NICA Days and XII Collaboration Meeting of the MPD
02-06/010/2023

Serbia, Belgrade 2023

VINČA
INSTITUTE OF NUCLEAR SCIENCES
University of Belgrade
NATIONAL INSTITUTE OF THE REPUBLIC OF SERBIA

Status of the solenoid assembling

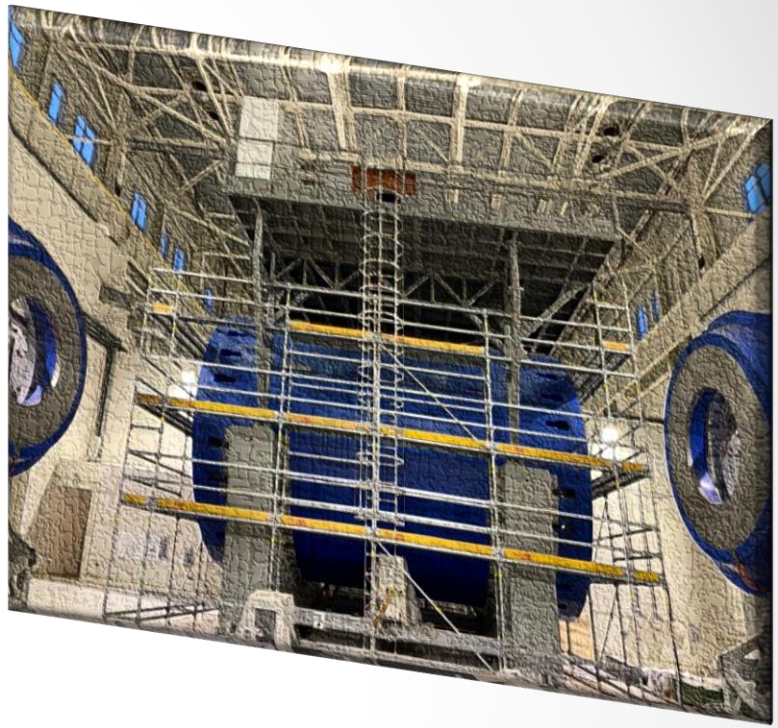
From drawing

to facility

Speaker: K. Mukhin

Plan of talk

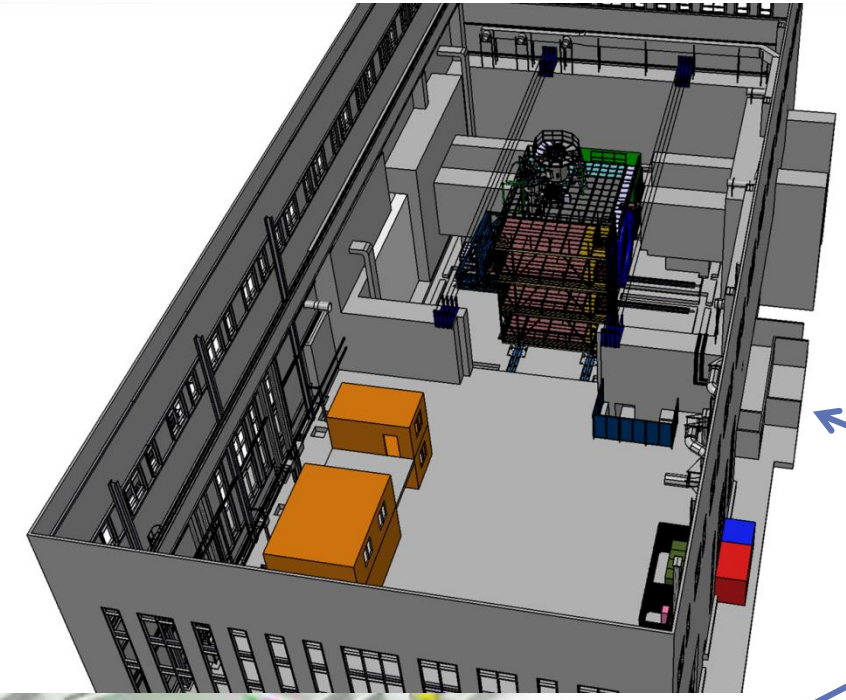
- Magnet construction
- Cryogenic infrastructure
- Ready to cooling
- Control and protection system
- Timeline

