The SPL Short Cryo-module: Requirements

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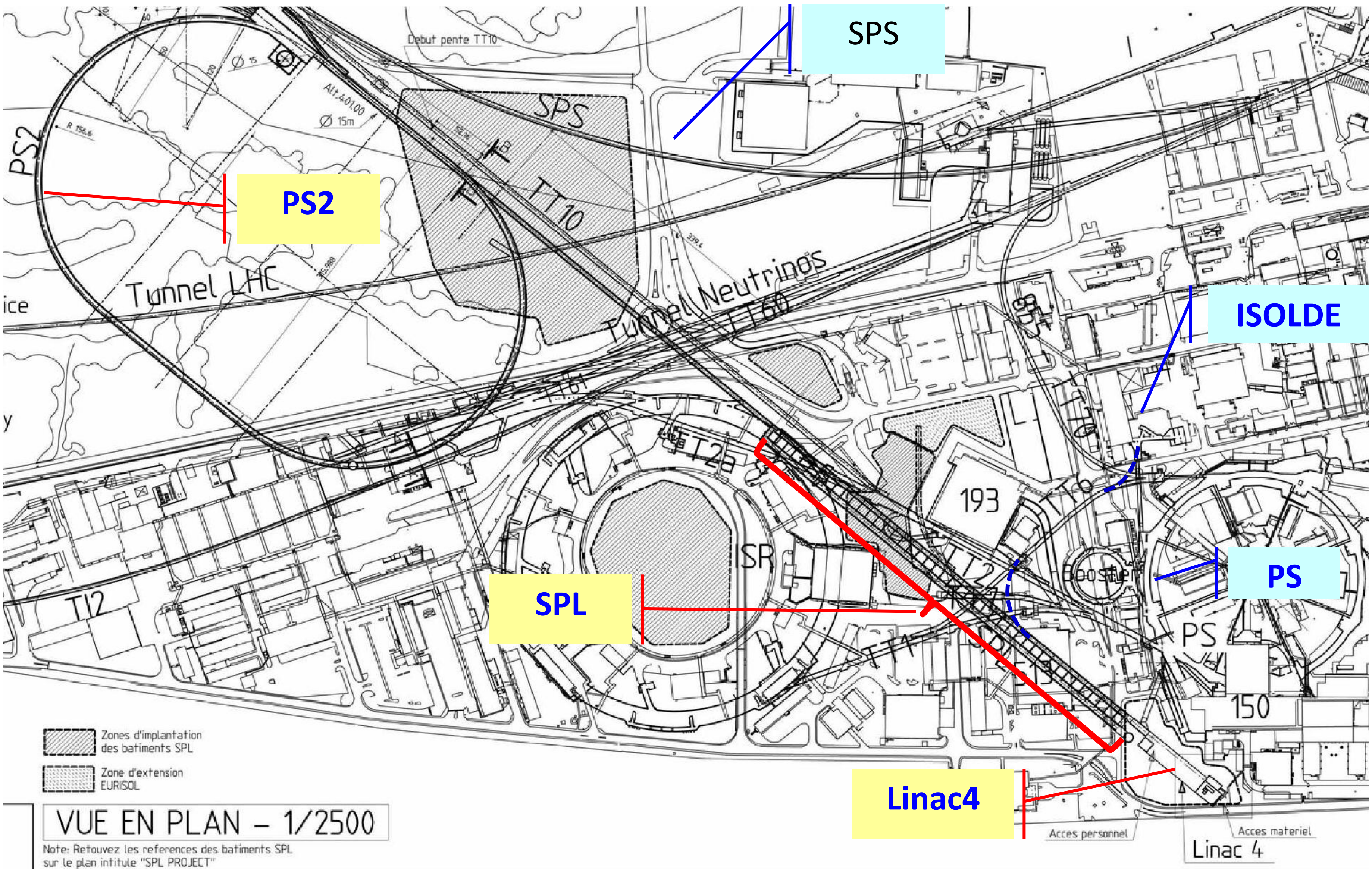
CERN, TE-MSC

Conceptual Design Review of the SPL Short Cryomodule
CERN, 4th November 2011

Outline

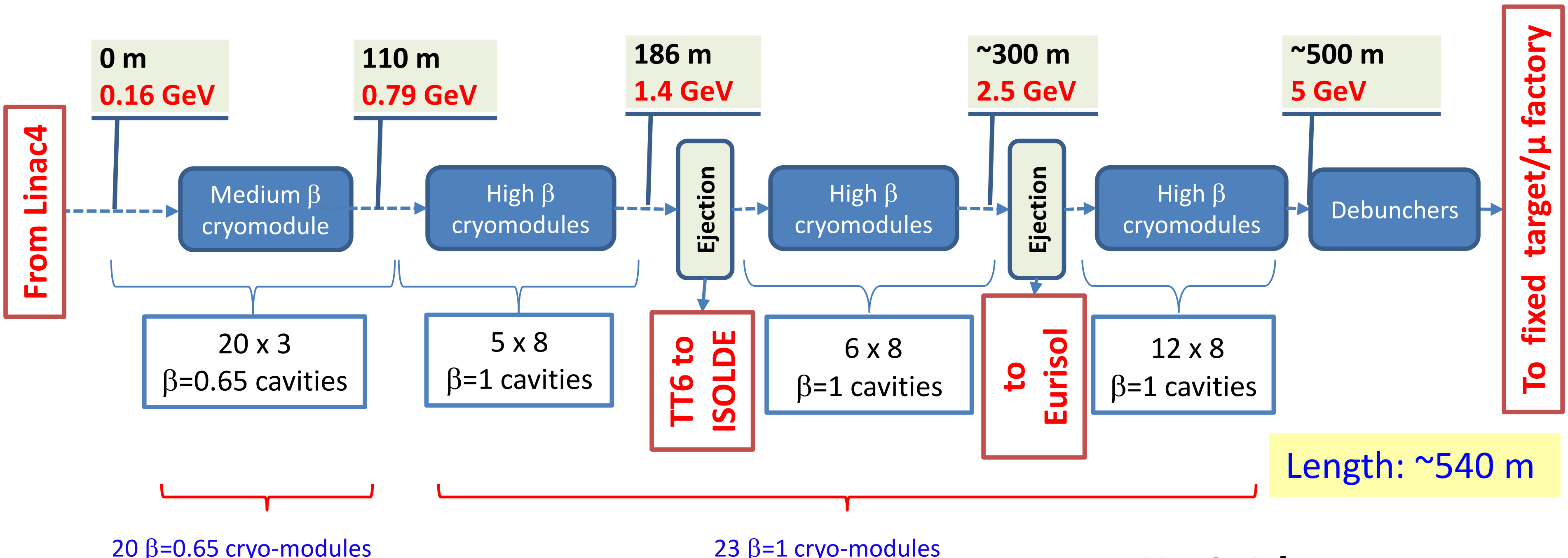
- Introduction: from the SPL cryo-module to the SPL Short Cryo-module (SSC)
- Work organisation: who does what ?
- Test requirements:
  - RF test plans
  - Infrastructure in SM18
- Design requirements:
  - Assembly constraints
  - Cavity alignment requirements
  - Cryostat main features
  - Cryogenics, p & T requirements
  - Magnetic shielding requirements
  - Instrumentation needed

Layout injector complex



The SPL study at CERN

- R&D study for a 5 GeV and multi MW high power beam, the HP-SPL
- Major interest for non-LHC physics: ISOLDEII/EURISOL/Fixed Target/Neutrino Factory



HP-SPL beam characteristics

The SPL study: new orientation in 2010

New objective of the SPL study:

Up to 2013:

- Focus on R&D for key technologies for the high intensity proton source (HP SPL)

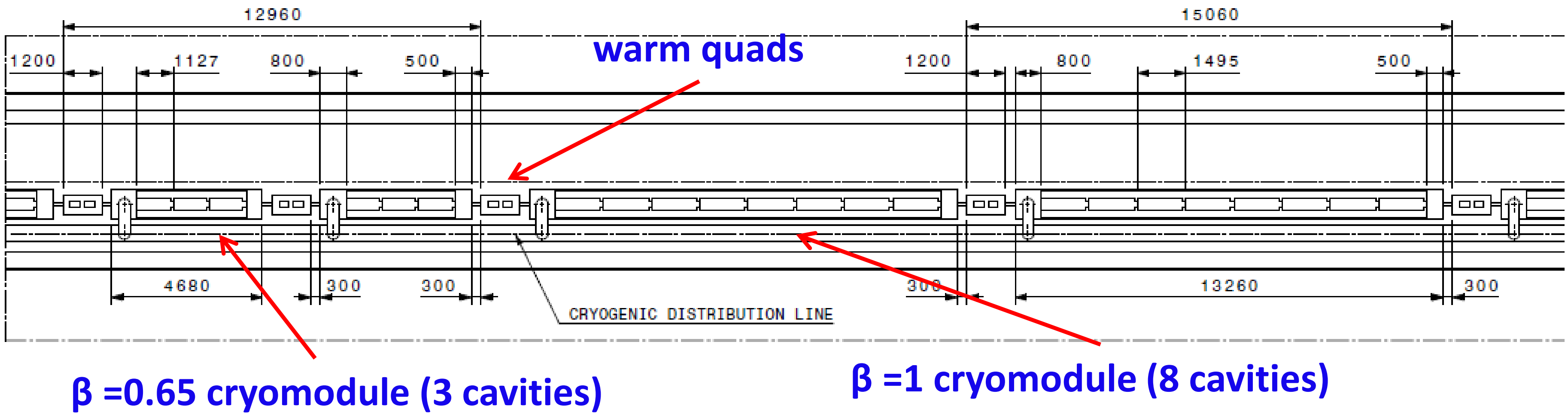
In particular:

- Development, manufacture and test of high-gradient β=1, 5 cellules ,704 MHz cavities
- Development, manufacture and test of RF couplers
- Testing on initial set of 4 β=1 cavities in a machine-type configuration:
  - Housed in helium vessels
  - Equipped with tuners
  - Powered by machine-type RF coupler

→ Need for a **short cryomodule (SSC)** for testing purposes

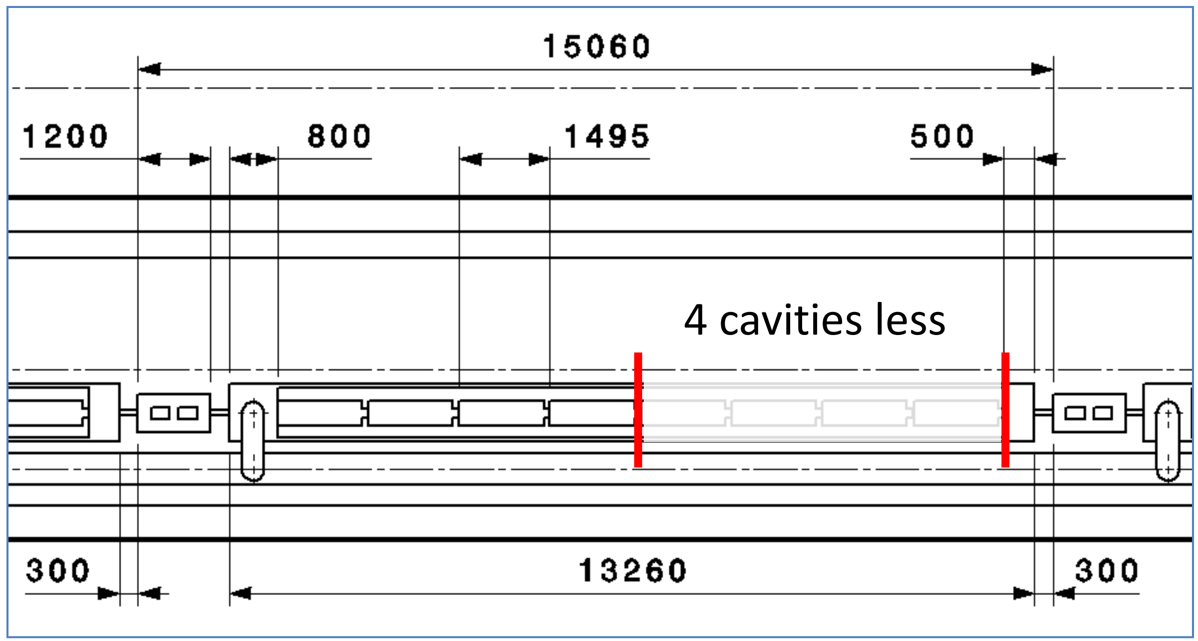
A possible SPL architecture

«segmented» with warm quads and a cryo distribution line:



Short Cryomodule designed possibly to be compatible with a full-lenght 8 cavity cryomodule:

- Mechanical design
- Cryogenics (Heat loads, T and p profiles)



(from workshop on SPL vacuum and cryogenic sectorisation http://indico.cern.ch/conferenceDisplay.py?confId=68499)

Short Cryo-module: Goal & Motivation

Goal:

