i r f u

cea

saclay

Cavity design

Fundamental parameters : frequency, beta, number of cells (gaps), Eacc

Optimisation :
R/Q, surface fields / Eacc, Qex, damping of HOMs, kloss, cell to cell coupling
Multipactor, surface preparation
Sensitivity to LHe pressure, to LFD, to microphonics

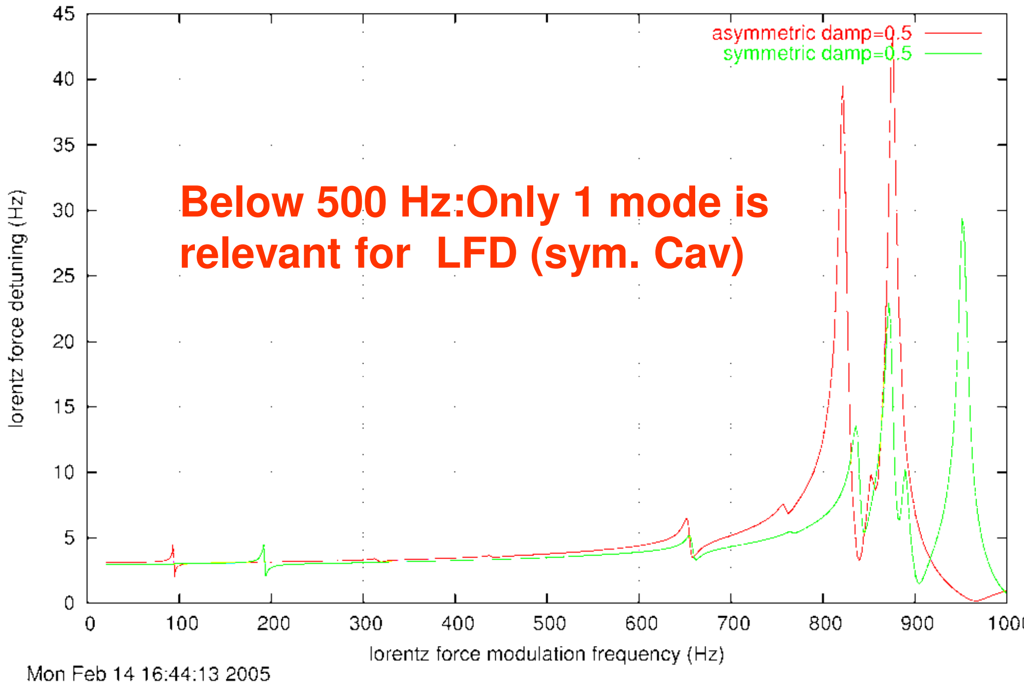
Extraits des présentations CARE/HIPPI
(G. Devanz, J. Plouin, S. Chel)

irfu
cea
saclay

Example : HIPPI cavity

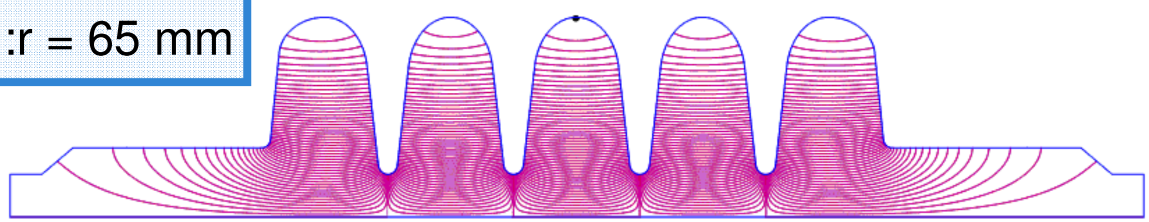
RF parameters

Frequency [MHz]	704
geom β	0.47
opt β	0.52
r/Q [Ω]	173.4
G [Ω]	161.2
Epeak/Eacc	3.36
Bpeak/Eacc	5.59

