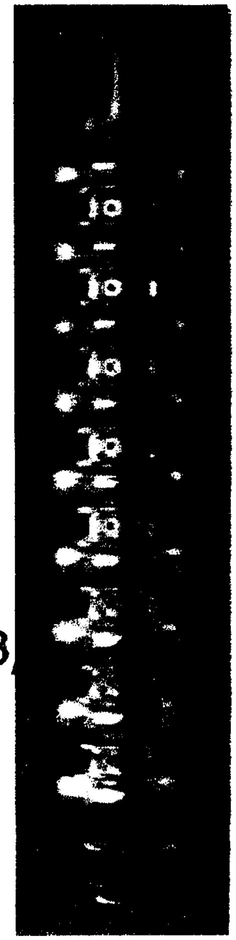
R&D in RF Superconductivity

Research Axis :



Chemistry

New chemical treatments

Electrochemistry

Thermal treatment

Purification annealing

Grain boundaries behaviour (segregation, resistivity)

Surface analyses

Kapitza resistance

Nuclear microprobe, SIMS, microscopy (opt, MEB, STM, AFM), roughness...

Field emission :

Surfaces under high field studied by :

X Ray interferometry

Scanning Tunneling Microscope

Fabrication costs

New fabrication techniques ⇒ welding, hydroforming , plasma deposition (copper on Nb)

Thin films (magnetron sputtering of Nb on copper)

New activities

$\beta<1$ Cavities for high power proton

Fabrication Techniques

Standard Technique

- 9-cell Cavity. bulk Nb : ~ iris, equator, clan welding ; stiffeners welding .

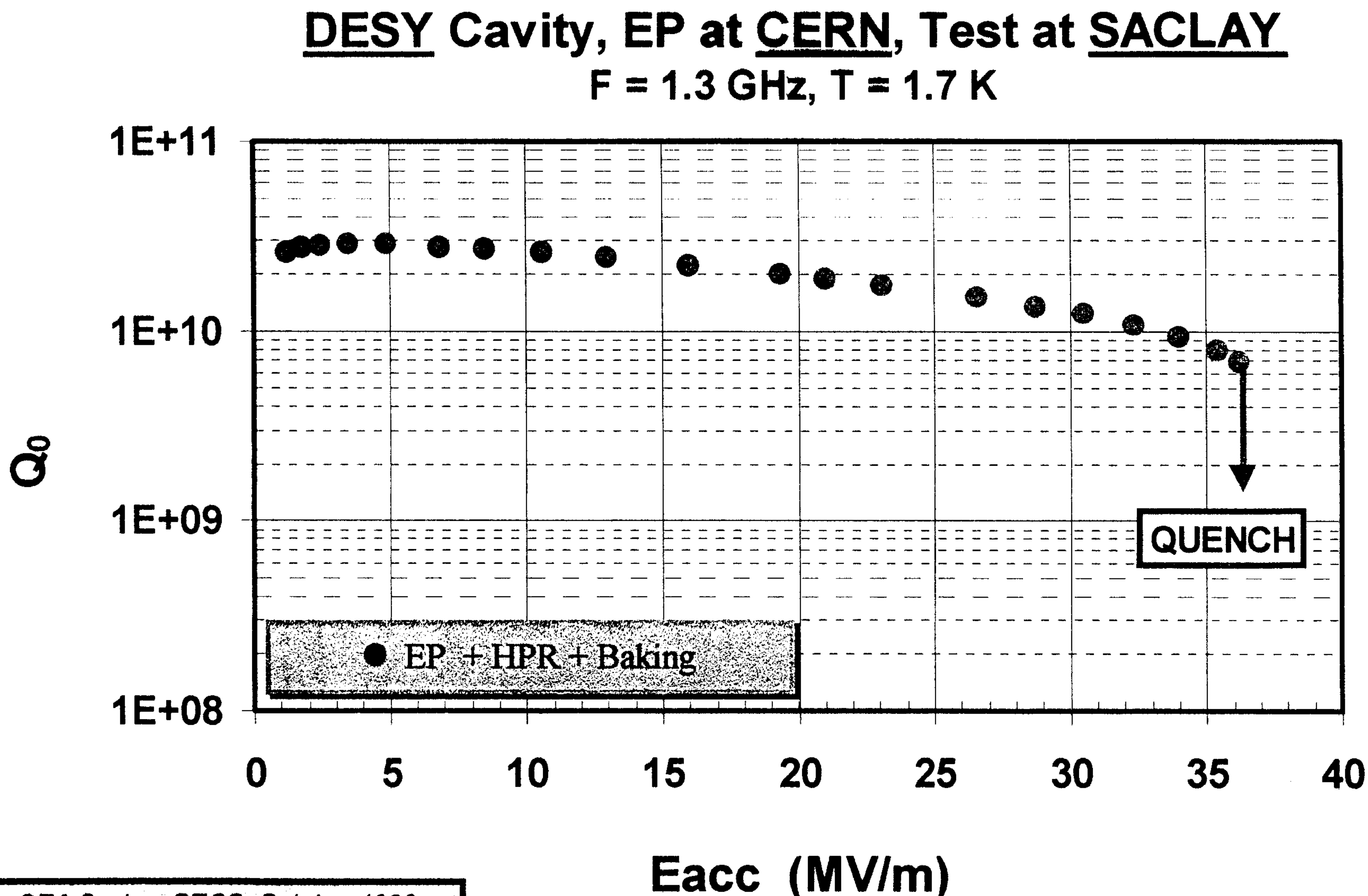
New techniques (bulk Niobium)

- Hydroforming : welding suppression (iris, equator)
- Plasma Cu deposition : in place of stiffeners, allows to reduce Nb thickness

Thin films

- magnetron sputter coated Nb/Cu (and NbTiN/Cu)

Cavity D122 / 1S2 Electropolishing



CEA Saclay, GECS, October 1999

FORMING SEAMLESS CAVITIES

- **Hydroforming**

  2-cells cavities from Nb tubes at SIBB Indust.