- Design and construct a ½-lenght cryo-module for testing of a string of 4 $\beta=1$ cavities

1st Motivation:

- Test-bench for RF testing on a multi-cavity assembly driven by a single or multiple RF source(s)
- Enable testing of critical components like RF couplers, tuners, HOM couplers in their real operating environment

Cryo-module-related goals:

- Validation of design & construction issues
- Learning of the critical assembly phases (from clean-room to cryostat assembly)
- Learning and validation through operational experience:
  - Cool-down/warm-up transients and thermal mechanics
  - Alignment/position stability of cavities
  - Cryogenic operation (He filling, level control, RF coupler support tube cooling …)

The cryomodule development: a collaboration effort

System/Activity	Responsible/member	Lab
Cryo-module coordination	V.Parma	CERN
Cryo-module conceptual design	V.Parma. Team: N.Bourcey, P.Coelho, O.Capatina, D.Caparros, Th.Renaglia, A.Vande Craen	CERN
Cryo-module detailed design & Integration CNRS	P.Duthil (P.Duchesne) + CNRS Team	CNRS/IPNO-Orsay
Cryostat assembly tooling	P.Duthil (P.Duchesne)	CNRS/IPNO-Orsay
Cavities/He vessel/tuner, RF coupler)	W.Weingarten (now O.Brunner)/O.Capatina/S.Chel	CERN/CEA-Saclay
RF Coupler	E.Montesinos/S.Chel	CERN/CEA Saclay
Vacuum systems	S.Calatroni (now G.Vandoni)	CERN
Cryogenics	U.Wagner	CERN
Survey and alignment	D.Missiaen	CERN
SPL Machine architecture	F.Gerigk	CERN
ESS cryo-module requirements	W.Hees	ESS Lund (Sweden)

RF test plan for the SCC (1/2) *(W.Weingarten)*

Overall goal SCC test campaigns

- testing without a beam of a fully equipped cryo-module of "half" size
- The test should include four cavities, the power couplers, the higher order mode (HOM) couplers (probably to be mounted in a second stage), the tuners
- Measure Q values, X-ray emission characteristics and other properties

More specific reasons for testing in a cryo-module:

i. The individual cavities are powered by a high power source (klystron) of hundreds of kilowatts, being strongly coupled to the cavity. In case of a quench, this feature may lead to a self-amplification of the RF power provided to the cavity with unwanted consequences, such as pressure spikes and mechanical damage to the cavity body;
ii. The diagnostic equipment is much less developed and any intricacies harder to identify;
iii. The length of the accelerating section is much bigger and therefore any electron dark current (created by field emission or multipacting) may uptake larger kinetic energies and lead to, directly or indirectly, discharges, excessive heating, quenches, helium pressure spikes, X-rays and possibly radiation damage to vital components (power couplers, HOM couplers, valves);
iv. The standing wave field pattern in the double wall tube of the power coupler is different from that under which the power coupler was conditioned at room temperature. This may lead to gas discharges in the cold and relatively thin copper coating of the stainless steel made outer conductor of the coaxial line.

RF test plan for the SCC (2/2) *(W.Weingarten)*

1) First step: assess the correct functioning of the interlock and safety systems.

They comprise the protection against: helium over-pressure (due to a quench); gas discharges in the power coupler coaxial line (by gas pressure, light, and current probes); overheating of the HOM couplers (by a temperature probe); excessive X-radiation (by a radiation monitor); loss of lHe level.

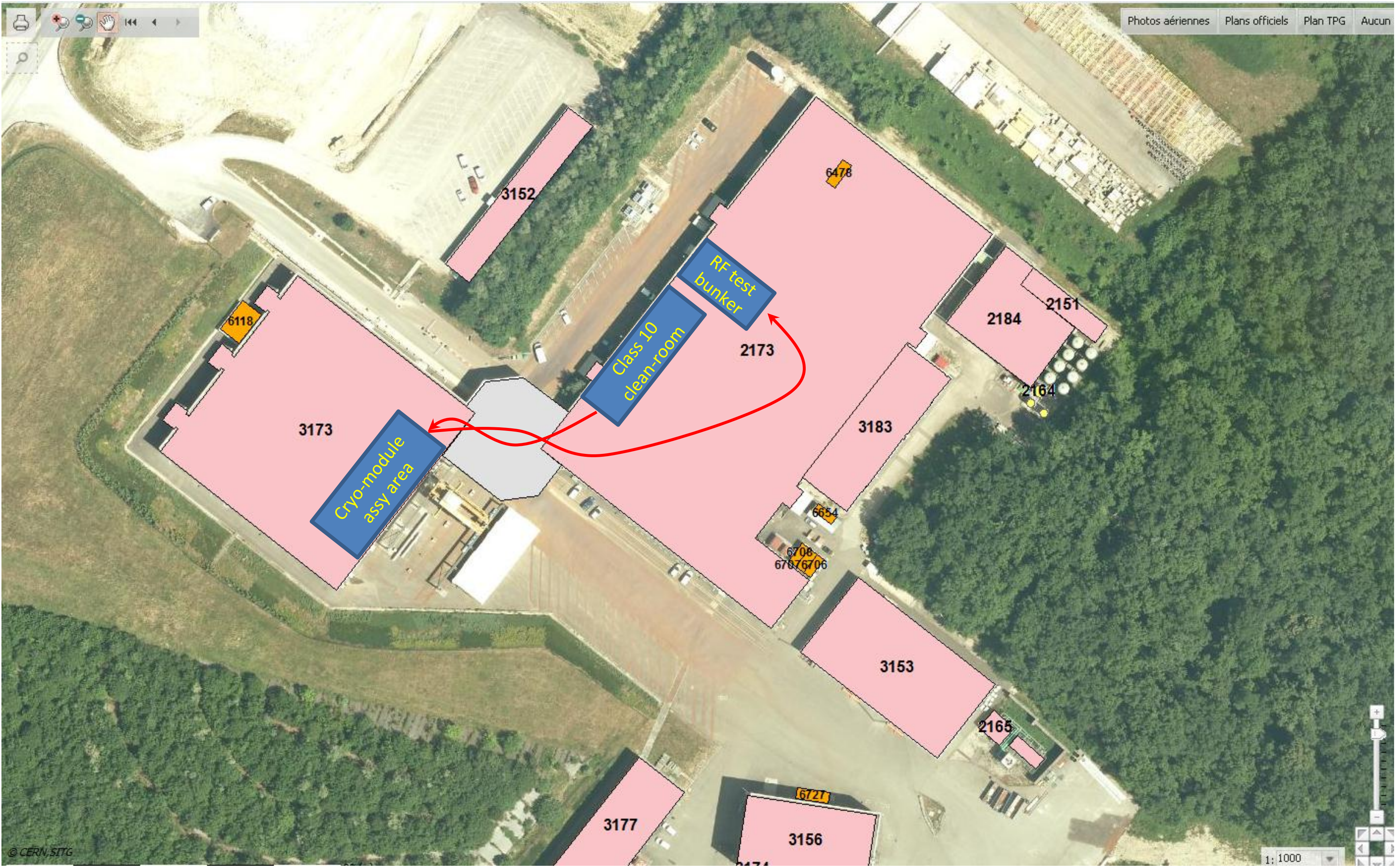
2) Second step. Commissioning of the individual cavities, one after the other. Determination of the external Q-values of the power coupler, antenna probe, and the HOM couplers.

The external Q-values of the power coupler shall be adjusted, if needed, to the design value. The commissioning may be achieved, in pulsed mode with constant pulse repetition rate, by raising the accelerating gradient, and the pulse length, step by step subject to the cavity pressure, X-radiation and HOM fundamental power, up to the nominal gradient (25 MV/m) and pulse length (1 ms) plus a safety margin. Once the design gradient achieved, the dynamic losses shall be measured by the "heater replacement" method. This means that the cryogenic load per cavity is always kept constant in order not to compromise the loss measurement by any instability of the cryogenic system. The power of the heater located in each helium tank is reduced in parallel with the increase of the RF dissipation such that the helium bath pressure is kept constant.

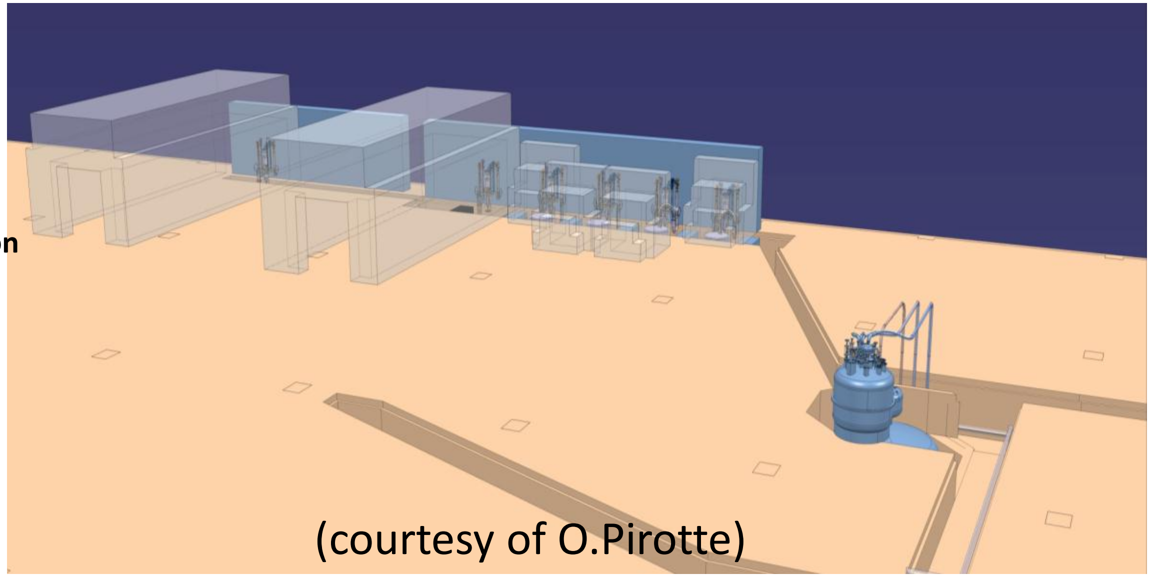
3) Third step. All four individual cavities shall be powered simultaneously up to the design gradient and the dynamic heat load measured under the same procedure and precautions as outlined above.

4) Fourth step. Test the correct functioning of the vital elements for accelerating the beam shall be tested including the low level RF control system. This step comprises the tuner operation and total range, the assessment and sufficient counteraction against detuning from external (microphonics, helium pressure) or internal sources (ponderomotive oscillations, Lorentz-forces by radiation pressure). The correct layout of the HOM couplers must also be verified by determining the external Q-values of the most prominent HOMs.

