12th International Workshop on RF Superconductivity

Cornell University, Ithaca, New York, USA - July 10-15, 2005

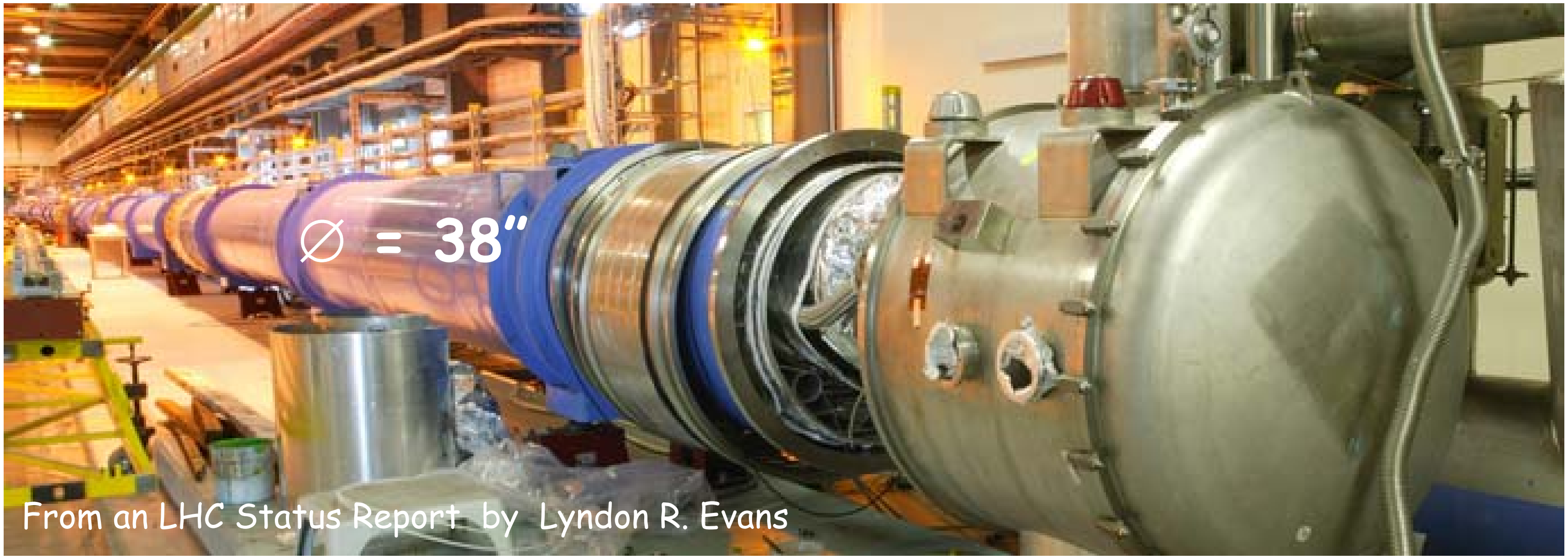
Cryomodule Design, Assembly and Alignment

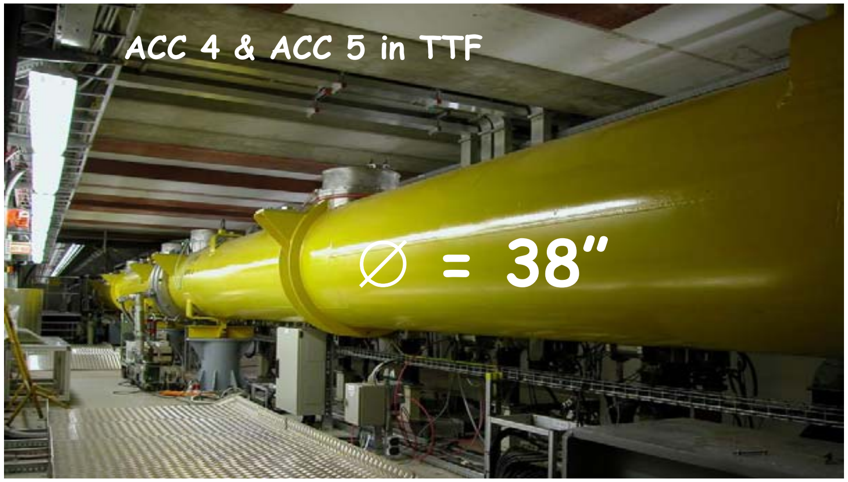
Carlo Pagani

INFN Milano and DESY

On leave from University of Milano

LCH and TESLA Cryomodule Comparison





SRF Cavities and Ancillaries - 1

Cavities and ancillaries design are chosen on the basis of a complex optimization that depends on:

- Accelerated particles
  - Electron : $\beta = 1$
  - Protons and ions : $\beta < 1$ up to very high energies
- Beam energy
  - A variety of shapes for protons and ions
- Beam current
  - High current asks for consistent HOM dumping
  - Low current produces high external Q and tight resonance
- Beam quality requirements
  - Alignment tolerances
  - High Order Mode damping

SRF Cavities and Ancillaries - 2

- Pulsed operation
  - High field dominant wrt minimum losses
  - Lorentz force detuning impact the cavity design
  - Active fast tuner required for high field
  - High peak power coupler for high current
- CW operation
  - High Q, low losses, dominant wrt maximum field
  - Microphonics can be crucial
  - Active fast tuner considered for low current
  - High average power coupler for high current
- Other machine dependent features
  - High filling factor : interconnections, tuner, magnets, etc
  - Very low static losses : long cryo-strings

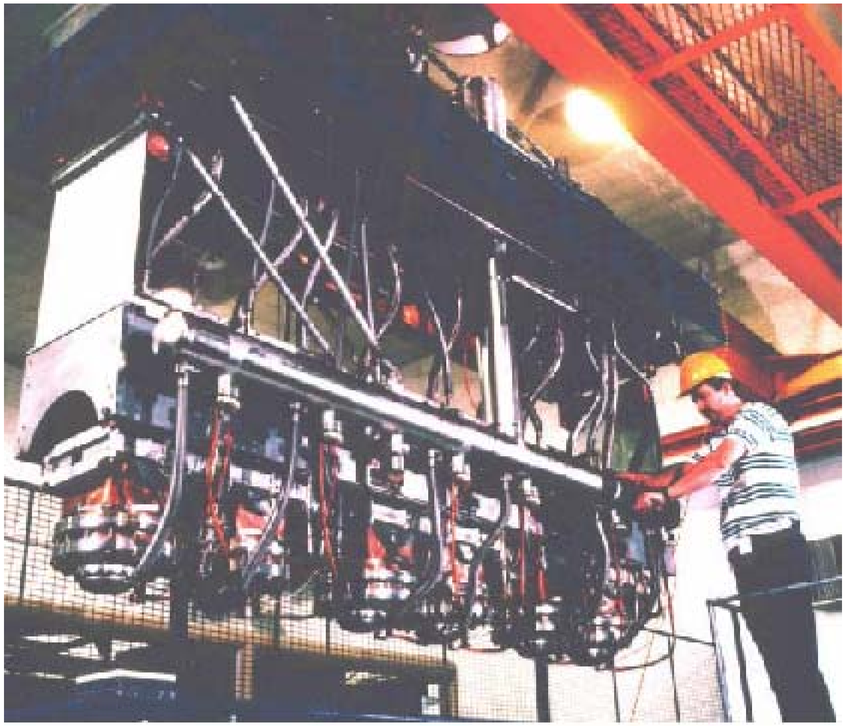
General Considerations on Cryomodules

- Many of the past cryomodules can be viewed as the combination of a cavity system and an independently designed cryostat to contain it with minimum losses.
- The design of the new generation cryomodules are more and more integrated in the original concept and optimization of the foreseen accelerator.
- In these cases the cryostat is one of the cryomodule components and its optimization can affects the cavity system design.
- For a given SRF accelerator the overall cryomodule cost and performance dominates with respect to the individual components
- Components and systems reliability, together with the accelerator availability for experiments, are concepts that are now included in the large accelerator design from the beginning
- Redundancy or MTTR (mean time to repair)?
- Improve QC (quality control) for MTBF (mean time to repair)

Heavy Ion Machines: ATLAS and JAERY

Medium Beta Cryomodule at JAERY

ATLAS Injector Cryomodule



Heavy Ion Machines: ALPI at LNL

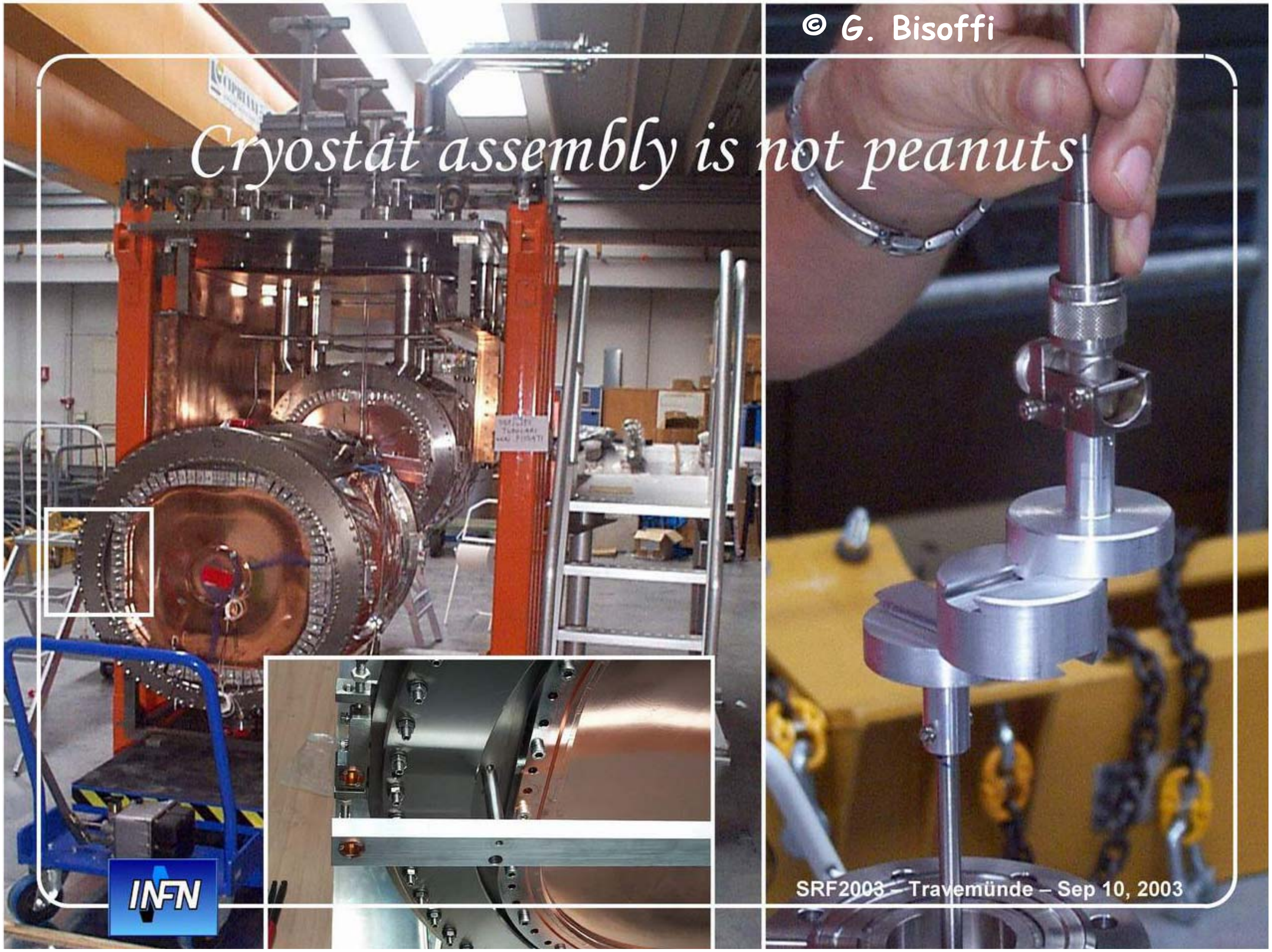
The internal 4.2 K components
of an ALPI cryomodule at LNL

Cryomodules and room temperature
optics in the ALPI heavy ion Linac

Heavy ion cryomodule general futures

- Cavities are grouped to improve filling factor
- No clean room assembly
- Each cavity is independently suspended and aligned
- Cavities cooled at 4.2 K through a Liquid He reservoir
- No magnetic elements in the modules
- Beam vacuum and iso-vacuum non independent
- Limited use of MLI insulation because of vacuum problems
- Liquid nitrogen shield often used to reduce LHe consumption

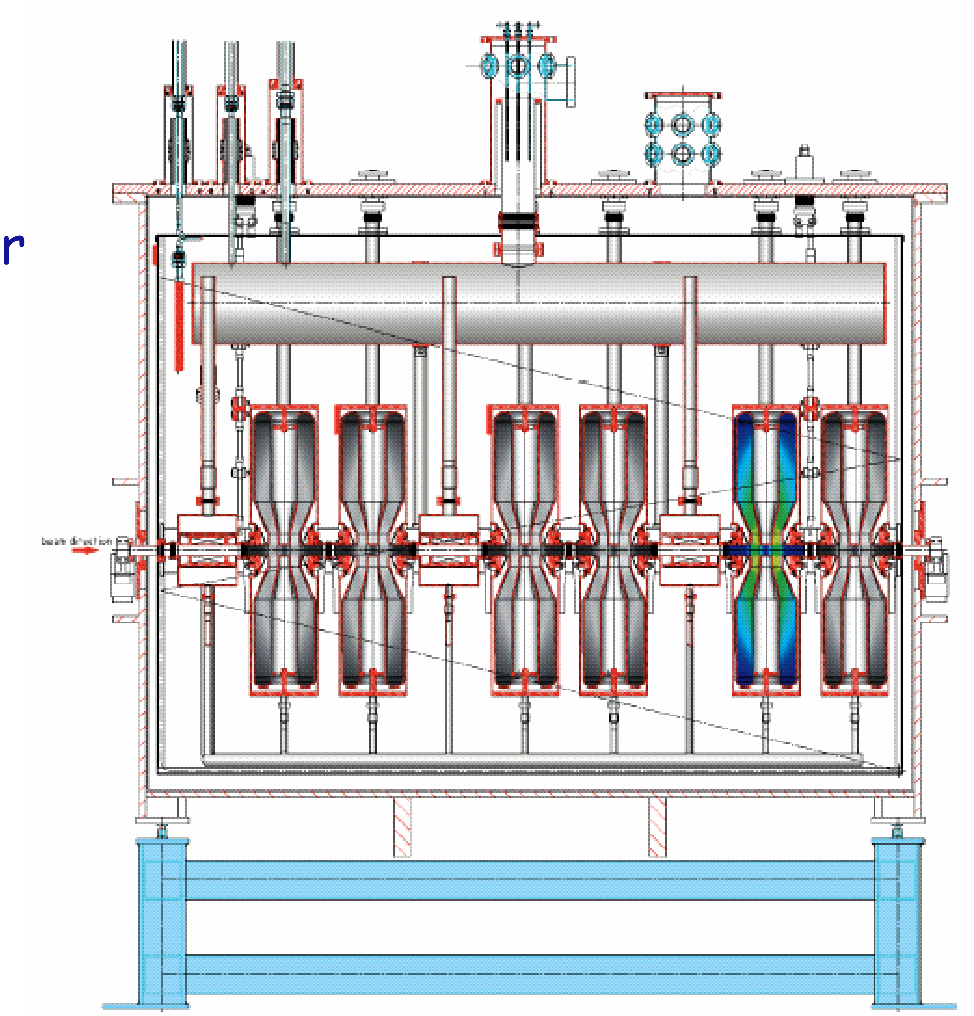
The LNL RFQ Cryostat



Some Improvement from Industry

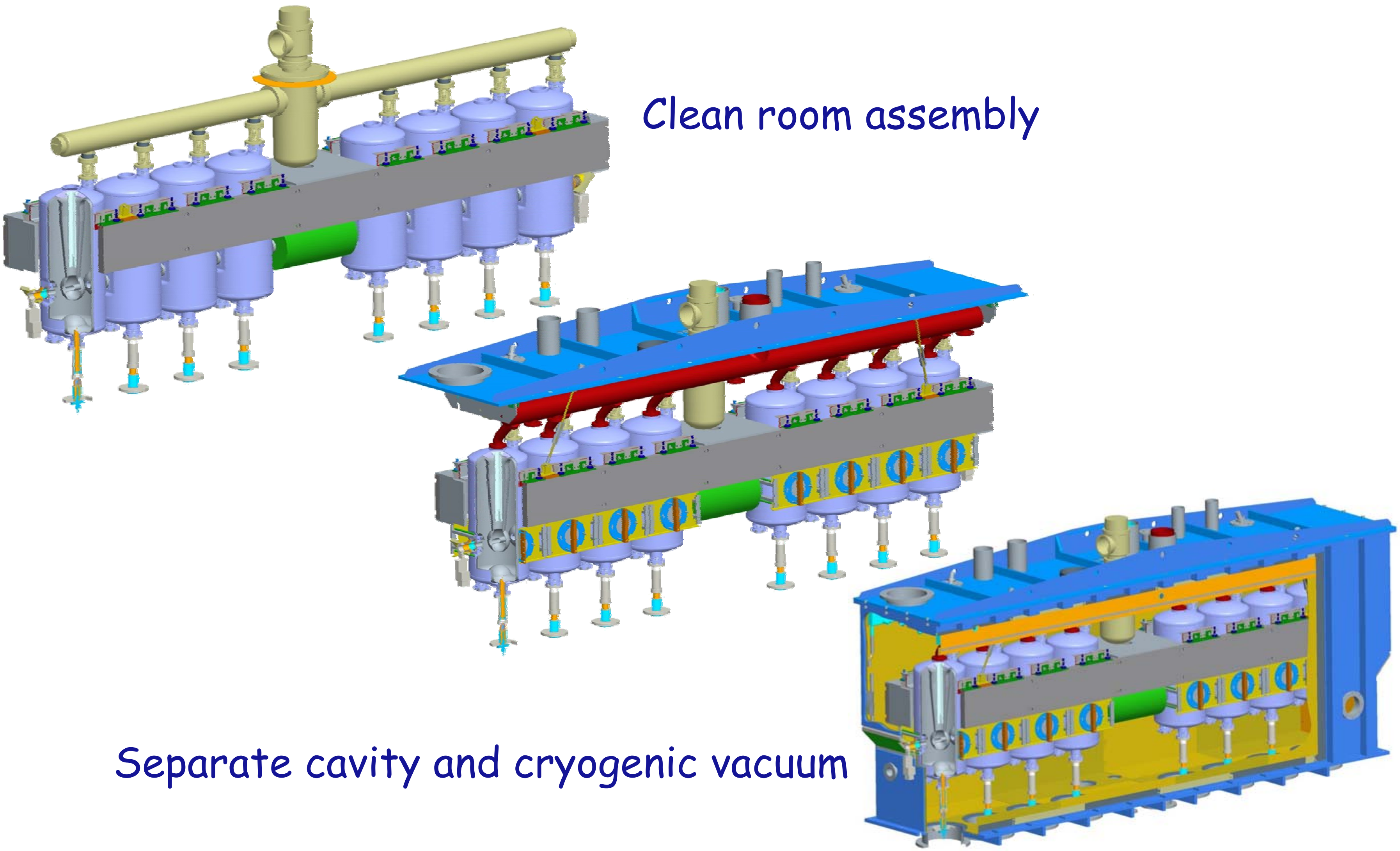
SRF Module with six Half-Wave Resonators for Proton/Deuteron Linac developped by ACCEL

- Design concept from Jaery and LNL
- Magnetic elements included
- Higher QC and Cost



RIA / ATLAS Upgrade Cryomodule

Clean room assembly



Separate cavity and cryogenic vacuum

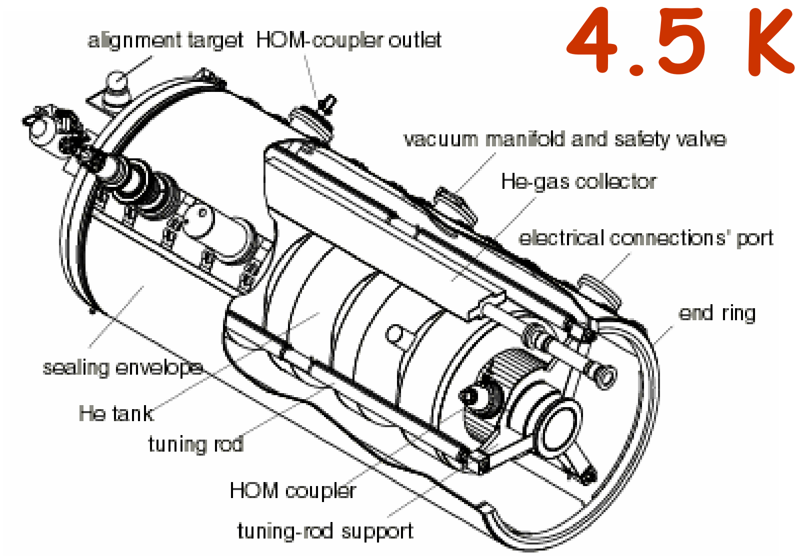
Large project impact on SRF technology

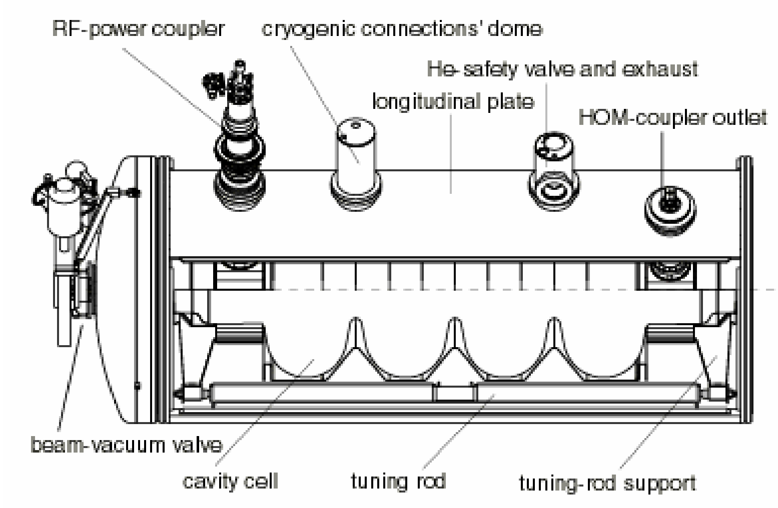
- In 1985 the successful test of a pair of SC cavities in CERS opened the door to the large scale application of SRF for electrons
- The decision of applying this unusual technology in the largest HEP accelerators forced the labs to invest in Research & Development, infrastructures and quality control
- The experience of industry in high quality productions has been taken as a guideline by the committed labs
- At that time TJNAF and CERN played the major role in SRF development, mainly because of the project size
- The need of building hundreds of cavities pushed the labs to transfer to Industry a large part of the production
- R&D and basic research on SRF had also a jump thanks to the work of many groups distributed worldwide

Effect on Cryomodule Concept

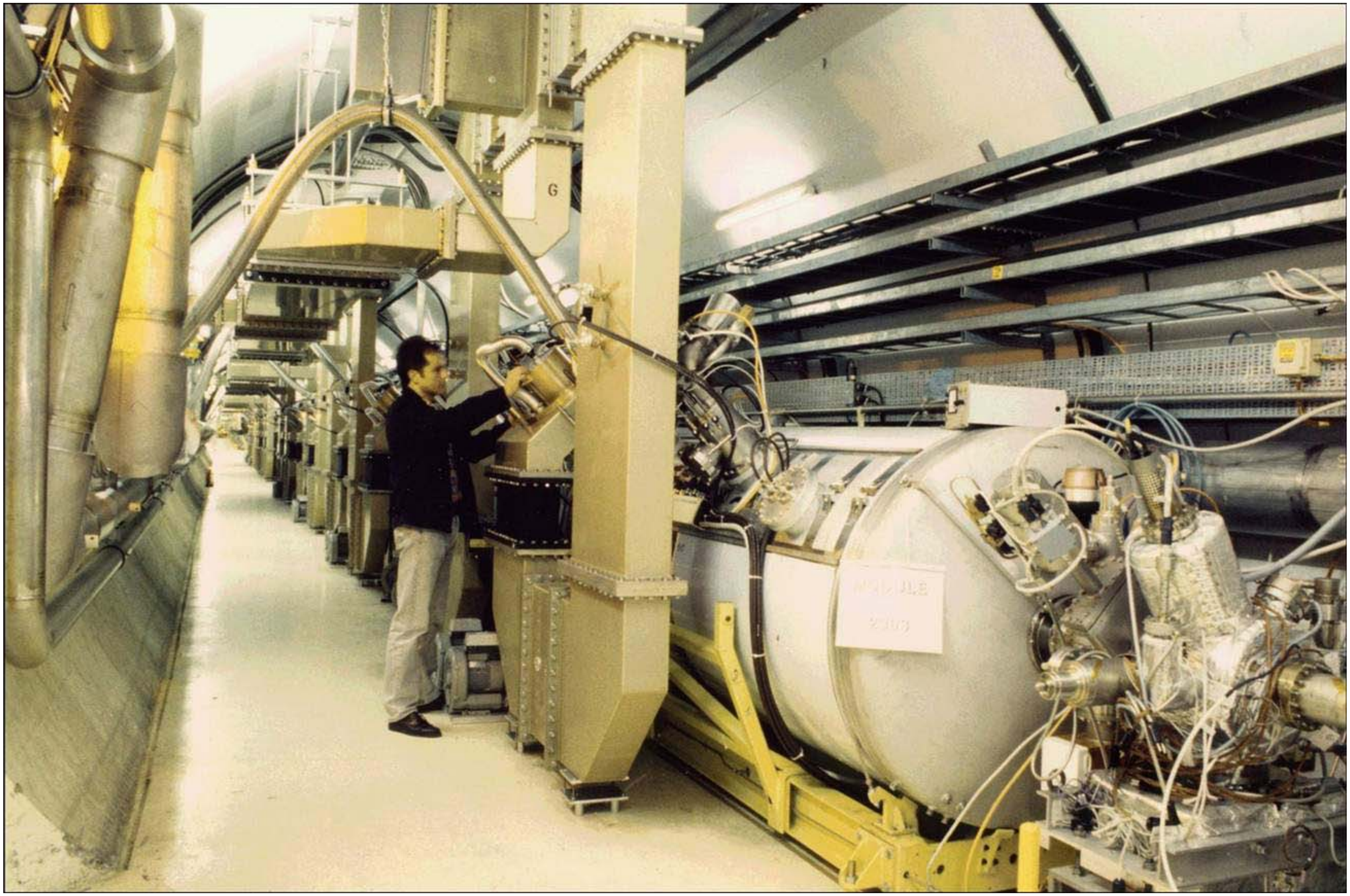
- Independent insulation vacuum
- Clean room assembly of the cavity string
- Large dedicated infrastructure
- New level of system integration and Quality Control
- Cost driven issues included
- Long cryo-strings when possible