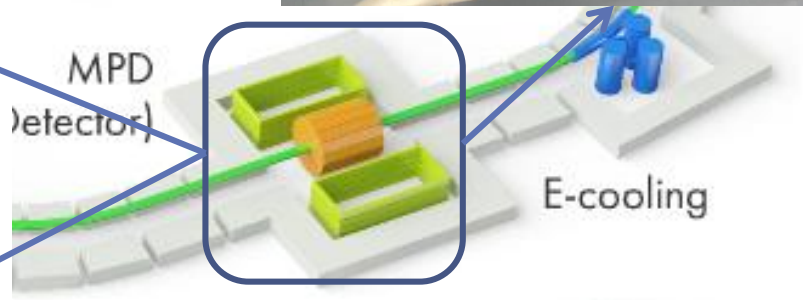


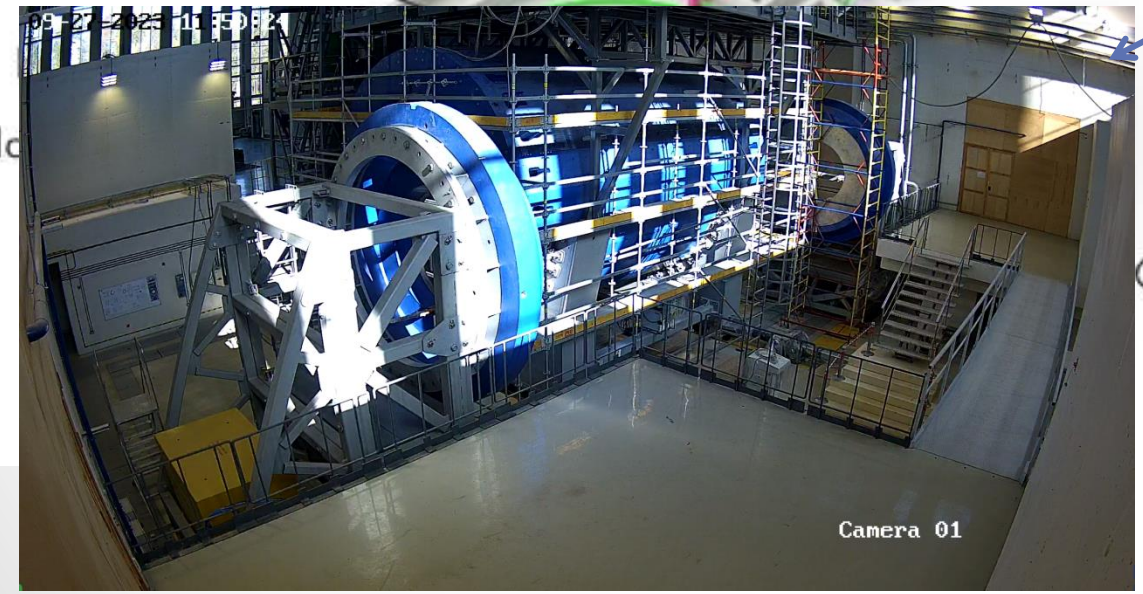
Chapter 1

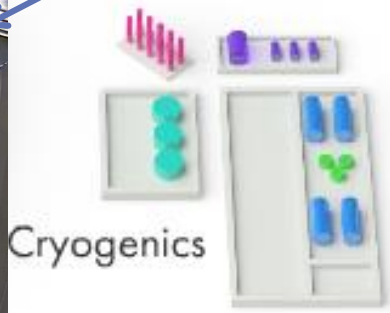
Magnet construction

MPD in NICA complex

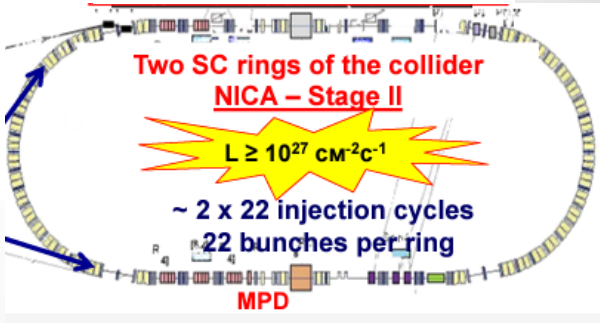




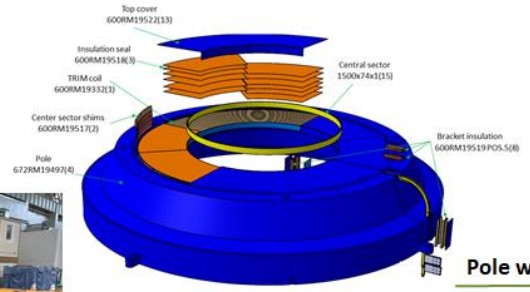




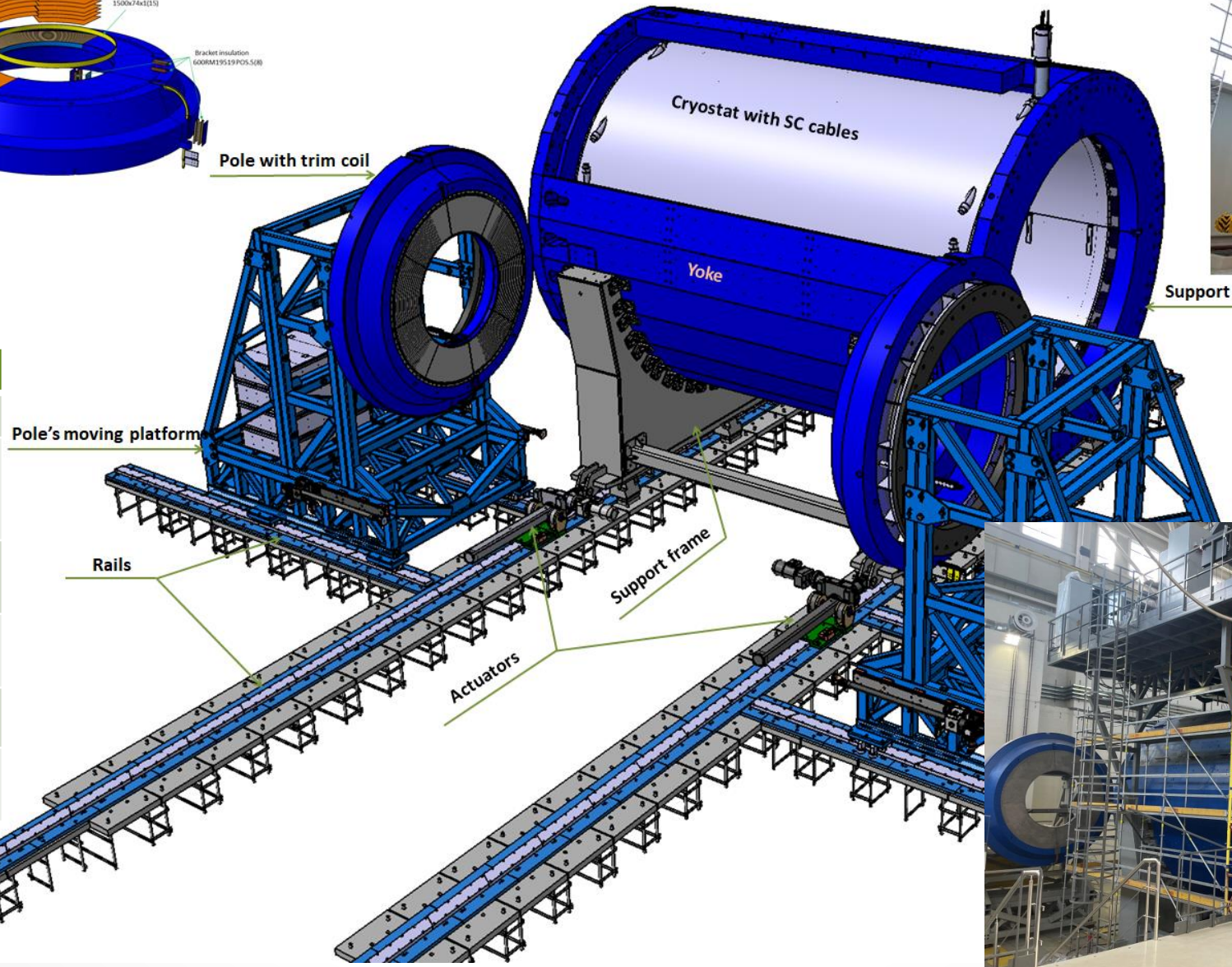
NICA parameters



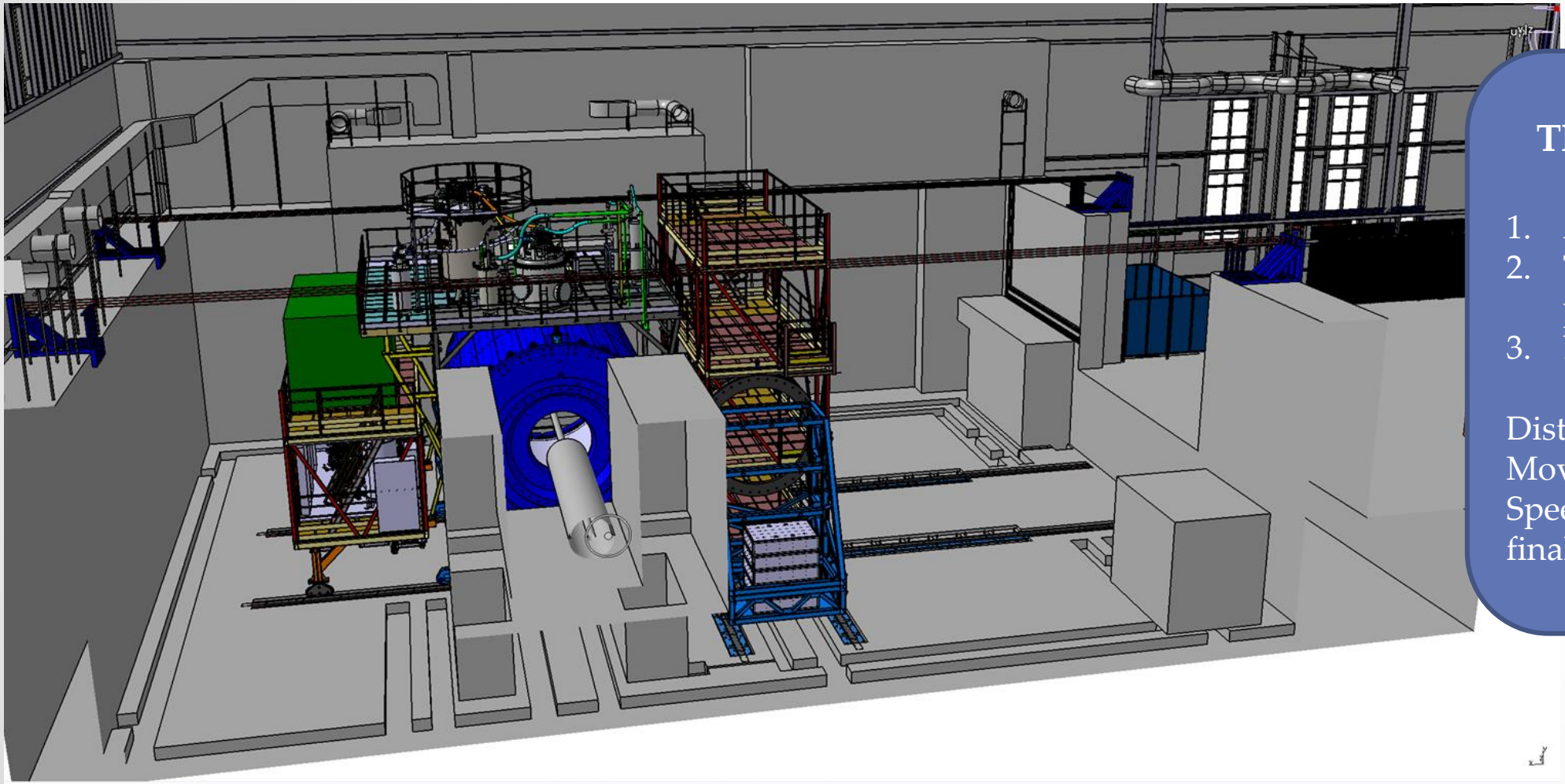
MPD magnet construction



Parameters of the magnet	
Magnetic field	0,57 T
