# XFEL Module

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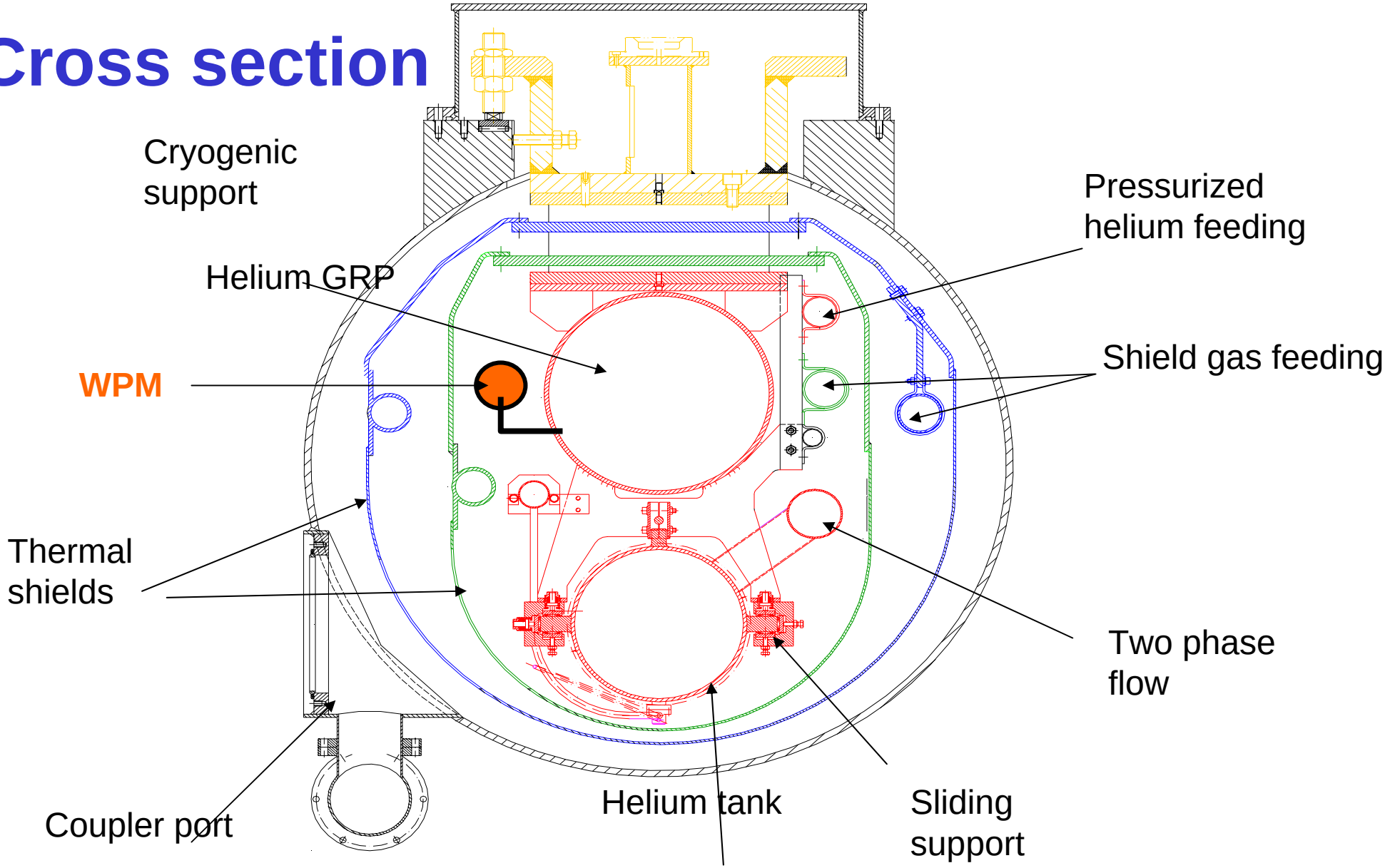
# Overview

- Summarize the technical changes which are going to be implemented for the next cryomodules:
  - Length
  - Layout
  - Magnet, BPM, HOM package
  - …



# Cross section



# Layout for shield cooling

- The main dynamic load are the input couplers.
  - In the existing pipe layout (50 mm inner diameter) their load would result in a high pressure drop on the 40/80K cooling line.
  - Therefore it is desirable to increase the inner diameter of the tubes to DN 65 (71 mm).
  - This will be also done for the 4/8K shield tubing.



# Module Length TTF-Type 3 and XFEL Modules

- **Lamda: 230,6 mm**
  - **module length: n x lambda/2**
  - **n x module length within a few millimeters (linac installation!!)**

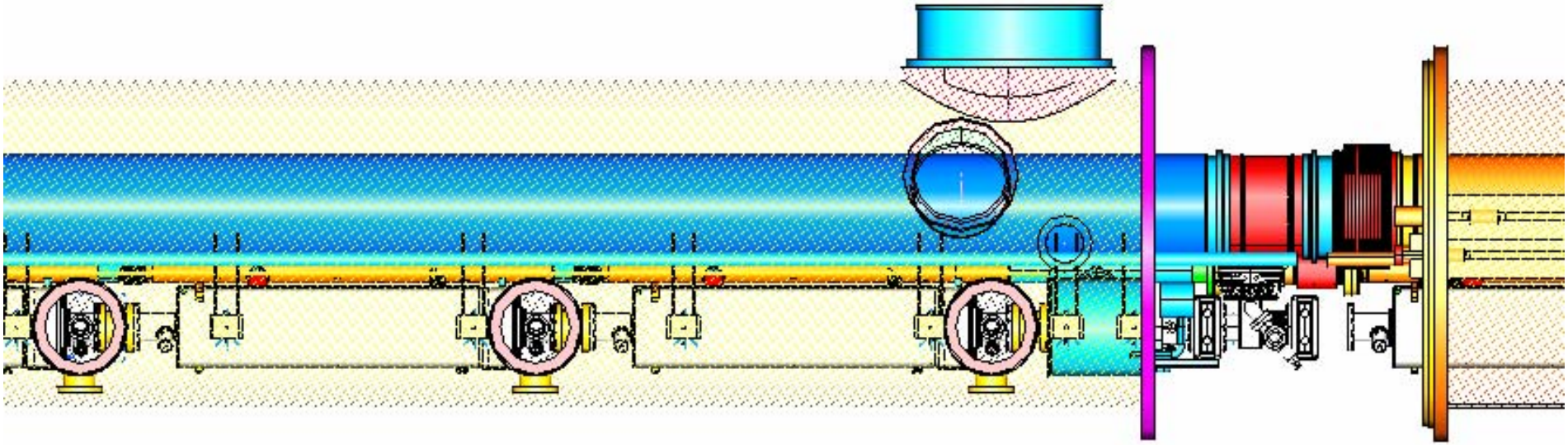
- **TTF type 3** **12 200 mm, but 53 x lambda = 12 221,8 mm**
  **➔ TTF type 3 is to short by 21,8 mm**

