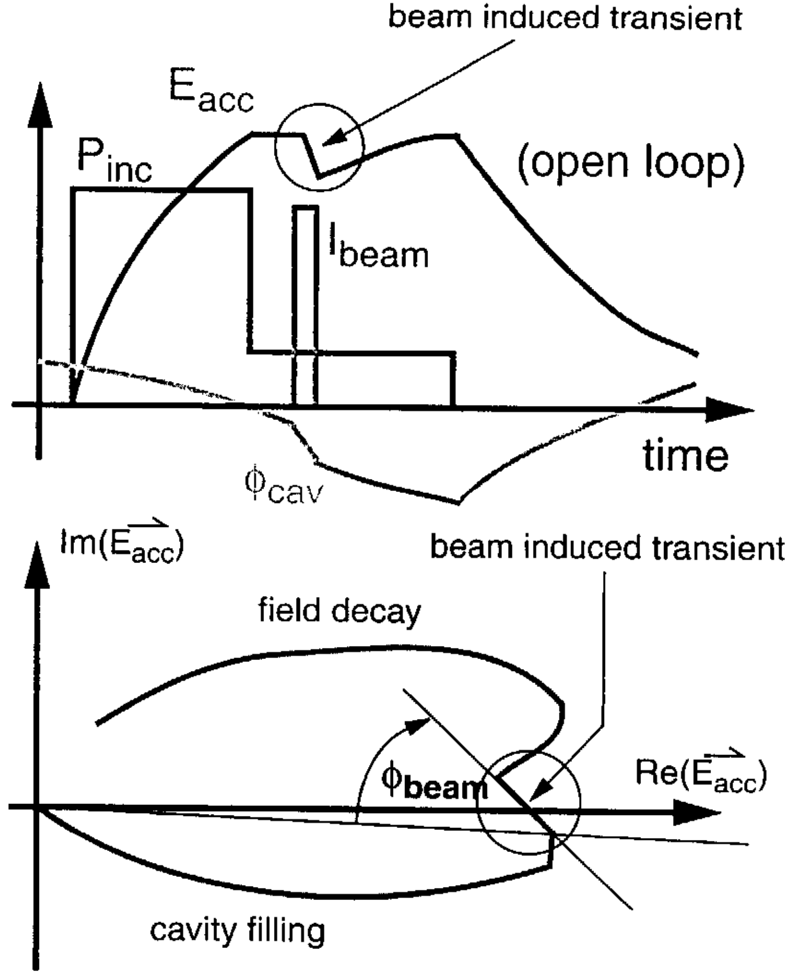
Result:

28.1. 550 4nC



TTF

Beam Based Gradient Calibration



for $\Delta t << \tau_{cav}$:

$$\Delta V_{ind} = I \cdot \Delta t \cdot \left(\frac{r}{Q}\right) \cdot \pi \cdot f$$

S.Simrock

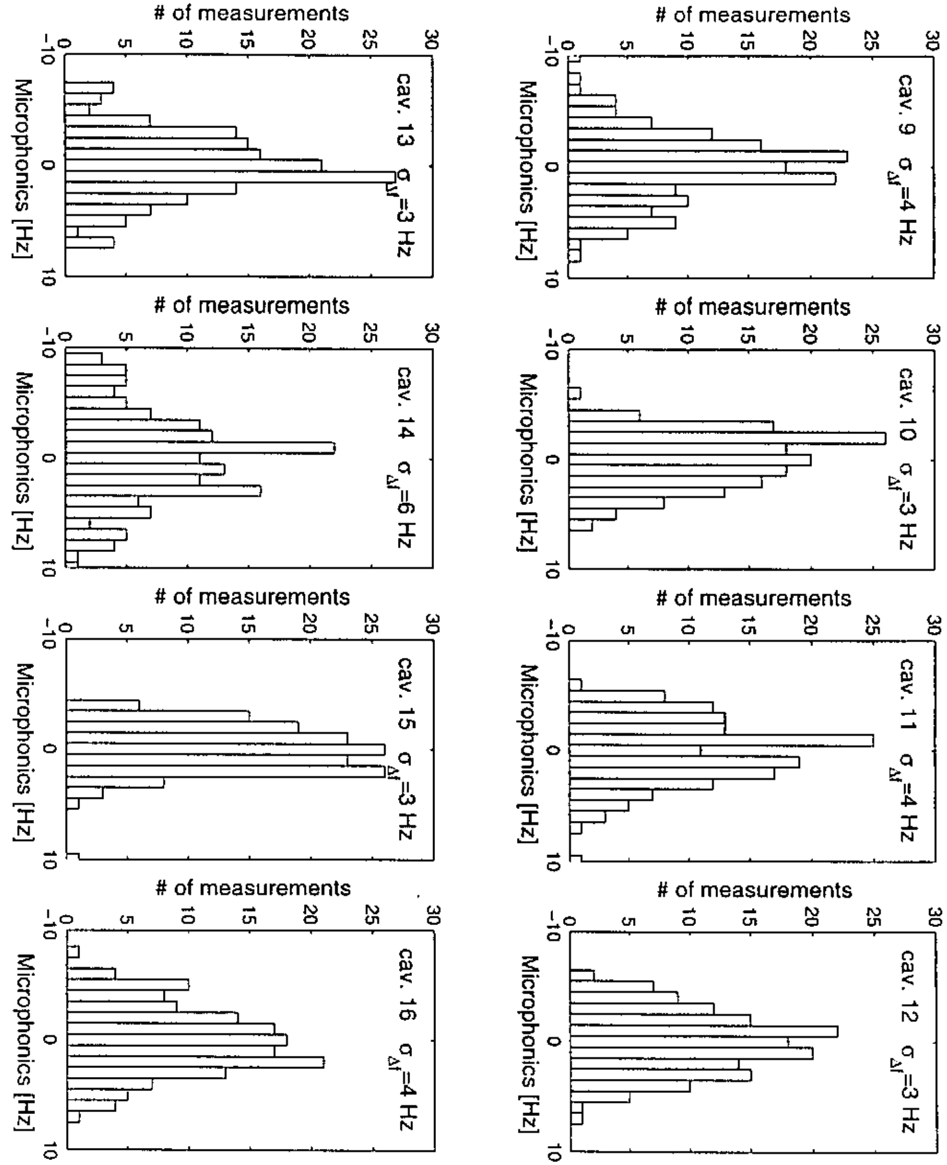
/usr/ttfsvr2/simrock/doc/frame/ttf_meeting/ttf_meet_jun_97/cal_grad_princ.doc

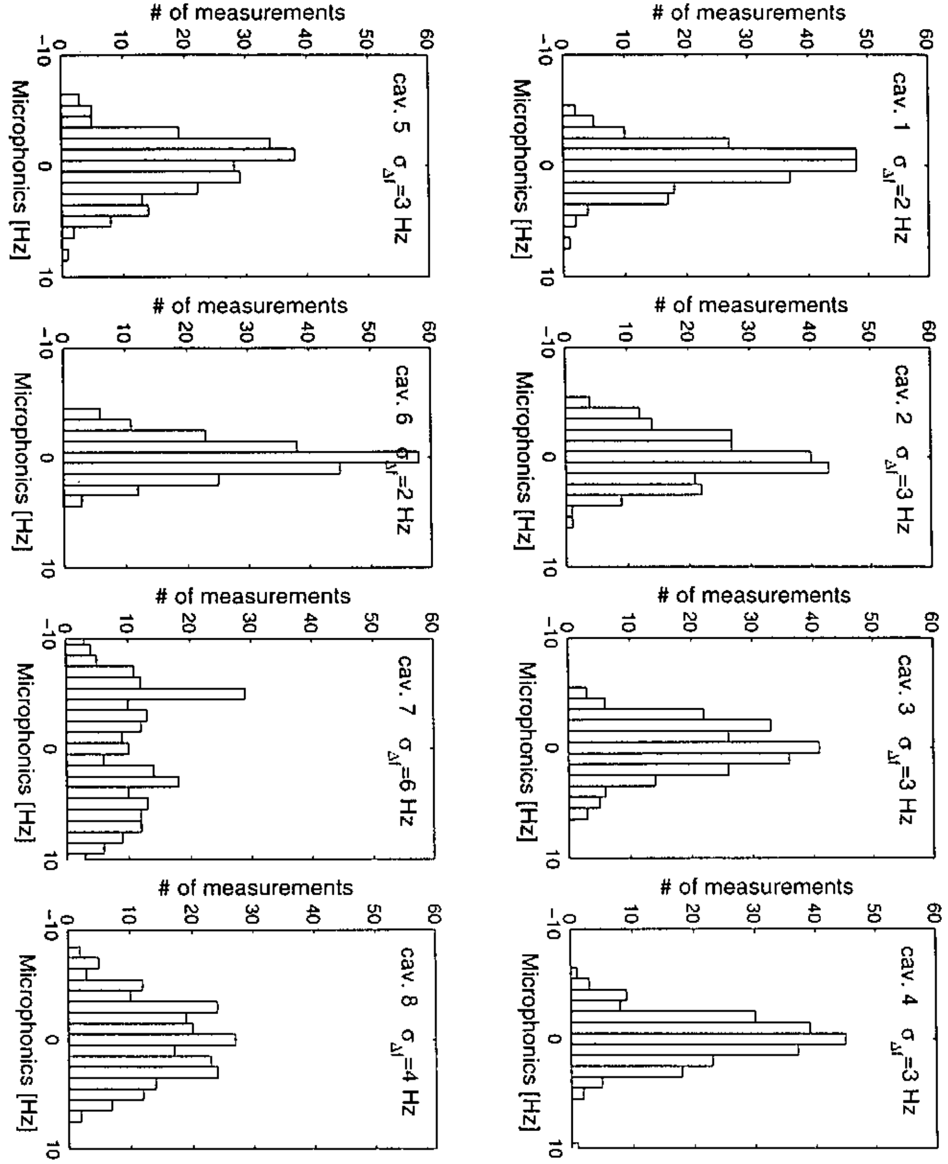
June 21, 1997 7:02 pm

Module RF commissioning (2)

4. Operation

- Stepper motor driver induced crashes resolved, stable operation since then
- vacuum interlocks due to slow ramping of modulator with feedback enabled (will be addressed by exception handling DSP)
- Microphonics measurement $\sigma_{\Delta f} < 5Hz$
- Lorentz force detuning measurement





Module RF commissioning (3)

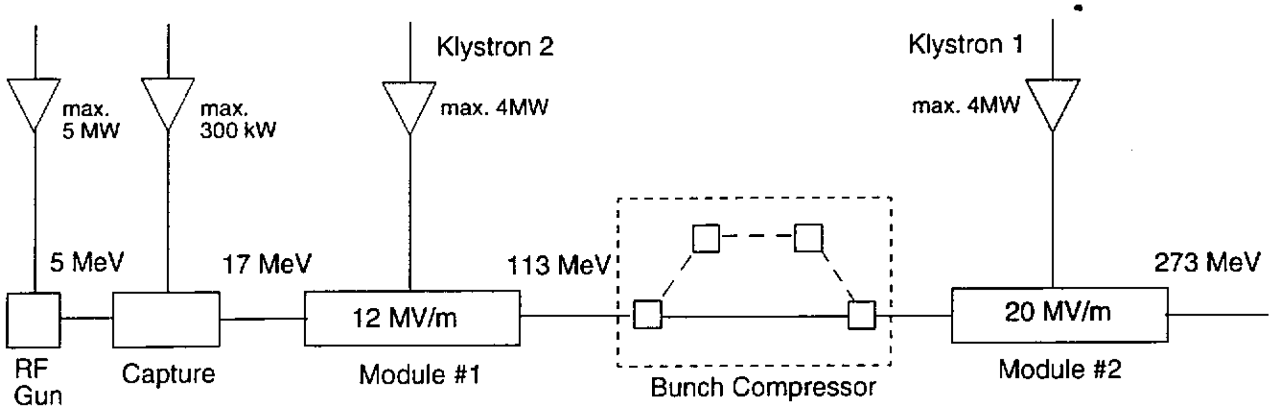
Module 2 at high gradients

- connect modules to Klystrons 1 and 2
- control module 1 from Linac DSP
- control module 2 from Checcia DSP (Feedforward only)
- 3 days processing without beam

- gradients of 18MV/m per cavity reached (after increasing fill time)
- maximum beam energy 240MeV
- high field emission from cavity 8
- limited by couplers 2 and 6 (vacuum and photomultipliers)
- reduced power to couplers 2+6 -> limited by 1 and 3, field breakdown in cavity 8 during flat top

G. von Walter

RF System Diagram for high gradient operation

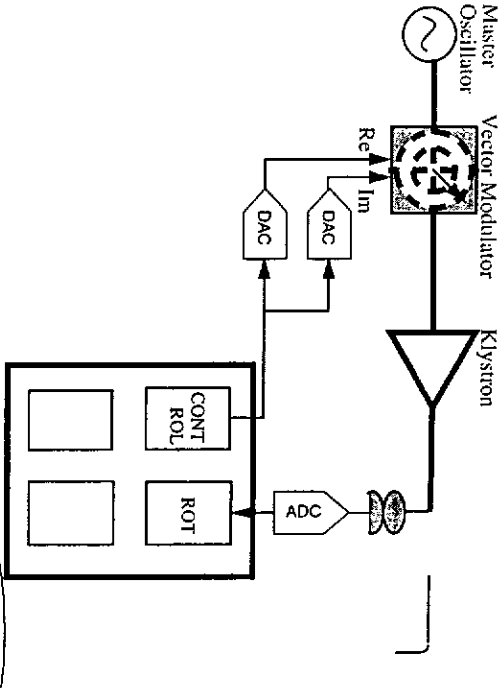


G. von Walter

RF Gun

System overview

- identical DSP software, identical control software
- two DSPs
- no use made of feedback loop due to short time constant of normal conducting cavity ($Q_l = 22000$)
- control by adjusting feedforward table between pulses



G. von Walter

RF Gun Operation

Operation

- temperature drift of water cooling (0.5°C) results in a detuning (25kHz per °C)
  -> Phase changes by 15°
- Phase and amplitude drift regulated between pulses
  [illegible] from pulse to pulse
  cannot predict fluctuations from pulse to pulse
- regulation on mean value, there is a slope left, during operation the stability is around ±3°
- Tests with new downconverter boards have been made to improve signal quality and reduce 250kHz noise

---

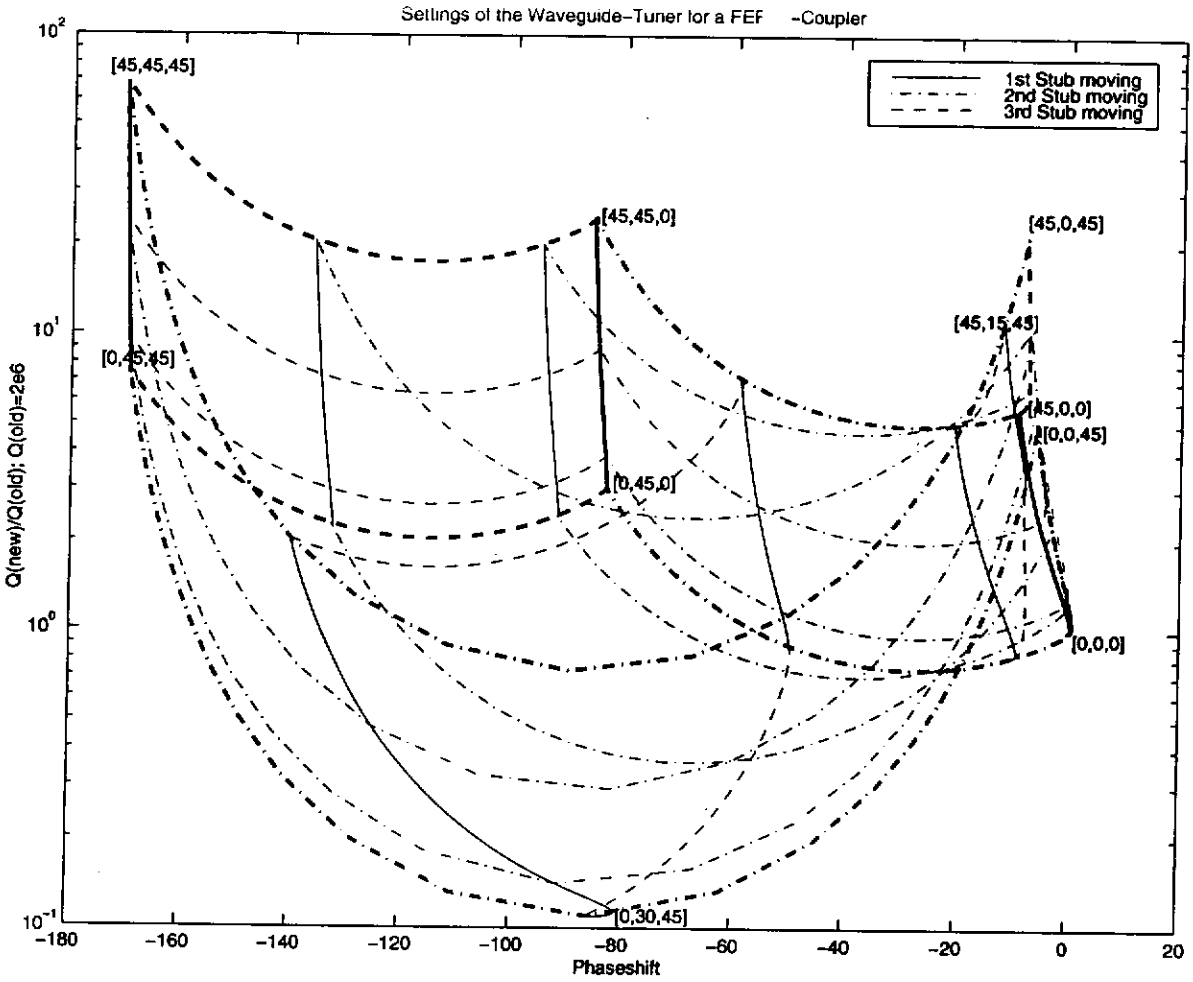
Conclusion + Outlook

LLRF achievements:

- 24 cavity Linac RF system operational
- New LLRF operator interface
- RF Gun system

Future developments

- Integrate **exception handling** into the interlock system, provide a fast shut off of the klystron
- **State machine** will simplify operator's perception of the system
  provides automated startup
  state transitions (on/off, interlock, mode changes) can be programmed
- Increase RF Gun pulse length and change DSP code to perform correction during flat top


Settings of the Waveguide–Tuner for a FEF -Coupler
1st Stub moving
2nd Stub moving
3rd Stub moving
[45,45,45]
[0,45,45]
[45,45,0]
[0,45,0]
[45,0,45]
[45,15,45]
[45,0,0]
[0,0,45]
[0,0,0]
[0,30,45]
Q(new)/Q(old); Q(old)=2e6
Phaseshift
10^2
10^1
10^0
10^{-1}
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
20

Author		Sheet 1
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99

Subject foramtion

1. Historical summery
2. Some impressions of the RF-Transmitters
3. Situation at moment
4. Projects in future

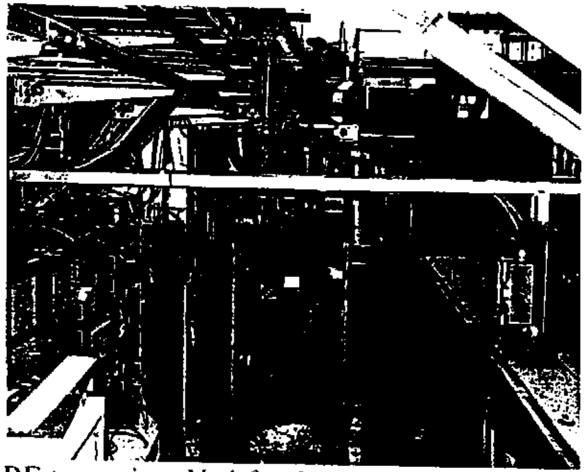
Author		Sheet 2
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99

Presentation of the RF-transmitter:

Manufacturer	Type	Nation
Saclay Orsay	RF-transmitter cavite de capture	Fr
Fermi National Accelerator Laboratory	RF-transmitter 1 – 3	USA

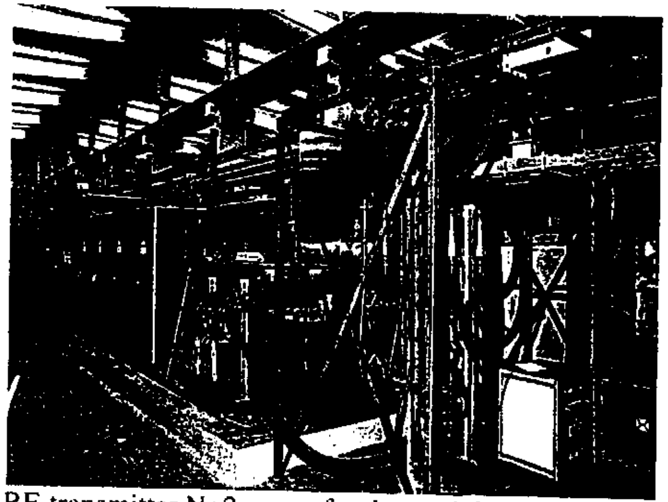
Author		Sheet 3
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99

Presentation of the RF-transmitters:



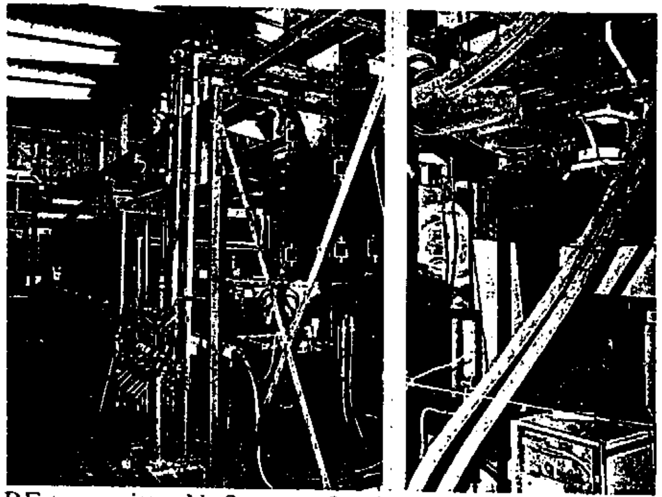
RF-transmitter Nr.1 for the cavity testing

Author		Sheet 4
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99



RF-transmitter Nr.2 server for the module 1 and 2

Author		Sheet 5
		Date
Joachim Kahl	RF-transmitter for TTF	03.03.99

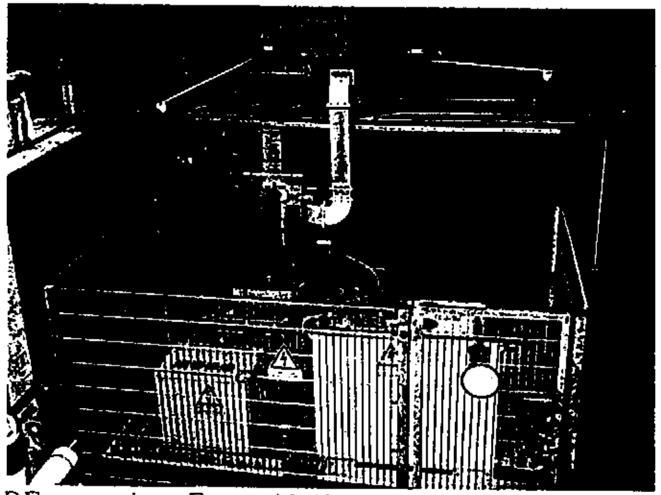


RF-transmitter Nr.3 server for the gun

Deutsches Elektronen-Synchrotron Desy
Notkestrasse 85
22607 Hamburg Germany

Section MHF-p /55A-Z120

Author		Sheet 6
		Date
Joachim Kahl	RF-transmitter for TTF	03.03.99



RF-transmitter-Fr provide the capture cavity

Deutsches Elektronen-Synchrotron Desy
Notkestrasse 85
22607 Hamburg Germany

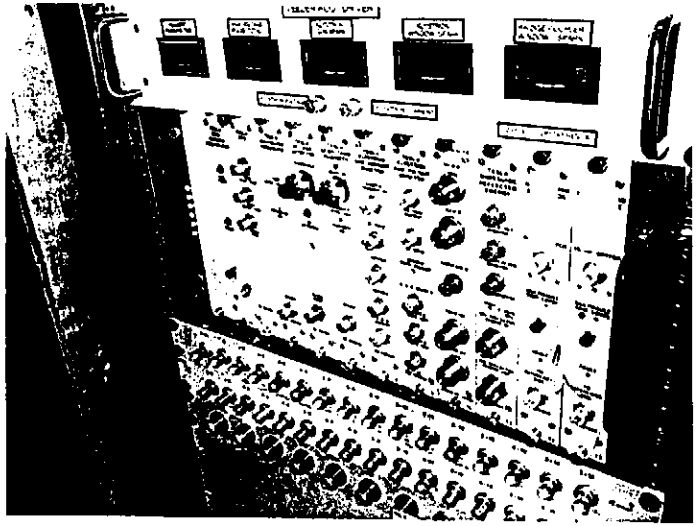
Section MHF-p /55A-Z120

1. Historical summery

Historical summery of the 3. RF-transmitter:

41-42 week	RF-transmitter destructed at Fermi National Accelerator Laboratory
	RF-transmitter reseived at Desy with a small damage on cabinet No.1
47. week	mounting of the Klystron
48. week	connection to the Main Power 400V-AC
49. week	voltage safty tested
51. week	first high voltage
52. week	conditioning the Klystron

Author		Sheet 9
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99



Author		Sheet 10
Joachim Kahl	RF-transmitter for TTF	Date 03.03.99

Some impression of the 3. RF-transmitter

3. A situation at the moment.

When everything is working, nobody takes any notice ot the RF-transmitter, but whenever there are small mistakes, caused by using, they realize that there are RF-transmitters. In the beginning of this year they had to realize more than once that there are RF-transmitters.

As the electronic parts, installed into the RF-transmitters, partly used up to their limit, it might happen that they stop working.

The RF-transmitter stopped working, as it did not stand the requirements. Just by the immediat helpful support of **Peter Prieto** and **Mike Kucera** it became possible to keep the period of not working limited.

The RF-transmitter of the capture cavity had a runstop because of their using up. I want to thank the developer **Michel Desmons** very much that he supported me whenever he could. Michel Demont left his electronic parts to me, which enable us to eliminate the damage rather soon.

4. Future projects

In the near future we want to prepare the RF-transmitters for remote control more then it now exists. We want do this with new equipments.
That means an improuvement of the remote control as well as automatic of service-functions.

For example we want to mention the calibration of the perseverance with a micocontroller system.

Another pointe is to diagnose instabilities which might be found in the system. By this diagnosis we will be able to react of endurance limits and to improve the working of the mechines.

At the time we are discussing about the development and the construction of a fourth RF-transmitter. This RF-transmitter will be delivered by the factory Puls-Plasmatechnik.

A. Gamp 26. 2. 99

Modulator and Klystron Procurement

Multibeamklystron:

RF Performance was ok.
A leak has ocurred. This opportunity is used to implement improvements in the gun.
Testing at Thomson foreseen for June. Delivery to DESY foreseen for
September 99.

The following items have been ordered:

Two additional 5 MW Klystrons. There is already one reserve tube.
Expected **December 99 and January 00**.

Two vertical MBKs.
Expected **April 00 and July 00.**

One Modulator.
Expected **May 00.**

Call for tender for **two additional modulators** is out. These modulators could be here by
December 00.

SMES will hopefully be at DESY in the
first half of 00.

The pulse transformer for SMES has been delivered to DESY
end of December 98

Status of Cryogenics

(Extended TTF / FEL-Supply)

TESLA Meeting
1.-3. March 1999

DESY-MKS-
B.Petersen

Overview:

- Status of the TTF – 900W-plant
- Objectives of the extended supply
- Concept of the extended supply
  - Redundancy
- Status of the main components
- Concept for a Module Test Stand

Status of the TTF-900 W Plant

The plant is operable as projected in 1993
(vertical dewars 1,2,3; CHECHIA; LINAC)

still missing:
third cryo module, large heat exchanger

still room for improvements:
capacities for parallel operation of dewars
changes in tubing

(vertical dewars are cooled down and filled with liquid in about 1 h - still too slow !!!)

maintenance in week 12 :
2 screw compressors (C101 > 60 000 h !)
vacuum compressors (> 16 000 h)

remember:
- **the 900 W plant was projected as a test facility**
- **main parts of the equipment older than 15 y**
- **screw compressors are ‘individual prototype’ machines – the manufacturer is no longer interested in big repairs**
- **cooling water supply of screws ‘superannuated’**

Extended Cryogenic Supply
Main Components

HERA-FEL-Valve-Box **(operable)**

HERA-FEL-Transfer-Line (installation end of March)

HERA-FEL-Line of Construction (critical!)
(delayed – installation in March)

FEL-Subcooler-Box (under fabrication)

2 nd set of Vacuum Compressors (order in March)

FEL-Cryo-Building (ready)

SMES-Transfer-Line (see schedule)

TTF-Transfer-Line-Connection (order in March)

Single-Module-Test (some ideas –see schedule)

2 nd BCBTL (start of layout - see schedule)

Warm-Gas-Tubing (call for tender)

Low Pressure HEX (delivery in July)

The Concept of the Extended Cryogenic System

the heat loads of the TTF / FEL – linac will exceed the capacities of the existing 900 W / 4.5 K TTF refrigerator

the helium distribution system of the TTF / FEL – linac will be connected to the HERA helium refrigeration plant

the helium distribution system of the linac will be maintained as designed for the operation of the original TTF – linac
(consisting of three cryo modules)

the existing TTF-900 W / 4.5 K helium refrigerator and the 1st set of vacuum compressors will supply the TTF test plant for single cavities (four cryostats)

a 2nd set of vacuum compressors will be added to the system for the supply of the TTF / FEL -linac

Objectives of the Extended Supply:

Cryogenic supply of

the 1 GeV TTF / FEL-Linac consisting of 6 – 10 TESLA cryo modules (2 K , 4.5 K and 40 / 80 K temperature levels)

a Superconducting Magnetic Energy Storage Cryostat (SMES)
(4.5 K and 40 / 80 K temperature levels)

a test for single cryo modules
(2 K , 4.5 K and 40 / 80 K temperature levels)

and optional

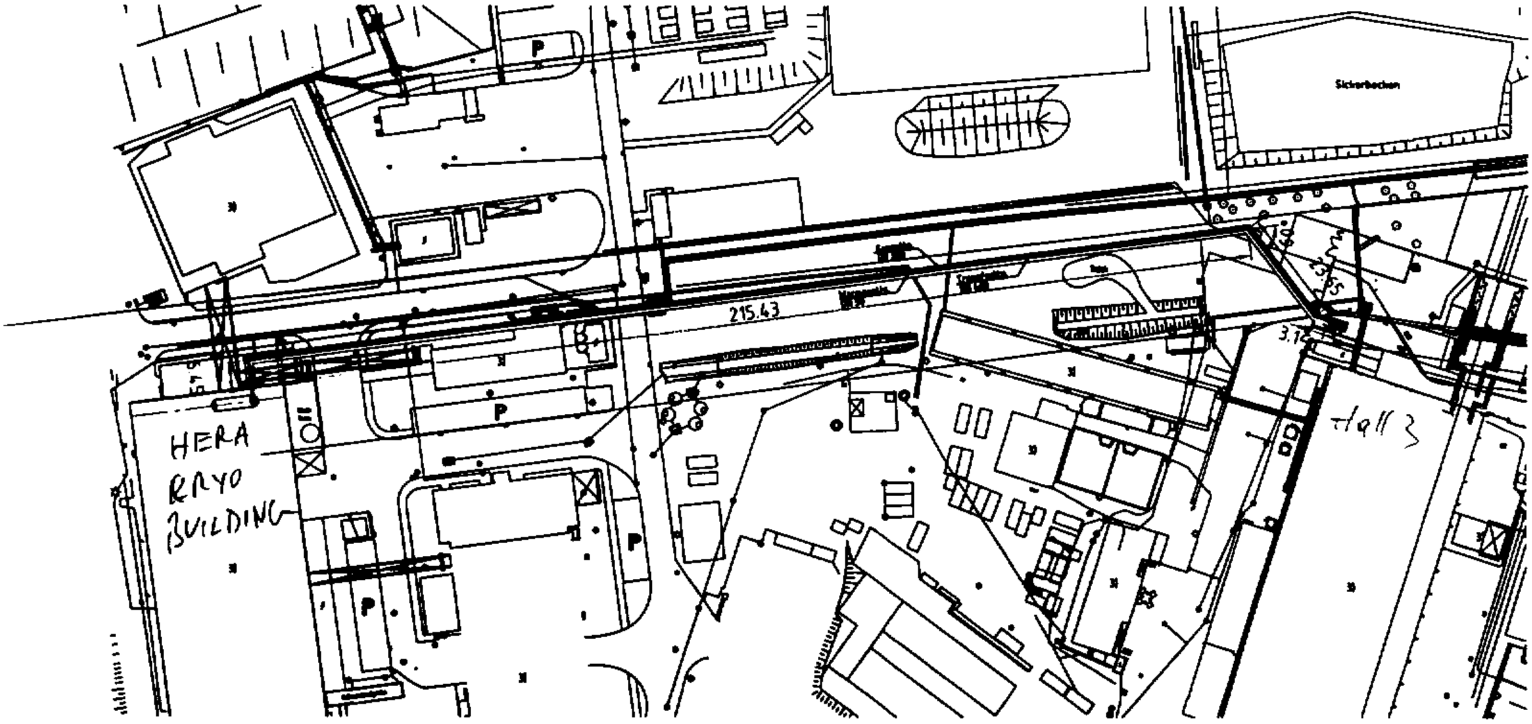
the supply of the TESLA Test Facility for the test of single cavities (2 K , 4.5 K and 40 / 80 K temperature levels)

further advantages:

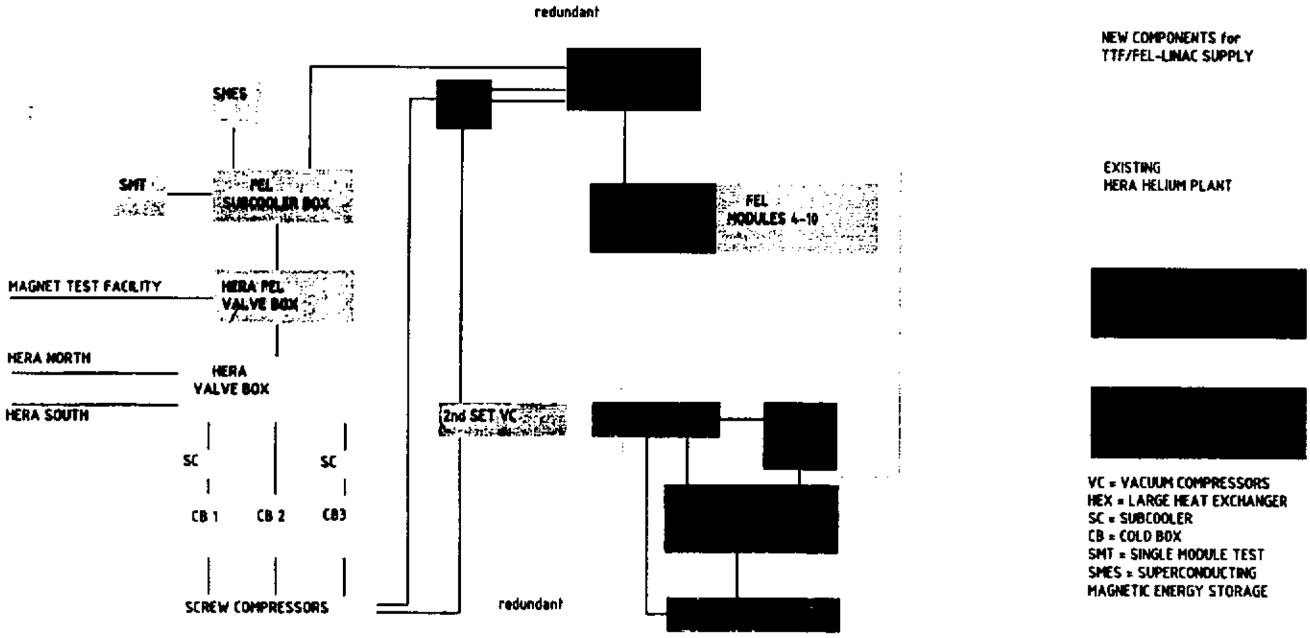
Decoupling of the 2K Supply of Linac and Test Plant ! (Heat Load Measurements !!!)

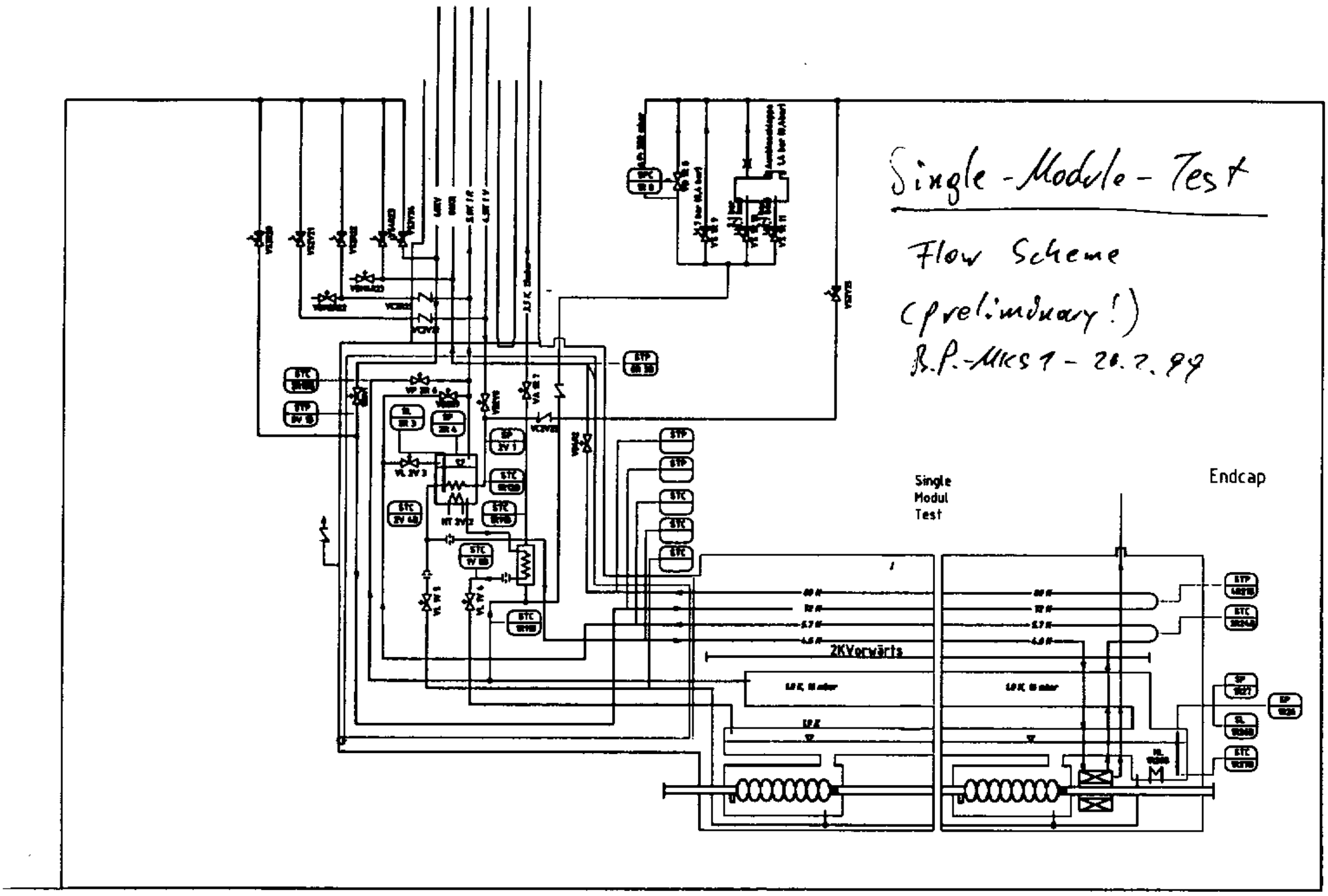
Redundant supply of the TTF / FEL -Linac

HERA-FEL-Line-of-Construction



BLOCK DIAGRAM of the EXTENDED CRYOGENIC SYSTEM



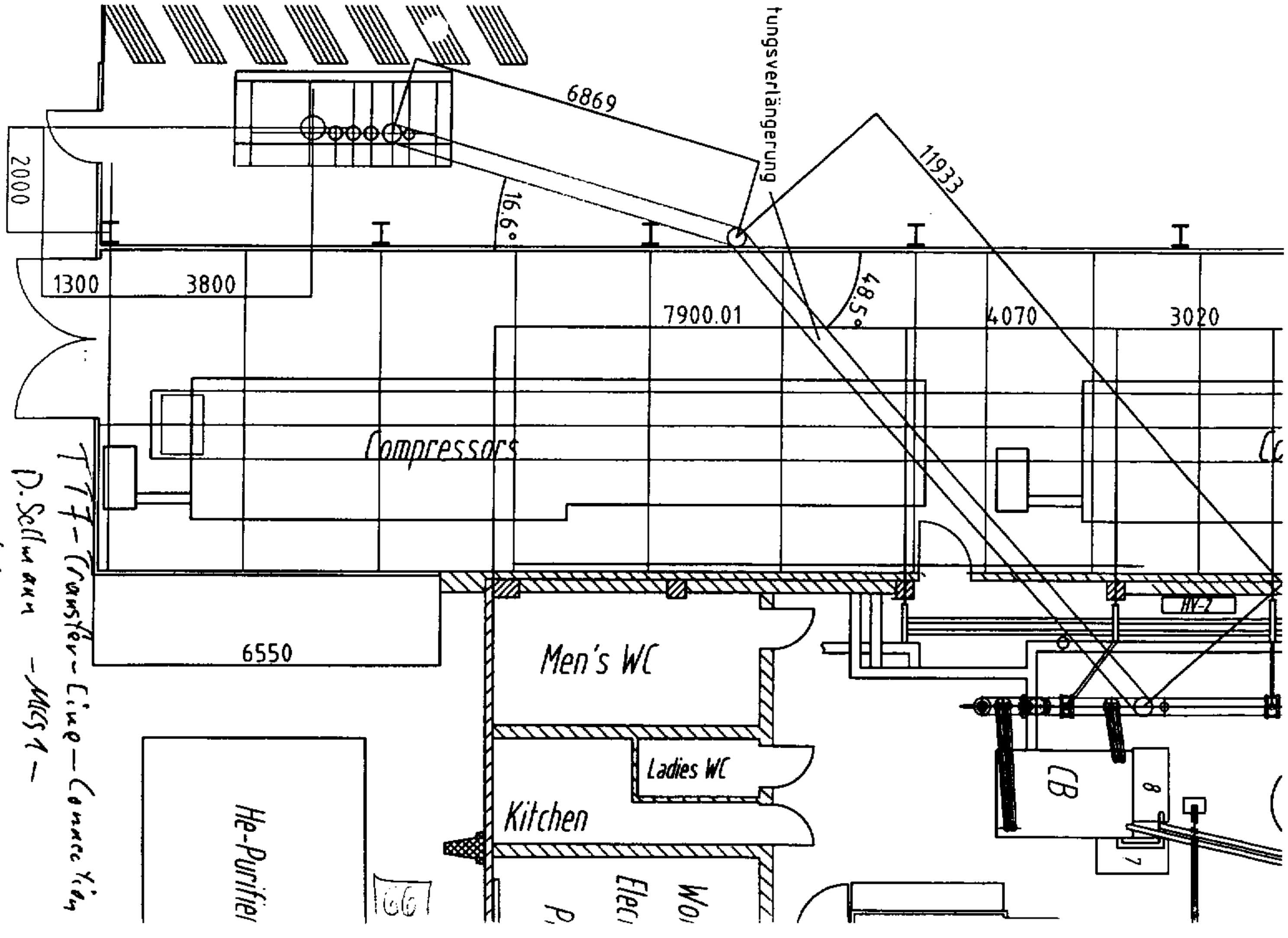


Single-Module-Test

Flow Scheme

(preliminary!)

B.P.-MKS1 - 20.2.99



TTF-Transfer-Line-Connection

D. Sellmann -MKS1-

Status: 21.7.04

Single Cryo-Module-Test:
Proposal for a Test Program

(input from W.D.Moeller / M.Pekeler)

<u>no Beam !</u>

Mechanical check of the components

Leak tests of the vacuum systems

Conditioning of the main RF-couplers (cavities off resonance)

Conditioning with resonant cavities (check of tuning systems)

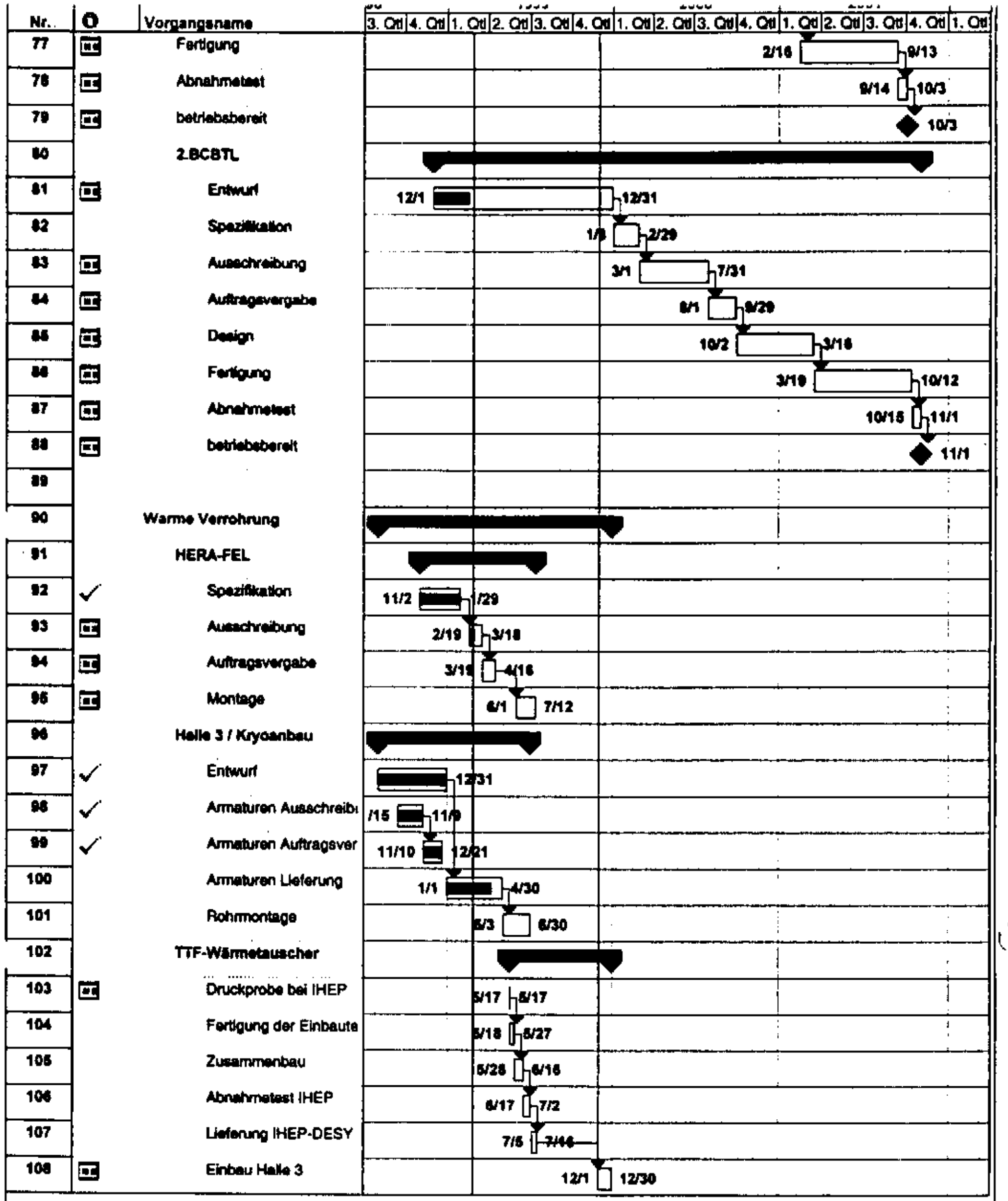
Measurement of the dynamic cryogenic loads of the cavities (Q versus E_{acc} characteristics of the cavities)

HPP-treatment of the cavities

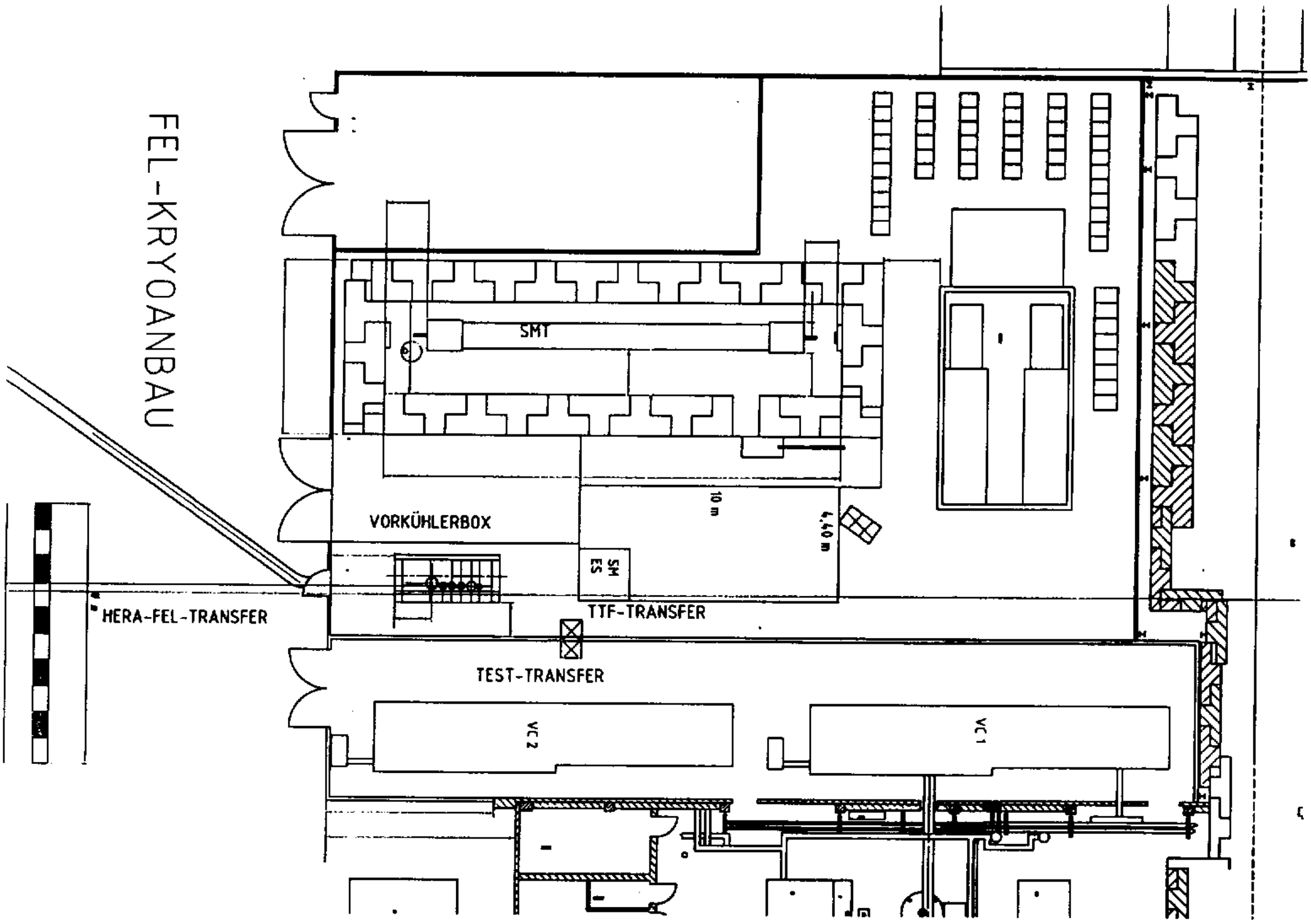
Test of the superconducting quadrupole

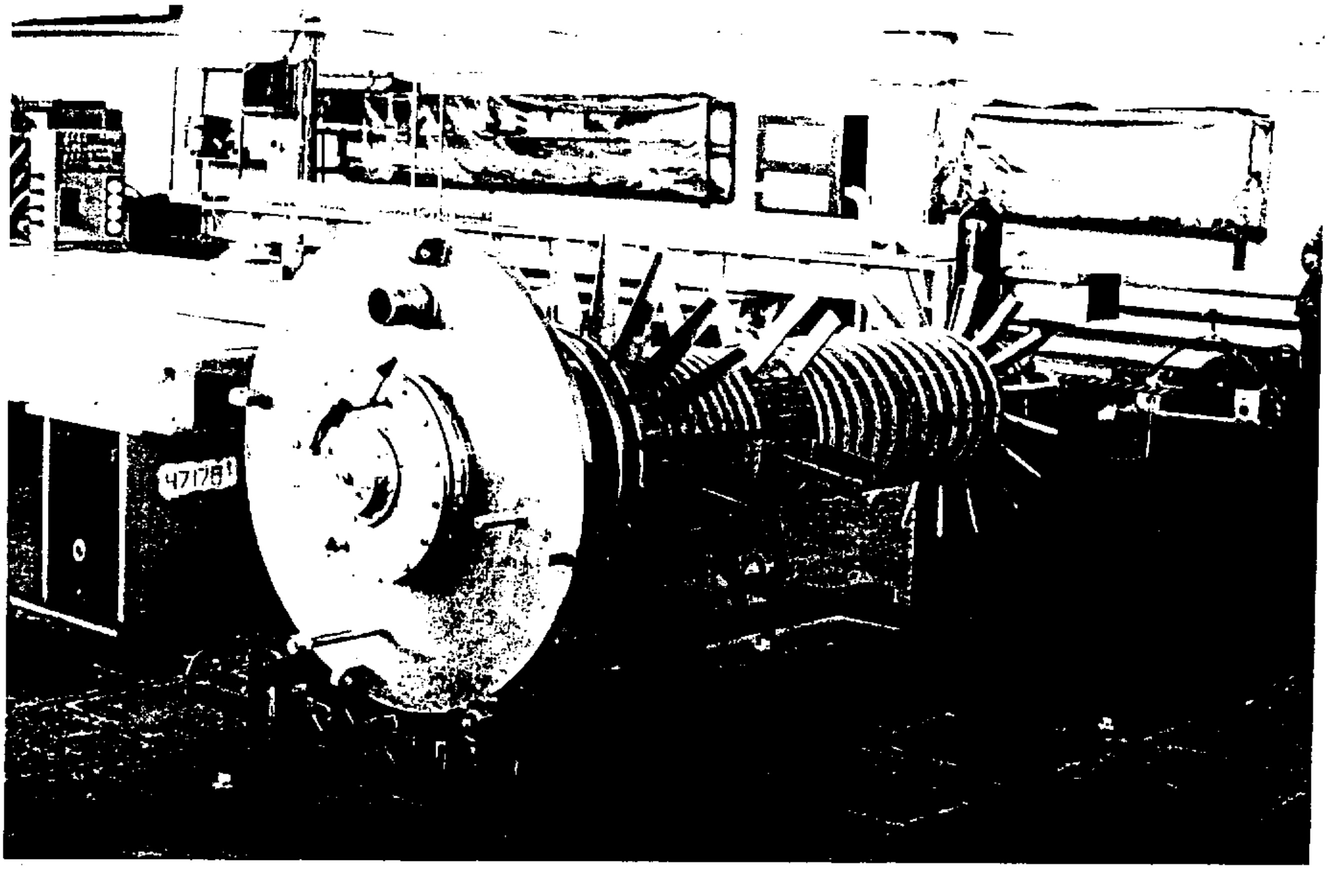
Measurement of the static cryogenic heat loads

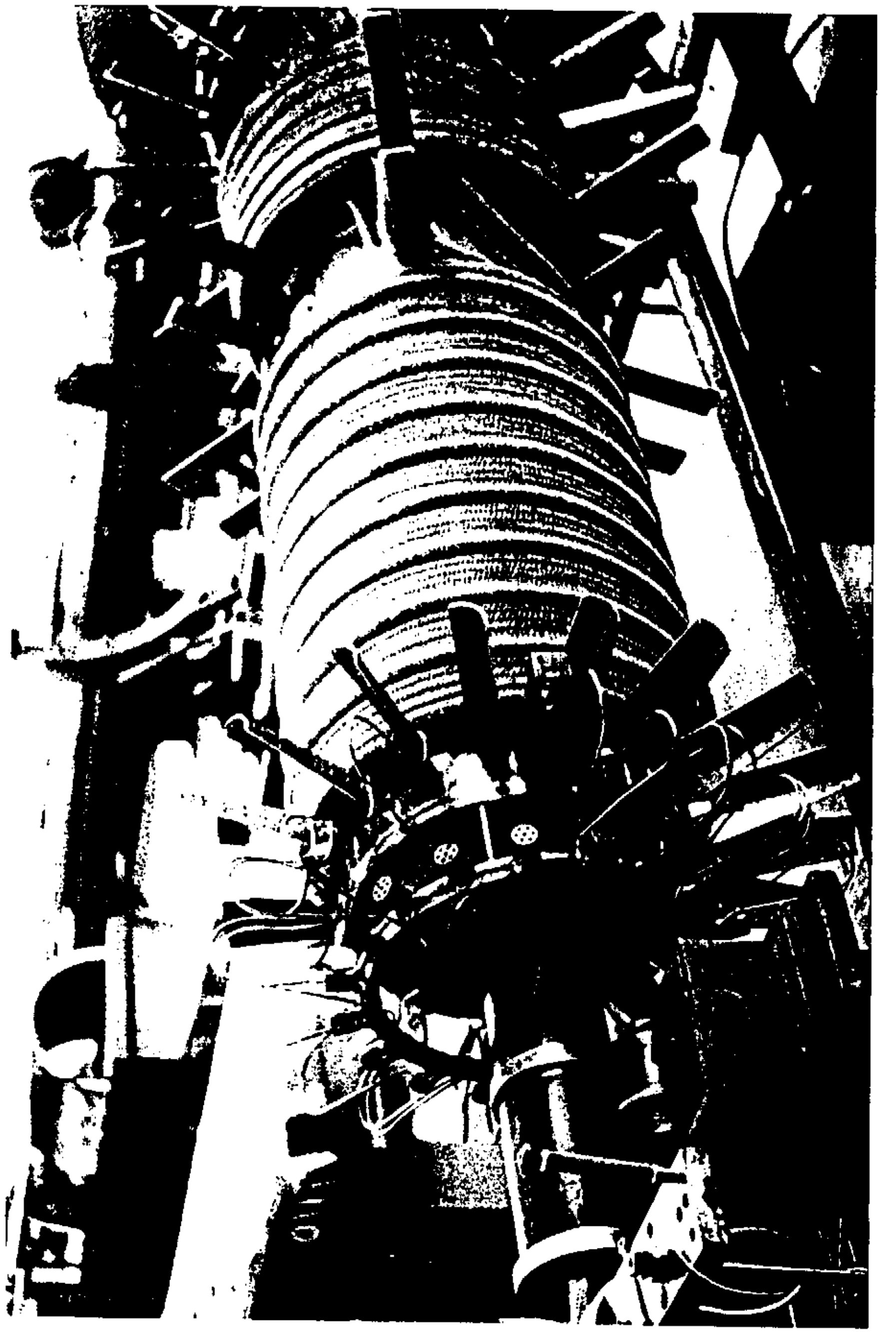
Measurement of the alignment of the cavities during cool down and warm up

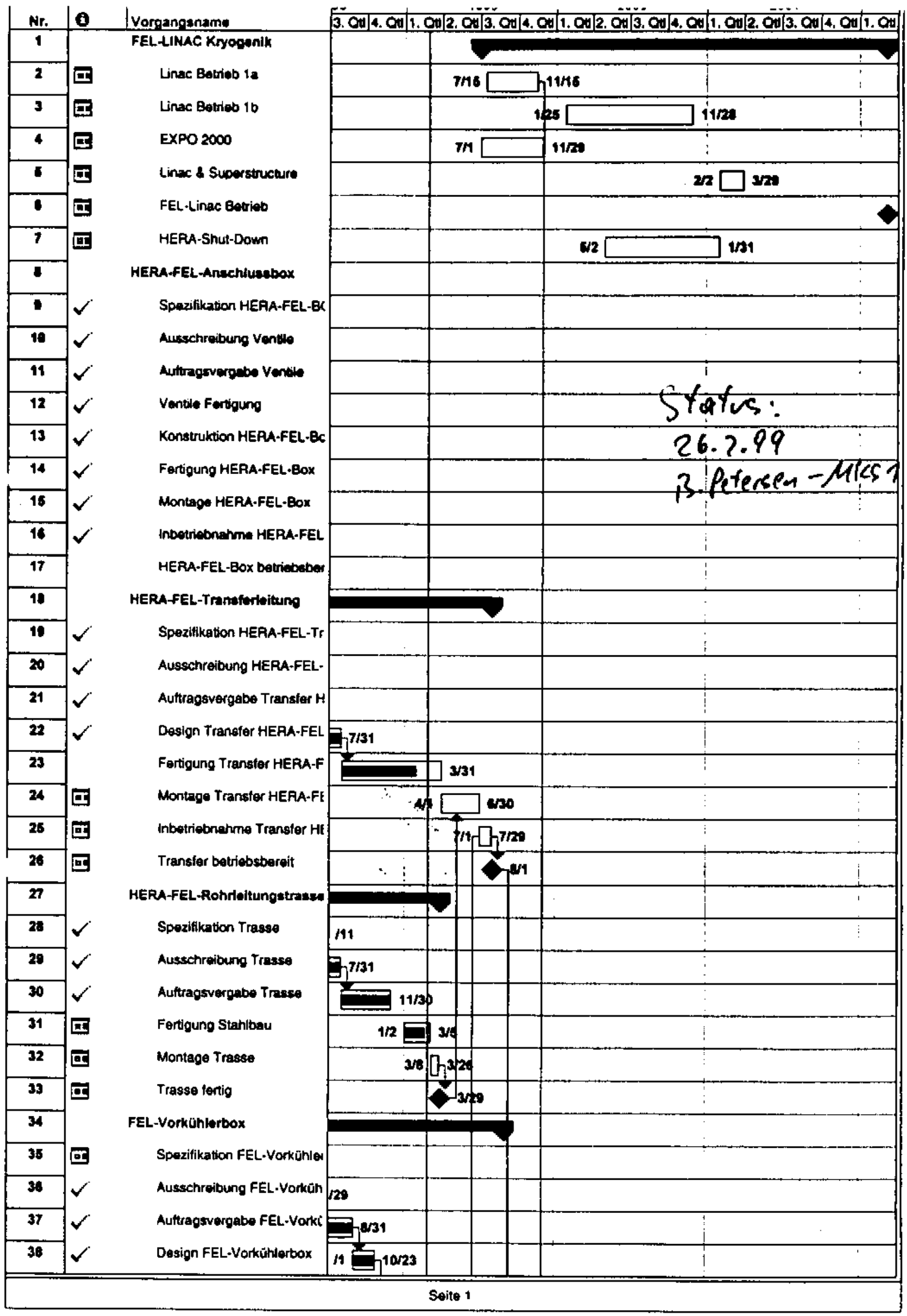


Status: 26.2.99
B.Petersen


FEL-KRYOANBAU
SMT
VORKÜHLERBOX
SM ES
10 m
4,40 m
HERA-FEL-TRANSFER
TTF-TRANSFER
TEST-TRANSFER
VC 2
VC 1


47178

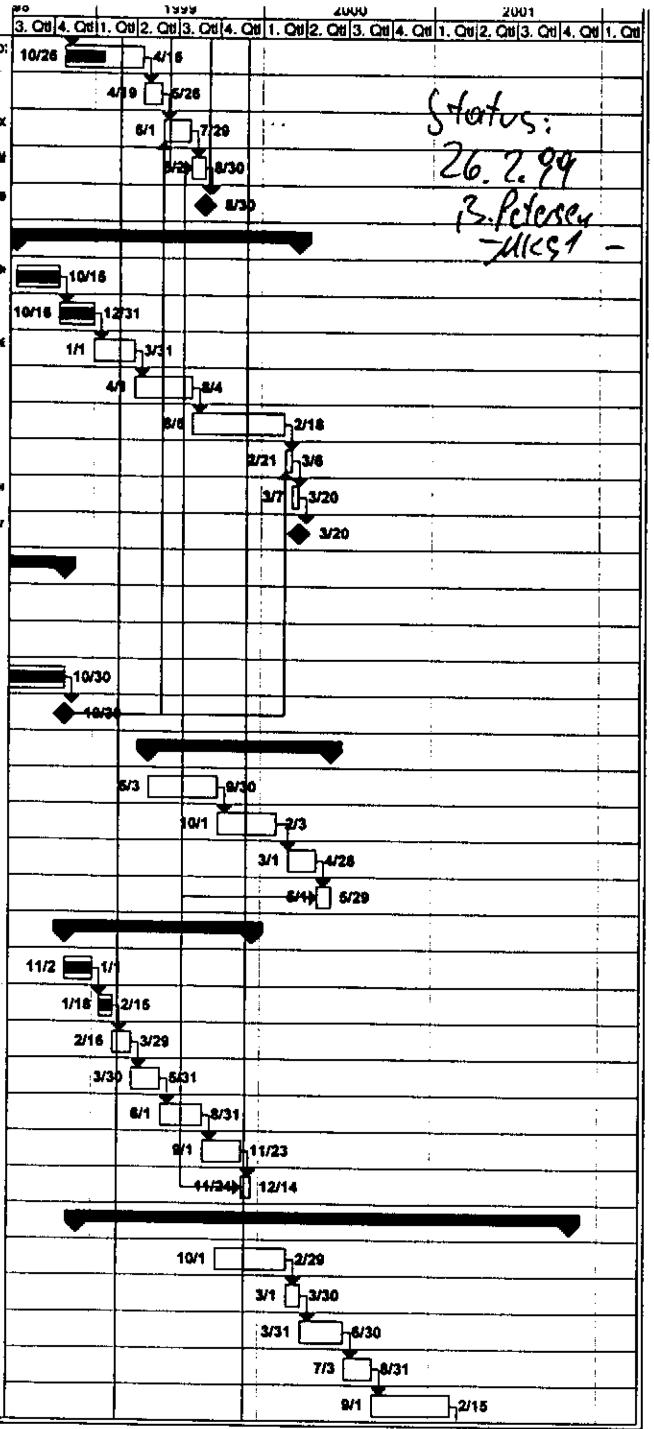




Nr.	❶	Vorgangsname
1		**FEL-LINAC Kryogenik**
2	▦	Linac Betrieb 1a
3	▦	Linac Betrieb 1b
4	▦	EXPO 2000
5	▦	Linac & Superstructure
6	▦	FEL-Linac Betrieb
7	▦	HERA-Shut-Down
8		**HERA-FEL-Anschlussbox**
9	✓	Spezifikation HERA-FEL-B(
10	✓	Ausschreibung Ventile
11	✓	Auftragsvergabe Ventile
12	✓	Ventile Fertigung
13	✓	Konstruktion HERA-FEL-Bc
14	✓	Fertigung HERA-FEL-Box
15	✓	Montage HERA-FEL-Box
16	✓	Inbetriebnahme HERA-FEL
17		HERA-FEL-Box betriebsber
18		**HERA-FEL-Transferleitung**
19	✓	Spezifikation HERA-FEL-Tr
20	✓	Ausschreibung HERA-FEL-
21	✓	Auftragsvergabe Transfer H
22	✓	Design Transfer HERA-FEL
23		Fertigung Transfer HERA-F
24	▦	Montage Transfer HERA-FE
25	▦	Inbetriebnahme Transfer HE
26	▦	Transfer betriebsbereit
27		**HERA-FEL-Rohrleitungstrasse**
28	✓	Spezifikation Trasse
29	✓	Ausschreibung Trasse
30	✓	Auftragsvergabe Trasse
31	▦	Fertigung Stahlbau
32	▦	Montage Trasse
33	▦	Trasse fertig
34		**FEL-Vorkühlerbox**
35	▦	Spezifikation FEL-Vorkühler
36	✓	Ausschreibung FEL-Vorküh
37	✓	Auftragsvergabe FEL-Vorkü
38	✓	Design FEL-Vorkühlerbox

Status:
26.7.99
B. Petersen - MKS 1

Nr.	ⓘ	Vorgangsname
39	▣	Fertigung FEL-Vorkühlerbo:
40	▣	Werkstests
41	▣	Montage FEL-Vorkühlerbox
42	▣	Inbetriebnahme FEL-Vorkül
43		FEL-Vorkühler betriebsbere
44		**Heliumpumpen 2.Satz**
45	✓	Spezifikation Heliumpumpe
46	✓	Auschreibung He-Pumpen
47		Auftragsvergabe He-Pumpe
48		Design He-Pumpen
49		Fertigung Pumpen
50		Montage He-Pumpen
51		Inbetriebnahme He-Pumpe
52		Betriebsbereitschaft He-Pur
53		**Bauten**
54	✓	Planung Bauten
55	✓	Ausschreibung Bauten
56	✓	Bauausführung
57		Bauten fertig
58		**SMES-Transfer**
59	▣	Transfer Design
60		Transfer Bau
61	▣	Montage DESY
62		Inbetriebnahme
63		**TTF-Transfer-Verbindung**
64	✓	Spezifikation
65	✓	Ausschreibung
66		Auftragsvergabe
67		Design
68		Fertigung
69		Montage
70		Inbetriebnahme
71		**Modultest**
72	▣	Entwurf
73	▣	Spezifikation
74	▣	Ausschreibung
75	▣	Auftragsvergabe
76	▣	Design



Status:
26.2.99
B. Petersen
-MKS1 -

SACLAY / ORSAY

- × R/D SRF
  - × E.P. < KEK, CERN, DESY
  - × Cu / Nb
  - × New technique of fabrication
  - × Measurement of Hsh
- × LINAC
  - × Experiments
  - × BPM, Toroids.
  - × Input couplers.

M.FOUAIDY

Test	Test-cell Samples	Nb RRR * and Cu & Nb thickness	R_O(K.m²/W) @ 1.8 K	ΔR_O(K.m²/W) @1.8 K	Remarks
1	4 rods (Φ8)	100 *	$5.6\ 10^{-4}$		OK
1	4 rods (Φ8)	e_{Cu} : 1-1.5 mm or 2- 2.5 mm	$6.5 - 7.5\ 10^{-4}$	0.9 à $1.9\ 10^{-4}$	OK
2	2 Nb Cabot disks, BCP 50µm	30-40 * e_{Nb} = 1.96 mm	$1.46\ 10^{-3}$		OK
2	2 Nb cabot disks, BCP 50 µmwith APS bonding alloy and APS Cu coating (Mallard)	e_{Nb} = 1.96 mm e_{Cu} = 2.5 mm	$2.07\ 10^{-3}$	$6.2\ 10^{-4}$	permeability test to be performed on the APS Cu coating disk
3	2 Nb Plansee disks, BCP 40µm	30-40 * e_{Nb} = 2 mm	$6.32\ 10^{-4}$		OK
3	2 Nb Plansee disks BCP40µm with APS bonding alloy	e_{Nb} = 2 mm e_{AlL} = 0.2 mm	$1.27\ 10^{-3}$	$6.4\ 10^{-4}$	OK
4	2 Nb Wah-Chang disks BCP 50µm	30-40 * e_{Nb} = 0.5mm	$3.84\ 10^{-4}$		Nb k(T) not yet measured (without HT : Ti @1200 °C).
4	2 Nb Wah-CHang disks, BCP 50µm with APS bonding alloy and APS Cu coating (Mallard)	e_{Nb} = 0.5 mm e_{Cu} = 2.2 mm	$7.48\ 10^{-4}$	$3.6\ 10^{-4}$	permeability test to be performed on the APS Cu coating disk
5	2 Nb disks Wah-Chang machined on the lathe	200 * e_{Nb} = 2.02 mm	$5.6\ 10^{-4}$		Nb k(T) not yet measured
5	2 Nb disks Wah-Chang machined on the lathe with CAPS (Argon) Cu coating.(CEA/DAM)	e_{Nb} = 1.85 mm e_{Cu} = 2.0 mm	$5.6\ 10^{-4}$	≅ 0	Nb/Cu interface analyzed by US, Micrograph to be done (after second test ?).

TABLE I :OVERALL THERMAL RESISTANCE R_O OF ALL Nb and Nb/Cu SAMPLES TESTED UP TO NOW

1. FOUAIDY

Fabrication and test of monocell and multicell cavities

- 3GHz cavities (number: 7)
- Five 1.3GHz monocelle cavities
- TWO 1.3GHz Tri cell cavities

- Nb sheets supplied by Heraeus RRR = 140
  Thickness : 1mm

- Coat cavities with thermally sprayed deposit

→ coating thikness : 2-3 mm

→ " Material : to be decided After Mechanical and thermal tests on samples

→ coating technique : APS or VPS or HVOF
To be chosen according to several criteria :

- High Bonding strength
- High Young modulus
- Good thermal performance
- Best mechanical properties (Low Temp.)

....

Measure of the superheating magnetic field

C.Thomas (PhD), G.Bienvenu, M.Fouaidy*, H.Sun**

- Direct measuring H_{sh} in High Power RF Short Pulsed mode
- $H_{sh} = f(\lambda/\xi)\, H_c$
  - Measuring λ on cavity

*IPNO **Visitor

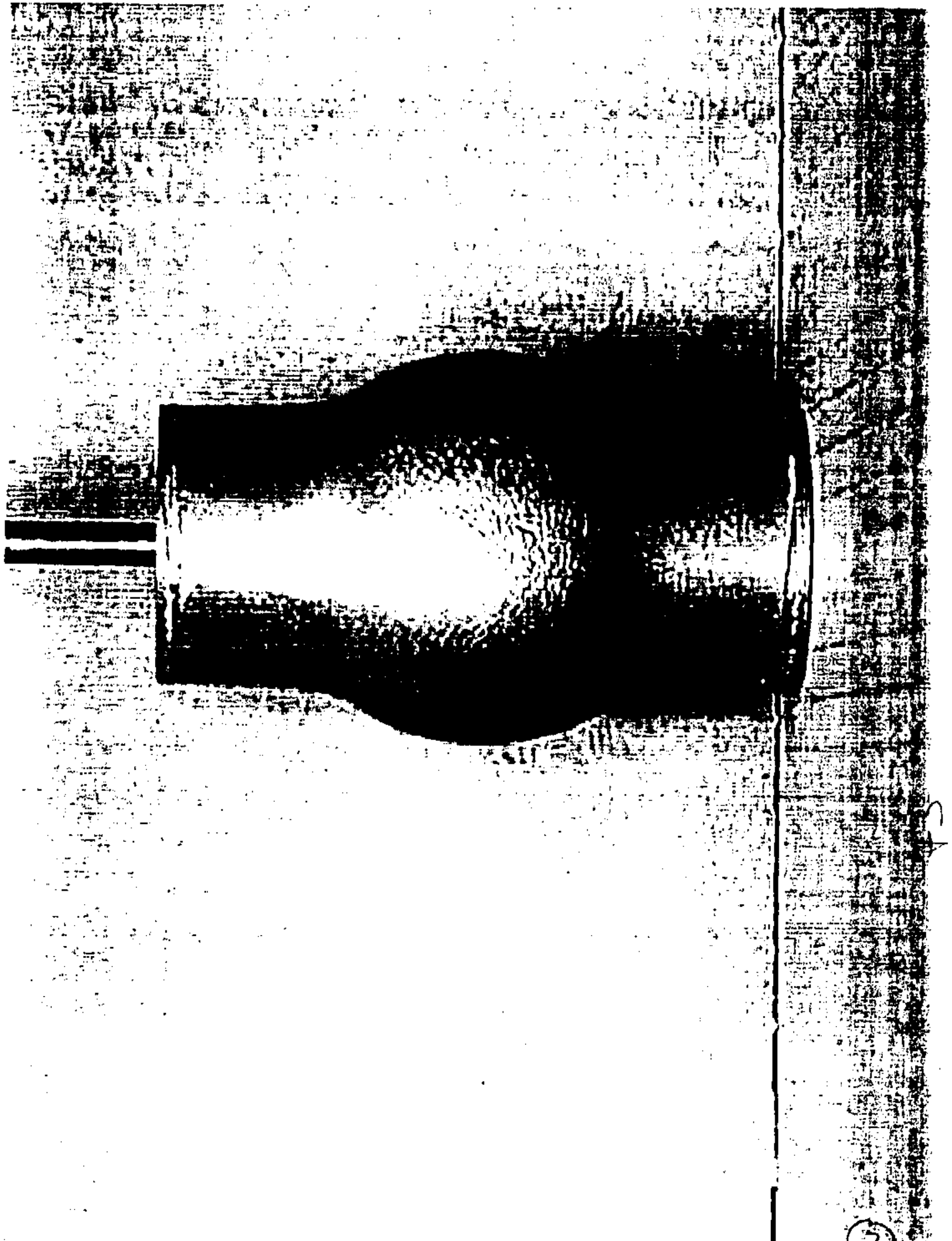
LAL - ORSAY

CAVITIES R&D

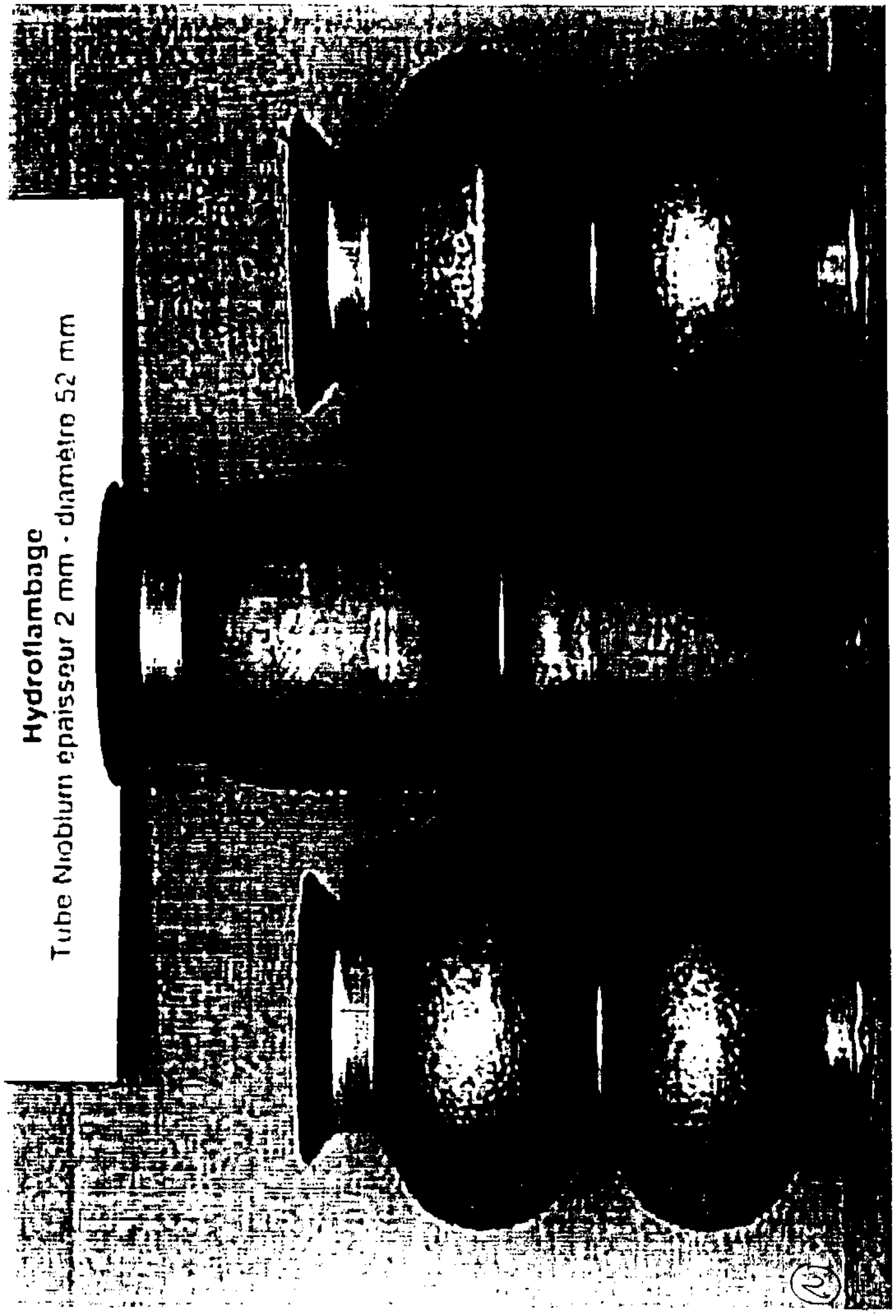
- Hydroforming
- hot forming
- plasma spraying of copper
- E.B. welding
- non destructive controls
- mechanical tests

more tomorrow…..

grandsir@lal.in2p3.fr



③



Hydroflambage

Tube Niobium epaisseur 2 mm - diamètre 52 mm

EXPERIMENTS SACLAY / KEK
on ElectroPolishing

- 3 single cell cavities (CERCA) tested at Saclay, then sent to KEK for EP and test.

1/ Summary:

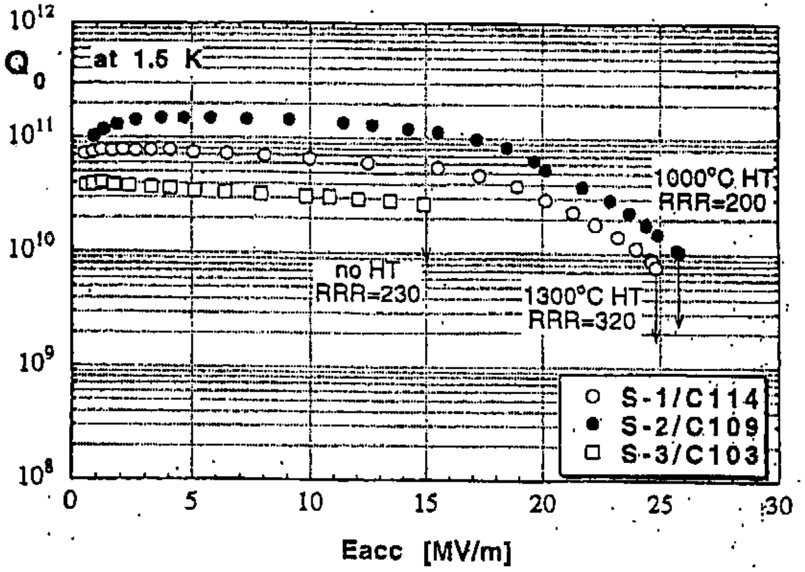
			E_{max} Saclay	E_m KEK(EP5c	
S1	RRR 300	HT 1300°	25 / slope	32	no slop.
S2	RRR 200	HT 1000°	26 / slope	32	
S3	RRR 300	no HT	15	33	

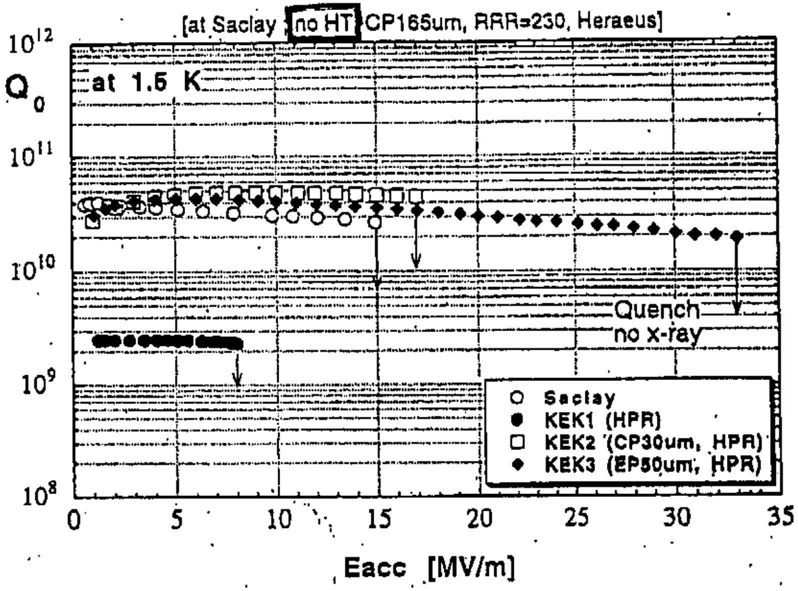
2/ on cavity S3:

- After further EP (70μm) → $\boxed{\begin{array}{c}37\text{ MV/m}\\ \sim 2\,10^{10}\end{array}}$

(
- BCP 60μm → 28 MV/m + slope
- BCP 70μm → 24 MV/m + slope

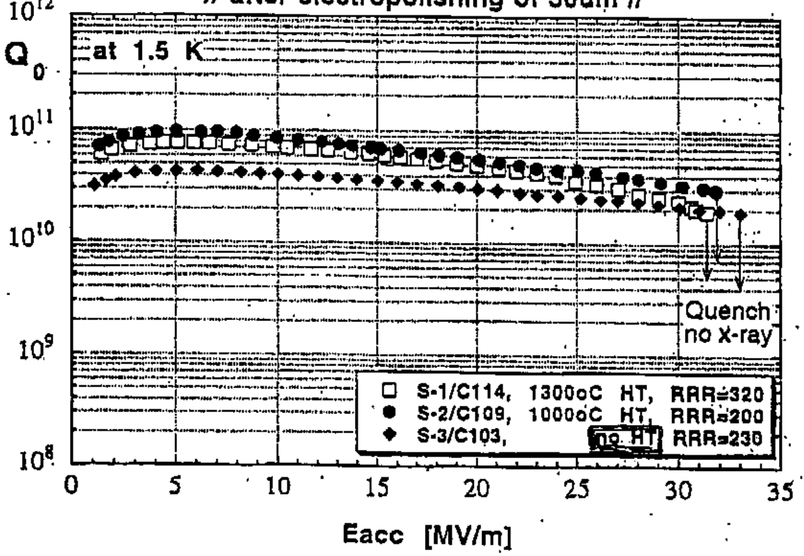
Test Results at Saclay





Three Saclay's Cavities

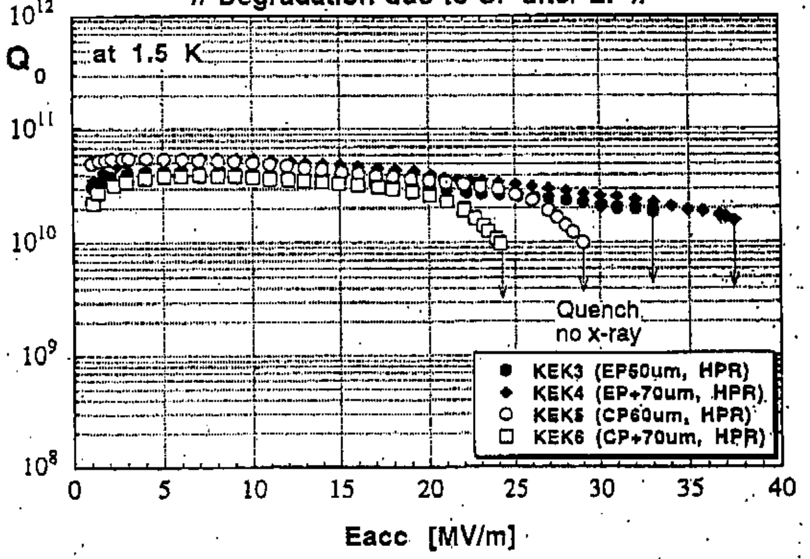
// after electropolishing of 50um //



☆ New Results

S-3 / C103 Cavity

// Degradation due to CP after EP //



OF THE REENTRANT BPM ON THE HIGH CHARGE BEAM OF TTF.

M. LALOT
C. MAGNE
B. PHUNG
J. NOVO
Saclay

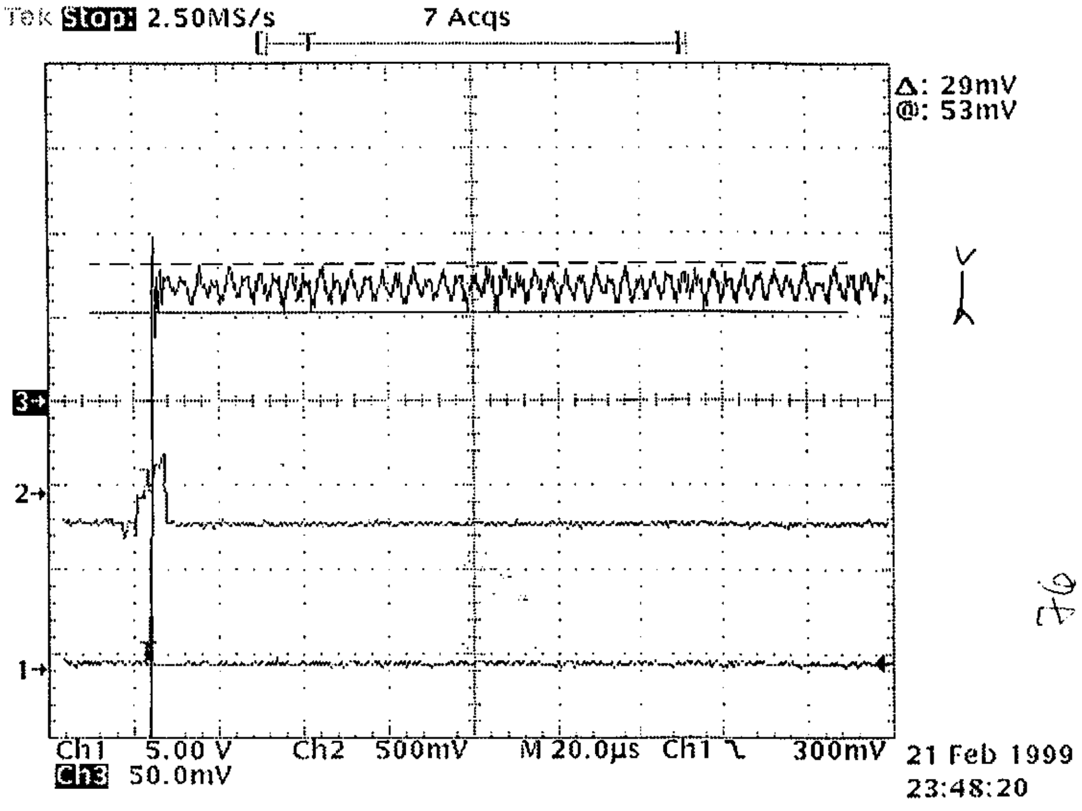
H. SCHLARB
Desy

A BPM designed to achieve both:

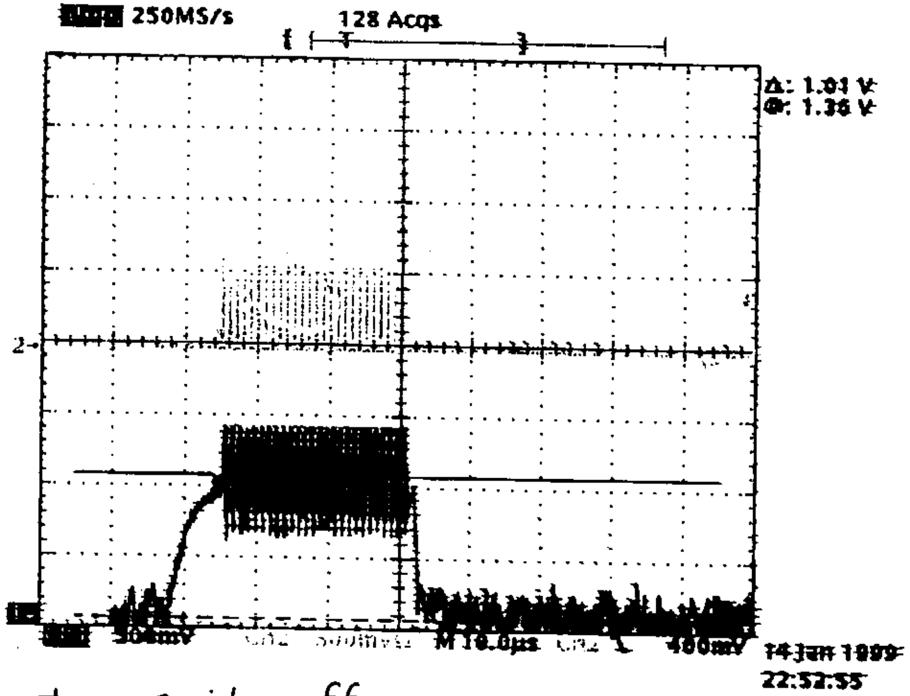
- HIGH RESOLUTION (RF cavity, reentrant shape, cylindrical symmetry)
- WIDE BAND measurements (antennae coupled to Q ~ 3 ⇒ BW ~ 200 MHz)

RESOLUTION OF THE REENTRANT BPM ESTIMATED FROM THE SIGNAL/NOISE RATIO.