Facilities in Point 18

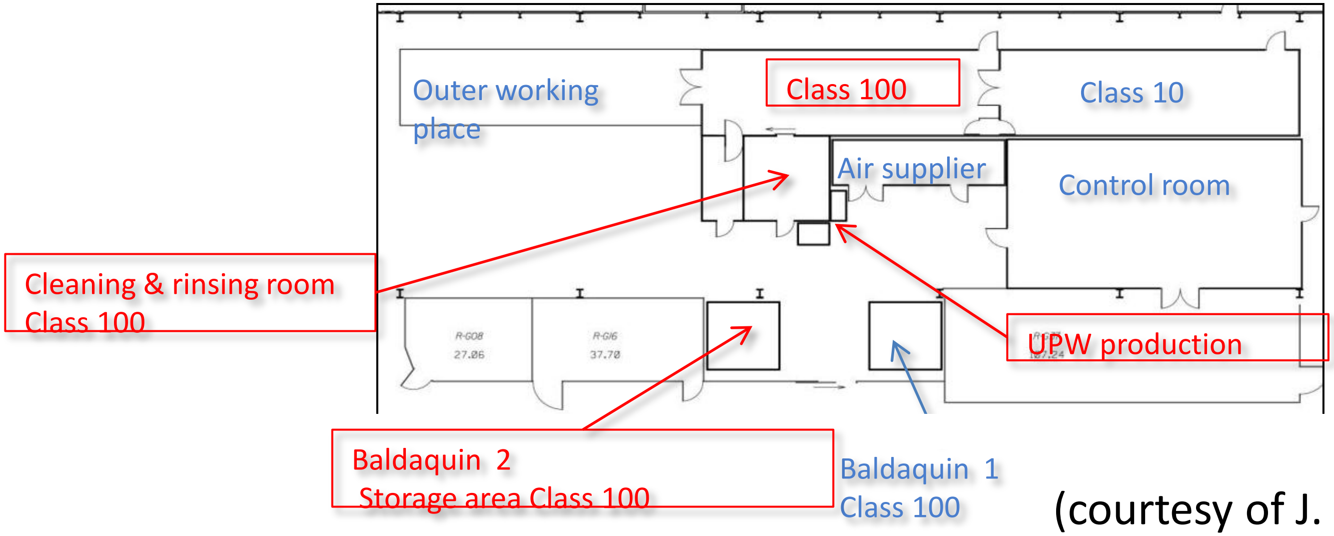


Upgrade of SM18 facilities



SCRF test station

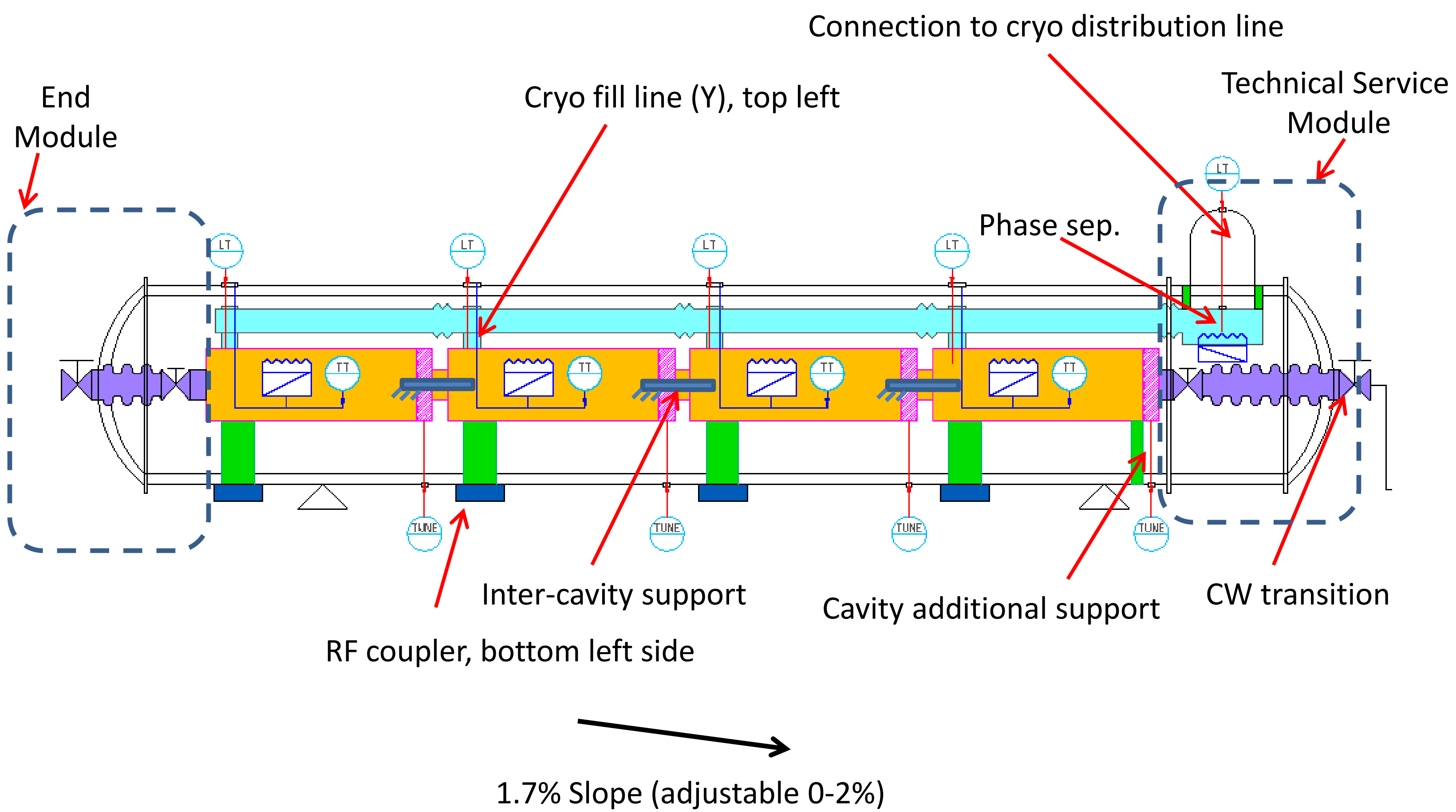
- new cryo distribution line and cryo connection boxes
- ESS/CERN klystron modulator



Clean-room (class 10)

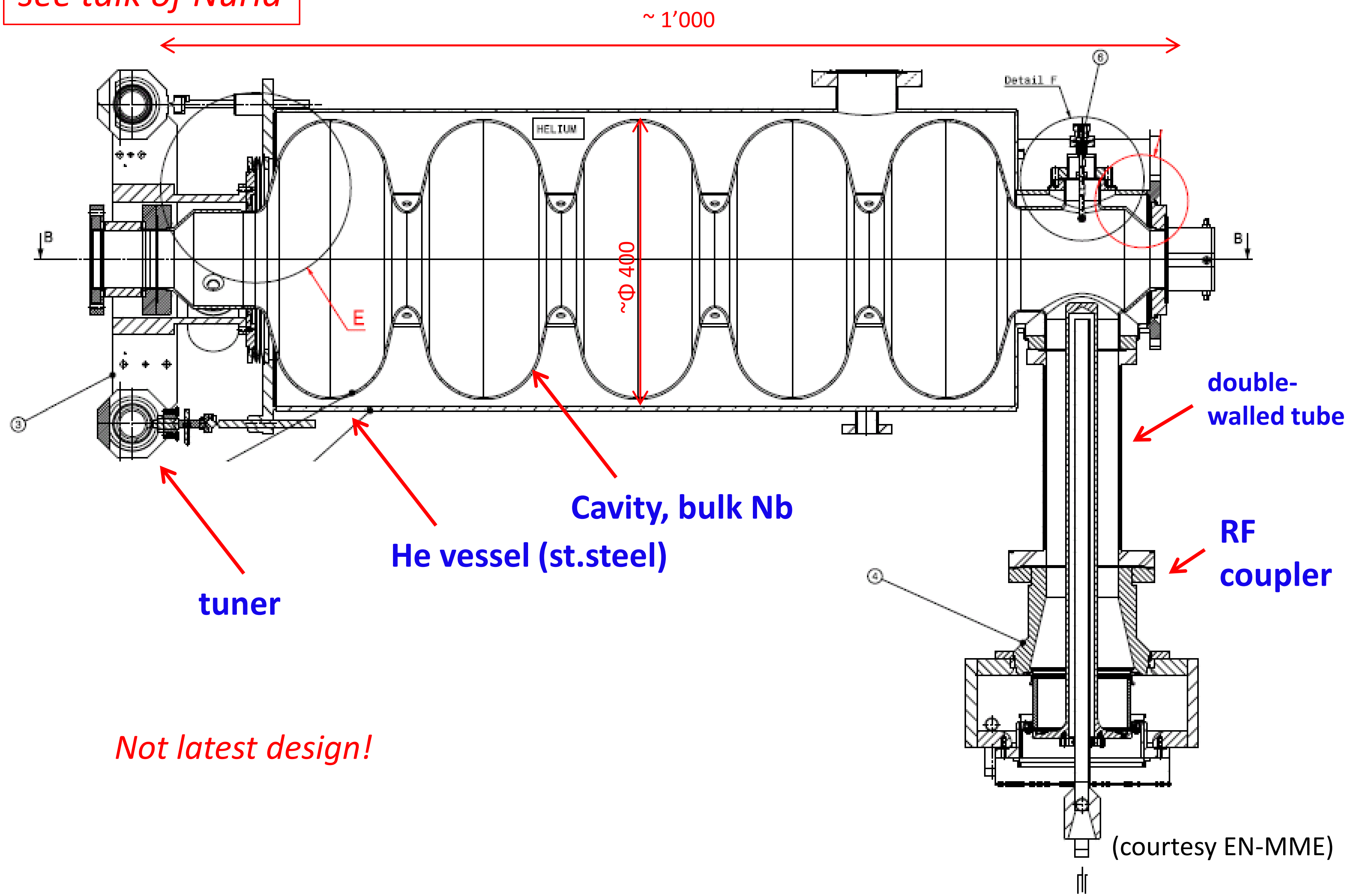
(courtesy of J. Chambrillon)

Short cryomodule: layout schematic



Cavity/He vessel/tuner assembly

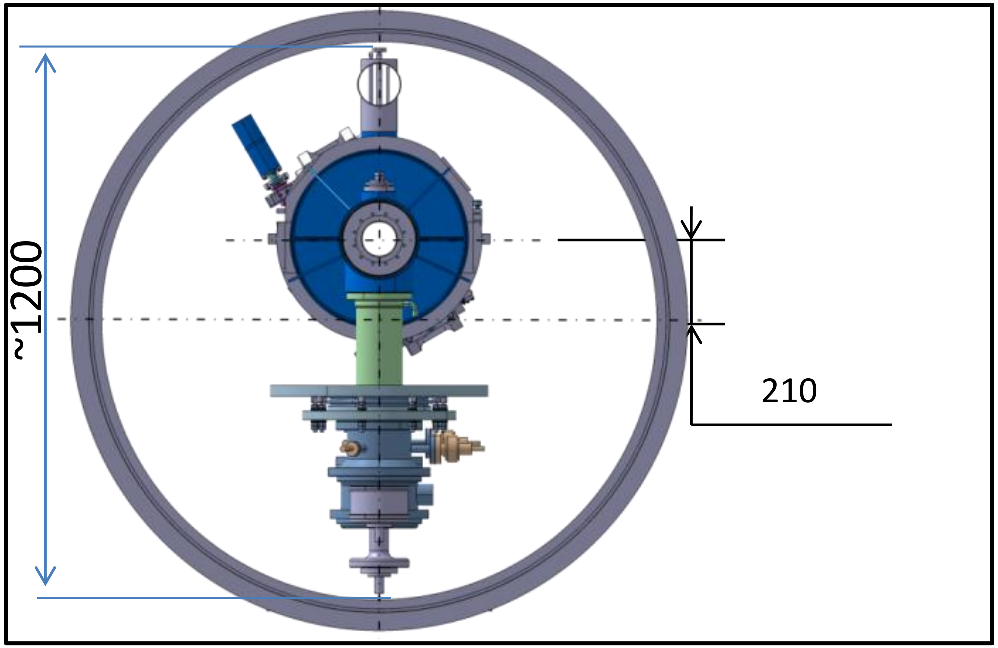
see talk of Nuria

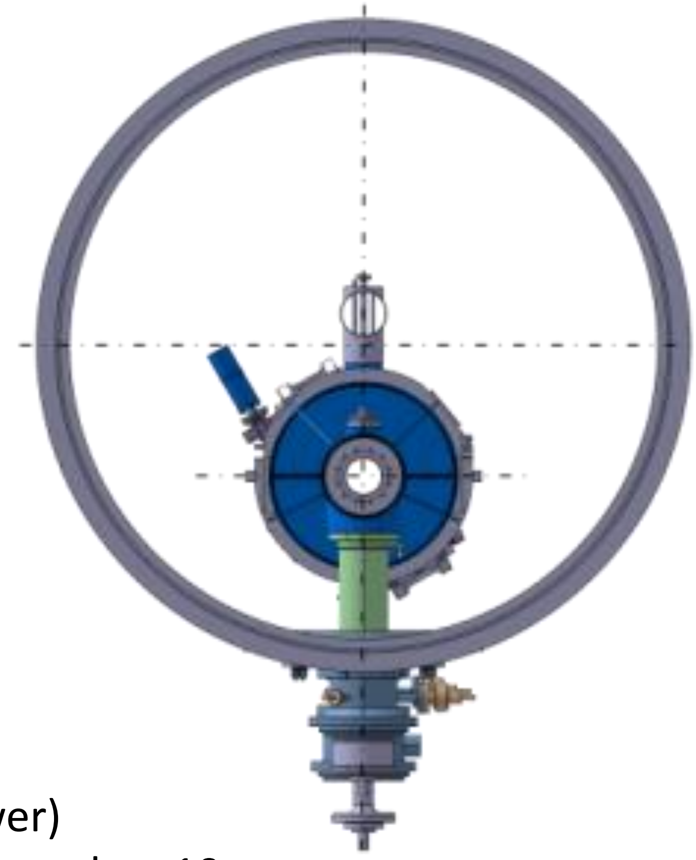


Not latest design!

