Cryogenic distribution system for the ESS linac

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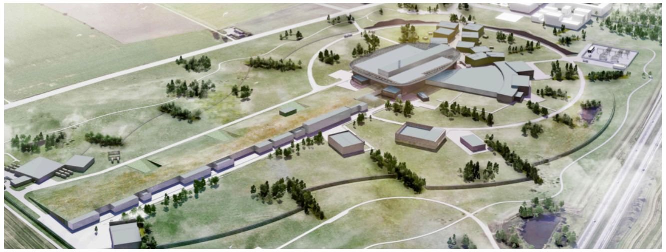
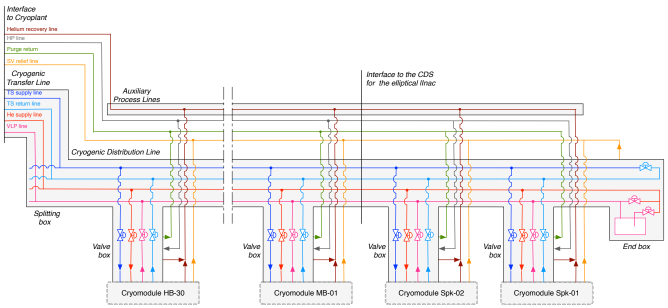
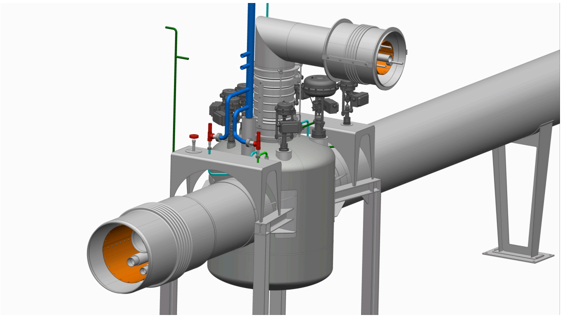
Outline

- Introduction to ESS
- Cryodistribution for the ESS linac
  - Function and layouts
  - Requirements
  - Flow scheme and P&IDs
- Preliminary design of the valve boxes
- Project execution plan
- Summary







European Spallation Source

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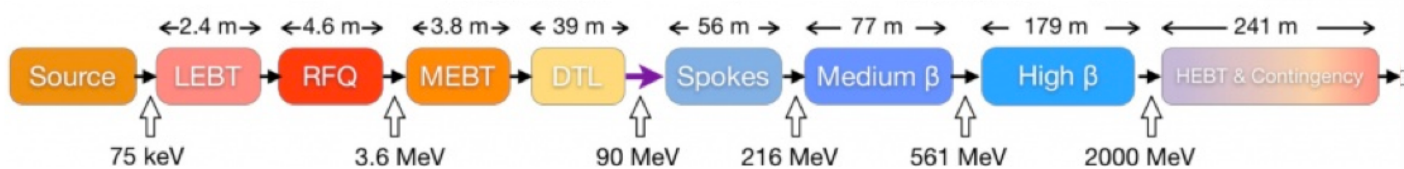
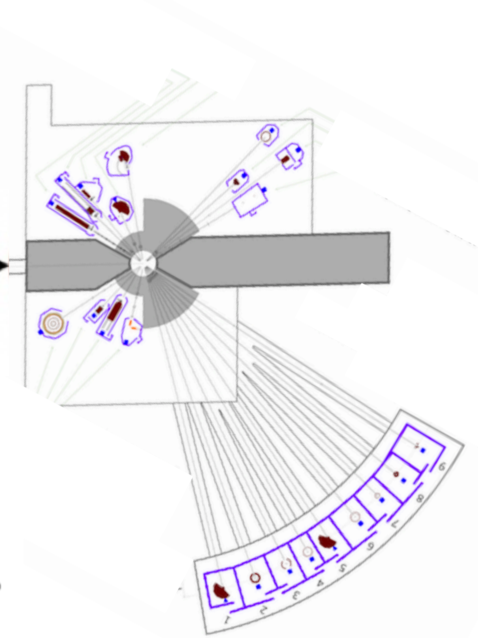
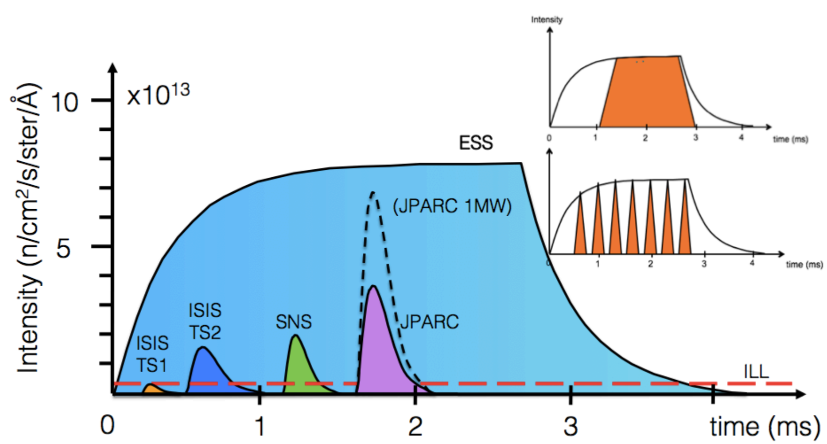
As a project **ESS is a partnership of 17 European nations** committed to the goal of collectively building and operating the world's leading facility for research by use of neutrons.

As a scientific facility **ESS will be an accelerator-driven neutron source** for investigations of the molecular building blocks of matter.





ESS long pulse will be more powerful and brighter than existing neutron facilities.