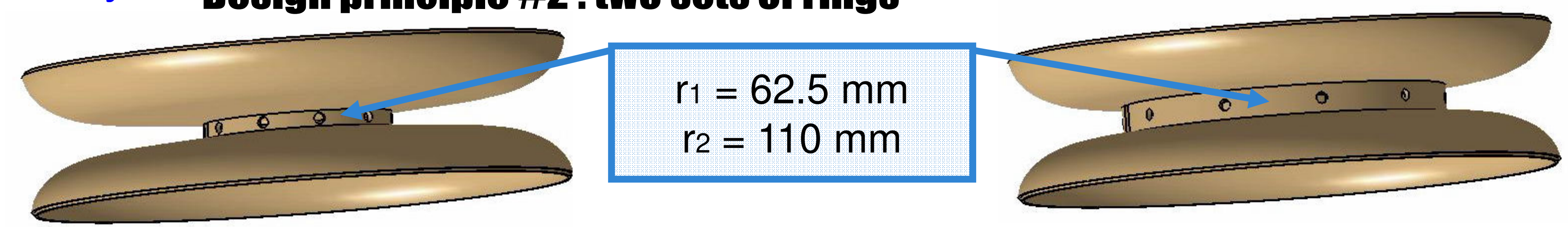


Design principle #1 : symetric end-tubes

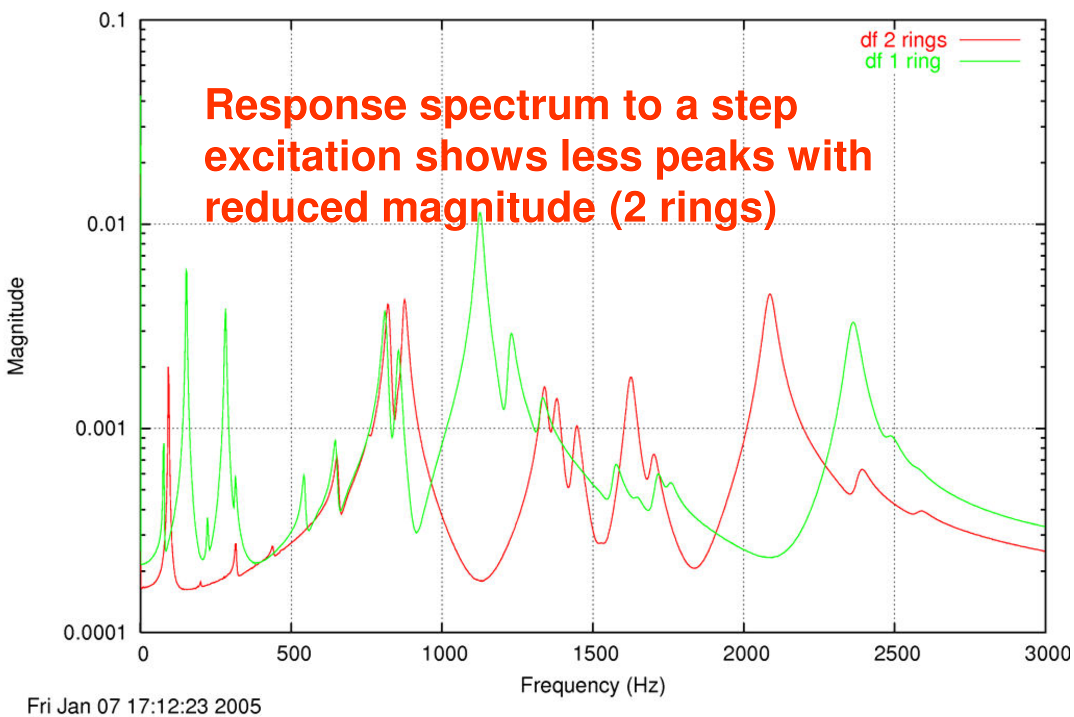
end-tubes :r = 65 mm



Design principle #2 : two sets of rings

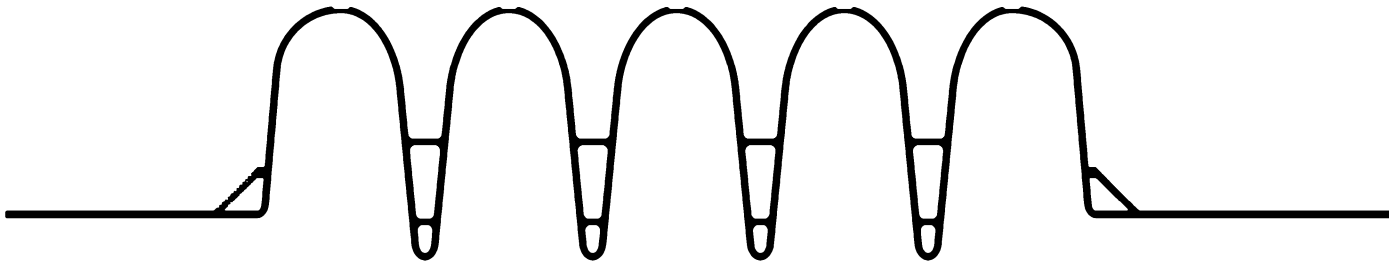


Strengthen the cavity w.r.t external pressure



Mechanical Parameters

Stiffness	2.25 kN/mm
Tuning sensitivity	308 kHz/mm
tuning stress	49 MPa/mm
Tuning range@ 300K assuming σy = 40 MPa	+/- 250 kHz



Regulations ⇒ the cavity must sustain twice the maximum pressure

Max Pressure = 1.3 bar during test in vertical cryostat -> Preg = 2.6 bars

Structural FEM calculations with fixed ends

Sym + 1 set of rings :

max stress on beam tube iris 90 MPa

Sym + 1 set of rings + stiffeners on beam tube iris :

max stress around ring /cell junction 70 Mpa

and 50 Mpa @ equator weld

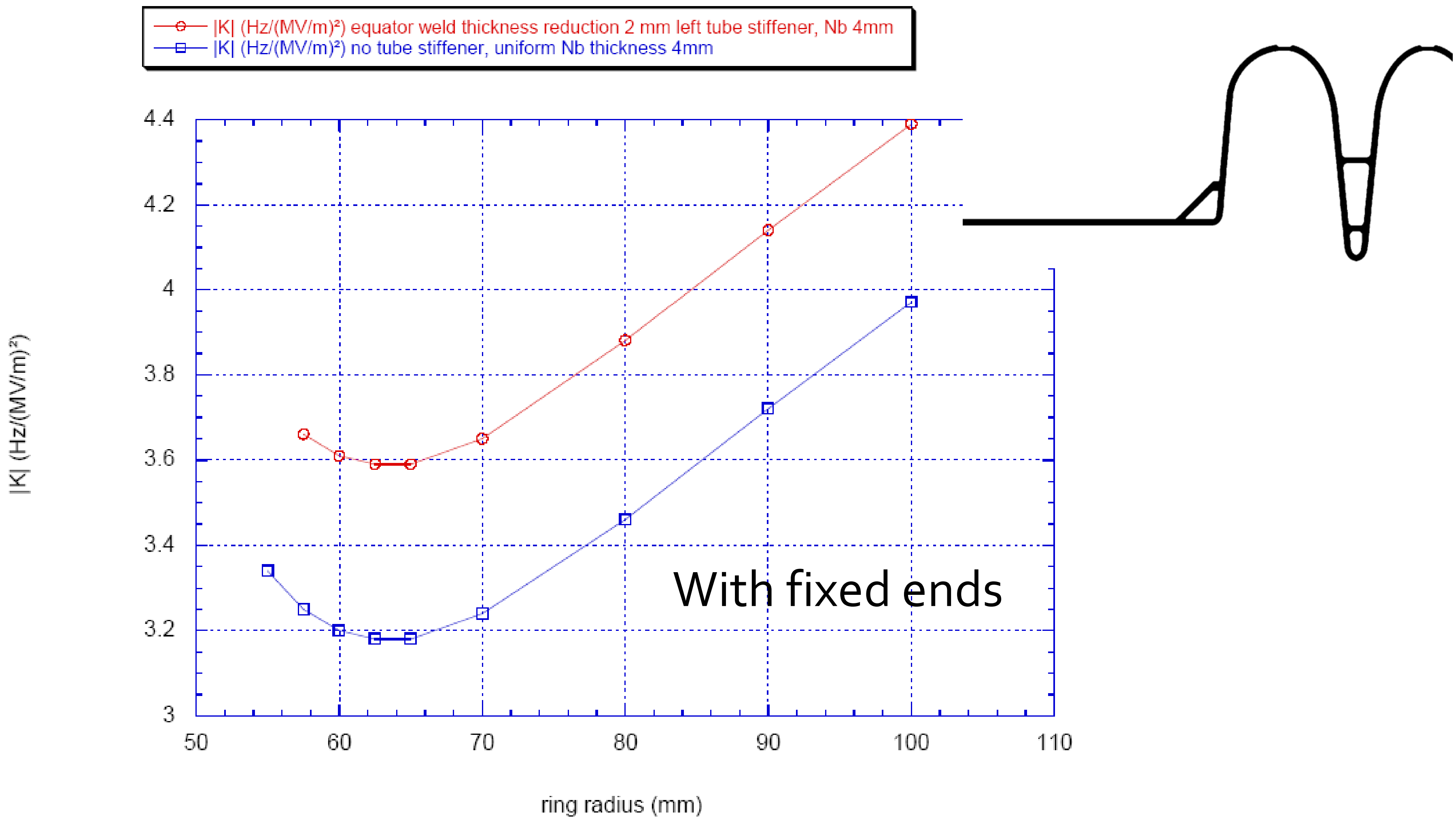
And with second set of rings:

