TESLA - COLLABORATION

Transparencies from the

TESLA Meeting at DESY, July 6 - 8, 1998

July 1998, TESLA 98-19

TESLA Reports are available from:

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TTF Collaboration Meeting
(6th - 8th July 1998) at DESY

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Agenda for the TTF Collaboration Meeting (6th - 8th July 1998) at DESY

July 6th, Seminarroom 4a+b, Building 1b

Chair: B. Aune

9:00	Welcome and Introduction	B.H. Wiik
9:20	Summary of Cavity Tests	M. Pekeler
9:50	Linac Operation	M. Jablonka
10:20	Coffee Break	
10:50	Further Installation (Phase 1)	H. Weise
11:10	Further Installation (Phase 2)	J. Rossbach
11:30	Status of Laser	I. Will
11:50	Status of RF-Gun	K. Floettmann
12:10	Multibeam Klystron	A. Gamp
12:30	Lunch	

Chair: S. Tazzari

14:00	Laboratory Reports	
	Saclay/Orsay	B. Aune
	INFN	C. Pagani
	FNAL	H. Edwards
	Univ. Wuppertal	G. Mueller
	INP Protvino	V. Vogel
	Univ. Rostock	H.-W. Glock
15:40	Coffee Break	
16:10	Bunch Length Measurement	M. Geitz
16:40	Plans for Further Cavity R+D	P. Schmueser
17:10	Organisation of Working Groups	

19:00 Social Event (DESY Canteen, Annex)

July 7th

9:00 Working Groups

R+D	Seminarroom 4a, Building 1b	(G. Müller/ P. Schmueser)
Installation	Seminarroom 4b, Building 1b	(D.Michelato/S.Schreiber)

18:00 Meeting of Technical Board Room 292, Building 1d

July 8th, Seminarroom 4a+b, Building 1b

Chair: H. Edwards

9:00	EDM and CAD for TTF	U. Gensch/ H. Kammerlocher
9:30	Summary of Working Groups	
	Next Collaboration Meeting	
	AOB	

Members of the TESLA-Collaboration

B.H.Wiik

Yerevan Physics Institute

IHEP
Academia Sinica, Beijing

Tsinghua-University, Beijing

Institute of Physics,
Helsinki

CEA/DSM
(DAPNIA, CE-Saclay)

IN2P3
(IPN Orsay + LAL Orsay)

Max-Born-Institut,
Berlin-Adlershof

DESY, Hamburg und Zeuthen

GH Wuppertal
Fachbereich Physik

Universität Hamburg

IAP, University of Frankfurt

GKSS, Geesthacht

FZ Karlsruhe

IfH, TH Darmstadt

ITE, TU Berlin

IKK, TU Dresden

RWTH Aachen

Univ. Rostock

INFN Frascati

INFN Legnaro

INFN Milano

INFN and Univ. Roma II

Polish Academy of Science

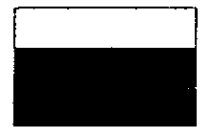
University of Warsaw

University of Cracow

Univ. of Mining & Metallurgy

Polish Atomic Energy
Agency

Soltan Inst. for Nuclear
Studies, Otwock-Swierk



JINR Dubna

IHEP Protvino

INP Novosibirsk

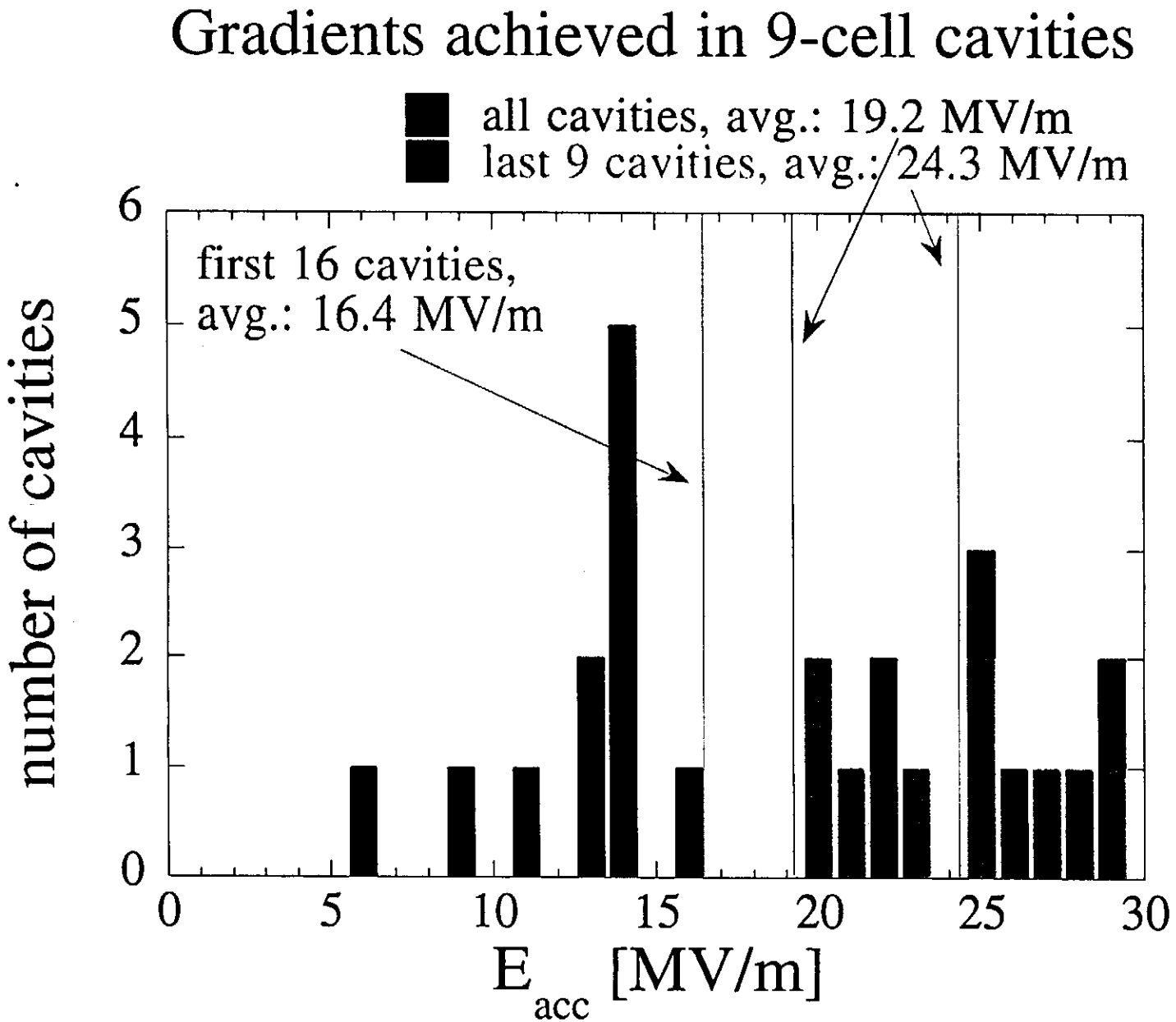
ANL
Argonne IL

Cornell University
Newman Lab. Ithaca NY

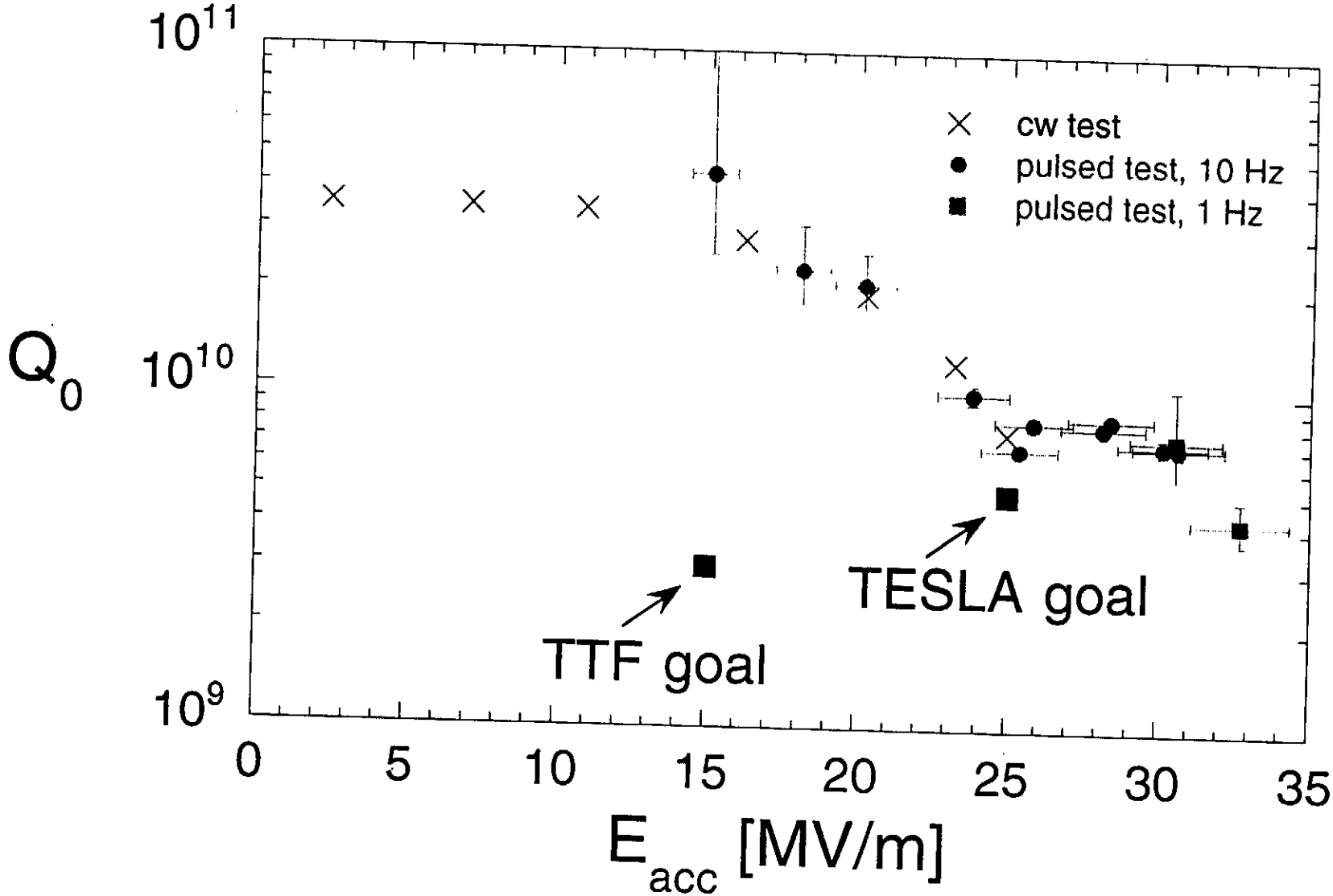
Fermilab
Batavia IL

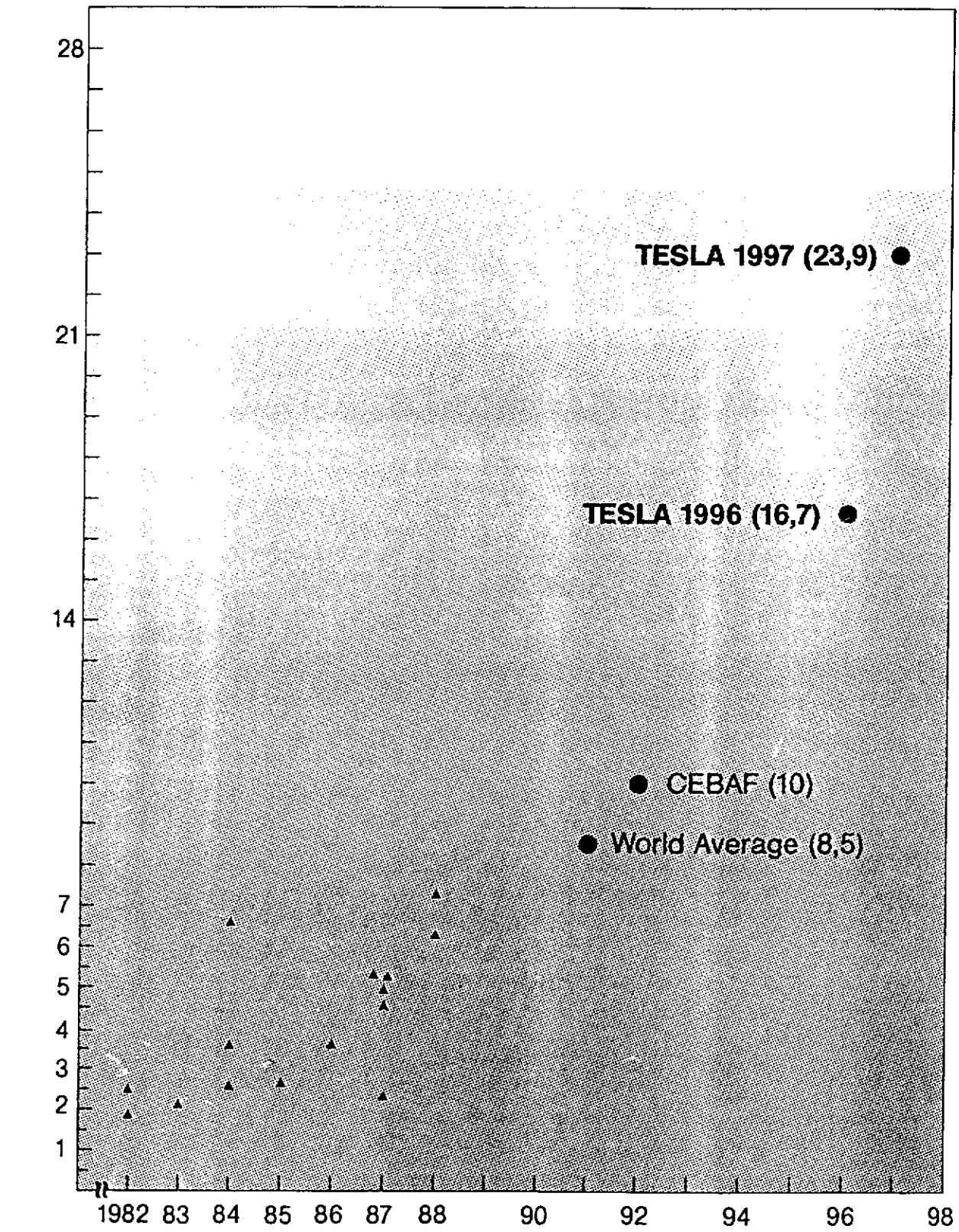
UCLA
Los Angeles CA

June '98

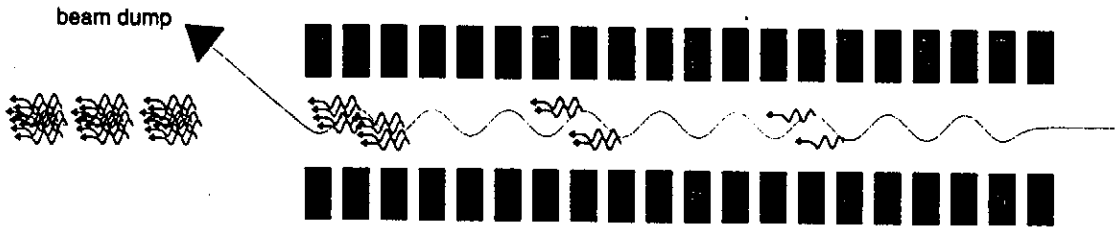

Gradients achieved in 9-cell cavities
all cavities, avg.: 19.2 MV/m
last 9 cavities, avg.: 24.3 MV/m
first 16 cavities,
avg.: 16.4 MV/m
number of cavities
0
1
2
3
4
5
6
0
5
10
15
20
25
30
E acc [MV/m]

Horizontal test result on cavity C23

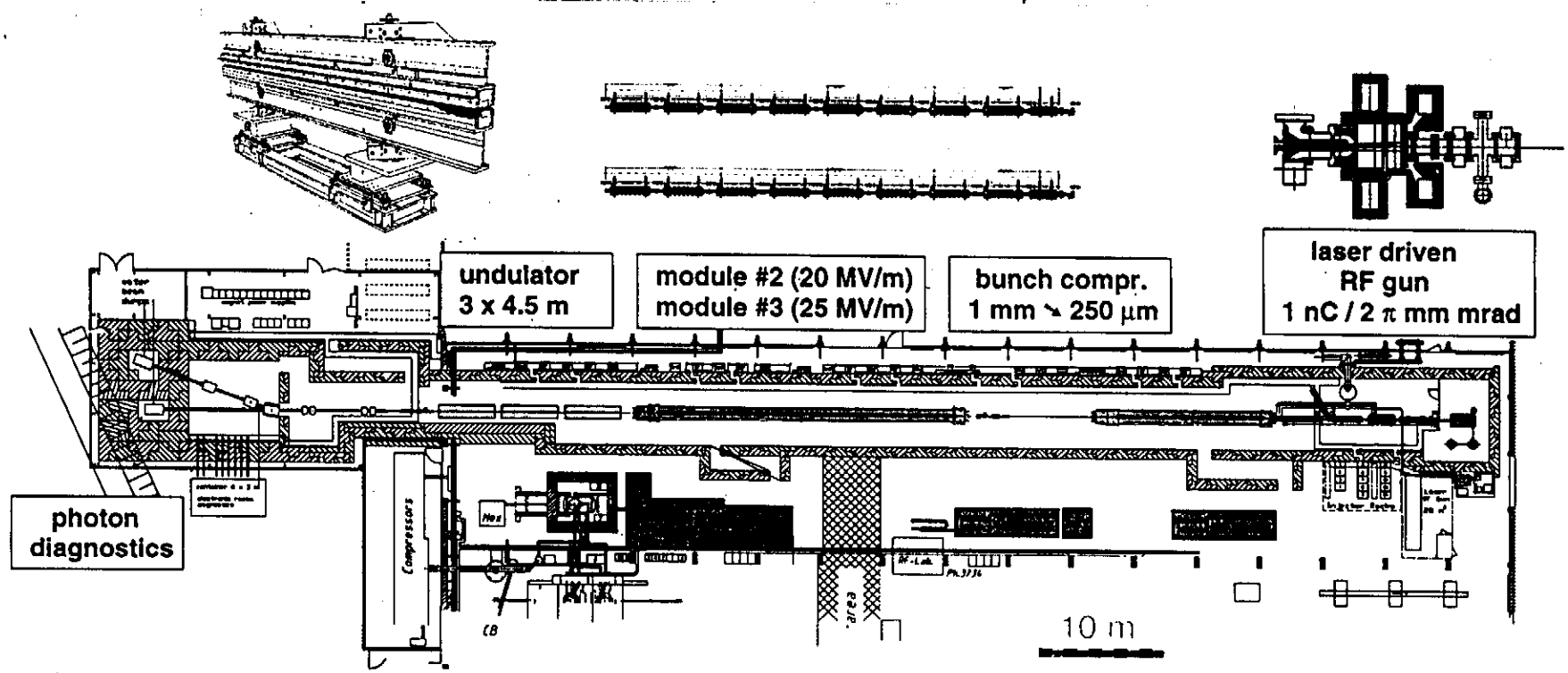



E_{acc} [MV/m]
28
21
14
7
6
5
4
3
2
1
TESLA 1997 (23,9)
TESLA 1996 (16,7)
CEBAF (10)
World Average (8,5)
1982
83
84
85
86
87
88
90
92
94
96
98

SASE Proof of Principle Experiment

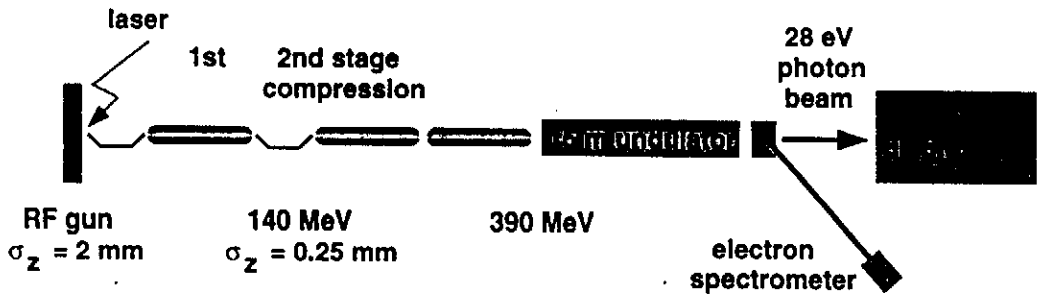


photon beam		undulator		electron beam	
λ_{ph} =	42 nm	λ_u =	27.3 mm	I_{peak} =	500 A
m.p.length	800 µs	B_{max} =	0.497 T	ε_n =	2 π mm mrad
nbr. of bunches	≤ 7200	N ≈	1000	σ_z =	0.25 mm
rep.rate	≤ 10 Hz	gap =	12 mm	σ_γ/γ =	0.17 %
				γ =	760



Program 1998 - 2003

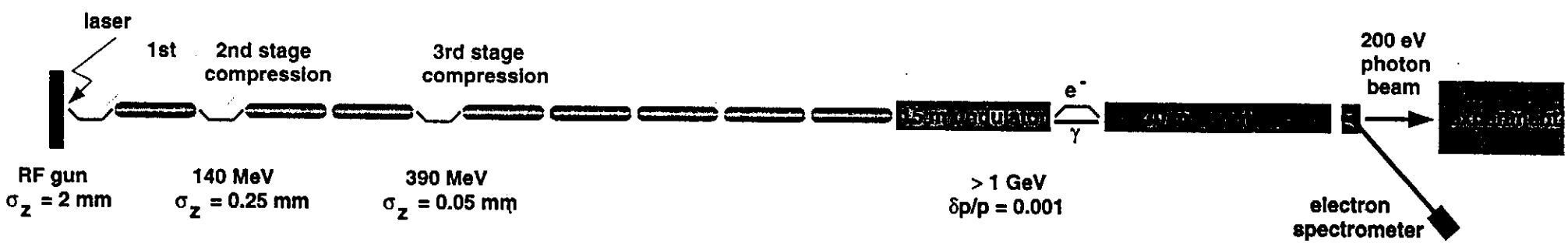
TTF with SASE FEL Proof of Principle Experiment



Linac 400 MeV end of 1998
Module #2 E_{acc} ~ 20 MV / m
Module #3 E_{acc} ~ 25 MV / m

SASE FEL Test at λ ~ 40 nm
Undulator ready for installation by the end of 98; test spring 99

TTF II with SASE FEL User Facility



Scientific American, January 25, 1896
Vol. LXXIV, No. 4, p. 51

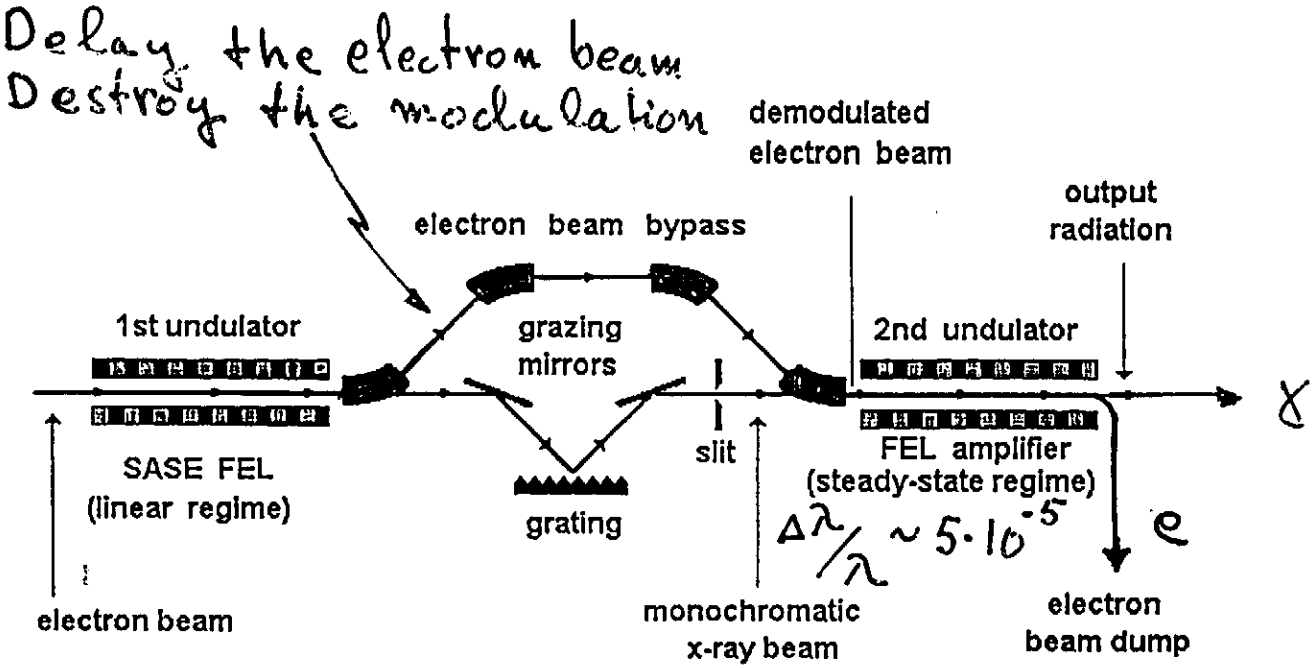
Professor Röntgen's Wonderful Discovery.

There have been received from Europe by cable very insufficient accounts of a discovery attributed to Professor Röntgen of Würzburg University. By the use of a radiant state of matter tube, a Crookes tube, it is stated that he has succeeded in obtaining photographic effects through opaque objects.

It is yet too soon to indulge in the wild possibilities that have been suggested for the process. When the details reach us, the process will probably prove to be of scientific rather than of practical interest.

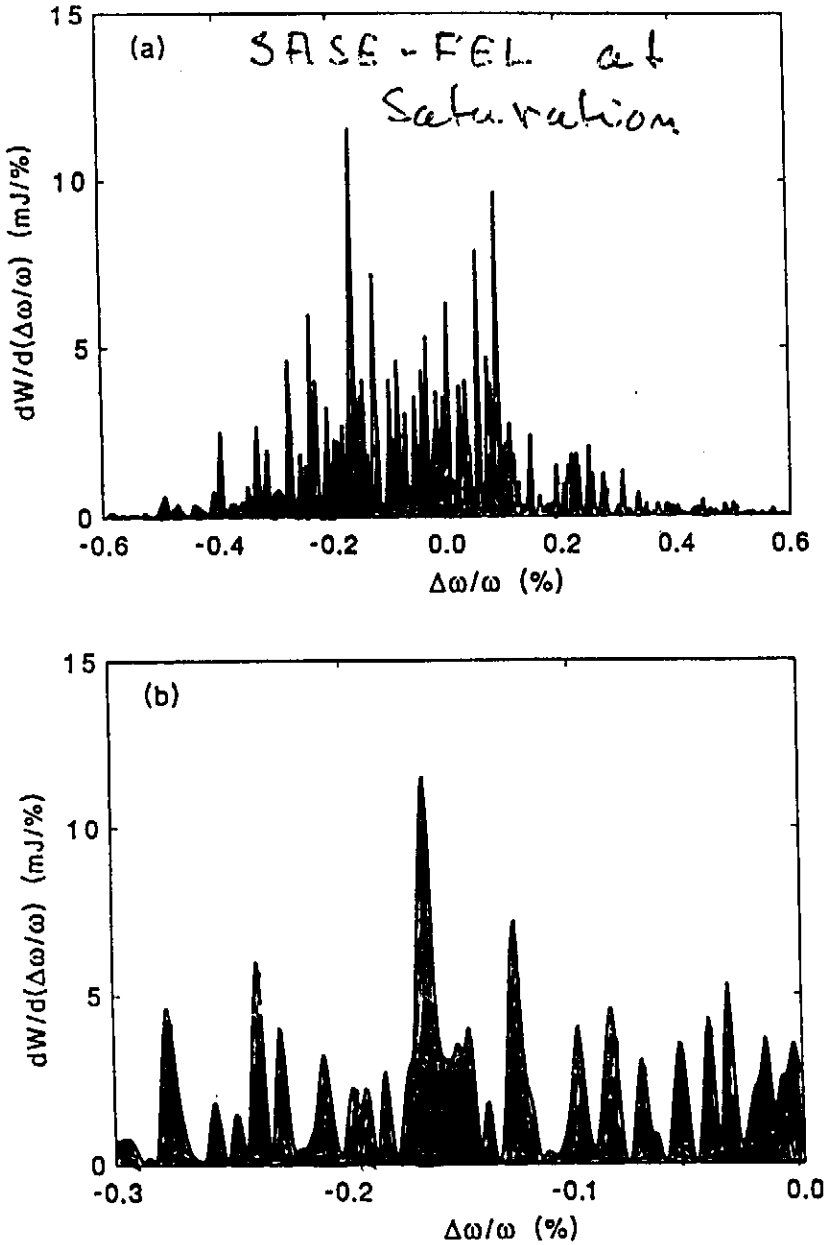
J. Feldhaus, E.L. Saldin, J.R. Schneider, E.A. Schneidmiller, M.V. Yurkov

Possible application of X-ray optical elements for reducing the spectral bandwidth of an X-ray SASE FEL



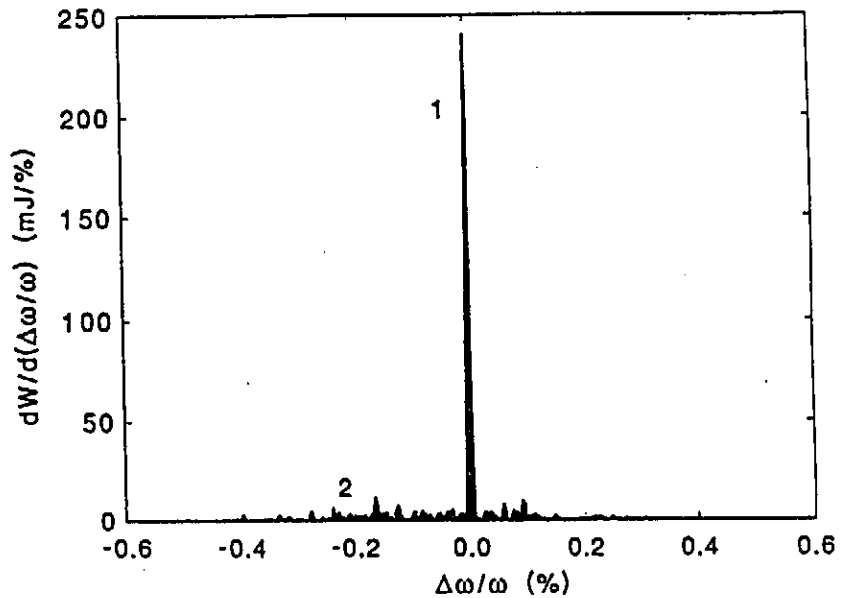
The principal scheme of a single-pass two-stage SASE X-ray FEL with monochromator.

Power Spectrum of a conventional



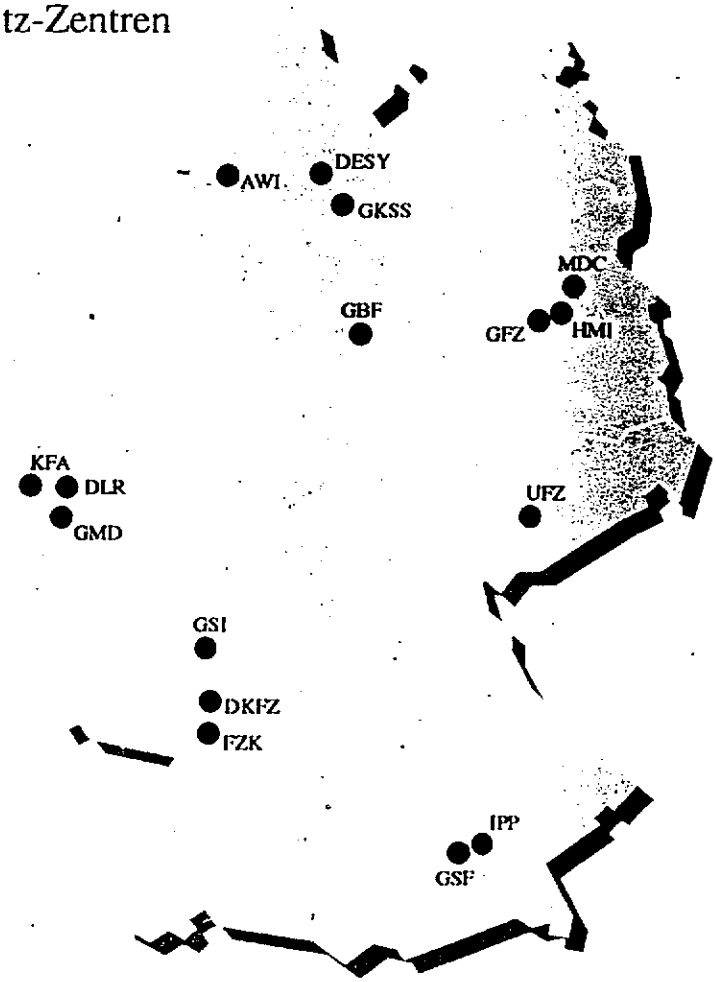
Spectral distribution of the radiation pulse at the saturation point of the conventional SASE FEL. Graph (a) is a plot of the full spectrum and graph (b) presents an enlarged fraction of graph (a).

Power Spectrum of an FEL amplifier operating in the steady state regime. P_{in} = 10kW



Spectral distribution (1) of the energy in one radiation pulse of the FEL amplifier operating in the steady-state regime for an input power P_{in} = 10 kW and an undulator length L_w = 16 m (saturation point). Curve (2) presents the typical spectrum of a conventional SASE FEL operating at saturation.

Sitz der Helmholtz-Zentren



AWI
Stiftung Alfred Wegener Institut für Polar- und Meeresforschung, Bremerhaven

DESY
Deutsches Elektronen Synchrotron, Hamburg

DKFZ
Stiftung Deutsches Krebsforschungszentrum, Heidelberg

DLR
Deutsche Forschungsanstalt für Luft- und Raumfahrt e. V., Köln

GBF
Gesellschaft für Biotechnologische Forschung, GmbH, Braunschweig

FZK
Forschungszentrum Karlsruhe GmbH, Karlsruhe

GFZ
Stiftung GeoForschungsZentrum Potsdam, Potsdam

GKSS
GKSS-Forschungszentrum Geesthacht GmbH, Geesthacht

GMD
GMD-Forschungszentrum Informationstechnik GmbH, Sankt Augustin bei Bonn

GSF
GSF-Forschungszentrum für Umwelt und Gesundheit GmbH, Oberschleißheim (Neuherberg)

GSI
Gesellschaft für Schwerionenforschung mbH, Darmstadt

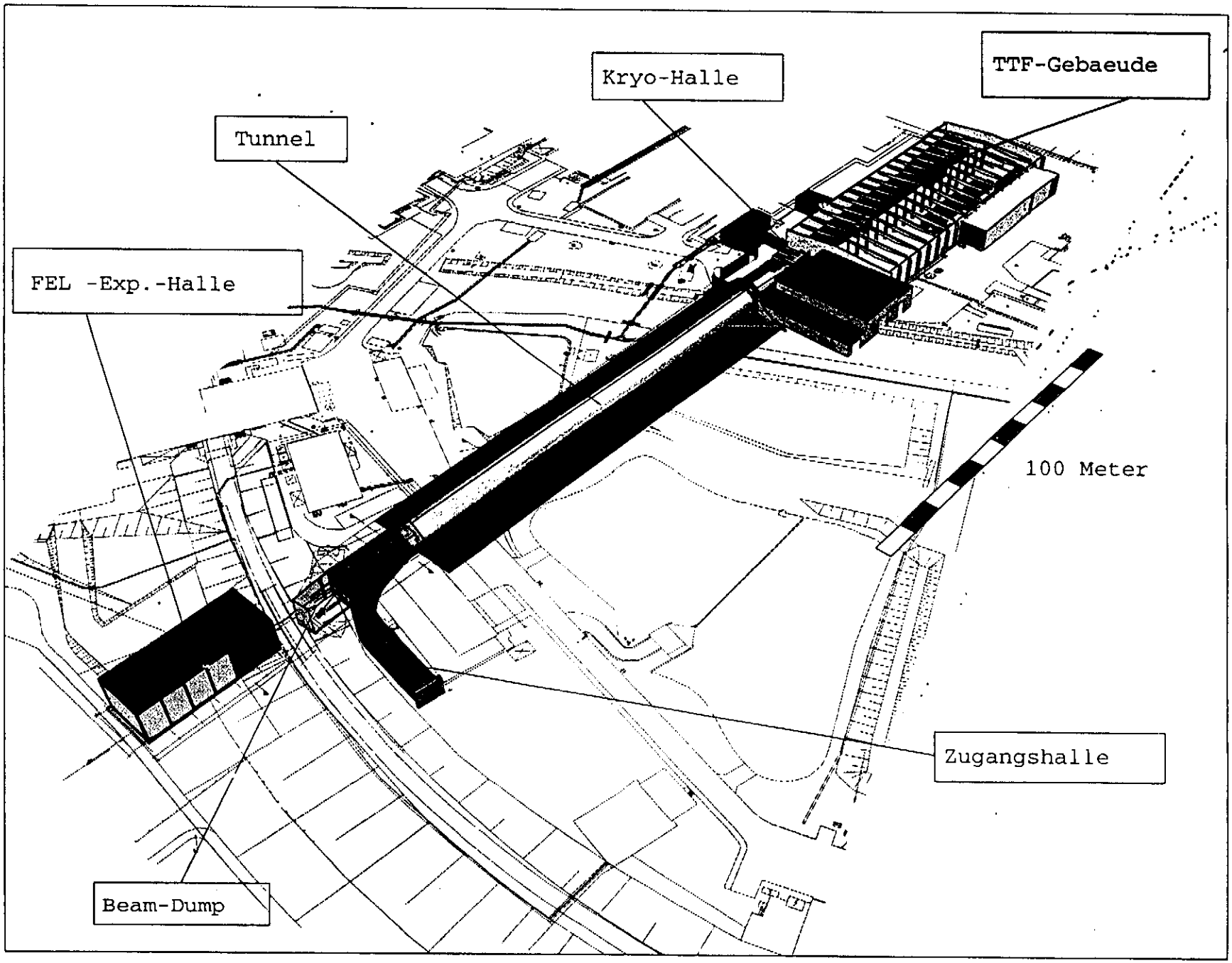
HMI
Hahn-Meitner-Institut Berlin GmbH, Berlin

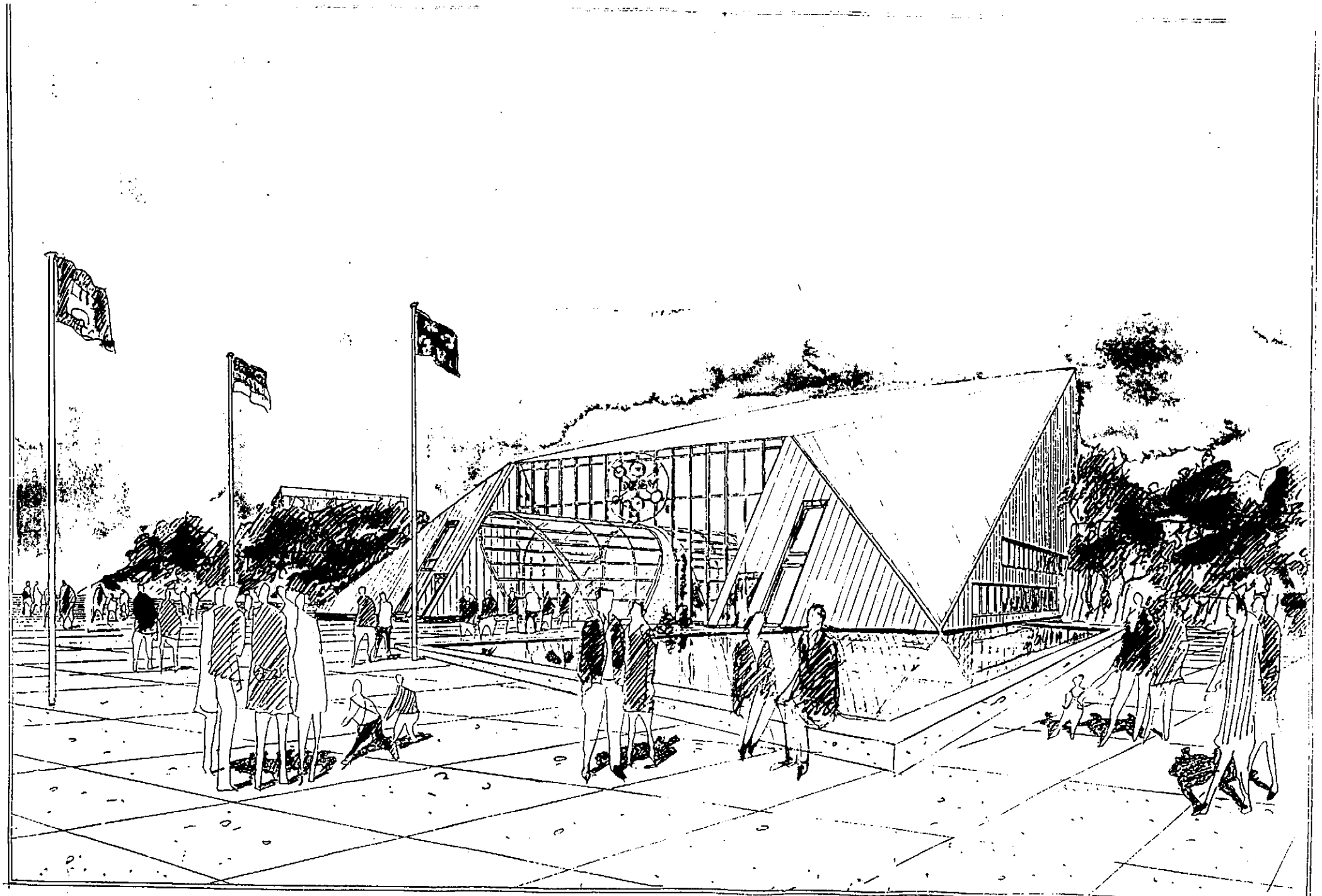
IPP
Max-Planck-Institut für Plasmaphysik, Garching bei München

KFA
Forschungszentrum Jülich GmbH, Jülich

MDC
Stiftung Max-Delbrück-Centrum für Molekulare Medizin, Berlin-Buch

UFZ
UFZ-Umweltforschungszentrum Leipzig-Halle GmbH, Leipzig


TTF-Gebaeude
Kryo-Halle
Tunnel
FEL -Exp.-Halle
100 Meter
Zugangshalle
Beam-Dump



TESLA Parameters

	TESLA-500 (old)	TESLA-500 (new)	TESLA-800 (new)	
site length	32.6	32.6	32.6	km
t_{pulse}	800	950	850	μm
gradient	25	21.7 (20.6)	35.0 (33.2)	MV/m
n_b/pulse	1130	2820	4500	
Δt_b	708	337	189	ns
f_{rep}	5	5	3	Hz
N_e/bunch	3.63	2	1.4	10^{10}
$\varepsilon_x / \varepsilon_{y\,(@\,IP)}$	14/0.25	10/0.03	8/0.01	10^{-6}m
σ_x^* / σ_y^*	845/19	553/5	391/2	nm
σ_z	0.7	0.4	0.3	mm
δ_B	2.5	2.8	4.7	%
Disr. D_y	18	33	39	
P_{AC} (2 linacs)	95	95	132	MW
luminosity L^1	0.6	3.1	5	10^{34} cm^{-2} s^{-1}

CDR

← 80% damping ring

← head on coll.

← single stage b. compression

13

ECFA / DESY Workshop on the TESLA Linear Collider

- Organizing Committee
  Michael Danilov, Enrique Fernandez, Rolf Heuer, Leif Joensson, Paolo Laurelli, Martin Leenen, Francois Richard, Ron Settles, Torbjorn Sjostrand, Albrecht Wagner, Peter Zerwas

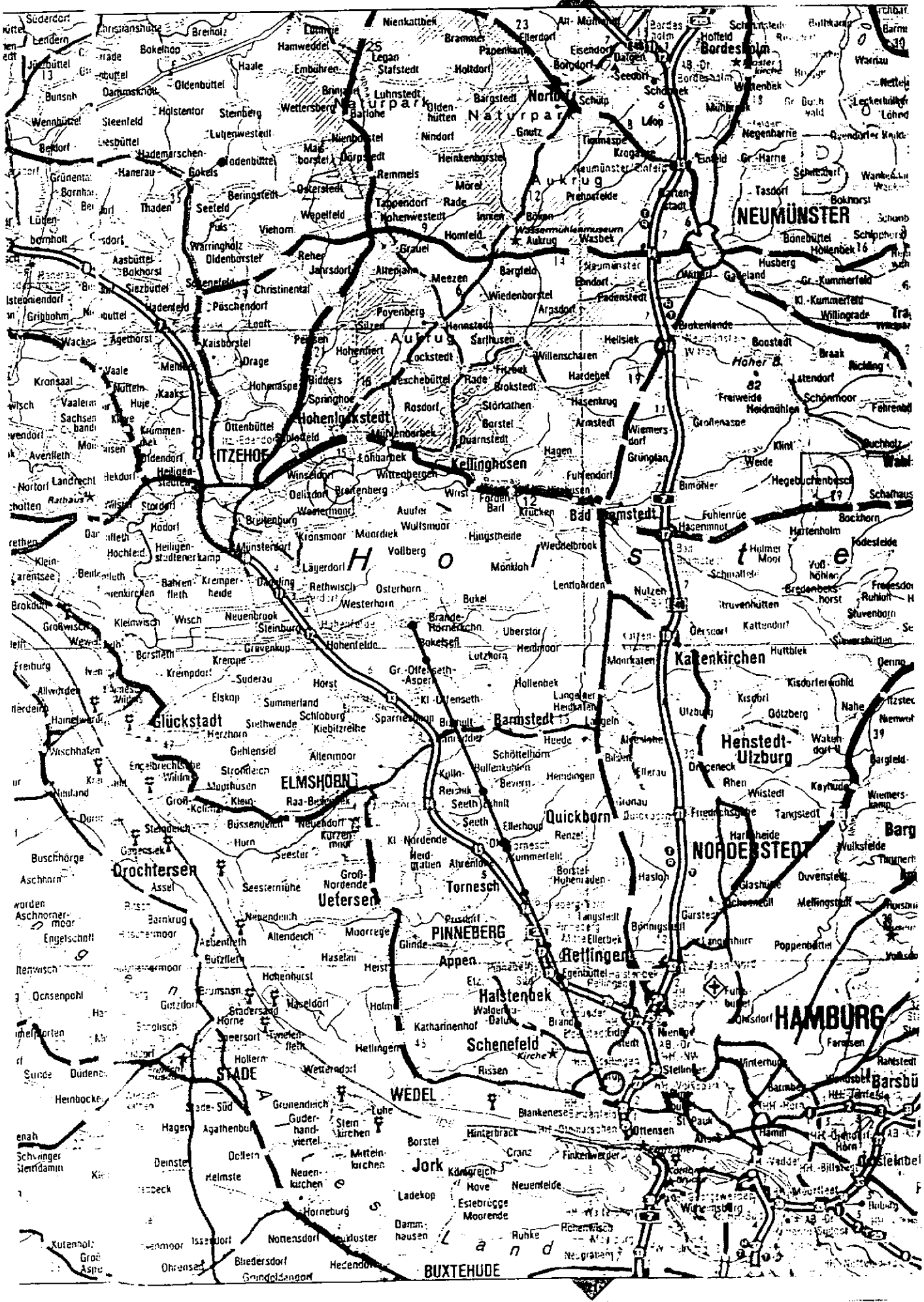
- Chairman
  David J. Miller, Professor of Physics
  Dept. of Physics and Astronomy, University College London
  Gower Street, London WC1E 6BT, UK
  http://www.hep.ucl.ac.uk/people/djm.html
  UCL phone 44 171 380 7152 (fax 7145)
  home phone/fax 44 171 627 1913

- Charge to the Working Groups

  a) Evaluation of new opportunities with a luminosity of $5 \cdot 10^{34}$ or more.
  b) Physics programme as a function of energy from 250 GeV to 960 GeV.
  c) The need for gamma-gamma and e^+e^- options.
  d) Complete the feasibility study begun in late 1996.
  e) Identify the needs for detector R&D.
  f) Detector layout and technology.

- Structure of Working Groups

  1. Physics topics; theorists and experimenters working together:
     a) Top quark
     b) QCD, including gamma-gamma
     c) Higgs
     d) SUSY
     e) Electroweak, TGCs etc.
     f) Alternative theories.


NEUMÜNSTER
Bordesholm
Norderstedt
Kaltenkirchen
Henstedt-Ulzburg
Quickborn
Barmstedt
Bad Bramstedt
Kellinghusen
Hohenlockstedt
ITZEHOE
Glückstadt
ELMSHORN
Drochtersen
Uetersen
Tornesch
PINNEBERG
Rellingen
Halstenbek
Schenefeld
Appen
STADE
WEDEL
Jork
BUXTEHUDE
HAMBURG
Barsbü
Ottensen
Stellingen
Hamm
Wilhelmsburg
Hoher B.
Naturpark
Aukrug
Holstein
Altes Land

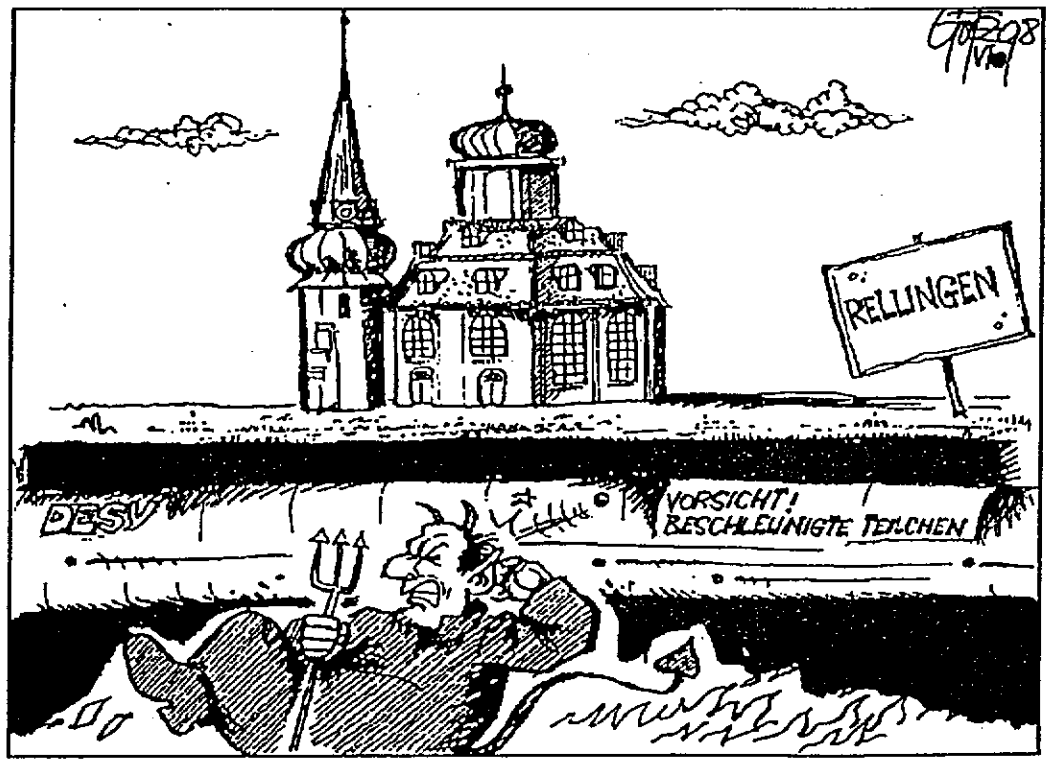
Eine Begegnung der ungewöhnlichen Art

DESY plant Forschungstunnel unter der Rellinger Kirche

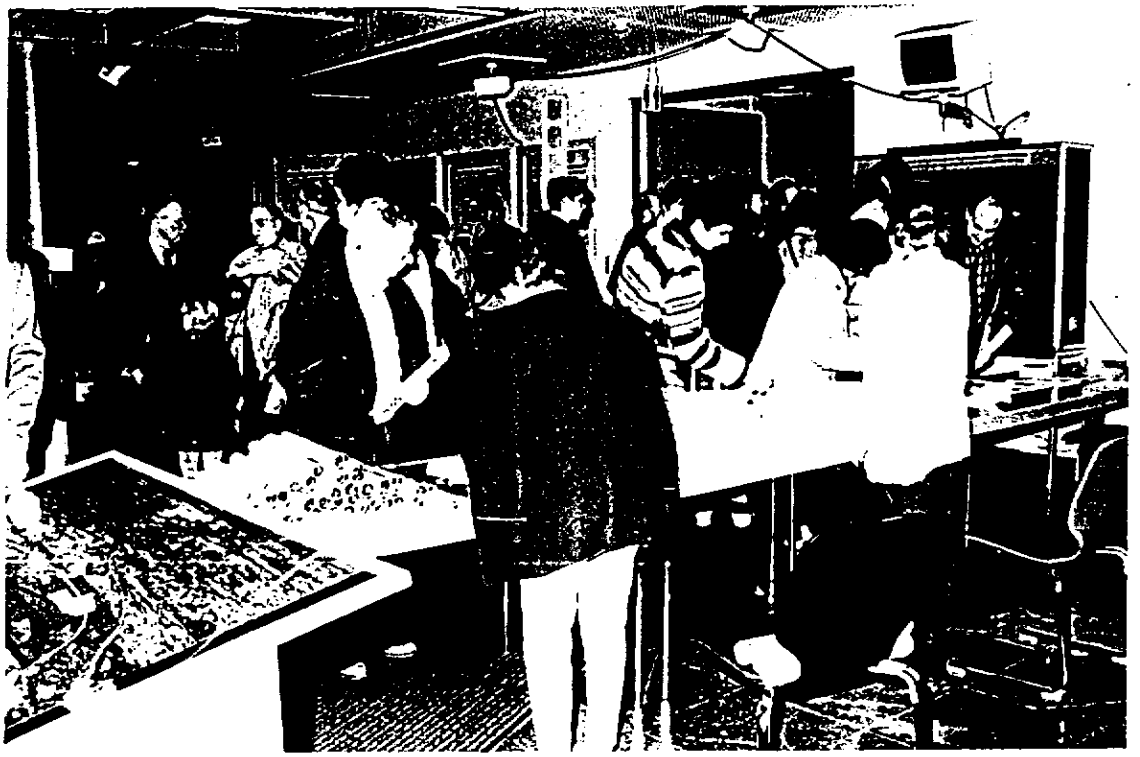
Pinneberger Tageblatt 1.7.1997 Seite 7

Gestern haben Arbeiter mit Drucksondierungen rund um die Rellinger Kirche begonnen. Foto: Onken

 Pinneberger Tageblatt 1988



„Au – früher haben sie mich hier mit Weihwasser ferngehalten…" Karikatur: Wiedenroth



42948/4

42948/5

SUMMARY OF CAVITY TESTS

Michael Pekeler
TTF Collaboration Meeting
July, 6th, 1998

1. Summary of first TTF cavity production
2. Cavities for module 2
3. New cavity production (first results)
4. Multipacting & Field emission
5. (spun and hydroformed single cell cavities, Peter Schmüser, this afternoon)

Summary of first TTF cavity production

25 cavities from all 4 manufacturers were tested so far in a vertical cryostat.

The average gradient in the vertical test was 19.2 MV/m @ Q > $3 \cdot 10^9$.

14 cavities showed Eacc > 20MV/m.

3 cavities showed Eacc > 28 MV/m

Last 9 cavities **delivered to the TTF:**

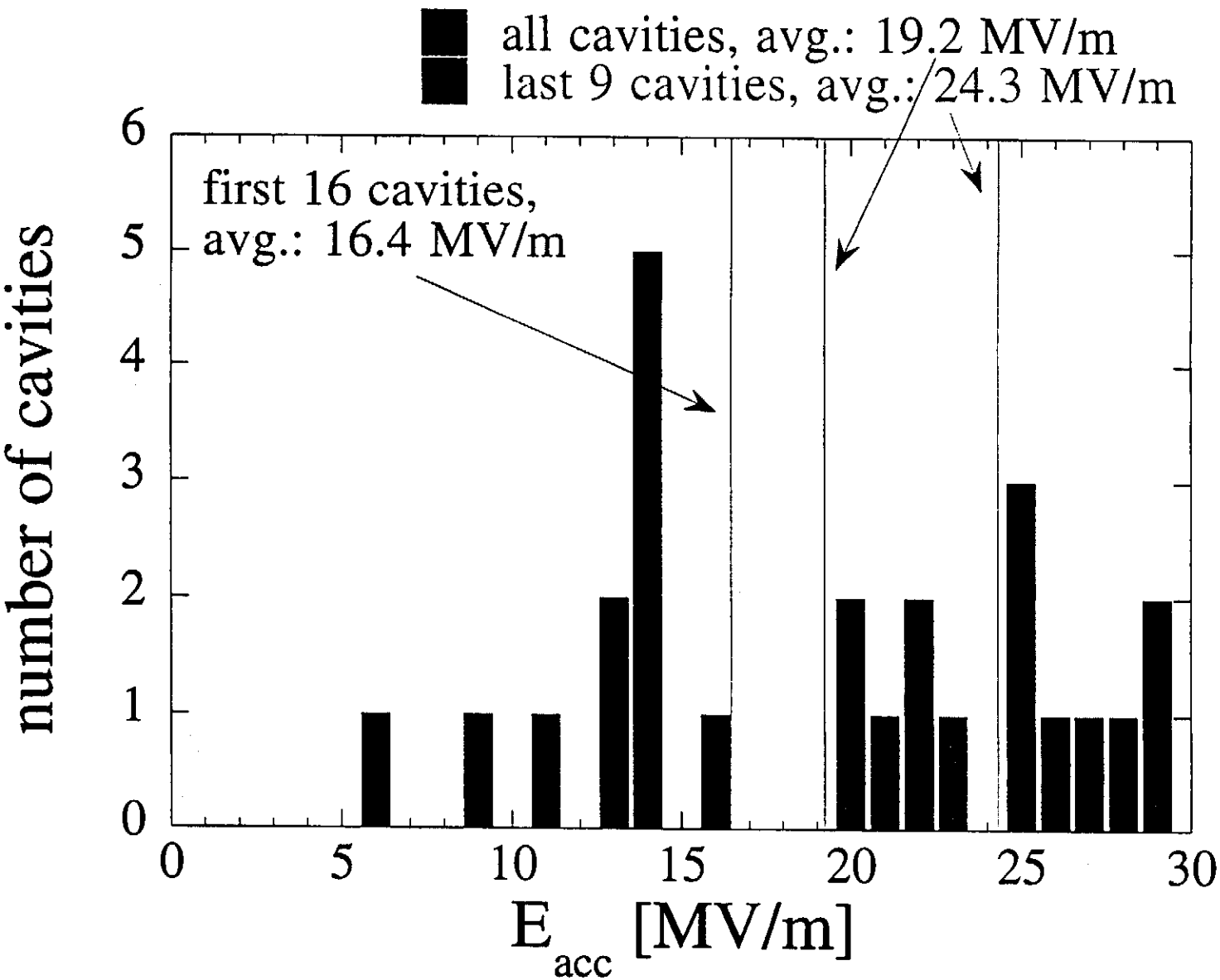
- **avg. gradient:** 24.3 MV/m @ Q > $3 \cdot 10^9$.
- **main limitation:** field emission and available cw RF power.

All 4 manufacturers were able to produce cavities with gradients above or close to 25 MV/m

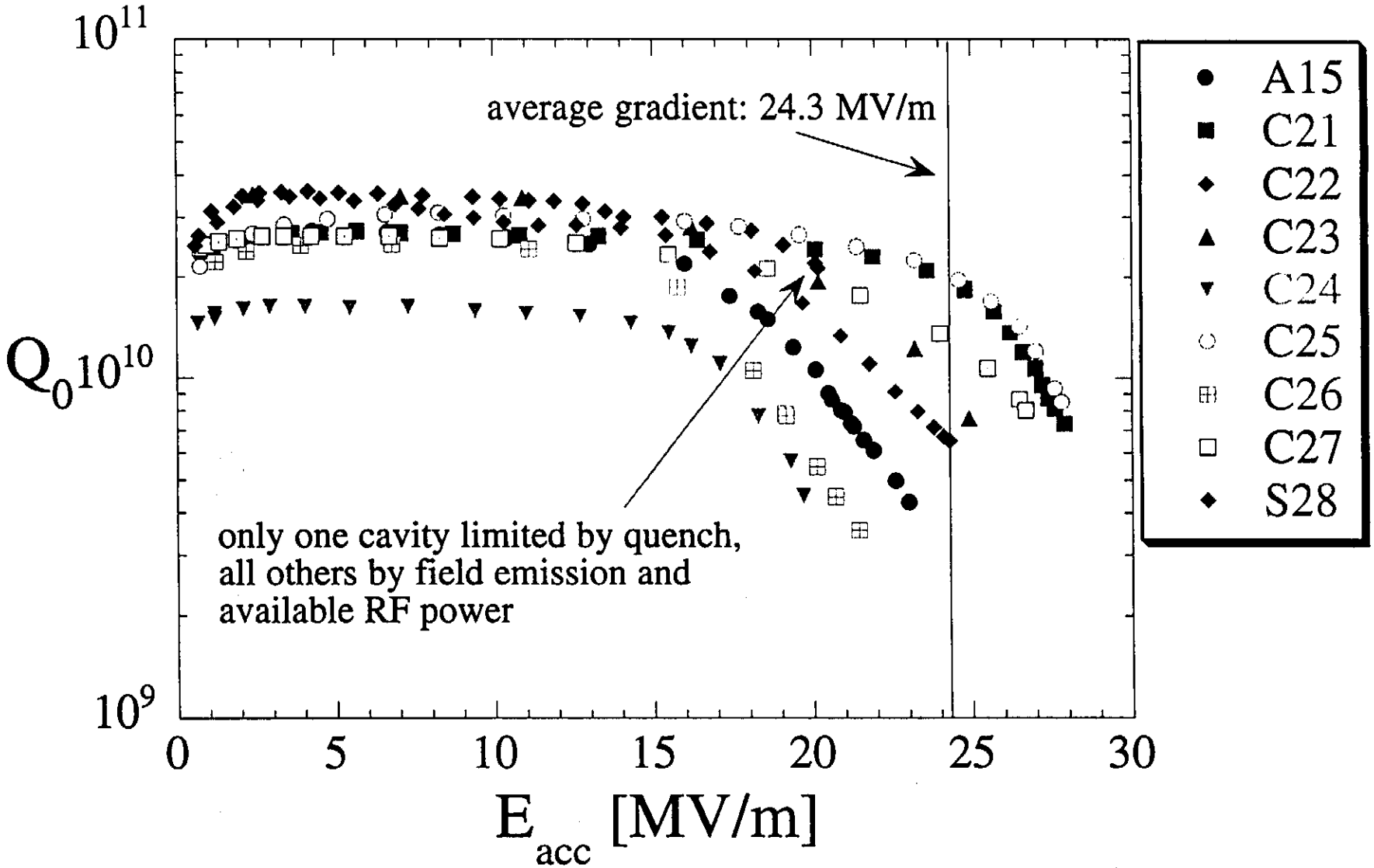
not tested yet: A16, A17, A18

All 4 manufacturer were able to produce cavities with gradients above or close to 25 MV/m

Gradients achieved in 9-cell cavities



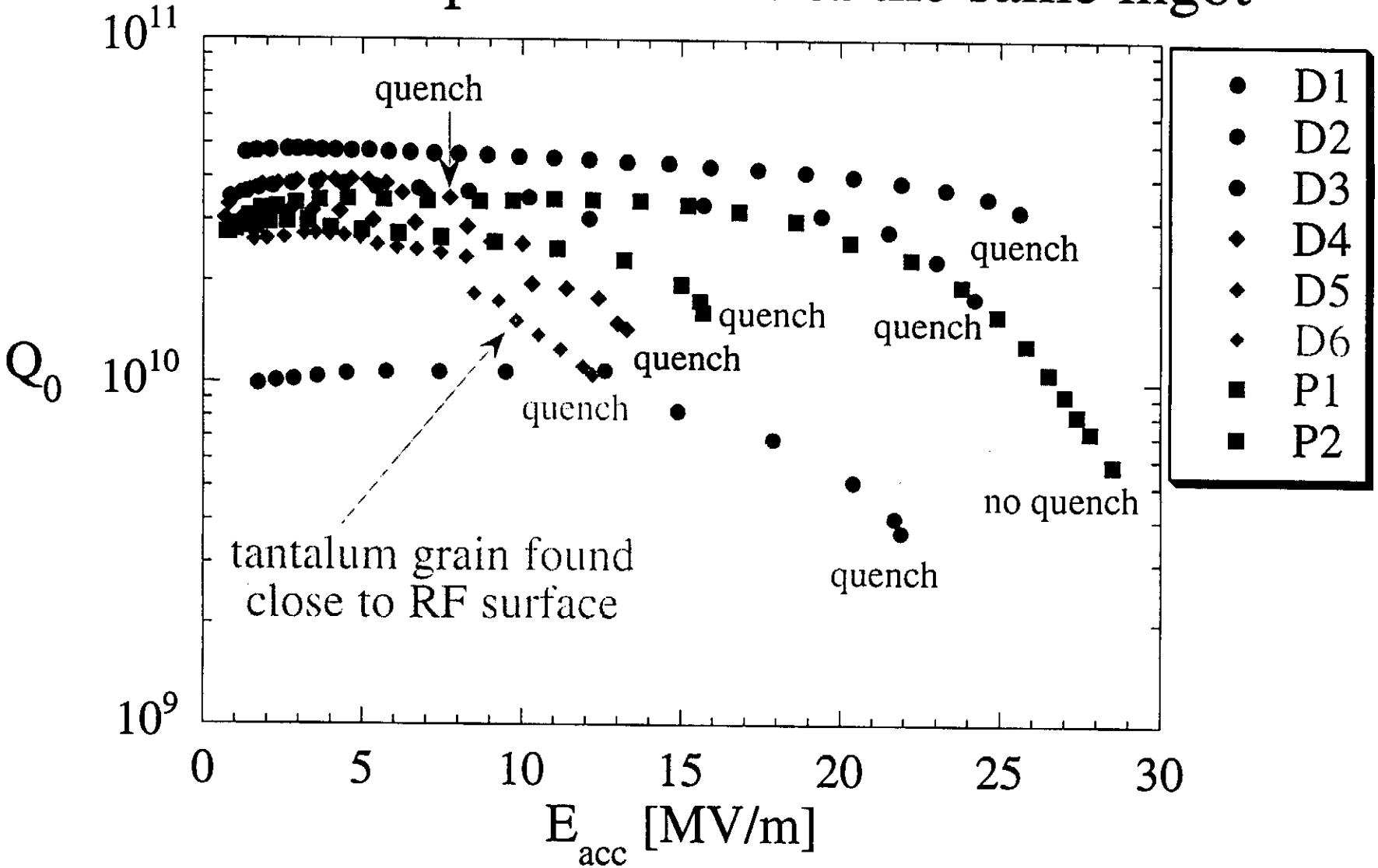
Results of the last nine cavities arrived at TTF



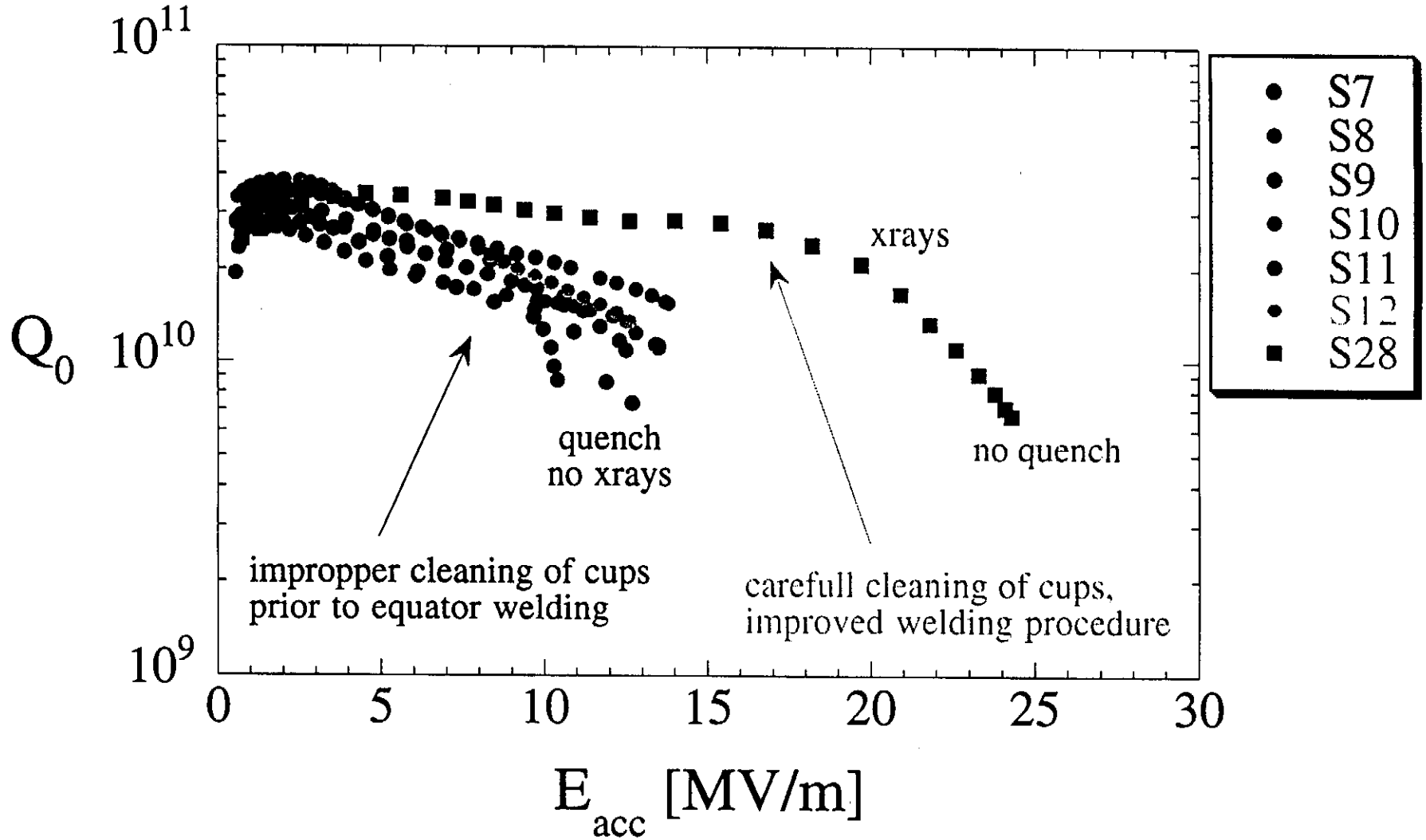
Best vertical test results of TTF cavities

cavity	Eacc [MV/m]	Q_0 [10^9]	comment
P1	>29.1	6	Prototype
P2	16.3	22	Prototype
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
D5	8.6	24	defect
D6	13.6	12	defect
S7	13.8	8	Module 1 / weld defect
S8	12.5	12	Module 1 / weld defect
S9	11.4	11	weld defect
S10	14.2	16	Module 1 / weld defect
S11	13.5	13	Module 1 / weld defect
S12	12.6	13	weld defect -> FNAL
S28	>24.9	5	new welding procedure
A14	6.4	11	weld defect
A15	>23.0	4	-> Module 2
C19	22.1	2	capture cavity
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
avg	**19.2**		

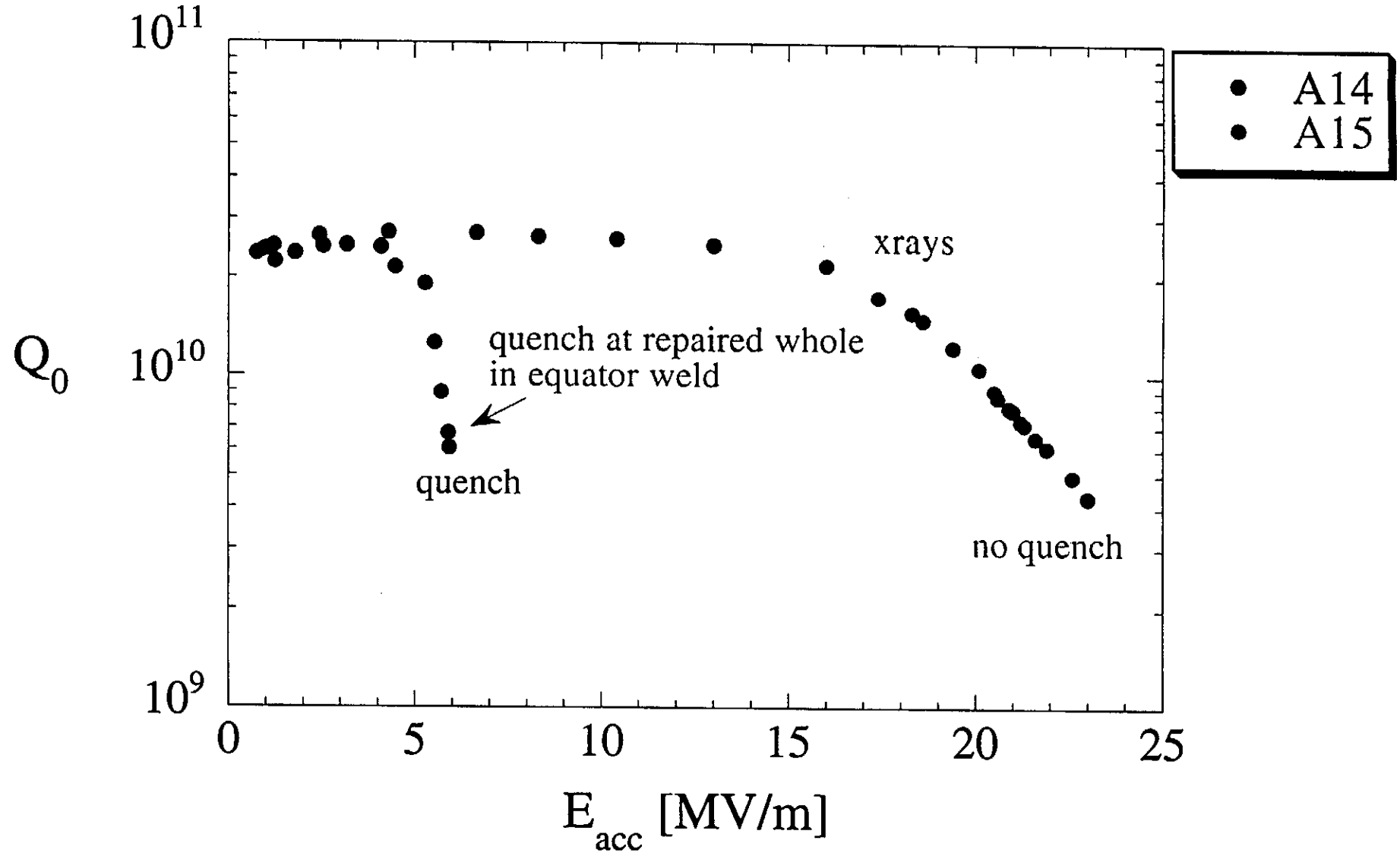
All cavities produced out of the same ingot

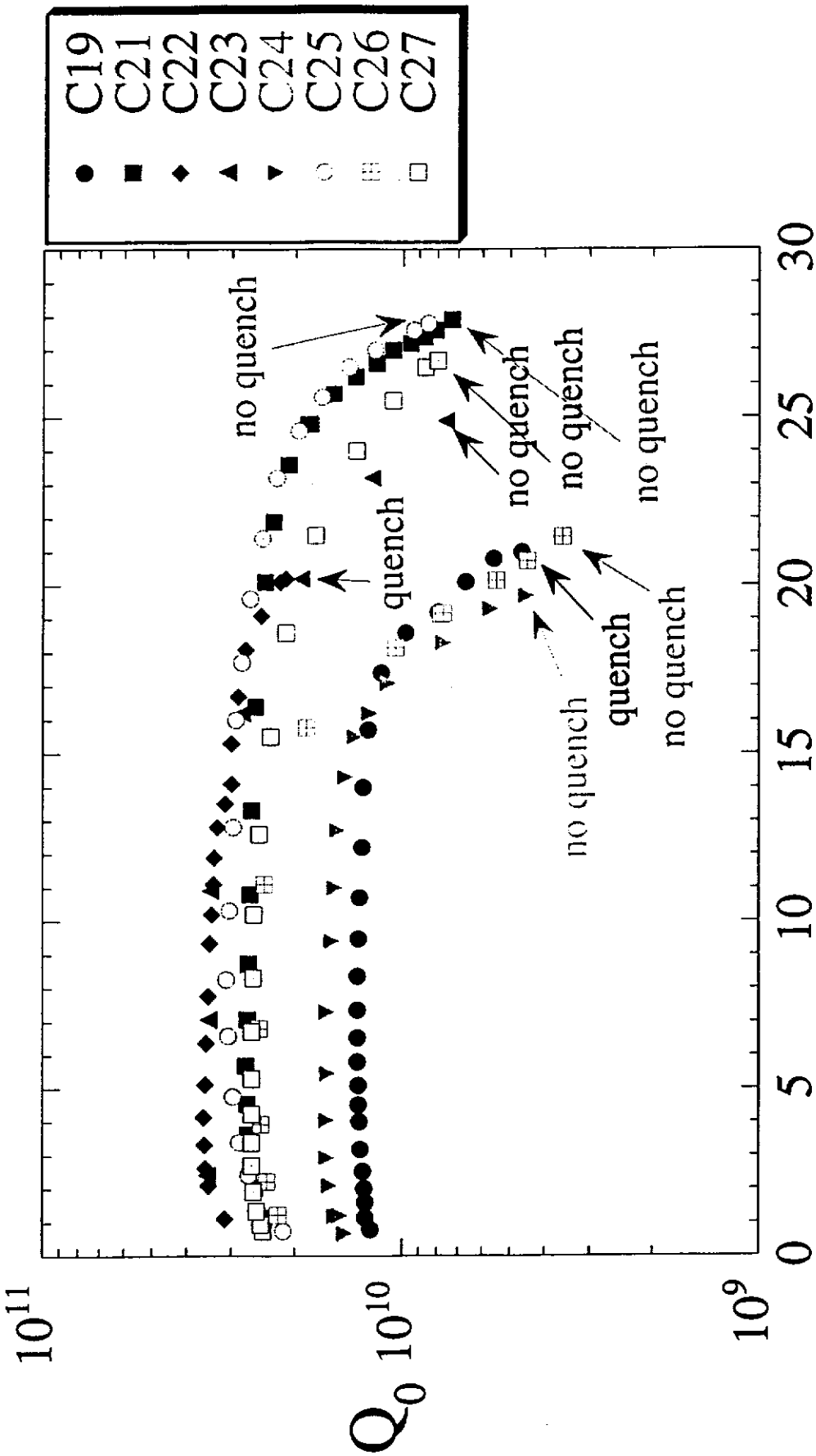


new developed eddy current scanning aparatus
should find material inclusions in the niobium sheets


10^{11}
10^{10}
10^{9}
Q_0
0
5
10
15
20
25
30
E_{acc} [MV/m]
S7
S8
S9
S10
S11
S12
S28
xrays
quench
no xrays
no quench
impropper cleaning of cups
prior to equator welding
carefull cleaning of cups,
improved welding procedure

25


10^{11}
10^{10}
10^{9}
Q_0
0
5
10
15
20
25
E_{acc} [MV/m]
A14
A15
xrays
quench at repaired whole
in equator weld
quench
no quench


C19
C21
C22
C23
C24
C25
C26
C27
no quench
quench
no quench
no quench
no quench
no quench
quench
no quench
Q_0
10^{11}
10^{10}
10^9
0
5
10
15
20
25
30
E_{acc} [MV/m]

Performance of individual cells:

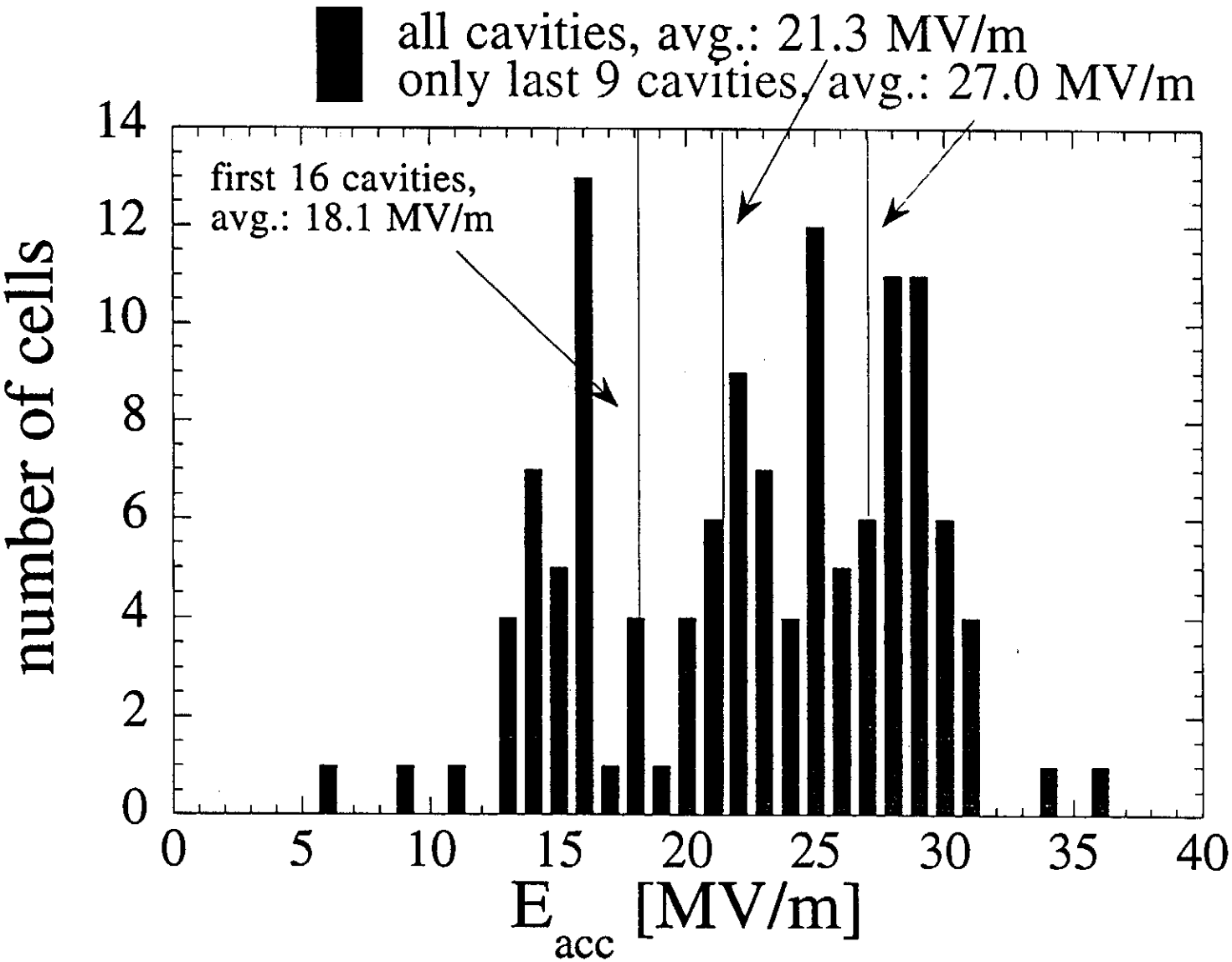
By excitation of the 8 members of the fundamental mode, one is able to reach higher fields in individual cells of the 9-cell structure than in the π-mode.
(π-mode: all cells have equal amplitude, other fundamental modes: bad cells can have low or zero field)

Gradients up to 36 MV/m have been reached in individual cells.

The average gradient reached in individual cells of the last 9 cavities arrived at TTF was 27.0 MV/m.

The main limitation of the individual cells at very high gradients was again field emission loading.

Performance of individual cells



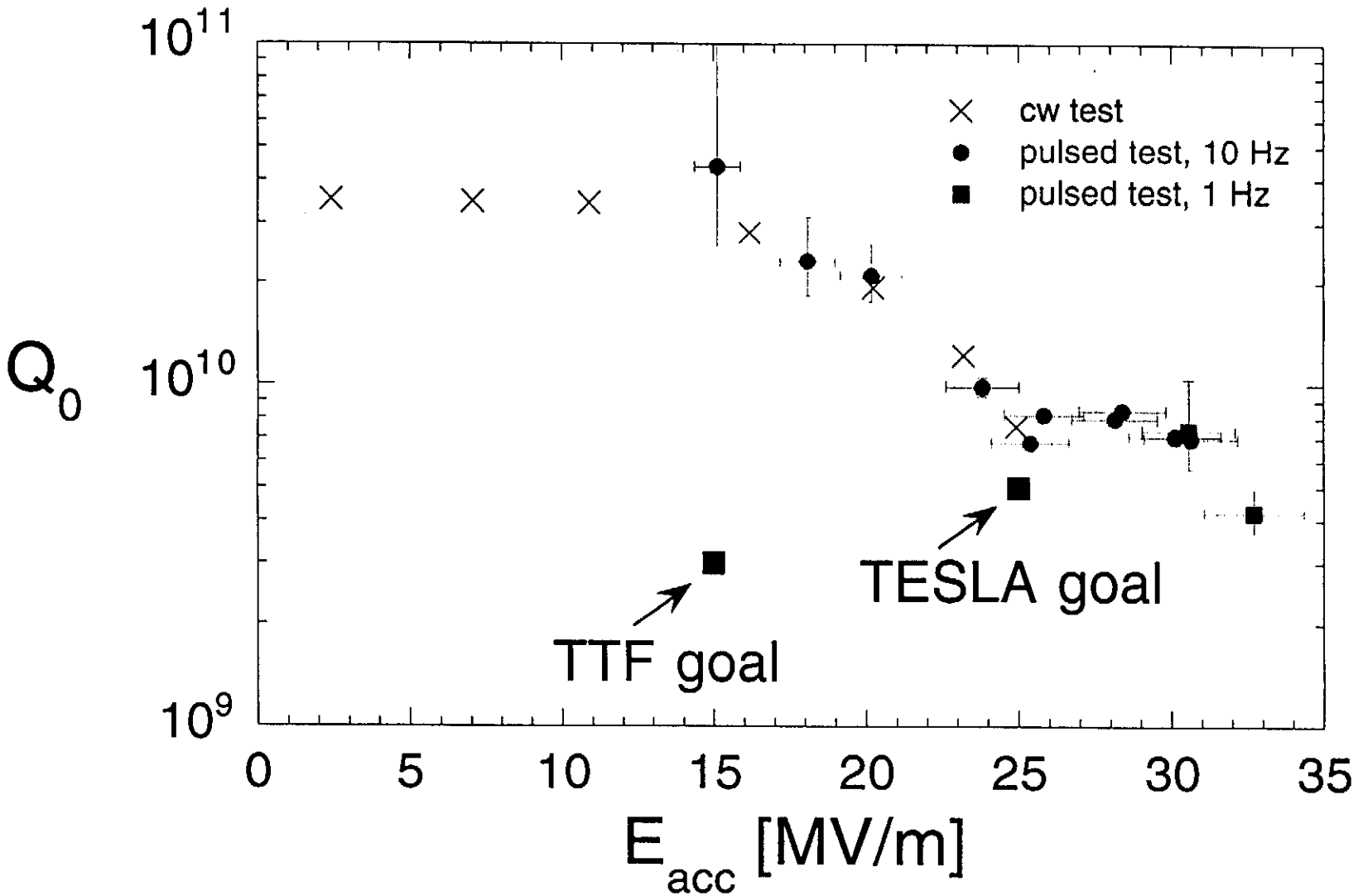
Cavities for module 2

cavity	vert. test [MV/m]	CHECHIA [MV/m]	comment
C21	29.3*	18.3	new HPR after CHECHIA test
C22	20.2	18.1	new HPR after CHECHIA test
C23	25.3*	33.0 !!	
C24	20.2*		strong FE in vert. test
C25	28.4*	24.0	limited by coupler in CHECHIA test
C26	21.4*		
C27	26.7*		
A15	23.0*		bad vacuum behaviour

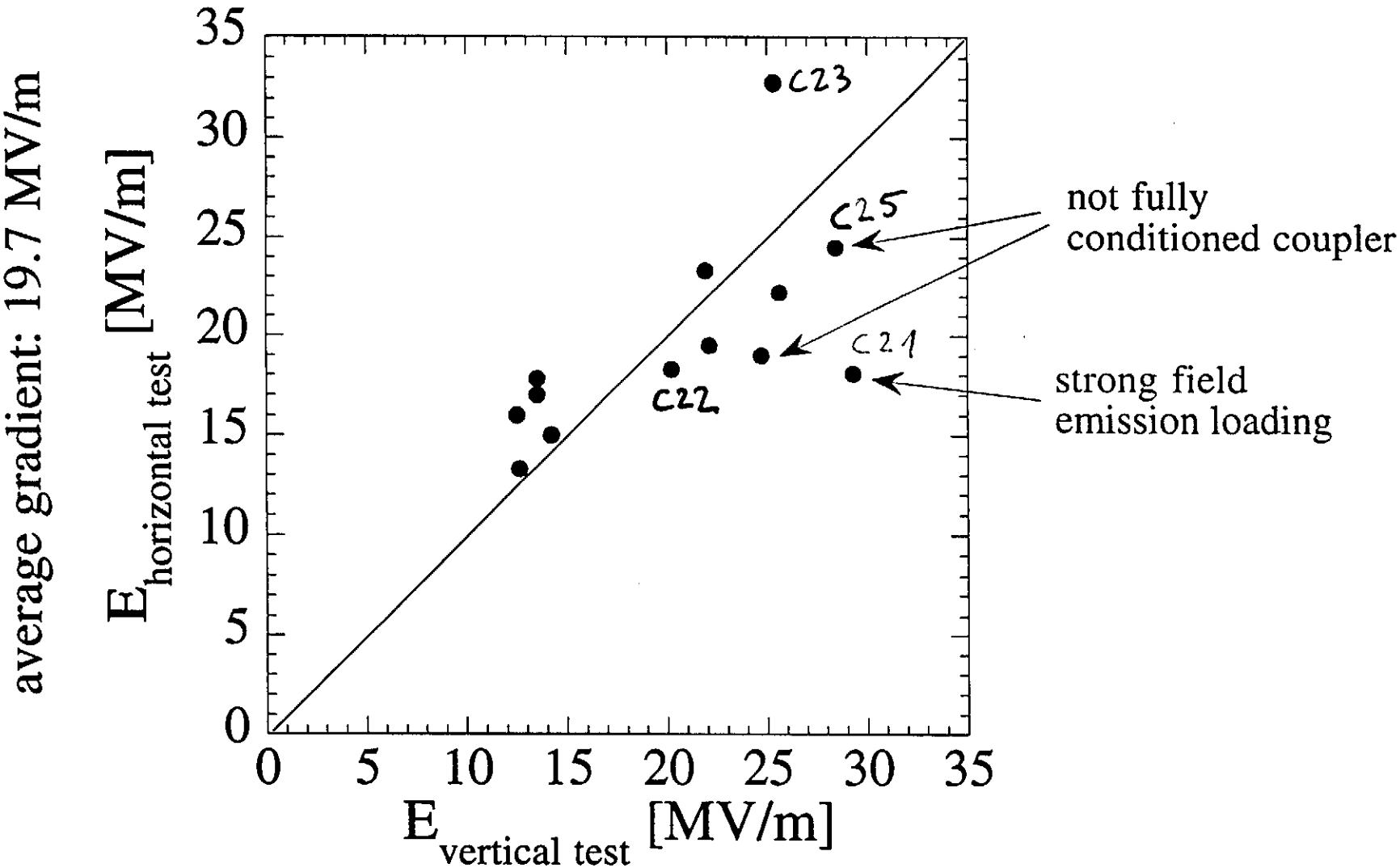
* limited by field emission and available cw RF power
!! stiffening rings not good enough for 33 MV/m

C24, C26 and C27 will not be tested in CHECHIA !!

Horizontal test result on cavity C23



Test results in horizontal cryostat compared to the results obtained in the vertical cryostat



2 cavities (C23 and C25) showed (very) good result, 2 cavities (C21 and C22) showed poor result.

Why?

We do not know yet, but:

- C22 and C21 were the first cavities tested in CHECHIA since 1 year
- leak problems occured at main coupler flange for C21 and C22
- cold part of main coupler was baked 2 times at 800 °C in the case of C23 and C25
- e- singnal at cavity-side pick-up of cold window observed in the case of C21 and C22. No signal present in the test of C23 and C25.

We would like to make more CHECHIA tests, and take our time for R&D there.
=> We still loose too much time between last vertical test and CHECHIA test.

New cavity production (first results)

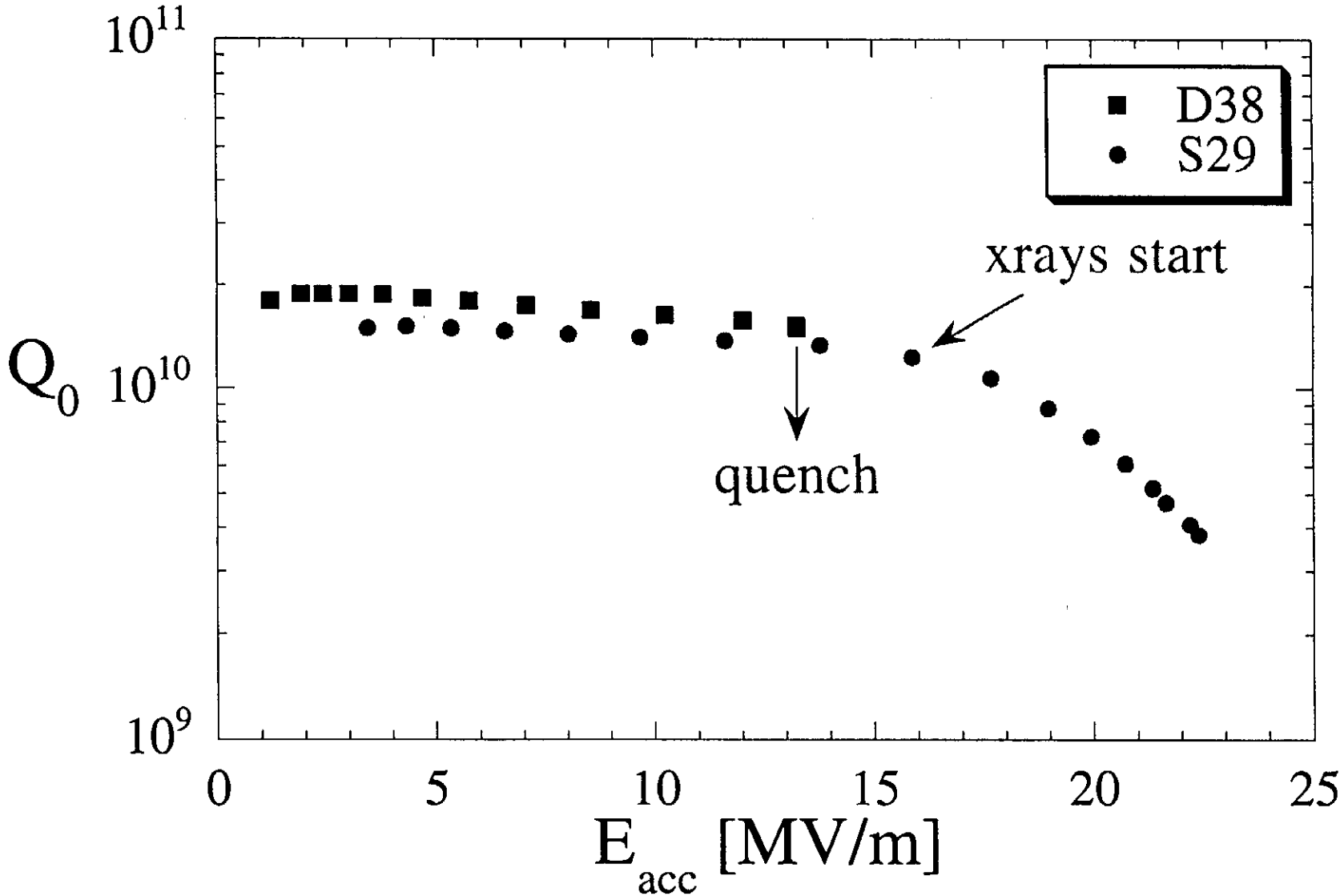
11 new cavities arrived at TTF (all produced out of eddy current scanned niobium sheets)

ACCEL: S29, **S30, S31, S32**
Dornier: D37, D38, **D39, D40, D41, D42**
CERCA: C43,

Only S29 and D38 have been tested so far. They were tested after the HT at 800 C. They will be soon tested after the HT 1400 C **(D38 with rot. Tmapping)**

Results:	**S29** [MV/m]	limit	**D38** [MV/m]	limit
π-mode	22.4	**PWR**	13.3	**BD**
cell 1/9	**23.0**	**BD**	**13.3**	**BD**
cell 2/8	**22.4**	**PWR**	**13.5**	**BD**
cell 3/7	**24.4**	**PWR**	**13.3**	**BD**
cell 4/6	**23.9**	**PWR**	**14.1**	**BD**
cell 5	**26.0**	**PWR**	**15.0**	**BD**

All other **cavities from the second production will be** tested only after the HT 1400 C.


10^{11}
10^{10}
10^{9}
Q_0
D38
S29
xrays start
quench
0
5
10
15
20
25
E_{acc} [MV/m]

Multipacting & Field Emission

Between Aug. 1997 and Feb. 1998 **we observed** multipacting induced quenches **in the 16 to 23 MV/m region in cavities from Dornier, Zanon and Cerca.**

Since Feb. 1998 no MP induced quenches observed anymore, although cavities reached fields up to 27 MV/m.

Often field emission is present in the first power rise **at fields** around **10 MV/m.**

Normally we can somewhat process the FE with low power (150 W available)

But good cavities always suffer from FE.

How did we manage in the past to prepare D1, D3 and C21 up to 24 MV/m without field emission?

DATABASE:

Mr. Gall **offers a Presentation of the Database and its Graphical User Interface at his PC in his office all time during this collaboration meeting**

P.D. Gall
Building 55
Room 107
Tel.: 3948

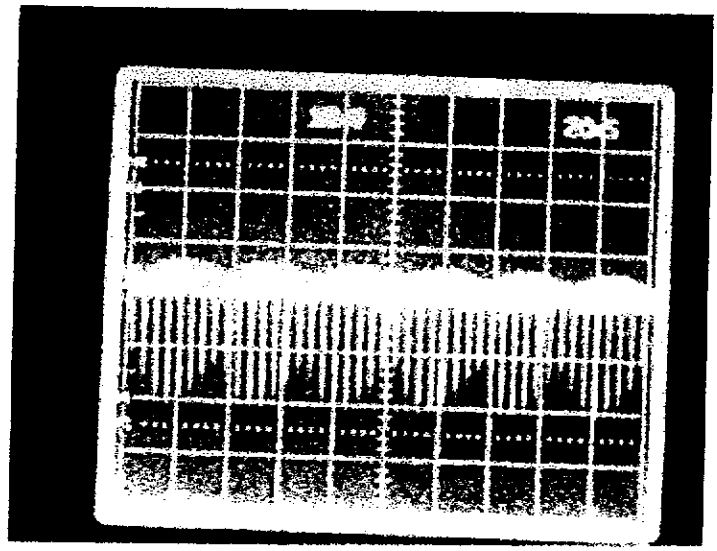
M. Jablonka

Linac Operation

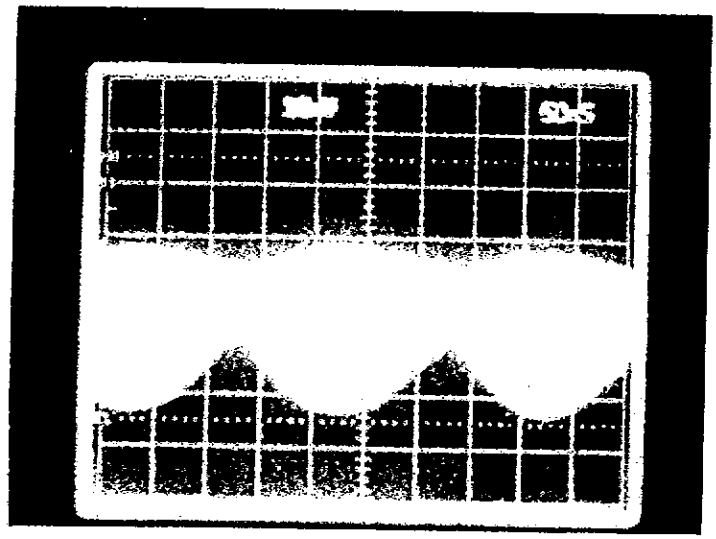
TTF Injector #1 bunch train modulation

Signals observed on the capacitive pick-up located at the gun exit

Maximum amplitude of micropulses corresponds to an 8mA beam

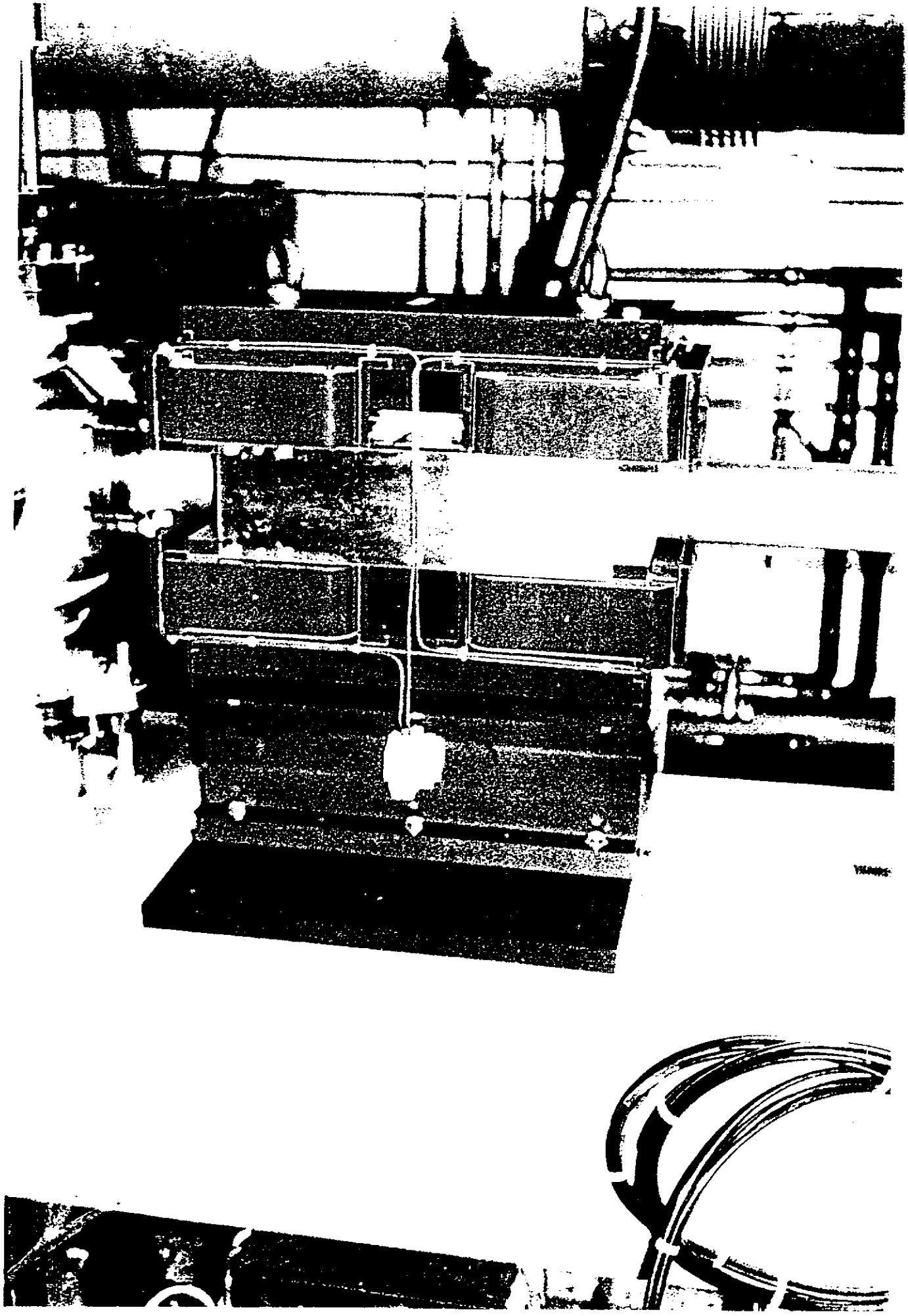


30 MHz modulation



5 MHz modulation

Beam was then accelerated to 10 MeV through capture cavity, transported in the Analyzing beamline. Pulse length was increased to 200 μs



[illegible] magnet designed by M. Juillard, Saclay

Modifications for S. Fartoukh HOM experiment

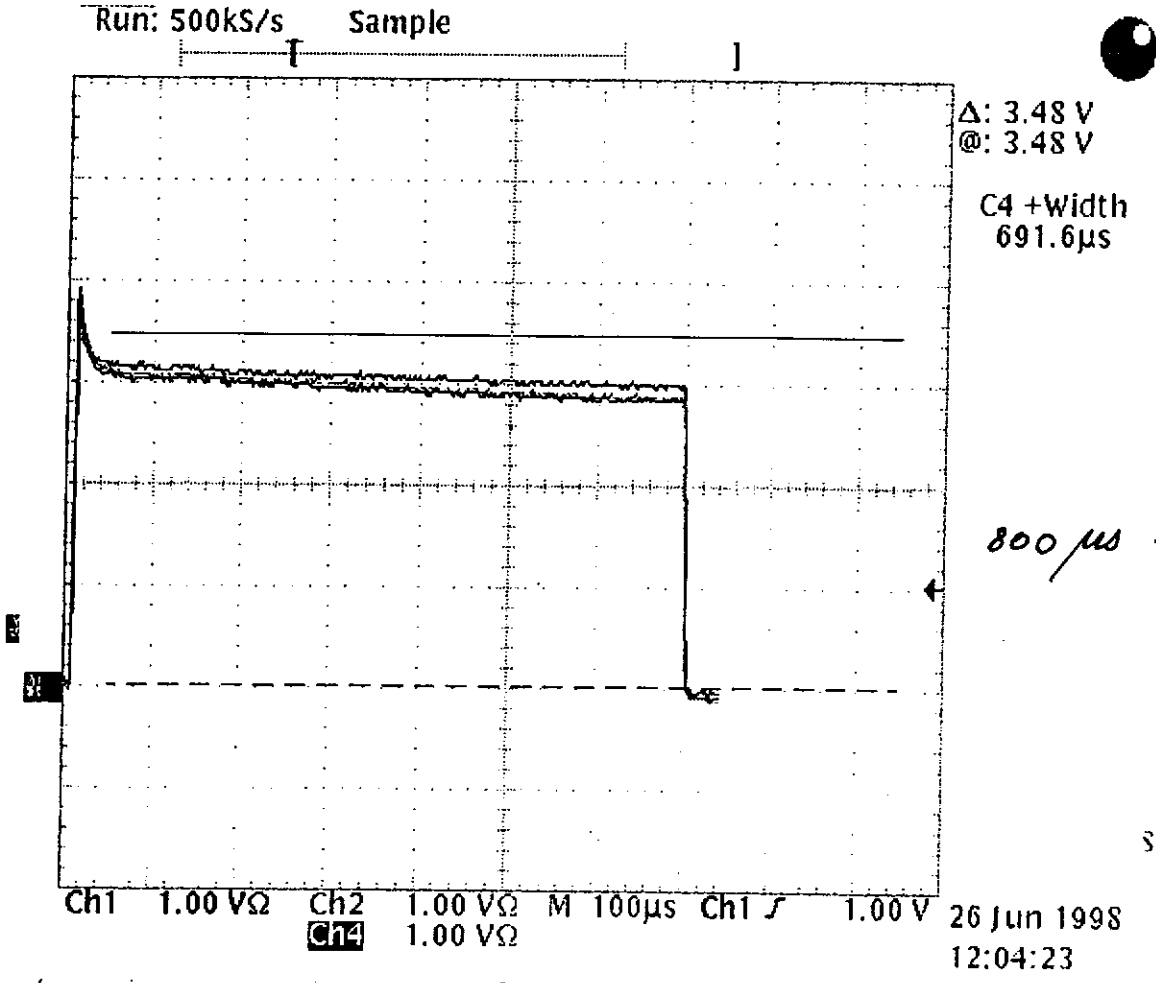
1- Gun electronics to produce modulation of the micropulse train amplitude

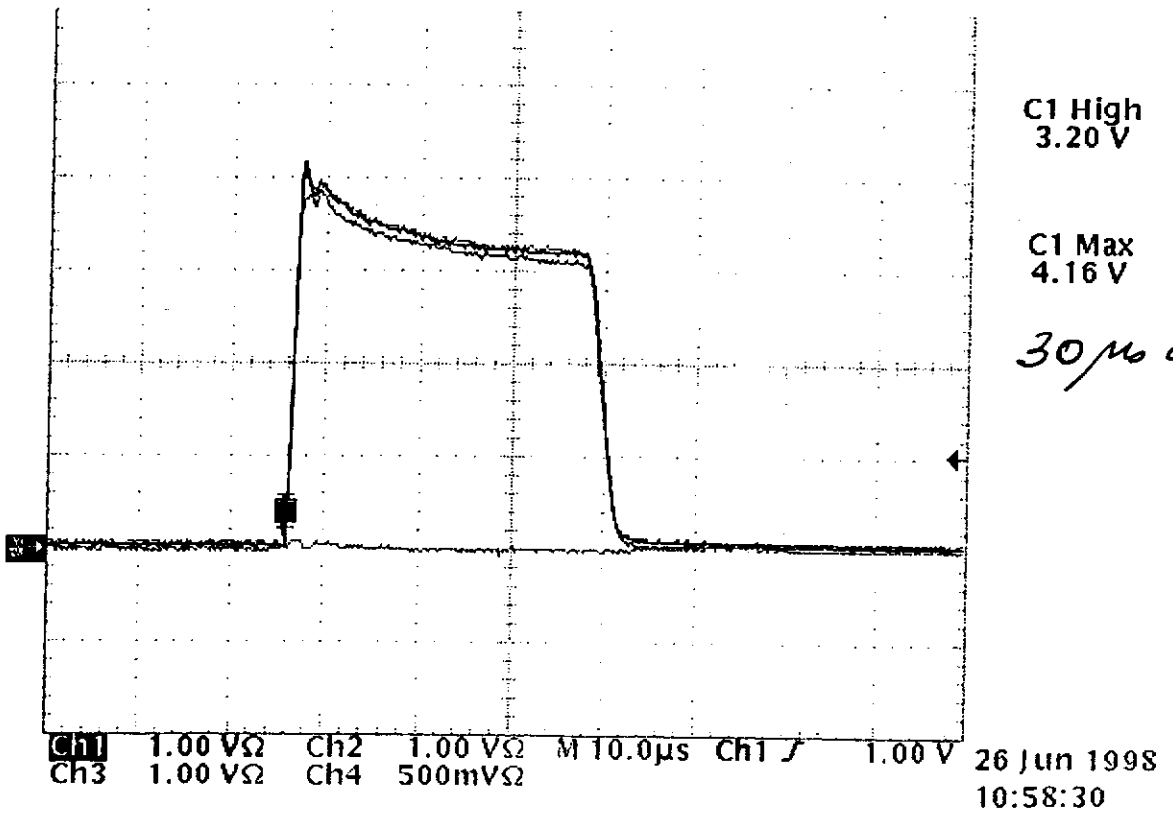
2- Installation of the DOGLEG magnet

3- Displacement of the Saclay (reentrant cavity) BPM from Injector to BC1

4- Installation and test of simplified BPM electronics

800 μs beam pulse 6.4 mA 92 MeV



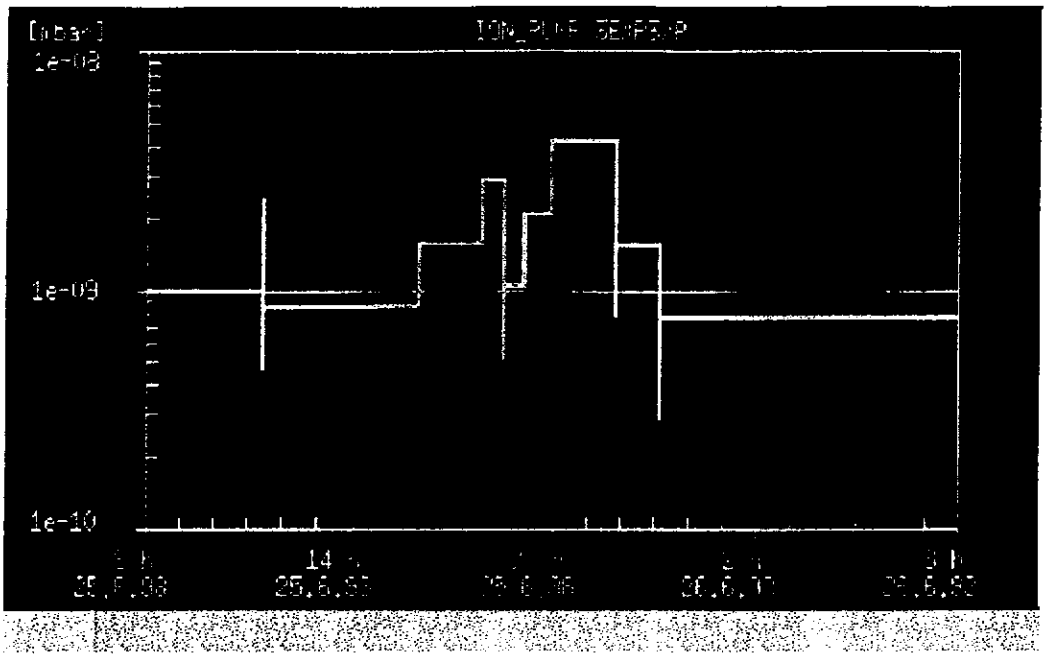


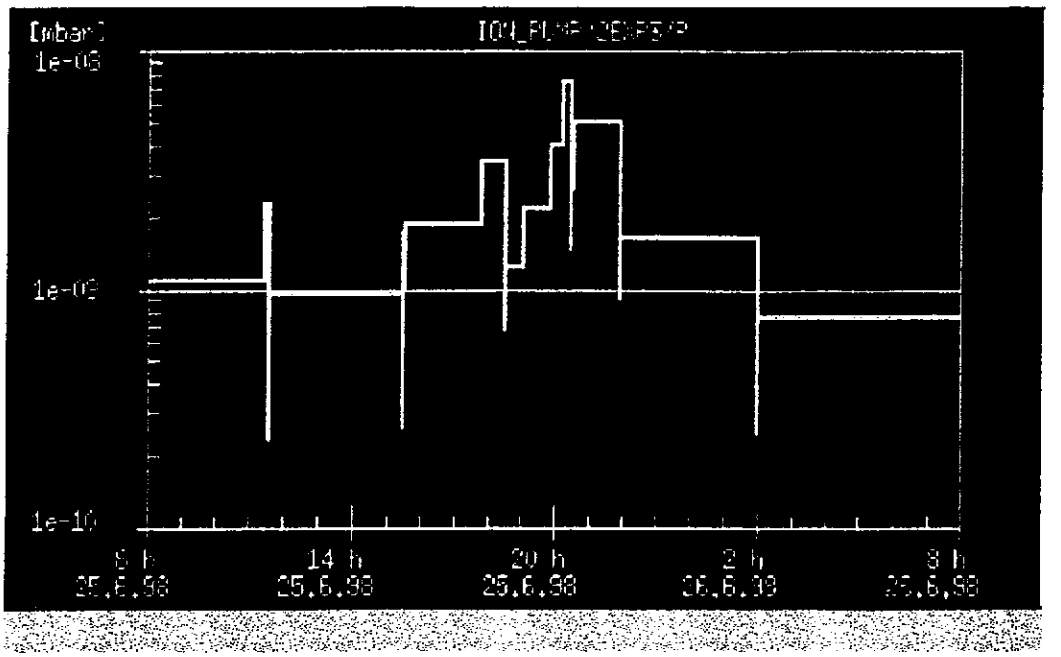
Long pulse beam experiment

25 June 98

Vacuum recorded in TTF high energy analyzing line (EXP3)

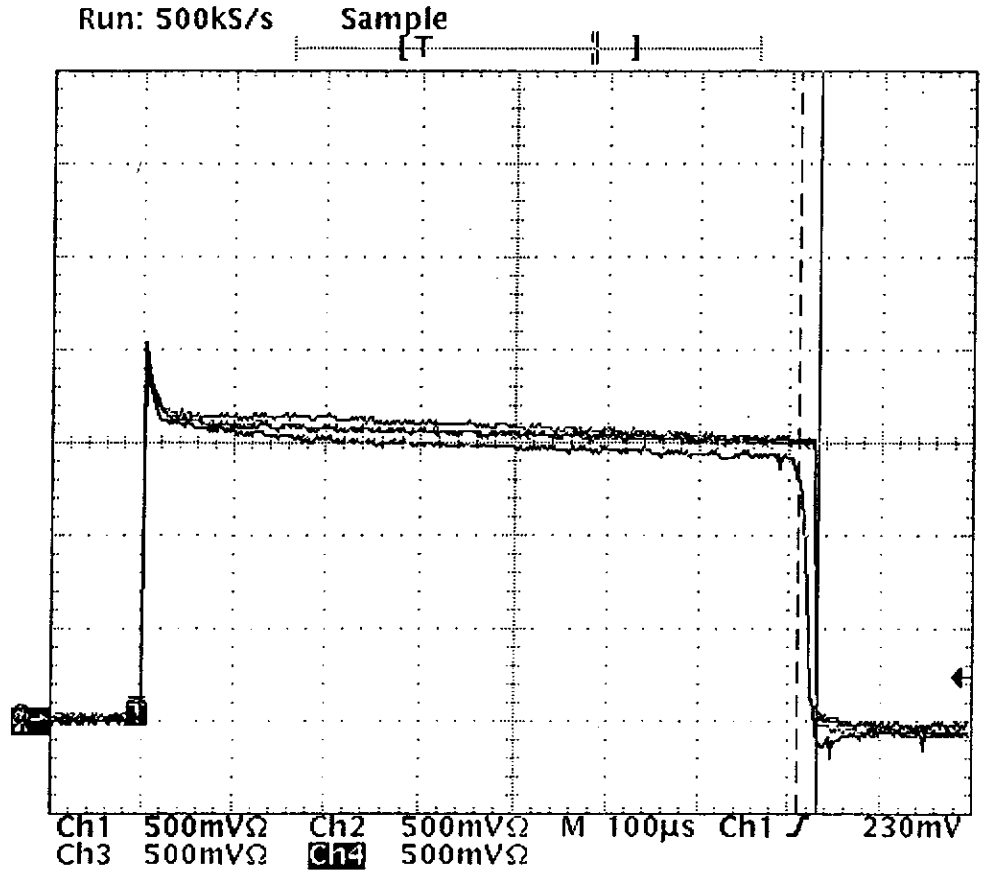
92 MeV 3.4 mA 30 to 800 μs beam pulse





Module #1 long pulse run

3.4mA 92 MeV 736 µs (limitation) 800 µs pulse length

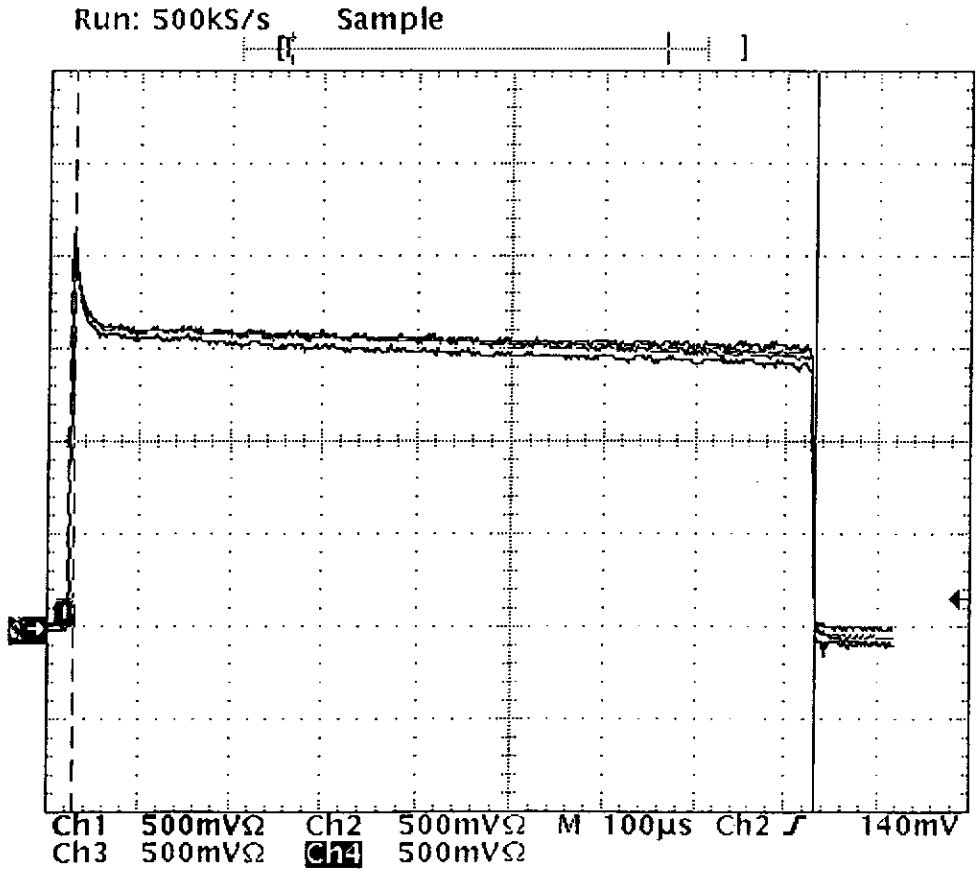


736 µs

lost charge:

$\frac{1}{2}(3{,}4\ mA \times 22\ \mu s) + \frac{1}{2}(0{,}1\ mA \times 800\ \mu s) =$

$80\ \mu s \times mA$

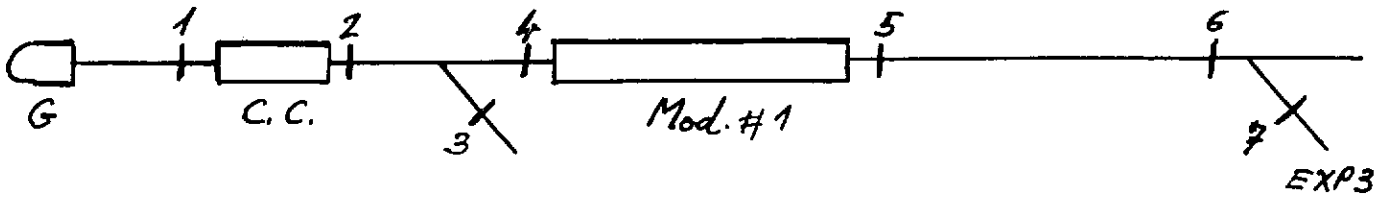


800 µs

Differential Protection System

Goal Ensure limitation of beam loss by differential current measurement between 6 pair of toroid transformers

1-2	4-5
2-4	4-6
2-3	4-7



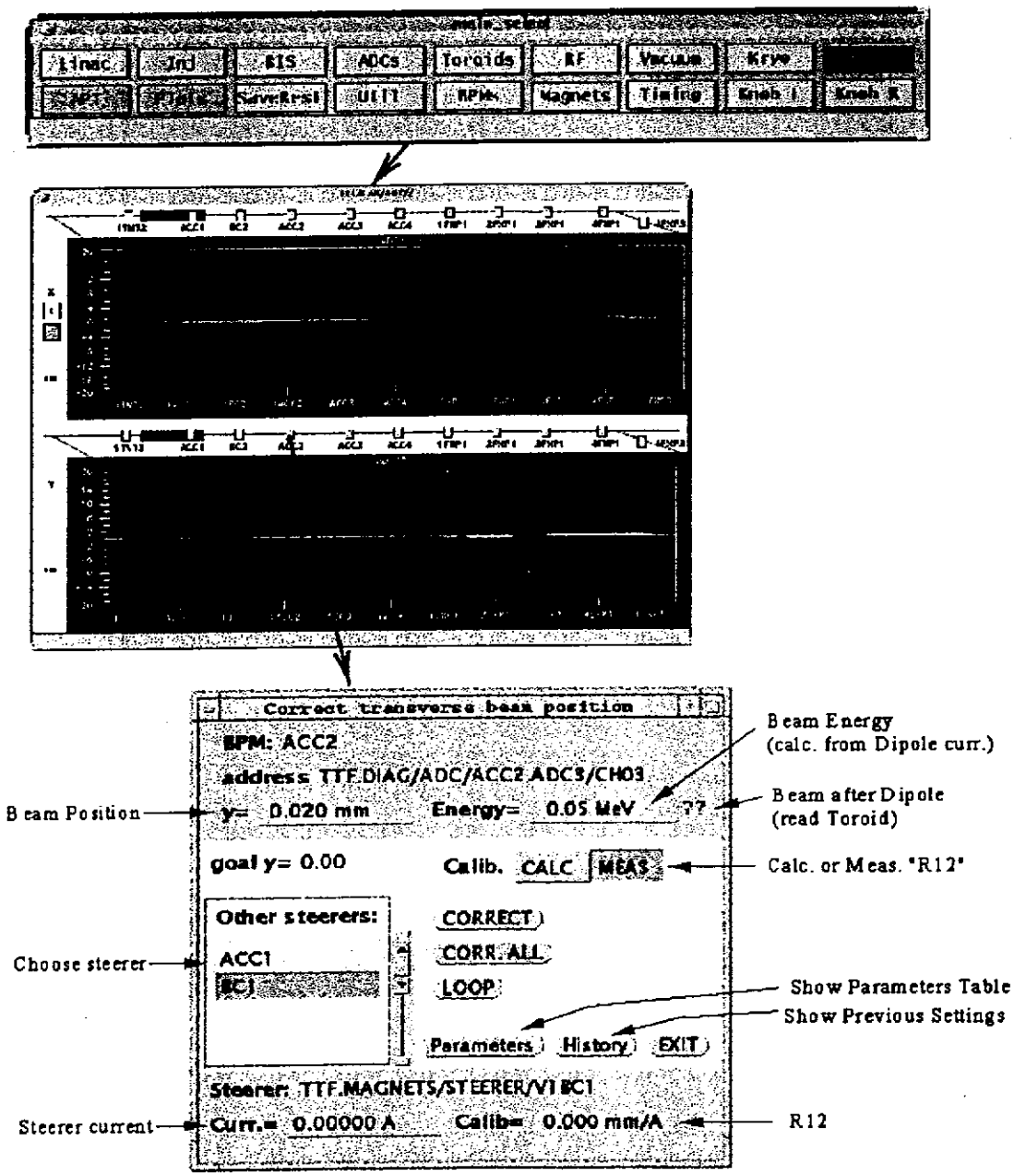
Fast diff. protection (FDP) 2 toroid signals are sampled at 100 kHz. If difference between corresponding samples is greater than 500 μA 3 consecutive times, a trip signal is delivered to the gun electronics

Slow diff. protection Signals in comparison are integrated. Then, if the difference is greater than 100 μA x 8, a trip signal is delivered to the B.I.S.

	FDP	SDP
Max. loss/pulse	20 μs x 8 mA ↓ 160 nC	800 μs x 0.1 mA ↓ 80 nC

Computer aided BPM correction

(program developed by P. Castro)



CORRECT: steer the beam to the center of the BPM (or to goal position)

CORR.ALL: steer the beam to the center of BPMs: ACC2, ACC3 and ACC4

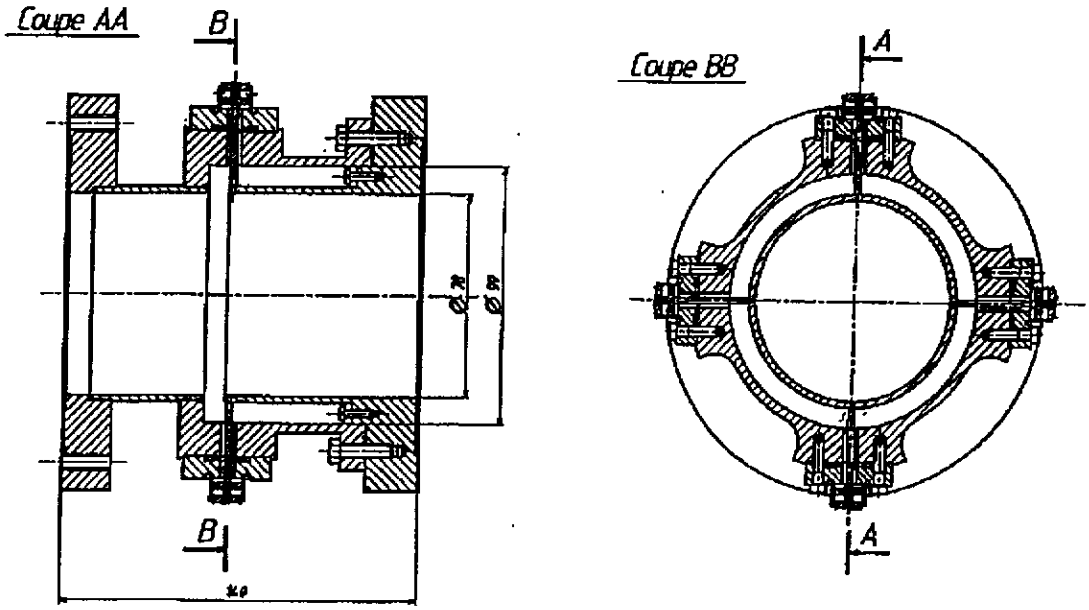
LOOP: keep beam position at the center of the BPM (or at goal position)

Typical accelerating gradients in TTF

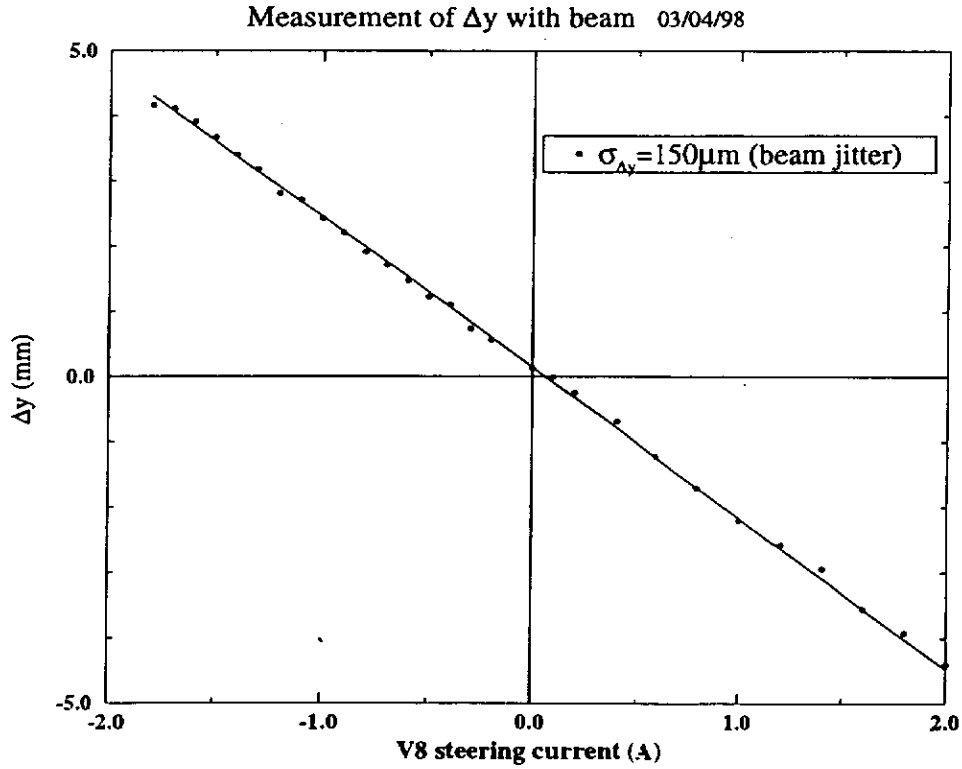
		Final beam energy
Capture Cavity		
• Standard gradient :	11 MV/m	10 MeV
• Maximum gradient :	14 MV/m	
limited by klystron power and FE		
Module #1		
• Standard gradient for short pulse mode :	12 MV/m	102 MeV
• Standard gradient for 800 μs pulse mode :	10 MV/m	92 MeV
• Maximum gradient with a 300 μs long pulse :	15.5 MV/m	
limited by arc detection in Coupler of Cavity 3		

Further tests for maximum gradients in the module are to be made

REENTRANT CAVITY BPM



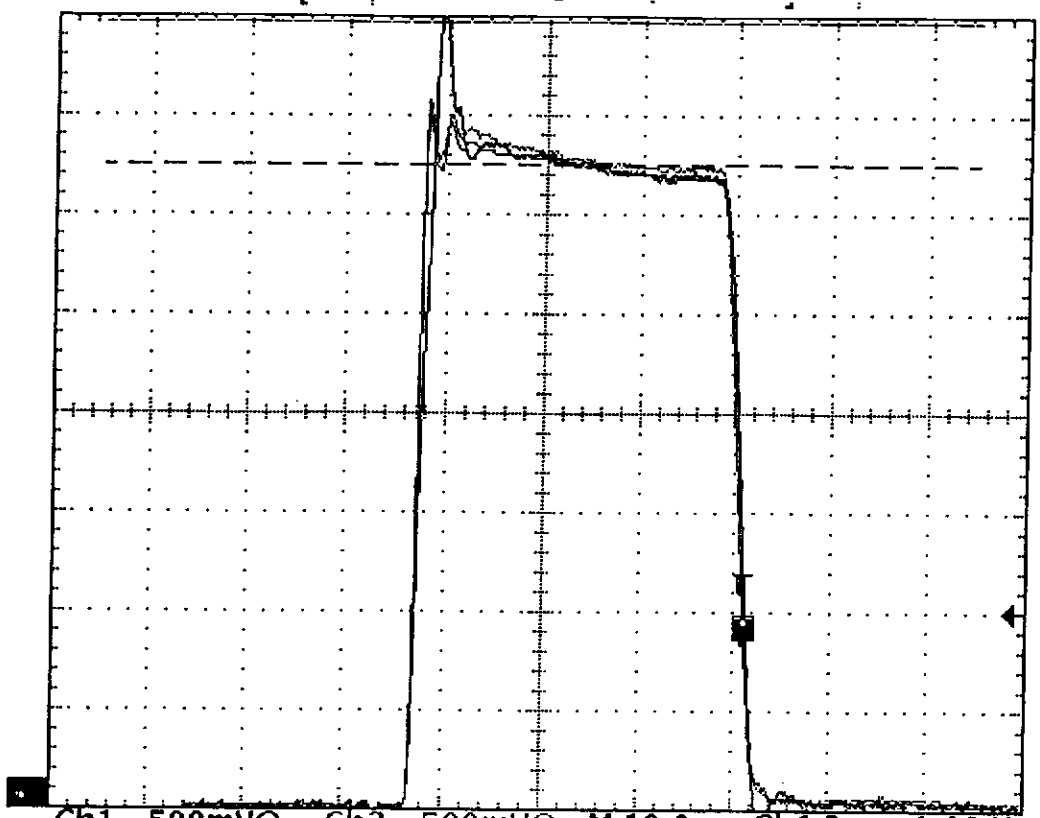
Resolution for Ibeam = 8mA (injector 1) : 10 μm



(sector 600, 8mA, 10Hz, 35ms, beam size : $\sigma_x = \sigma_y = 3$mm.)

