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PRODUCTION of SUPERCONDUCTING MAGNETS and CRYOGENIC SYSTEMS at IHEP

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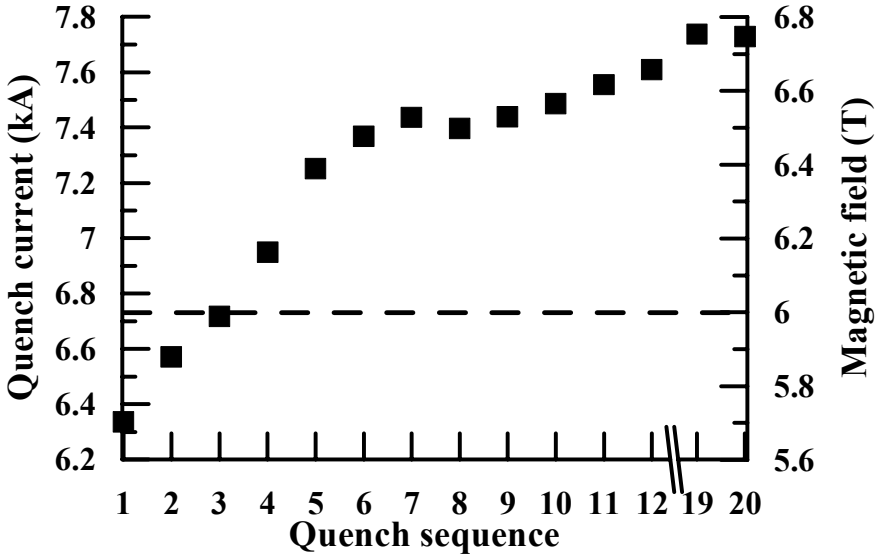
SIS300 superconducting high field fast cycling dipole model

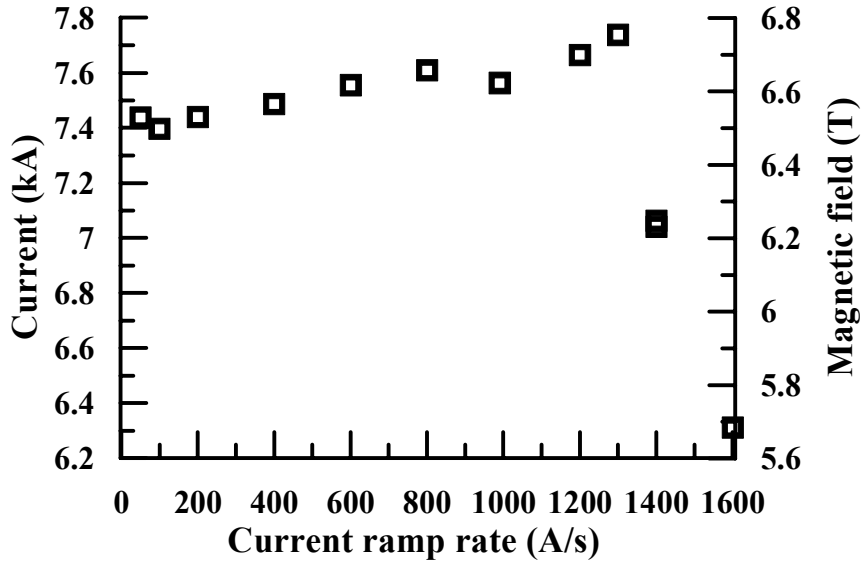
Parameter	Value
Magnetic field, T	6
Operating current, kA	6.72
Field ramp rate, T/s	1
Number of layers	2
Cable strand number	36
AC losses, W/m	4.7
In coil, W/m	3.4
In iron yoke, W/m	1.3
Stored energy, kJ	260
Inductance, mH	11.7
Coil inner diameter, mm	100
Length of SC coil, m	1
Mass of magnet, ton	1.8

