DE LA RECHERCHE À L'INDUSTRIE

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ESS ELLIPTICAL CRYOMODULE

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With material provided by the ESS ECCTD team

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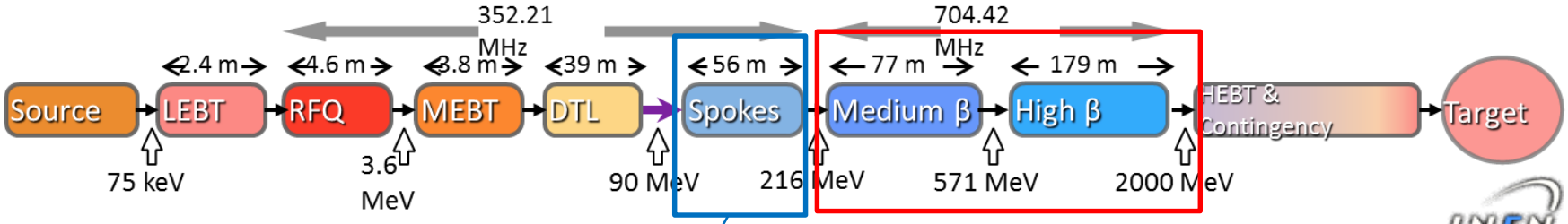
EUROPEAN SPALLATION SOURCE (ESS)

- European Spallation Source is under construction in the city of Lund, in southern Sweden
- ESS will offer neutron beams of unparalleled brightness for cold neutrons, delivering more neutrons than the world's most powerful reactor-based neutron sources today, and with higher peak intensity than any other spallation source
- ESS Cold Linac: a collaborative project



M-β

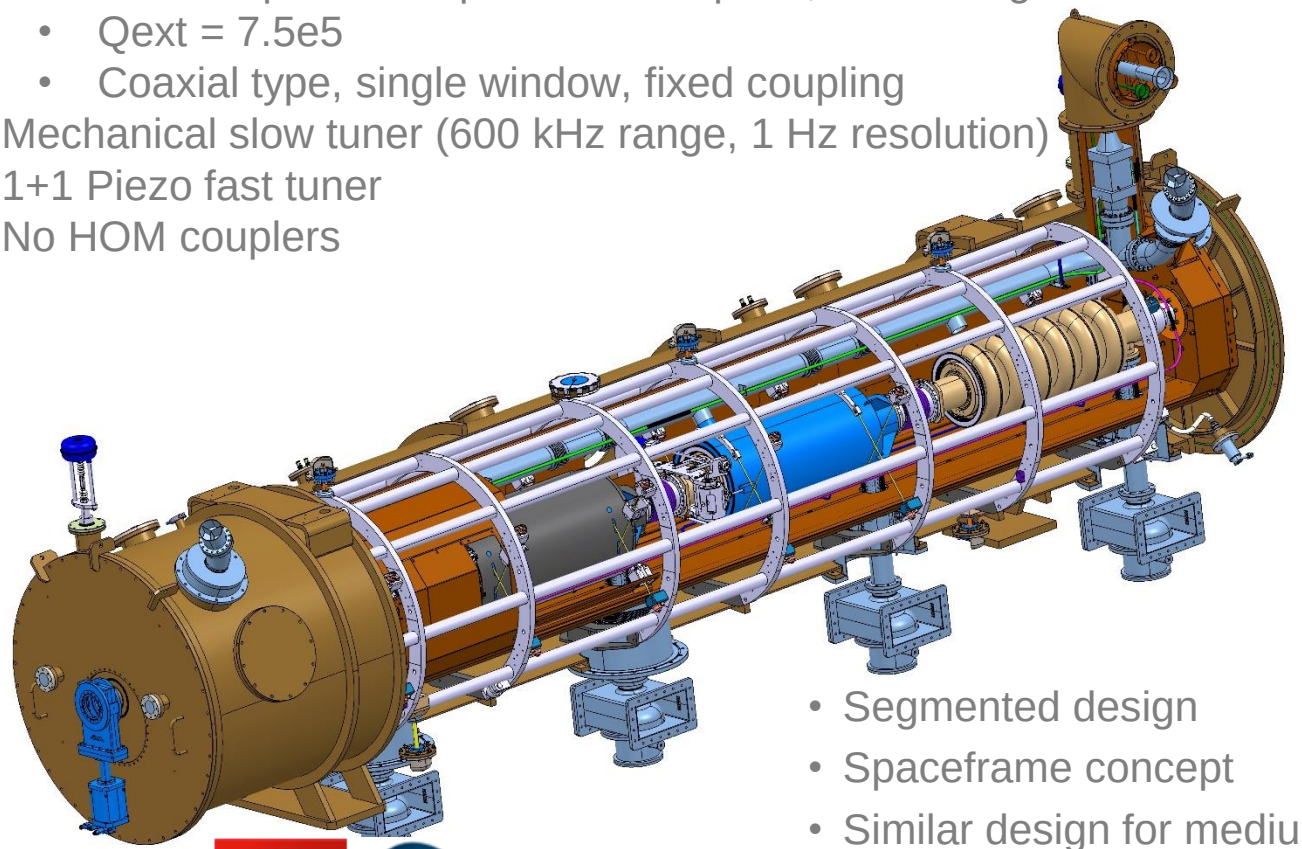
H-β

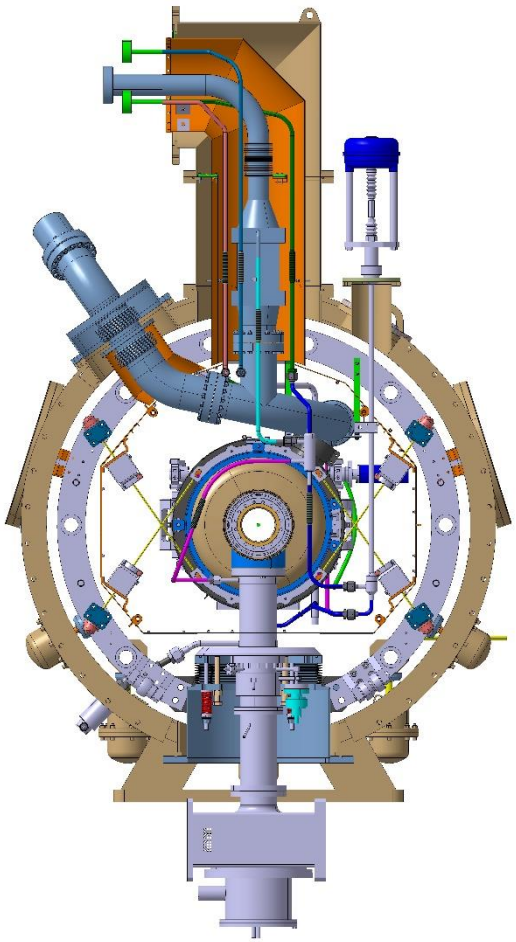
UPPSALA UNIVERSITET

Science & Technology Facilities Council

ELLIPTICAL CRYOMODULE MAIN FEATURES

- 704 MHz, 3.6 ms RF pulse at 14 Hz
- Eacc = 16.7 MV/m (MB) and 19.9 MV/m (HB) (Epeak = 40/44 MV/m)
- Q0 > 5e9 at 2 K
- Fundamental power coupler: 1.1 MW peak, 55 kW avg.
  - Qext = 7.5e5
  - Coaxial type, single window, fixed coupling
- Mechanical slow tuner (600 kHz range, 1 Hz resolution)
- 1+1 Piezo fast tuner
- No HOM couplers

