XFEL-Cryomodule Assembly & Test

XFEL-Cryomodule Design Basics
Cryomodule Assembly
Cryomodule Tests (Prototypes)
Cryomodule Tests (Serial Production)

Only some ‚Impressions' will be shown.
Details can be found in 2 published Industrial Studies.

Bernd Petersen DESY –MKS- (XFEL Wps 10 & 13)
View graphs are taken from several colleagues and presentations.

Use of ‚TESLA-Technology‘

In general concepts , which were developed for the TESLA linear collider, will be applied

Most of the concepts were validated at the TTF1/ VUV-FEL/FLASH linacs

Each cryomodule consist of:

8 1.3 GHz 9-cell Nb cavities (2K)

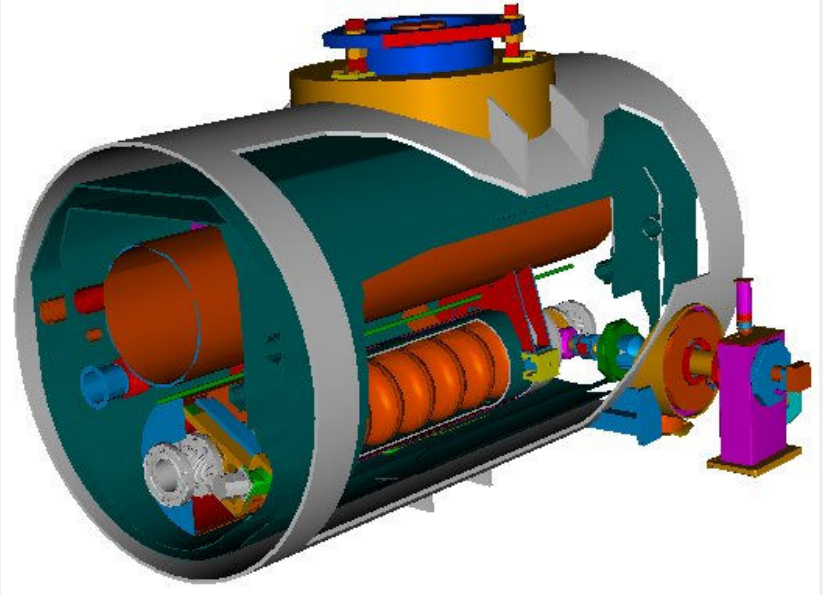
1 magnet package (2K)

2 thermal shields (5-8K;40-80K)

8 main RF couplers

8 cold tuners

23.6 MV/m needed for 20 GeV XFEL-operation



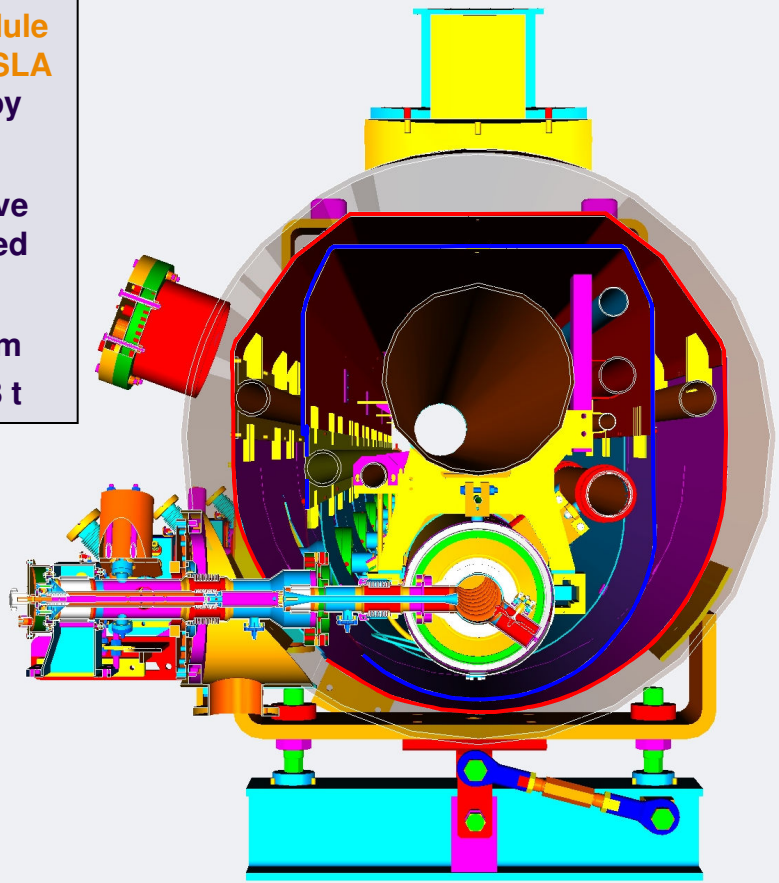
Cryomodule cross-section

XFEL Accelerator Module (Cryomodule)

The XFEL accelerator module is based on the 3rd cryomodule generation tested at the TESLA Test Facility and designed by INFN.

Already 10 cryomodules have been built and commissioned for the TTF Linac.

