Updated concept of the CBM dipole magnet

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Outline

- Main demands to the CBM magnet
- Schedule of the work
- Changes from CDR. Samurai magnet
- Scope of BINP work
- Interfaces with other CBM systems
- Status of the work

Design parameters of the CBM magnet to be realized

Geometry
- Opening angle: ±25° vertically, ± 30° horizontally from the target
- Free aperture: 1.44 m vertically x 1.8 m horizontally, no conical geometry
- Distance target- magnet core end: 1m (STS detector must fit in)
- Total length: 1.5 m
- Space upstream of the magnet: <1 m

Magnetic field
- Field integral within STS detector (along straight lines): **0.972 T*m** -> max. Field ≈ 1 T, depending on the magnet length
- Field integral variation over the whole opening angle along straight lines: ≤ 20% (± 10%)
- Fringe field downstream < reasonable value of the order of 50 to 100 Gauss at a distance of 1.6 m from the target (RICH only)

Operating conditions
- Operates at both polarities
- 100% duty cycle, 3 months/year, 20 years
- No real time restriction on the ramp: 1 hour up ramp
- Radiation damage (<10MG for organics): no problem
- Radiation Energy deposit in the cryosystem: max. 1 W

Design parameters of the CBM magnet to be realized, continued

Assembly
- Field clamps dismountable for MUCH
- Assembly in situ
- Weight restriction: crane 30 tons (including lifting jacks)
- Maximum floor load: 100 tons/m2
- beam height over the floor: 5.8 m

Alignment
- Position accuracy: **± 0.2 mm (too high precision?)**
- Orientation accuracy (roll): ± 0.5 mrad

The requirements given above are mandatory.

Remark: the free aperture was increased from 1.4m (TDR) to 1.44 m. However, the integral field was decreased in order to keep the nominal current the same as in the TDR.

The CBM superconducting dipole will be designed as follows:
- Warm iron yoke (huge vertical and horizontal balks)
- Warm round poles
- Removable field clamps
- cylindrical NbTi coils wound on cylindrical bobbin, cooled with LHe
- Thermal shields cooled with Helium gas (50-80K)
- Two independent cold masses and cryostats (**now not independent**)
- Vertical forces transferred from the coil to the cryostat and finally to the yoke
- Normal conducting leads

Schedule of the work, April 2018

1. Conceptual Design review, April 2018

items to be approved:

- magnetic field calculations;

- iron yoke design;

- general conception of the coil design

the support struts as separate elements of the coil to be approved in FDR stage after manufacturing and testing a dummy samples of several designs;

- cooling conception of single cryostat based on thermosyphon method;

- system of powering and energy extraction;

2. Preliminary Design Review, October 2018

- cryostat design including cold valves;

- current leads design based on HTS incertions;

- design of the support struts;

- control system

Schedule of the work, April 2018, continued

3. Final Design Review, January-February 2019
- support struts tested;
- all drawings will be finished;
- manufacturing process presented;
- quality assurance procedures to be presented;

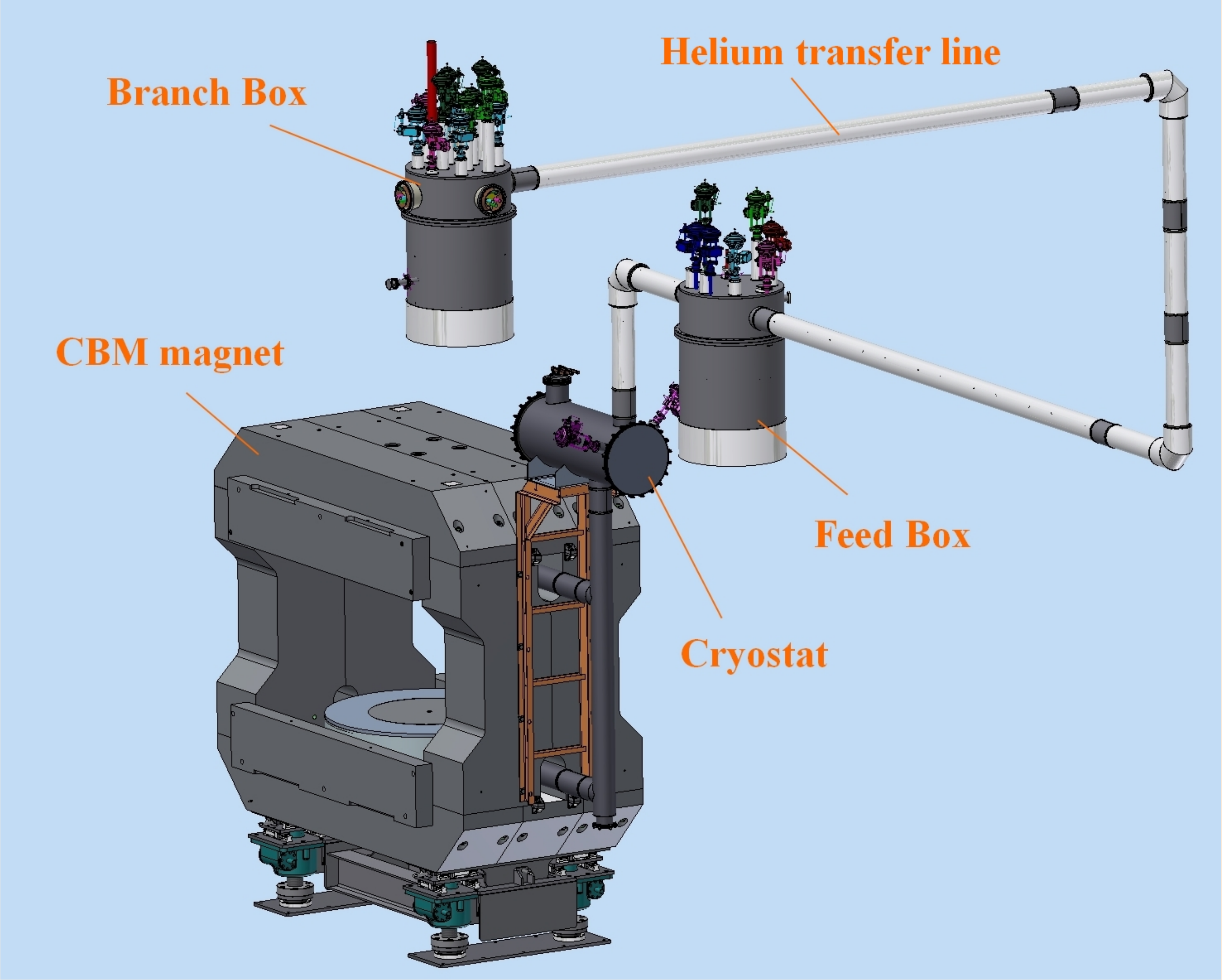
4. Manufacturing stages
- SC cable manufactured November 2018 – March 2019;
- iron yoke (8 months after the contract signed)
- technologies of coils impregnation tested
- tools manufactured
- coils manufactured
- cryostat manufactured

5. Factory acceptance tests in BINP, October 2019 – January 2020
the cryostat will be modified to use LN2 instead of 50 K GHe and a cryocooler will be used for the current leads cooling.