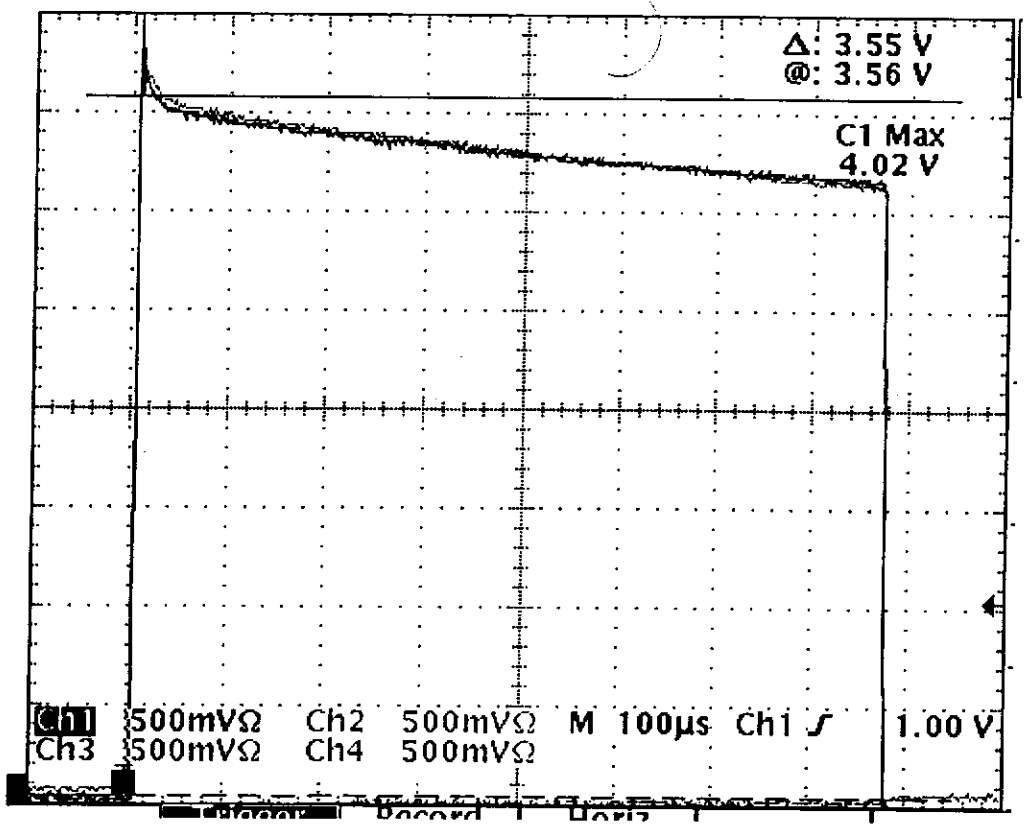
Expected resolution for 8 nC/bunch (injector 2) : 700 nm.

New Injector #1 run



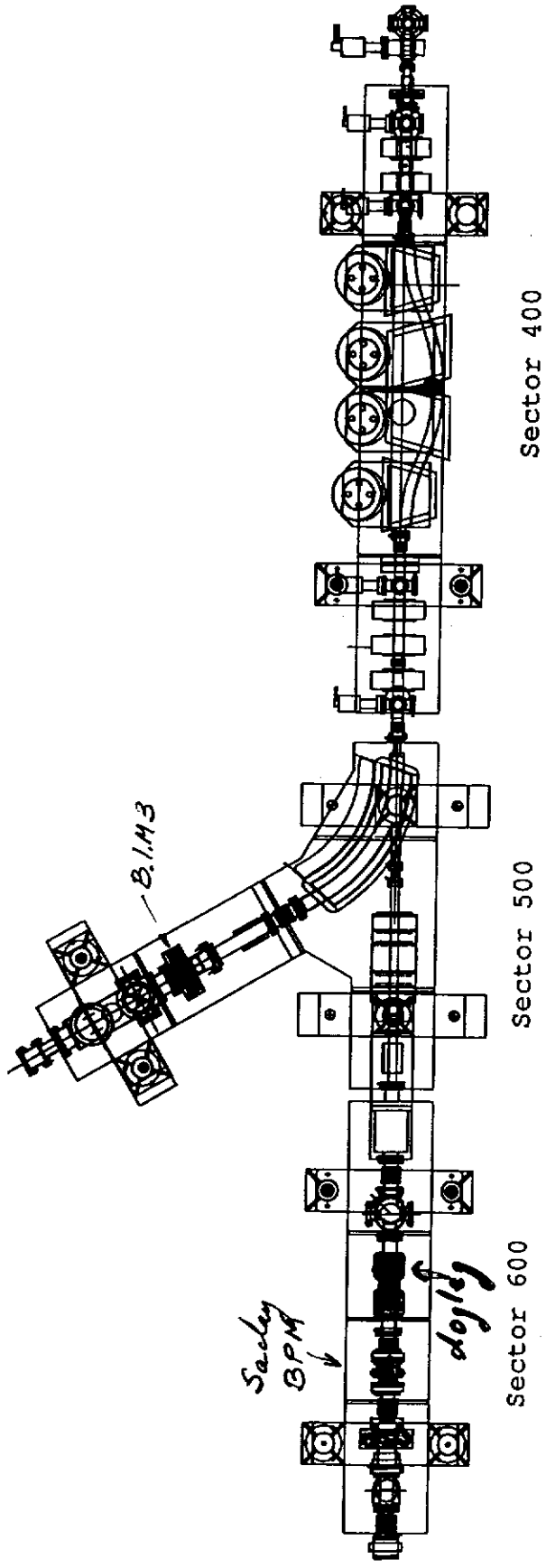
7mA

30µs



7mA

800µs


Sector 400
Sector 500
Sector 600
B.1.43
Saclay BPM
doyley

Results from Injector #1 Operation

1- 100% transmission in Analyzing line thanks to

- Moving upstream of BIM #3 toroid
- Better control on beam loading compensation in SHB
- New cathode

2- 8 mA, 800 μs in Analyzing line
Consequence of 1

3- Instability reduced in SHB
Unbalanced mechanical tuners (manual and automatic) caused transverse unstability

4- Bunch length has been optimized and measured
σ_{Tbunch} = 1.5 ps therefore σ_{ϕ}=0.7 ° as PARMELA prediction

5- Beam (30 μs pulse) was transmitted through linac without RF
This was an unexpected experiment : RF in Linac was erroneously timed 100 μs too late. 100% transmission through the module however was obtained quite easily.

Changes on the Injector #1

1- "Fermilab" beamline replaced old sector 400

- Chicane not yet in place
- New power supplies and control
- Problem with viewscreens has been solved solved

2- New cathode

Apparently longer lifetime may be due to

- Vacuum procedure used for mounting and pumping(J-M Joly et. al)
- Precautions in operation

3- New board for bunch frequency

- Suppression of "intermediate" bunch frequencies
- 1 MHz bunch available (T. Krzywinski et al. experiment)

4- In sector 500, toroid moved upstream

Facilitates transmission without reducing machine protection

5-In sector 500 viewscreen ceramic changed

Dispersed beam image now available. Still too remnant

6- Timing reorganized

One unique slider (TIMING_INJ1_PRECURSOR) permits to shift in time all injector sub-assemblies in preserving "internal" adjustments (Gun, SHB, Capture cavity LLRF and modulator, diagnostics)

7- Modification of SEM grid electronics

Acquisition of negative signals made possible. Problems remain thought to be due to reflected electrons from beam dump, too close

TTF activities since last meeting

Last meeting was held in week #11, i.e. 16 weeks until now. How has this period of time been used ?

2 weeks delay due to leak in Module #1 between cavity and isolation vacuums

3 weeks shutdown (in April) for He tubing modification, viewscreen correction in Fermilab beamline, Saclay BPM displacement....

2 weeks for injector "re-commissioning", long pulse beam tests and Saclay BPM tests

1 week for "RF steering" experiment and bunch train modulation test

1 week for "Linac long pulse" experiment and Desy RF gun installation in tunnel

1 week for OTR experiments (M. Castellano)

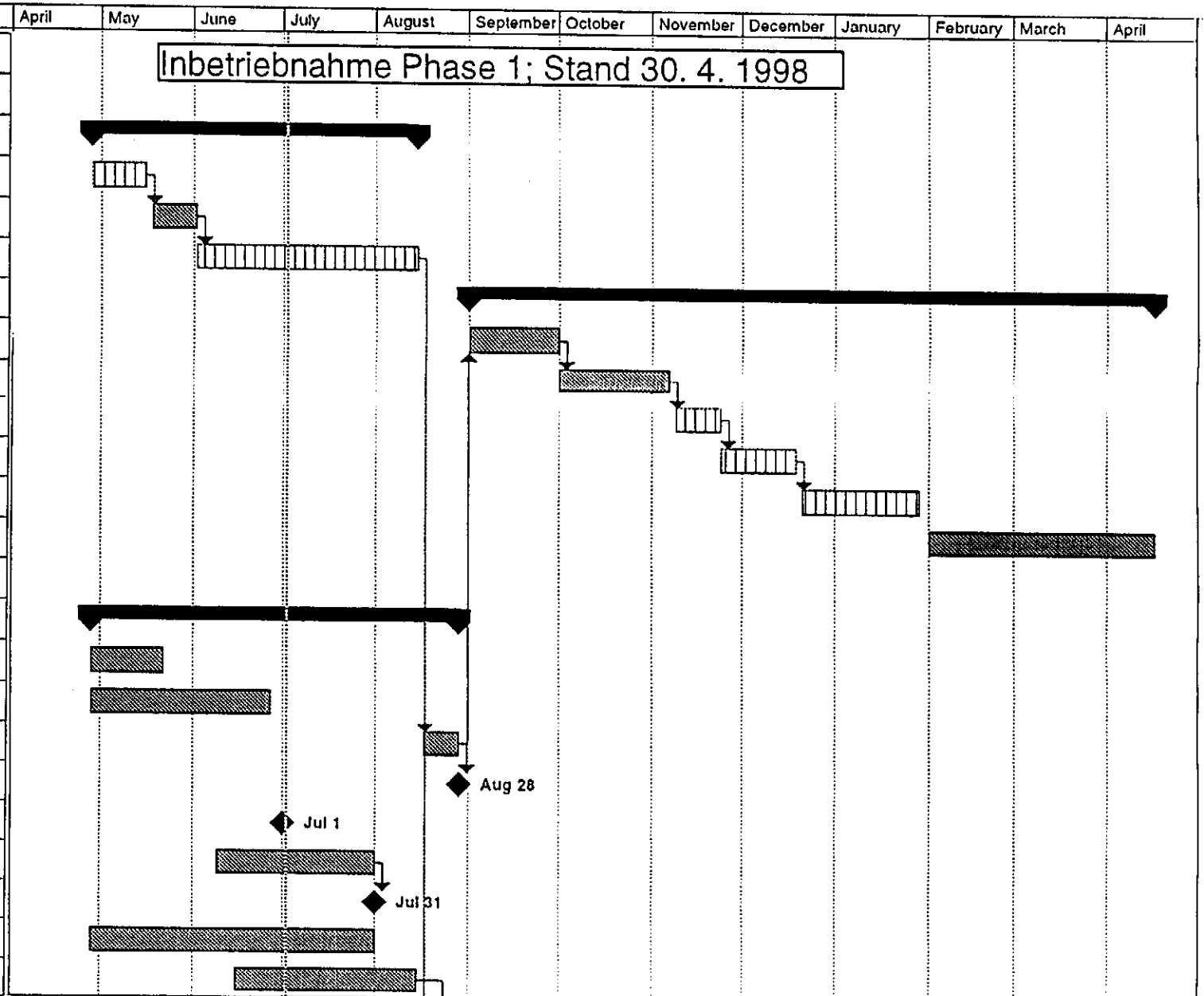
Therefore 6 weeks remain that have been used (or partly lost) for

- bunch length measurements, transverse phase space tomography
- search for "stable beam optics"
- RF tests
- breakdowns

H. Weise

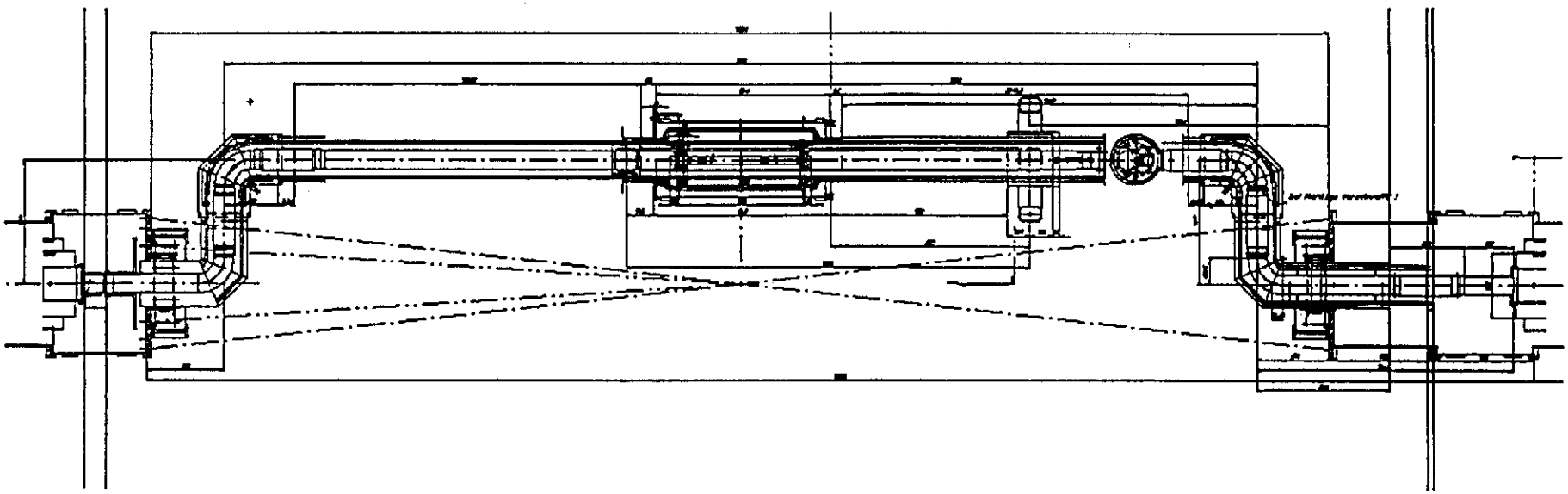
Further Installation (Phase 1)

ID	Task Name
1	
2	
3	TESLA Module #1
4	beam operation
5	cryogenic shutdown
6	beam operation
7	TESLA Modules #2 and #3
8	installation cryo bypass
9	intallation module #2
10	cryog.commissioning
11	rf commissioning
12	beam operation mod.#1&2
13	installation module #3
14	
15	Bunch Compressor 2
16	check dipole magnets
17	construction of supports
18	disassemble temp.beamline
19	magnets are installed
20	magnet power supplies ready
21	beam diagnostics -> clean room
22	beam diagn. ready for inst.
23	construction of vac. chambers
24	vac.chambers -> clean room



Bunchcompressor-Bypass-Transferline

Feedcap Modul 2 | 2 phase flow Testsection | Endcap Modul 1



Status: Design: work is in progress for the last piping and shield drawings of the module connections

fabrication of parts: most parts for the transferline section are delivered
the last parts for the module connections are expected to be ready till the middle of august

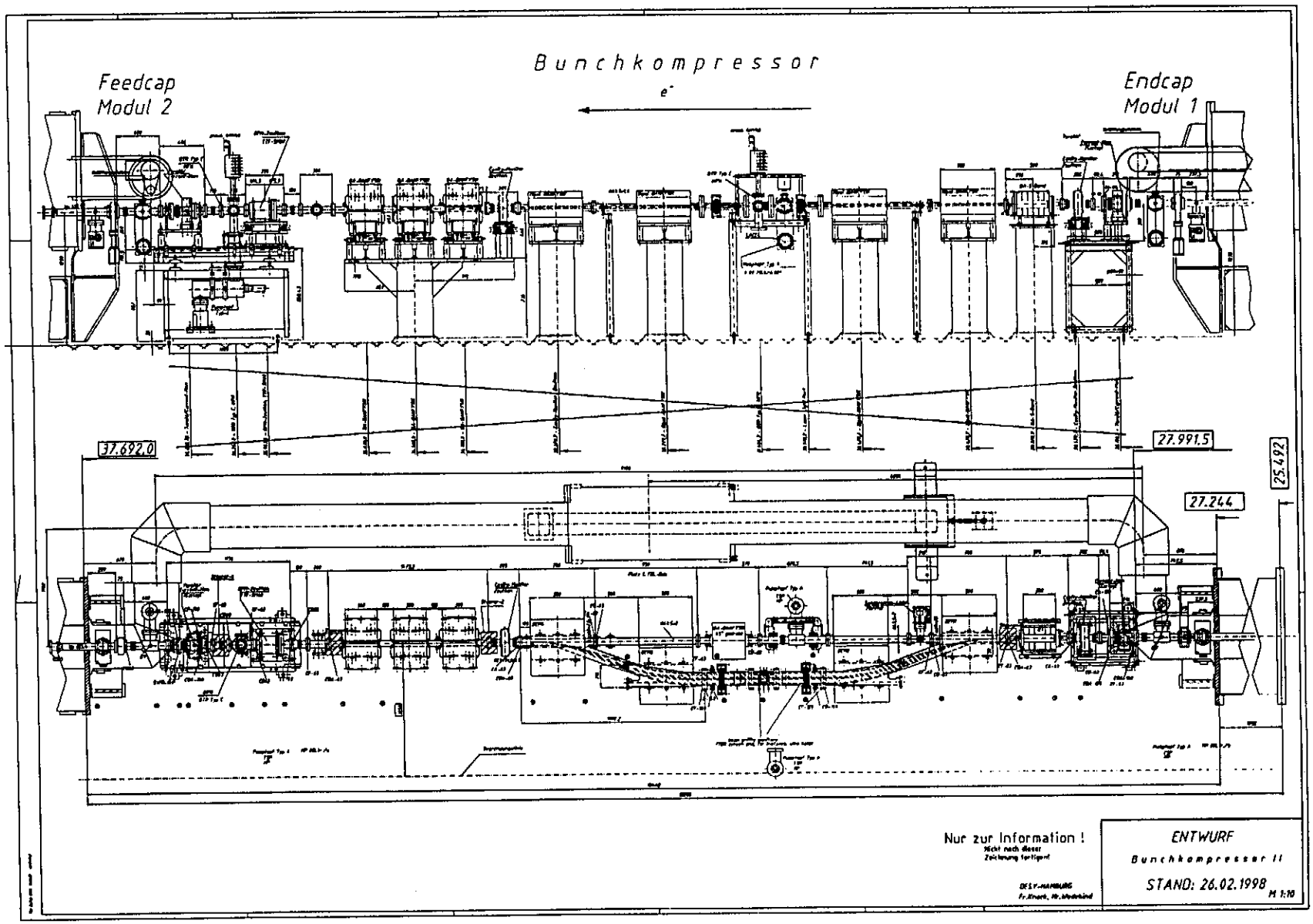
assembly: the straight line with the testsection is actually constructed

completion date: as scheduled 18.9.98

Bunch Compressor II Component Status

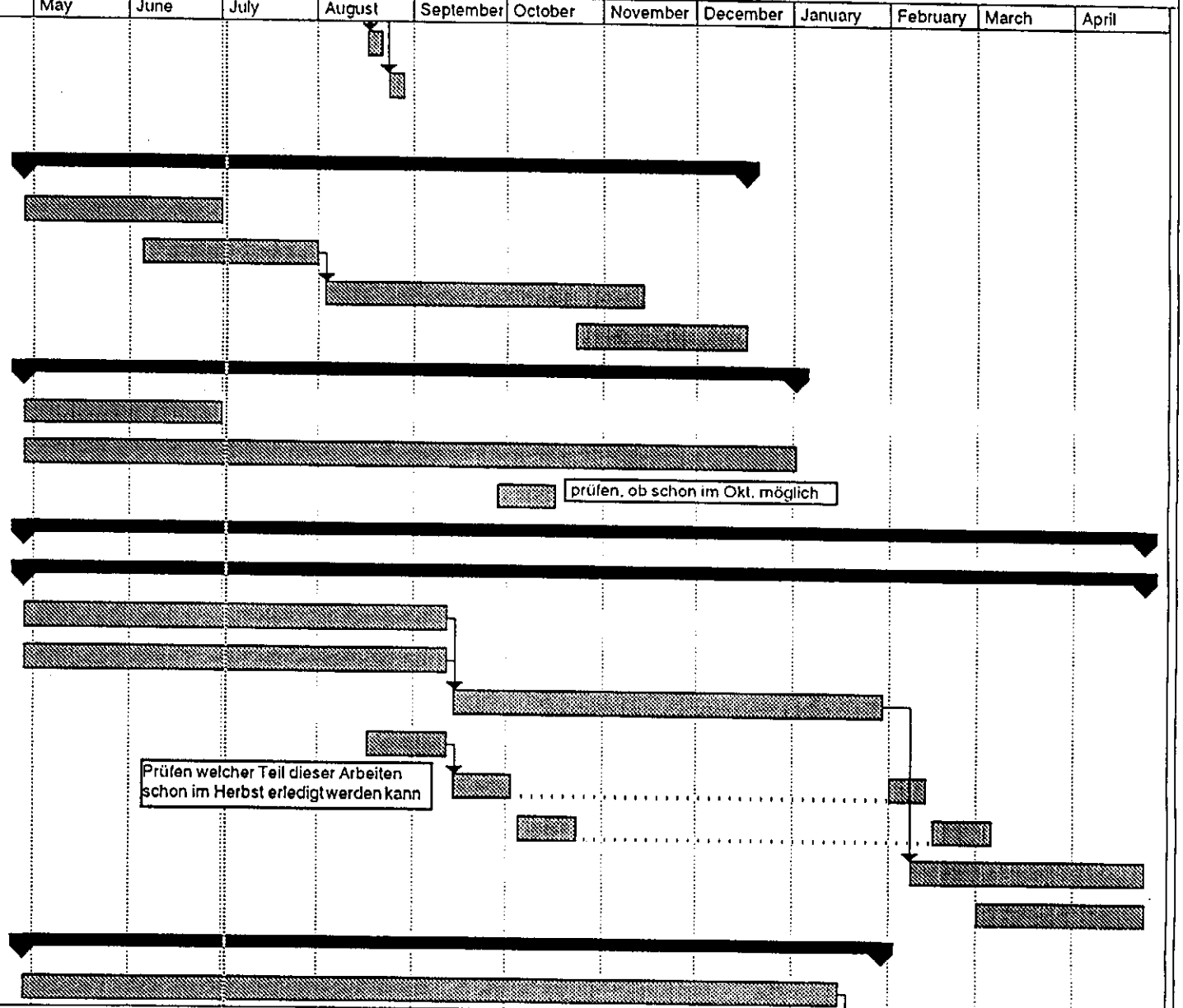
July 2, 1998

- Vacuum Chambers
  - Dispersive section: delivered 1st week of July, final assembly will be finished last week of August
  - OTR chamber: manufacturing started, finished last week of August
  - Standard chambers: in-house manufacturing, finished 1st week of August
  - Special bellows dispersive section: ✔
- Magnets
  - Bending dipoles: ✔, measuring partially done
  - Quad Triplets: upstream: ✔, downstream: available when rebuilding section and inserting module #2
  - Steerers: ✔
- Power supplies
  - Dipoles: ✔
  - Quads: ✔or will become available
  - Steerers: finished end of July
- Instrumentation
  - Toroids: ✔
  - Cavity BPMs: have been delivered, final assembly until mid of August
  - OTRs: components will be delivered end of July, final assembly until mid of August

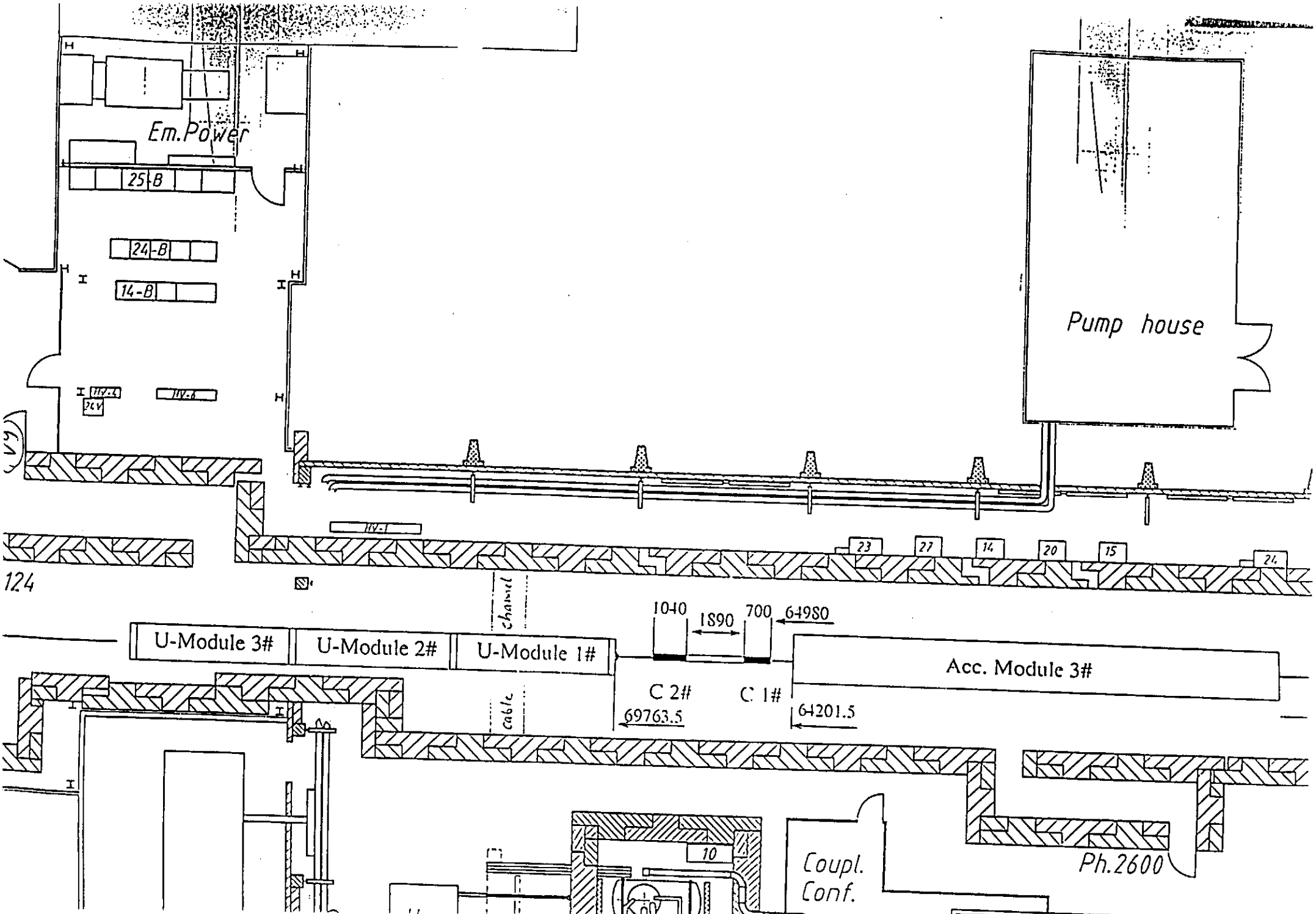

Bunchkompressor
e⁻
Feedcap
Modul 2
Endcap
Modul 1
37.692.0
27.991.5
27.244
25.492
Nur zur Information !
Nicht nach dieser
Zeichnung fertigen!
DESY-HAMBURG
ENTWURF
Bunchkompressor II
STAND: 26.02.1998
M 1:10

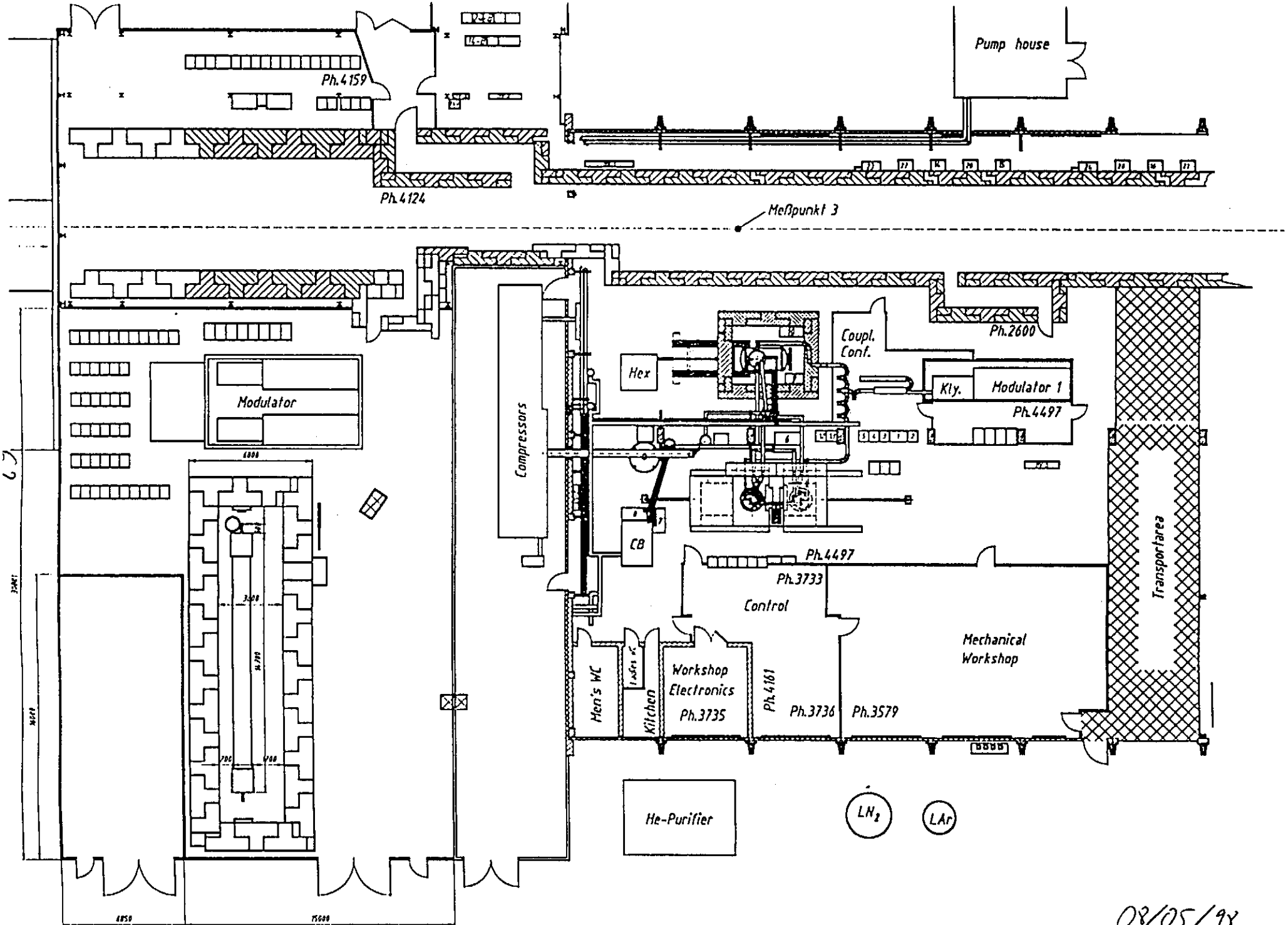
Inbetriebnahme Phase 1; Stand 30. 4. 1998

ID	Task Name
25	installation of magnets
26	intsllation of vacuum chambers
27	
28	Collimator
29	design
30	prep. of construction
31	construction
32	cleaning
33	Undulator Beamline
34	design beamline
35	design/constr./cleaning of comp.
36	modification TTFL shielding
37	Undulator
38	undulator modules 1 - 3
39	construction of und.mechanics
40	constr. of magnet structures
41	measurement magnetic field
42	cabling / water tubing
43	installation of air cond.room
44	cabling / water tubing
45	installation of modules
46	finish cabling / water
47	undulator vacuum chamb.
48	constr. incl. BPMs / steering coil

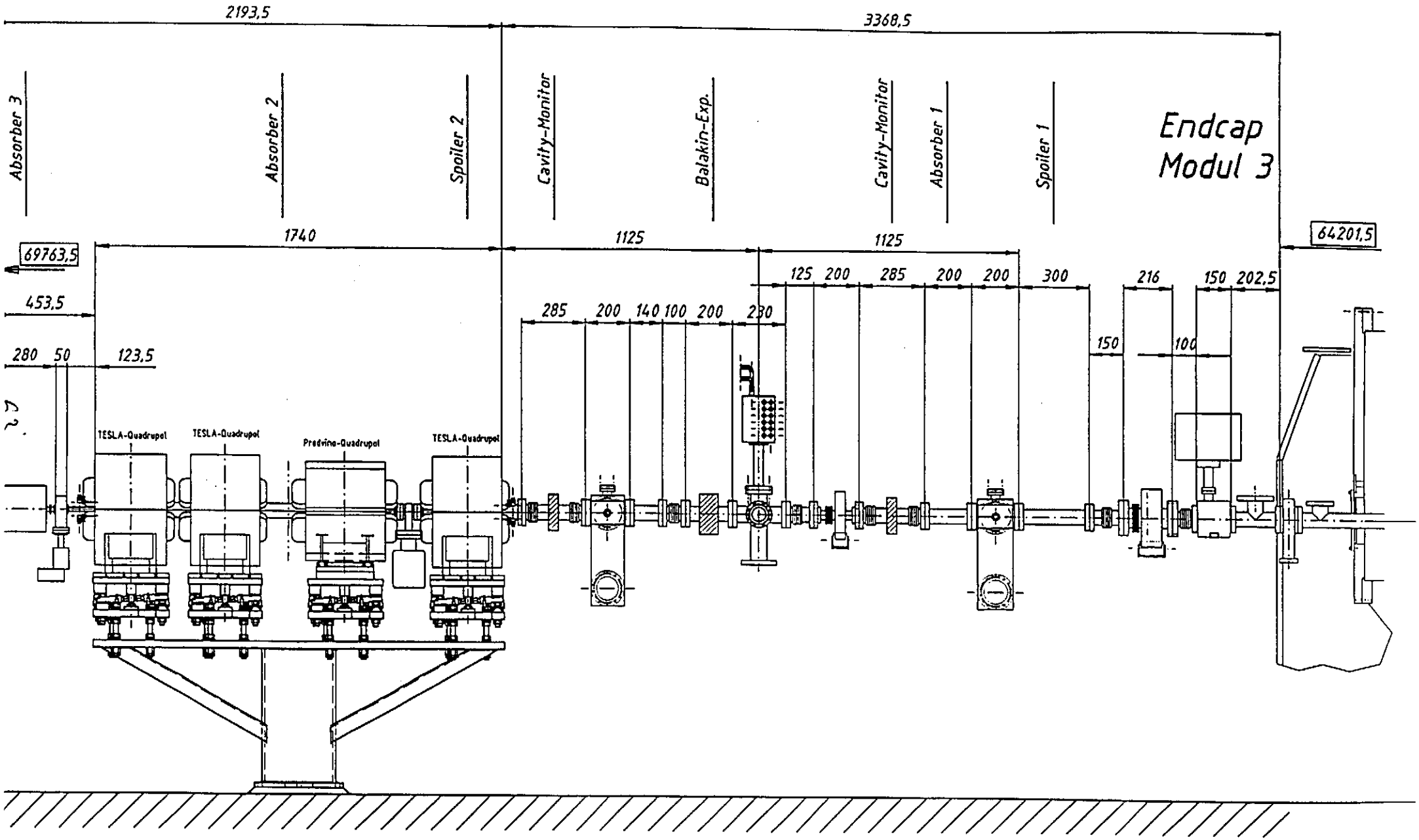


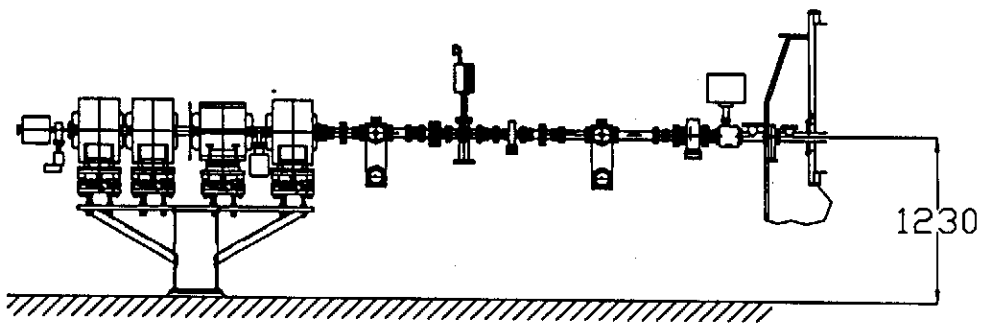
09


Em.Power
25-B
24-B
14-B
Pump house
124
23
27
14
20
15
24
chanel
1040
1890
700
64980
U-Module 3#
U-Module 2#
U-Module 1#
Acc. Module 3#
C 2#
C 1#
69763.5
64201.5
cable
10
Coupl.
Conf.
Ph.2600

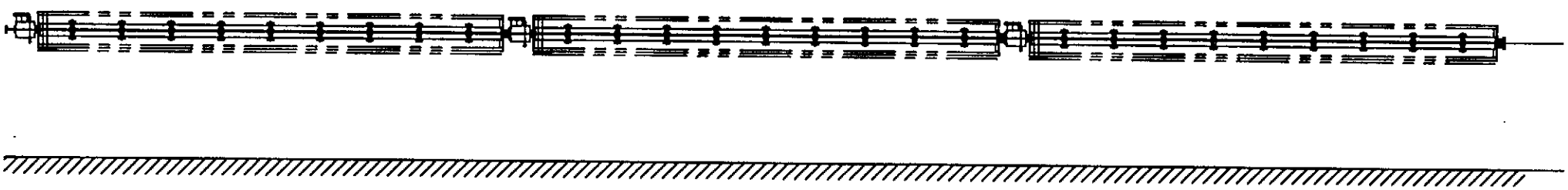

Pump house
Ph.4159
Ph.4124
Meßpunkt 3
Modulator
Compressors
Hex
Coupl. Conf.
Ph.2600
Kly.
Modulator 1
Ph.4497
CB
Ph.4497
Ph.3733
Control
Mechanical Workshop
Transportarea
Men's WC
Kitchen
Workshop Electronics
Ph.3735
Ph.4161
Ph.3736
Ph.3579
He-Purifier
LN2
LAr

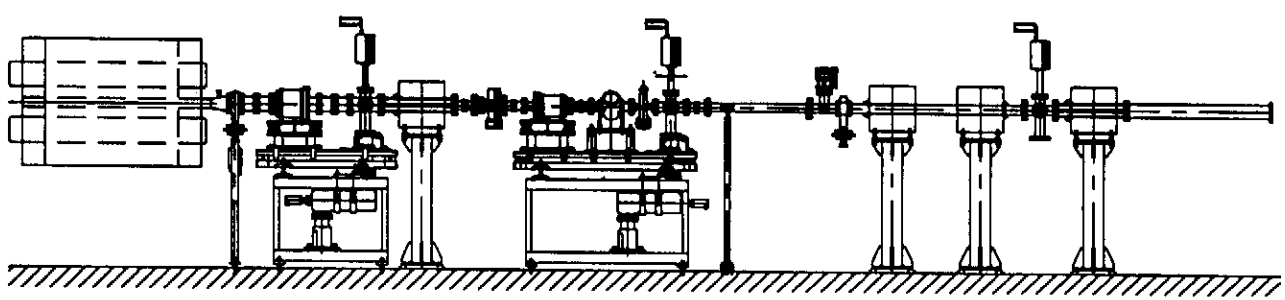
08/05/98

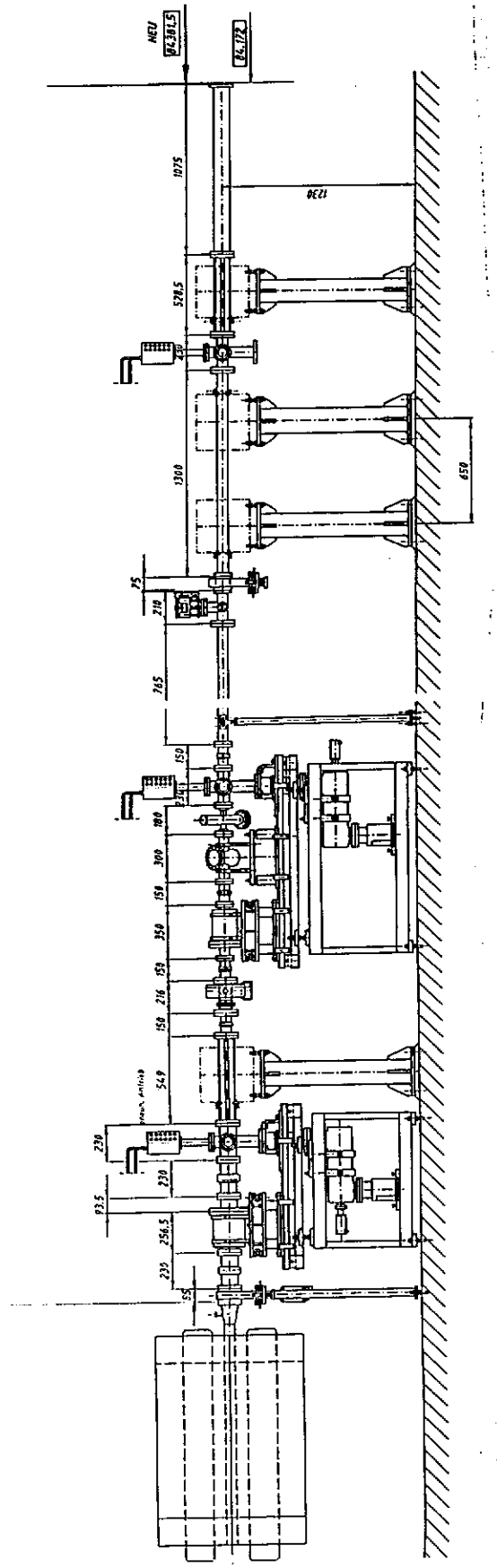

2193,5
3368,5
Absorber 3
Absorber 2
Spoiler 2
Cavity-Monitor
Balakin-Exp.
Cavity-Monitor
Absorber 1
Spoiler 1
Endcap
Modul 3
69763,5
64201,5
1740
1125
1125
453,5
280
50
123,5
285
200
140
100
200
230
125
200
285
200
200
300
150
216
100
150
202,5
TESLA-Quadrupol
TESLA-Quadrupol
Predvino-Quadrupol
TESLA-Quadrupol



Strahlrichtung

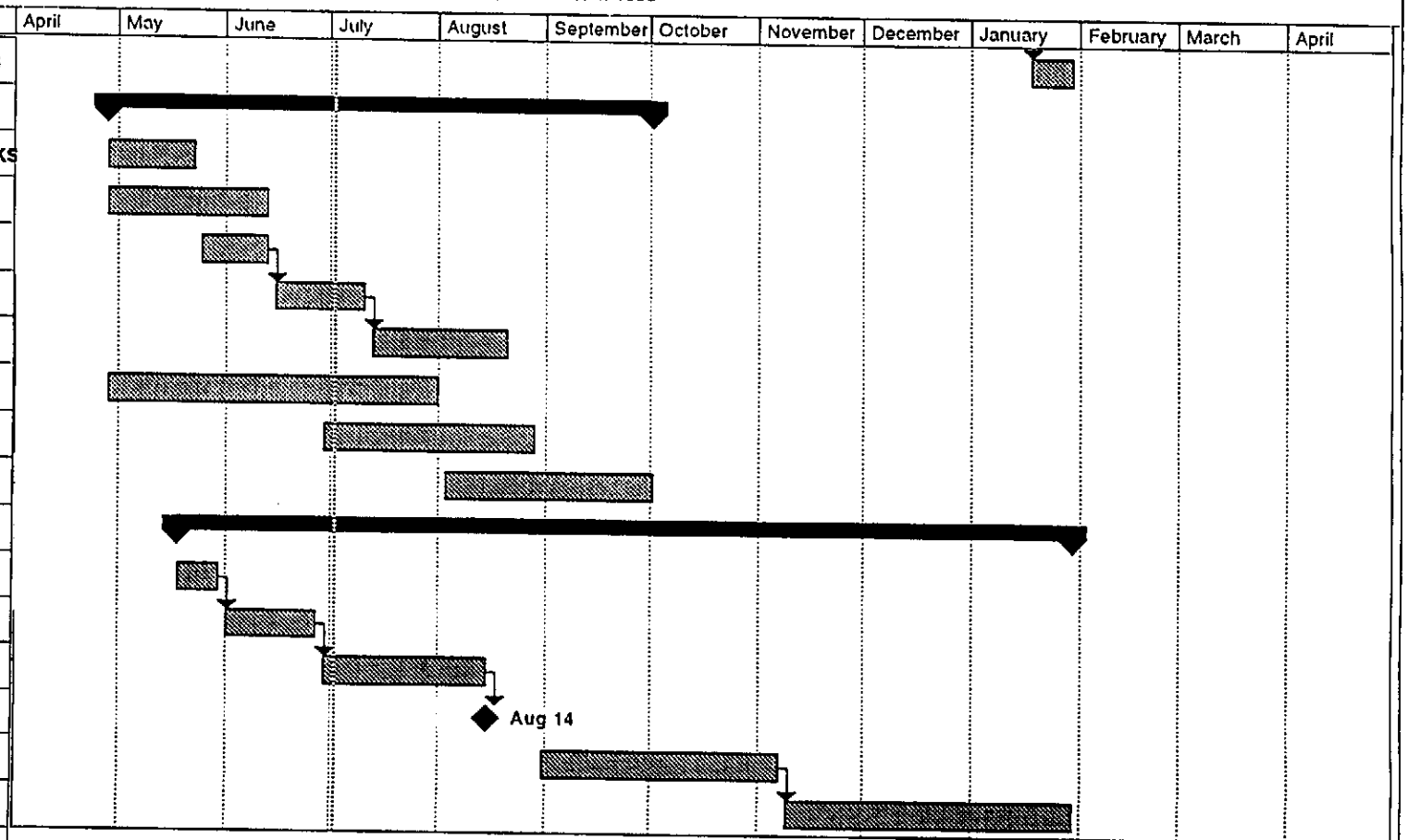





NEU
84.381.5
84.172
1075
1230
528.5
1300
650
75
210
265
150
180
300
150
350
150
216
150
549
230
230
93.5
256.5
230

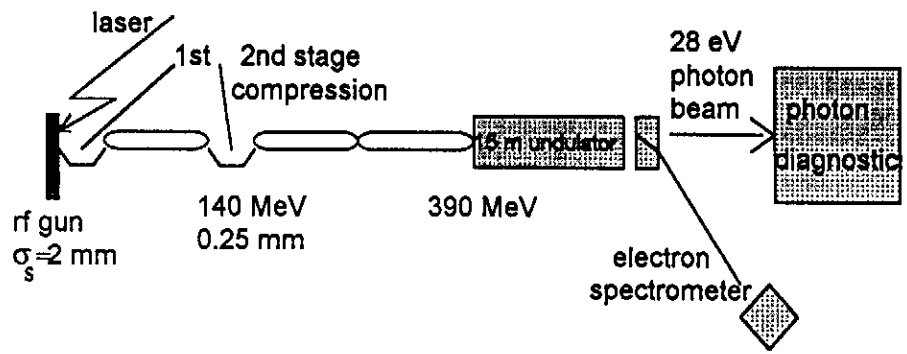
Inbetriebnahme Phase 1: Stand 30. 4. 1998

ID	Task Name
49	intsllation of vacuum chambers
50	diagnostics
51	constr. supports diagnost.blocks
52	constr. of 4 diagn.blocks
53	constr. of cavity BPMs
54	installation of cavity BPMs
55	cleaning
56	constr. of wire scanners
57	cleaning of wire scanners
58	alignment
59	Photoinjectors
60	installation of test beam line
61	conditioning rf gun
62	operation test beam line
63	ovaluation of both rf guns
64	installation injector II
65	operation injector II

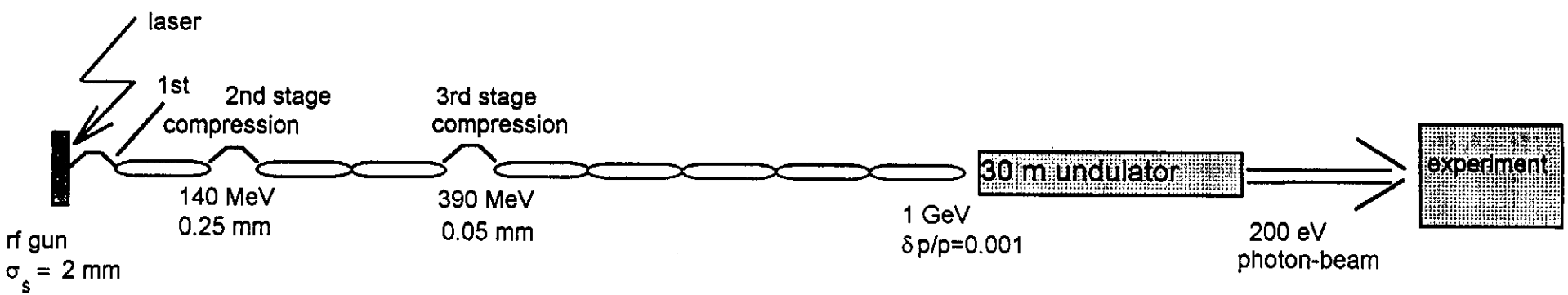


J. Rossbach

Installations for Phase II



Phase 1 of the TTF Free Electron Laser



Phase 2 of the FEL facility based on the TESLA Test Facility including the energy upgrade to 1 GeV (assuming 15 MV/m). The bunch length is reduced from 2mm to 50μm within three steps of bunch compression. The over-all length is approx. 300 meters.

Objectives

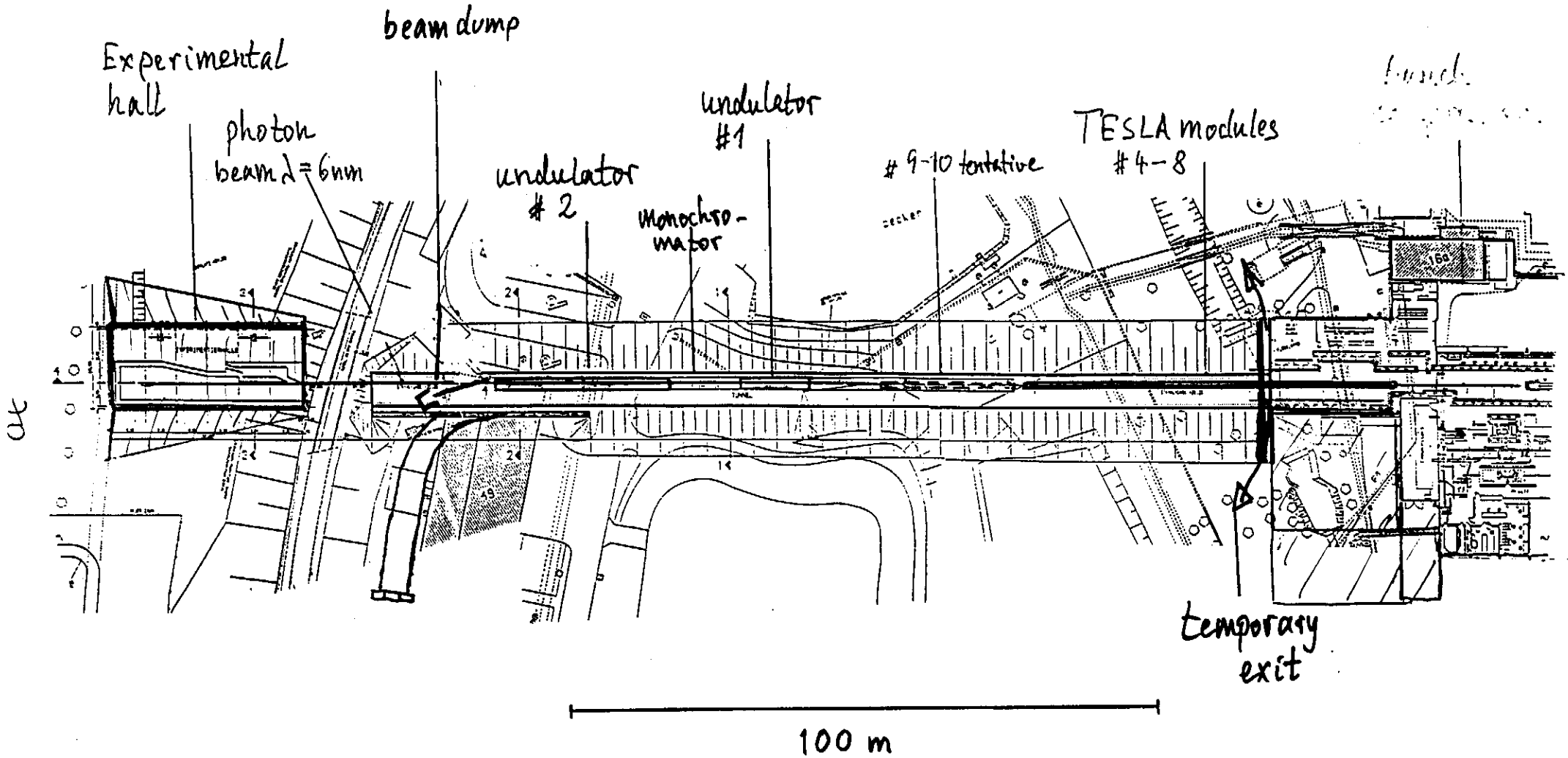
PHASE 1:

- Proof of the Self Amplified Spontaneous Emission (SASE) principle for single Pass FELs in the wavelength regime $\lambda < 100$ nm

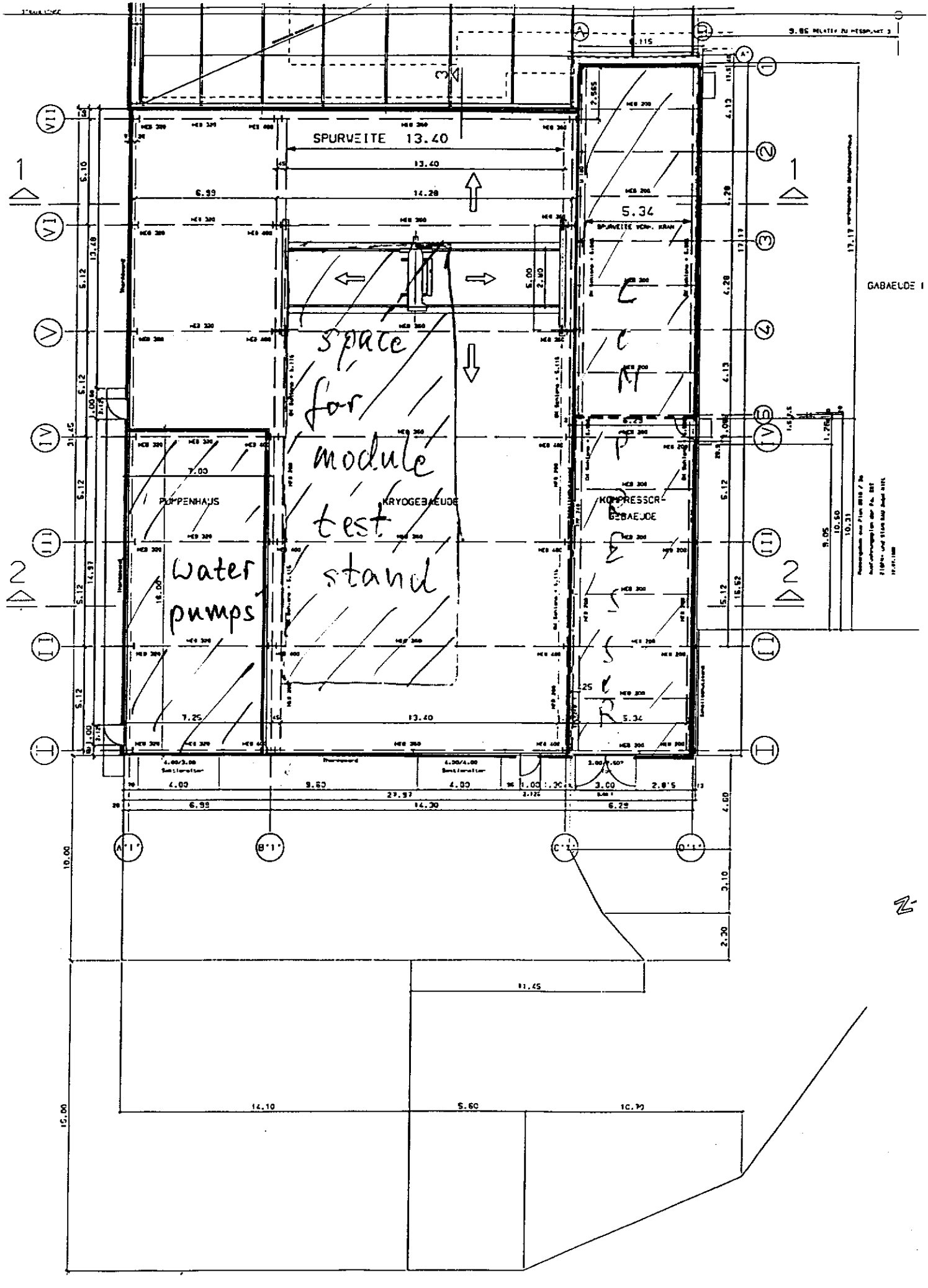
- Development of required accelerator technology

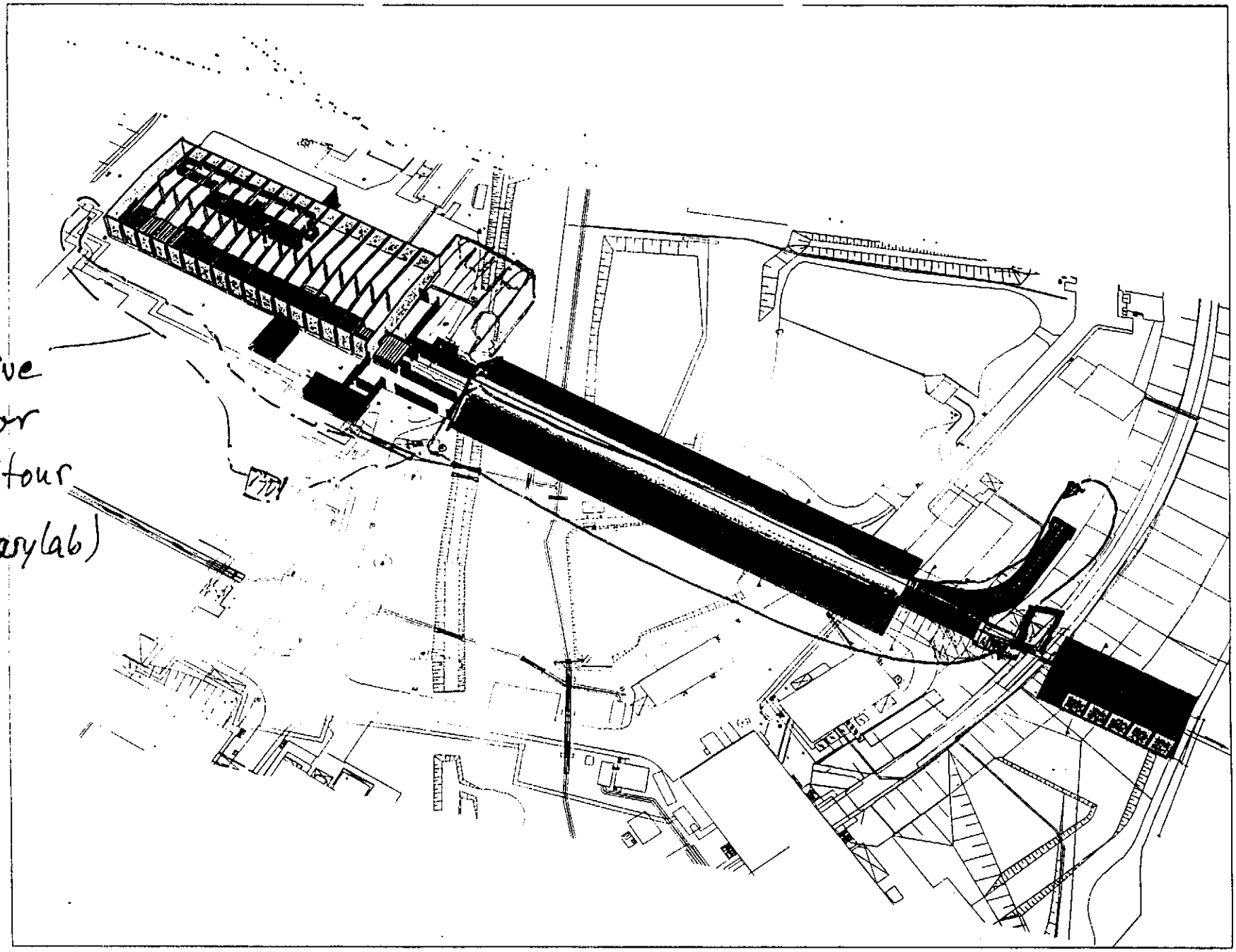
PHASE 2:

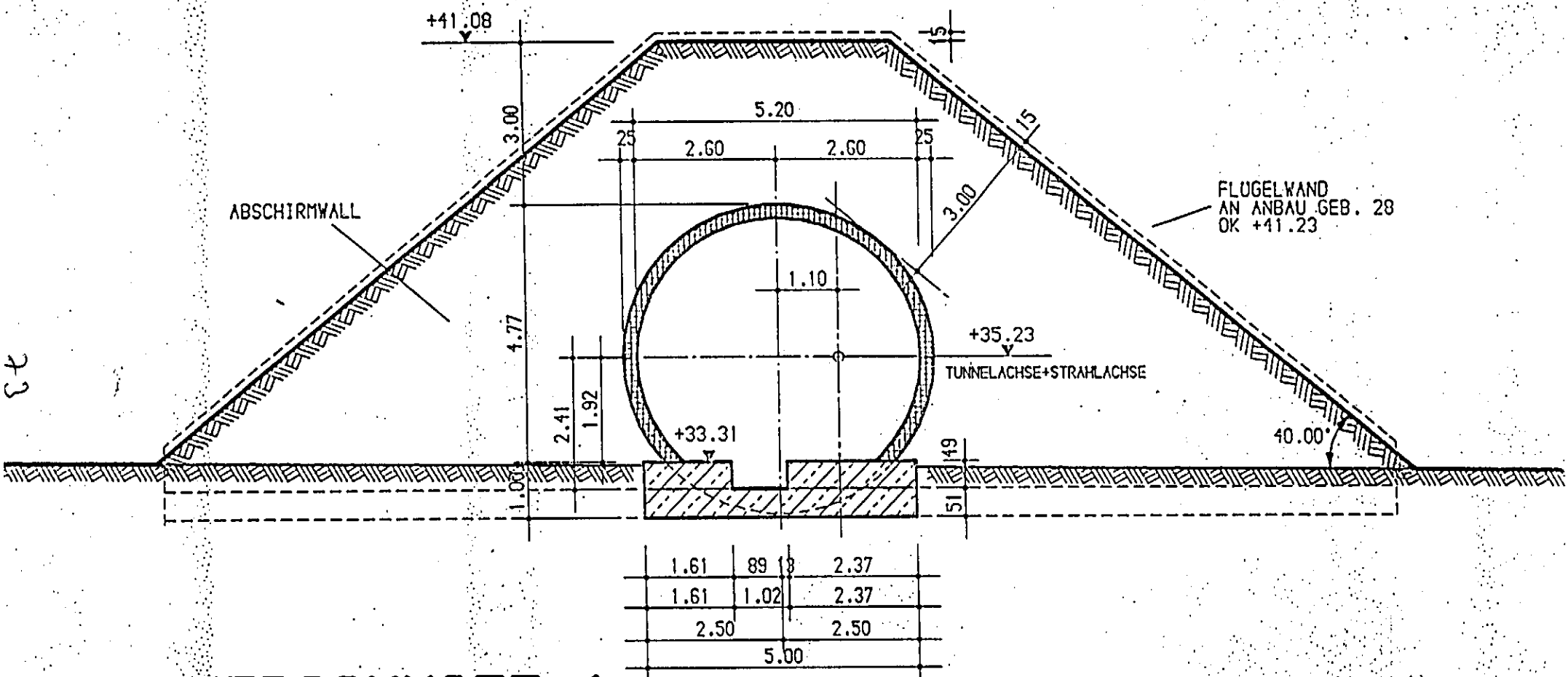
Installation of an FEL User Facility at $\lambda = 6$ nm



TTF FEL : Extension for Phase 2


SPURWEITE 13.40
13.40
14.28
6.99
5.34
GABAEUDE I
space for module test stand
water pumps
PUMPENHAUS
KRYOGEBAEUDE
KOMPRESSOR-GEBAEUDE
7.00
7.25
13.40
5.34
27.97
14.30
6.29
11.45
14.10
5.60
10.70

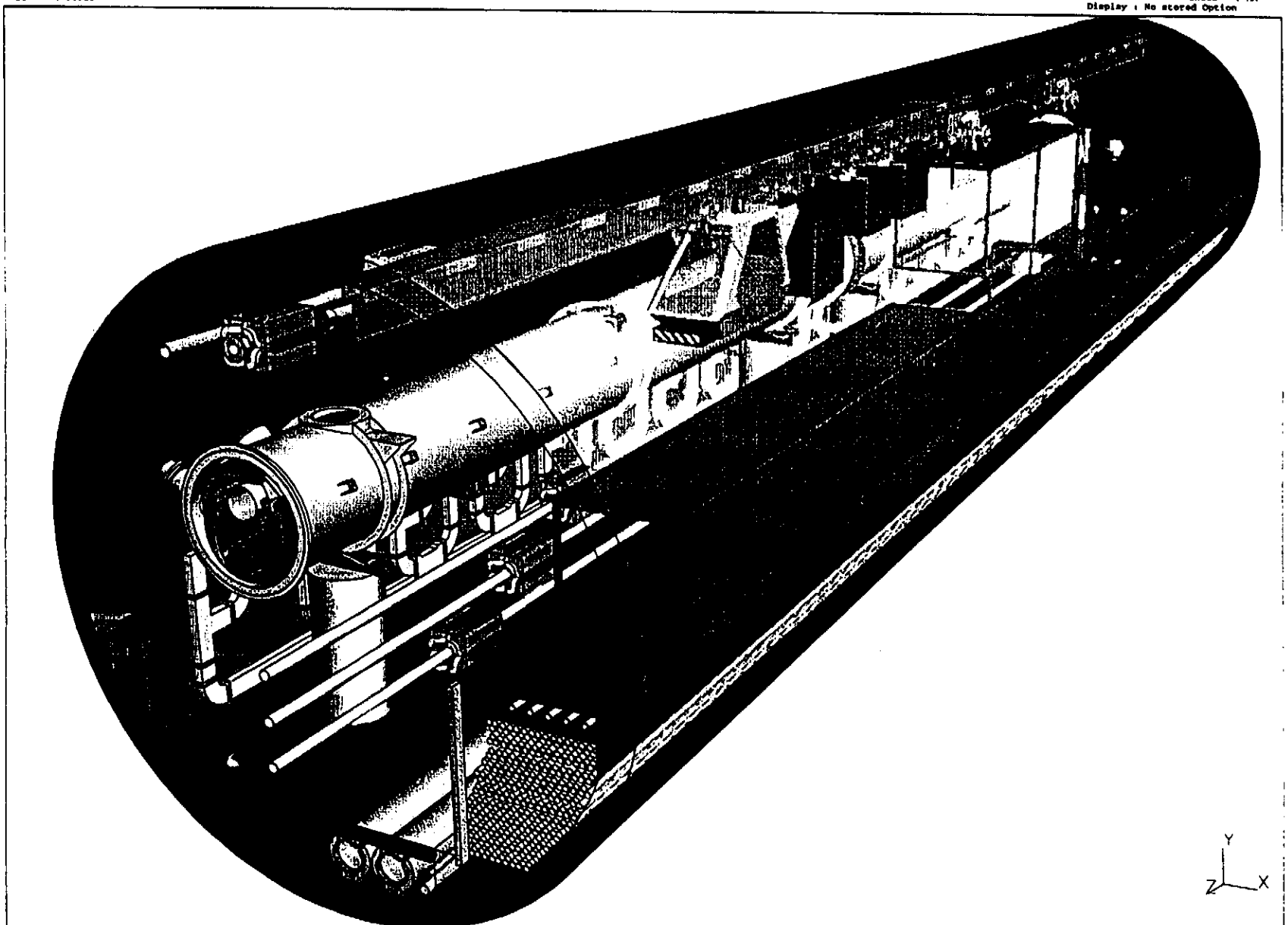

tentative
track for
guided tour
(TTF, Hasylab)



QUERSCHNITT 1

TUNNEL

M 1:100


Y
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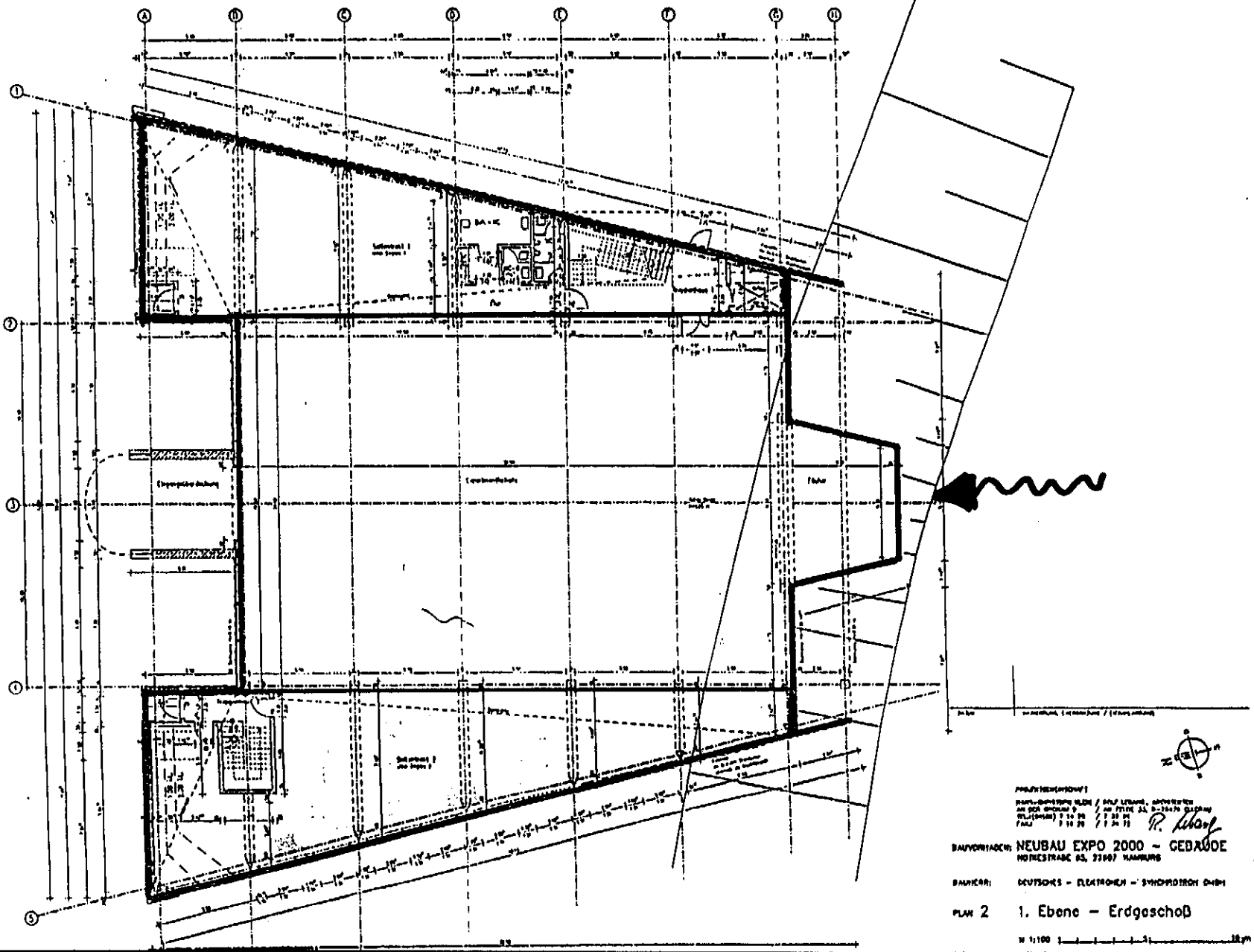
st


BAUVORHABEN: NEUBAU EXPO 2000 – GEBÄUDE
NOTKESTRASSE 85, 22607 HAMBURG
BAUHERR: DEUTSCHES – ELEKTRONEN – SYNCHROTRON GMBH
PLAN 2 1. Ebene – Erdgeschoß

EXPO 2000

date : June 1 - Oct 31 2000

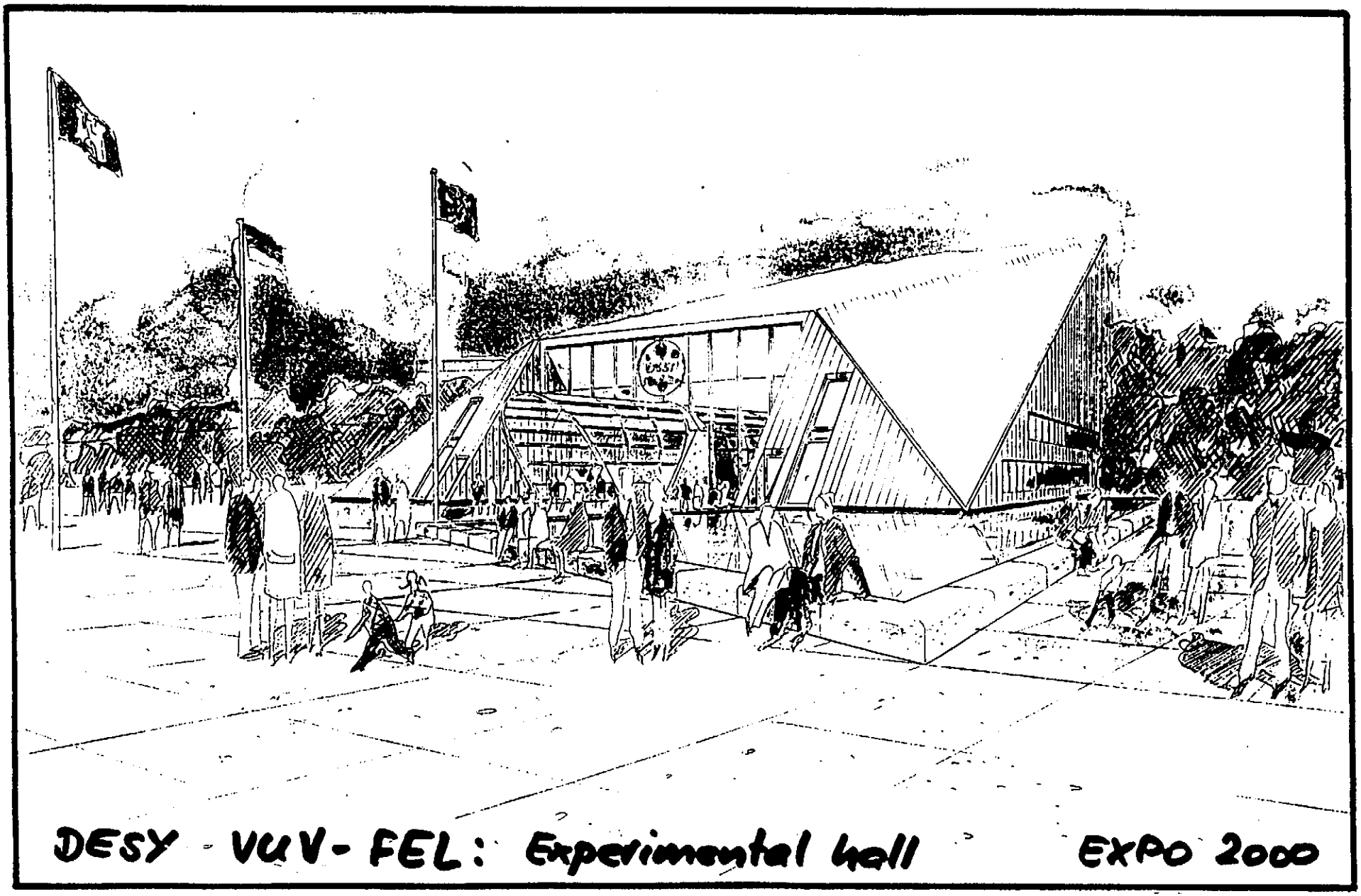
„ Worldwide Project"

= unique, under construction or just finished, not transportable

Hamburg/DESY plan to present:

A superconducting X-ray Laser microscope

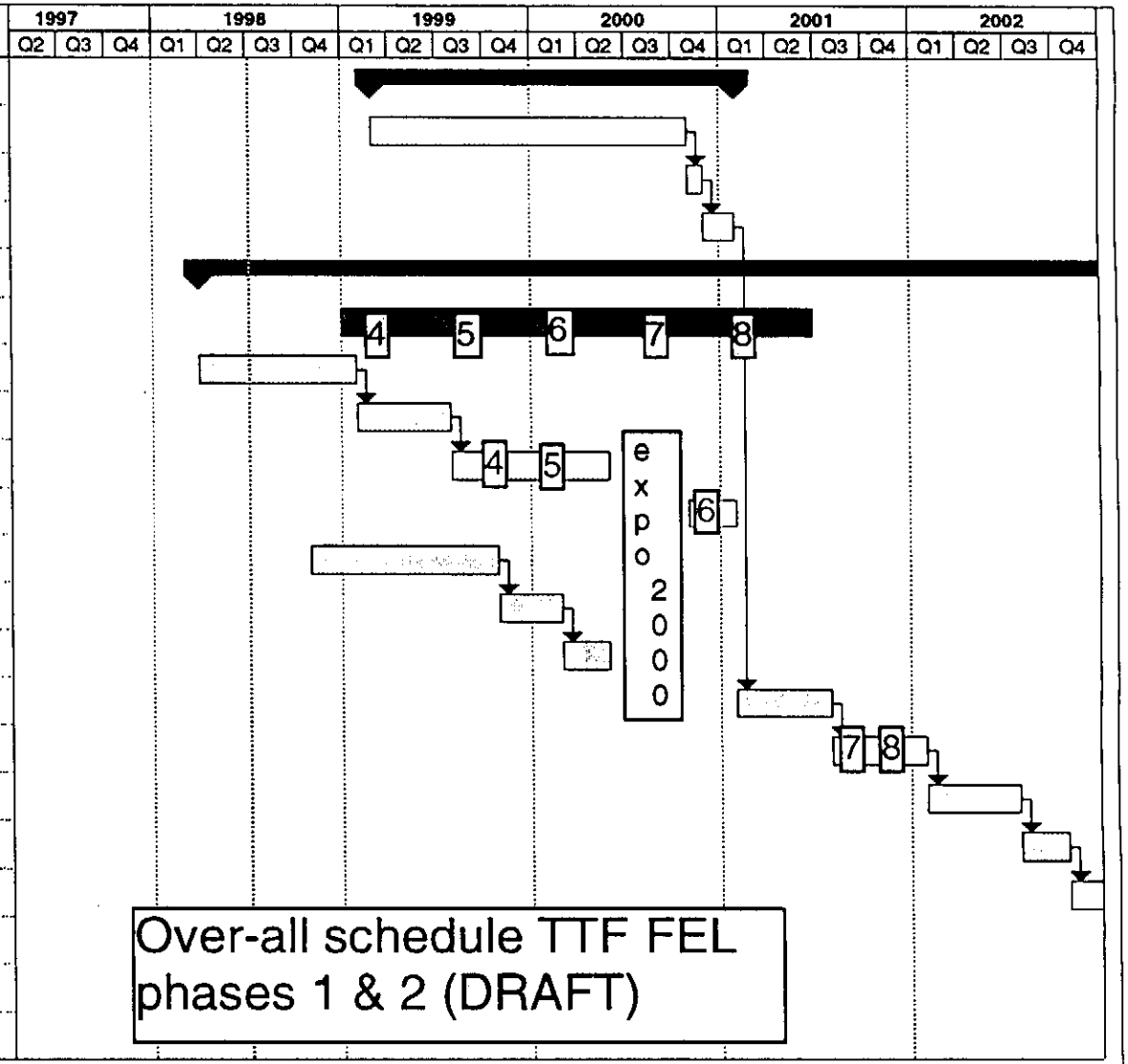
* 500 - 1000 visitors per day
* avoid interference with operation
* demonstrate fascination of accel. techn. and its spectrum of applications
* demonstrate capabilities of DESY and its collaborating institutes


DESY - VUV - FEL: Experimental Hall
EXPO 2000

schedule determined by:

* construction time modules 4 - 8
* operation time TTF/FEL phase 1
* time to connect tunnel to hall III
  + to install components in this area
  assumption: $\frac{1}{2}$ year civ. eng
  $\frac{1}{2}$ year install. modules 7+8
* avoid installation during EXPO 2000

ID	Task Name
1	**FEL PHASE I:**
2	Combined operation TTF with FEL phase 1
3	replace undulator by bunch compressor 3
4	combined operation TTF with BC 3
5	**FEL PHASE II:**
6	fabrication modules 4 - 8
7	construction linac tunnel incl. dump
8	tunnel installations
9	installation modules 4 - 5
10	installation module 6
11	construction experimental hall & aux. bldgs.
12	infrastructure experimental hall
13	
14	connect phase 1 and phase 2 tunnels
15	installation modules 7 + 8
16	linac commissioning at 1 GeV
17	installation undulator & monochromator
18	combined operation TTF with FEL phase 2



Project: PHASE2A
Date: Sun 7/5/98

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress
External Tasks
Project Summary
Split
Rolled Up Split

to be done in 1998:

* civ. eng. tunnel + start exp. hall
* techical design 3rd bunch compressor
* " " spectrometer + dump
* " " monochrom. section (2 stage undulator)
* module 4 : start fabrication cavities
* module 5 : finish design

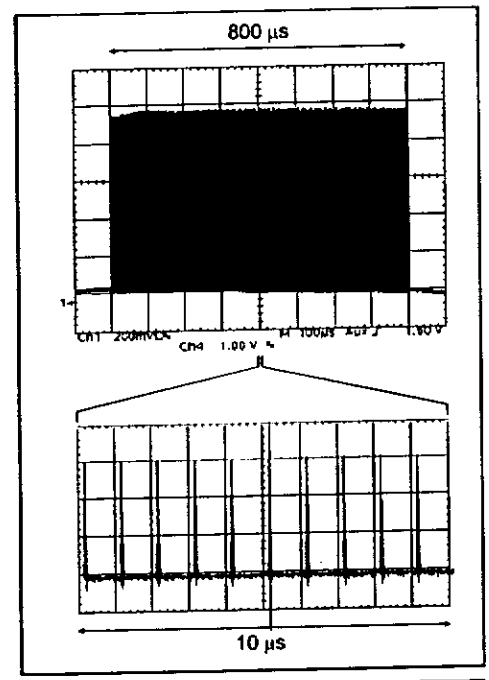
Status of the photocathode laser

July ´98

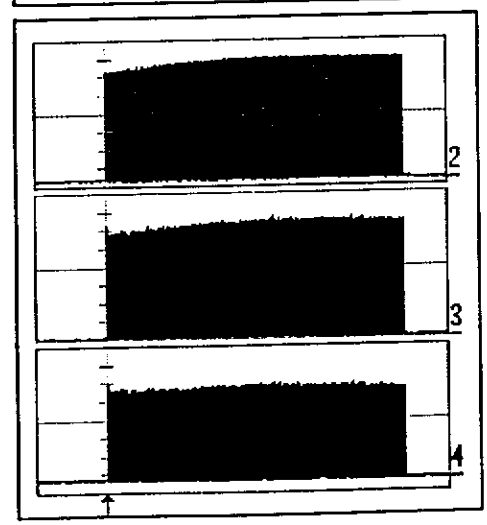
A.Liero, I.Will, W.Sandner

Summary of status in March 1998:

- Pulse trains of the desired energy and stability have been generated, envelope is freely programmable. (Infrared radiation, λ = 1.047 μm)
- Pulse duration:
  σ_t = 10...12 ps (λ = 1.047 μm)
  σ_t = 5...8 ps (expected at λ = 0.26 μm)
- Feedback loop for an increased stability has been tested. (requires 800 μs total length of the train)



- Pulses have been converted to the UV (wavelength λ = 0.26 μm, required by the photocathode)



Main effort of the last months:

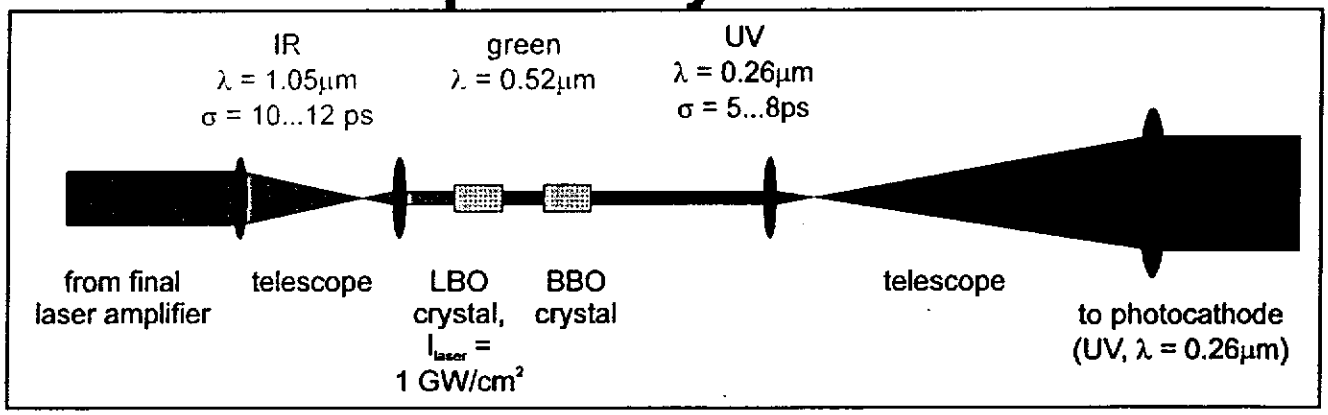
1. Improvement of the beam profile after frequency conversion:
   successful.

2. Run the laser over long periods (days and weeks):
   conducted in part only.
   - total up to now: 400 h ($4 \cdot 10^6$ shots)
   - special test performed recently to test the frequency conversion crystals:
     laser operated over a period of 16 h:
     -> no degradation in the crystals seen.

3. New operational modes:
   generates a reduced number of micropulses
   (<< 800, mainly for alignment and test runs of the LINAC):
   successful.

4. Interface which allows to run the laser remotely
   (from the control room):
   continuous, but somewhat slow progress;
   - Approx. 80% of our time spent for the control system and programming.
   - Much support from Kay Rehlich, Olaf Henzler and Arthur
   - Creating the control programs was found to be much more difficult and more time-consuming than initially expected.

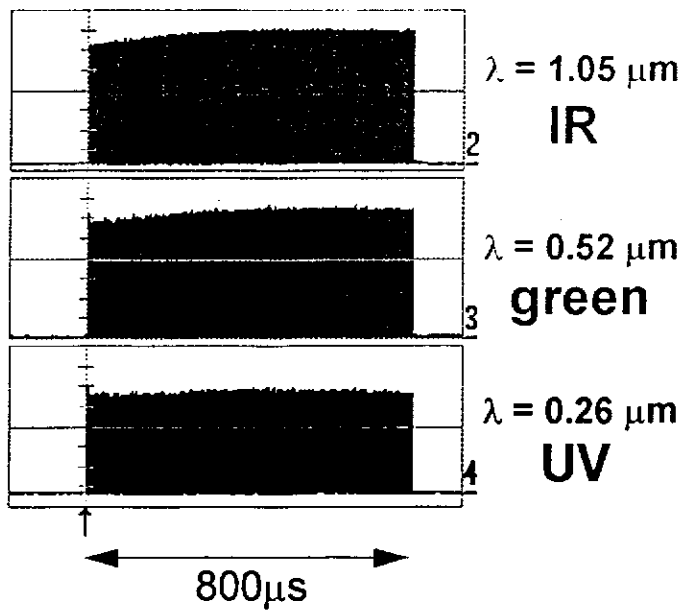
Wavelength conversion stage based on nonlinear optical crystals installed



- IR -> green: LBO crystal: Lithium Triborate (LiB_3O_5)
  Green -> UV: Beta-Barium Borate crystal (β-BaB_2O_4)

Measurements:

- Total energy of a micropulse in the UV: 25μJ (at 5Hz repetition rate) (5μJ required at the photocathode for 8nC bunch charge)
- Total conversion efficiency from IR to UV: 10-12% (at 5Hz rep. rate)
- 1% changes of the laser power in the IR causes 2...3% change in the UV

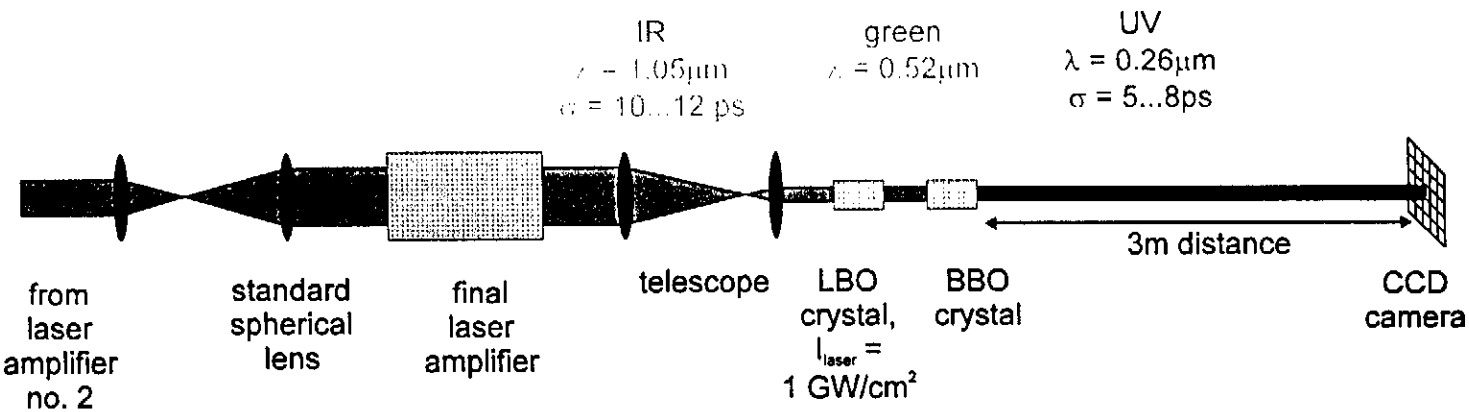


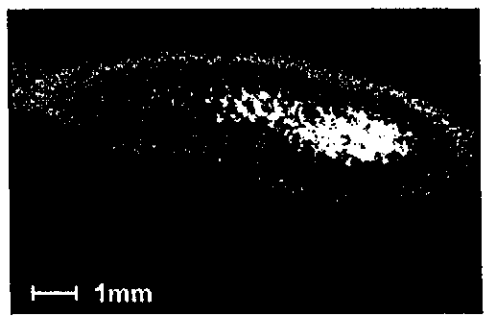
Problems:

1. Envelopes of the train are slightly different in the IR, Green and UV
2. Beam profile was not good enough due to non-symmetrical thermal lensing

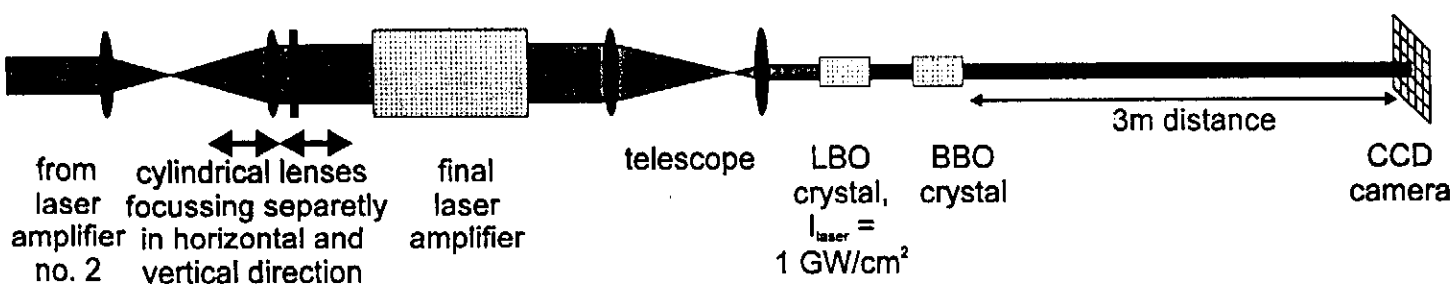
Beam divergency significantly improved by placing a pair of cylindrical lenses in front of the final amplifier

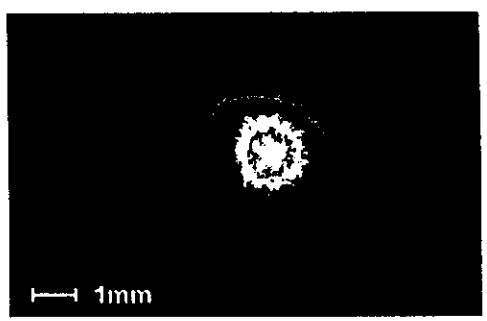
old setup:



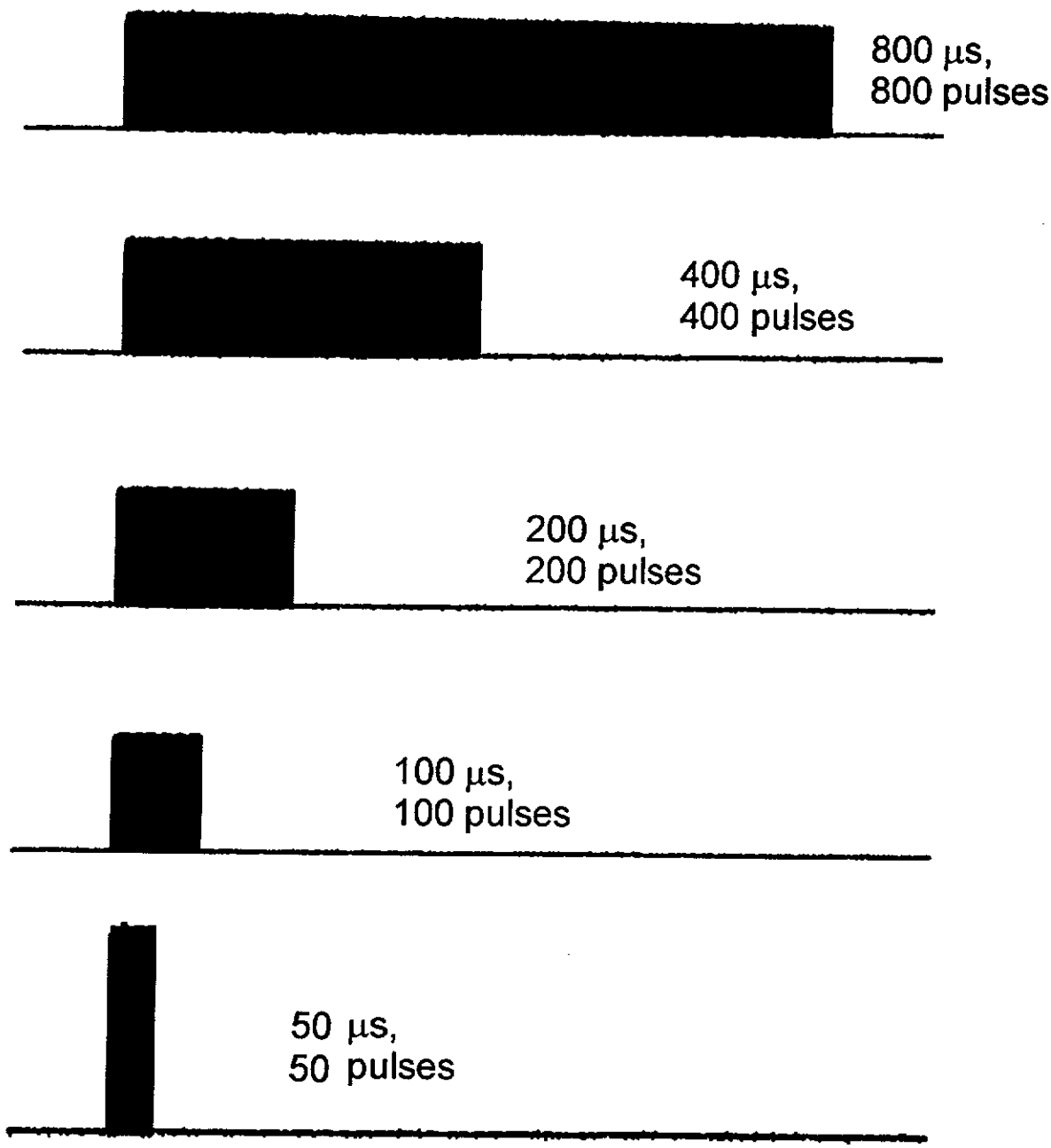


Improved setup:

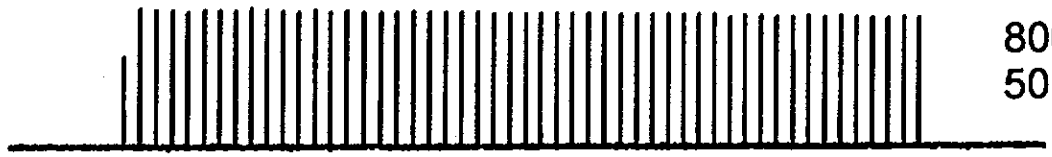




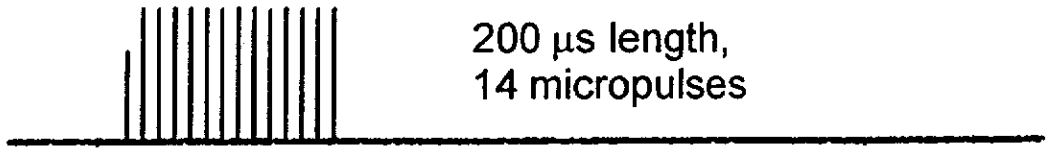
Operating the laser with a shorter pulse train



Operating the laser with both a shorter pulse train and a reduced frequency of the micropulses



800 μs length,
50 micropulses



200 μs length,
14 micropulses

Summary

- Photocathode laser generates pulse trains of 800 micropulses, design energy routinely achieved (
  E >25uJ at 0.26 μm wavelength (5 μJ required for 8nC);
- Operational modes with a reduced number of micropulses successfully tested;
- Wavelength conversion stage to the UV in operation, 12-15% total conversion efficiency obtained routinely;
- Beam profile at the output is satisfactory;
- Laser is ready for the alignment of the beamline and for first tests of the photocathode and the RF gun.

Next steps:

- Installation of a control system for the laser based on DOOCS (mainly programming effort)
  Side effect: Documentation system which is implemented in DOOCS can be used

- Measurement of the long-term stability of the laser

Status of rf gun development for the FEL

DESY, 6.7.98

K. Flöttmann

some problems:

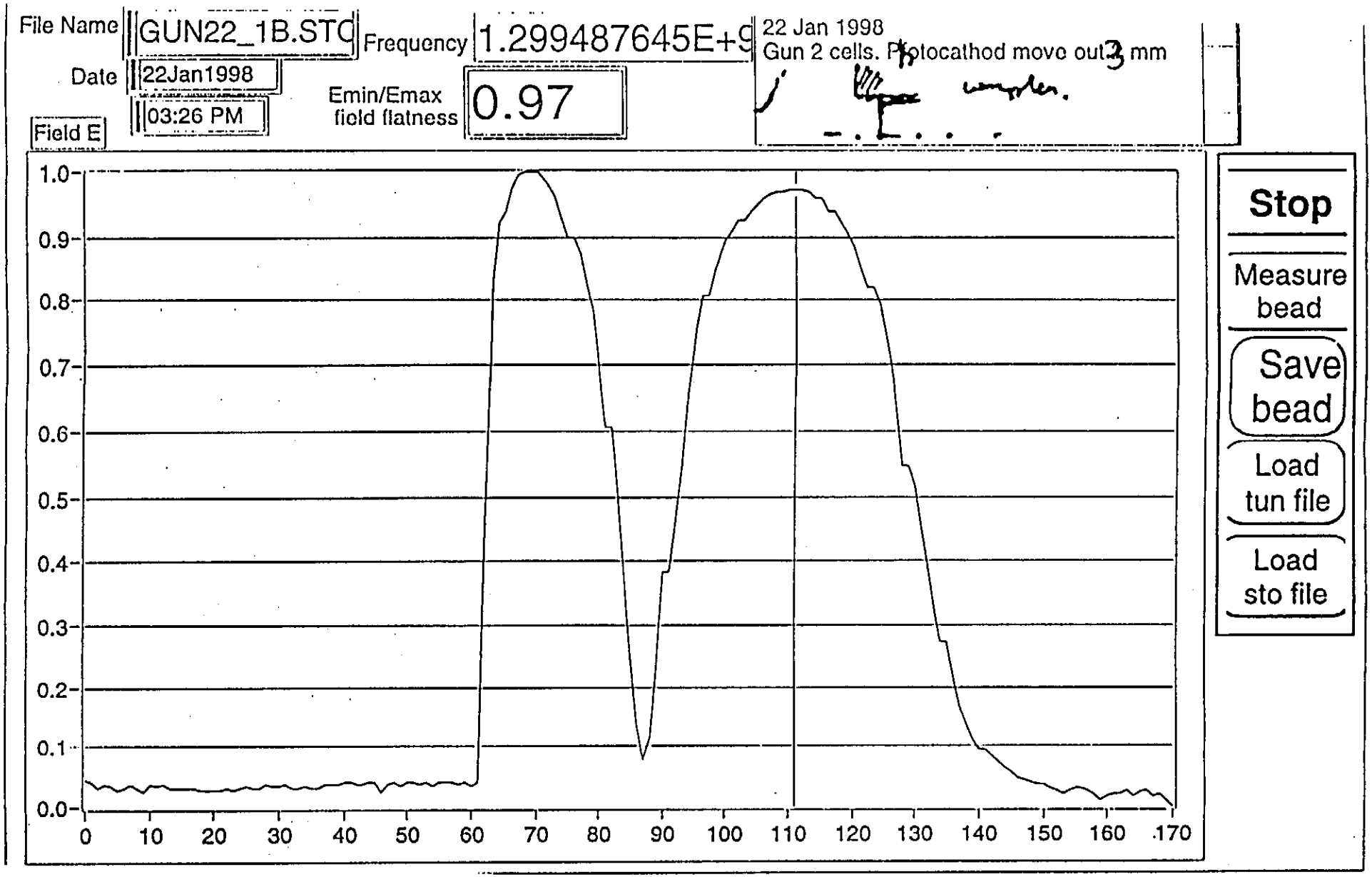
- Vacuum leaks and spots of brazing alloy on the inner cavity surface due to porous copper.

- Vacuum leaks due to bad weldings at the flanges. The flanges at both sides of the cavity have been removed and welded again.

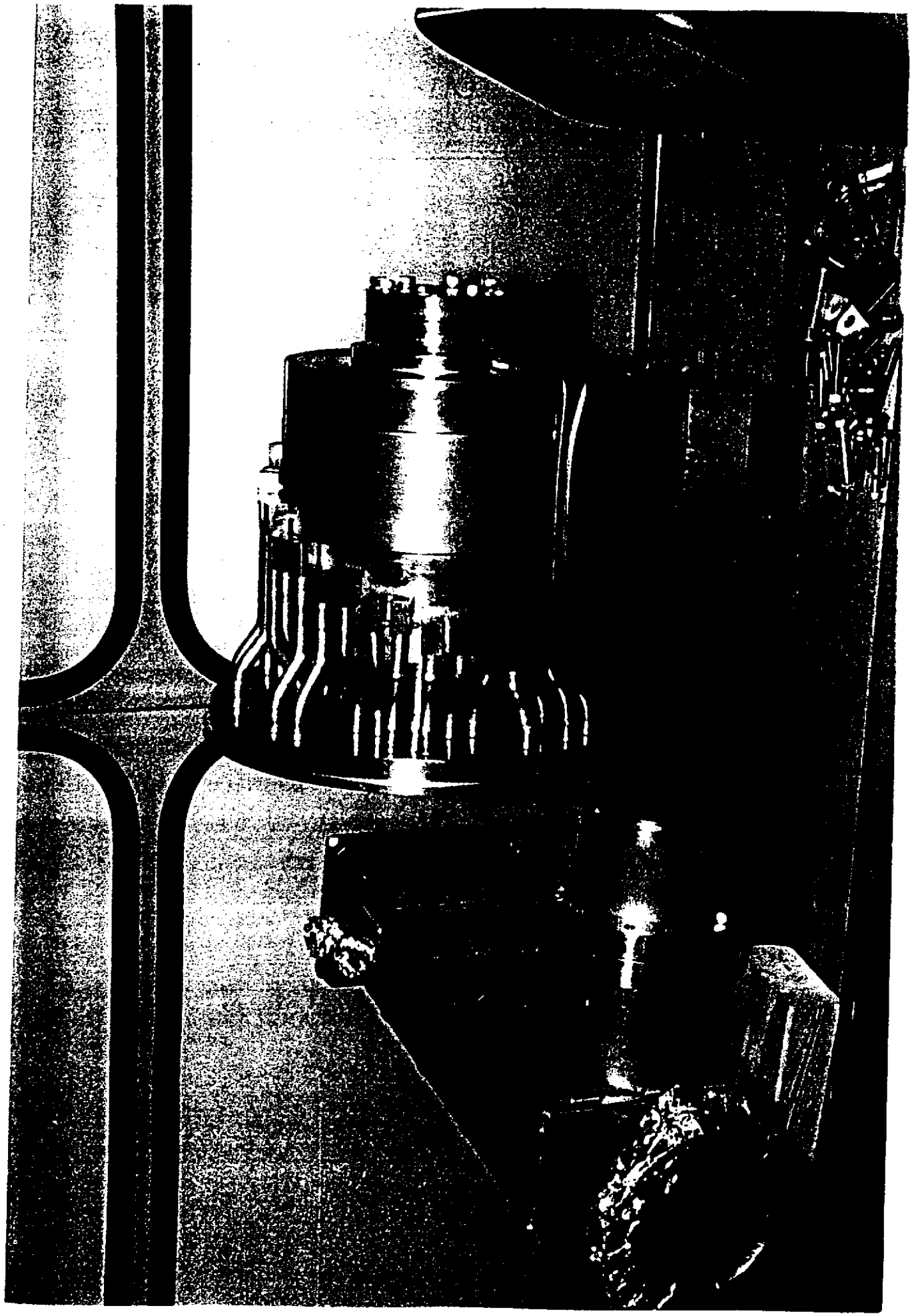
  ➢ The cavity is not tuned to 1.3GHz to avoid new vacuum problems

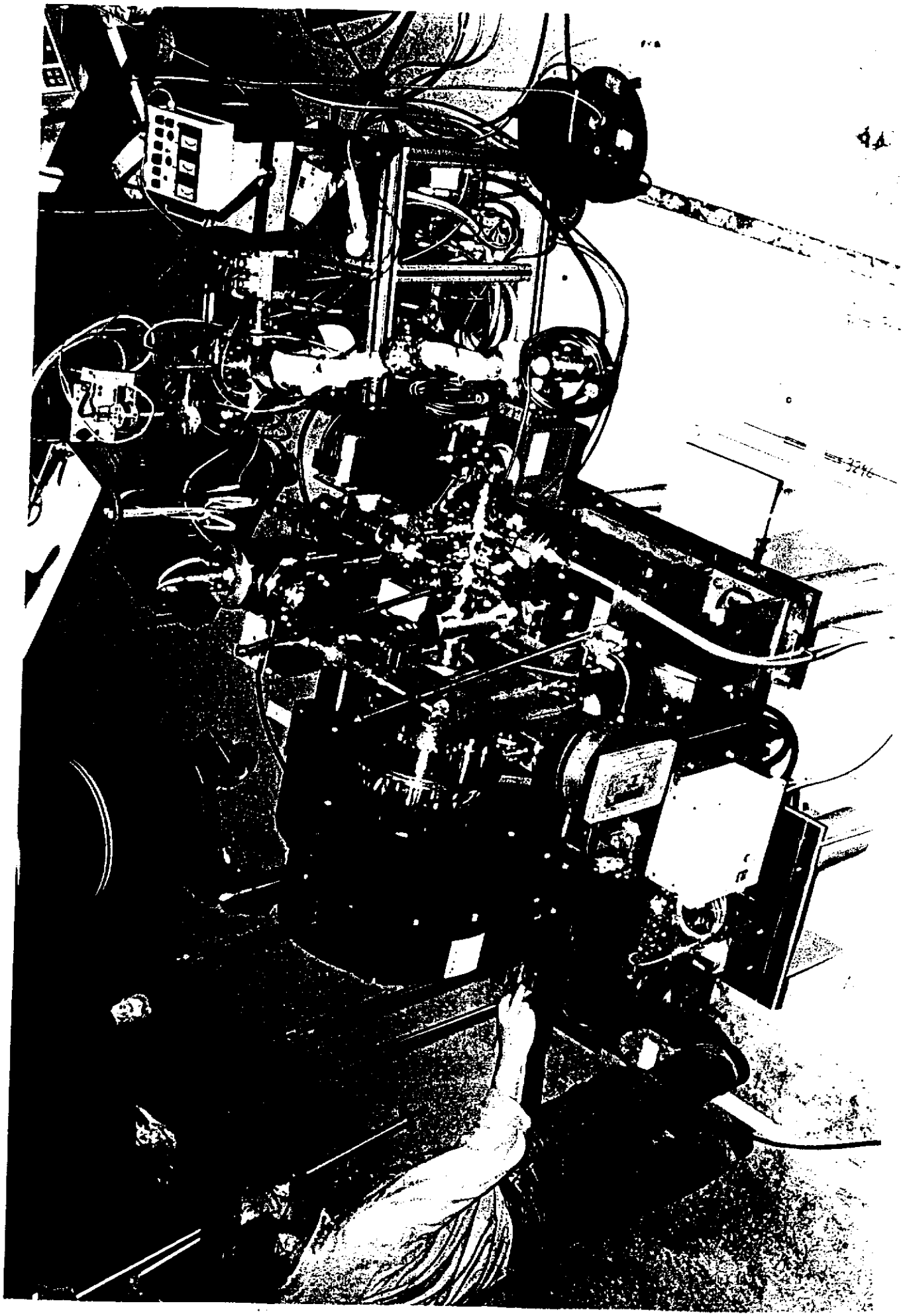
- oxidization spots on the cavity surface after first cleaning in the clean room. Removed with nitric acid before second cleaning.

➢ A second gun cavity is under construction. Finished up to September?

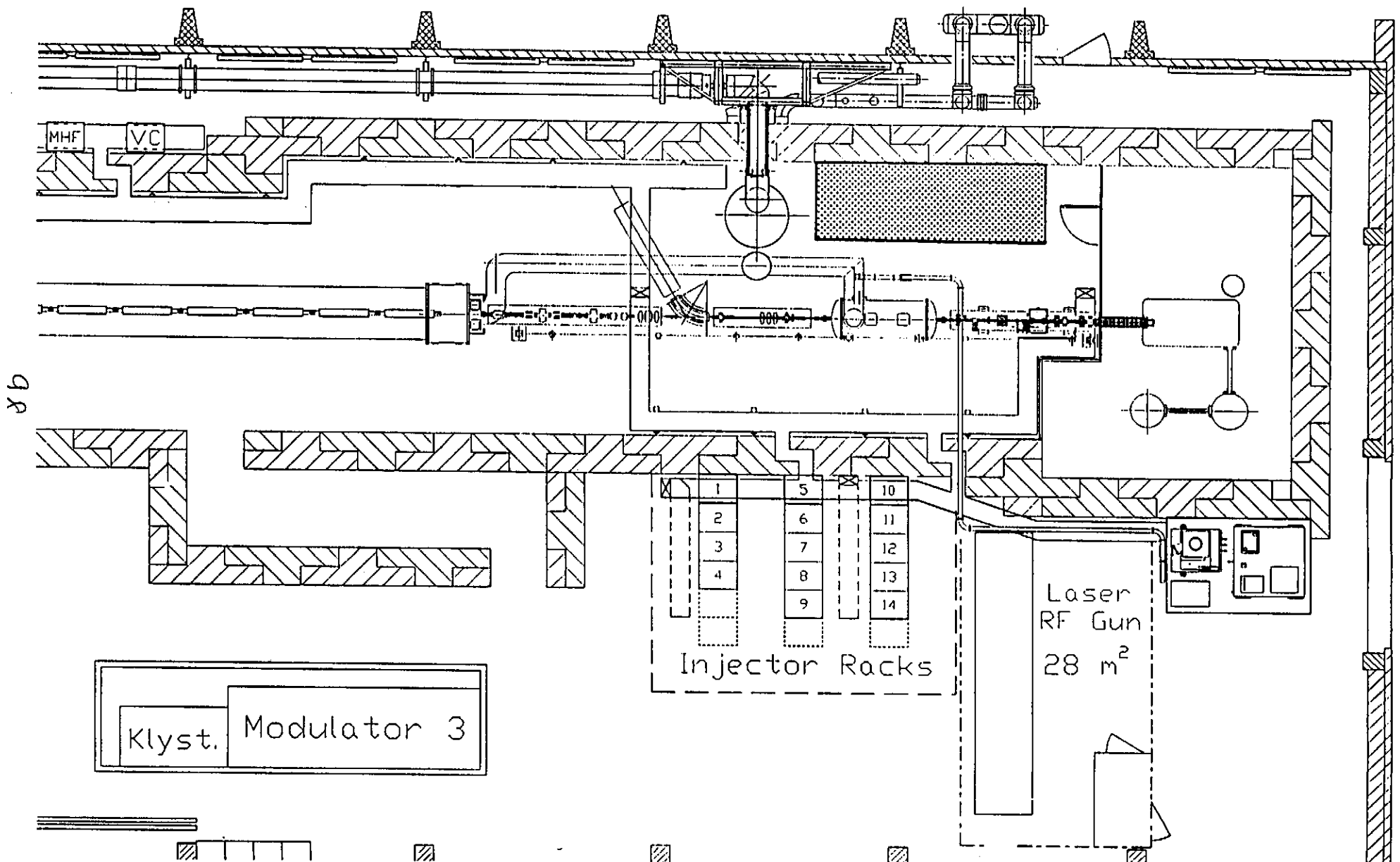


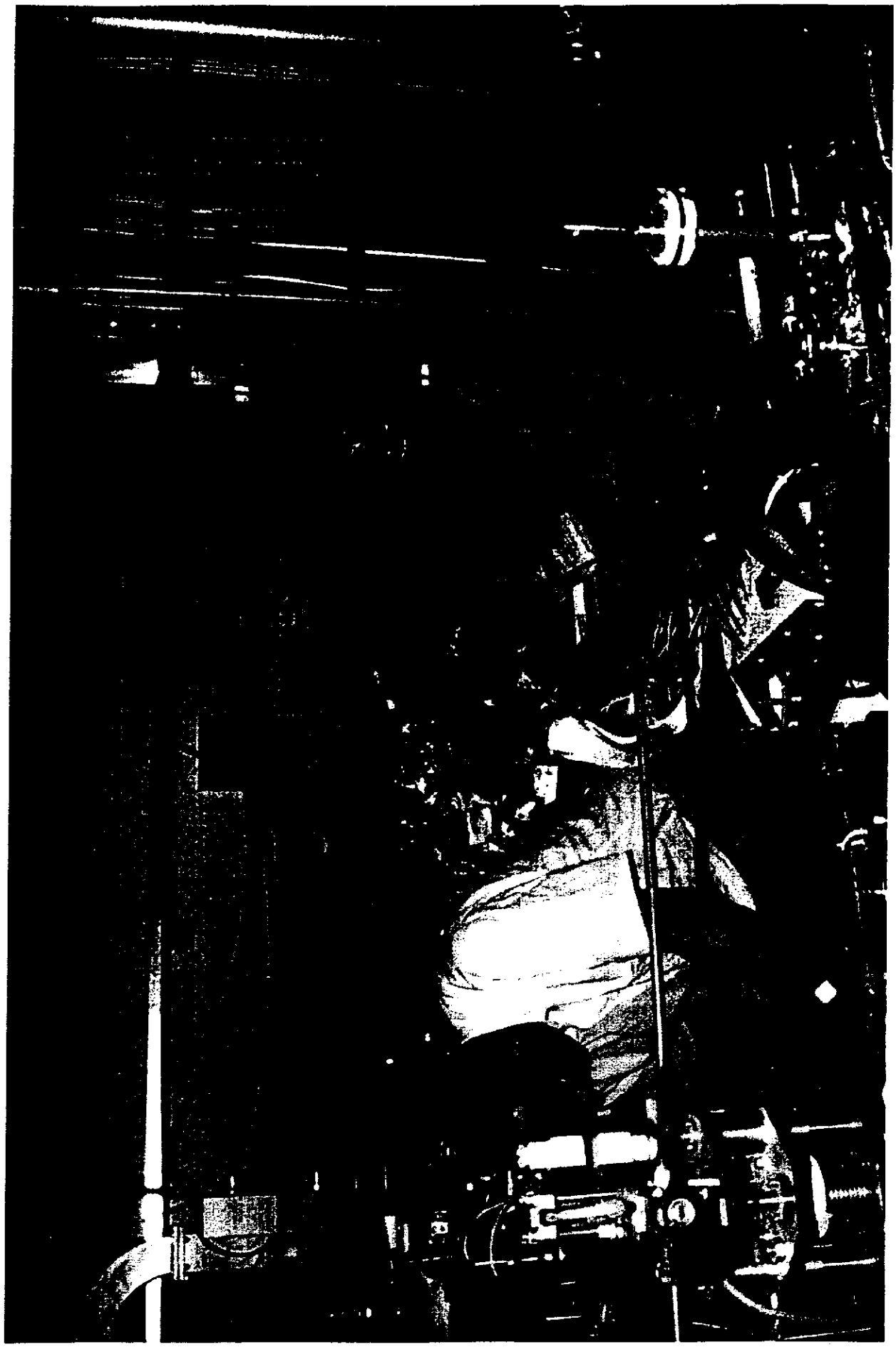
Field profile of the rf gun cavity





Low energy test beam Line





Status of Installation:

- all components are in the tunnel, connected and pumped with getter pumps (~10^{-8} mbar). Titan sublimation pumps will be started today.

- the cooling circuit is running. Presently it is used for heating of the gun cavity (~60°C).

- the wave-guide connection to the klystron is ready. 200W cw from an amplifier have been in the cavity which behaves as expected, i.e. the resonance frequency is about 1MHz to low at 60°C.

- all but one magnet are connected to power supplies.

- cathode transportation chamber with activated cathodes is installed.

Next access: Today

- Installation of rf window diagnostics

  ➢ test of technical interlock

  ➢ start conditioning

- start titan sublimation pumps, connect last magnet, installation work for beam diagnostics, final alignment ...

A.Gamp 3. 7. 98

Multibeam-Klystron News

The tube has delivered full RF power.

The max. efficiency obtained so far was 65%.

Without Rf the beam interception with the Klystron body was below 0.5%.

With Rf the interception in the region between output cavity and collector was about 3%.

Our field measurements of the MBK focusing magnet show that it is ok.

The modified MBK prototype has been reassembled and is now in the furnace for bakeout.

Frequency:		**1300 MHz**	
R F Pulse length:		**1500 μs**	
Repetition rate:		**10 Hz**	
Beam Voltage:		**110 kV**	
Beam Current	**(total):**	**130 A**	
Perveance per beam		**0.5*10-6**	
Drive Power:		**200W max.**	
Output Power:		**10MW peak**	**150kW average**
Body Dissipation	**:**	**15kW max.**	
Efficiency:		**> 70 %**	
Gain:		**48 dB**	
Bandwidth	**(1 dB):**	**3MHz min.**	
No.of beams:		**7**	

Design parameters of the Thomson Multibeam-Klystron.

The gain of 48 dB means that the drive power is below 160 Watts. This power can be generated at low cost with solid state amplifiers.