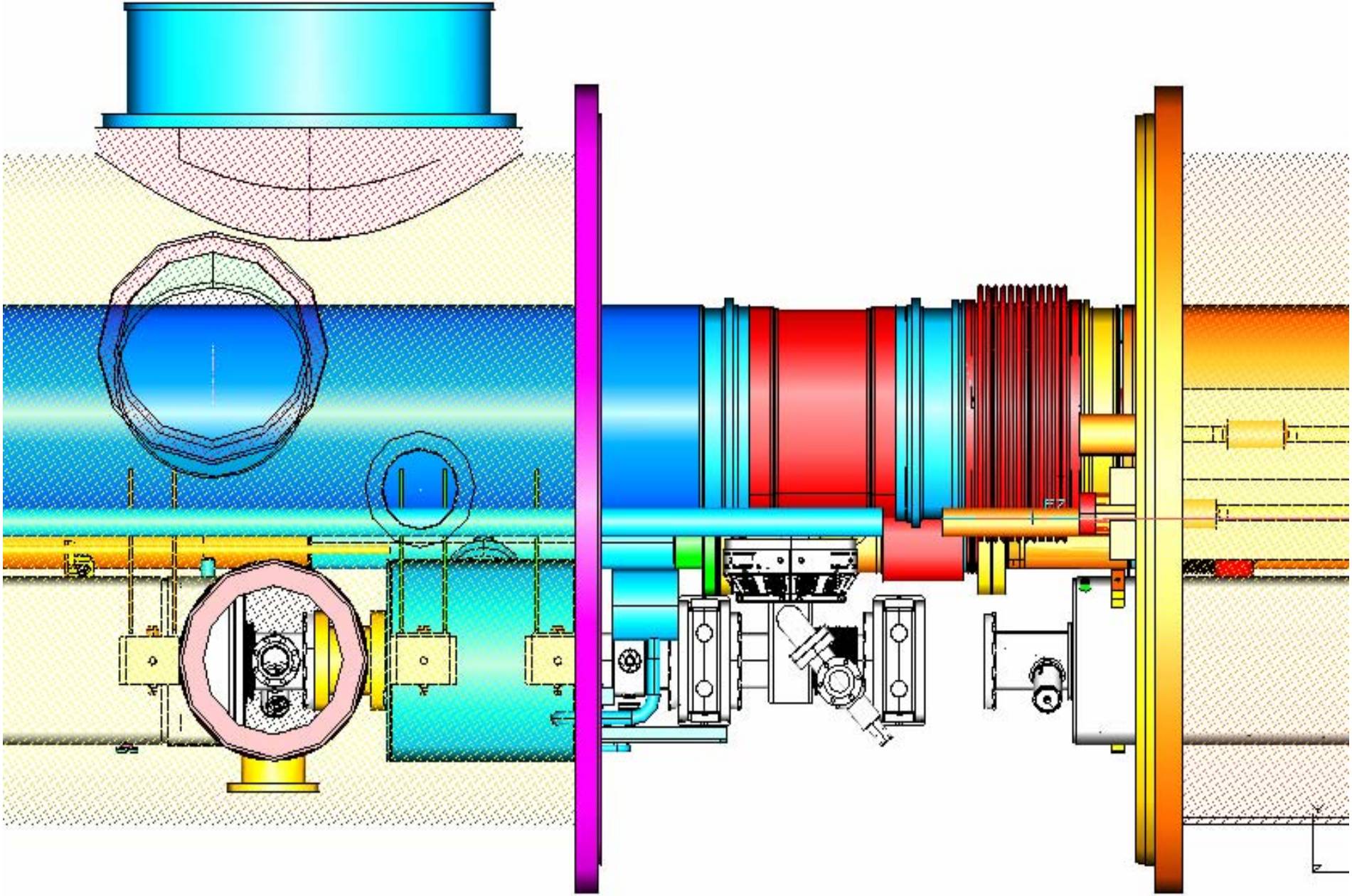
- **XFEL type** **Goal: Shorten module length by 230,6 mm**
  **➔ depends on space needed for magnet, BPM and HOM-absorber (detailed design underway)**

# Module length

- Module length fixed to
  - **$L_{XFEL\ module} = 52\ \lambda = 11991.2$ mm**
    - $L = n/2\ \lambda$
    - $\lambda = 0.2306$ m (= 299792458 /1300000000)
  - Length reduced by about one wavelength as compared to TTF
- Magnet package
  - 300 mm
  - Comment:
    - this needs confirmation with field calculations
    - Crosscheck saturation (steering coils)
- BPM
  - 170 mm
- HOM absorber
  - 216 mm
  - Detailed thermal calculations for potential cw operation to be presented
- Reserve is about 70 mm
  - Might be used partially for modifications of the magnet package
- Drawing available







# Differences for Magnet / BPM longitudinal movement

- **Because:**
  - **XFEL magnet will be cooled at 2K (like the cavities)**
  - **XFEL magnet vessel will be made of Titanium**
  - **And most important:**
    - **XFEL magnet/BPM will be supported like cavities!!!**
    - **This means, longitudinal movement will be reduced drastically.**

- **Rough comparison for longitudinal movements at the end of the of beam line in direction module center:**
  - **TTF type 3 ~17 mm**
  - **XFEL type ~ 4 mm**