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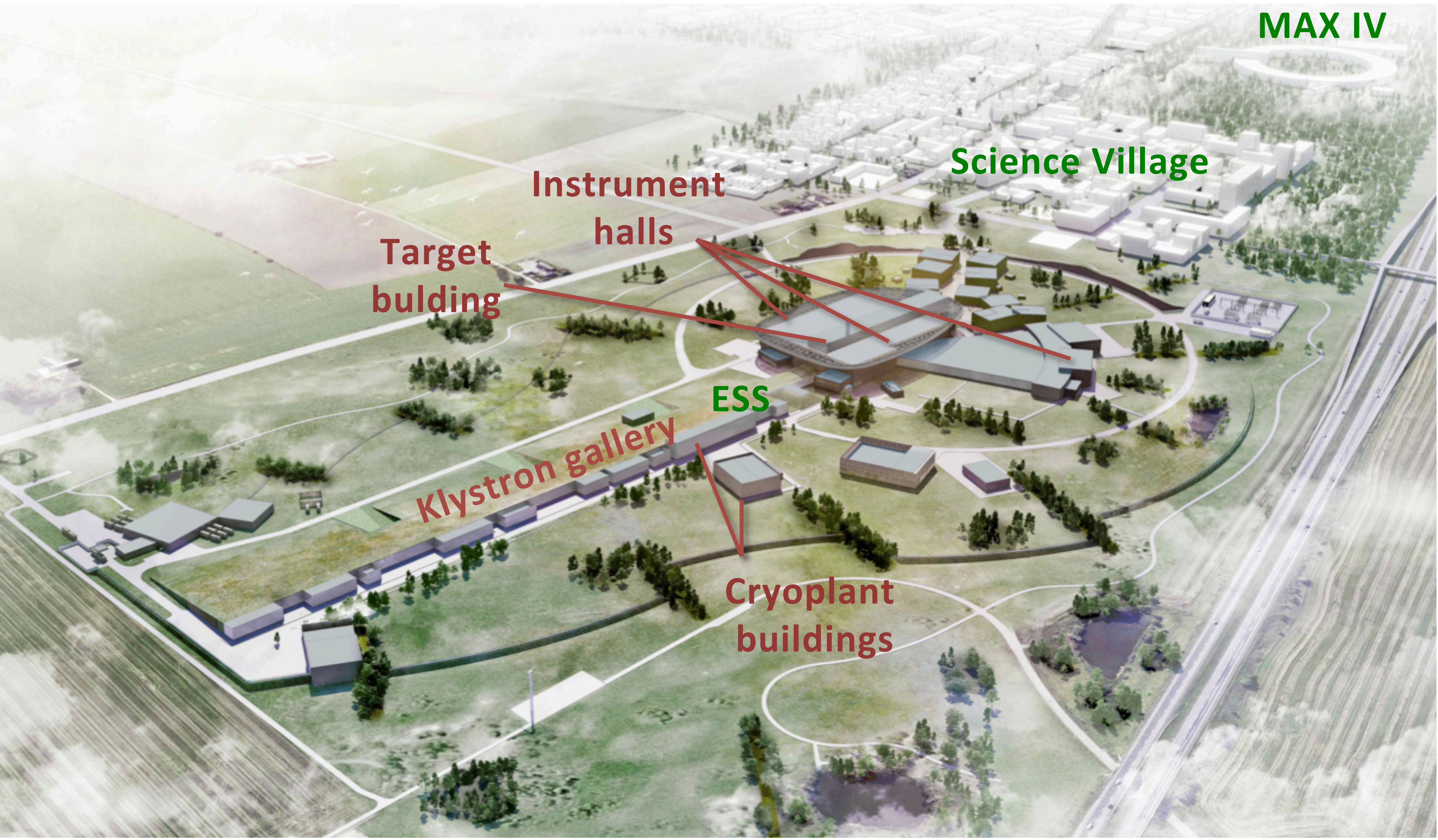
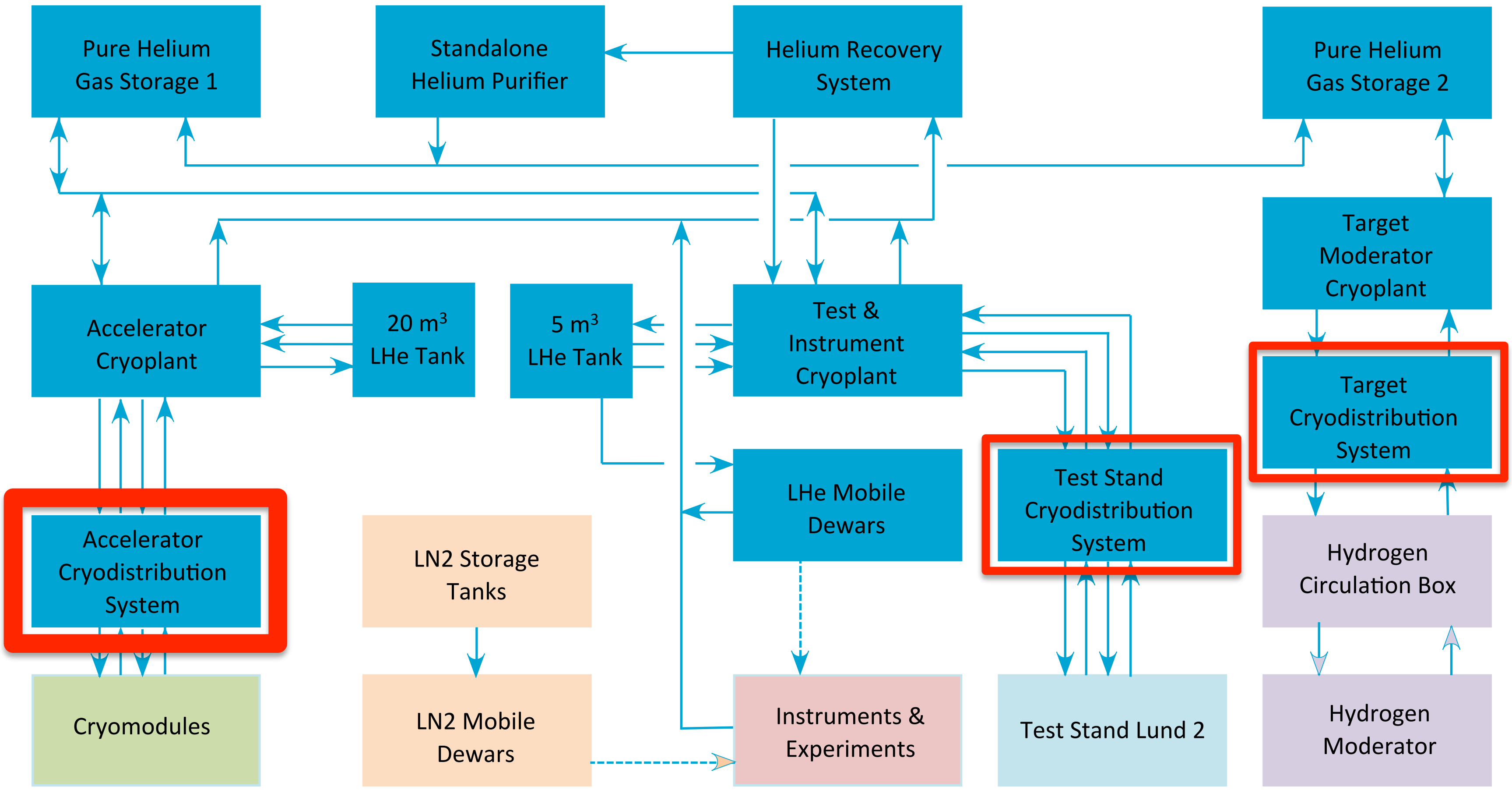
ESS is under construction in Lund, in the southwest of Sweden.

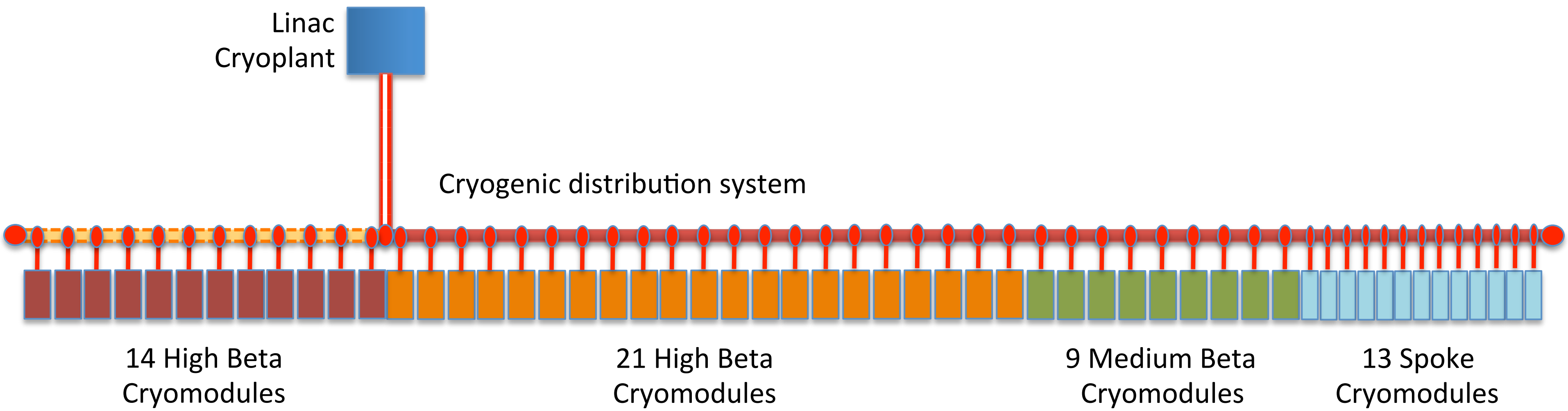
European Spallation Source



ESS cryogenic system



Linac cryogenic system



Design contingency (116 m)