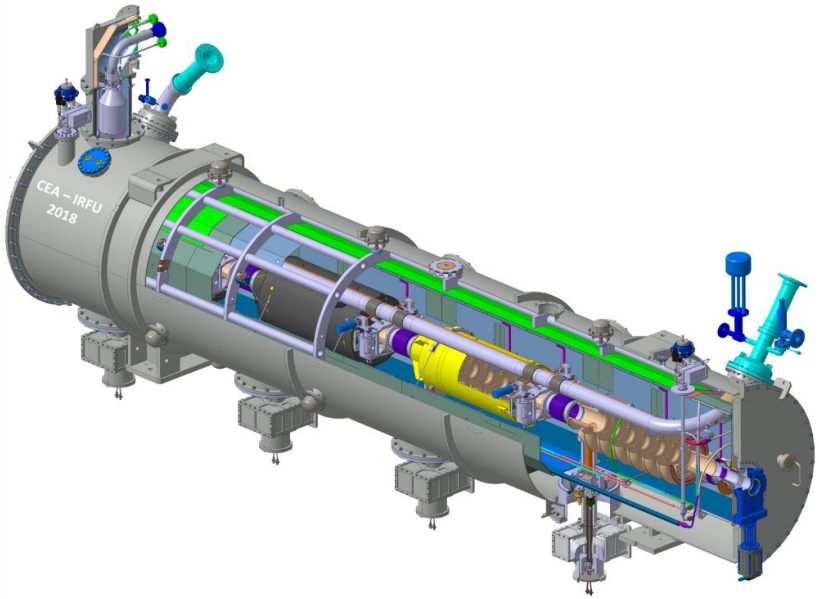


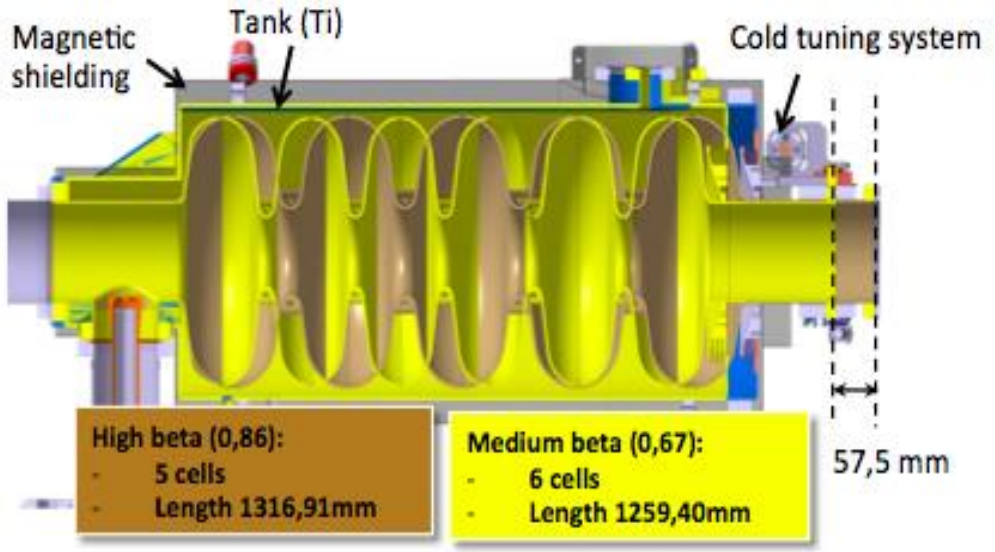


- Segmented design
- Spaceframe concept
- Similar design for medium and high beta cavities

