Wrocław University of Technology

Possible in-kind contribution from Wrocław University of Technology

Maciej Chorowski

Faculty of Mechanical and Power Engineering

ESS Partner and Industry Day in Poland 25.03.2014 Krakow

Content

1. Intro to Wrocław University of Technology
2. Scope if in-kind contribution to ESS
3. References from XFEL

Wrocław University of Technology

- **Employees**
  Academicians – 1921
  Administration – 2185 **All: 4106**
- **Students 32800**
- **Degree programmes**
  Bachelor of Sc. – 13, Master of Sc. – 25, PhD - 17

Wroclaw University of technology – 12 Faculties

- Faculty of Architecture
- Faculty of Civil Engineering
- Faculty of Chemistry
- Faculty of Electronics
- Faculty of Electrical Engineering
- Faculty of Geoengineering, Mining and Geology
- Faculty of Environmental Engineering
- Faculty of Computer Science and Management
- Faculty of Mechanical and Power Engineering
- Faculty of Mechanical Engineering
- Faculty of Fundamental Problems of Technology
- Faculty of Microsystem Electronics and Photonics

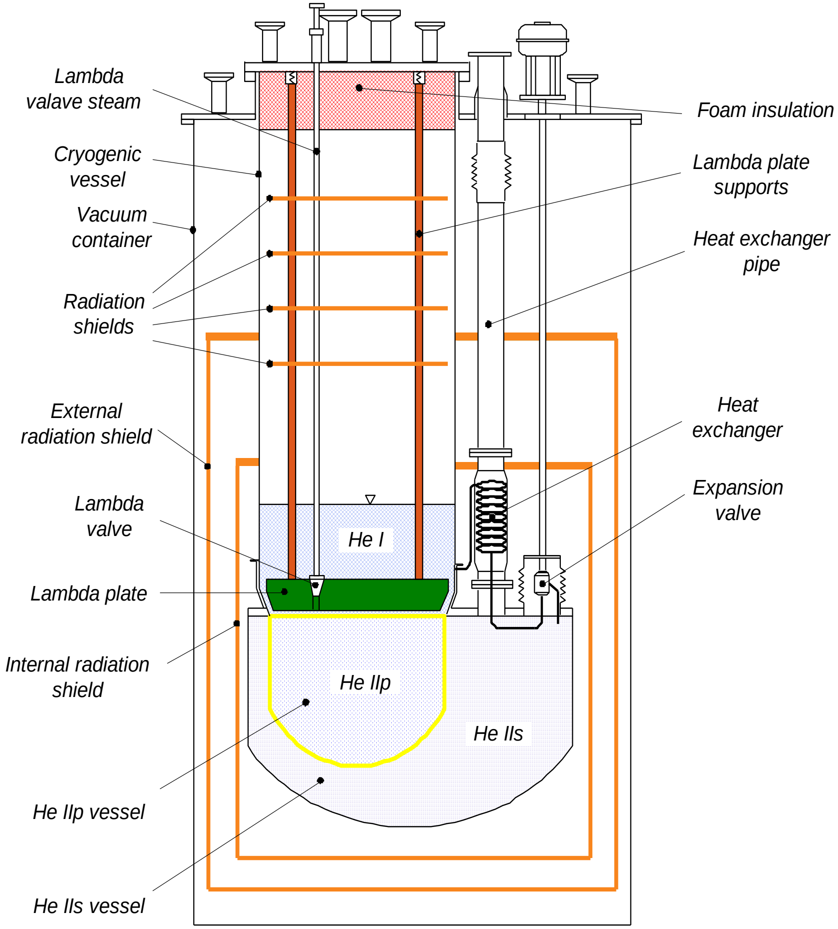
Main topics of competence in cryogenics

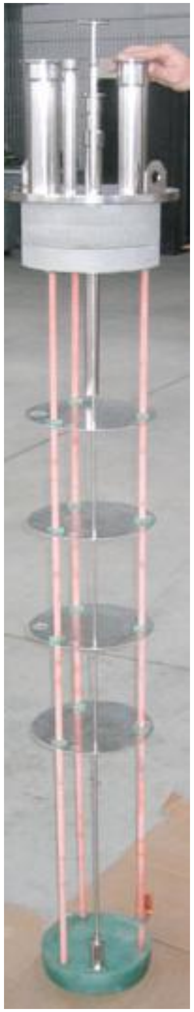
- Thermodynamic studies of cryogenic systems
- Design and commissioning of cryogenic installations including gas liquefiers
- Risk and safety analysis of cryogenic systems
- Reception tests of cryogenic installations
- Pressure and helium tightness tests of cryogenic equipments
- Transfer lines and cryostats (including superfluid helium cryostats) designs and studies
- Modeling and experimental investigation of cryogenic thermal insulation
- Numerical investigation of cryogenic phenomena
- Cryogenic technologies for medical applications
- New materials in cryogenics
- Modelling of the dynamics of high order inertia systems

Wrocław University of Technology

Superfluid helium cryostat designs and studies

Next European Dipol cryostat

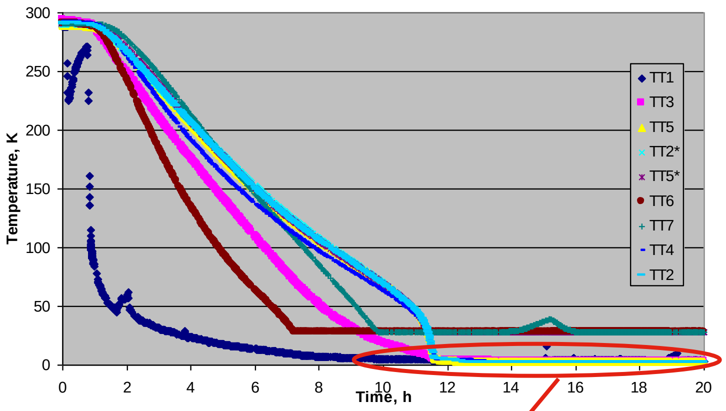


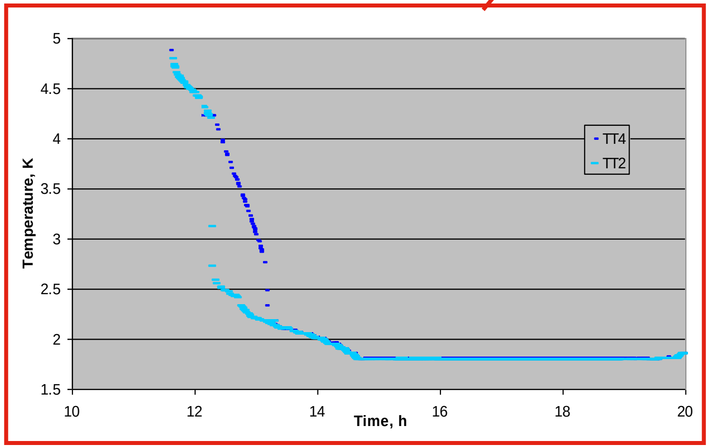


Superfluid helium cryostat designs and studies

The cryostat in the CARE-NED experimental set-up in CEA Saclay,

1 – Cryostat NED
2 – Cryostat insert
3 – Instrumentation
4 – Pumping and recovery line
5 – Liquid helium dewar





Temperatute evolution during the first cryostat cool-down

Wrocław University of Technology

Risk and safety analysis of cryogenic systems

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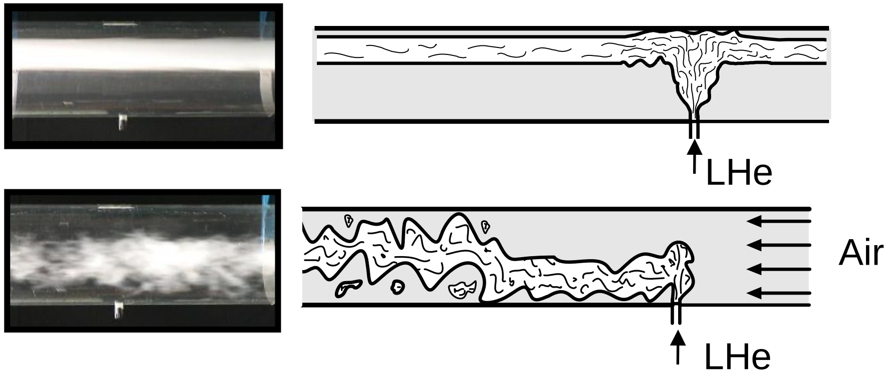
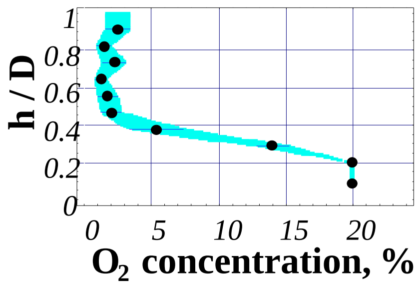
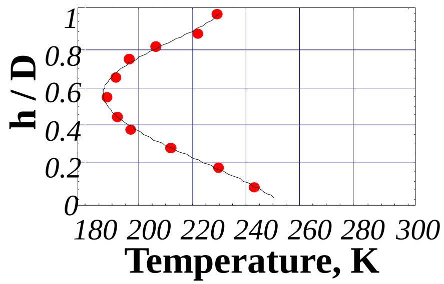
Test set-up build and operated at WUT

Visualisation results



Measurement results



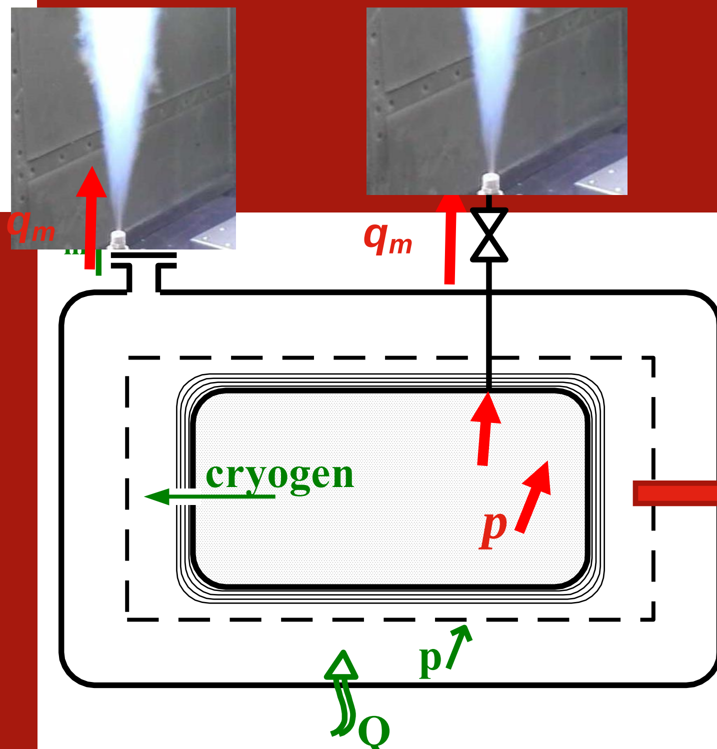


Reception tests of cryogenic systems

Some members of WUT cryogenic grup in the LHC tunnel

The LHC Cryogenic Distribution Line during the reception tests in sector 8-1

Safe operation of cryogenic systems



- Mechanical break of warm vacuum vessel
- Fast degradation of vacuum insulation with air
- Intensive heat flow to the cryogen
- *Magnet quench (optionally)*
- Pressure increase of the cryogen
- Opening of the safety valve
- Cryogen discharge through the safety valve