max stress @ stiffener/outer cell junction 40 MPa

stress @ equator 29 MPa

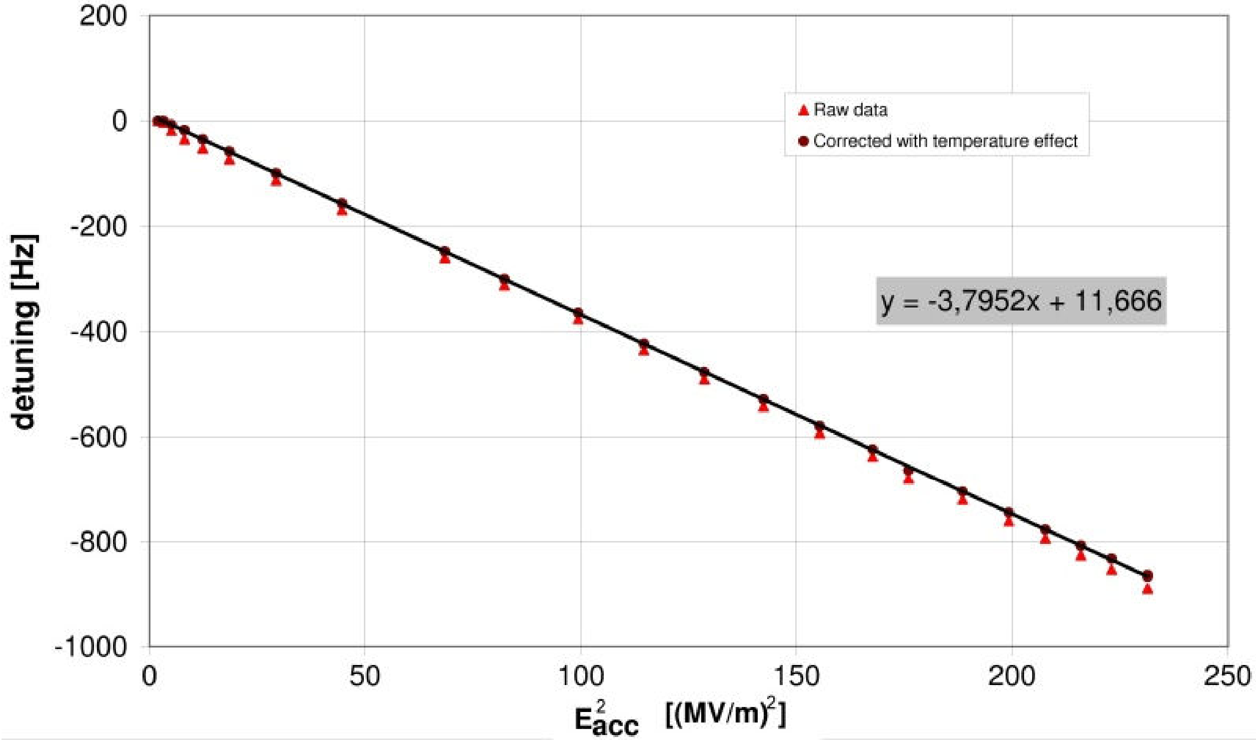
irfu

saclay



|K| (Hz/(MV/m)²) equator weld thickness reduction 2 mm left tube stiffener, Nb 4mm
|K| (Hz/(MV/m)²) no tube stiffener, uniform Nb thickness 4mm
4.4
4.2
4
3.8
3.6
3.4
3.2
3
|K| (Hz/(MV/m)²)
50
60
70
80
90
100
110
ring radius (mm)
With fixed ends

Measurement of static LFD (1)



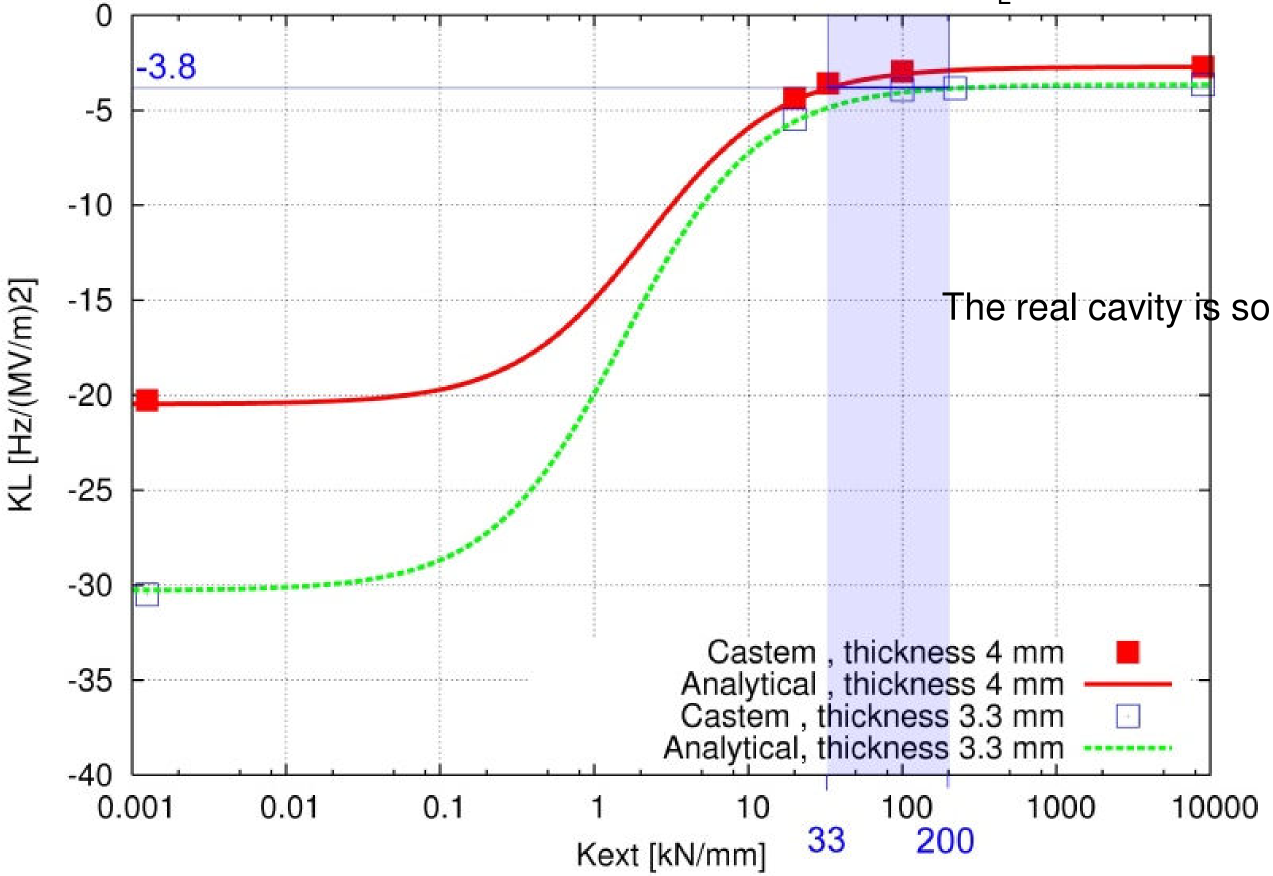
temperature changes during experiment -> pressure changes-> need for a correction of the frequency measurements (black dots)

Very good result KL = -3.8 Hz/MV/m

Measurement of static LFD (2)

taking into account the fact that the thickness of the real cavity is not constant:
extreme cases :
- 4 mm theoretical basis for the design
- 3.3 mm average value measured on the real cavity on the non stiffened part of the cells

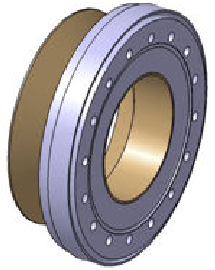
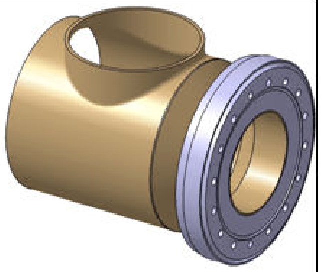
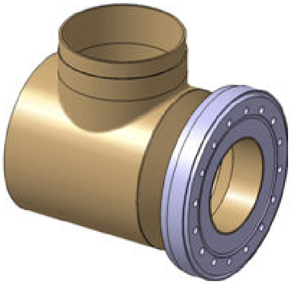
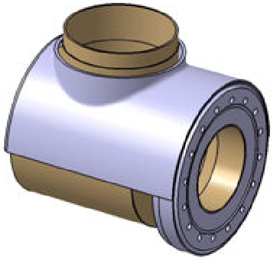
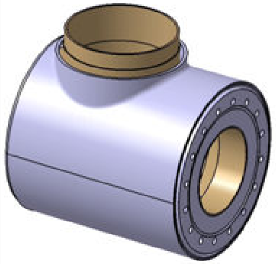
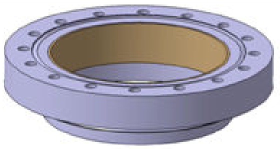
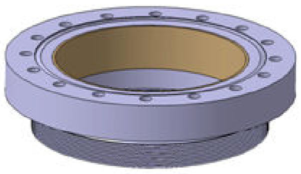
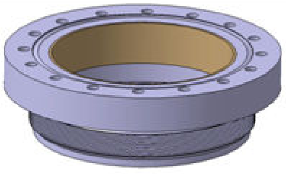
effect of the external stiffness on K_L