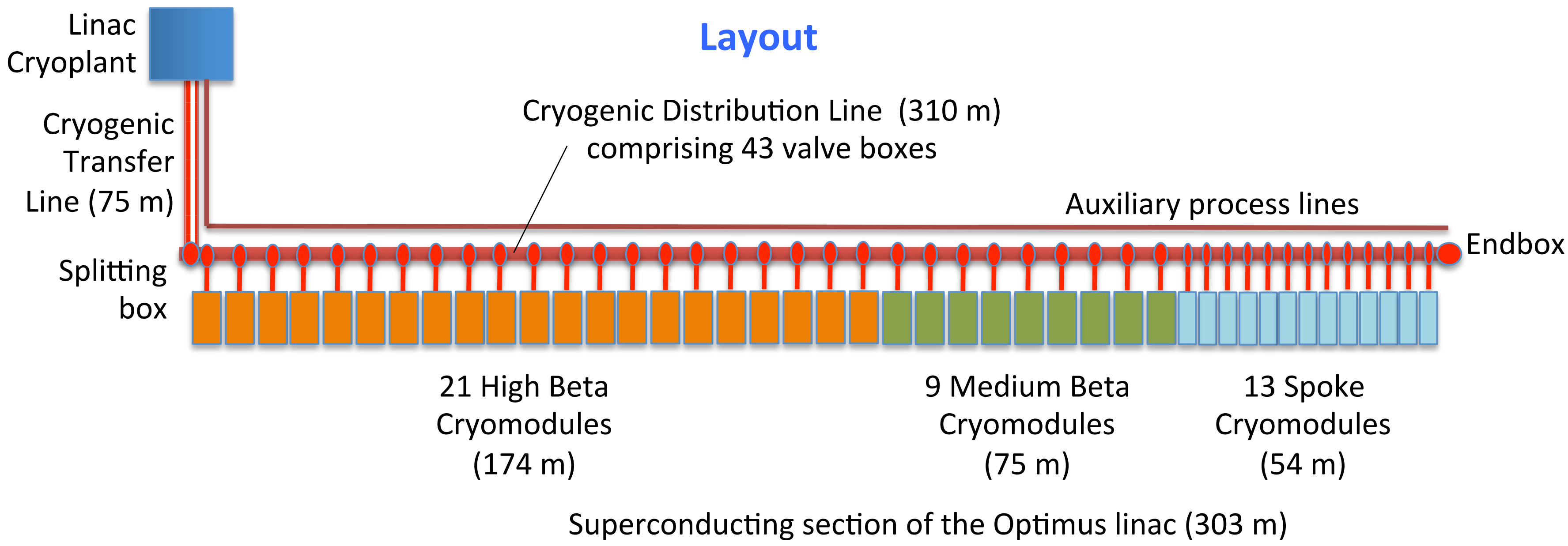
Superconducting section of the Optimus linac (303 m)

Cryogenic system of the ESS linear accelerator (linac) will be composed of a large scale cryoplant, cryogenic distribution system and 43 cryomodules. The cryomodules will consist of 120 elliptical and 26 spoke cavities, which will be cooled with saturated superfluid helium at 2 K.

The design contingency of the ESS accelerator includes up to 14 additional cryomodules, which will require another cryogenic distribution line.

Linac CDS – function and layout

Linac Cryogenic Distribution System

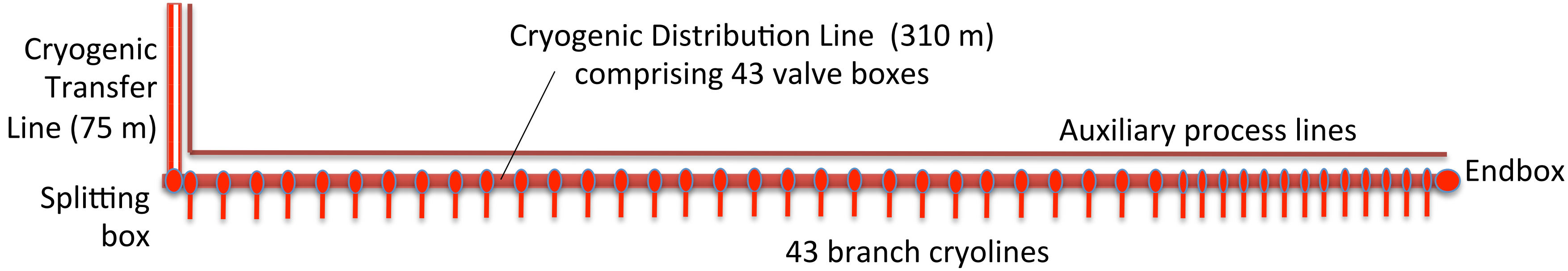


Cryogenic Distribution System for the ESS linear accelerator is intended for delivering the cooling power from the linac cryoplant to the cryomodules by means of the constant flows of supercritical and cold gaseous helium, at 4.5 K and 40 K, respectively.

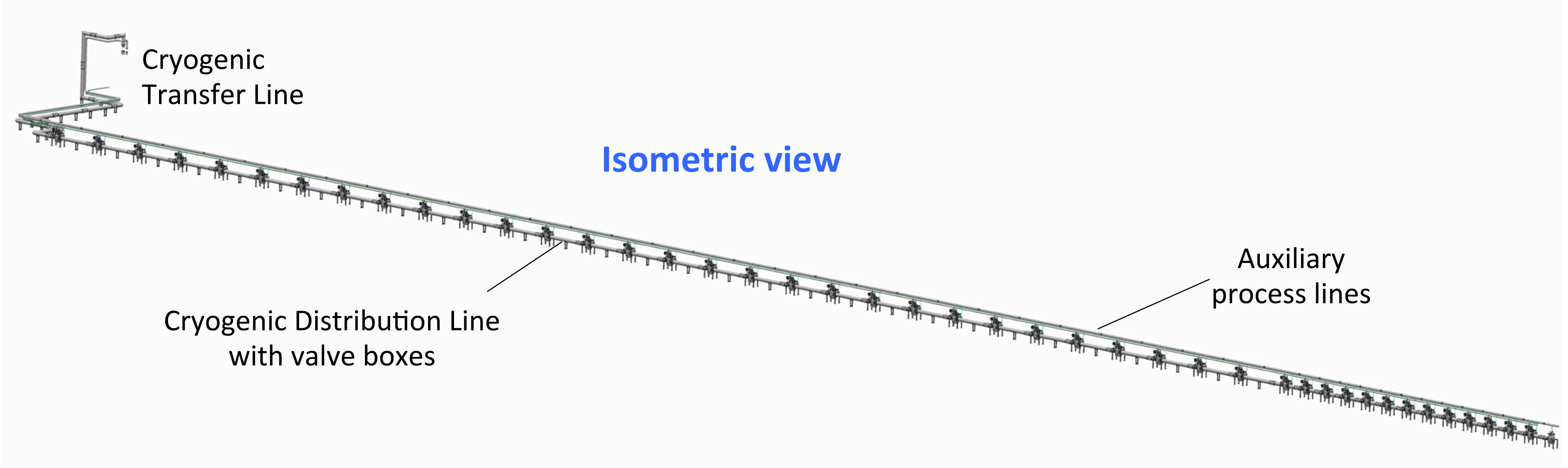
Linac CDS – function and layout

Linac Cryogenic Distribution System

Layout



Isometric view



General requirements

Main general requirements
for the design and construction
of the ESS Cryogenic Distribution System