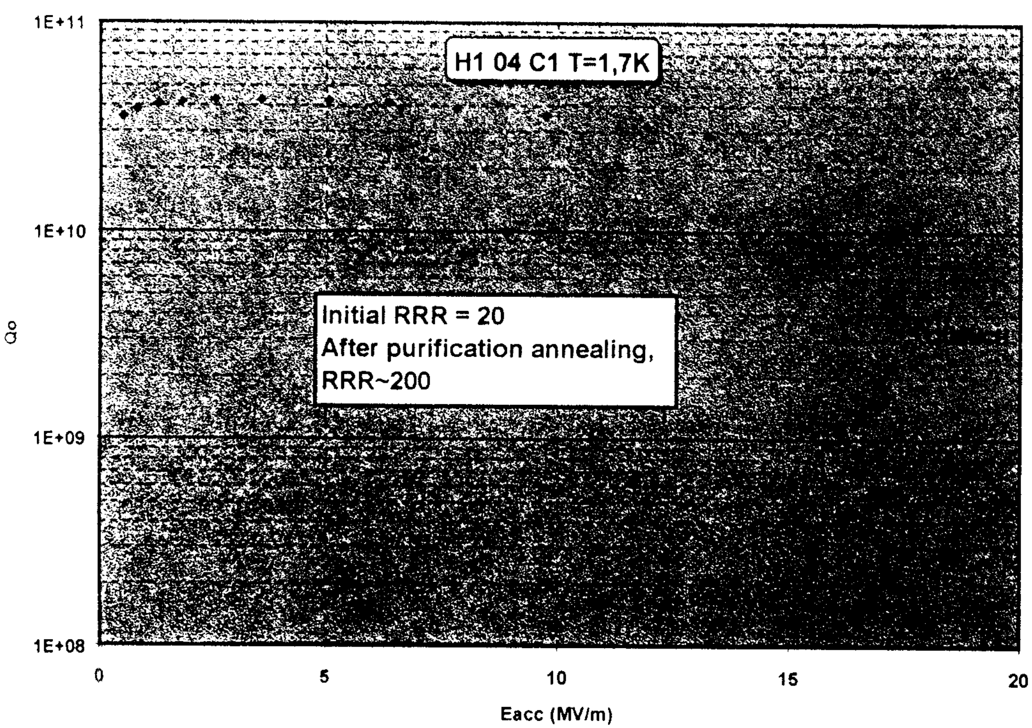
  ø = 51.7 mm - 2 mm thickness r/a = 2/1 - annealing 800º at 40% deformation