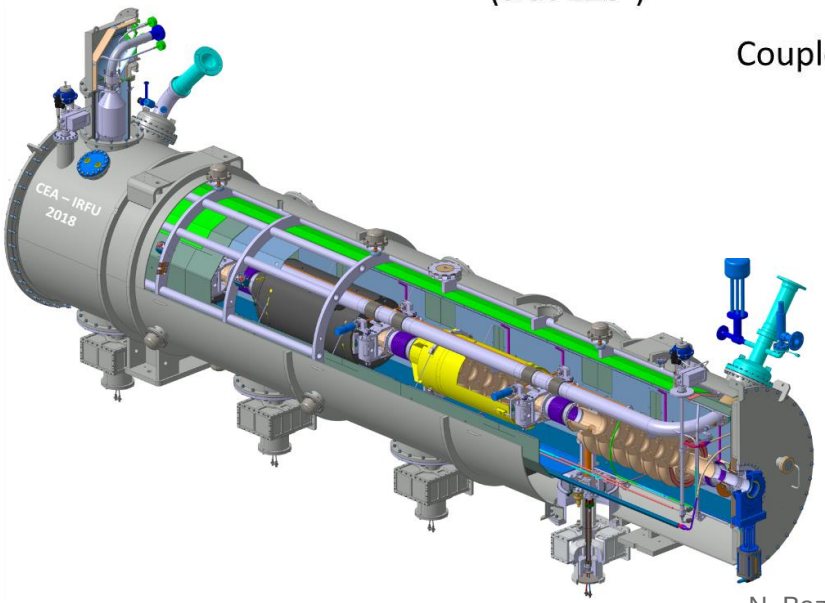
ELLIPTICAL CRYOMODULES

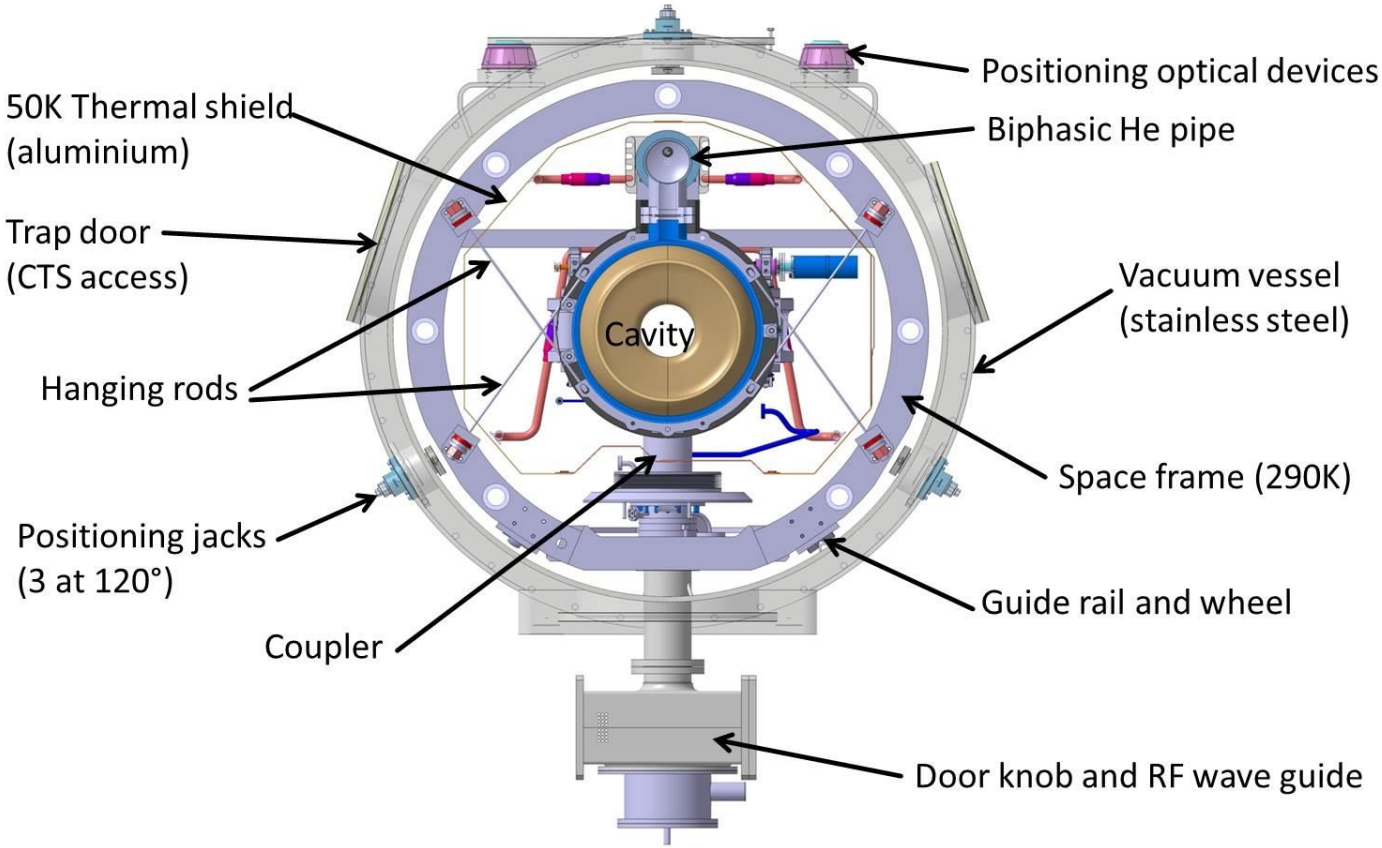
- Common design for medium and high beta cryomodules:
  - Made sensible thanks to the small length difference between 6-cell medium and 5-cell high beta cavities
  - Main components are identical: vacuum vessels, thermal shields, supports, spaceframes, alignment system …
  - Only few elements differ: details in cryo piping, beam pipe bellows
  - Same assembly tooling