Underestimation of heat flux to the helium caused serious damage of the LHC accelerator in 2008

Large Hadron Collider accident - faulty electrical joint of two superconductors

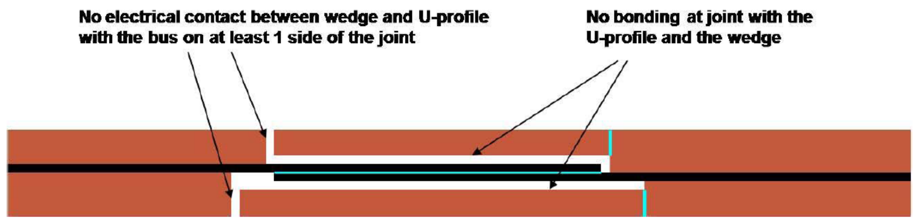
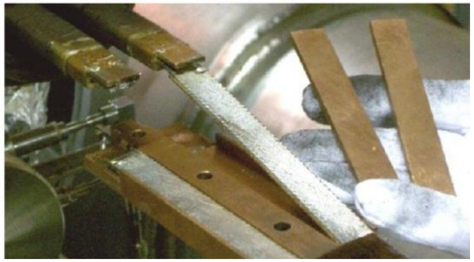
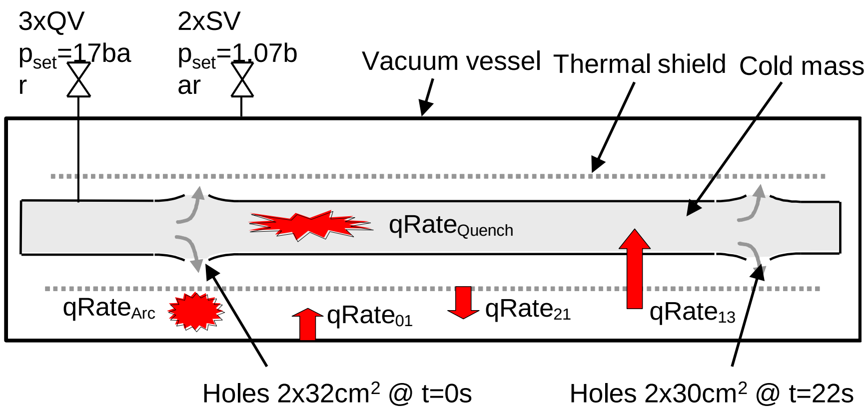
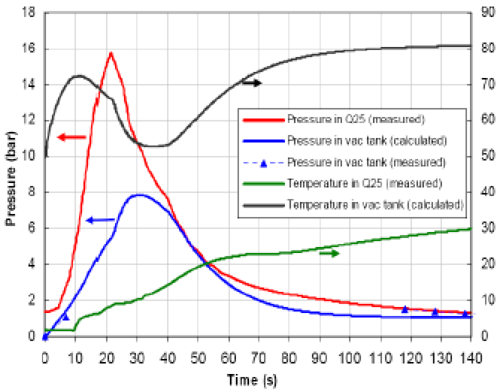


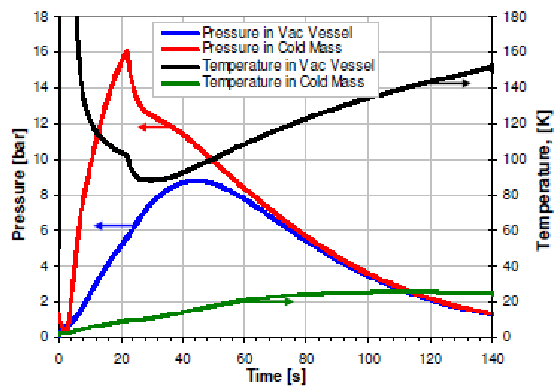
Figure 7: Model of resistive joint in bus bar with bad electrical and thermal contact with the stabilizer



Thermodynamic model







Maciej Chorowski et. al., CERN Note 2009

The European Spallation Source
Call for Expressions of Interest Response Form

The following form is provided for your convenience to assist in responding.

Organisation Name: Wroclaw University of Technology

Address: Wybrzeze Wyspianskiego 27, 50-370 Wrocław, Poland

Contact Person: Prof. Maciej Chorowski

Email: Maciej.Chorowski@pwr.wroc.pl

Telephone: +48695350487

1. Has your organisation already had cooperation with the European Spallation Source? **YES** / NO

2. Has your organisation already discussed contributing to ESS with your relevant funding agencies or ESS Steering Committee representative? **YES** / NO

3. Please briefly describe your organisation and experience with projects similar to the contribution(s) you are proposing, including relevant in-kind contributions. Please include any publications or references you feel are relevant:

Wroclaw University of Technology (WrUT) is a leading Polish technical university with excellent competencies in mechanical and thermal engineering including cryogenics. The University is composed of 12 faculties including Mechanical and Power Engineering Faculty and Mechanical Faculty. The cryogenic group from the Faculty of Mechanical and Power Engineering has cooperated with international laboratories and organizations since 1998. The main topics of collaborations are: risk analysis of cryogenic systems (performed for the LHC, ITER, XFEL and other projects), thermohydraulics of magnet resistive transitions, superfluid He II cryogenic systems and heat transfer, design and commissioning of complex helium transfer lines and cryostats. Wroclaw University of Technology contributed the XFEL free electron laser construction with the in-kind supply of four process pipes helium transfer line XATC1 and two vertical He II cryostats XATC1 and XATC2 with transfer lines. The responsibility of WrUT was conceptual and technical design of the items, production supervision, instrumentation and control loops installation, and reception tests (both factory and final).The other works relevant for a potential contribution to ESS were: thermomechanical analysis of ITER helium transfer lines and storage system, thermo-mechanical analysis of LHC helium storage tanks, construction and commissioning of various He II cryostats (commissioned e.g. at CEA Saclay).

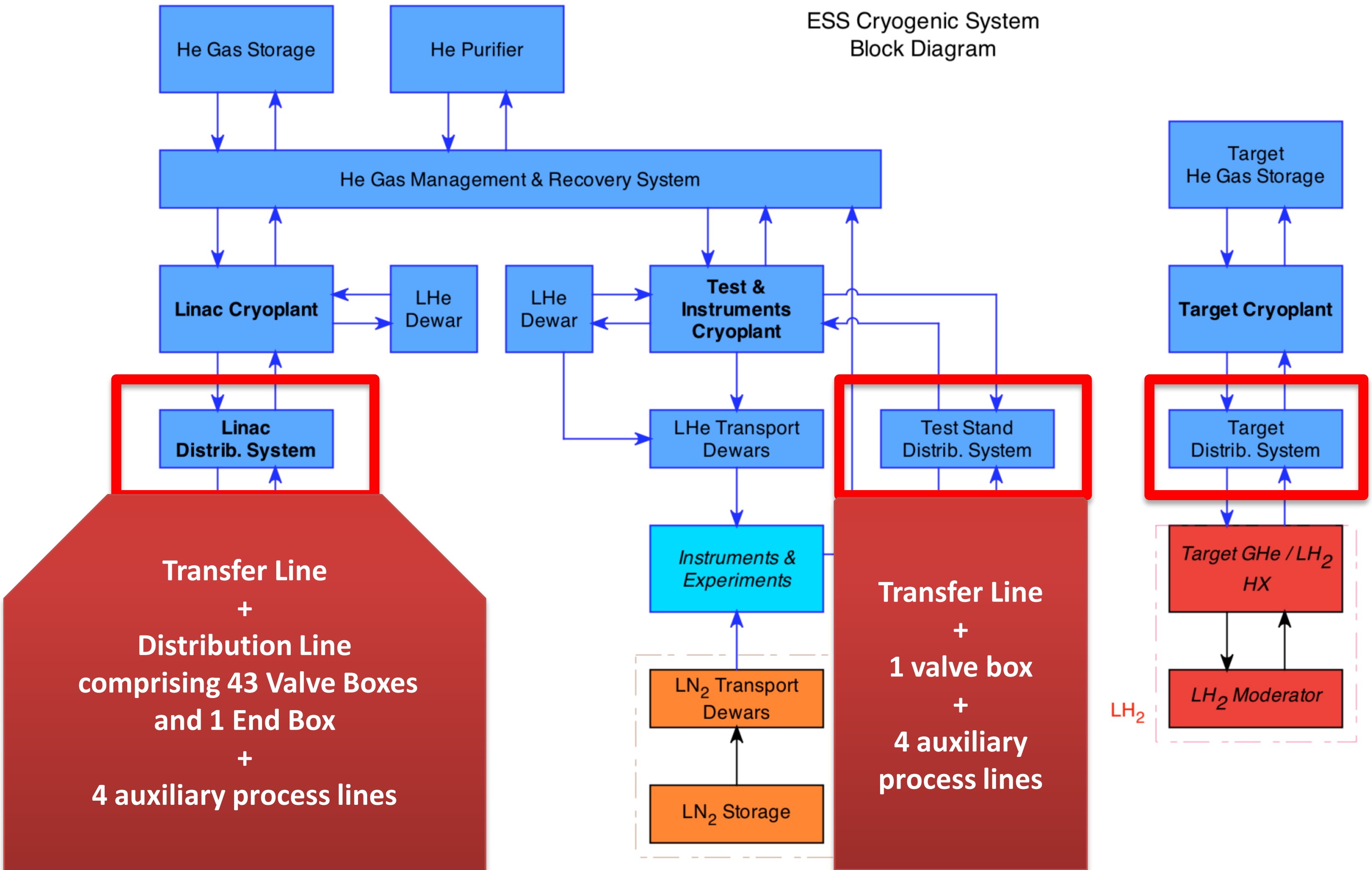
European Spallation Source ESS AB
Visiting address: ESS, Tunavägen 24
P.O. Box 176
SE-221 00 Lund
SWEDEN
www.esss.se

4. Work Package(s) - Please indicate which work package(s) your organisation is interested in contributing to

WBS Code	WBS Name	Would your organisation like to contribute to the package in total or in part? Please write "total", or if in part, please describe your proposed contribution.
ACCSYS.11	Cryogenics	We would like to contribute to development of an integrated Helium Gas Management System. The proposed contribution comprises a conceptual and detailed design for an integrated Helium gas management system including connections to the Accelerator and Test & Instruments cryoplants, Accelerator Distribution system, recovery system for helium used in the neutron instruments (including piping, recovery compressor, storage etc.), gas storage tanks, helium purifier (including a low temperature stage) and instrumentation for determining helium purity. Based on the detailed design, we would like to produce, install and commission all system equipment at the ESS site in Lund. We would also like to contribute to the risk analysis of the ESS cryogenic system.
ACCSYS.11.5	Cryogenic Distribution	We would like to contribute to the package in total.