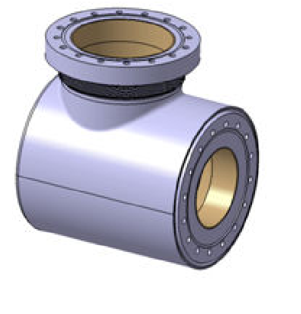
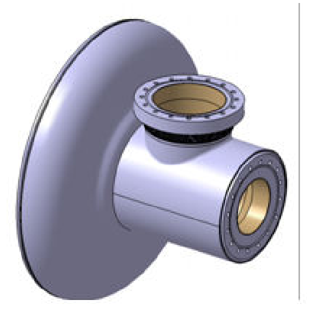
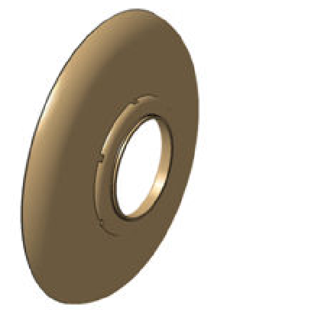
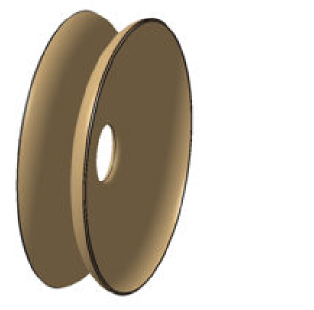
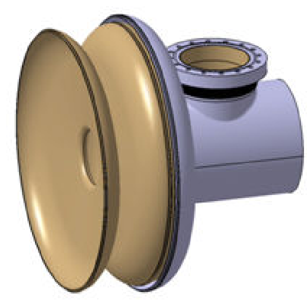
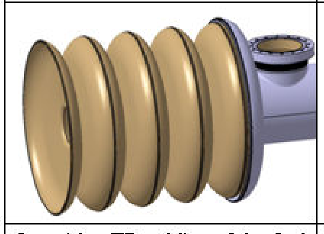
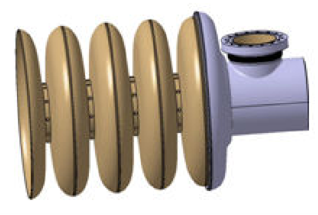
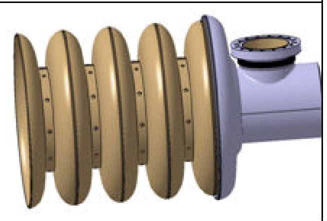


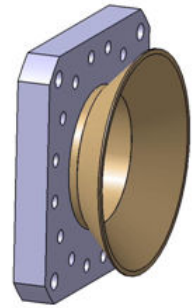
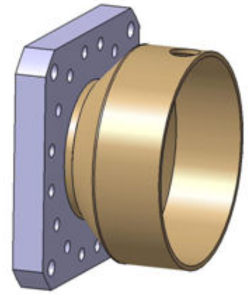
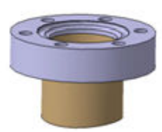
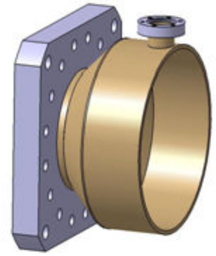
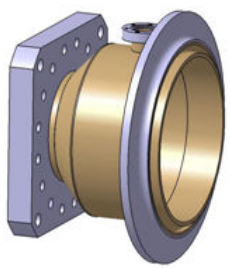
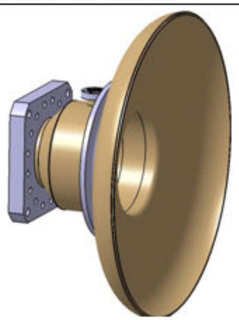
The real cavity is somewhere in between...

Other requirements:

-Global Stiffness > 50 kN/mm (shape of Helium tank)
-Appropriate cooling of the FPC (port inside the helium tank)
-Provide enough space for PU port, tuning system, HOM ports
-Ability to add stiffening rods for tests w/o tuning system

		
Step_1 = EB welding of Ø80 beam tube _C with conical ring _C	Step_2 = brazing of end-flange_C on step_1 piece	Step_3 = EB welding of step_2 piece with Ø130 beam tube _C
		
Step_4 = EB welding of step_3 piece with coupler tube	Step_5 = TIG welding of step_4 piece with helium tank top cylinder	Step_6 = TIG welding of step_5 piece with helium tank bottom cylinder
		
Step_7 = brazing of the coupler flange on the coupler tube	Step_8 = TIG welding of the bellow with the step_7 piece	Step_9 = TIG welding of the ring with the step_8 piece

		
Step_10 = TIG welding and EB welding of step_6 piece with step_9 piece	Step_11 = TIG welding of step_10 piece with helium tank cup_C	Step_12 = EB welding of end stiffener_C on end half-cell_C
		
Step_13 = EB welding of step_12 piece on step_11 piece	Step_14 = EB welding of two middle half-cells	Step_15 = EB welding of step_14 piece on step_13 piece
		
Step_16 = EB welding of the final "diabolo" on the cavity	Step_17 = EB welding of the Ø62 stiffening rings on step_16 piece	Step_18 = EB welding of the Ø110 stiffening rings on step_17 piece

		
Step_19 = EB welding of Ø80 beam tube _P on conical ring _P	Step_20 = brazing of end-flange_P on step_19 piece	Step_21 = EB welding of step_20 piece with Ø130 beam tube_P
		
Step_22 = brazing of the Pick-up flange with the Pick-up tube	Step_23 = EB welding of step_22 piece on step_21 piece	Step_24 = brazing of the helium tank end disk with the H shape ring
		
Step_25 = EB welding of step_24 piece on step_23 piece	Step_26 = EB welding of end half-cell_P (with already welded end stiffener_P) on step_25 piece	Step_27 = EB welding of step_25 piece on step_26 piece *FIRST DELIVERY TO CEA-Saclay*

AISI 316LN bellows after 650° heat treatment=ok

Fabrication of the Niobium cavity

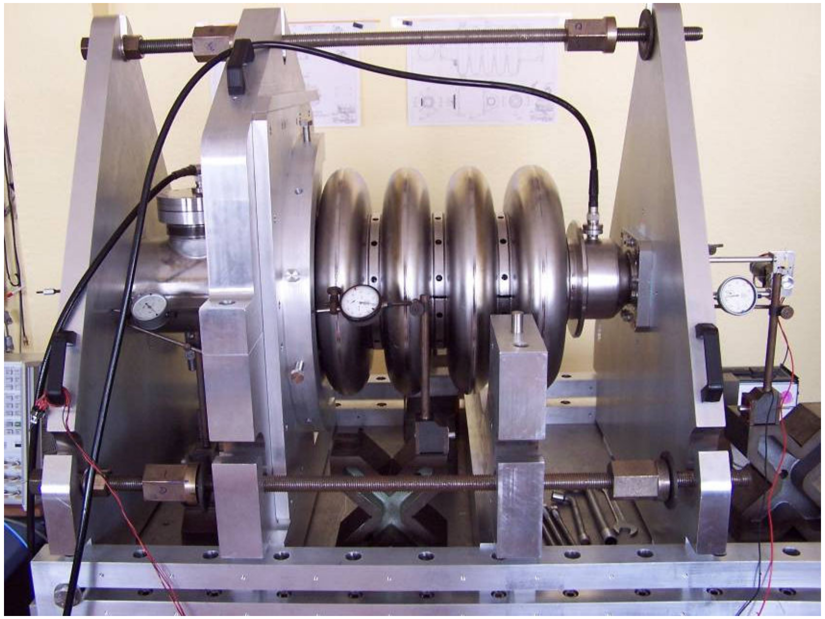
- *Dimension controls and visual inspection (endoscope)*
- *Degreasing in ultra-sonic bath*
- *Vacuum test ; frequency+ dispersion curve measurement*
- *Preparation of the antenna for cold test in vert. cryostat*
- *Chem. polishing on the inner face (FNP 1-1-2, 150 um)*
- *Ultra-pure water rinsing*
- *Field flatness ; frequency+ dispersion curve measurement*
- *Degreasing in ultra-sonic bath*
- *Heat treatment at 650 ° for 24 hours (<10-6 mbar)*
- *Field flatness ; frequency+ dispersion curve measurement*
- *Chem. polishing on the inner face (FNP 1-1-2, 20 um)*
- *Ultra-pure water rinsing*
- *HPR, drying, cavity assembly and vacuum test in CR*
- *Cold test in vertical cryostat with a fast cool down*
- *Cold test in vertical cryostat with a slow cool down*
- *Slow admission of CR air in the cavity up to 1bar*
- *Sealing up of the cavity in CR ; delivery to manufacturer*