(courtesy EN-MME)

Cryostat assembly constraint





Constraints:

- RF coupler in 1 part (single window for high power)
- Cavity and RF coupler are assembled in clean-room class 10
- Train of cavities assembled in clean room class 10

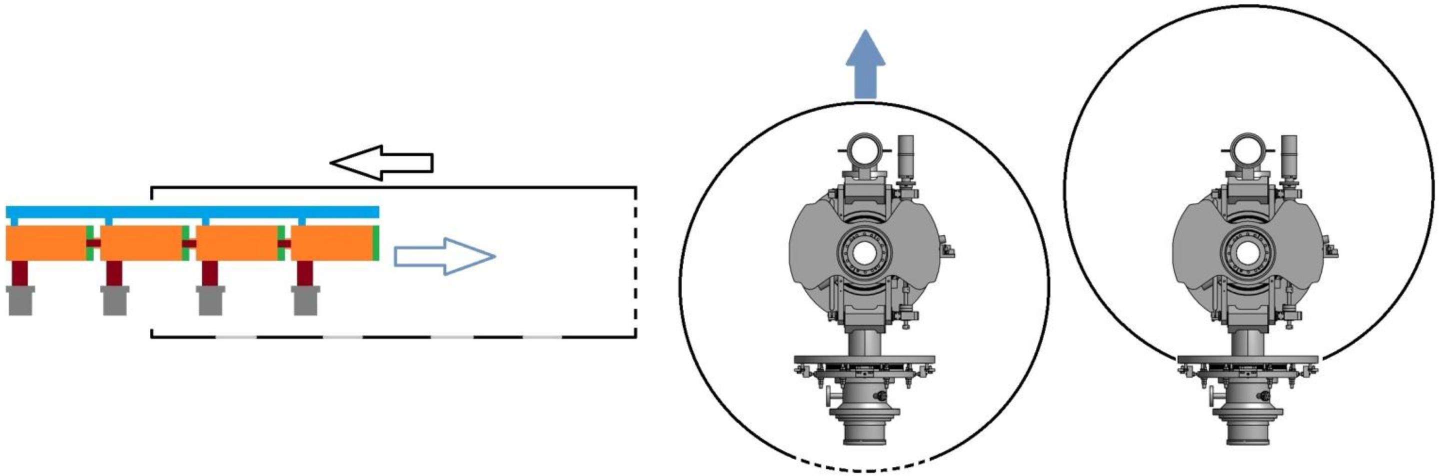
Consequences:

→ No cryostat component allowed in a class 10 clean room

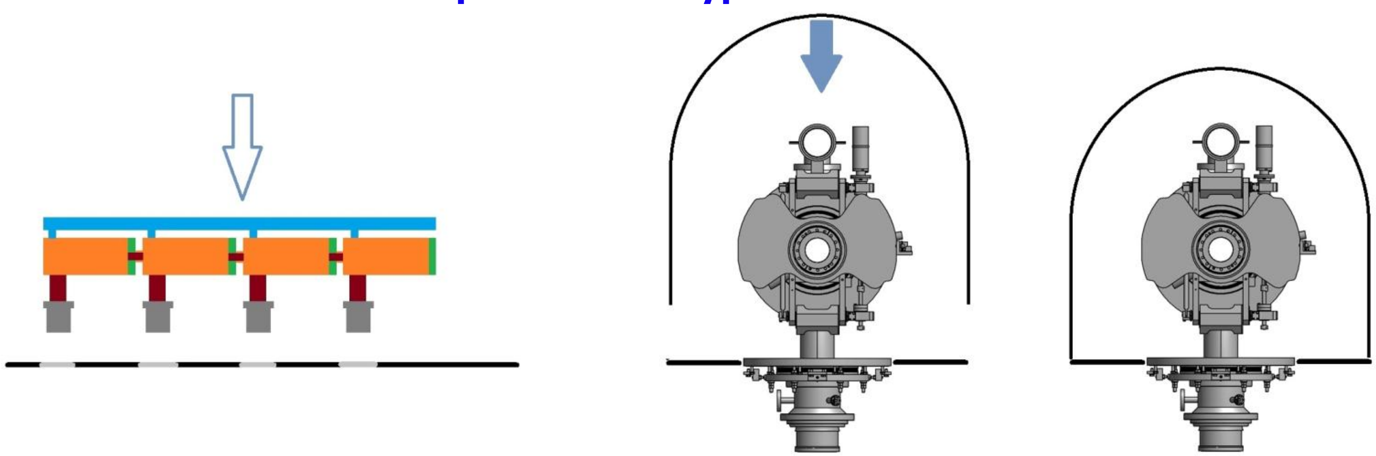
→ An LHC-type cryostat leads to a large diameter (i.e. tunnel space, HL from RT,…)

Vacuum vessel conceptual alternatives

Cylindrical vessel type (LHC like)

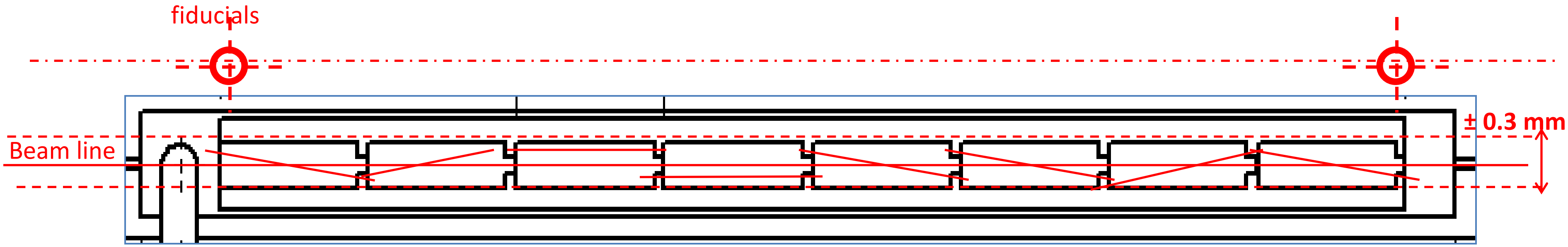


2-part vessel type

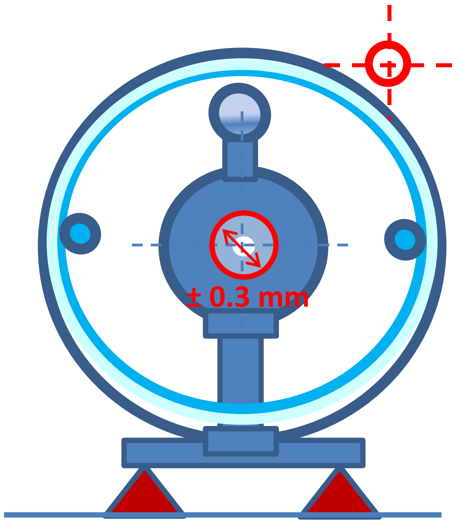


see talk of Patxi

Cavity alignment requirements



- Position of each cavity shall be precise w.r.t. cryostat mounted external fiducials within ± 0.5 mm
- Position of each cavity axis shall be stable and reproducible within ± 0.3 mm w.r.t. an ideal beam axis
- Cryo-module alignment using cryostat mounted external fiducials (i.e. no need for active alignment of individual cavities)



Cavity alignment requirements

Transversal position specification

BUDGET OF TOLERANCE			
Step	**Sub-step**	**Tolerances (3σ)**	**Total envelopes**
Cryo-module assembly	Cavity and He vessel assembly	*± 0.1 mm*	Positioning of the cavity w.r.t. external referential **± 0.5 mm**
	Supporting system assembly	*± 0.2 mm*	
	Vacuum vessel construction	*± 0.2 mm*	
Transport and handling (± 0.5 g any direction)	N.A.	*± 0.1 mm*	Reproducibility/Stability of the cavity position w.r.t. external referential **± 0.3 mm**
Testing/operation	Vacuum pumping	*± 0.2 mm*	
	Cool-down		
	RF tests		
	Warm-up		
	Thermal cycles		

Construction precision

Long-term stability

Cryostat main features

«Standalone» cryostat:

- Connection to a cryo distribution line (welded for SCC in SM18)
- Cold-to-warm transitions for beam tube at cryostat extremities

Maintenance and accessibility:

- Accessibility ports for in-cryostat maintenance (tuner motor, 2 HOMs)
- Cryostat disassembly should be possible (for example for refurbishment/replacement of proto cavities)

Supporting system:

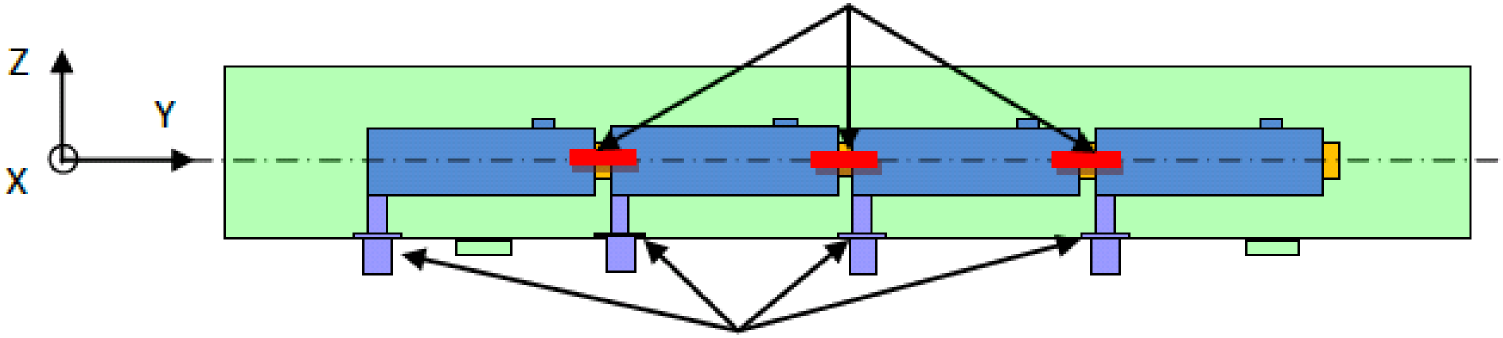
- RF coupler as main support of cavity (*next slide*)

Thermal shielding:

- One single thermal shield cooled @ ~50K
- 30 layers of MLI (*à la LHC*)
- Thermal shield mechanically independent from cavities (avoid thermo-mechanical interference with alignment)

Supporting scheme

RF coupler double-walled tube as cavity support



The RF coupler (its double-walled tube) provides:
- fixed point for each cavity (thermal contractions)
- mechanical supporting of each cavity on the vacuum vessel

The intercavity support provides:
- a 2nd vertical support to each cavity (limits vertical self-weight sag)
- relative sliding between adjacent cavities
- increases of transvere stiffness to the string of cavity (increases eigenfrequencies of first modes to higher frequencies)

see talks of Paulo+Arnaud

Assembly Sequence/Constraints

Clean-room (class 10) activity (SM18):

- Each dressed cavity is equipped with RF coupler and HOMs
- Mount inter-cavity bellows (relative roll adjustment needed)
- Mounting of vacuum valves and vacuum conditioning
- Roll out of trolleys with string of cavities on external platform

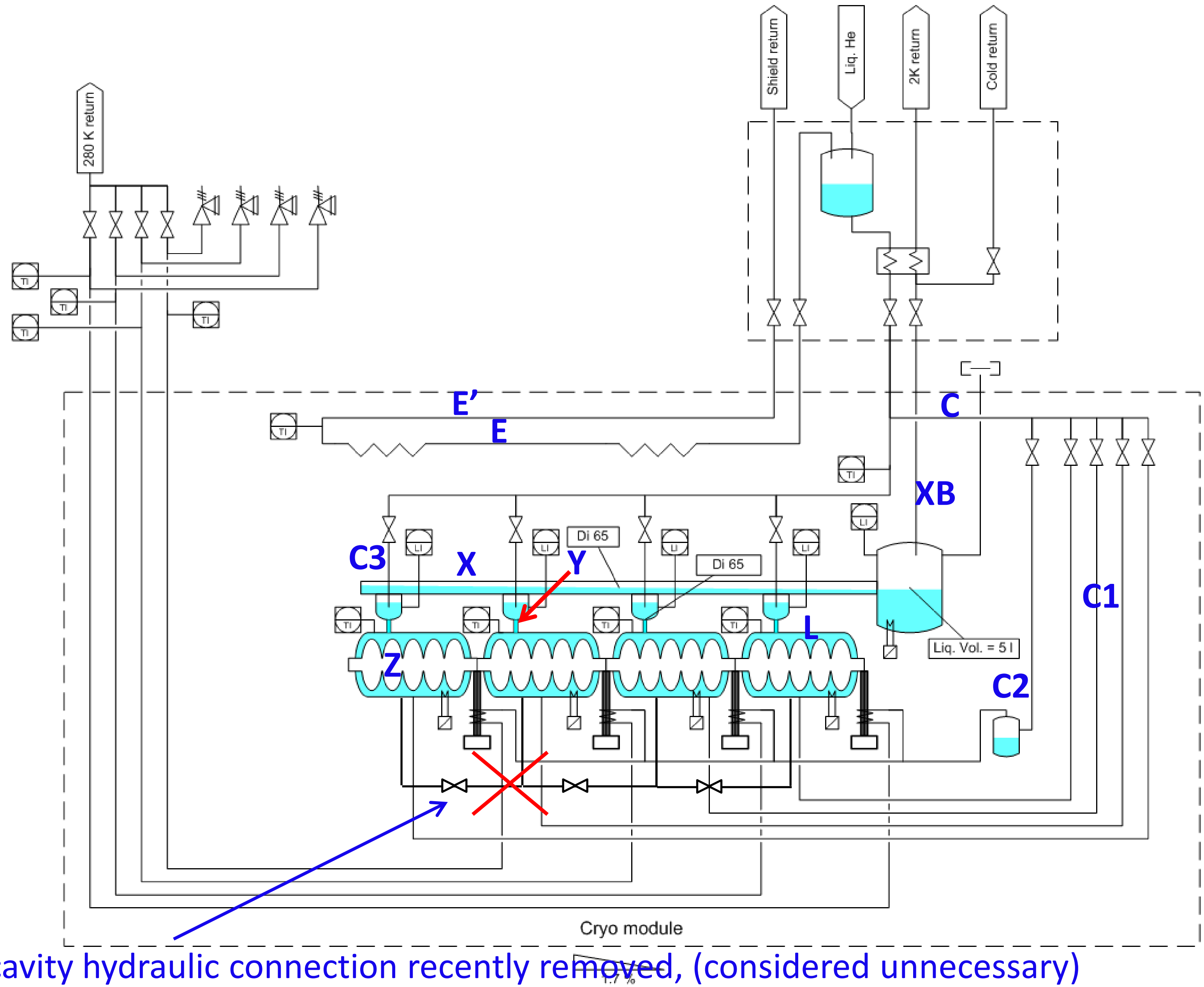
Cryostat assembly activity (SMA18):