LEP II Cavity and Cryomodule

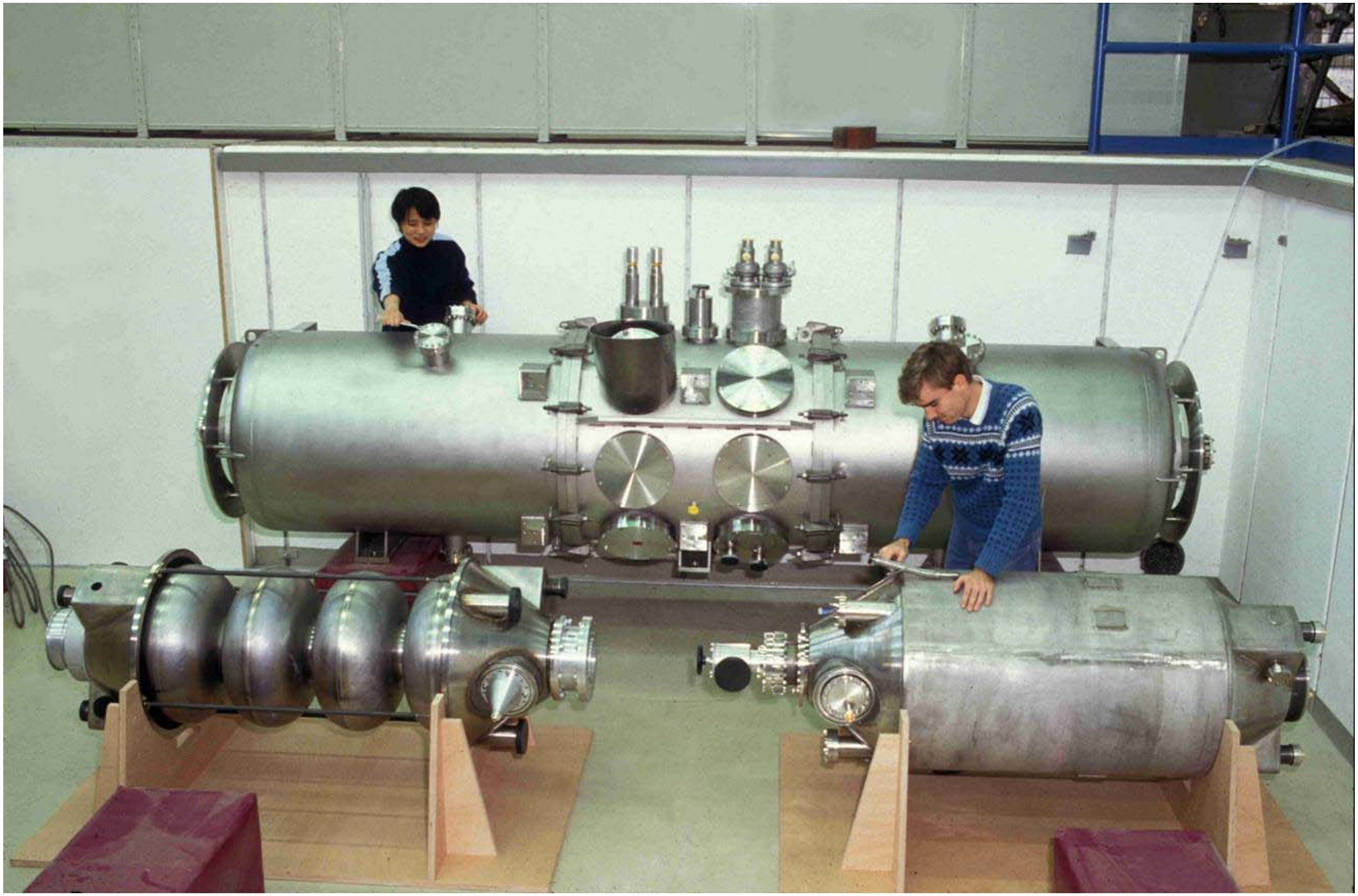




LEP II Cryomodules inside the Tunnel



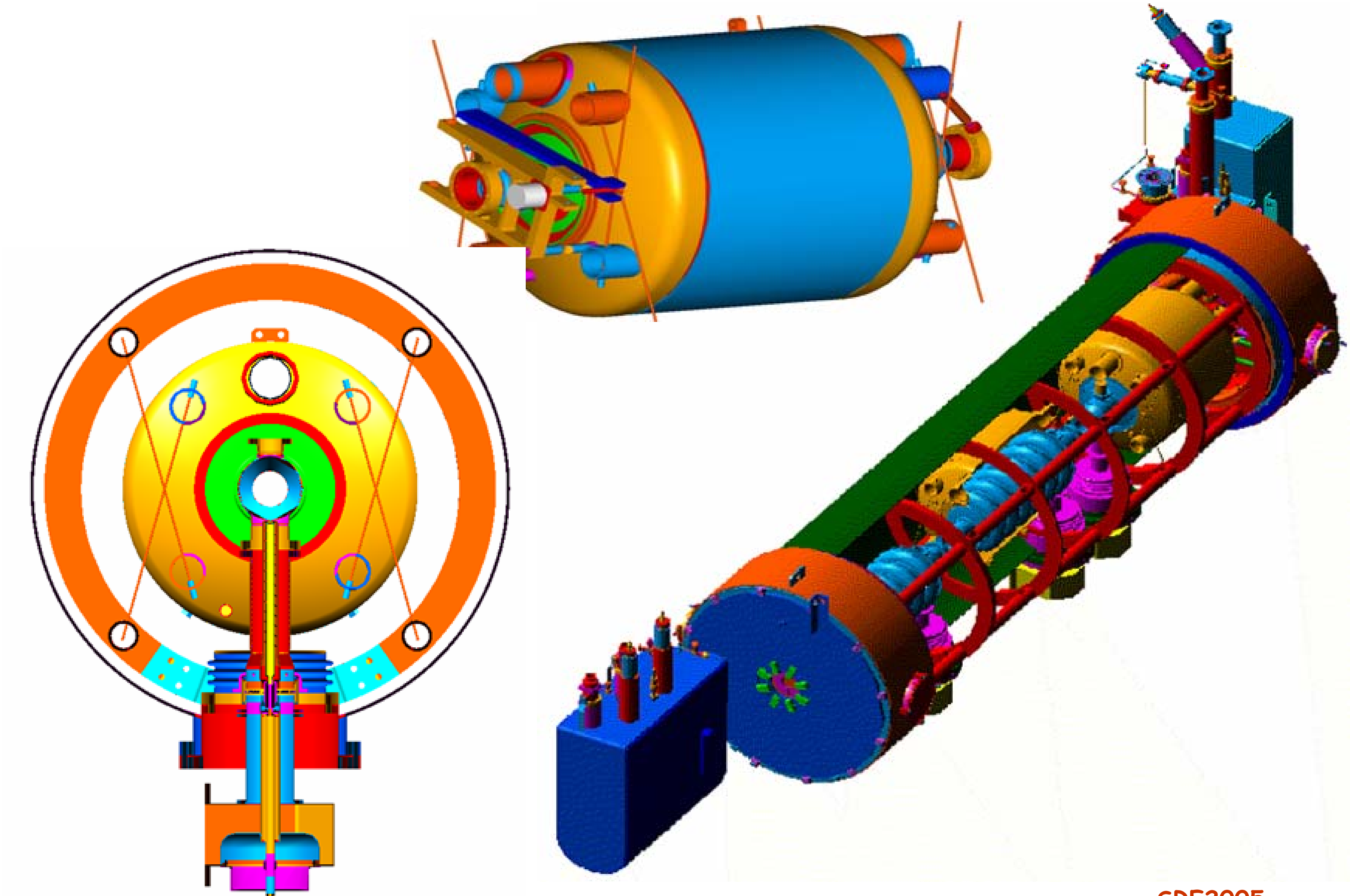
HERA Cavities and Cryomodule



Clean Assembly of a CEBAF Cavity Pair

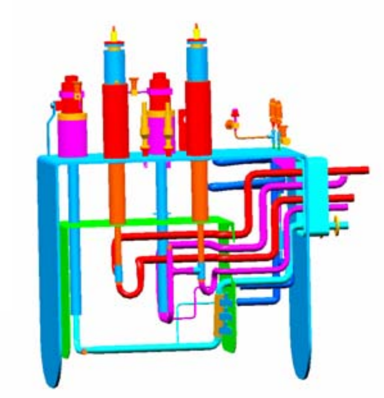
2 K

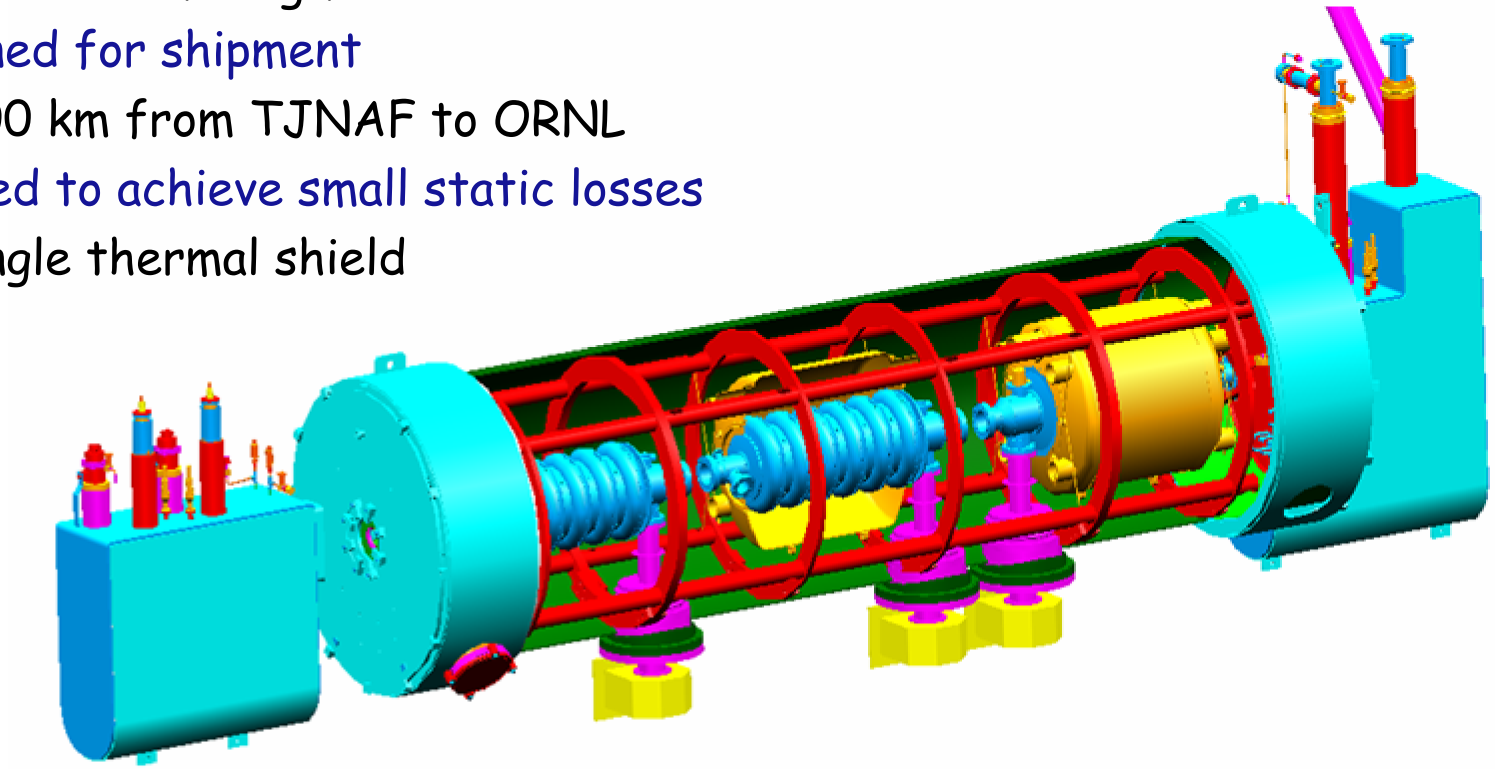
The SNS Cryomodule



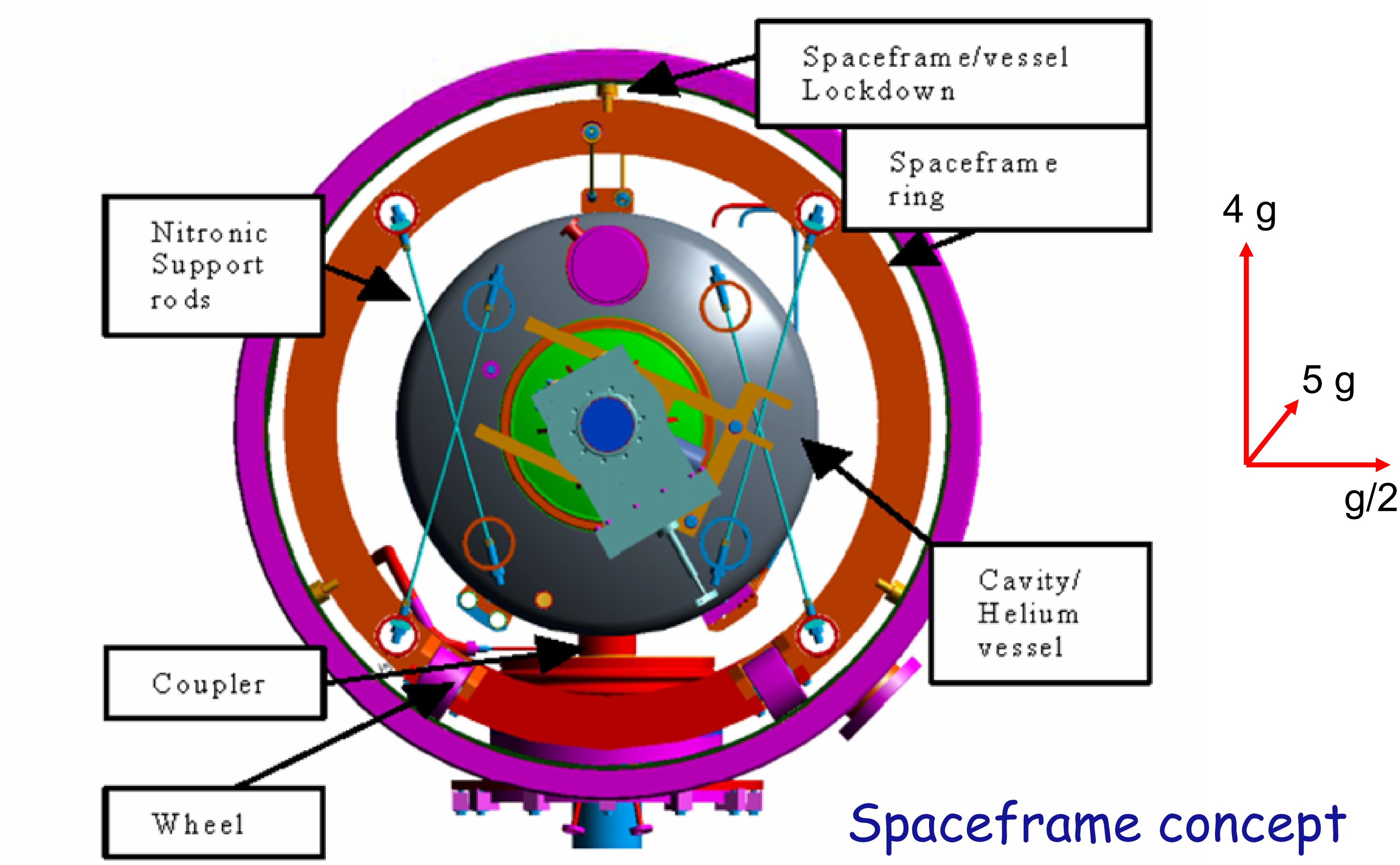
Design Rationales

- Fast module exchange and independent cryogenics (bayonet connections)
  - ✓ 1 day
  - ✓ 2K production in CM
- Warm quad doublet
  - ✓ Moderate filling factor
- Designed for shipment
  - ✓ 800 km from TJNAF to ORNL
- No need to achieve small static losses
  - ✓ single thermal shield





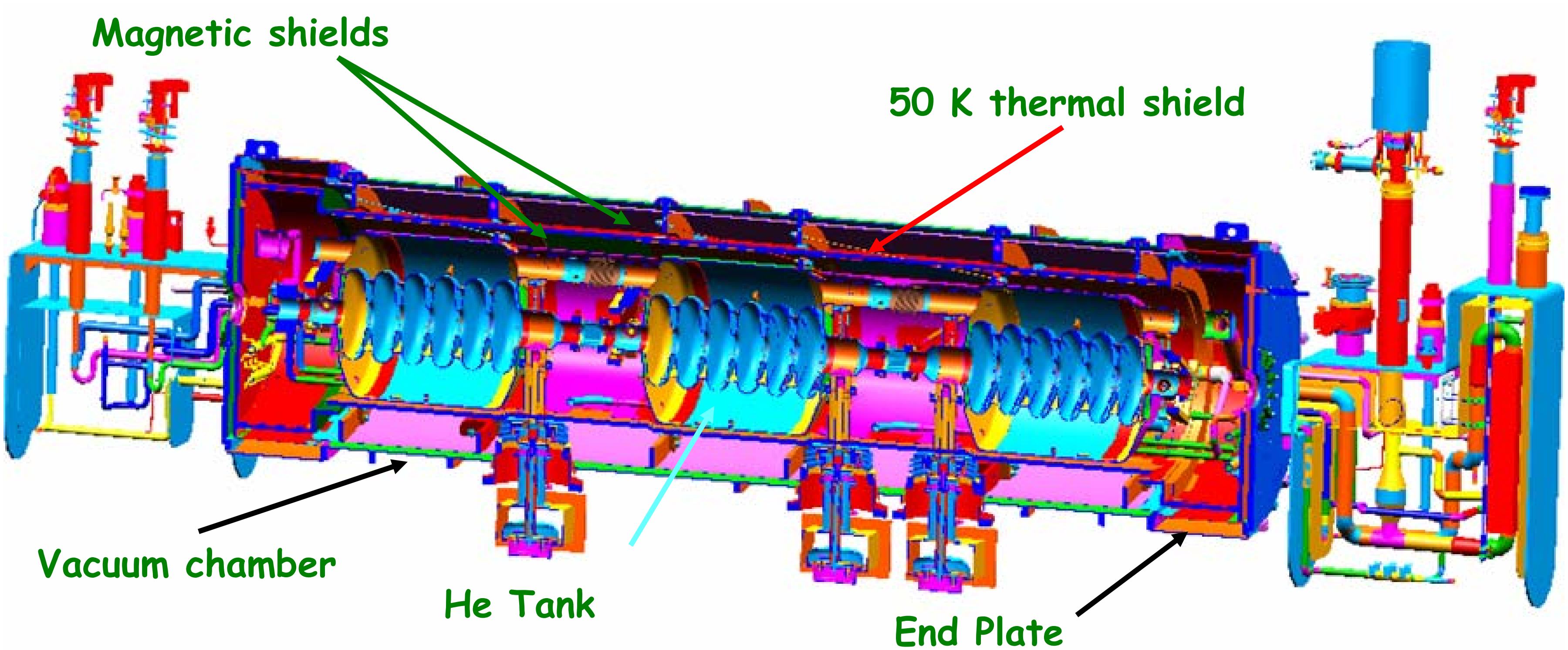
Design for shipment (TJNAF to ORNL)



Spaceframe concept

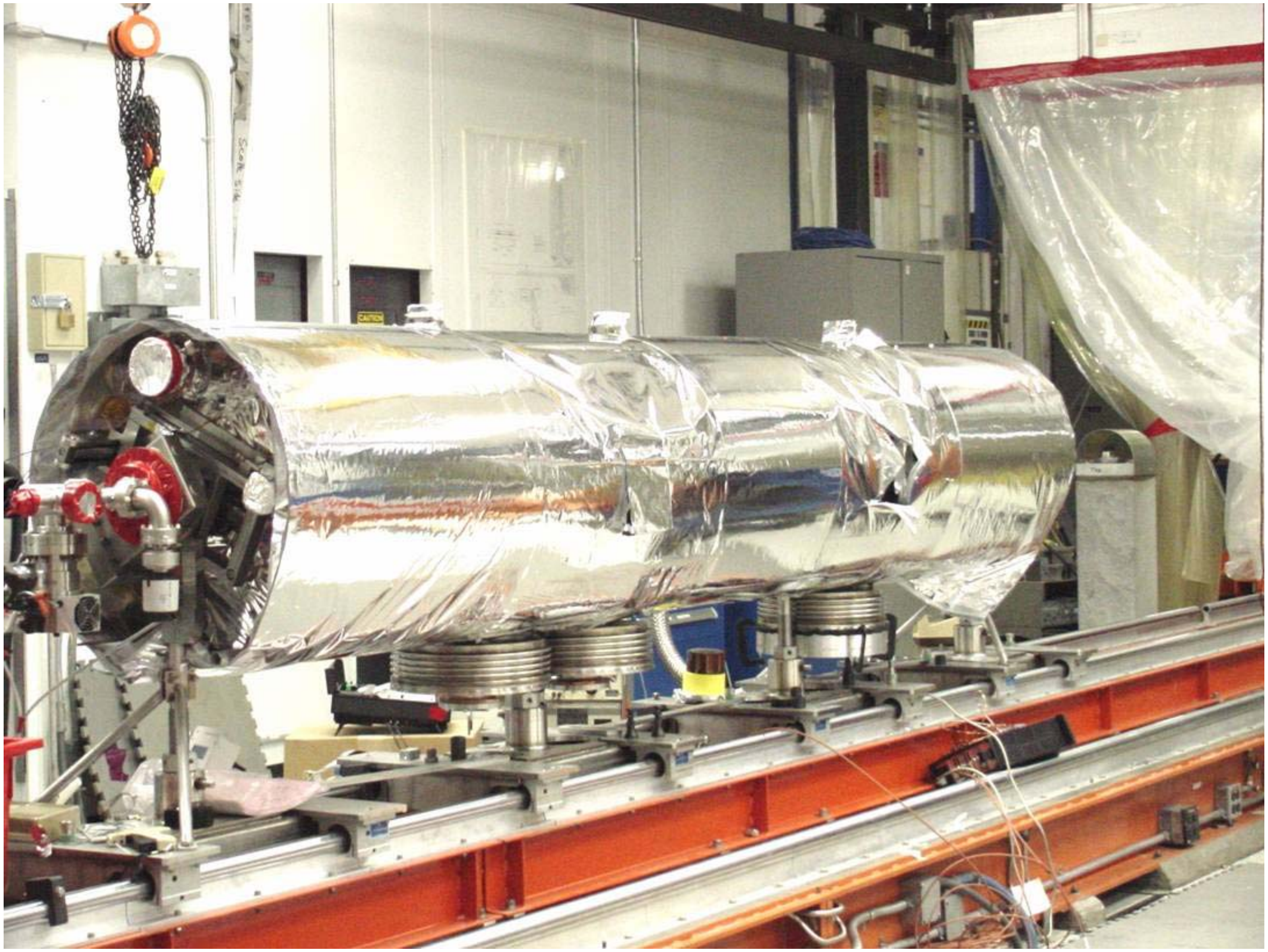
Around the cold mass

- Helium to cool the SRF linac is provided by the central helium liquefier
- He then piped to the 4.5K cold box and sent to the cryomodules
- Joule Thomson valves on the cryomodules produce 2.1 K (0.041 bar) LHe for cavity cooling, and 4.5 K He for fundamental power coupler cooling
- Boil-off goes to four cold-compressors recompressing the stream to 1.05 bar and 30 K for counter-flow cooling in the 4.5K cold box