Length	**12.2 m**
Total weight	**7.8 t**



38" carbon steel vessel

300 mm He gas return pipe acting as support structure

8 accelerating cavities

cavity to cavity spacing exactly one RF wavelength

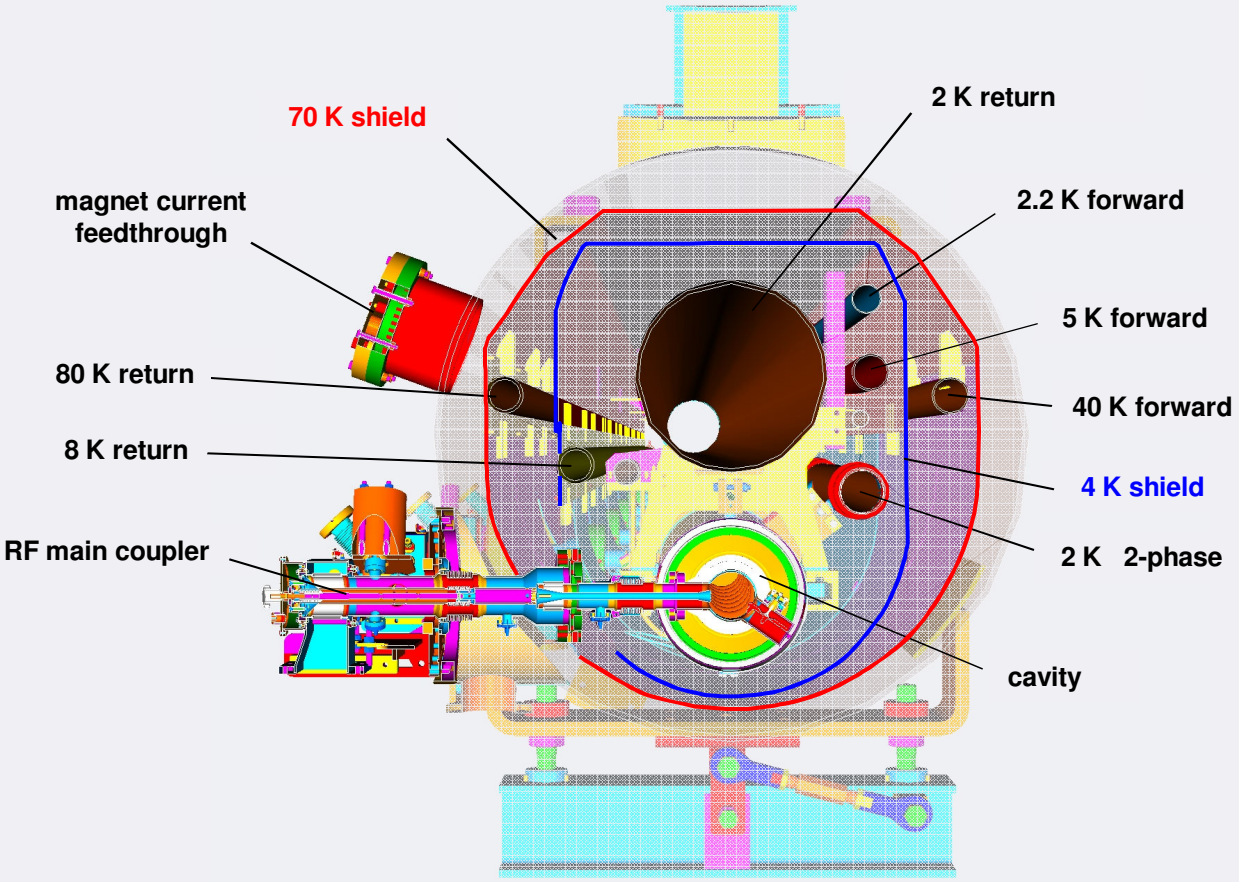
inter-module cavity to cavity spacing a multiple of one RF wavelength

one beam position monitor / magnet unit

manually operated valves to terminate the beam tube at both ends

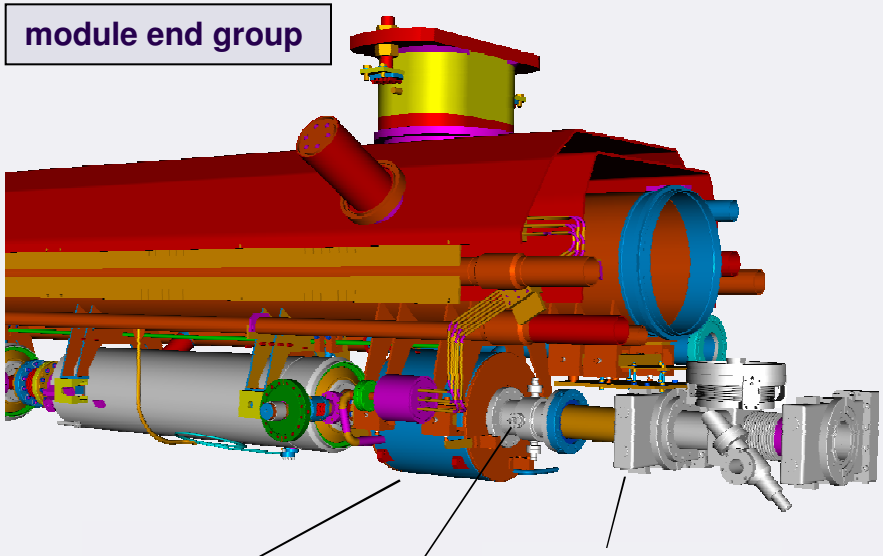
longitudinal cavity position independent from the contraction / elongation of the HeGRP during cool-down / warm-up procedure

XFEL Accelerator Module (Cryomodule)

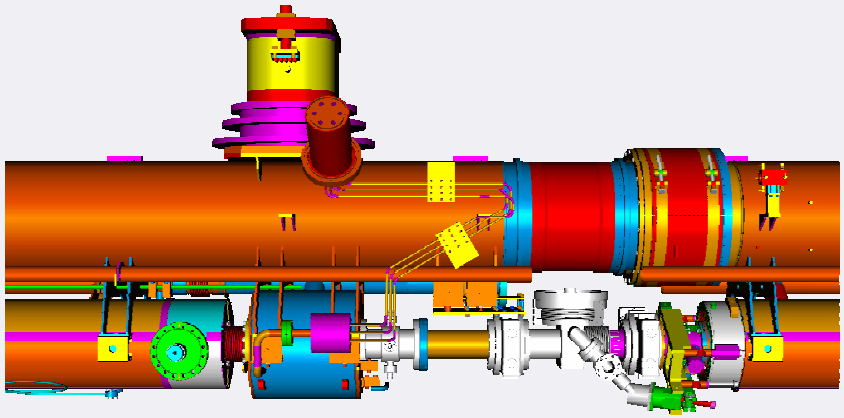


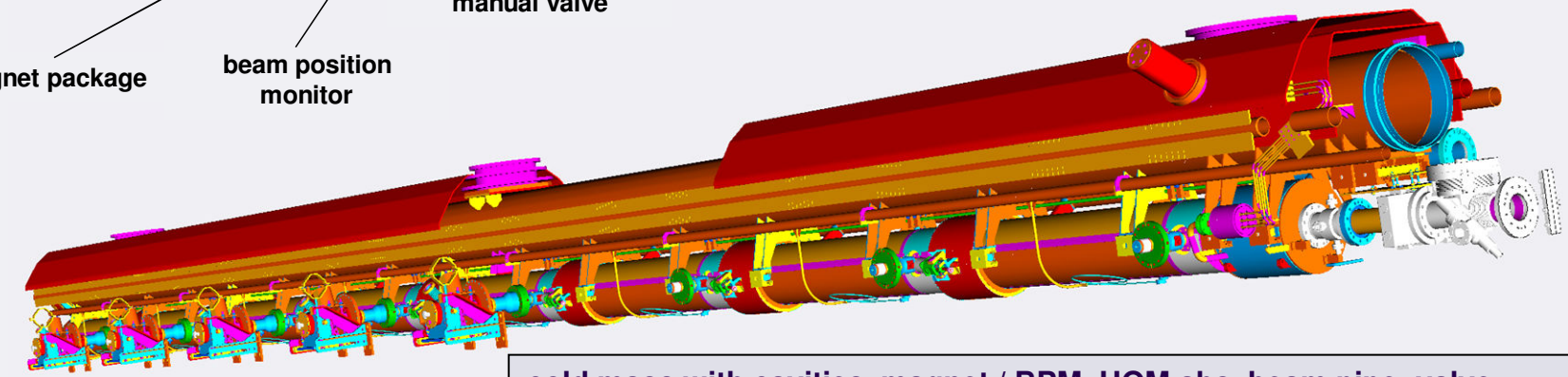
XFEL Accelerator Module (Cryomodule)

module end group



module to module connection.





cold mass with cavities, magnet / BPM, HOM abs. beam pipe, valve.