- Load transfer of string of cavities from trolleys to a handling girder
- Transport of girder to cryostat assembly area (~40 m distance)
- Align the cavities, then fix the inter-cavity supports
- Equip with tuners, instrumentation, magnetic shield, MLI blankets, cryogenic piping, thermal shields + MLI blankets
- Introduce in the vacuum vessel and fix RF coupler flanges
- Check/fine-adjust cavity alignment
- Qualification tests (e.g. leak testing)

Cryo-module testing in SM18:

- Transport from SMA18 to SM18 RF bunker
- Connect cryogenics and RF to cryo-module
- Commissioning and testing

Cryogenic Scheme



Inter-cavity hydraulic connection recently removed, (considered unnecessary)

2 K Heat Loads (per β=1 cavity)

Operating condition	Value	
Beam current/pulse lenght	**40 mA/0.4 ms beam pulse**	**20 mA/0.8 ms beam pulse**
cryo duty cycle	4.11%	8.22%
quality factor	10 x 10^9	5 x 10^9
accelerating field	25 MV/m	25 MV/m

Source of Heat Load	Heat Load @ 2K (per cavity)	
Beam current/pulse lenght	**40 mA/0.4 ms beam pulse**	**20 mA/0.8 ms beam pulse**
dynamic heat load per cavity	5.1 W	20.4 W
static losses	<1 W (tbc)	~ 1 W (tbc)
power coupler loss at 2 K	<0.2 W	<0.2 W
HOM loss in cavity at 2 K	<1	<3 W
HOM coupler loss at 2 K (per coupl.)	<0.2 W	<0.2 W
beam loss	1 W	1 W
Total @ 2 K	**8.5 W**	**25.8 W**

Cryogenic requirements (main)

Cooling:

- Cooling of 2K heat loads
  - ~ 26 W/cavity, i.e. ~ 100 W per Short Cryomodule;
  - Heat flux in LHeII per cavity (~ 1.3 g/s) → sizing of He vessel diameter, line Y
  - He boil-off and transport in line X (bi-phase), 5.2 g/s (4 cavities), (10.4 g/s for 8 cavities):
    - ✓ Sizing of line X (limit p drop for constant T, and limit vapours velocity above liquid)
- Cooling of 50 K heat loads (mainly thermal shield+ heat intercepts)
  - Typical figures (depends on final design): 30-40 W/m length
- Cooling of 5 K heat loads (dominated by active cooling of couplers)
  - Typical figures: ~40 mg/s per coupler → ~ 200mg/s (4 cavities+heater)
- "Fast" cool down (avoid Q disease): 100 K/h as a goal though not a real specification
- Redundancy in cryo control for testing operation in various modes (also with and without tunnel slope)

Maximum Credible Incidents (MCI) to be considered:

- Accidental venting with air of cavity/beam vacuum: e.g. break-off of gate valve: orifice Φ80
  - Large cold surface per cavity:~1.7 m^2/cavity, large LHe inventory: ~64 l/cavity
  - → Check minimum I.D. of lines, choose valves/burst disks, to limit p to 0.2 MPa (protect cavities)
- Accidental venting of cryostat insulation vacuum: e.g. rupture of RF coupler bellows

  → MLI (10 layers) on cold surfaces + cryostat over-pressure valves, to limit p to 0.15 MPa (protect vacuum vessel)

Pipe sizes and T, p operating conditions

New, more complete

Line	Description	Pipe Size (ID min value) [mm]	Normal operating pressure [MPa]	Normal operating temperature [T]	Cool-down / warm-up pressure [MPa]	Cool-down / warm-up temperature [K]	T range [K]	Maximum operating pressure [MPa]	Maximum pressure in case of MCI [MPa]	Design pressure [MPa]	Test pressure [MPa]	Comment
Z	cavity/beam vacuum	N.A.	I.P. 10^{-9} mbar (tbc)	2	N.A.	N.A.	2-293	N.A.	0.2 @ 2K	0.15 @ 293K	N.A.	design pressure limited by cavity plastic deformation
L	Cavity-helium vessel enclosure	cavity OD + 10	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K; 0.2 @ 2K (tbc)	0.2 @ 2K	0.15 @ 293K	N.A.	design pressure limited by cavity plastic deformation
X	Bi-phase pipe	80	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K (tbc)	0.2 @ 2K	0.15 @ 293K	N.A.	"
Y	Cavity top connection	80	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K (tbc)	0.2 @ 2K	0.15 @ 293K	N.A.	"
XB	Pumping line	80	0.0031	2	0.13 @ 293K 0.2 @ 2K	293-2	2-293	0.15 @ 293K 0.2 @ 2K (tbc)	0.2 @ 2K	0.15 @ 293K	N.A.	"
E	Thermal shield supply	15	1.8	~50	2	293-50	50-293	2	N.A.	2	2.5	Heat intercept
E'	Thermal shield return	15	1.8	~50	2	293-50	50-293	2	N.A.	2	2.5	Return only
W	Cryostat vacuum vessel	TBD	I.P. 10^{-6}mbar	293	vacuum	293	237-293	O.P. 0.1	I.P. 0.15 @237K	O.P. 0.1 @ 293K; I.P. 0.15 @237K	N.A.	
C/C1	Cavity filling	6	0.1	4.5	0.1	293-4.5	4.5-293	0.15 @4.5K	N.A.	0.15 @ 293K	N.A.	Liquid supply
C2	Coupler cooling	6	0.1	4.5-293	0.1	293-4.5	4.5-293	0.15 @ 4.5K	N.A.	0.15 @ 293 K	N.A.	Gaseous supply
C3	Cavity top supply	10	0.1	2	0.1	293-4.5	2-293	0.15 @ 4.5K	N.A.	0.15 @ 293 K	N.A.	Liquid supply

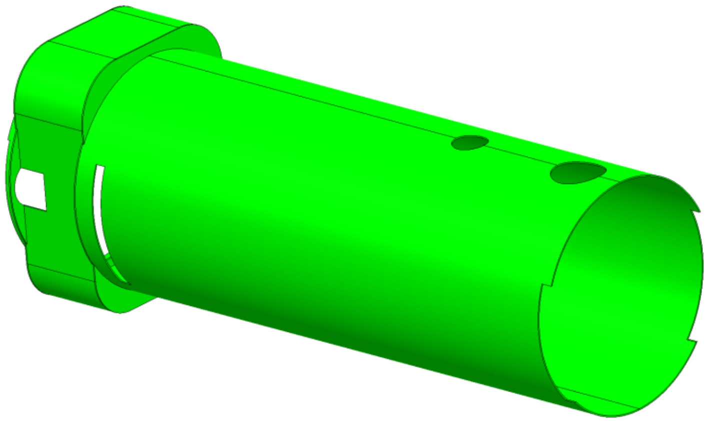
→ Pipe sizes justification in Udo's presentation

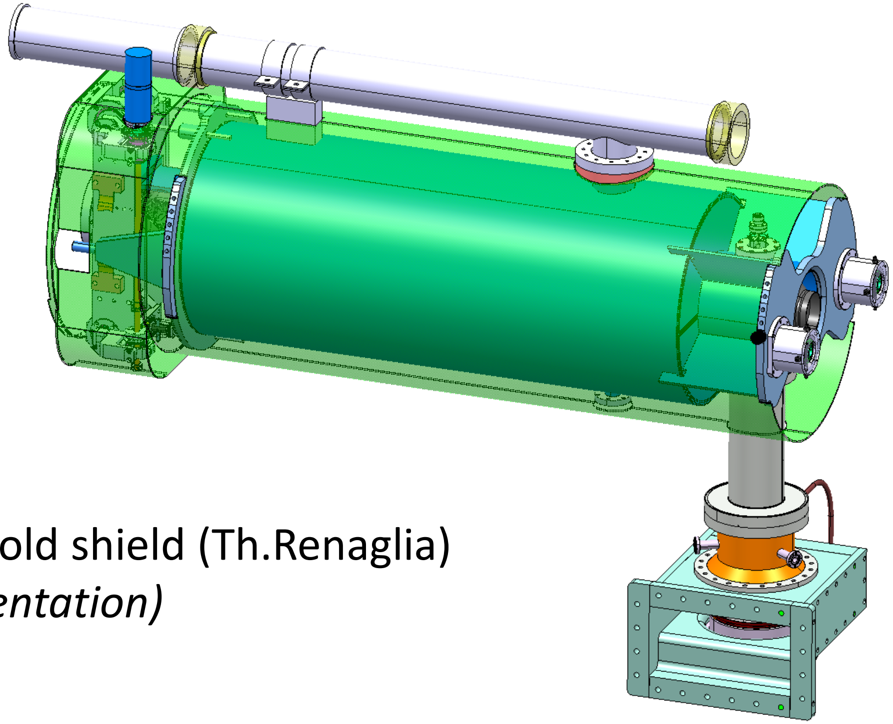
Magnetic shielding requirements

- Requirement: < 1µT on cavity surface

→ 2 magnetic shields are required:

  – 1 cold shield, external to He vessel, 1 mm Cryoperm™ 10 (passively cooled)
  – 1 RT shield: low-carbon steel vessel seems possible solution





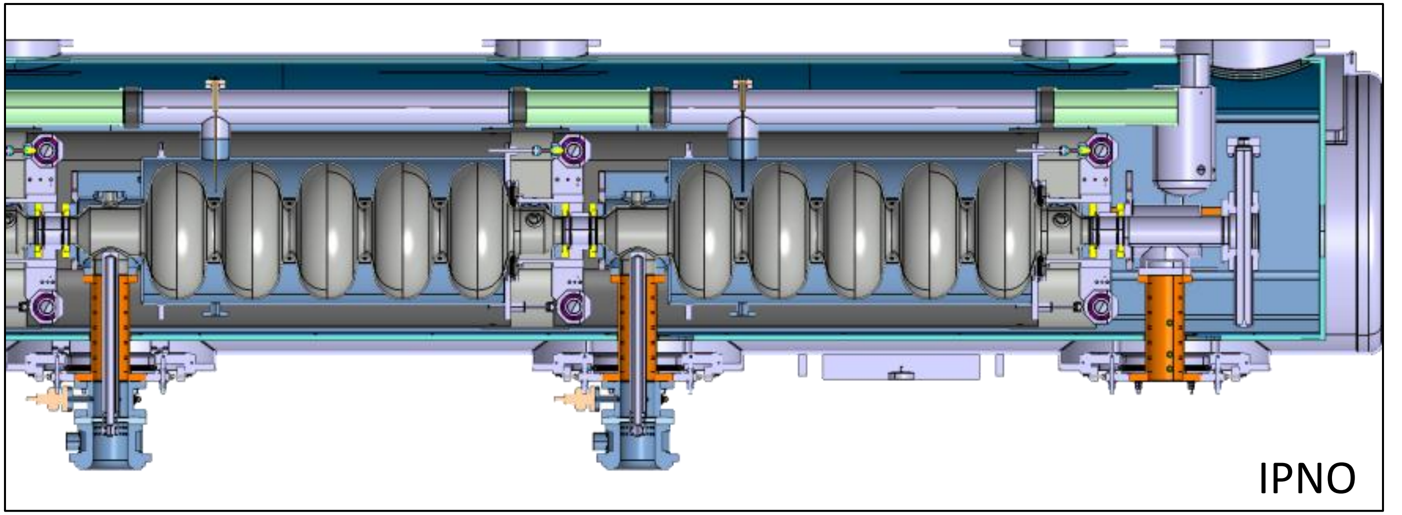
Conceptual view of cold shield (Th.Renaglia)
(more in Patxi's presentation)