10 μm @ 3 nC/bunch



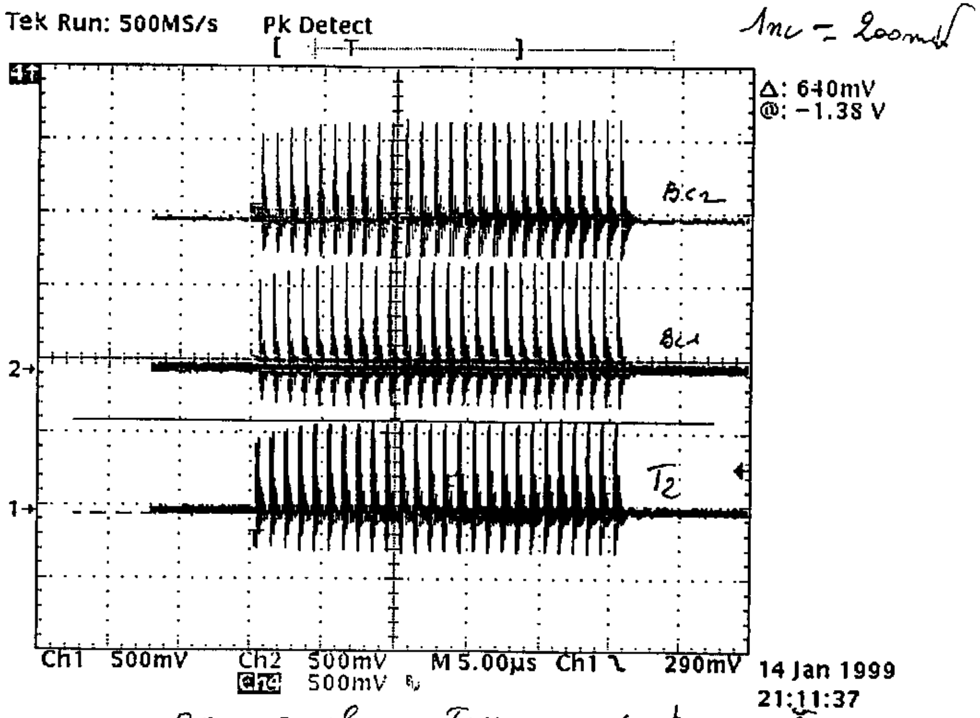
noise 30 mV ⇒ 11 μm @ 3 nC



Capture cavity off
GUN 2 MW module 1 on

DARK CURRENT = 14 µA @ CAPCAV

ON ~~Thurs~~ Friday 26/02/99 the Dark current was measured at BC2 :
200 nA for gun: 2.9 MW @ BC2



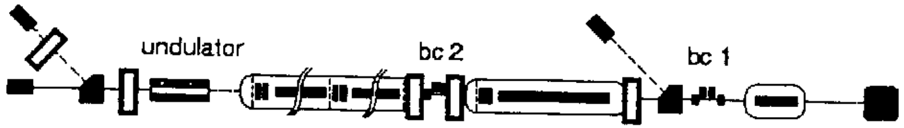
1nc = 200mV

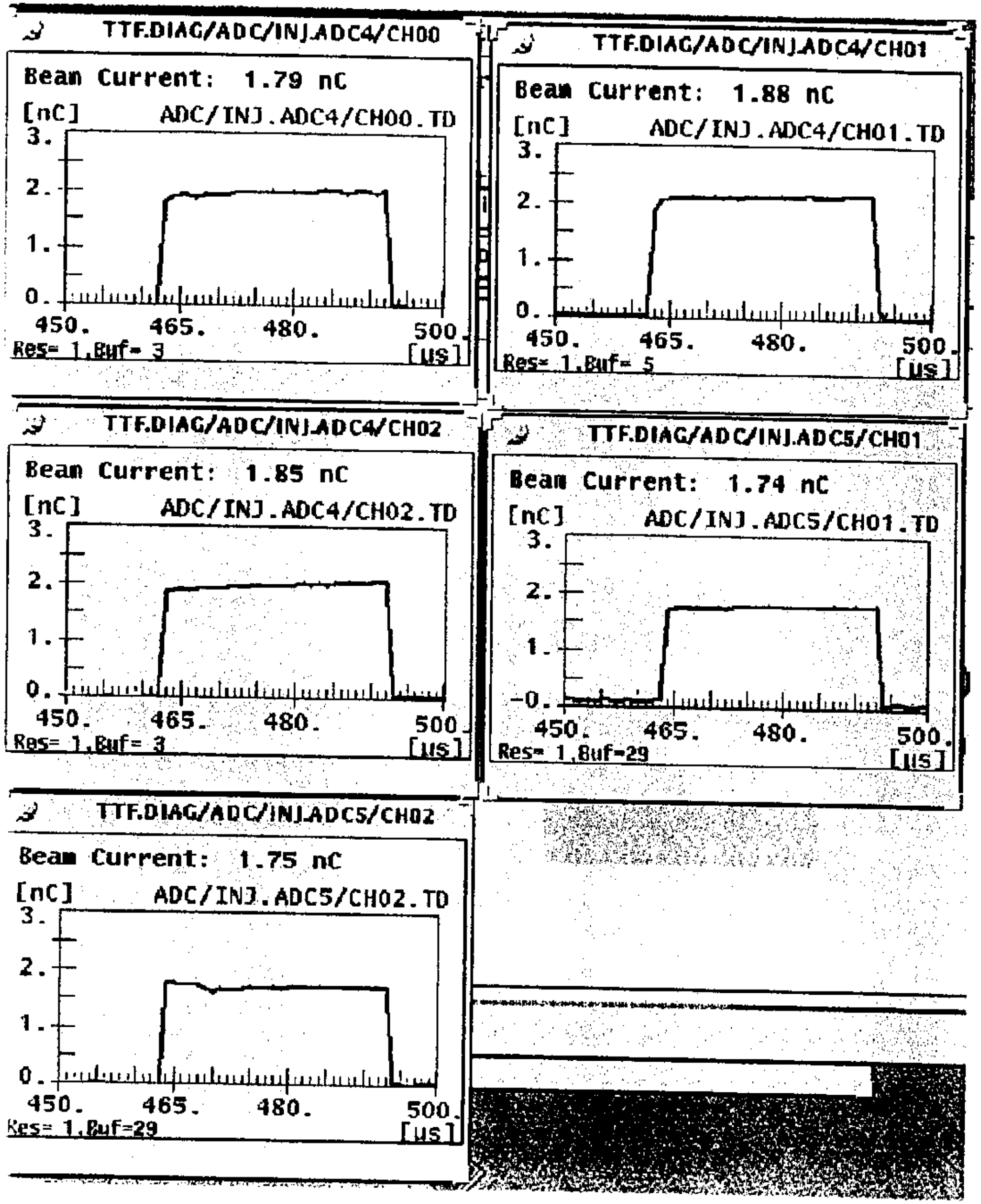
– Apres reglage Timming systeme (Laser)

TOROIDS w/ INJECTOR II

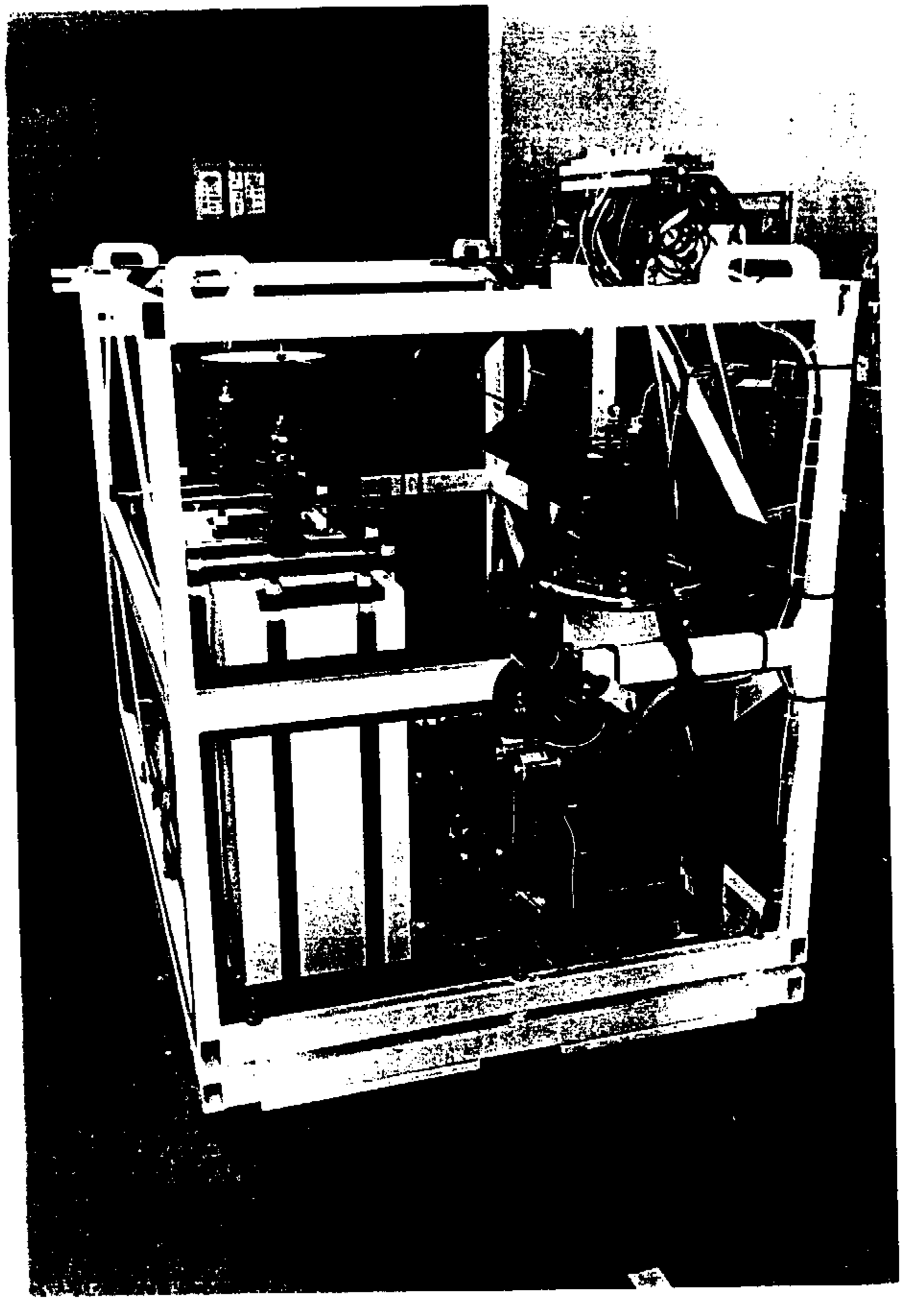
- Signals out of pre-amplifier

Beam current measurement by "Saclay" toroids





CRYHOLAB MODULATOR (M. OMEICH / ORSAY)



TTF Collaboration Meeting
DESY, March 1-3, 1999

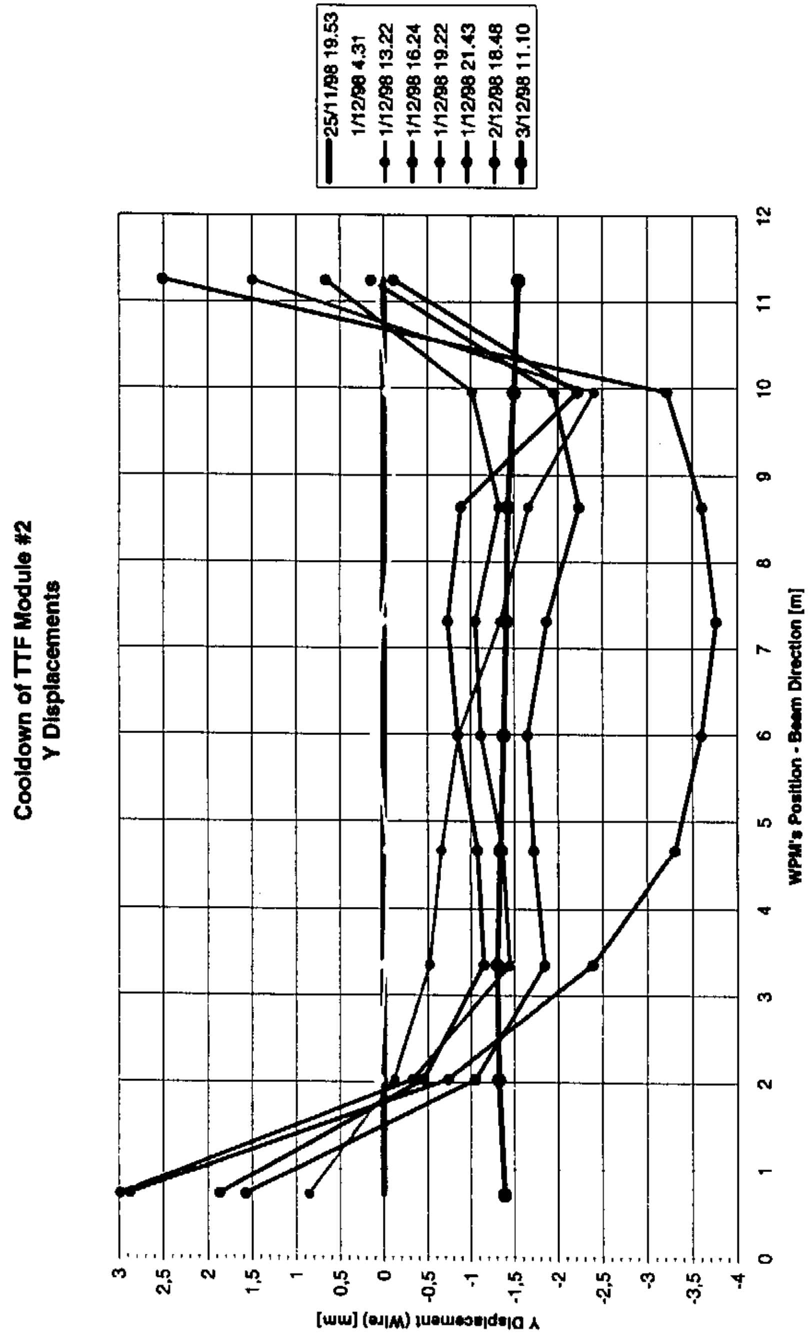
News on TTF Activities at INFN

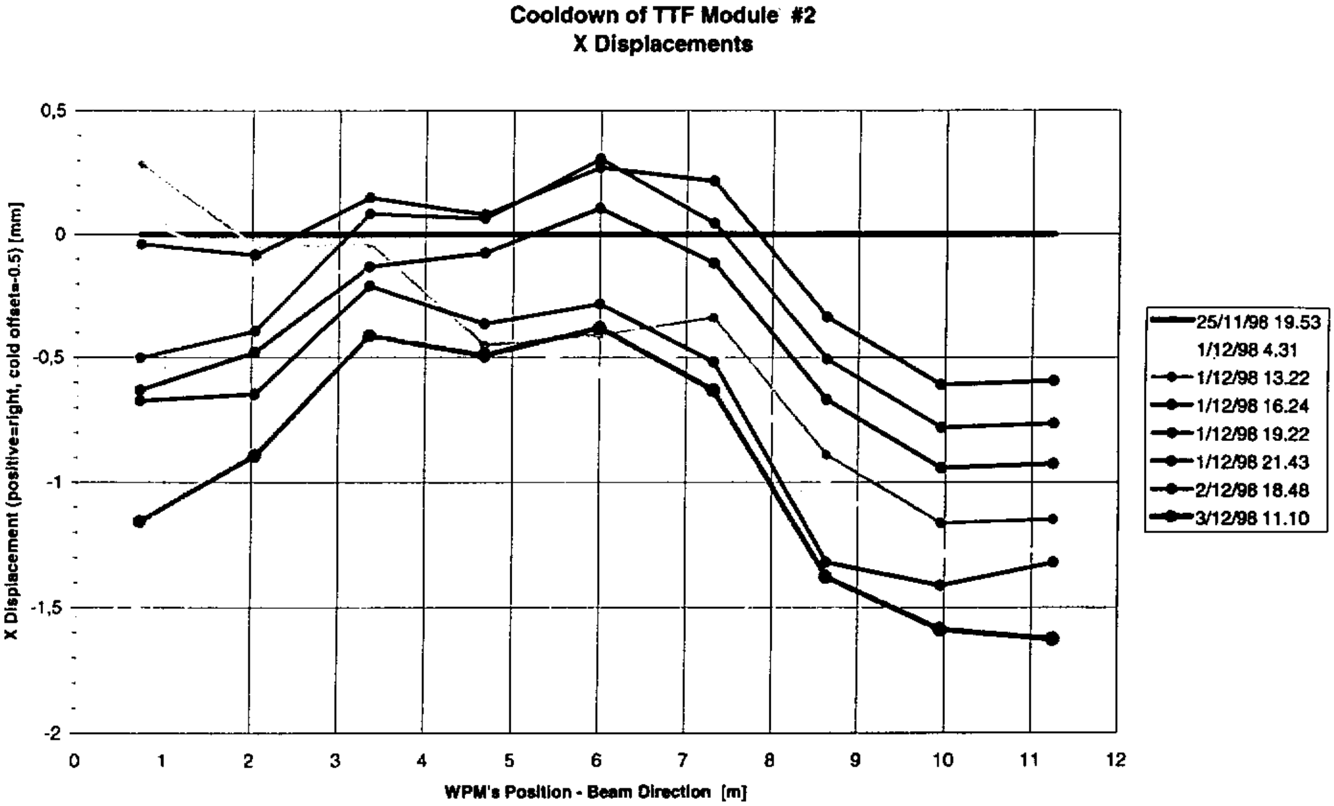
(LNF, LNL, Milano & Roma2)

Presented by **Carlo Pagani**

1) Cryostat Design & Cryomodule Assemby

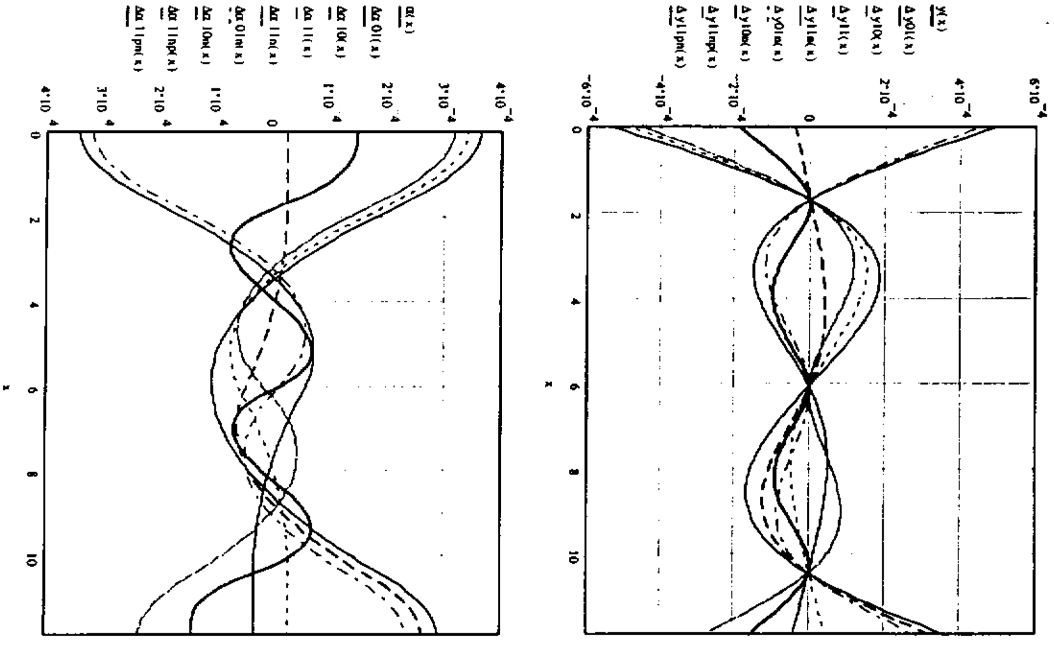
- Cryostats # 2 & # 3 - including WPMs
  - 2nd Cryomodule in operation successfully
  - 3rd Cryomodule assembly: starts this month
- Cryostat # 1 to # 1* order close to be sent out
  - From May to October 99: cavities and shields replaced
- Cryostats # 4 to # 8 - # 4 & # 5 in fabrication
  - Final drawings at ZANON since end 98
  - Expected delivery at DESY: October 99
    - Composite posts (FNAL design) in fabrication
- New Assembling Tools - order close to be sent out
  - New assembling tools compatible with Cryo # 1 to # 3
  - Design has been defined
  - Tooling due by September '99





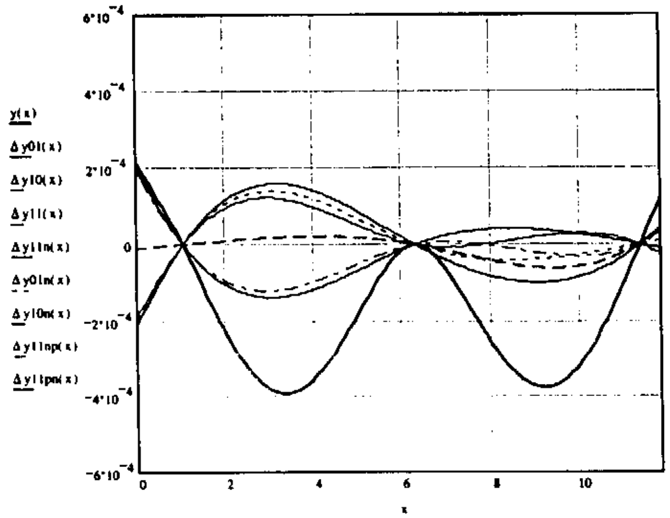
2nd Generation Cryostat

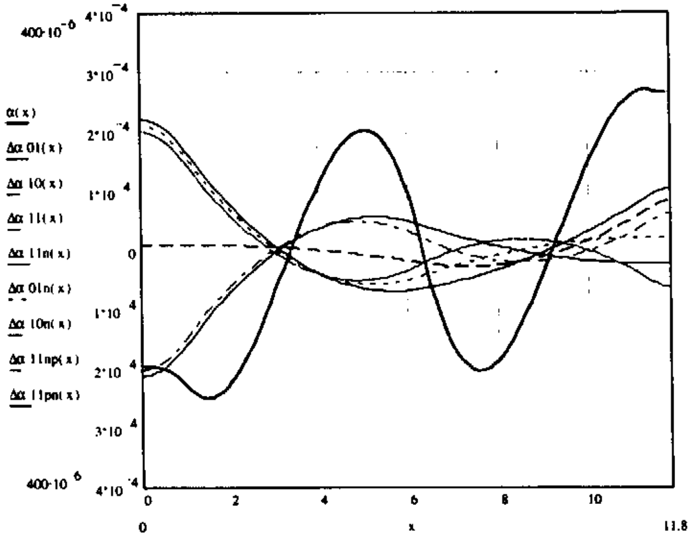
Active element movements for a 1000 N force at the edges



3rd Generation Cryostat

Active element movements for a 1000 N force at the edges





Carlo Pagani
INFN Milano - LASA

---

2) Photocathodes (P.Michelato)

- TTF Injector II Cathode System
  - INFN Photocathodes in operation at DESY and FNAL
  - Cathodes prepared at Milano transported to DESY
- R&D Activity
  - "New" photoemissive materials: K-Te & K-Cs-Te
  - Poisoning and life tests on new cathodes
  - Low energy electron spectrometer for thermal emittance

3) Beam Diagnostics (LNF & Roma 2 groups)

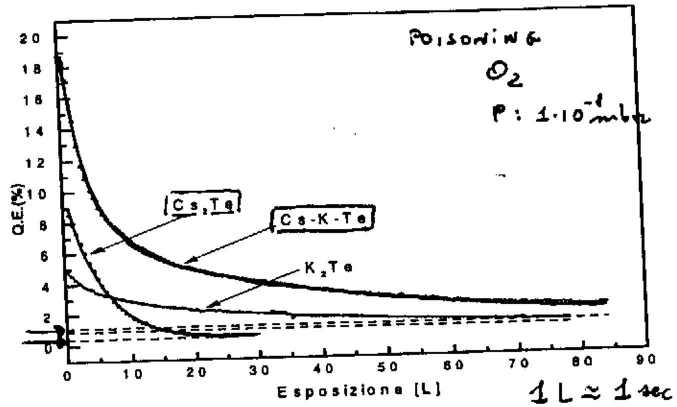
- Diagnostics instrumentation
  - Actuators for new OTR screens
  - Actuators for the pepper pot screen
  - New fast electronics modules for the strip-lines
- Beam parameter measurements with OTR
  - Emittance and energy spread measurements
  - Emittance measurements with pepper pot

4) Cavity Fabrication

- Standard Cavities - A13 to A18 delivered
  - A15 in module # 2: 26.4 MV/m @ 1.2 W (800 µs - 10Hz)
- New Technologies - Spinning at LNL

5) Theoretical activity (M. Ferrario)

- Beam behavior in Superstructures
- quasi-on line calculations for RF Gun optimization



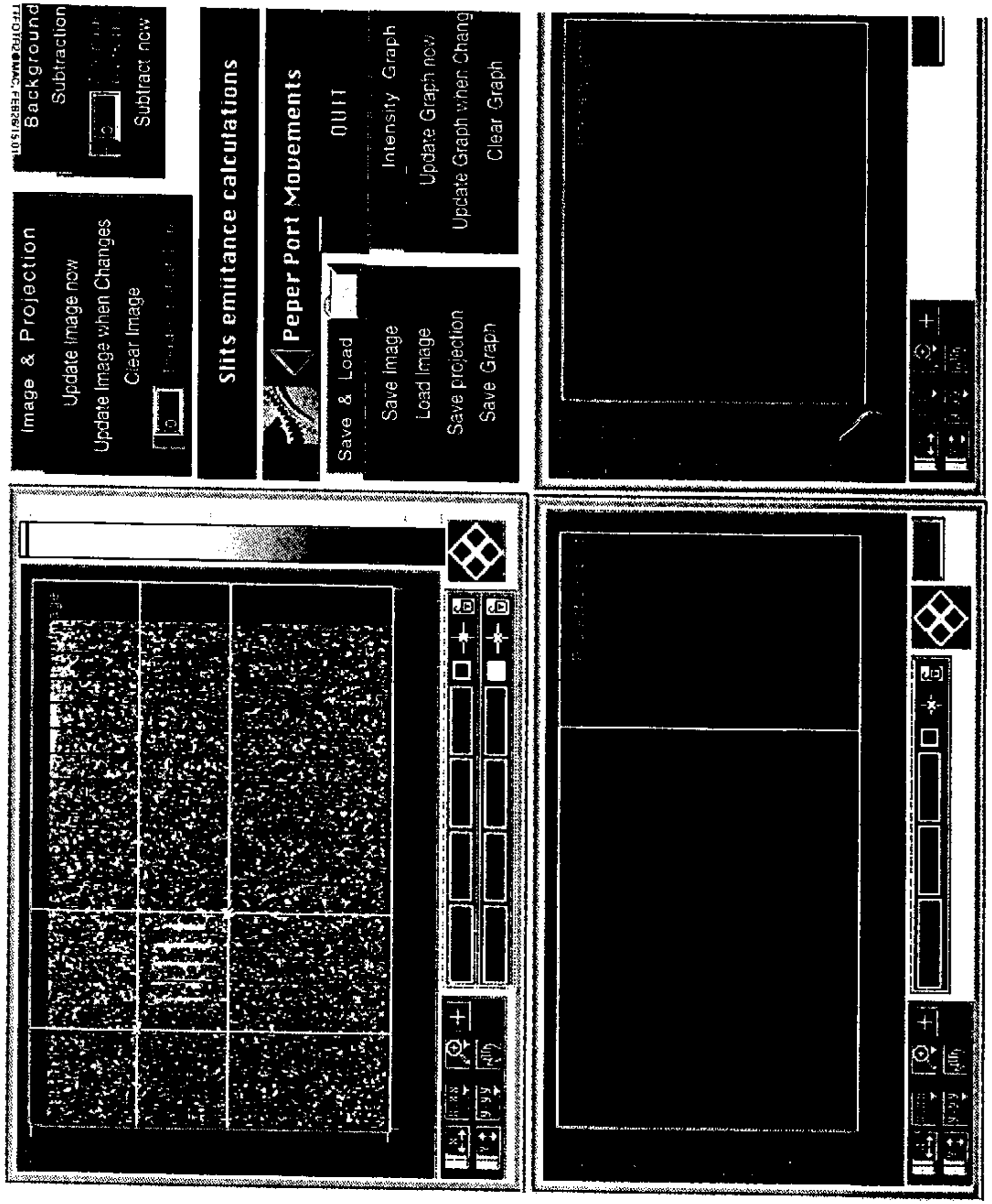
1 L ≃ 1 sec · $1\cdot10^{-6}$ mbar

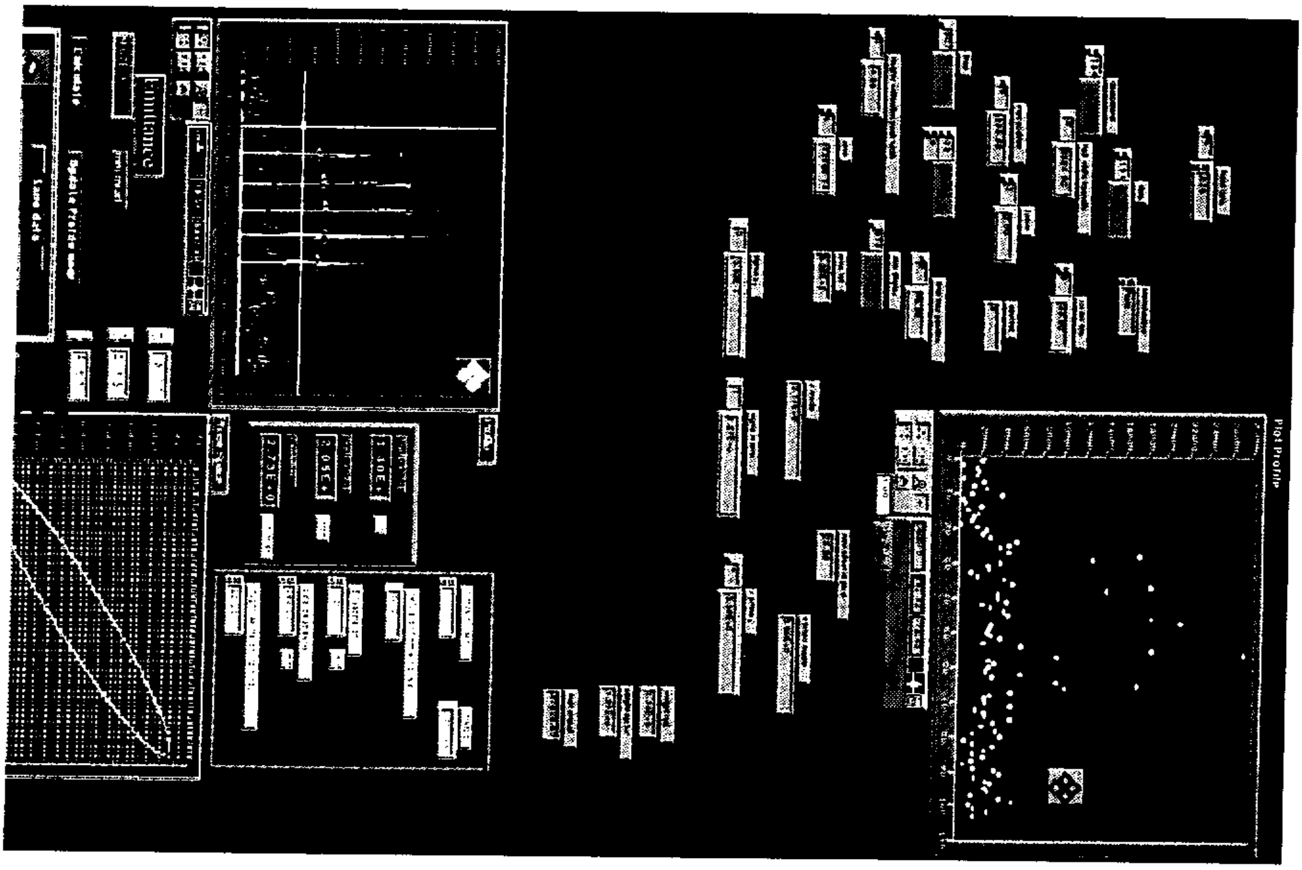
Fig. 3.14 Q.E. in funzione dell'esposizione ad O_2 di catodi in K_2Te, Cs_2Te e Cs-K-Te (esposizione effettuata a $1\cdot10^{8}$ mbar, λ=254 nm).

$$y(t) = y_0 + A_1 e^{-(t/t_1)} + A_2 e^{-(t/t_2)}$$

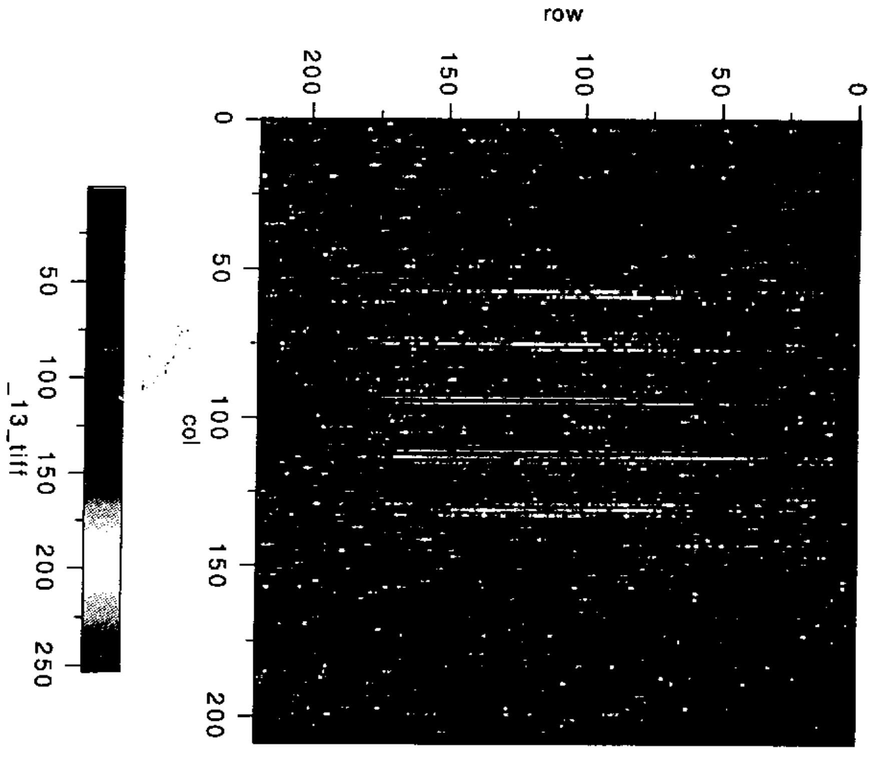
	A1	t1 (L)	A2	t2 (L)	y0 (Q.E.%)	@254 nm
K2Te	1.7	3.8	2.4	34	0.89	
⇒ Cs2Te	4.5	5.7	5	5.7	0.34	L → ∞
⇒ Cs-K-Te	12	3.7	6.2	38	$\boxed{1.12}$	

Tab. 3.2 Risultati del "fit" sulle curve di avvelenamento





TTFOTR2@MAC, FEB26/14:06



Fermilab Report
Don Edwards
1 March 1999

There are two activities underway at Fermilab that may be of potential interest to the TESLA Collaboration.

The Photoinjector

The equipment installed in service building A0 is very similar to Injector II in Halle 3. The RF gun is the twin of the one at DESY, the capture cavity is S12 from DESY installed in the cryostat of ORSAY design. The bunch compressor following the capture cavity is identical, as is the INFN Milan cathode preparation chamber.

The schedule for Halle 3 shown earlier today by Dieter Trines is quite ambitious. The program at Fermilab has considerable overlap in the study of the RF gun, of space charge dominated beams, and of related diagnostics for the investigation of the 3 d-o-f emittance. It is quite possible that the A0 work can be helpful as regards schedule.

RF Separated Kaon Beam

The old (1970 vintage) Main Ring at Fermilab has been replaced by the Main Injector, a 120–150 Gev proton synchrotron in a separate tunnel. While performing its role as particle source for the Tevatron collider, it can also deliver beam to a fixed-target physics program in simultaneous operation. When the Main Injector was proposed over ten years ago, a kaon physics effort was to be part of the fixed-target activity.

The spill duty factor of the Main Injector is one second out of three. A separator system for kaons must therefore employ superconducting cavities. I commented on the possibility of such a project at the collaboration meeting in Zeuthen during November 1997. Last year, we developed a design report, which was reviewed last October. Now, in the last few days, initial funding is in place.

Kaon economy favors high frequency; the rise of surface resistivity with frequency as well as concern for unreasonable extrapolation from experience argues for caution. Our conclusion is that 4 GHz is an upper limit. Taking 25 MV/m as a given for TESLA style resonators, in the deflecting mode considered here the corresponding figure is 5 MV/m with the assumption that surface magnetic field is the limiting factor.

Two remarks are in order. The development of deflecting mode structures in this frequency range may find application for beam splitting toward several FEL's at some stage in the TESLA program. And, it is important to recognize that because of the past seven years of the TESLA development program, it has become possible to approach the kaon separator project with some confidence that the goals can be achieved.

TESLA Electropolishing of single cells

C. Antoine, B. Aune, D. Bloess, J.P. Charrier, E Chiaveri,
L. Ferreira, E Haebel, L. Lilje, J. P. Popov, H. Safa, B. Thony,

CEA-CERN-DESY

1 Electropolishing of Half Cells

Is working. 10 half-cells have been polished. However, copper dissolved from cooling circuits and from cathode and got deposited onto niobium. Copper deposit was effectively removed with nitric acid.

In two hours $100 \mu m$ **polished.** For an example of surface finish see the transparents of L. Lilje.

2 Electron Beam Welding

No rhombic raster. Welding from outside in two passages (warming and then welding)

However, **much improved vacuum:** better than $10^{-6} mb$.

Ten half cells have been successfully been welded.

3 Electropolishing of Single Cells

Installation will be **ready beginning April**

Instead of copper electrodes niobium electrodes will be used, and then e baked after electropolishing in order to outgass the hydrogen

The cooling circuits will be made from PFA with longer pipes to compensate for less efficiency.

4 Measurements

The first Measurements have been done at CEA without any surface or thermal treatment after welding. A thin niobium film deposited by evaporation during welding explains the moderate results. However, **no effect from hydrogen has been observed.**

Another installation for measurements is ready at CERN. This will permit more measurements to be done.

5 Oven Treatment

Single cells can be treated at Temperature up to 1500^0C

Quantitative degassing measurements can be done

6 Improvement of HP-rinsing

An adapter for the LEP cavity HPR installation is being built to permit high quality rinsing at pressures of 100 bar for 1.3 and 1.5 GHz cavities

Will be ready in April

7 Niobium-copper Cavities

Breakthrough

The slope has been very much reduced

Residual resistance 2–4 nOhm

Still many electrons (see 6)

1.5 GHz Nb/Cu R & D

(Benvenuti Calatroni Daniulat
Arbet-Engels Peck Valente) Feb'99

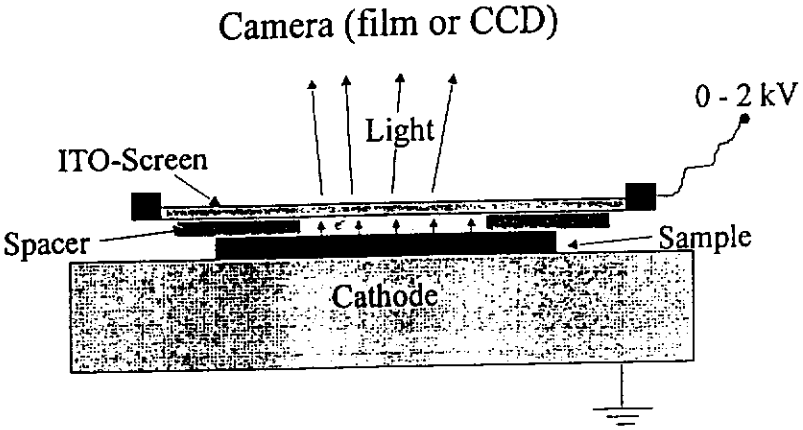
Current Status

- We are now routinely producing "slope-free" cavities having a residual resistance which does not increase with RF field by more than $1 n\Omega / MVm^{-1}$ (this would contribute a Q of 10^{10} at 30 MVm^{-1}).
- However the accelerating field is currently limited typically to 10 MVm^{-1} as a result of field emission, even if it did reach 20 MVm^{-1} in some occasions. Experimental evidence exists that this limitation can be postponed to 25 MVm^{-1} by improving cavity rinsing and handling

- Current effort is on
  - commissioning our modified double cathode sputtering system and chasing an unexplained "pollution" at the 30 to 50 nΩ level
  - constructing a new high pressure rinsing station which should be in operation before the end of March
- We have completed or nearly completed studies on:
  - trapped magnetic flux induced losses and pinning mechanism
  - hydrogen pollution and hydride precipitation in films
  - influence of the interface film - substrate on the film properties
  - factors contributing to the residual resistance.

IMLS

Planar diode configuration



- Pressure 10^{-7} mbar
- Spacer thickness 10 – 100 µm (Teflon foil)
- Maximal anode Voltage 2 kV => Ep ≤ 200 MV/m
- I-U measurement with PC

FE-measurements at University of Wuppertal

B. Günther, T. Habermann, G. Müller

Outline

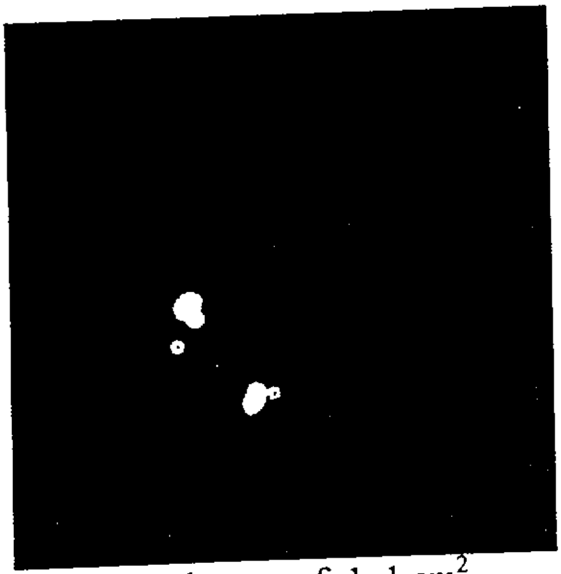
- DC field emission measurements with a new planar I-U measurement technique configuration with a luminescent ITO screen (IMLS)
    - Measurement configuration
    - First results on niobium samples
    - Comparison of FESM and IMLS
- Investigation of enhanced field emission due to etching defects
    - Etching of niobium cavities
    - FESM scans of differently etched niobium samples

Samples prepared at TTF by D. Reschke

Comparison of IMLS and FESM

IMLS	FESM (field emission scanning microscope)
Advantages - simple and cheap apparatus - fast sample investigations (2h): - onset of FE : E_{on}(I=0,5nA) - integral I-U measurements - imaging of strongest emitters - long term current- and gasprocessing possible	Advantages - very high spatial resolution (100nm) - in situ SEM for emitter analysis - single emitter investigations (E_{on}, Fowler-Nordheim : β,S) - reliable non-destructive Fe measurements - UHV 10^{-10} mbar - in situ AES, Ion gun
Disadvantages - limited spatial resolution (≈100 µm) - reidentification of emitters impossible - no single emitter investigations - danger of (multi-) discharges due to switch on effects	Disadvantages - slow Fe investigations (1 day/sample) - complex and expensive measurement system

First tests of IMLS on a niobium sample



sample area of 1x1 cm^2

U = 880 V; I = 50 µA; d = 50 µm

7 light spots visible at 17.6 MV/m

(mechanically bad prepared sample)

TTF Collaboration Meeting
DESY, Hamburg
1-3 March 1999

New configuration of accelerating structure for TESLA

V. Balakin

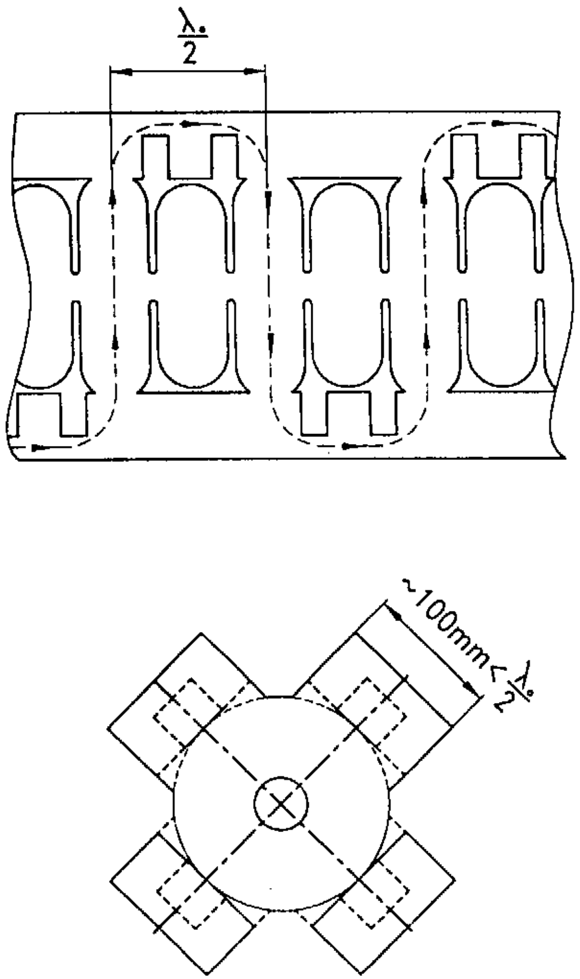
Branch of the Institute of Nuclear Physics
Protvino, Russia

TTF Collaboration meeting
DESY,Hamburg
1-3 March 1999

BINP activity in TESLA project

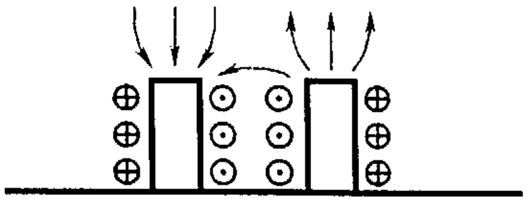
1. Measurements of the tapped higher order modes for two polarization in the superconducting cavities of the TTF linac.
2. Studying of microbunch-to-microbunch jitter, using BPM's with submicron resolution.
3. Measurements of vibrations of the superconducting quadrupoles in the cryogenic modules of the TTF linac.
4. Experimental study of the fast feedback system on TTF linac, using this equipment (fast kickers, BPM's, etc.)
5. Development of a new SC accelerating structure with a high gradient for TESLA project.

A new proposed accelerating structure consists of two standing wave coupling resonator systems



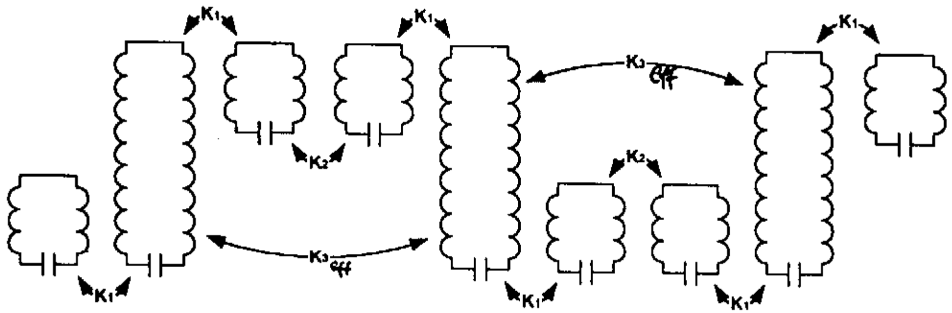
The accelerating resonators of each systems are coupled by two cut-off waveguides.

The resonant coupling on π-mode is formed by two stubs inside waveguide. π-mode frequency is equal to operating frequency f_0.



π-mode $f = f_0$

Equivalent circuit for one of two chains of resonantly coupled cavities.



Structure simulations carried out by P. Avrakhov (Branch of INP) show that for a practically realizable structure the coupling koefficients

$K_1 \approx$ ~~10 %~~ 6 %
$K_2 \approx 30$ %
$K_{3_{eff}} \approx 10$%

can be achieved.

Advantages of new configuration

1. High accelerating gradient

   $\text{Acc.gradient}_{\text{New config.}} \approx 2 * \text{Acc.gradient}_{\text{TESLA}}$

2. No problem with trapped modes

   a) transverse

   b) longitudinal

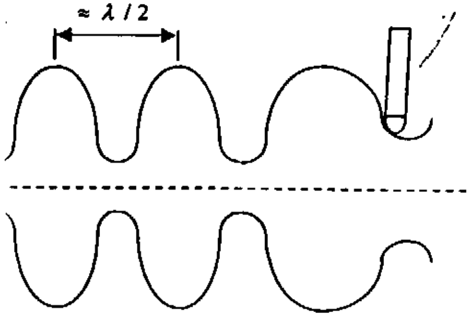
3. Easy tolerance (according to P. Avrakhovs simulations)

   $\downarrow$8m $\downarrow$4m
   0.5 ÷ 1 MHz - for accelerating resonators
   4 ÷ 8 MHz - for coupling resonators

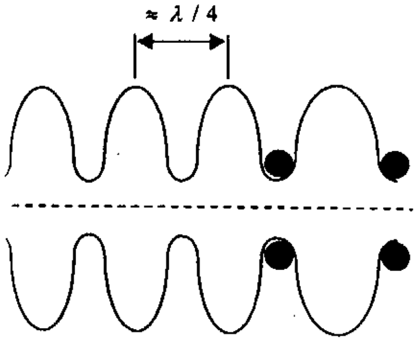
4. Few input couplers

   (1 per 8 meters)

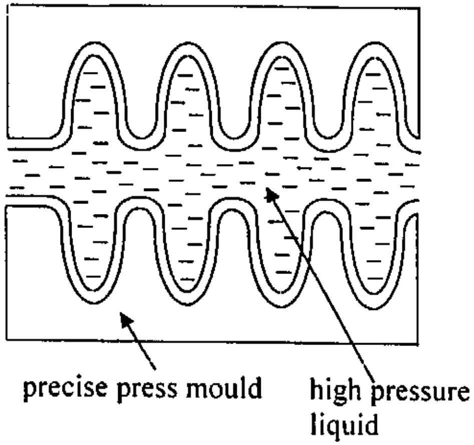
Cavity manufacture



Pressing
(not precise)

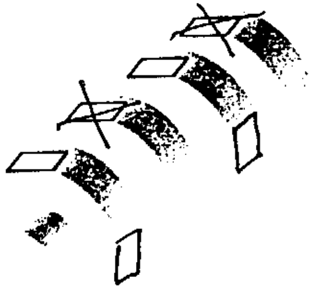


Squeezing
(not precise)



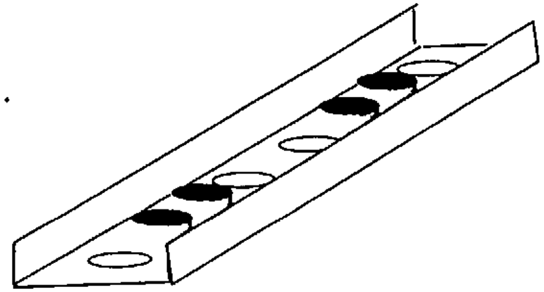
Hydroforming
(precise)

4.



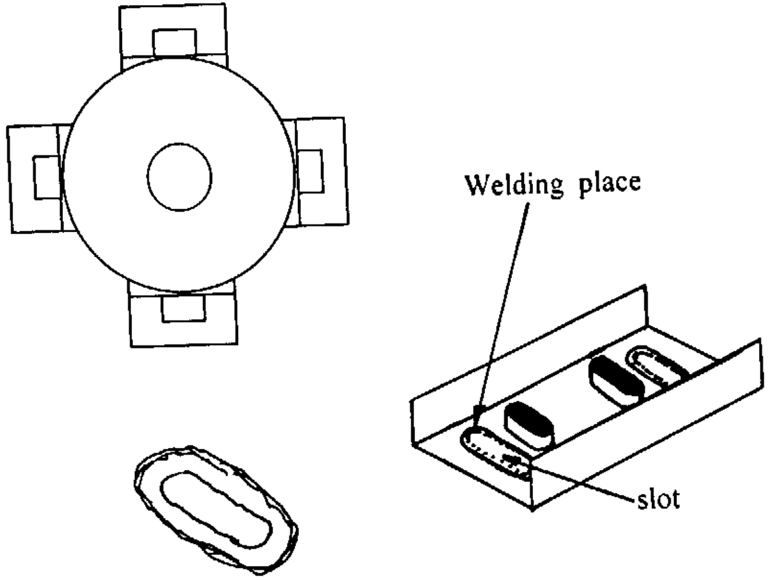
Machine-cutting
of coupling slots

5.



Stamping waveguide
with stabs and slots

6.



Welding

Problems

I. Short-range wake-fields because of small aperture ($\varnothing \cong 30$ mm)

Solutions

1. Bunch charge should be reduced two times because of two times higher accelerating gradient (Luminosity can be kept by changing of repetition rate)

2. Due to waveguides the structure is more rigid. It means alignment can be better.

3. Signal from waveguides can be used for the alignment.

II. Accidental breakdowns can damage a structure surface because of big storage energy and high group velocity.

Solutions

1. Experiment

2. Reduction of group velocity

III. Electron multipacting in complex cavity geometry.

Solutions

1. Experiment

2. Computer simulation

OVERVIEW OF THE "SMES" MODULATOR DEVELOPMENT (Feb 26, 1999)

	STATUS	SCHEDULE
POWER SUPPLIES FOR SMES AND CAPACITOR	**ORDERED**	**10/99** DELIVERY
POWER PULSE FORMER UNIT	**BEING ORDERED BY COMPONENTS**	**11/99** DELIVERY
PULSE TRANSFORMER	**DELIVERED**	**1/99** DELIVERY
SAFETY SYSTEM	**SPECIFICATIONS READY**	**11/99** DELIVERY
CONTROL SYSTEM	**UNDER WORK**	**11/99** DELIVERY
SC MAGNET SYSTEM	**MODEL COIL SUCCESSFULLY TESTED**	**9/99** DELIVERY
CRYOSTAT incl. CURRENT LEADS	**BEING ORDERED**	**10/99** DELIVERY
MODULATOR CONSTRUCTION		**12/99 – 2/00**
SYSTEM TEST AT FZK	**PREPARATIONS**	**3/00 - 4/00**
TRANSPORT & MOUNTING		**5/00**
SYSTEM TEST AT DESY		**6/00**

2.585 GHz - Mode in Three Cavities:

Experimental Results and Numerical Uncertainties

TESLA-Meeting

DESY, 1.-3.3.99

D. Hecht, U. van Rienen, K. Rothemund, H.-W. Glock

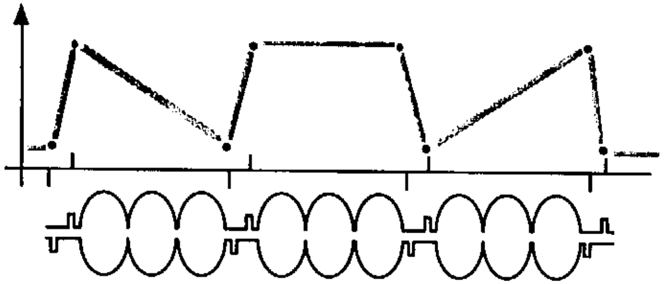
Institut für Allgemeine Elektrotechnik, Universität Rostock

2.585 GHz - Mode in Three Cavities (Mod 1 Cav 3, 6; Mod 2 Cav 5)

Summary of Experimental Results

(N. Baboi, S. Fartoukh, H.-W. Glock, G. Kreps, F. Marhauser,
O. Napoly, H. Schlarb, S. Simrock, G. v. Walter .... and many else)

- Spectral position of passbands is shifted upwards at least ≈10 MHz.
- Transmission measured with a network analyzer between different pairs of HOM couplers leads to certain pattern of field distribution/coupling:



- Beam induced HOM-coupler signal measured with spectrum analyzer **confirms this pattern** (Cav 6, Mod 1 not measured).
- Mode causes relevant beam deflection; measured with resonant excitation (Cav 6, Mod 1 not measured).

Conclusion:

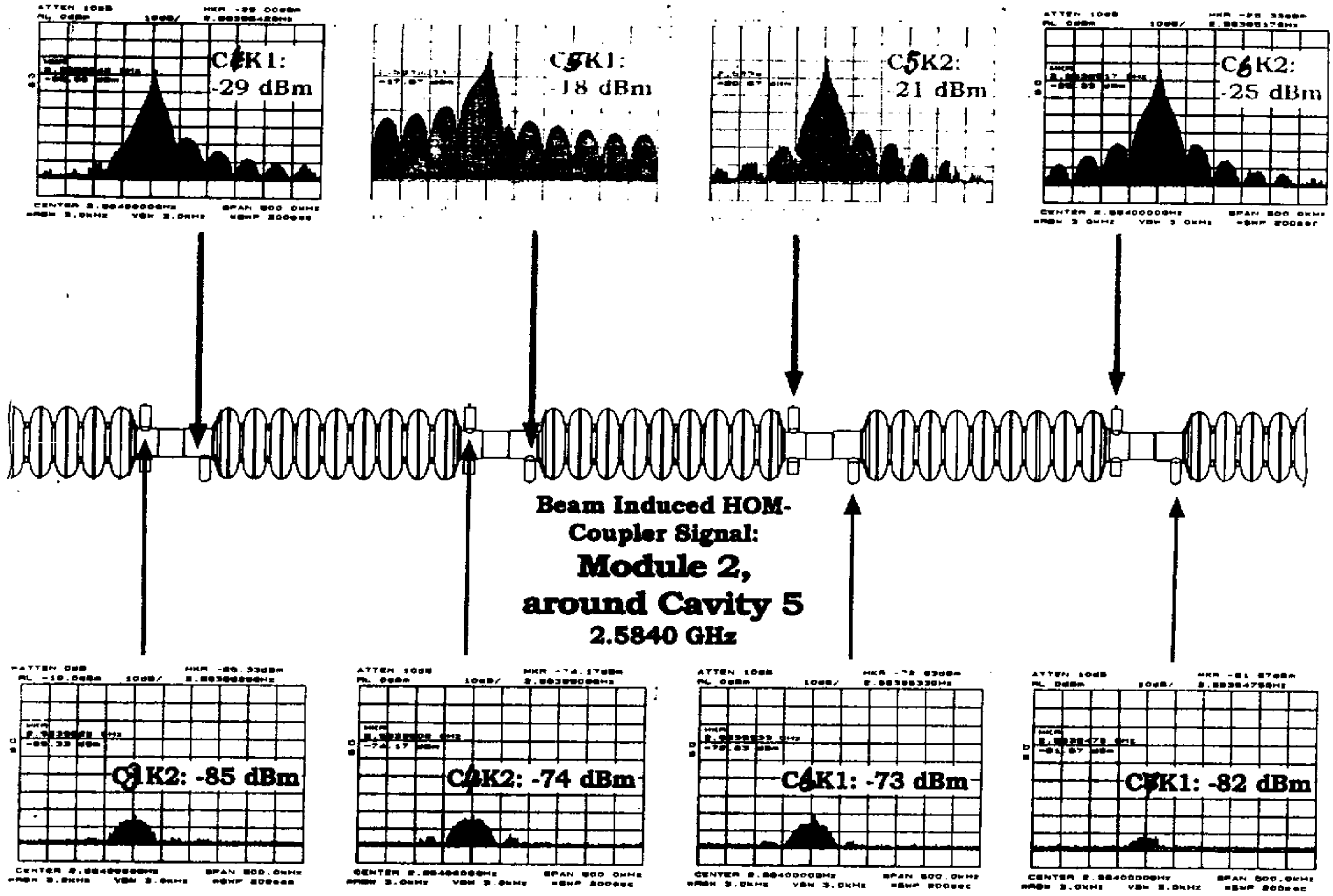
Beam relevant field pattern exists, coupling three cavities.

Astonishingly high amplitude spread (> 30 dB) in neighbouring HOM-couplers.

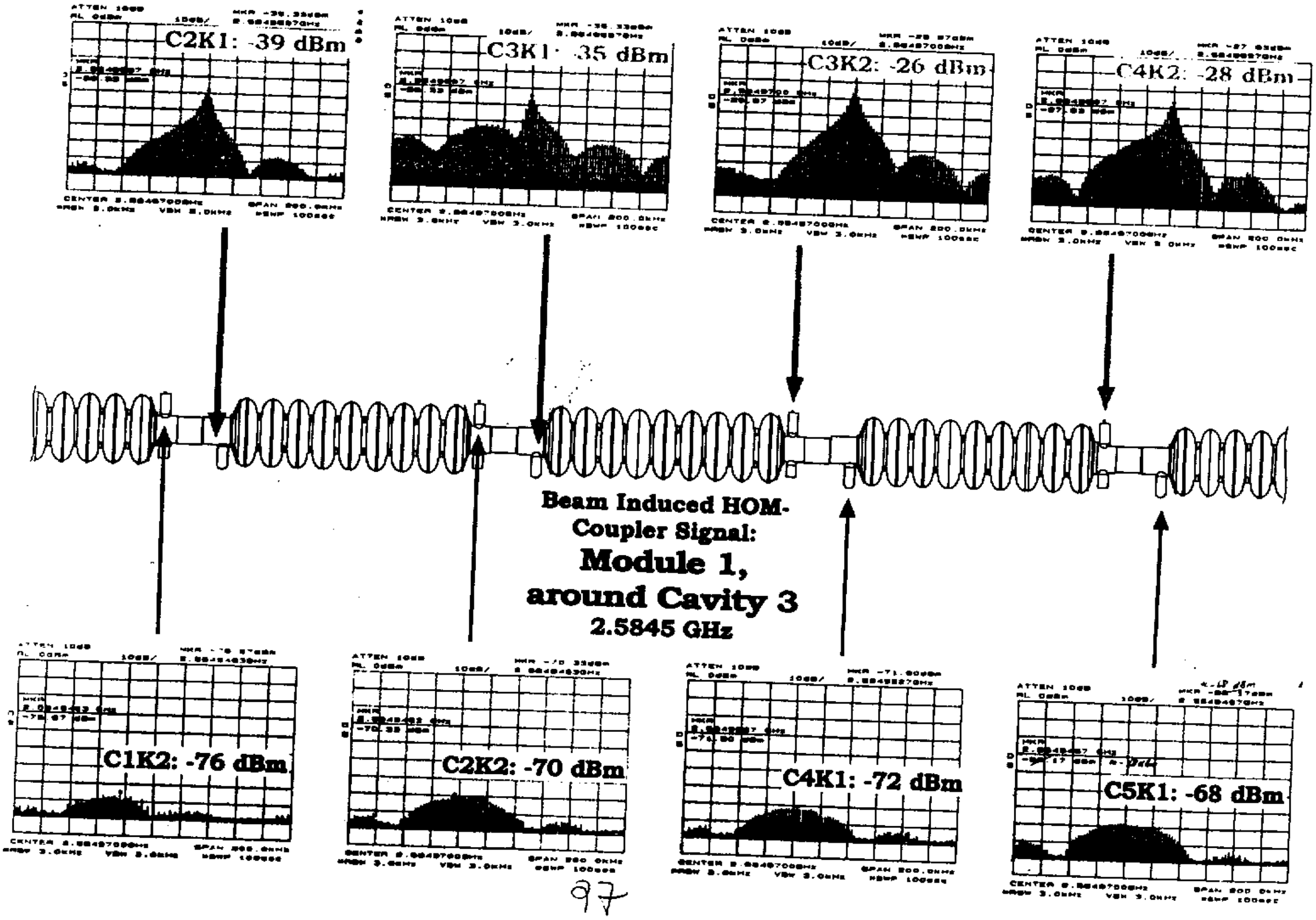
Aim:

Identify cause in order to avoid.

Try to simulate.



Beam Induced HOM-Coupler Signal:
Module 2,
around Cavity 5
2.5840 GHz



Beam Induced HOM-Coupler Signal:
Module 1,
around Cavity 3
2.5845 GHz

2.585 GHz - Mode in Three Cavities (Mod 1 Cav 3, 6; Mod 2 Cav 5)

Attempts of Explanation

- Type of cavity or coupler?	- Not likely: M1C3 and M1C6: Saclay-type cavities and HOM-couplers, but not the only ones in M1. But: M2C5 is the only A-type cavity in module 2.
- Spezial beam-pipe length?	- Yes: Allows for beam-pipe-centered mode, which is beam relevant. But: Variation of length in a reasonable range does neither change the character of the mode ensemble nor the order of beam relevance - so why not elsewhere? And: How to explain very weak coupling of one of the HOM-couplers at each pipe?
- Polarization effect?	- Maybe: On each side of a "dangerous" cavity only couplers of one polarization talk to each other. But: Polarization changes across "dangerous" cavity, i.e. rotation of about at least 60° - why?
- Beam pipe bellows?	- No. (Very slight change in S-parameters due to bellow.)
- Not a dipole field?	- No. (Neither monopole nor quadrupole modes near this frequency.)
- Strange field pattern, caused by different passband frequencies?	- If yes, not found yet: The only field geometry somewhat similar depends very sensitively on tuning. Furthermore there is no explanation of weak coupling of one HOM-coupler.

All models neglecting the influence of the couplers on the field geometry may be insuficient.

Attempt of S-parameter description of combined 2D/3D-structure:

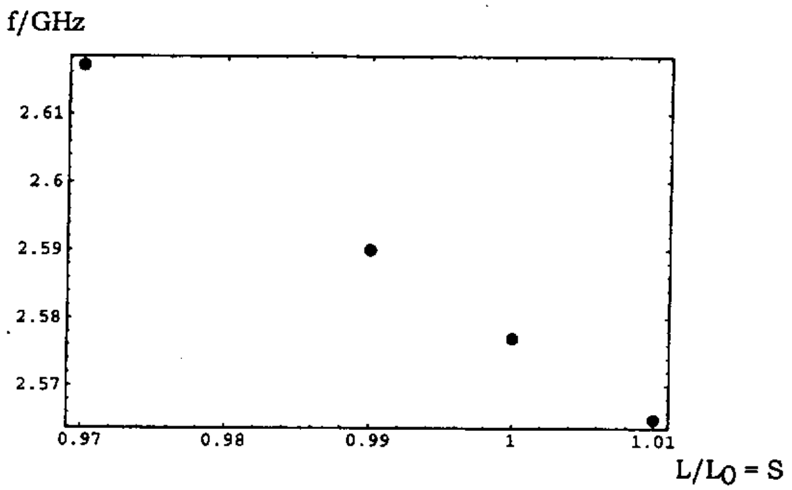
Module 1

No.	Cav.	HOM-Coupler	Inp.-Coup.
1	03	DESY	FNAL
2	S8	Saclay	DESY
3	S10	Saclay	DESY
4	01	DESY	FNAL
5	02	DESY	FNAL
6	S11	Saclay	DESY
7	04	DESY	FNAL
8	S7	Saclay	FNAL

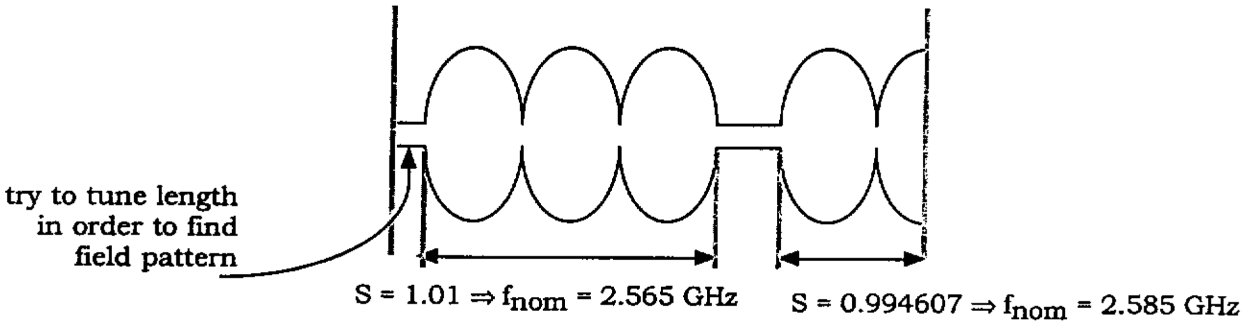
Module 2

1	C22	Saclay	FNAL
2	C21	Saclay	"
3	C25	Saclay	"
4	C23	Saclay	"
5	A15	DESY	"
6	C26	Saclay	"
7	C27	Saclay	"
8	C24	Saclay	"

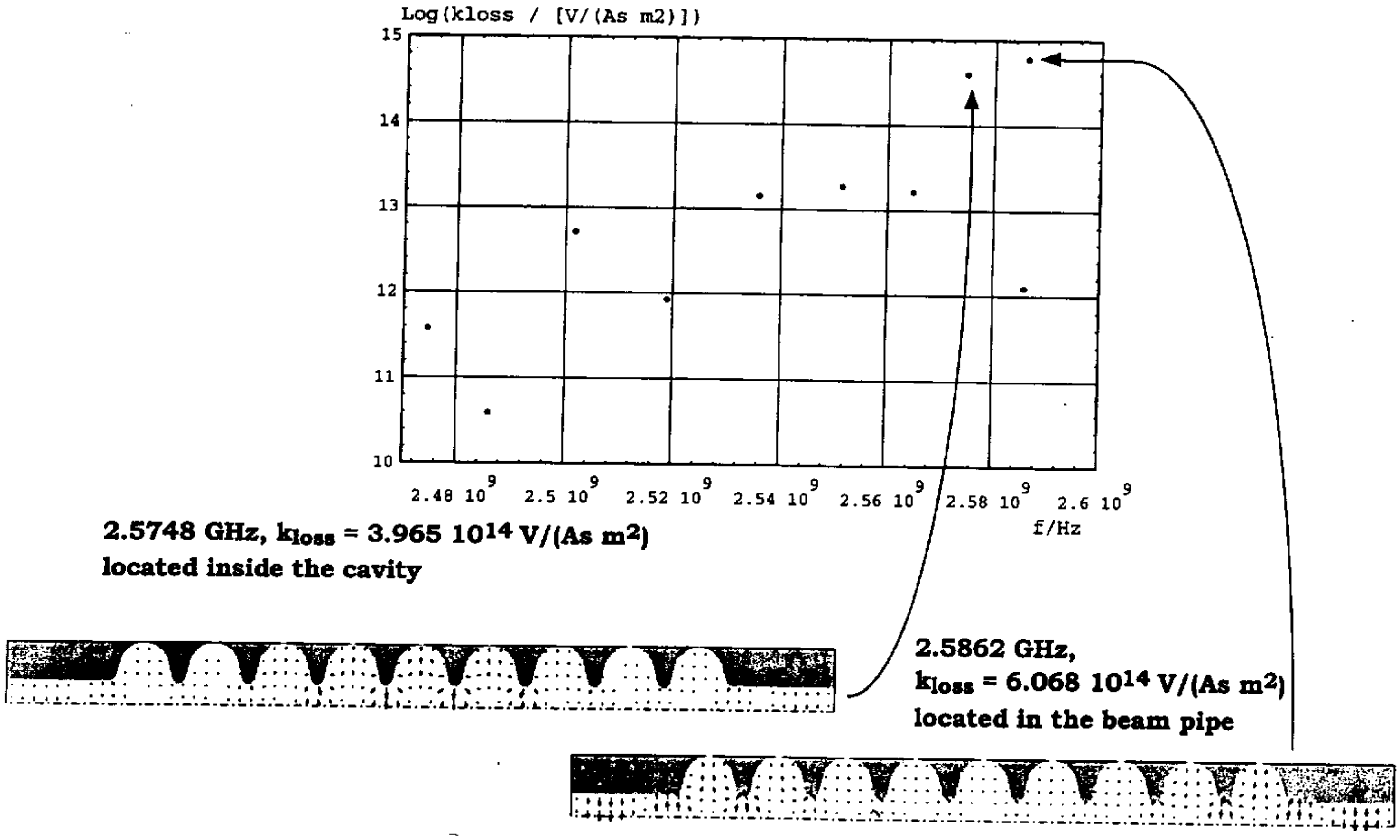
Frequency shift of cavity-localized mode in symmetrical cavity vs. common length scaling factor



Setup for calculations:

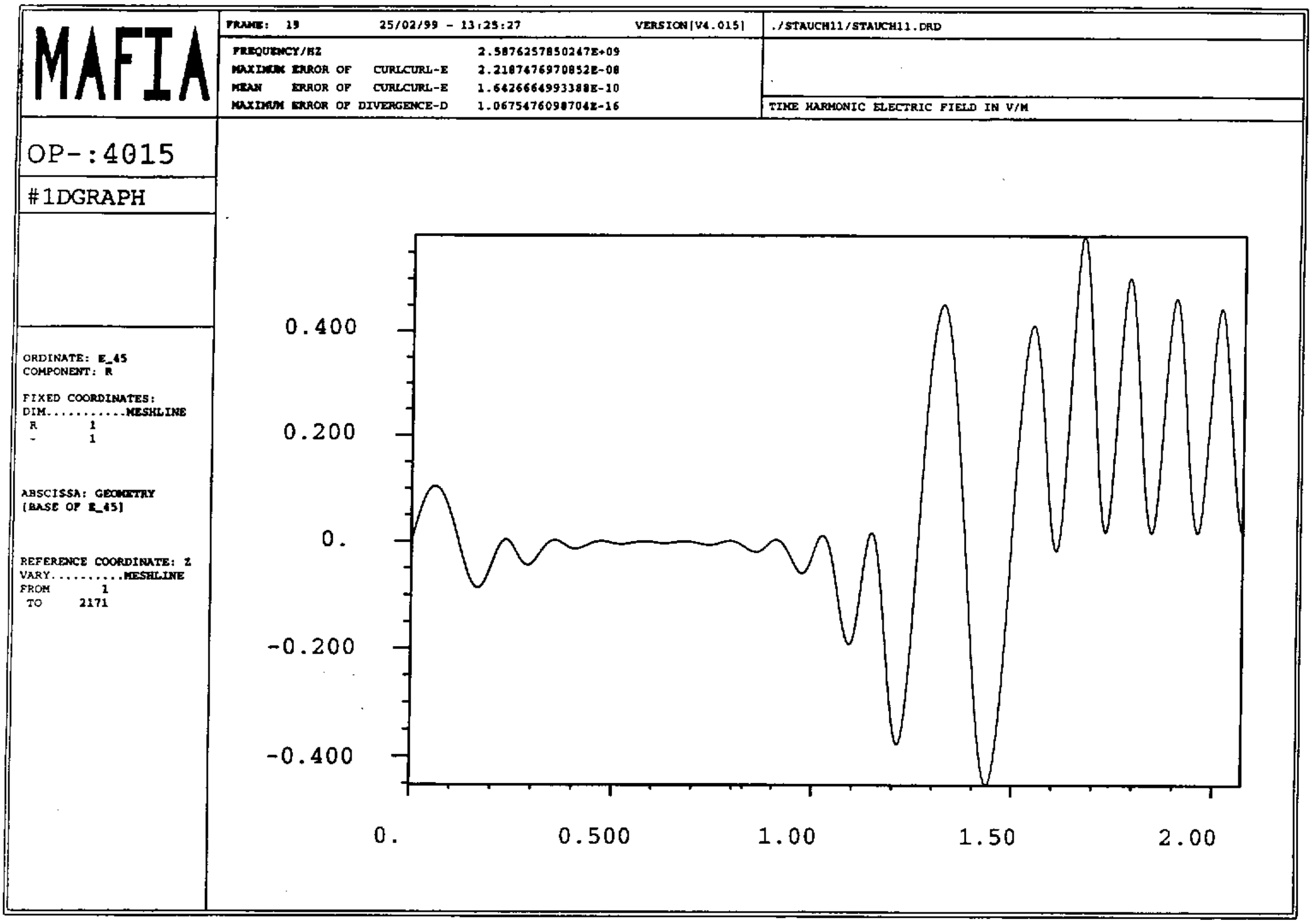


MAFIA-Calculations of 9-cell cavity with 3/2-cell-length beam pipes

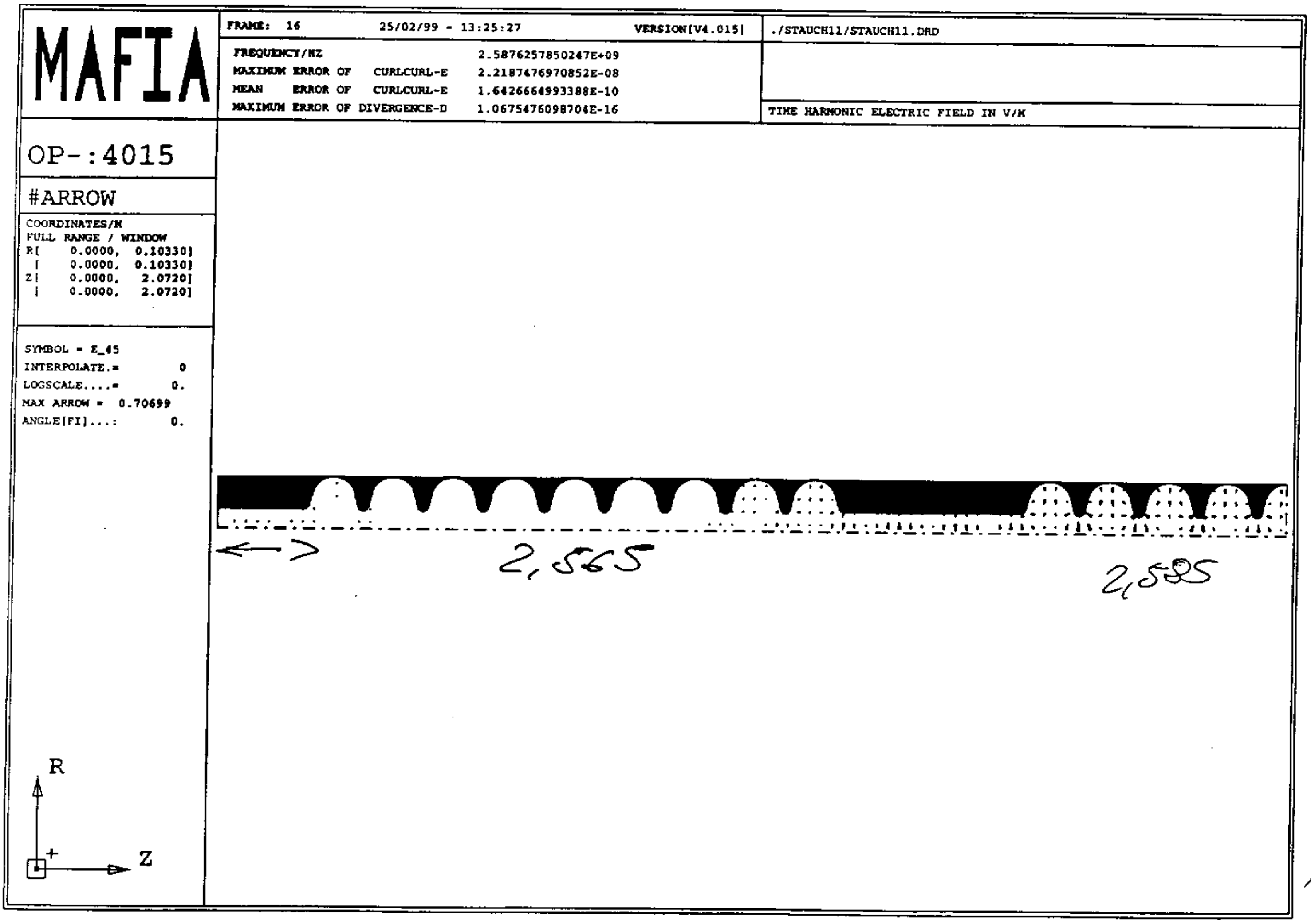


2.5748 GHz, k_{loss} = 3.965 10^{14} V/(As m^2)
located inside the cavity

2.5862 GHz,
k_{loss} = 6.068 10^{14} V/(As m^2)
located in the beam pipe



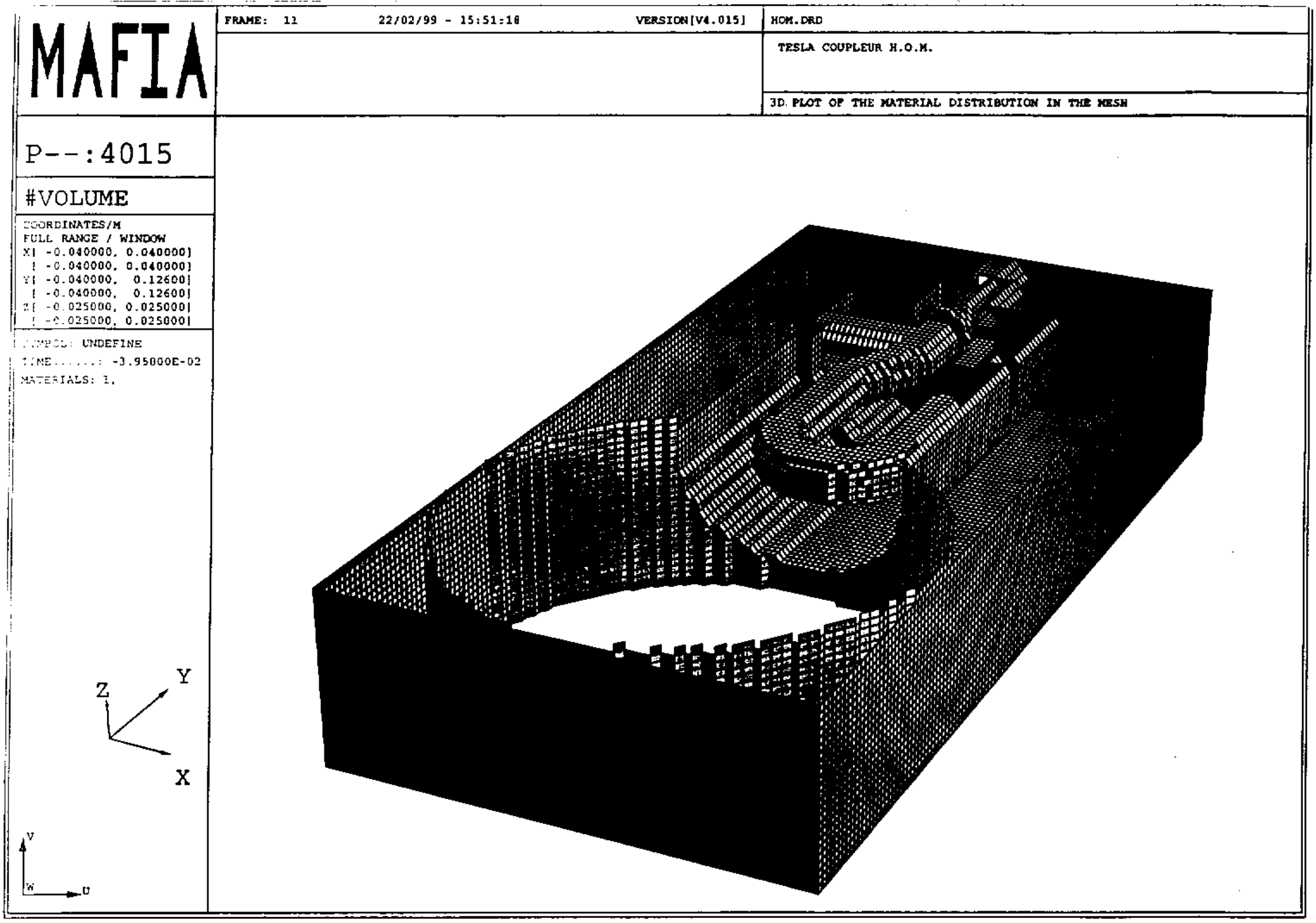
```
MAFIA                  FRAME:  19          25/02/99 - 13:25:27           VERSION[V4.015]   ./STAUCH11/STAUCH11.DRD
                       FREQUENCY/HZ                       2.5876257850247E+09
                       MAXIMUM ERROR OF   CURLCURL-E      2.2187476970852E-08
                       MEAN    ERROR OF   CURLCURL-E      1.6426664993388E-10
                       MAXIMUM ERROR OF DIVERGENCE-D      1.0675476098704E-16      TIME HARMONIC ELECTRIC FIELD IN V/M
OP-:4015
#1DGRAPH

ORDINATE: E_45
COMPONENT: R

FIXED COORDINATES:
DIM...........MESHLINE
 R         1
 -         1

ABSCISSA: GEOMETRY
(BASE OF E_45)

REFERENCE COORDINATE: Z
VARY..........MESHLINE
FROM         1
 TO       2171
```



```
MAFIA                  FRAME:  16          25/02/99 - 13:25:27           VERSION[V4.015]   ./STAUCH11/STAUCH11.DRD
                       FREQUENCY/HZ                       2.5876257850247E+09
                       MAXIMUM ERROR OF   CURLCURL-E      2.2187476970852E-08
                       MEAN    ERROR OF   CURLCURL-E      1.6426664993388E-10
                       MAXIMUM ERROR OF DIVERGENCE-D      1.0675476098704E-16      TIME HARMONIC ELECTRIC FIELD IN V/M
OP-:4015
#ARROW
COORDINATES/M
FULL RANGE / WINDOW
R[     0.0000,  0.10330]
 [     0.0000,  0.10330]
Z[     0.0000,   2.0720]
 [     0.0000,   2.0720]

SYMBOL = E_45
INTERPOLATE.=        0
LOGSCALE....=       0.
MAX ARROW =  0.70699
ANGLE(FI)...:       0.
```

2,565

2,585



MAFIA

FRAME: 11 22/02/99 - 15:51:18 VERSION[V4.015]

HOM.DRD

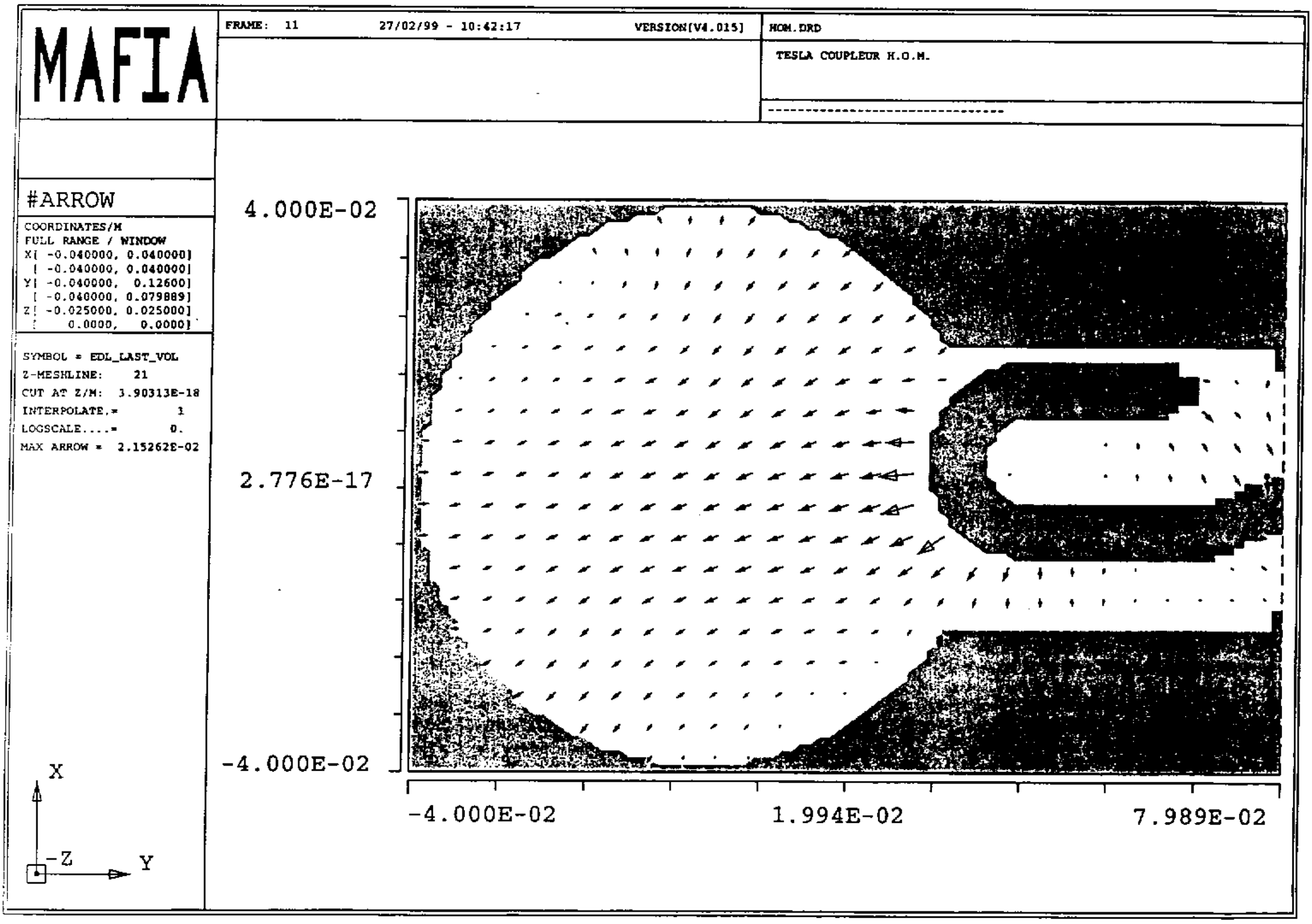
TESLA COUPLEUR H.O.M.

3D PLOT OF THE MATERIAL DISTRIBUTION IN THE MESH

P--:4015

#VOLUME

```
COORDINATES/M
FULL RANGE / WINDOW
X[ -0.040000, 0.040000]
 [ -0.040000, 0.040000]
Y[ -0.040000,  0.12600]
 [ -0.040000,  0.12600]
Z[ -0.025000, 0.025000]
 [ -0.025000, 0.025000]
SYMBOL: UNDEFINE
TIME.......: -3.95000E-02
MATERIALS: 1,
```



MAFIA

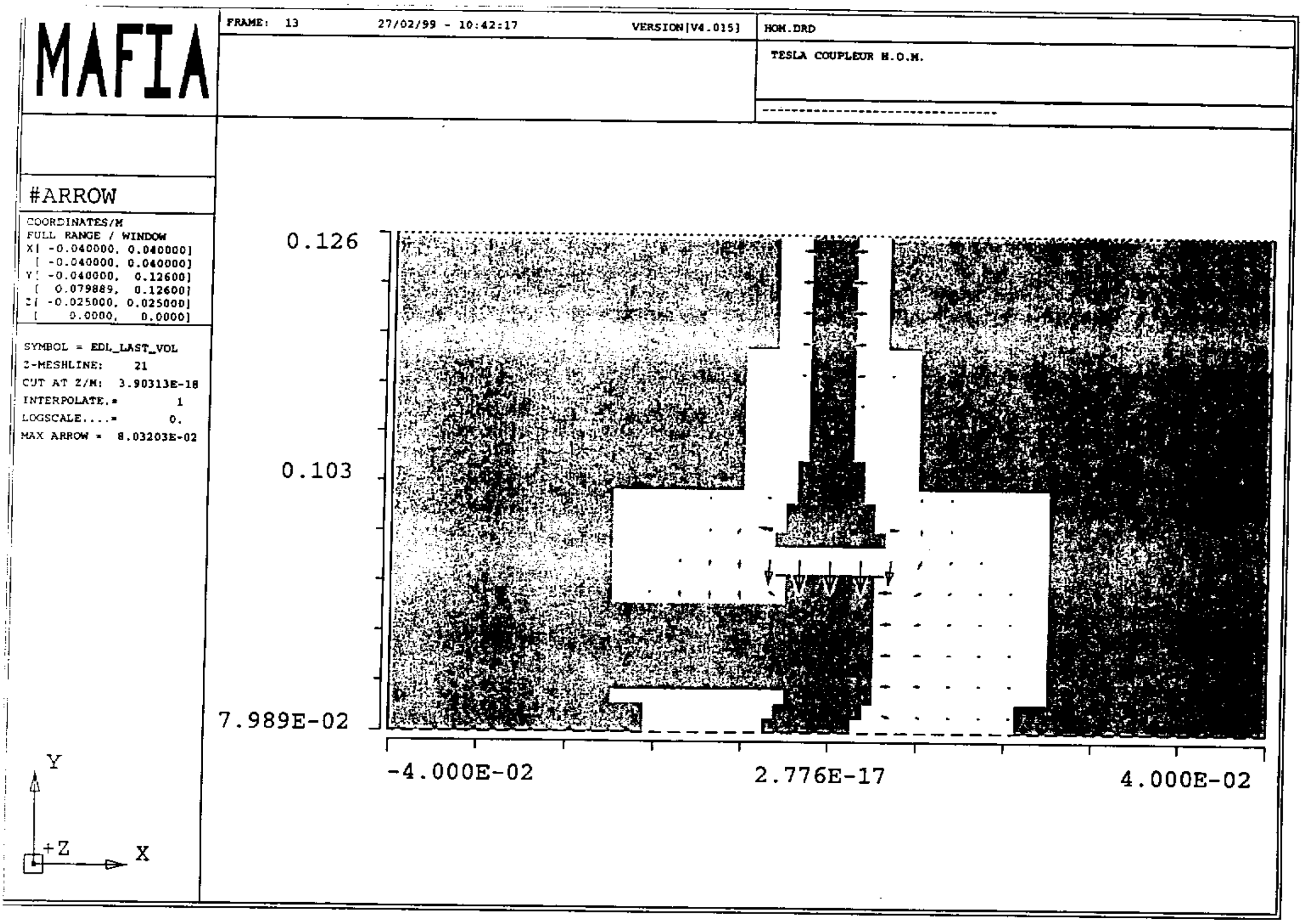
FRAME: 11 27/02/99 - 10:42:17 VERSION[V4.015]

HOM.DRD

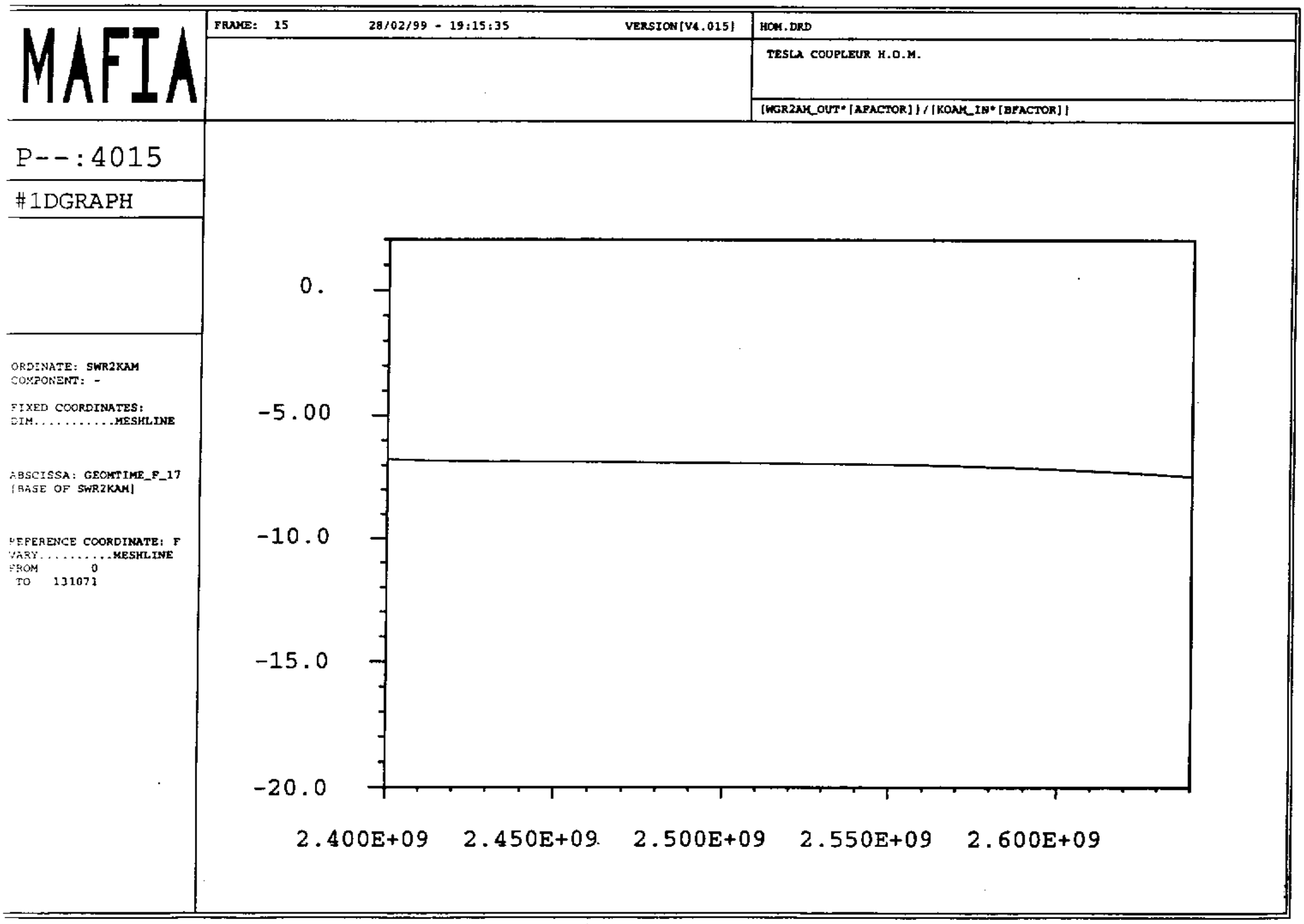
TESLA COUPLEUR H.O.M.

#ARROW

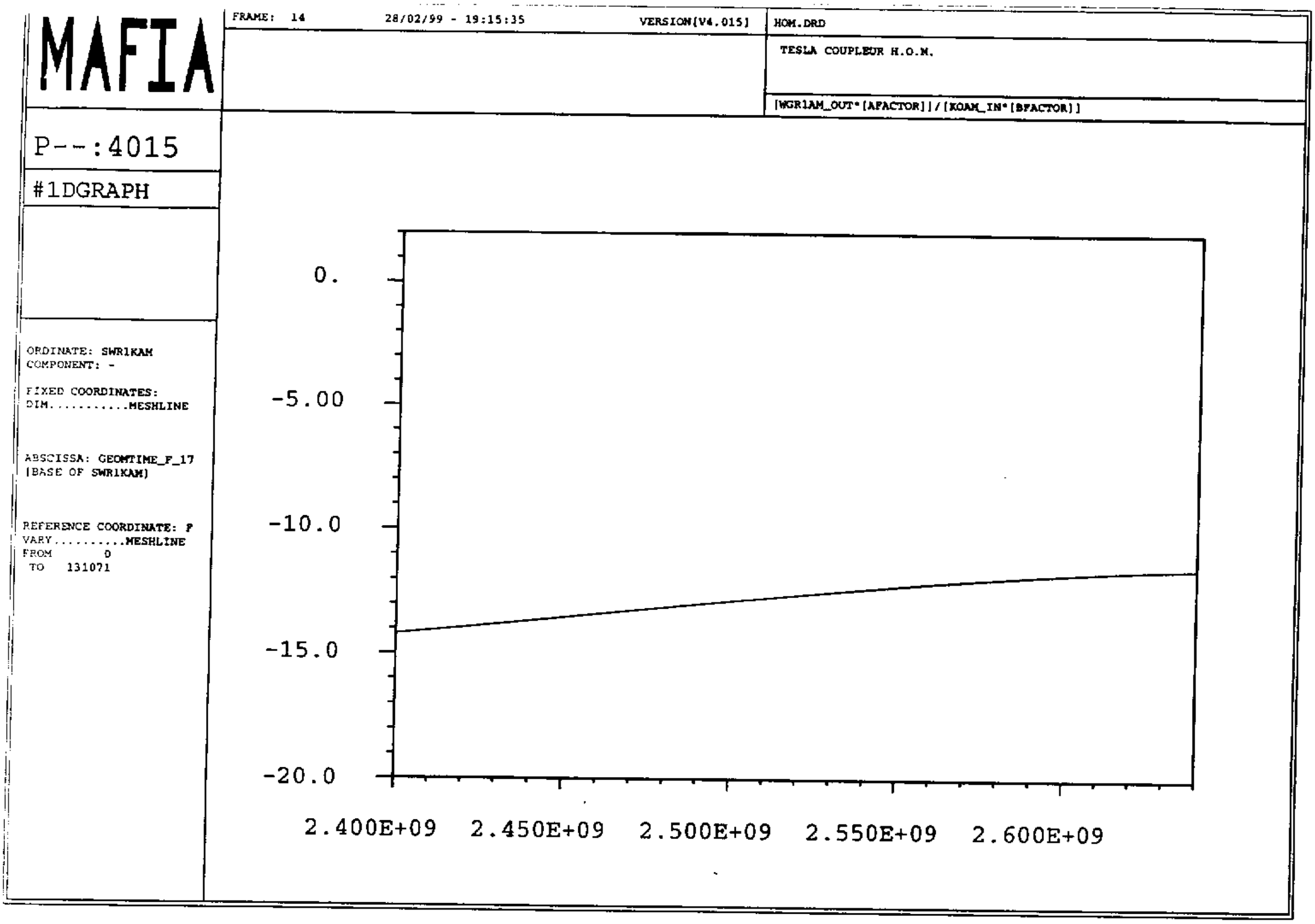
```
COORDINATES/M
FULL RANGE / WINDOW
X[ -0.040000, 0.040000]
 [ -0.040000, 0.040000]
Y[ -0.040000,  0.12600]
 [ -0.040000, 0.079889]
Z[ -0.025000, 0.025000]
 [    0.0000,   0.0000]

SYMBOL = EDL_LAST_VOL
Z-MESHLINE:    21
CUT AT Z/M:  3.90313E-18
INTERPOLATE.=        1
LOGSCALE....=        0.
MAX ARROW =  2.15262E-02
```



```
MAFIA
FRAME:  13          27/02/99 - 10:42:17          VERSION[V4.015]
HOM.DRD
TESLA COUPLEUR H.O.M.
--------------------------------

#ARROW
COORDINATES/M
FULL RANGE / WINDOW
X[ -0.040000, 0.040000]
 [ -0.040000, 0.040000]
Y[ -0.040000,  0.12600]
 [  0.079889,  0.12600]
Z[ -0.025000, 0.025000]
 [    0.0000,   0.0000]
SYMBOL = EDL_LAST_VOL
Z-MESHLINE:      21
CUT AT Z/M:   3.90313E-18
INTERPOLATE.=           1
LOGSCALE....=          0.
MAX ARROW =   8.03203E-02
```



```
MAFIA
FRAME:  15          28/02/99 - 19:15:35          VERSION[V4.015]
HOM.DRD
TESLA COUPLEUR H.O.M.
(WGR2AM_OUT*[AFACTOR])/(KOAM_IN*[BFACTOR])

P--:4015
#1DGRAPH

ORDINATE: SWR2KAM
COMPONENT: -

FIXED COORDINATES:
DIM...........MESHLINE

ABSCISSA: GEOMTIME_F_17
(BASE OF SWR2KAM)

REFERENCE COORDINATE: F
VARY..........MESHLINE
FROM        0
 TO    131071
```


MAFIA

FRAME: 14 28/02/99 - 19:15:35 VERSION(V4.015)

HOM.DRD

TESLA COUPLEUR H.O.M.

[WGR1AM_OUT*[AFACTOR]]/[KOAM_IN*[BFACTOR]]

P--:4015

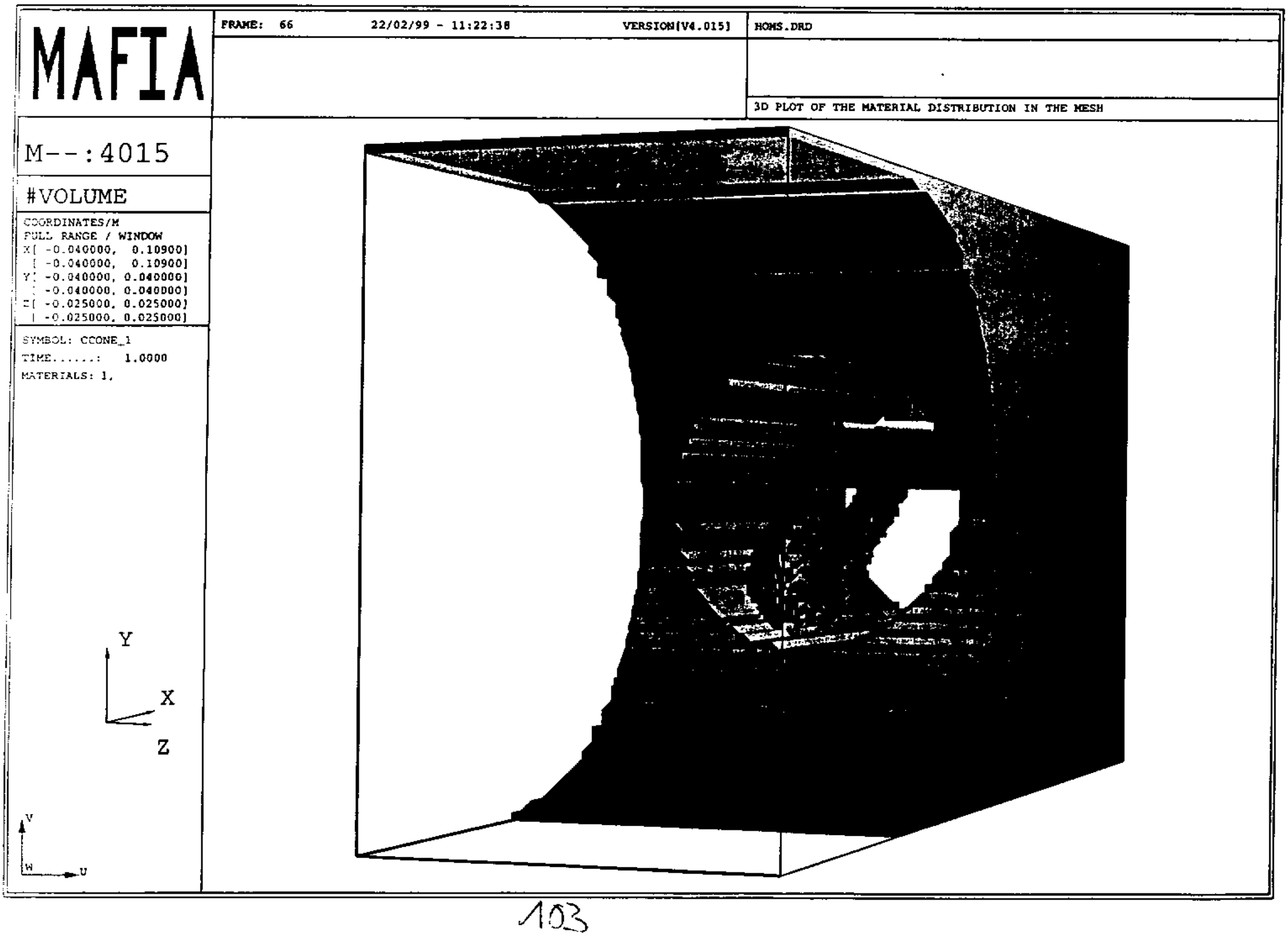
#1DGRAPH

ORDINATE: SWR1KAM
COMPONENT: -

FIXED COORDINATES:
DIM...........MESHLINE

ABSCISSA: GEOMTIME_F_17
(BASE OF SWR1KAM)

REFERENCE COORDINATE: F
VARY..........MESHLINE
FROM 0
TO 131071


MAFIA

FRAME: 66 22/02/99 - 11:22:38 VERSION(V4.015)

HOMS.DRD

3D PLOT OF THE MATERIAL DISTRIBUTION IN THE MESH

M--:4015

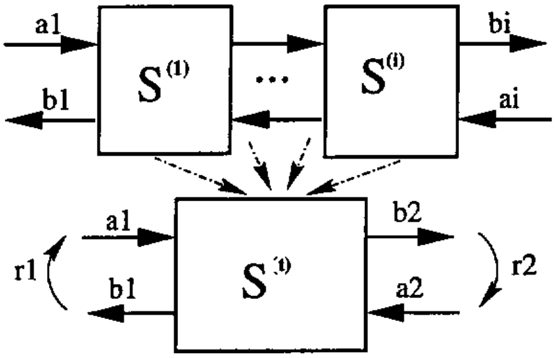
#VOLUME

COORDINATES/M
FULL RANGE / WINDOW
X[-0.040000, 0.10900]
[-0.040000, 0.10900]
Y[-0.040000, 0.040000]
[-0.040000, 0.040000]
Z[-0.025000, 0.025000]
[-0.025000, 0.025000]

SYMBOL: CCONE_1
TIME......: 1.0000
MATERIALS: 1,

Eigenmode Calculation of RF-Structures using S-Parameters

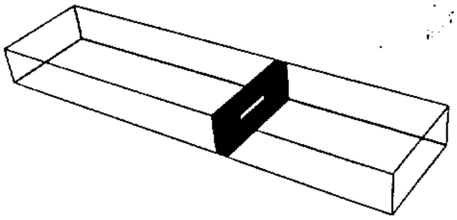
- structure too complex to calculate eigenmodes directly
- subdivide structure and calculate S-parameters of each part
- define boundary conditions

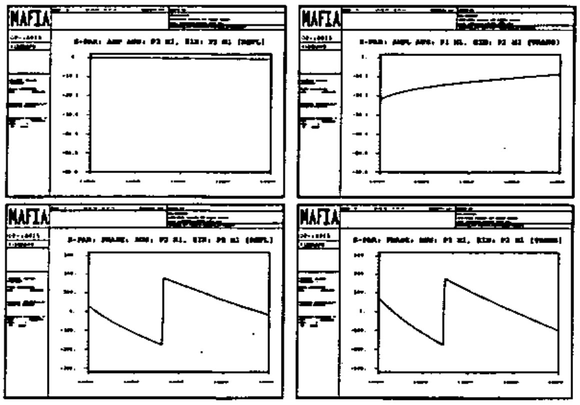


- get S-parameter matrix of the whole structure
- calculate eigenmodes and -frequencies ...

A First Test

- two equal sections linked together: wave guide with iris
- calculate s-parameters





- $S_{11}, S_{12}, S_{22} \Rightarrow |S_{11}^{(t)}|, \varphi_{11}^{(t)}, \varphi_{12}^{(t)}$

The Eigenvalue Problem

- boundary condition: $a_1 = r_1(\omega) b_1$, $a_2 = r_2(\omega) b_2$
- $\Rightarrow$ find non-trivial solution of

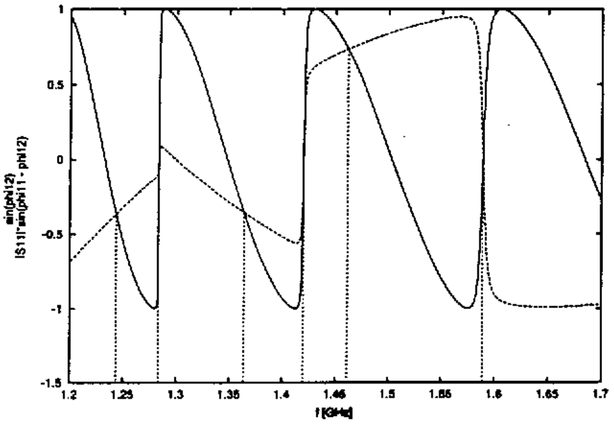
$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} S_{11}^{(t)}(\omega) & S_{12}^{(t)}(\omega) \\ S_{21}^{(t)}(\omega) & S_{22}^{(t)}(\omega) \end{pmatrix} \begin{pmatrix} r_1(\omega) & 0 \\ 0 & r_2(\omega) \end{pmatrix} \begin{pmatrix} b_1 \\ b_2 \end{pmatrix}$$

- with (for instance) electric short: $r_1 = r_2 = -1$
- and assumptions: the structure is
  1. reciprocal: $S_{mn} = S_{nm}$
  2. loss-free: $\mathbf{S}^* \mathbf{S} = \mathbf{E}$
- $\Rightarrow$ resonance frequencies ω_0 are solutions of

$$\sin(\varphi_{12}^{(t)}(\omega_0)) - |S_{11}^{(t)}(\omega_0)| * \sin(\varphi_{11}^{(t)}(\omega_0) - \varphi_{12}^{(t)}(\omega_0)) = 0$$

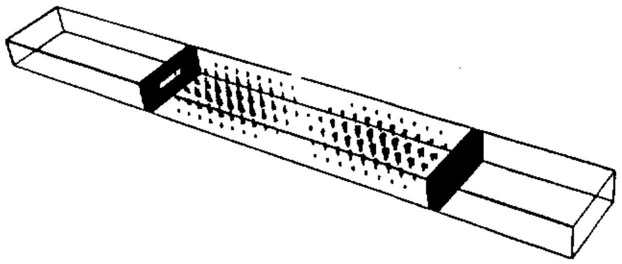
- solve

$$\sin(\varphi_{12}^{(t)}(\omega_0)) = |S_{11}^{(t)}(\omega_0)| \sin(\varphi_{11}^{(t)}(\omega_0) - \varphi_{12}^{(t)}(\omega_0))$$



eigen frequencies:

S-parameters	MAFIA E-mod.	Δ%
1.243639 GHz	1.243016 GHz	0.50
1.283487 GHz	1.283967 GHz	−0.04
1.363857 GHz	1.363793 GHz	0.005
1.419875 GHz	1.420691 GHz	−0.06
1.461280 GHz	1.459711 GHz	0.11
1.588825 GHz	1.589970 GHz	−0.07



Prospects

- advantage
  - eigenmode calculation of complex structures possible
  - exploit symmetry of each subsection
  - "re-use" calculation of repeated subsections
- future plans: use this procedure on "real" structures like
  - TESLA-modules with cavities, beam pipes, coupler
  - bunch compressor section

Argonne Nat'l Laboratory
Advanced Photon Source

Lab Report

M. White

Advanced Photon Source

TTF Undulator Vacuum Chamber Cleaning:

Flush rinse with 2% Ridoline-18* detergent in DI water

Immerse in ultrasonic bath for 10 minutes at 65° C
with 2% Ridoline-18 detergent in DI water.

Water is purified by a de-ionizing bed and an activated
carbon bed, then particle-filtered to 20µm.

Flush rinse with DI water.
The rinse water is filtered to 0.5µm by a particle filter

Rinse with ethyl alcohol.

Blow-dry with dry nitrogen that has been
filtered to 0.5µm by a particle filter

*Many tests were done in the early days of APS construction to find the best detergent for cleaning aluminum. Ridoline-18 is an alkaline detergent; it etches the native oxide and rebuilds the thinnest oxide layer of any detergent we tested. It is also environmentally friendly enough to pour down the drain.

Electropolishing -

The chambers with BPMs were electropolished
to eliminate burrs in the BPM holes.

Proprietary process - no details were given out.

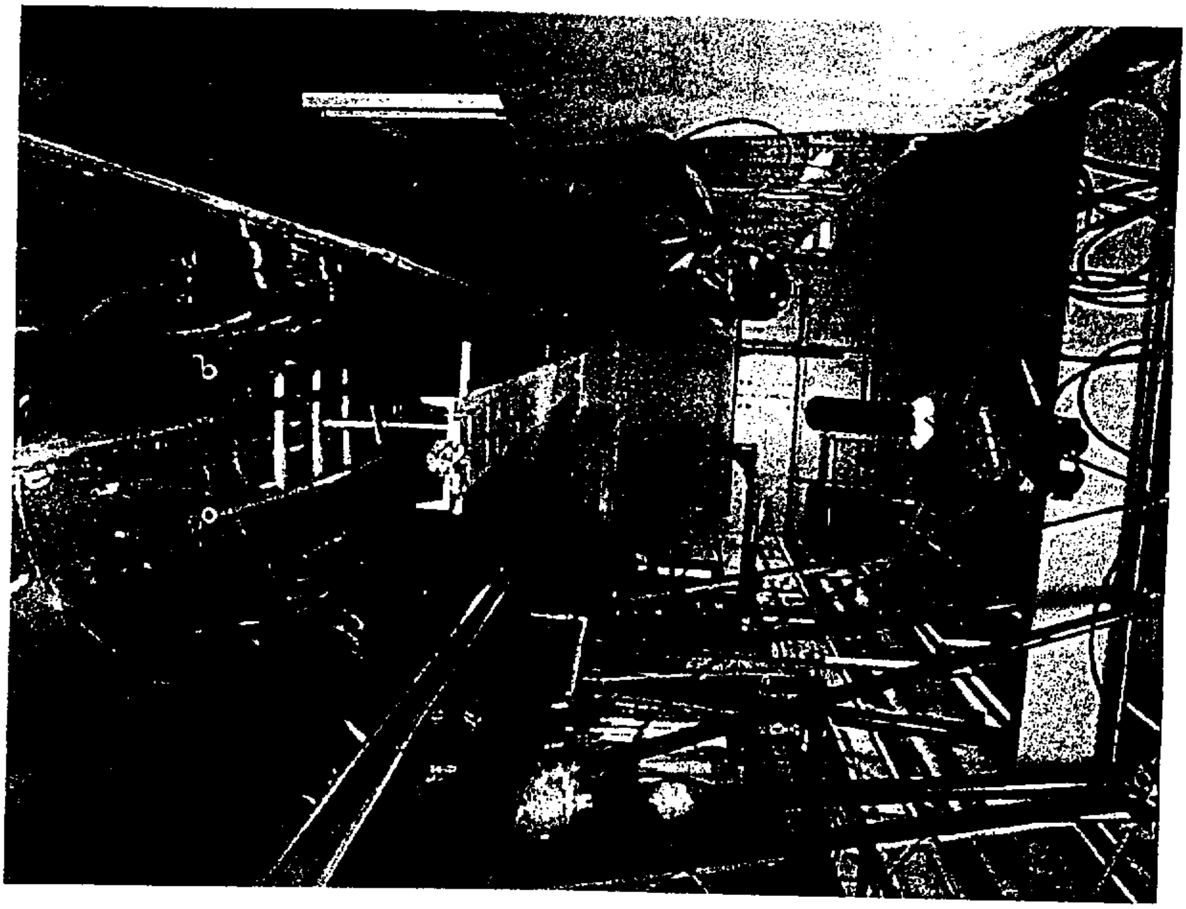
Success at removing burrs from BPM holes
was verified with a boroscope.

A sample of the electropolished profile remains at ANL.

