

TESLA - COLLABORATION

**R & D Issues in the Field of Superconducting
Cavities (TESLA Meeting 9 - 11.03.98)**



March 1998, TESLA 98-05

TESLA Reports are available from:

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R & D Issues, TESLA Meeting at DESY, March 9-11, 1998

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Sample Preparation

(Sample material: Heraeus, RRR 300)
General procedures: US-Cleaning of the samples at the beginning
water rinsing after each BCP: 9x filling/emptying
2x 20 min flow

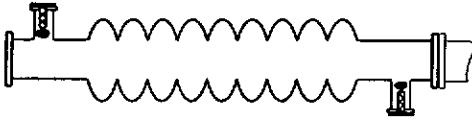
DC Field Emission Investigations of Samples Prepared in TESLA Cavities at DESY (TTF Cleanroom)

T. Habermann, A. Göhl, G. Müller, D. Nau, H. Piel
Universität Wuppertal

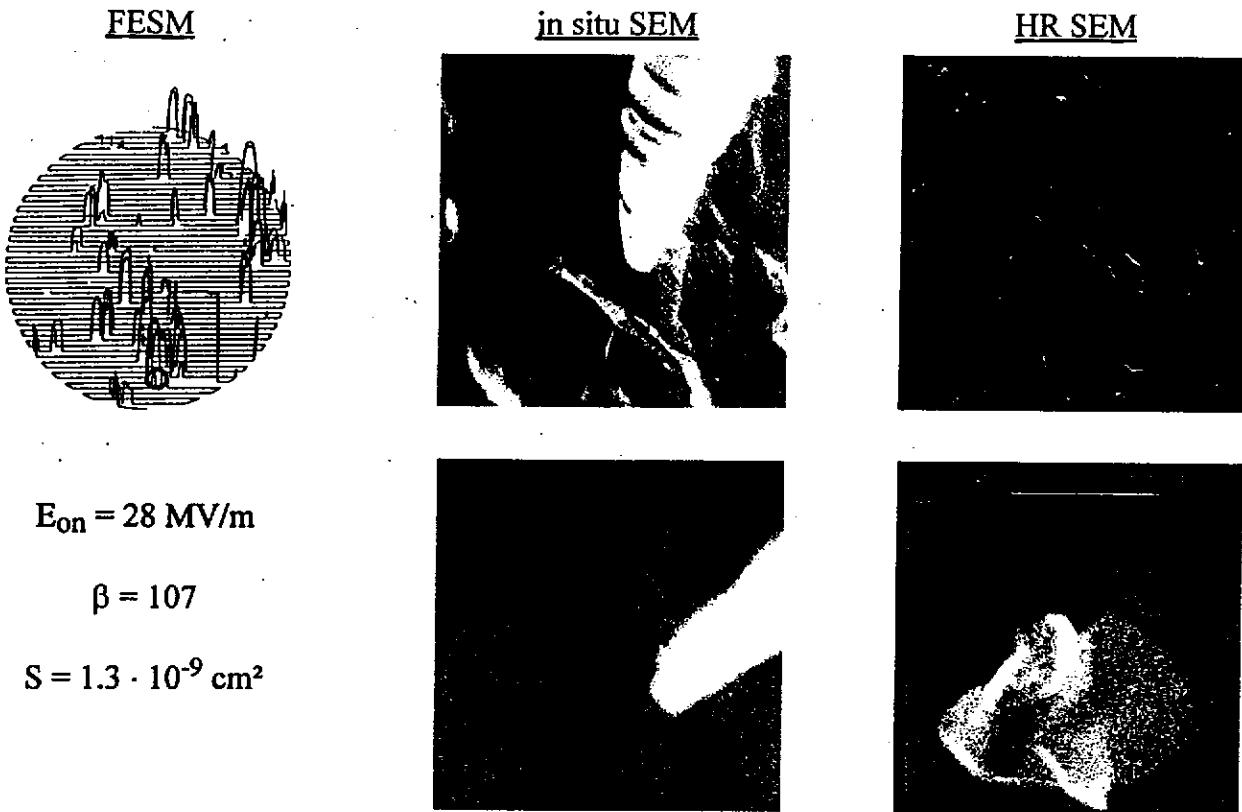
D. Proch, D. Reschke
DESY

Sample A (top)	Sample B (bottom)
800°C (2h) in cavity C23:	
'Ti-BCP' in cavity C23: 70 µm, bottom	60 µm, top
'Nb-BCP' in cavity C23: 28 µm, bottom	15 µm, top
US / Ultra-Pure Water Rinsing in Cavity D6 (up to 12 MΩcm)	
High Pressure Water Rinsing in Cavity D6 (100 bar, 120 min)	
Drying, Packaging (Class 10)	

Sample C (top)	Sample D (bottom)
'Ti-BCP' in cavity C22: 55 µm, top	70 µm, bottom
1400°C (4h) + Ti in cavity C22	
30 µm 'Ti-BCP' in cavity C22 top	bottom
15 µm 'Nb-BCP' in cavity C22: top	bottom
25 µm 'Nb-BCP' in cavity C24: top	bottom
Ultra-Pure Water Rinsing in Cavity _____ (up to 17 MΩcm)	
High Pressure Water Rinsing in Cavity D6 (100 bar, 120 min)	
Drying, Packaging (Class 10)	



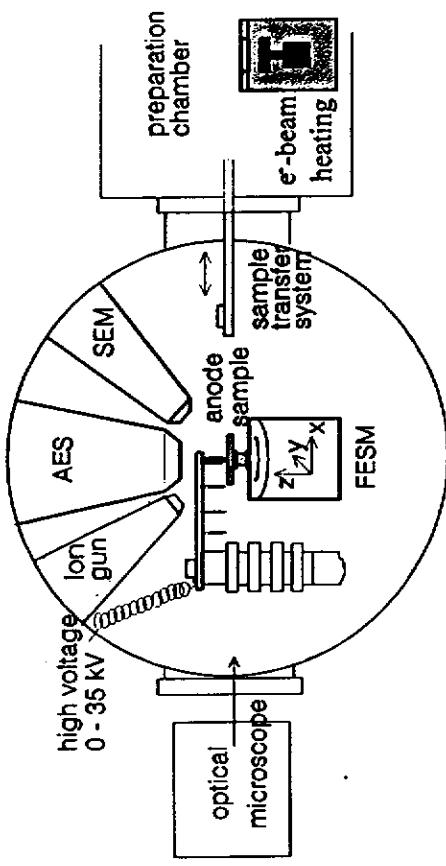
Single Emitter Analysis



T.Habermann, A.Göhl, G.Müller, D.Nau, H.Piel

Berg. Univ. Wuppertal

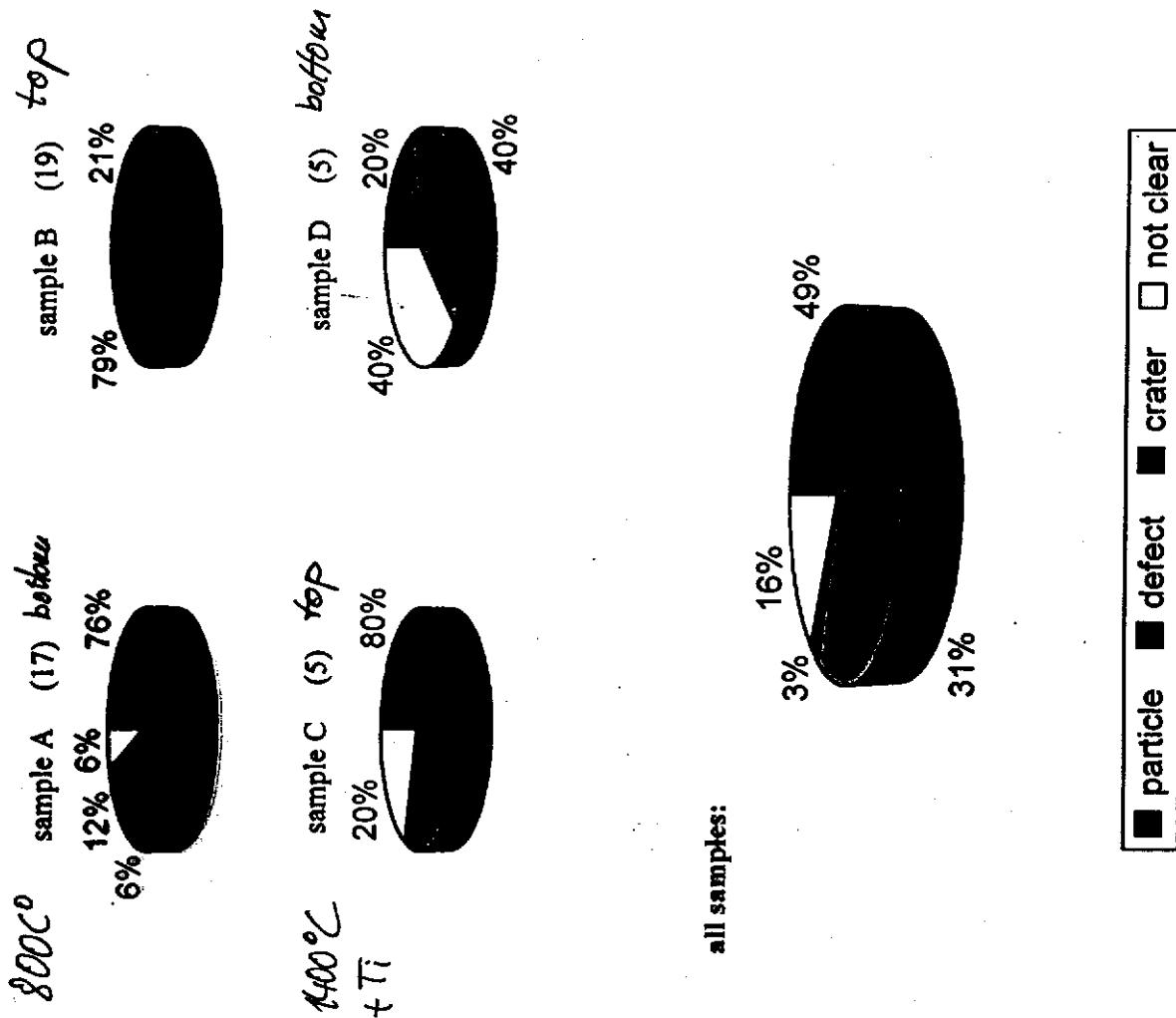
EXPERIMENTAL



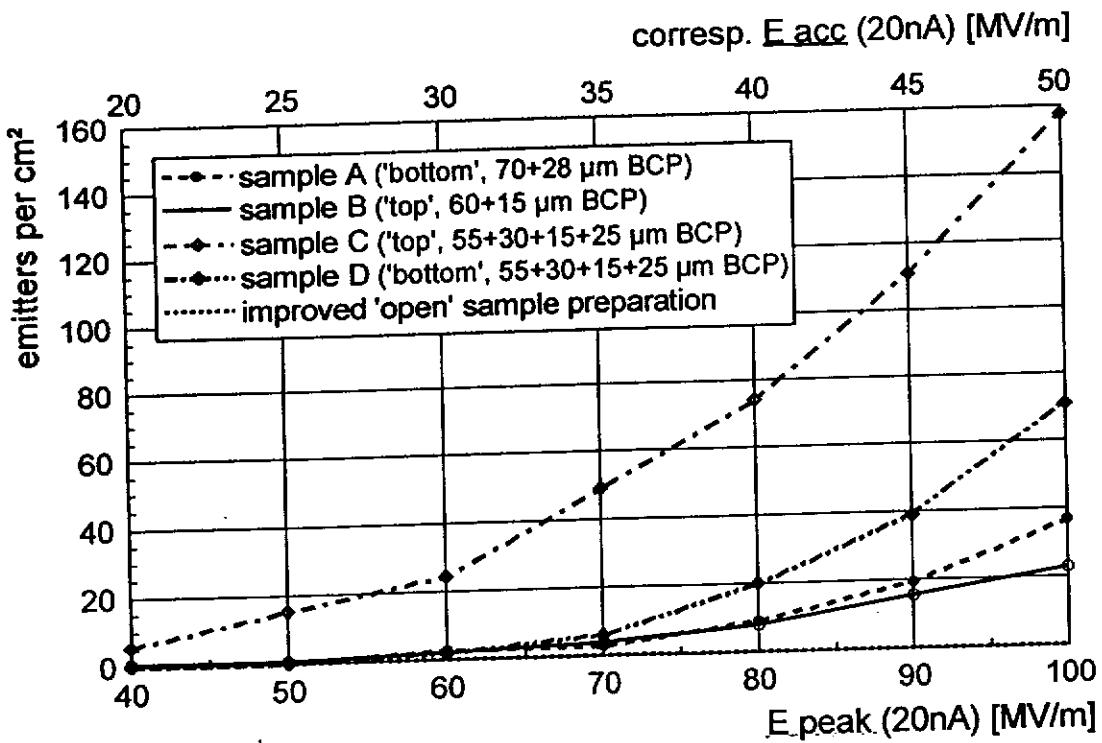
UHV-analysis- and preparation chamber of the
Field Emission Scanning Microscope (FESM)

- Non-destructive emitter localization (spat. resol. ~ 1 μm) and characterization of the field emission properties:
 - Field emission scans of sample areas up to $\varnothing 25 \text{ mm}$
 - Measurement of the onset field strength of emitting sites
 - I vs. E behavior
 - Emitter stability by current application (up to 1 mA) and long term behavior
- Emitter morphology by in situ SEM (resol. 70 nm)
- Chemical composition ($Z > 3$) by in situ AES
- Selective Emitter-modification by in situ ion bombardment
- Emitter-modification by in situ heat treatment and gas exposure

SEM Analysis - Statistics



DC FE-Samples Prepared in TESLA-Cavities



Analysis of single emitters on sample B

$$E(0.5nA) = \underline{35 \text{ MV/m}}$$

$$\beta = 86$$

$$S = 7 \cdot 10^{-11} \text{ cm}^2$$

particle, slanted view:



view from the side:



$$E(0.5nA) = \underline{40 \text{ MV/m}}$$

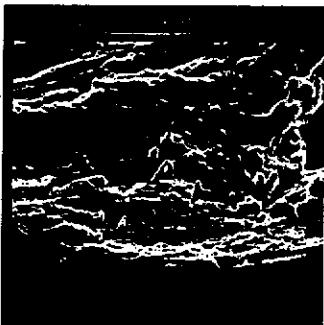
$$\beta = 88$$

$$S = 2 \cdot 10^{-12} \text{ cm}^2$$

defect, slanted view:



slanted view:

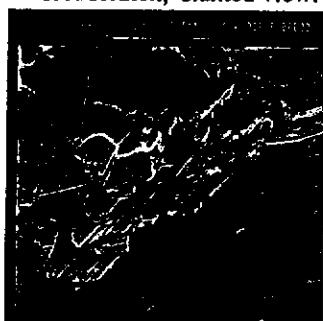


$$E(0.5nA) = \underline{47 \text{ MV/m}}$$

$$\beta = 103$$

$$S = 2 \cdot 10^{-14} \text{ cm}^2$$

defect/scratch, slanted view:



view from the side:



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Analysis of single emitters on sample A

$$E(0.5nA) = \underline{19 \text{ MV/m}}$$

$$\beta = 83$$

$$S = 2 \cdot 10^{-4} \text{ cm}^2$$

particle, slanted view:



view from the side:



$$E(0.5nA) = \underline{28 \text{ MV/m}}$$

$$\beta = 107$$

$$S = 1 \cdot 10^{-9} \text{ cm}^2$$

particle, view from above:



view from the side:

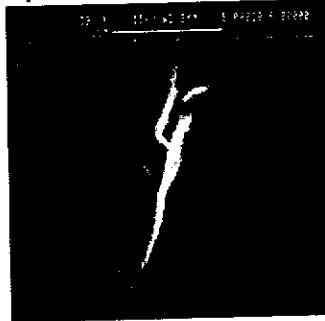


$$E(0.5nA) = \underline{28 \text{ MV/m}}$$

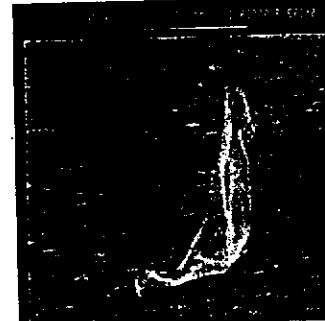
$$\beta = 310$$

$$S = 4 \cdot 10^{-16} \text{ cm}^2$$

particle, view from above:



view from the side:



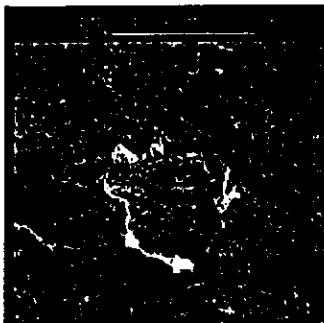
Analysis of single emitters on sample D

$$E(0.5nA) = 12 \text{ MV/m}$$

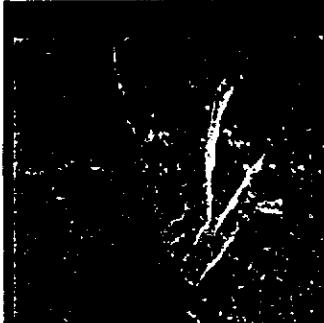
$$\beta = 233$$

$$S = 2 \cdot 10^{-10} \text{ cm}^2$$

defect, slanted view:



slanted view:

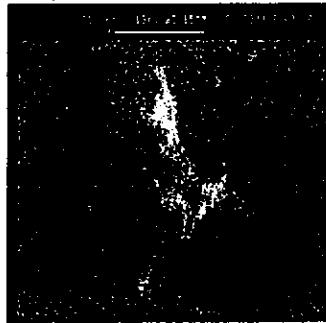


$$E(0.5nA) = 31 \text{ MV/m}$$

$$\beta = 101$$

$$S = 3 \cdot 10^{-11} \text{ cm}^2$$

particle, slanted view:



view from the side:

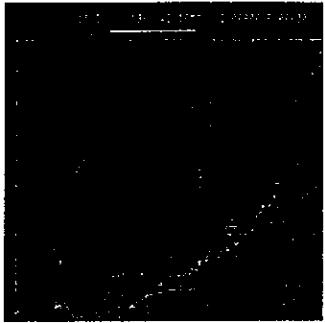


$$E(0.5nA) = 62 \text{ MV/m}$$

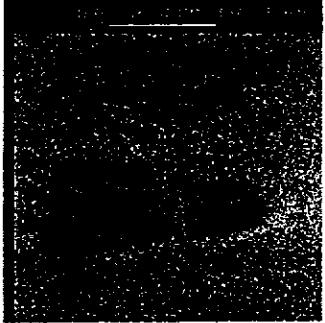
$$\beta = 43$$

$$S = 8 \cdot 10^{-10} \text{ cm}^2$$

defect, slanted view:



view from the side:



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Analysis of single emitters on sample C

$$E(0.5nA) = 19 \text{ MV/m}$$

$$\beta = 98$$

$$S = 2 \cdot 10^{-5} \text{ cm}^2$$

particle, slanted view:



view from the side:



$$E(0.5nA) = 24 \text{ MV/m}$$

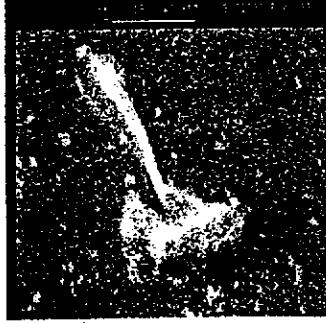
$$\beta = 118$$

$$S = 6 \cdot 10^{-10} \text{ cm}^2$$

particle, slanted view:



view from the side:

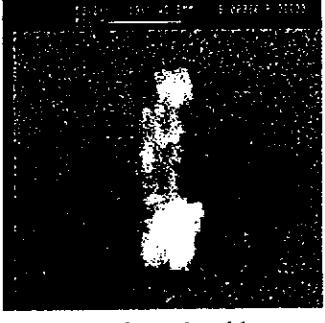


$$E(0.5nA) = 26 \text{ MV/m}$$

$$\beta = 119$$

$$S = 6 \cdot 10^{-11} \text{ cm}^2$$

particle, slanted view:



view from the side:



T. Habermann, A. Göhl, G. Müller, D. Nau, H. Piel

Outlook

- Chemical analysis of the emitters (EDX, AES?)
→ origin of the emitters?
- Electropolished samples
→ easier to clean?
- High pressure rinsing parameters (pressure, nozzle)
→ better cleaning?
- Further changes in the preparation (e.g. rinsing with warm water, shorter delay between BCP and water rinsing)
→ better cleaning?

Summary

- 4 samples prepared in TESLA cavities at TTF cleanroom
→ *emitters relevant to TESLA cavity preparation*
- Average emitter density of $4/\text{cm}^2$ at $E_{\text{acc}} = 25 \text{ MV/m}$
and $28/\text{cm}^2$ at $E_{\text{acc}} = 40 \text{ MV/m}$
→ *for reliable cavity production further improvement required*
- Analyzed emitters: micron and submicron-sized particles (49%) as well as (mechanical) defects (31%)

Status of Quality control and preparations development of clean room work

4

- Philips, HH:
Good contacts concerning cleaning procedures + chemical topics established
- Transferzentrum f. Reinraumtechnik, Offenbach:
First contacts about quality control / monitoring of inhalable dust
- Wacker Siltronic / Geltec Tec (Wacker lab):
First contacts about quality control of processes
 - Inhouse structure and preparation
- Special / topics:
 - FE-samples
 - Filters
- Contacts to industry

... many more

Contacts to industry

- Future:
- control / of processes
 - "mechanical / "automated" assembly

- General Infrastructure

- Air:
 - Cl. 100 / 100 routinely checked with particle counters → o.k.
 - but no continuous monitoring of the whole cleanroom
 - Monthly check of whole cleanroom should be established!

→

→ Monthly check of whole cleanroom should be established!

• Water:

- Supply water of chemistry, US, HPLC etc. routinely checked for particles, TOC, S → o.k.

→ o.k.

• Acid:

- Routinely checked for contaminations ⇒ ?

- Cleaning after Chechia ?
⇒ no infrastructure

Chemistry

- Hot water rinsing after final chemistry installed
 - does not solve FE problems alone; more statistics necessary
 - Separated work circuit for chemistry installed
- Why do we have fluctuations of the resistivity of the final rinsing water?
 - Correlation to FE onset ?? No !!
- Chemistry procedures work stable?
 - Variations of removal of Iris's equal understood (Lepes, Mathiesen)

(- Rinsing in case of emergency drastically improved!)

High pressure rinsing

- Drain water particle counting difficult due to air bubbles \rightarrow no sufficient results.
- \Rightarrow start of filter measurements and microscopic read-out
- \Rightarrow Many (even large) particles are collected.
(systematic investigations take more time?)
- Resistivity measurement under commissioning
 \Rightarrow (drain water)
- No quality control of high pressure supply water of HPR system?
- Closed cabinet around HPR system?

Assembly

- Standard procedure has good probability of FE onset Face $\approx 20 \text{ mJ/m}^2$
 \rightarrow problems of reproducibility.
- \Rightarrow Improvements of procedure, tooling and cleaning of parts need time (of money), but are necessary!
(Examples: bolts + nuts, ion guns, assembly tooling, pumping procedure etc.)
- Documentation of assembly is still under development:
 \rightarrow no database in formations available!
- High probability of vacuum leak after 1400C drying of the facilities
 \rightarrow no short correlation between number of assemblies and FE onset!
- \Rightarrow a tendency?
- mechanic assembly

Planning procedure + assembly to test stand

FE-samples

- Simplification of planning procedure under development ("WPF")
 - less "movement" of the cavity less assemblies

- Cleanliness of assembly to test stand is checked

→ the improved procedure under development

10

- step wise check of preparation procedure (BCP, HPR, EP; assembly difficult to check)
 - results presented by Th. Habermann
 - faster turn-around desirable!

- General Infrastructure

• Air:

- Cl. 100 / 10 routinely checked with particle counters → o.k.

→ but no continuous monitoring of the whole cleanroom
→ Monthly check of whole cleanroom should be established!

• Water:

- Supply water of chemistry, US, HPLC etc. routinely checked for particles, TOC, S → o.k.

• Acid:

- Routinely checked for contaminations ⇒ ?

- Cleaning after Cleaning 2.0

→ no infrastructure

Cleaning procedure + assembly to teststand

• Simplification of cleaning procedure under development (ULD) procedure

→ less "movement" of the cavity
less assemblies

• Cleanliness of assembly to teststand is checked

→ the improved procedure under development

FE-samples

- stepwise check of preparation procedure
(BCP, HPR, EP; assembly difficult to clean)
- results presented by Th. Habermann
→ faster turn-around desirable.
- - - - -
- check of surface quality with optical +
electron microscope
→ (e.g. after 200 h at HPR)

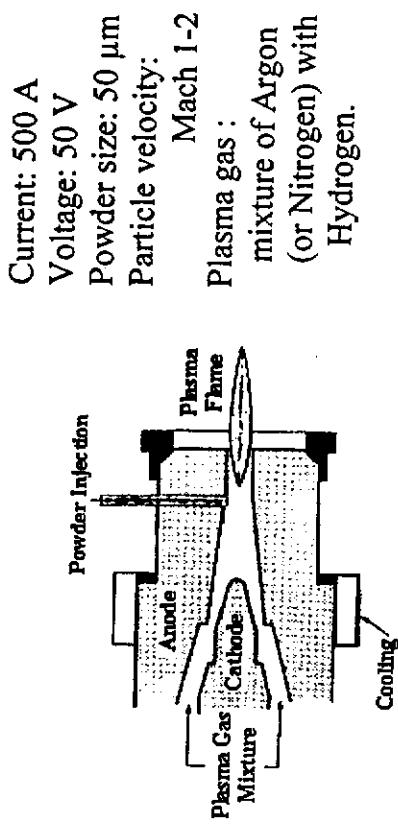
Fillers

- check of HPR drain water
- Simple to handle, read-out in clean room
but time-consuming for systematic studies
- Read-out under e-microscope + EDX to
be checked
- - - - -
- Comparison with particle counters

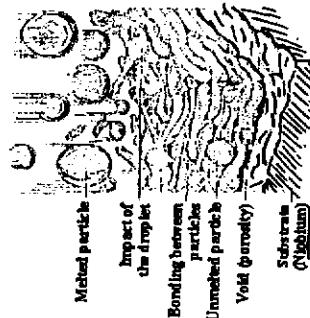
M. Tovarid y / Activities at Saclay & Orsay

A R&D program concerning new fabrication techniques of SRF cavities has started in a close collaboration with CEA and LAL(CNRS-Orsay).

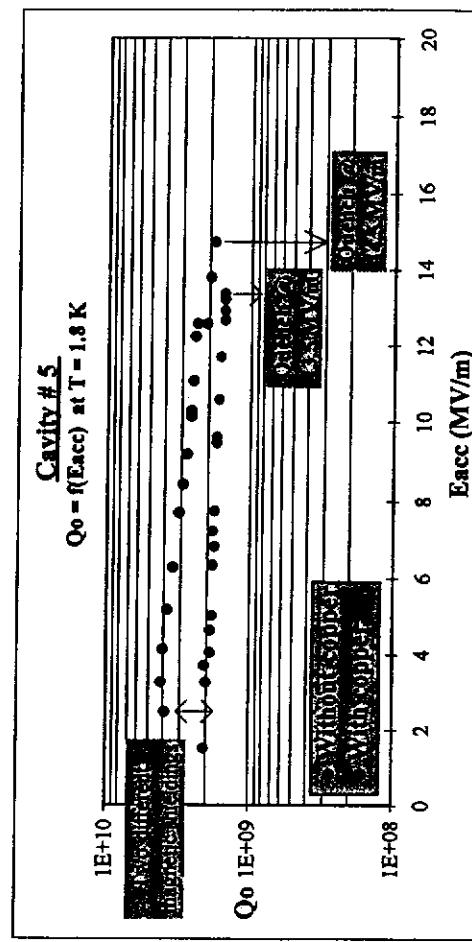
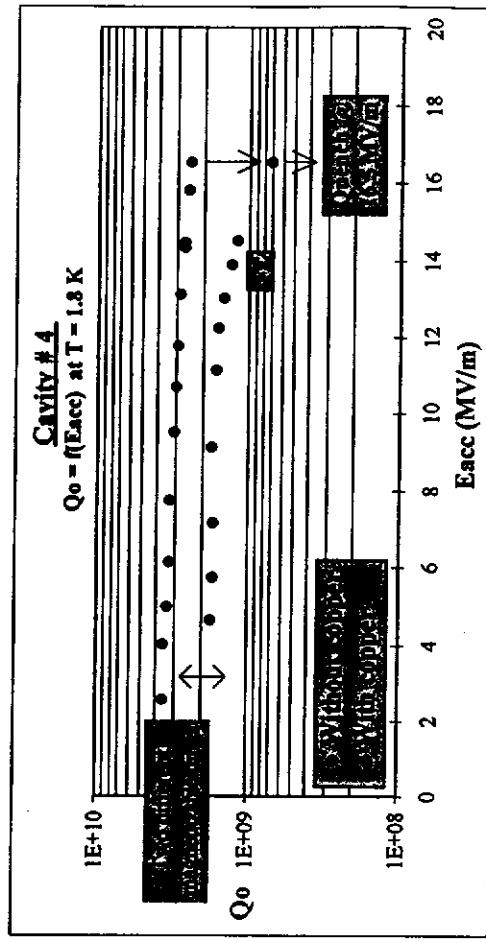
The technique is based on copper plasma sprayed onto thin wall (~ 1 mm) Niobium cavities. The ultimate goal is to produce 1.3 GHz hydroformed (or deep drawed and EB welded) multicell niobium cavities stiffened by the copper layer.



Plasma Spray Gun

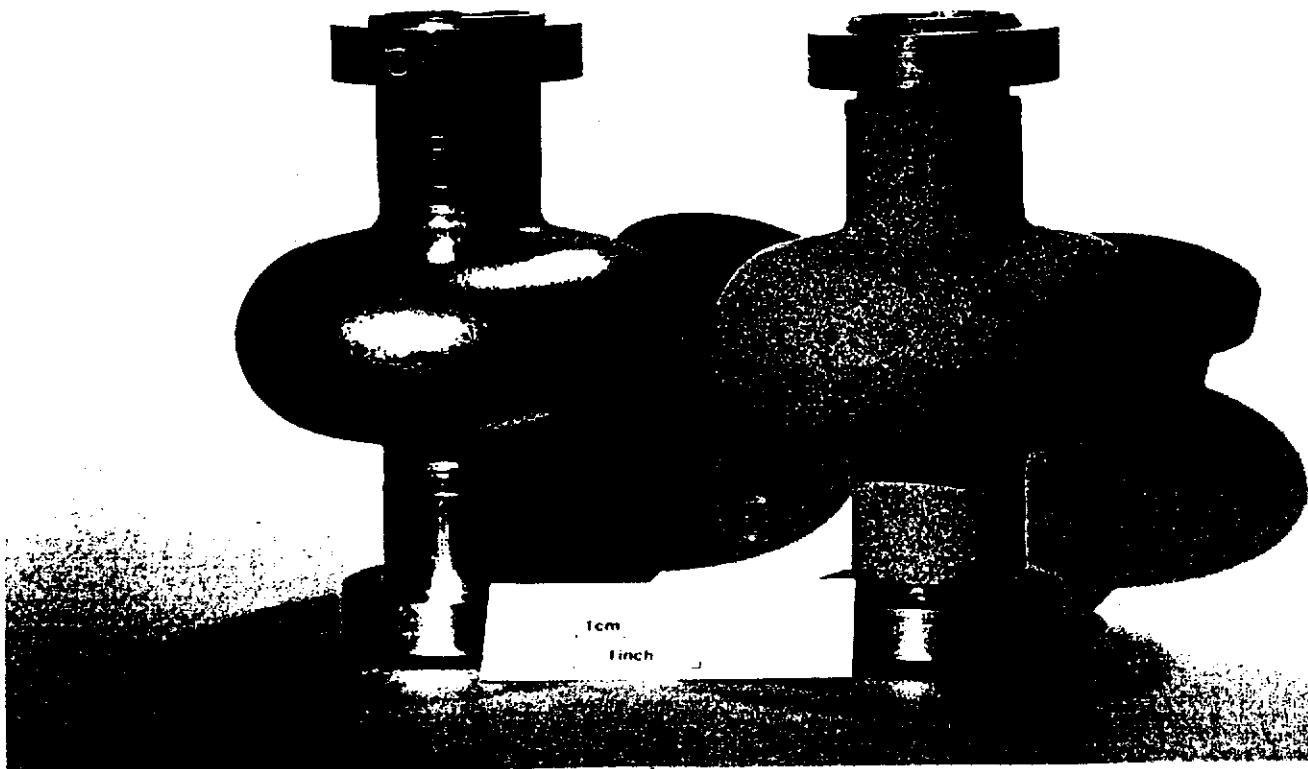


FIRST RESULTS:



	Section 1	Section 2	Section 3	Section 4
Cavity # 4	16.5 MV/m	16.5 MV/m	16.5 MV/m	16.5 MV/m
Cavity # 5	16.5 MV/m	16.5 MV/m	16.5 MV/m	16.5 MV/m

The cavity performances ($E_{acc\ max}$) are not (or very slightly) affected by the copper deposition.



TESLA cavities (comparison Nb vs Nb/Cu)

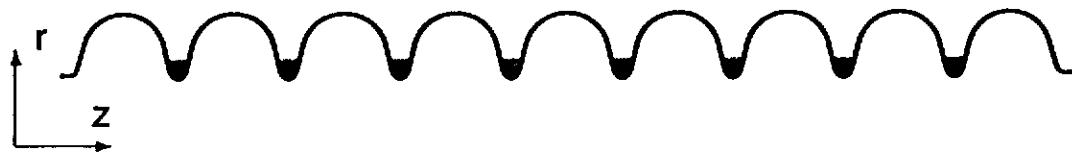
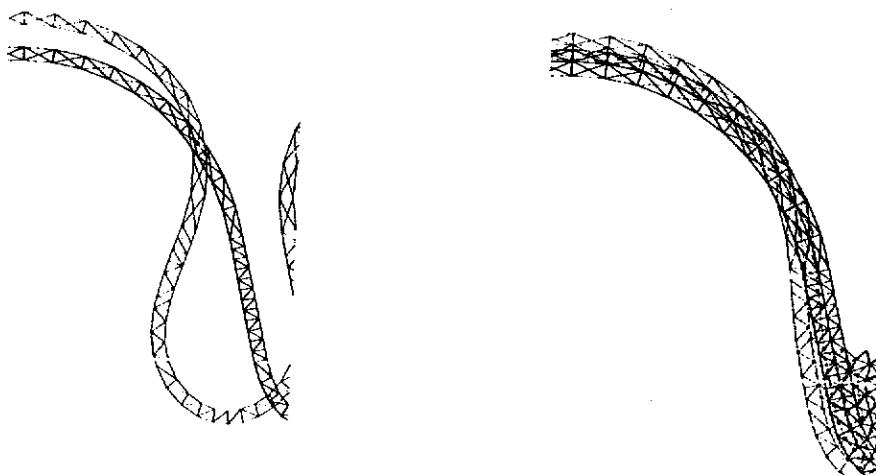
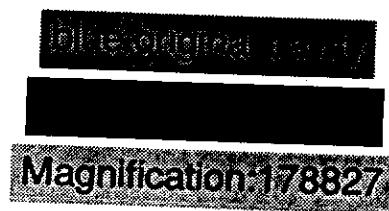


FIG. 1 – $E_{acc} = 25MV/m$, Bandwidth:434Hz ($Q_{ext} : 3.10^6$)

design	Δr	Δz	
niobium 2.5mm unstiffened	$0.038\mu m$	$0.252\mu m$	[Image]
niobium 2.5mm present stiffening sheme	$0.034\mu m$	$0.171\mu m$	[Image]
niobium 2.5mm + cuivre 2mm (homogeneous layer)	$0.019\mu m$	$0.106\mu m$	[Image]
niobium 2.5mm + cuivre 2mm + iris stiffening	$0.016\mu m$	$0.056\mu m$	[Image]
niobium 1mm + cuivre 2mm + iris stiffening	$0.023\mu m$	$0.094\mu m$	[Image]



NB 2.5 mm unstiffened Nb 1mm+Cu 2mm with iris stiffening

Kapitza Resistance Experiment

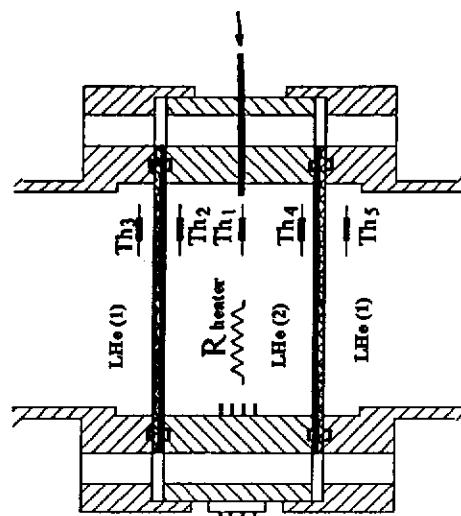
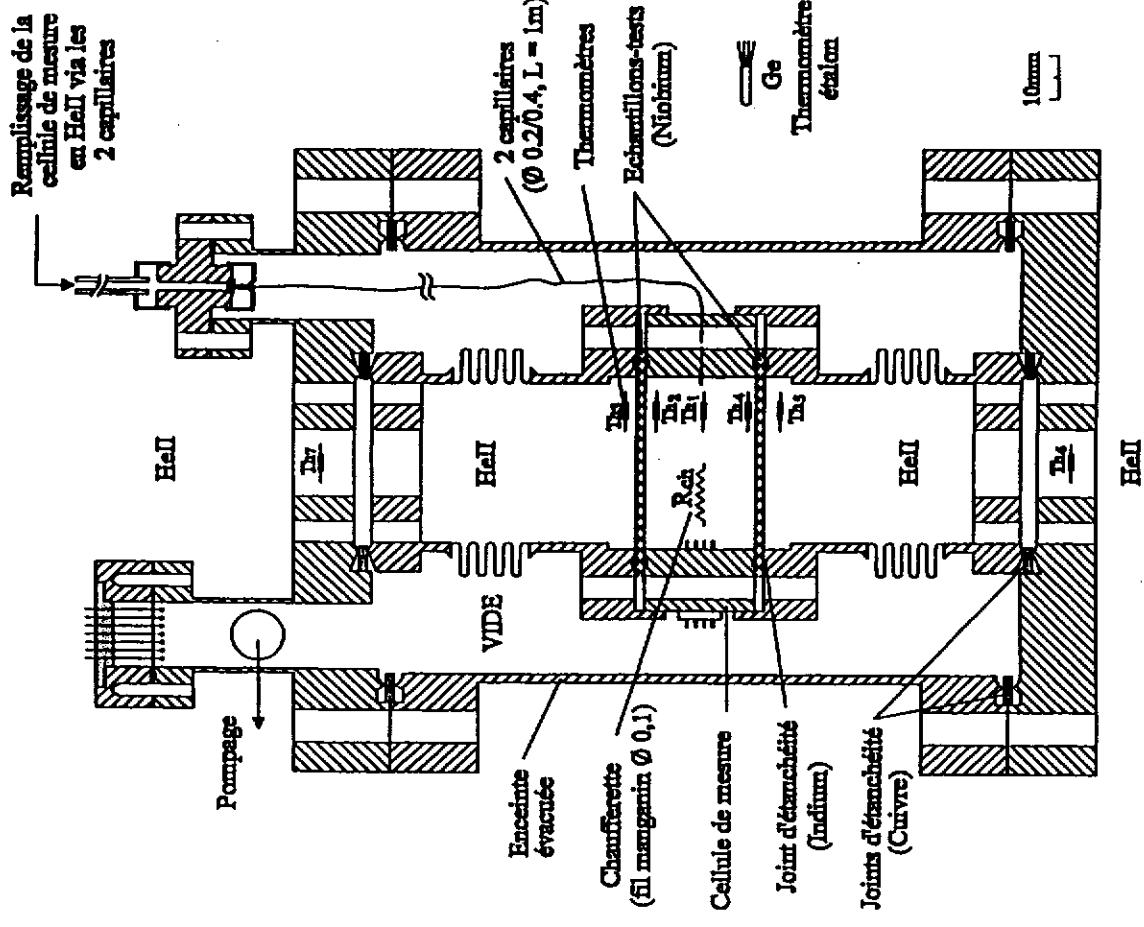
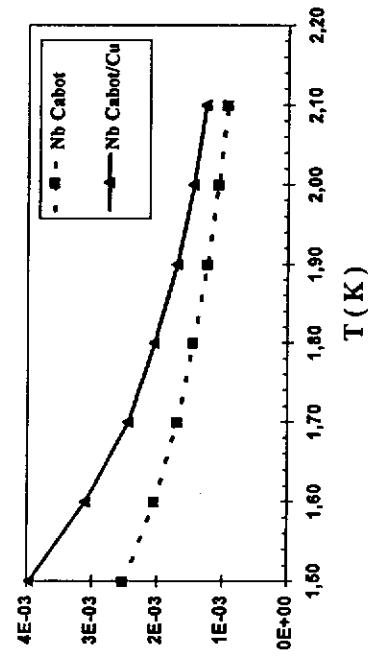
Total Thermal Resistance (K.m²/W)

Fig. 3.2.1 : Schéma du dispositif expérimental utilisé

- Theoretical estimation of the interfacial thermal resistance between Nb and Cu Little theory (1955)
- Based on acoustic mismatch between the two media :

$$R_I^{\text{th}} (\text{K} \cdot \text{m}^2 / \text{W}) \approx 2.4 \cdot 10^{-4} T^{-3}$$

$T_e (\text{K})$	1.5	1.7	1.8	1.9
$R_I^{\text{th}} (\text{K} \cdot \text{m}^2 / \text{W})$	6.10^{-5}	$4.2 \cdot 10^{-5}$	$3.6 \cdot 10^{-5}$	3.10^{-5}

R_g : Total thermal resistance

$R_g \rightarrow \text{Nb} ; R_{g2} \rightarrow \text{Nb}_3\text{Sc}$

$$\Delta R = R_{g2} - R_{g1}$$

$$\Delta \frac{R}{R_I^{\text{th}}} : 1.5 \rightarrow 2.5 \text{ for } T: 1.9 \text{ K} \rightarrow 1.5 \text{ K}$$

Thickness of the bonding layer (Cu-Al alloy 10% of Al) : $e_b \approx 0.2 \text{ mm}$

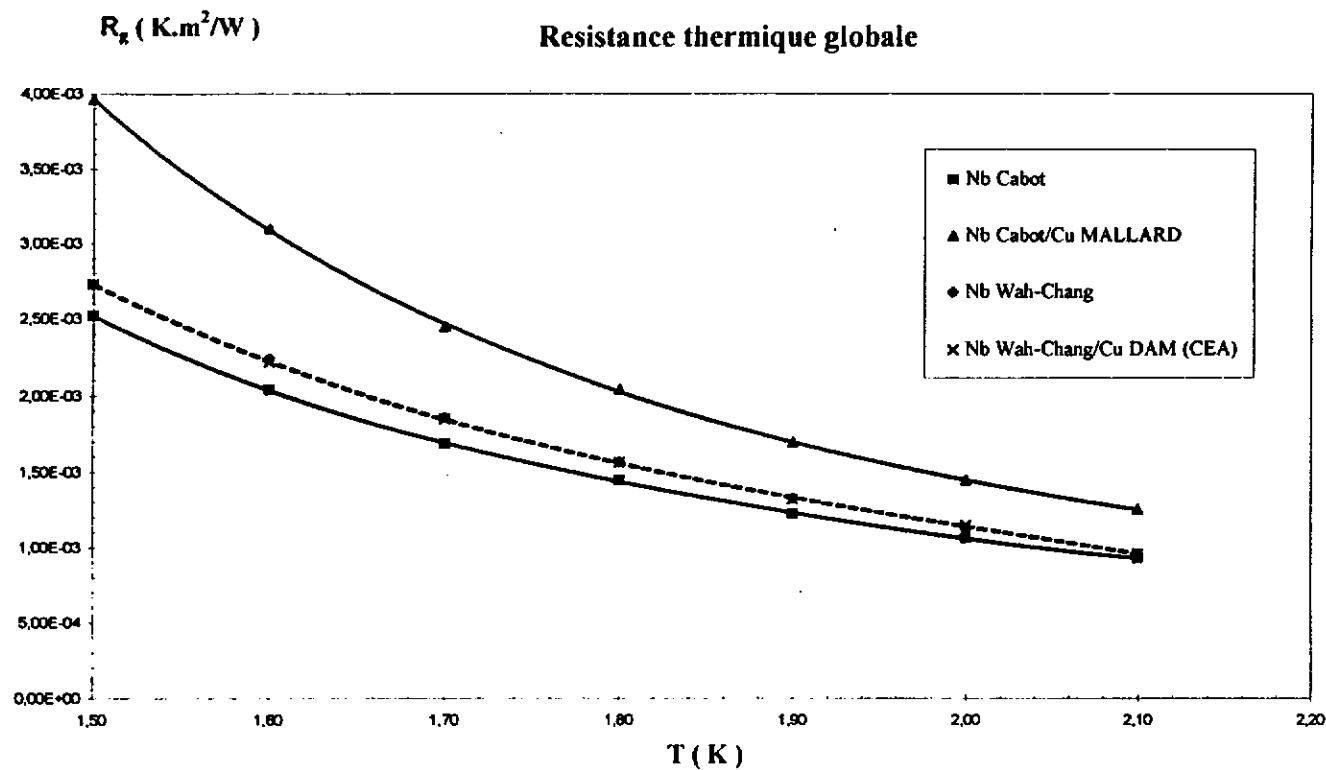
same bond thermal conductivity $\rightarrow k \approx 1 \text{ W/m.K}$ at 2.0 K

$$R_{\text{Alloy}} = \frac{e_b}{k} \approx 2.10^{-4} \frac{\text{K} \cdot \text{m}^2}{\text{W}}$$

$$R_{\text{Alloy}} / R_I^{\text{th}} \approx 8 \text{ at } 2.0 \text{ K} !$$

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

Something else ???



- ∞
- ## R&D PROGRAM FOR THE NEAR FUTURE
- Measure the cavity detuning Δf (Nb vs Nb/cu) due to Lorentz force and comparison of experimental data with numerical simulation results (Monocell, Multicell)
 - Sensitivity of the cavity frequency to bath pressure variations around $P_{sat}(T_0)$ $\{\pm 8K\}_{T_0}$ $\{\pm 2.0K\}_{T_0}$ (9 cells)
 - Modal analysis (Mechanics) of unshielded (Nb) versus copper plasma sprayed 9 cell cavity.
 - optimum copper layer shape (Δf min.)
 - thermal simulation (quench studies) with the measured thermal properties once the optimum deposition parameters are fixed (reduced thermal resistance, increased copper porosity without spoiling the mechanical properties)
 - How the copper layer is effective for quench stabilization?
 - ⚠ As the copper layer is in principle a porous media (open porosity), the modelling might be a difficult task!
 - The copper layer is anisotropic: what are the consequences on simulation (mechanical properties) results?
 - characterization of the copper layer microstructure - here we measure porosity (permeability - Darcy).
 - experimental study of the interface (HEG....)
- I- Mechanical and thermal characterization of samples produced with different deposition parameters
- V- Numerical simulation of the cavity mechanical behaviour (stiffening problem) using the mechanical properties measured on samples.

Status of Hydroforming of Seamless Cavities

79

Participants

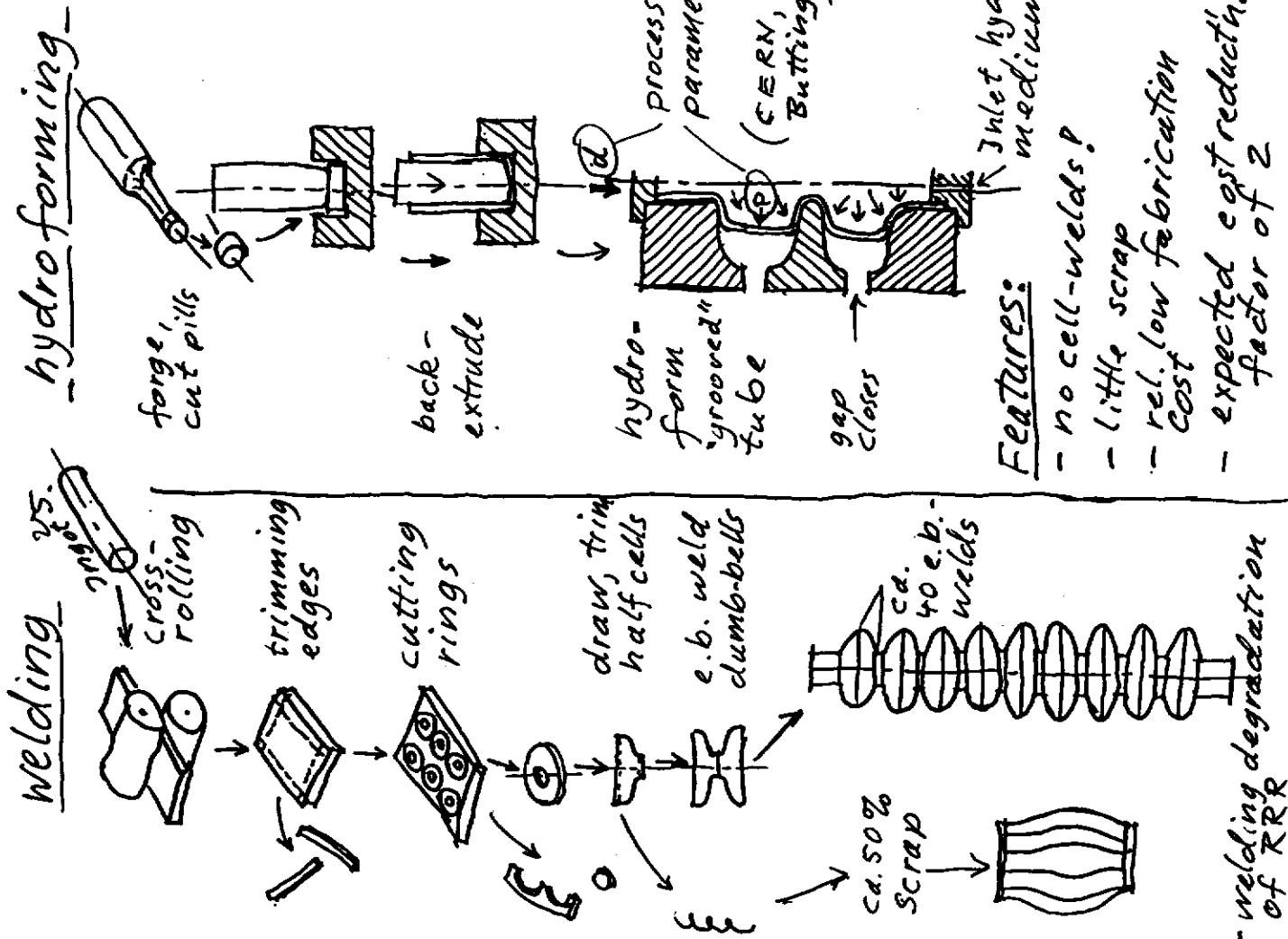
J. Gonin
J. Jelezov
T. Khabiboulline
V. Kuchtiev (formerly)
MOSCOW
N.R. Stepanov ()
at
DESY

H. Kaiser
G. Weichert
W. Singer
DESY

DESY Technical Services
GKSS
Institutes
Uni Wuppertal
Uni Bundeswehr

Butting
Dück
Heraeus
--

Nb Kr - Cavities by:



Why go seamless?

expect rel. welded cavities:

Improved performance
Lowered cost

- no welds!