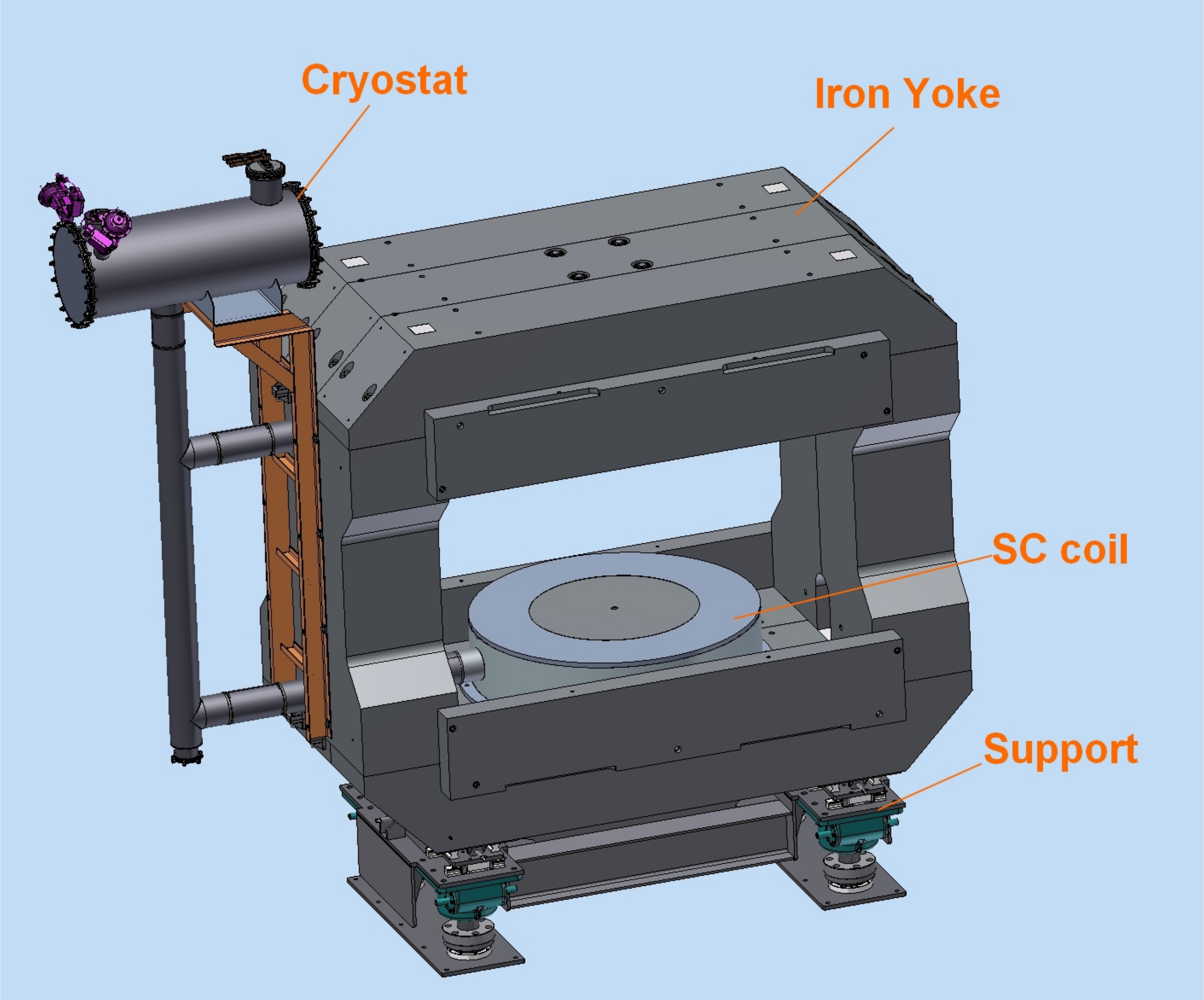
6. Assembling December 2021 – March 2022 (1^{st} scenario)