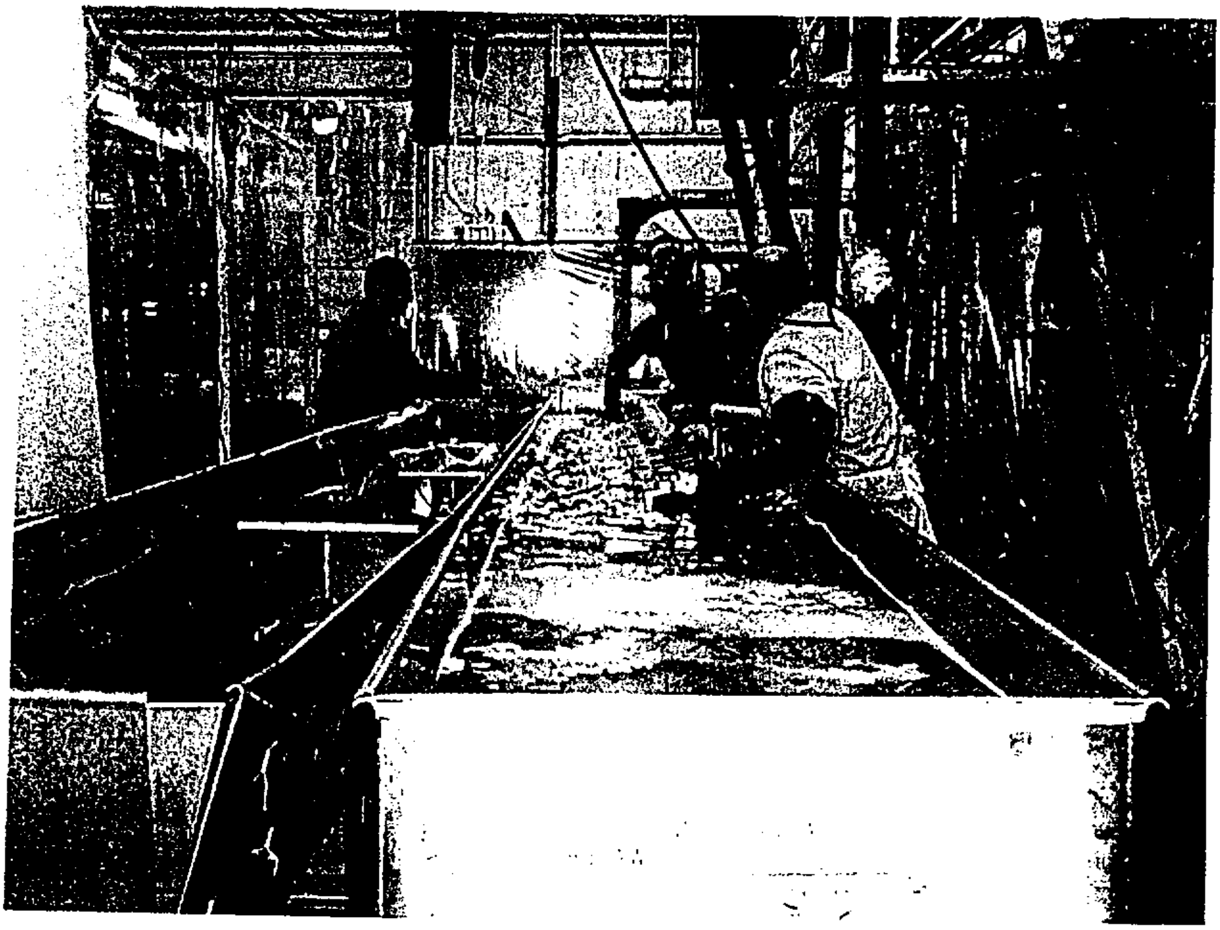
It will be cut and the surface will be measured
to determine whether the electropolishing process
also decreased the surface roughness.

Chambers measured 24 Feb for packing crate.
Should arrive at DESY in a couple of weeks.

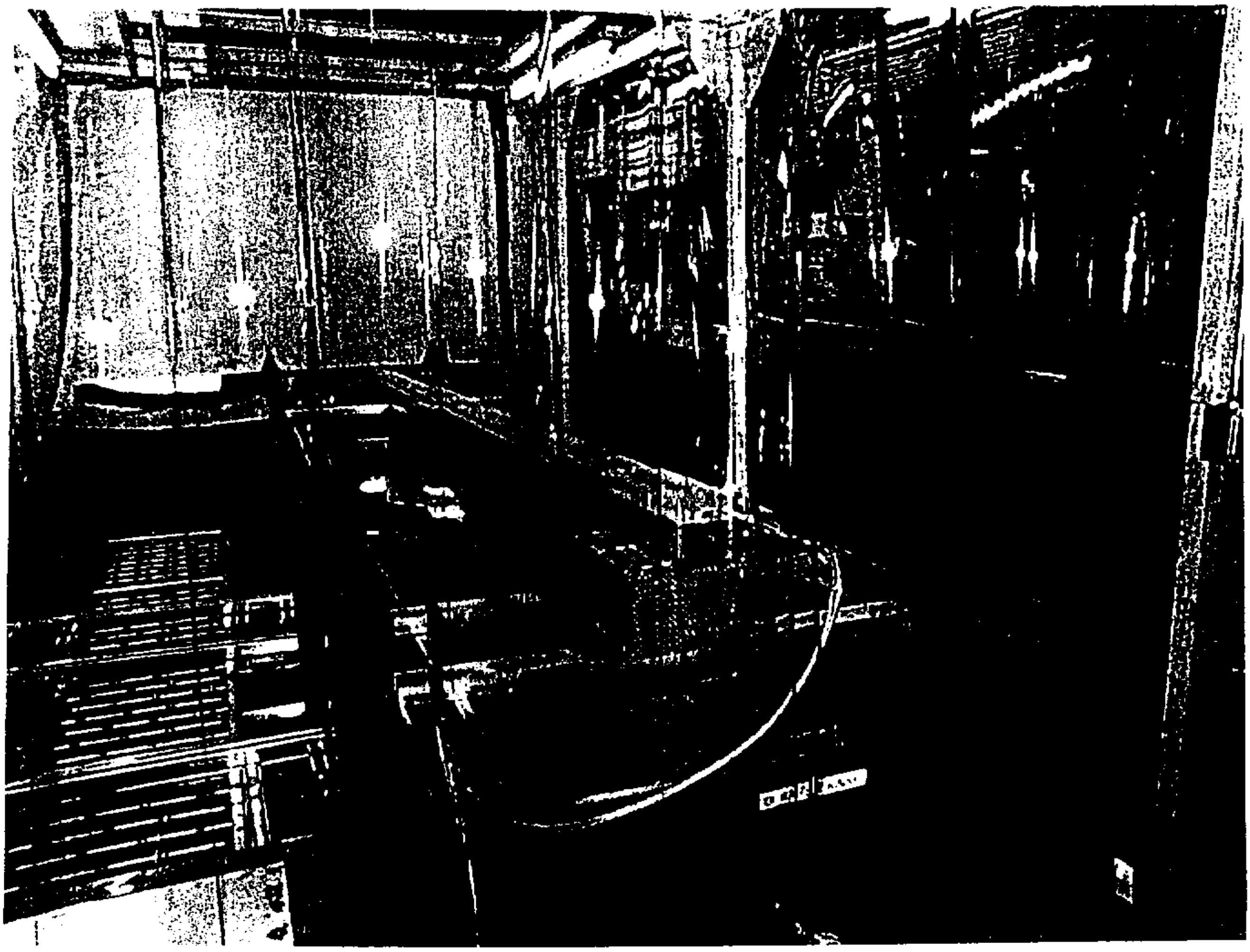
4 Feb 99 Prep for BPM installation



~4.5 meters @ 3mm



107-4



117-5

Cavity Fabrication - Learning Process

Made two single-cell copper cavities.

Beta version of the new bead-pull system exists
is being used for cavity measurements
[next version will be better].

Making aluminum end and center salad bowls that can be
mechanically combined as desired to form a cavity.

Making two Type-1 Nb single-cell cavities.

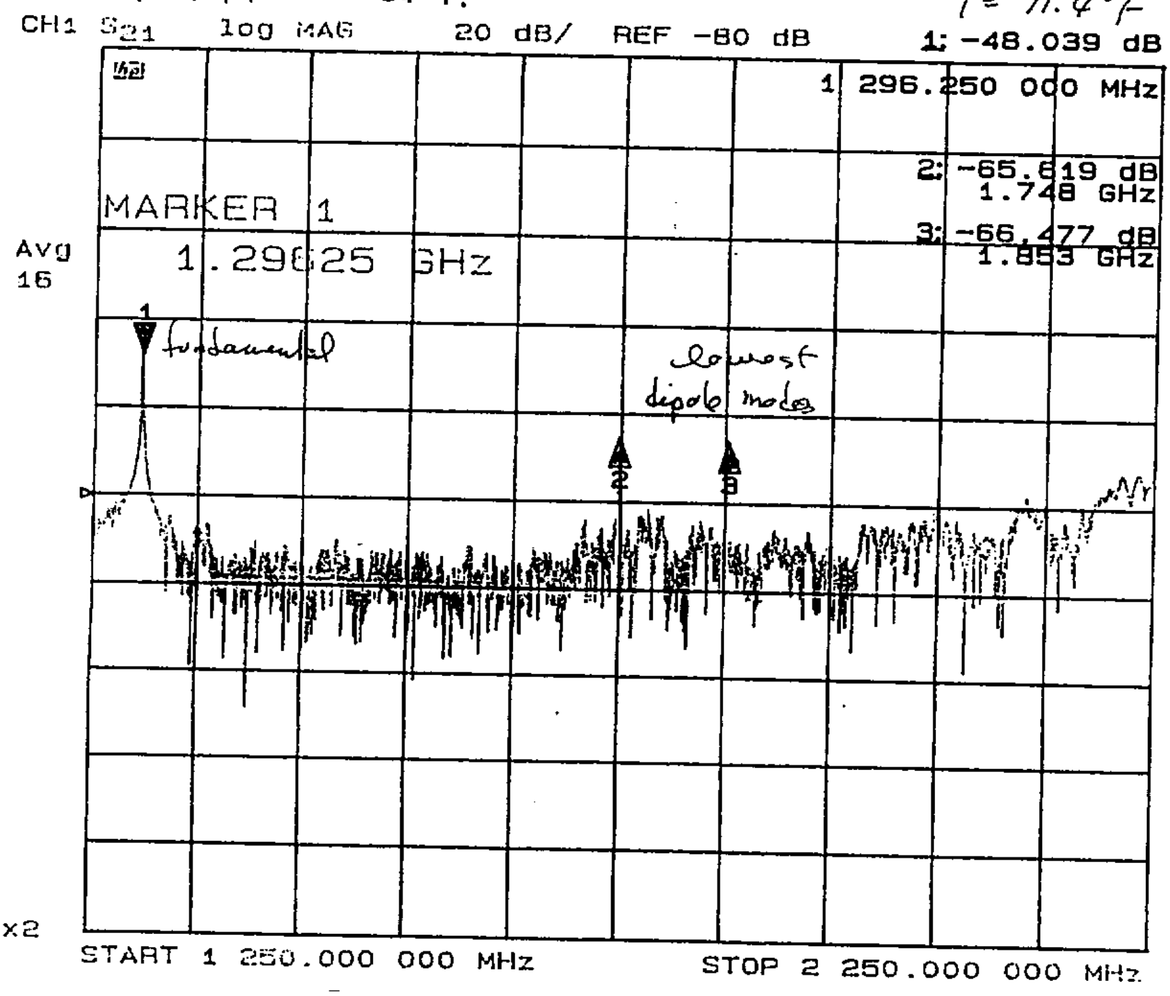
Plan to make a RRR300 single-cell cavity
before end of the summer.

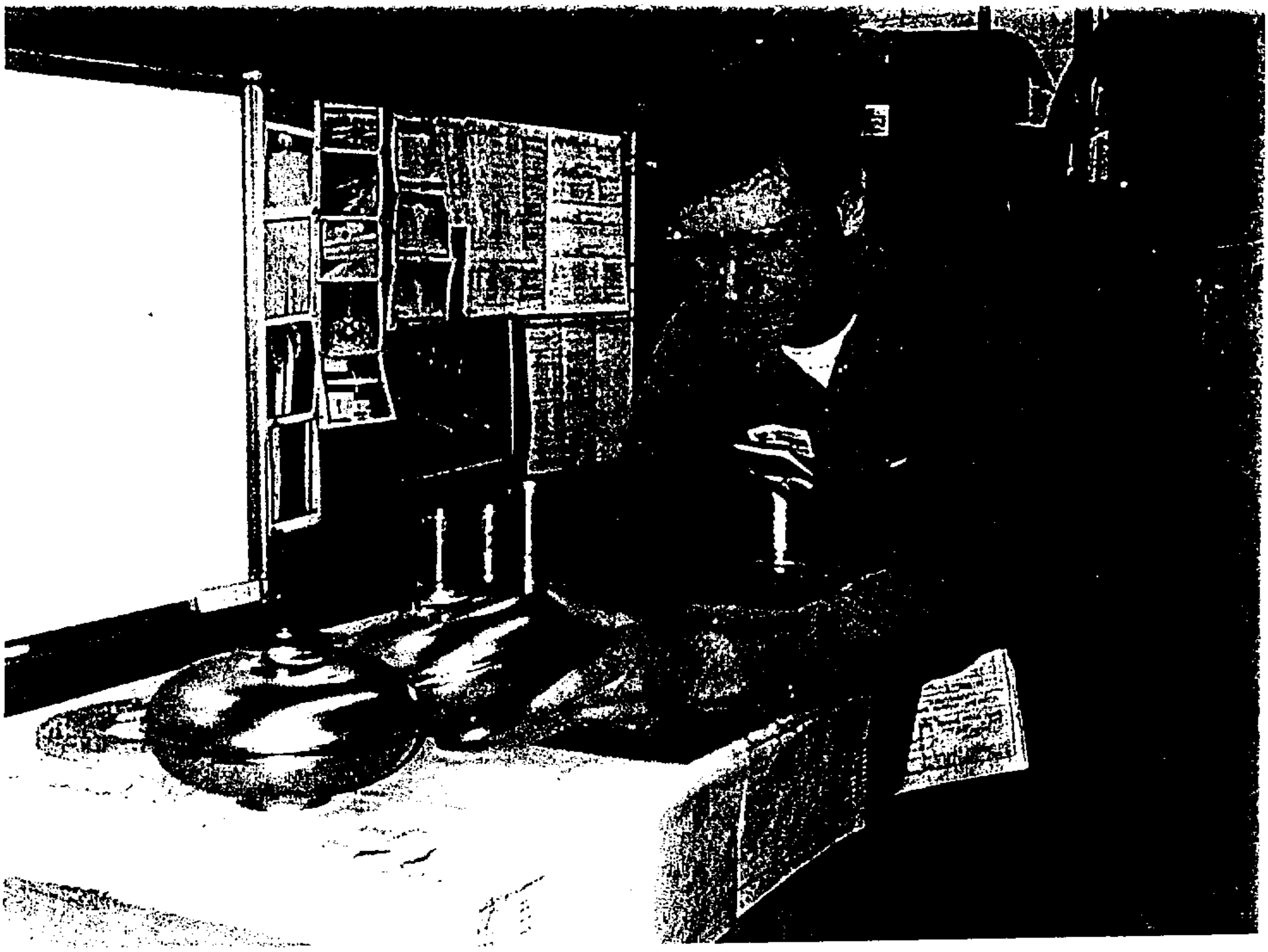
1.3-GHz 1-Cell Copper Cavity #1

Monopole Modes

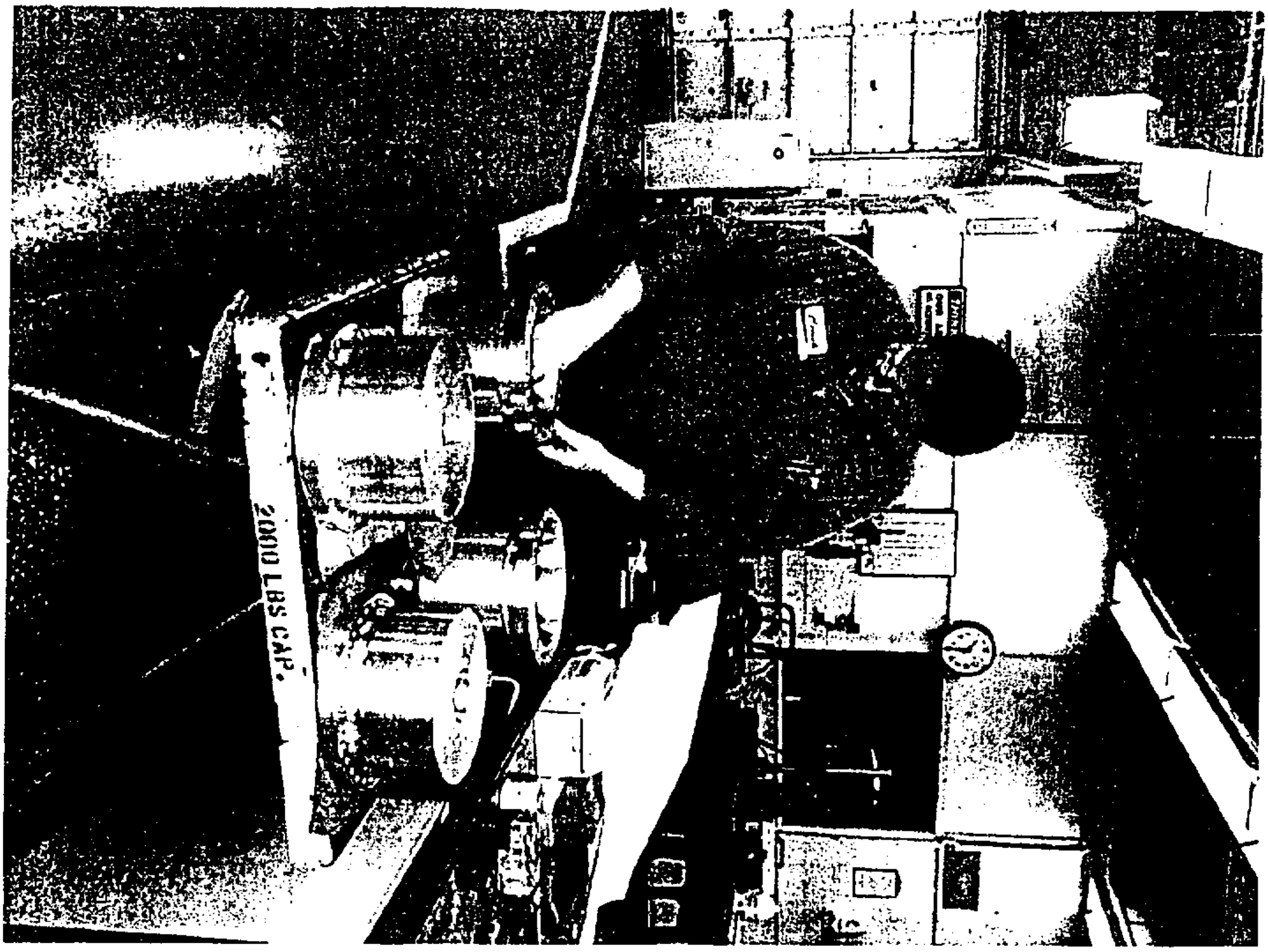
Monopole	f (MHz)	(R/Q) Ω at $R_0 = 0.0$ m	Q	f(measured)	Q(measured)	(R/Q) Ω measured
TM0-EE- 1	1292.33	17.29	29490	1295.95	25900	10.51
TM0-EE- 2	2386.09	37.960	31510	2468.24	28900	26.30
TM0-EE- 3	2698.21	0.227	44230	2720.31	35900	
TM0-EE- 4	3314.54	0.026	26930	above cut-off	N/A	
TM0-EE- 5	3360.80	0.644	23940			

2/10/99 Cu-1. T= 71.4°F





TP#1



107-8

Advanced Photon Source

Vacuum Seal Studies

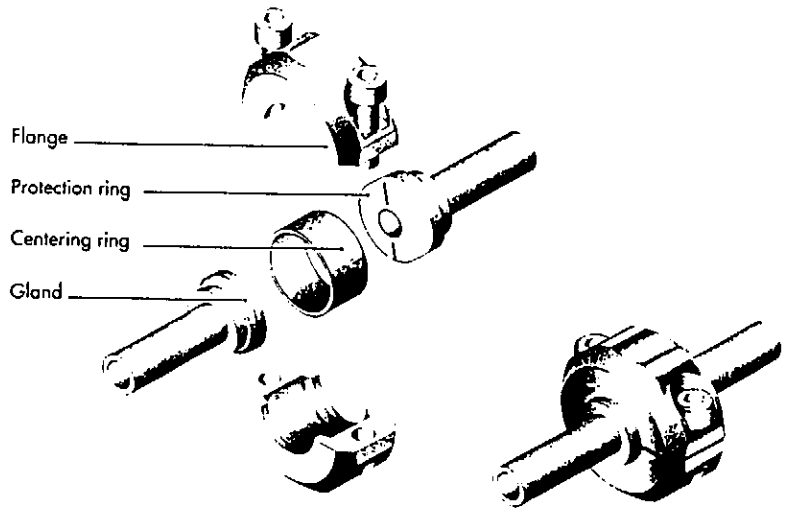
Investigation of a gasketless vacuum sealing method is underway to see if it could be suitable for Nb cavities. In tests, the seals are able to go from cryogenic temperatures to 550C without problems. It could be very cost-efficient if it works.

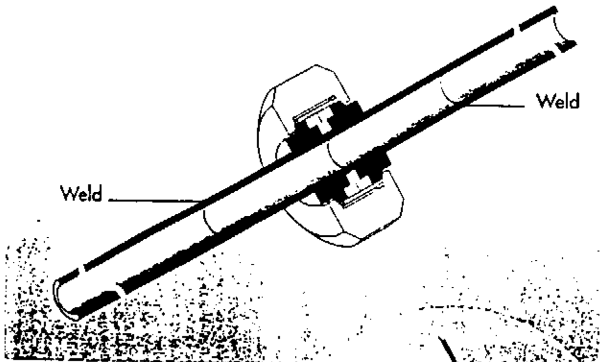
Nb Material studies:

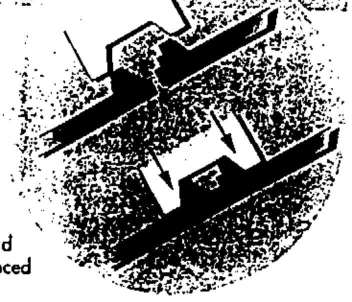
Ordered single-crystal Nb pieces - delivered at DESY soon.

Reference for lifetime and magnetic studies.

RHP FITTING







PRINCIPLE

Tube torque and metal friction on assembly are eliminated by transforming the standard perpendicular force into two balanced axial opposed forces.

ADVANTAGES

- **Optimal conduit continuity**
- **No dead volume**
- **Metal-to-metal sealing** (only on joining plane)
- Excellent performance at high pressure *9,425 PSI (650 bar) under Helium pressure and 27,530 PSI (1,900 bar) under oil pressure*
- No metal-to-metal rubbing on assembly
- Multiple assembly and disassembly without **loss of efficiency**
- **Easy assembly and dissassembly** (3 or 4 mm CHC key)
- **No male and female** end fittings
- **No gasket**
- **Reduced foot print**
- **Axial tightening** (no torque on the tubes)
- **Accurate alignment** of the glands by centering ring

Leak test: <1.10^{10} atm.cm^3/s Helium with the protection rings –100 °C to +180 °C degree and without protection rings, to 550°C.
CETIM Report Recorder # 6022404/681/4A.

Two RHP fittings tested n° 6 Ø1/4" and n° 16 Ø 3/8".

Temperature and pressure	Fitting RHP ref.	Leak atm.cm^3/s
+20° C, 80 bars	N° 6	< 1.10^{10}
+20° C , 200 bars	N° 6	< 1.10^{10}
+180° C, 80 bars	N° 6	< 1.10^{9}
+20° C , 80 bars	N° 16	< 1.10^{10}
+20° C , 200 bars	N° 16	< 1.10^{10}
+180° C, 80 bars	N° 16	< 1.10^{9}

Tests were carried out after temperature has been kept stable for at least one hour.

Another test has been carried out for these 2 fittings at 650 bars, +20° C.

Temperature and pressure	Fitting RHP ref.	Leak atm.cm^3/s
+20° C, 650 bars	N° 6	< 1.10^{10}
+20° C , 650 bars	N° 16	< 1.10^{10}

Tests were carried out after temperature has been kept stable for at least one hour.

3.3 HIGH PRESSURE OIL TEST (UP TO BURST)

RHP fitting N° 8 Ø 1/4"

Pressure (Bars)	Observation
300	no detected leak
400	no detected leak
500	no detected leak
600	no detected leak
700	no detected leak
800	no detected leak
900	no detected leak
1000	no detected leak
1100	no detected leak
1200	no detected leak
1300	no detected leak
1400	no detected leak
1500	no detected leak
1600	no detected leak
1700	no detected leak
1800	no detected leak
1900	no detected leak

RHP fitting N° 18 Ø 3/8"

Pressure (Bars)	Observation
300	no detected leak
400	no detected leak
500	no detected leak
600	no detected leak
700	no detected leak
800	no detected leak
900	no detected leak
1000	no detected leak
1100	no detected leak
1200	no detected leak
1300	no detected leak
1400	no detected leak
1500	no detected leak
1600	burst pipe

FLOWMECA, Inc. · 19450 Stevens Creek Boulevard · Cupertino, CA, 95014 · Phone & Fax (408) 343 1110
FLOWMECA France · 47 rue du Bois Chaland · Lisses · 91029 Evry cedex · Tél. : (33) 1 69 11 22 83 · Fax : (33) 1 69 11 22 84

107-10

DYNAMIC TEST OF FLOWMECA RHP CONNECTOR

Prepared by:

CETIM

C.E.T.I.M. : 74 Route de la Jonelière · BP 957 · 44076 NANTES Cedex 03

1 WHERE WERE THE TESTS PERFORMED?

CETIM Mecanical Industries Technical Center. Tests have been carried out on March 25 th, 1994

FINAL REPORT RECORDER N° 6 022404/681/4A

2 HOW WERE THE TESTS CARRIED OUT?

2.1 LEAK TEST

Test has been carried out on a spectrometer type ASM181T (ALCATEL) under Helium pressure.
Fitting assembly was tested.

2.2 TEMPERATURE TEST

Test has been carried out on a PYROX feature type CETIM 911772.
(temperature scale: between - 150° C and + 300° C).
For higher temperatures, tests have been carried out on a PYROX feature type N° CETIM 901673.

3 THE TESTS

3.1 VACUUM TEST

3.1.1 VACUUM TESTS WITH PROTECTION RINGS

Two RHP fittings tested n°2 Ø 1/4" and n°12 Ø 3/8".

Temperature °C	Fitting RHP ref.	Leak atm.cm^3/s
+20° C	N° 2	< 1.10^{-10}
-100° C	N° 2	< 1.10^{-10}
+180° C	N° 2	< 1.10^{-10}
+20° C	N° 12	< 1.10^{-10}
-100° C	N° 12	< 1.10^{-10}
+180° C	N° 12	< 1.10^{-10}

Tests were carried out after temperature has been kept stable for at least one hour.

3.1.2 VACUUM TEST WITHOUT PROTECTION RING

Two RHP fittings tested n°4 Ø 1/4" and n°14 Ø 3/8".

Temperature °C	Fitting RHP ref.	Leak atm.cm^3/s
+20° C	N° 4	< 1.10^{-10}
-100° C	N° 4	< 1.10^{-10}
+550° C	N° 4	< 1.10^{-10}
+20° C	N° 14	< 1.10^{-10}
-100° C	N° 14	< 1.10^{-10}
+550° C	N° 14	< 1.10^{-10}

Tests were carried out after temperature has been kept stable for at least one hour.

107-11

DRAFT

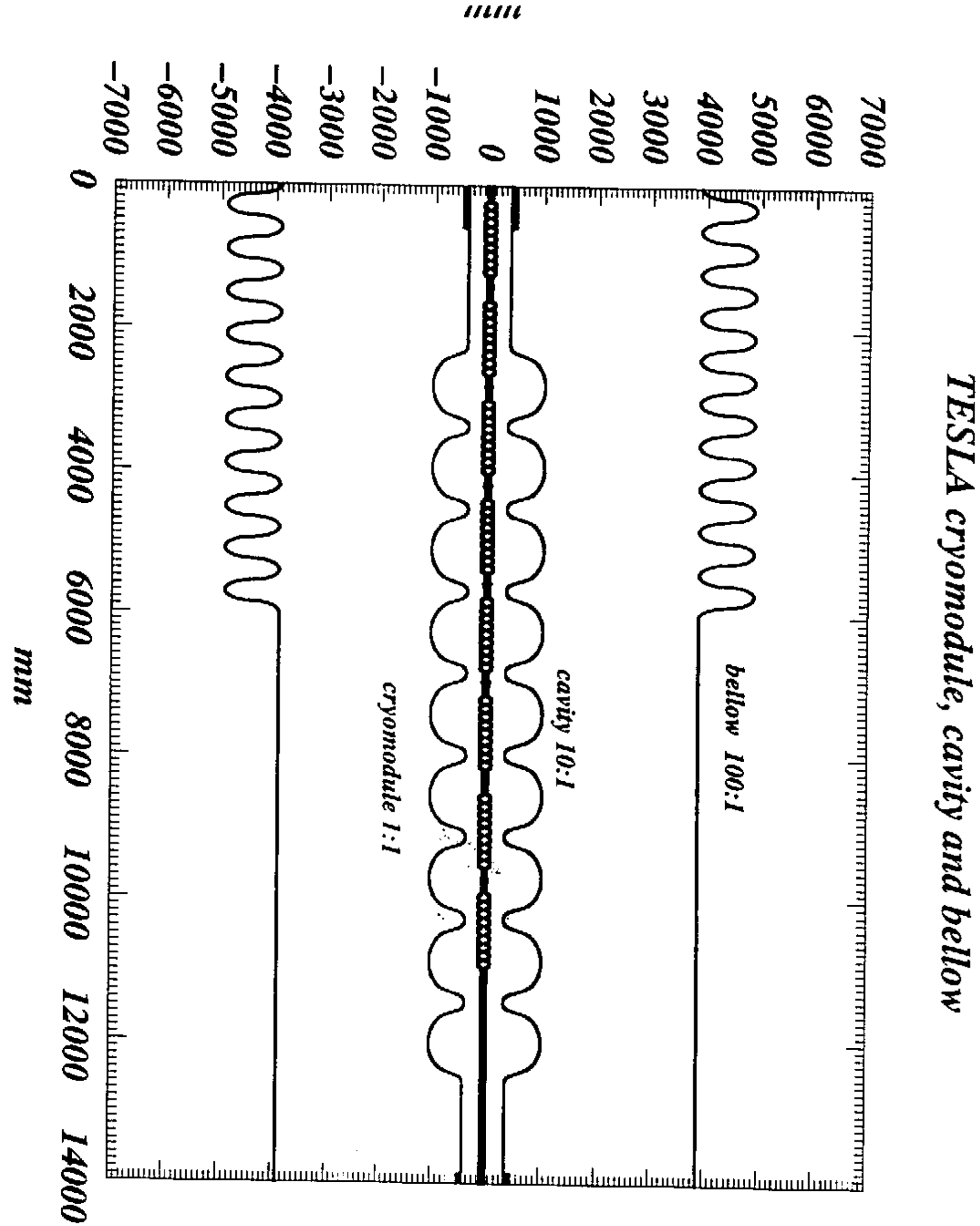
Single Bunch Energy Spread in a TESLA Cryomodule

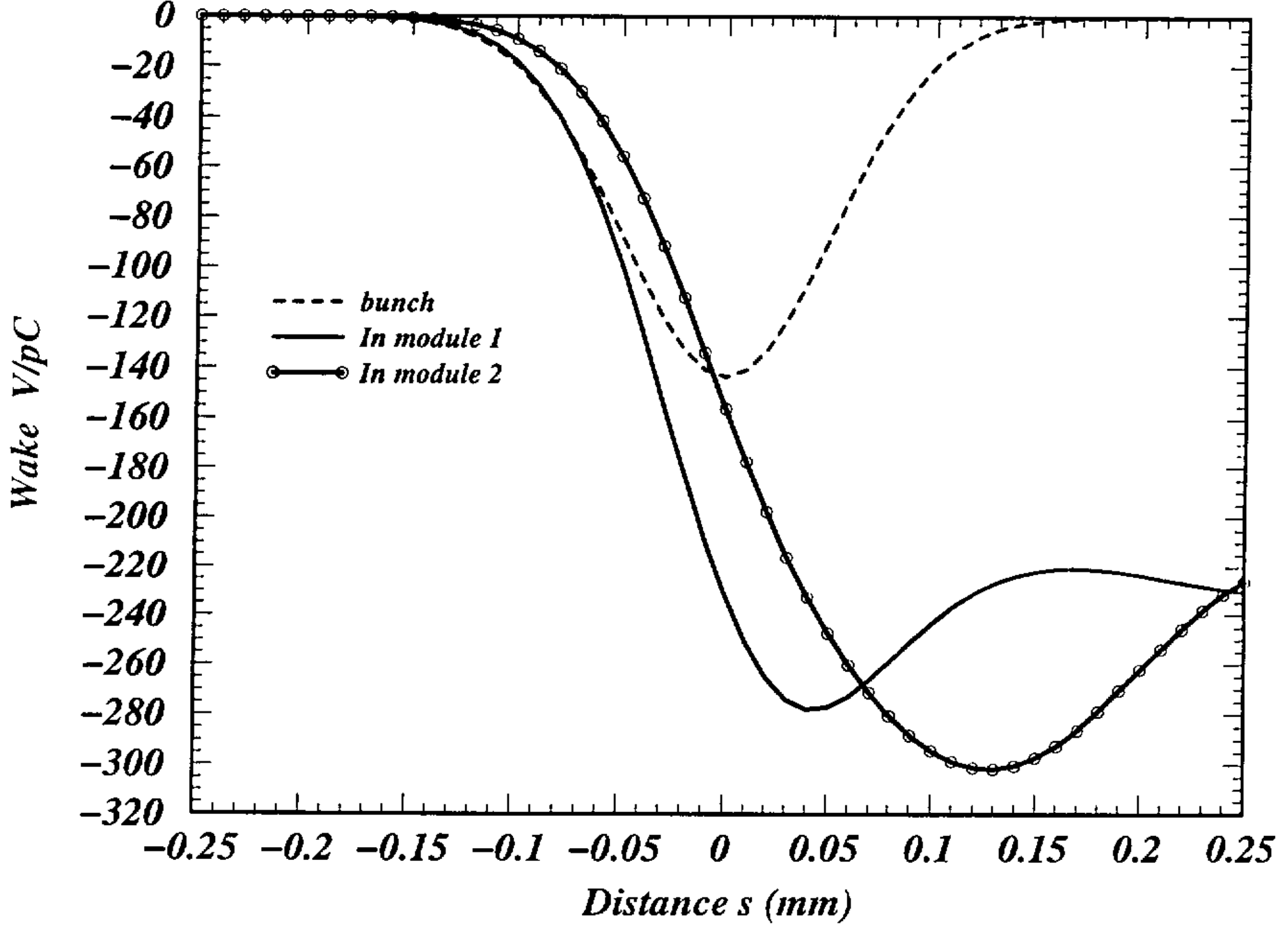
Alexandre Novokhatski, Martin Timm and Thomas Weiland
Fachgebiet Theorie Elektromagnetischer Felder
Technische Universität Darmstadt
Schloßgartenstraße 8, D-64289, Darmstadt

February 26, 1999

Abstract

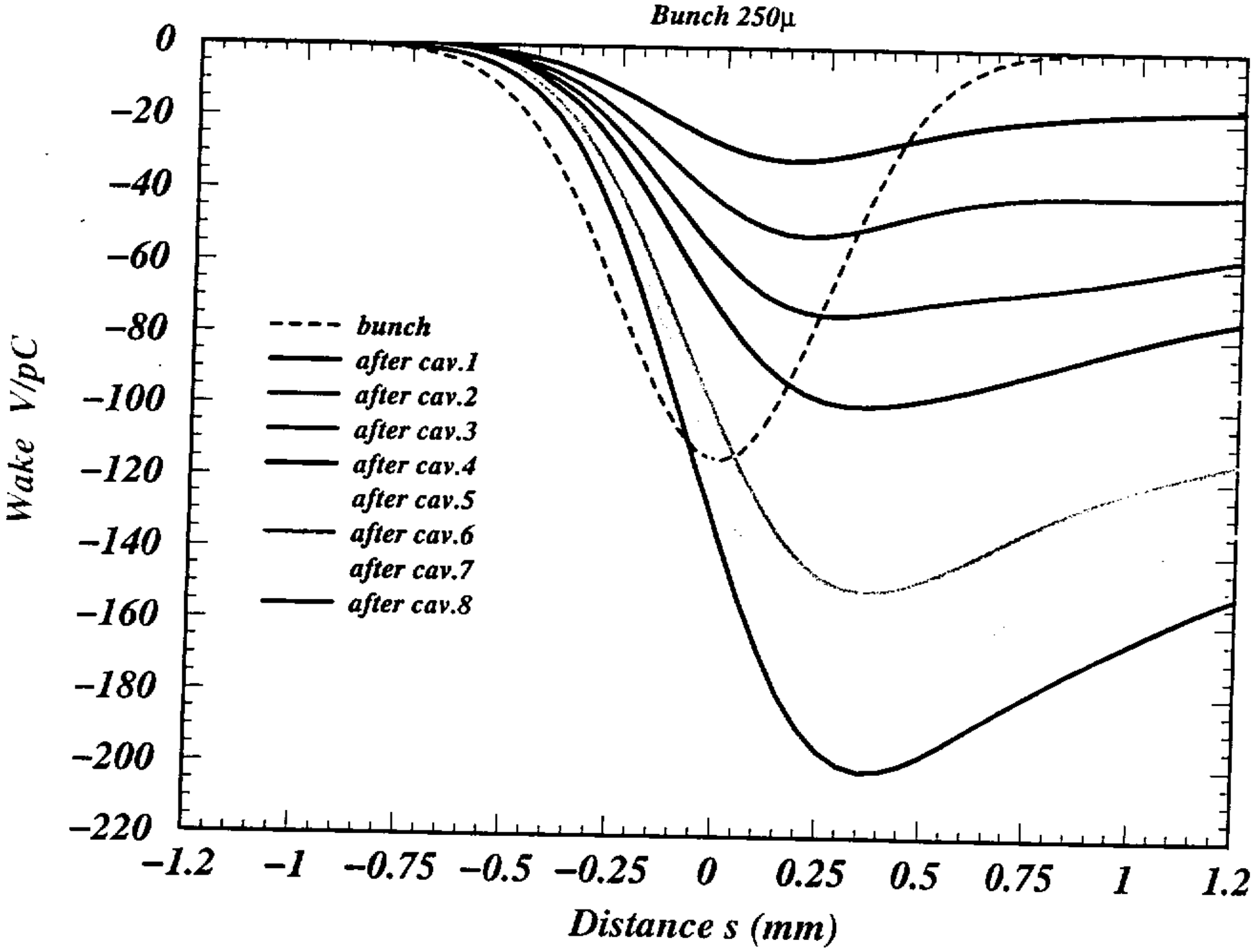
The present paper is a compilation of results of the wake field calculation of single Gaussian bunches with different length (700μm, 250μm and 50μm) in the TESLA Cryomodules. In order to take the transition dynamics into account, the wake fields are calculated in a sequence of two TESLA Cryomodules, including bellows and drift tubes. The single bunch energy spread is calculated as the rms-deviation from the average energy gain of the bunch. It is derived for the combination of accelerating voltage and wake fields. The energy spread is computed for acceleration with maximum energy gain. Furthermore the minimum energy spread achievable for different bunch charges and bunch length is calculated. The resulting phase and thus the energy gain at this phase are given.





Wakes in the TESLA cryomodules

Bunch: 50μ Distance between modules 7λ



Wakes in the cavities of the TESLA cryomodule

Bunch 250μ

1 Energy spread and Integral parameters of the Wake fields

The energy spread (squared) $(\Delta U)^2$ in the bunch is

$$(\Delta U)^2 = U_0^2(\Delta V)^2+Q^2(\Delta W)^2+2U_0Q(\langle V(s)W(s)\rangle-\langle V\rangle\langle W\rangle)$$

The energy spread due to the accelerating voltage $(\Delta V)^2$

$$(\Delta V)^2 = \frac{1}{2}(1-e^{-(k\sigma)^2})(1-\cos(2\phi)e^{-(k\sigma)^2})$$

Integral parameters of the wake field:
The energy spread (squared) caused by the wake fields is

$$(\Delta W)^2 = \int_{-\infty}^{+\infty} q(s)(W(s)-K_\sigma)^2 ds \tag{1}$$

Introducing the Cosine-Fourier part

$$I_{cos} = \int_{-\infty}^{+\infty} q(s)W(s)(\cos(ks)-e^{-(k\sigma)^2/2})ds \tag{2}$$

and the Sine-Fourier part

$$I_{sin} = \int_{-\infty}^{+\infty} q(s)W(s)\sin(ks)ds \tag{3}$$

we finally get the total energy spread

$$\boxed{(\Delta U)^2 = U_0^2(\Delta V)^2 + Q^2(\Delta W)^2 + 2U_0Q(I_{cos}\cos(\phi) - I_{sin}\sin(\phi))}$$

Integral parameters in [V/pC] for the wakes of 700μm and 250 μm long Gaussian bunches in one cryomodule are given in table 1. The wakes of a 50μm long Gaussian bunch are given for first and second cryomodules in the same table. For the wavelength of the accelerating field $\lambda = 230.768$mm was taken.

σ	K_σ	I_{cos}	I_{sin}	$\sqrt{(\Delta W)^2}$
700μ	-98.33152	-0.2461643E-02	-0.8492748	47.49361
250μ	-125.8672	-0.3346571E-03	-0.3944211	60.83610
50μ(1)	-198.2546	-0.4340105E-04	-0.0960391	79.86720
50μ(2)	-153.2351	-0.5752997E-05	-0.1107154	82.82798

Table 1: Integral parameters for the wakes of 700μm, 250μm and 50μm Gaussian bunches in the TESLA cryomodule

The relative energy spread $\Delta U/\langle U\rangle$ and the energy gain $\langle U\rangle$ upon the phase degree are shown in Fig.1 and Fig.2 for $U_0 = 120$MeV, $\sigma = 250\mu$m and $Q = 8nC$.

The same parameters, but for the charge of $Q = 1nC$ are shown in Fig.3 and Fig.4

From the pictures we can see, that there is an optimal phase, where the bunch gets the minimum energy spread. Energy distributions for such cases are shown on Fig.5($Q = 8nC, \phi = -32.5^o$) and Fig.6 ($Q = 1nC, \phi = -45^o$)

Even after compensation, the energy spread has still linear dependence, at least for 60% of the particles.

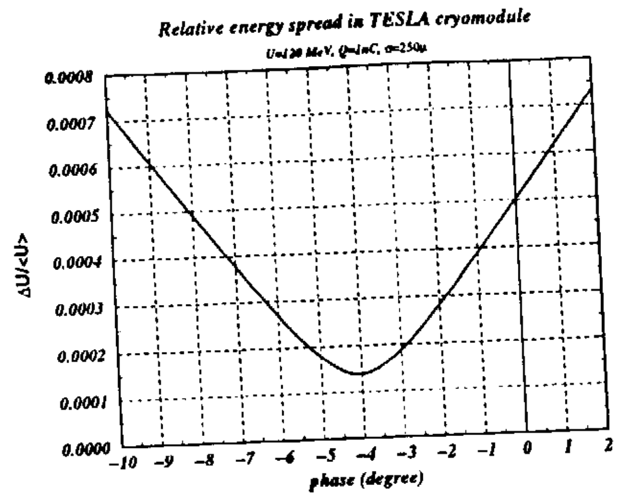


Figure 3: Relative energy spread.

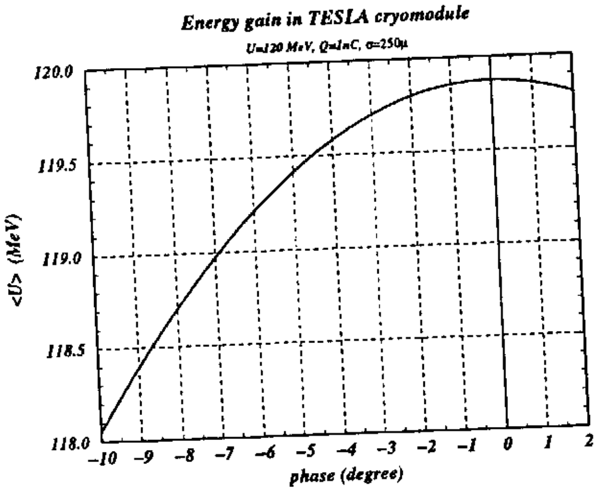


Figure 4: Average energy gain.

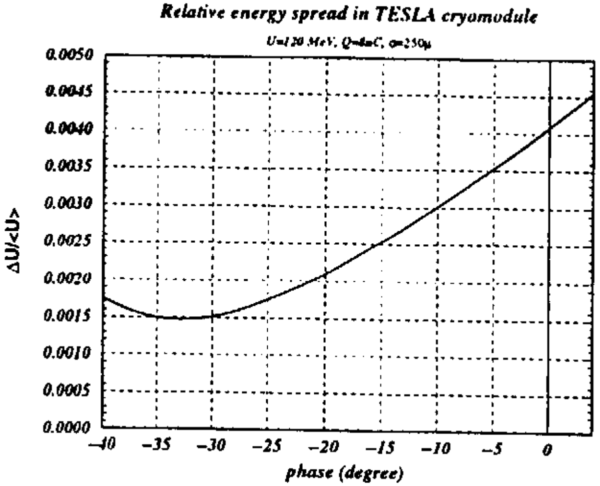


Figure 1: Relative energy spread.

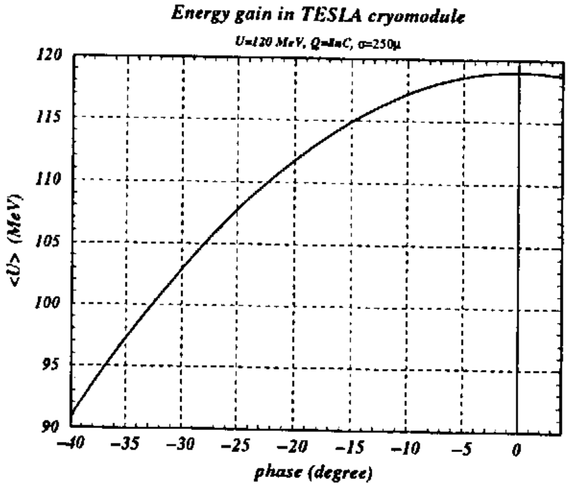


Figure 2: Average energy gain.

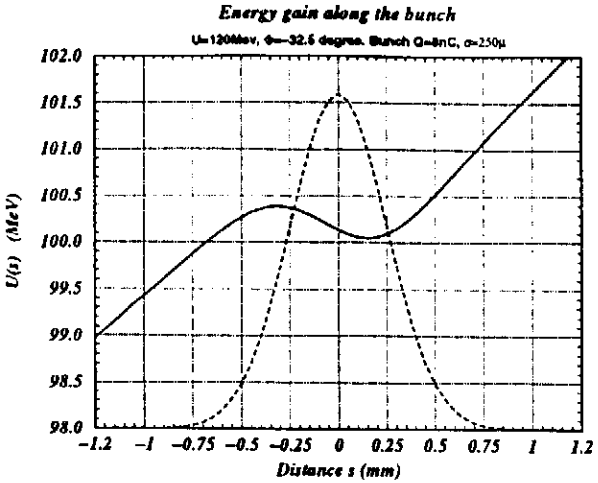


Figure 5: Energy gain distribution for $Q = 8nC$.

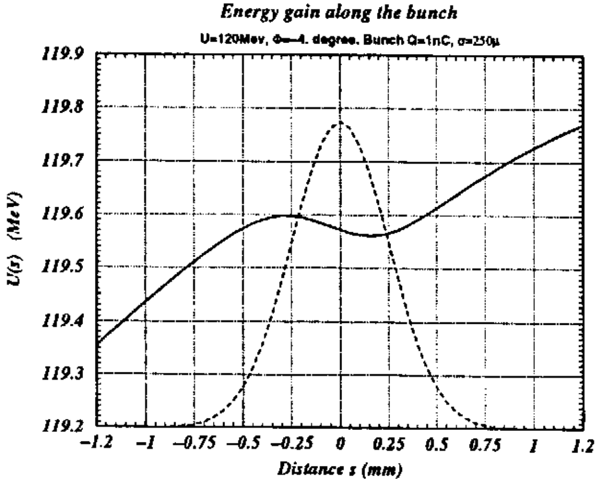


Figure 6: Energy gain distribution for $Q = 1nC$.

Table 2: Maximum energy gain and minimum energy spread of a $\sigma = 250\mu m$ bunch in a TESLA cryomodule. Charge $Q = 1$nC

Voltage MV	Phase	$\langle U \rangle$ MeV,	$\Delta U/\langle U \rangle \cdot 1000$
100	$\phi = 0$	99.872	0.6032
	$\phi = -4.9$	99.506	0.1655
120	$\phi = 0$	119.871	0.5017
	$\phi = -4.1$	119.564	0.1347
140	$\phi = 0$	139.871	0.4293
	$\phi = -3.5$	139.61	0.1128
160	$\phi = 0$	159.87	0.3751
	$\phi = -3$	159.651	0.0968
180	$\phi = 0$	179.87	0.3293
	$\phi = -2.7$	179.67	0.0841
200	$\phi = 0$	199.87	0.2993
	$\phi = -2.4$	199.694	0.0744
320	$\phi = 0$	319.867	0.1861
	$\phi = -1.5$	319.757	0.0429

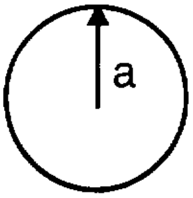
Table 3: Maximum energy gain and minimum energy spread of a $\sigma = 250\mu m$ bunch in a TESLA cryomodule. Charge $Q = 8$ nC.

Voltage MV	Phase	$\langle U \rangle$ MeV,	$\Delta U/\langle U \rangle \cdot 1000$
100	$\phi = 0$	98.991	4.9097
	$\phi = -39$	76.706	1.964
120	$\phi = 0$	118.99	4.083
	$\phi = -32.8$	99.859	1.477
140	$\phi = 0$	138.99	3.4949
	$\phi = -28.2$	122.373	1.1937
160	$\phi = 0$	158.989	3.0544
	$\phi = -24.6$	144.467	1.006
180	$\phi = 0$	178.989	2.712
	$\phi = -21.8$	166.117	0.8715
200	$\phi = 0$	198.988	2.4391
	$\phi = -19.6$	187.4	0.7696
320	$\phi = 0$	318.986	1.5192
	$\phi = -12.2$	311.759	0.4537

Application of Iris Model to different Tubes

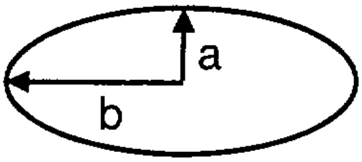
- **Circular Aperture**

$$k^2 = \frac{\varepsilon}{\varepsilon - 1}\frac{2}{a\delta} \qquad k_{loss} = \frac{Z_0 c}{2\pi a^2}\mathrm{H}(k\sigma_z)$$



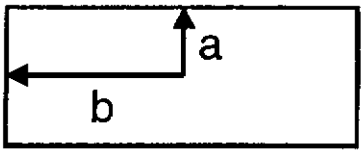
- **Elliptical Aperture**

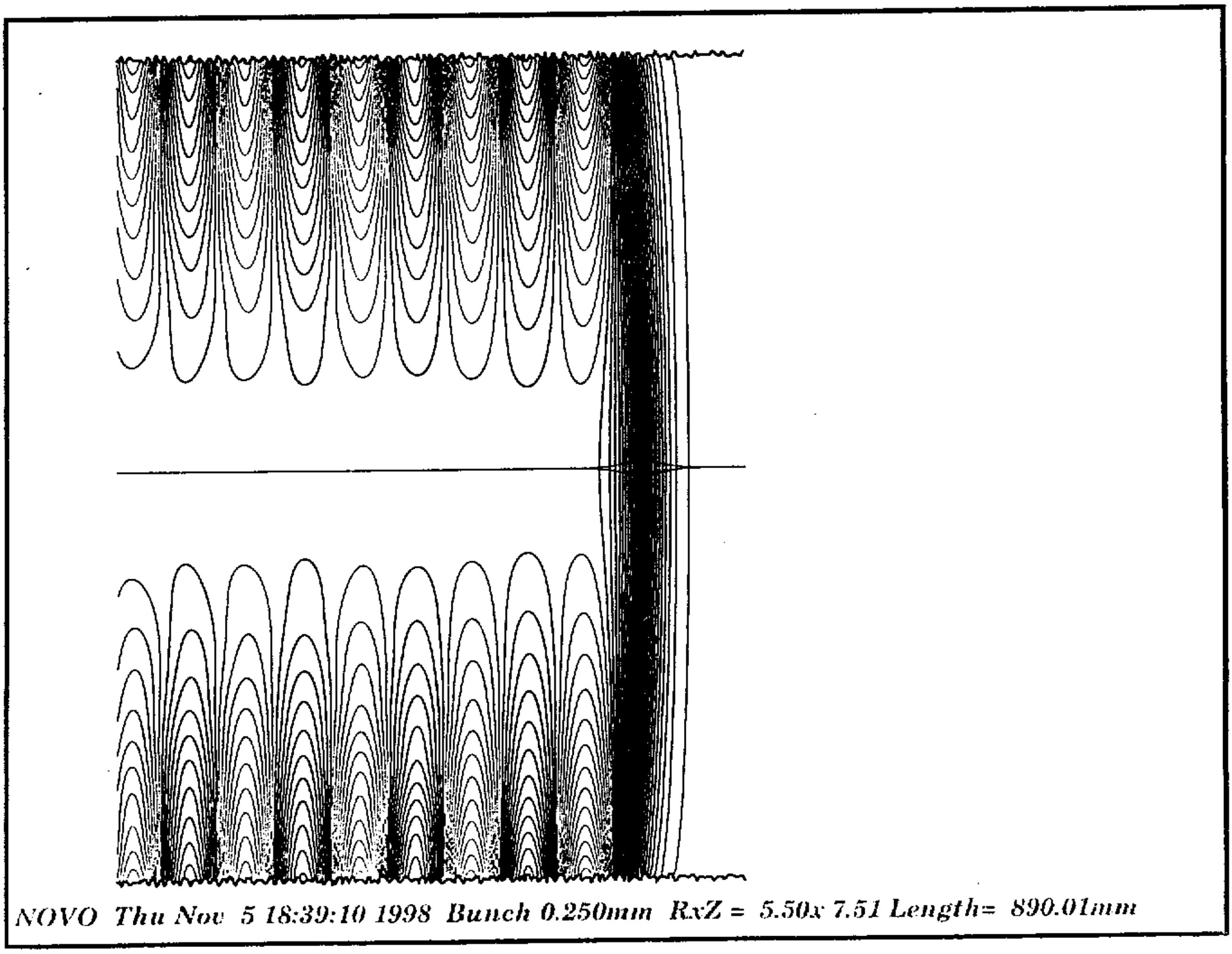
$$k^2 = \frac{\varepsilon}{\varepsilon - 1}\cdot\frac{a+b}{ab}\cdot\frac{1}{\delta} \qquad k_{loss} = \frac{Z_0 c}{2\pi ab}\mathrm{H}(k\sigma_z)$$



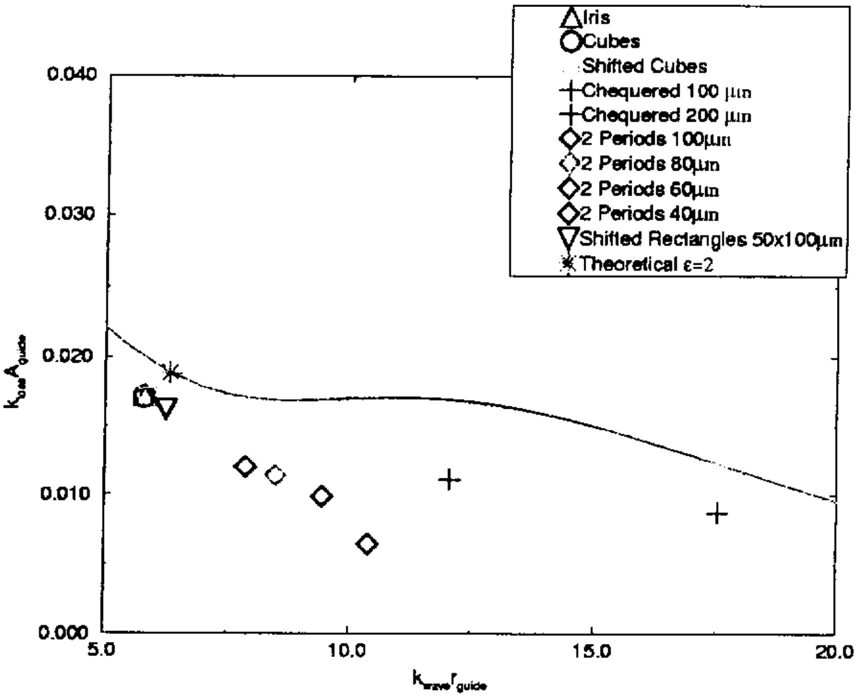
- **Rectangular Aperture**

$$k^2 = \frac{\varepsilon}{\varepsilon - 1}\cdot\frac{a+b}{ab}\cdot\frac{1}{\delta} \qquad k_{loss} = \frac{Z_0 c}{8ab}\mathrm{H}(k\sigma_z)$$

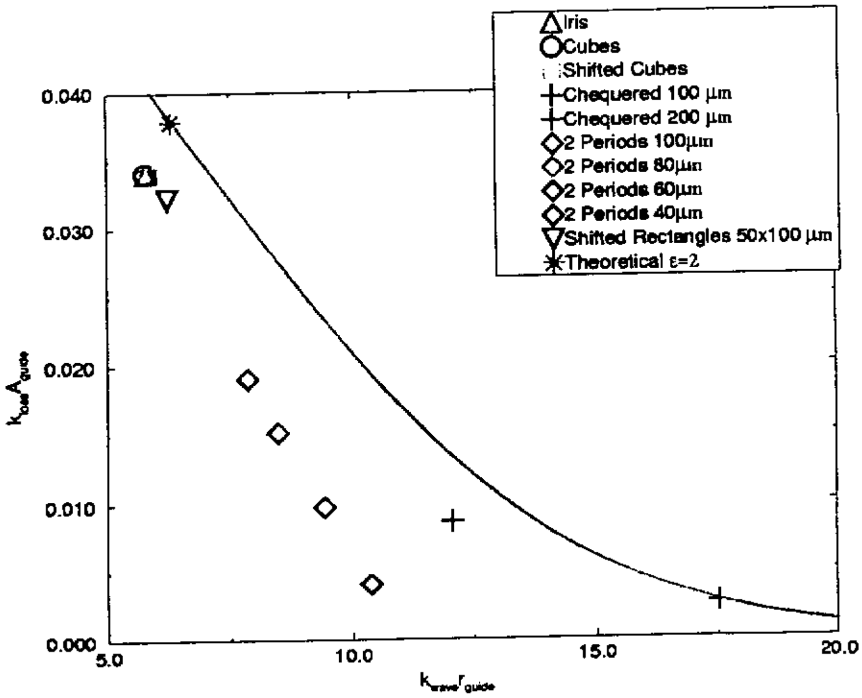


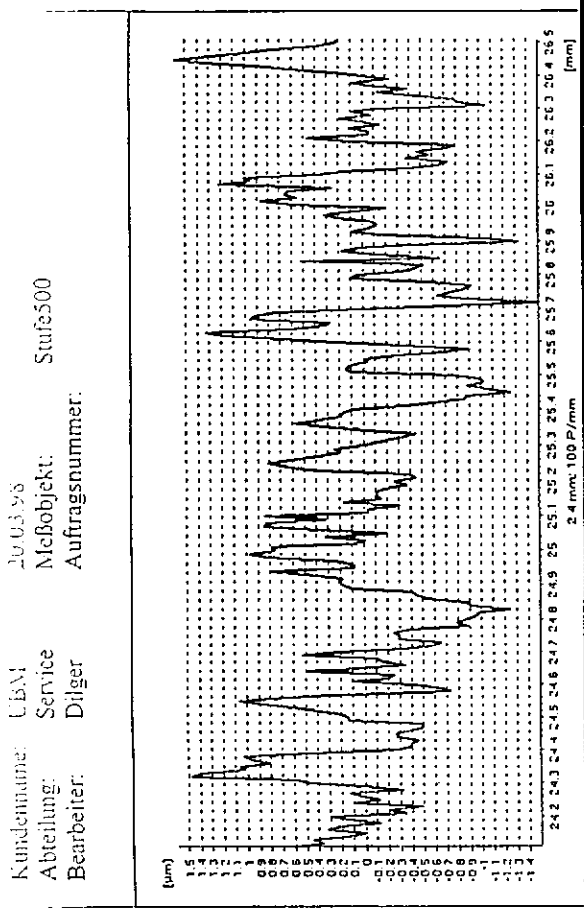


Energyspread of 3D-Structures



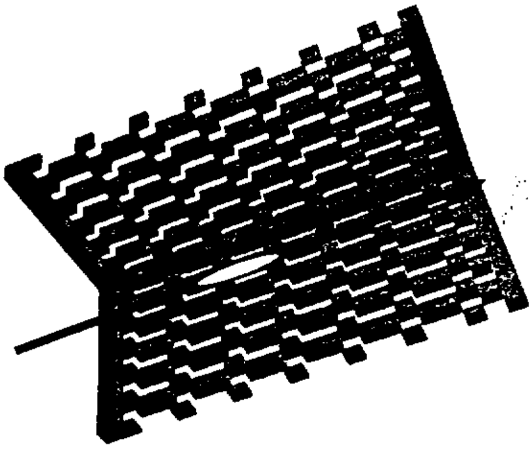
Lossfactor of 3D-Structures

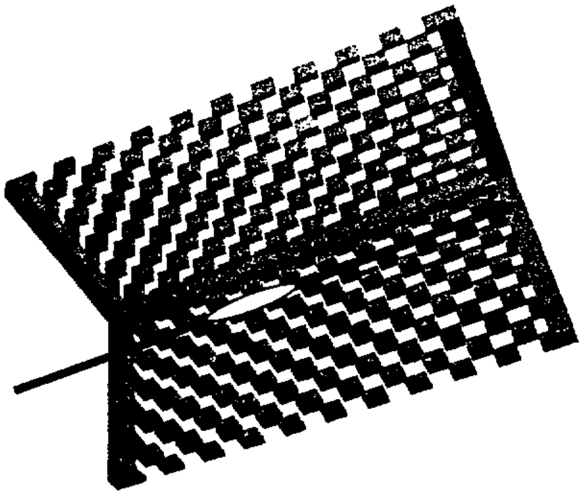




Shifted Rectangle and 2 Periods Structure

TUD





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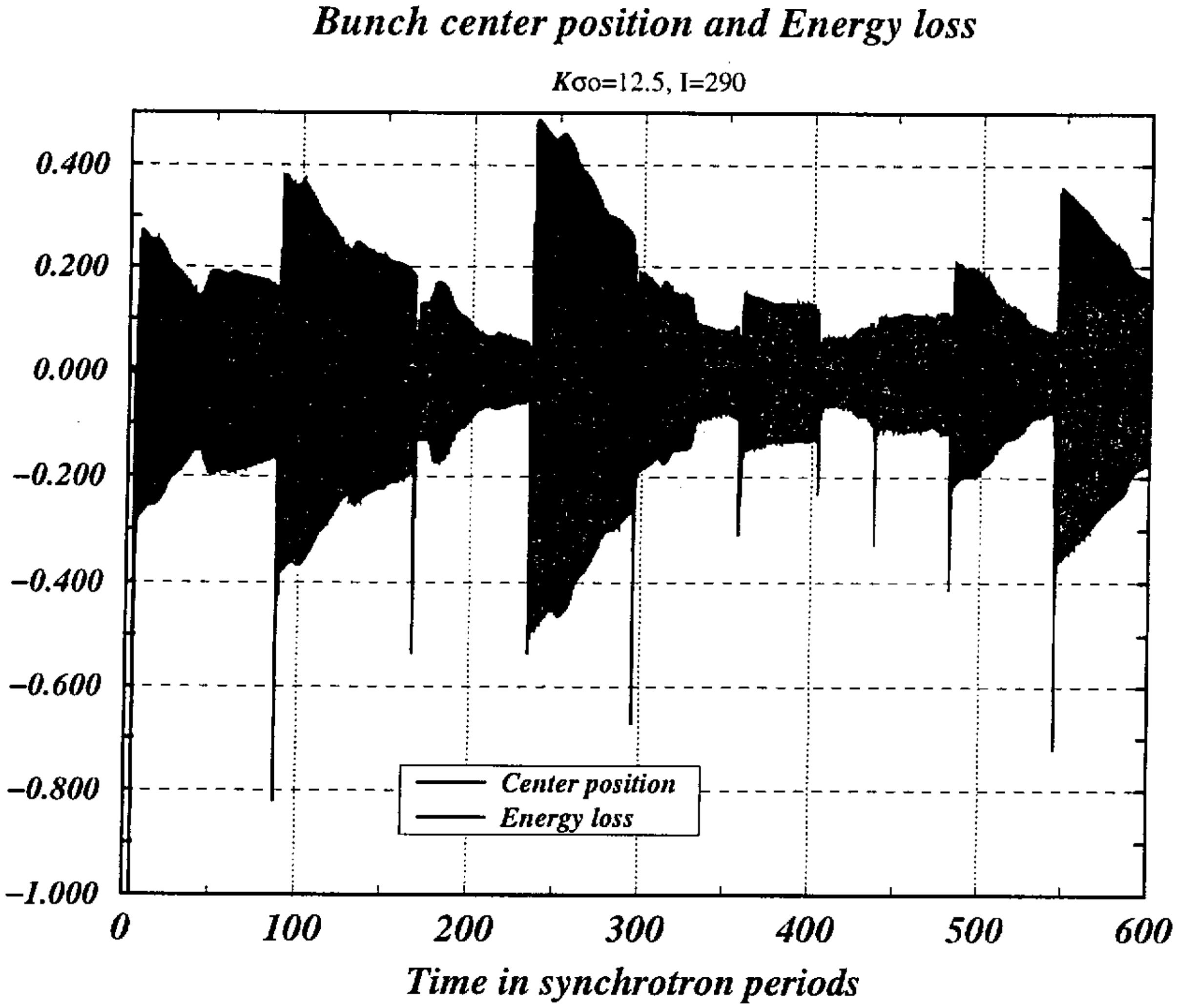
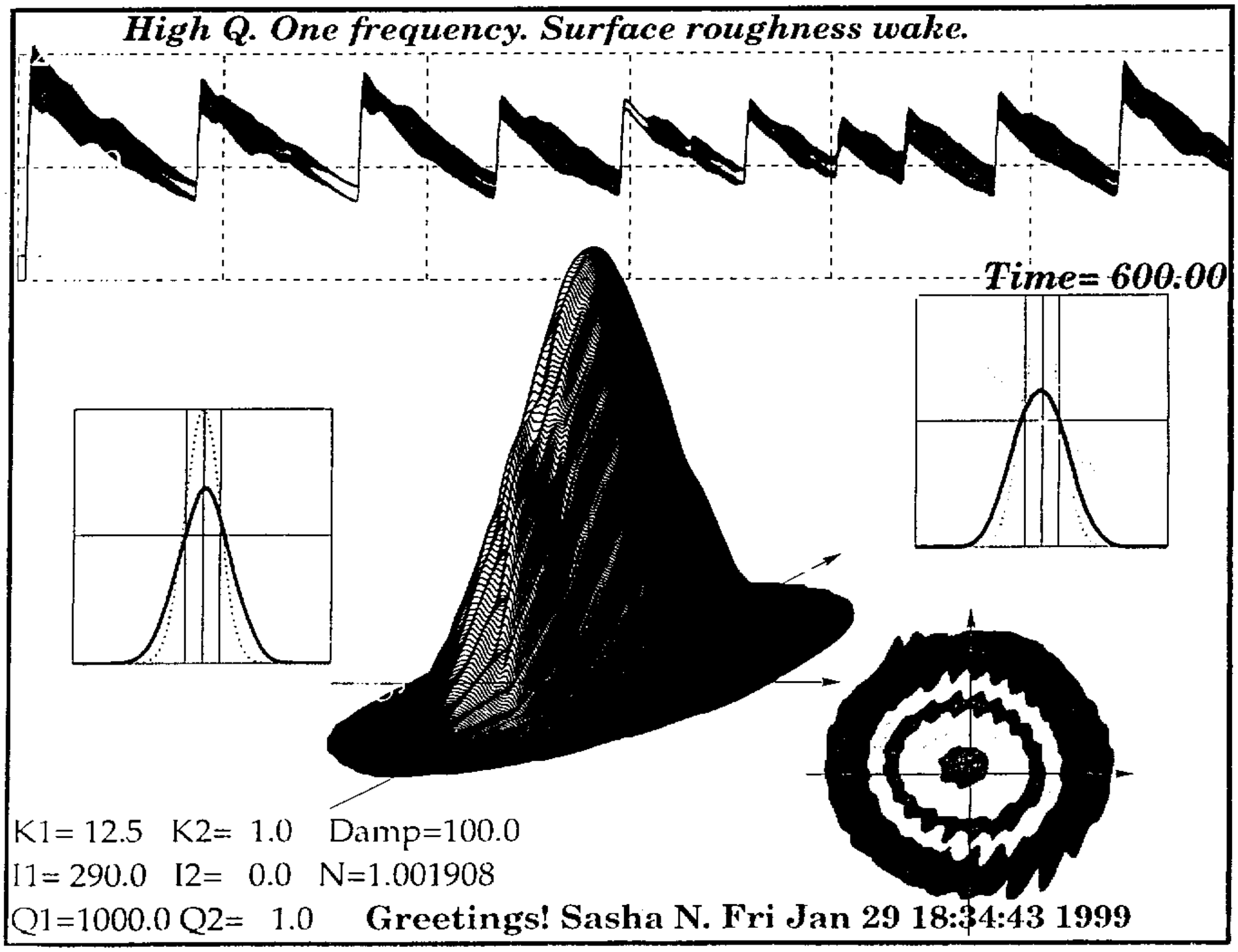




K1= 12.5 K2= 1.0 Damp=100.0
I1= 290.0 I2= 0.0 N=1.001908
Q1=1000.0 Q2= 1.0 **Greetings! Sasha N. Fri Jan 29 18:34:43 1999**

MG

TESLA Damping Ring

Parameters of the ring:

$$\sigma_{\rm DR} = 9.5mm, Q = 5.8nC$$

$$V_{\rm RF} = 25MV, f_{\rm RF} = 433MHz, k_{\rm RF}\sigma_{\rm DR} = 0.086$$

Parameters of the vacuum chamber:

$$L = 17km, 52 \times 28mm^2, \;\; roughness \;\; \delta = 0.5\mu$$

Roughness wake frequency parameter

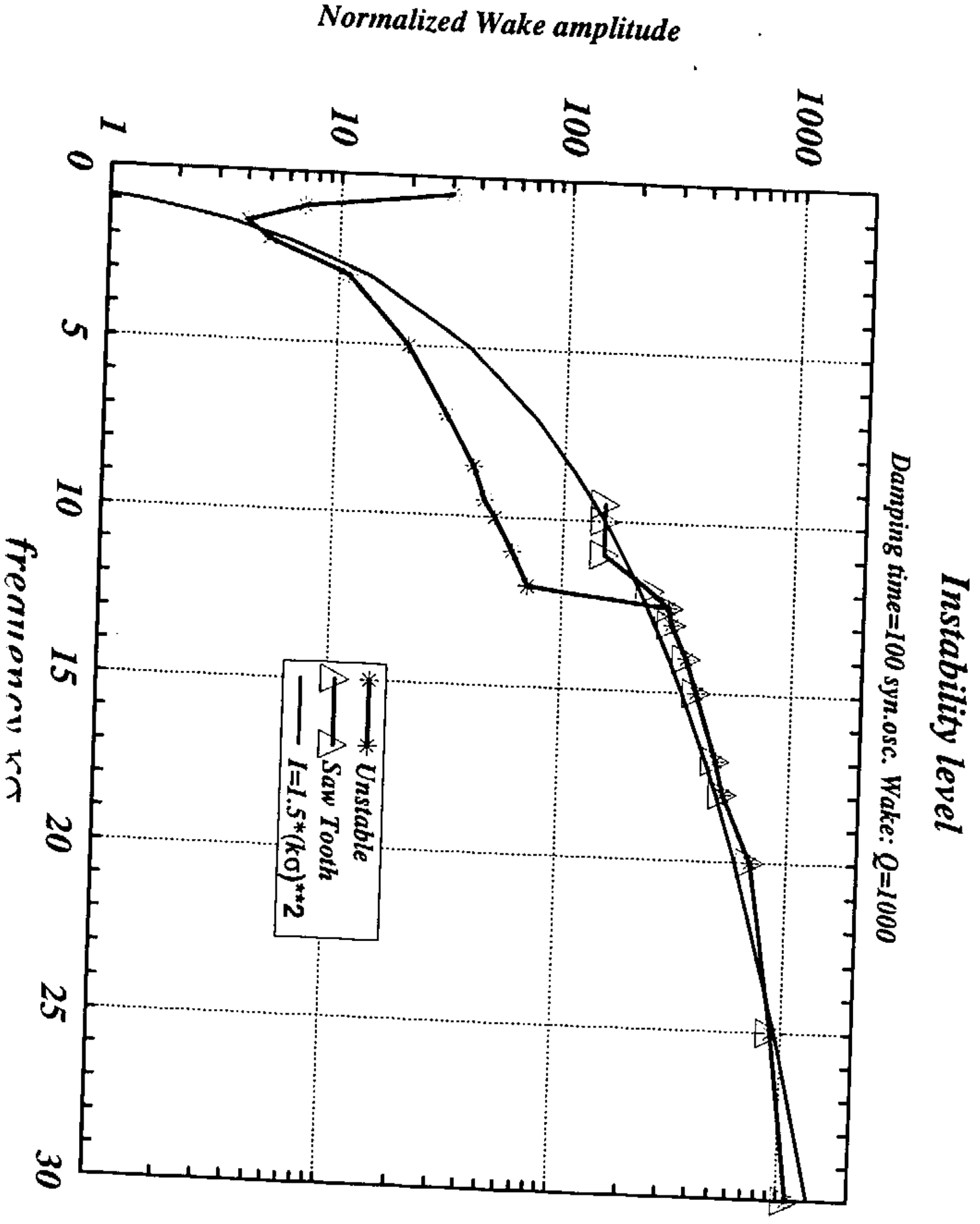
$$k_0\sigma_{\rm DR} = 190$$

Intensity parameter

$$I_0 = \frac{QW_0L}{V_{\rm RF}k_{\rm RF}\sigma_{\rm DR}} = \frac{QZ_0cL}{\pi a^2 V_{\rm RF}k_{\rm RF}\sigma_{\rm DR}} = 4 \times 10^3$$

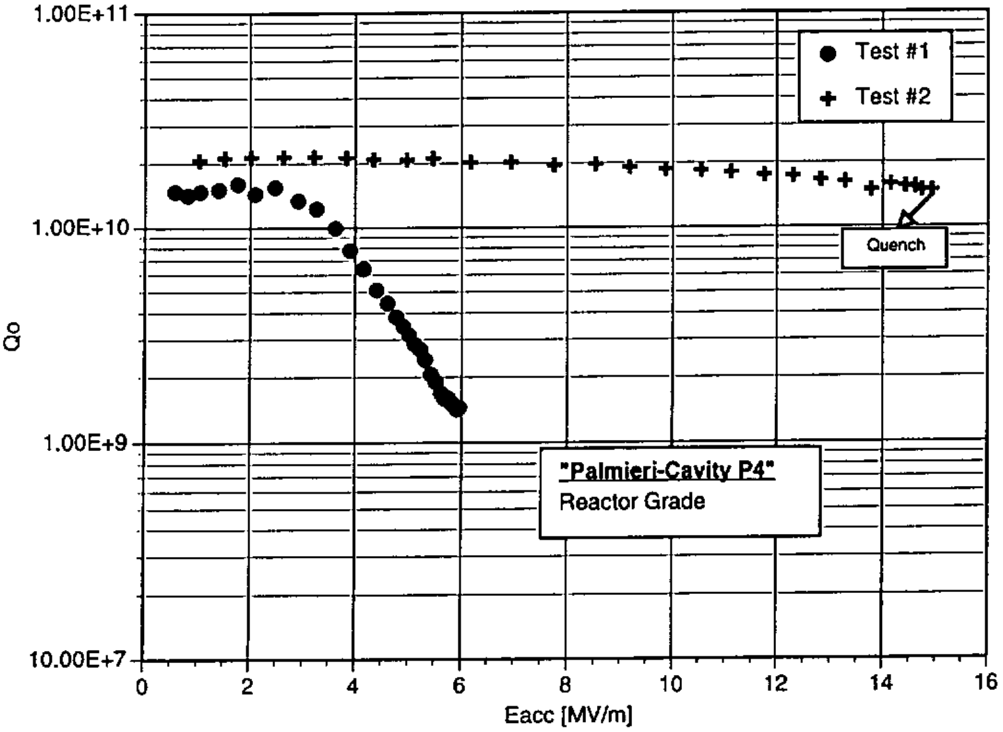
Estimation for threshold

$$I_0^{th} = 1.5(k_0\sigma_{\rm DR})^2 = 54 \times 10^3 \quad (13.5 \; times \; larger)$$

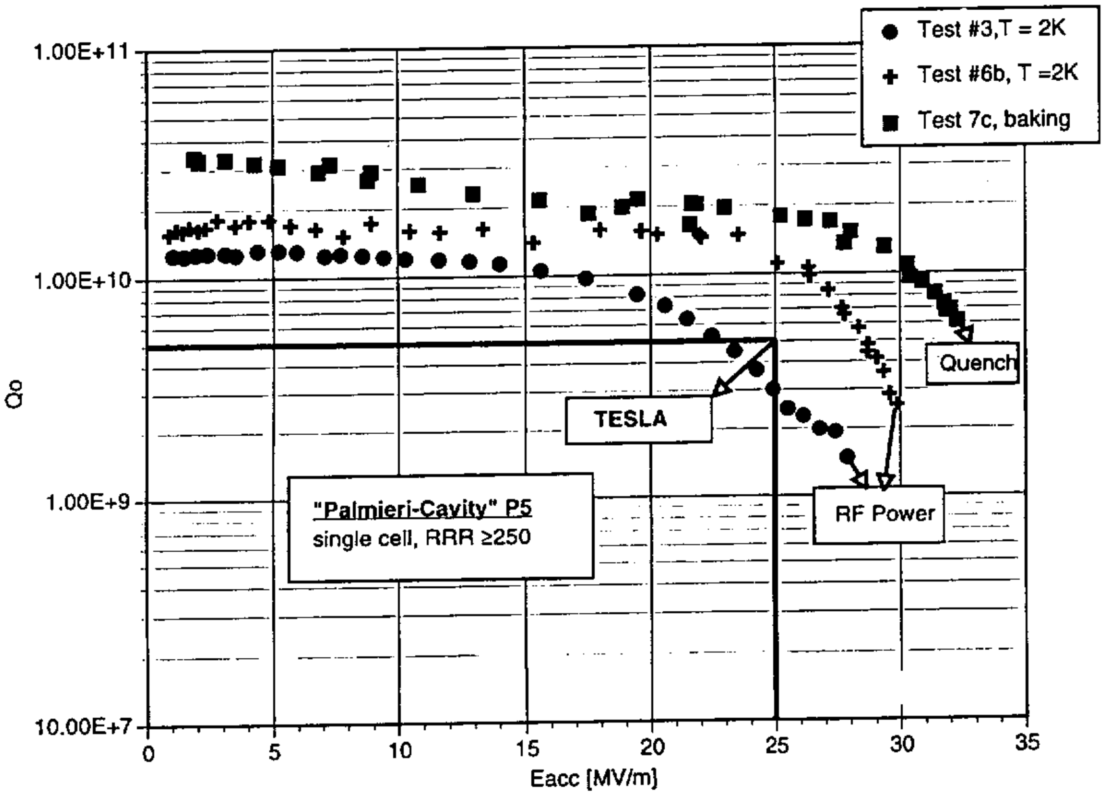


Palmieri
NFN Legnaro

DESY	1.3 GHz	Spinning from Planar disks Spinning from deep drawn tubes Spinning from flowturned tubes	
Jefferson lab	1.5 GHz	Spinning from planar disk	250 RRR Nb reactor grade Nb
		Spinning from deep drawn tubes (monocell after mechanical grinding; 5 cell in preparation)	
KEK	1.3 GHz	Nb clad Cu from disks (Plan to reduce internal cracks)	
Orsay	3 GHz 1.5 GHz	500 mm thick wall Nb cavities in program.	
Genoa Univ.	3 GHz	Spinning onto an Al mandrel Spinning onto a collapsible mandrel	
Saclay	1.5 GHz	Spinning of OFHC Cu monocells for Nb sputtering	



Test #1: after manufacturing tumbling for ≈ 90 hrs, ≈ 90 µm bcp, heat treatment at 800 C for 2 hrs, 70 µm bcp
Test #2: Heat treatment at 1200 C for ≈ 30 min, tumbling for ≈ 95 hrs, grinding of cracks at beam pipe, ≈ 80 µm bcp



Test #3: ≈ 234 µm bcp
Test # 6b: tumbling for ≈ 100hrs,80 µm bcp,heat treatment at 900C for 1 1/2 hrs, 60 µm bcp,grinding of cracks at beam pipe, 50 µm bcp
Test #7c: 20 µm bcp, baking at 115 C for ≈ 40 hrs "in situ"

Undulator Status Report

1-3-99

J. Pflüger, HASYLAB

Overview

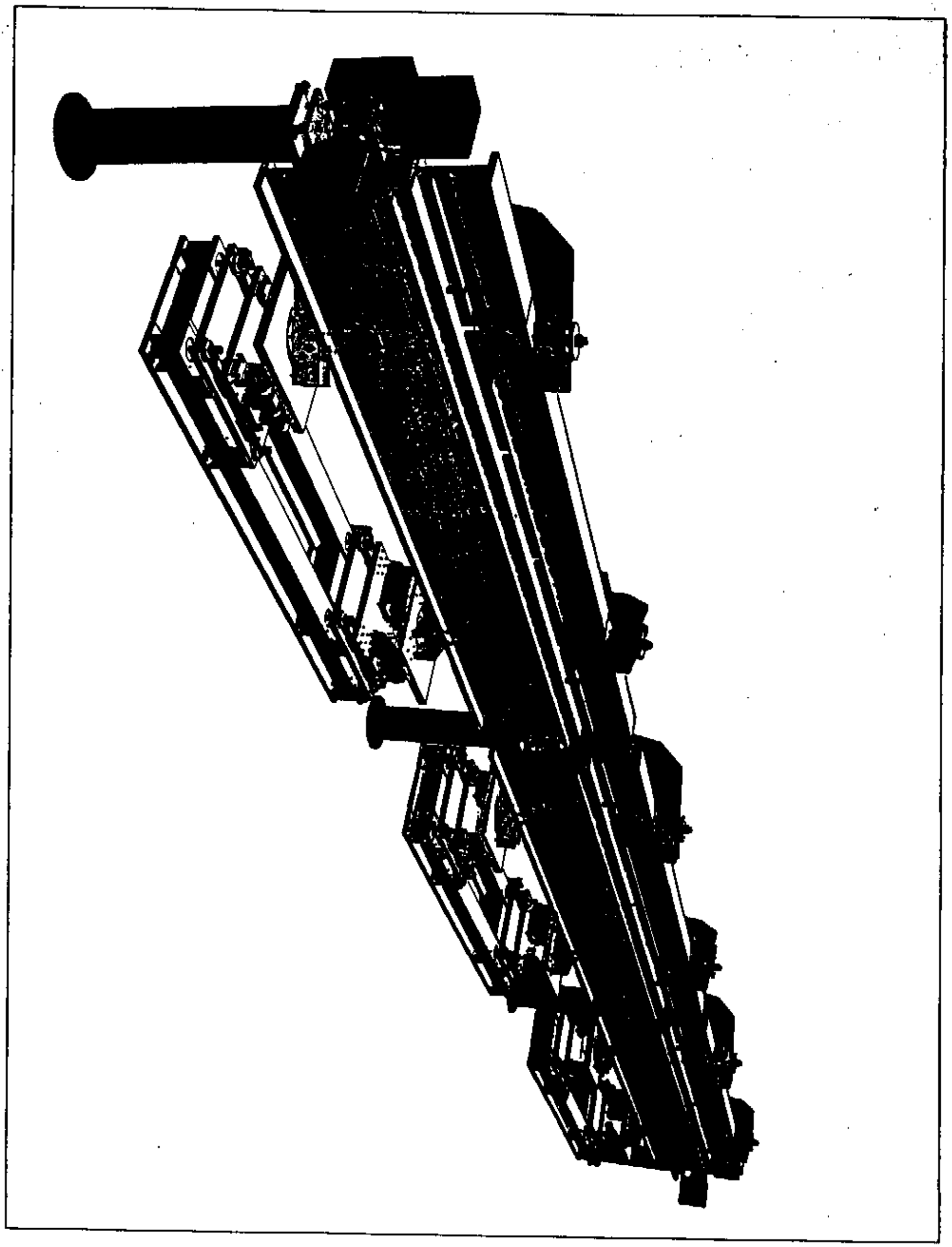
Vacuum System - U. Hahn

Undulator - Mechanical

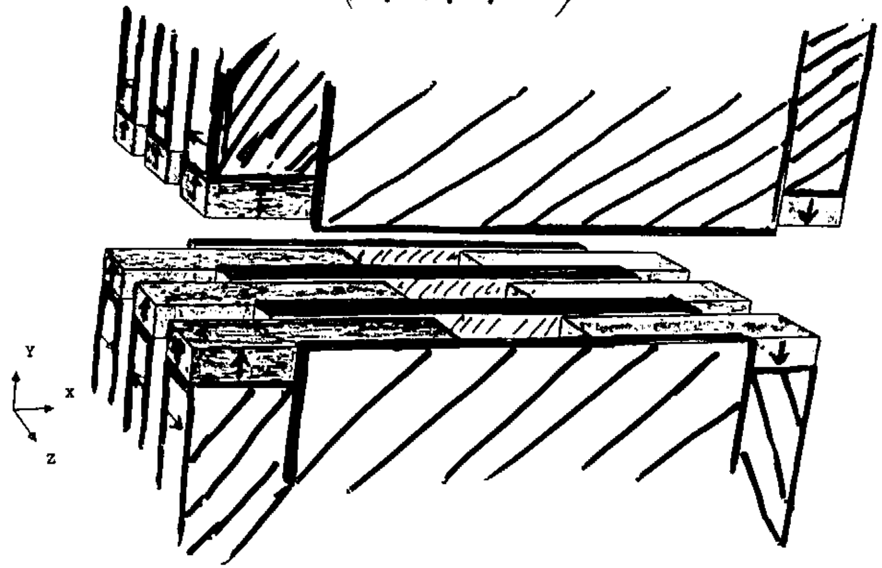
Magnetic Measurements 1. Undulator Module

- Hor. Field tuning →shimming ✓
- Vert. Field tuning →Pole height adjustment ✓
- Quad tuning → Rectangular Coil Method ✓
- Fiducialisation of Quad Axis ✓

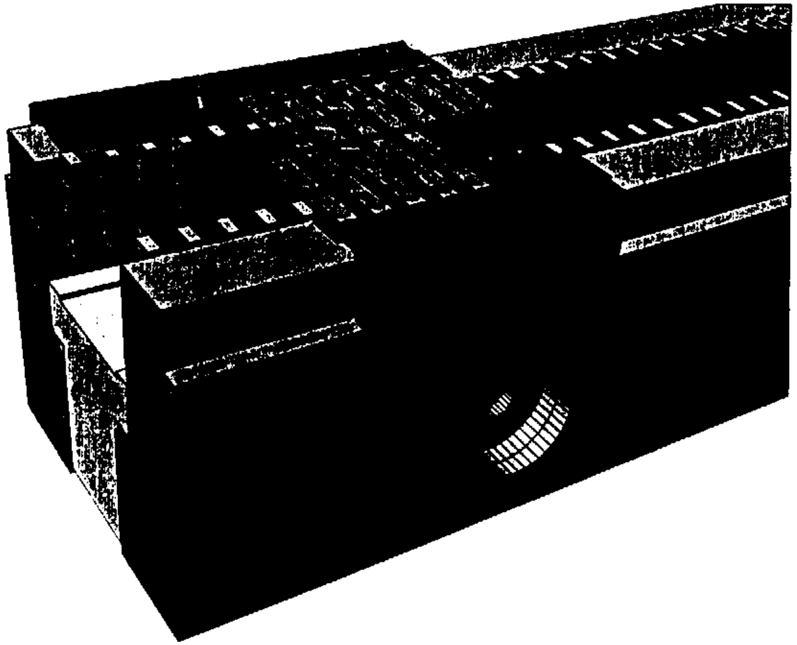
Time schedule 2. & 3. Module



Four Magnet Focusing Undulator (4MFU)



Pflüger



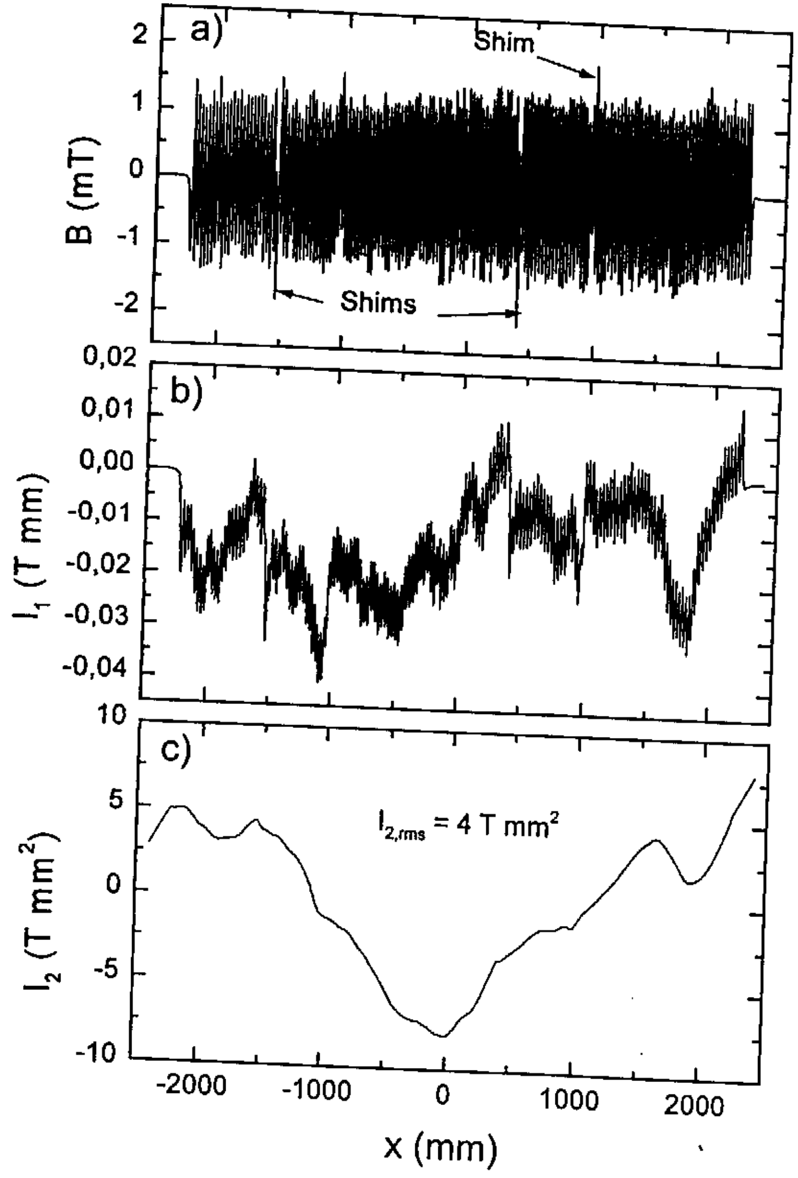


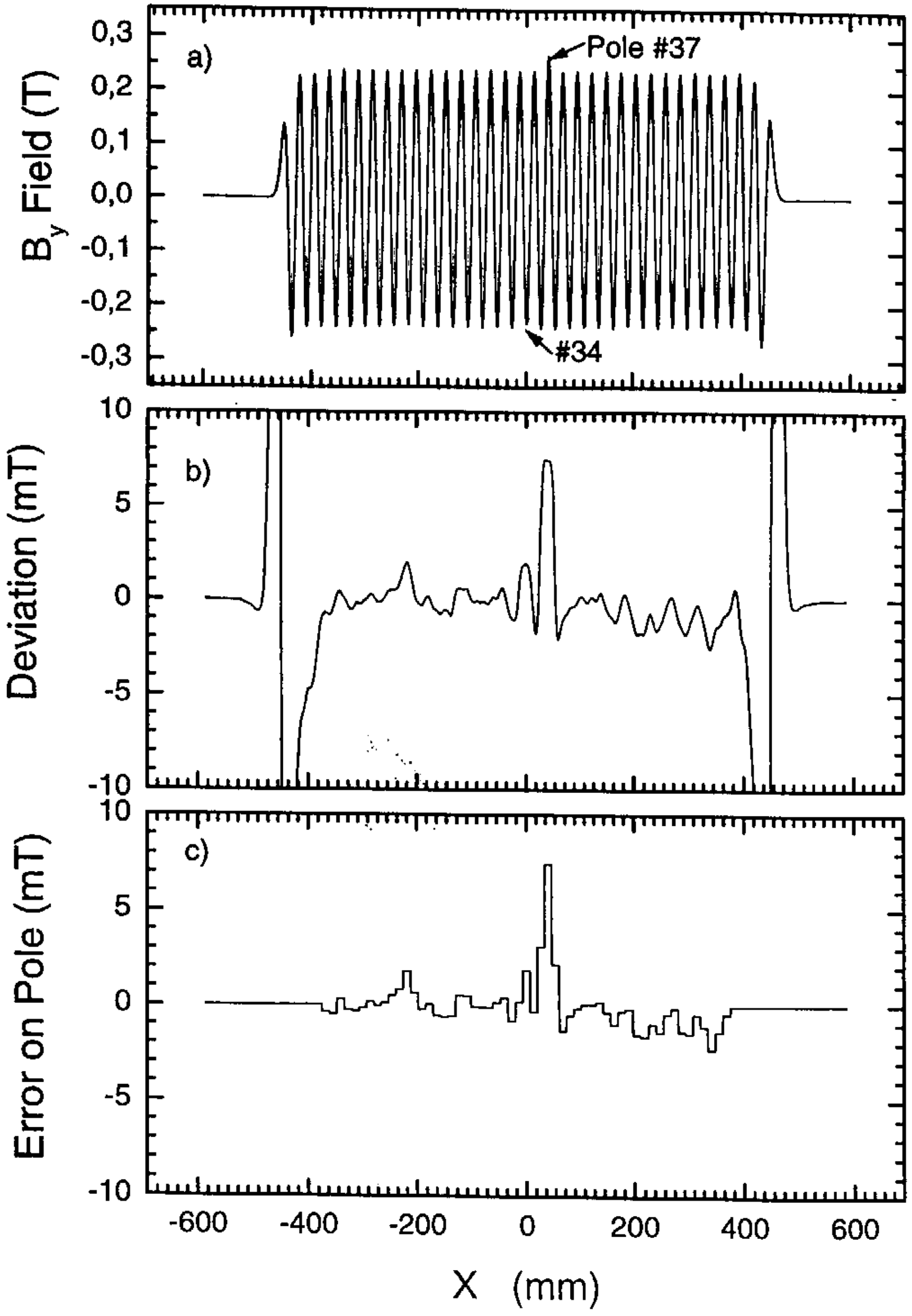
Fig 4

For constant Field $\bar{B}$:

$I_2 = \bar{B} \cdot \frac{x^2}{2}$; If $I_2 \simeq 10$ T mm²

$x \simeq 5$ m

$\bar{B} \simeq 0.8\,\mu T$



S_j : Field on j *th* Pole [T]

p_i : Shift of i *th* Pole [mm]

$a_{i,j}$: Norm. Field change on Pole j due to shift of pole i

$$
\begin{array}{llllllllllll}
S_1 & = & a_0 \cdot p_1 & + & a_1 \cdot p_2 & + & a_2 \cdot p_3 & +\ldots+ & a_{i-1} \cdot p_i & +\ldots+ & a_{N-1} \cdot p_N \\
S_2 & = & a_{-1} \cdot p_1 & + & a_0 \cdot p_2 & + & a_1 \cdot p_3 & +\ldots+ & a_{i-2} \cdot p_i & +\ldots+ & a_{N-2} \cdot p_N \\
S_3 & = & a_{-2} \cdot p_1 & + & a_{-1} \cdot p_2 & + & a_0 \cdot p_3 & +\ldots+ & a_{i-3} \cdot p_i & +\ldots+ & a_{N-3} \cdot p_N \\
\cdot & = & & & & & \cdot & & & & \cdot \\
\cdot & = & & & & & \cdot & & & & \cdot \\
S_j & = & a_{1-j} \cdot p_1 & + & a_{2-j} \cdot p_2 & + & a_{3-j} \cdot p_3 & +\ldots+ & a_{i-j} \cdot p_i & +\ldots+ & a_{N-j} \cdot p_N \\
\cdot & = & & & & & \cdot & & & & \cdot \\
\cdot & = & & & & & \cdot & & & & \cdot \\
S_N & = & a_{1-N} \cdot p_1 & + & a_{2-N} \cdot p_2 & + & a_{3-N} \cdot p_3 & +\ldots+ & a_{i-N} \cdot p_i & +\ldots+ & a_0 \cdot p_N
\end{array}
$$

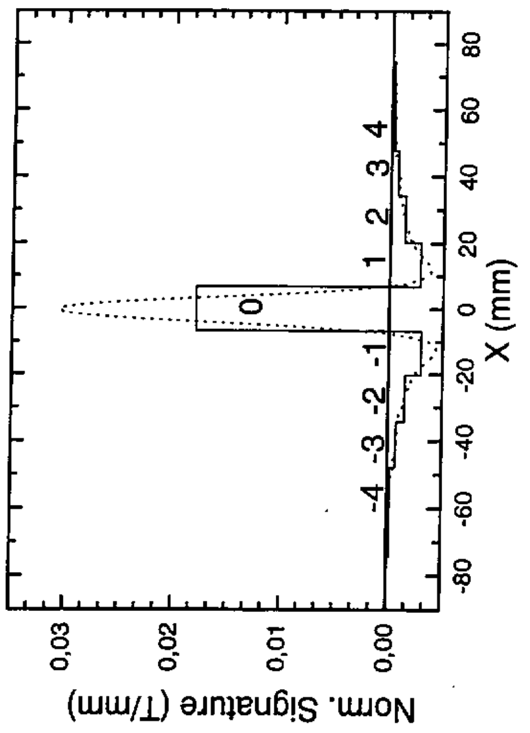
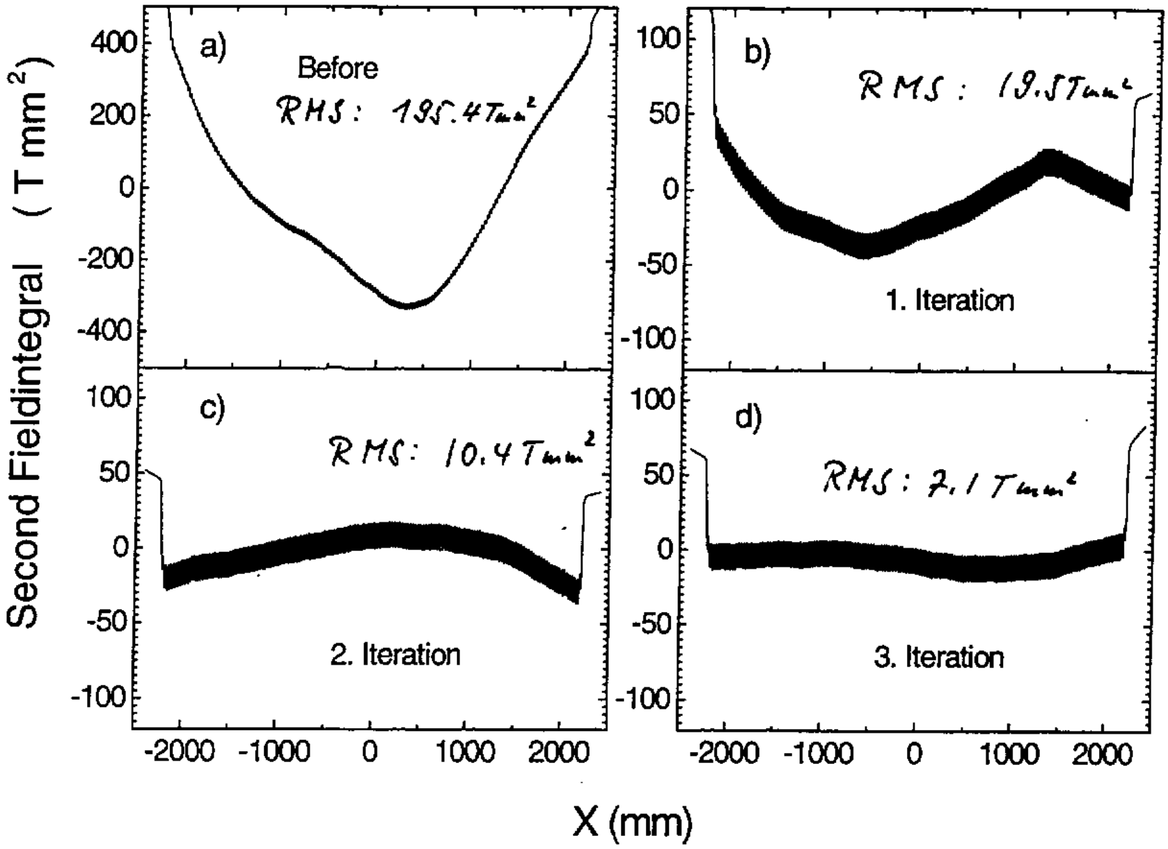
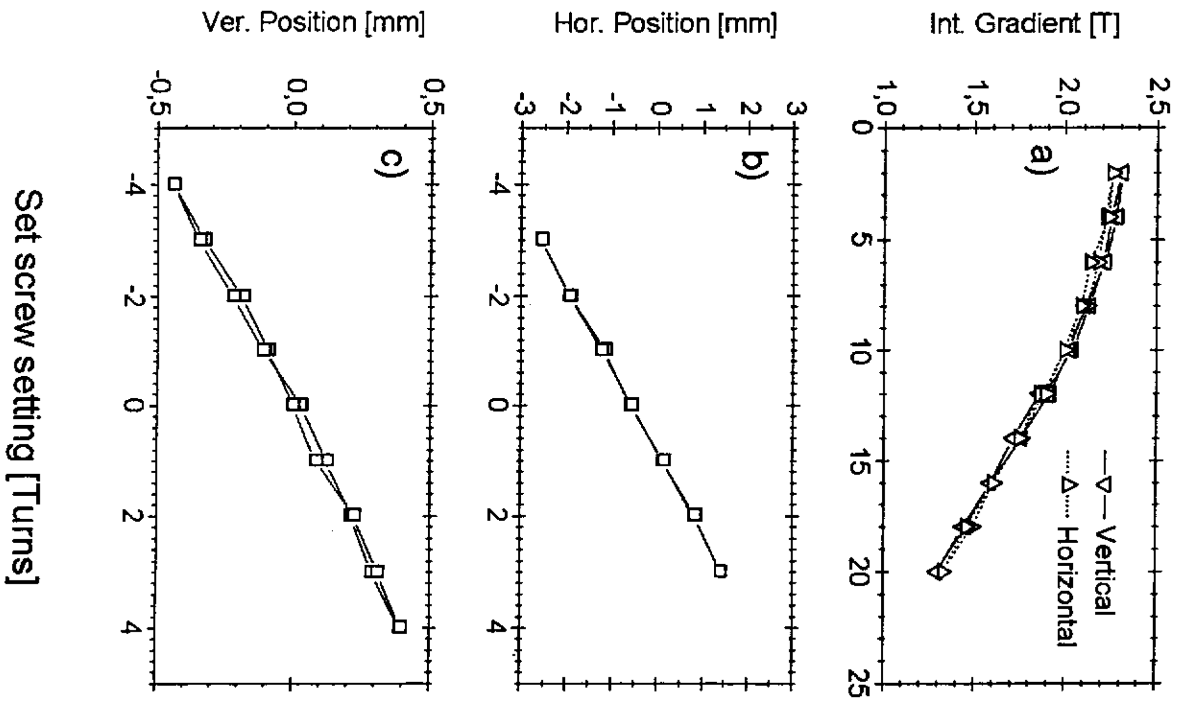


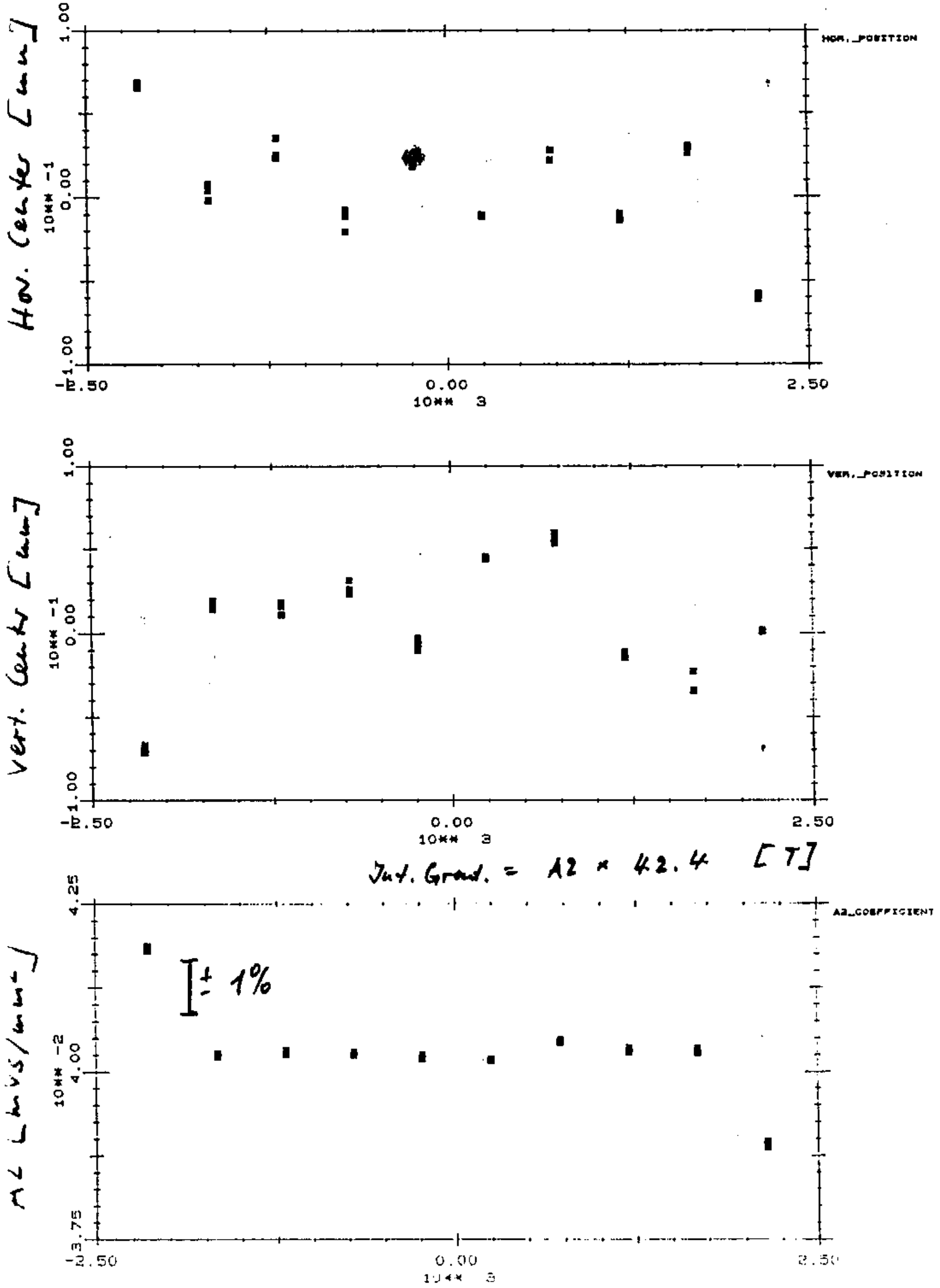
Fig 2

$\frac{1}{2}\cdot\left(\frac{\lambda}{2\pi}\right)\cdot 3. = 4.7\,\mathrm{Tmm}^2$