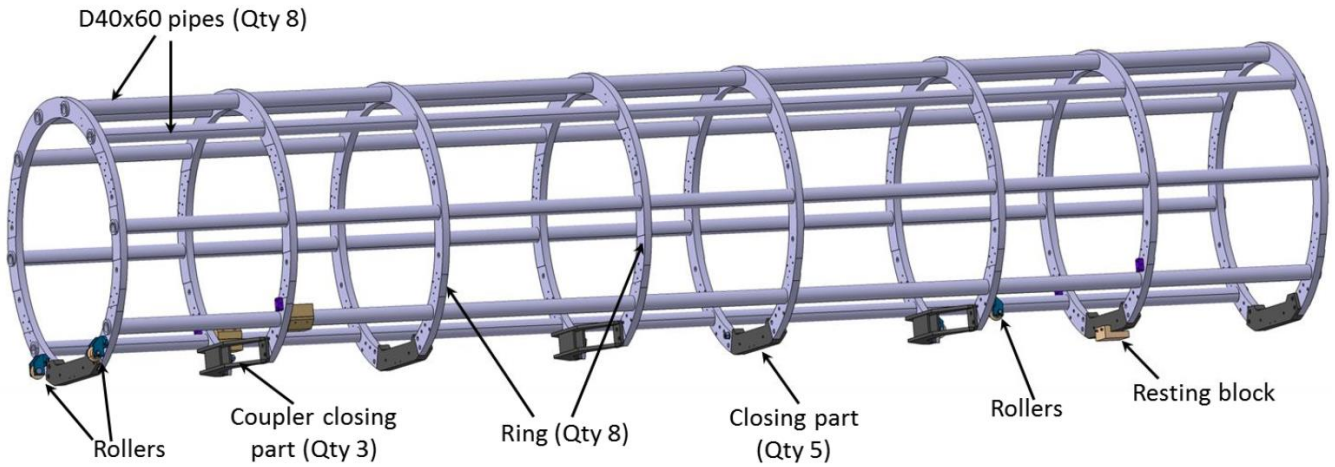


ELLIPTICAL CRYOMODULE





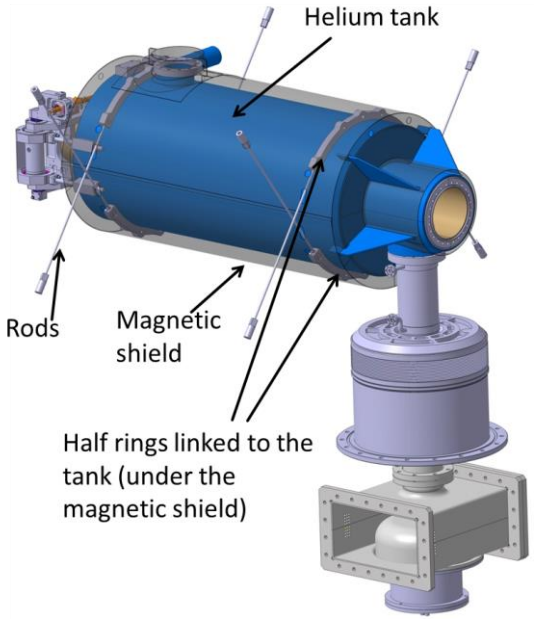
SPACEFRAME: PRESENTATION

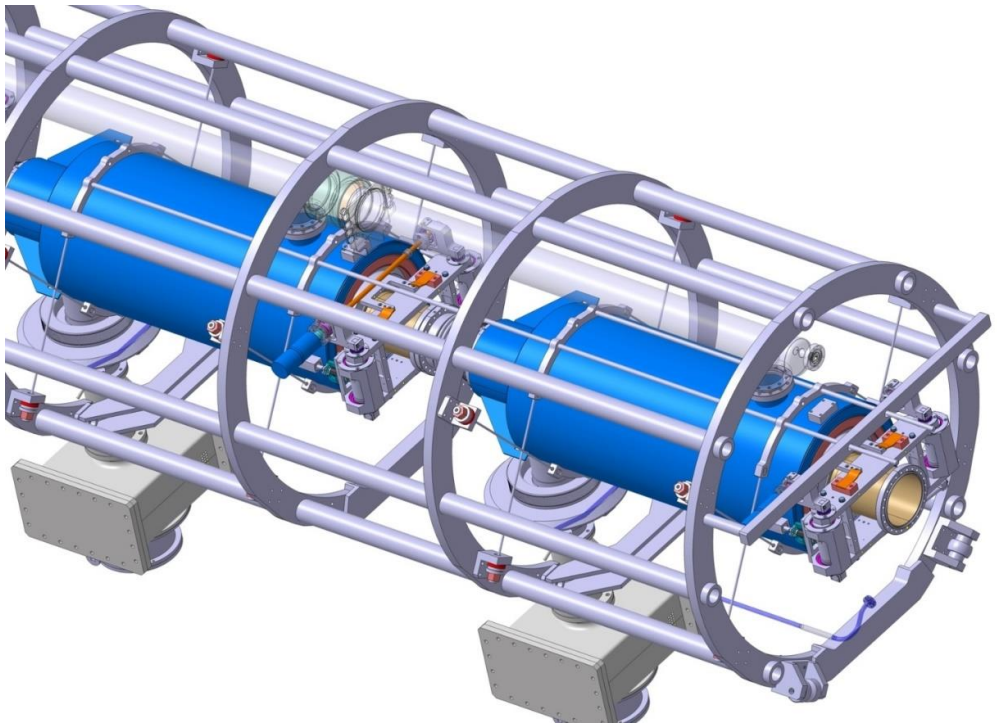


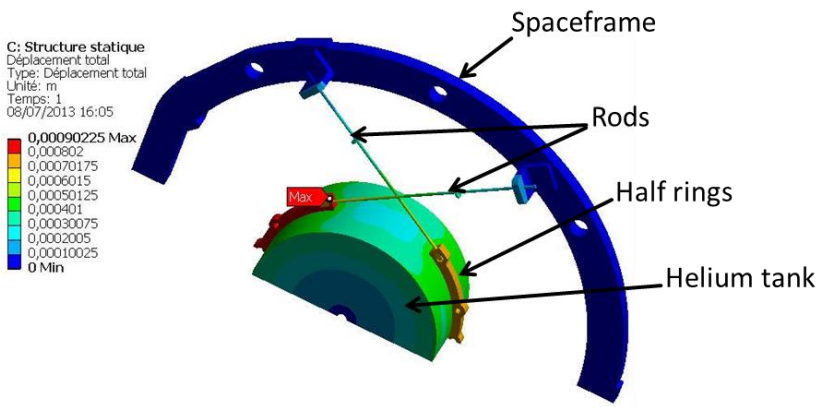
- Role of the spaceframe
  - Supports the cavity string
  - Key element for the alignment of the string → deformations along the assembly process shall be controlled
- Stays at room temperature → no deformation due to thermal shrinkage
- Made of aluminium

CAVITY: MOTIONS DURING COOL DOWN

- Each cavity are attached to the spaceframe thanks to eight rods
- Preloading in the rods → no motion of the cavity in transverse direction during cool down