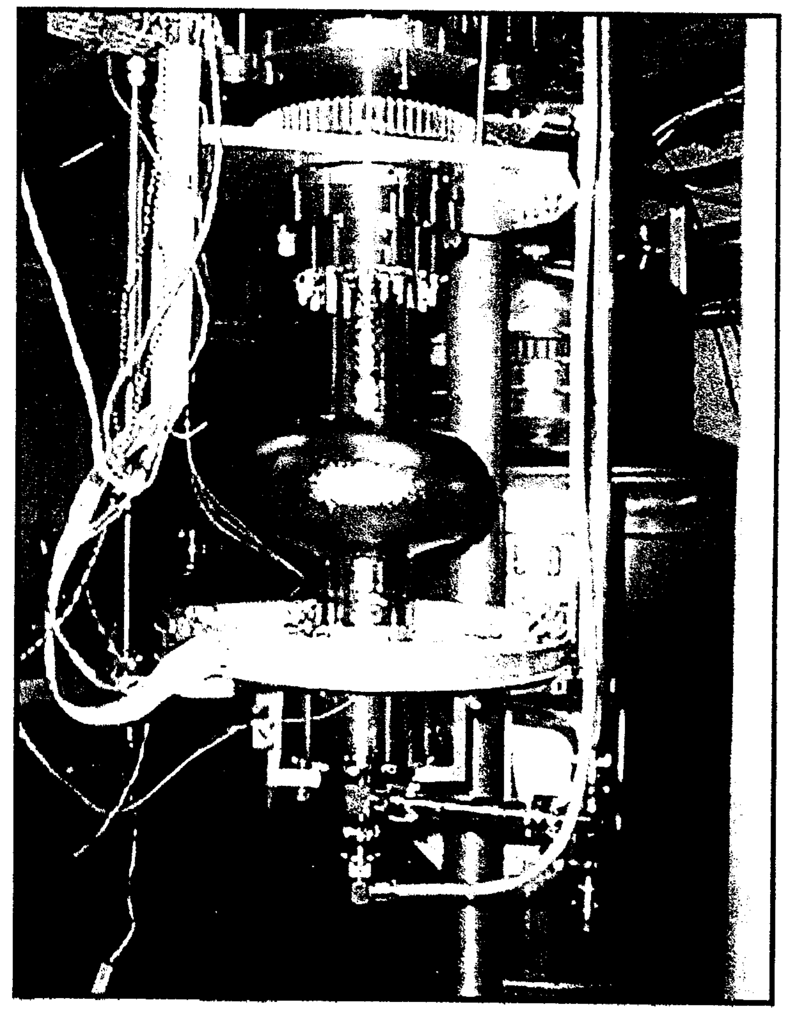
- **Hot forming**

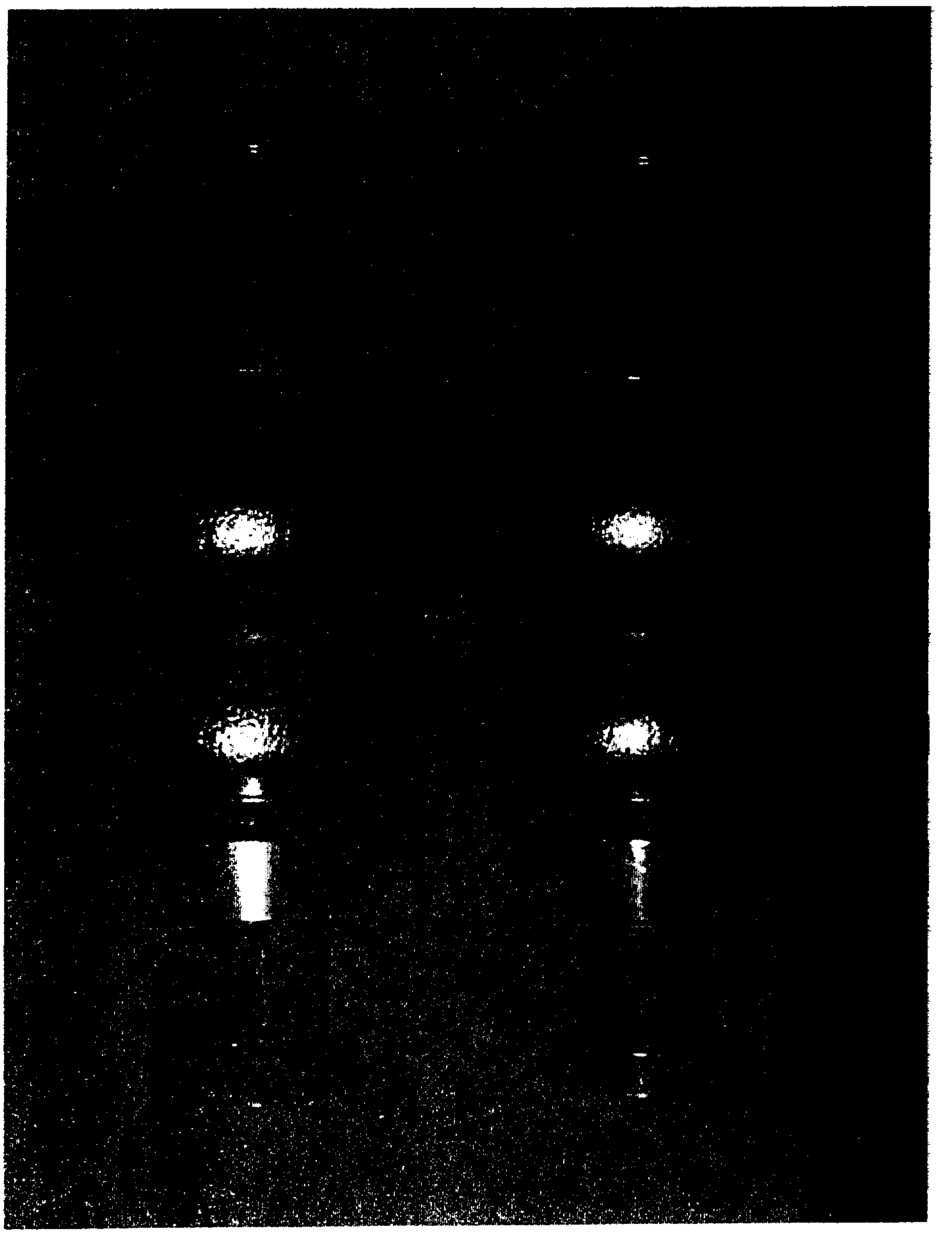
  most appropriate temperature found to be 900 and 1400º

  mechanical behaviour however show max. deformations below 120%

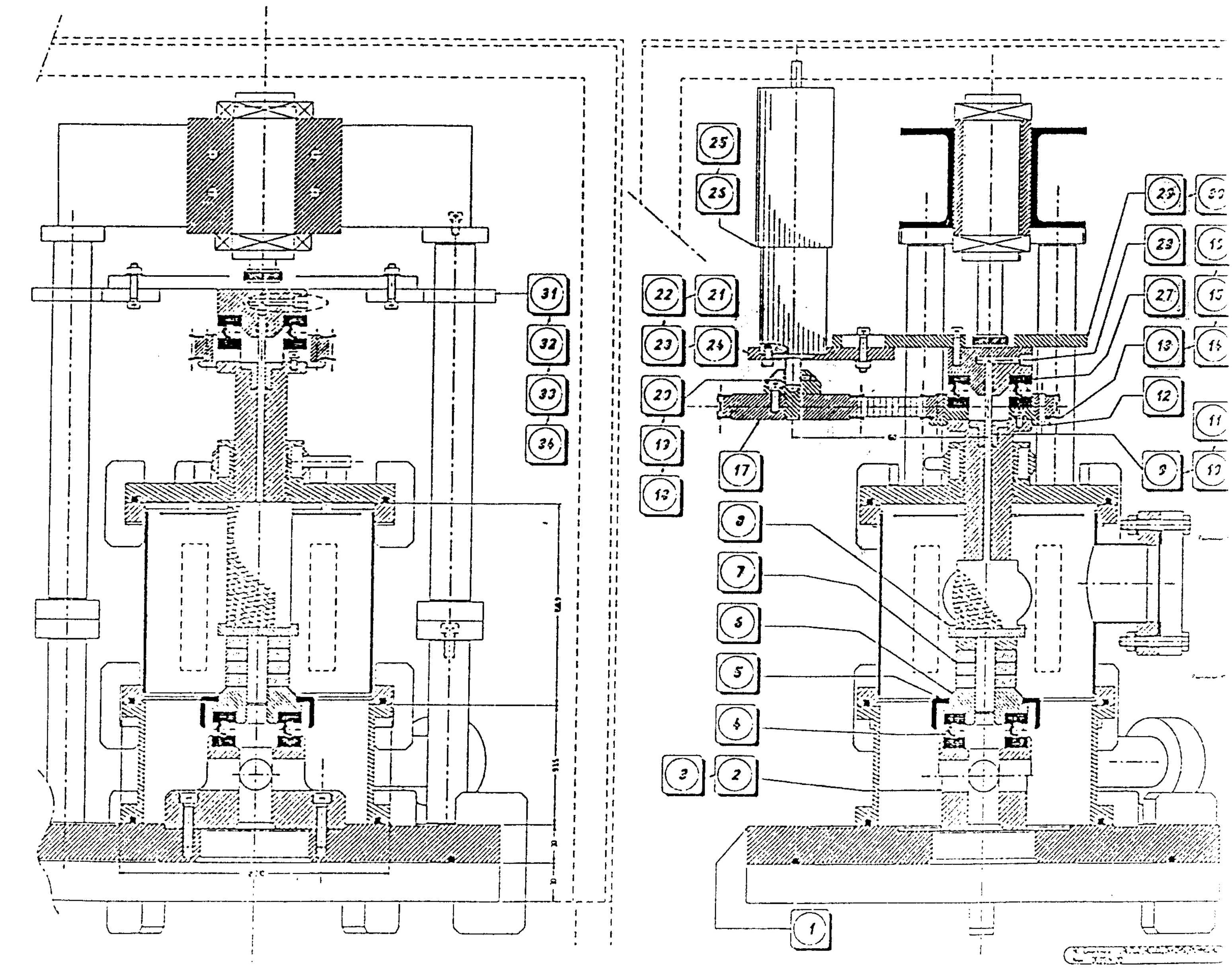
Hydroforming







- First annealing at 900° before delivery to the company
- First two-cell cavities hydroformed



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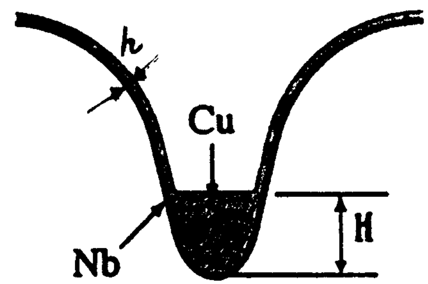
Formage à chaud Température 850 °
Tube Niobium épaisseur 0,5 mm - diamètre 38 mm
Pression interne 20 bar - Poussée axiale 500 kg

THE ALTERNATIVE STIFFENING SCHEME

3

The principle: add a copper layer onto the cavity outer wall by thermal spraying.