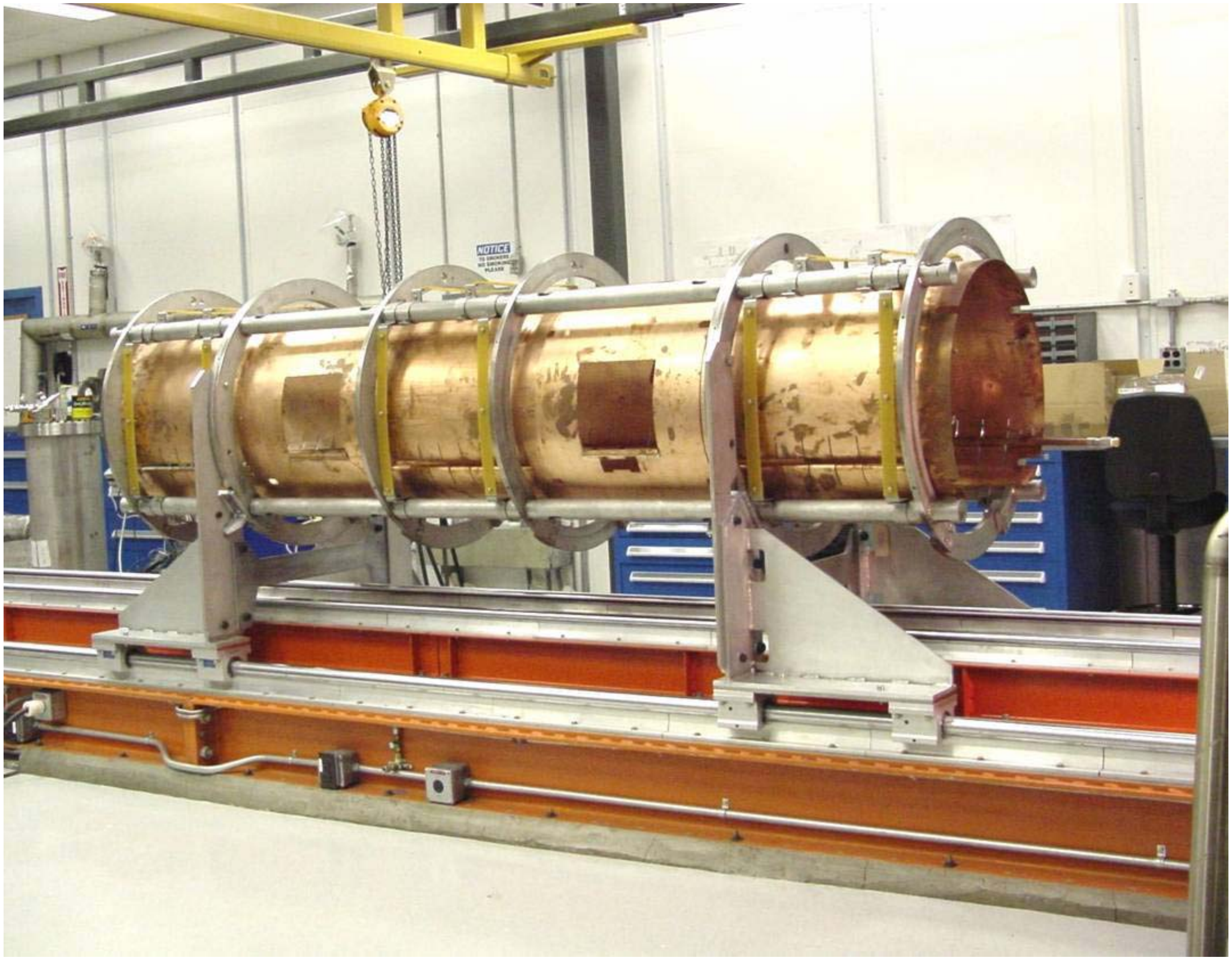


SNS β=0.61 Cryomodule Assembly -1

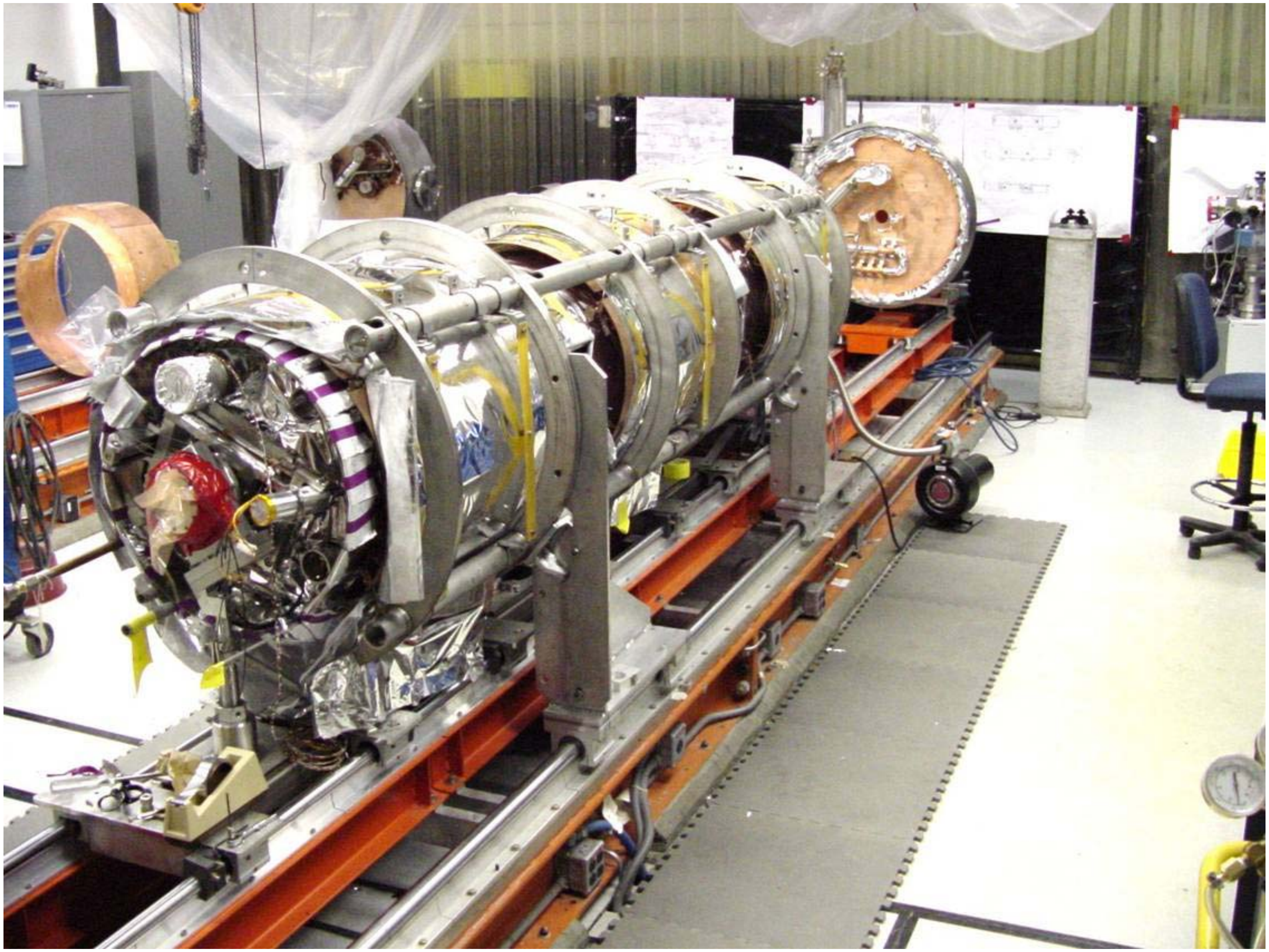
SNS β=0.61 Cryomodule Assembly -2



SNS β=0.61 Cryomodule Assembly -3

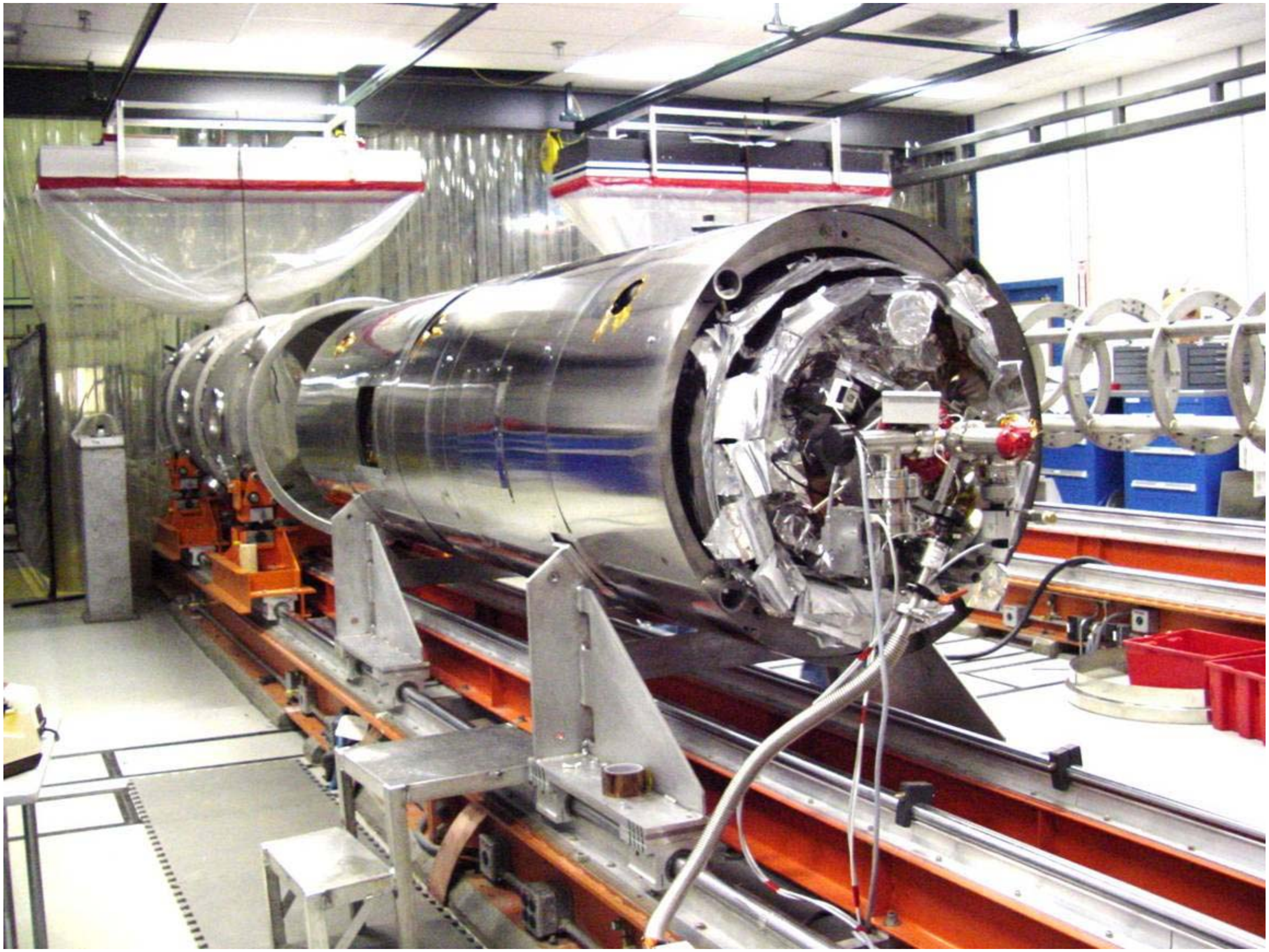


SNS β=0.61 Cryomodule Assembly -4

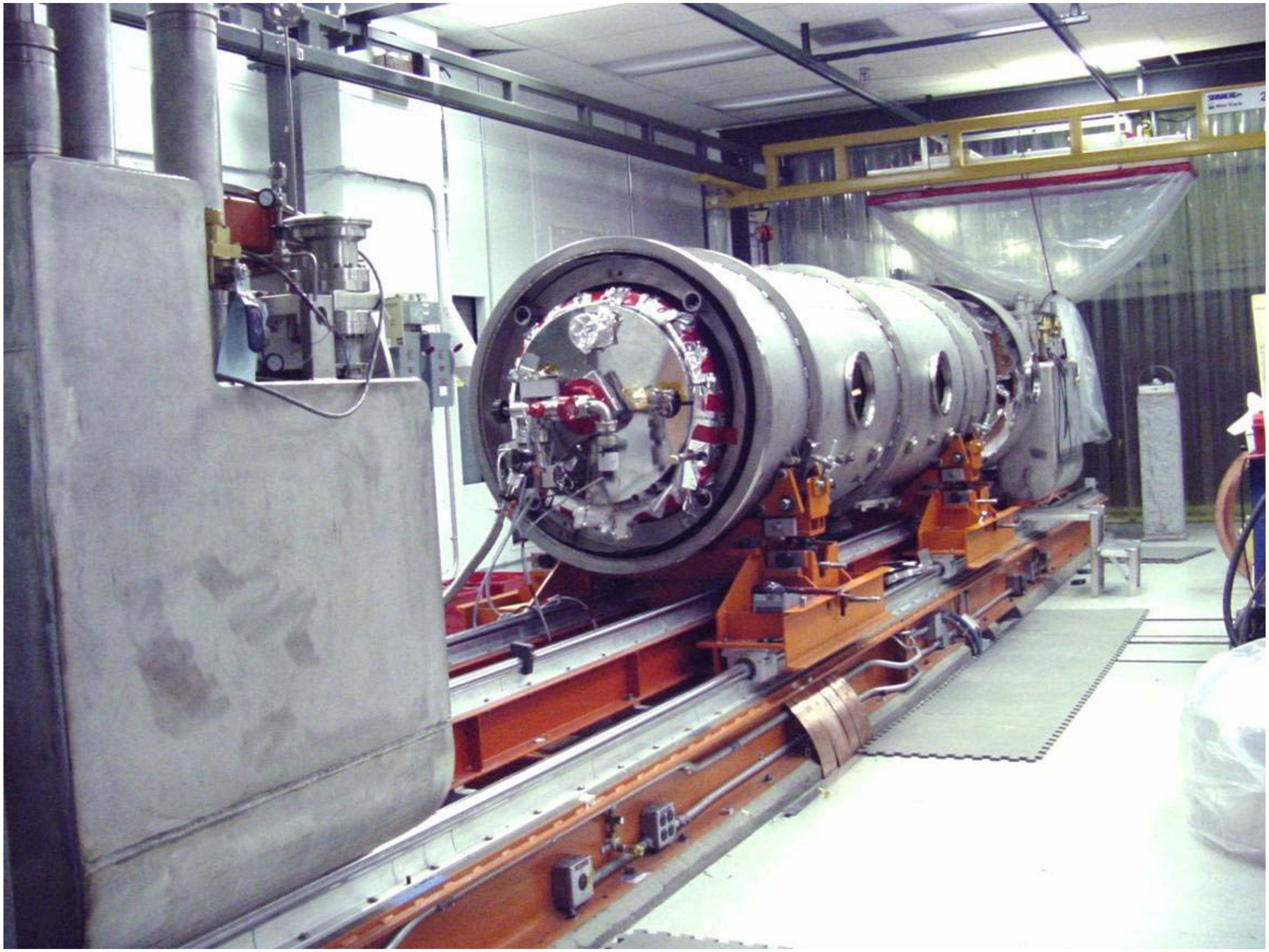


SNS β=0.61 Cryomodule Assembly -5

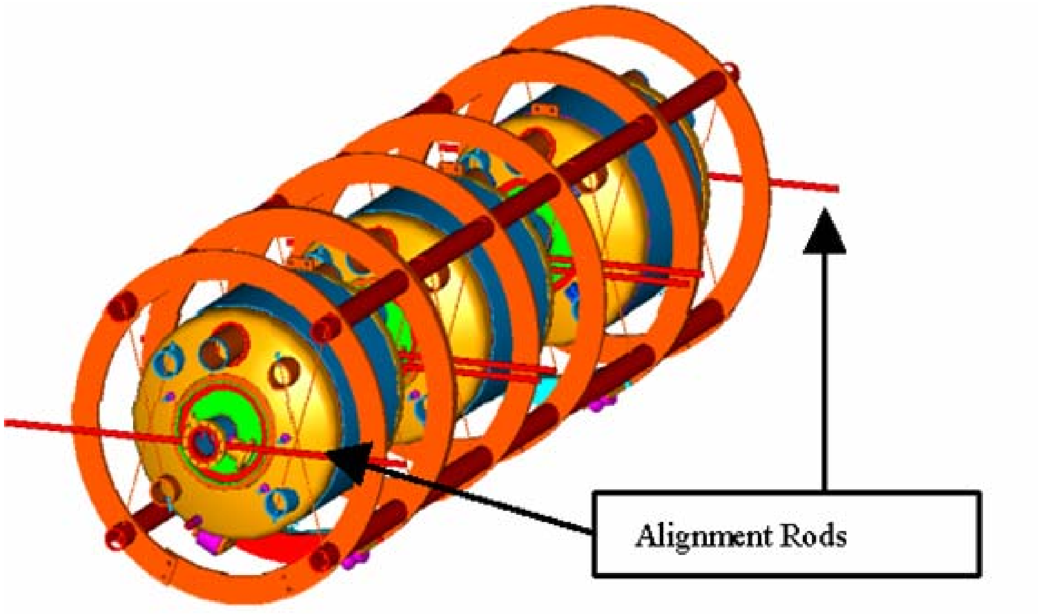
SNS β=0.61 Cryomodule Assembly -6



SNS β=0.61 Cryomodule Assembly -7



Alignment strategy



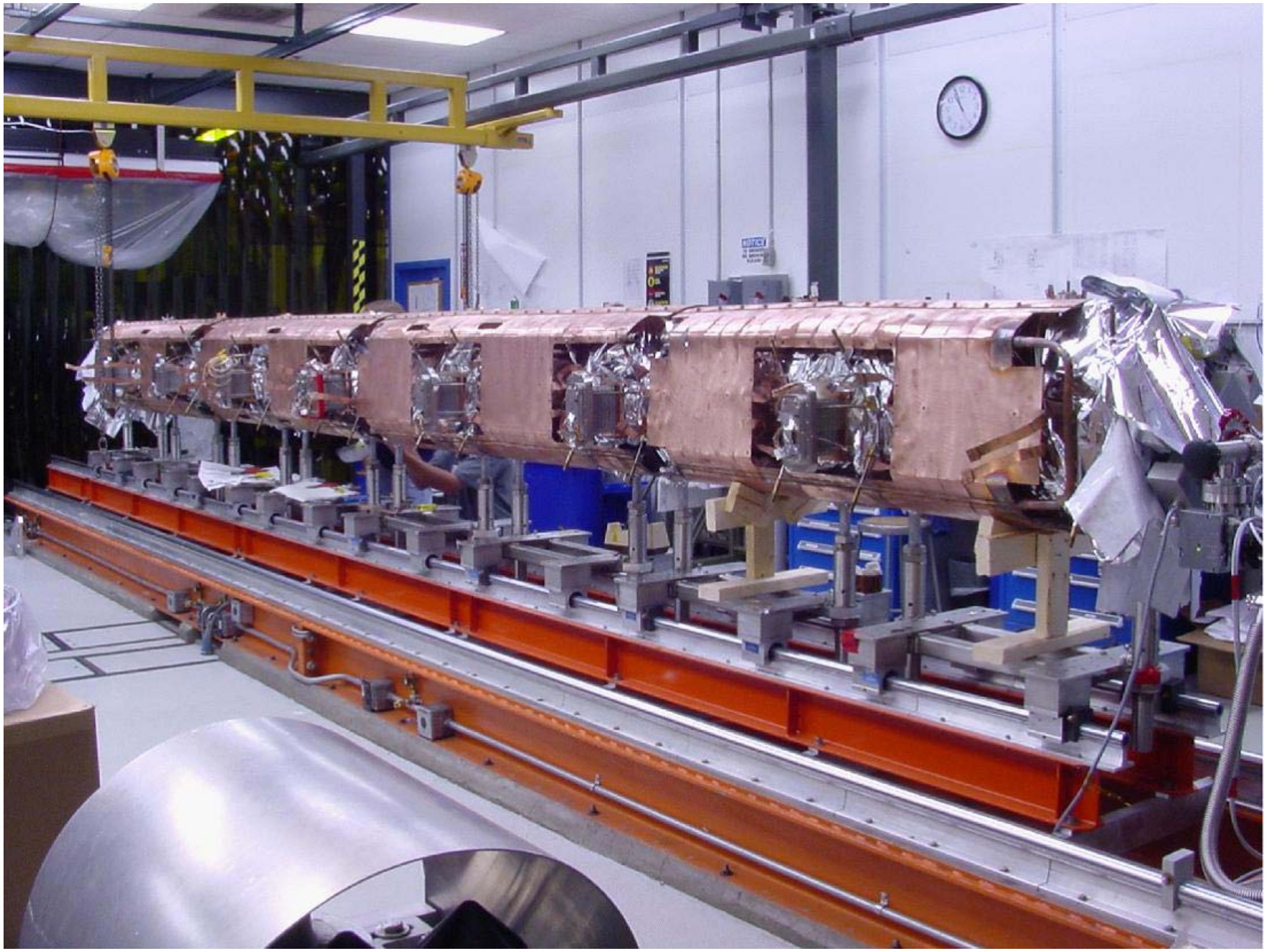
- Indexing off of the beamline flanges at either end of each cavity
- Nitronic support rods used to move the cavity into alignment
- Targets on rods on two sides of each flange.

- Cavity string is supported by the spaceframe
- Each target sighted along a line between set monuments (2 ends and sides)
- The nitronic rods are adjusted until all the targets are within 0.5 mm of the line set by the monuments
- Cavity string in the vacuum vessel: the alignment is verified and transferred (fiducialized) to the shell of the vacuum vessel.

