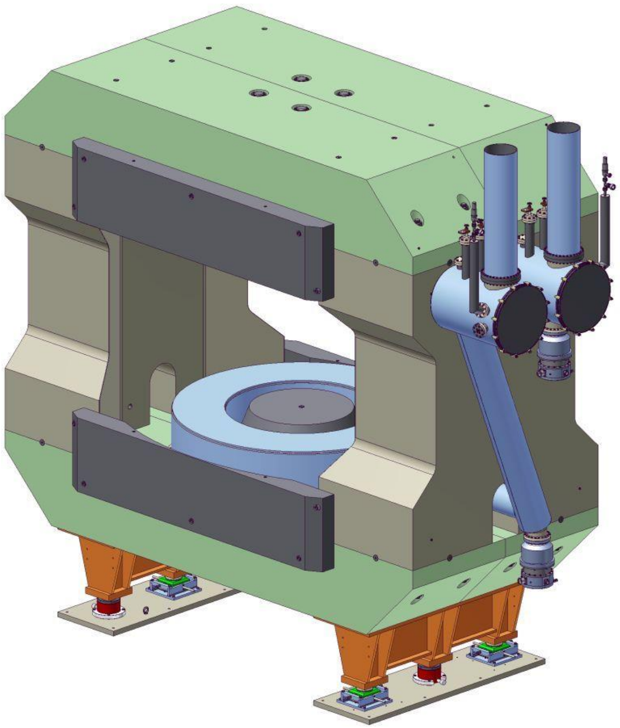
Superconducting dipole magnet for the CBM experiment at FAIR



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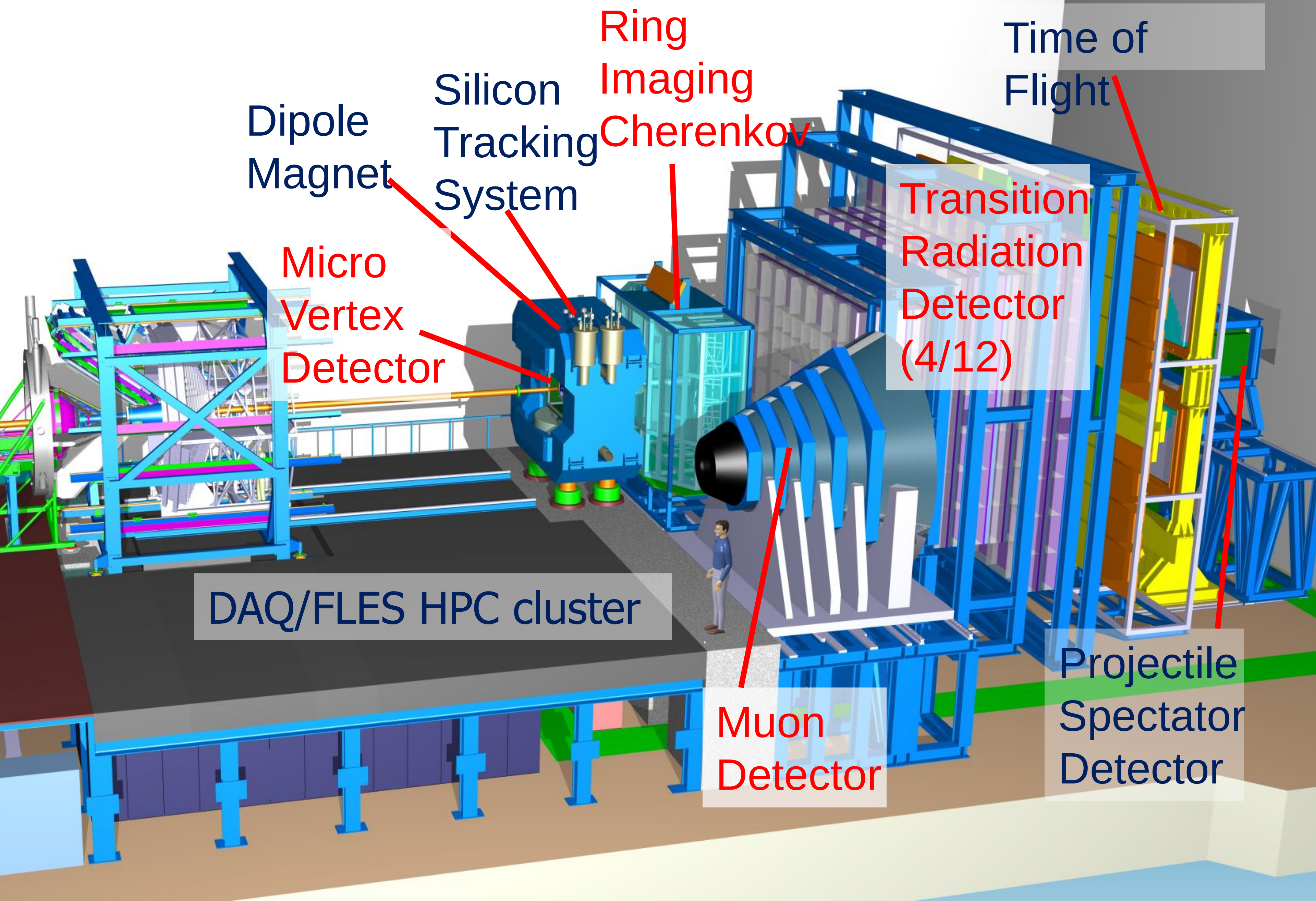
P.Akishin (*LIT JINR*)
G.Moritz, P.Senger (GSI Darmstadt)

Baldin ISHEPP XXIII, September 19-24, 2016

Content of the talk

- Introduction
- Specification of CBM magnet
- Magnet yoke and support
- Coil cryostat and feed boxes
- Quench protection scheme for CBM magnet:
- Conclusion

CBM experimental setup

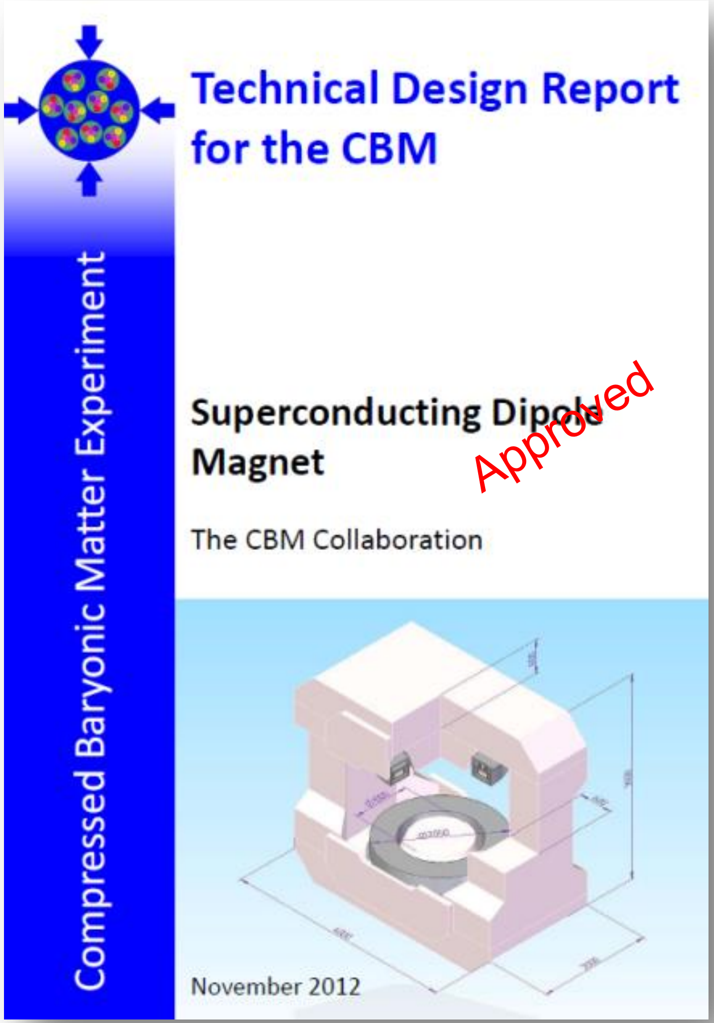


Technical Design Report

Technical Design Report for CBM superconducting dipole magnet was accepted by FAIR council in 2014.