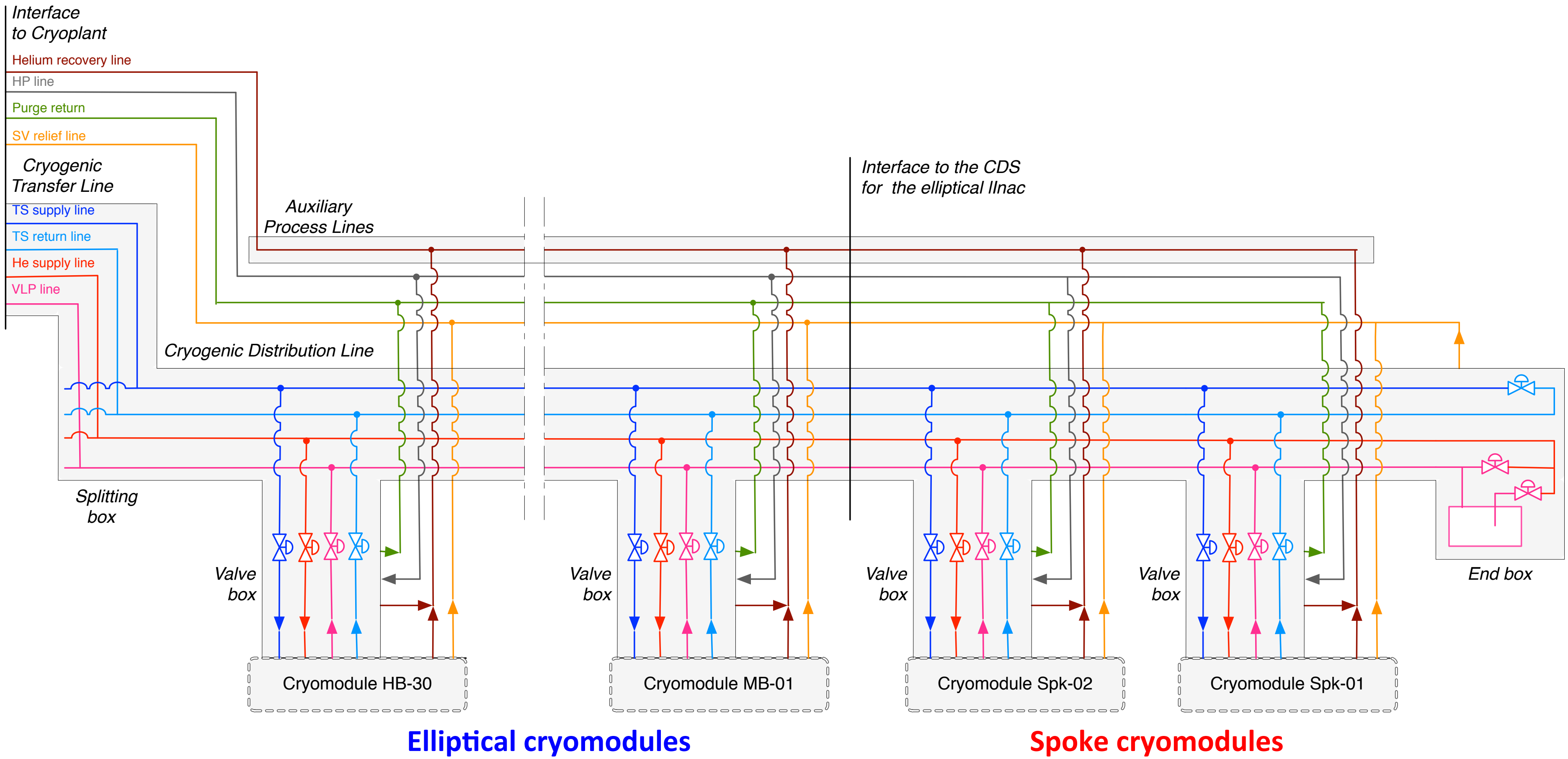
- adequate to ensure smooth operation throughout the **expected lifetime of 45 years**,
- suitable for **continuous operation** (with limited scheduled interruptions only) to meet top-level requirement of 95 % availability of the linac itself,
- ensure **no deterioration of thermal and mechanical properties** within the operation lifetime,
- must allow for the **separation of a single cryomodule** from the cryodistribution line,
- must allow for **the warm-ups and cool-downs of a single cryomodule**, while keeping the rest of the system at cryogenic temperatures,
- must **comply with Swedish and European legislation** concerning occupational health, safety and environmental protection, as well as pressure and cryogenic equipment regulation and standards (PED97/23/EC, SS-EN 13480, SS-EN 13458, etc.)

Technical requirements

Main technical requirements
for the design and construction
of the ESS Cryogenic Distribution System

- **heat loads not higher than 420 W and 3.66 kW** to the cold helium circuit and thermal shield, respectively,
- **supercritical helium temperature below 5.2 K** in the interfaces to the cryomodules at nominal operation conditions,
- **vacuum insulation below 10^{-6} mbar** at nominal working condition (below $5 \cdot 10^{-3}$ mbar at ambient temperature with active vacuum pumping),
- **integral helium leak rate below $1 \cdot 10^{-7}$ mbar·l/sec** from the helium circuit to the vacuum,
- **tightness of the valve seats ≤ $1 \cdot 10^{-4}$ mbar·l/sec**,
- **200 full thermal cycles**,
- all materials and components must **tolerate the radiation dose of $5 \cdot 10^{5}$ Gy**,

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)

Valve box PIDs

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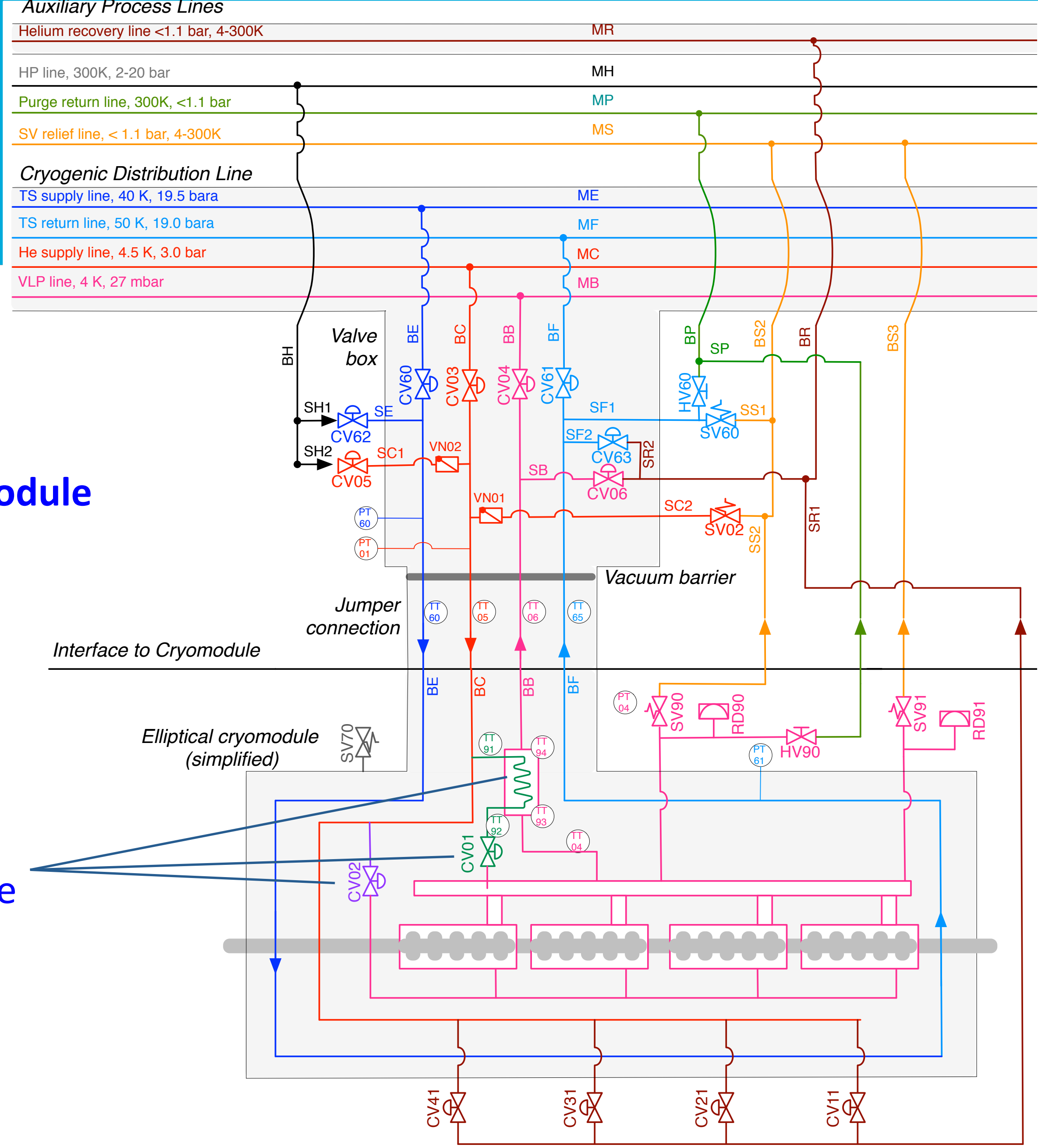
Valve box
for the elliptical cryomodule

The heat exchanger,
JT and filing valves are
in the cryomodule!