- save on N6

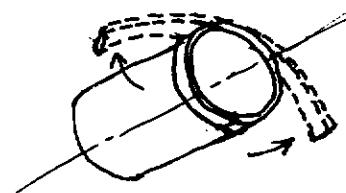
• much (ca. 10x)
reduced amount of
welding

• reduced risk
of RRR-degra-
dation at
equator
caused by:

- no inclusions of foreign matter
- reduced risk of N₂O uptake in welding

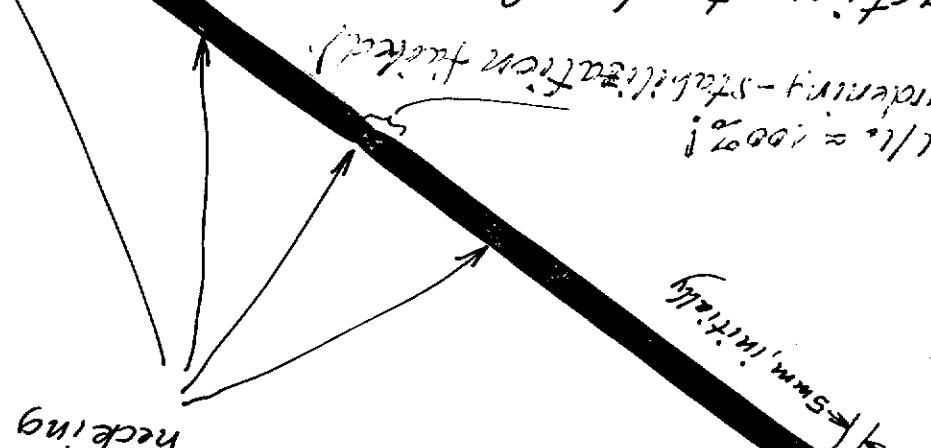
The 3 Main Activities

Study/improvement of Nb-material properties	Computer simulation of forming	Forming experiments
<ul style="list-style-type: none"> - 1D/2D traction and bulge tests - $\dot{\epsilon}_{max} = \dot{\epsilon}_{max}(\dot{\epsilon})$? - heat treatment optimization for RRR, forming properties - stabilization of tube wall in hydroforming - better formability of less "pure" Nb? - Nb-tubes: <ul style="list-style-type: none"> welded? optimized fabrication path? deep drawn? spun? extruded? 	<ul style="list-style-type: none"> - optimum p(d)-path - control via p or cell form? - iris forming - optimum starting dia. of tube? - find wall thickness - distribution for acceptable formability 	<ul style="list-style-type: none"> - tests in Cu (1 cell, 2 cell) - reduced scale tests: <ul style="list-style-type: none"> - Iris (1:4) - cell (car:2) - tests in Nb <ul style="list-style-type: none"> - failures - success via trick - d(D)-control of hydroforming - computer control of hydroforming - 2000 bar water upgrade



Hydroforming of Nb tubes
slit and flared ends

$$\Delta L/L_c \approx 100\%$$



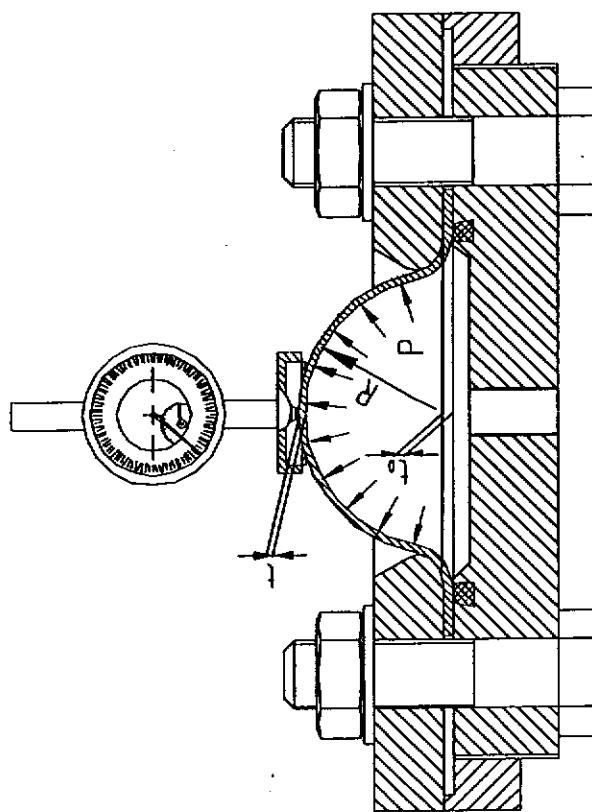
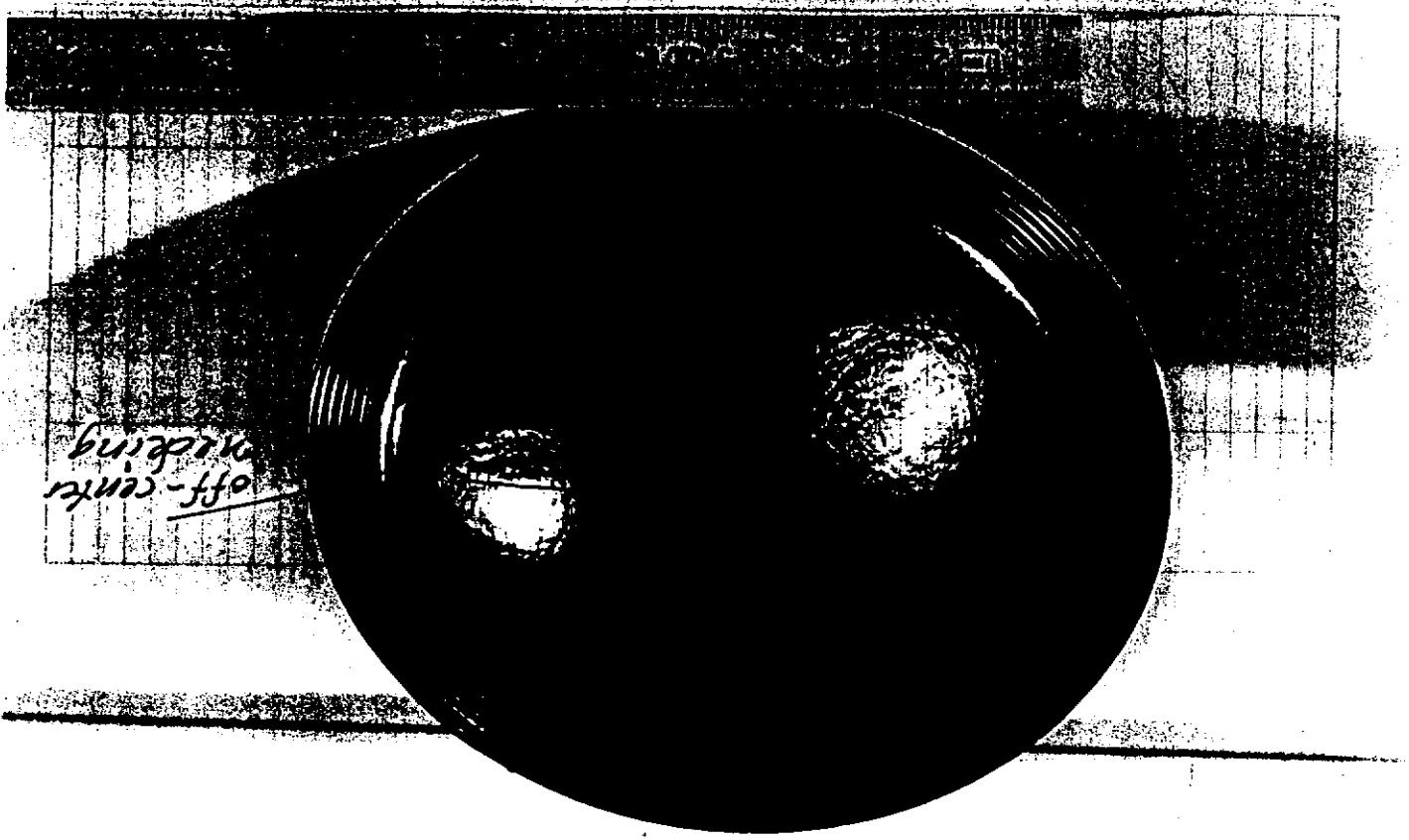


Fig. 3 Scheme of the bulging device

At zenith

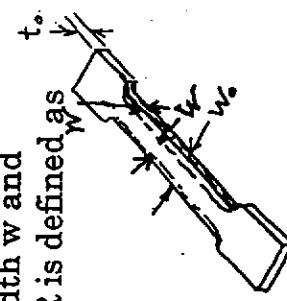
$$\left. \begin{aligned} \sigma_{true} &= \frac{P \cdot R}{2t} \\ \epsilon_{true} &\approx \ln\left(\frac{t}{t_0}\right) \end{aligned} \right\} \text{stress/strain characteristic}$$

↓
FEM-simulation
of hydroforming

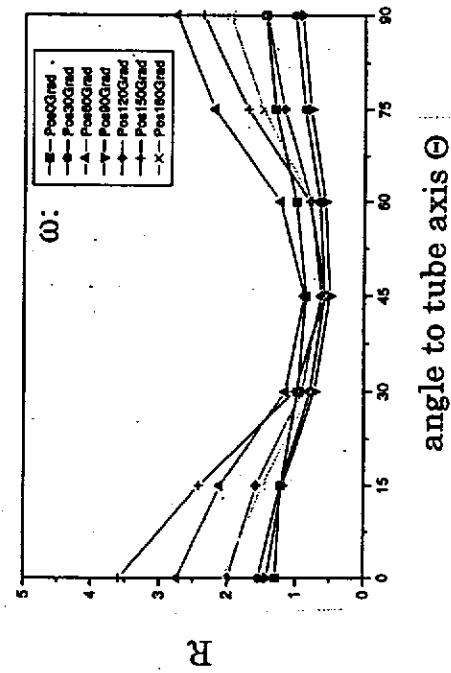
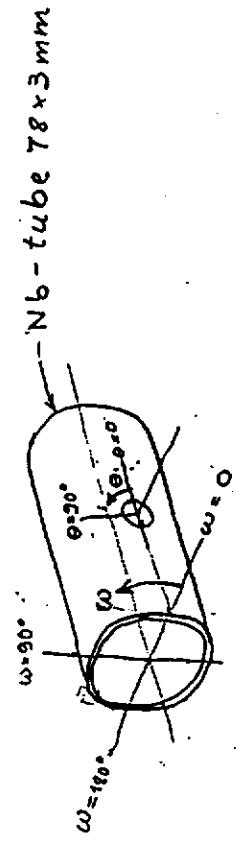
Brokmeier Uni Clausthal

For traction test of strip sample of width w and thickness t the Lankford-parameter R is defined as

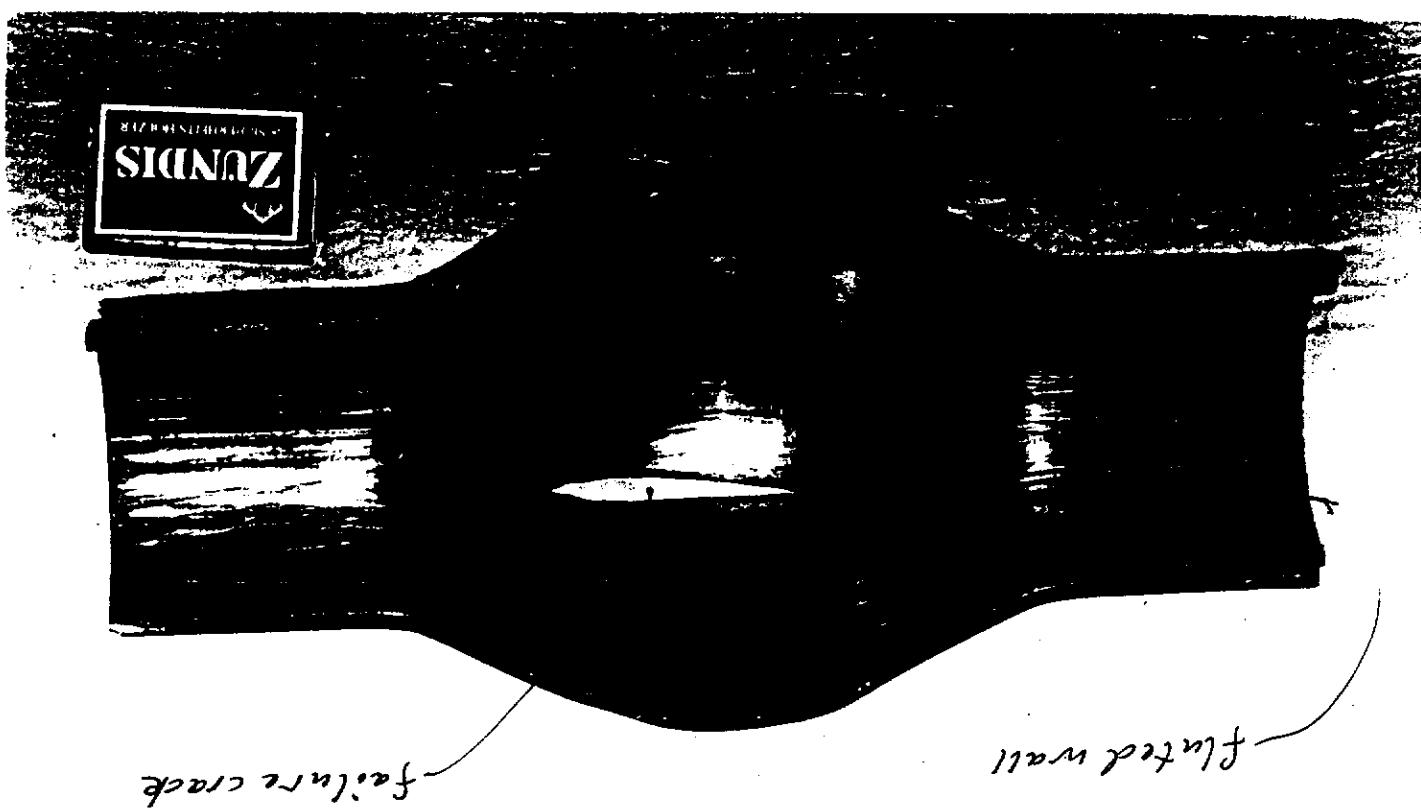
$$R = \frac{\ln(w_0/w)}{\ln(t_0/t)} = \frac{\epsilon_x}{\epsilon_z} \text{ for small strain.}$$



For hydroforming the R -value should be constant everywhere in the tube wall. This is not the case:



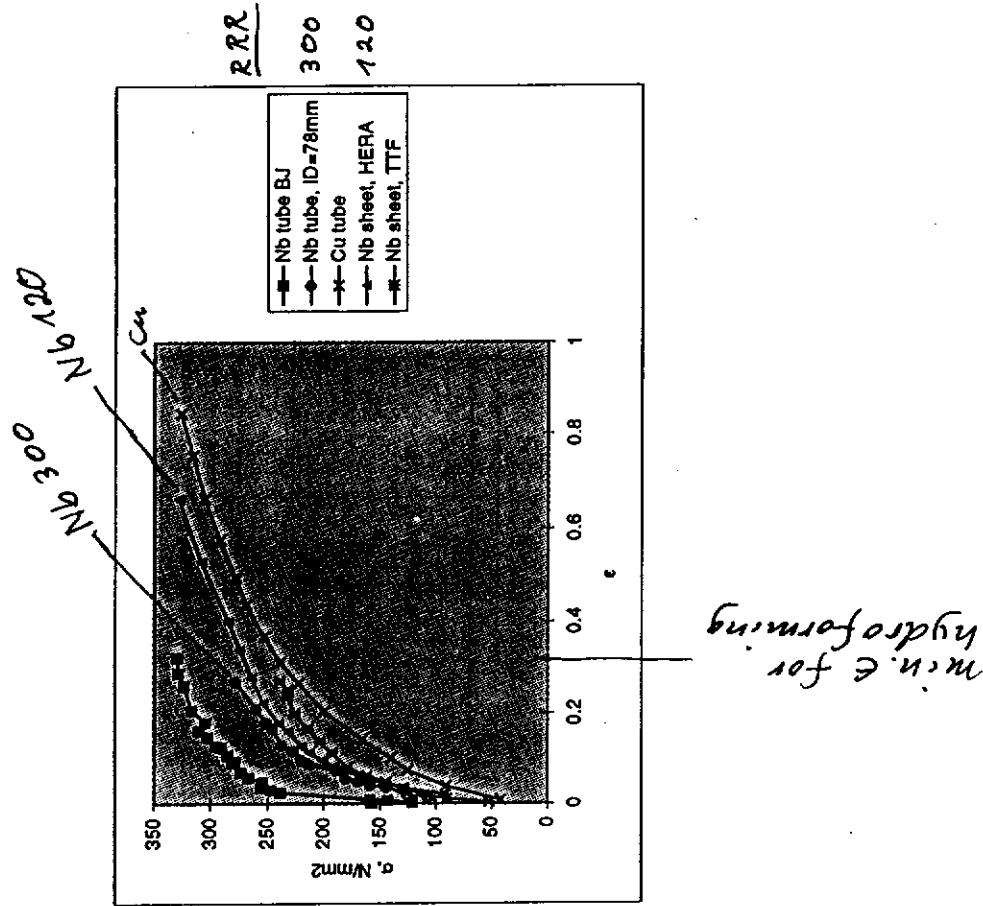
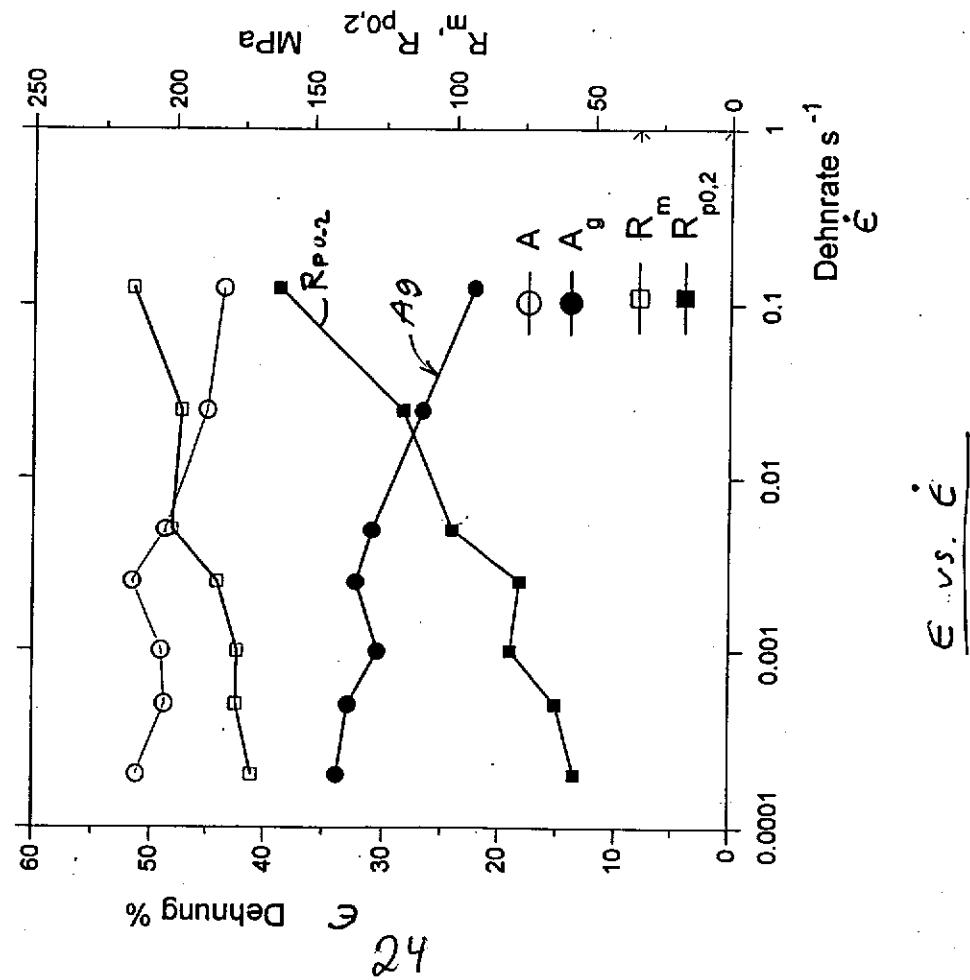
Anisotropy of Lankford-parameter R as function of angle to tube axis Θ and azimuth about tube axis 0 .
(Measurement by H.-G. Brokmeier by neutron

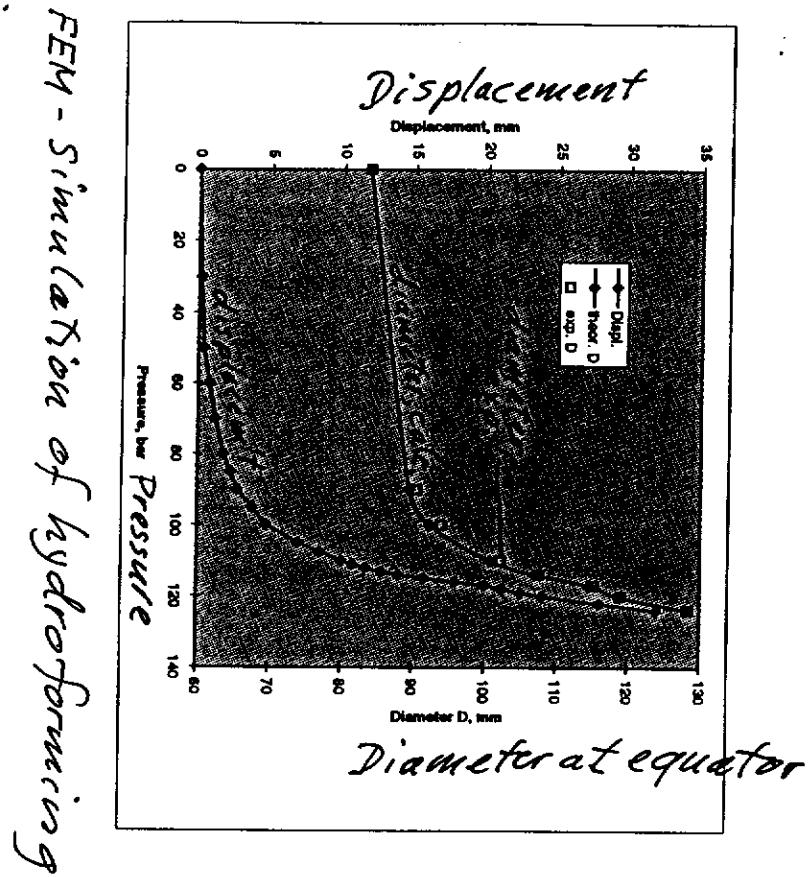


- flattening, crack parallel to tube axis
- flattening, thickness varies over circumference

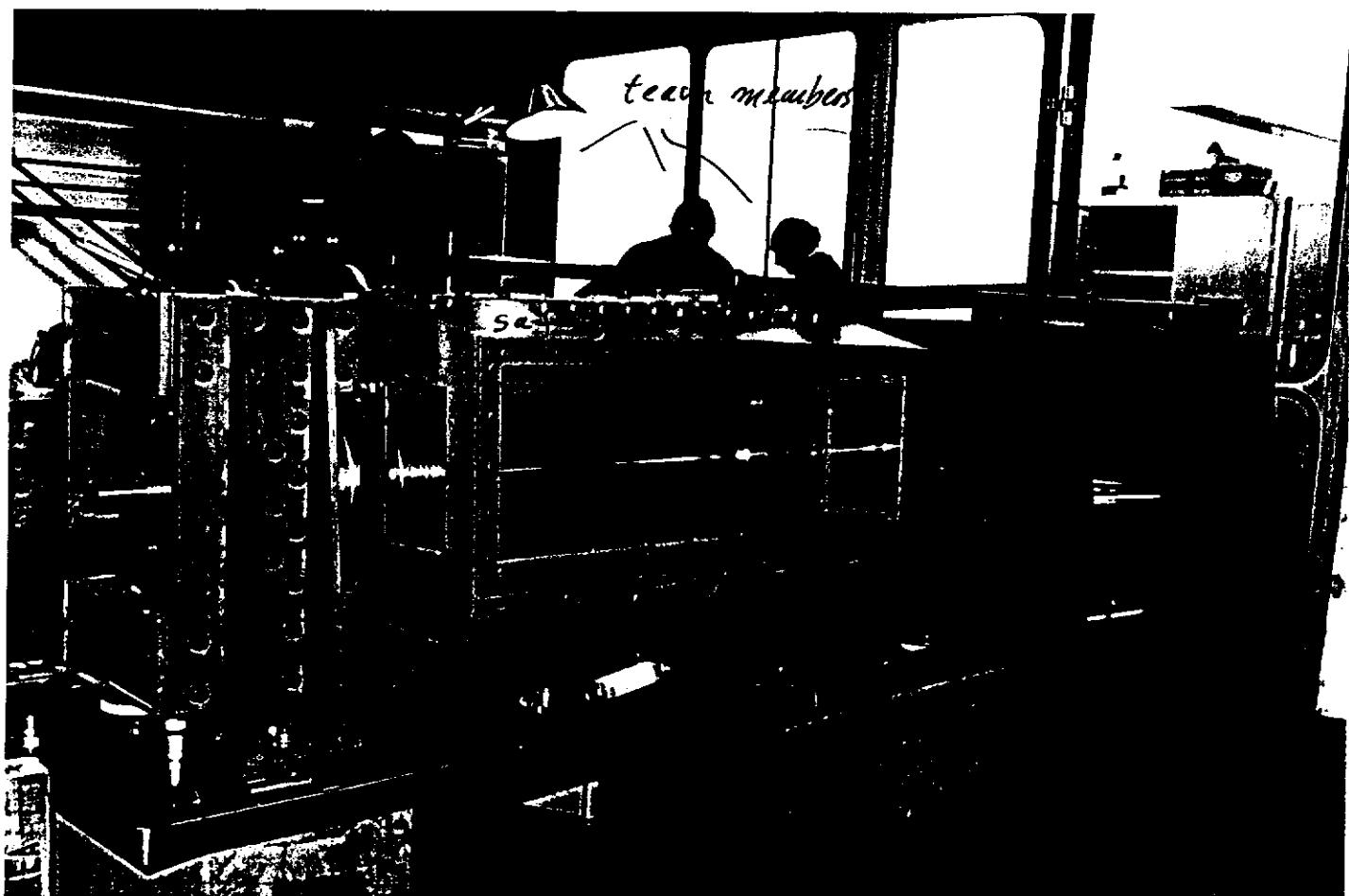
Zugversuche an Niob 120

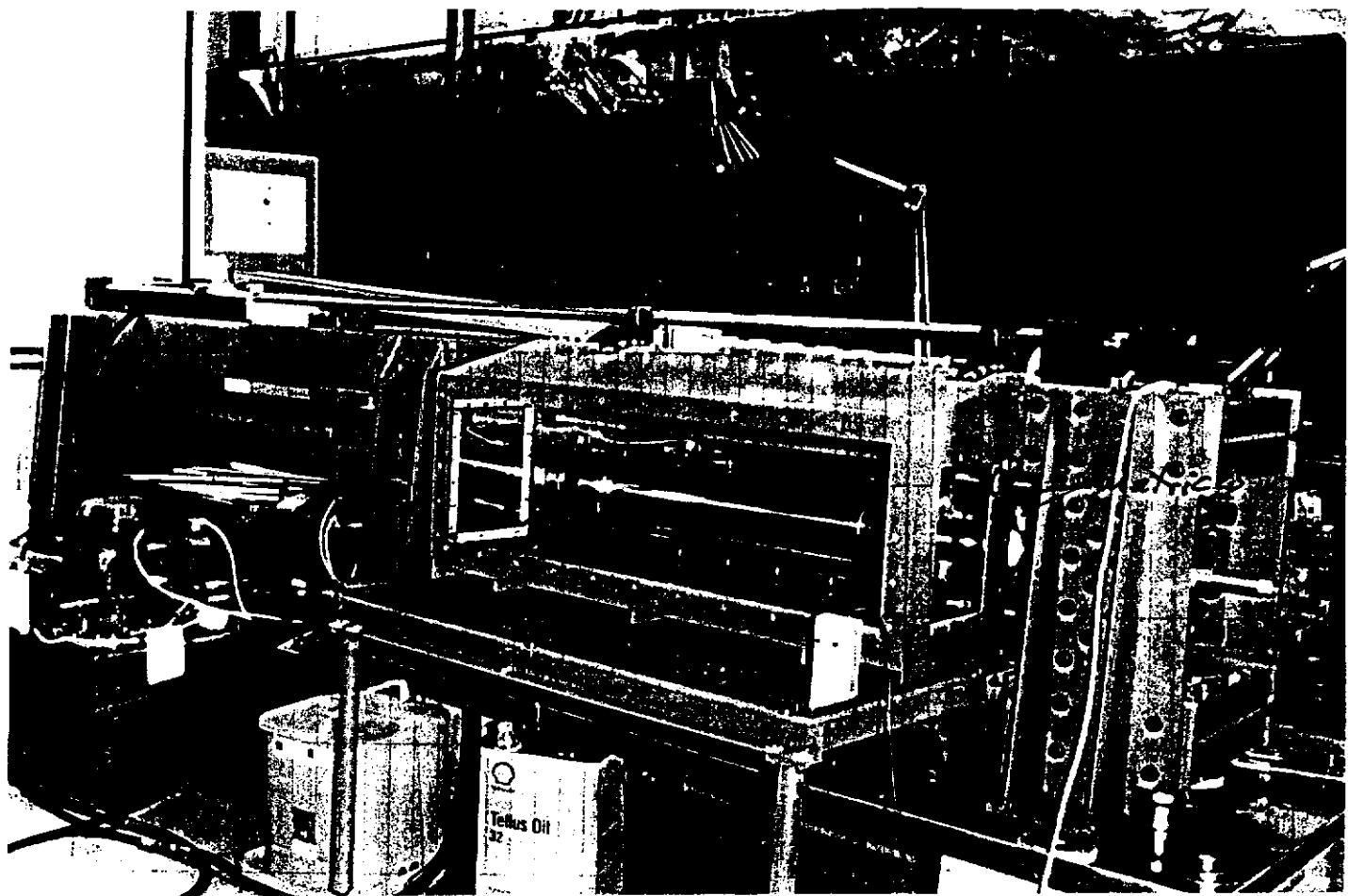
Prof. Kreye
Uni. Bundeswehr



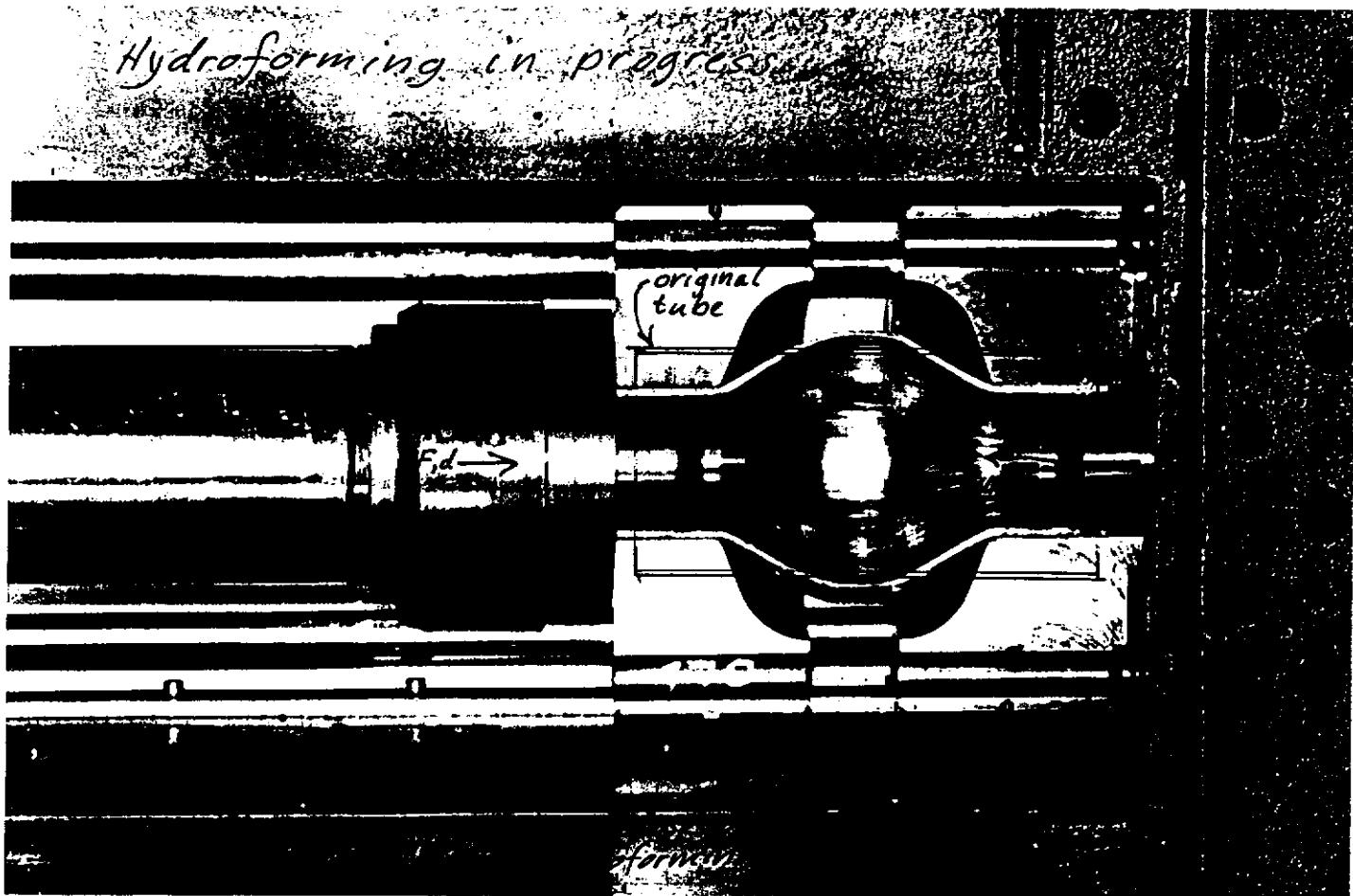


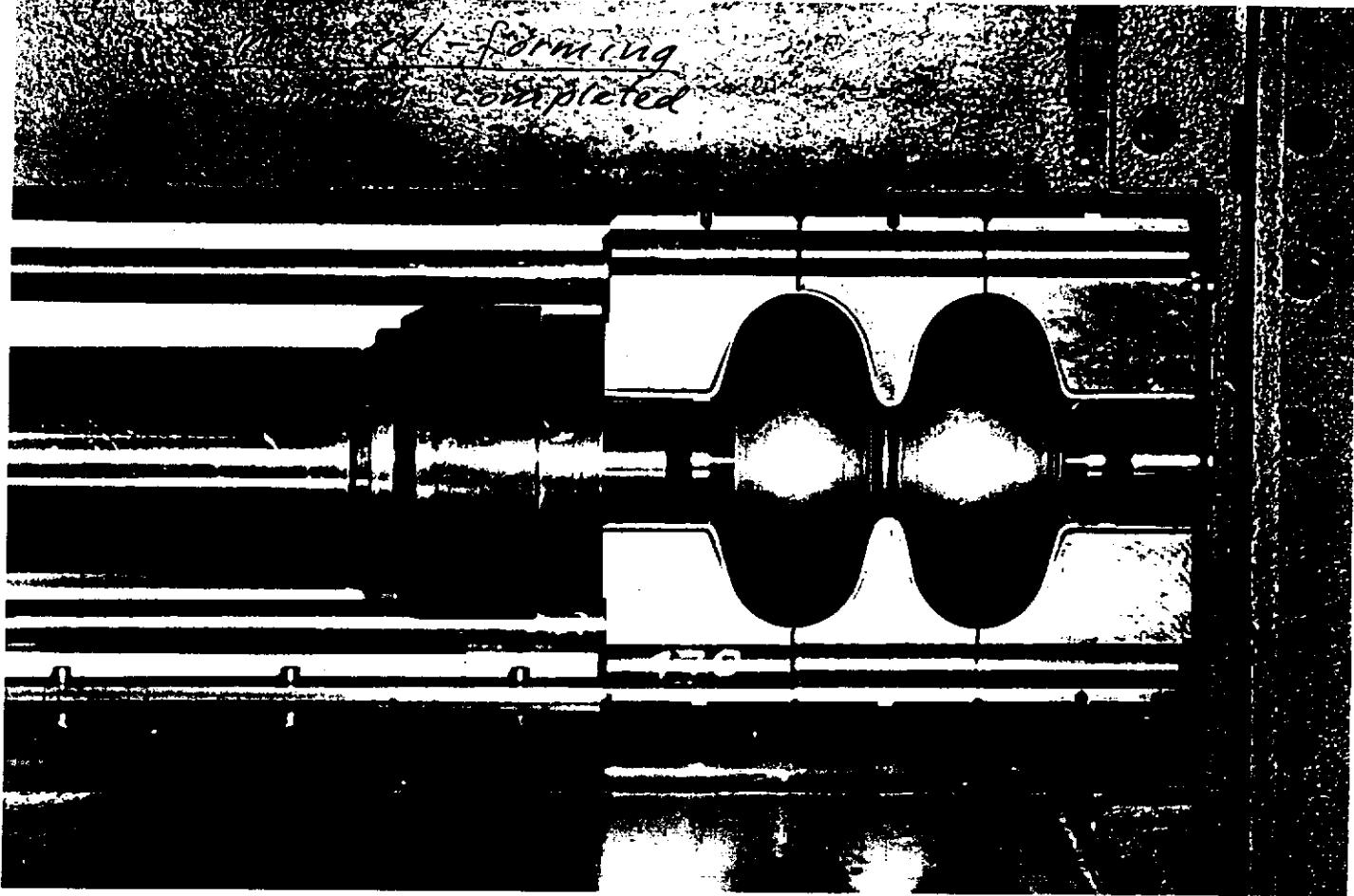
JELZOV @ MIFRINGER, MAR03/12:19





Hydroforming in progress





First hydroformed NB TESLA-membrane

Test status:

- being fitted with endtubes for RF-testing

Fabrication of tanks:

- frame made of tube 130 mm diameter
- ends of tank made with corner ways
- tank made of stainless steel
- tank filled with hydro

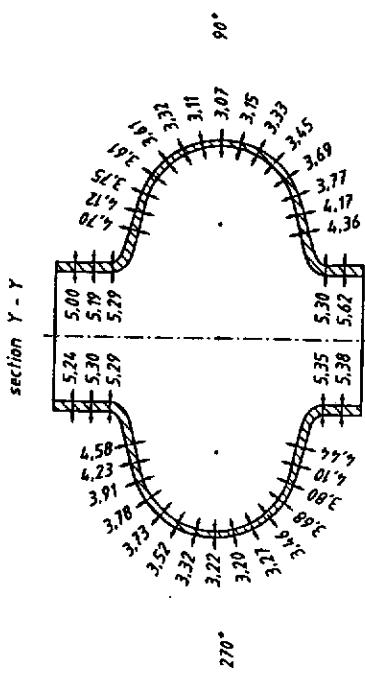
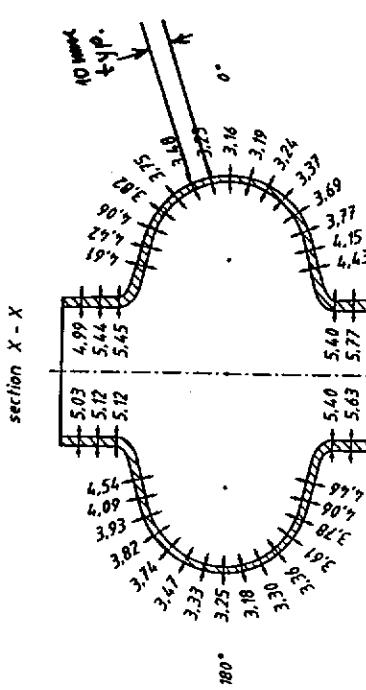
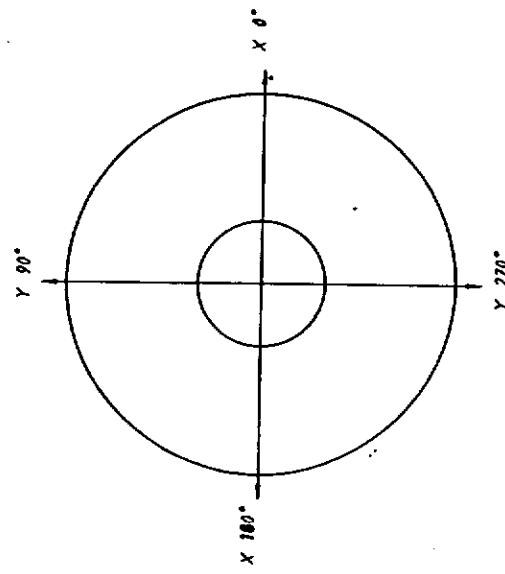


2997 GHz

TTF-Resonator 1K1

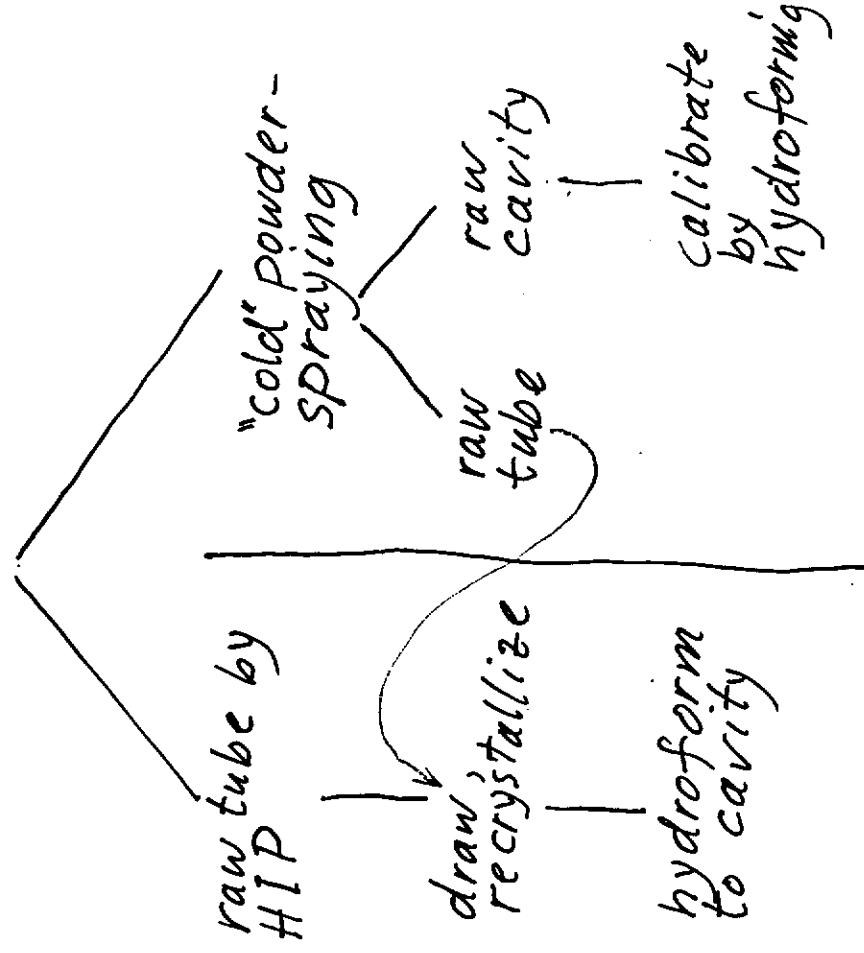
Future

- half scale Nb tubes made in 6 different ways mid 98
- full size tubes in optim. way end 98
- cavities without jacket/liner spring 95
- 2000 bar H₂O hydraulics mid 98
- computer control of hydroforming mid 98
- alternate routes for making tubes/cavities

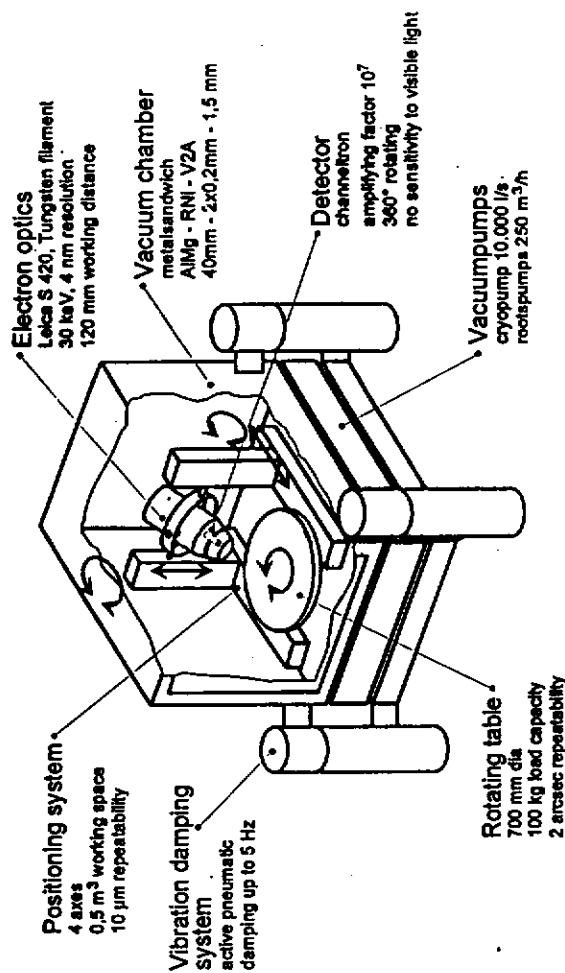


Nb-tubes/cavities from powder?
(speculative!)

powder of RRR 300
(Nb < 10 ppm)



C. D. Friedrich

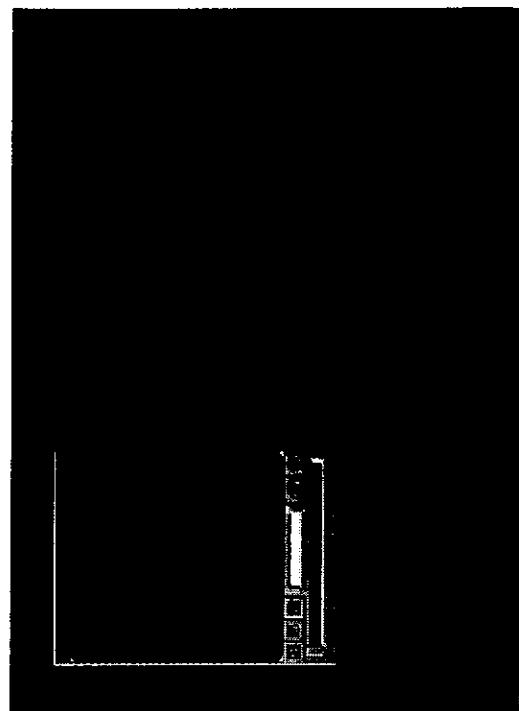


Nondestructive Search for Defects in Nb Sheets with Help of Large Chamber SEM

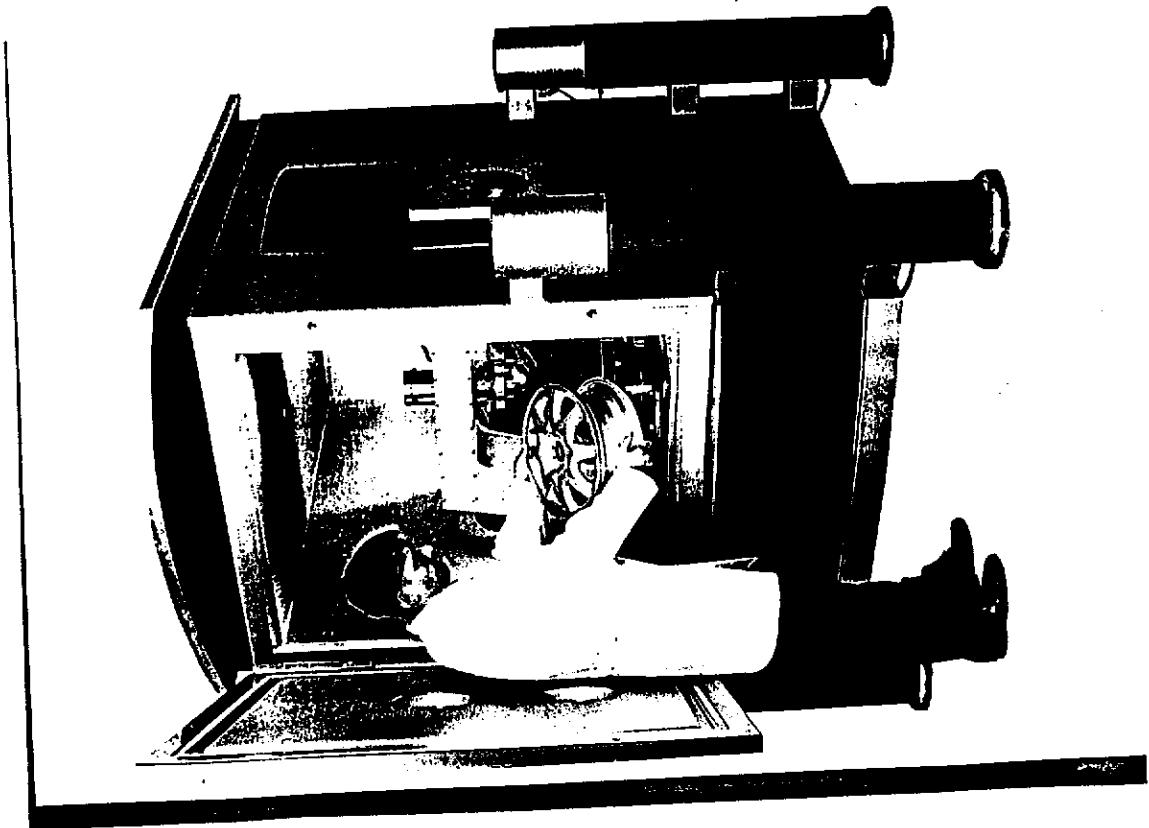
W.Singer, A.Brinkmann

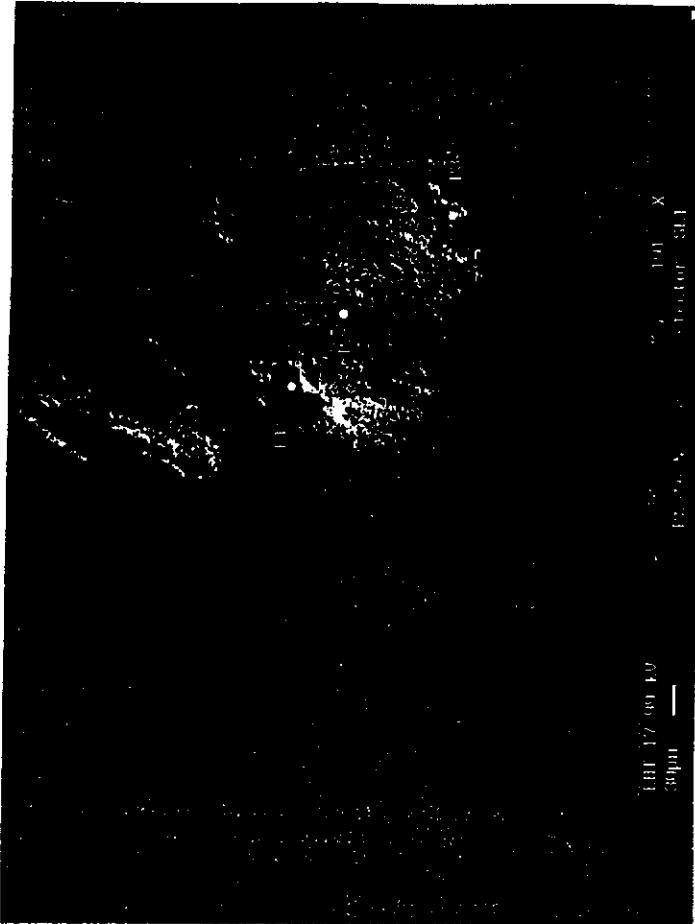


Niobium-Sheet with Iron-Clusters.