- Works on the further design of the magnet, cryostat, support as well as on quench and magnetic field calculations were continued at JINR and GSI.
- Seach for the potential manufactors of the different CBM magnet parts: coils, cryostats and magnet yoke was very active

The Technical Design Report for the CBM Superconducting Dipole Magnet. http://www.fair-center.eu/fileadmin/fair/experiments/CBM/TDR/CBMmagnetTDR31102013-nc.pdf



Preparation of drawings in two standards

VNITEP Company and JINR design team prepared the drawings in two standards (ESKD for Russia and ISO for Europe).

The next drawings in ISO are done:

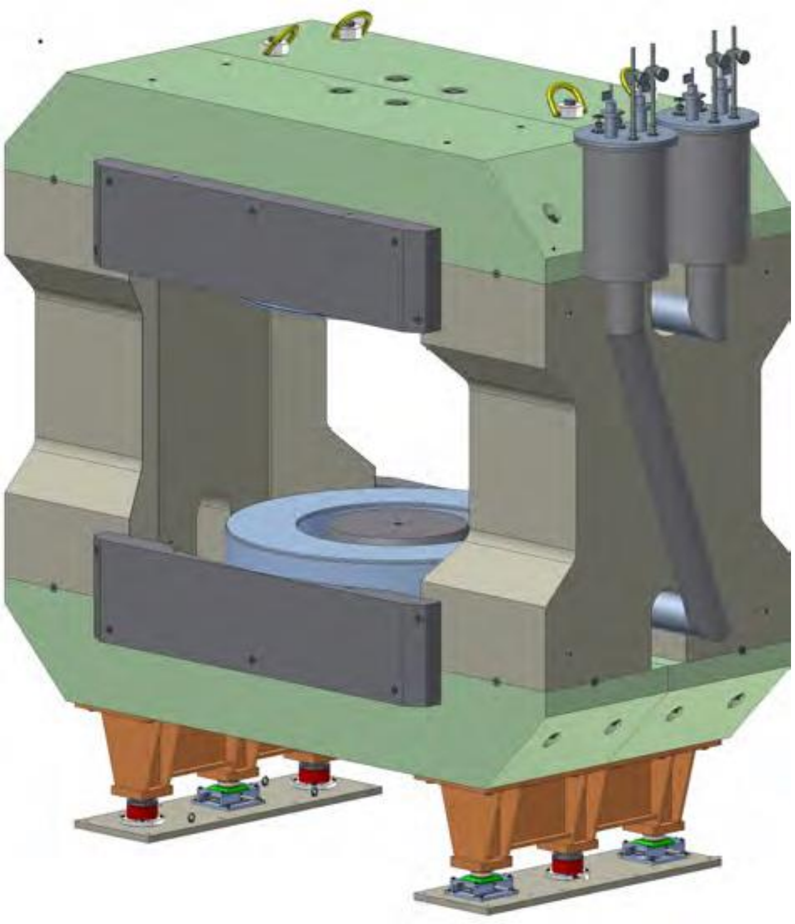
1. Yoke (DM-Y-000.00);
2. Support (DM-S-000.000);
3. Coil cryostat (DM-CC-000.000);
   - Superconducting coil (DM-SC-000.000);
   - Heat shield (DM-HS-000.000);
   - Vacuum vessel (DM-VV-000.000);
   - Support strut (DM-SS-000.000);
   - Tie rod (DM-TR-000.000);
4. Feed box1 (DM-FB1-000.000);
5. Feed box2 (DM-FB2-000.000);
6. Top coil (DM-TC-000.000);
7. Bottom coil (DM-BC-000.000);
8. Dipole magnet (DM-000.000);

Main parameters of magnet

Specifications of the superconducting dipole magnet	
Type	**H-type**, circular coils
Number of turns	1749 /coil
Number of layers	53 /coil
Windings of coil	Orderly
Coil cross section	V131mm x H158.8 mm
Outer diameter of coil	1.724 m
Inner diameter of coil	1.426 m
Nominal current	**686 A**
Magnetomotive force	1.2 MAT/coil
Current density	58.8 A/mm^2
Central field	**1.08 T**
Maximum field at coil	**3.25 T**
Field integral	**1.0 Tm**
Inductance	21,9H
Stored energy	**5,15 MJ** @686

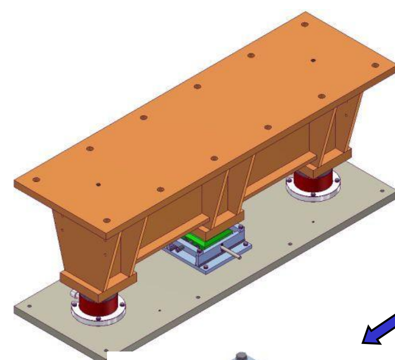
Specifications of the superconducting wire	
Material of SC cable	**NbTi/Cu**
Dimension of conductor	2,02x3.25 mm
Cu/S.C. ratio	**9.1**
Insulation	Kapton + GF tape
Filament diameter	< 40 μm
Number of filaments	~ 552
Twist pitch	45 mm
RRR	>100
Critical current @ 4.2K	1330 A @5 T
Load factor	**~0.52**

CBM Superconducting Dipole Magnet

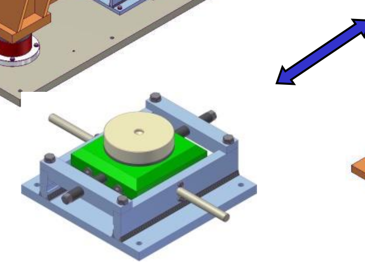


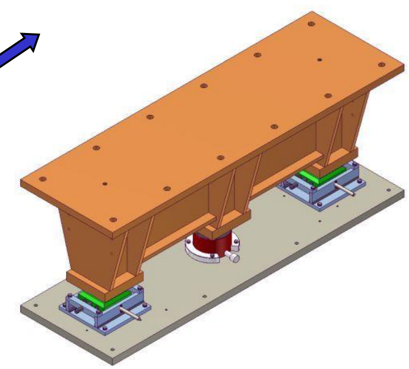
The magnet weigth	- 150 t
The beam axis from the floor	- 2600 mm
The height of the support	- 750±20 mm
The support points	- 3
The maximal load on point	- 85 t
The vertical adjustment	- ±20 mm
The horizontal adjustment	- ±20 mm