MBK TH1801 DESY

ESSAIS HF

résultats obtenus :

10 MWc 20 kWm rendt 65% 100 µs 20 Hz 116 kV 132 A 47 dB

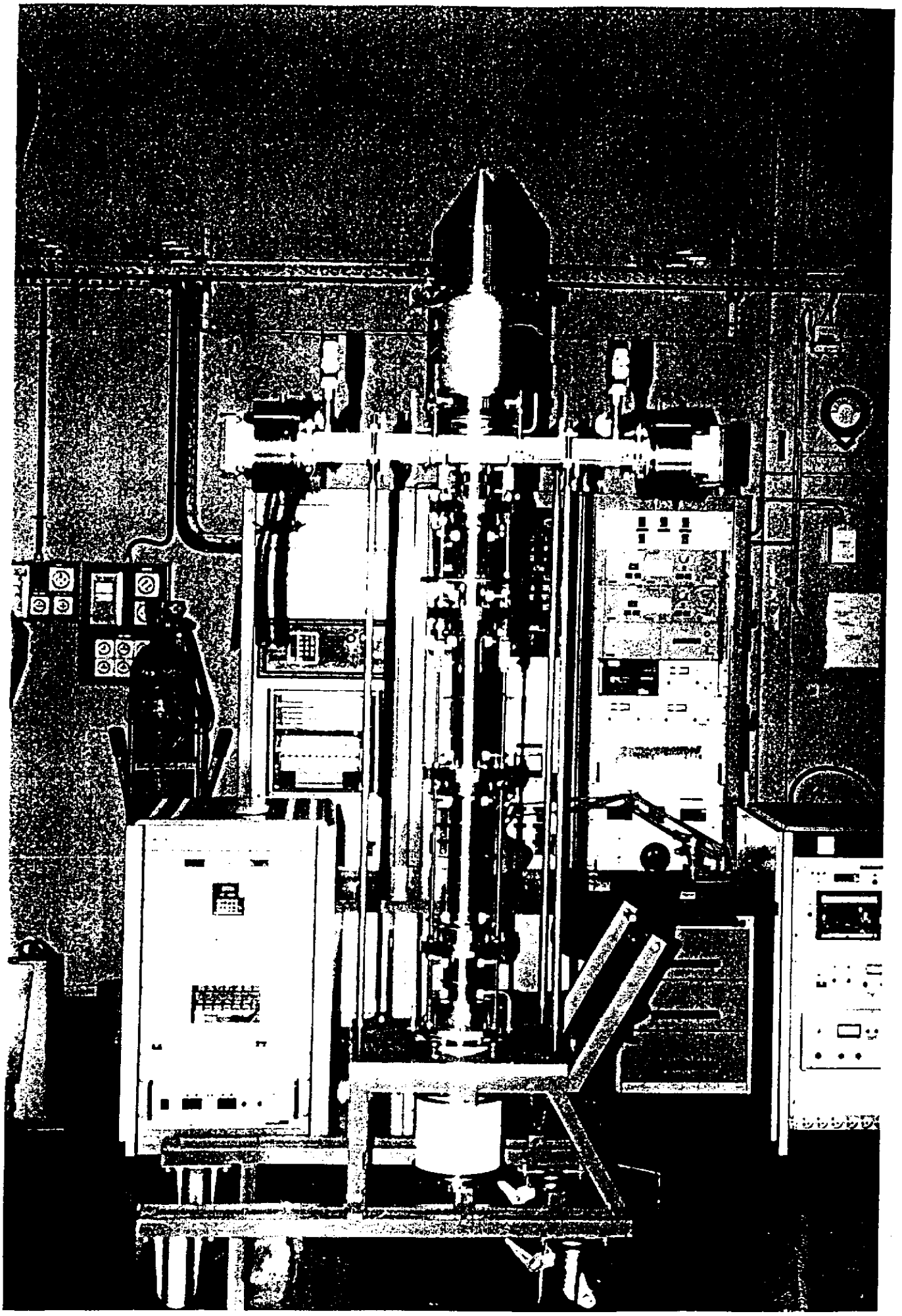
9.6 MWc 40 kWm rendt 63% 400 µs 10 Hz 116 kV 132 A 47 dB

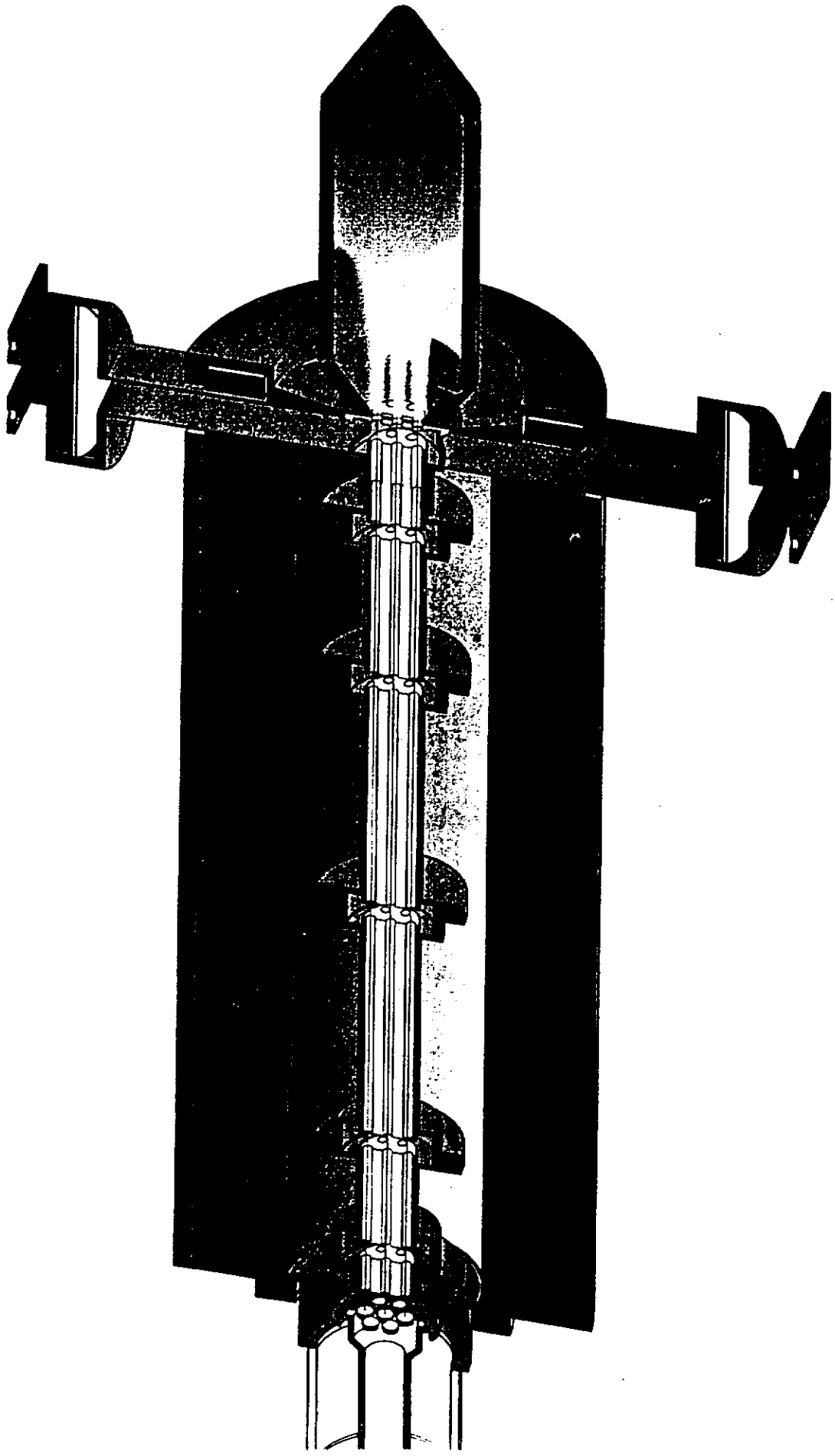
*** réglage des cavités 4 et 5 non optimum**

objectif :

10 MWc 150 kWm rendt 70% 1.5 ms 10 Hz 115 kVmax 47 dB

S:\BEUNAS\MBK1300\COMM\091297.WPD 09-12-97





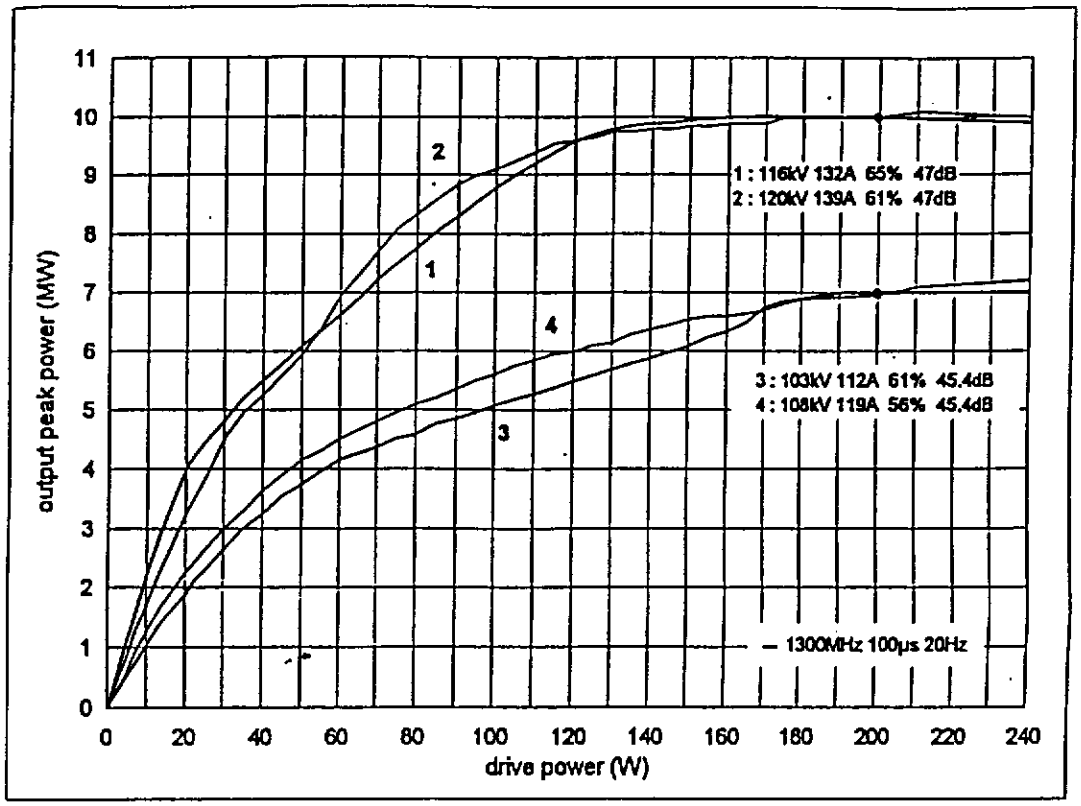


fig. 5 TRANSFERT CURVES

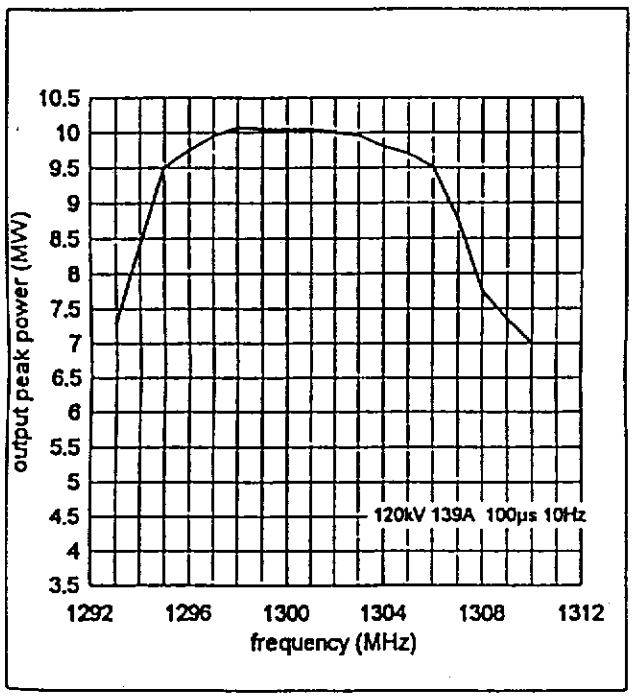


fig. 7 BANDWIDTH

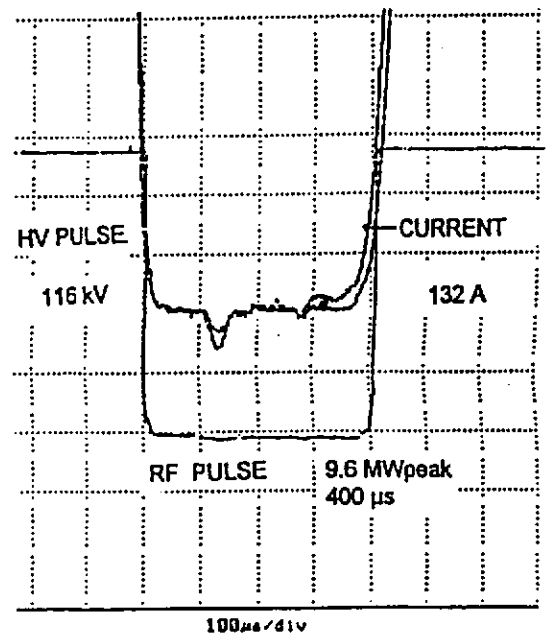
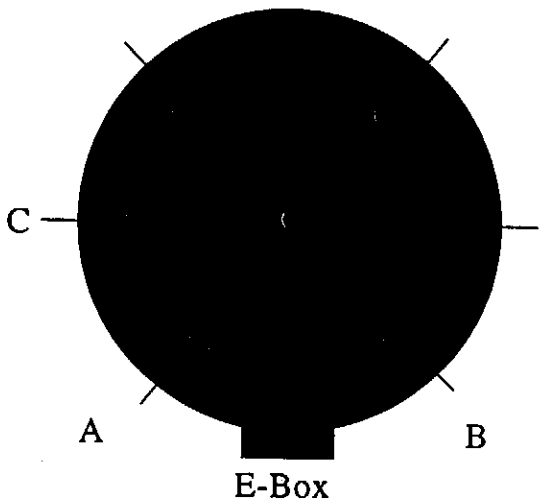
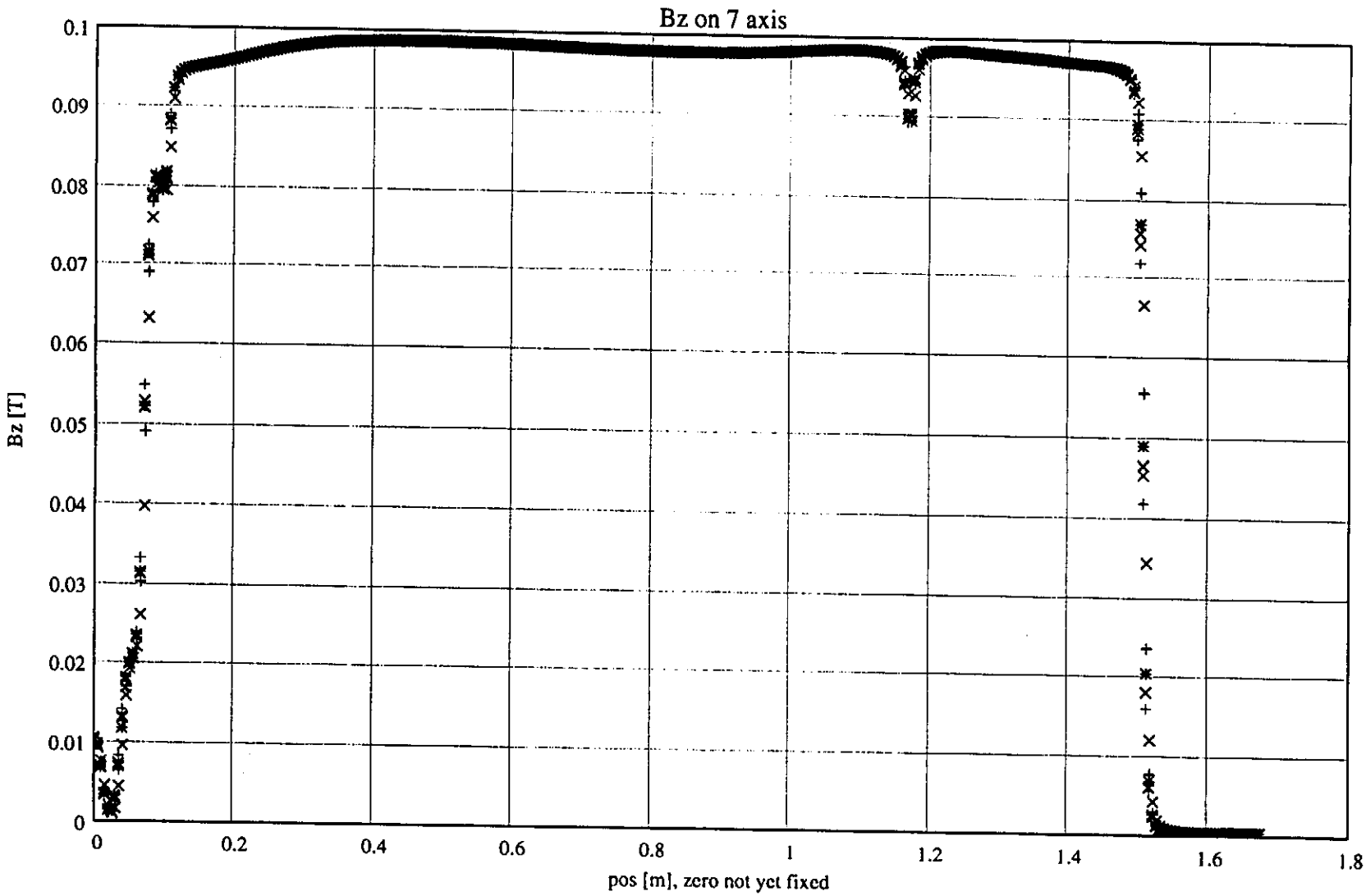
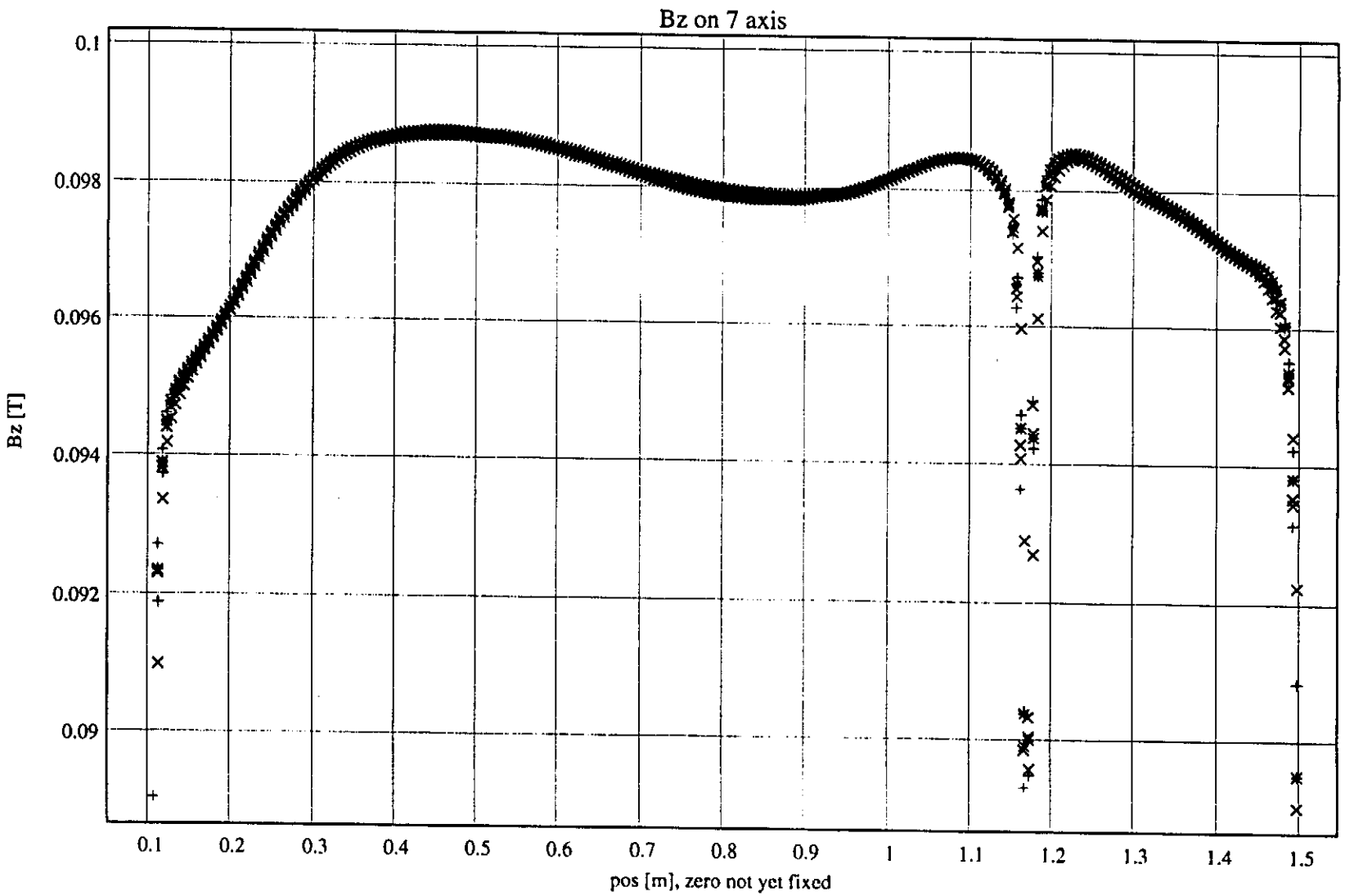


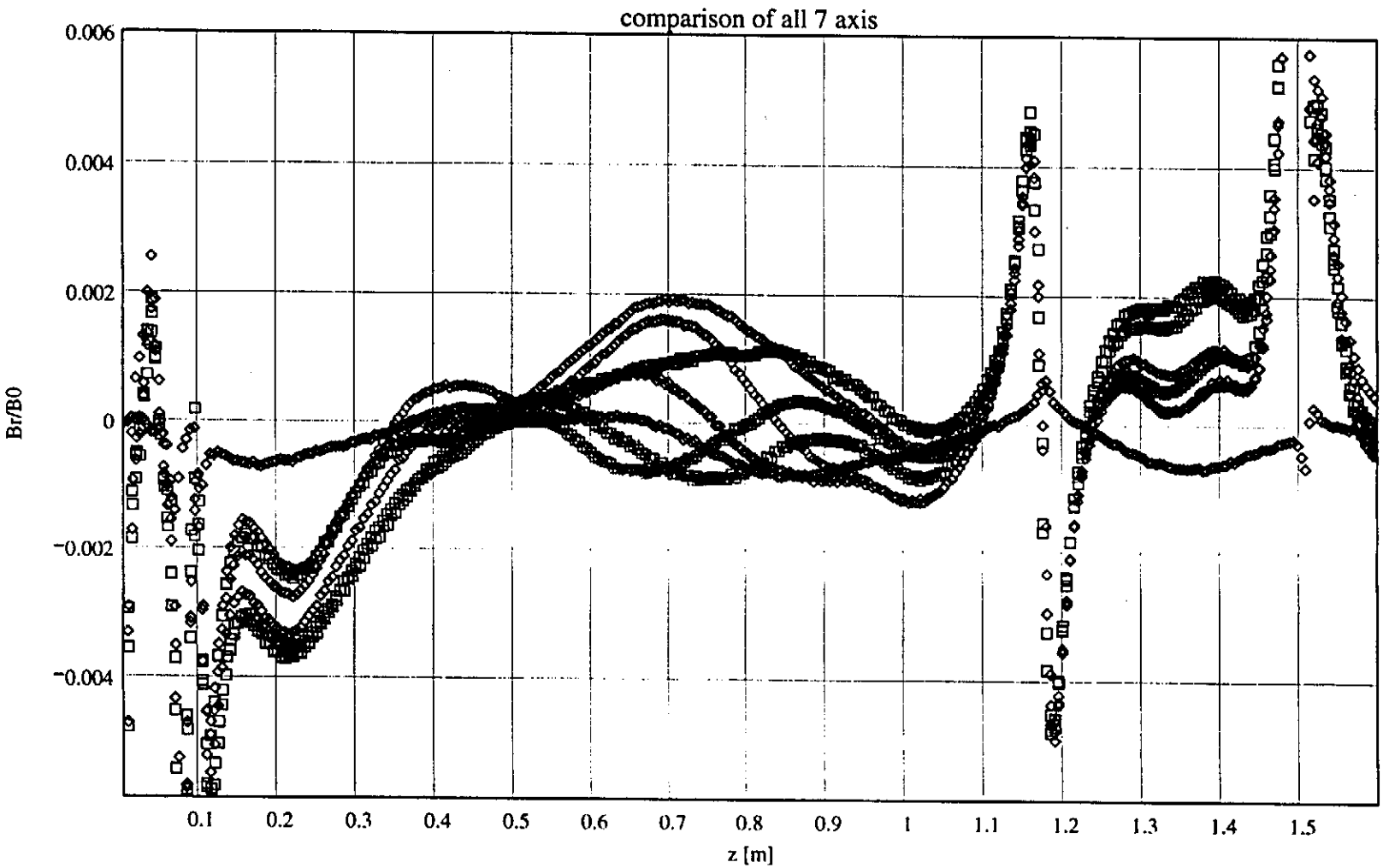
fig. 6 MEASURED PULSES

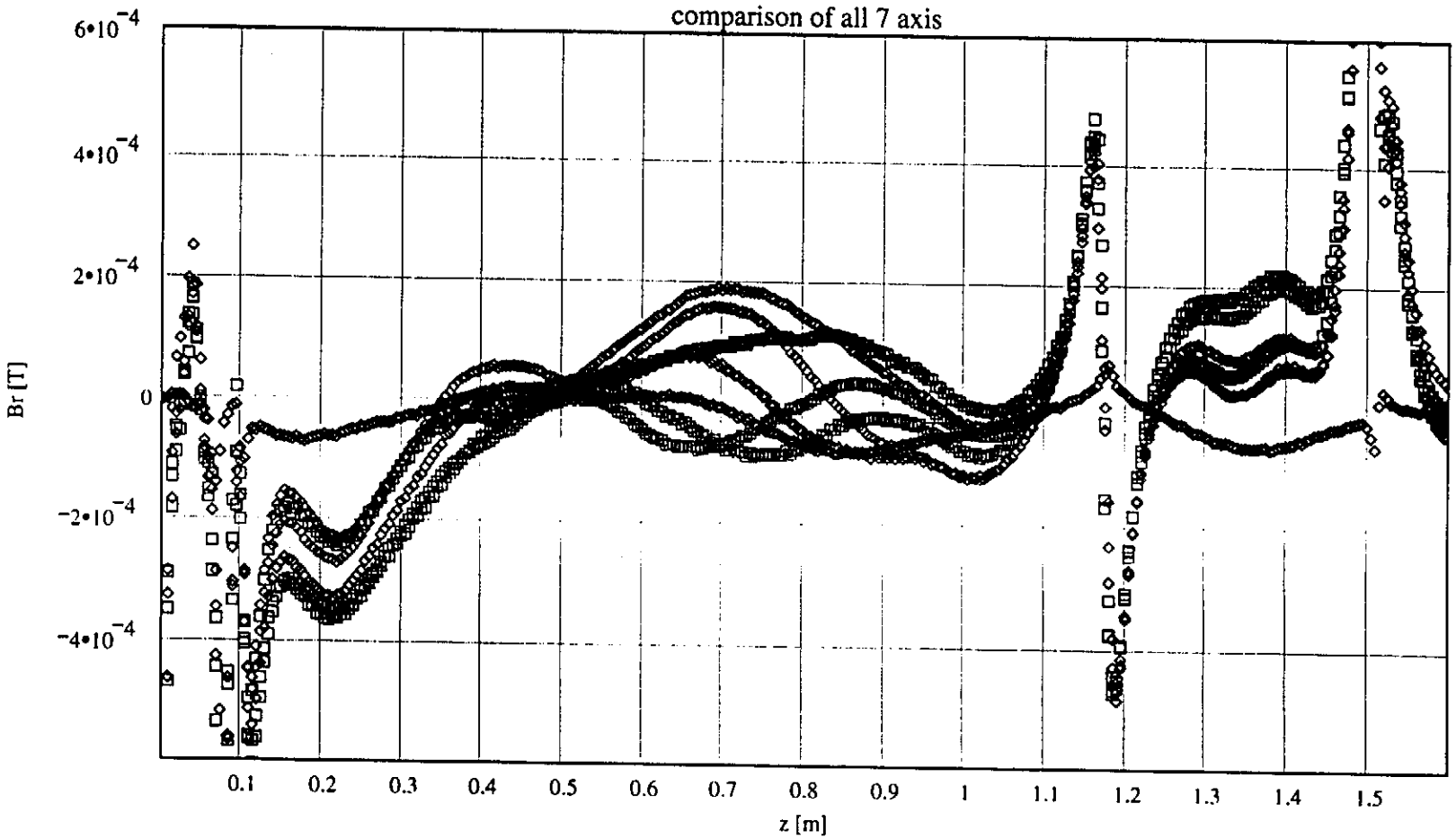

C
A
B
E-Box


Bz on 7 axis
Bz [T]
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
pos [m], zero not yet fixed

OVV


Bz on 7 axis
Bz [T]
0.1
0.098
0.096
0.094
0.092
0.09
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
pos [m], zero not yet fixed


comparison of all 7 axis
0.006
0.004
0.002
0
−0.002
−0.004
Br/B0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
z [m]
axis 1
axis 2
axis 3
axis 4
axis 5
axis 6
axis 0


comparison of all 7 axis
6•10^-4
4•10^-4
2•10^-4
0
-2•10^-4
-4•10^-4
Br [T]
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
z [m]
axis 1
axis 2
axis 3
axis 4
axis 5
axis 6
axis 0

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Modulator News

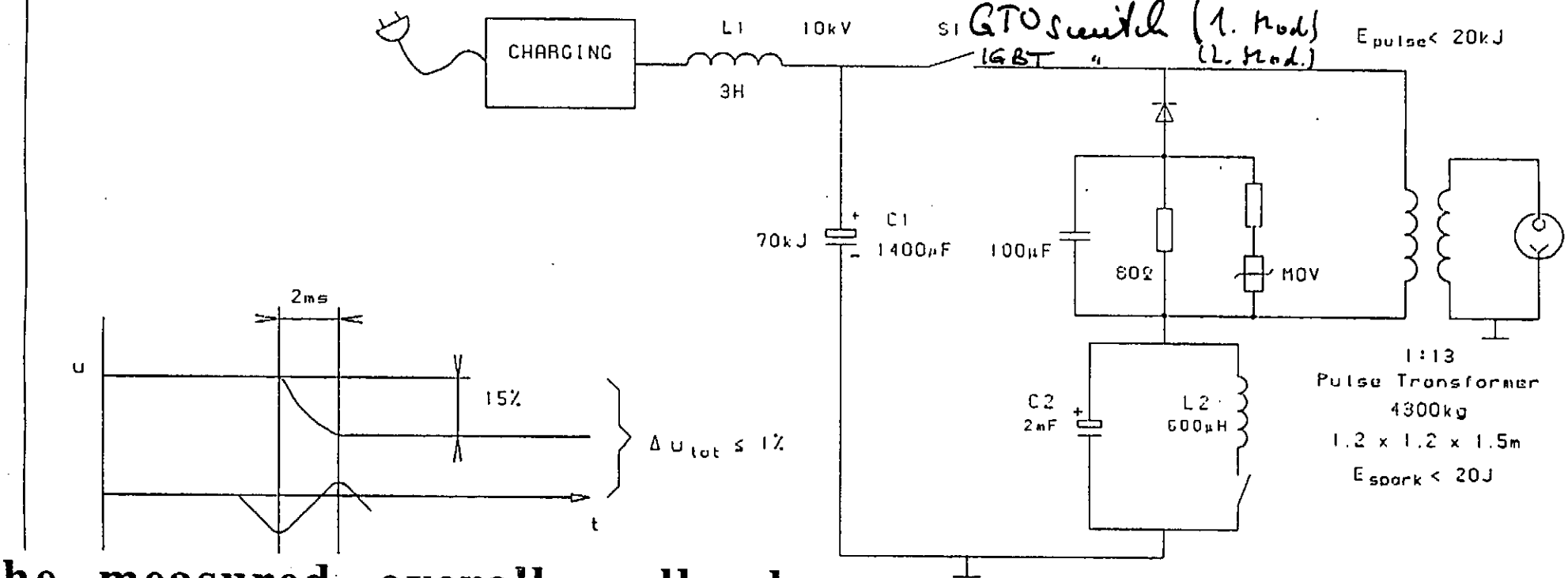
Last Friday I received an information offer from PPT (Puls-Plasmatechnik GMBH) for a bouncer type modulator which sounds acceptable.

DESY will build the constant power charging supply according to a russian idea and we would also procure the pulse transformer.

Two weeks ago a german company showed interest in manufacturing the Pulse transformer.

In principle the complete modulator could be ready in 20 months from now.

Modulator Schemes



The measured overall wall plug power to useful HV conversion efficiency was 86% for a pulse length of 2.2 ms. "Useful" means that only the flat top of the HV pulse, which is good for rf generation, has been taken into

Trise ≈ 150 μs for TTF

$\eta \propto$ Tpulse/(Tpulse+Trise)

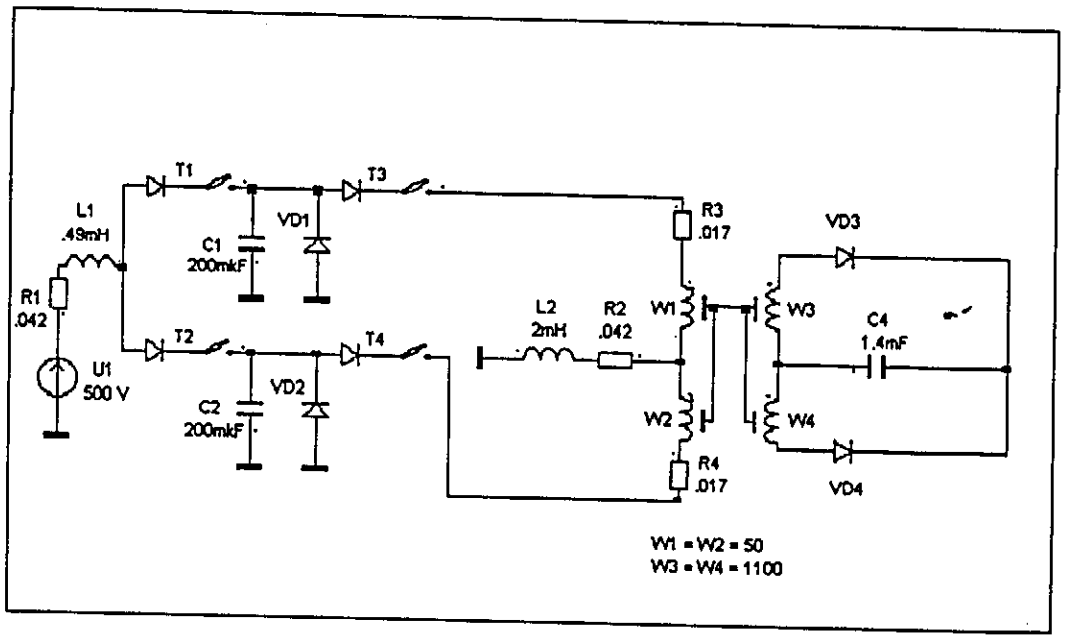


Figure 45: Scheme of the charge device for calculations.

B. Aune 6/07/98

SACLAY - ORSAY

1 - R/D cavities / couplers

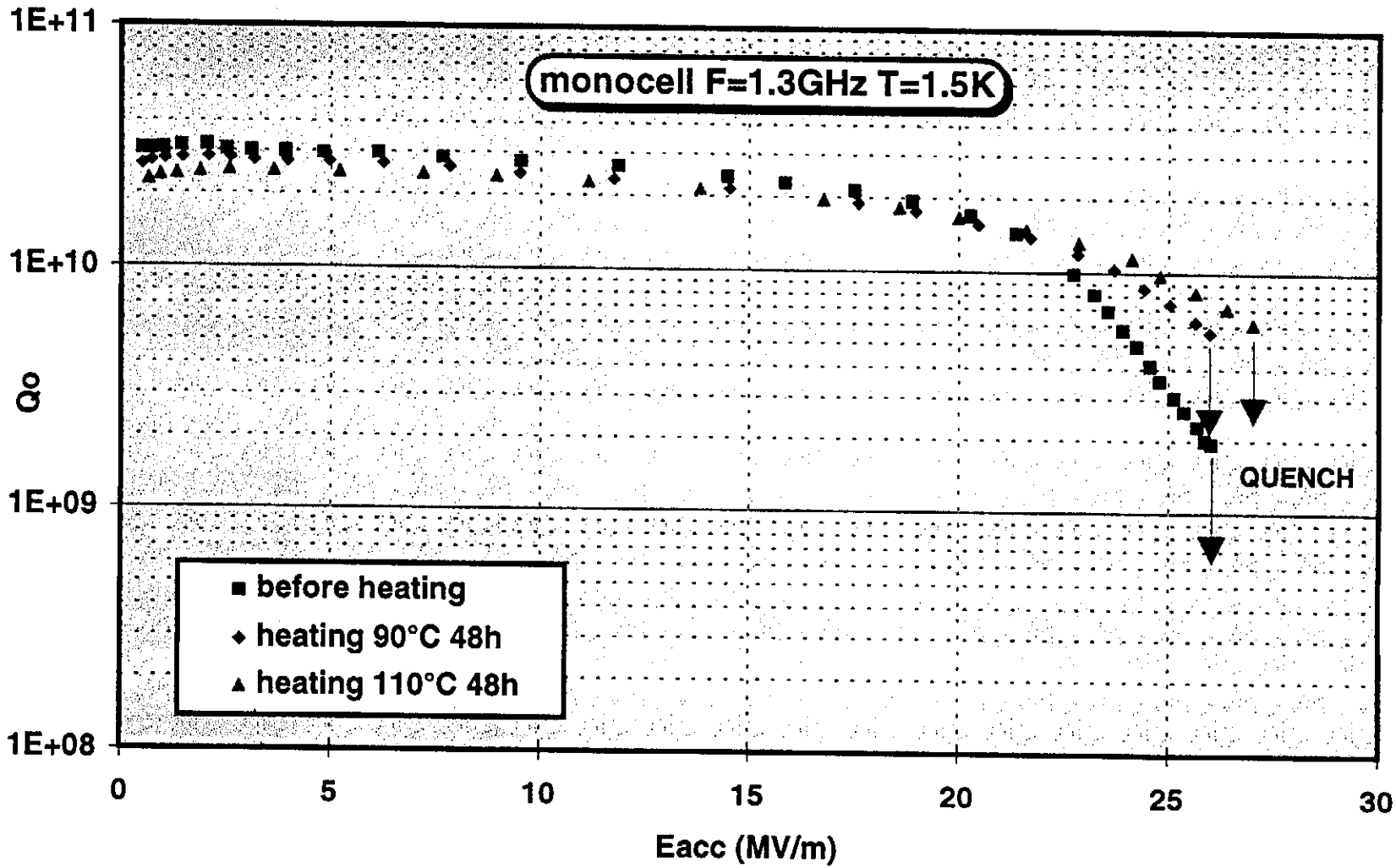
- → Q degradation at high field
- → New fabricat. techniques
- → Input couplers

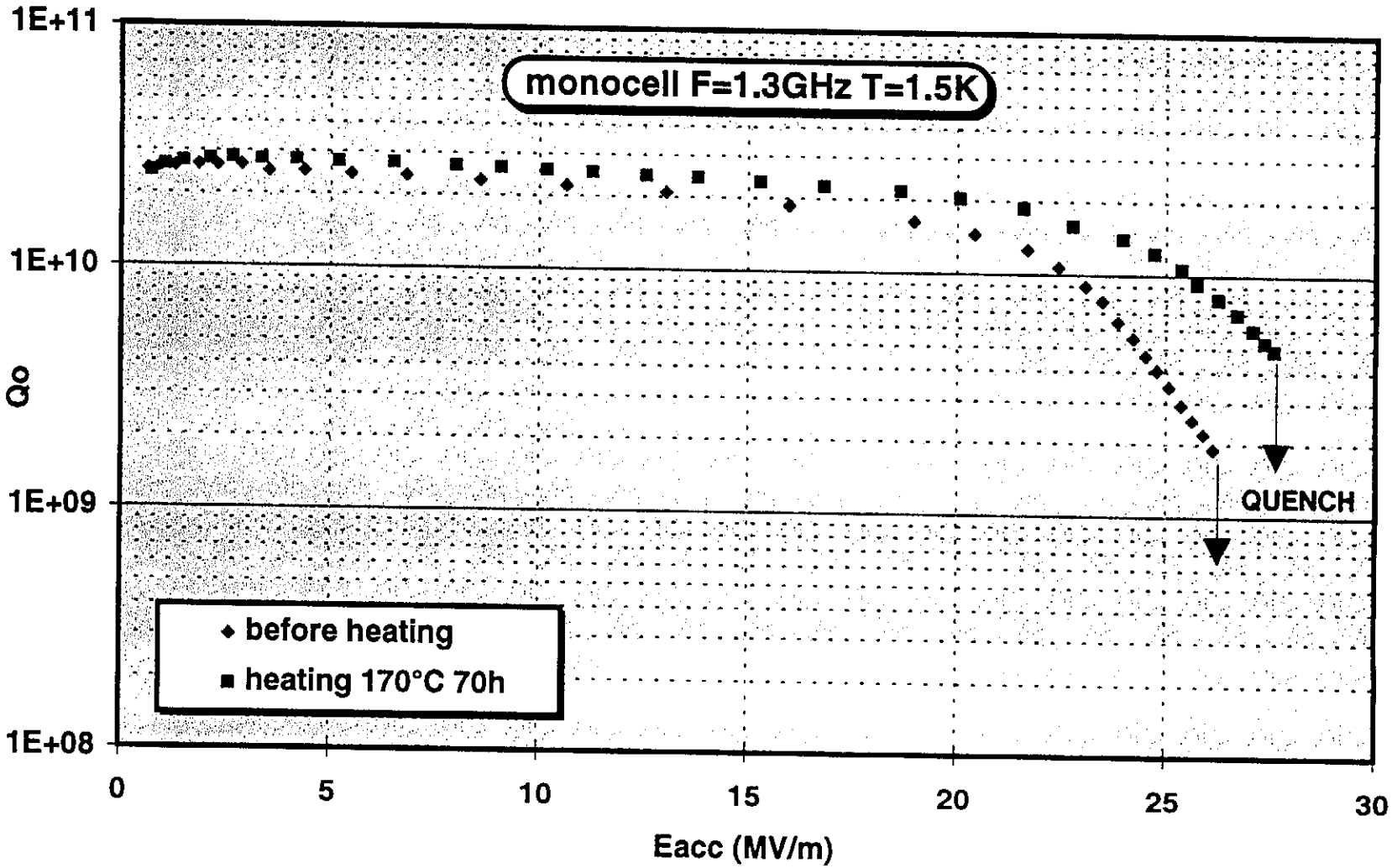
2 - Experiments on TTF L

- → RF Steering
- → Proposal for HOM w/ Inject. I
- → Proposal for orbit feedback

3 - TTF L Components

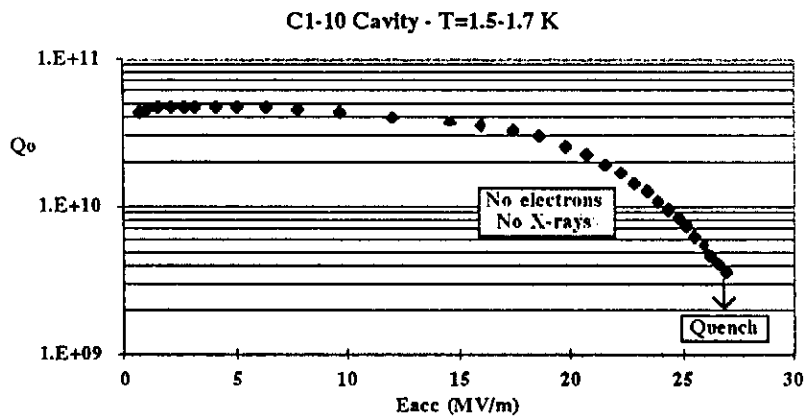
- → Toroids, BPM
- → Tuners, HOM couplers
- → ...

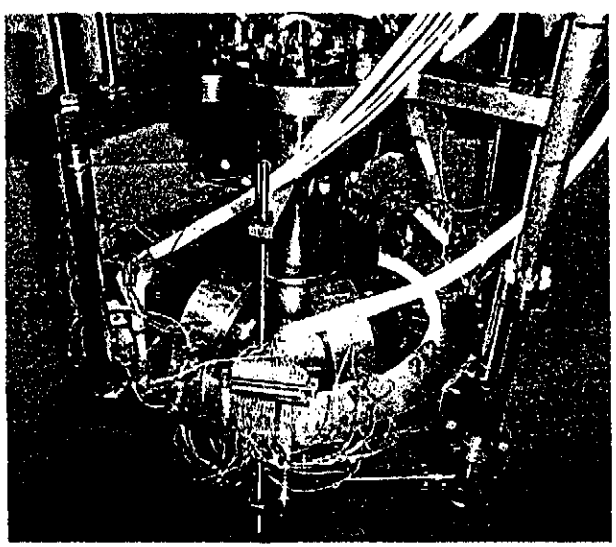

monocell F=1.3GHz T=1.5K
1E+11
1E+10
1E+09
1E+08
Q0
0
5
10
15
20
25
30
Eacc (MV/m)
QUENCH
before heating
heating 90°C 48h
heating 110°C 48h

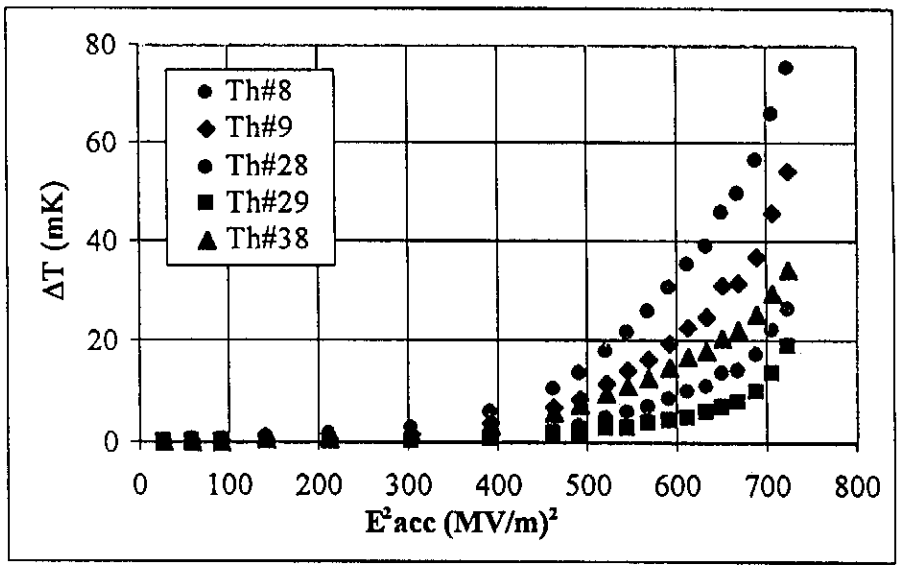

monocell F=1.3GHz T=1.5K
1E+11
1E+10
1E+09
1E+08
Q0
0
5
10
15
20
25
30
Eacc (MV/m)
QUENCH
before heating
heating 170°C 70h

Qo Slope at High Fields: Thermometric Investigations

60 fixed thermometers mounted on single-cell 1.3 GHz cavities having a strong Qo decrease at high fields with no X-rays or e⁻ detected.
Two cavities were tested (C1-10 and C1-05).







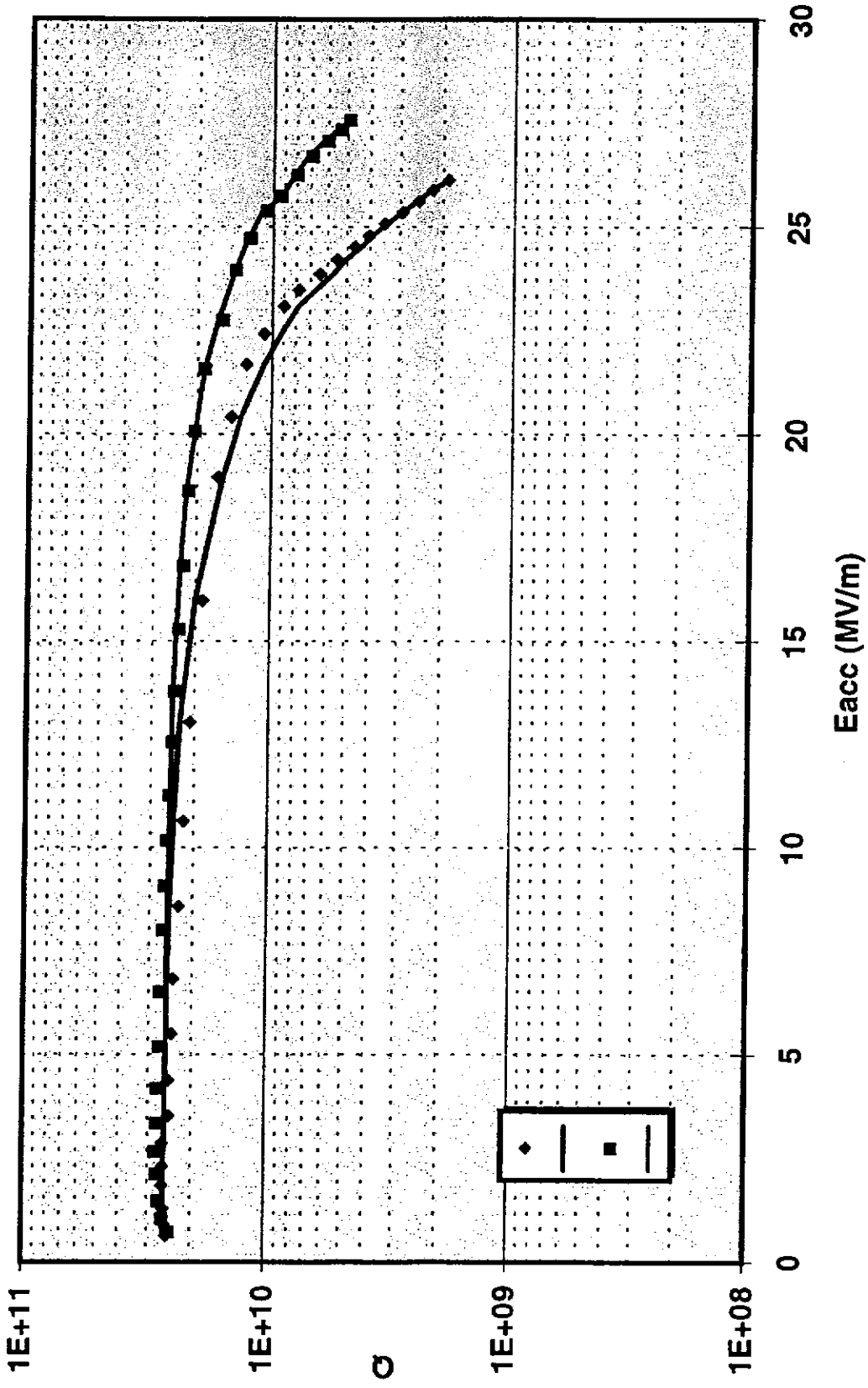
- For almost every thermometer:
  ΔT do not vary quadratically with Eacc
  ⇒ Qo drop is due to anomalous RF losses
- A lot of thermometers having this characteristic:
  ⇒ Broad areas are involved in this new loss mechanism at high fields.
- Heatings do not exceed 80 mK:
  ⇒ not sufficient to explain an increase of Rs by a temperature increase of the RF wall with Rbcs for pure Niobium.

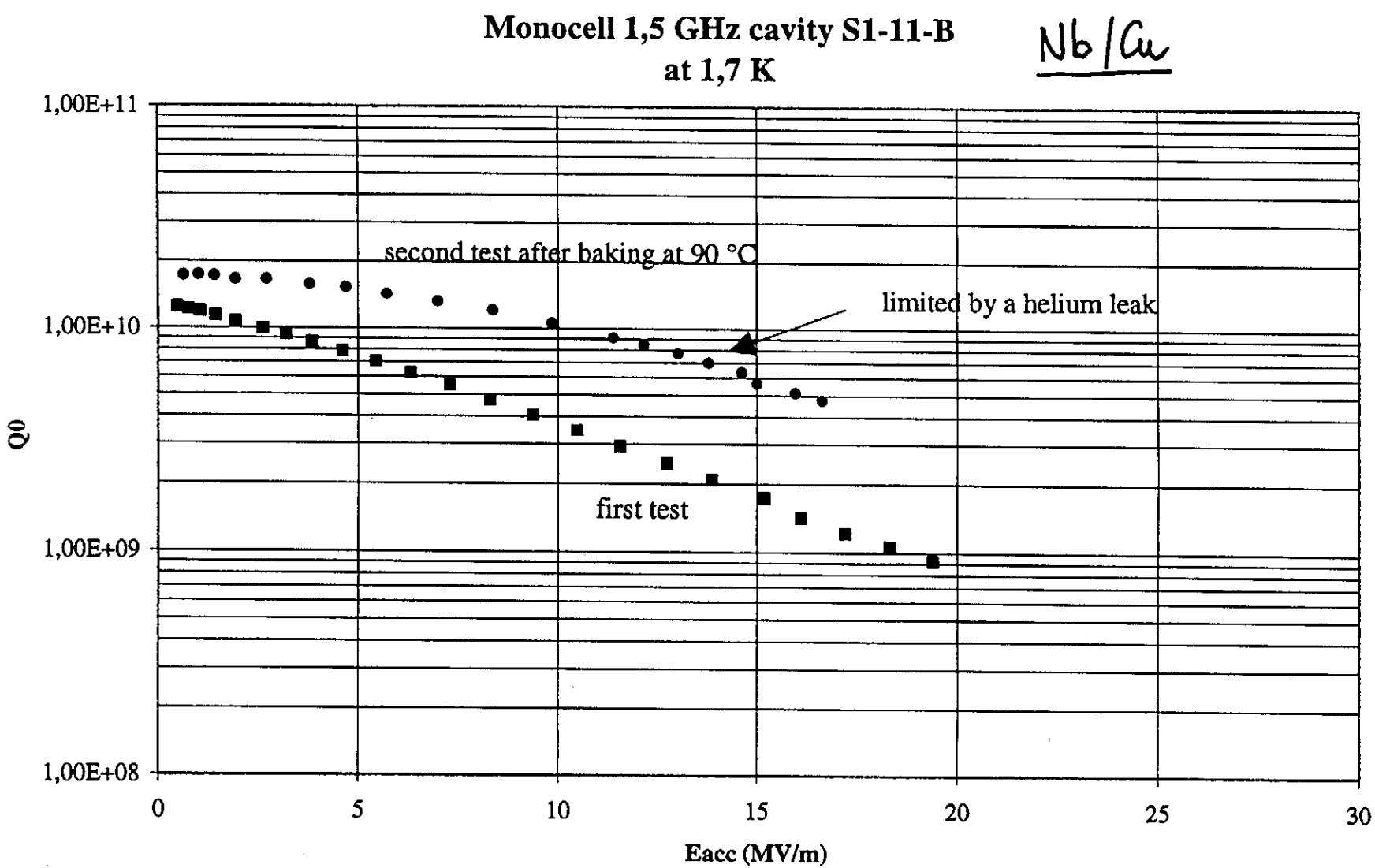
$Q_o (E_{acc})$ calculated curve .

$$R_s = R_{res} + A/T \exp (- \Delta_0 [1 - \alpha(B/B_{cb})^2] / kT)$$

experimental data	E_{acc}, T	$\rightarrow$	$B = 4.10^{-9} E_{acc}, T$
	$R_s(1/T)$	$\rightarrow$	R_{res} , A, Δ_0
fitting parameter	B'_c	$\rightarrow$	$B'_c = B_{cb} / \alpha^{1/2}$

no heating $B'_c = 180$ mT heating $B'_c \uparrow$

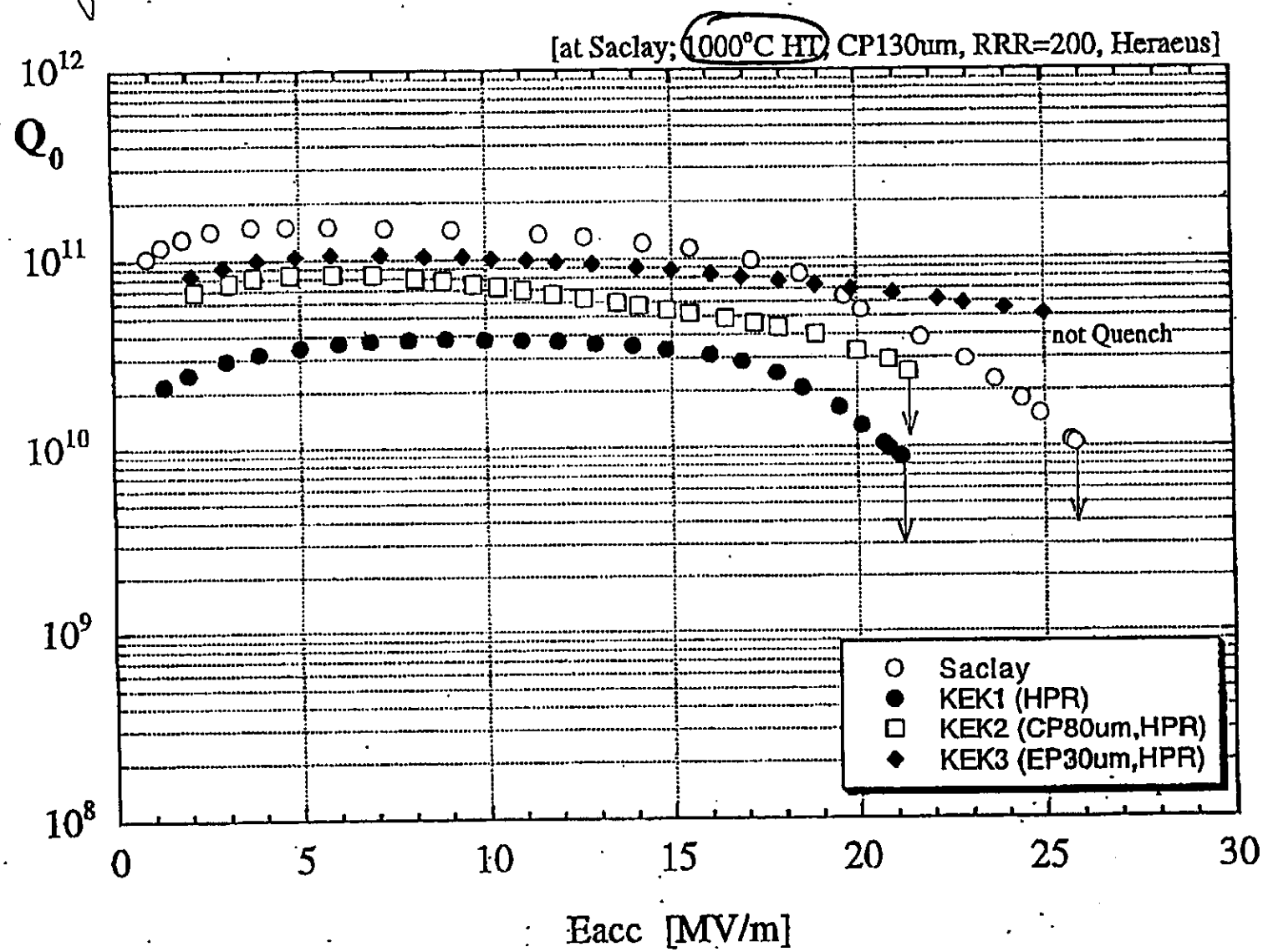

1E+11
1E+10
1E+09
1E+08
σ
0
5
10
15
20
25
30
Eacc (MV/m)


Monocell 1,5 GHz cavity S1-11-B
at 1,7 K
Nb/Cu
1,00E+11
1,00E+10
1,00E+09
1,00E+08
Q0
second test after baking at 90 °C
limited by a helium leak
first test
0
5
10
15
20
25
30
Eacc (MV/m)

SACLAY-KEK

Electro Polishing

S-2/C109 Cavity



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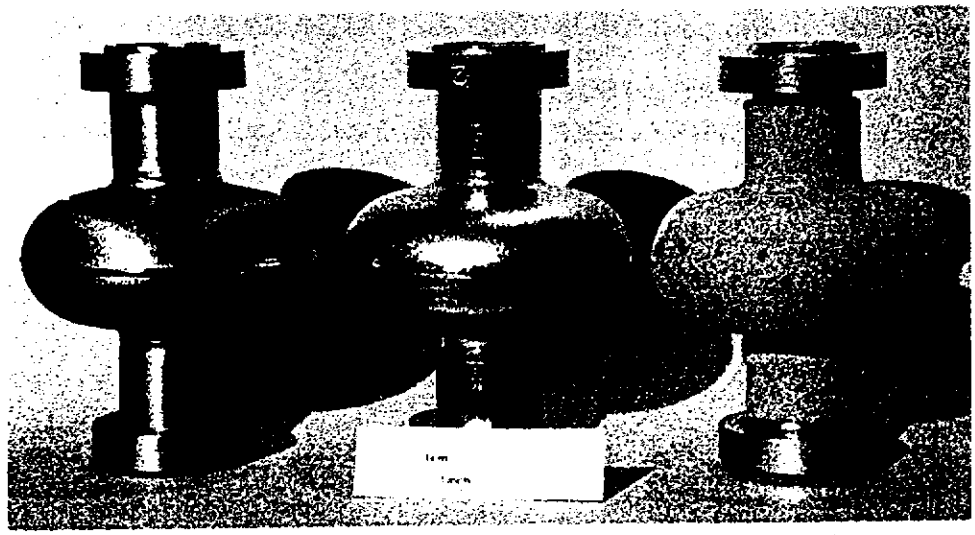
de : 81298643182
26/06/98 12:14 Pg: 2

R&D Activities at the I.P.N. Laboratory (CNRS-IN2P3) Orsay - France

Copper Plasma Sprayed Niobium Cavities

Goal: Fabrication of 1.3 GHz multicell cavities stiffened with copper deposited by plasma spraying onto Niobium.

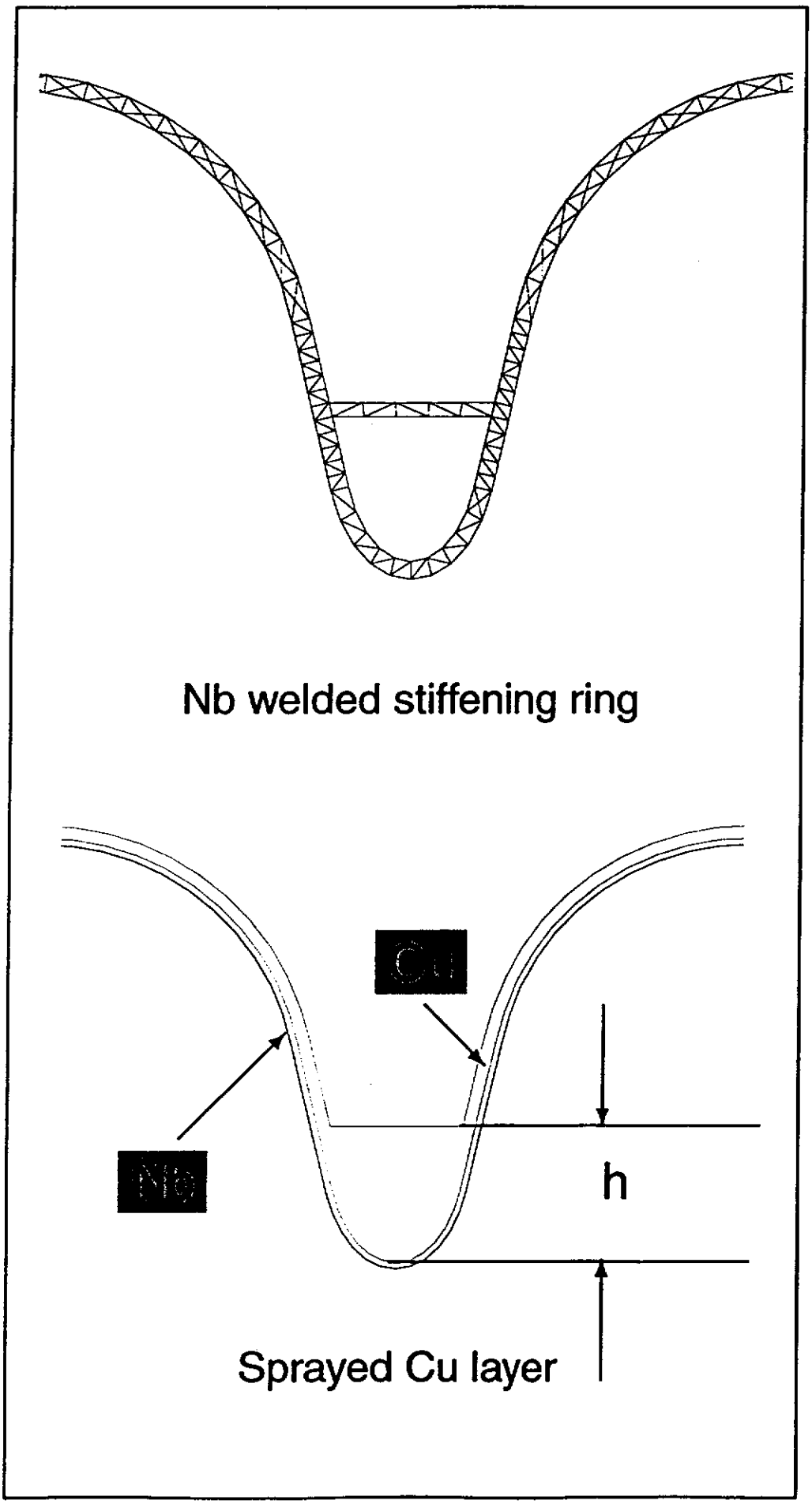
First studies: Five 3 Ghz Nb cavities fabricated: 0.5 mm thickness, initial RRR = 40, HT at 1200°C before copper plasma spraying (2mm deposited).



First RF tests results on 2 cavities: The cavity performances (Eacc max) are not (or very slightly) affected by the copper deposition.

Near Future Study Program:

- The last two 3 Ghz cavities tested in september 98.
- Fabrication of 1.3 Ghz monocell and multicell cavities from RRR≈200 Nb sheets of 1 mm thickness. RF tests before/after copper deposition.
- Mechanical and thermal characterization of samples produced with different deposition parameters.


Nb welded stiffening ring
Cu
Nb
h
Sprayed Cu layer

TESLA cavities (comparison Nb vs Nb/Cu)

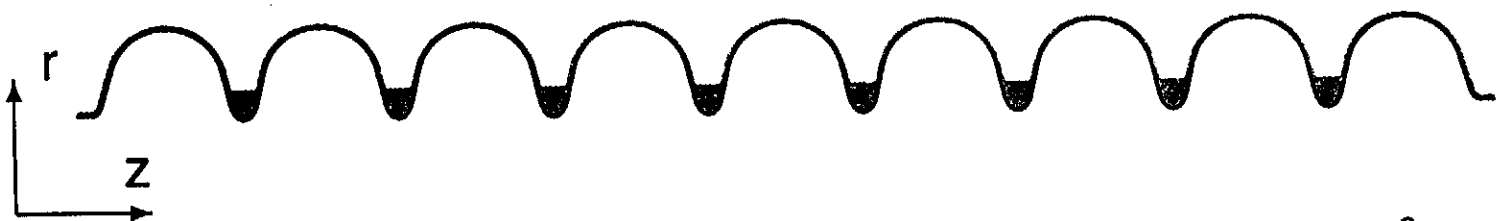


FIG. 1 – $E_{acc} = 25MV/m$, *Bandwidth:*$434Hz(Q_{ext} : 3.10^6)$

configurations	Δf
niobium 2.5mm unstiffened	[redacted]
niobium 2.5mm actuel stiffening	-387 Hz
niobium 2.5mm + copper 2mm (homogeneous layer)	-345Hz
niobium 2.5mm + copper 2mm + iris stiffening(h=20cm)	-140Hz
niobium 1mm + copper 2mm + iris stiffening(h=20cm)	[redacted]

STATUS OF COUPLER DEVELOPMENT SINCE LAST TTF MEETING

1) The 70 K cryostat was completed and tested. Its performances are:

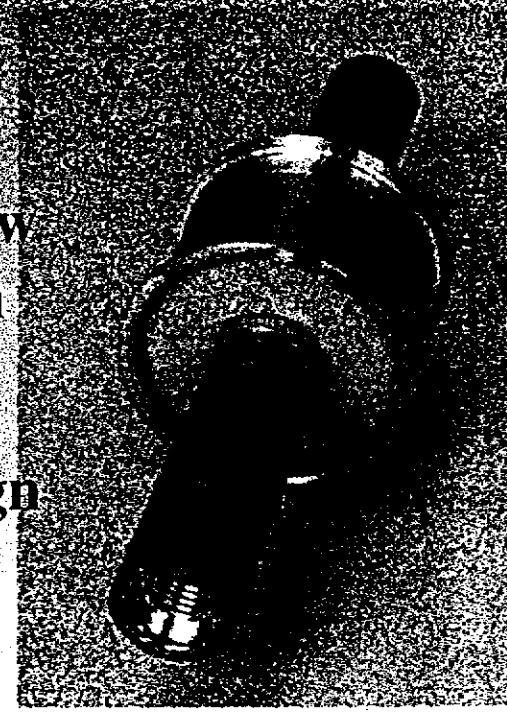
- Cooling time : 7-10 hours
- Nitrogen consumption for one cool-down: 17 to 20 l
- Static nitrogen consumption: 0.4 to 0.6 l/h
- RF power losses can be measured by:
  - thermal flux measurement 5 K/W
  - gas flow measurement ; 17 l/h/W

2) The λ/2 window fabricated by SICN was delivered

- RF test at room temperature and 70 K will be done during the summer

3) Travelling Wave window will be ordered this month

4) Complete coupler design has started



S. Fartoukh
TTF meeting, Hamburg
04/06/1998

RF steering experiment (week 25)

• Objective:

Measure the transverse effects on beam induced by the TESLA power couplers. The expected effects are mainly in the horizontal plane.

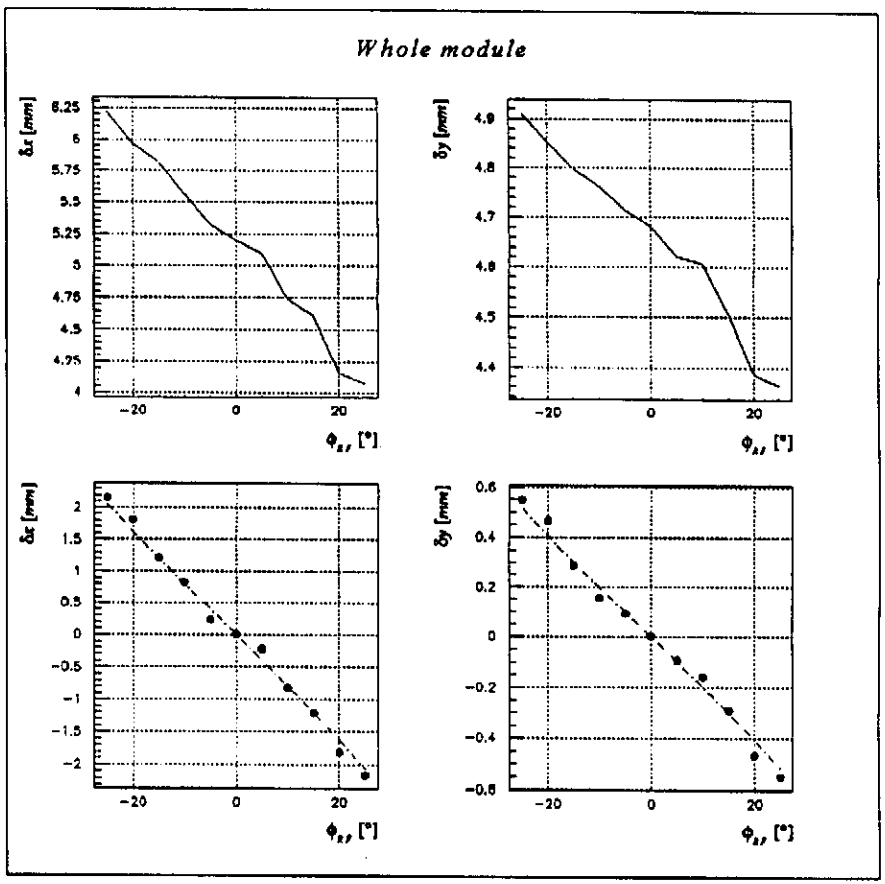
•Theory:

At the exit of each cavity, the beam of energy $E(\phi_{rf})$ is kicked:
$\delta x' = T_x * G_{rf} L_{cav} / E(\phi_{rf}) * \cos(\phi_o + \phi_{rf})$ + contributions coming from the unknown cavity misalignments, the latter being **independent on the sign of the rf phase.**

• Principle:

1. Keep the accelerating gradient constant.
2. Vary the klystron phase.
3. Monitor the beam displacement at BPM versus ϕ_{rf} and compute the factors T_x and T_y by fitting the anti-symmetrical part of the data obtained.

• Result with the whole module:



$$< T_x > = 0.32 \ mrad$$

(theoretical value: $T_x = 0.2$ ***mrad*** **, M. Zhang and Ch. Tang**)

$$< T_y > = 0.08 \ mrad$$

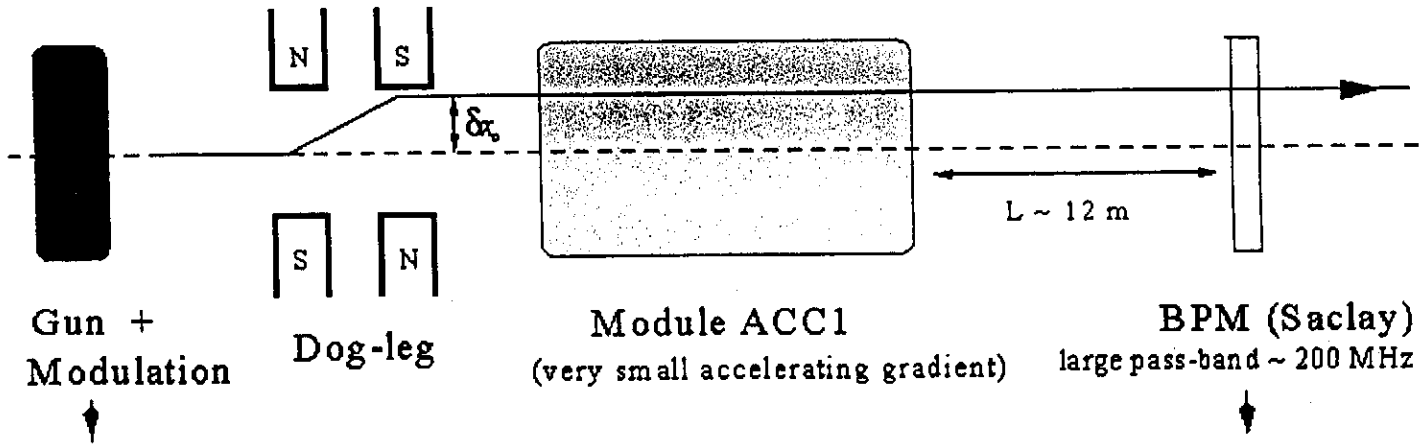
(tolerances: $T_y = 0.1$ ***mrad*** for the CDR beam parameters , ***A. Mosnier*** and $T_y = 0.05$ ***mrad*** for the high luminosity parameters)

•Experiment with cavity 1, cavities 2-8 detuned:

$T_x >> T_y$ as expected, but the T_x - value measured is 3 to 5 times higher than expected, certainly due to low energy problems (difficulty to tune the optics, bad transmission, etc…).

S. Fartoukh
TTF meeting, Hamburg
04/06/1998

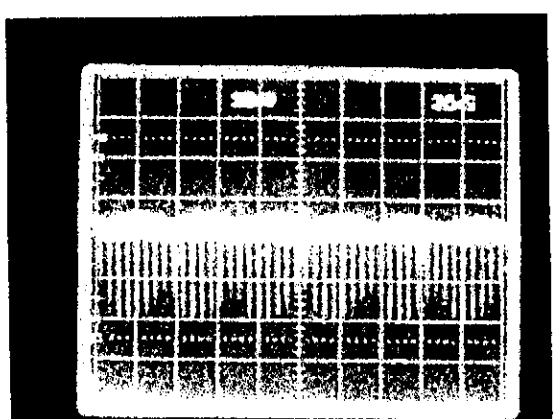
HOM experiment with Inj. I



$$\begin{cases} Q_b(t) = Q_{b_0} \sum_n \delta(t - nT_b)\left[1 + \lambda \sin(\Omega t)\right] \\ \delta x(t) = \delta x_0 \sum_n \delta(t - nT_b) \end{cases}$$

$$\Rightarrow \quad \begin{cases} Q_b(t) = Q_{b_0} \sum_n \delta(t - nT_b)\left[1 + \lambda \sin(\Omega t)\right] \\ \delta x(t) = \delta x_0 \sum_n \delta(t - nT_b)\left[1 + \lambda \times A(\Omega) \times \sin(\Omega t + \varphi(\Omega))\right] \end{cases}$$

$0<\lambda<1$ and
$0<\Omega< \omega_b/2=108$ MHz

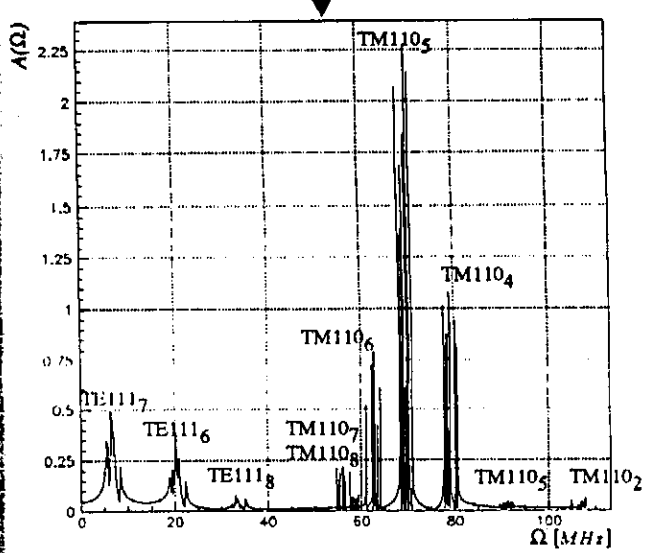


Resonance when the dipole mode $\omega_{\alpha i}$ of cavity number i verifies

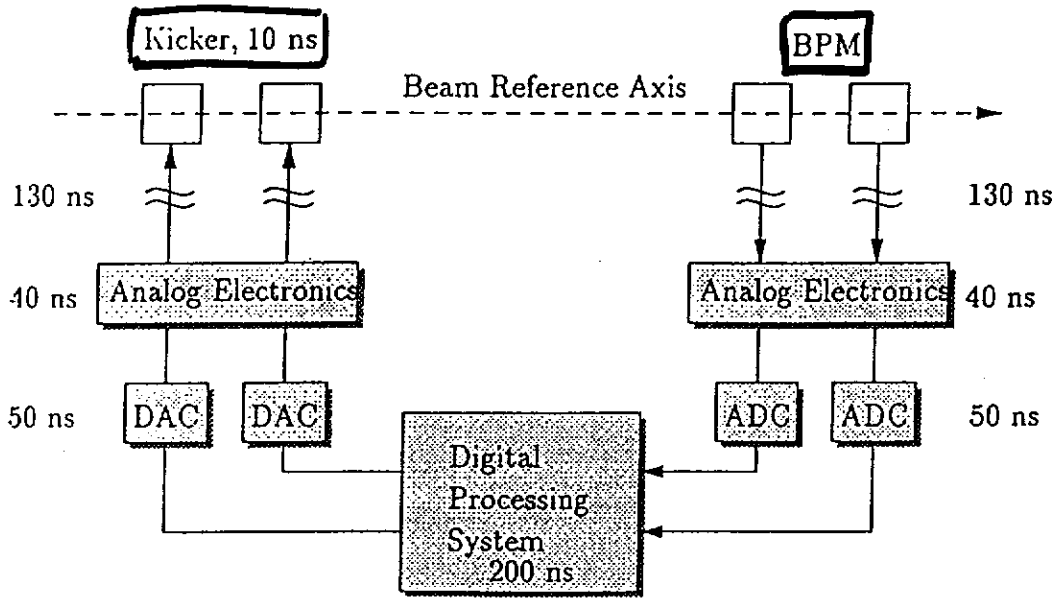
$$\omega_{\alpha,i} \pm \Omega_{res} = n\, \omega_b$$

$$\Downarrow$$

$$\begin{cases} \varphi(\Omega_{res}) = \pm \pi/2 \\ A(\Omega_{res}) \propto \dfrac{\langle I_b \rangle}{E_0} \times \left(\dfrac{R}{Q}\right)_{\alpha,i} \times Q_{\alpha,i} \end{cases}$$



Proposal for a "Fast Orbit Correction" Experiment with TTF



- Fast ($<1\mu s$) orbit correction is crucial for **TESLA**
- Experiment with TTF Beam the 3 main components:

1) Test-bench for high resolution BPM's:
($\sim 5\,\mu m$, for δy^*, $\sim 1\,\mu m$, for $\delta\theta_y^*$)

→ Three stacked BPMs provide direct measurement of resolution
(Like @FFTB)

2) Test a short ($\sim 0.5m$) module of the traveling wave fast kicker, with beam
(Riimmler, Shiltsev, et al)

3) Test the fast electronics overall system

TOROIDS

- New toroids ordered (spare + new...)
- Electronics:
  - Adapt existing electronics to Dufech. II
  - Differential loss monitor w/ Bergoz
  - Fast differential interlock (ondulator)

BPM

- BPM in front of module 1 moved...
  will be replaced
- New BPM ?

TUNERS ... (modules 2 and 3)

- Mechanical parts and motors at DESY
- Pb with gear box: (too tight tolerances)
  - sent back to Japan for machining
  - Back to France

Next: Coating

⇒ **At DESY 2017**

HOM COUPLERS

- 8 couplers delivered end July

  ⇒ at DESY 13 August

- 20 couplers : delivery foreseen 15/10

TTF Collaboration Meeting
DESY, July 6-8, 1998

C. Pagani

TTF Activities at INFN

(Milano, LNF, Roma2 & LNL)

1) Cryostat Design & Cryomodule Assembling

- **Cryostats # 2 & # 3 (including WPMs)**
  - 2nd and 3rd Cryostat ready, all components at DESY
  - 2nd Cryomodule assembly starts on July 27
  - 3rd Cryomodule preparation depends on cavities
    Expected installation together with FEL undulator (Spring 99)
- **Cryostats # 4 to # 8**
  - The new design has been completed and finalised
  - A complete set of drawing on the Web this week
  - Warm and cold friction measurements started at LASA
  - Final drawing due by the end of October
  - Components for the composite posts to be ordered
- **New Assembling Tools - not funded yet**
  - Design will be completed by November 98
  - New assembling tools compatible with Cryo # 1 to # 3
  - Tooling exchange planned in Spring 99

3rd Generation Cryostat

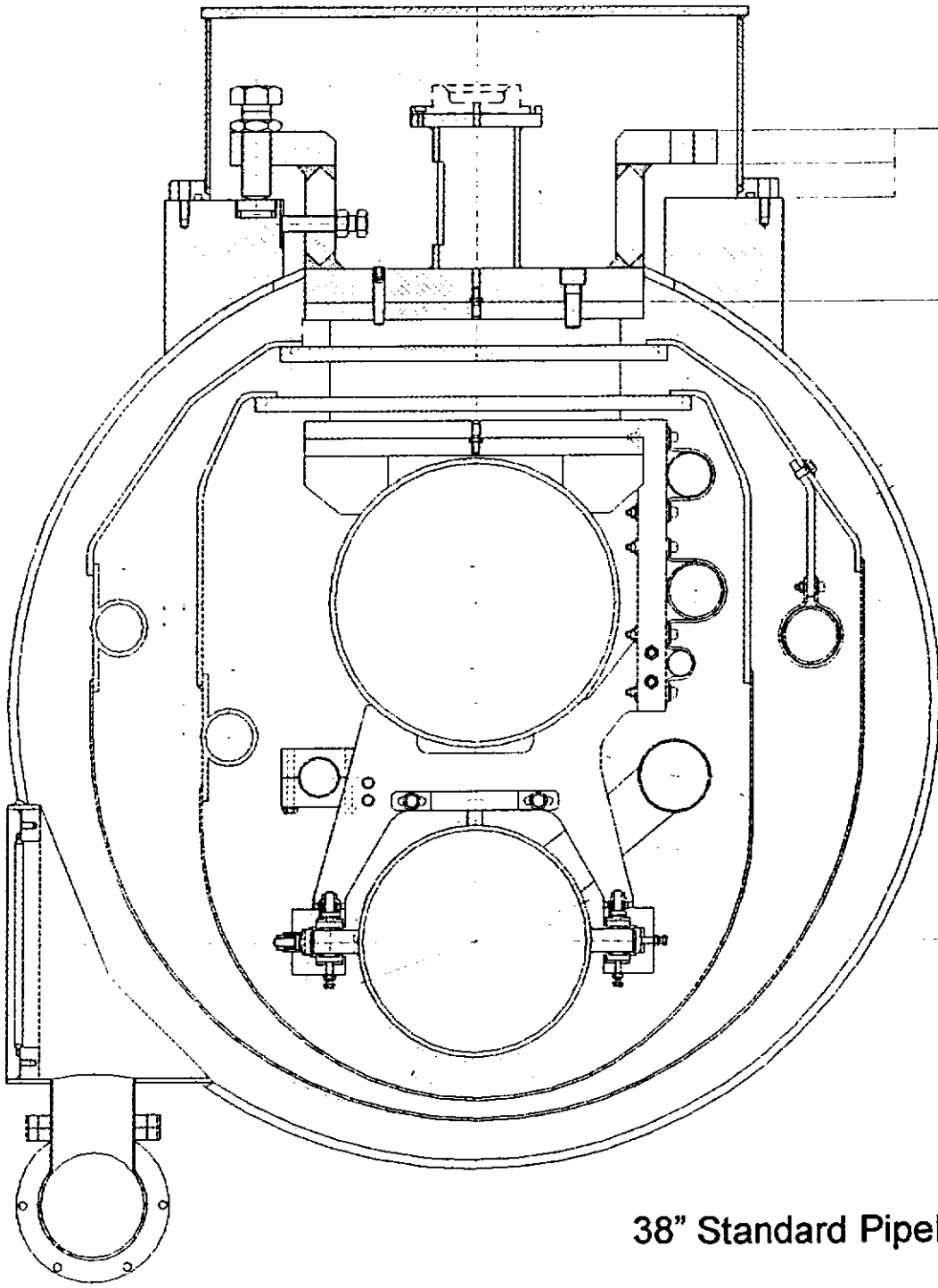
Thinking to TESLA 500

- Reduce the Cross Section **and use a** standard "pipeline" tube
  - Redistribute the internal components
  - Reduce the distances to the minimum
- **Compatible with** "rigid coupler" **and** "Superstructures"
  - Position of the active elements longitudinally free
- Improve the connection **of the active elements to the HeGRP**
  - Poor in the present scheme
- Reduce alignment sensitivity **to the forces on the HeGRP edges**
  - Move the external posts closer to the edges
- **Further** simplify the assembling procedure
  - Simplify coupler cones and braids
  - Reduce by a factor two the shield components
- **System thought for** mass production cost cutting
  - Tolerances reduced to the required ones
  - Simpler components and standard tubes wherever possible

Carlo Pagani
INFN Milano - LASA

3rd Generation Cryostat

Cross section on Cavity

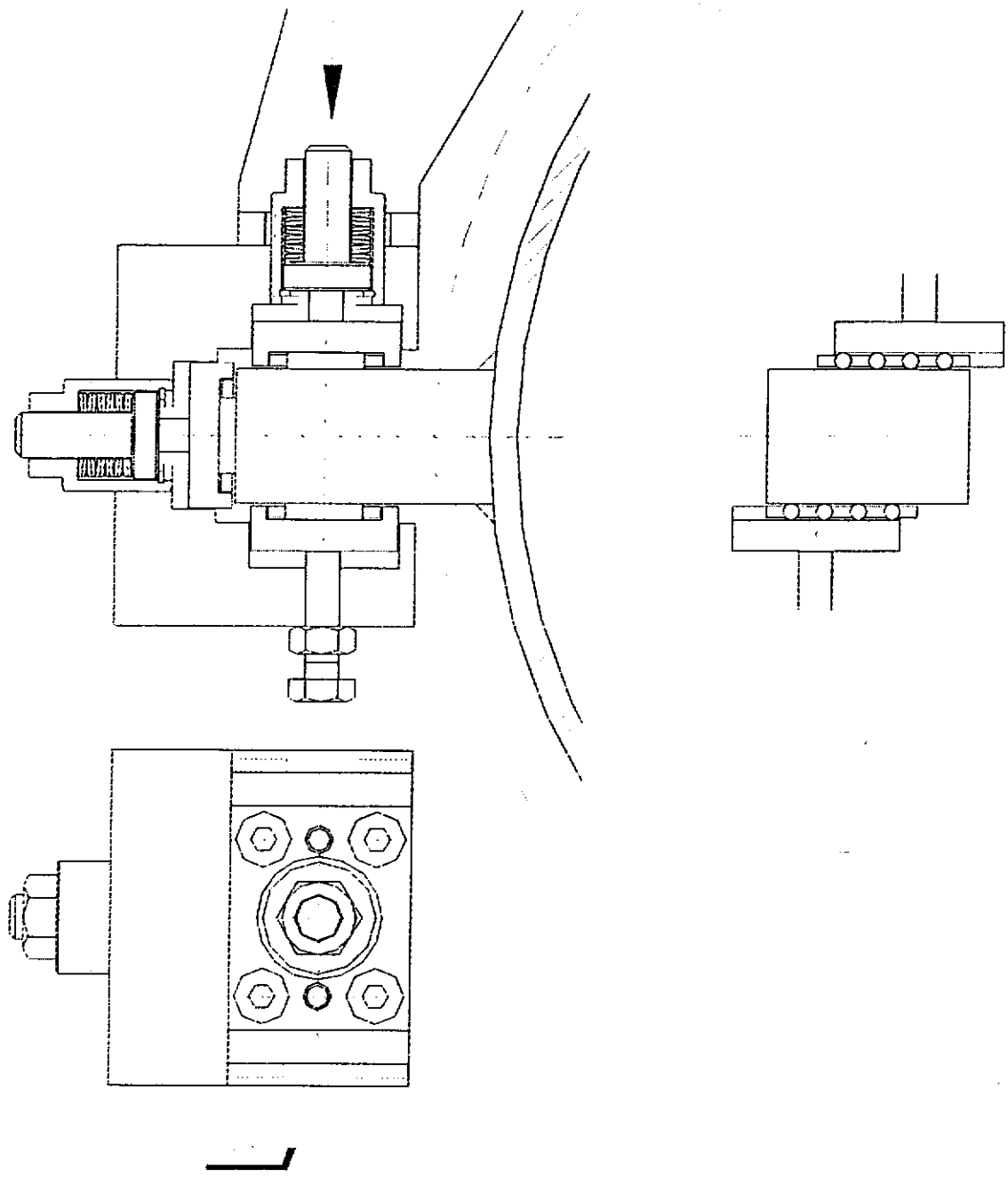


38" Standard Pipeline

Carlo Pagani
INFN Milano - LASA

3rd Generation Cryostat

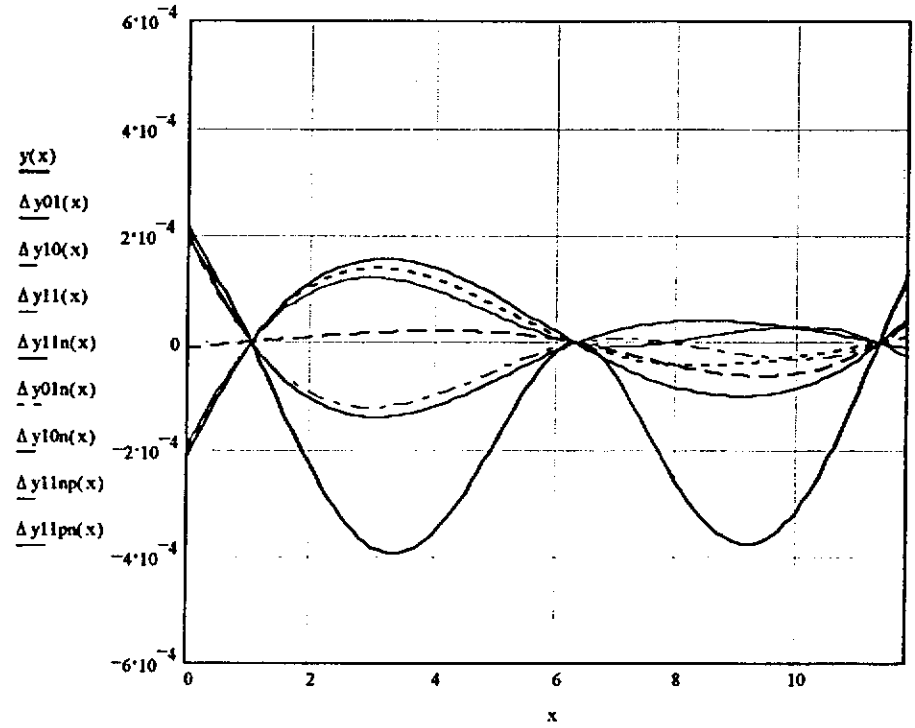
Cross section on Cavity - Sliding fixture detail

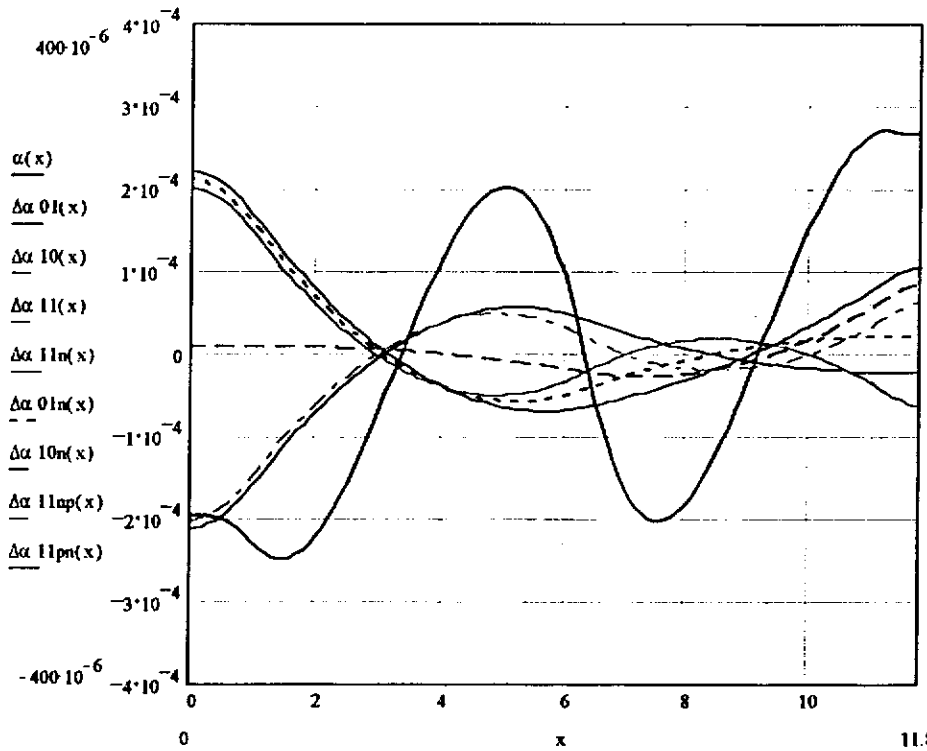


Carlo Pagani
INFN Milano - LASA

3rd Generation Cryostat

Active element movements for a 1000 N force at the edges





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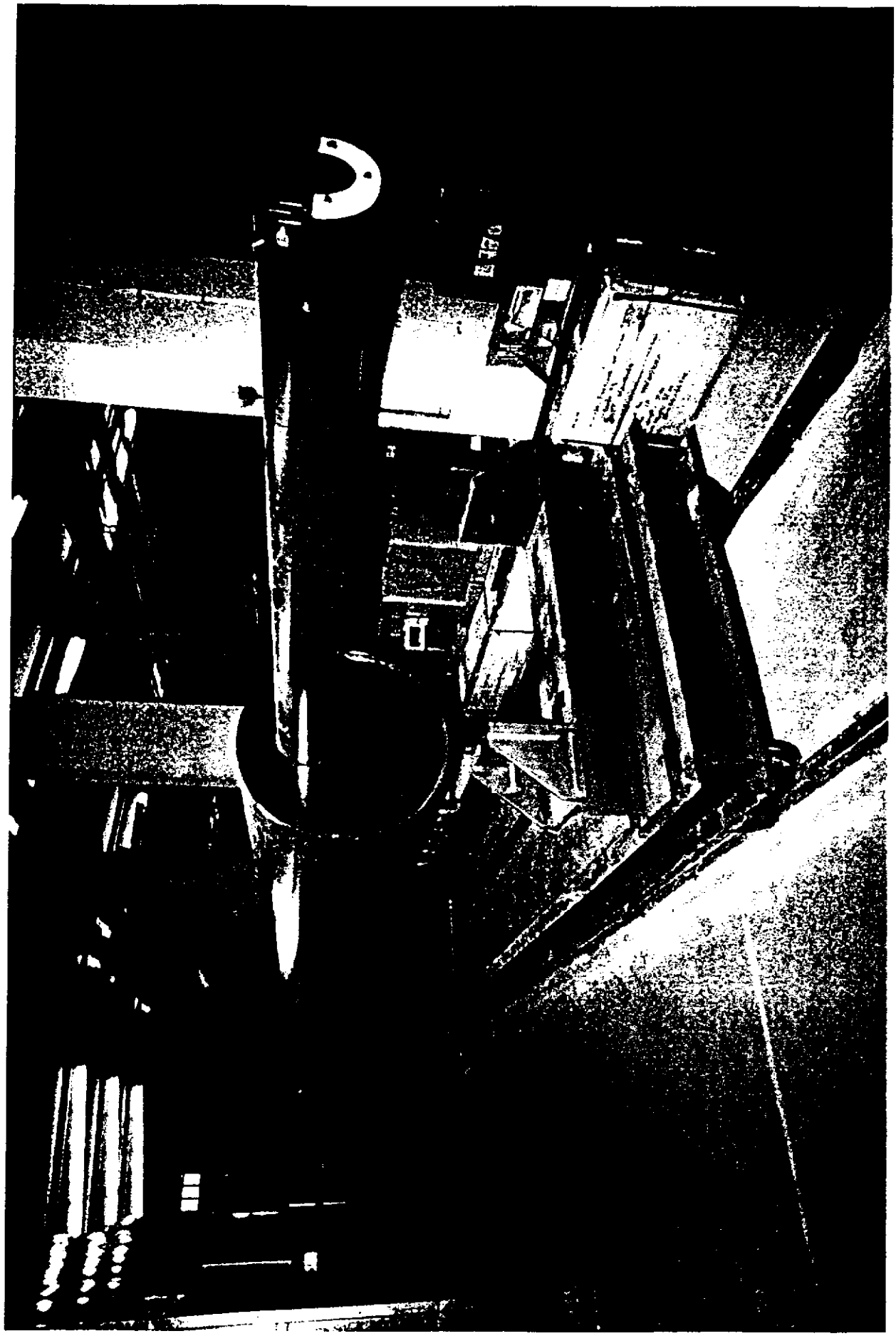


2) Activity on Photocathodes (P. Michelato)

- **TTF Injector II Cathode System**
  - Installation at DESY completed
  - First Cathodes prepared at Milano
  - Cathodes prepared at Milano transported to DESY
  - Cathode transport system connected at 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) Activity on Beam Diagnostics (M. Castellano)

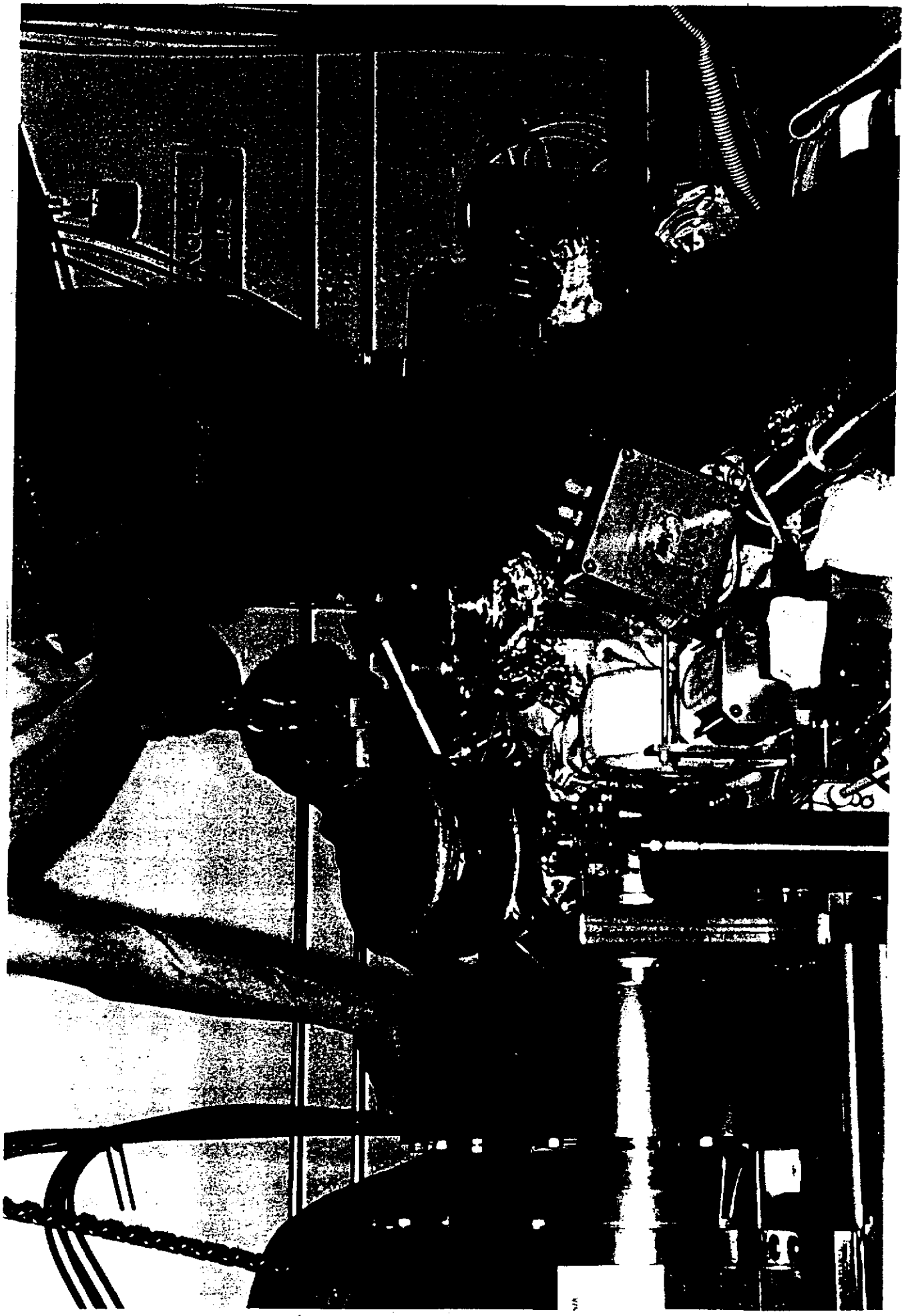
- **Diagnostics instrumentation**
  - Actuators for new OTR screens completed
  - Actuators for the pepper pot screen in construction
  - New fast electronics modules for the strip-lines ready
  - Eventual new diagnostics for injector II to be discussed
- **Beam parameter measurements with OTR**
  - Emittance and energy spread measurements done

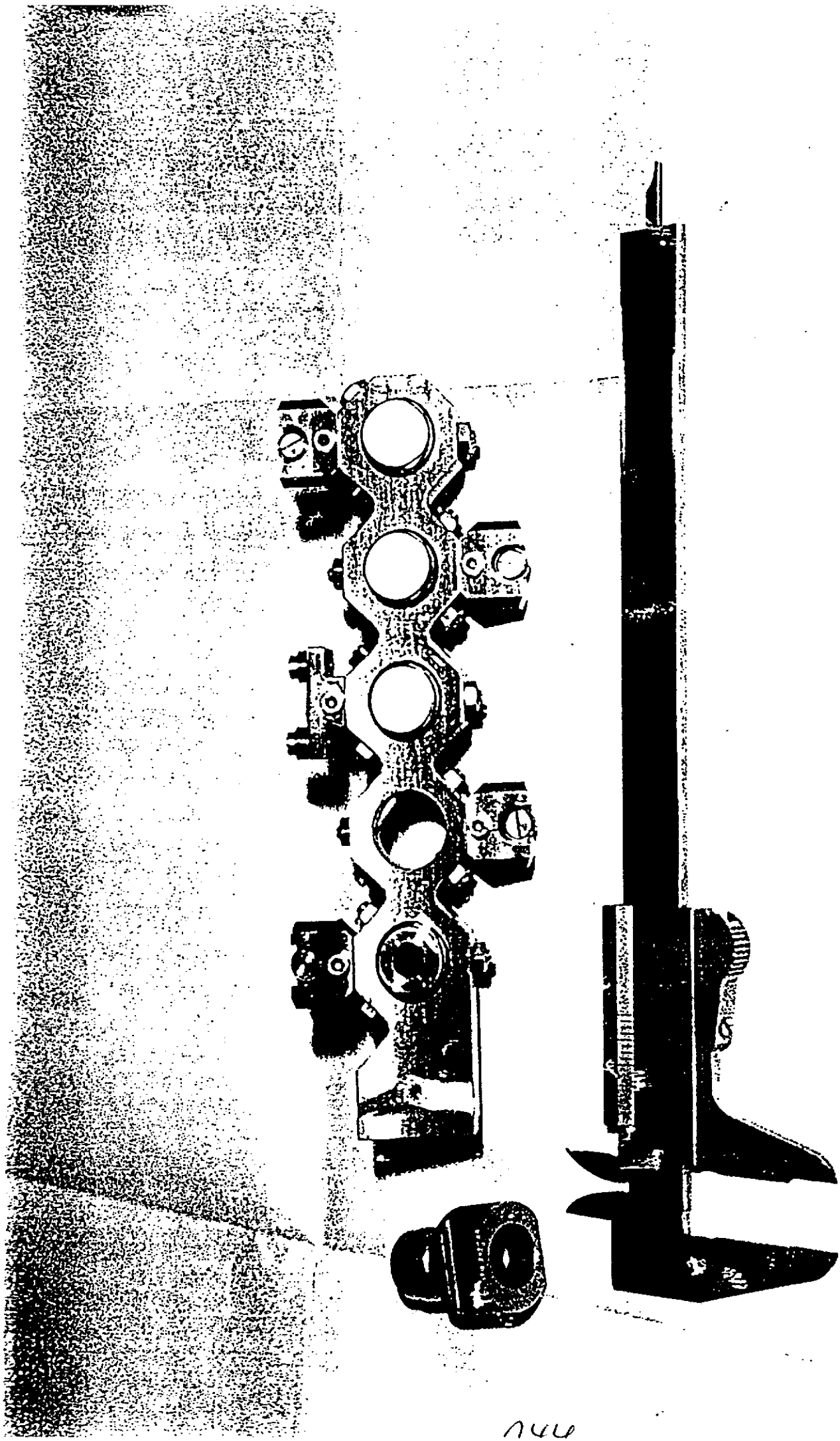
4) Cavity Fabrication

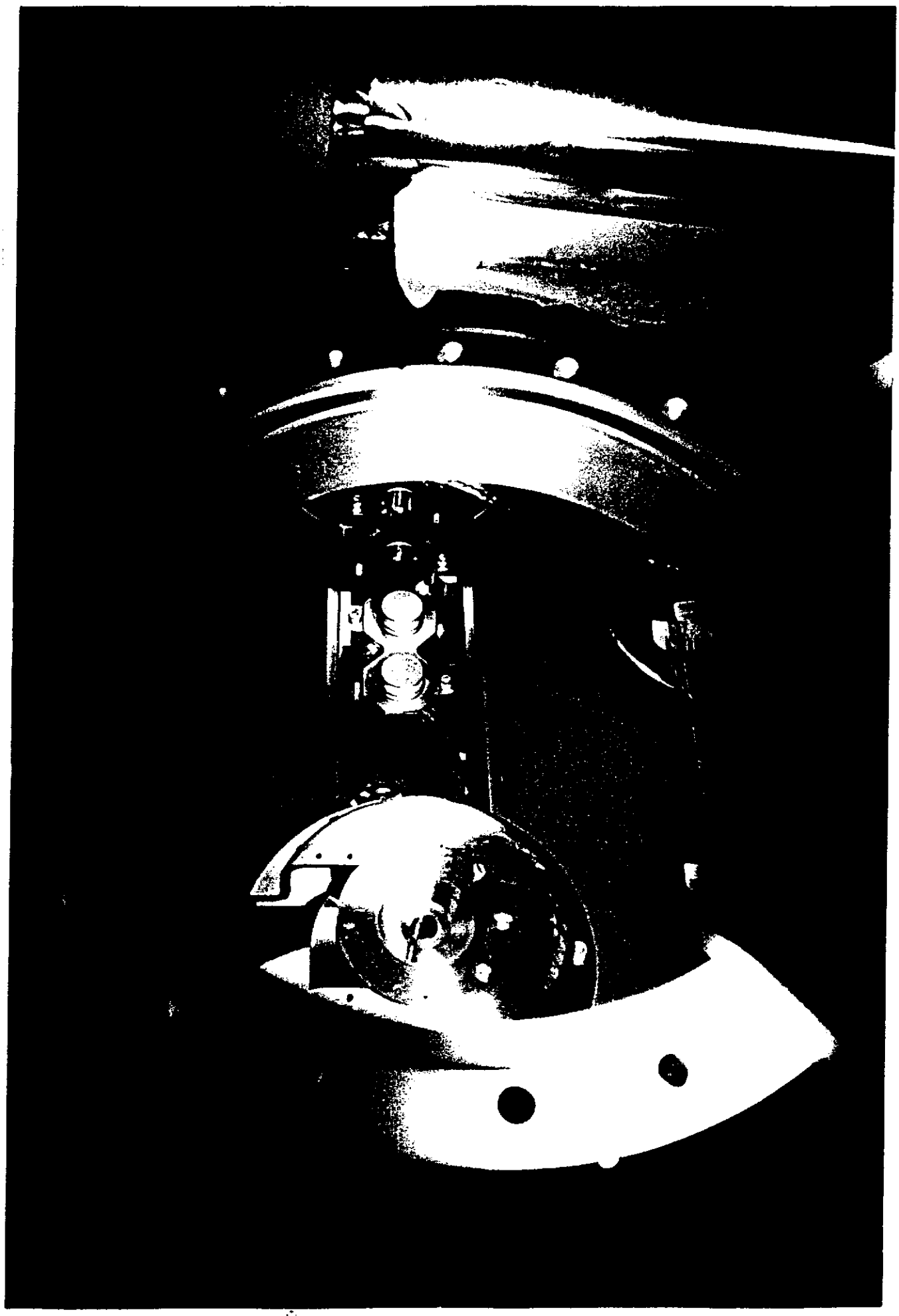
- **Cavities A13 to A18 delivered**
- **Alternative cavity production, spinning, at LNL**

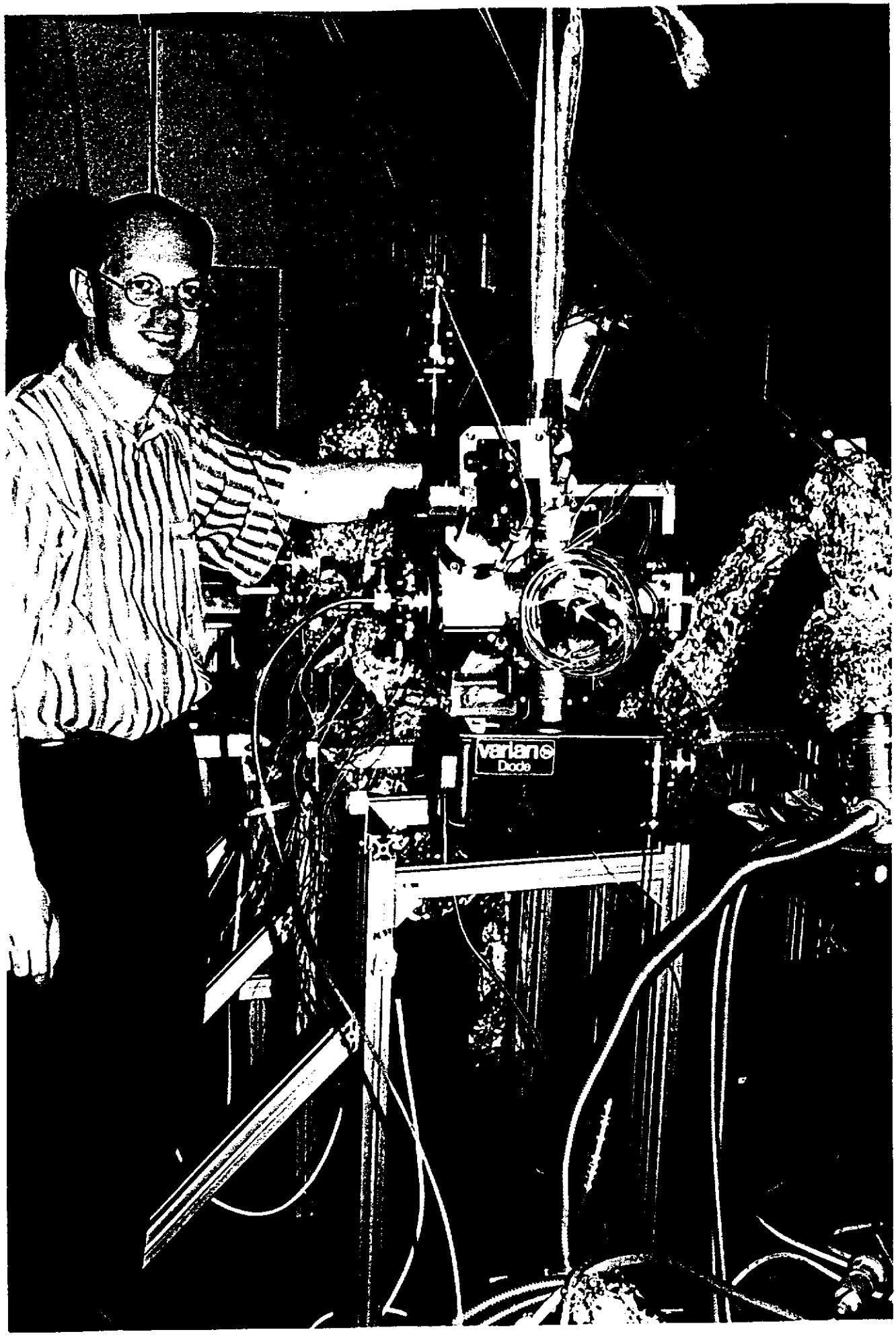
5) Theoretical activity

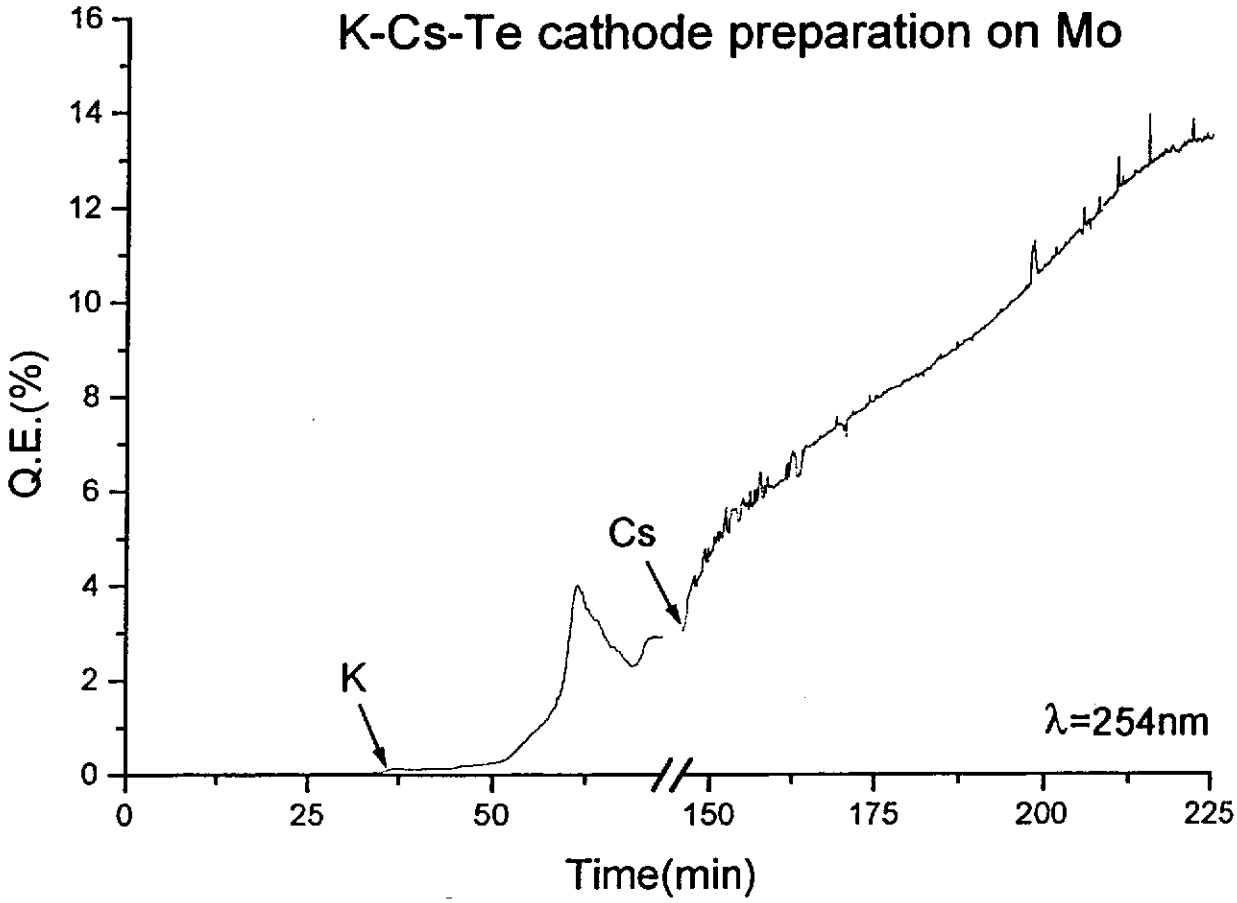
- **Further studies on RF Gun dynamics** (L. Serafini)
- **Beam behavior in superstructures** (M. Ferrario)



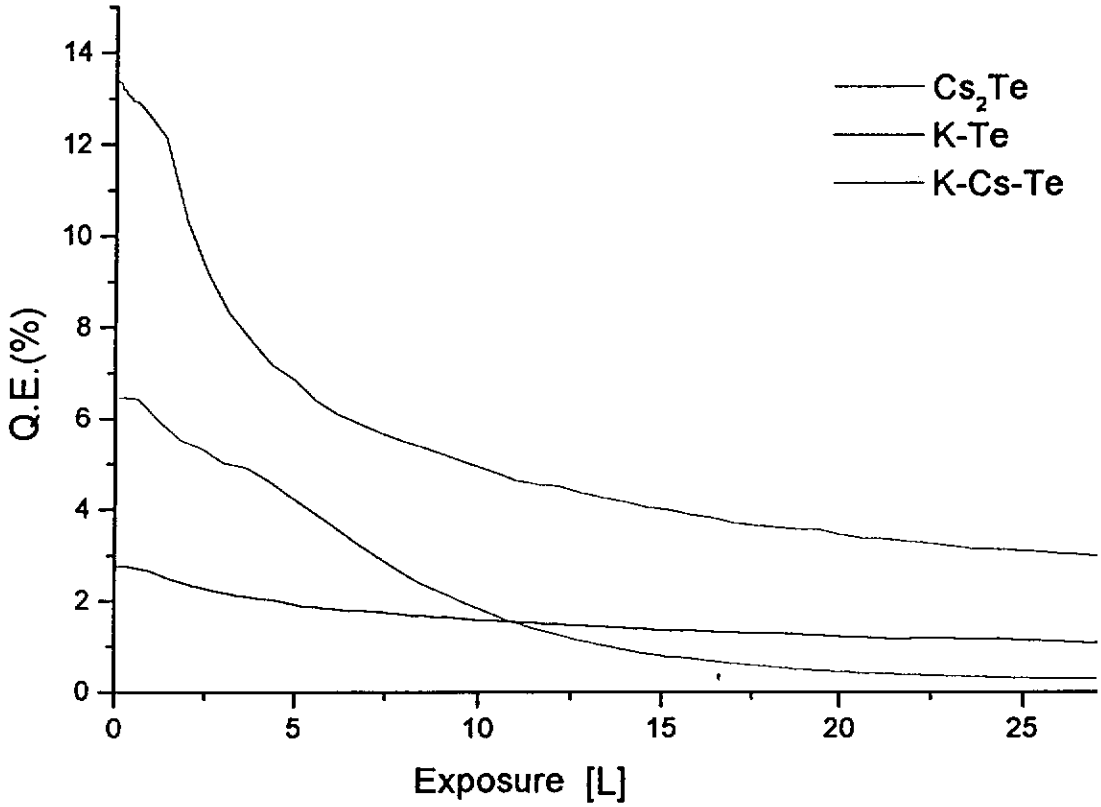


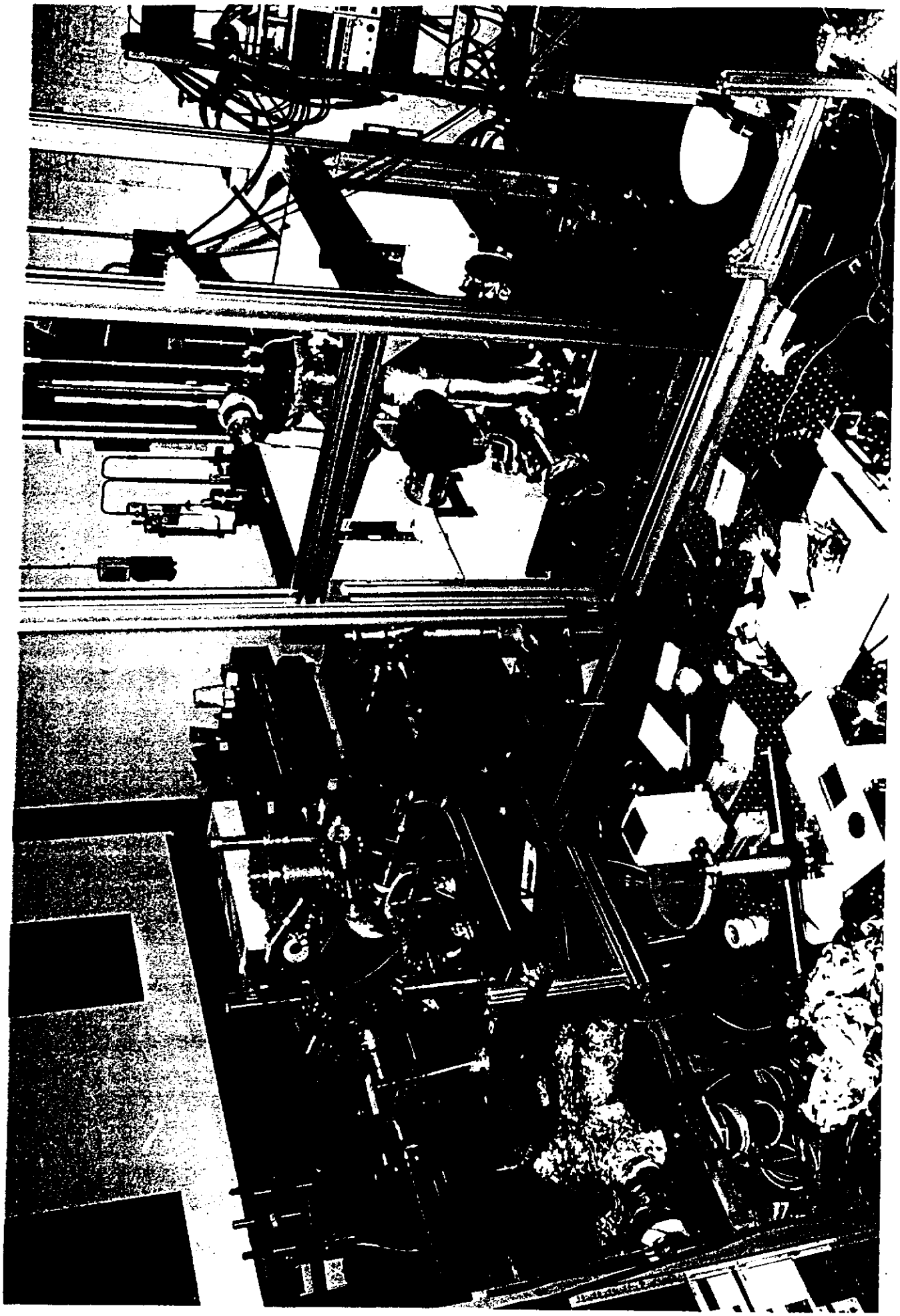



varian
Diode

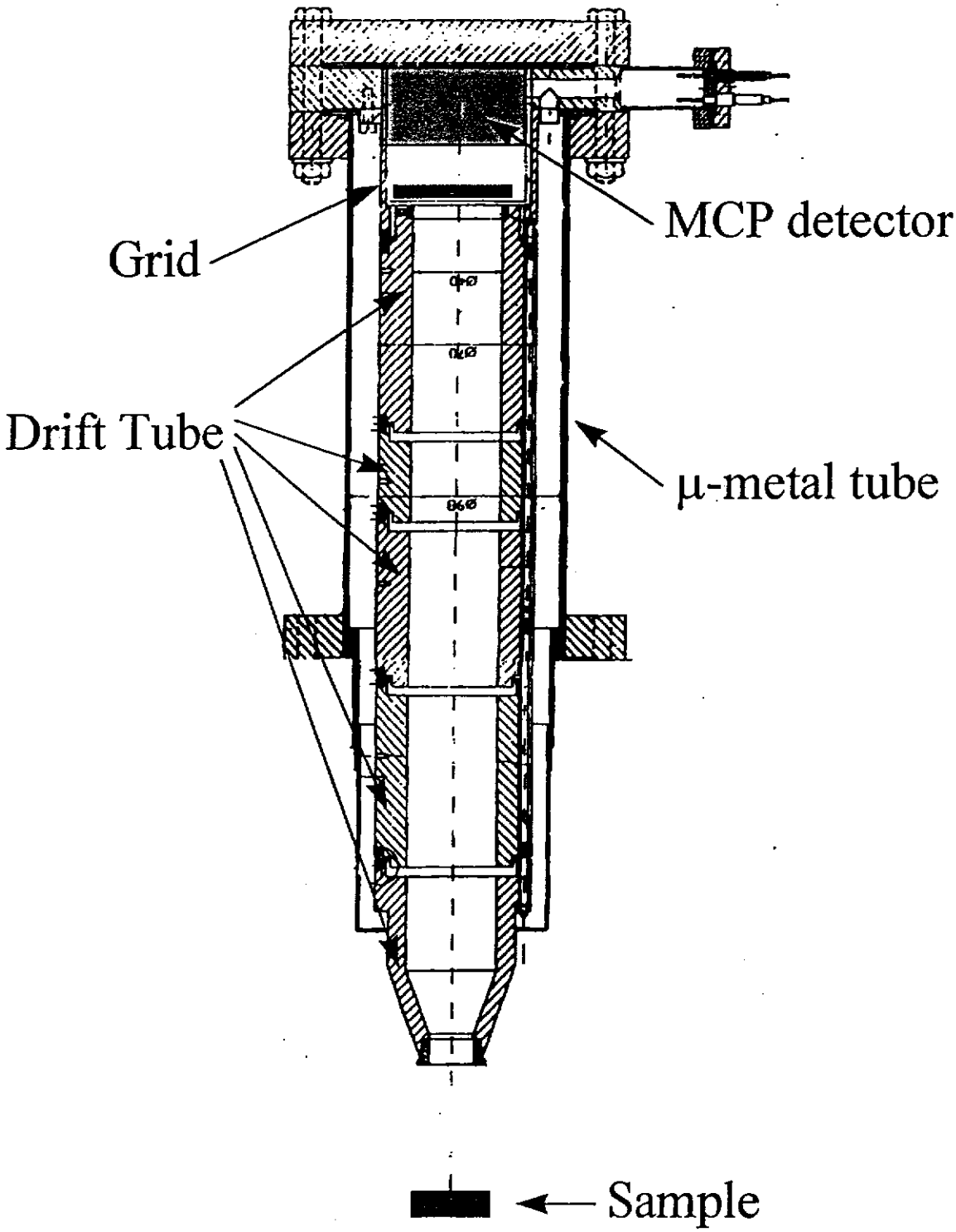

K-Cs-Te cathode preparation on Mo
Q.E.(%)
Time(min)
K
Cs
λ=254nm
0
2
4
6
8
10
12
14
16
0
25
50
150
175
200
225

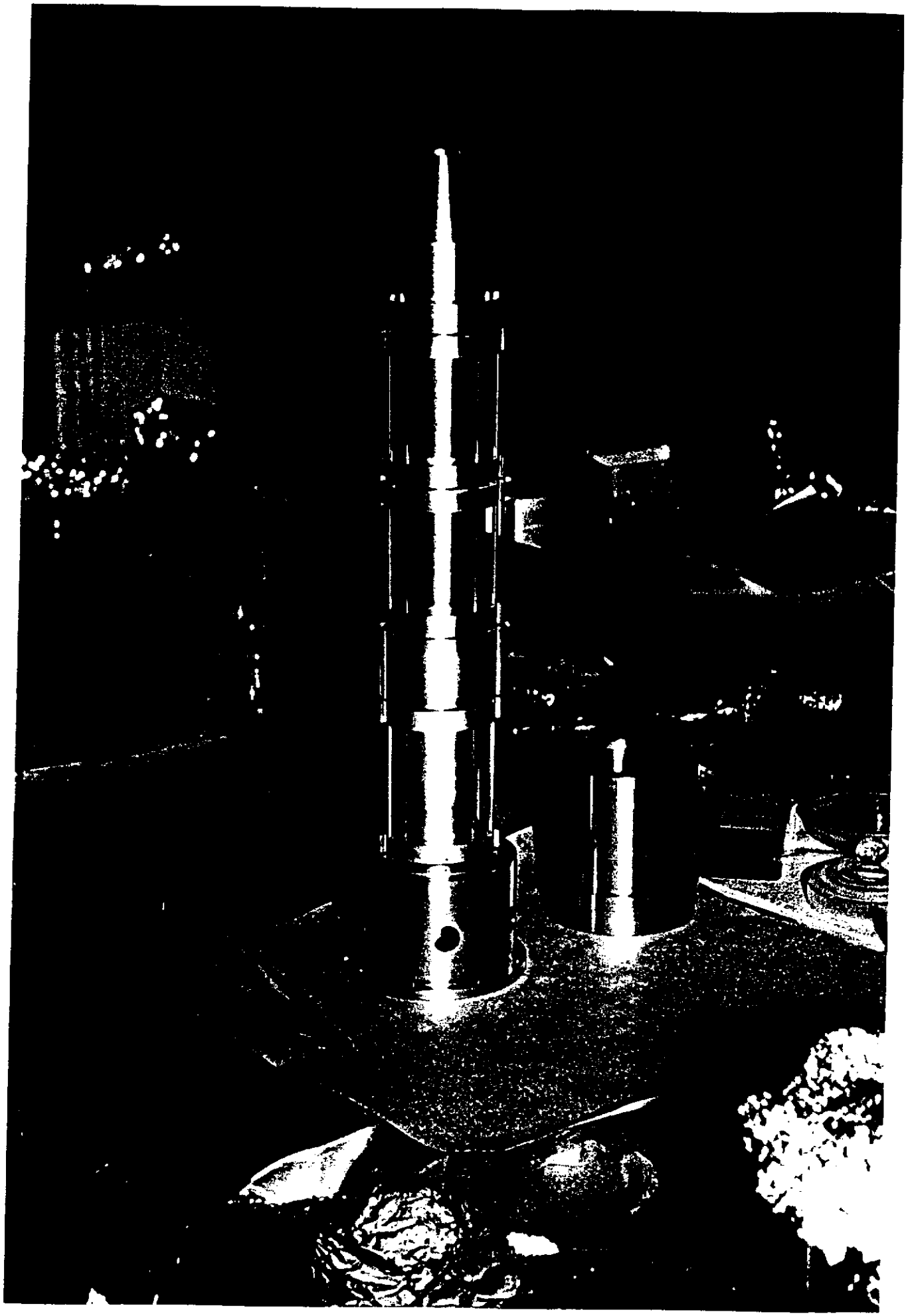
Different photocathodes exposed to 10^{-8} mbar oxygen pressure

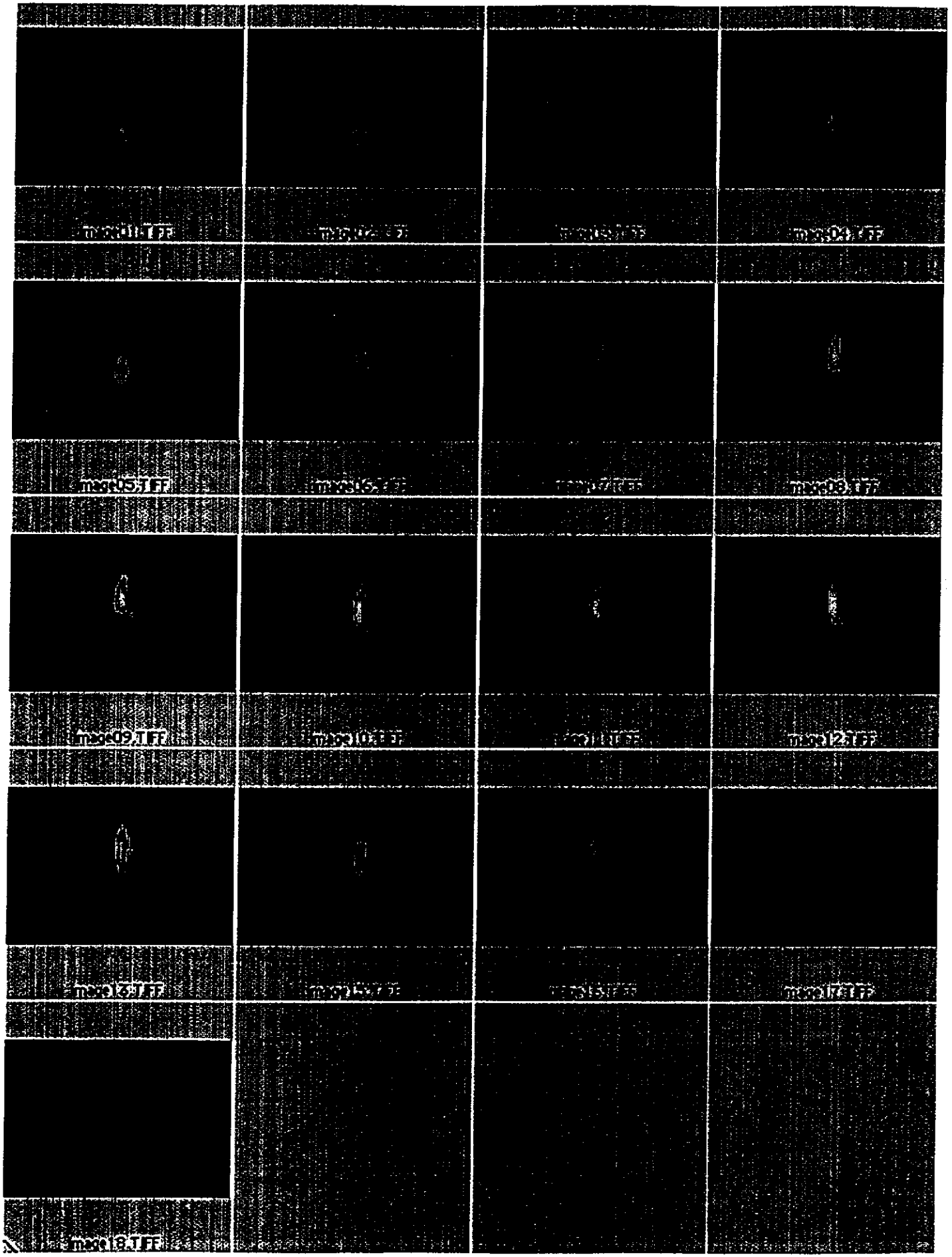


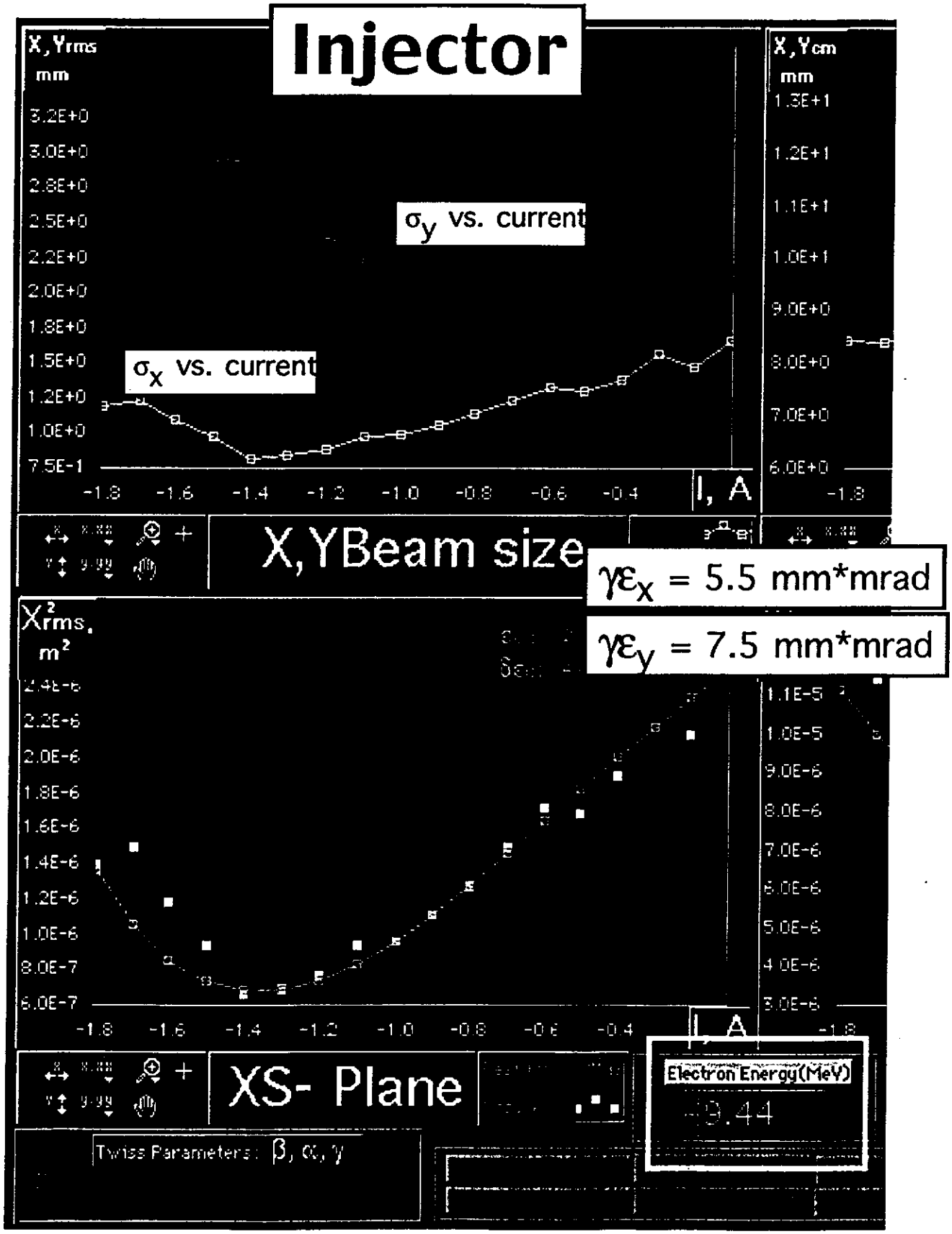


Time-Of-Flight spectrometer








Injector
X,Yrms
mm
3.2E+0
3.0E+0
2.8E+0
2.5E+0
2.2E+0
2.0E+0
1.8E+0
1.5E+0
1.2E+0
1.0E+0
7.5E-1
σy vs. current
σx vs. current
-1.8
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
-0.4
I, A
X,Ycm
mm
1.3E+1
1.2E+1
1.1E+1
1.0E+1
9.0E+0
8.0E+0
7.0E+0
6.0E+0
X,YBeam size
γεx = 5.5 mm*mrad
γεy = 7.5 mm*mrad
Xrms, m²
2.2E-6
2.0E-6
1.8E-6
1.6E-6
1.4E-6
1.2E-6
1.0E-6
8.0E-7
6.0E-7
1.1E-5
1.0E-5
9.0E-6
8.0E-6
7.0E-6
6.0E-6
5.0E-6
4.0E-6
3.0E-6
XS- Plane
Twiss Parameters: β, α, γ
Electron Energy(MeV)
-18.44

h edwards

Fermilab TTF Report July 6, 1998

Contributions from: Jean Paul Carnerio, Mark Champion, Alan Fry, Walter Hartung, Don Edwards

Outline

Injector II - high charge gun effort

3 guns :
prototype "Argonne gun"- low average power, will show beam measurements
gun 3 - rf processing
gun4 - fabrication

Beam test results with Argonne gun at Fermilab
May-July 97, Sept-Dec 97.