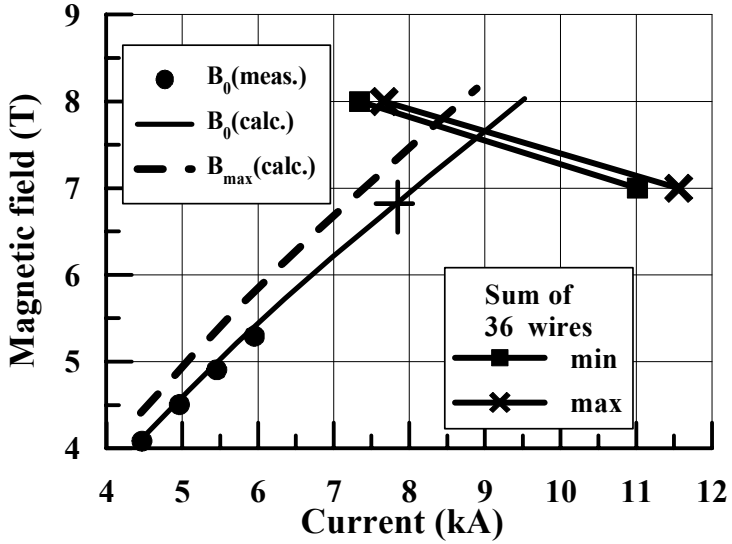
SC cable for SIS300 SC model dipole

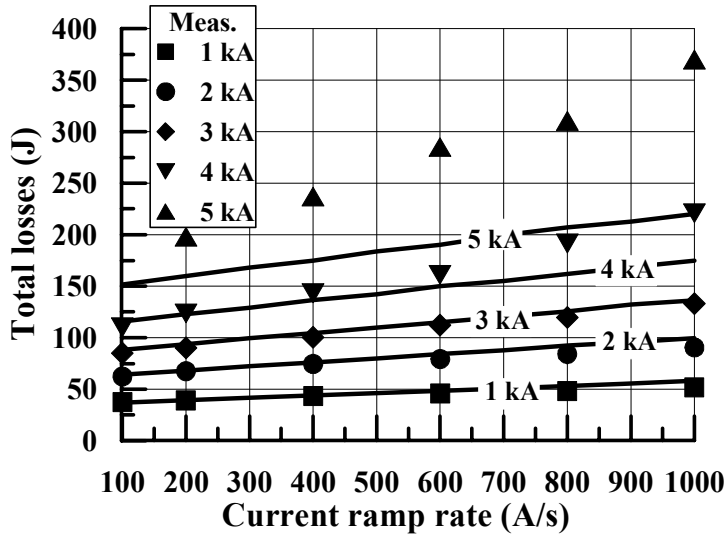
Number of strand	36
Strand diameter, mm	0,825
Cable width, mm	15,1
Cable middle thickness, mm	1,48
Transposition pitch, mm	100
Coating of strands	Sn+5%Ag
Stainless steel core, μm	25
R_c (R_a), mΩ	20 (0.2)
Insulation (polyimide film): 3 layers×25μm 1 layer×55μm	130 μm