7. Cryogenics test in GSI during April – December, 2023

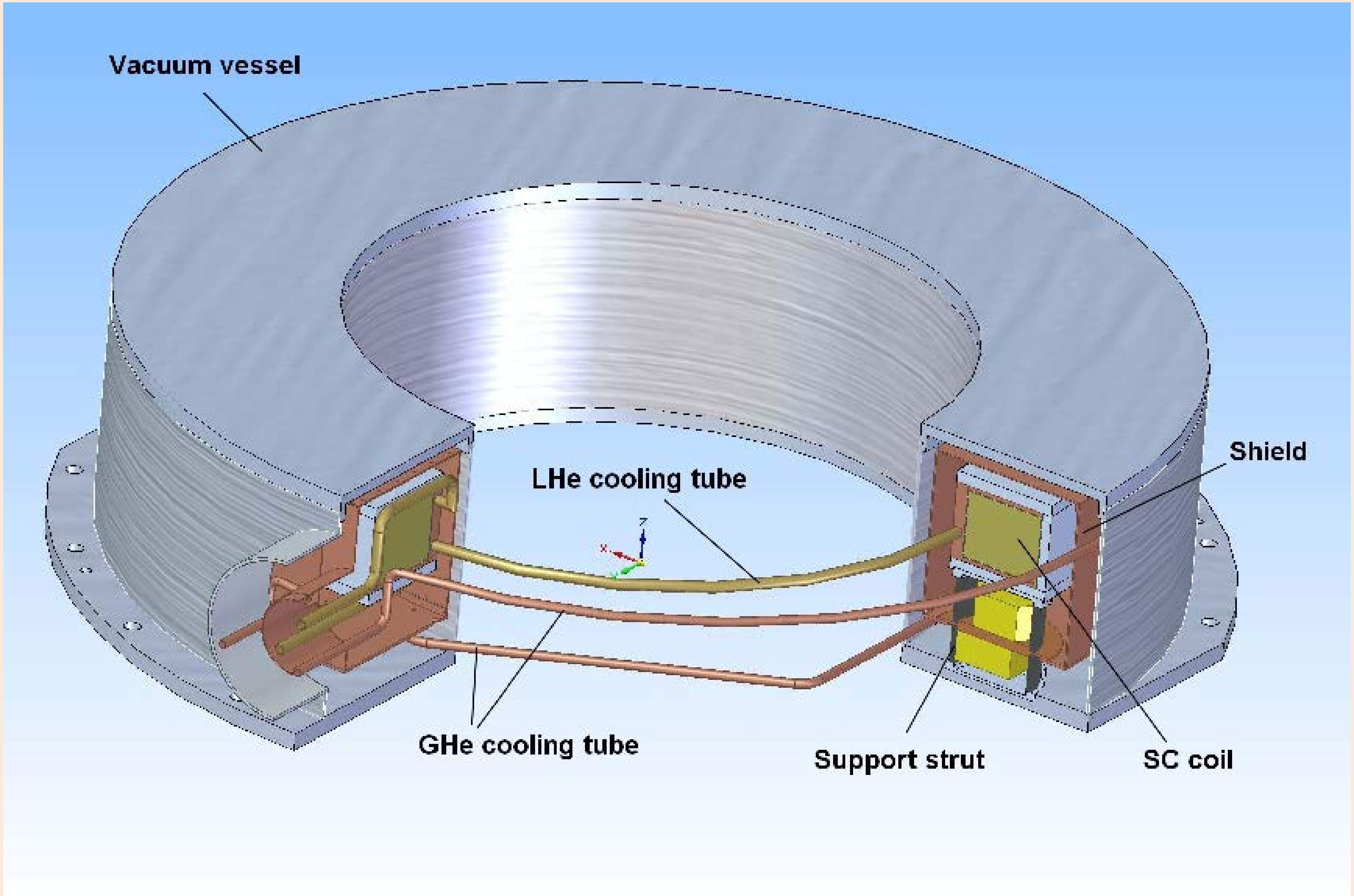
General view of the CBM magnet



The CBM magnet general view



New coil design – indirect cooling



Difference from Samurai design

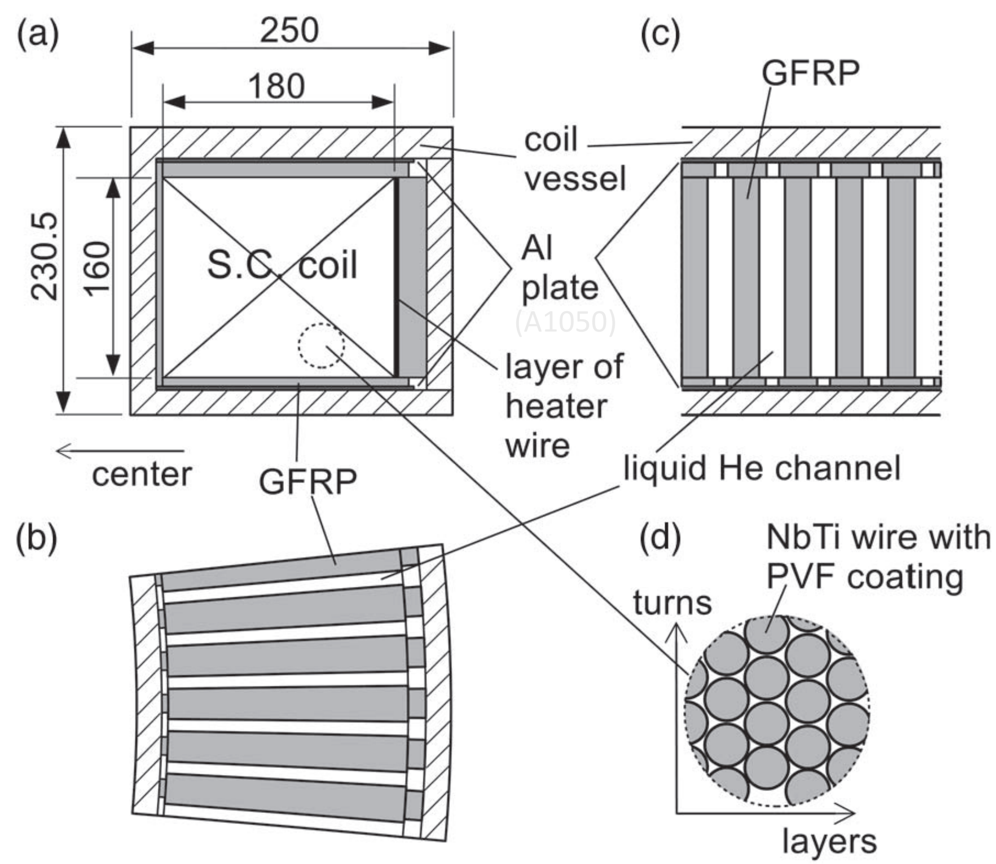


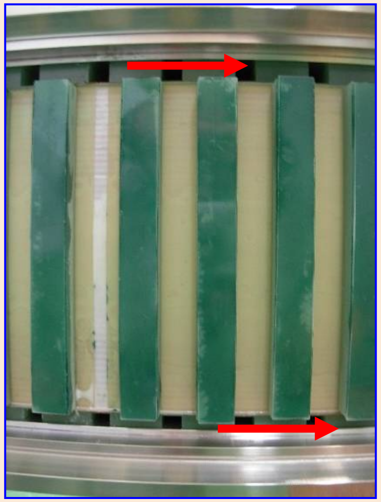
Fig. 7. Schematic view of the superconducting coil and the coil vessel. The coil vessel is made of SUS 316L. (a) Cross-sectional view. The copper heater wire is wound on the outermost layer of the coil. (b) Top (bottom) view of the inside of vessel. (c) Side view of the inside of vessel. (d) A detailed view of the wires in the coil. The epoxy resin is applied layer by layer.

The SS case does not work as bondage. It shrinks less than the winding.

The G-10 spacers are less rigid than stainless steel at least by a factor of 5.

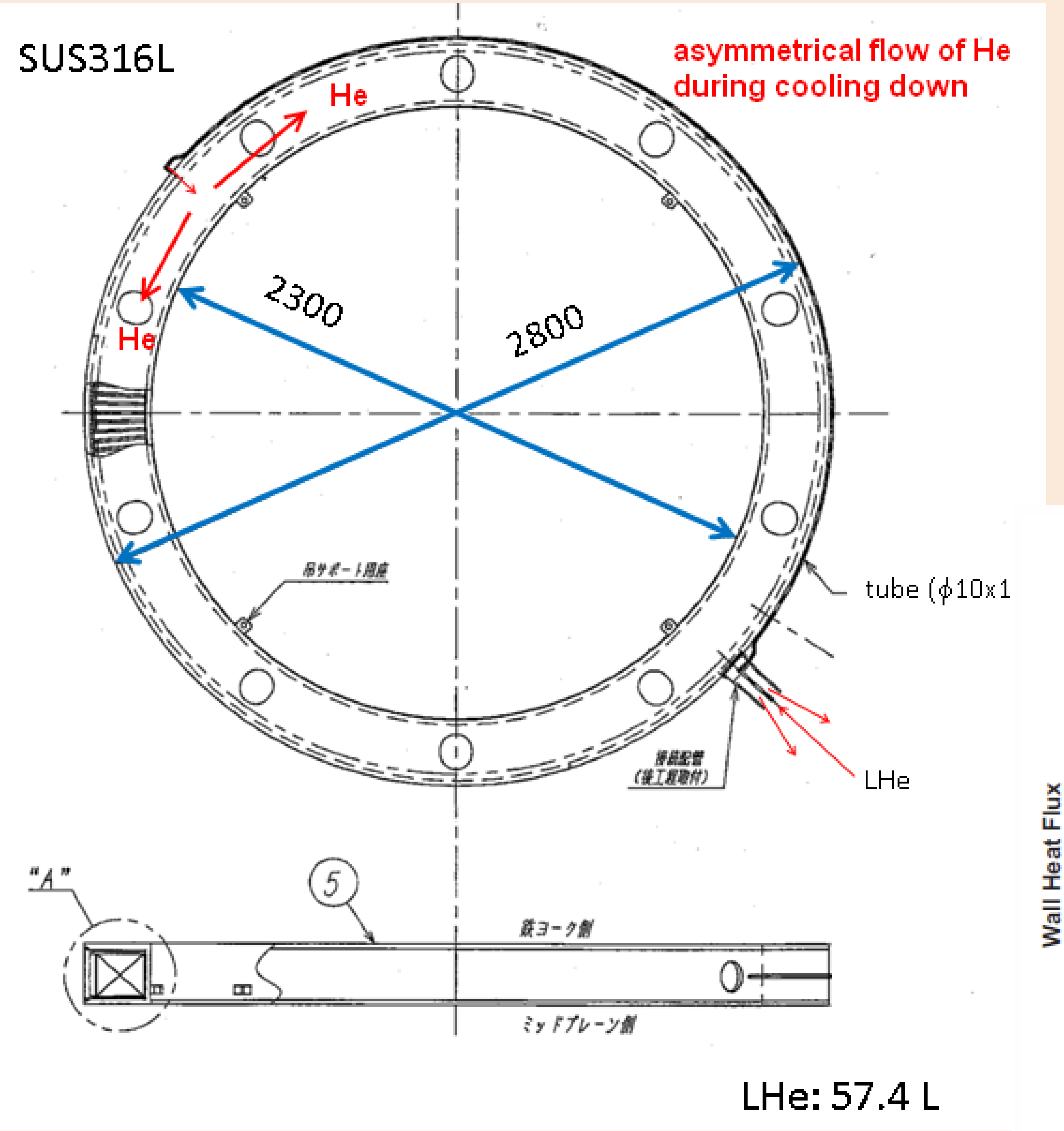
The winding is cooled via two narrow channels during down. Helium faces only G-10

Helium flow



Aluminum foils do not help in cooling down – too thin

Difference from Samurai design, continued



The cooling system of Samurai magnet is very different, it is based on the cryocoolers.

