

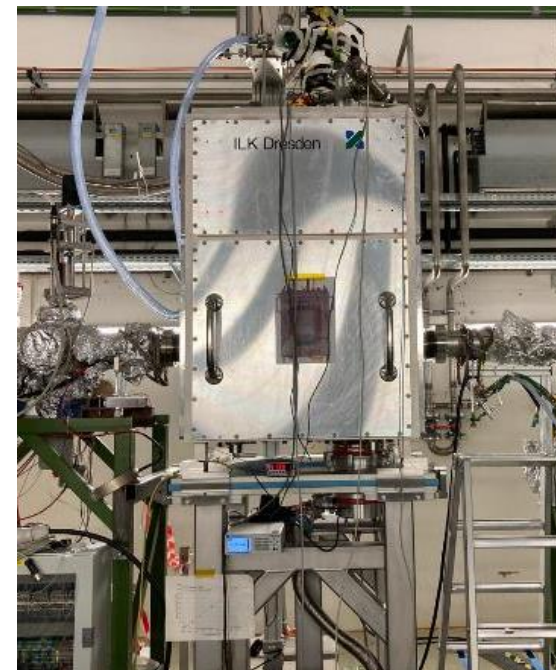
IBIC 2021 – Seoul, September 2021

Commissioning of the Cryogenic Current Comparator (CCC) at CRYRING

David Haider

GSI/FAIR, Germany

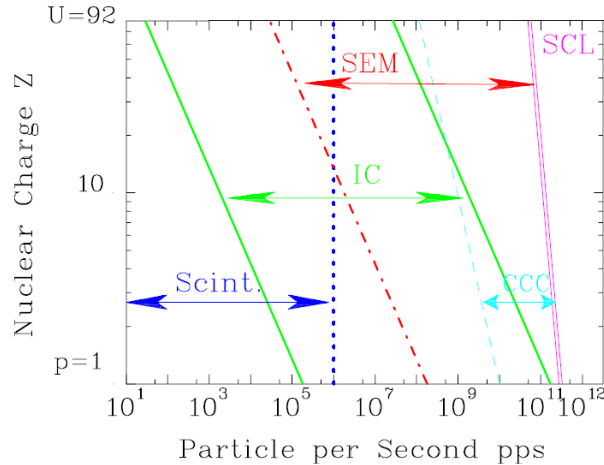
On behalf of the CCC collaboration



CCC@CRYRING

Motivation & operating principle

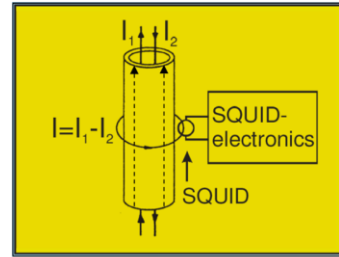
Gap in non-destructive diagnostics



Detector systems used for slow extraction at SIS18 (P. Forck)

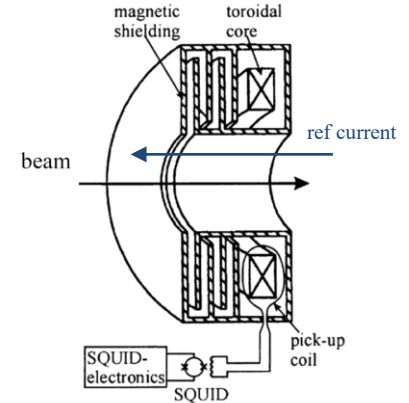
- SCL ... Space charge limit
- IC ... Ionization Chamber
- SEM ... Secondary Electron Monitor

Cryogenic Current Comparator - Schematic



CCC (Harvey 1972):

- Uses Meissner-effect and SQUID for I_1/I_2 measurement
- If $I_1 \neq I_2$ magn. field produces compensation current
- Magnetic flux through SQUID \rightarrow voltage change



- SC shielding for non-azimuthal fields
- SC pickup coil with toroidal core ($\mu_r \approx 50000$)
- Low noise, high performance DC SQUID

DC-SQUID magnetometer
(Superconducting Quantum Interference Device)