Test results of SIS300 superconducting high field fast cycling dipole model

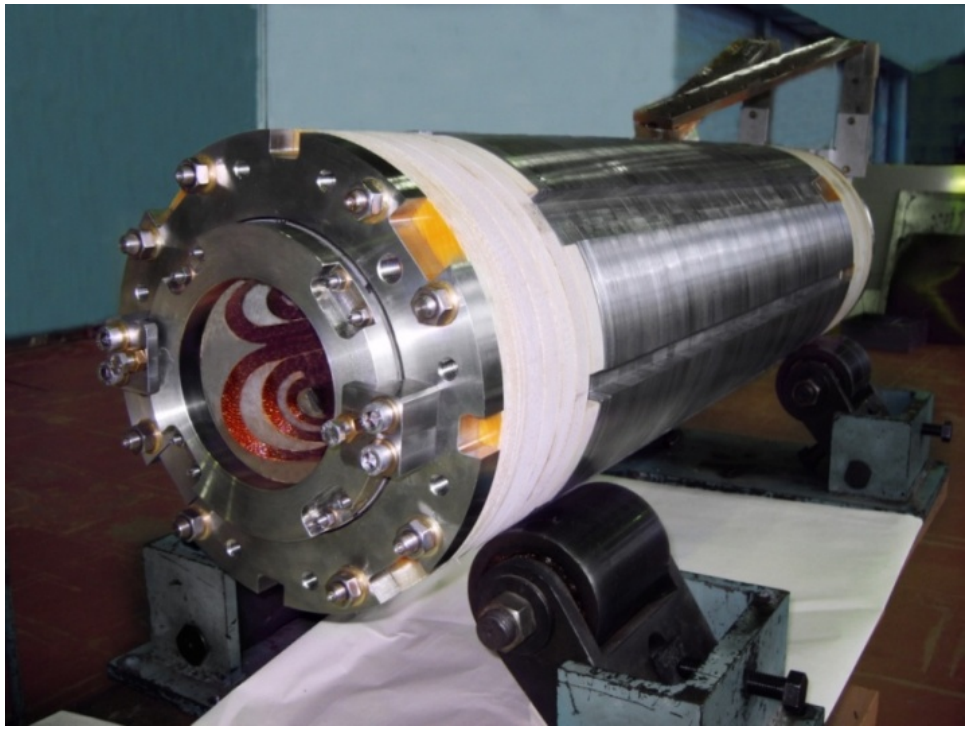








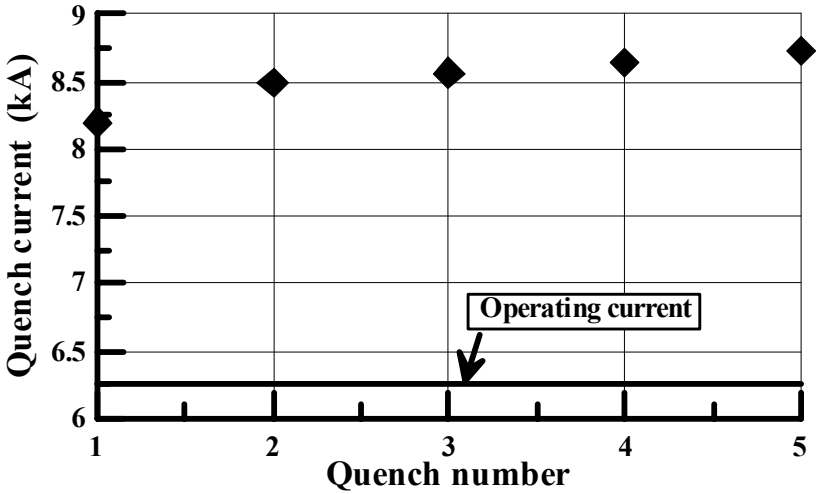
SIS300 fast cycling quadrupole prototype