These results should be taken as " learning how to operate and make measurements".

Beam measurements

Dark current

Laser operation

Quantum Effic

Capture Cavity S12- test results - again learning

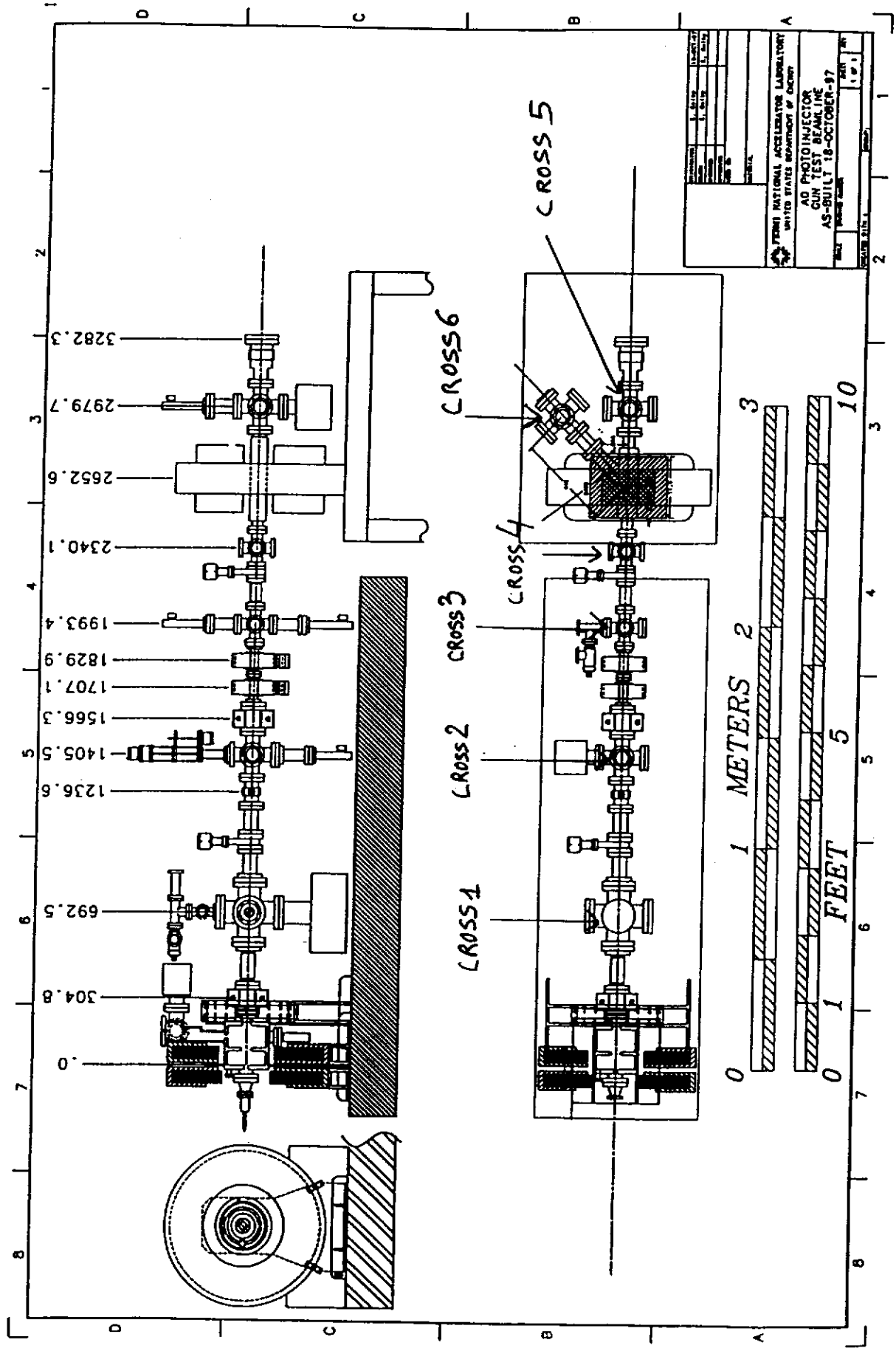
Gun 3- rf processing

Gun 4 - fabrication

Module 2 warm coupler parts

Srf at Fermilab- interest in a Kaon separated beam from the Main Injector

INTRODUCTION : LAYOUT OF THE PHOTO-INJECTOR



Prototype gun test results at Fermilab

	Measured	Design
Tot Energy	4.7 MeV	4.4 MeV
Energy Spread (sigma)	~ 0.5%	1%
Emittance normalized	7-9 π e-6m @ 1.2 nC	20 π e-6m @ 8 nC
Max # elect bunches	200	800
Typical # elect bunches	15	

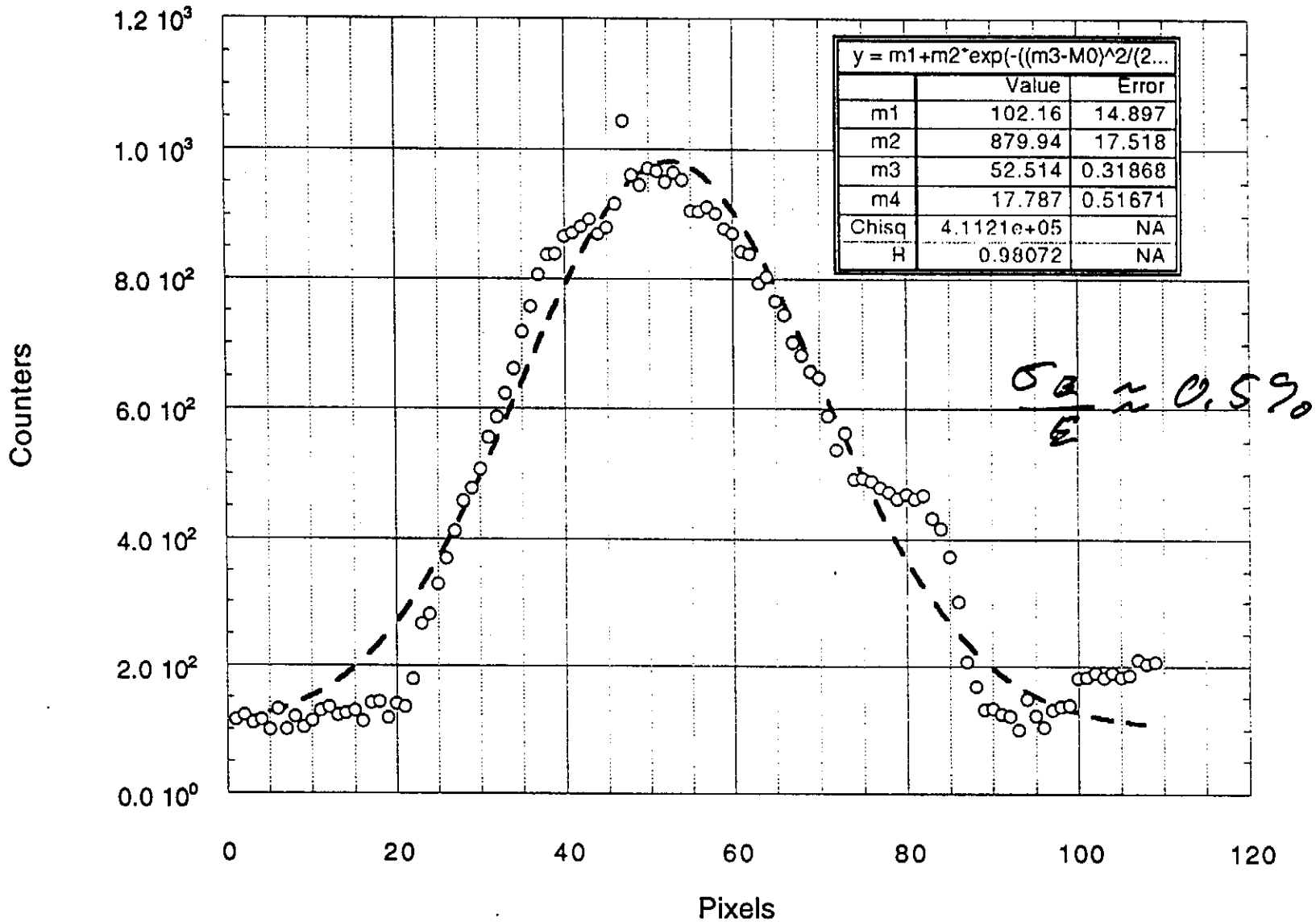
Laser pulse length probably much shorter than design (pulse stacker)

Energy slope for bunch compression not adjusted.

Investigations of calibrations and saturation

Energy spread 12/17

Energy ≈ 4.7 MeV



$\frac{\sigma_E}{E} \approx 0.5\%$

8-SV

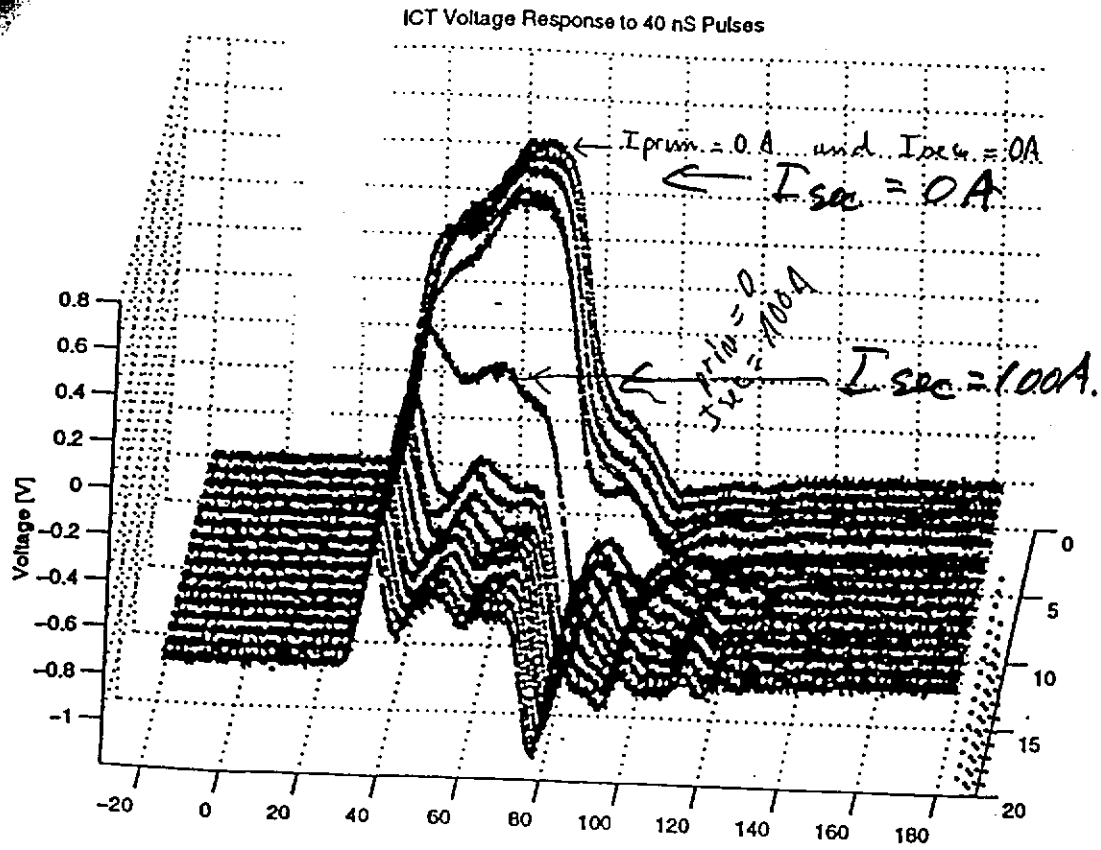


Figure 7.3 : ICT1 Vs Iprim and Isec for a 40 ns pulse

ICT affected by Solenoid

7.2. Measurement of the length and the cables attenuation

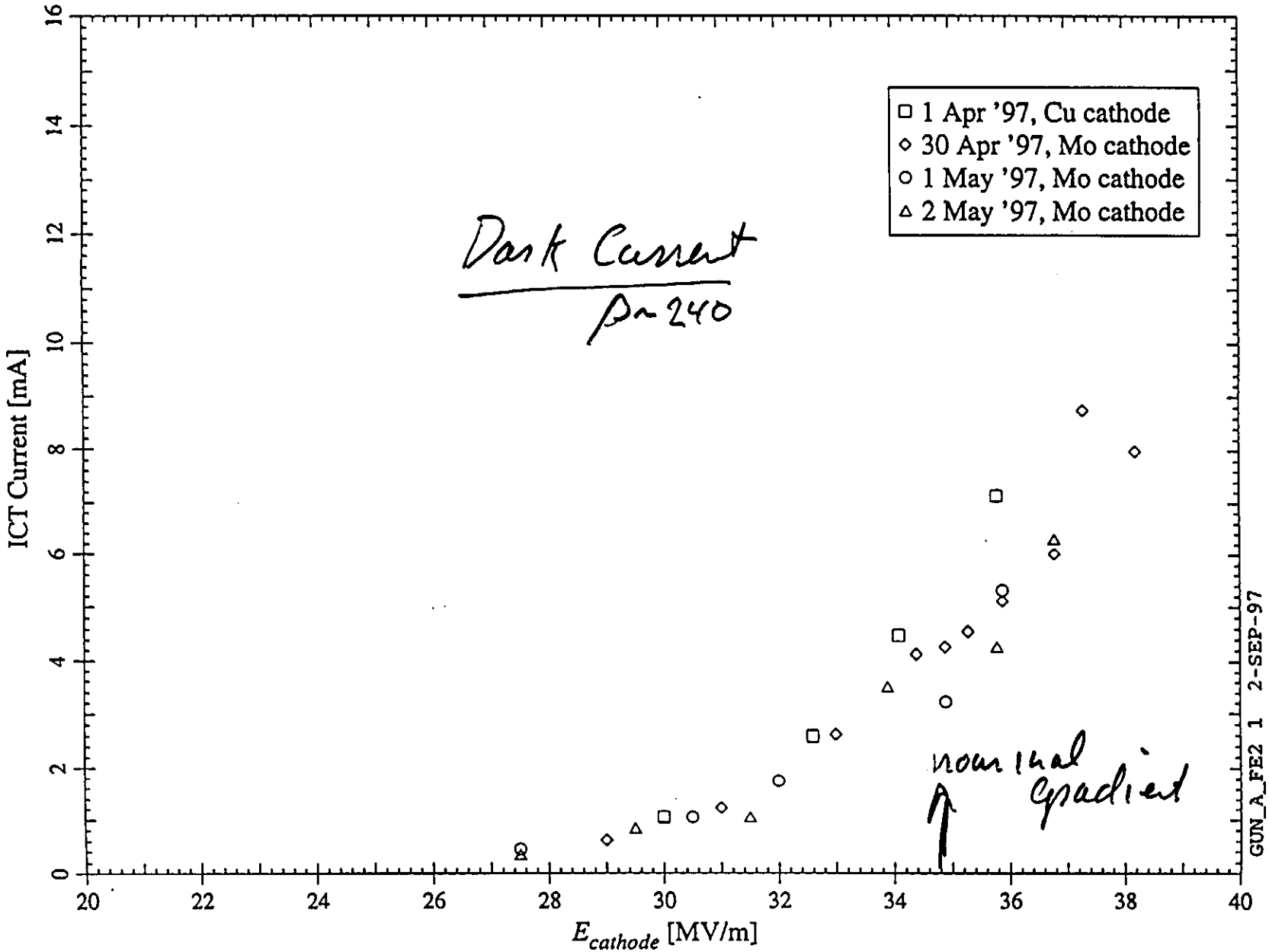
To do this measurement, we used a Hewlett Packard Network Analyzer (NWA).

- **Length of the cables**

Using a single-port network analyzer measurement, we obtained the round-trip time for each cable : 450.56 ns for the ICT1 cable and 451.68ns for the ICT2 cable. Because $\beta_{cable} = v/c = 2/3$ (given by the manufacturer), the round-trip distance is 90.05 m for the ICT1 cable and 90.273 m for the ICT2 cable.
This leads to :

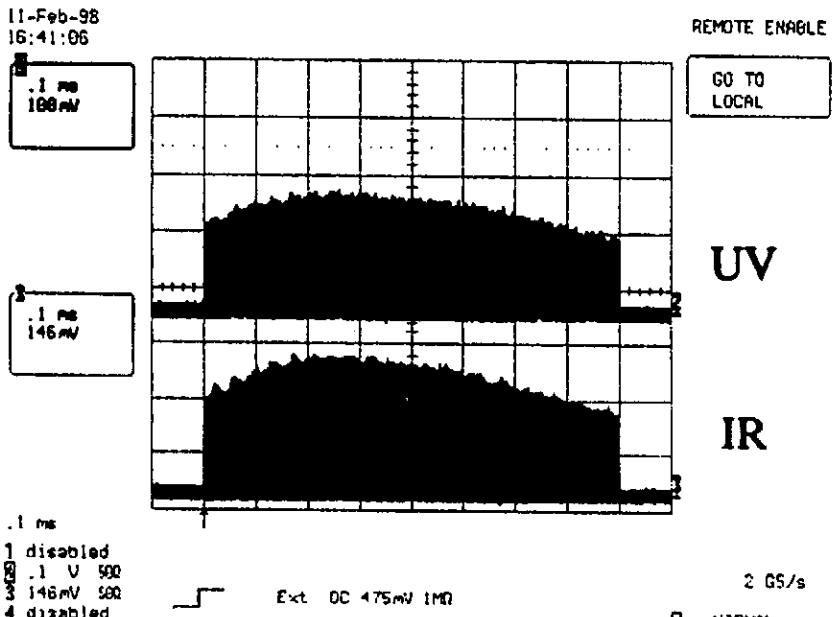
Cable length ICT1 = 45.0 m
Cable length ICT2 = 45.1 m

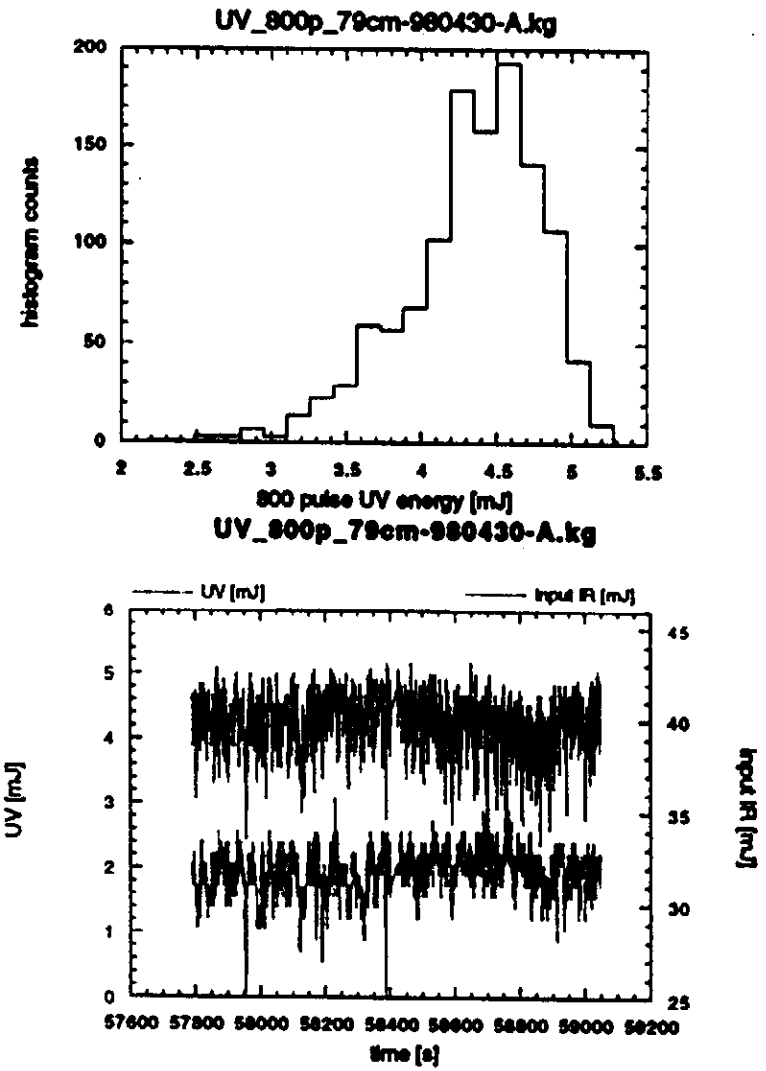
Gun A Pulsed Processing



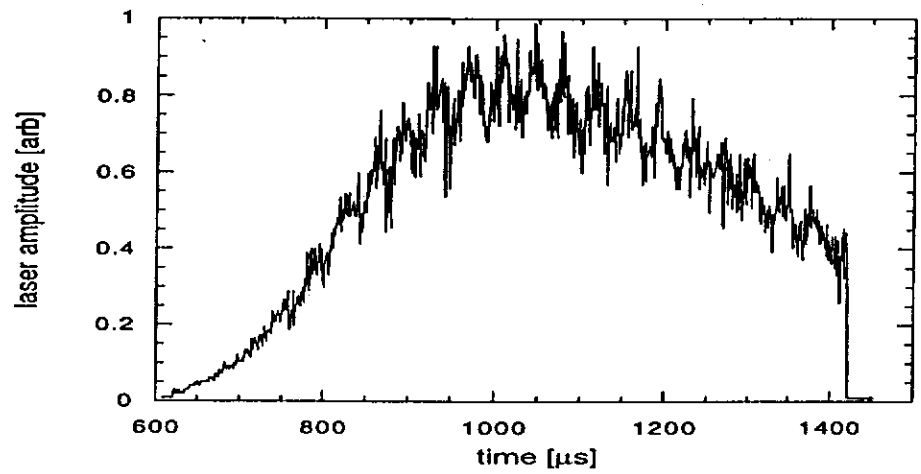
091

800 Pulse Multipass/2-Pass Output

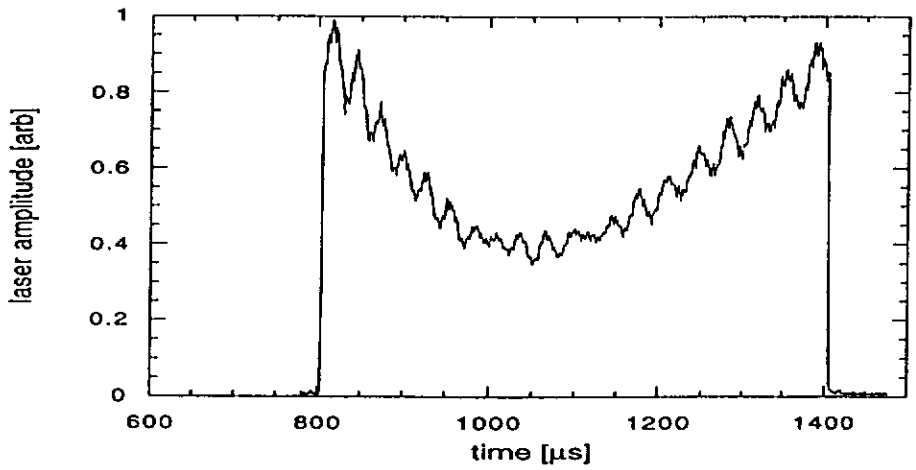




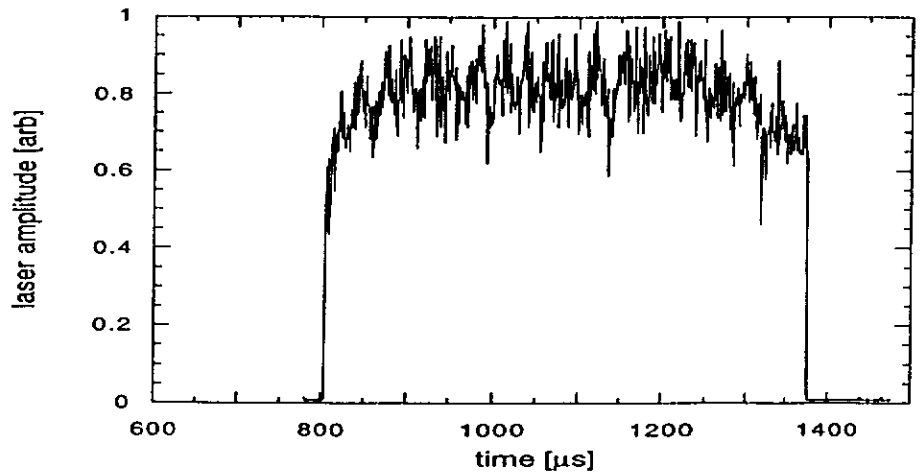
Input Envelope Preshaping



unshaped
output
multipass

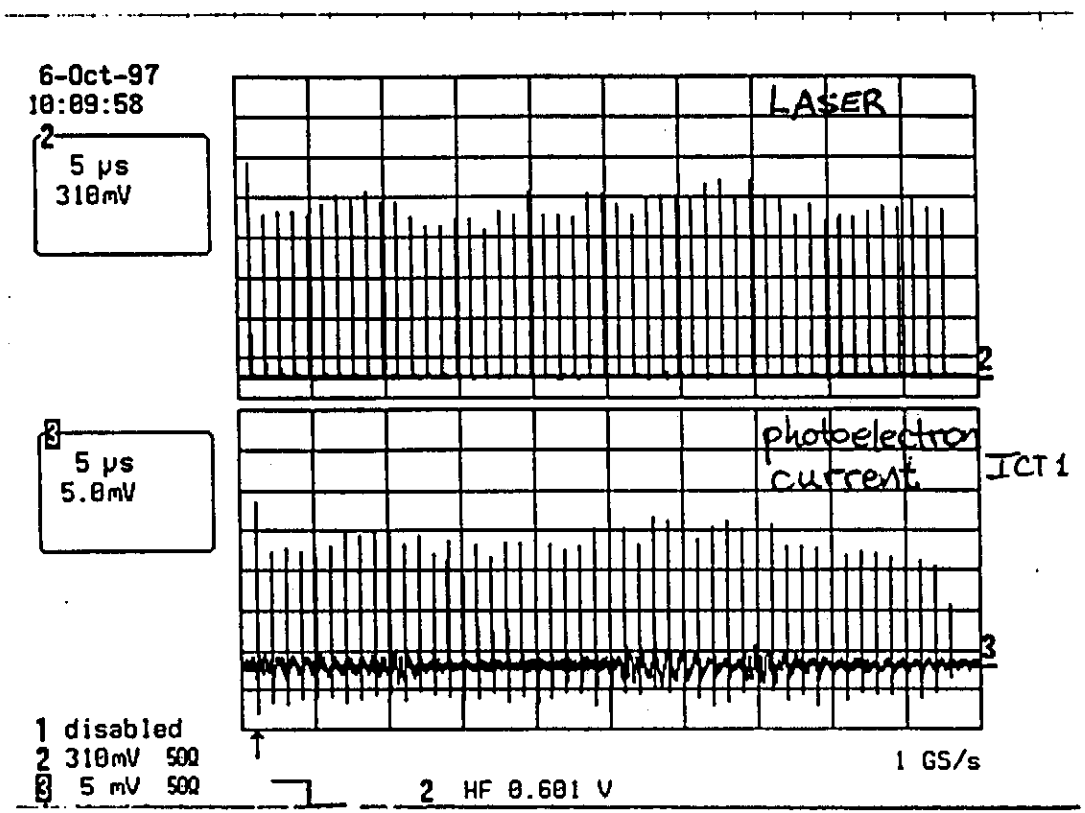


shaped
input
oscillator

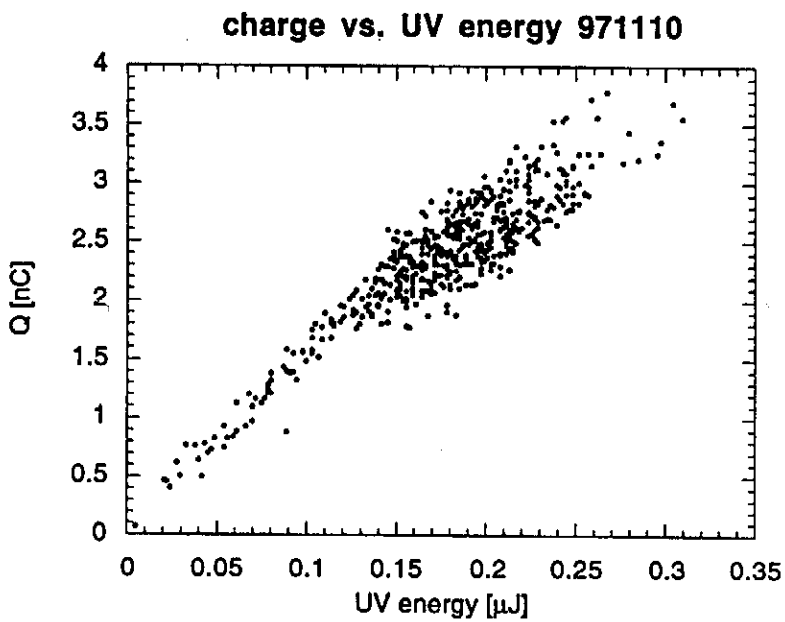


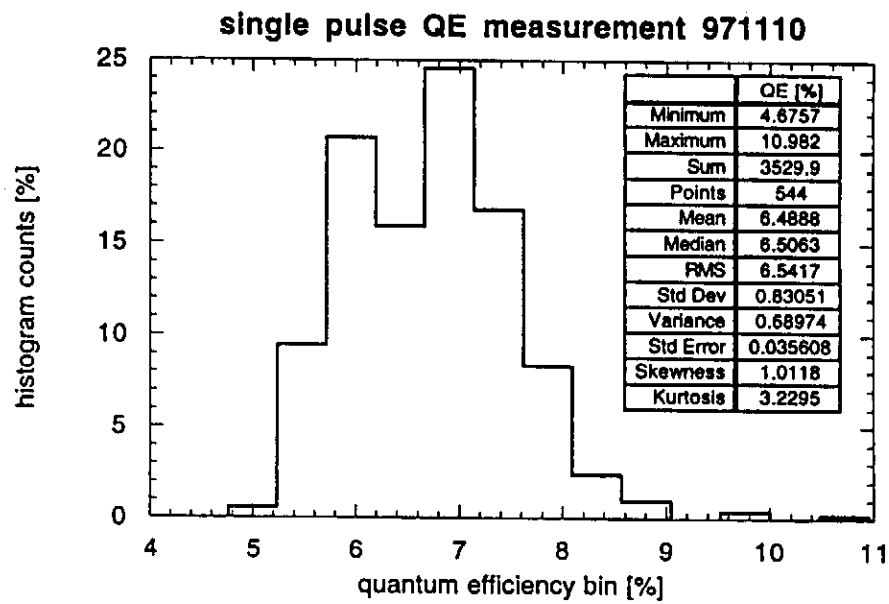
shaped
output
multipass

Multibunch Photoelectron Train



Photocathode Performance in RF Gun





Laser Pulse Train Energy Performance

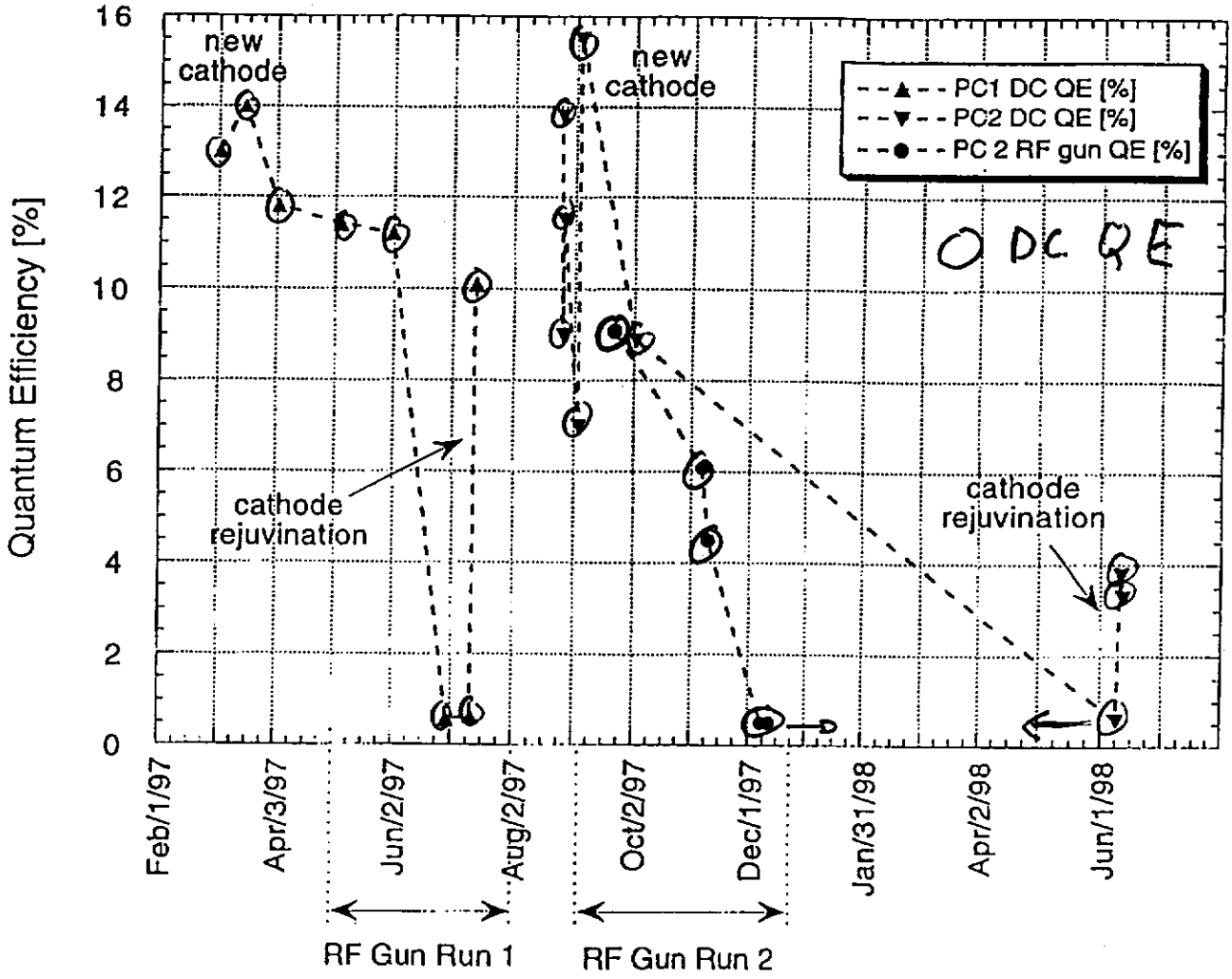
# of pulses	IR energy/pulse [μJ]	UV energy/pulse (laser room) [μJ]	UV energy/pulse (photocathode) [μJ]	min QE for * 10nC bunch [%]
800	40	4	0.8	5.8
500	80	4	0.8	5.8
250	80	4	0.8	5.8
14	240	12	2.4	1.9
10	280	14	2.8	1.7
1	400	20	4.1	1.2

* accounting for beamtransport and pulse stacker losses

@ 1% QE 2nC/μj (on cathode)

5 μj ⇒ 10nC

Evolution of Cs_2Te photocathode quantum efficiency

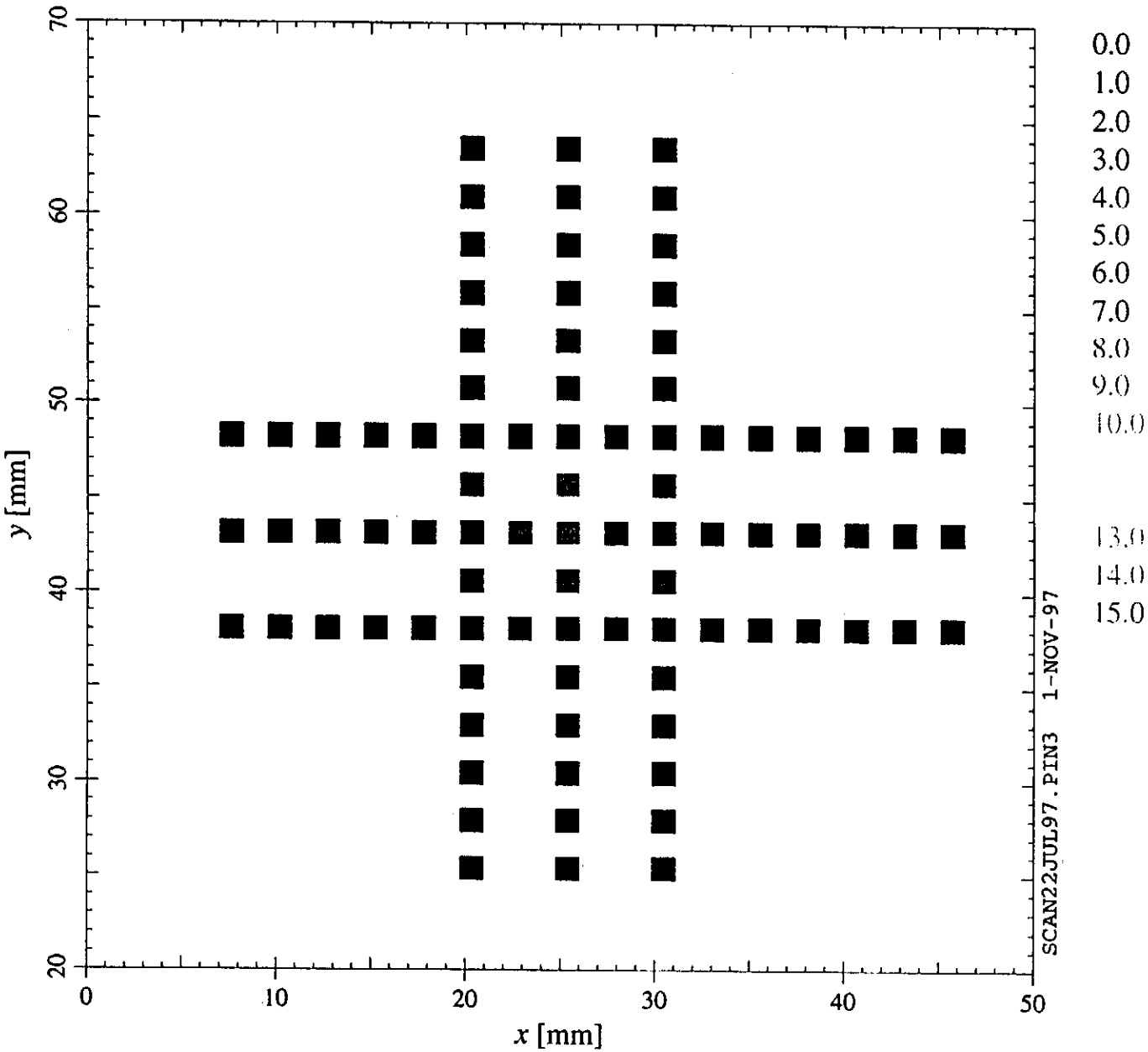


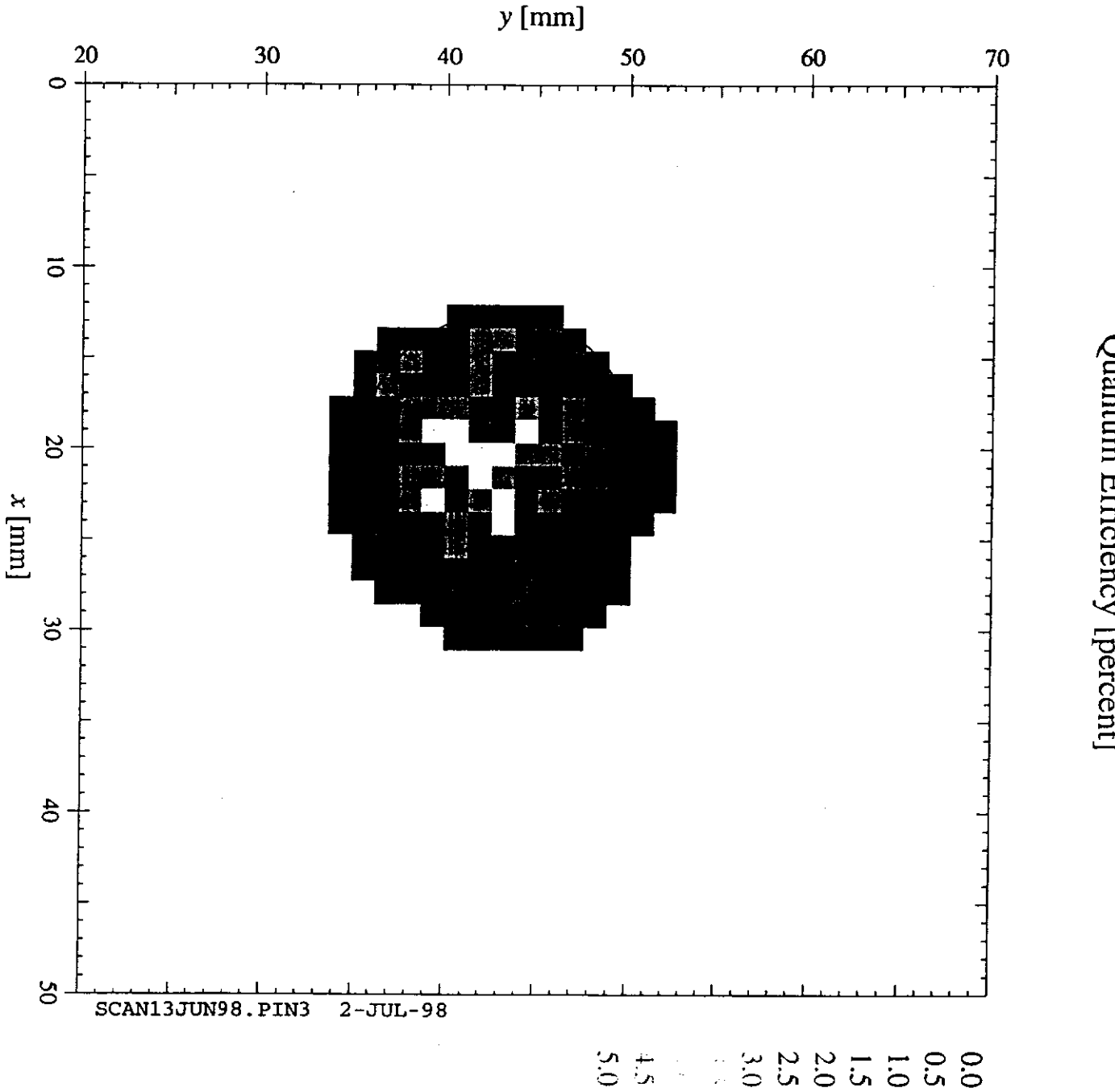
date	PC1 DC QE [%]
3/4/1997	13
3/17/1997	14
4/4/1997	11.8
5/6/1997	11.4
6/2/1997	11.2
7/1/1997	0.59
7/1/1997	0.57
7/13/1997	0.65
7/14/1997	10.1

date	PC2 DC QE [%]
8/26/1997	13.8
8/27/1997	9
8/27/1997	11.5
9/4/1997	7
9/4/1997	15.5
10/3/1997	8.9
6/10/1998	0.6
6/12/1998	3.8
6/13/1998	3.3

date	PC2 pulsed QE [%]
9/22/1997	9.1
11/7/1997	6.1
11/10/1997	4.5
12/8/1997	0.5
12/12/1997	0.5

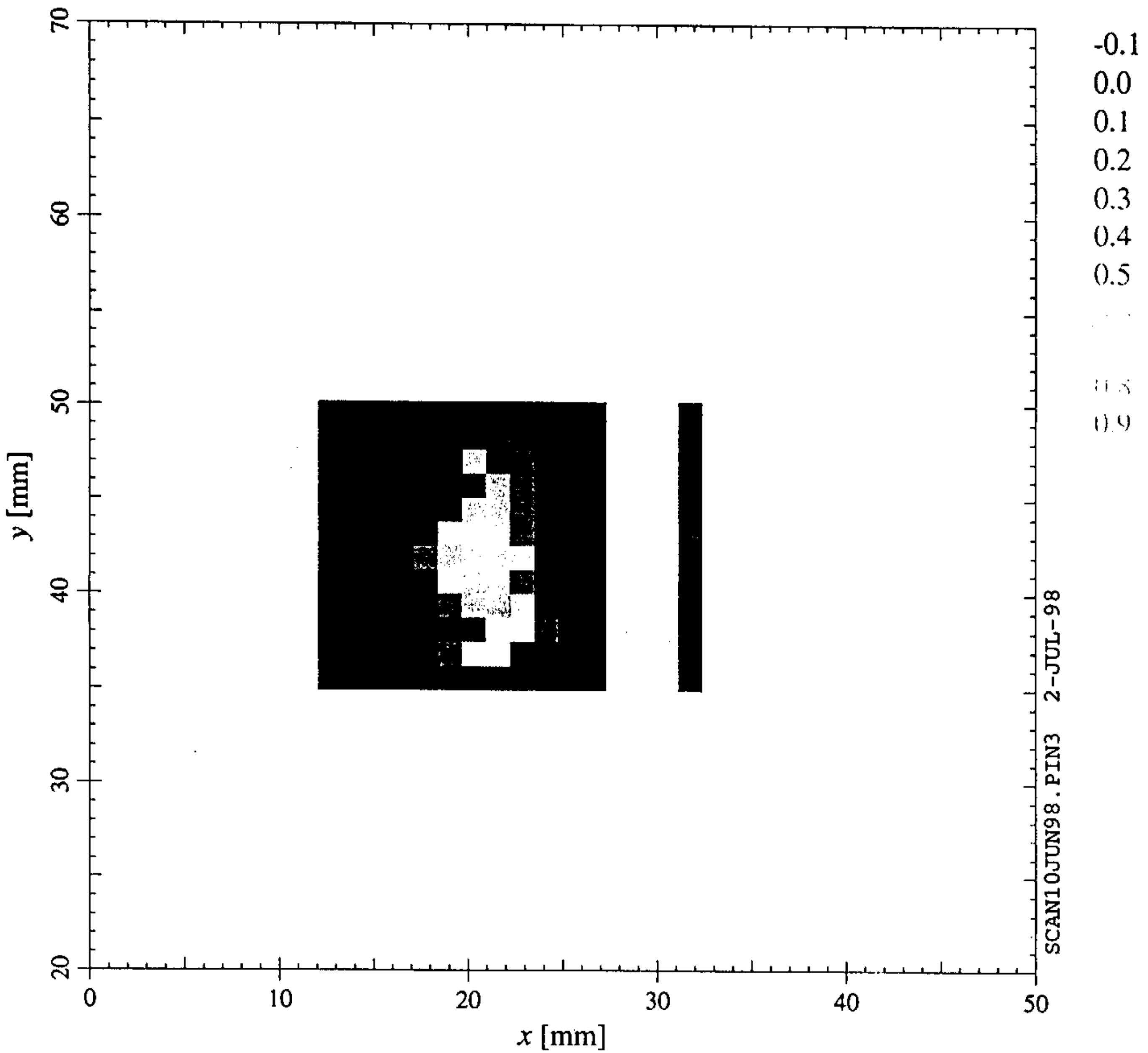
Quantum Efficiency [percent]





Hartung, Kuchnir

Quantum Efficiency [percent]

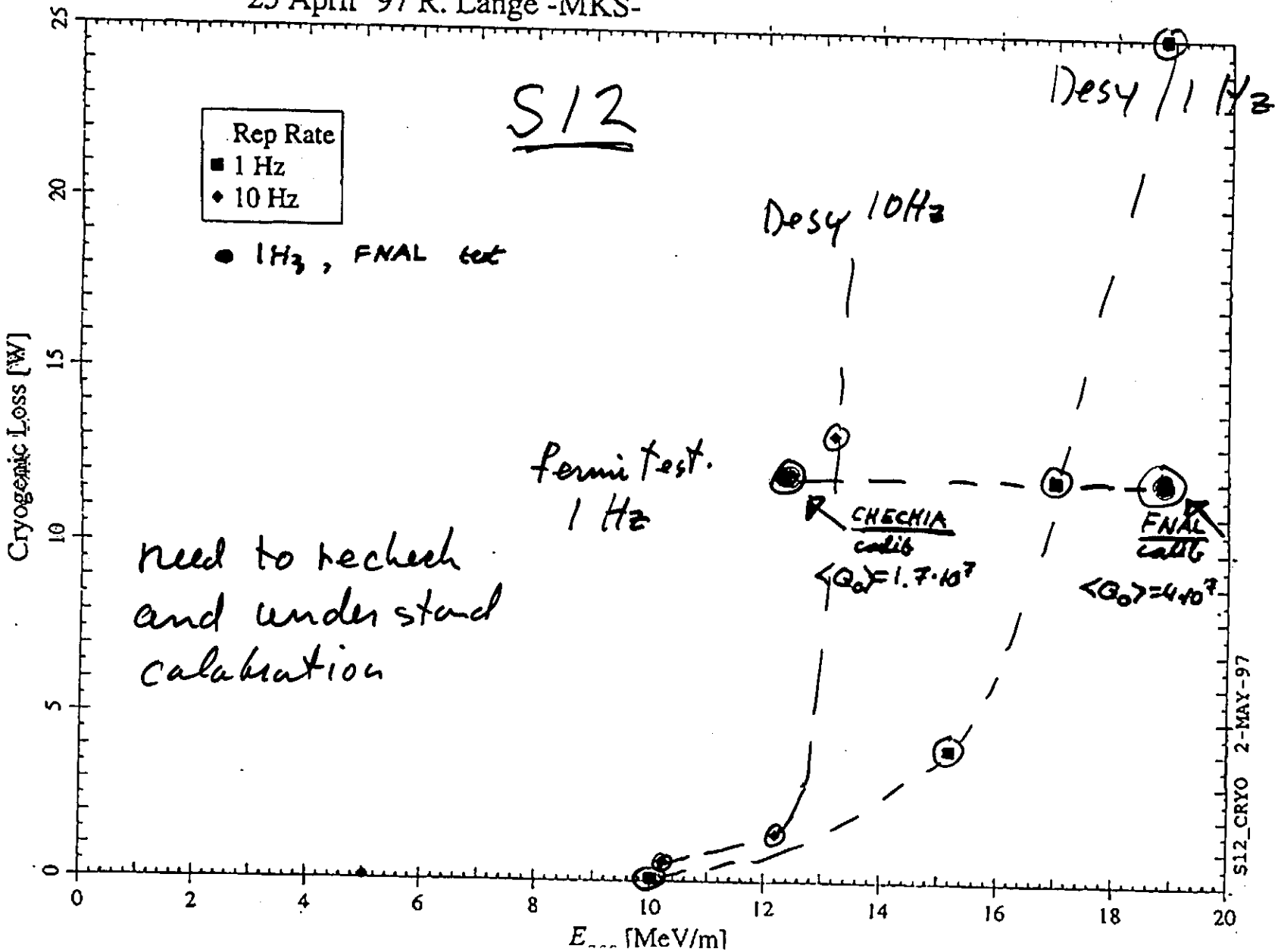


169

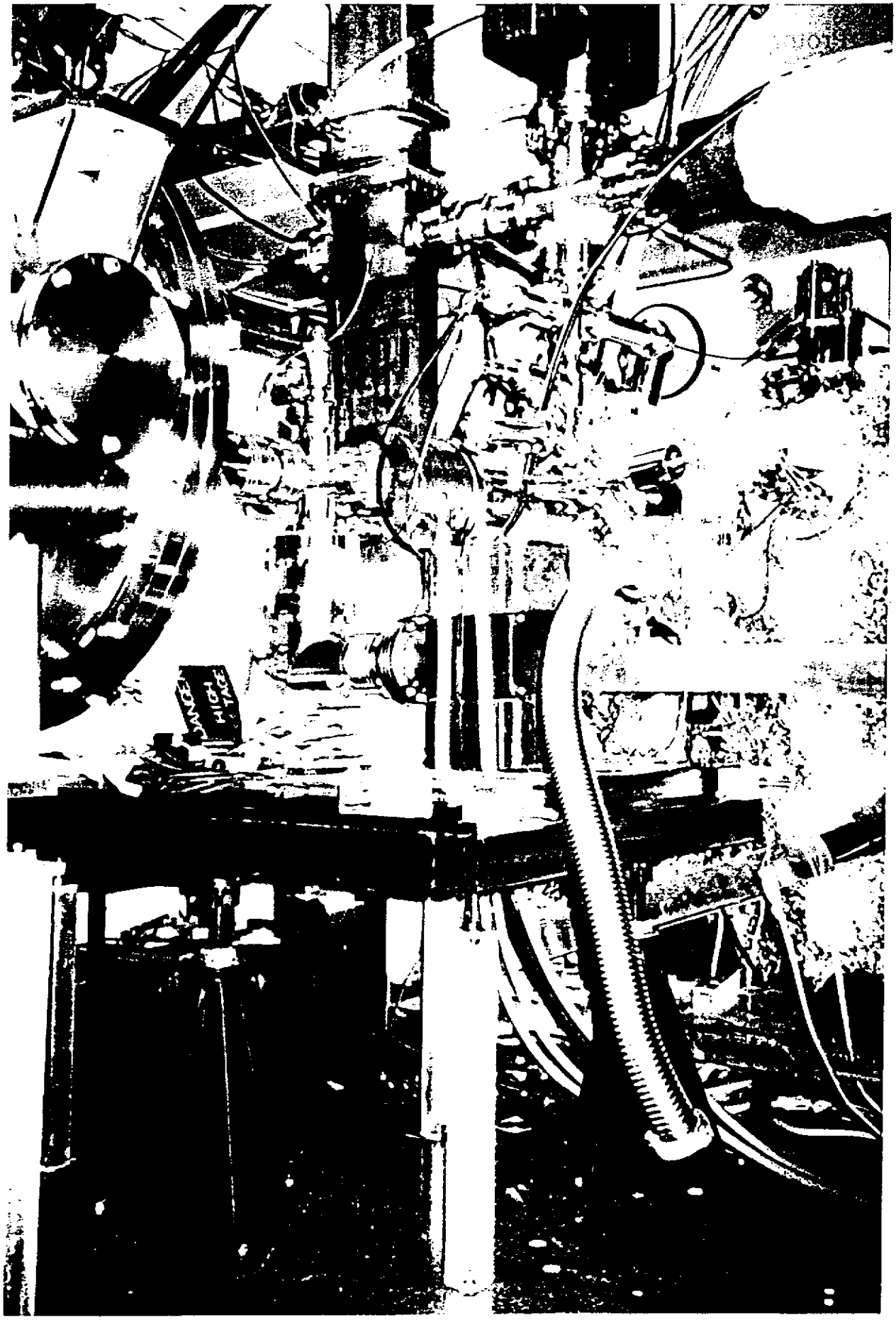
Chechia Test of S12

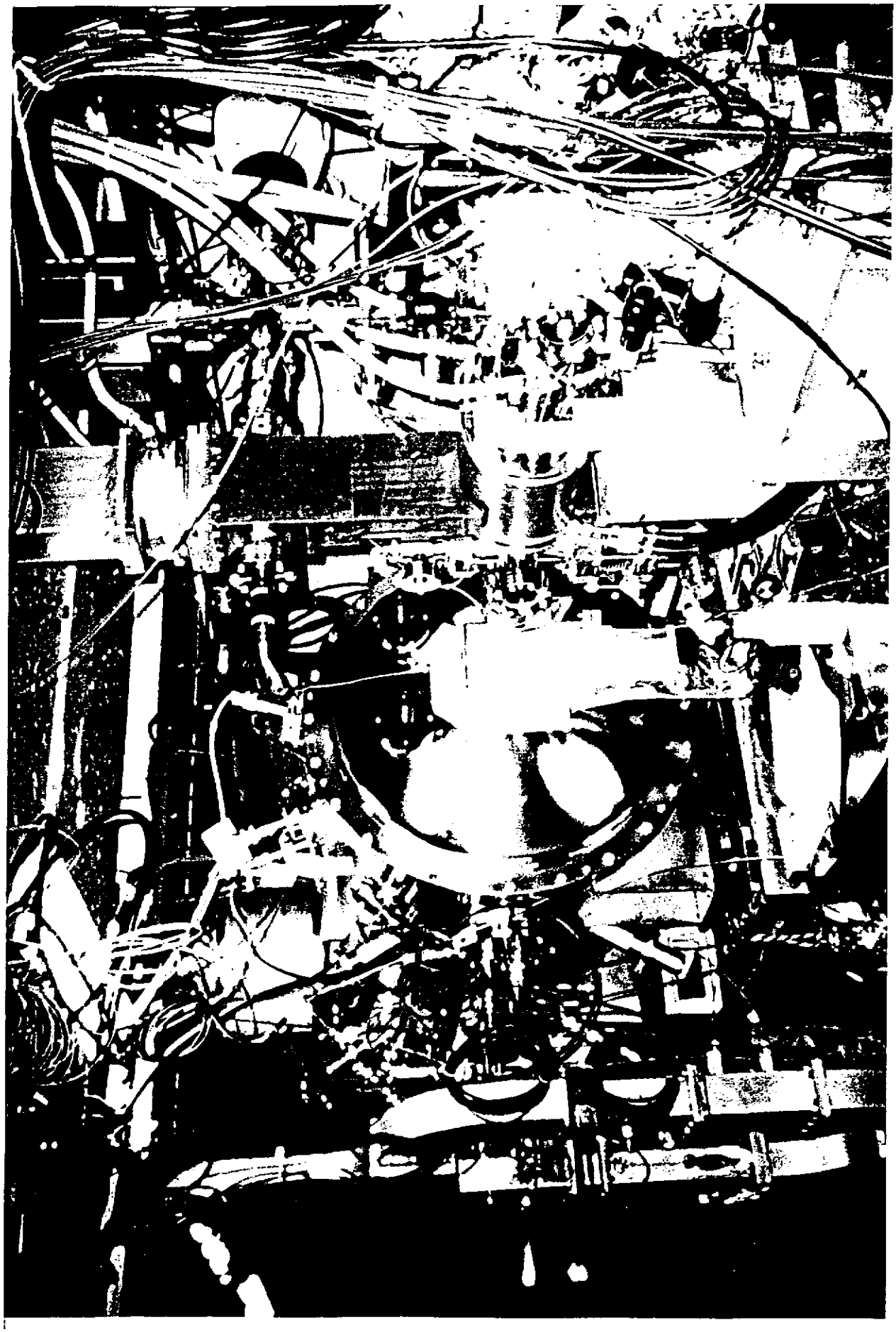
Cryogenic losses with flat top, 1.3 ms

25 April '97 R. Lange -MKS-



170


DANGER
HIGH
TACE



Gun 3

final tuning May 1

cleaning
+ vac bake

start RF June 29.

July 2 -
3.3MW - 200μs 1 Hz
vac < $7e^{-8}$

Bat appears to have
Dark current.
~ 1-2ma

Gun 4

lost by Fed Ex for 3 weeks
go for "final" brazes ~ July 20

SRF Separated Kaon Beam

- Interest in rare Kaon decays
- Potential of high Kaon flux from Main Injector.
- High duty factor ⇒ SRF
- Tentative parameters:
  - 3.9 GHz as balance between TESLA experience and Kaon economy
  - 10 MeV/c permeter transvers deflection
  - Investigate helical deflection
- Schedule - operation by 2002!

DC Field Emission of Nb-Samples Prepared in TESLA Cavities

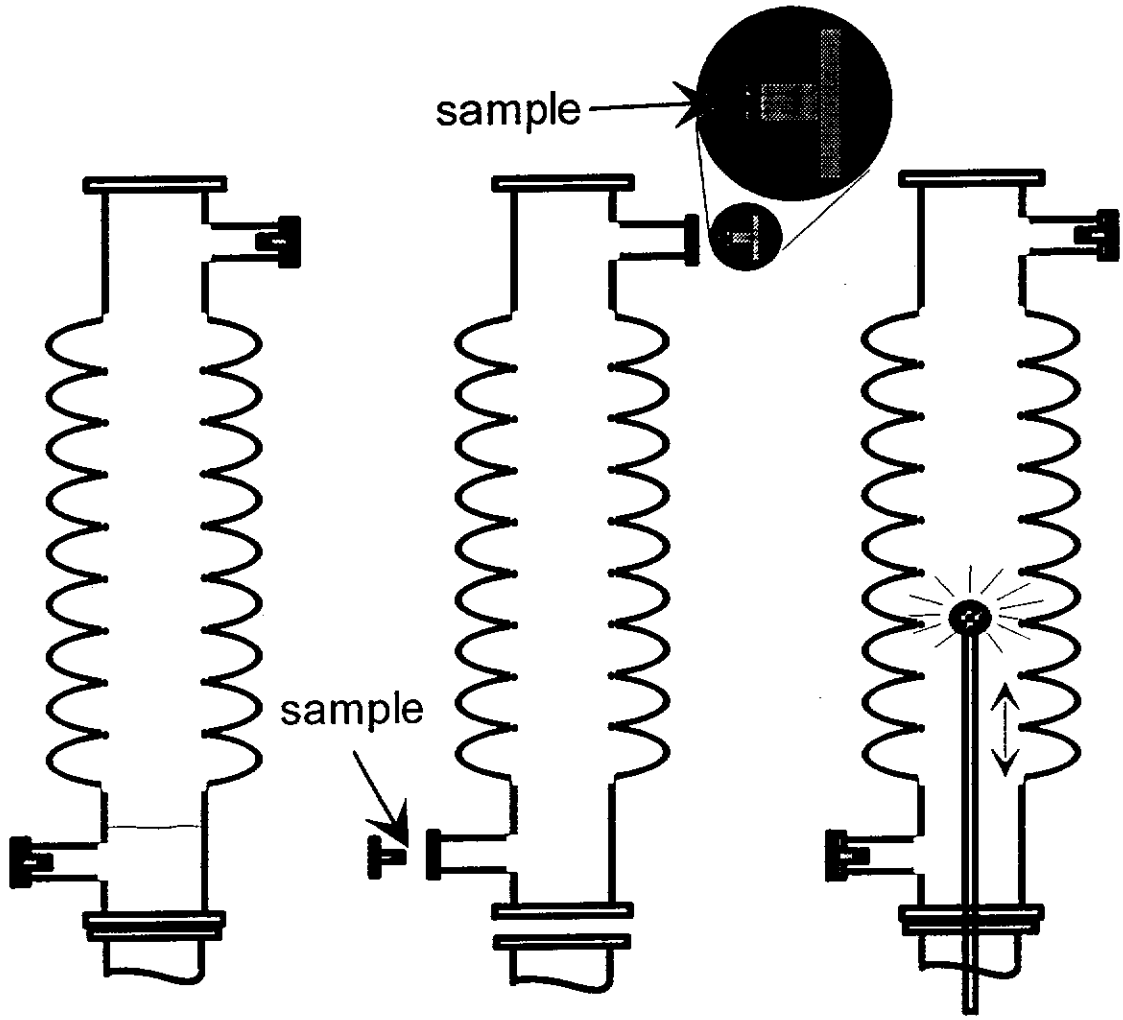
6. July 1998

T. Habermann, A. Göhl, B. Günther, D. Nau, G. Müller
Universität Wuppertal

D. Reschke, A. Matheisen D. Proch
DESY

Contribution to EPAC 98

Wet Sample Preparation



BCP water rinsing
+ UPW rinsing

disassembly
+ UPW rinsing

HPWR

in real TESLA cavity

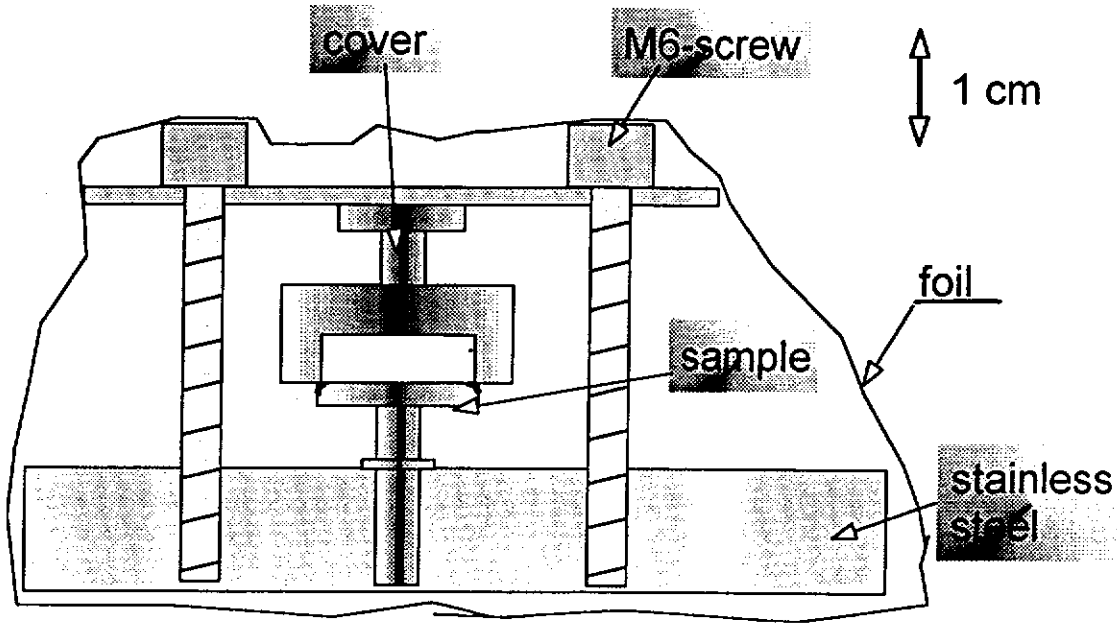
in dummy structure
(D6)

- Ultrapure Water Rinsing (18 MΩcm, Particle Filter)

  modifications : 1. faster emtying + UPW filling
  last filter closer to cavity
  2. wet assembly into HPWR

- High Pressure Water Rinsing (Sapphire Nozzle, 100 bar)

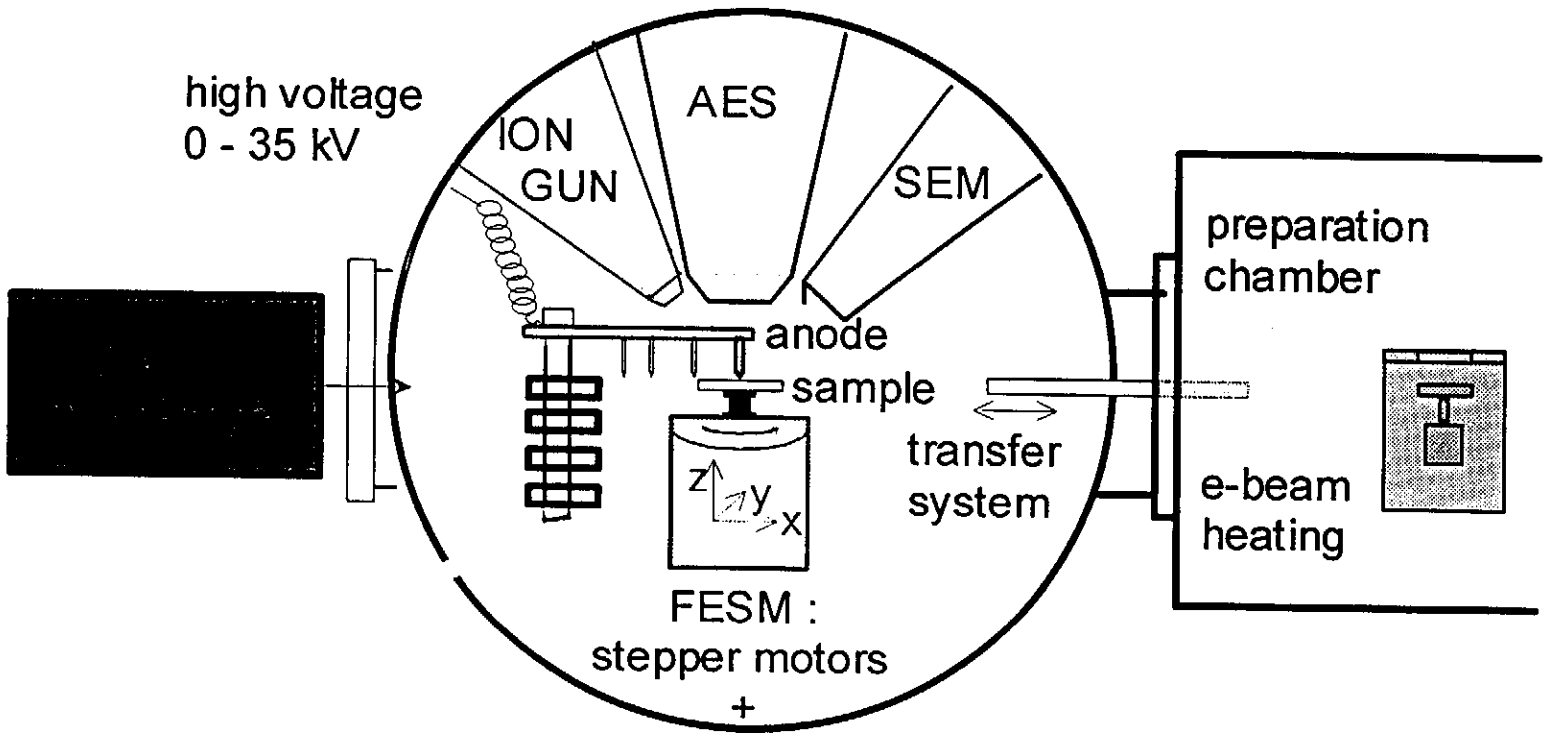
Transport System for Samples



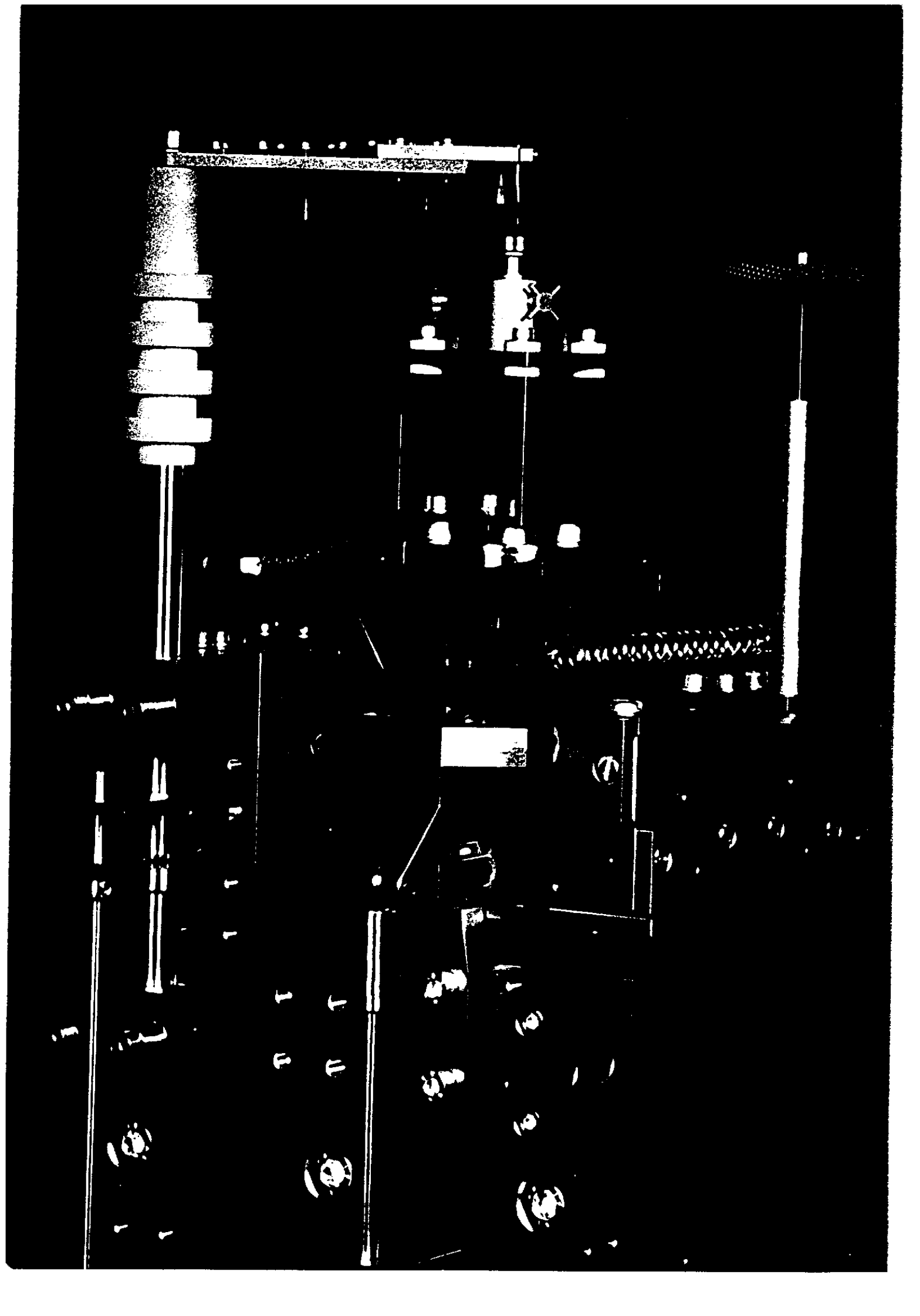
- Removement of the Cover only under UHV- Conditions (FESM) or in Cleanroom (TTF)
- Additional Protection Foil
- Multiple-polished Samples → Scratches at Edges

T. Habermann, A. Göhl, B. Günther, D. Nau, H. Piel , G. Müller Berg. Univ. Wuppertal

Experimental



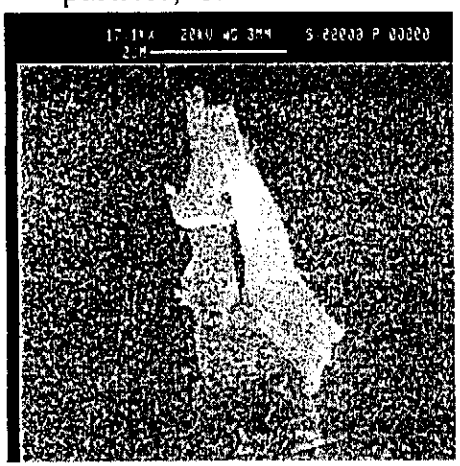
UHV-Analysis- and Preparation Chamber of the Field Emission Scanning Microscope (FESM)



Analysis of single emitters on sample A

E(0.5nA) = 19 MV/m
β = 83
$S = 2 \cdot 10^{-4}$ cm²

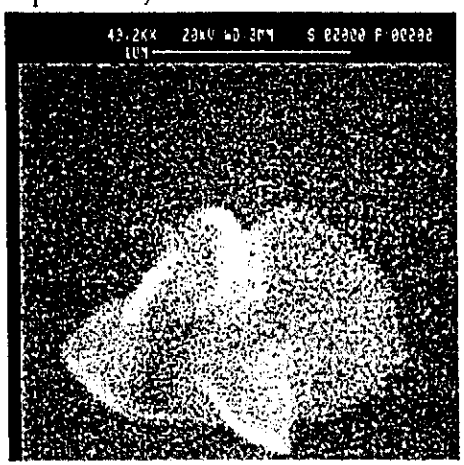
particle, slanted view:



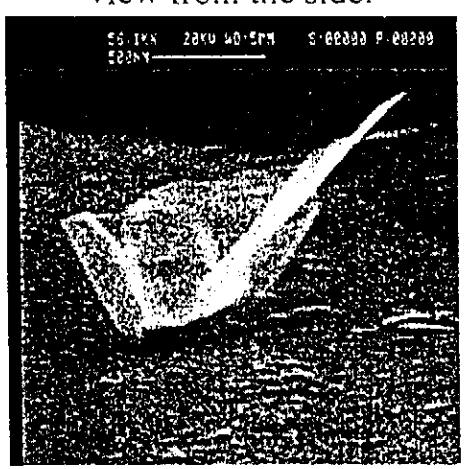
view from the side:

E(0.5nA) = 28 MV/m
β = 107
$S = 1 \cdot 10^{-9}$ cm²

particle, view from above:

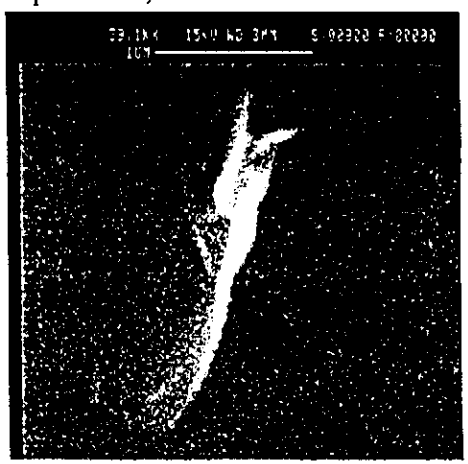


view from the side:

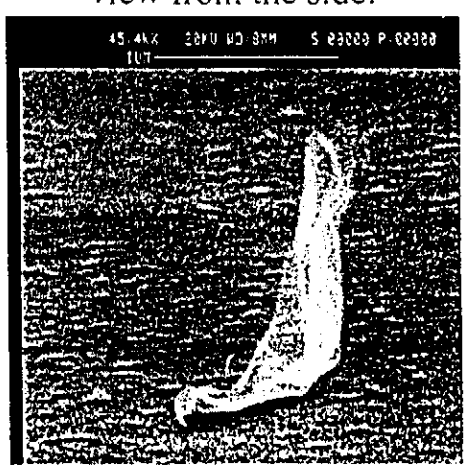


E(0.5nA) = 28 MV/m
β = 310
$S = 4 \cdot 10^{-16}$ cm²

particle, view from above:



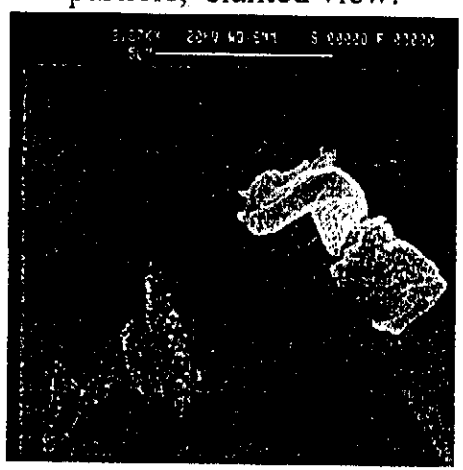
view from the side:



Analysis of single emitters on sample B

E(0.5nA) = 35 MV/m
$\beta = 86$
$S = 7 \cdot 10^{-11}$ cm²

particle, slanted view:

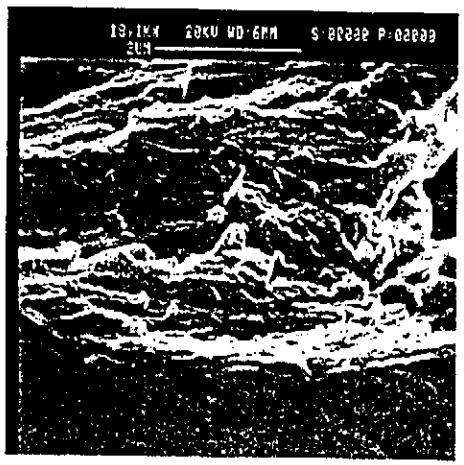


view from the side:

E(0.5nA) = 40 MV/m
$\beta = 88$
$S = 2 \cdot 10^{-12}$ cm²

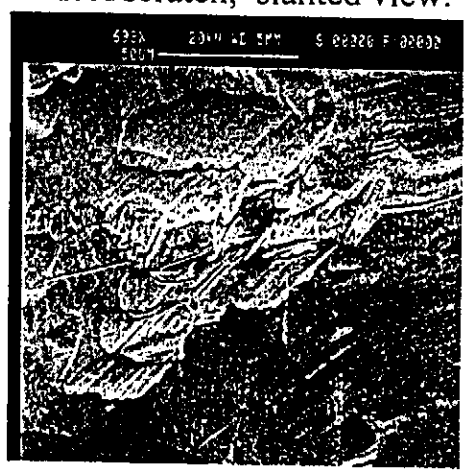
defect, slanted view:

slanted view:

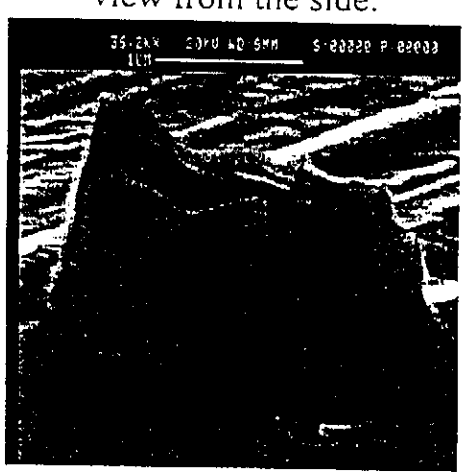


E(0.5nA) = 47 MV/m
$\beta = 103$
$S = 2 \cdot 10^{-14}$ cm²

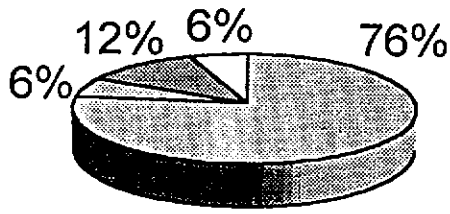
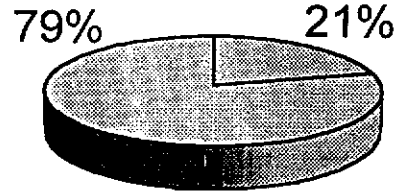
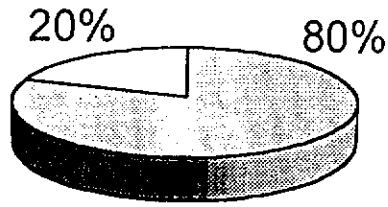
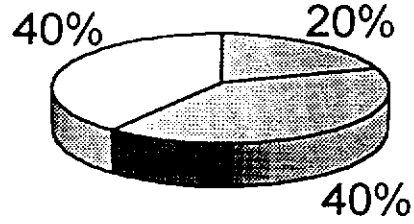
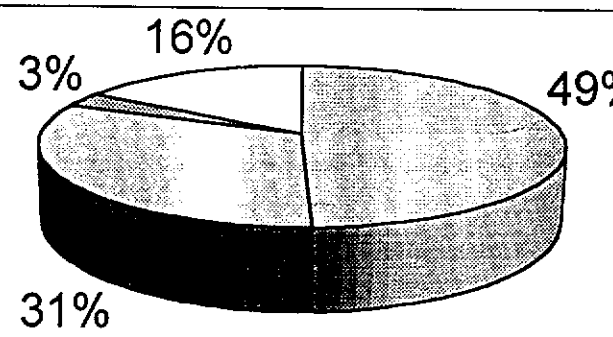
defect/scratch, slanted view:



view from the side:



Emitter Analysis with SEM

800 °C	sample A (17)  bottom	sample B (19)  top
1400 °C	sample C (5)  top	sample D (5)  bottom
all samples :	 	

Overview of sample preparations performed at the TESLA test facility

Sample	Position	in Cavity	BCP-μm	UP/HPWR
A + 800C	bottom	C23	70+28	in D6
B + 800C	top	C23	60+15	in D6
C + Ti	top	C22/C24	55/45+25	in D6
D + Ti	bottom	C22/C24	70/45+25	in D6
D2-Test1	1 year stored		> 200	no
D2-Test2	24h exposition in class 10 cleanroom			
D2-Test3	no BCP			mod1,yes
D2-Test4	top	C27	20	mod2,yes
D3-Test1	bottom	A15	20	mod1, no
D3-Test2	fundam. coupler test assembly on C26			

All 6 samples: machined Heraeus Nb (RRR 300)

BCP in two steps: 1.Ti-contaminated acid

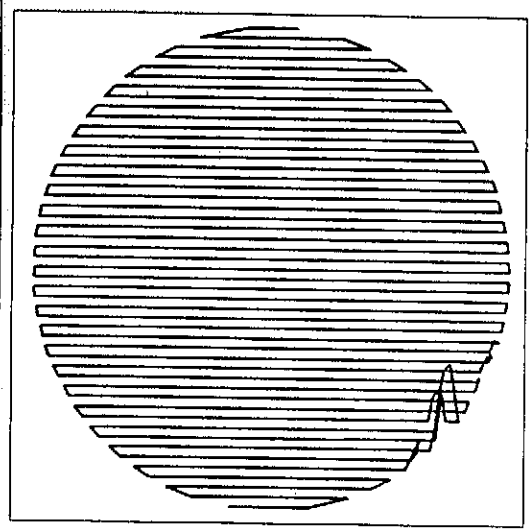
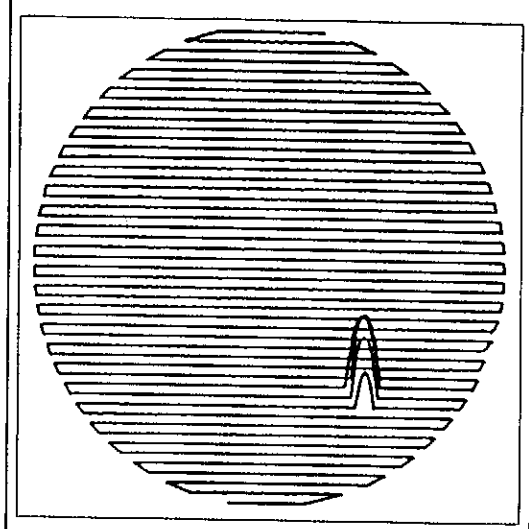
+ 2. "pure-Nb" acid.

Two final UPWR modifications:

1. faster filling proc. and filter closer to cavity
2. wet assembly into HPWR.

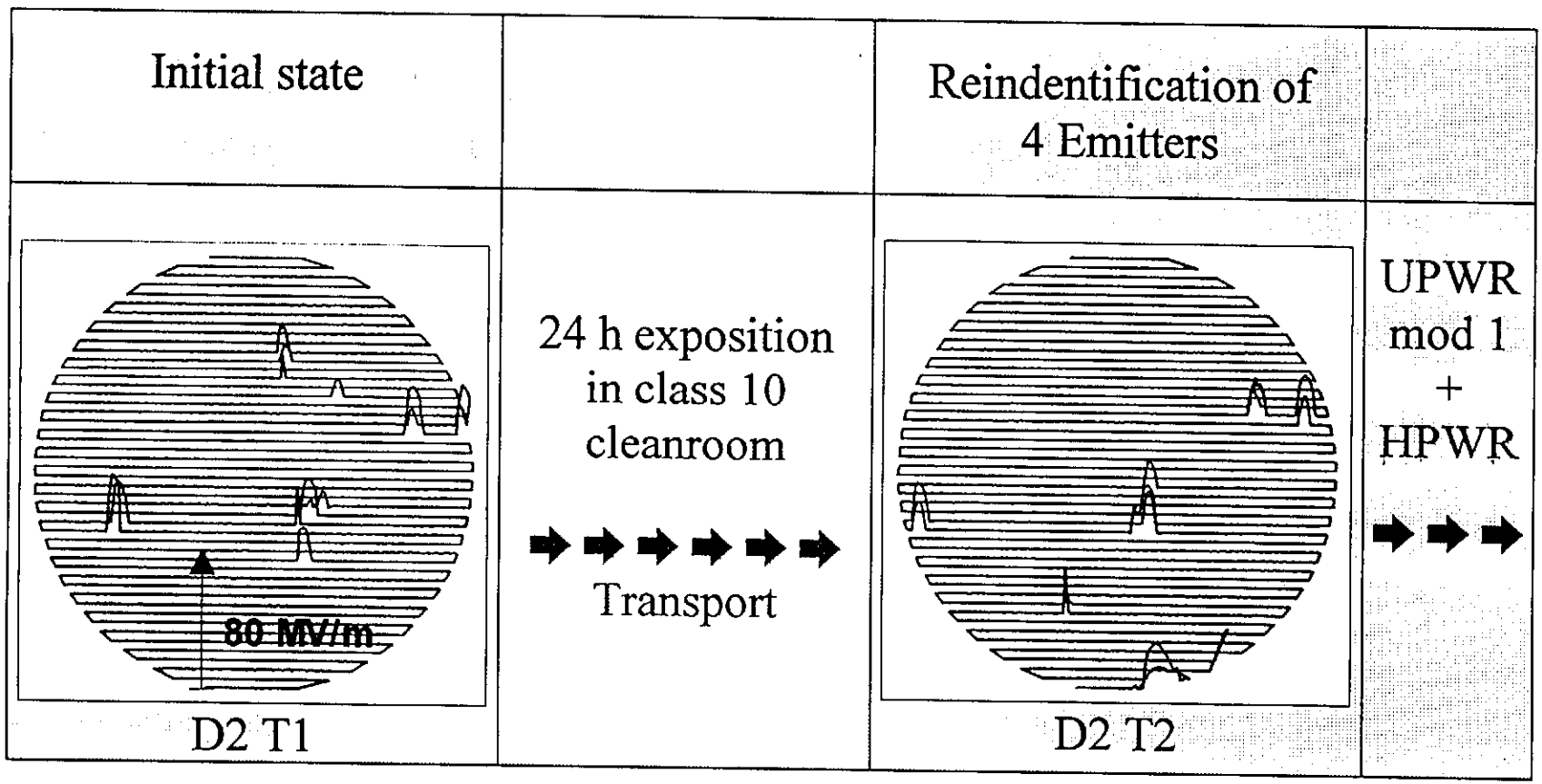
Field Emission Scans
Test of Single Preparation Steps

Electric surface field 80 MV/m, Scan radius ∅ 12 mm, Anode ∅ 0,5 mm

	Removement of FE due to HPWR		1 strong emitter allready at 50 MV/m
UPWR mod 1 + HPWR → → →	 D2 T3	Preparation in cavity C27 top position wet assembly into HPWR → → → → → →	 D2 T4

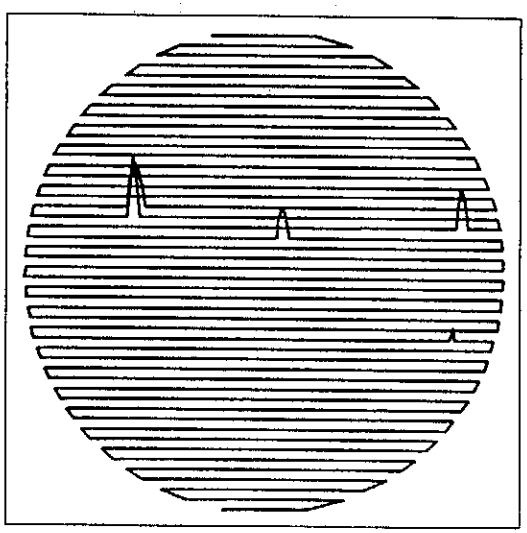
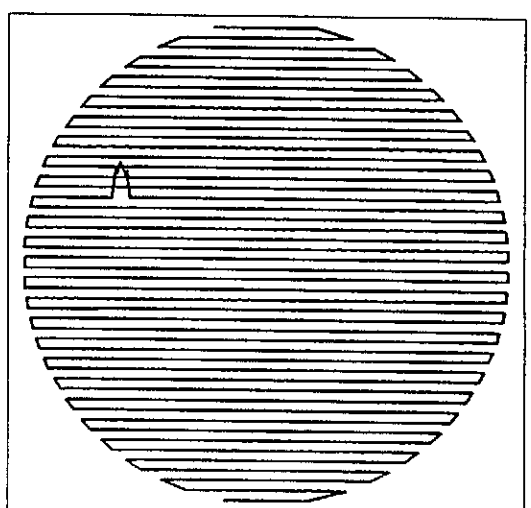
Field Emission Scans
Test of Single Preparation Steps

Electric surface Field 80 MV/m, Scan radius ∅ 12 mm, Anode ∅ 0,5 mm

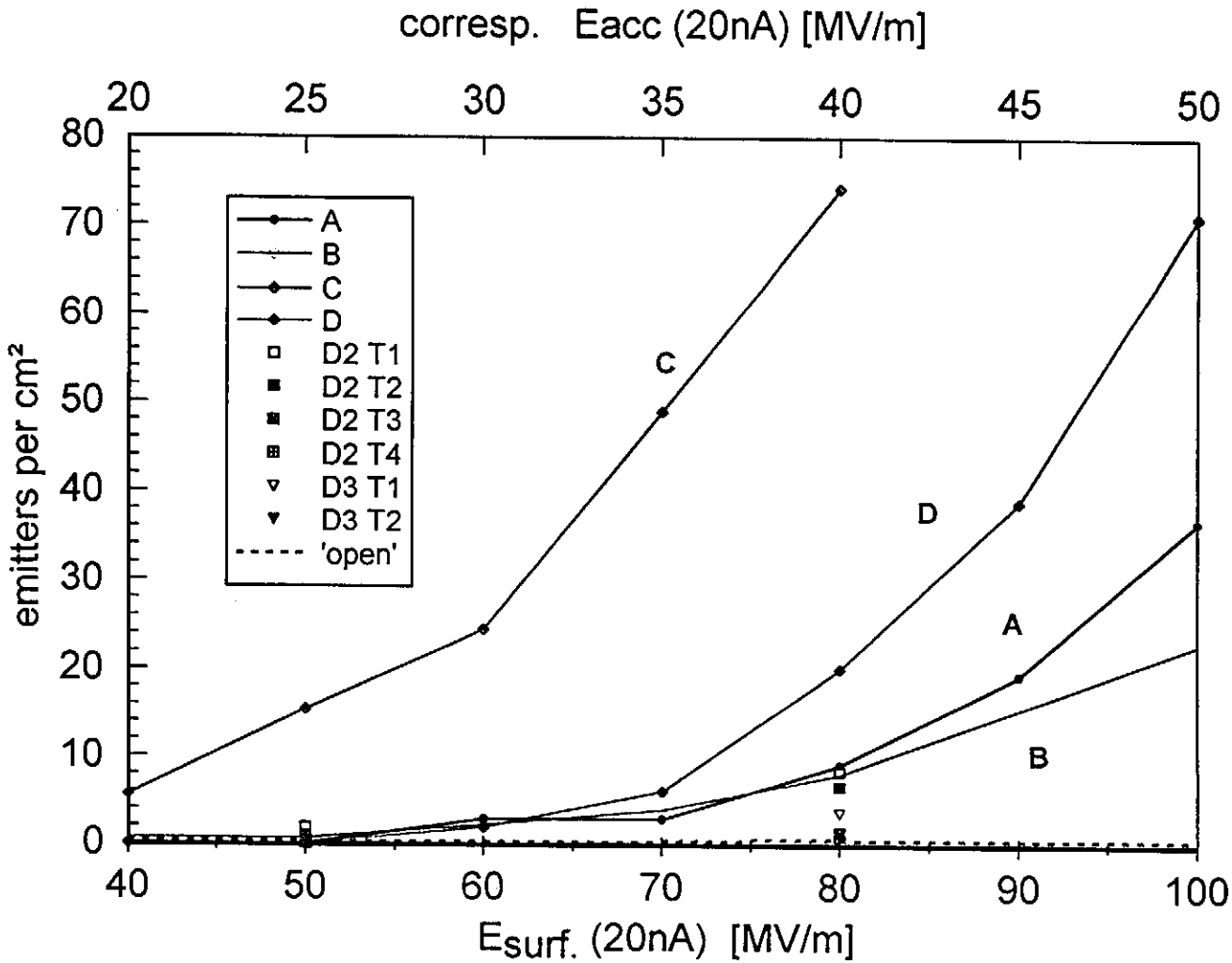


Field Emission Scans
Test of Single Preparation Steps

Electric surface field 80 MV/m, Scan radius ∅ 12 mm, Anode ∅ 0,5 mm

BCP-20µm in A 15 (mod 1) no HPWR		Reindentification of 1 Emitter
 D3 T1	Fundamental coupler test assembly on C 26 ➡ ➡ ➡ ➡ ➡ ➡	 D3 T2

Emitter Number Density vs. Electric Surface Field



- significant improvement due to modifications of wet preparation

Summary

- 6 samples prepared in TESLA cavities at TTF cleanroom
  → *emitters relevant to TESLA cavitiy preparation found*

- Position-dependent etching effects not observed yet
  → closed-cycle chemistry of nine-cell-cavities don´t cause extra field emission

- After modifications of the wet sample preparation average emitter density of 2 (4)/cm² at E_{acc} = 25 (40) MV/m
  → *for reliable cavity production further improvement required*

- Morphology of emitters: micron and submicron-sized particles (49%) as well as (mechanical) surface defects (31%)
  → *more microscopic analyses of emitters required to derive suggestions for preparation improvements*

Outlook

- Chemical analysis of strong emitters (EDX, AES ?)
  → *hint for the origin of the emitters ?*

- Electropolished samples
  → *easier to clean ?*

- High pressure rinsing parameters (pressure, nozzle)
  → *better cleaning ?*

- Other changes of the wet preparation
  (e.g. UPWR with warm water)
  → *better cleaning ?*

July 6-8, 1998
DESY

NEW TYPE OF RF STRUCTURE WITH A HIGH ACCELERATING GRADIENT FOR TESLA PROJECT

V. Balakin

Branch of INP, Protvino, Russia

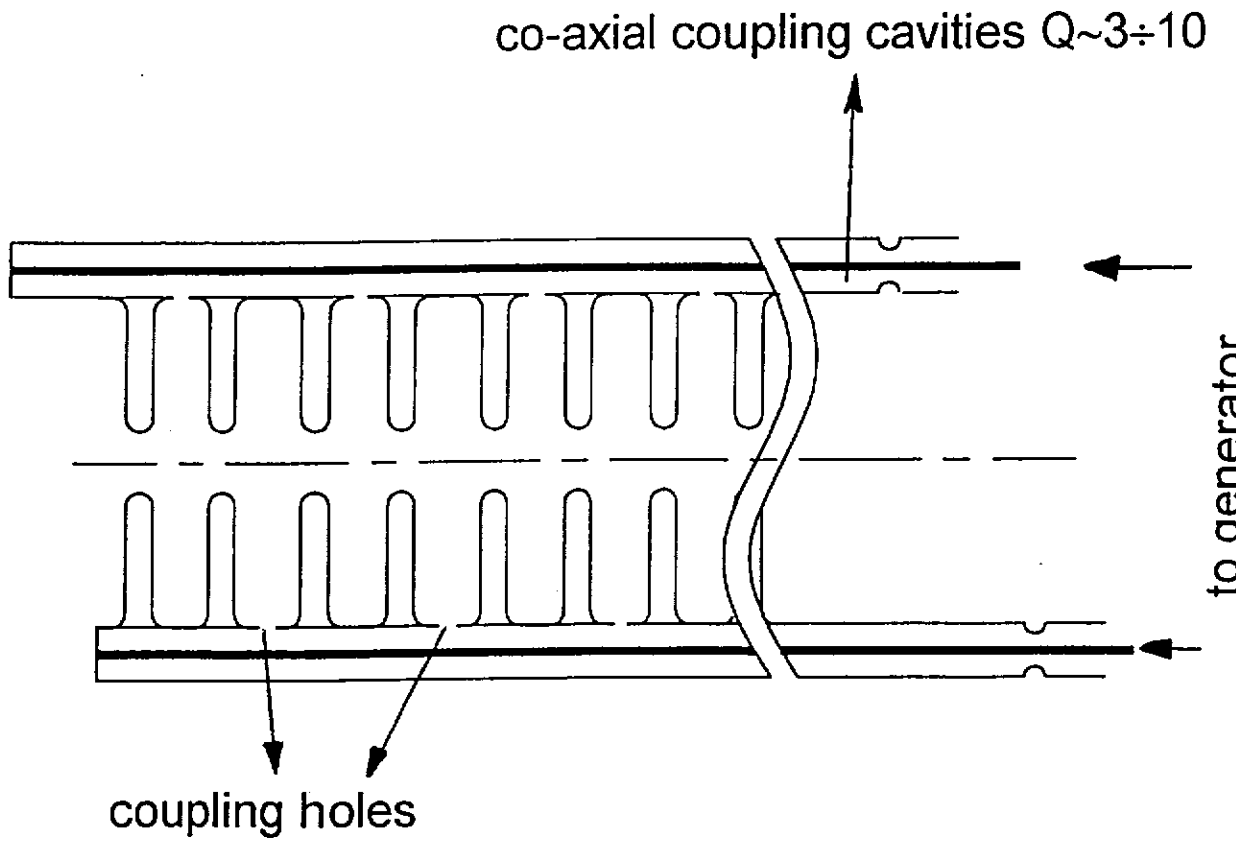
As is known, in the accelerating structure adopted for the TESLA project, the ratio of the accelerating voltage to the strengths of electric and magnetic fields may be improved by the factor of 1.7 under the transition to the "traveling wave" $\pi/4$ structure [1] and a small aperture for the beam (D=20mm) [2].

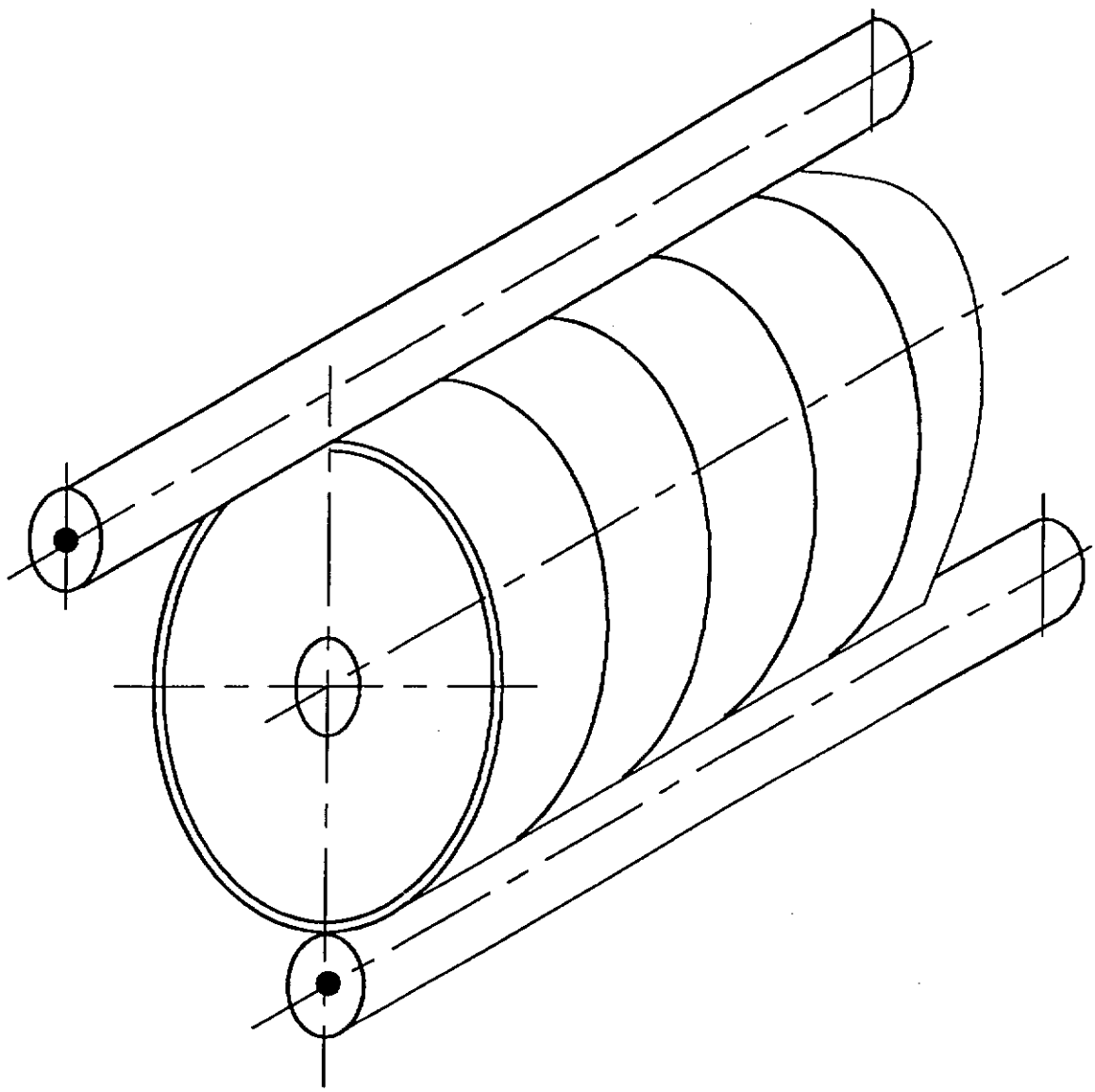
[1] Avrakhov. P, Travelling Wave Structure for Superconducting Accelerator. Report at TESLA meeting at Orsay, June 1997.

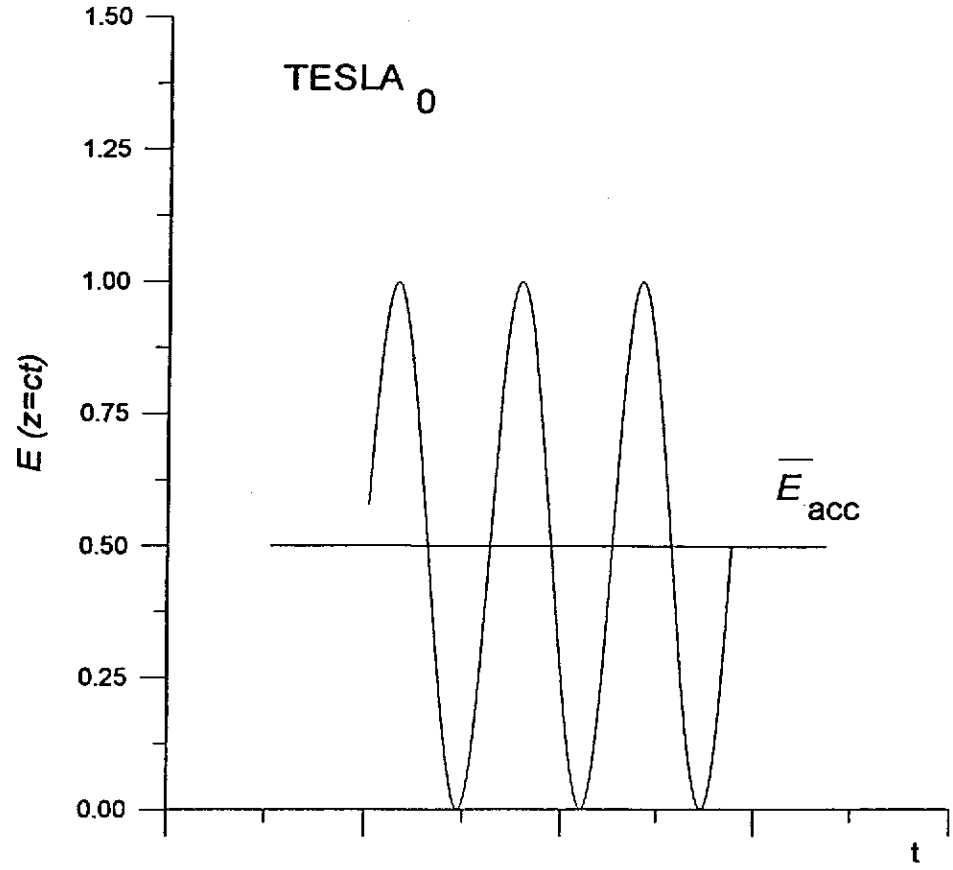
[2] Balakin V.E., Solyak N.A. Some Estimations of Superconducting TW Structure with a High Accelerating Gradient. Preprint BINP, Protvino, 1998.

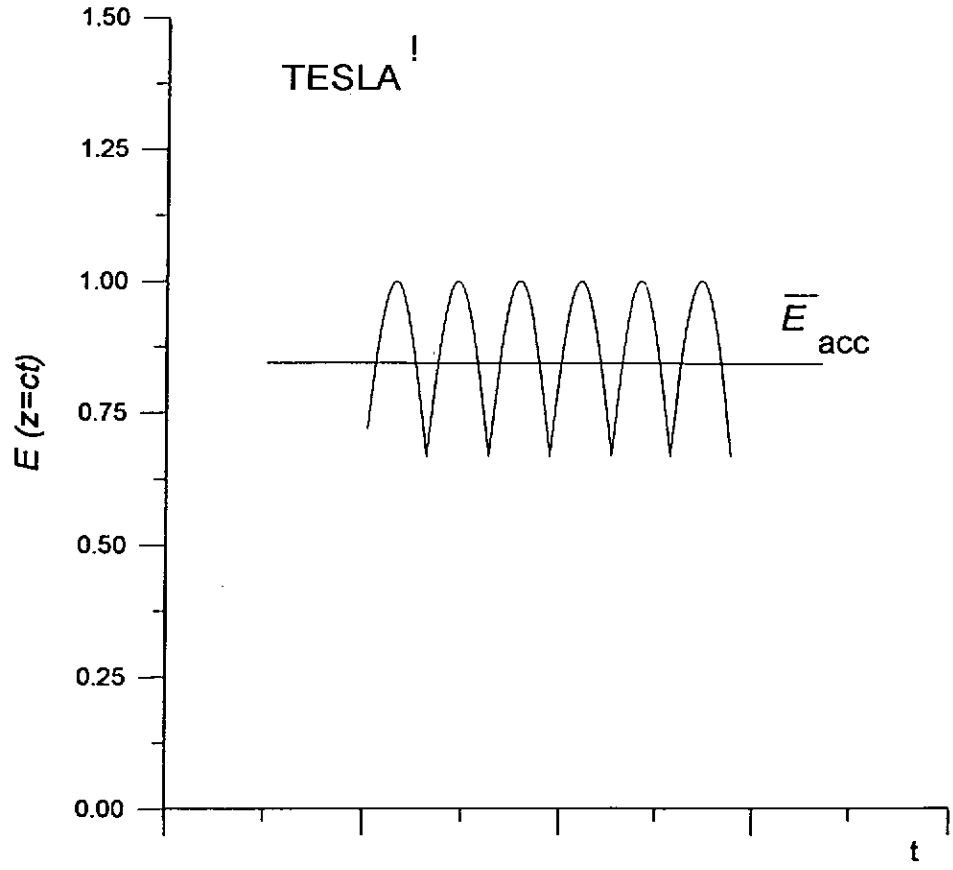
The major difficulty in realizing this idea is maintenance of the "traveling wave" regime associated with the requirements imposed upon the reflection factor in the "traveling wave" ring.

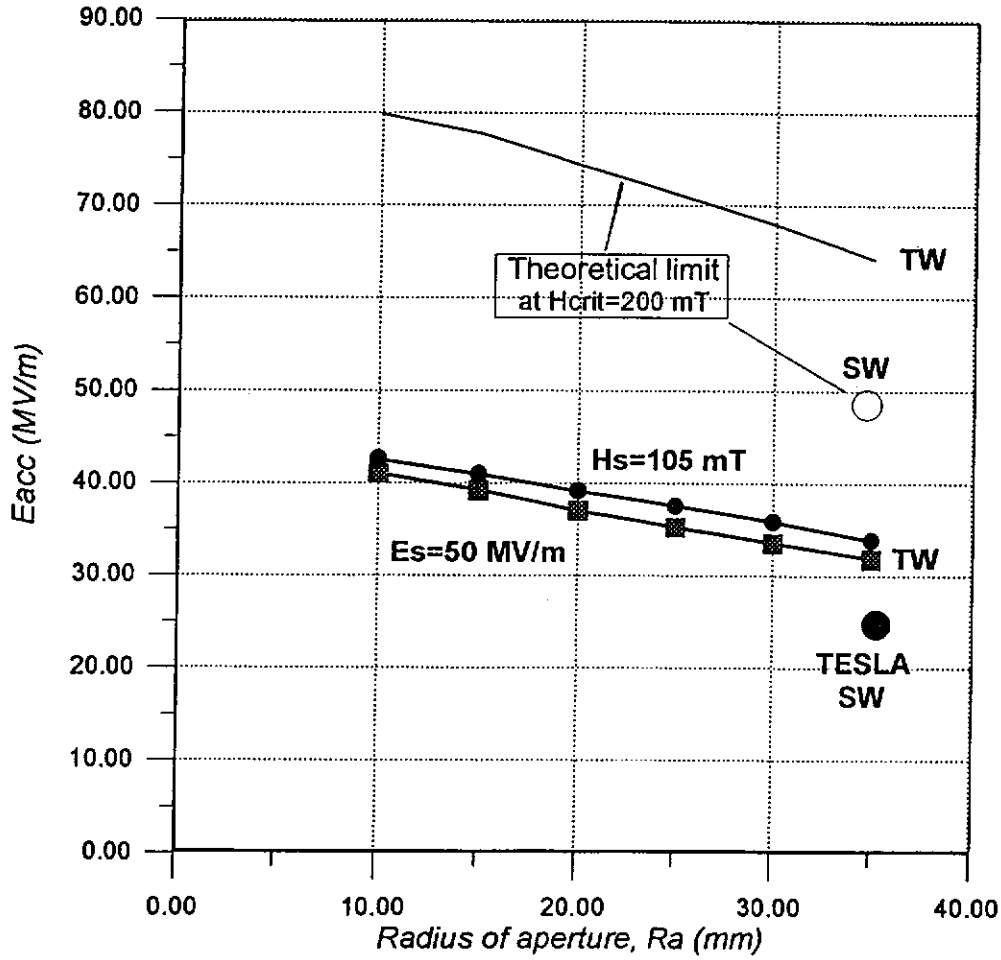
This drawback is remedied in the accelerating structure of a new type proposed built as a combination of two structures exploiting a "standing wave" regime.






TESLA 0
1.50
1.25
1.00
0.75
0.50
0.25
0.00
E (z=ct)
$\overline{E}_{acc}$
t


TESLA !
1.50
1.25
1.00
0.75
0.50
0.25
0.00
E (z=ct)
$\overline{E}_{acc}$
t



Accelerating gradient of TW and SW structures vs. aperture radius.

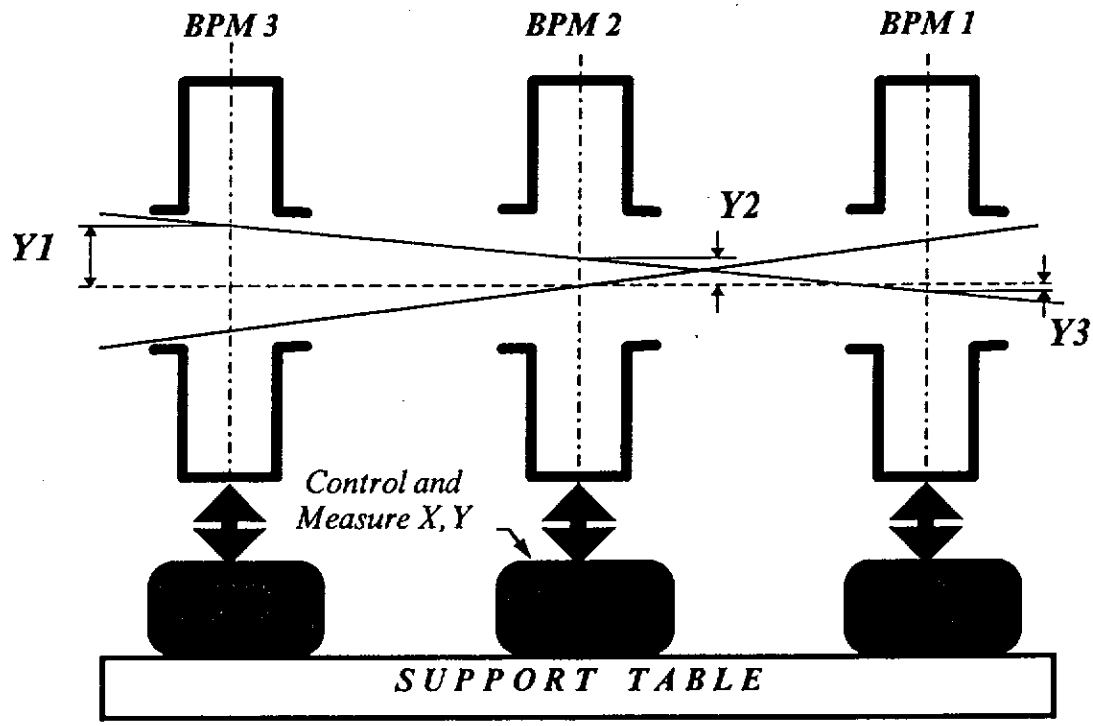
TTF meeting
July 6-8, 1998
DESY

Experimental test Beam Position Monitor for Linear Collider

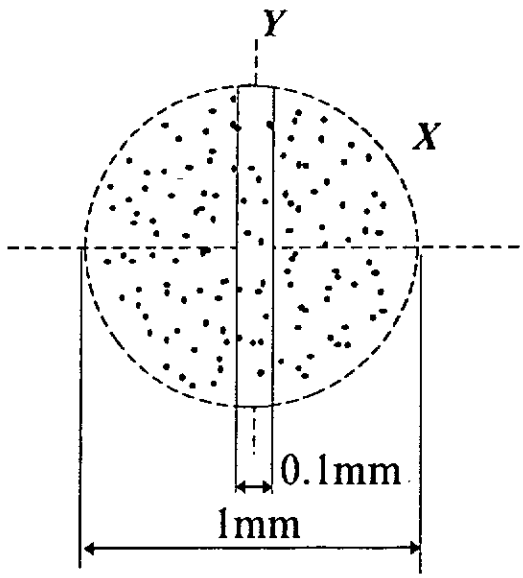
V. Balakin, A.Bazhan, P.Lunev, I.Skarin, V.Vogel, P.Zhogolev
Branch of INP, Protvino, Russia

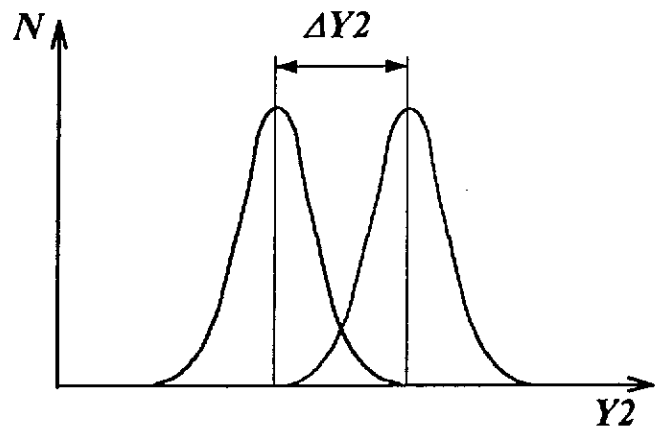
V.Yakimenko
ATF BNL-Brookhaven, USA

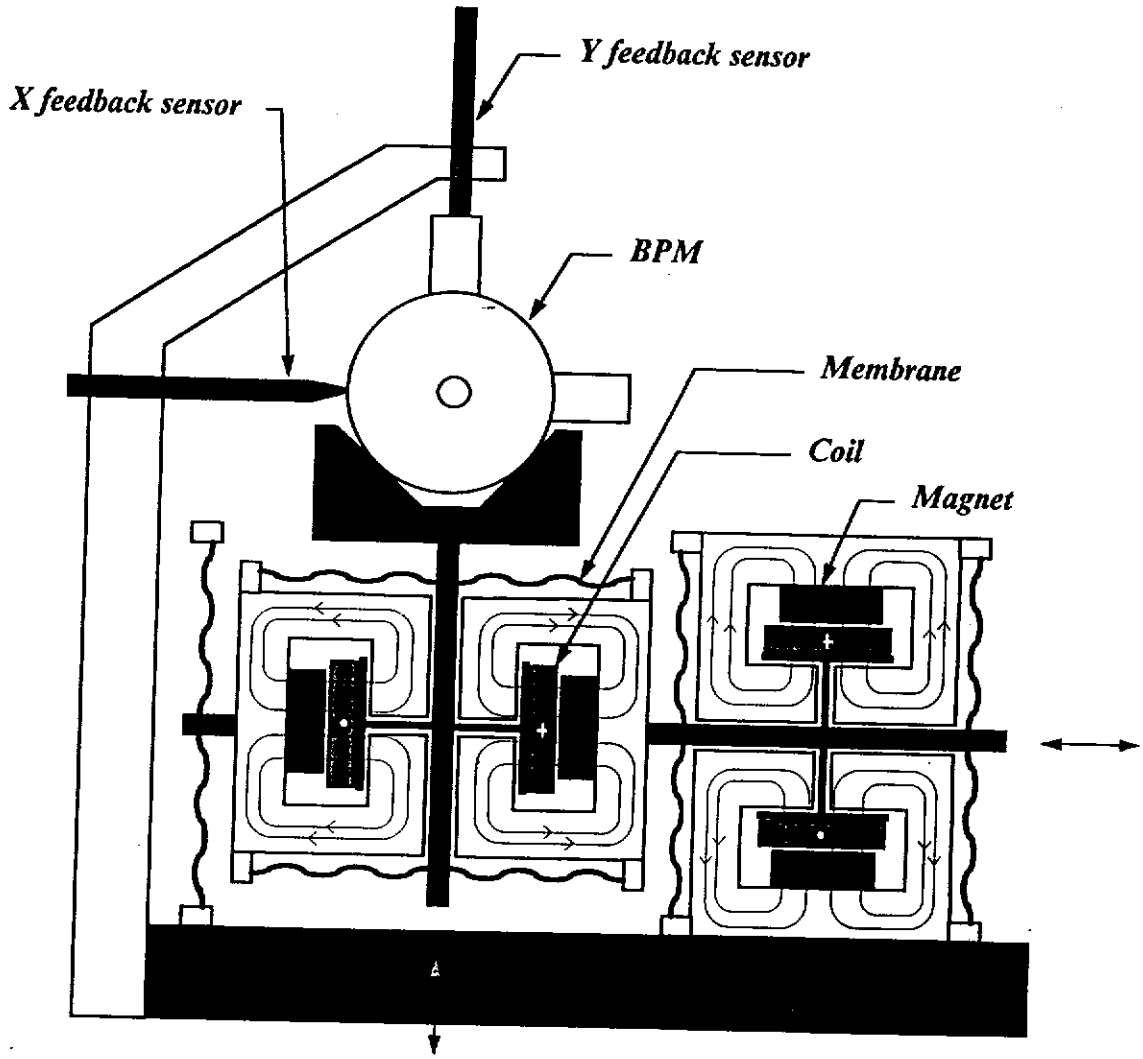
A.Lisitsyn
SSIE "Istok", Moscow, Russia


BPM 3
BPM 2
BPM 1
Y1
Y2
Y3
Control and
Measure X, Y
SUPPORT TABLE

$$Y2 = (Y1 + Y3)/2$$

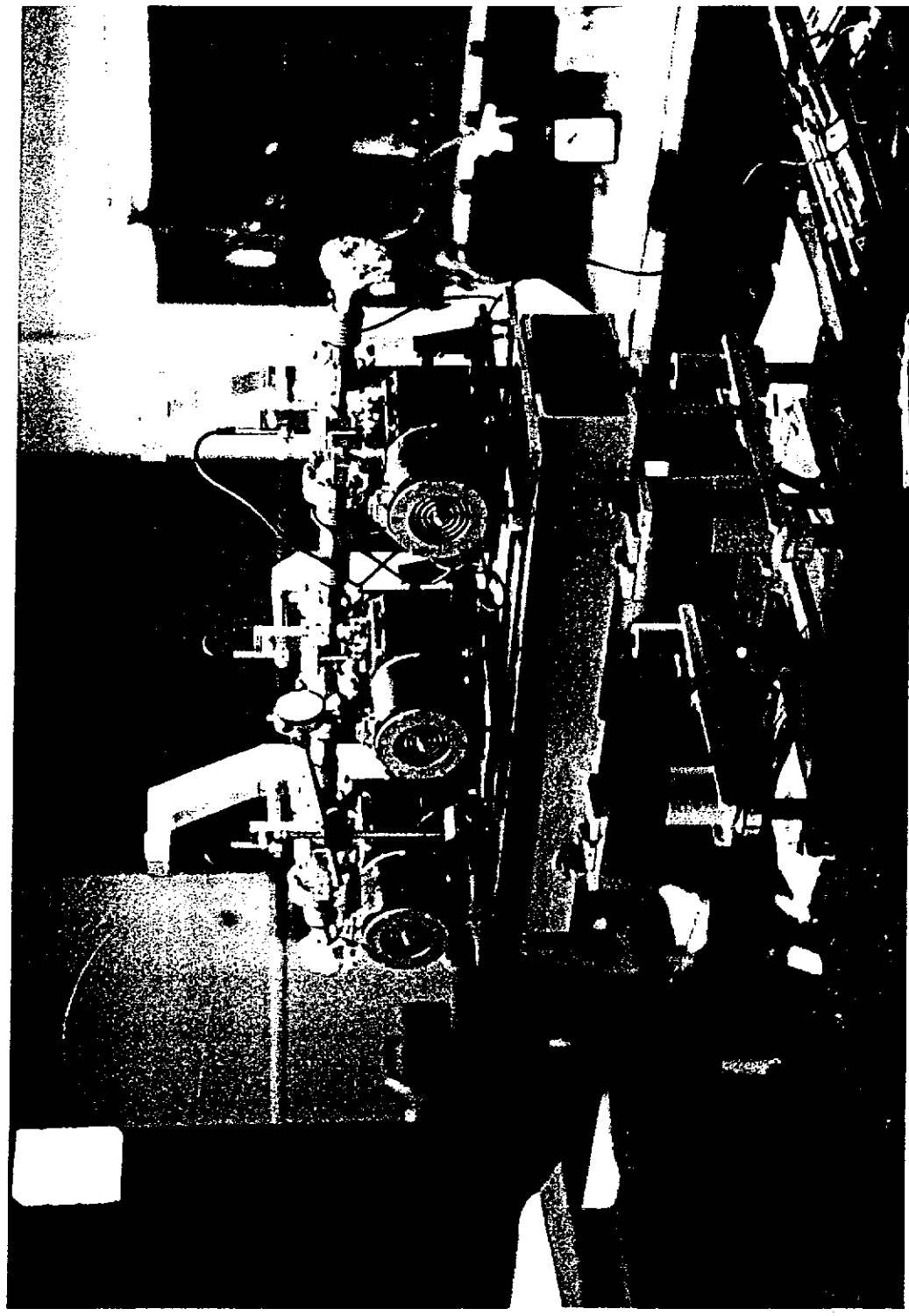

Y
X
0.1mm
1mm


N
ΔY2
Y2

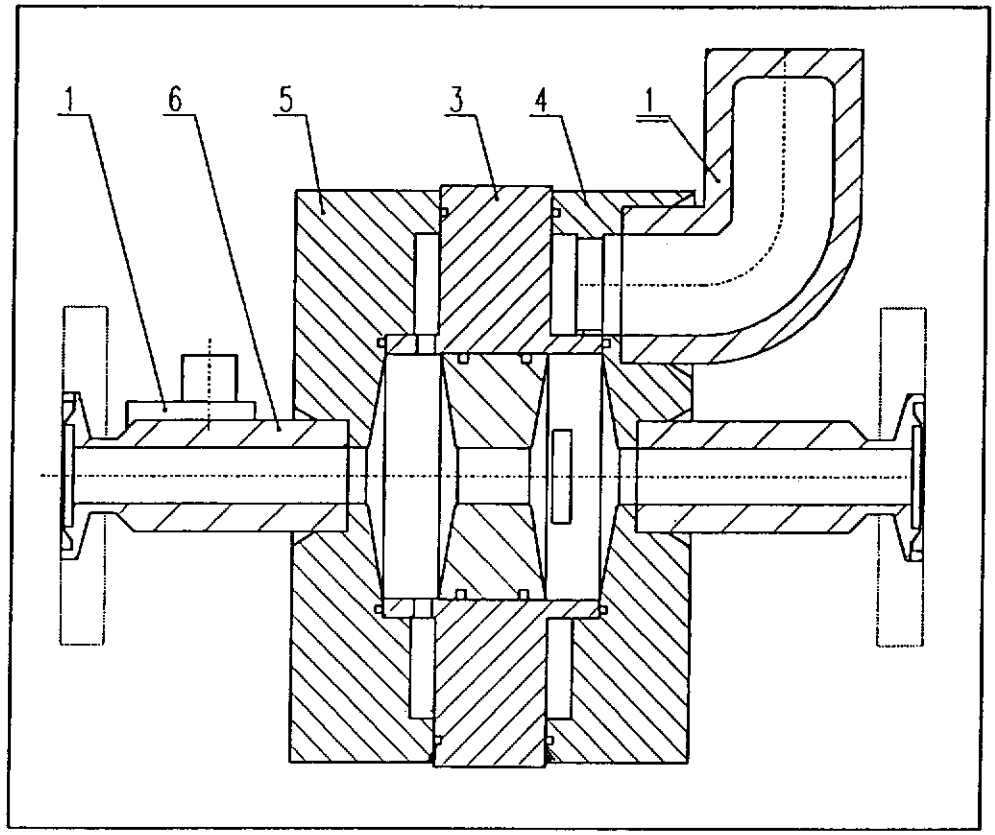


Moving and measuring diagram

- 0.5mm < X < + 0.5mm , Δx = 50 nm
- 0.5mm < Y < + 0.5mm , Δy = 50nm

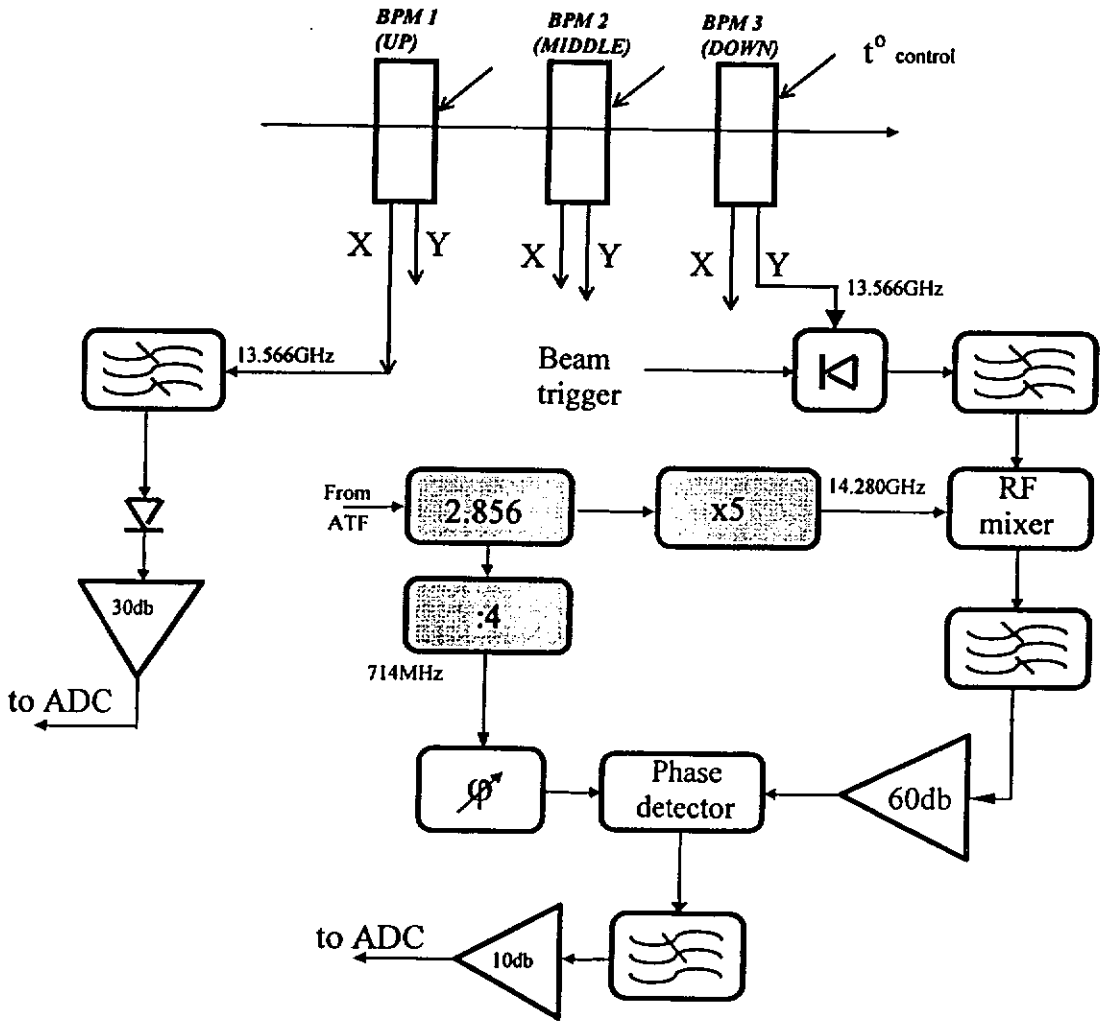


The setup for testing Beam Position Monitor

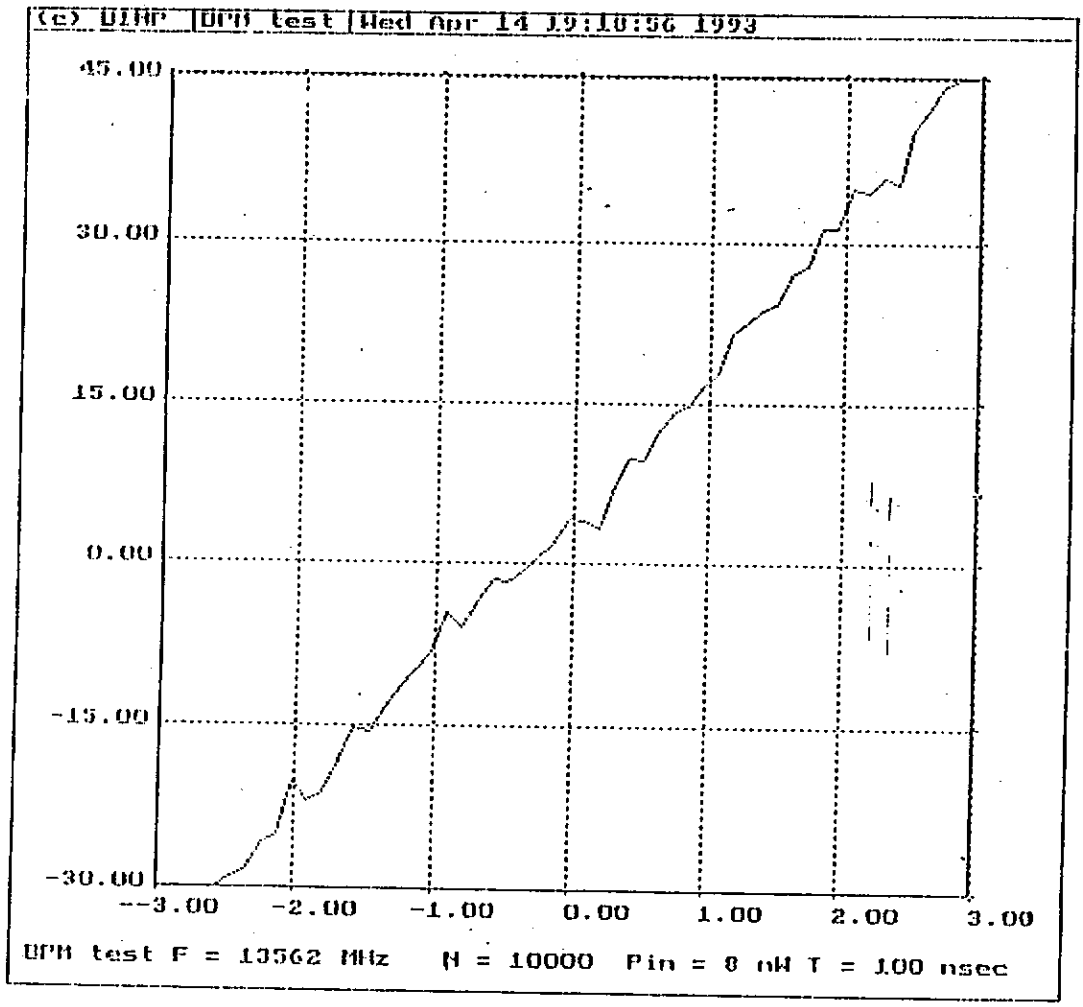


BPM Prototype for VLEPP.