Valve box PIDs

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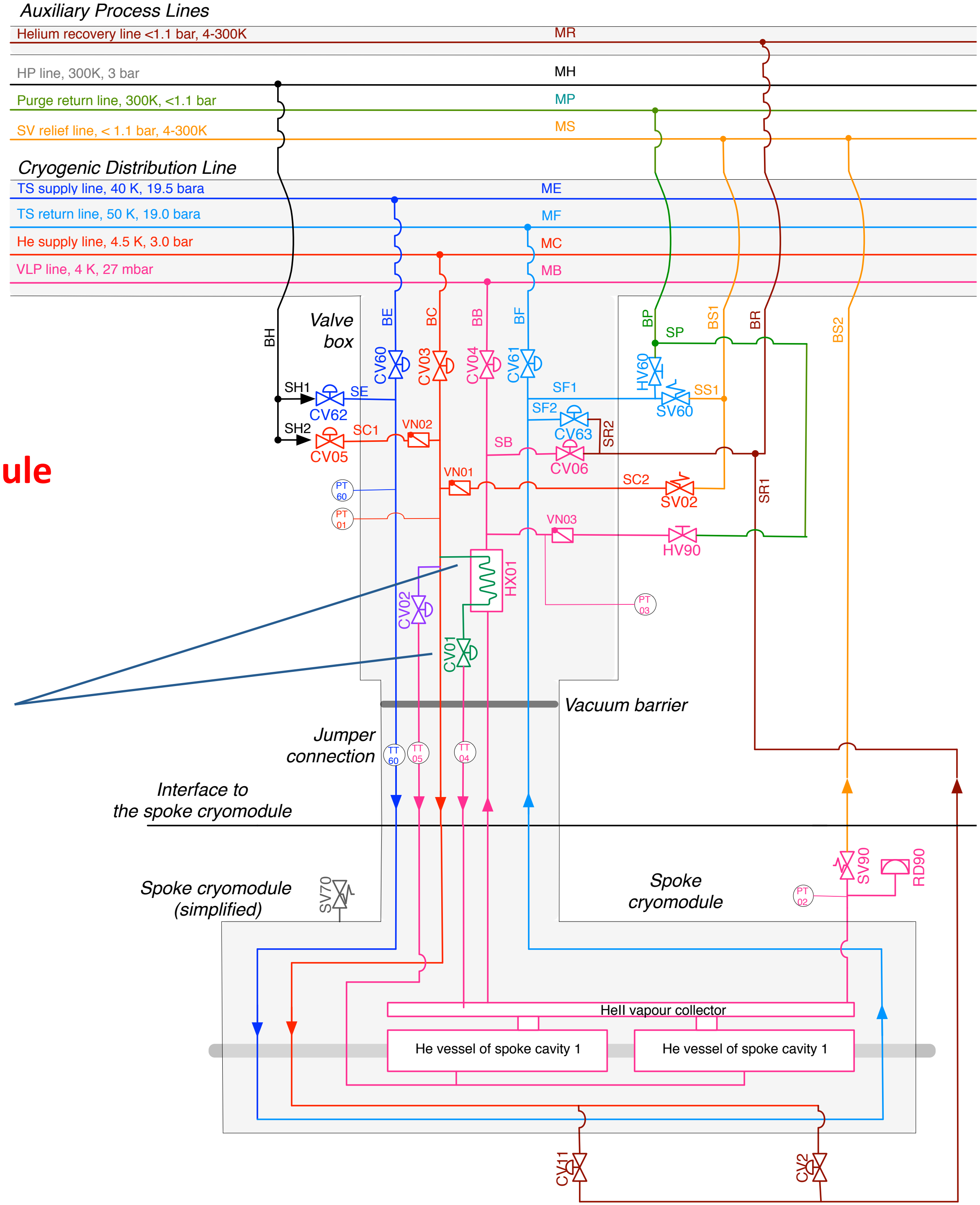
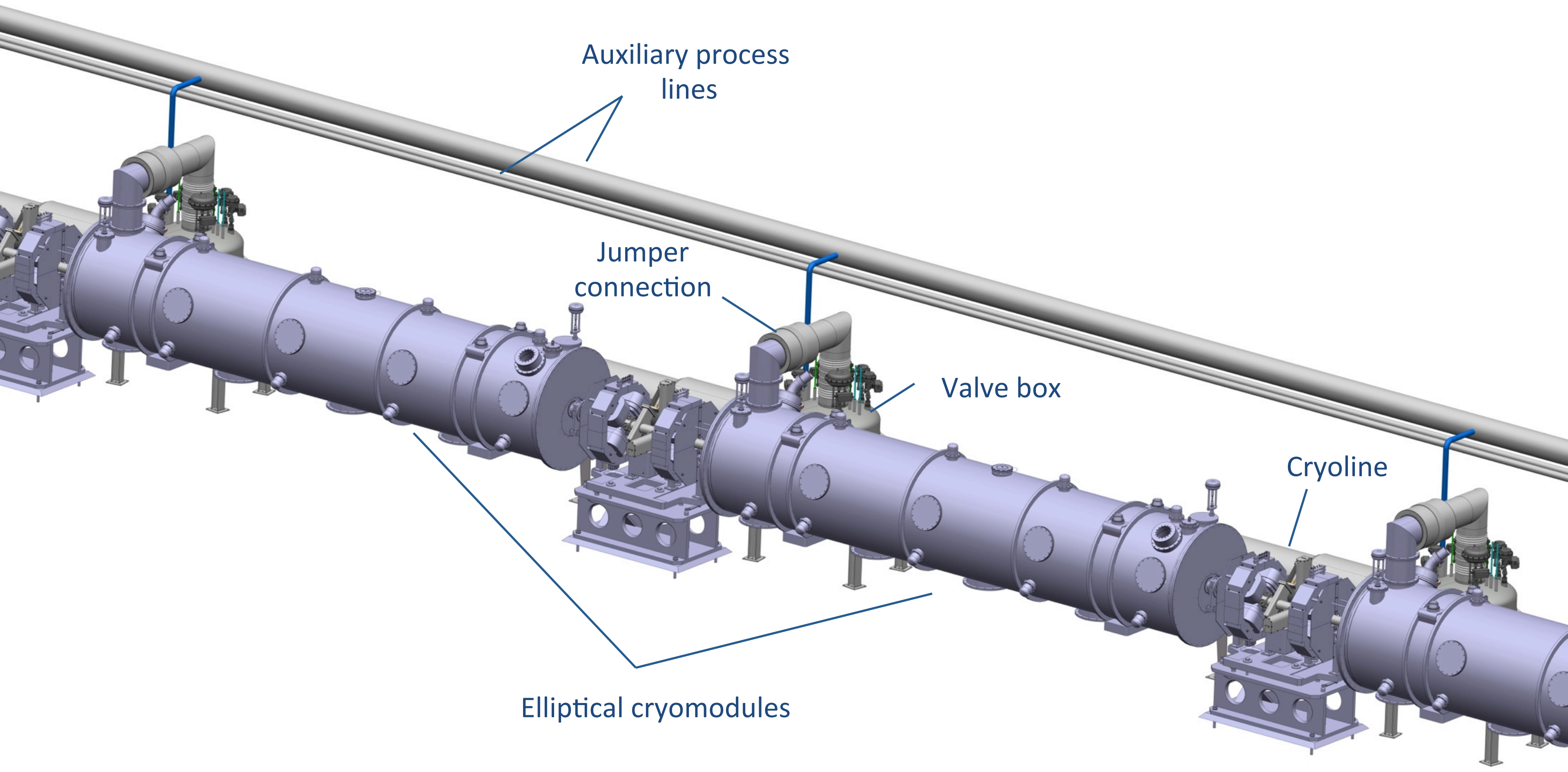


Valve box
for the spoke cryomodule

The heat exchanger,
JT and filing valves are
in the valve box!