5. Please provide any additional information you think is relevant for evaluating your organisation's proposed in-kind contributions:

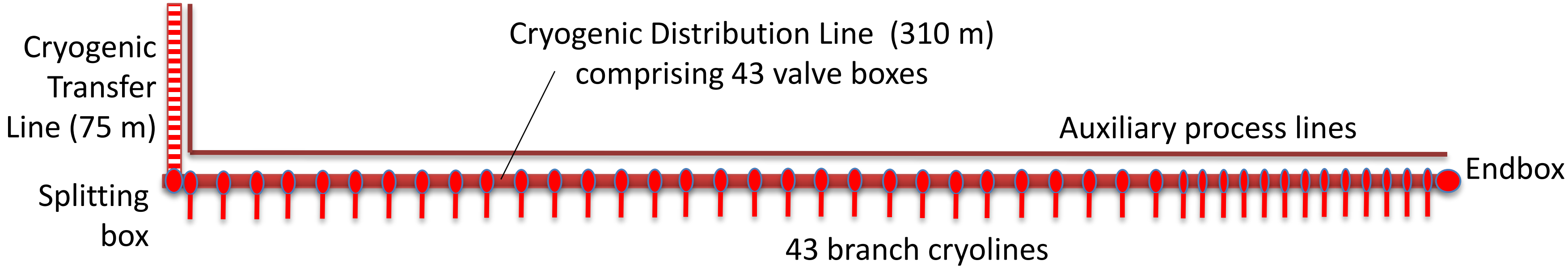
ESS Cryogenic System



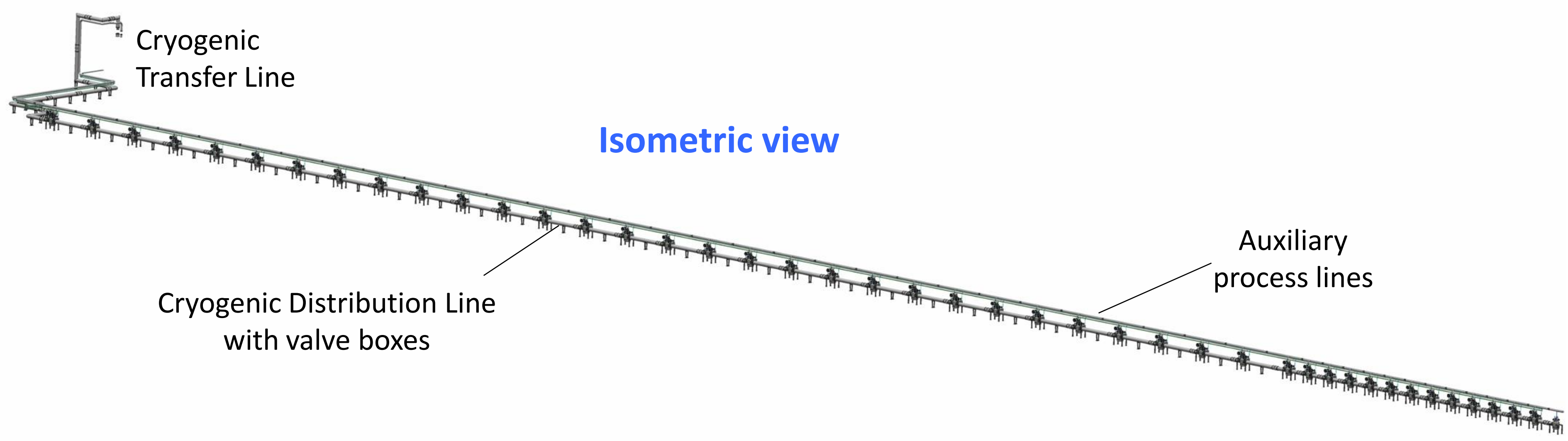
Linac CDS – function and layouts

Linac Cryogenic Distribution System (L-CDS)