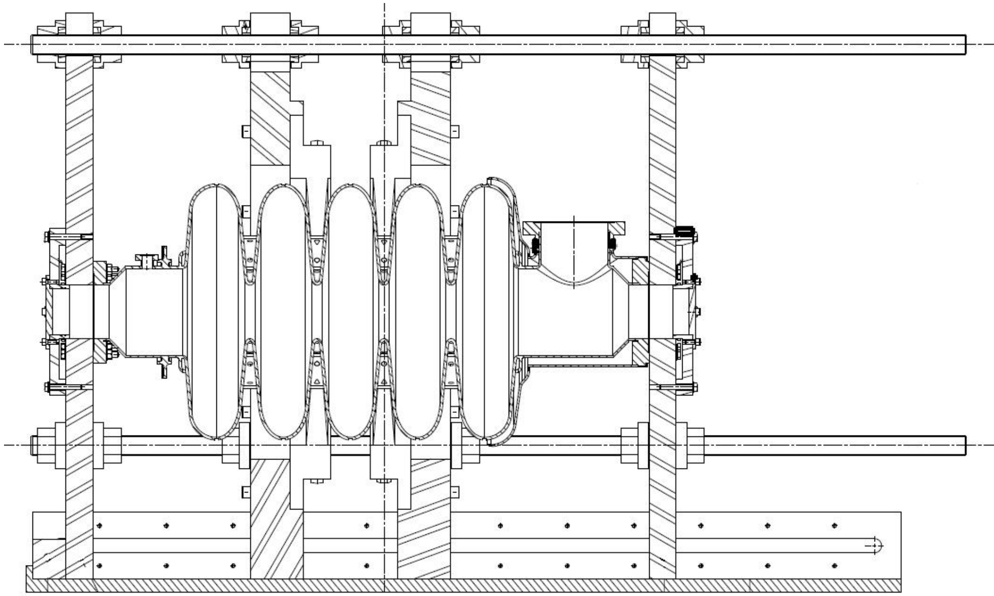
irfu
saclay

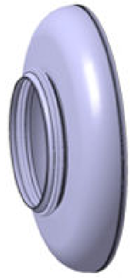
Set-up for adjustment of field flatness

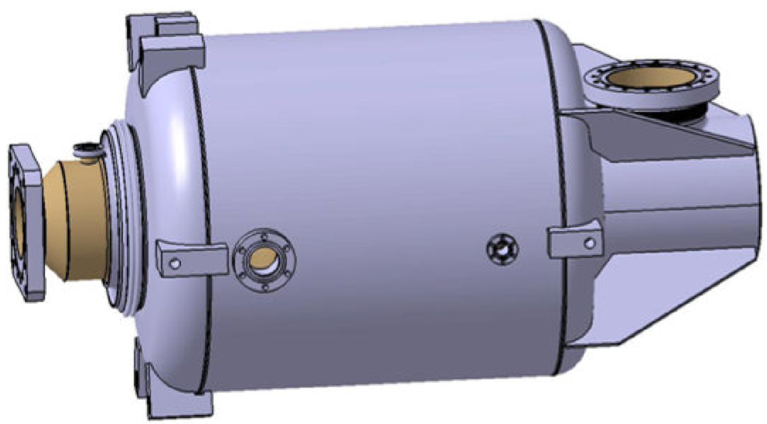
Specifications

Plastic deformation DL [mm]	2
Cavity axis & set-up axis parallelism [°]	2
Total axial displacement [mm]	5
Precision of axial displacement [mm]	0.5





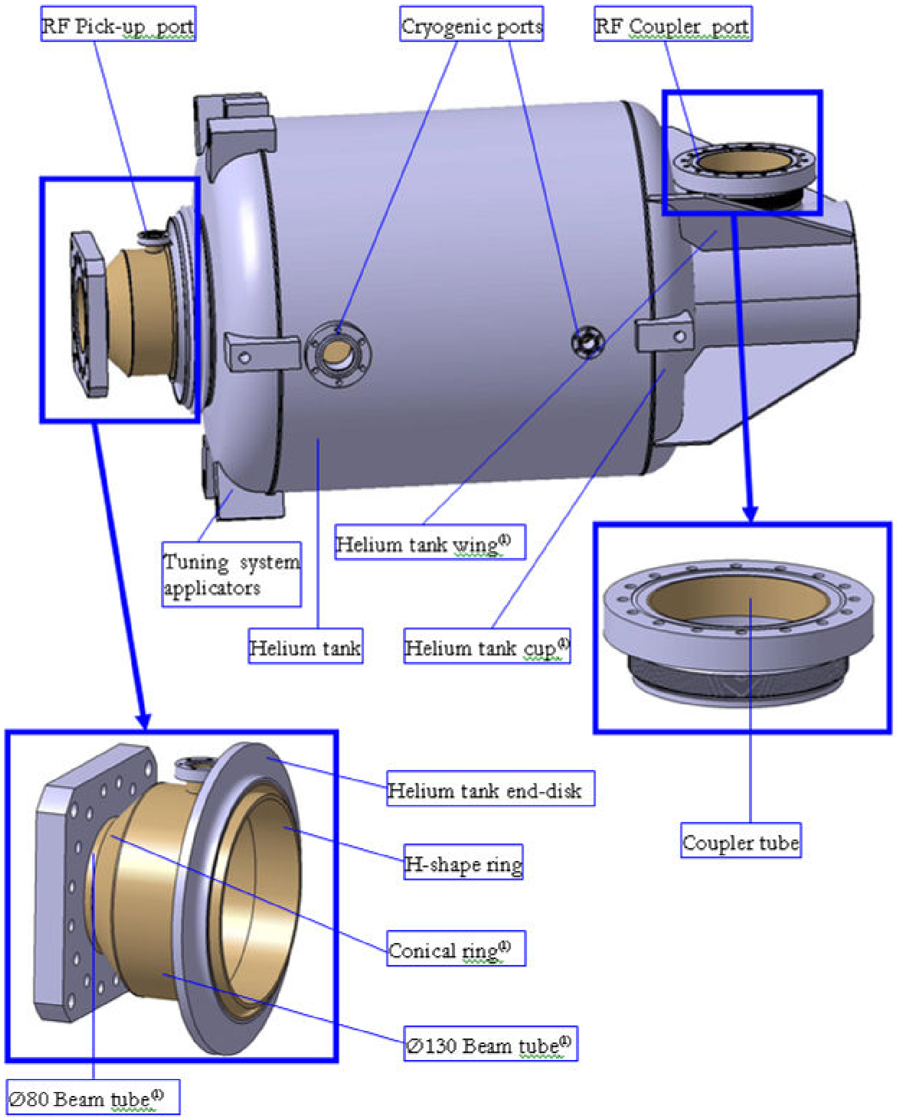
		
Step_28 = TIG welding of step_27 piece with helium tank cylinder	Step_29 = TIG welding of helium tank cup_P with stainless steel bellow	Step_30 = TIG welding of step_29 piece with step_28 piece