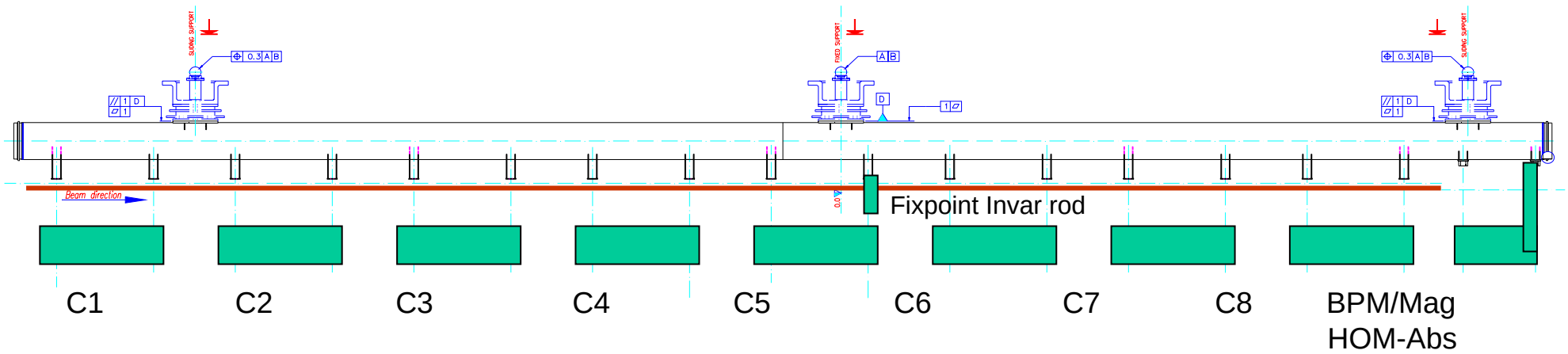
- **➔Impact for beam line bellows…**



# Helium GRP/Posts

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

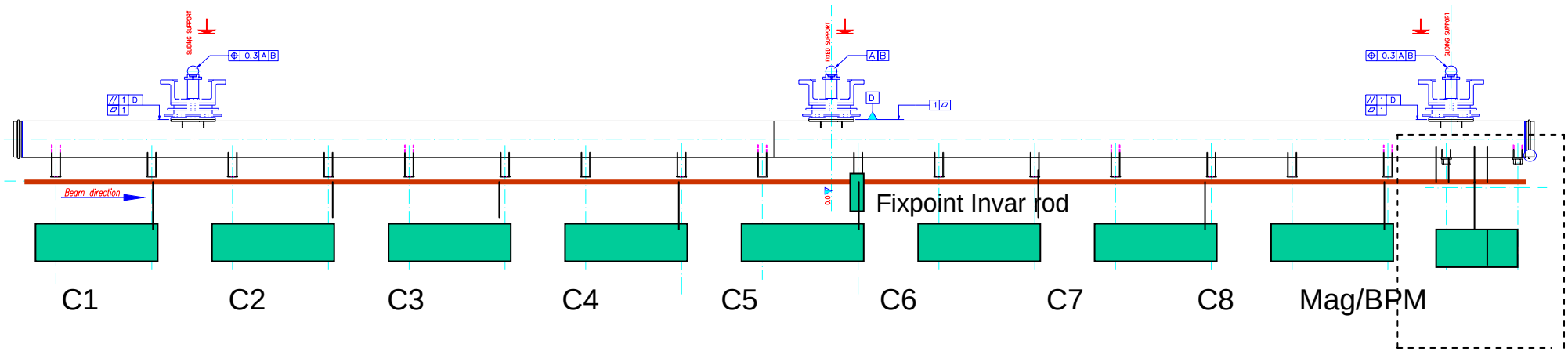
-->sliding fixed ←sliding



# Helium GRP/Posts

**longitudinal movement posts during cool down** **module type TTF III plus (XFEL)**

-->sliding fixed ←sliding

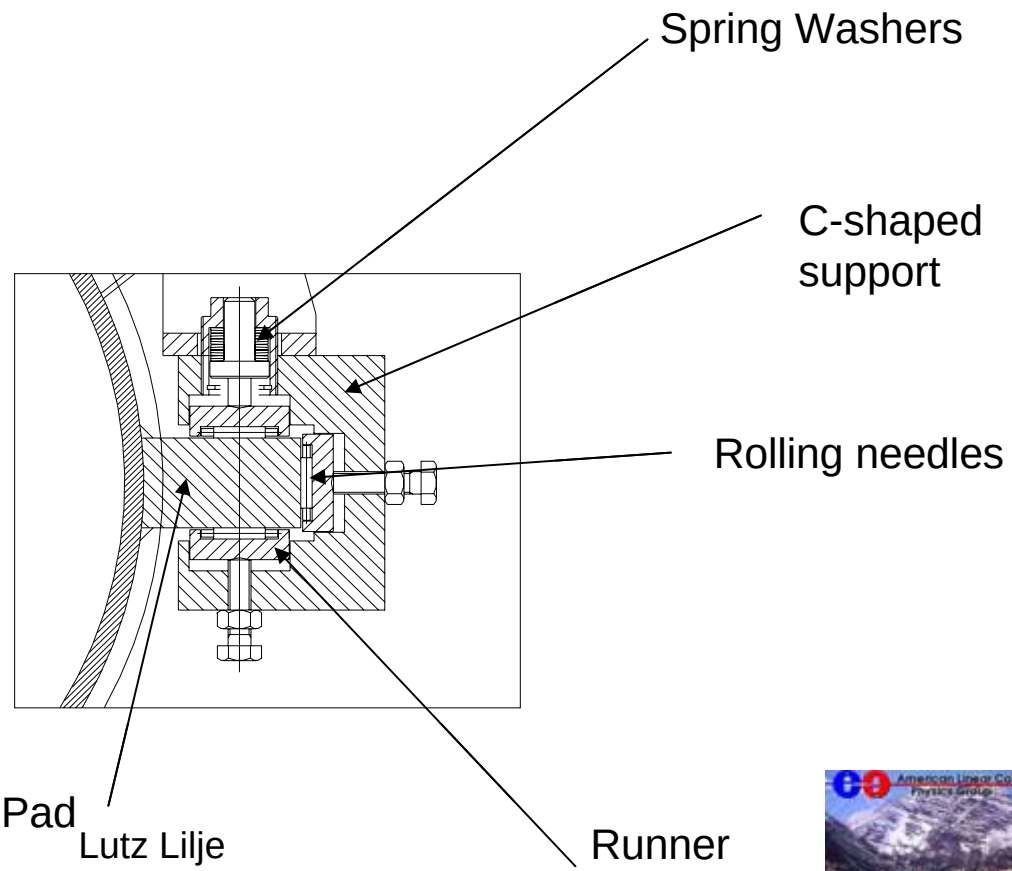


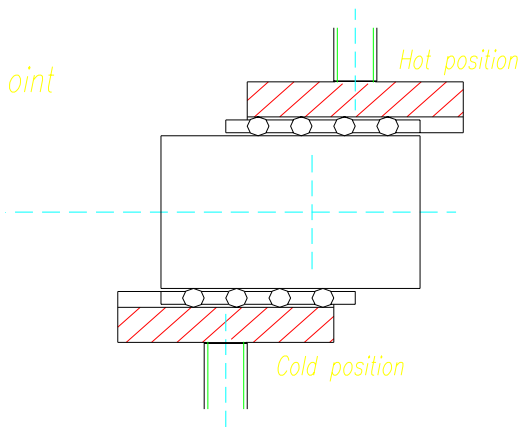

HOM-Absorber

Between Modules