CBM is cooled by forced flow.

The total heat in-leak is very low. The cooling regime is in liquid single phase state.

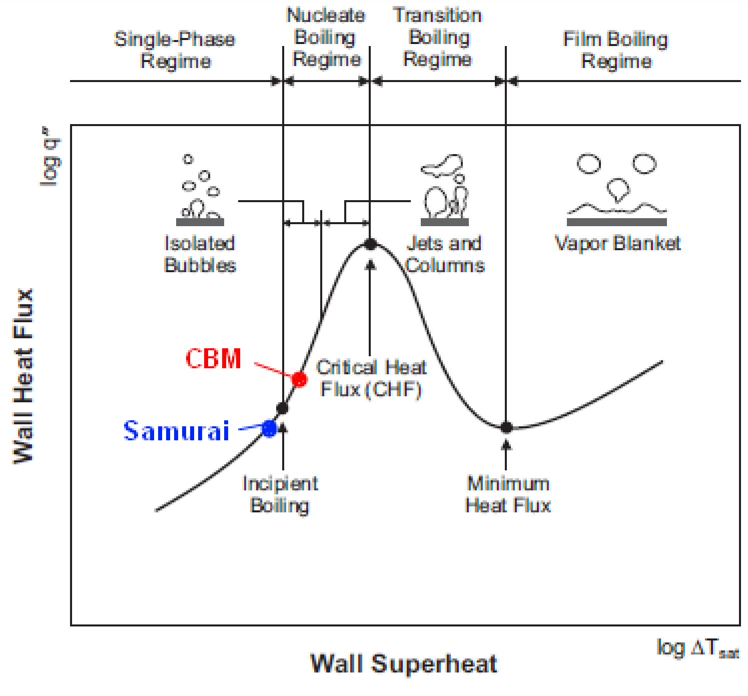
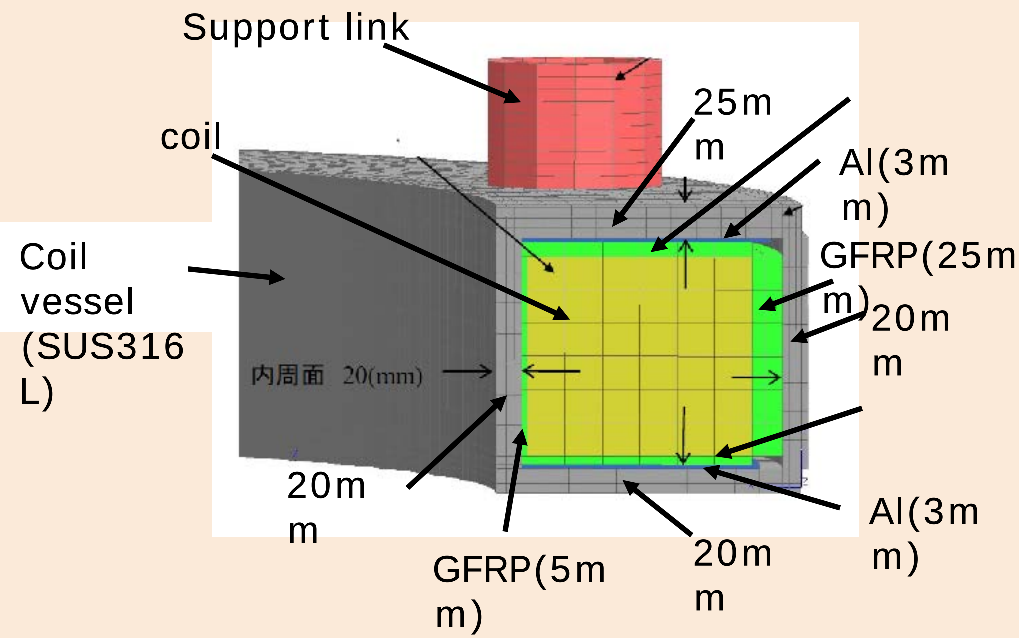
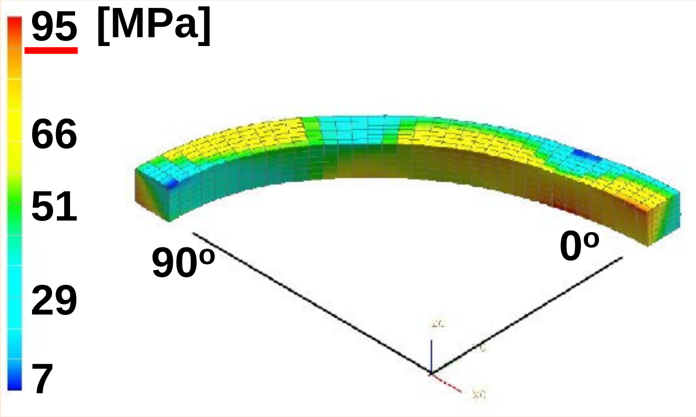


Fig. 1. Pool boiling curve.

Samurai calculations



Principal stress in the coil



Allowable tress=180MPa@RT?

TABLE V
MATERIAL PARAMETERS OF THE COIL AND THE VESSEL

Material		Young's modulus	Poisson's ratio	Transverse elasticity modulus
Coil	r direction	30 GPa	0.3	17 GPa
	ϕ direction	97 GPa	0.3	19 GPa
	y direction	30 GPa	0.3	17 GPa
GFRP		32 GPa	0.3	-
SUS316L		200 GPa	0.3	-
Aluminum		80 GPa	0.3	-