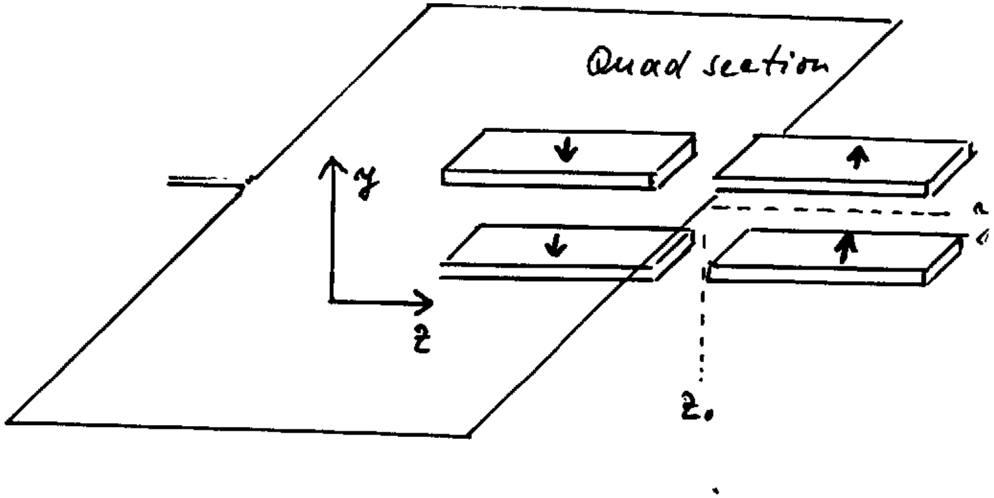


10.2.99



Int. Grad. = A2 × 42.4 [T]

The Rectangular Coil Method (RCM)



Flux through rectangular coil moving along y :

$$\Delta\Phi(y) = N \cdot L \cdot \int_{y_a}^{y} B_z(y') \cdot dy' = N \cdot L \cdot g \cdot \tfrac{1}{2}\left((y-y_0)^2 - (y_a - y_0)^2\right)$$

$$B_z(y) = -g \cdot (y - y_0)$$

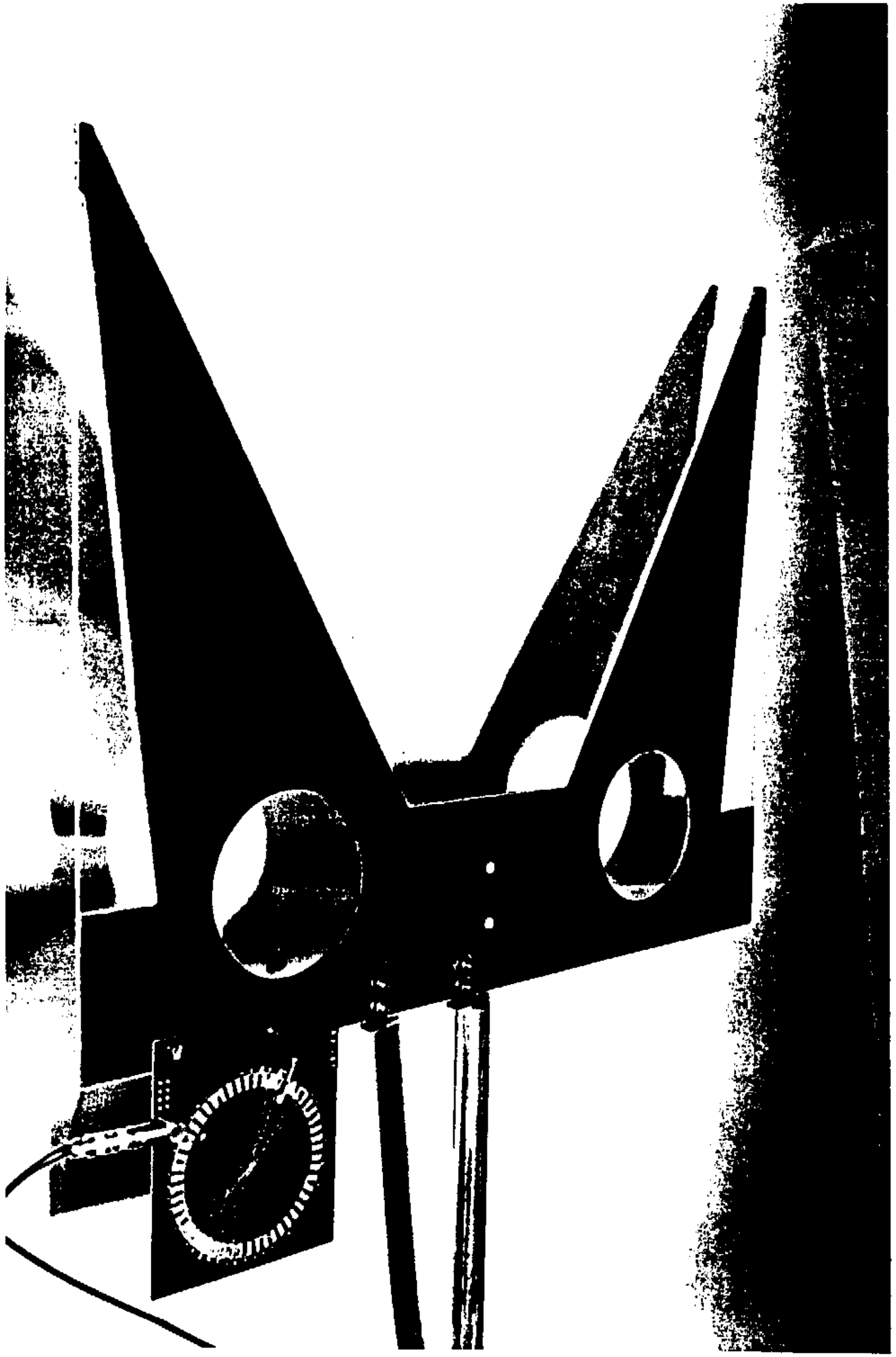
same coil moving along z :

$$\Delta\Phi(z) = N \cdot L \cdot \int_{Z_a}^{Z} B_y(z') \cdot dz' = N \cdot L \cdot g \cdot \tfrac{1}{2}\left((z-z_0)^2 - (z_a - z_0)^2\right)$$

$$B_y(z) = g \cdot (z - z_0)$$

Polynomial Fit: $\Phi_{y,z} = a \cdot (y,z)^2 + b \cdot (y,z) + c \Longrightarrow (y_0, z_0) = -b/2 \cdot a \;\; ; \;\; g = 2 \cdot a / L \cdot N$

g	field gradient
L	effective quad length
y_a, z_a	Start point
y_0, z_0	quad center
N	Number of turns (49)
L_{Coil}	Coil length (327.6)
w_{Coil}	width of coil (330mm)



Time Schedule 1-3-99

1. Undulator Module finished (good News)

2. & 3. Modules to be finished (bad News)

Estimated time for one Module :
5-6 weeks, now that all problems are solved

→ End of May 99 for all three
Modules to be finished

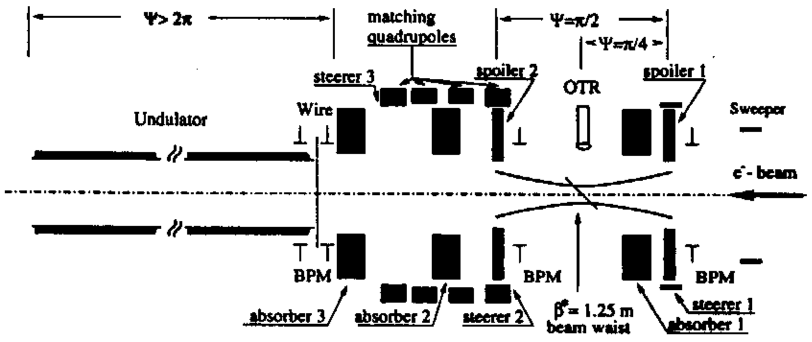
Collimator Section

Holger Schlarb
March 1, 1999

- Overview
- Status of the components
- Beam loss detection
- Installation scadule

Main Features of the Collimator System

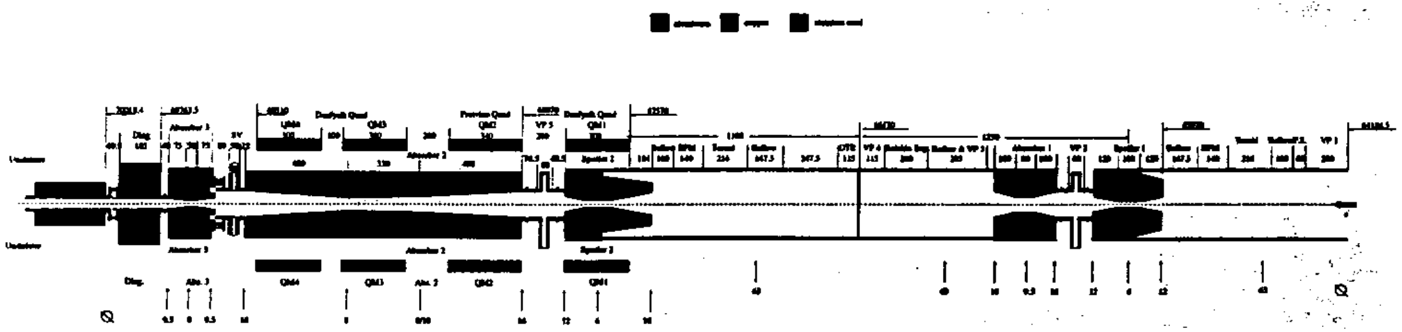
Scheme collimator section

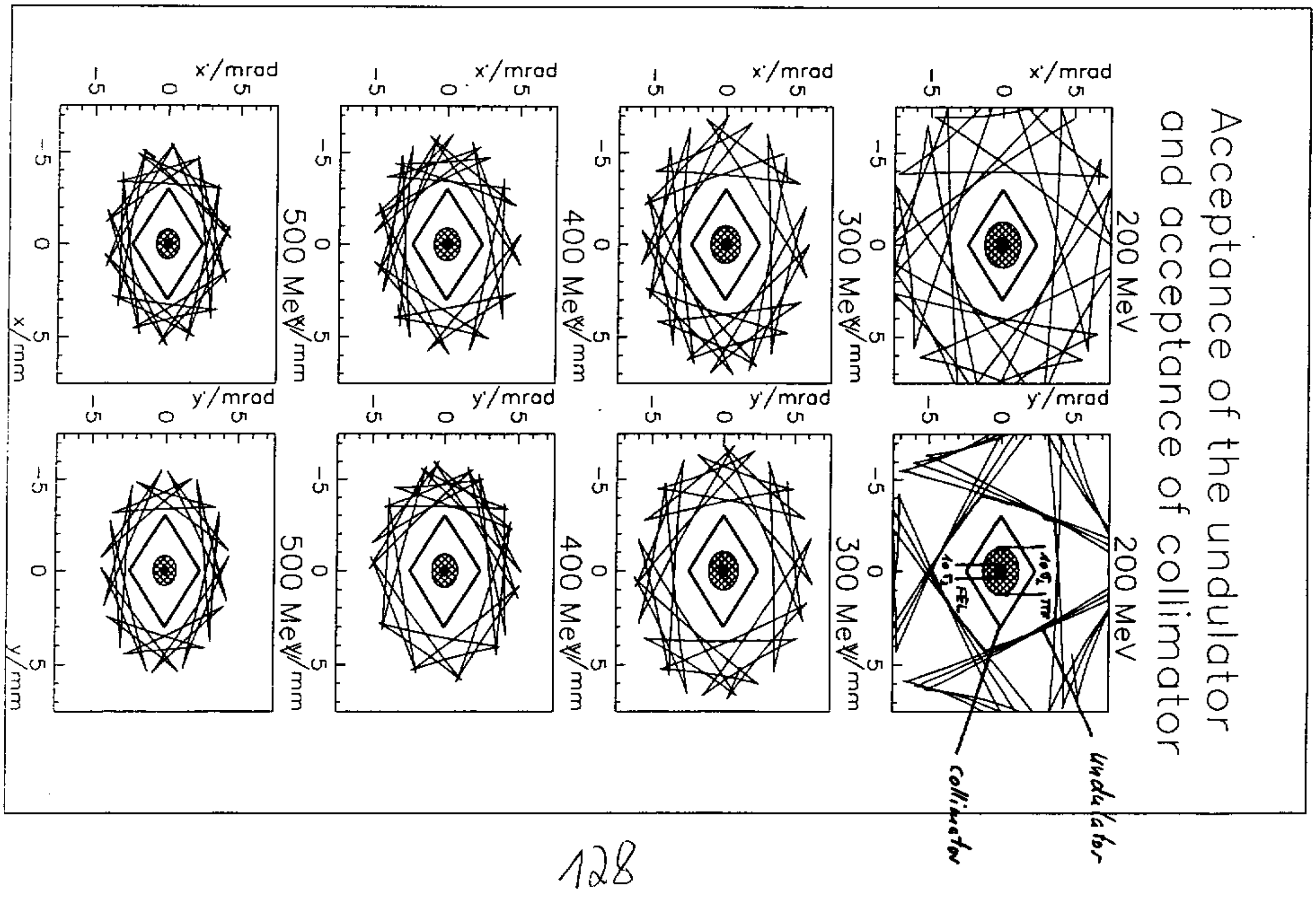


- Type: Two stage spoiler/absorber system
  primary particles are intercepted by spoilers (Al)
  secondary particles are absorbed by absorber system (Cu)
- Possible variation of beam energy $E_0 = 200\text{-}500$ MeV
- Full performance of the collimator within an energy width of $\Delta E_0/E_0 = 3$ %
- Diameter of spoilers $g = 6$ mm
  $\leftrightarrow$ $8.3\,\sigma_\perp$ at 200 MeV TTF-beam parameters
- Optic
  - design $\beta^*_{x,y} = 1.25$ m at OTR-screen
    → maximum transition
  - functionality of collimator independent of the beam optic
  - maximum variation of beam cross-section at the OTR-screen $\sigma_\perp^{max}/\sigma_\perp^{min} \geq 5$ for all energies
    → accurate measurement of β-function

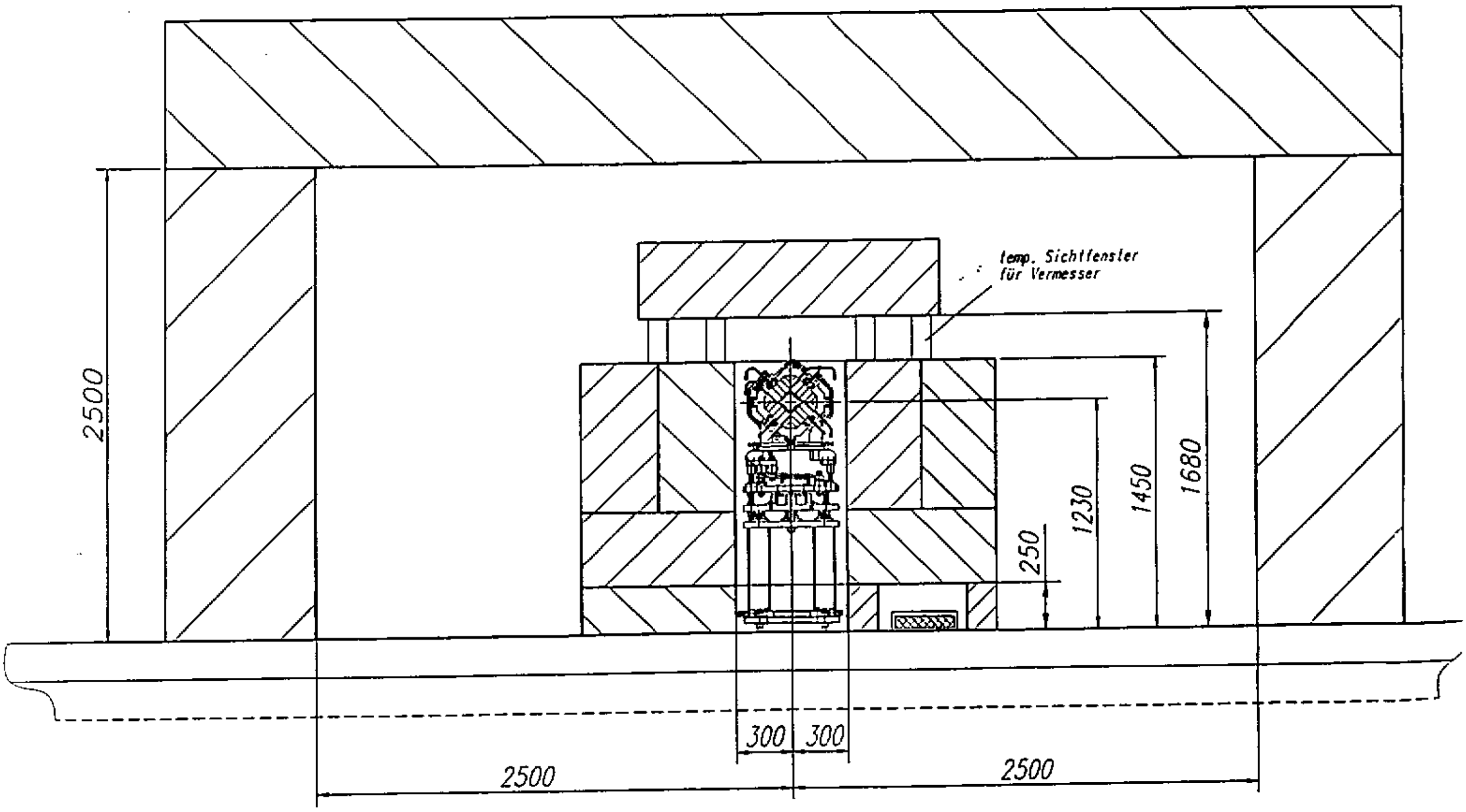
Collimator System

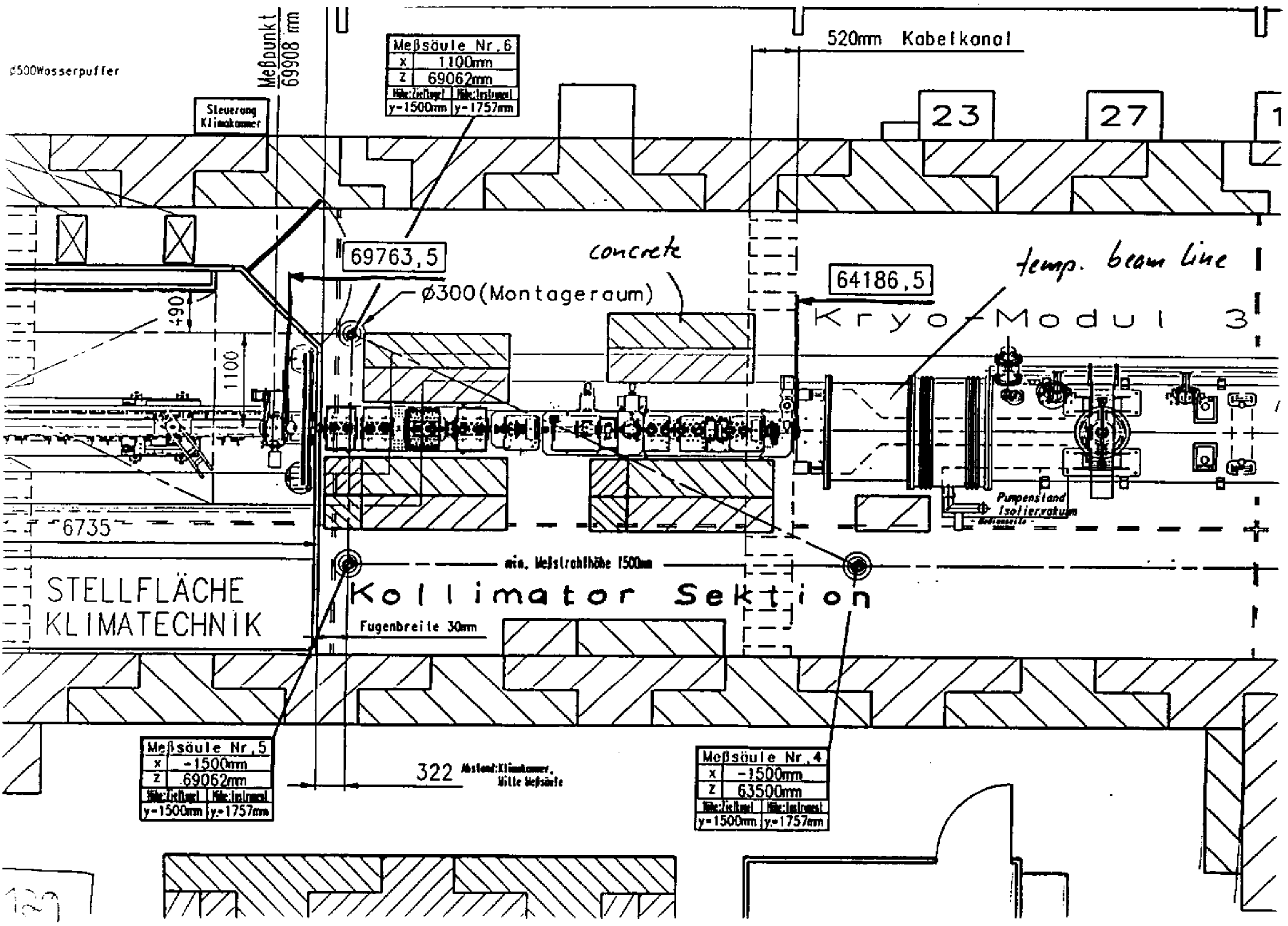
01.11.98

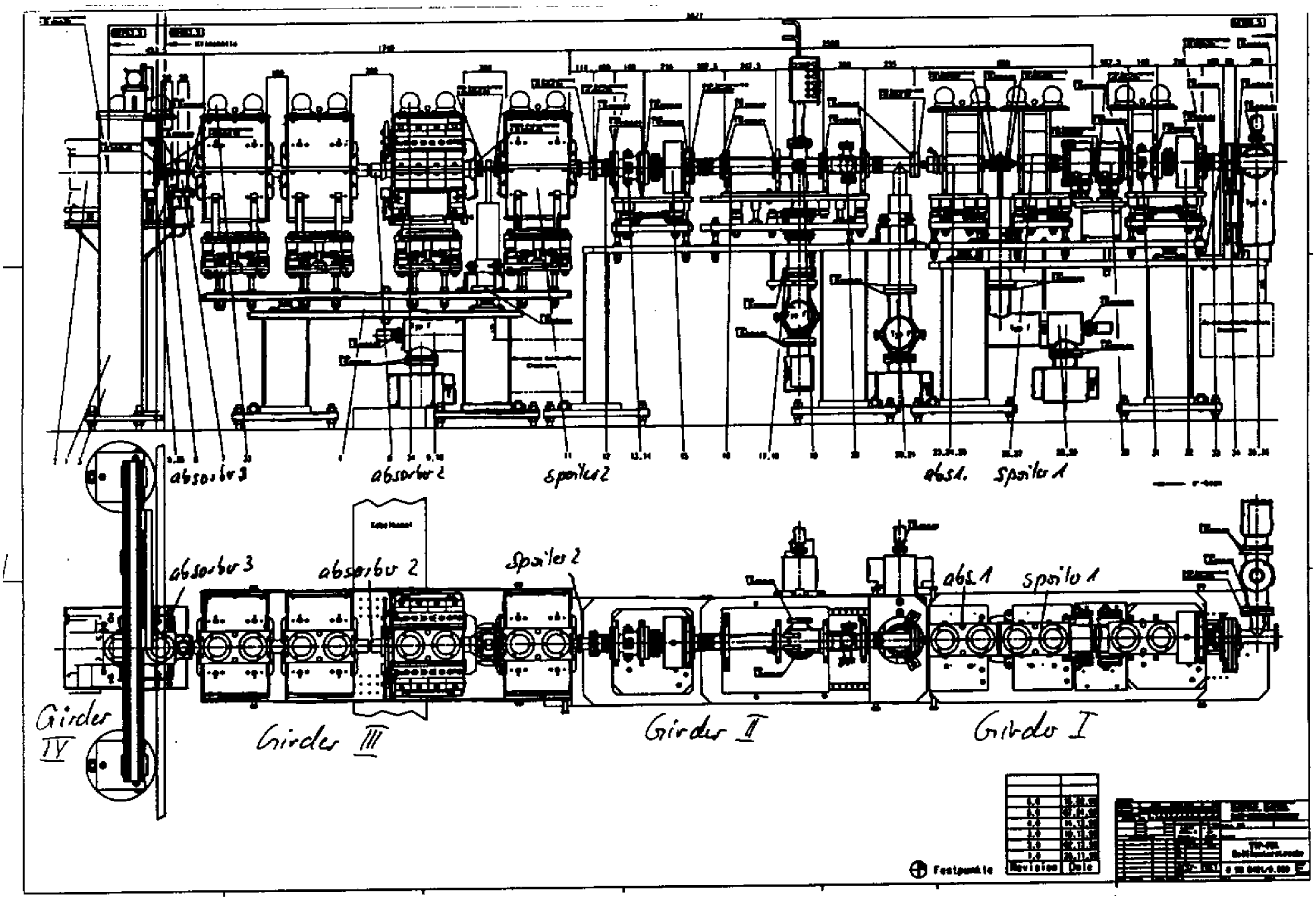


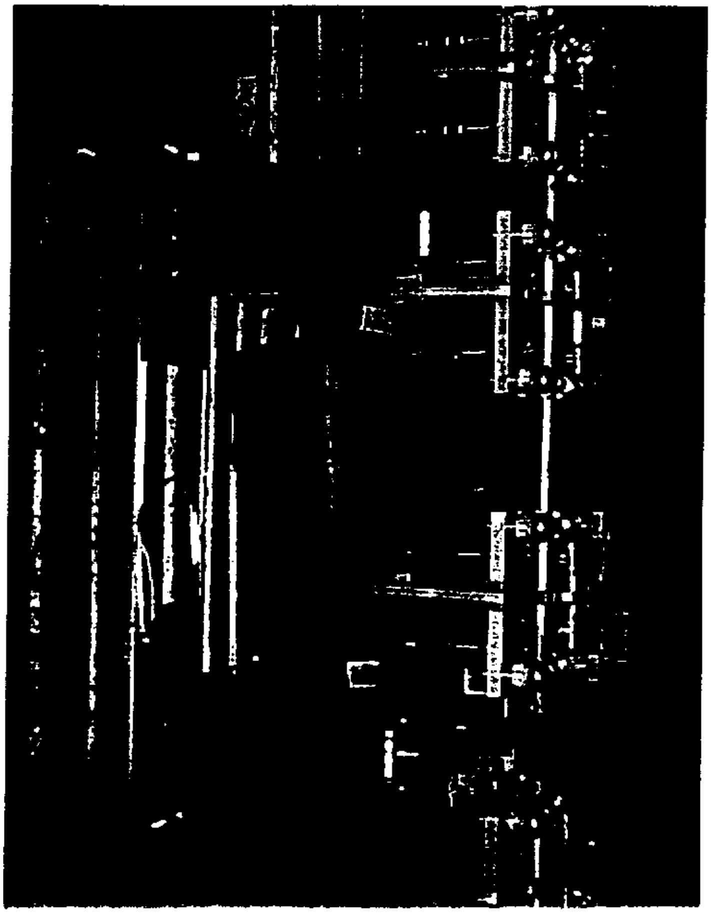


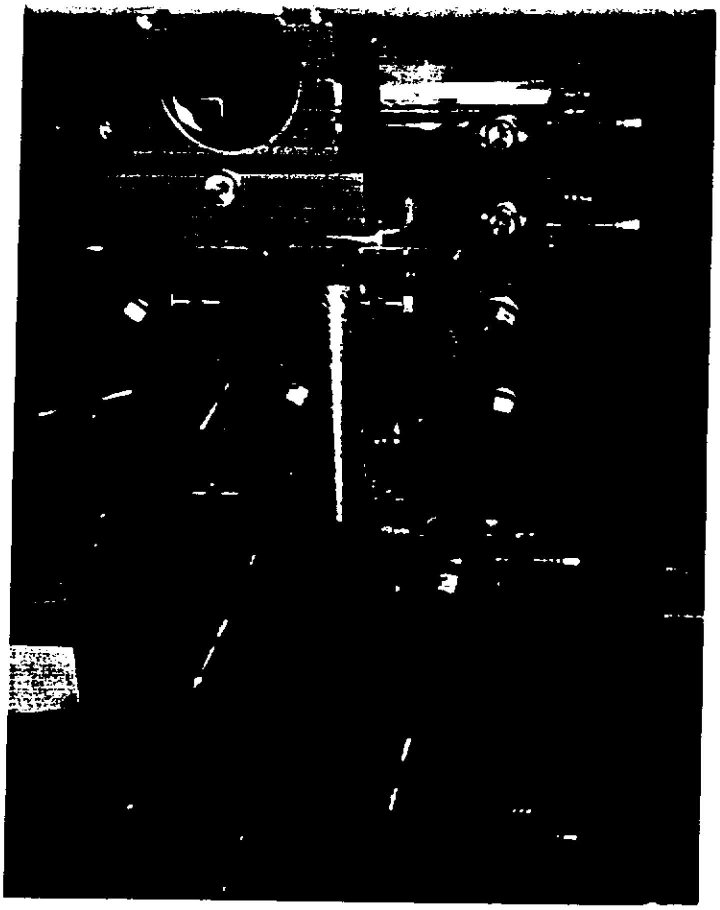
Schnitt B-B (M 1:20)

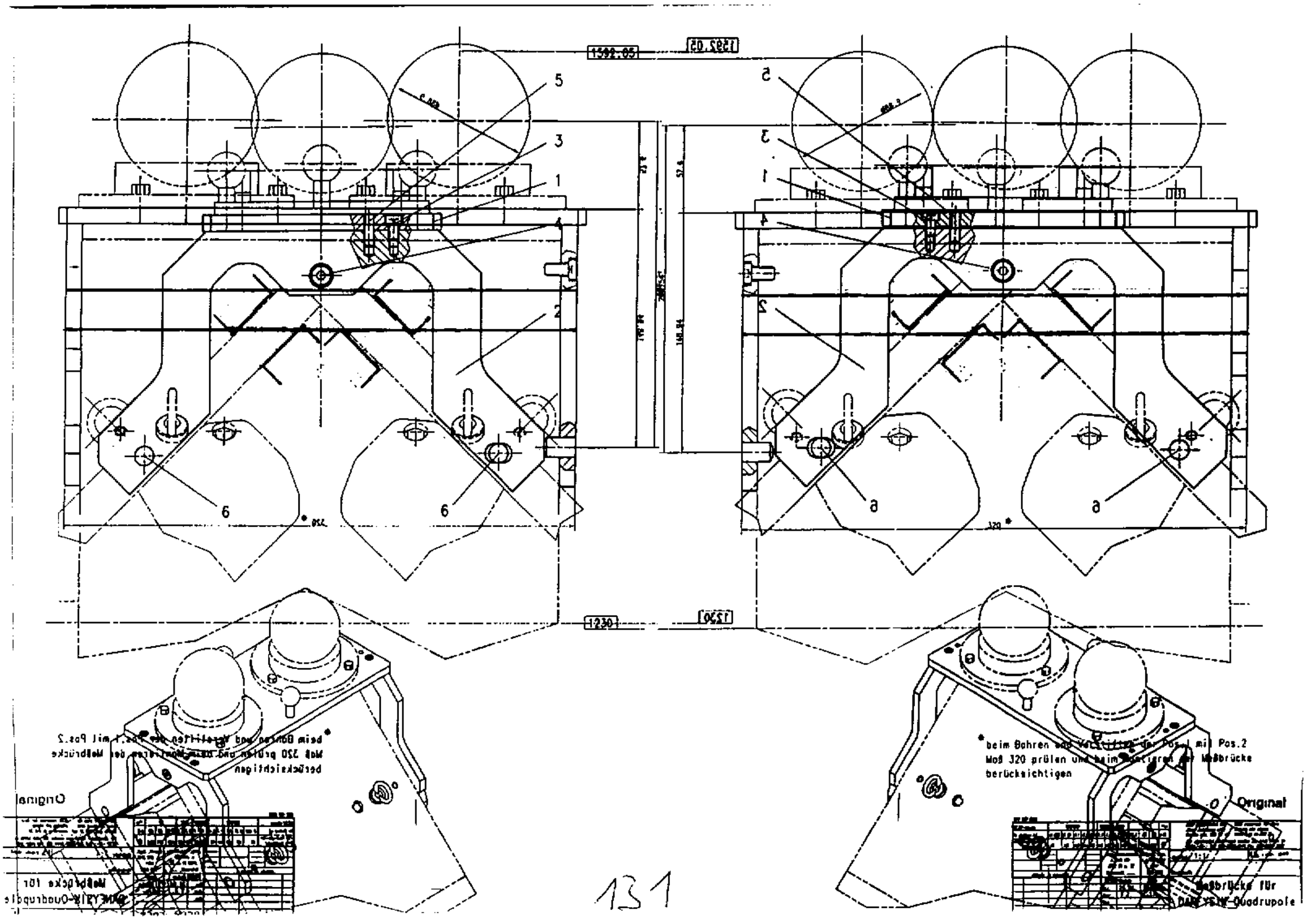




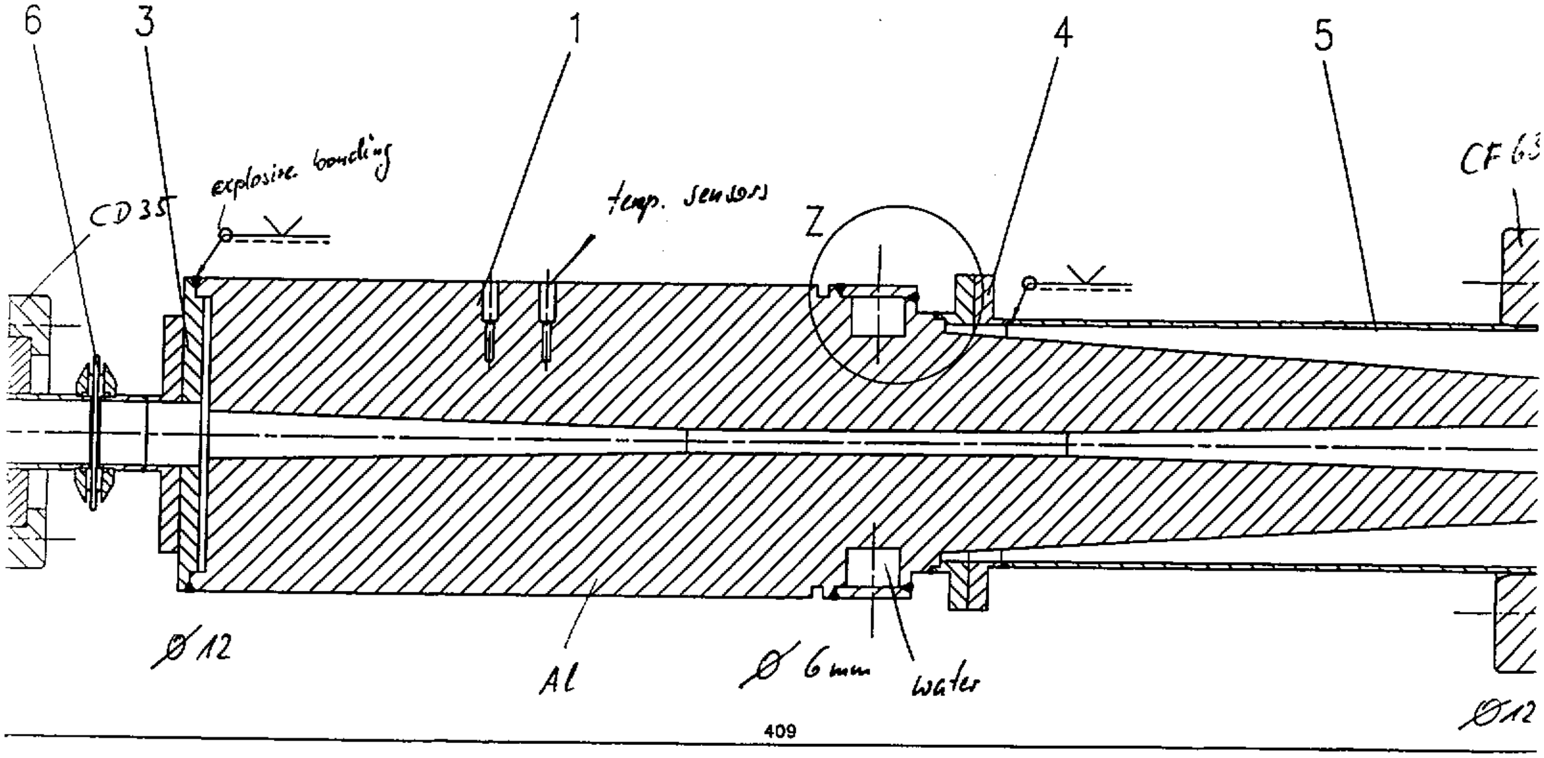

absorber 3
absorber 2
spoiler 2
abs. 1
spoiler 1
Girder IV
absorber 3
absorber 2
spoiler 2
abs. 1
spoiler 1
Girder III
Girder II
Girder I
Revision
Date
Festpunkte



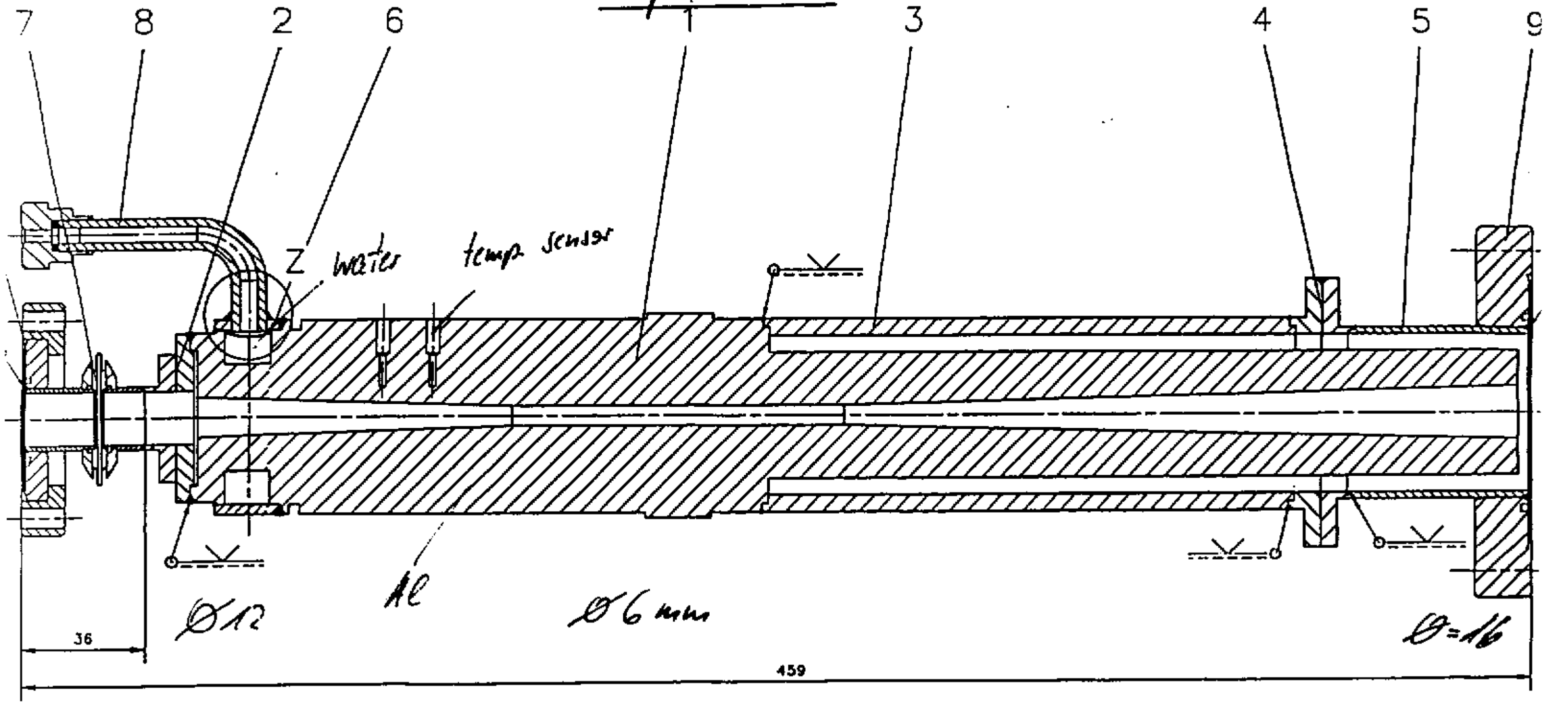


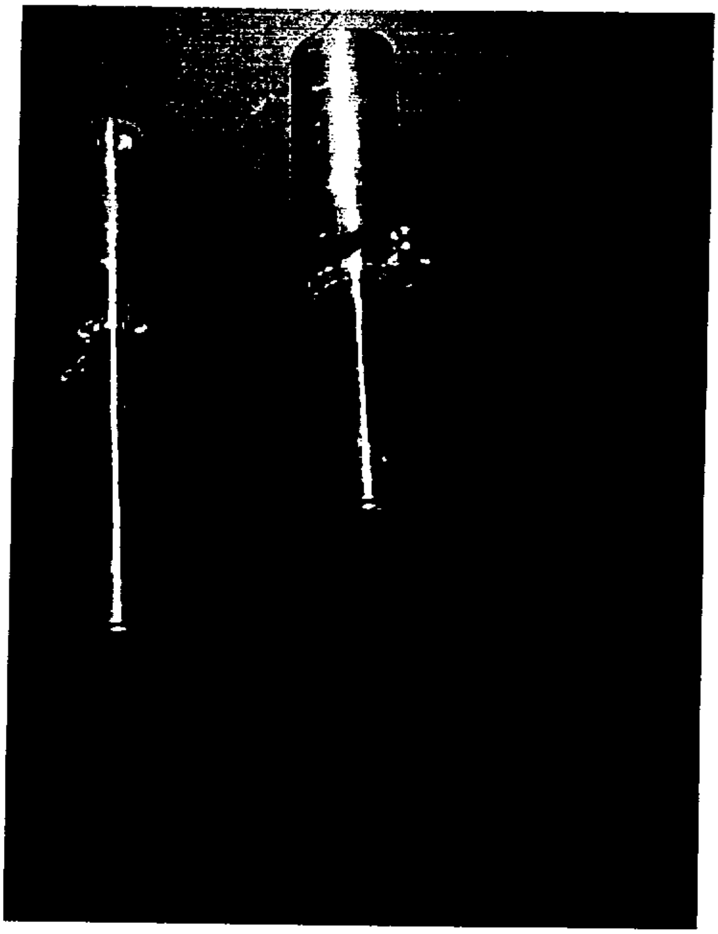

1590.05
1592.05
5
3
1
4
2
6
6
320
1230
1230
*beim Bohren und Verstiften der Pos.1 mit Pos.2
Maß 320 prüfen und beim Montieren der Meßbrücke
berücksichtigen
Original
Meßbrücke für
DANFYSIK-Quadrupole

Spoiler 1

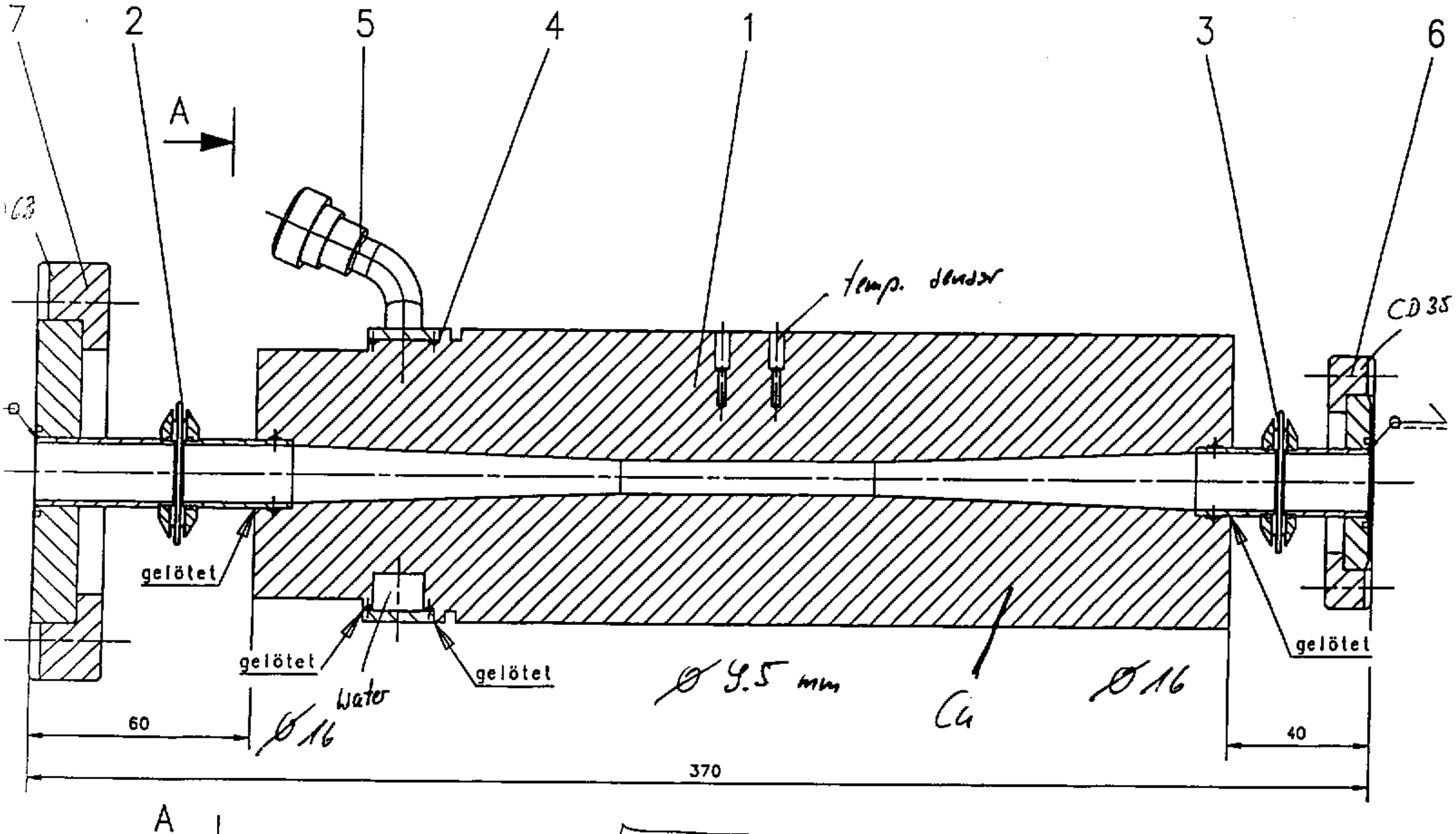


Spoiler 2

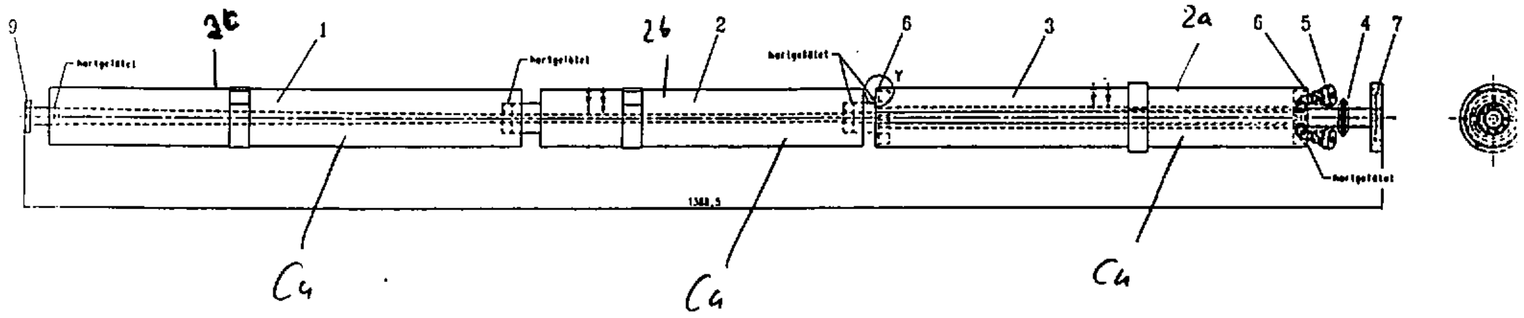


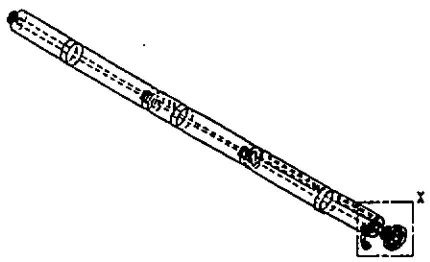


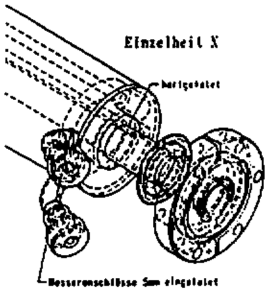
Absorber 1

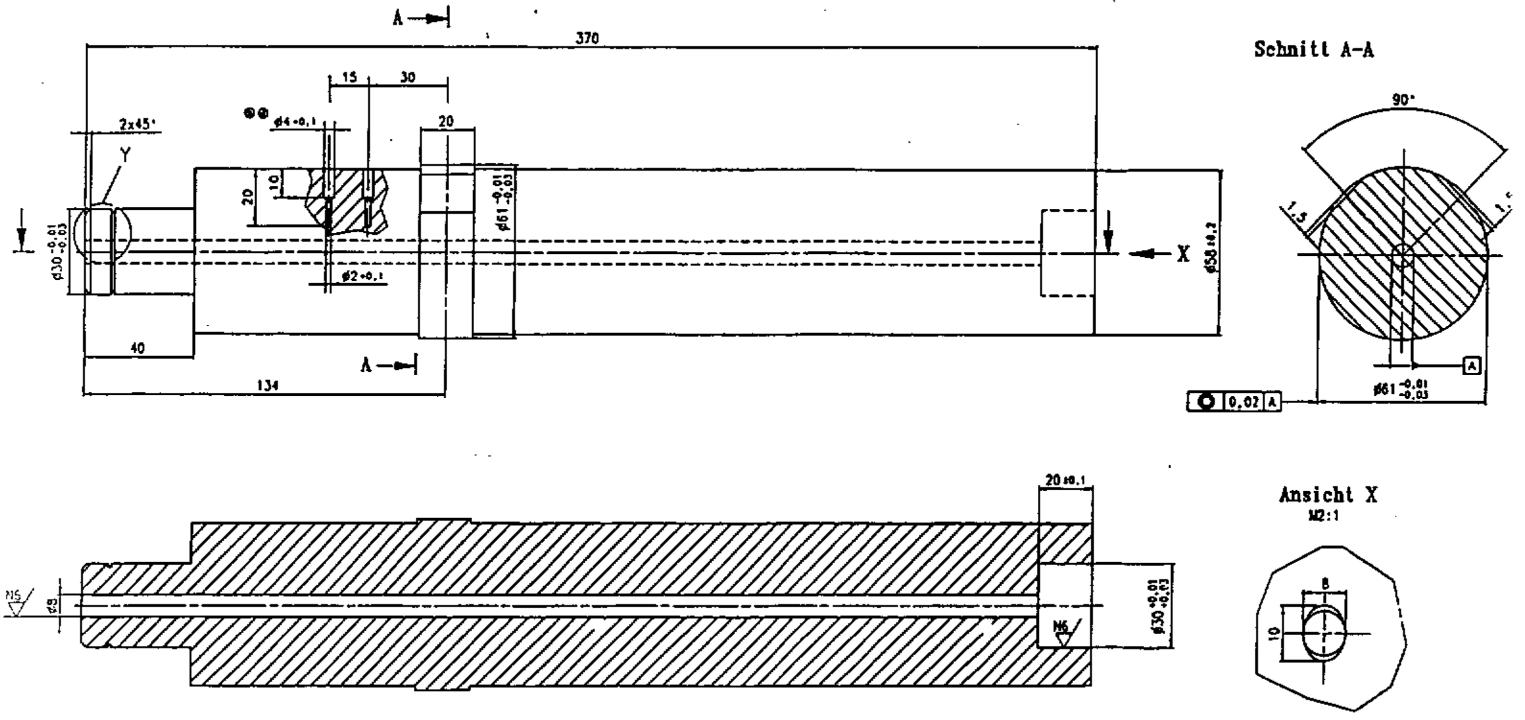

7
2
5
4
1
3
6
A
C3
temp. sensor
CD35
gelötet
gelötet
gelötet
gelötet
water
Ø 9.5 mm
Cu
Ø16
Ø16
60
40
370
A

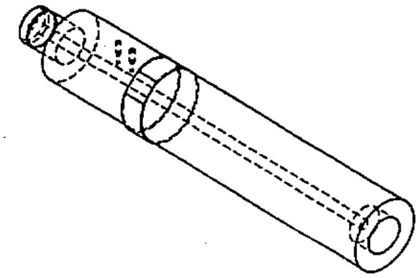
Absorber α

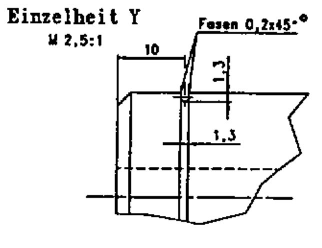












Alle Kanten gebrochen

N8 (N6)

Original

Maßstab: 1:1 2,5:1

Werkstoff: OF-Cu

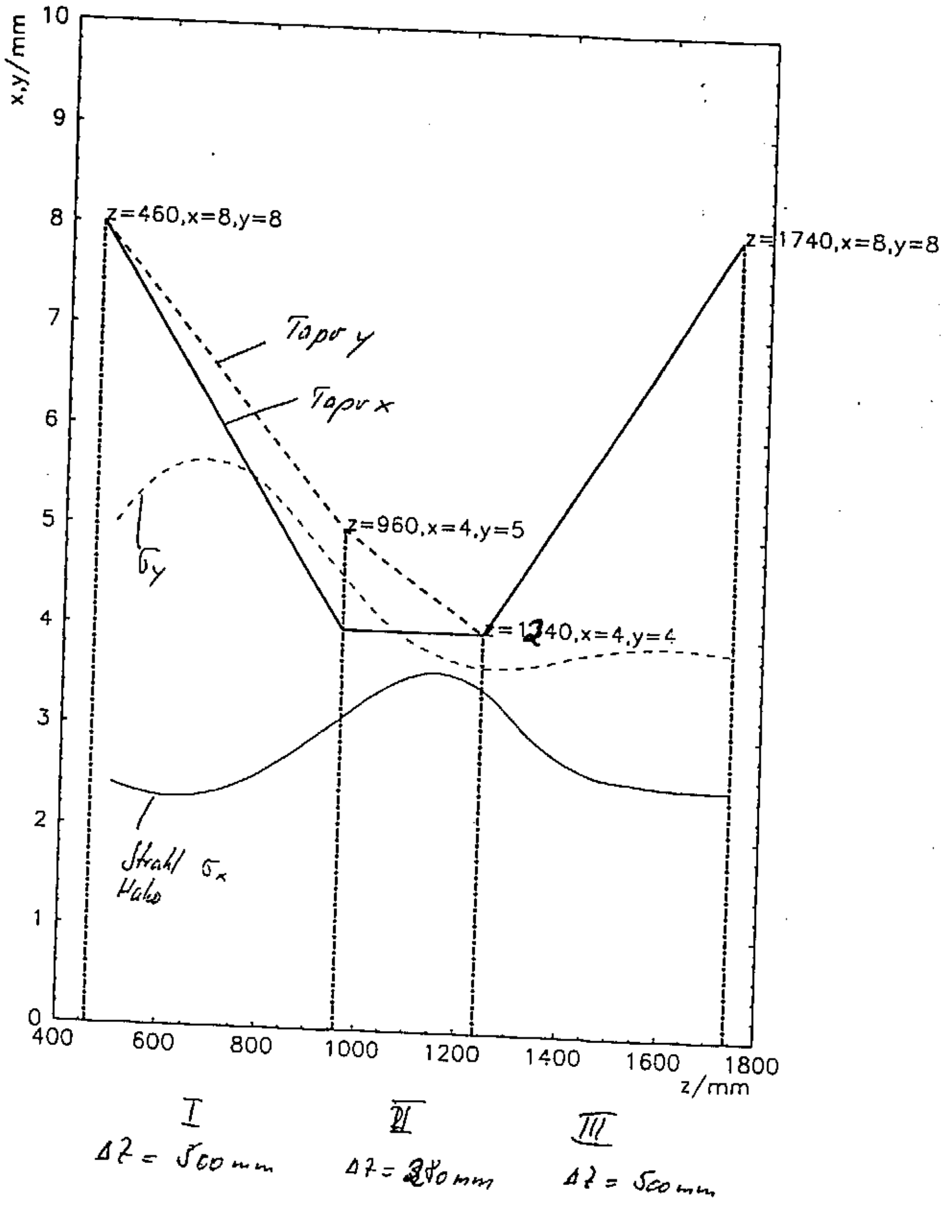
1990 Datum Name

Bearb. 07.09 Greulich

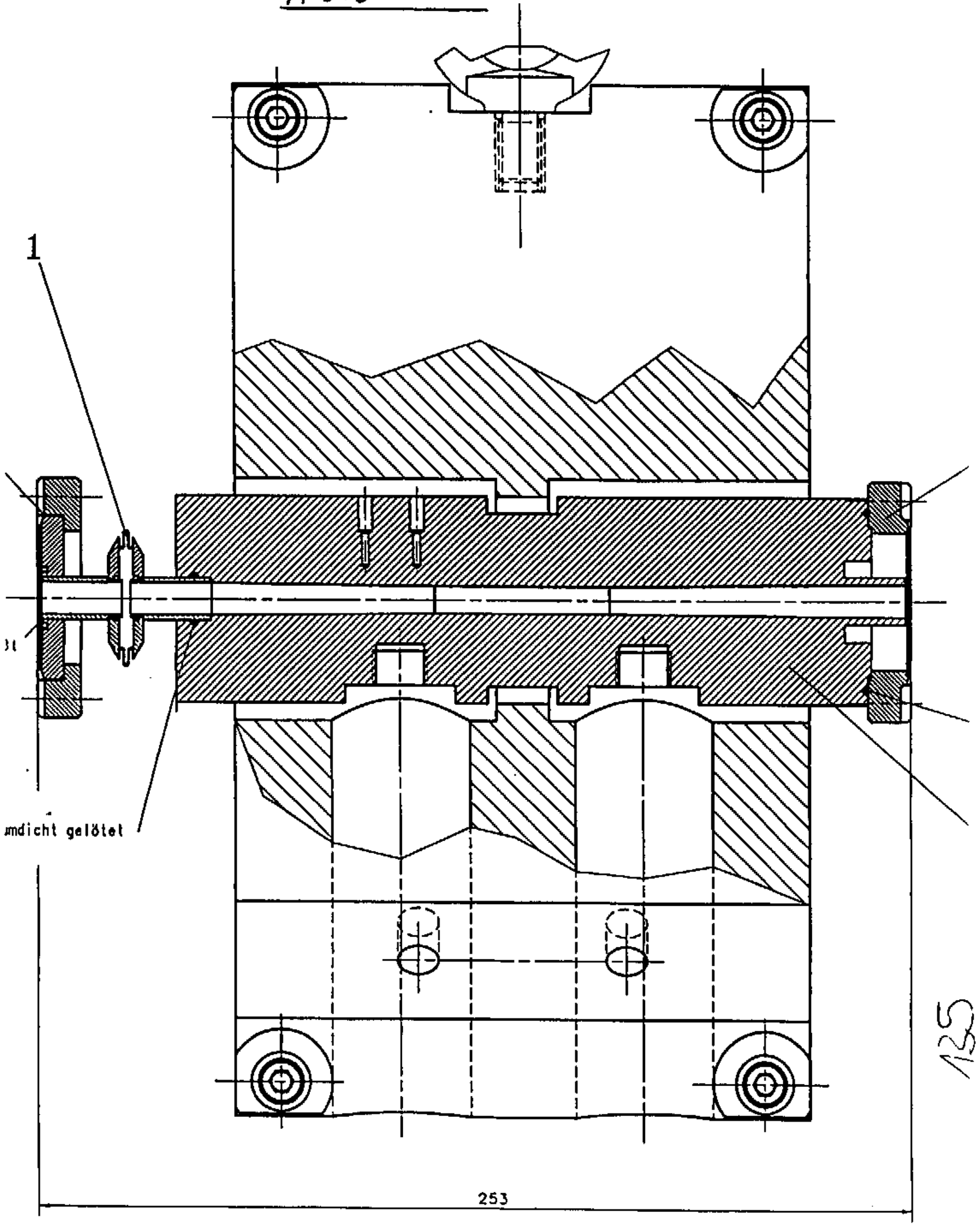
Absorberteilstück 2

z = 0

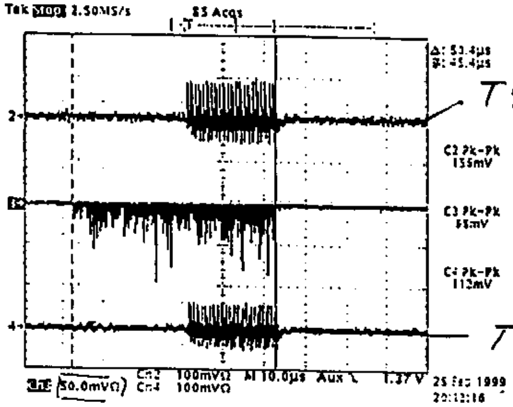
z = 500



Absorber 3



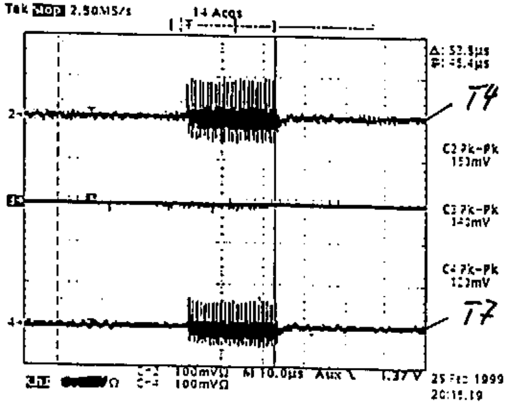
Beam loss detection by photomultiplier



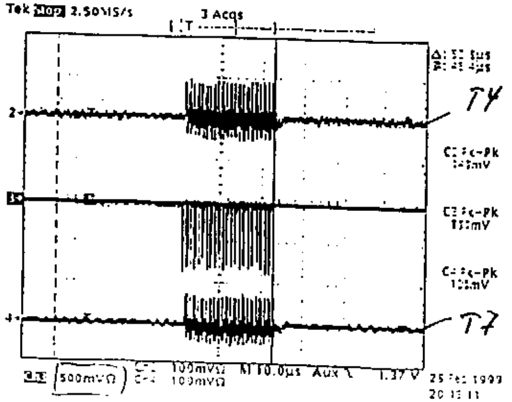
T4 (toroid)

dark current from gun

T7 (toroid)



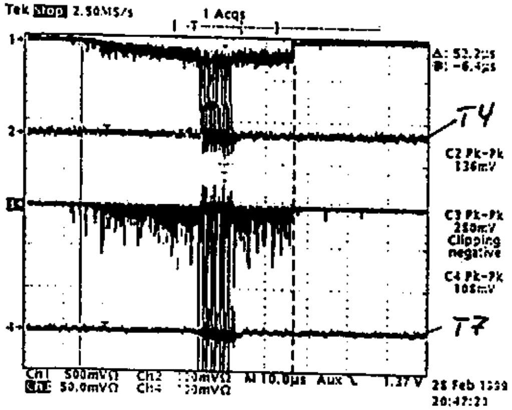
same as above



View screen in

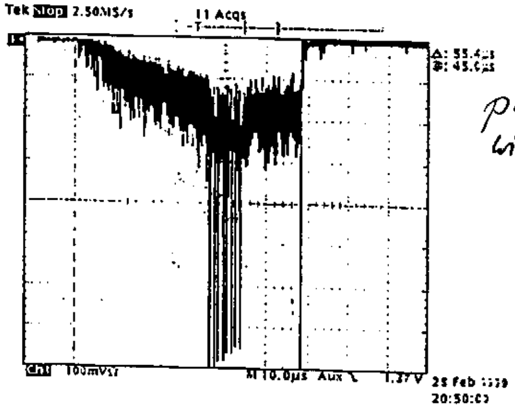
beam N=22

Different photomultiplier type



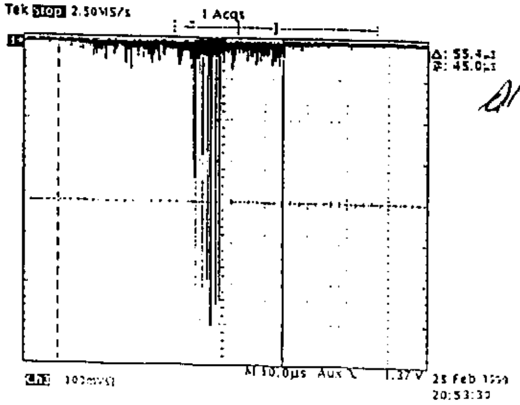
(1)

(c)



(C)

photomultiplier with scintillator

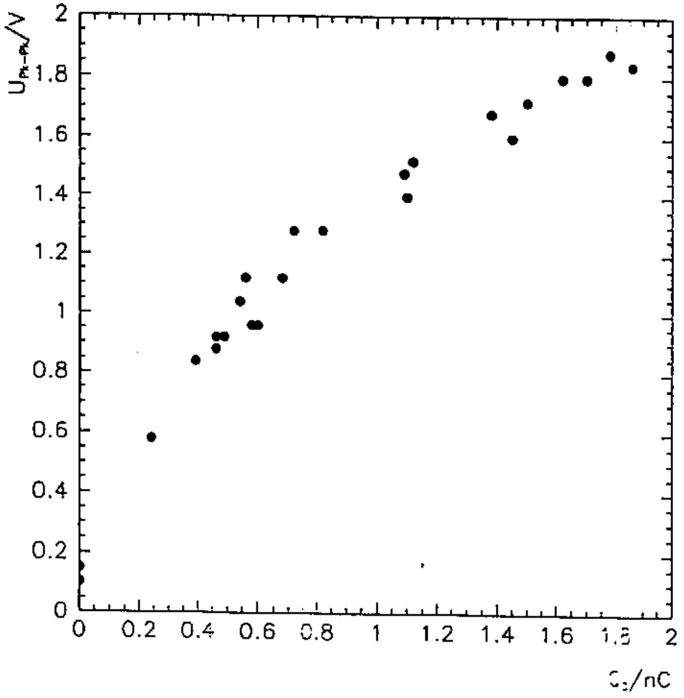


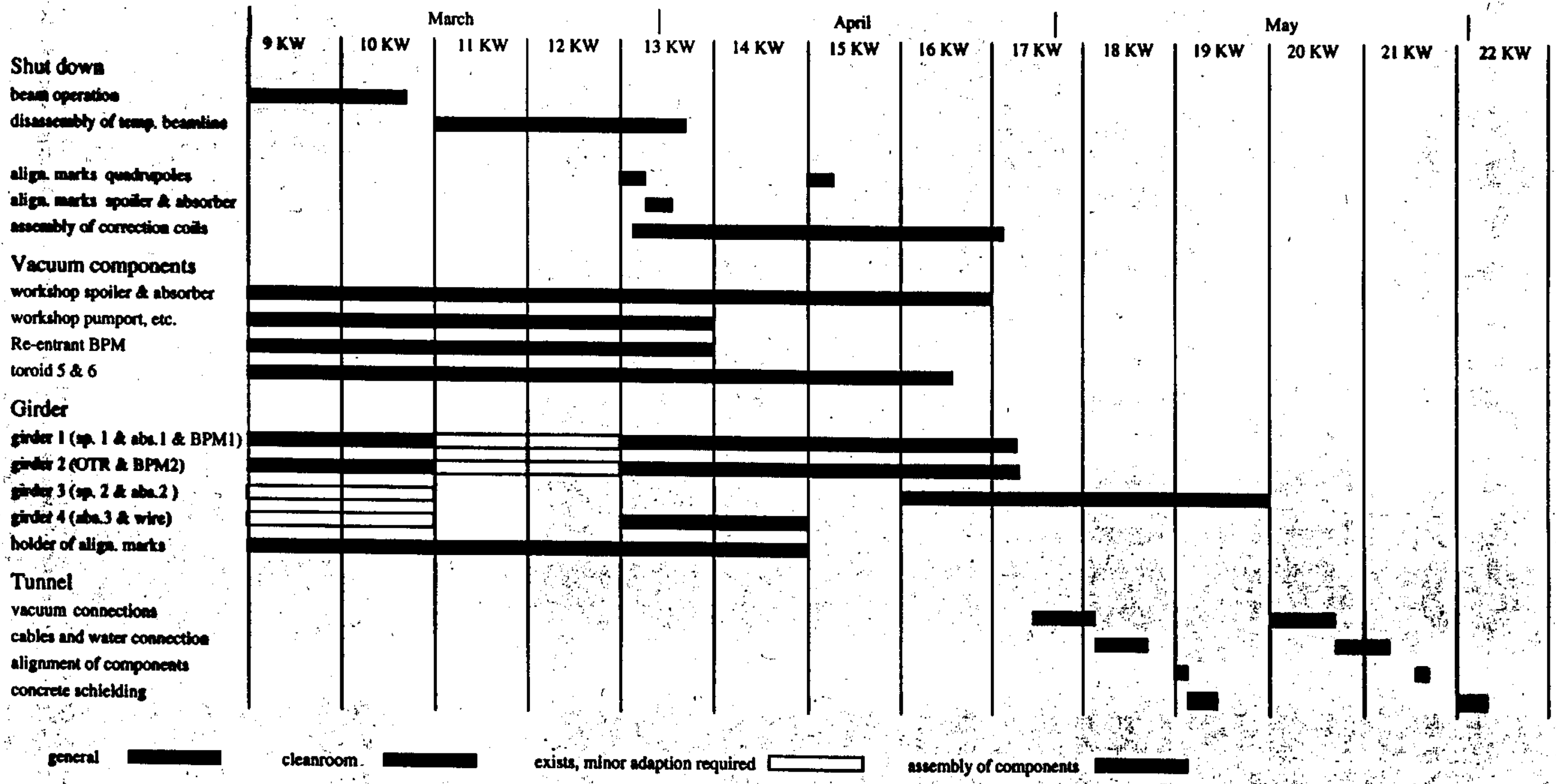
(B)

Al- coated

Photomultiplier signal versus current

Photomultiplier Voltage	U = 1.1 kV
Number of bunches	N = 10
Number of lead bricks	M = 1 (5 cm)
Screen	1EXP1




March
April
May
9 KW
10 KW
11 KW
12 KW
13 KW
14 KW
15 KW
16 KW
17 KW
18 KW
19 KW
20 KW
21 KW
22 KW
Shut down
beam operation
disassembly of temp. beamline
align. marks quadrupoles
align. marks spoiler & absorber
assembly of correction coils
Vacuum components
workshop spoiler & absorber
workshop pumport, etc.
Re-entrant BPM
toroid 5 & 6
Girder
girder 1 (sp. 1 & abs.1 & BPM1)
girder 2 (OTR & BPM2)
girder 3 (sp. 2 & abs.2)
girder 4 (abs.3 & wire)
holder of align. marks
Tunnel
vacuum connections
cables and water connection
alignment of components
concrete schielding
general
cleanroom
exists, minor adaption required
assembly of components

Electron Diagnostics for FEL
Physics requirements and expected performance

Pedro Castro / MPY

1. **Beam current monitors**
2. **Beam position monitors**
3. **Transverse emittance monitors**
4. **Bunch length monitors**

Beam transmission

Danger:

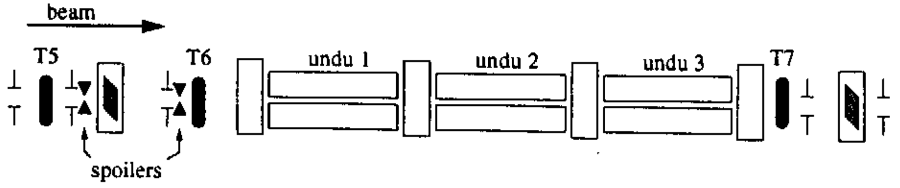
- high peak energy losses in collimators
  ⟶ cracks in material
  (collimator chamber with a minimum of d=6 mm)
- irradiation of permanent magnets
  ⟶ loss of magnetization
  (undulator chamber: d=9.5 mm and 15 m long)

Requirements:

- meas. of transmission loss up to 1%
- fast inhibit signal if transmission losses

Saclay current monitors

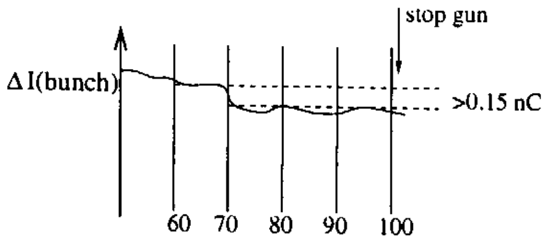
J. Fuselliu. J.M. Joly, M. Jablonka/Saclay



- were designed for injector 1, adapted to 1 MHz
- lab. test resolution 0.1 nC, with beam >0.1 nC
- 9 MHz: it would require change toroids

Fast differential security system

- works at 100 kHz (every 10 bunches)
- between pairs of toroids, for example: T3-T7, T4-T6
- if diff.> 0.15 nC during 30 bunches. stop laser in 5 μs
- first test in July



Beam trajectory

Needed:

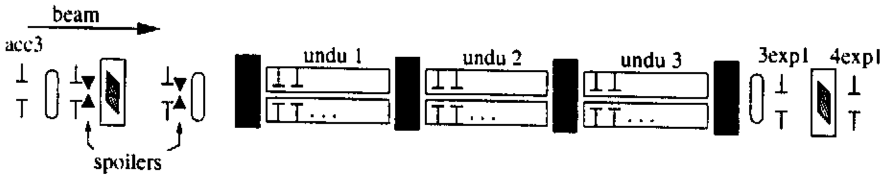
- for collimation of beam halo:
  centering of beam at spoilers ~ 0.2-0.5 mm
- for amplification of photon beam (SASE):
  beam alignment along undulator ~ 10-20 μm

Requirements:

- high accuracy on absolute beam position
- high resolution + beam based alignment

Scheme:

- BPMs in undulator
- diagnostic blocks → absolute reference
- other BPMs



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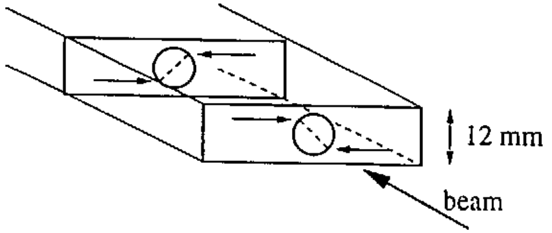
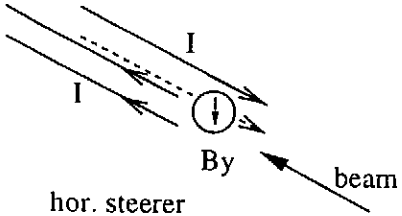
BPMs IN UNDULATOR

Requirement: 1-2 μm resolution (averaged over one pulse)

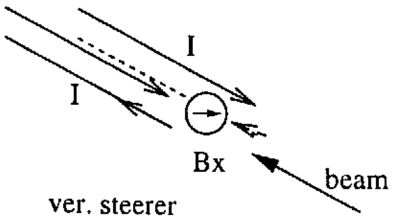
Vacuum chamber

U. Hahn/Argonne



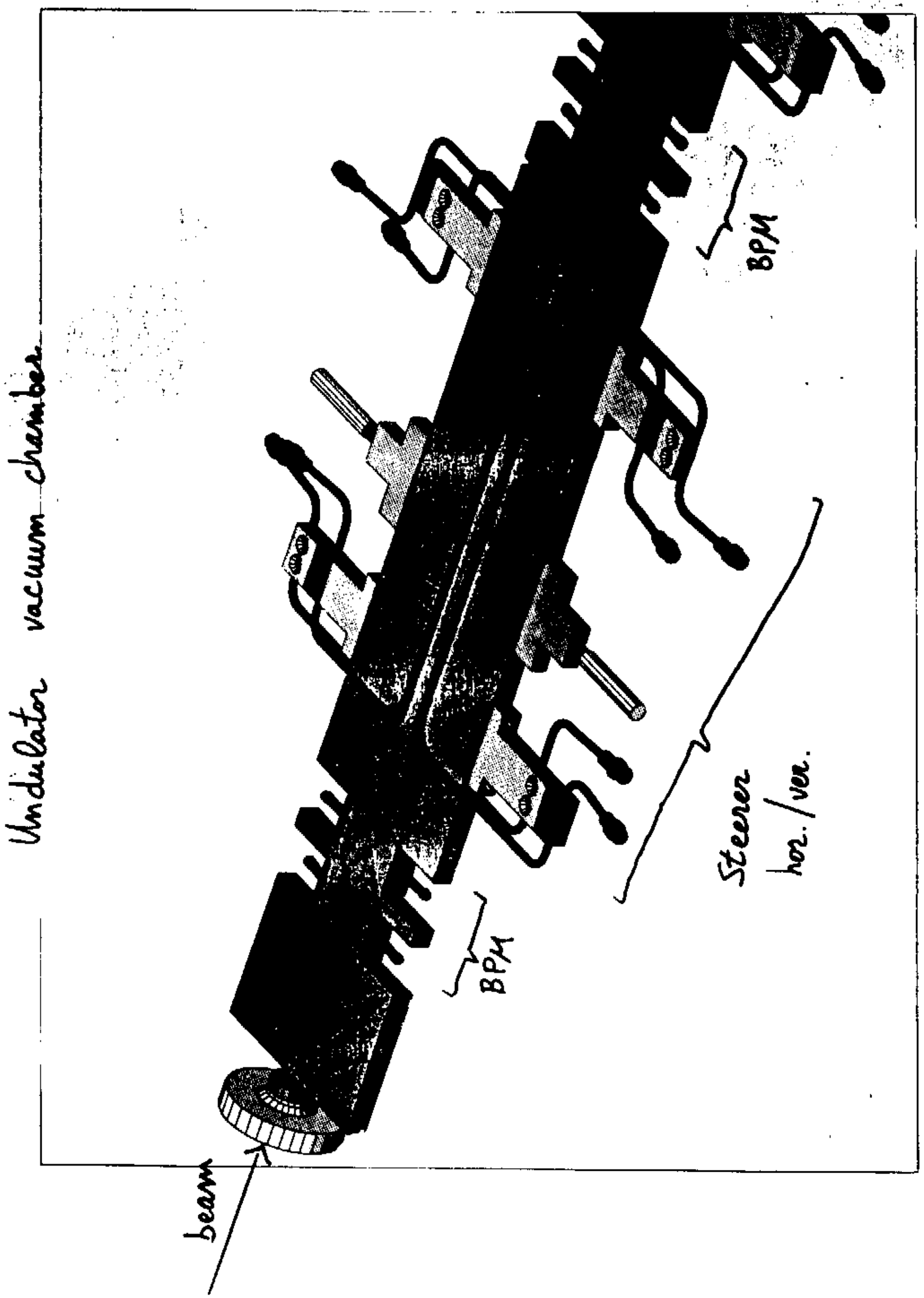


hor. steerer



ver. steerer

Undulator vacuum chamber



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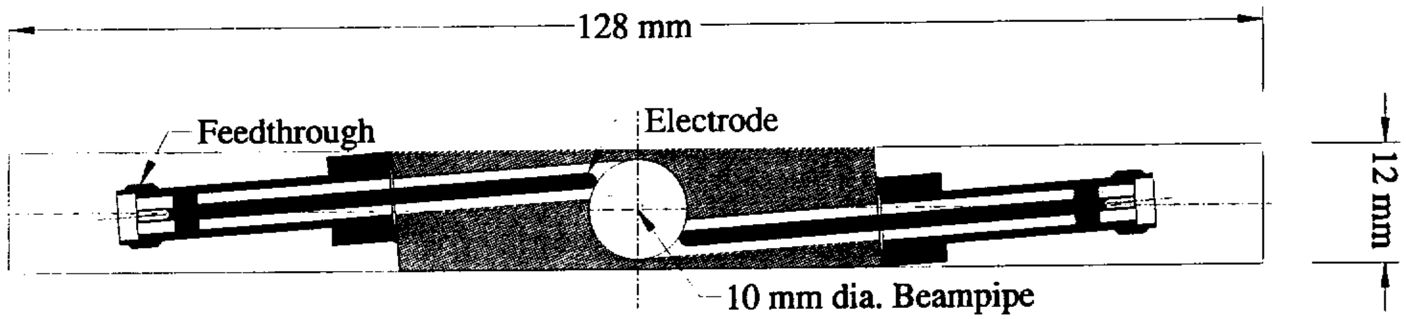
Argonne/Hasylab

TTFL-FEL: Electrostatic BPM Pickup

Cross-section of a couple of opposide electrodes



Coaxial line monitor

M. Wendt/DESY

- number: 20 at undulator mod. 1 and 2
- expected resolution: 20 μm per single bunch
- 1-8 nC ok, amplifier included for < 1 nC
- 2 signals to ADC: need digital conversion to x,y
- installation in Argonne: ready
- electronics: in summer

Wave guide monitor

T. Kamps, R. Lorenz et al./DESY-Zeuthen

- number: 10 at undulator mod. 3
- expected resolution: few μm
- ok for 9 MHz
- 4 signals to ADC: current measurement possible

New design:

- mechanics: new wave guide-coax. adapter
  → robust mechanical pieces

Measurements of prototype in S-band (1 nC, for single bunches):

- linear range ±1 mm
- ~ 50 μm resolution limited by 8-bit ADC of scope

Measurement of coupling between slots:

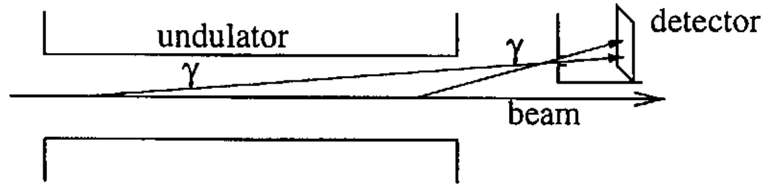
- coupling similar as in prototype
- slots in two BPMs have mechanical defects, coupling a factor 100 larger:
  → large error on absolute position
  → however, resolution should be ~10 μm

Installation:

- vacuum chamber Argonne → DESY, March
- vacuum preparation, 1-2 weeks
- electronics

Beam Trajectory monitor

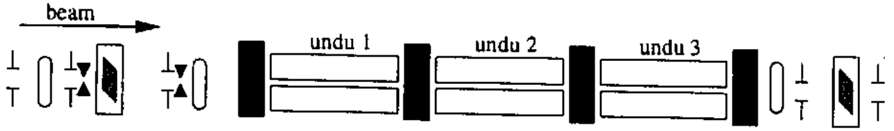
J.S.T. Ng, S. Roth/DESY



- experimental device
- number: 1 at undulator mod. 3
- range ±500 μm
- position resolution ~ 10 μm
- absolute pos. depends on alignment hole-detector

Diagnostic Block

U. Hahn/Argonne, H. Rüter, G. Schmidt/DESY



Function: High accuracy absolute beam position and absolute beam profile

- number: 4 diagnostic blocks
- length = 300 mm
- has hor. and ver. wire scanners and a cavity BPM
- installation: mid-April

Wire scanner

G. Schmidt, H. Schultz, M. Werner, K. Wittenburg et al./DESY

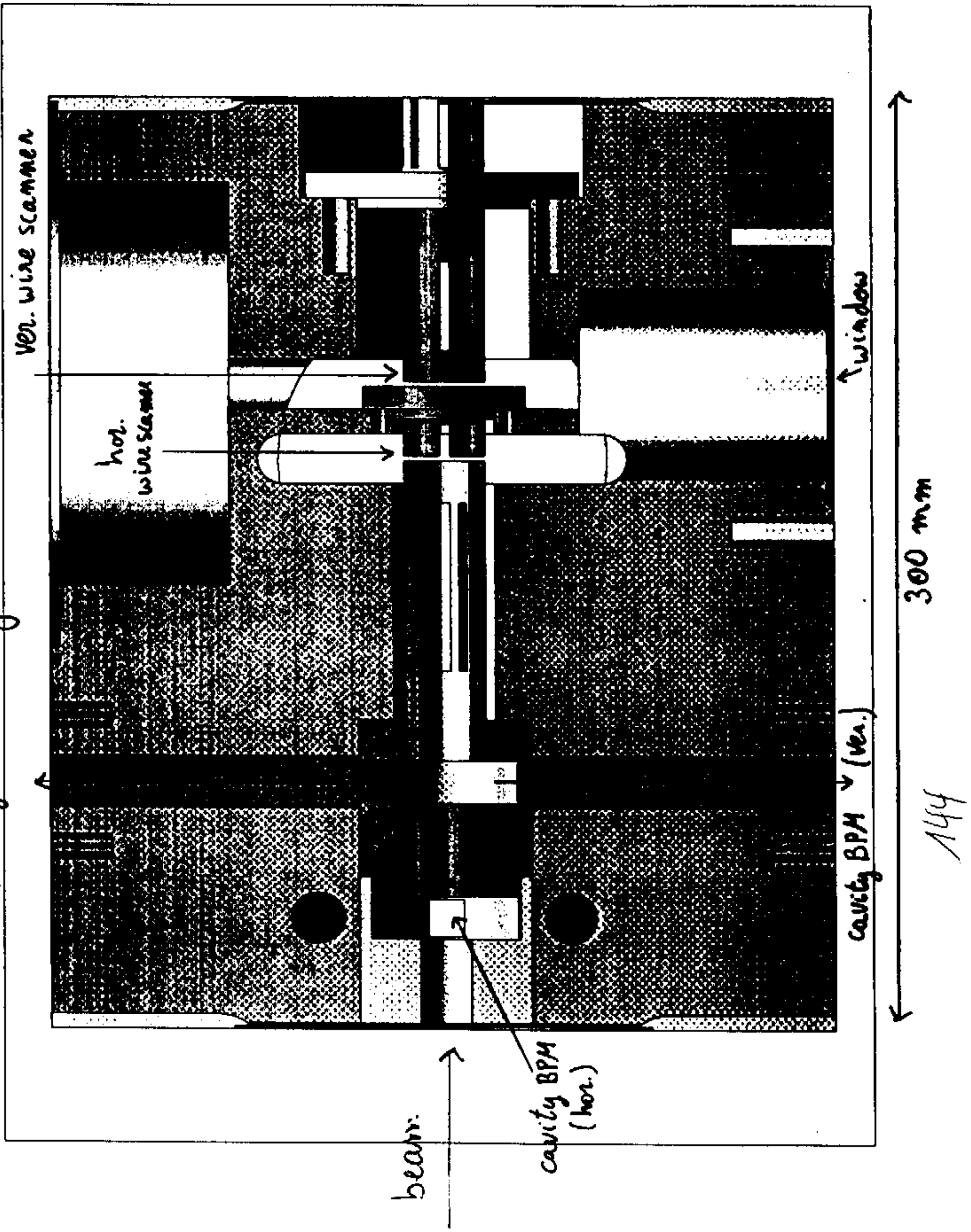
- relative position 1 μm with optical ruler
- absolute position ~ 15 μm against undulator reference

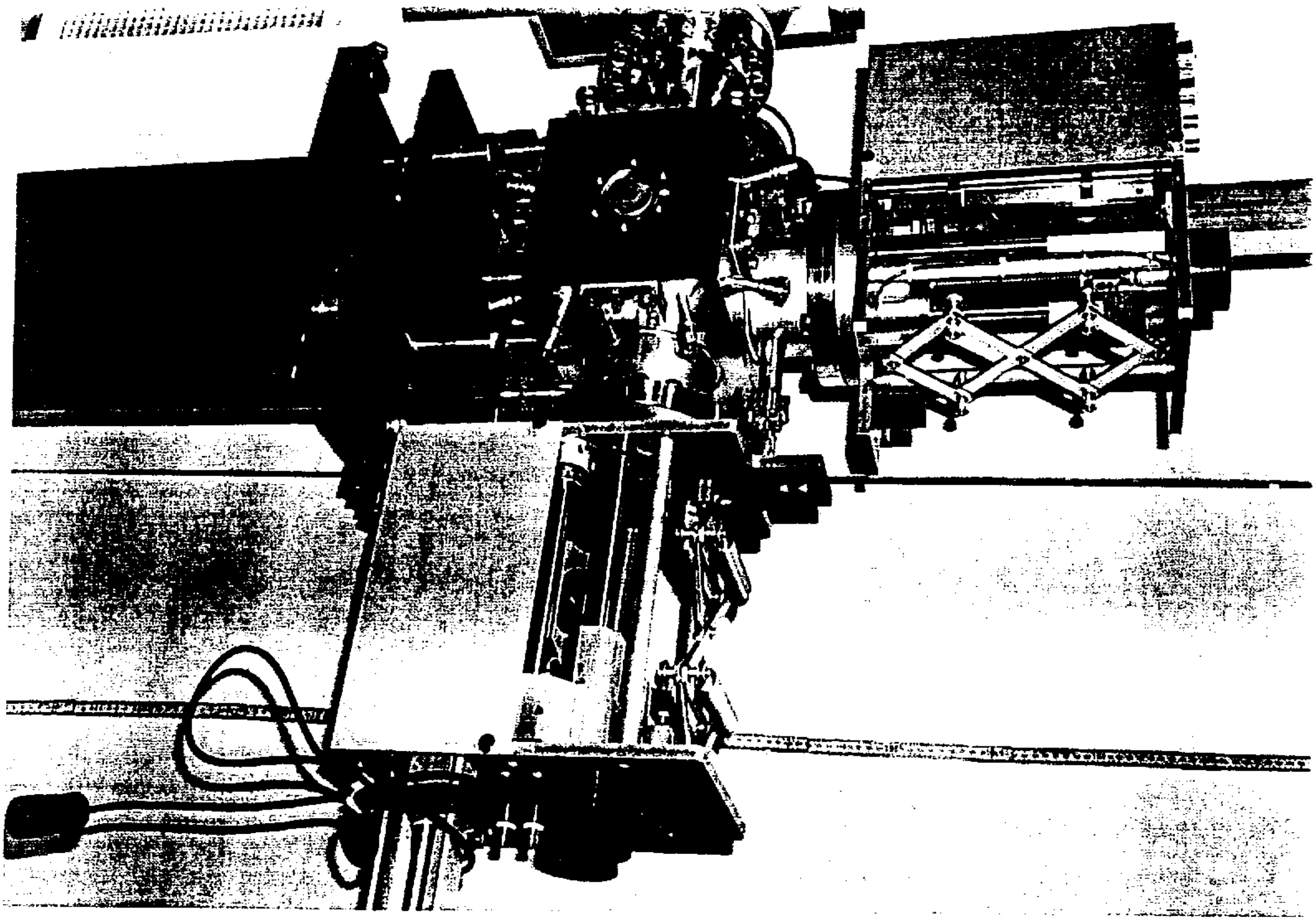
Detection:

- (1) lead glass detector with photo-multiplier at the end of the linac
  decay time is 20 ns (9 MHz oper. ok)
- (1) plastic scintillator with photo-multiplier at each monitor block
- (2) current on the conducting wire (due to secondary electron emission)

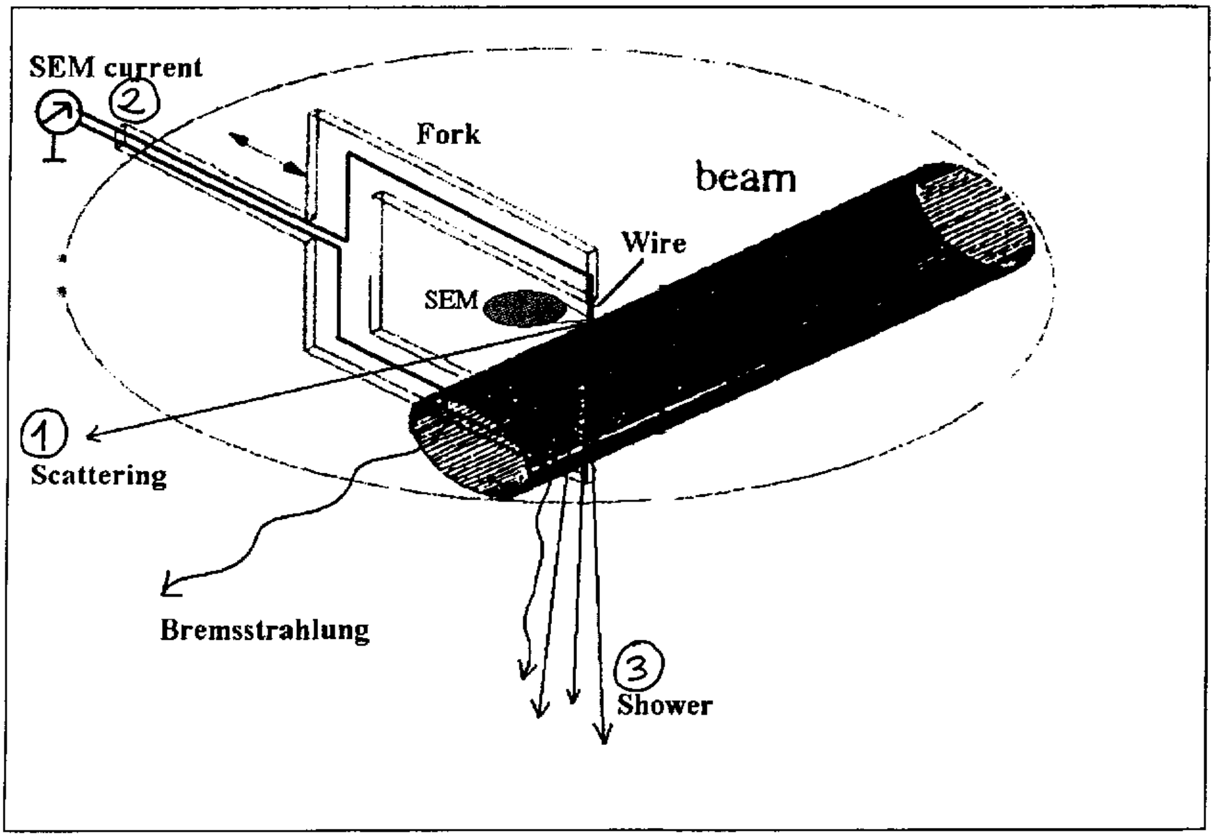
G. Schmidt

Cross section of the Diagnostic Block





• Principles


SEM current
②
Fork
beam
Wire
SEM
①
Scattering
Bremsstrahlung
③
Shower

- ③ Future option: photo diode to measure reflected photons from the FEL radiation on the wire (only vertical direction through the window below)

Problem: Heat load on the wire

- with 8 nC : wire survives only few hundreds μs
  solution: operate with short pulses or low bunch current
- full FEL power: at the last block: sublimation of wire material (operation limited to 0.1 nC)

Solution: 3 wires per frame (spares)

Cavity BPM

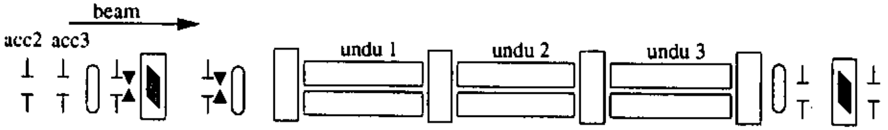
R. Lorenz/DESY-Zeuthen, S. Sabah/TU-Berlin

- expected resolution 1 μm (for single bunches)
- current measurements
- electronics installation: ready for March

OTHER BPMs

Cold cavity monitor

R. Lorenz/DESY-Zeuthen



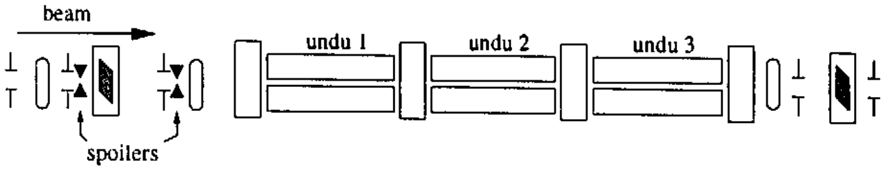
- number: 2 in acc. module 2 and 3
- expected: 10-20 μm resolution (averaged over one pulse)

Problem:

- no self-calibration on beam current
  (work in progress with tests in BPM "3BC2")

Reentrant cavity monitor

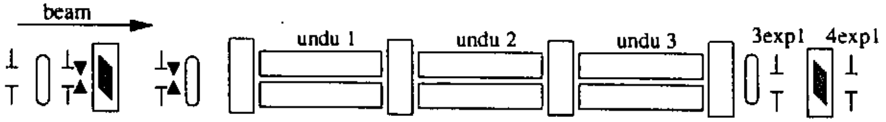
M. Lalot, C. Magne, J. Novo, B. Phung/Saclay



- number: 2 at spoiler locations
- resol. ~ 10 μm (meas. with beam at 3 nC)
- bunch charge range 1-8 nC
- up to 3 MHz (for 9 MHz needs change of electronics)
- installation: electronics: July and August

Strip-line monitor

F. Tazzioli et al./INFN



- number: 3 behind undulator
- resol. ~ 20 μm
- bunch charge range 1-8 nC

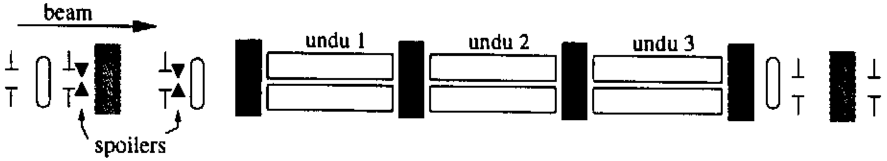
Beam transverse emittance - Optics

Needed:

- for collimation of beam halo:
  90° phase advance between spoilers
- β matching linac - undulator

Instrumentation:

- OTR and view screen
  resolution of camera: pixel 20x20 μm (387x256 pixels)
  resolution of very small spots limited by diffraction
- Wire-scanners in diagnostic blocks



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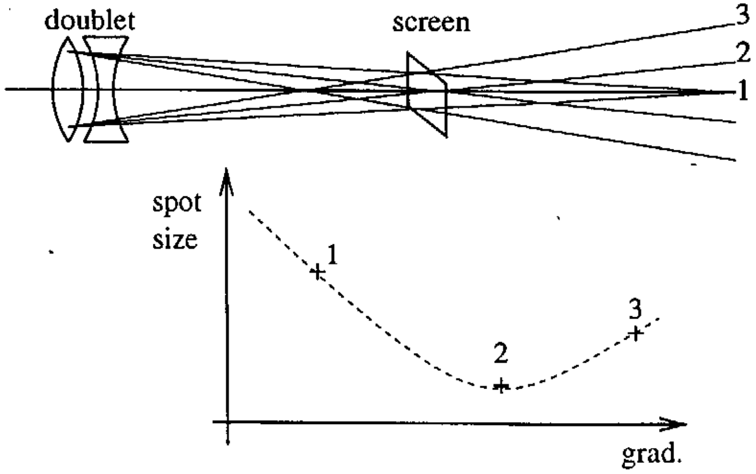
TECHNIQUES

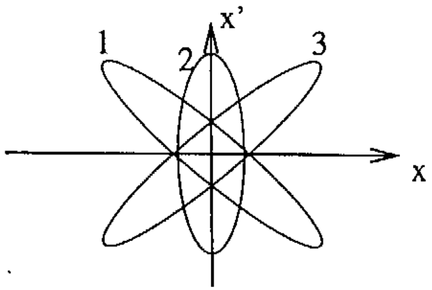
Quadrupole scan

M. Castellano et al./INFN



Phase-space tomography

M. Geitz/DESY



- to get good resolution: 18 rotations in steps of 10°
- intrinsic errors of tomography: 10%(symmetric) to 30%(non-sym.)

- measurement time: ~20 min.
- systematic errors: beam jitter, quad. field errors, screen calibration → 50%
- problem: beam dispersion
  solution?
  - measure dispersion
  - correct with dispersion bumps

Bunch length

Needed

- large charge density for SASE

Interferometry with OTR light

M. Geitz et al./DESY

Coherent light emitted by the beam when crossing the OTR screen.
Detectors:

- Pyro-electro det.: interferogram in ~ 30 min.
- Josephson junction det. : voltage scan in few min.