CEBAF Upgrade Module Assembly - 1

CEBAF Upgrade Module Assembly - 2

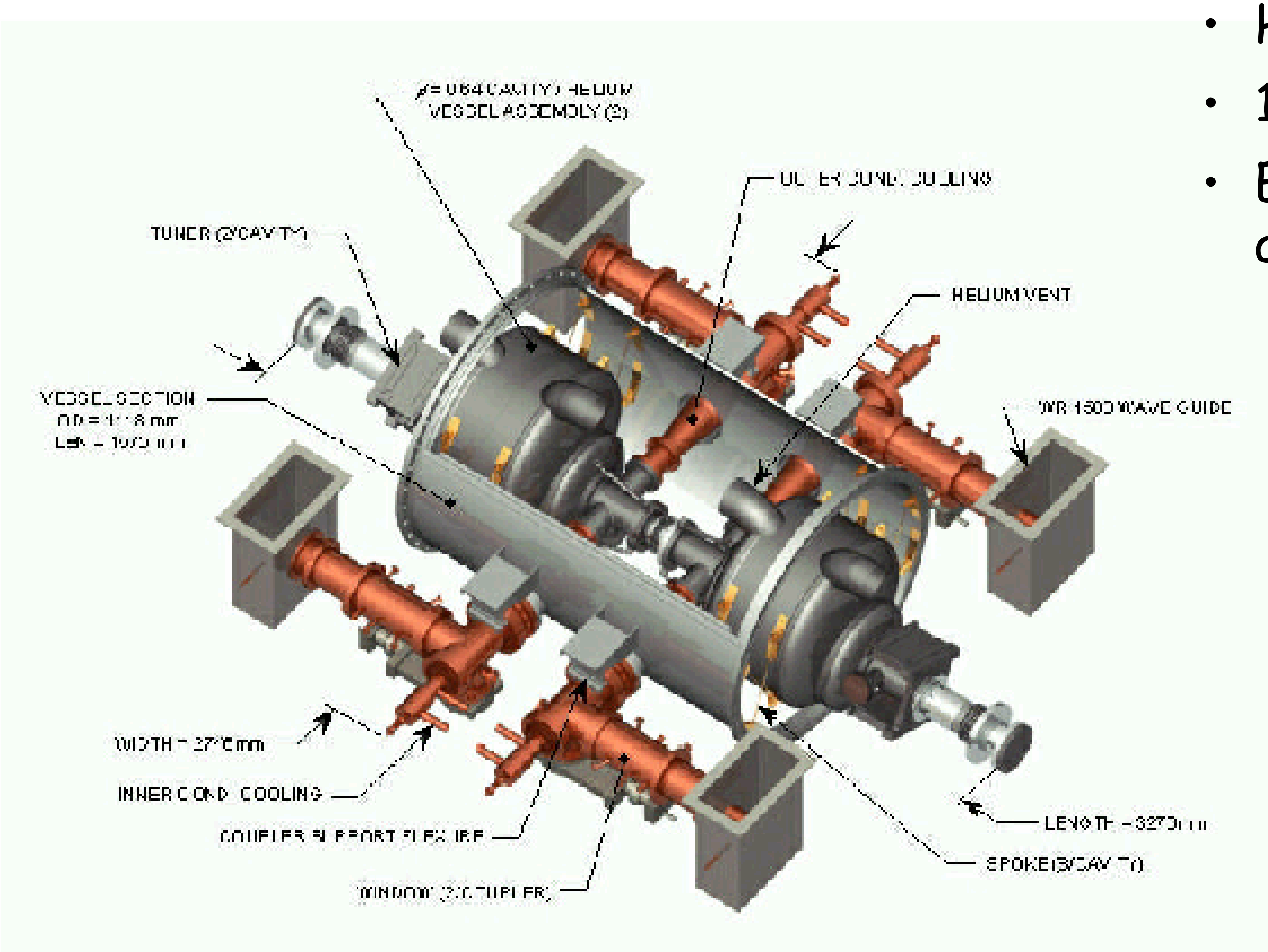
CEBAF Upgrade Module Assembly - 3



CEBAF Upgrade Module Assembly - 4

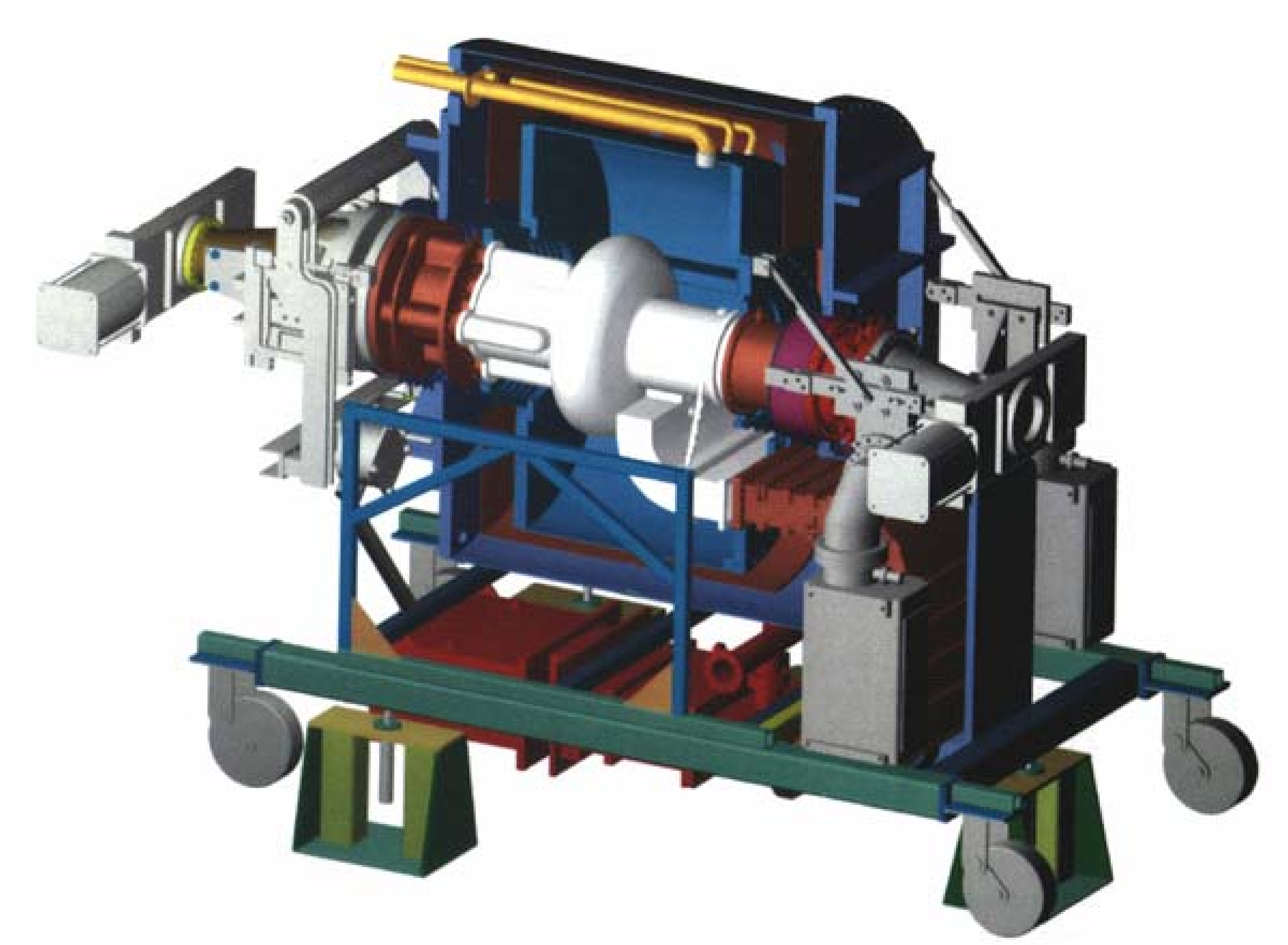
CEBAF Upgrade Module Assembly - 5

The APT Coupler Dominated Case

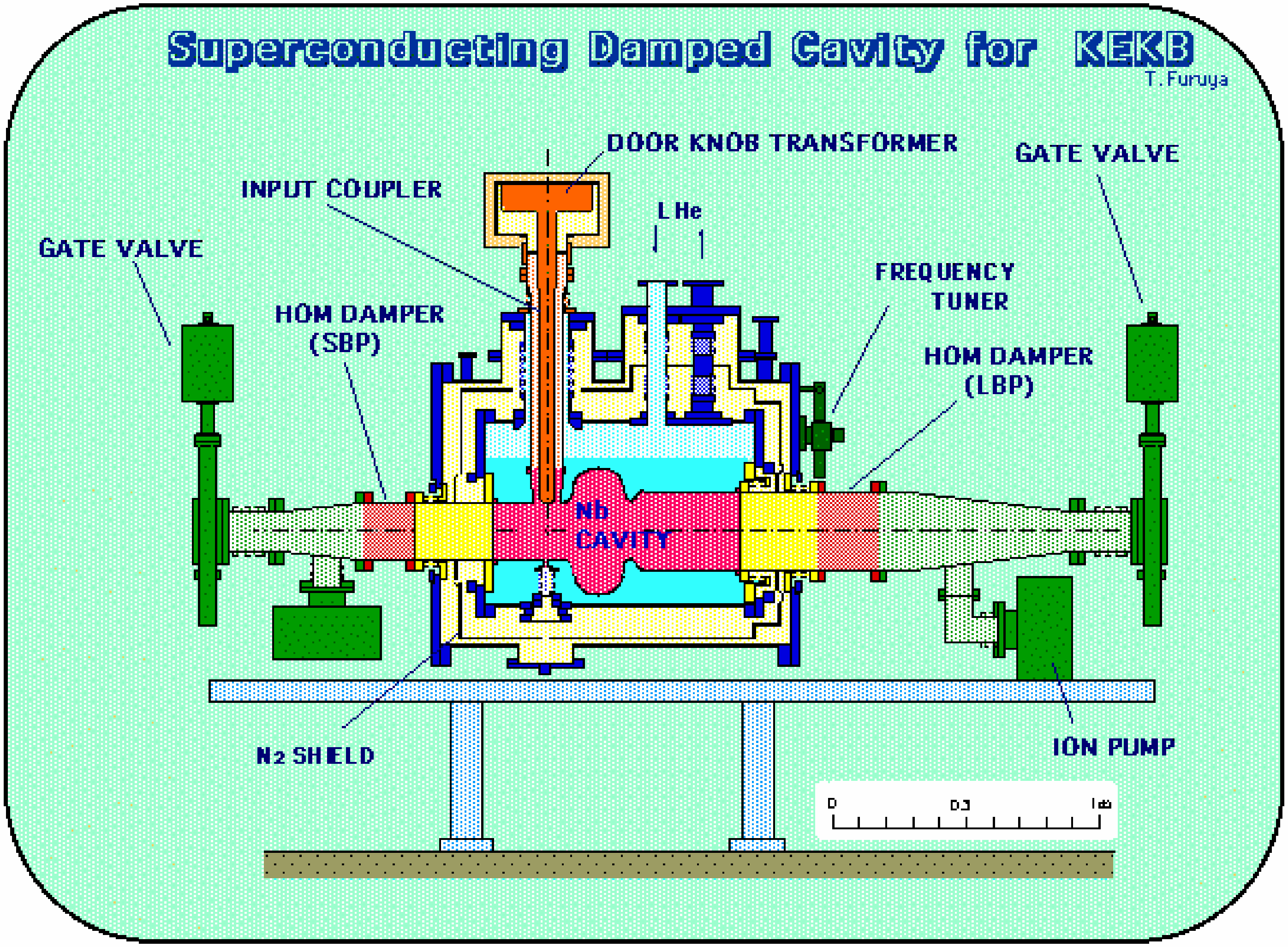


- Huge power specs
- 100 mA cw!
- Everything built around coupler…

The CESR Cryomodule



The KEKB Cryomodule



The Soleil Cryomodule

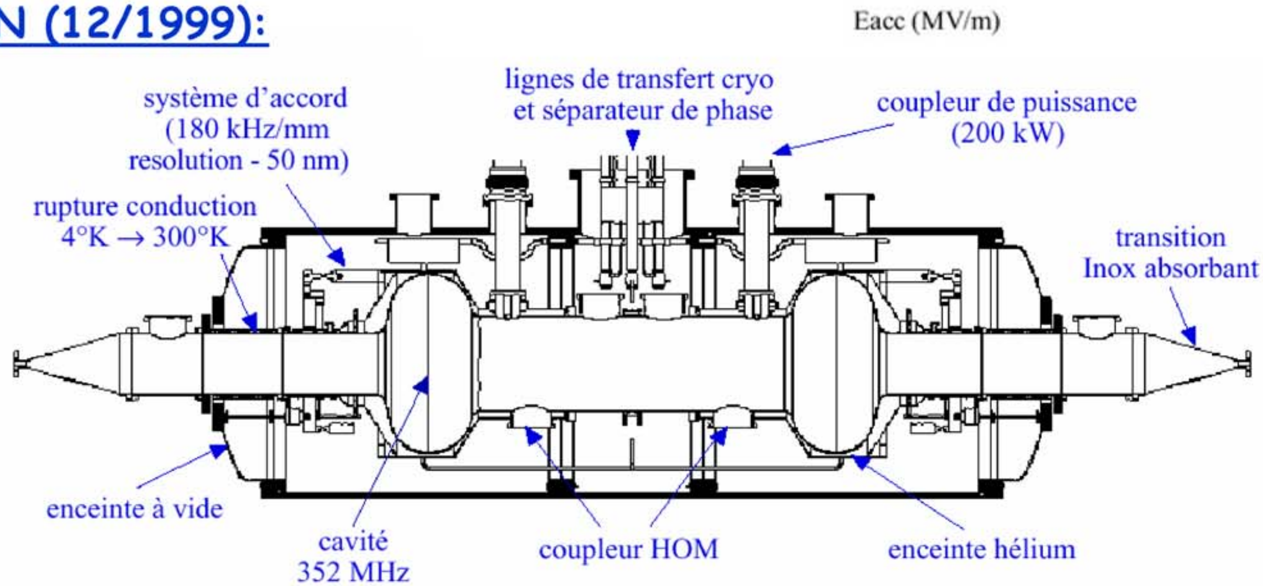
2.75 GeV, 500 mA Light Source

Design Parameters

- Nb/Cu single-cell HOM damped cavities
- Designed and built by Saclay/CERN collaboration
- 352 MHz
- 2 two-cavity cryomodules
- 1.2 MV/cavity
- LEP input couplers @ 200 kW
- loop HOM couplers
- Static heat loss 42 W

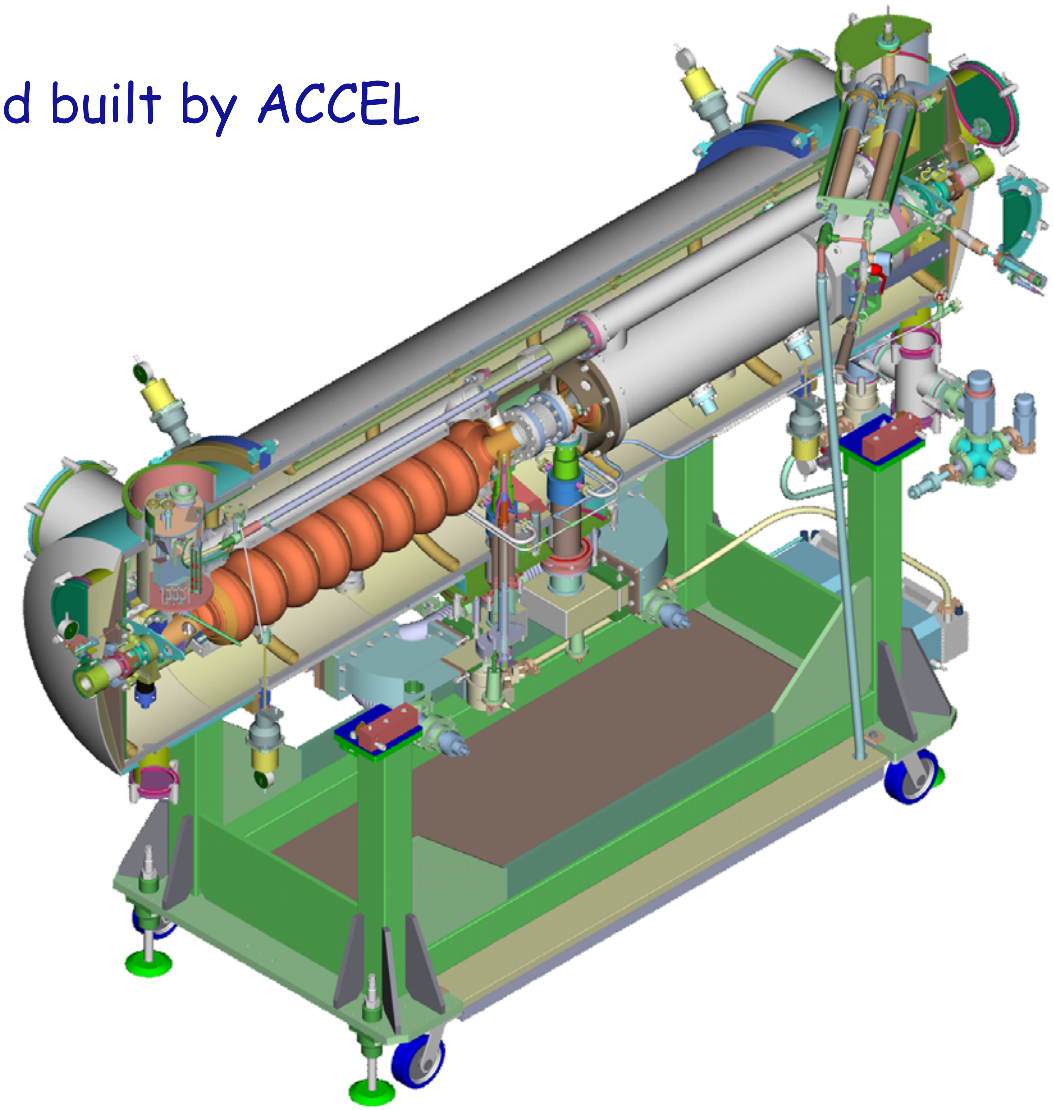
High power test at CERN (12/1999):

- E_{acc} up to7 MV/m
- 120 kW RF power
- 20 W static heat leak
- Not optimal $Q_{ext,fund}$ of dipole HOM couplers



The Rossendorf Cryomodule

Designed and built by ACCEL



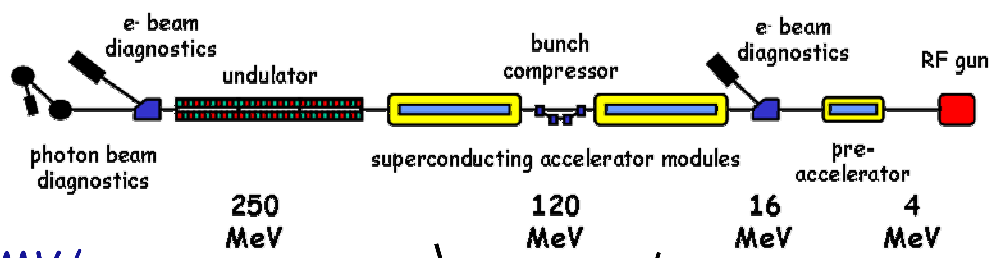
TTF for TESLA

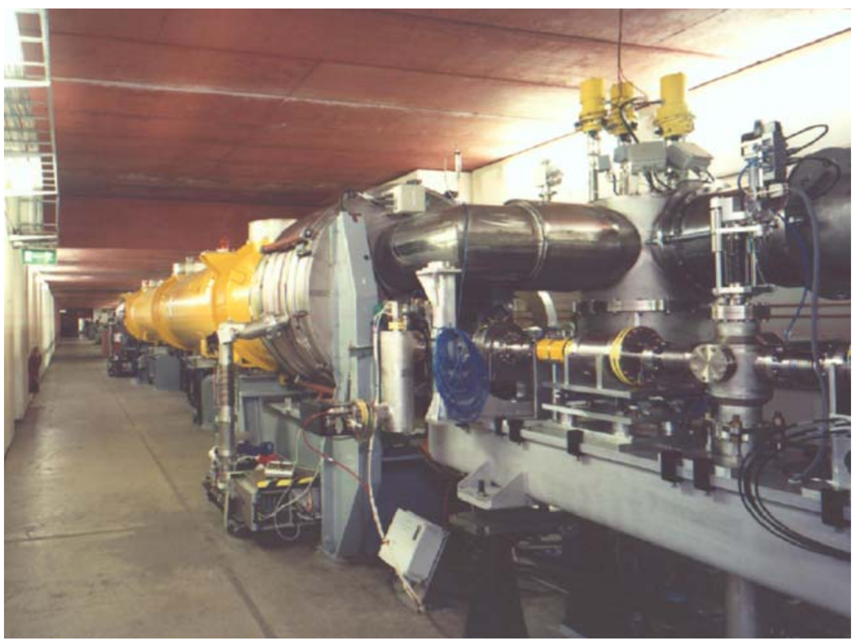
TTF = TESLA Test Facility

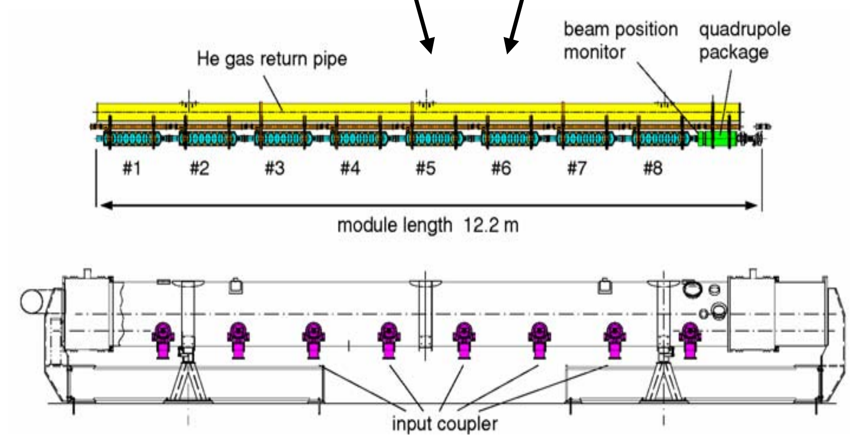
TTF Goals:

- Demonstrate that Superconducting RF technology is suitable for LC
- Operate TTF at $E_{acc} > 15$ MV/m
- Develop cavity technology for Eacc > 25 MV/m

TTF as operated for SASE FEL



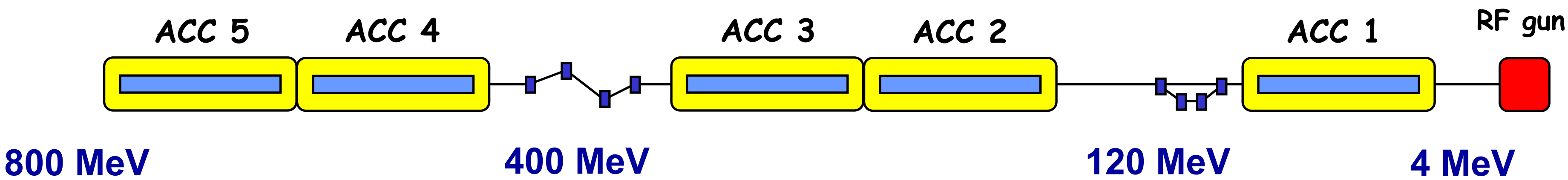


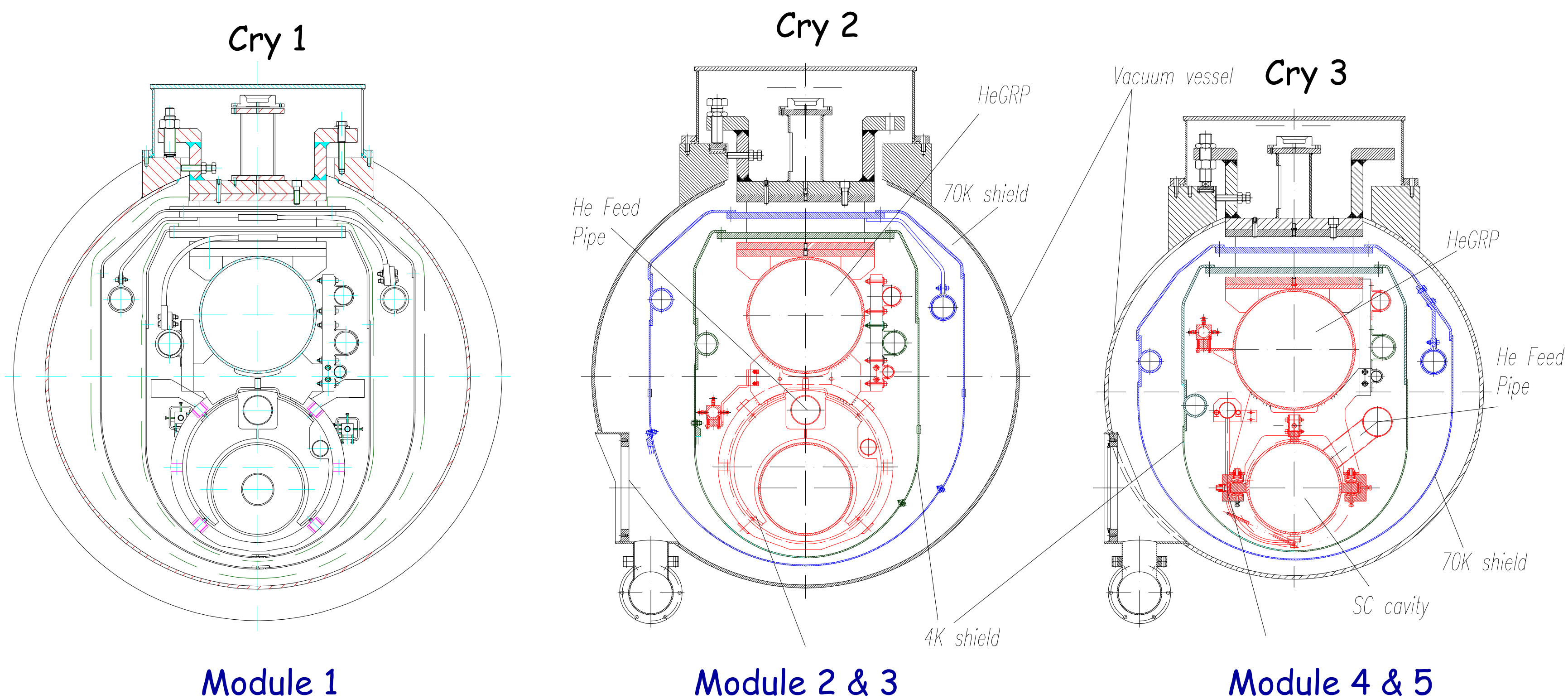


TESLA Cryomodule Design Rationales

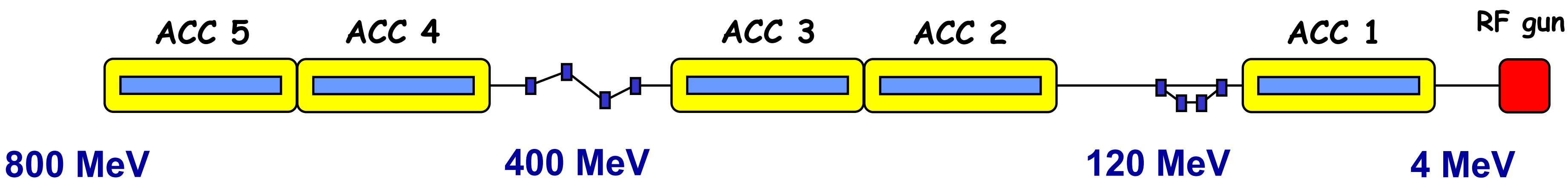
- High Performance Cryomodule was central for the TESLA Mission
  - More then one order of magnitude was to be gained in term of capital and operational cost
- High filling factor: to maximize real estate gradient
  - Long sub-units with many cavities (and quad): cryomodules
  - Sub-units connected in longer strings
  - Cooling and return pipes integrated into a unique cryomodule
- Low cost per meter: to be compatible with a long TeV Collider
  - Cryomodule used also for feeding and return pipes
  - Minimize the number of cold to warm connections for static losses
  - Minimize the use of special components and materials
  - Modular design using the simplest possible solution
- Easy to be alligned and stable: to fullfil beam requirements

Three Generation Cryomodules in TTF



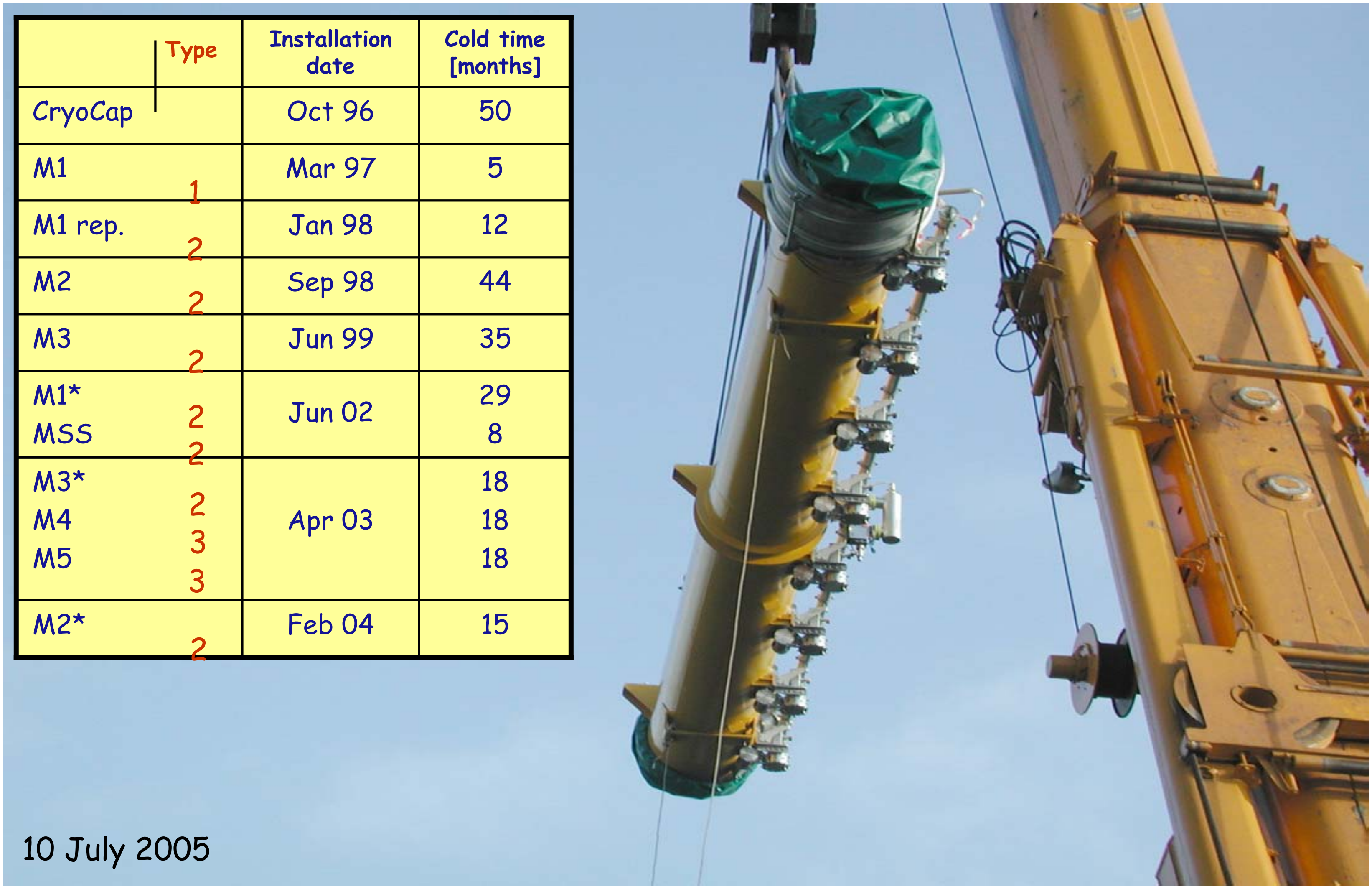


Cryoodules installed in TTF II



TTF Cryomodule Operation Experience

Type	Installation date	Cold time [months]
CryoCap	Oct 96	50
M1 1	Mar 97	5
M1 rep. 2	Jan 98	12
M2 2	Sep 98	44
M3 2	Jun 99	35
M1* 2 MSS 2	Jun 02	29 8
M3* 2 M4 3 M5 3	Apr 03	18 18 18
M2* 2	Feb 04	15

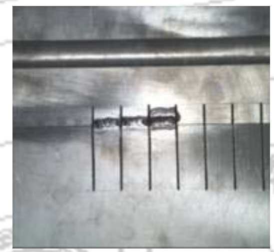


Performing Cryomodules

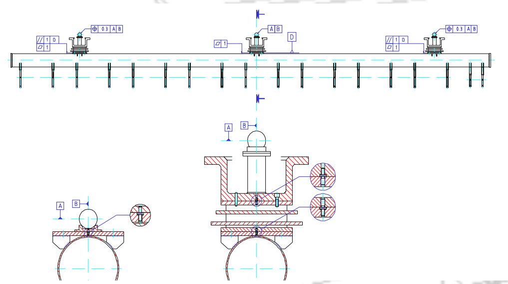
Three cryomodule generations to:

- improve simplicity and performances
- minimize costs

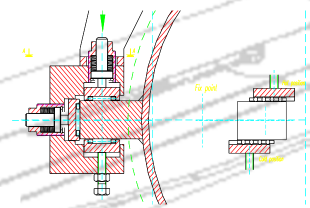
"Finger Welded" Shields



Reliable Alignment Strategy



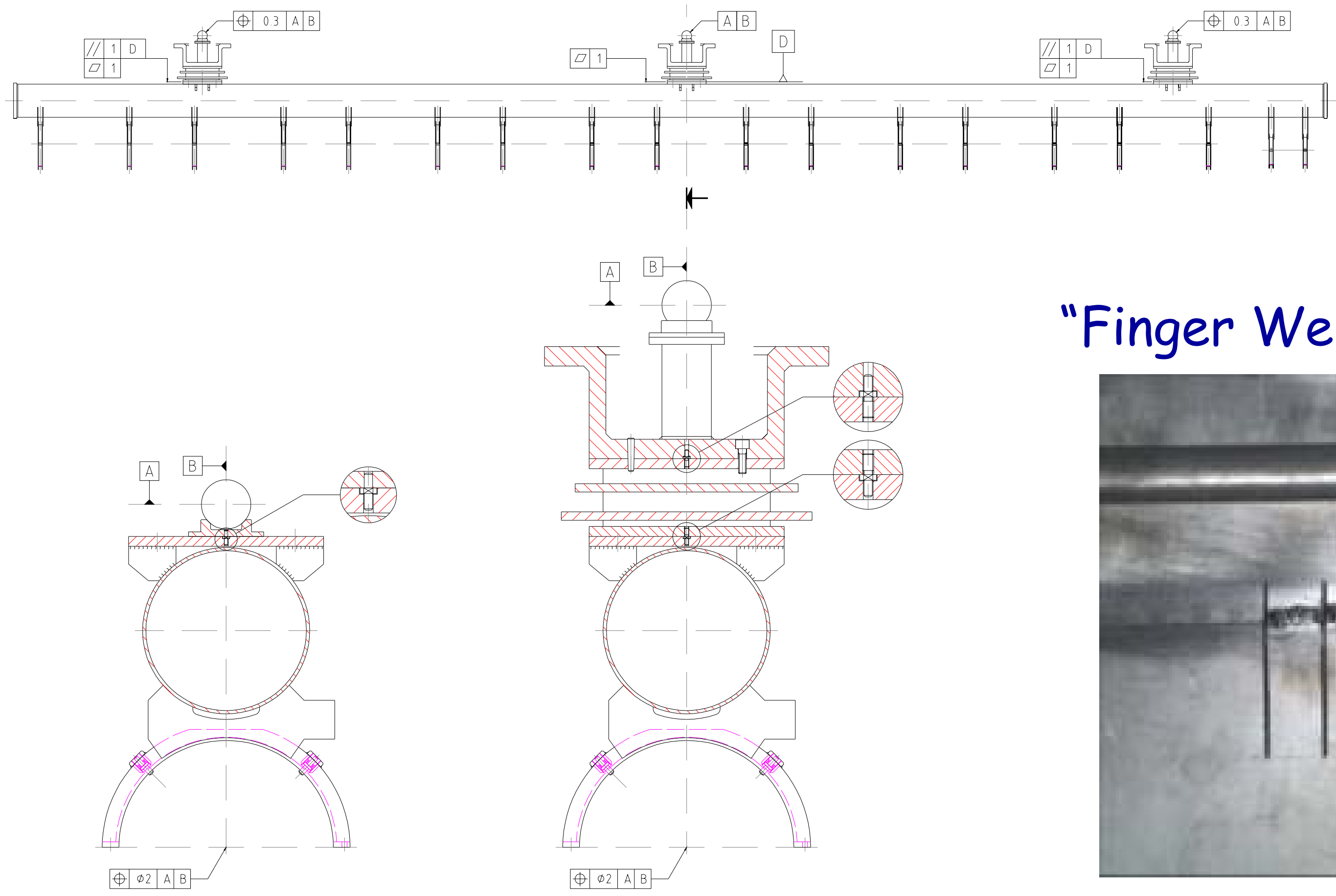
Sliding Fixtures @ 2 K



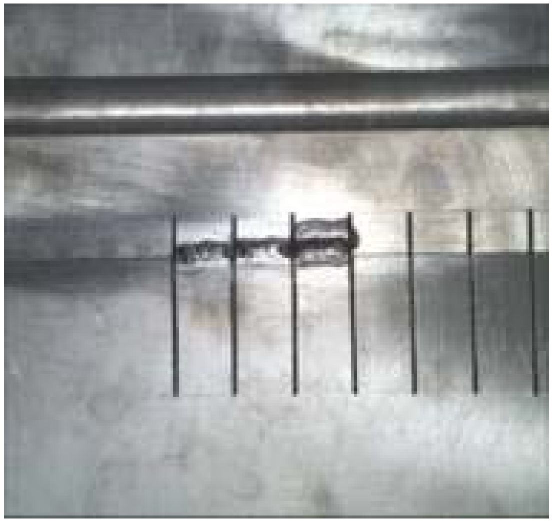
Required plug power for static losses < 5 kW/(12 m module)

