SRF Developments in View of Snowmass

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- Goals for Snowmass
- Recent developments in SRF technology
  - What is available?
  - What is already being worked on?
  - What actually does need work ?
- Goals for this meeting
  - List European Assets for the ILC
  - Define necessary R&D and its benefits and needs

Charge to Snowmass (Accelerator Part)

- To collect and review the results of the First ILC Accelerator workshop (KEK, 13-15 November 2004) and subsequent related activities. See http://lcdev.kek.jp/ILCWS/.
- To enumerate design options that need consideration, e.g. damping rings of different sizes, under the guidance, it is hoped, of the Central Team of the Global design (GDE) effort.
- To carry needed accelerator physics and technology studies to the deepest level possible within the time and resources available, keeping in mind the need for the GDE to produce a baseline design and R\&D plan as early as possible.

More detailed charge

- The Working Groups must work to agree upon the configuration of a large fraction of the collider design before and during the Workshop[Snowmass]. They should use the Workshop to develop paths to working decisions for the remaining critical issues with the expectation that these could be decided at one or two subsequent meetings during the fall of 2005.
- The Workshop should also be used to start the initial documentation of the BCD.
- Finally, the Working Groups should identify critical R&D topics and timescales for alternative solutions to the ILC Baseline Configuration that could have a significant impact on the performance or cost of the linear collider.

A lot of things are under discussion:

- Where are the ones everybody agrees upon?
  - E.g.: A new infrastructure for cavity preparation needs to be set up (like discussed at the TESLA Technology Collaboration Meeting)
    - This is non-contradictory because it can serve many types of cavities (LL, RE, Standard) and is independent of the surface preparation (should include both EP and BCP)
  - WHAT ELSE??? Examples:
    - Either tuner can fit the module, it is therefore not a critical decision
    - High Power Input Coupler is being perceived to be problematic e.g conditioning times
      - » Is this really true? Real data needs to be looked at. This needs to be ready for Snowmass
- Generally, some entropy is in the system (which is natural and not problematic), but
  - false assumptions, perceptions should be avoided
  - Duplication of efforts should be avoided where not needed

ILC Hot Topics (incomplete…)

- Need work on gradient
  - Process quality control is a major issue
  - Hints on a sulphur contamination in the EP setup at DESY
  - A new R&D infrastructure would extremely valuable
    - Refer to the discussion at the last TESLA Technology Collaboration Meeting
      - Tesla.desy.de , then 'Meetings', 'Collaboration Meetings', 'DESY' in early 2005 Technical developments
  - New Cavity Shapes
    - Strong development at KEK and JLab in colloboration with DESY and others
  - New niobium material
    - Single-crystal or large grain vs. standard material
    - Cost reduction seems possible
  - Couplers
    - TTF III has performed well
      - Is the processing of the coupler too long?
      - Is this a design or rather a handling problem?
    - Other designs are proposed
      - This needs significant R&D effort (cost, time)
- Industrialisation issues
  - Improved Quality Control measures needed
  - Transfer of Technology to industry outside Europe

European Contributions to ILC SRF R&D

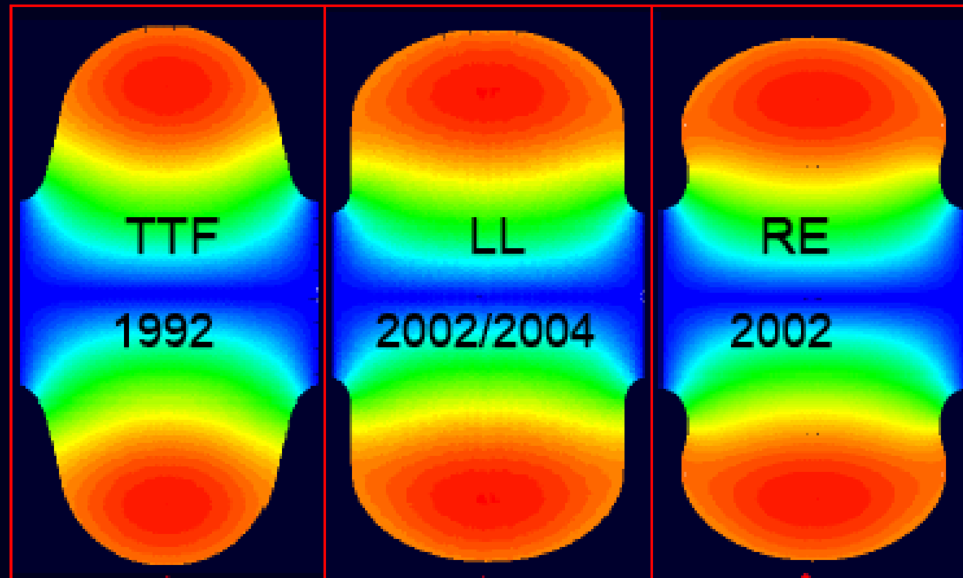
- There can be significant contributions from Europe
  - CARE funding
    - Ongoing R&D on the multi-cell EP setup (DESY)
      - EP is baseline for XFEL (to avoid 1400°C high temperature treatment)
      - System is still a prototype (e.g. materials in system need further investigation)
    - Systematic studies on the EP process (e.g. CEA, INFN)
    - Dry-ice cleaning as future option
  - XFEL
    - Installation of a new HPR system
      - Old system is aging
      - Has failed several times in the last year
      - Needs a lot of maintenance

Cavity Shapes

- Goal:
  - Modify the geometry such that the B_{peak}/E_{acc} ratio goes down
  - Penalty
    - E_{peak}/E_{acc} goes up
    - Field emission is still a major source of limitations
      - First indications for optimisation of the process are underway (CEA – talk by C. Antoine)
      - ‘In-Situ‘ Baking is crucial and needs further development (talk by B. Visentin)

1. Introduction: Evolution of the elliptical cavities cont.

Example: 1.3 GHz inner cells for TESLA and ILC



r_{irisb}	[mm]	35	30	33	
k_{cc}	[%]	1.9	1.52	1.8	field flatness
E_{peak}/E_{acc}	-	1.98	2.36	2.21	max gradient (E limit)
B_{peak}/E_{acc}	[mT/(MV/m)]	4.15	3.61	3.76	max gradient (B limit)
R/Q	[Ω]	113.8	133.7	126.8	stored energy
G	[Ω]	271	284	277	dissipation
R/Q*G	[Ω*Ω]	30840	37970	35123	dissipation (Cryo limit)

Our japanese colleagues are moving fast:

- First LL nine-cell finished
- HOM design might need another iteration
- First cold test underway