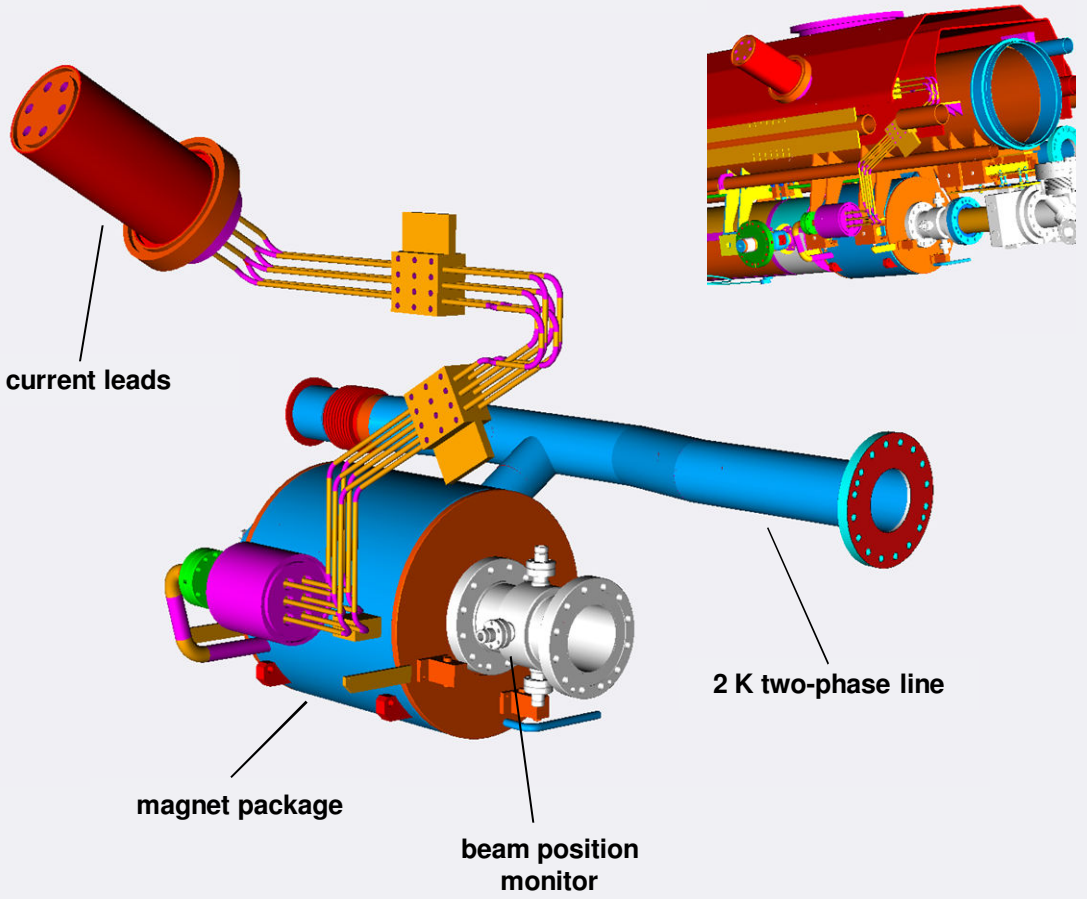
XFEL Magnet Package and Cold BPM

At the downstream end of the cavity string of each module a magnet package and an attached BPM is placed.

- a super-ferric quadrupole
- a vertical and a horizontal dipole
- BPM is either re-entrant (SACLAY design) or pick-up (DESY design) type.

Quadrupole to BPM alignment is 0.3 mm and 3 mrad.

The magnet design is done in collaboration with CIEMAT. The current leads are based on the CERN design used at LHC.



Cryomodule Assembly

All steps of the assembly procedures, in particular the assembly inside the clean room, can strongly affect the final performance of the cryomodule. The final accelerating gradients and the occurrence of dark currents are extremely sensitive to any contamination with particles caused during the assembly. Also the mounting of other equipment, like the tuners and main couplers, requires extreme care.

Cleanroom assembly

Assembly outside cleanroom

Cavity String Assembly

The assembly of an 8 cavity string

- **is a standard procedure**
- **is done by technicians from the TESLA Collaboration**
- **is well documented using the cavity database as well as an Engineering Data Management System**
- **was the basis for two industrial studies.**

This well known and complete procedure can be transferred to industry.

Assembly outside Cleanroom

Figure 2: Cavity string positioned below module cold mass, numbering of cavities 1-8