The goal: find a good technical solution, of high stiffening capability and not affecting the cavity performances (Qo level and max field)

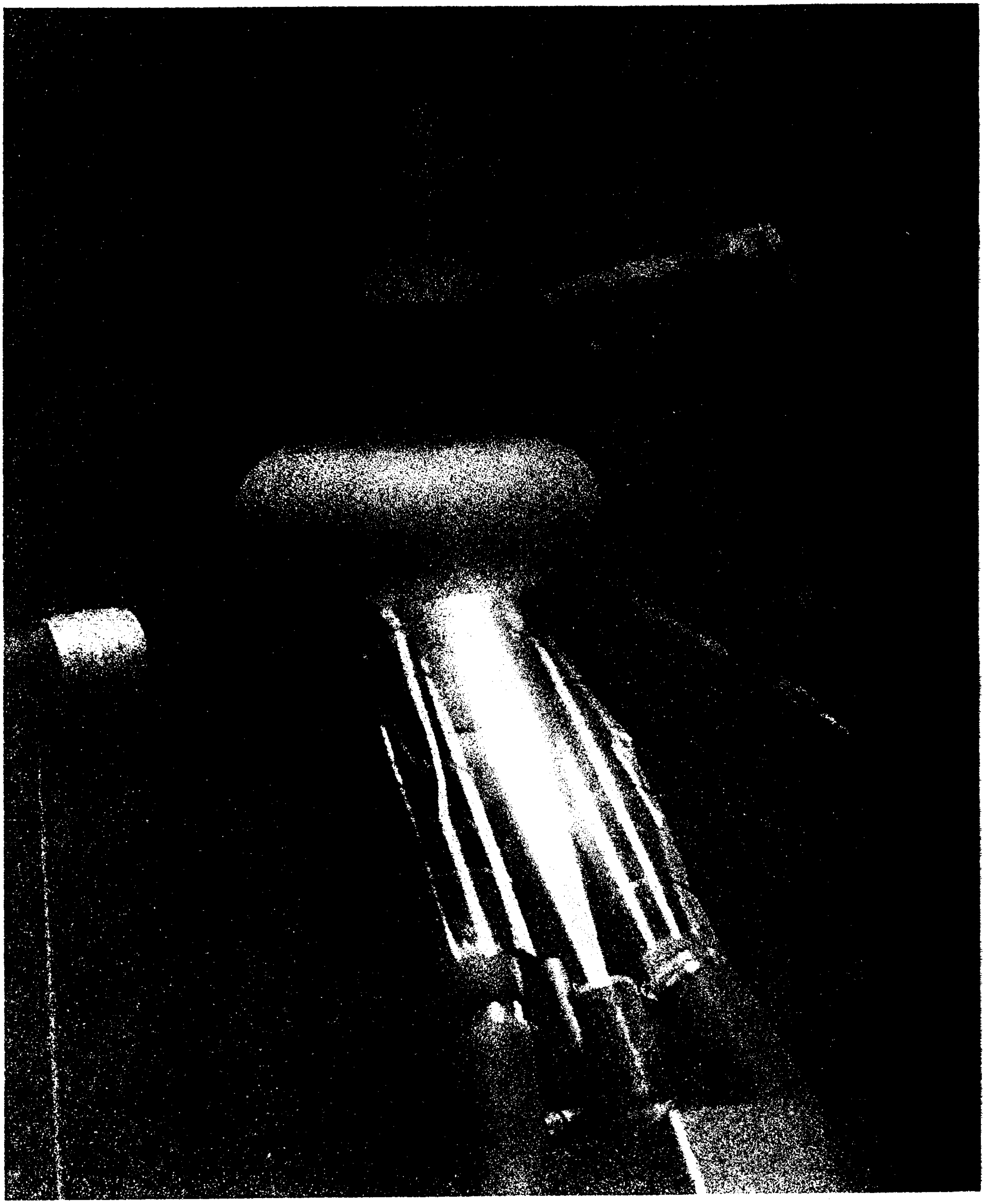
The advantages: industrial (fully automated process, compatible with large scale production), lower cost (reducing Nb thickness, avoiding expensive EB weldings of stiffening rings), could be efficient even for high gradients (40 MV/m).

THE THERMAL SPRAYING TECHNIQUES

4

A lot of different thermal spraying techniques exits, each of them can produce coatings with specific properties. The main differences are the heat source and the environment.

Process	Flame Spraying (FS)	High Velocity Oxy-Fuel (HVOF)	Atmospheric Plasma Spraying (APS)	Controlled Atmosphere Plasma Spraying (CAPS)	Vacuum Plasma Spraying (VPS)	Arc Spraying (AS)
Heat source	Combustion of fuel gas in oxygen	Combustion of fuel gas in oxygen at high pressure	Plasma (mixture of Ar/H_2, Ar/He or Ar/N_2)	Plasma (mixture of Ar/H_2, Ar/He or Ar/N_2)	Plasma (mixture of Ar/H_2, Ar/He or Ar/N_2)	Arc heating (consumable electrodes)
Heat source temperature	3000 - 3500 K	3000 - 3500 K	10000 K - 15000 K	10000 K - 15000 K	10000 K-15000 K	-
Exhaust jet speed	80 - 100 m/s	1500-2000 m/s	500 - 800 m/s	500 - 800 m/s	1500 - 3000 m/s	particle speed < 150 m/s
Particle size	Powder: 5-100 µm Wire diameter 3-6 mm	5 - 50 µm	5 - 100 µm	5 - 100 µm	5 - 20 µm	Wire diameter: 2 - 5 mm
Atmosphere	Air	Air	Air	Inert Gas Ar, He, N_2	vacuum (50 mbar)	Air
Porosity	10 - 20 %	< 5 % < 1 % possible	1- 10 % typical	1- 10 %	< 2 %	10 -20 %
Bonding strength	30 MPa typical 70 MPa max.	> 60 MPa typical 100 MPa achievable	20 - 80 MPa	20 - 50 MPa 80 MPa achievable	> 80 MPa	10-30 MPa typical
Remarks	Industrial, high oxidation	Industrial, high bonding strength	Industrial, high oxidation	Low oxidation homogeneous coating	Low oxidation, high bonding strength	Industrial, poor coating properties