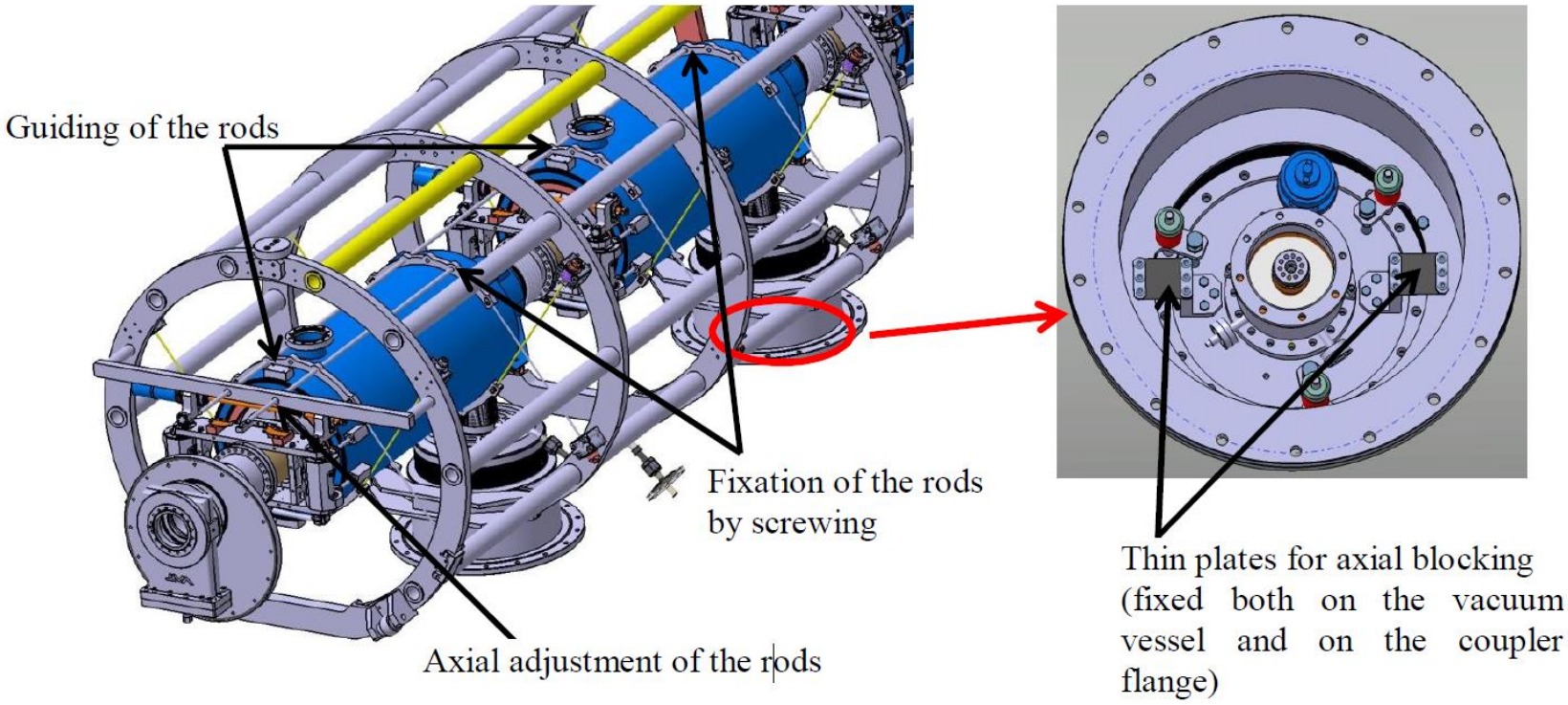






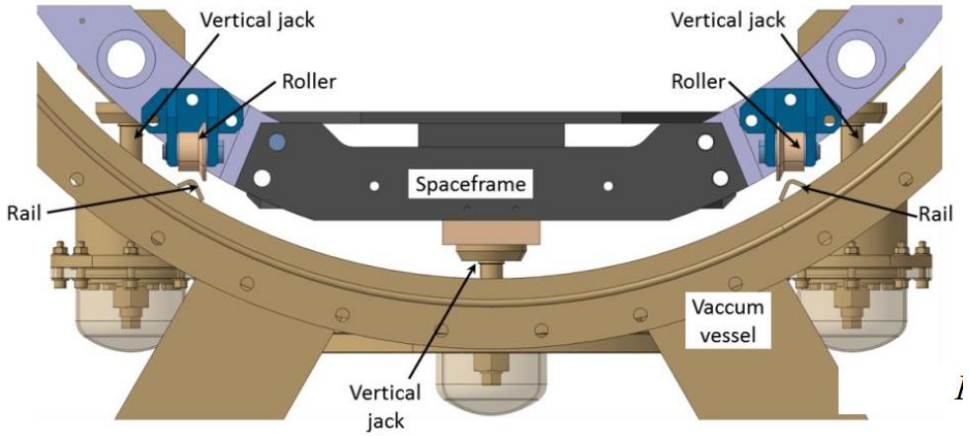
CAVITY: MOTIONS DURING COOL DOWN

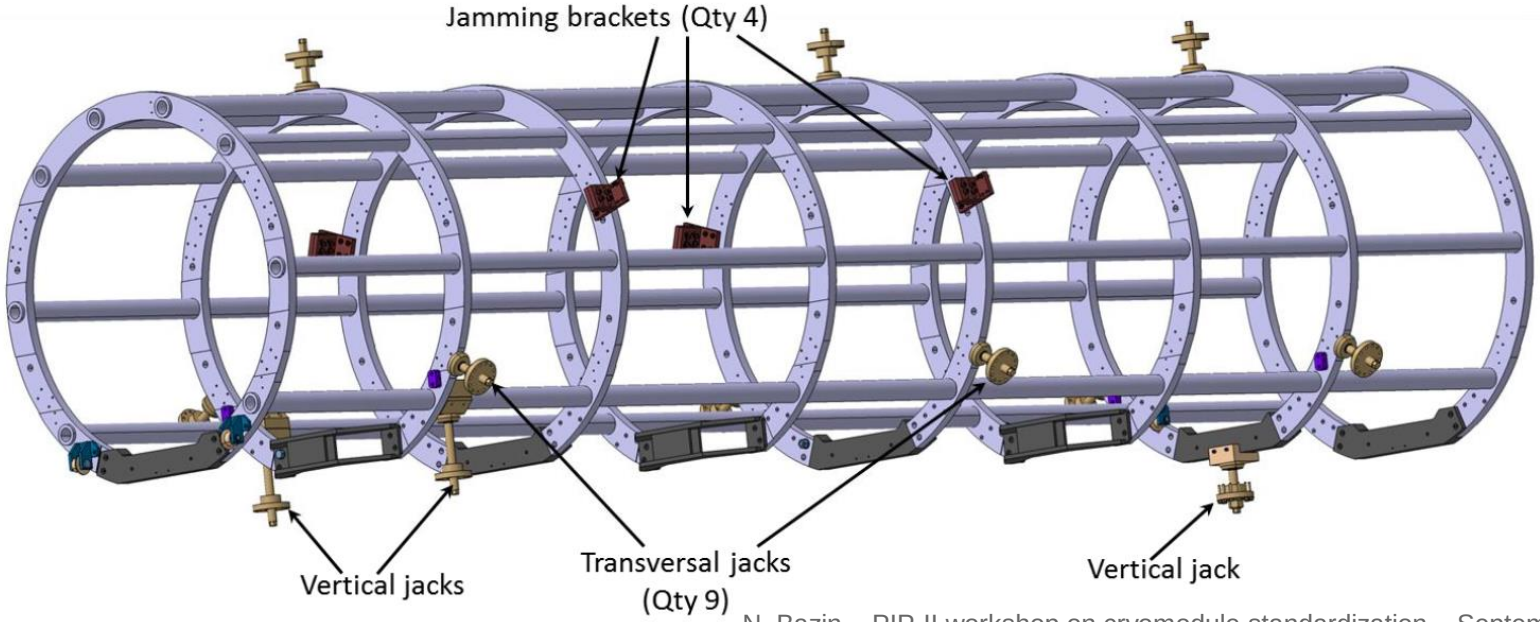
- Axial position of each cavity is fixed during the assembly (use of temporary rods of temporary rods removed after the insertion of the cold mass inside the vacuum vessel)
- Plates fixed on the coupler flange and the vacuum vessel set the axial position but allow a vertical motion of the coupler (needed for the thermal contraction while cooling)



POSITIONING THE SPACEFRAME IN THE VACUUM VESSEL

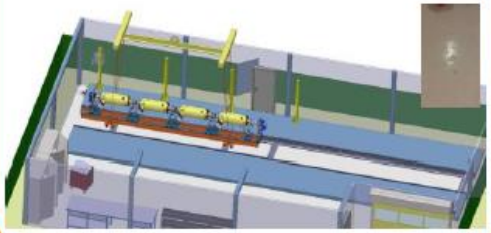
- After insertion inside the vacuum vessel, the complete assembly is positioned by means of 3 mechanical jacks (2+1) located at the 2nd and 7th rings.
- After positioning of the whole assembly, the spaceframe is blocked by means of 9 transversal jacks (2nd, 5th and 7th rings) and fixed to the vacuum vessel using 4 brackets (3rd and 5th rings).