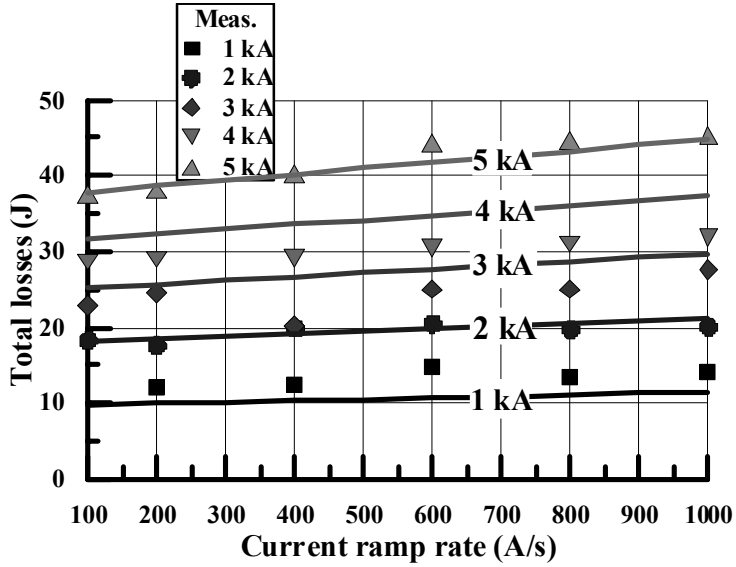


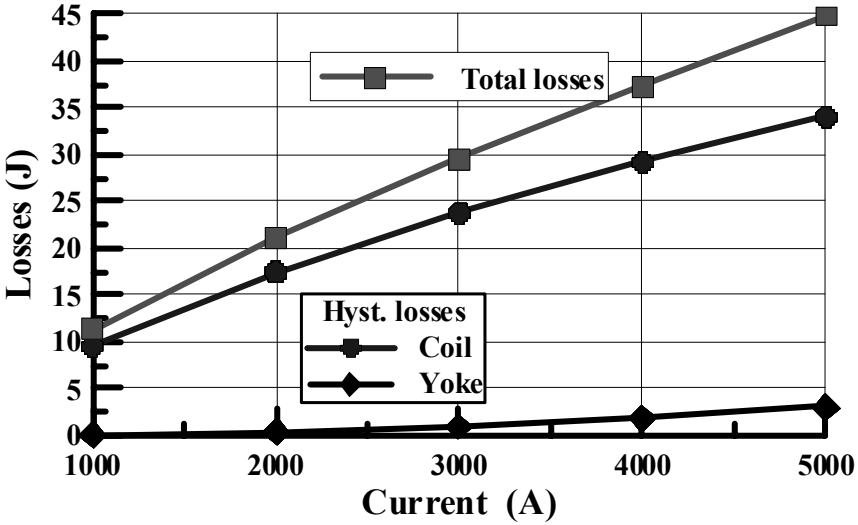
Parameter	Value
Field gradient, T/m	45
Operating current, kA	6.26
Ramp rate, T/m/s	10
AC losses, W/m	1
Coil inner diameter, mm	125
Length of SC coil, m	1
Number of layers	1
Cable strand number	19
Strand diameter, mm	0.825
NbTi filament diameter, μm	3
Step pitch, mm	8
J_C (5 T, 4.2 K), A/mm^2	≥2700

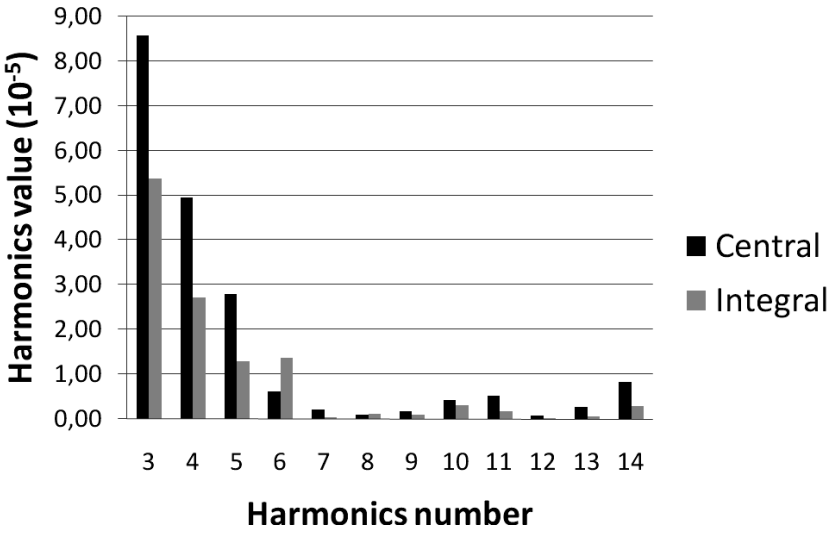
Test results of SIS300 superconducting fast cycling quadrupole prototype

Critical current is higher than 8.5 kA up to 5 kA/s (36 T/m/s, 2.8 T/s) ramp rate