Cryostat weight and size (diameter/length) mm	66 tons 5443/7910
Yoke weight and size (diameter/length) mm	630 tons 6583/8970
Current Voltage	1790 A 10V
Each pole weight	45 tons
Total weight with support equipment	800 tons



Possibility of magnet moving



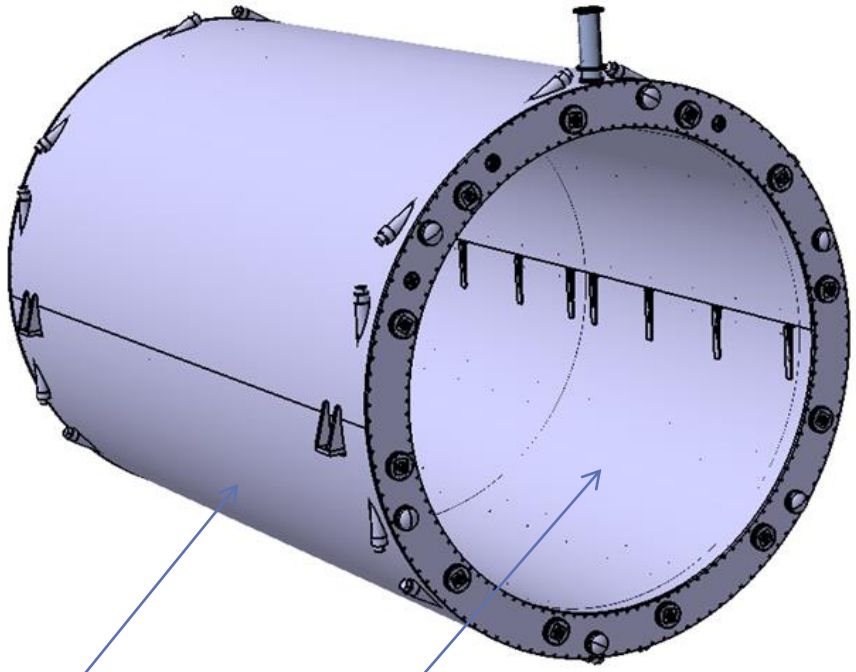
Three main position

1. Assembling position
2. Trim coils installation position
3. Beam position

Distance – 12 m
Moving time about 5 hours
Speed 2 – 3 mm/s (for the final step 0,4-0,5 mm/s)