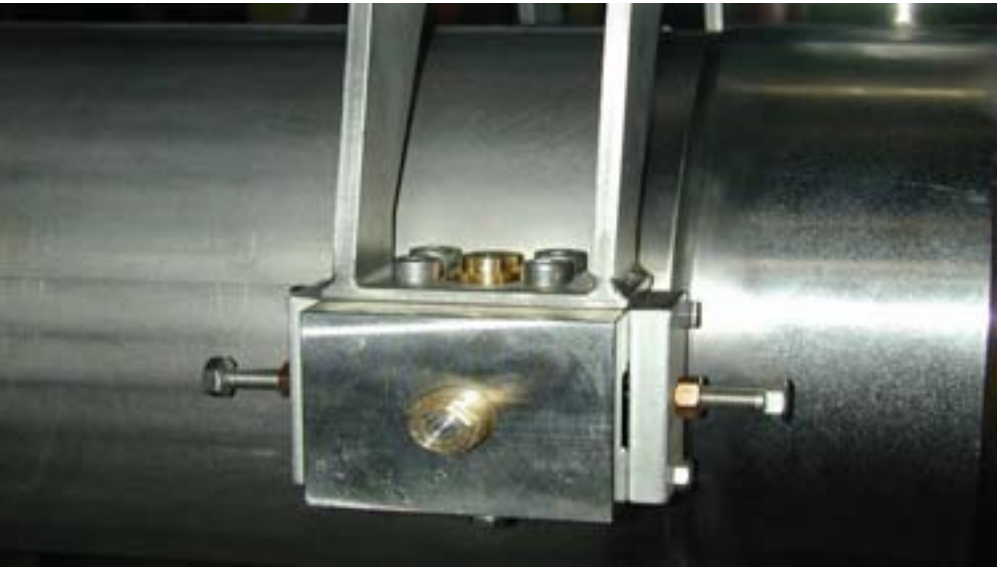
# Cavity supports principle

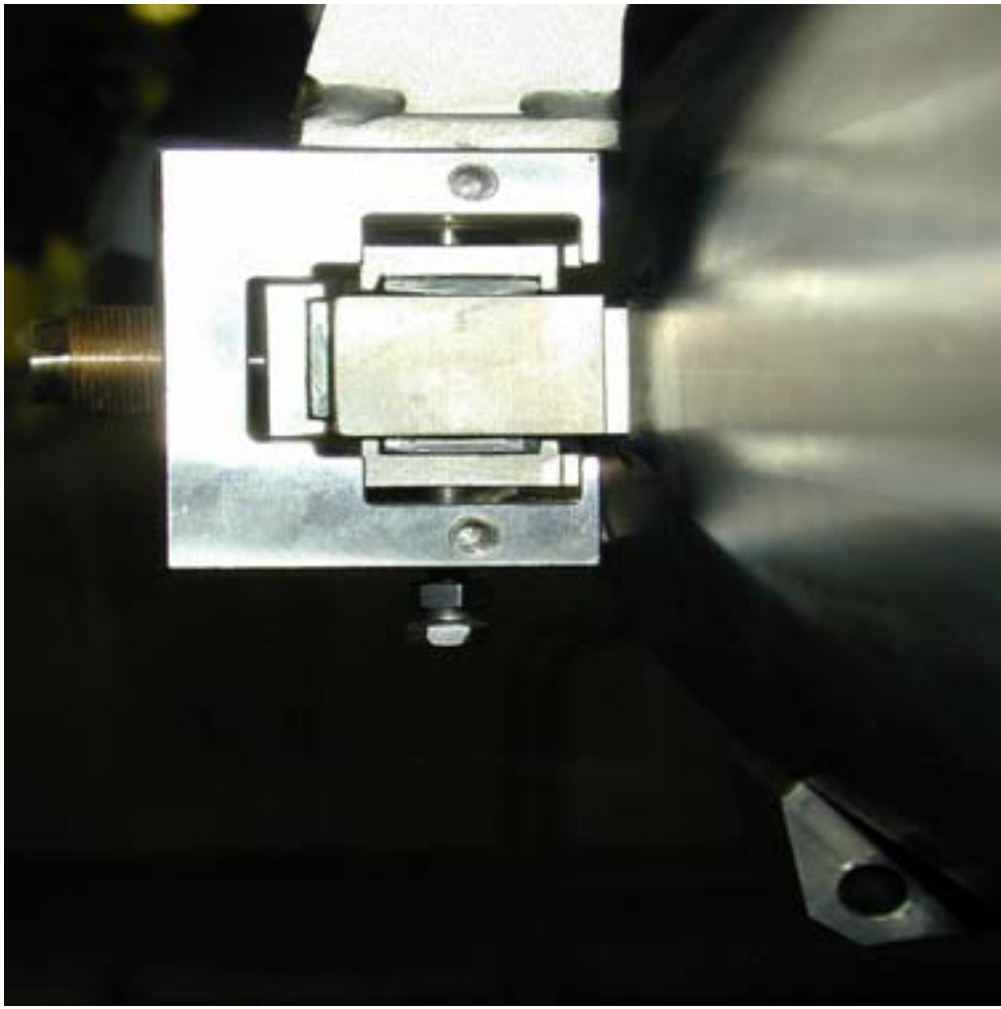
- Four C-shaped stainless steel elements clamp a titanium pad welded to the helium tank.
- Rolling needles reduce drastically the longitudinal friction
- Cavities are independent from the elongation and contraction of the HeGRP.
- Lateral and vertical position are defined by reference screws
- Longitudinal position can be fixed by the use of an Invar rod