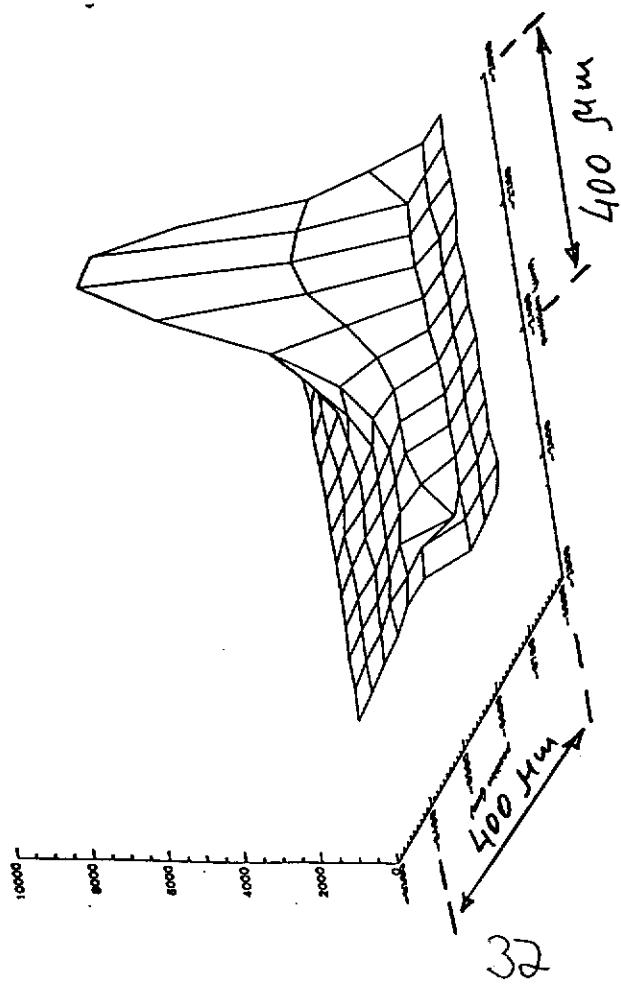


Zoom of the area with Iron-Clusters. The Scope picture shows the Eddy-Current Signal of a scan of the cluster in the lower right position.



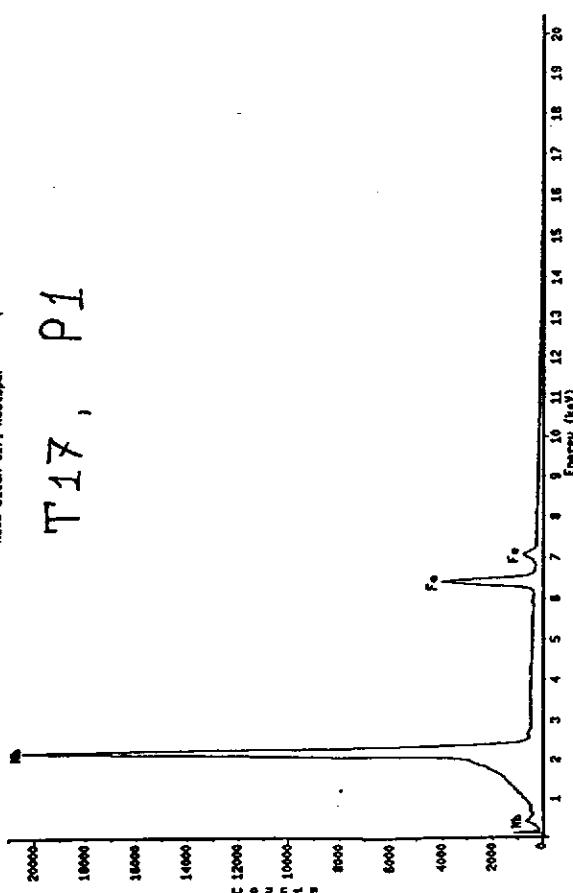


Position	Element	Atom%	Wt %
P 1	Ni	59.3	64.9
	Fe	46.6	34.7
P 2	Ni	90.1	93.9
	Fe	8.75	5.48
P 3	Ni	59.7	71.13
	Fe	40.2	28.8



SYRFA
3D-distribution of Fe -signal
(sheet T 17)

T17, P1



Micro-Block 117, Restspur

Column	: NTR0, Pioneer
Take-off angle	: 40
Requisition type	: adn
Creation Date	: 9/7/12/05 6:31
Livetime	: 500
Deadline	: 259.1
Channels	: 2048
Channel width	: 10
Detector type	: Silicon/Lithium
Hindrance type	: normal
Hindrance thickness	: 0.3
Coating material	: Al
Coating thickness	: 0.04
Contact material	: Au
Contact thickness	: 0.02
Crystal thickness	: 3

Accelerating voltage : 15
Magnification : 500
Beam current : 1
Beam spot size : 0
Beam location : 0,0
Working distance : 15
Stage X : 0
Stage Y : 0
Stage Z : 0
Stage tilt : 0
Stage rotation : 0
Contamination material : none
Contamination thickness : 0

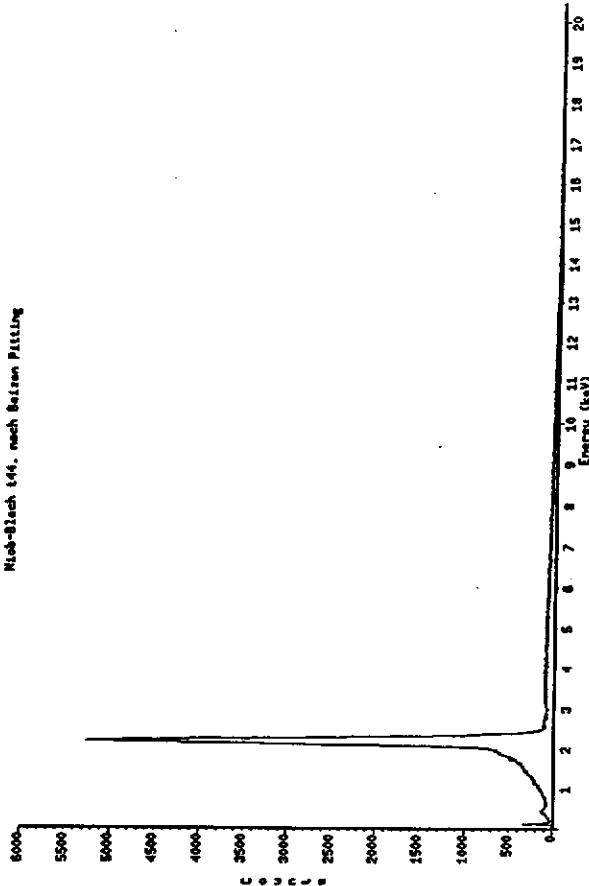
File name : /var/nas01/home/roeger/spectra/t17e.ads

Notes:

33

Scan - Picture of t144 with etching - pits

Nickel-Blech 144, nach Galvan. Plating



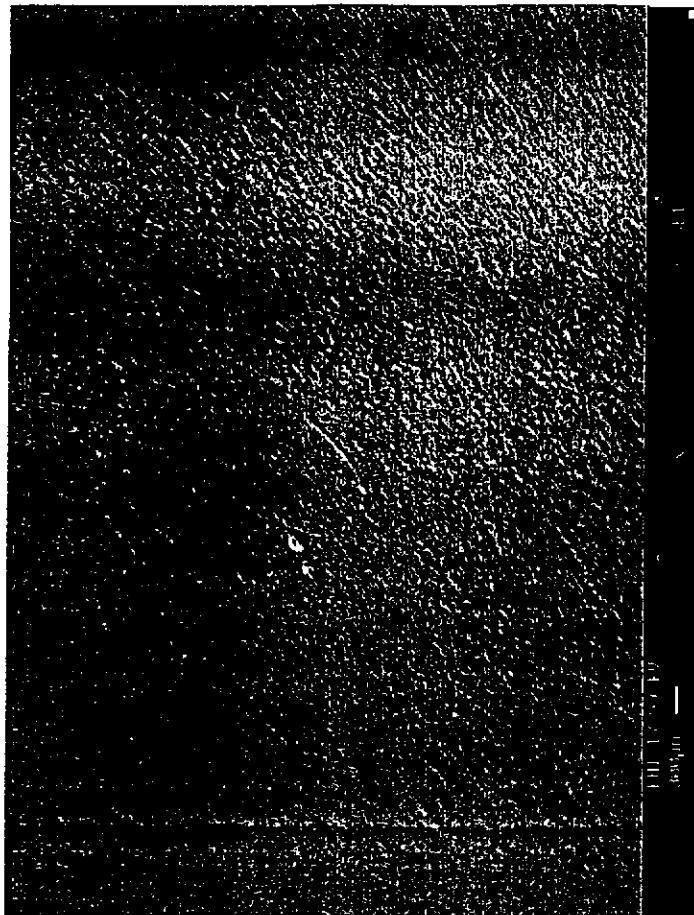
Nickel-Blech 144, nach Galvan. Plating
 Column : HITACHI
 Thru-off angle : 50-350°
 Acceleration voltage : 10 kV
 Replication type : 9772/95 9:44
 Creation time : 12:58
 Live-line : 72.547
 Beamline : 204
 Channel width : 10
 Detector type : Silicon/Lithium
 Mirror type : mirror
 Mirror thickness : 0.3
 Coating material : Al
 Coating thickness : 0.04
 Contact material : Au
 Contact thickness : 0.02
 Crystal thickness : 0.3
 Contamination thickness : 0

File name : Amr/home/regeger/spectra/n144.eade
 Notes:



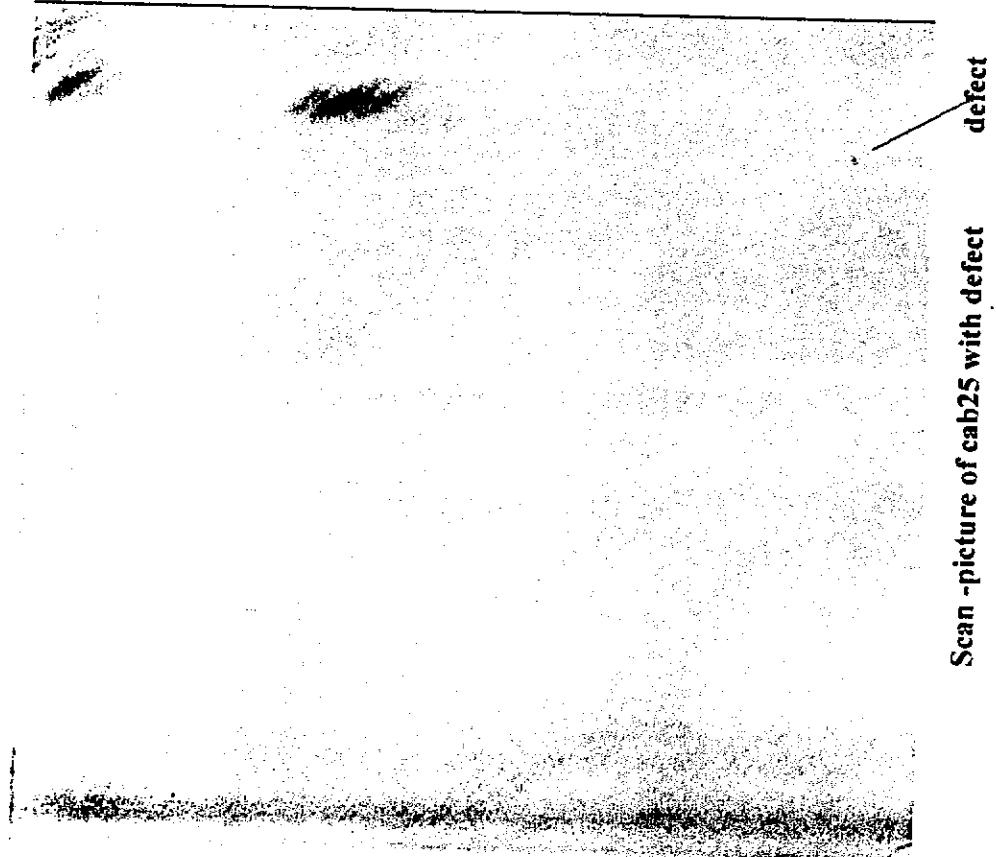
T 44
 after etching 30 μm)

34



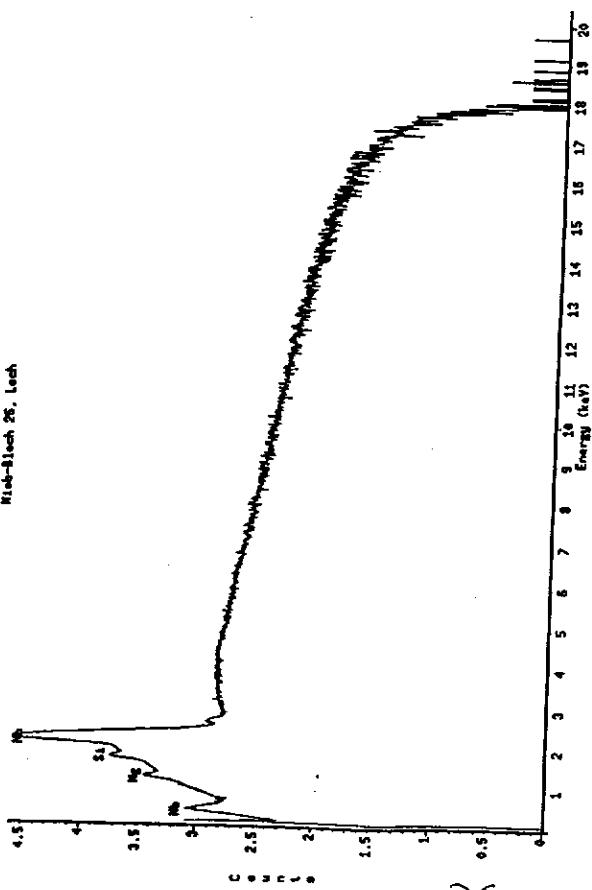
Ca 60 ± 25
black spot

Element	Atten.%	Wt %
N	87,9	96,2
Si	7,62	2,52
Mg	4,48	1,28



Scan -picture of cab25 with defect

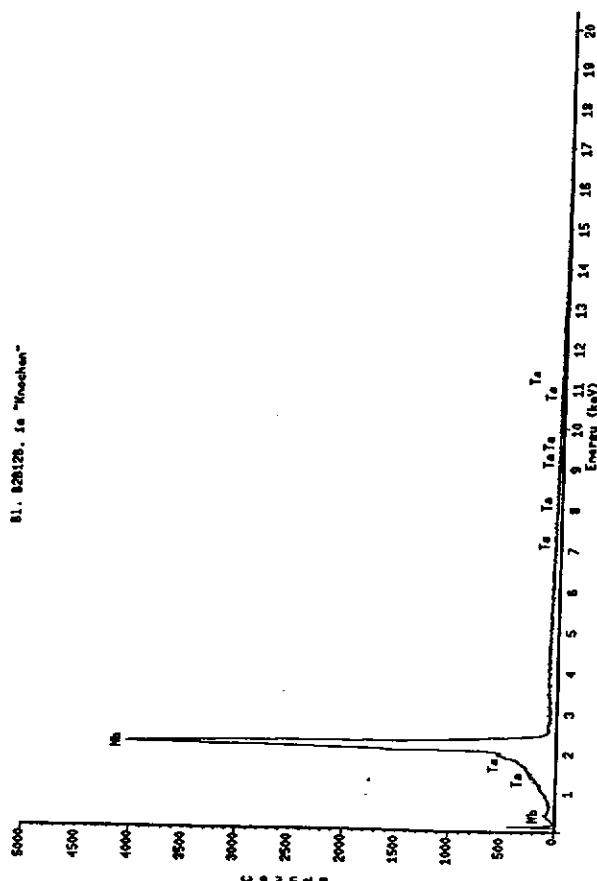
High-Bleach 25, Lech



36

High-Bleach 25, Lech
Teller, Klemm
Takeoff angle : 40
Depolarization type : odd
Creation time : 97/12/05 5:31
LiveTime : 560
Deadtime : 431.095
Channels : 2048
Detector width : 10
Detector type : Silicon/Lithium
Window type : narrow
Window thickness : 0.3
Coating material : Al
Coating thickness : 0.04
Contact material : Au
Contact thickness : 0.02
Crystal thickness : 3
File name :
Notes:
Fri Dec 5 05:33:04 1997
High-Bleach 25, Lech
Fuller Fit Method
Chi Squared = 12.12 LiveTime = 560.0 Sec.
Standards Analysis
Element Relative Error Net Error
Mg-L 0.98229 +/- 0.00081 Counts (1-Sigma)
Si-K 0.02885 +/- 0.00071 780328 +/- 3090
Fe-K 0.01067 +/- 0.00038 31595 +/- 859
Adjustment Factors
Z-Balance: N L K
Shell: 0.00000 0.00000 0.00000
1.00000 1.00000 1.00000

81. 826126. Is "Knechen"



Ta-Deposit D: $\varnothing = 0.2$ mm Ta-Deposit C: $\varnothing = 1$ mm.
Ta-Deposit E: $\varnothing = 0.2$ mm

81. 826126. Is "Knechen"

EDS spectrum plot showing atomic concentration (%) versus Energy (keV). The plot shows peaks for Carbon (C), Oxygen (O), Nitrogen (N), and Ta. The Ta peak is very sharp and prominent at approximately 6 keV.

Instrument parameters:

Parameter	Value
Take-off angle	58.3506
Acquisition type	eds
Creation time	97/12/06 10:59
Livetime	269
Doselive	89.631
Chambers	2048
Channel width	10
Detector type	Silicon/Lithium
Window type	borvar
Window thickness	0.3
Cooling material	Al
Cooling thickness	0.04
Contact material	Au
Contact thickness	0.02
Orbital thickness	3

Notes:

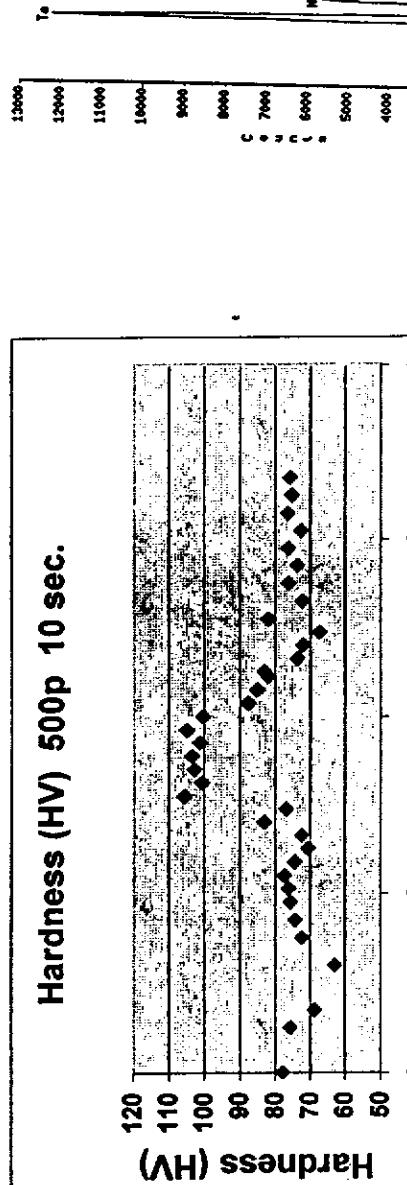
File name : /usr/nas/roger/spectra/826126.edt

Ta - Deposit A:
 $\varnothing = 0.5$ mm.
Ta - Deposit B:
 $\varnothing = 1$ mm.

37

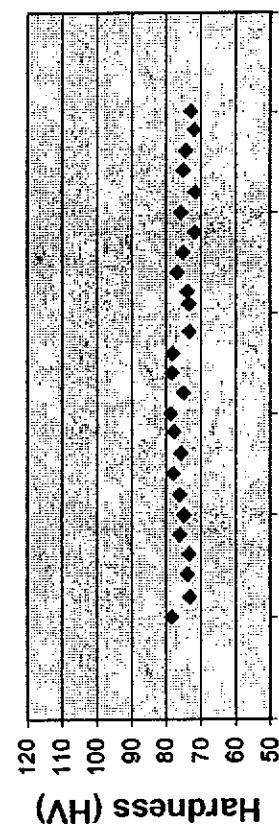
Ta test sheet, P1

Testblech Nr. mit Ta-Draht, Nitte

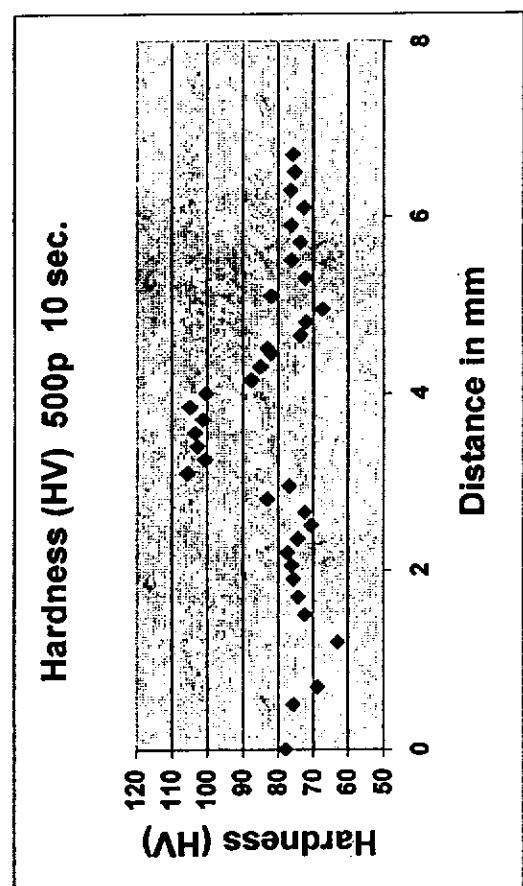


Hardness of Ta - Deposit "B".

Hardness (HV) 500p 10 sec.



Hardness of Nb somewhere on the sheet.



66

Testblech Nr. mit Ta-Draht, Nitte
 Column : KDM Pioneer
 Take-off angle : 50.2506
 Acquisition type : edd
 Creation time : 97/12/05 10:04
 Livetime : 500
 Deadtime : 201.208
 Channels : 2048
 Detector type : Silicon/Lithium
 Window type : normal
 Window thickness : 0.3
 Coating material : Al
 Coating thickness : 0.04
 Contact material : Au
 Contact thickness : 0.02
 Crystal thickness : 3
 File name : /usr/floes/megger/spectra/Tatesta.edd

Notes:

Fri Dec 5 10:05:26 1997
 Testblech Nr. mit Ta-Draht, Nitte

Filter Fit Method : Chi-Sqd = 2.69
 Standardless Analysis : Livetime = 500.0 Sec.
 Element : Relative Error
 k-ratio (1-Signal) : Net
 Nb-L : 0.22167 +/- 0.00320
 Te-L : 0.77853 +/- 0.01286
 Te-H : _____
 Adjustment Factors : Contamination (1-Signal)
 Z-Balance : 0.00000 185533 +/- 897
 Shell : 1.00000 1.00000

only one site of the sheet
 shows Ta - lines

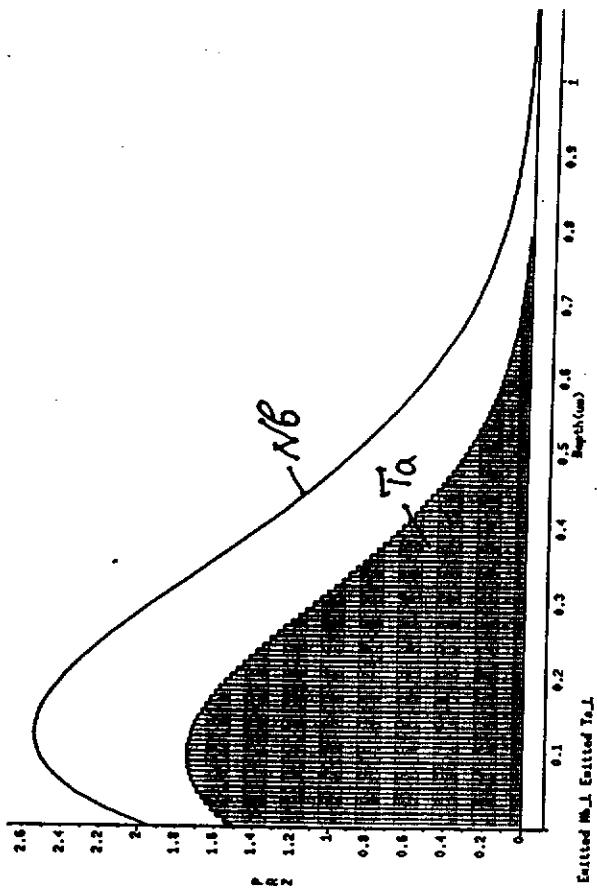
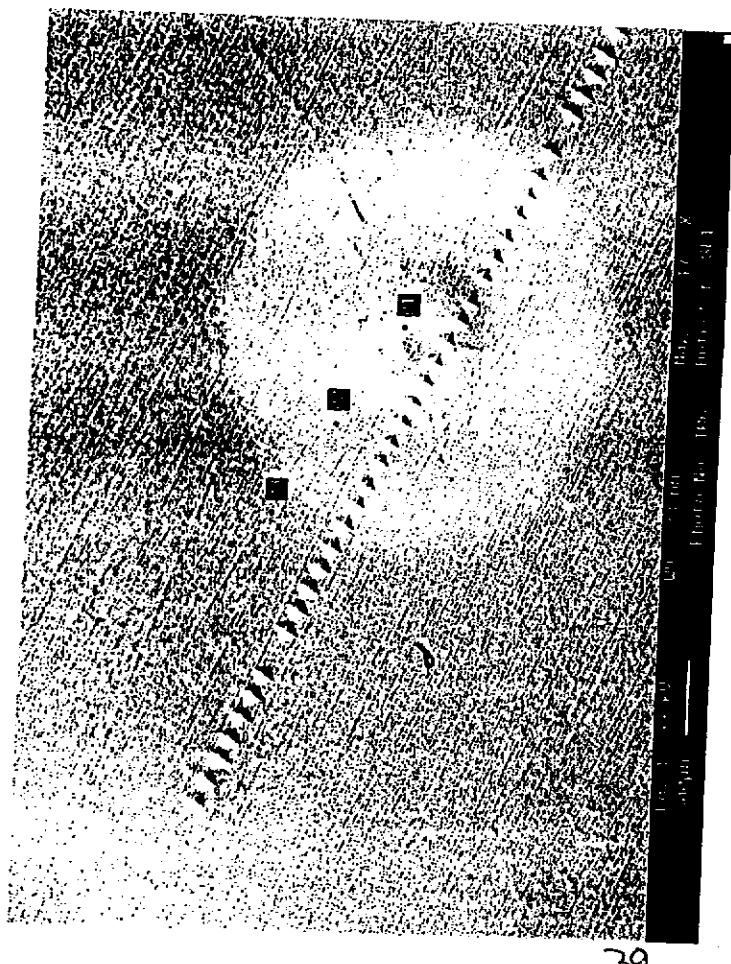


Bild 2: Tiefenverteilung der erzeugten und austretenden Röntgenstrahlung bei 18keV
 $\sim 1\% \text{ Ta in } \text{Nb}$



Ta test sheet

Conclusion

The Large Chamber SEM is an efficient tool for nondestructive analysis of defects on the surface of Nb sheets, half-cells, dumb-bells and another large specimens

The eddy current quality control of 715 new No sheets for TTF from three suppliers (Company A,B,C).

Company A:-276 sheets

- 217 sheets free of defects
- 38 sheets show a special defect structure („dog bone“) most likely due to rolling imprints (no foreign material inclusions detected by Microhardness, SYRFA, XAFS, NAA, Large Chamber SEM).
- 23 sheets show grinding marks

Company B:-265 sheets

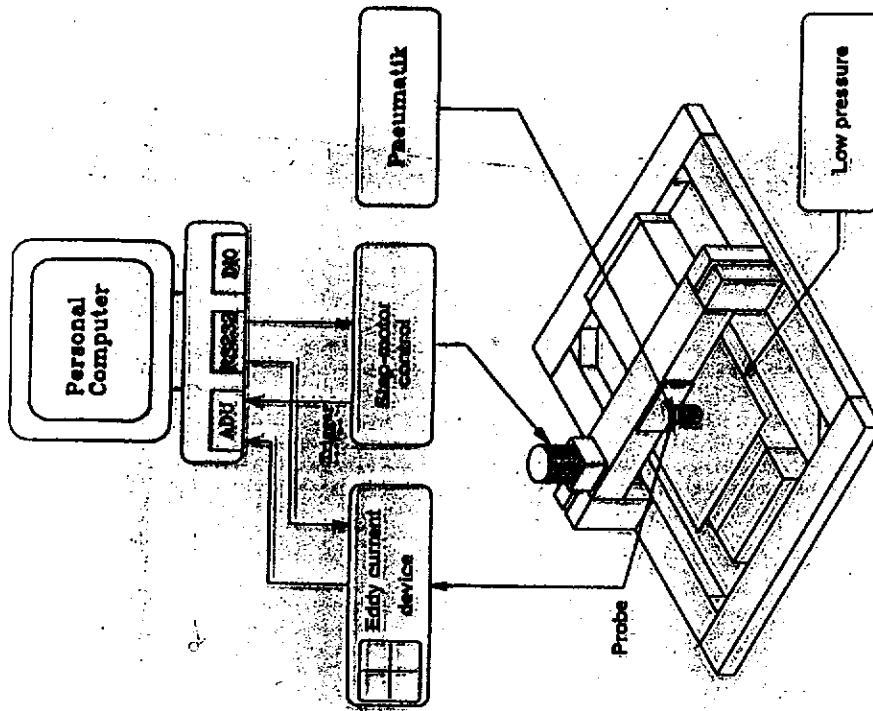
- 261 sheets are free of defects
- 4 sheets show defect signals, evidently grinding marks (no foreign material detected).

Company C:-174 sheets

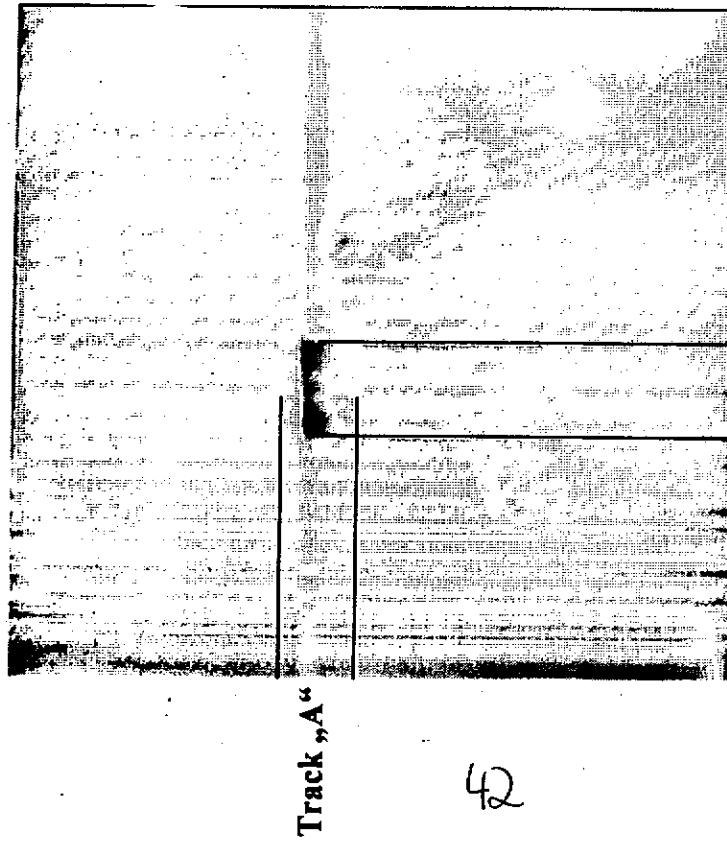
- 15 sheets show sharp defect signals, some are identified as iron inclusions (after chemical etching of 40 µm most of the iron signals normally disappeared).
- many grinding marks with defect signals still present in the ground centre.

**Eddy Current Scanning System
Newest Set Up**

W.Singer, D.Proch, A.Brinkmann



Niobium Sheet with "Dogbone".



The depth of signal penetration
(Skin Effect)

$$S = A \sqrt{\frac{P}{\mu}}$$

BAM: Two frequency set up

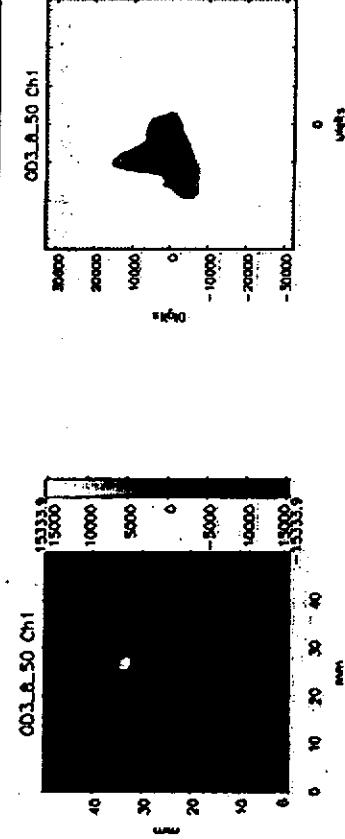


Bild 13a: Mulde mit verdeckten Bohrungen Kanal 1
(80 kHz)

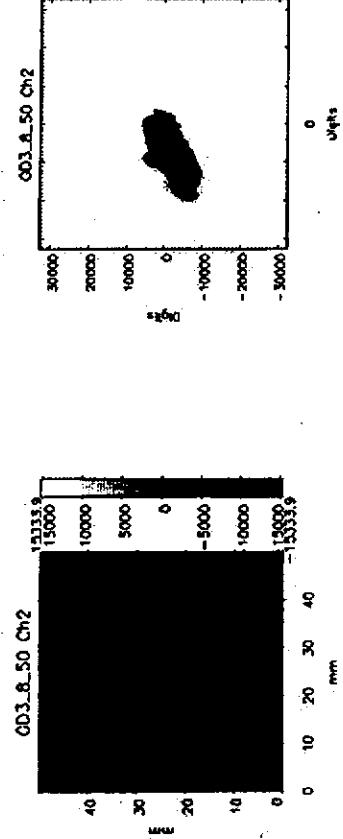


Bild 13b: Mulde mit verdeckten Bohrungen Kanal 2
(500 kHz)

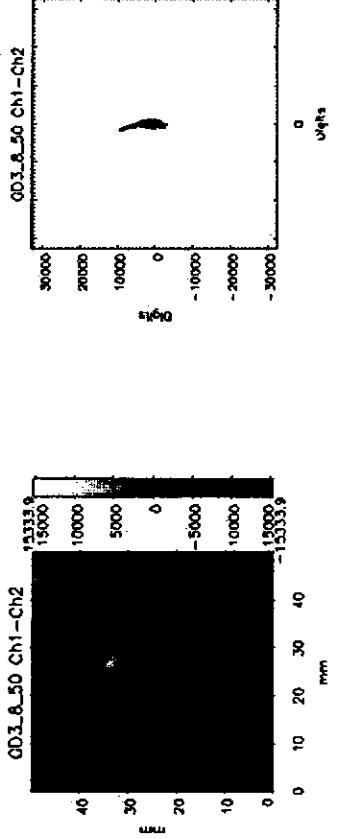


Bild 13c: Mulde mit verdeckten Bohrungen Verknüpfung beider Kanäle
($\mathbf{f}_1 - \mathbf{f}_2$)

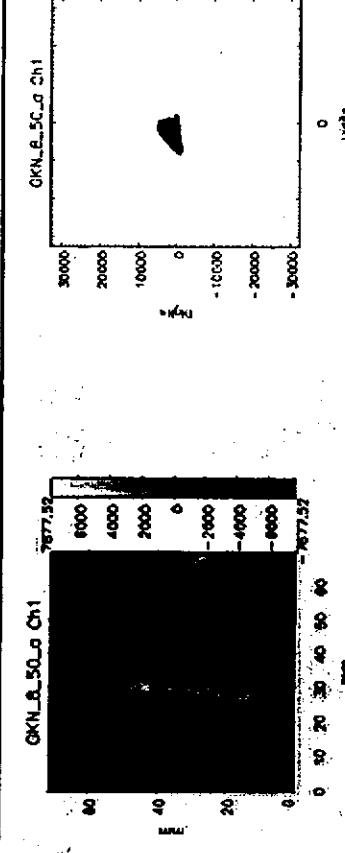


Bild 14 a: Vertiefung im Blech B2B10B Kanal 1
(80 kHz)

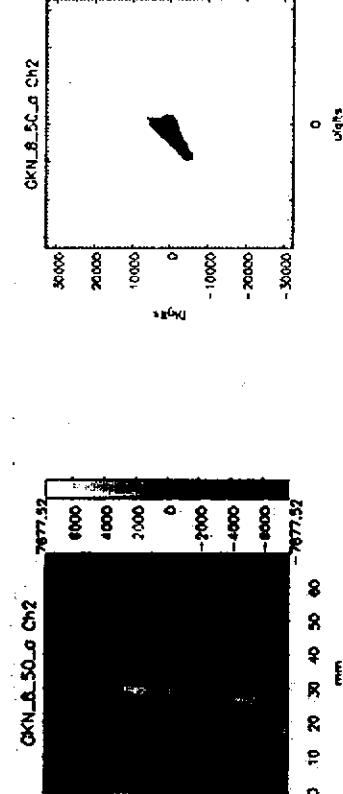


Bild 14 b: Vertiefung im Blech B2B10B Kanal 2
(500 kHz)

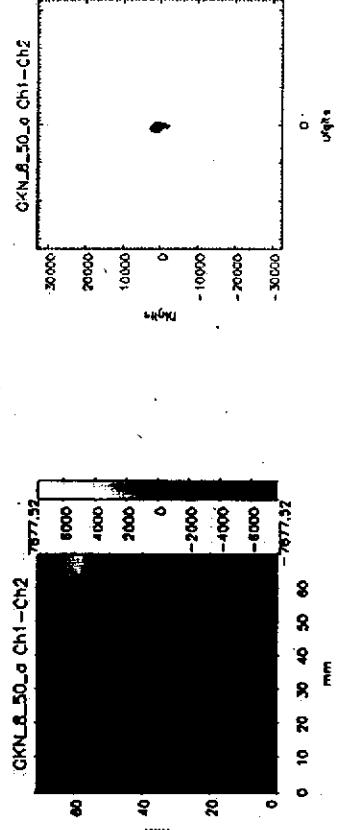
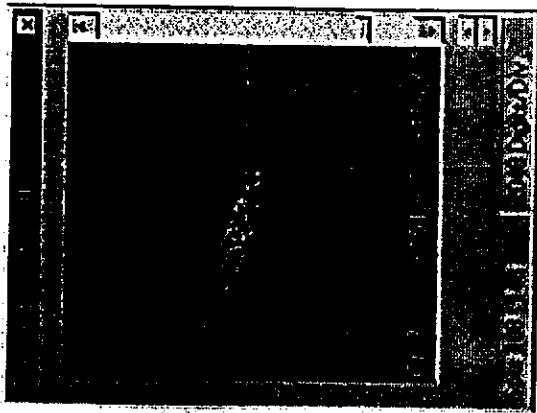
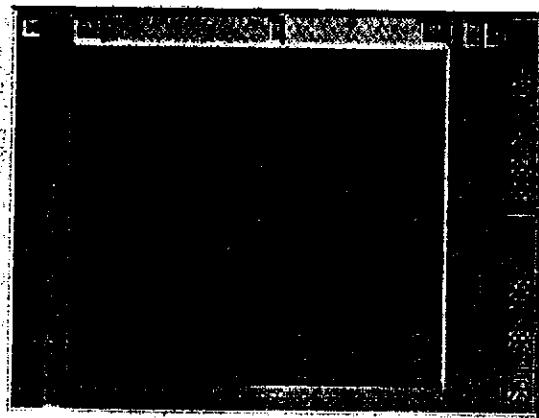


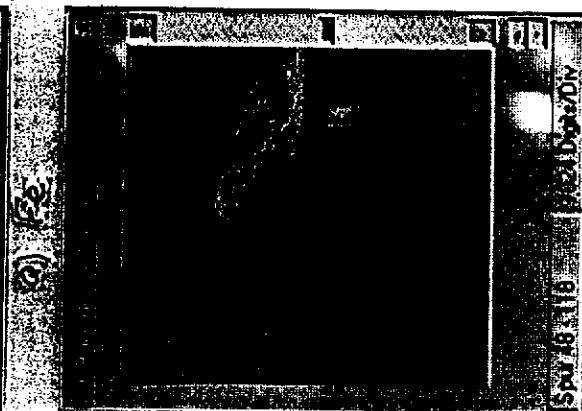
Bild 14 c: Vertiefung im Blech B2B10B Verknüpfung beider Kanäle
($\mathbf{f}_1 - \mathbf{f}_2$)



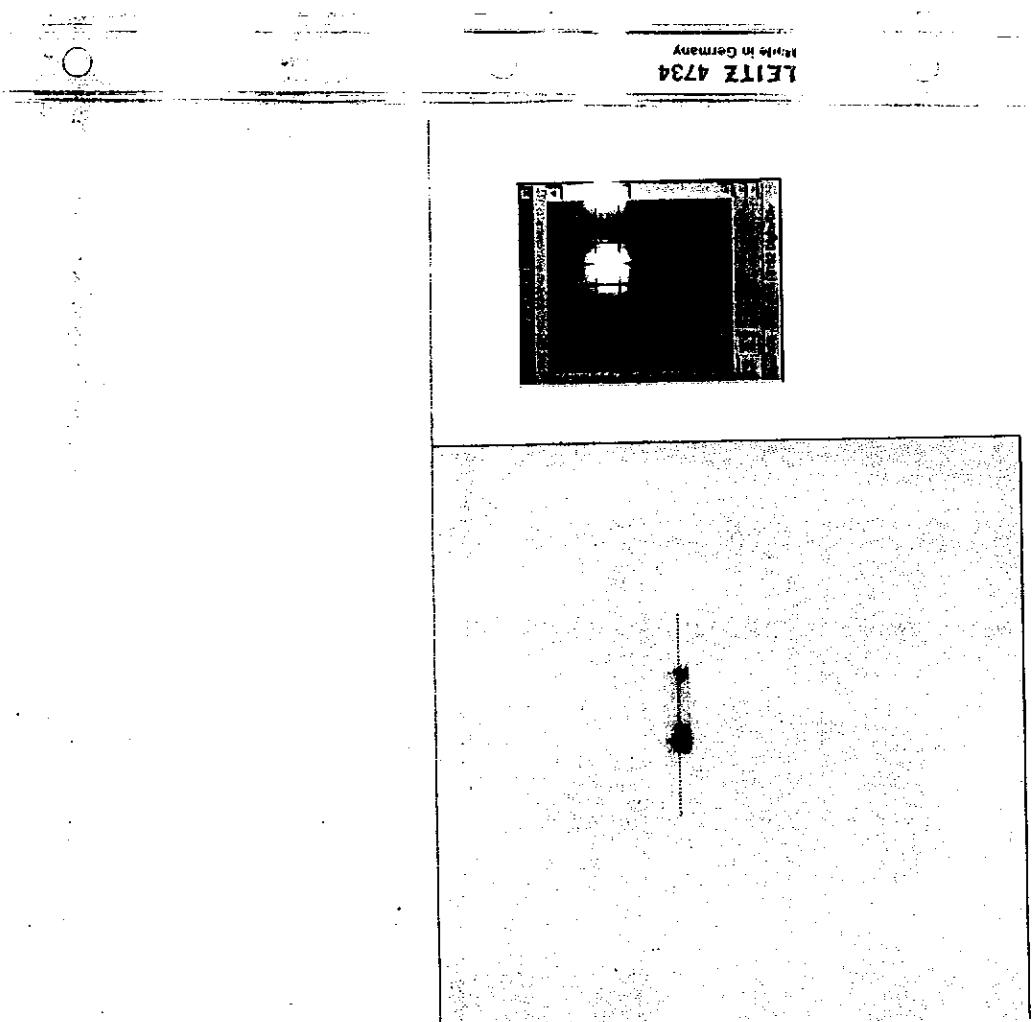
6) Ae



6) Ae



c) Cu



Scan-Picture of a "Dogbone" f2 = 1MHz

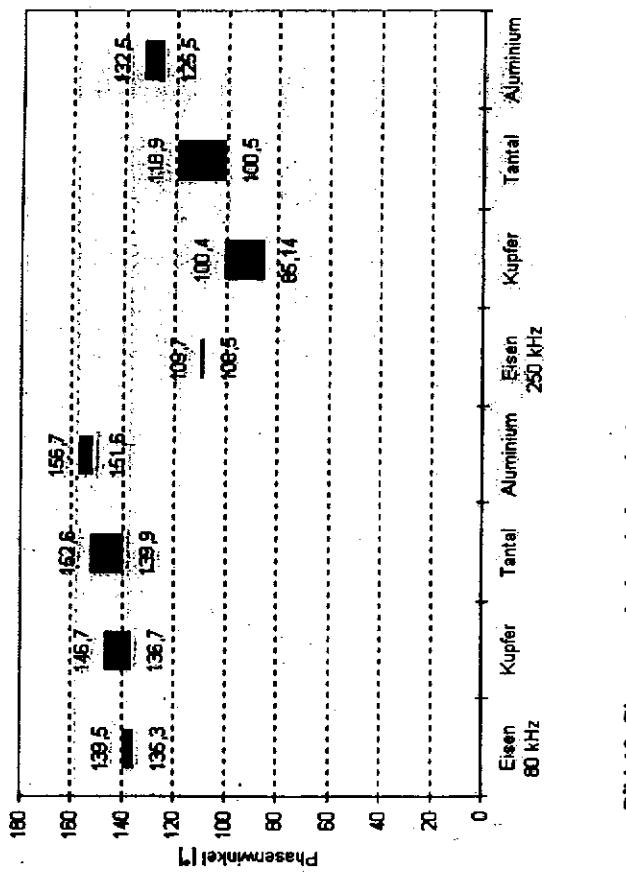


Bild 16: Phasenverhalten bei verdeckten Materialeinschüssen für die Prüffrequenzen 80 kHz und 250 kHz

BAM Improvement of Eddy Current Scanning System

1. Installation of two frequency measurement system
2. Stabilisation of the scanning table, reduction of noises because of vibration
3. Construction of a new probehead
4. Improvement of the software (upgrade the conditions of remote control and signal utilisation)
5. Suppression of the noises induced by cable movement



Bild 1:
Veränderte Konstruktion des Abtaststiftes für die Blechprüfung

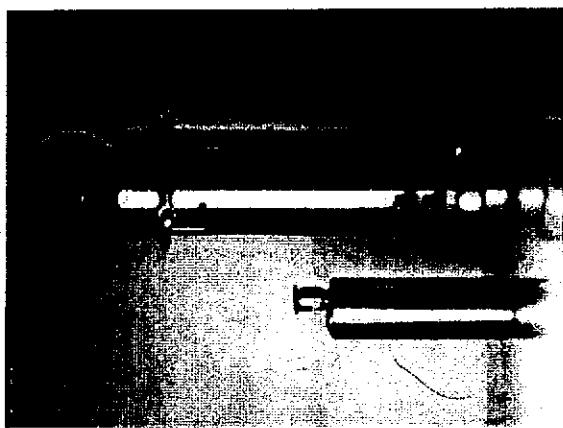


Bild 2:
Größenvergleich: Links der neue Sondenhalter, rechts der Vorgänger

Q_0 slope at high fields Thermometers investigation

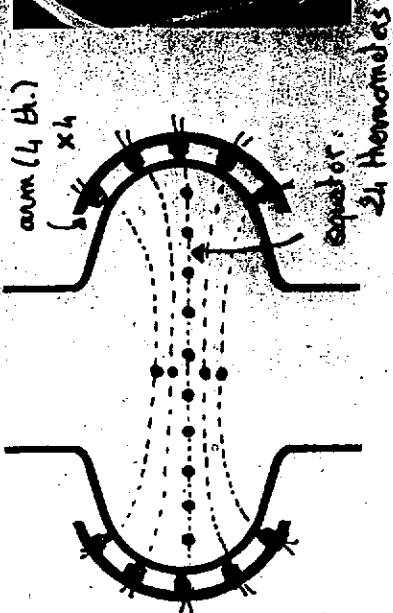
IPN Orsay
CEA Saclay
SC Cavities:
No X-rays
C1-10: Quench @ 26.9 MV/m
C1-05: Quench @ 27.6 MV/m

BOTH showed a strong Q_0 decrease at high fields
without any X-rays or electron beam

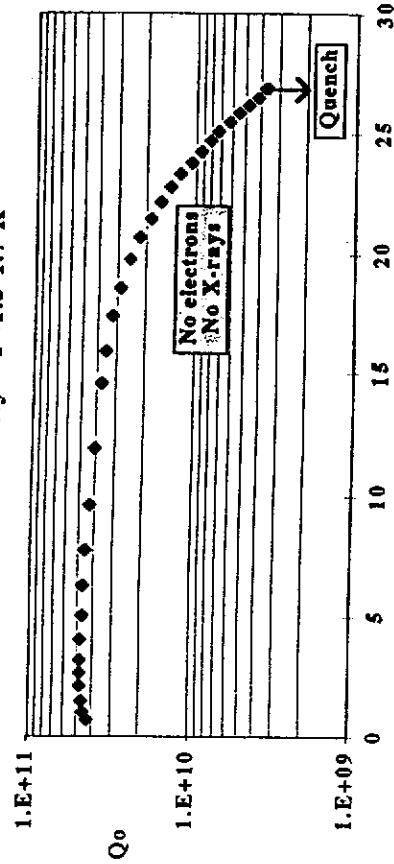
Experimental setup:

- 40 fixed spot thermometers
- 2 bath thermometers
- 4 bath thermometers

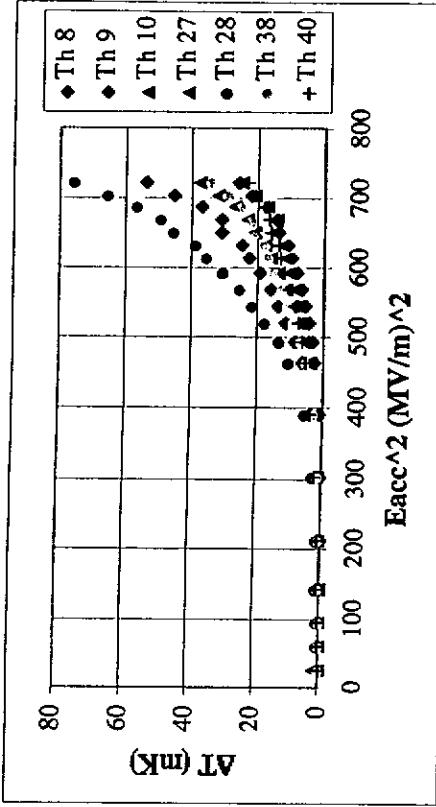
7



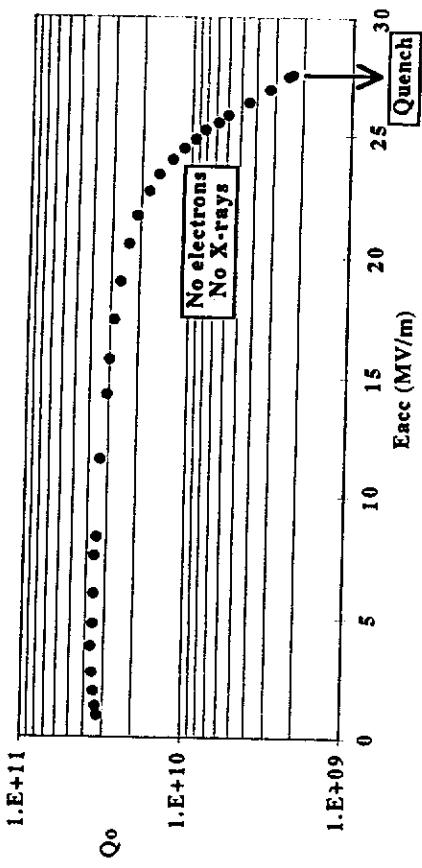
C1-10 Cavity - T=1.5-1.7 K



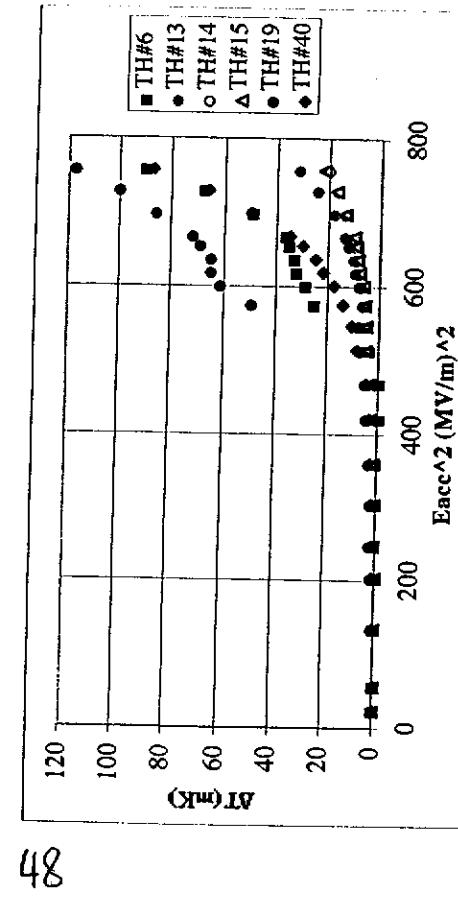
Temperature measurements clearly showed non-quadratic heatings
versus the accelerating field.