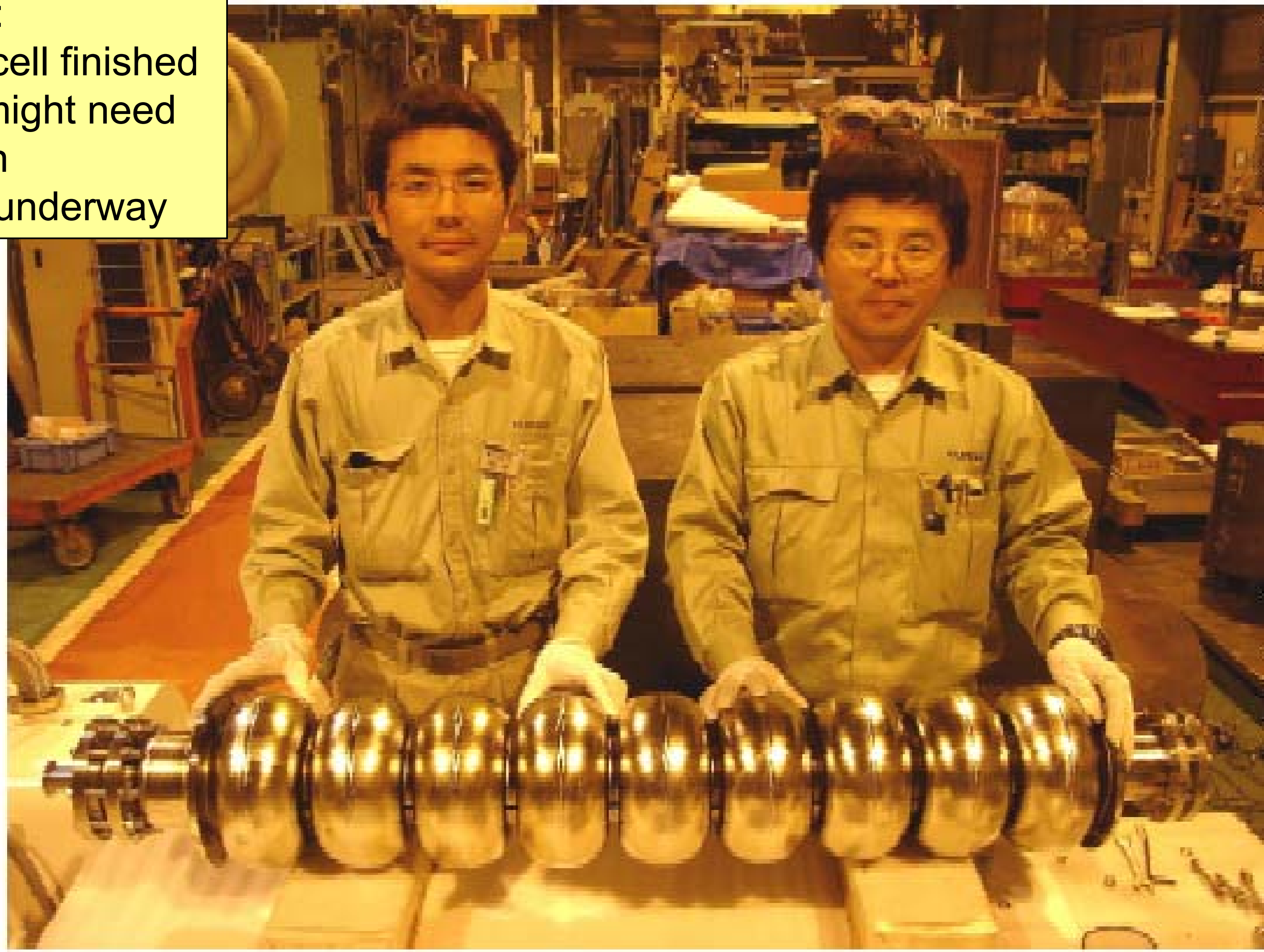


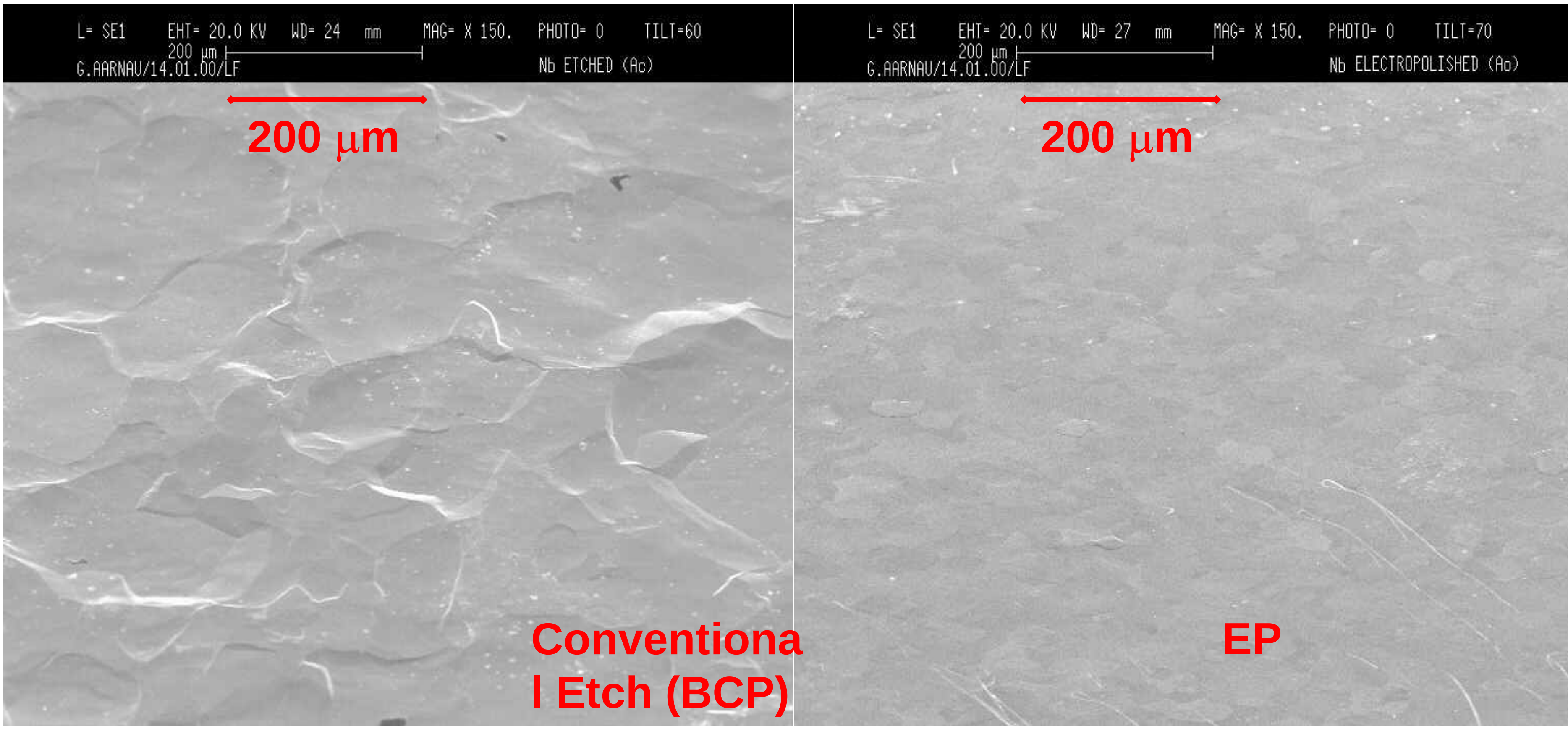
Fig. 5: ICHIRO 9-cell 1st cavity

Completed at Kuroki Industries Corporation in Himeji on 3 May 2005

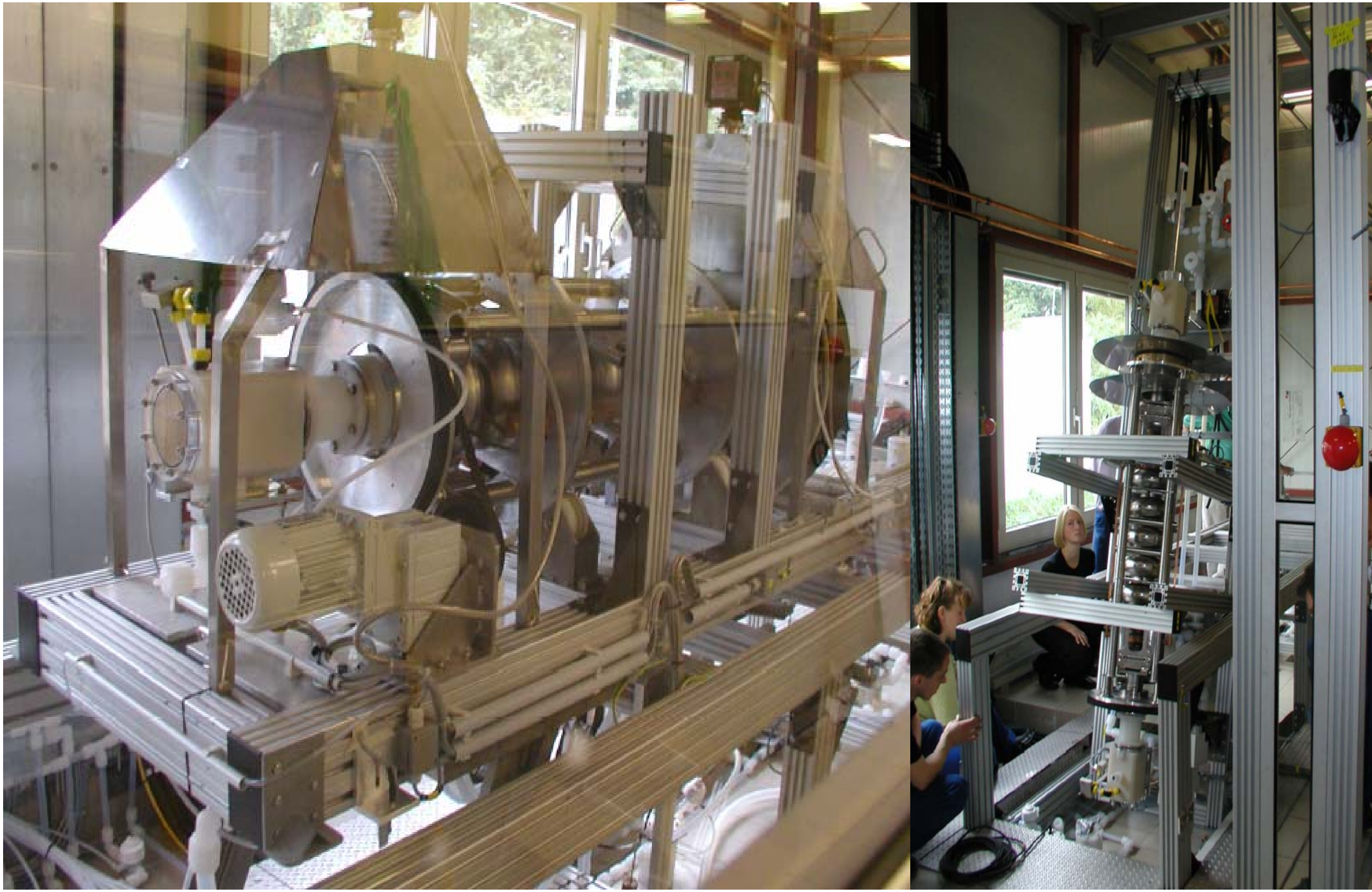
Surface Preparation: Electropolishing

- Electropolishing (EP) of niobium surfaces is a key technology to achieve the highest electrical and magnetic surface fields
- KEK/ Nomura Plating pioneered application of EP to elliptical niobium cavities since TRISTAN using a Siemens’ recipe
- Since then EP has also been successfully applied to
  - Low-Beta Quarter wave structures
  - TESLA nine-cells
- Better quality control needed

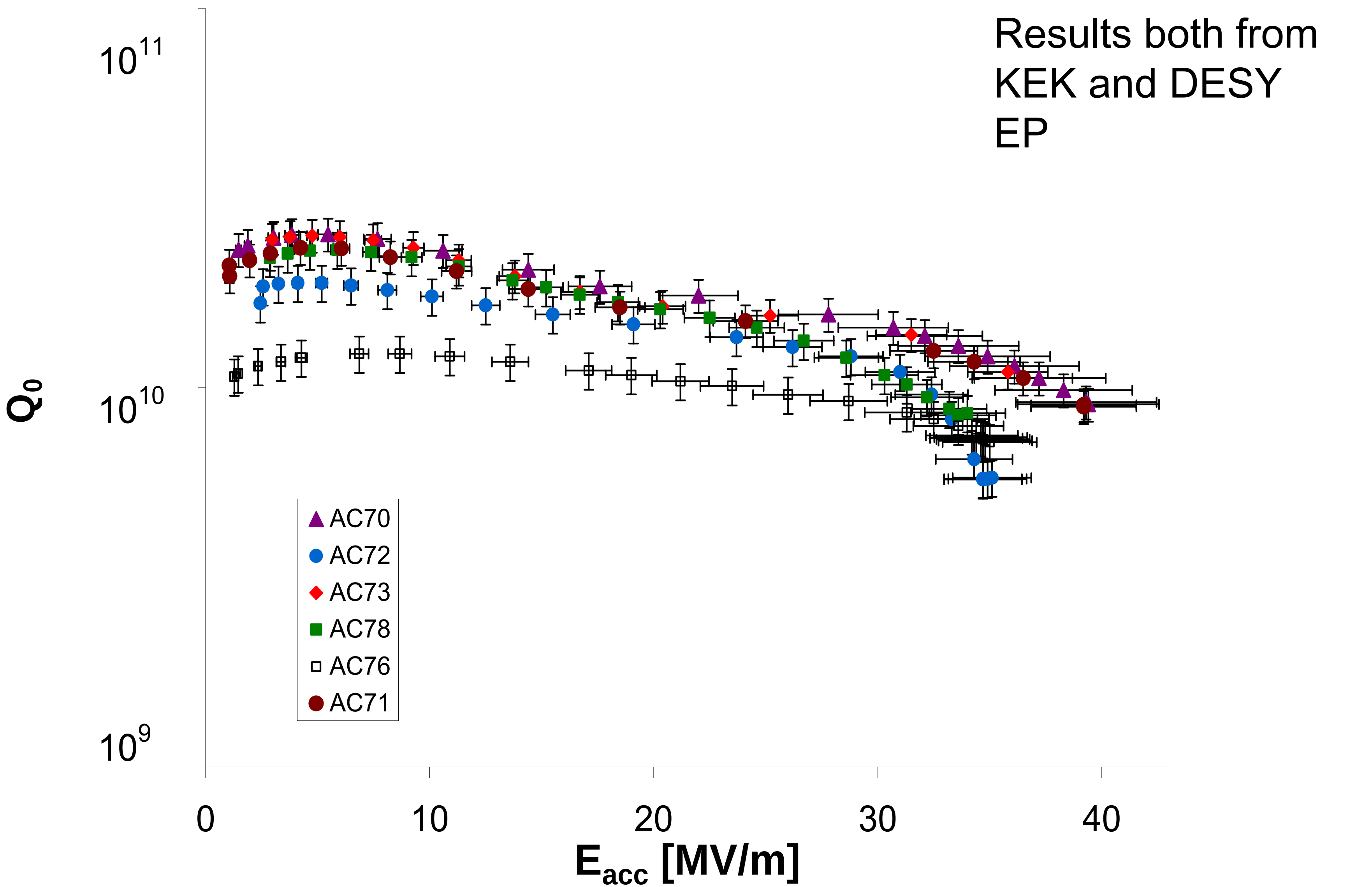
Electropolishing Offers Improved Surface Quality