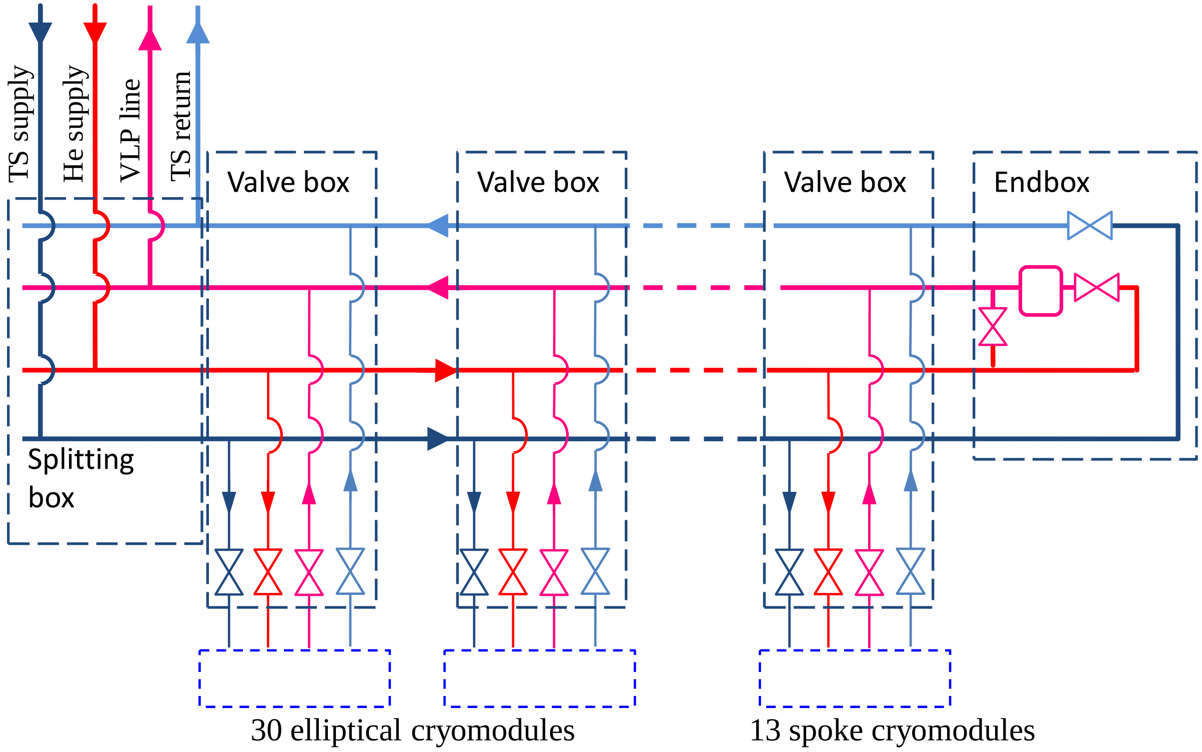
Layout



Isometric view



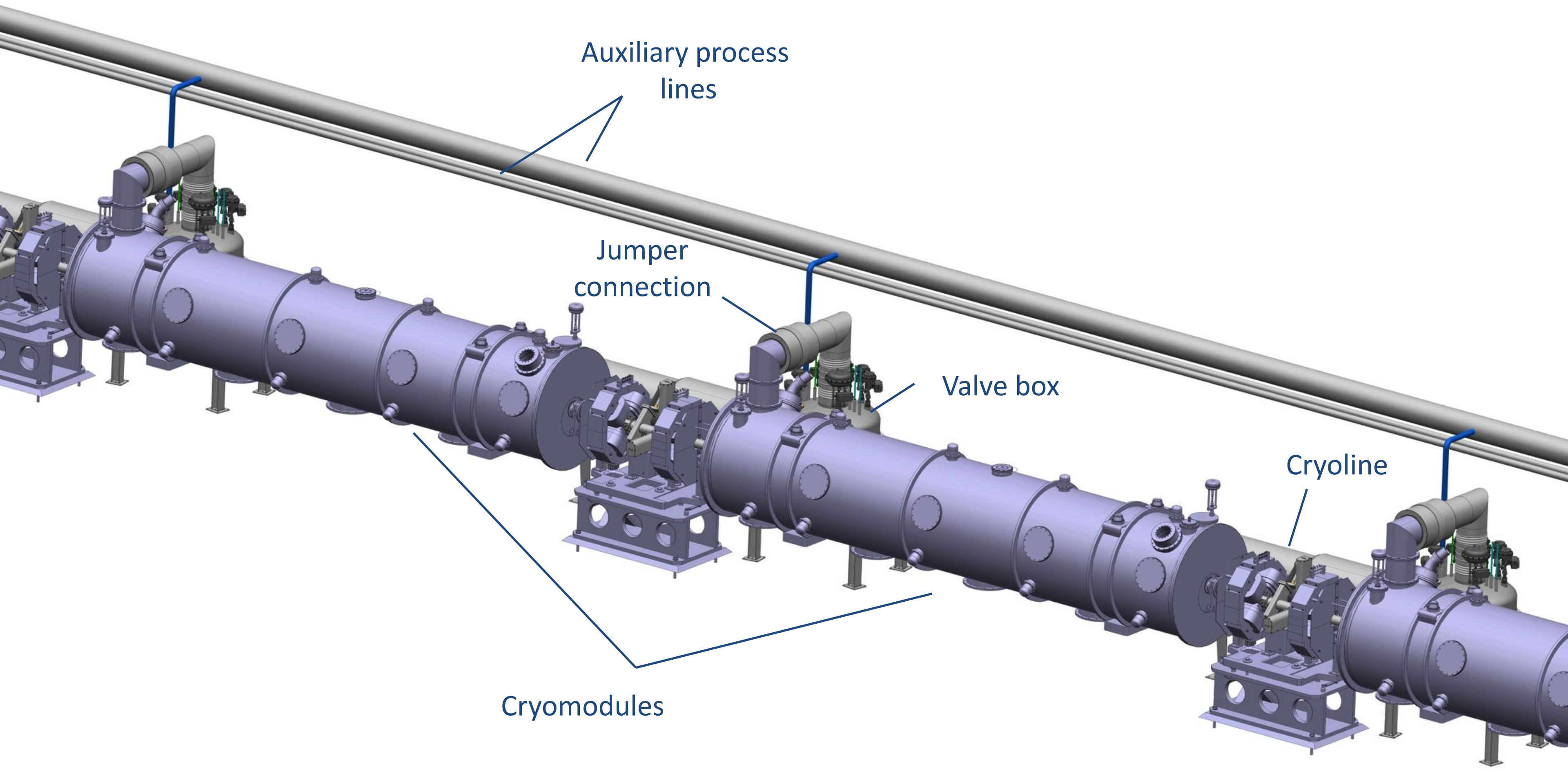
Linac CDS – general flow scheme



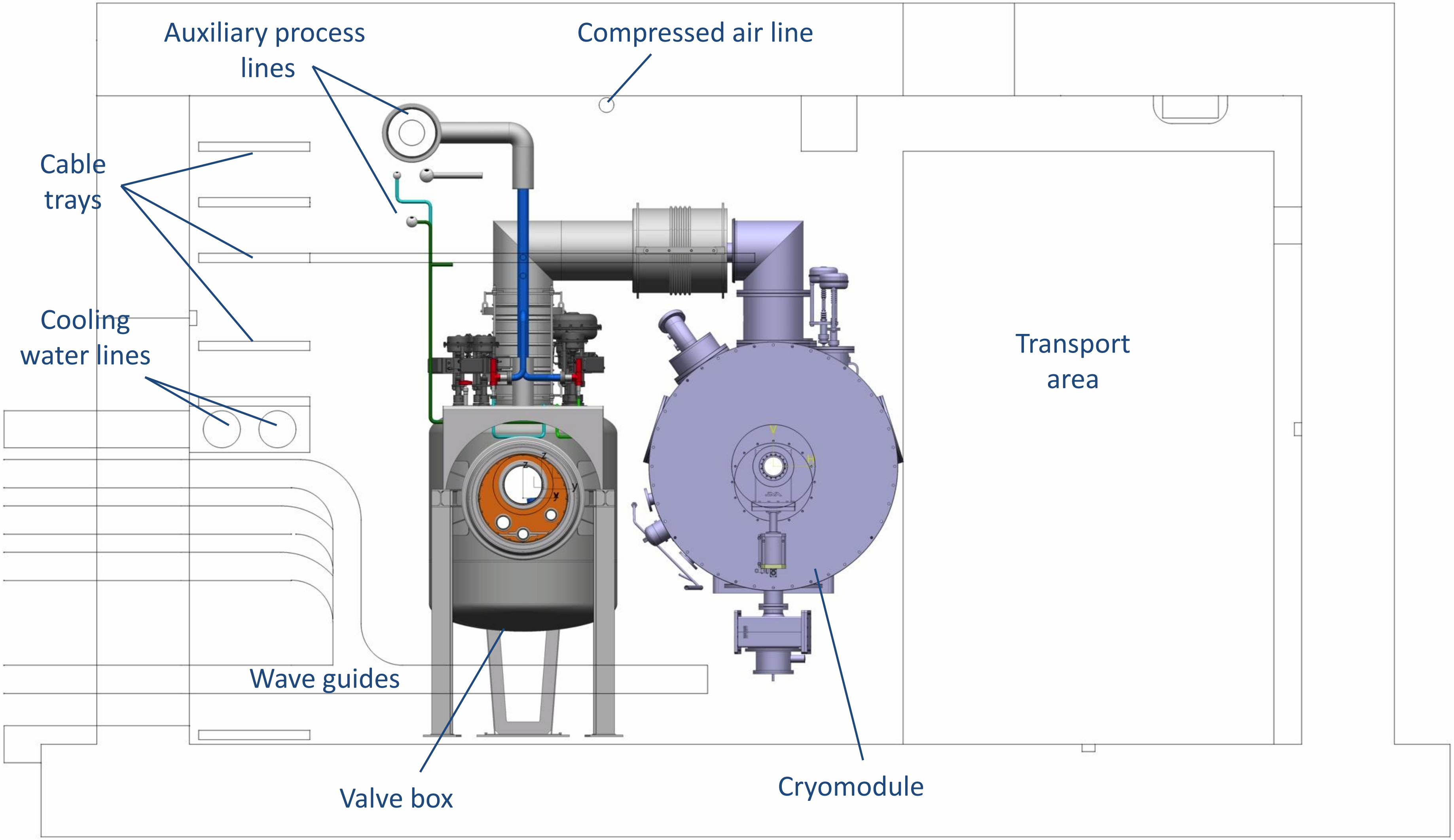
Two main cryogenic circuits:

- thermal shield circuit (TS supply and TS return lines)
- cold helium circuit (Helium supply and VLP lines)