Young's modulus of the CBM magnet coil

phi direction 73 GPa

r direction 28 GPa

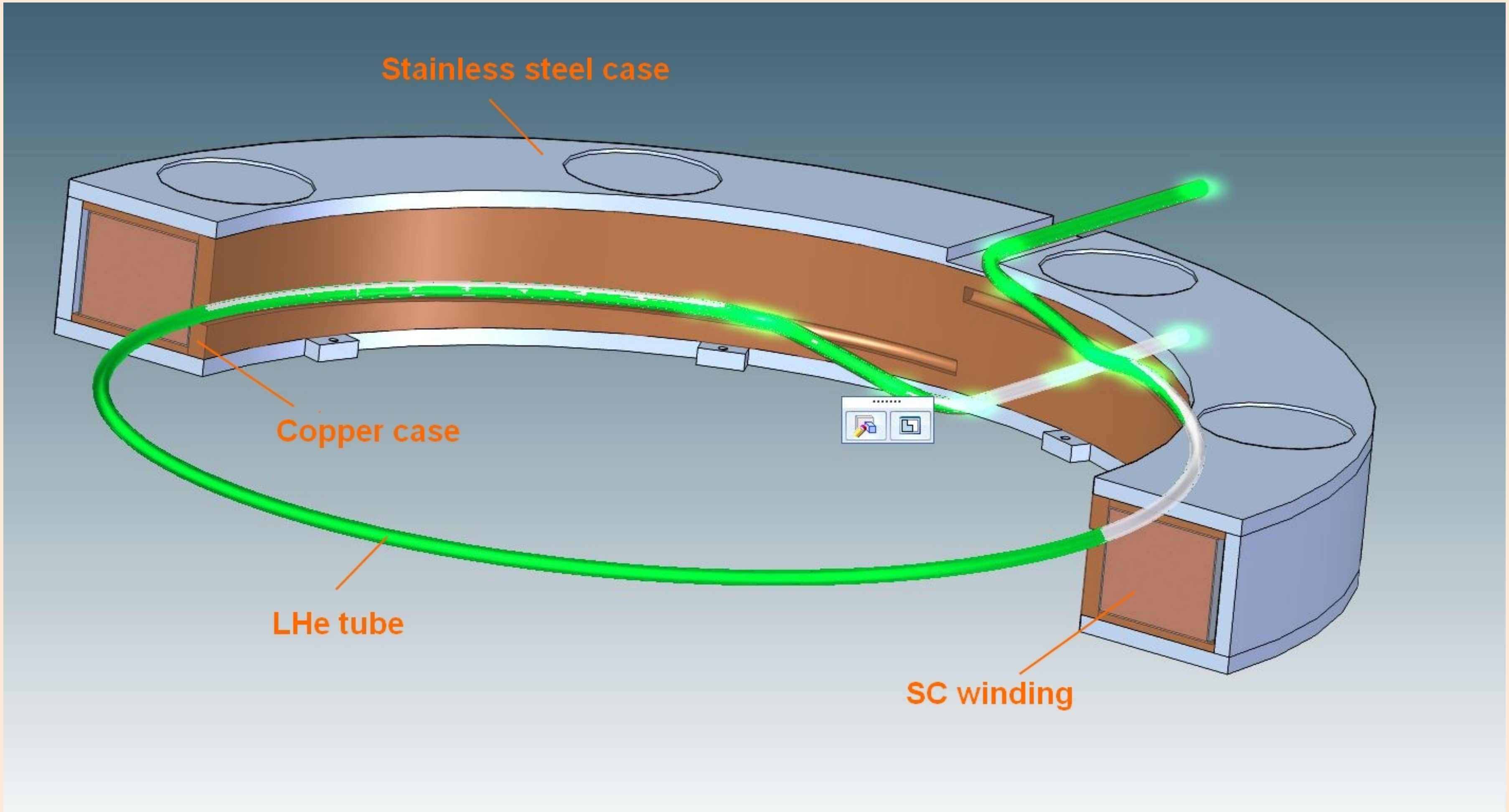
y direction 28 GPa

for copper f = 0.564, insulation f = 0.436

YM may be for copper 120 GPa, f~ 0.8

for insulator 7 GPa,

Design of the coil



Cooling of the CBM magnet

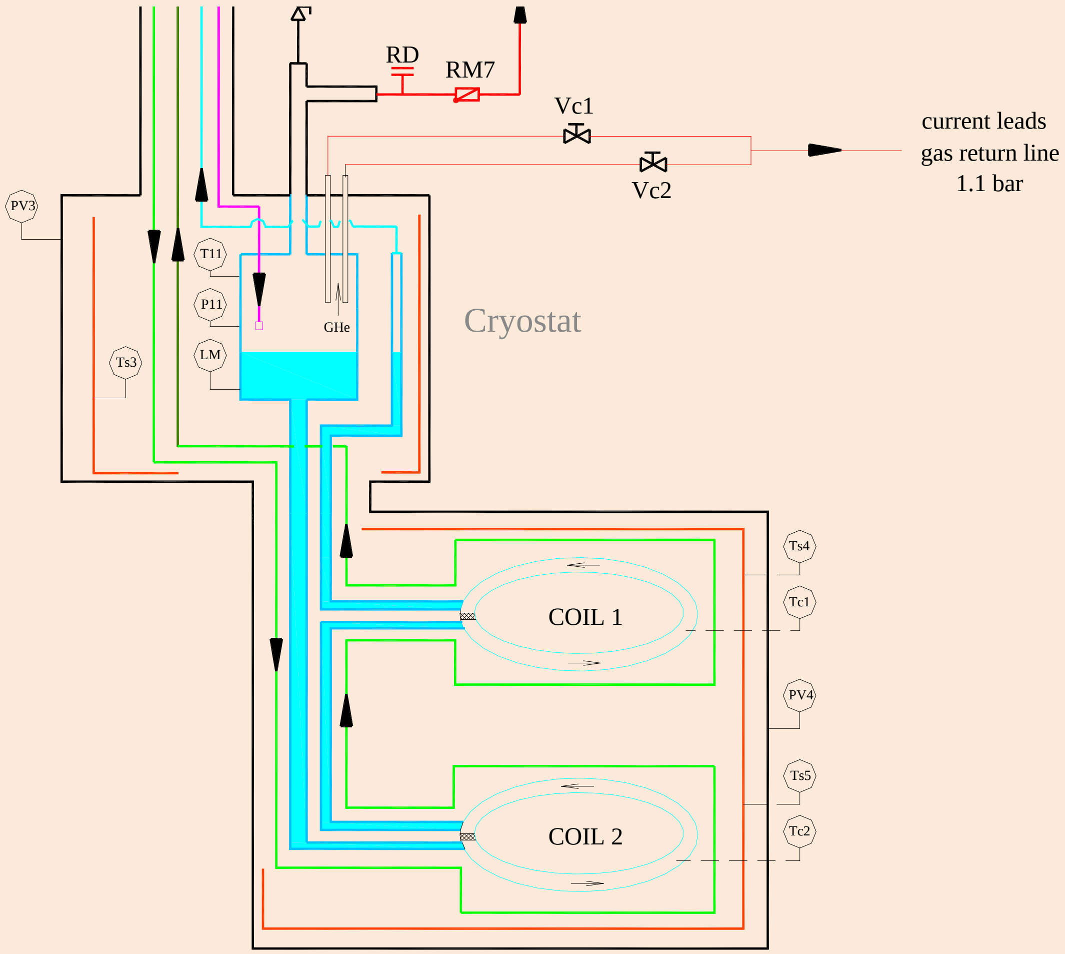
Single cryostat cooling.

Thermosyphon.

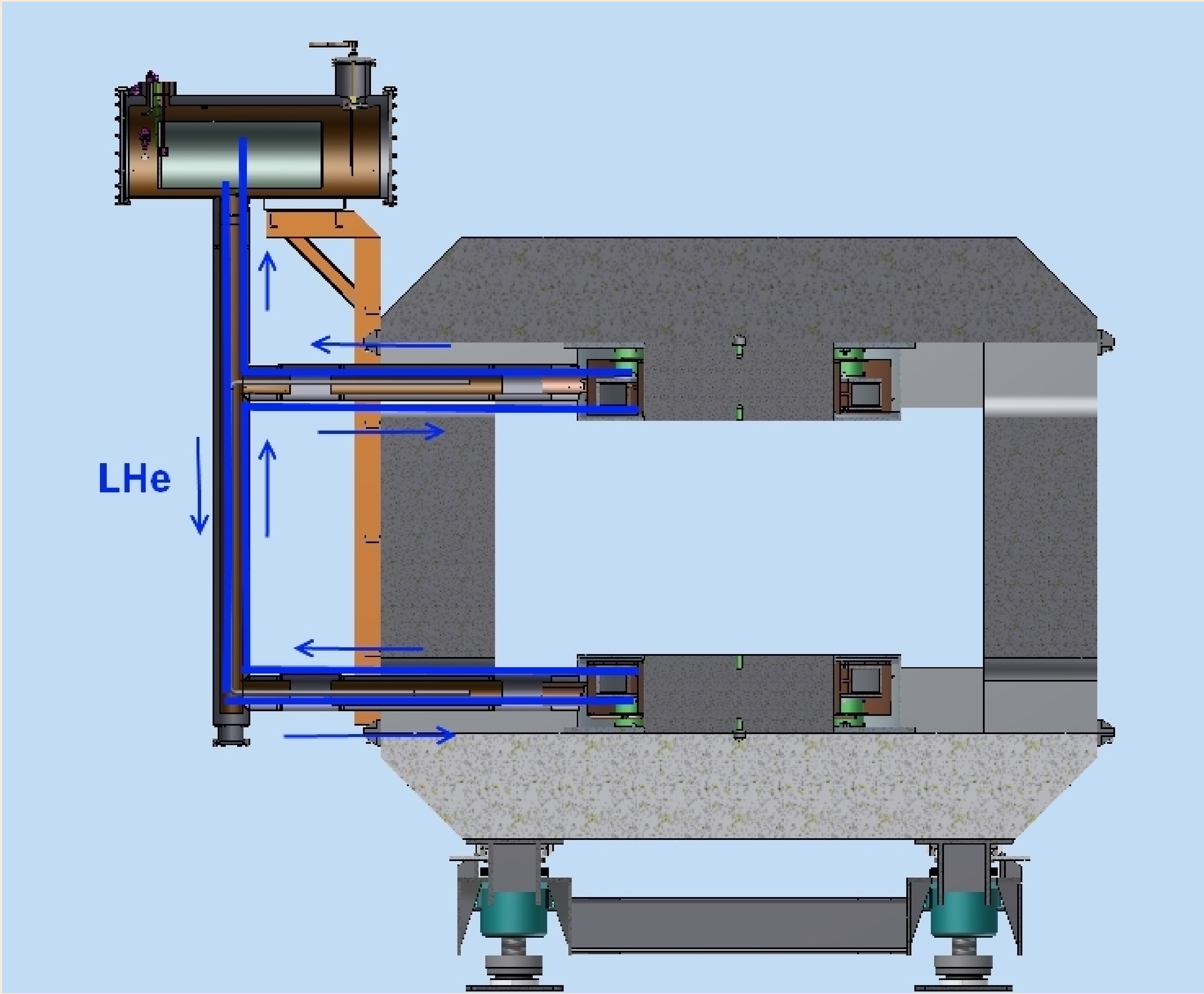
Liquid helium at 4.5 K from the cryostat goes down to the coils