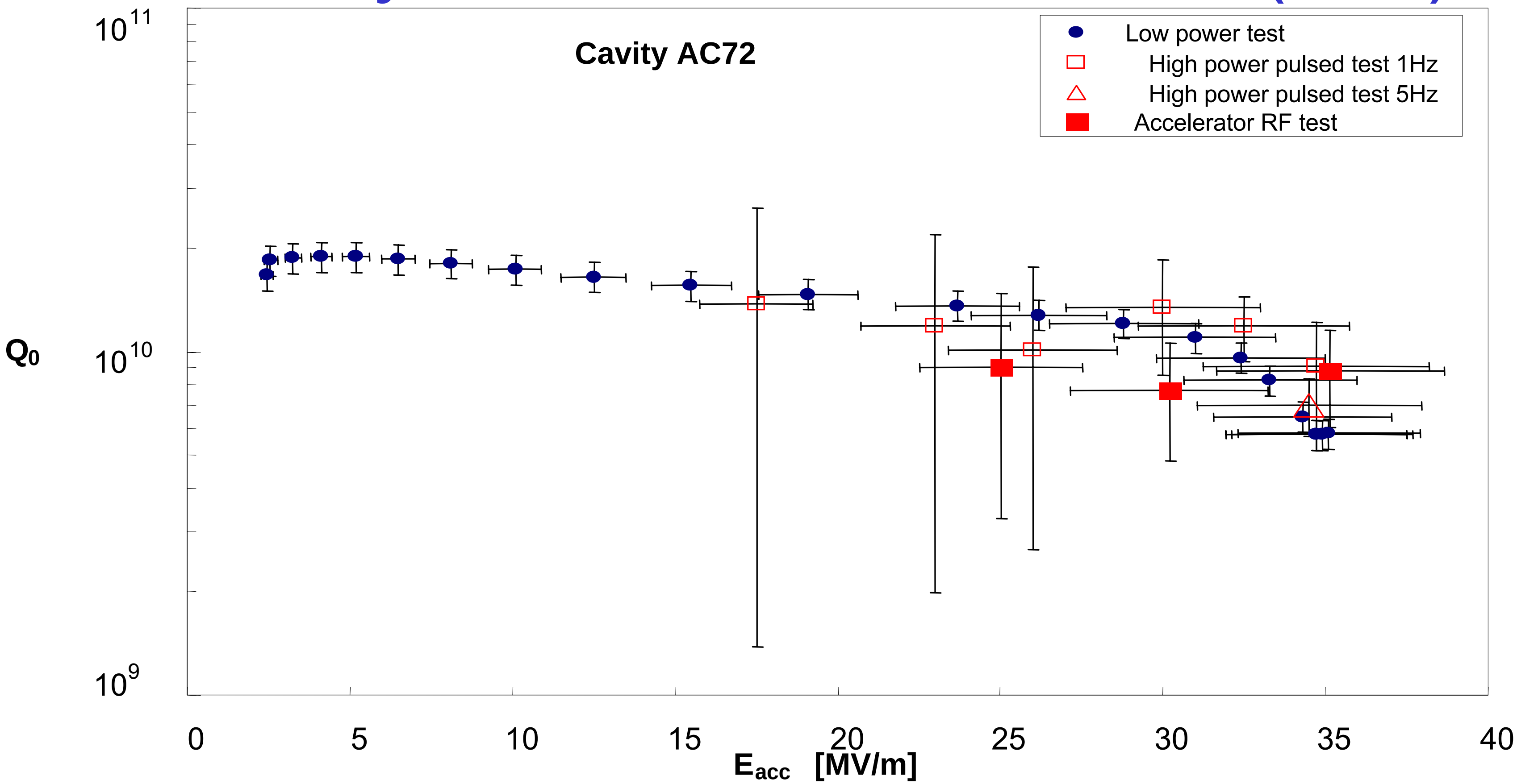
Electropolishing Setup at DESY



Electropolishing: Test Results

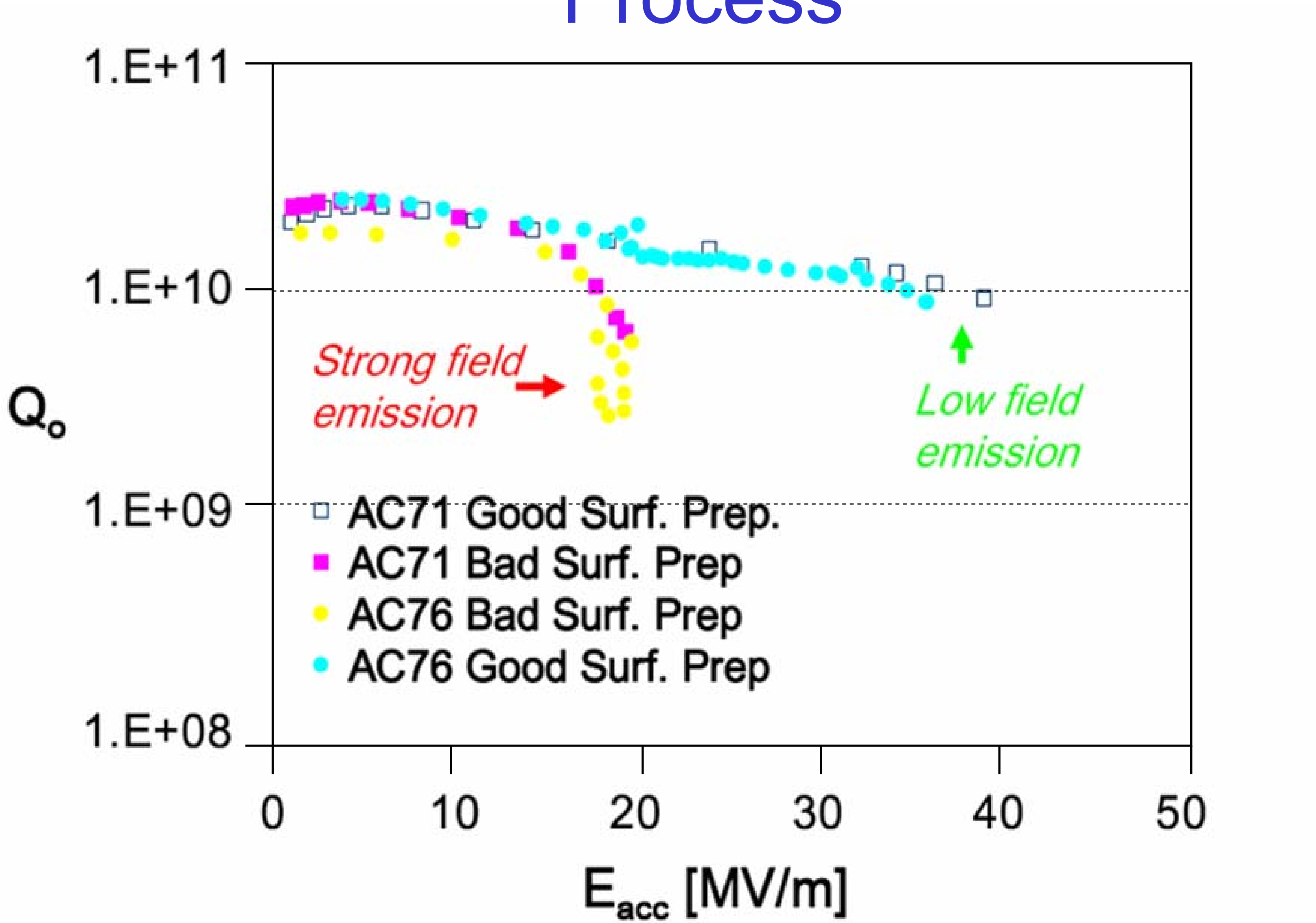


Cavity Test Inside a Module (ctd.)



- One of the electropolished cavities (AC72) was installed into an accelerating module for the VUV-FEL
- Very low cryogenic losses as in high power tests
- Standard X-ray radiation measurement indicates no radiation up to 35 MV/m

Problems: Reproducibility in the EP Process



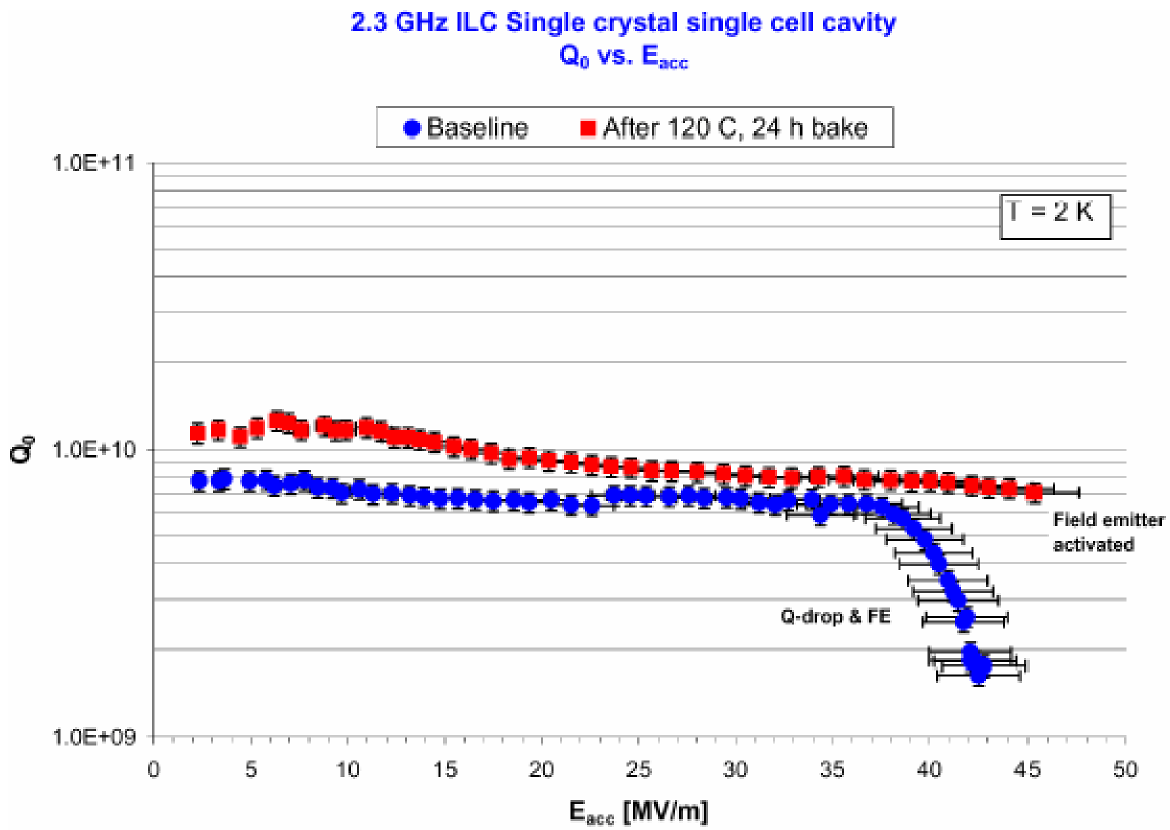
Single Crystal Cavity

P. Kneisel at al., JLAB

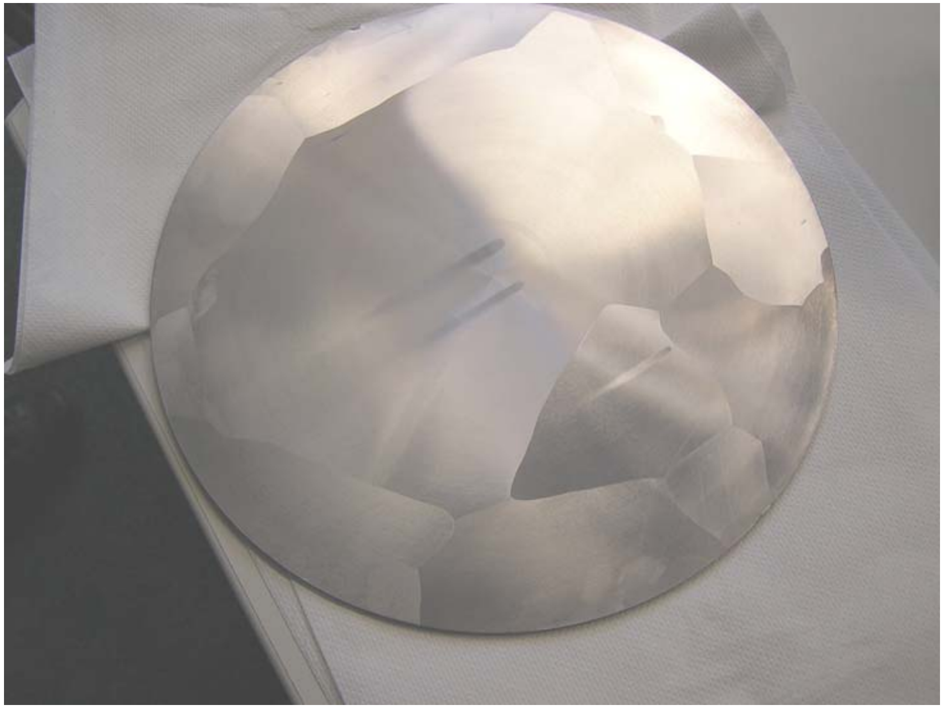
Single cell cavity made from a single crystal of niobium.