Instrumentation/control devices

Instrumentation/control device	Location	Function	Range	Type	No.Units	Remarks
Ph.Sep. Lhe level gauge	Ph.Sep.pot, in LHeII	cryo control	top of line X to bottom of ph.sep.	tbd	1	
Cavity LHe level gauge	Line Y, in LHeII	cryo control	cavity top to center of line X	"	4	level measure on each cavity
Cavity electrical Heater	He vessel, in LHeII	cryo control, cavity HL compensation	25W	"	4	25 W, used for RF testing too
Cavity T gauge	He vessel, in LHeII	cryo control	293-2K	"	4	precision not essential for control
RF coupler double-walled tube T gauges	along tube, in insulation vacuum	T mapping for thermal performance diagnostics	293-5K	"	15	3 per coupler, also on dummy coupler
RF coupler external electrical heater	external vessel interface	active cooling control		"	5	1 per coupler, one per dummy coupler
Thermal shield T gauges	thermal shield, in insulation vacuum	T mapping for thermal performance diagnostics	293-50 K	"	6	tentative No.
CWT T gauges	CWT, in insulation vacuum	T mapping for thermal performance diagnostics	293-50 K	"	4	tentative No.
Tech.Service Module T gauges	critical points, in insulation vacuum	T mapping for thermal performance diagnostics	293-2 K	"	5	tentative No.
Tuner T gauges	on tuner mechanical parts, in insulation vacuum	for tuner CD/WU monitoring	293-2K	"	16	for tuning diagnostics, 4 per tuner (CEA's input)
Tuner motor	cavity extremity, in insulation vacuum	coarse slow tuning	see specs	CEA tuner	4	
Tuner piezo	cavity extremity, in insulation vacuum	fine fast tuning	see specs	CEA tuner	4	
HOM couplers	2 on each cavity, in insulation vacuum	extract unwanted modes--> HL	tbd	to be designed	8	Probably mounted at SCC upgrade
Wire Position Monitor (WPM)	along cryostat, in insulation vacuum	monitor CD/WU movements of cavities on SCC	0-3mm	Optocouplers	16	4 optocouplers per cavity. R&D in progress
JT, control valves	Valve Box	cryo control	see specs		14	4 JT valves, 4 CD/WU valves, 1 couplers cooling supply valve, 4 RT couplers cooling return valves + 1 for dummy coupler

Open issue:

Can cavity heaters & T gauges: can they be in the insulation vacuum ? If not, a leak-tight reliable ceramic feed-through is needed



Thank you

for your attention...

..and enjoy the review!

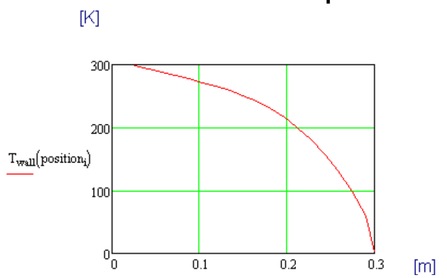
SPARE SLIDES

Actively cooled RF coupler tube

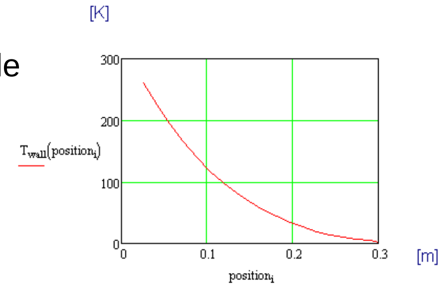
SPL coupler double walled tube, active cooling to limit static heat loads

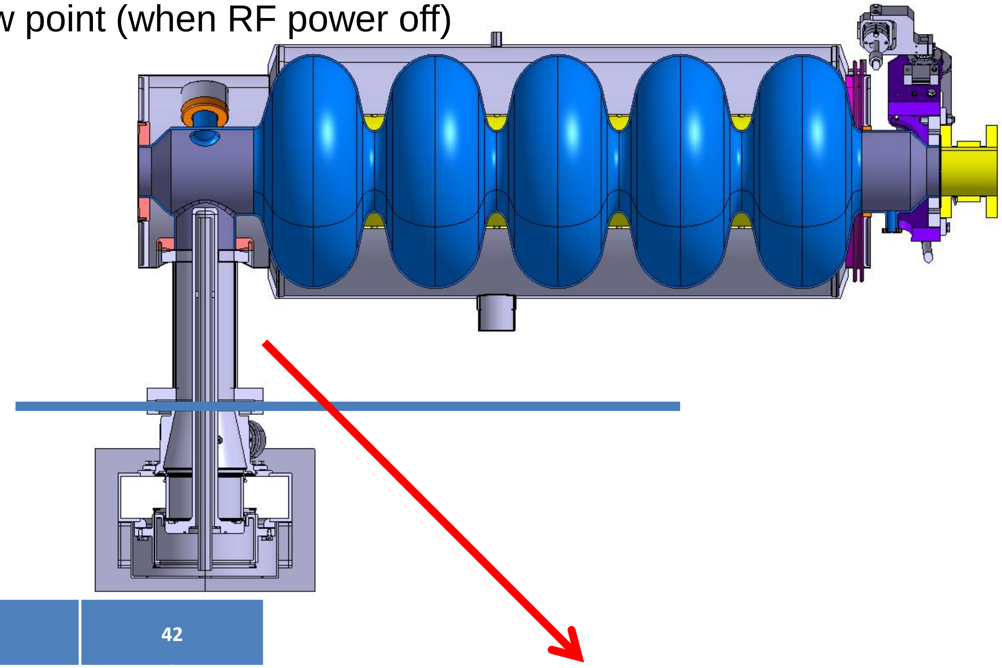
- Connected at one end to cavity at 2K, other end at RT (vessel)
- Requires elec. Heater to keep T > dew point (when RF power off)

No cooling T profile
→ 21W to 2K

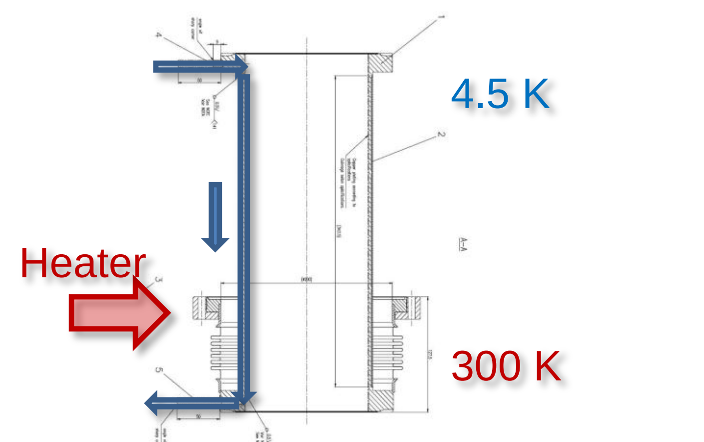


Cooling (42 mg/sec) T profile
→ 0.1 W to 2K





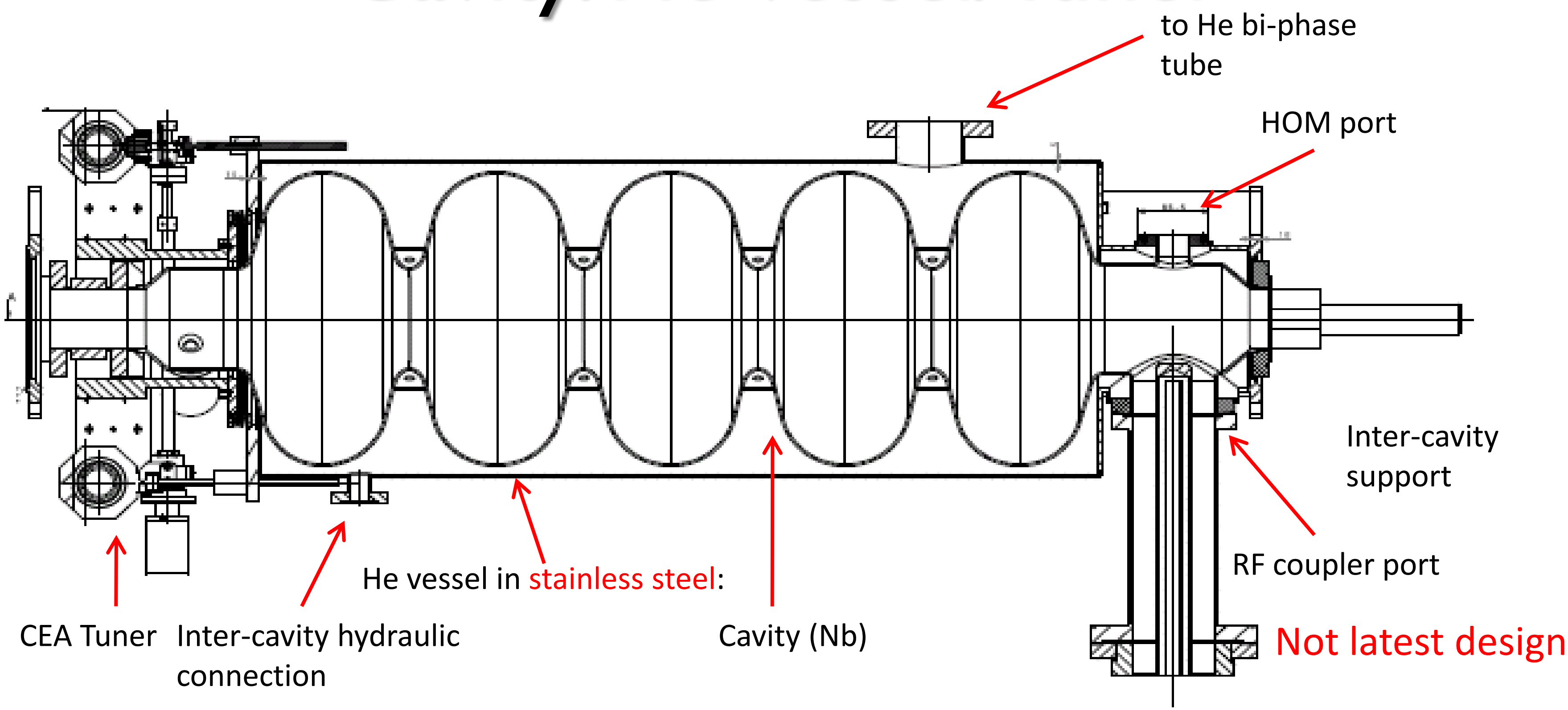
Massflow mgram/sec	21		23		28		35		42	
Power	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Temp. gas out	286 K	277 K	283 K	273 K	271 K	242 K	255 K	205 K	232 K	180 K
Q thermal load to 2K	2.4 W	0.1 W	1.7 W	0.1 W	0.4 W	0.1 W	0.1 W	0.1 W	0.1 W	0.1 W
Q heater	19 W	32 W	21 W	34 W	29 W	38 W	39 W	41 W	46 W	44 W
ΔL	0.1 mm (0.63-0.53)mm				0.05 mm (0.66-0.61)		~ 0 mm (0.67-0.67)			



Helium gas cooling the double wall

→ Yields a certain degree of position uncertainty (<0.1 mm?)