Cavity string positioned under the cold mass

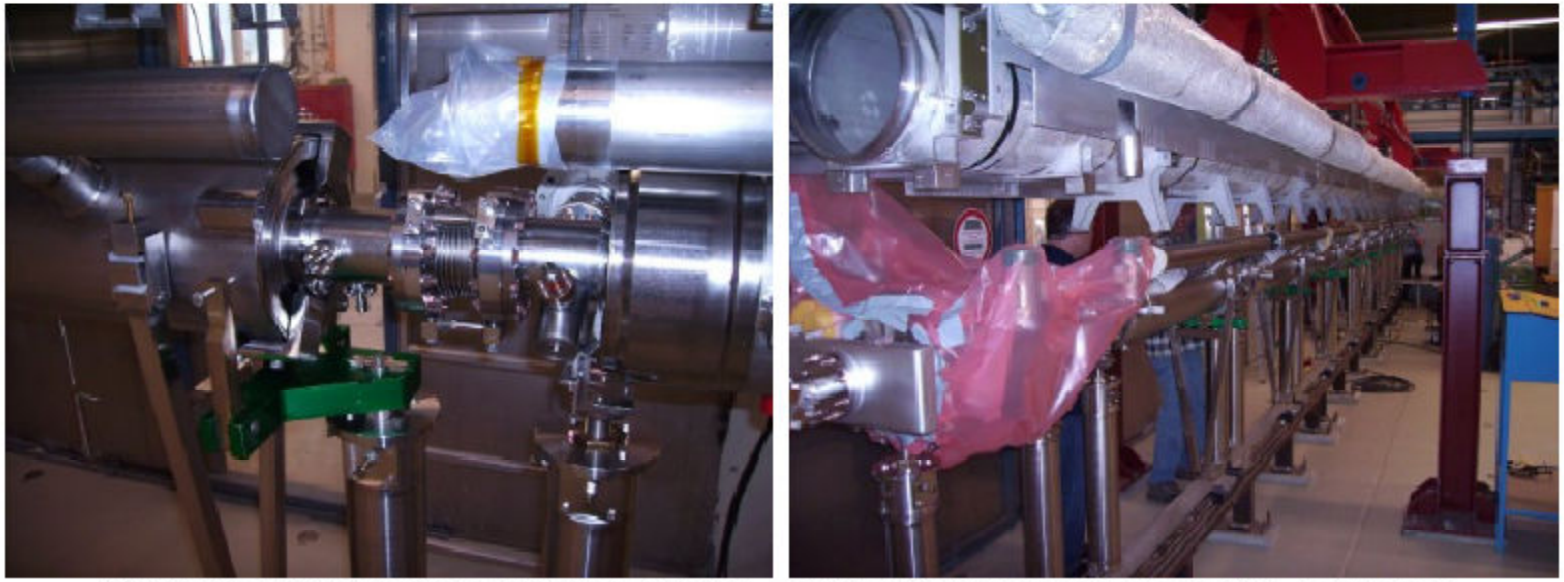
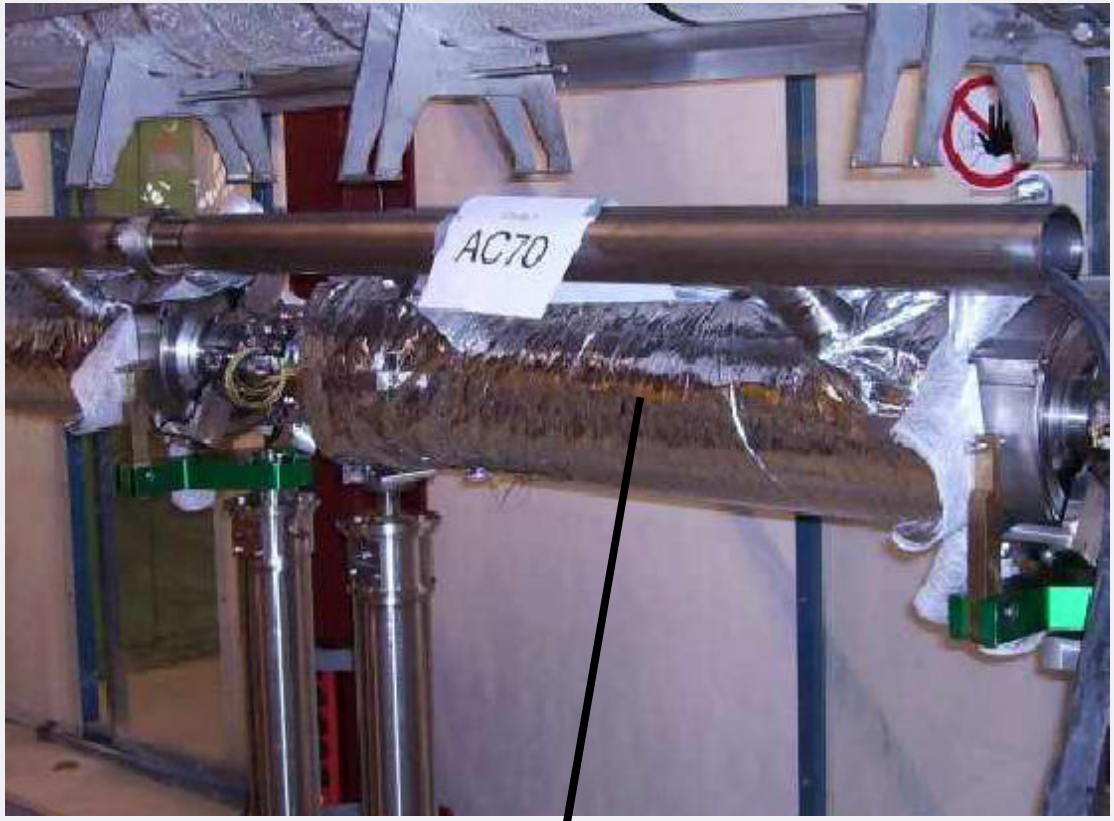


Figure 3: Bellow bridges between cavities, cavity string positioned under the cold mass

… in addition the Helium vessel get their magnetic shielding

Single parts of magnetic shield and assembly of magnetic shielding

MLI around the 2K Helium vessels



2 K Helium Vessel of TESLA Cavity

Note:

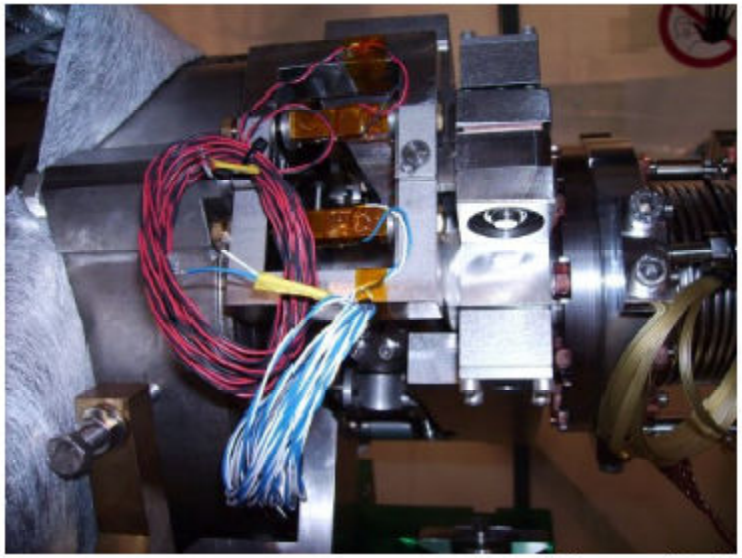
All helium process areas inside the cryostat should be covered with about 5-10 layers of MLI to limit the impact of insulation vacuum loss !