Low-Loss shape design

Cavity performs better than the ILC design goal



Large Crystal Tests at DESY



Fabricate cavities directly from Nb ingot

Potential advantages:

Simpler (cheaper?) production

Smaller impurities due to absence of rolling/forging

~ 70 sheets ordered from industry

Accelerator Modules and Components

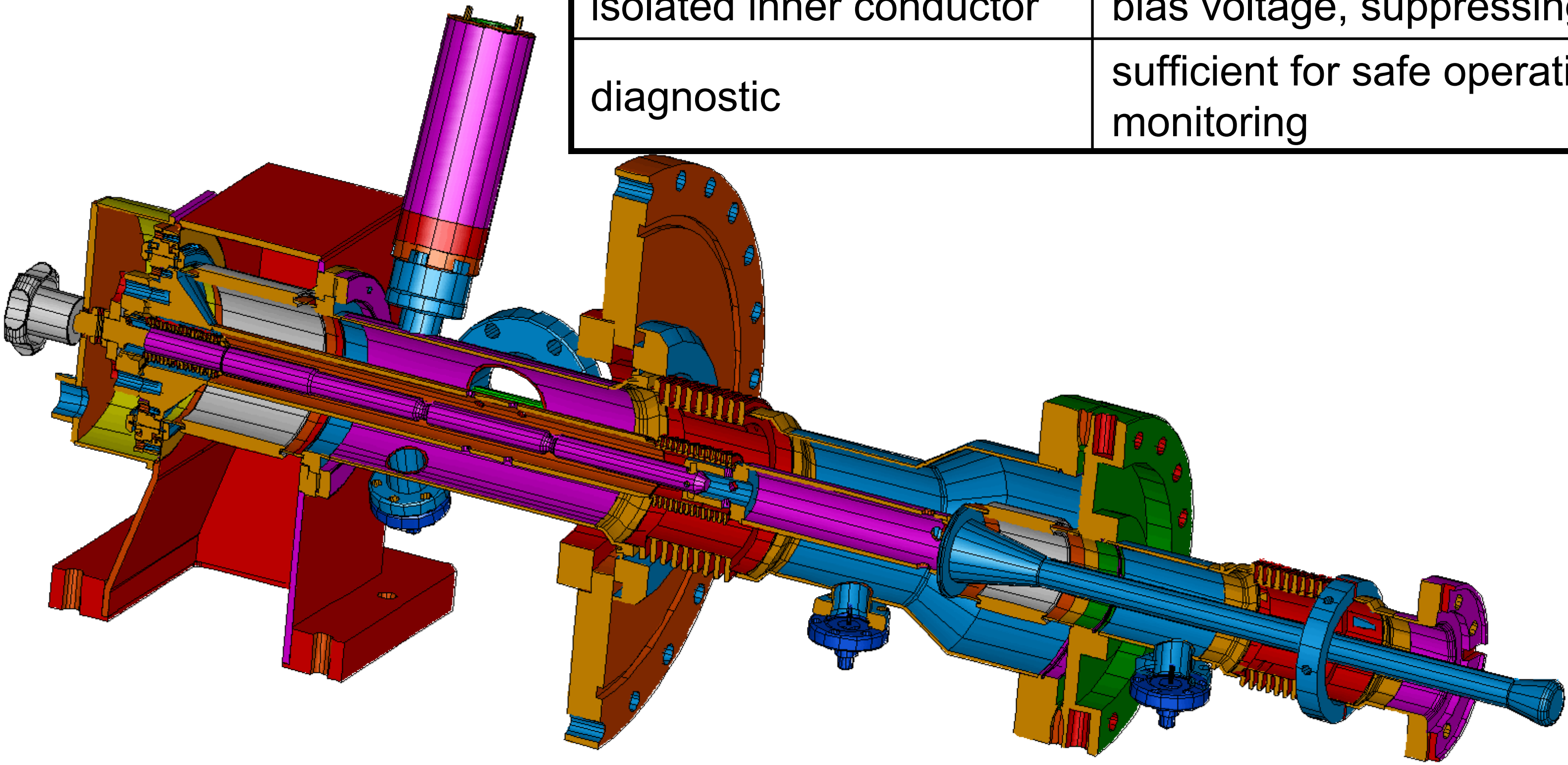
- High Power Couplers
- Frequency tuners
- Module Layout

Coupler

- High Power Input Coupler is being perceived to be problematic e.g conditioning times
  - Is this really true? Real data needs to be looked at. This needs to be ready for Snowmass
  - Is this a design problem (if at all)?
  - Or rather a handling problem?
- The coupler has operated very reliably in the endurance tests of the EP cavities in CHECHIA (high power cavity test stand)

TTF III Coupler

frequency	1.3 GHz
operation	pulsed: 500 μsec rise time, 800 μsec flat top with beam
two windows, TiN coated	• safe operation • clean cavity assembly for high Eacc
2 K heat load	0.06 W
4 K heat load	0.5 W
70 K heat load	6 W
isolated inner conductor	bias voltage, suppressing multipacting
diagnostic	sufficient for safe operation and monitoring



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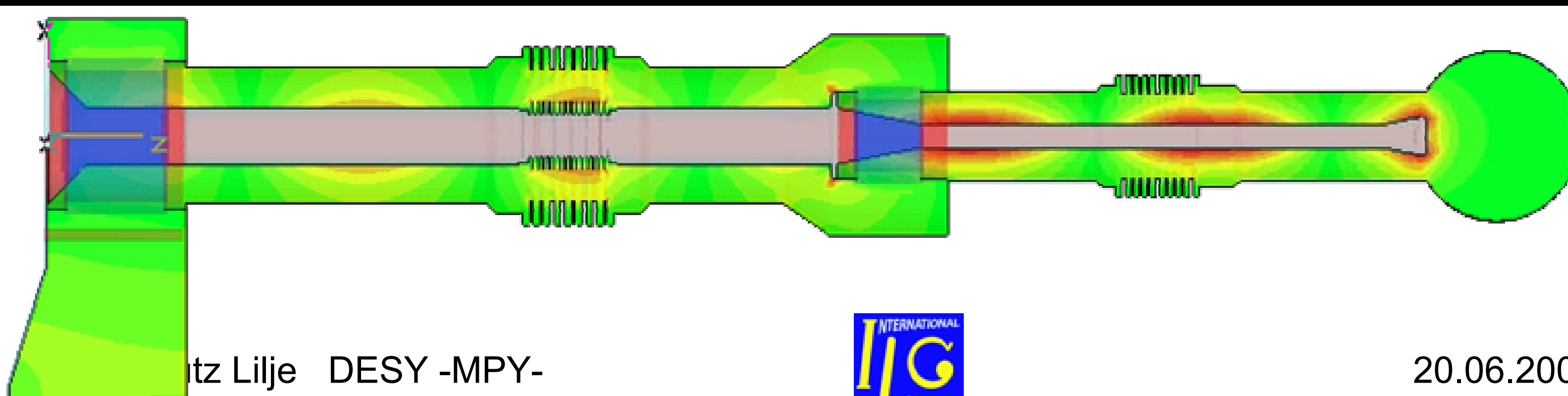
RF Specifications

	TTF	TESLA 9cell / upgrade	XFEL
Peak power + control margin	250 kW	250 kW / 500 kW	150 kW
Repetition rate	10 Hz	5 Hz	10 Hz
Average power	3.2 kW	3.2 kW / 6.4 kW	1.9 kW
Coupling (Qext)	adjustable (10^6 - 10^7)	fixed ($3*10^6$)	adjustable (10^6 - 10^7)

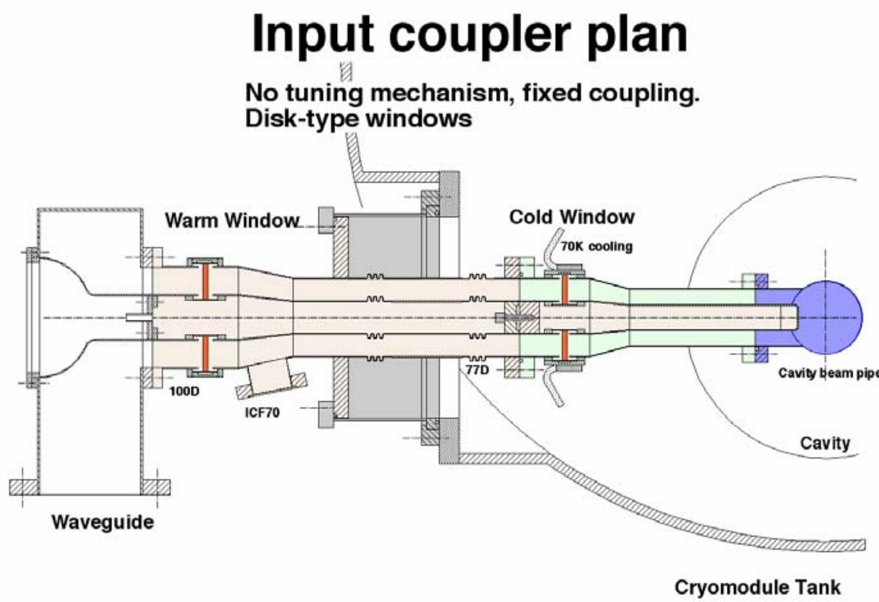


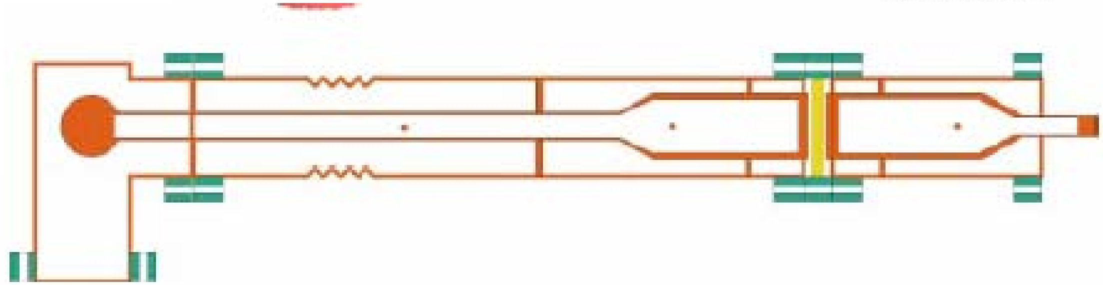
Coupler type		FNAL	TTF II	TTF III
cold part	window	conical	cyl.	cyl.
	coax diameter, mm	40	40	40
	Impedance, Ohm	50	70	70
bias		no	yes	yes
TiN coating		FermiLab	FermiLab	DESY
test stand TW	2Hz / 500μs	1MW	2MW	1MW
	2Hz / 1.3ms	1MW	1.8MW	1MW
	cold test done	yes	no	no
hiigh power test with Cavity	2Hz / <500μs	1MW	1MW	1MW
	5Hz/ 1.3ms SW	500 kW	500 kW	600 kW
	10Hz / 1.3ms	33MV/m	35MV/m	35MV/m
	cold test done	yes	yes	yes
fabricated total		16	20	62
assembled to		Mod.1*, 2	Mod.1*, 3*, 4	Mod.5, 6 (7, 8) SS
operated		1997-2004	1998-2004	2001-2004

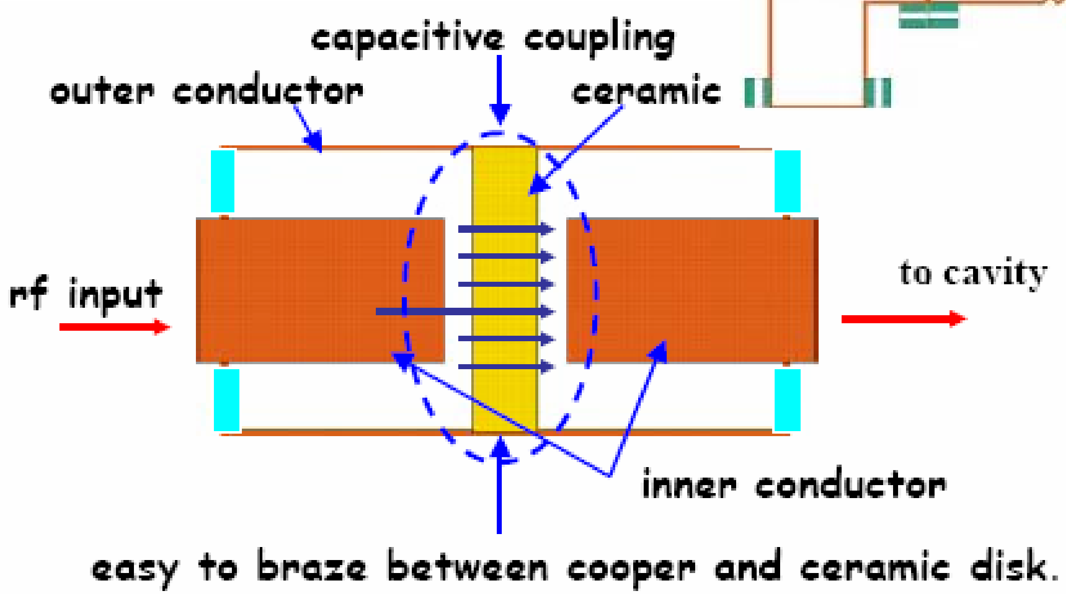
Coupler Test Results

Japanese Coupler

- At least two designs
  - TTF III like but other windows (Noguchi et al.)
  - Capacitive coupling through a ceramic (Kazakov, Matsumoto)
  - Bias to suppress Multipacting?