COATINGS CHARACTERISTICS

13

Thermal and mechanical characteristics of coatings for various deposition process

(An X means no sample available for measurement)

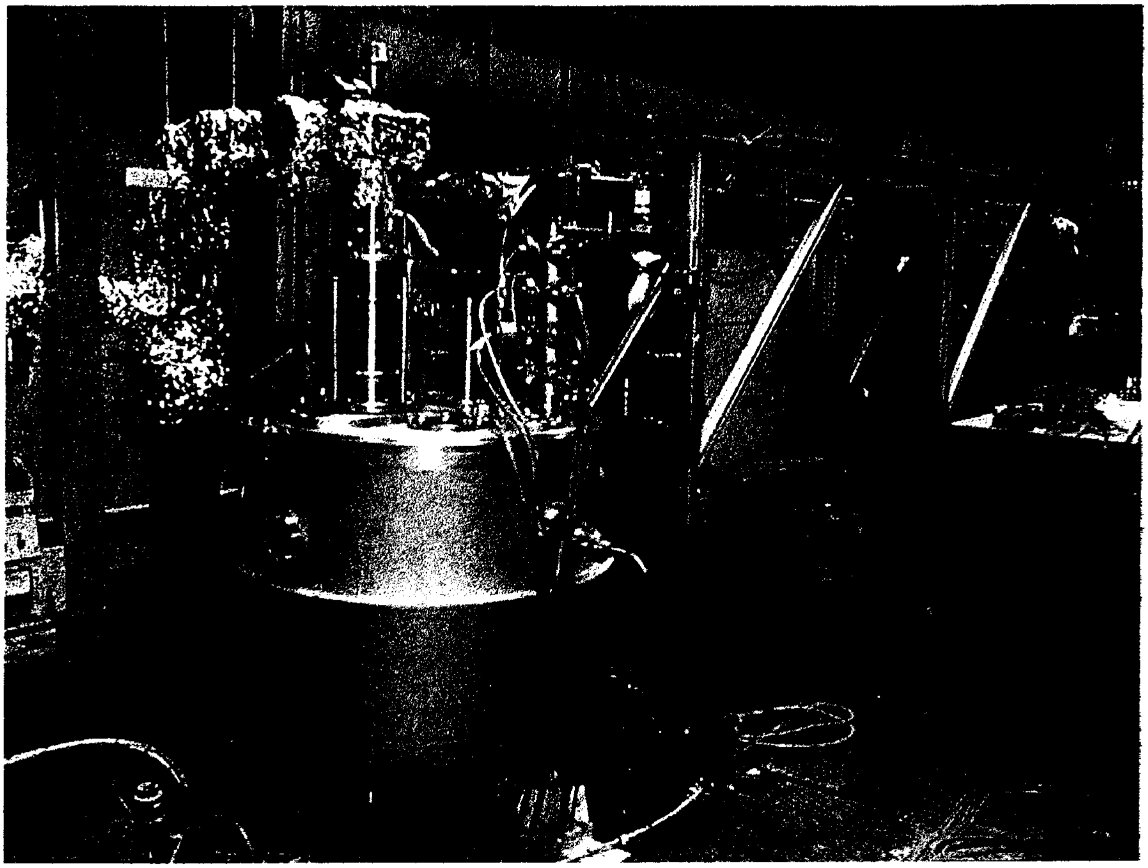
Cu APS *Mollard*	3	25	≈ 20/30%	4.0 10^{-4} (2 mm)	3	1.55	≈ 75	Stiffening 33 MV/m
Cu CAPS *CEA*	X	≈ 60	9.8 %	3.9 10^{-4} (2 mm)	3	X	≈ 100	Stiffening > 35 MV/m
Cu HVOF *Sevenans*	3	53	2.6 %	> 1.43 10^{-3} (3 mm)	> 10	0.19	≈ 100	Heat transfert < 30 MV/m
Ti APS *SICN*	3	18	≈ 20/30%	5.0 10^{-4} (2 mm)	3.5	X	X	Stiffening < 32 MV/m
Cu APS *Evry*	4	60	1-2 %	> 1.8 10^{-3} (3 mm)	> 16	0.22	≈ 100	Heat transfert < 25 MV/m
Ultimate Goal		95		4.2 10^{-4}	3	4.8 (for e_{Cu}=2mm & no He penetration)	80 -100	40 MV/m