Heat input caused by the break down of Insulation vacuum:

40kW / m2 without MLI

6kW/ m2 with MLI

Cold tuner assembly



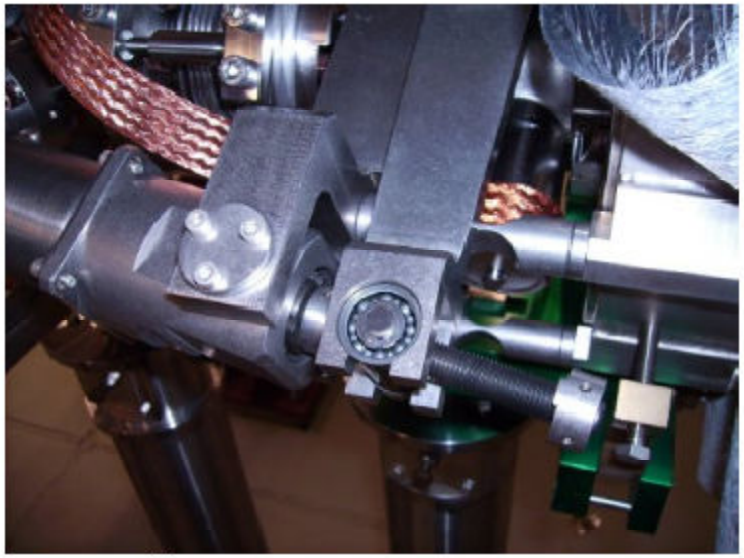


Figure 13: Tuner assembly

2.2.3.4 Assemble inverted Tuner on cavity 1

Alignment is a big issue !!!

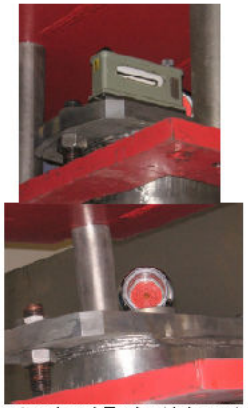


Figure 36: Optical leveler (left), water level and Taylor Hobson ball (right)

2.3.2.2 Build up Laser tracker on site

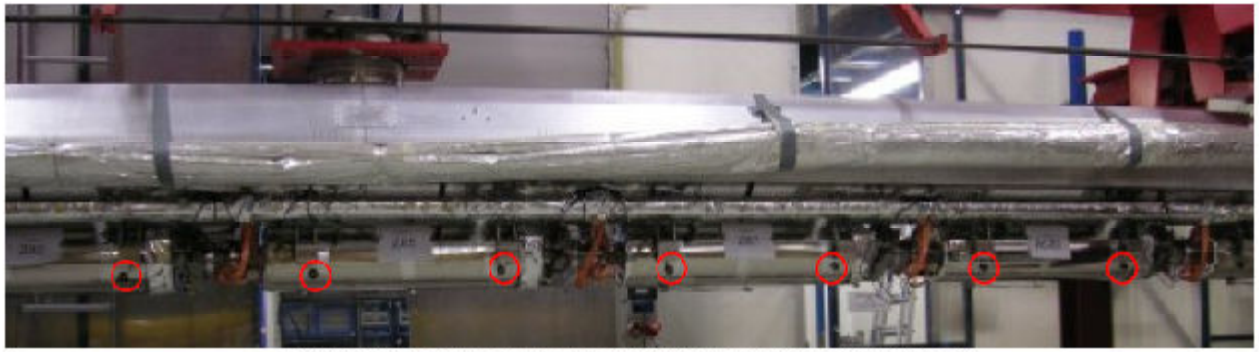


Figure 37. Reference survey points on magnetic shield

2.3.2.4 Measure basing point to create coordinate system on site with Laser tracker

Cold mass on cantilever

Figure 50: Transport to cantilever and disassembled posts

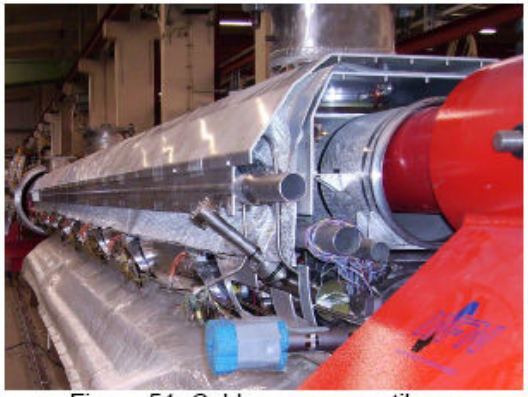
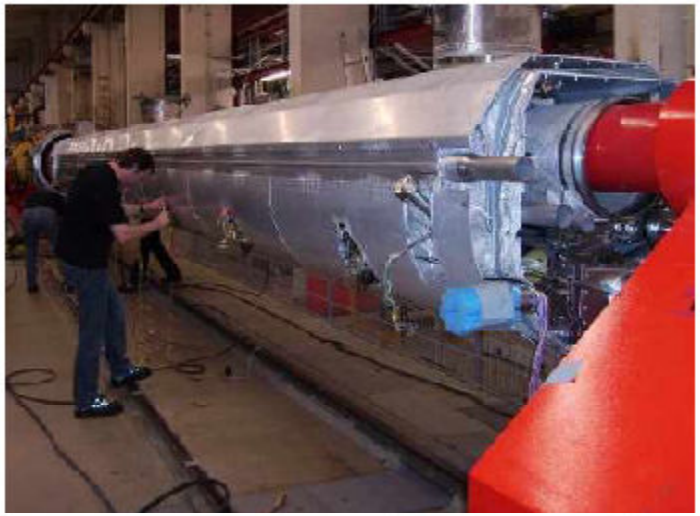


Figure 51: Cold mass on cantilever

Assembly of thermal shields & MLI application



spacer
glas fiber
net

(vitrolan)

Support post assembly and adjustment

Figure 70: Measurement of vessel and setting of side panel

Figure 71: Adjustment of height and rotation
(left: vessel rotation and height, middle: position of cold mass, right: rotation of string;
middle and right action are done while measuring with Laser tracker)