Linac CDS isometric



Linac CDS isometric

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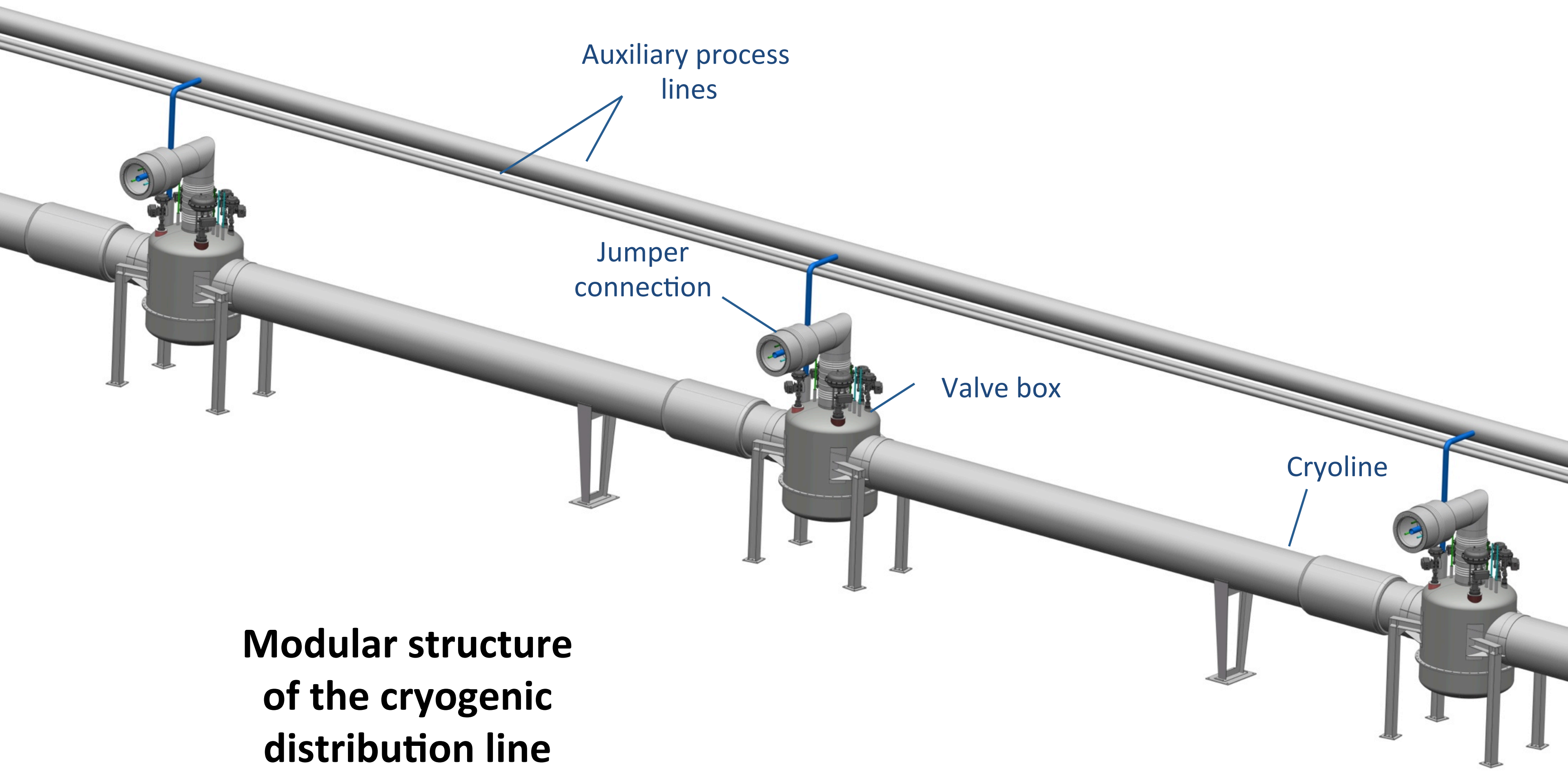
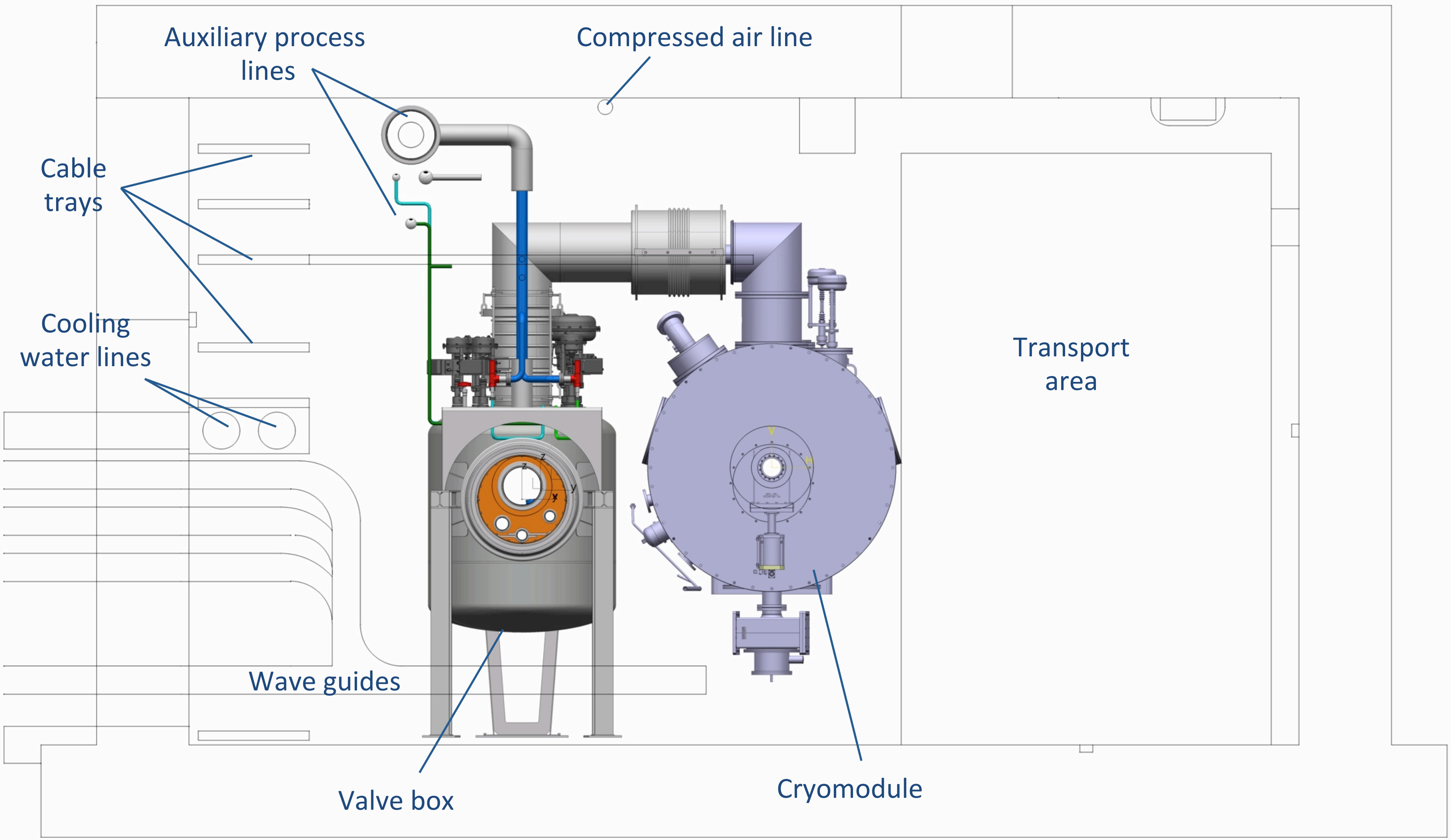
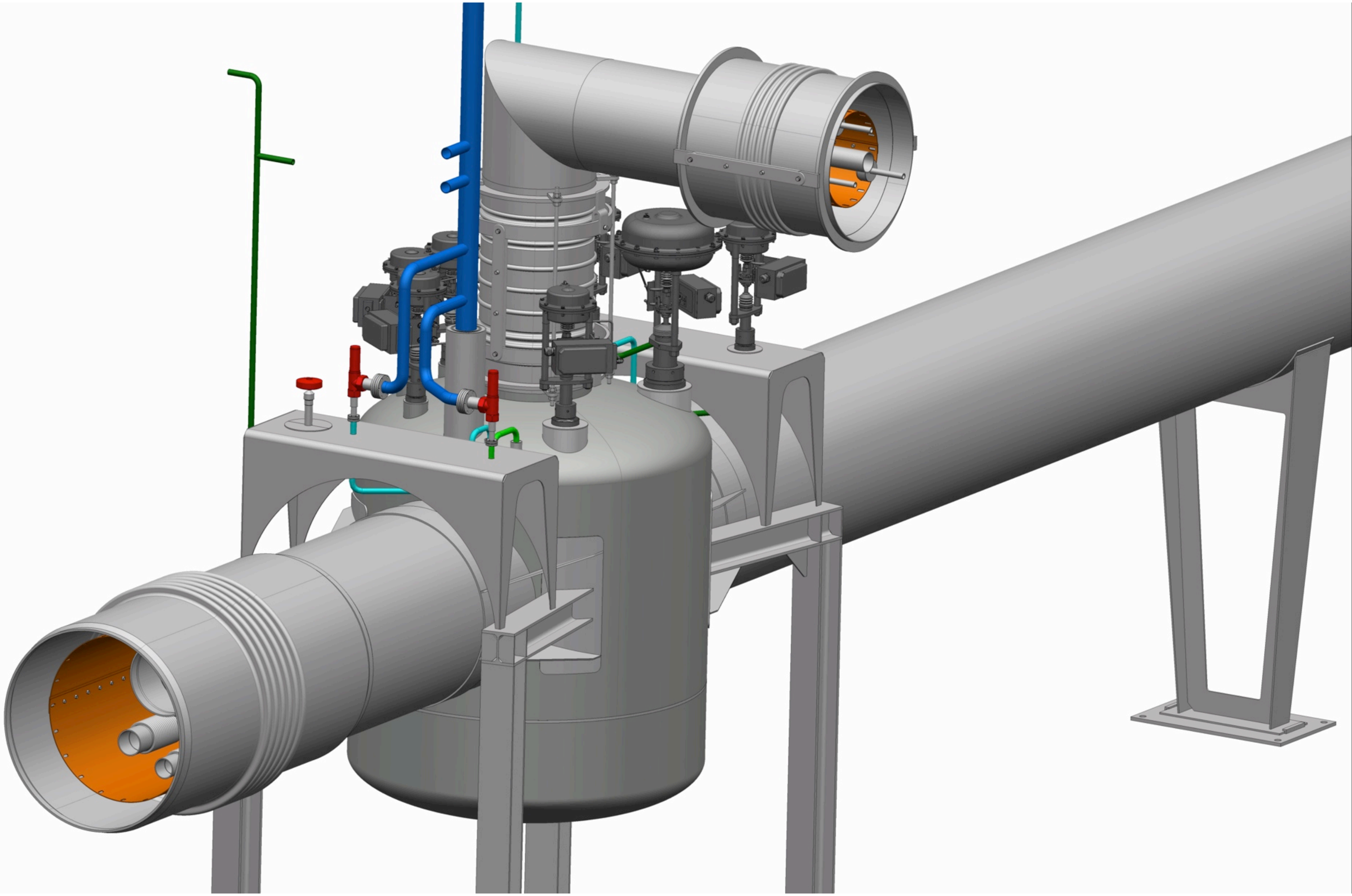