The magnet support



3 hydraulic jacks for vertical adjustment

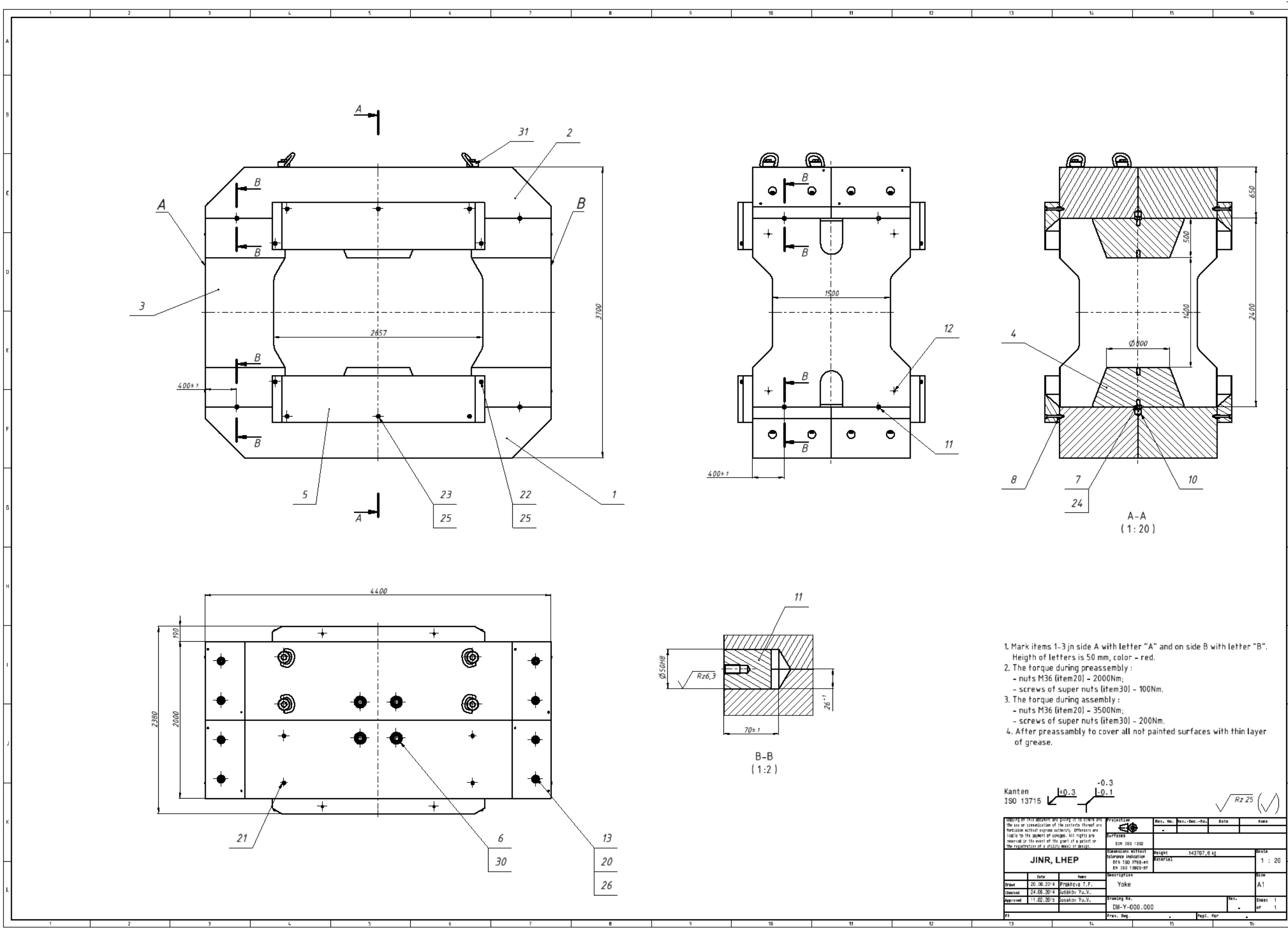




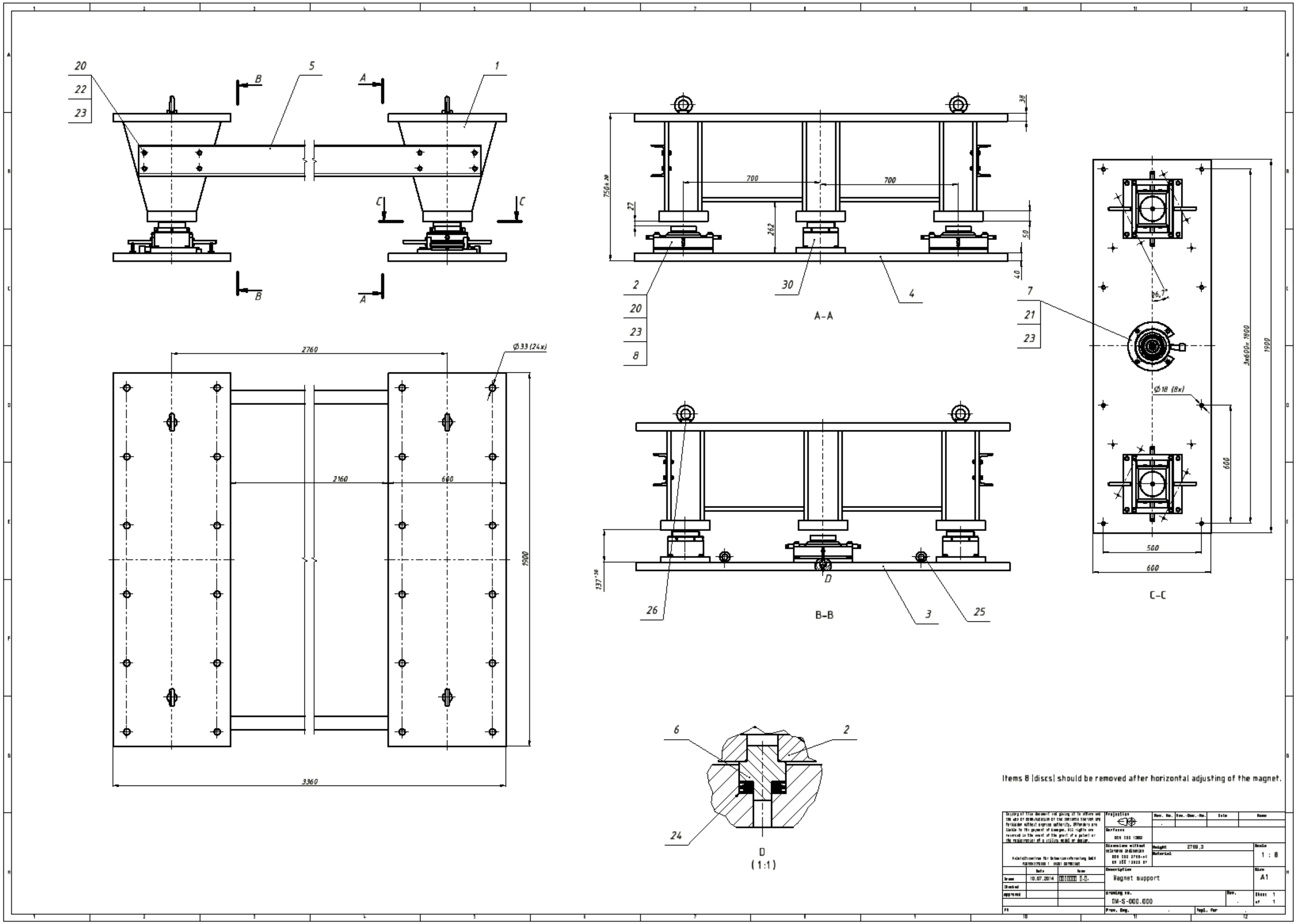
3 roller skid for horizontal adjustment

The adjustment process is divided on two main stages: horizontal and vertical movements.