Main RF coupler assembly

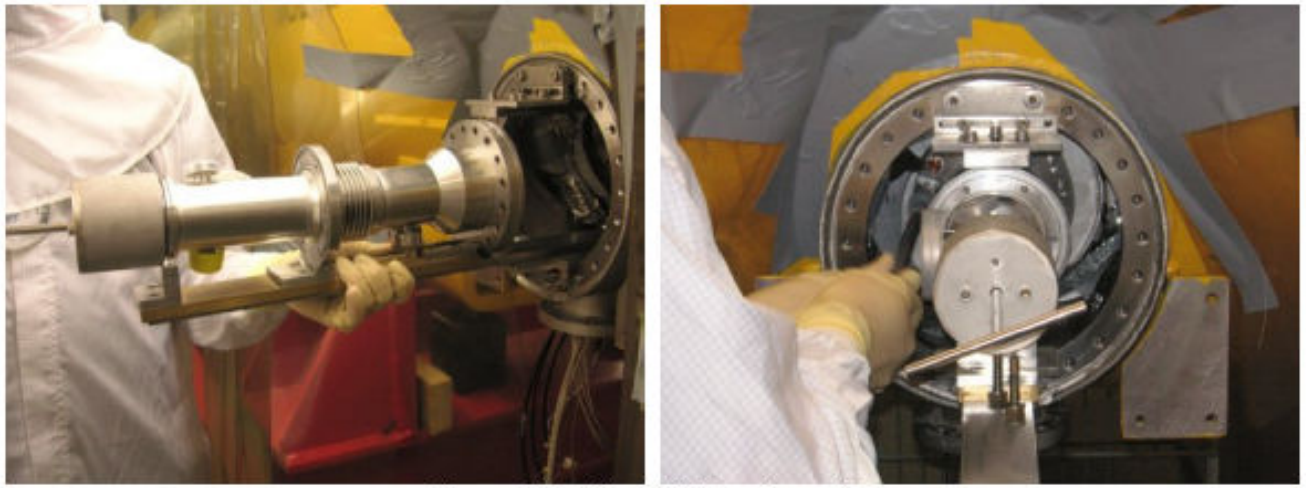


Figure 77: Fix CF100 of coupler
(left: slide in the warm part of the coupler; right: tighten it to the CF100 flange of the cold part of the coupler)

Coupler vacuum line

Figure 89: Finished coupler ports and coupler-vacuum line

ACCEL Cryomodule Assembly Study I

S. Bauer, B. Griep, M. Pekeler, H. Vogel, J. Zeutschel
ACCEL Instruments GmbH
Friedrich-Ebert-Str. 1
51429 Bergisch Gladbach

BILFINGER BERGER
Power Services

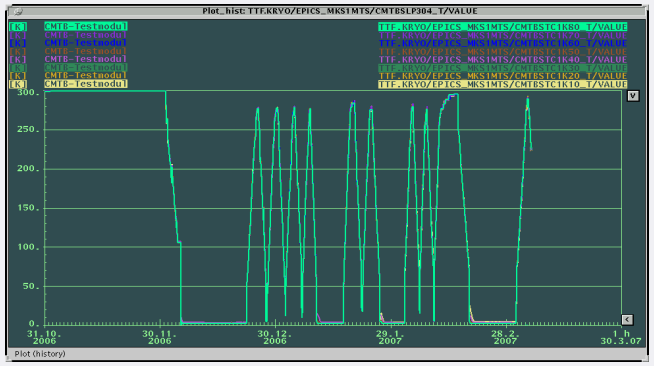
BABCOCK NOELL

Industry Study on the Series Production of XFEL Cryomodules

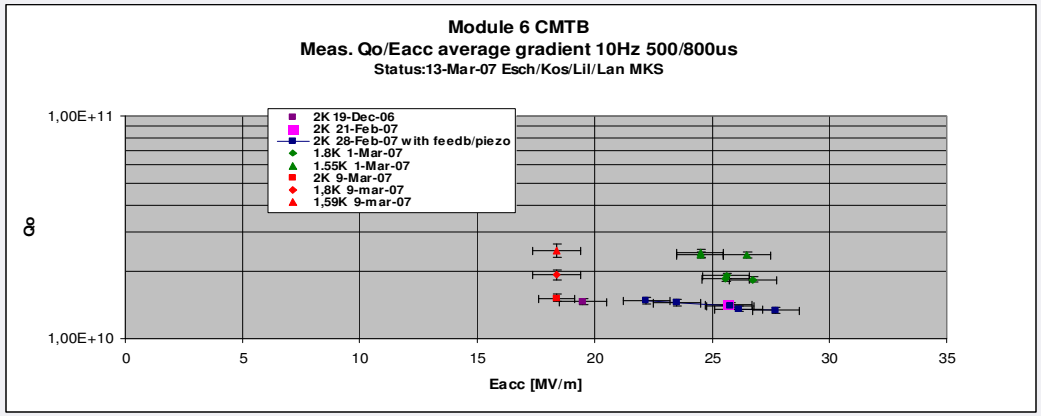
C.Boffo, W. Gärtner, S. Sattler, G. Sikler, U.-M. Tai

Cryomodule Test Bench (CMTB)

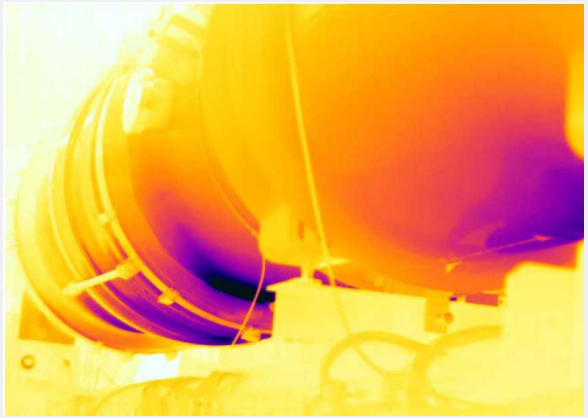
Extensive testing of prototypes– at the limits



Thermal cycling (M6)