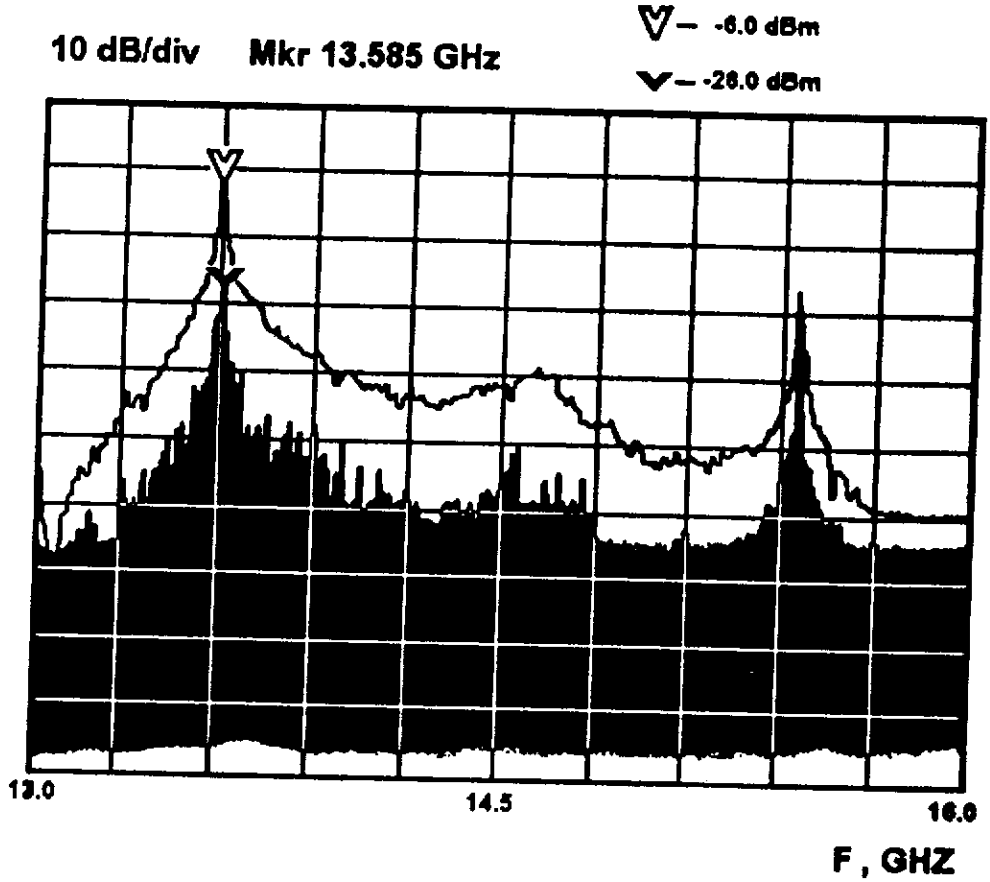
$V \sim K \cdot q \cdot \delta$



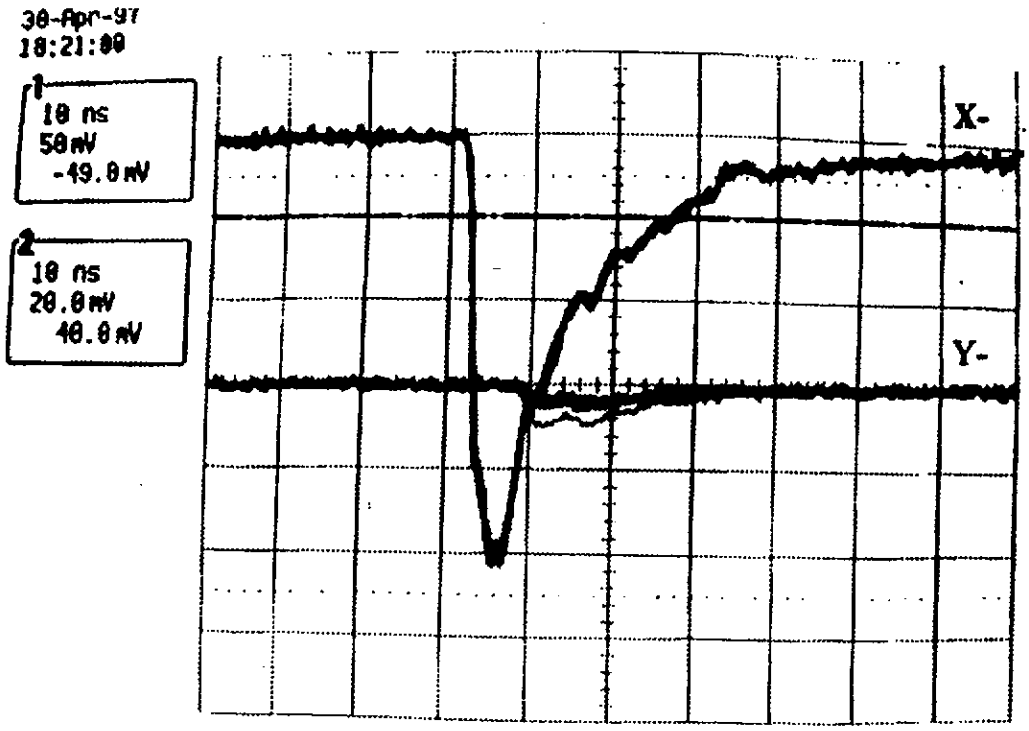
RF detection electronics


(c) UIHP DPM test Wed Apr 14 19:10:56 1993
45.00
30.00
15.00
0.00
-15.00
-30.00
-3.00
-2.00
-1.00
0.00
1.00
2.00
3.00
DPM test F = 13562 MHz N = 10000 Pin = 8 nW T = 100 nsec

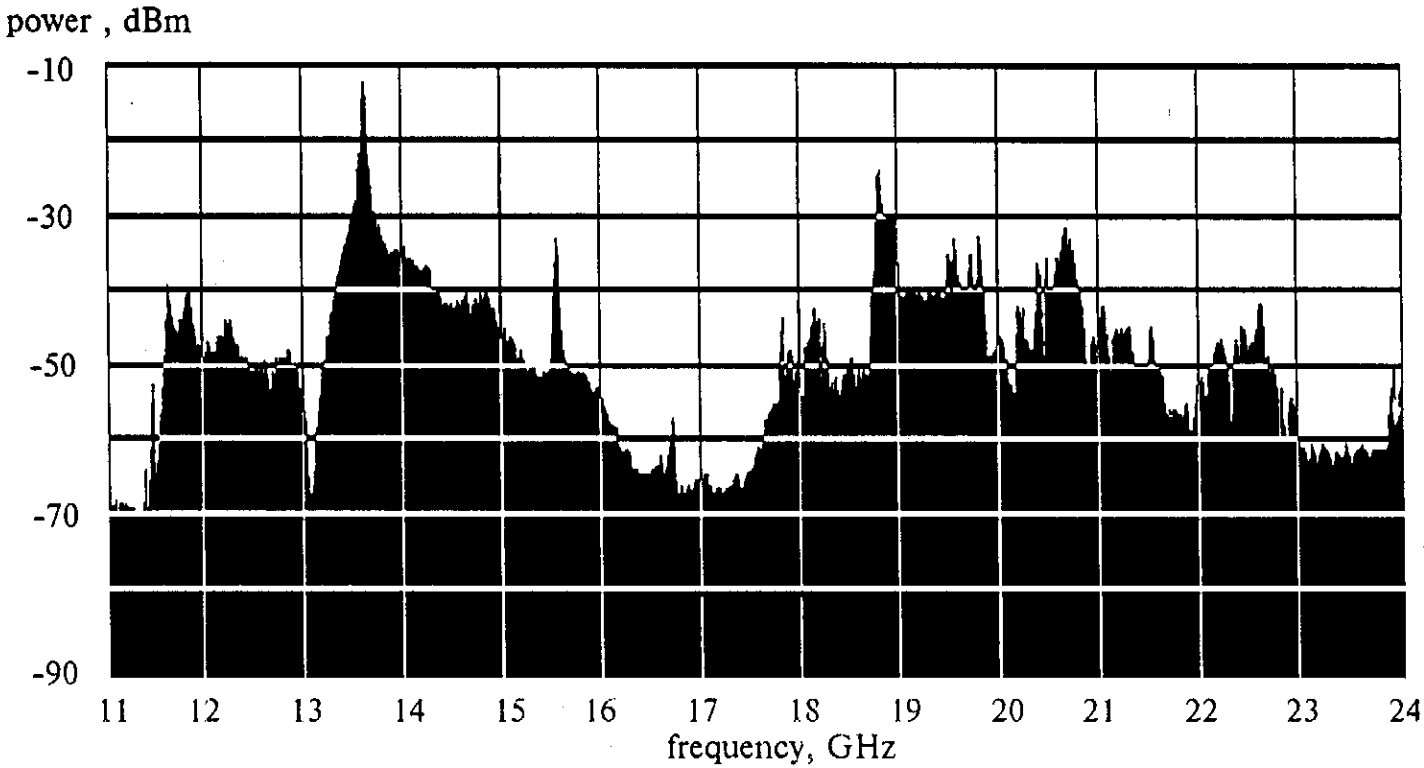
Spectrum from BPM for two several beam off-set.



BPM output signals for X- and Y- directions from detector.



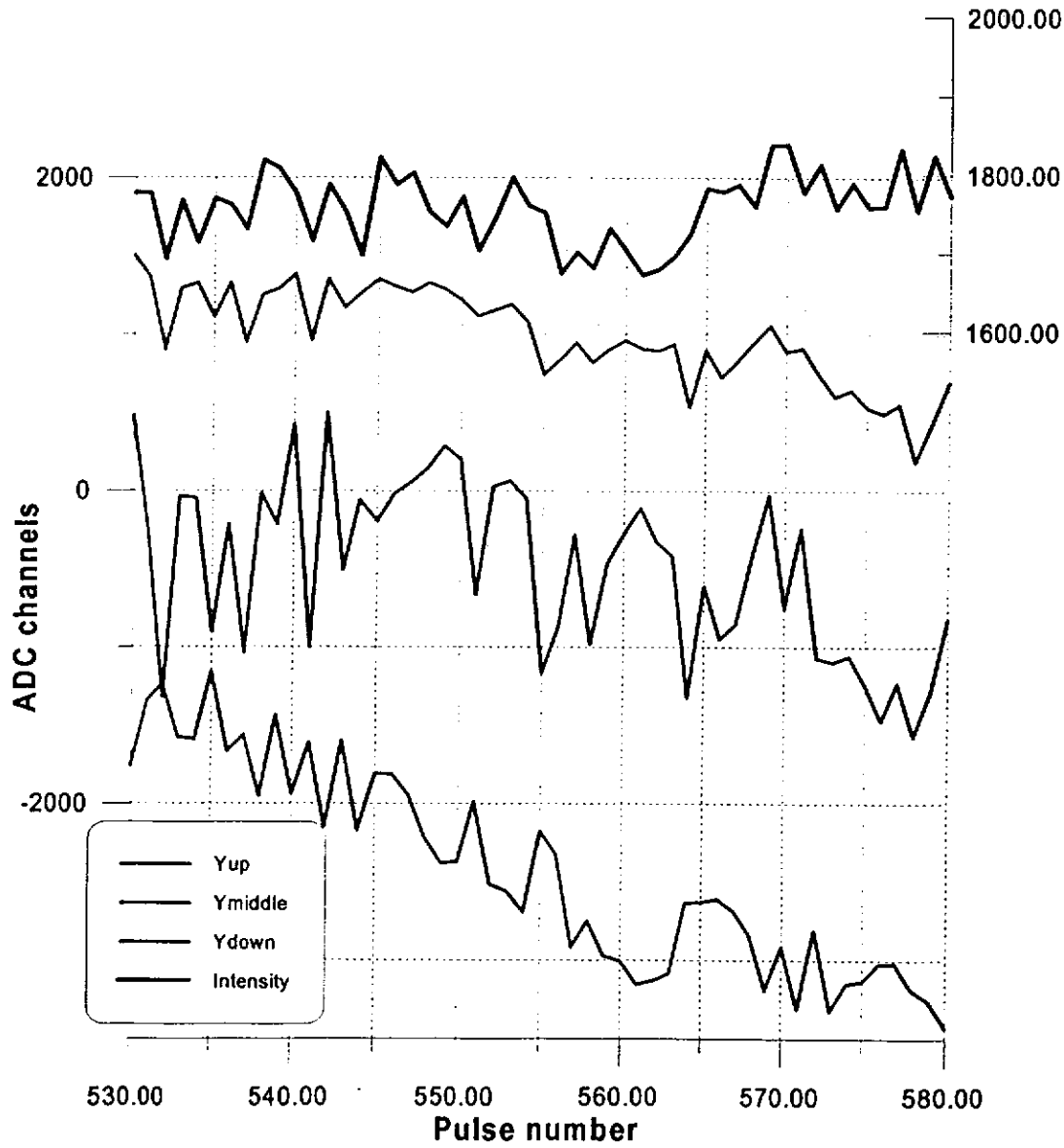
Output signal from BPM



BINP - BNL ATF
BPM-experiment
26 march 1998

Phase method. Jitter measurement.

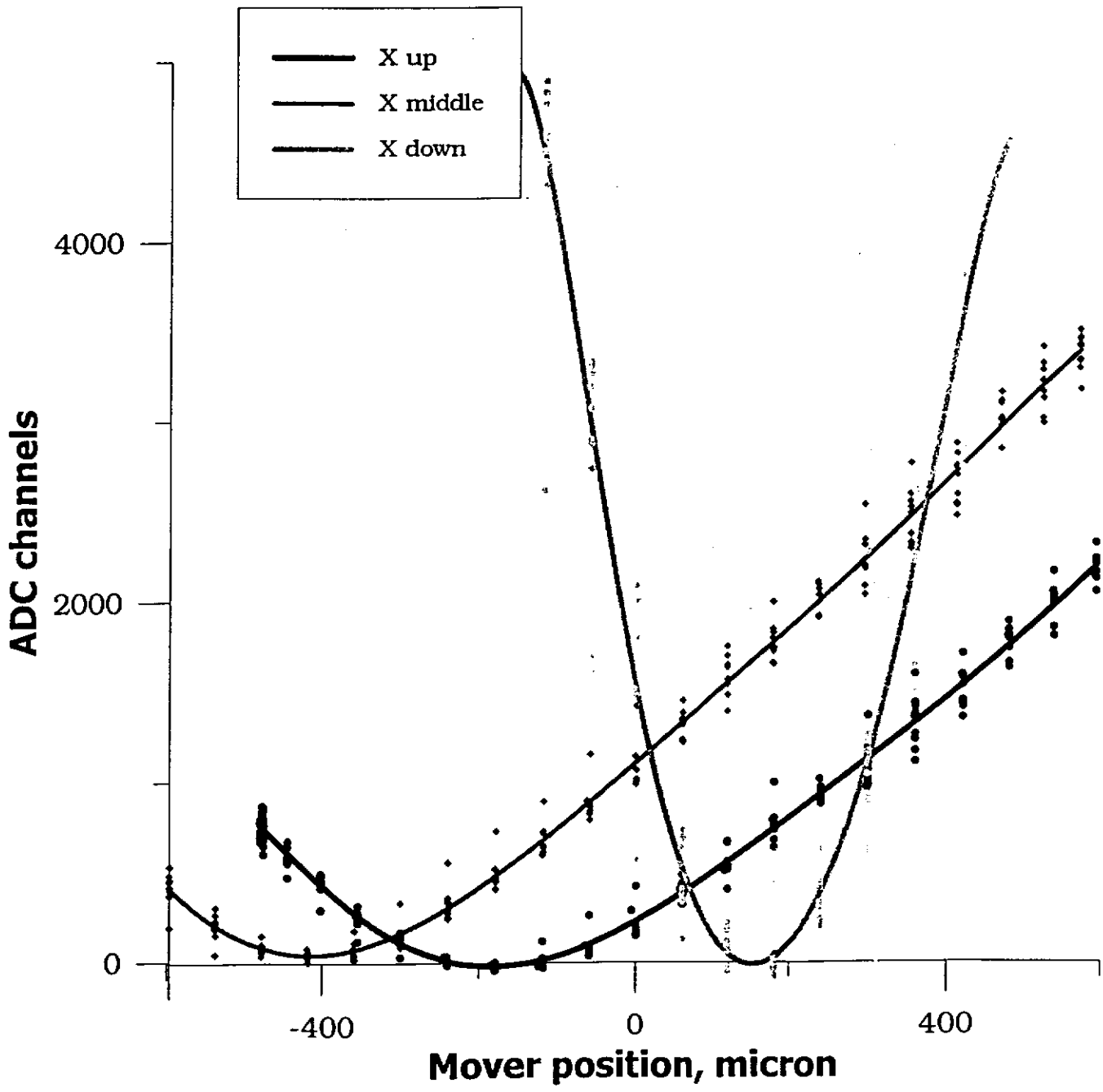
30 dB attenuation on input signal
all BPMs are moving 0.34 micron/pulse



BINP - ATF BNL
BPM's experiment
march,26,1998

Amplitude method sensitivity measuring.

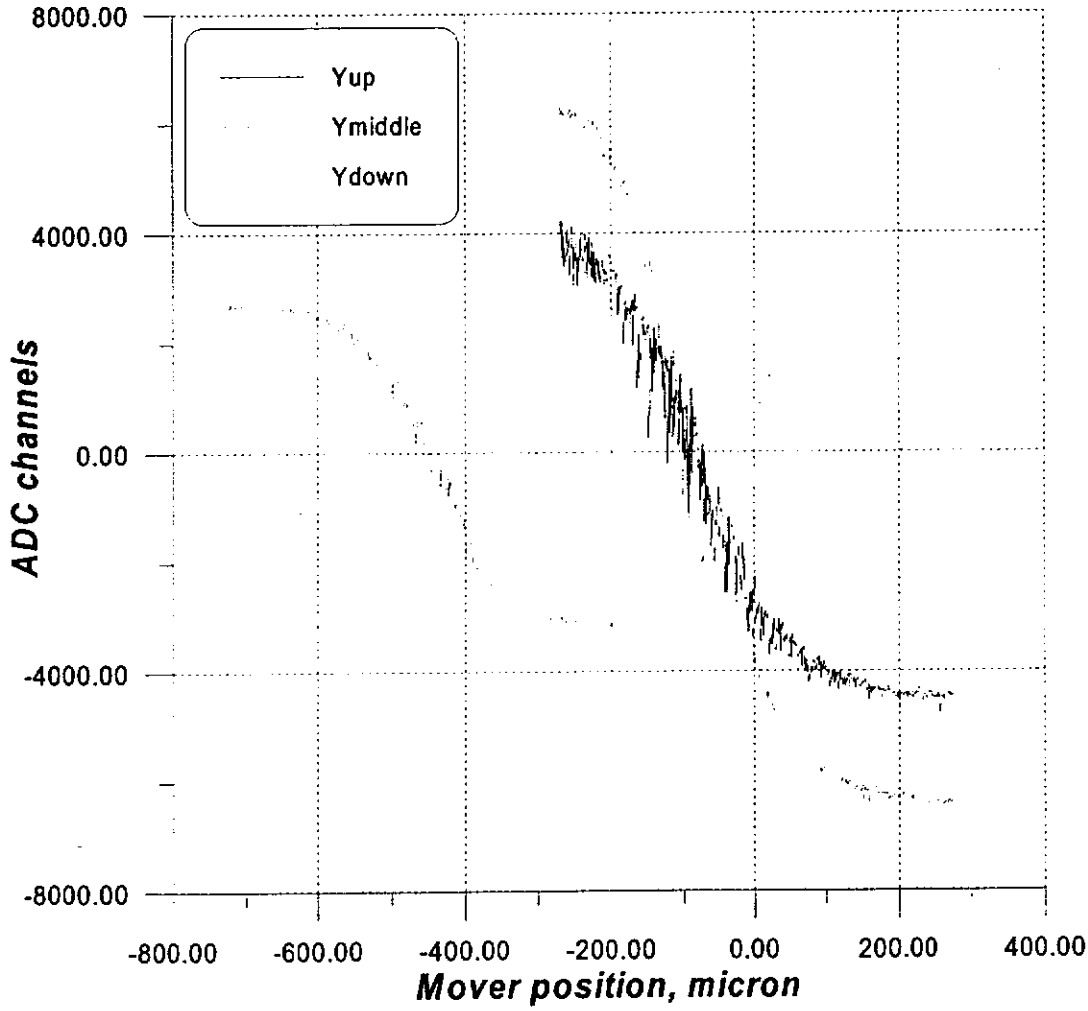
(Two tipes of diod have been used.)

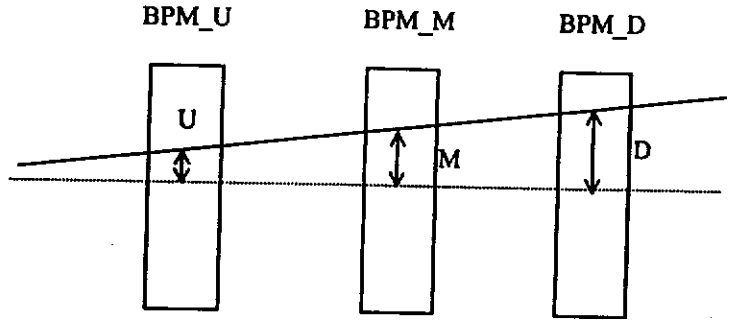


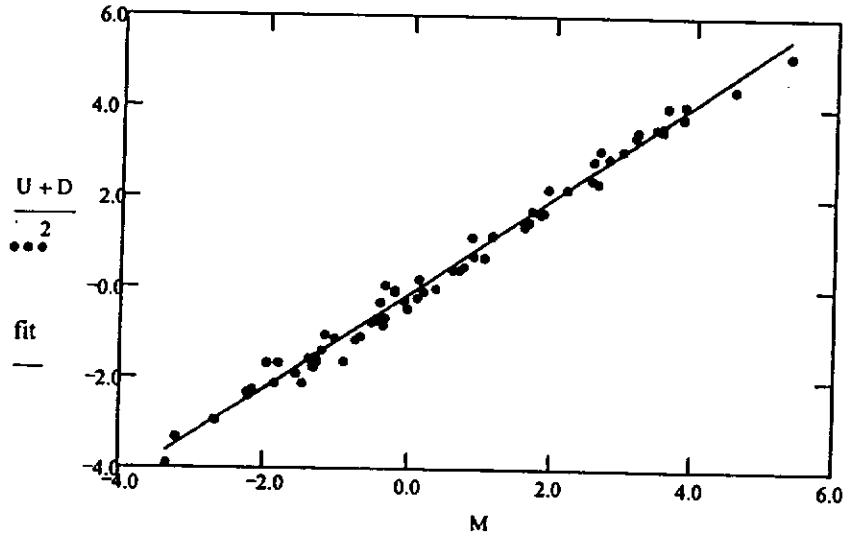
BINP - ATF BNL BPM's experiment March , 26 1998

Phase method sensitivity measuring.

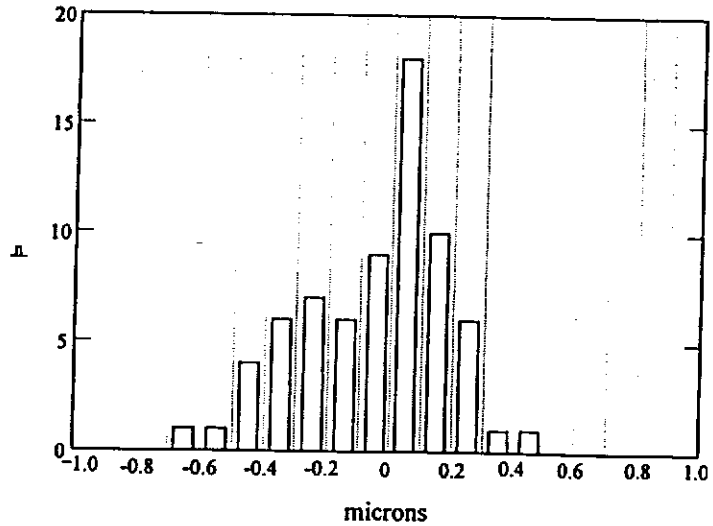
Sensitivity adapted to dinamic range +/- 150 micron
(BPM Ymiddle mechanical offset is 360 micron)

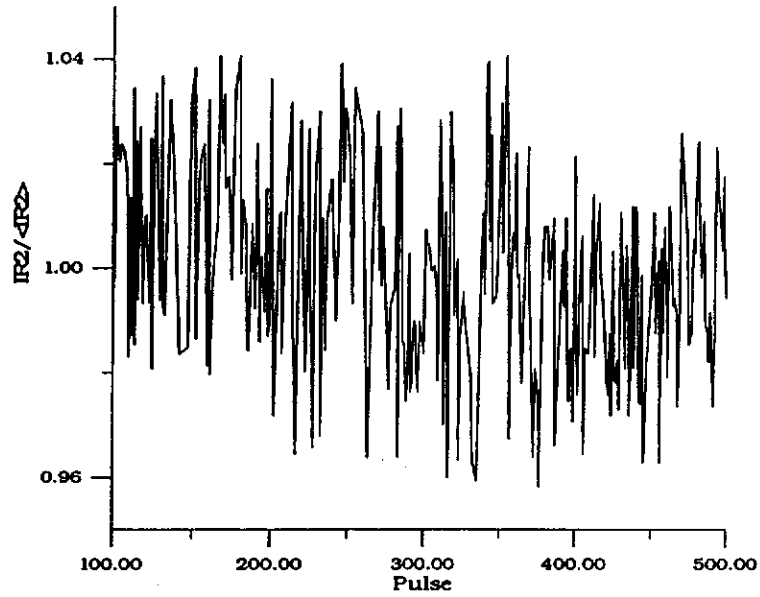




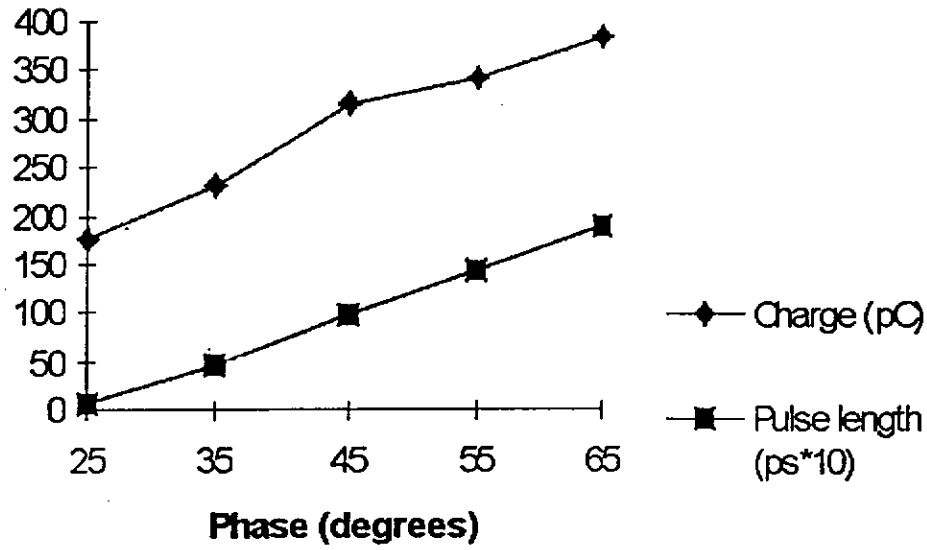


σ=0.23 microns

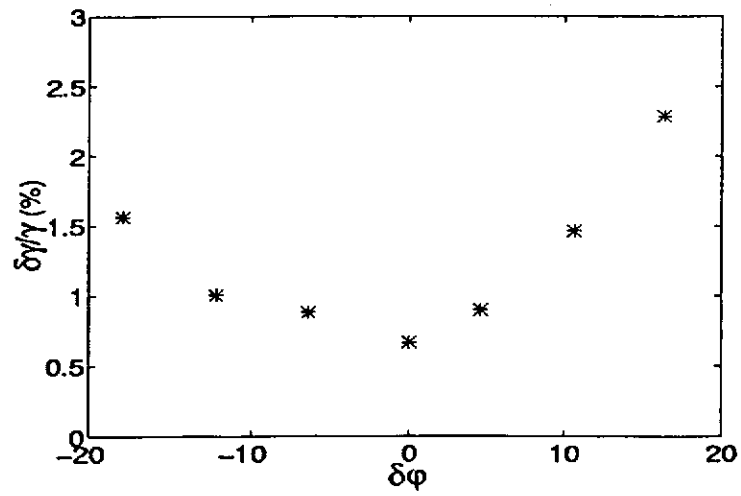




Beam intensity jitter



Measured charge and pulse length as a function of the phase at a constant laser energy.



Measured energy spread vs. linac phase detune (degrees).

CONCLUSIONS

The upper limit on BPM system resolution of 0.2÷0.3 μm has been determine with BNL ATF beam using three BPMs for excluding beam jitter influence. We expected to obtain resolution about 0.1 μm. Difference between expected and obtained resolution can be explained following reasons:

dynamic rang of used in the experiment electronics wasn't enough for measurements with real beam jitter. That is why BPM output signal was attenuated;

time of laser pulse in RF gun not absolutely stable relatively of accelerating RF signal, which is used as reference signal for phase measurements. That is why "beam phase" has jitter relatively reference oscillations and it is the cause of additional jitter noise in the output signal of phase detection electronics. And this jitter couldn't exclude using three BPMs;

beam trajectory through BPMs is not absolutely rectilinear because the magnetic field of earth has influence on moving charged particles. Trajectory deflection from line depends on beam energy that is why energy jitter in accelerator cause mistakes in resolution determination using three BPMs. For instance energy spread on 1% for 45MeV beam cause beam trajectory jitter about ±0.4 μm if distance between BPMs are 0.5 m. Influence of this addition jitter can be decreased to put BPMs closer one to other.

Institut für Allgemeine Elektrotechnik

Prof. Dr. Ursula van Rienen

Dr. Dirk Hecht
Dr. Hans-Walter Glock (since Feb. 98, previously Frankfurt/M.)
Dr. Uwe Richter (since June 98)
Dipl.-Phys. Karsten Rothemund (since July 98)

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Filling and Beam Loading in TESLA Superstructures

M. Dohlus
(DESY)

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

(Institut für Allgemeine Elektrotechnik
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email: Rienen@warnow.e-technik1.uni-rostock.de)

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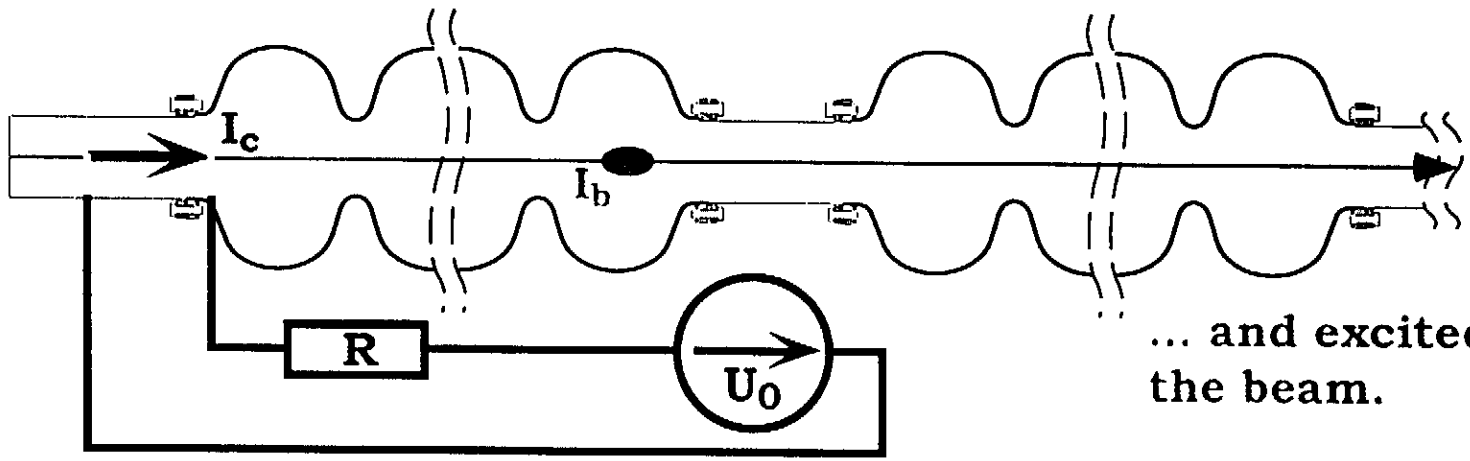
compare similar work:

M. Ferrario, J. Sekutowicz (TESLA-Rep. 98-08, EPAC 98)

Model of cavity chain ...

(M. Dohlus)



... and excited by the beam.

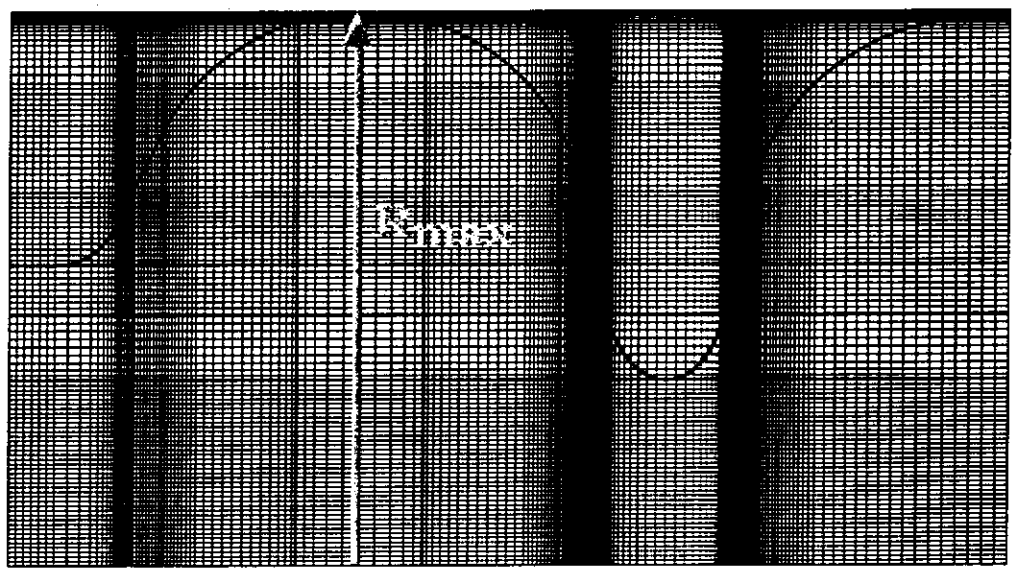
... coupled to external transmitter ...

- **Calculate interaction of currents and fields in terms of eigenmodes found with MAFIA.**

- **Solve system of coupled ordinary differential equations to find eigenmode amplitudes as functions of time.**

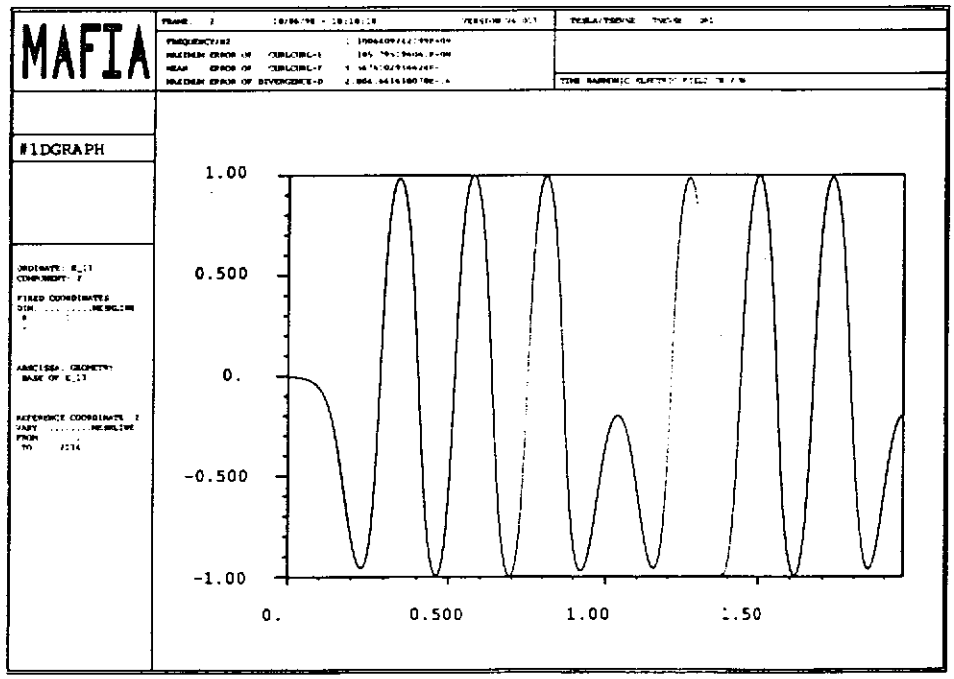
MAFIA eigenmode calculation

- **Find "ideal" grid - no stairs in cavity boundary:**



Univ. Rostock

- **Fit R_{max} of outermost cells to improve field flatness:**



- **Extract f_j, W_j and $E_{z(j)}$ for all 28 modes of fundamental passband.**

MAFIA

FRAME: 2 04/06/98 - 13:00:57 VERSION[V4.013]

../TSEVSE16/TSEVSE16.DRD

FREQUENCY/HZ	1.3006125889398E+09
MAXIMUM ERROR OF CURLCURL-E	7.7854047370009E-09
MEAN ERROR OF CURLCURL-E	1.5408109389743E-10
MAXIMUM ERROR OF DIVERGENCE-D	2.6193374734701E-16

$\rho_{max} = 105.094$ mm

TIME HARMONIC ELECTRIC FIELD IN V/M

$\nu = 1300.6126$ MHz

OP-:4013

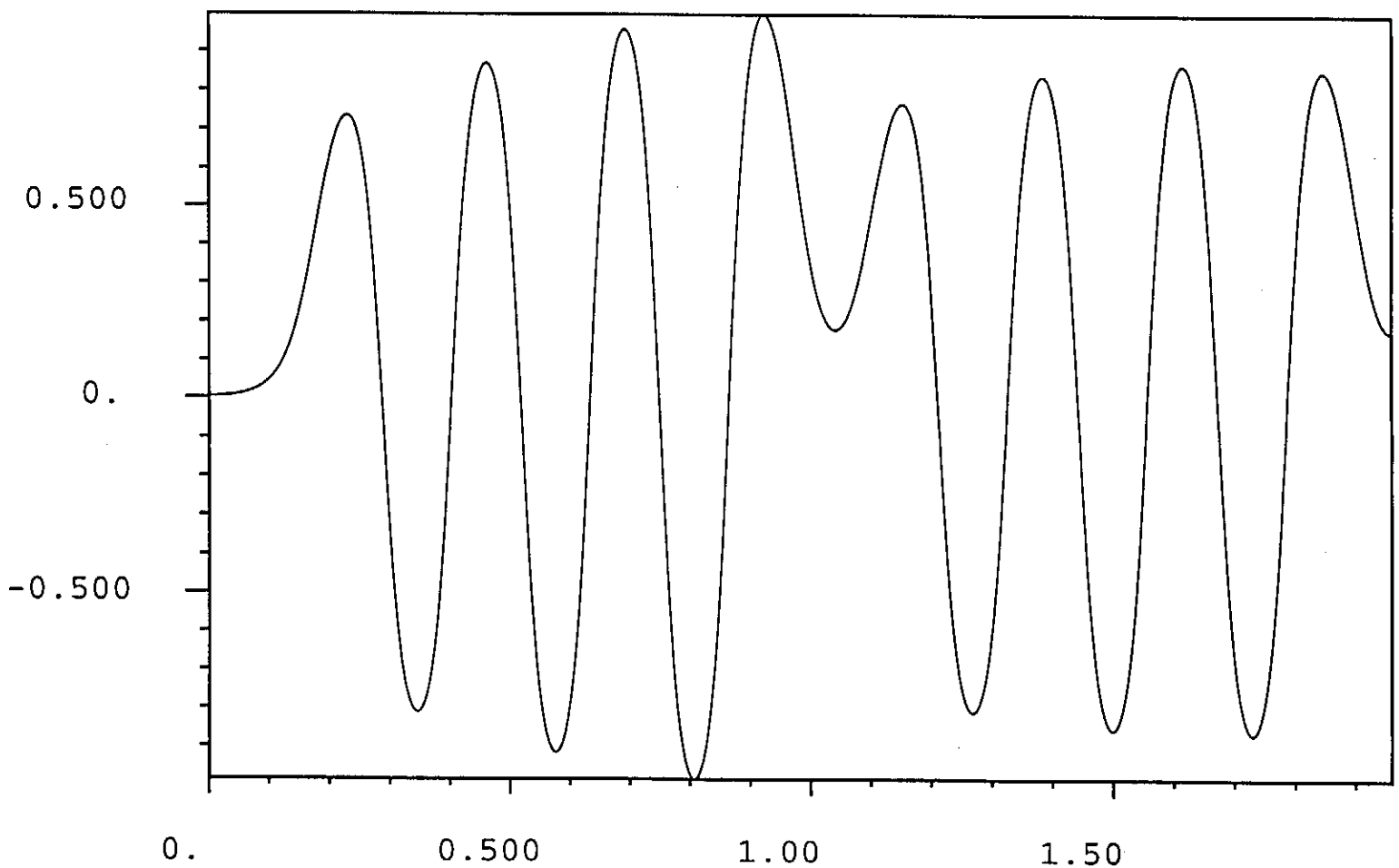
#1DGRAPH

ORDINATE: E_13
COMPONENT: Z

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

ABSCISSA: GEOMETRY
[BASE OF E_13]

REFERENCE COORDINATE: Z
VARY.....MESHLINE
FROM 1
TO 2134



MAFIA

FRAME: 2 04/06/98 - 06:31:45 VERSION[V4.013]

TSEVSE15.DRD

FREQUENCY/HZ	1.3006662749736E+09
MAXIMUM ERROR OF CURLCURL-E	5.0782812382824E-10
MEAN ERROR OF CURLCURL-E	1.1634389863769E-11
MAXIMUM ERROR OF DIVERGENCE-D	2.5992867582400E-16

$f_{max} = 104.994\,mm$

TIME HARMONIC ELECTRIC FIELD IN V/M

P--:4013

#1DGRAPH

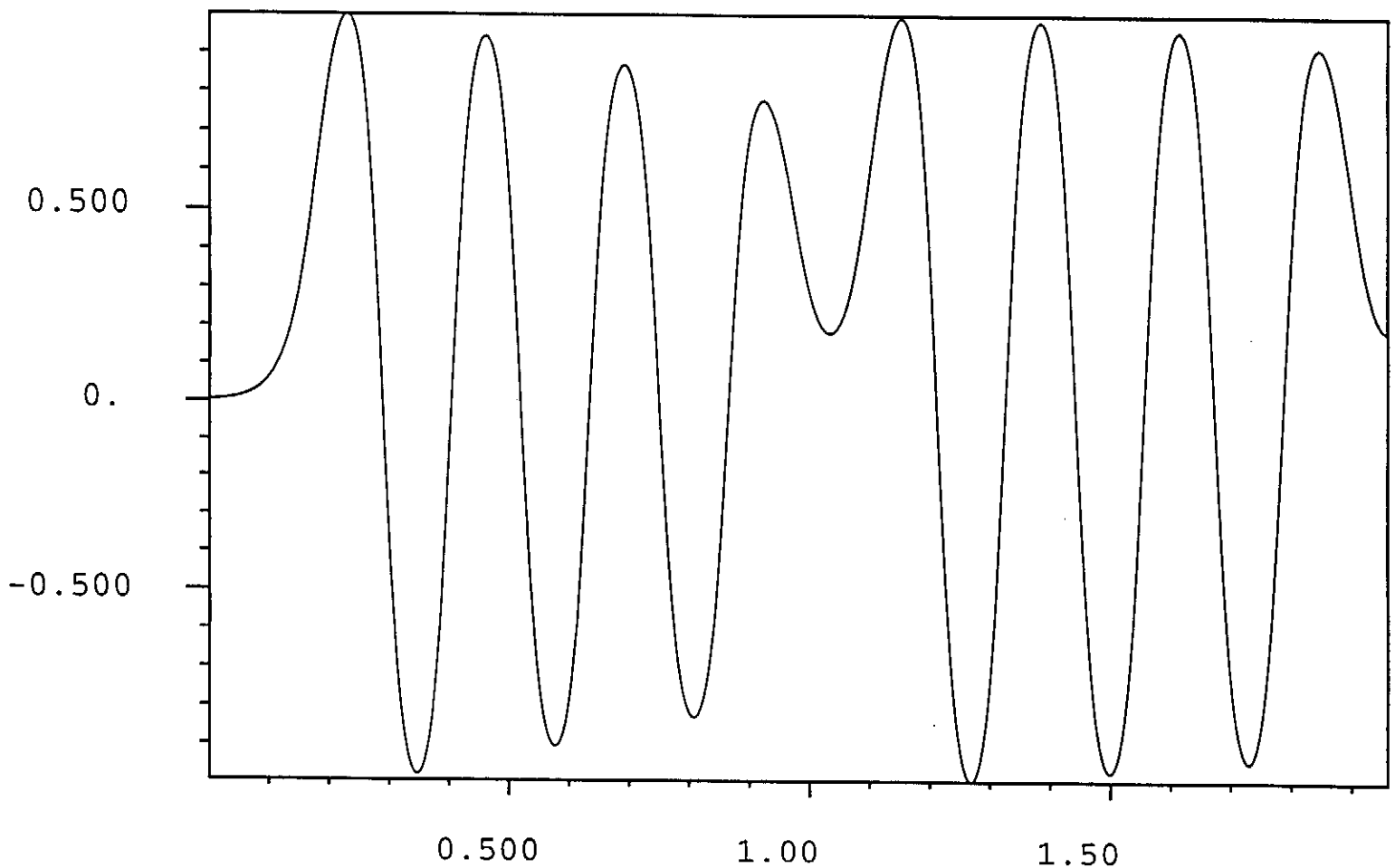
$\nu = 1300,6663\ MHz$

ORDINATE: E_13
COMPONENT: Z

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

ABSCISSA: GEOMETRY
[BASE OF E_13]

REFERENCE COORDINATE: Z
VARY.....MESHLINE
FROM 1
TO 2134



220

MAFIA

FRAME: 2 04/06/98 - 15:01:40 VERSION[V4.013]

./TSEVSE17.DRD

FREQUENCY/HZ	1.3006409242199E+09
MAXIMUM ERROR OF CURLCURL-E	1.3051795196061E-08
MEAN ERROR OF CURLCURL-E	9.5676102936624E-11
MAXIMUM ERROR OF DIVERGENCE-D	2.8041663638078E-16

$\lambda_{max} = 105.044$ mm

TIME HARMONIC ELECTRIC FIELD IN V/M

OP-:4013

#1DGRAPH

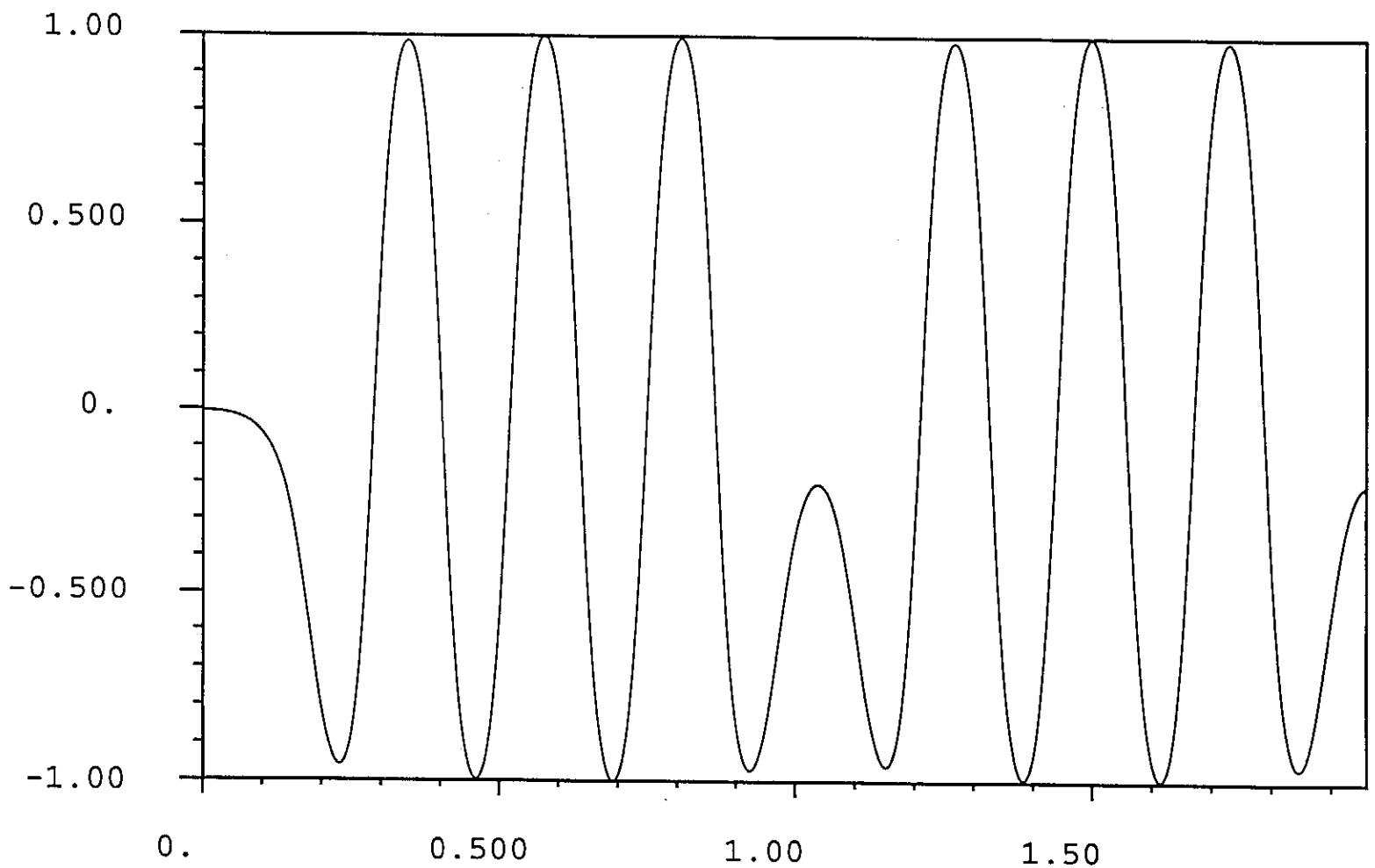
$\nu = 1300.6409$ MHz

ORDINATE: E_13
COMPONENT: Z

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

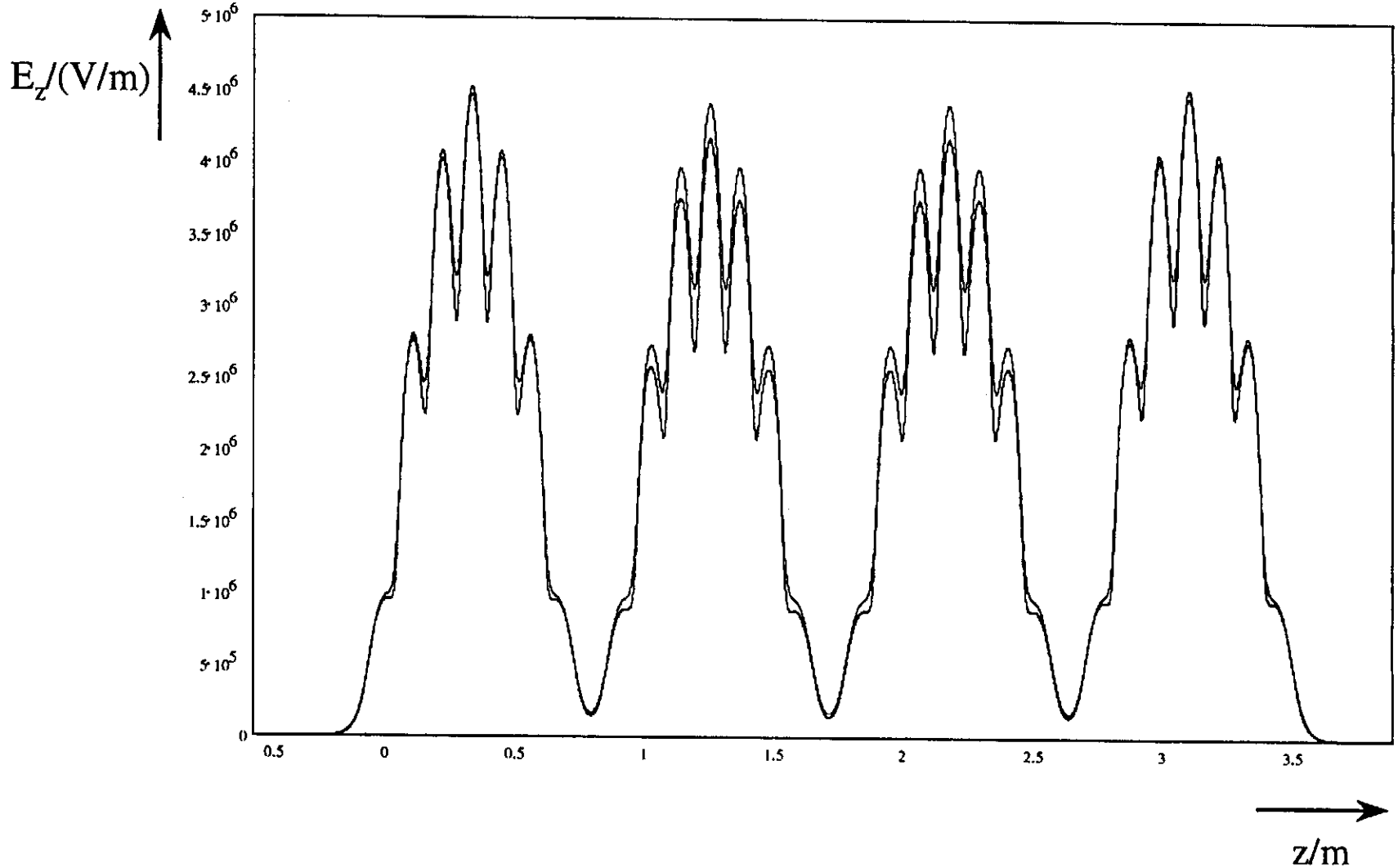
ABSCISSA: GEOMETRY
[BASE OF E_13]

REFERENCE COORDINATE: Z
VARY.....MESHLINE
FROM 1
TO 2134



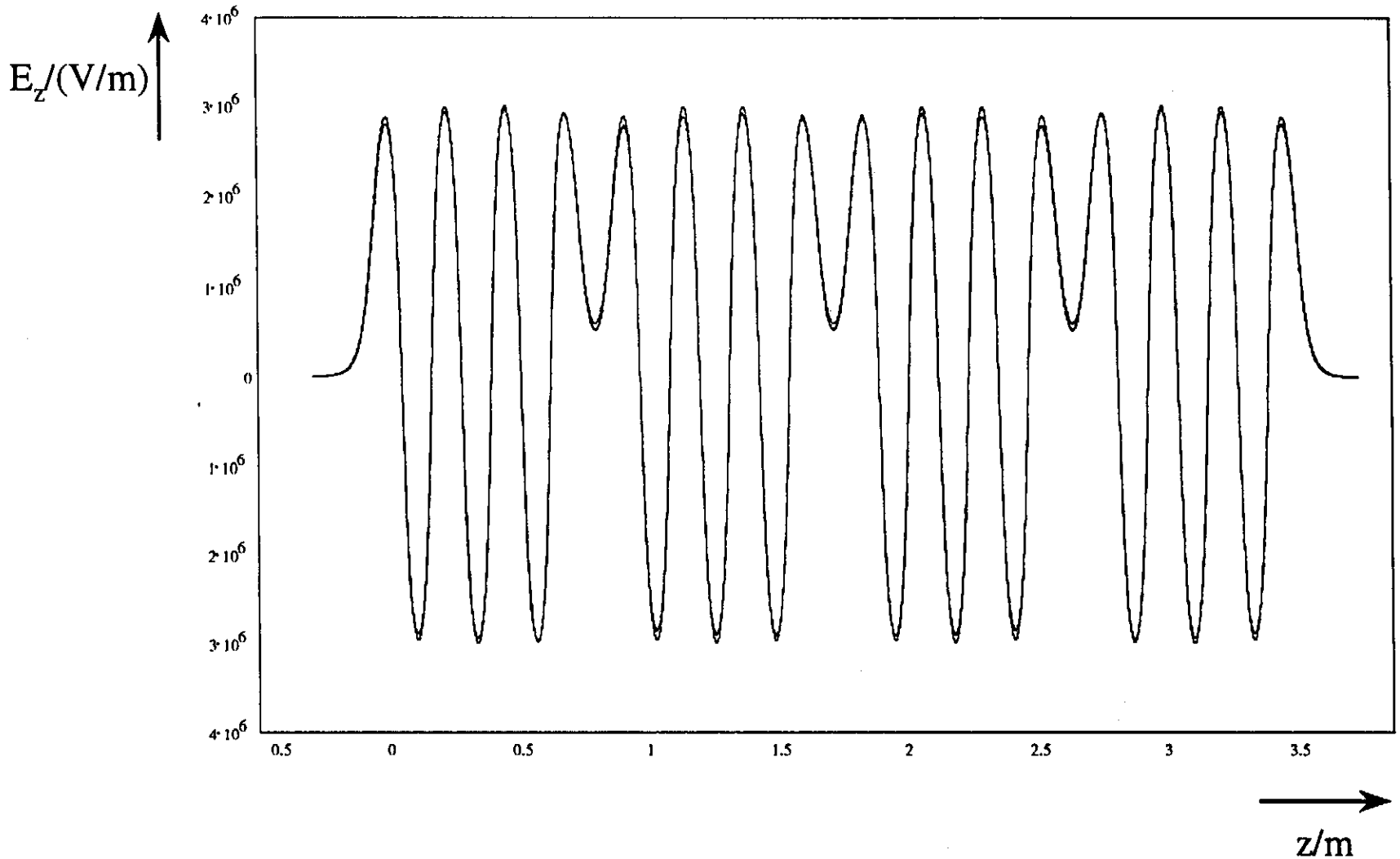
221

Mode 1: MAFIA, FEM W_{tot}= 1J



Martin Dohlus Deutsches Elektronen Synchrotron

Mode 25: MAFIA, FEM W_{tot}= 1J

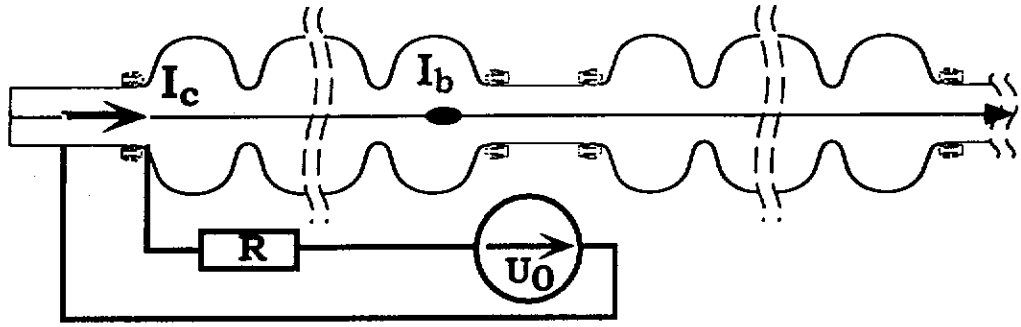


Martin Dohlus Deutsches Elektronen Synchrotron

DOHLUS@MPYNTDOHLUS, JUL03/10:55

Eigenmode Expansion...

$$\vec{E}(\vec{r},t) = \sum_{j=1}^{n=28} a_j(t)\,\vec{E}_j(\vec{r})$$



... leads to system of differential equations in a(t):

$$\frac{d}{dt}\begin{pmatrix} a_1 \\ b_1 \\ \vdots \\ a_n \\ b_n \end{pmatrix} - \begin{pmatrix} 0 & i\omega_1 & \cdots & 0 & 0 \\ i\omega_1 & -\frac{k_1^2}{R} & \cdots & 0 & -\frac{k_1 k_n \omega_n}{R\,\omega_1} \\ \vdots & \vdots & & \vdots & \vdots \\ 0 & 0 & \cdots & 0 & i\omega_n \\ 0 & -\frac{k_n k_1 \omega_1}{R\,\omega_n} & \cdots & i\omega_n & -\frac{k_n^2}{R} \end{pmatrix} \begin{pmatrix} a_1 \\ b_1 \\ \vdots \\ a_n \\ b_n \end{pmatrix} = \begin{pmatrix} 0 \\ s_1 \\ \vdots \\ 0 \\ s_n \end{pmatrix}$$

$$k_\nu = \frac{-\int_{\text{"loop"}} \vec{E}_\nu \, d\vec{r}}{\sqrt{2\,W_\nu}}$$

$$s_\nu = \frac{i}{\omega_\nu}\frac{d}{dt}\left(\iiint_V \frac{\vec{j}_{beam}\,\vec{E}_\nu}{\sqrt{2\,W_\nu}}\,dV + \frac{k_\nu}{R}\,U_0 \right)$$

... with an explicit solution (eigenvalues and –vectors of matrix provided numerically).

Parameters and Assumptions:

- **Beam injection after N_{inj} = 760336 rf-periods ($\approx$ 580 μs).**

- **Beam injection at half the steady state field**

$$\Rightarrow Q_{ext} = \frac{N_{inj}\,\pi}{\mathrm{Ln}(2)} = 3.44612\,10^{6}.$$

- **Solution yields** $Q_{ext} = \dfrac{\mathrm{Im}\,(\lambda_{acc.})}{2\,\mathrm{Re}\,(\lambda_{acc.})}$,

  ($\lambda_{acc.}$ eigenvalue of matrix). Q_{ext}(accel. mode) **is adjusted by modification of transmitter resistance R.**

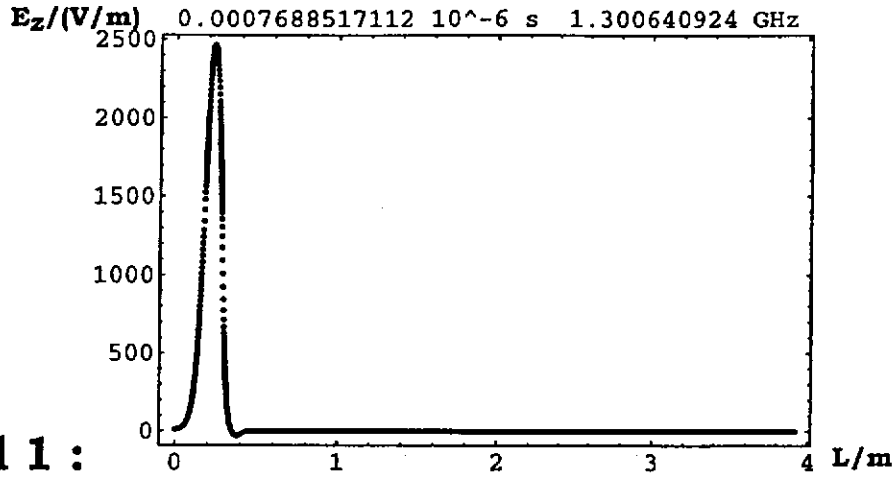
- **Amplitude of transmitter voltage is adjusted to a gradient, seen by the <u>first bunch</u>, of 25 MV/m over length of 28 cells = 80.6756 MV.**

- **Transmitter voltage constant.**

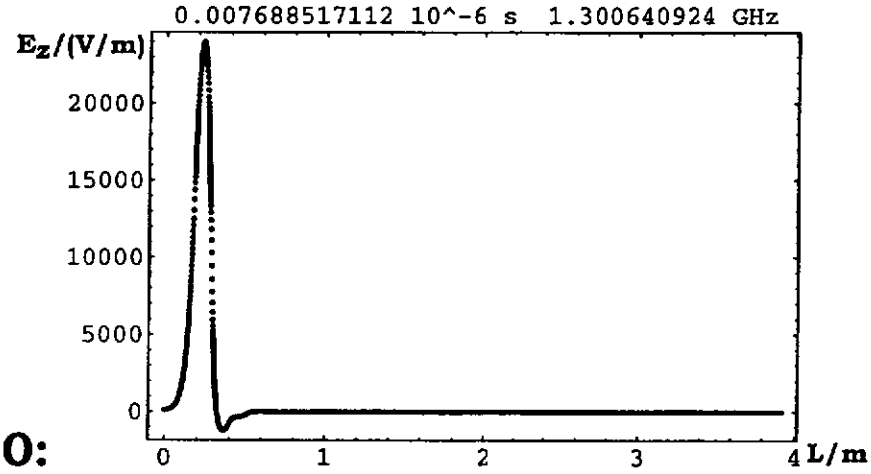
- **Bunch charge of 5.7267 nC; bunch spacing of 919 rf–periods; 1130 bunches in total.**

Results 1 - Field profiles after 10^j rf-periods

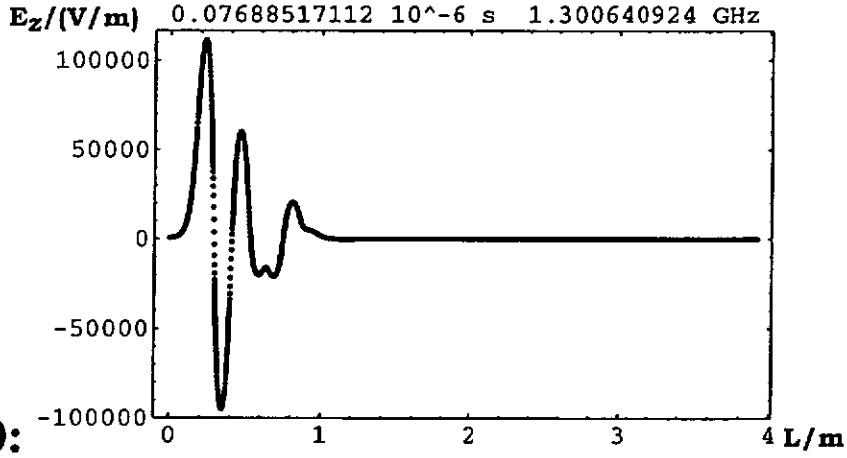
rf-period 1 :



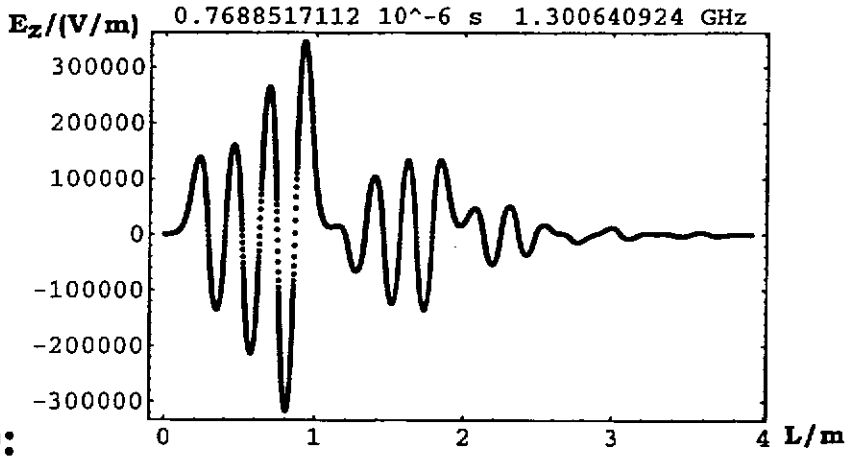
rf-period 10:



rf-period 100:

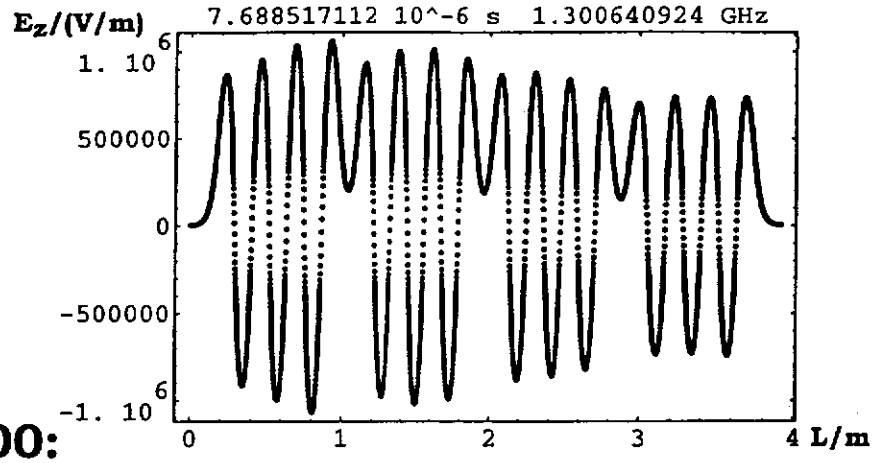


rf-period 1000:

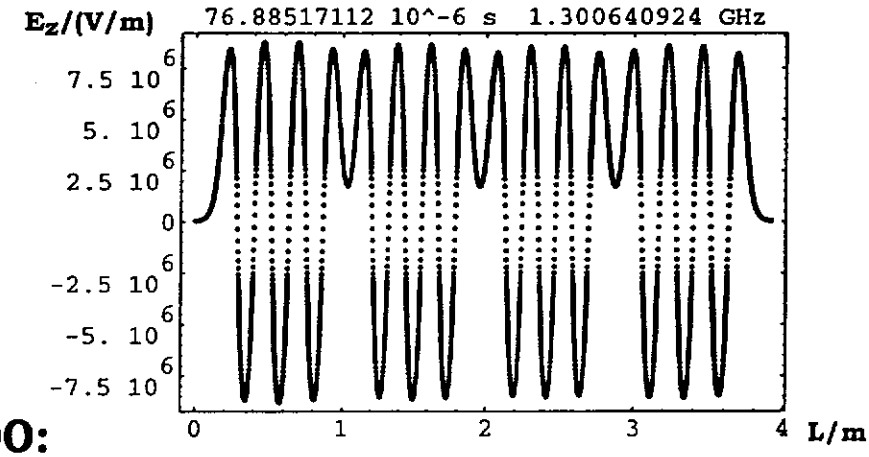


Field profiles (contd.)

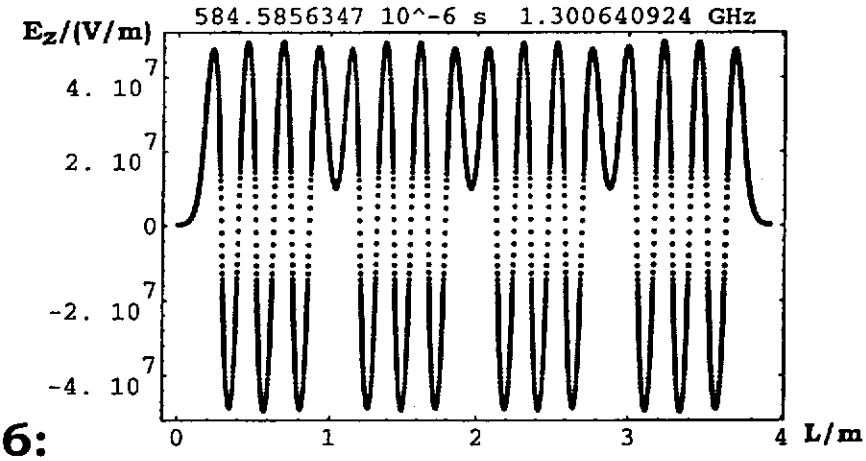
rf-period 10.000:



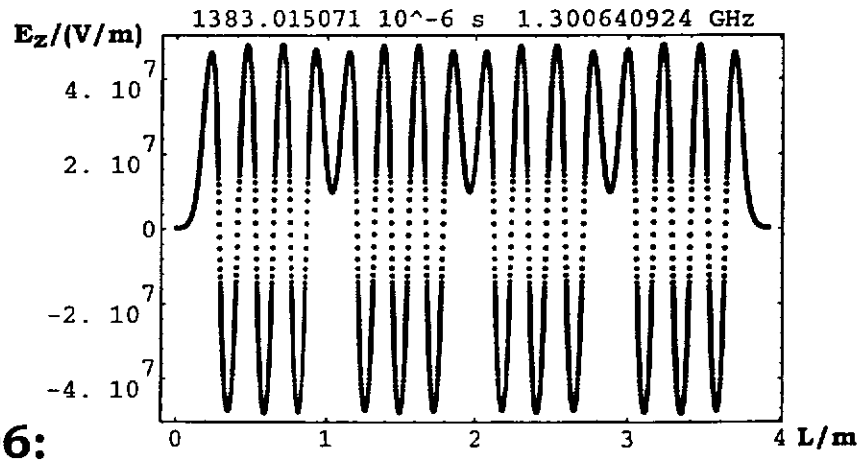
rf-period 100.000:



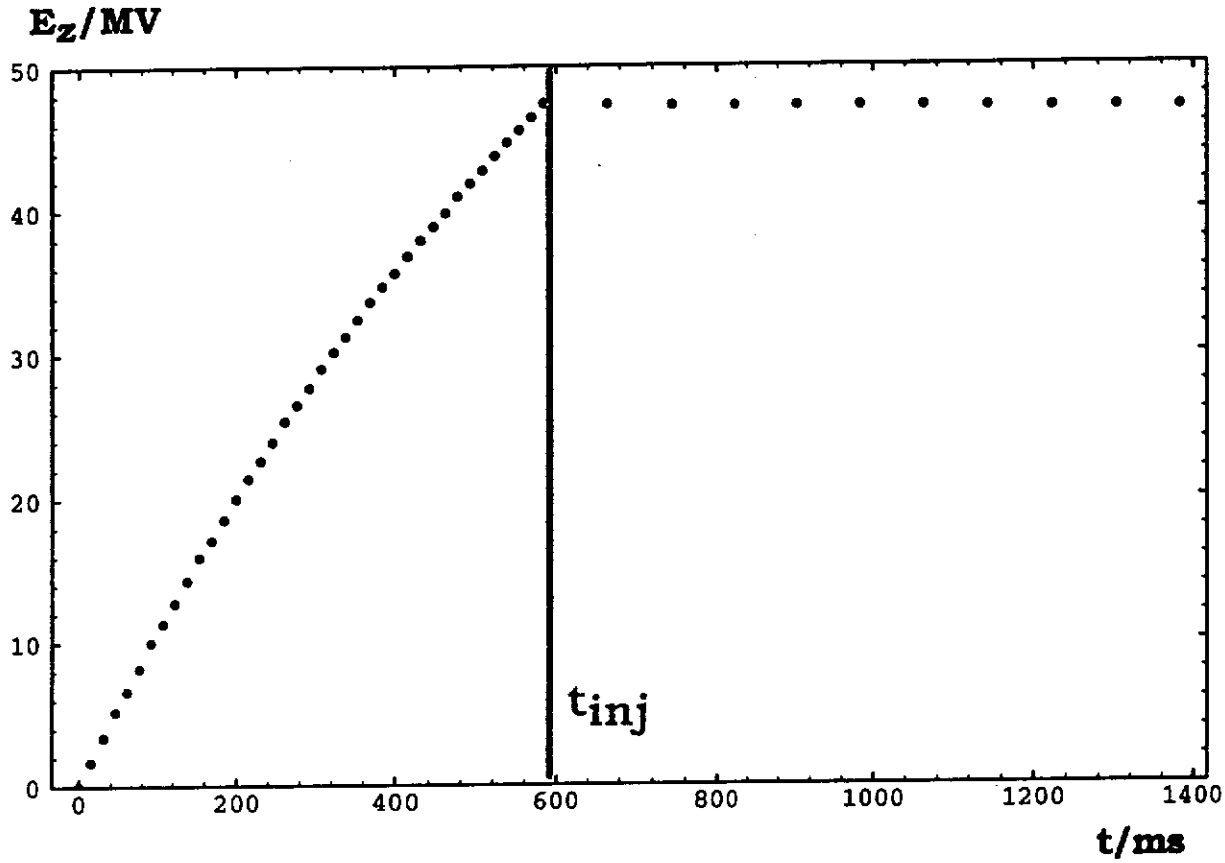
first bunch
rf-period 760.336:



last bunch
rf-period 1.798.806:



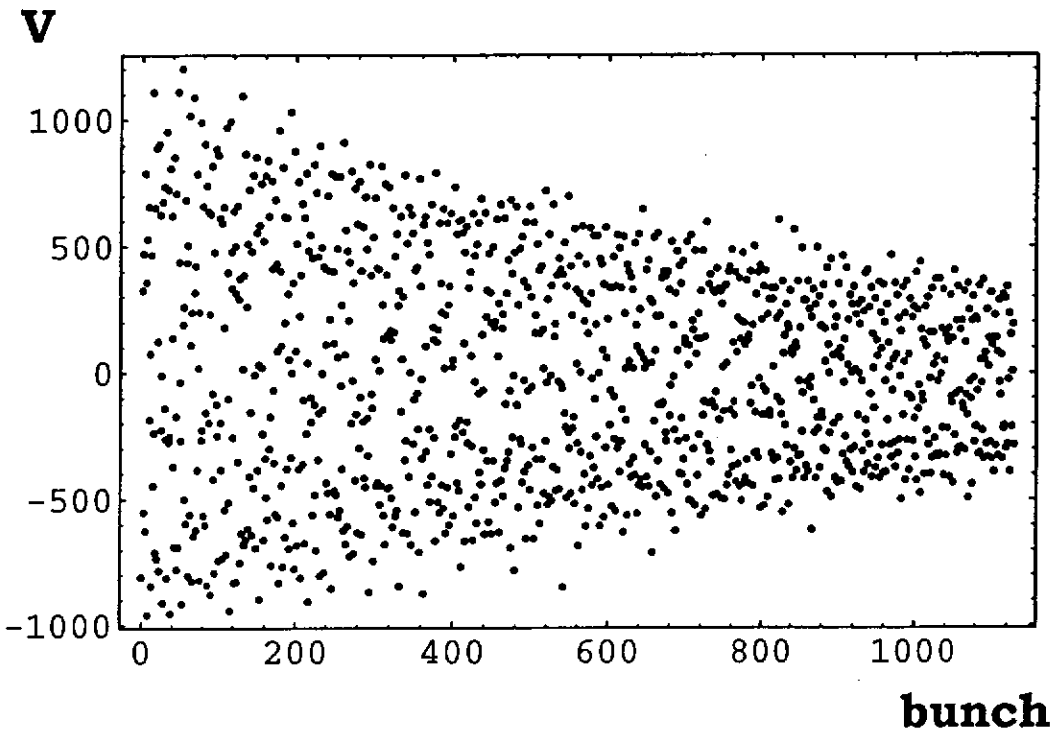
Results 2: Field in Last Cell (28) vs. Time



Field amplitude remains stable - proper refilling even in cell with largest distance to the input coupler.

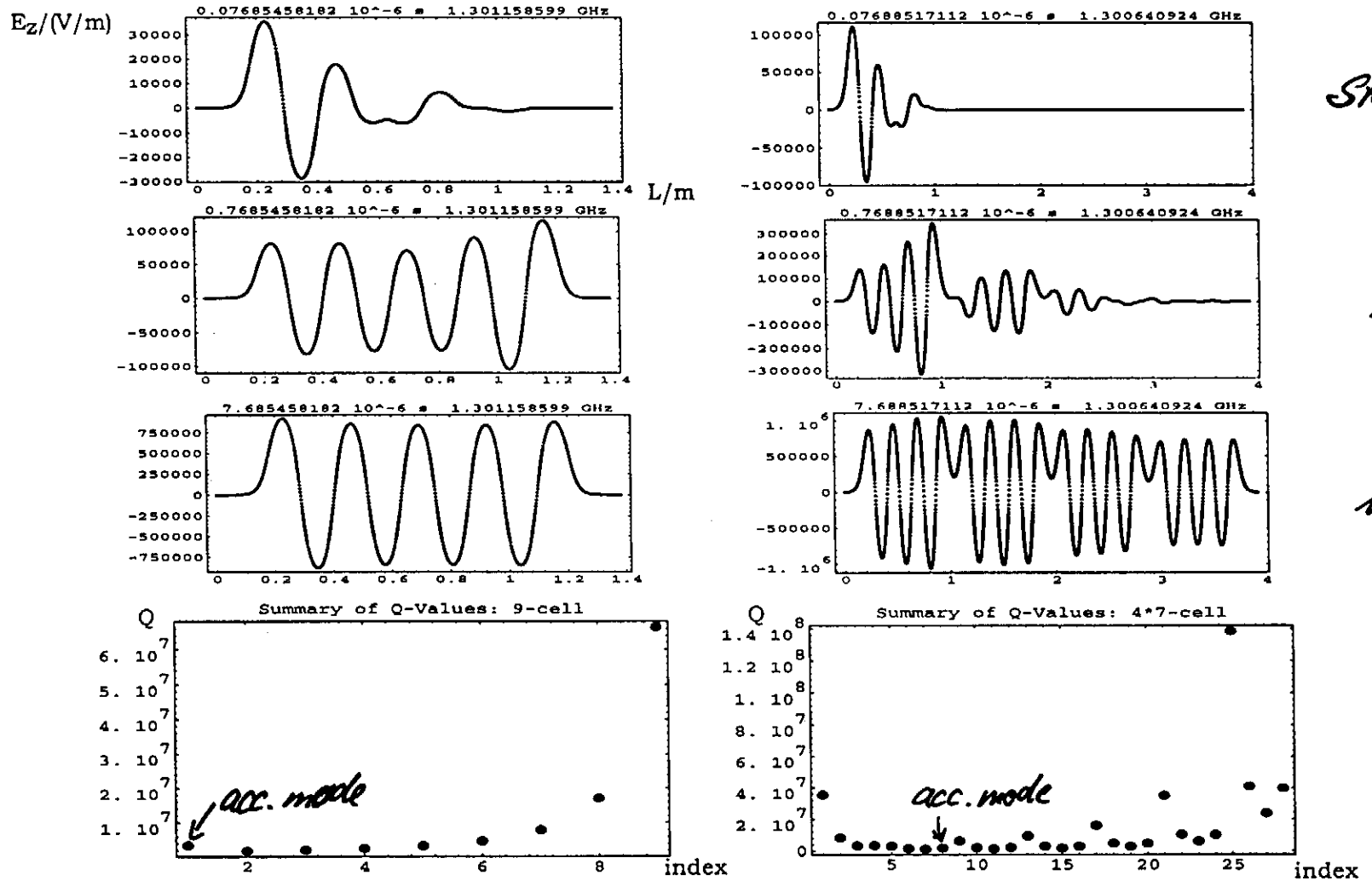
Results 3: Voltage Deviation vs. Bunch No.

(M. Dohlus)



Integrated accelerating voltage scatters ±1000 V around mean value (80.6756 MV) in case of constant bunch charges.

Results 4: Comparison of 9-Cell and 4x7-Cell-Structure



- **Field profiles of 9-cell-structure show faster stabilization, which should be expected.**
- **Highest Q-values of 28-cell about twice as large (Q_{acc} fixed !).**

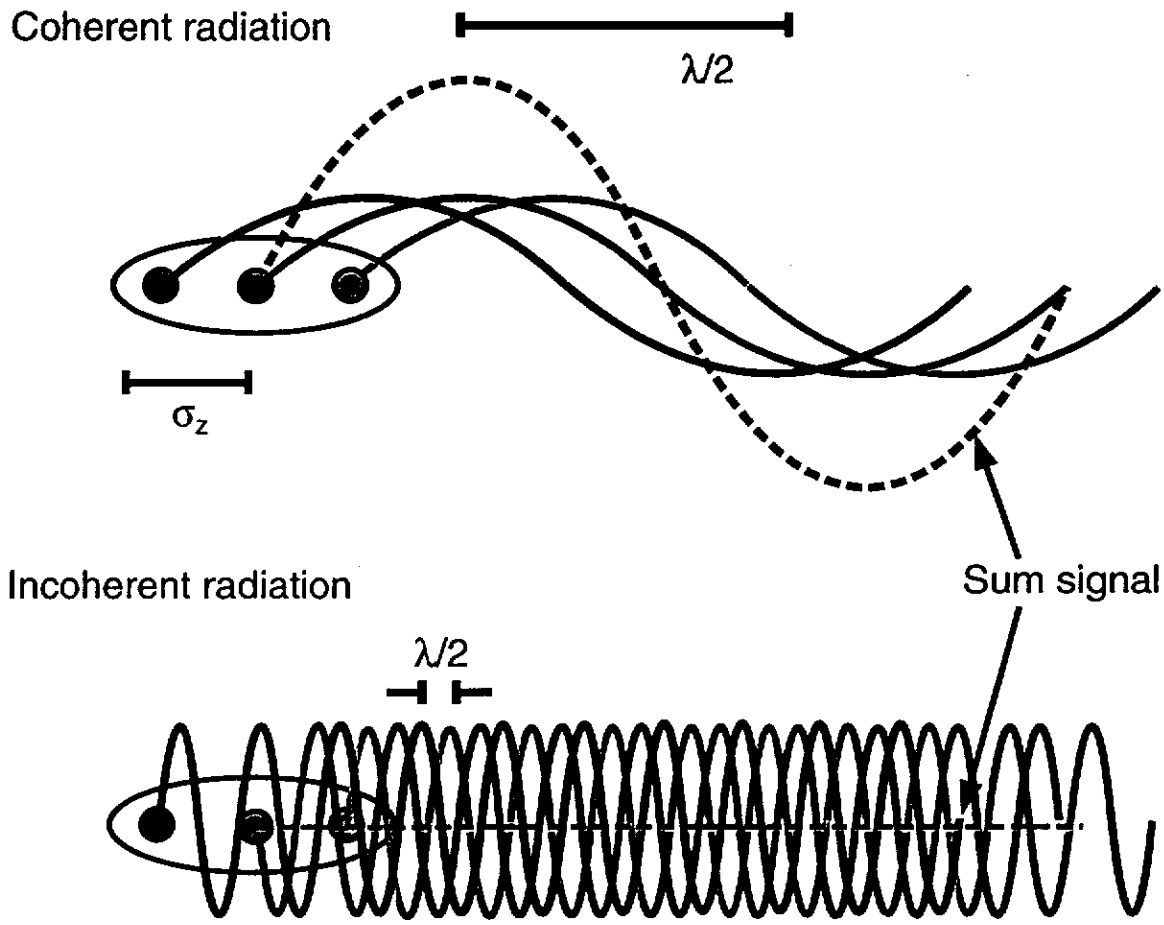
M. Geitz

BUNCH LENGTH MEASUREMENTS USING COHERENT TRANSITION RADIATION

1. INTRODUCTION
2. FOURIER TRANSFORM SPECTROSCOPY USING A MARTIN-PUPLETT INTERFEROMETER
3. HILBERT TRANSFORM SPECTROSCOPY USING A JOSEPHSON JUNCTION

TTF-MEETING, DESY 7/98

Bunch Length Measurement Using Coherent Radiation

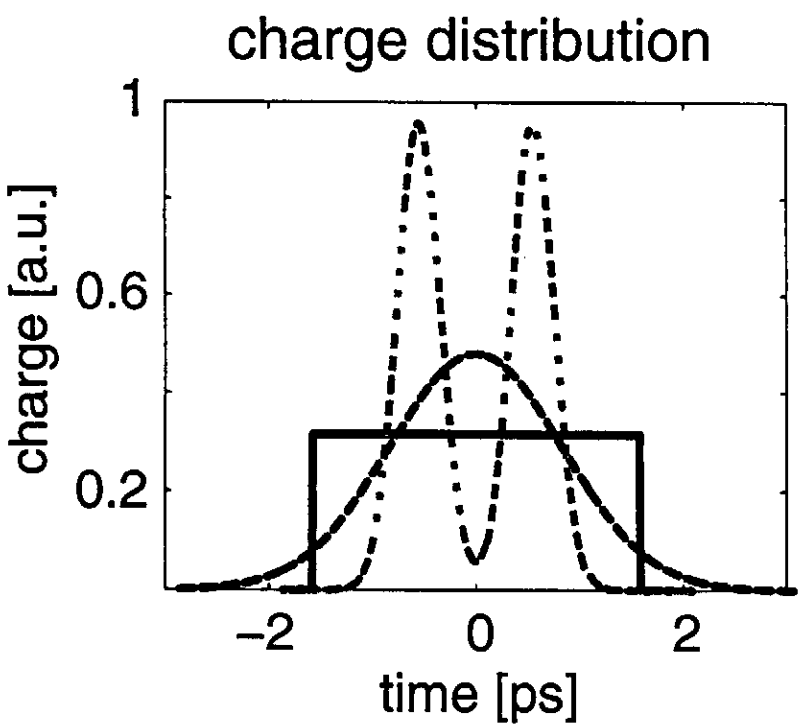


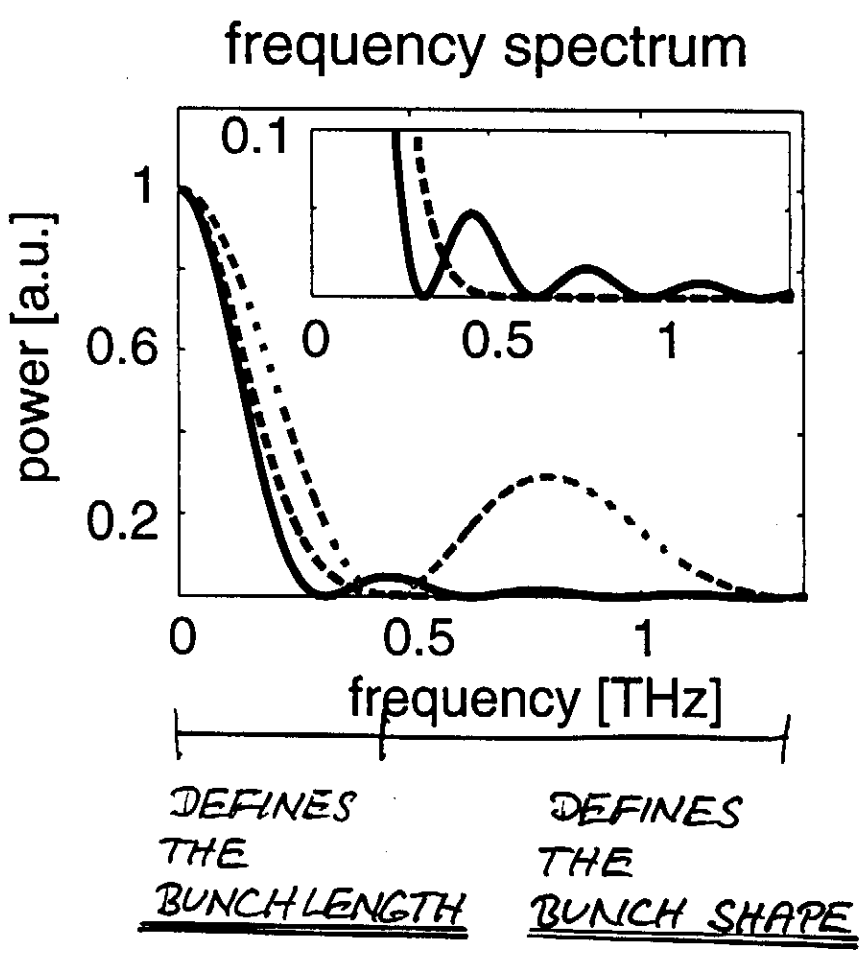
Coherent radiation

$$I_{tot}(\lambda) = I(\lambda)\left\{N + N(N-1)\left|F(\lambda)\right|^2\right\}$$

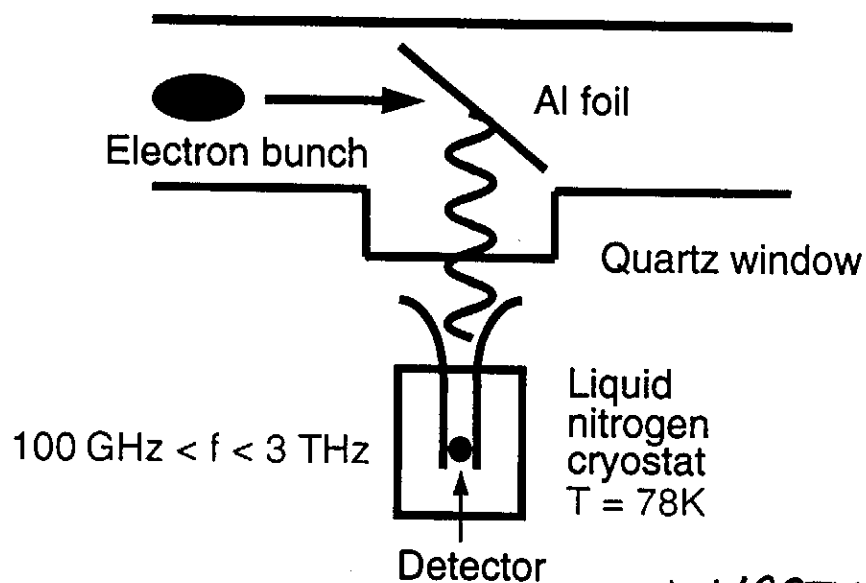
$$F(\lambda) = \int_{-\infty}^{\infty} \rho(z)\exp\left(\frac{2\pi i z}{\lambda}\right)dz$$

⇨ spectrum is proportional to the Fourier transform of the longitudinal charge distribution and the number of particles N^2.


charge distribution
charge [a.u.]
1
0.6
0.2
−2
0
2
time [ps]


frequency spectrum
power [a.u.]
0.1
1
0.6
0.2
0
0.5
1
0
0.5
1
frequency [THz]
DEFINES THE BUNCH LENGTH
DEFINES THE BUNCH SHAPE

Detection of Coherent Radiation



Generation of transition radiation on a thin aluminum foil

The radiation is transmitted onto the detector through a quartz window and a WR-10-type waveguide

÷ MARTIN-PUPLETT INTERFEROMETER

THE MARTIN-PUPLETT INTERFEROMETER

DESIGN AND CONSTRUCTION:

SIEDLING, CH. BERGER } I. PHYS. INST. RWTH AACHEN

M. TONUTTI III PHYS. INST. RWTH AACHEN

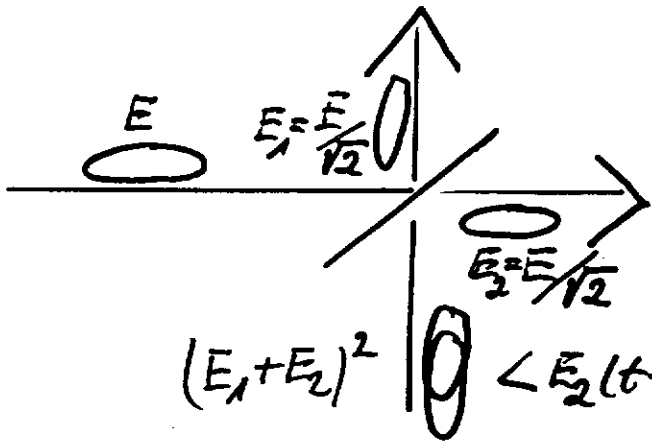
MEASUREMENT AND ANALYSIS:

B. LEISSNER I. PHYSIK. INST RWTH AACHEN

M. GEITZ DESY

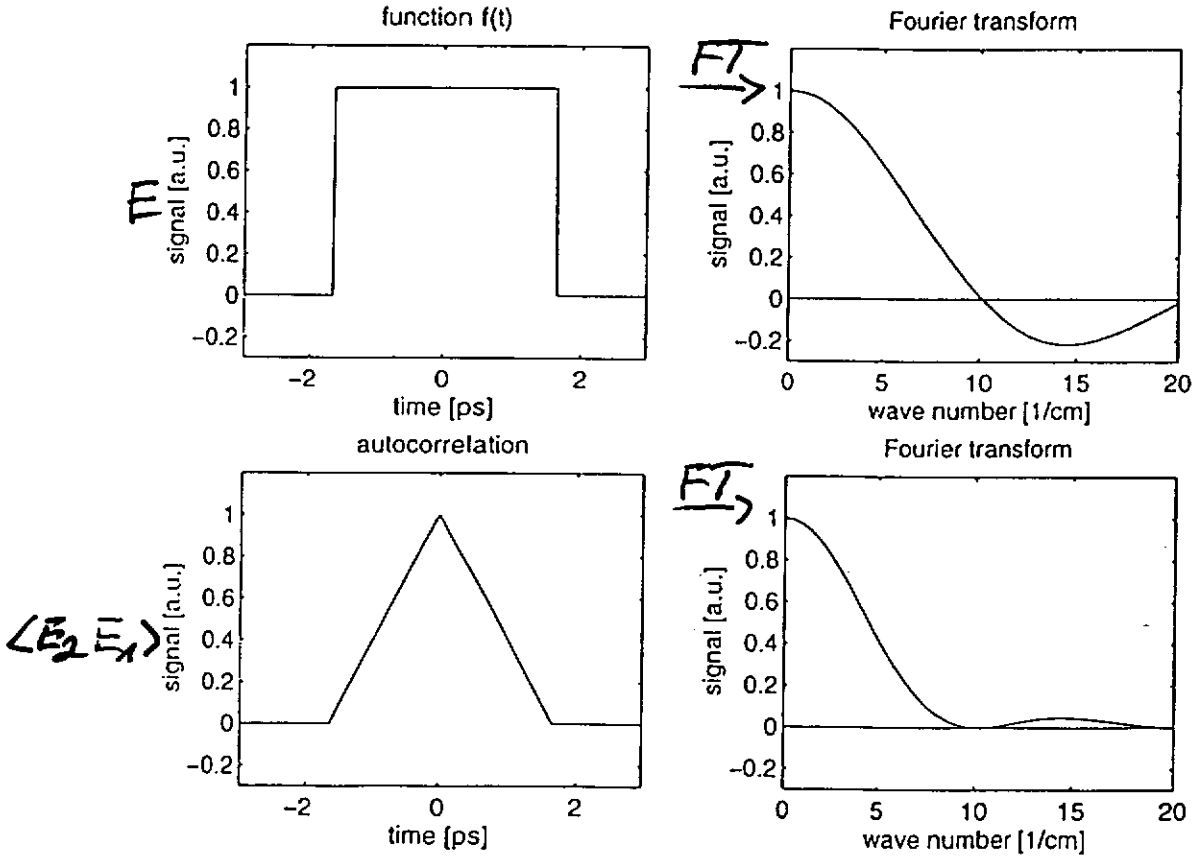
P. SCHMÜSER II. PHYS. INST. UNIV. HAMBURG

PRINCIPLE OF FOURIER TRANSFORM SPECTROSCOPY



"TIME DOMAIN MEASUREMENT"

AUTOCORRELATION FUNCTION



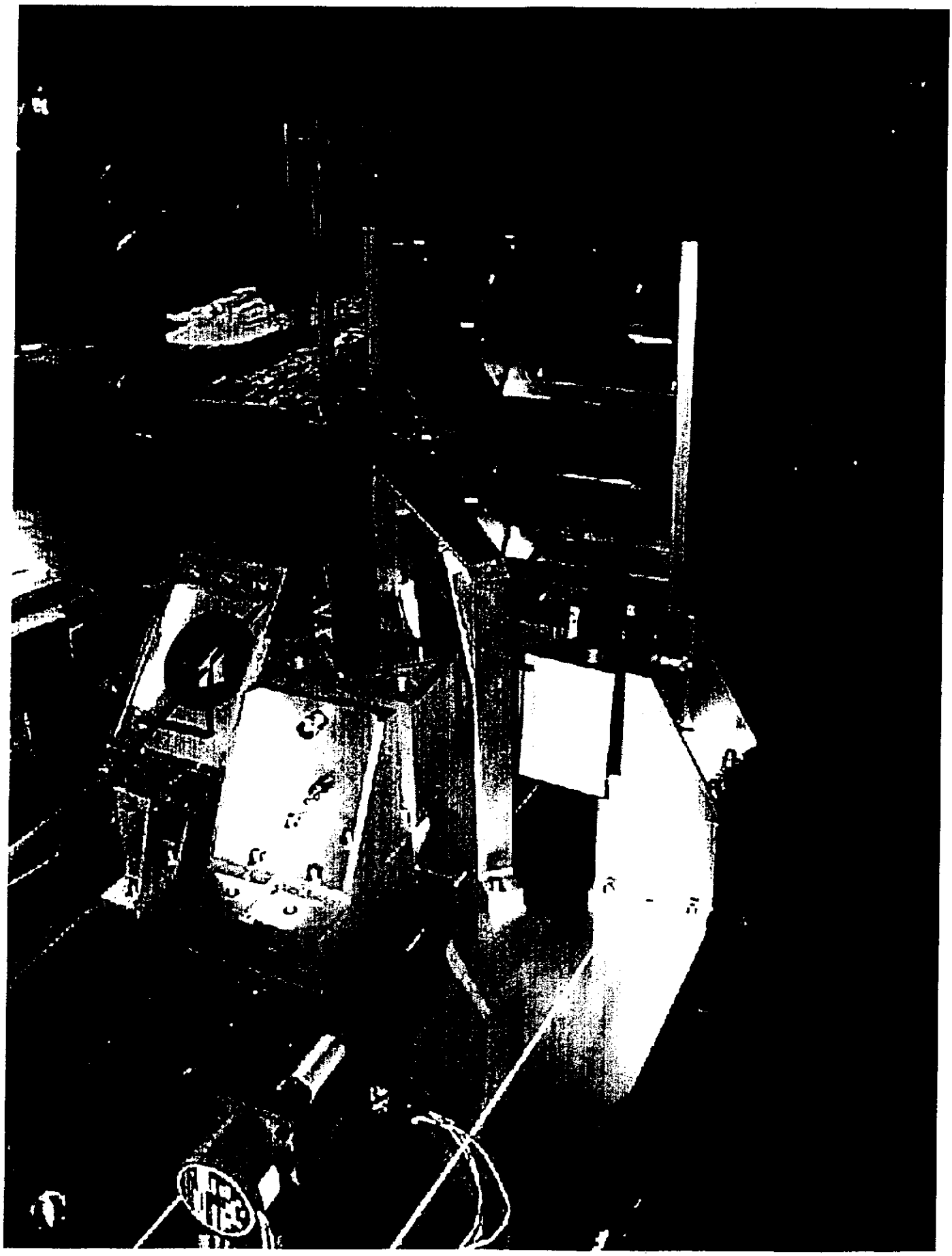
- **NEW SETUP:**

(i) TWO "ANTICORRELATED" DETECTORS

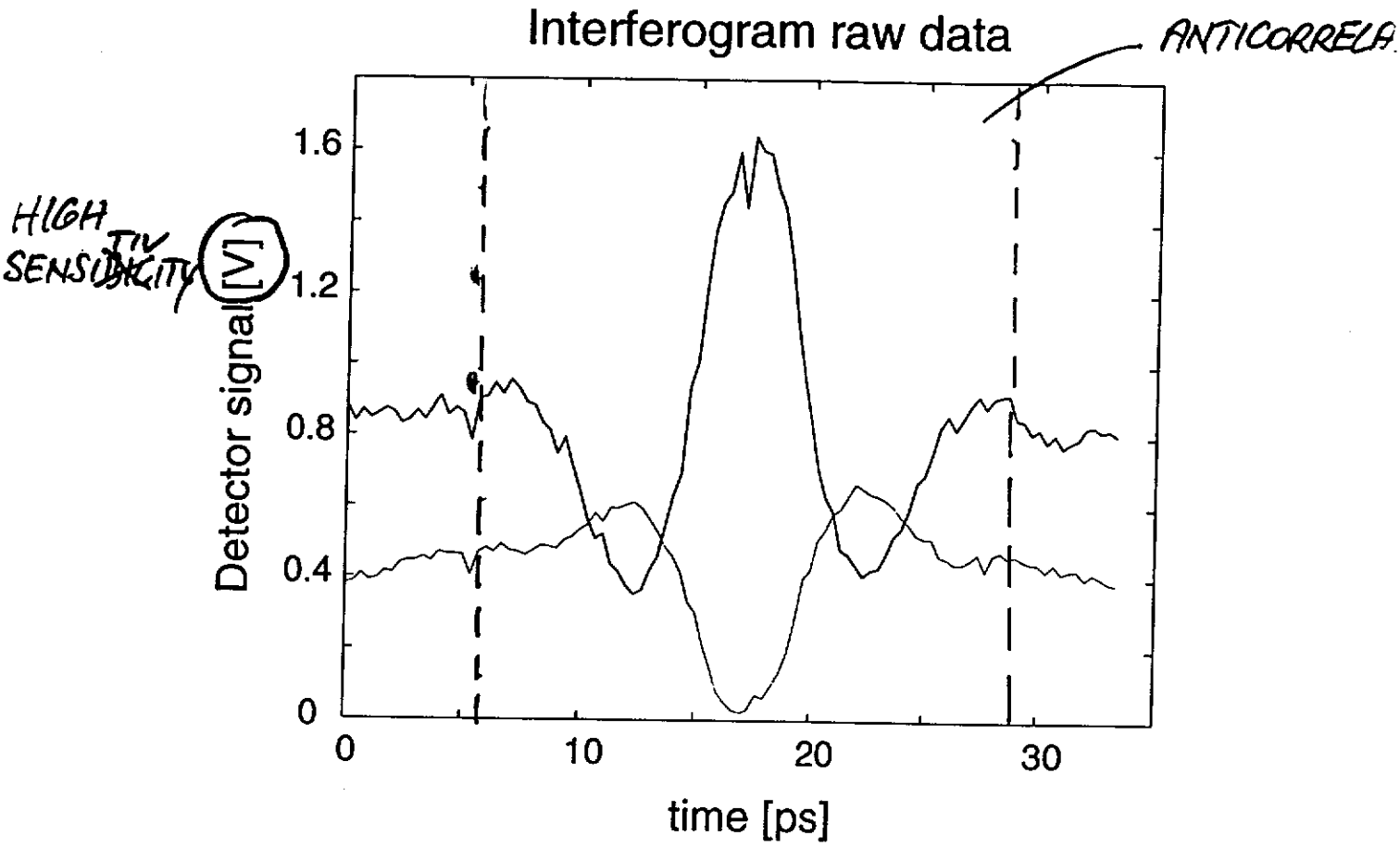
(ii) LARGER APERTURES

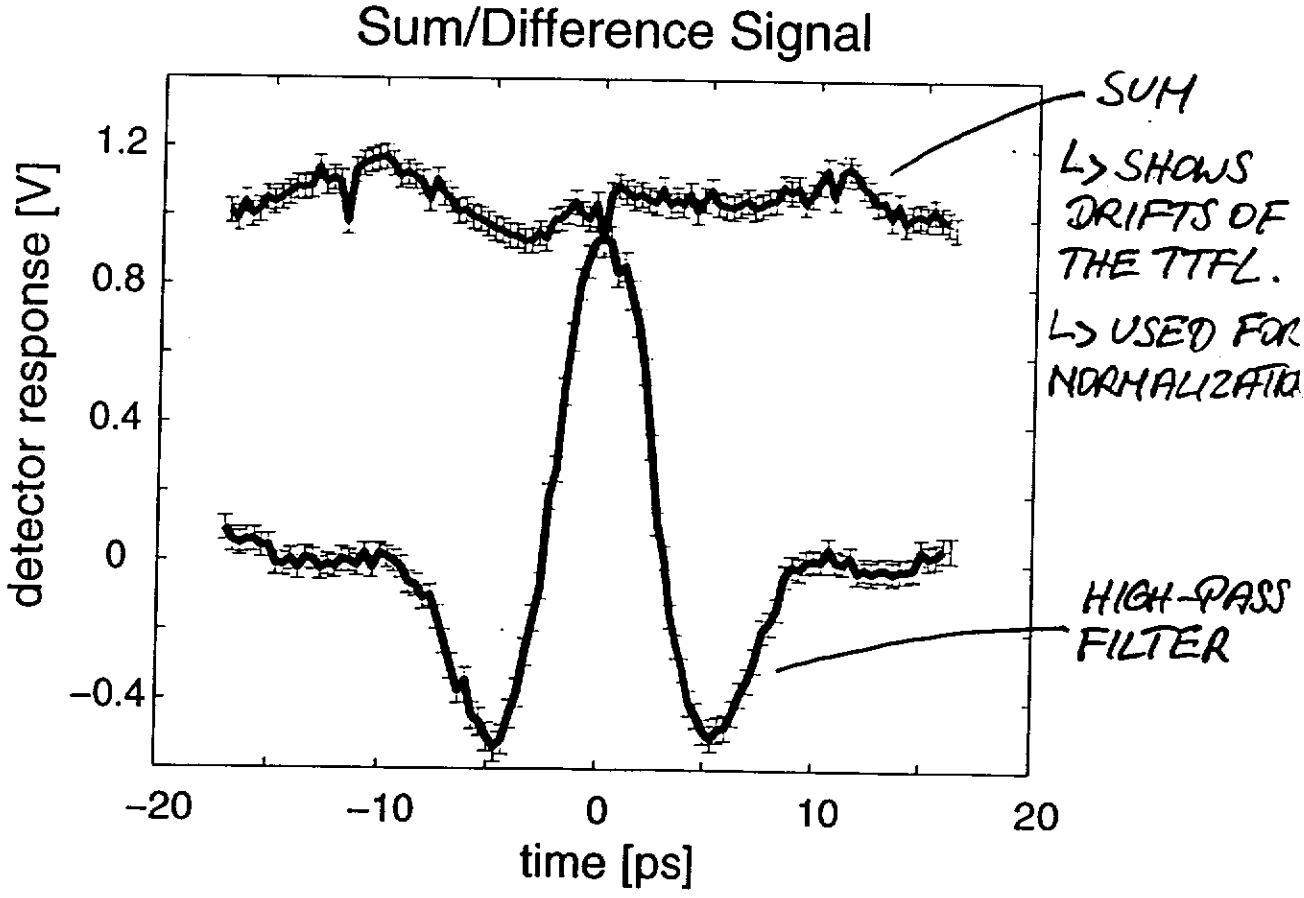
(iii) HIGHER MECHANICAL PRECISION

K. Hanke, Tesla 97-?

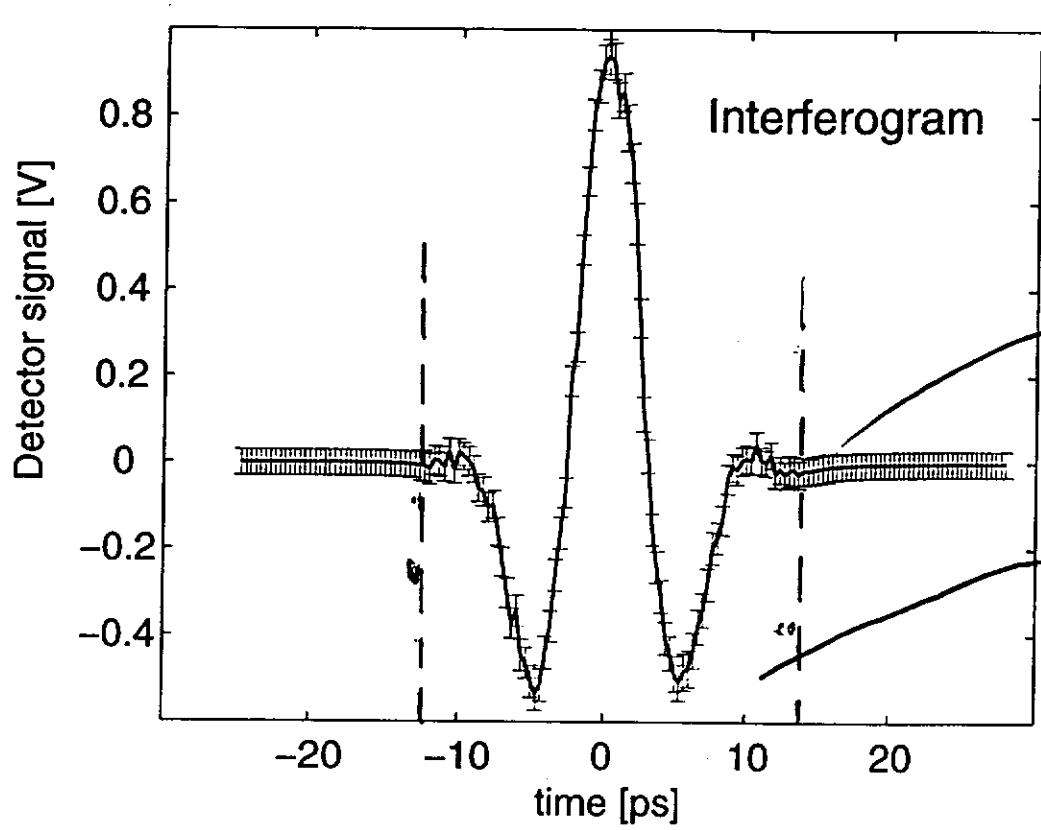


MEASUREMENTS

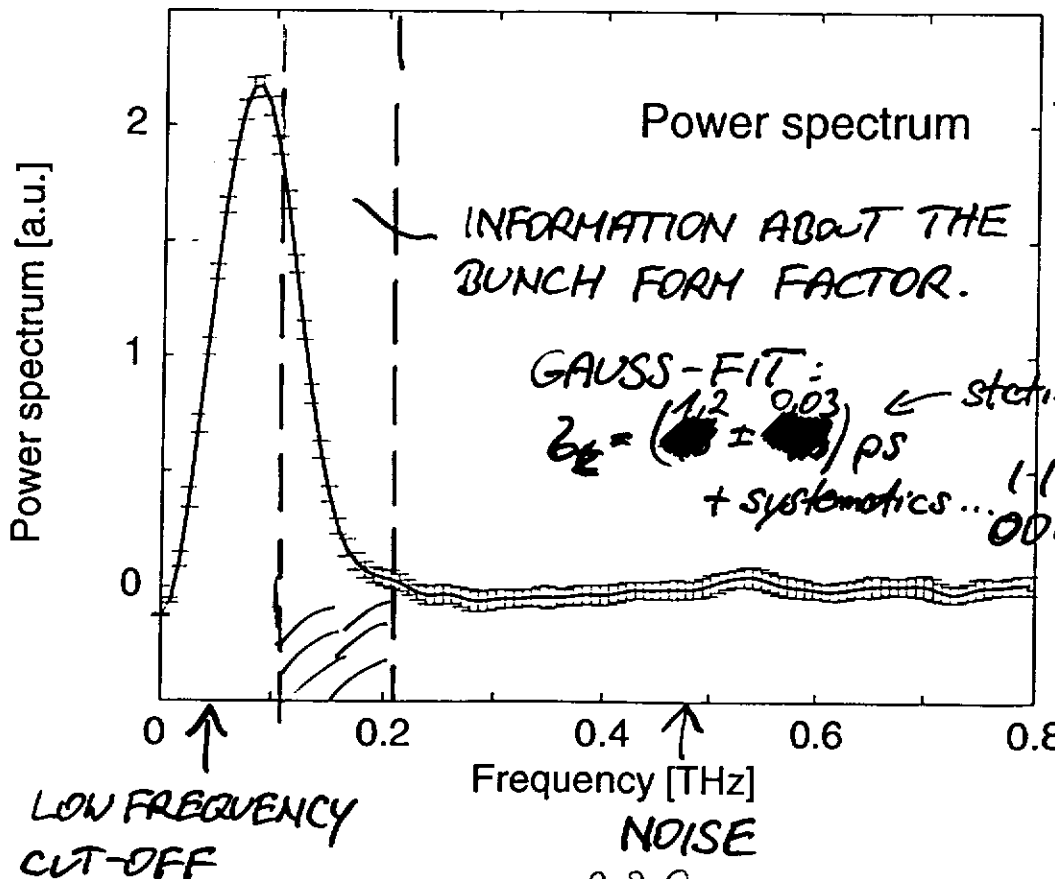




INTERFEROGRAM = $\frac{\text{DIFFERENCE SIGNAL}}{\text{SUM SIGNAL}}$



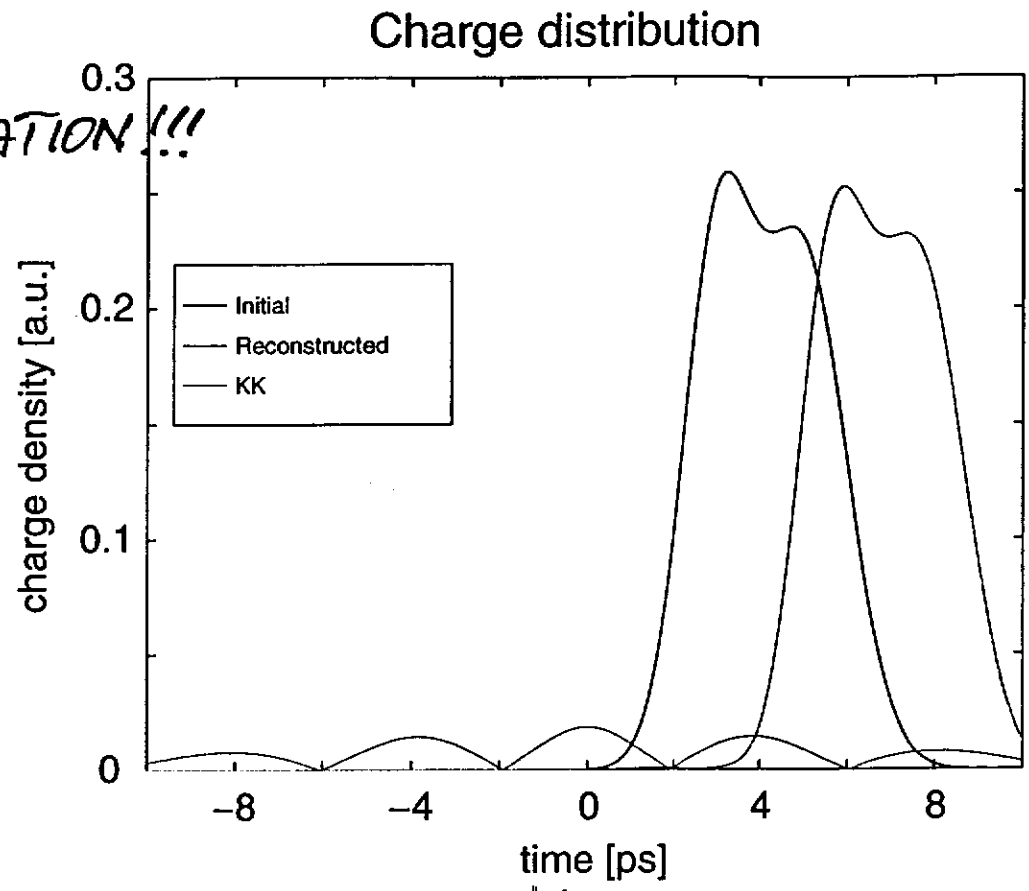
FOURIER TRANSFORM



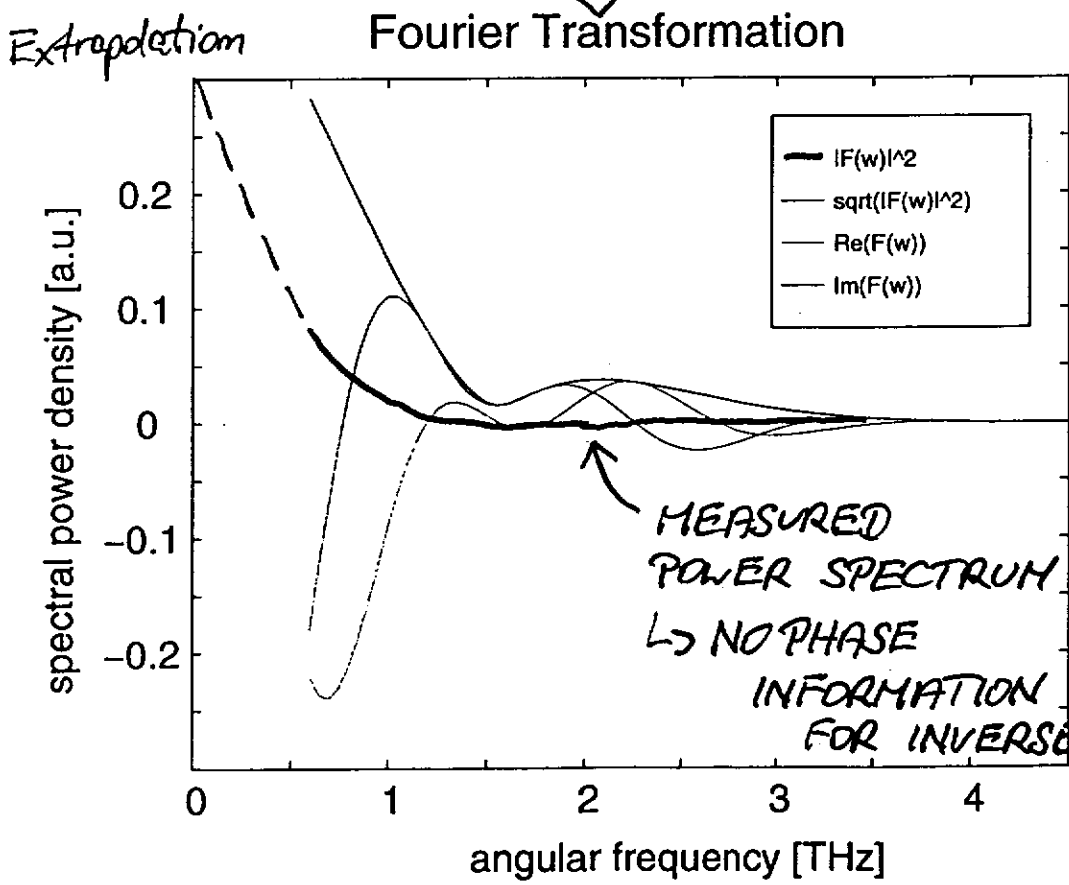
Error bars -> Monte Carlo (upper limit)

111
000

KRAMERS-KRONIG ANALYSIS (SIEVERS, CORNELL)



FOURIER TRANSFORM



MEASURED POWER SPECTRUM
↳ NO PHASE INFORMATION FOR INVERSE TRANSFORM

?? HOW TO OBTAIN THE BEST "GUESS" FOR THE PHASE INFORMATION ??

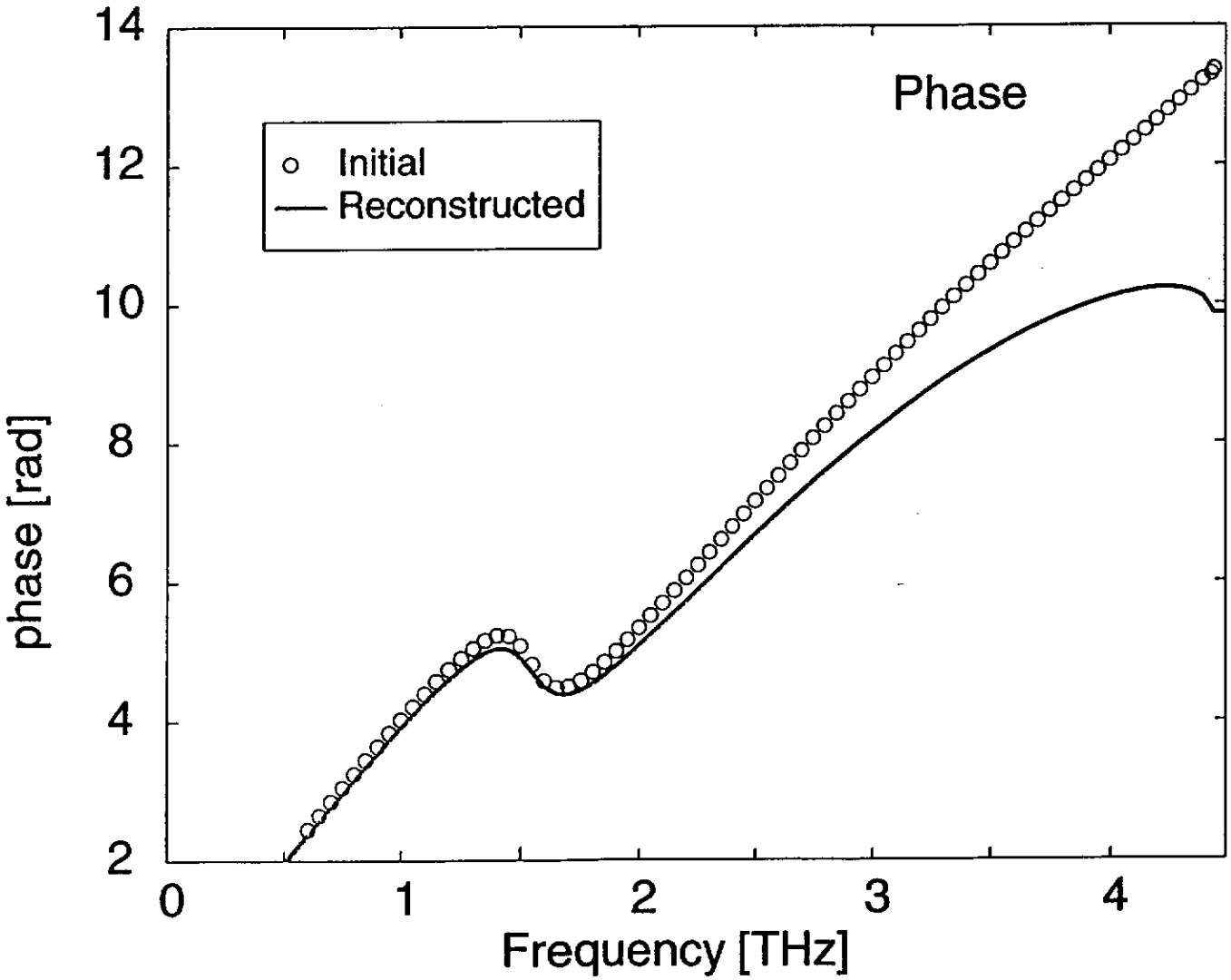
USE "KRAMERS-KRONIG" DISPERSION INTEGRAL:

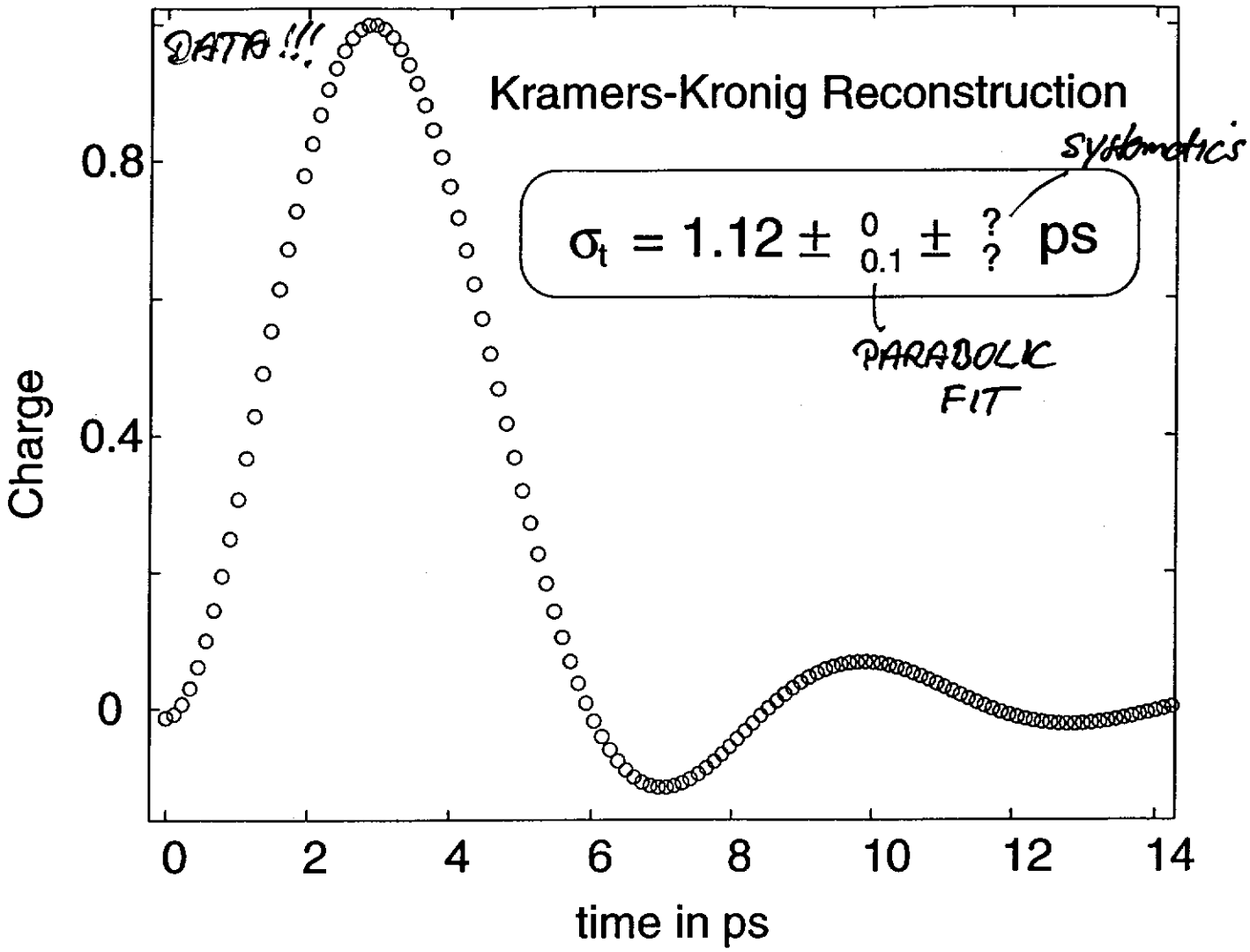
$$\varphi(\omega_0) = -\frac{2\omega_0}{\pi} P \int_0^\infty \frac{\ln\left(\bar{P}(\omega)/\bar{P}(\omega_0)\right)}{\omega_0^2 - \omega^2}\, d\omega$$

PRINCIPAL VALUE INTEGRAL

$$\Rightarrow \quad S(t) = \frac{1}{\pi}\int_0^\infty f(\omega)\cos(\omega t - \varphi(\omega))\, d\omega$$

S(t): CHARGE DISTRIBUTION; f(ω): FORM FACTOR; φ(ω): KK PHASE





KRAMERS-KRONIG RECONSTRUCTION

(i) Extrapolation to small frequencies:

PARABOLIC FIT → TAYLOR EXPANSION OF THE FORM FACTOR

(ii) Extrapolation to large frequencies:

$R\omega \sim \omega^{-\alpha}$, $\alpha > 0$. → VANISHING CONTRIBUTION OF THE DISPERSION INTEGRAL IN THE COMPLEX PLAIN AT $Im \neq 0$. (Cantar)

EVALUATION OF SYSTEMATIC ERRORS

(i) WAVELENGTH - DEPENDENT ACCEPTANCE OF THE INTERFEROMETER

- FINITE SIZE OF THE OTR SCREEN
- FRESNEL DIFFRACTION
- FINITE DETECTOR OPENING

↳ LOSSES AT LONG WAVELENGTH

↳ BUNCHES LONGER IN REALITY !!