2nd Generation TESLA Cryomodule

- New fabrication sequence
- New strategy for tolerances



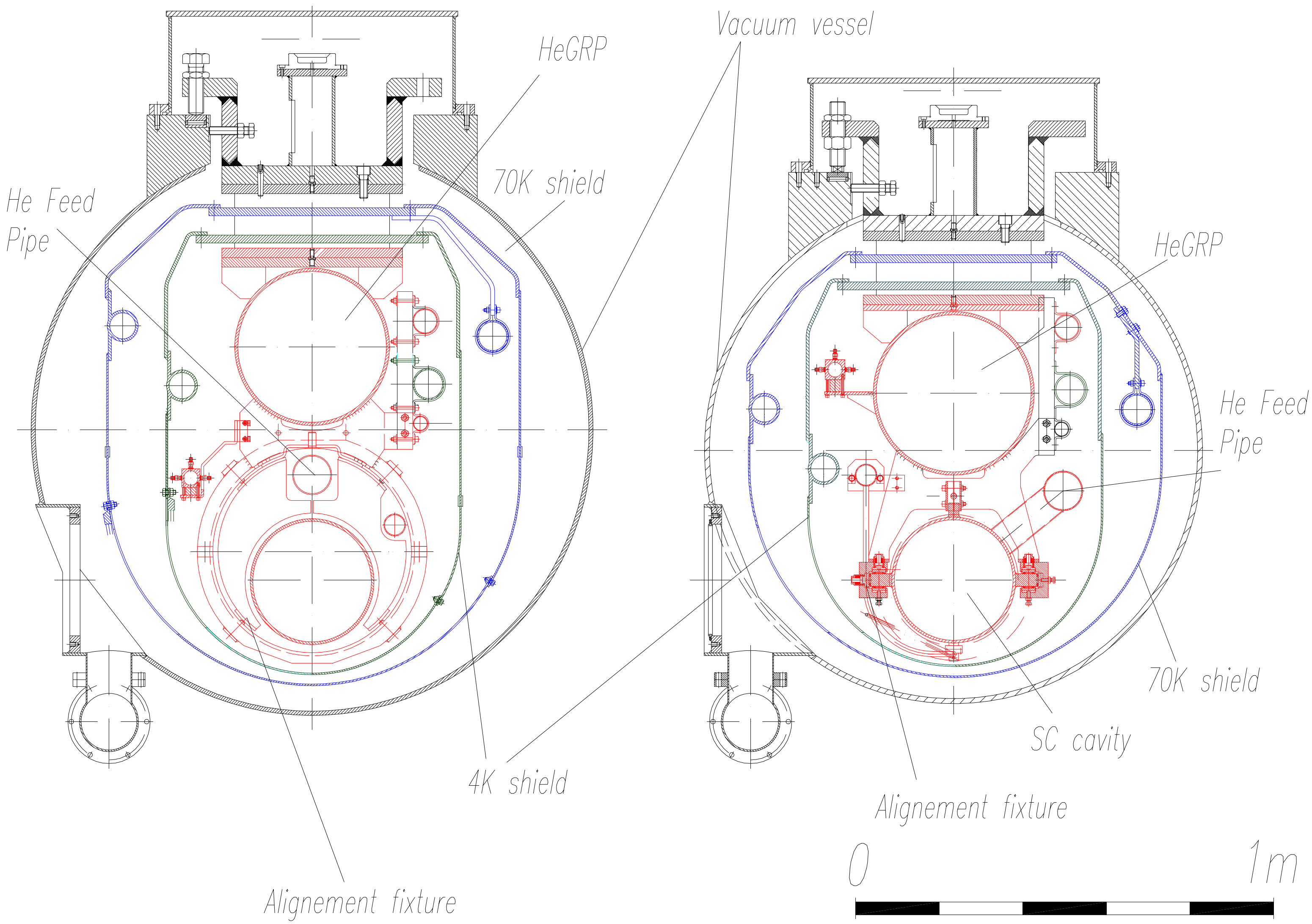
“Finger Welded” Shields



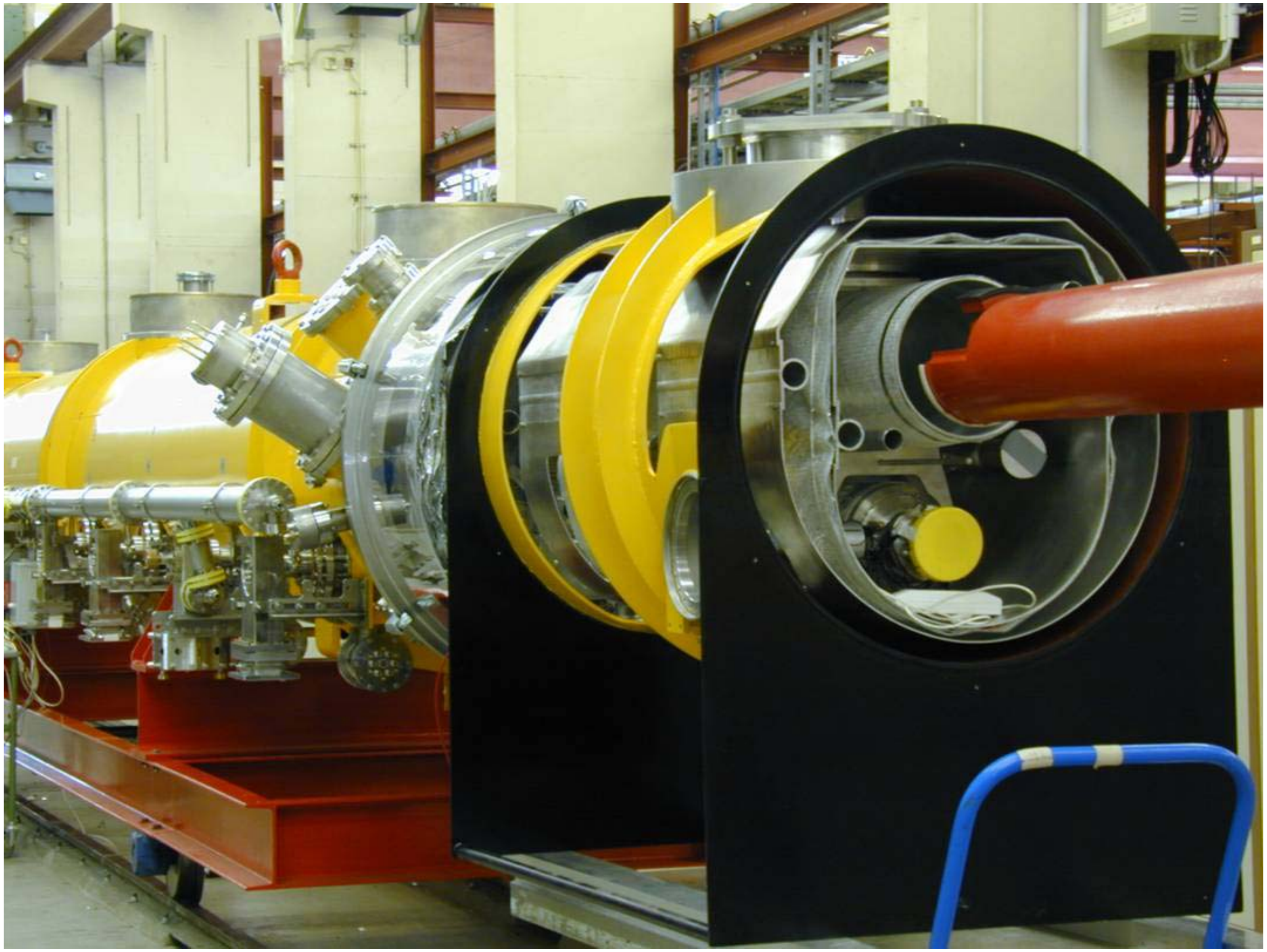
3rd Generation TESLA Cryomodule

- **Reduce the Cross Section and use a standard "pipeline" tube**
  - Redistribute the internal components
  - Reduce the distances to the minimum
- **Improve the connection of the active elements to the HeGRP**
  - Sliding fixtures to allow "Semi Rigid Coupler" and Superstructures
- **Reduce alignment sensitivity to the forces on the HeGRP edges**
  - Move the external posts closer to the edges
- **Further simplify the assembling procedure**
  - Simplify coupler cones and braids
  - Reduce by a factor two the shield components
- **System thought for mass production cost cutting**
  - Tolerances reduced to the required ones
  - Simpler components and standard tubes wherever possible

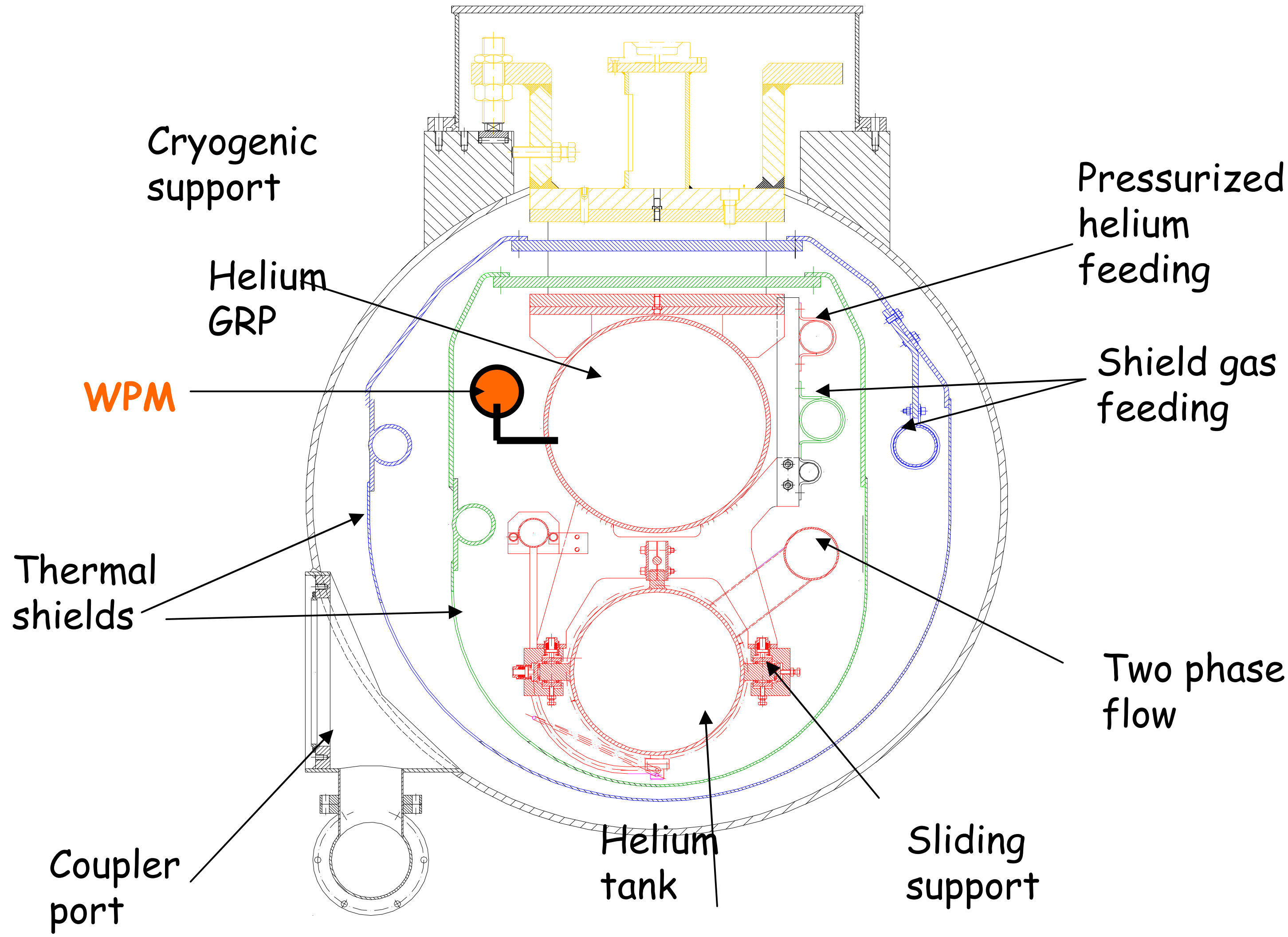
Cry2 & Cry3: Cross Sections



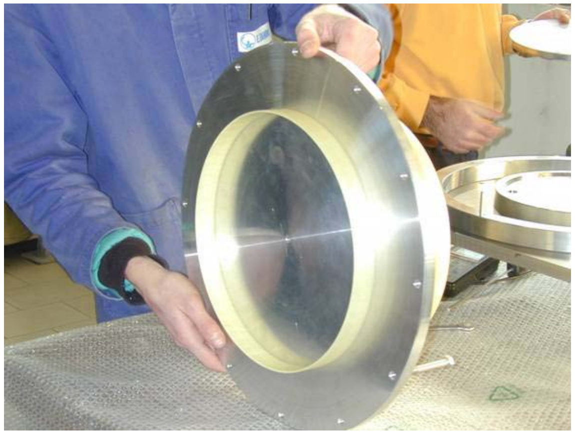
Cry2 to Cry3: Diameter Comparison



Cry3 Cross Section

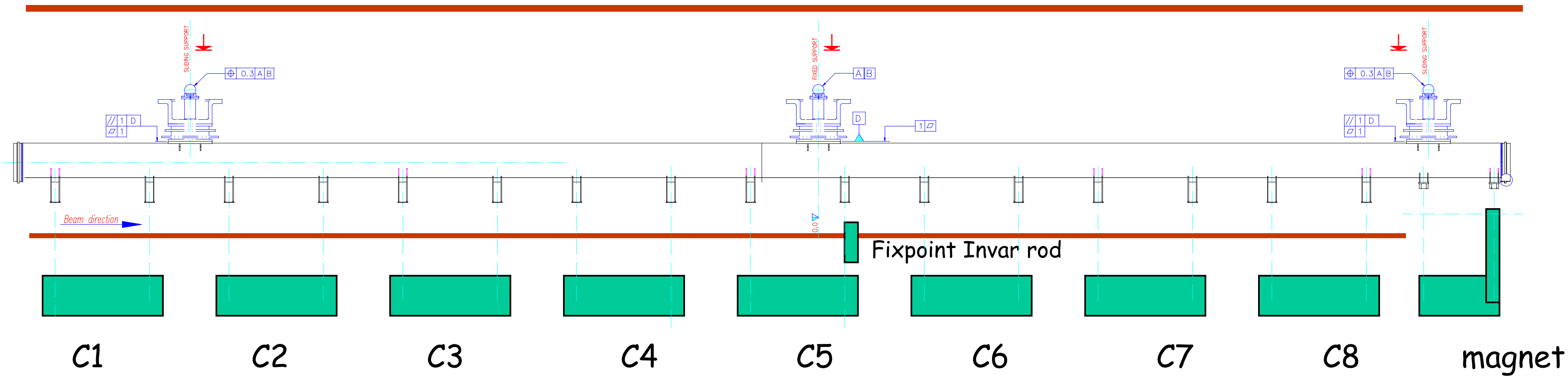


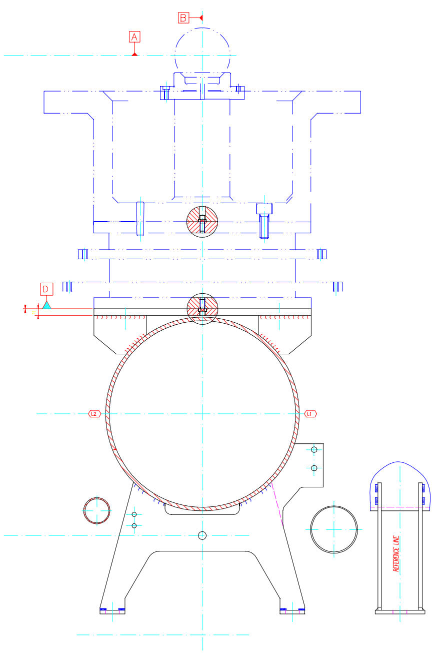
Support Posts



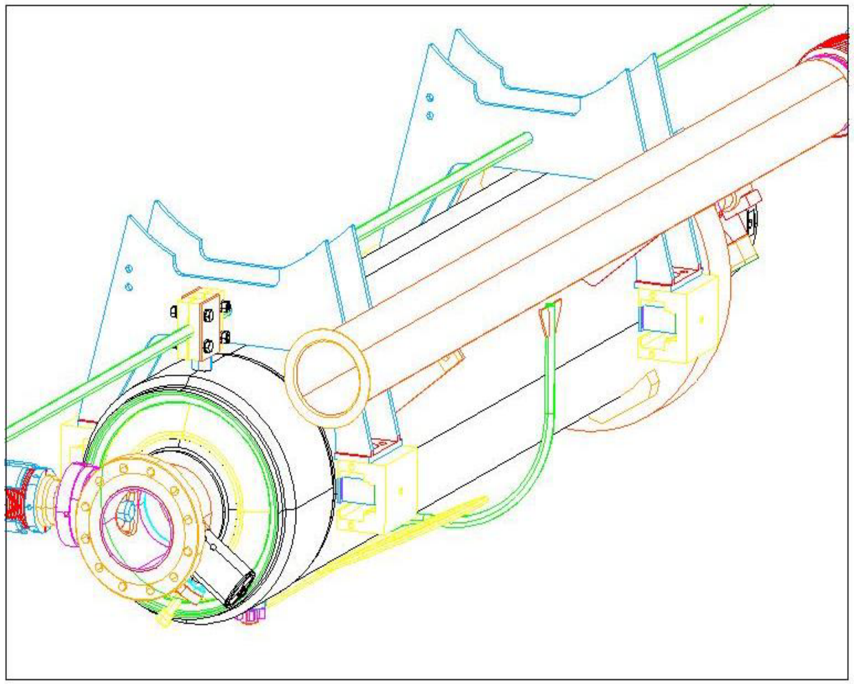
Helium GRP/Posts

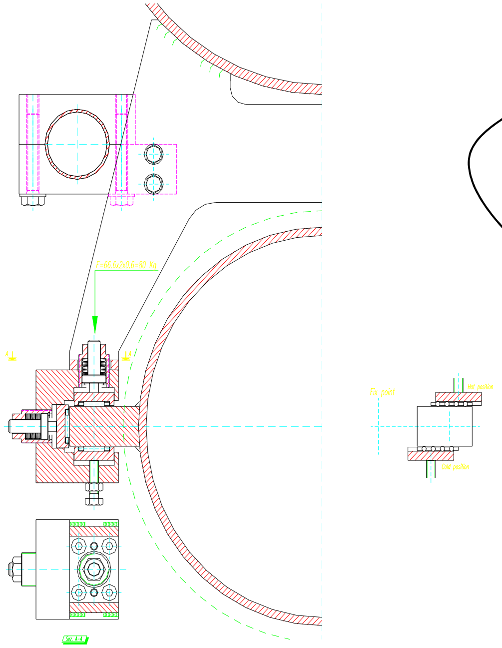




Sliding Fixtures to HeGRP

- Four C-Shaped SS elements clamp a titanium pad welded to the helium tank.
- Rolling needles reduce drastically the longitudinal friction
- Cavities result independent from the elongation and contraction of the HeGRP.
- Lateral and vertical position are defined by reference screws
- Longitudinal position by an Invar Rod

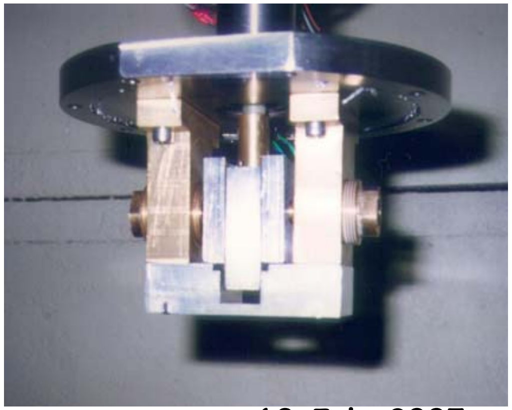




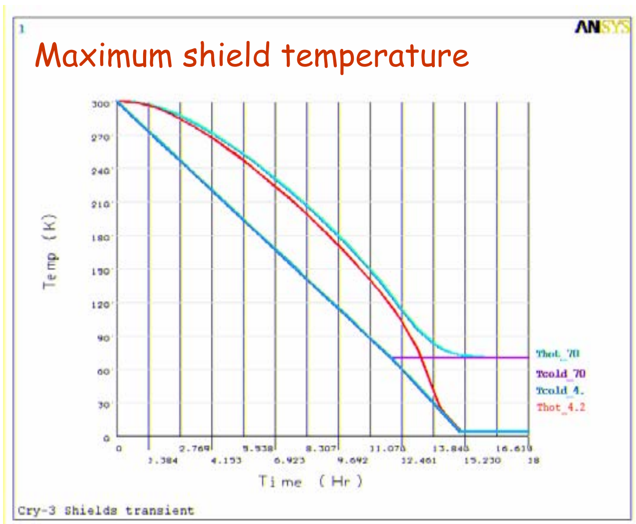
A Moke-up has been built to measure Friction force.

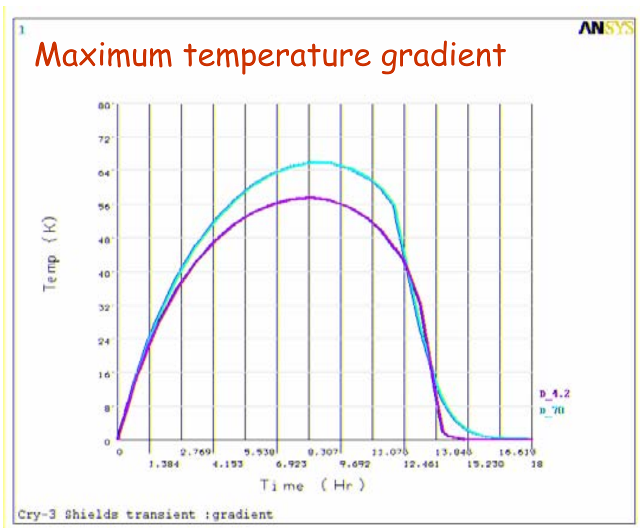
Results presented at CEC-99.

Friction force: 0.1 kgf

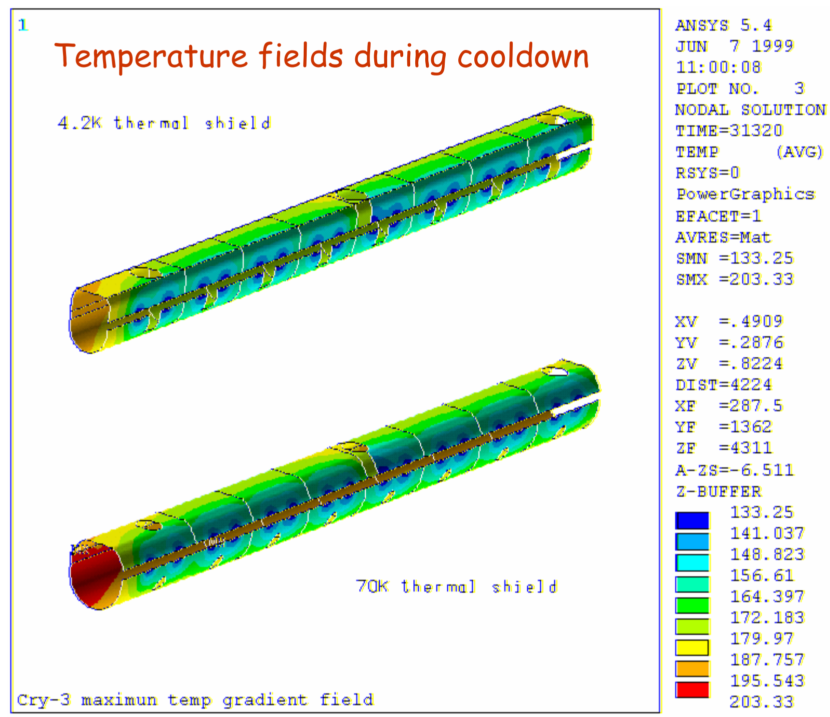


Finger-Welded Shield Behavior





- Cooldown simulation of the 4.2 K and 70 K aluminum thermal shields.
- We used a simultaneous 12 hour linear cooldown.
- The maximal thermal gradient on the shields (upper left graph) is below 60 K, a safe value.
- The temperature fields show that the gradient is concentrated in the welding region, where the fingers unload the structure

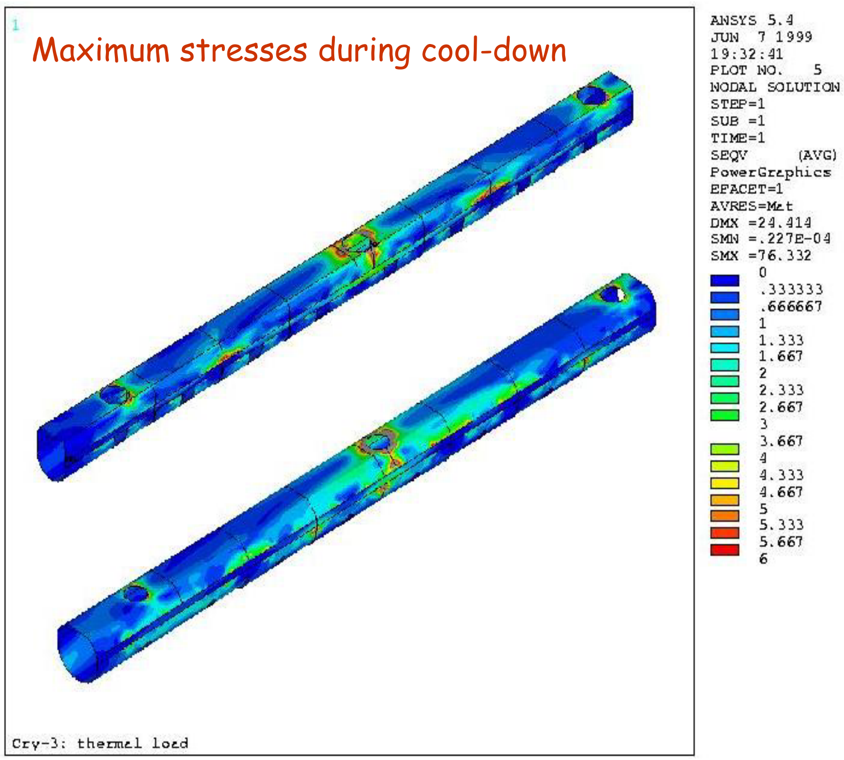


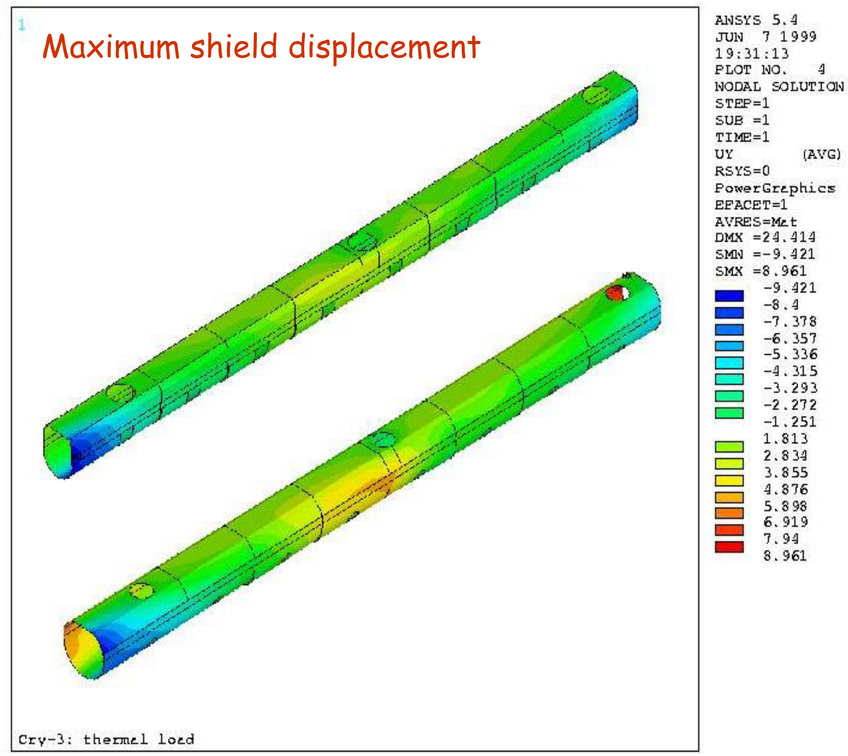
Thermo-mechanical analysis of Shields

Applying the computed temperature field, deformations and stress distribution can be easily computed.