Step_31 = TIG welding of step_30 piece with tuning system applicators and helium tank wings
FINAL DELIVERY TO CEA-Saclay

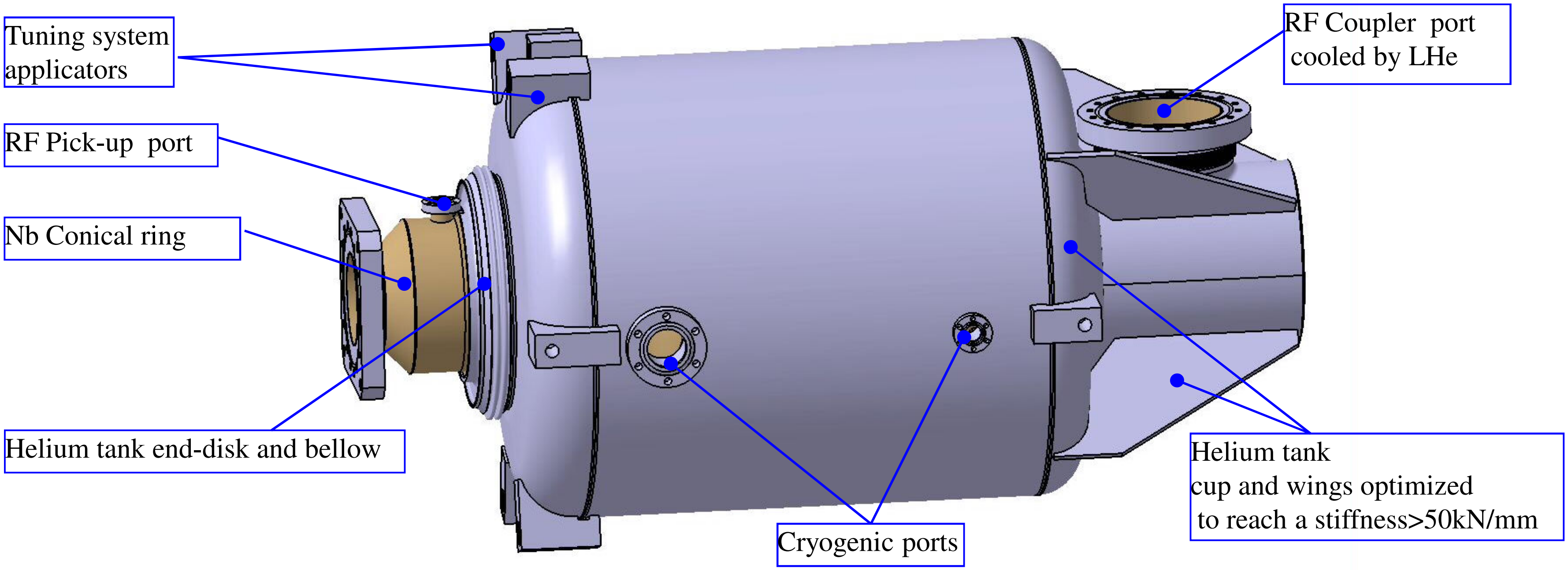
irfu

saclay



RF Pick-up port
Cryogenic ports
RF Coupler port
Tuning system applicators
Helium tank wing(I)
Helium tank
Helium tank cup(I)
Helium tank end-disk
H-shape ring
Conical ring(I)
Ø130 Beam tube(I)
Ø80 Beam tube(I)
Coupler tube

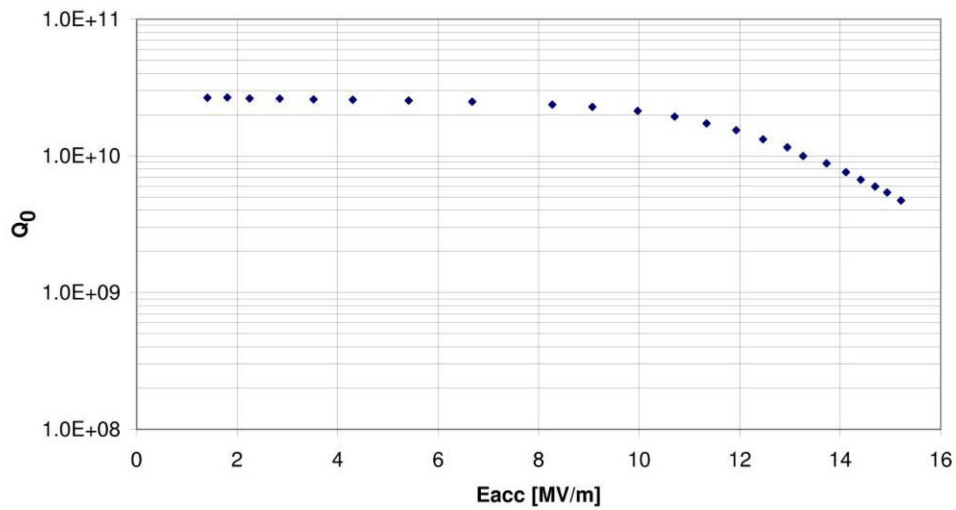
- End of Helium tank fabrication <u>without opening the cavity (sealed up with clean air)</u>
- Vacuum test of the Helium tank and mandatory controls
- Delivery to CEA-Saclay



At the end of Phase 2, the cavity is ready for preparation, measurements and cold tests in horizontal cryostat

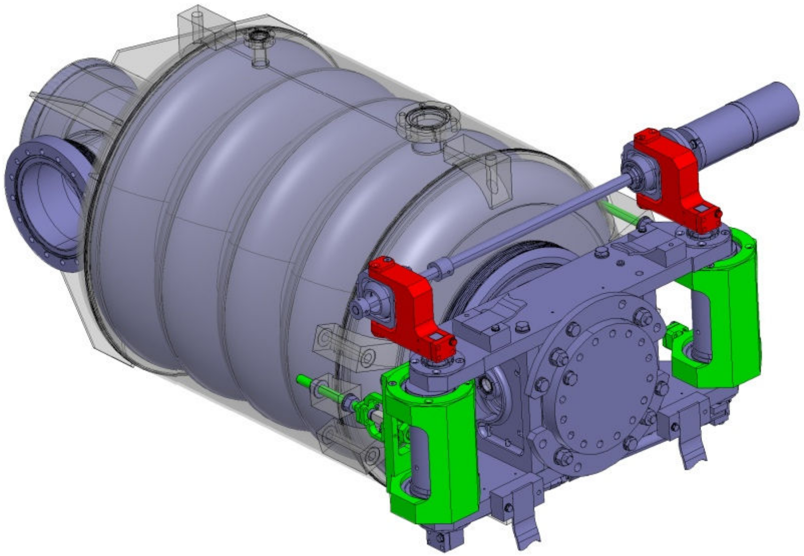
β = 0.47 cavity tested in vertical cryostat

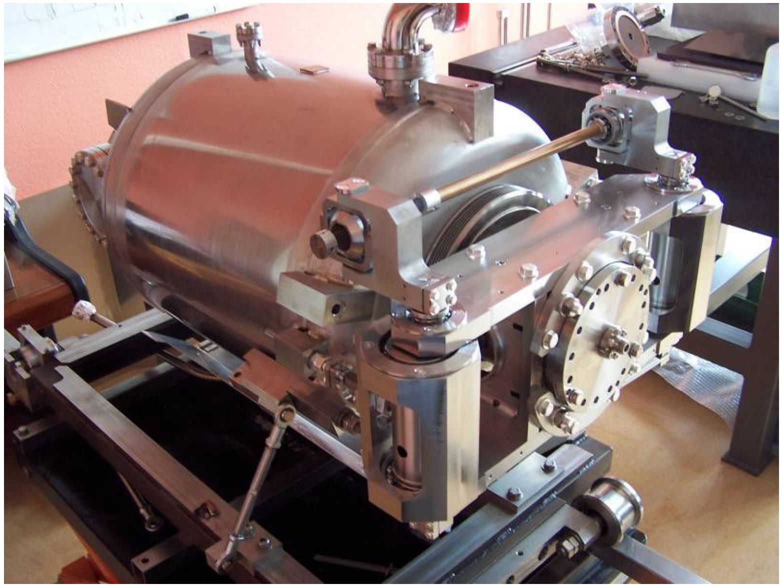
- cavity equipped with the helium tank (left open for the tests)
- stiffening rods replaced by a compact stiffener to reduce the effect of k_{ext} on the static Lorentz detuning coefficient KL
- test at 1.8 K after HPWR only (no new BCP since the first test)