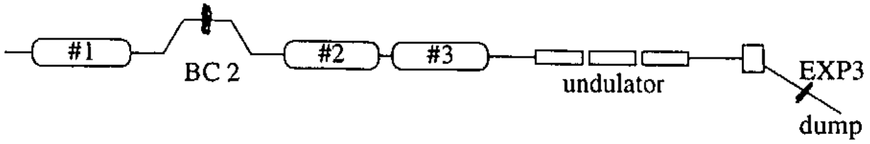
Freq. range 100-1500 GHz, i.e. 3 to 0.2 mm

Long. phase-space tomography

M. Geitz et al./DESY

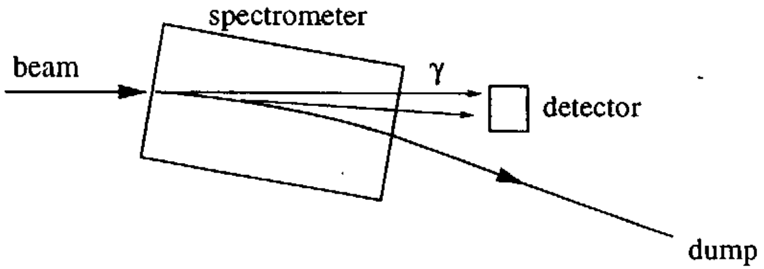
Rotation of long. phase-space

- at 1BC2 screen: changing phase cav. 8 in module 1
- at 1EXP3 screen: changing phase of module 2 or 3
- first tests: this week #8



Intensity interferometry of spontaneous synchrotron light

J. Fink-Finowicki, J. Krzywinski, L. Plucinski, R. Sobierajski/
IP PAS-Warsaw



Synchrotron light emitted at spectrometer

- experimental technique
- no cut-off freq. effects
- no systematic errors
- for FEL-parameters and over 1000 bunches: 10% resolution

Photon diagnostics

J. Feldhaus, HASYLAB at DESY

- Overview
- Status
- Schedule

HASYLAB
Univ. HH
IFPAN, Warsaw
Dublin City Univ.
FZ Jülich
Univ. Jena
⋮

Photon beam characterization

1. Total flux of each photon pulse

spontaneous radiation: 0.2 μJ - PtSi Schottky diodes

FEL at saturation (70 nm): 0.4 mJ - thermo-electric detector

2. Beam size and angular distribution

~5 mm diameter at ~1 mm resolution
- pinholes
- fast thermopile matrix
- $PbWO_4$ crystal + CCD

3. Spectral distribution of individual pulses

spont. radiation at low resolution 1m NIM, 1200 l/mm, b.i. CCD

FEL fine structure at high resolution 3600 l/mm, ICCD

4. Time structure

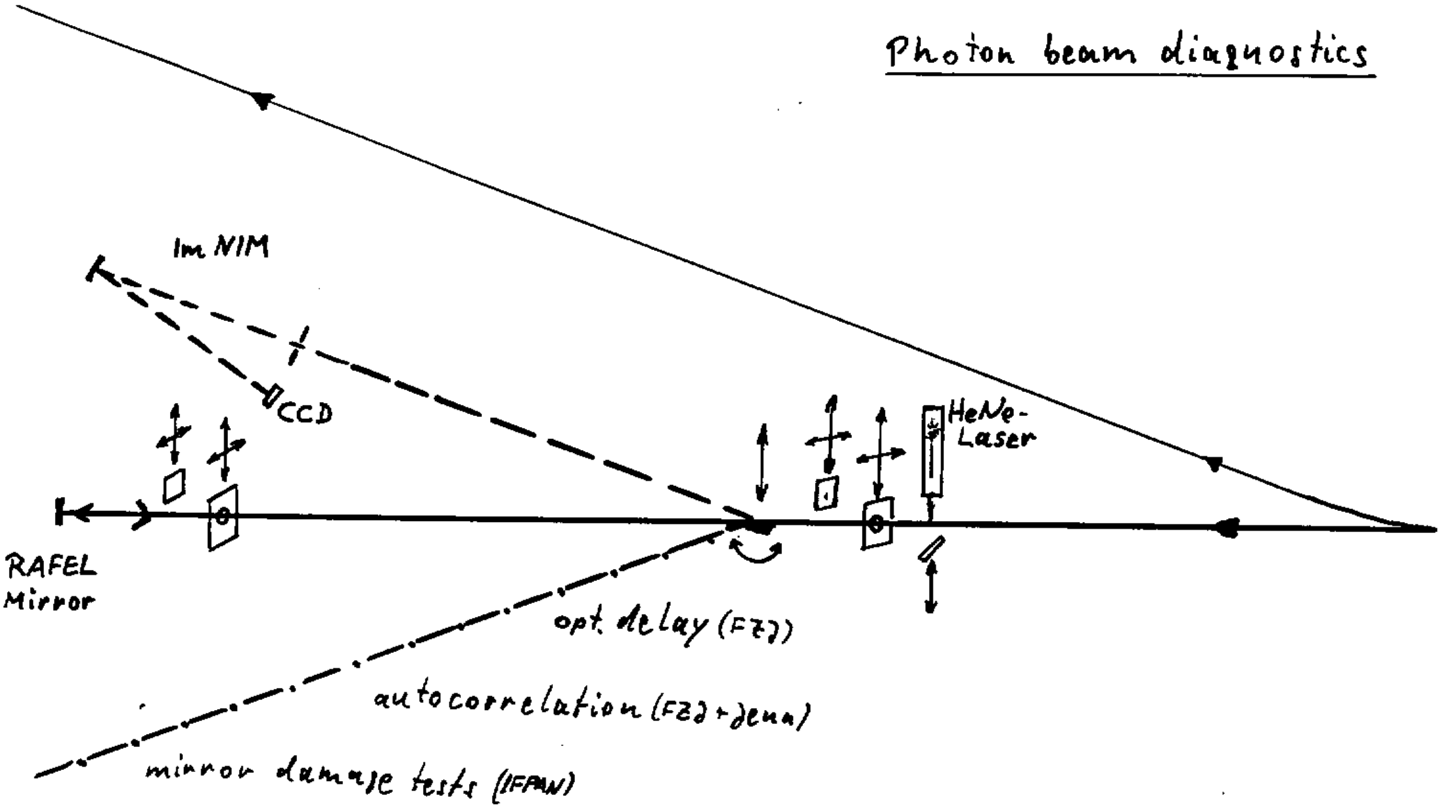
bunch length: T ~ 1 ps - autocorrelation exp. (Jülich)

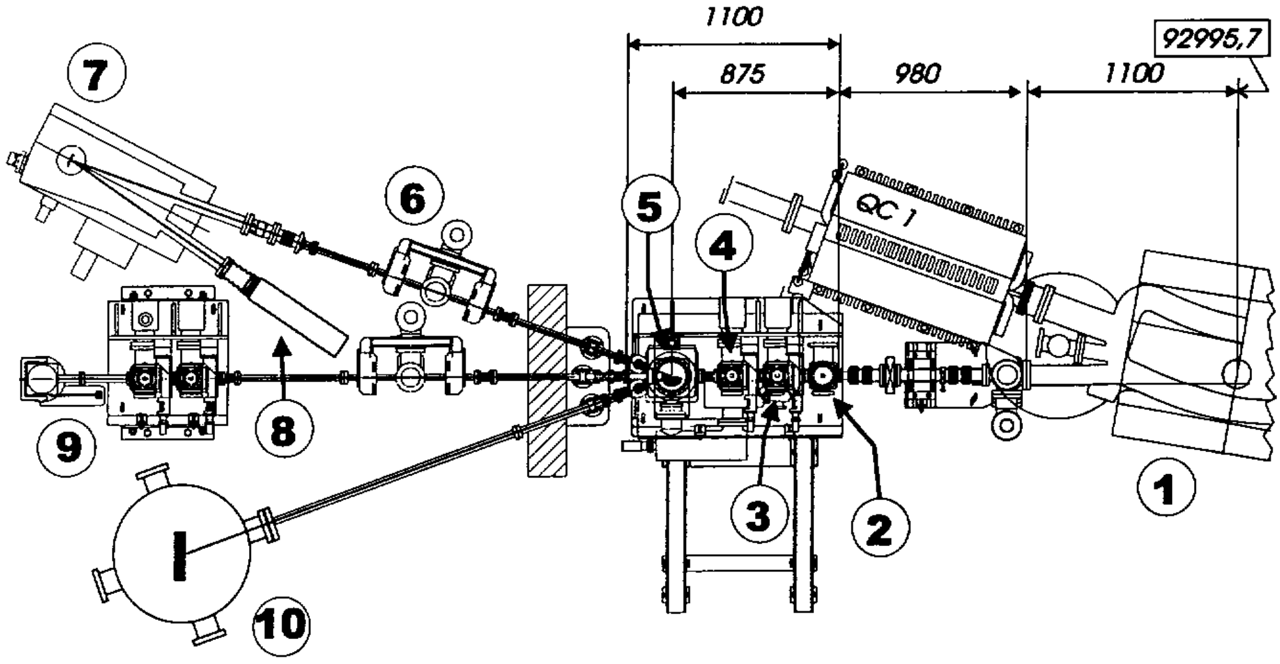
fine structure: Δt ~ 10 fs - crosscorrelation exp. (Jena)

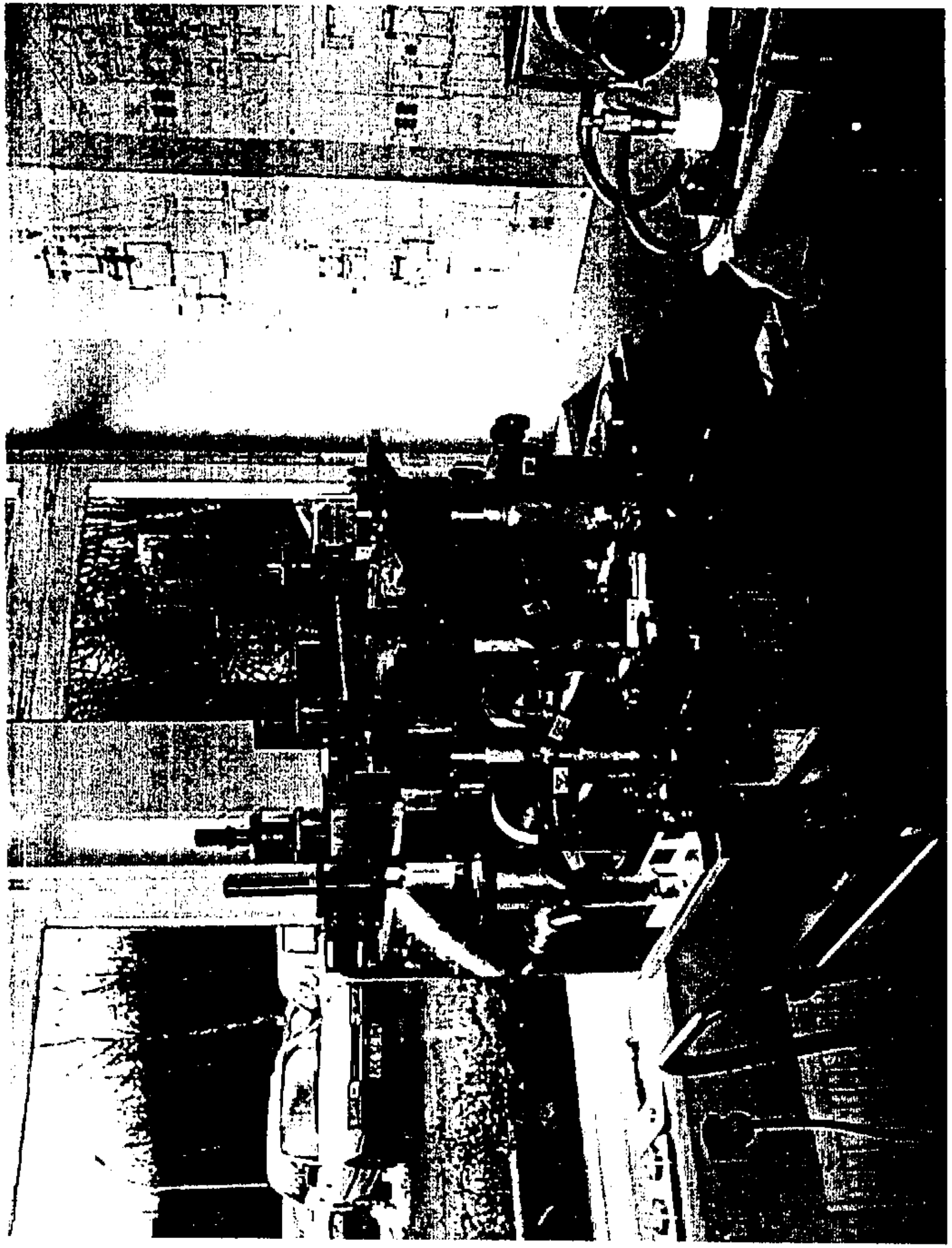
5. Radiation damage of optical components

peak power density 10^9 - 10^{16} W/cm^2 special experiment using focusing mirror and various detectors (Warszawa)

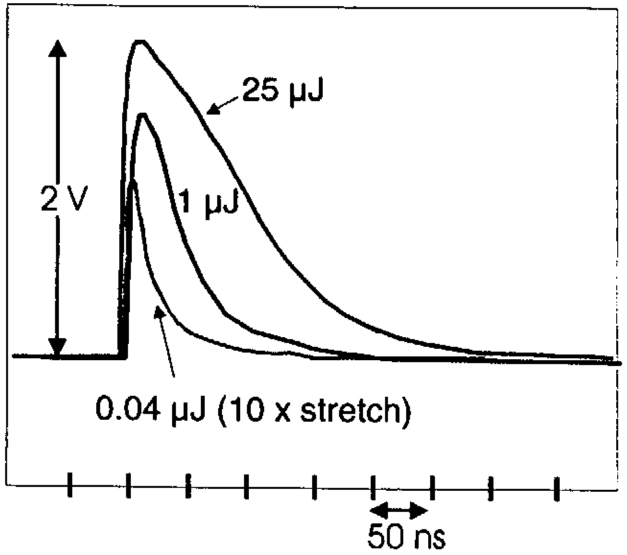
Photon beam diagnostics







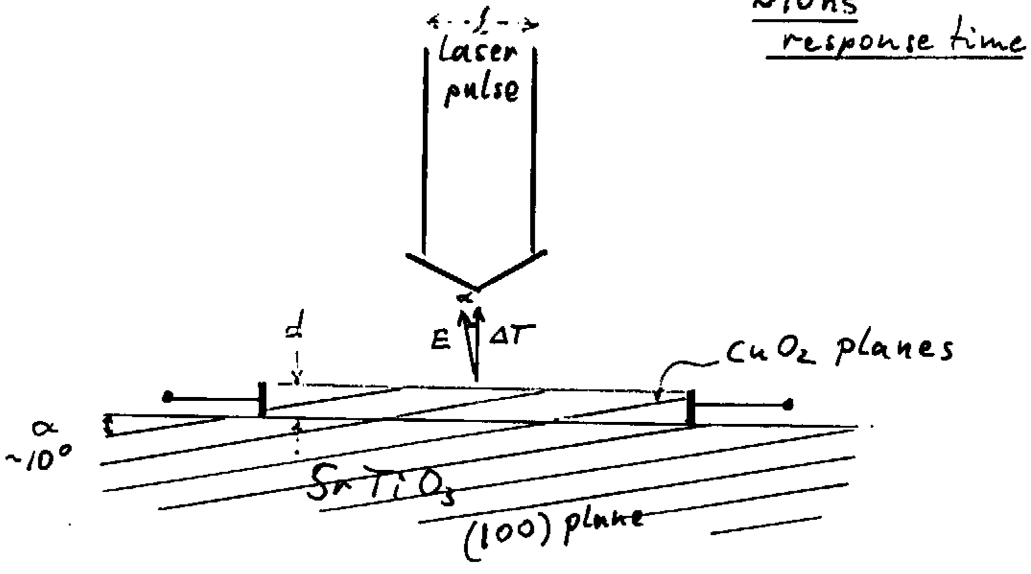
Saturation of the Pt-Si photodiode



Approximated micropulse energies at
527µm wavelength
(2. Harmonics of a Nd:YLF laser)
U_{rev}=12 V

Thermopile detector

~10ns
response time



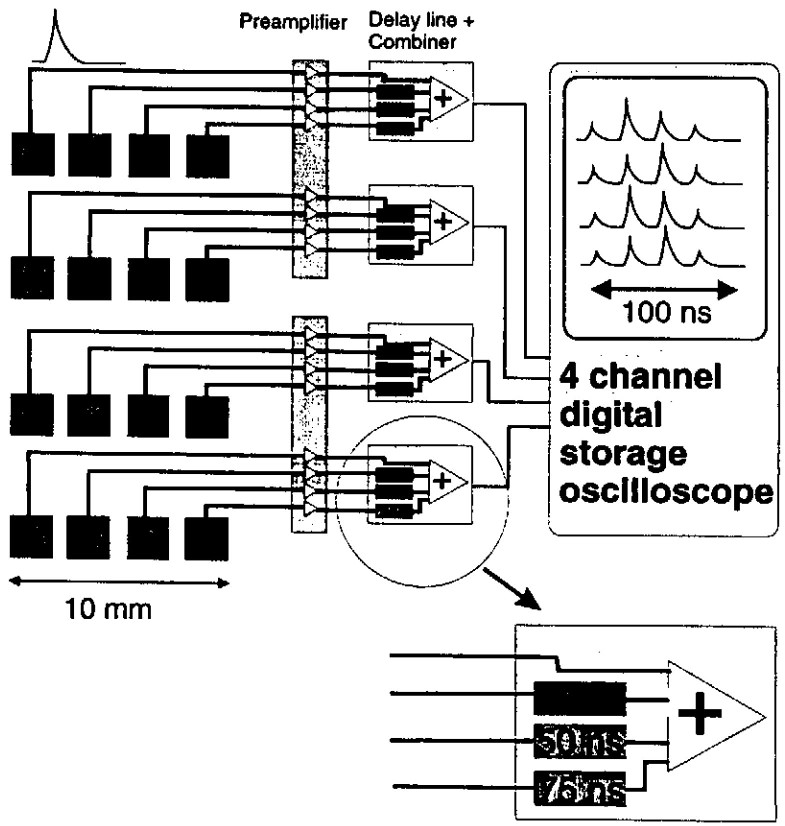
$YBa_2Cu_3O_{7-\delta}$ film (35... 500nm)
on a $SrTiO_3$ substrate

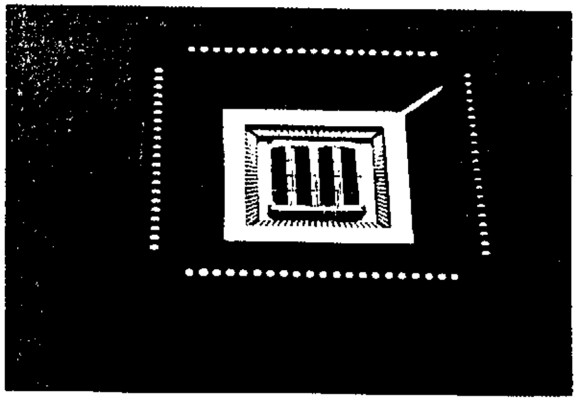
[illegible] · ΔT · $\frac{l}{d}$ [illegible]

⇒ [illegible]

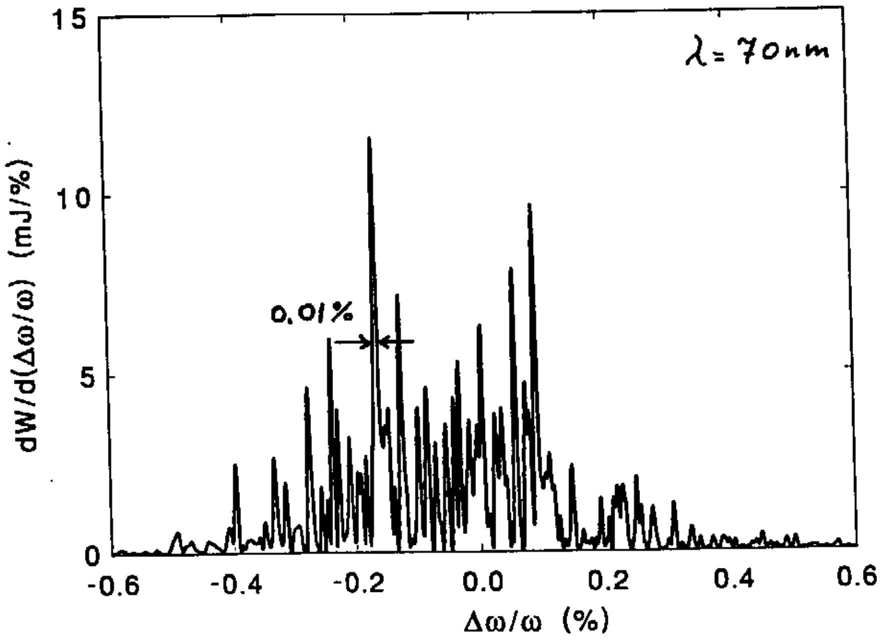
S. Zeuner et al., Appl. Phys. Lett. 66, 1833
(1995)

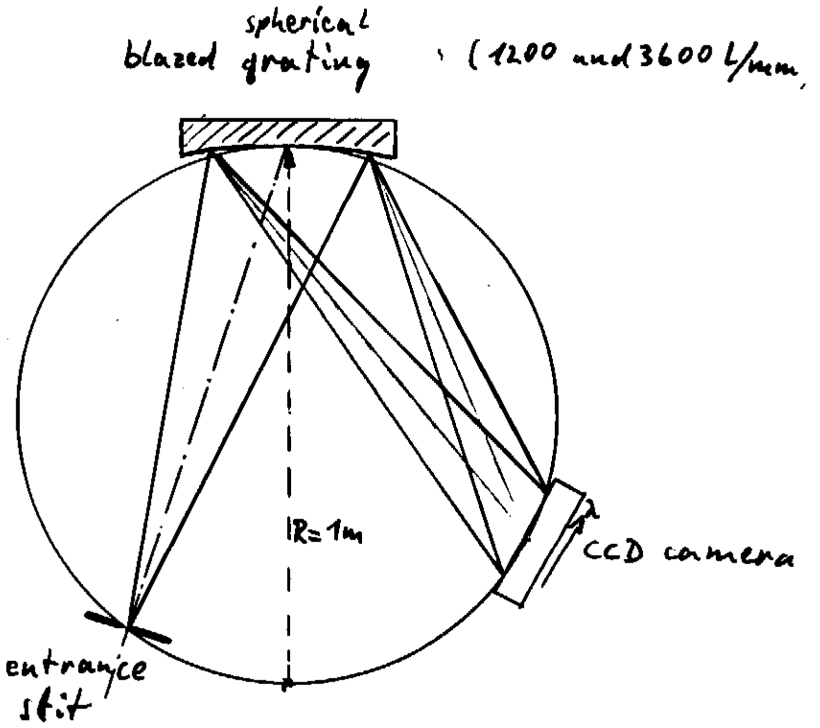
Fast thermopile matrix detector



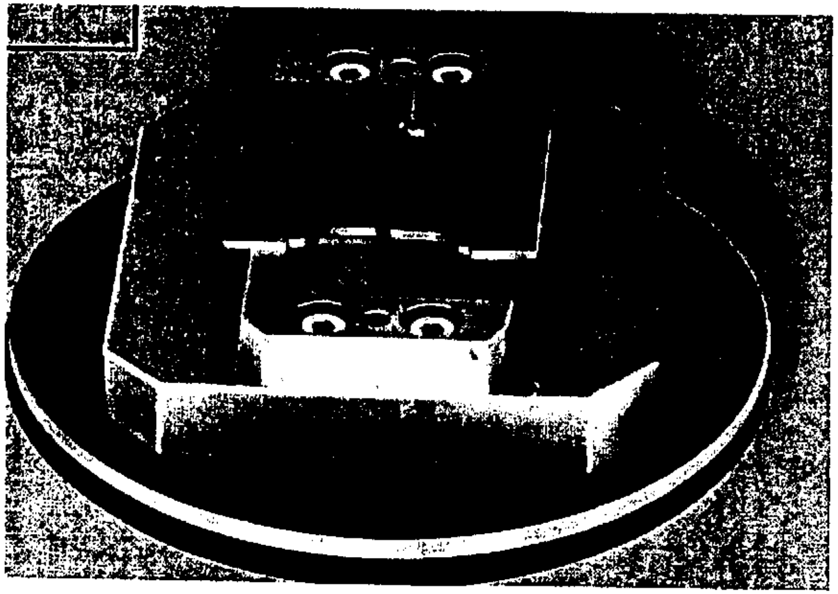


4*4 matrix detector (prototype)

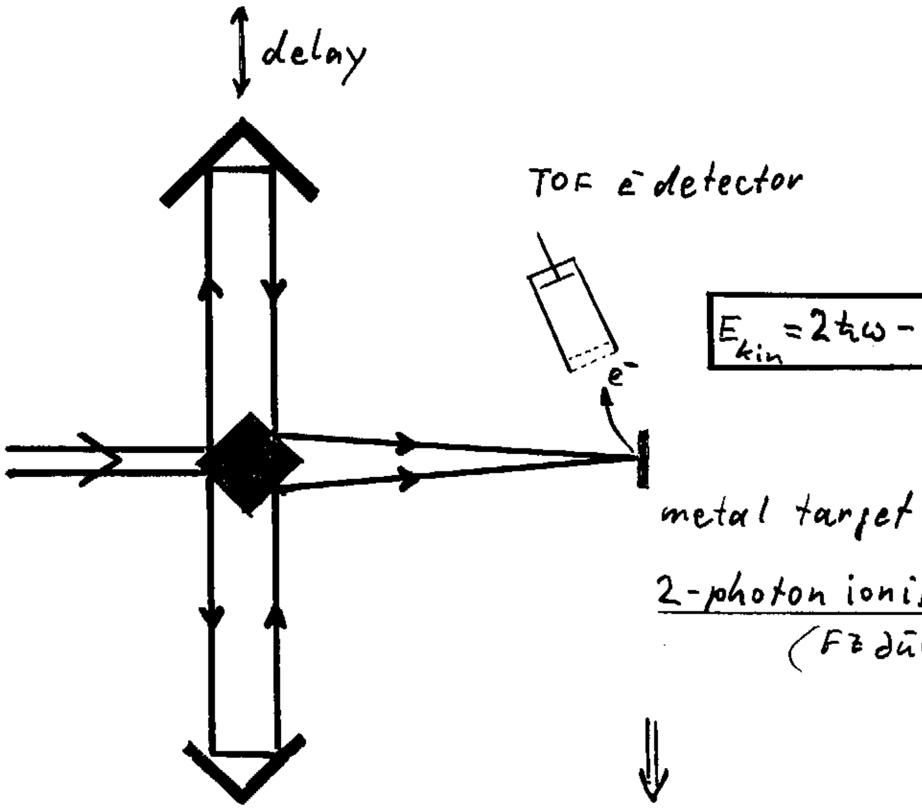

λ= 70nm
0.01%
dW/d(Δω/ω) (mJ/%)
0
5
10
15
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
Δω/ω (%)


spherical
blazed grating
, (1200 and 3600 l/mm,
R=1m
λ
CCD camera
entrance
slit

Piezo-actuator



TEMPORAL STRUCTURE



$\boxed{E_{kin} = 2\hbar\omega - E_B}$

2-photon ionisati
(FZ Jülich

⇓

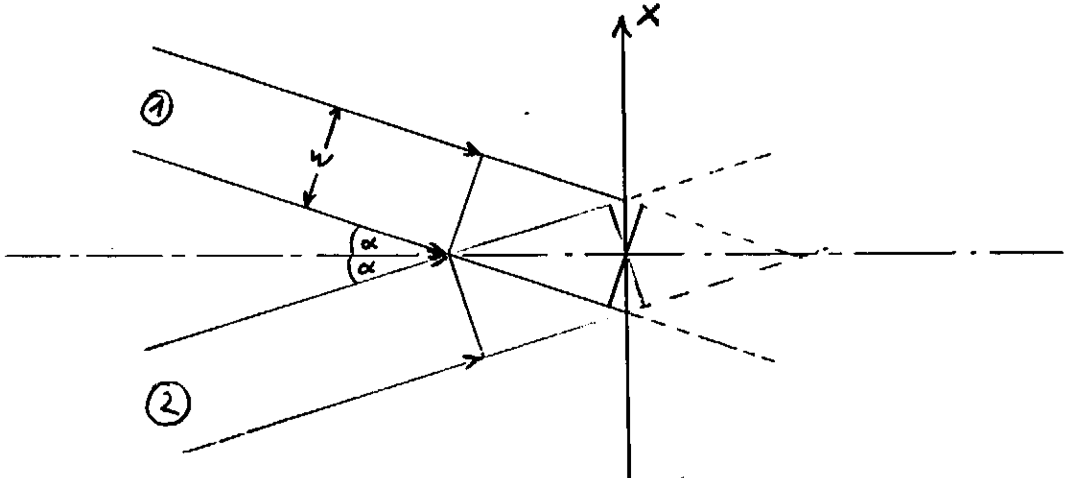
autocorrelation time

≈ 10 fs

FZ Jülich

Cross correlation experiment

(Uni Jena)



„detector“ surface: SSHG on SiC

delay $\tau = t_2 - t_1 = \frac{2x}{c} \sin\alpha$

(1) total delay across w : $T = \frac{2w}{c} \tan\alpha = 2ps$

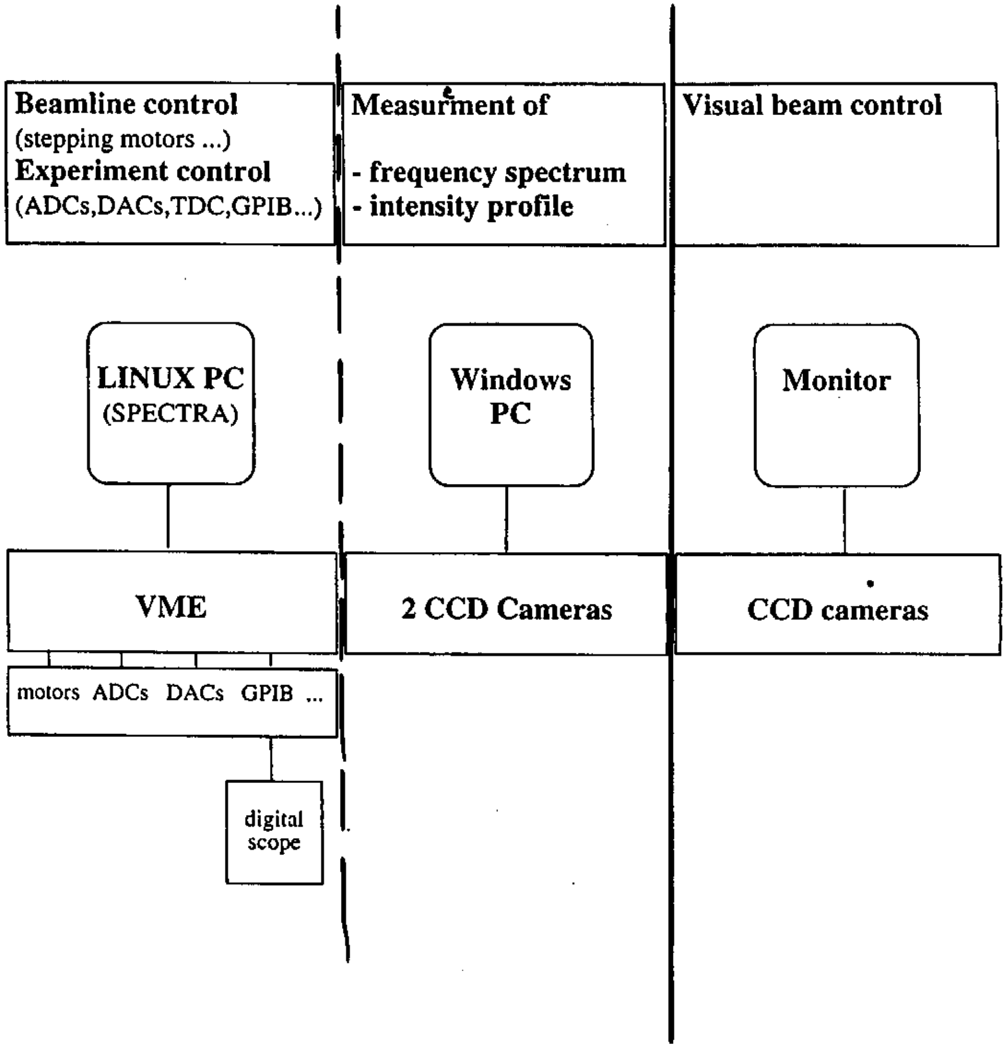
$w = 2mm \Longrightarrow \alpha = 8.5°$

detector resolution: $20\mu m$ → time resolution: $20fs$

(2) high resolution: e.g. $1fs/20\mu m \Rightarrow \alpha \approx 0.43°$

→ - total range across beam: 100fs

- very long mirrors
- large distance (FZ Jülich!)



Schedule for photon diagnostics

Vacuum	
pre-assembly, test	4 weeks in March
cleaning, final assembly in cleanroom	4 weeks in May
installation	2 weeks in June
Detectors	
delivery, tests	March / April
assembly, tests	April
Monochromator	
dismounting from HASYLAB beamline	1st week in April
re-configuration, tests, calibration	April / May
installation	June
Cabling for motors and signals	March / April
Computer control	
hardware configuration	May
software	May / June
installation, tests	June

B. Aune

WORKING GROUP CAVITIES

I - Superstructure

- Parameters, general	J. Sekutowicz
- W-G. Coupler	M. Dohlus
- W.G. Coupler	A. Zavadsev

II - Trapped modes

- Simulation + tests on 9-cell	F. Marhauser
- Measurements on modules	H. Glock
- Measurements on 4 cavities	N. Baboi
- Beam experiments	N. Baboi

III - Cavity fabrication techniques

- Activities at Legnaro	E. Palmieri
- " at IPN Orsay	M. Fouaidy
- " at LAL Orsay	L. Grandsire

IV - R/D

- E.P. CERN/DESY/SACLAY	L. Lilje
- Measurements at Wuppertal	G. Müller

TRAPPED MODES

- Experiment with beam July 98 for HOM:
  Unexpected mode at 2.585 GHz
  in one cavity of module 1
- Calculations, Measurements on modules 1 and 2 - Measurements on cavities
- Experiments with beam (injector II) on cavity # 3 of module 1 and # 5 of mod. 2

Some facts:

- on cavity 3 (1) and 5 (2) these modes exist at a frequency ~ 2.58 GHz and are poorly damped.
- Comparison with other cavities on the same pass band → look as additional modes
- Transmission thru a chain of 3 cavities similar in mod 1 and mod 2 - Difficult to understand.
- Varying the length of the beam tube has large influence on field pattern (Calcul. and measurement)
-

SUPERSTRUCTURES

Build and test with beam a superstructure : 4 × 7-cell.

Best estimate = 1st quater 2001.

Need: { - New tuner
- New HOM coupler
  - will use flanges btw cavities
  - Test with existing Power Coupler

- Individual cavity tested in V cryostat
- Installation in a module similar to present design.

* Test with beam necessary:
- Correct acceleration
  (LLRF - Energy dispersion)
- HOM, trapped modes

Need moderate Eacc (~10 MV/m)

W-G. Input Couplers

Discussion on some parameters:

- 1 coupler / 4 cavities
- Fixed coupling (adjusted for max. beam power : ≈ 2 10^6)
- Designed for the 800 GeV parameters
  ⇒ P ≈ 1.3 MW

- 2 designs of WG Coupler presented (i.e. // to work on coax coupler)

1. Elliptical WG -
   - window masked from beam by 'wall' or 'chicane'
   - Calculation of - RF kick
     - Heat load

2. Rectangular WG
   - Window in pill box configuration

{ In both designs the WG goes straight to the outside

CAVITY FABRICATION TECHNIQUES

I. **Spinning** - E. Palmieri

- Several cavities for different labs.
- Importance of grinding of cracks
- Spinning better than hydrof. for Cu Cavities (Nb/Cu)

II. **Cu deposition of Nb cavities** - M. Fouaidy

- Several cavities under preparation
- Systematic studies on sample
- Role of bonding alloy.

III **Hydroforming** - L. Grandsire

- 2-cell, S-Band, RRR 40, $\frac{Req}{Rir} = 1,9$
- Hot hydroforming: test of deformation
- Equipment for diagnostic.

Conclusions - Questions

- We need more calculations (3D?) and measurements (on several cavities)
- Influence of beam tube? acts as a resonator?
- Model of 'superstructure' for dipole modes?
- Are there other modes?
- Consequence for TESLA and FEL of the existence of such modes.

- **Beam experiment** are important
- Easy with module I, good location for further tests
- Exper. easier with 54 MHz beam and charge modulation
  => work on laser.

TESLA Waveguide Coupler

J.Boster, J.Dicke, M.Dohlus, A.Gamp, H. Hartwig, K.Jin, A.Jöstingmeier,
C.Martens, V.Kaljuzhny, S.Yarigin, A.Zavadsev

1. Versions
2. Elliptical Waveguide
3. Windows
4. Integrated Waveguide-Coupler / Window
5. Tuning

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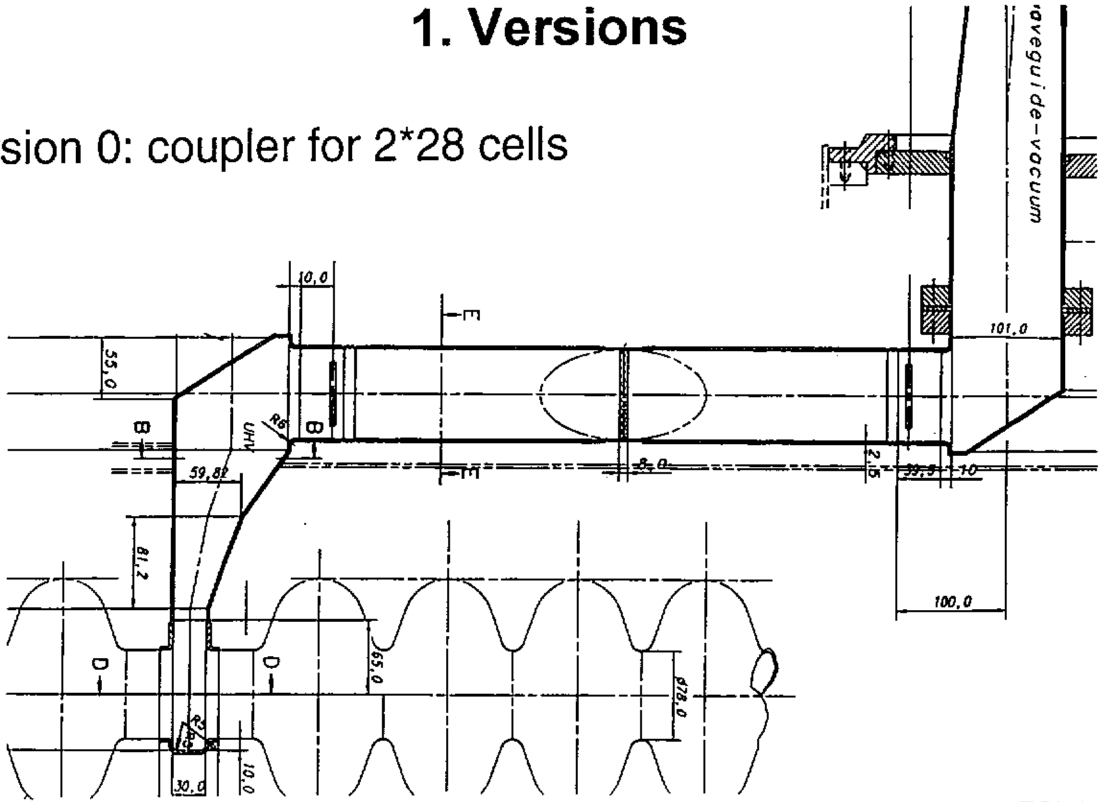
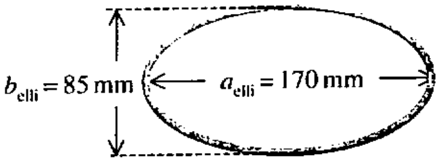
1. Versions

version 0: coupler for 2*28 cells



Report: TESLA 99-01

2. Elliptical Waveguide



$$f_{cutoff} = 1.051\text{GHz}$$

$$f_0 = 1.3\text{GHz}$$

$$\max\{\vec{E}\}_{P=1\text{MW}} = 449\,\text{kV/m}$$

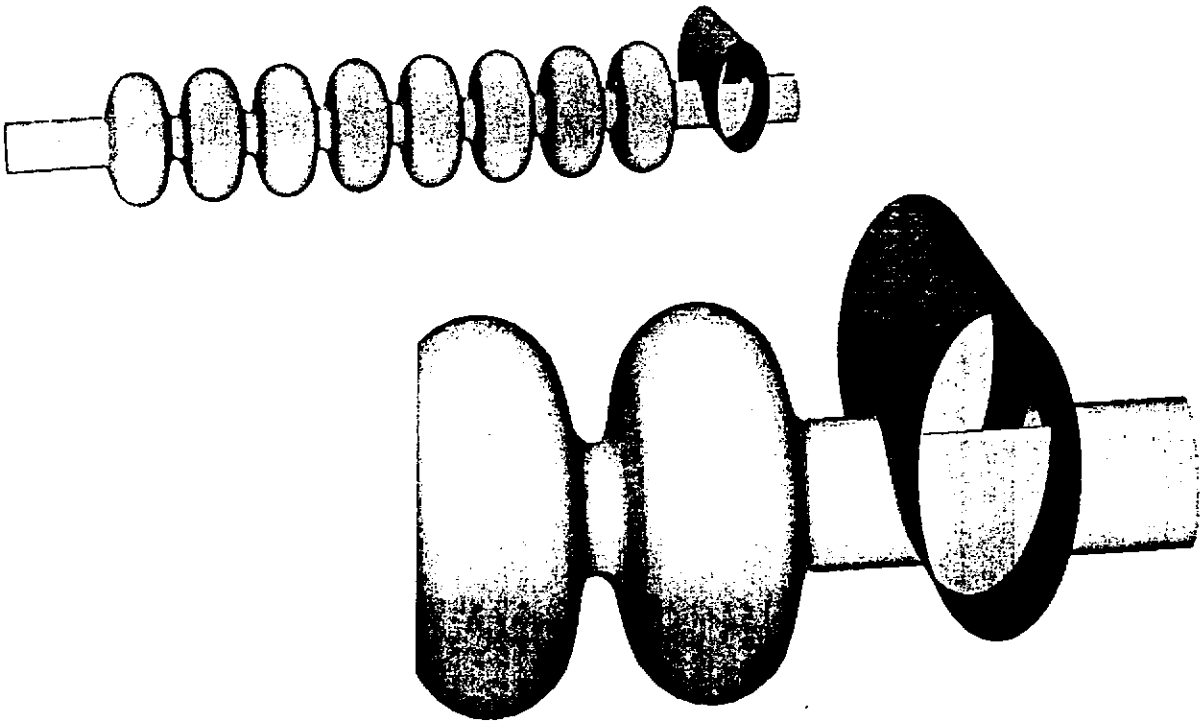
$$\alpha = 8.71 \cdot 10^{-4}\,\text{N/m} \quad \text{for } \kappa = 58 \cdot 10^6\ 1/(\Omega\text{m})$$

$$\alpha = 2.10 \cdot 10^{-4}\,\text{N/m} \quad \text{for } \kappa = 10^9\ 1/(\Omega\text{m})$$

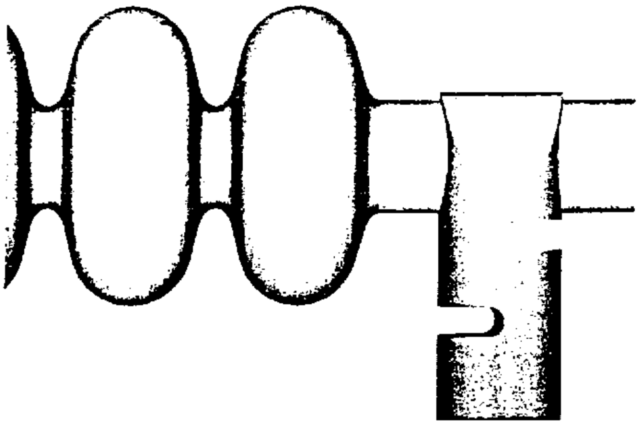
e.g. $P = 1\,\text{MW}$, $t = 1.4\,\text{ms}$, $f_{\text{rep}} = 5\,\text{Hz}$, copper(40 K) ⇒ 2.5 W/m

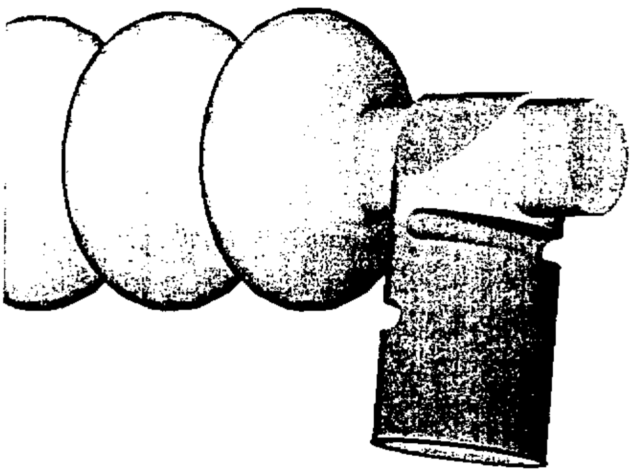
---

version 1: coupler with wall and straight waveguide



version 2: coupler with “chicane” and straight waveguide





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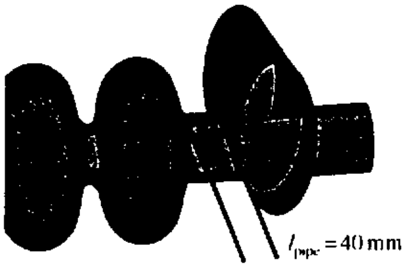
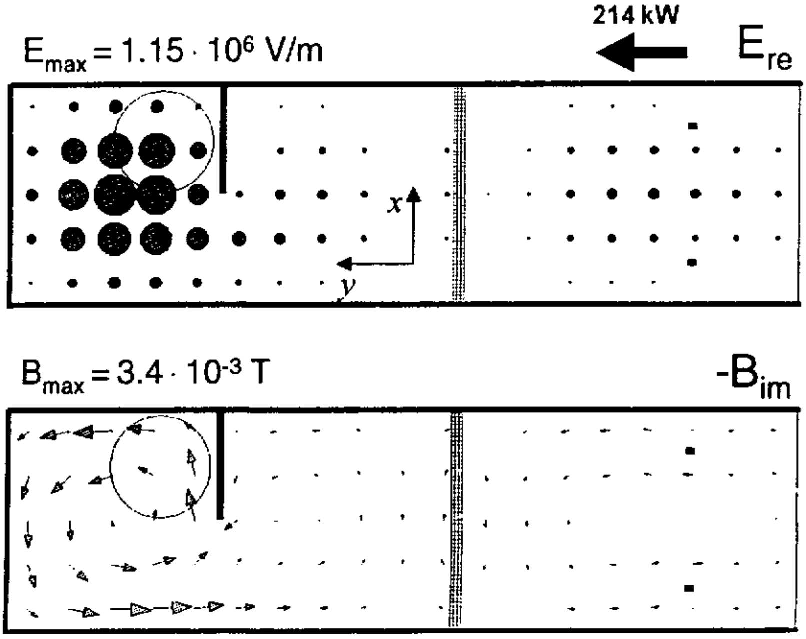
4. Integrated Waveguide-Coupler / Window

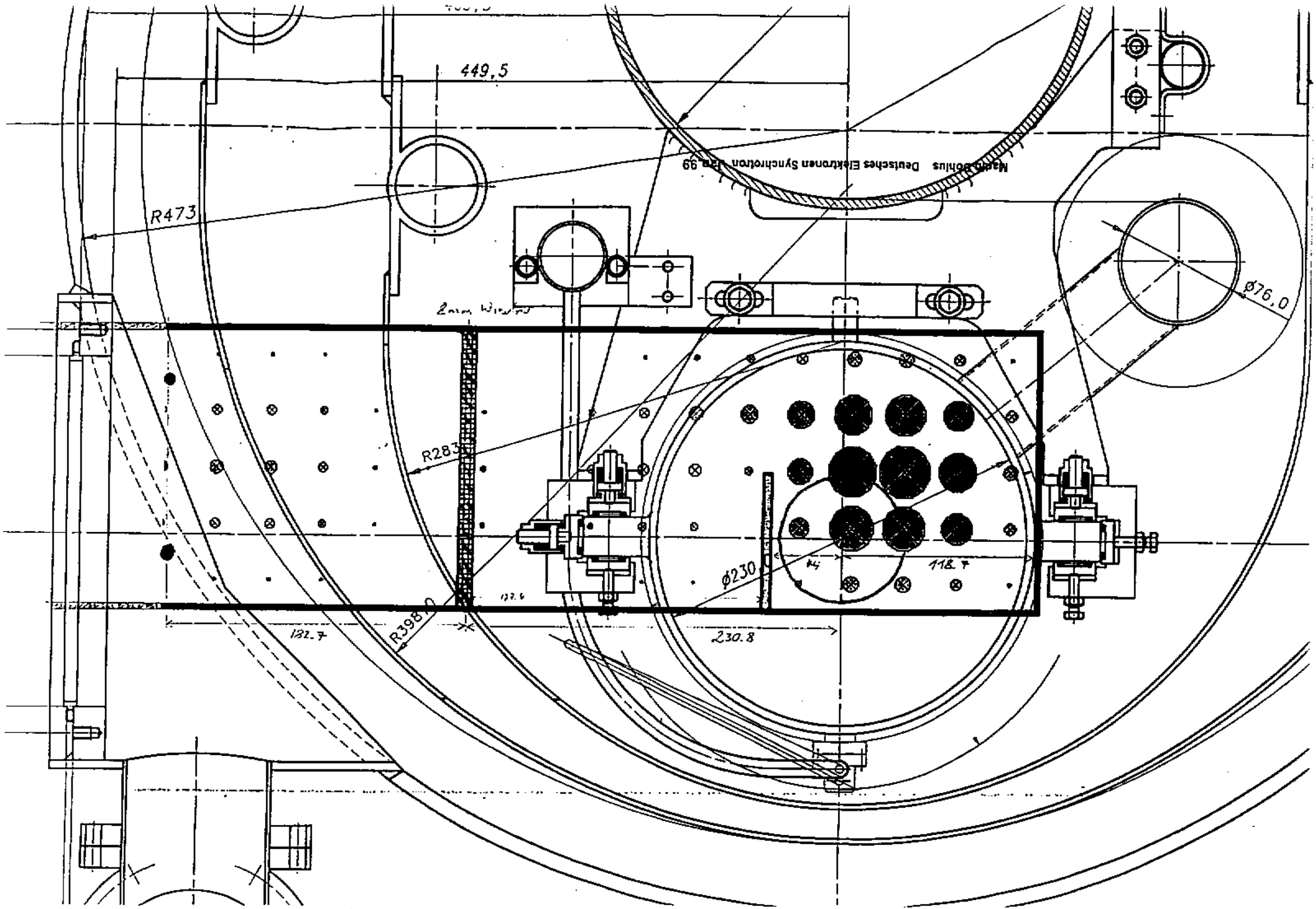
4.1 Version 1: coupler with wall and straight waveguide + integrated window



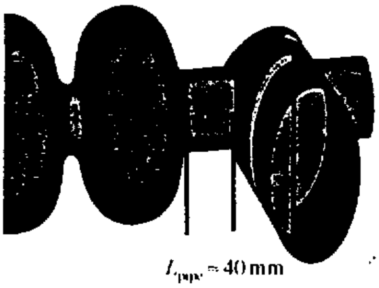
$Q_{ext} = 3.1 \cdot 10^6$
ceramic in SW minimum
for $t << t_{fill}$

Problems:
“resonator” losses
kick: $\vec{K} = 16.0\,\mathrm{kV}\,\vec{e}_x + 11\,\mathrm{kV}\,\vec{e}_y$





4.2 Version 2: coupler with "chicane" and straight waveguide + integrated window



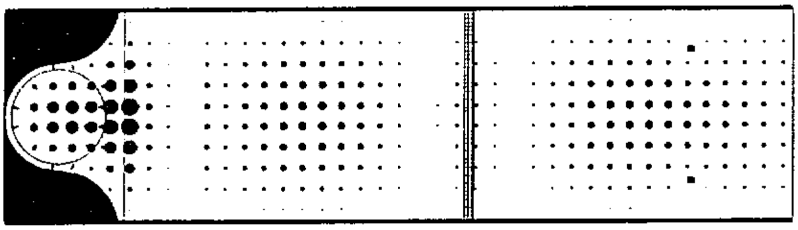
$Q_{ext} \approx 3.1 \cdot 10^6$
ceramic in SW minimum
for $t << t_{fill}$

a) Fields

$E_{max} = 0.75 \cdot 10^6$ V/m $\approx 3.5\ E_0$

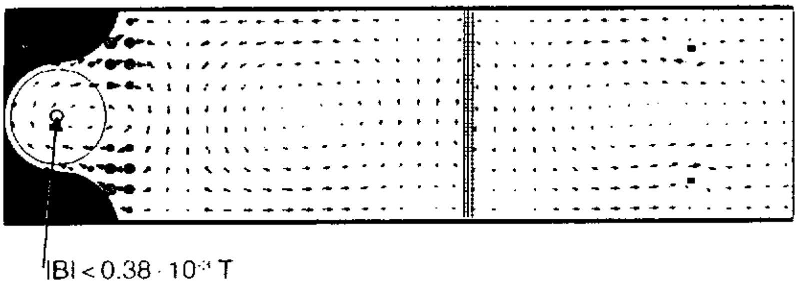
214 kW

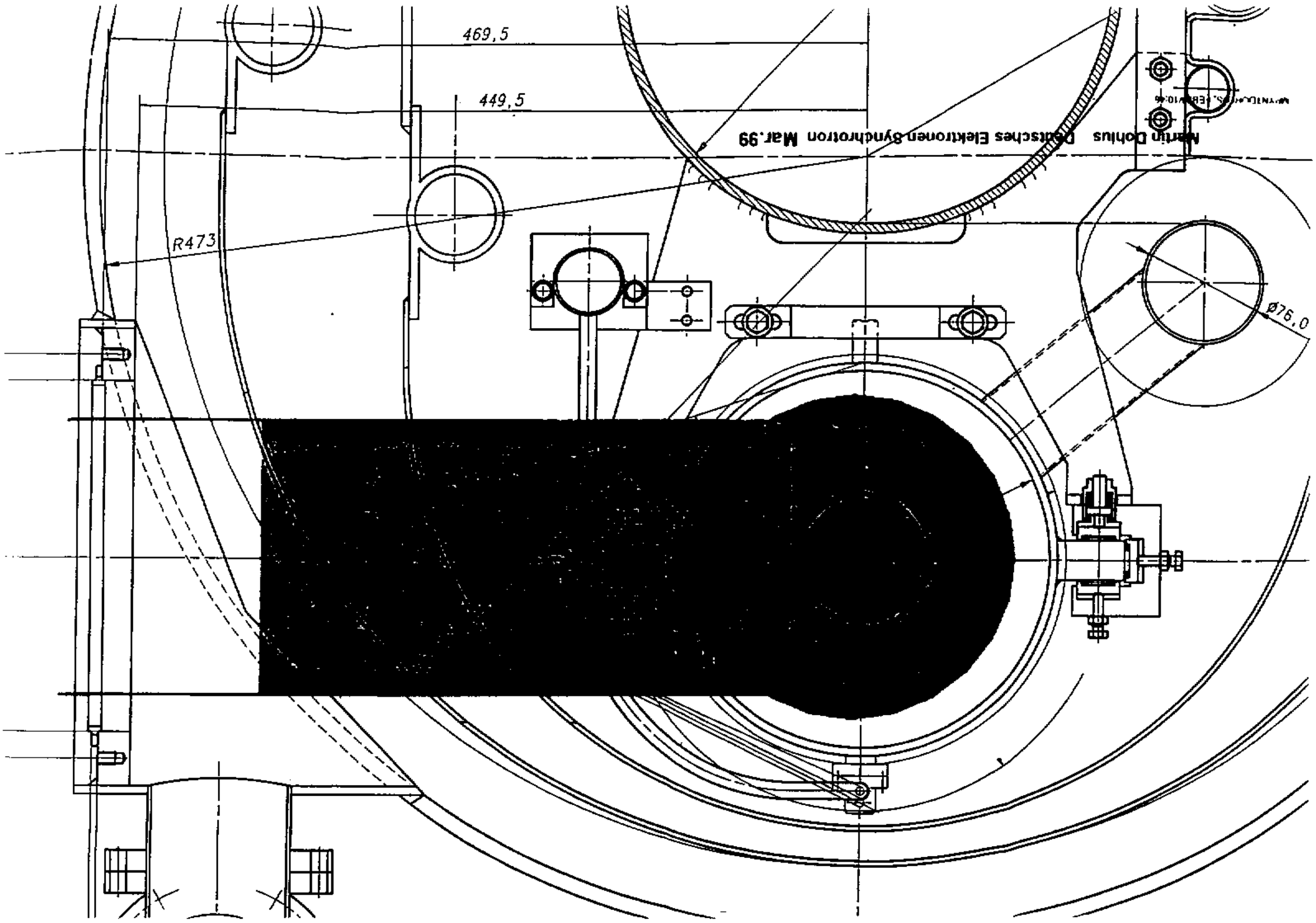
E_{re}



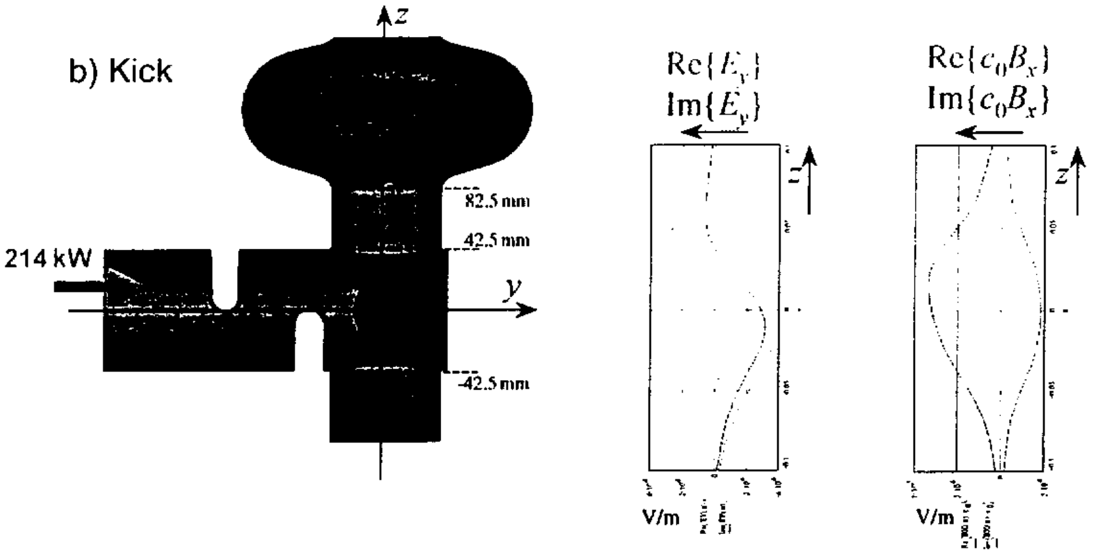
$B_{max} = 1.6 \cdot 10^{-3}$ T

B_{im}

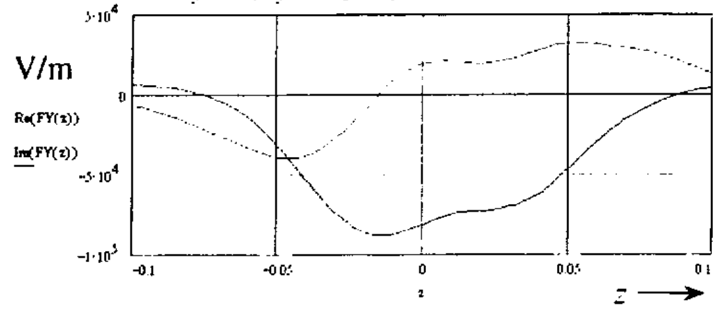




b) Kick



$$F_y = \left(E_y + c_0 B_x\right)\exp\left(j\beta\left[z - z_{\text{offset}}\right]\right)$$



kick

$$\int F_y dz = (0.7 - j\,7.7)\text{kV}$$

Martin Dohlus Deutsches Elektronen Synchrotron Mar.99

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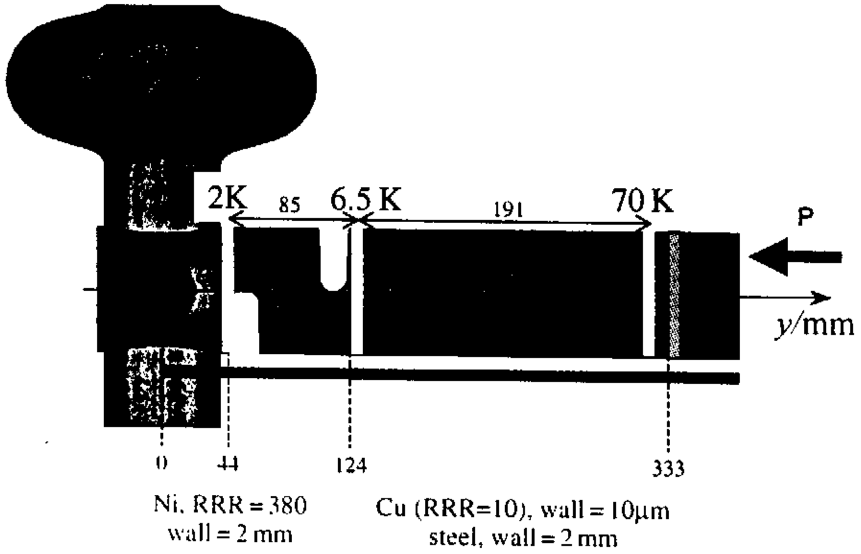
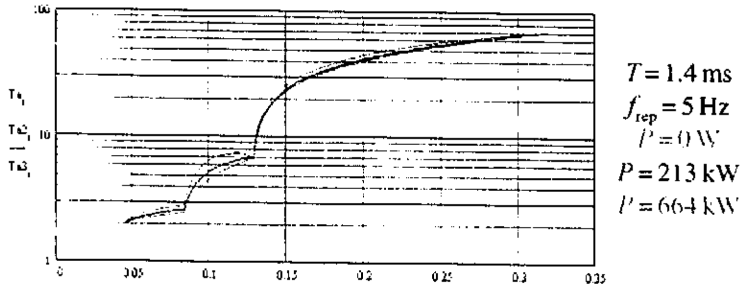
c) Losses

setup 1:

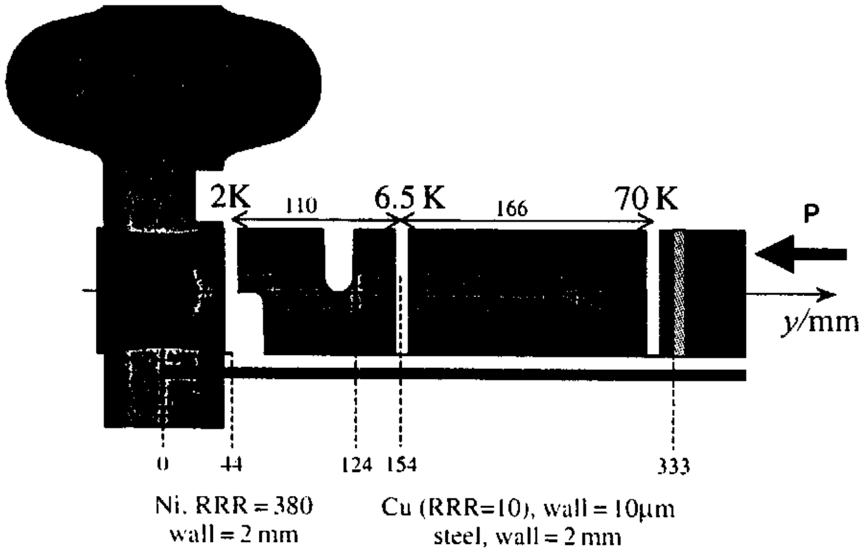


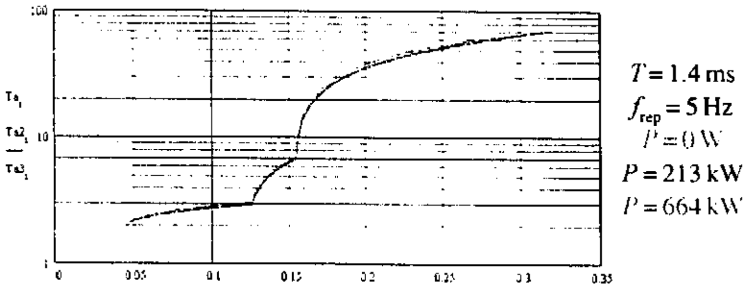


2 K losses: 0.061 W, 0.093 W, 0.162 W
4 K losses (6.5 K): 1.74 W, 1.96 W, 2.43 W

---

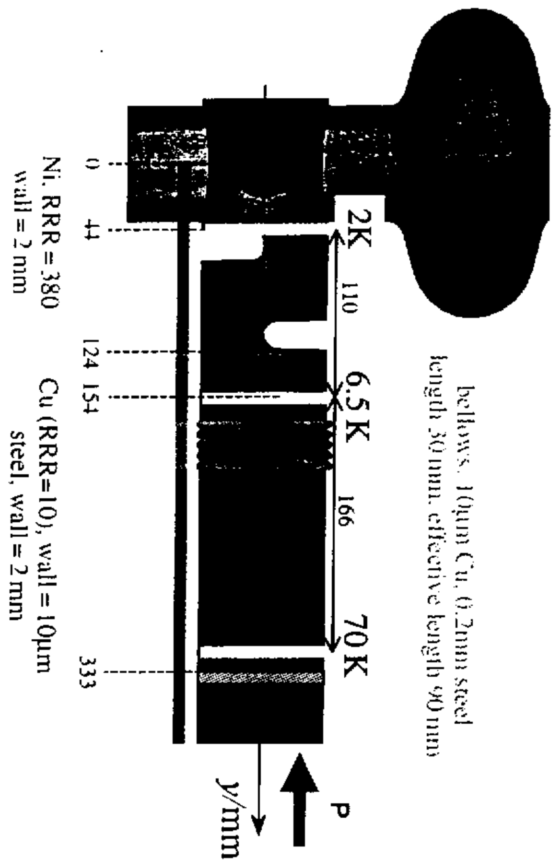
setup 2:

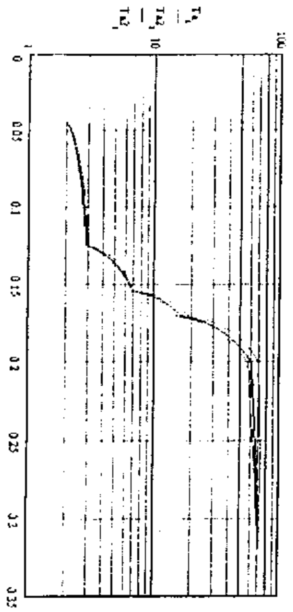




2 K losses: 0.091 W, 0.101 W, 0.124 W
4 K losses (6.5 K): 1.98 W, 2.16 W, 2.54 W

setup 3:





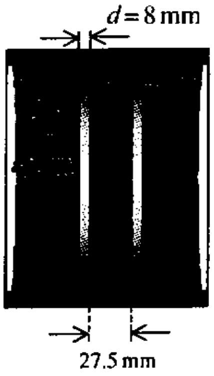
$T = 1.4$ ms
$f_{rep} = 5$ Hz
$P = 0$ W
$P = 213$ kW
$P = 664$ kW

2 K losses: 0.091 W, 0.101 W, 0.124 W

4 K losses (6.5 K): 0.77 W, 0.99 W, 1.46 W

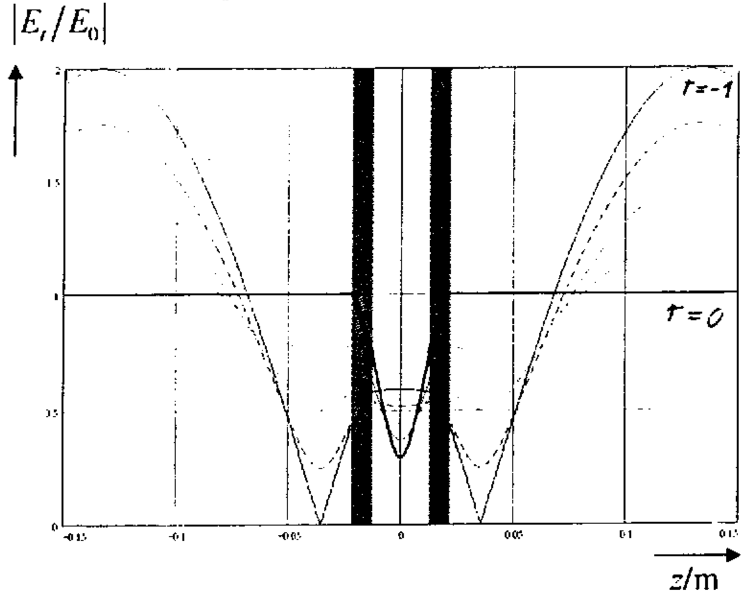
Martin Dohlus Deutsches Elektronen Synchrotron Mar.99

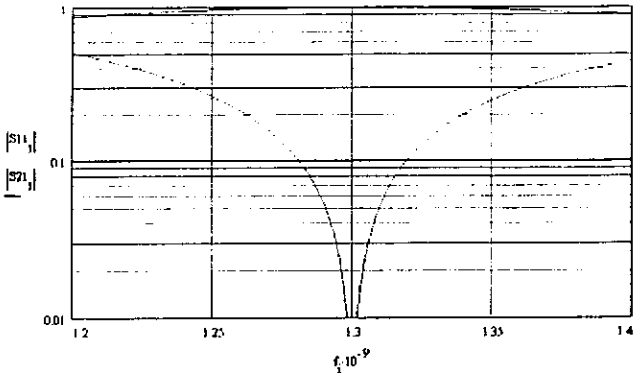
3.6 Double Window



Normalized Transverse
E-Field in Waveguide ($r = -1 .. 0$)

$E_0(P = 1\,\mathrm{MW}) = 0.449\,\mathrm{MV/m}$





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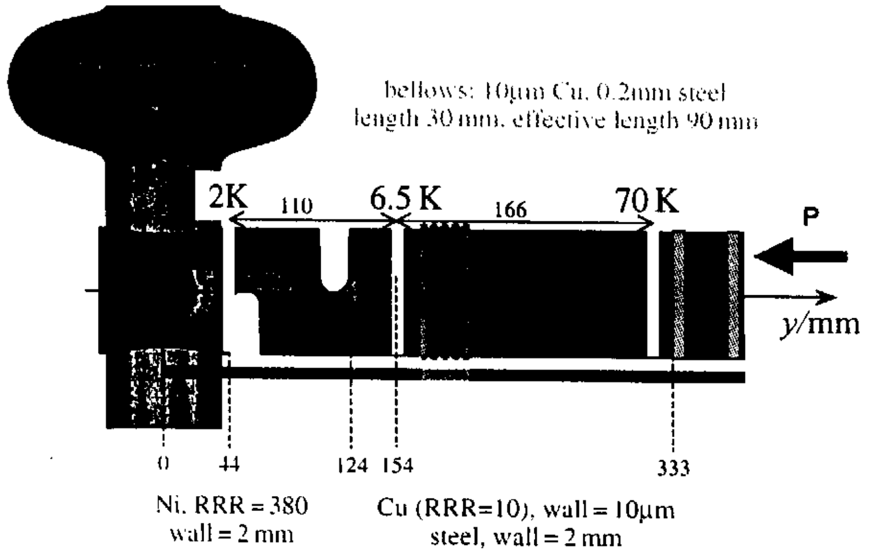
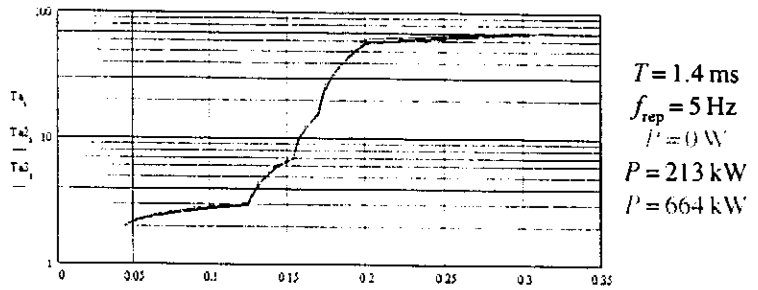
setup 4: (double window, estimated)





2 K losses: 0.091 W, 0.101 W, 0.122 W
4 K losses (6.5 K): 0.77 W, 0.87 W, 1.09 W

---

5. Tuning

5.1 Coupler with adjustable coupling: ???

5.2 External Tuning

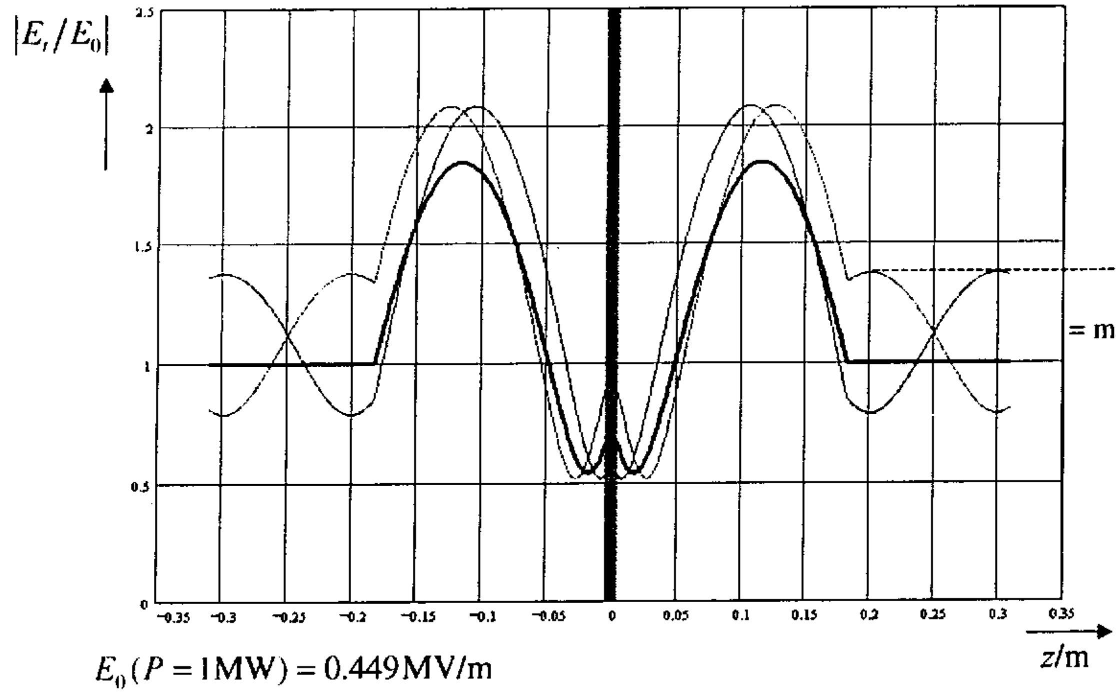
design: $Q_{\mathrm{ext}} = 3.10 \cdot 10^6$

e.g. wrong coupling: beam pipe 5 mm too long → $Q_{\mathrm{ext}} = 5.44 \cdot 10^6$

beam pipe 5 mm too short → $Q_{\mathrm{ext}} = 1.80 \cdot 10^6$

reflection by external tuner: $|r| = \left| \frac{Q_{\mathrm{ext}}^{\mathrm{design}} - Q_{\mathrm{ext}}}{Q_{\mathrm{ext}}^{\mathrm{design}} + Q_{\mathrm{ext}}} \right|$ example $|r| = 0.27$

field distribution in window $r = -0.27, 0, +0.27 \quad P_{\text{forward}} = \text{const}$



$$\sqrt{\frac{1+r}{1-r}} = \max\left\{\sqrt{\frac{Q_{\text{ext}}}{Q_{\text{ext}}^{\text{design}}}}, \sqrt{\frac{Q_{\text{ext}}^{\text{design}}}{Q_{\text{ext}}}}\right\}$$

$E_0(P = 1\text{MW}) = 0.449\text{MV/m}$

Measure of the superheating magnetic field

C.Thomas (PhD), G.Bienvenu, M.Fouaidy*, H.Sun**

- Direct measuring H_{sh} in High Power RF Short Pulsed mode
- $H_{sh} = f(\lambda/\xi)\ H_c$
  - Measuring λ on cavity

*IPNO **Visitor

LAL
LABORATOIRE
DE L'ACCÉLÉRATEUR
LINÉAIRE

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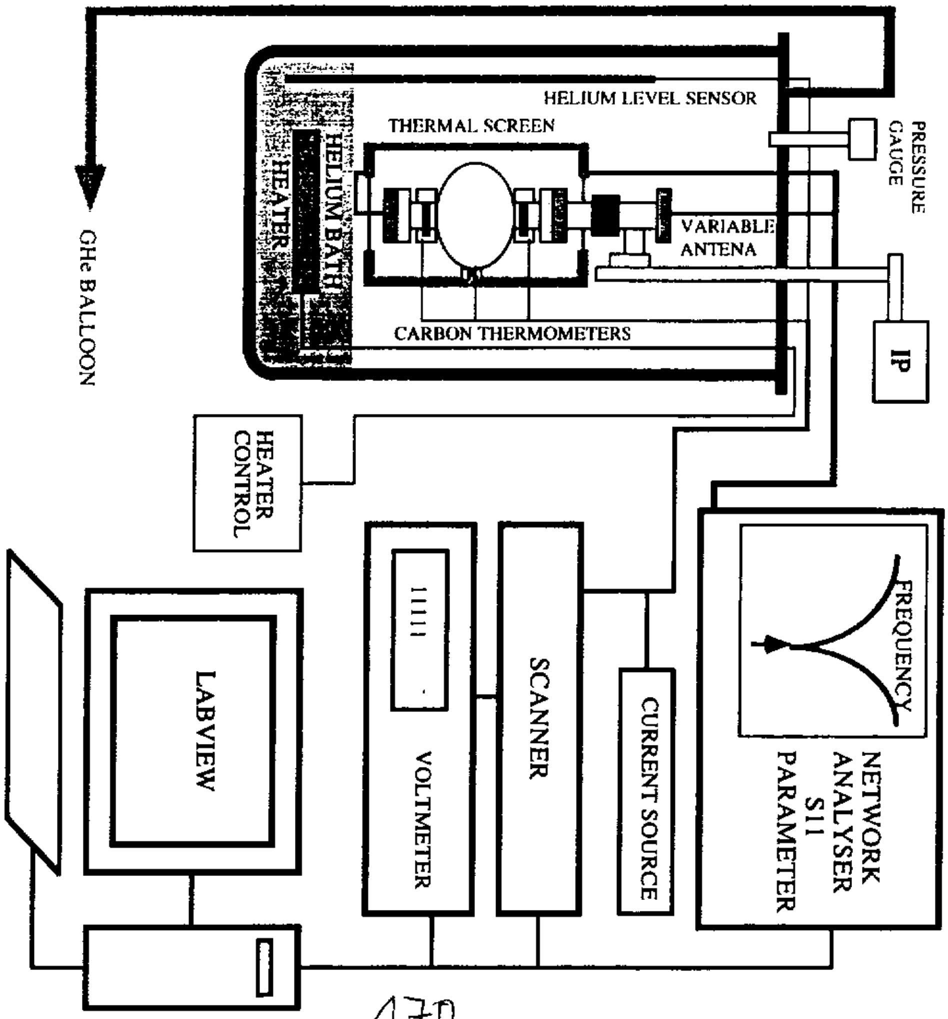
3 GHz Nb CAVITIES

λ EXPERIMENTAL DETERMINATION



Theory :

London -> $$\lambda_L = \frac{\lambda_{L0}}{\sqrt{1-t^4}}$$

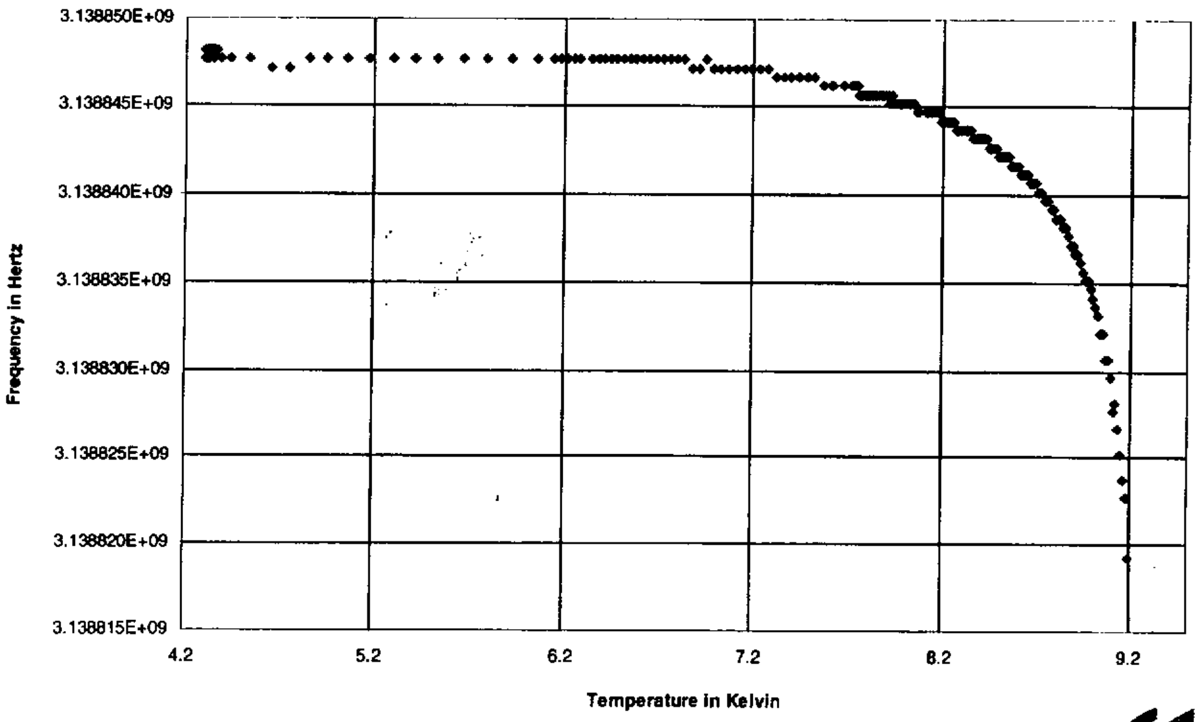
GL -> for clean supra $$\lambda = \frac{\lambda_{L0}}{\sqrt{2(1-t)}}$$

for dirty supra $$\lambda = \frac{\lambda_{L0}}{\sqrt{2(1-t)}}\sqrt{\frac{\xi_0}{133l}}$$

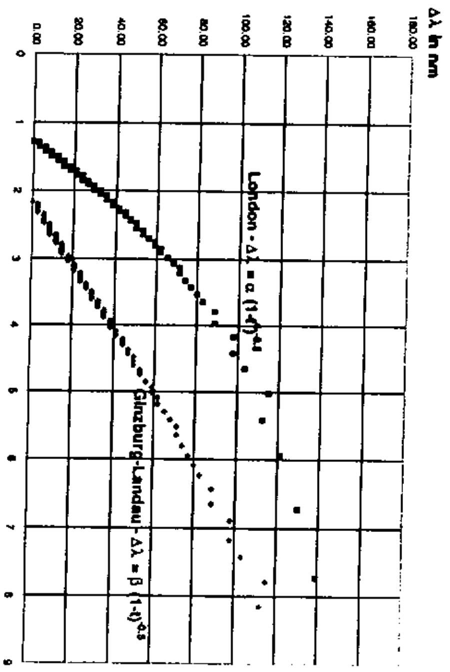
Method :

Variation of the reactance $$\Delta\lambda = \frac{2G}{\mu_0}\left(\frac{\omega_0-\omega}{\omega_0^2}\right)$$

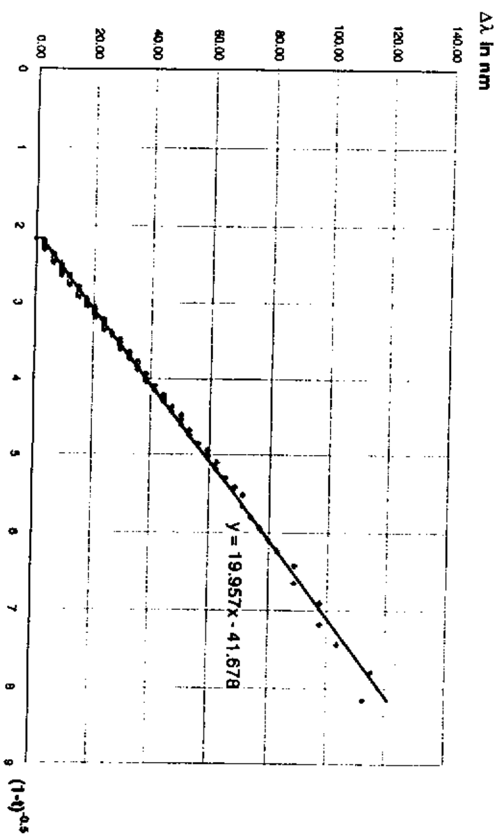
Evolution of experimental frequency as a function of temperature



Preliminary Results



Δλ plotted as a function of London and Ginzburg-Landau models



Fit of the experimental Δλ by Ginzburg-Landau model

Dirty case : $31 < l\ (nm) < 119$

$12 < RRR < 44$

Caracteristic of the direct meaurement of H_{sh}

$P_I < 5$ MW

$T_{RF} = 4.5\ \mu s$

f = 3 GHz

$$Q_{ext} \in \left[30000\ ;10^7\right]$$

IPN Orsay - SEA Collaboration

SURFACE RESISTANCE MEASUREMENT OF SUPERCONDUCTING SAMPLES WITH VACUUM INSULATED THERMOMETERS

M. Ribeaudeau, S.Chel, JP.Charrier, M.Juillard SEA/DAPNIA/DSM CEA
M.Fouaidy IPN Orsay (CNRS/IN2P3-Univ. Paris XI)

Abstract

A cylindrical niobium TE011 cavity is used at Saclay for measuring, with a differential method , the overall surface resistance R_S of superconducting thin films (Nb or NbTiN) sputtered on removable copper disks (Nb/Cu samples). An alternative device, for Nb/Cu samples RF properties characterization purpose was developed. The main feature of this technique, which is based on thermometry, is an improved accuracy and sensitivity as compared to the usual method. The thermometric method, conjointly with a thermal model, is used for the measurement of the absolute R_S distribution on superconducting thin film samples. Precise calibration of test-samples RF losses is performed by means of a removable DC heater and temperature sensors pressed on the back of the disk and placed in a vacuum chamber. This new facility allows in-situ determination of all the thermal parameters involved in the model (substrate thermal conductivity and heat transfer coefficient at the solid-Lhe interface). The thermometric technique was first successfully validated and RF properties of several Nb/Cu sample was studied with this new device. Interesting data was obtained and analyzed. In particular, the effect of the copper substrate surface conditions on the Nb/Cu sample RF properties was investigated and the corresponding results discussed.

Motivations for developing such an instrument

● Why did we need to develop a new instrument for measuring the RF surface resistance (R_s) of sputtered superconducting films with such SRF cavity ?

1) In order to improve the accuracy and the sensitivity of R_s measurement, because the lack of accuracy and sensitivity at 4.2 K in the case of measurements performed by the usual so-called end plate replacement method !

2) Measure exclusively the test-sample RF losses by excluding any extra RF losses :

➔ Some of these extra RF losses are inherent to the 'classical' method namely : rest of the cavity, indium gasket, RF coupling loops.

➔ Potentially, anomalous RF losses induced by Field Emitted electron impacting area other than the sample .

● Purpose :

☒ improve the accuracy, reliability and sensitivity of R_s measurement.

☒Thorough and precise RF characterization of sputtered Nb and NbTiN films onto Copper substrate :

➢ Study the effect of sputtering process parameters and substrate surface preparation on the films RF properties in order to improve the superconducting sample performance and master the technology.

➢Investigate $R_s(T)$ in the temperature range : 1.6K - 4.5 K

➢ Study R_s spatial distribution on the sample .

☒Progress in the understanding of SRF properties and get more insight into superconducting film physics and develop new superconducting material interesting for accelerators applications.

● Main advantages of this method

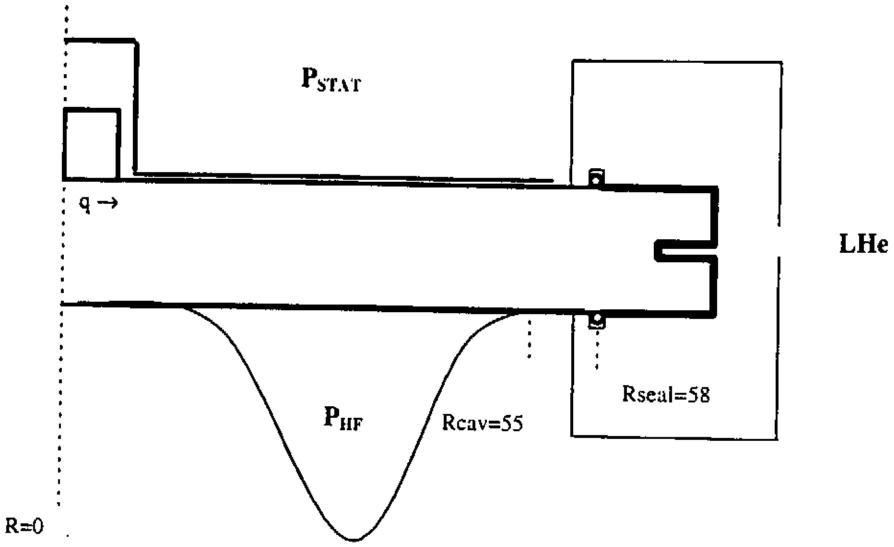
➔ Absolute, direct and local method as compared to the usual RF technique.

➔ no reference disk needed (save time, no assumption concerning the rest of the Niobium cavity RF surface).

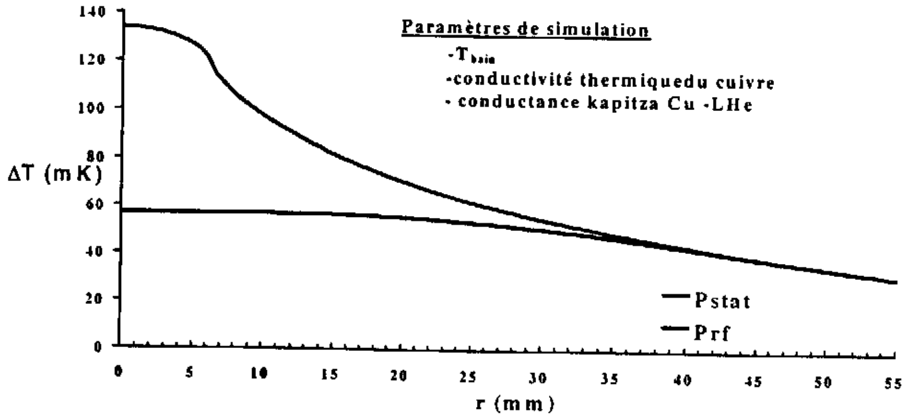
➔Vacuum insulation and hence a precise temperature measurement (the thermometers are in contact with a non-wetted solid wall) .

➔in-situ measurement of substrate thermal parameters.

Shéma de principe

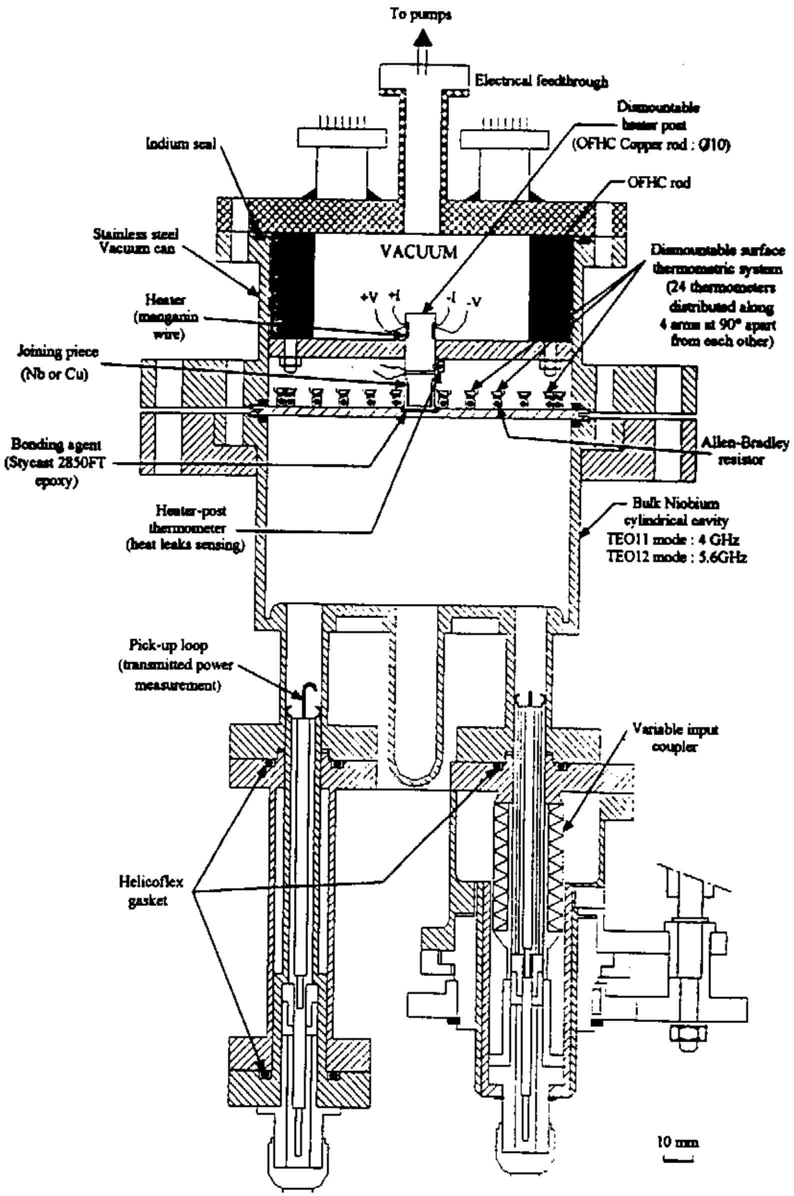


Profil radial de température ($T\text{-}T_{Bain}$) sur le disque ($P_{STAT}=P_{RF}=242mW$)



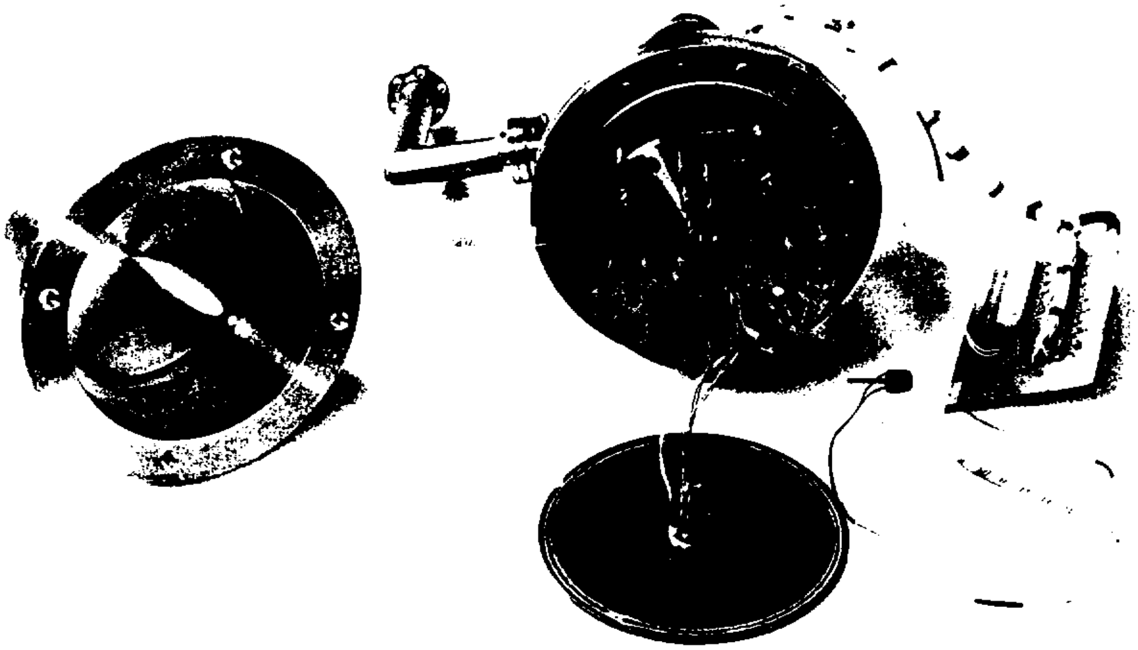
$\forall$r>40mm $P_{STAT}=P_{RF} \Rightarrow \Delta T_{STAT}= \Delta T_{RF}$
$\Rightarrow$détermination via la relation(1) des coefficients (R_0,R_1,R_2)

COLLABORATION IPN Orsay - SEA/DAPNIA/DSM/CEA
M. FOUAIDY, M. RIBEAUDEAU

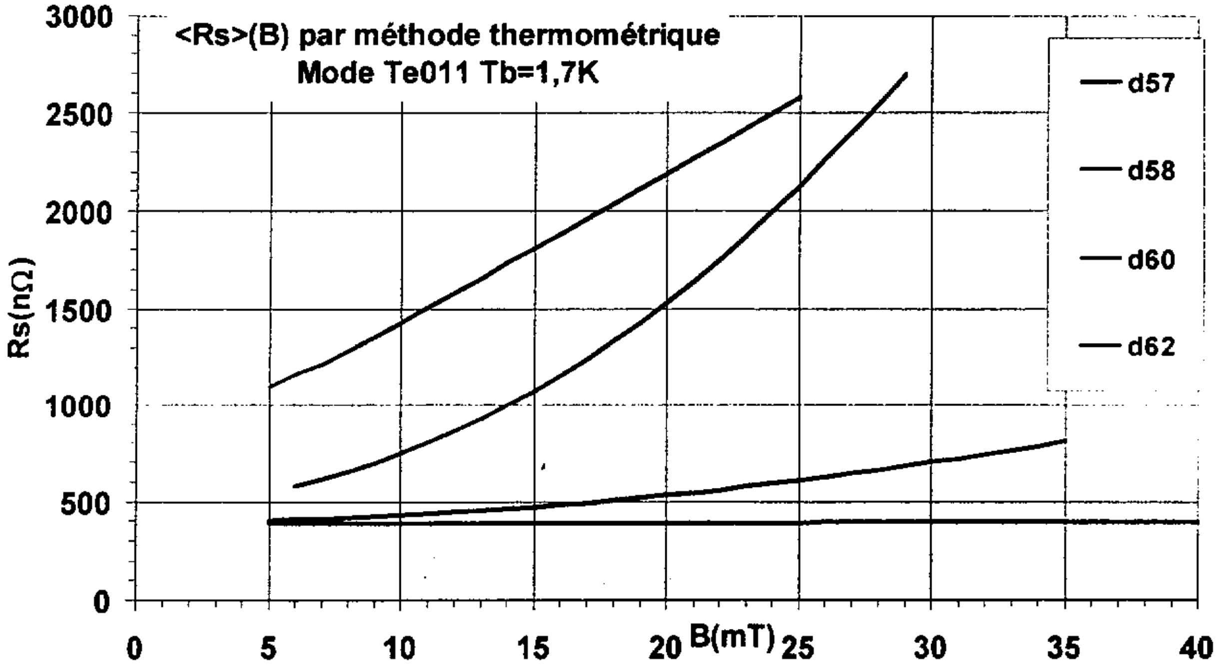


EXPERIMENTAL SET-UP

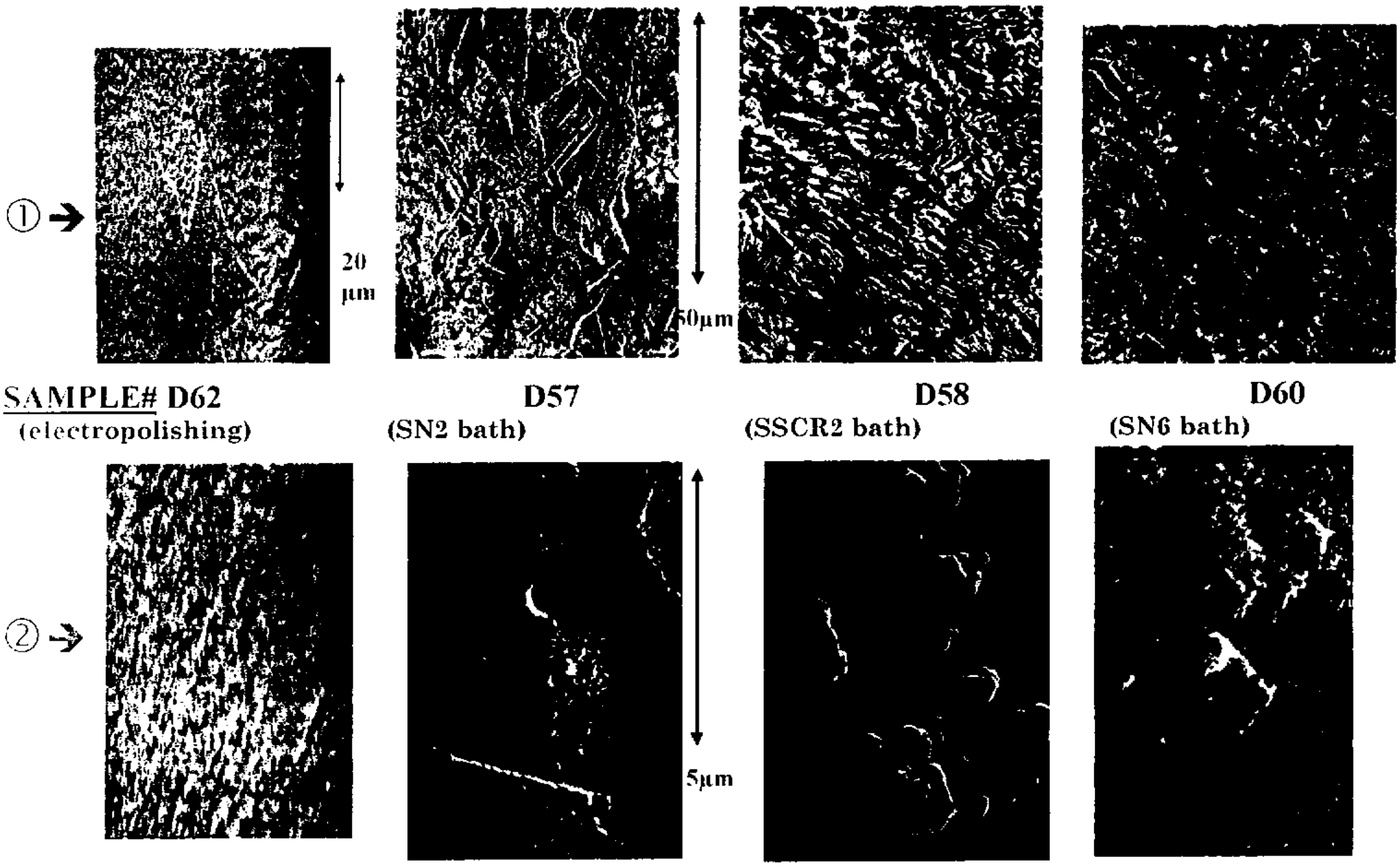
→http://ipnweb.in2p3.fr/~yaniche/



Rs vs B measurement of Nb Films on Cu substrate (T=1.7K, f=4GHz)



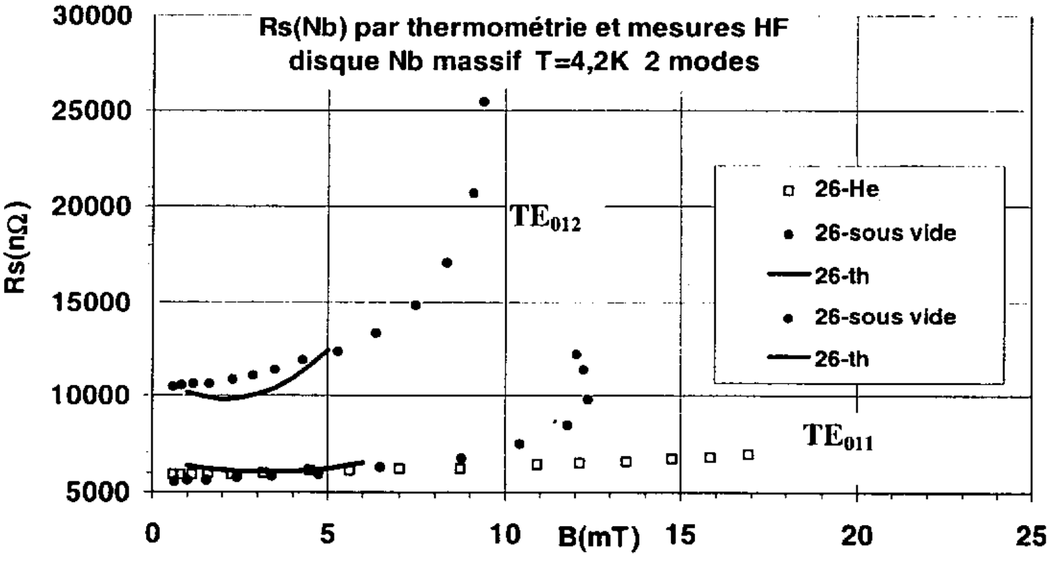
➔The Nb film RF surface resistance increases with the substrate roughness.



1 Copper substrate before coating with the Nb film - 2 Nb film (1.5 µm) coating on copper substrate (magnetron sputtering)

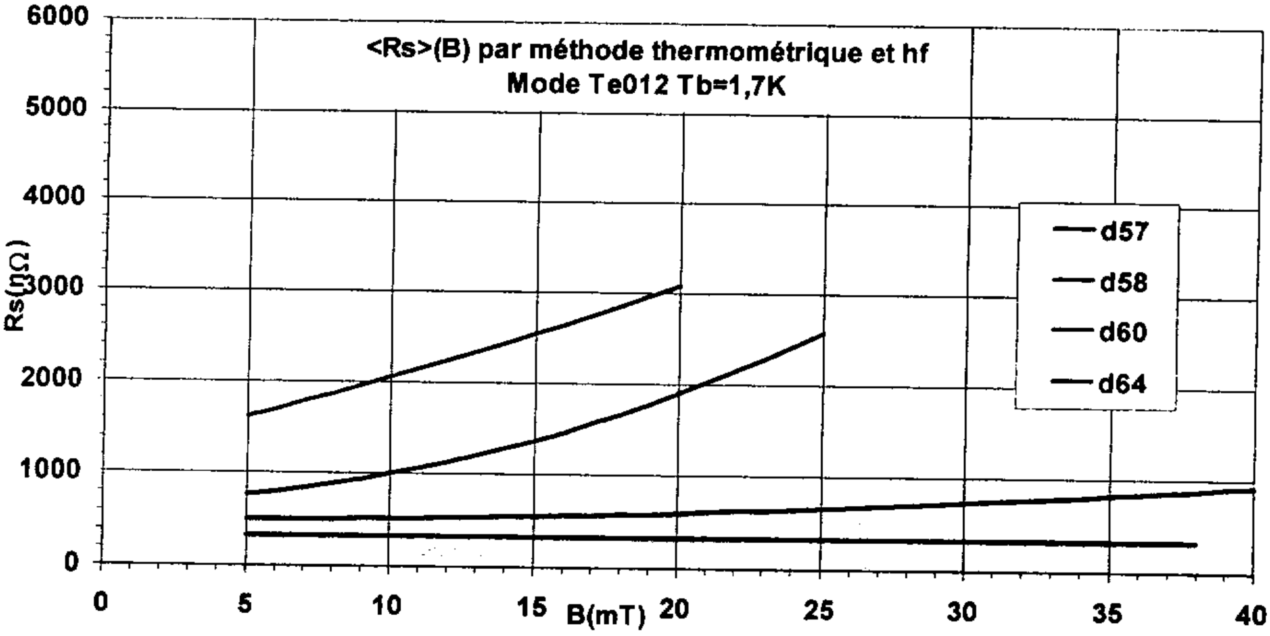
Résultats HF à Tb=4,2K

1/Validation de la méthode de mesure : comparaison à bas champ deRs (Nb massif) par méthode HF et thermométrique



⇒ **Valeurs comparables entre les deux méthodes de mesures**

Rs vs B measurement of Nb Films on Cu substrate (T=1.7K , f=5.6GHz)



Orsay

[1]TESLA Meeting, Desy Hamburg March
1999

M.FOUAIDY for IPN Orsay, LAL, SEA/CE Saclay collaboration

SRF NIOBIUM CAVITIES STIFFENING BY THERMAL SPRAYED COATING

S.Bousson, A.Caruette, M.Durante, M.Fouaidy, H.Gassot, N.Hammoudi,T.Junquera,
J.C.Lescornet, J.Lesrel, IPN Orsay - France
J.L Borne, J.C.Bourdon, L.Grandsire, A.Thibault, LAL Orsay - France
C.Antoine. SEA CE Saclay - France

MAIN OBJECTIVES

⊙➢ Cavity stiffening in order to reduce frequency shift Δf induced by Lorentz forces

⊙➢ Develop an alternate scheme to the actual Nb stiffening rings which are no more efficient for E_{acc}>28 MV/m (i.e Δf > 434 Hz = TESLA cavity BW @ Q_{ext} =3.10^6)

⊙➢ Possible gain in cavity thermal performance ?

⊙➢ Reliability and cost reduction ?

MAJOR ISSUES OF THE R&D PROGRAM

❶ Compare different thermal spraying techniques.

➔ Focus on 4 thermal spraying methods in collaboration with 2 French Laboratories .

1) Vacuum Plasma Spraying (VPS),
2) Atmospheric Plasma Spraying (APS) ,
3) Controlled Atmosphere Plasma Spraying (CAPS) ,
4) High Velocity Oxy-Fuel Spraying (HVOF)

---

[1] M.FOUAIDY TESLA Meeting, Desy Hamburg March 1999

❷ Material characterization on ~~specimens~~ samples

➢Metallurgy, microstructure, porosity

➢Mechanical properties and thermal properties,

❸ Numerical simulation of cavity mechanical and thermal behaviour.