Challenge - Perturbations

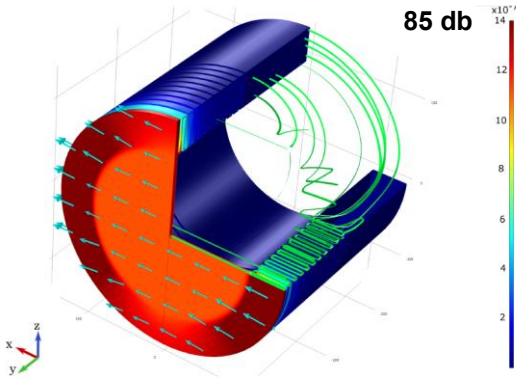
MAGNETIC FIELDS

- Static (Earth): **~50 μT**
- Dynamic (Ramped dipole): **~10 μT**

much bigger than

Field of 100 nA ion beam: **~150 fT**
(10 cm distance)

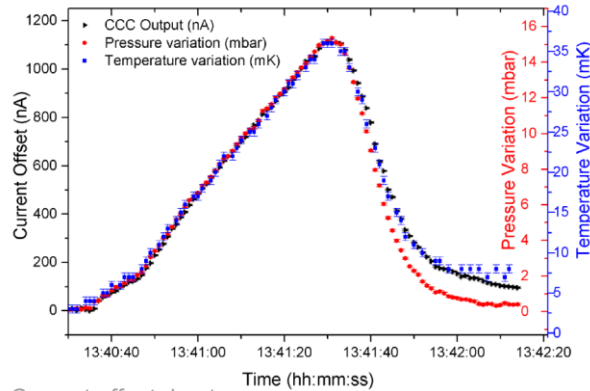
field attenuation
85 db



Simulation of field attenuation with Comsol Multiphysics® (F. Kurian)

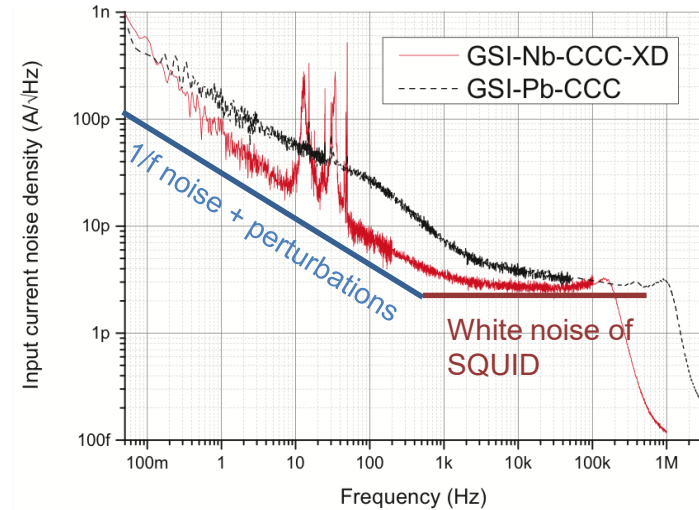
TEMPERATURE/PRESSURE

- Drift of **73.7 nA/mbar**
- 33.5 nA/mK**



Current offset due to pressure and temperature variation.

VIBRATIONS/ACOUSTIC



Current noise density of background measurement in the lab.

Challenge - Closed cryogenic system

Specifications of cryostat

Materials: Al, 316(Ti), 304, OFC, Ti6Al4V suspension, ceramic

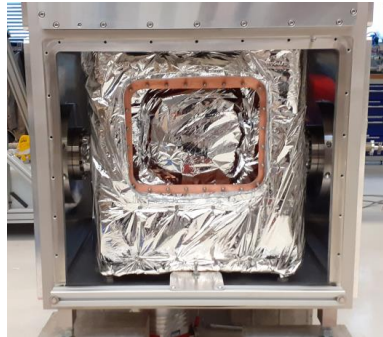
Dimensions: 850 x 850 x 1200 mm (~1.1 t)

Properties: UHV-beamline (bakeable), vibration damping, large maintenance windows

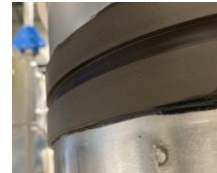
Cryogenics: Helium bath (80 l), gas cooled shield, stand-alone-system design