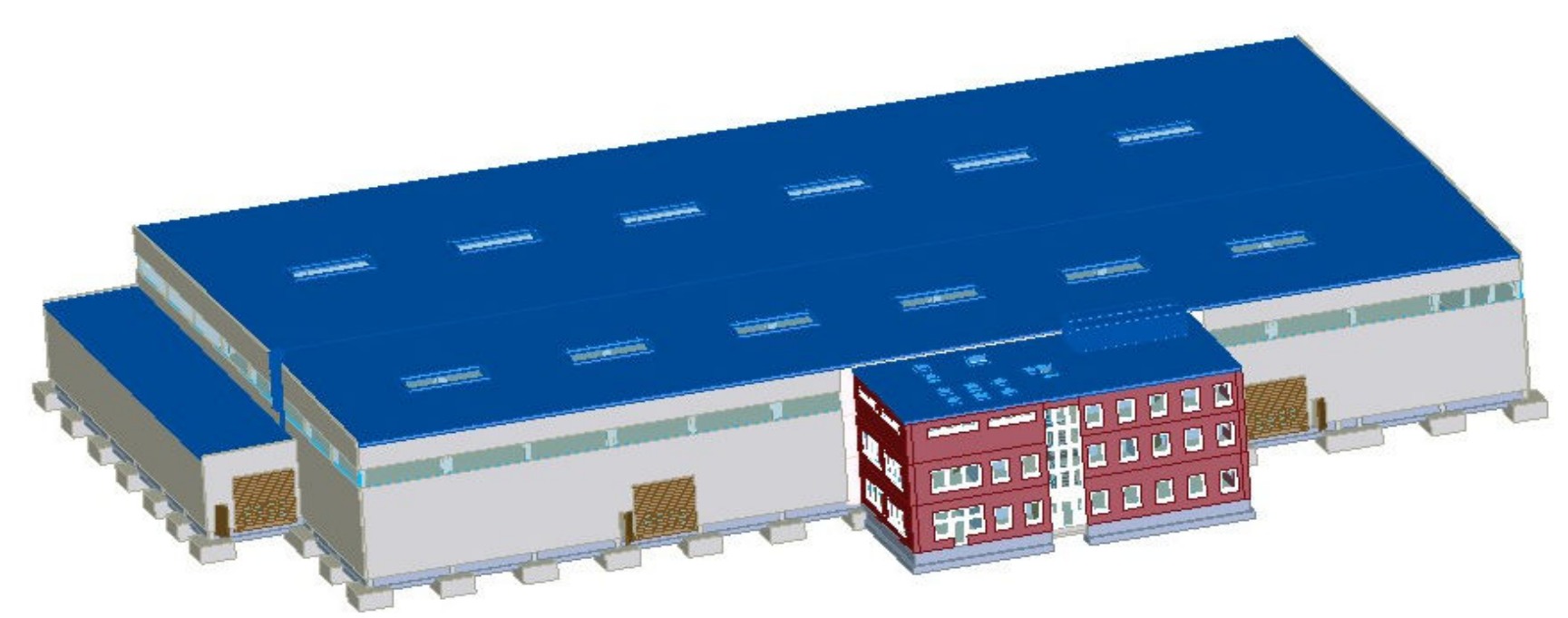


RF Cavity performance

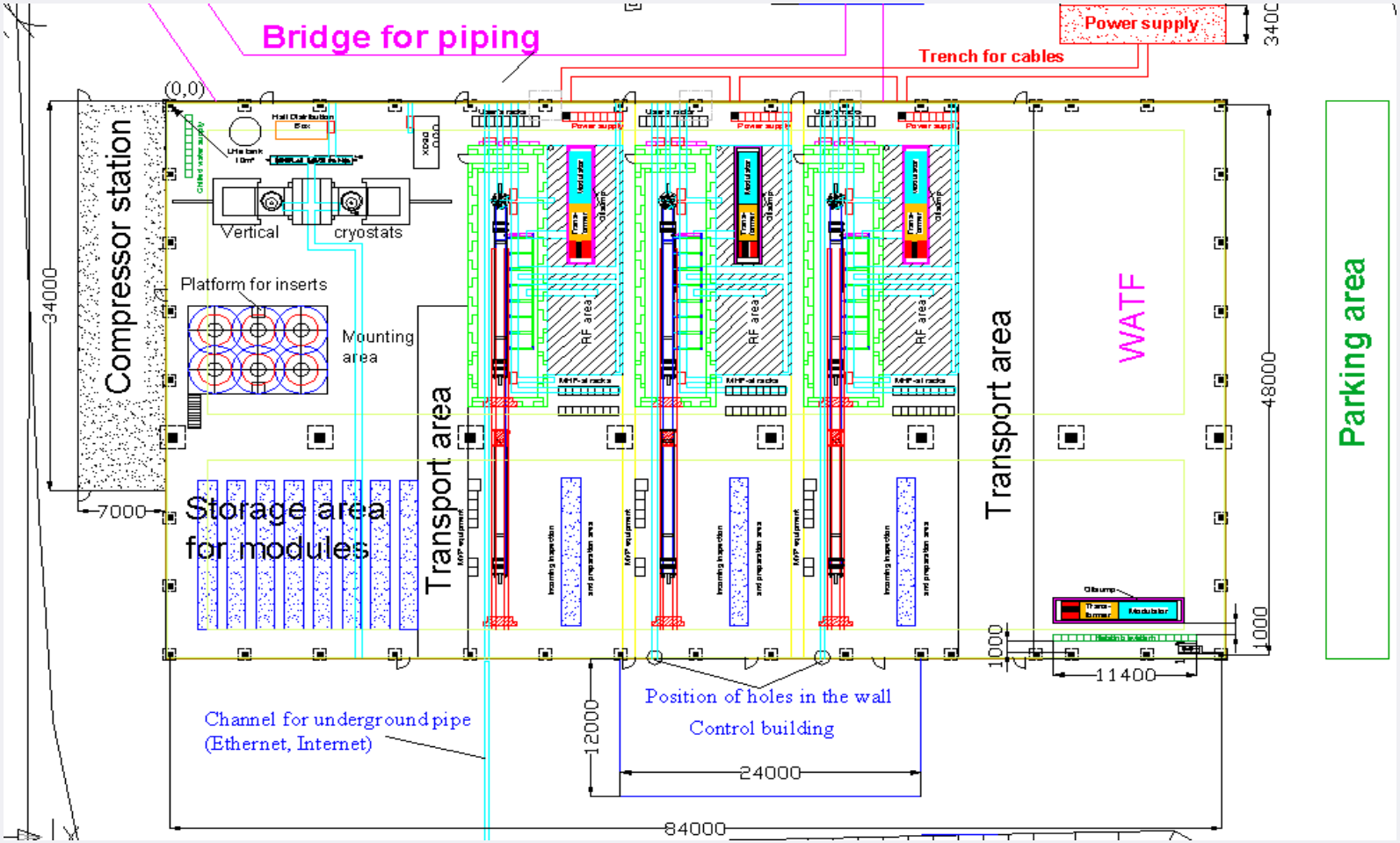


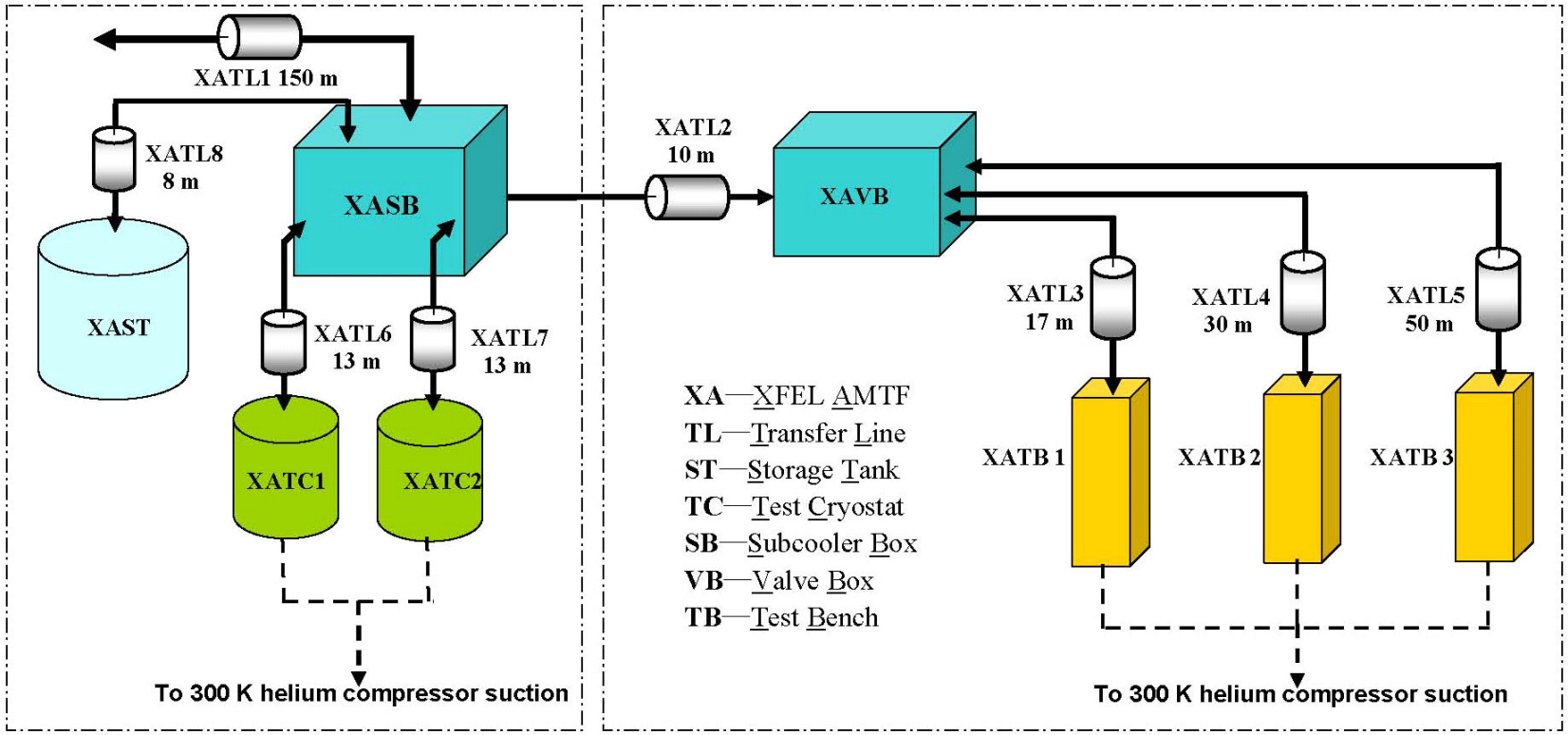
Vacuum venting (M3*)

Accelerator Module Test Facility (AMTF)



Accelerator Module Test Facility (AMTF)