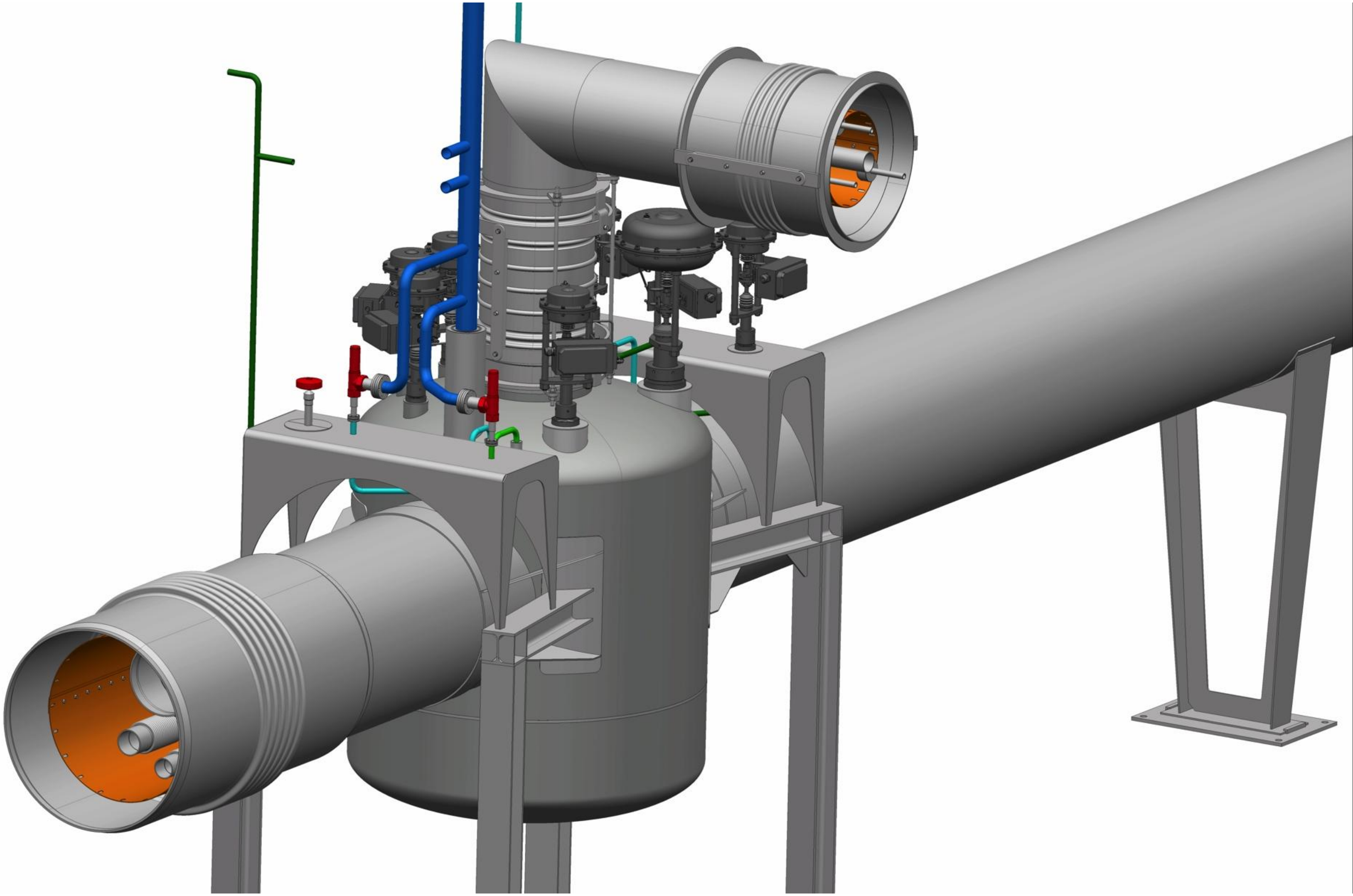
Linac CDS isometric



Linac CDS - position in the tunnel

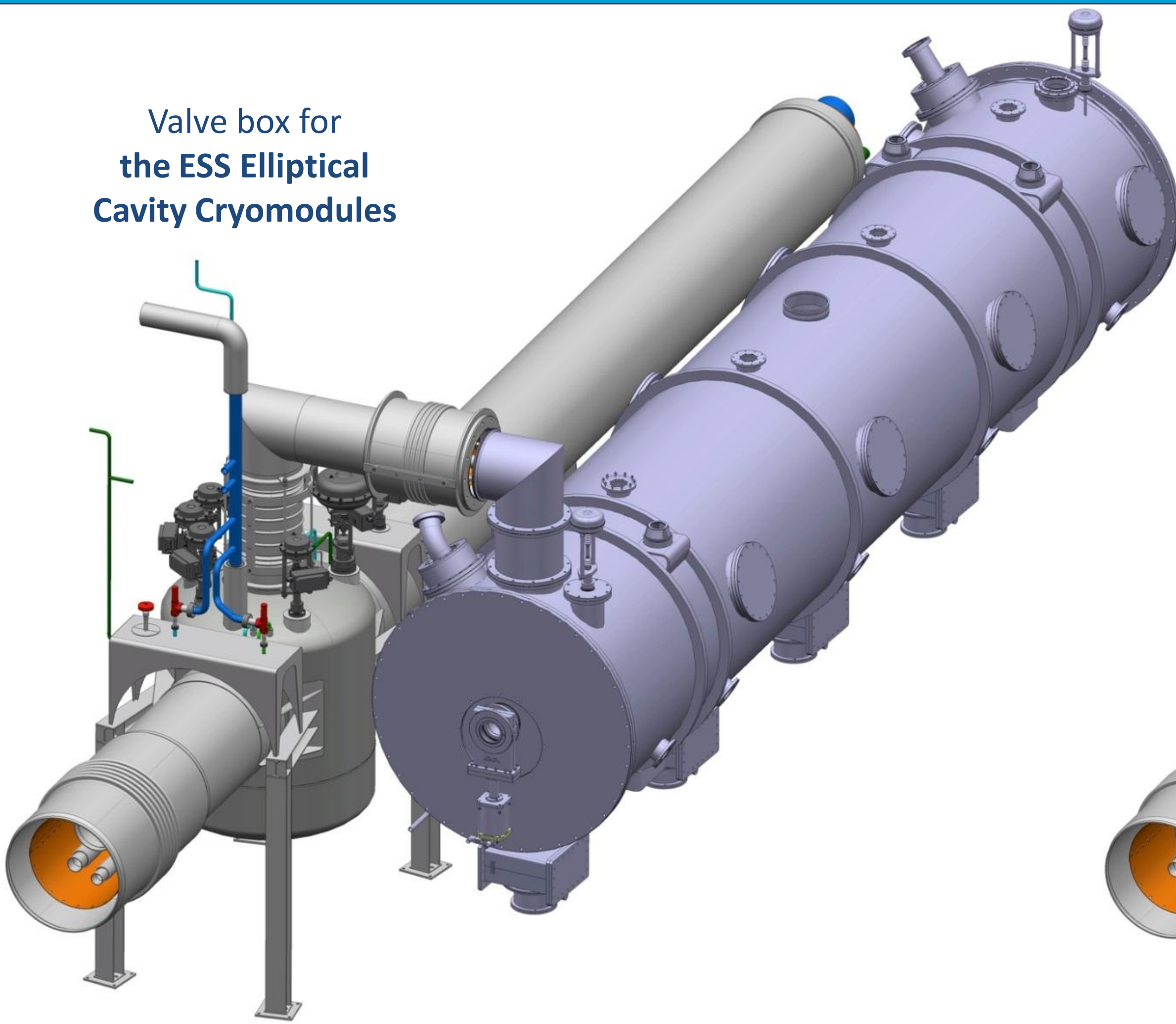


Valve box conceptual design

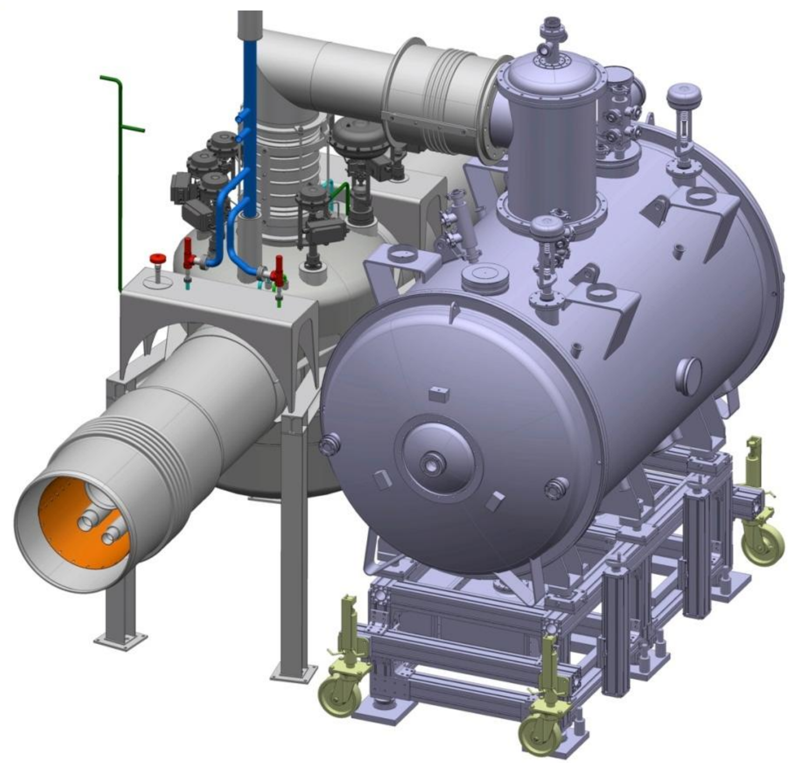


Valve box types

Valve box for
the ESS Elliptical Cavity Cryomodules



Valve box for
the ESS Spoke Cryomodules



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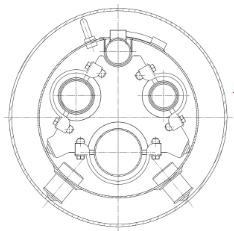
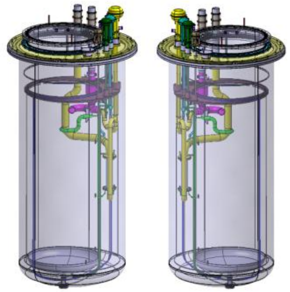
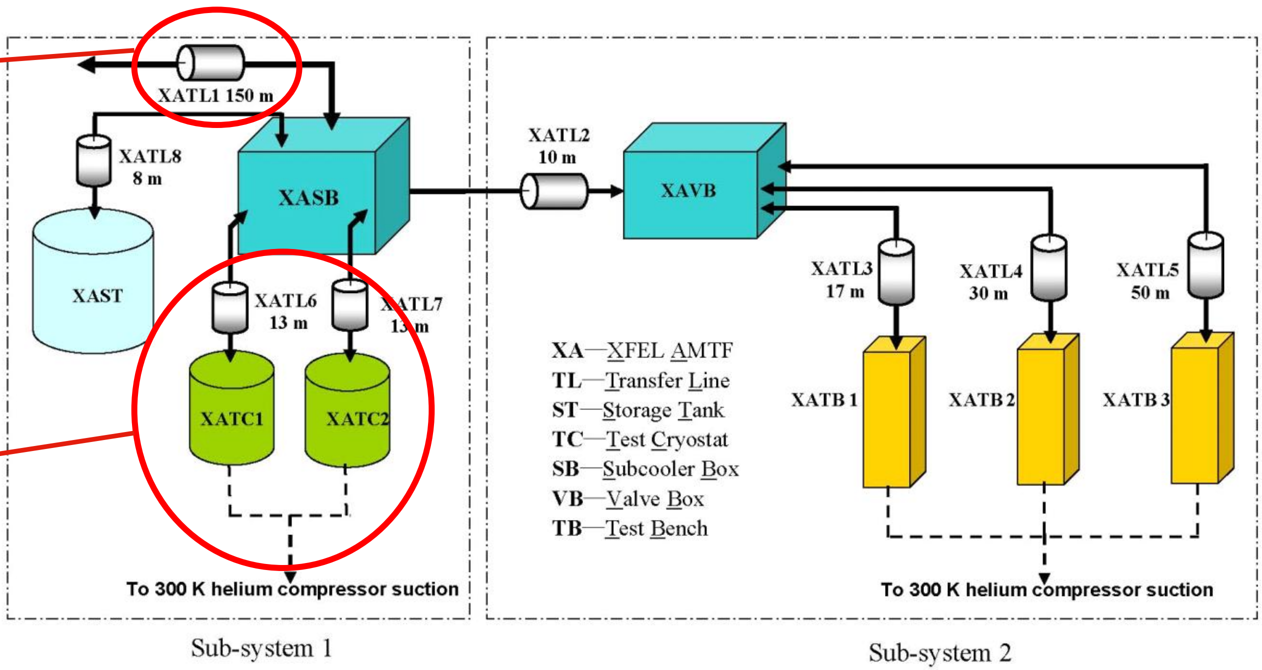
Example of WUT in-kind contribution - transfer line and vertical cryostats for the XFEL AMTF hall at DESY site, Hamburg

WUT at IKC to the XFEL cryogenics

Wroclaw University of Technology is responsible for design, manufacturing, transportation and installation of the cryogenic transfer line XATL1 and two vertical cryostats XATC1/2 together with their connection cryolines XATL6/7.

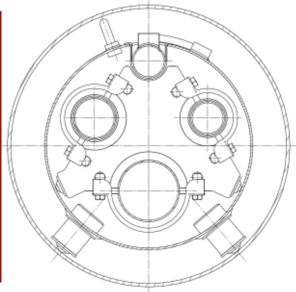


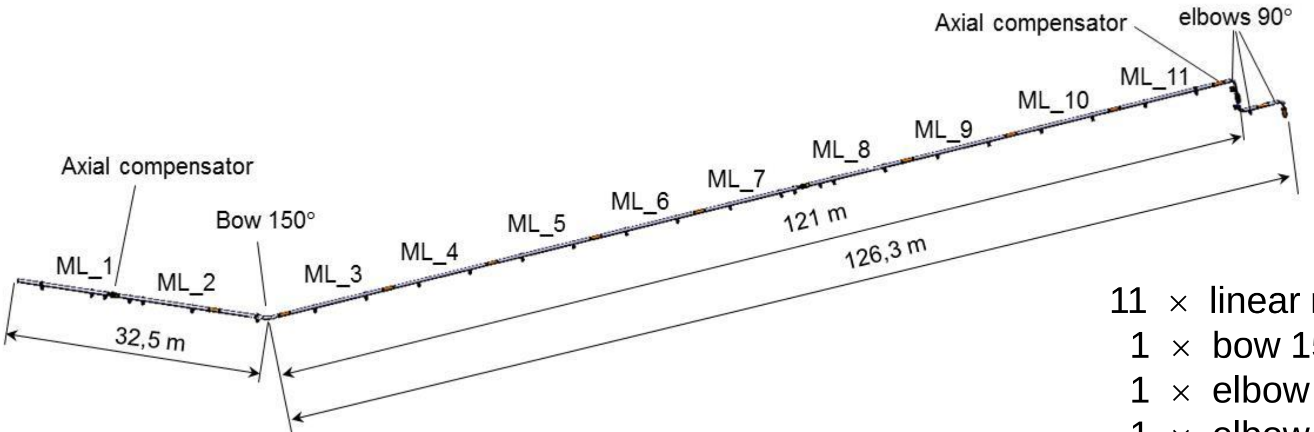




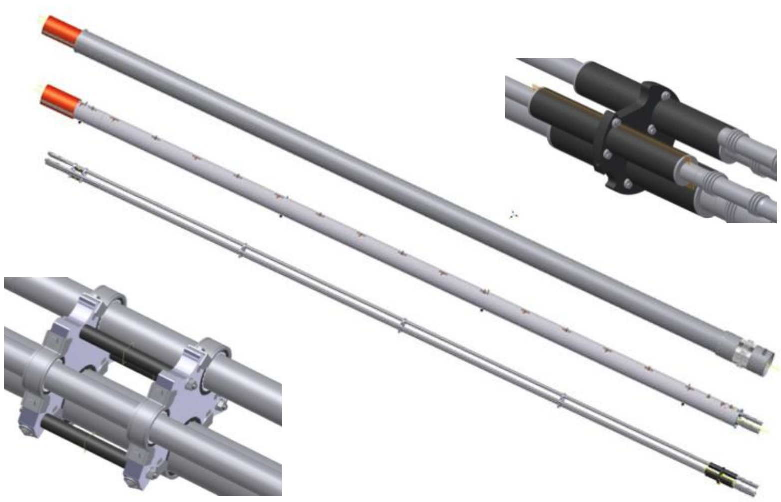
Layout of the Accelerator Module Test Facility

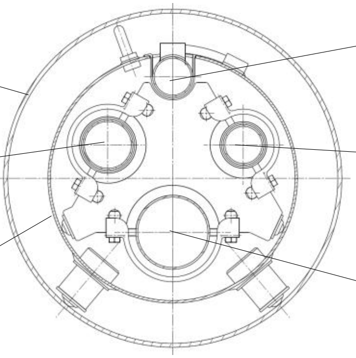
Design of the XATL1 cryoline





11 × linear modules (13 m)
1 × bow 150° (6,5 m + 1,5 m)
1 × elbow 90° (2,5 m + 3,7 m)
1 × elbow 90° (2,0 m + 3,2 m)
1 × elbow 90° (2,0 m + 2,7 m)
in tota: ~167 m





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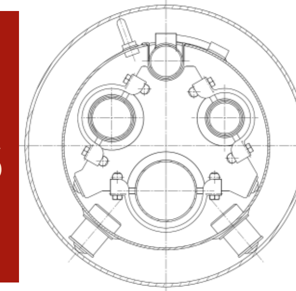
Production of the XATL1 modules



Chosen phases of the manufacturing and assambly of the linear modules

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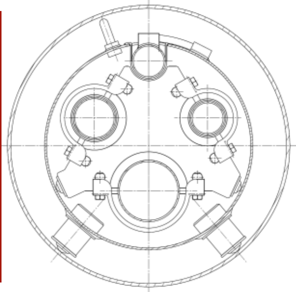
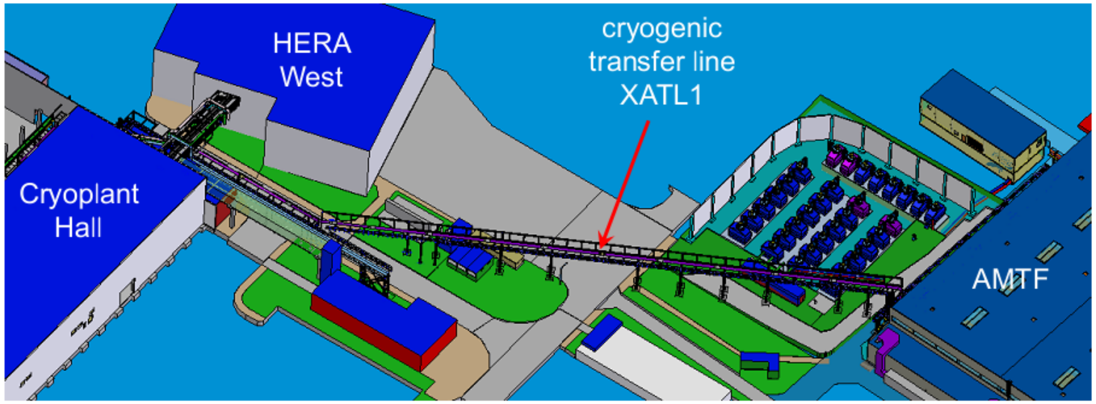
Installation of the XATL1