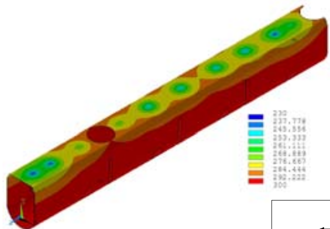
Maximum stresses are within acceptable limits

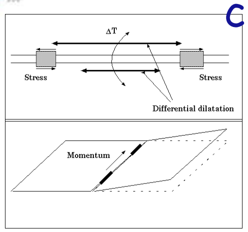
Maximum deformations due to asymmetric cooling is below 10 mm.

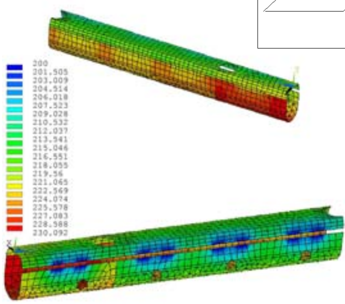




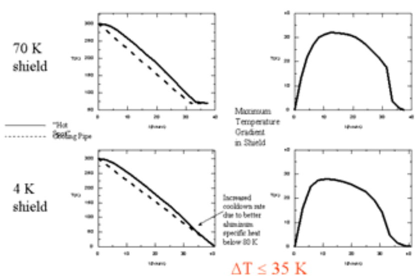
From Prototype to Cry 3



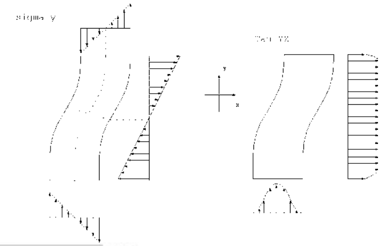


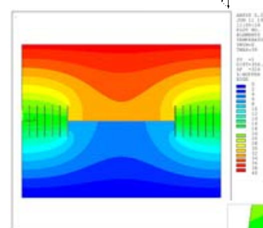


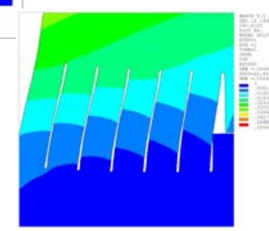
Welded Shields

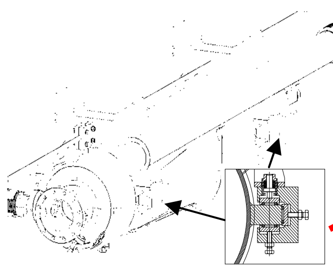


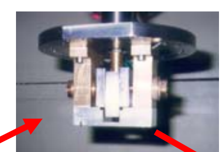
- Extensive FEA modeling (ANSYS™) of the entire cryomodule
  - Transient thermal analysis during cooldown/warmup cycles,
  - Coupled structural/thermal simulations
  - Full nonlinear material properties
- Detailed sub-modeling of new components and Laboratory tests
  - Finger-welding tests at ZANON
  - Cryogenic tests of the sliding supports at INFN-LASA









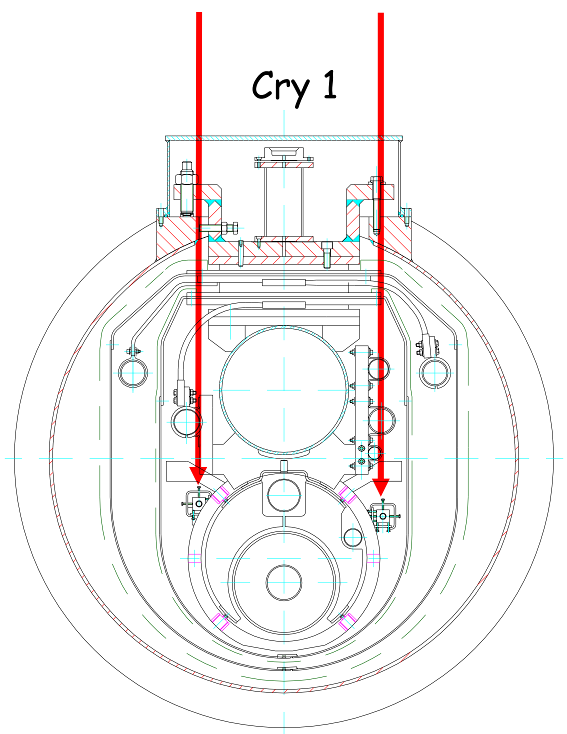


WPMs to qualify alignment strategy

WPM = Wire Position Monitor

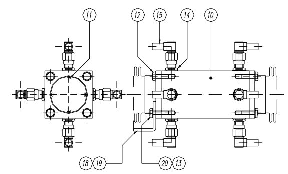
On line monitoring of cold mass movements during cool-down, warm-up and operation

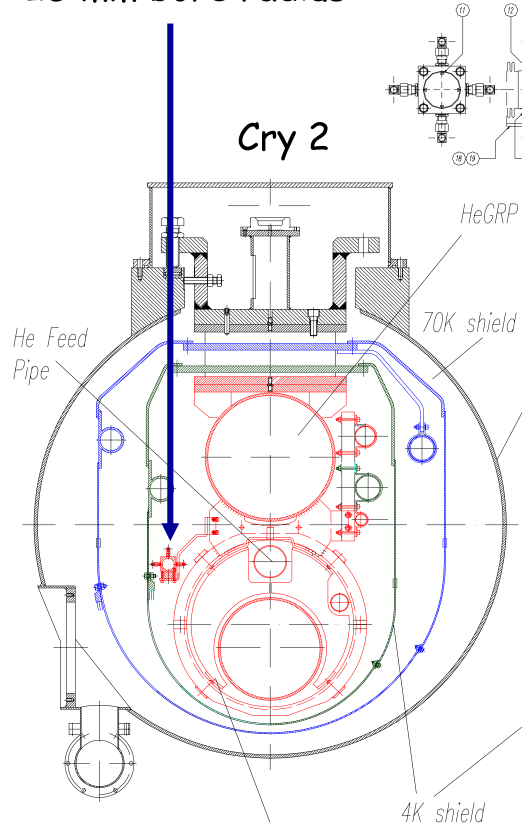
2 WPM lines with 2 x 18 sensors
4 sensors per active element
8 mm bore radius



Module 1

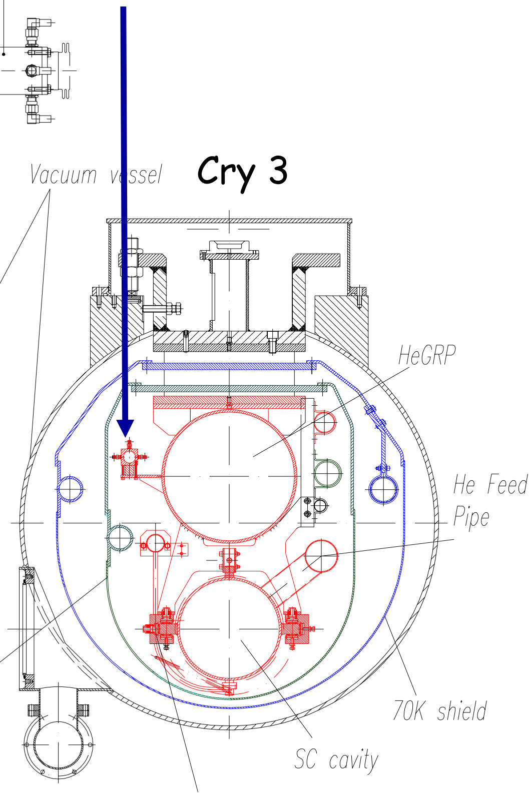
1 WPM lines
1 sensors per active element
25 mm bore radius





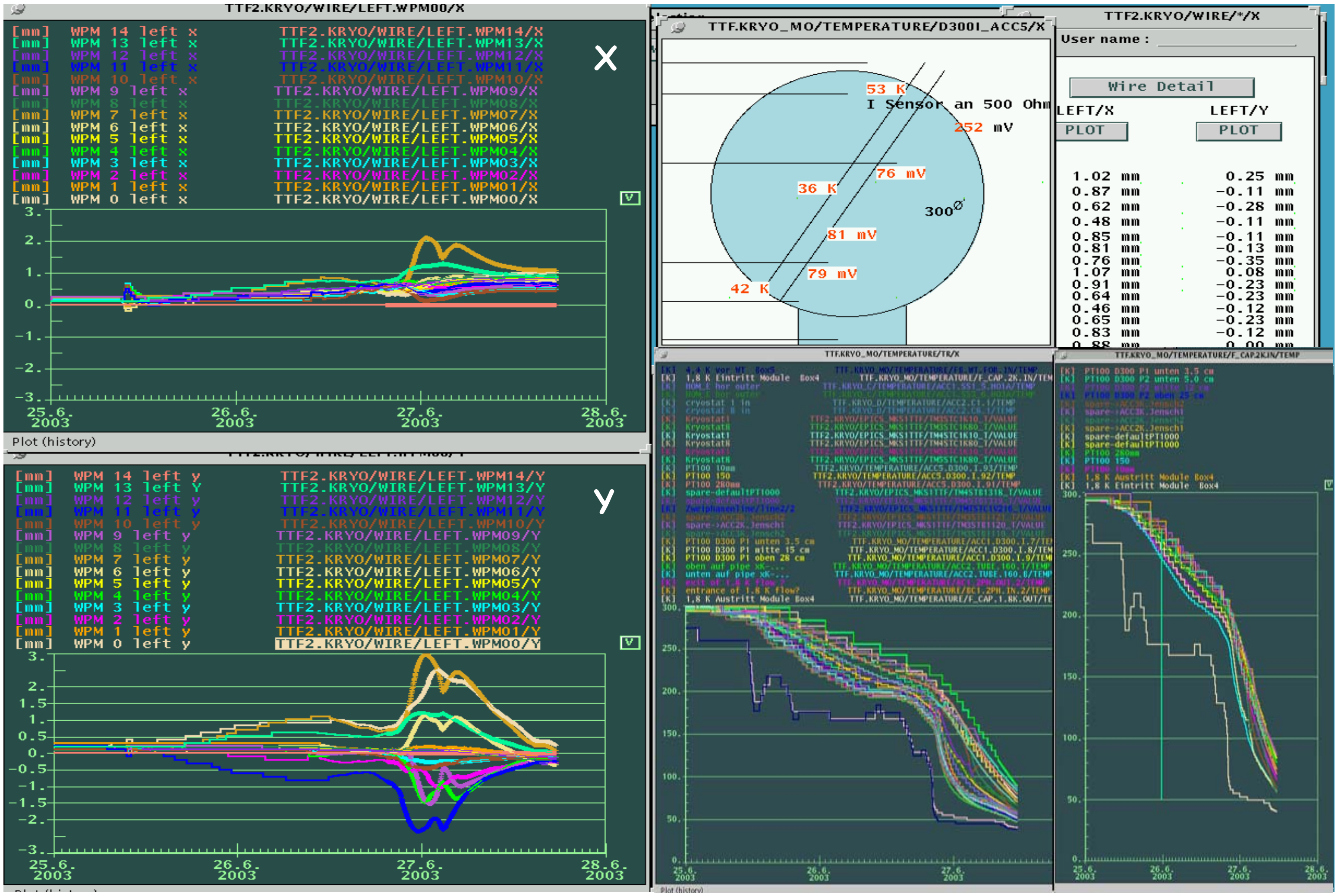
Module 2 & 3

1 WPM line
7 sensors/module
25 mm bore radius



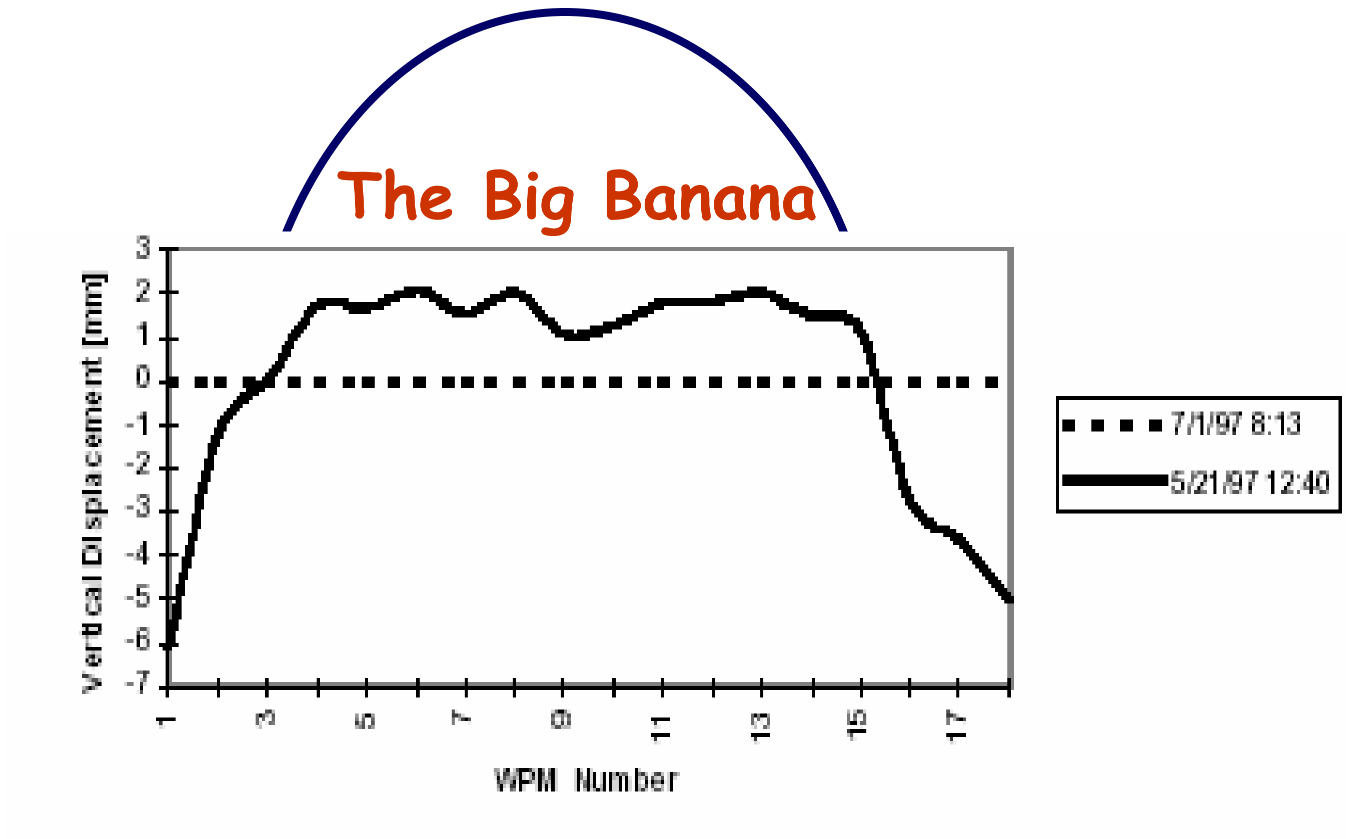
Module 4 & 5

Safe Cooldown of ACC4 and ACC5

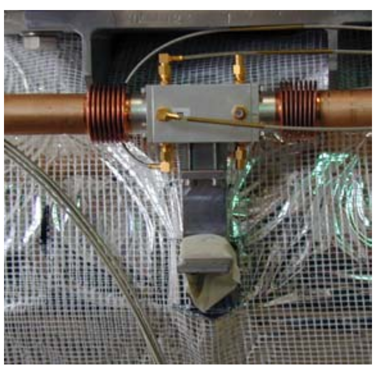


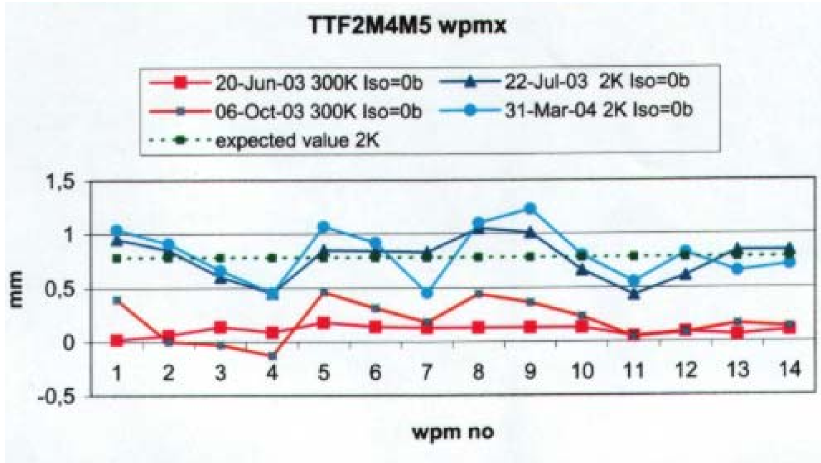
Large Bending in First Cooldown

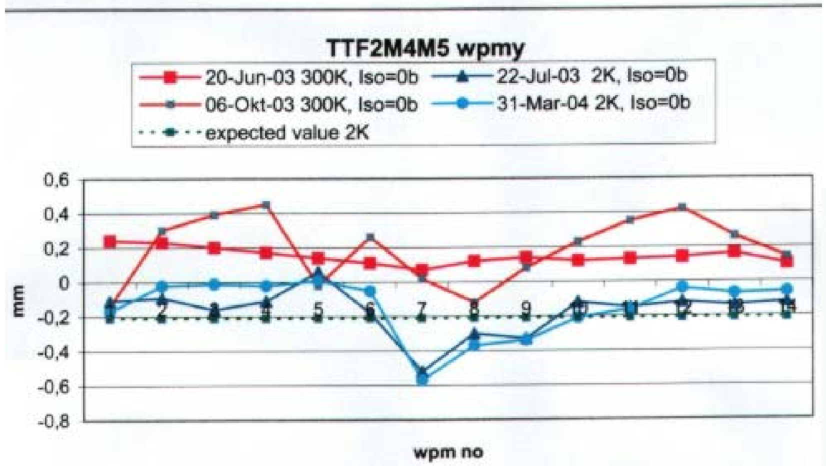
New Cooldown procedure suggested by the WPM's measurements during the first "fast" cooldown



ACC4 & ACC5 Met Specs







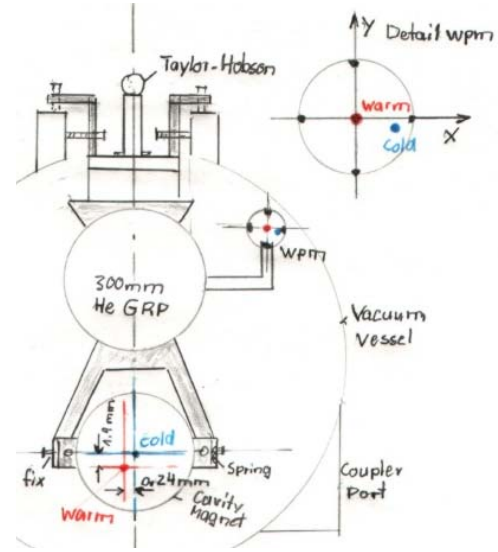
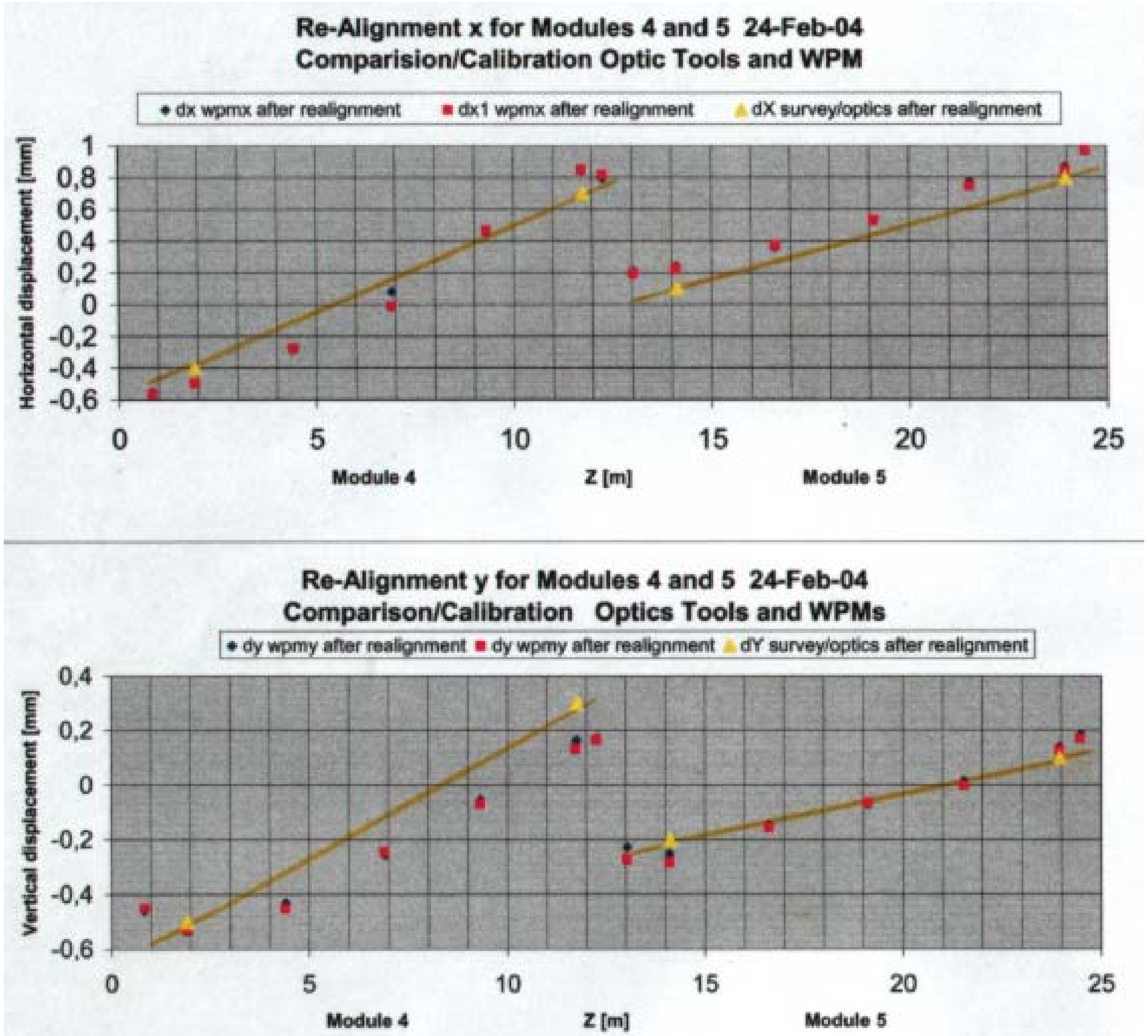


Table 1: Result Summary.