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Tuner

- Two options are available
  - Lateral (CEA Saclay)
    - Similar to the SLS or Ellettra design
    - Open question: Do the cavity distances allow usage?
  - Coaxial (INFN, (DESY))
    - Used for Superstructure test
    - Open question: Magnetic shielding is slightly more difficult
  - Both new designs feature the integration of a fast element for Lorentz-Force compensation
- In Japan additional tuner designs are underway
  - Coaxial left/right turning screws
  - Motor placed for easy access or even outside
    - Cost issue?
- Either tuner can fit the module
  - Not a really critical decission
  - Cavity spacing plays a role on decision

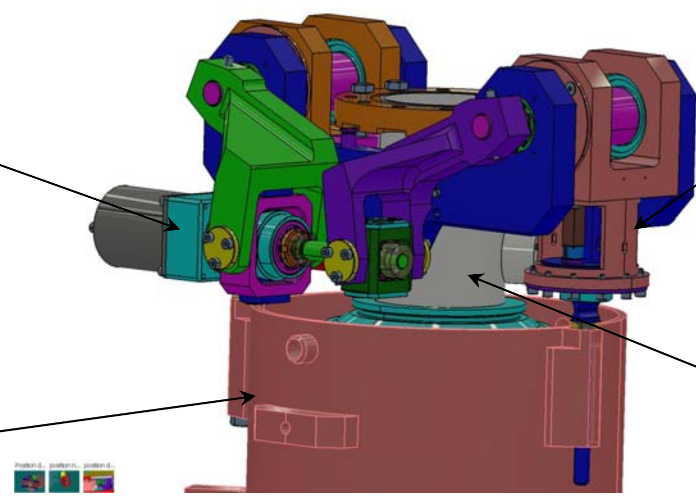
Piézo Tuning System - PTS

P. Bosland

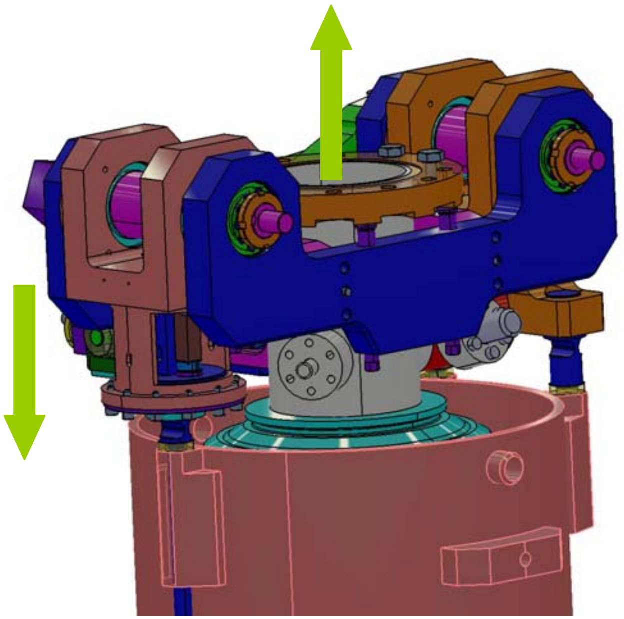
Principle of the Super-3HC tuner with 3 fixations on the TTF helium tank

Full tuning range: ± 460 kHz

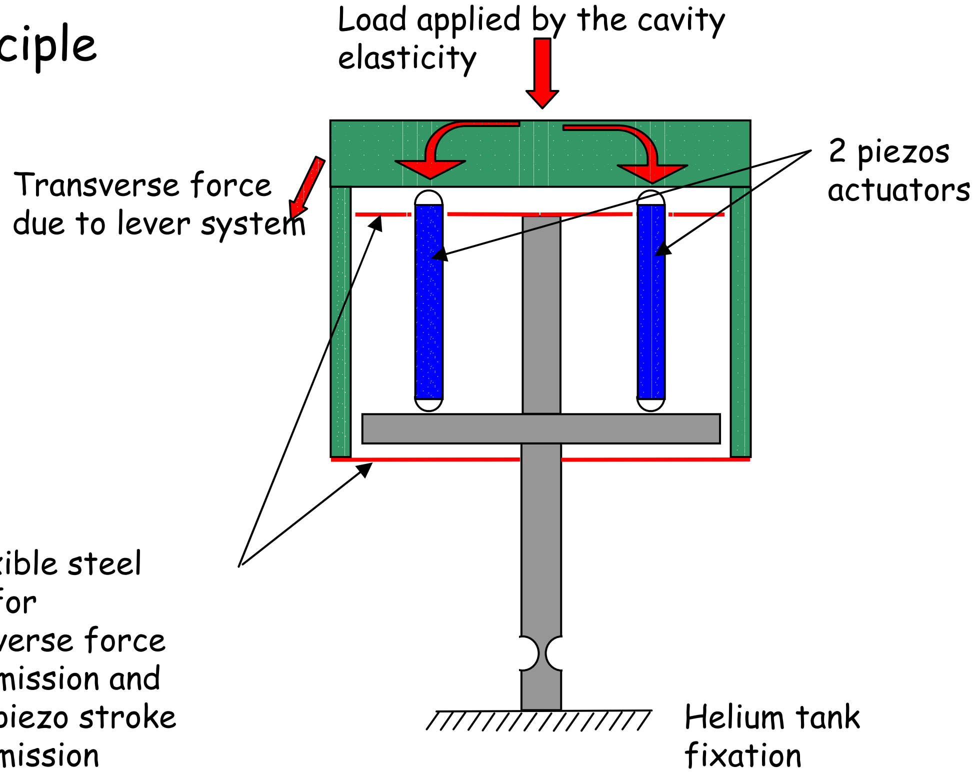
Resolution ~ present TTF tuner (~ 4 nm)

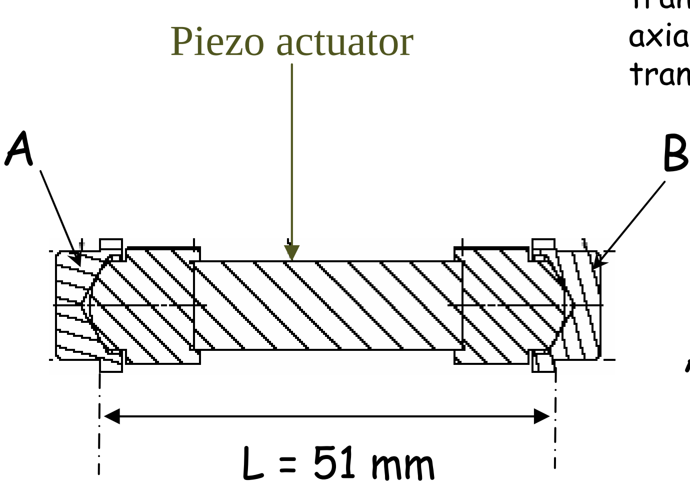


The cavity is stretched



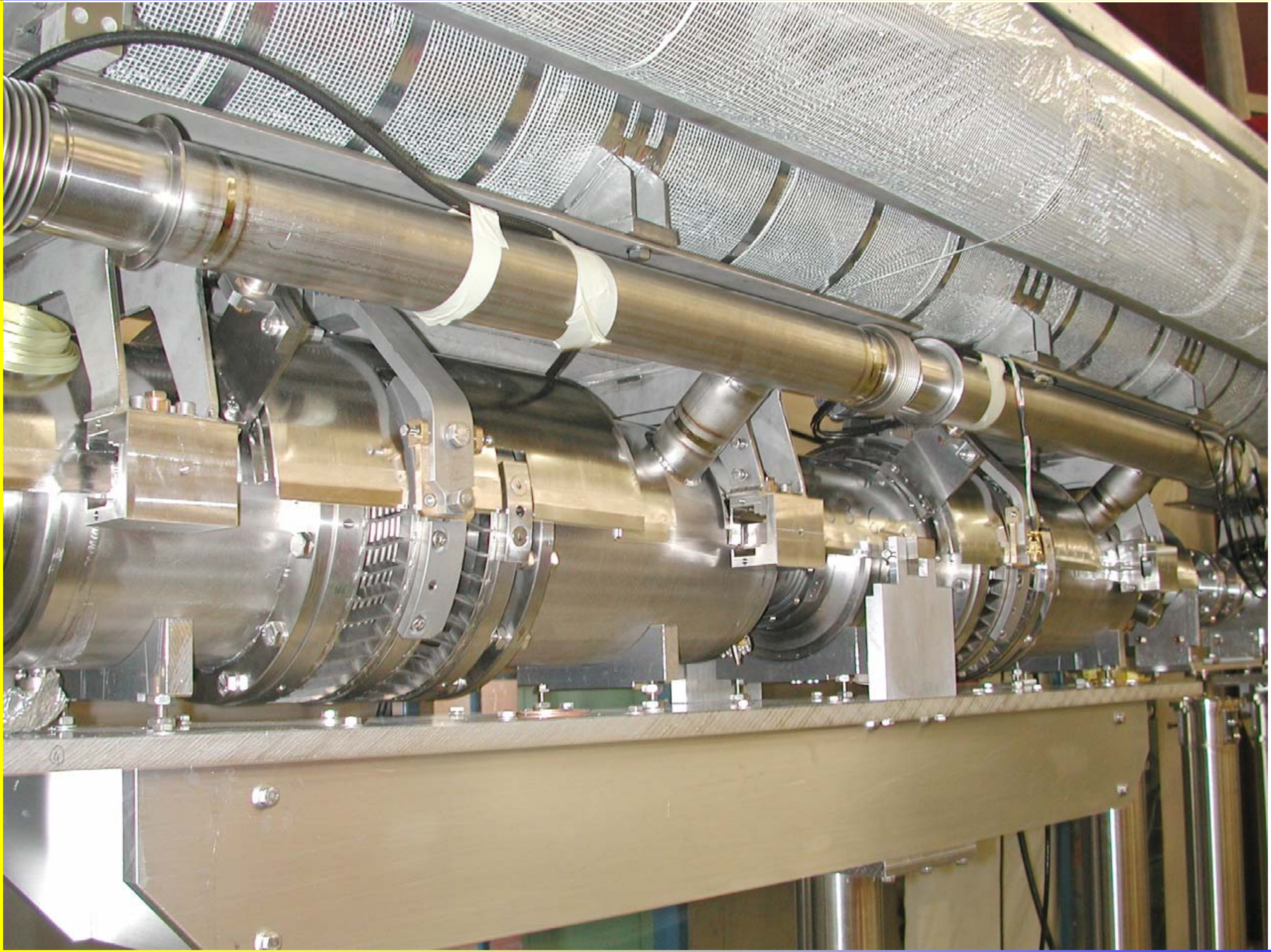
Piezo support is compressed by the cavity elasticity piezo support principle





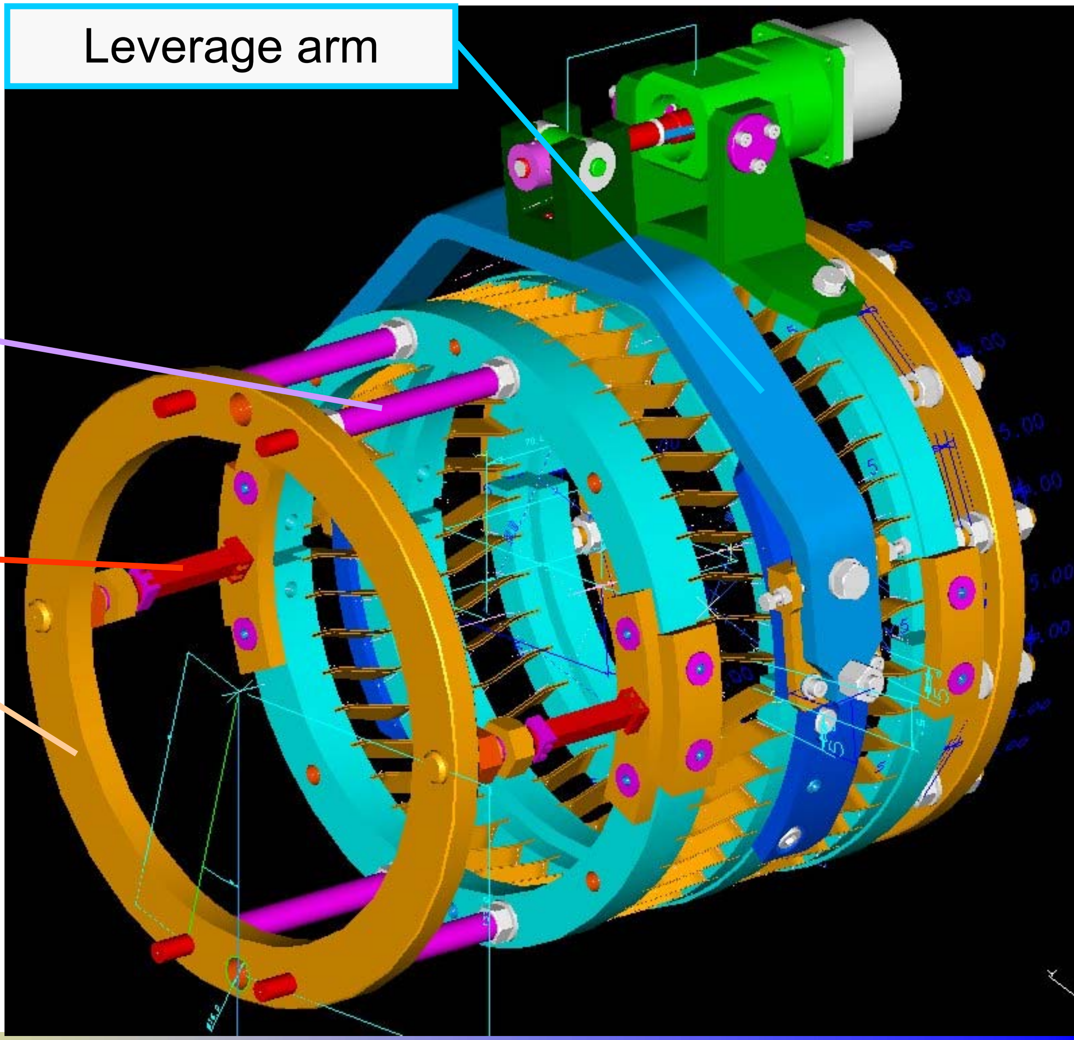
A and B pieces have to be machined in order to adjust the length L for the 2 piezos

