Cryogenics for Super-FRS at FAIR
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Introduction
The Super-FRS at FAIR is a radioactive secondary beam fragment separator of large acceptance, equipped with a number of superconducting dipole and multiplet (quadrupole, hexapole, octupole and steering dipole) magnets operating at 4.5 K. The total weight up to 1,400 tons of the cold mass, dominated by iron and the total He inventory of 47.0 m³ could be envisaged for the full version of the Super-FRS. It is a great challenge for the Super-FRS cryogenics to cool down such large cold mass. The advantage of using LN2 precooling at 80 K is obvious in order to have a reasonable cooldown time of 3 to 4 weeks to reach 4.5 K operation temperature. The important features of the refrigerator and the cryogenic distribution system at FAIR will be presented. Most of the SC magnets of Super-FRS will be cold tested at CERN. The key issues for the cryogenic test facility planning and for the machine safety at FAIR must be clarified in terms of the limitation of cooldown / warmup rates, interface definition, the magnet cryostat protection against over-pressure under worst-case scenarios, i.e., quench and insulation vacuum sudden loss to air.

Cooldown of the large cold mass and LN2 precooler

Conclusions
- Cooldown of the 1,400 tons cold mass down to 4.5 K has been addressed as one of the great challenges for the Super-FRS cryogenics. The capacity of the LN2 precooler at 80 K as well as the 4.5 K cooling power have been specified in order to have reasonable cooldown time of 3 to 4 weeks.
- Interface constraints between the helium distribution system and the magnet cryostats have been checked by using ANSYS 14.5 in terms of mechanical forces and deformation compensation for the test at CERN and the later tunnel installation at FAIR.
- The European Standards DIN/BS EN 13458 and 13648 are being implemented to correctly size of the safety devices based upon risk analysis under the worst-case scenarios, i.e., quench by accident with full energy deposition in helium system and the over-pressurization of helium vessel in case of insulation vacuum sudden loss to air.
- The process headers in cryogenic transfer line / feedback units of the 4 branches for the helium distribution have been sized under the most conservative assumption upon the operation conditions of the cryostat.

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