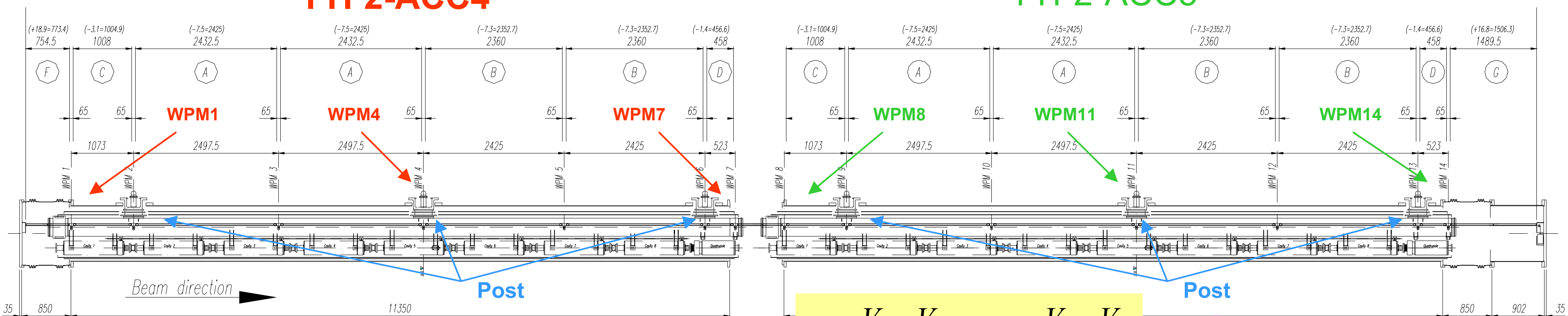
TDR Specifications (rms)		
Cavities	x/y	± 0.5 mm
Quadrupoles	x/y	± 0.3 mm
WPM results (peak)		
Cavities	x	+ 0.35/- 0.27 mm
	y	+ 0.18/- 0.35 mm
Quadrupoles	x	+ 0.2/- 0.1 mm
	y	+ 0.35/- 0.1 mm

- Still some work at the module interconnection
- Cavity axis to be properly defined

WPMs and Linac Realignment



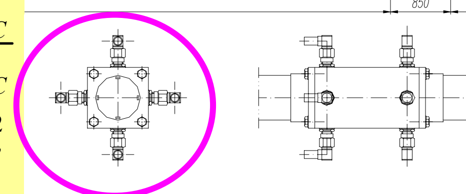
WPM as Vibration Sensors

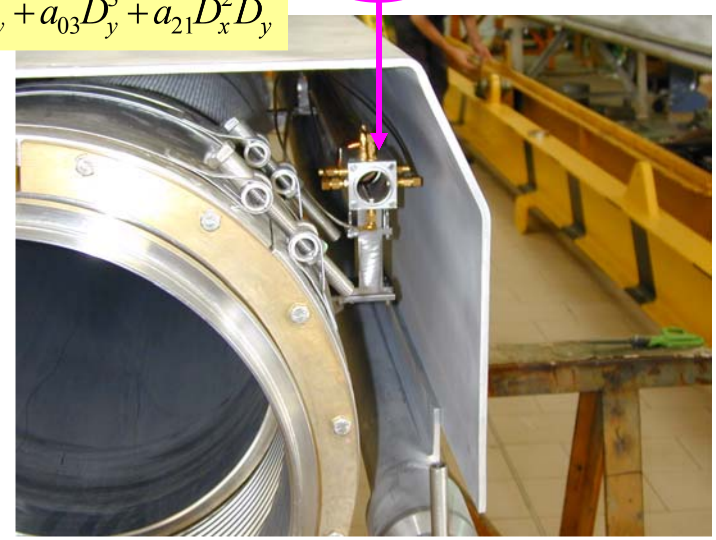


$$D_x = \frac{V_B - V_D}{V_B + V_D} \qquad D_y = \frac{V_A - V_C}{V_A + V_C}$$

$$x = a_{10} D_x + a_{30} D_x^3 + a_{12} D_x D_y^2$$

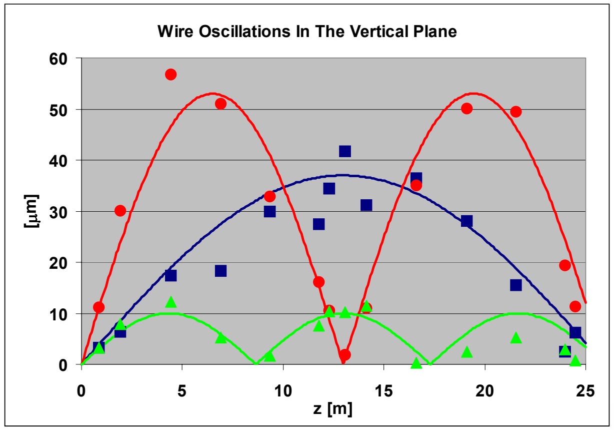
$$y = a_{01} D_y + a_{03} D_y^3 + a_{21} D_x^2 D_y$$

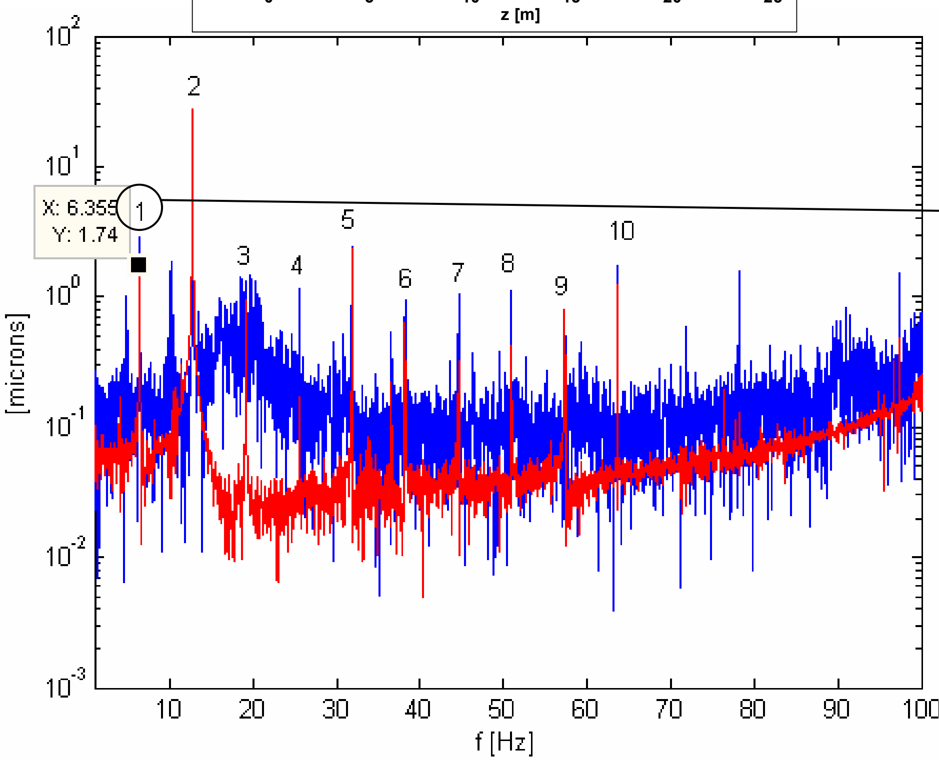




- A WPM is a sort of microstrip four channel directional coupler. A 140 MHz RF signal is applied on a stretched wire placed (nominally) in the center of the monitor bore.
- A Wire Position Monitor (WPM) system has been developed for on-line monitoring of the cold mass during cooldown and operation.
- The low frequency vibrations of the cold mass, amplitude modulate the RF signals picked up by the microstrips.
- The microphonics (and the sub-microphonics) can be recovered de-modulating the microstrip RF signal.

A sample spectrum





- The wire proper vibration spectral lines (fundamental and harmonics) overcome the cold mass mechanical vibration lines.
- On the other hand, being their frequencies well predictable by VSE which completely agrees with the experimental data, it's easy to filter them when processing the data.

Vibrating String Equation (VSE)

$$f_n = \frac{n}{2\ell}\sqrt{\frac{F}{\rho A}} = n \cdot 6.4 \text{ Hz}$$

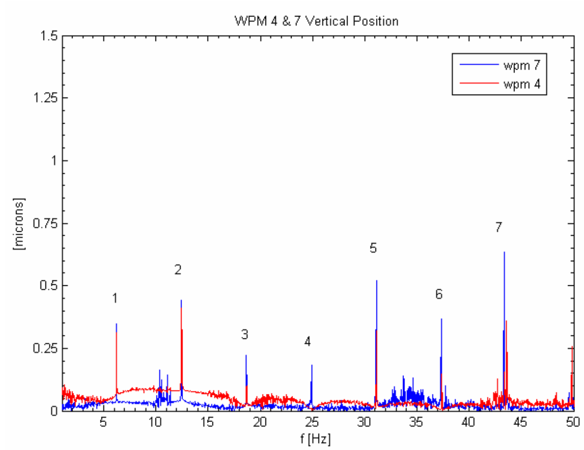
Wire parameters

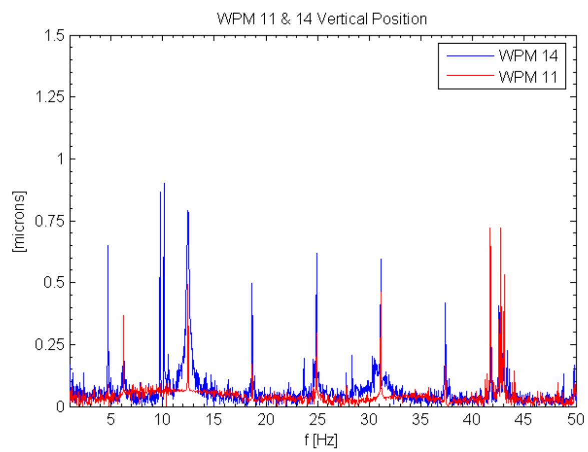
- Wire: (CuBe) (BERYLCO 25)
- Density (ρ): 8.25 g/cm^3 = 8250 kg/m^3
- Cross Section (A): 0.196 mm^2
- Stretched Wire Length (ℓ) 25.950 m
- Tensile Strength: 18 kgp = 176.58 N

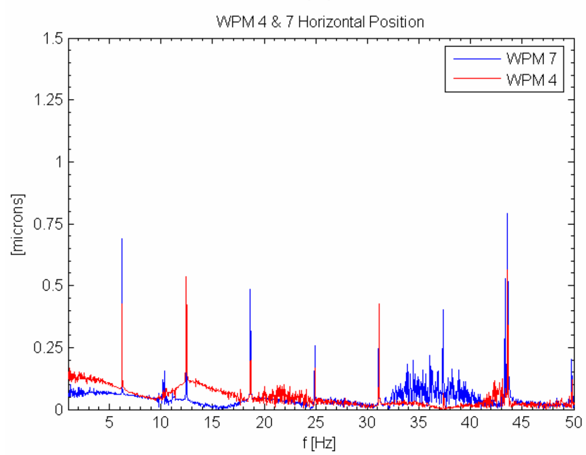
Preliminary Vibration Spectra

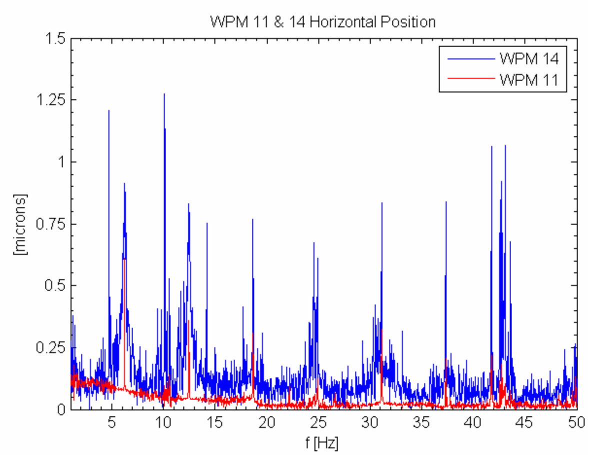
WPMs 4 and 11 are close to the central post: cold mass fix point.

WPMs 7 and 14 are at the end of the corresponding cryomodules.









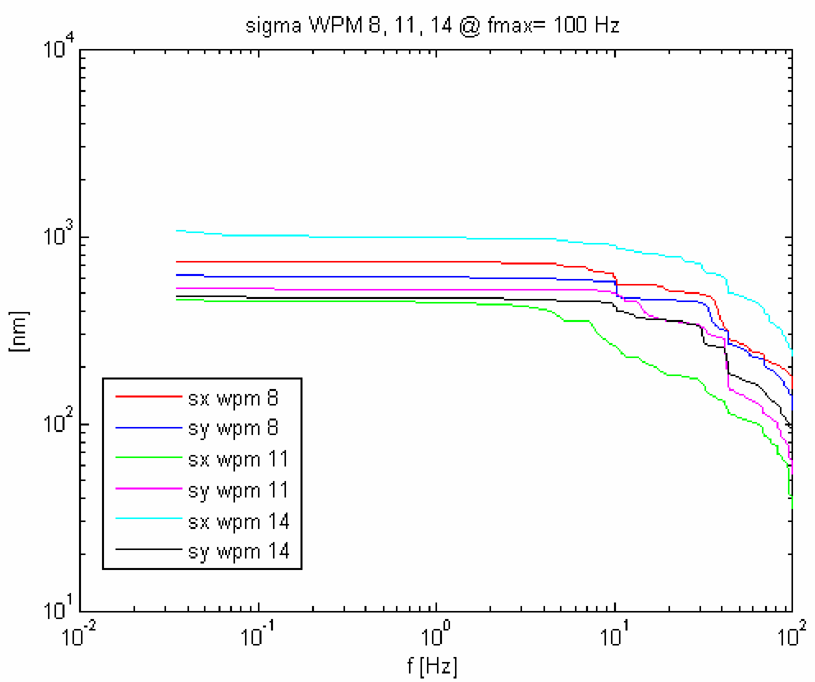
We have preferred to not filter completely the wire oscillation lines to not suppress useful information.

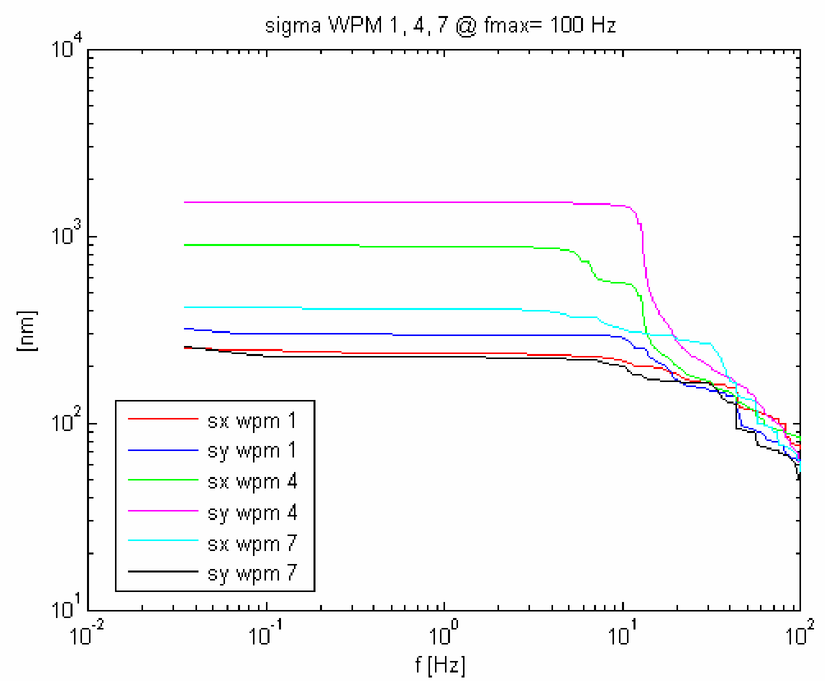
Looking to WPM 14, a significant amount of noise is present between 10 Hz and 30 Hz, 30 Hz and 40 Hz, due to the proximity of vacuum pumps and similar devices, and under 10 Hz, possibly due to the cryogenic system.

On the contrary, the spectra of the WPM 11 signals, which is at the central post position, shows only the harmonics (filtered) of the wire oscillations.

Vibration Variance

- WPM 1 & 8 are at the beginning of the cryomodule 4 & 5 respectively.
- The variances of WPM 4 is dominated by the low frequency noise as shown in the PSD.
- For all the WPMs, a small contribution to the variance comes from the spectral losses of the wire self oscillations lines.
- A more efficient procedure to remove these contributions is under study.





TTF Module Cold test Overview

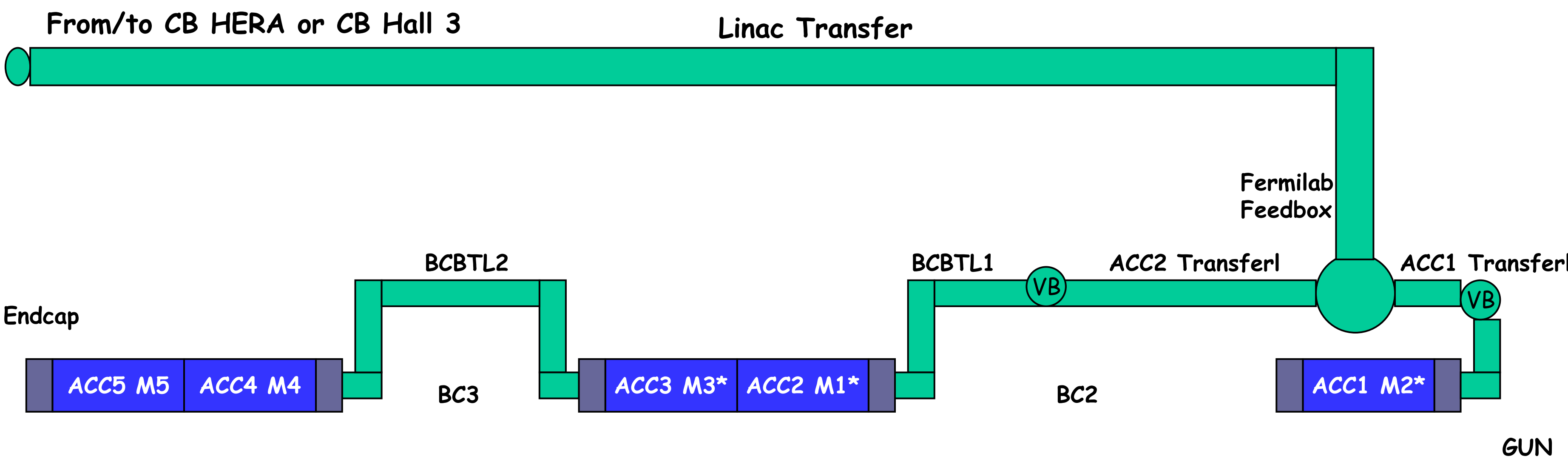
Module	Type	Assembly Year	Days	Installation and Test in TTF-Linac		Therm. Cycles cold/warm
Capture	Spec.	Saclay 1996		Oct-96	96-->Sep-03	c/w 13
M1	I	1997	>>	Mar-97	97-->Sep-97	c/w 2
M1 rep.	I	1997/98	>>	Jan-98	98-->Mar-99	c/w 3
M2	II	1998	>>	Sep-98	98-->May-02	c/w 3
M3	II	1999	35+15	Jun-99	99-->May-02	c/w 1
M1*	II	2000	24	Jun-02	02-->	c/w 3 +1
M4	III	2001	18+10	Apr-03	03-->	c/w 1 +1
M5	III	2002	30	Apr-03	03-->	c/w 1 +1
MSS	Spec.	2002	36	Jun-02	02-->Sep-03	c/w 3
M3*	II	2003	18+6	Apr-03	03-->	c/w 1 +1
M2*	II	2004	20	Feb-04	04-->	c/w 1
(M6 EP)	III	(end 2004?)		Modules under test in TTF2-Linac		

Status:15-Sep-04 RLange-MKS-

TTF Cryomodule Performances

						Status:15-Sep-04 R.Lange -MKS1-				
Designed, estimated and measured static Cryo-Loads TTF-Modules in TTF-Linac										
Module	40/80 K [W]			4.3K [W]			2 K [W]			Notes
Name/Type	Design	Estim.	Meas.	Design	Estim.	Meas.	Design	Estim.	Meas.	
Capture			46,8			3,9			5,5	Special
Module 1 I	115.0	76.8	90.0 *	21.0	13,9	23.0 *	4,2	2,8	6,0 *	Open holes in isolation
Modul1 rep. I	115.0	76.8	81,5	21.0	13,9	15,9	4,2	2,8	5,0	2 end-caps
Modul 2 II	115.0	76.8	77,9	21.0	13,9	13.0	4,2	2,8	4,0	2 end-caps
Module 3 II	115.0	76.8	72.0 **	21.0	13,9	48.0 **	4,2	2,8	5,0 *	Iso-vac 1E-04 mb, 2e-caps
Module 1* II	115.0	76.8	73.0	21.0	13,9	13.0	4,2	2,8	<3.5	1 end-cap
Module 4 III	115.0	76.8	74	21.0	13,9	13.5	4,2	2,8	<3.5	1 end-cap
Module 5 III	115.0	76.8	74	21.0	13,9	13.0	4,2	2,8	<3.5	1 end-cap
Module SS	115.0	~76.8	72.0	~21.0	~13.9	12.0	~4.2	>2,8	4,5	Special, 2 end-caps
Module 3* II	115.0	76.8	75	21.0	13,9	14	4,2	2,8	<3.5	1 end-cap
Module 2* II	115.0	76.8	74	21.0	13,9	14,5	4,2	2,8	<4,5	2 end-caps
Module 6 EP	Type III, EP-Cavities Goal:Solution close to XFEL Modules									(Assembly End-04??)
	Design and estimated values by Tom Petersen 1995 -Fermilab-						Modules under Test in TTF2-Linac			

TTF2 Cryogenics since March 2004



Overview:

21-Mar-04	Start of cool down
28-Mar-04	4.3K/1.1bar
29-Mar-04	2 K / 31mbar
07-Jun-04	Linac shut down, cavities kept cold (4.3K/1.1bar)
01-Sep-04	Start of TTF2 Commissioning

Static Cryo losses [Watt]:

	Total	/Module
40/80K	1300	74
4.3K	320+1.6g/s	13
2.0K	21	<3.5

Cold Leaks Experience at TTF

Summary of Vacuum/He Leaks after Cold Tests in TTF/TTF2-Modules

Status:15-Sep-04 R. Lange -MKS-

Module	M1	M2	M3	MSS	M1*	M3*	M4	M5	M2*
Number of leaks Vac	1	6	7	0	1	1	0	0	
Number of cool/warm	3	3	1	3	3 +1	1 +1	1 +1	1 +1	1
He-->insulation	0	0	1 C5 tank weld	0	0	0	0	0	0
			1 C8 bellow w						
Insulation-->coupler	0	0	0	0	0	0	0	0	?
Insulation-->beam pipe	Cav-flange	4 BPM feed-thr	1 BPM feed-th	0	1	1(more?)	0	0	?
		1 C6 e-pickup	2 C2/C8 e-pick						
			1 C7 coup-flan						
Coupler-->beam pipe	0	1 C1 ceram wi		0	0	0	0	0	?
He-->beam pipe	0	0		0	0	0	0	0	0

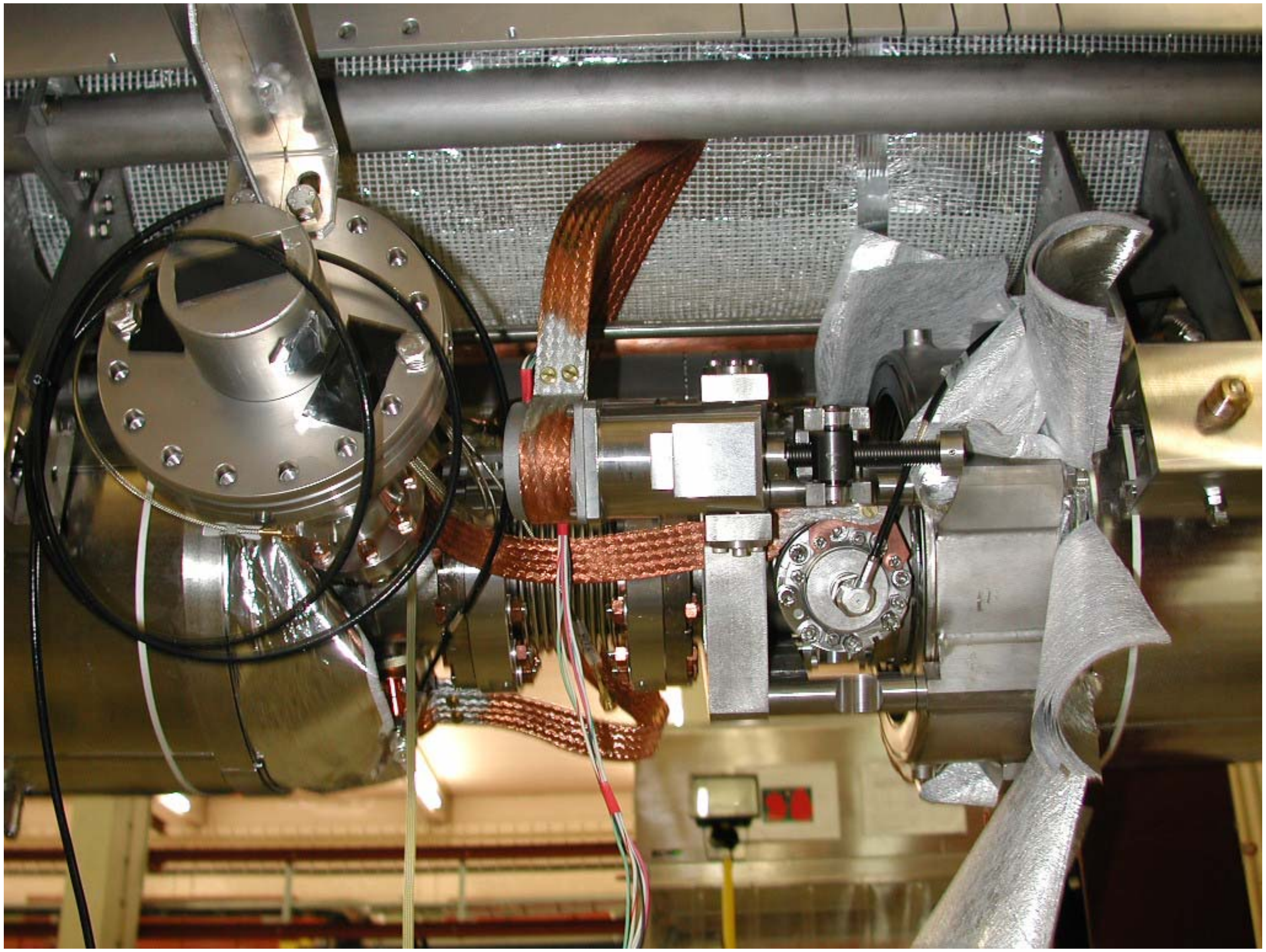
Module assembly picture gallery - 1

String inside the Clean Room

Module assembly picture gallery - 2

String in the assembly area

Module assembly picture gallery - 3



Cavity interconnection detail

Module assembly picture gallery - 4

String hanged to he HeGRP

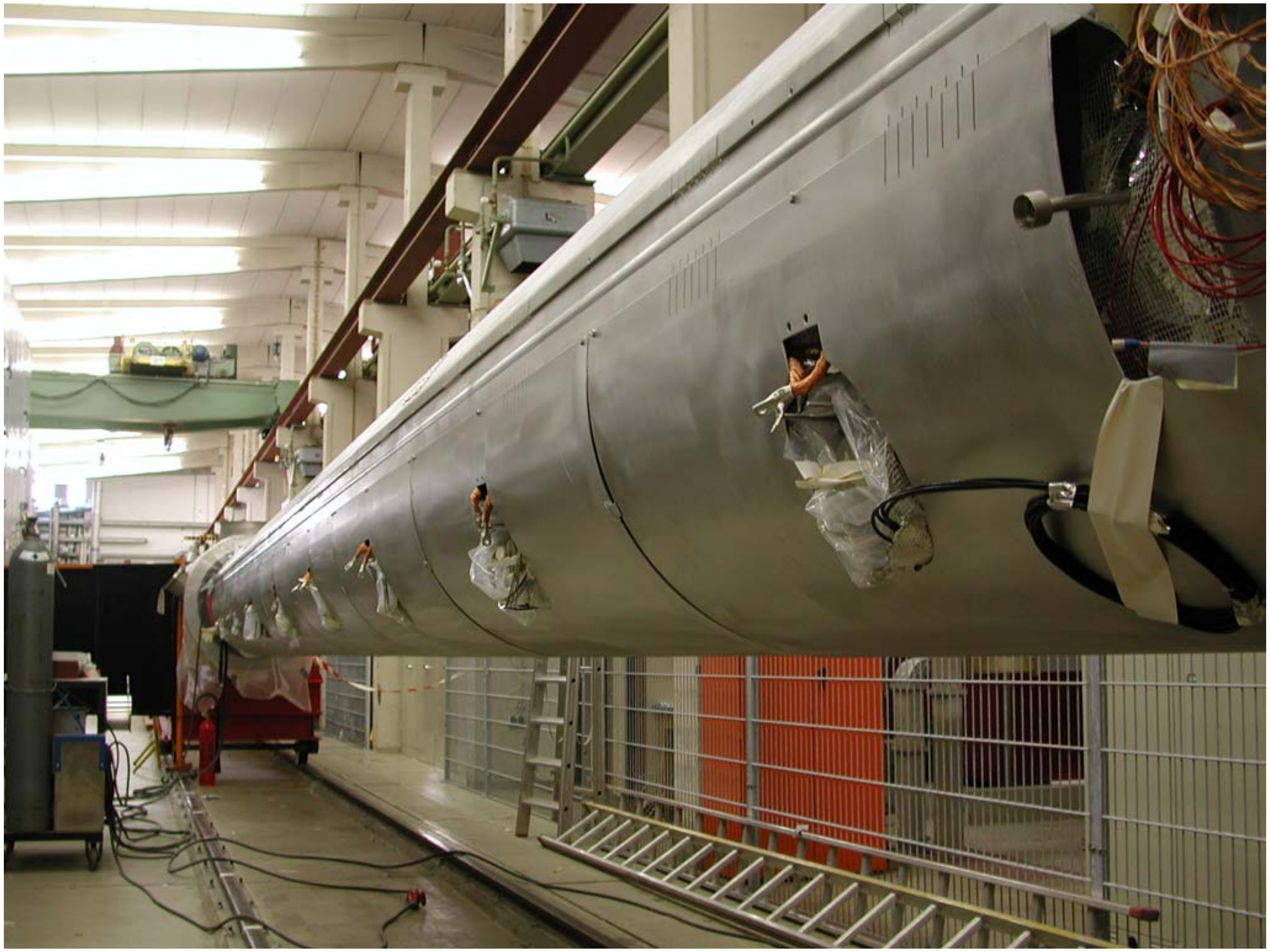
Module assembly picture gallery - 5

String on the cantilevers

Module assembly picture gallery - 6

Close internal shield MLI

Module assembly picture gallery - 7



External shield in place

Module assembly picture gallery - 8

Welding “fingers”