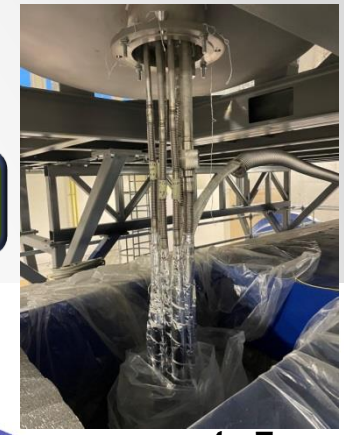
Solenoid construction

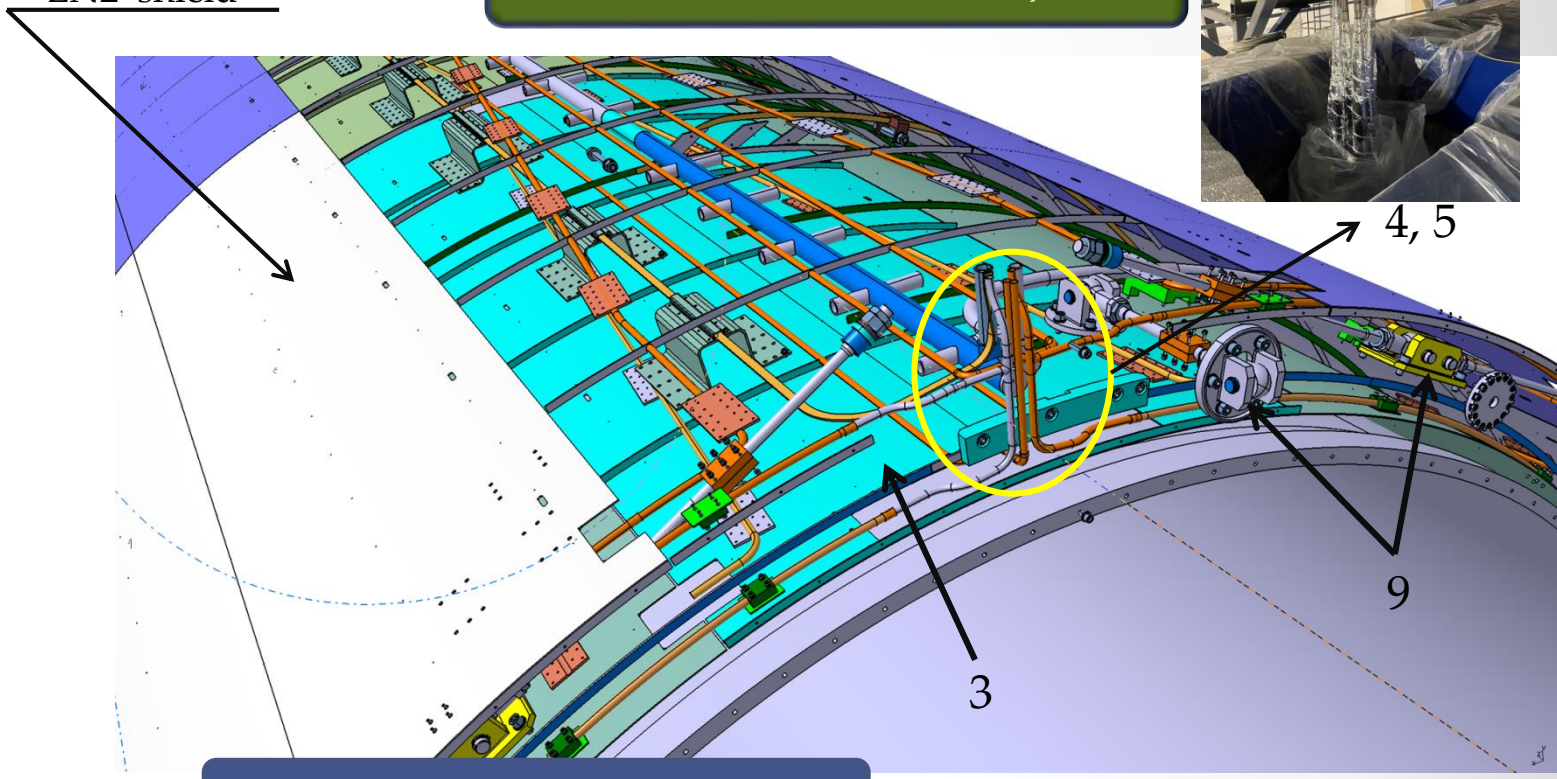
Solenoid with vacuum jacket



Inner diameter is 4656 mm
Outer diameter is 5443 mm
Length is 7910 mm

Solenoid without vacuum jacket



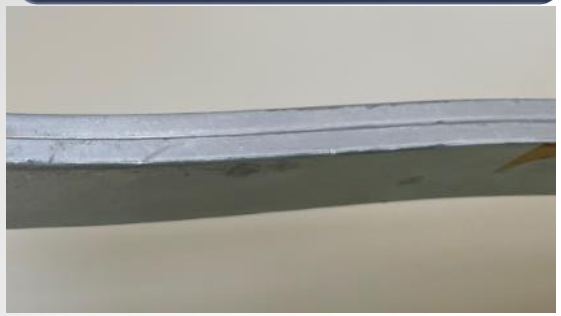


Parameters of solenoid

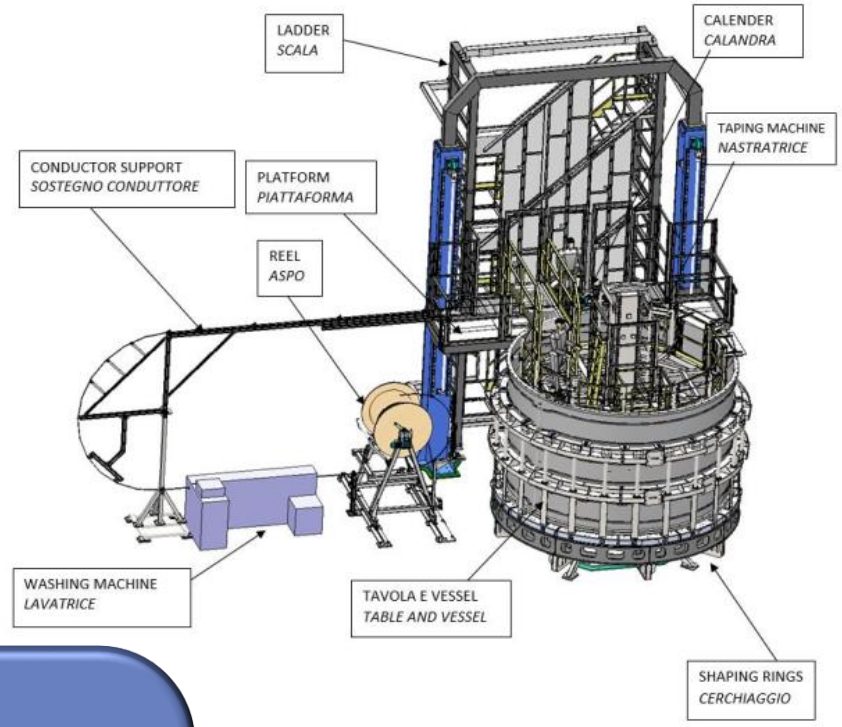
1. Vacuum jacket (10-5 Torr in warm mode)
2. LN2 thermal shield (80K)
3. Cold mass (support cylinder for SC cables)
4. Superconductor cables (3 parts) total length 27 km, NbTi in pure aluminum matrix.
5. Cooling LN2 and LH pipes (cimmny area)
6. Number of turns – 1674
7. Operation temperature 4,5 – 5,5 K
8. Operation current / Rated induction – 1,79 A / 0,5 T.
9. 12 Radial and 6 axis cold mass suspensions
10. Total heat gain – 1056 W