- Rs = 6 nW
- Field emission onset 12 MV/m
- Quench at 15 MV/m

Système d'Accord: Saclay IV

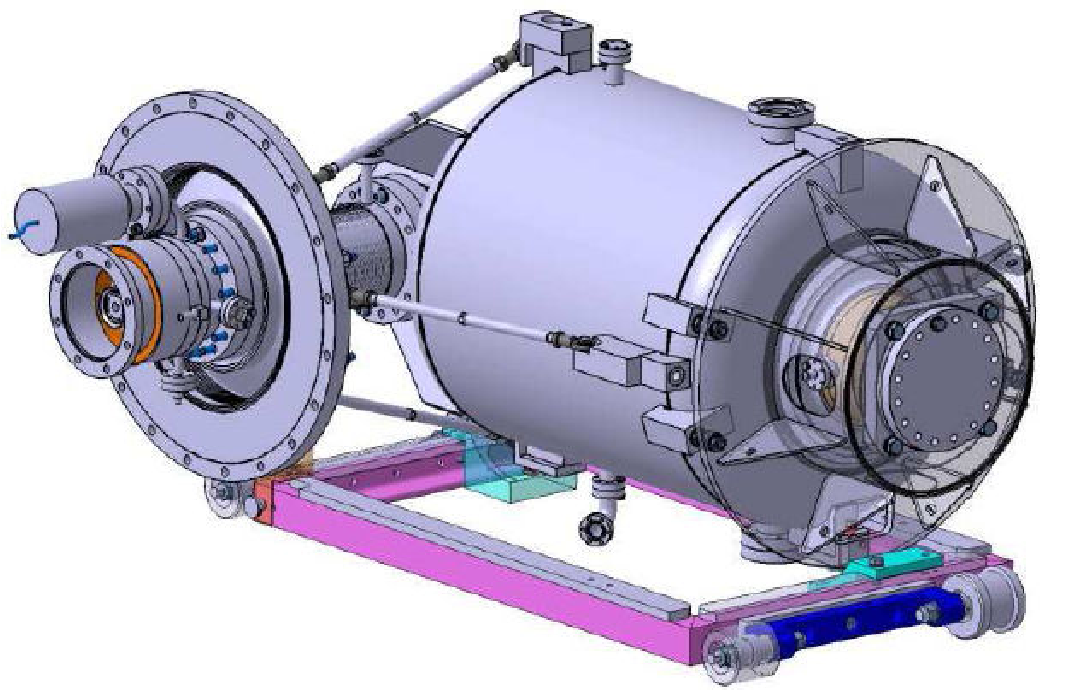


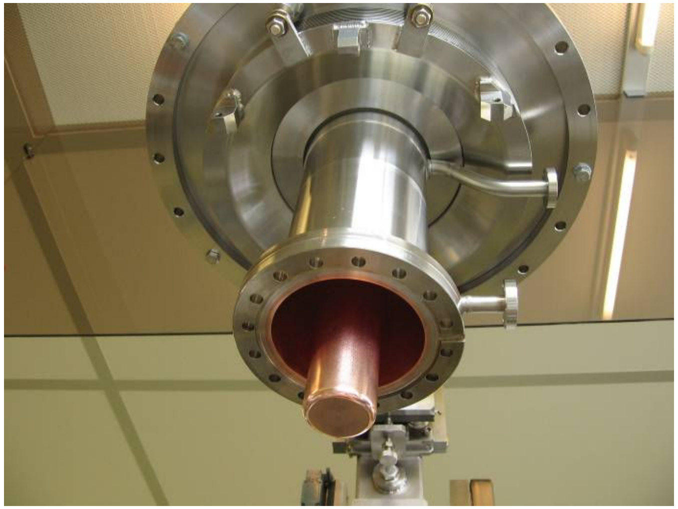


- design based on Soleil, 3HC, CARE-SRF (aka Saclay-II) family of tuners
- symmetric slow tuning +/- 2.5 MHz
- planetary gear box for reliability
- single piezo frame with preload independent of cavity tuning
- does not increase cavity length

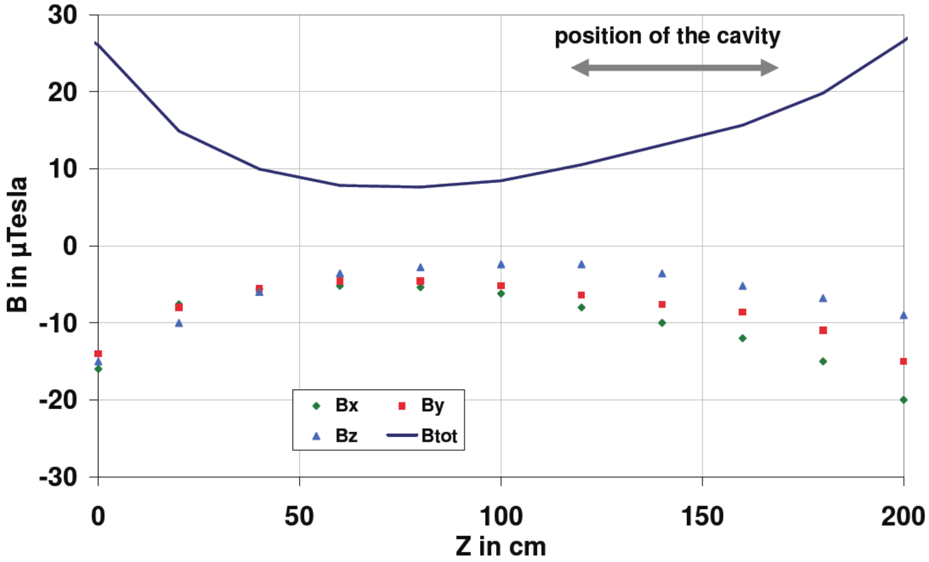
Assembly with

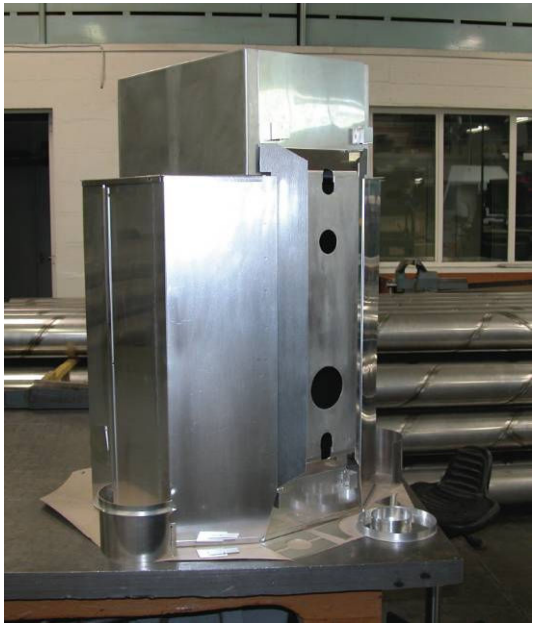
- cavity + sealed coupler (including window) have to be inserted in CRYHO
cavity has to be set off center
- heavy coupler flange + window have to be supported during installation
- the tray can be cleaned and used in the clean room.