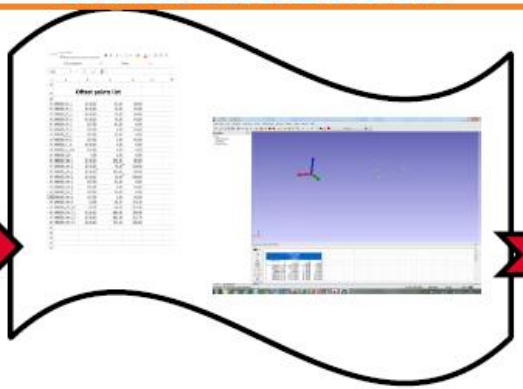


ALIGNMENT PHASES

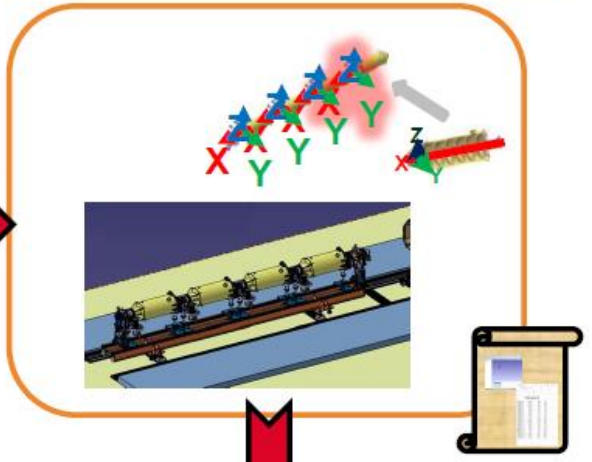
PRELIMINARY SURVEY OF WORKING AREAS



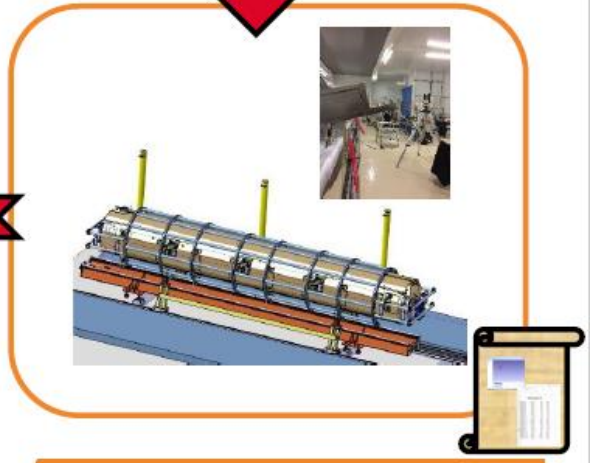
DATA IMPORT AND STORING



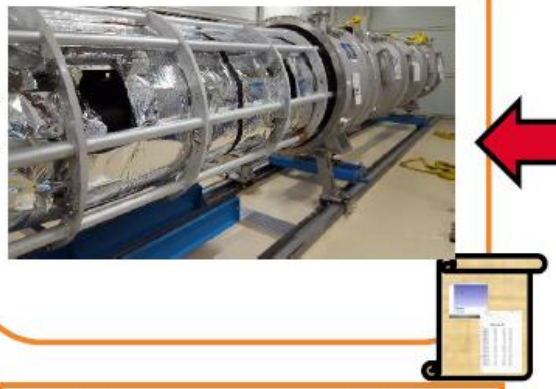
CAVITY STRING ALIGNMENT



CAVITY STRING ALIGNMENT INTO SPACE FRAME

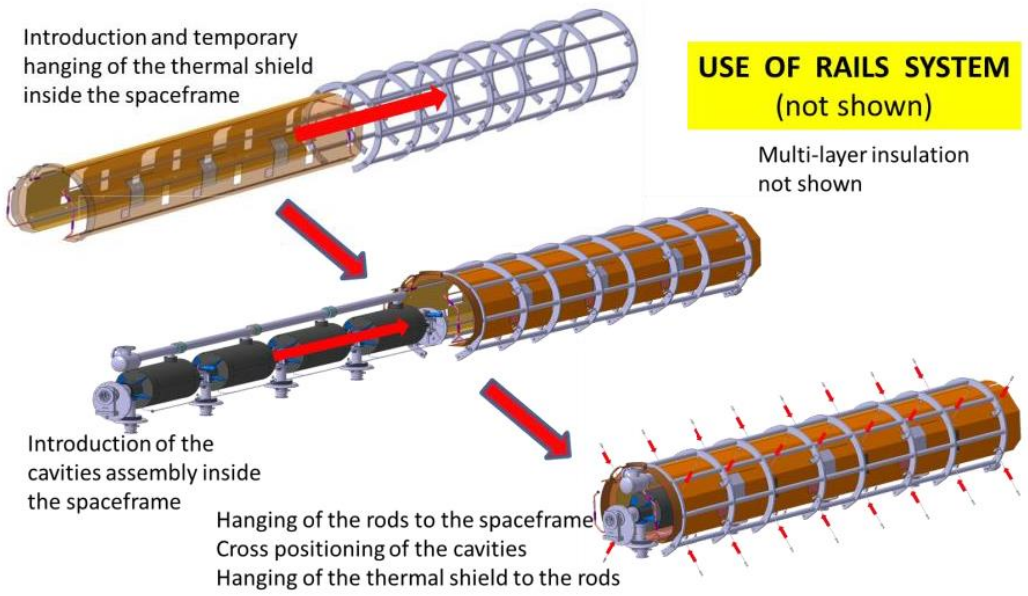


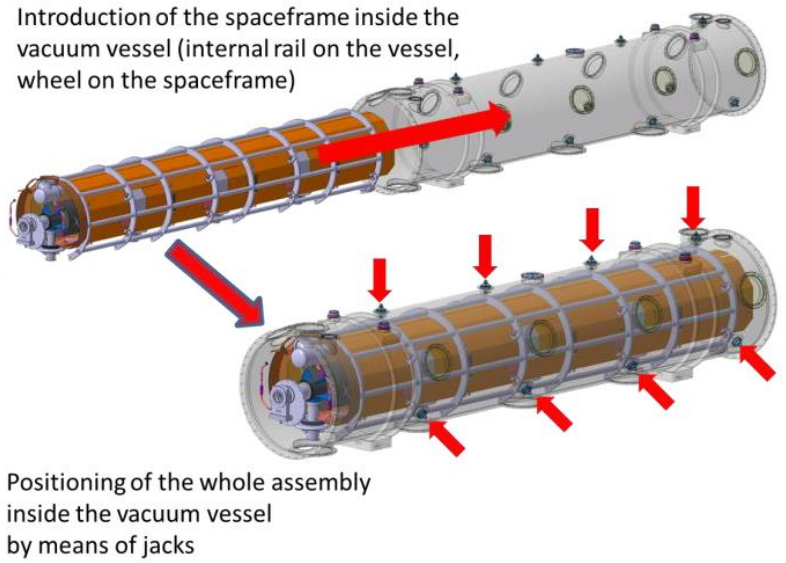
COLD MASS ALIGNMENT INTO VACUUM VESSEL