❹Fabrication and test of monocell and multicell cavities

- 3GHz monocell cavities
- 5 1.3GHz monocell cavities

Nb : Heraeus : thickness : 1mm RRR ≈130

M. FOUAIDY

Fabrication and test of monocell and multicell cavities

- 3GHz cavities (number: 7)
- Five 1.3GHz monocelle cavities
- Two 1.3GHz Tri cell cavities
- Nb sheets supplied by Heraeus RRR = 140
  Thickness : 1mm
- Coat cavities with thermally sprayed deposit

→ Coating thickness : 2-3 mm

→ Material : to be decided After Mechanical and thermal tests on samples

→ coating technique : APS or VPS or HVOF
To be chosen according to several criteria :

- High Bonding strength
- High Young modulus
- Good thermal performance
- Best mechanical properties (Low Temp.)

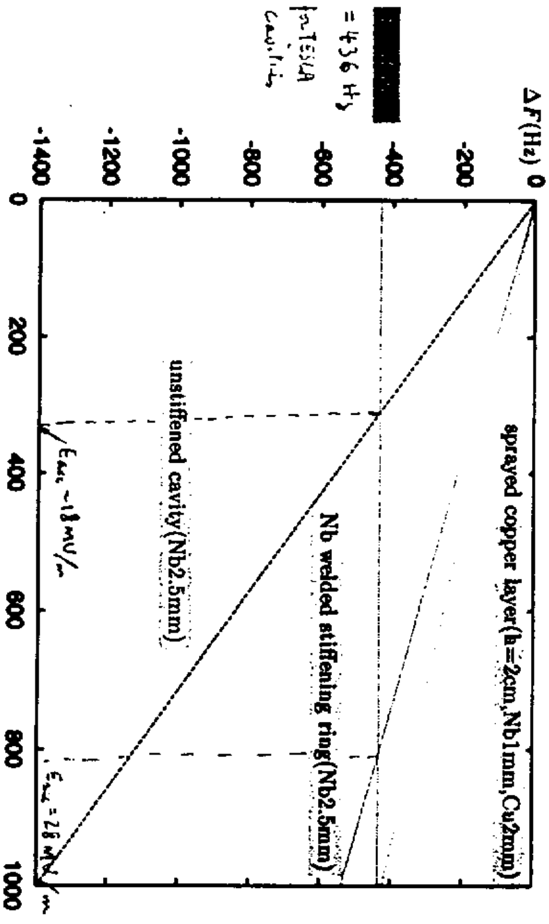
......

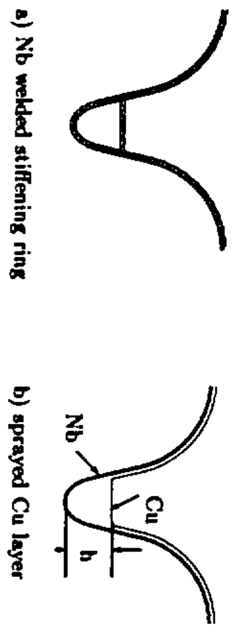
S. Bousson
IPN Orsay (France)
13/1/99

Test of copper coated 3 GHz monocell cavities

Cavity # Nb RRR 40 e=0.5 mm	1			2			3			4			5		
	Emax	Qo	Rem.	Emax	Qo	Rem.	Emax	Qo	Rem.	Emax	Qo	Rem.	Emax	Qo	Rem.
First Test	4	5 10^8 à 3 10^8	Quench	12	2 10^9 à 2 10^9	Quench	*	*	not tested	*	*	not tested	*	*	not tested
Heat treated 800°C	11	5 10^9 à 3 10^9	Quench	16	4 10^9 à 3 10^9	Quench	yes	yes	not tested	no	no	not tested	no	no	not tested
Heat treated 1200°C	12.5	3 10^9 à 2 10^9	X-rays Quench	<u>24.5</u>	4 10^9 à 1 10^9	X-rays Quench	no	no	not tested	16.5	2 10^9 à 1 10^9	X-rays Quench	14.6	4 10^9 à 2 10^9	Q-Switch Quench
Copper Coating (2 mm)		01/99			01/99		10	4 10^9 à 3 10^9	Quench	16.5	3 10^9 à 2 10^9	Quench	13.6	2 10^9 à 2 10^9	Quench

FREQUENCY SHIFT



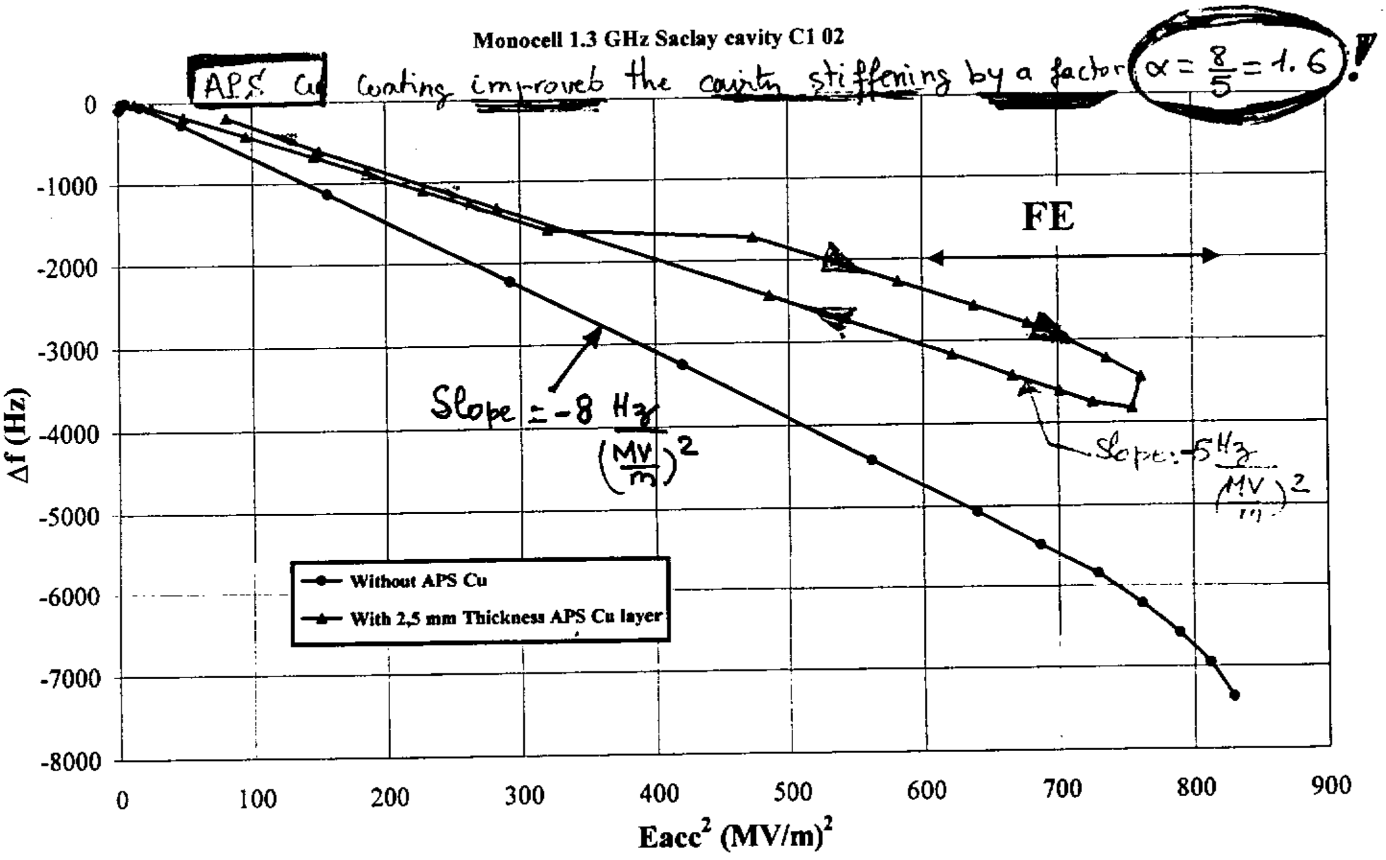


a) Nb welded stiffening ring

b) sprayed Cu layer

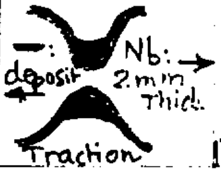
COPPER COATING by PLASMA SPRAY:
A New Method to Improve the Stiffering of TESLA Cavities

M.FOUAIDY



28/02/99

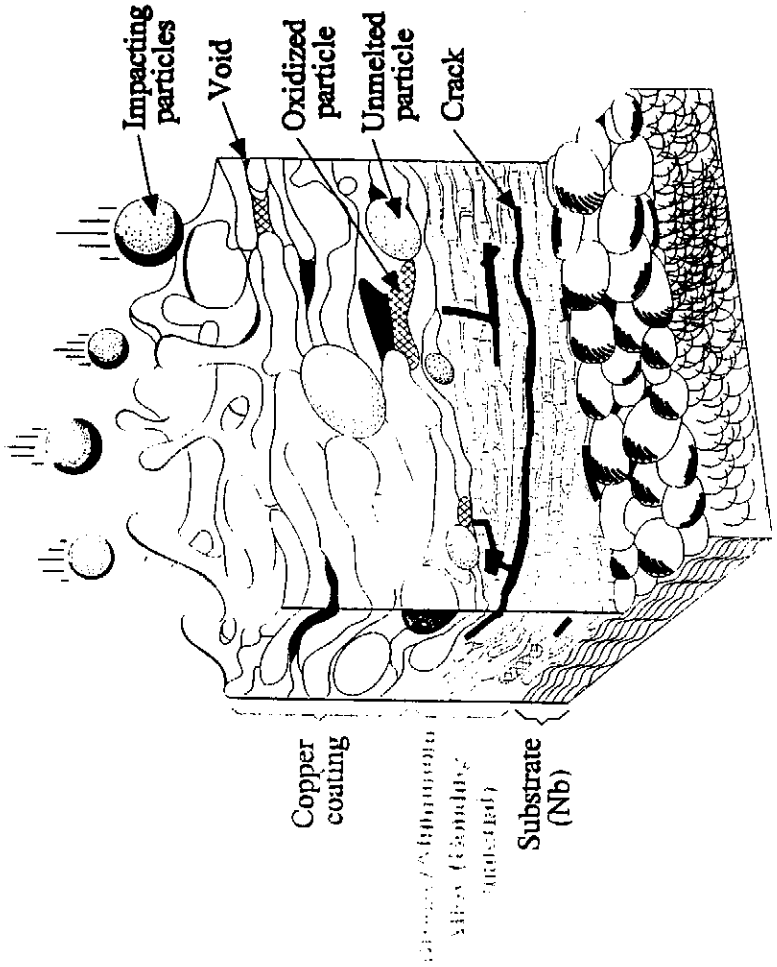
(Tests on Samples) IPN Orsay – LAL – SEA

	IPN Diff. Thermal Contraction	Residual Stresses (ENSAM)	Cracks prop.: thermal shock [illegible]-(ENSAM)	Young Modulus at 300K (E)	Simulate Cavity Tuning	Porosity
MECHANICAL / METALLURGY	CuAgZr AlTi.. Tubes } LPPS	CuAgZr AlTi.. Tubes } LPPS	CuAgZr AlTi.. Tubes } LPPS →	Measure Hardness ⇒ Estimate E	Two half-cells (Diabolo) 	CuAgZr LPPS Cu HVOF AlTi LPPS Ti LPPS, APS Cu APS (Tubes)
	Cu : HVOF Tube.	Cu HVOF Tube	Cu : HVOF Tube.	• LAL ? • LEREHPS (Belfort)		
PROPERTIES / Microstructure			FLAT SAMPLES }	AlTi.. LPPS Cu: HVOF Cu: APS (*) Ti (LPS, APS) Traction exp. Flexion ≠ Lab.	FLAT SAMPLES }	Cu APS Ti LPPS, APS
THERMAL PROPERTIES	OVERALL Ther. Resist.	THERMAL CONDUCTIVITY	Permeability			
	AlTi..: LPPS → Cu : HVOF → Cu : APS → Ti {LPPS, APS ? →	? ? ? ? Depend on the previous tests !	→ OK → OK → OK → OK			

M.FOUAIDY

COMPARISON OF DIFFERENT SPRAYING TECHNIQUES

Technique	Particles velocity, Temperature and spraying distance	Atmosphere	Porosity (%)	Bond strength for metals (MPa)	Coating thickness (µm)	Powder particle size (µm)	Remarks
Flame Spraying (F.S)	80-100 m/s 3000-3500 K d :120-250 mm	air	10-20 0 for self-fluxing coating	30 (Typical) 60-70 (Max.)	100-2500	5-100	Inflight Particle Oxidation (IPO), trapped air...
Atmospheric Plasma Spraying (APS)	120-350 m/s (400-550 m/s) 2000-3500 K d : 50-150 mm	air	1-7 could be greater	>70 **bonding alloys**	50-500 2500 obtained	5-100	IPO, Oxygen content up to 2% density ≅ 80%Bulk inhomogeneous
Vacuum Plasma Spraying (VPS or LPPS)	Up to Mach 3 2000-3500 K d : 300-400 mm	Inert gas Ar at ~50 mBar	1-2	>80	150-500	5-20	Oxygen content less than 500 ppm density ≅ 95%Bulk homogeneous high bonding strength
Controlled Atmosphere Plasma Spraying (CAPS)	80-100 m/s 2000-3000 K d :100-250 mm	Ar, He, N_2 1-5 Bar	1-7	20-45	50-500	5-100	low bonding strength
D-Gun Spraying	750-900 m/s 3500-4500K d ≈100 mm	Air	0.5-1	>70-80	300	5-60	high bonding strength
High Velocity Oxy-Fuel Spraying (HVOF)	< 1500 m/s 1500-2500 K d :150-300 mm	Air	<1	up to 90	100-300	5-45	high bonding strength



Atmospheric Plasma Sprayed Coating Build-up

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[1]M.FOUAIDY
IPN Orsay

CHARACTERIZATION OF PLASMA SPRAYED COPPER COATINGS

○ microstructure analysis by SEM and image processing :

→ get data on the structure morphology, pores dimension distribution, microchannels geometry and flow pattern, interface region analysis (inter-splat area and Nb/Cu interface), coating porosity....

→ optimize the spraying parameters which have an influence on the coating properties

Micrograph of Cu coating deposited onto a Nb substrate
(Atmospheric Plasma Sprayed Copper Coating)

→ Main features of this APS Cu coating :

- big number of unmelted particles,
- low cohesion between particles,
- high porosity,
- some discontinuities observed at the Nb/ bonding layer interface (MEB)

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[1] [1]M.FOUAIDY TESLA Meeting, Desy Hamburg March 1999

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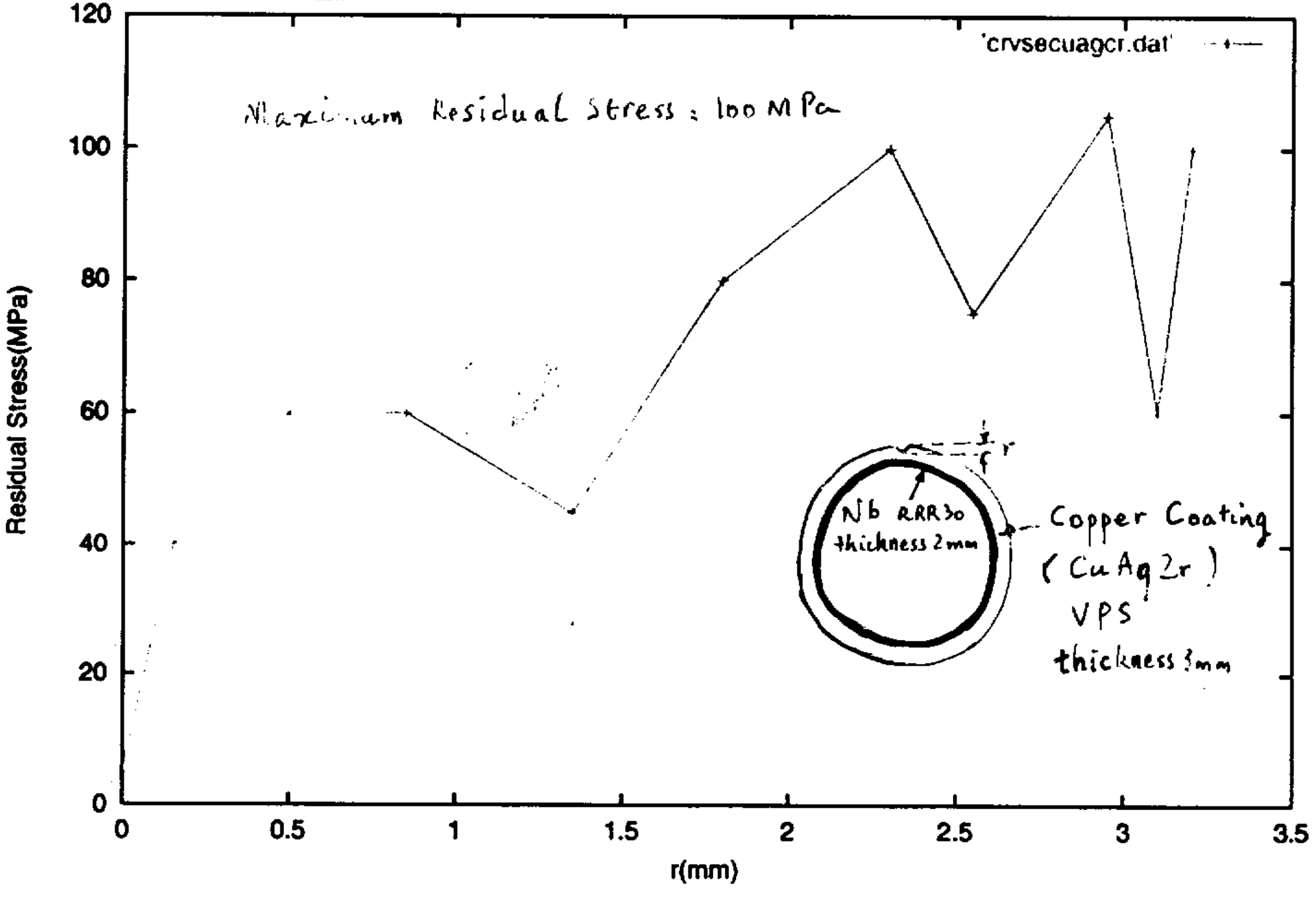
T. Junquera
18/2/99

Mechanical properties of coatings

Sample type	**Young's modulus (elastic constants) @ room temperature**	**Porosity**	**Residual stress**	**Thermal Stress @ 4 K**	**Thermal shocks @ 70 K...4K (fatigue,crack growth)**	**Bond Strength**
Tube Ø 40…50	Estimated from hardness meas.	**OK** (Archimede, Image analysis)	**OK** X-diffraction	**OK** (strain gauges)	**OK** Optical Microscopy SEM Microscopy	---
Plate 100…150 (width : 10…30)	**Strain-stress meas.** a) tensile b) compressive c) cantilever beam or 3 –points bending meas.	**OK** (Archimede, Image analysis)	**OK** X-diffraction	**OK** (deflection, strain gauges)	**OK** Optical Microscopy SEM Microscopy	---

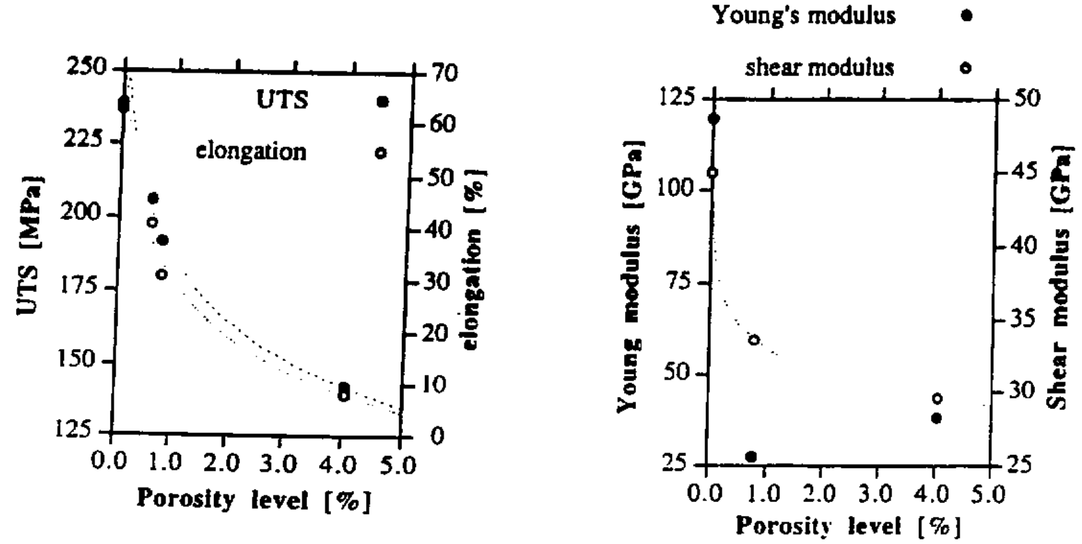
- **Thick deposits (two welded half-cells) : coating growth, thermal shocks, plastic deformation,…**
- **Bonding Homogeneity : ultrasonic tests**

Residual Stress Measurement by X diffraction
H. GASSOT / IPN/FRANCE V. JI / ENSAM / FRANCE



Tensile properties of V.P.S. Copper Deposits

G. Montavon et al. LERMPS (Belfort, France) 1996



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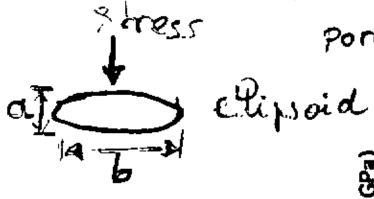
Porosity and Elastic Properties Model

Kuroda (NRIM, Japan) 1991

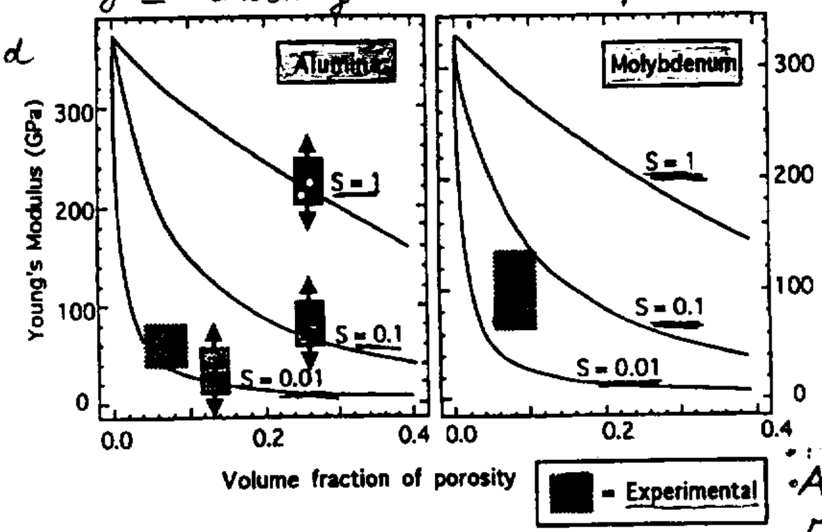
- Homogeneous inclusion model → predict Young Modulus (E)

Porosity ≡ ranbomly distributeb ellipsoids



(S): pore aspect ratio

→ $S = \frac{a}{b}$



• [illegible]

• APS alumina deposi

Molybdenum : Experimental data

$\frac{E_{APS\ Coating}}{E_{Bulk}} = 0.3$

Orsay

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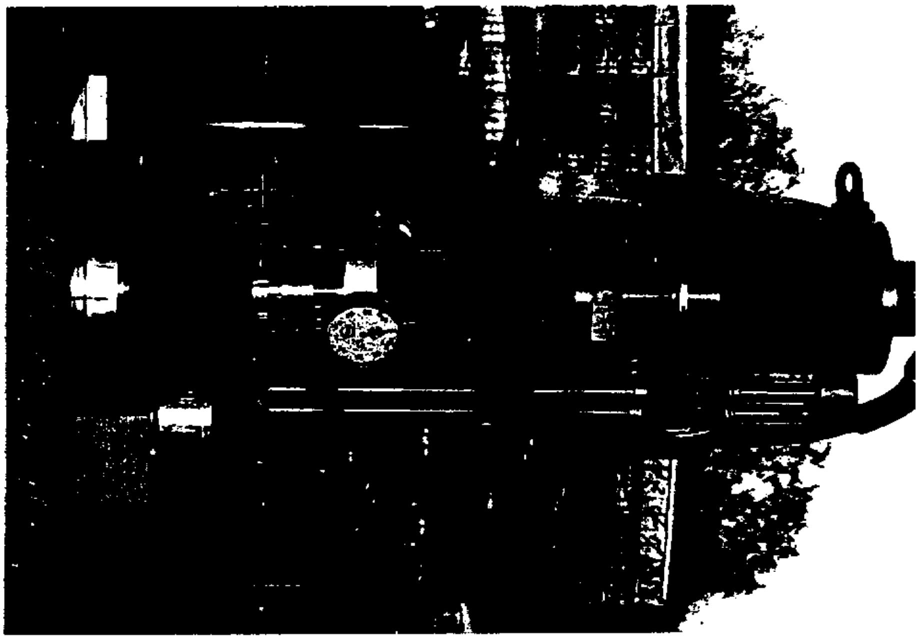
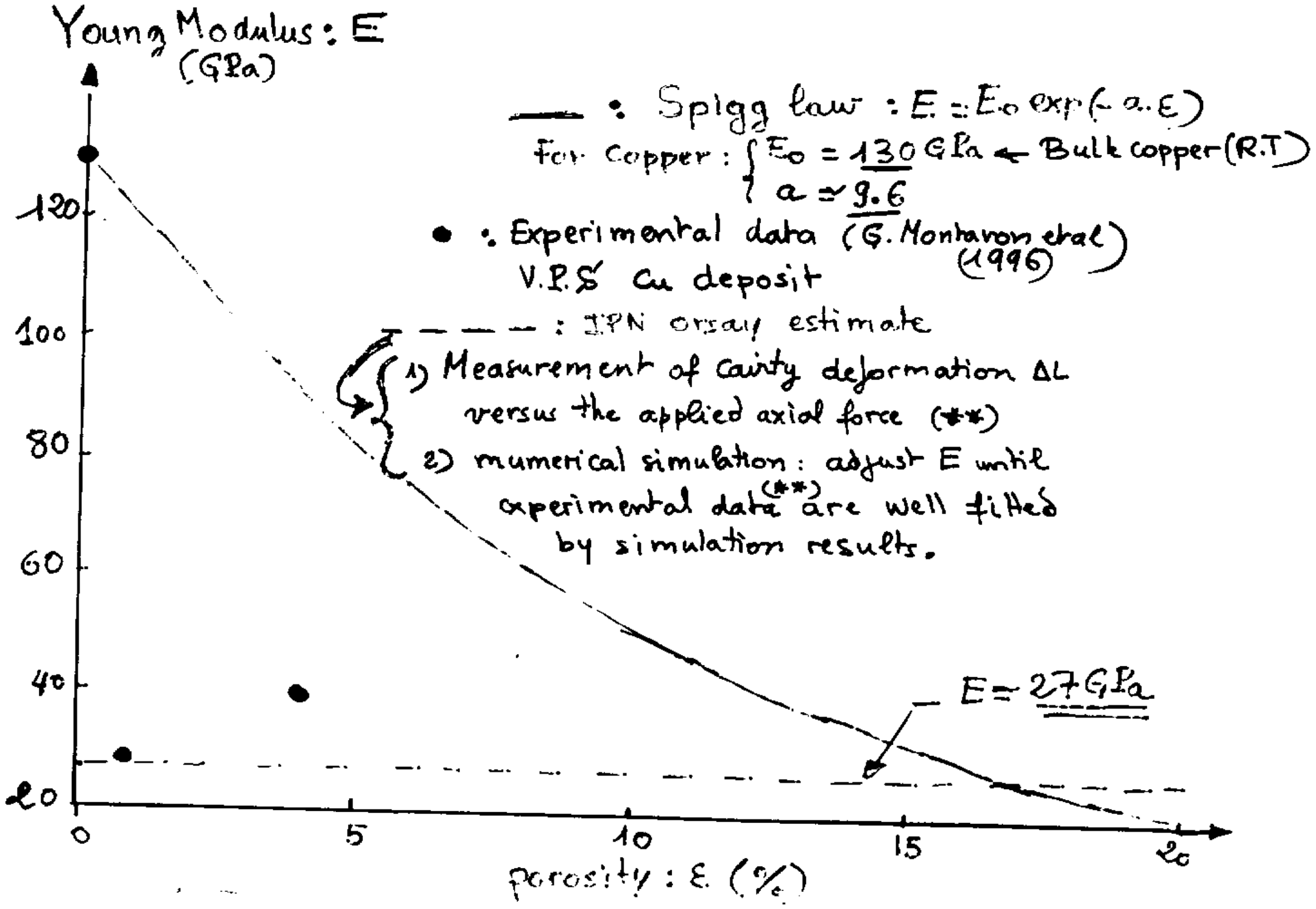
Young modulus experiment performed on a Cu APS coated 3 GHz Nb cavity



Experimental set-up

The cavity is subjected to an axial deformation and we measure ΔL vs Force



—— : Spigg law : $E = E_0 \exp(-a.\varepsilon)$

For Copper : $\begin{cases} E_0 = \underline{130}\ \text{GPa} \leftarrow \text{Bulk copper (R.T)} \\ a \simeq \underline{9.6} \end{cases}$

● : Experimental data (G. Montavon et al (1996))
V.P.S Cu deposit

– – – – : IPN Orsay estimate

1) Measurement of cavity deformation ΔL versus the applied axial force (**)

2) numerical simulation : adjust E until experimental data(**) are well fitted by simulation results.

E = 27 GPa

Estimation of APS Cu deposit Young Modulus

Orsay
M.FOUAIDY

LOW TEMPERATURE (4.2 K - 300 K) DIFFERENTIAL THERMAL CONTRACTION EXPERIMENT

IPN Orsay- LAL Collaboration

- **Goal : measure the thermal stresses associated to the differential contraction between bulk niobium and plasma sprayed copper coating.**

Low Temperature Strain Gauge Calibration Set-up

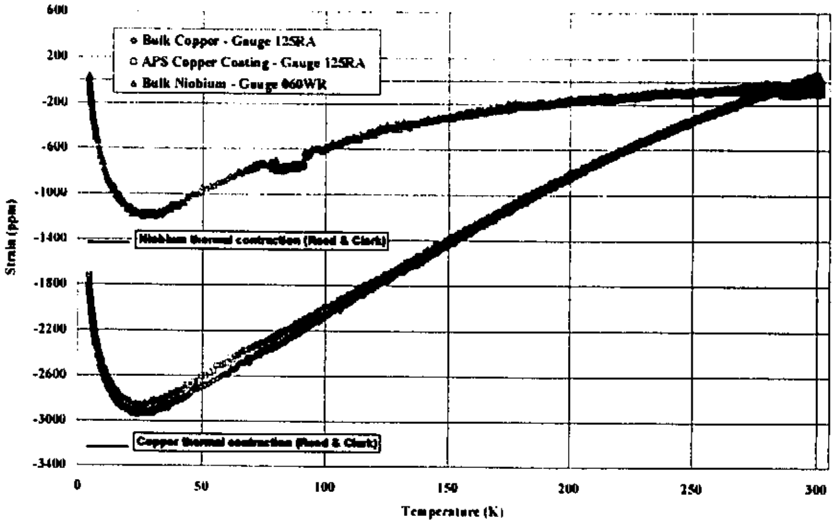
→ 3 samples : Bulk Nb, Bulk Cu, APS Cu coating.
Each sample is equipped with strain-gauges and 2 calibrated thermometers (Carbon & Platinum resistors).
Rosette ≡ 3 superposed strain-Gauge (resistive sensors made of Nickel-Chrome Alloy)

→The strain-Gauge are calibrated by the supplier : but the calibration curve **(Temperature effect correction)** depends on the material **to be tested and the mounting conditions (bonding agent.....).**

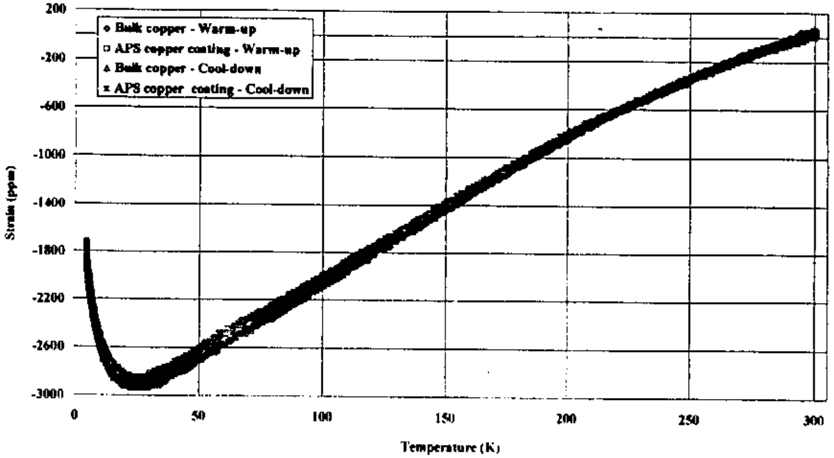
→One need calibration to get the temperature-induced apparent **strain for the test-specimens** (Bulk Niobium, Bulk Copper and APS Cu coating).

Orsay
M.FOUAIDY

Low Temperature Strain-Gauges Calibration results

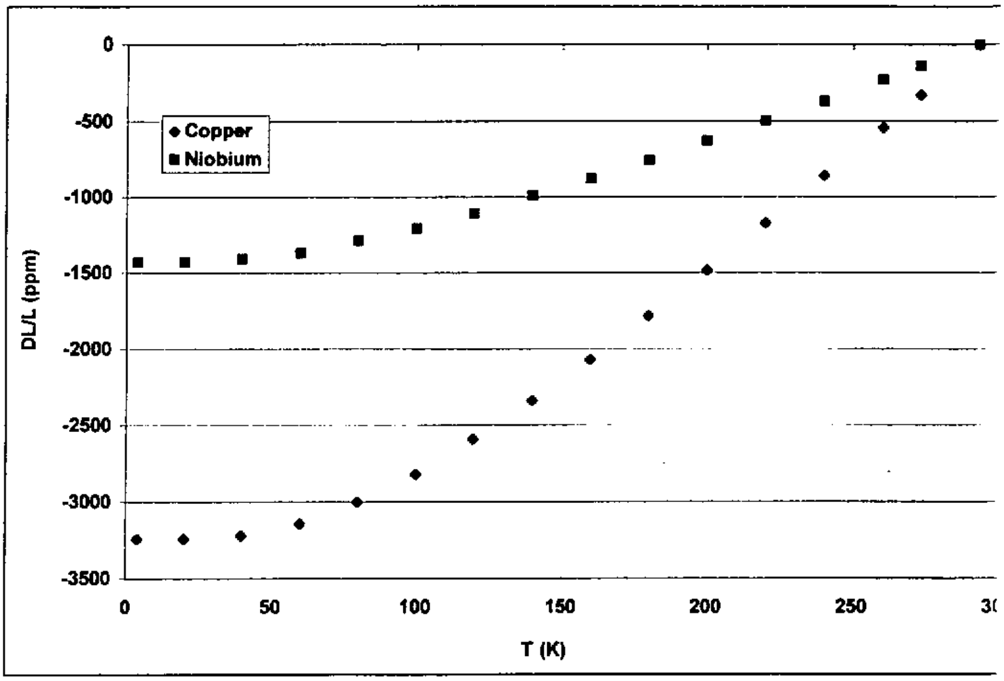


Apparent Thermal Contraction of Bulk Niobium, Bulk Copper and APS Copper during Samples Warm-up from 4.2 K to Room Temperature.



Bulk Copper and APS Copper Apparent Thermal Contraction : Samples Cool-down versus Warm-up between 300 K and 4.2 K.

	[L(293)-L(T)]/L(293)	
T (K)	Copper	Niobium
293	0	0
273	-330	-140
260	-540	-230
240	-860	-370
220	-1170	-500
200	-1480	-630
180	-1780	-760
160	-2070	-880
140	-2340	-990
120	-2590	-1110
100	-2820	-1210
80	-3000	-1290
60	-3140	-1370
40	-3220	-1410
20	-3240	-1430
4	-3240	-1430



Orsay

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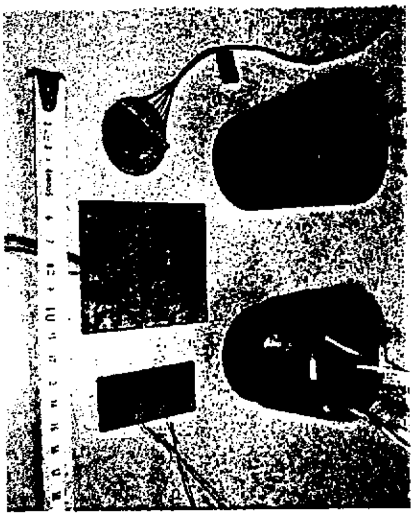
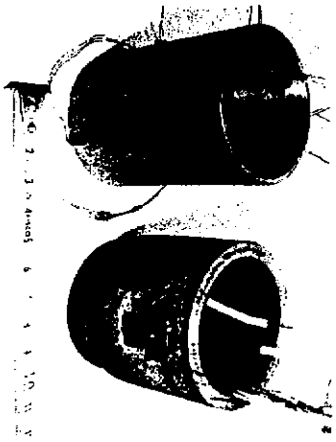
LOW TEMPERATURE (4.2 K - 300 K) DIFFERENTIAL THERMAL CONTRACTION EXPERIMENT



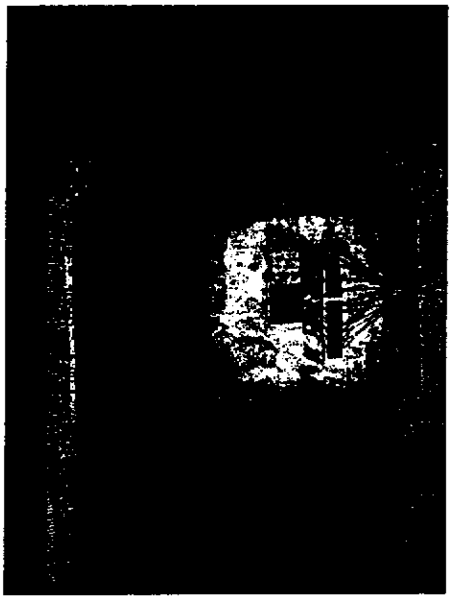
Test-samples : Bulk Nb tube (left), Nb tube with LPPS CuAgZr (Ag :3%,Zr :0.5%) coating, APS Cu coating disk (left) Bulk Cu and Bulk Nb plates.



Close view to the two tubes

(All the samples are equipped with Strain-gauges and temperature sensors)

☺ The experiment will be performed during TESLA Meeting (March 1999) ! ! !



Close view to the flat samples already used for calibration experiment

Orsay
M.FOUAIDY

EFFECT OF PLASMA-SPRAYED COATING ON THE CAVITY OVERALL THERMAL RESISTANCE

● We performed up to now 10 experiments with different Test-cells

➔ Purpose : measure the effective thermal resistance of the plasma sprayed copper

➔ Differential method : measure and compare heat transfer between Niobium and superfluid helium (naked Nb specimen (pure Nb) versus copper coated Nb specimen).

⇨ **Kapitza resistance R_K at Nb-He II interface is reproducible :**

× **Assumption : R_K have the same value for two similar samples**

- **machined from the same Niobium sheet**
- **prepared at the same time and**
- **according to exactly the same procedure (Mechanical polishing, degreasing, heat treatment, chemical etching,...etc).**

● **For comparing all the experimental data obtained up to now (different test-cells used) the analysis is restricted to the overall thermal resistance R_O data @ 1.8 K.**

➢ **The measured overall thermal resistance R_O is given by :**

$$R_O = R_K + \frac{e_{Nb}}{k_{Nb}} + R_K$$

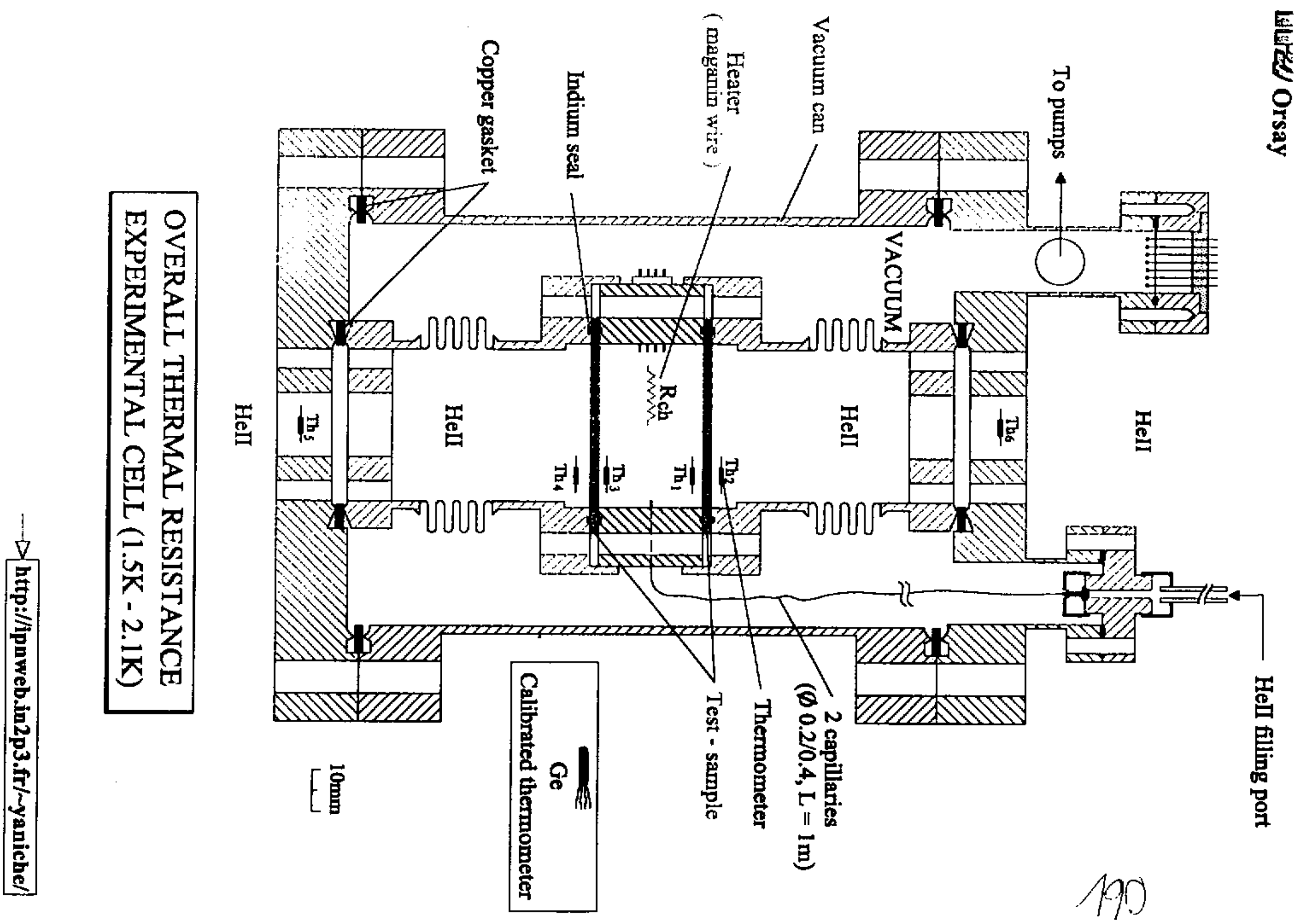
k_{Nb} : Niobium thermal conductivity,
e_{Nb} : Niobium thickness.

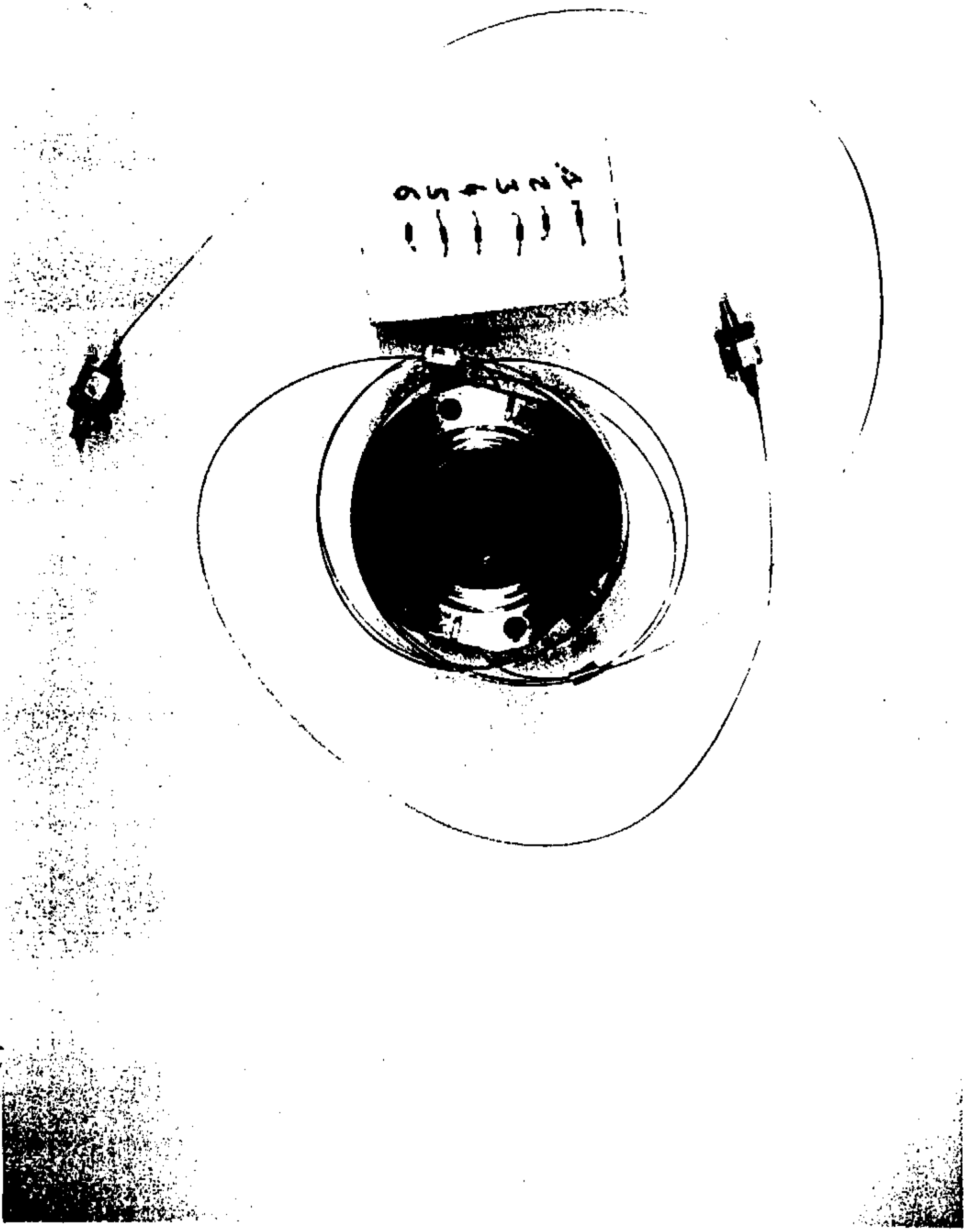
Obviously, for a cavity, the effective thermal resistance (uniform heating case) is :

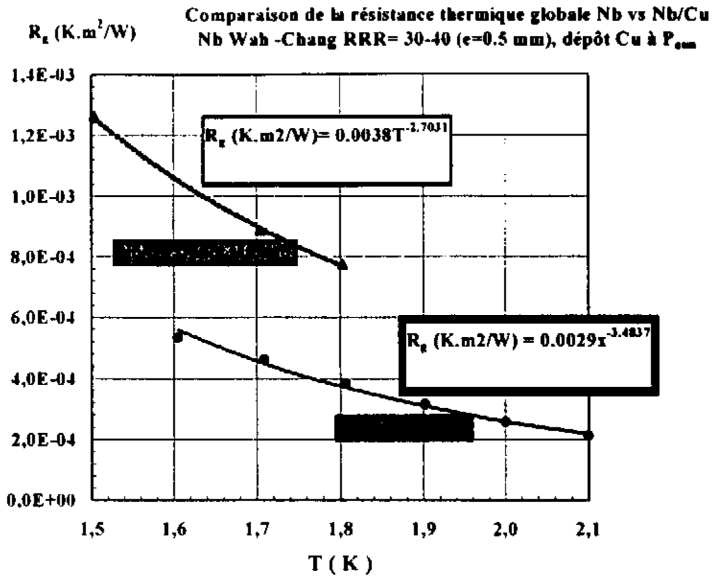
$$R_O = \frac{e_{Nb}}{k_{Nb}} + R_K$$

The data are summarized in Tableau I : the same test number correspond to similar Niobium specimen (naked Nb sample (Nb) versus coated Nb sample (Nb/Cu) similar samples.

➢same Niobium sheet (initial RRR, heat and chemical treatment, same surface conditions)







Echantillon Nb Wah Chang avec chimie 40 µm (RRR ≅40) et échantillon Nb/Cu (dépôt Cu avec sous-couche d'accrochage sous air à la pression atmosphérique)

○ Mesure du RRR (**Residual Resistivity Ratio)**

➢ **Banc de mesure opérationnel à l'IPN . Test de 10 échantillons simultanément .**

Echantillon	Traitement	RRR mesuré	RRR (Specifications)	Fournisseur
010	Brut	136	160-200	Heareus
011	Brut	132	160-200	Heareus
013	Soudure B.E	112	160-200	Heareus
014	Soudure B.E	111	160-200	Heareus

Exemples de résultats

➢Très bon accord entre les valeurs mesurées directement (**méthode électrique), les valeurs calculées** (teneurs en impuetés O.N ..) et **celles déduites des valeurs** expérimentales de conductivité thermique à 4.2 K (**RRR ≅ a.k$_{4.2}$, a = 4-5 m.K/W).**

M.FOUAIDY

Test	Test-cell Samples	Nb RRR * and Cu & Nb thickness	R_O(K.m^2/W) @ 1.8 K	ΔR_O(K.m^2/W) @1.8 K	Remarks
1	4 rods (Φ8)	100 *	5.6 10^{-4}		OK
1	4 rods (Φ8)	e_{Cu}: 1-1.5 mm or 2- 2.5 mm	6.5 - 7.5 10^{-4}	0.9 à 1.9 10^{-4}	OK
2	2 Nb Cabot disks, BCP 50µm	30-40 * e_{Nb} = 1.96 mm	1.46 10^{-3}		OK
2	2 Nb cabot disks, BCP 50 µmwith APS bonding alloy and APS Cu coating (Mallard)	e_{Nb} = 1.96 mm e_{Cu} = 2.5 mm	2.07 10^{-3}	6.2 10^{-4}	permeability test to be performed on the APS Cu coating disk
3	2 Nb Piansee disks, BCP 40µm	30-40 * e_{Nb} = 2 mm	6.32 10^{-4}		OK
3	2 Nb Plansee disks BCP40µm with APS bonding alloy	e_{Nb} = 2 mm e_{AlL} = 0.2 mm	1.27 10^{-3}	6.4 10^{-4}	OK
4	2 Nb Wah-Chang disks BCP 50µm	30-40 * e_{Nb} = 0.5mm	3.84 10^{-4}		Nb k(T) not yet measured (without HT : Ti @1200 °C).
4	2 Nb Wah-CHang disks, BCP 50µm with APS bonding alloy and APS Cu coating (Mallard)	e_{Nb} = 0.5 mm e_{Cu} = 2.2 mm	7.48 10^{-4}	3.6 10^{-4}	permeability test to be performed on the APS Cu coating disk
5	2 Nb disks Wah-Chang machined on the lathe	200 * e_{Nb} = 2.02 mm	5.6 10^{-4}		Nb k(T) not yet measured
5	2 Nb disks Wah-Chang machined on the lathe with CAPS (Argon) Cu coating.(CEA/DAM)	e_{Nb} = 1.85 mm e_{Cu} = 2.0 mm	5.6 10^{-4}	≅ 0	Nb/Cu interface analyzed by US, Micrograph to be done (after second test ?).

TABLE I :OVERALL THERMAL RESISTANCE R_O OF ALL Nb and Nb/Cu SAMPLES TESTED UP TO NOW

- Theoretical estimation of the interfacial thermal resistance between Nb and Cu
  Little theory (1959)
  Based on Acoustic Mismatch Between the two media :

$$\boxed{R_I^{th}(K.m^2W^{-1}) \simeq 2.1\,10^{-4}\,T^{-3}}$$

T_I(K)	1.5	1.7	1.8	1.9
$R_I^{th}\left(\frac{K.m^2}{W}\right)$	6.10^{-5}	$4.2\,10^{-5}$	$3.6\,10^{-5}$	3.10^{-5}

R_g : Total thermal resistance

$R_{g1} \rightarrow$ Nb ; $R_{g2} \rightarrow$ Nb & Cu

$\Delta R = R_{g_2} - R_{g_1}$

Δ. $\frac{R}{R}$: 15 → 2.5 for T: 1.3K → 1.5K:

thickness of the bonding layer (Cu- Al alloy 10 % of Al) . $e_b \simeq 0.2$ mm

[illegible] Bad thermal conductivity → $k \simeq 1$ W/m.K at 2.0K

$R_{Alloy} = \frac{e_b}{k} \simeq 2.10^{-4}\,\frac{K.m^2}{W}$

$R_{Alloy}, R_I^{th} \simeq$? at 2.0K !

- low porosity of the plasma sprayed copper
- "dirty material"

Something else ???

O DARCY permeability κ

①→ Room temperature tests (300 K) using a gaseous helium permeameter : measurement of the pressure ΔP across the porous medium (thickness : l) versus the gas mean gas velocity v (flowrate).

$$\kappa = \frac{\eta\, l v}{\Delta P}$$

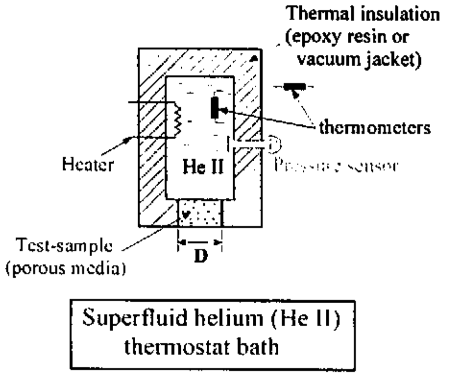
η : helium dynamic viscosity = 20.10⁻⁶ Pa.s.

➢First result obtained with a copper coating (APS) : we measured κ = 2.4 10⁻¹⁵ m². This figure is within the range of Darcy permeability of porous plug devices operated in He II in space applications.

②→ Thermal method in superfluid helium (under development)

➢ **Goal** : Characterization and modelling of the heat transfer in the porous medium cooled by He II.

➢ **Principle : Based on the outstanding thermohydrodynamics and thermal properties of superfluid helium. (Two-fluid model)**



Darcy permeability experimental method in He II

Darcy permeability experimental method in He II

According to the phenomenological two-fluid model (Tisza, Landau &Lipschitz) of superfluid helium, the heat flow is controlled by He II thermohydrodynamics (counterflow of the two components).

● We distinguish two main heat flow regimes :

➢ Low heat flux linear Landau regime, where the dissipation is dominated by the normal fluid viscosity according to the relationship :

$$Q = A\frac{\rho^2 S^2 T}{\eta_n}\frac{\Delta T}{l}\kappa_n \qquad (1)$$

A : porous medium cross section ,
Q : heat flux (W),
ΔT : temperature difference between the heated He II inside the test-cell and the thermostat (He II bath),
η_n : dynamic viscosity of the normal fluid ,
κ_n : Darcy permeability relative to the normal fluid,
S, ρ: specific entropy and He II density .

From equation (1) , we could define an effective thermal conductivity K_{eff} in the Landau regime :

$$K_{eff} = \frac{\rho^2 S^2 T}{\eta_n}\kappa_n \quad (2)$$

By comparing the relation (2) with the similar expression of K_{eff} for the case of He II counterflowing in a cylindrical duct (diameter D), the physical meaning of the Darcy permeability is quite obvious :

$$\kappa_n = \frac{D^2}{32} \qquad (3)$$

→For this simple model ,The porous medium equivalent hydraulic diameter is $D_h = 4(2\kappa_n)^{1/2}$.

M.FOUAIDY, N.HAMMOUDI, J.C LE SCORNET

THERMAL CONDUCTIVITY k(T) TEST-CELL

CELLULE DE MESURE DE CONDUCTIVITE THERMIQUE
(Gamme de température : 1.5 K - 60 K)

➔ Steady-state axial heat flow method

- *Four specimens tested simultaneously (temperature range : 1.54 K - 9.0 K)*
- *Each specimens is equipped with a heater ant 3 calibrated thermometers*

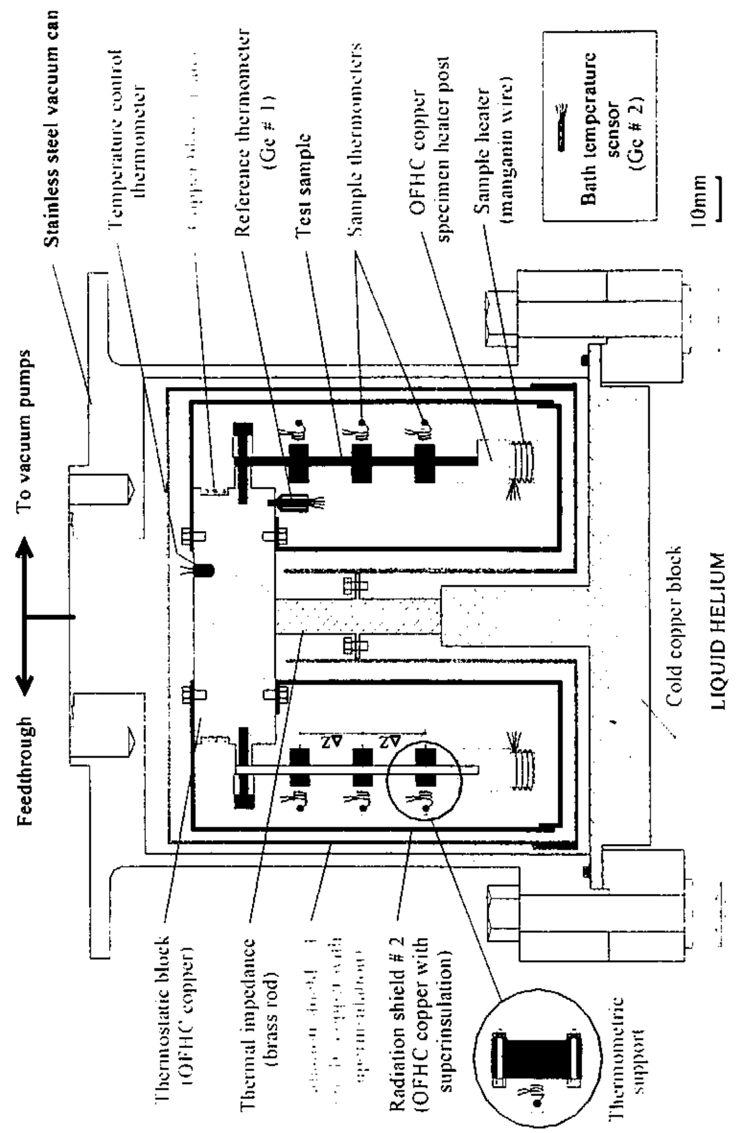
Test-samples description:

➢ **Samples dimensions in mm : 55x10xthickness (th.)**

➢ **Sample #1 : Niobium** Heraeus **RRR (Spec.) = 160-200** As received **(th. = 0.92mm)**
➢ **Sample #2 : Niobium** Wah-Chang Teledyne **RRR ((initial Spec.)= 30-40** , measured after Heat Treatement with titanisation @ 1200 °C **(th.= 0.36 mm)**
➢ **Sample #3 : Niobium** Cabot **RRR (Spéc.) = 30-40** -As received **(th. = 2.05 mm)**
➢ **Sample #4 : Niobium** Plansee **RRR (Spéc.) = 30-40** -As received **(th. = 1.94 mm).**

→ Good agreement between the RRR values as deduced from $k_{4.2}$ ($k_{4.2}$ ∝ RRR) those measured directly (electrical resistivities ratio) and calculated (impurities content O, N...).

→ *http ://ipnweb.in2p3.fr/~yaniche*

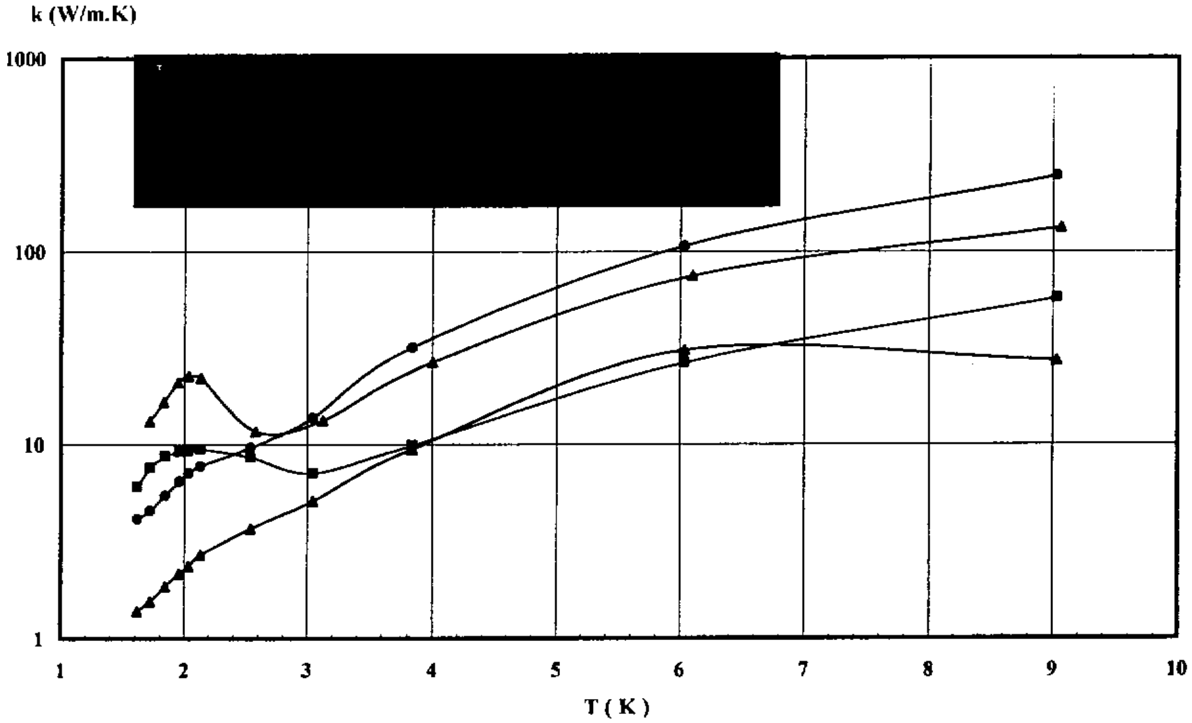


THERMAL CONDUCTIVITY TEST-CELL
(TEMPERATURE RANGE : 1.5K - 60K)

→ http://ipnweb.in2p3.fr/~yaniche/

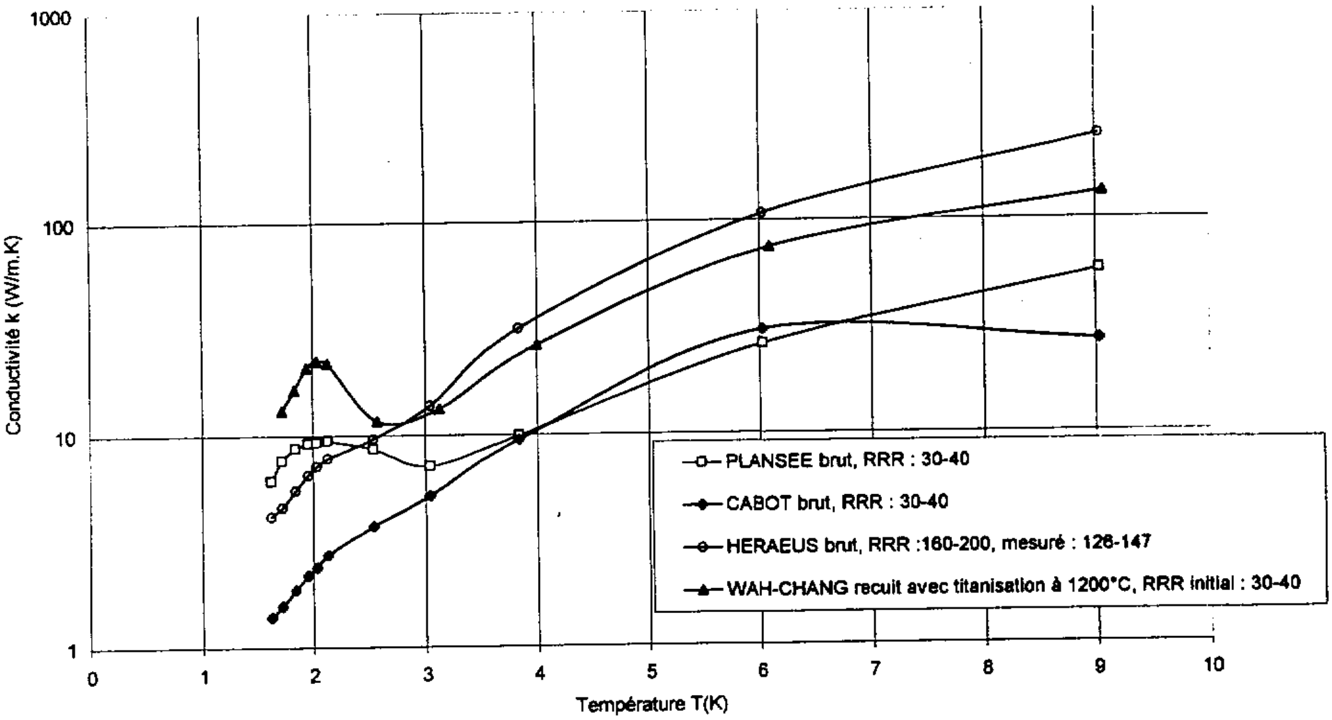
M.FOUAIDY
IPN Orsay

Thermal conductivity of 4 Niobium samples tested at IPN Orsay Lab. (Nov. 1998)


[redacted]

M.FOUAIDY-TESLA meeting, Desy (Hamburg) March 1999

Valeurs expérimentales (Novembre 98)
des échantillons de Niobium PLANSEE, CABOT, WAH-CHANG et HERAEUS
k (W/m.K) = f(T)



LOW TEMPERATURE THERMAL CONDUCTIVITY MEASUREMENT AT IPN Orsay

Tests of November 1999 4 specimens tested simultaneously

Test-samples description

SAMPLE #	**1**	**2**	**3**	**4**
Material	**Niobium**	**Niobium**	**Niobium**	**Niobium**
Length (mm)	55	55	55	55
Width (mm)	10	10	10	10
Thickness (mm)	0.36	1.94	0.92	2.05
Supplier	**Wah-Chang Teledyne**	**Plansee**	**Heraeus**	**Cabot**
Inititial RRR (Spec.)	**30-40**	**30-40**	**160-200**	**30-40**
Initial RRR (Calc.)	36-46	56	166	**41**
RRR (Measured)	not Meas.	not Meas.	**126-147**	not Meas.
RRR (a. $k_{4.2}$)	**122-153**	45-56	164-205	50-63
$k_{4.2}$ (W/m.K)	**30.5**	**11.2**	**41**	**12.5**
Treatment	HT@ 1200 °C withTi	**as received**	**as received**	**as received**

26/02/1999

STATUS OF CAVITIES R&D AT LAL ORSAY

- Laurent Grandsire
- Jean Claude Bourdon
- Jean Luc Borne
- Jean Marini
- Bernard Jacquemard
- Joel Leduff
- Emmanuelle Vernay
- Alice Thiébault
- Patrick Lecoeur

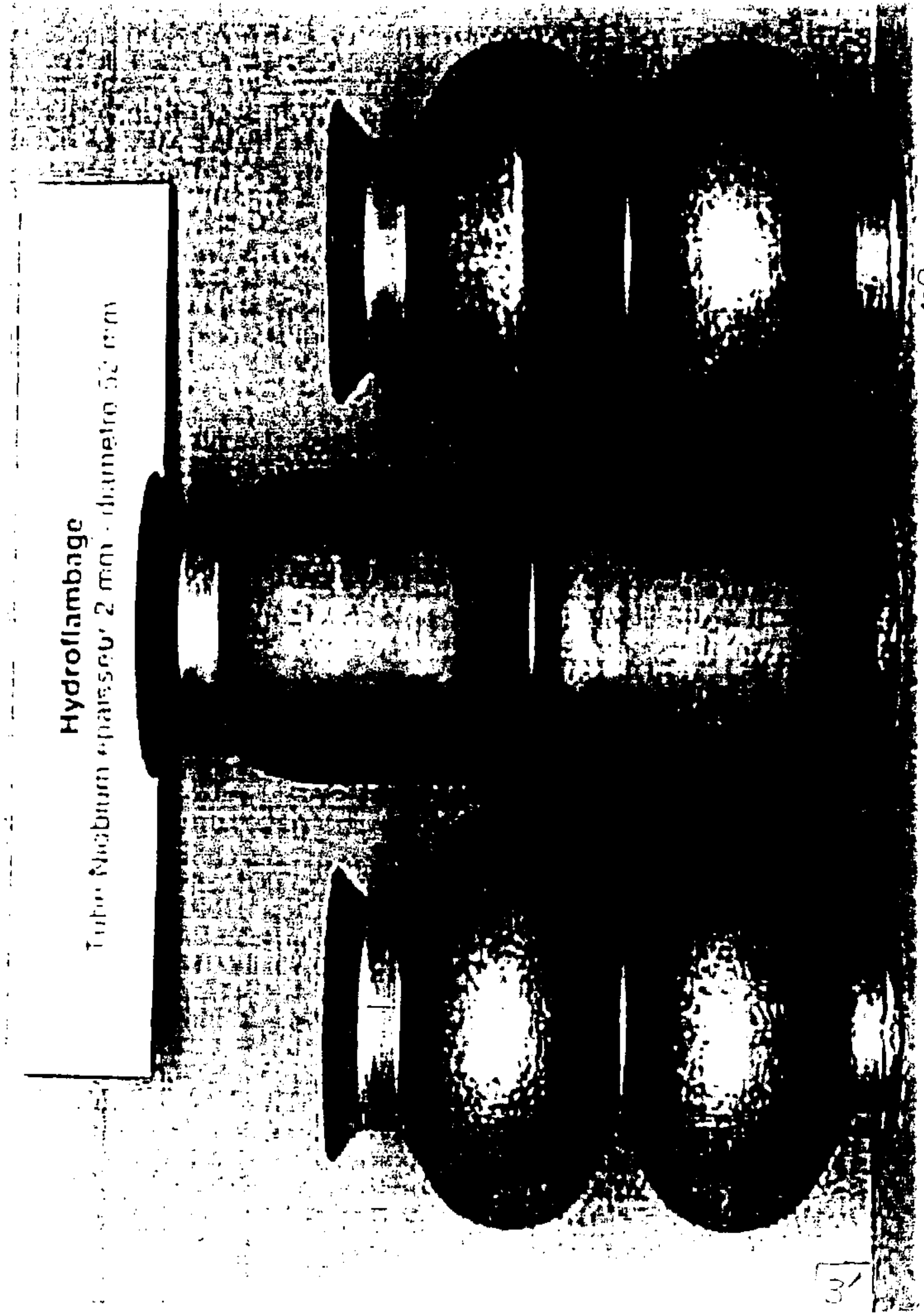
PLAN

- Hydroforming
- hot forming
- plasma spraying of copper
- E.B. welding
- non destructive controls
- mechanical tests

HYDROFORMING
(SIBB)

- Principle
  - process in 2 steps
    - 40 % of deformation in first step,
    - annealing (900 °C, 2 hours),
    - 90 % in second step
- Operative conditions
  - bi-cells 3 GHz cavities
    - Diris ext = 51.7 mm,
    - Deq ext = 94.6 mm (r = 1.89)
    - Th init = 2 mm
- Results
  - 21 tested tubes
  - 5 tubes to 40 %
  - 4 bicell-cavities
- Conclusions
  - Perfecting period (buckling)
  - correlation success / textures of tubes ?
  - To come:
    - chemical etching (Saclay) and test (IPN Orsay)
    - chemical polishing (saclay) and test (IPN)

grandsir@lal.in2p3.fr



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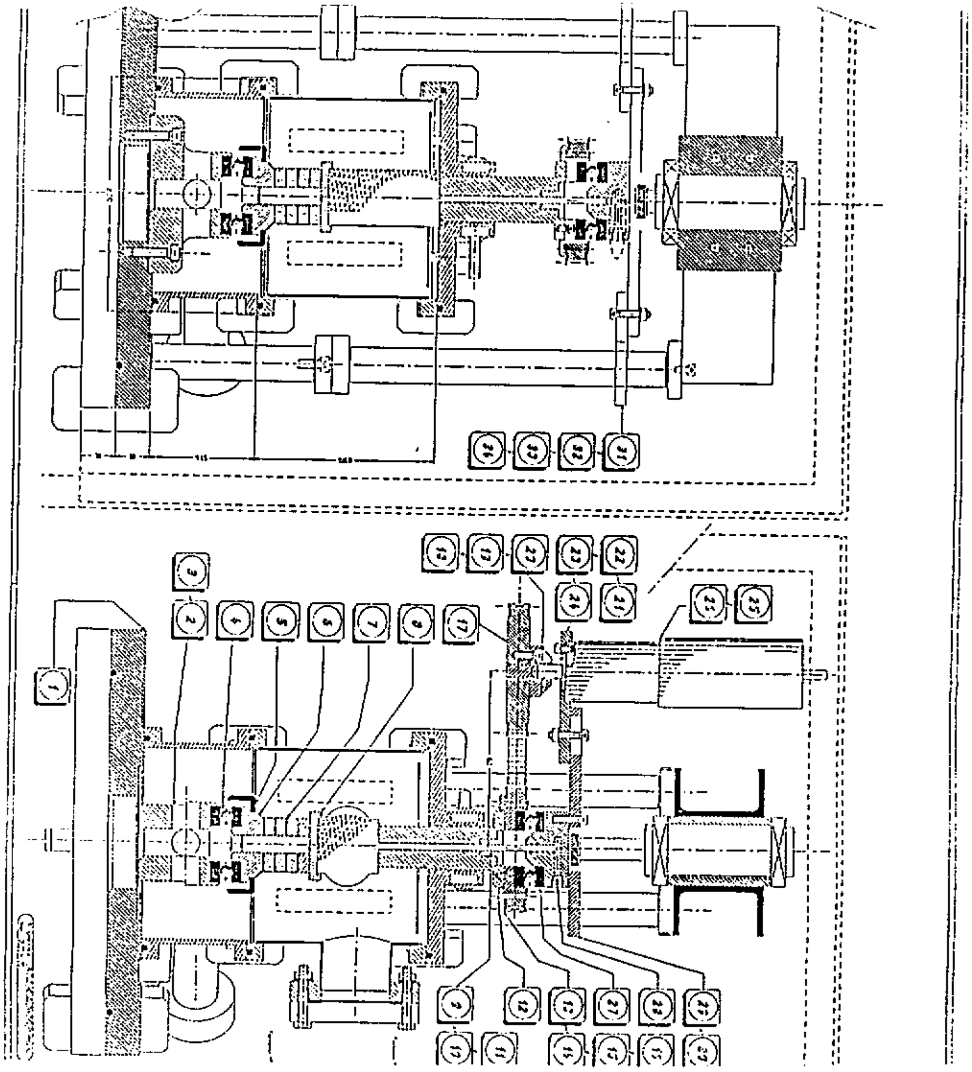
HOT FORMING (I)

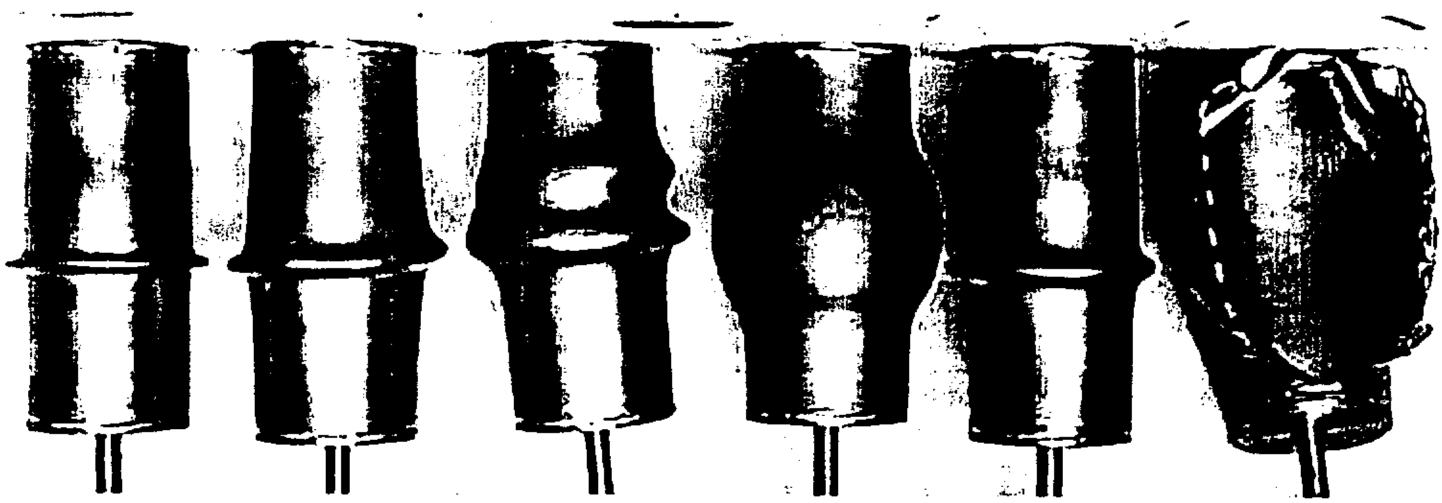
Two parallel methodologies in order to conciliate scientific, technological and practical knowledge:

- **empiric studies**
- **scientific studies**

HOT FORMING (II)
EMPIRIC STUDIES

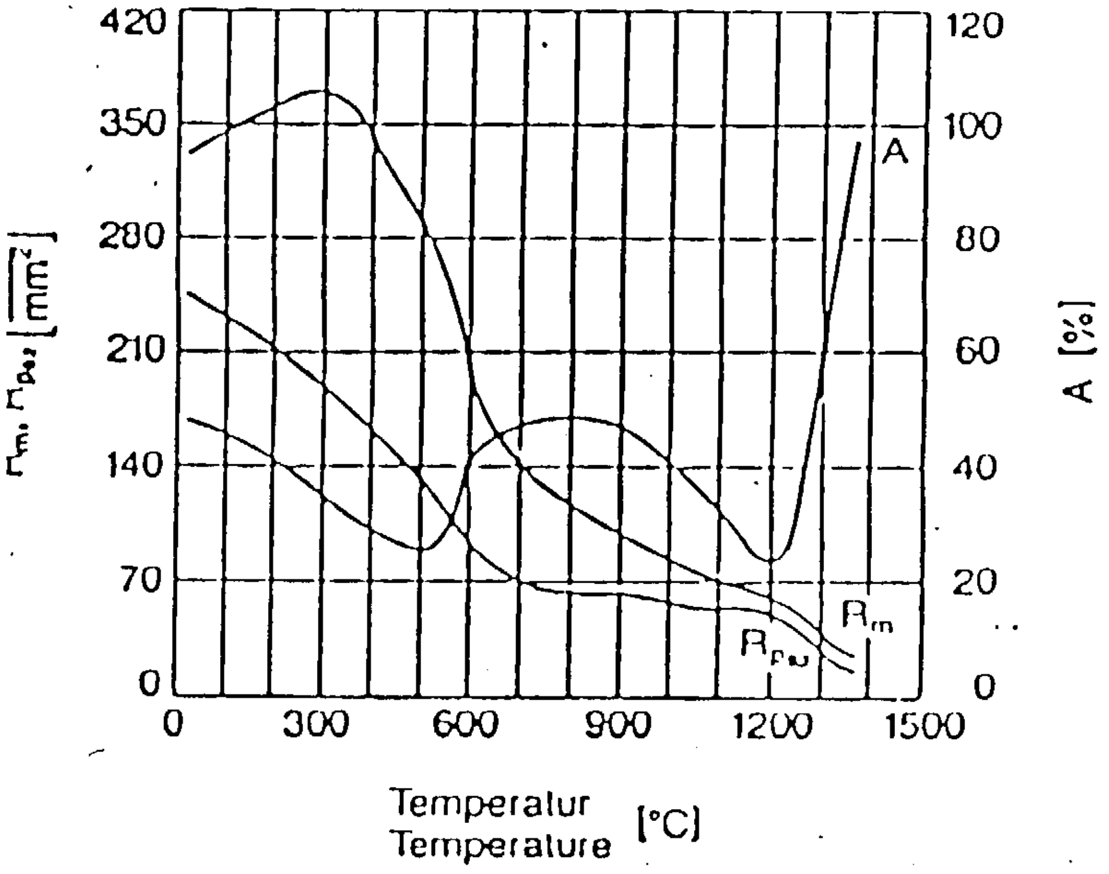
- Principle
  - Axial load + internal pressure
  - No dies
  - Induction heating (800 °C)
  - VERMETAL
- Operative conditions
  - Dext = 38 mm, Th = 0.5 mm
    - 50 % of deformation (limited by induction turn)
  - Dext = 51.7 mm, Th = 2 mm
    - tubes too rigid for the device (axial load and pressure limitations)
  - Dext = 49.7 mm, Th = 1 mm
    - to be continued….
- Knowledge of the ratio Pressure/axial load (tear / buckling)





HOT FORMING (III)
SCIENTIFIC STUDIES

- 2 successive steps
  - mechanical characterization of niobium
    - HERAUS RRR 120
    - 700-900 & 1300-1500 °C
    - SEP Bordeaux
    - determination of
      - optimal temperature (900 & 1400 °C)
      - optimal speed of deformation (10^{-3} s^{-1})
      - mechanical law (tensile test)
  - simulation of hot forming
    - risks of breaking
    - Initial and final thickness
    - cycle of temperature / pressure
    - die geometry
    - ENSAM Angers (ABAQUS EXPLICIT)



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PLASMA SPRAYING OF COPPER

- Goals:
  - Removal of iris rings
    - easiness of manufacturing
  - Thinner thickness of Nb
    - cost
- first studies about the process (Malard)
- in collaboration with IPN Orsay
  - study of induced stress by differential dilatations beetween copper and niobium
  - stress and deformation gauges
  - US NDT (unsticking ?)

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Ⓐ

E.B. WELDING

- Stamping and E.B. Welding devices at LAL
- bench mark programme with CERCA
  - monocell 3 GHz 1 mm RRR 120 HERAEUS
  - 3 CERCA cavities (CERCA etching) + 4 LAL cavities (Saclay etching)
  - IPN testing
  - quality of weldings, vacuum, proceedings
- Realizations and work program:
  - thickness (0.5; 1; 2 mm)
  - RRR 40; 120; 200
  - 1.3 & 3 GHz
  - parameters

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NON DESTRUCTIVE CONTROLS

- Ultrasonic and eddy currents devices
- control of sheets and tubes after delivery and before deformation
- ultrasonic (immersion) device:
  - 0.4 mm of resolution for cracks
  - 0.5 mm of resolution for Ta inclusions
- Eddy current device:
  - $50 \text{ KHz} \leq f \leq 400 \text{ KHz}$
  - $0.1 \text{ mm} \leq \delta \leq 1 \text{ mm}$

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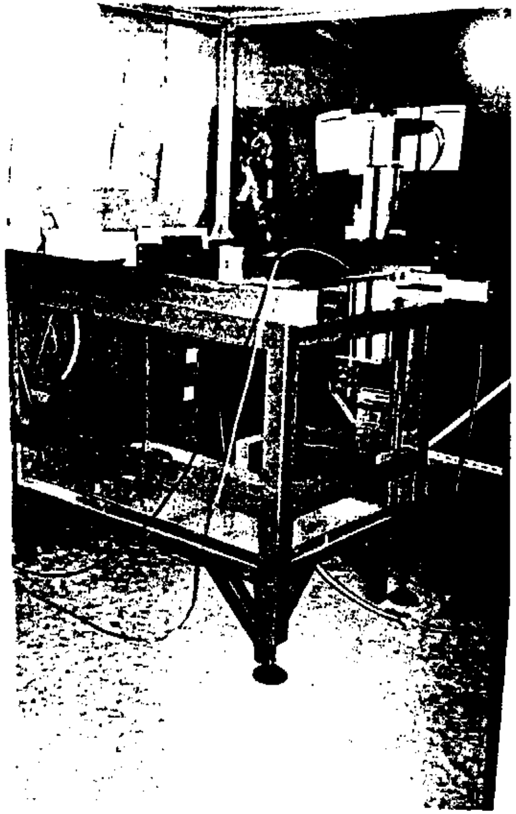

MECHANICAL TESTINGS

- Mechanical device
  - MTS Systems 150 KN
  - tensile test
  - compression
  - tear /peel
  - flexion
  - cryogenic test in the future ?
- Program:
  - Data base
  - Optimisation of annealings
  - Material characteristics (copper)

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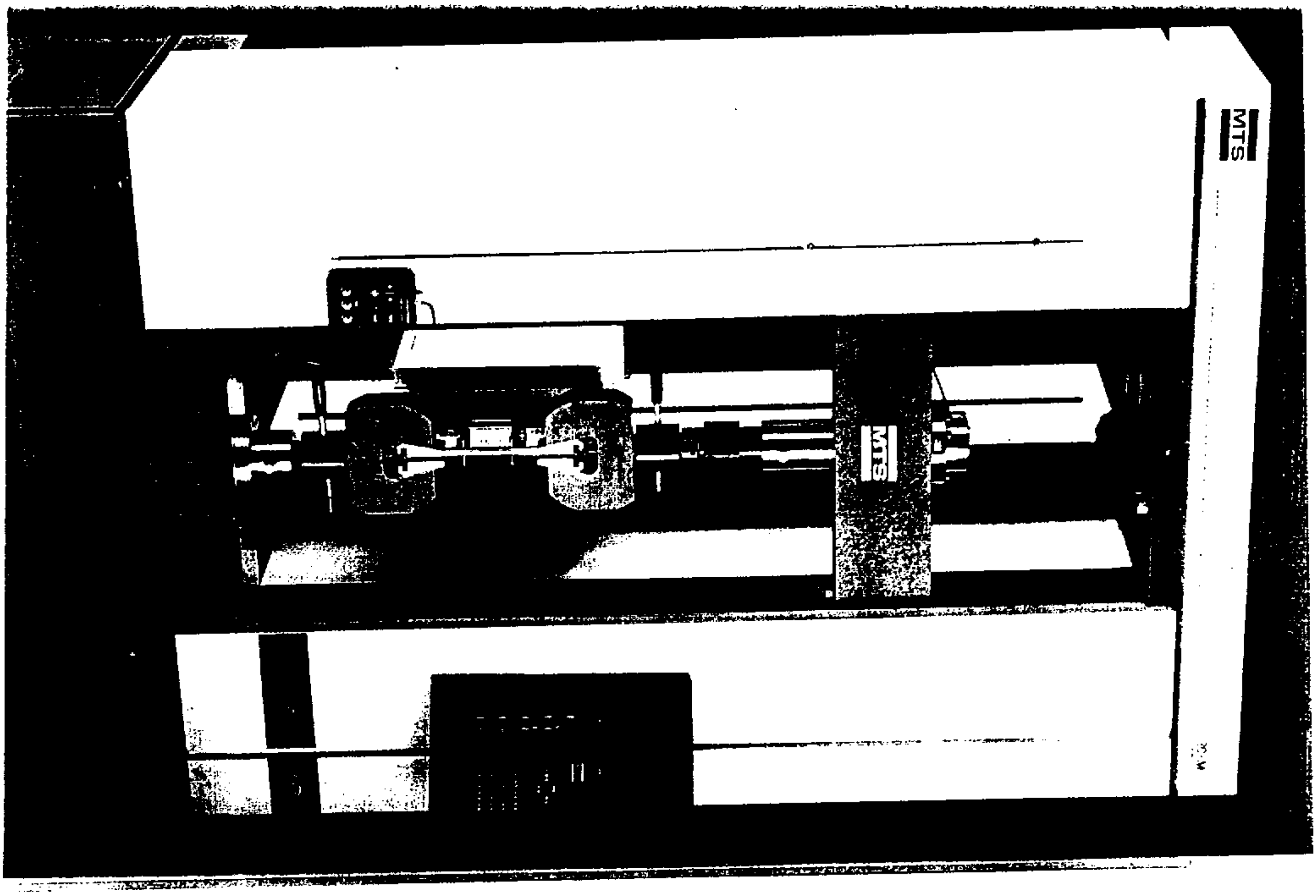

MTS
MTS

HOM Measurements at TTF

- February 1999 -

O. Napoly, N. Baboi, H.-W. Glock, F. Marhauser,
C. Magne, H. Schlarb, S. Simrock, G. Kreps,
G. von Walter, M. Hüning, T. Garvey and *others*

(DESY, CEA - Saclay, University of Rostock,
Inst. of Applied Physics - Frankfurt)

TTF Collaboration Meeting, 2.03.99

Nicoleta Baboi

HOM Experiments at TTF

- FEBRUARY '99 -

SCOPE : MEASURE BEAM DEFLECTION INDUCED BY TRANSVERSE HOM IN THE TTF CRYOMODULES.

METHOD : DETUNE 1 CAVITY SUCH THAT THE STUDIED MODE FREQUENCY BECOMES A MULTIPLE OF THE BUNCH FREQUENCY

$$f_{HOM} = n \cdot f_b \left(1 \pm \frac{1}{2Q}\right)$$

LOOK AT BOTH BPM & SPECTRA

SMALL NUMBER OF BUNCHES !

24.2.99 NICOLETA BABOI

- 1st MODULE / CAVITY 3

  30 BUNCHES

  3 nC / bunch

  GRADIENT: ~ 6 MV/m.

  MODE AT 2.584970 GHz

  $Q \cong 10^6$

  DETUNING −20 kHz for HOM

  +12.6 kHz for FM

  STEER THE BEAM WITH THE DOG LEG → HEAD–TAIL RESONANCE

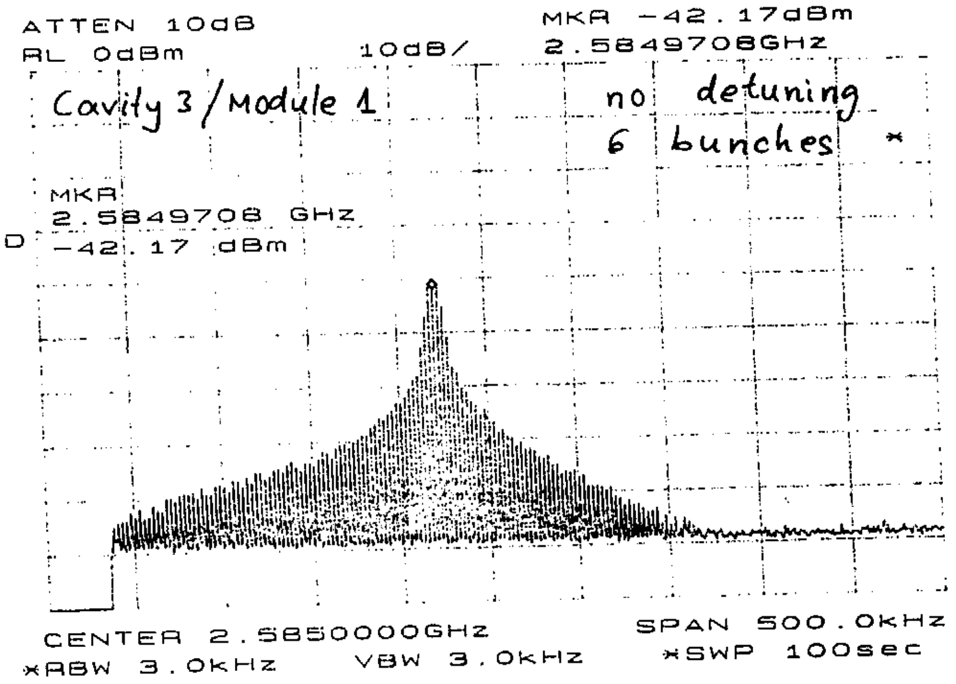
- 2ND MODULE / CAVITY 5

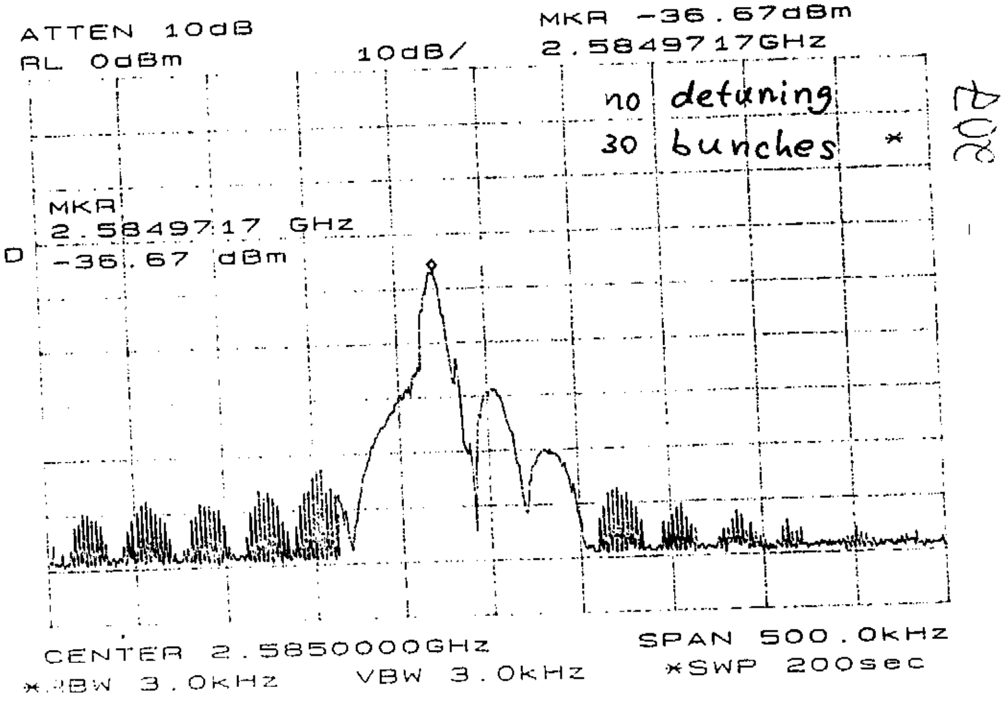
  MODE AT 2.584494 GHz

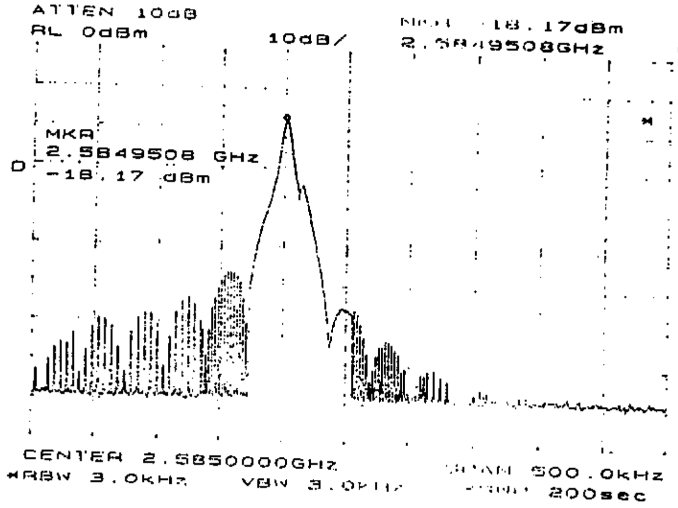
  Q = 400000

  DETUNING −544 kHz for HOM

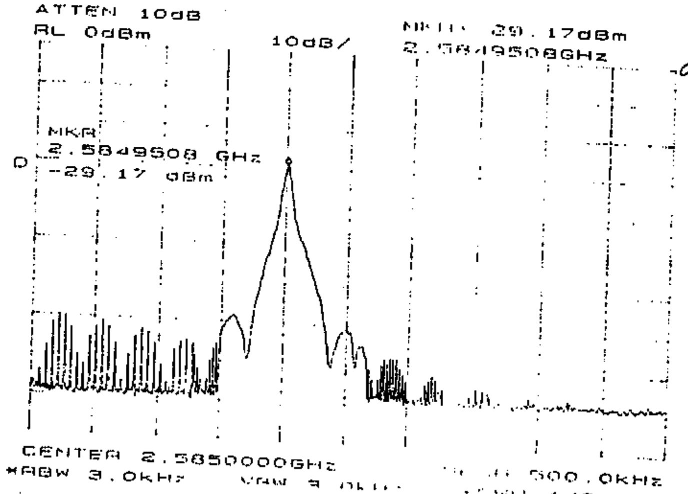
  +340 kHz for FM



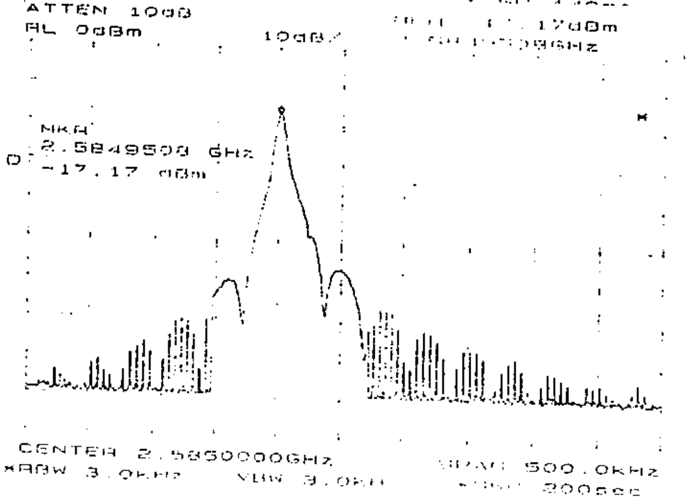




dogleg -3A



dogleg 0A



dogleg 3A

Run at ~~4~~ o'clock :

We reproduce exactly the head-tail resonance

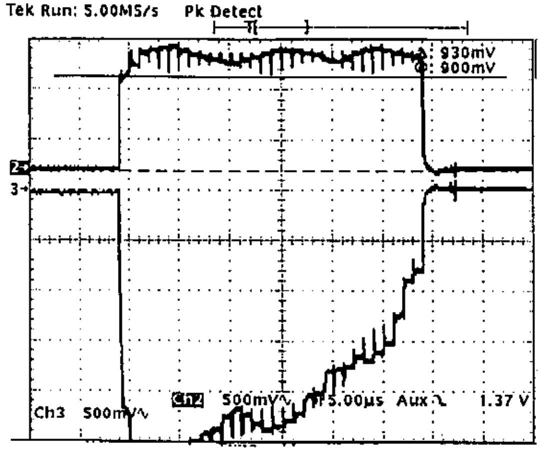
this time monitoring with reentrant BPM

beam current is monitored on the same oscilloscope screen

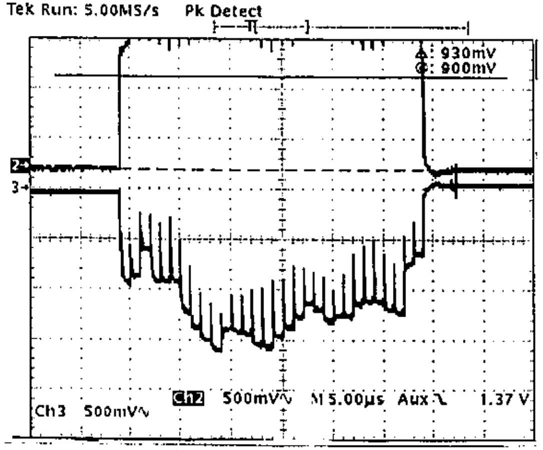
channel 2 : I beam
$\frac{1.4}{3.4}$ ~~400~~ mV/nC (T4)
channel 3 : ΔX
700 mV/mm @ 3.4nC