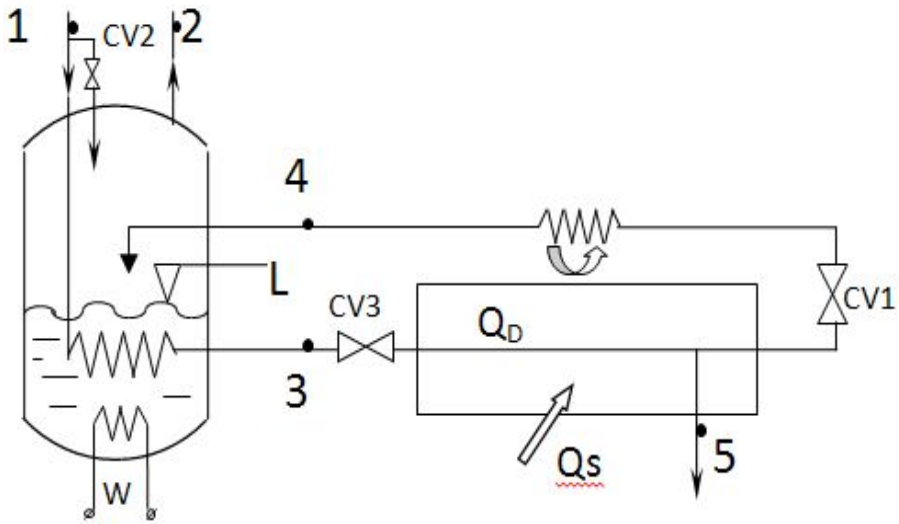




Requirements to SIS300 fast cycling corrector magnets

Type of corrector	Force	Coil length, m	Powering time, s
Chromaticity sextupole	130 T/m^2	0.78	0.21
Resonance sextupole	325 T/m^2	1	0.5
Steering magnet:			
Vertical dipole	0.5 T	0.65	2.27
Horizontal dipole	0.5 T	0.65	2.27
Multipole:			
Quadrupole	1.8 T/m	0.65	2.25
Sextupole	60 T/m^2	0.65	2.18
Octupole	767 T/m^3	0.65	2.24

SIS300 cryogenic system



SIS300 helium flows	parameters
Length of SIS300 ring	1.1 km
Magnet string number	2
T_1	4.6 K
T_3	4.35 K
P_3	3 bar
P_4	1.105 bar
T_4	4.3 K
x_4	≤95%

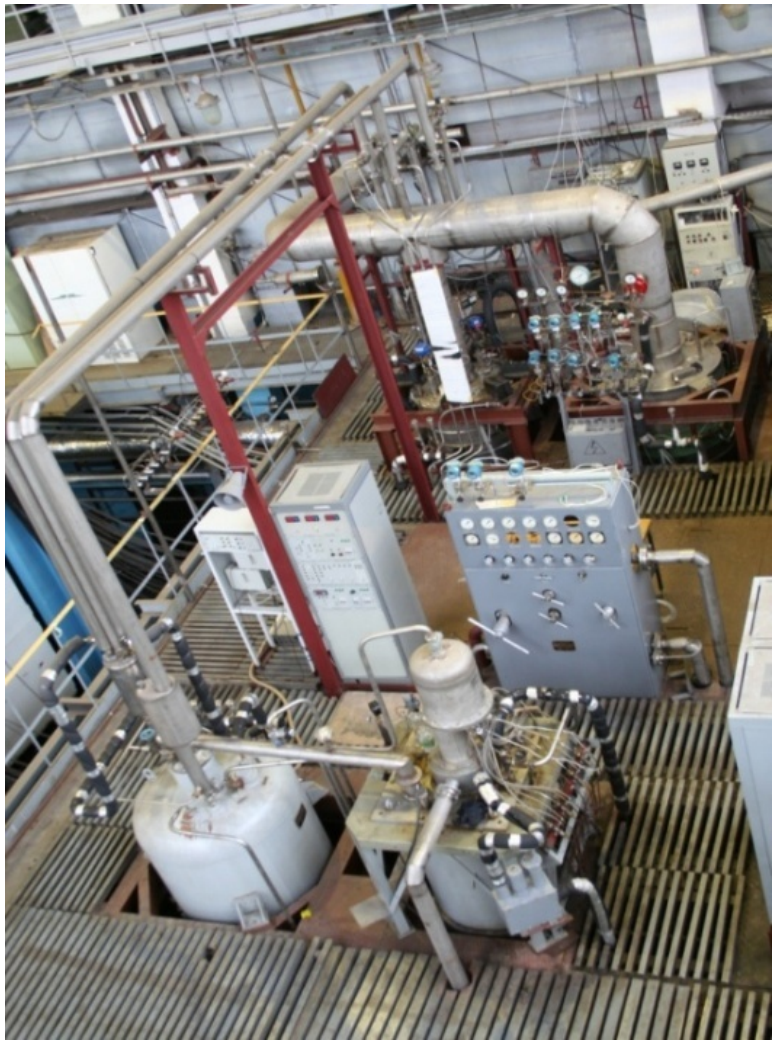
Total SIS300 heat load	T=4.5 K
AC losses	2472 W
Ambient heat leak	1367 W
Beam pipe RF mirror current heat release	450 W
Total heat load	4289 W
Liquid helium for cooling the current leads	4.53 g/s

Results of calculation

- **4 additional helium heat exchangers in SIS300 ring;**
- **Temperature of helium, which cools the SIS300 magnets, will not exceed 4.7 K;**
- **Cooling down time of SIS300 SC magnets will be about 60 hours.**