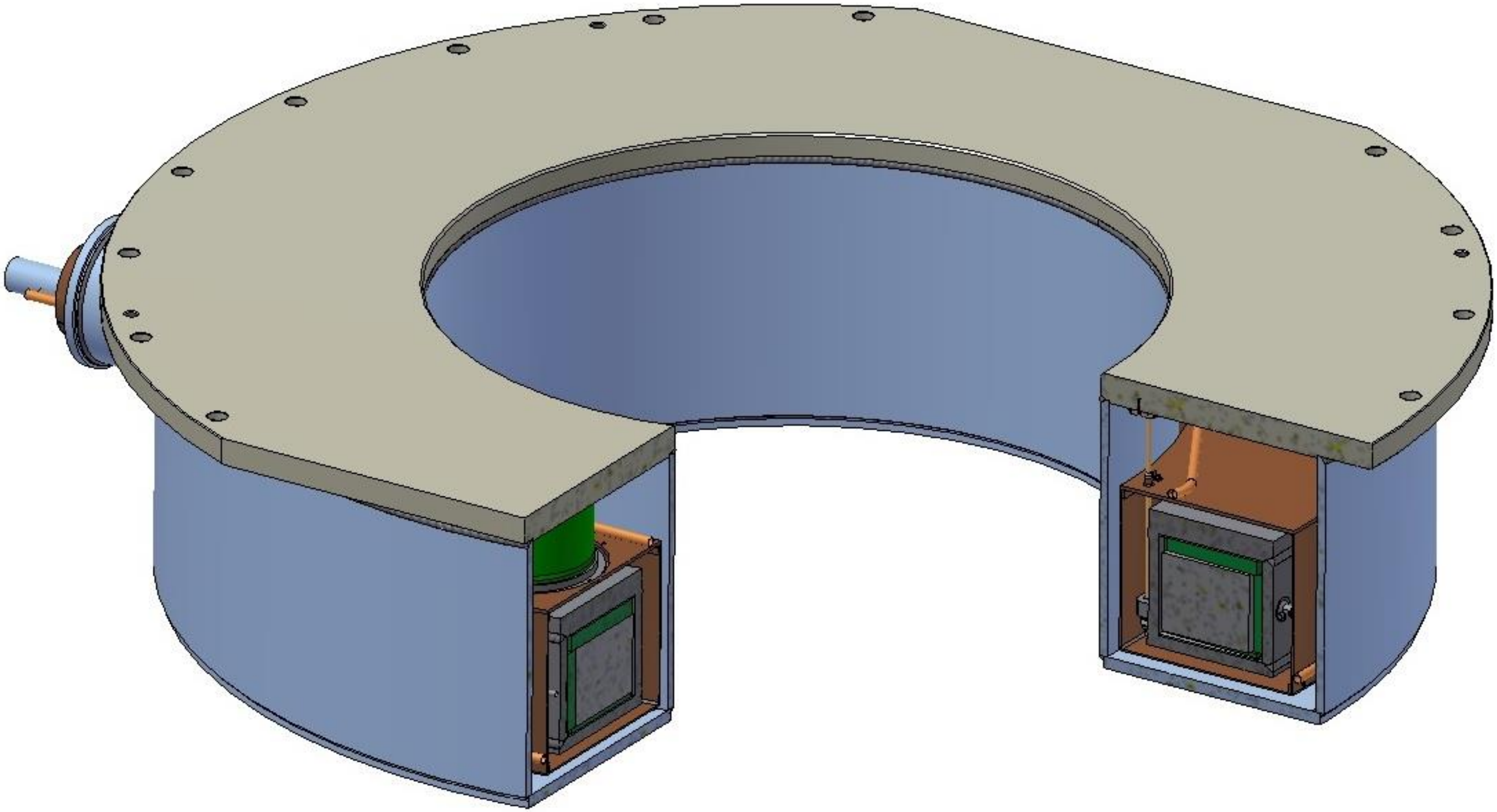
Assembly drawing (ISO) of magnet yoke



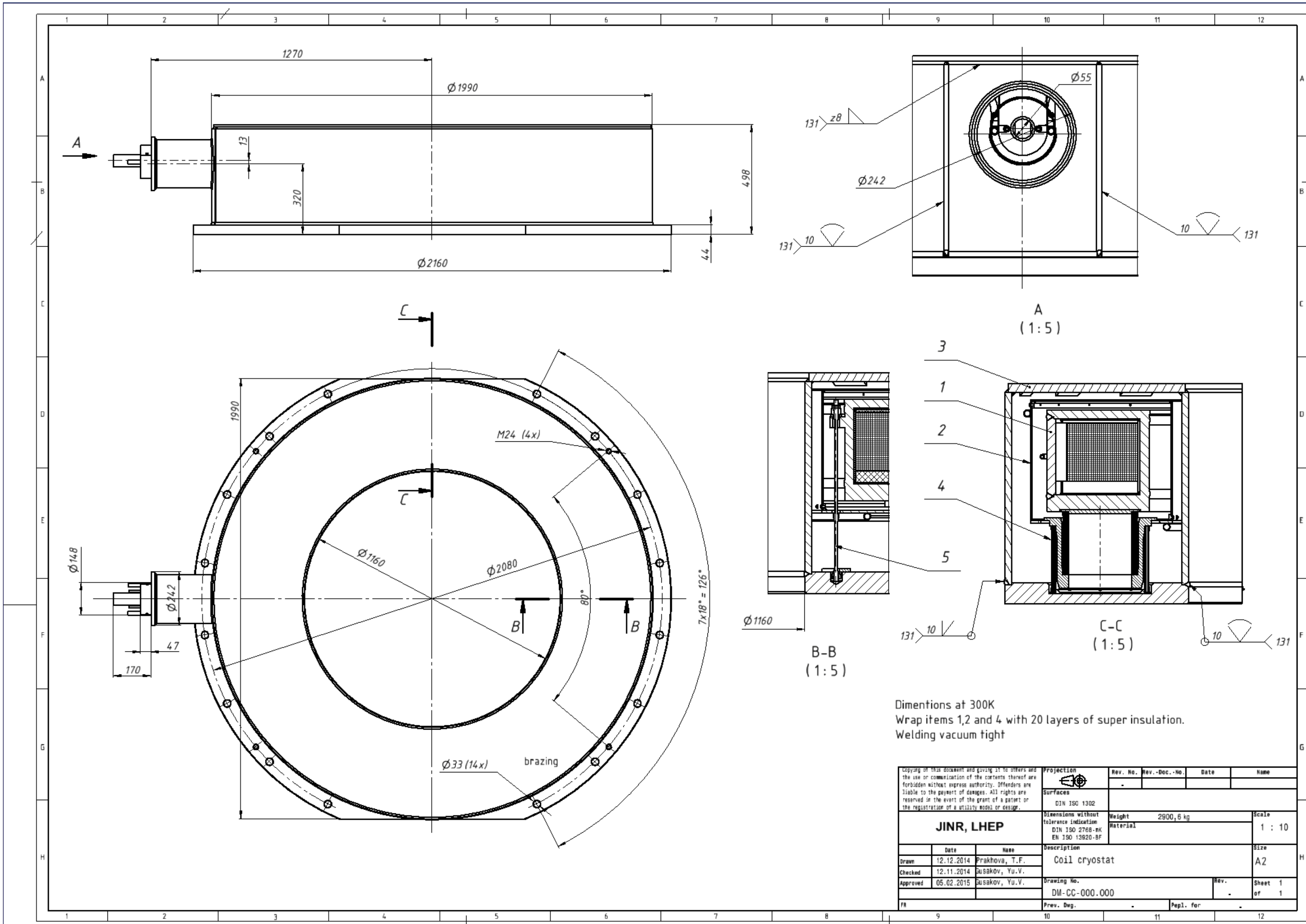
Assembly drawing (ISO) of magnet support