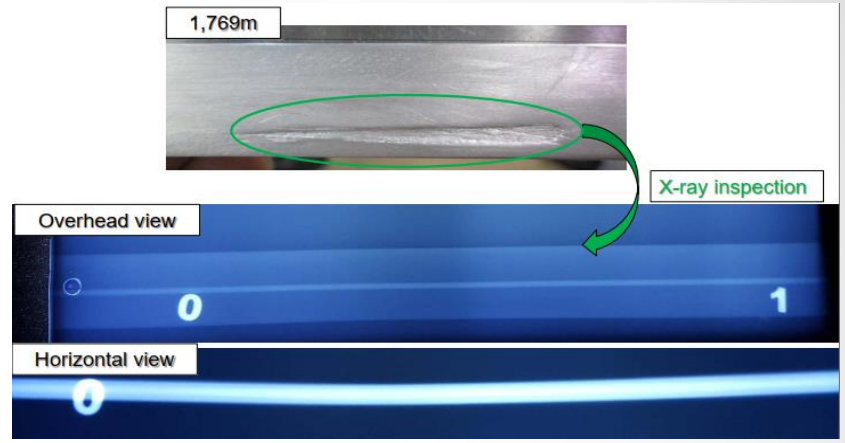
Superconductor cable

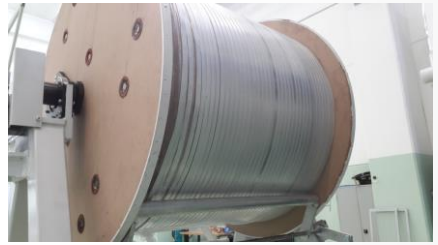
Original SC cables for MPD



Winding and tests of SC cable in ASG



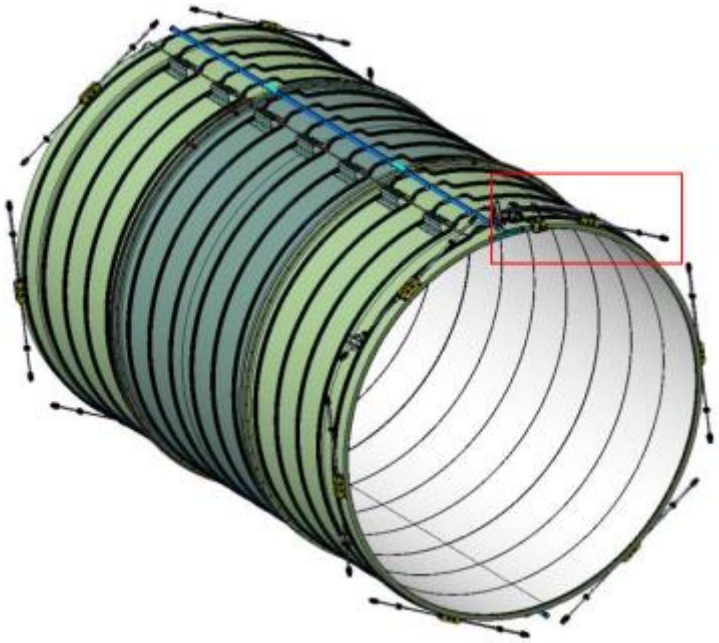


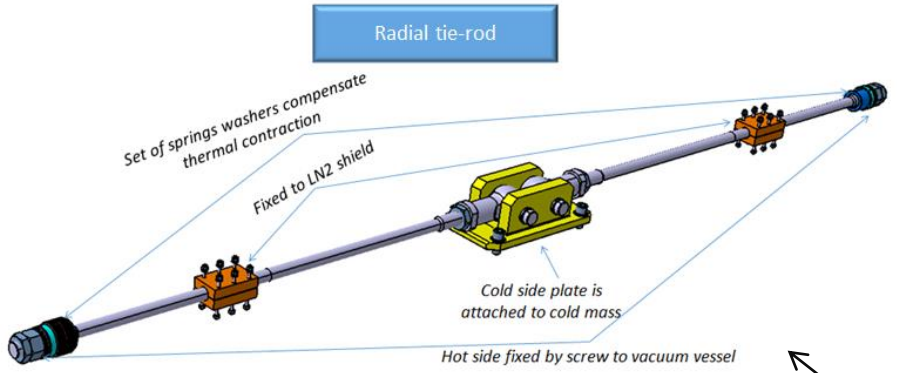


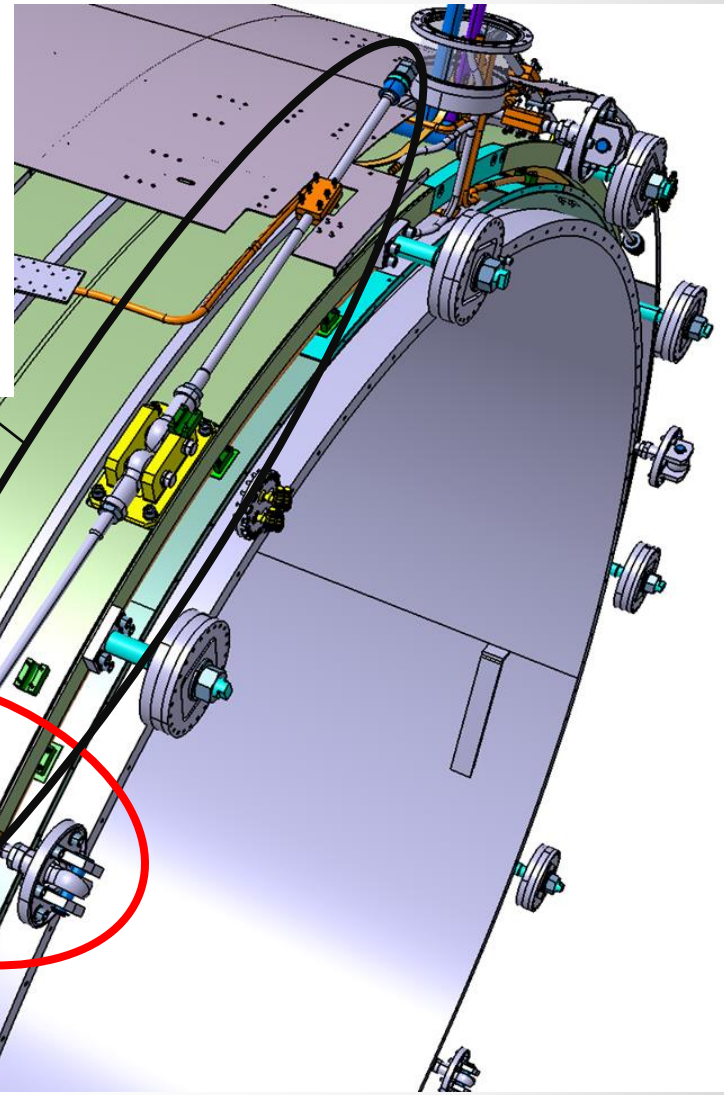
SC cables parameters

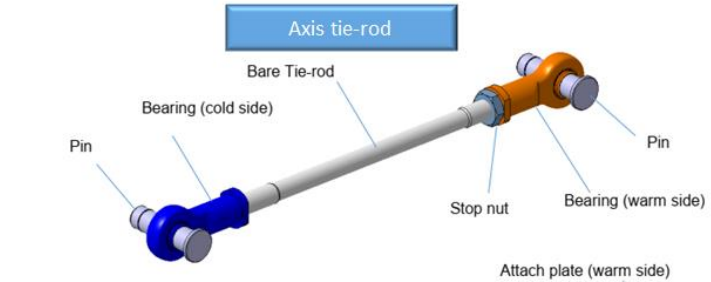
1. SC Materials – NbTi/Cu.
2. Cable composition is pure aluminum matrix (4,1 x 20 mm) and inside string of Cu/SC ratio 0,9/1 (d – 1,5 mm).
3. Insulation – kapton tape, glass tape and epoxy resin.
4. Critical current (1,2 T, 4,5 K) – 6,9 kA
5. Cable length - 27 km.
6. Cable weight – 6,3 tons

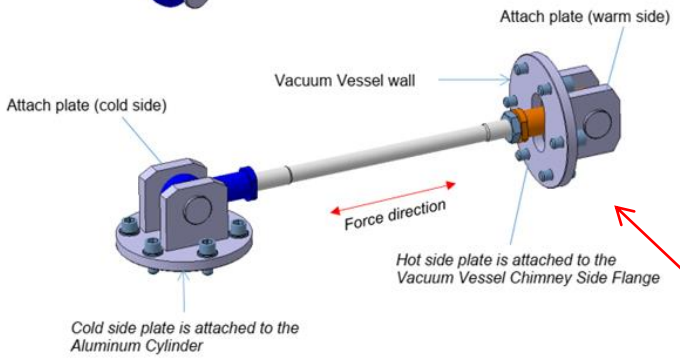
Suspension system of cold mass











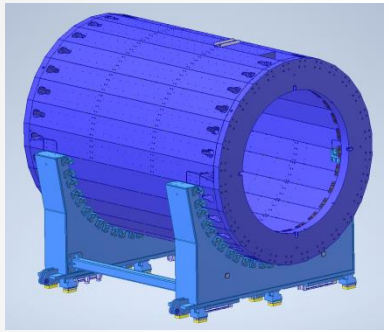
Suspension system consist of 6 axils and 12 radial tie-rods.