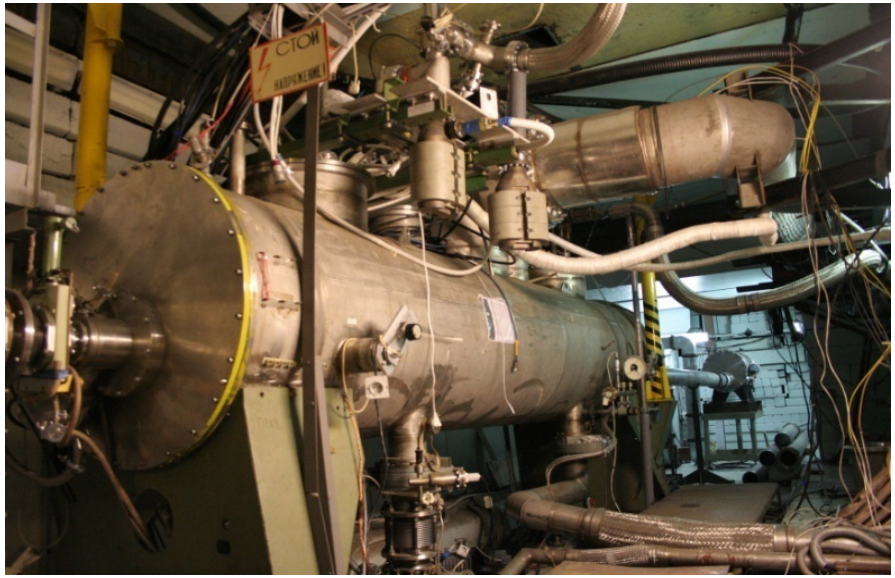
Superfluid cryogenic system of IHEP kaon channel (280 W at 1.8 K)

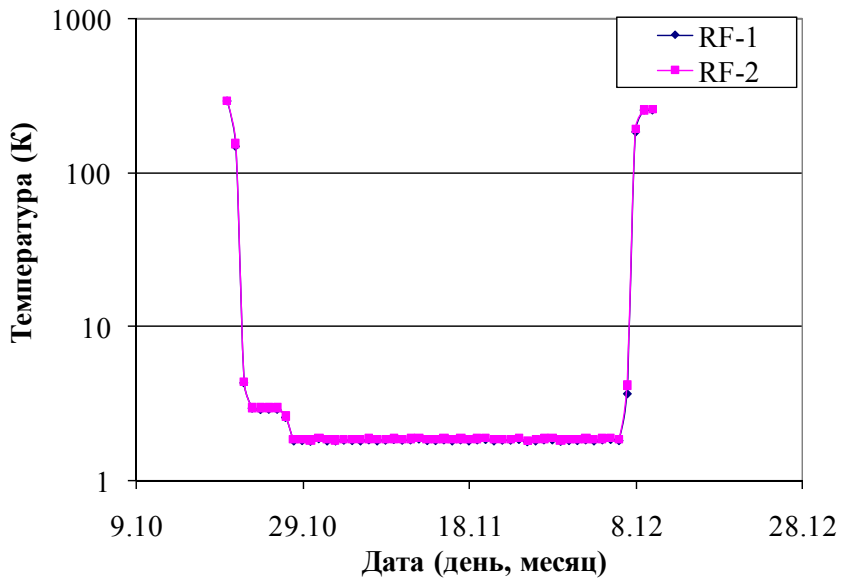
Cryogenic plant KGU500/4.5



Cryogenic helium vacuum heat exchanger (10g/s helium flow, 300-2 K temperature range)

Superfluid cryogenic system of IHEP kaon channel (280 W at 1.8 K)





Conclusion

IHEP develops superconducting fast cycling magnets and cryogenic system for SIS300 accelerator of FAIR project:

- 6.8 T magnetic field in aperture of the dipole model was reached and the magnetic field value did not reduced up to 1.2T/s ramp rate. Combination of these dipole parameters is unique in world practice.
- The critical current of SIS300 quadrupole prototype is 8734 A that corresponds to 40 % current margin. The critical current was higher than 8.5 kA up to 5 kA/s (2.8 T/s) ramp rate.
- SIS300 cryogenic system supplies maximal temperature of single-phase helium in cryogenic strings to 4.7 K that it necessary for stable SC magnets operation.

Successful operation of the cryogenic system for separated kaon beam at IHEP allowed to supply necessary parameters of superconducting RF cavities and record more than one million of kaon decay events.