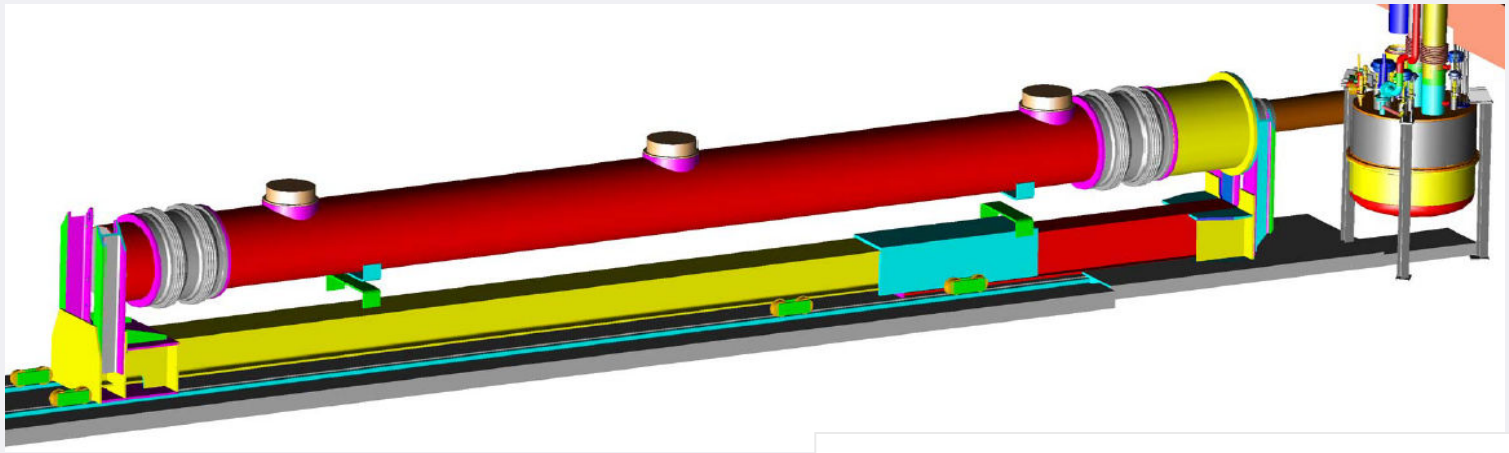


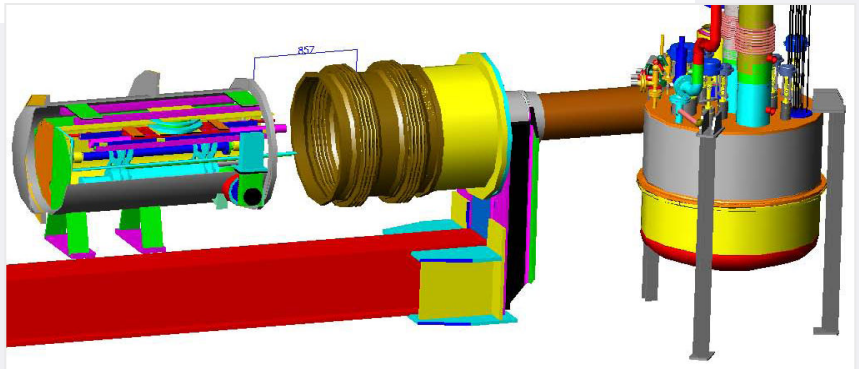


Sub-system 1

Sub-system 2

AMTF: 3 cryomodule test stands & cryostat adapters





Accelerator module test scenario

12 days +/- 2 d