(ii) SPECTRAL ACCEPTANCE OF THE PYROELECTRIC DETECTORS AT $f < 300\,GHz$.

THE HILBERT TRANSFORM SPECTROMETER

1. COLLABORATION

Y. DIVIN, U. POPPE } IFF, FZ JÜLICH

2. COLLABORATION

M. SCHILLING, F. LUDWIG } MIKROSTRUKTURZENTRUM UNIV. HAMBURG

M. GEITZ — DESY

J. MENZEL — III. PHYS. INST. RWTH AACHEN

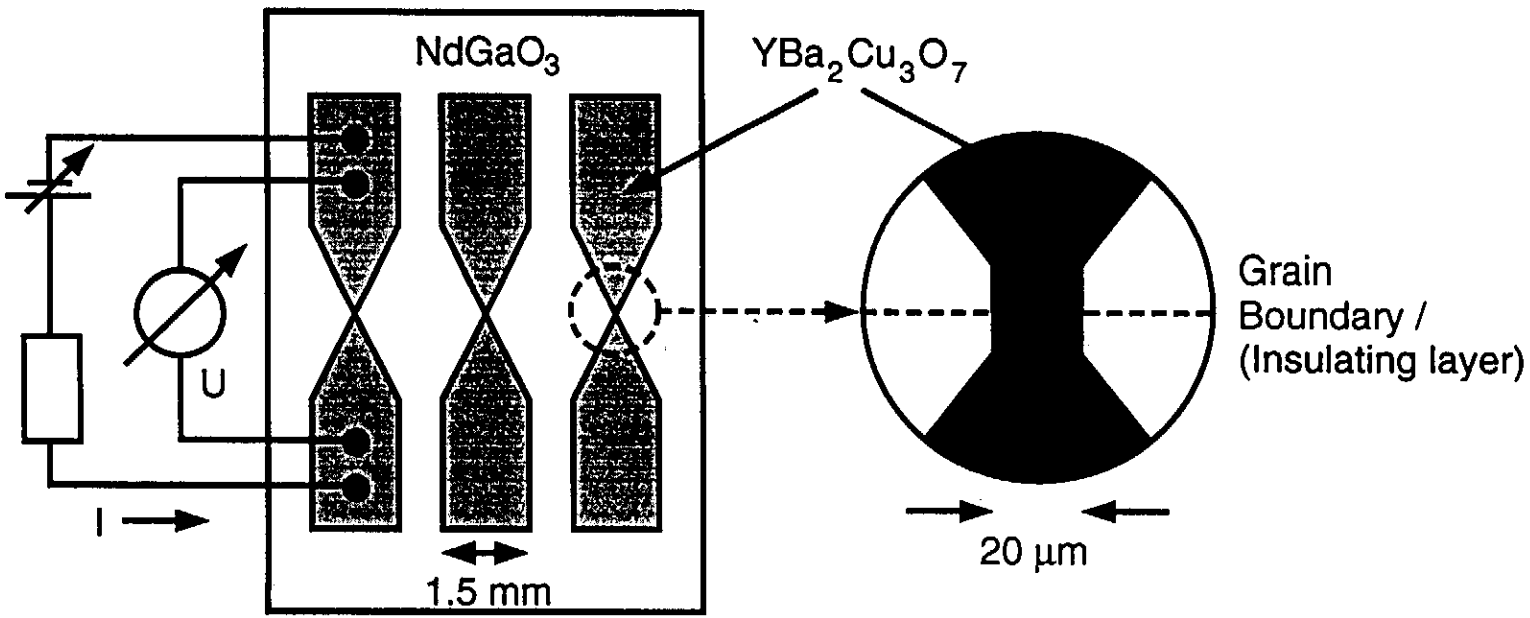
S. SIMROCK — DESY

P. SCHMÜSER — II. PHYS. INST. RWTH AACHEN

M. TONUTTI — III PHYS. INST RWTH AACHEN

- MOTIVATION: HIGH SPEED SPECTROSCOPY

The Josephson Junction [5]



○ Josephson equations

$$I = I_c \sin(\varphi(t))$$

$$\frac{d\varphi(t)}{dt} = \frac{2e}{\hbar} U(t)$$

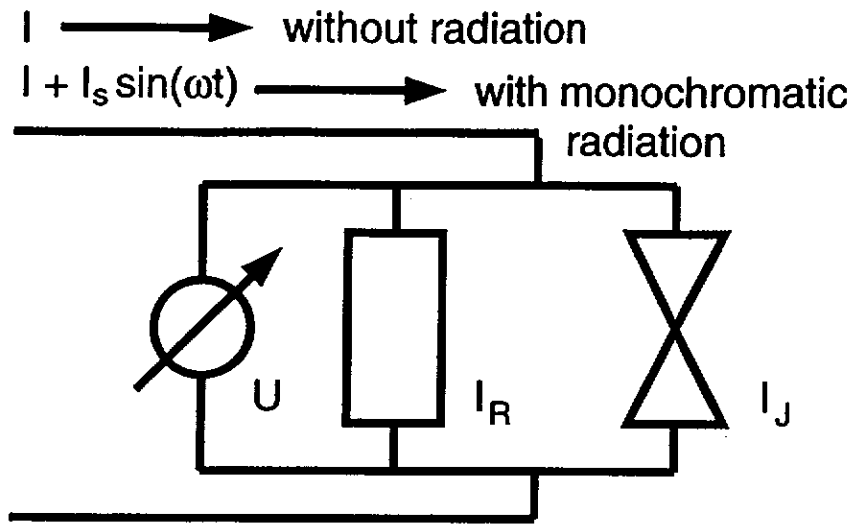
⇨ U(t) is the voltage drop, I is the current flowing } across the junction

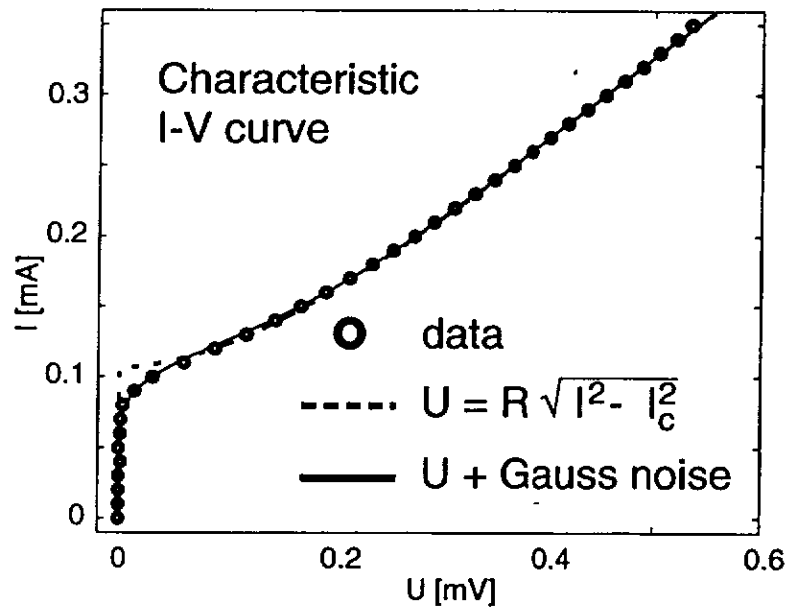
⇨ φ(t) is the phase difference of the Cooper-pair wave functions on both sides of the junction

⇨ I_c is the critical current

Current-Voltage Characteristic of a Josephson Junction

"Resistively Shunted Junction" (RSJ) Model:



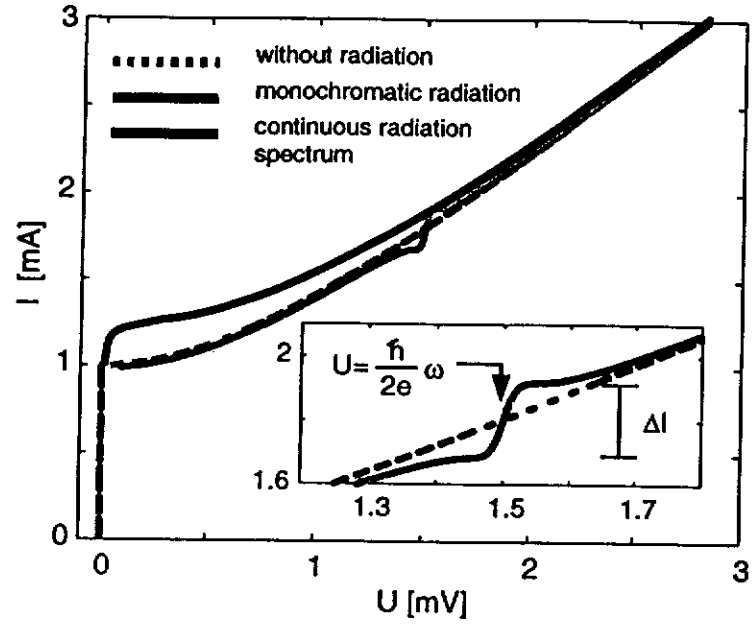


⇨ DC Josephson effect:
Direct current with U = 0

⇨ AC Josephson effect:
Alternating current with $U \neq 0$
Frequency of Josephson oscillation

$$\omega_0 = \frac{2e}{\hbar} U \quad \Leftrightarrow \quad 484\ \text{GHz} \cong 1\ \text{mV}$$

Modification due to incident radiation



⇨ RSJ Model prediction: [7]

$$\Delta I = -\frac{1}{4I}\left(\frac{2eRI_c}{\hbar}\right)^2 \frac{I_s^2}{\omega - \omega_0}$$

→ Current step ΔI at $\omega = \omega_0 = \frac{2e}{\hbar}U$

→ frequency-selective device

→ ΔI proportional to incident radiation power

→ quadratic detector

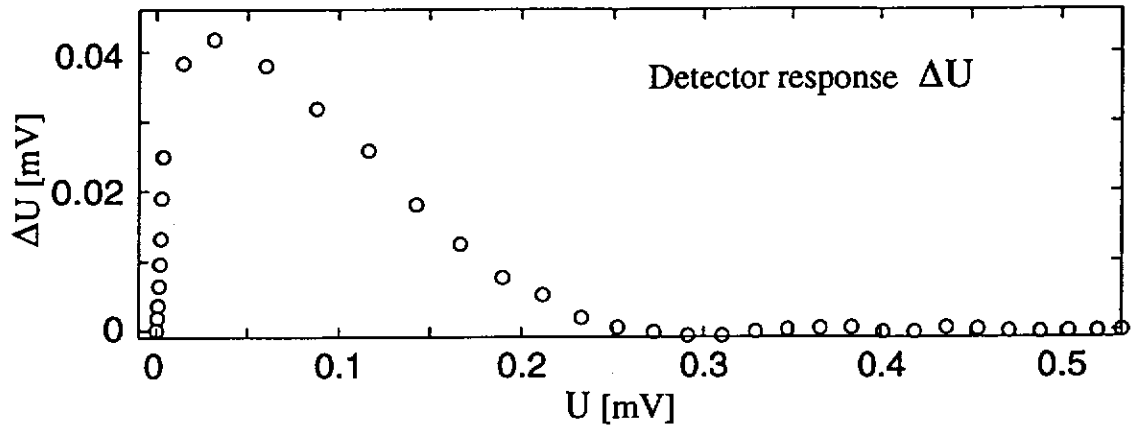
$$\Delta I = -\frac{1}{8I\omega_0}\left(\frac{2eRI_c}{\hbar}\right)^2 \wp \int \frac{S(\omega)\, d\omega}{\omega - \omega_0}$$

⇨ Continuous radiation spectrum $S(\omega)$

→ continuous I-U modification [7]

The principal value integral
→ Hilbert transformation

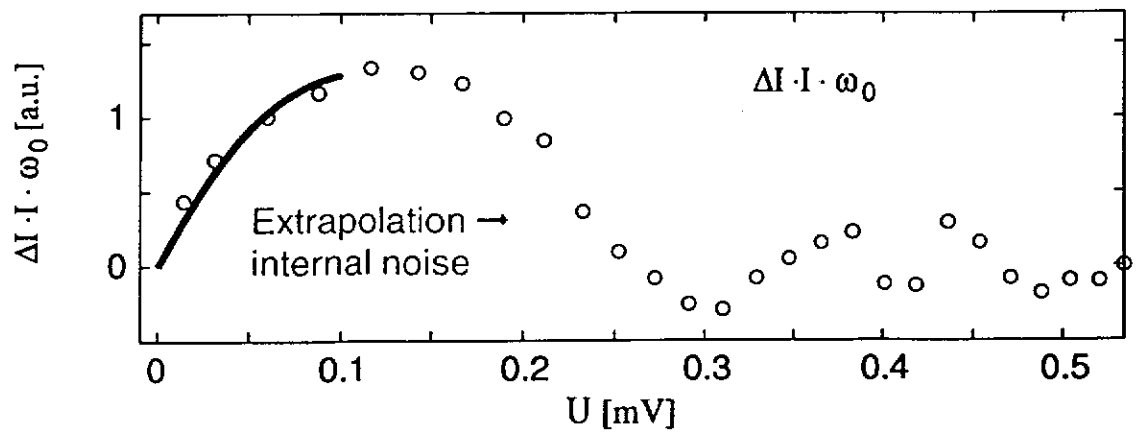
- Scan I-U curve with and without incident radiation.



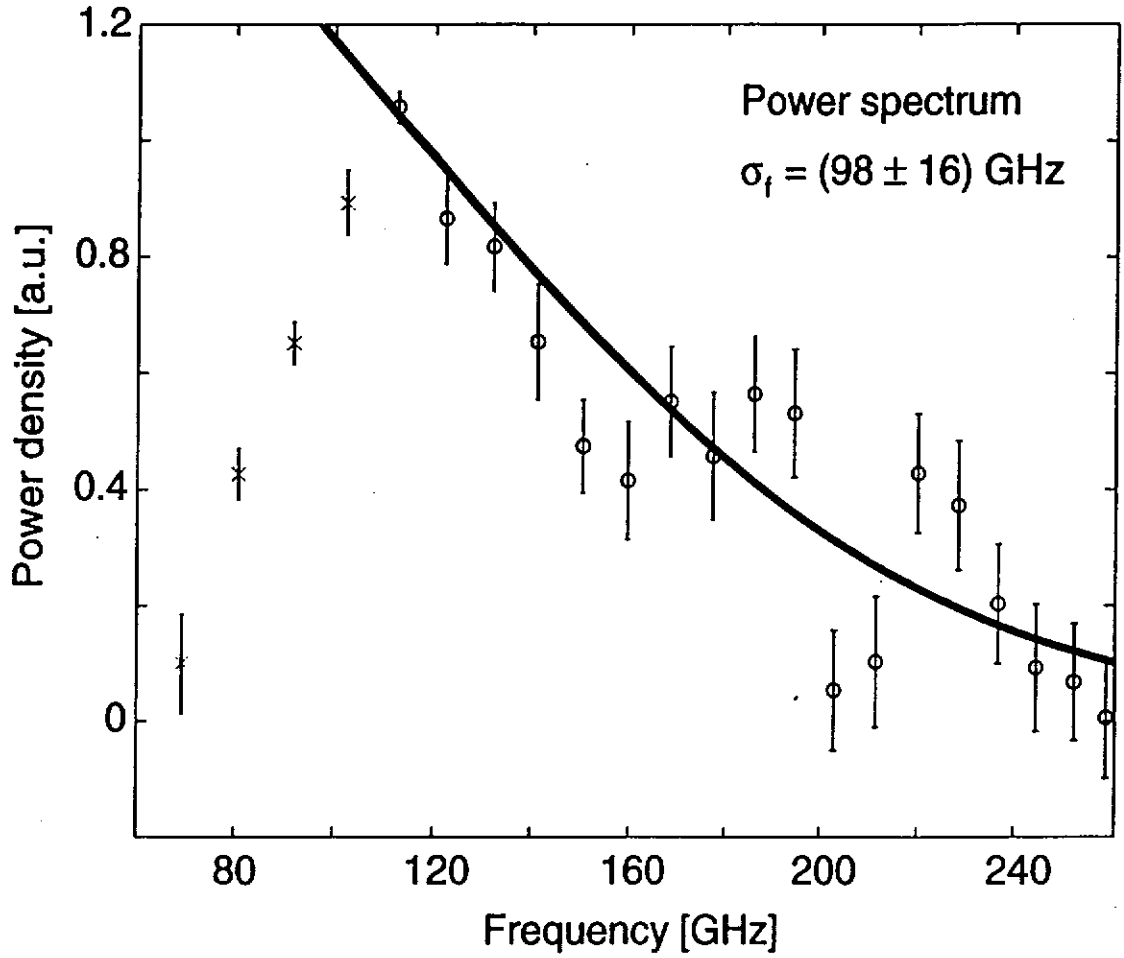
- ΔI is calculated from ΔU via the differential resistance dU/dI of the unperturbed I-U curve

- Multiply ΔI with U and I of the unperturbed I-U curve
  → Radiation spectrum:

$$S(\omega) = \frac{8}{\pi}\left(\frac{\hbar}{2eRI_c}\right)^2 \wp \int \frac{\Delta I \, I \, \omega_0 \, d\omega_0}{\omega - \omega_0}$$



○ Power spectrum



⇒ Decrease below 100 GHz:

Low frequency cut-off
(WR-10-type waveguide)

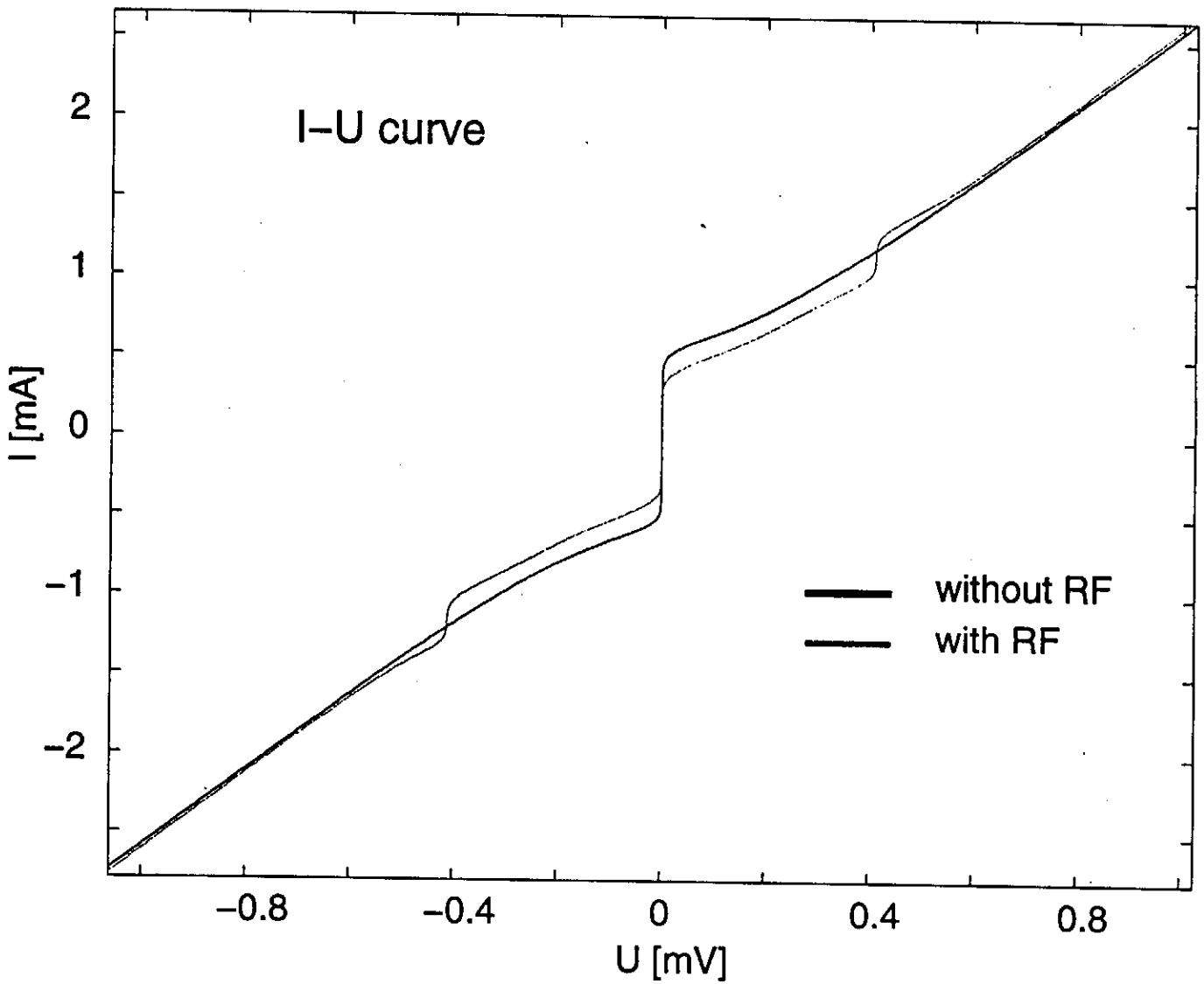
⇨ Error evaluation:

- ○ Wavelength dependent acceptance of the transmission line
- ○ Point-to-point error dominated by ΔU

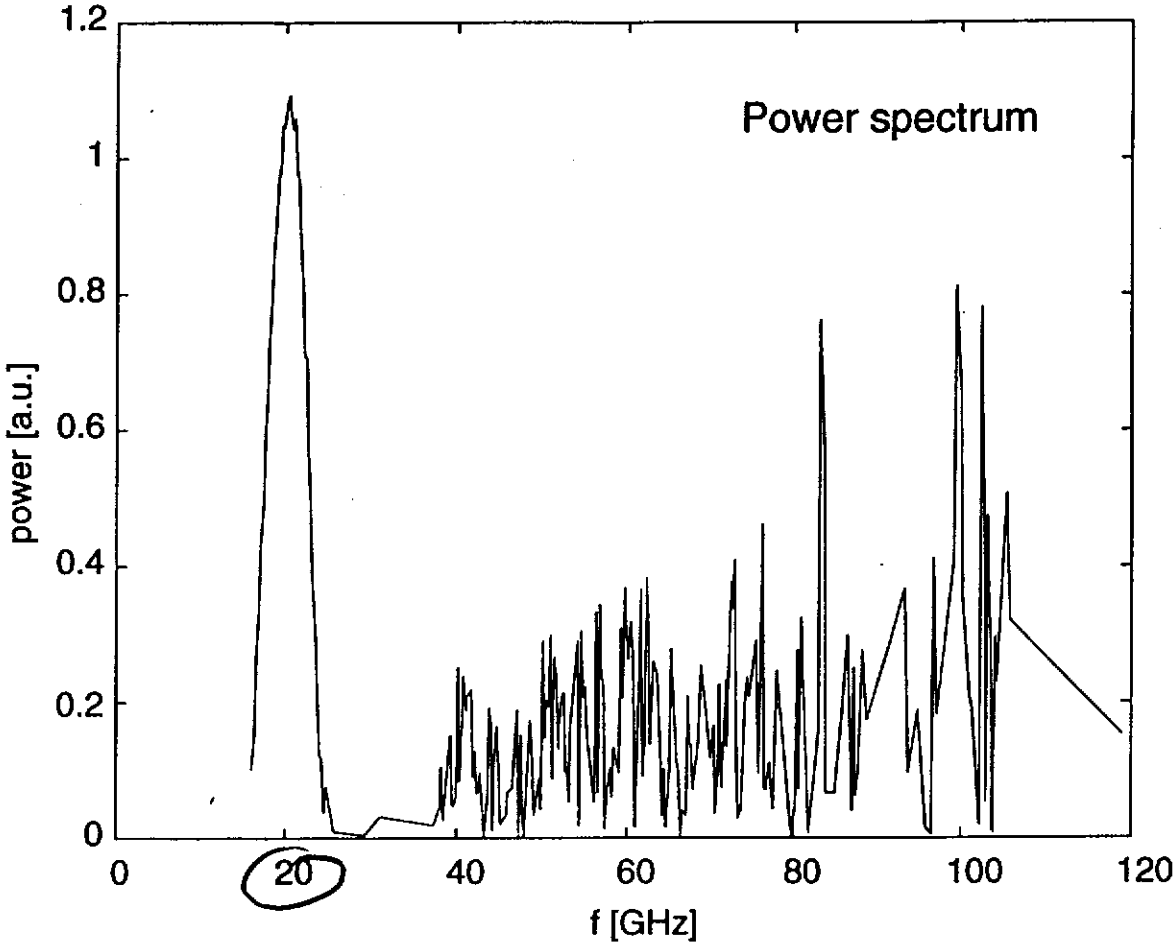
⇒ $\sigma_f = (98 \pm 16)$ GHz ⇨ $\sigma_t = \frac{1}{2\pi\sqrt{2}\sigma_f} = (1.2 \pm 0.2)$ ps

DEVELOPMENT OF A NEW JOSEPHSON JUNCTION DETECTOR

Test measurement with a 20 GHz source



252


Power spectrum
power [a.u.]
f [GHz]
0
0.2
0.4
0.6
0.8
1
1.2
0
20
40
60
80
100
120

CONCLUSION

- MARTIN-PUPLETT INTERFEROMETER
  - SUCCESSFUL INTERFEROMETER SCANS PERFORMED
  - ANALYSIS ✓
  - → BETTER UNDERSTANDING OF THE SYSTEMATIC ERRORS NEEDED

- JOSEPHSON JUNCTION
  - SUCCESSFUL "TEST MEASUREMENT"
  - → WORK ON 2 DIFFERENT SETUPS IN PROGRESS
  - ANALYSIS ✓
  - WE PROFIT FROM ERROR ANALYSIS OF THE M-P INTERFEROMETER

Plans for further cavity R&D

Peter Schmüser

Two main motivations:

(1) Achieve gradients well above 25 MV/m

(2) Simplification and cost reduction of cavity production

R&D associated with 9-cell program

- quality control of niobium sheets (W. Singer, A. Brinkmann ...)
- reduction of field emission (G. Müller, D. Reschke ...)
- miscroscopic investigations of niobium surface (F. Herrmann, D. Reschke, L. Lilje ...)
- avoid contamination during assembly (A. Matheisen, D. Reschke ...)

R & D on special cavities (1-cells..)

- cavities made by spinning (Palmieri)
- cavities made by hydroforming (Kaiser et al.)
- cavities with electropolished surface
  (CERN: Bloess, Chiaveri, Benvenuti...
  " L. Lilje..)
- cavities from high RRR Nb
  (Cornell; DESY: material ordered)

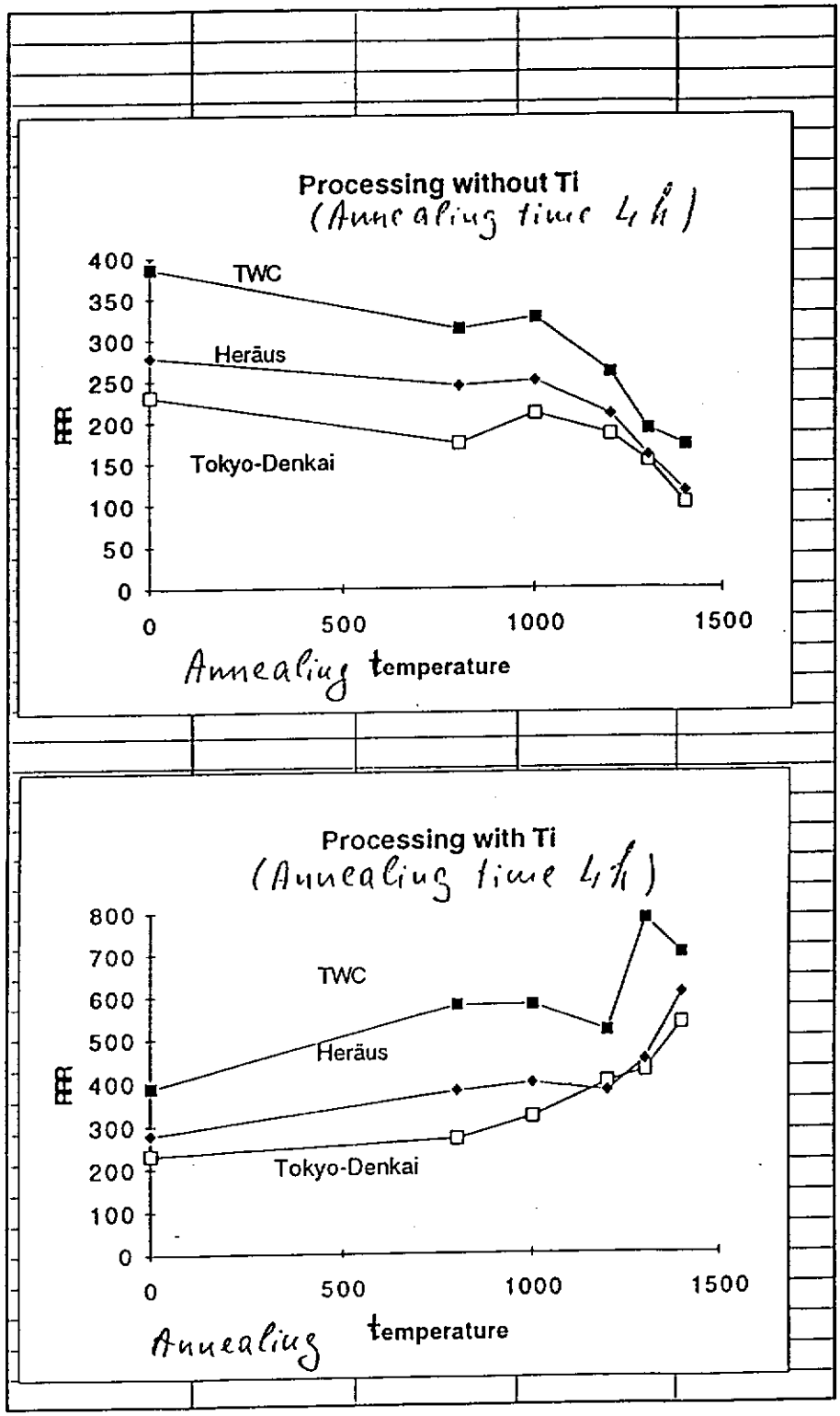
For special cavities: extra facilities needed for preparation and test

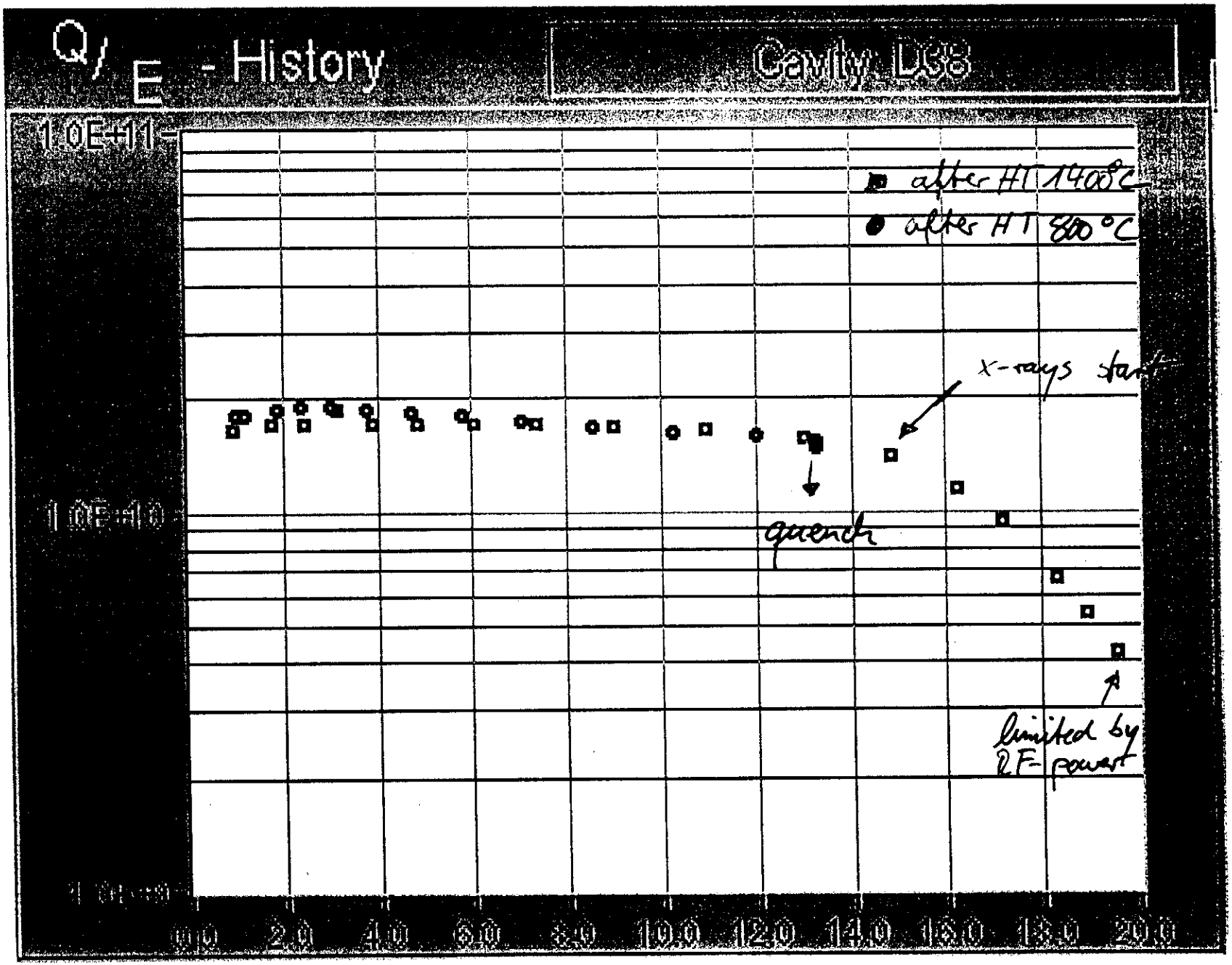
- HERA cavity clean room
  needed: UHV pump station
  high pressure water rinsing
- Biologische Anstalt Helgoland
  electron beam welding machine
- Tests at Cornell University

There is a shortage in manpower

R&D Issues

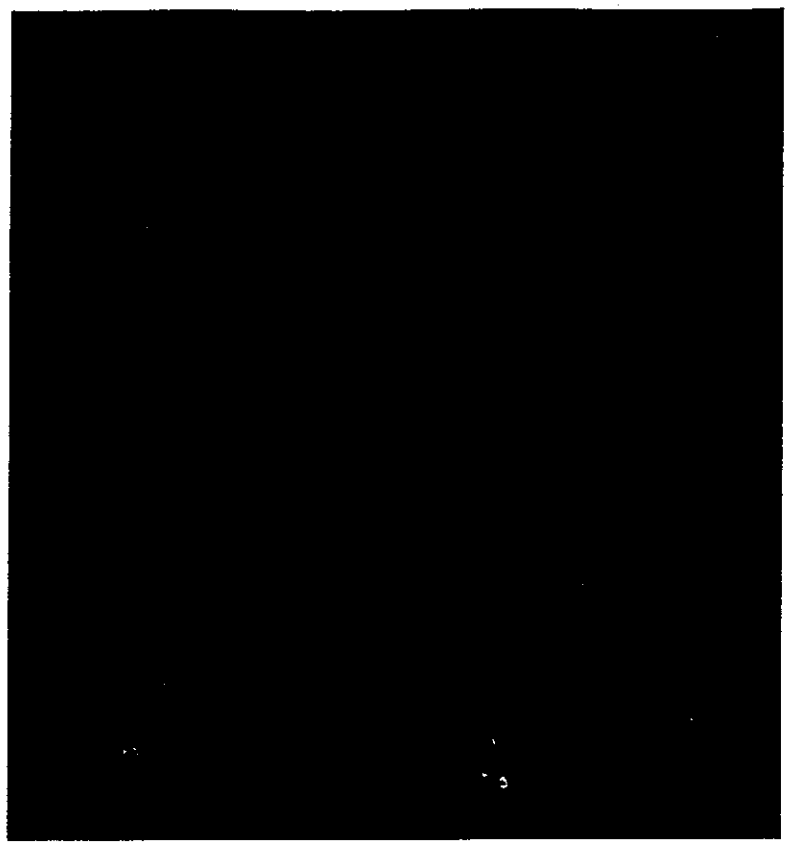
- Quality improvement, qual. control of Nb
- quality control of surface
- reduction of field emission
- smoother surface (electropolishing)
- can one avoid 1400° C heat treatment ? cavities from RRR 500 - 1000
- reduction of secondary emission coeff.
- improved cavity shffening (needed for >25M
- feasibility of seamless cavity production (≥ 30MV/m range without Q slope)
- 4 × 7 cavity superstructure
- improvement + cost reduction of coupler
- cost reduction of tuner
- understanding of Q drop without FE


Processing without Ti
(Annealing time 4 h)
400
350
300
250
200
150
100
50
0
RRR
TWC
Heräus
Tokyo-Denkai
0
500
1000
1500
Annealing temperature
Processing with Ti
(Annealing time 4 h)
800
700
600
500
400
300
200
100
0
RRR
TWC
Heräus
Tokyo-Denkai
0
500
1000
1500
Annealing temperature

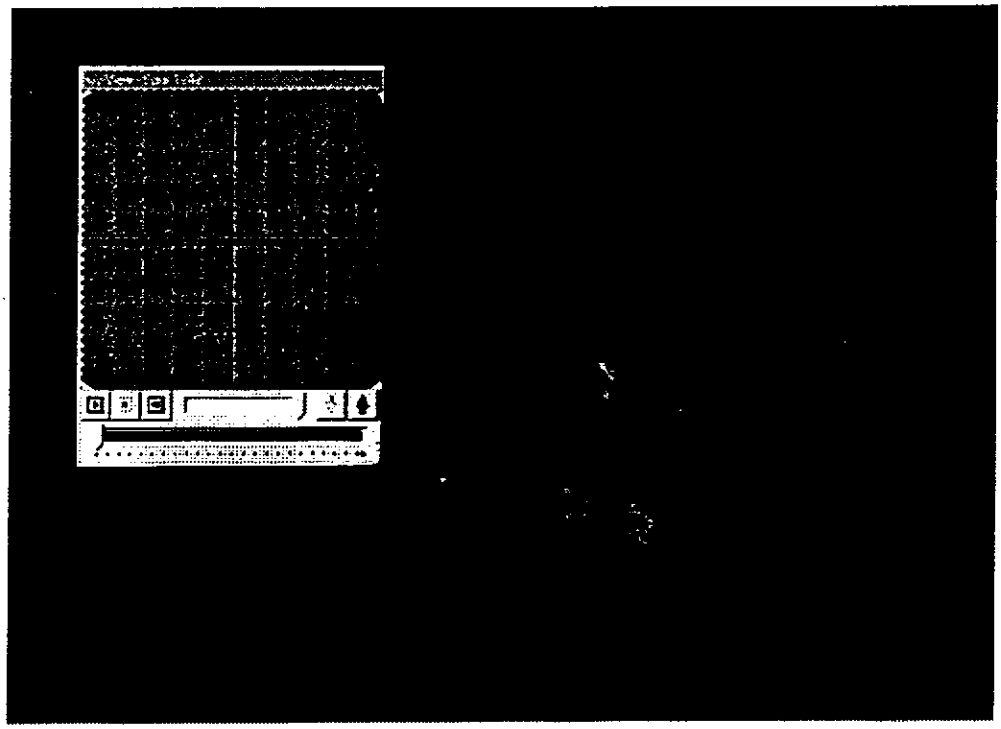


D38 reaches 19.8 MV/m after HT 1400 °C

Eddy current system



Niobium-Sheet with Iron-Clusters.



Zoom of the area with Iron-Clusters. The Scope picture shows the Eddy-Current Signal of a scan of the cluster in the lower right position.

SQUID System (F.I.T.)

Prinzipansicht des Meßaufbaus

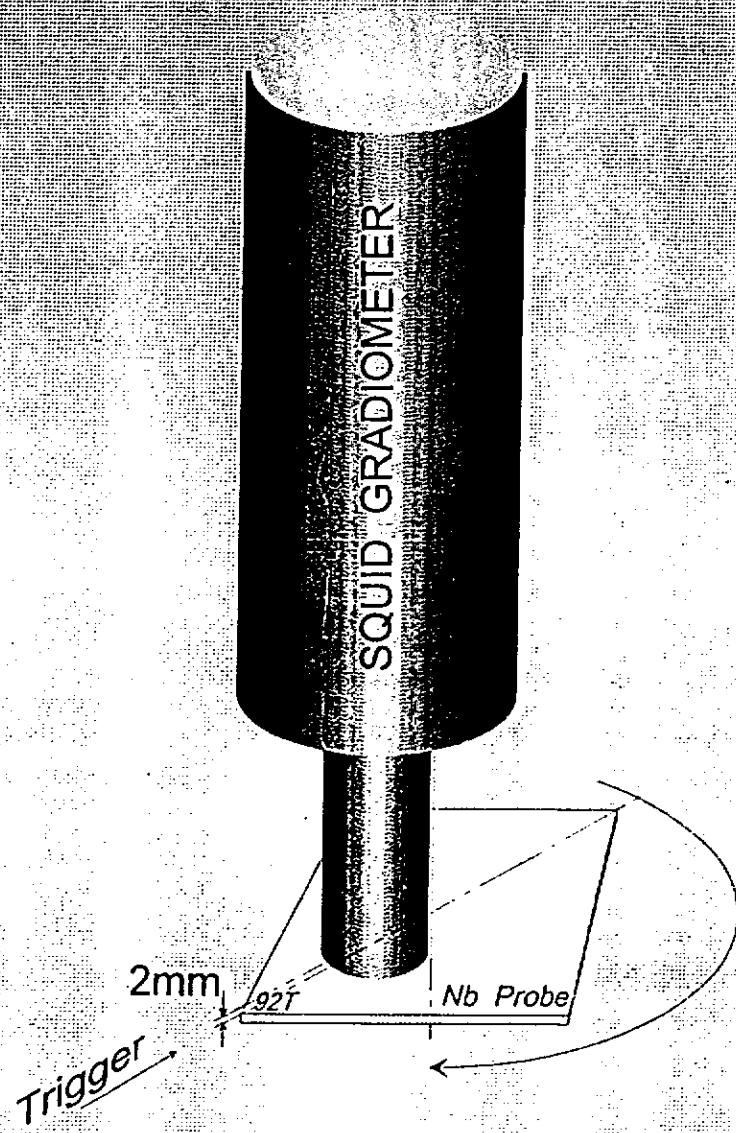


Bild 2

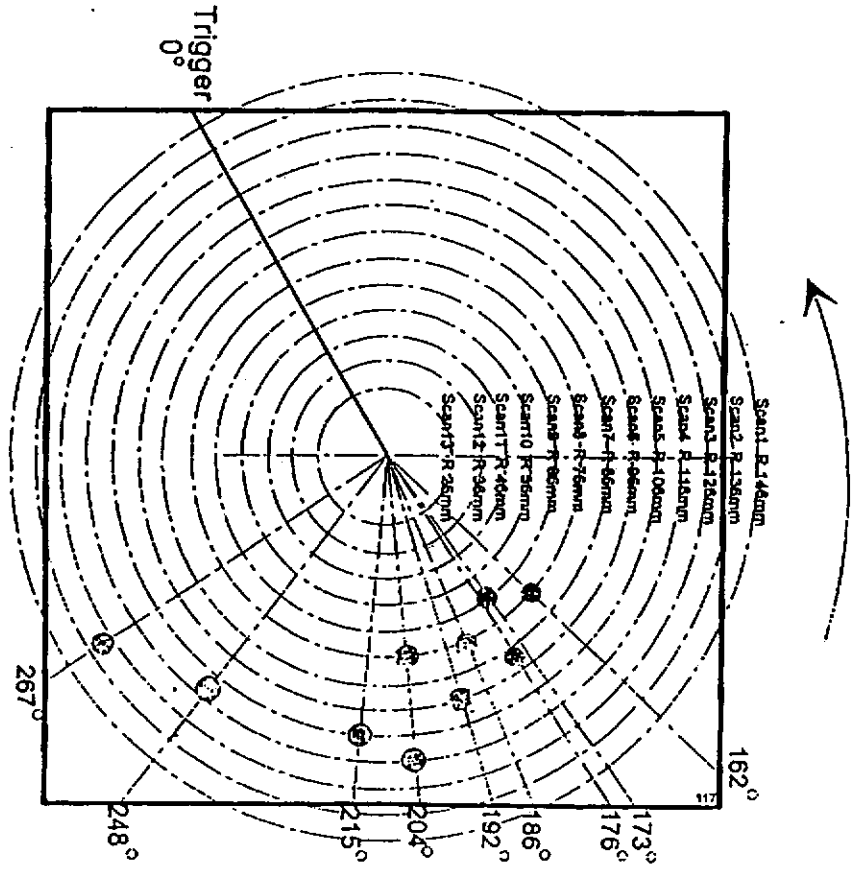
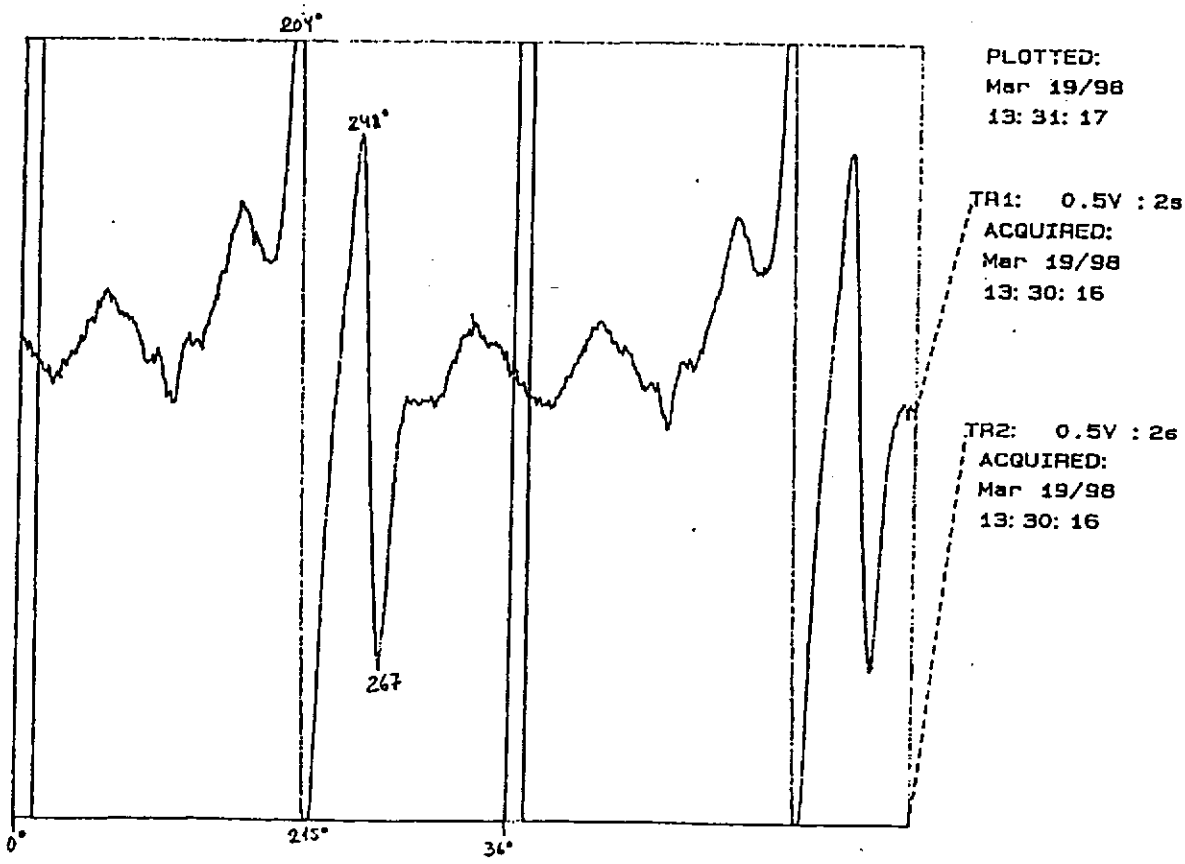


Bild1

(0,03 ÷ 10) Hz



760

Bild4

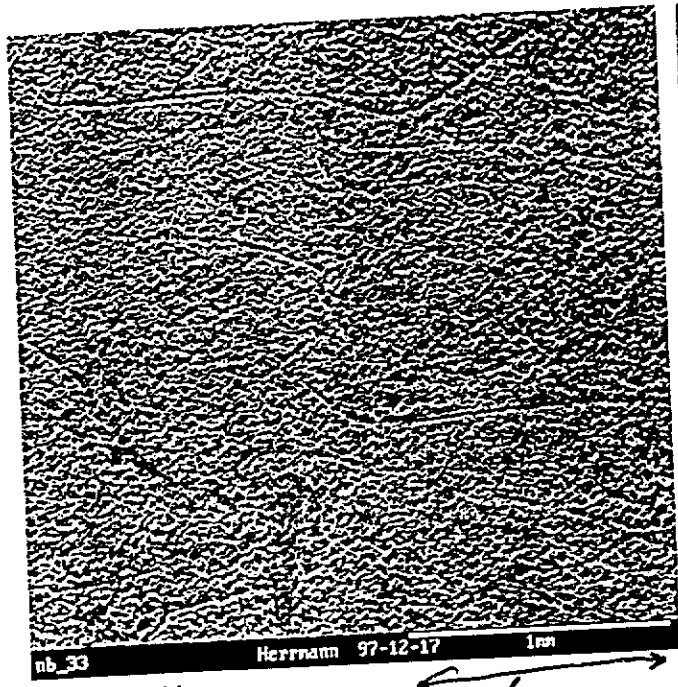
#nb_33

- chemistry 28 µm
- annealing 2h at 800°C

Frank Herrmann

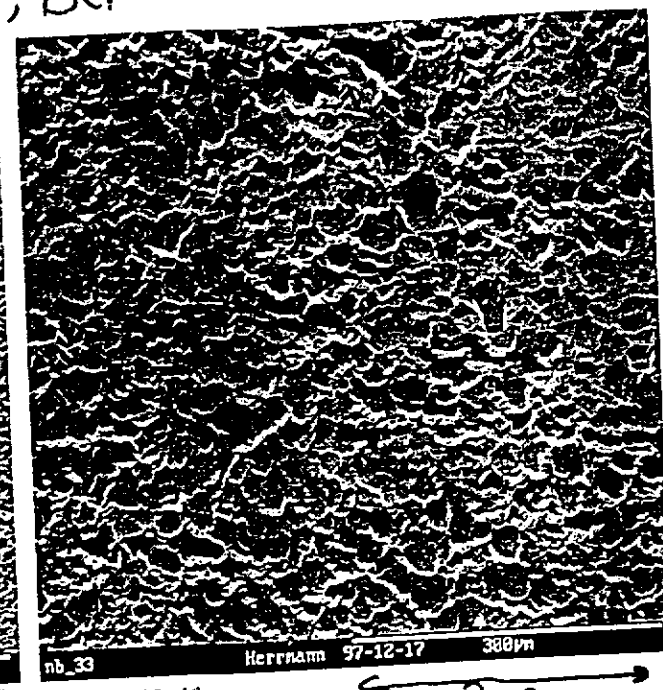
SEM investigations

Nb 800°C, BCP



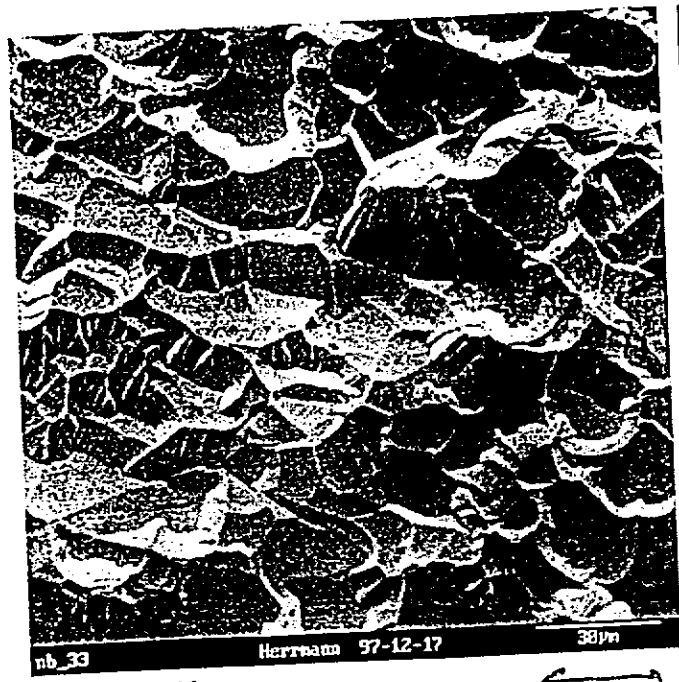
nb33_40.tif

1mm



nb33_160.tif

300µm



nb33_655.tif

30µm

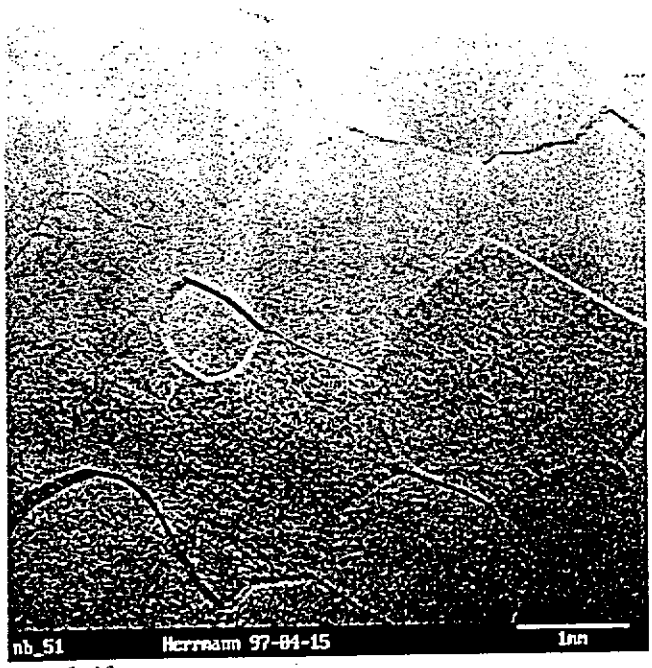
nb33_26x.tif

10µm

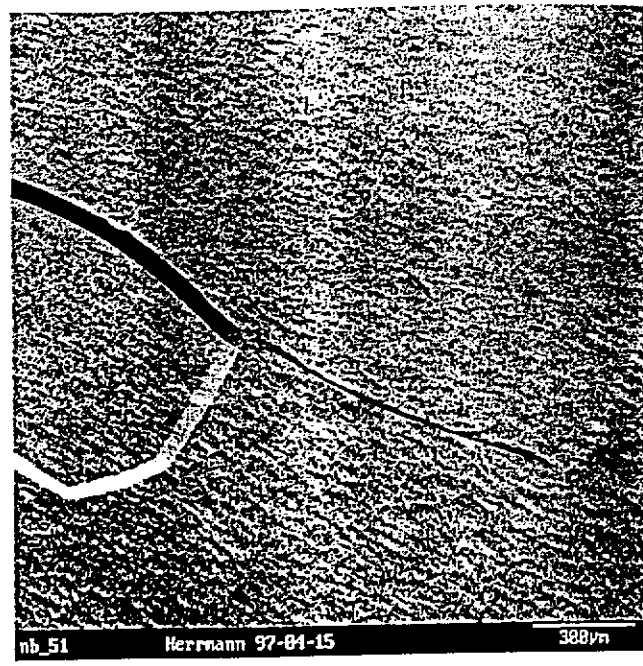
Institut für Angewandte Physik
Uni Hamburg
Prof. R. Anton

N651

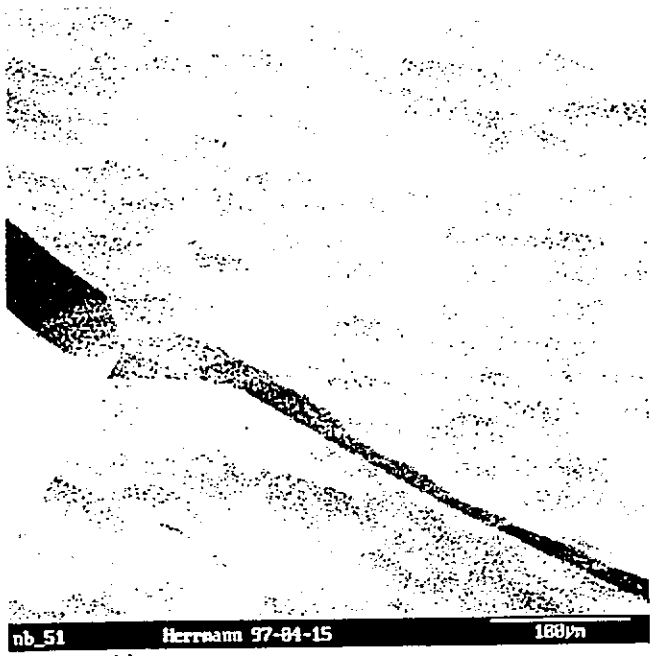
SEM investigations Nb 1400 °C, BCP



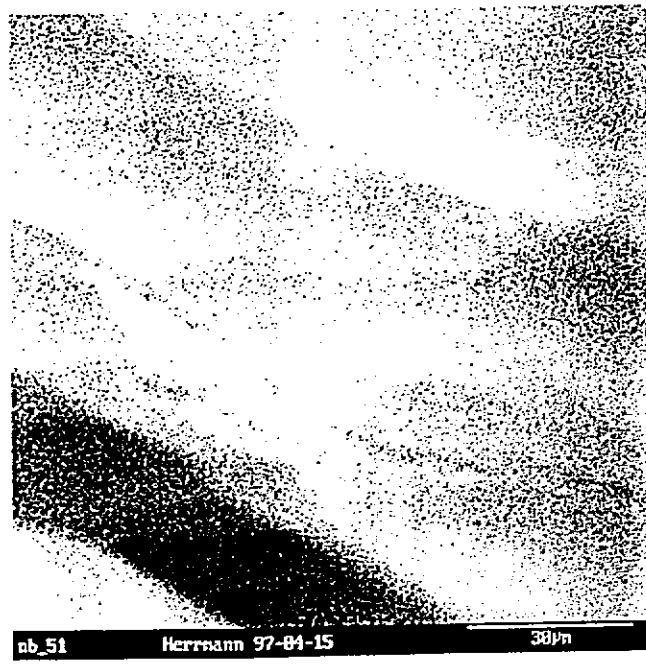
m_16.tif



m_50.tif



m_203.tif

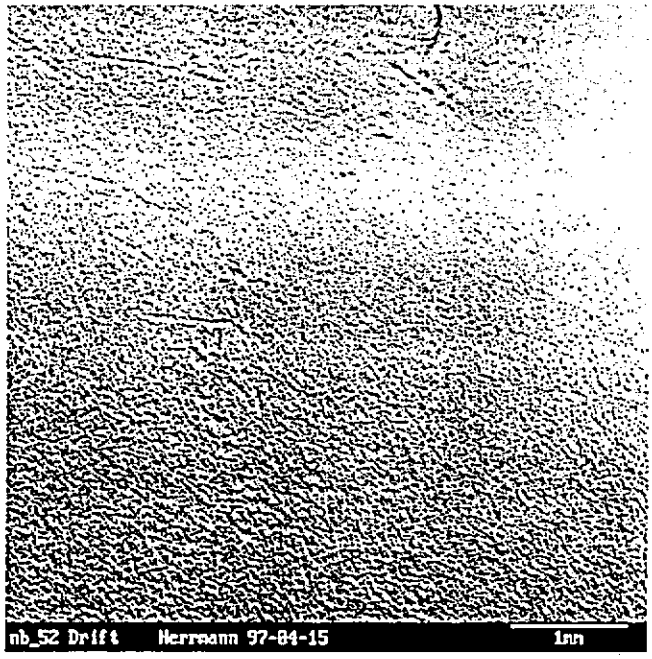


m_810.tif

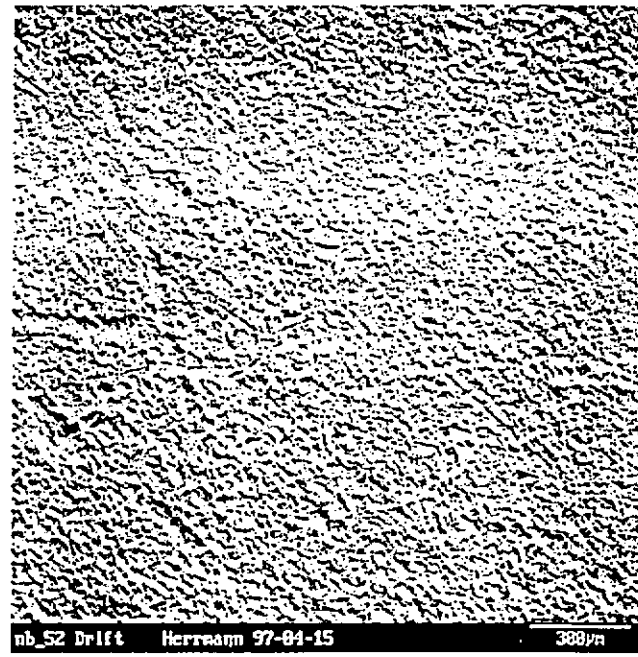
N652

Nb 1400°C with Ti
no final BCP

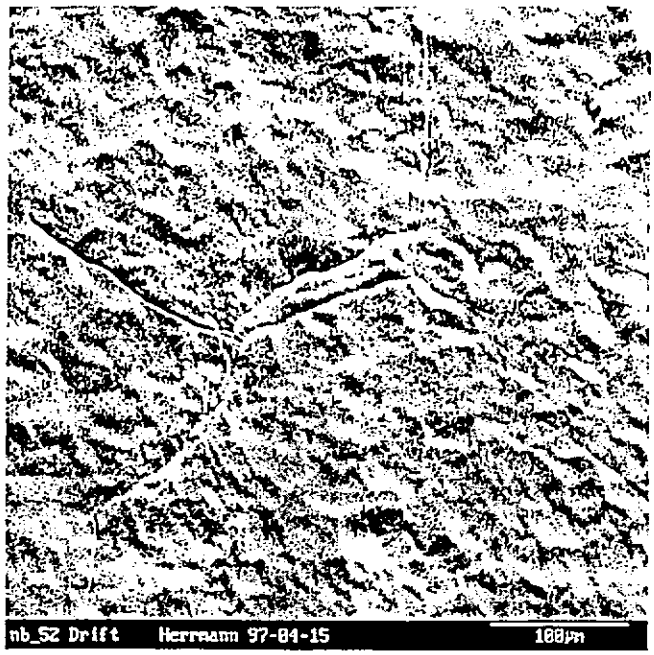
SEM investigations



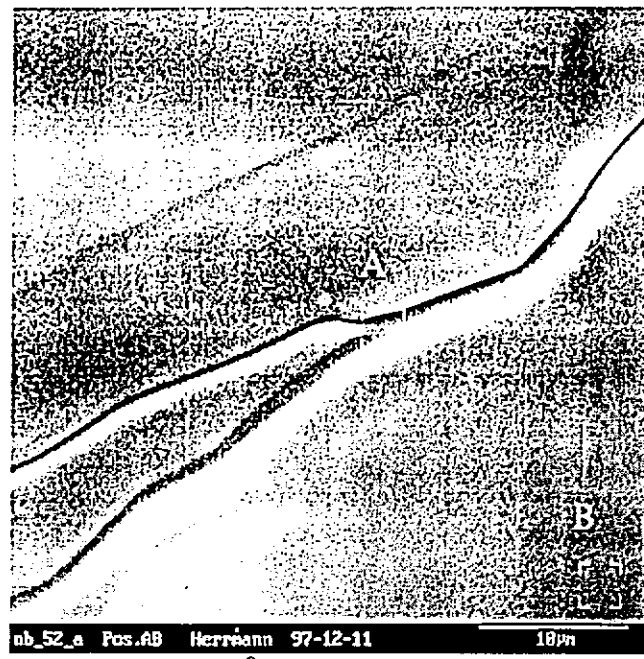
m_17.tif



m_50.tif



m_302.tif



nb_52_ab.tif, tilt 0°

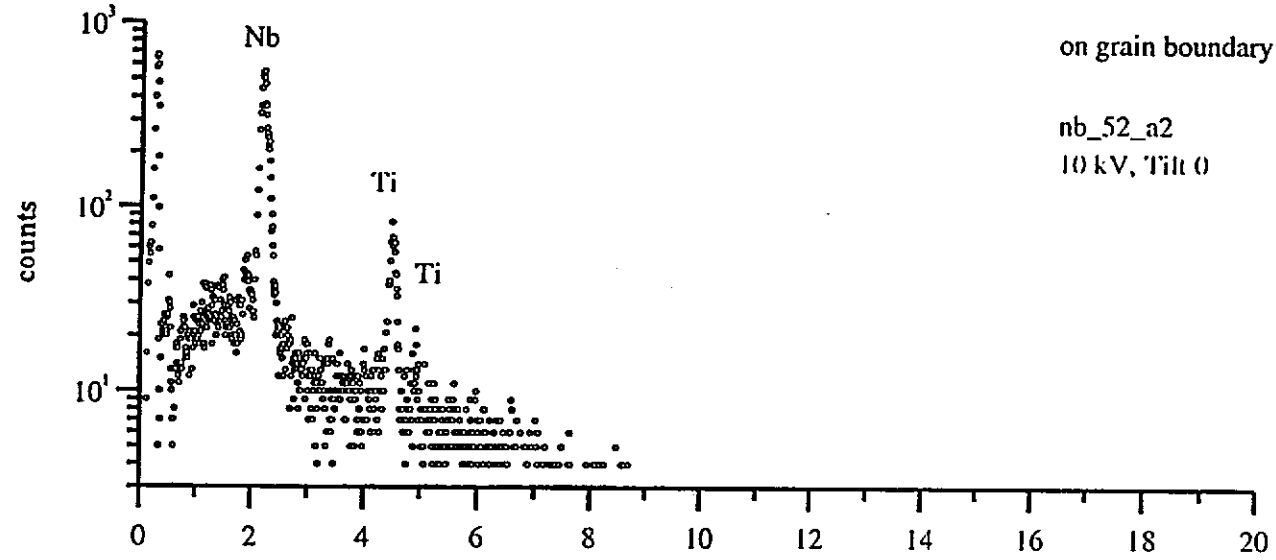
263

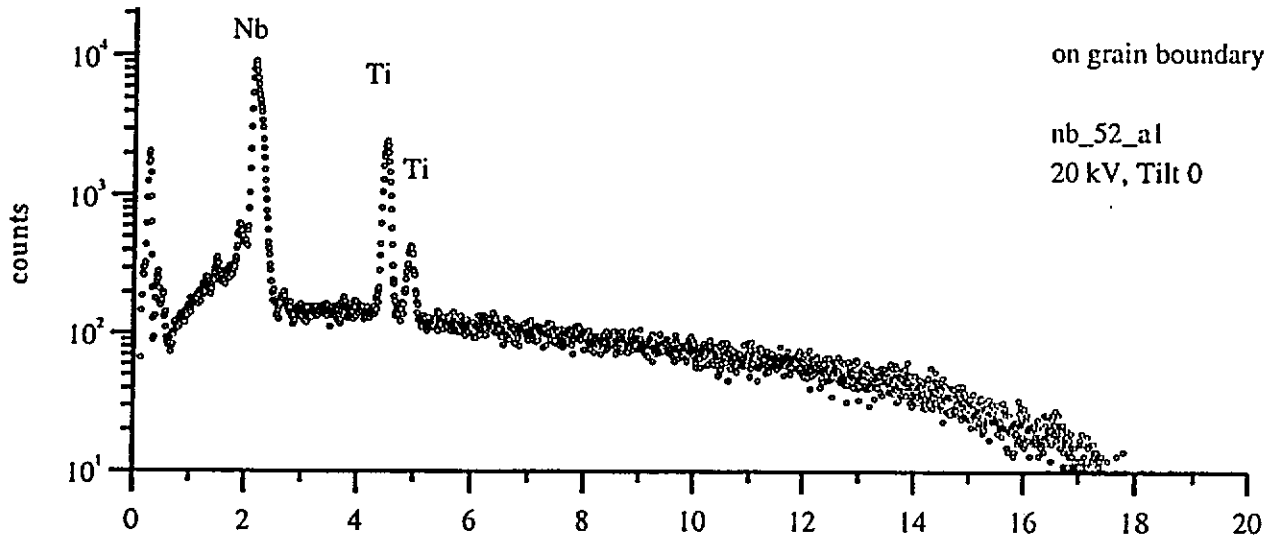
Frank Herrmann, 20th Jan. 1998

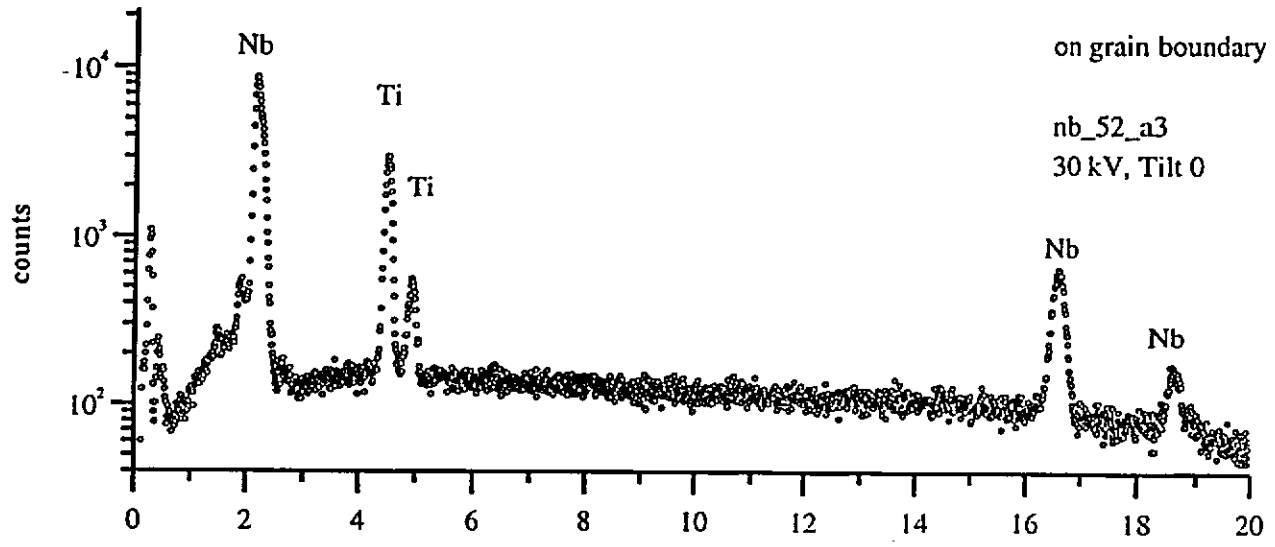
Nb 1400°C mit Ti

EDX investigations

detail investigation on the grain boundary (position A)







energy [keV]

nb_52_1_on_gb.epsi

Frank Herrmann, 20th Jan. 1998

#nb_32 - particle

Origin: Heraeus

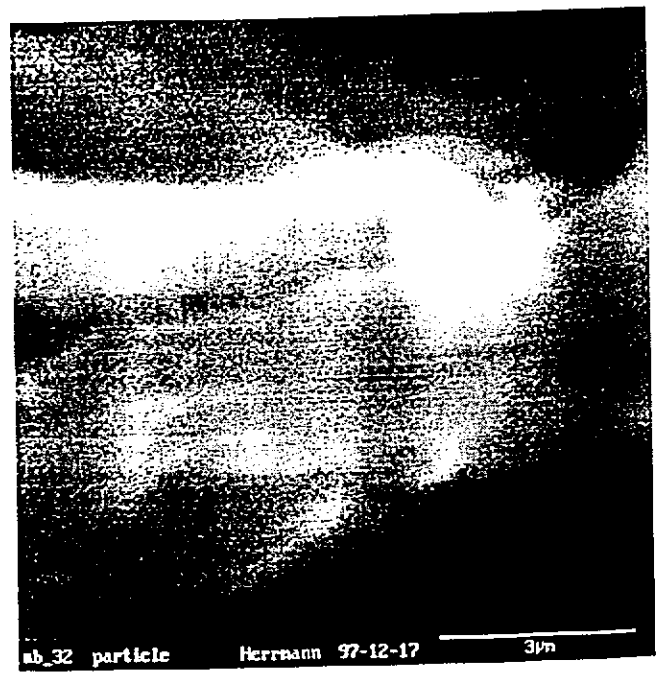
Preparation status:
- none
- chemistry 119µm + 6µm
- annealing 2h at 800°C

SEM parameters: 20kV, 50nm, tilt 30° corrected
cleaned by ultrasonic acetone and propanol bath

nb32p160.tif

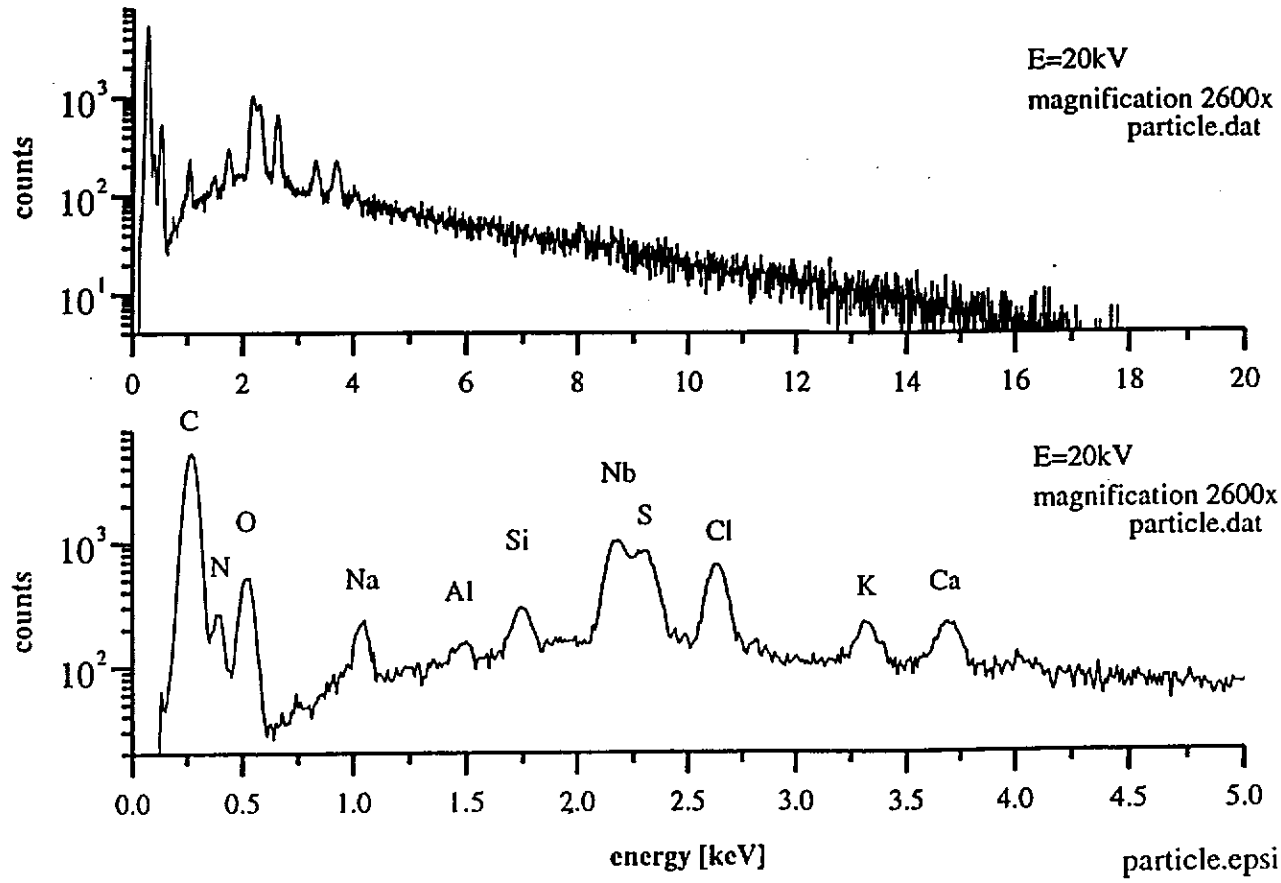
nb32p655.tif

nb32p26x.tif



nb32p1xx.tif

EDX parameters: 20 kV, 50 nm, tilt 0°, EDX done on the particle, typical information depth about 0.8 µm, sensitivity of about 1%



Conclusion/results:

- particle is not removable by an extensive ultrasonic bath (acetone and propanol), flat bottom of the particle visible in the micrographs points also to a good junction
⇨ strong adherence to the niobium surface (removable by HPP?)

- tips on tips visible down to <0.5 µm on 1.5 µm
⇨ field emission?

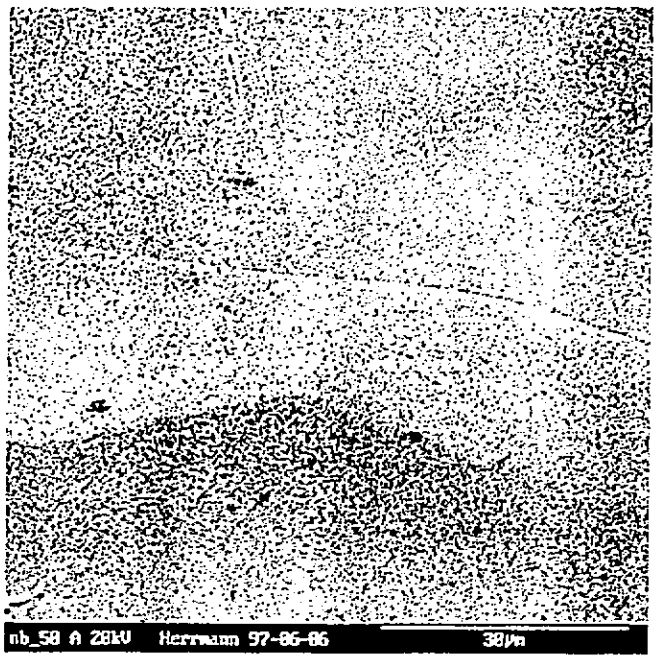
- manifold composition:	high part	carbon, oxygen, sulfur, chlorine
	medium part	nitrogen, sodium, silicon, potassium, calcium
	low part	aluminum

⇨ typical dust

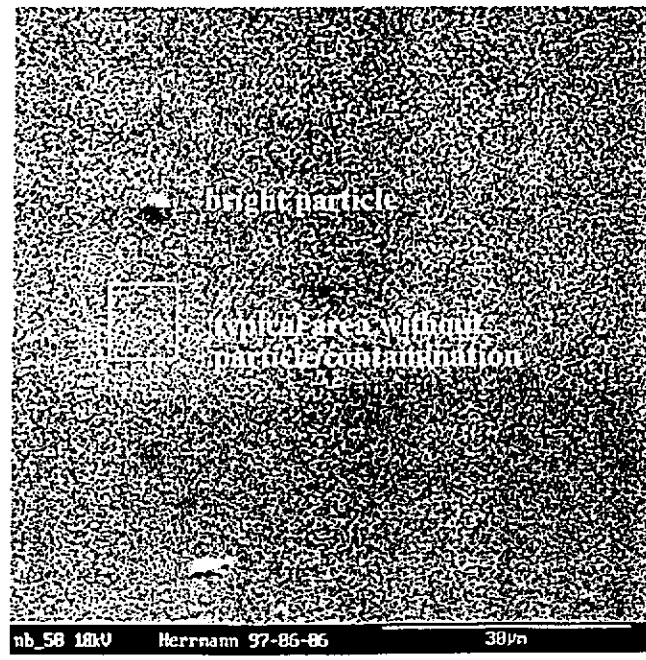
∩ ∩ ∩

SEM investigations

a_300.tif, 20 kV



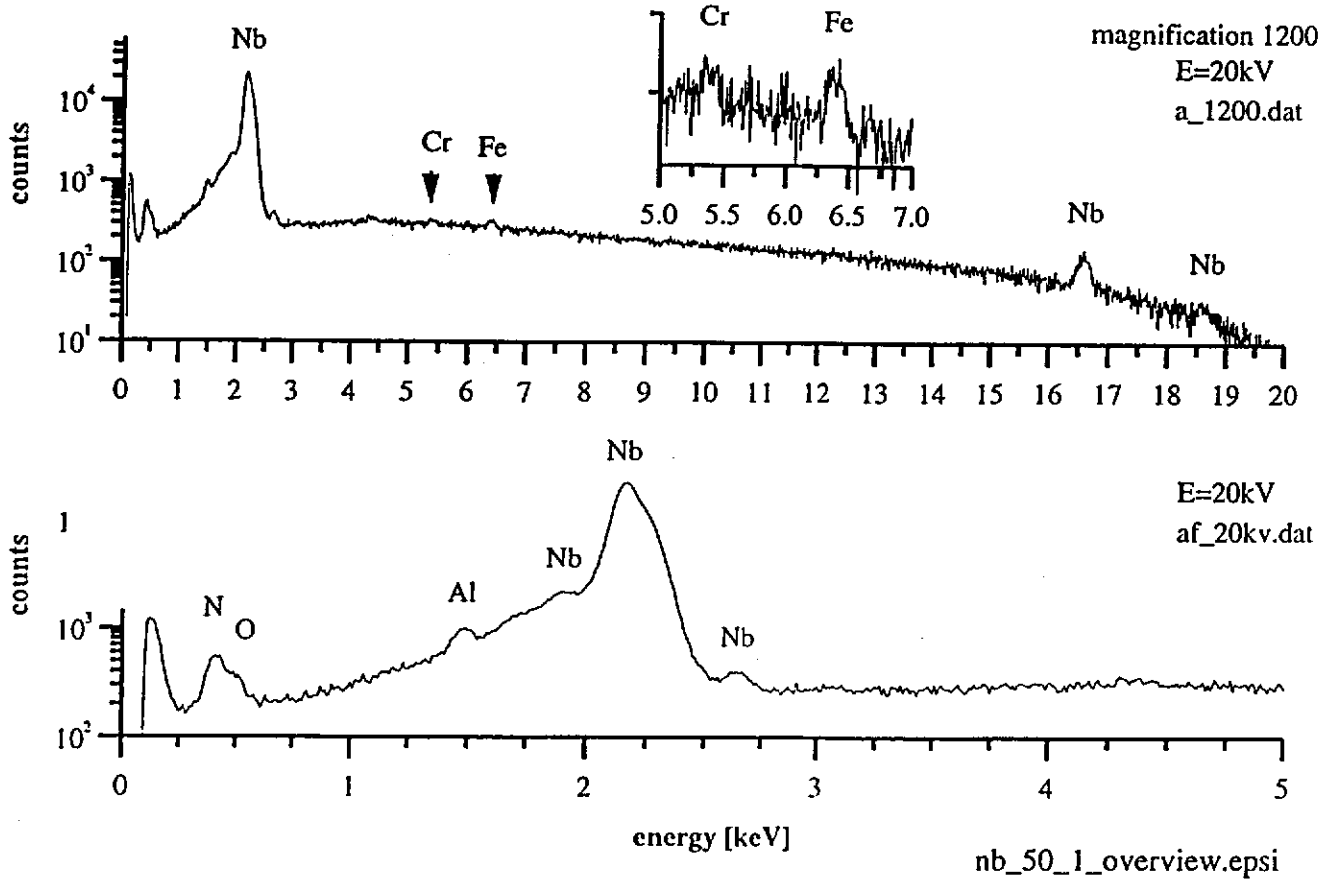
a_1200.tif, 20 kV



a2_1200.tif, 10 kV

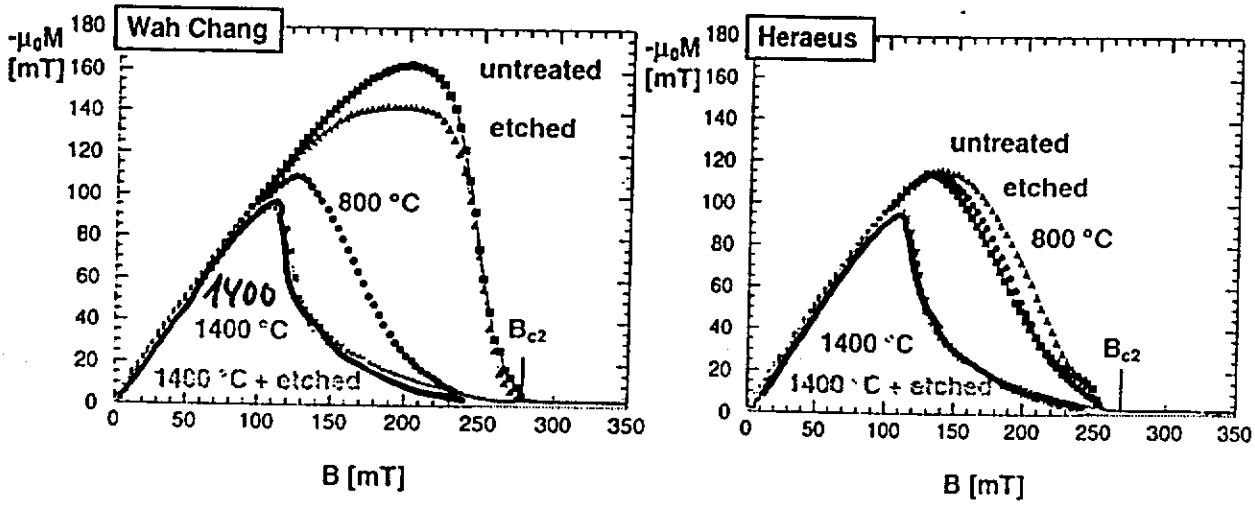
EDX investigations

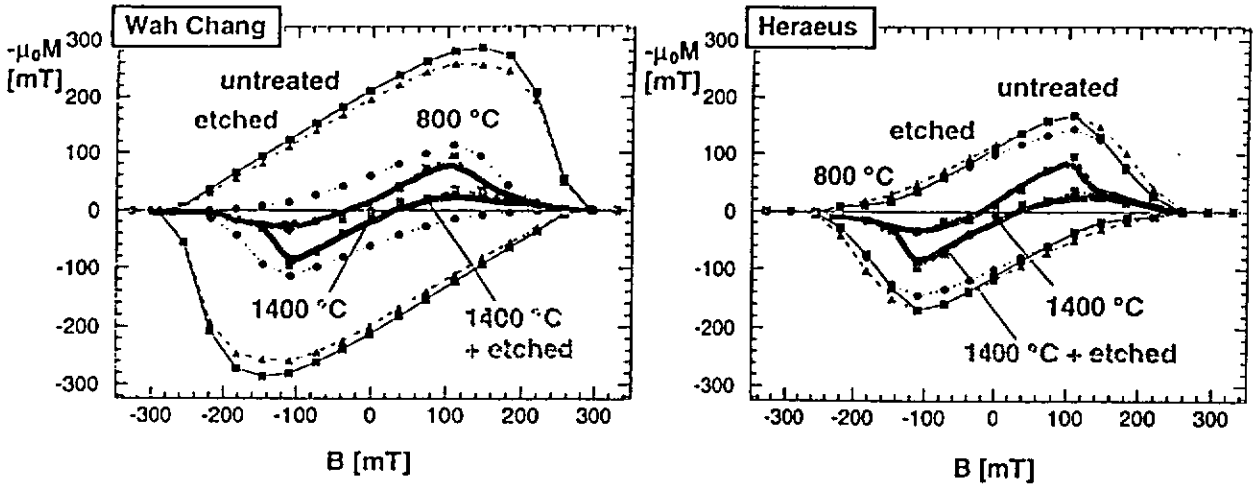
overview investigation (scanning whole area of micrograph a_1200.tif)

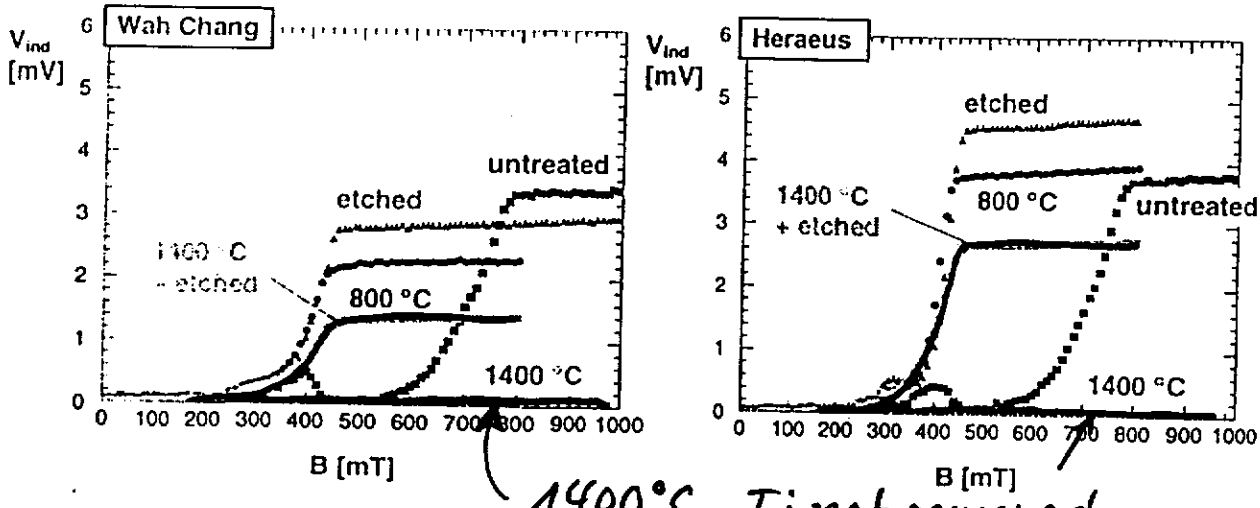


nb_50_1_overview.epsi

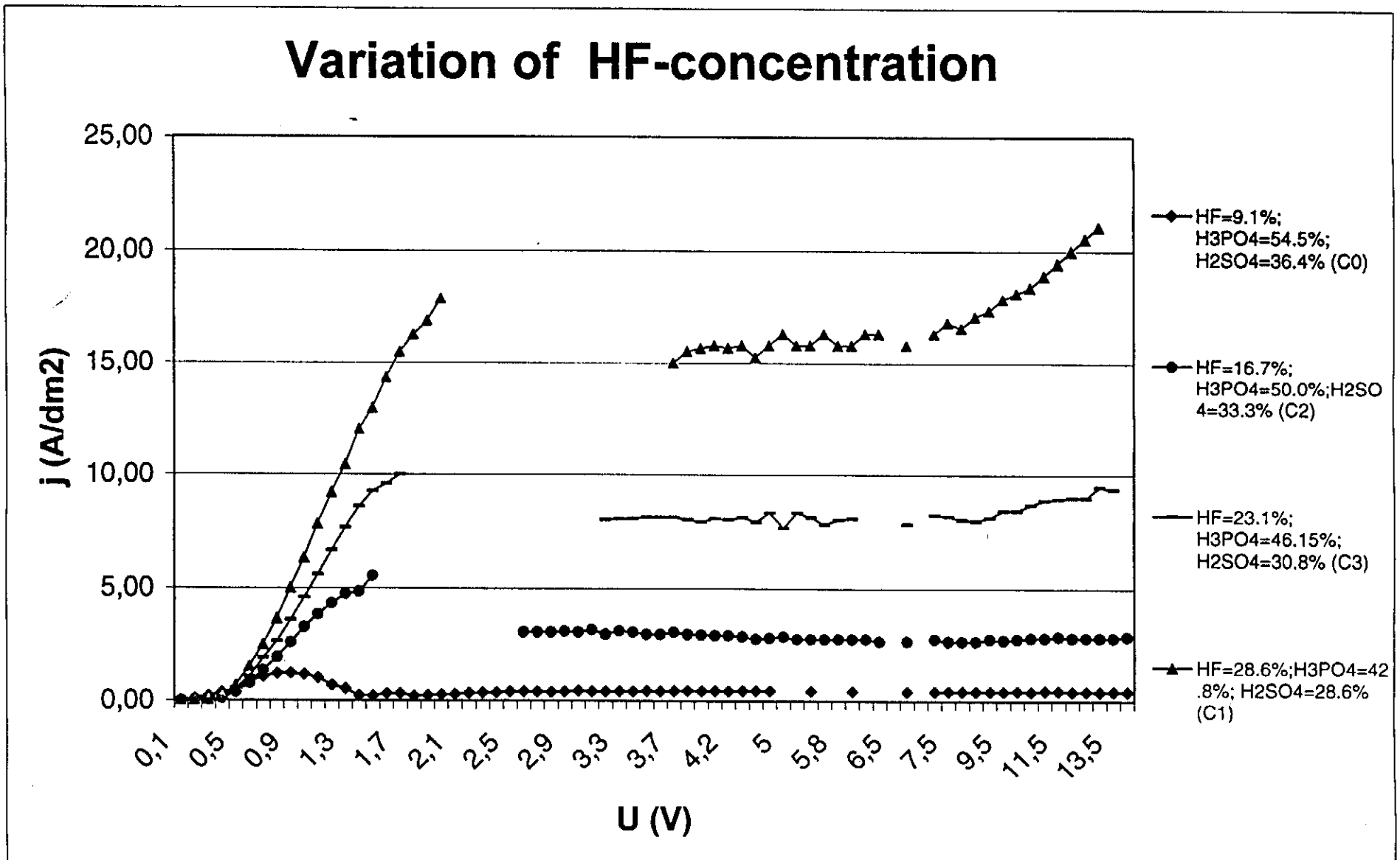
M. Bahte





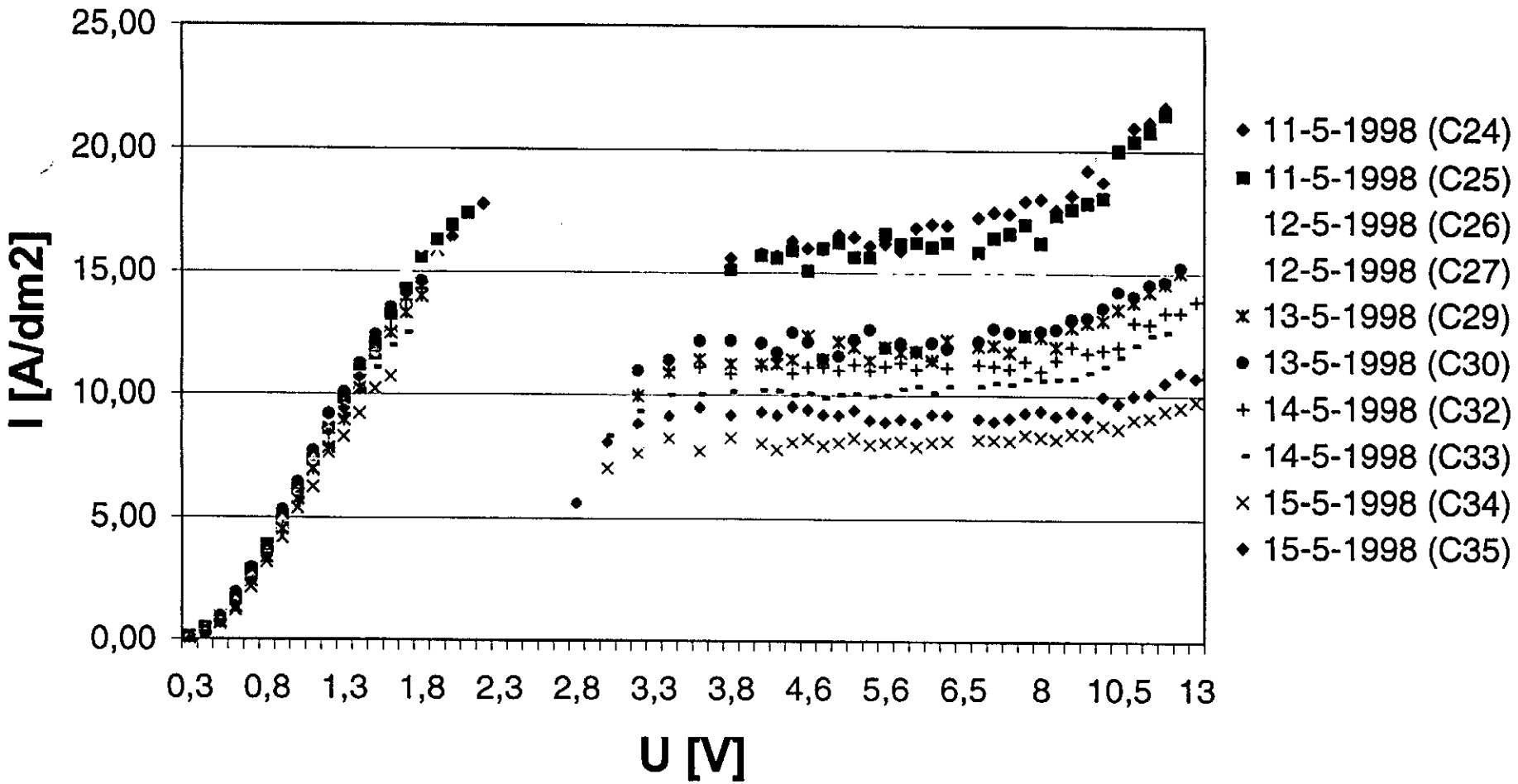


1400°C, Ti not removed



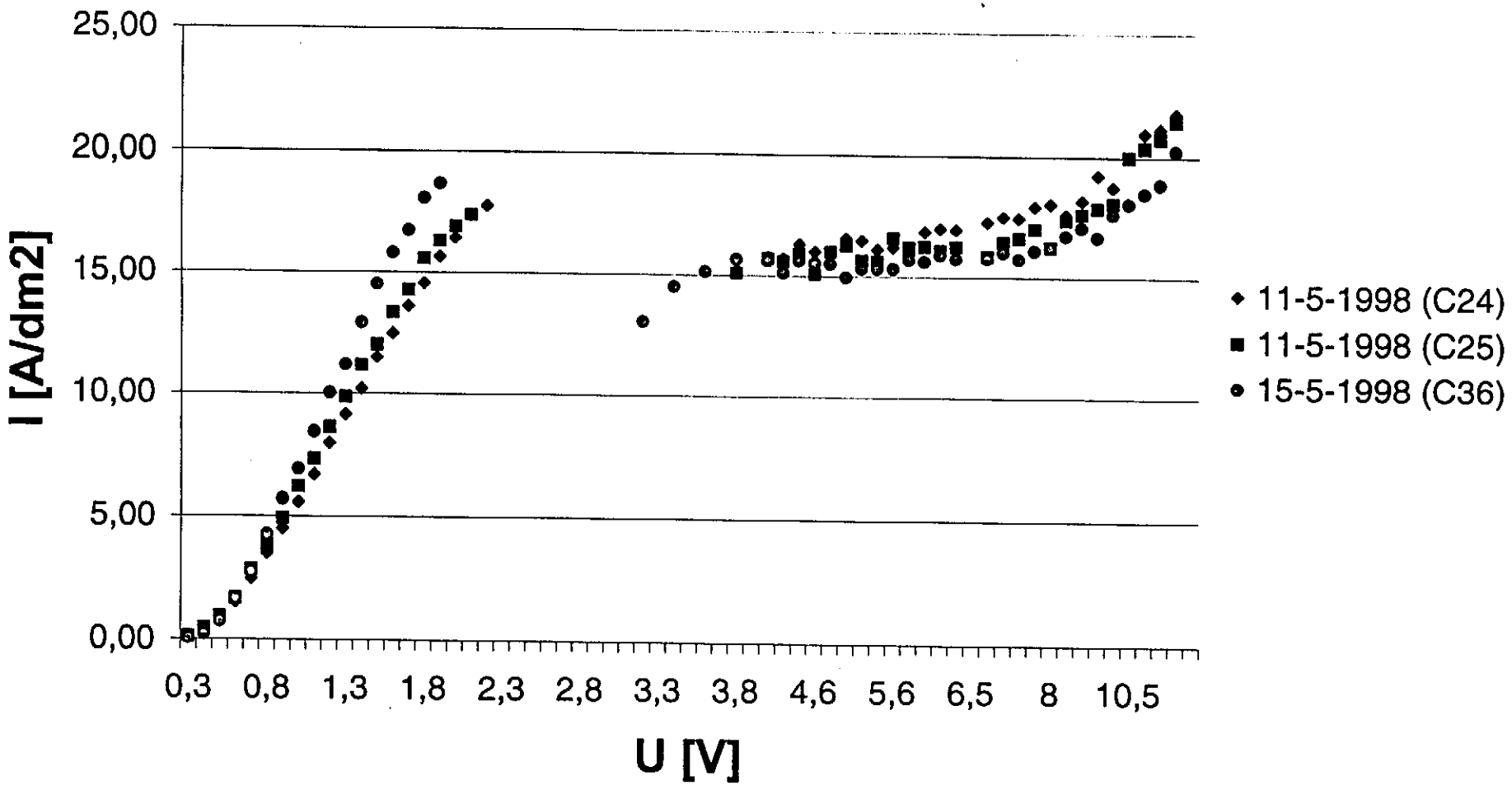
L. FERRARA, CERN
J. GUERIN, CERN

Aging of polishing bath



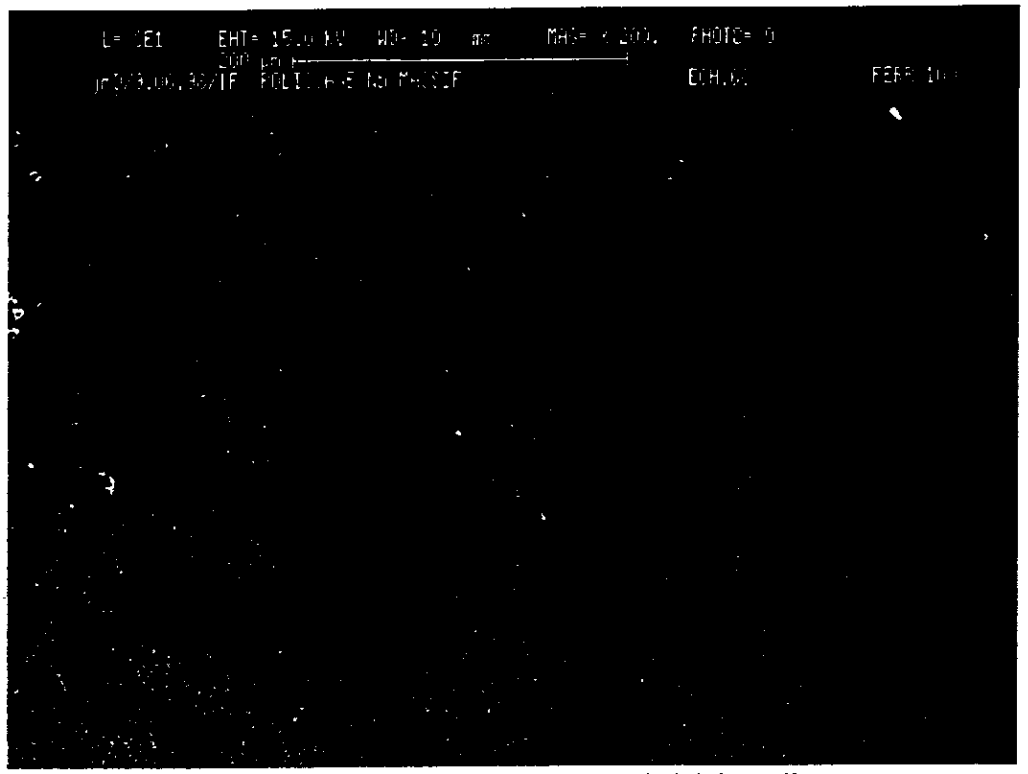
L. FERRARA, CERN

Curing bath aging by adding HF

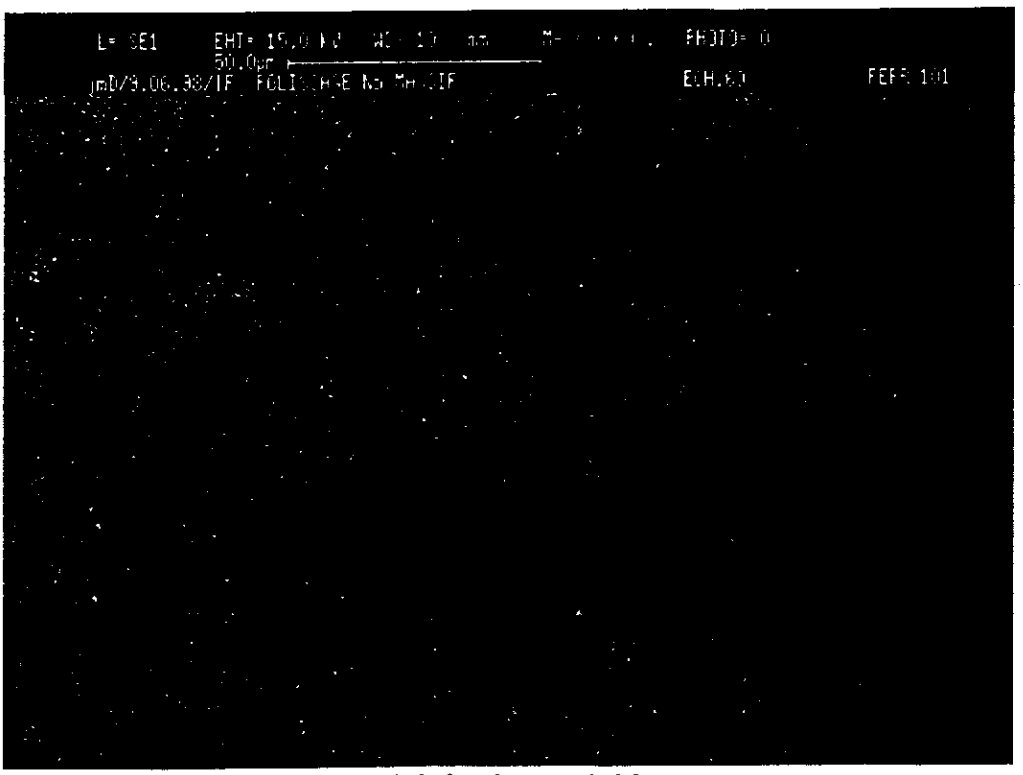


L. FERRARA
CER

Echantillon n° 60:

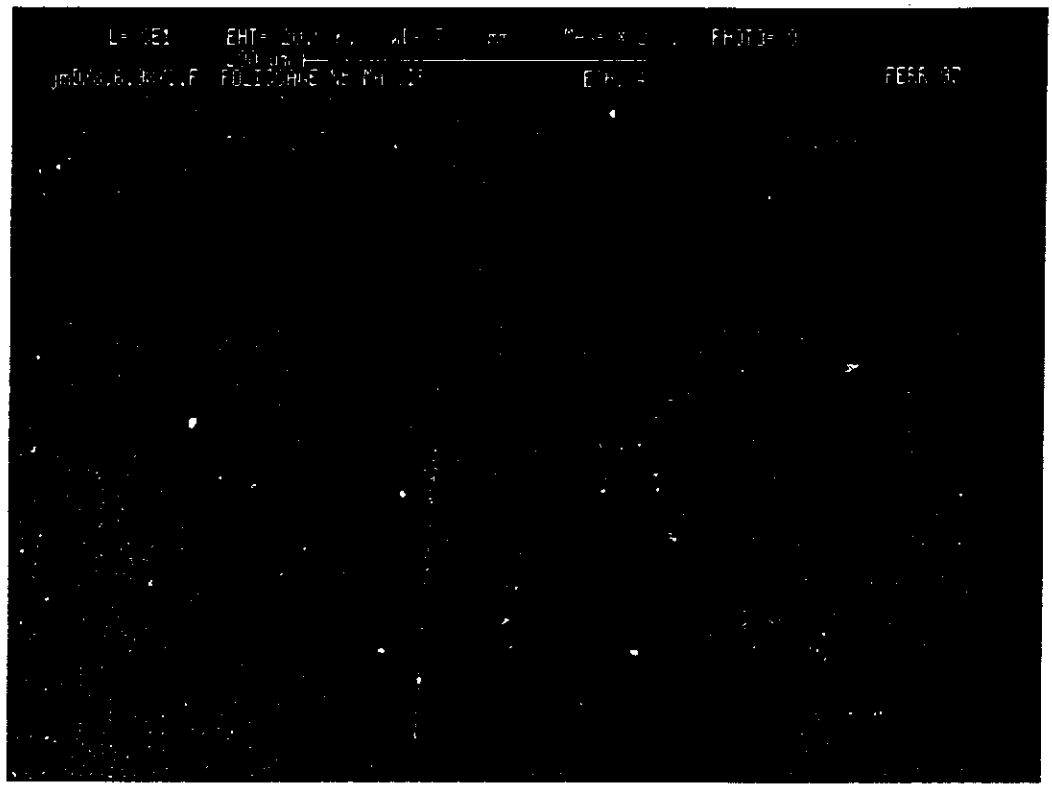


Observation générale de la surface de l'échantillon.



Détail de la photo précédente.

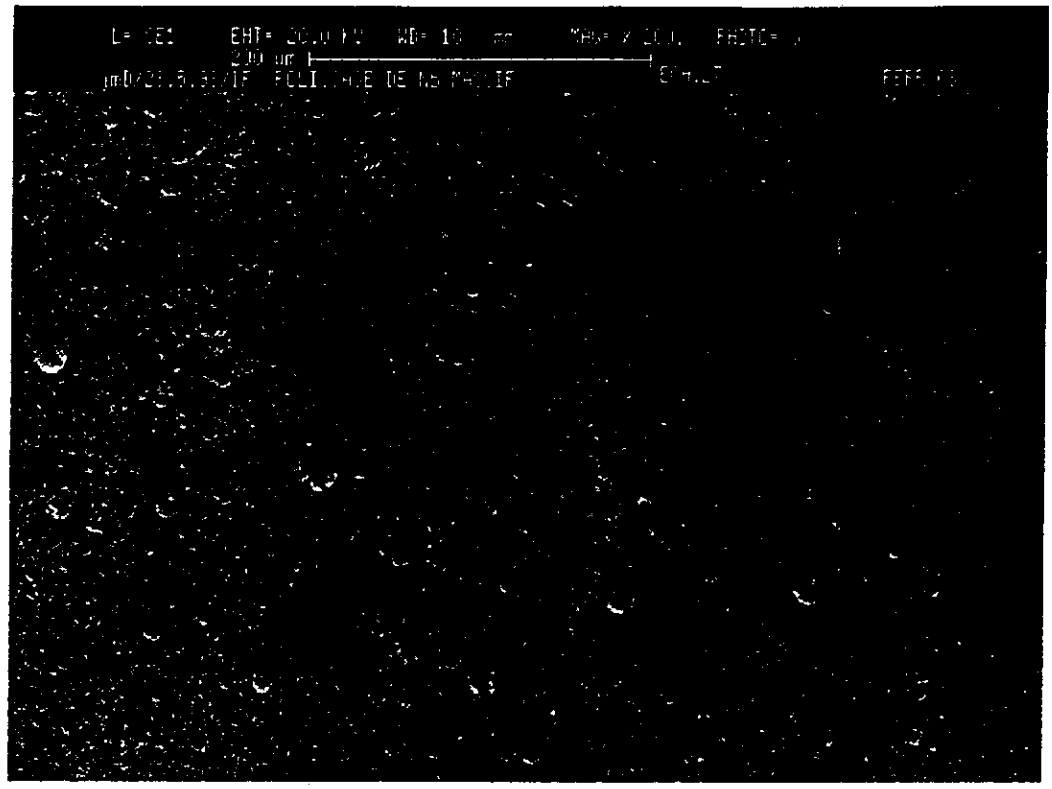
Echantillon n° 40:



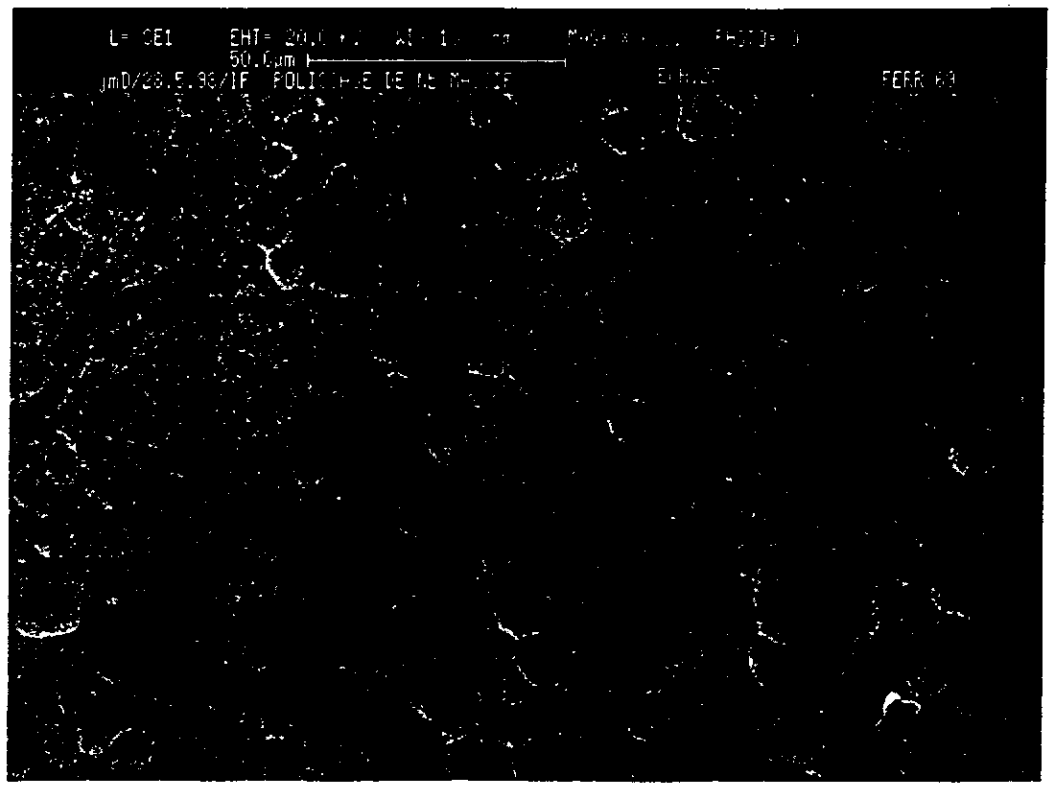
Observation de l'état de surface e l'échantillon.

Détail de la photo précédente.

Echantillon n°27.



Etat de surface de l'échantillon.



Détail de la photo précédente.

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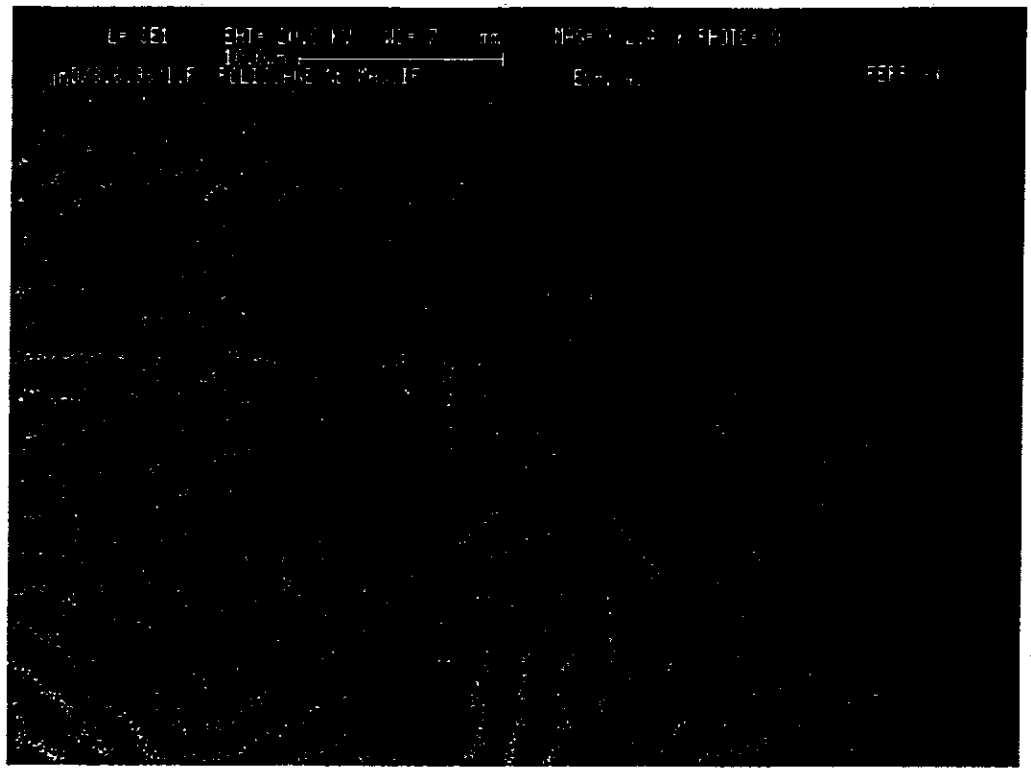
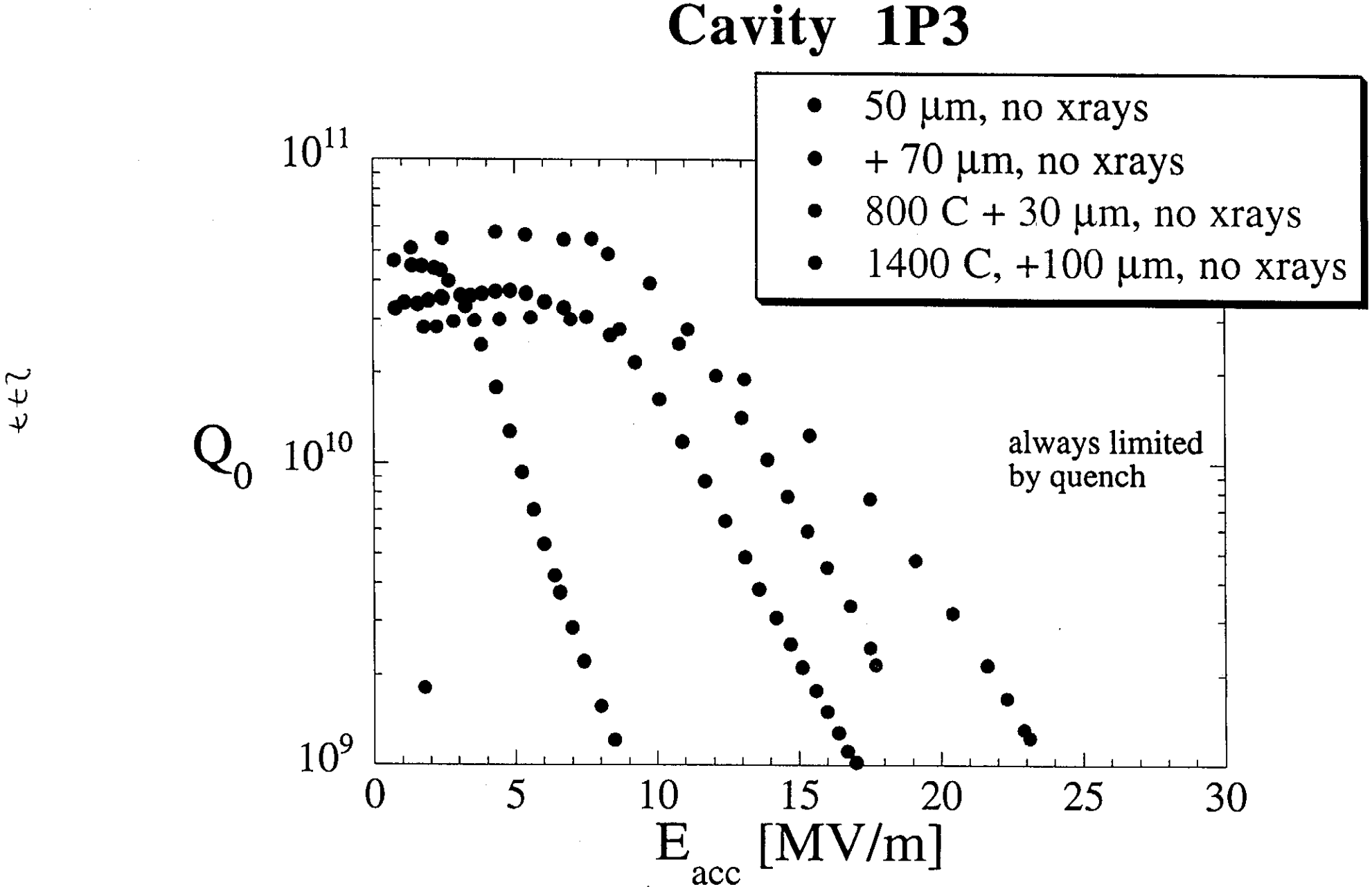
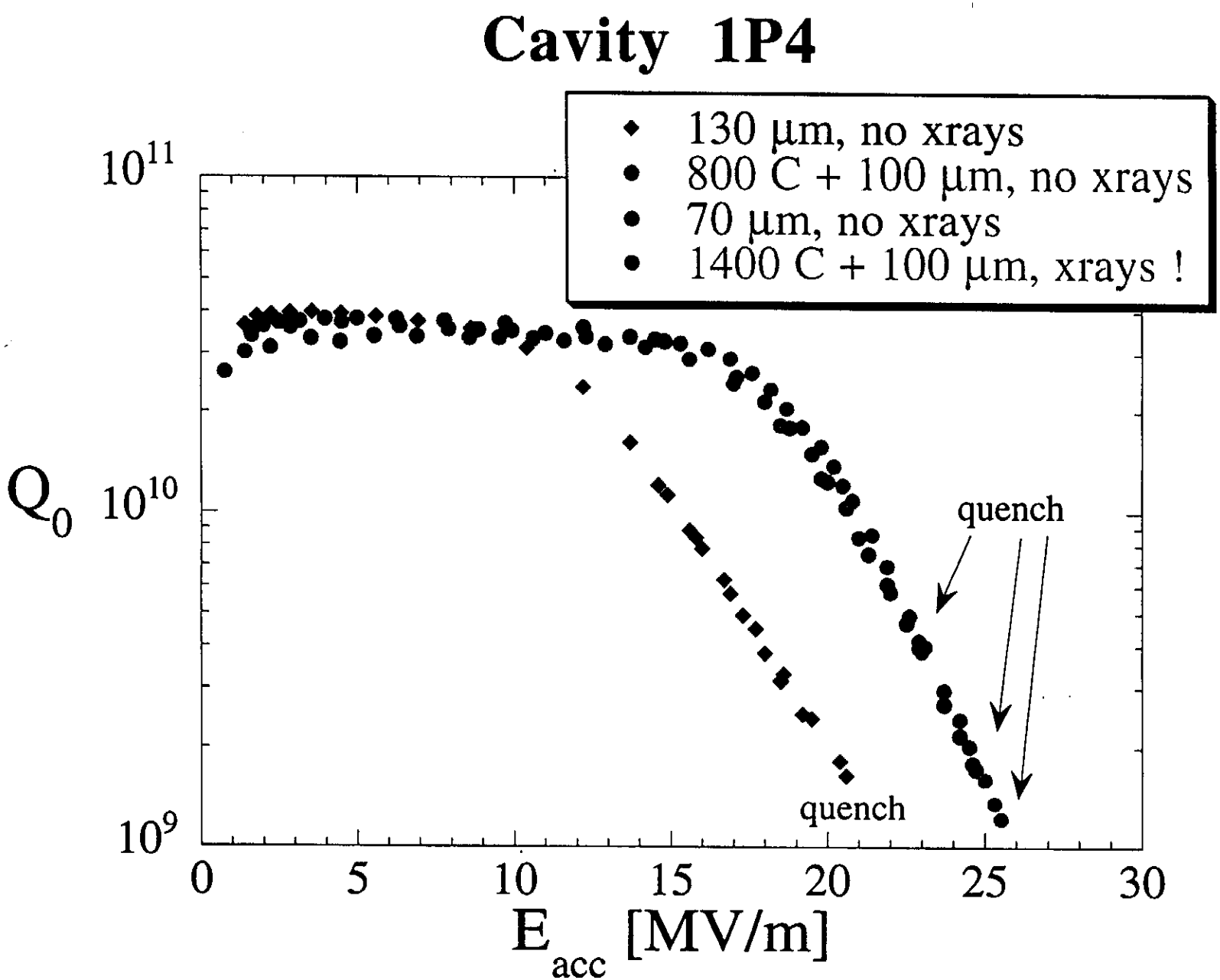


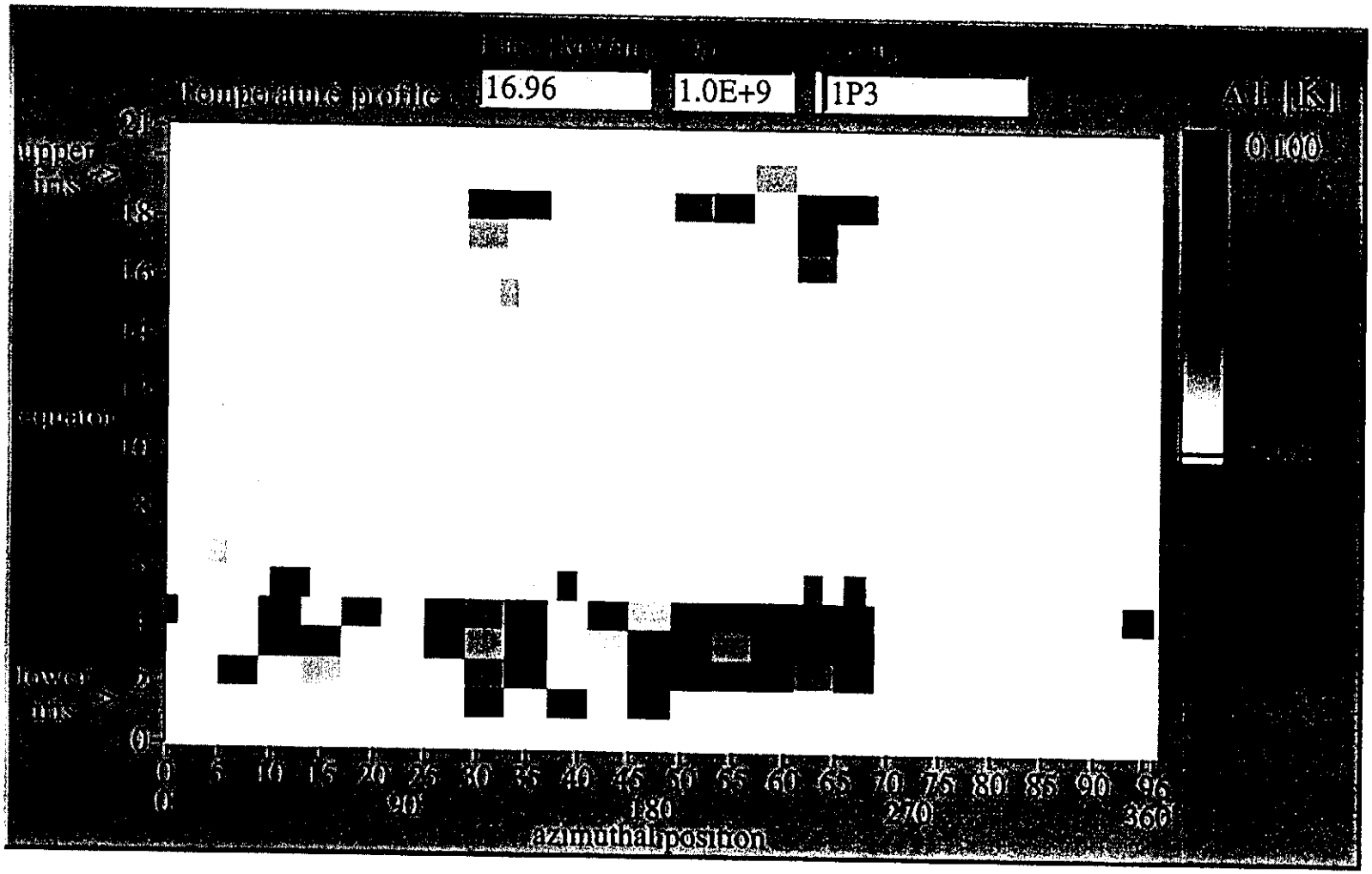
Observation rapprochée de la surface de l'échantillon.