C1-05 Cavity - T=1.5-1.7 K



Temperature measurements clearly showed non-quadratic heatings versus the accelerating field.



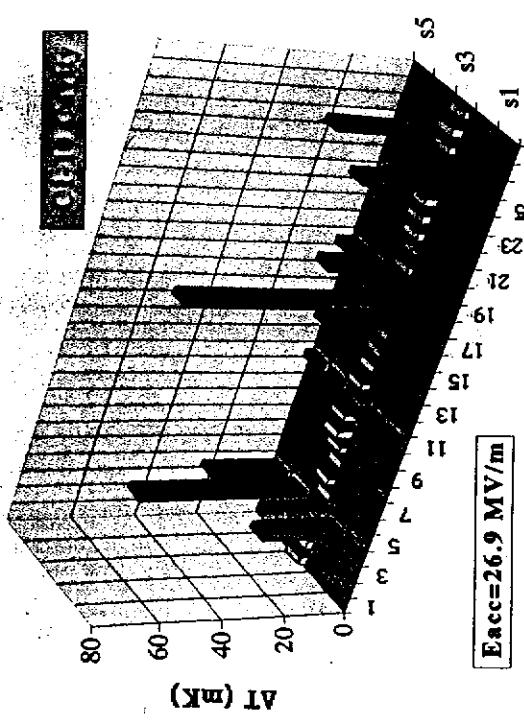
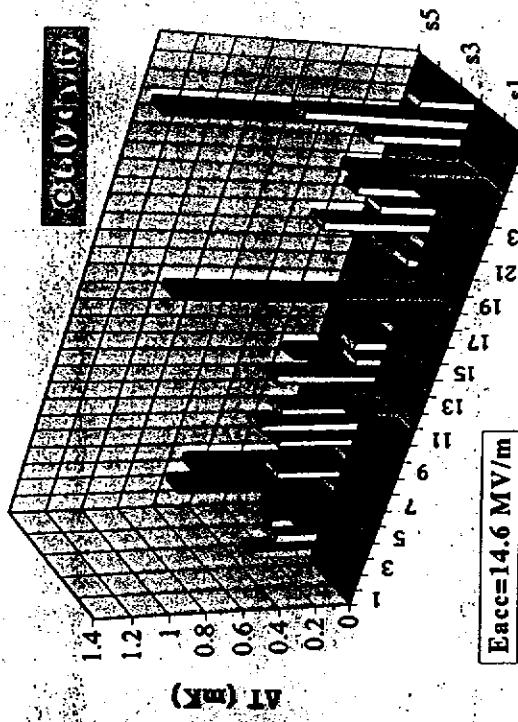
Some thermal considerations: example - of - Q1-05 cavity

- low field. $Q_0 = 3.5 \cdot 10^{10}$ $R_s = R_{Bcs} + R_{res} = 8 \text{ m}\Omega$
 \uparrow
 $\downarrow 14!$
 $(0.8 \text{ m}\Omega) (7 \text{ m}\Omega)$
- High field. $Q_0 = 2.5 \cdot 10^9$ $E_{acc} = 27.6 \text{ MV/m}$ $P_c = 38 \text{ Watt}$
 "Equivalent" surface resistance $R_s = 120 \text{ m}\Omega$

- 1) Effect of bath temperature drift?
 low field $T_b = 1.53 \text{ K}$ High field $T_b = 1.73 \text{ K}$
 Could only explain a ΔQ drop of a factor 2.5.
- 2) Could it be "standard" Bcs Heating?
 $R_s = 120 \text{ m}\Omega$ explained with $R_{Bcs} = \frac{A \cdot f^2}{T} e^{-\beta_f}$
 MEANS: $T = 2.85 \text{ K}$!
 To be consistent with $T_{bath} = 1.73 \text{ K}$ MEANS that
 the Josephson resistance should be a factor 10 higher than the known values.
 Anyways, should be seen with surface thermometry.

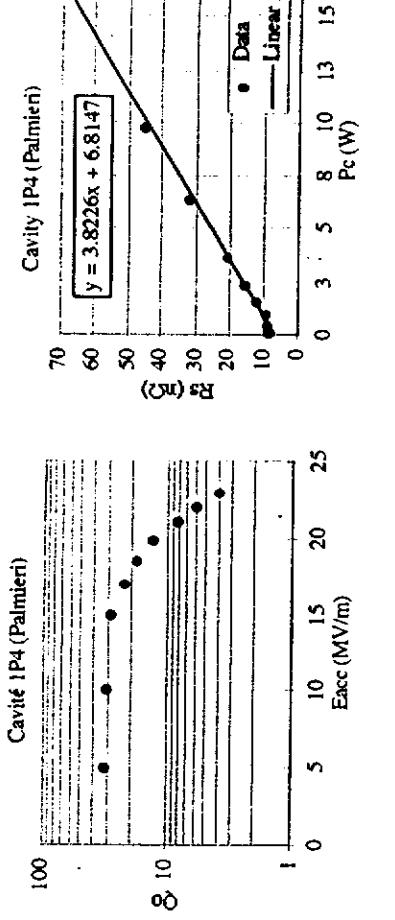
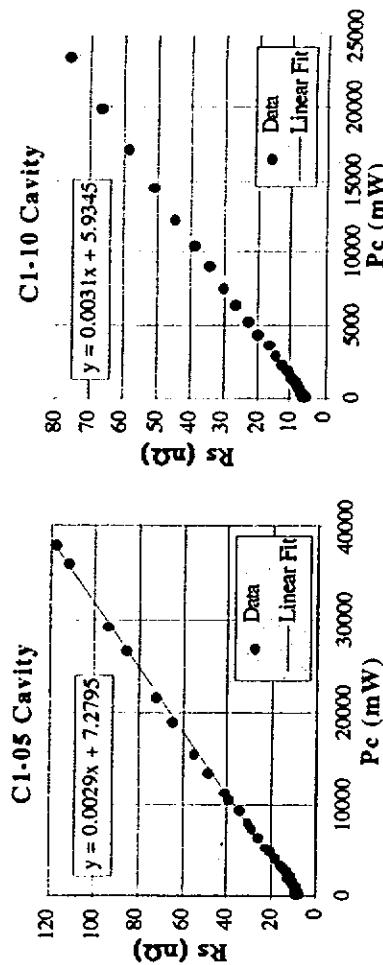
- 3) "Bad" broad areas?
 3 thermometers around $\Delta T = 100 \text{ mK}$ - Assuming 20% efficiency that means real $\Delta T = 500 \text{ mK}$.
 To explain "anomalous" power dissipation of 35W 85% of the cavity should be "bad".

→ Not verified with thermometry: must be even worst region.



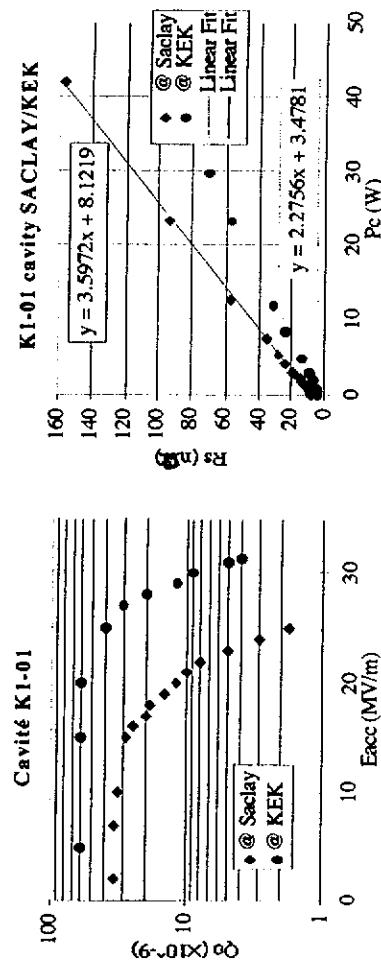
Variation of R_s versus the dissipated power

Assuming an increase of the global surface resistance R_s with E_{ac}



The linear dependency of R_s vs P_c seems to be a constant:

KEK Cavities:



- This behaviour is not seen on thin films cavities.

- BUT cavities having strong FE also have a linear dependency of the "equivalent" surface resistance with the dissipated power.

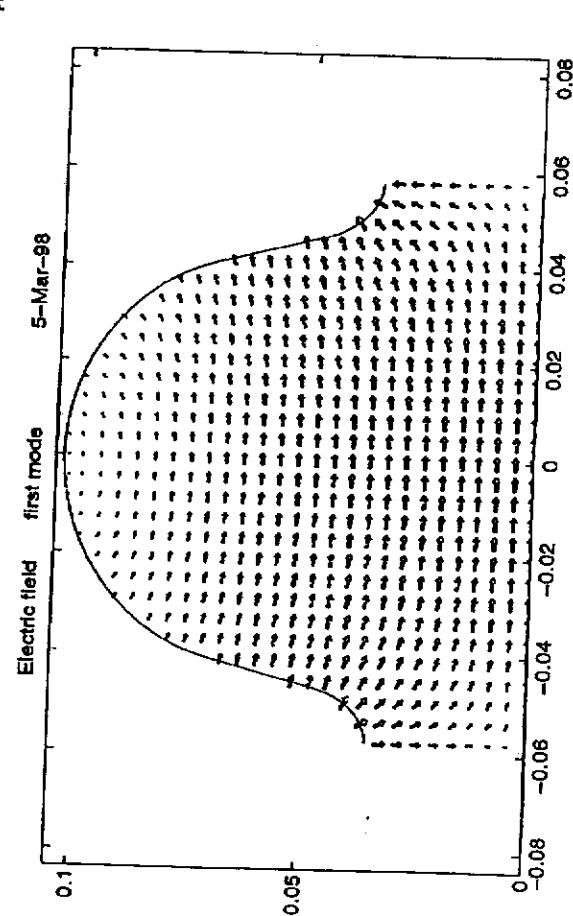
CONCLUSION:

- Anomalous heatings clearly measured
- Non uniform heatings
- Maximum heatings measured not sufficient to explain a so important Q_0 -drop.

OPEN QUESTIONS:

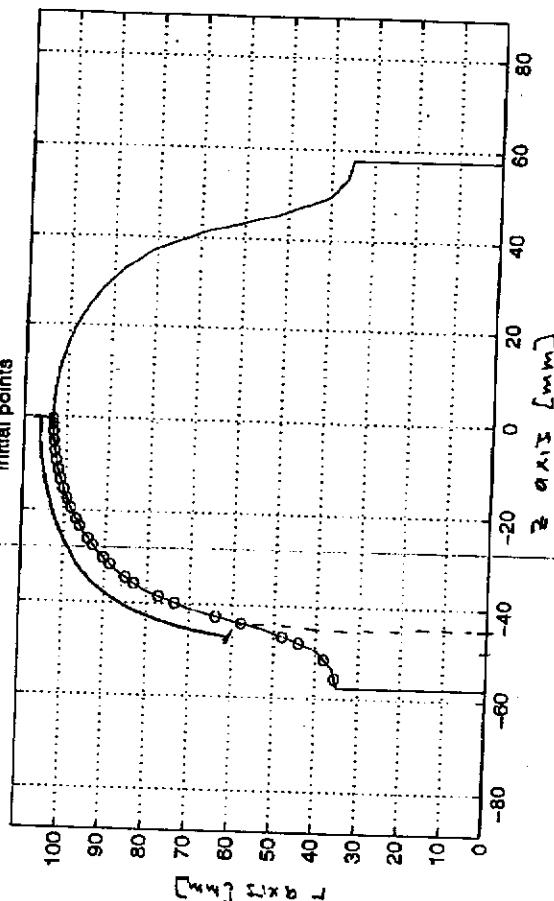
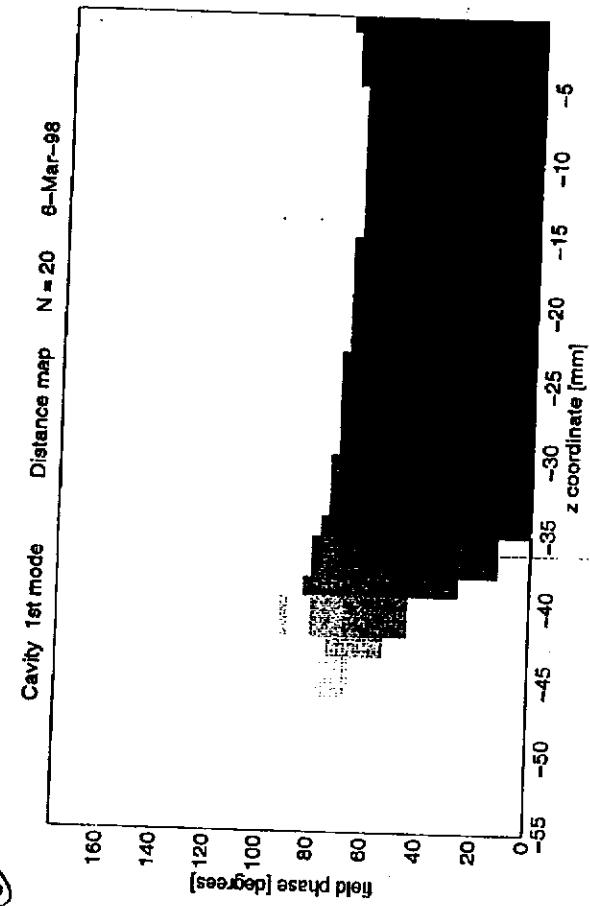
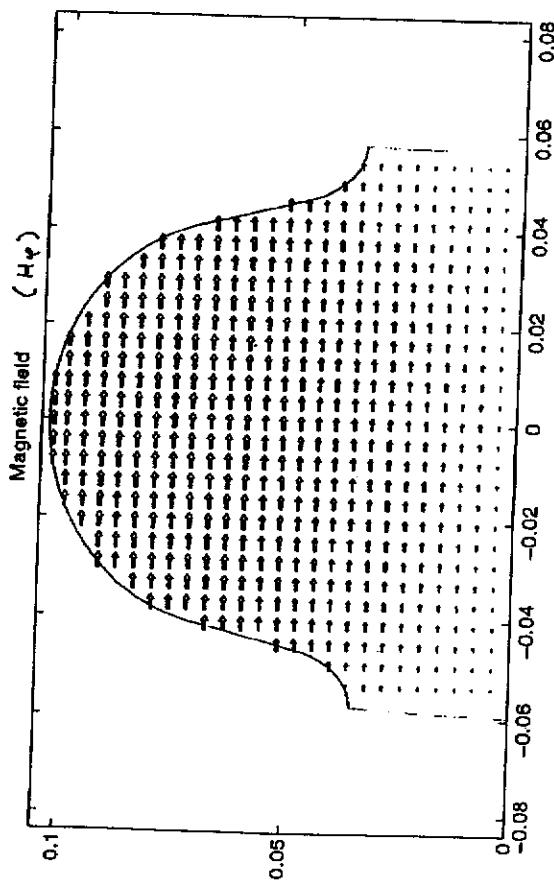
- Bad spots or wide "bad" areas ?
- 57. Are we sure there is no FE ?
(resonant or not)

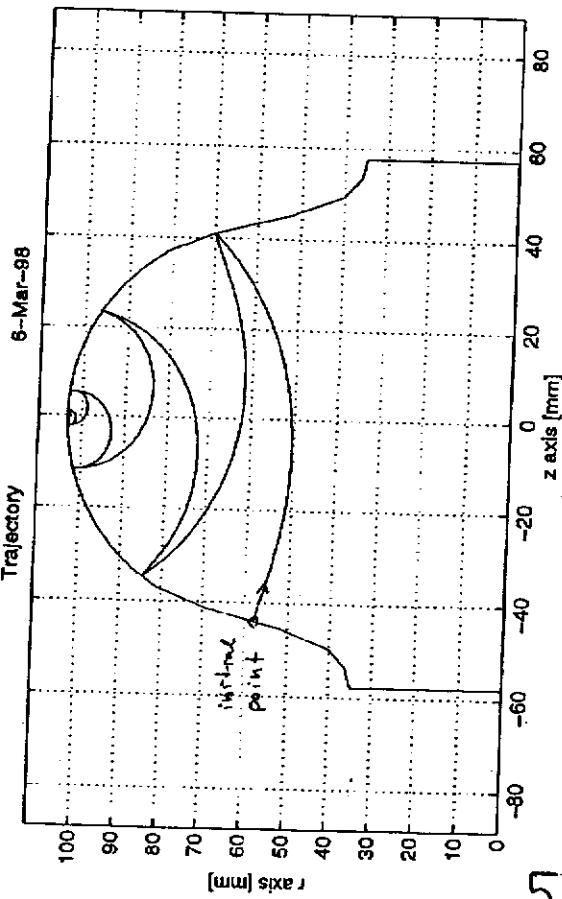
⇒ AGAIN, surface thermometry could give answers !



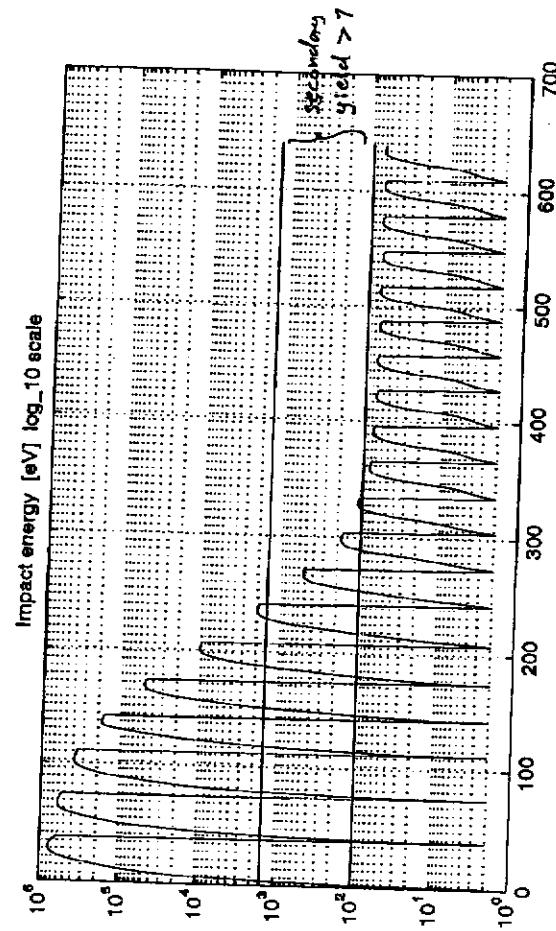
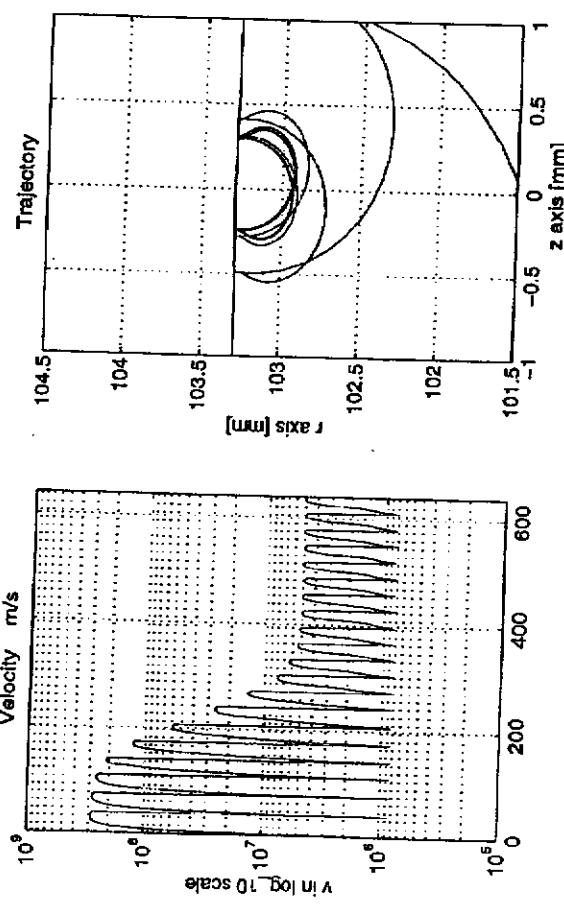
52

Multimode in my column, this is from Van Heijink.

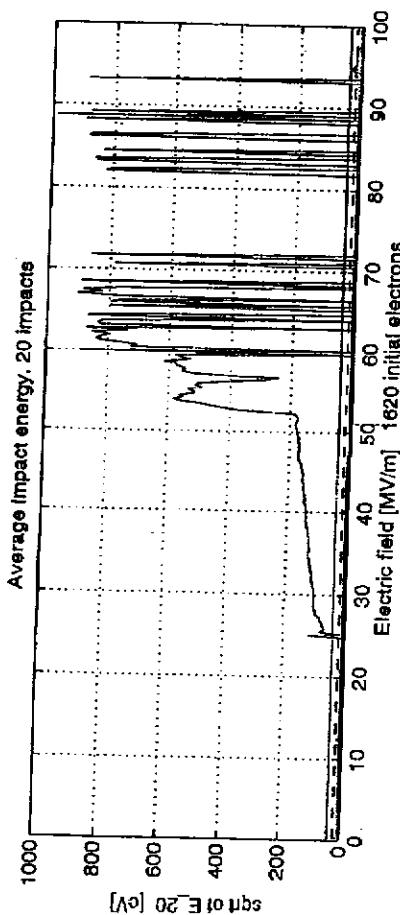
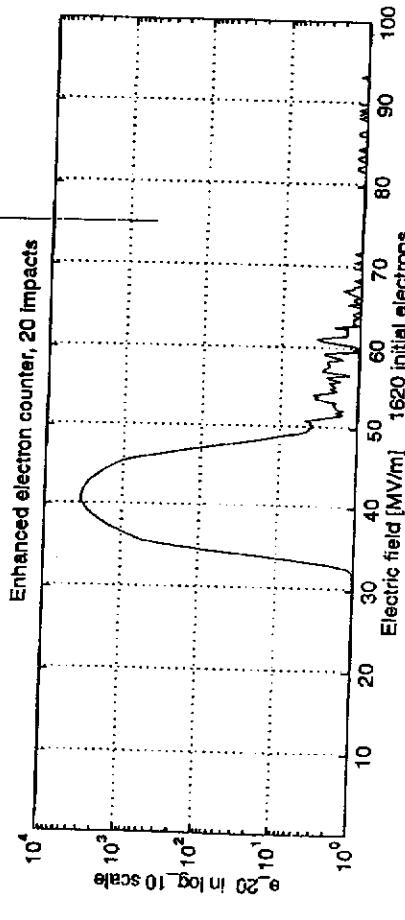
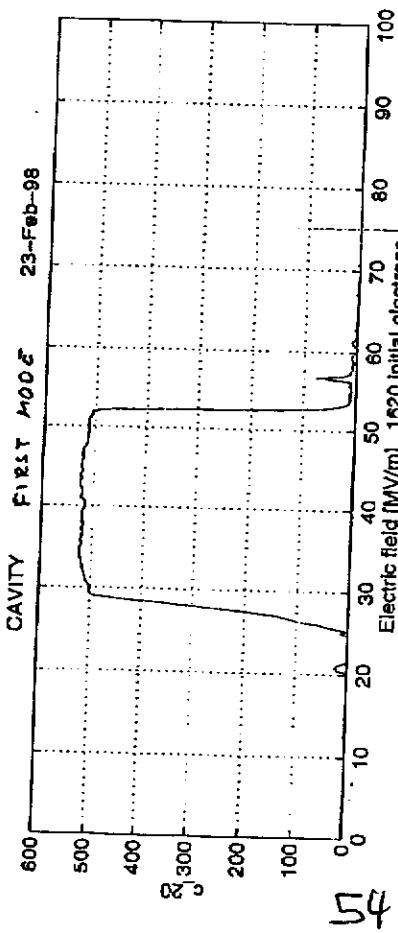




W



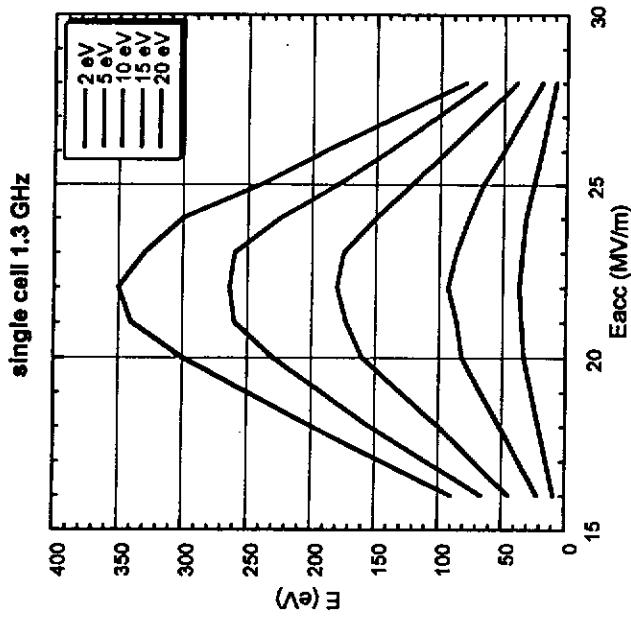
MULTIPACTING in 1.3 GHz CAVITIES



MPI - calculation of boundary
Stable trajectories near equator for $E \sim 17\text{-}27 \text{ MV/m}$

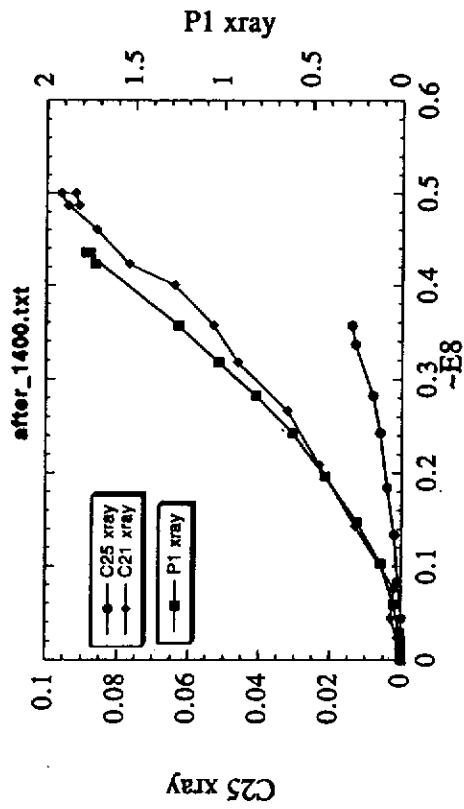
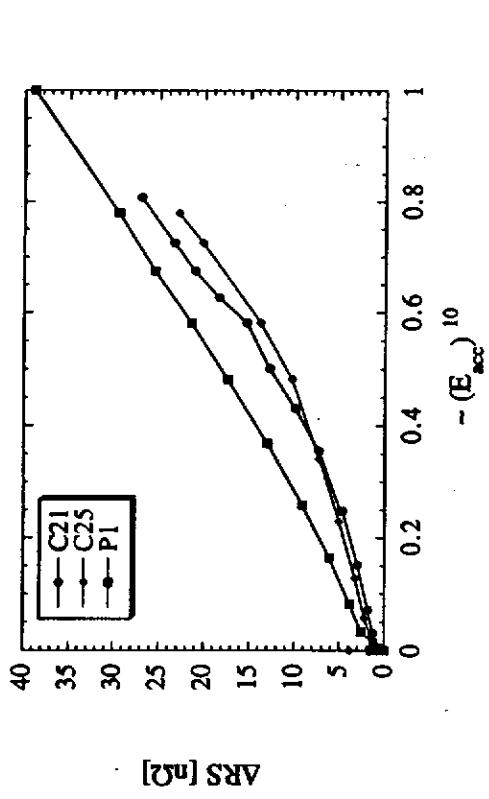
Small distance from the equator (0.2 - 0.5 mm)

Impact energy can be in the range where $\delta > 1$

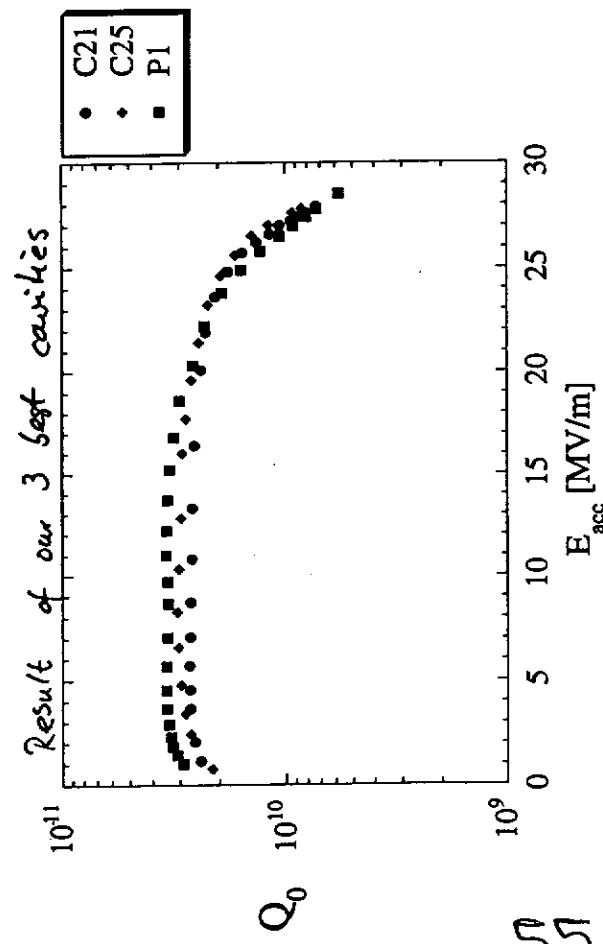


Impact energy for various initial energies

Pehlert: Q-drop and no x-rays in
vacuum condition

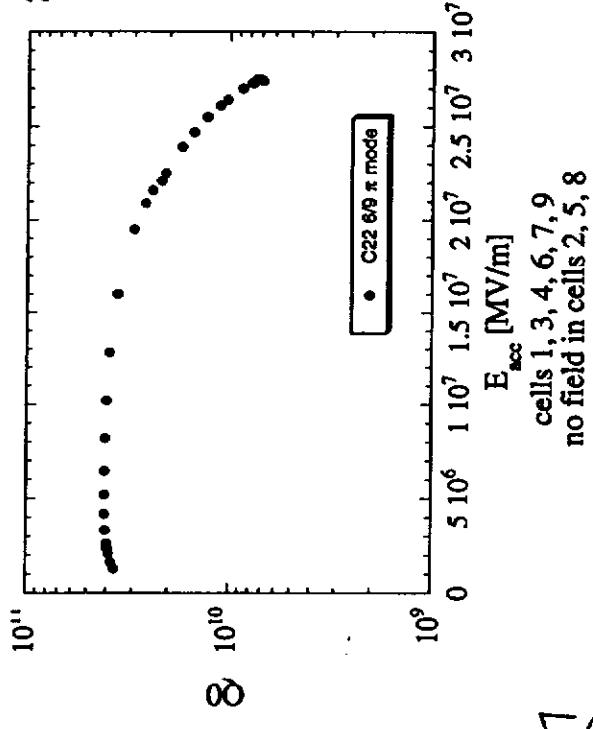


- Q-drop at high gradients
1. We always have x-rays in TC-mode at high gradients
 2. We have observed Q-drop without x-rays in other modes.

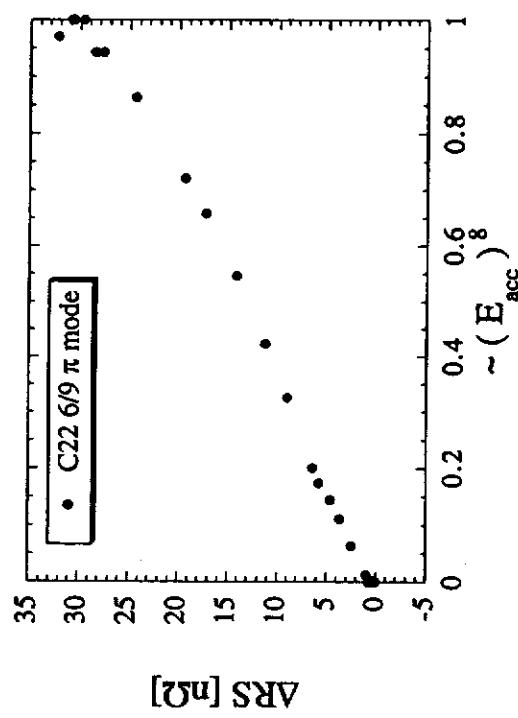


always x-rays, but in case of C25 very low
why are the 3 curves almost identical?

C22: no x-ray in π -mode also, quench at 20%
at cell 5
flat Ω_{RF} in π



56



Improvement of Q slope for high fields.

preliminary results (february 98)

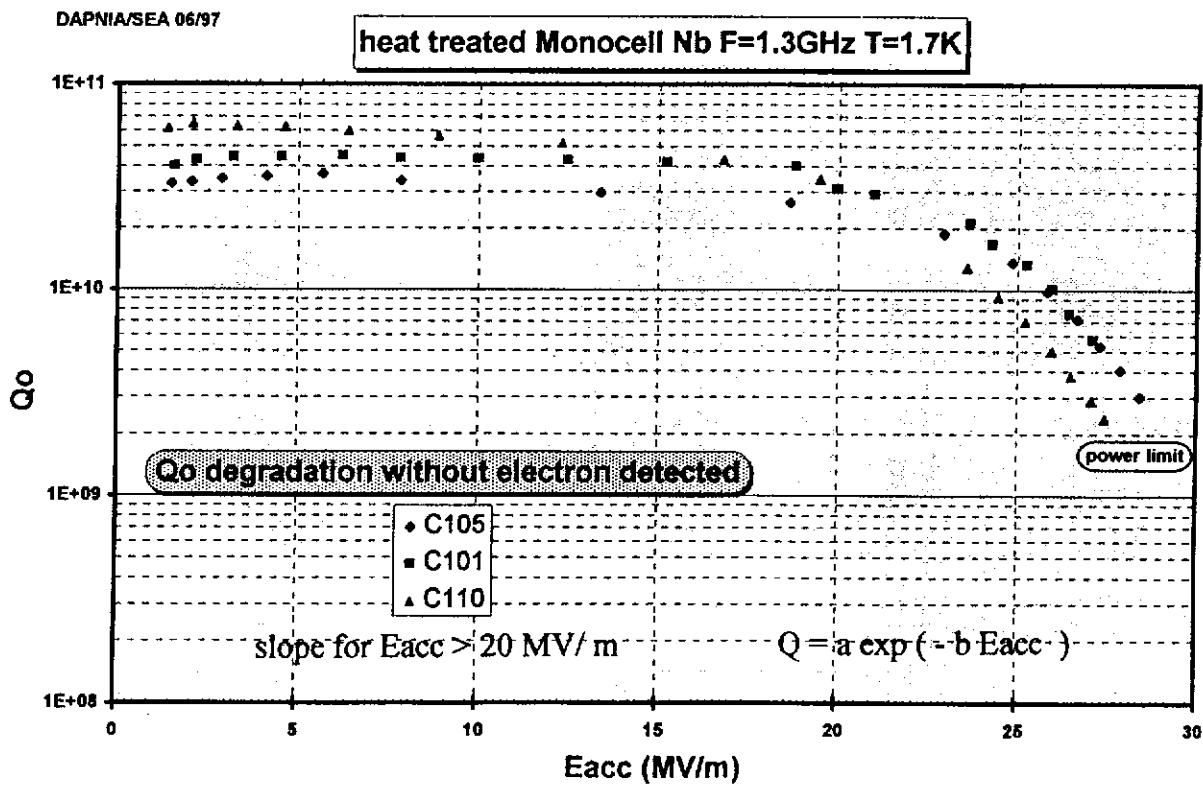
cavity warm-up (90 °C) before cool down (1,6 K)

TTF Meeting - March 98

BV- CEA/Saclay- DSM/DAPNIA/SEA

3

Saclay cavities features.

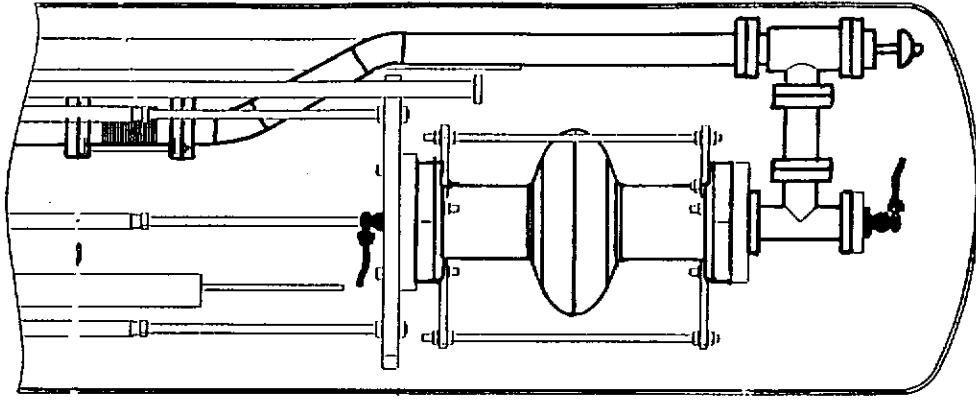


Cleaning process.

- Degreasing ultrasonic hot bath (15 mn)
- Chemical polishing by immersion
(HF / HNO₃ / H₃PO₄, 1 / 1 / 2 , 10 µm)
- Ultra pure water rinsing

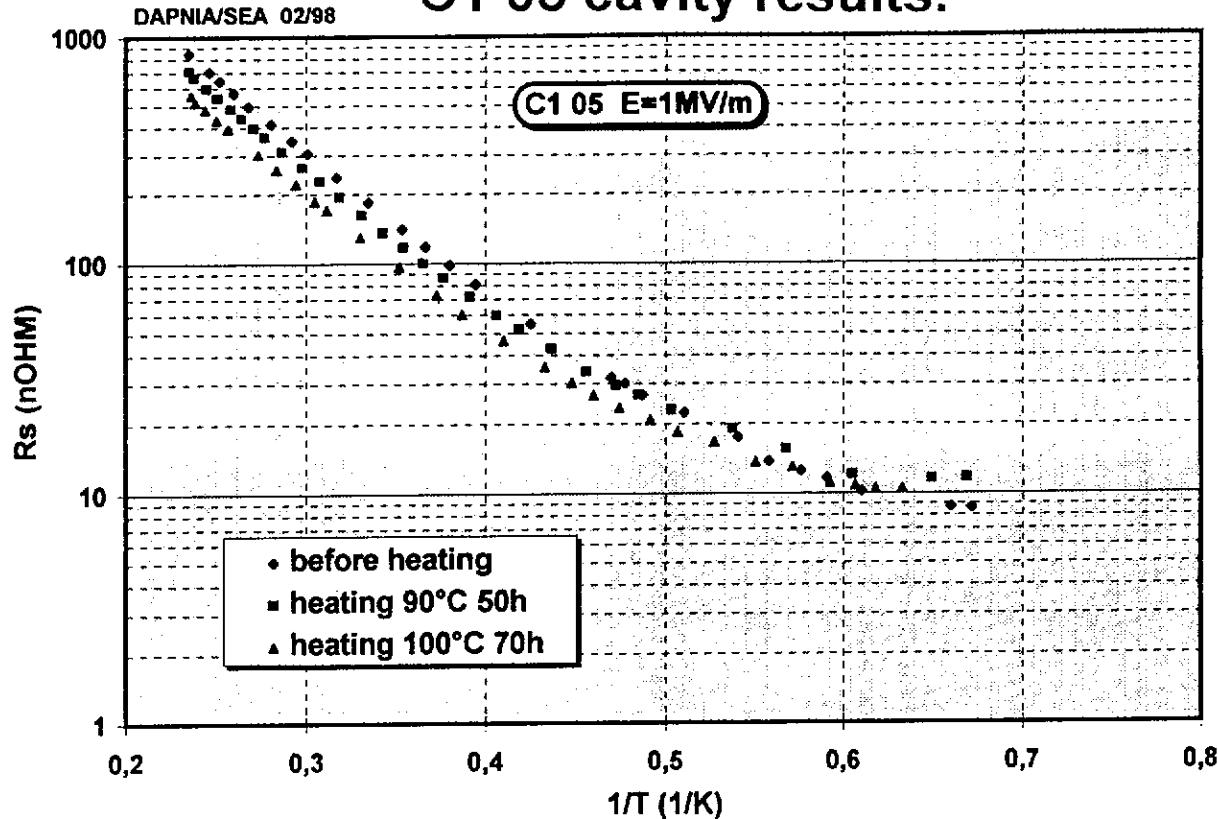
88

- Inside the cryostat
cavity in test position
several valve apertures
- Resistance
He gas (1 atm)
heat conduction
external Nb oxidation
- High pressure water rinsing (85 bar)
- Clean room
(class 100)
 - Drying
 - Assembling and pumping (TMP)
- Temperature limited to 90°C
connection damage
- Duration 50 h (P = 1.10⁻⁷ mbar)
- Limit pressure before cool down 1.10⁻⁸ mbar
- warm-up before cool down
- Cool down to LHe



Heating process and experimental set-up.

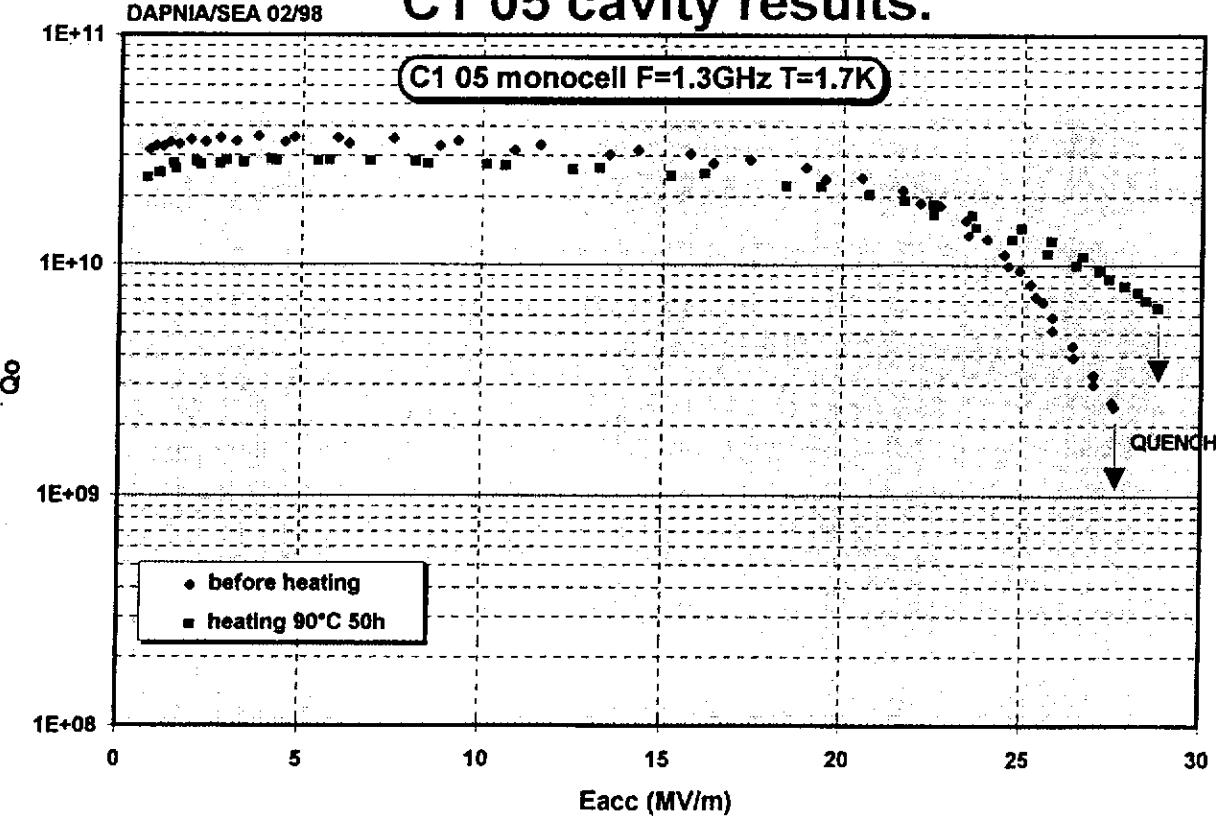
C1 05 cavity results.



TTF Meeting - March 98

BV- CEA/Saclay- DSM/DAPNIA/SEA

C1 05 cavity results.



TTF Meeting - March 98

BV- CEA/Saclay- DSM/DAPNIA/SEA

Goal: Thermal feed back
to nonlinear Q driver

Do we need $R_s = R_s(H) \rightarrow$
get a Q_o drop? no
We always have $R_s = R_s(\tau)$!
Thermal feed back

$$P_{dis} \approx R_s(\tau) \cdot U \quad (1)$$

$$U \approx E_{acc}^2 = \text{stored energy}$$

$$R_s(\tau) = R_s(\tau_0) + \left(\frac{\partial R_s}{\partial \tau} \right)_{\tau_0} \Delta \tau \quad (2)$$

$$\Delta \tau = R_{th} \cdot P_{dis} \quad (3)$$

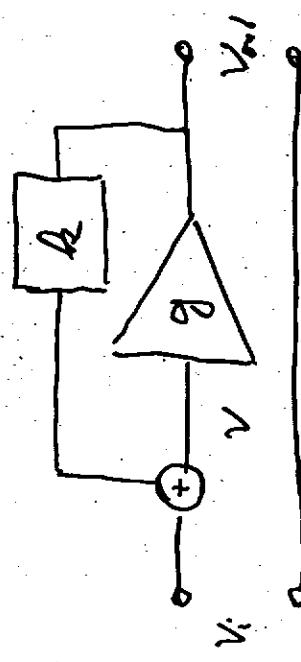
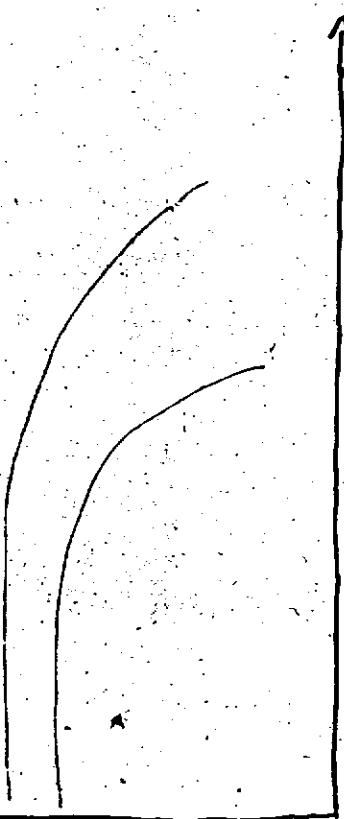
$$(2)+(3): \quad R_s(\tau) = R_{s0} + \left(\frac{\partial R_s}{\partial \tau} \right) R_{th} P_{dis} \quad (4)$$

$$(1)+(4): \quad P_{dis} \approx \left\{ R_{s0} + \left(\frac{\partial R_s}{\partial \tau} \right) R_{th} P_{dis} \right\} U \quad (5)$$

$$Q_o \approx \frac{U}{P_{dis}} = \frac{a}{R_{s0}} - b \frac{R_{th}}{R_{s0}} \left(\frac{\partial R_s}{\partial \tau} \right) U \quad (6)$$

$$Q_o \approx F_1 - B E_{acc}^2$$

$$\Delta \tau \approx \frac{R_{s0} R_{th} \cdot U}{1 - \frac{\partial R_s}{\partial \tau} R_{th} U} \quad \Sigma. \text{Value}$$



6

$$V_{out} = gV = g(V_i + gV_{out})$$

$$V_{out}(1-g^2) = gV_i$$

$$V_{out} = \frac{gV_i}{1-g^2}$$

Research issues

1. How to avoid field emission safely?
2. Best surface preparation
3. Q-drop at high field without X-rays and new physics
4. New cavity production line (spun +hydroformed)
5. Quench origins

⇒ Single cell program

because of

- fast turnaround time
- T-mapping possible
- good diagnostics
- cutting of cavities possible (Cornell)
- + probes for H_{C2} , etching parameters, FE,HPR, etc.

at DESY, CORNELL, CERN (EP), INFN Legnaro (EP)

Many things to do, a joint effort is needed!