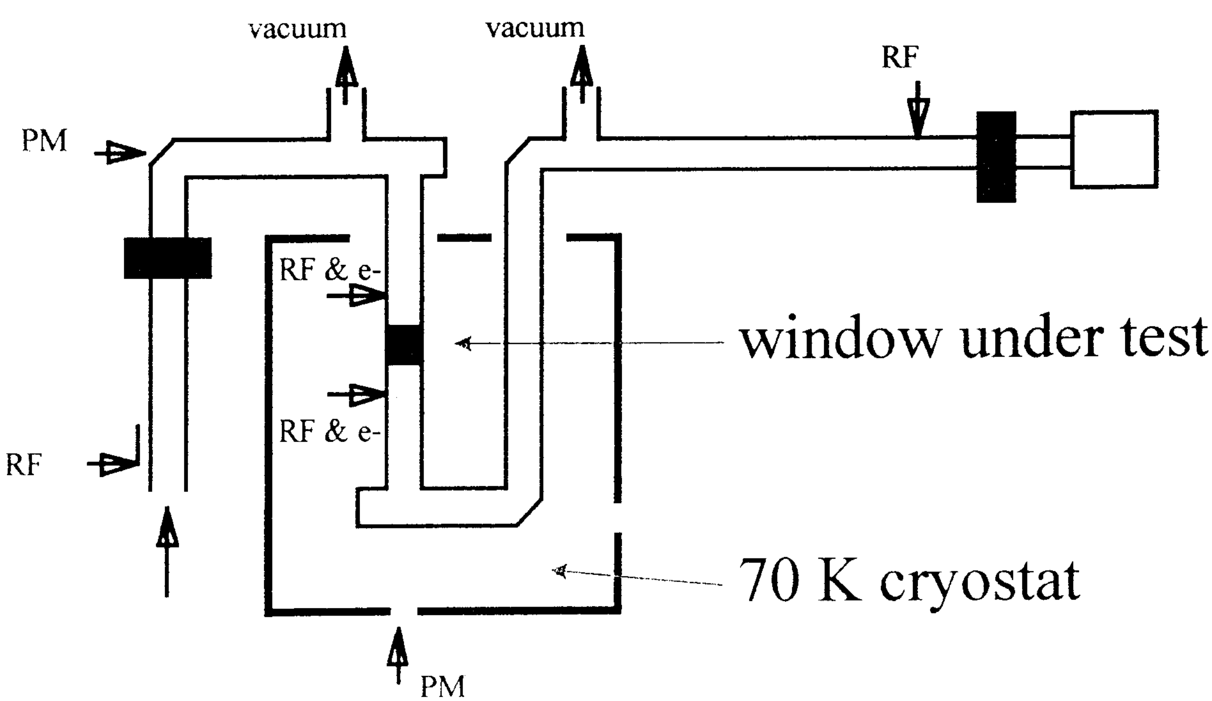
The room-temperature electrical resistivity is a factor 5 lower than the bulk copper resistivity.
The oxide content of the copper coating obtained by the APS (Evry) process was measured to be 12 % (quite high).

The coating thermal conductivity is much lower than the bulk material one, probably due to the high oxidation. As showed with Ti, the poor coating thermal conductivity is short-circuited by the superfluid helium when the porosity rate is high.
The CAPS process (under inert gaz), thanks to the reduced oxidation, seems to be a possible solution for TESLA -800 cavity stiffening (34 MV/m).

SACLAY-ORSAY COUPLER TEST STAND

M. Desmons (Saclay)





$\lambda/2$ window tests results

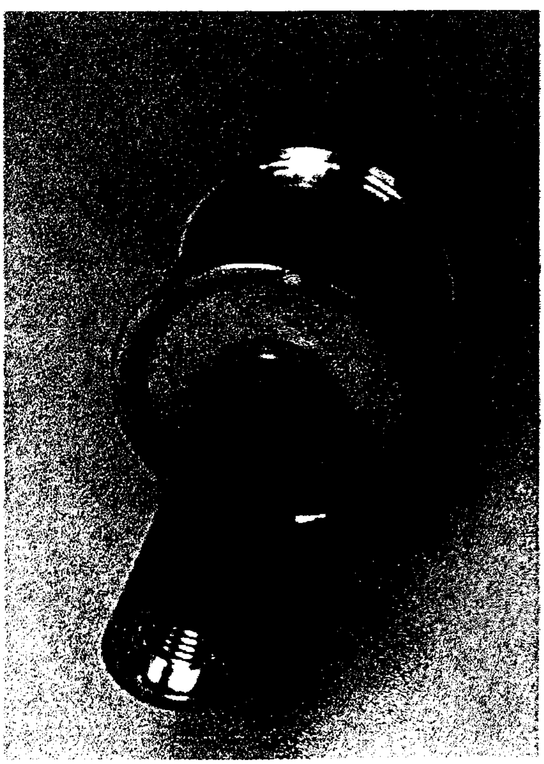
C. Travier (Saclay)

Advantages

- easiest concept
- low cost
- robustness
- E field parallel to ceramic
  ➡ no multipactor

Drawbacks

- maximum field at brazing point
- high dielectric losses
- direct view of cavity electrons



Test results

1 MW, 1.3 ms, 0.1 Hz
at 300 K and 80 K

no multipactor on window
no problems with max field on brazing
dielectric losses depends on position
in SW regime (factor9 between max and min)

Travelling wave window

C. Travier (Saclay)

Advantages

- pure TW in ceramic
- no direct view of cavity electrons
- low field at brazing point
- low dielectric loss
- great flexibility in parameter choice
- moderate cost
- E field parallel to ceramic
  ➡ no multipactor