Gaseous helium goes up due to gravitation.

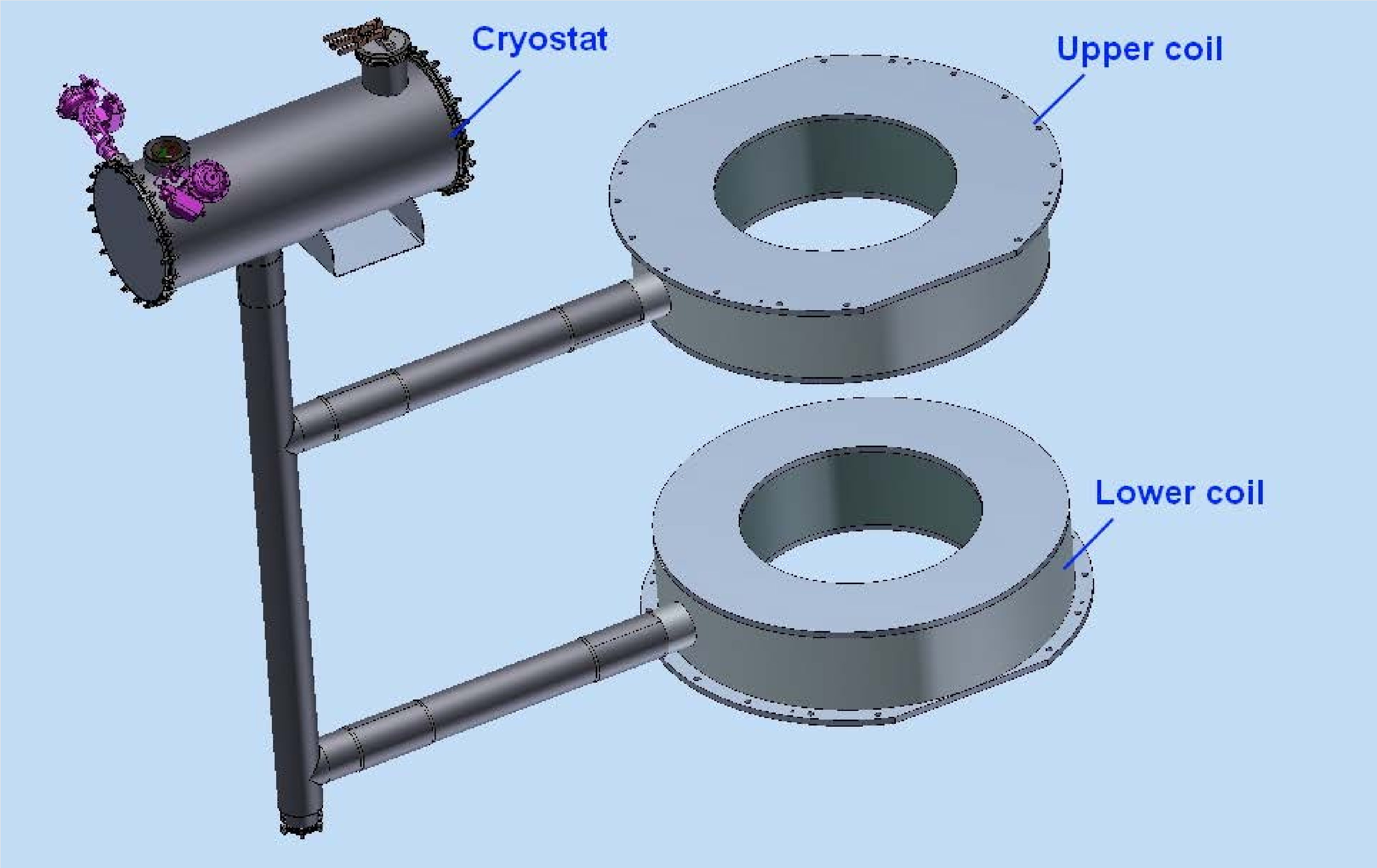
Coil design should not have gas pockets.