M. Liepe & L. Lilje 9.3.98

Standard surface preparation

- remove damage layer (50 - 100 µm BCP)
- 800 degrees firing
- 20 µm BCP
- Test
- 1400 degrees firing
- 100 µm BCP
- Test
- always 1:1:2 BCP
- always drying by pumping

New preparation ideas

- BCP with dilution at the end (reduced heating of surface)
- BCP 1:1:1 ...
- BCP and rinsing with H_2O_2 , O_3
- HPR with hot water and/or higher pressure
- Electropolishing
- Tumbling and EP or BCP
- hardening of niobium surface

M. Liepe & L. Lilje 9.3.98

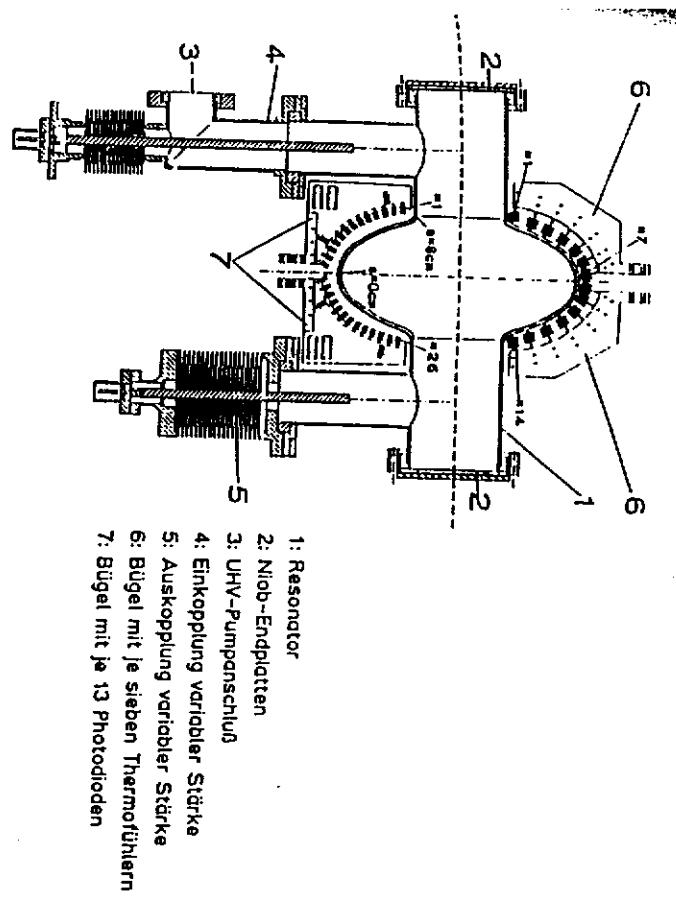
Standard deep drawing and welding	Spinning	Hydroforming	TE011-Resonator
test of standard preparation and of alternative preparation at Cornell	test of manufacturing procedure	test of manufacturing procedure	test of critical field
many tests	many tests	few tests	few tests
in collaboration with Cornell	in collaboration with INFN Legnaro	DESY	DESY
build and test EP at Cornell (learn technology)	EP at Legnaro (or CERN)	EP at CERN (or Legnaro)	?
Cornell: build 1-cell cavities build EP build T-map for 1.3 GHz	DESY: cleanroom (Hall NO) infrastructure (pumps, antennas, 2nd T-mapping, own insert...)	DESY: cleanroom	new design special insert DESY: cleanroom <i>SACLAY, OR.SAY</i>

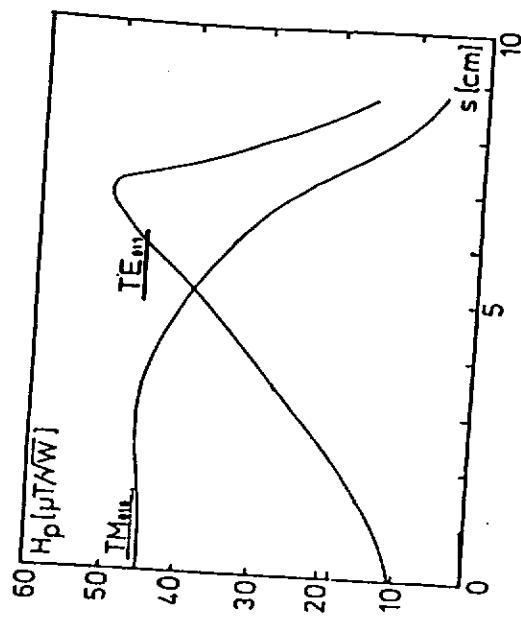
EP of sheets
half-cells

M. Liepe & L. Lilje 9.3.98

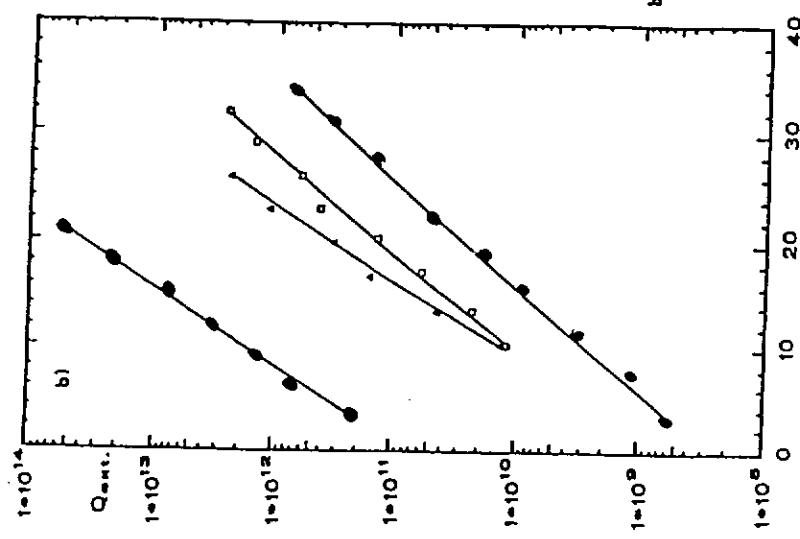
Modenbezeichnung URMEL in Zyl.- Zahlen	f [MHz] Gesch. exp.	G [Ω] gerechnet exp.
TM0-EE-1 TM010	1472 ± 2 1473,6	245 ± 10 228
2-NE-1 TE211	2654 ± 4 2627,6	510 498
2-EE-1 TM210	2741 ± 4 2755,0	421 ± 10 386
TE0-ME-1 TE011	2874 ± 4 2853,2	488 ± 10 594
3-EE-1 TM310	3240 ± 5 3378 ± 5	555 ± 10 442
		415
		474
		465
		3398,3

Frequenz und Geometriefaktor einiger Moden hoher Güte im L-Band-Resonator (Abb.3.16)





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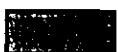


Power coupler development at Saclay/Orsay

Christian TRAVIER (CEA Saclay)



CEA



IPN



LAL

- Introduction
- Coupler Test Facility
- A few results
- Comparaison of different windows
- Miscellaneous

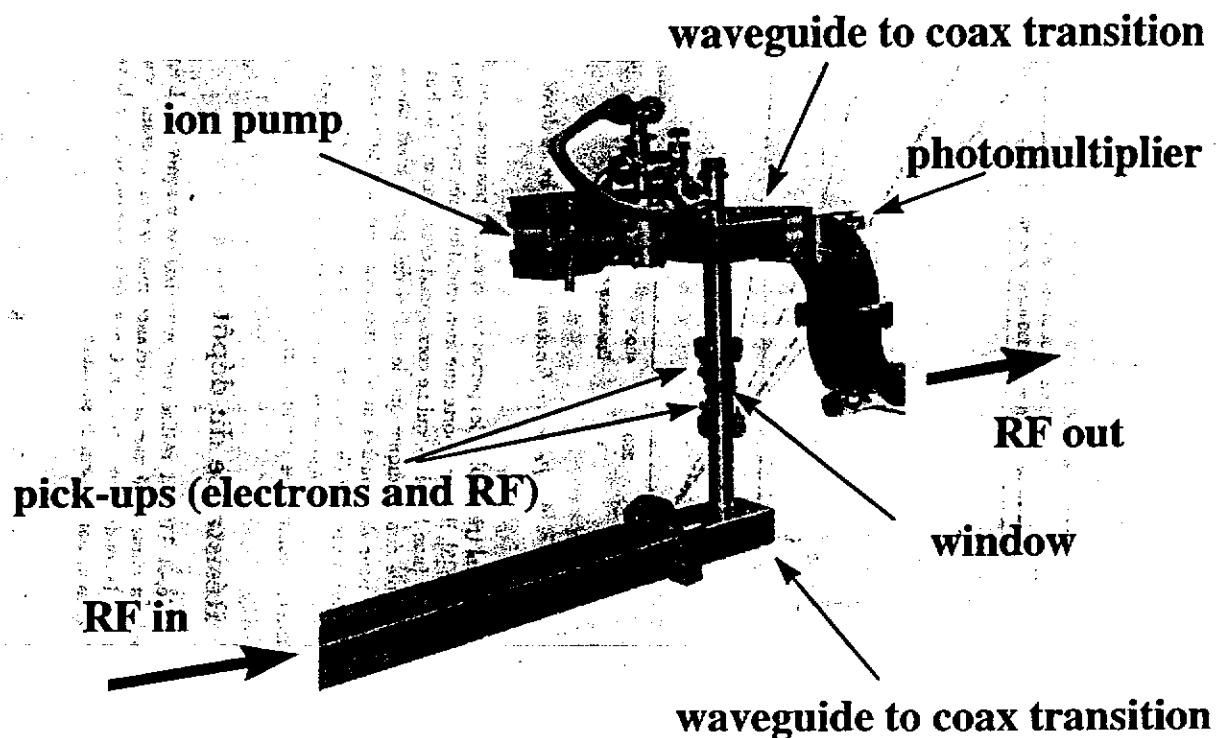
Coupler development at Saclay/Orsay

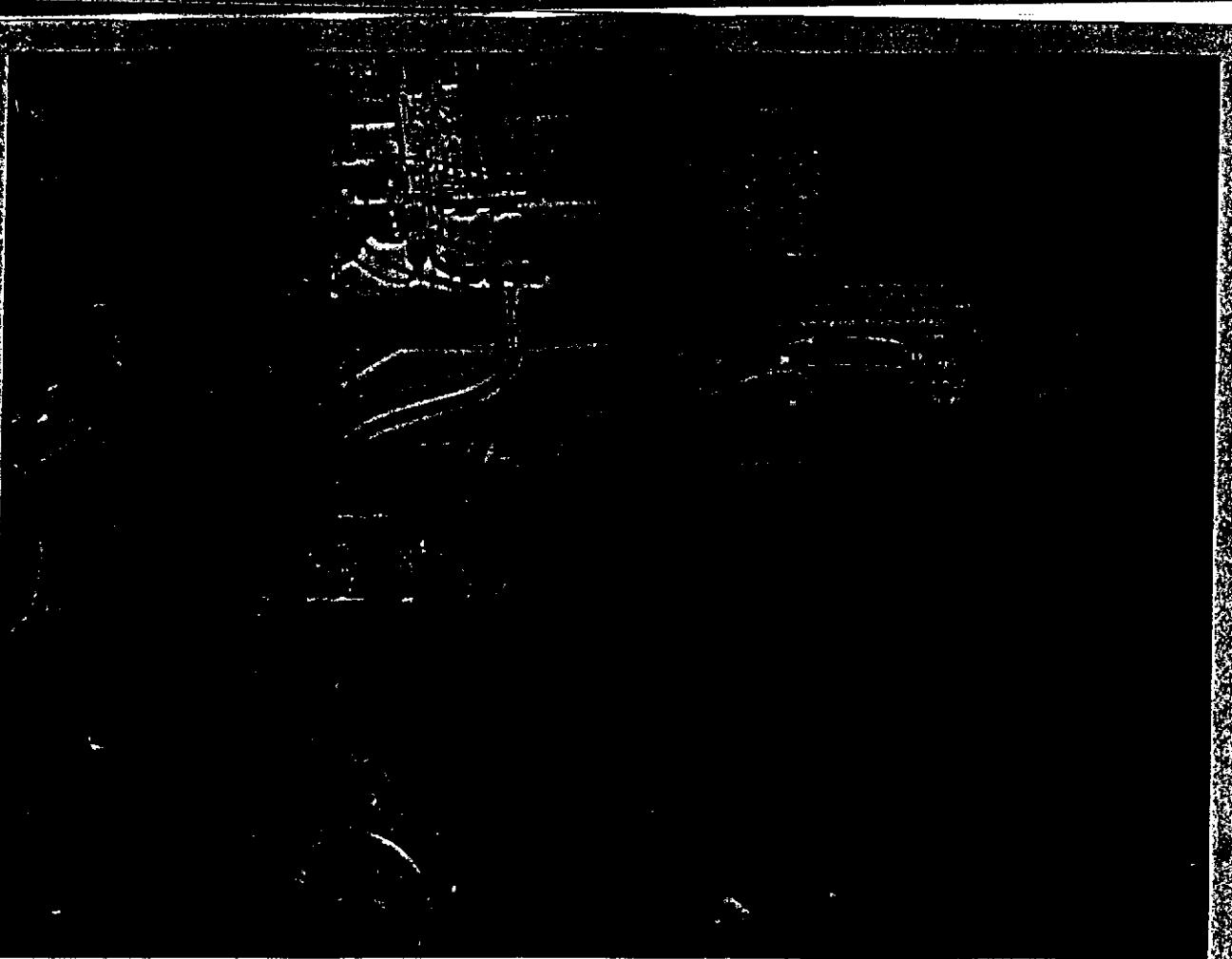
- collaboration started in 1996
- test different designs of coupler components
- build a cheap prototype coupler (goal 1 MW - factor 2-3 reduction in cost)

Present Coupler Test Stand

- modulator - klystron: 1 MW, 800 μ s, 0,1 Hz
- waveguide system (SW or TW)
- RF pick-ups
- electron pick-up
- photomultipliers
- vacuum measurement
- computer system (PC + Labview)

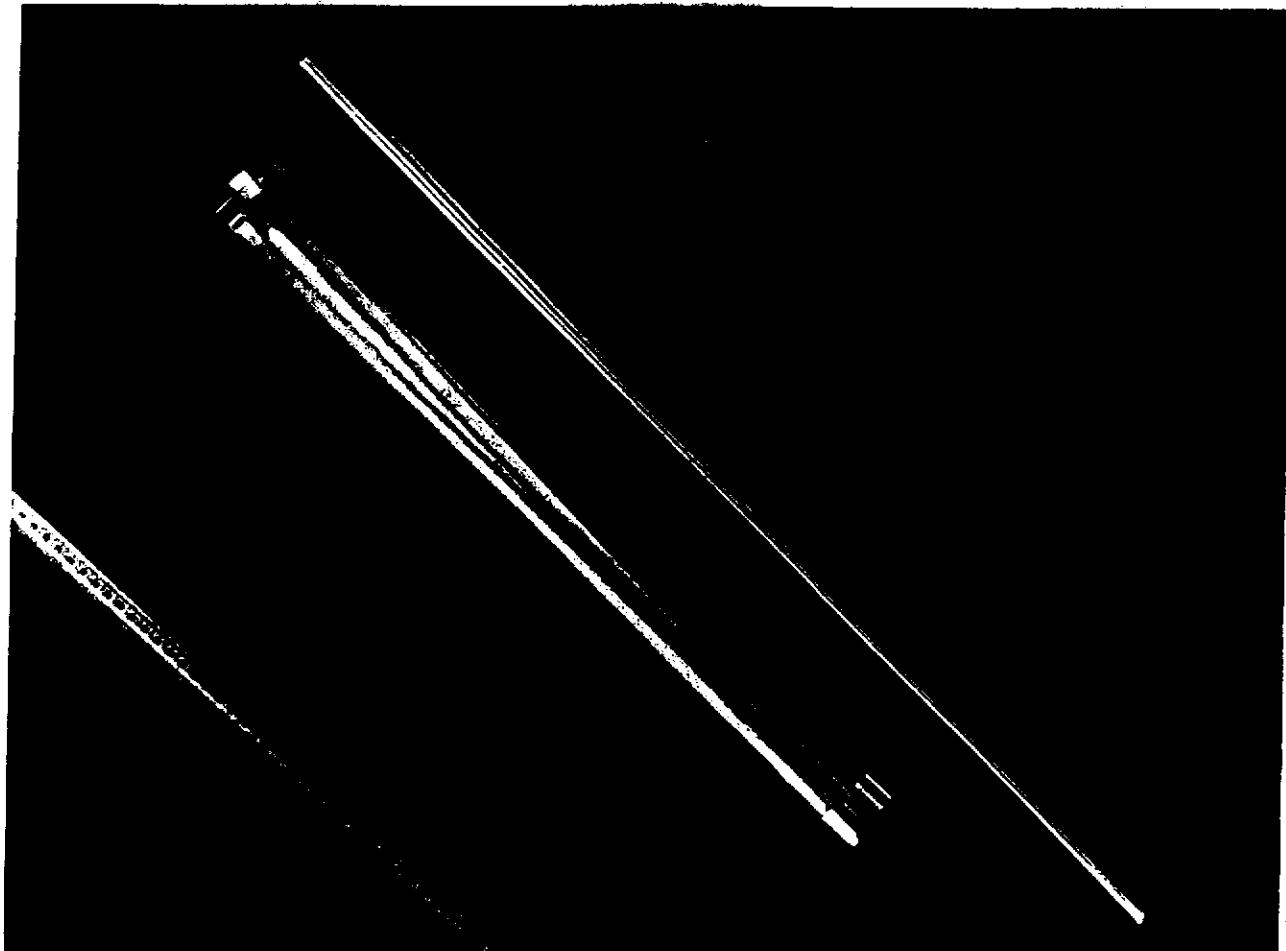
Present Coupler Test Stand





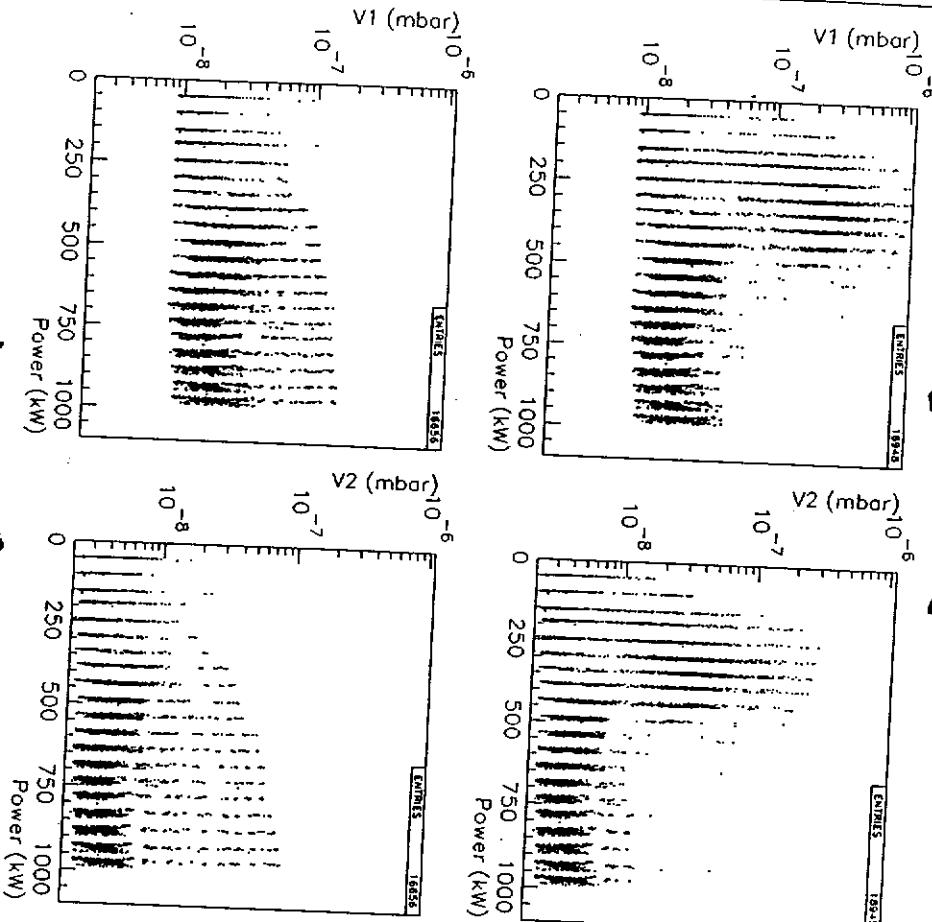
1997 experiments

- **04/97:** test stand ready to operate
- **04-06/97:** conical coax transition ($\Phi 40-\Phi 60$)
- **07/97:** RF contact
- **08-11/97:** FERMI window (référence)
- **12/97:** antenna transition



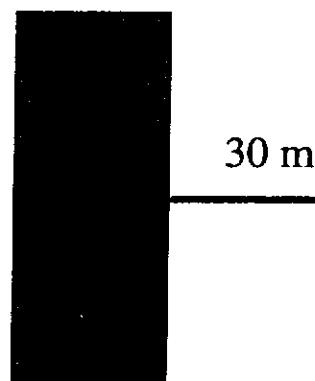
$P_{UC} = 0$

97/10/10 09:29



Upgrade coupler test stand cryogenic system

nitrogen tank 1200 l



computer



heat exchanger

pump

cryostat

monitoring

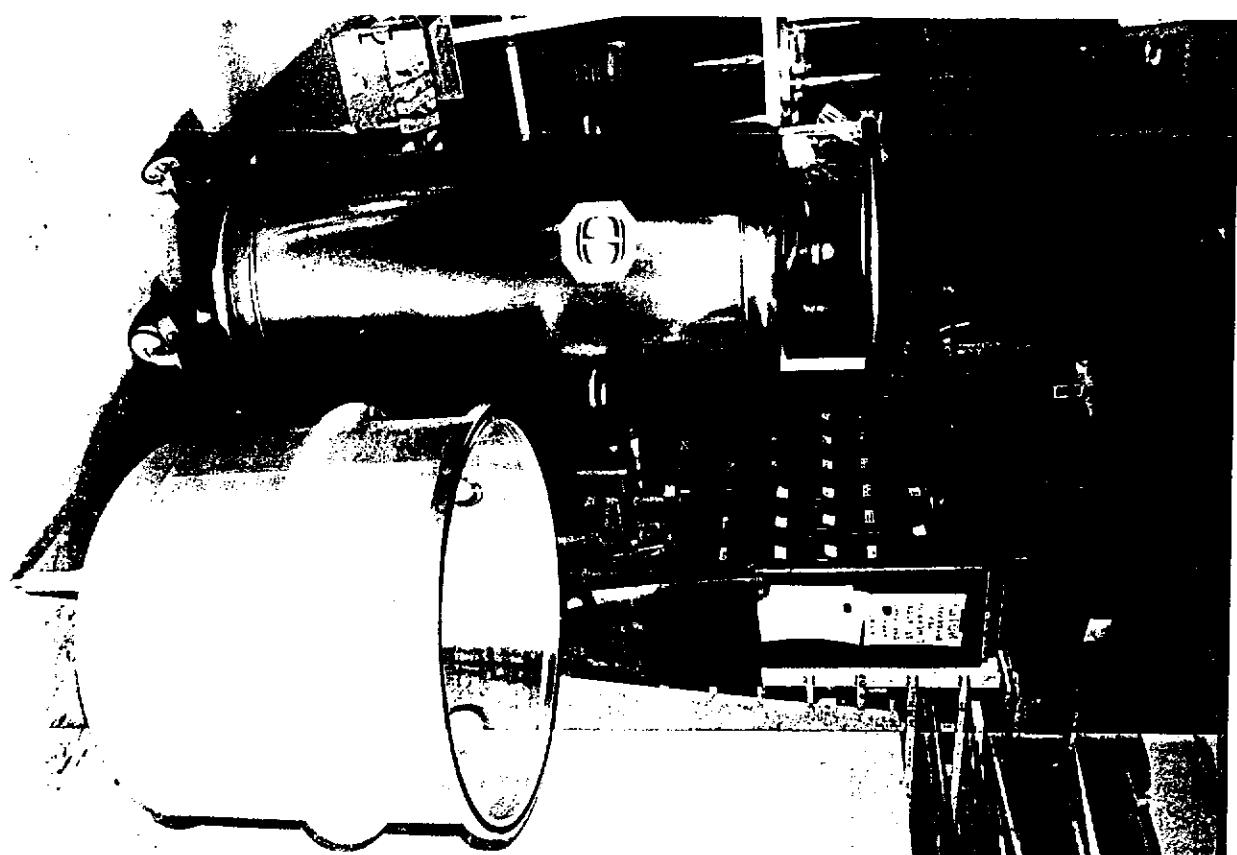
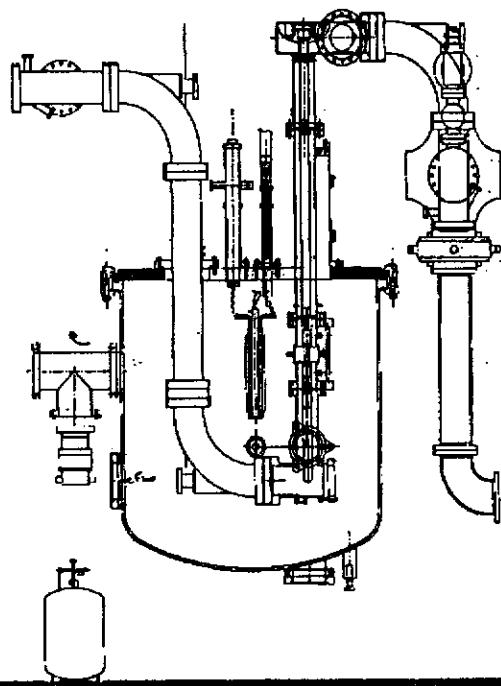
200 l tank

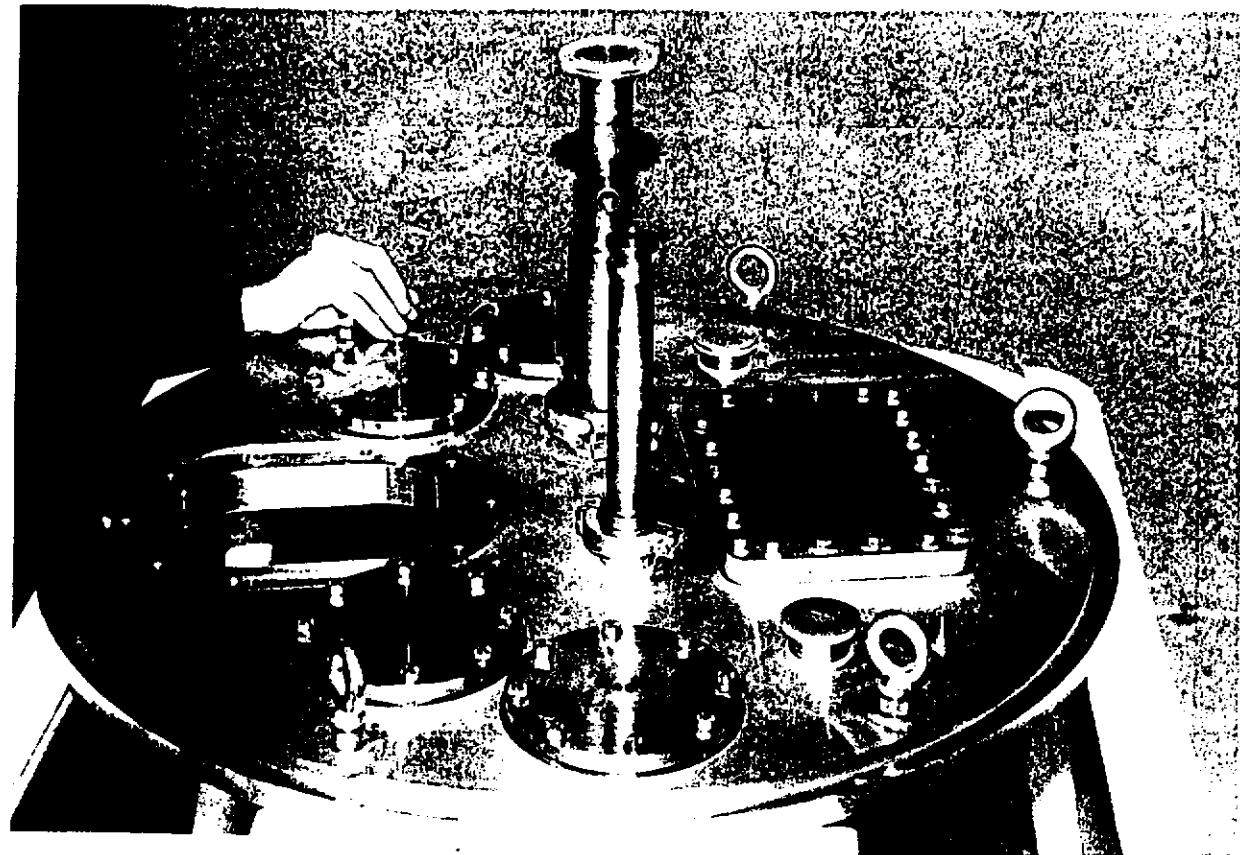
CEA IPN LAL

Cryostat

- temperature 70 K
- allow bakeout 150 C
- local heating of window during cool down to avoid cryogenic adsorbtion

ready to start test: avril 98





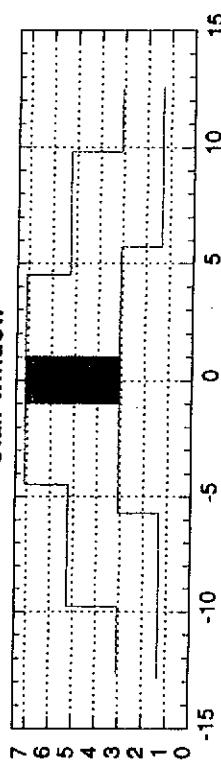
Cold window comparison

Criteria to compare windows:

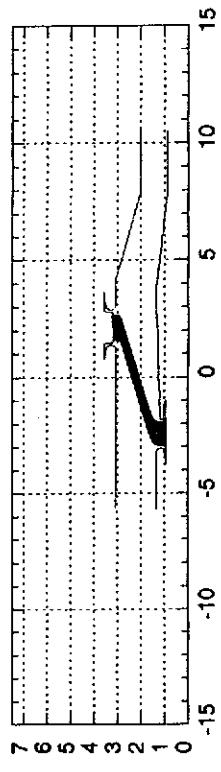
- maximum field on ceramic, at brazing location
- bandwidth
- multipactor (normal E field at ceramic)
- ghosts modes
- dielectric losses
- exposure to cavity electrons and X-rays
- mechanical and thermal properties
- mechanical tolerances
- number of braze or weld
- fabrication process (price)

Window comparaison

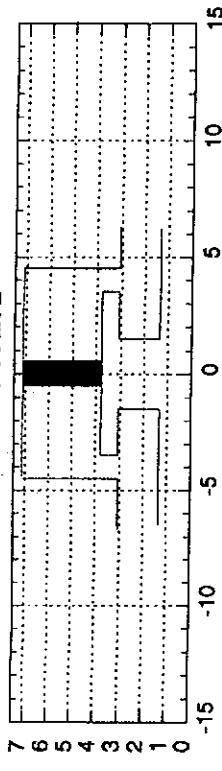
"Stair window"



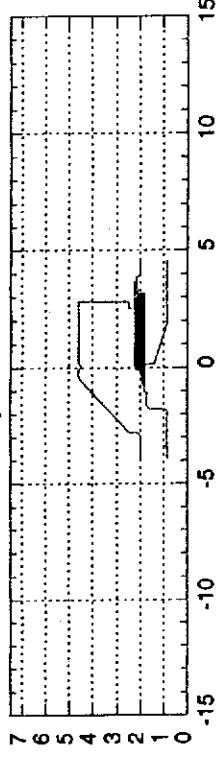
Conical



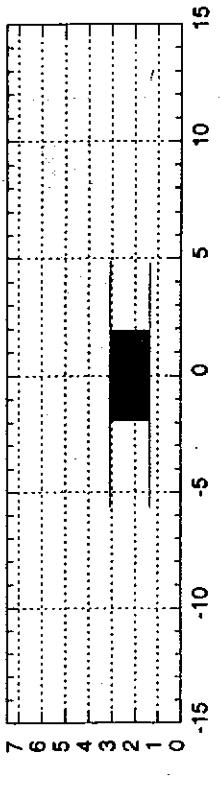
Double coax 2



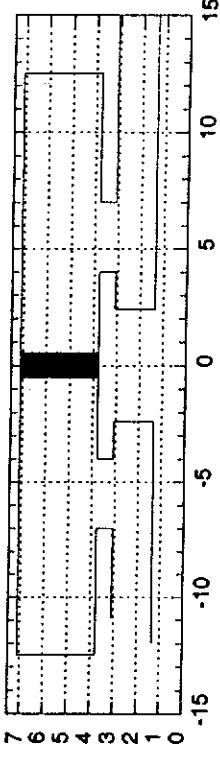
Cylindrical



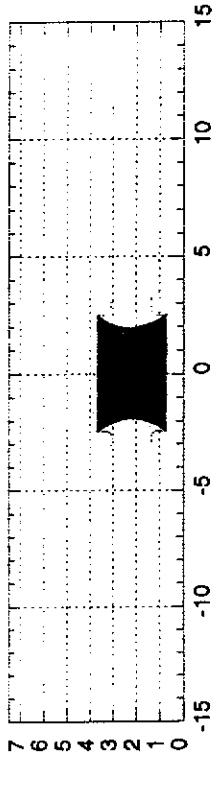
Lambda/2



Double coax 1



Lambda/2 Concave



Travelling wave



Window comparaison

Window comparison

good

bad

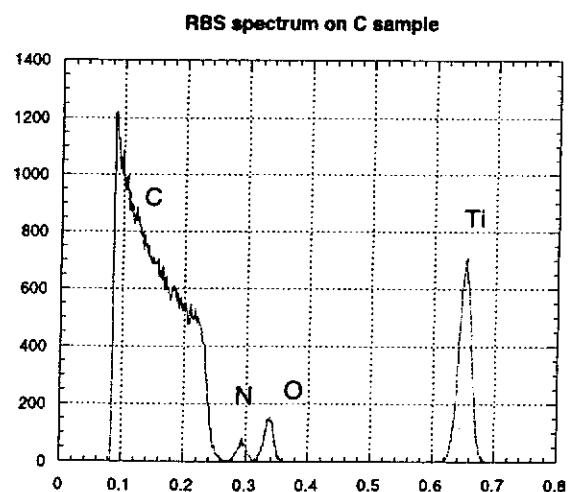
	Conical	Cylindrical	Lambda/2	Concave	TW	Double coax 1	Double coax 2	Stair
Ceramic thickness (mm)	3	4	38,4	38,4	20	10	10	20
Bandwidth (MHz) (S11<0,2)	> 1000	> 1000	31	390	340	120	170	220
Emax/Ecoax Ø60	1,2	3	1	1,6	2,2	2,6	2,4	2,4
Emax brazing/ Ecoax F60	0,4	1,5	1	0,1	0,6	0,2	0,2	0,2
Emax ceramic/ Ecoax F60	1	2,9	1	0,6	0,6	0,2	0,2	0,2
Dielectric power loss /Conical window power loss	1	1,3	13,6	10,2	7,7	1,6	2,4	5,2
Multipactor	--	--	++	+	++	++	++	++
Exposure to electrons	--	++	--	--	--	++	++	+
Impact	--	--	--	--	--	--	--	--
Fabrication (price)	--	--	++	+	+	+	+	++

TiN coating studies

Goal: define fabrication process to obtain a good reproducible coating of known thickness and stoichiometry

Tools:

- Rutherford back scattering analysis
- 4 probe resistivity measurement
- quartz thickness monitor



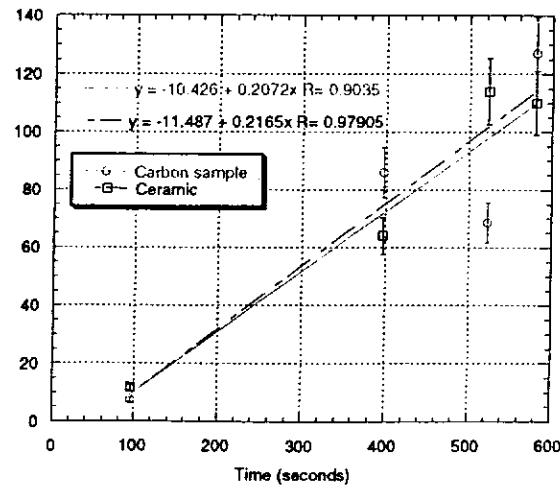
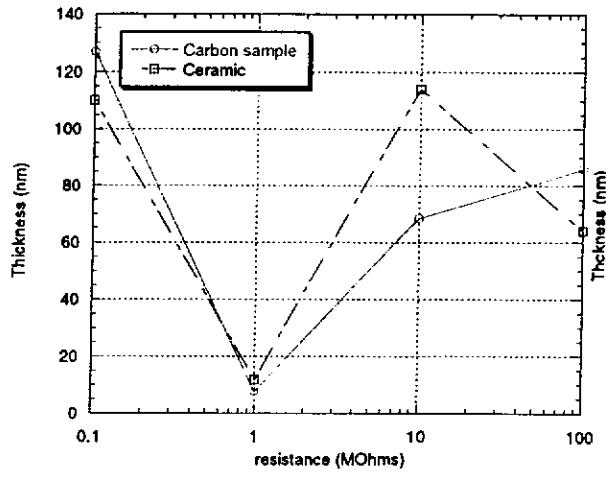
Windows RF studies

RF studies are done with SUPERFISH

- run on a PC
- allow good definition (small mesh size
0.5 mm -> 400 k mesh -> 5 minutes)
- good plotting facilities
- simulation of TW
- FORTRAN codes to calculate SWR,
do automatic matching, calculate bandwidth

Preliminary results

Resistance is not a good parameter to characterize thickness

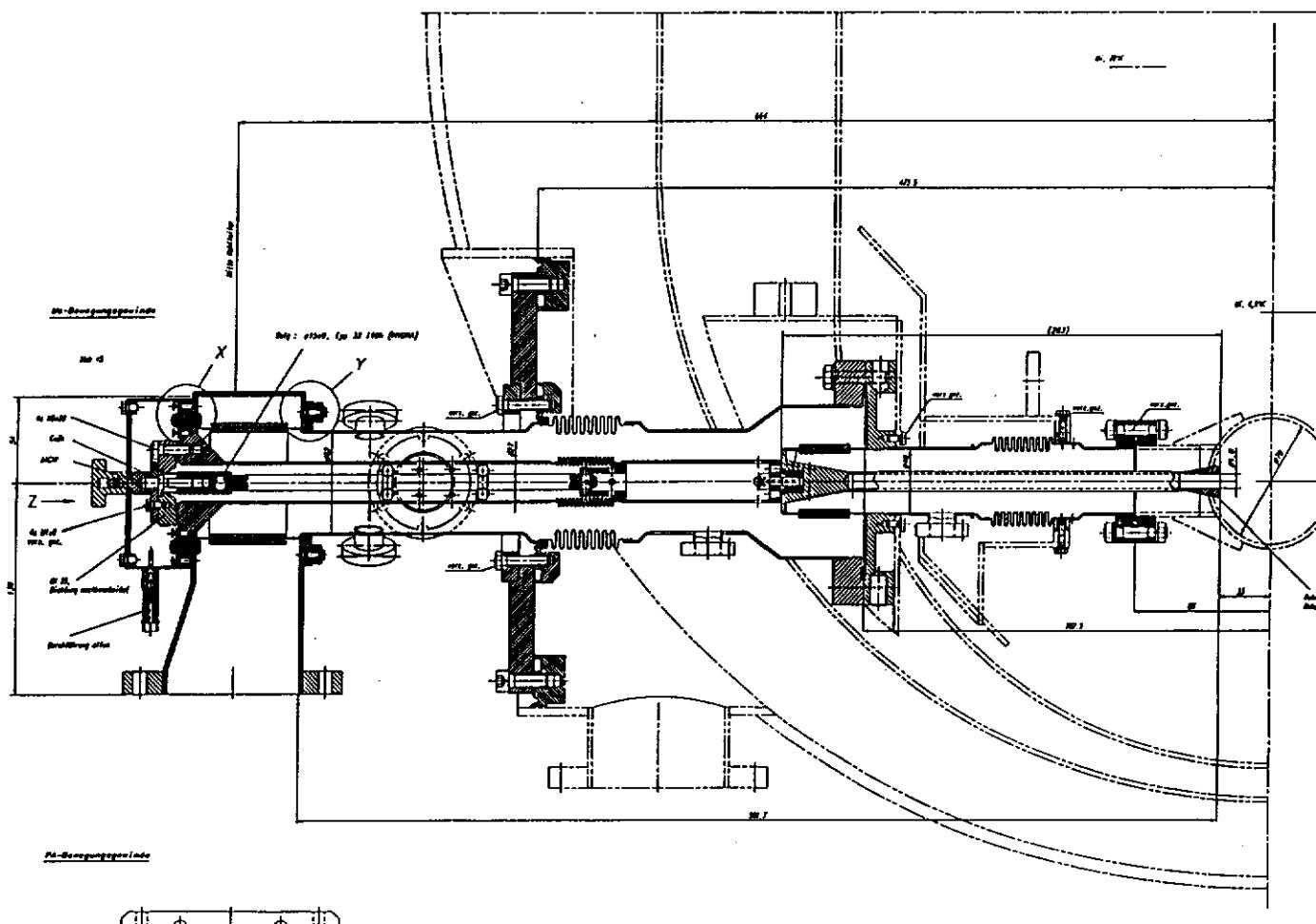
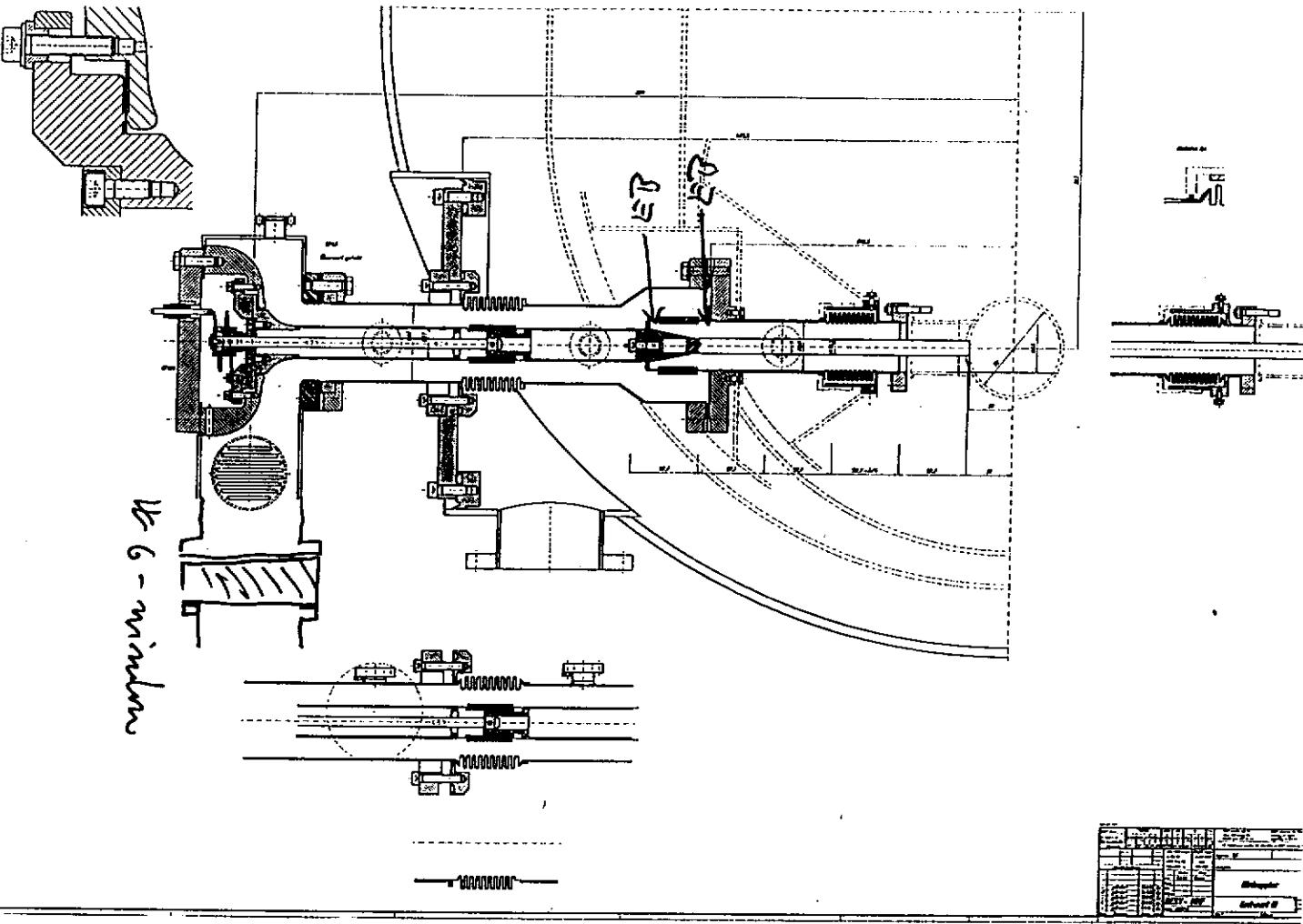


73

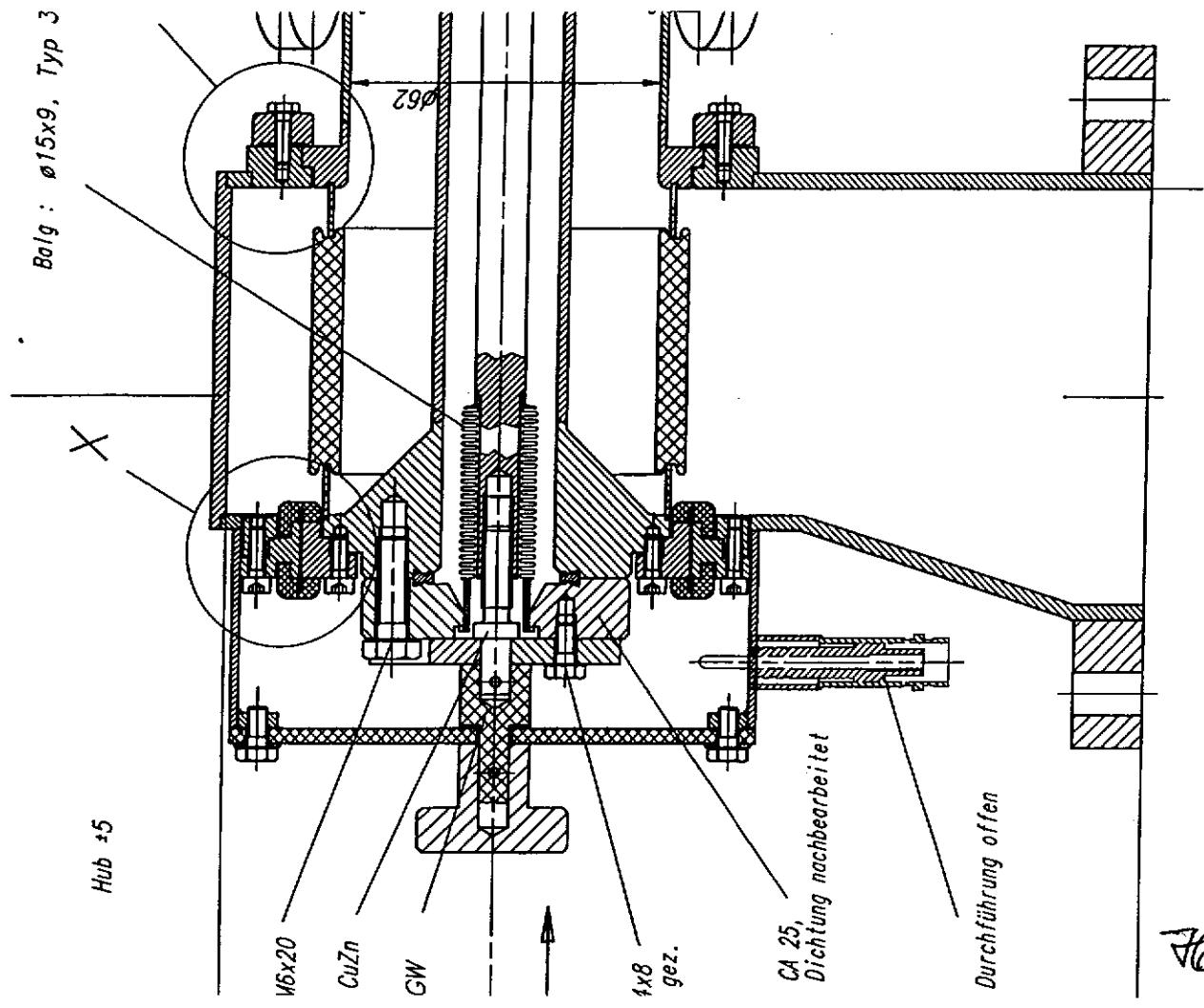
Planning

- march-april:
 - - assembly and test new cryostat
 - - start overall study of prototype coupler
 - - continue TiN coating analysis
- may-june:
 - - test Lambda/2 window
 - - fabrication TW window
- july-october:
 - - continue test windows (TW)
 - - test polarized transition
 - - start fabrication of first coupler prototype
- end of 1998
 - - installation of new modulator (10 Hz)
- beginning of 1999
 - - test first prototype coupler

D. Proch- Status of Couplers TTF III



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Advantages of the RWG coupler in compare with the Coaxial one:

1. RWG coupler allows higher value of the input power:

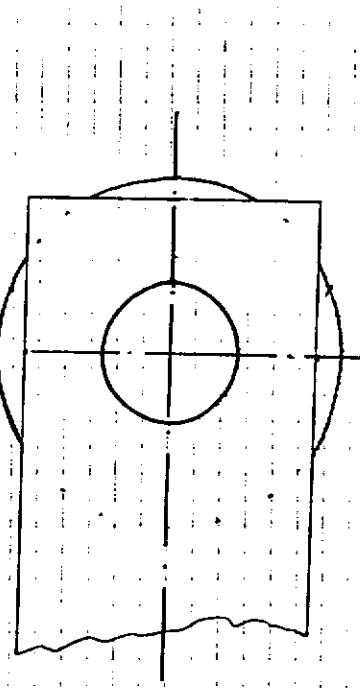
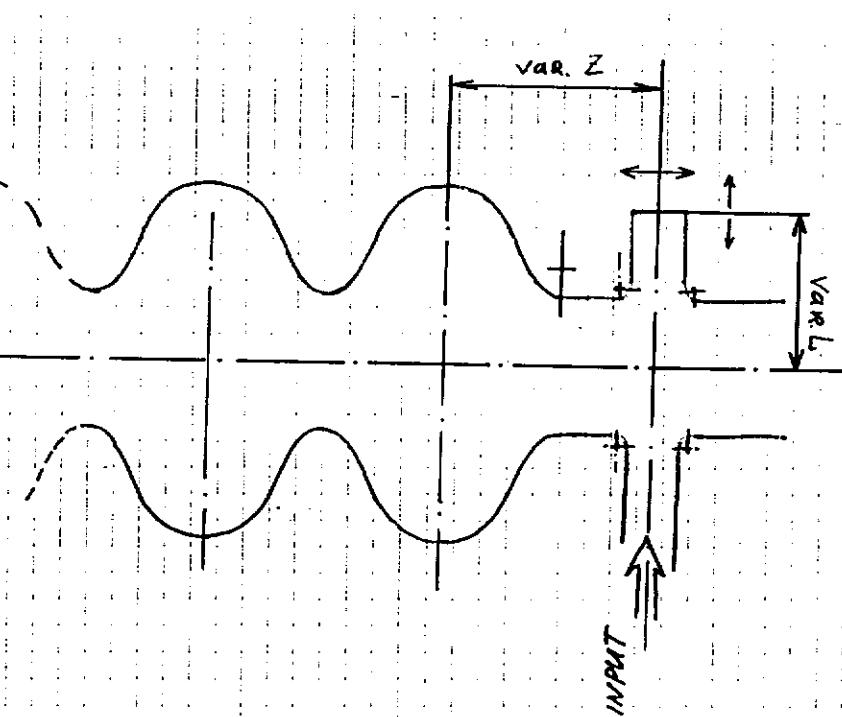
- 1.a. The surface field strength in RWG will be less than in Coaxial.
- 1.b. RWG has less problems with multipacting.