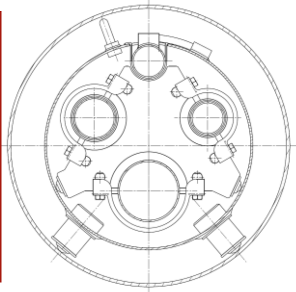


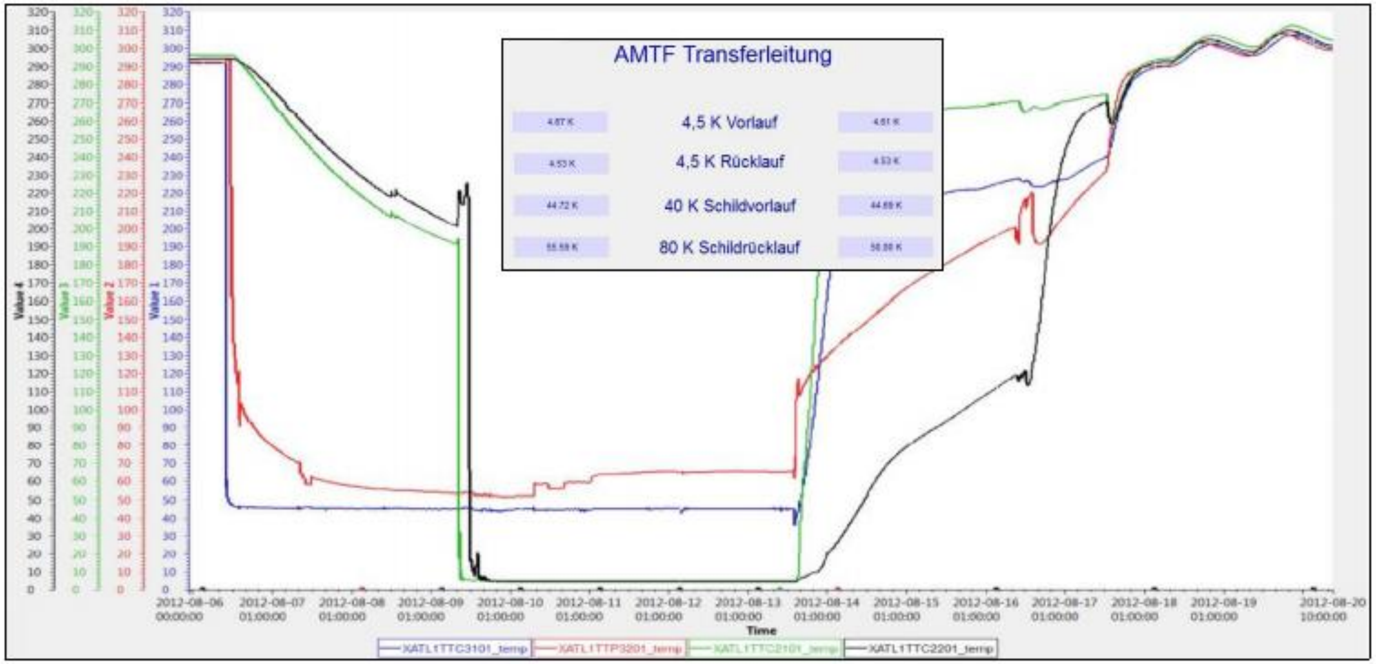


Schematic location of the crygenic transfer line XATL1 on the bridge between cryoplant hall and XFEL/AMTF hall

Installation of the XATL1 included precise positioning, high-quality welding works, wrapping superinsulations in the 16 module interconnections

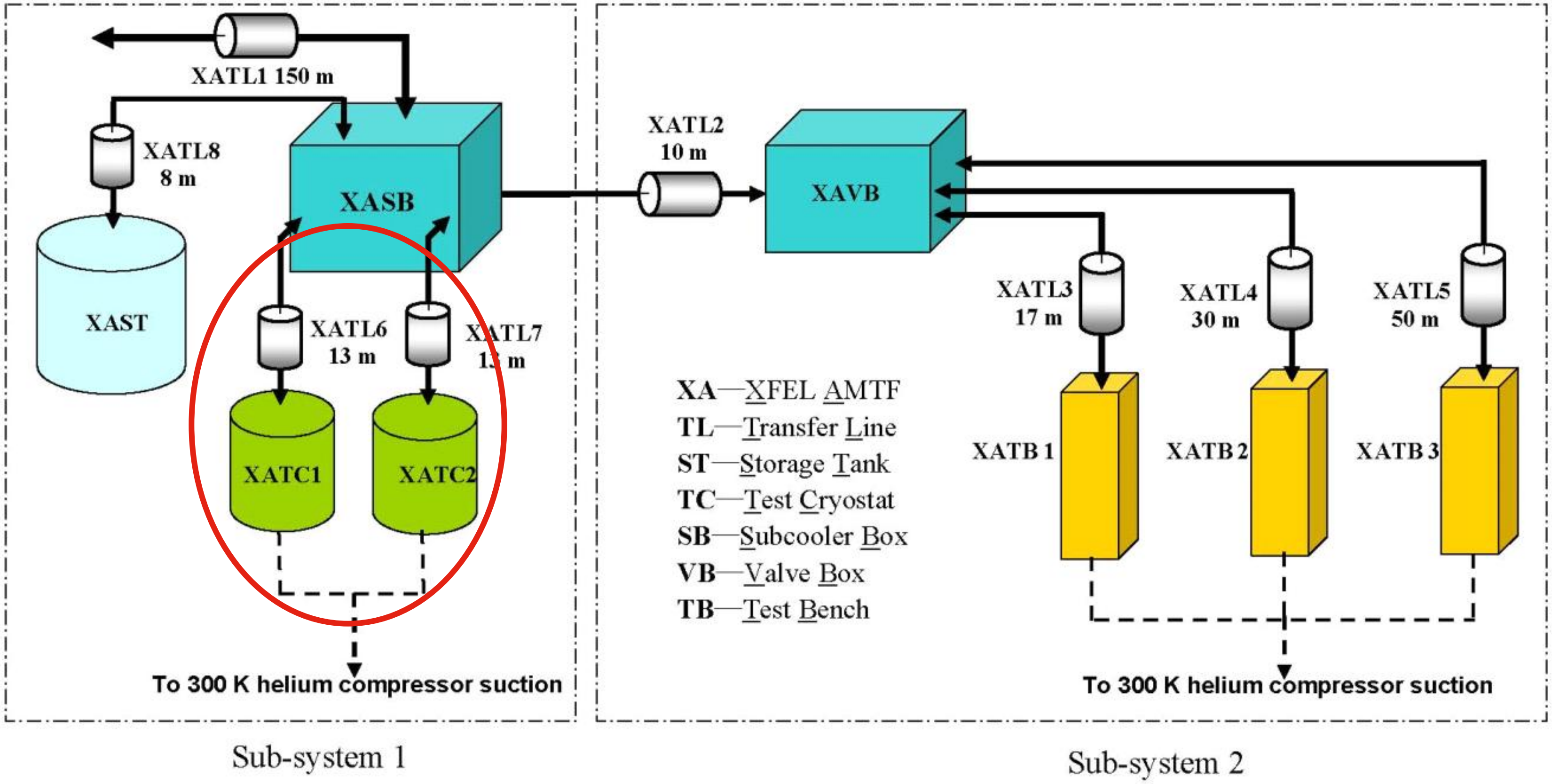
XATL1 first cool down



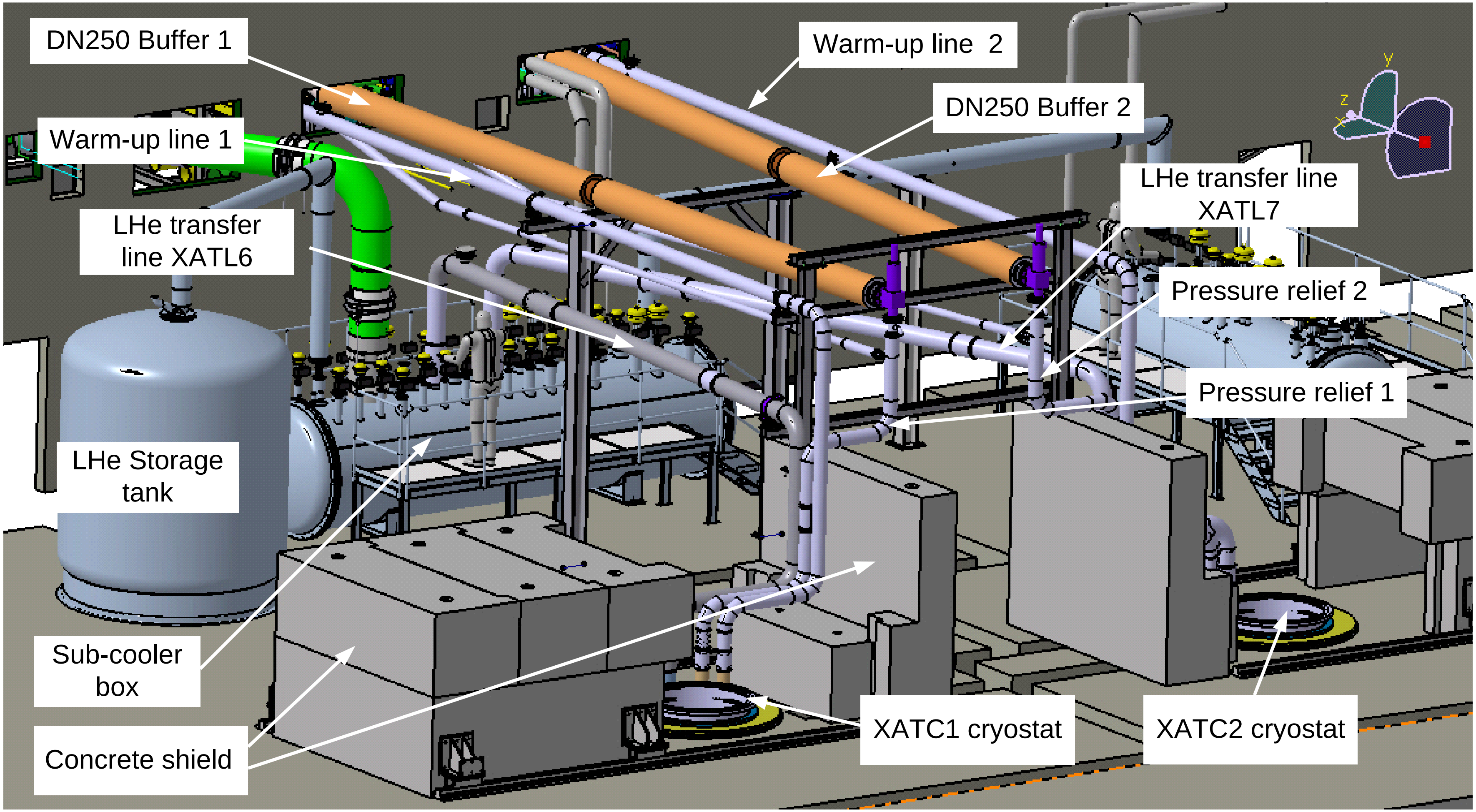


The first cool down of the cryogenic transfer line XATL1 to the nominal temperatures was succesfully carried out in August 2012

