Status of the improved Cryogenic Current Comparator for FAIR*

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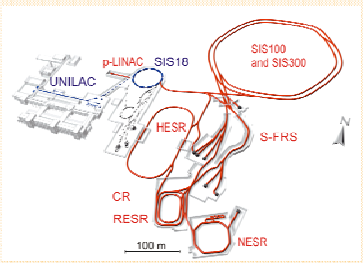
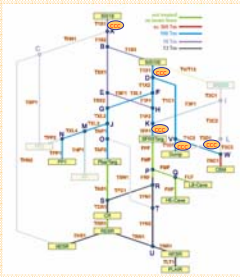
The FAIR project and Cryogenic Current Comparator

The upcoming FAIR facility will deliver beams of very high energy and unprecedented intensity for nuclear experiments and for the production of rare isotopes and antiprotons. Apart from the high intensity beams, slowly extracted beams also have to be transported to the experiments. This operational mode demands high resolution and low detection limits for the diagnostics devices in the High Energy Beam Transfer (HEBT) sections of FAIR. A Cryogenic Current Comparator (CCC) is foreseen to be installed for the non-destructive measurement of the beam current down to nA range. A new improved version of a CCC system is under development in collaboration between FSU/HI Jena, MPI-K Heidelberg and GSI.



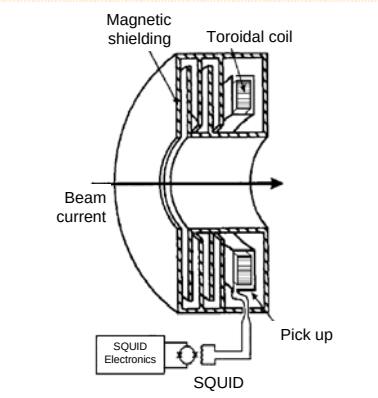
FAIR accelerator complex



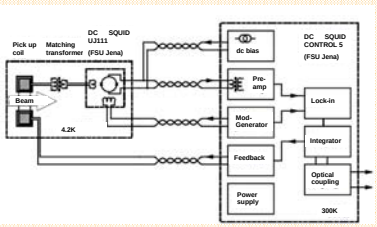
HEBT sections of FAIR

CCC Working principle

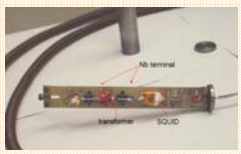
High-resolution detection of the beam's azimuthal magnetic field



- As the ion beam passes through the toroid, the magnetic field associated with the beam induces screening current (I_{sc}) in the superconducting magnetic shielding
- This screening current generates a magnetic field (Bsc) inside the shield
- The ferromagnetic shielding allows only the azimuthal component of the magnetic field inside.
- This magnetic field component induces an image current in the pick up coil
- The current in the pick up coil is fed to the matching transformer and transformed to the DC-SQUID input coil
- Corresponding output voltage from the SQUID is measured and calibrated to the resultant beam current



Simplified scheme of CCC



Typical DC SQUID Sensor PCB (UJ111)

Re-Installation of the CCC system at GSI

•A complete study on the noise spectrum is necessary for improved current resolution

•Investigations on the occurrence of the zero current drift which had been measured with the old system during the operation in GSI synchrotron SIS-18

•All the vacuum components have been renewed or serviced to reach the necessary vacuum of ~1E-7mbar

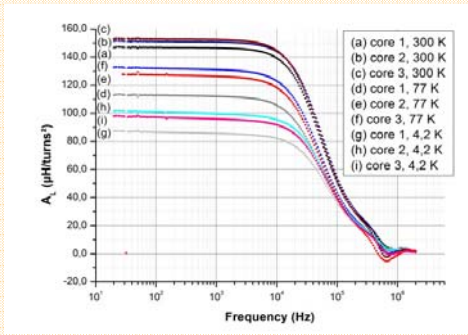
•The superinsulated copper irradiation shield enclosing the liquid helium dewar containing the SQUID sensor and pick-up coil is being cooled down by a Gifford-McMahon refrigerator.

Characterization of Nanoperm®[5] M033 at 4.2 K

•The resolution of CCC is dominated by the noise contribution of the ferromagnetic core

•Nanoperm-M033 (Nano-crystalline) was selected after detailed study on high permeability materials [2,3]

The temperature and frequency dependence of the relative permeability



Frequency dependent inductance factor A_L of the Nanoperm cores at different temperatures

A_L: Inductance of the core divided by the square of number of loops

The serial inductance and the serial resistance of these coils were measured in a frequency range from 20 Hz to 2 MHz at 300 K, 77 K and 4.2 K with a vector LCR-Meter

•As the material is cooled down to 4.2K, the inductance factor decreases only to ~100 µH

Ongoing Experiments

•Test run of the re-commissioned CCC unit is planned for first the half of April, including

- •Detailed study on the complete noise spectrum of the CCC
- •Shielding factor of the superconducting magnetic shielding

•Simulation on the attenuation of external magnetic field components against various geometrical and material parameters by means of FEM simulations

• Noise studies with simple Nb shielding will be carried out by the end of April at FSU, Jena along with study of the magnetic field to the shielding factor using a Helmholtz coil in the magnetic shielded chamber

Recent developments towards the improved CCC

- SQUID Unit : New SQUID electronics with improved time resolution and low noise is available (from the Jena group)
- Ferromagnetic Core : Studies in FSU Jena showed that the Nano-crystalline "Nanoperm M033" shows better ferromagnetic properties at 4.2 K than the previously used "Vitrovac 6025".
- Nanoperm M 033 has been purchased has been tested for it's bulk properties at liquid He temperatures.

References

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3. W. Vodel, The SQUID based Cryogenic Current Comparator – a useful tool for beam diagnostics-Workshop on „Low Current, Low Energy Beam Diagnostics"Hirschberg-Großsachsen, November 24-25, 2009
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