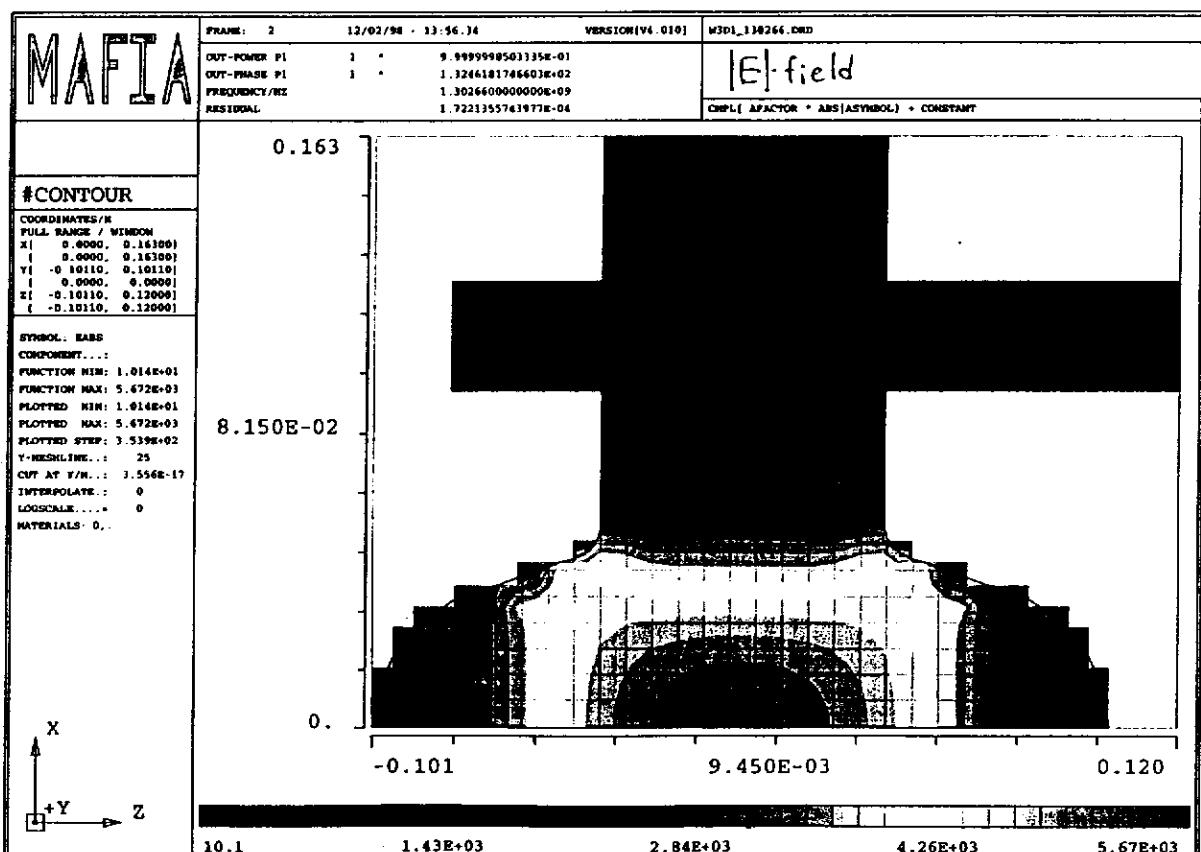
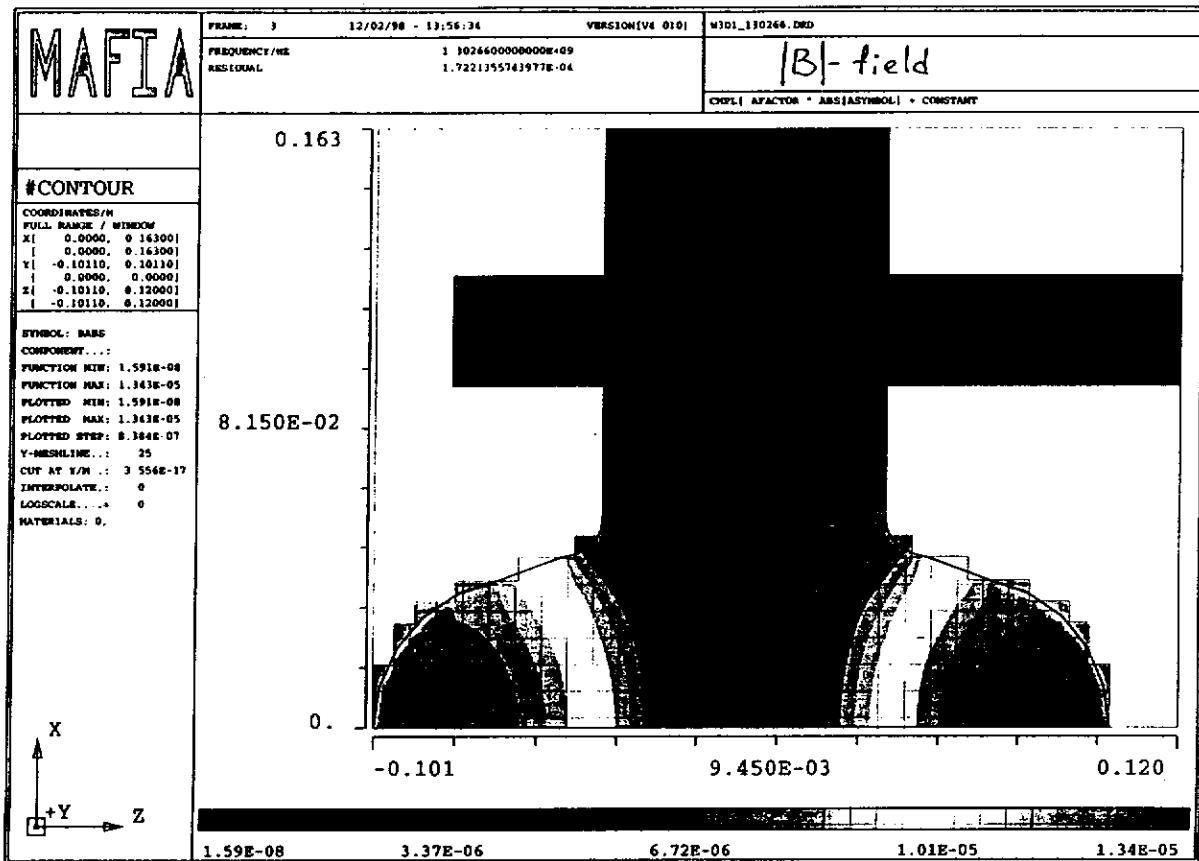
47

2. The costs of a new coupler can be less:

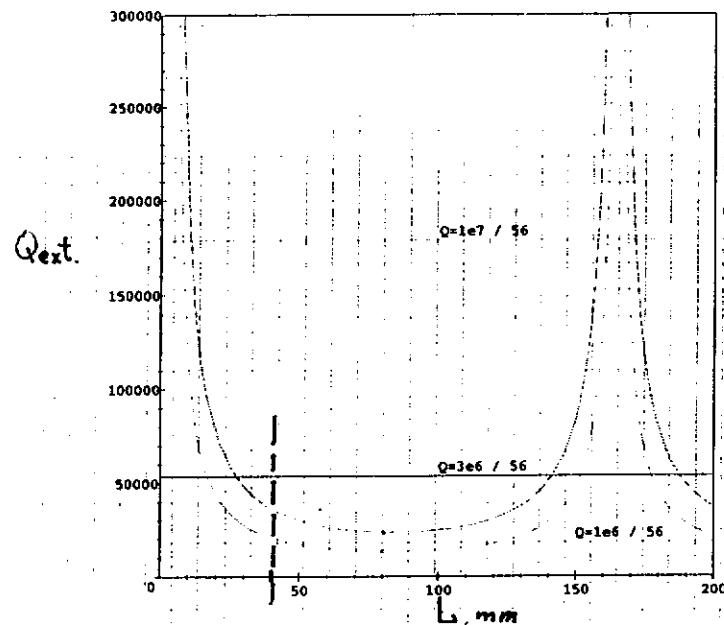
- 2.a. RF vacuum windows for RWG are easier to make.

- 2.b.? Design of tuners can be less complicated?





$$Q_{ext} \sim \frac{1}{|\sin(k\ell + \varphi_0)|}$$



Page 1

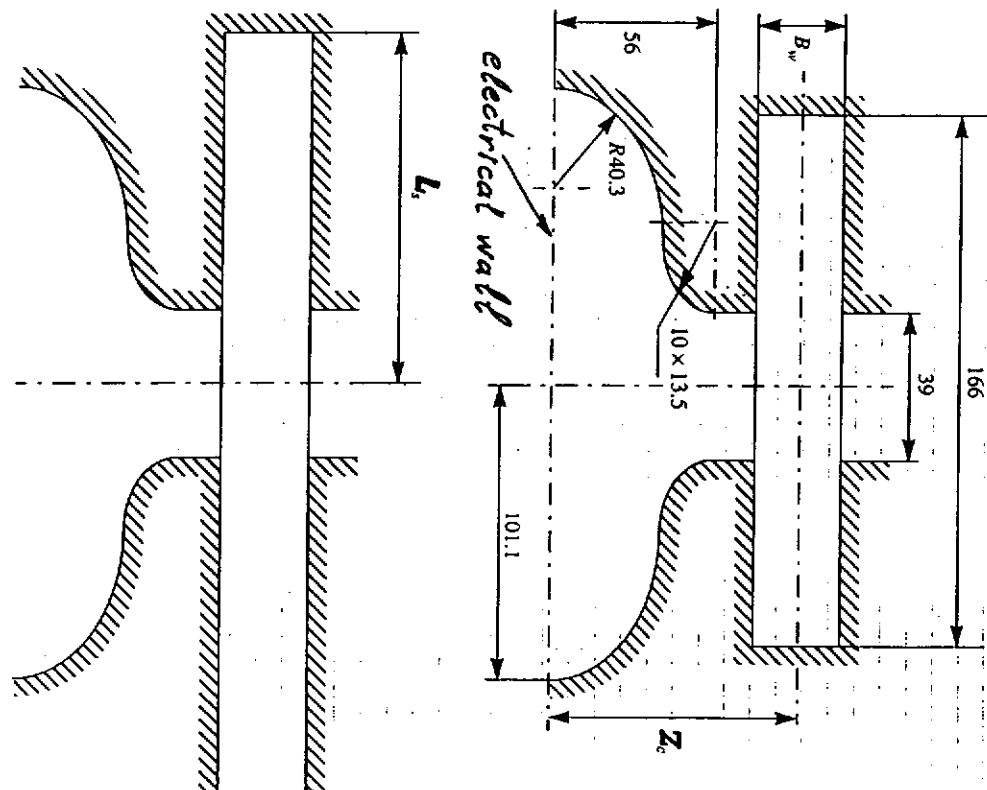
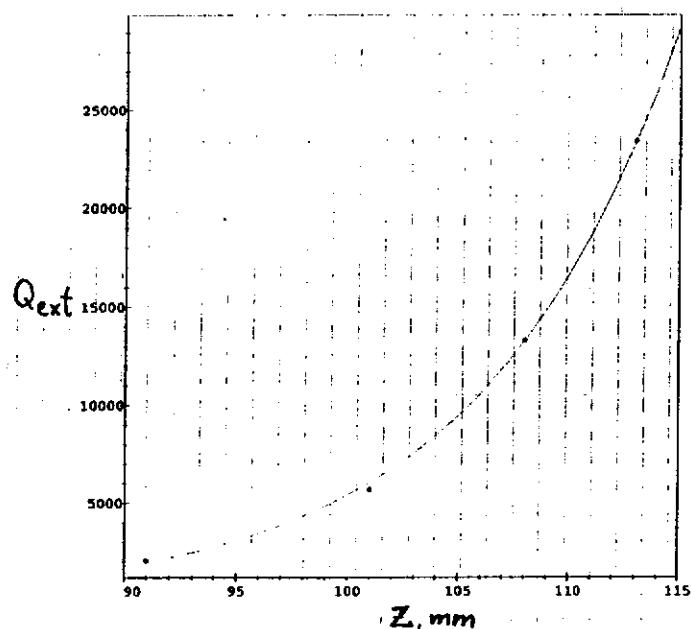


Table 1:

Z_c	B_w	L_s	Q_{ext}
108	30	160.29	$1.68 \cdot 10^5$
108	30	80.145	$1.33 \cdot 10^4$
113	30	57.65	$3.66 \cdot 10^4$
113	30	80.145	$2.34 \cdot 10^4$
113	30	160.29	$2.96 \cdot 10^5$
101	30	82.74775	$5.68 \cdot 10^3$
91	30	82.74775	$2.06 \cdot 10^3$



Measurement of A Super-Structure

J. Sekutowicz, M. Ferrario, Ch. Tang*

(10/3/98)

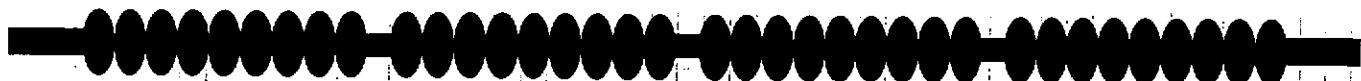
4 TTF Copper Cavities:

Cavity #1

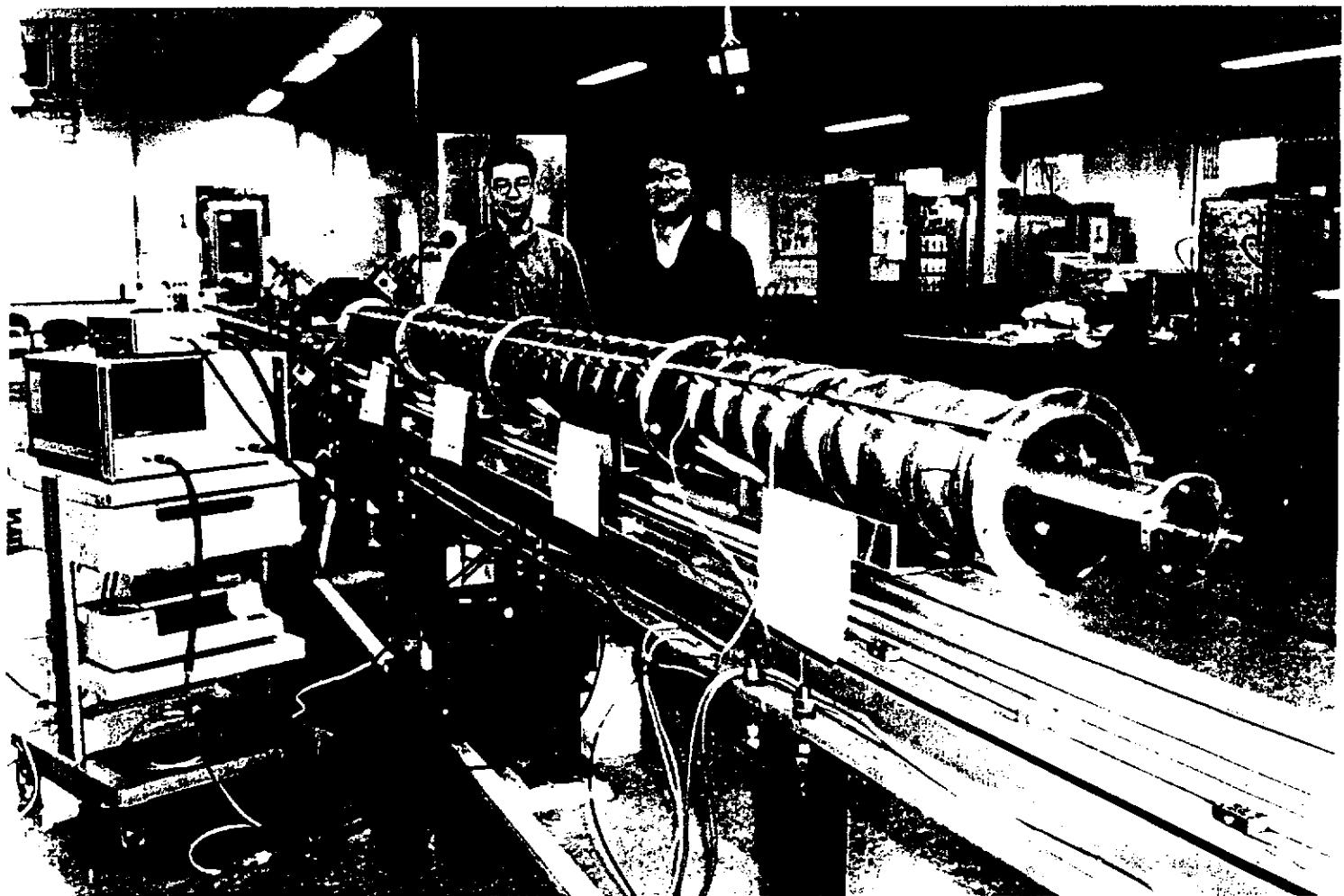
Cavity #2

Cavity #3

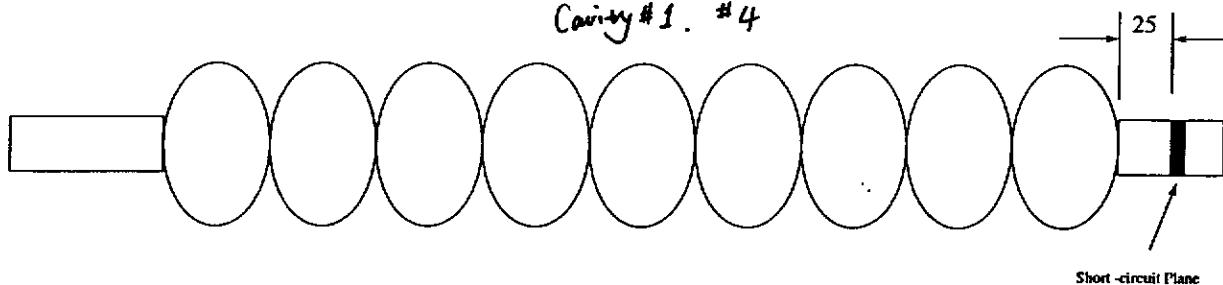
Cavity #4



- Tuning : Field Flatness $\geq 95\%$
- Steady State Properties, Field Profiles
Dispersion Property
- Transient Responses .

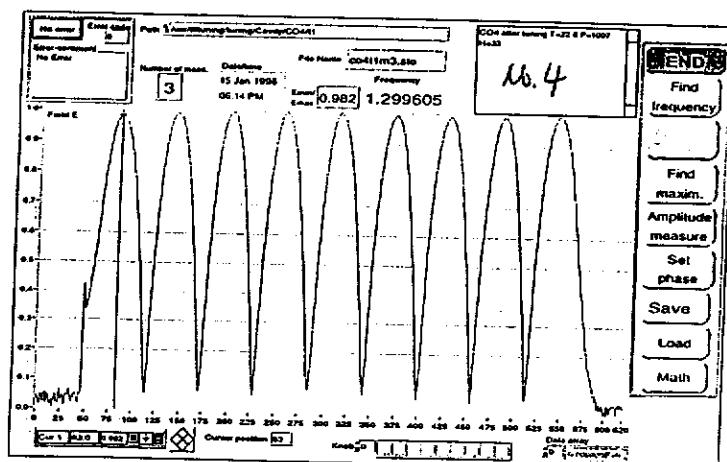
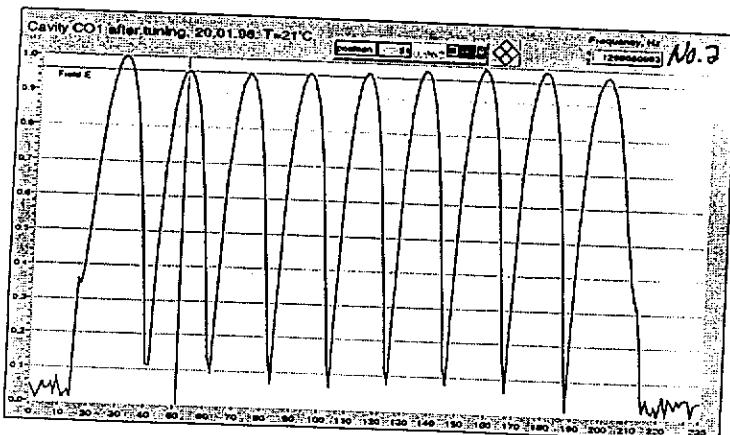
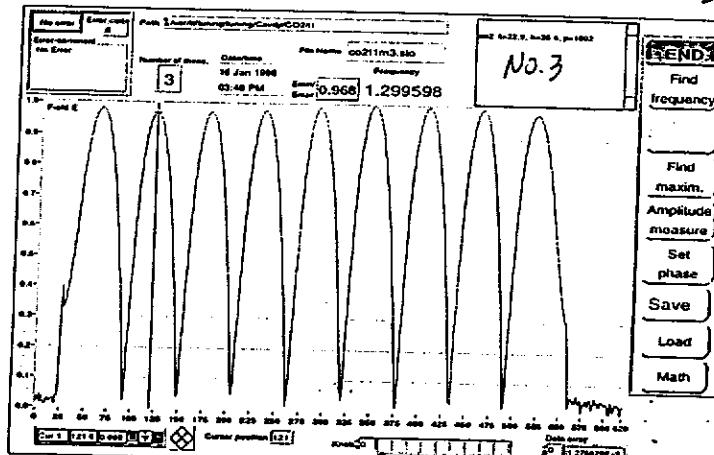
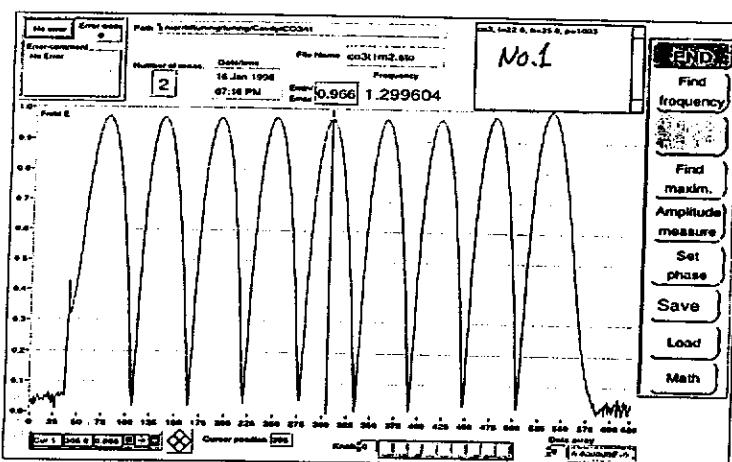
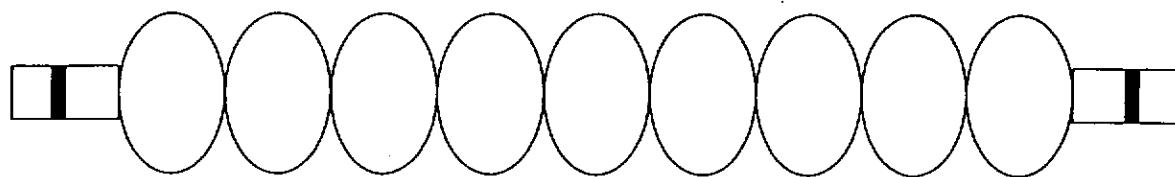


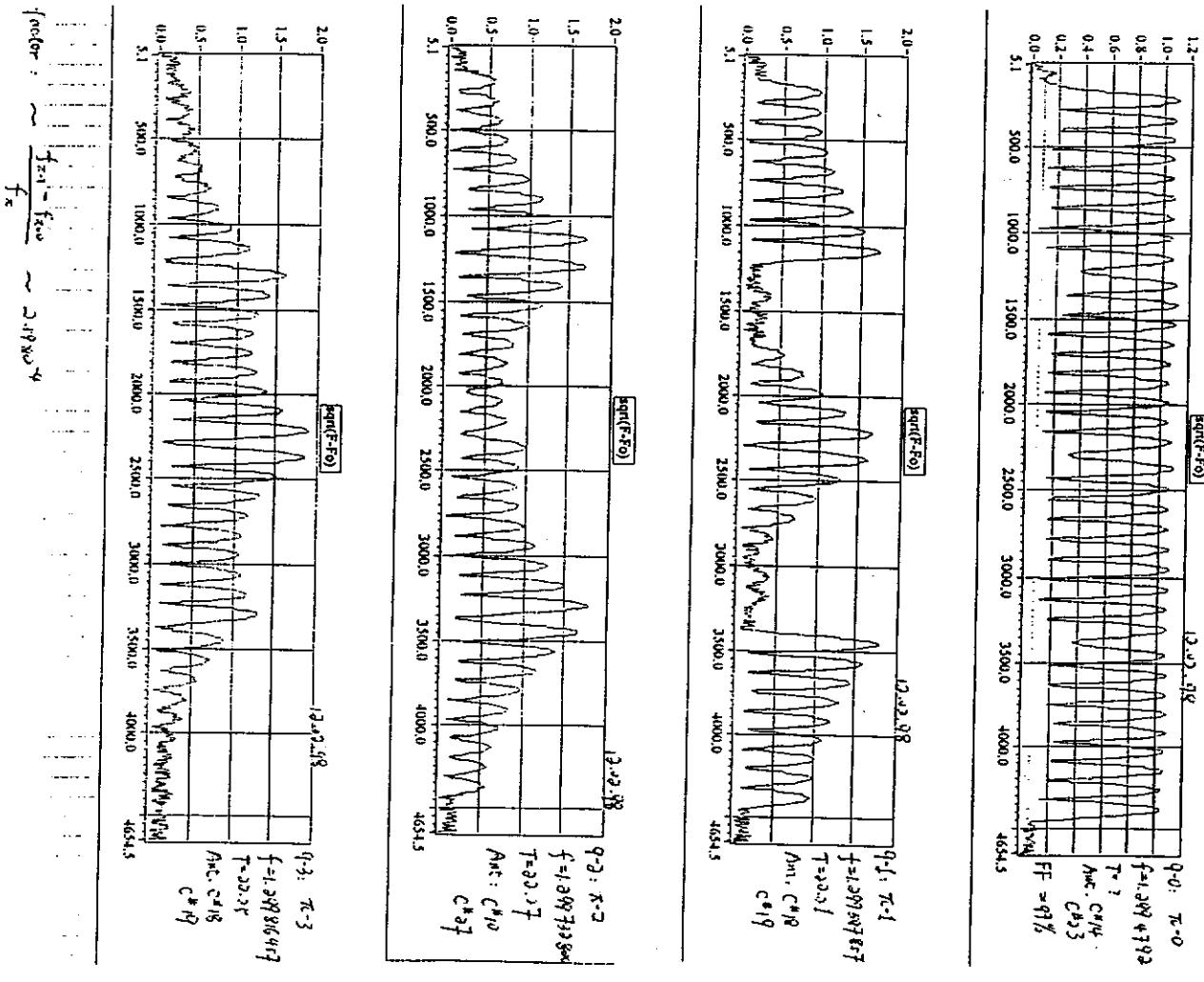
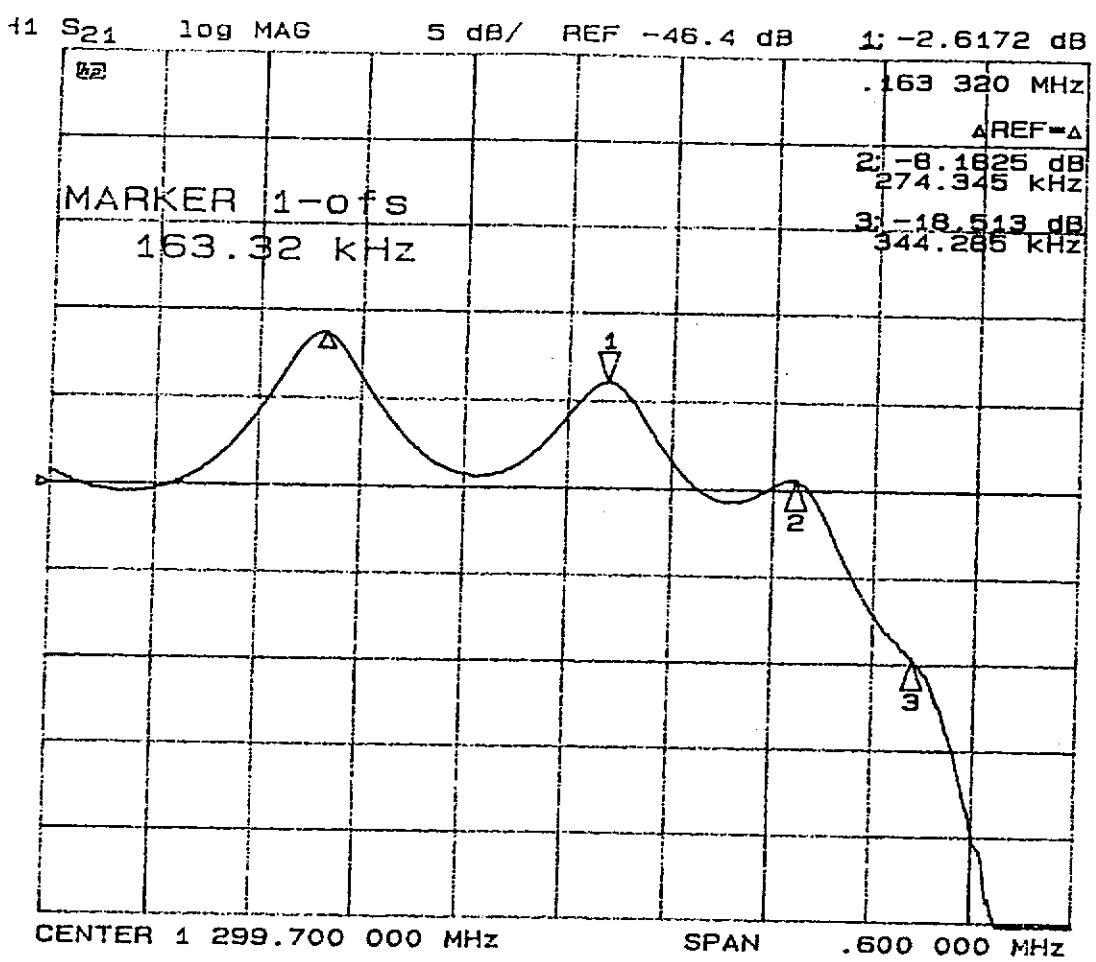
Cavity #1, #4



Short-circuit Plane

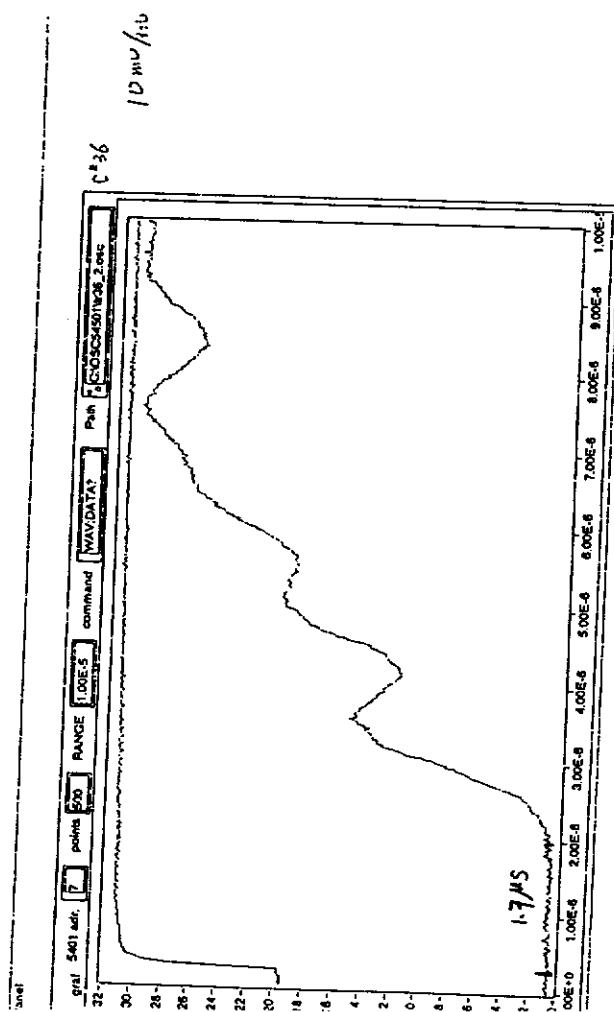
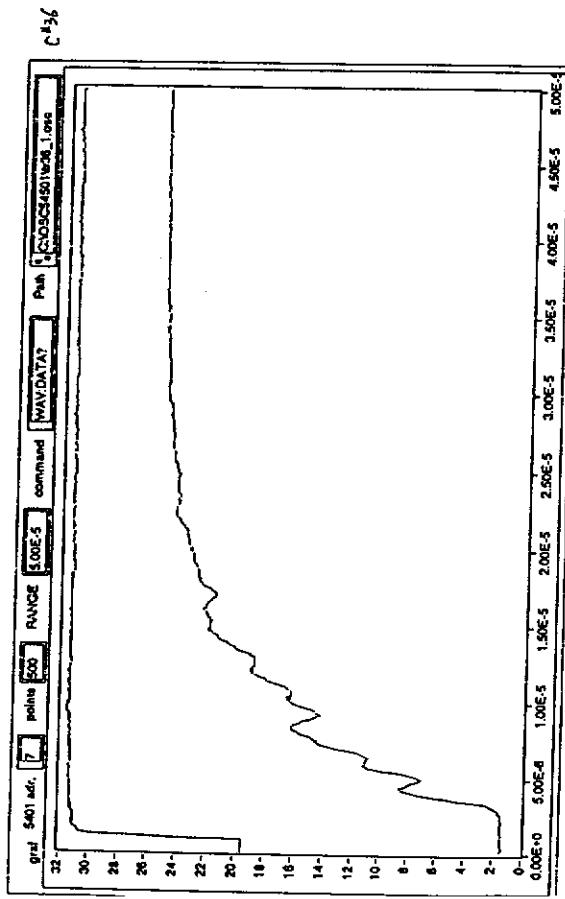
Cavity #2, #3





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6



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NORMAL MODES EXPANSION

- TM_{01m} LONGITUDINAL MODES

$$\begin{aligned}\vec{E}(\vec{r}, t) &= \sum_m \alpha_m(t) \hat{e}_m(\vec{r}) \sin(\omega_m t + \phi_m(t)) \\ &= \sum_m \left(d_m(t) \hat{e}_m(\vec{r}) e^{i\omega_m t} + d_m^*(t) \hat{e}_m^*(\vec{r}) e^{-i\omega_m t} \right)\end{aligned}$$

J. SEKUTOWICZ, M. FERRARIO, C. TANG
 DESY INFN
 HIF LWF

COMPUTATIONS AND MEASUREMENTS OF TRANSIENTS IN A SUPERSTRUCTURE PRE-PROTOTYPE

- COMPLEX AMPLITUDE:

$$d_m(t) = \frac{\alpha_m(t)}{2} e^{i\phi_m(t)}$$

- EIGENFUNCTION: \Rightarrow (SEKUTOWICZ \Rightarrow FINITE ELEMENT - CODE)

$$\begin{cases} \nabla^2 \hat{e}_m(\vec{r}) + \kappa_m^2 \hat{e}_m(\vec{r}) = 0 \\ \nabla \cdot \hat{e}_m(\vec{r}) = 0 \quad \text{on } V \\ n \times \hat{e}_m(\vec{r}) = 0 \quad \text{on } S \end{cases}$$

- ORTHOGONALITY CONDITIONS:

$$\int_V \hat{e}_k \cdot \hat{e}_m^* = \delta_{km}$$

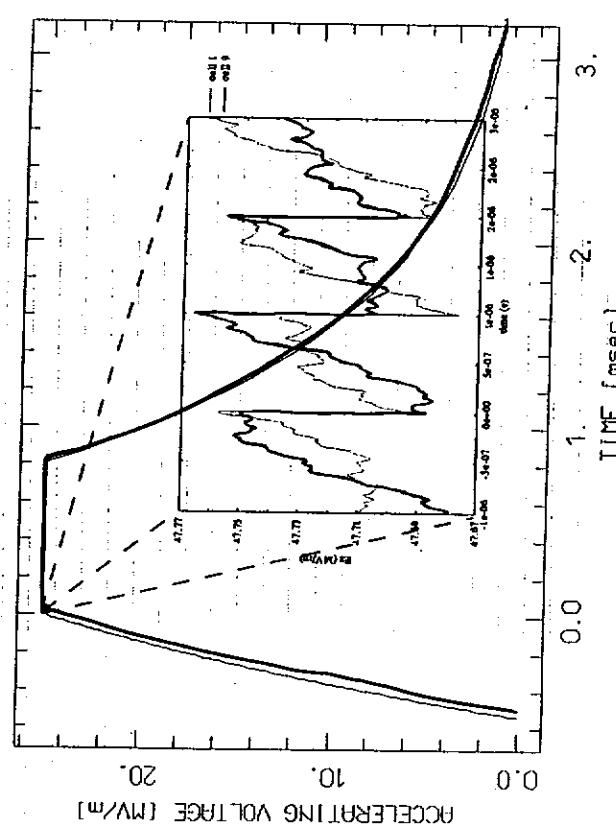
- S.V.E.A. APPROXIMATION:

$$\partial \ll \omega_m \Delta \quad \Rightarrow \quad \partial \ll \omega_m^2 \Delta_m$$

- I ORDER EQUATION:

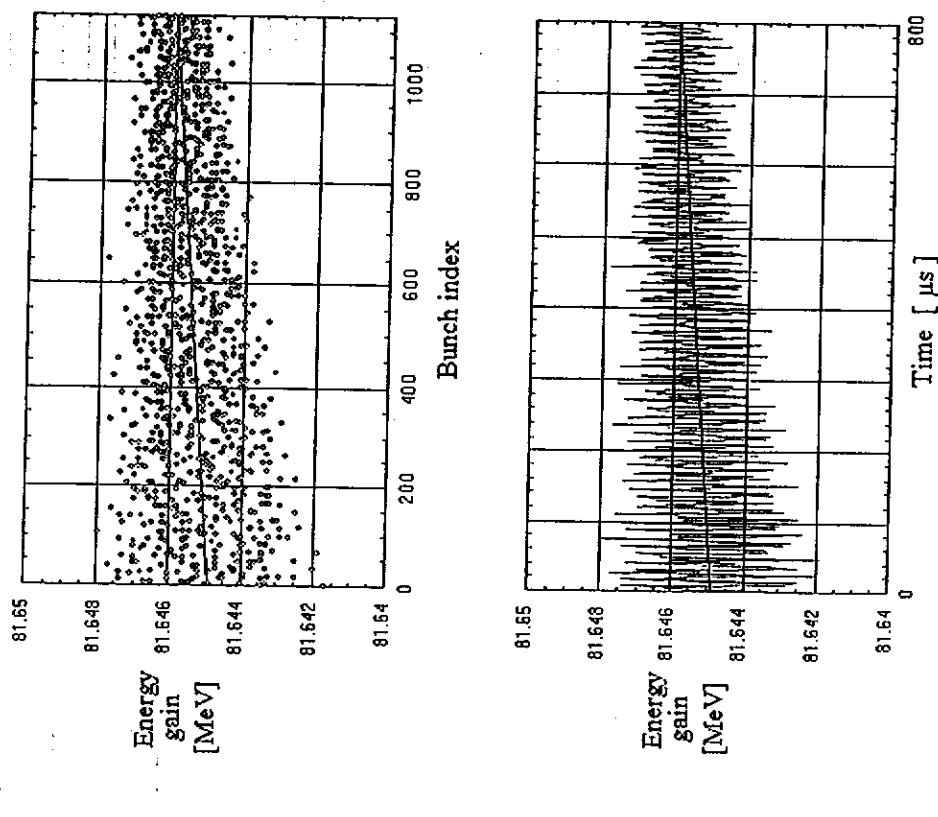
$$\partial_t + \frac{\omega_m}{2} (1 + \frac{1}{1 + \frac{\partial}{\omega_m \Delta}}) \Delta_m = \frac{1}{1 + \frac{\partial}{\omega_m \Delta}} \frac{\partial}{\omega_m \Delta} \Delta_m$$

CAVITY REFILLING



86

Energy gain of 1130 bunches accelerated by the small iris superstructure ($N=7, N_s=4$) as computed by HOMDYN:



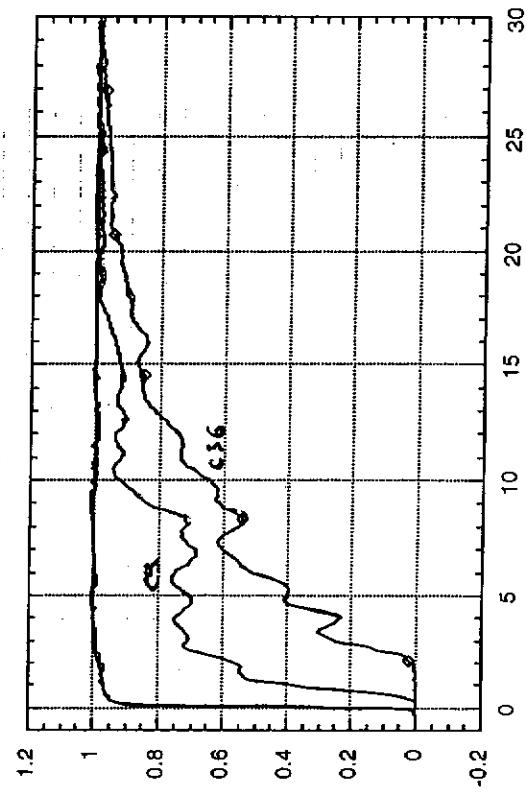
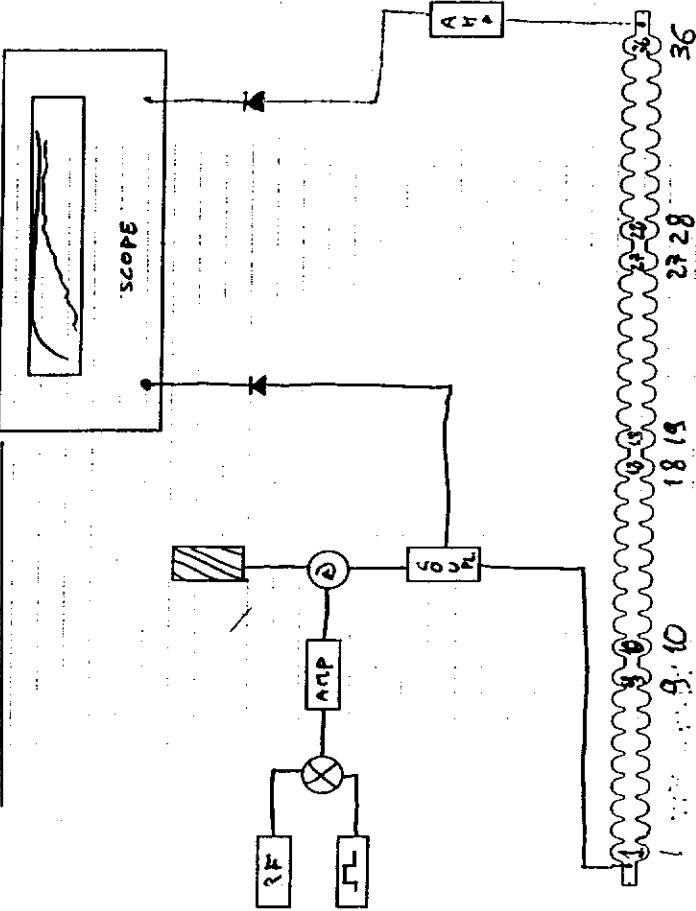
The oscillation seen on the diagram has the frequency:

$$80 \text{ kHz} = f_{\pi/4} - f_{\pi/0}$$

$$\frac{\Delta\omega}{\omega} = 2 \cdot 10^{-5}$$

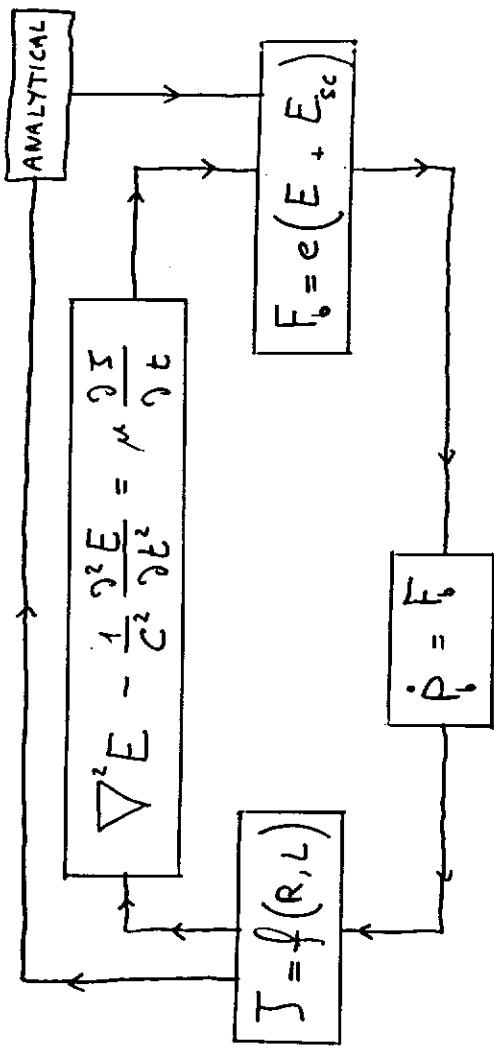
(3)

TRANSIENTS MEASUREMENT ON A PRE-PROTOTYPE



~ SELF CONSISTENT MODEL

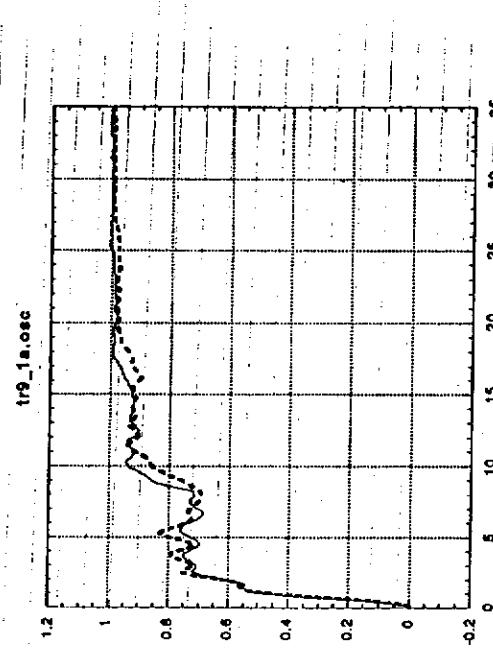
LONG TERM (MULTI BUNCH) BEAM-CAVITY INTERACTION



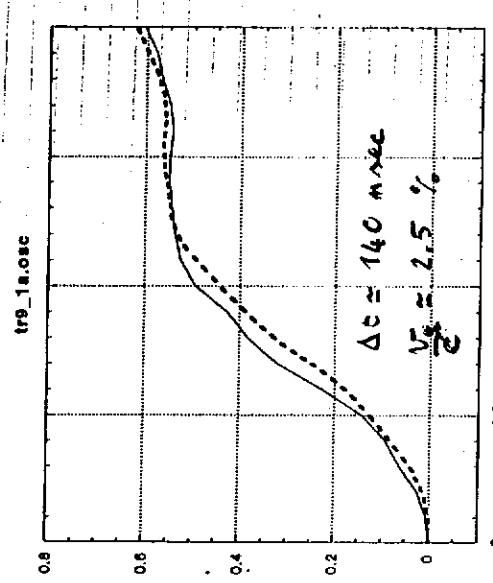
- NORMAL MODE EXPANSION OF CAVITY FIELD
- CURRENT DENSITY DESCRIPTION OF BUNCHES (UNIFORM CHARGED CYLINDER) J_b
- ANALYTICAL COMPUTATION OF SPACE CHARGE FIELD
- $J = J_b + \int_{\text{bunch}} (1 - e^{-t/t_b})$

• ANALYTICAL COMPUTATION OF FIELDS FROM BUNCH TC BUNCH

CELL N° 9

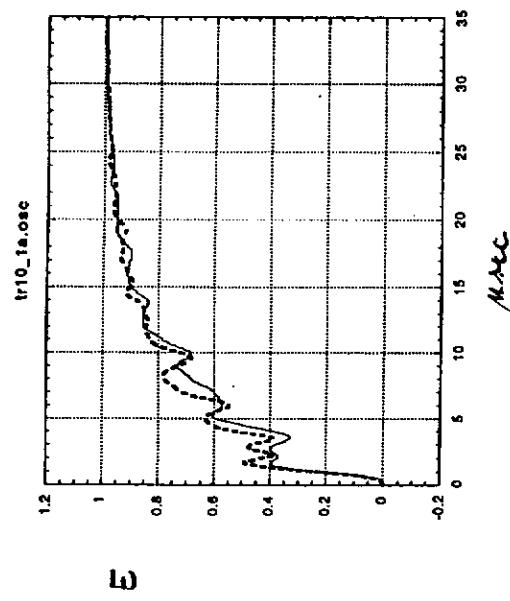
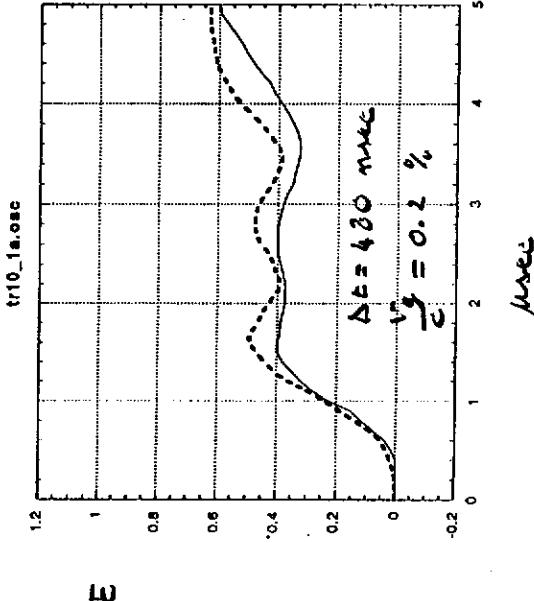


COMPUTED
MEASURED

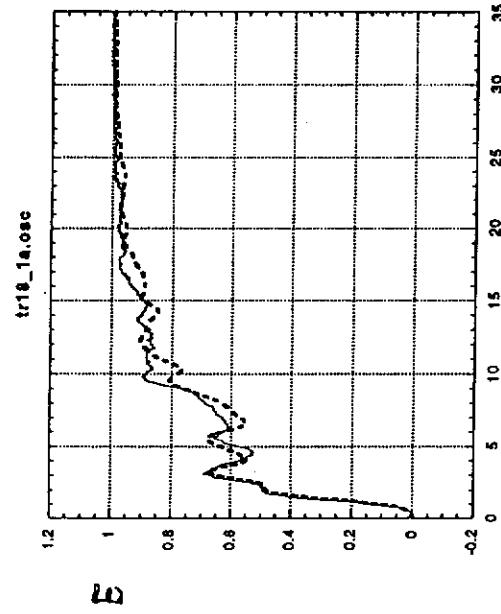


(2)

CELL N° 10

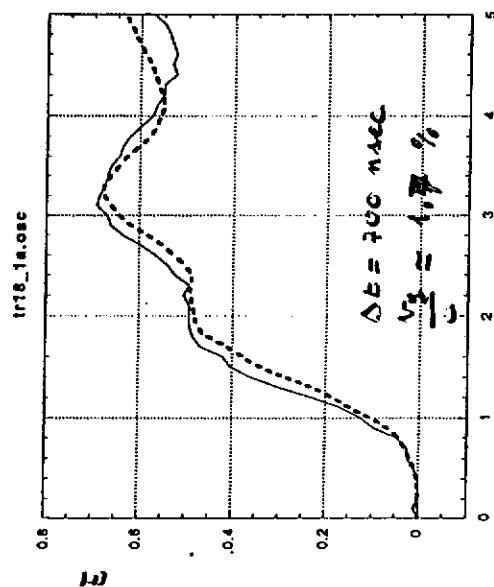
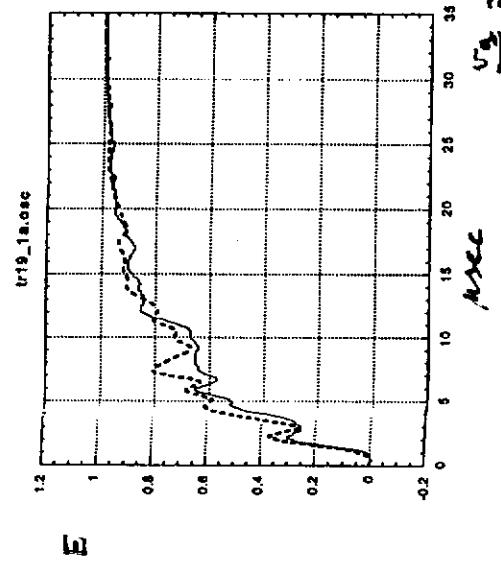
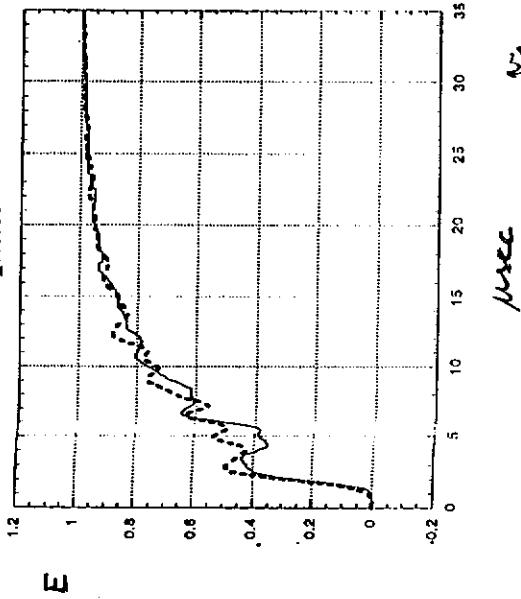
COMPUTEDMEASURED

(8)

$\triangle ELL \text{ No } 18$ 

μsec

89

 $\triangle ELL \text{ No } 19$  $\frac{v_3}{c} \approx 0.2 \%$ $\triangle ELL \text{ No } 27$ 

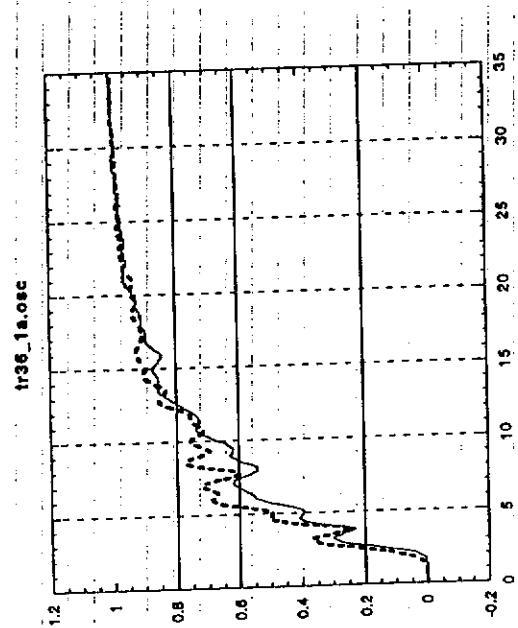
μsec

μsec

 $\frac{v_3}{c} \approx 1.5 \%$

(17)