SS Tuner under installation



Tuner with piezo: last version

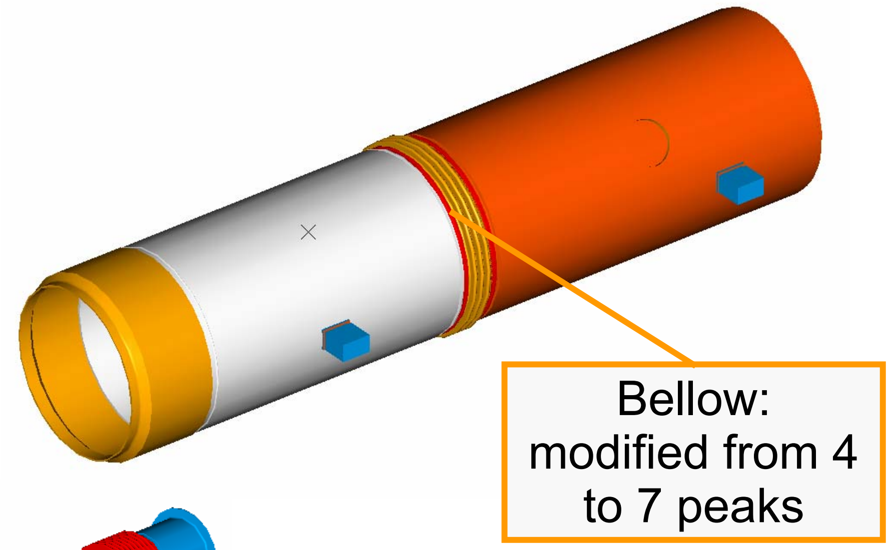
- we plan to have a test of the integrated system before end of the year
  - Requirements
    - Maximum of 2 mm slow tuner action

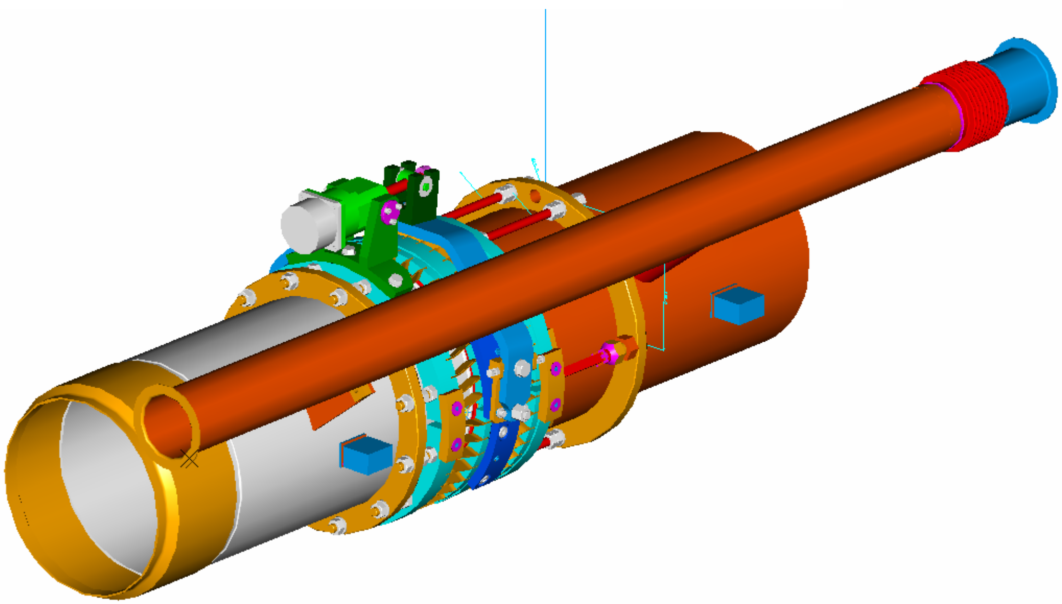


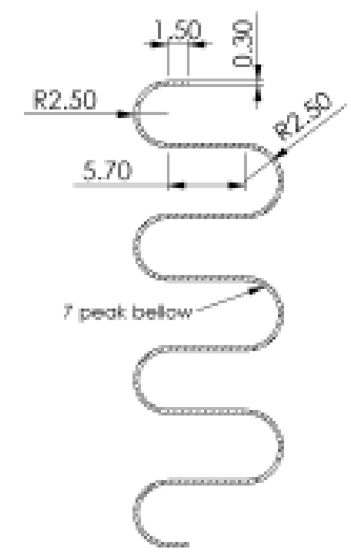
  - Need modifications to standard He tank

Revised He Tank

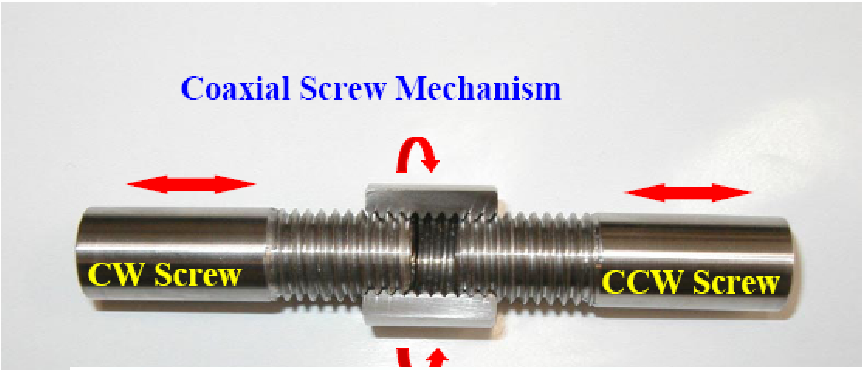
- Now the He tank needs to be split in two parts, with a bellow in between to allow the cavity elongation
- Magnetic shield assembly should probably be modified