276


Cavity 1P3
50 μm, no xrays
+ 70 μm, no xrays
800 C + 30 μm, no xrays
1400 C, +100 μm, no xrays
always limited by quench
Q_0
10^{11}
10^{10}
10^9
0
5
10
15
20
25
30
E_{acc} [MV/m]

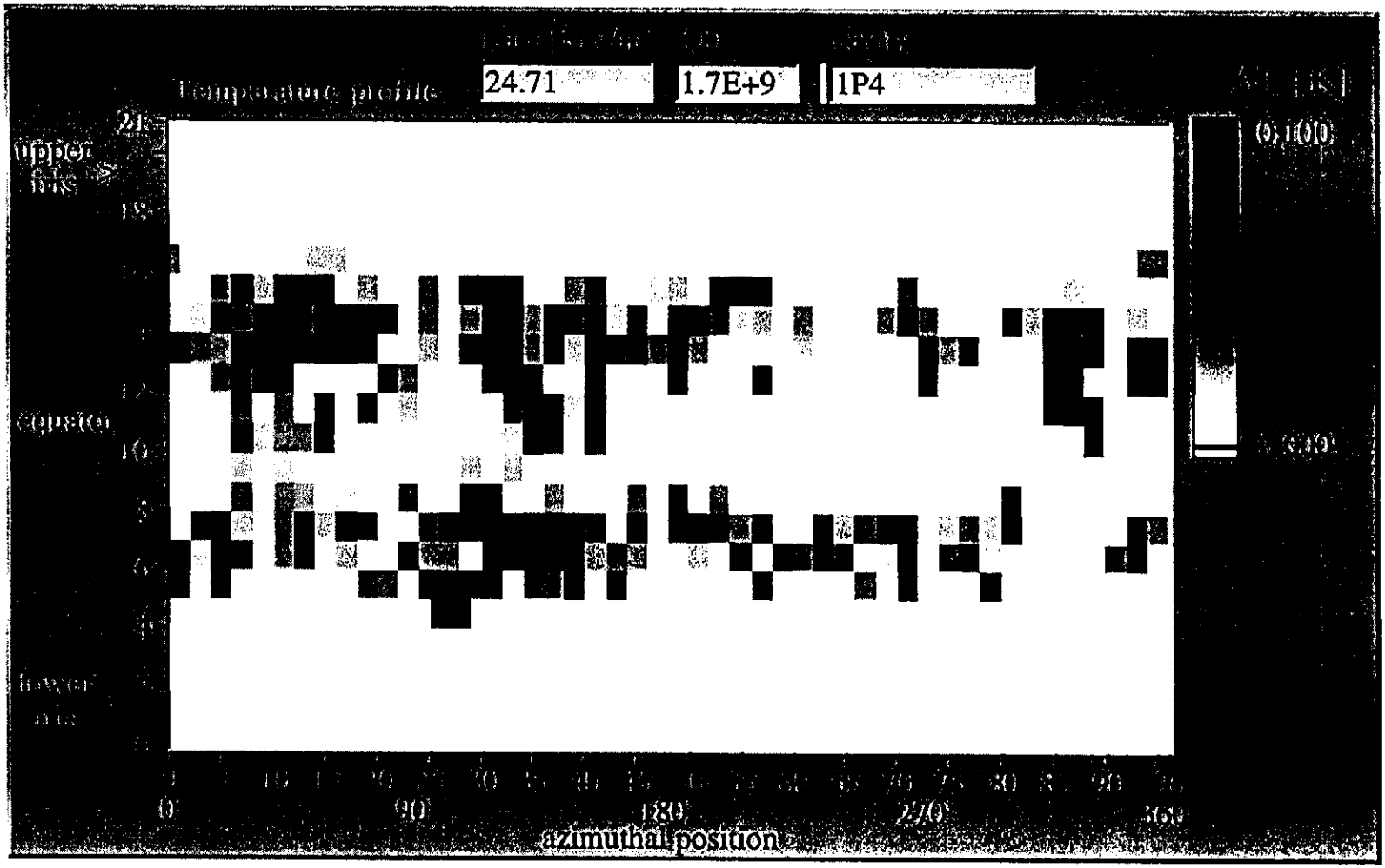

Cavity 1P4
130 µm, no xrays
800 C + 100 µm, no xrays
70 µm, no xrays
1400 C + 100 µm, xrays !
10^{11}
10^{10}
10^{9}
Q_0
quench
quench
0
5
10
15
20
25
30
E_{acc} [MV/m]

1P3

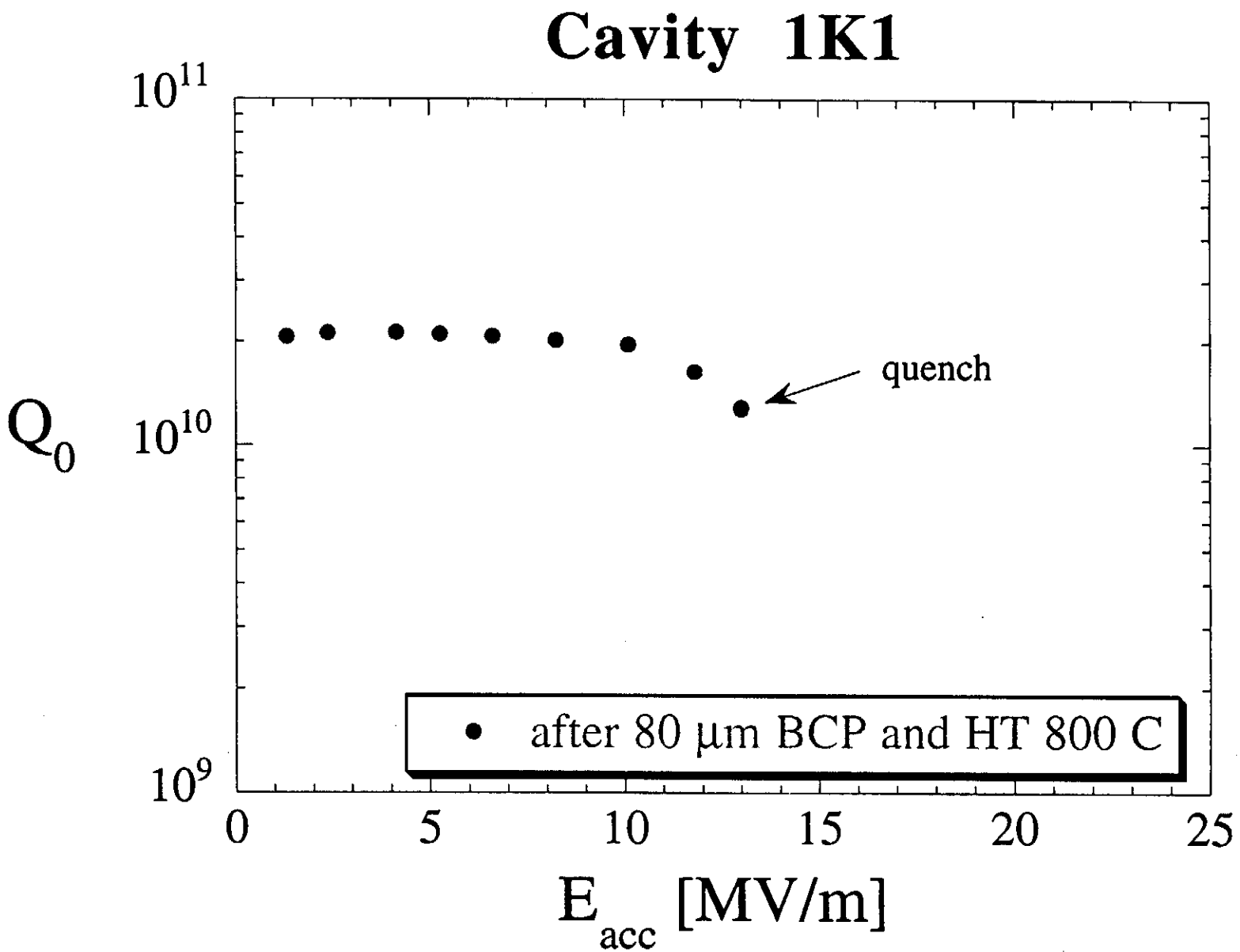


Temperature profile
16.96
1.0E+9
1P3
ΔT [K]
0.100
upper iris
equator
lower iris
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
0
90
180
270
360
azimuthal position

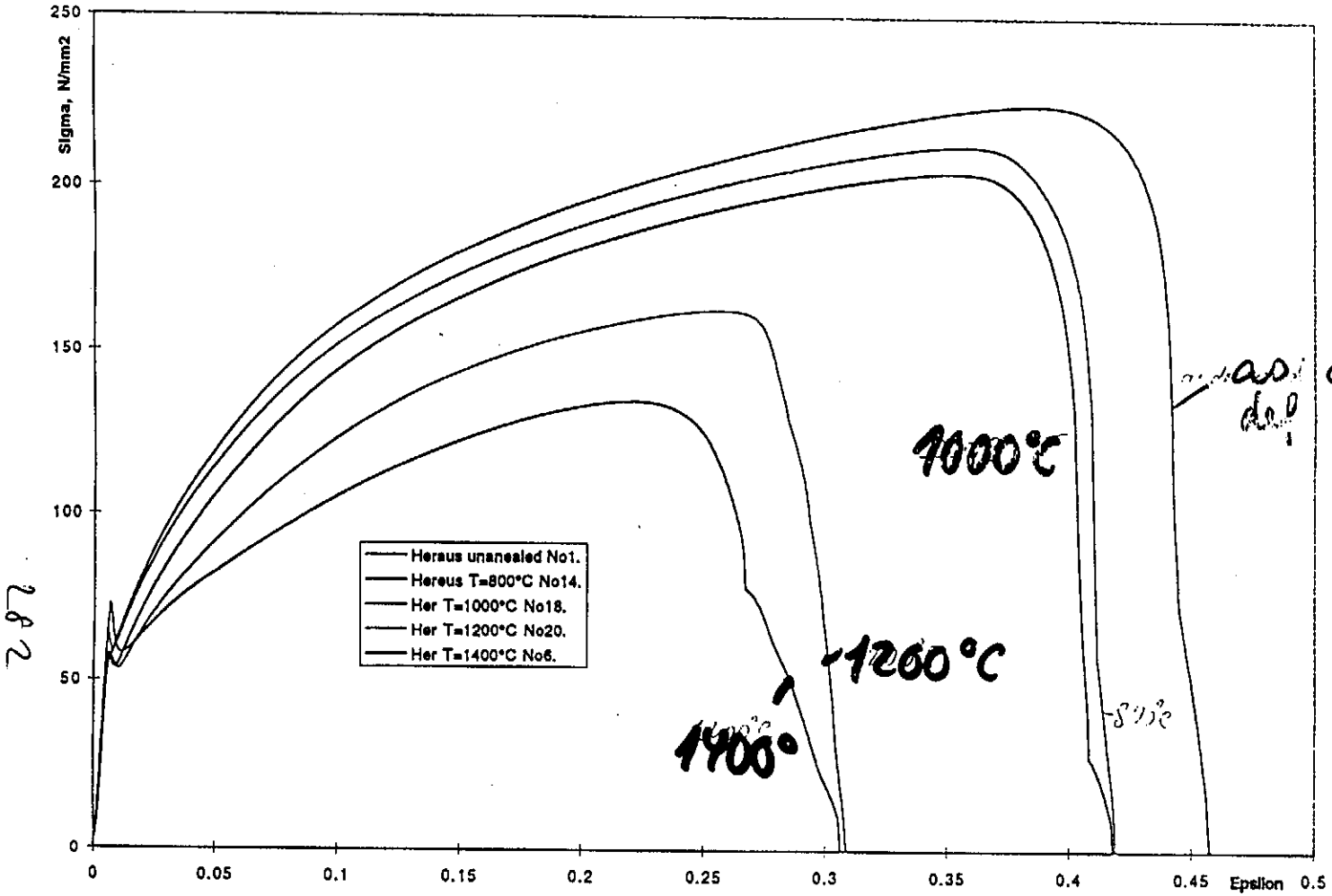
1P4


Temperature profile
24.71
1.7E+9
1P4
upper
equator
azimuthal position
0
90
180
270
360

290


Cavity 1K1
10^{11}
10^{10}
10^{9}
Q_0
quench
after 80 µm BCP and HT 800 C
0
5
10
15
20
25
E_{acc} [MV/m]

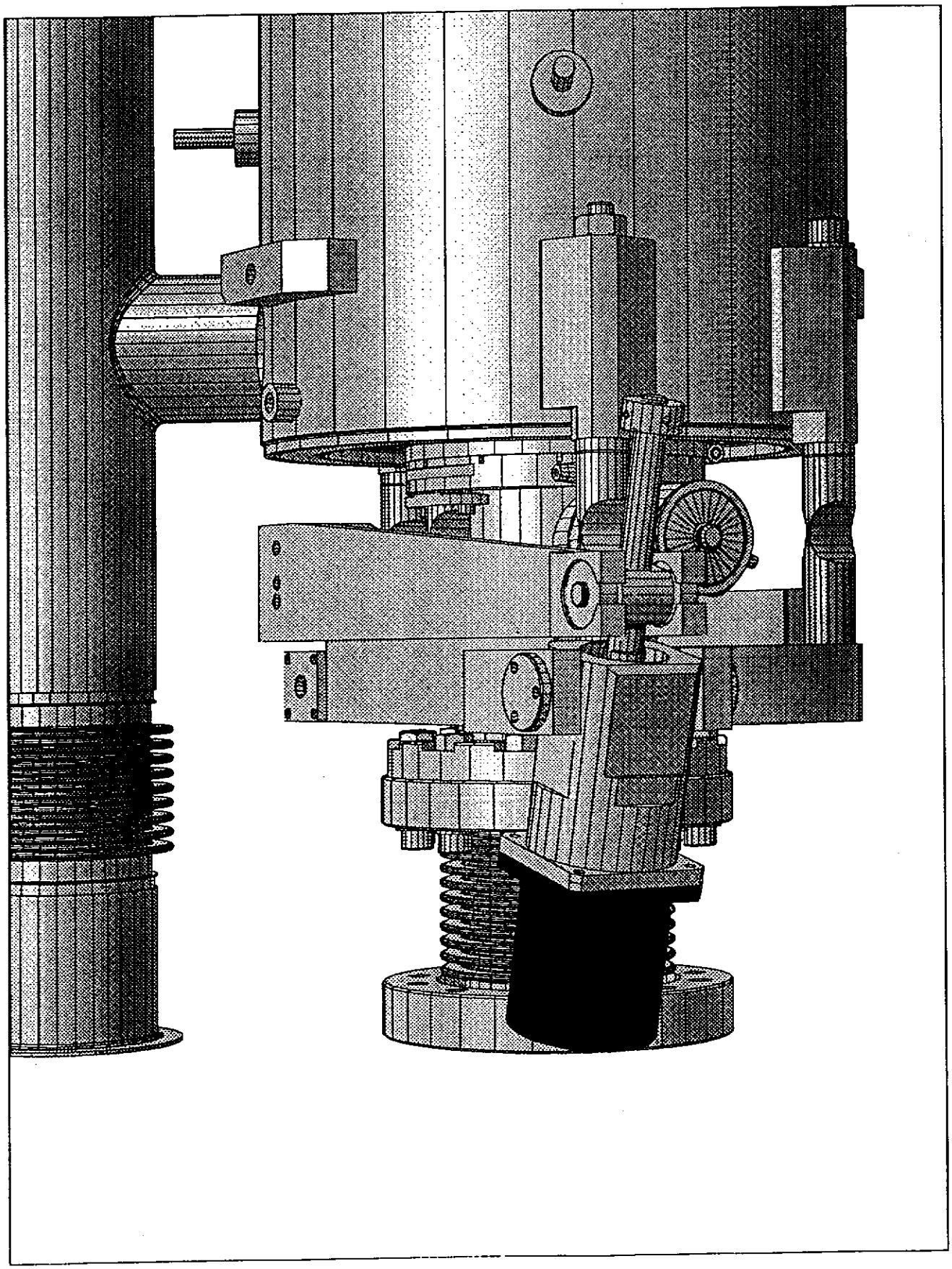
W. Singer

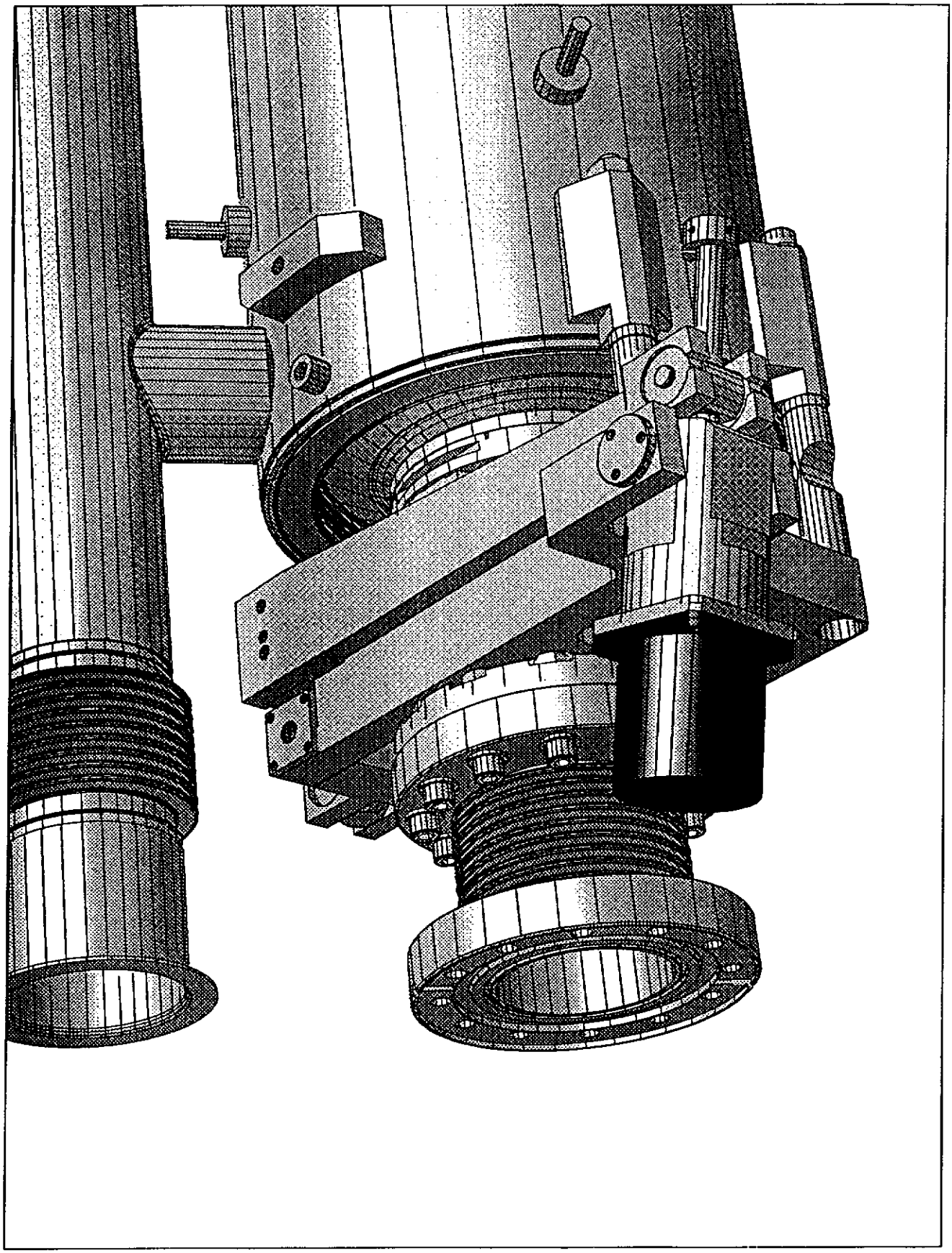


Nb tubes (Heraeus, GKSS)
RRR 150, 300

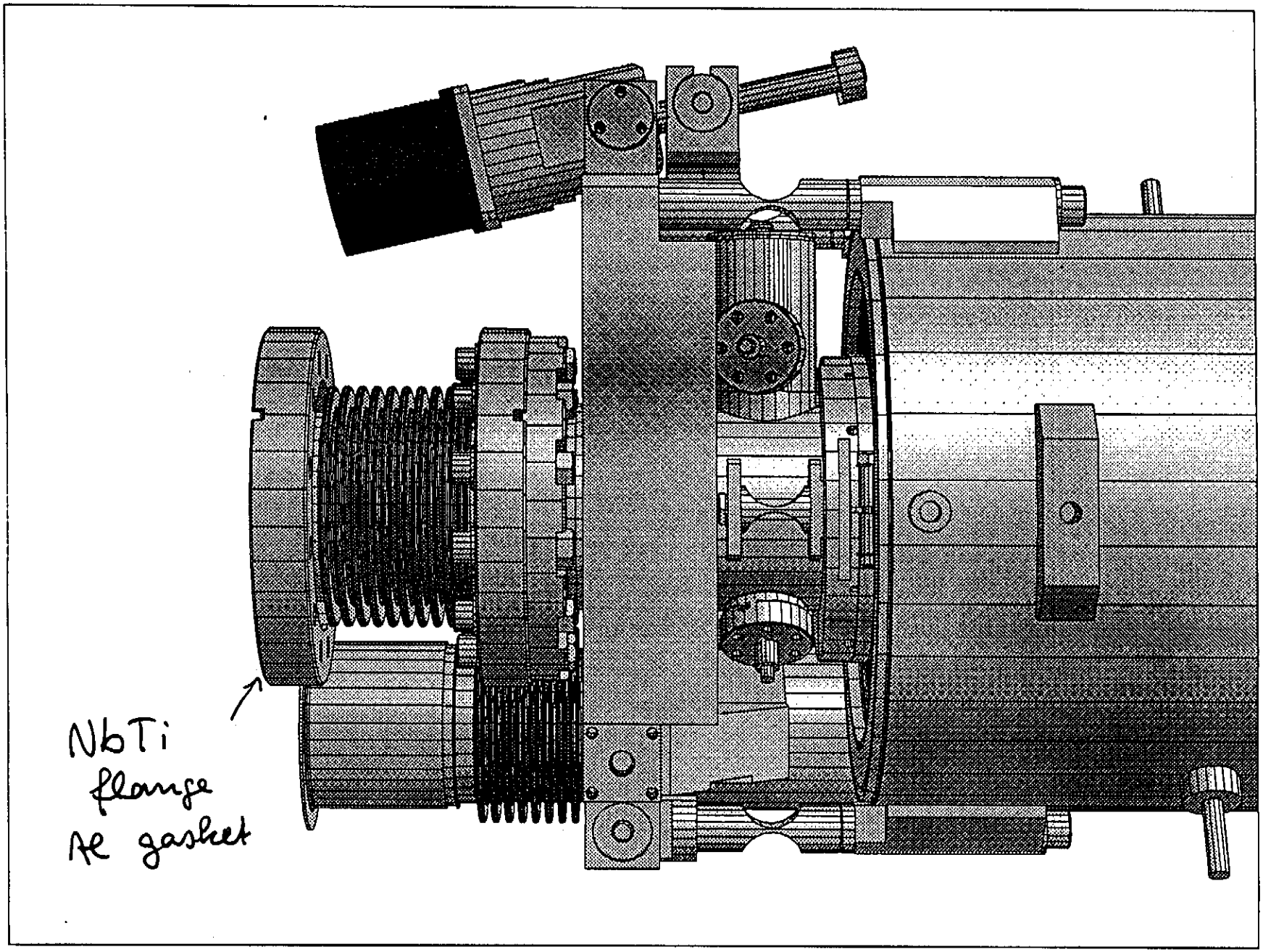
so far: very unisotropic
strain 50% along axis
" ~15% along circumference

3D model T. Shoge

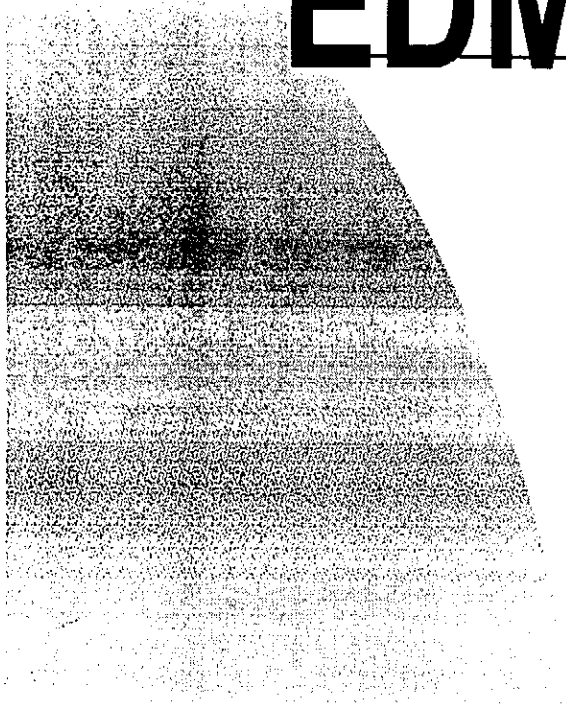




3D model H.B. Peters ...



EDM and CAD for TTF



U. Gensch, J. Bürger,
H. Kammerlocher

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Content

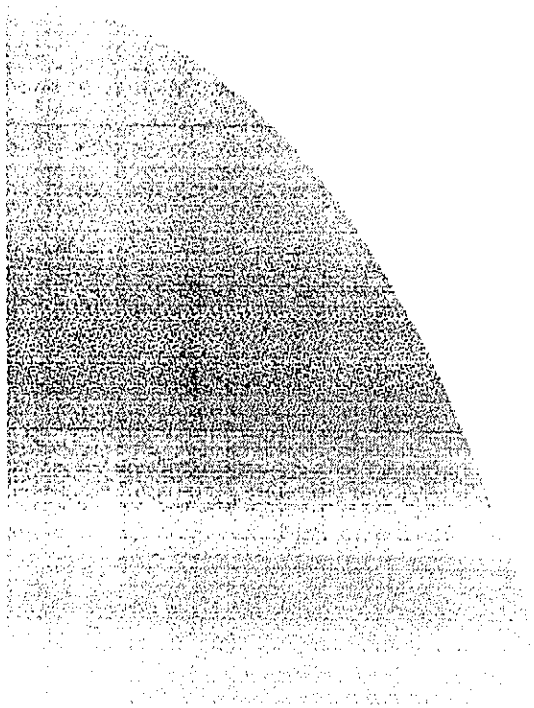
- DESY Intentions on CAD and EDM
- General Overview EDM/PDM
- WEB Based Document Management for TTF - TuoviWDM - Functionality
- TuoviWDM Status
- Outlook

DESY Intentions: CAD

- Limiting Mechanical CAD on DESY Site
  - 2D - AUTOCAD
  - 3D - IDEAS
- No Replacement for 2D TV2000 System
- Integration of these Systems into EDM
- Digital Archive for CAD Drawings

DESY Intentions: EDM

- EDM Project Group since 4/1997
- EDM System for DESY (Pilot: TTF)
  - 1. Step TuoviWDM Document Management
- Support for TTF Drawings Archive by the EDM Group



EDM Task Force

- EDM Group:
  - W. Busjan
  - H. Kammerlocher
  - O. Stöver
- W1:
  - H. Münch
  - K.-P. Schriefers
  - T. Stoye
  - B. Singer
- ZDV:
  - G. Erhorn
  - L. Hagge
- MEA:
  - U. Segelbacher
- F-Bereich:
  - J. Bürger
  - U. Behrens
- M-Bereich:
  - R. Bacher

General Overview EDM/PDM

- Management of all Technical Information
  - Part Structure
  - Classification of Information
  - Different Views for Access
  - Versions of Parts and Documents
  - Configurations of TTF or Components
  - Save Storage and Access
  - Tracking of History

General Overview EDM/PDM

- Managment of Processes (Workflow)
  - Concurrent Engineering
  - Part Release Procedures
- Communication
  - Automatic Notification
  - Markup and Redlining
- International Availability 24h/7d

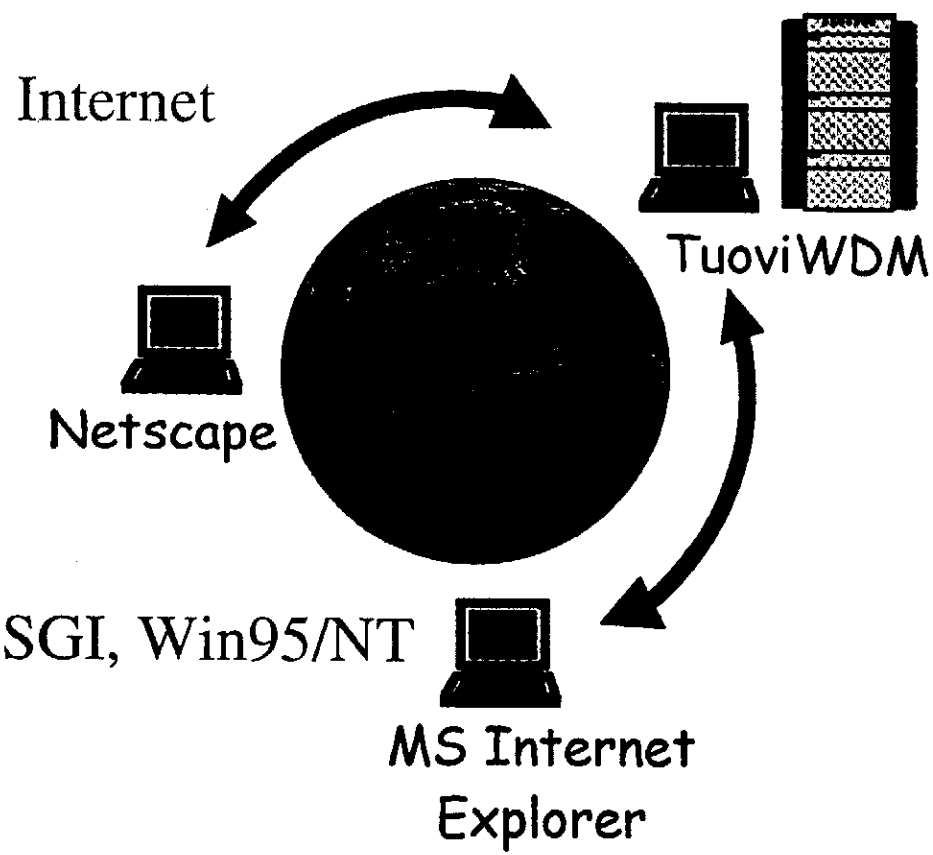
TUOVIWDM

- TuoviWDM - simple document Management system
- made by Helsinki Institute of Physics
- made for CERN

TuoviWDM - characteristics

- WEB based
- easy tree based navigation
- search engine
- document load and storage through WEB Browser by the creator or owner
- access control for individuals and groups

TuoviWDM


Internet
Server:
SUN Ultra
TuoviWDM
Netscape
Clients:
SUN, HP, SGI, Win95/NT
MS Internet
Explorer

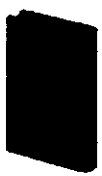
TuoviWDM - Client

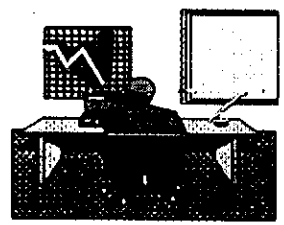
- Requirements for the client
- Modern www browser
  - Netscape 3, MS Internet Explorer 4
- Applications to view the document:
  - Ghostview for ps files
  - acrobat reader for pdf
  - graphic viewer for tif, hgpl, ...
  - application which has been used to create doc.
  - .....

Types of Documents

Physics Paper

Specification

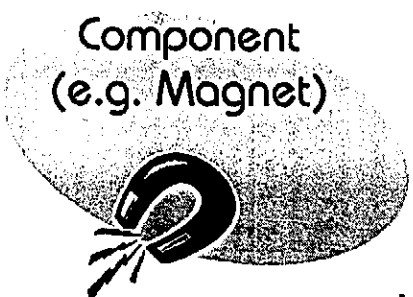




Project Plan

Calibration Constants

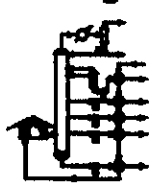
Component (e.g. Magnet)



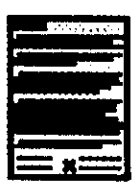
Mechanical Design

Notes

Infrastructure Design



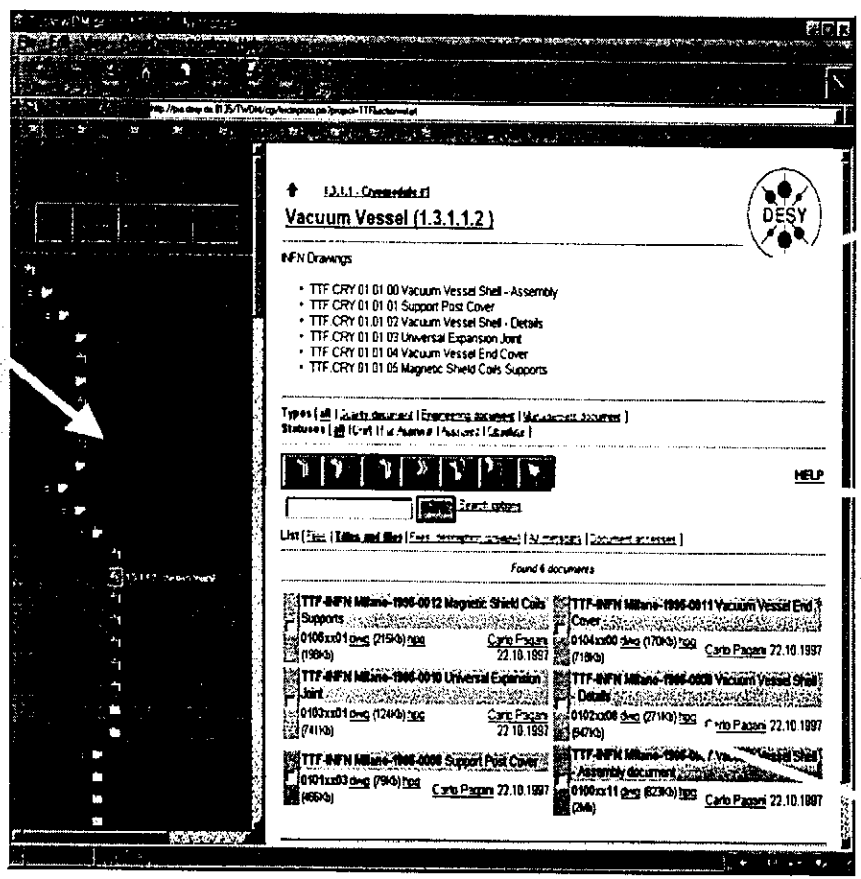
Contracts



Electrical Design

TUOVIWDM - Layout

Tree Structure for Navigation in the Archive



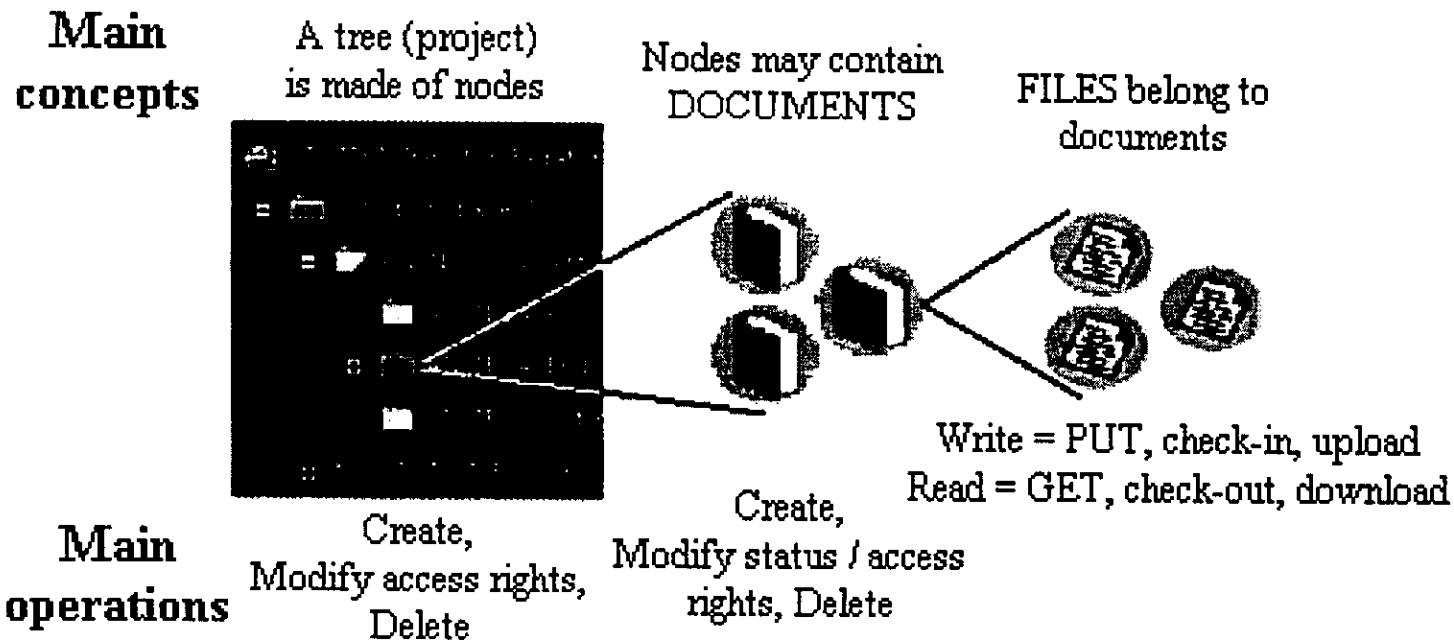
Header with Description

Control Buttons

List of Documents

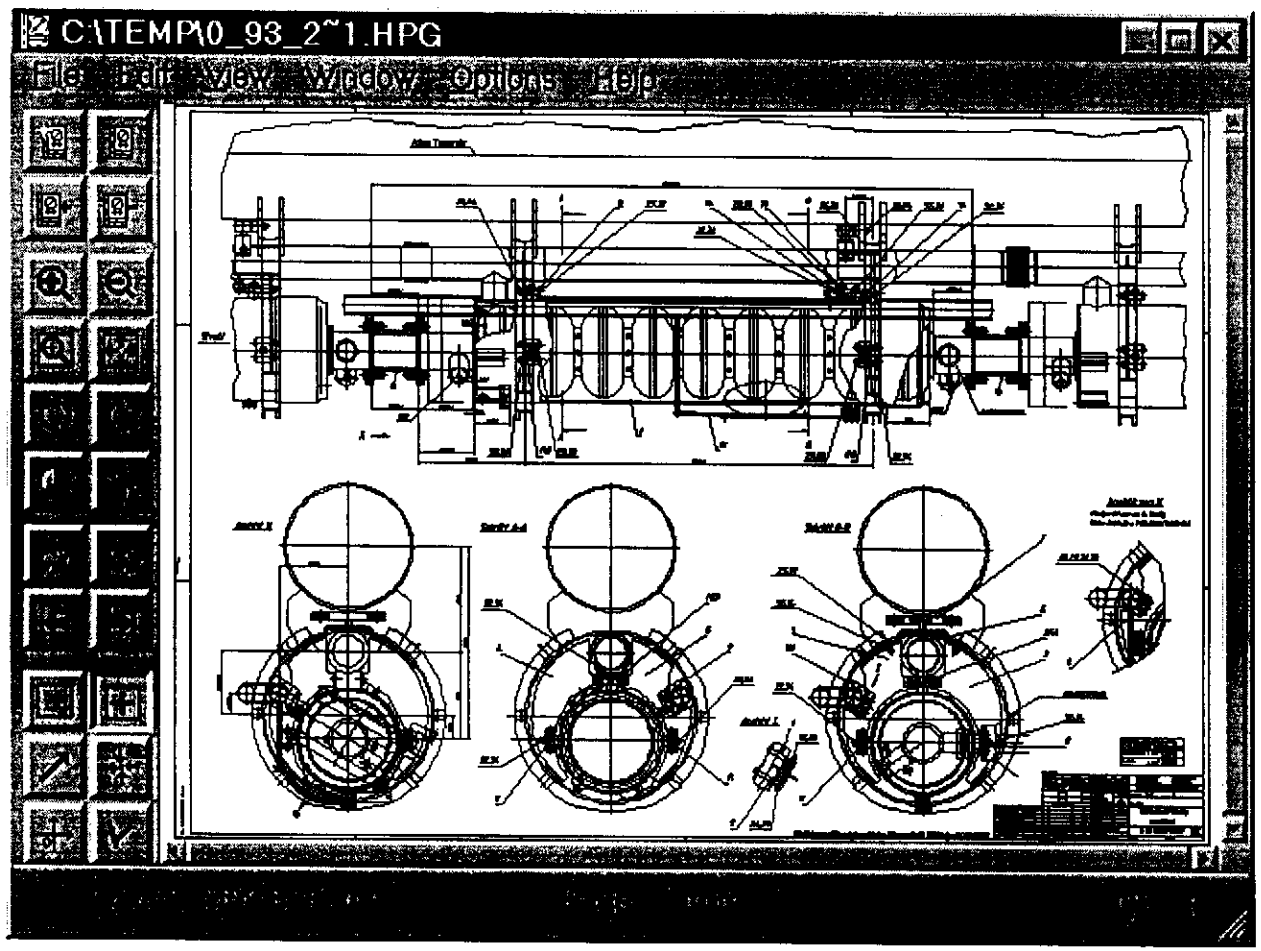
Documents in TuoviWDM

Navigation in directory structure
Organisation in documents
Storage in files



CERN HPGL Viewer

Features:
- Zoom
- Rotate
- Print
- Redline



Free for all HEP Institutes

TuoviWDM Status

- TuoviWDM TTF Project since 11/1997
- >800 TTF Drawings checked in by now
- Administrator for TTF: H. Weise
- NT PC with A3 Printer in Hall 3 for TTF Reconstruction Phase 1998 available
- 23 Projects in total at DESY

TuoviWDM - add ons

- Code number generator
- Preview-function
- List of new and changed Documents

EDM Contacts

- H. Weise as TTF Administrator
- W. Busjan wolfgang.busjan@desy.de Tel. 4946
- H. Kammerlocher kammerlocher@desy.de
  Tel. 3521
- CERN HPGL Viewer:
  Marcel Mottier E-Mail: marcel.mottier@cern.ch

TuoviWDM Present Concern

- Drawings need to be up to date mid August
- Join in and give us your drawings now or check them in on your own

Outlook

- Complete Set of TTF Drawings in 1998
- Selection of commercial EDM Product
- Move of TTF Environment in 1999 into commercial EDM System

Working Group R + D

P. Schmüser, (D. Proch), G. Müller

1.) Structure development:

- FM-Coupler for superstructure
  - rectangular waveguide — Holthaup
  - coaxial waveguide — Proch
- TW-structure as alternative? (2 interfering linefeeds) — Bolshakin ~~Vogel~~
- Numerical simulation of superstructure — Gloch/Schutowicz
- (• Tuner) THz-Absorber/Schlarb

2.) Cavity fabrication:

- Material quality control
  - SQUID-Scanning of sheets — Singer/Schmüser
  - (– Nb-Surface by HRSEM + EDX) → 3.)
  - H_{c1}/H_{c2}-Measurements – Pinning — Schmüser/Halbritter
- Seamless cavities
  - Hydroforming — Aune ~~Kaiser~~
  - Spinning — Singer
  - Nb-tubes — Lilje
- Nb/Cu-cavities — Aune

Study of a Wave Guide Coupler for SC Cavities.

M. Dohlus, A. Gamp, H. Hartwig, N. Holtkamp, A. Jöstingmeyer, C. Martens, M. Marx, C. Pagani, J. Weisend, I. Yaregin

- General Advantages of a Waveguide Coupler
  - » space (longitudinal)
  - » window design
  - » power capability + dynamic losses
  - » behaviour with multipactor
- Layout of a Waveguide Coupler
  - » Coupler Design
  - » window integration
  - » mechanical constraints for transverse movement
  - » static and dynamic losses+ material choice
- Geometry and Environment of the Waveguide coupler
  - » available space for the window
  - » temperature of the window
  - » 1 or 2 window concept + vacuum pumping
  - » connection between coupler and cavities

Dynamic Losses

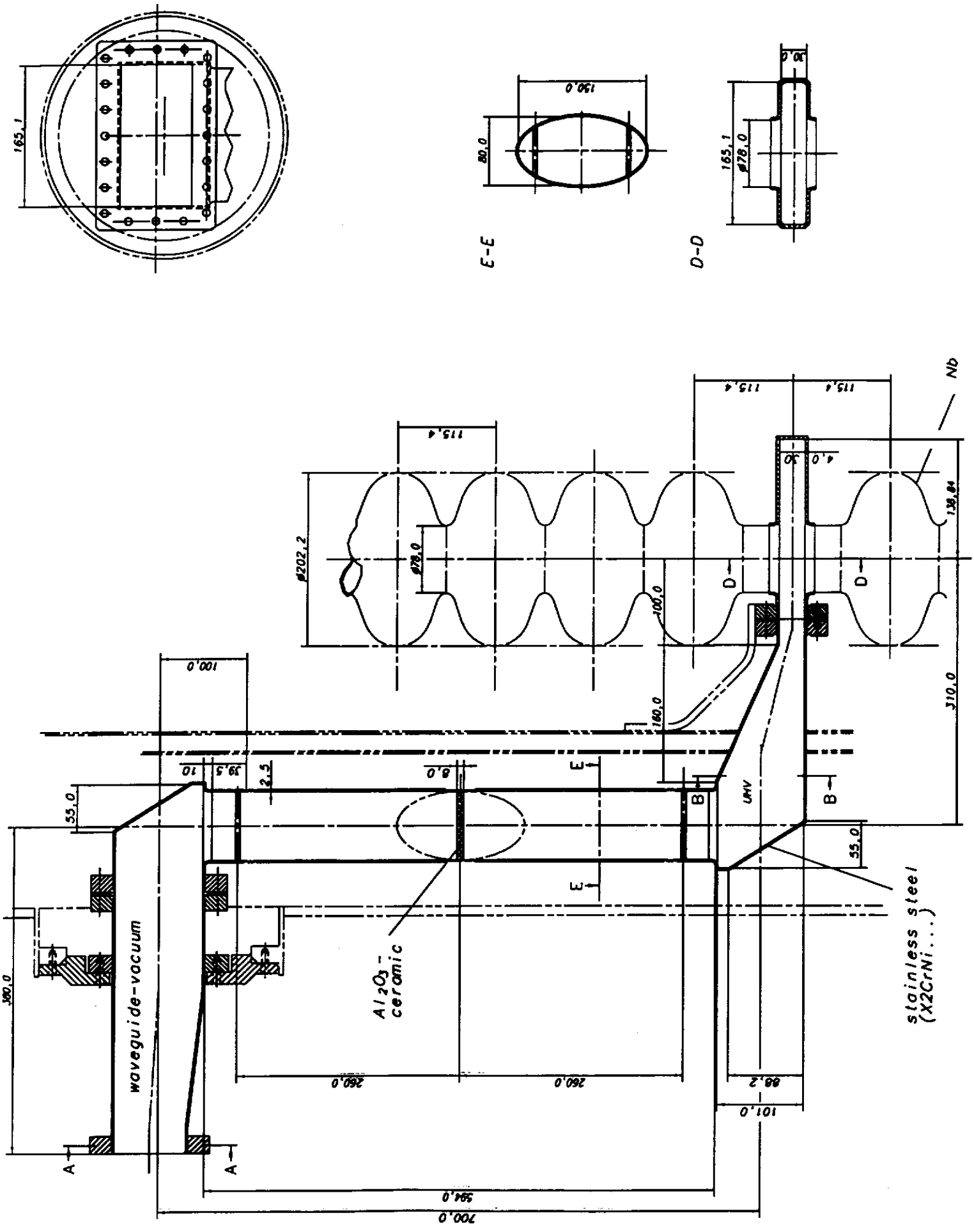
- General:
  - » losses in the coax coupler are higher because: Z_{coax}=50 Ω <-> $Z_{rect.}$ ~500 Ω
  - » losses mainly occurr at inner conducter (bad for cooling and heat flow)
  - » example : stainless steel ($\sigma = 0.5*10^7$) ratio: $\log(P_{inner}/P_{outer})$= 0.082-0.035 dB/m

$$U = \sqrt{2 \cdot P \cdot Z_f}$$

$$I = \sqrt{2 \cdot \frac{P}{Z_f}}$$

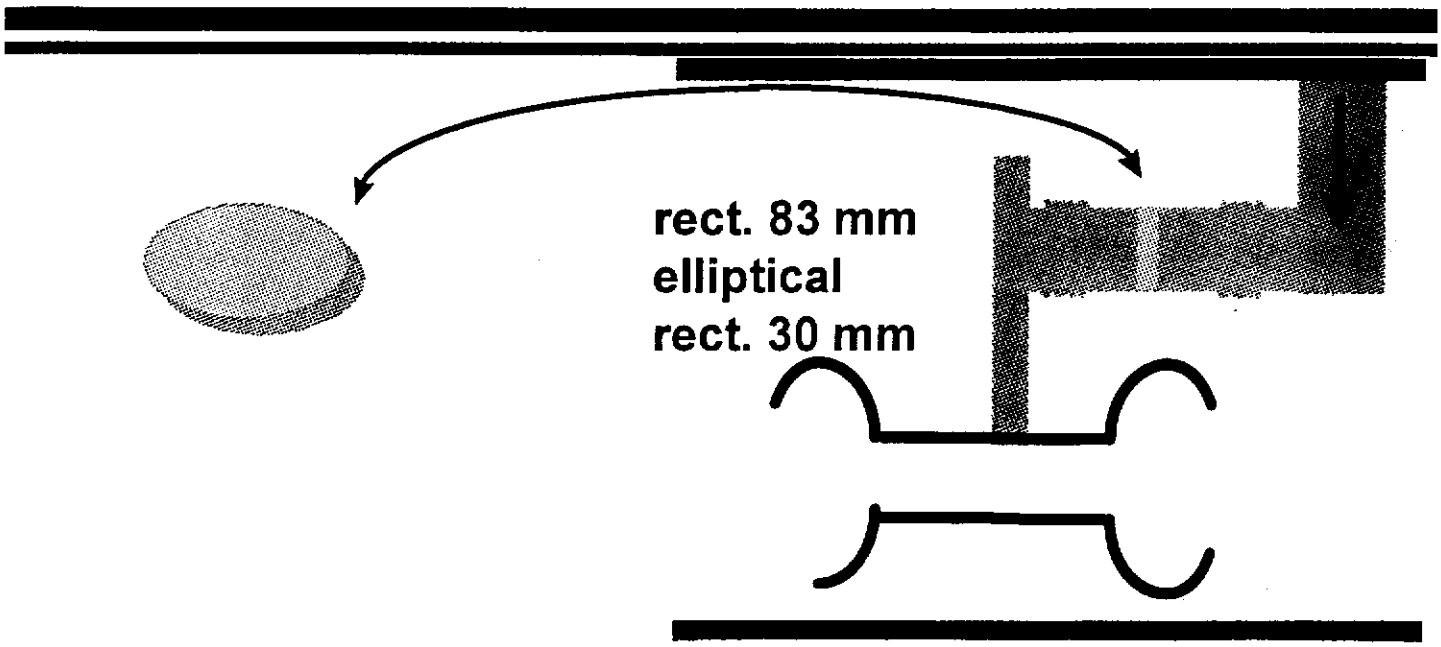
- for comparison:
  - » 50 cm coax, 60 mm diam, copper, T= 70° K
  - » 50 cm waveguide, CrNi steel, 70° K
  - **» P_{diss}(rect. waveguide) = 2 x P_{diss} (coax)**
  - **» 40 Watt** for 1 MW

MPYHJL ©MINNTHOLTKAMP, MAY08/09:40

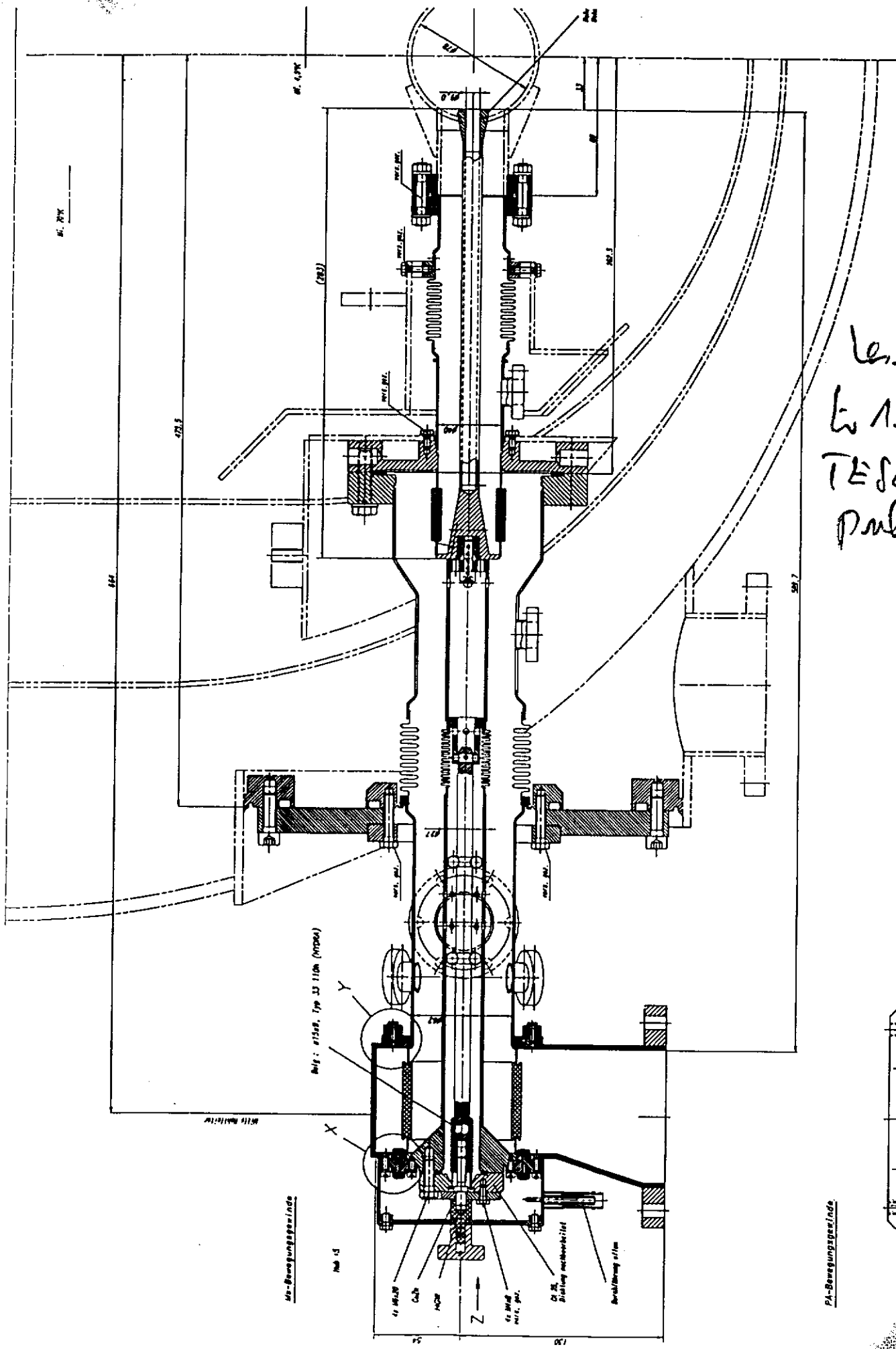

165,1
190,0
80,0
E-E
30,0
165,1
ø78,0
D-D
ND
115,4
115,4
115,4
4,0
30
130,84
ø202,2
ø78,0
100,0
D
D
310,0
180,0
100,0
10
39,5
2,5
8,0
E
E
B
B
UHV
55,0
55,0
waveguide-vacuum
Al2O3-ceramic
stainless steel (X2CrNi...)
300,0
260,0
260,0
88,2
101,0
A
A
594,0
700,0

310

Window Design



- Window Geometry
  - » reflection: <1.01 in any case with compenstion
    - – 2 or 4 posts parallel to E-field
    - – metallization of ceramic to create diaphragm
  - » thickness: most probably: 5-10 mm
    - – min. refl. at d=0 or d=37 mm
      - • both not good for manufacturability
    - – given by mechanical and thermal constraints



Lesteil
to 1.7 M
TESLA
pulse

Pro's

- Well understood multipacting scaling in coax lines

  with large outer diameter no multipacting

- Well calculated cold window design

  no danger of multipacting

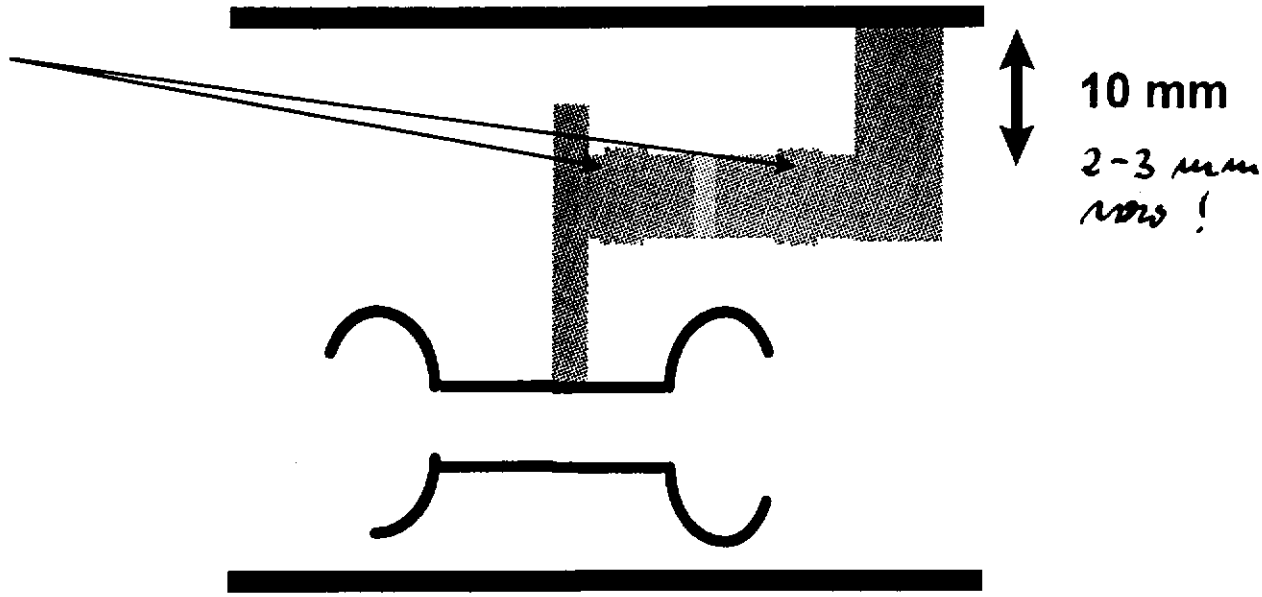
- First calculation of warm window

  no hint of multipacting

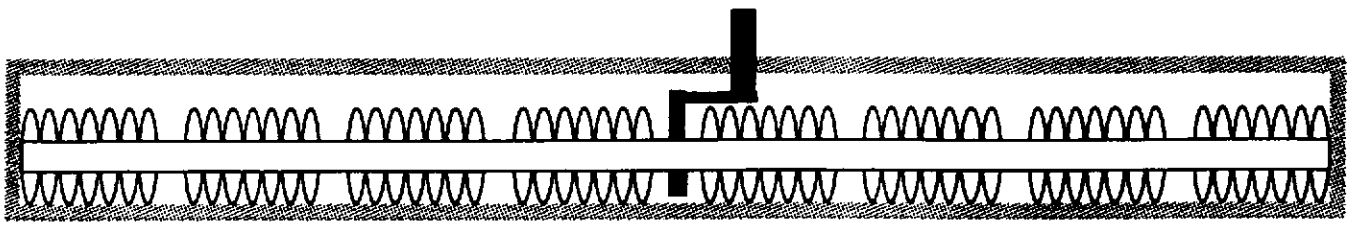
- small radial extension after closing the beam vacuum
- round flanges / welded connections
- lower RF loss on outer conductor as compared to rectangular WG
- lower peak voltage as compared to rectangular WG

Mechanical Constraints for Transverse Movement

two bellows for transverse movement of < 10 mm during cooldown

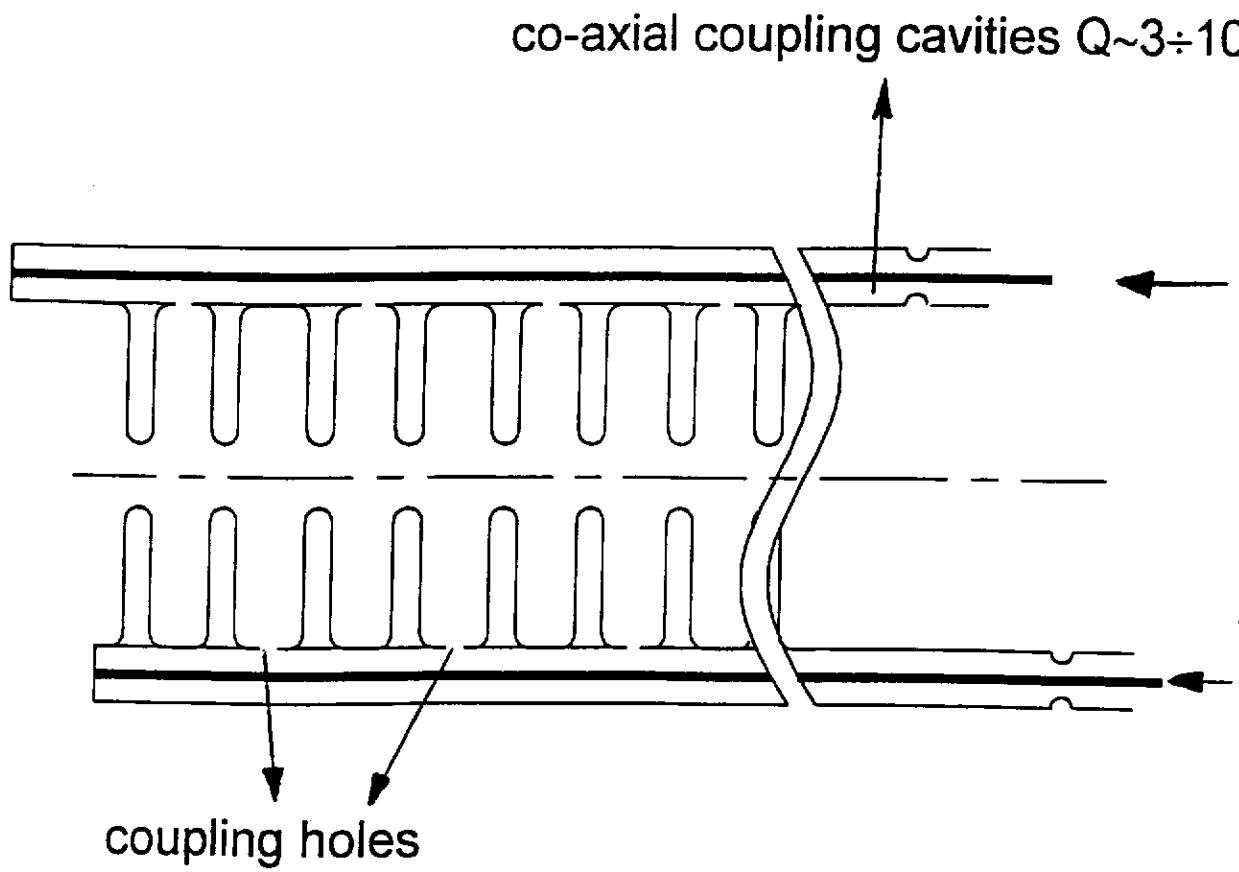


- Design of bellows
  - » reflection: < 0.7 %
  - » 4 groves, 5 x 5 mm
- longit. movement
  - » none (few: 2-3 mm) → C for new module

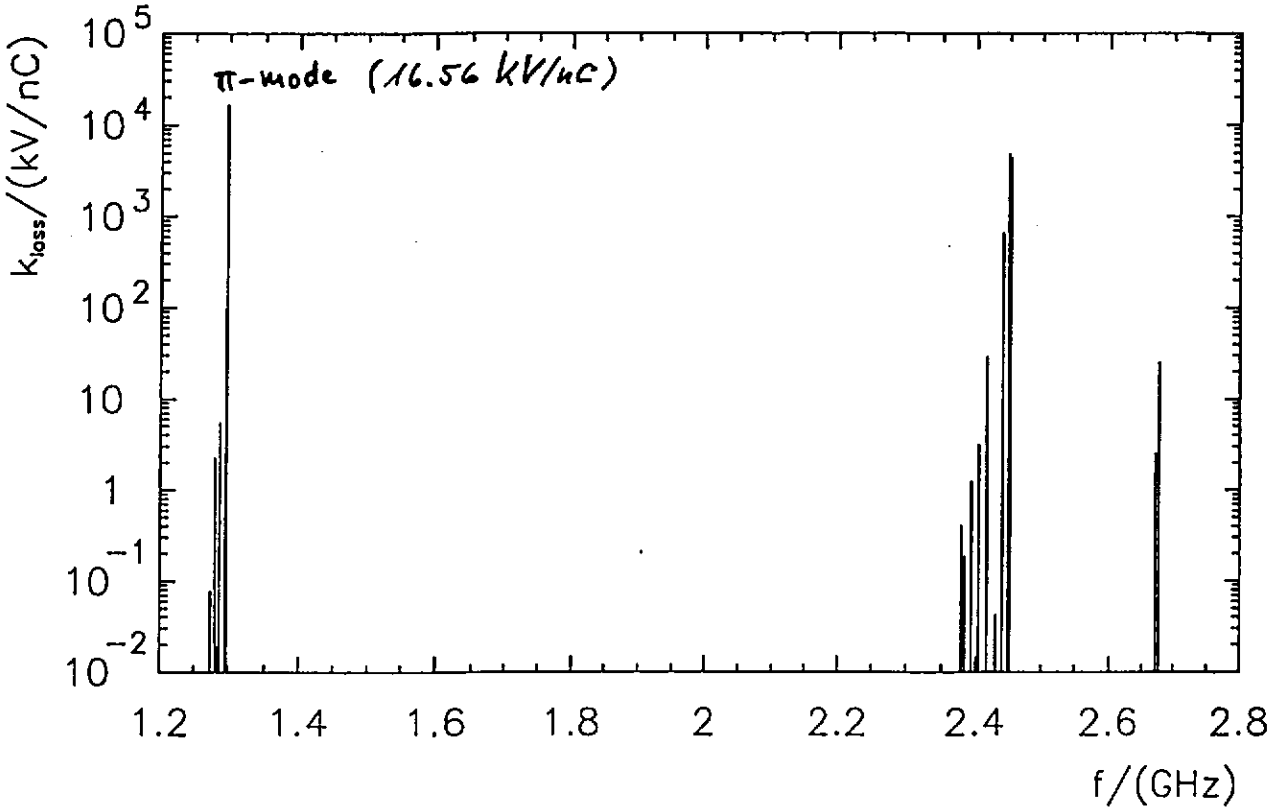


15 mm 15 mm

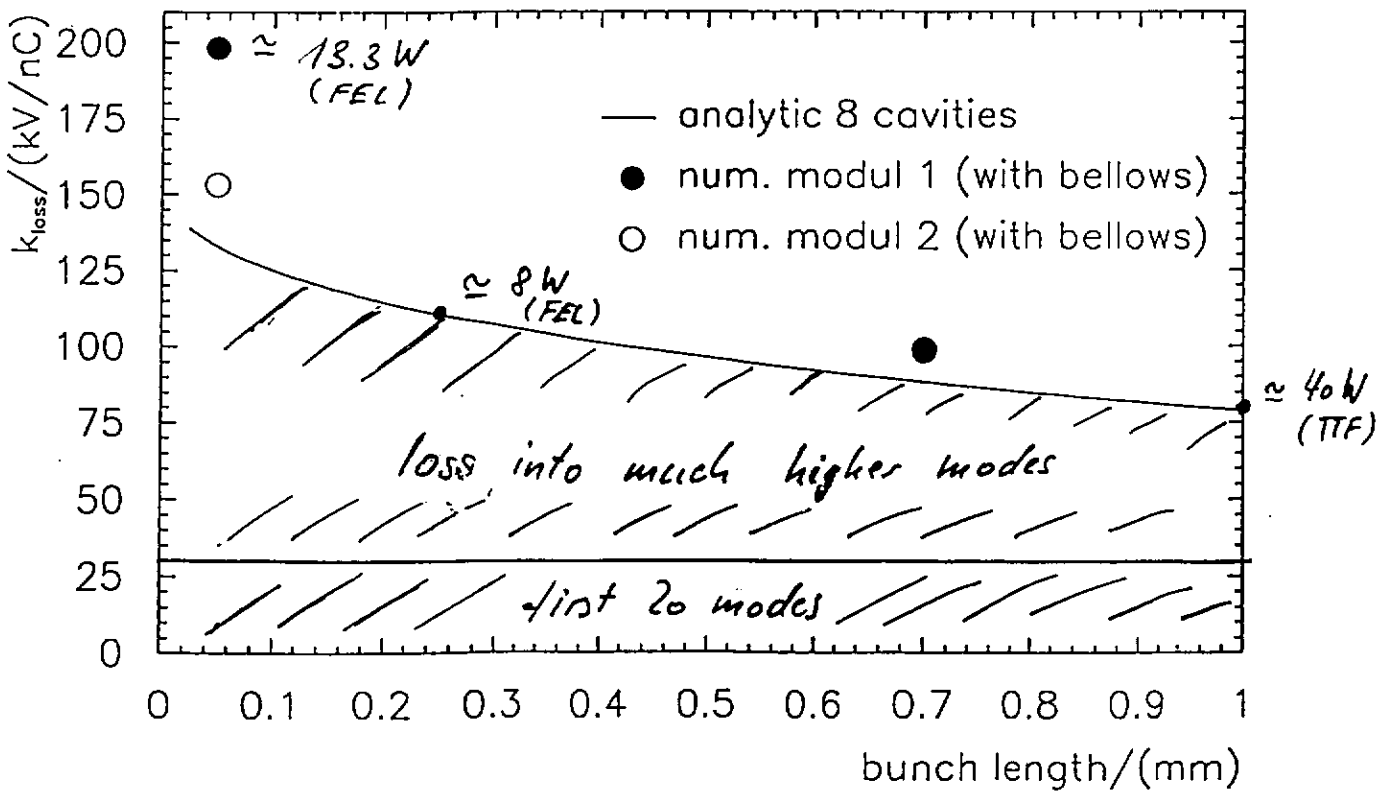
This drawback is remedied in the accelerating structure of a new type proposed built as a combination of two structures exploiting a "standing wave" regime.



Loss factor of the first 20 monopole modes* at one module – sum(k_{loss}) = 26.6 kV/nC

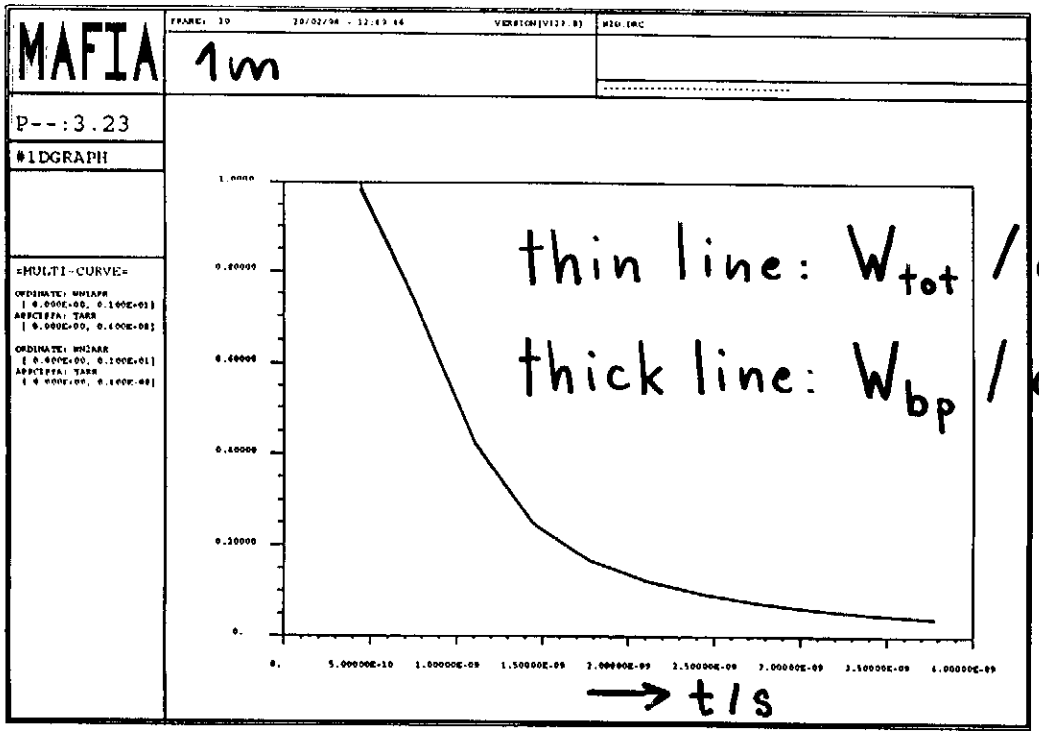


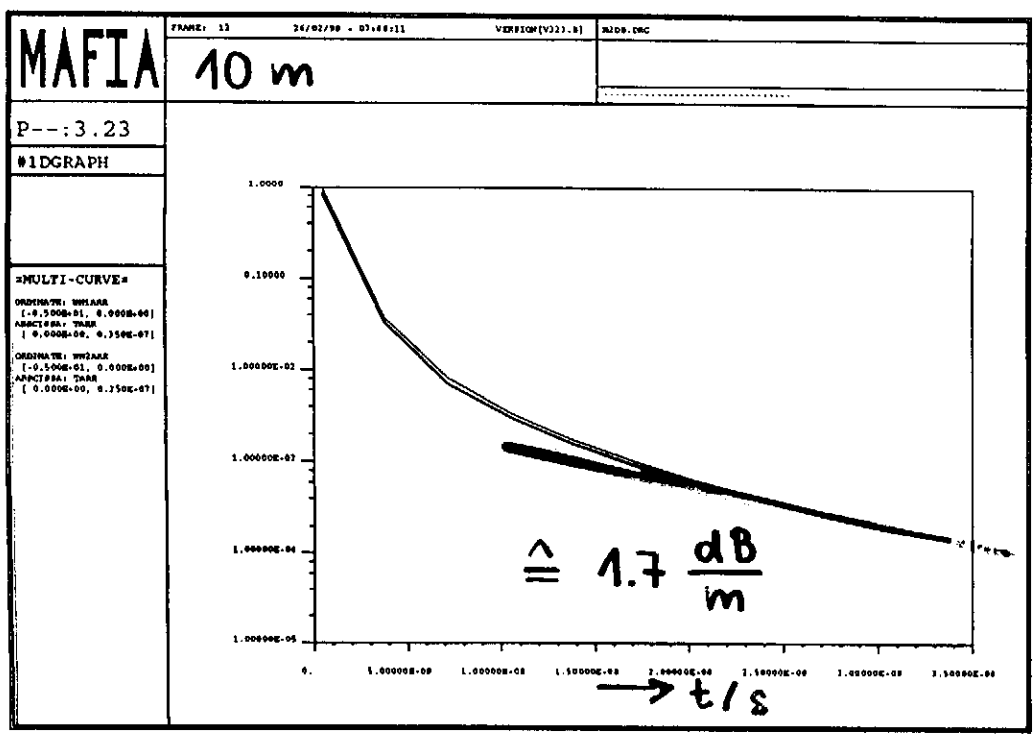
Loss factor at different bunch length @



* @ Tang

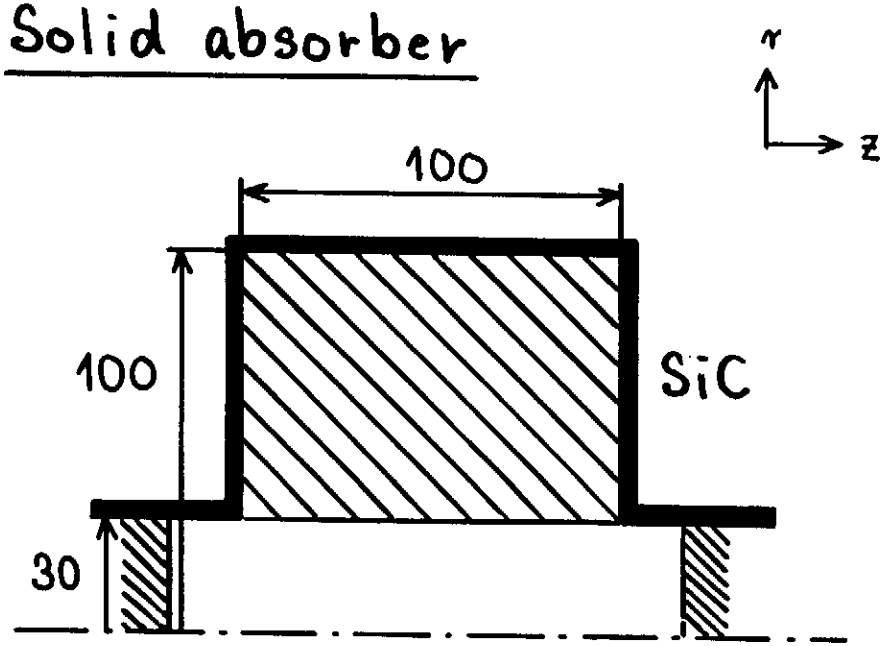
Holger Schlarb





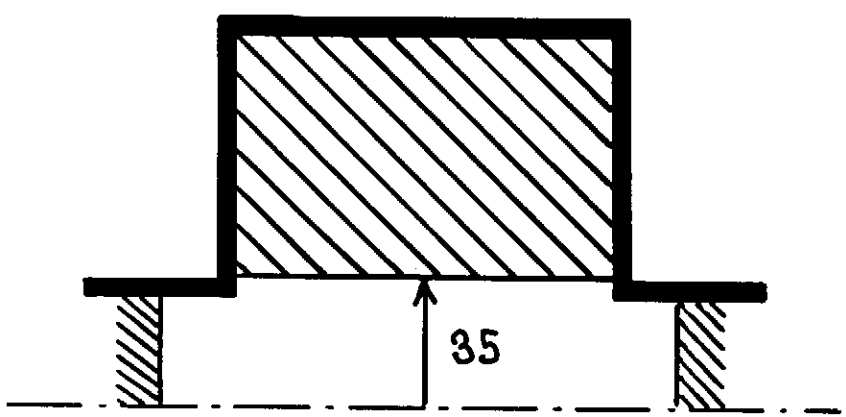
tvs

Solid absorber

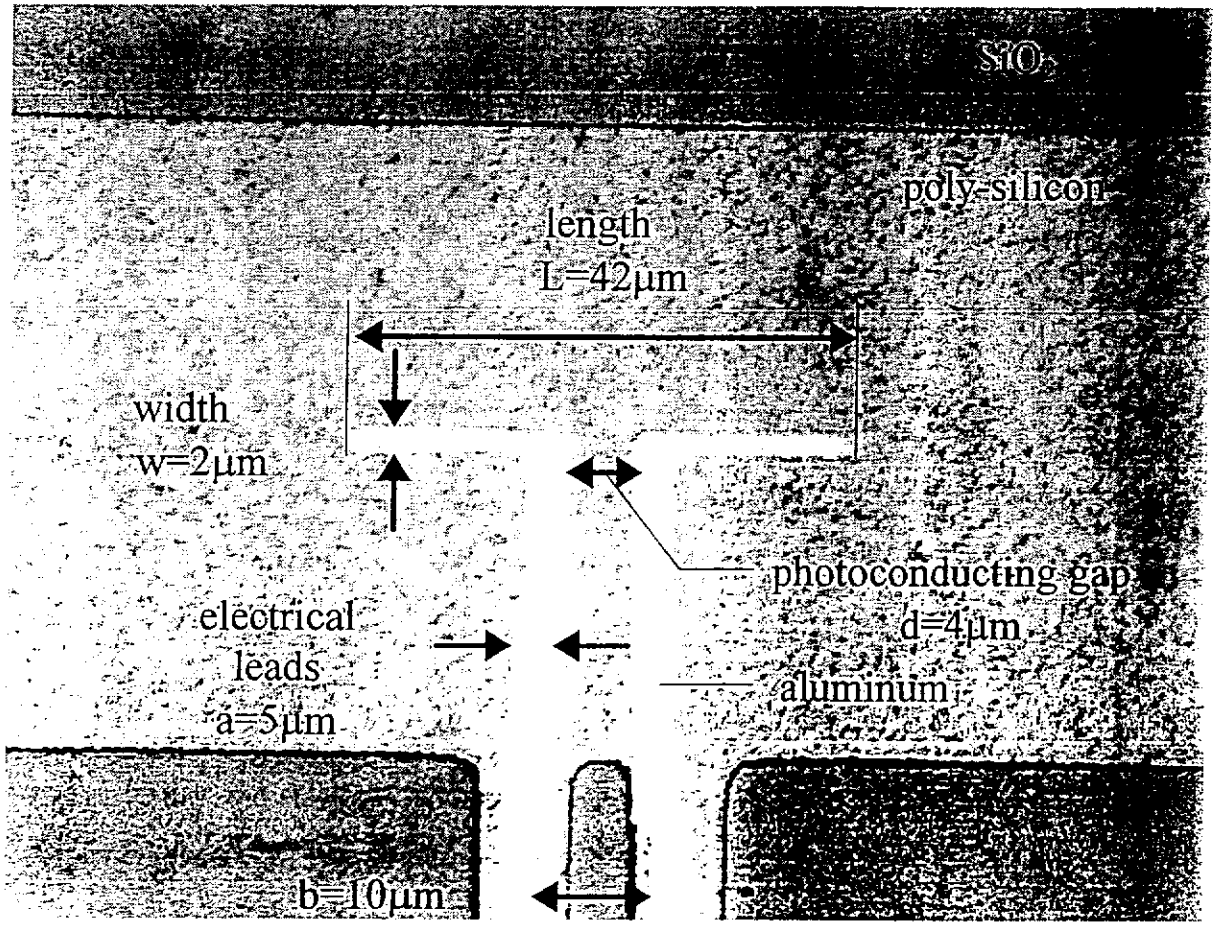


electric wall

Solid absorber (hidden):

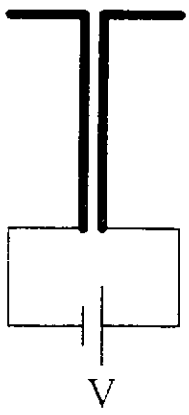


photoconducting dipole antenna
(top view)



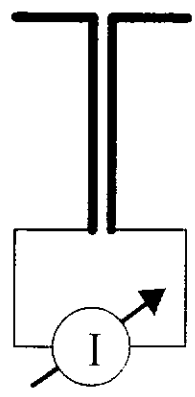
electrical circuitry

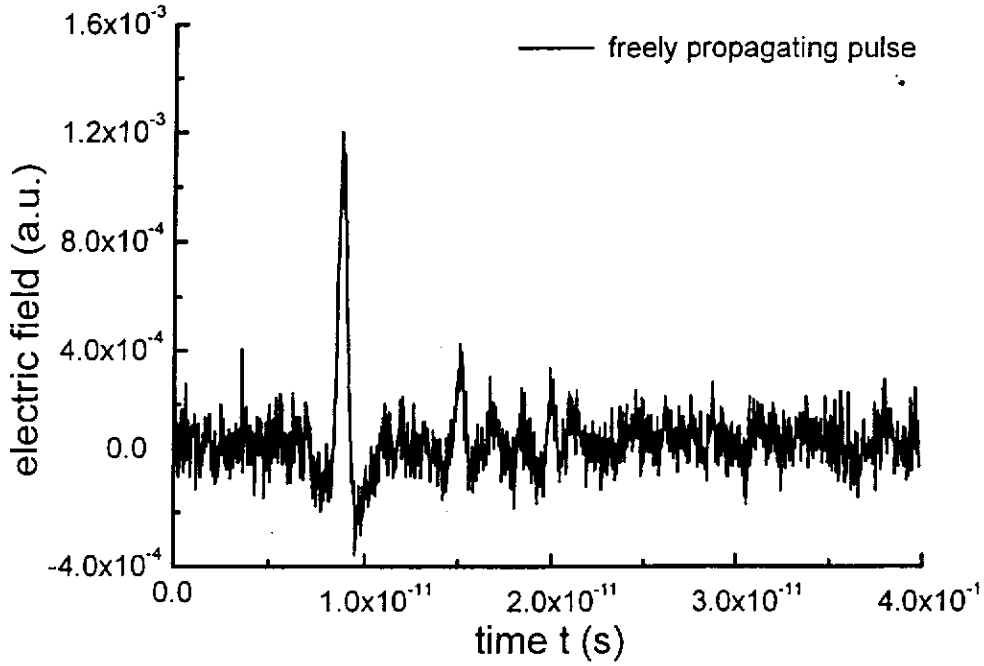
THz-emitter

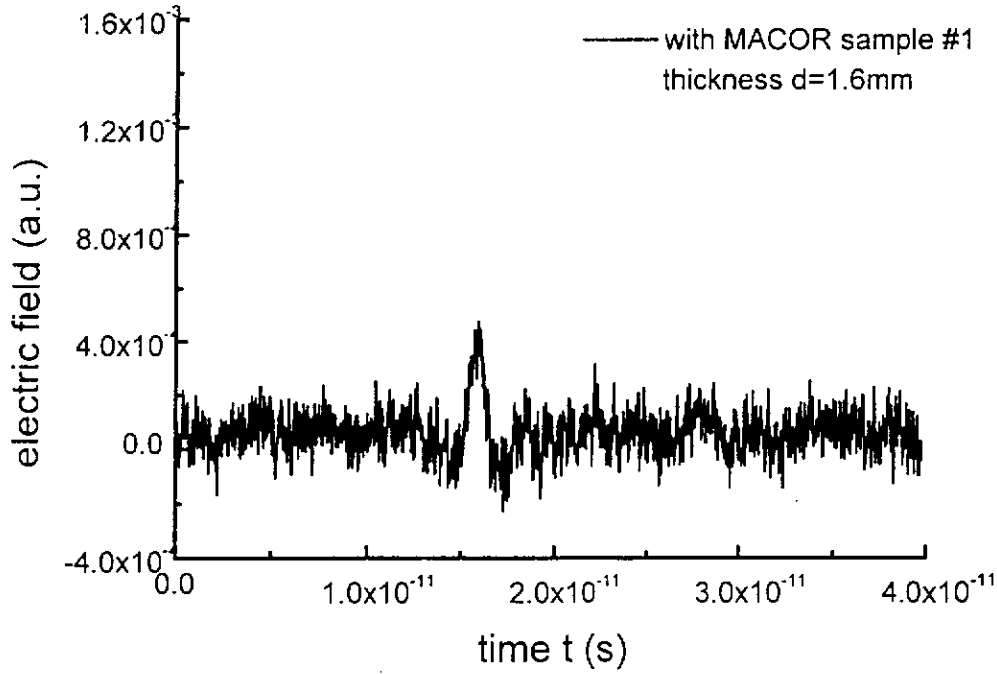


bias voltage

THz-receiver



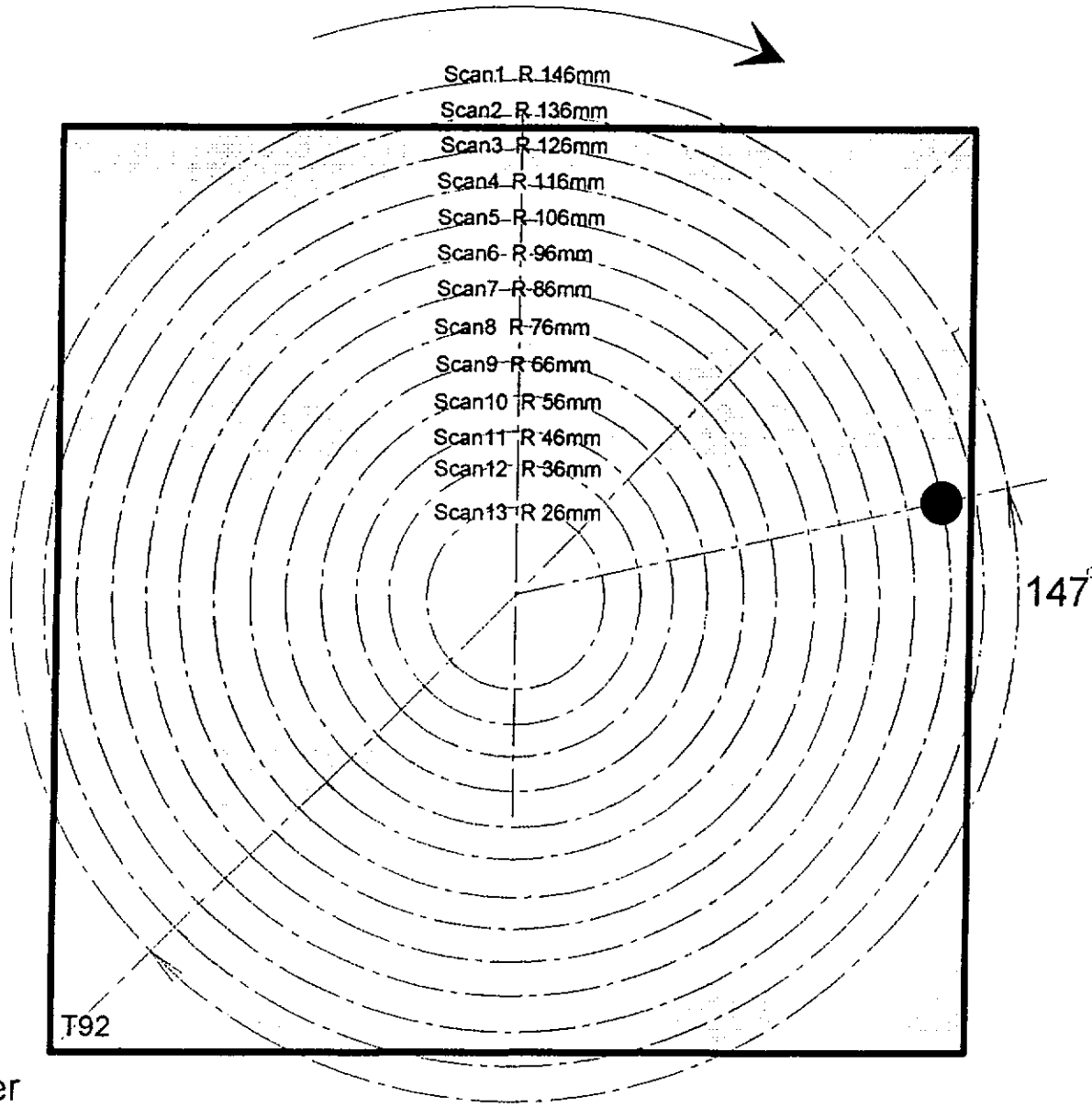

freely propagating pulse
electric field (a.u.)
1.6x10-3
1.2x10-3
8.0x10-4
4.0x10-4
0.0
-4.0x10-4
0.0
1.0x10-11
2.0x10-11
3.0x10-11
4.0x10-11
time t (s)


with MACOR sample #1
thickness d=1.6mm
electric field (a.u.)
1.6x10-3
1.2x10-3
8.0x10-4
4.0x10-4
0.0
-4.0x10-4
0.0
1.0x10-11
2.0x10-11
3.0x10-11
4.0x10-11
time t (s)

Sichger

F.I.T. Messtechnik GmbH

PROBE T92



m < 0,5 µg

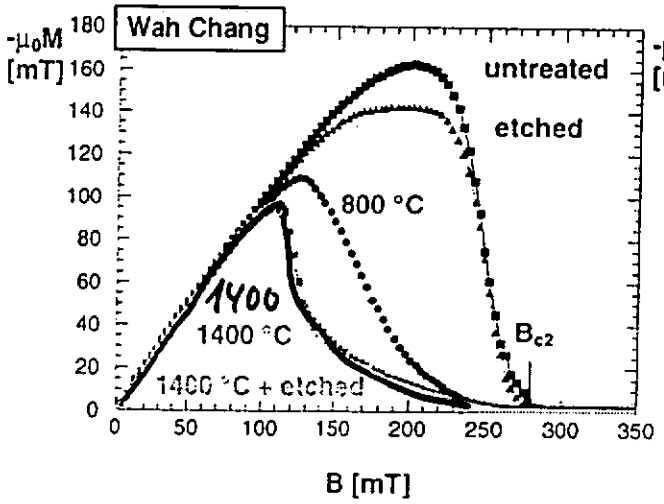
Ø < 50 µm

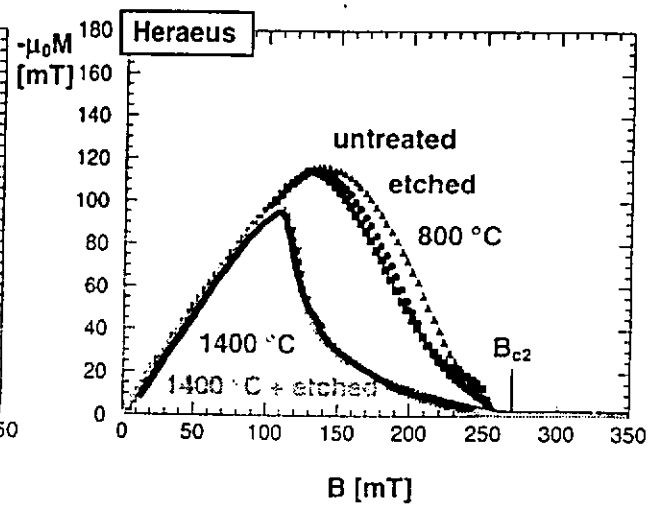
Test time of Nb-Sheet x 2 min

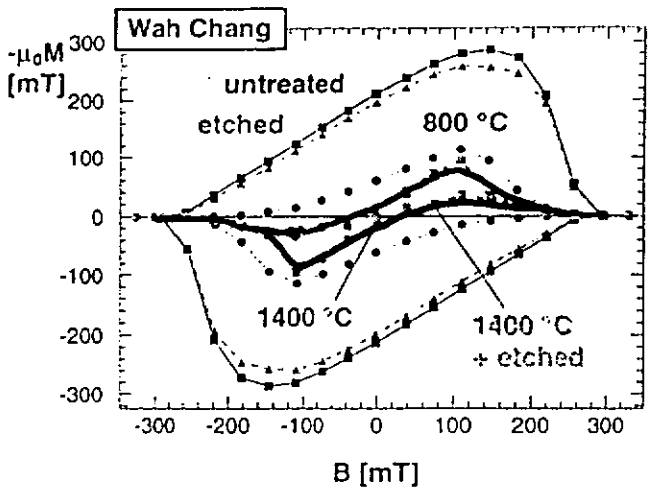
transparent

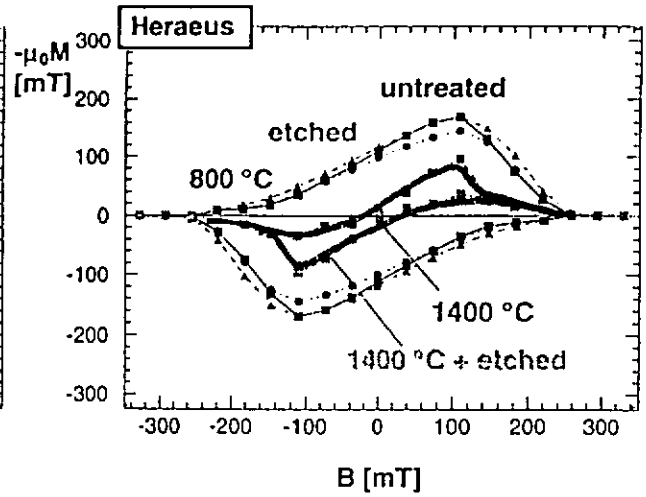
Bild 1

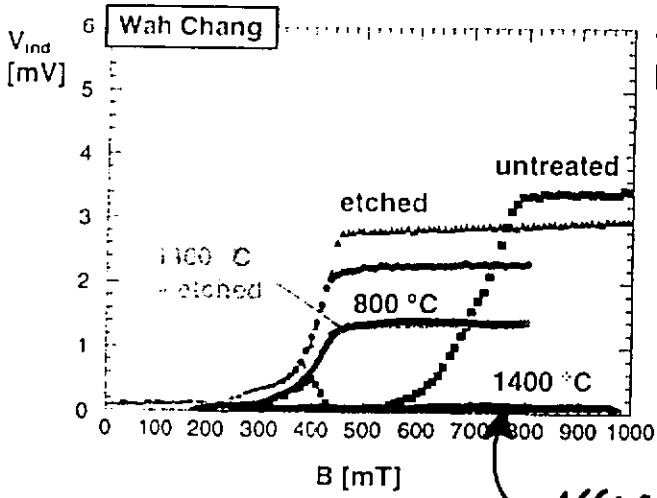
M. Bahte

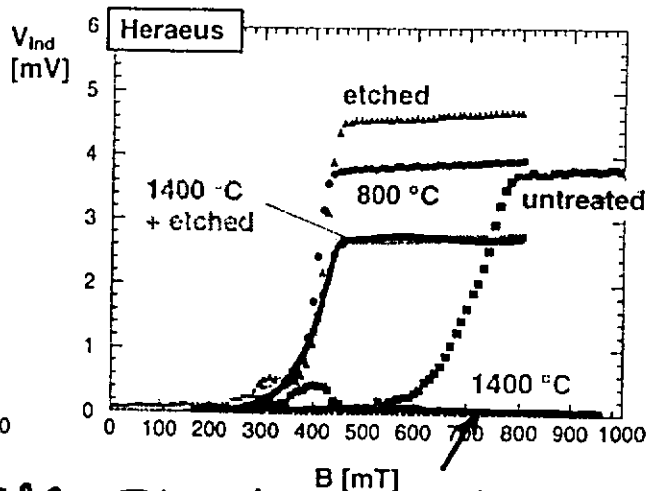












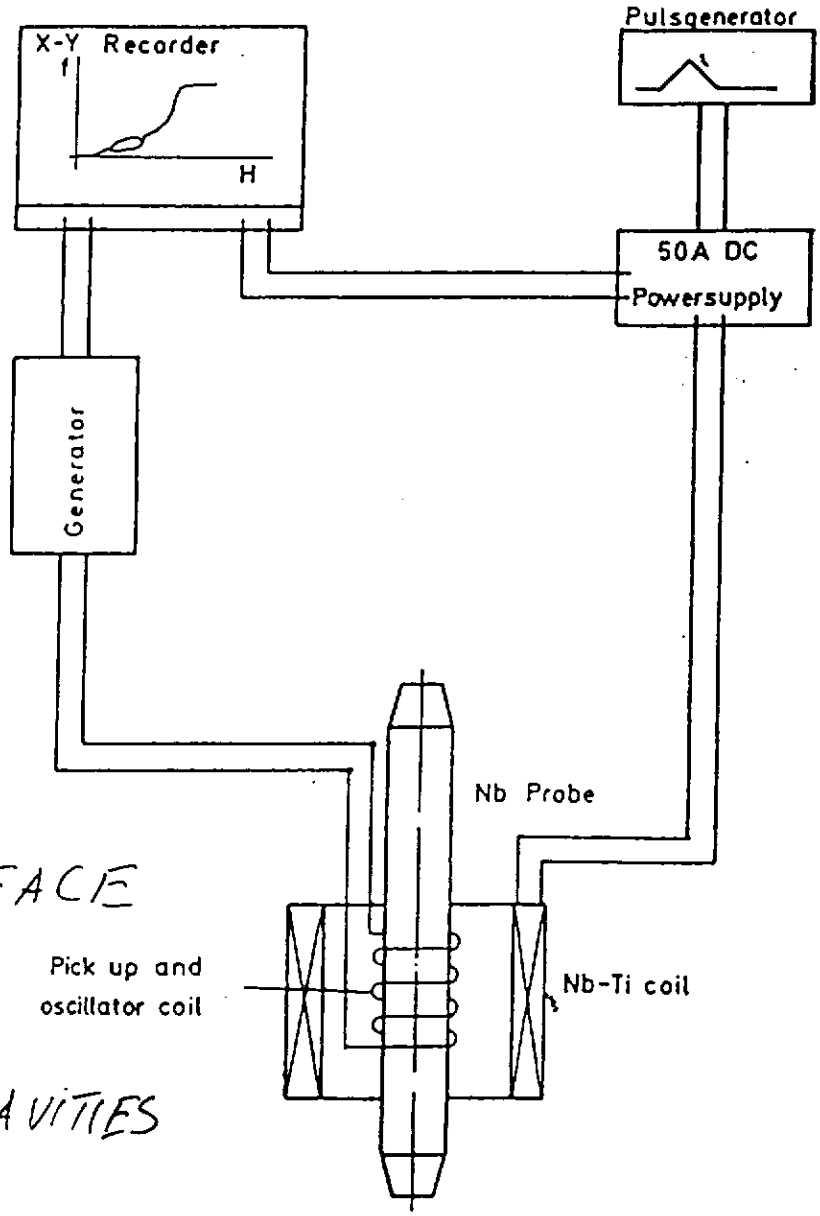
1400°C, Ti not removed

Hallwitter

SURFACE CONDUCTION METHOD

QC PENETRATION DEPTH

f ~ 10 - 1000kHz



H // SURFACE

AS

H⊥ IN CAVITIES

H > Hc1

| Hc2

Hc3

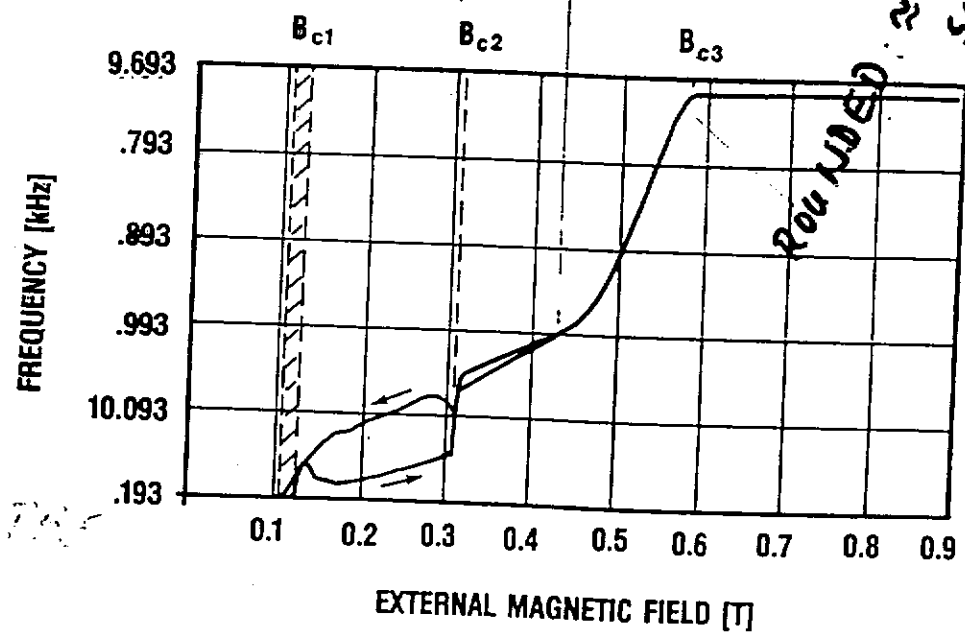
FIG. 2. Experimental setup for the measurement of fluxoid penetration depth of Nb samples at 10 kHz. The penetration depth changes with applied field changing the inductance, hence the eigenfrequency of a *LC* circuit.

$l_{BULK} \approx 0.2\,\mu m$

$l_s \simeq 0.1\,\mu m$

BULK B_{c2} (SURFACE)

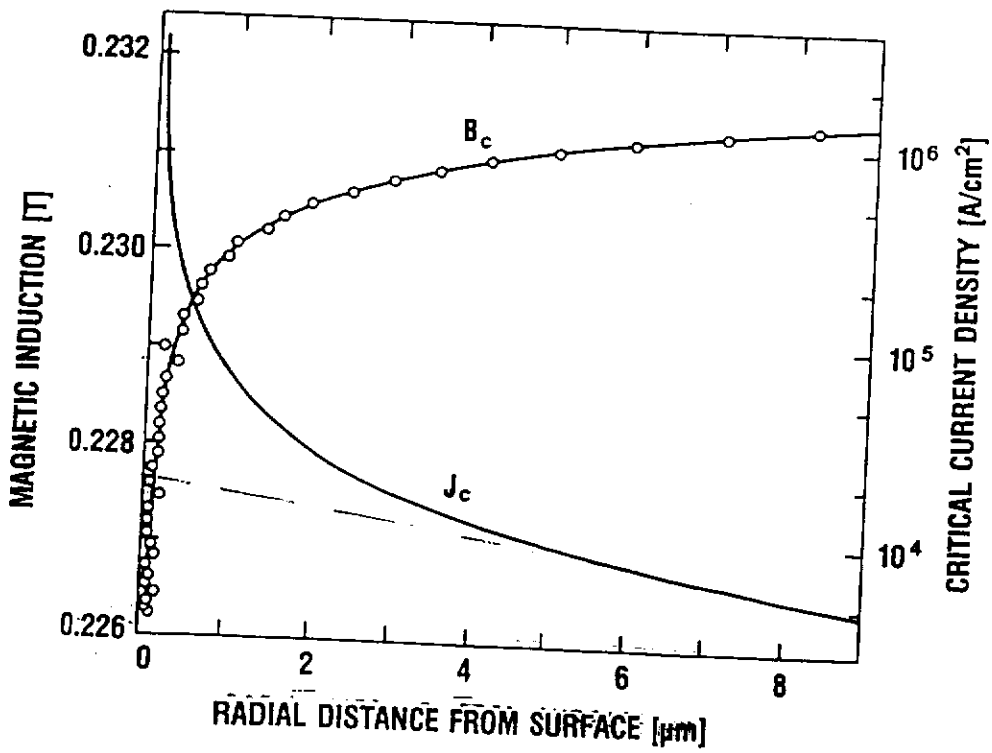
ROUNDED: ≈4% OF SURFACE GOOD



500 μm

PINNING

O-PRECIPITATES



SURFACE PINNING: $T_c^* \approx 7K$

O-PRECIPITATE

DUE TO OXIDATION AT PT

323

8.7.98

Conclusions R+D

1.) Structure Development:

- FM-Coupler for Superstructure

⊙	▭
approved for TESLA-Pals	design complete
compatible with SRF	larger, assembly/welding, FE
managable rf-losses	theor. lower
compact	potential for longer superstr.
	cost advantage?
70K, cylindrical window	at RT, elliptical disk
no MP	needs stub compensation
safe way	worthwhile to be tested

- Open question: Maximum length of Superstructure
  Simulation ok for symmetric case
  but exp. verification needed (tolerances)
  ⇒ start with 8 Cav. N coupler

- New Double ⊙-feeded SW structure: Higher Gradients!?
  Many open questions: Interference due to cell-to-cell coupling
  field/losses in ⊙ line?
  HOM – beam loading?
  Tuning?

- THz-Adsorber:
  Simple dielectric block loads (e.g. MACOR) sufficient
  but radiation and SRF compatibility?

2.) Cavity fabrication:

- Material quality control

fast SQUID-Gradiometer scanning good for (2mm) very small defects (< 50 μm) (f. magnetic, in B-field also paramagn.?)

- $H_{c1}/H_{c2}/H_{c3}$ - measurements on samples
  - magnetization / shielding ⇒ bulk
  - penetration depth (change of magnetization ⇒ surface

both techniques show influence of preparation on pinning and material homogeneity but correlation to SRF-cavity results has to be investigated more systematically!

P. Schmüser

- Seamless cavities

• Hydroforming of high RRR (200) Niobium tubes caused problems
unisotropic elongation ~ 50% along axis
~ 15% circumference

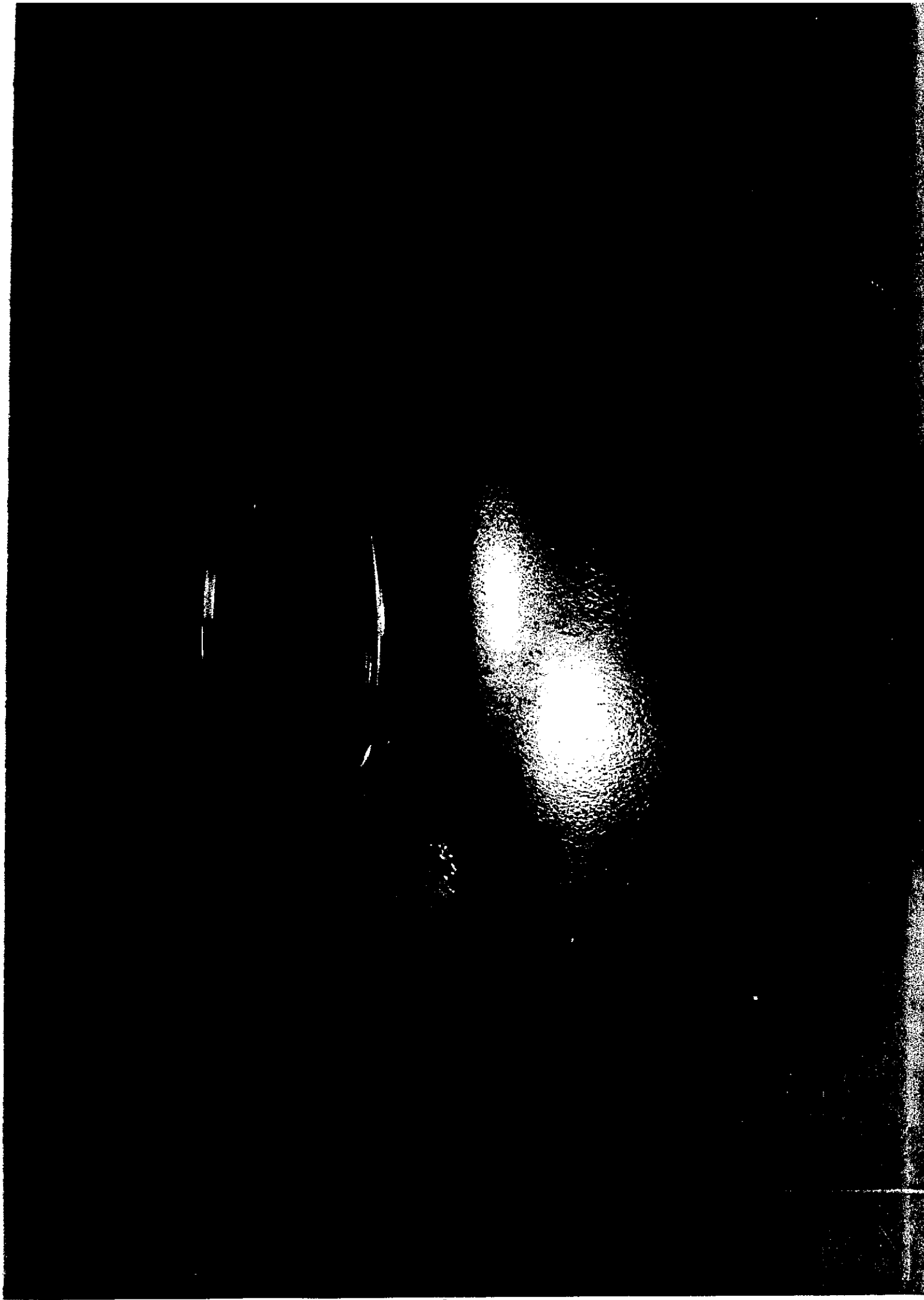
DESY (Kaiser, Singer...): forming with inner and outer SS layer
Saclay + French company RRR 20

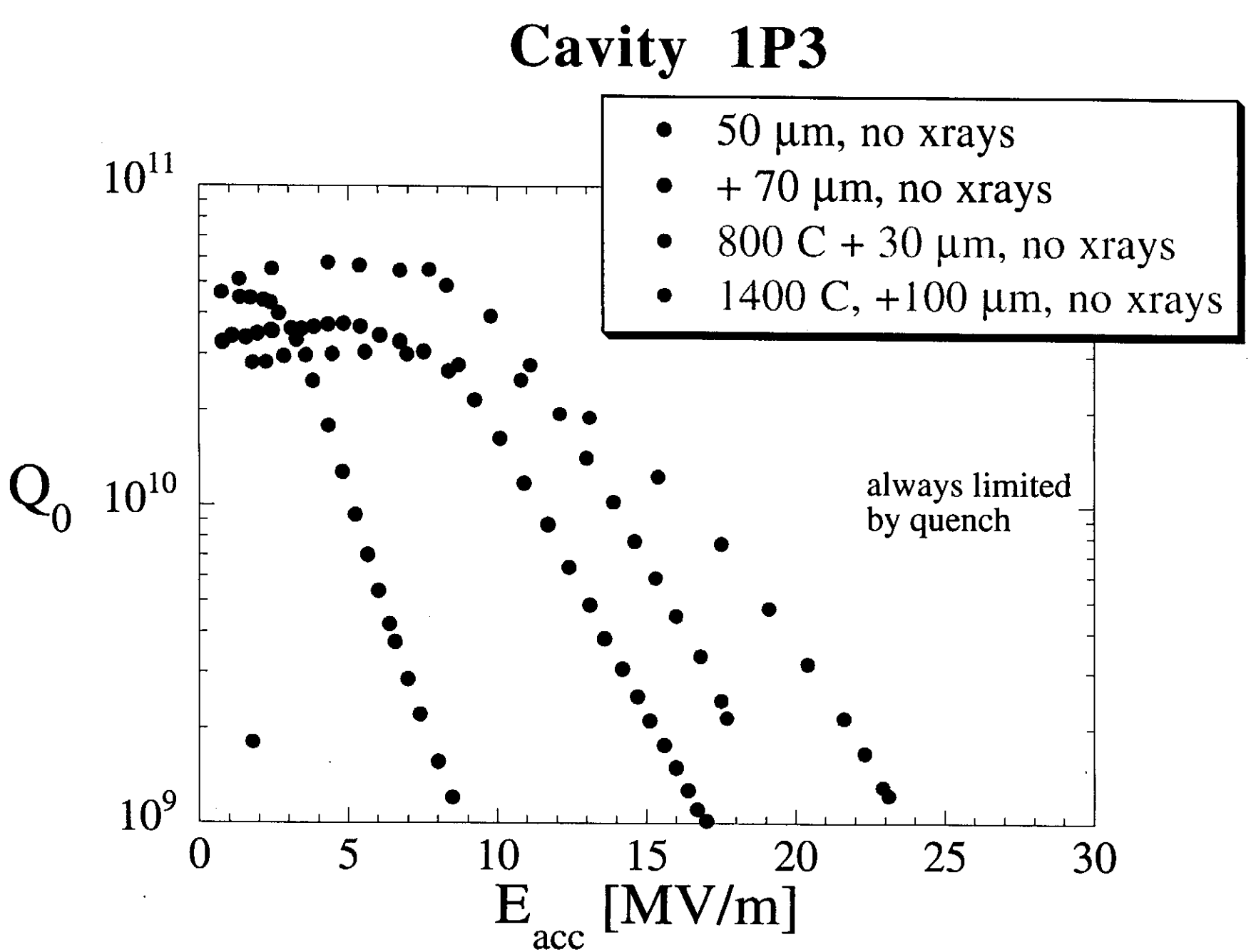
Goal: make RRR 200 tube with isotropic behaviour
Saclay 2-3 1-cell until end of 98

• Spinning
Strong @ slope, excessive heating in certain areas, no foreign materials seen in X ray picture

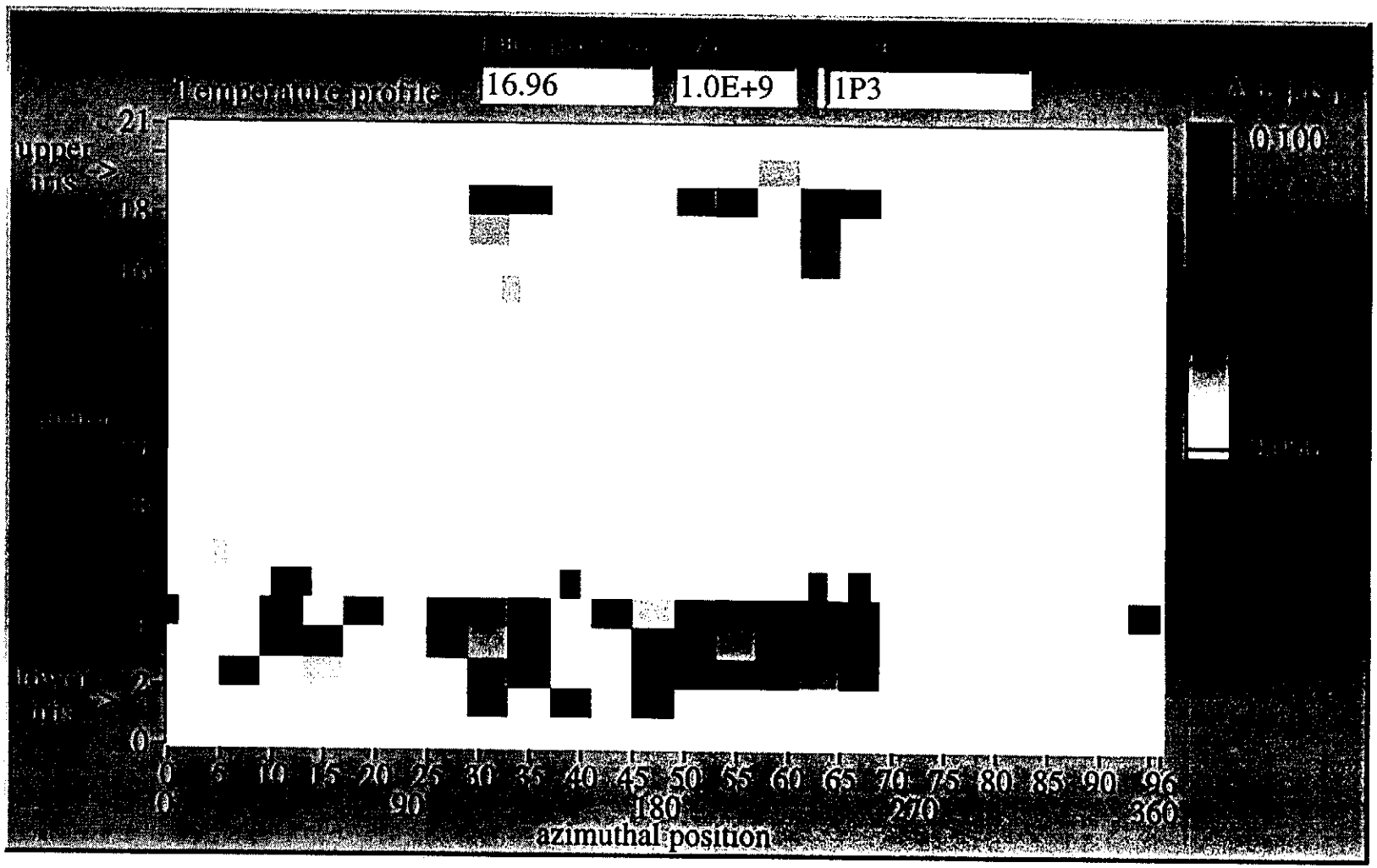
• Superplastic forming at high temperature using ultrapure Argon at Orsay

Kirchgessner (Cornell): at 1200°C a diameter increase of 50% possible




Cavity 1P3
50 μm, no xrays
+ 70 μm, no xrays
800 C + 30 μm, no xrays
1400 C, +100 μm, no xrays
always limited by quench
Q_0
10^{11}
10^{10}
10^9
0
5
10
15
20
25
30
E_{acc} [MV/m]

1P3



Temperature profile
16.96
1.0E+9
1P3
0.100
upper iris ->
lower iris ->
21
18
2
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 96
0 90 180 270 360
azimuthal position

330

- Copper-sprayed Nb cavities

  Orsay: 3 GHz, 0.5 mm Nb
  ~2 " Cu

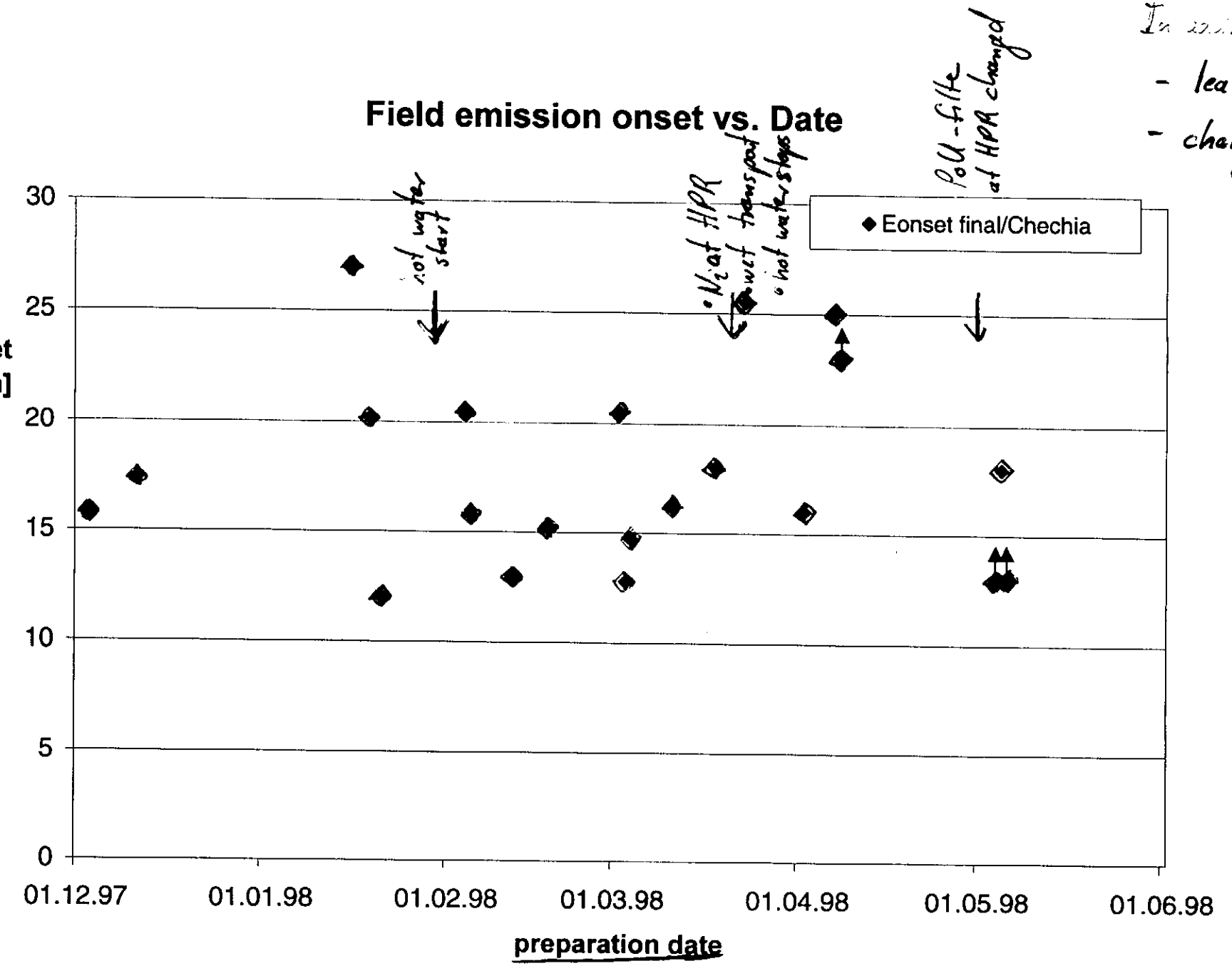
  - Q(E) as good as in pure Nb cavity
  - Kapitza resistance ~ 20% higher at 2K

→ Promising approach for cavity stiffening against Lorentz force detuning

(Remember: stiffening rings in TESLA cavities are only good up to 25 MV/m)

- Investigations on particle contamination

  - onset of field emission still around 15-18 MV/m
  - significant improvements in DESY high pressure water system (HPR)
  - detailed investigation of particle contamination in clean room, HPR, filters (Reschke)



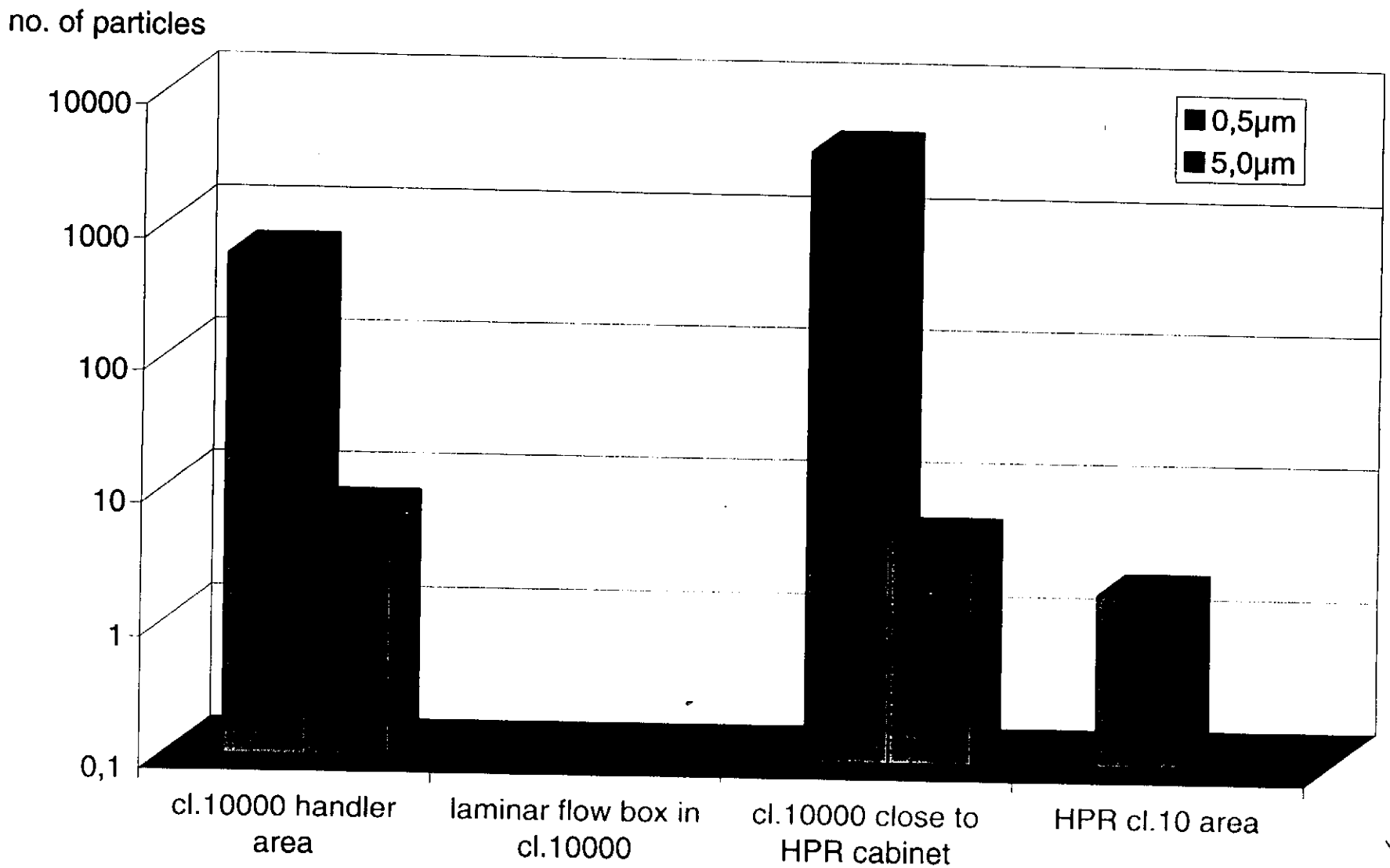
In addition:
- leaks
- change of pic-up

E_{acc}:

332

03.07.98

Number of particles vs. location in cleanroom

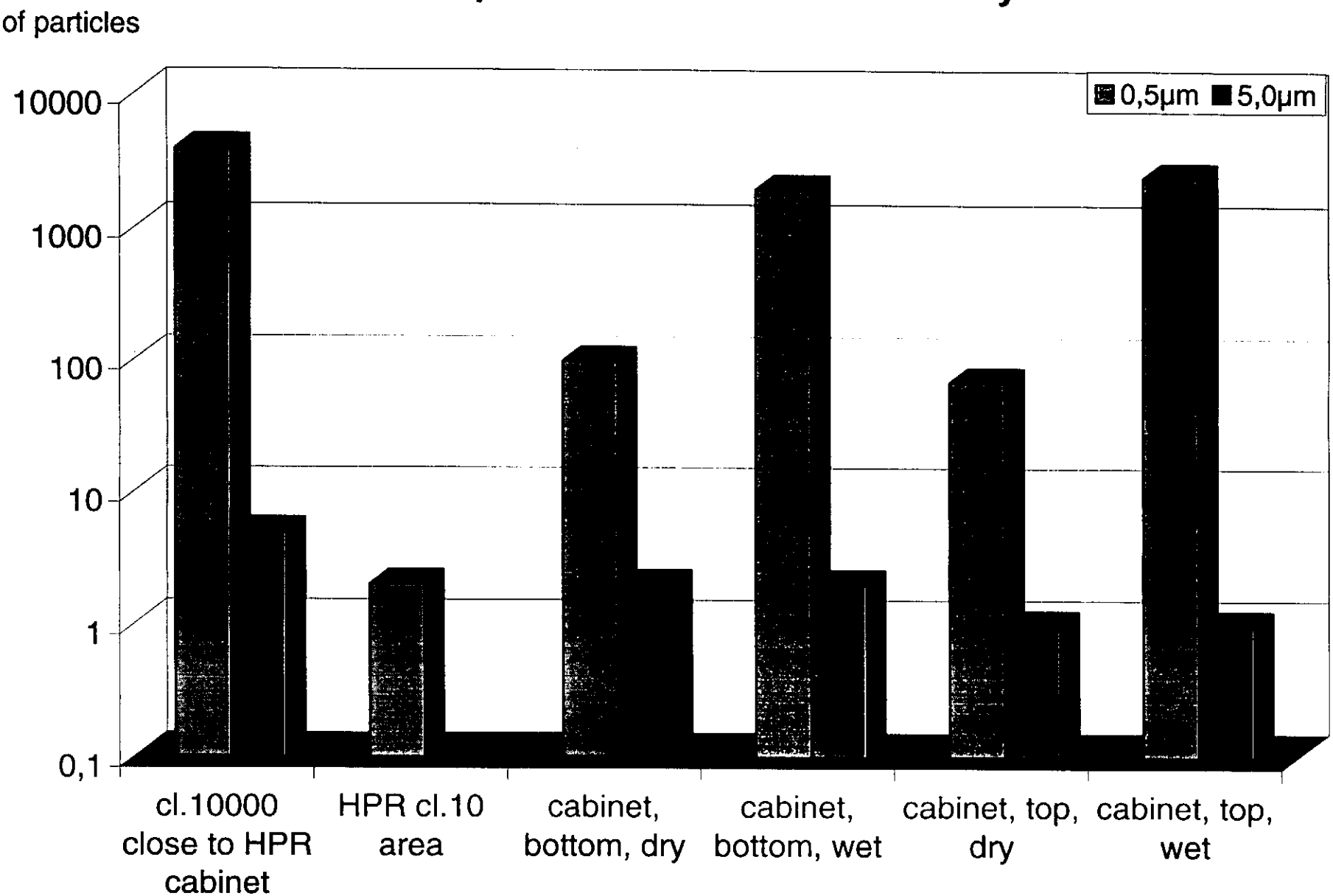


333

D. Reschke

LuftpartikelHDSpüle

Number of particles vs. location at HPR system



LuftpartikelHDSpüle

Quality Control: Filters at HPR drain water

- easy to handle
⇒ danger of contamination during handling

- **membrane filters in drain water of HPR:**
  21 filters used with 2,0µm (+0,4µm) pore size

- **6 filters** optical analysed:
  (~ 1cm^2 of the filter surface analysed; resolution down to 5µm) ⇒ large particle found (up to ~100µm)

- **4 filters** SEM + EDX analysis
  example of SEM:

EDX shows:
Al
Fe, Cr ⇒**SS**
Cu
C
(F) → piping

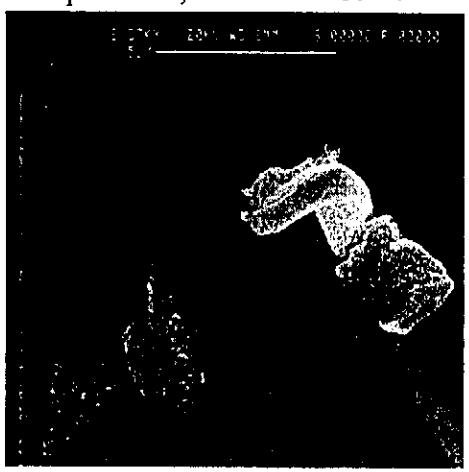
- field emission studies on Nb samples (G. Müller et al)
  - significantly higher FE from Nb samples accompanying the TTF cavity cleaning steps than in manually prepared samples
  - an automatized scanning electron microscope inside a clean room would be very valuable
    → correlation between #particles on sample and FE in cavities
    → origin of field emitters

- Electropolishing at CERN
  Bloess, Chiaveri, Benvenuti, Guerin, Ferreira, Forel, Thony
  Lutz Lilje (DESY)
  - much smoother surfaces than BCP
  - welding of 1-cell cavities + beam tubes starts 15. August
  - EB welding of electropolished Nb works well

Analysis of single emitters on sample B

E(0.5nA) = 35 MV/m
$\beta = 86$
$S = 7 \cdot 10^{-11}$ cm²

particle, slanted view:

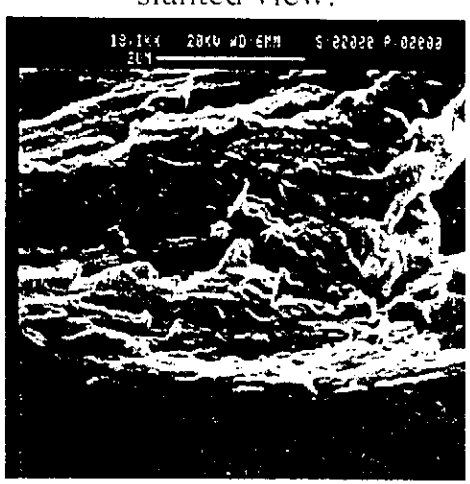


view from the side:

E(0.5nA) = 40 MV/m
$\beta = 88$
$S = 2 \cdot 10^{-12}$ cm²

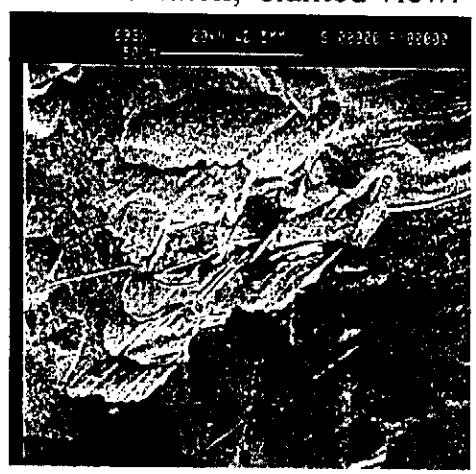
defect, slanted view:

slanted view:

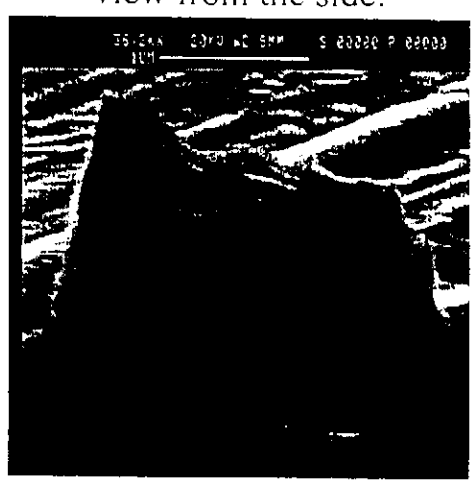


E(0.5nA) = 47 MV/m
$\beta = 103$
$S = 2 \cdot 10^{-14}$ cm²

defect/scratch, slanted view:



view from the side:

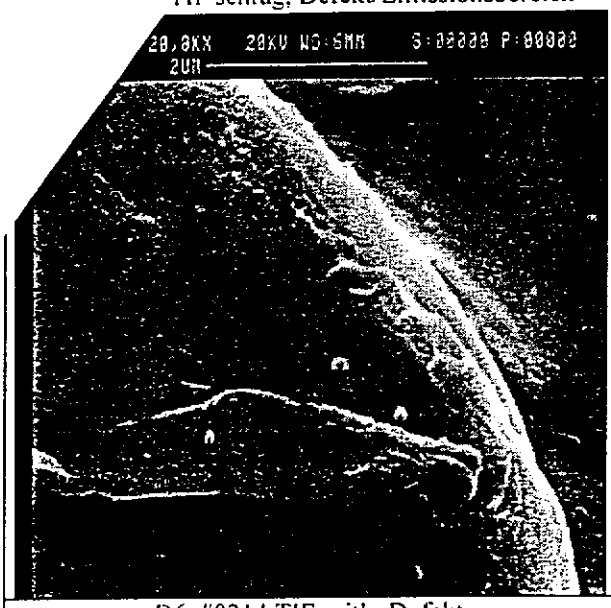


#8 #20 #17

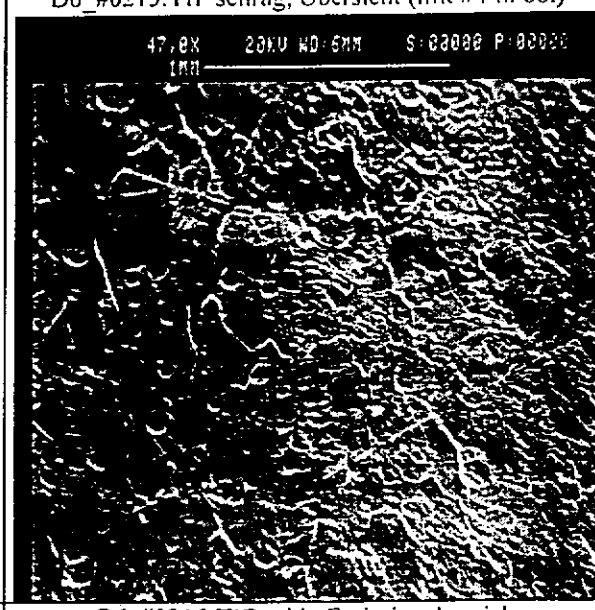
#2 (B)

..98. D6 (file: D6_9.DOC)

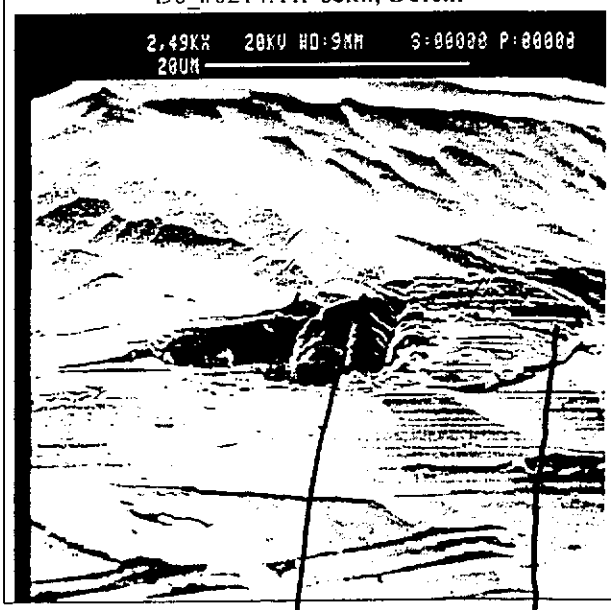
'TIF schräg, Defekt/Emissionsbereich



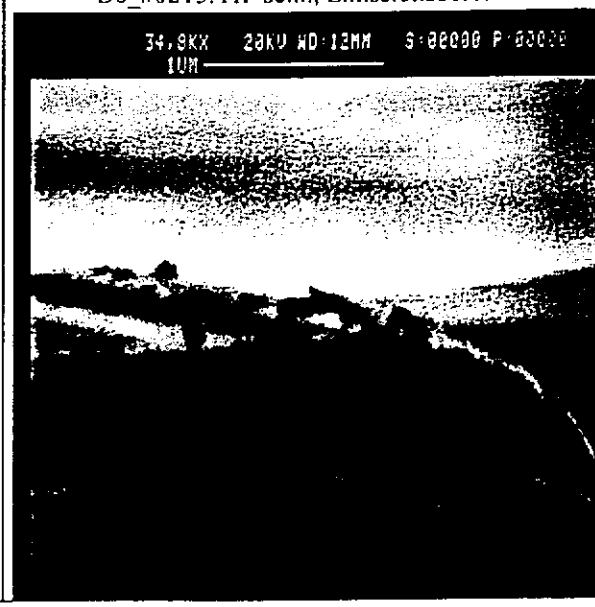
D6_#0213.TIF schräg, Übersicht (mit #4 li. ob.)