Damping bellow connecting liquefier



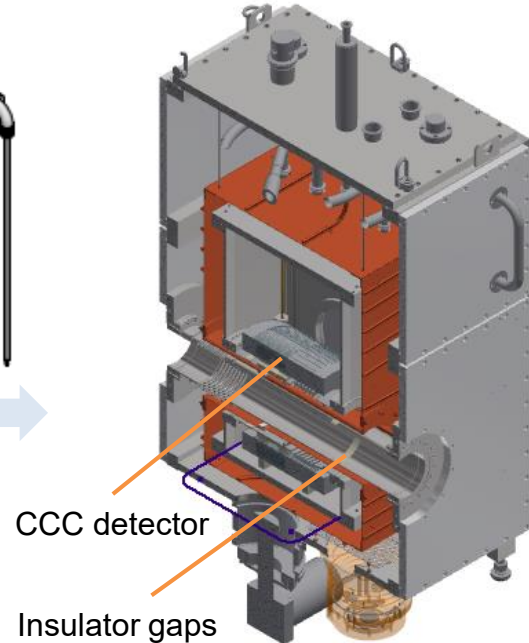
CF125 UHV beam tube through cryostat



19 l/day liquefier
(CRYOMECH)

- 2A

15 l/day evaporation



- 2020/9: Installation at CRYRING

- tool for commissioning
- support for experimental program
- test bench for further CCC development

CRYRING characteristics

Circumference: 54 m

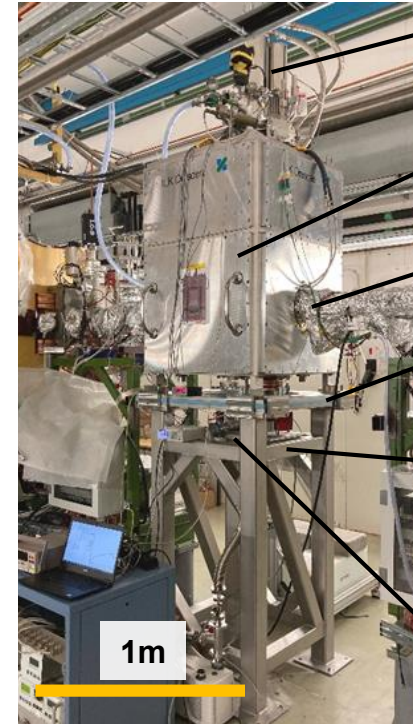
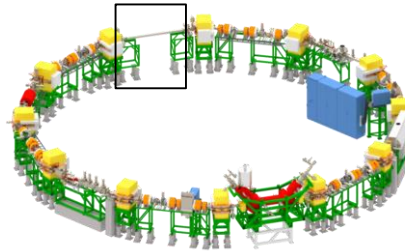
Magnetic rigidity: 0.8 Tm

Proton energy: < 30 MeV

Vacuum: 10^{-12} mbar (final)

Beam pipe diameters: 100 – 150 mm

Beam lifetime: 3 – 1000 s



Liquefier
(mechanically
decoupled)

Detector chamber
suspensions

Bellows to
connect beamline

Alignment Plate
with damping mat

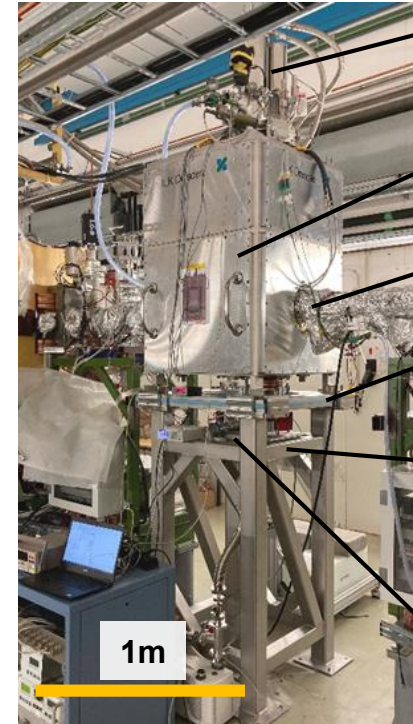
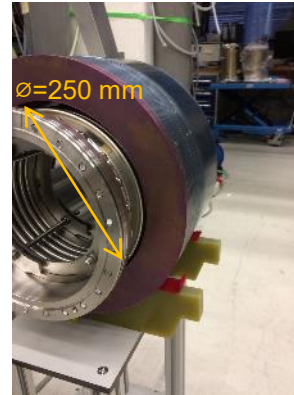
Heavy support
(sand filled)

Separate Support
Turbo + Pre-Pump

CCC@CRYRING

Commissioning of the Cryogenic Current Comparator

- 2020/9: Installation at CRYRING
- Cryogenic operation since 2020/11 for more than 5 weeks (available for 3 experiments, 5 different ion species)
- Tested measurement range 5 nA - 20 μ A (DC – 100 kHz)
- ➔ Factor 1000x improvement to traditional PCT measurement



Liquefier
(mechanically
decoupled)