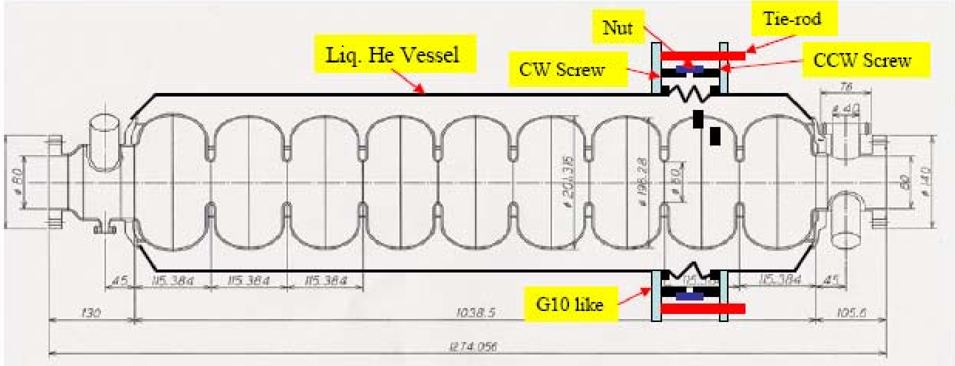


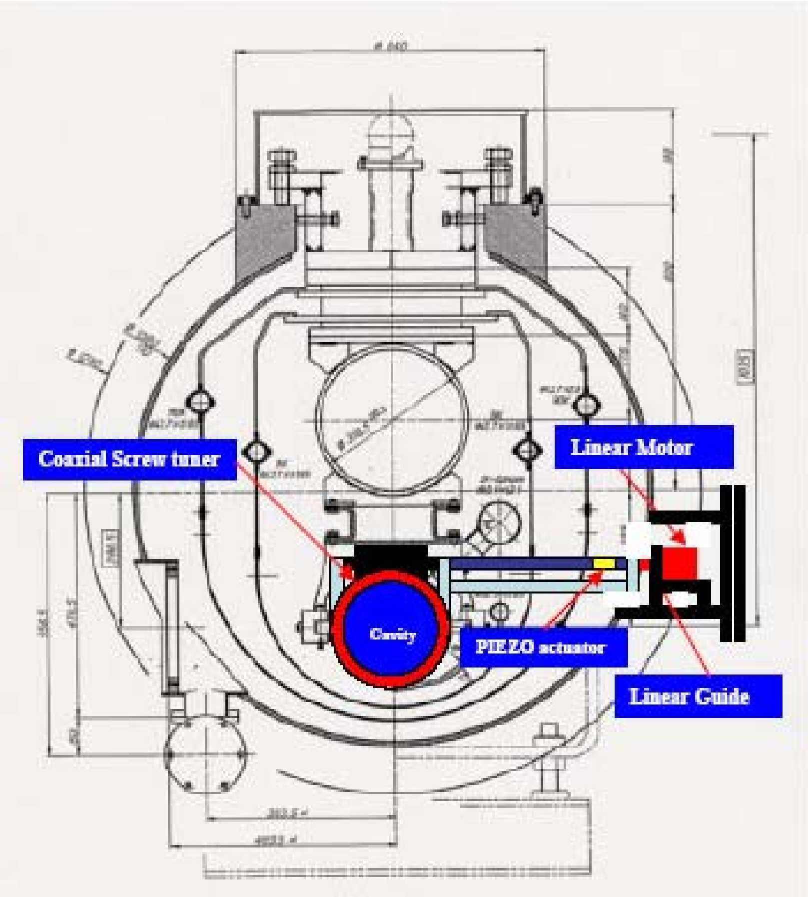




Tuner conceptual design by Y.Higashi







Dia of screw : 350 mm

Screw pitch : 2 mm working on squeezing and stretching

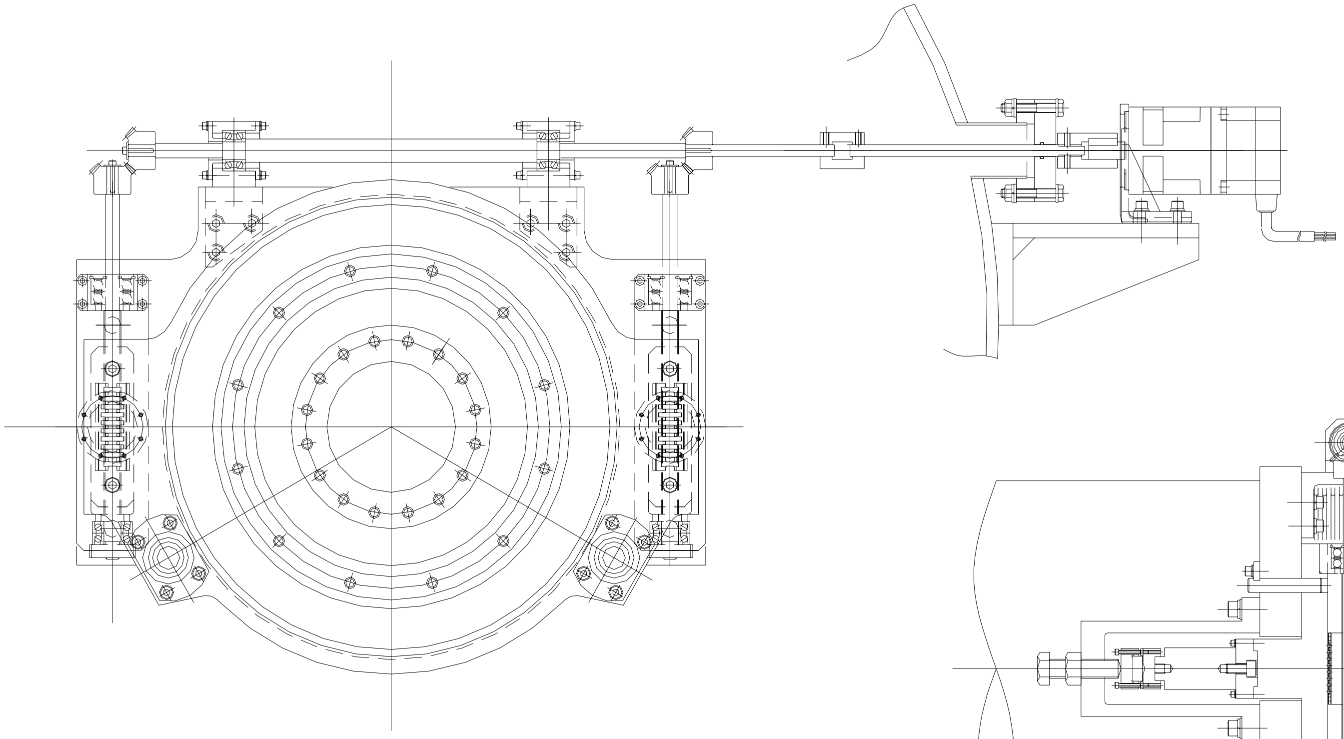
1 rev. : 4 mm

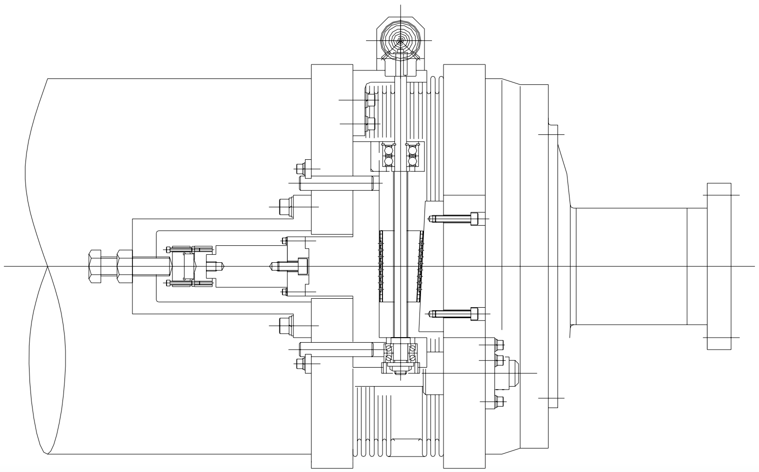
Minimum rotation (9μm) : 2.5×10^{-3}rad (0.5 mm)

Maximum rotation (1mm) : ($\pi/2$ rad.)

Maximum rotational force : 730Kgf/274 = 2.7 Kgf

Synchronous Tuner on Jacket

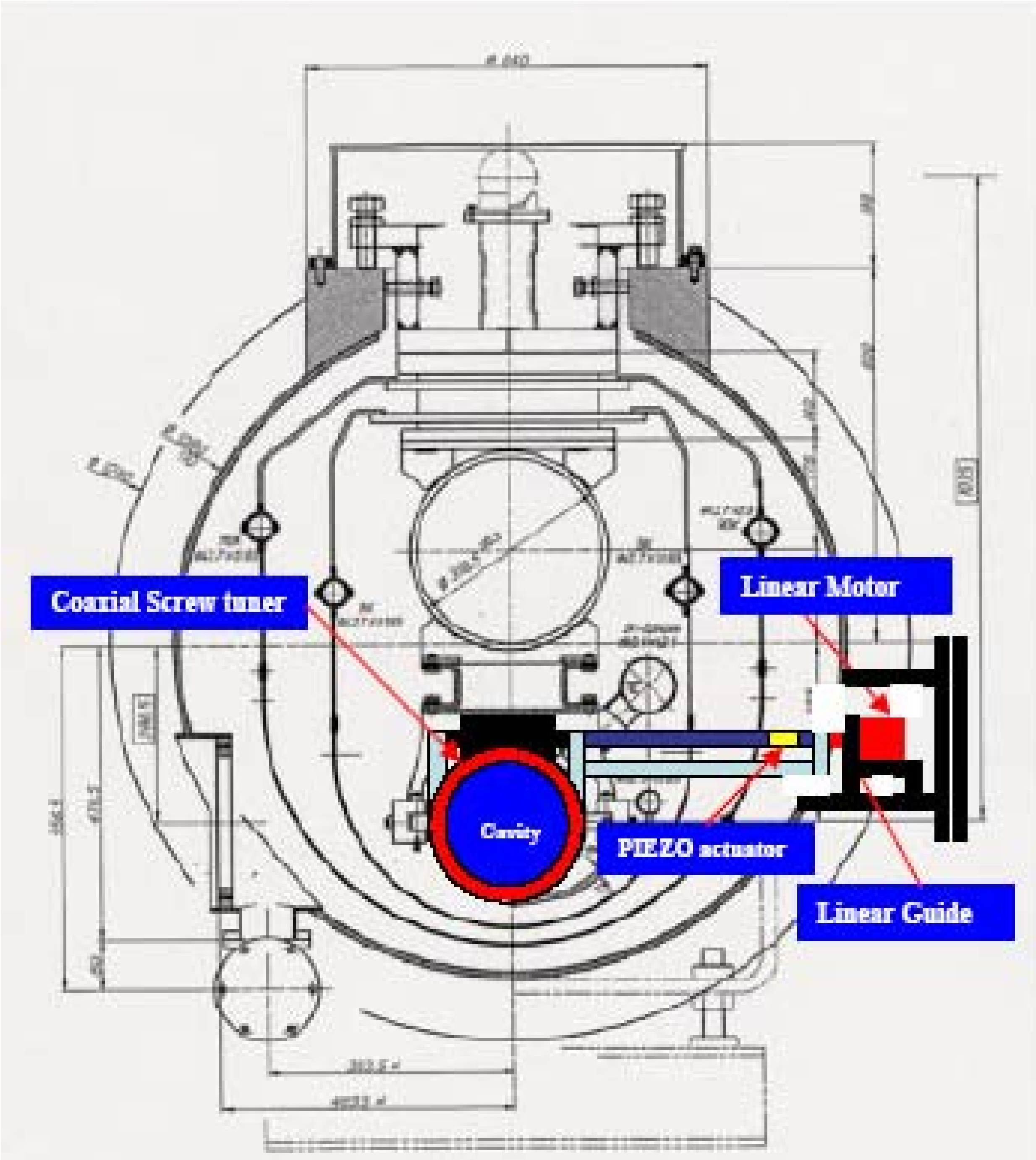




Accelerator Modules
XFEL and ILC modules

- Cross section likely to be the same
  - Standard diameter piping is desirable
    - Which standard? (DIN, Japan, US….)
  - Cavity position will be kept nearly fixed with the help of an invar rod
- Transport issues needs to be solved
  - Safety fixtures need work
- Technical improvements from TTF for XFEL known to day
  - Quad package supported like cavities (sliding fixtures)
- XFEL ≠ ILC for a few cases only
  - Cavity spacing
    - XFEL: N times lambda distances needed
      - Minor change on TTF cryostat
    - ILC: As compact as possible
      - Cavity design / position not fixed yet
  - 12 m ≠ 17 m

Japanese Module layout



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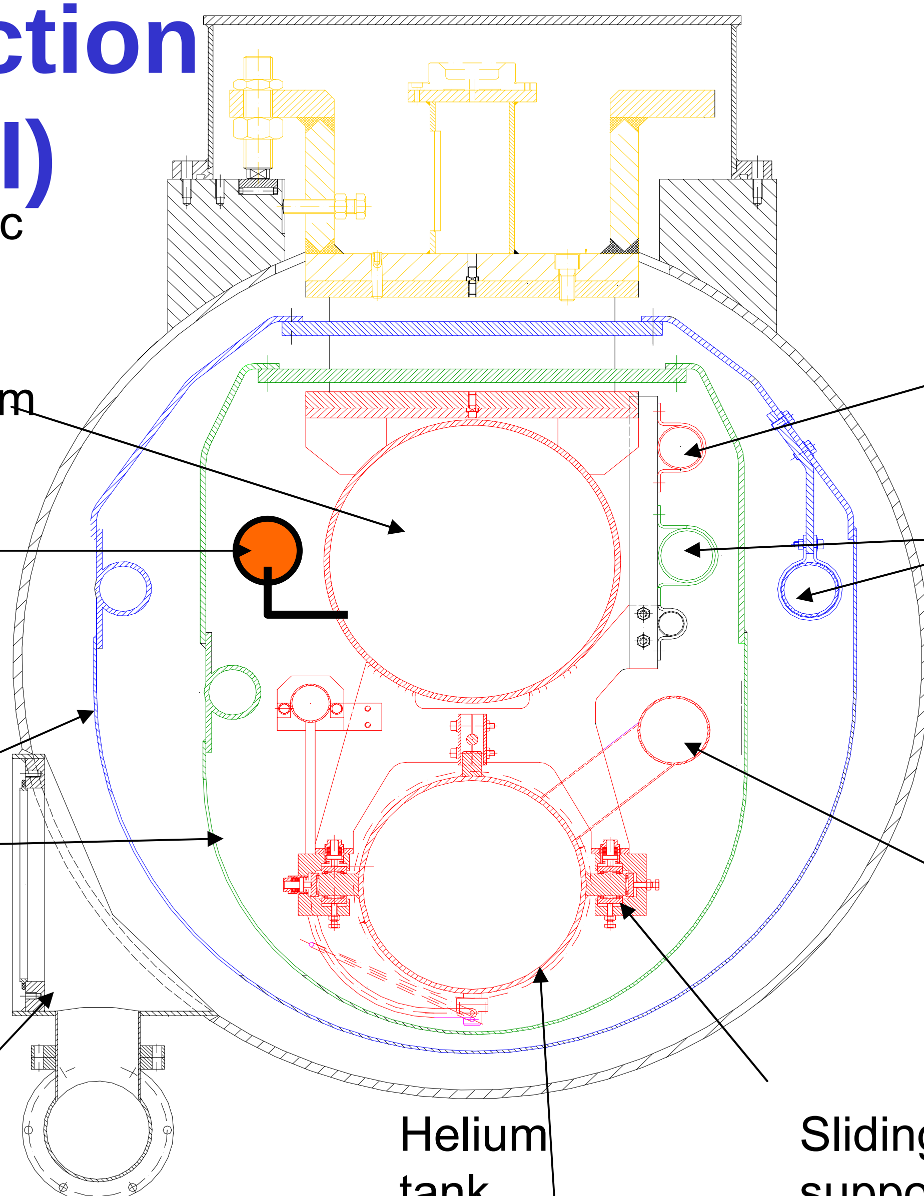
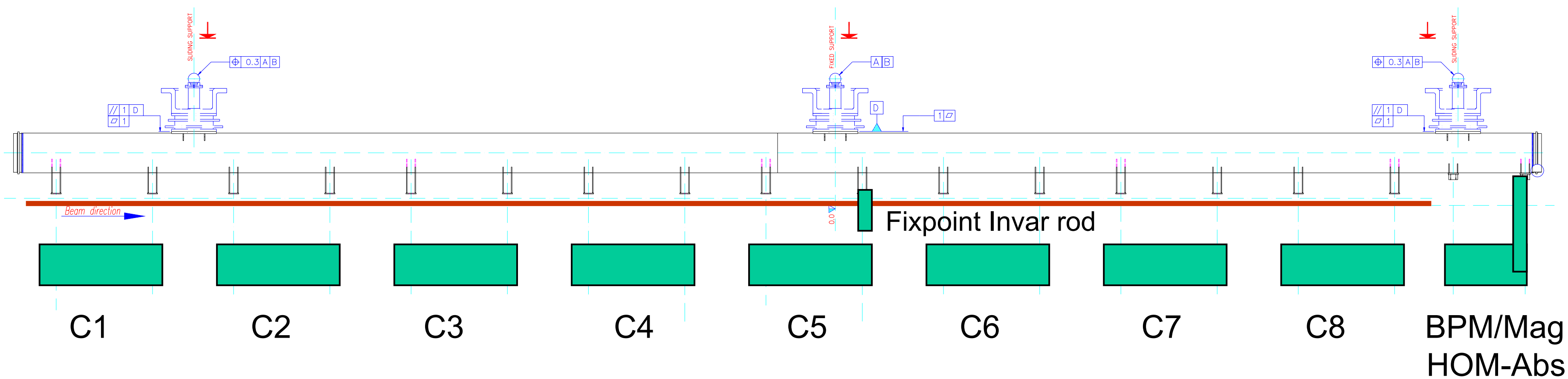
Cross section (TTF III)