Modular structure of the cryogenic distribution line

Linac CDS - position in the tunnel



Valve box conceptual design



Valve box – process lines, supports and vacuum barrier

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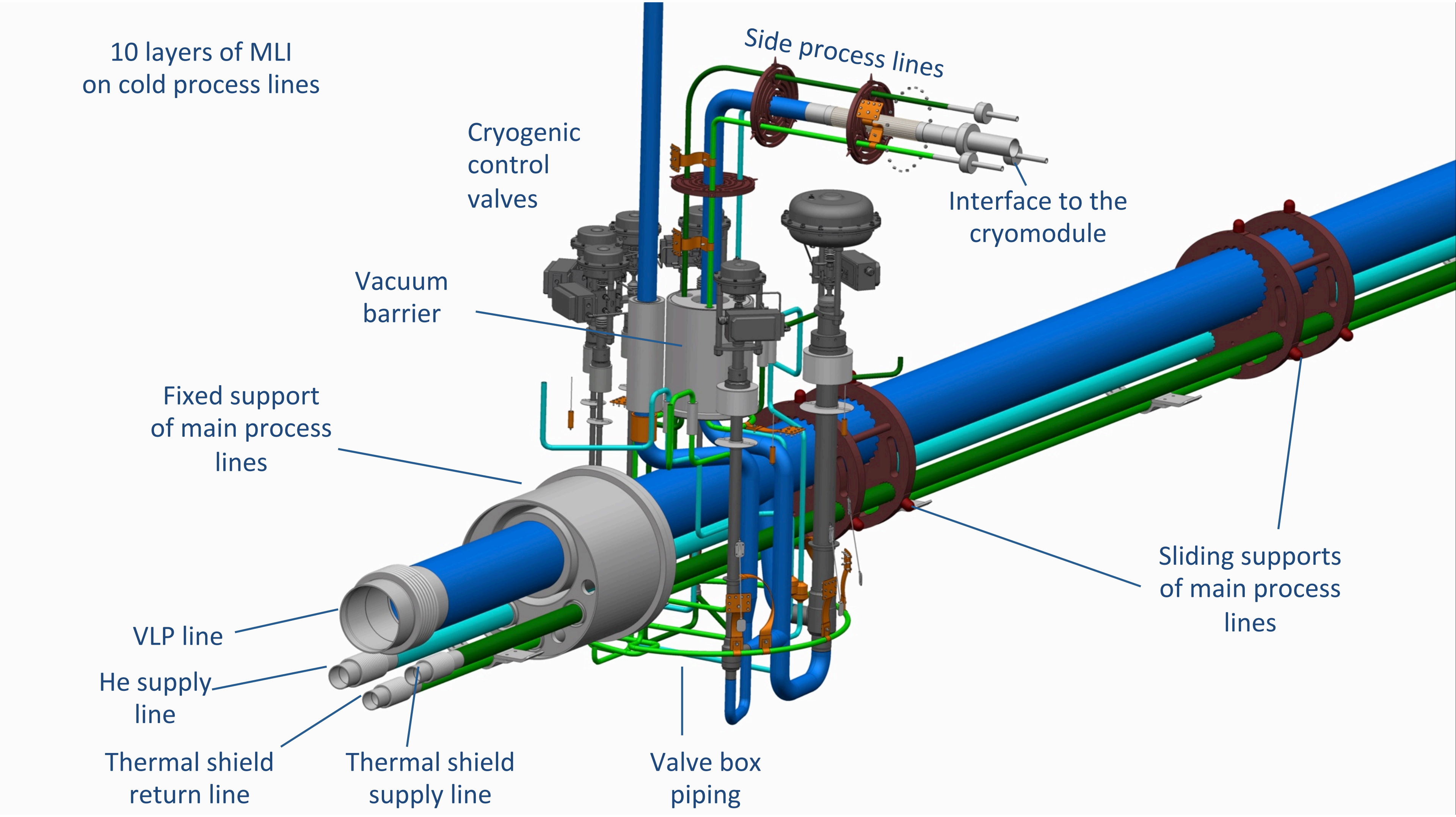
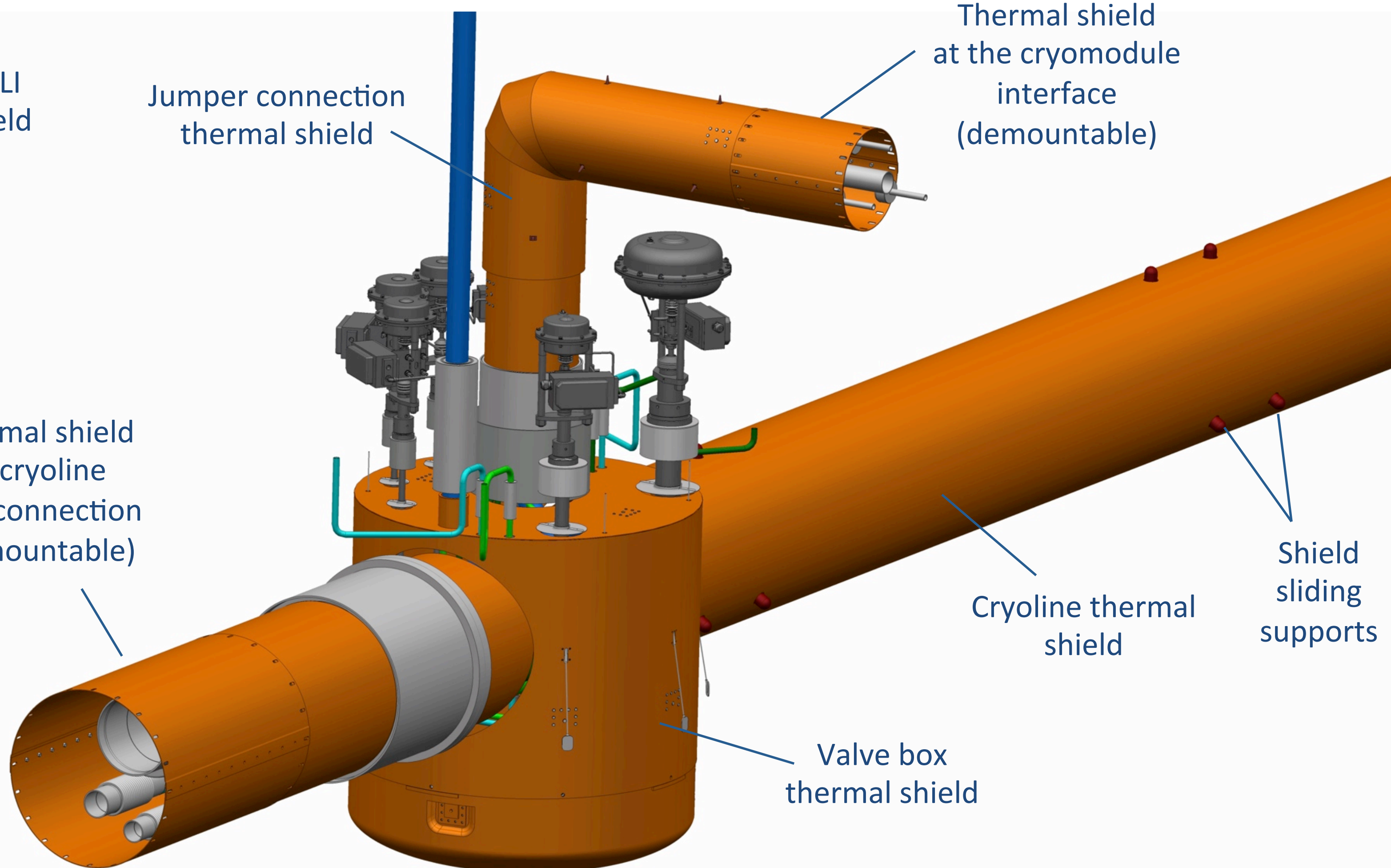
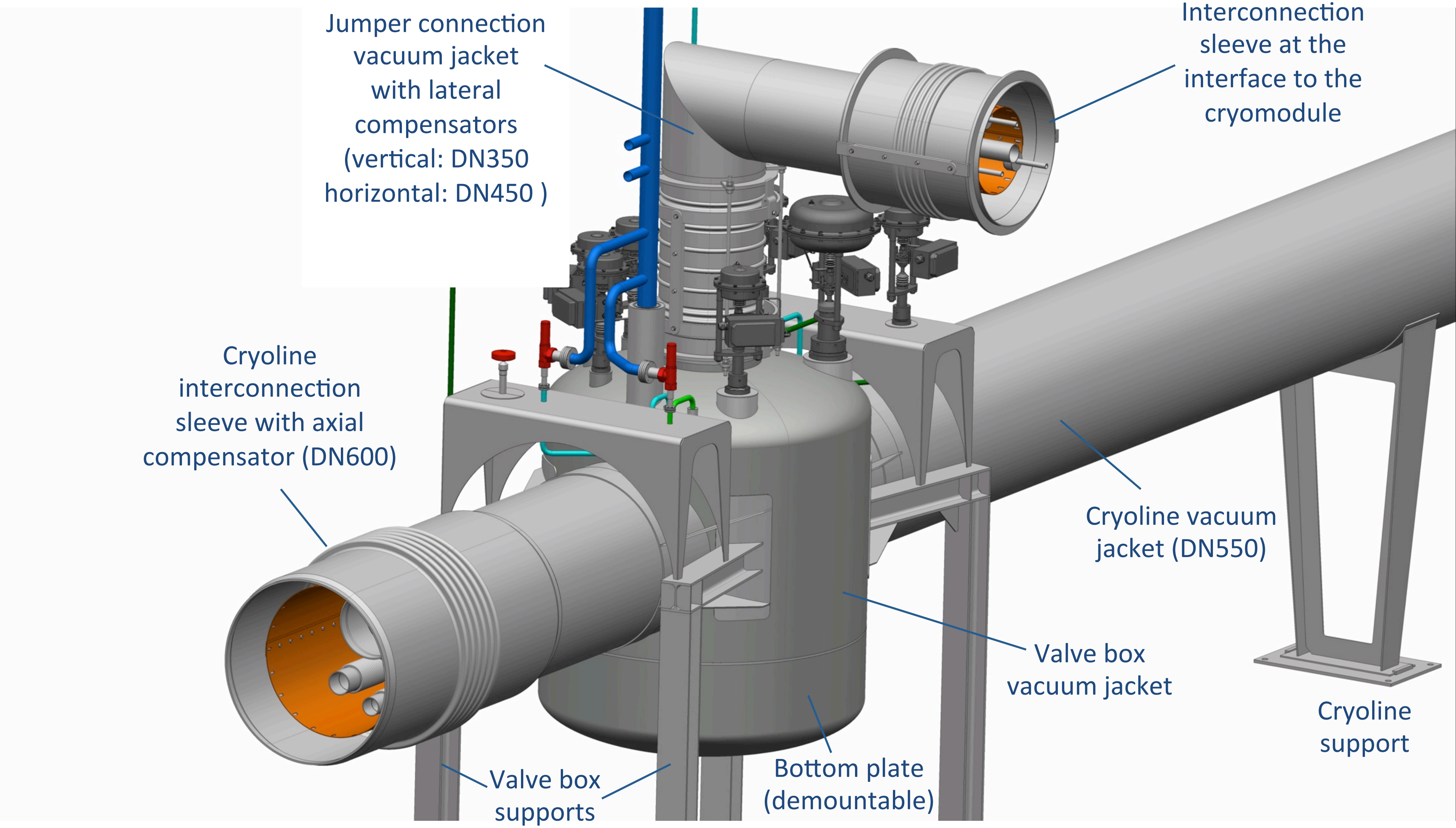


Valve box – thermal shields



Valve box – vacuum jacket



Project execution plan

- Conceptual designs
  - already finished
- Negotiations and agreements
  - in-kind contribution (optional European open tender process)
  - CDS for the spoke linac will be provided by the French in-kind partner
  - CDS for the elliptical linac - negotiations are in progress
- Further phases
  - Detailed design: Q1-Q3 2015
  - Production: Q4 2015 – Q2 2017
  - Installation: Q1-Q2 2017
  - Commissioning: Q3 2018

Summary

- The ESS linac requires an extensive cryogenic distribution system.
- General and technical requirements for the ESS cryogenic distribution system are specified.
- These requirements have strongly affected a vast number of conceptual and detail design choices.
- Detailed 3D model of the valve box conceptual design was used for the feasibility study.

Thank you
for your attention