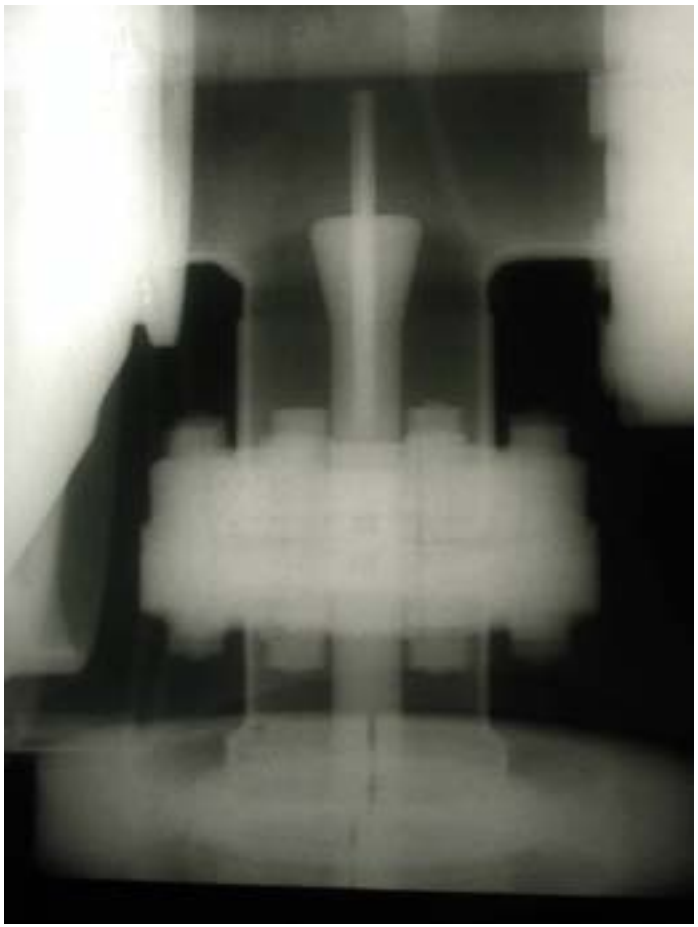
# Cavity supports pictures





# Koppler 2K/300K

2 K



290 K

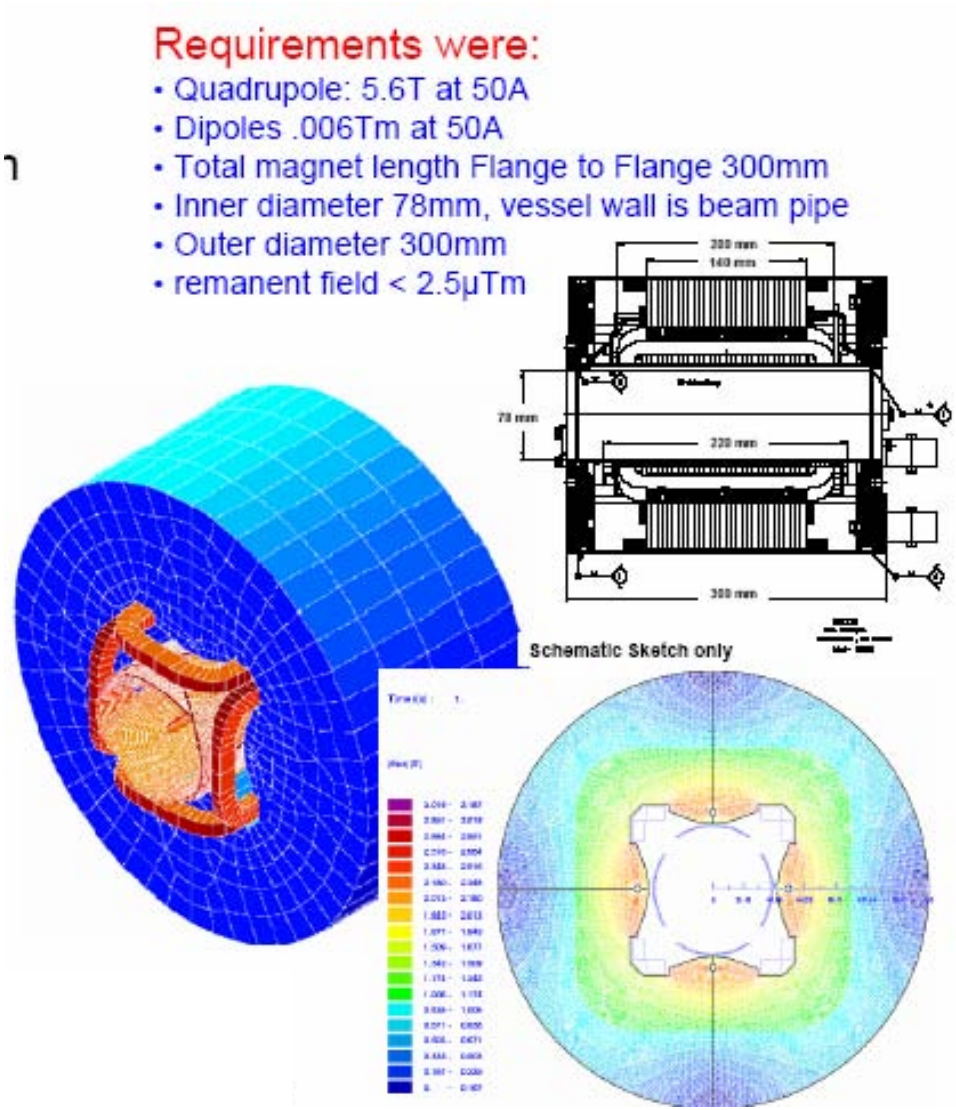
# XFEL magnet

- About a factor of 2 shorter than TTF design
- Operation at 2K
- Titanium vessel
- The magnet should have a cavity-like support.
- Current leads under discussion
- The field calculations for remnant fields and the magnetic field at the neighbouring cavity are not finished yet.
- For the injector, it might be desirable to put the magnets in a separated cryostat (similar to a string connection box) as the magnetic lattice differs from the one in the main linac.