SET BOTH CHANNELS OF THE OSCILLOSCOPE TO :
1 MΩ load
AC ∼

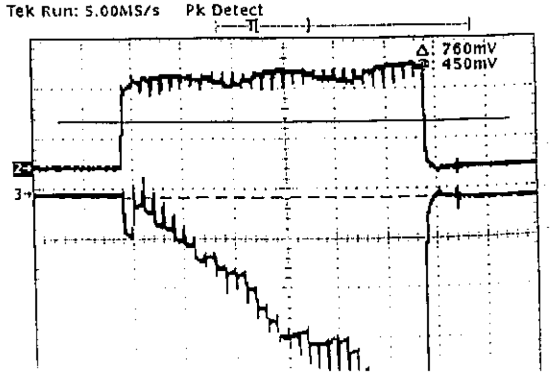
dogleg - 3A   1A <-> 5mm



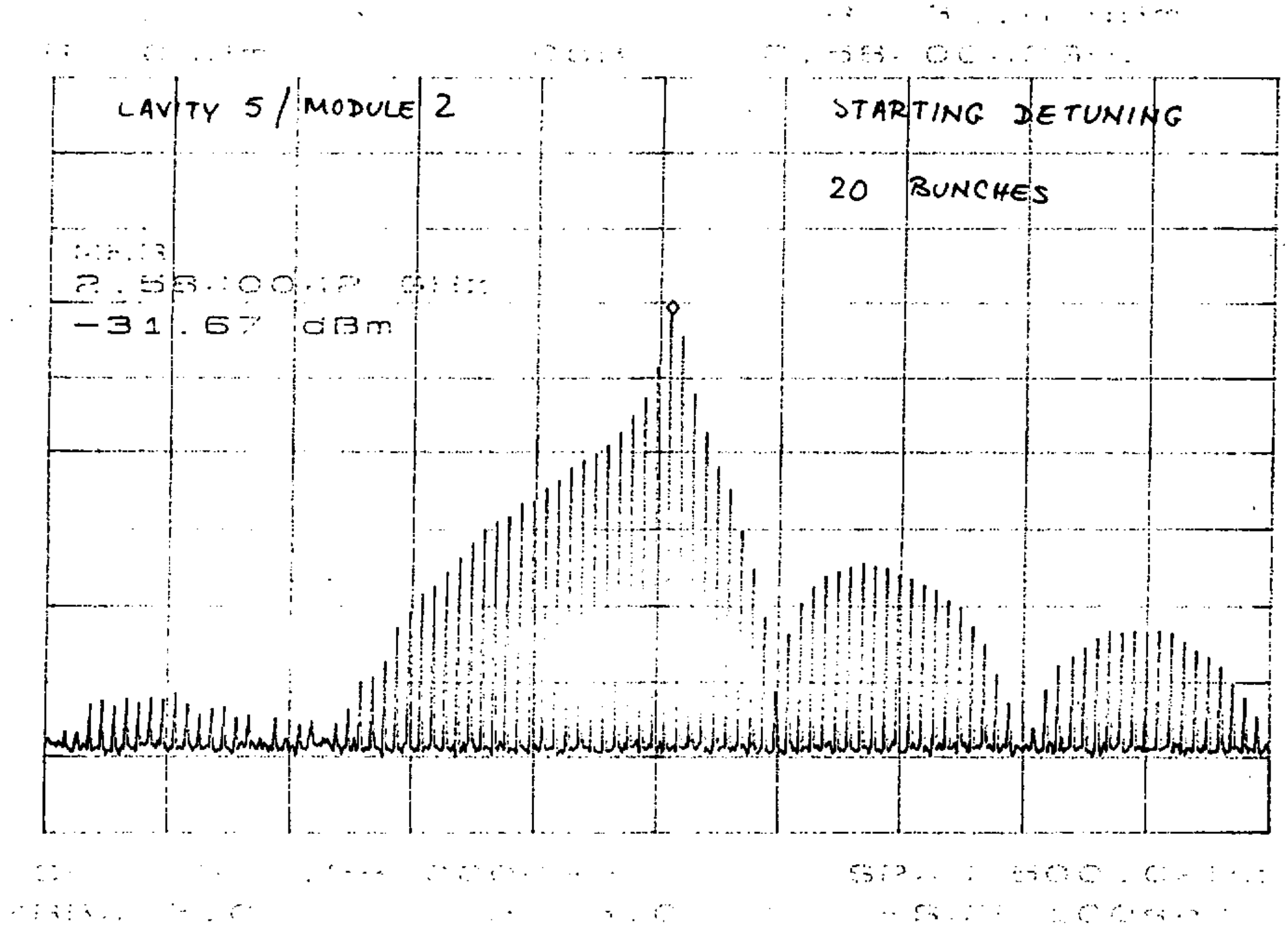
dogleg = 0



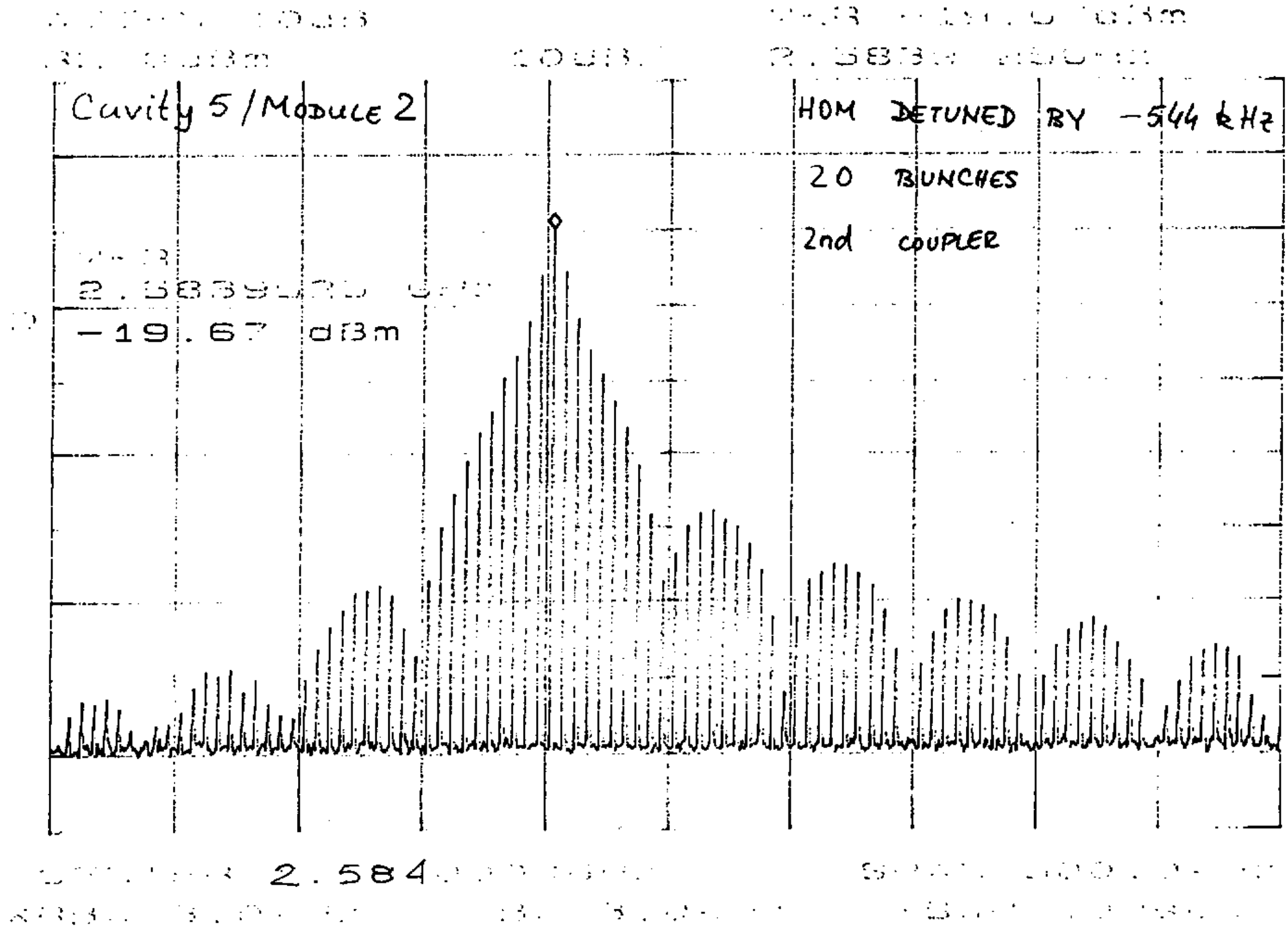
dogleg + 3A



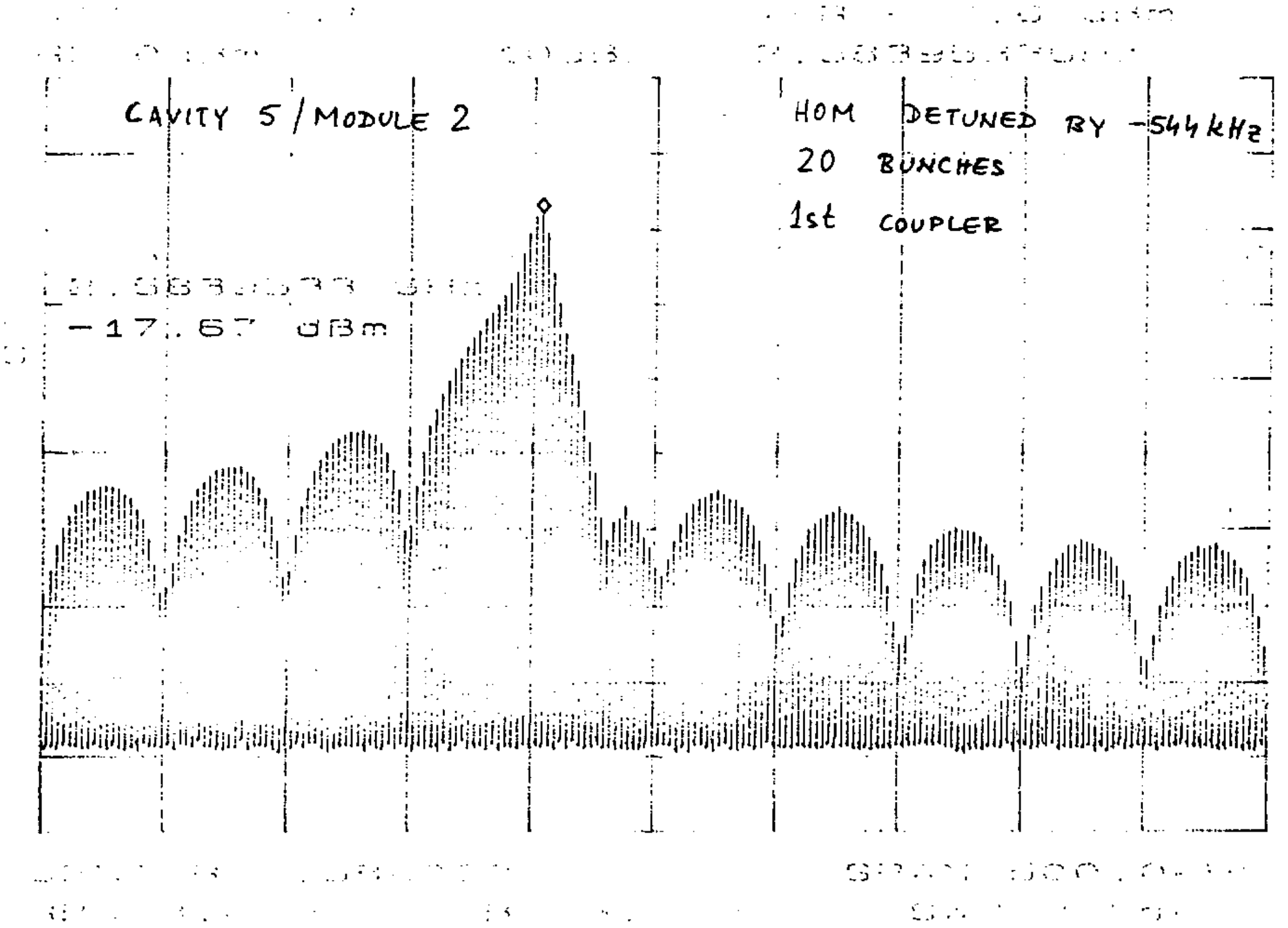
Mod 2
C5K2
10 dBm
C'Band
Shif
+500
GHz



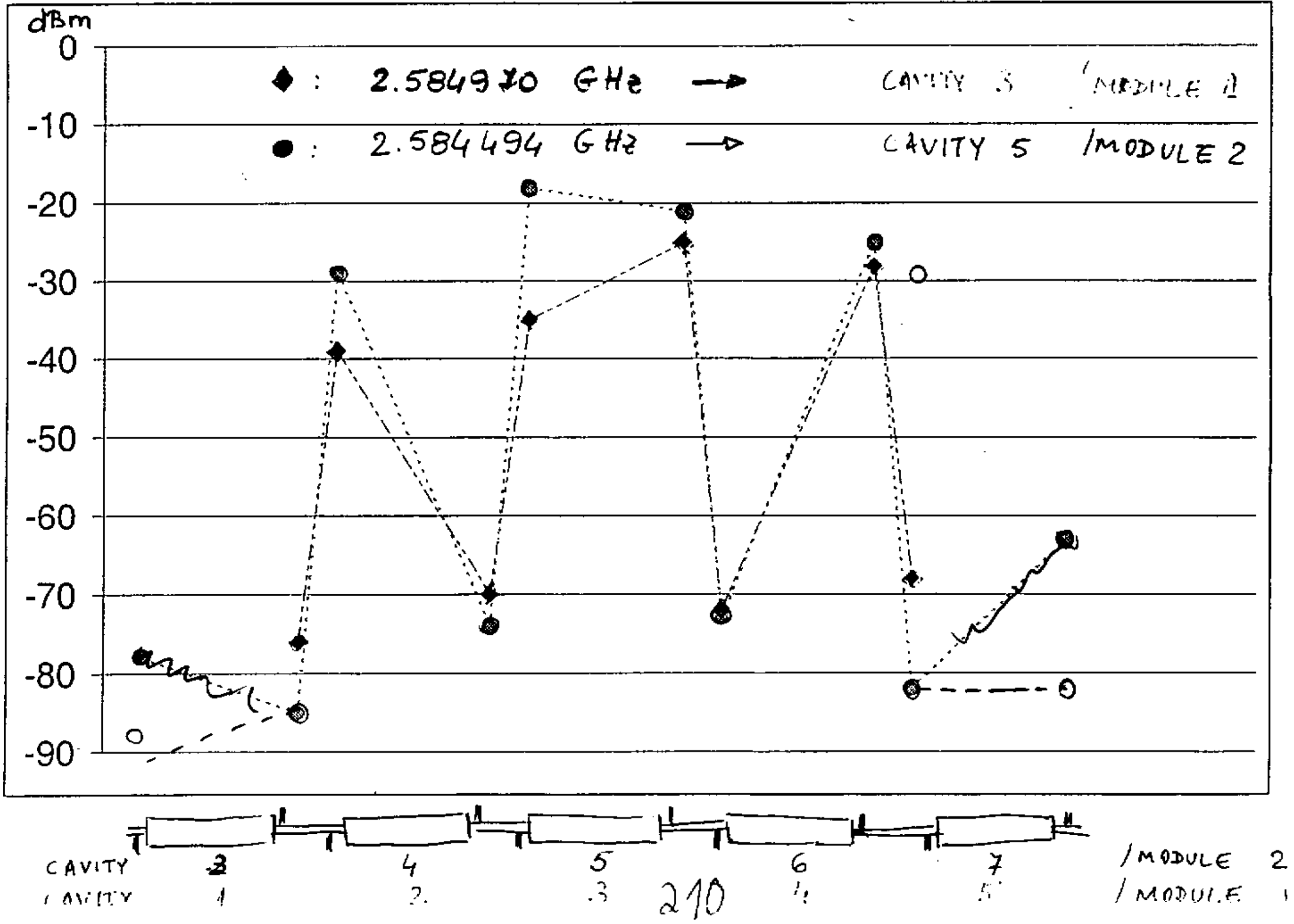
4:14
Mod 2
C5K
20 dBm

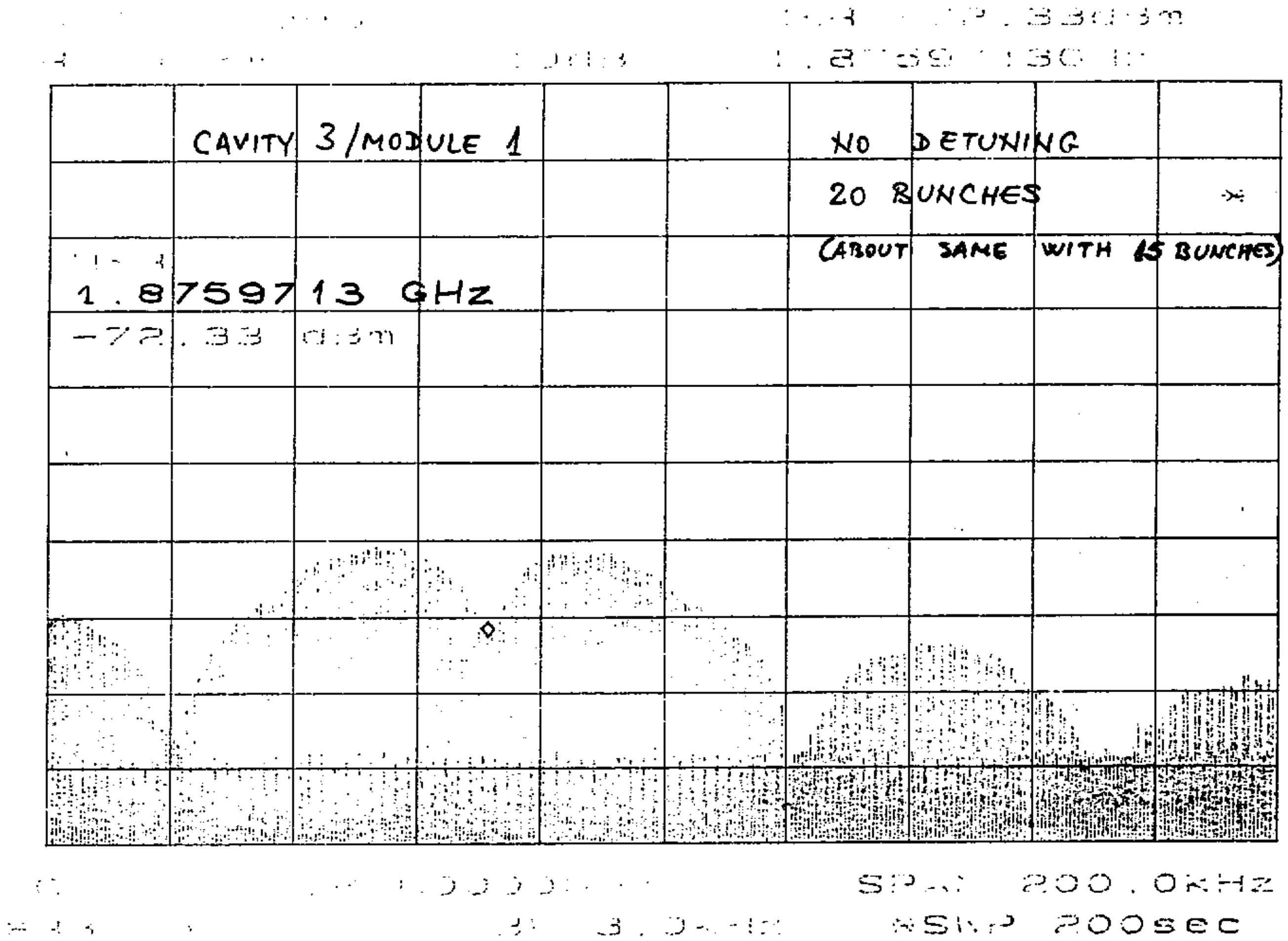


Mod
CSk
206



PEAK POWER OF THE MODE FROM DIFFERENT HOM COUPLERS





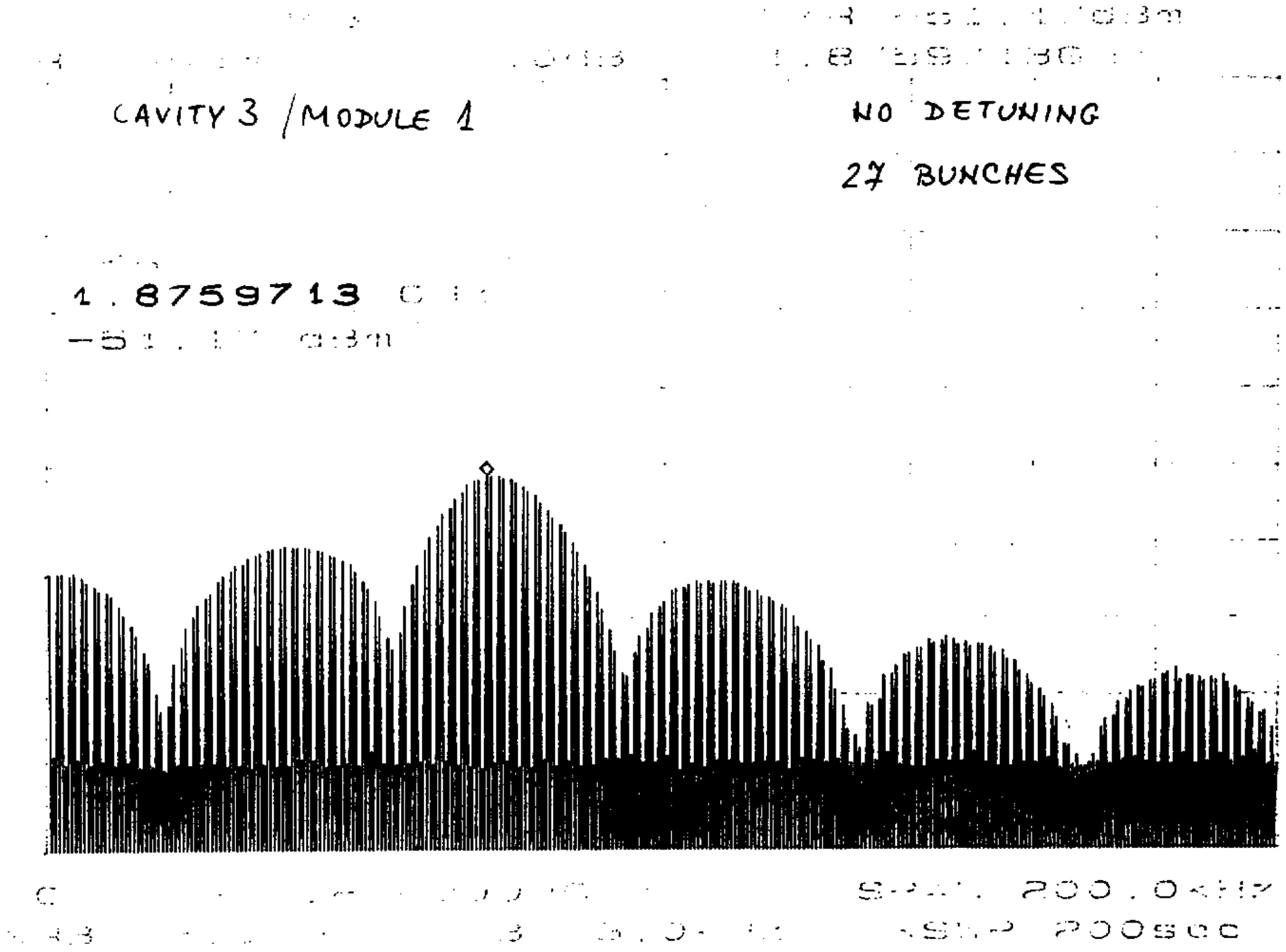
CAVITY 3/MODULE 1

NO DETUNING

20 BUNCHES

(ABOUT SAME WITH 15 BUNCHES)

26.2.9



CAVITY 3 /MODULE 1

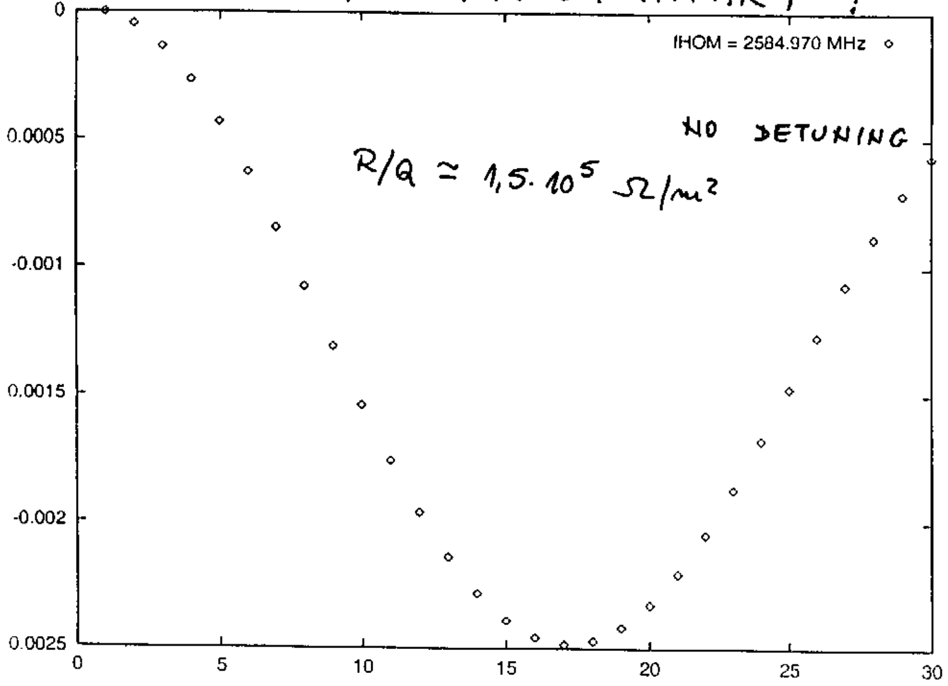
NO DETUNING

27 BUNCHES

26.2.9

27 bu
1,7 nC
dofley
0A

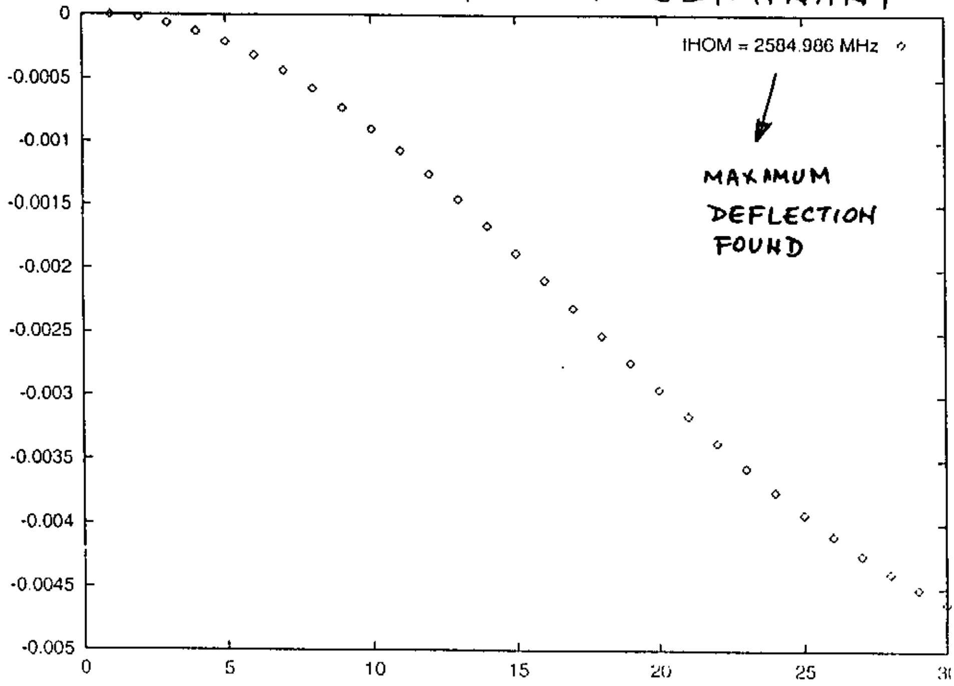
VERY PRELIMINARY !



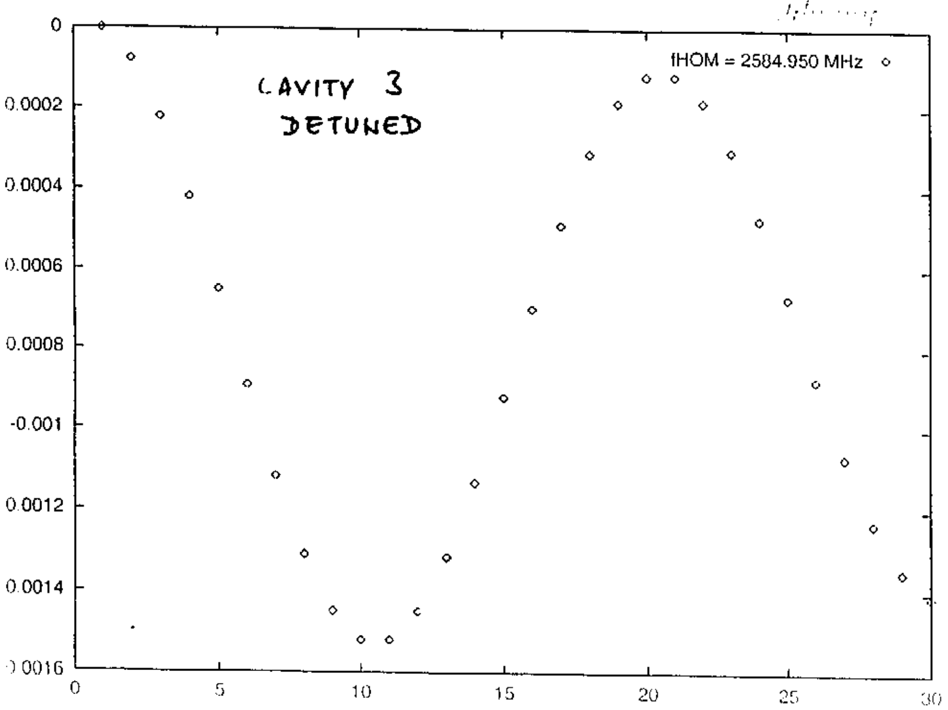
NO DETUNING

$R/Q \simeq 1{,}5 \cdot 10^5 \ \Omega/m^2$

VERY PRELIMINARY



MAXIMUM DEFLECTION FOUND



CAVITY 3 DETUNED

$R/Q = 1.5 \cdot 10^5 \ \Omega/m^2$ (VERY PRELIMINARY!

$Q \simeq 10^6$

ARE OTHER MODES CONTRIBUTING SIMULTANEOUSLY TO THE BBU ?

PRELIMINARY CONCLUSIONS

WE SAW THE HEAD-TAIL RESONANCE AND THE CORRESPONDING SPECTRUM ANALYSER SIGNAL $(P \sim x^2)$

NEED MORE CALCULATIONS / TIME TO UNDERSTAND:

- WHY BUNCH TRAIN SIGNAL $\neq n \cdot 1\,\mathrm{MHz}$?
- WHY MODE PRESENCE DEPENDS ON NUMBER OF BUNCHES AND HOW ?
- WHERE IS THE MAXIMUM SIGNAL TO BE EXPECTED ?
- CONTRIBUTION OF MORE MODES ?
- LIMITED NUMBER OF BUNCHES !

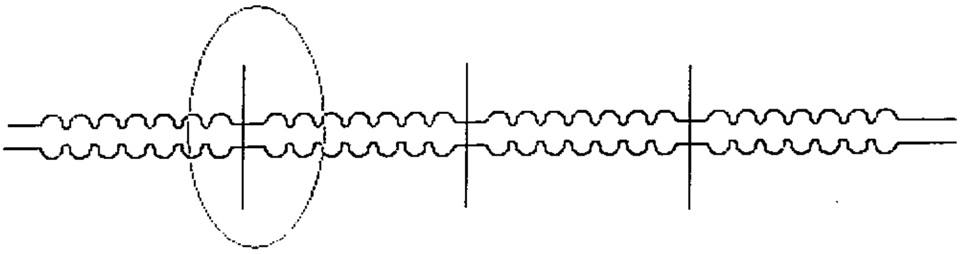
J. Sekutowicz
MHF-SL

List of tasks to build and to test with the beam the first Nb prototype of the 4x7-cell superstructure

---

To minimize the cost and the effort we like to perform all <u>treatments and tests for each sub-unit</u> (7-cell) individually and then make assembly of 4 sub-units in the superstructure.

This allows to use with some changes the existing "9-cell" infrastructure for the cleaning procedures and test.



It seems to us that for the first prototype it will be easier to use the flange connection between 7-cell structures.

The welding procedure, cheaper for the mass production, is not require to test the first prototype and is not very well established at the moment .

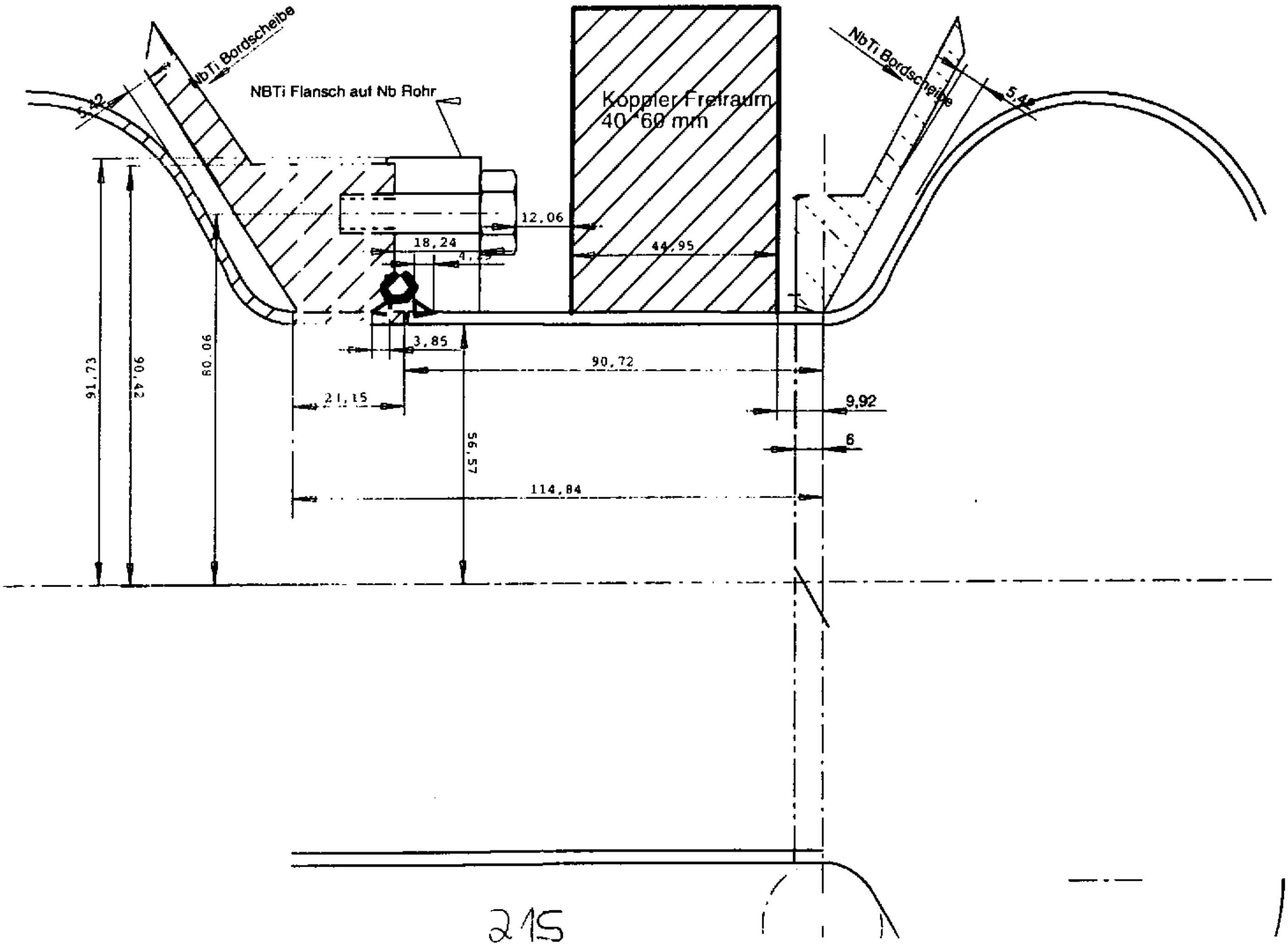
Tasks can be splitted into groups :

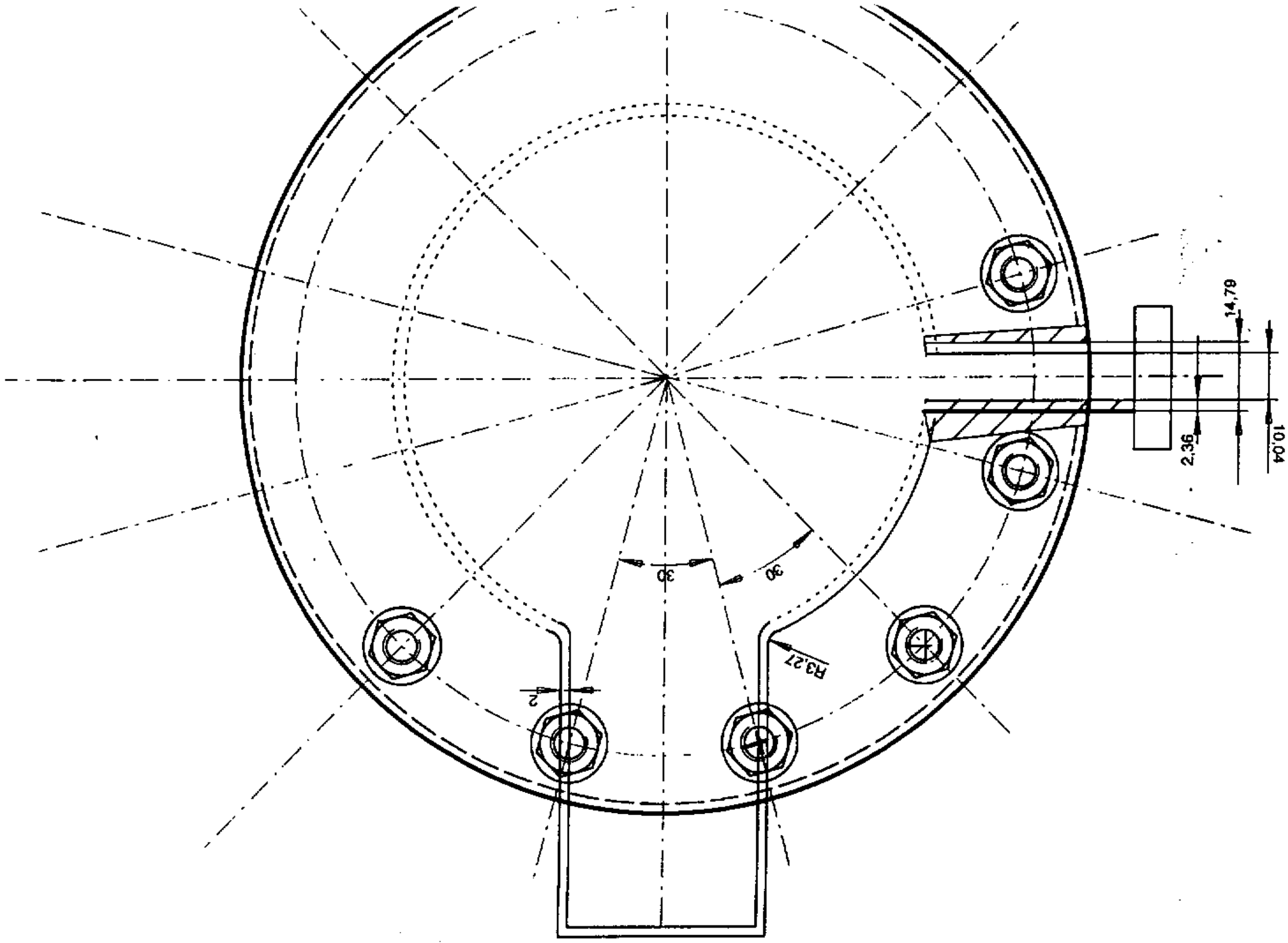
I. Changes in the design and in the fabrication of:

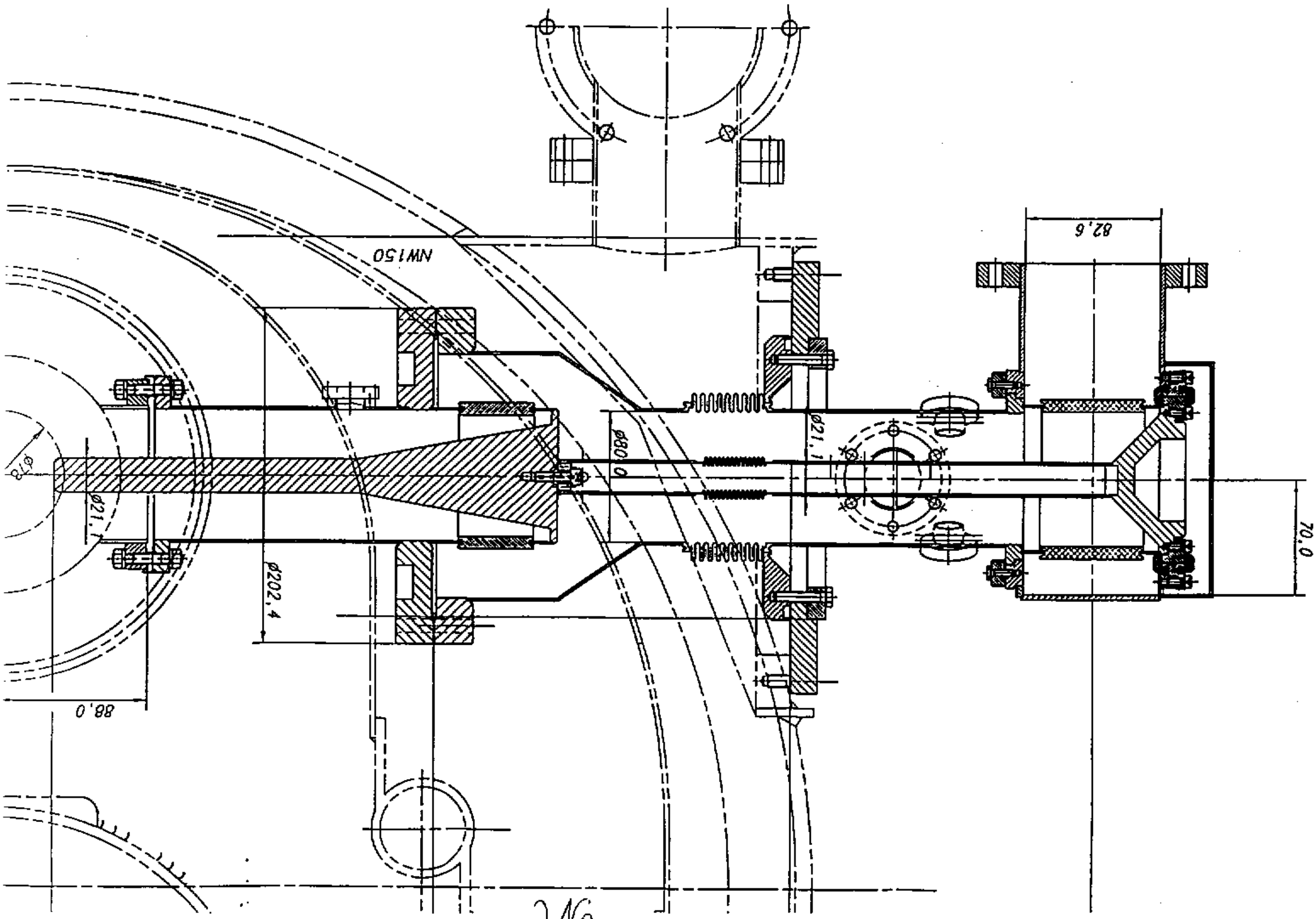
- **Cavities :** tooling to form new end-cells, **superconducting flange connection of sub-units as proposed by A. Matheisen.**

- **FM coupler :** increase outer diameter to Ø 60-80 mm and make FM shorter by 18 mm (important for position of standing wave under full-reflection) D. Proch, B. Dwersteg, W-D. Möller, A. Zavadsev

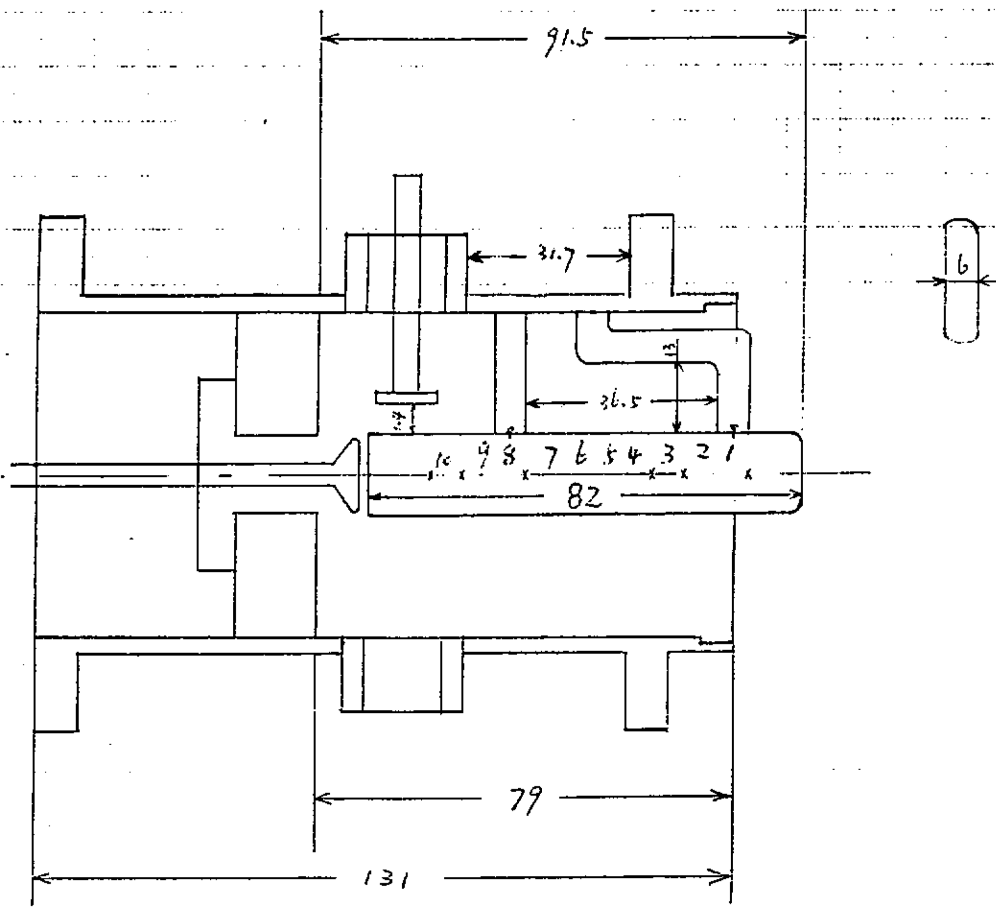
- **HOM couplers :** new requirements on HOM damping (H. Chen , V. Puntus, JS)



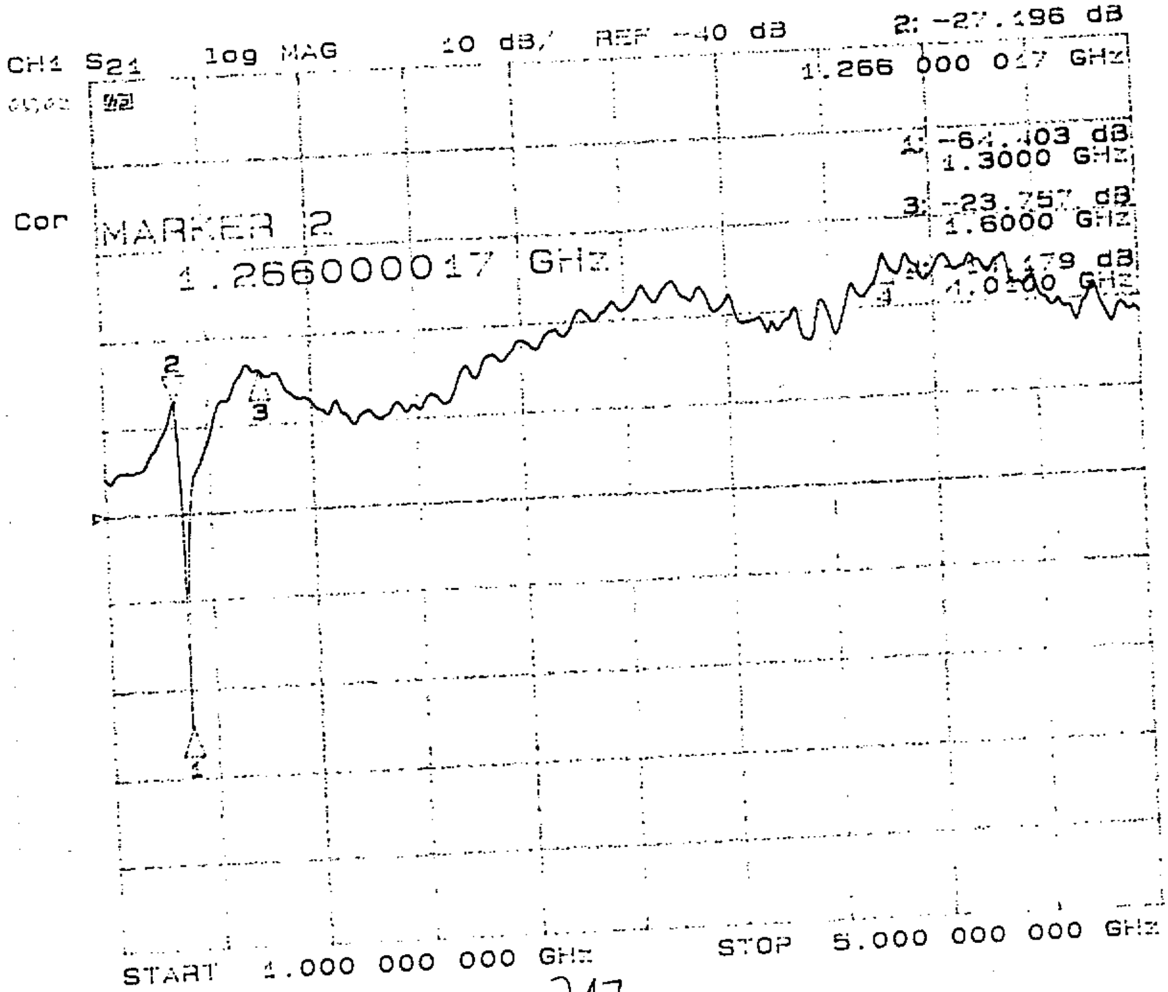

14,79
2,36
10,04
30
30
R3,27
2


NW150
82,6
ø80,0
ø21,1
ø202,4
ø78
ø21,1
88,0
70,0

05, 02.



91.5
31.7
6
13
36.5
2.7
10 9 8 7 6 5 4 3 2 1
82
79
131



CH1 S21 log MAG 10 dB/ REF -40 dB
2: -27.196 dB
1.266 000 017 GHz
1: -64.403 dB
1.3000 GHz
3: -23.757 dB
1.6000 GHz
4: 479 dB
4.0100 GHz
Cor
MARKER 2
1.26600017 GHz
2
3
1
4
START 1.000 000 000 GHz
STOP 5.000 000 000 GHz

II. Changes in the design of :

- **Tuners and LHe vessels : there is not enough space between cavities for the present version of the tuner (new solution proposed by H. Kaiser)**
- **Cryomodule :** new position the sliding supports

III Treatments and preparation : generally no problem since sub-units are shorter than the TTF cavities

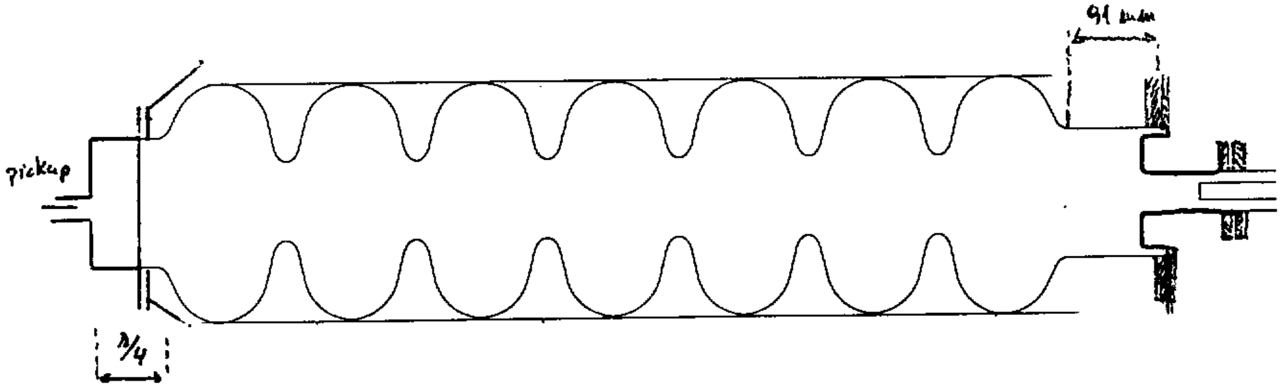
IV Cold test of sub-units:

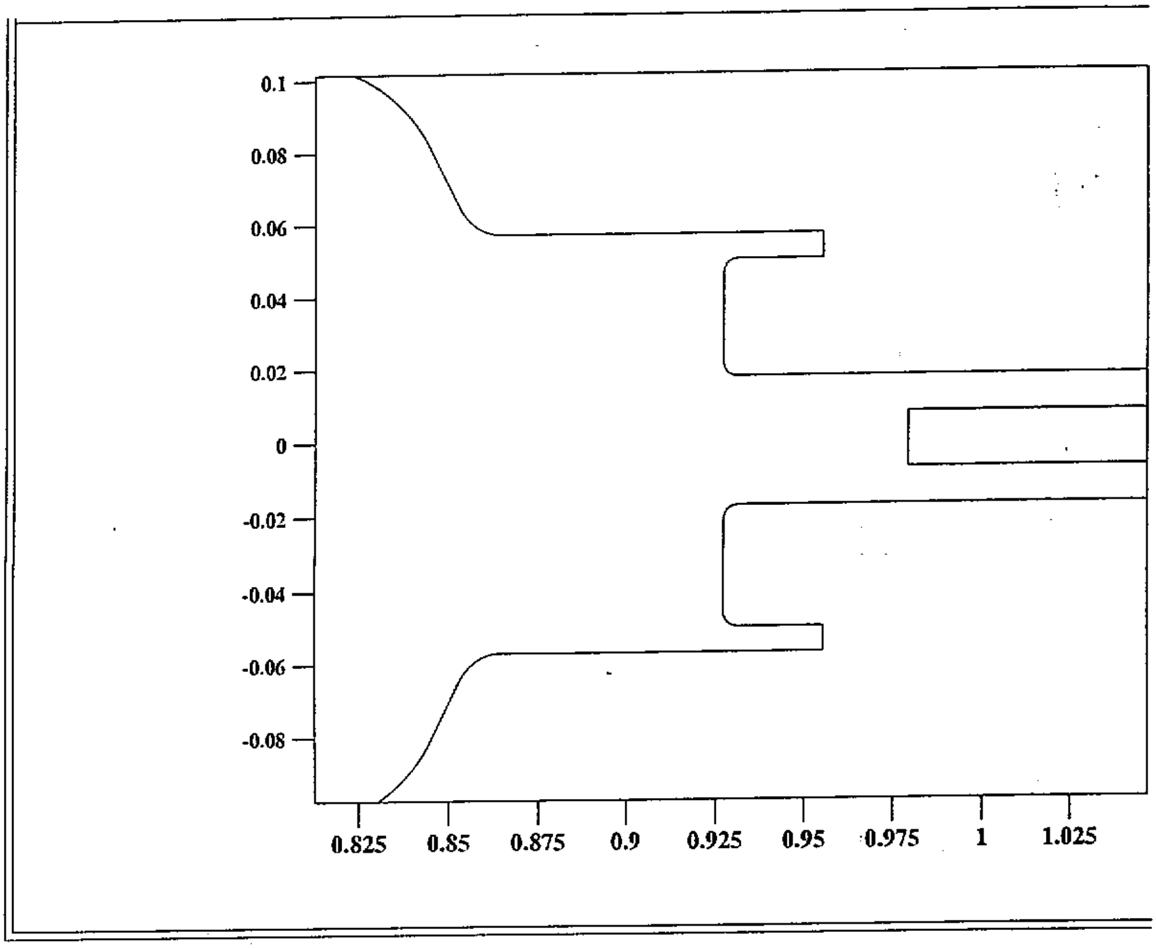
7-cell cavities are terminated with two type of beam tubes:
the short one 21 mm and/or
the long one 91 mm.

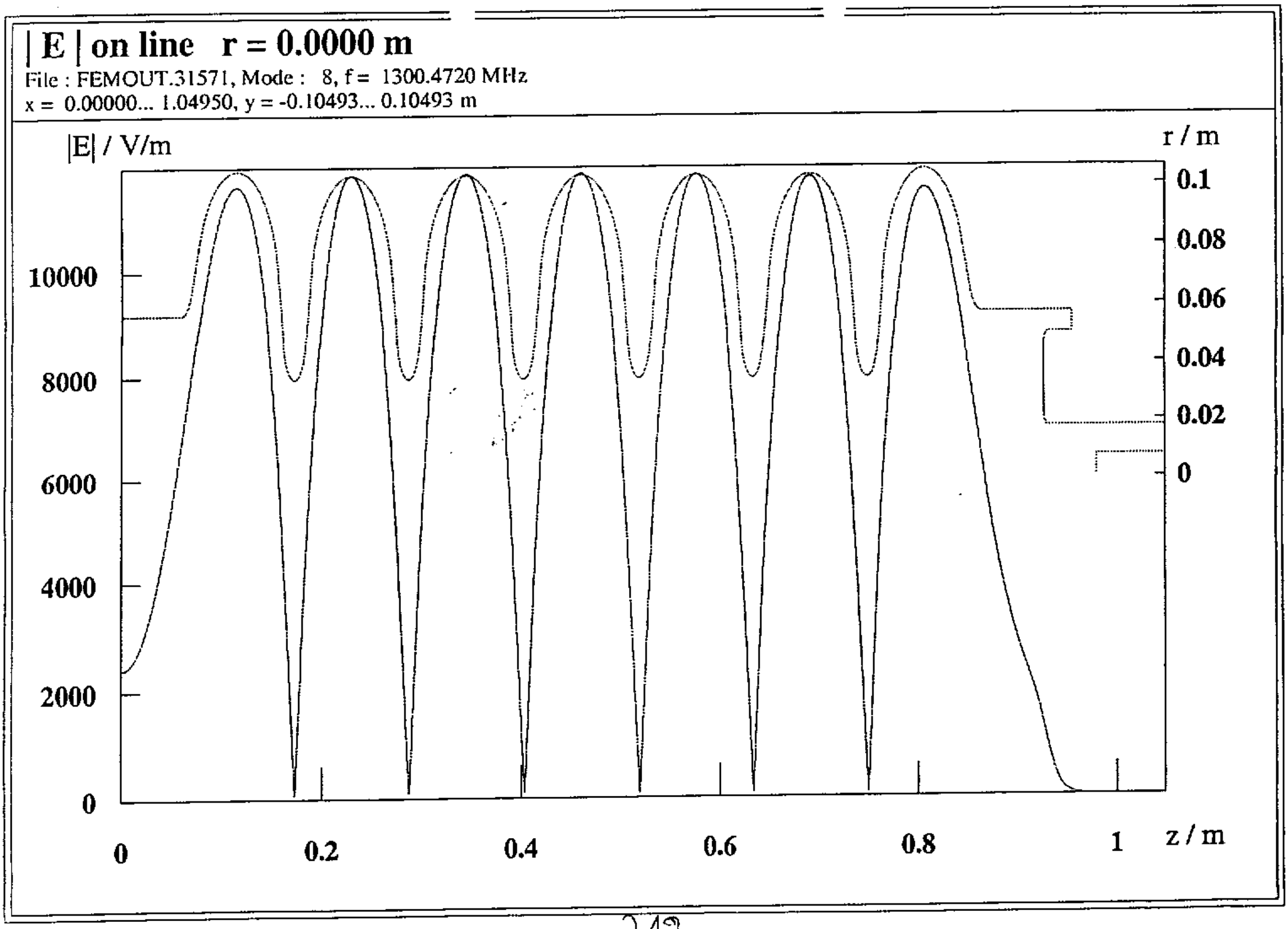
This asymmetry reduces number of the flange connections to 3. But to test 7 cells with the reasonable field profile one has to use two superconducting end-cups:

- **end-cup with the variable input coupler**
- **end-cup with the pickup antenna**

which provide electric short at the distance of λ/4.



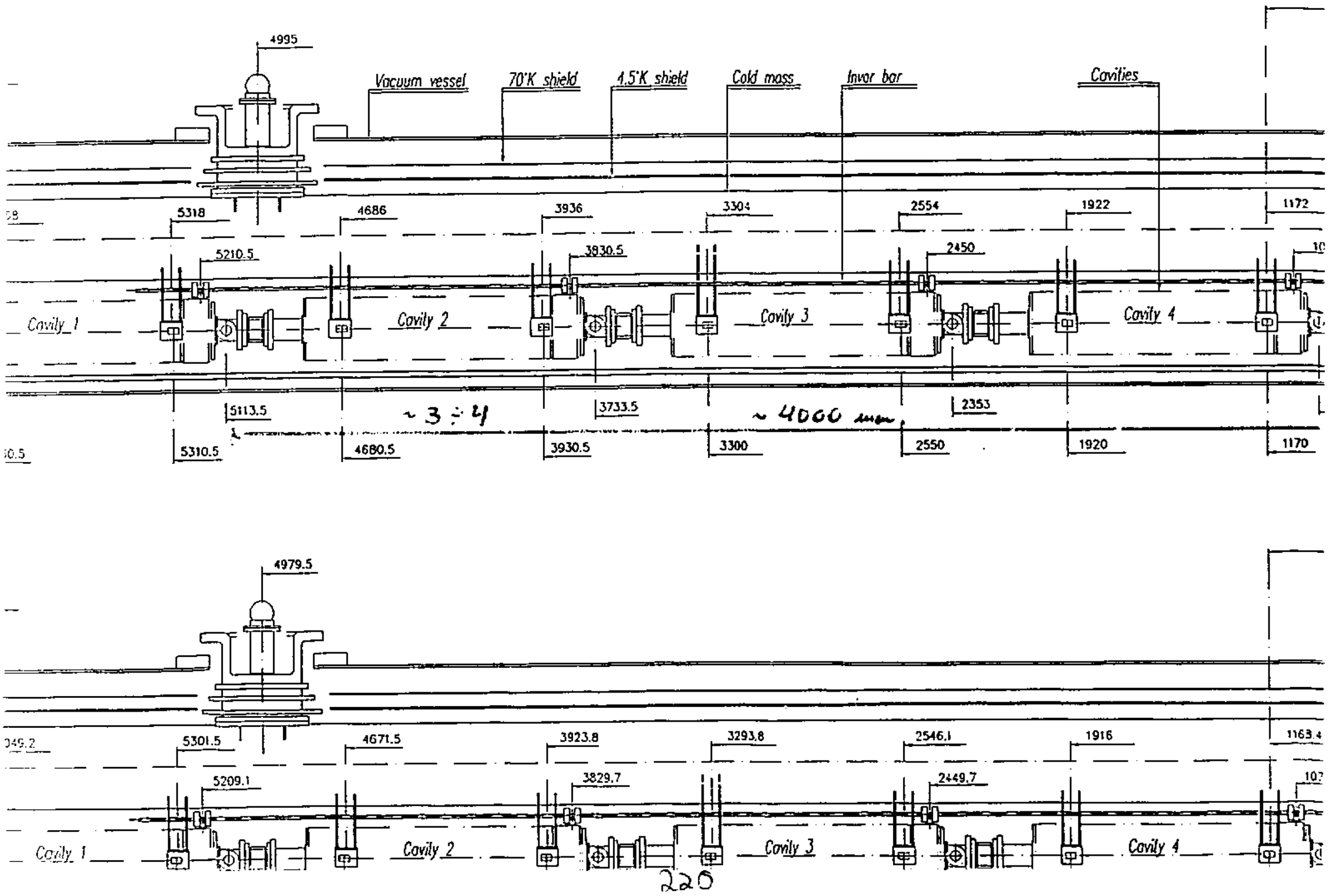



| E | on line r = 0.0000 m

File : FEMOUT.31571, Mode : 8, f = 1300.4720 MHz

x = 0.00000... 1.04950, y = -0.10493... 0.10493 m

V Assembly in the cryomodule and final test with the beam. (J. Weisend , C. Pagani).



Waveguide Input Coupler for Accelerating System

(one of possible constructions)

A.Zavadtsev
DESY

1. APPOINTMENT

The power input coupler may be used for RF feeding of:
- one N-cells cavity (N=9 or more) or
- two N-cells cavities (N=9 or more) or
- one Superstructure [1] (4*7=28 cells) or
- two Superstructures (2*4*7=56 cells).

2. COUPLER STRUCTURE

The power input coupler is destined for power transition from gas-filled rectangular waveguide at the room temperature to the high clean vacuum filled accelerating structure at 2K.

The final variant of the input coupler (coaxial or rectangular waveguide) may be chosen after carrying out the following main works:

- calculation of the form and sizes of the coupler;
- calculation of the field in the coupler;
- calculation of the kick for the beam;
- investigation of the multipacting ;
- design of the coupler construction (in the cryomodule);
- design of the cooler circuits (70 and 2 K), calculation of the heat regime and the temperature distribution;
- design of the HOM couplers;
- design of the processes of manufacture, chemistry development, heating, tuning, assembling and high power tests of the input coupler and the accelerating system.

The waveguide input coupler consists of
- warm ceramic window,
- cool ceramic window (at 70K),
- coupling element,
- connecting lines.

Each commercial waveguide window with satisfactory parameters may be used as the warm ceramic window.

The coupling element may be used as in [2].

The parameters of the waveguides and the coaxial line in travelling wave regime are represented in Table 1. All parameters in this report correspond to P=1.3 MW (two Superstructures - 56 cells).

Table 1: Feeding lines parameters.

Feeding line	Maximal electric field, kV/cm	Maximal voltage, kV	Decrement relative values
Waveguide 165x82 mm	4.48	37.0	1
Waveguide 165x50 mm	5.76	28.8	1.44
Waveguide 165x30 mm	7.44	22.3	2.18
80 mm 80 Ohm coaxial line - inner conductor - outer conductor	10.3	14.4	1.78 1.41 0.37

The multipacting chart in the rectangular waveguide in travelling wave regime is available [3].

3. CERAMIC WINDOW

3.1. Common ideas

The main requirements for the ceramic window are:
- the window should have minimal sizes because it will be install into the cryomodule;
- the ceramic should not be seen from the beam axis;
- the electric field in the window should be minimized.

The power transmission through the window is

$$K = \frac{4\beta_1\beta_2}{(1+\beta_1+\beta_2)^2} \cdot \frac{1}{1+\left(\frac{2Q_0\Delta f}{(1+\beta_1+\beta_2)f}\right)^2}$$

β_1 and β_2 are the coupling coefficients of the cavity with input and output waveguides,

Q_0 is own Q-factor of the cavity,

Δf is frequency shift.

Analysing this equation one can say that
- the power transmission is equal to 1 at resonance frequency if $\beta_1 = 1+\beta_2$;
- the window has more broad frequency band for higher β_1 and β_2.

Therefore it is better to make $\beta_1 >> 1$ and $\beta_2 >> 1$. The good matching may be got for $\beta_1 = \beta_2$ in this case. It means that the window may be symmetrical about the window centre.

3.2. Calculated parameters.

The configuration of the window is the development of the idea proposed in [4]. The waveguide cross-section is 165.1x30 mm. The coupling slots sizes are h*30 mm.

Table 2: Parameters of the window variants in the frequency range 1.0-1.6 GHz.

Variant	Mode	f_0, MHz	Δf, MHz (S_{11}=0.1)	E_{cer} kV/cm
One-mode variant with h=90 mm.	TM_{010}	1155	10	12.3
	TE_{111}	1225	<10	11.0
	TE_{211}	1400	10	11.0
Tree-modes variant with h=114 mm.	TM_{010} $+TE_{111}$ $+TE_{211}$	1300	170	5.0

4. CONNECTING LINES

Table 3: Connecting lines parameters.

Connecting line	f_0, MHz	Δf, MHz (S_{11}=0.1)	E_{max}, kV/cm
82-30 mm transition	1300	160	7.5
30-30 mm S-bend	1300	540	7.5

HP 85180A High-Frequency Structure Simulator was used for all calculations.

5. CONCLUSION

Proposed construction of input coupler has following properties:

- **minimal sizes**; the ceramic window is disposed inside the waveguide volume practically;

- **low electric field**; the optimization of the window sizes provides the travelling wave in the window cavity practically like in the transmission line rather then the standing wave like in the resonator;

- **admissible frequency band** - 160 MHz at S_{11}=0.1 level (cool window and connecting lines).

7. REFERENCES

1. J.Sekutowicz. Status of Superstructure Studies. The TTF Coupler Meeting, Saclay, October 19-20, 1998. November 1998, TESLA 98-28.

2. M.Dohlus, A.Gamp, H.Hartwig, N.Holtkamp, A.Jostingmeier, C.Martens, M.Marx, C.Pagani, J.Weisend, V.Kaljuzhny, K.Jin, A.Zavadtsev, S.Yarigin. Status of Waveguide Coupler Activity at DESY. The TTF Coupler Meeting, Saclay, October 19-20, 1998. November 1998, TESLA 98-28.

3. D.Proch. Multipactor Simulations. The TTF Coupler Meeting, Saclay, October 19-20, 1998. November 1998, TESLA 98-28.

4. A.Zavadtsev. New Idea for Waveguide Coupler Window. The TTF Coupler Meeting, Saclay, October 19-20, 1998. November 1998, TESLA 98-28.

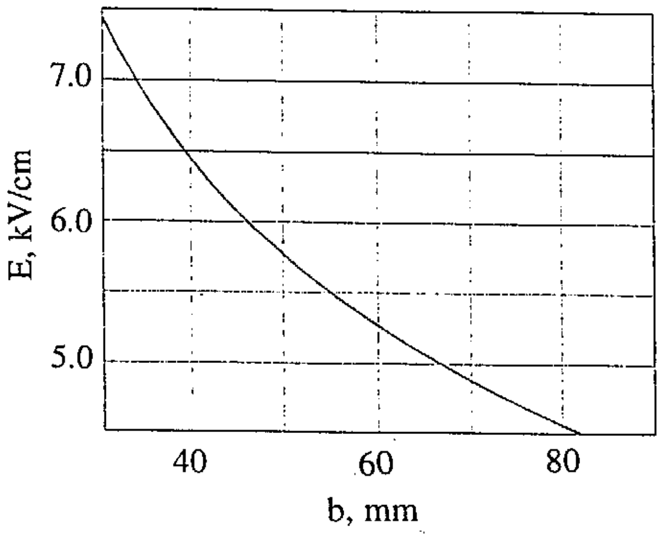


Fig.1. Maximal electric field E in the waveguide with the cross-section 162xb at power P=1.3 MW.

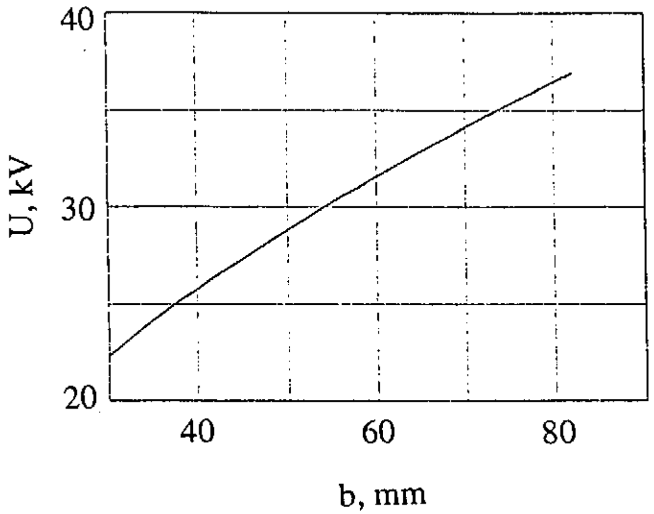


Fig.2. The voltage U in the waveguide with the cross-section 165xb at power P=1.3 MW.

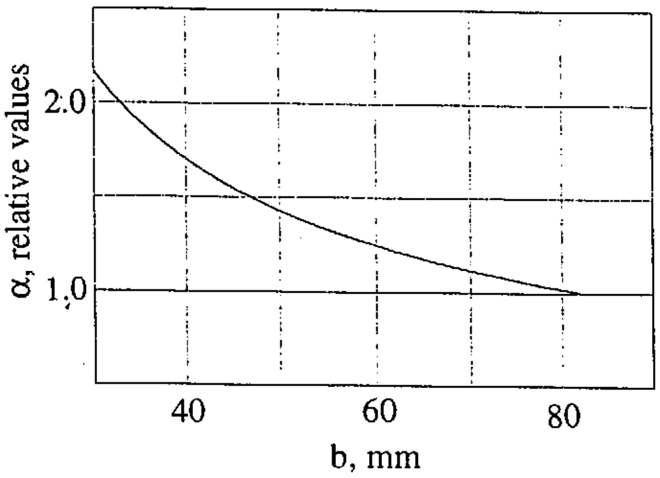


Fig.3. The decrement α depending on b.

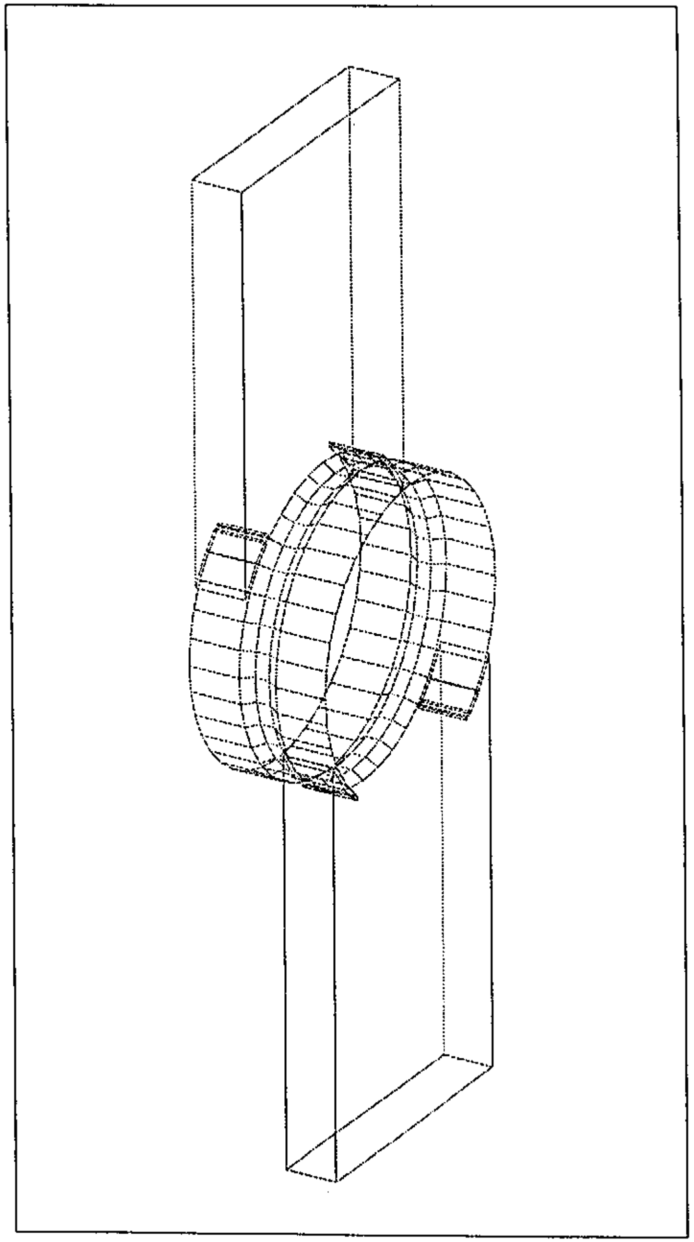


Fig.4. View of the window.

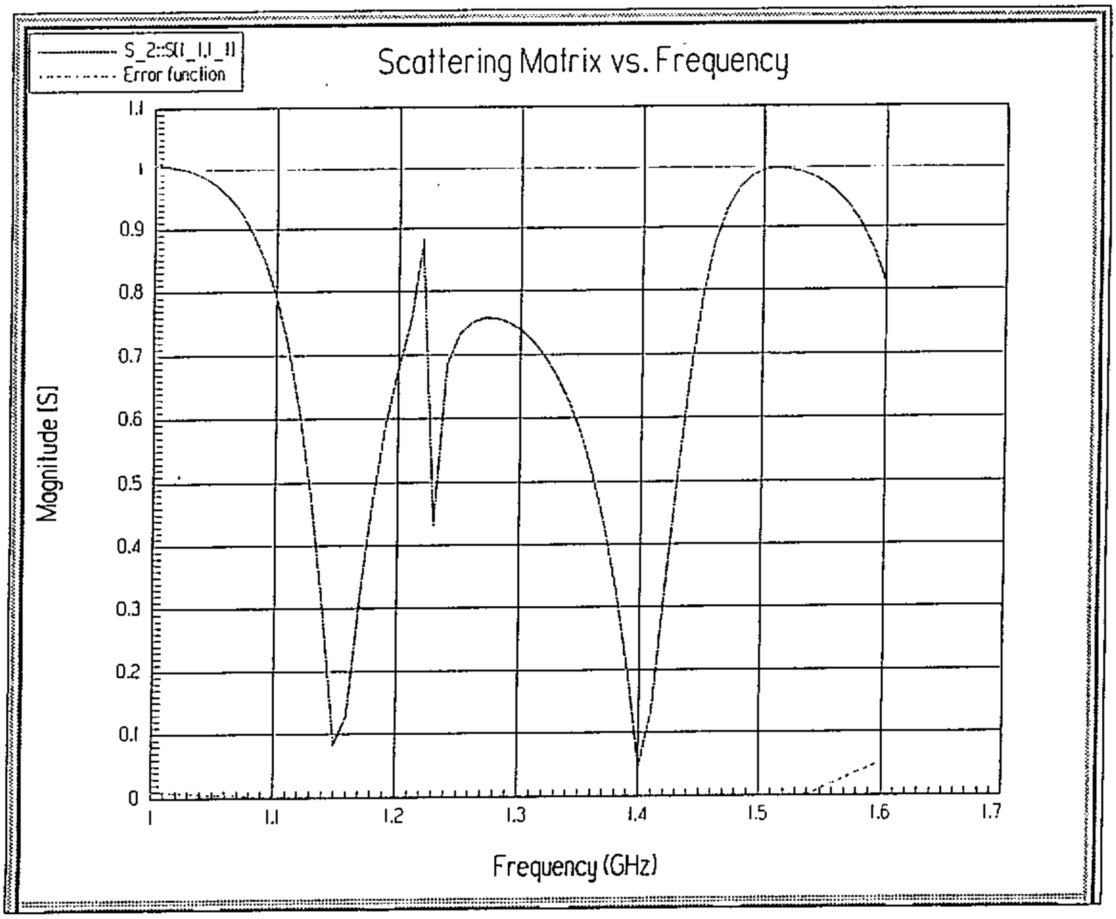


Fig.5. $S_{11}(f)$ dependence for window with h=90 mm.

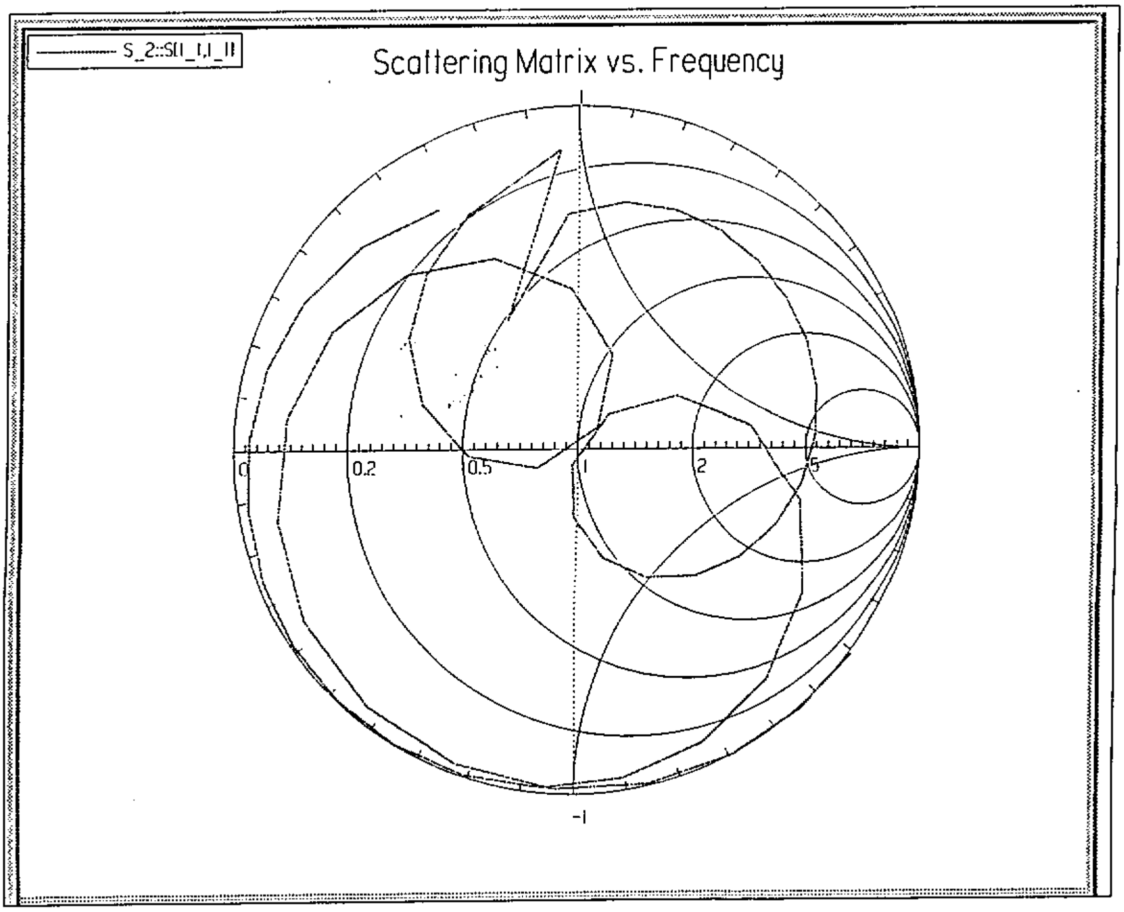


Fig.6. $S_{11}(f)$ dependence in Smith chart for window with h=90 mm.

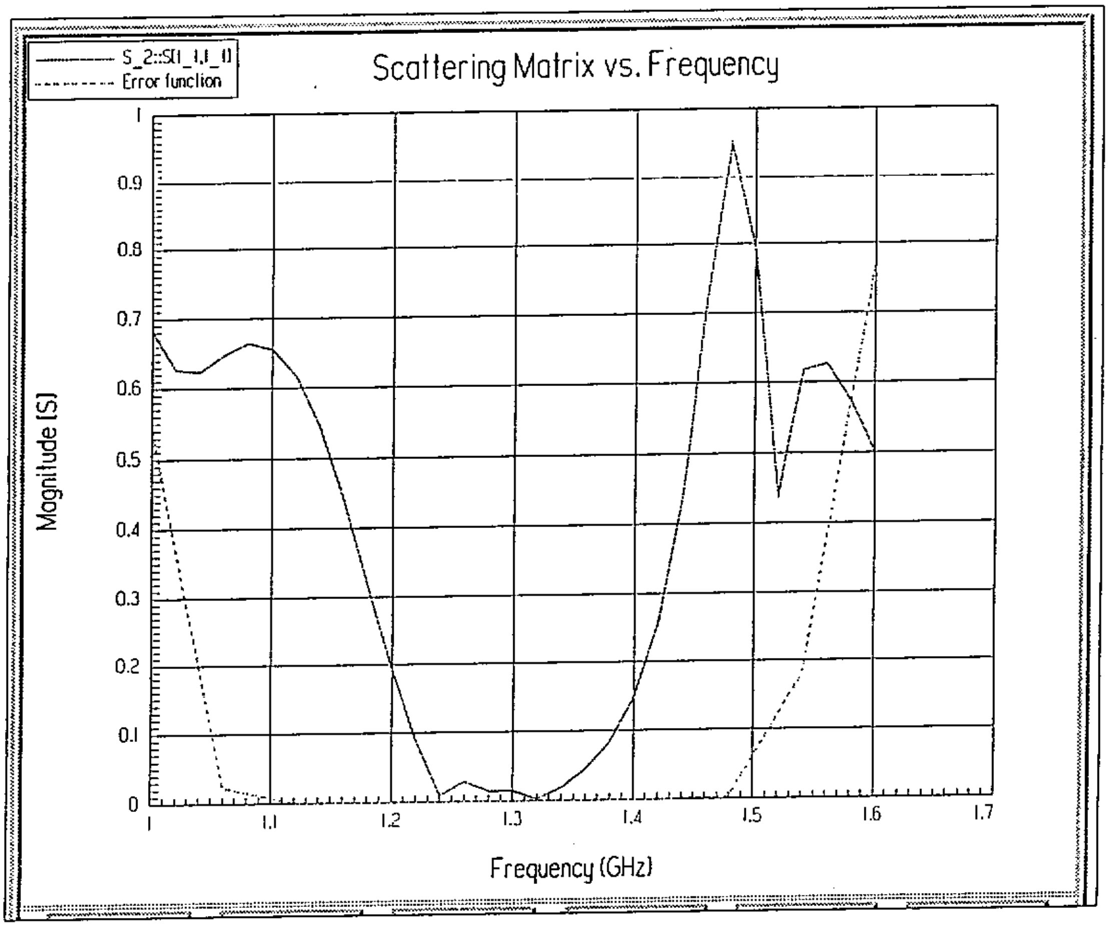


Fig.7. S_{11}(f) dependence for window with h=114 mm.

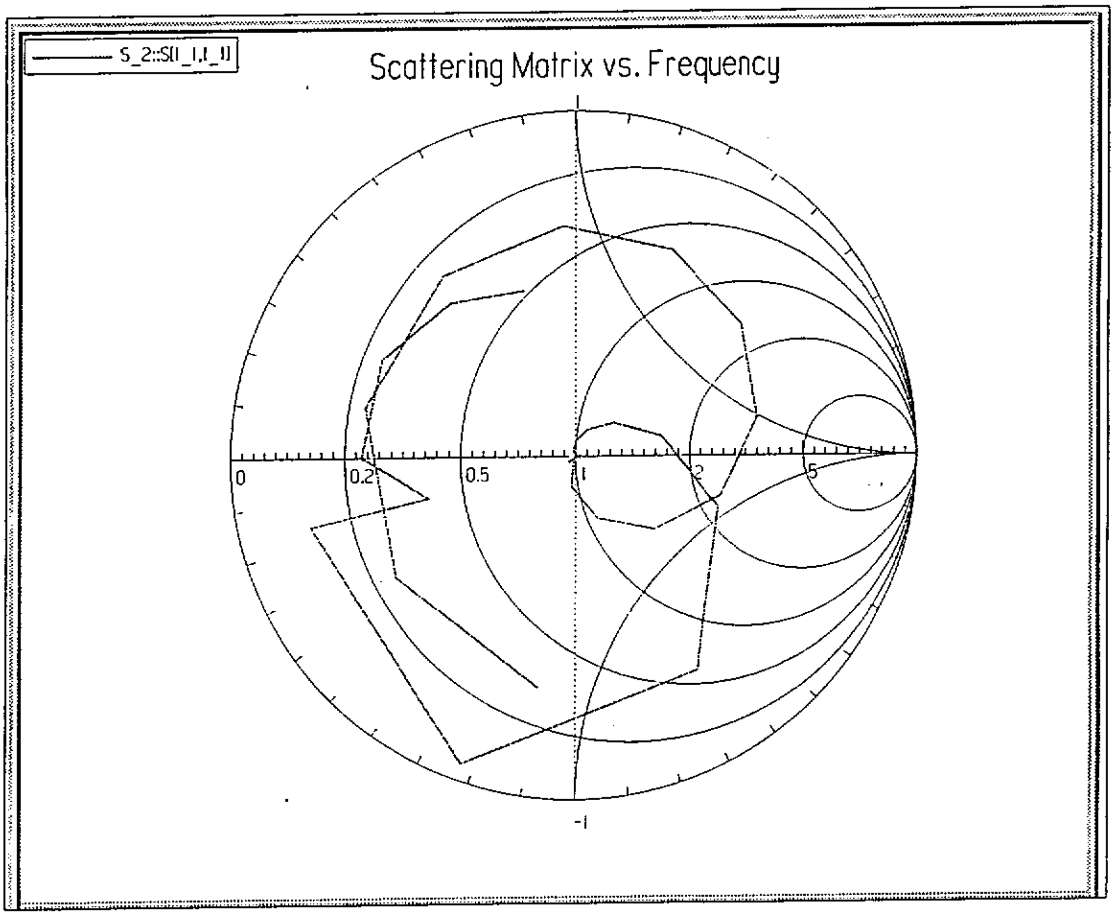


Fig.8. S_{11}(f) dependence in Smith chart for window with h=114 mm.

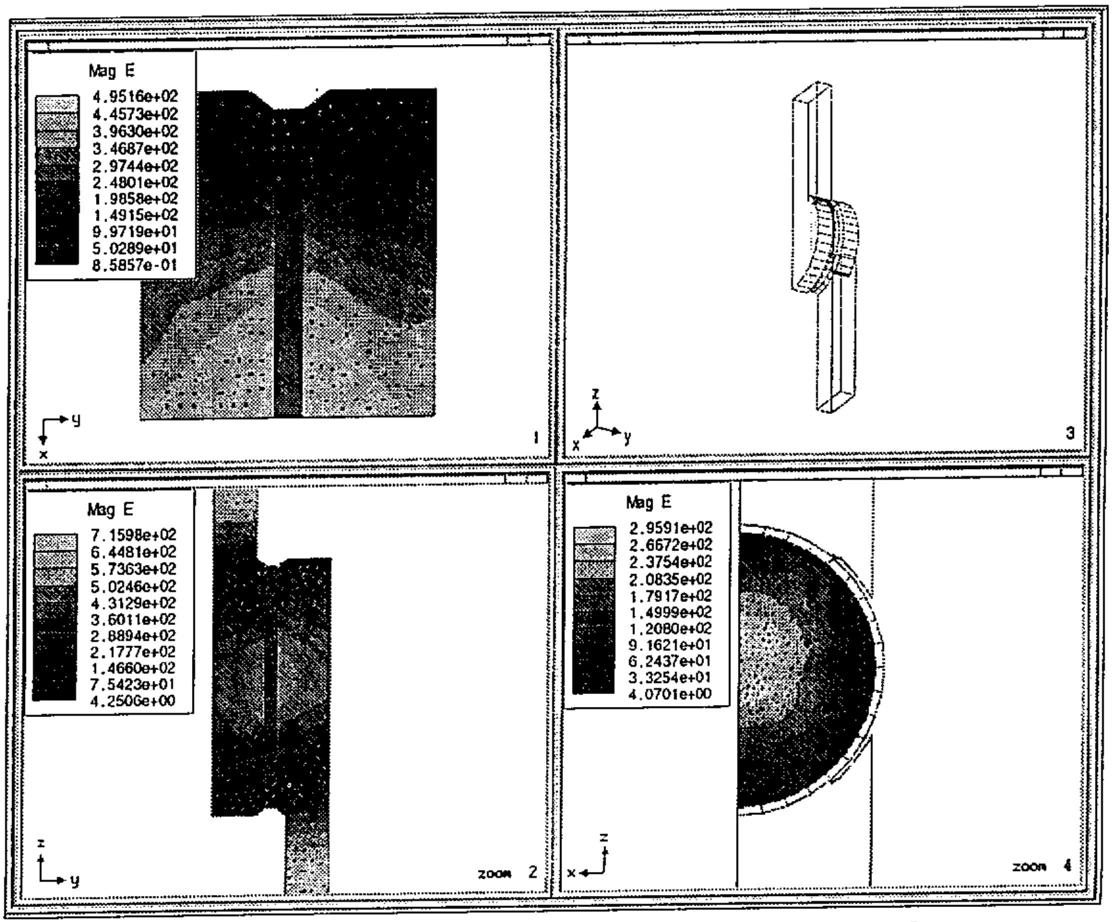


Fig.9. The field distribution in the window at phase 0^0.

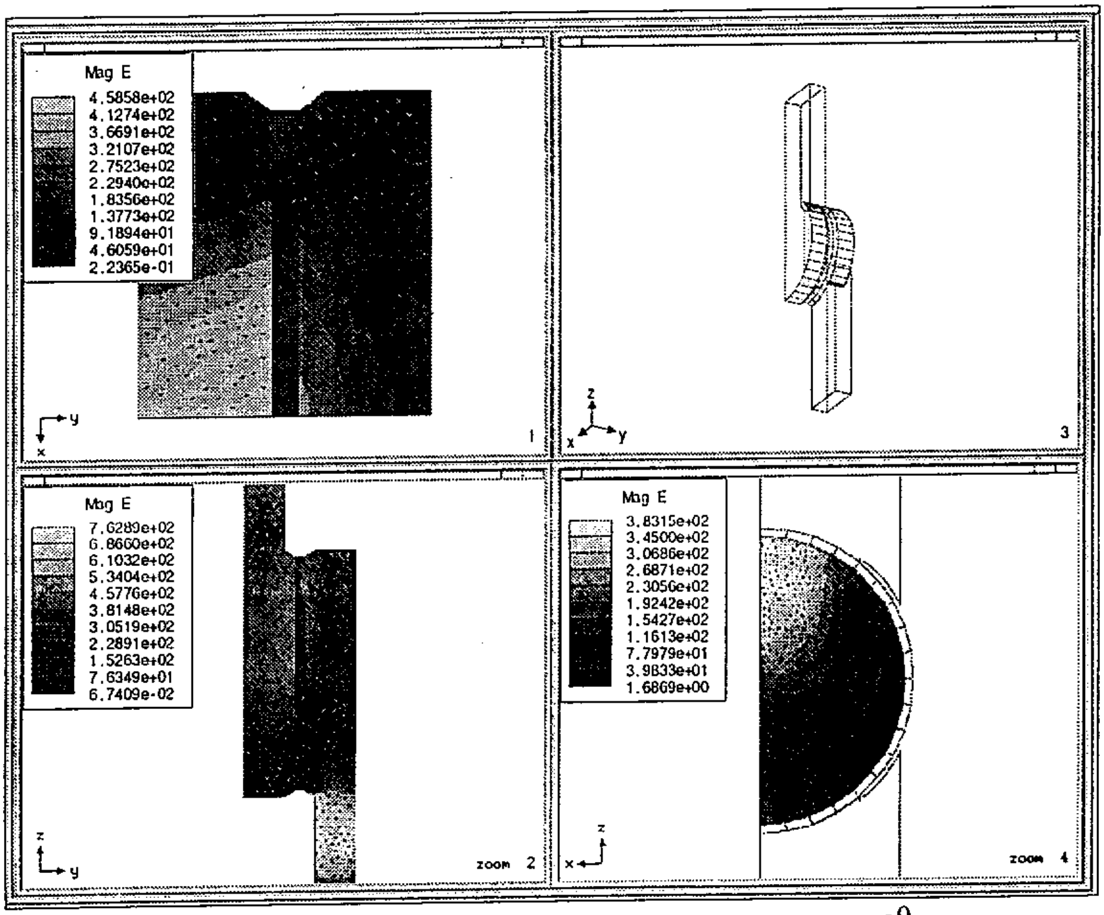


Fig.10. The field distribution in the window at phase 30^0.

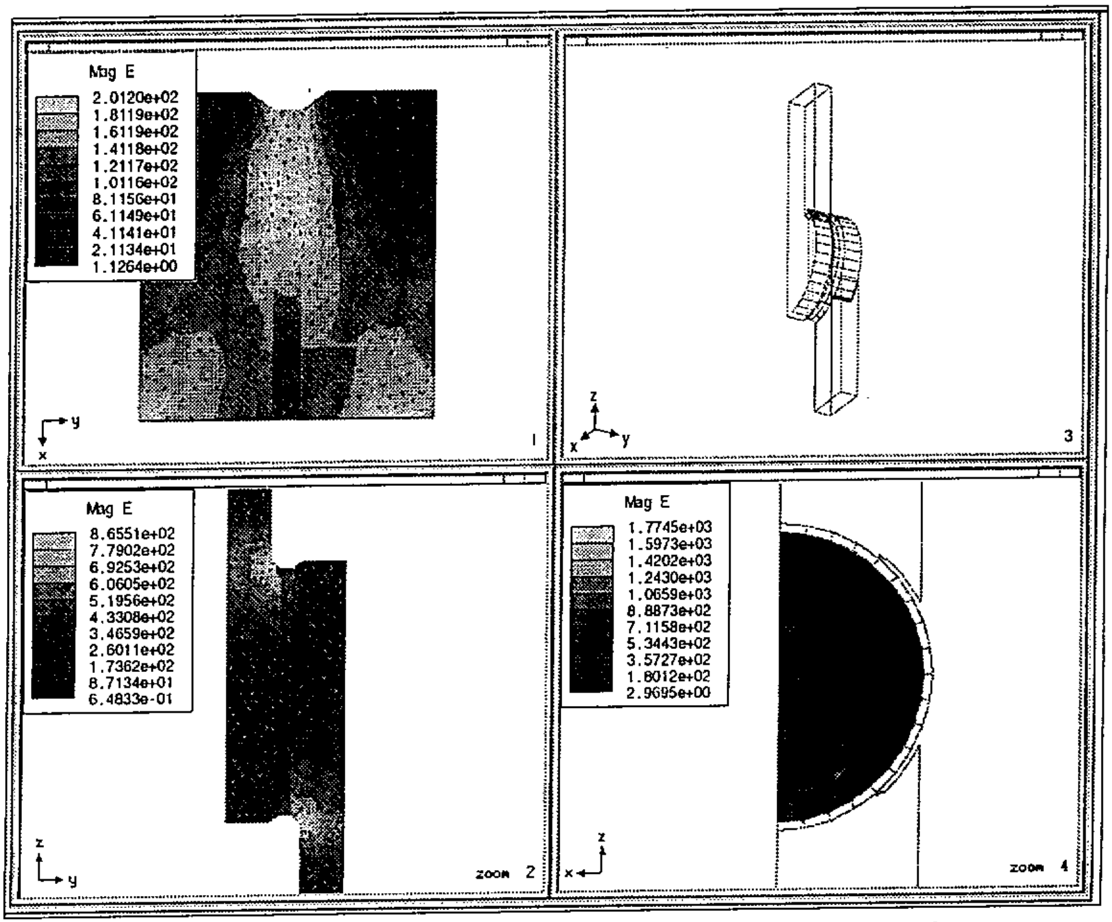


Fig.11. The field distribution in the window at phase 90^0.

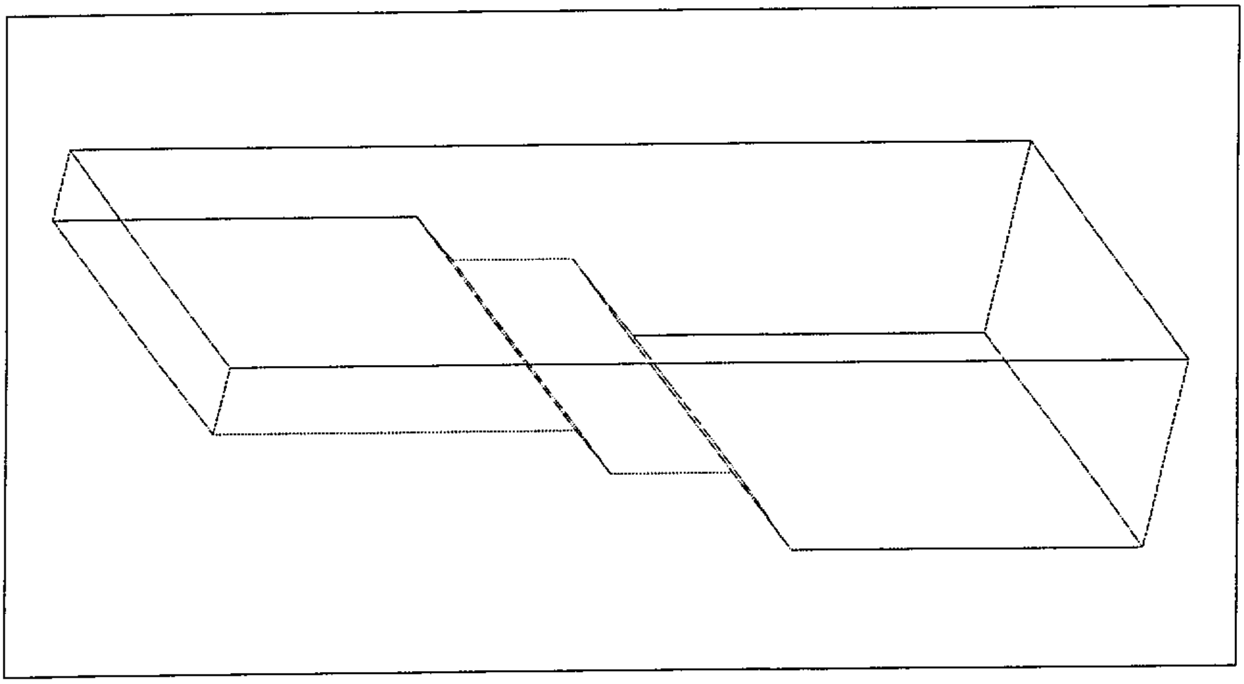


Fig.12. 82-30 mm transition.

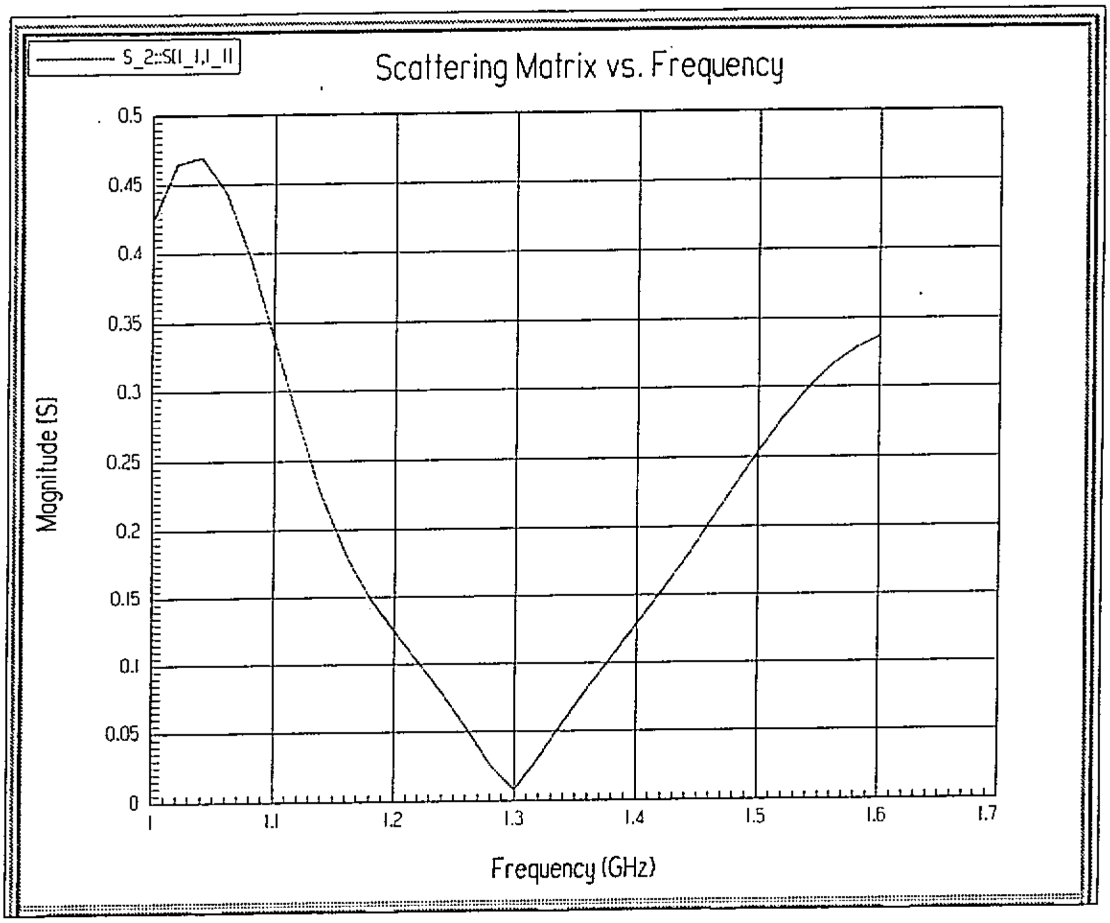


Fig.13. S_{11}(f) dependence for 82-30 mm transition.

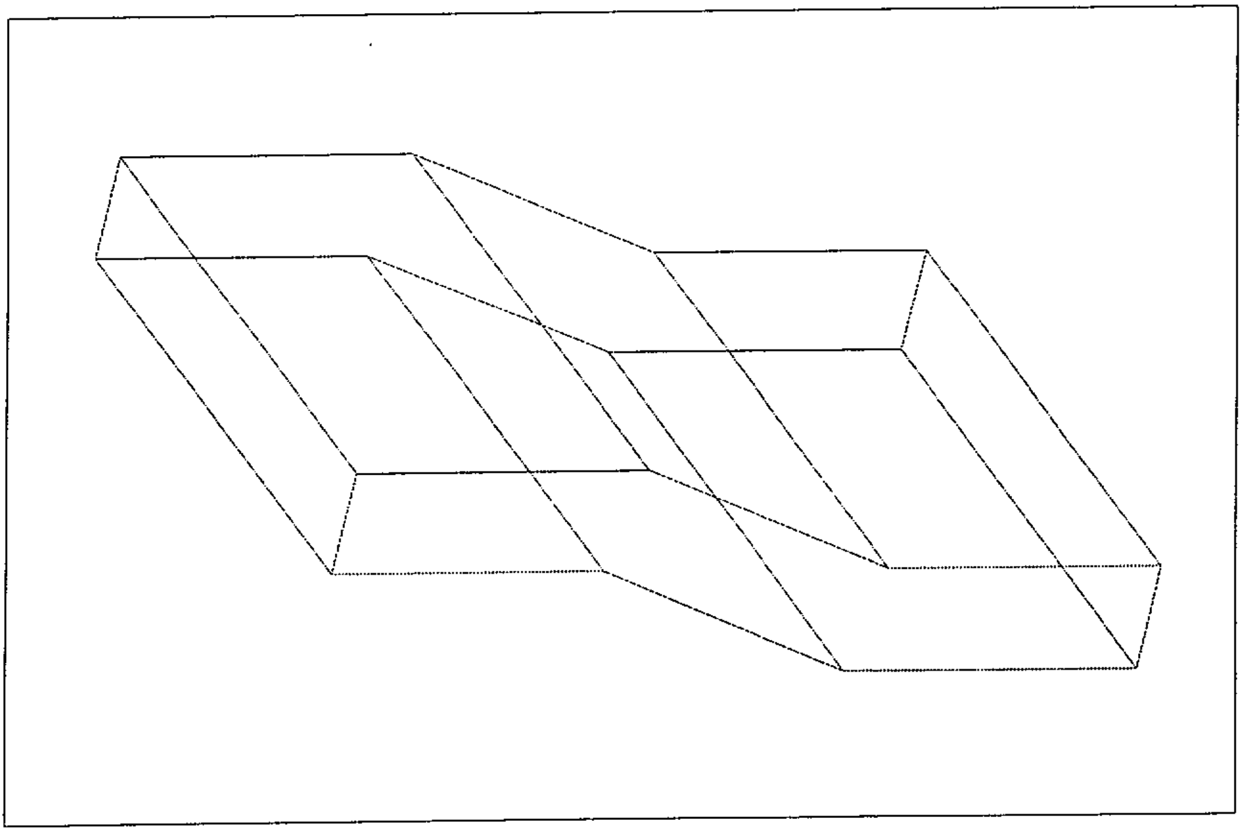


Fig.14. 30-30 mm S-bend.

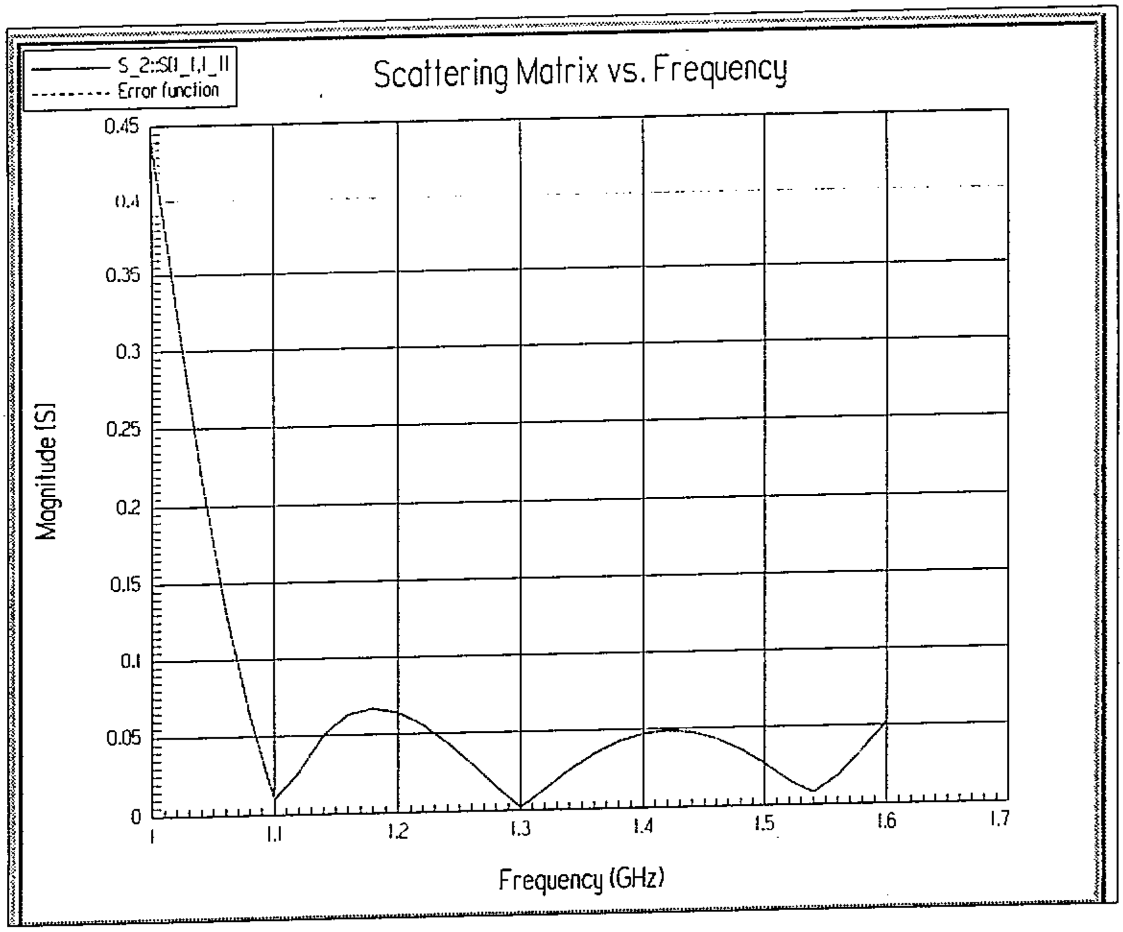


Fig.15. S_{11}(f) dependence for 30-30 mm S-bend.