MODULE FINAL SURVEY AND DELIVERY

ASSEMBLY PROCESS





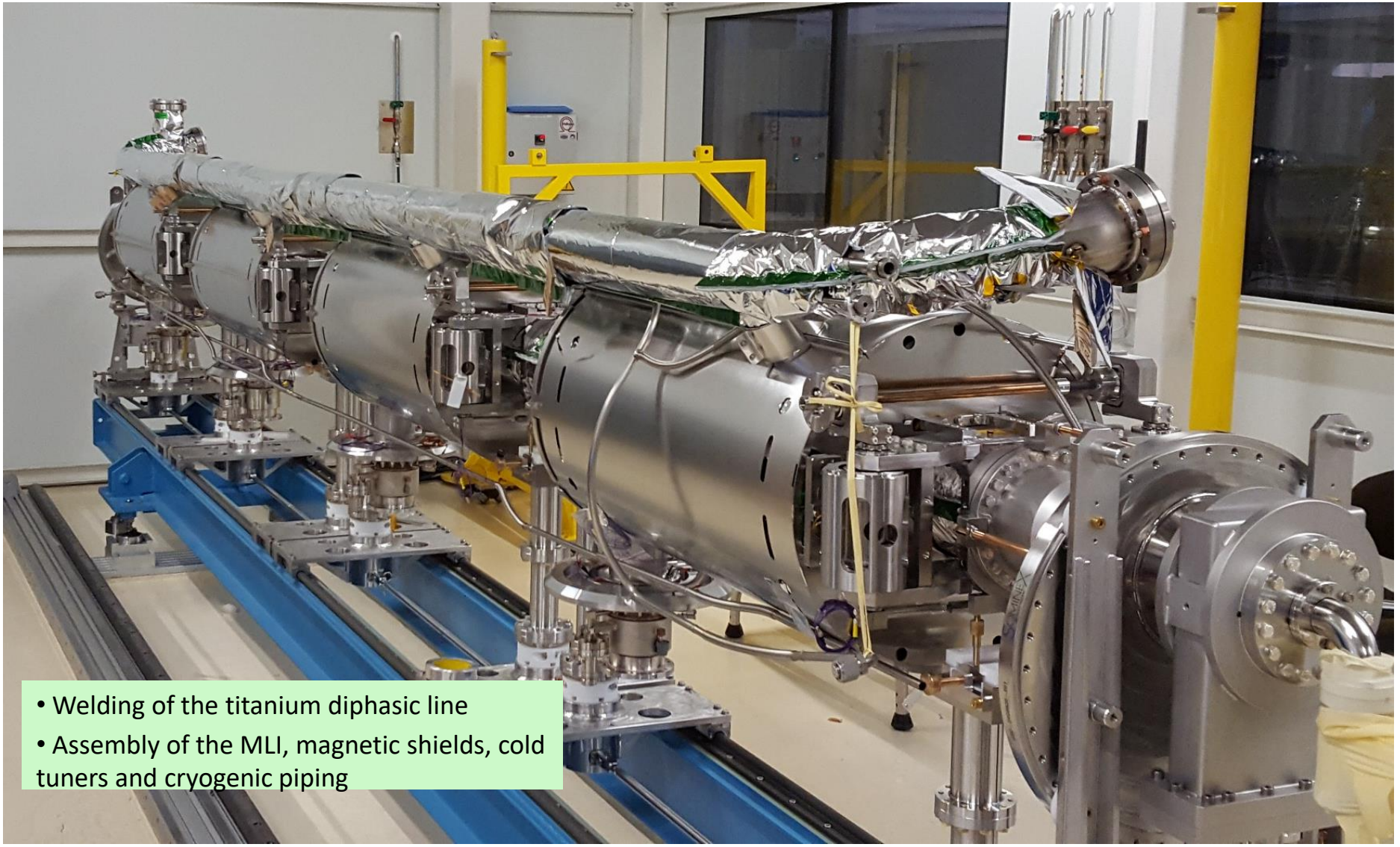
CRYOMODULE ASSEMBLY TRAINING USING A MOCK-UP CAVITY

- First validation of assembly toolings and assembly procedures
- Integration until the vacuum vessel

M-ECCTD CRYOMODULE CLEAN ROOM ASSEMBLY

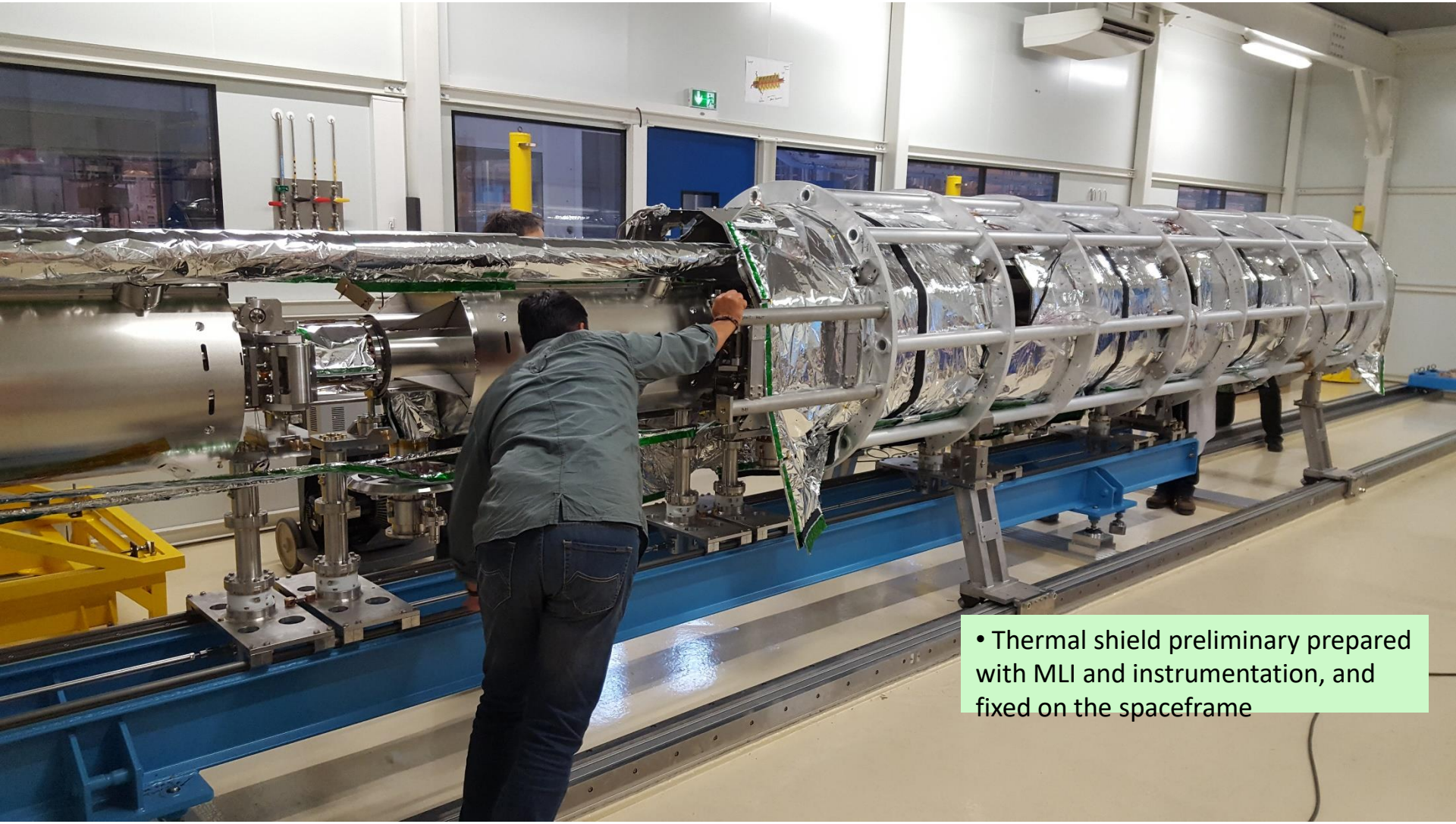
- Performed in the ISO4 Saclay clean room
- Nitrogen venting during assembly process
- XFEL type aluminium gaskets
- Cavities pre-aligned