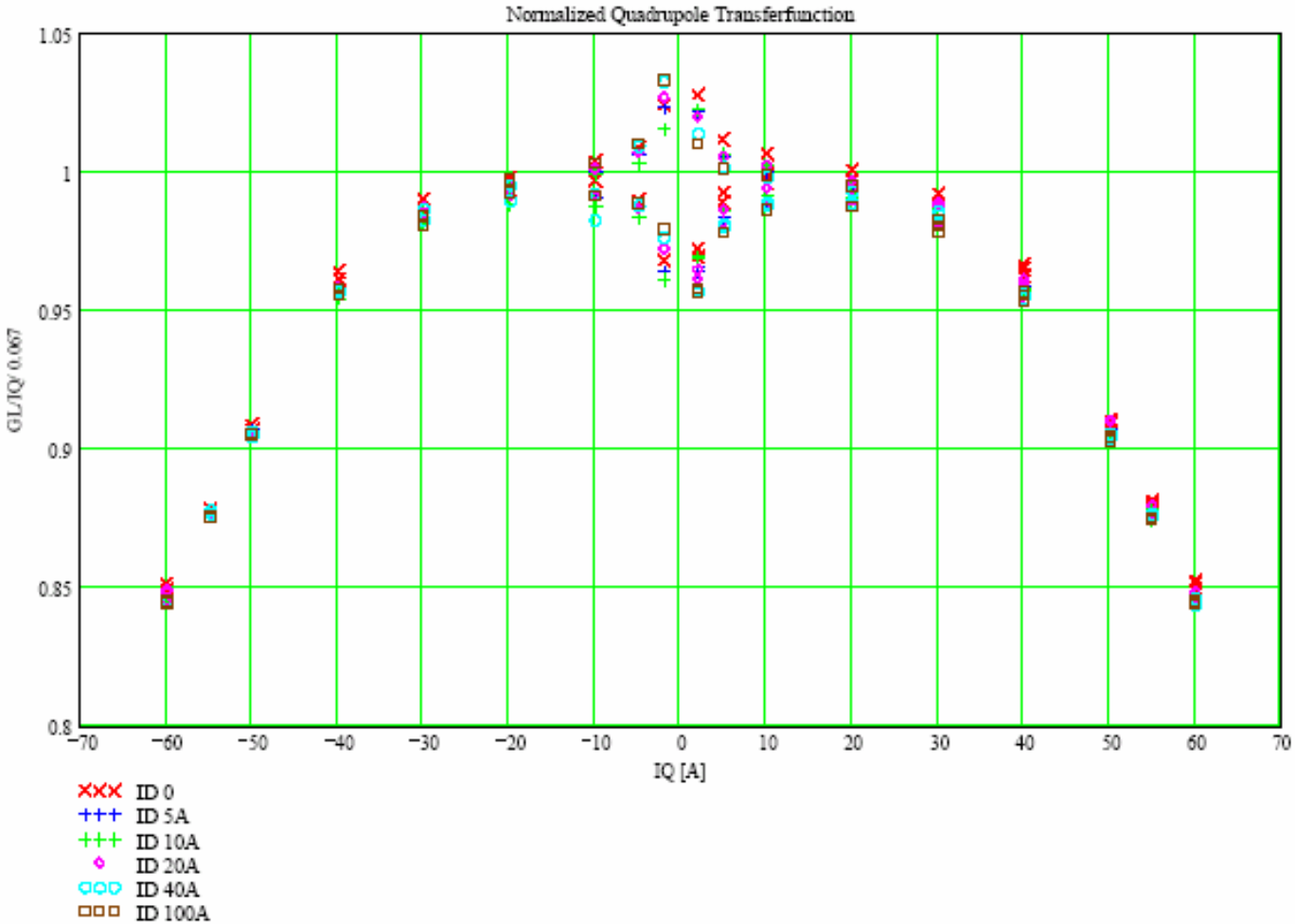


# XFEL Magnet Work is being done by CIEMAT

- Field calculations are still underway
  - Check fields outside the magnet
  - Reemant fields from steerer coils