Helium GRP/Posts

logitudinal movement posts during cool down <u>module type TTF III</u>

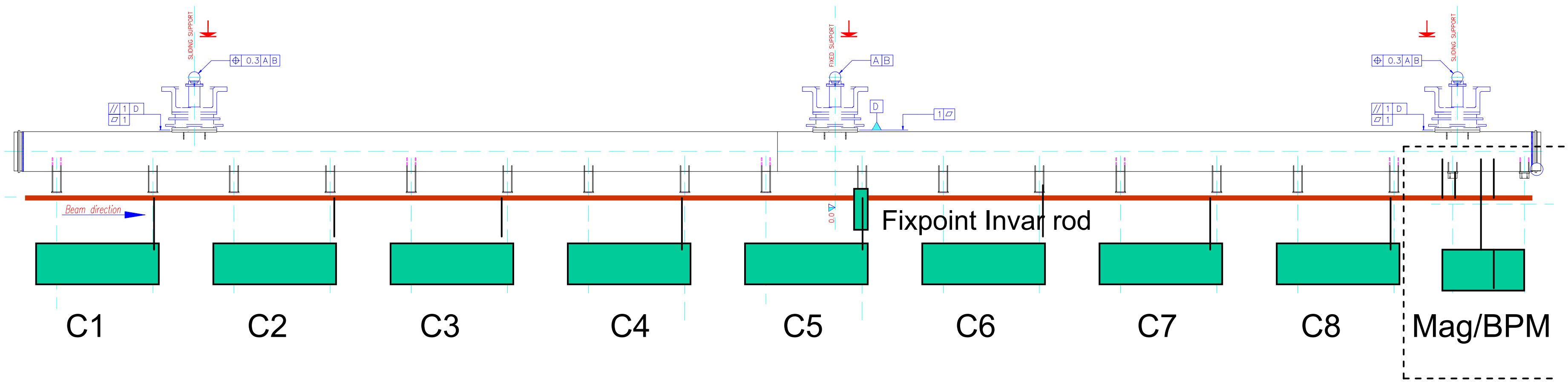
-->sliding fixed ←sliding



Helium GRP/Posts

longitudinal movement posts during cool down **<u>module type TTF III plus (XFEL)</u>**

-->sliding fixed ←sliding



HOM-Absorber

Between Modules

Cavity supports principle

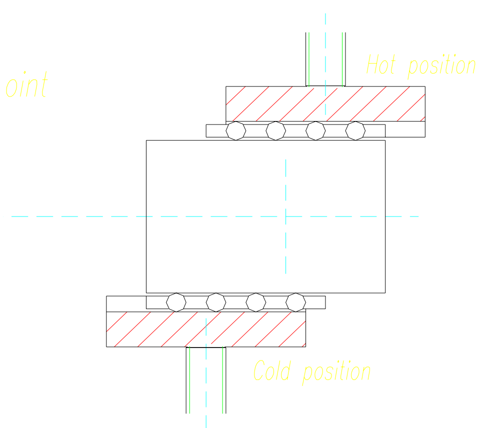
• Four C-shaped stainless steel elements clamp a titanium pad welded to the helium tank.

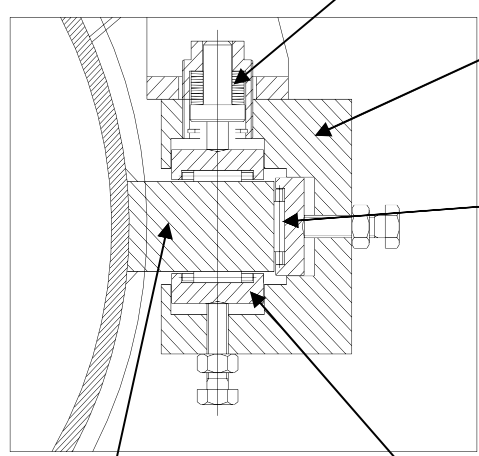
• Rolling needles reduce drastically the longitudinal friction

• Cavities are independent from the elongation and contraction of the HeGRP.

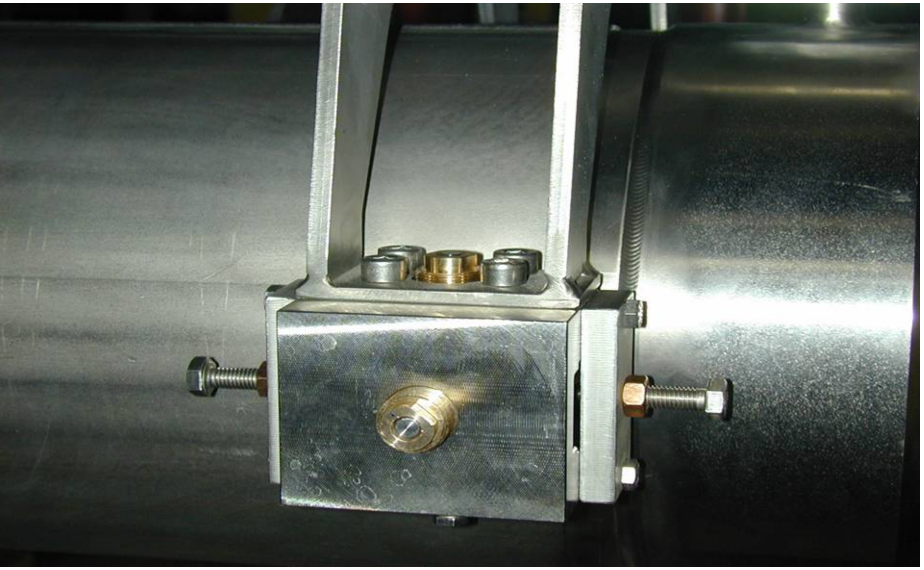
• Lateral and vertical position are defined by reference screws

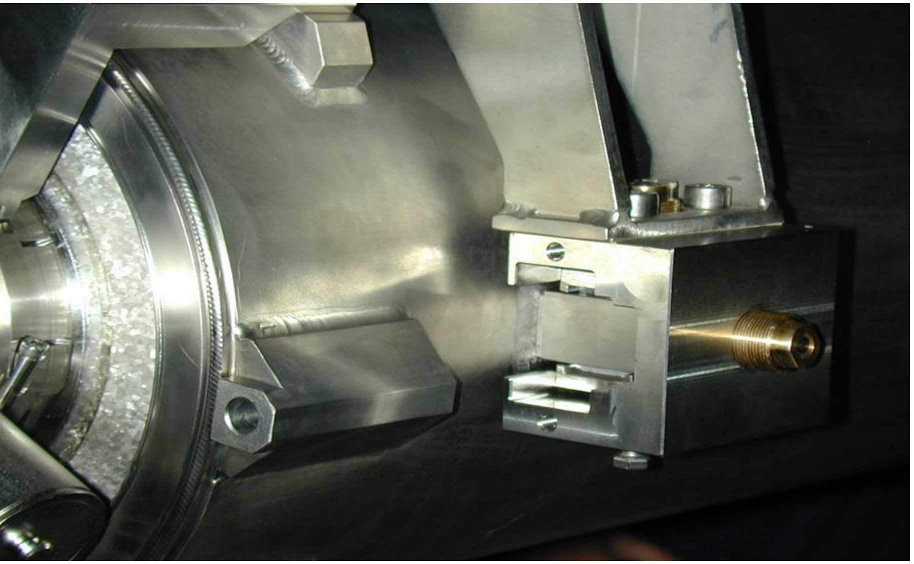
• Longitudinal position can be fixed by the use of an Invar rod

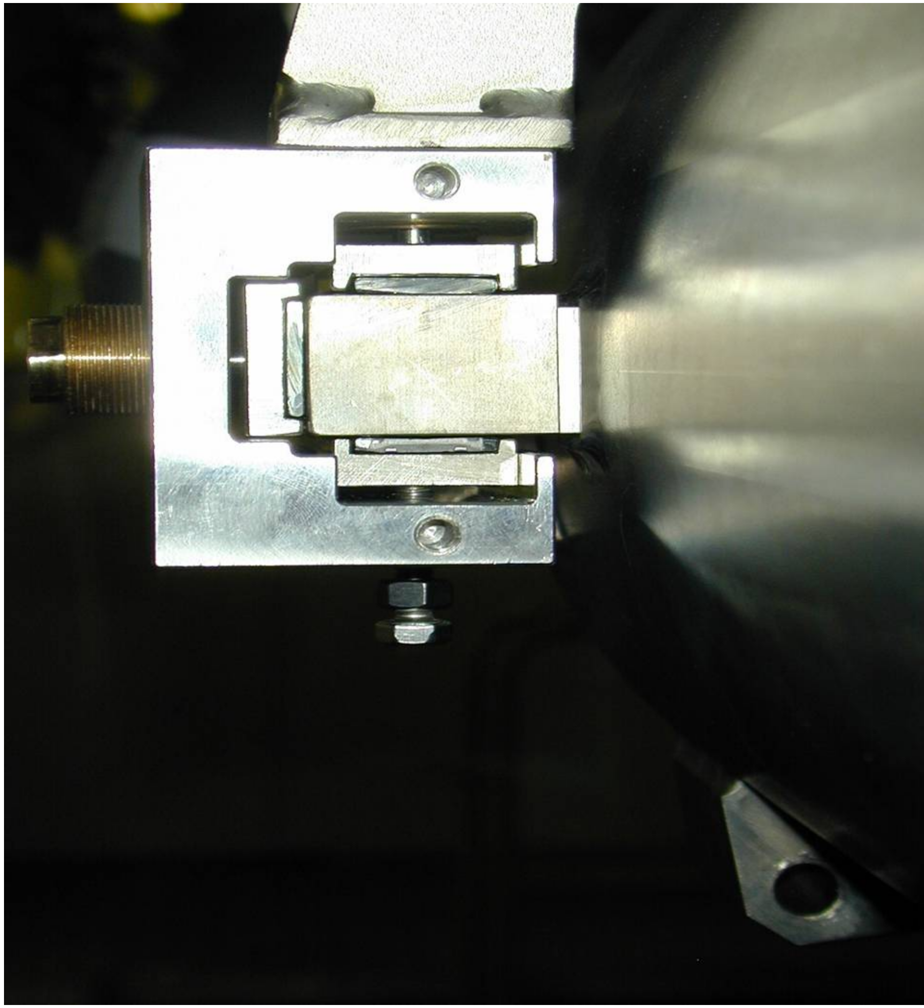




Cavity supports pictures







Cryomodule Design Choice

- TTF III as baseline ?
  - Layout for TTF III is very old 1999
  - What need to be fixed soon
    - Is the average spacing of klystrons
    - 12 cavities might be too many
    - Detailed layout might come later
  - Quality control on assembly is a major issue
  - Need some discussion on detailed module layout

Cryomodules: European Assets

- Module test stand (EUROFEL)
- Work on Module 6 (35 MV/m)
  - EP system investigations
- XFEL Module development
- Industrialization
  - Main path
    - Studies with industry on
      - » Assembly of accelerator modules
      - » Coupler fabrication (LAL)
      - » Tuner fabrication (CEA – under discussion)
  - There will be an update TDR (incl. Cost) this year (DESY)

Agenda SRF WG

- Arts Building Tuesday 8:30
- Intro to WG SRF – L. Lilje
- ILC Europe Assets – D. Proch
- Topical talks
  - ‘In-Situ’ baking for SRF cavities – B. Visentin
  - Electropolishing Issues – C. Antoine
  - Accelerator Modules – C. Pagani
  - Couplers for ILC – A. Variola
  - Tuners for the ILC – C. Pagani
  - BPM designs – O. Napoly?
  - Crab Cavities in the BDS – G. Burt
  - …
- Discussion round
  - Development of a WBS for the Accelerator modules
  - Finalising the list of European Assets

Thanks for your attention!