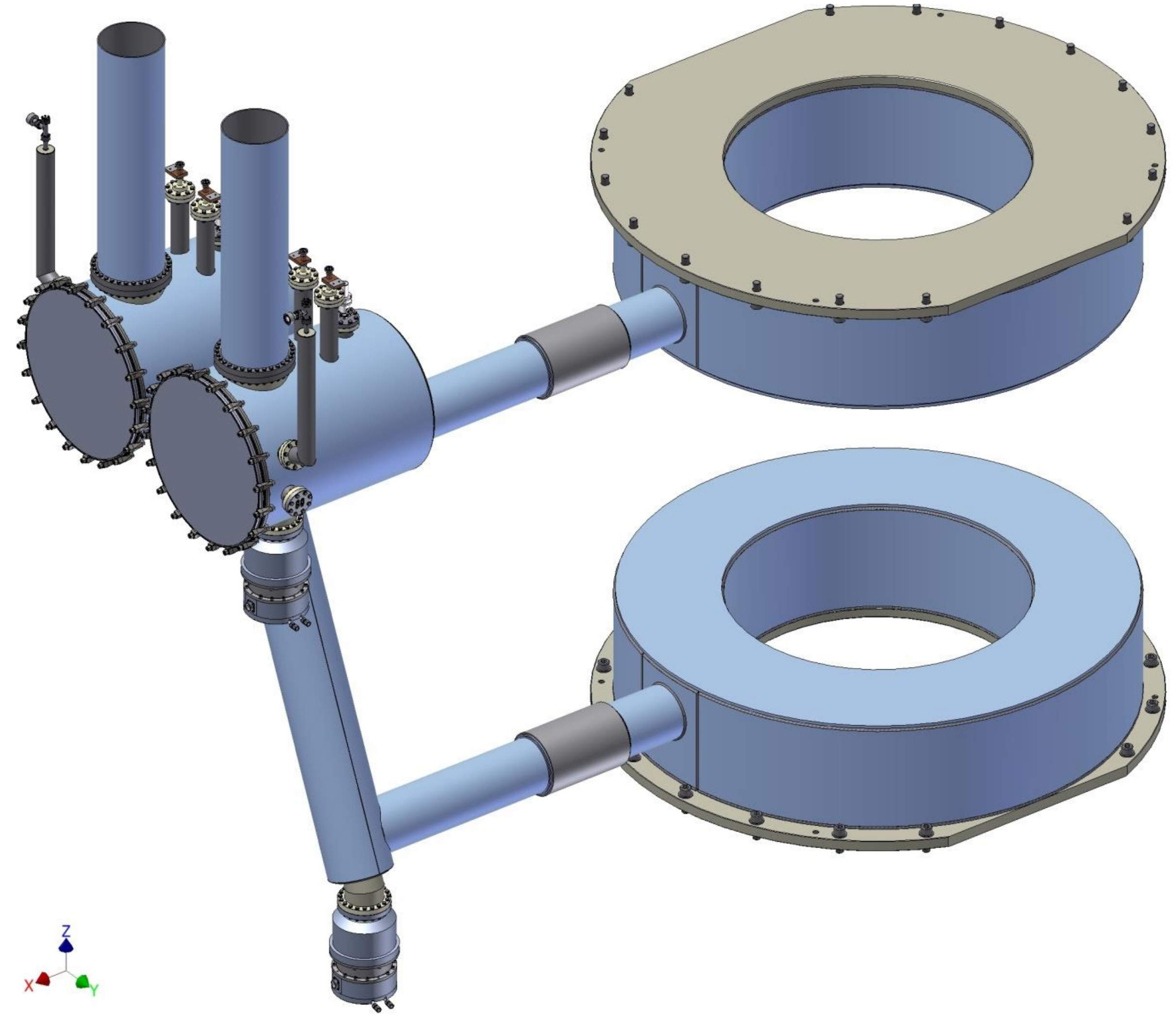
Cryostat of superconducting coil



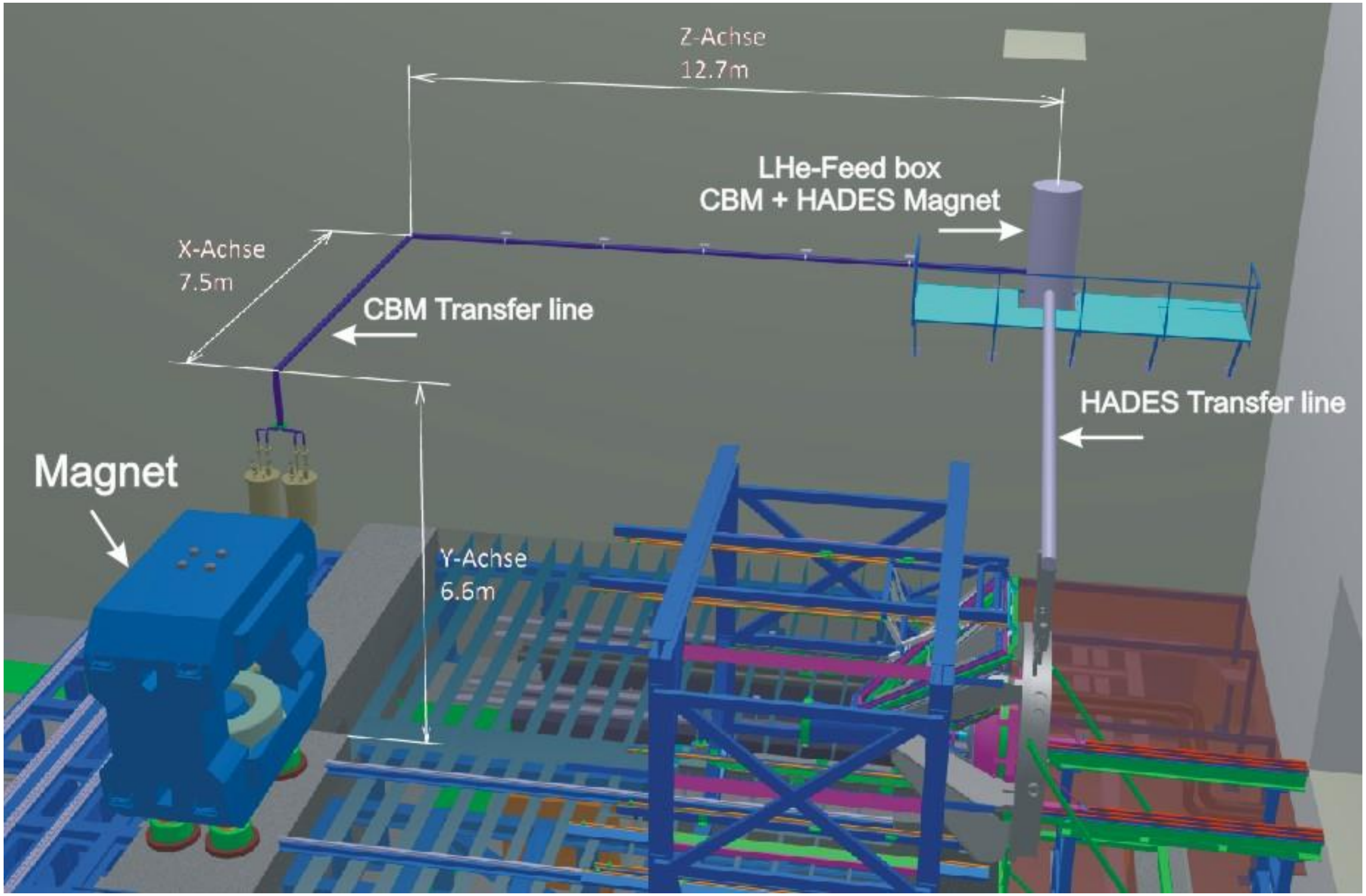
Assembly drawing (ISO) of coil cryostat



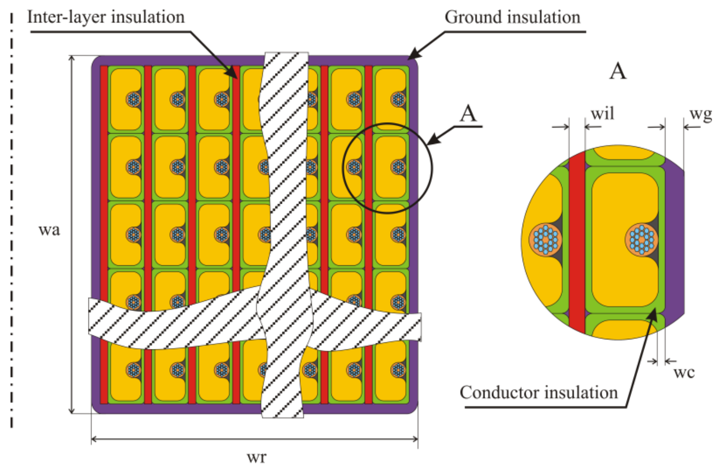
Top and bottom coils with feed boxes

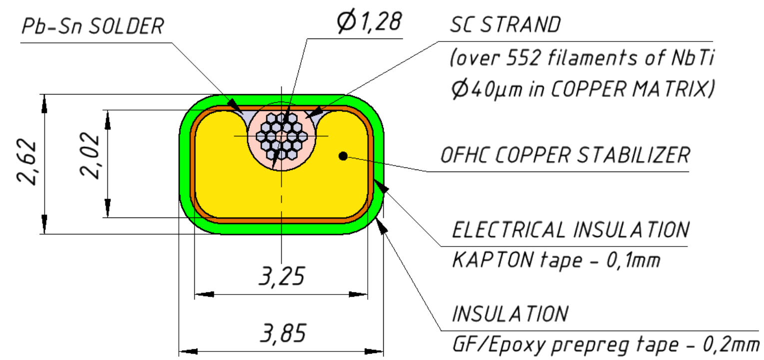


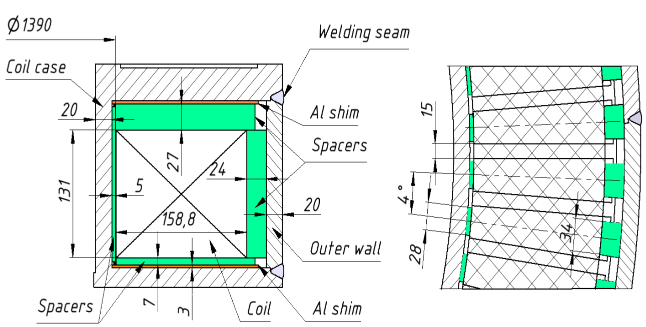
CBM magnet and feed box



Superconducting coil of magnet







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Data used in 3D modified SQUID simulation code