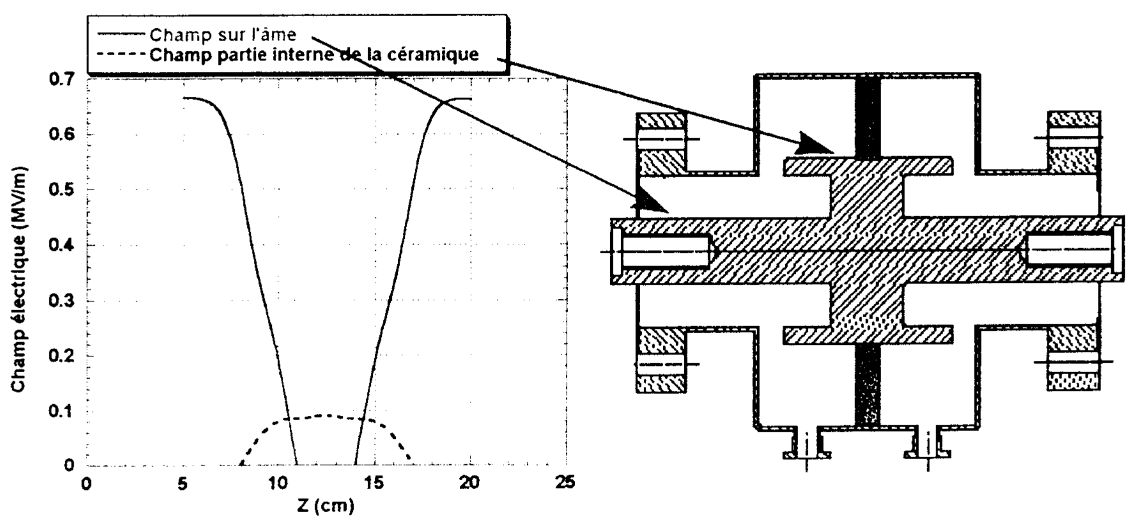
Drawbacks

- large diameter
- high field on noses

difficult to clean

Test results

1 MW, 1 ms, 0.1 Hz
@ 300 K and 100 K.
- no multipactor

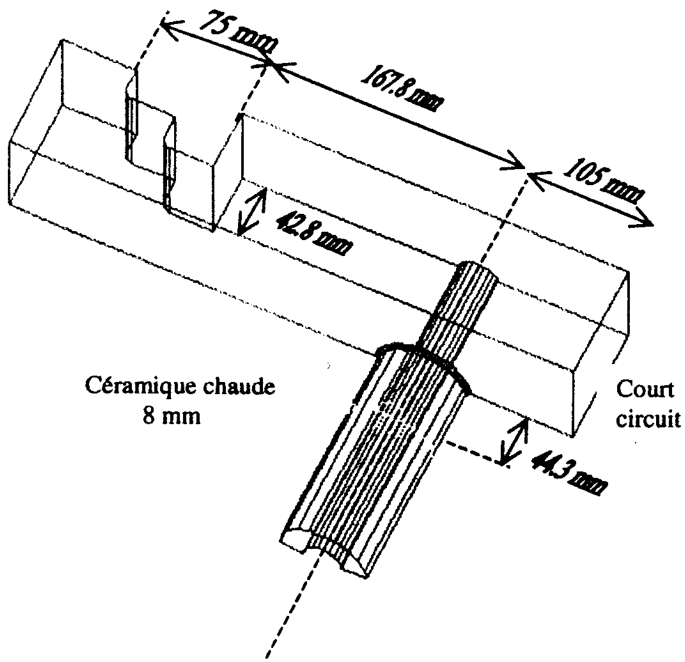


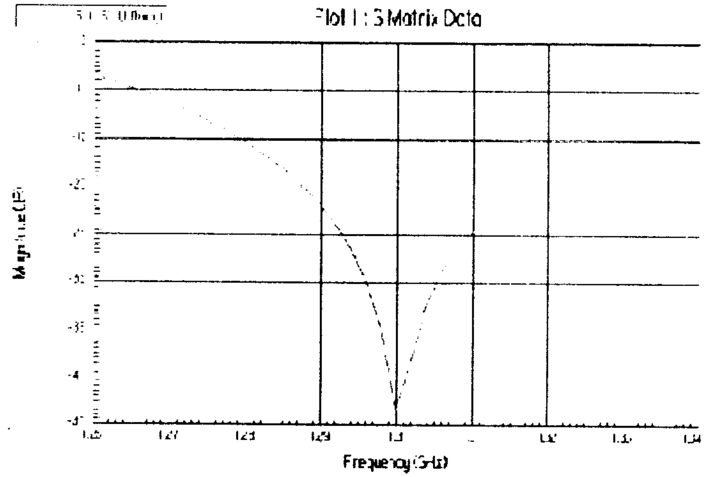
See poster on Wednesday WEP015

ON GOING STUDIES
- TiN coating
- multipacting simulations
- metal / [illegible]

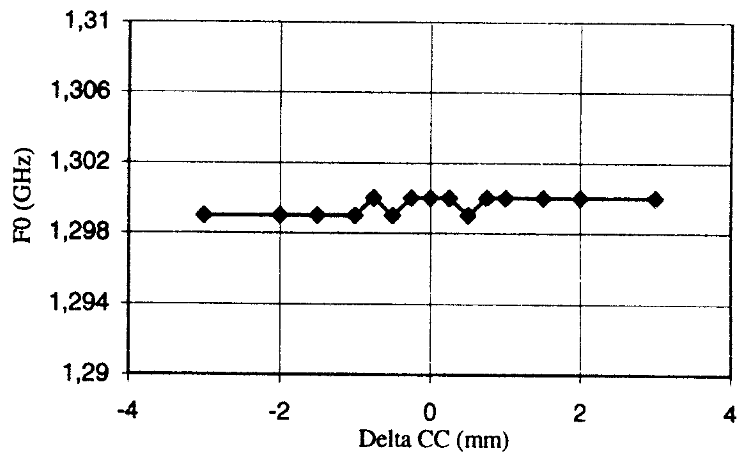
HIGH POWER COUPLERS

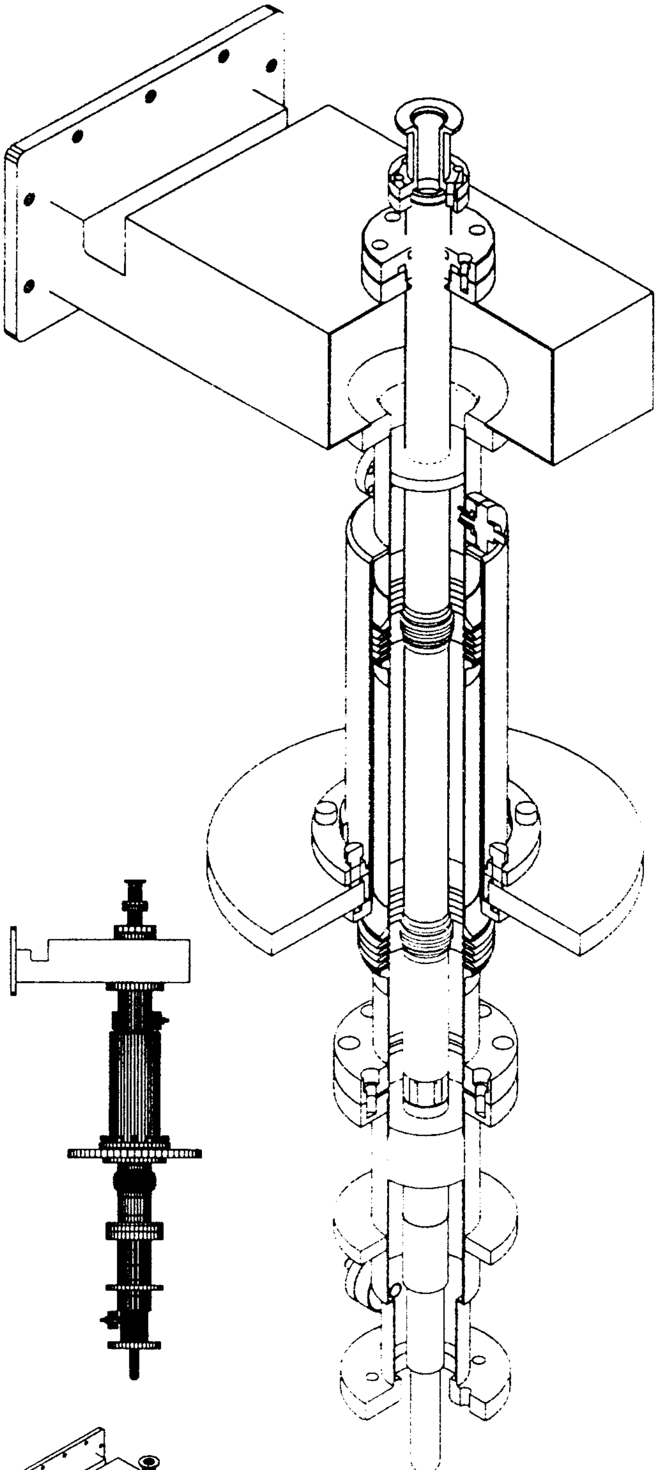
- Goals were to build a transition operated with neutral gas pressure and that integrates the warm ceramic window
- The proposed transition uses a thin ceramic and is matched at 1.3 GHz using reduced sizes waveguides
- The transition can be upgraded to include a DC bias
- Mechanical tolerances are relaxed and cost [illegible]