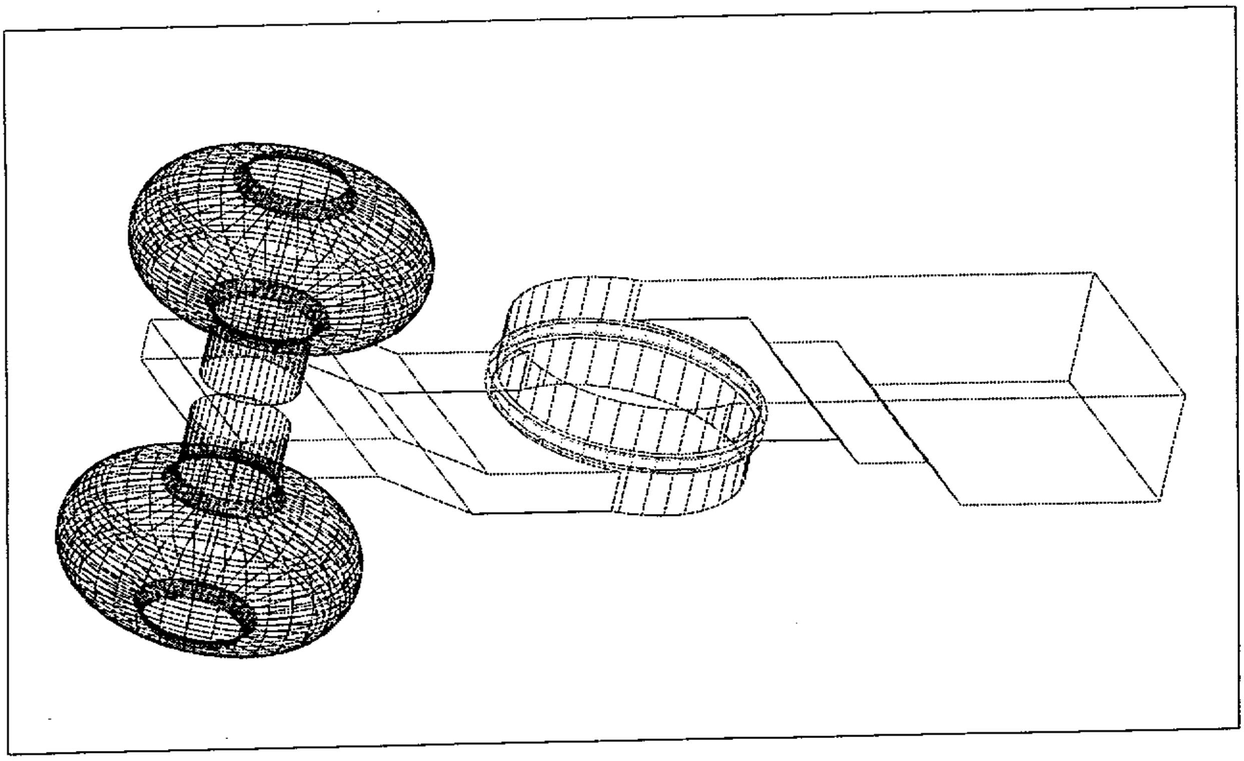


Fig.16. Common view of the coupler.

FIELD MEASUREMENTS FOR
A 4-CAVITIES CHAIN

PASSBAND LIMITS (BY INDIVIDUAL MEASUREMENTS)

		MONOPOLE	DIPOLE
1.	A 17	2.460425	2.5803
2.	A 18	2.469575	2.5815
3.	S9	2.461375	2.5748
4.	A19	2.467140	2.5790

TRANSMISSION CURVES → VERY DIFFERENT THAN AT TTF.

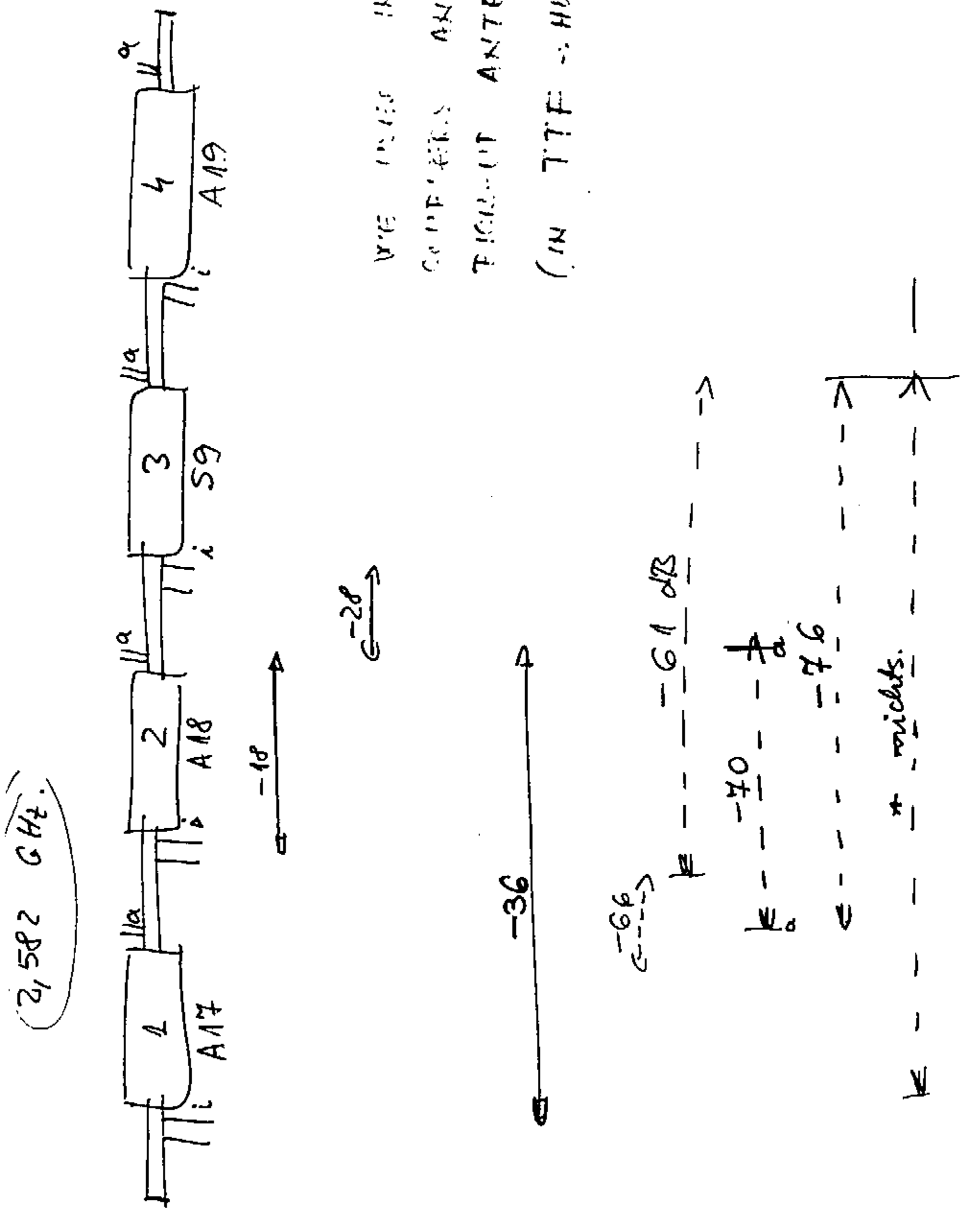
STRENGTHENING BELLOW ⇒ HIGHER PASSBAND LIMIT.

NEXT : COPPER CAVITY IN CHAIN

2.3.99

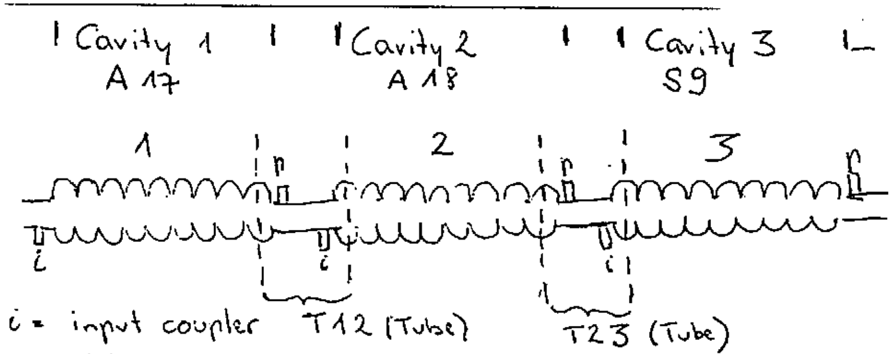
NICOLETA BABOI

9.2.99



WE USED INPUT COUPLERS AND PICK-UP ANTENNAS.
(IN TTF → HOM COUPLERS

TUBE 1-2 : 344,5 mm



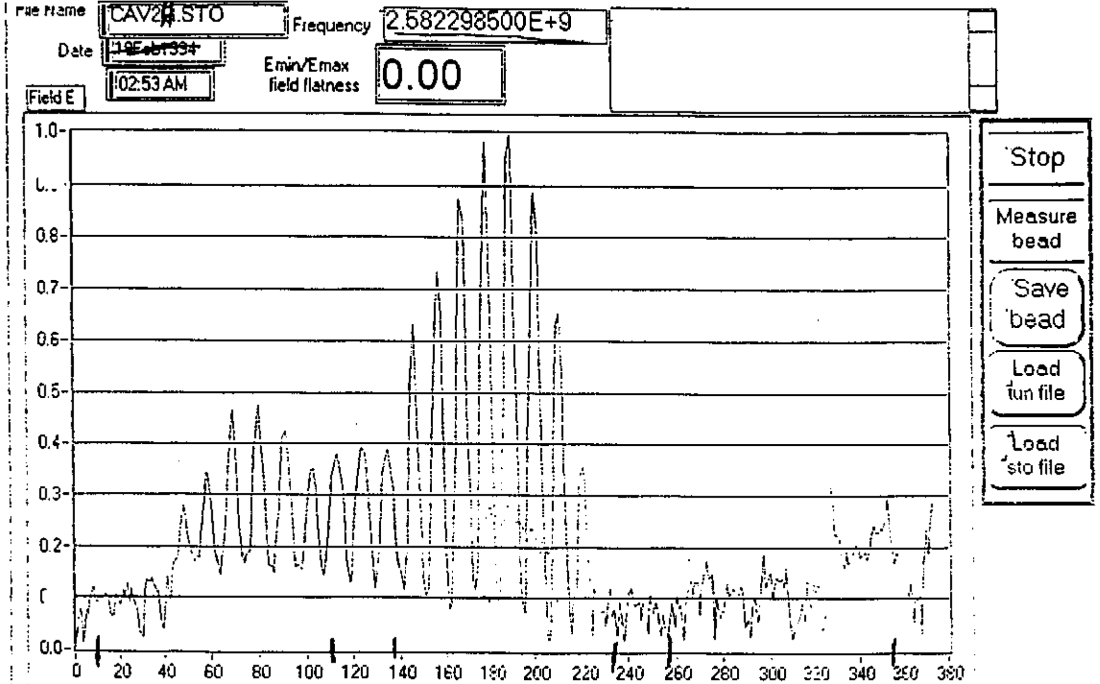
i = input coupler

p = pickup

⋔ Amp, +20 dB = + Amp

Cav, 2i - 2p

T12 = 460 mm
T23 = 445,5 mm } relative lengths of tubes


File Name CAV2[illegible].STO

Date ~~19Feb1994~~

02:53 AM

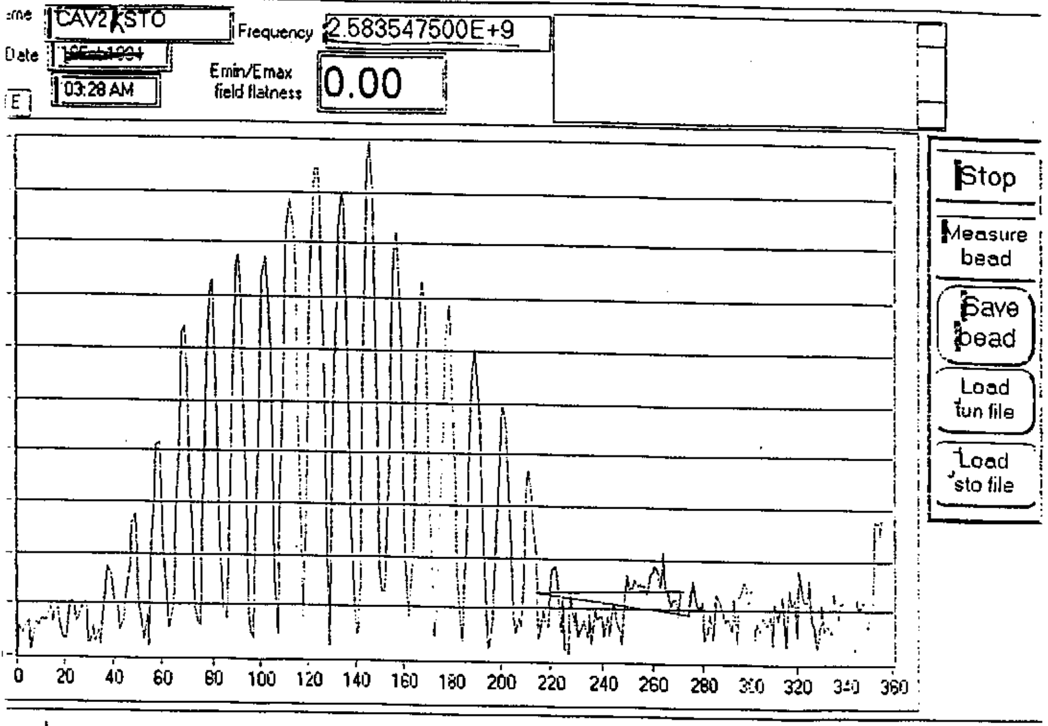
Frequency 2.582298500E+9

Emin/Emax field flatness 0.00

-Amp

TUBE 1-2 : 334.5 mm

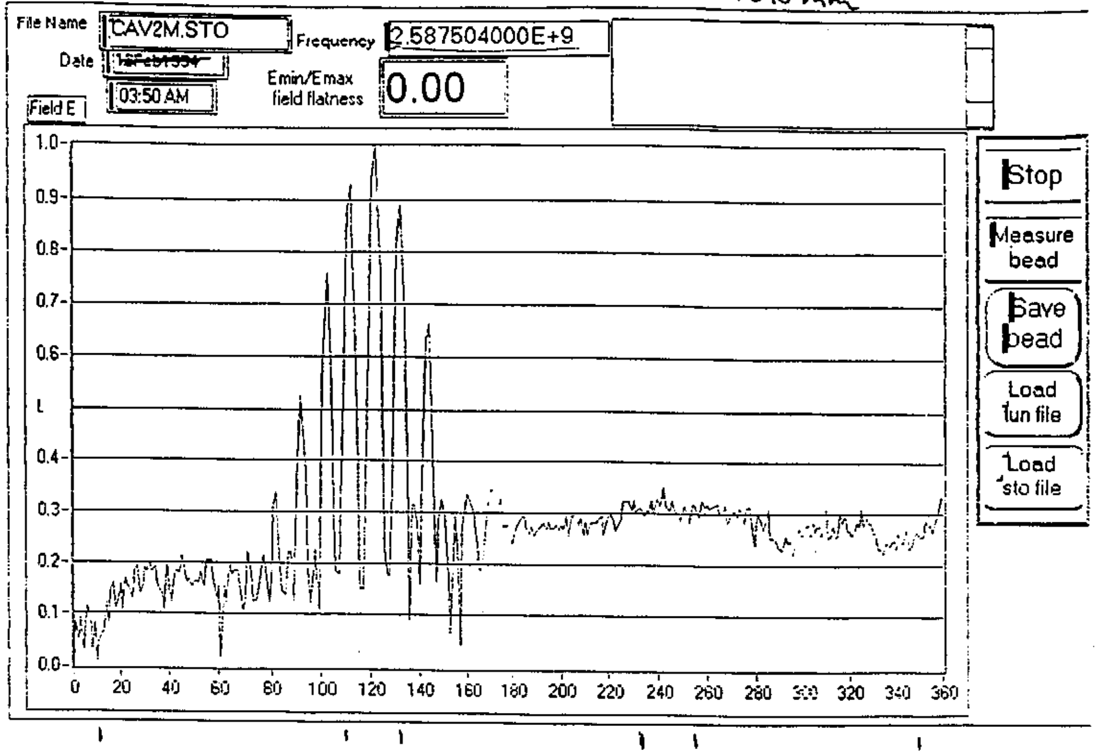
Cav.2i-2p T12 = 450 mm
T23 = 495,5 mm



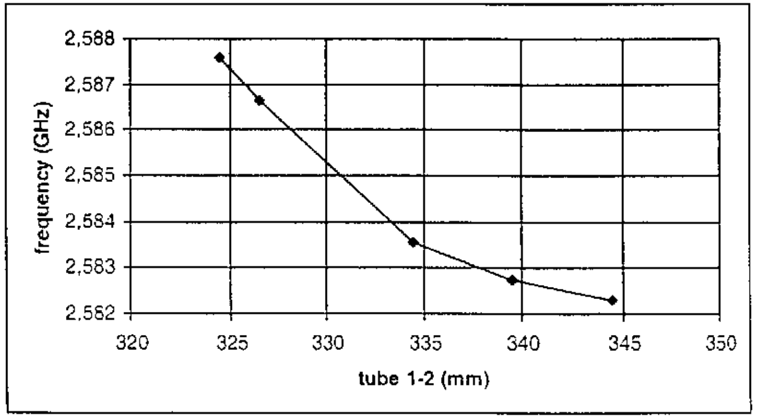
ame CAV2KSTO
Date [illegible]
03:28 AM
Frequency 2.583547500E+9
Emin/Emax field flatness 0.00

TUBE 1-2 : 324.5 mm

~~Tube~~ Cav.2i-2p T12 = 440 mm
T23 = 445,5 mm



File Name CAV2M.STO
Date [illegible]
03:50 AM
Frequency 2.587504000E+9
Emin/Emax field flatness 0.00



Amp

- Amp

(NO) CONCLUSIONS

- TRANSMISSION CURVES – DIFFERENT THAN IN TTF

  BUT: IN TTF → HOM COUPLERS
  HIER → INPUT COUPLERS + PICK-UP ANTENNAS

- SHORTENING BEAM TUBE → MODE <u>FREQUENCY INCREASES</u>

- BELLOWS → <u>NO EFEECT</u>
  (H.W. GLOCK → CALCULATIONS)

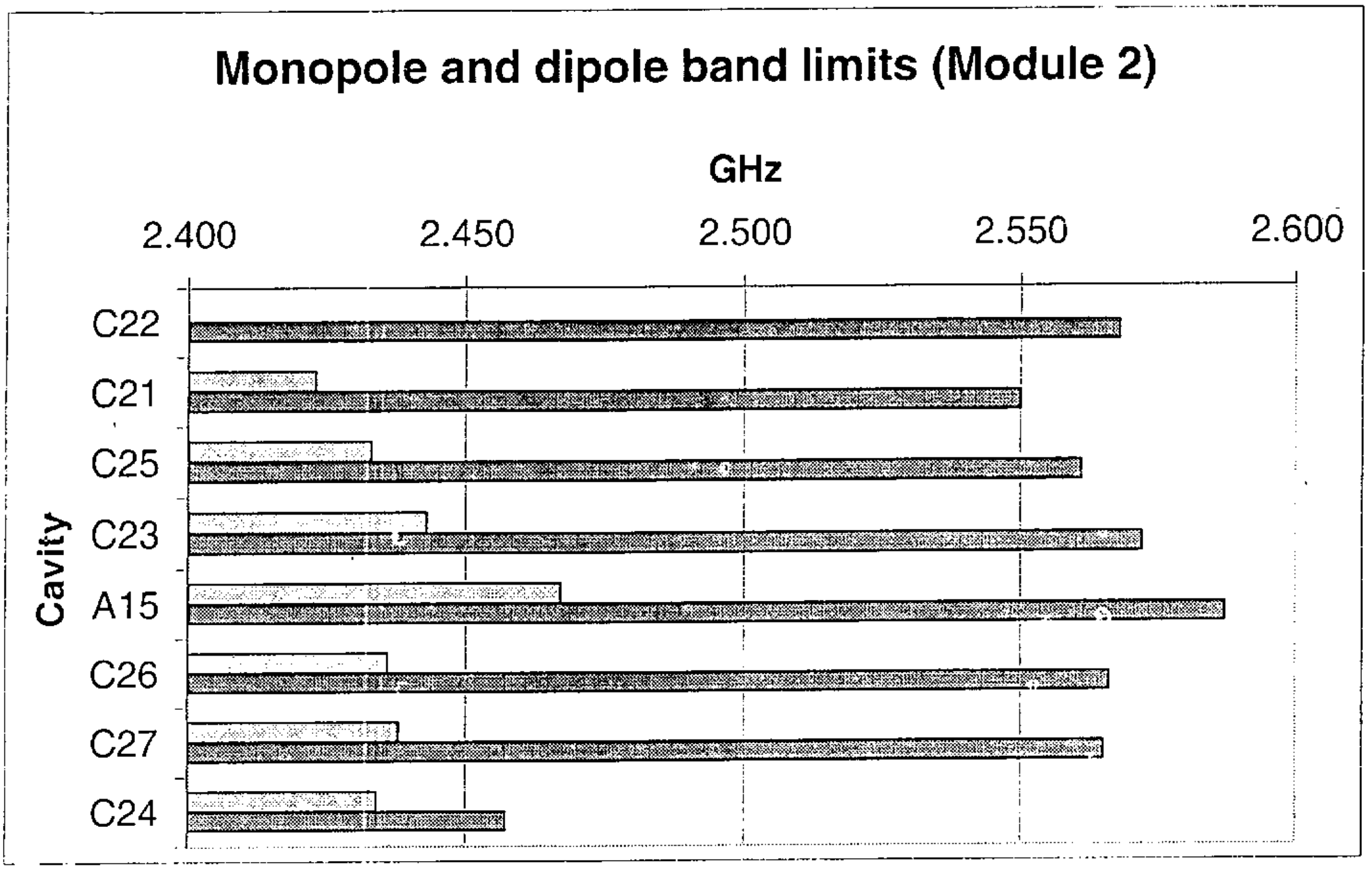
- NEXT: COPPER CAVITY IN THE CHAIN
  → STUDY POLARIZATION EFFECTS

MODULE 1

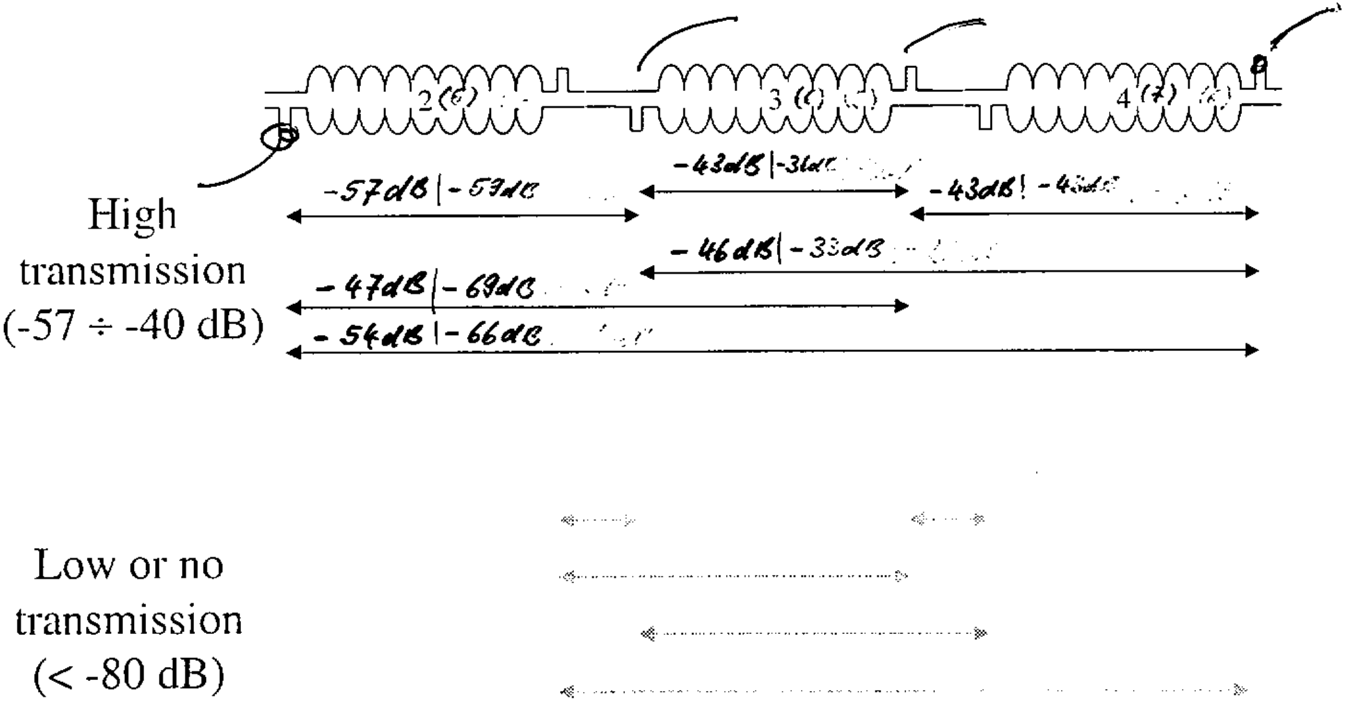
	8	7	6	5	4	3	2	1
CAVITY	S7	D4	S11	D2	D1	S10	S8	D3
INPUT COUPLER	FNAL	FNAL	DESY	FNAL	FNAL	DESY	DESY	FNAL
HOM COUPLER	SACLAY	DESY	Saclay	DESY	DESY	Saclay	Saclay	DESY

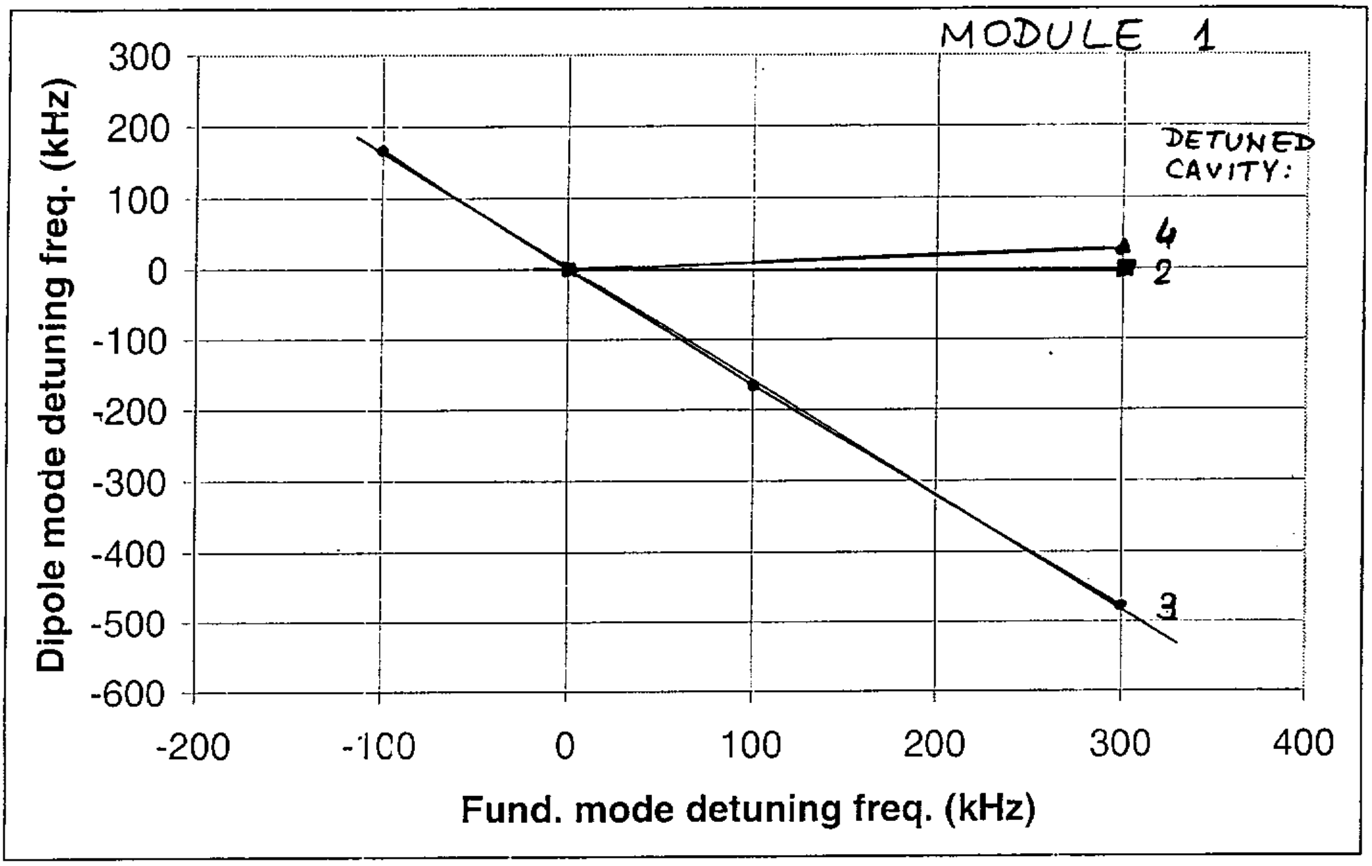
MODULE 2

	1	2	3	4	5	6	7	8
CAVITY	C22	C21	C25	C23	A15	C26	C27	C24
INPUT COUPLER	FNAL	FNAL	FNAL	FNAL	FNAL	FNAL	FNAL	FNAL
HOM COUPLER	Saclay	Saclay	Saclay	Saclay	DESY	Saclay	Saclay	Saclay



Module 1 Cav.3, Module 1 Cav.6,




MODULE 1
DETUNED CAVITY:
4
2
3
Dipole mode detuning freq. (kHz)
300
200
100
0
-100
-200
-300
-400
-500
-600
Fund. mode detuning freq. (kHz)
-200
-100
0
100
200
300
400

FE-measurements at University of Wuppertal

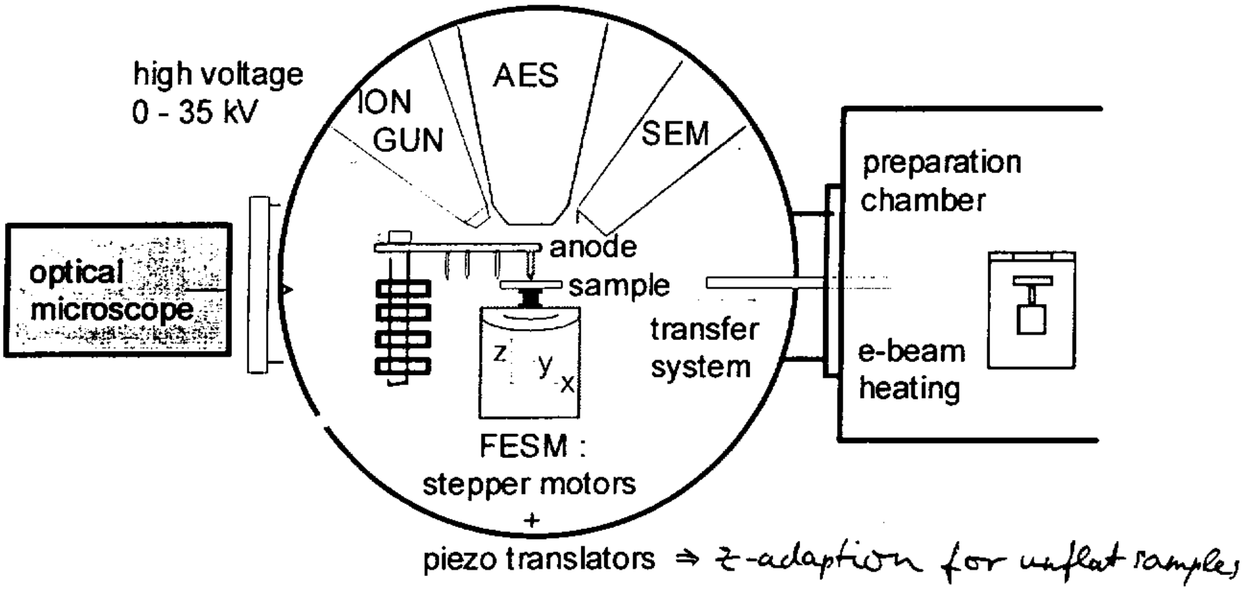
B. Günther, T. Habermann, G. Müller. K Theunissen

Outline

- DC field emission measurements with a new planar I-U measurement technique configuration with a luminescent ITO screen (IMLS)
    - Measurement configuration
    - First results on niobium samples
    - Comparison of FESM and IMLS
- Investigation of enhanced field emission due to etching defects
    - Etching of niobium cavities
    - FESM scans of differently etched niobium samples

Samples prepared at TTF by D. Reschke

Experimental

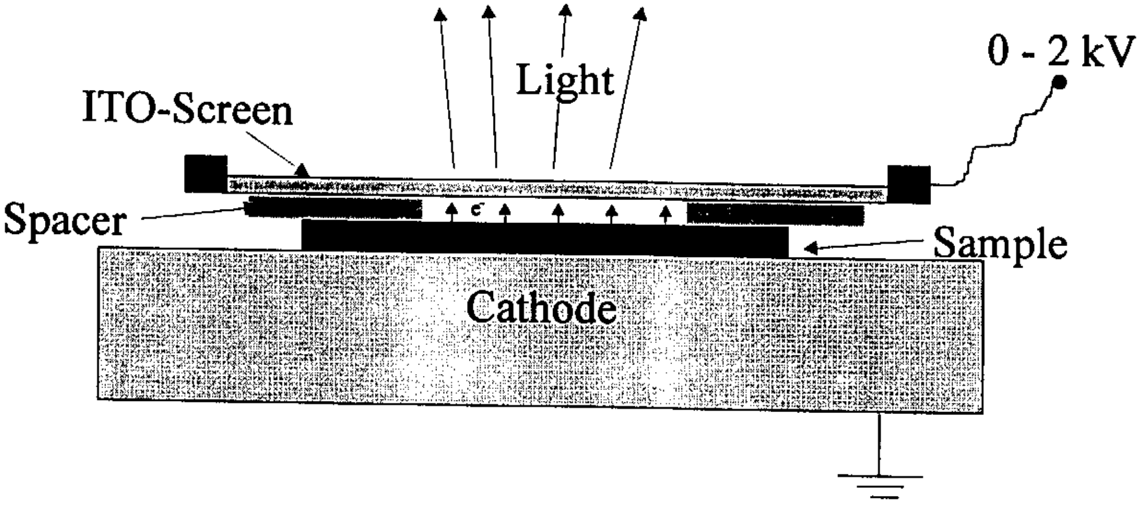


UHV-Analysis- and Preparation Chamber of the Field Emission Scanning Microscope (FESM)

IMLS

Planar diode configuration

Camera (film or CCD)

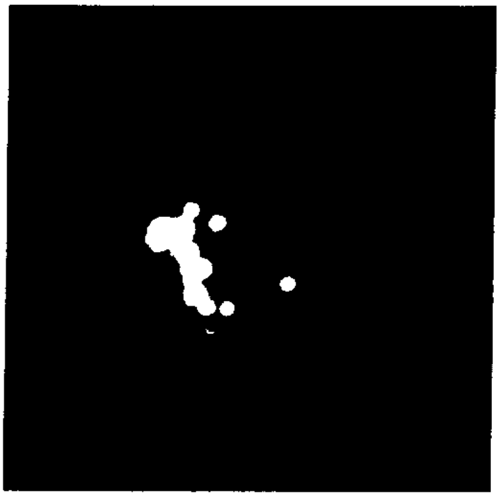


- Pressure 10^{-7} mbar
- Spacer thickness 10 – 100 µm (Teflon foil)
- Maximal anode Voltage 2 kV => Ep ≤ 200 MV/m
- I-U measurement with PC

Comparison of IMLS and FESM

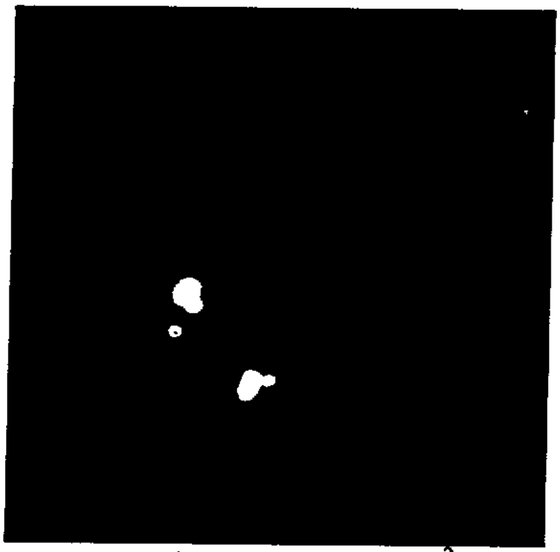
IMLS	FESM (field emission scanning microscope)
Advantages - simple and cheap apparatus - fast sample investigations (2h): - onset of FE : $E_{on}(I=0,5nA)$ - integral I-U measurements - imaging of strongest emitters - long term current- and gasprocessing possible	Advantages - very high spatial resolution (100nm) - in situ SEM for emitter analysis - single emitter investigations (E_{on}, Fowler-Nordheim : β,S) - reliable non-destructive Fe measurements - UHV 10^{-10} mbar - in situ AES, Ion gun
Disadvantages - limited spatial resolution (≈100 µm) - reidentification of emitters impossible - no single emitter investigations - danger of (multi-) discharges due to switch on effects	Disadvantages - slow Fe investigations (1 day/sample) - complex and expensive measurement system

Emitter activation due to discharges on Nb sample

Multidischarge starting from I = 5 µA	Enhanced emission
	
U = 2050 V; d = 50 µm E = 40.1 MV/m	U = 880 V; I= 15 µA; d = 50 µm E = 17.6 MV/m

Sample area 1x1 cm^2

First tests of IMLS on a niobium sample



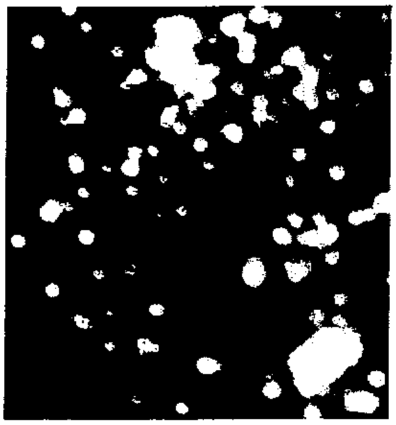
sample area of 1x1 cm^2

U = 880 V; I = 50 µA; d = 50 µm

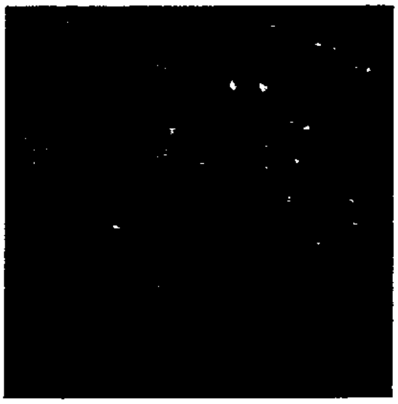
7 light spots visible at 17.6 MV/m

(mechanically bad prepared sample)

Field Emission Scans of a Graphite Film: Comparison between IMLS and FERM



IMLS; constant U
U=1200V
d=200µm
I_{int}=65 µA



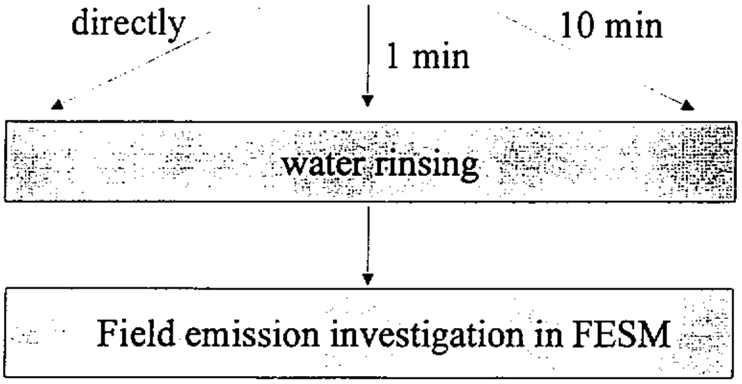
FERM: constant I(x,y)
I(x,y)=10nA (local)
d=50µm
U=250-2500V

Etching of cavities

Problem : Enhanced surface etching by residual acid during filling/emptying period

Question : Enhanced field emission due to etching defects ?

Three samples were prepared at DESY :



Etching for 15 min
removal of acid

directly

1 min

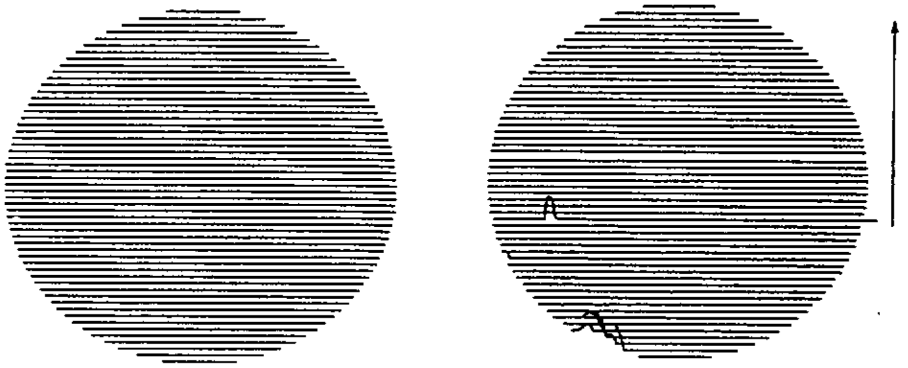
10 min

water rinsing

Field emission investigation in FESM

Sample D6

Direct water rinsing after etching



50 MV/m

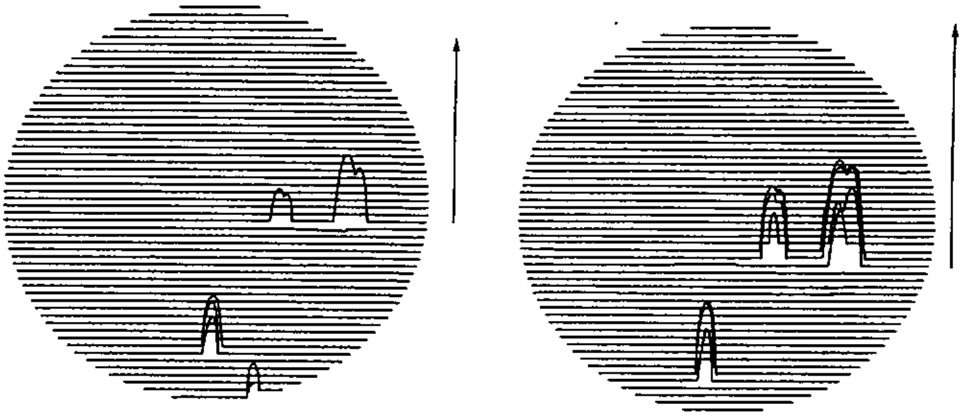
80 MV/m

Field emission scans in FESM : Ø 13,5 mm

=> Only 1 weak emitter at 80 MV/m ($E_{on} \approx 70$ MV/m)

Sample D13

Water rinsing 1 min after removal of acid



50 MV/m

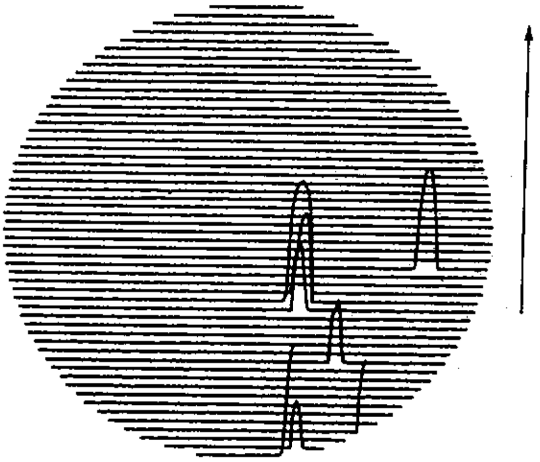
80 MV/m

Fieldemission scans in FESM : Ø 13,5 mm

=> four strong emitters at 50 MV/m and 80 MV/m with E_{on} = 25-40 MV/m
=> switch on effects

Sample D10

Water rinsing 10 min after removal of acid



50 MV/m

=> three strong emitters at 50 MV/m (E_{on} = 30-40 MV/m)
=> switch on effects
=> dark currents at 80 MV/m

Conclusions

- IMLS measurements provide a fast and simple FE-characterisation
  => similar apparatus planned at DESY (D. Reschke)
- FESM measurements necessary for microscopic emitter analysis
- FESM advantageous in case of heavy or unstable emitters (switch on effects)

- Etching from residual acid seems to enhance the FE
  => further FE-investigations with FESM in situ SEM planned
- Statistics on etching experiments not sufficient
  => additional measurements on other samples

Electropolishing of cavities

CEA-CERN-DESY

Lutz Lilje -FDET-

Electropolishing and welding status at CERN

Why? - try to reduce field emission
- easier EB welding?
- less diffusion into grain boundaries?

1. Collaboration

Thanks to:
D. Bloess
L. Ferreira
S. Forel
J. Guerin
B. Thony
E. Chiaveri
...

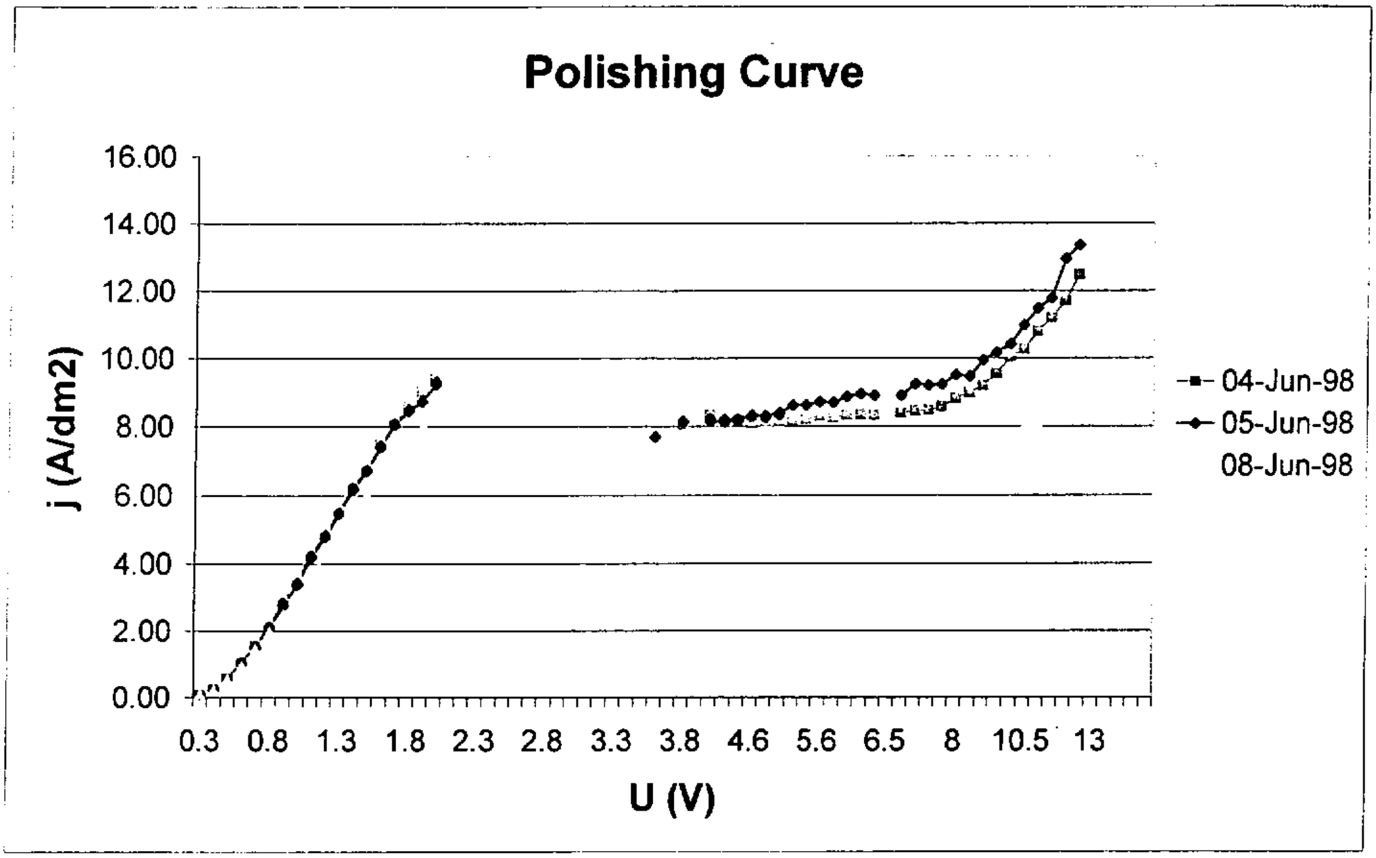
L.LILJE 7.2.98

Introduction

- 1 BCP cavity and 4 EP cavities have been manufactured by CERN
- EP has been done by polishing the half cells, then welding

Aim

- Has polishing of half-cells a benefit?
- What is the procedure for the preparation of a electropolished cavity?
- Can one do a pre-polishing on half cells?



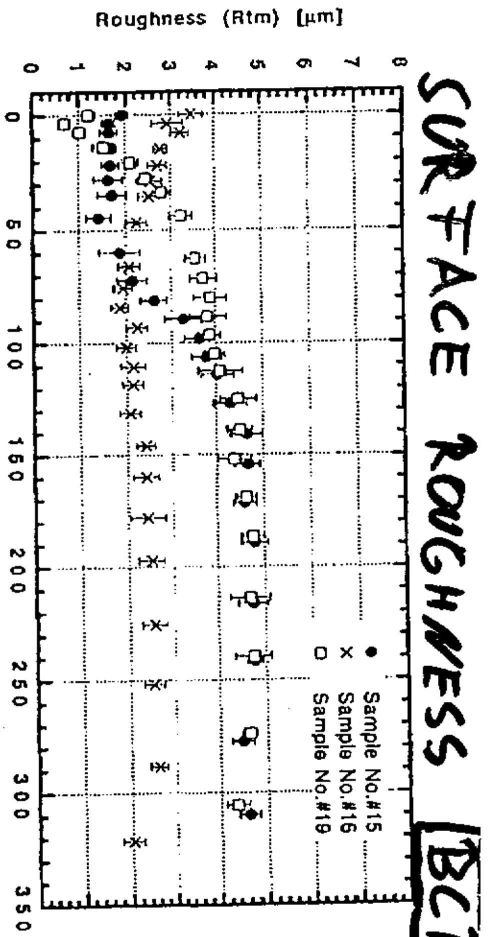


Fig.11 Relationship between material removal and surface roughness with CP.
The error bar means the variation in three polis measurements.

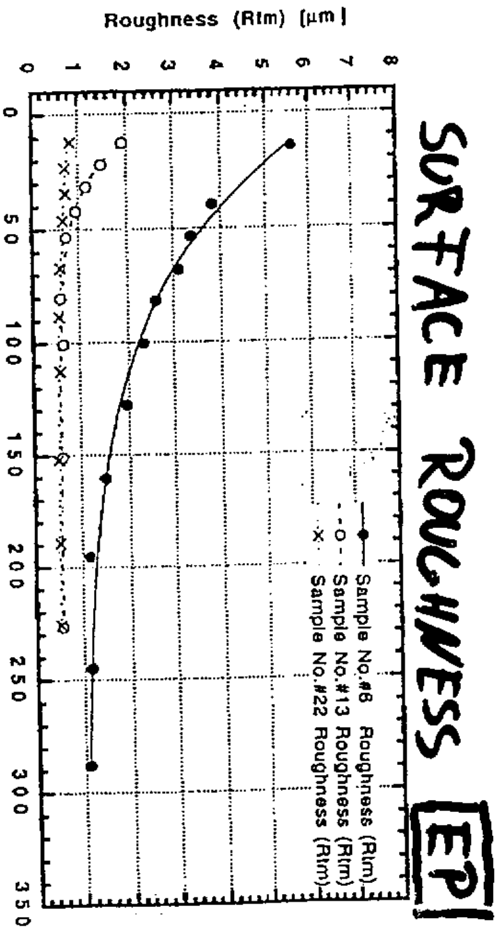


Fig. 12 Relationship between material removal and surface roughness with EP.

K. SAITO et al.
1997

247

rUMO
HEIN 1996

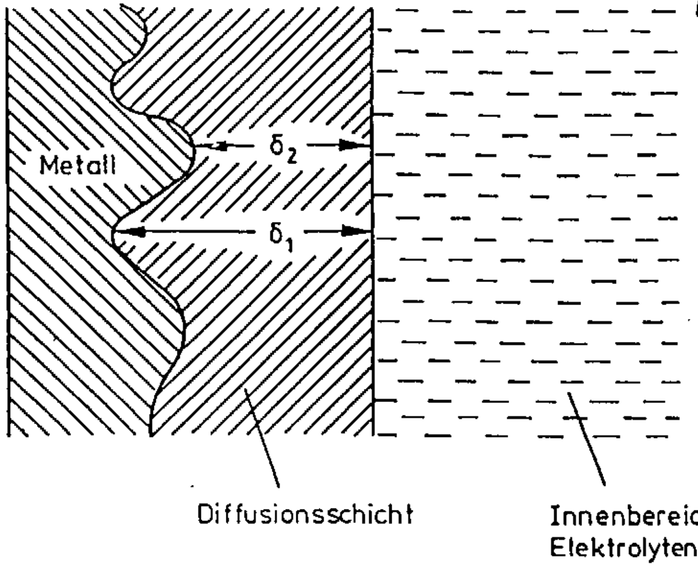


Abb. 1: Schematische Darstellung einer Diffusionsschicht über Oberflächenrauhigkeiten.

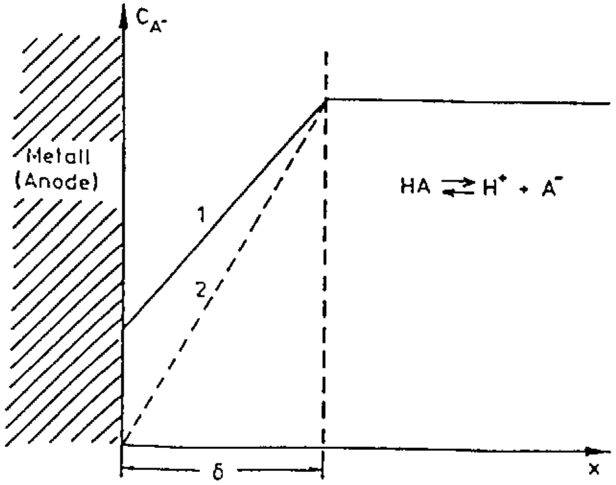


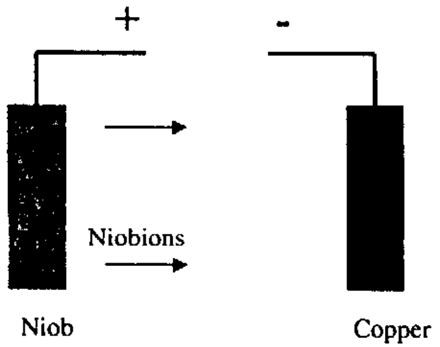
Abb. 2: Änderung der Ionenkonzentration innerhalb der Diffusionsschicht.

2. Principle of Electropolishing

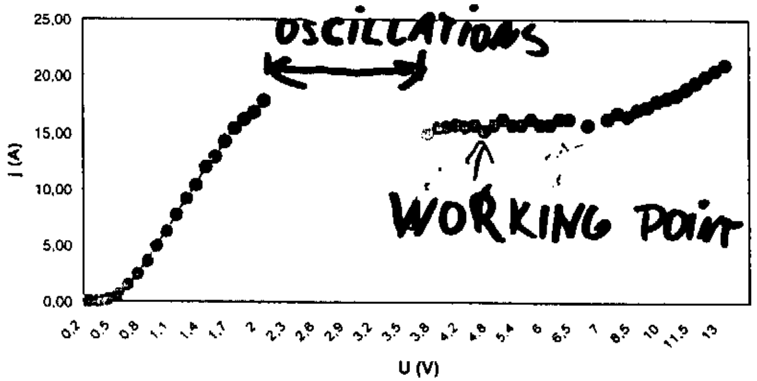
Reverse process of electroplating in a chemical reaction

Nb + ne- + H_20 --> Nb_2O_x + HF --> $H_2NbO_xF_{(7-x)}$ + HF + H_2SO_4 --> $HNbF_6$
insoluble Niobium acid

Possible ingredients are:
HF (40 %)
H_2SO_4 (96 %)
H_3PO_4 (85 %)
+ additives (Butanol, Ethyleneglycol, Glycerol,...)

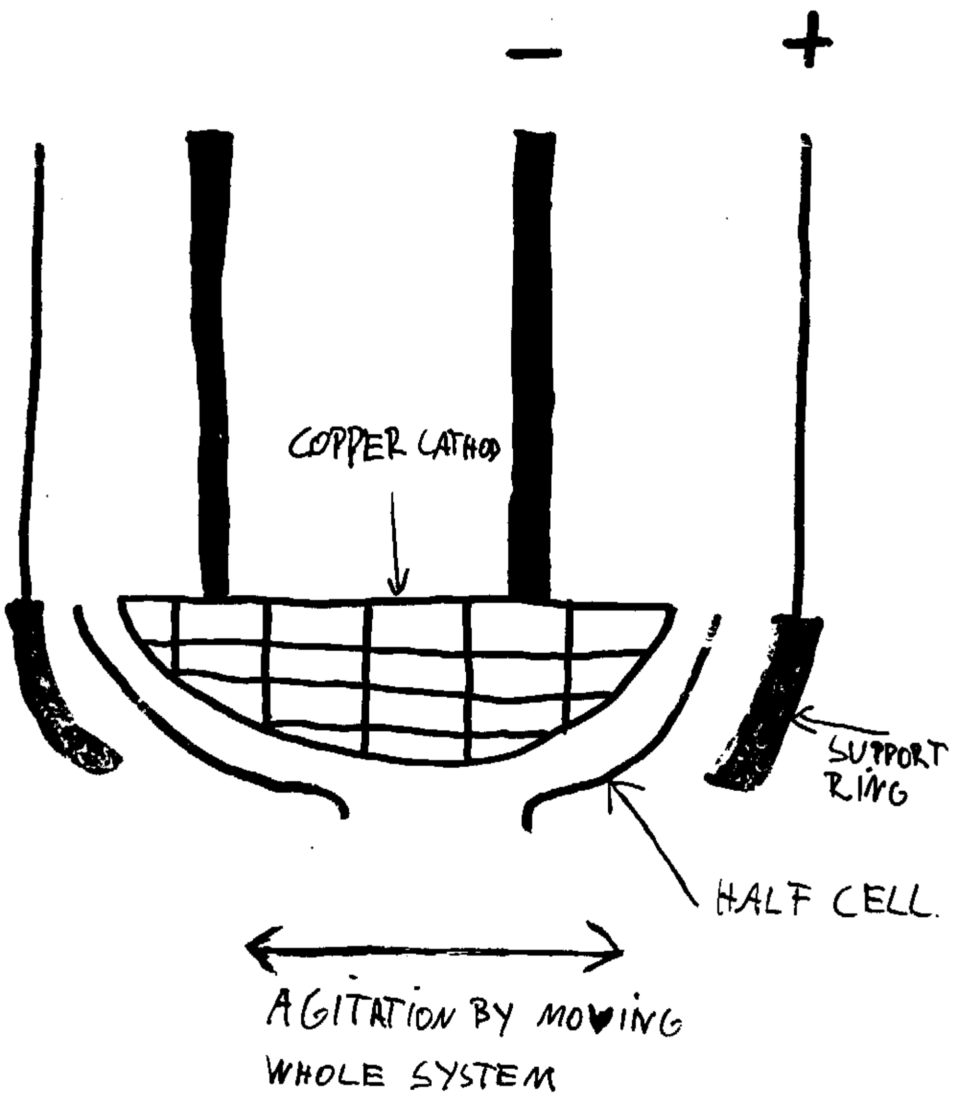


Typical I-U characteristic of electropolishing



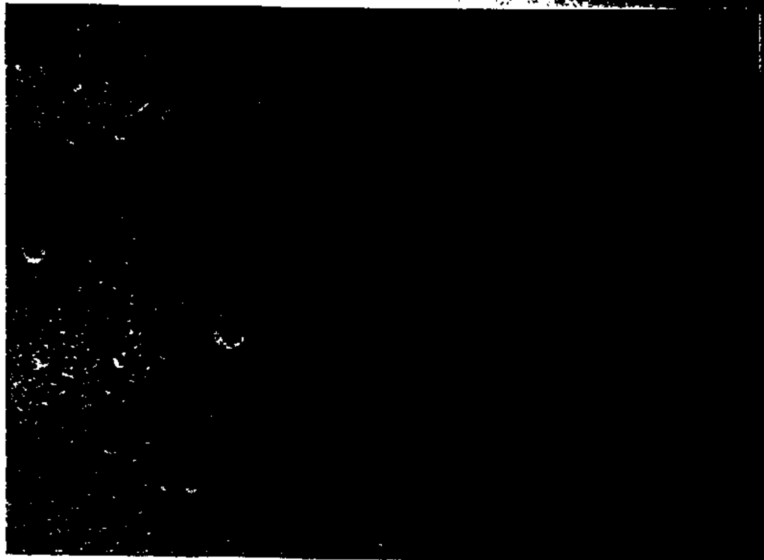
Aim:
- large plateau
- Reasonable removal rate of min. 1-2 um/min

HALF CELL POLISHING



FERREIRA et al.

Echantillon n°27.



Etat de surface de l'échantillo

Détail de la photo préc

F. HERRMANN

Niobium — surface etching

Origin: Wah Chang
File: wh.tex

Preparation status:

- sample dimensions $1cm^2$, manufactured by electroerosion
- scratch made with the edge of a niobium sheet
- chemical etching $20\mu m$, mixture from hydrofluoric acid - nitric acid - phosphoric acid (1-1-2)

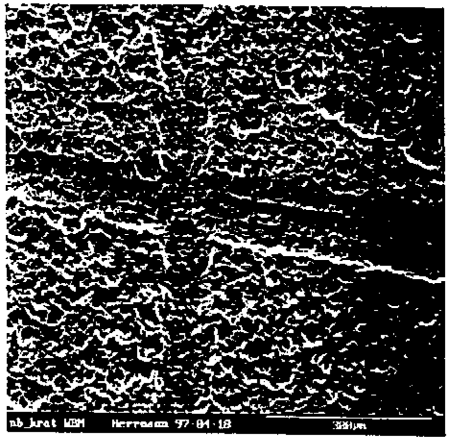


Figure 1: magnification 120, right upper corner

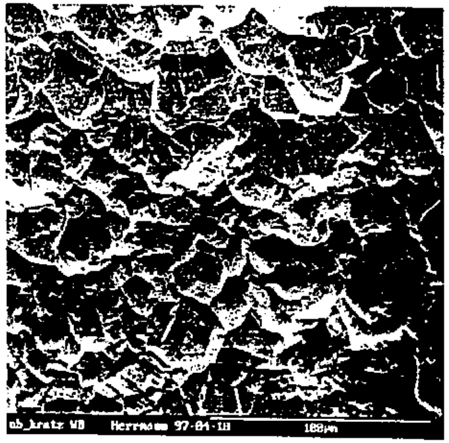


Figure 2: magnification 482

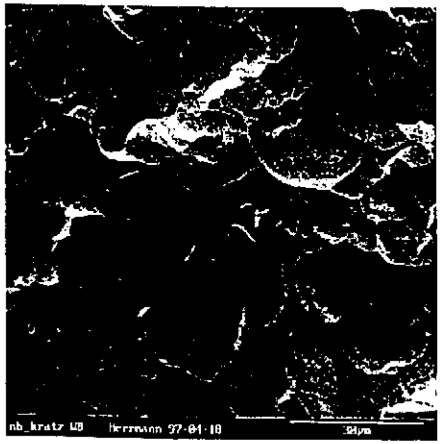
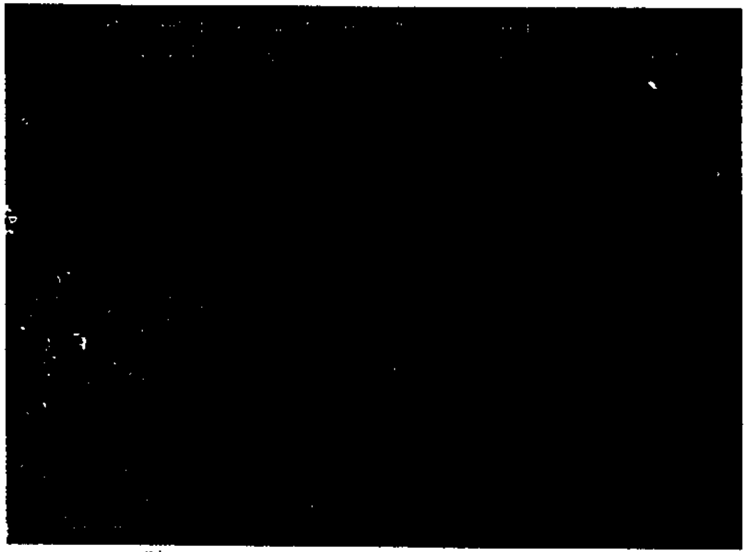
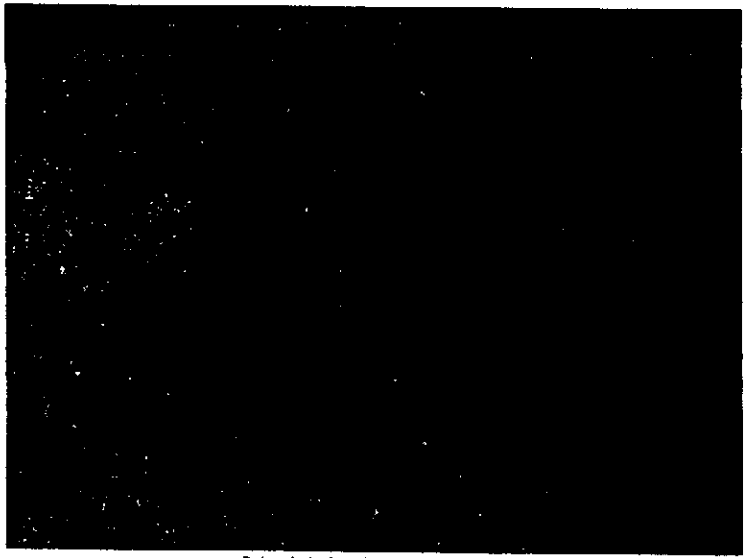


Figure 3: magnification 965

Echantillon n° 60:



Observation générale de la surface de l'échantillon.



Détail de la photo précédente.

250

Procedures on all electropolished cavities

- EP 100 um on the half cells
- Welding preparation with HF
- Welding
- HF+ Rinsing
- Delivery to CEA

Lutz Lilje -FDET-

First measurements at CEA Saclay

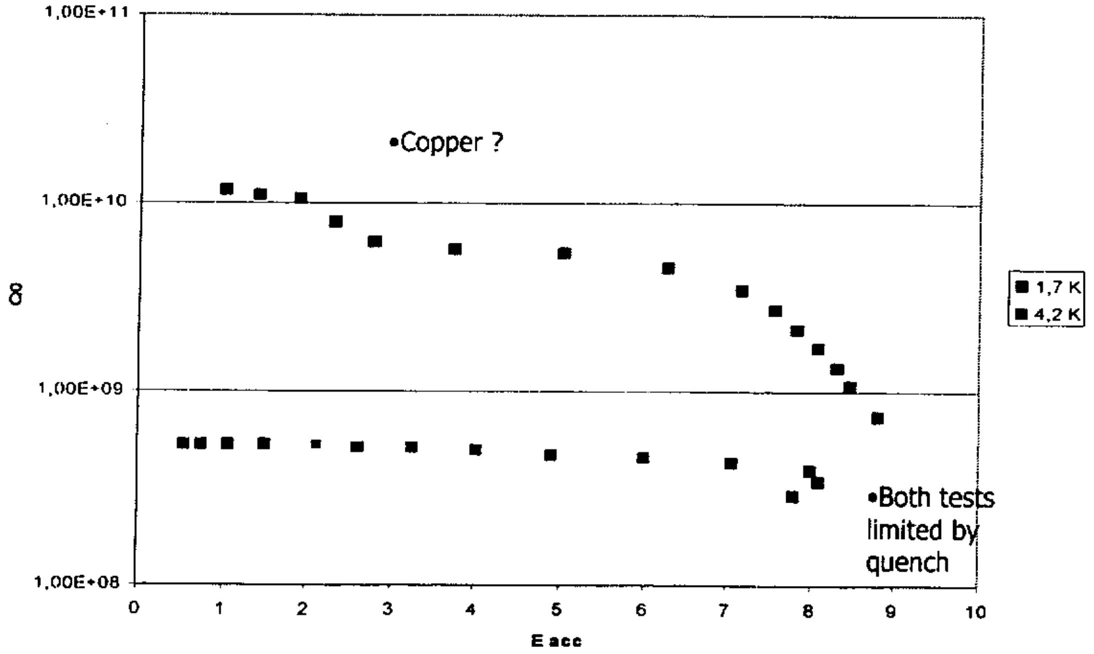
- Thanks
  - H. Safa
  - B. Aune
  - and many more

Lutz Lilje -FDET-

1B5 Handling

- HPR only
- Idea: Minimum impact on the surface. Try to avoid BCP.

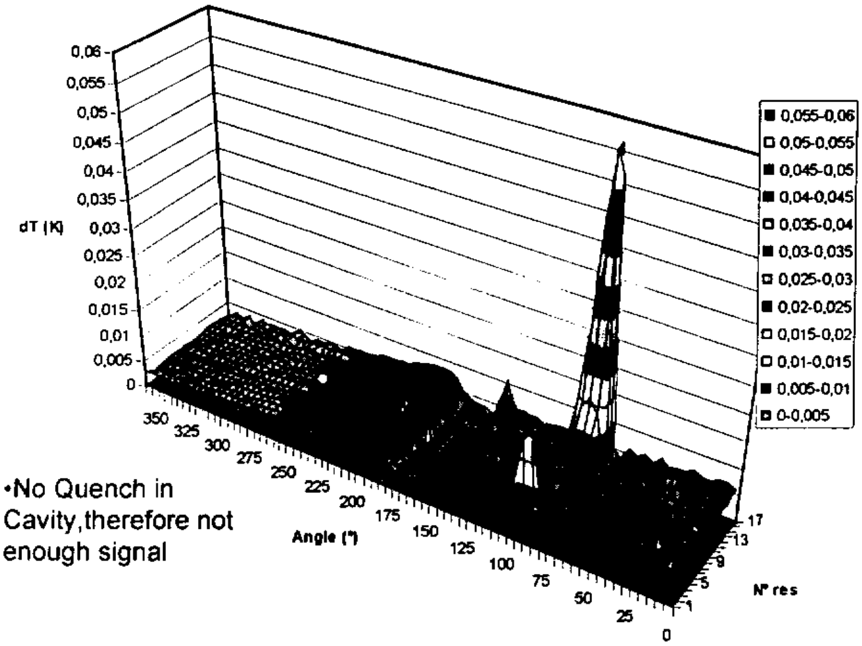
1B5 Tests



•Copper ?

•Both tests limited by quench

1B5 T-Map

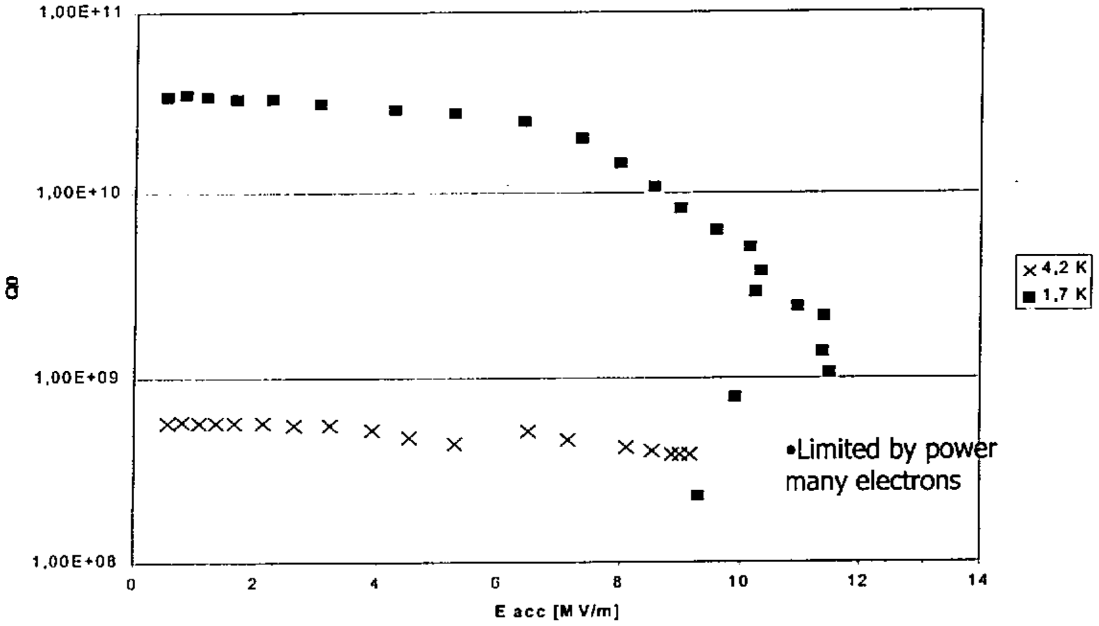


- No Quench in Cavity,therefore not enough signal

1B3 Handling

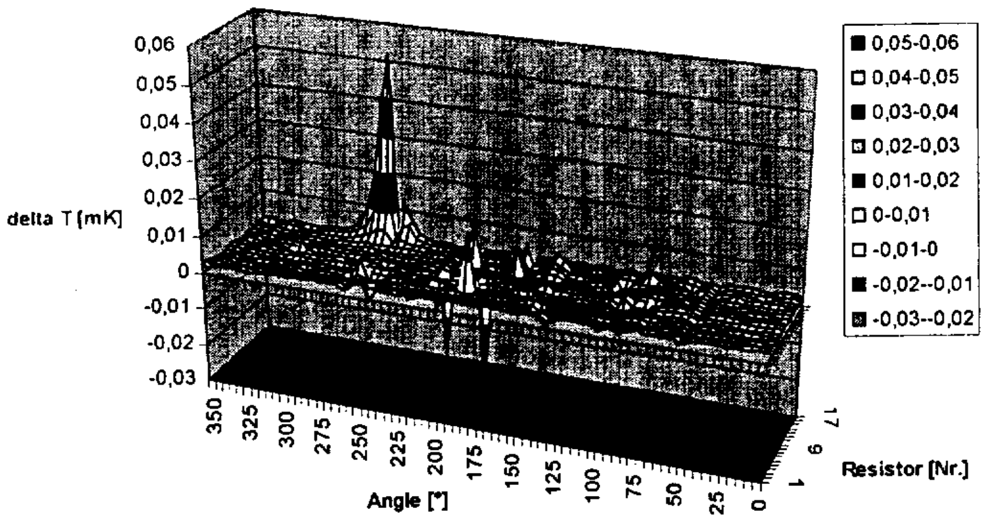
- US ->copper!
- Nitric acid -> no copper traces anymore
- BCP 2 um -> brilliance got lost

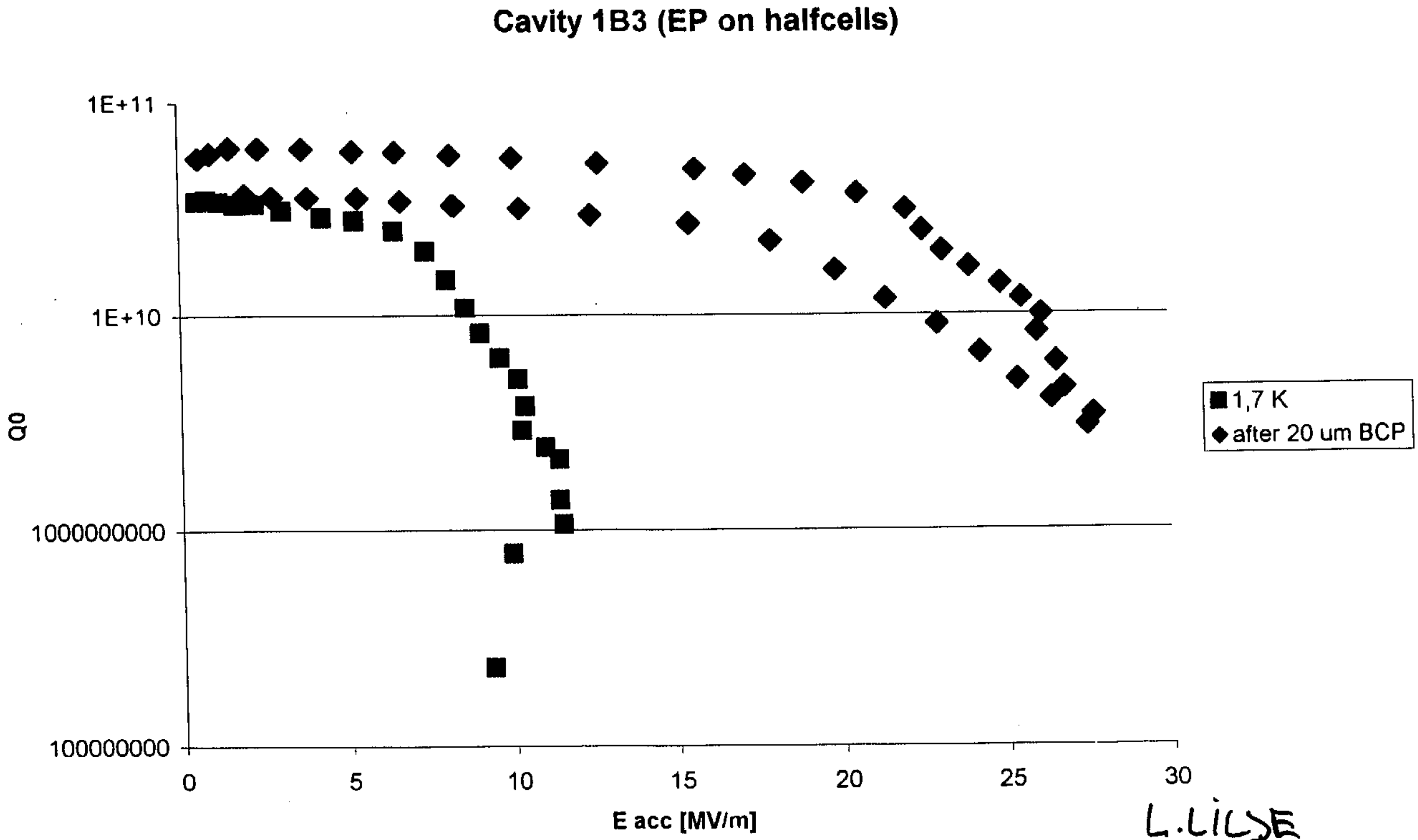
1B3 Tests



•Limited by power
many electrons

1B3 T-Map





Cavity 1B3 (EP on halfcells)

L. LILJE
J.P. CHARRIER
H. SAFA et al.

Outlook

- How much chemical treatment ? (20 um)
- Build one-cell apparatus

2.3.99:

$Q_0 = 3 \cdot 10^{10}$ @ 20 $\frac{MV}{m}$

$Q_0 = 3 \cdot 10^{9}$ @ 27,5 $\frac{MV}{m}$

¬ electrons

- quench @ equator!

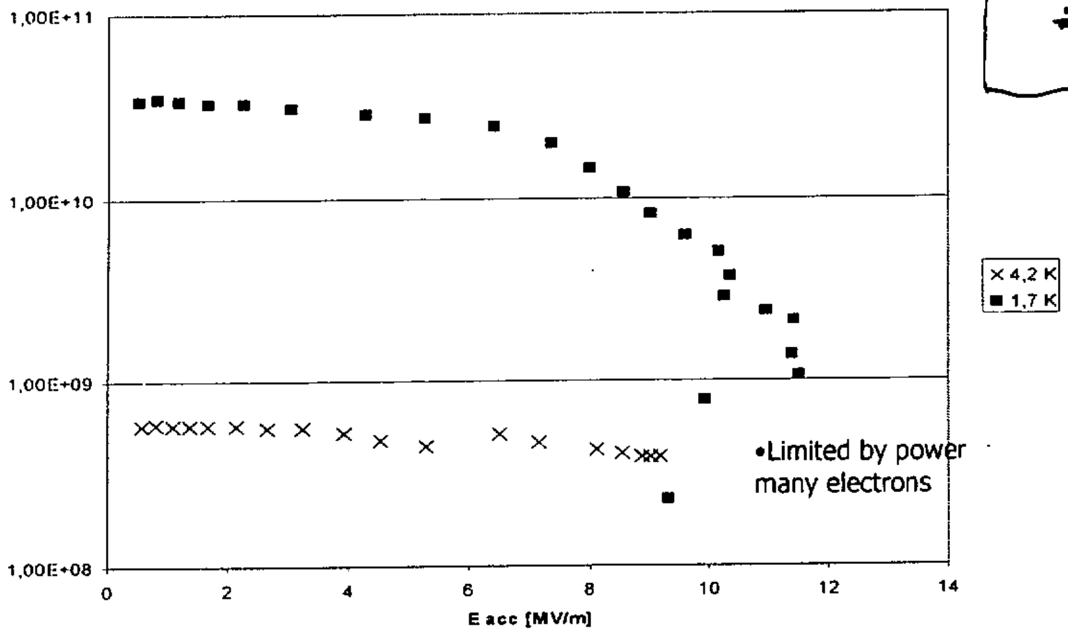
⇒ copper in weld?

J.P. CHARRI

CEA

1B3 Tests

8



Problems

- Copper
  - Comes from the electrode or the cooling pipes
- Electrons
  - Niobium weld beads

Conclusions

- Copper-free electrode
- What material ? (Gold-plated copper ?)
- Half-cell-polishing ?
  - Difficult (Impossible?) to avoid a chemical treatment after welding
  - BCP ?
  - One-cell polishing!

LINAC OPERATION

- N. Baboi (H.O.M. Experiments)
- M. Castellano (Emittance measurements)
- S. Schreiber (Laser performance)
- M. Timm (Surface Roughness Wakefields)
- M. Hunning (Expt'l proposal for above)
- H. Edwards (Machine improvements!)

Charging?
lasers mirrors? dielectric/metal.
Wake Fields?

gun stability
- feed forward on flat top
φ, Amp during pulse.

gun sparks-
Wb sparks-
<u>need gun reset</u> (recover from lower gradient)

tech interlocks
- more uniform approach
- fast inter locks and response.
i.e 1-few μs not relay
- what have will not work for long pulses.!

must still supply
BPM electronics
slits / screen

must get
ICT line drivers

must fix - inj P.S.
one corrector regulation
some P.S. broken.

Controls: (comments only)

Timing: get. timing lined up.
- at least ADC's
- make use of Events.

Displays
- Cursor.
- screen distance.
- plots scaling.
- up/dn control (open windows don't want)

Display - tree.

too many windows.

too many ways to see same. information

on to set things on/off.

Suggest index page with #'s to call favorite page.

Energy Spread - ΔE - OTR?

camera vertical?

FEL - Commissioning

P. Castro : Beam - Based Alignment

H. Schlarb : Collimator

FEL - Performance:

Design - Parameter $\varepsilon_n = 2\,\pi$ mm·mrad $\sigma_t = 0.8\,ps$

Power Gain @ 15 m : $\approx 5 \cdot 10^4$ (Saturation)

Worst Case $\varepsilon_n = 20\,\pi$ mm·mrad $\sigma_t = 1.6\,ps$

Power Gain @ 15 m : < 100

New + Modified Components

- Timing (9 MHz → effect on most diagnostic)
- Magnets (polarization, limitation on the collimator steerer)
- Module #3 (conditioning, Phase + Gradient optimization)
- Undulator (Alignment)
- Collimator (Single bunch operation - Photomultiplier
  - reduced use of view screen)
- Toroids (Timing, beam for new toroids)
- BPM - strip-line (operational, check with beam)
  - reentrant cavity (collimator: July + August, Injector: exist callibration with beam)
  - cavity (mech. call. before, elec. calli. with single bunch)
- Waveguide monitor + Wire Scanner (callibration with single bunch)
- perimental Area (reconnect + timing)

FEL - commissioning (Run: July '99)

① Module # 3 - conditioning etc.

② Single Bunch Operation
   I) high transmission (view screens)
   II) diagnostic callibration

③ Callibration of Photon Diagnostic using Spontaneous undulator radiation

④ Stable optics @ 230 MeV

⑤ Improvement of beam quality for SASE-FEL operation

⑥ SASE-FEL

Summary on Schedule for installation and Commissioning 99

1) Undulator & experimental area

2) Module

3) Injector

4) Schedule

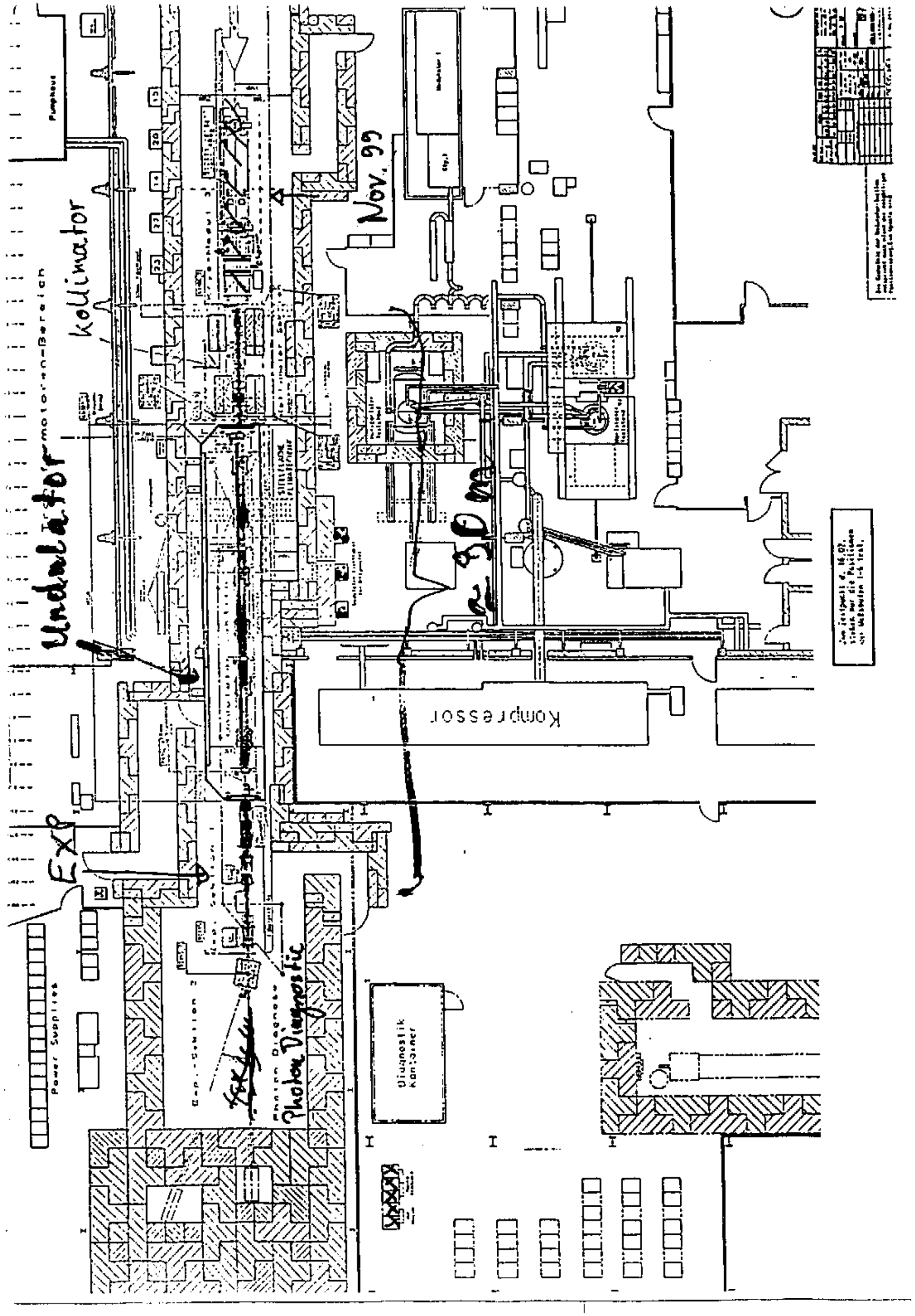
5) Discussion

---

1) Undulator & experimental area

Consists of Collimator, Undulator & Undulator vacuum chamber, Diagnostic blocks, experimental area.
⇒ ~ 30 m beamline are exchaged

Important milestones:
15.3.99 Start to disassemble EXP
22.3.99 Start to disassemble ACC4
19.4.99 Collimator components ready
19.4.99 Start collimator assembly
26.4.99 EXP area installed
26.4.99 Undulator ready
26.4.99 Diagnostic block ready
14.6.99 Final vacuum connection to exp and collimator
28.6.99 Ready for beam



G. Schmidt, -MPY-, 1.3.99

2) Module

Module 3 replaces module 1.
Important dates: 19.4.99 Module into Linac tunnel
14.6.99 Module ready to be cooled down

3) Injector

Work needed for installation of:

Balakin BPM
Balakin kicker
Optimization of the gun elements (i.e. laser mirror)

Best time is at the end of the shut down in parallel to the alignment of the undulator

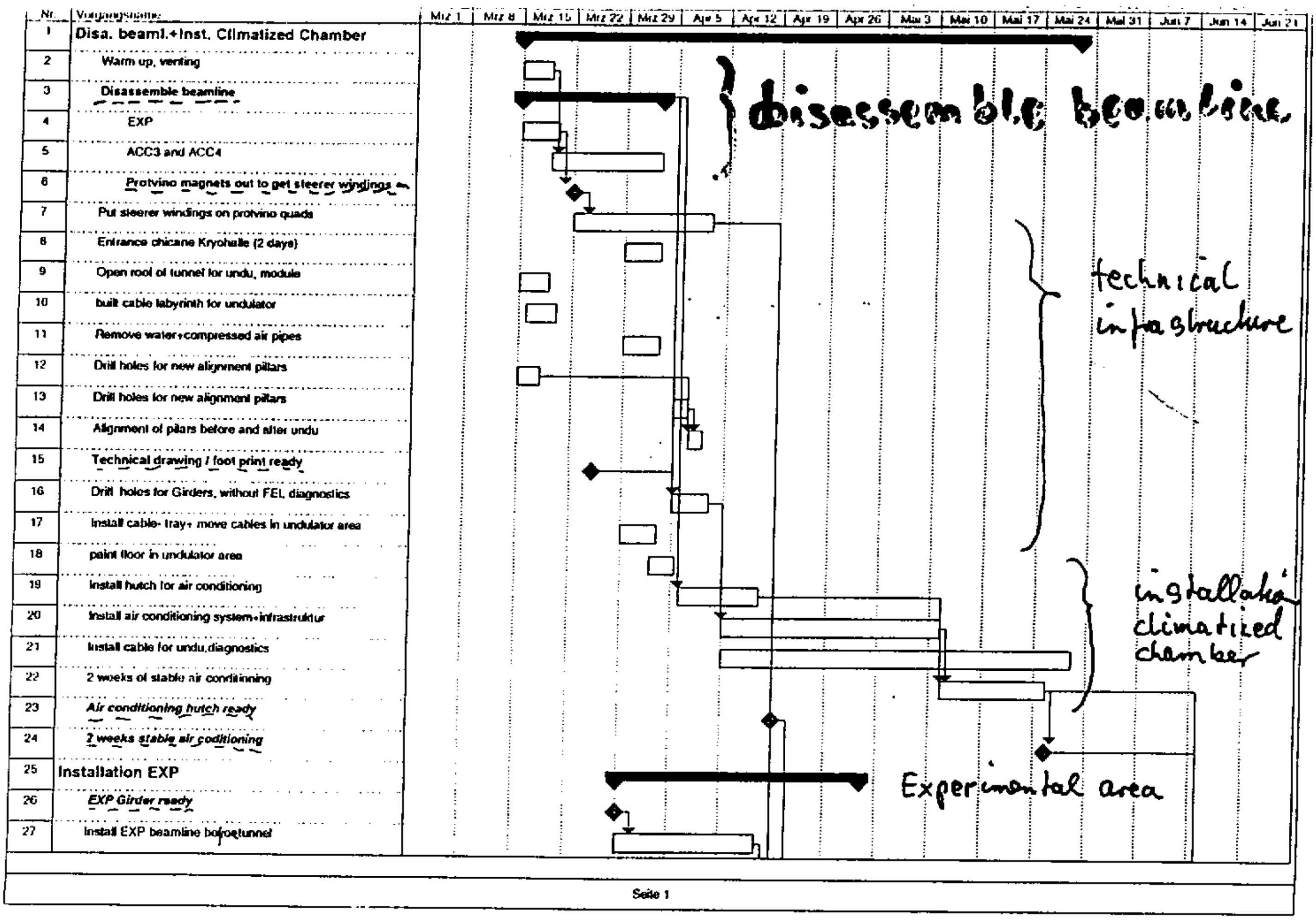
4) Schedule

Start of shutdown 15.3.99

Ready for commissioning 28.6.99

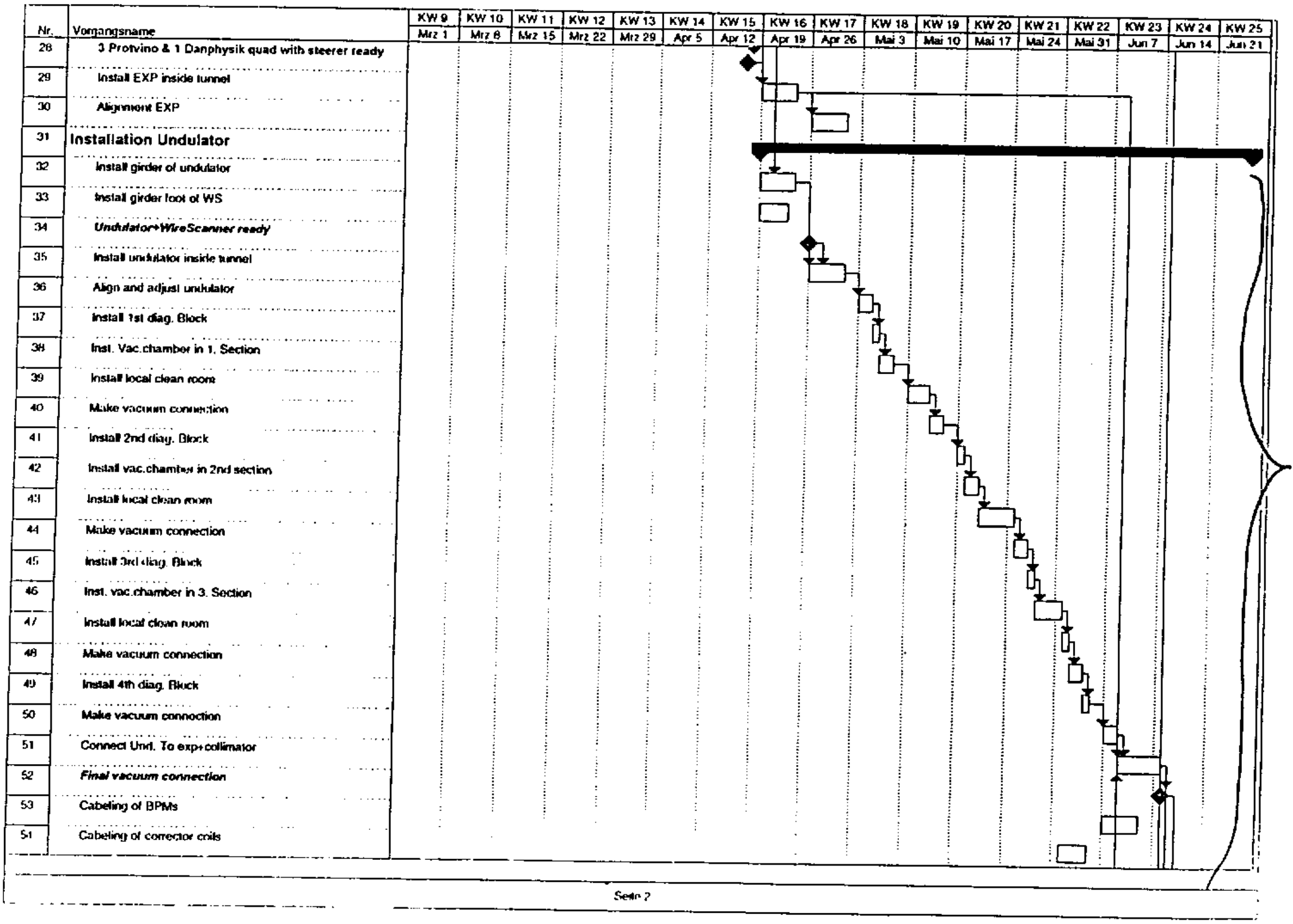
Ready for beam : Week 28 / 12.7.99

→ detailed information in the afternoon talks



Nr.	Vorgangsname
1	**Disa. beaml.+Inst. Climatized Chamber**
2	Warm up, venting
3	Disassemble beamline
4	EXP
5	ACC3 and ACC4
6	Protvino magnets out to get steerer windings
7	Put steerer windings on protvino quads
8	Entrance chicane Kryohalle (2 days)
9	Open roof of tunnel for undu. module
10	built cable labyrinth for undulator
11	Remove water+compressed air pipes
12	Drill holes for new alignment pillars
13	Drill holes for new alignment pillars
14	Alignment of pilars before and after undu
15	Technical drawing / foot print ready
16	Drill holes for Girders, without FEL diagnostics
17	Install cable- tray+ move cables in undulator area
18	paint floor in undulator area
19	Install hutch for air conditioning
20	Install air conditioning system+infrastruktur
21	Install cable for undu.diagnostics
22	2 weeks of stable air conditinning
23	*Air conditioning hutch ready*
24	*2 weeks stable air coditioning*
25	**Installation EXP**
26	*EXP Girder ready*
27	Install EXP beamline before tunnel

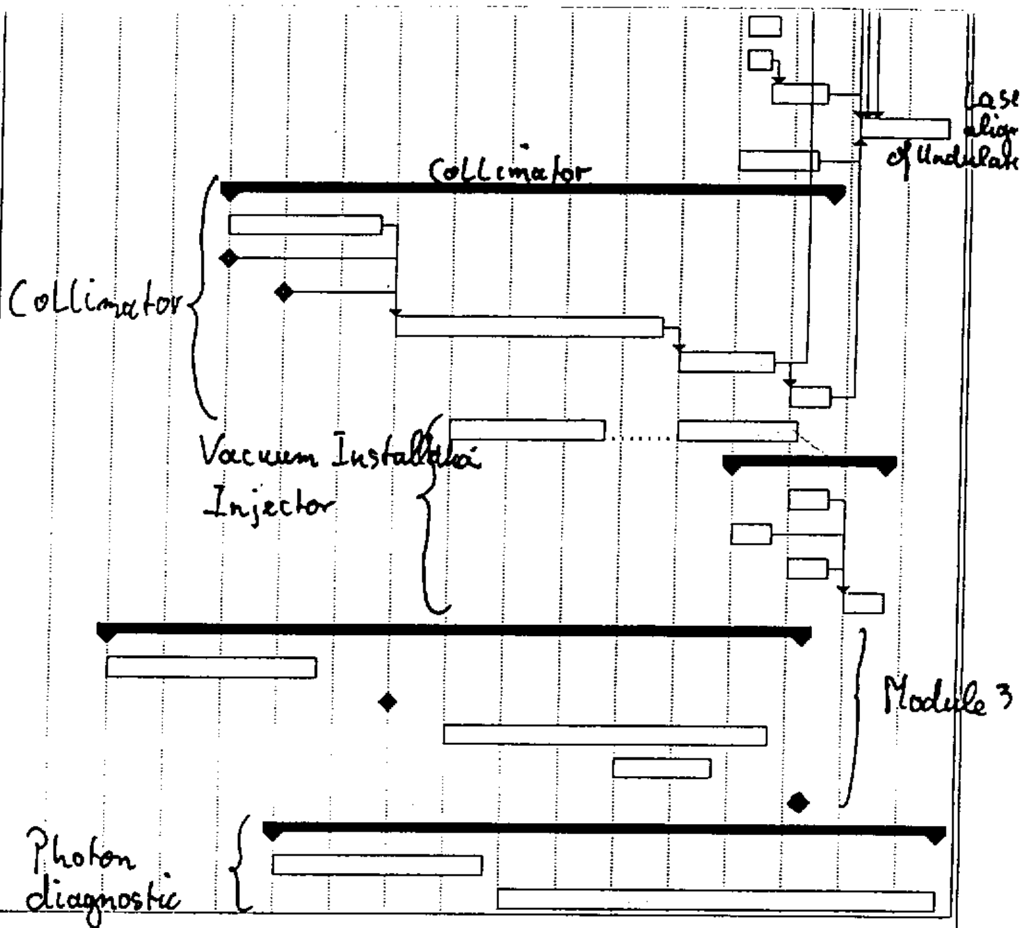
G. Schidt



Nr.	Vorgangsname
28	3 Protvino & 1 Danphysik quad with steerer ready
29	Install EXP inside tunnel
30	Alignment EXP
31	**Installation Undulator**
32	Install girder of undulator
33	Install girder foot of WS
34	*Undulator+WireScanner ready*
35	Install undulator inside tunnel
36	Align and adjust undulator
37	Install 1st diag. Block
38	Inst. Vac.chamber in 1. Section
39	Install local clean room
40	Make vacuum connection
41	Install 2nd diag. Block
42	Install vac.chamber in 2nd section
43	Install local clean room
44	Make vacuum connection
45	Install 3rd diag. Block
46	Inst. vac.chamber in 3. Section
47	Install local clean room
48	Make vacuum connection
49	Install 4th diag. Block
50	Make vacuum connection
51	Connect Und. To exp+collimator
52	*Final vacuum connection*
53	Cabeling of BPMs
54	Cabeling of corrector coils

G. Schidt

55	Water connection
56	Install alignment system
57	Adjust Laser alignment system
58	Laserinterferometrische Feinvermessung
59	Close roof of tunnel
60	**Collimator installation**
61	Cleaning of components
62	*Girder for collimator*
63	Latest date für girder delivery
64	Collimator vacuumm outside tunnel
65	Inst. collimator vacuum inside tunnel
66	Shielding of collimator inside tunnel
67	Alignment collimator
68	**Other vacuum installation**
69	Gun laser mirror etc. exchange
70	install Balakin BPM & Kicker in the injector
71	Install Re.-Cav. in injector
72	vacuum, leak search in Inj
73	**Module 3**
74	Take out module 1 (Vacuum disconnection)
75	Module into Linac
76	MVP work on module
77	Alignment module ??
78	Module ready to cool down
79	**Install photon beam diagnostic**
80	Take out beamline
81	Install components



G. Schmidt

5) Discussion :

room: 4b building: 1b

Tomorrow after the Linac and FEL working groups. after the two other working groups

Everybody interested is invited to participate.

BC area no changes needed up to now.

Diskussion on: - Shut down planing.
- Commissioning.

Changes and correction to the Schedule for installation and Commissioning 99

-Time schedule seemed to be reasonable. start: 15.3.99
ready : 12.7.99

-Main problem will be the work load and space in the clean room.

-No further components have been asked to be installed except one OTR foil for the EXP area

1) Module

Important milstones: 15.03.99 start of string assembly

until mid April module 1 must be taken out (2 weeks of work)

04.05.99 module ready to go into the tunnel
23.06.99 module ready for cool down
01.07.99 module cold

Agreed on:

Clean room is needed for cavity installation until 15.03.99.
After that date the clean room is used with highest priority for beamline components

2) Collimator

-All parts at Desy end of March.

-Built collimator up for checking if everything fits (2 weeks)

-2 weeks for cleaning

-then start of installation beginning of May.

3) Photon diagnostic

installed beginning of June inside the tunnel.

2 weeks for commissioning with permanent access to the tunnel needed, which can be done in parallel to the undulator alignment.

Comissioning was discussed in the working group

→ first tentative schedules proposed in the next weeks.

M. Leenen
25/2/1999

Preliminary Agenda
for the TTF Collaboration Meeting
DESY, 1st - 3rd March 1999

March 1st, Seminarroom 4a+b, Building 1b

			Chair:
9:00	Introduction and Future Planning	D. Trines	S. Tazzari
9:30	Summary of Cavity Tests	M. Pekeler	
10:00	FNAL Gun Status	H. Edwards	
10:20	Coffee Break		
10:50	Linac Operation Experience	M. Geitz	
11:10	RF Operation of two Cryomodules	G. v. Walter	
11:20	Modulators and Klystrons	J. Kahl/A. Gamp	
11:40	Status of Cryogenics	B. Petersen	
12:00	Lunch		
			Chair:
13:30	News from Collaborating Institutions		B. Aune
	Saclay/Orsay		
	INFN		
	FNAL		
	CERN		
	Univ. Wuppertal		
	INP Protvino		
	FZ Karlsruhe		
	Univ. Rostock		
	Argonne		
	TU Darmstadt		
	Others as requested		
15:30	Coffee Break		
16:00	Undulator Status	J. Pflueger	
16:30	Collimator Section	H. Schlarb	
16:50	Electron Diagnostics	P. Castro-Garcia	
17:10	Photon Diagnostics	J. Feldhaus	
17:30	Organisation of Working Groups		
19:30	Social Event (DESY Canteen, Annex)		

March 2nd

9:00	Working Groups	
	1) Cavities and Auxiliaries Conveners: B. Aune, D. Proch	Seminarroom 4a, Building 1b
	2) Linac Operation and FEL Commissioning Conveners: T. Garvey, S. Reiche	Seminarroom 4b, Building 1b
	Meeting on General Schedule G. Schmidt	(Time and Room to be announced)
17:00	Technical Board C. Pagani	Room 292, Building 1d

March 3rd, Seminarroom 4a+b, Building 1b

Chair:
H. Edwards

9:00 Summaries of Working Groups
Group 1: B. Aune
Group 2: S. Reiche
10:30 Coffee Break
11:00 Summary on Schedule for Installation and Commissioning - G. Schmidt
11:25 Next TTF-Meeting
11:30 AOB
12:00 End of Meeting

On Wednesday afternoon (starting at approximately 13:30) a Coupler Workshop is scheduled (organized by D. Proch).