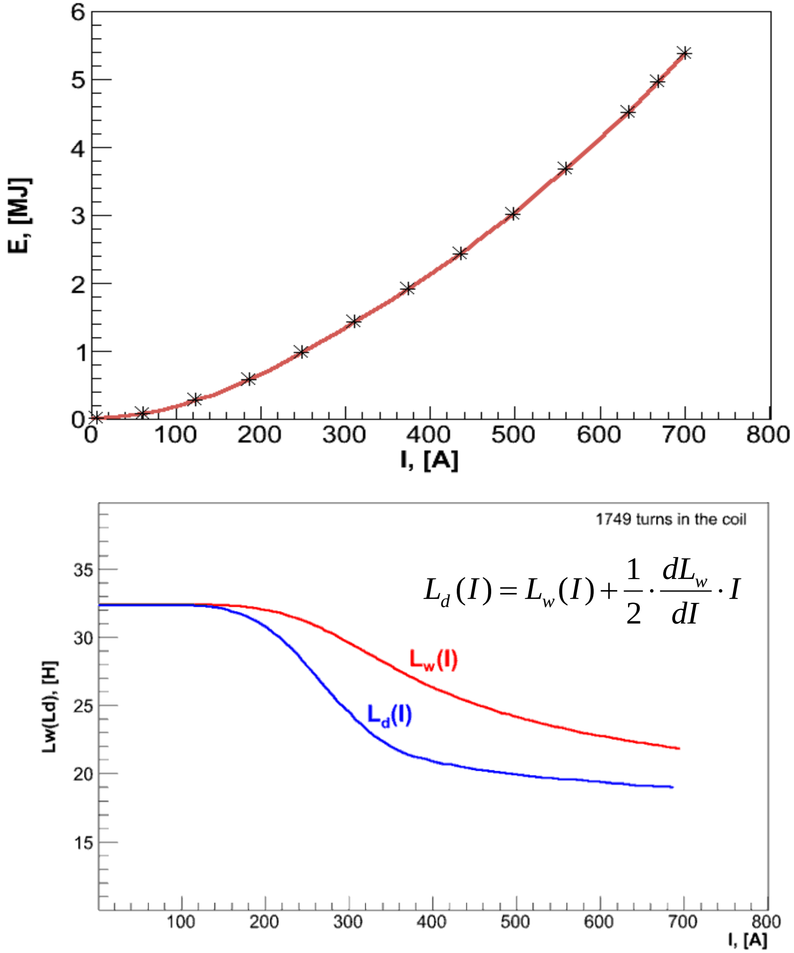


Fig.1: (a) Magnet energy and (b) inductances L_w and L_d (b) vs the current.

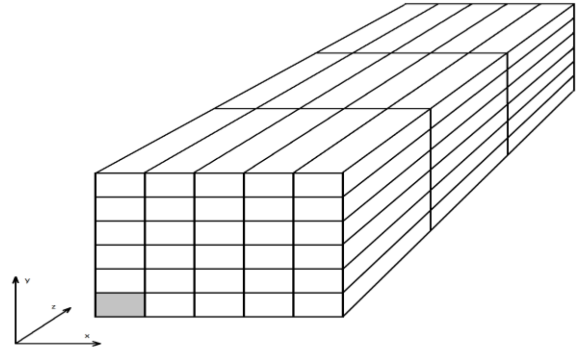


Fig.2: Simplified model in the CBM magnet coil.

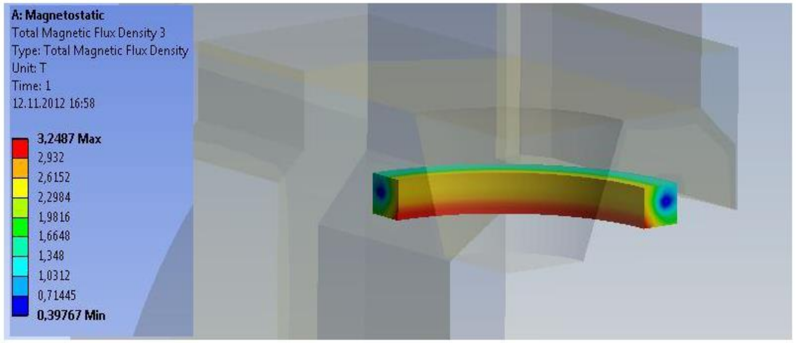
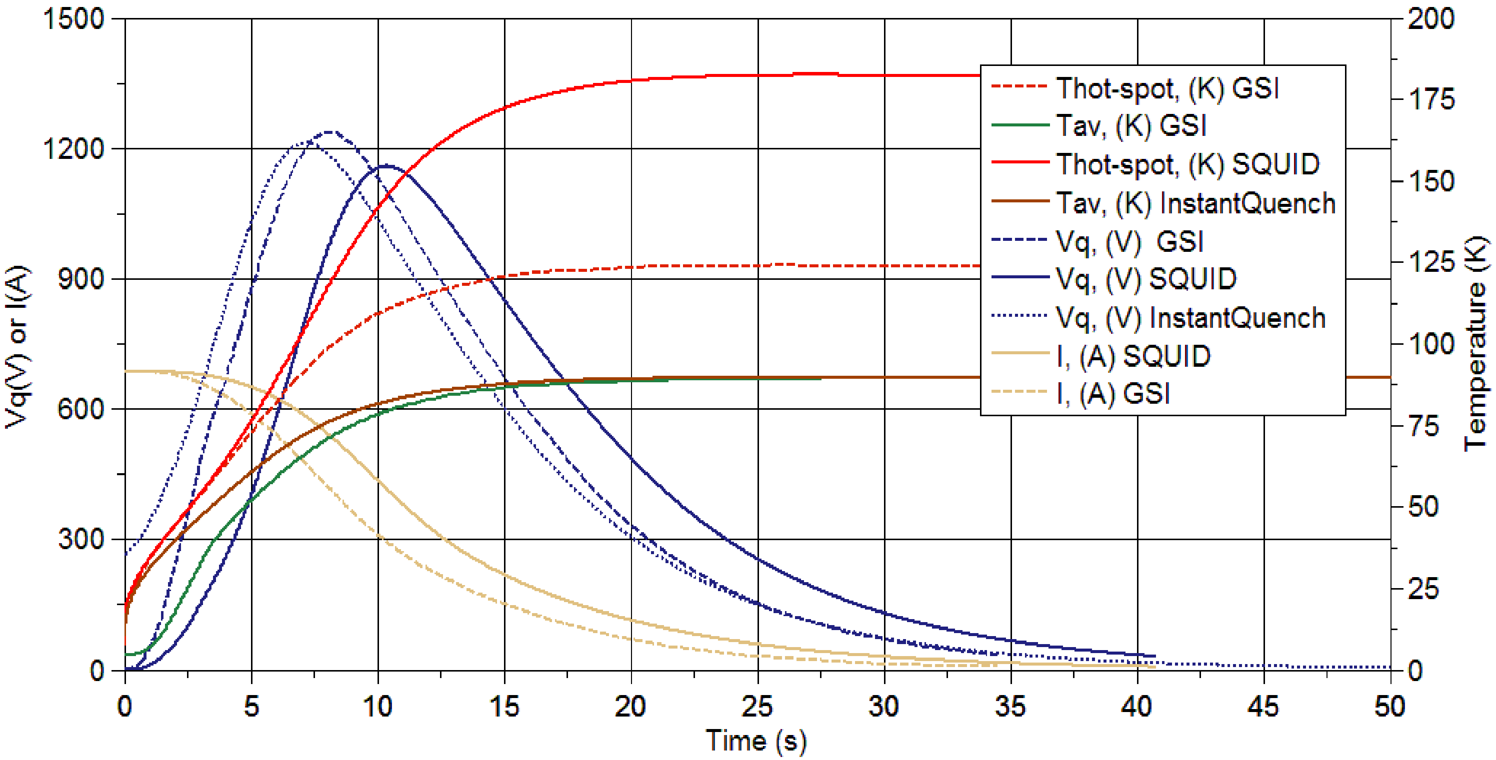


Fig.3: Magnet field in the coil.