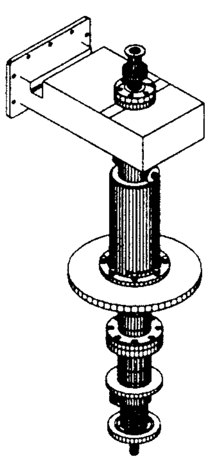


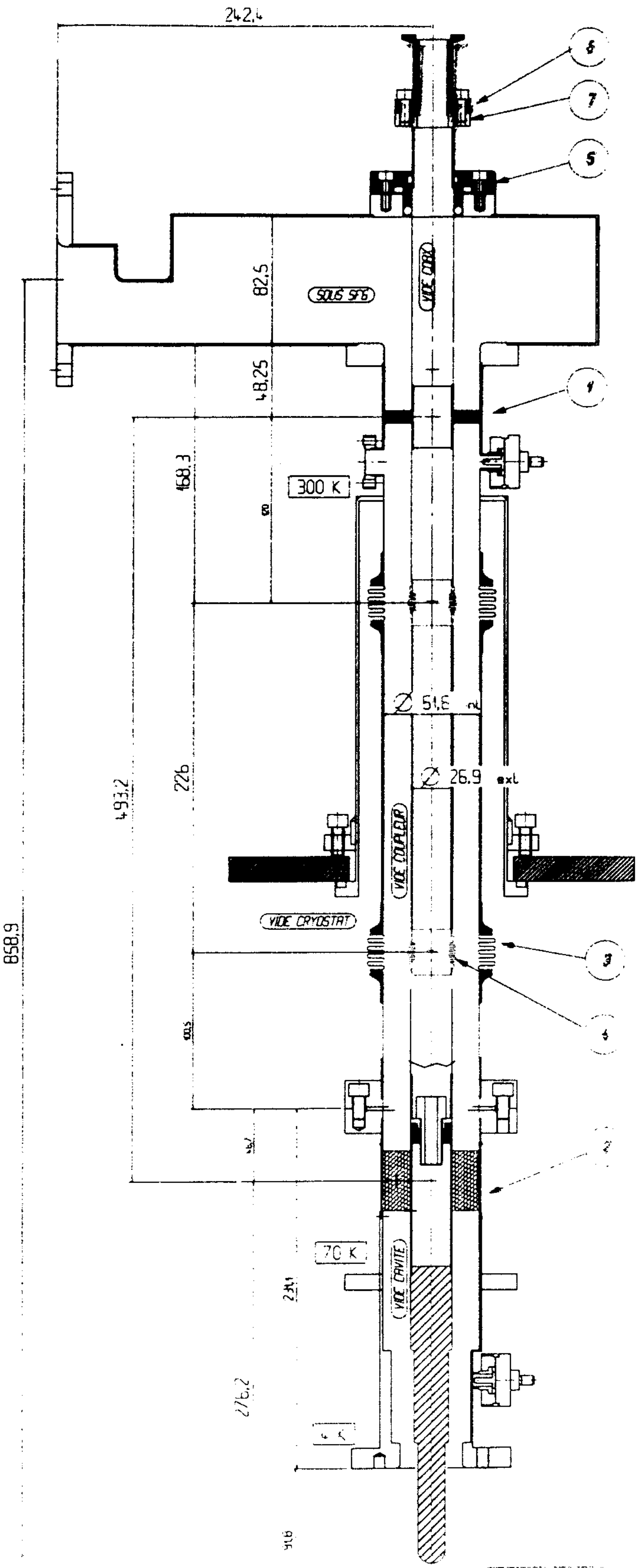


Variation of the localisation of the short-circuit









REP	QUANT	N° PLAN	DESIGNATION	MATIERE	QUAL	OBSERVATION
7		25APEO316-1	CONTRE BRIDE	RU-4		
	.		JOINT R 16	VITON		
6	.	25APEO316-2	PIPE KF25	RU-4		
			JOINT KF [illegible]			[illegible]
	5		VIS CHc 6-16 [illegible]			
			JOINT R 20	VITON		
			JOINT R 26	VITON		
5	.	25APEO316-3	BRIDE	RU-4		
4	2	25APEO318-2	SOUFFLET D=34			
3	2	25APEO318-1	SOUFFLET D=60			
2	.	25APEO351-2	PARTIE FROIDE			
	.		VIS CHc 4-25	INOX		ARGENTEE
	8		VIS CHc 8-30	INOX		
1	.	25APEO351	PARTIE CHAUDE			

[illegible] GHz
[illegible] MW
TAUX DE REPETITION
CONTINU

BASE DE DONNEES [illegible] COUPL2 [illegible]
TRAITEMENT
PROTECTION
MATIERE
TOLERANCES GENERALES
ASSOCIATE GENERALE

TTF
COUPLEUR PRINCIPAL

DESSINE
APPROUVE
SECAP
LAL
IN2P3