D6_#0214.TIF seitl., Defekt



D6_#0215.TIF seitl., Emissionsbereich



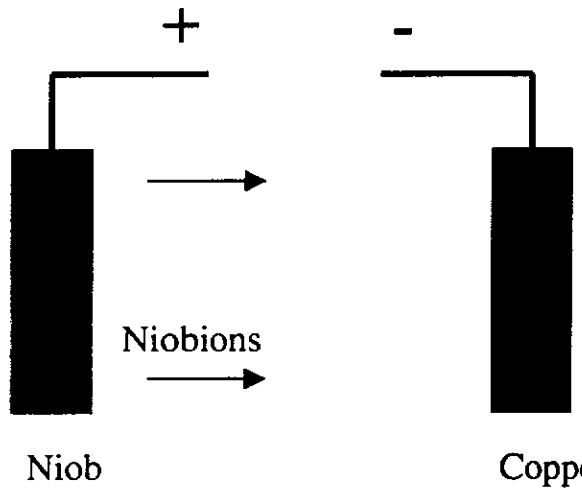
(1) (2)

2. Principle of Electropolishing

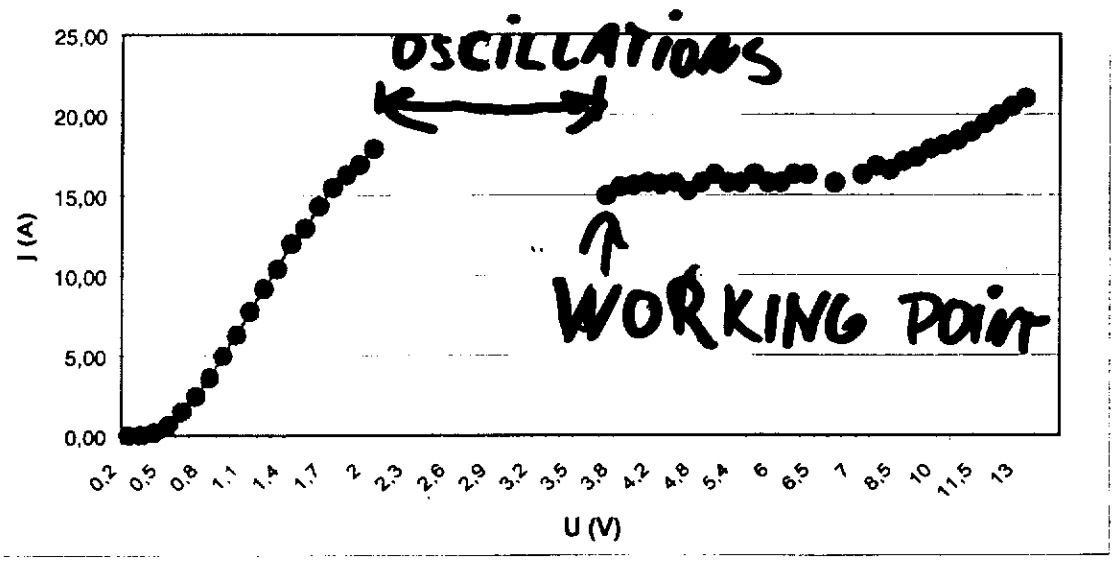
Reverse process of electroplating in a chemical reaction

$Nb + ne^- + H_2O \rightarrow Nb_2O_x + HF \rightarrow \underset{\text{insoluble}}{H_2NbO_xF_{(7-x)}} + HF + H_2SO_4 \rightarrow \underset{\text{Niobium acid}}{HNbF_6}$

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

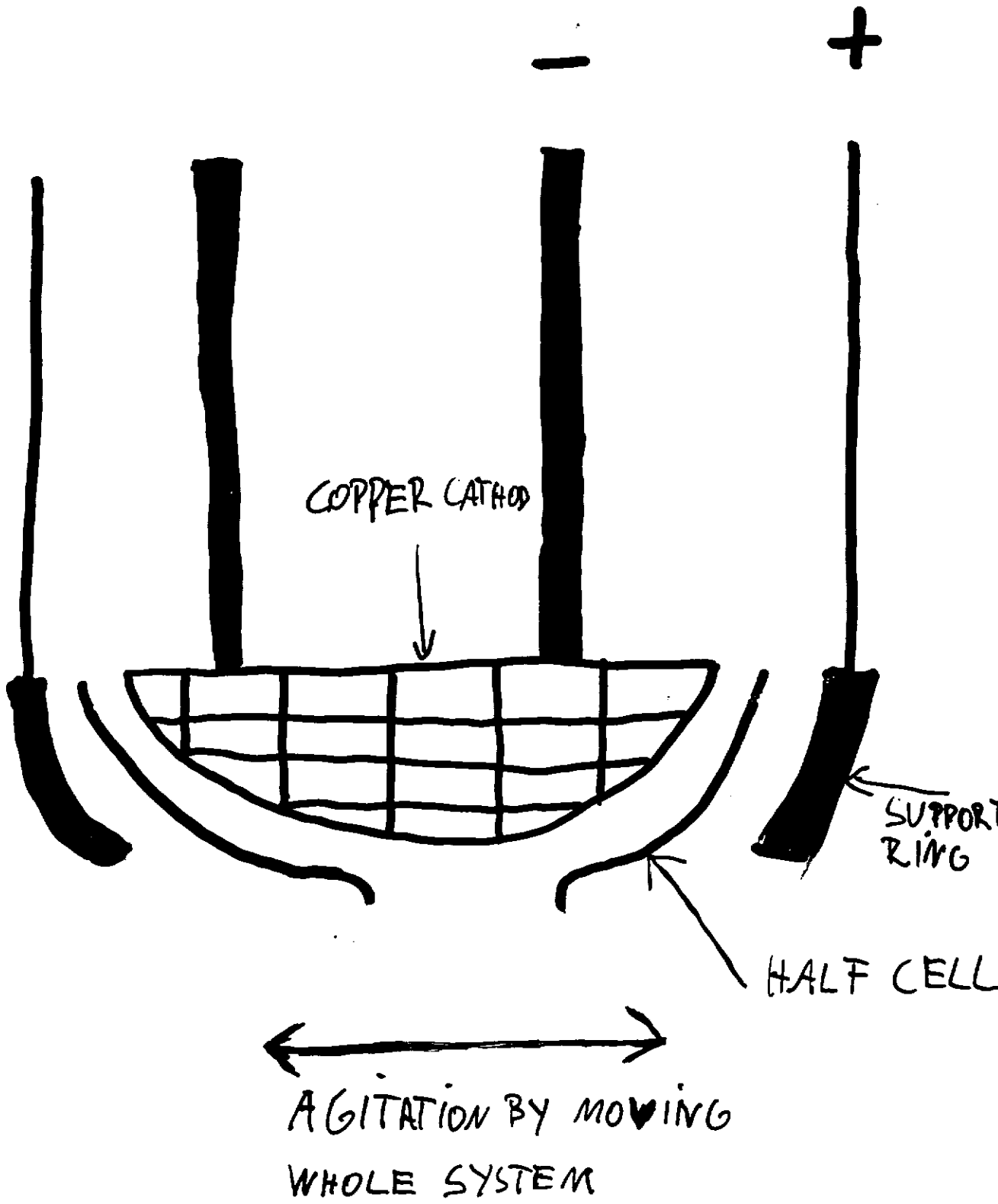


Typical I-U characteristic of electropolishing



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

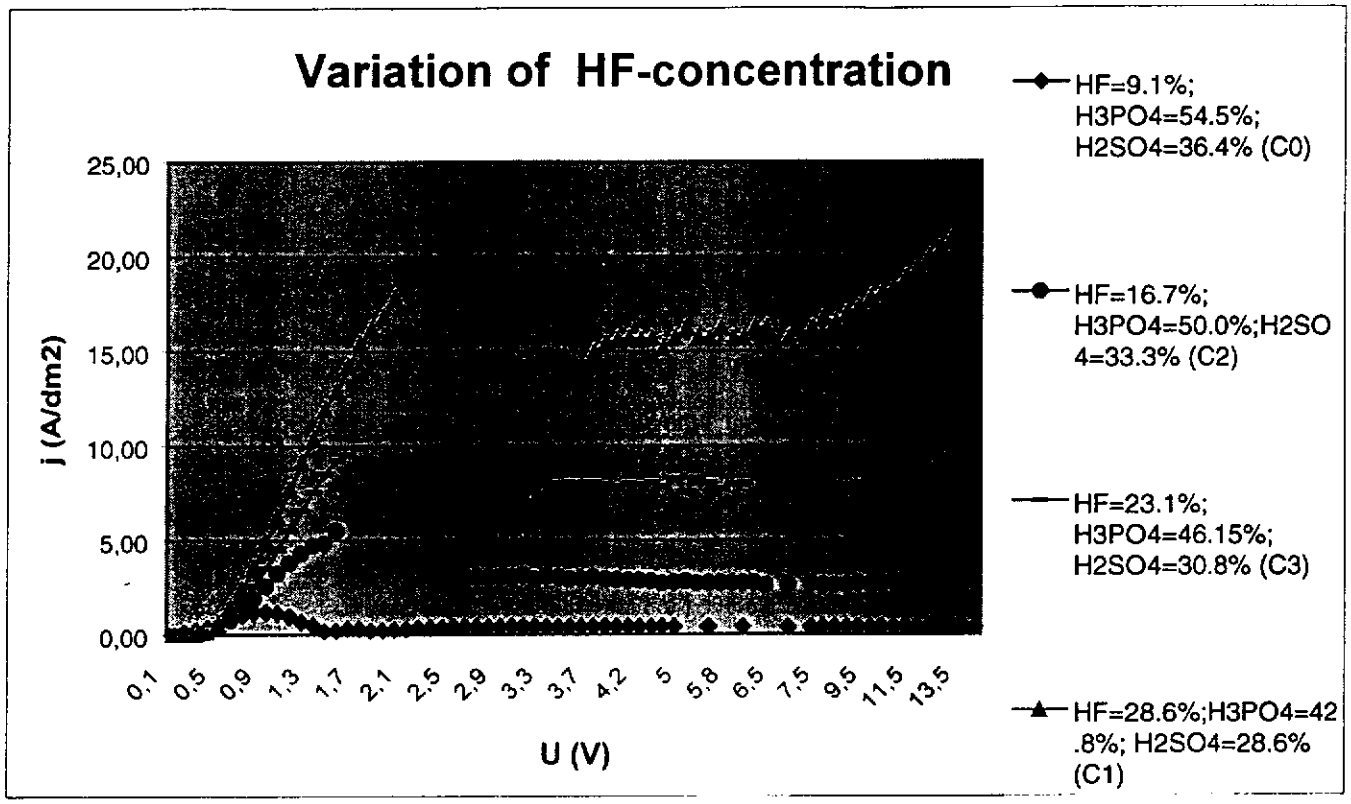
HALF CELL POLISHING



FERREIRA et al.

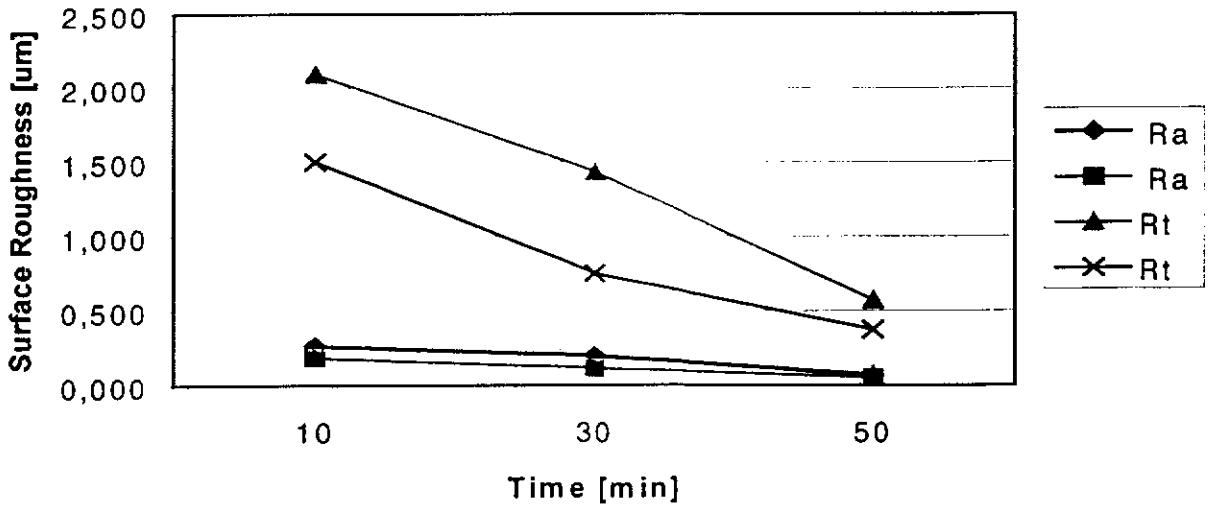
3. Finding the right solution

Example: How does concentration of HF influence I-U curve ?



Conclusion :
24 % HF
38 % H_3PO_4
21 % H_2SO_4
17 % Butanol (reduces surface tension, avoiding bubbles and therefore etching pits)

And it works well: REMOVAL RATE ~ 1-2 $\frac{\mu m}{min}$



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FERREIRA et al.

SURFACE AFTER 80µm BCP

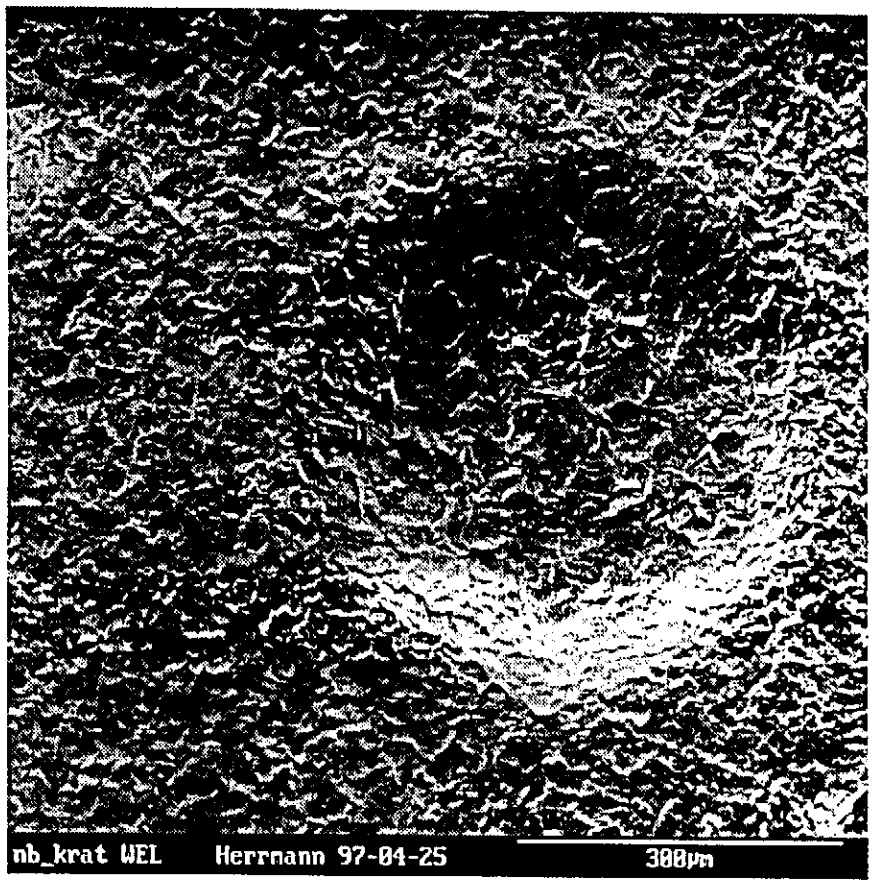


Figure 2: magnification 120

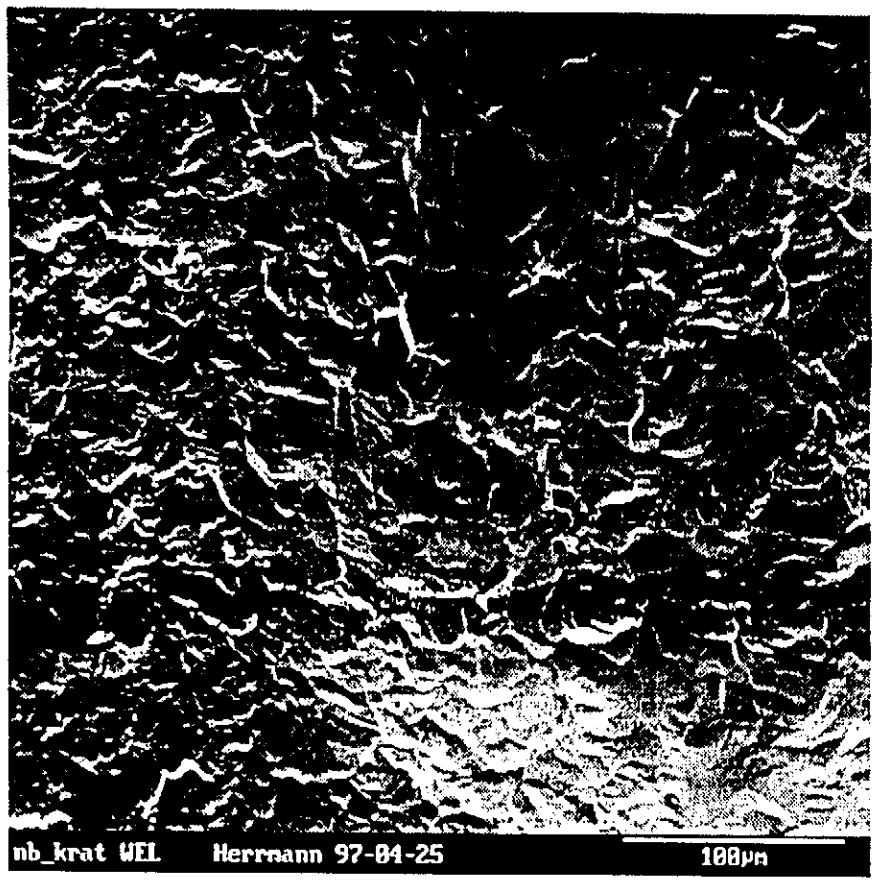


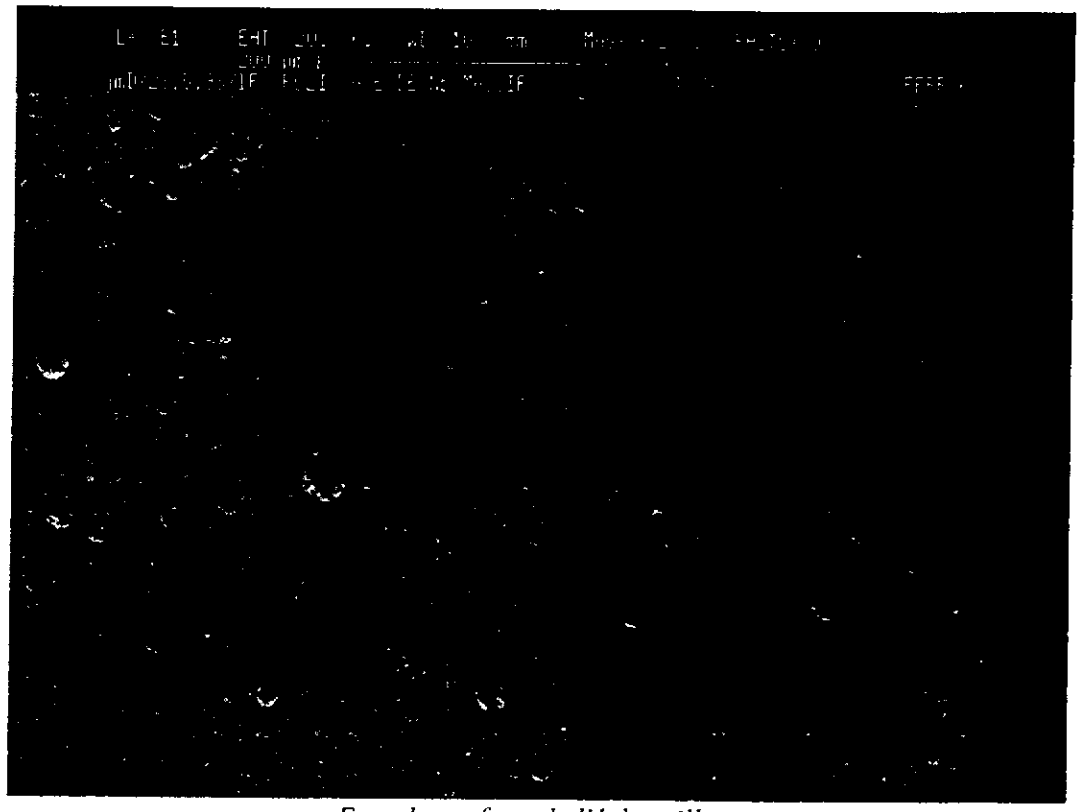
Figure 3: magnification 241

SEM parameters:

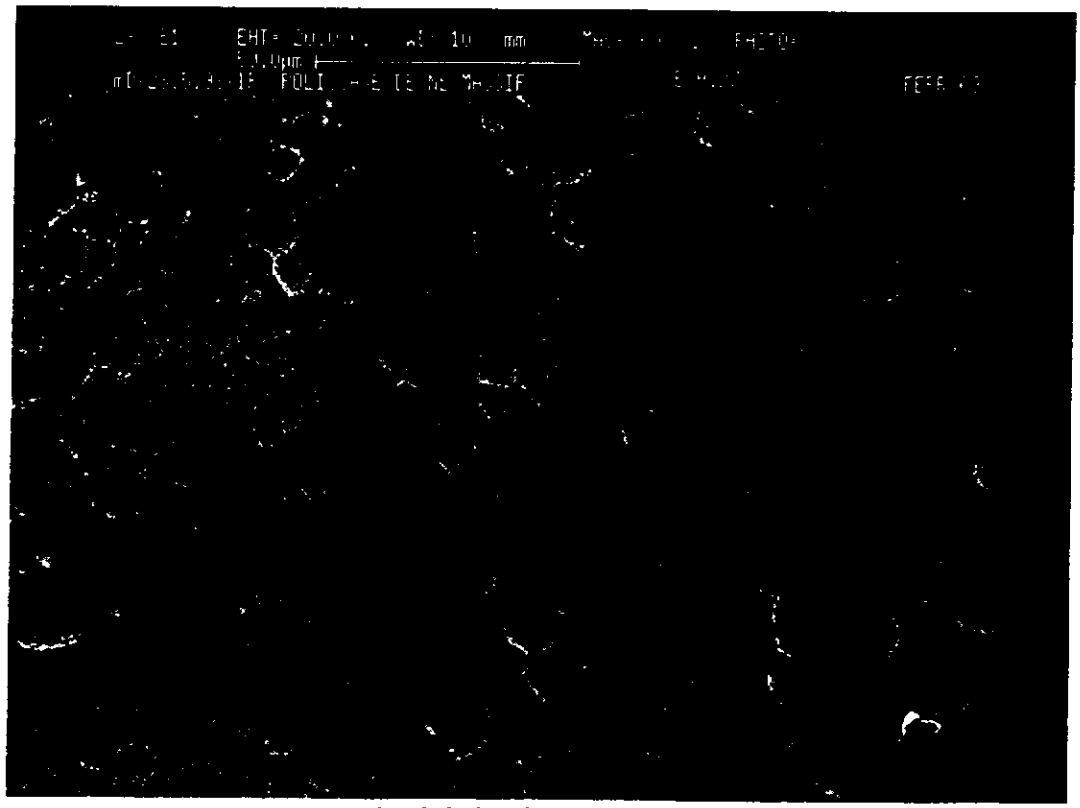
- high voltage 20kV, spotsize 50nm, tilt with correction 30°, measurement time per pixel 6μs, image size 512pixel×512pixel

Frank Herrmann, January 22, 1998

Echantillon n°27.



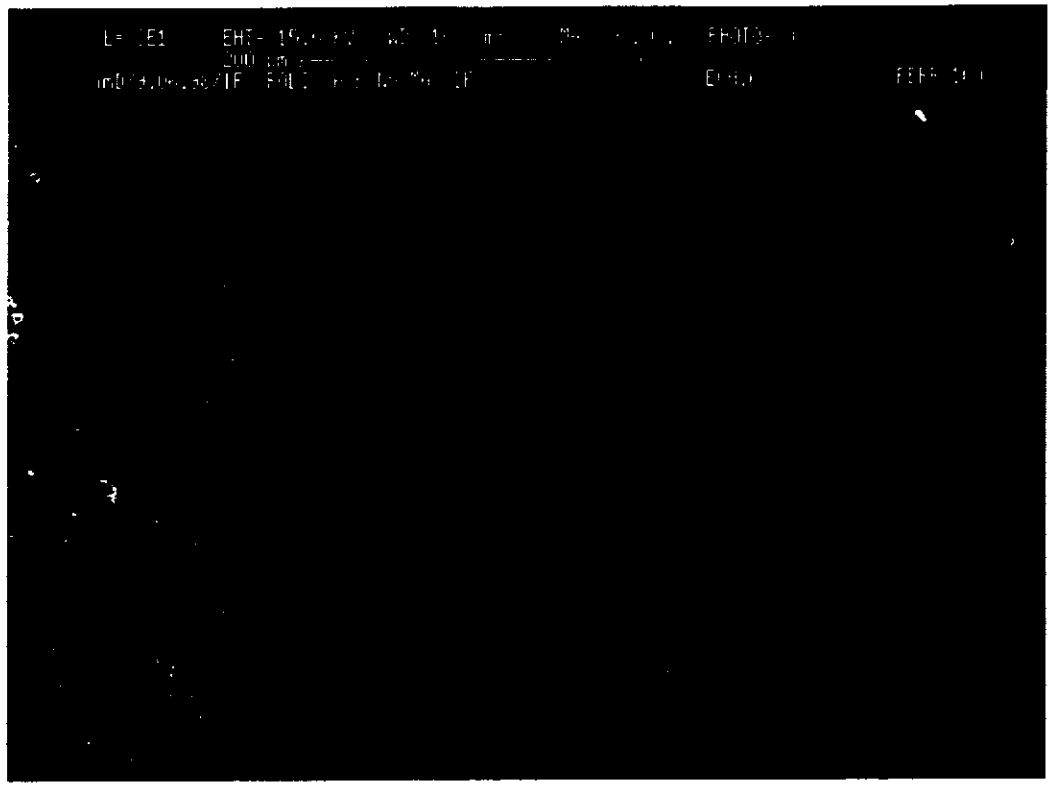
Etat de surface de l'échantillon.



Détail de la photo précédente.

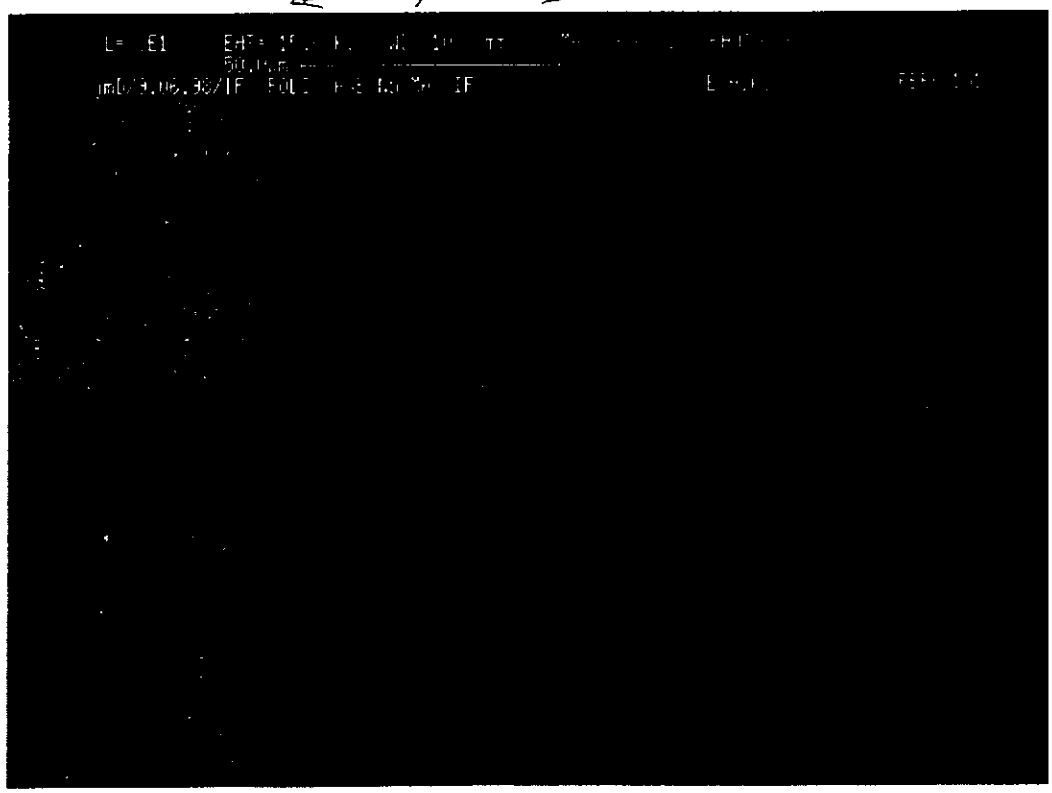
electropolishing

Echantillon n° 60:



Observation générale de la surface de l'échantillon.

50 µm

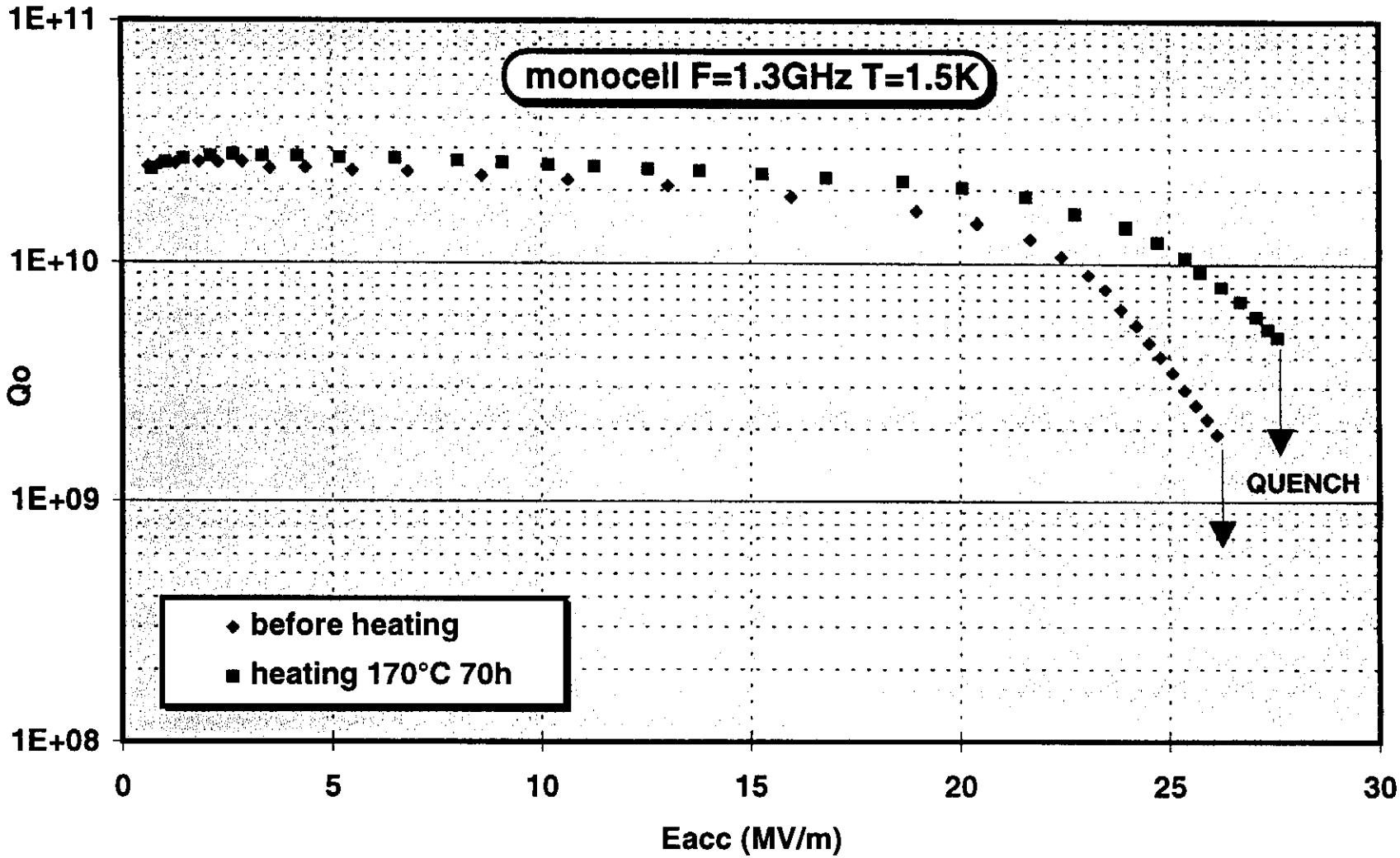


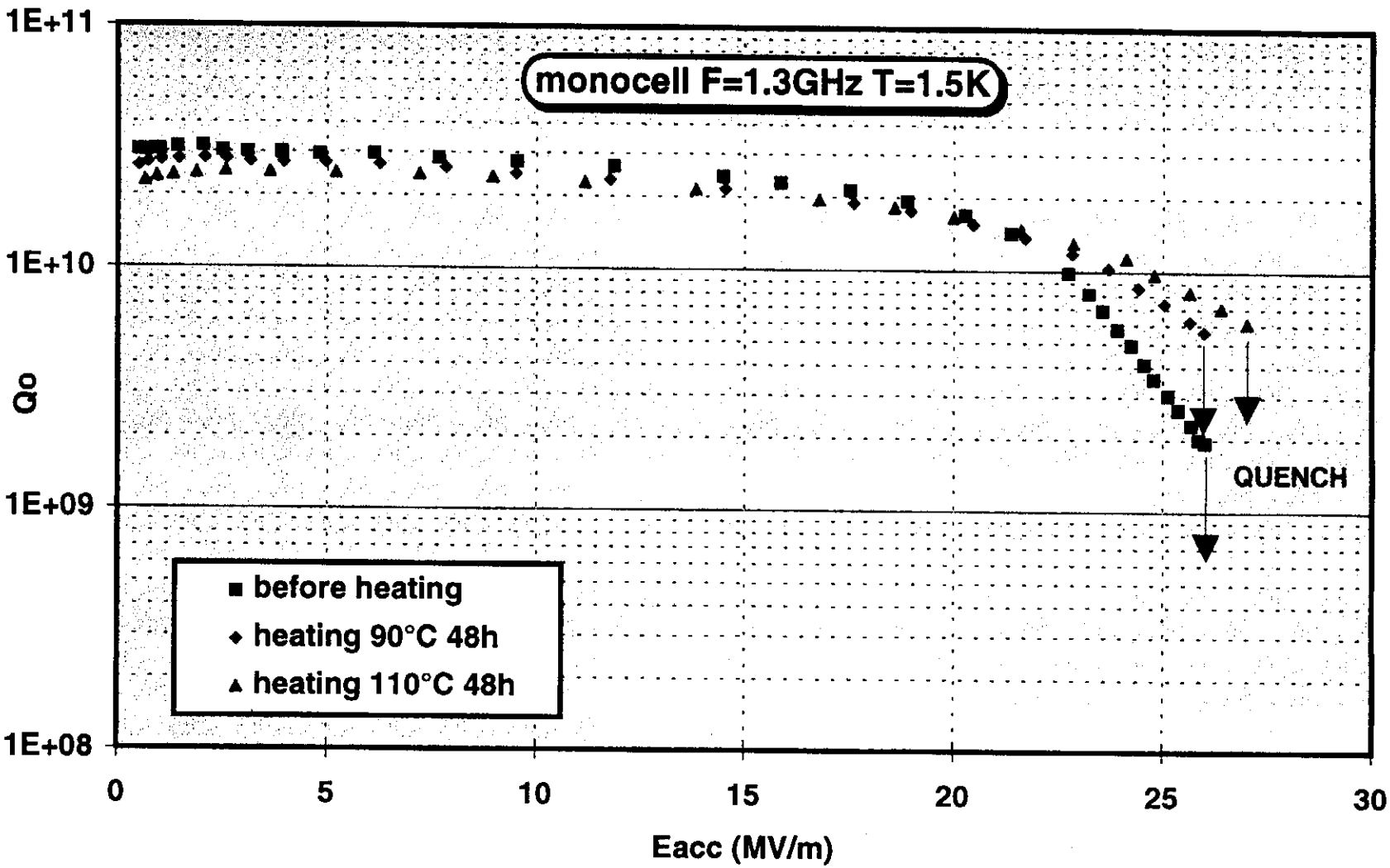
Détail de la photo précédente.

best electropolishing at CERN

344

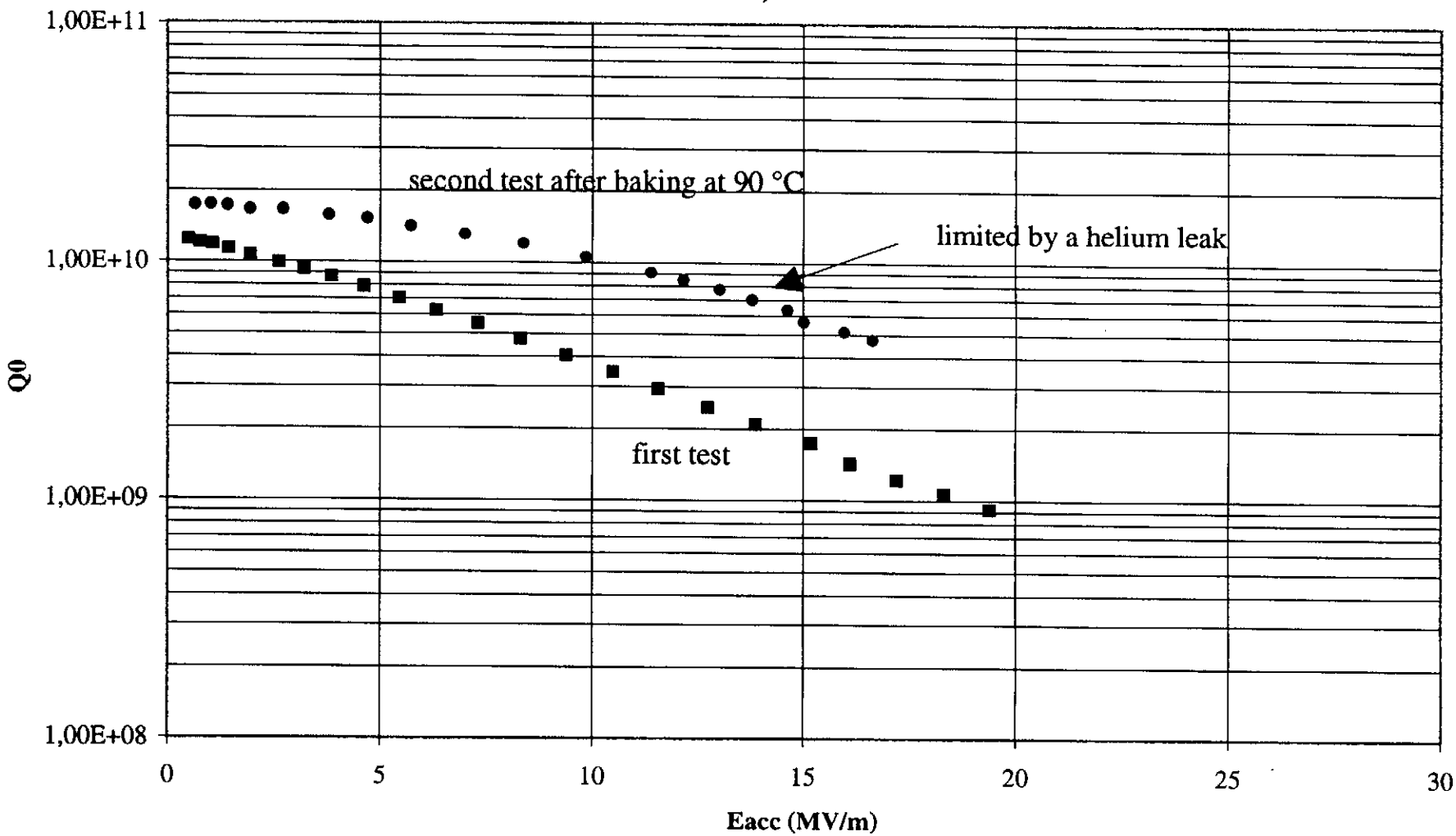
- investigations on Q-slope (without FE)
  - Saclay : heating evacuated cavity to 90 – 170°C for ≥ 24 hours reduces Q slope
  - excellent performance of Nb-sputtered copper cavity
    Q slope also reduced by heating


monocell F=1.3GHz T=1.5K
1E+11
1E+10
1E+09
1E+08
Qo
0
5
10
15
20
25
30
Eacc (MV/m)
QUENCH
before heating
heating 170°C 70h


monocell F=1.3GHz T=1.5K
1E+11
1E+10
1E+09
1E+08
Qo
0
5
10
15
20
25
30
Eacc (MV/m)
QUENCH
before heating
heating 90°C 48h
heating 110°C 48h

Nb sputtered on Cu

Nb/Cu



Installation WG at the TTF meeting, DESY July 7, 1998

Tuesday July 7, 9:00 - 18 h
Wednesday July 8, 11:00 - 13:00 h

Tentative Agenda.

9.00 - 12:00 h

A. Injector Installation

(T. Garvey, H. Edwards, P. Michelato, S. Schreiber, K. Floettmann, F. Stephan, A. Gamp, K. Zapfe, R. Hensler, K. Rehlich, D. Sertore, F. Ullrich, O. Krebs, H.J. Eckoldt, M. Castellano, L. Catani, Tonutti, M. Jablonka, O. Napoly, Balakin, J.M. Joly, Fusellier, I. Will, A. Liero, etc.)

1. RF Gun

- removal sector 200, column support
- FNAL gun installation
- move cathode system to linac
- water cooling system gun, solenoids
- vacuum, support structures
- power supplies (Solenoids etc.)
- laser beamline
- Klystron/Modulator 3
- controls

2. Modification Sectors 400 and 600

- Chicane Dipole Installation
- Diagnostics (OTR screens, slits, pepperpot, BPMs, ICTs, Interferometer)
- Reentrant Cavity BPM, dogleg
- Protvino Experiment

3. Beam Inhibit System, Fast Protection System

- upgrade to Injector II
- radiation level in the tunnel (machine related)
- personal security

13:00 - 14:00 h

B. Module 2

(C. Pagani, J. Weisend, S. Wolff, B. Petersen, at al.)

1. Schedule module installation

2. Schedule by-pass installation

14:00 - 15:00 h

C. Bunch Compressor 2

(A. Kabel, G. Schmidt, et al.)

1. Installation schedule

2. Diagnostics

15:30 - 18:00 h

D. Undulator Diagnostics and FEL beamline issues

(U. Hahn, H. Schlarb, T. Kamps, F. Tonisch, Th. Scholz, U. Mueller, S. Roth, T. Limberg, etc)

1. Vacuum

   - Vacuum chamber status
   - Collimator

2. Diagnostics

   - Waveguide BPM
   - Pinhole BPM
   - Alternative BPM designs

3. Beamline Optics for FEL operation

Wednesday 11:00 h (after Summary)

E. Linac Operation

(All of us)

1. Emittance measurements

2. Beam Deflection and HOM experiments

WG INSTALLATION

P. Michelato
S. Schreiber
TTF meeting July '98

(A) Injector Installation

1. RF-GUN

- removal Sector 200 → keep column under vacuum
- FNAL gun installation
  - → aim for a pre-installation in hall 55 and transportation assembled ➡ mid Sept ⬇ mid Oct
  - → Gun 4 most probable candidate
  - → preparation of pump assemblies as much as possible in advance
  - → Desy water system unfortunately ≈ 40-60 °C (FNAL 25°C) $\Delta f \approx -400$ kHz
  - → details of assembly discussed
  - → cathode system will move to linac
  - → will have rf phase control
  - → had a long discussion about running-in modes
    ideal for FEL/TTF : ~~beam~~ dyn. range 0.1 → 10nC

- Sectors 400 ... 600
  - → dipoles at FNAL ready to be shipped
  - → new reentrant cavity BPM
  - → dogleg installed (horiz. deflection)
  - → Protvino experiment ready for installation in Sept.
- BLS / FPS
  - → upgrade of toroid electronics required in preparation @ Saclay
  - → some worries about radiation @ BC2 and collimators

(B) Module 2

→ roll-out of ass. string 27.7.

module assembly 40 days

ready for inst. in linac 21.9.

→ BC transfer line (by-pass) completed 18.9.

→ module ass. in linac 38 days

modules+CC cold 17.11.

→ start cold coupler processing + @1E meas.

Bunch Compressor 2

→ warm up module 1 KW34 (mid August)

→ removal of temp. beamline

→ inst. of. bunch compressor

→ most components already ready

→ other parts will be ready end August

→ basic diagnostics OK (screen/BPM/ε)
more advanced in preparation

① Undulator

② → vacuum prototyp chamber built at Argonne

③ → collimator design ready

- 2 spoilers with an absorber each

→ strong constraints on β @ spoilers

will have to develop a start-up procedure

→ machine safety demands fast switchoff within 25 μs → FPS off in 5μs planned

→ Wakefields : ⊥ small

∥ ≈100 keV/nC (~ module)

④ → diagnostics

→ small cavity BPMs (Berlin) tested with beam (CTF)

→ redesign of couplers to improve balance

→ next tests with beam (S-band linac)

→ electronics in preparation

⑤ → pinhole monitor well progressed

prototyp test in September → inst. early '99

- → alternative BPM designs presented
  Coaxial beam position monitor

-

- Optics for TTF-FEL operation

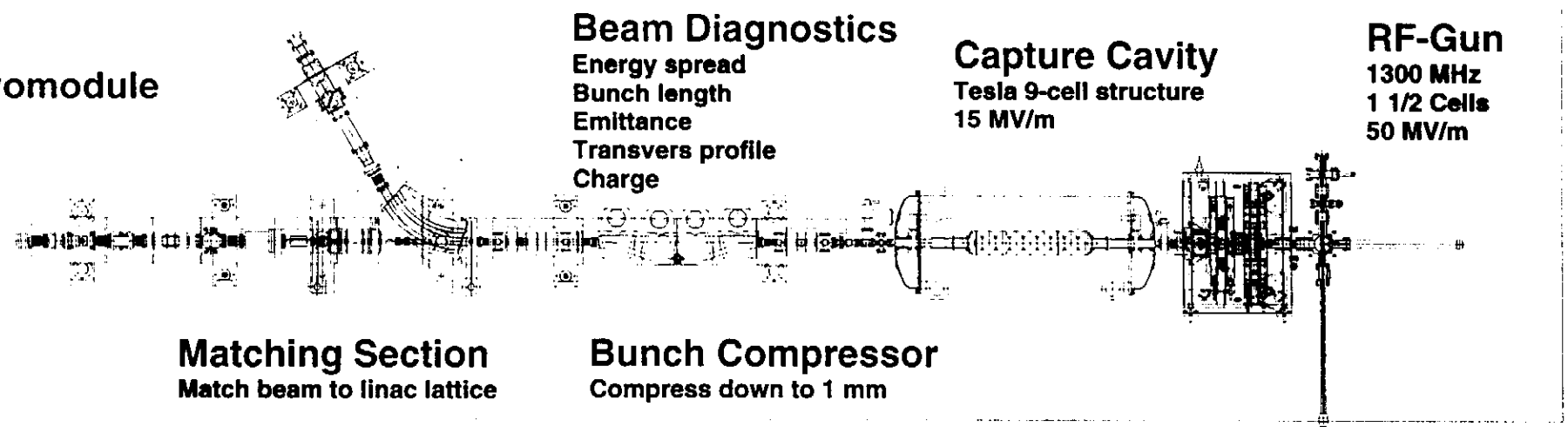
  → optics for 0.1, 0.5, and 1nC presented

  → linear optics incl. space-charge effects

  → use injector optics optimized with PARMELA → use COMFORT to build optics down to the undulator

TTF Injector II

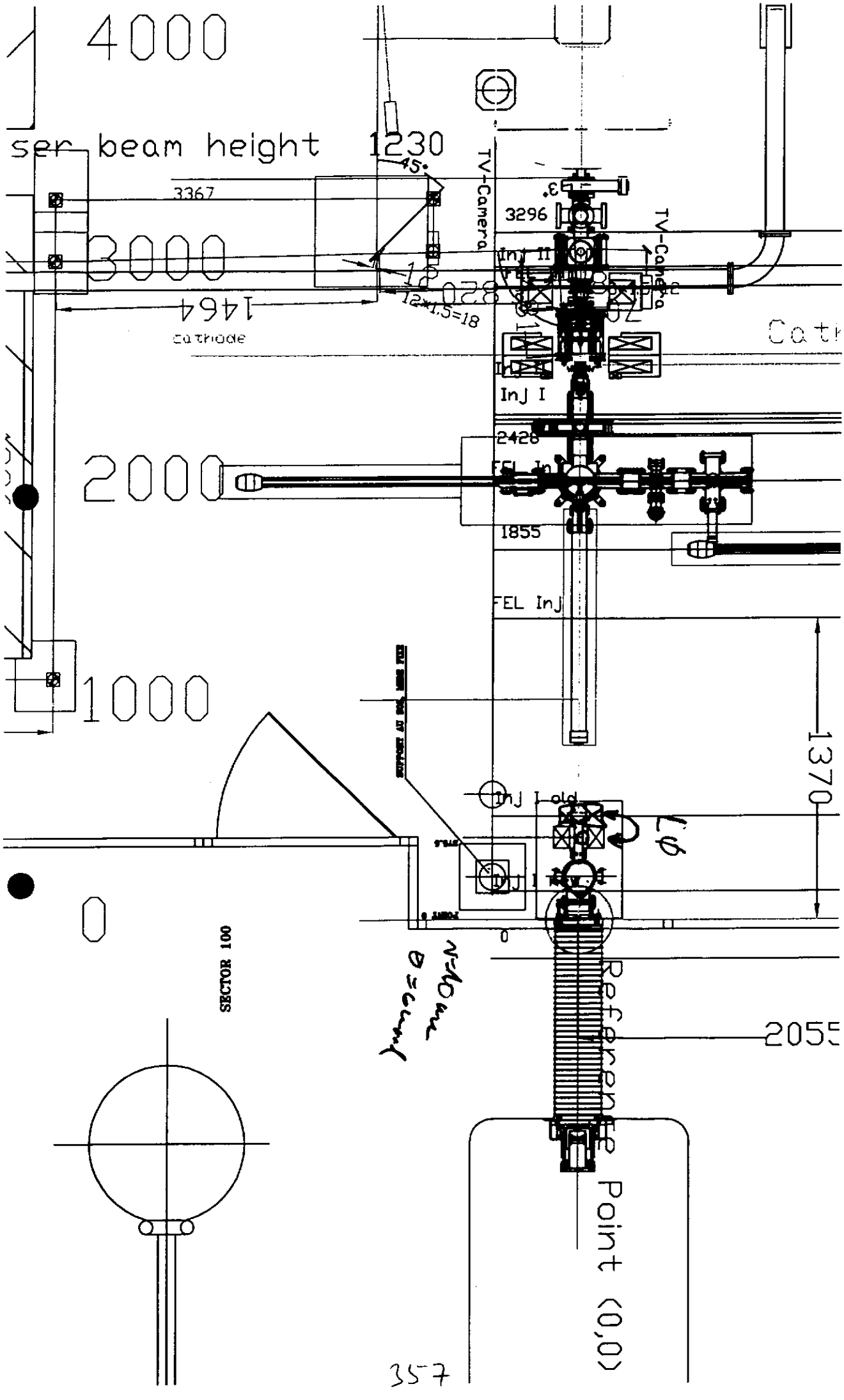
Train of 800 electron bunches, train length = 0.8 ms
Repetition rate 10 Hz
Bunch charge = 8 nC
Bunch length = 1 mm
Energy = 20 MeV
Emittance (x,y) = 20 π mm mrad



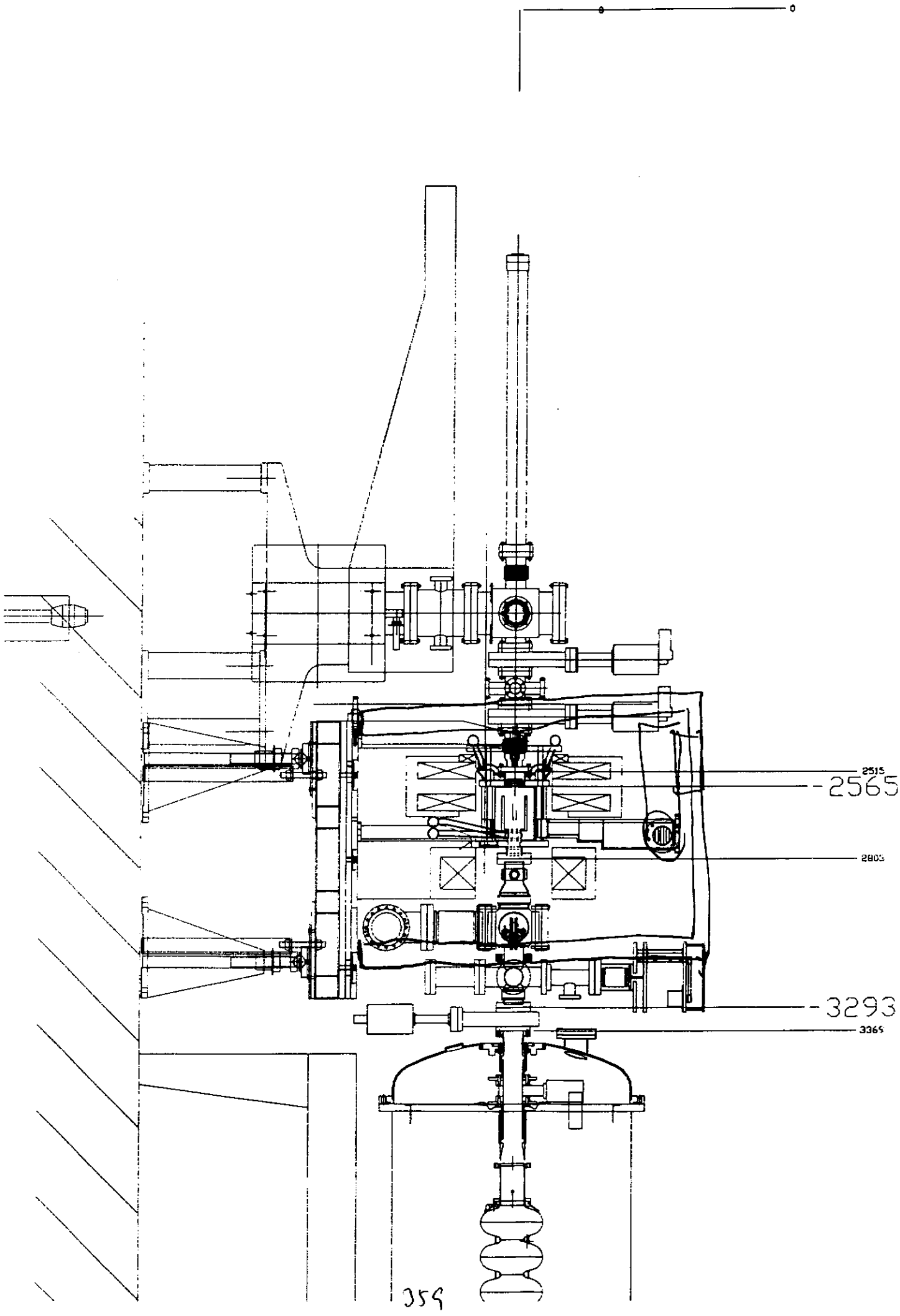
Laser
262 nm
≈5 μJ/pulse → 8 nC/bunch
800 pulses/train
10 Hz rep. rate

Cathode System
Material: Cs2Te
QE > 1 %

S. Schreiber
8.Nov.1997


4000
ser beam height 1230
45°
3367
3000
1464
cathode
12×1.5=18
TV-Camera
3296
Inj II
Inj I
2428
FEL Inj
1855
FEL Inj
2000
1000
1370
Inj I old
Inj I new
0
SECTOR 100
Reference Point (0,0)
2055

KEGVT


2515
2565
2803
3293
3365

1 MHz

0.1uC 10-30µs 1 Hz ≙ 3uC

1uC 1 bunch

FNL µm :

- 1uC 1 bunch 1MHz Hz
- 8uC "

DESY µm

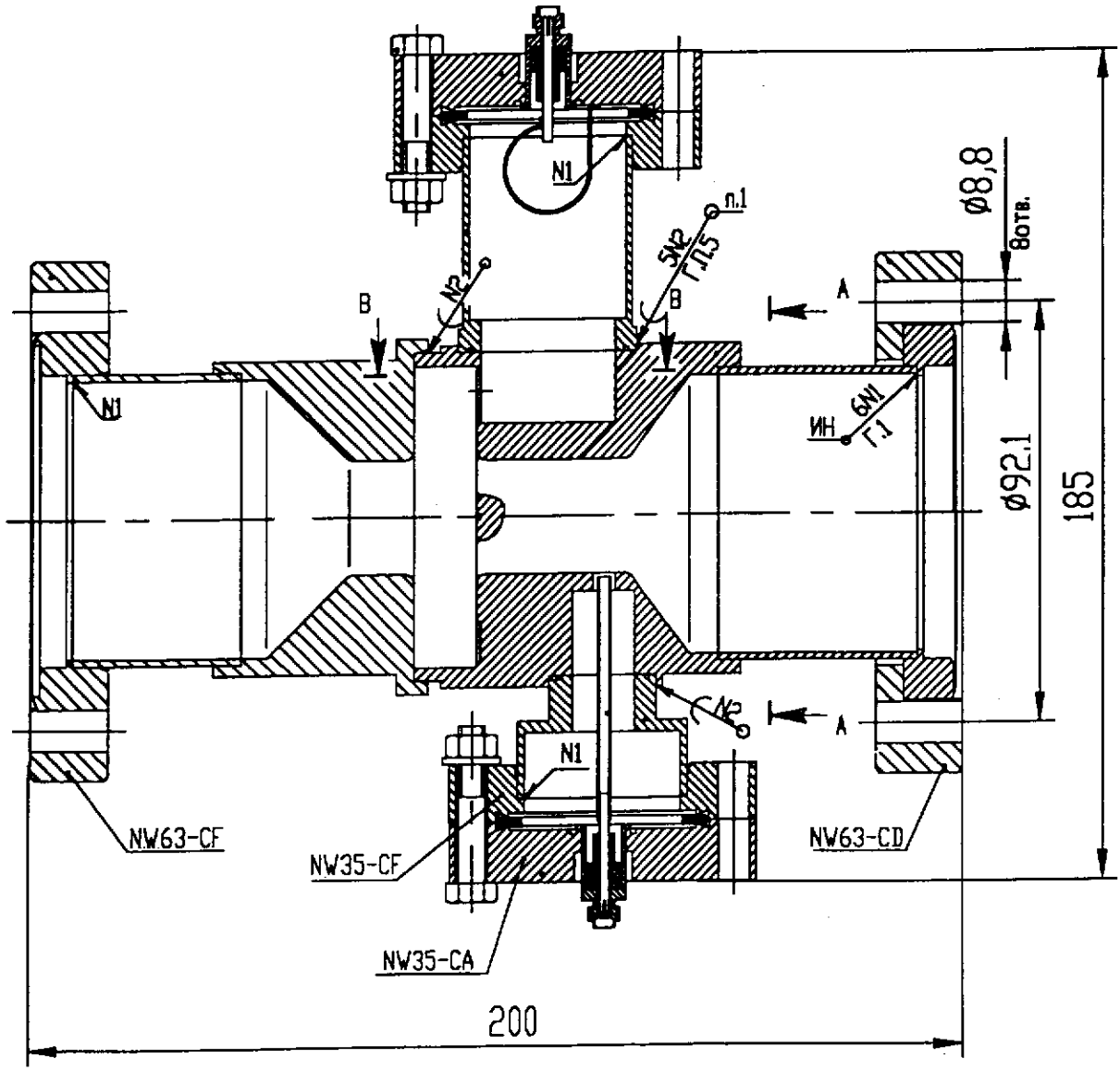
- 0.1uC
- 0.5uC
- 1uC

would work if we get 1MHz reading from Toroids (10µs for BLS ok.)

if NOT:

ux 0.1uC 10µs

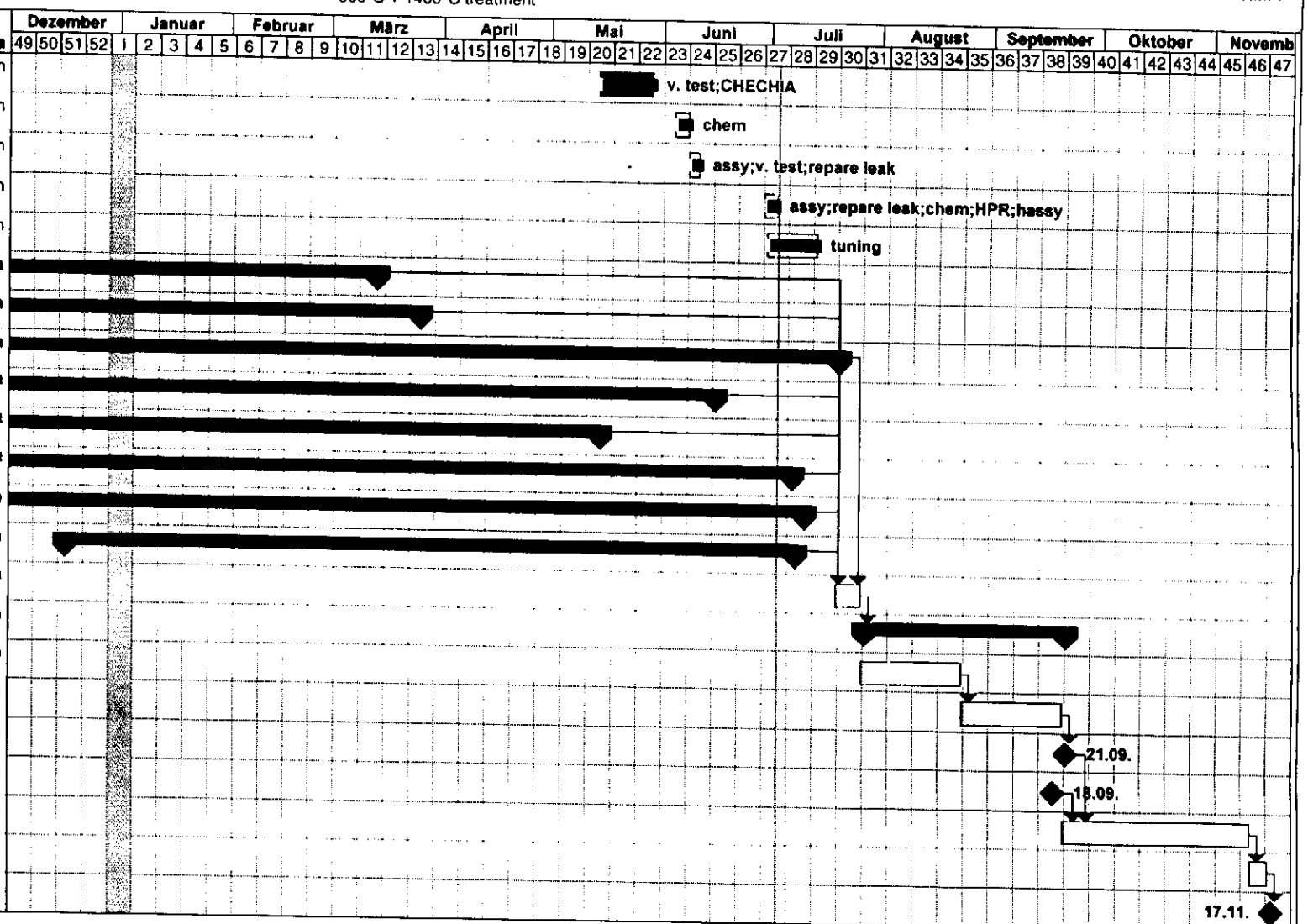
Vogel / Balakin



Modules 2 and 3
800°C + 1400°C treatment

S. Wolff, C:\WINPROJ\TESLA\M2030798.MPP

Nr.	Vorgangsname	Dauer	Gepla
1	cryoplant not available	10t	160h
2	Chemistry not available	2t	0h
3	cleanroom not available	3t	0h
4	cleanroom not available	3.5t	0h
5	transport tuning machine	10t	0h
6	**C22 cavity preparation**	**171t**	**436h**
67	**C21 cavity preparation**	**182t**	**328h**
104	**C24 cavity preparation**	**259.5t**	**464h**
172	**C25 cavity preparation**	**234t**	**#####**
230	**C23 cavity preparation**	**158t**	**#####**
288	**C26 cavity preparation**	**192.5t**	**#####**
344	**C27 cavity preparation**	**169t**	**404h**
403	**A15 cavity preparation**	**131.5t**	**384h**
441	remaining string assy in cl. rox	5t	0h
442	**module assy**	**40t**	**0h**
443	assy on 4-post system	20t	0h
444	assy on cantilever systen	20t	0h
445	module 2 ready for installatior	0t	0h
446	BCBTL ready	0t	0h
447	assy of module into linac	38t	0h
448	cool down of modules	3t	0h
449	modules cold	0t	0h



poject end Die 17.11.98

Fre 03.07.98

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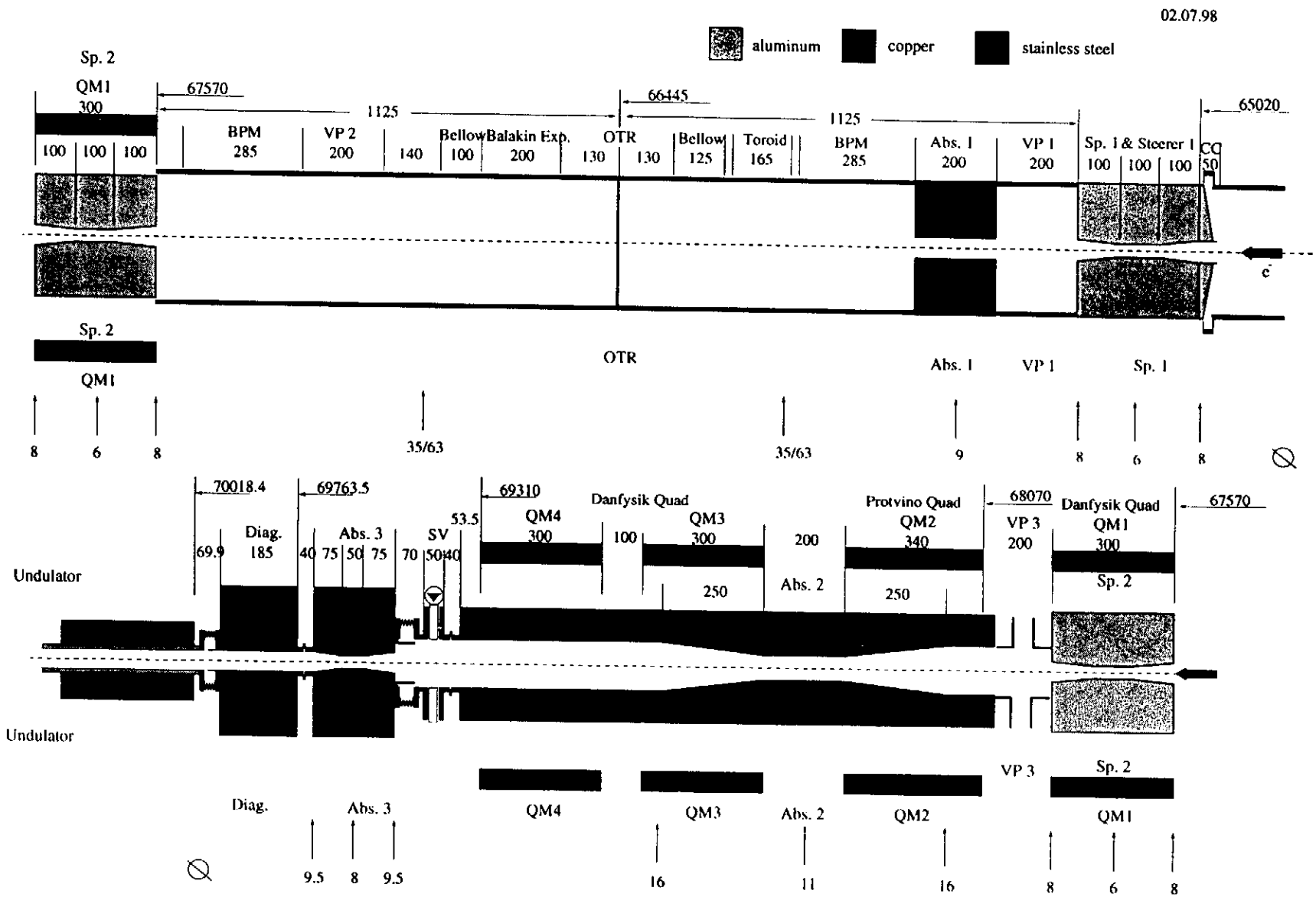
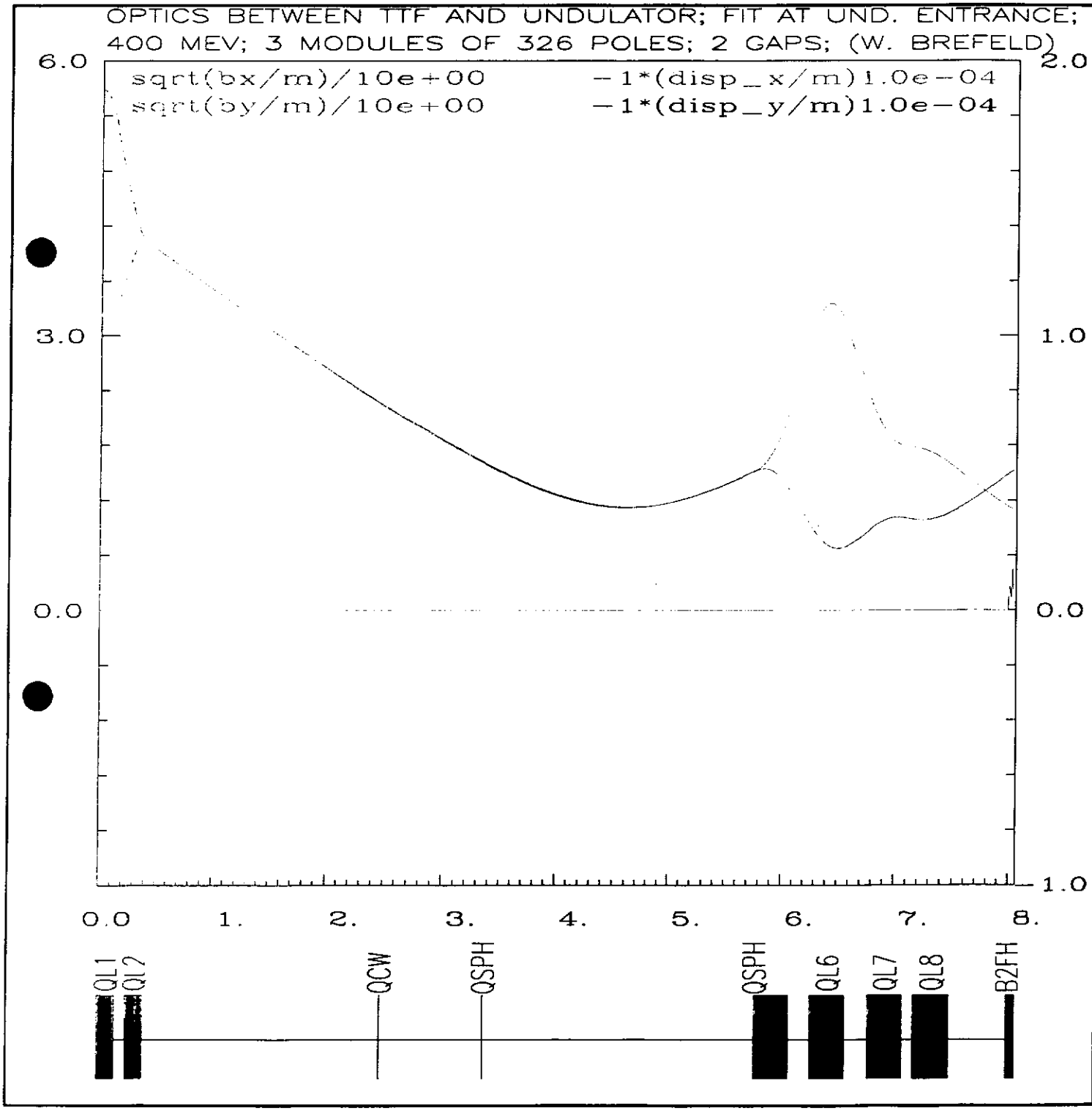
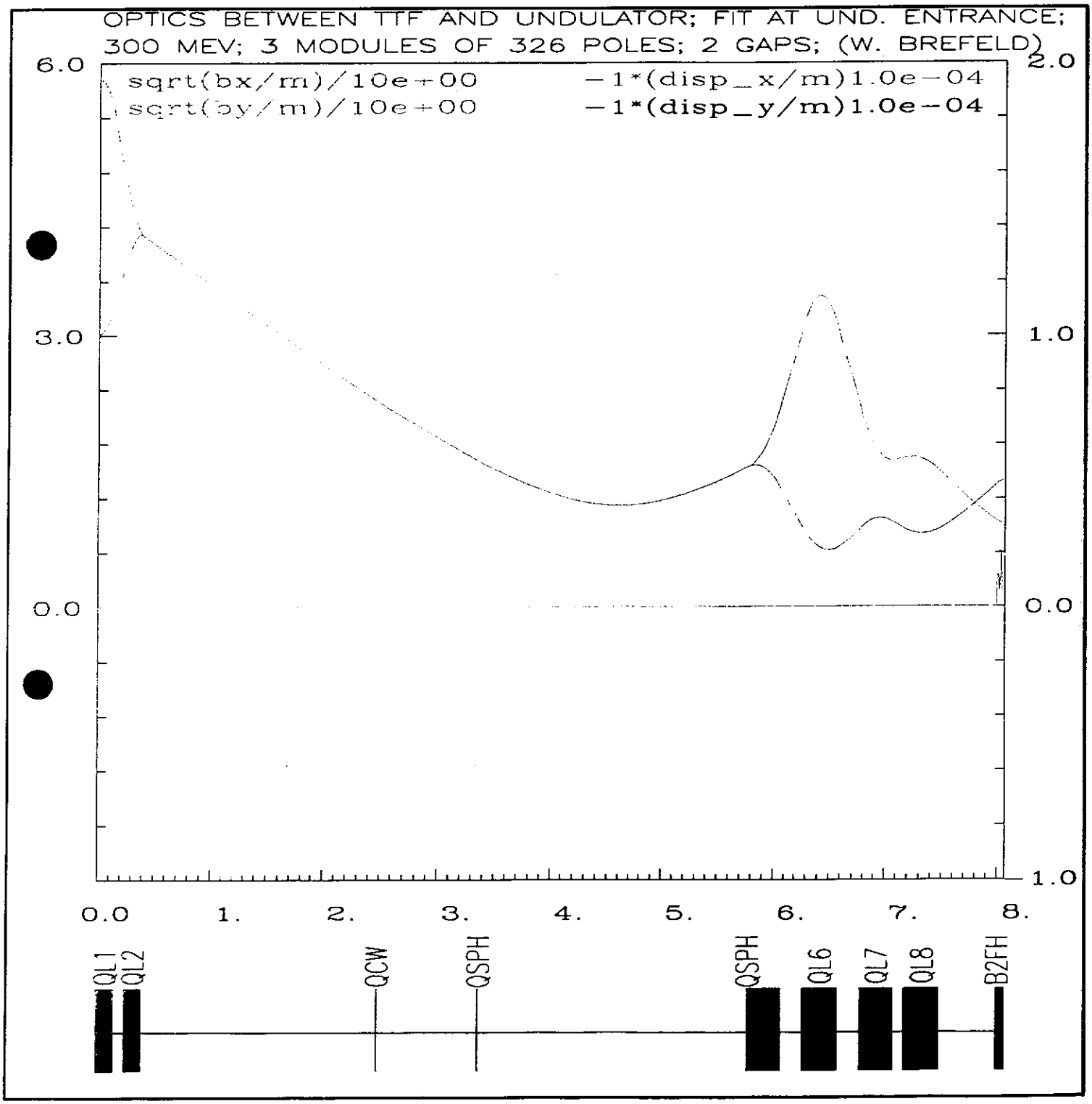
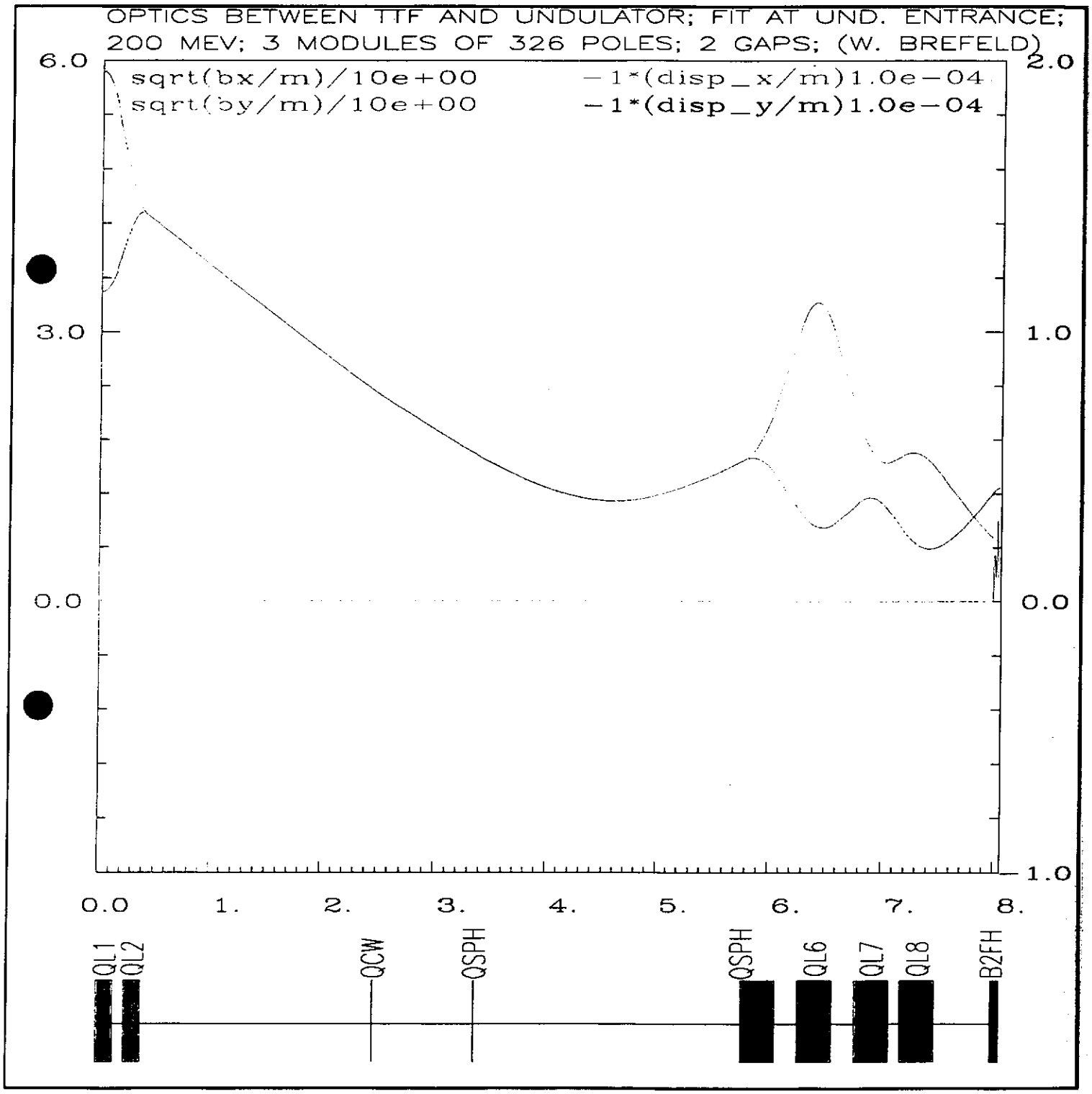
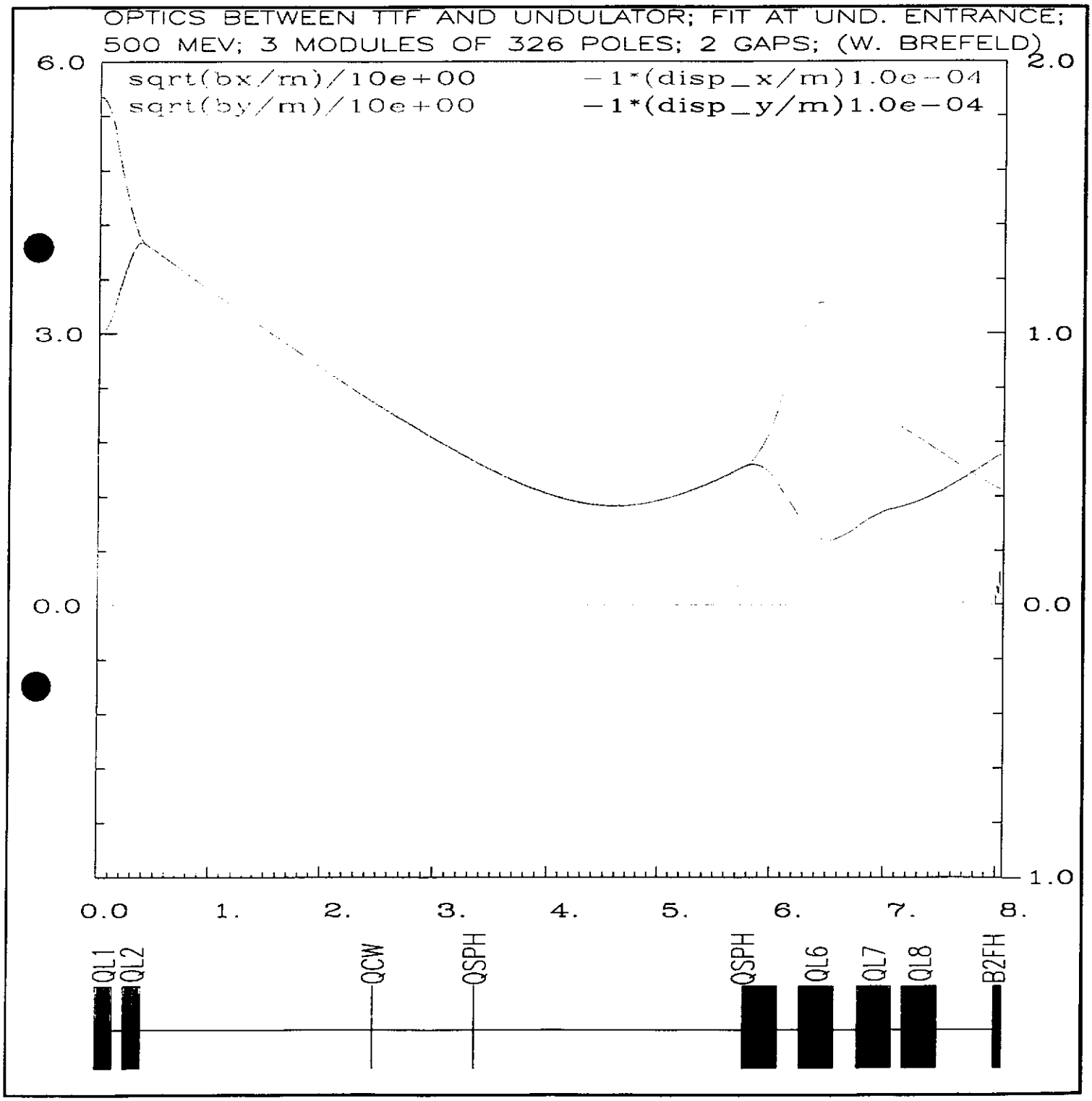
Collimator System

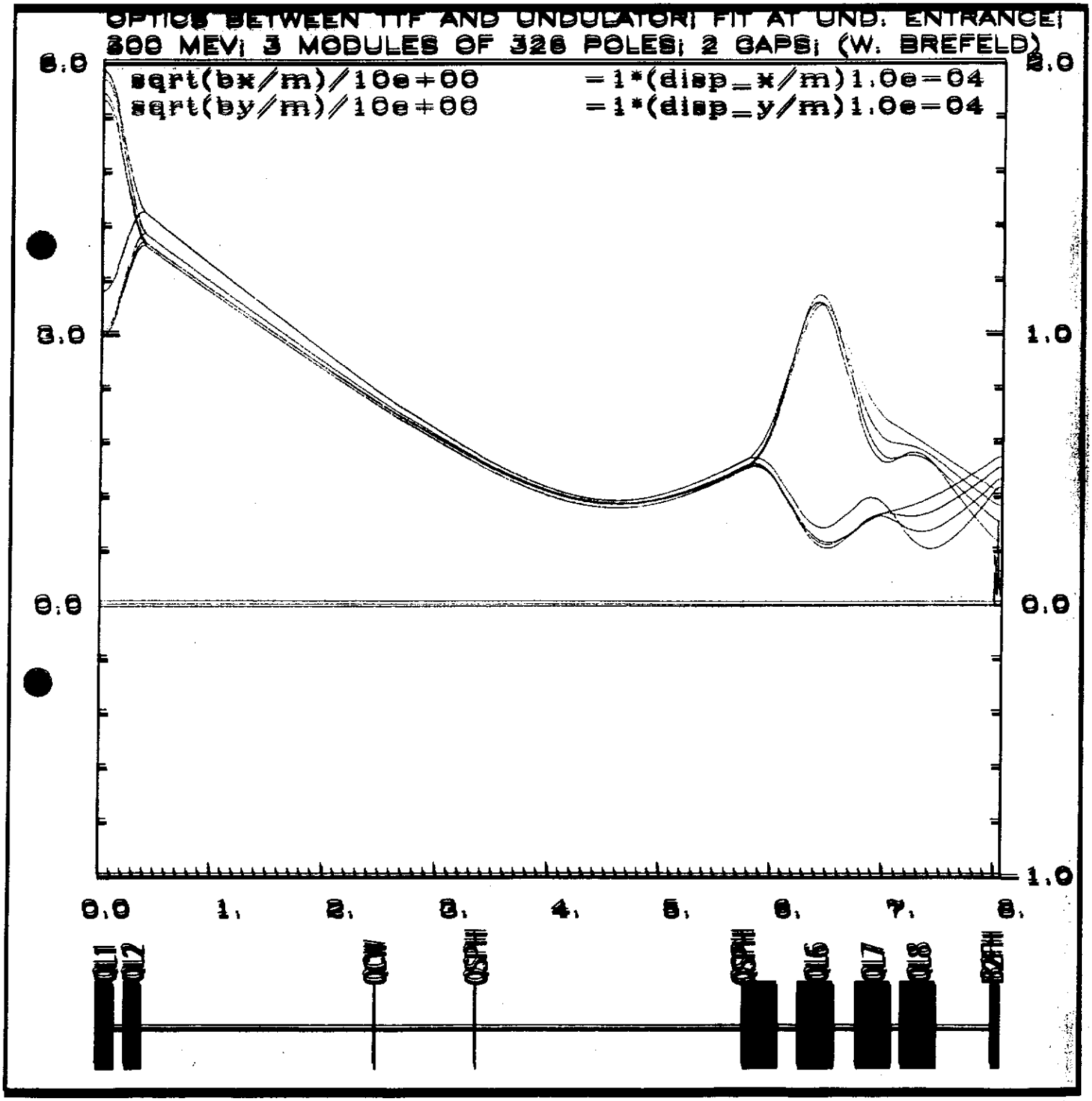



OPTICS BETWEEN TTF AND UNDULATOR; FIT AT UND. ENTRANCE;
400 MEV; 3 MODULES OF 326 POLES; 2 GAPS; (W. BREFELD)
sqrt(bx/m)/10e+00
sqrt(by/m)/10e+00
-1*(disp_x/m)1.0e-04
-1*(disp_y/m)1.0e-04
6.0
3.0
0.0
2.0
1.0
0.0
1.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.
QL1
QL2
QCW
QSPH
QSPH
QL6
QL7
QL8
B2FH


OPTICS BETWEEN TTF AND UNDULATOR; FIT AT UND. ENTRANCE;
300 MEV; 3 MODULES OF 326 POLES; 2 GAPS; (W. BREFELD)
sqrt(bx/m)/10e+00
sqrt(by/m)/10e+00
-1*(disp_x/m)1.0e-04
-1*(disp_y/m)1.0e-04
6.0
3.0
0.0
2.0
1.0
0.0
1.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.
QL1
QL2
QCW
QSPH
QSPH
QL6
QL7
QL8
B2FH


OPTICS BETWEEN TTF AND UNDULATOR; FIT AT UND. ENTRANCE;
200 MEV; 3 MODULES OF 326 POLES; 2 GAPS; (W. BREFELD)
sqrt(bx/m)/10e+00
sqrt(by/m)/10e+00
-1*(disp_x/m)1.0e-04
-1*(disp_y/m)1.0e-04
6.0
3.0
0.0
2.0
1.0
0.0
1.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.
QL1
QL2
QCW
QSPH
QSPH
QL6
QL7
QL8
B2FH

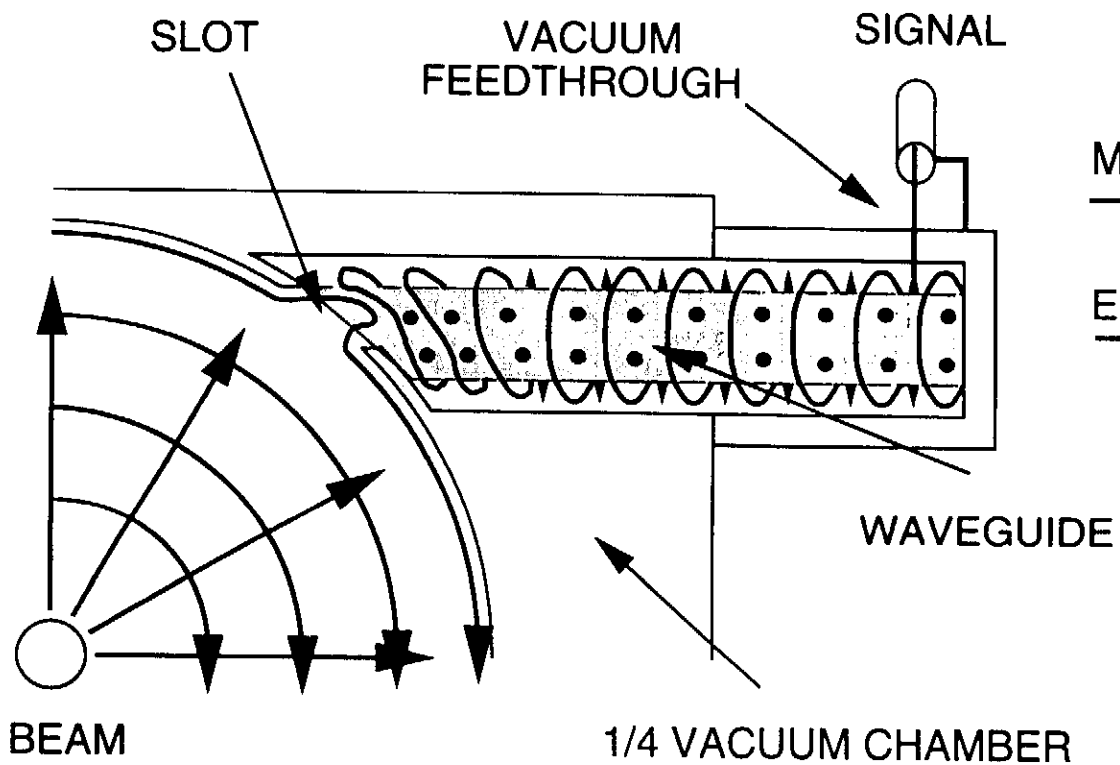

OPTICS BETWEEN TTF AND UNDULATOR; FIT AT UND. ENTRANCE;
500 MEV; 3 MODULES OF 326 POLES; 2 GAPS; (W. BREFELD)
sqrt(bx/m)/10e+00
sqrt(by/m)/10e+00
-1*(disp_x/m)1.0e-04
-1*(disp_y/m)1.0e-04
6.0
3.0
0.0
2.0
1.0
0.0
1.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.
QL1
QL2
QCW
QSPH
QSPH
QL6
QL7
QL8
B2FH


OPTICS BETWEEN TTF AND UNDULATOR; FIT AT UND. ENTRANCE;
300 MEV; 3 MODULES OF 326 POLES; 2 GAPS; (W. BREFELD)
sqrt(bx/m)/1e+00 =1*(disp_x/m)1.0e-04
sqrt(by/m)/1e+00 =1*(disp_y/m)1.0e-04
6.0
3.0
0.0
2.0
1.0
0.0
1.0
0.0
1.
2.
3.
4.
5.
6.
7.
8.

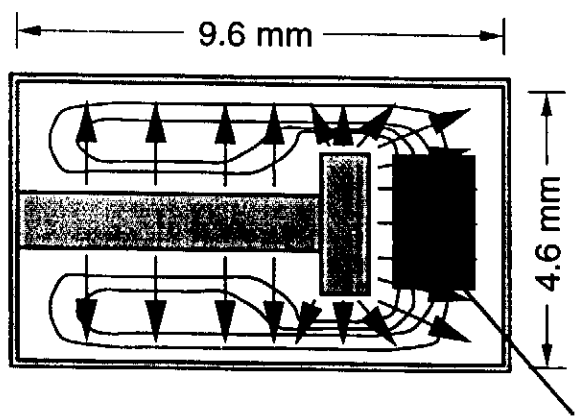
T. Kamps

BASIC IDEA

- Coupling to magnetic field of electron beam through four slots (72/36 degree apart in azimuth) in beam pipe



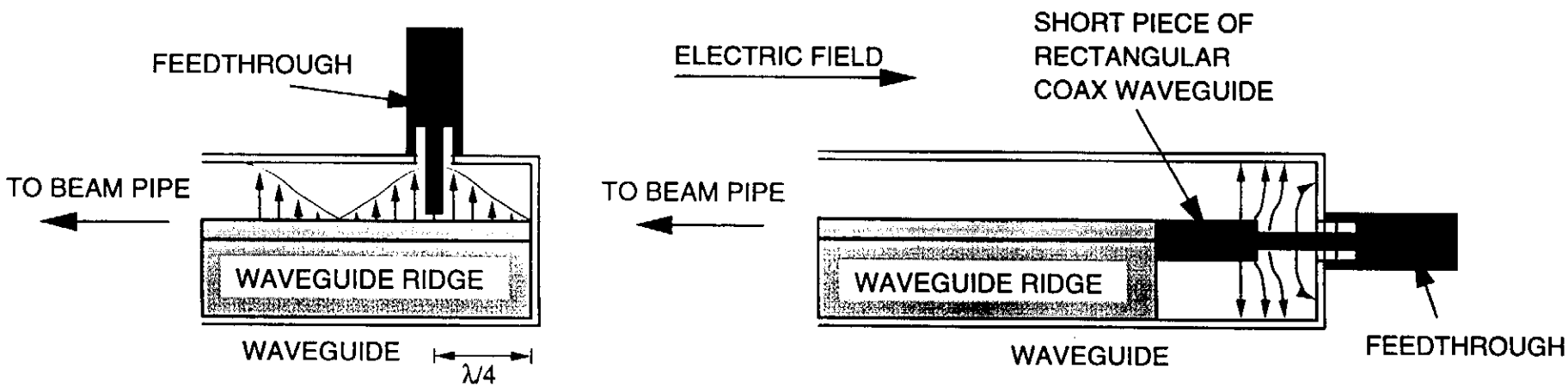
- Waveguide profile



- Ridged waveguide with cut off at 9 GHz
- Full dispersion of fundamental mode at 12 GHz

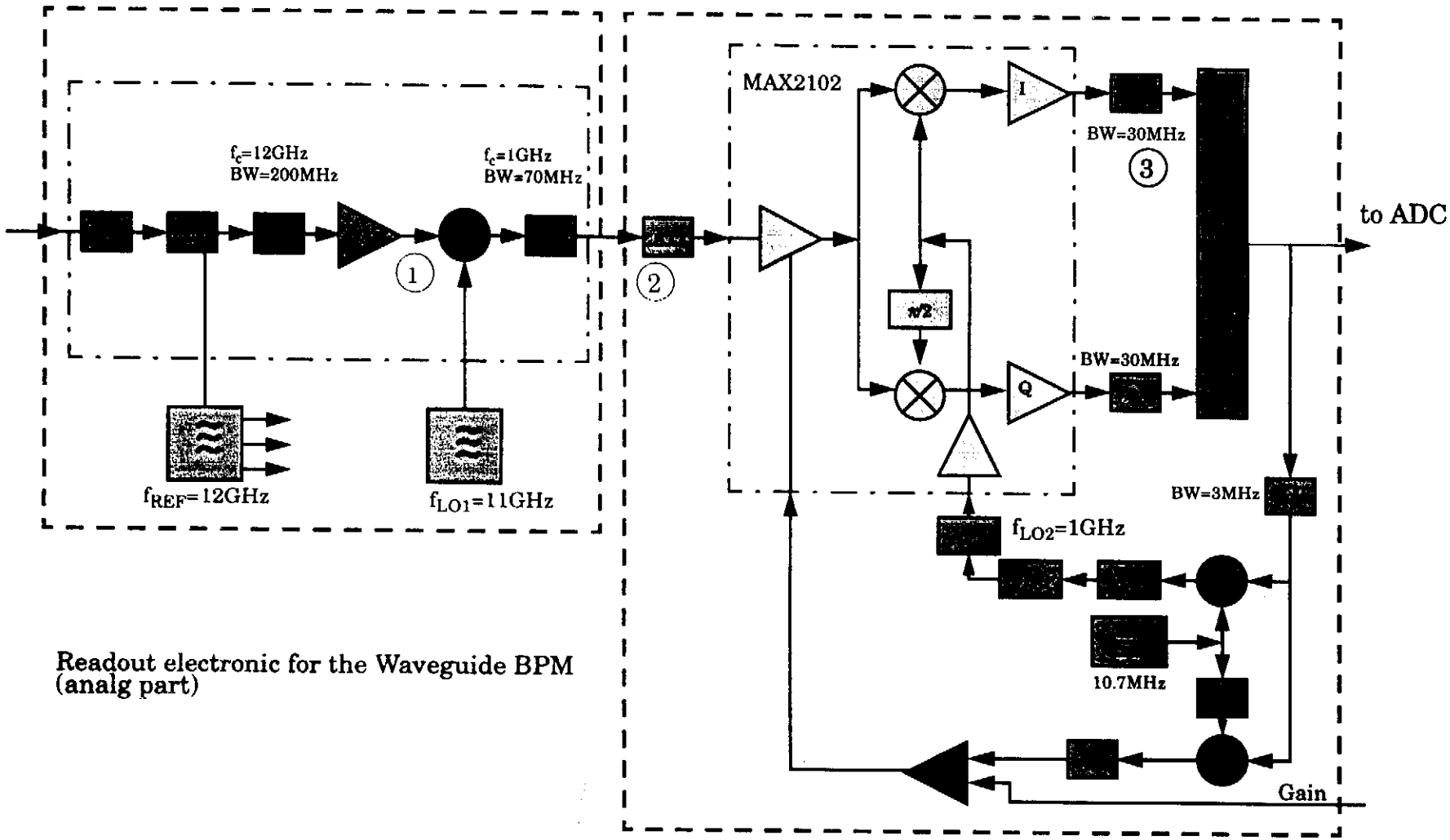
IMPROVEMENTS ON DESIGN - PROTOTYPE II

- Fabrication of ridge and waveguide by Electro-Discharge Maschining (EDM) in one step
- Transition ridged waveguide to coax system



PROTOTYPE I

PROTOTYPE II

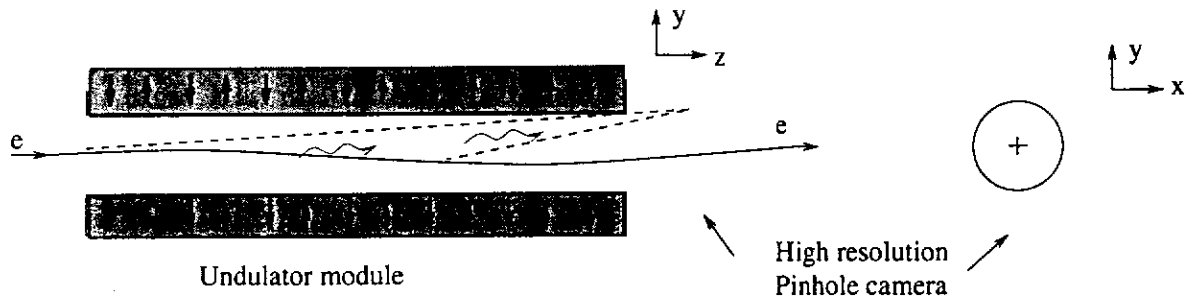


Readout electronic for the Waveguide BPM (analg part)

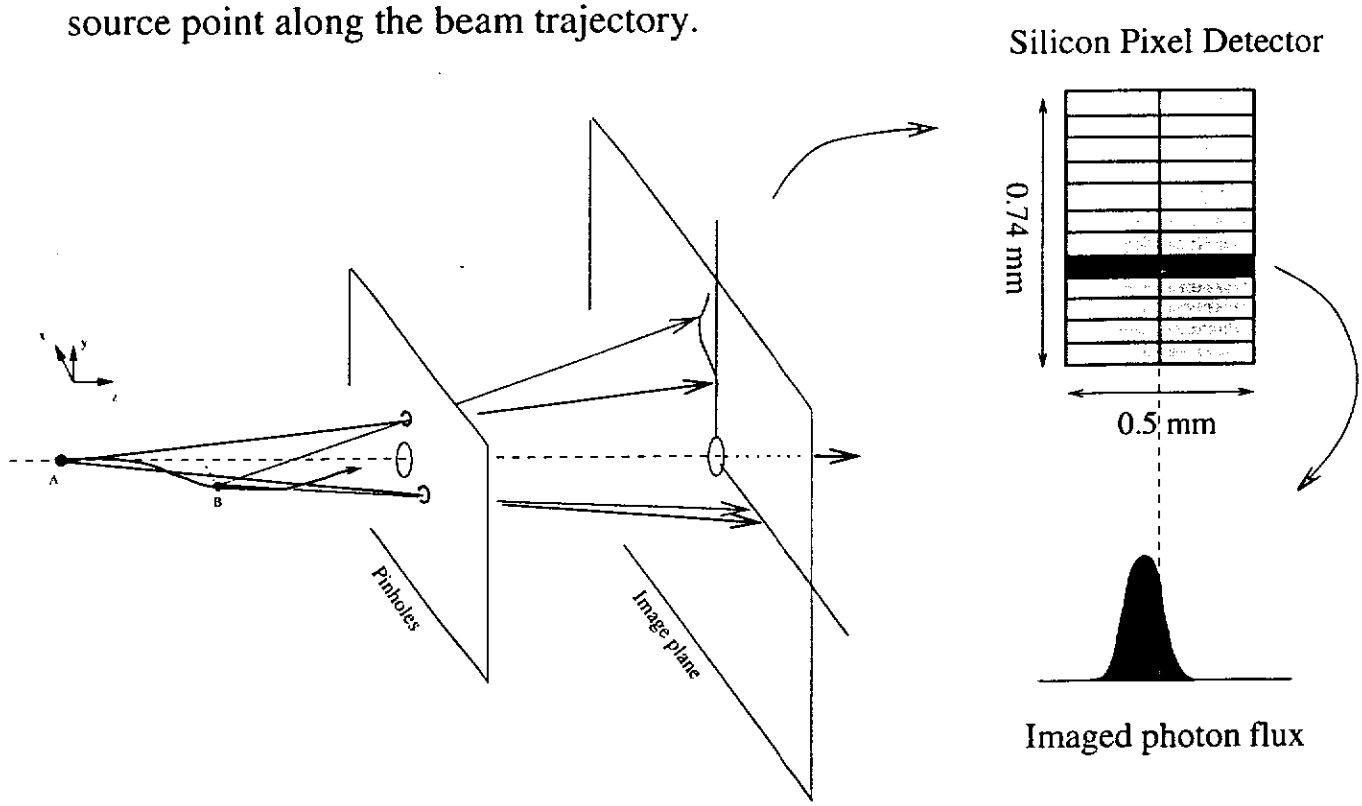
S. Roth

Beam Trajectory Monitor - Overview

- Undulator radiations imaged off-axis through pinholes



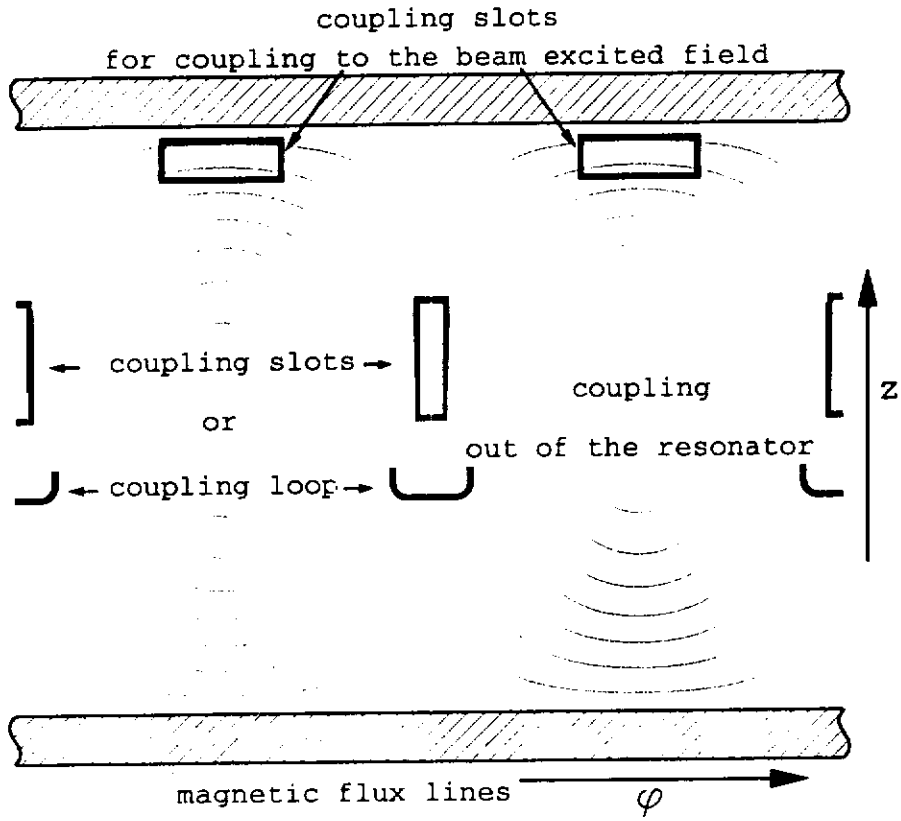
- Two imaged points uniquely determine the source point along the beam trajectory.



- Detector calibration defines reference lines precisely

A COAXIAL

BEAM POSITION MONITOR

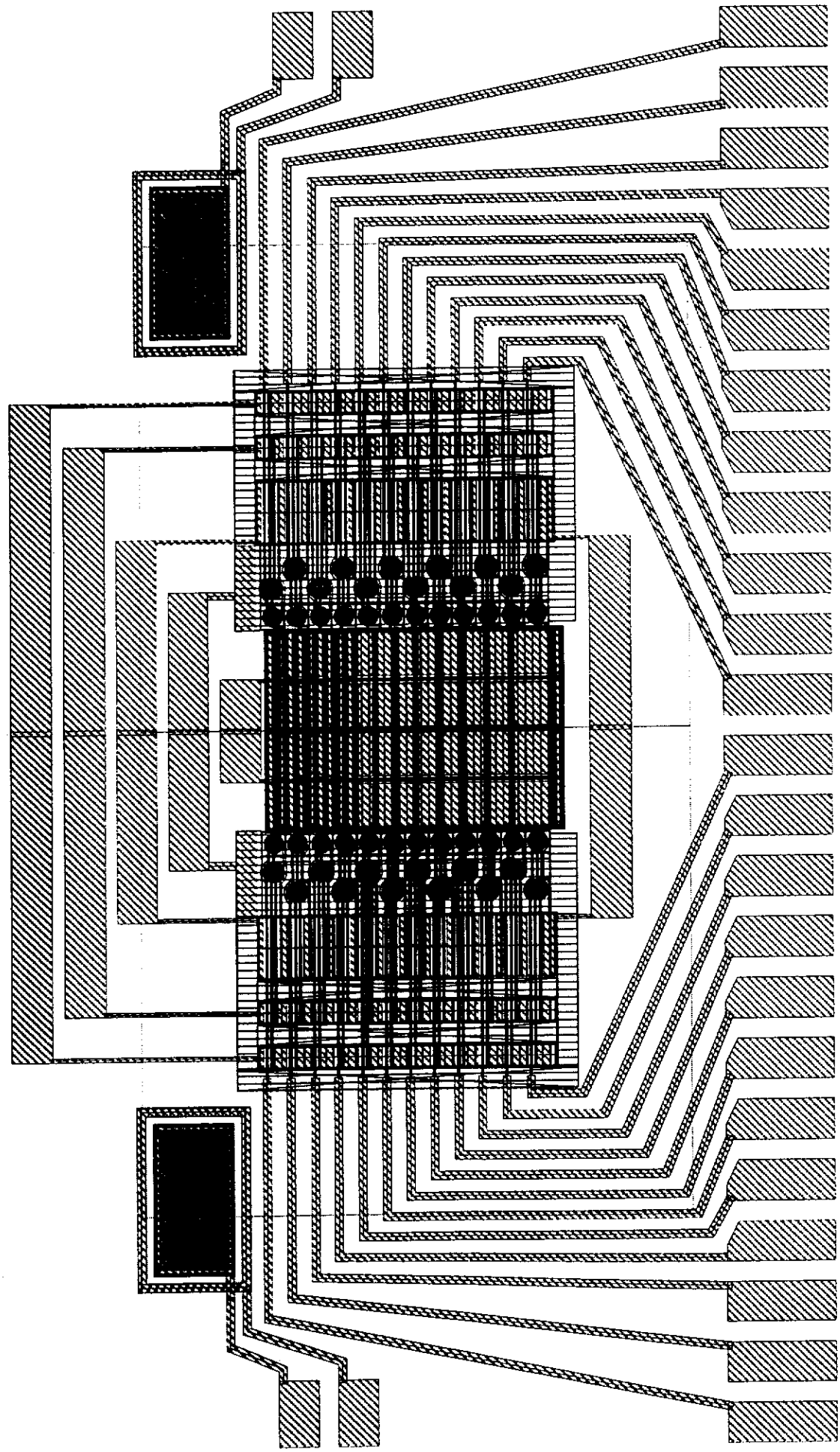


Principal mode of operation
of the resonant BPM.

	monitor A		monitor B	
mode	calculat. [GHz]	measurem. [GHz]	calculat. [GHz]	measurem. [GHz]
TE_{011}	0.944	1.000	1.171	1.147
TE_{021}	1.372	1.520	1.949	1.936
TE_{012}	1.605	1.677	1.748	1.729

Calculated and measured resonance frequencies
for the two monitor prototypes A and B.

Thomas Scholz



T. Limberg

How to proceed:

Use injector optics optimized with PARMELA up to first triplet * downstream of capture cavity, then take beam parameters at that point as initial values for the COMFORT code to build an optics which:

- keeps the beam as round as possible
- (minimize space charge effects)

- has a waist at the entrance of the first module and lets RF focusing produce another waist further down in the module (compensates space charge emittance growth)

- keeps the β-functions small and constant in the dispersive region of bunch compressor II
- (reduces emittance growth due to space charge distortion of dispersion trajectories and coherent synchrotron radiation)

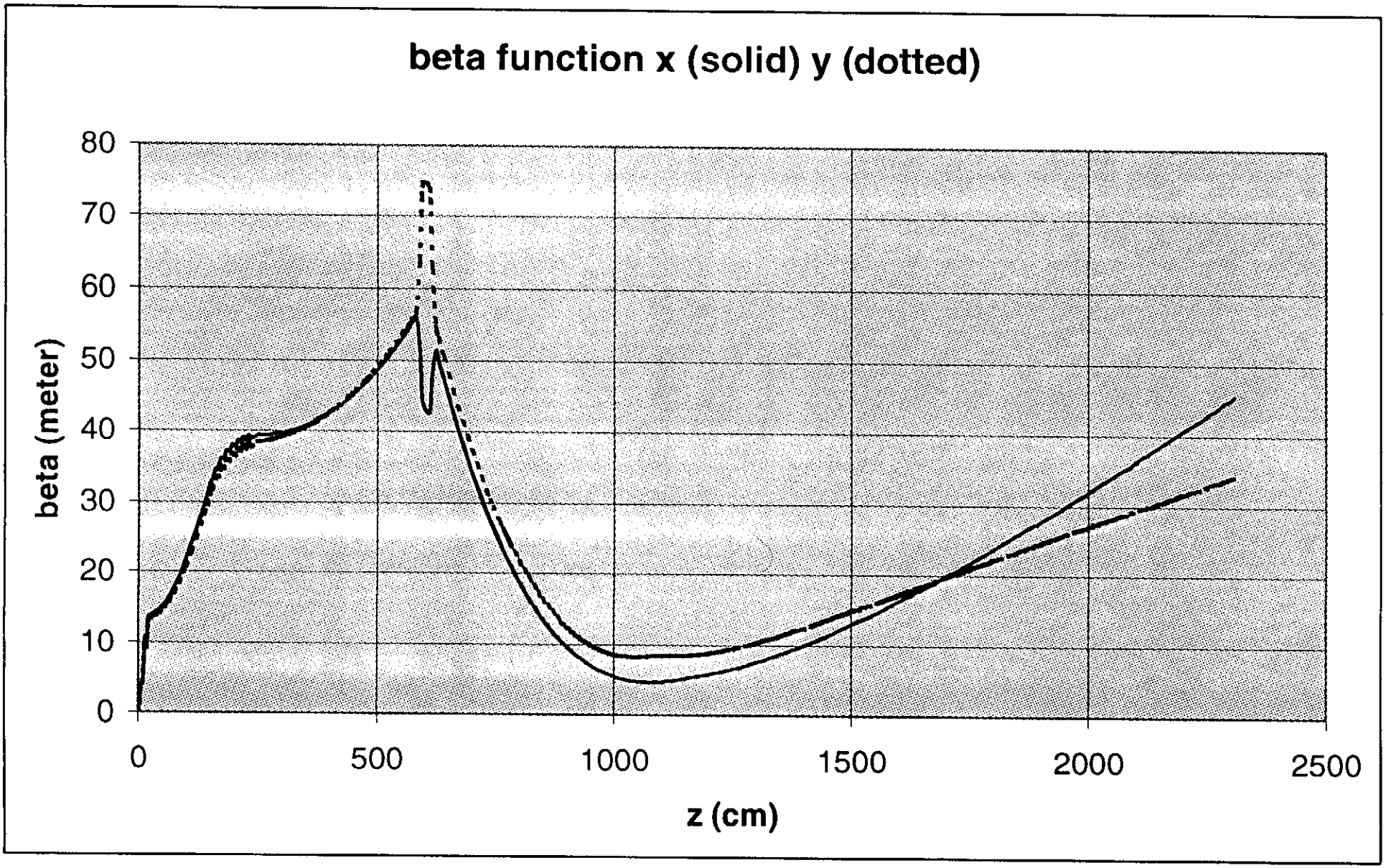
- fits into the optics of the collimator section

  minimizes variation of optical functions with charge density (reduces beam losses in the case of a non-ideal rectangular distribution in longitudinal phase space: stabilizes measurements etc.)

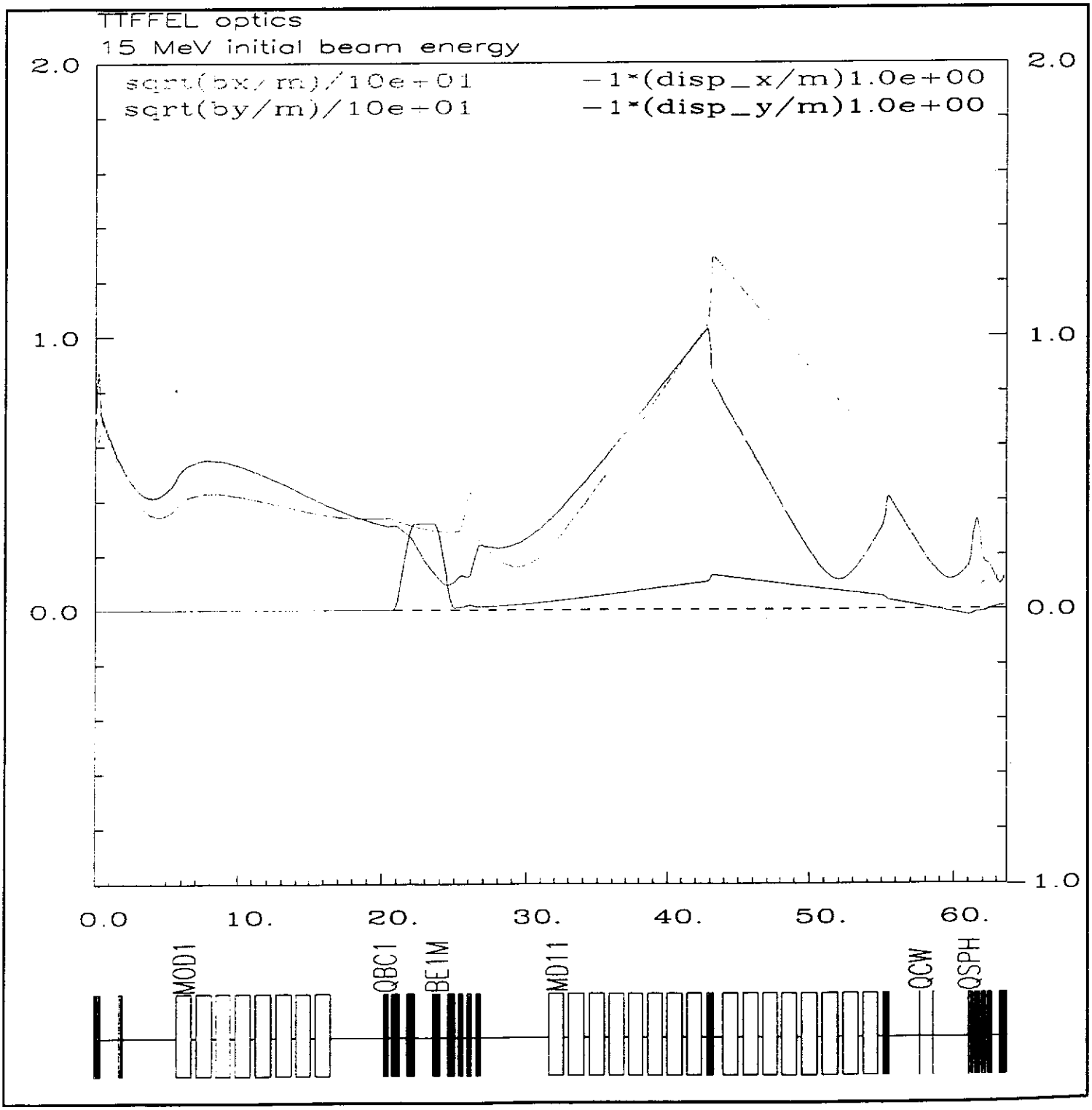
Then check emittance preservation with PARMELA and CSR runs.

*extended to end of Module 1

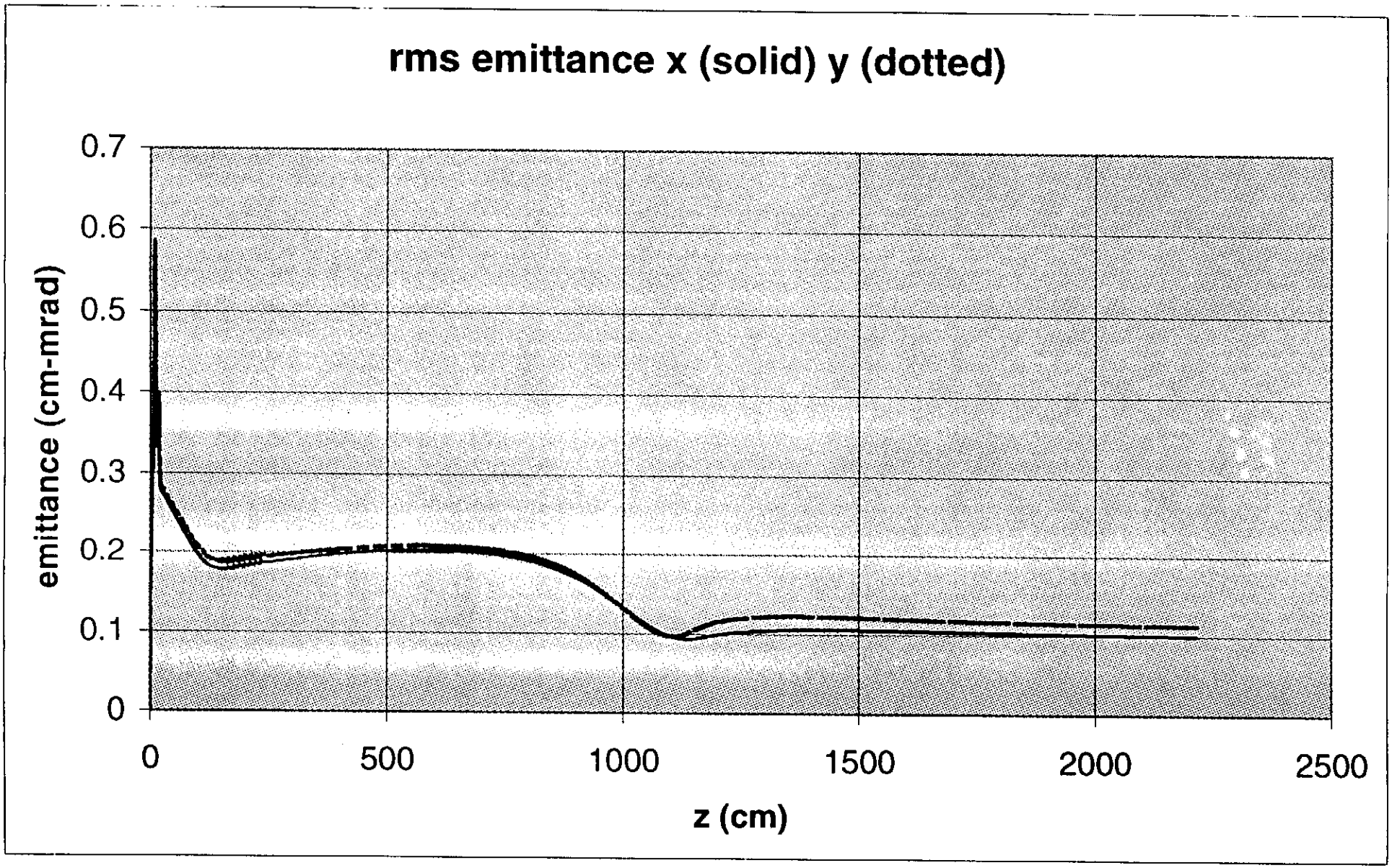
LIMBERG@MPYNTLIMBERG, JUL07/14:57


beta function x (solid) y (dotted)
beta (meter)
80
70
60
50
40
30
20
10
0
0
500
1000
1500
2000
2500
z (cm)

optic 1uC


TTFFEL optics
15 MeV initial beam energy
sqrt(bx/m)/10e+01
sqrt(by/m)/10e+01
-1*(disp_x/m)1.0e+00
-1*(disp_y/m)1.0e+00
2.0
1.0
0.0
1.0
0.0
10.
20.
30.
40.
50.
60.
MOD1
QBC1
BE1M
MD11
QCW
QSPH

1nC ~~0.5nC~~


rms emittance x (solid) y (dotted)
emittance (cm-mrad)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
z (cm)

btC

Proposal for the next TTF-Collaboration meeting

11-13 November 1998
INFN Frascati

(including meeting
on TESLA 500)

Workshop of ECFA/DESY
on Physics and Detectors
8-10 November 1998
INFN Frascati