CAVITY STRING DRESSING



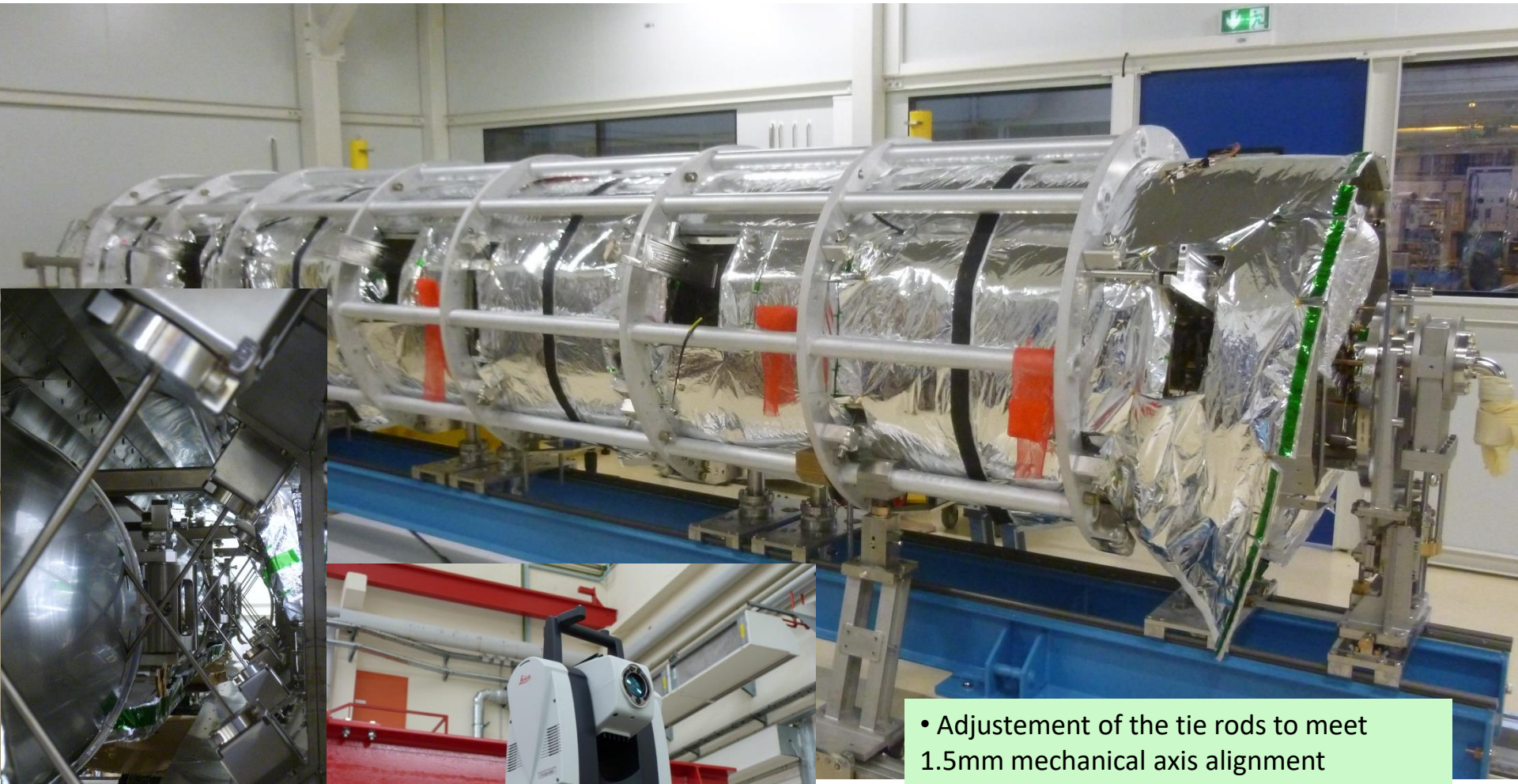
- Welding of the titanium diphasic line
- Assembly of the MLI, magnetic shields, cold tuners and cryogenic piping

CAVITY STRING INSERTION INSIDE THE SPACEFRAME



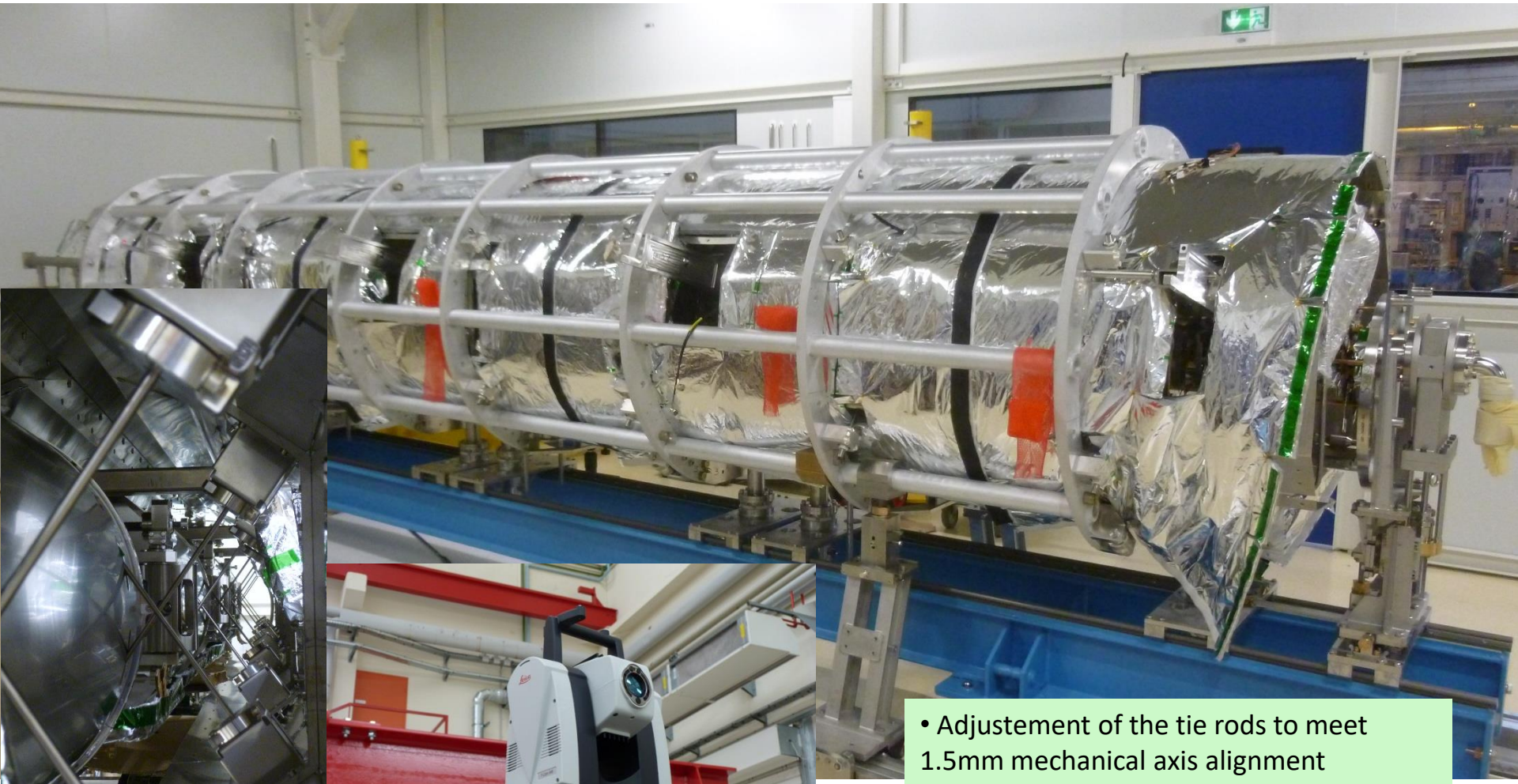
• Thermal shield preliminary prepared with MLI and instrumentation, and fixed on the spaceframe

ALIGNMENT



• Adjustement of the tie rods to meet 1.5mm mechanical axis alignment specifications

ALIGNMENT



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INSERTION OF THE COLD MASS INSIDE THE VACUUM VESSEL

INSERTION OF THE COLD MASS INSIDE THE VACUUM VESSEL

- Jumper connection assembly
- cryogenic connections at the cryomodule extremities
- Leak check of all the cryogenic circuits
- Closing the vacuum vessel