View of the thermosyphon cooling

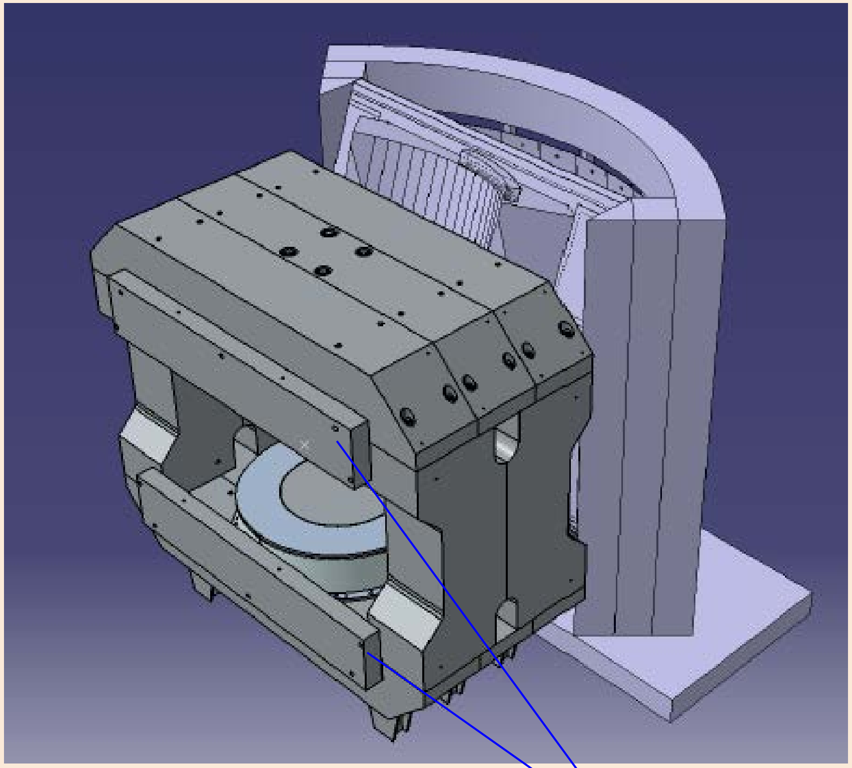


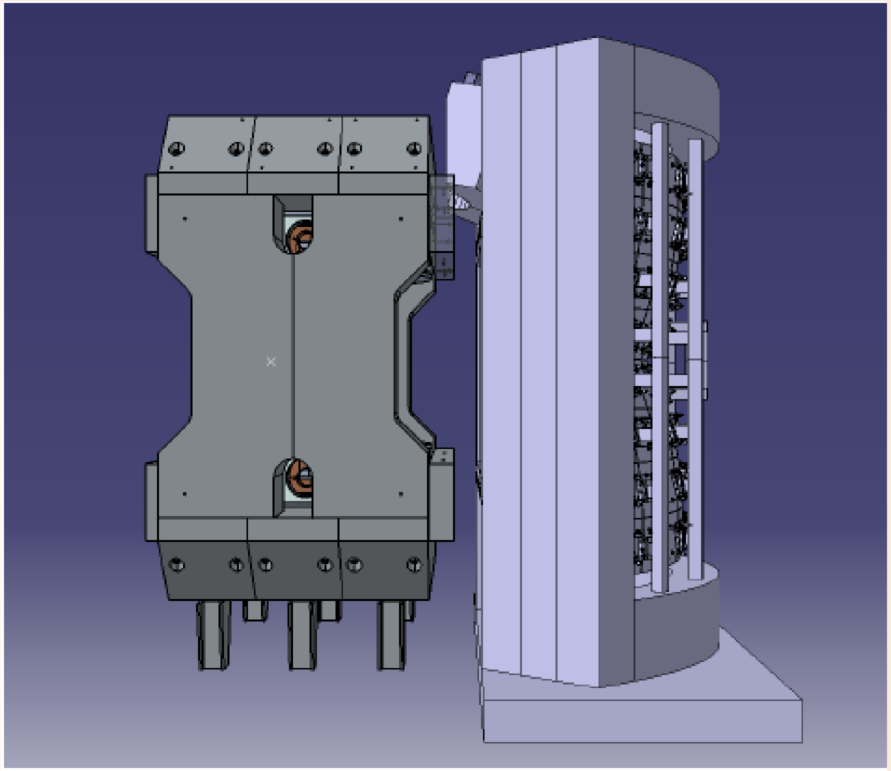
The Cryostat



Interfaces with other systems

The RICH detector is placed close to the magnet. Stray magnetic field is reduced by the field clamps.

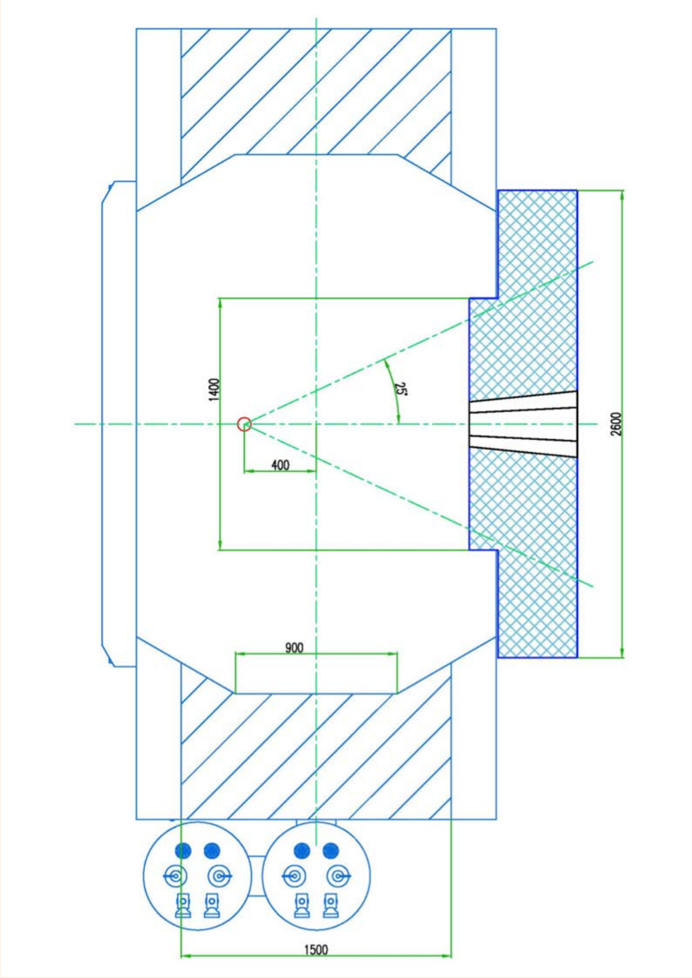


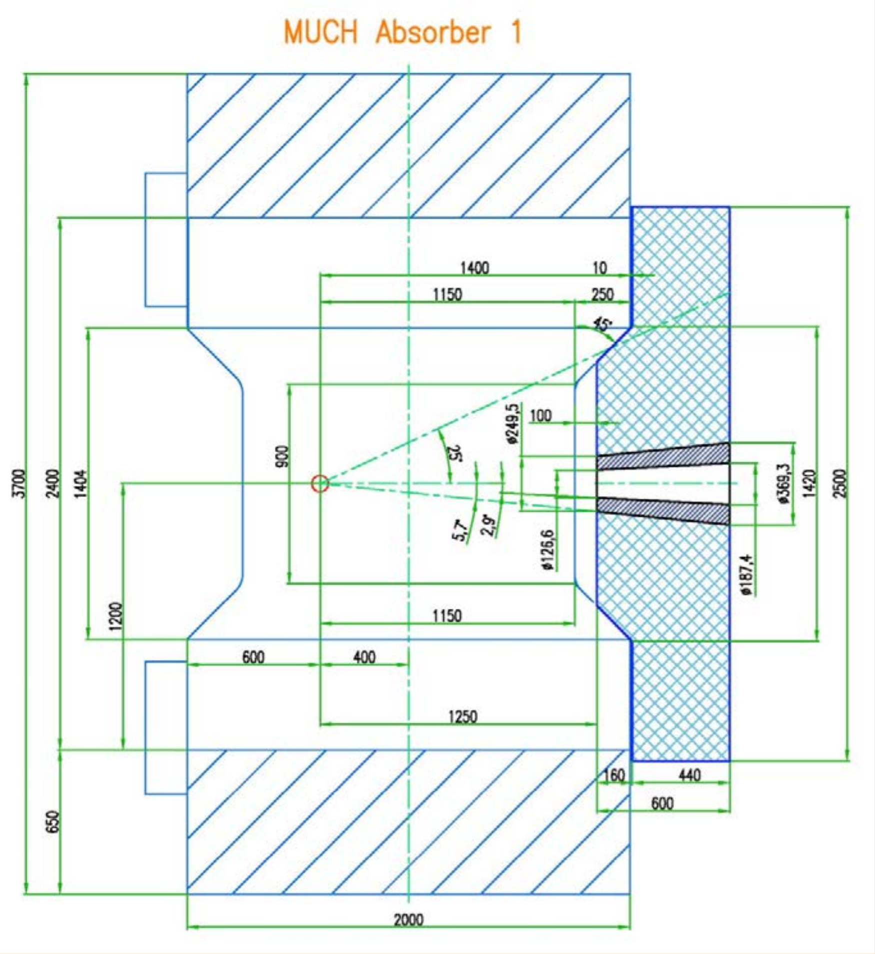


field clamps

Interfaces with other systems

The target will be placed near the center of the magnet.