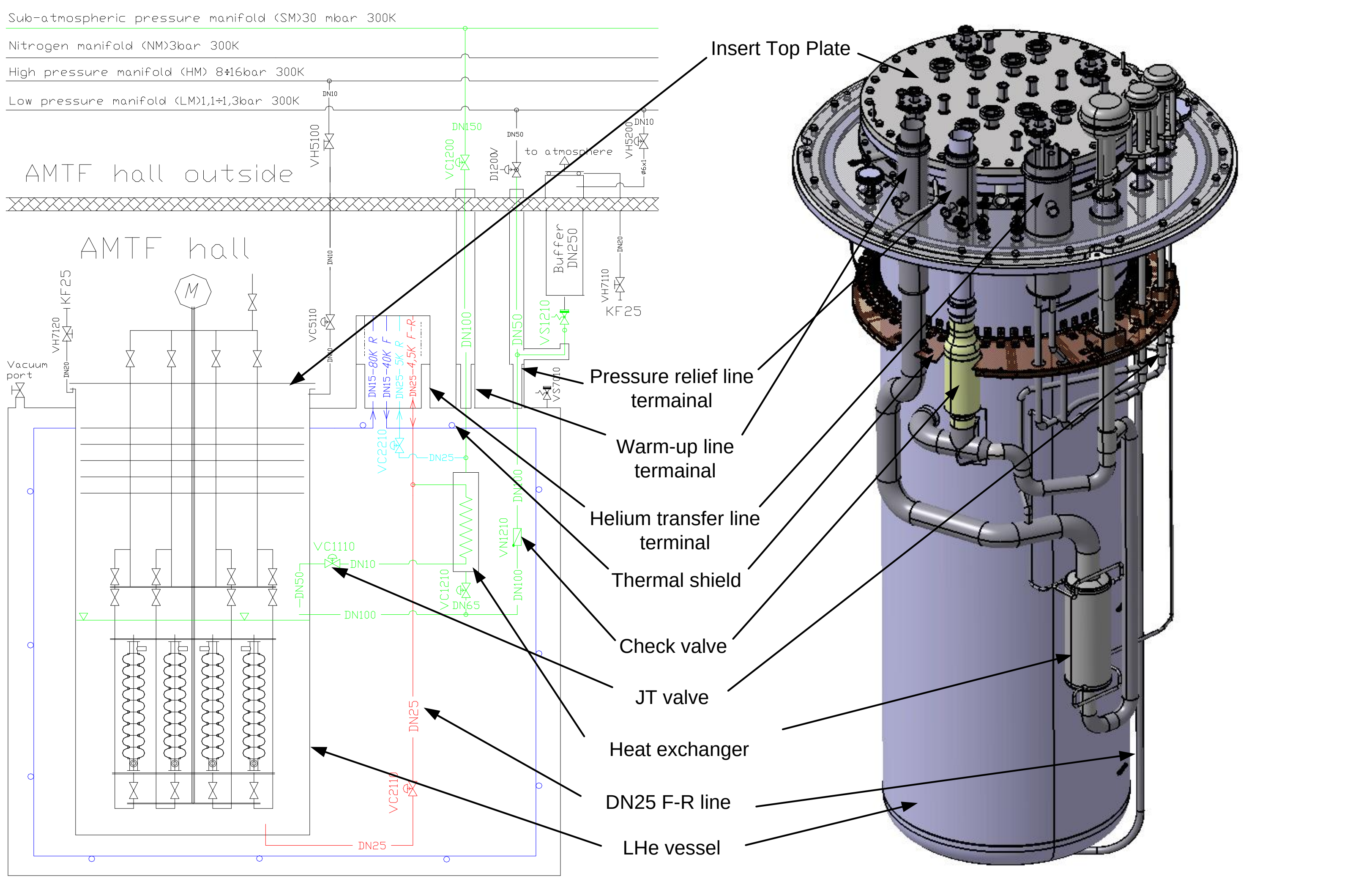
AMTF Hall cryogenic structure



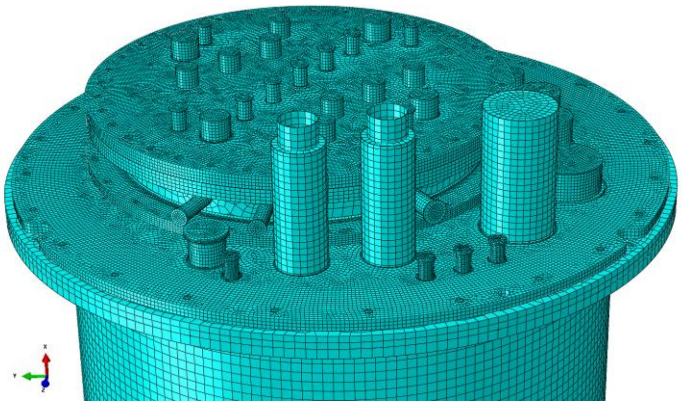
XATCs cryostats layout at AMTF Hall

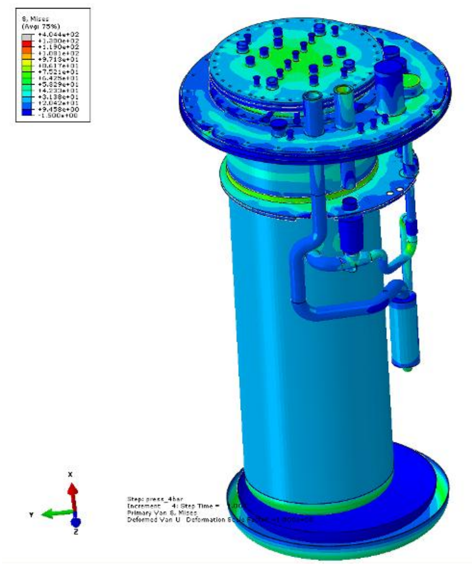


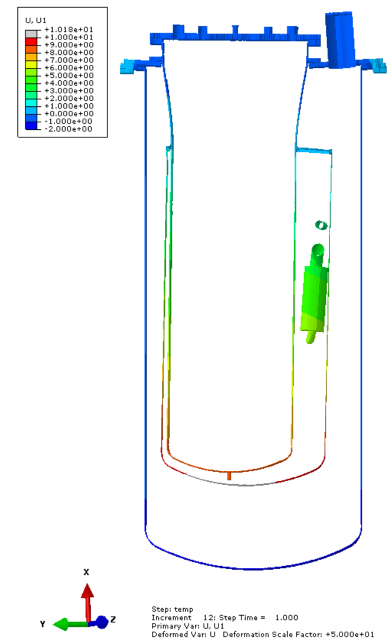
XATC cryostats conceptual design

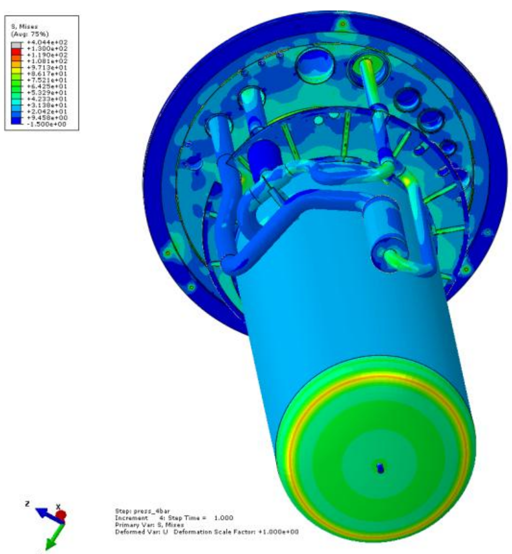


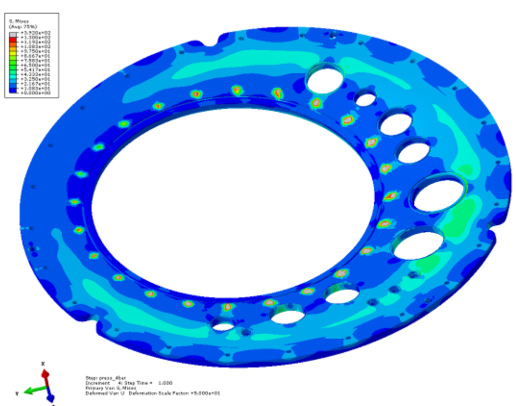
Thermo-mechanical calculation of XATC cryostat structure

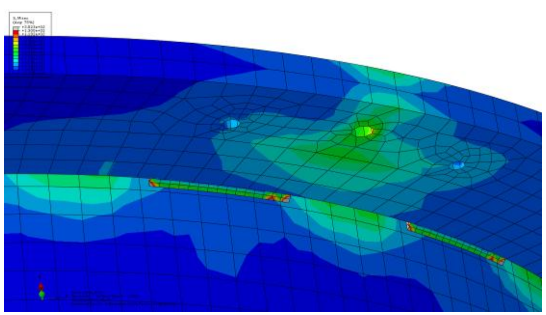




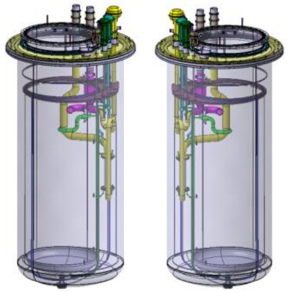




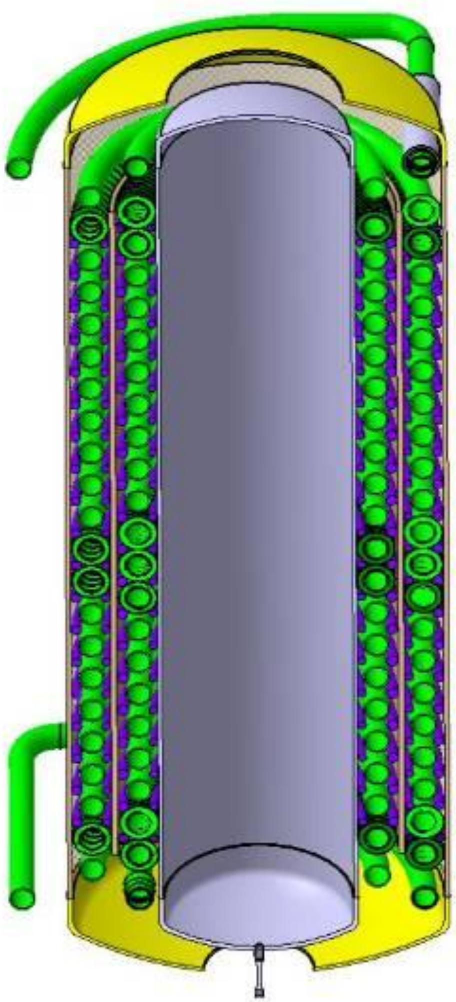


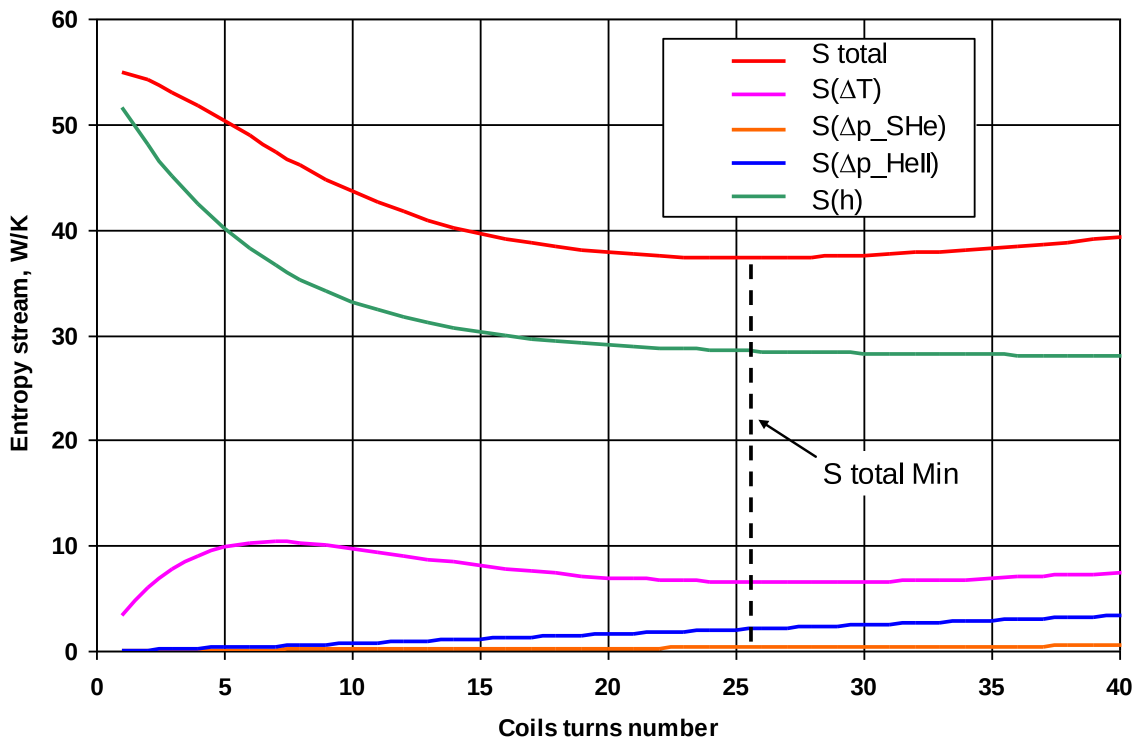


Production of the XATC cryostats



Design and thermodynamic optimization of the Low Pressure Heat Exchanger (LPHE)