CELL 36

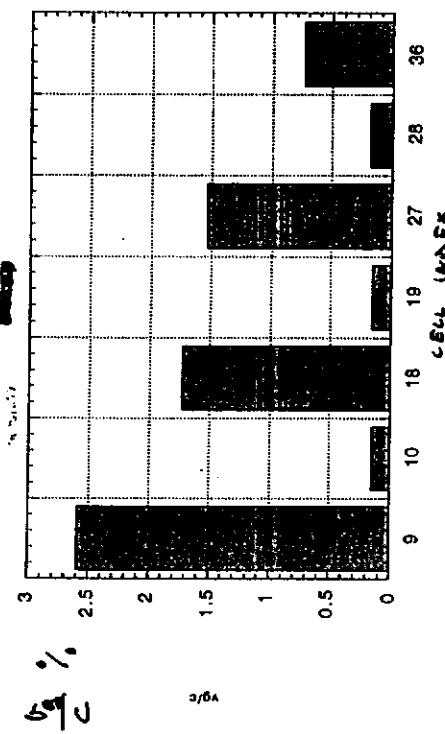


51

90

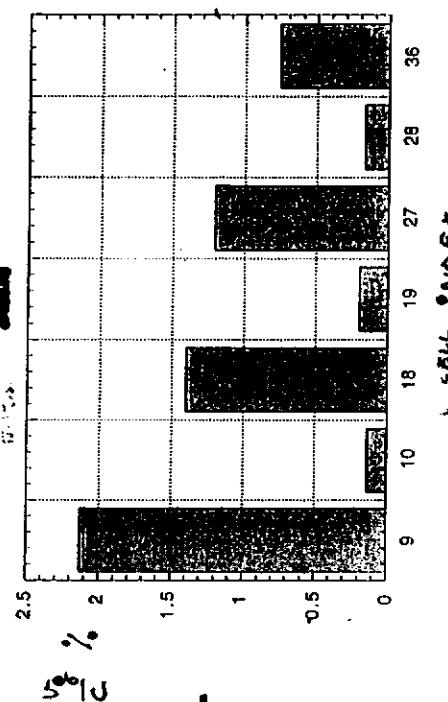
v/gc

MEASURED



v/gc

COMPUTED



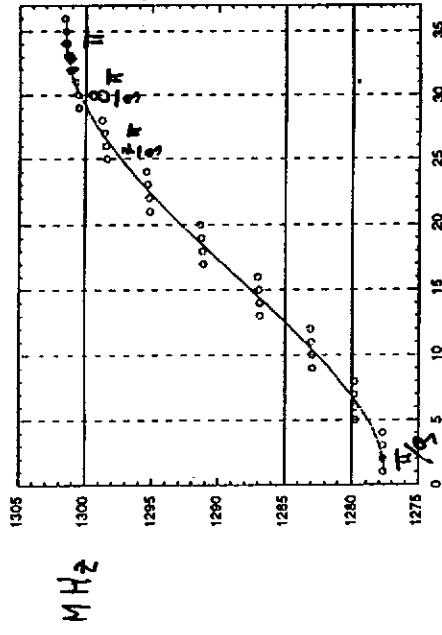
1. CELL PHASE

(12)

$$\frac{v_3}{c} = 0.7 \%$$

(11)

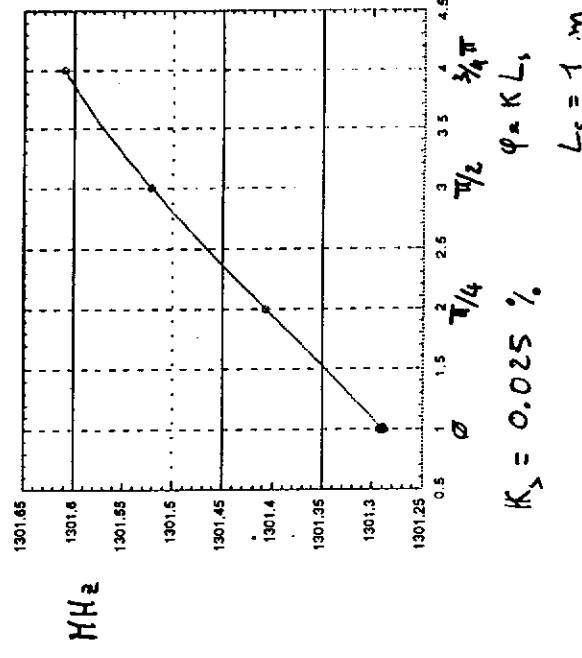
$$\omega_\varphi = \omega_0 \left(1 + \frac{K}{2} (1 - \cos \varphi) \right)$$



$$K_c = \frac{2(\omega_\pi - \omega_0)}{\omega_\pi + \omega_0} = 1.8\%$$

$$\varphi = K L_c$$

$$L_c = 0.445 \text{ m}$$

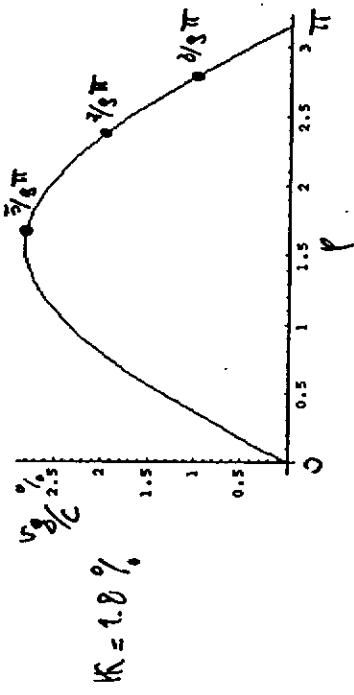
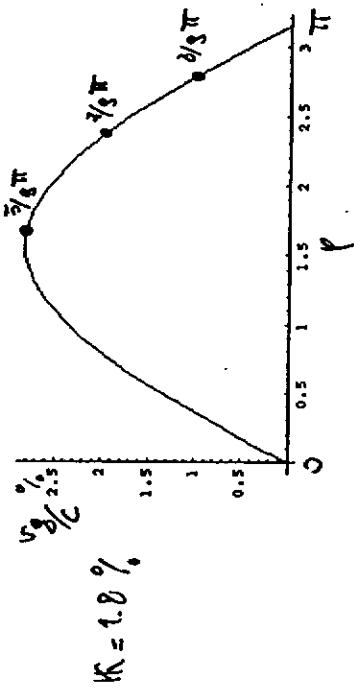


$$K_c = 0.025\%$$

$$\varphi = K L_s$$

$$L_s = 1 \text{ m}$$

GROUP VELOCITY



$$v_g = \frac{d\omega_\varphi}{d\kappa} = \omega_0 \frac{K}{2} L \sin \kappa L$$

$$\kappa = \kappa_c, L_s$$

(14)

(13)

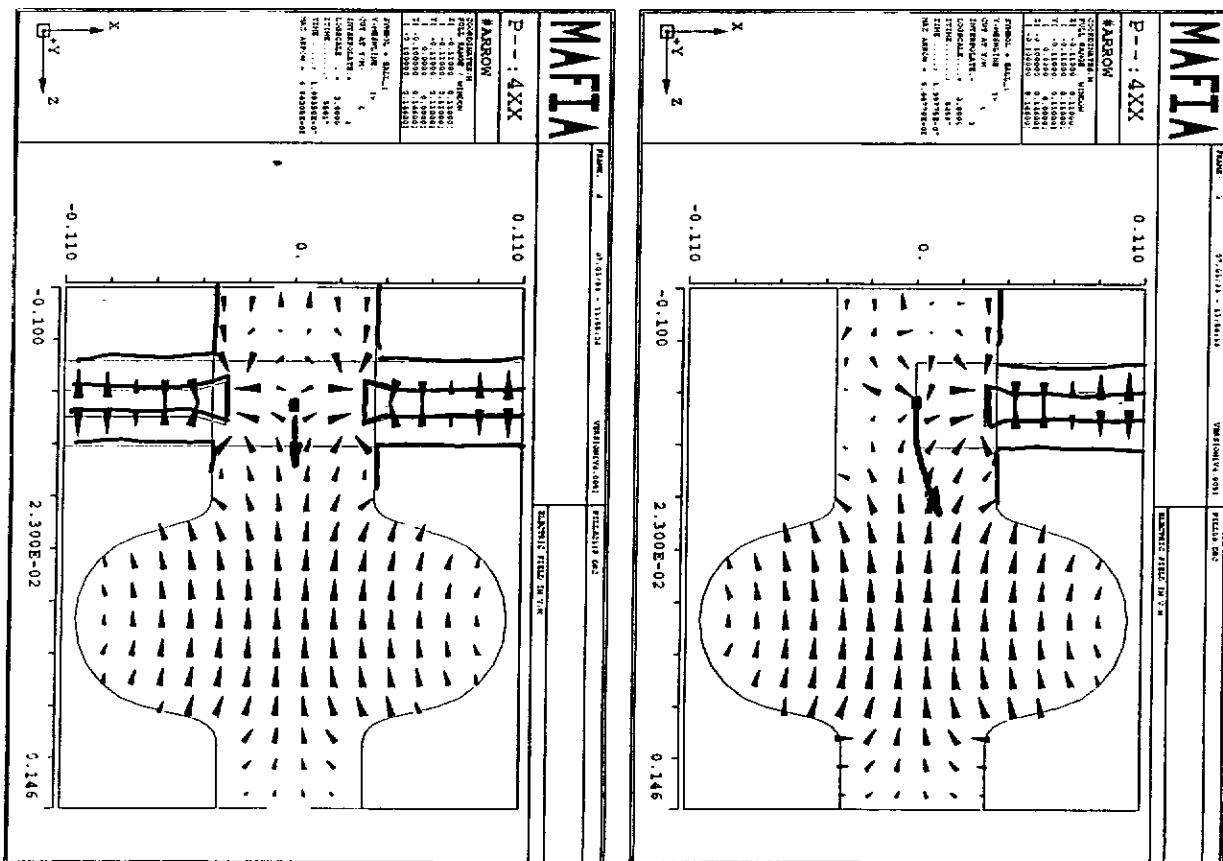
91

How strong the transverse kick due to the power coupler?

M. Zhang -MPY- and C.-X. Tang -MHF-SL-

TTF Meeting, March 9-11, 1998 DESY

- The kick
- Beam direction matters
- Why not symmetrical coupler ?
- W_t of the coupler as a reference

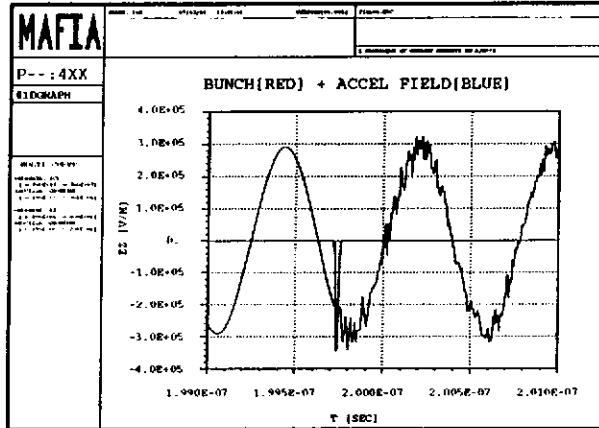
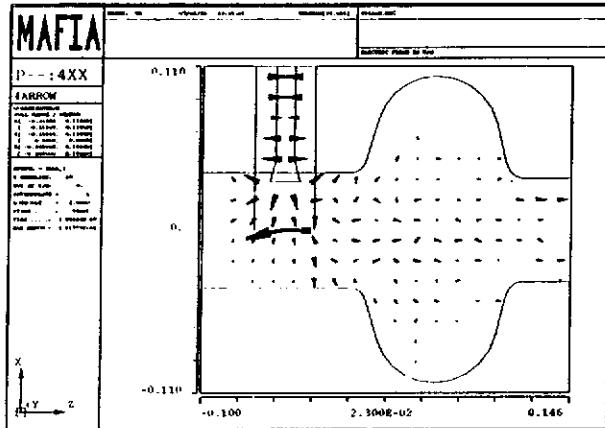
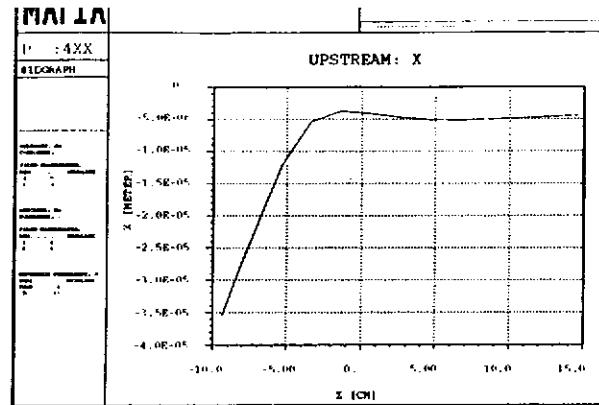
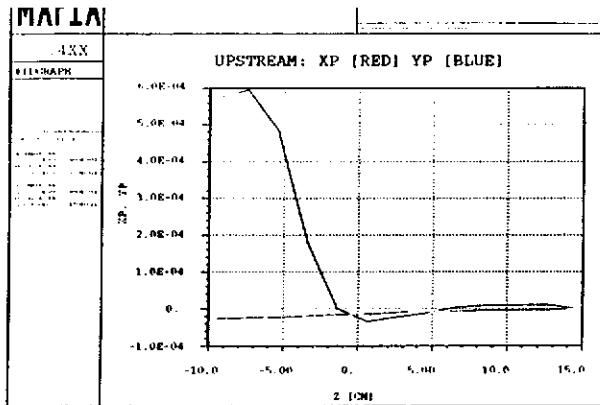


The Transverse Kick

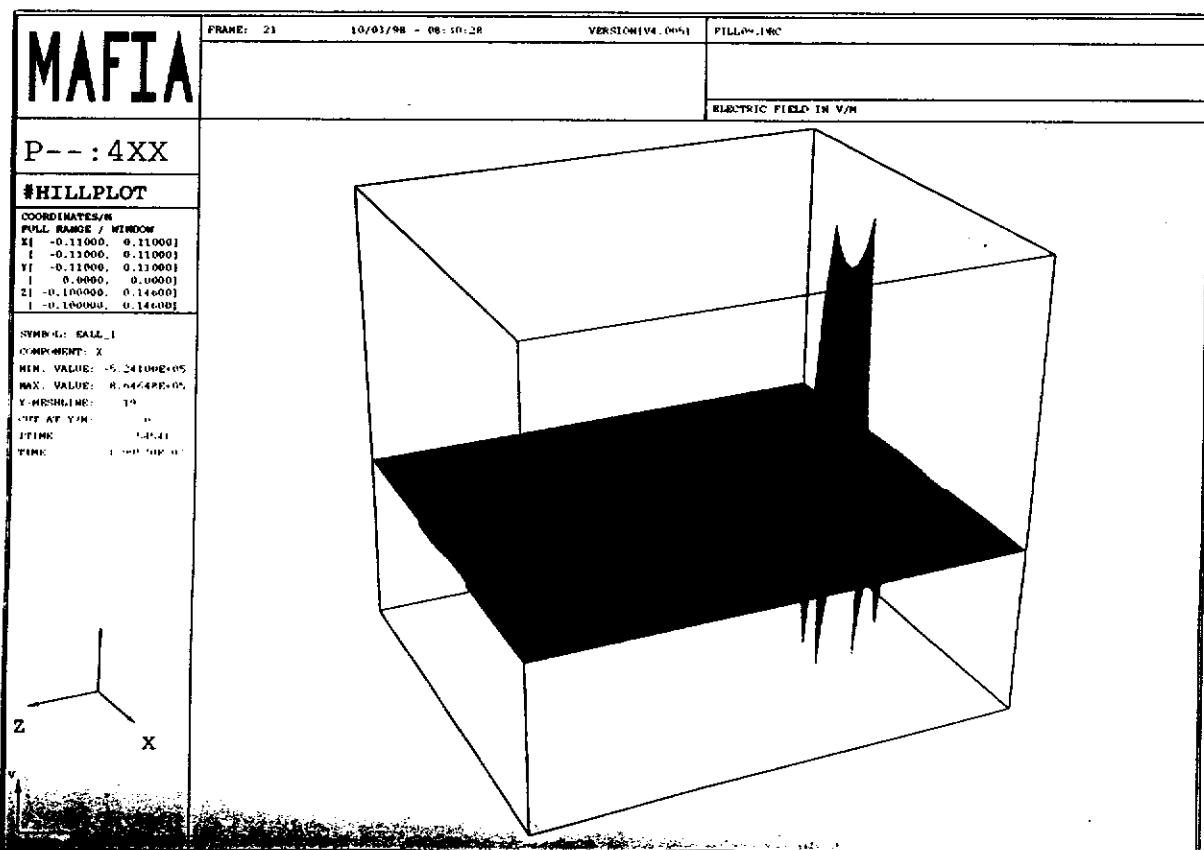
- Kick_{coupler-rf} is equivalent to the kick experienced by a 1nC $\sigma_s = 1\text{mm}$ bunch traversing the TESLA 9cell cavity with a *1.2cm* off-axis due to wakefield
- This number depends only on the cavity Q_{ext}
- The higher the Q_{ext}, the smaller the kick_{coupler-rf} (when E_{acc} fixed)

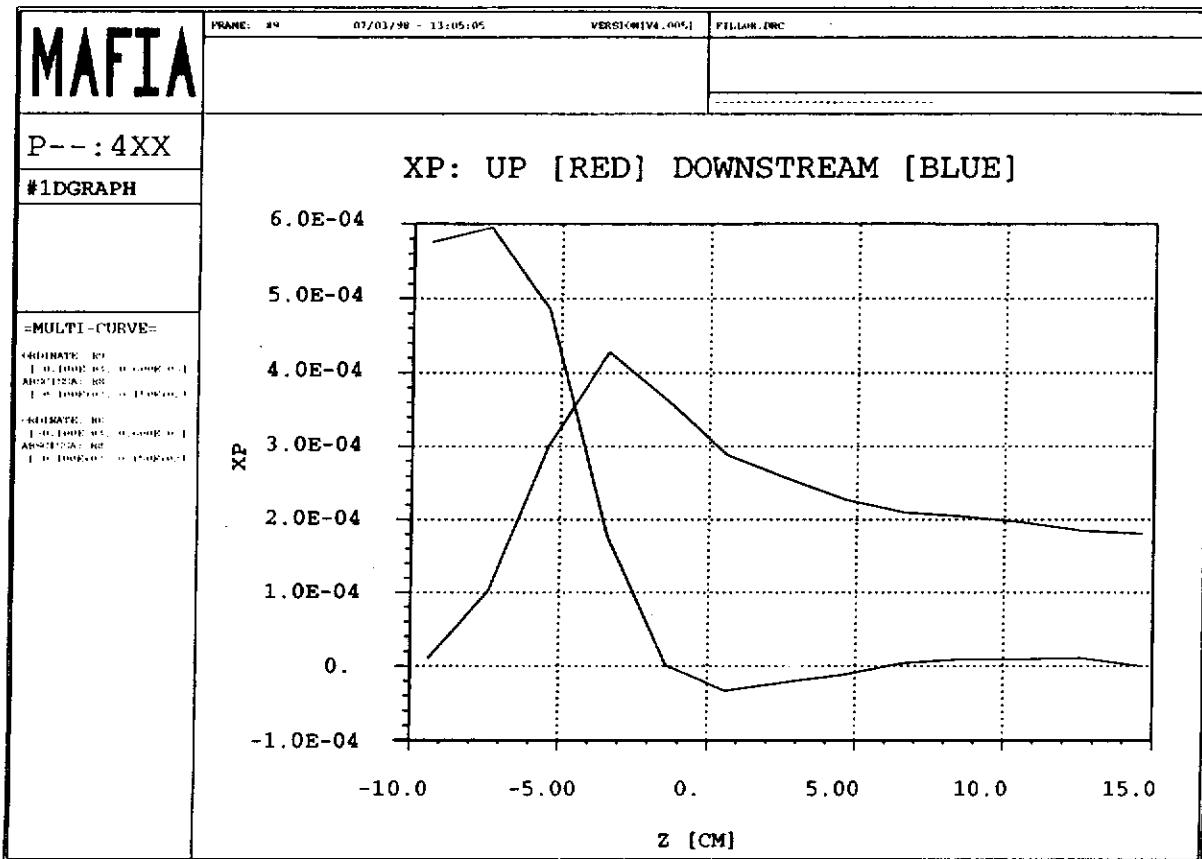
Beam Direction Matters

- Upstream the Poynting vector shows 2-3 times larger kick_{coupler-rf} than downstream
 - Upstream:
 - $P_{xu} = 5.8 \times 10^{-4}$
 - Downstream:
 - P_{xd1} (w/o cavity) = 3.1×10^{-4} , $P_{xu}/P_{xd1} = \underline{1.87}$
 - P_{xd2} (w/ cavity) = 1.9×10^{-4} , $P_{xu}/P_{xd2} = \underline{3.05}$
- This is confirmed by analytical expressions
- **Better to choose downstream direction**

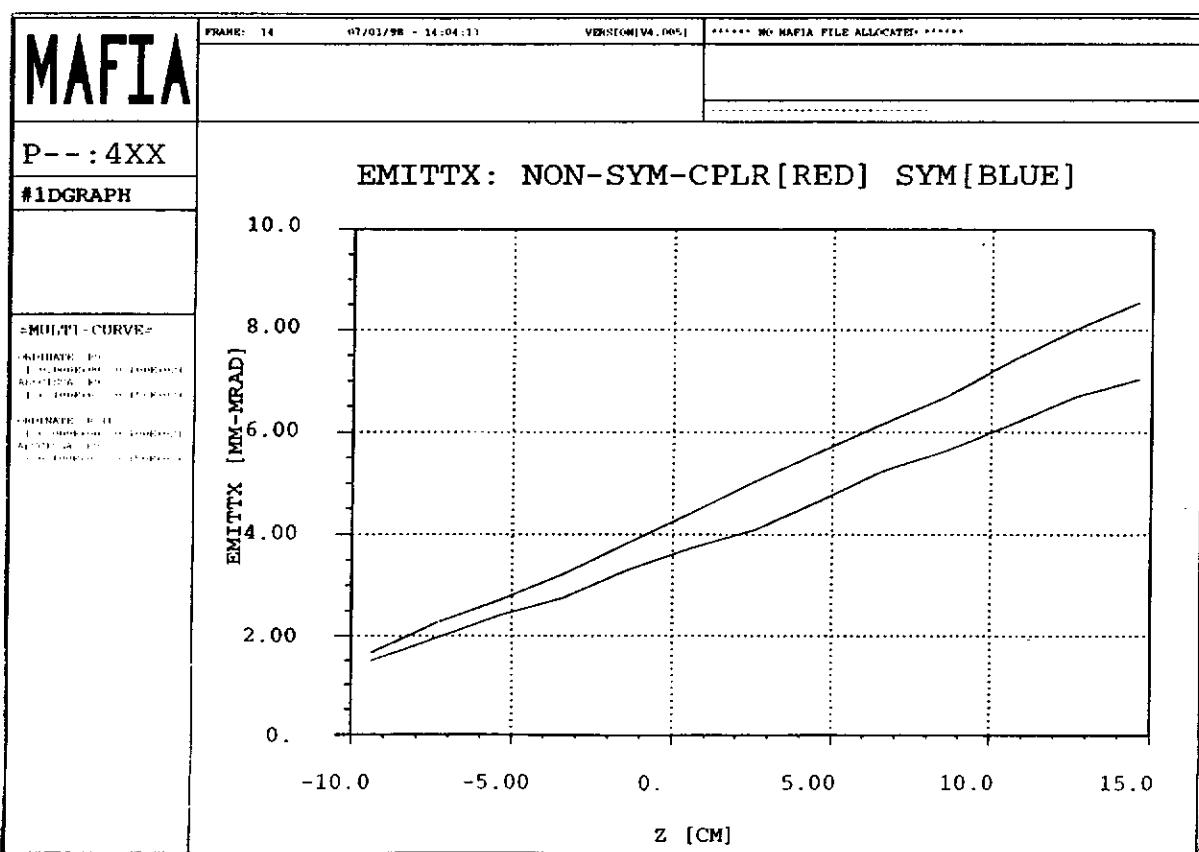


ZHANGM@SOLARIS, MAR07/13:45

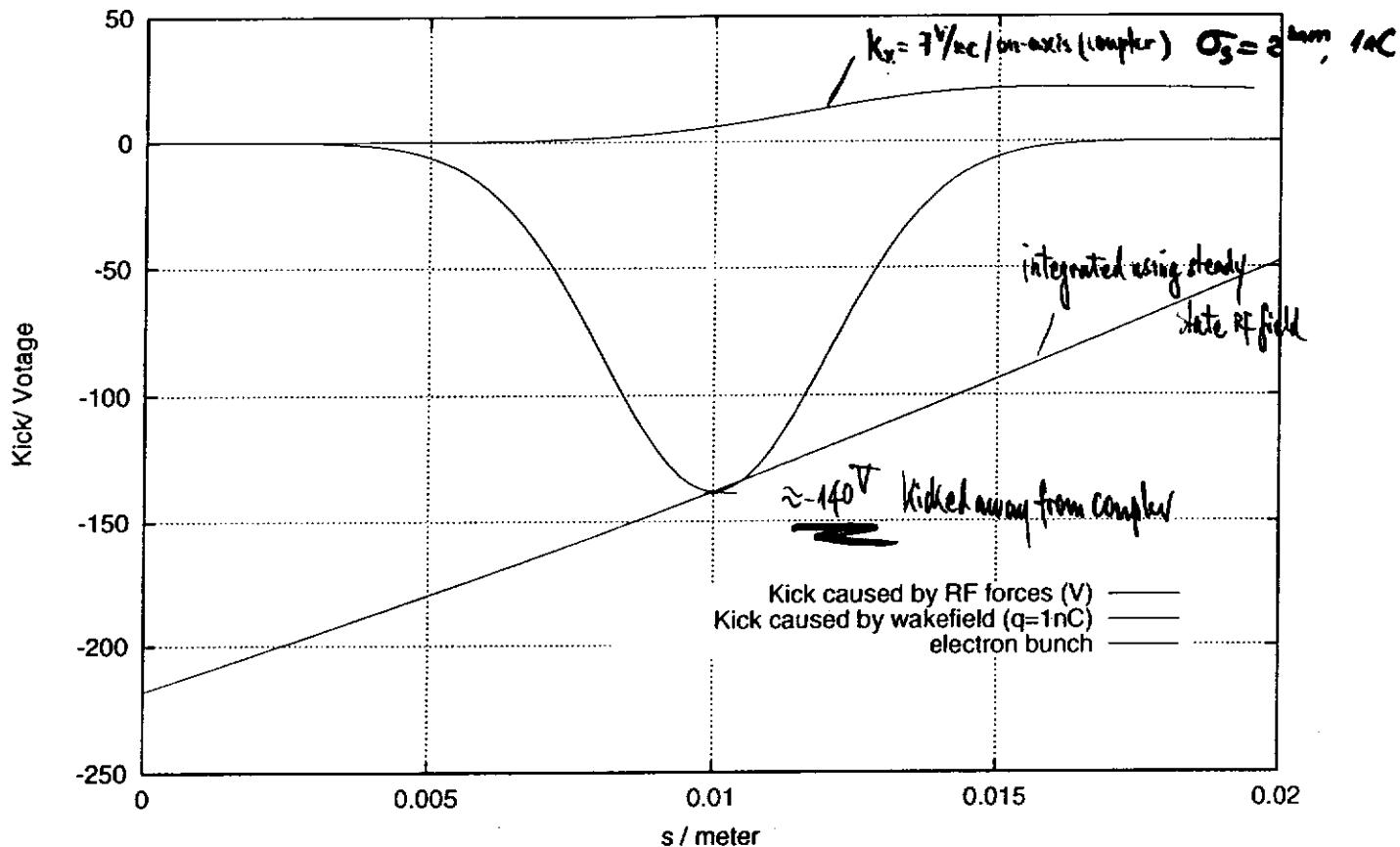




ZHANGM@SOLAR03, MAR07/13:46



Transverse kicks caused by a fundamental coupler on a bunch traveling on the axis



TANGCX@SOLAR03, MAR09/10:57

Why not Symmetrical Coupler ?

- Kick_{coupler-rf} can be reduced dramatically
- Example shows 10 times smaller than downstream and 20 times smaller than upstream
- A favorable by-product: ε_x improved 17%
- Push for the super-structure, since we can still spare 1/2 the number of the couplers

W_t of the Power Coupler

- Simulation shows $W_{t|_{\sigma_s=1mm}} = 0.011 \text{ V/pC}$ with beam on axis for one single power coupler
- It is ~ 5.3 times smaller than the 9cell cavity's $W_{t|_{\sigma_s=1mm}} = 0.06 \text{ V/pC/mm}$
- Taking the same factor for kick-factors, we get $k_{\text{coupler}}|_{\sigma_s=1mm} = 0.0032 \text{ V/pC}$, i.e. $\text{kick}_{\text{9cell}} = 5.3 \text{ kick}_{\text{coupler}}$
- $\Rightarrow \text{kick}_{\text{coupler-rf}}$ is equivalent to the wakefield kick caused by a $\sigma_s=1\text{mm}$ bunch of $62nC$ charge passing by the coupler on axis

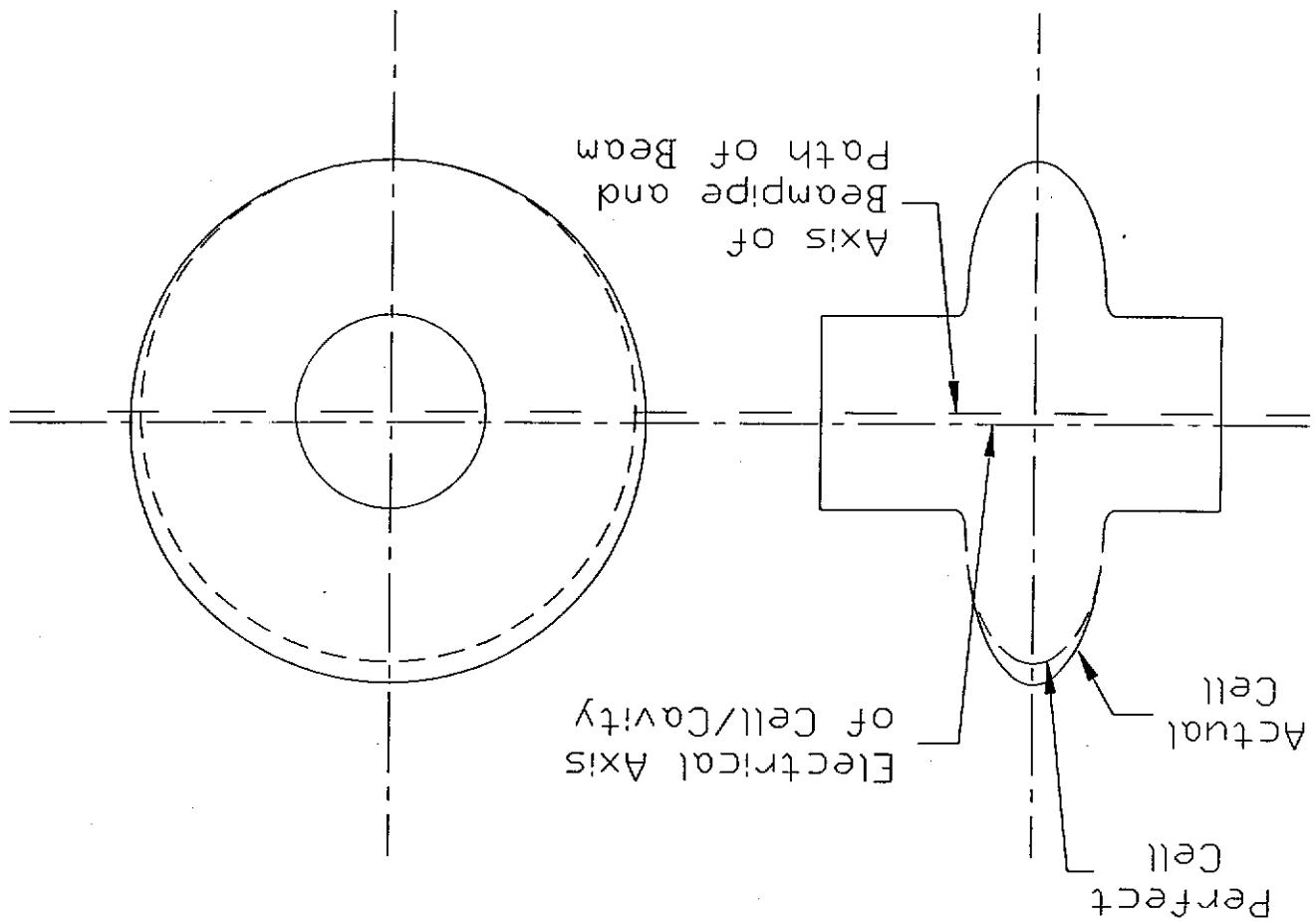
What next ?

- Kick and emittance growth measurement to verify the simulation at the exit of the capture cavity
- Symmetrical coupler prototype
- Measurement with symm coupler

Acknowledgment

We would like to thank:

B. Dwersteg, W.-D. Moeller, D. Proch, J.
Sekutowicz of the MHF-SL group for providing
geometry data and many constructive discussions !

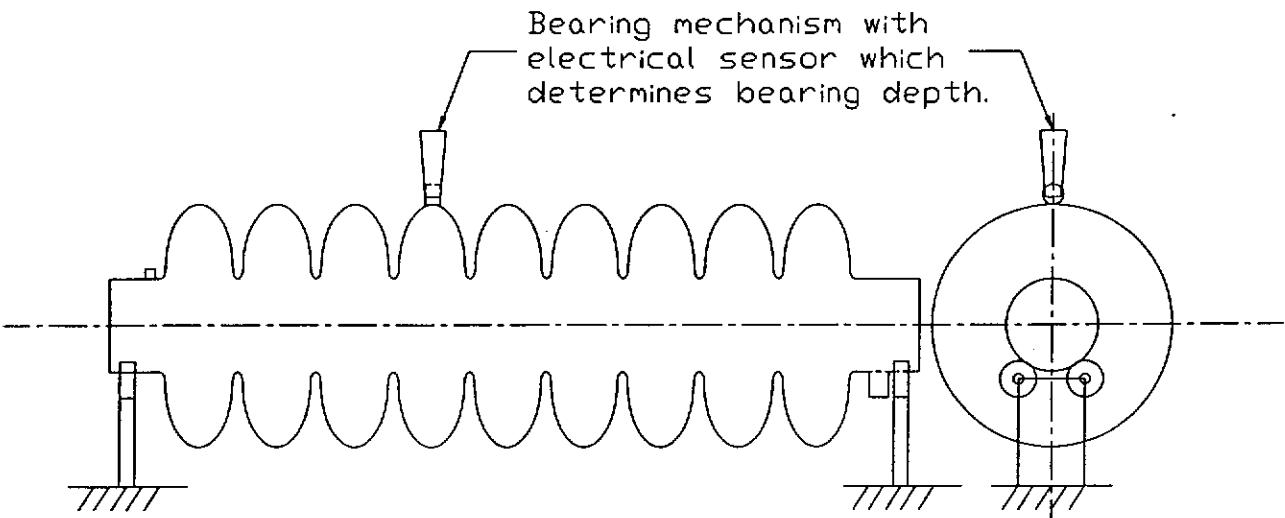


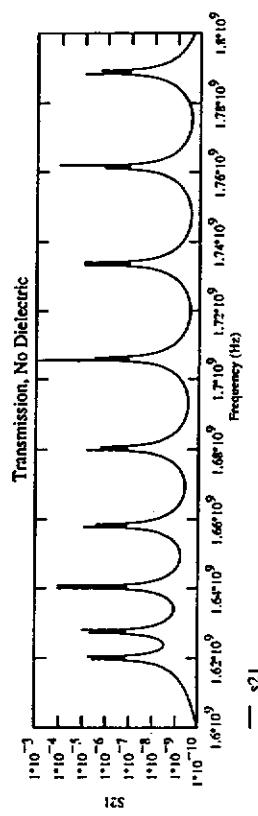
Experimental Determination of the Electrical Axis in TESLA Cavities

C. Deibele

Assumptions

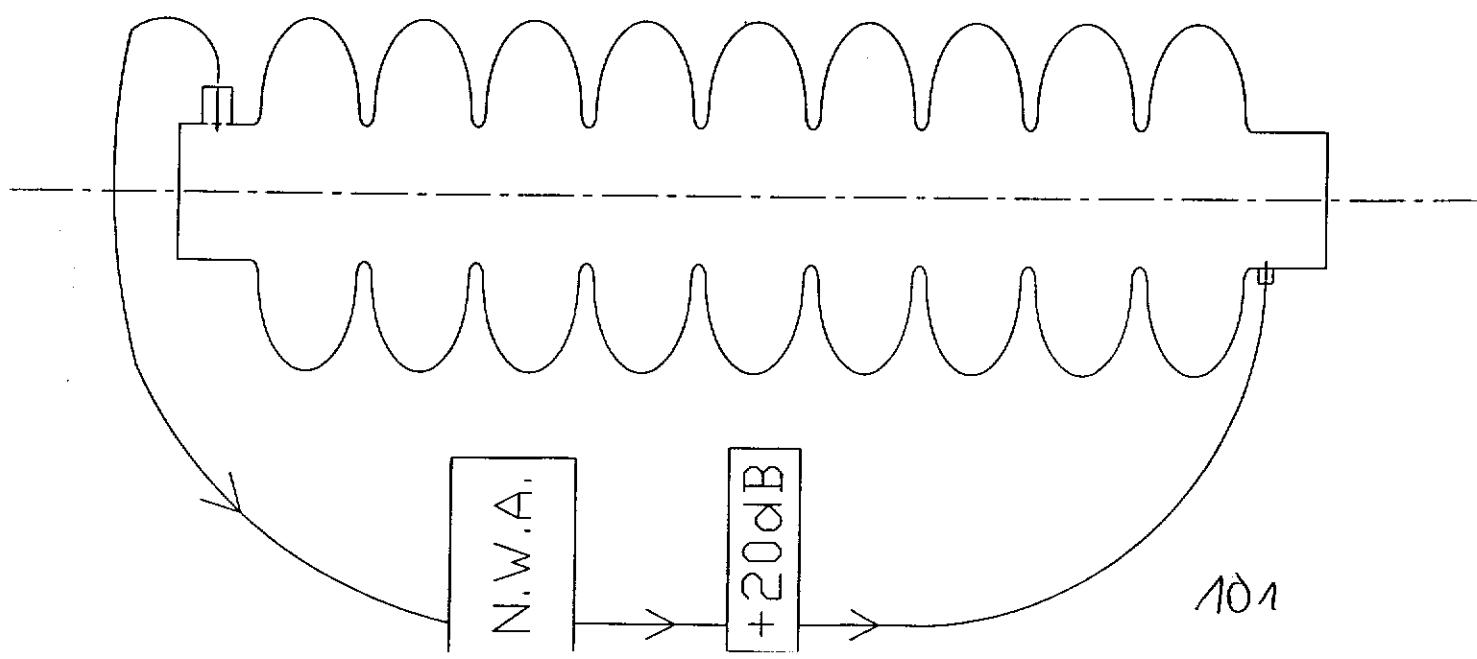
- ◆ The thickness of the niobium in each cell is constant.
- ◆ The quality of the weld from each $\frac{1}{2}$ cell is ideal and smooth.
- ◆ The beampipes at each end of the cavity are concentric.
- ◆ The surface quality of the beampipes at the position where the four bearings hold the cavity in place is both smooth and round.
- ◆ Uncorrelated noise in placement of each dumbbell piece together.

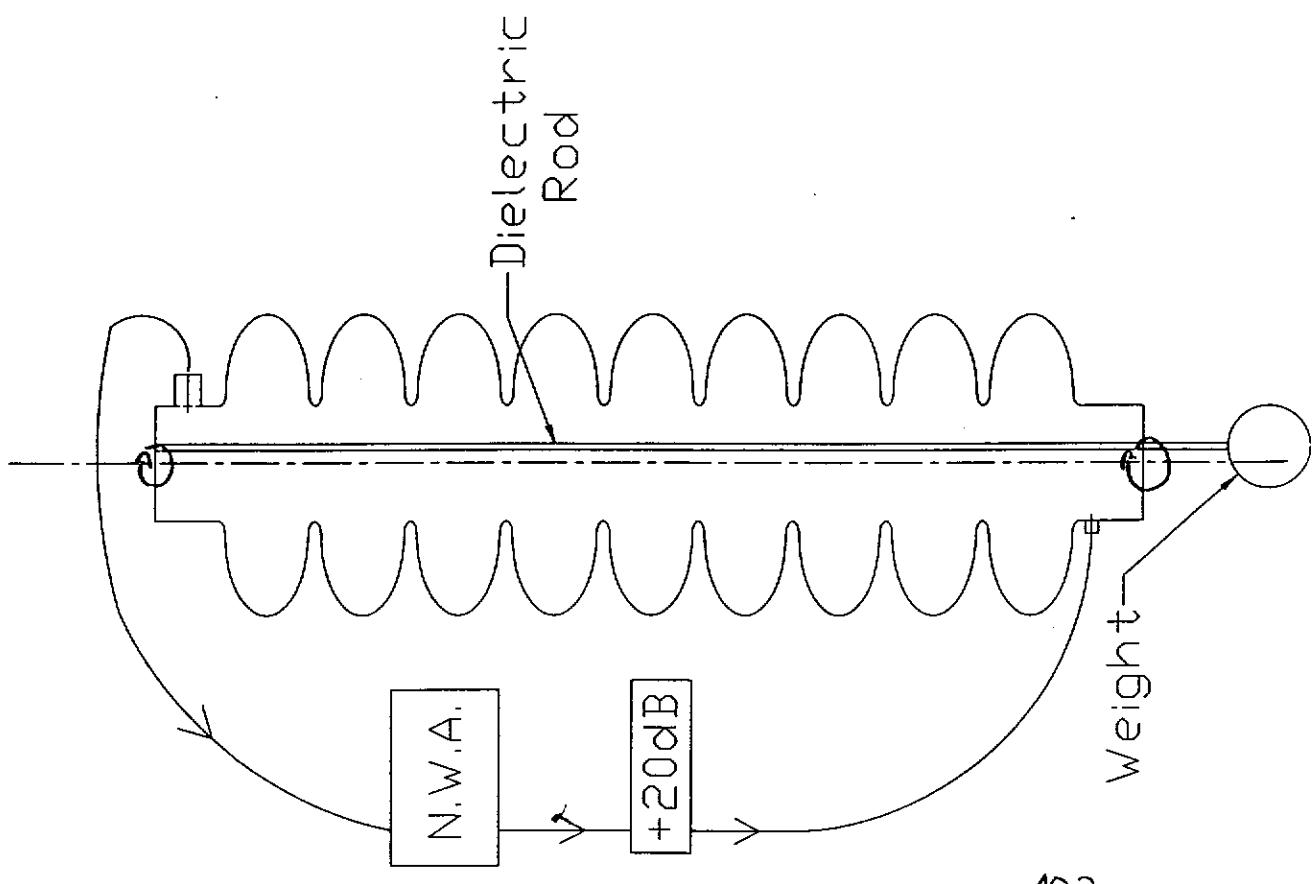
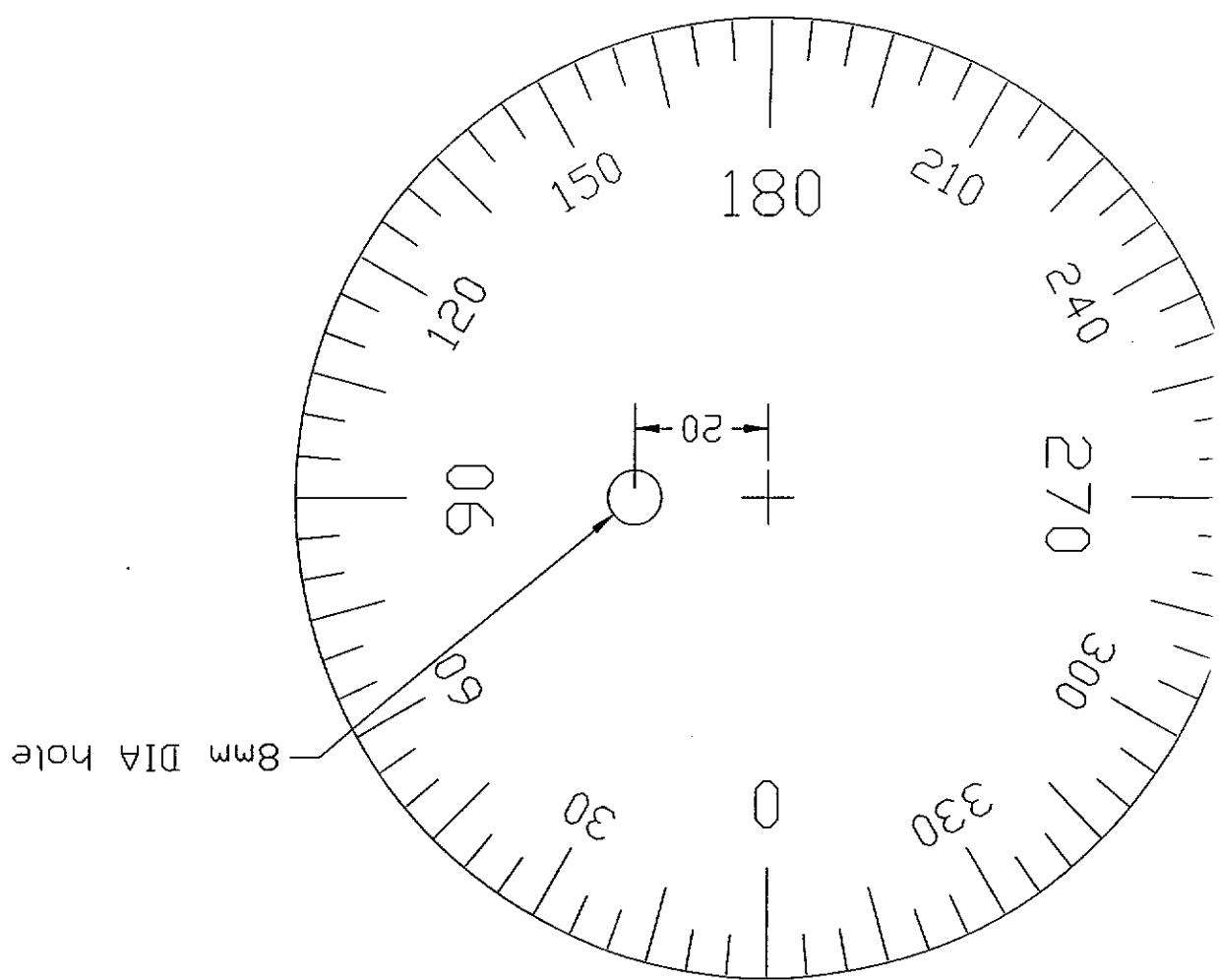


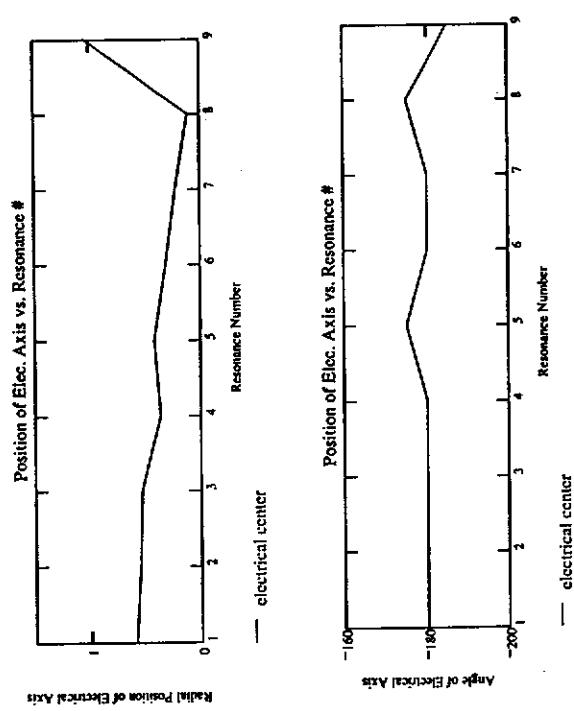


521

— §2.1



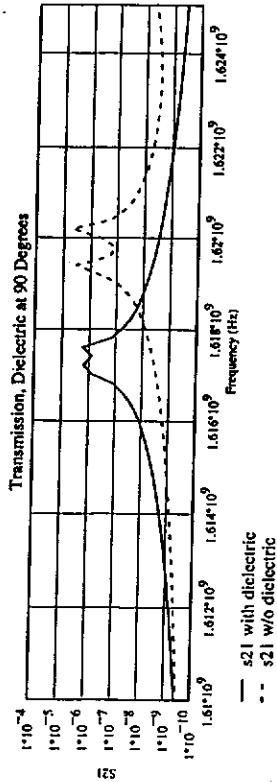
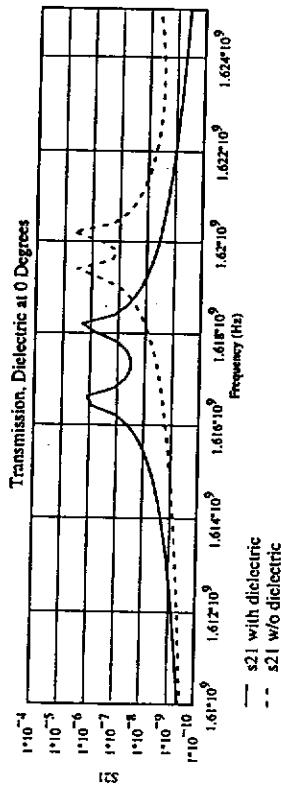




$$\frac{\omega - \omega_o}{\omega_o} \approx \frac{\Delta \epsilon \int_{dielectric} \vec{E}_{dielectric} \cdot \vec{E}_o^*}{2 \int_{cavity} \epsilon_o |\vec{E}_o|^2}$$

Changes from Zeuthen

- ◆ New Endcaps which enable coupling to single mode.
- ◆ Smaller Dielectric..
- ◆ Comparison of Axis measurements.



DESIGN OF A HOM

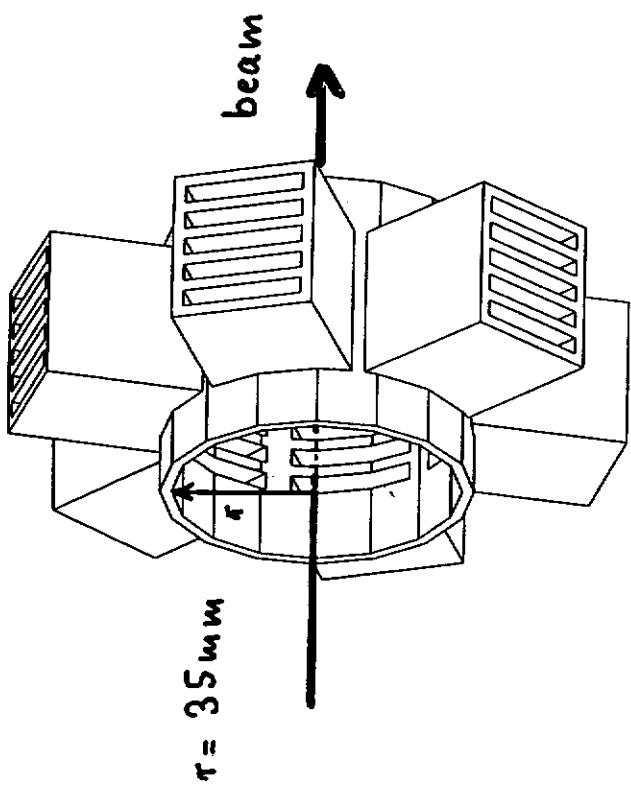
BROADBAND ABSORBER FOR TESLA (NEW RESULTS)

- Overview
1. Status at the last meeting
 2. 2d grating analysis
 3. Wakefield computation
for a periodic structure
 4. MATH computations
for a modified absorber
 5. Installation
 6. Conclusions + outlook

M. Dohlus, H. Hartwig, N. Holtkamp,
R. Jöstingmeier and D. Trines

1. Status at the last meeting

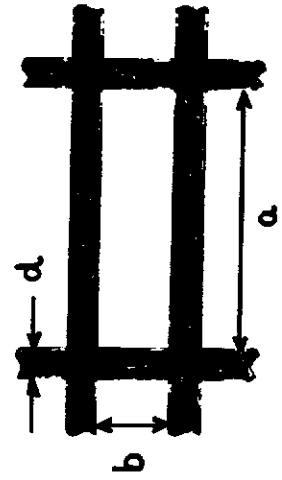
- Problem: Short bunches generate high frequency components
⇒ Broadband absorber
- MATIR discontinuity analysis ⇒ good absorption characteristics
- Manufacturing by etching + stacking



Schematic drawing of the absorber.