Axis tie-rods – fixed cold mass from moving in axis direction Maximum force of tensile/compressive is 240/89 kN. Safety factor is 4,3.

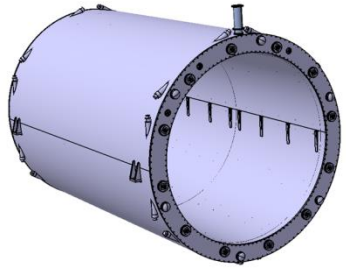
Radial tie-rods – supporting a cold mass inside vacuum vessel. Safe against shear + bending with the sizing load of 50 kN. Safety factor 1,8.

Vertical axis position and verification

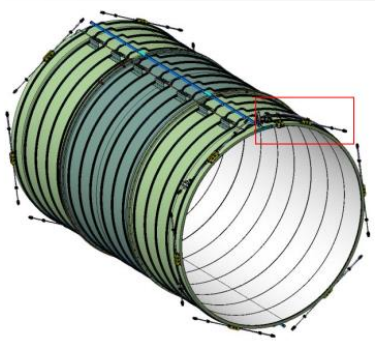
Yoke



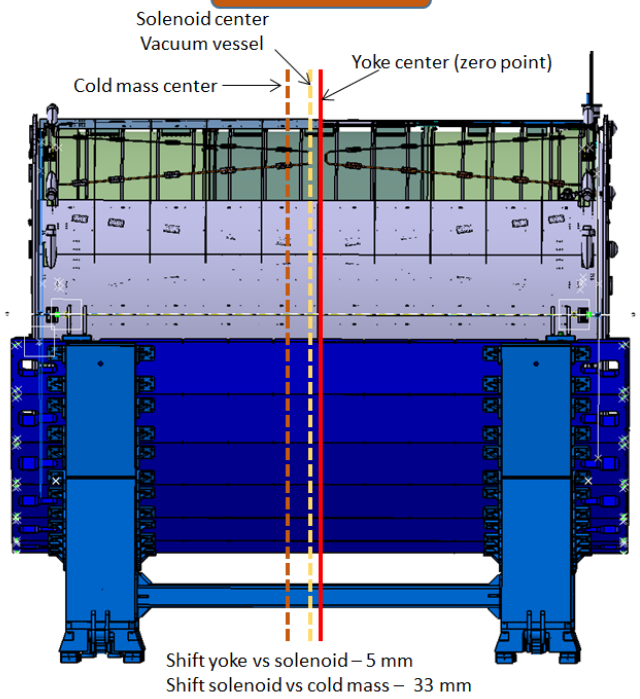
Solenoid (vacuum vessel)



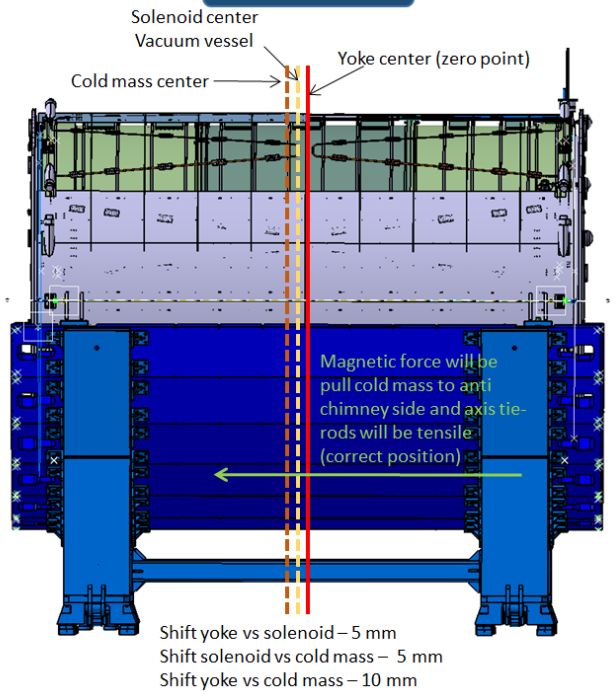
Cold mass with SC cables



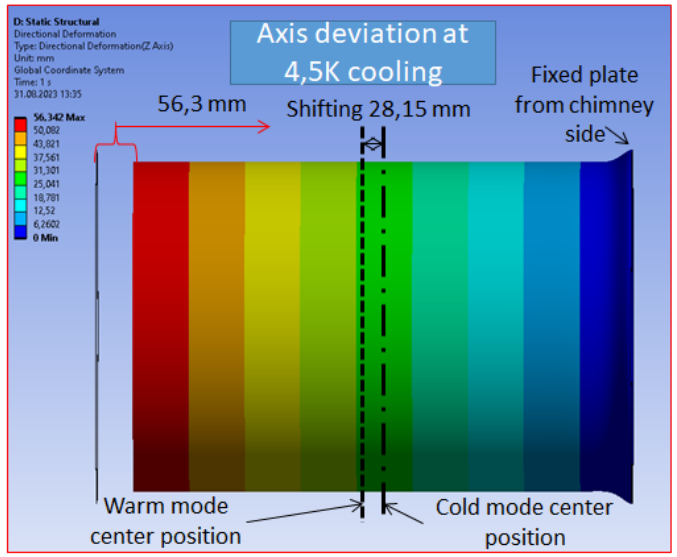
Warm mode



Cold mode



Computing simulation



Chapter 2
Cryogenic infrastructure.
Ready to cooling.

Cryogenic infrastructure at the present time

- Control Dewar (ready to operation)
- Refrigerator (ready to operation)
- MFS (ready to operation)
- LN2 and LHe heaters (was ordered in UK, re-ordered in Russia (Delived))
- LHe pipe (ordered in UK, drawings was ready, delivery not possible, transfer manufacturing in Russia March 2024)
- Cryogenic flexible connection pipes (LHe, LN2 installed)
- LN2 Tanks (2 pc) – can't be delivery from CR, ordered in Russia (installed)
- LHe Tanks (2 pc) – now in Russia ready to installation
- LN2 transfer pipe 120 m with two support frame (December 2023)
- Warm pipes for He, N2 and Instrumentation Air (installed and ready to operation)
- Flexible warm pipes (installed)
- Support system for flexible pipes (installed)
- Temporary pipes for cooling by temporary scheme (in JINR)