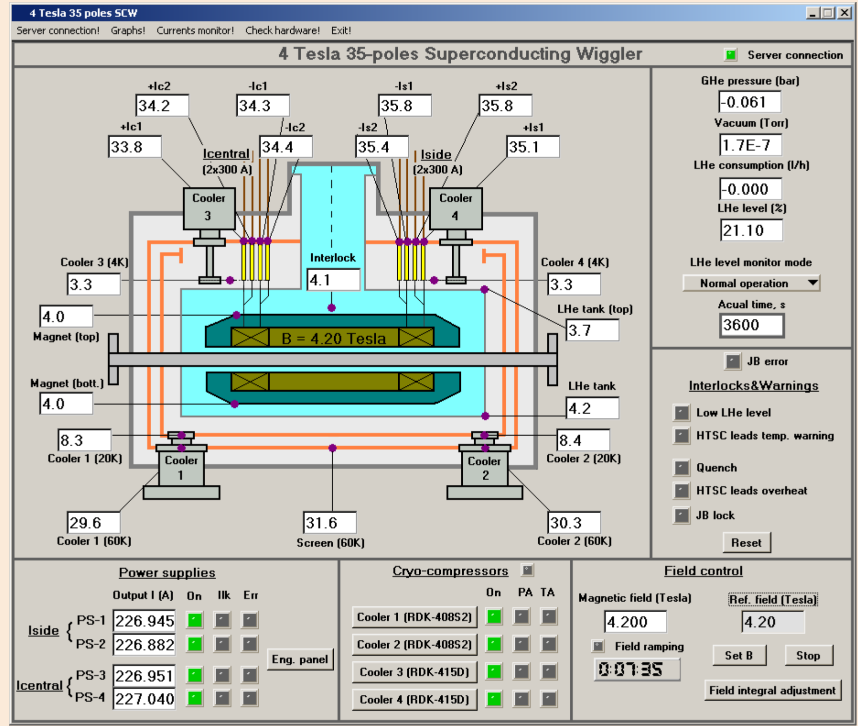




Control system

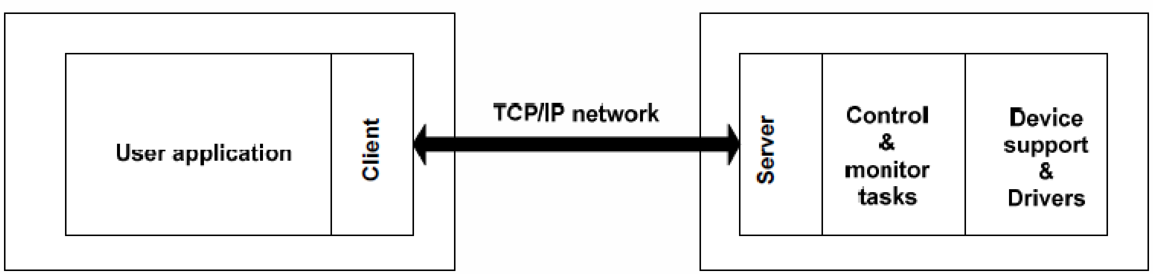
In further work BINP people responsible for the control systems should specify conditions demanded for FAIR.

Typically BINP provides the required control systems as presented on these figures.

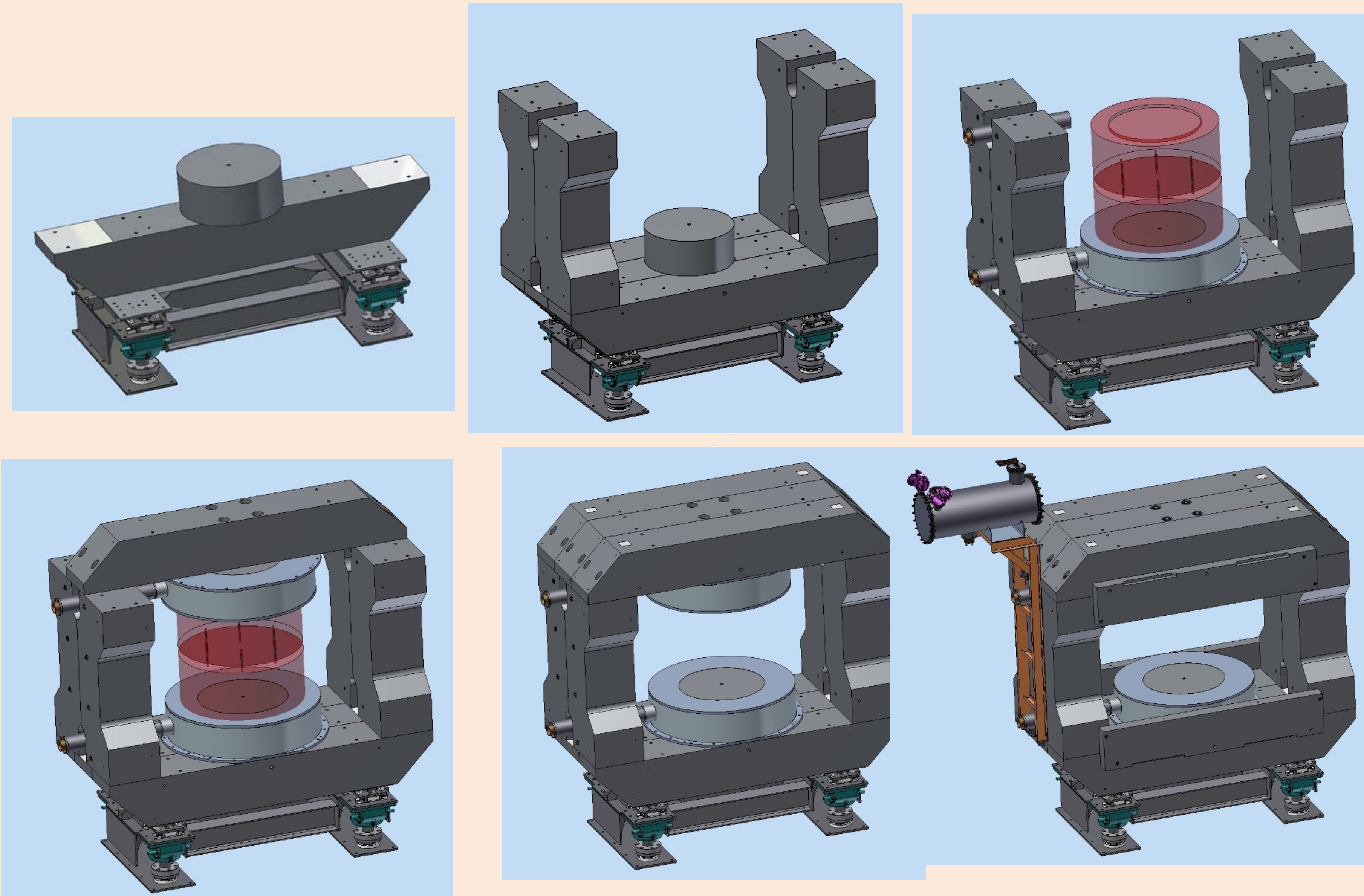


Operating system: MS Windows 2000/XP

Distributed multithread software hierarchy with client/server architecture is shown in **Figure 47**. TCP/IP communication protocol via sockets allows connection to the client application (user interface).



Assembling



Status of BINP work on the CBM magnet

- **The design of the coil, cryostat and the cryogenics is being developed.**
- **The design of the CBM magnet was changed from TDR. The calculations of new design will be presented and discussed.**
- **The SC cable will be manufactured in November 2018 as first test part and finished in March 2019.**
- **Test place in BINP will be ready in the 2019.**
- **Subcontractor for manufacturing of the iron yoke is ready to work.**
- **The discussions will be going on the cryogenics design. Its design may be finished and approved by GSI later by 2020 and to be manufactured in 2022.**
- **PDR tasks may be discussed during this meeting.**