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- Unanswered questions:
 - frequencies > 1000 GHz
 - obliquely incident field
 - short range wake
 - simplified construction



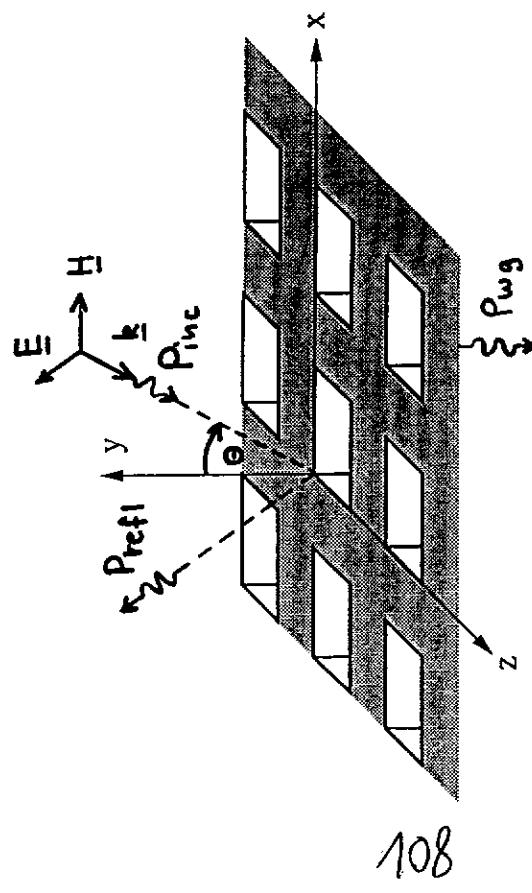
$$d = 0.1 \text{ mm}$$

$$b = 0.3 \text{ mm}$$

$$a = 1.5 \text{ mm}$$

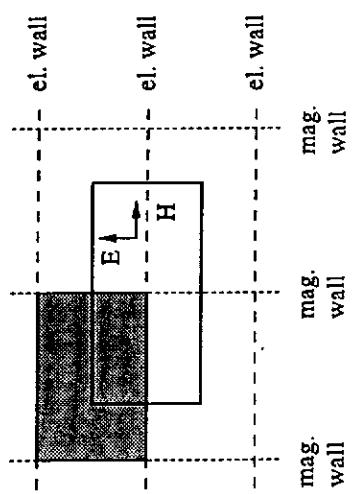
packages of wavyg.

2. 2d grating analysis

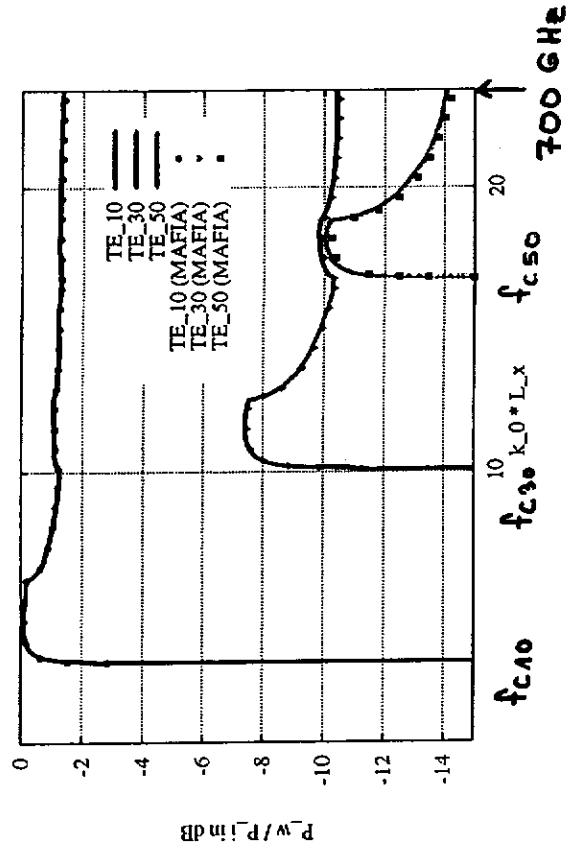


Schematic drawing of 3×3 cells of the grating.

- Field is pseudo-periodic for $y > 0$
⇒ Rayleigh expansion
- Eigenmode expansion inside the waveguides
- Field matching at $y = 0$
⇒ Linear system of equations
⇒ Field everywhere ⇒ P_{wg} / P_{inc}

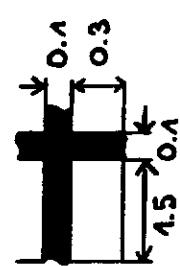
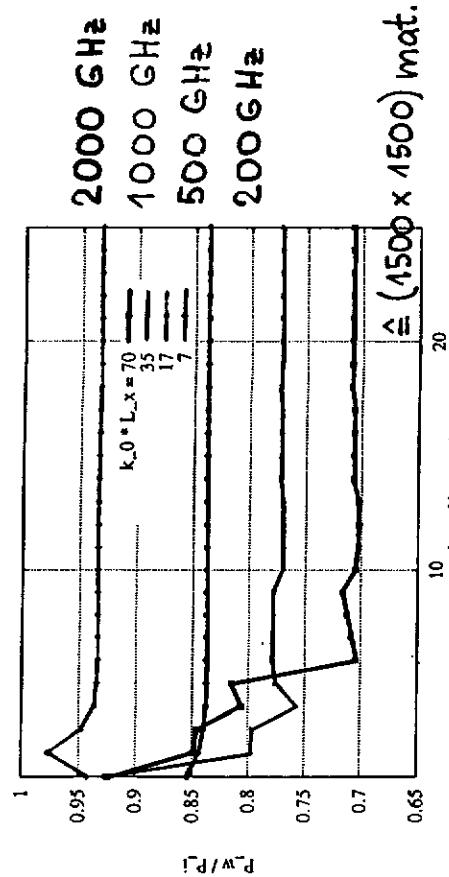


MAFIA waveguide discontinuity problem.

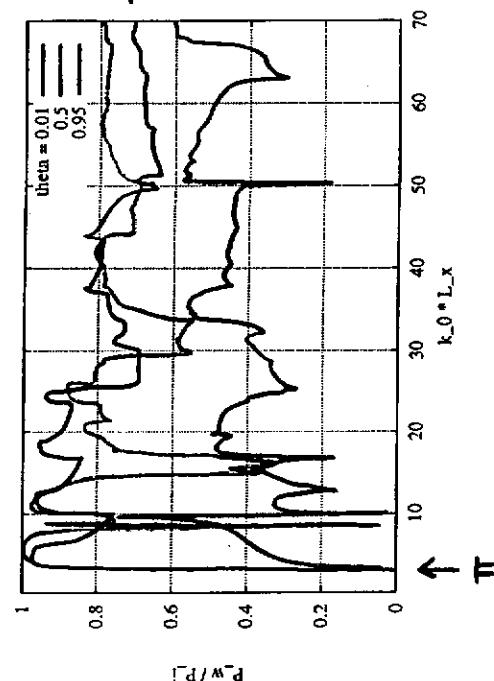


Comparison between MAFIA and the mode matching technique.

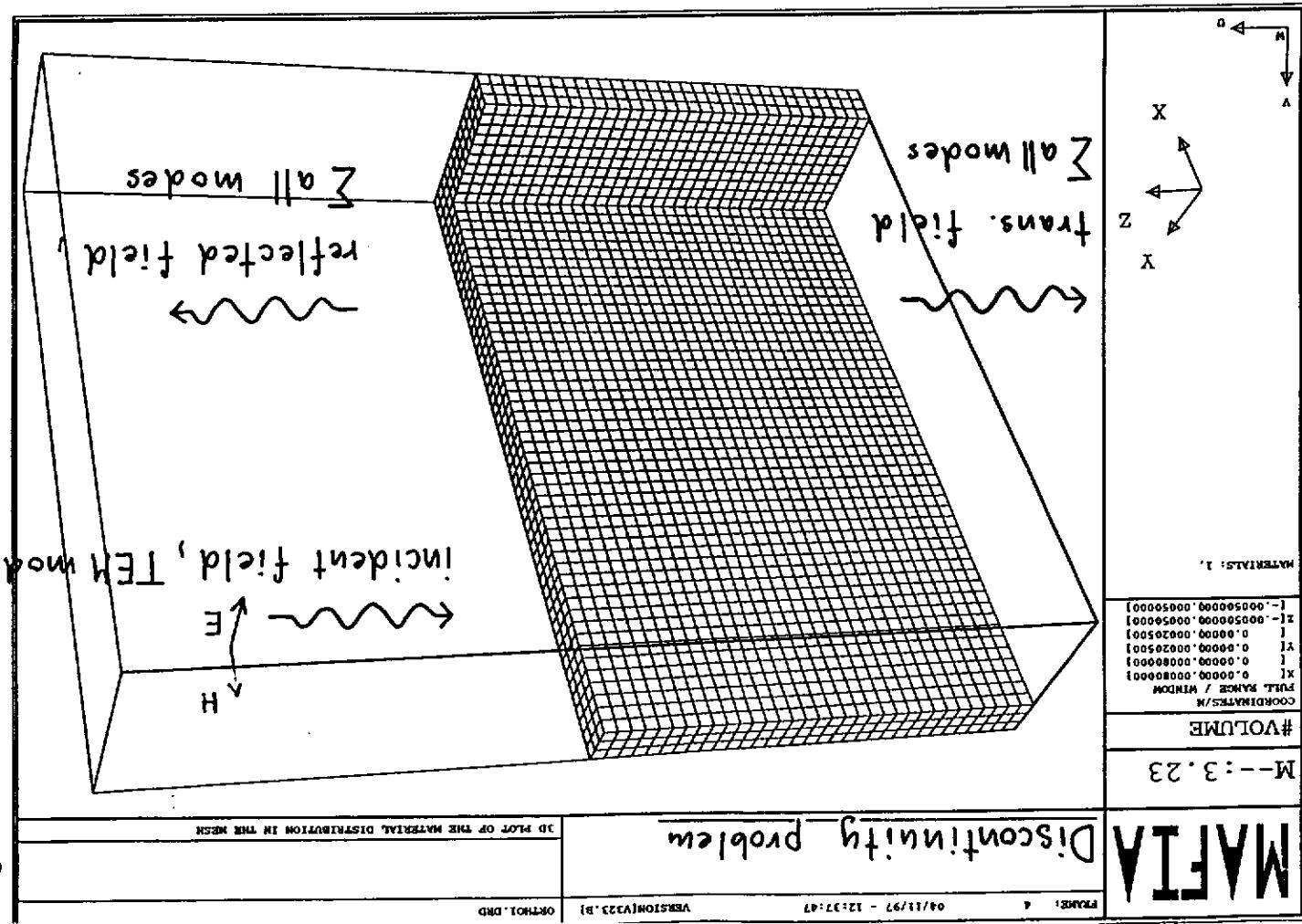
stable results



Study of convergence.

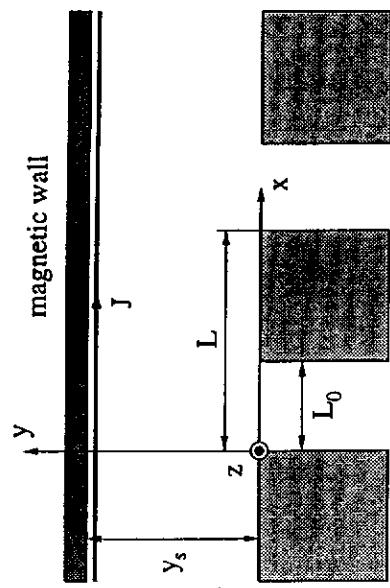


Absorber efficiency as a function of frequency.



3. Wakefield computation for a periodic structure

- Modified Rayleigh expansion for grazing incidence



One-dimensional planar grating.

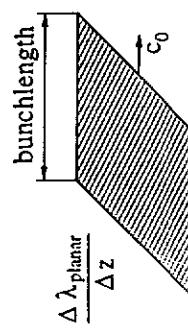
$$H_z = \sum \text{higher order space harmonics} + (a_0 + a_1 y) e^{-ik_0 x}$$

- Very accurate and numerically efficient

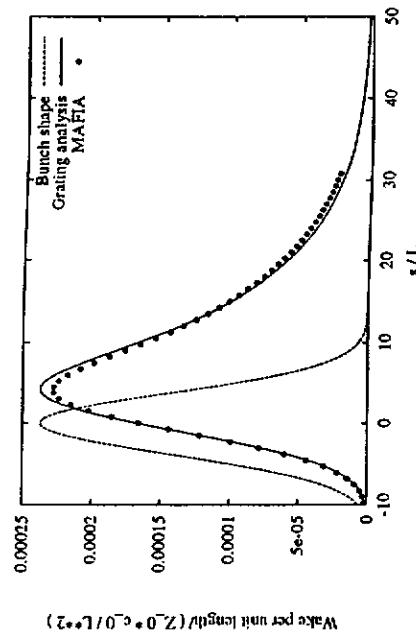
- Modular

Field analysis \Rightarrow impedance \Rightarrow wakefield
↑ bunch shape

$$\frac{\Delta \lambda_{\text{planar}}}{\Delta z} = \frac{\lambda_{\text{circular}}}{2\pi y_s}$$

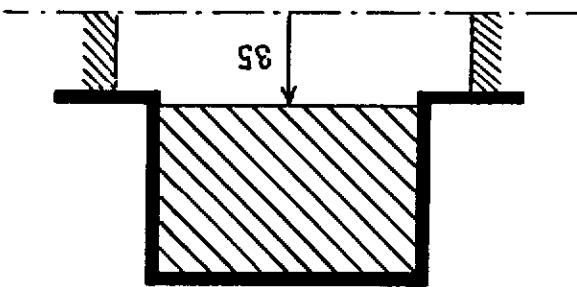


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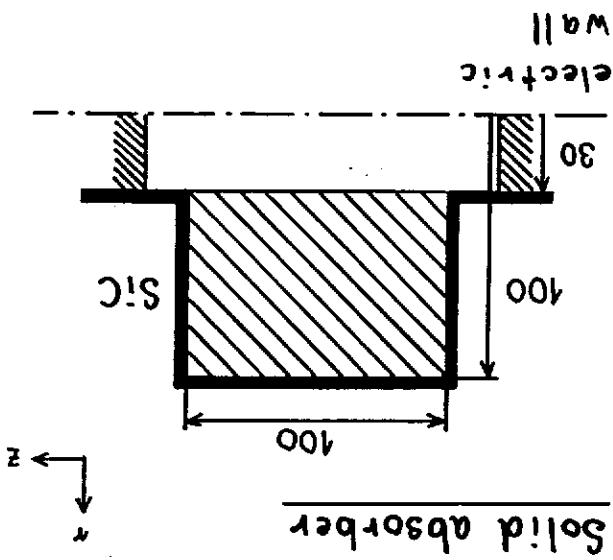


Relation between the circular and the planar structure.

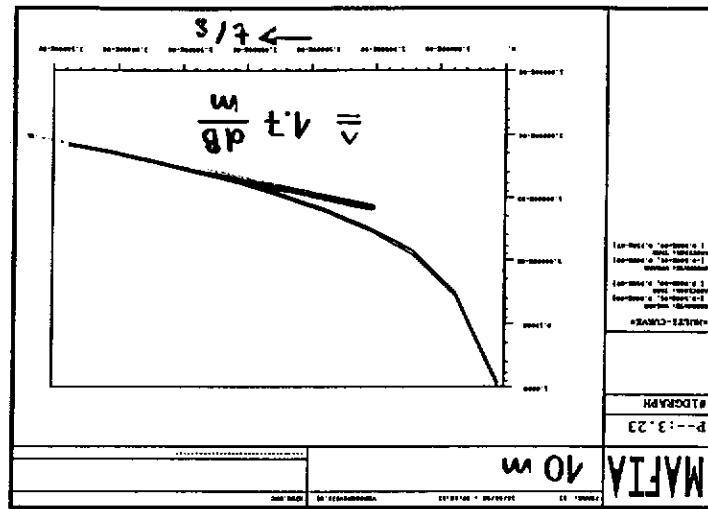
Comparison between MAFIA and the grating analysis.



Solid absorber (hatched)

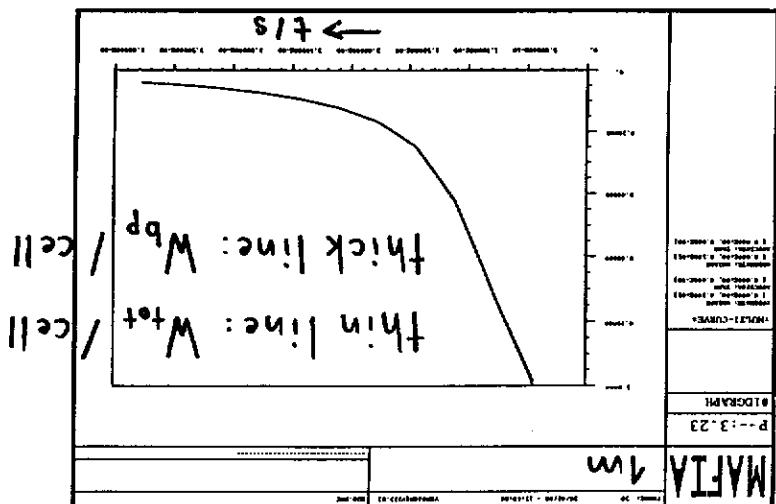


Solid absorber



MAFIA

10 m



MAFIA

1m

4. MAFIA computations for a modified absorber

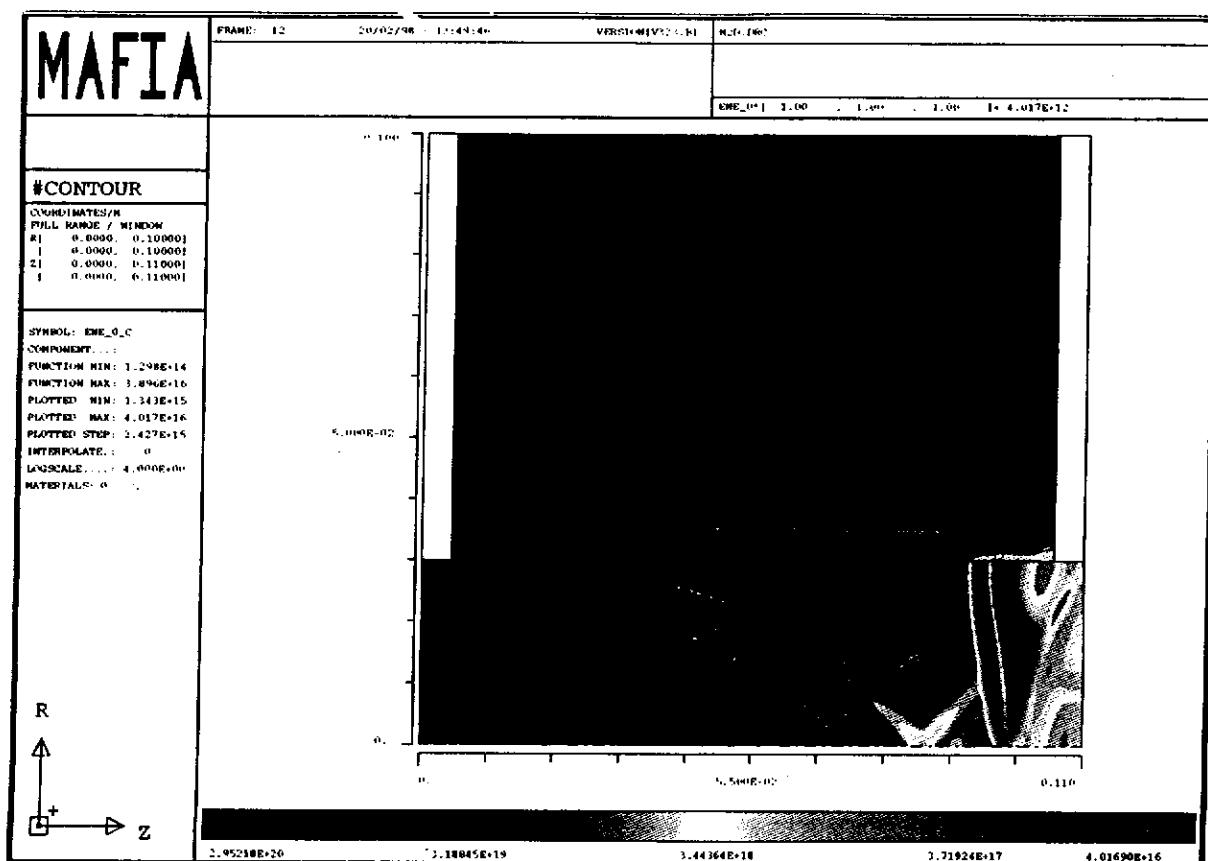
- Why do we need a modified absorber?
 - vacuum problems
 - difficult to manufacture

III

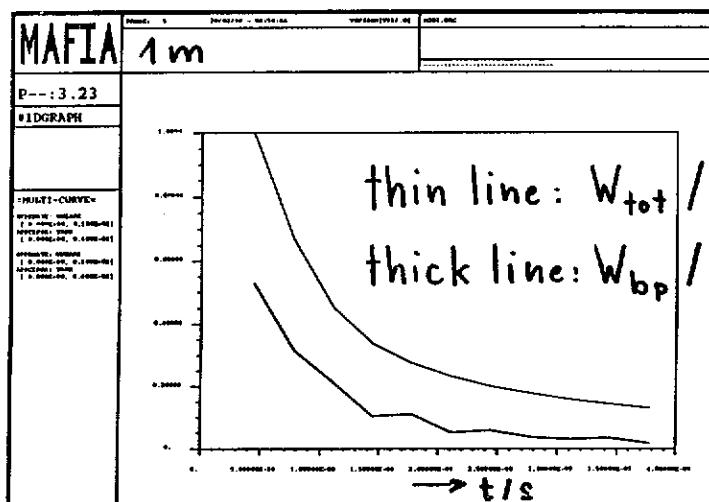
- Concept of the new absorber:
 - no cutoff frequency
⇒ an additional absorber is required for $f < 100 \text{ GHz}$ (long range wake)

- Why MAFIA computations:
 - $L_{crit} \approx \tau_{vis}^2 / \sigma$ especially for small σ

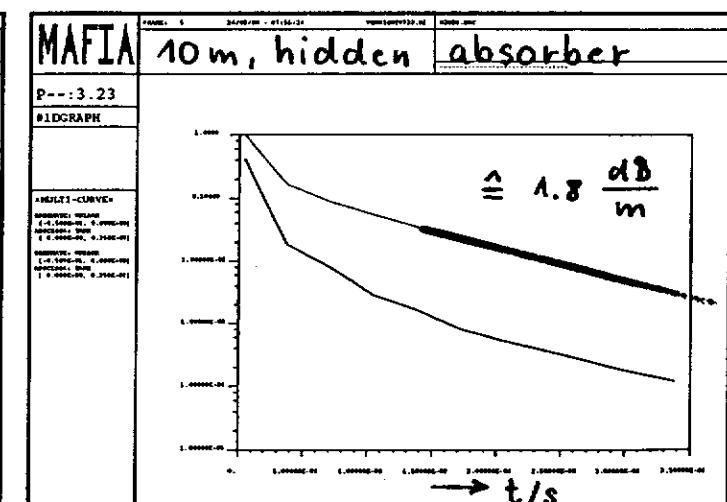
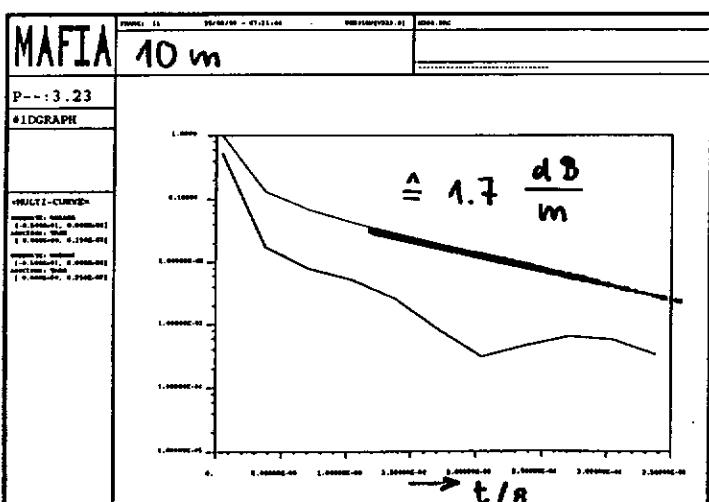
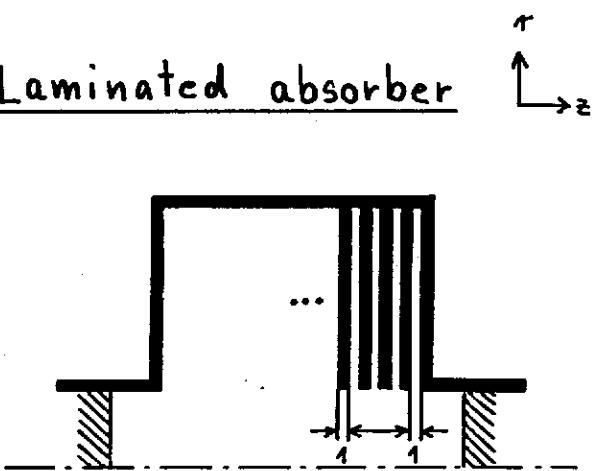
Energy density in a cell which contains the solid absorber



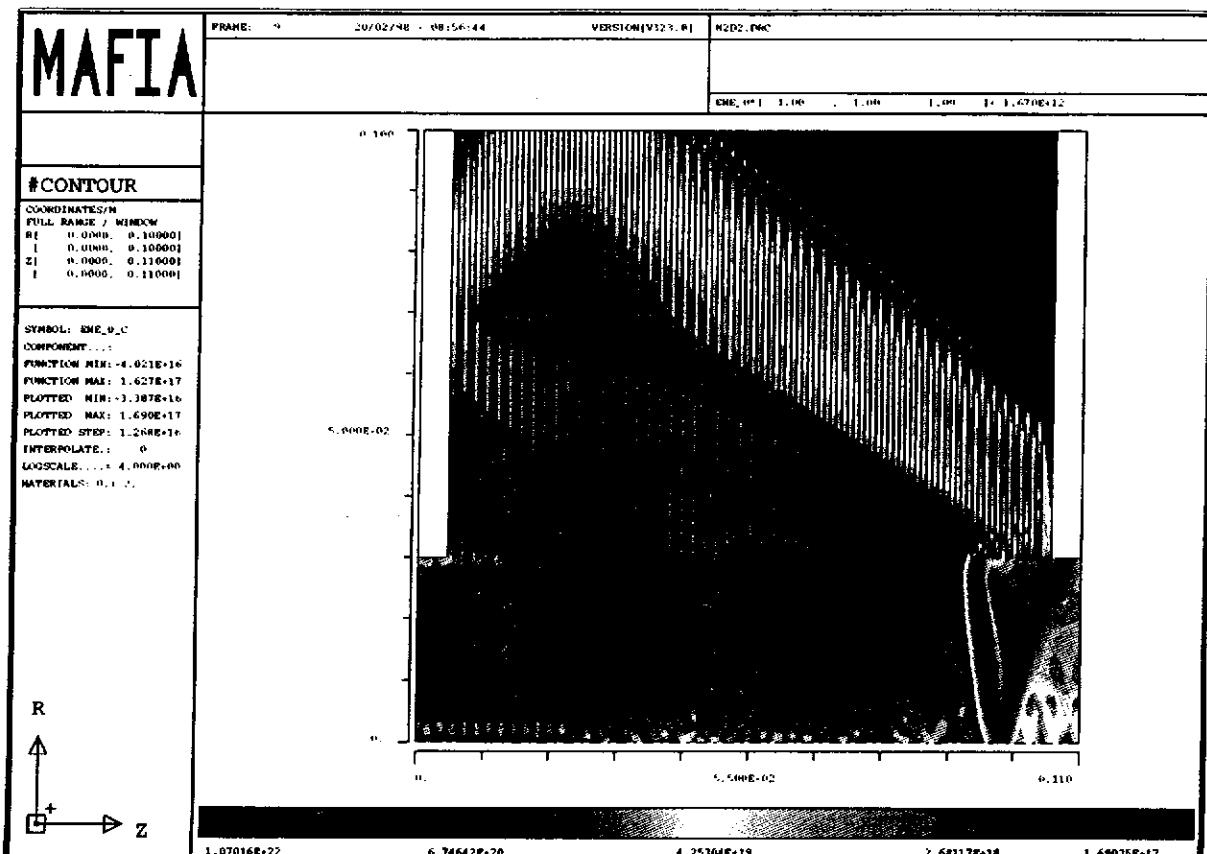
DOHLUS & SOLAR02, FEB20/13:18



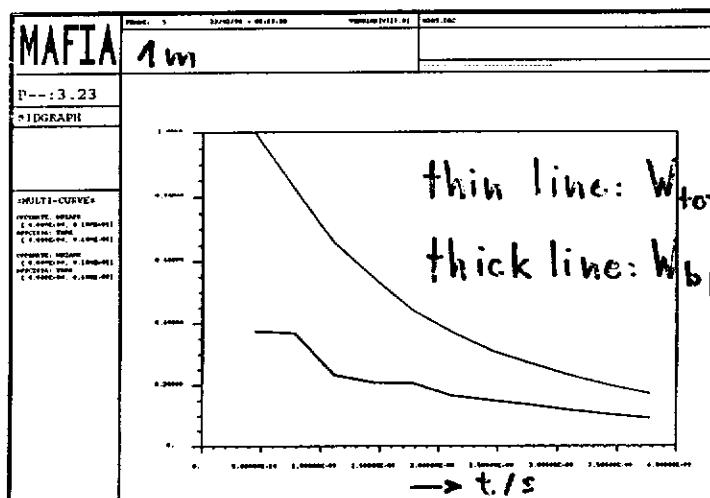
Laminated absorber



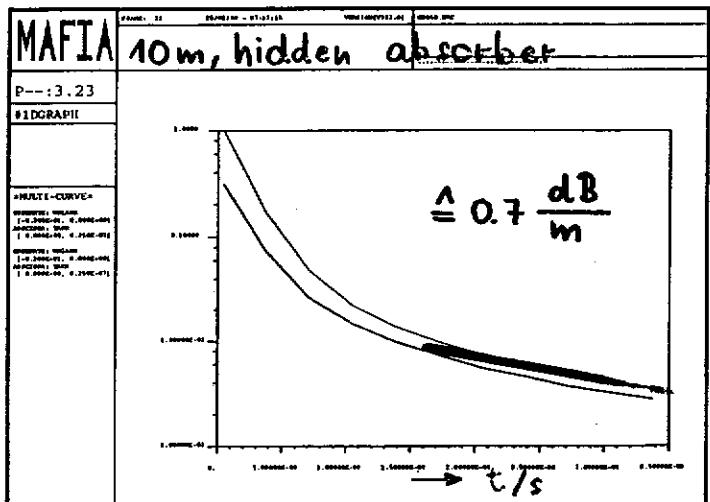
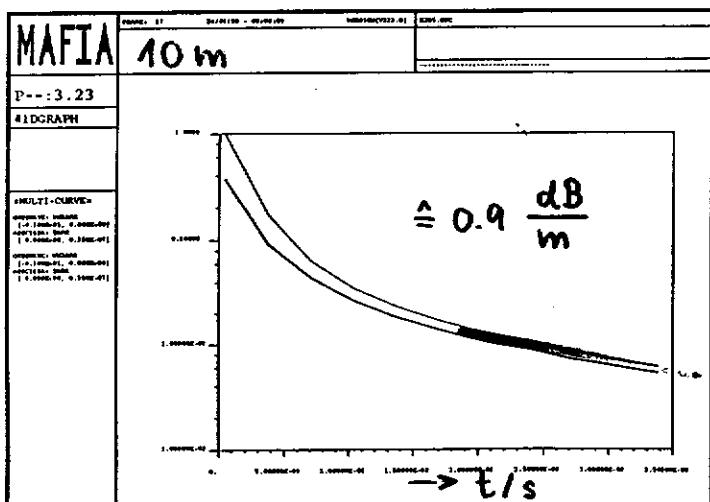
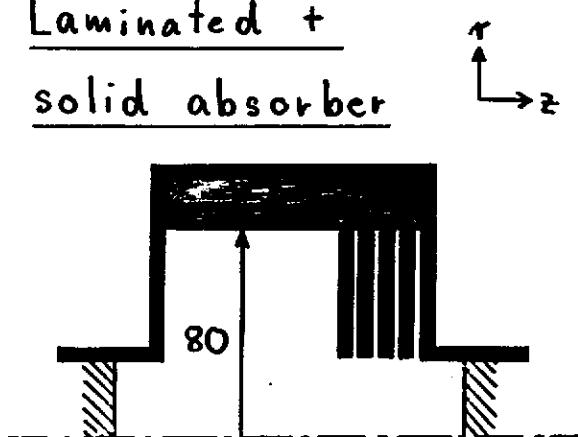
Energy density in a cell which contains the laminated absorber



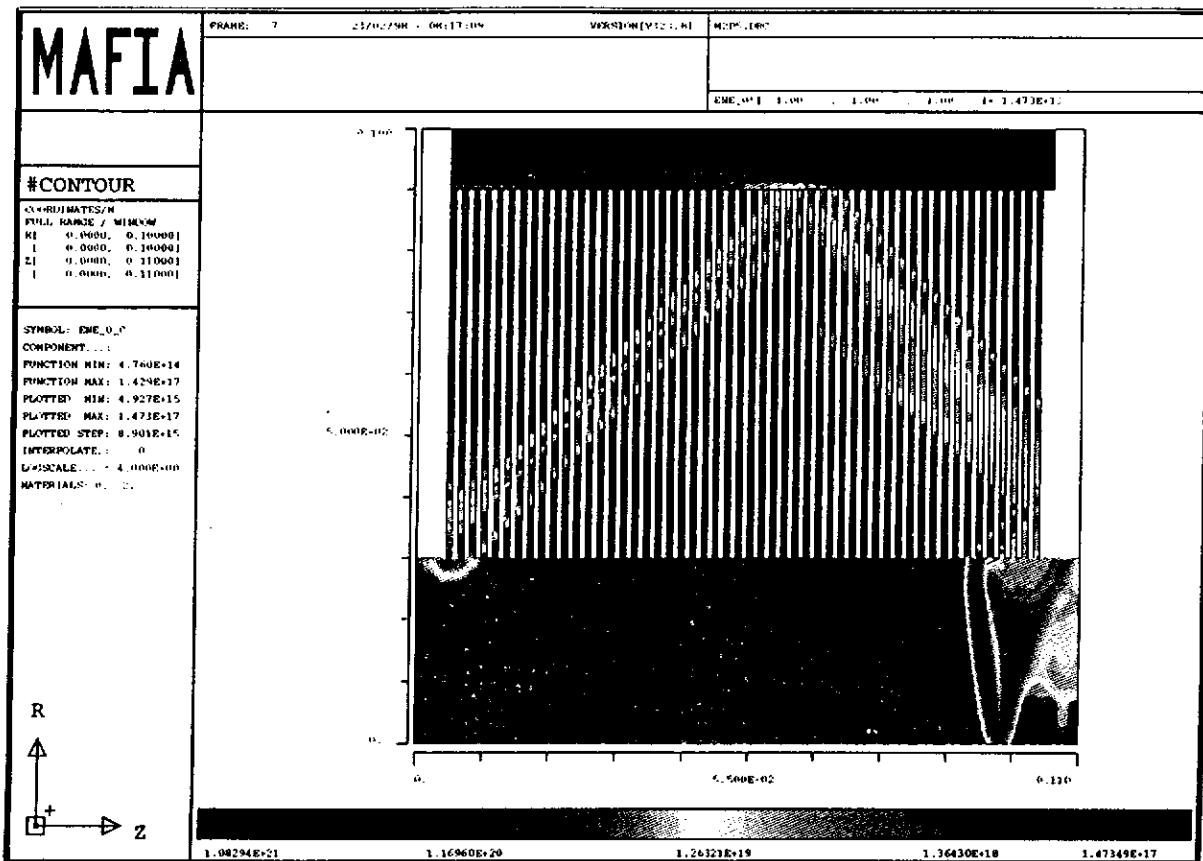
DORLUS@SOLAR02, FEB2010:03



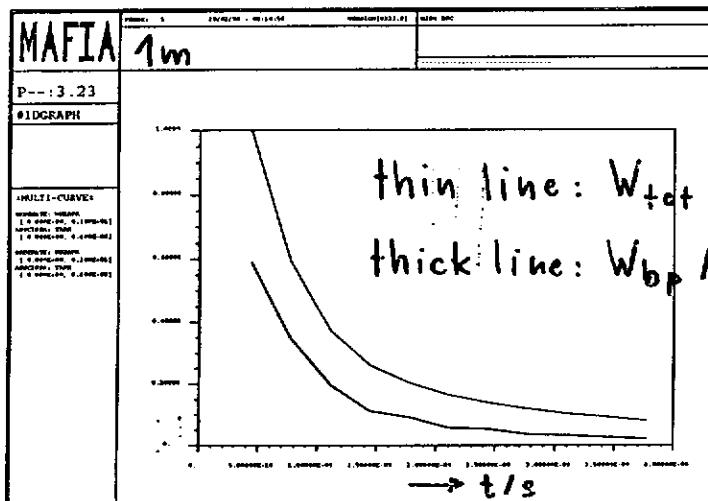
Laminated +
 solid absorber



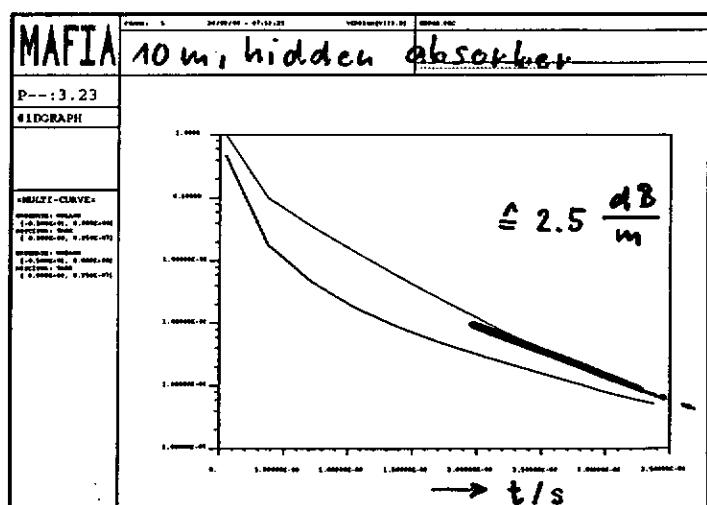
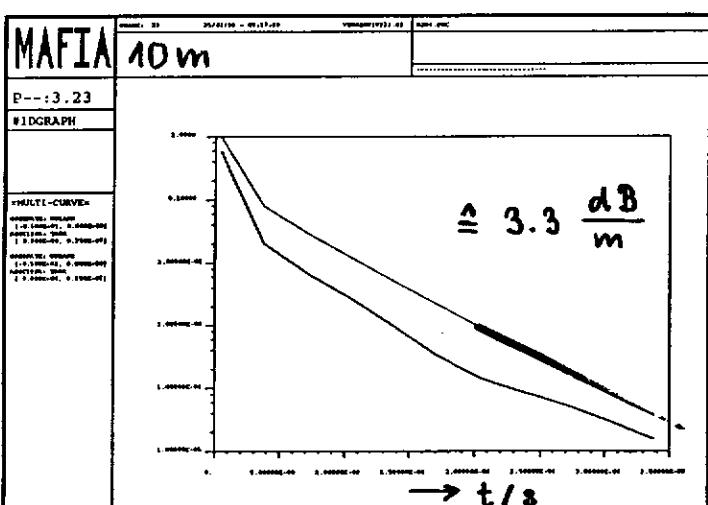
Energy density in a cell which contains the combined absorber



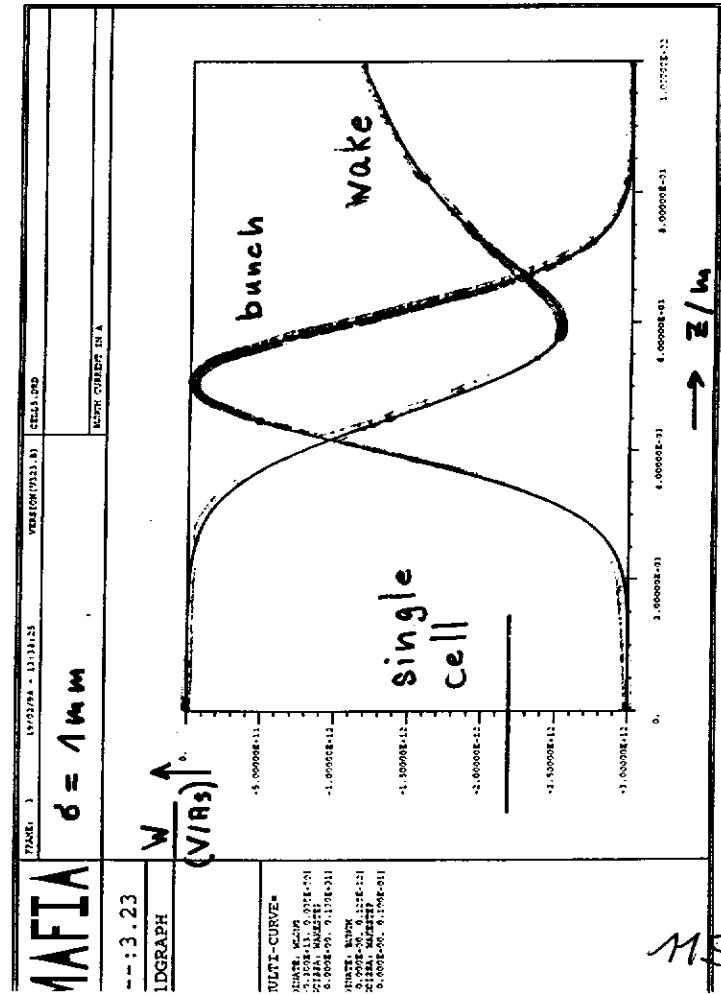
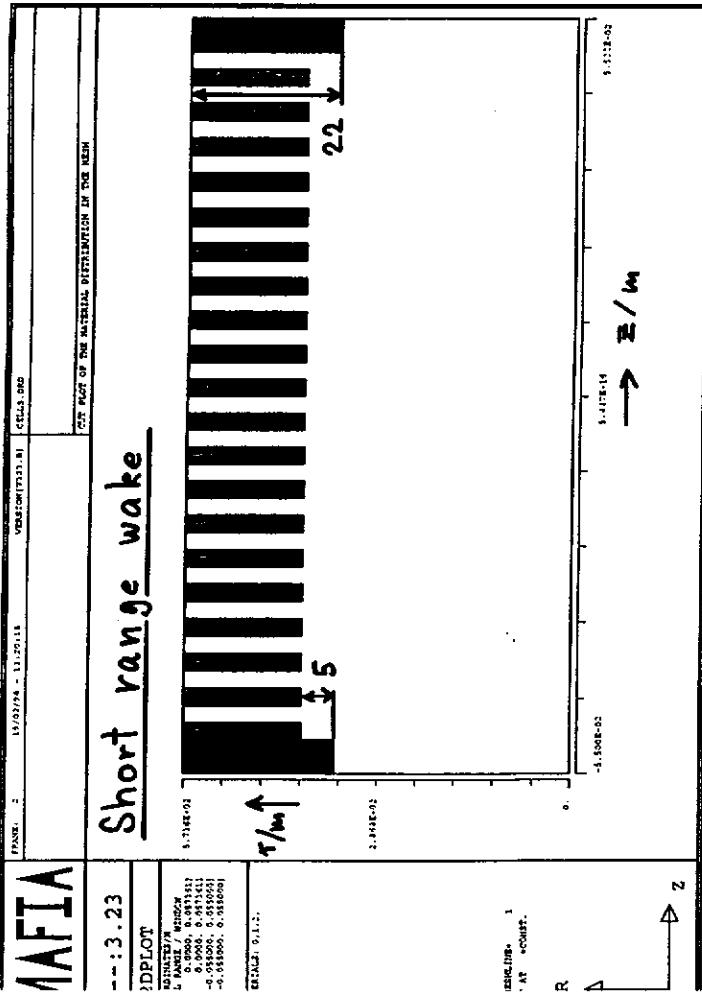
COHLUS@SOLAR02, FEB23/08:38



Metallized
laminated absorber

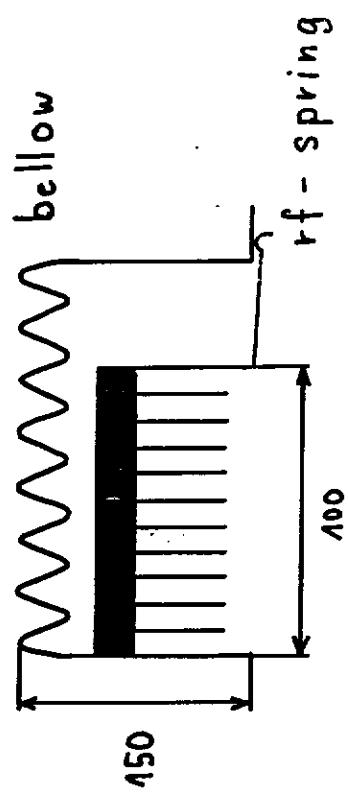


MAFTA

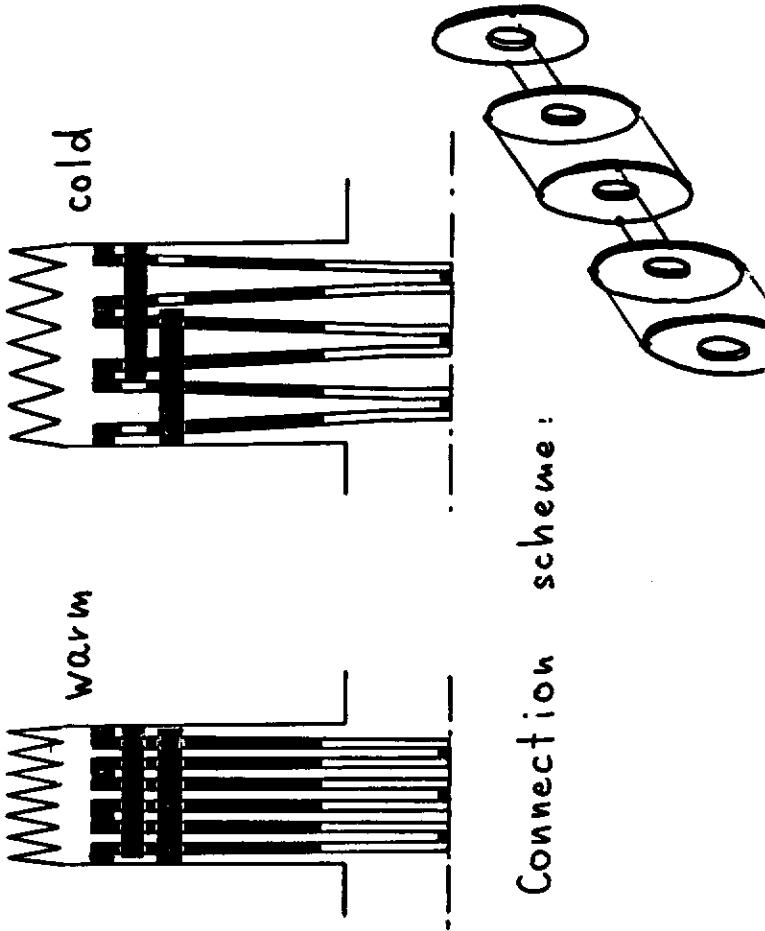


5. Installation

Straightforward solution:

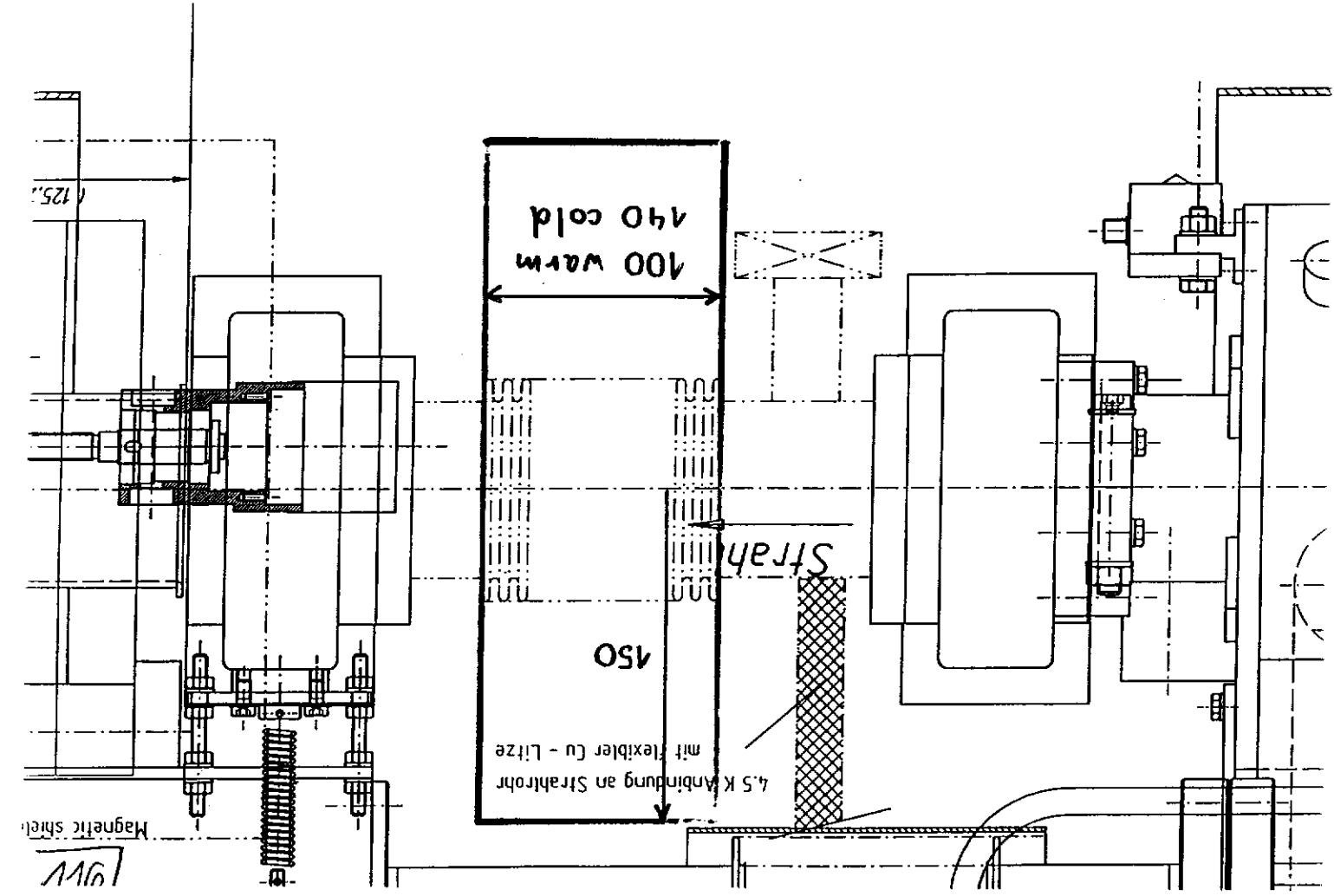


Flexible absorber:



6. Conclusions + outlook

- 2d grating analysis
- 1d periodic structure with beam
- Modification of the absorber
 - Low frequencies → SiC
 - High frequencies → Metallization
 - Reasonable attenuation properties
 - Small short range wake
- Further work
 - Material properties of SiC at 70K
 - Realization



Working Group Cavities
Tuesday, 9:00, Room 4b, Bldg. 1b

I : Cavity fabrication & treatment (Bloess)	
field emission scan on samples	(Haberman)
quality control in the clean-room	(Reschke)
activities at Saclay/Orsay	(Fouaidy)
hydroforming of cavities	(Singer)
material investigations	(Singer)
II : Cavity measurements (Schmüser)	
single cell program at Saclay/Orsay	(Bousson)
multipacting calculations for cavities	(Proch)
Q-drop and no x-rays in welded cavities	(Pekeler, Visentin)
Q-drop in cavities made by spinning	(Haebel)
cavity R&D for $E_{acc} \geq 30$ MV/m	(Lilj e,Liepe)
III : Couplers (Haebel)	
coupler development at Saclay	(Travier)
status of couplers TTF II, TTF III	(Proch)
rectangular coupler for TTF	(Yarigin)
IV : new cavities & components(Proch)	
first rf-meas. of the superstructure	(Tang)
transient calc. of the superstructure	(Ferrario)
calc. of trans. kick by the input coupler	(Zhang)
meas. of the electric cavity axis	(Deibebe)
calc. of a broad band HOM absorber	(Joestingm.)