Temporary scheme of cooling at 80 K

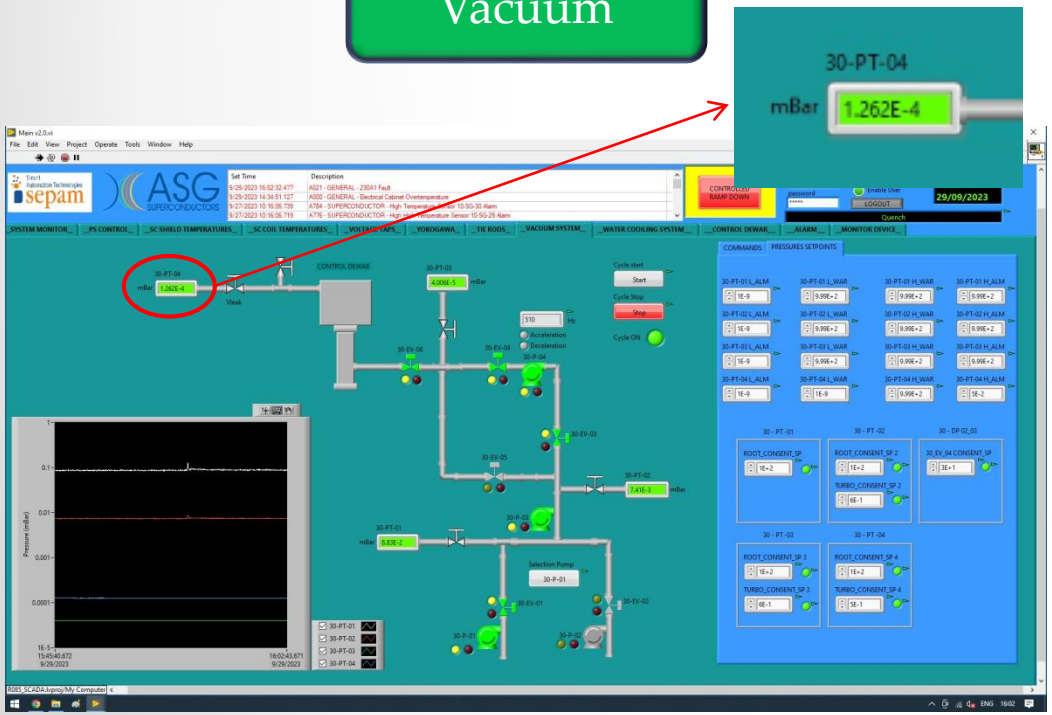
Solenoid is ready to cooling

Main point

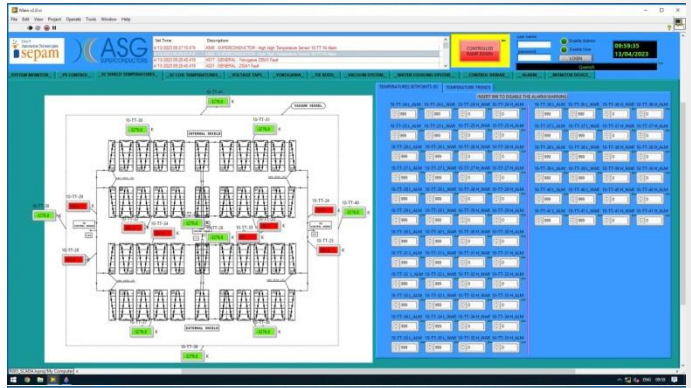
For the present day the main equipment (control cabinet of solenoid, refrigerator, control Dewar, heaters, flexible and stationary pipes) was successfully re-ordered, manufactured, tuned, passed test (pump, leak, electrical…), installed to operation position and integrated into a single system.

Control parameters by cooling mode

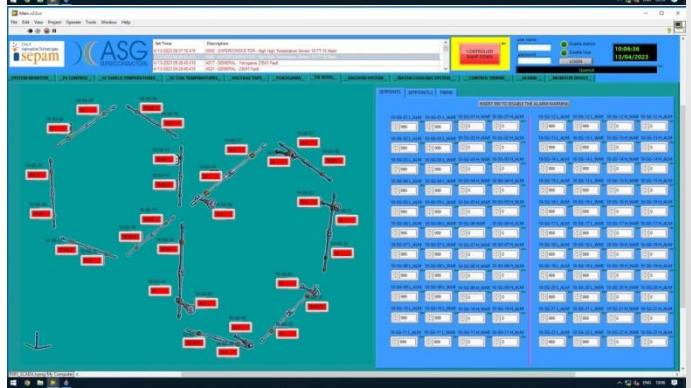
Vacuum



Temperature



Tie-rods

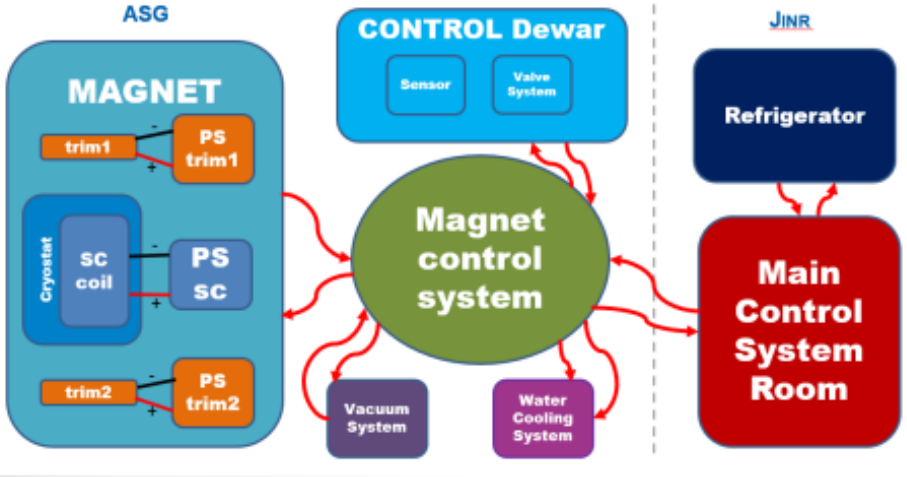


Chapter 3

Control and protection system.

Control system

All signals from solenoid engineering system connect to control system



Valves position in different operation and alarm modes

		V1 20-EV-01	V2 20-EV-02	V3 20-EV-03	V4 20-EV-04	V5 20-EV-05	V6 20-EV-06	V7 20-EV-07	V8 20-EV-08	V9 20-EV-09	V10 20-EV-10
7.11	Current Lead voltage drop	R	O	R	O	C	C	C	O	R	R
7.12	Vacuum loss	C	C	C	O	C	C	C	O	R	R
7.13	Satellite refrigerator failure	C	C	C	O	C	C	C	O	R	R
7.14	LN_2 line failure	C	C	C	O	C	C	C	O	R	R
7.15	Failure power loss	C	C	C	O	C	C	C	O	R	R
7.9	QUENCH	C	C	C	O	C	C	C	C	C	C
	Normal Status	C	O	C	O	C	C	C	C	O	O