The thermal properties of Kapton:

1. *http:/cryogenics.nist.gov*
2. Dissertation of J. N. Schwerg., “Numerical calculations of Transient Field Effects in Quenching Superconducting Magnets”, Berlin 2010

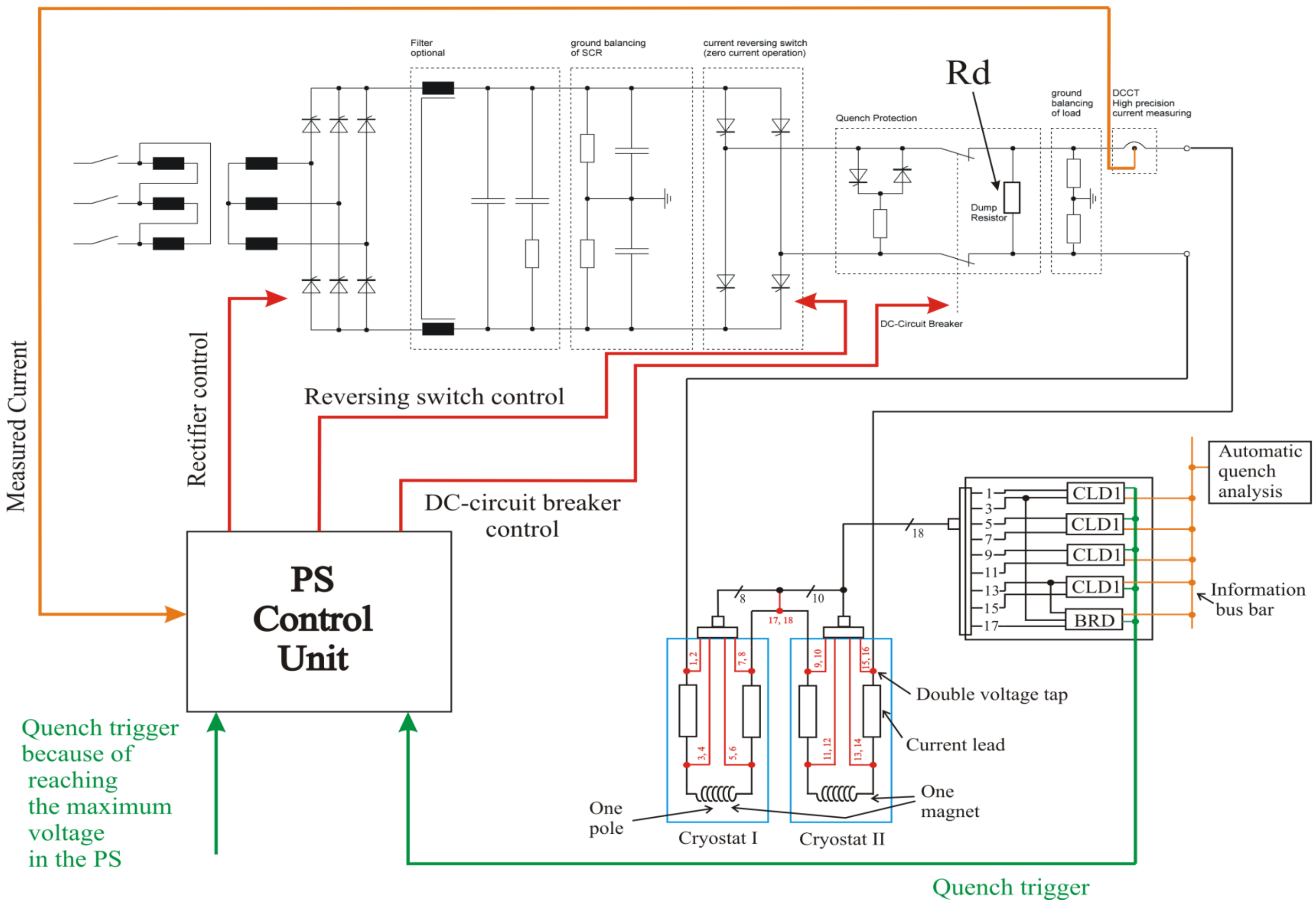
3D quench calculations for CBM magnet



Results of 3D GSI (E.Floch, P.Szwangruber) and SQUID (P.Kurilkin, F.Toral) quench programs.

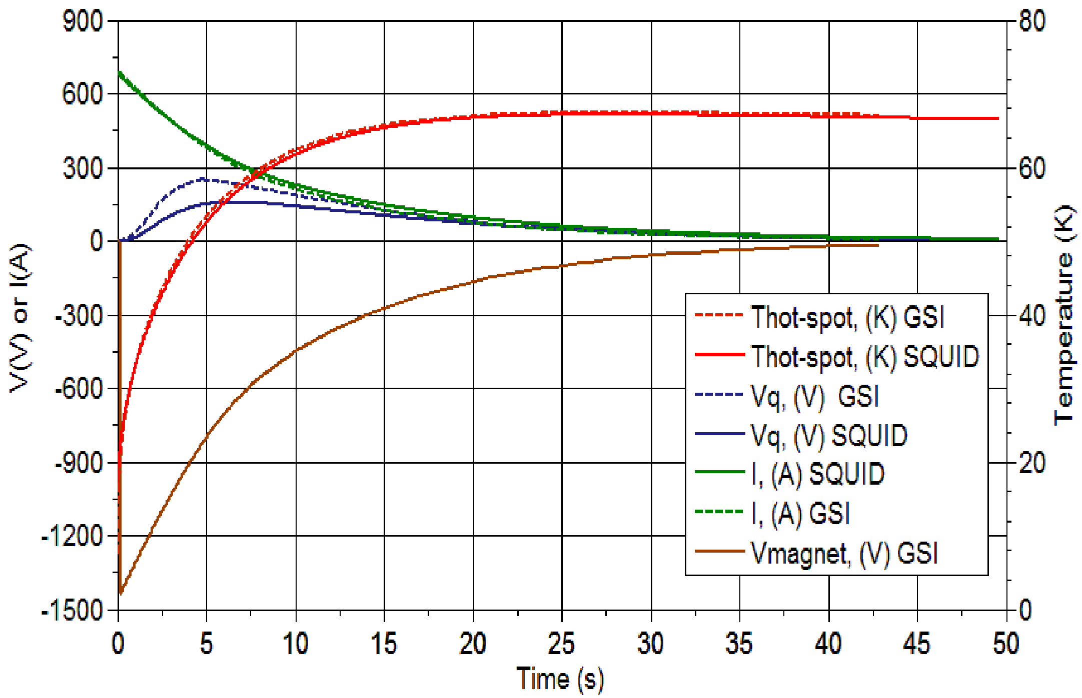
P. Szwangruber et al., "Three-Dimensional Quench Calculations for the FAIR Super-FRS Main Dipole", IEEE Transactions on Applied Superconductivity, 23 No.3 (2013) 4701704

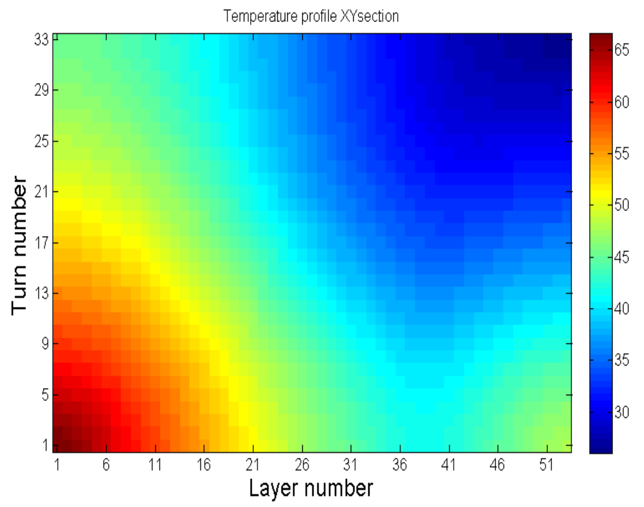
Quench protection and detection scheme of CBM magnet