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Low Pressure Heat Exchanger (LPHE)

LPHE double coil after installation

Fully assembled LPHE

XATC cryostats production

XATL 6/7 thermo-mechanical calculation

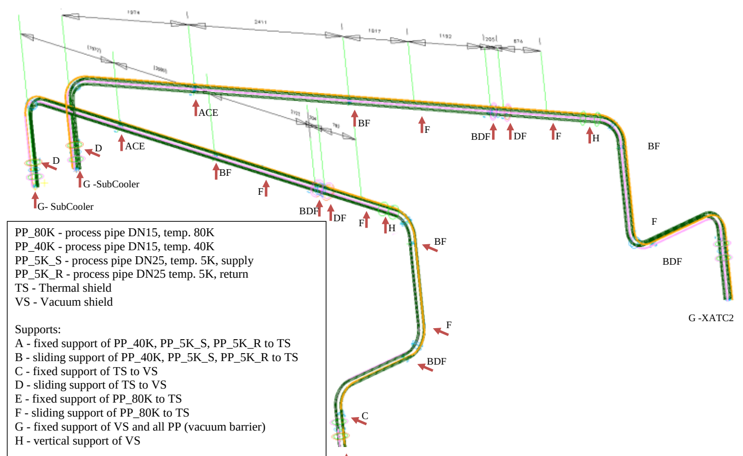
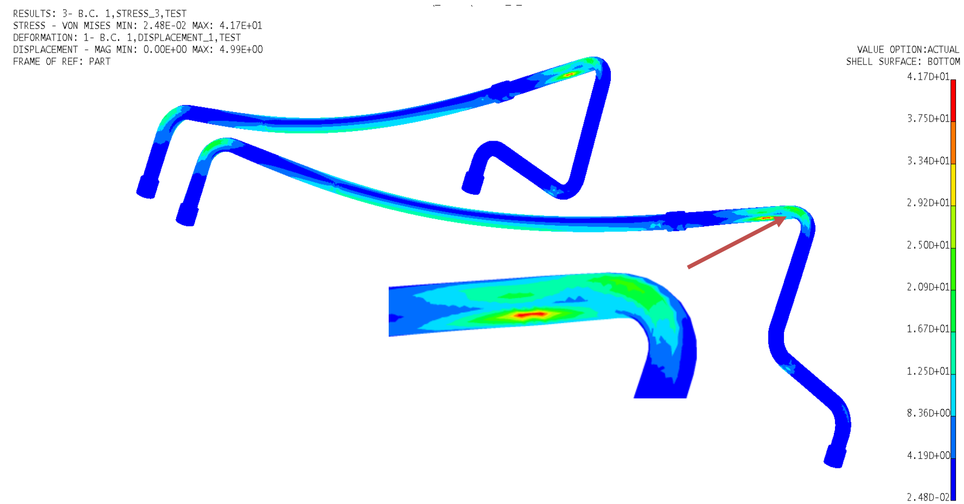
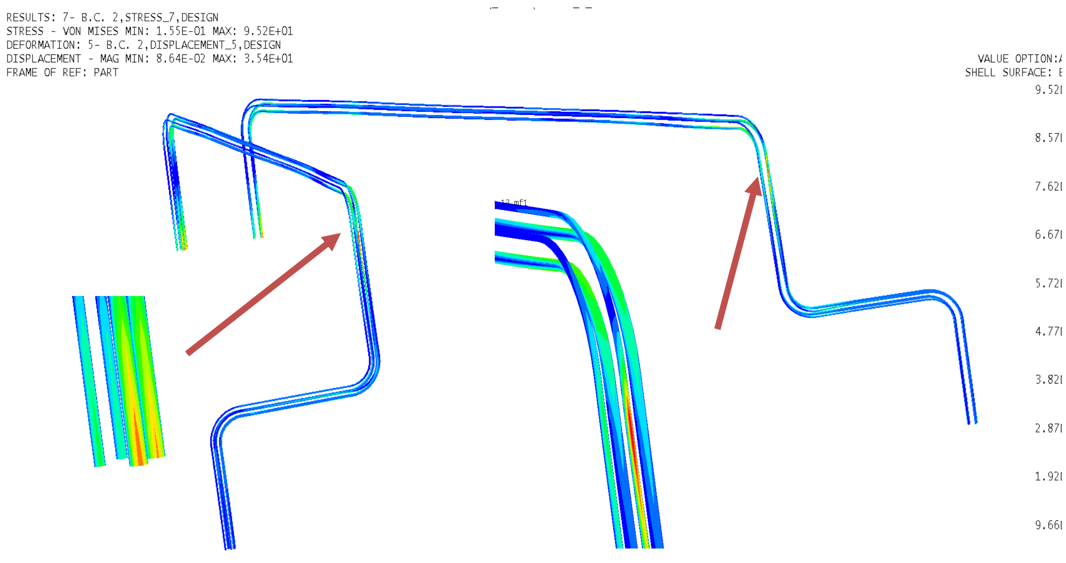
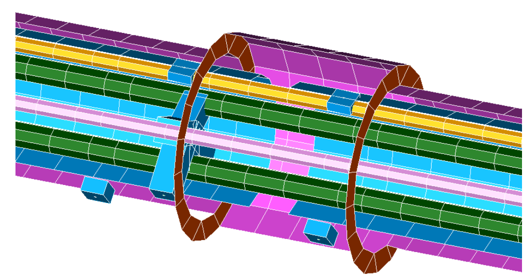


Fig. 5. Kinematic support system for XATL6&7 cryogenic lines.







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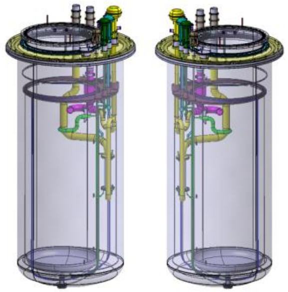
KrioSystem

XATL 6/7 production

Commissioning of the XATC1



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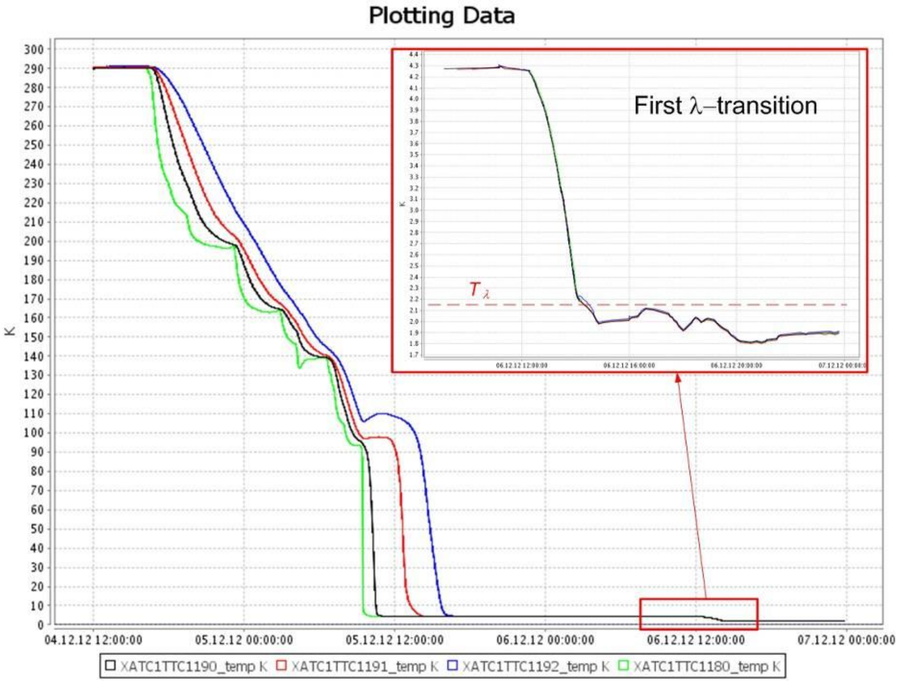
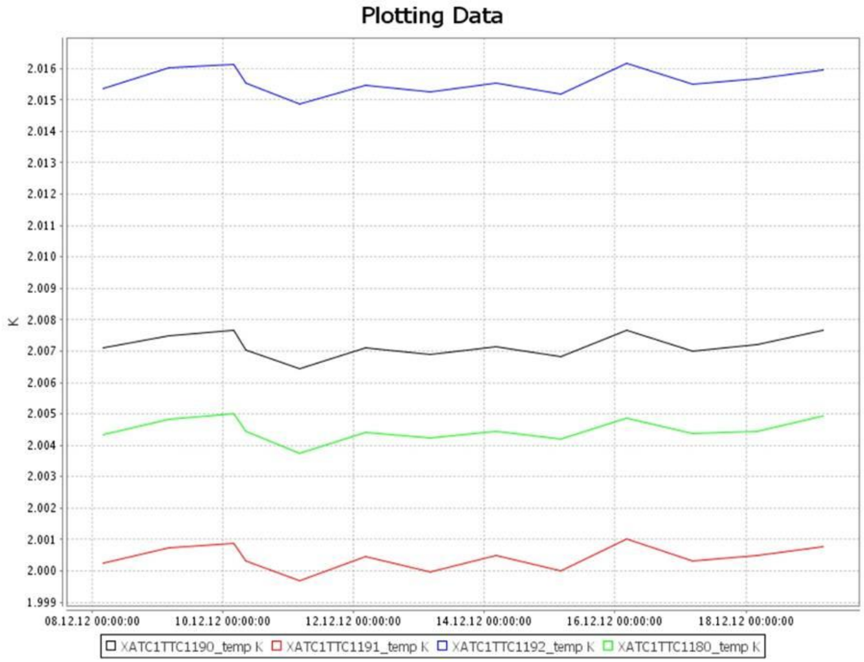
KrioSystem

XATC1 - first cool down to superfluid helium conditions



XATC1 cool down characteristic



Temperature stabilisation in the XATC1 helium vessel

Conclusion

WUT is ready to start design work of the ESS cryodistribution system
First stage:
Scope

1. Verification of the ESS cryogenic distribution system layouts and PIDs for all the operation modes.
2. Sizing of the process and control components (process pipes, control valves, check valves, safety valves, etc.).
3. Mechanical and thermal design of Linac Cryogenic Transfer Line including Splitting Box (L-CTL).
4. Mechanical and thermal design of Linac Cryogenic Distribution Line including Valve Boxes and End Box (L-CDL).
5. Mechanical and thermal design of Test Stand Cryogenic Distribution System including Test Stand Valve Box (TS-CDS).
6. Development of the complete detailed design and production documentation in conformance with all applicable European directives and standards (e.g.: PED97/23/ EC and EN13480).