Cavity/He vessel/Tuner



He vessel includes specific features for cryo-module integration:
- inter-cavity supports,
- cryogenic feeds
- external magnetic shielding cryoperm™ (not shown)

Requirement	Value
β	1
Frequency	704.4 MHz
Qo	10×10^9
Gradient	25 MV/m
Operat. T	2 K

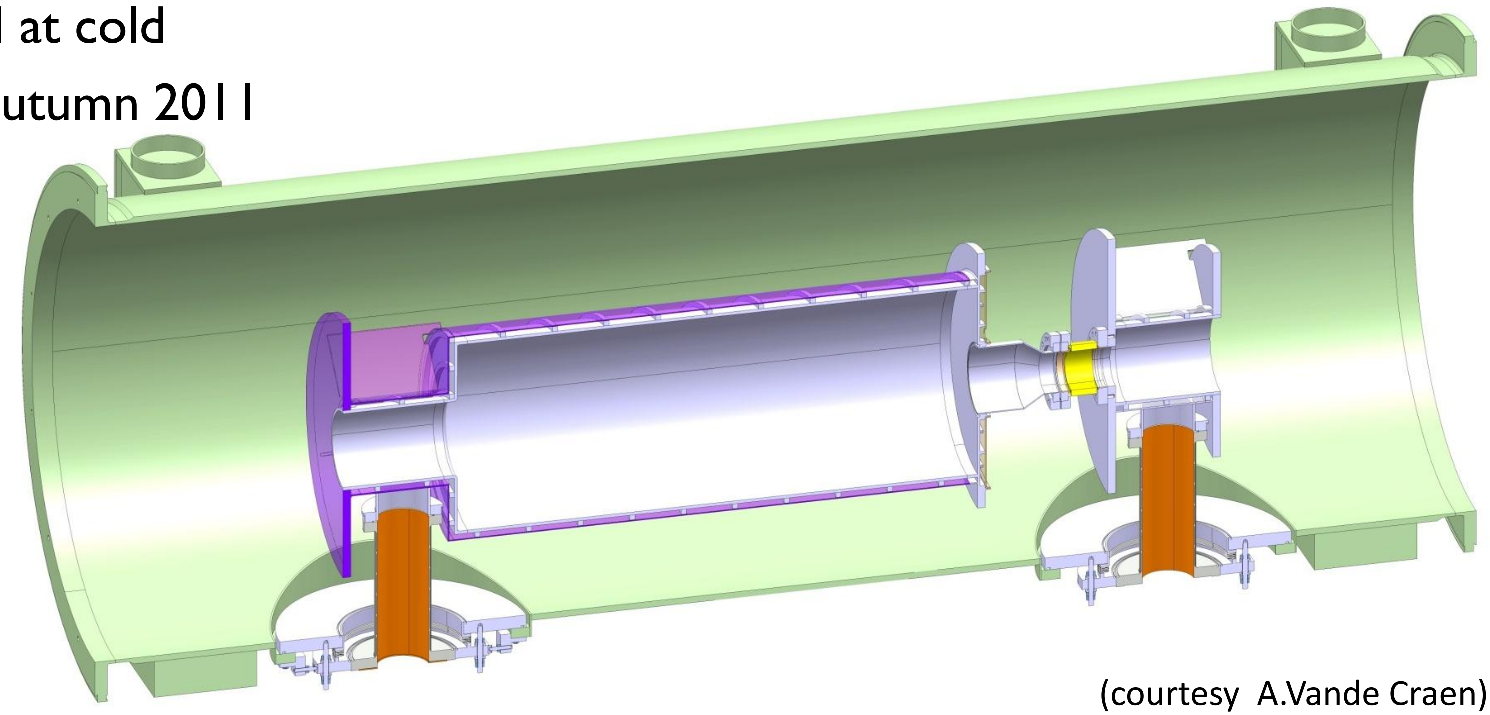
Full Mock-Up

- Same inertia as real helium tank
- Real double walled tubes, vacuum vessel fixtures, inter-cavity supports
- LN cooled
- Wire Position Monitor

Aims:

- Test assembly and alignment
- Test thermo-mechanical performance of supporting system
- Test WPM at cold

→ Ready in autumn 2011



(courtesy A.Vande Craen)

Wire Position Monitor (WPM)

Cavity position monitoring specs:

- Static position or slow movements: absolute movements (x,y,z) of each of 4 cavities during steady state operation and cool-down/warm-ups (300-2 K)
- Vertical range: 0-2mm
- Precision: <0.05mm
- Resolution : <0.01mm
- Possibly vibration measures (0-1kHz)

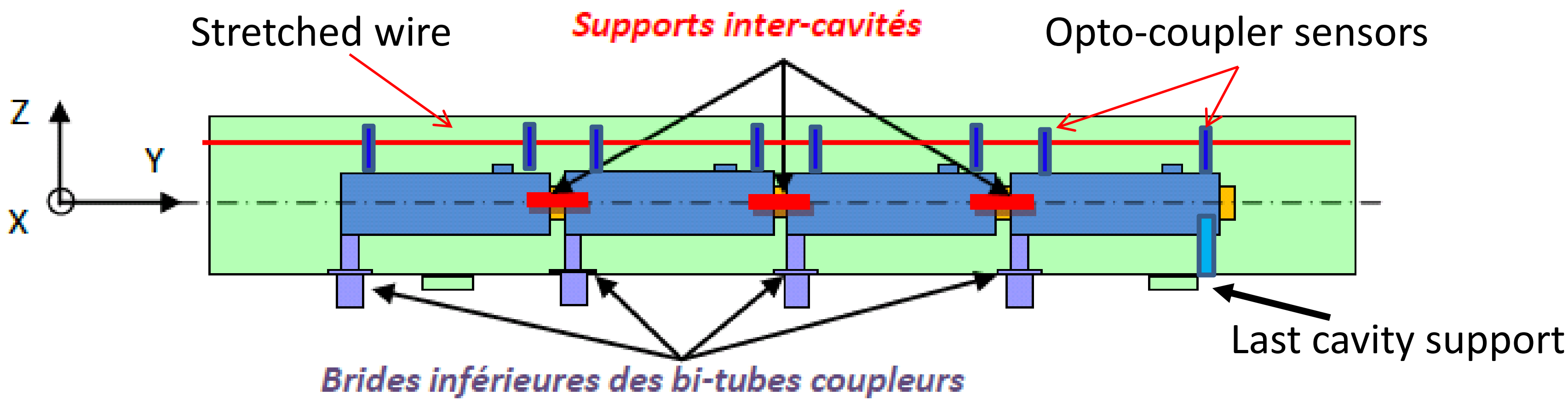
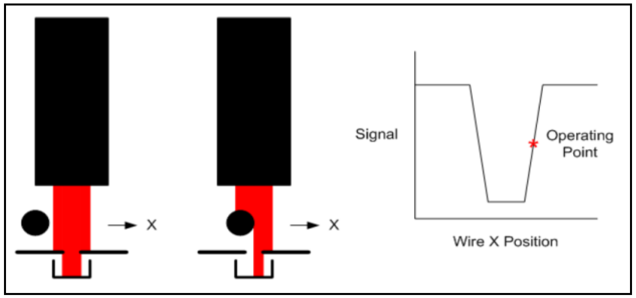
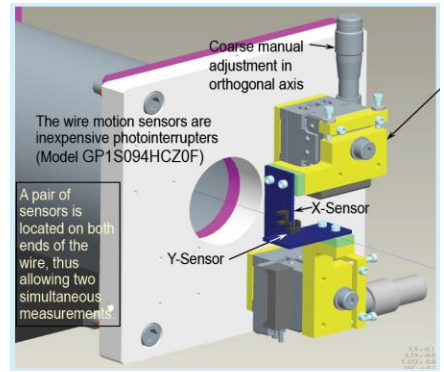
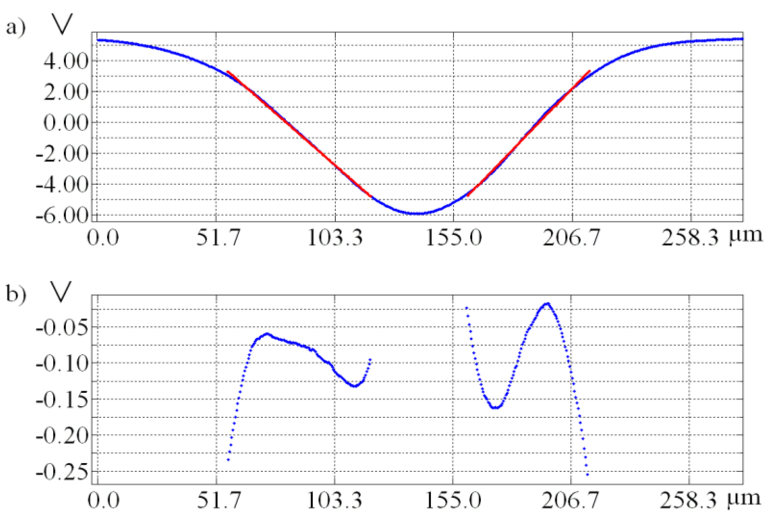


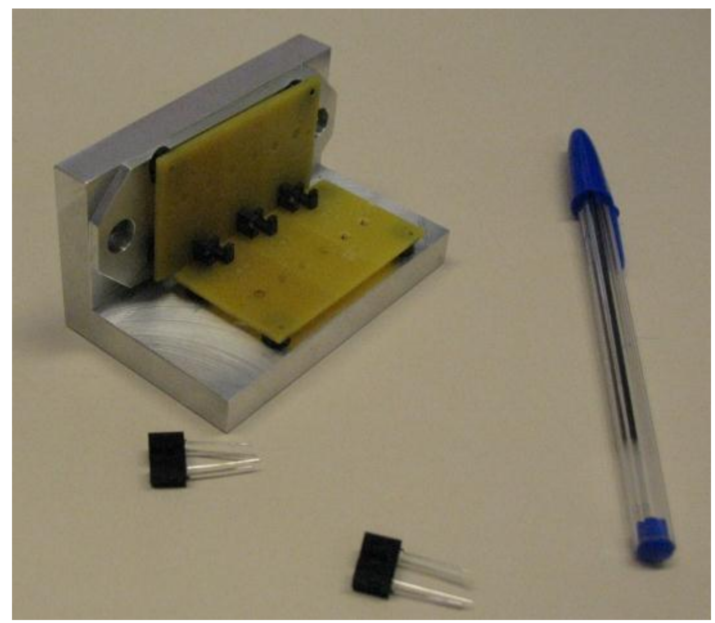
Photo-interrupter as displacement measurement devices: proof-of-principle in progress







Typical response and linearity curves (TJ0006 sensor, 1 mm wire)



Multiple interrupters to cover larger range

(courtesy: J.C.Perez)

The SPL Cryo-module Workspace

SPL Cryomodule Worskpace

This List: Documents

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Documents

New | Upload | Actions | View: All Documents

Type	Name	Modified	Modified By
PDF	Calculation_Note_2010_06_Weights_of_Cavity_Components	02/05/2011 09:26 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_02_PC_Double_Tube_Equivalent_Simple_Tube	02/05/2011 09:26 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_02_PC_HeVessel_Flanges_Test_Set_Up	02/05/2011 09:27 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_02_Transversal_Stiffness_of_HeVessel_bellow	02/05/2011 09:27 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_03_Cavity_and_He_Vessel_Deflection_Due_to_Self_Weight_and_Weight_of_Tuner	02/05/2011 09:28 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_03_HeVessel_StainlessSteel_vs_Titanium	02/05/2011 09:28 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_03_PC_HeVessel_Flanges_Test_Load_vs_Contact_Gap_and_Stress_Levels	02/05/2011 09:29 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_03_Transversal_Stiffness_of_Cavity_HeVessel_Connection_Via_Tuner	02/05/2011 09:29 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_04_Articulation_Position_Inter_Cavity_Support	02/05/2011 09:29 AM	Paulo Coelho Moreira De Azevedo
PDF	Calculation_Note_2011_06_Assembly_Tooling_Stiffness	22/06/2011 02:24 PM	Paulo Coelho Moreira De Azevedo
Word	Load_Case_SPL	23/06/2011 05:24 PM	Arnaud Vande Craen
Word	Torque_Stud	21/06/2011 03:41 PM	Arnaud Vande Craen