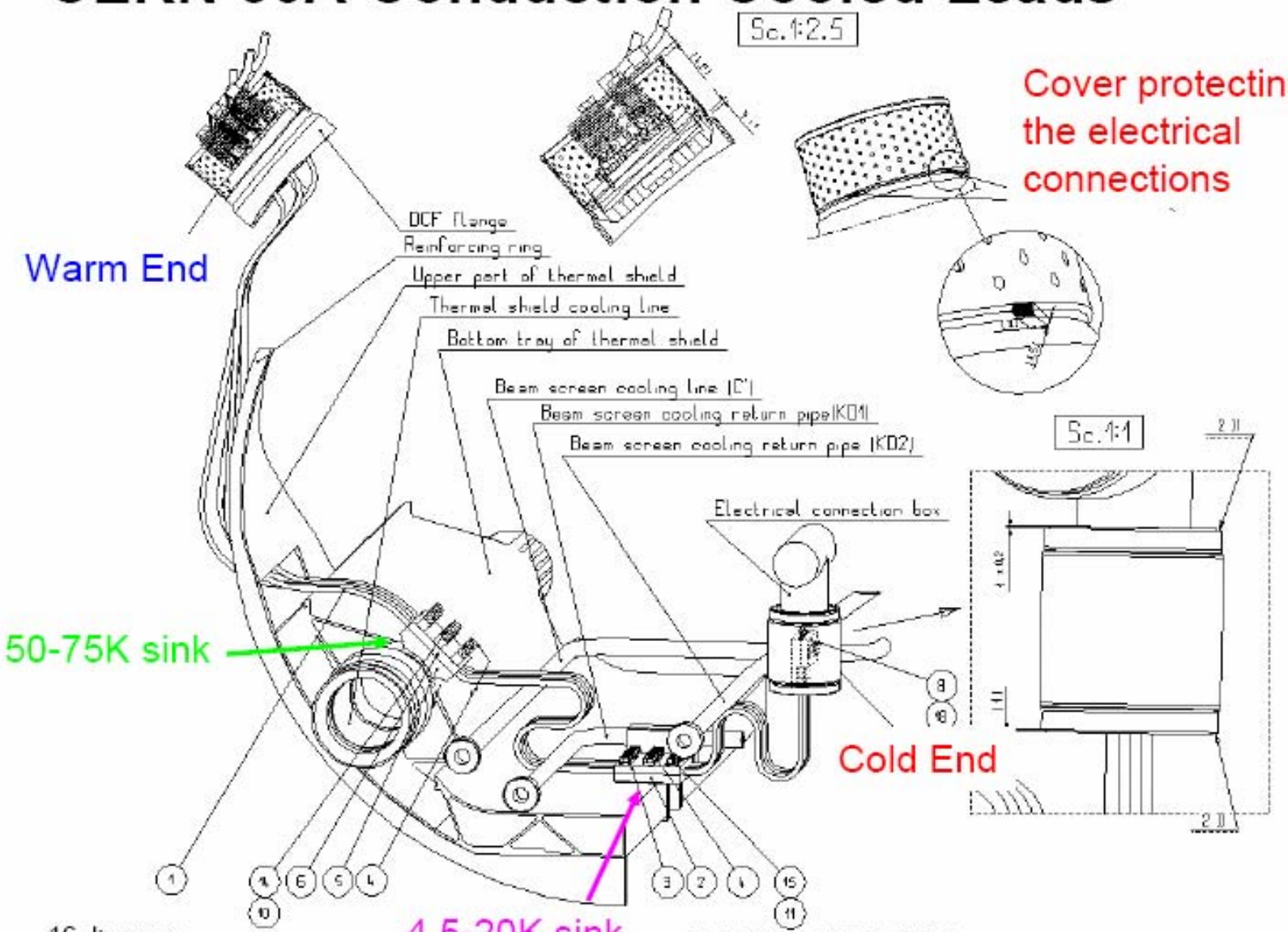


# Integrated Dipole Field (normalized), Quadrupole on various settings




- At high IQ saturation effects from the iron yoke
  - about 15% saturation as calculated
- At low IQ persistent current or remanence effects
  - about ±4%
- Some variation due to the powering of the dipoles
  - about 2% between 0A and 100A

# CERN 60A Conduction Cooled Leads



# Vibration measurements

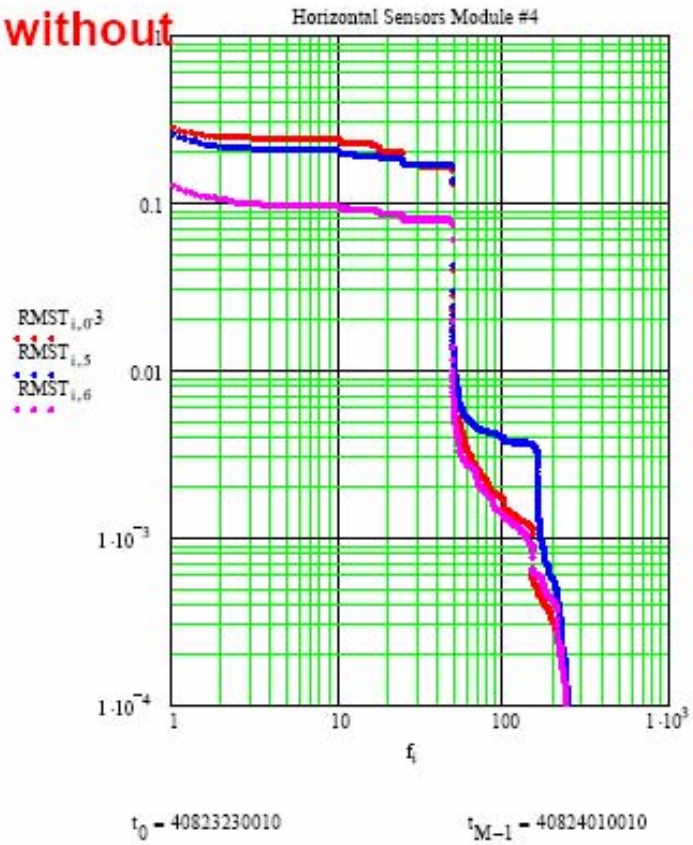
- Accelerometers
- Geophones / Seismic sensors
- Results
  - Experimental setups working
  - Cultural noise can be identified
  - Pumpstands for isolation vacuum identified as a noise source
    - Decoupling of mechanical vibrations tested and achieved
  - Amplitude on quadrupole 2-3 times higher than on the ground
  - Seismic sensors show larger amplitudes
- Experiments need to be continued on TTF
- Module test stand or TTF
  - Excite mechanical modes with an external vibration source



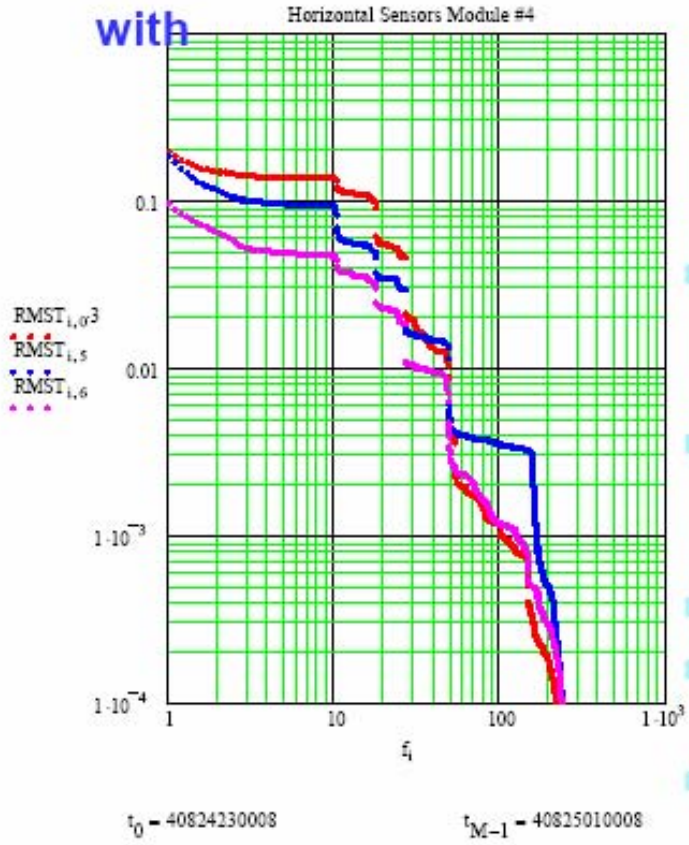
# Pump stand without/with modifications
# Horizontal Sensors (2 different days)

RMS average, midnight ± 1 hour

without




with




Sensors:
Cold
Top
Socket

- Different days
  - Mon "without"
  - Tue "with"
- Horizontal vibrations much larger
- Cold Signal *3
- Some reduction below 25 Hz
- Large reduction between 25 and 50 Hz

# Safety issues, AfA/TÜV

- Discussions with Authorities is going on
  - ‘Druckbehälterklassifizierung der XFEL-Cryomodule’
  - No problems expected
  - But:
    - Niobium is not a qualified material for cold temperature (mechanical properties)
    - This can be mitigated by arguing that the Ti-Vessel and the Cryostat are the safety containers
  - Introduction for the TÜV to propose a procedure for approval for
    - CrNi-welding 2K
    - Ti-Vessel weldings
    - ….