Failure list and feedback on CS

	Event	SC PS	PS TRIM1	PS TRIM2
1	Quench Detected [7.9]	breaker opening	shut down	shut down
2	Current Lead Voltage Drop warning	ramp stop	ramp stop	ramp stop
3	Current Lead Voltage Drop alarm [7.11]	breaker opening	shut down	shut down
4	SC temperature warning	ramp stop	ramp stop	ramp stop
5	SC temperature alarm	ramp down	ramp down	ramp down
6	TieRods warning	ramp stop	ramp stop	ramp stop
7	TieRods alarm	ramp down	shut down	shut down
8	Vacuum Loss [7.12]	breaker opening	shut down	shut down
9	SC PS failure	breaker opening	shut down	shut down
10	Failure PS trim1	normal operation	*failure*	shut down
11	Failure PS trim2	normal operation	shut down	*failure*
12	PS trim1 temperature warning	normal operation	ramp stop	ramp stop
13	PS trim2 temperature warning	normal operation	ramp stop	ramp stop
14	PS trim1 temperature alarm	normal operation	ramp down	ramp down
15	PS trim2 temperature alarm	normal operation	ramp down	ramp down
16	Shunt trim1 up - Shunt trim2 down	normal operation	shut down	shut down
17	Shunt trim1 down - Shunt trim2 up	normal operation	shut down	shut down
18	Control Dewar failure	ramp down	ramp down	ramp down
19	Satellite refr. failure (external) [7.13]	fast ramp down	ramp down	ramp down
20	Failure power loss [7.15]	fast ramp down	shut down	shut down
21	LN_2 line failure (external) [7.14]	ramp down	ramp down	ramp down
22	LHe level warning	ramp down	ramp down	ramp down
23	LHe level alarm	breaker opening	shut down	shut down
24	**RED BUTTON FROM JINR SYSTEM**	breaker opening	shut down	shut down

Main control parameters

- Temperature of CS cables (we add 6 sensors to chimney area and current leads)
- Temperature of thermal shield
- Volume of LHe in control Dewar vessel
- Voltage taps (drop current at CS, current leads)
- Pressure inside vacuum vessel
- Tie rods (stress sensors, position of cold mass)
- Water flow and temperature
- Refrigerator failure (by LHe level)

Test of solenoid protection system (voltage taps)

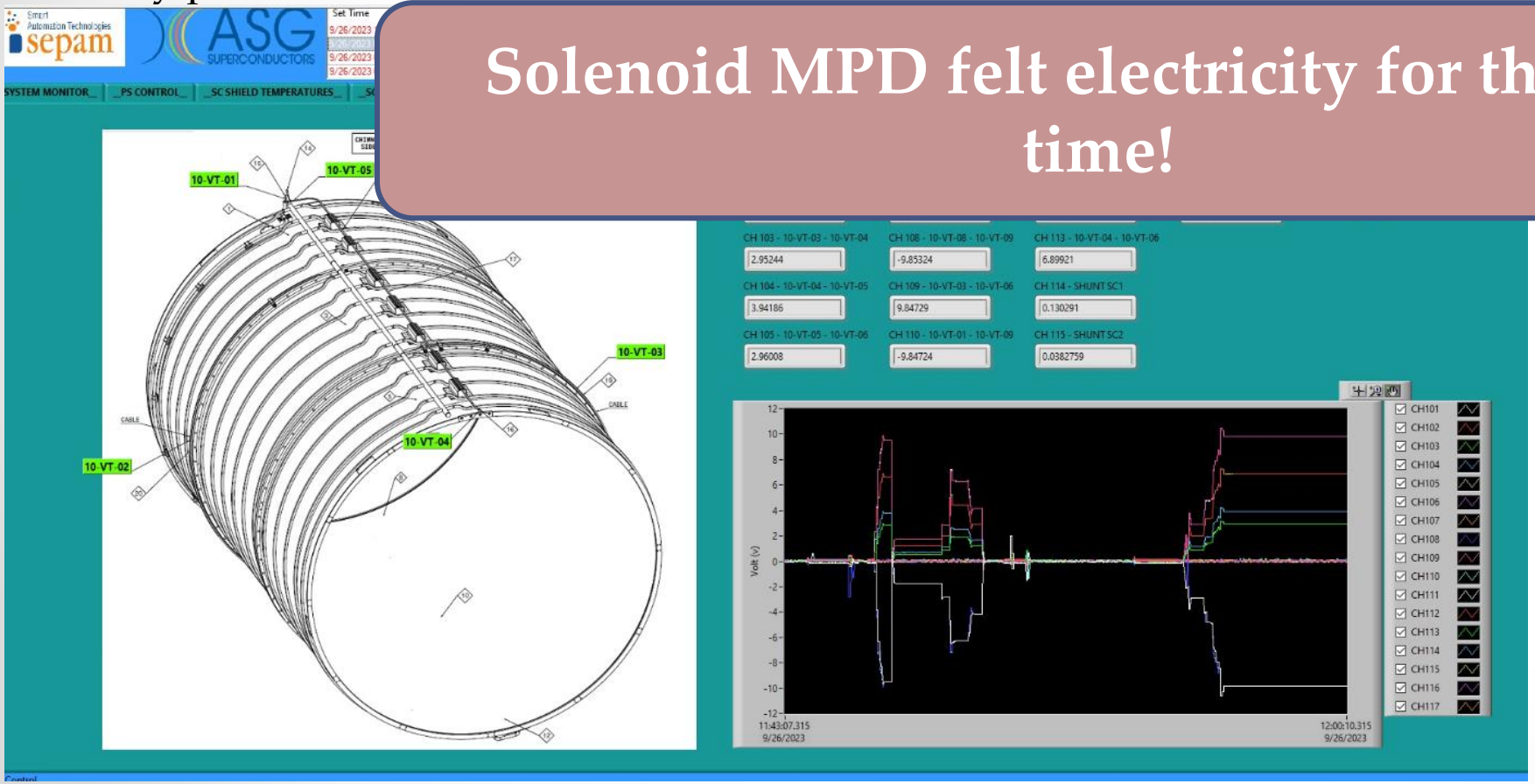
Nominal current - 1790 A
Nominal volts - 10 V
Induction – 0,5 T

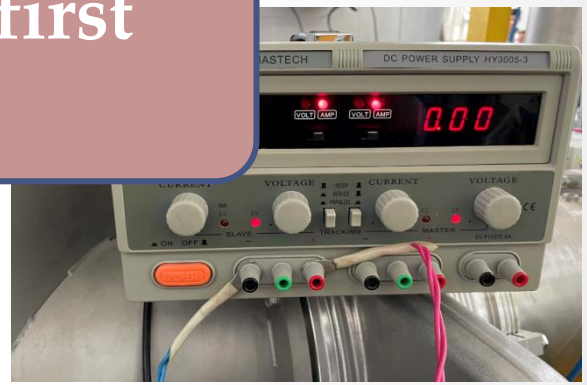
For the safety of SC cables and previously shout down power system, provide QD and voltage taps.

Voltage taps located in to welding points of SC cables, warm and cold part of current leads.
Signals from voltage taps transfer to Yokogawa, converted and gives a control signal to QD.
Safety parameters is +/- 1 V.

Test parameters 1,2A, 10V

Solenoid MPD felt electricity for the first time!





Timeline

September – October 2023 – preparation all system to cooling (clean, leak test, electricity test, vacuuming main equipment…)

October – December 2023 – cooling of solenoid to 80 K (analyzation process, correction, optimization…)

December 2023 – delivery LH Tank from Geliymash to JINR (preparation temporary line Tank - refrigerator)
January – March – cooling solenoid to 4,5 K

October 2023 – January 2024 – prepare a program and test stand for Power supply system, quench detection system and energy evacuation system.

January – March 2024 – tests power supply and energy evacuation system.

December 2023 – January 2024 – measurement of magnetic field of Earth in INP (Novosibirsk).

February – March 2024 – assembling and measurement Earth field in JINR.

April – May 2024 – installation and measurement magnetic field in MPD magnet.

May –… assembling detectors, correction parameters and development of control system…


Thank you for attention