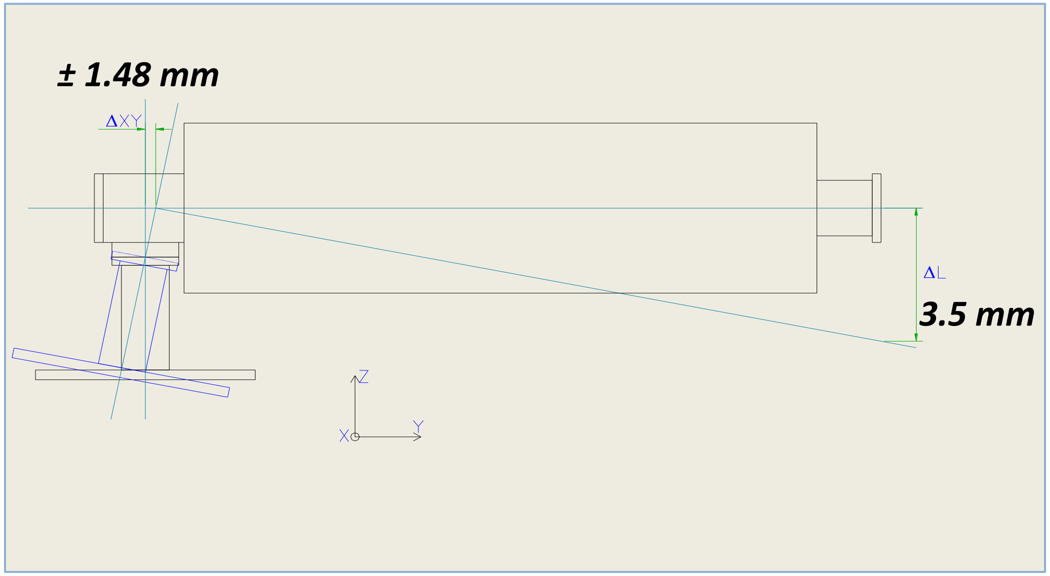
Local intranet | 100%

https://espace.cern.ch/spl-cryomodule/default.aspx

For more information: Arnaud.VandeCraen@cern.ch

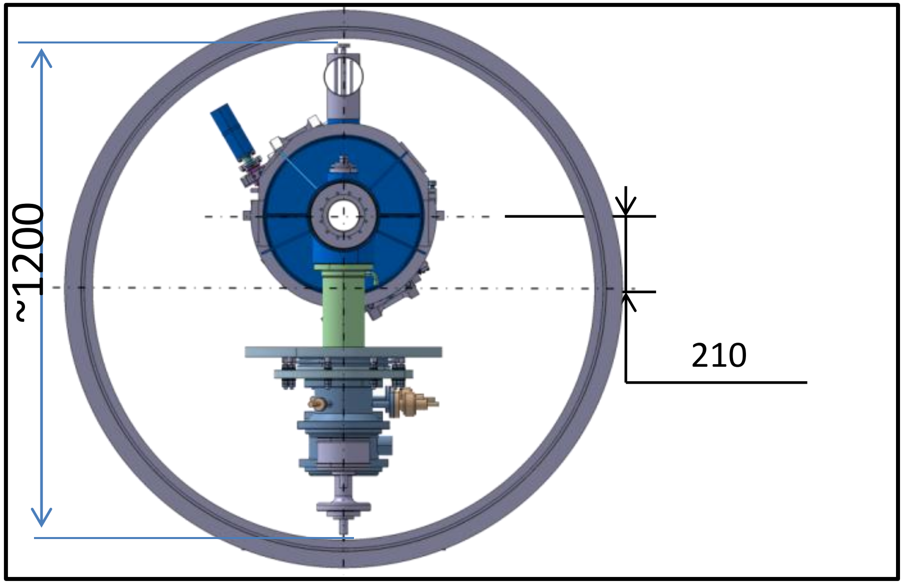
Cavity-to-vacuum vessel tolerances

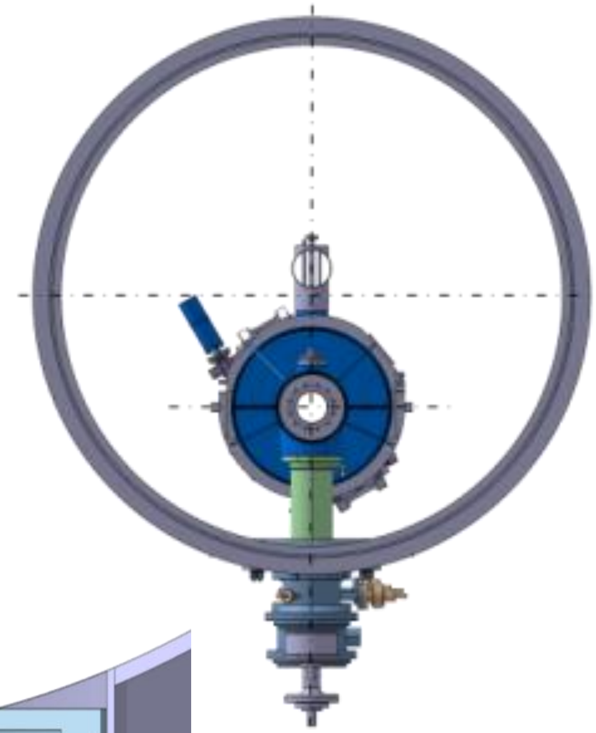
	Stack of construction tolerances					
#		**Angular tolerance (planarity or perpendicularity)**	**Radial tolerance induced by angular tolerance**	**Radial tolerance**	**Angle**	**Δz (@ cavity extremity 1100mm)**
1	Cavity flangeø152	0.3 mm (cavity design)	± 0.6 mm	± 0.1 mm (Th.Renaglia)	0.122°	**3.5 mm / 3.1 mm**
2	Double-walled tube top flange ø152	0.02 mm (drwg SPLACSMC0024)	± 0.04 mm			
3	Cu RF gasket ø152	N.A.	N.A.	± 0.05 mm (drwg SPLACSMC0025)		
4	Double-walled tube top flange ø500	0.02 mm (drwg SPLACSMC0024)	± 0.02 mm		0.06° / 0.037°	
5	Vac.vessel flange ø500	0.5 mm / 0.3 mm (experience LHC)	± 0.42 mm / ± 0.25 mm	± 0.25 mm (experience LHC)		
	TOTAL ΔXY		***± 1.48 mm / ± 1.31 mm***			

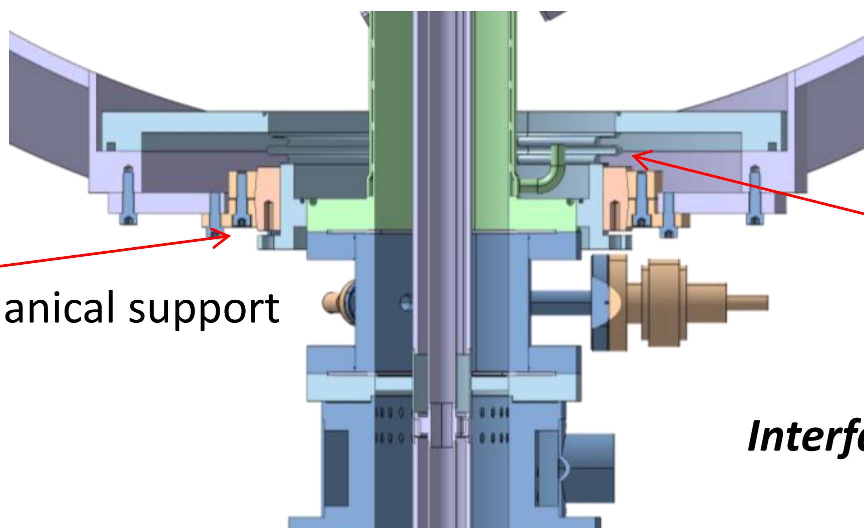


At each cavity:
- Vertical shimming
- Angular shimming

Transversal Space Constraint





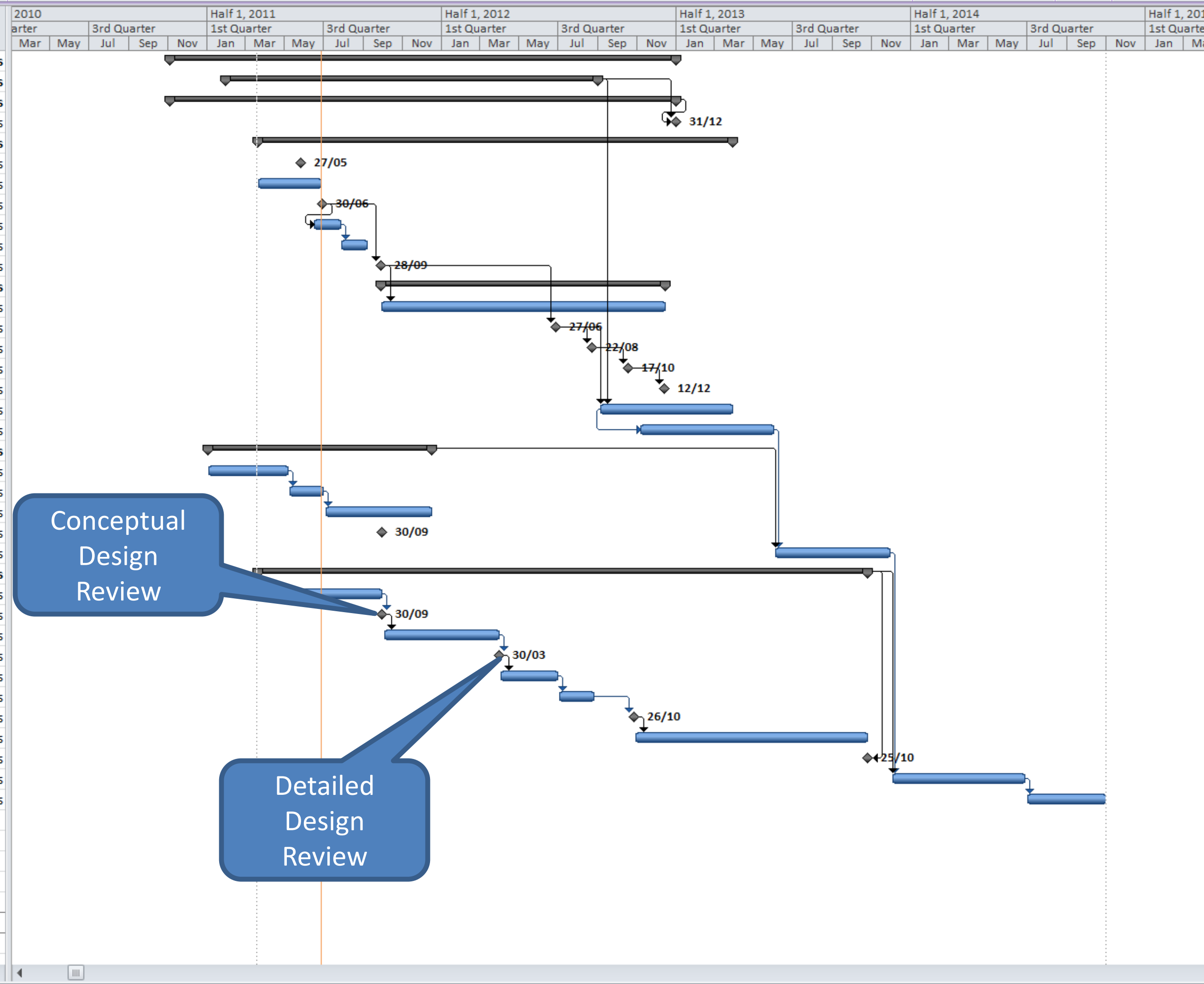


Interface to Vacuum Vessel

IPNO-Orsay

Schedule

		Task Name	Duration
1		SM18	562 days
2		Cryogenic	415 days
12		RF	562 days
138		SM18 ready	0 days
139		Cavities production	530 days
140		Niobium delivery	0 days
141		Cavities design (incl. detailed design)	71 days
142		Cavities design validation	0 days
143		Tech. spec.	6 wks
144		Call for tender	6 wks
145		Signature of contract	0 days
146		Cavities production	317 days
147		Production	63.4 wks
148		Cavity 1	0 days
149		Cavity 2	0 days
150		Cavity 3	0 days
151		Cavity 4	0 days
152		Cavities test in vertical cryostat (SM18)	30 wks
153		Insertion of cavities in helium enclosure	30 wks
154		Couplers	250 days
155		Brazing, EB welding, assembly (coupler,TD, test cavity)	18 wks
156		Clean room assembly (DESY)	8 wks
157		RF power tests (CEA), couplers ready for SPL cavities	24 wks
158		Prototypes validation	0 mons
159		Cavities - coupler assembly	26 wks
160		Cryostat	680 days
161		Conceptual design	28 wks
162		Conceptual design review	0 days
163		Detailed design	26 wks
164		Detailed design review	0 days
165		Preparation of tender documents	13 wks
166		Tendering	8 wks
167		Signature of contract	0 days
168		cryostat and tooling production	52 wks
169		Tooling ready for cryostating	0 days
170		Cryostating and RT qualification testing	30 wks
171		RF tests	18 wks

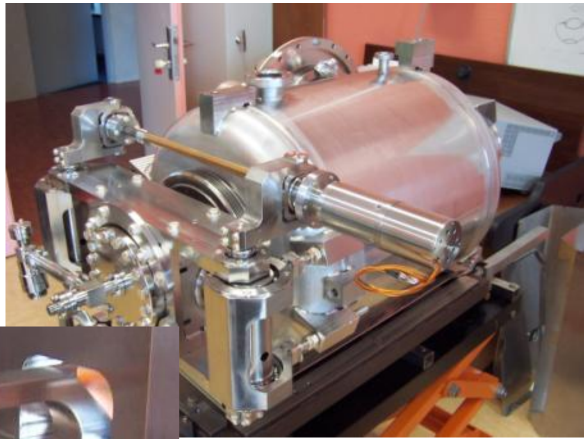


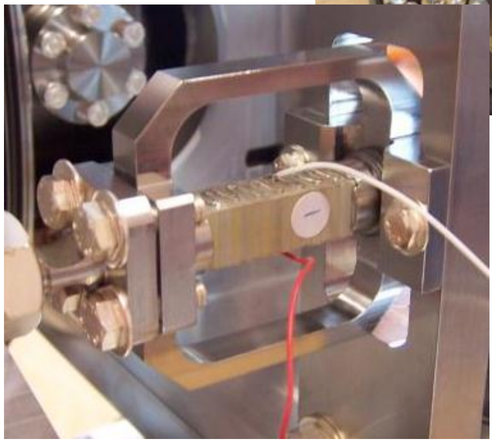
New Tasks : Auto Scheduled

Saclay piezo tuner for 700MHz cavities

G. Devanz, CEA-Saclay, SPL 3rd coll. meeting

- Slow tuner with symmetric action
- Excentric/lever arm proven Saclay design
- Planetary gear box (3 stages)
- Single NOLIAC 30mm piezo actuator
- Stiffness measured on the tuner pneumatic jack = 35 kN/mm
- Initially developed for the beta=0.5 5-cell cavity





Piezo Support