Magnetic shield



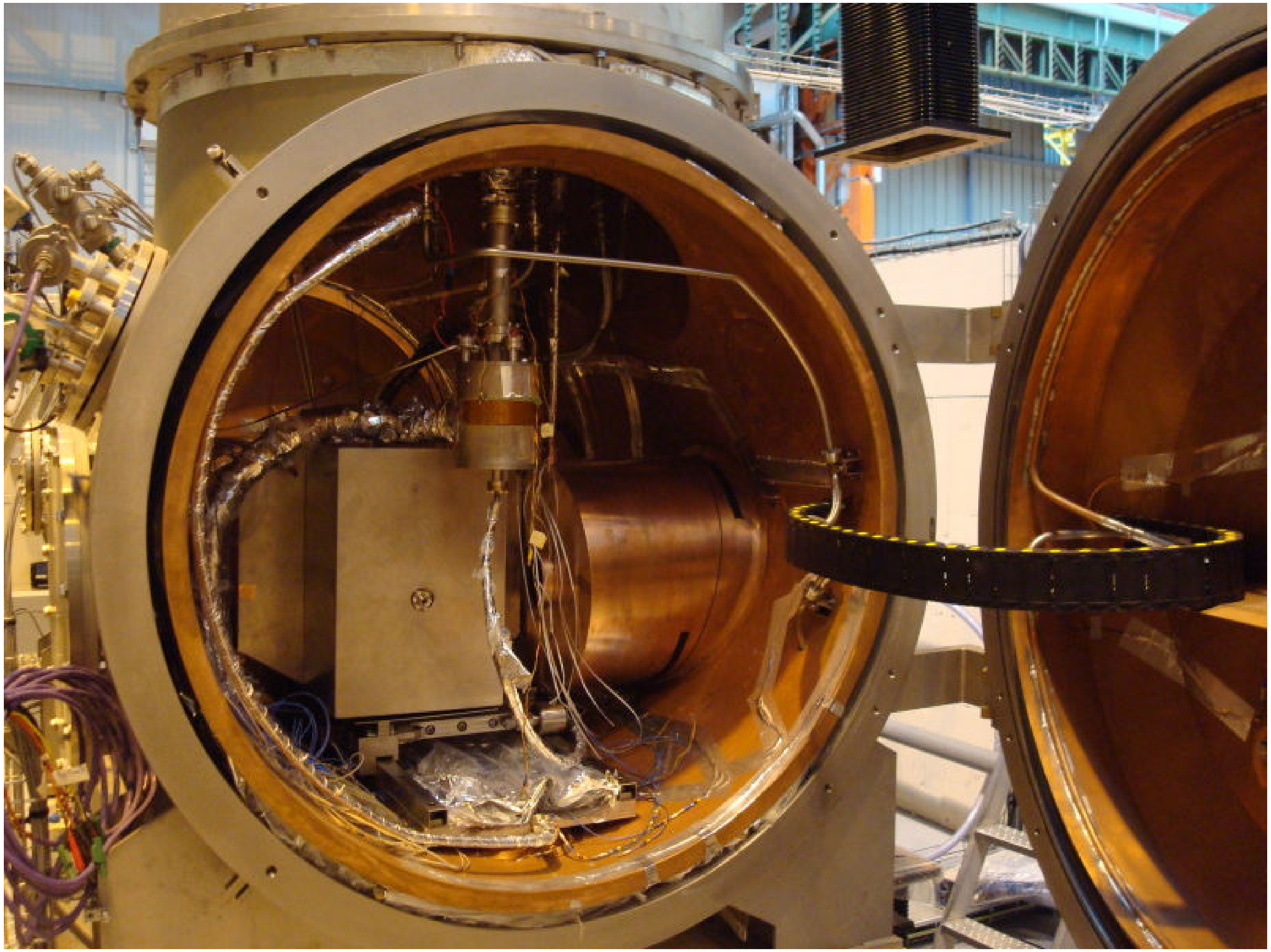


- Rs=6nΩ in vertical cryostat, low Eacc, 1.8 K
- Aiming at Rs < 8 nΩ in CryHoLab
- B<0.6 mT

Cryoperm® material
theoretical shielding factor 33
(opera 3D simulations)

irfu saclay

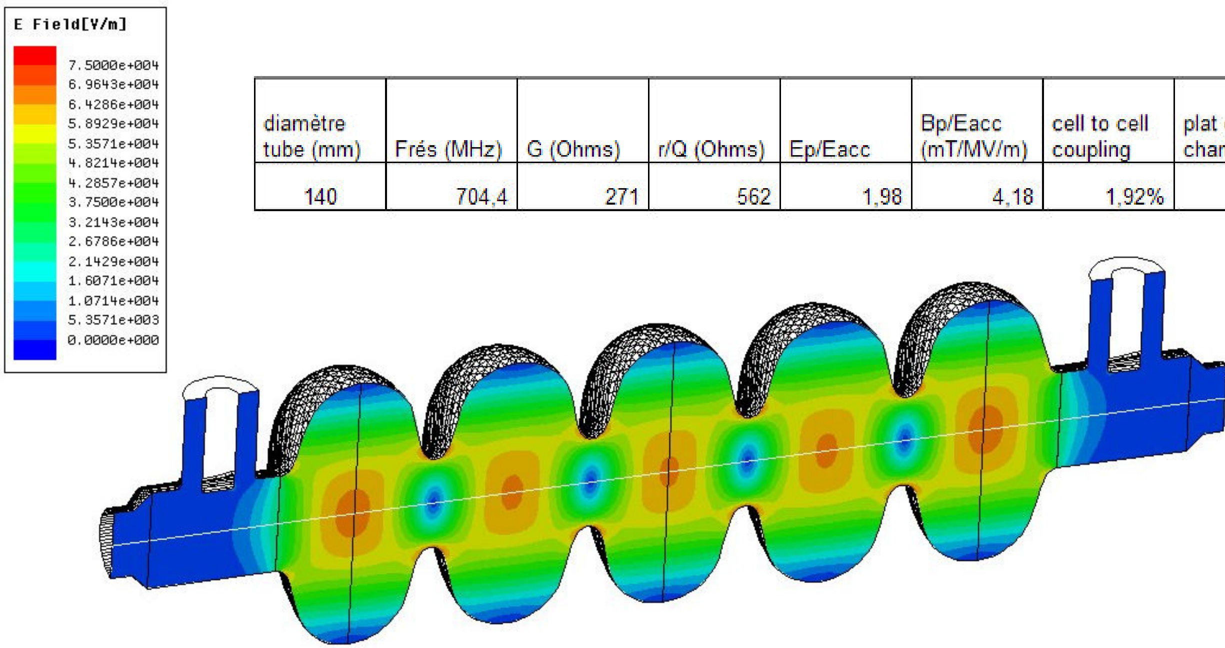
700 MHz setup



irfu
saclay

Cavité SPL_HE_v1 (704 MHz - β=1)

diamètre tube (mm)	Frés (MHz)	G (Ohms)	r/Q (Ohms)	Ep/Eacc	Bp/Eacc (mT/MV/m)	cell to cell coupling	plat de champ
140	704,4	271	562	1,98	4,18	1,92%	99%



beta	Eacc [MV/m]	K_L [Hz/(MV/m)²]	detuning statique [Hz]
0.47 (HIPPI)	15	-3.8 (mesure)	855
0.65 (SPL)	19	-2 (calcul cavité similaire)	720
→ 1 (SPL)	25	-0.5 (calcul)	313
1 (TTF)	25	-0.7 (mesure)	438

Cavité SPL_HE_v2 (704 MHz - β=1)