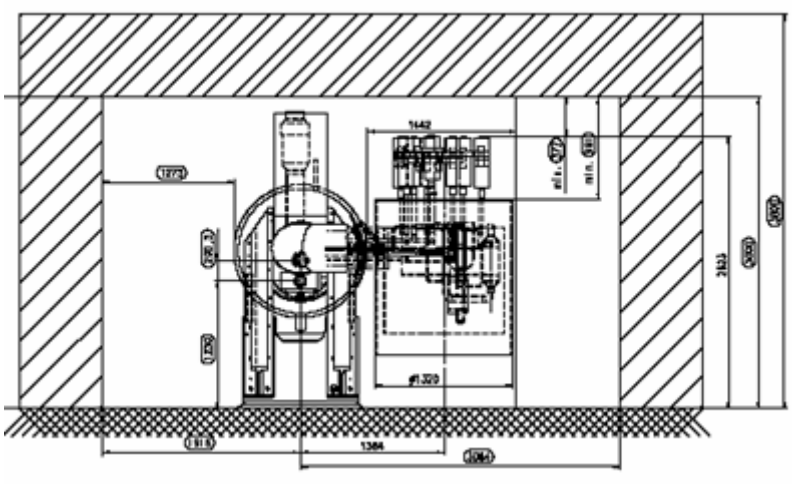


# Industrial Studies on Module Assembly

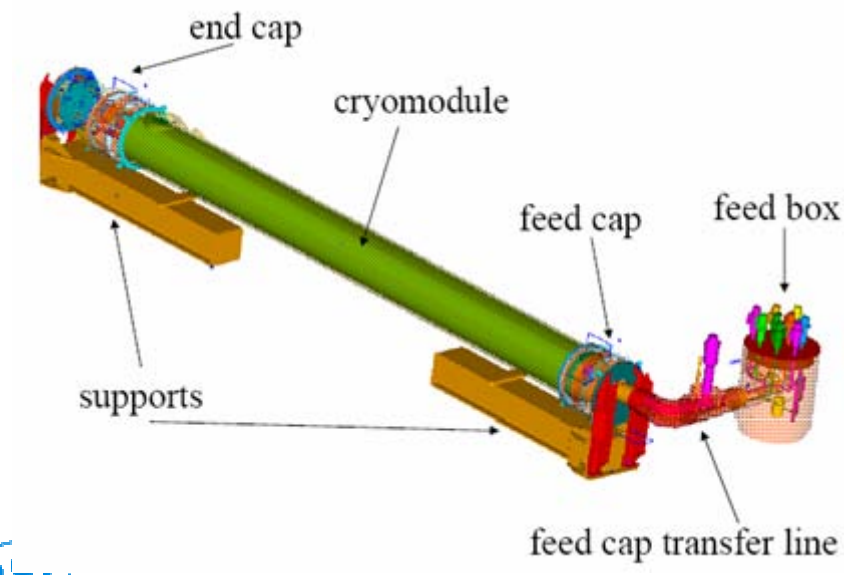
- Prepare a study by industry on the cryomodule assembly
  - Involve industry early
  - Profit of industrial experience
- Results of the study will be published
- Specification of XFEL-Cryomodule Design&Assembly for Industrial Studies

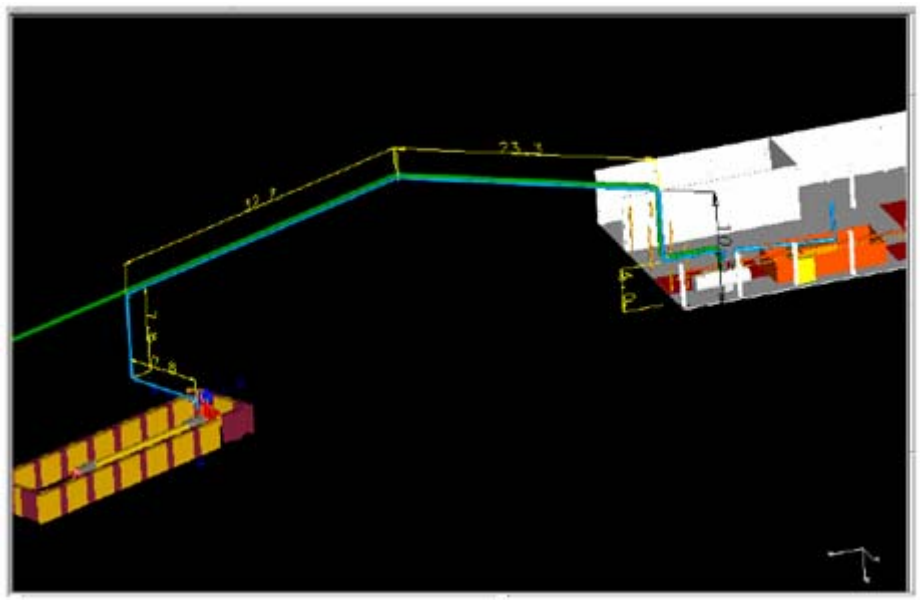


# Module Test Stand



- Allows cryogenic tests and RF measurements independent from the LINAC
  - No beam tests
  - Dark current measurements will be integrated



# Summary: Ongoing Work

- Full 3D-Model of type III cryostat under preparation
- Order for 2 new cryostats soon
  - Close to TTF
    - Not shortened by 1 lambda
    - New magnet, HOM,BPM
  - Still compatible with TTF
  - Close collaboration with INFN, ZANON

- Prepare to install into TTF in Summer 2006
  - Module 6 and 7 (replace M3*)
  - 3rd harmonic
  - Repair ACC5 (tuner motors)

- Module assembly studies with industry

- Build module test stand