Detector chamber
suspensions

Bellows to
connect beamline

Alignment Plate
with damping mat

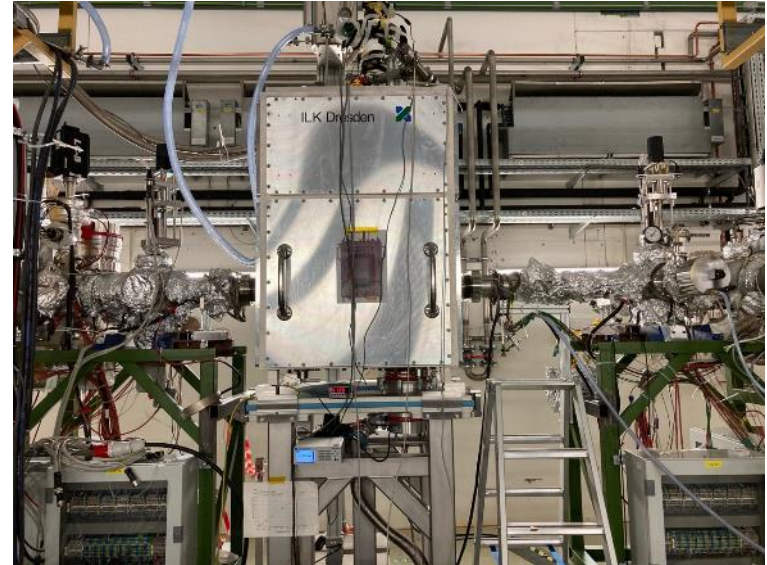
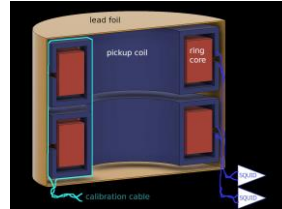
Heavy support
(sand filled)

Separate Support
Turbo + Pre-Pump

CCC@CRYRING

- Refinement of cryogenic system (extended cryogenic operation)
- Increase signal quality
 - Background suppression (e.g. signal filters)
 - Optimize SQUID stability (mechanical & electrical interference)
- Advanced detector design
 - Multi ring core (Dual-CCC)

V. Tympel, M. Stapelfeld



Cryogenic Current Comparator (CCC) at CRYRING

➔ *Preparation for FAIR series production*

Commissioning of the Cryogenic Current Comparator (CCC) at CRYRING

David Haider

GSI/FAIR, Germany

On behalf of the CCC collaboration

Open PhD position

More infos at:

<https://www.euraxess.de/de/node/677035>

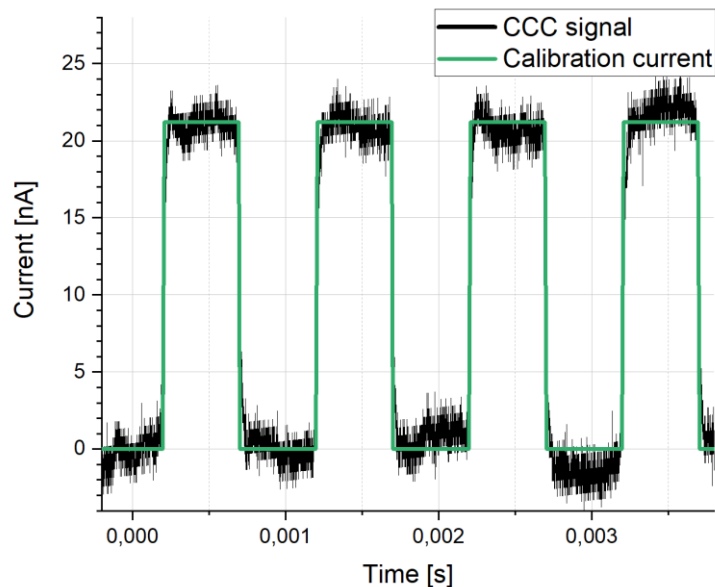


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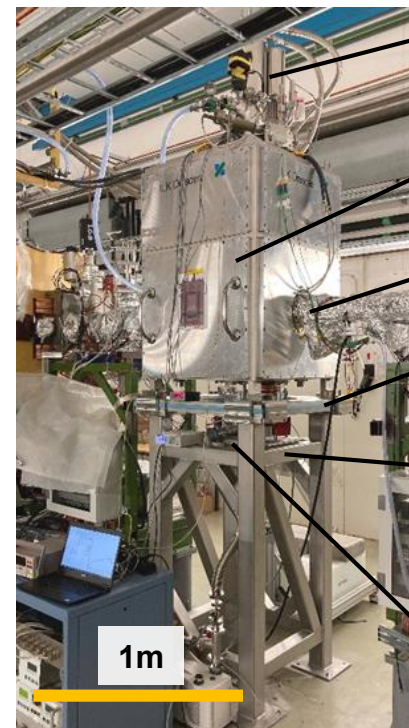
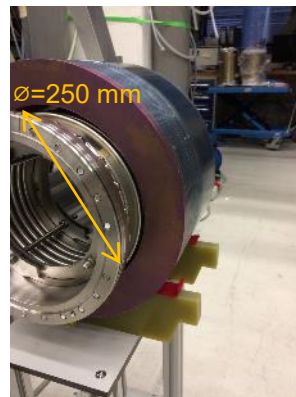
Commissioning of the Cryogenic Current Comparator

TEK36 - 28. Nov 2020

Input: 21.2 nA of calibration current (1 kHz square wave)



➔ Factor 1000x improvement to traditional PCT measurement



Liquefier
(mechanically
decoupled)

Detector chamber
suspensions

Bellows to
connect beamline

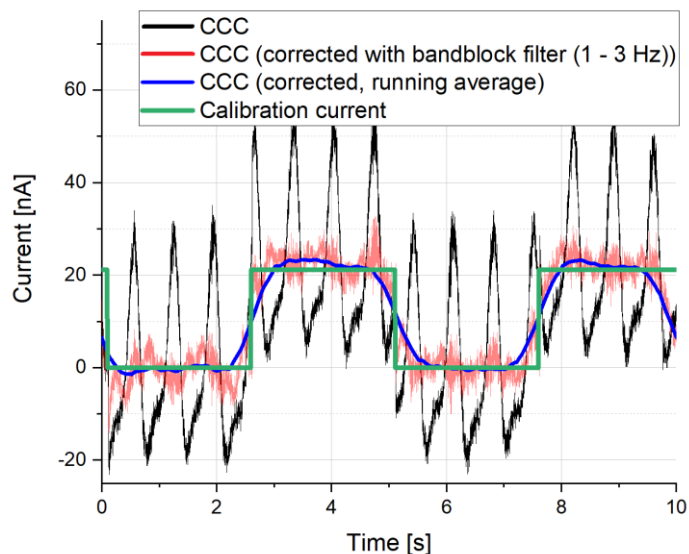
Alignment Plate
with damping mat

Heavy support
(sand filled)

Separate Support
Turbo + Pre-Pump

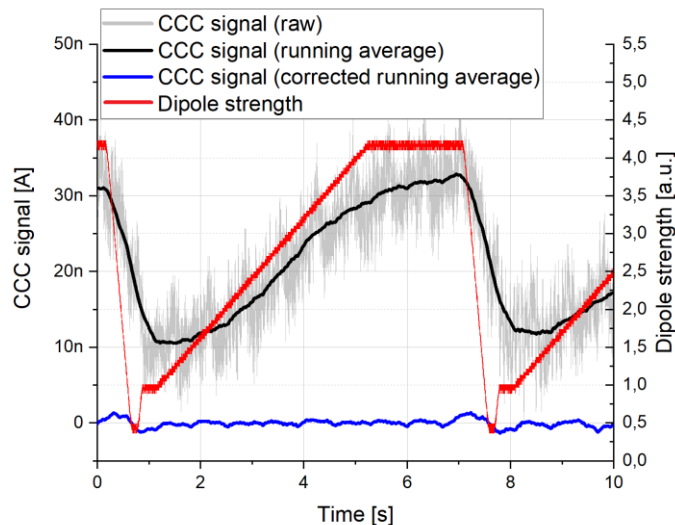
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Perturbations - Filters



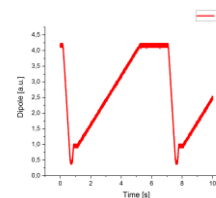
Helium liquefier

fixed frequency (1.4 Hz):
 >> bandblock filter

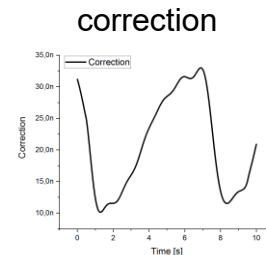


Dipole ramp

deterministic:
 subtracted using
 recorded response
 function



=>



calculated from
 dry run measurements