Module assembly picture gallery - 9

Sliding the Vacuum Vessel

Module assembly picture gallery - 10

Complete module moved for storage

Proven design, just few details to clean up

Most are useful, but not necessary, for X-FEL

Industrialization foreseen for X-FEL good for ILC too

A few examples

- Quad Fixture (sliding as for cavities) – planned for X-FEL
- Flange connections: Sealing and Fixing
- Various braids for heat sinking (all coupler sinking stile)
- Cables, Cabling, Connectors and Feed-through
- Composite post diameter (and fixture for transportation)
- Warm fixtures of cold mass on Vacuum Vessel (fixed and sliding)
- LMI Blankets for the 50-70 K shield (LHC Style)
- Module interconnection: Vacuum Vessel sealing, pipe welds, etc.
- Coupler provisional fixtures and assembly

Design changes important for ILC

- Move quadrupole to the center
  - Quad/BPM Fiducialization
  - High pressure rinsing and clean room assembly issues
  - Movers for beam based alignment? Why not if really beneficial
- Short cavity design
  - Cutoff tubes length by e.m. not ancillaries (coaxial tuner)
- Cavity inter-connection: Flanges and bellows (coating?)
  - Fast locking system for space and reliability (CARE activity)
  - Bellow waves according to demonstrated tolerances
- Coaxial Tuner with integrated piezo-actuators
  - Parametric “Blade Tuner” successfully operated on superstructures
  - Piezo fast tuner not integrated yet
- Longer module design: 10-12 cavities
  - Length to be based on the overall machine cost optimization

TESLA Cryomodule Concept Peculiarities

Positive

- Very low static losses
- Very good filling factor: Best real estate gradient
- Low cost per meter in term both of fabrication and assembly

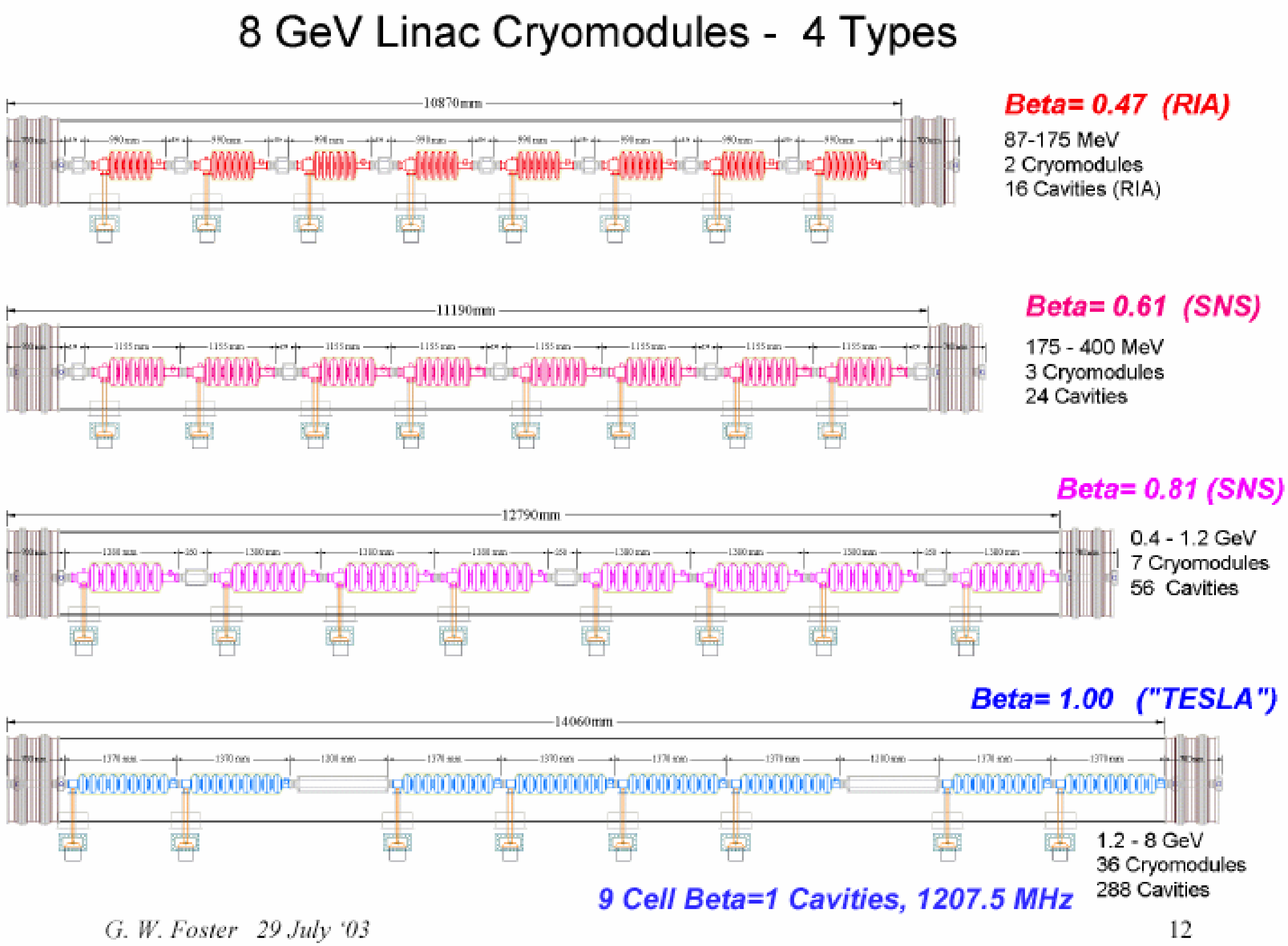
Project Dependent

- Long cavity strings, few warm to cold transitions
- Large gas return pipe inside the cryomodule
- Cavities and Quads position settable at ± 300 μm (rms)
- Reliability and redundancy for longer MTTR (mean time to repair)
- Lateral access and cold window natural for the coupler

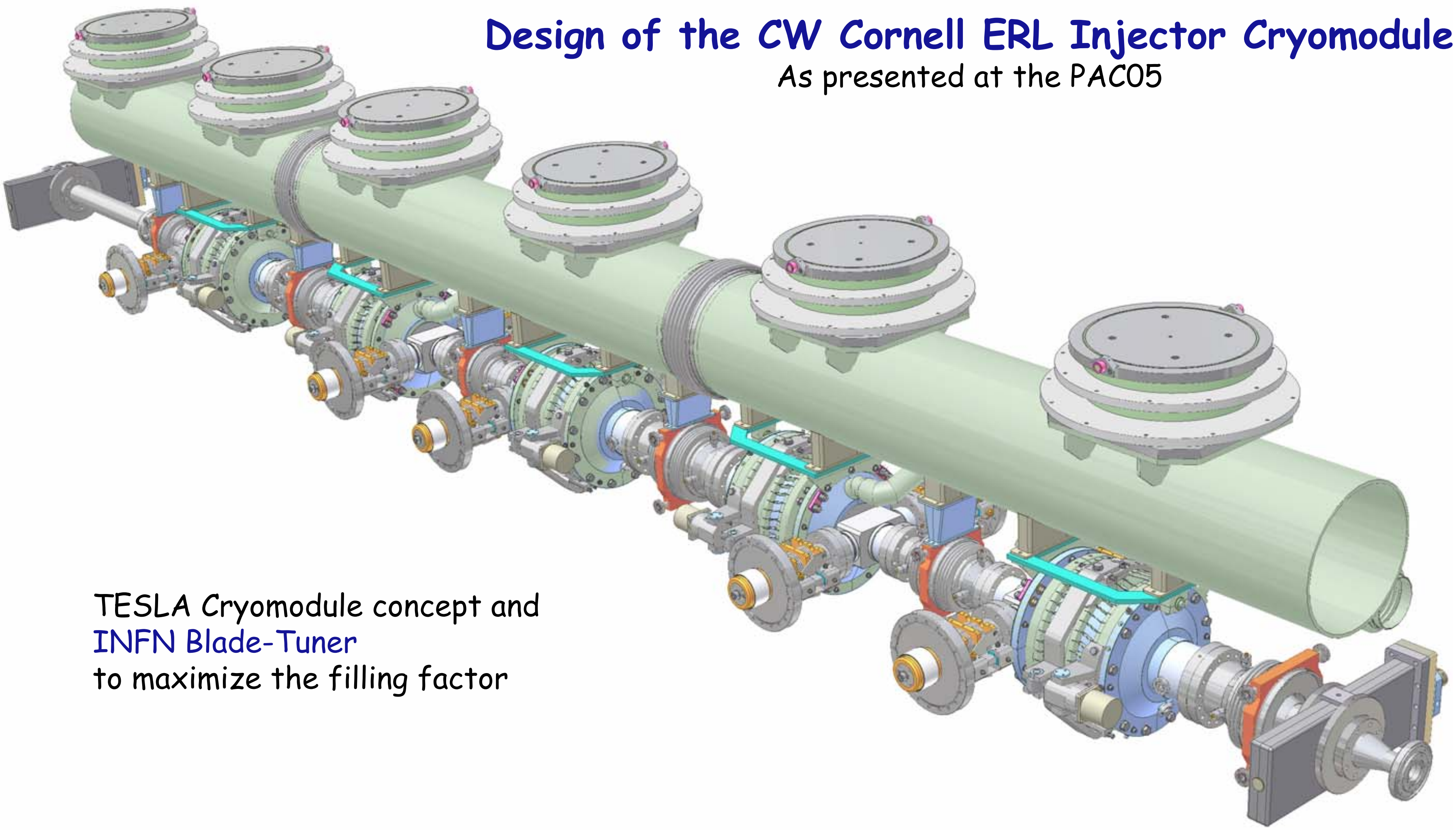
Negative

- Longer MTTR in case of non scheduled repair
- Moderate (± 1 mm) coupler flexibility required

TESLA Like Modules for Protons



TESLA Cryomodule and ERLs



Design of the CW Cornell ERL Injector Cryomodule

As presented at the PAC05

TESLA Cryomodule concept and
INFN Blade-Tuner
to maximize the filling factor

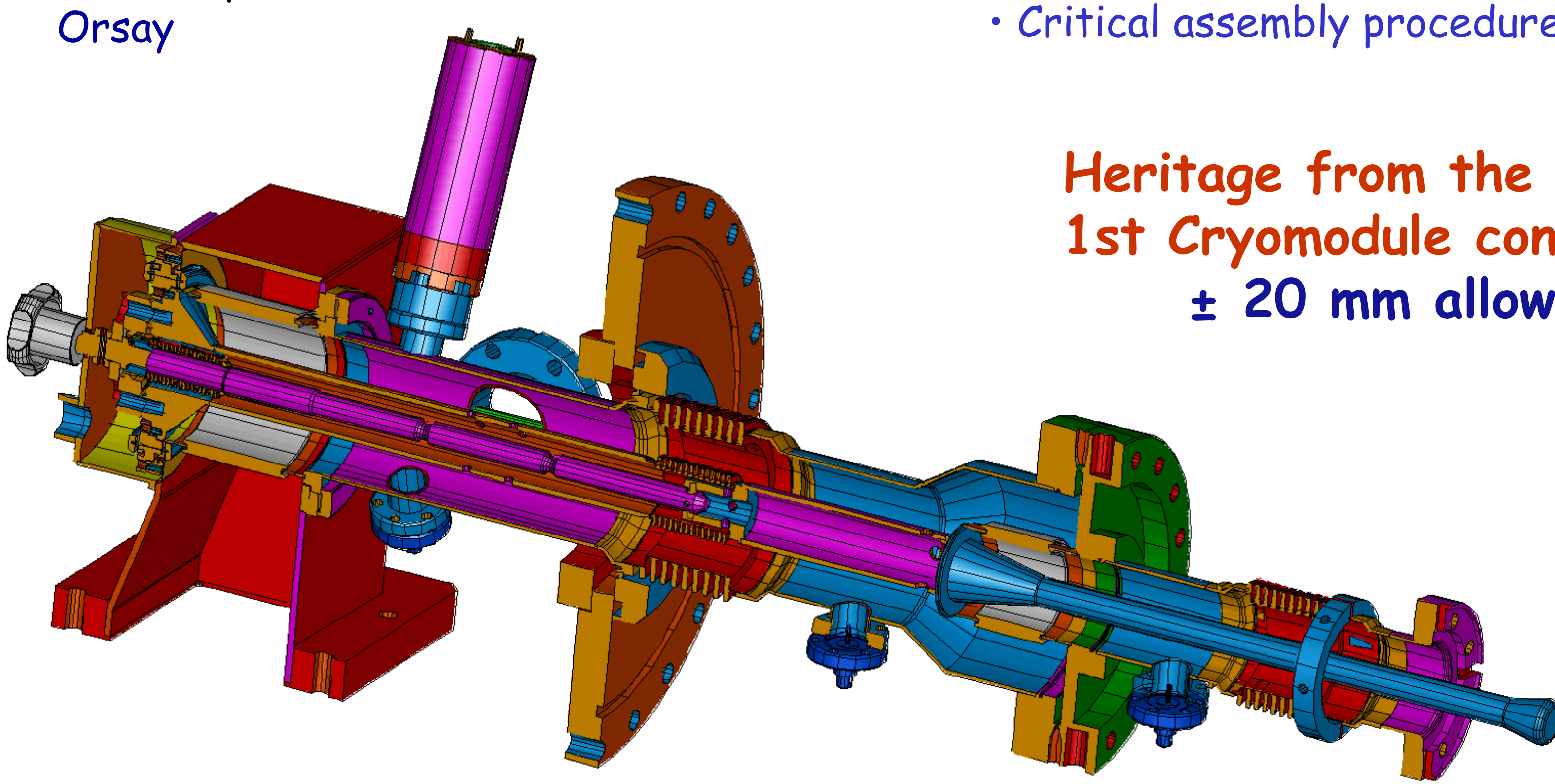
Ancillaries: Power Coupler

- TTF III Coupler has a robust and reliable design.
- Extensively power tested with significant margin
- New Coupler Test Stand at LAL, Orsay

Pending Problems

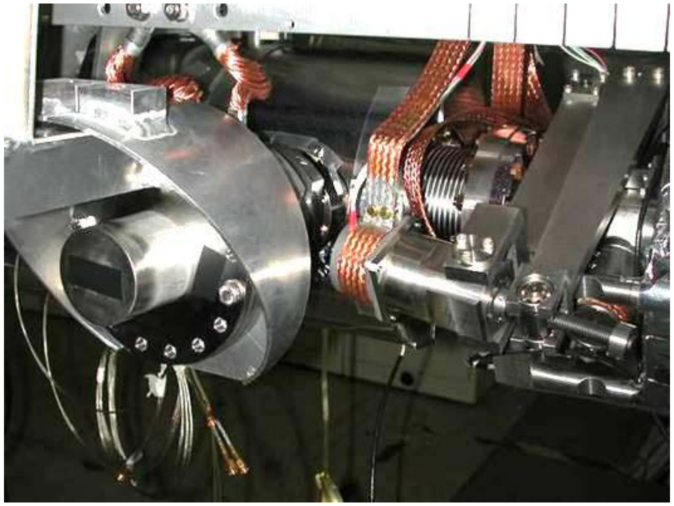
- Long processing time: ~ 100 h
- High cost (> cavity/2)
- Critical assembly procedure

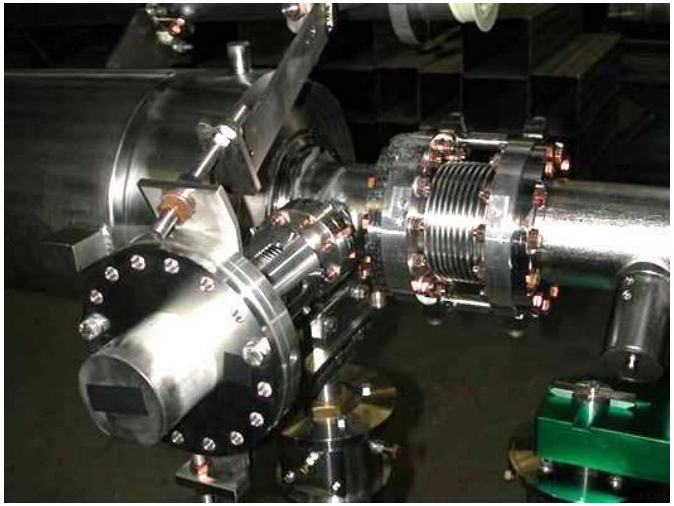
Heritage from the 1st Cryomodule concept: ± 20 mm allowed



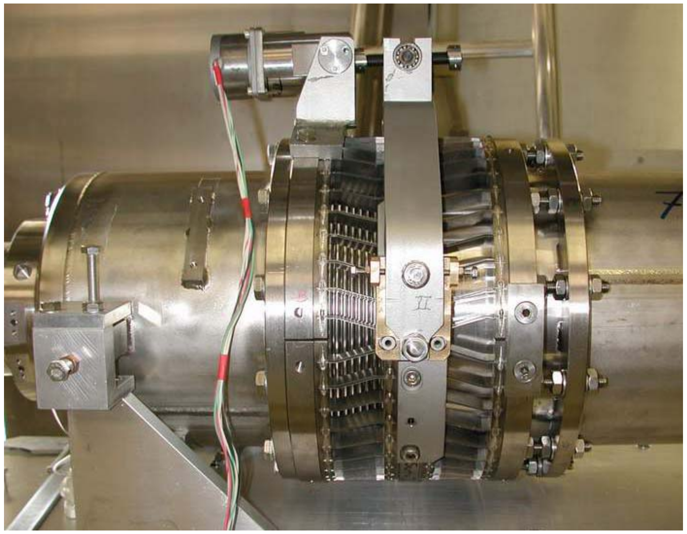
Ancillaries: Present Tuner Designs

The Saclay Tuner in TTF

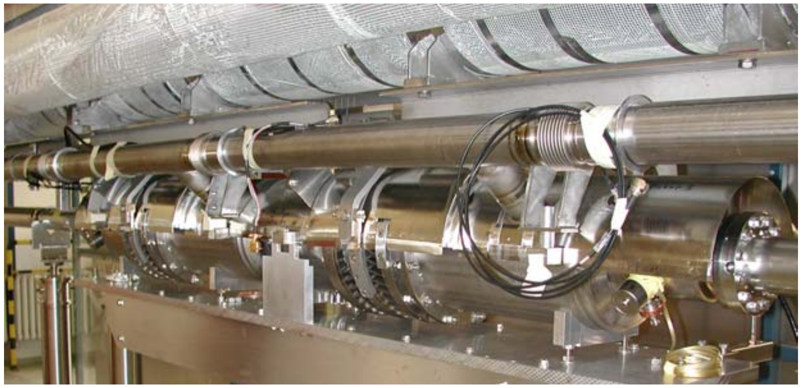




The INFN Blade-Tuner



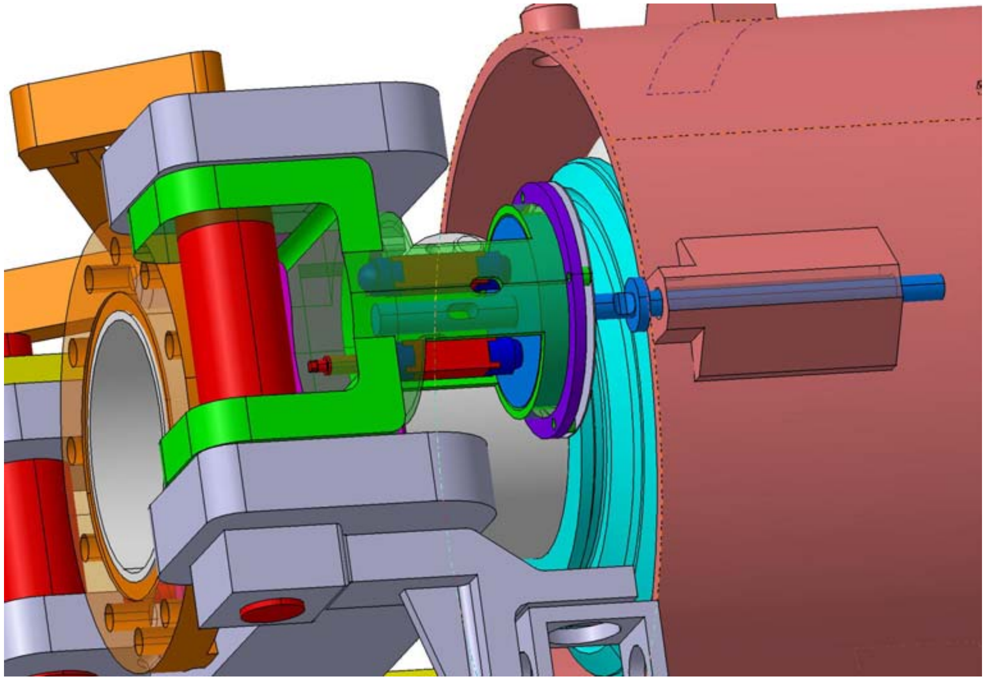
Successfully operated with superstructures



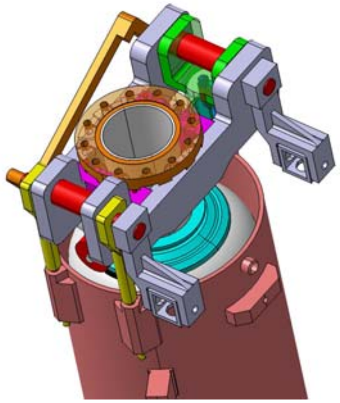
New CEA-Saclay Tuner

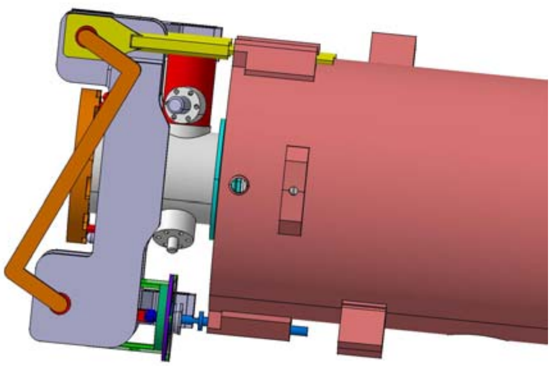
New design with piezos

- **CARE/JRA-SRF**
- **SOLEIL upgrades**
- **larger rigidity**

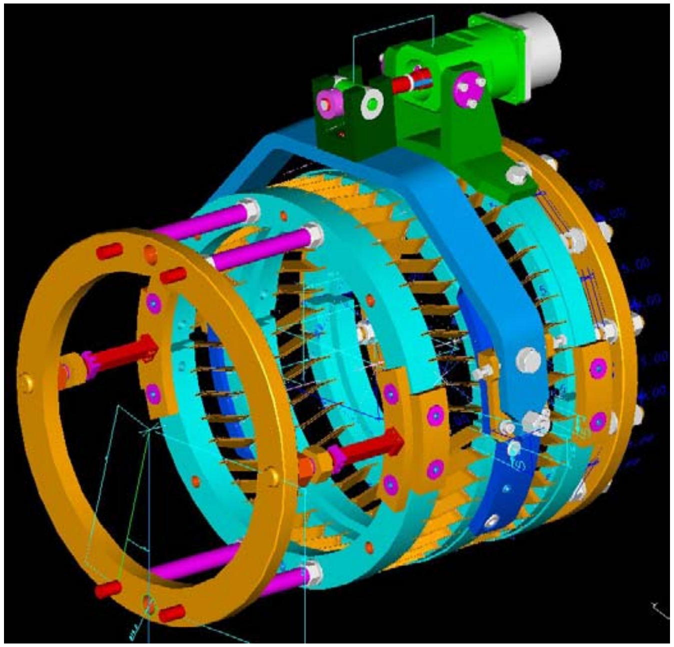


- Fabrication of 2 tuners under way. Available autumn 2005
- 12 NOLIAC piezos, 2 PHYTRON stepping motors ordered
- Coll. with IPN Orsay: CEA send NOLIAC piezos to IPN for characterization, and IPN send P.I. piezos for tests on tuners
- Coll. with INFN-Milano for measurement with stress sensors @ 2K

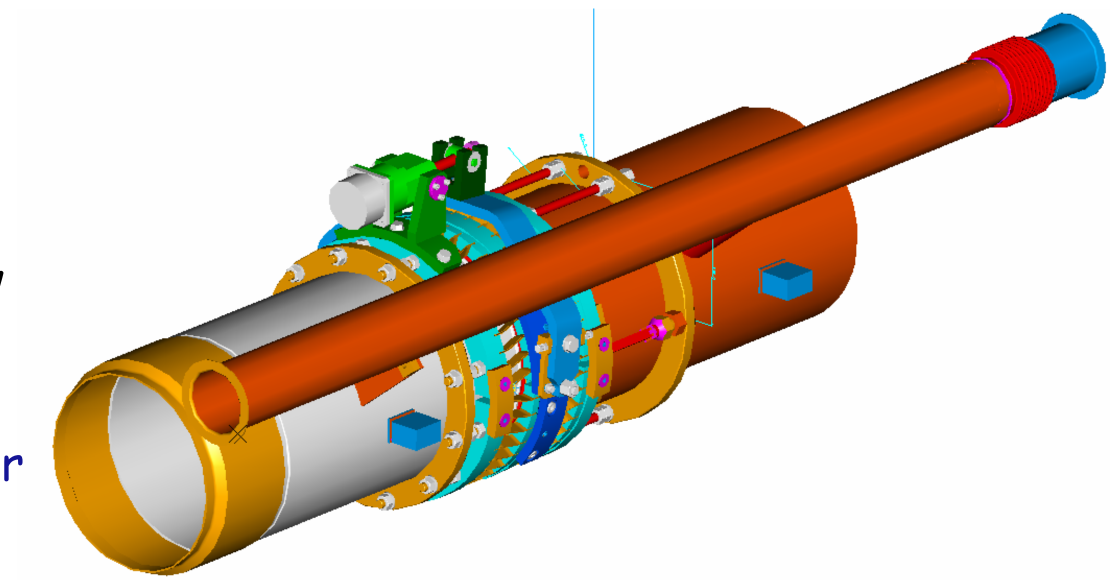




The New INFN Blade-Tuner



- Integration of piezos for Lorentz forces and microphonics completed.
- Final Drawing delivered for fabrication.
- Two prototype, including the modified helium tank, expected by end of September 2005
- Cold tests results by fall 2005 (DESY, BESSY, Cornell?)



- Now the He tank needs to be split in two parts, with a bellow in between to allow the cavity elongation
- *Magnetic shield assembly as for Superstructures*

From TTF to ILC

- TTF Operation Experience shows that Cry 3 Modules are close to the optimum in term of performances
- Improvements where conceived at the time of the TESLA TDR, but never developed because of sake of funding and personnel
- X-FEL will use the present design with minimum modifications
- ILC should use the TESLA TDR cryomodule design, very close to the so called Cry 3, as the basis for further improvements
- An international concentrated effort in this direction would have the advantage to have most of the modifications implemented in time for the X-FEL, with the strong support and expertise of DESY, INFN and of the European TESLA Collaboration members.
- A review of the Cry3 design for SMTF could the next step for ILC