E. Floch, H. Ramakers (GSI, Darmstadt)

Quench protection and detection scheme of CBM magnet: 3D calculation results





3D calculation, Rd=2.1Ohm

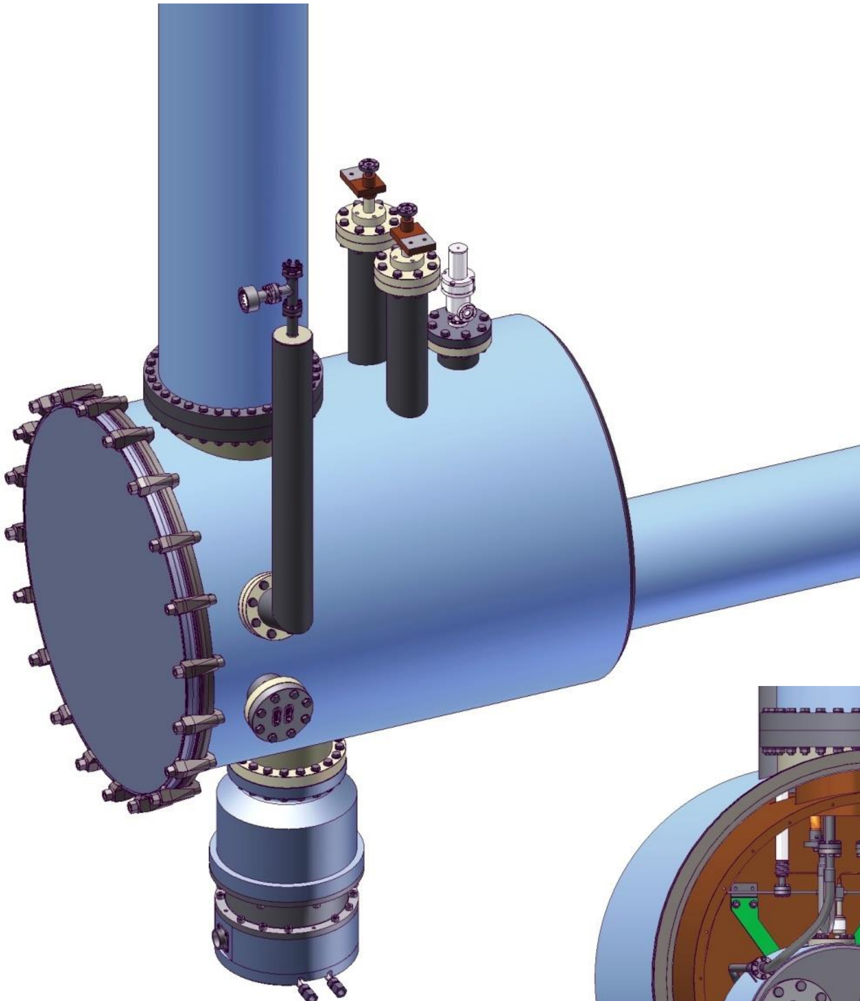
3D GSI (*E.Floch, P.Szwangruber)*
3D CIEMATm (*P.Kurilkin, F.Toral*)
In case of using 1.5-2.1 Ohm resistor 80-86% of 5.15 MJ are dissipated in outside of the coil.

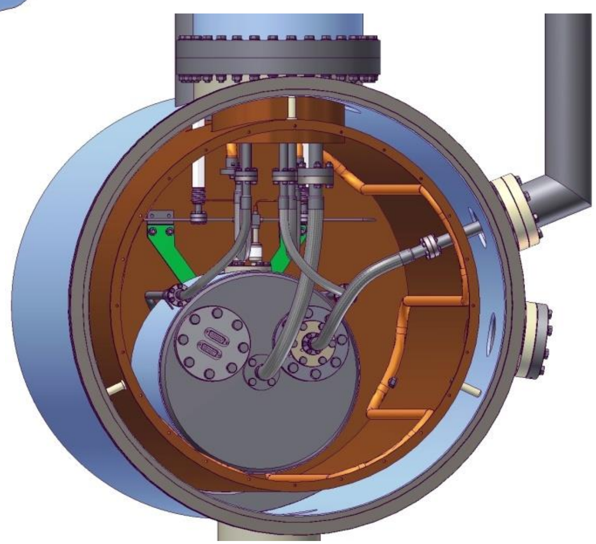
Conclusion

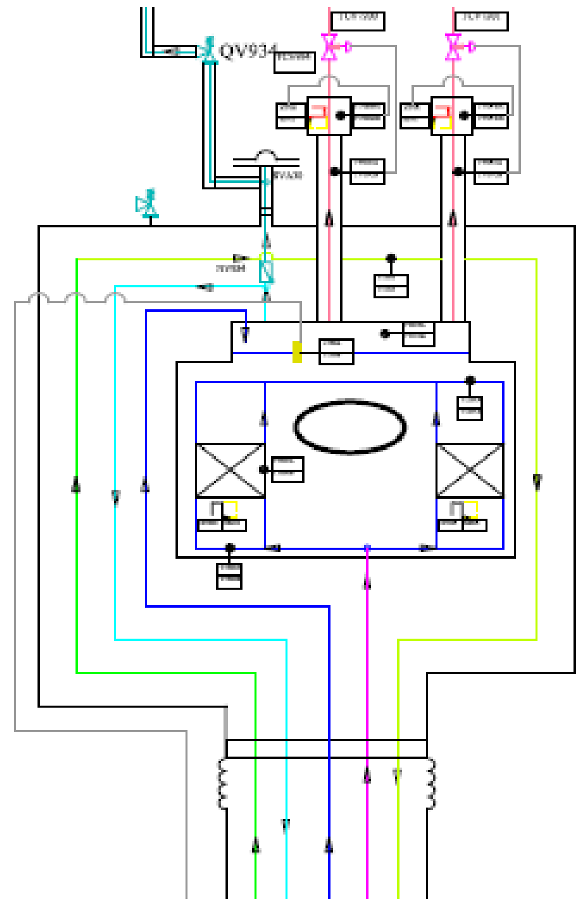
- The superconducting dipole magnet of CBM experiment will store about 5.15 MJ at its nominal current of 686 A.
- The drawing of magnet yoke, support, cryostats, superconducting coils, feed boxes were done in two standards
- The 3D quench program (*SQUID*) was developed for the CBM magnet quench calculation. The program takes into account the data on magnetic field distribution in the coil and double layer wire insulation.
- The quench protection system based on the energy evacuation via ~2.1 Ohm dump resistor was chosen as final for CBM magnet due to the lower temperature gradient in the coil.
- Preliminary results of dipole magnet with enlarged aperture have been obtained.
- Concept of feed boxes is chosen and drawings of them are done.

Thank you for the attention!!!

Flow scheme and 3d model of feed box for top coil





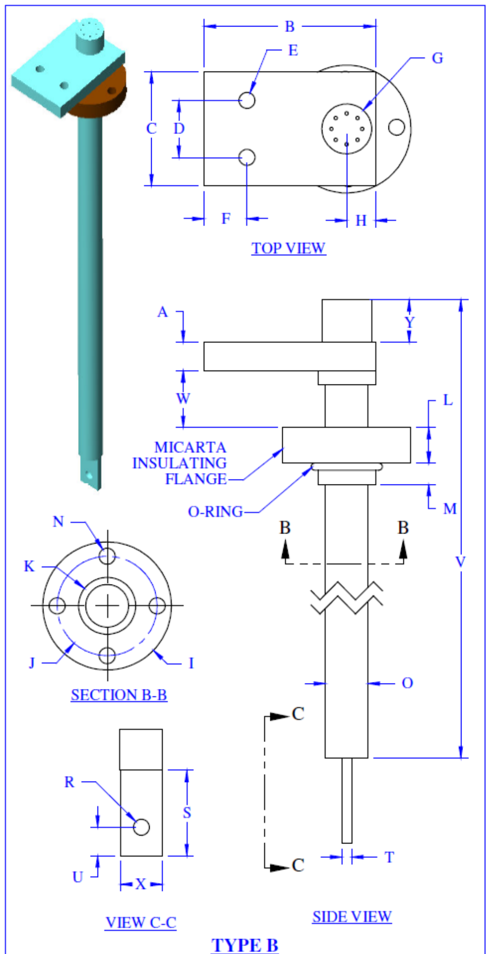


American Magnetics Inc.'s (AMI) Vapor Cooled Current Leads

www.americanmagnetics.com

Standard AMI current leads L-1000

Model Number		L-500	L-1000
Amperes		500	1000
Approx. Helium Consumption, Liters/Hr. (pair of leads)		1.6	3.2
Type		A	B
DIMENSIONS IN INCHES	A	1/2	1/2
	B	3	3
	C	1-1/2	2
	D	--	1
	E	9/16	9/32
	F	3/4	3/4
	G	1/2	7/8
	H	1/2	1/2
	I	--	2-1/4
	J	--	1-3/4
	K	1/2 NPT	1
	L	1-3/16	5/8
	M	3/4	3/8
	N	--	9/32
	O	1/2	3/4
	R	0.201	9/32
	S	1	1-1/2
	T	1/8	1/4
	U	1/4	1/2
	V	17-1/2	19-1/2
	W	Adjust.	1-1/2
	X	1/2	3/4
	Y	1/2	3/4



Adaptation of standard leads