CCC in FAIR

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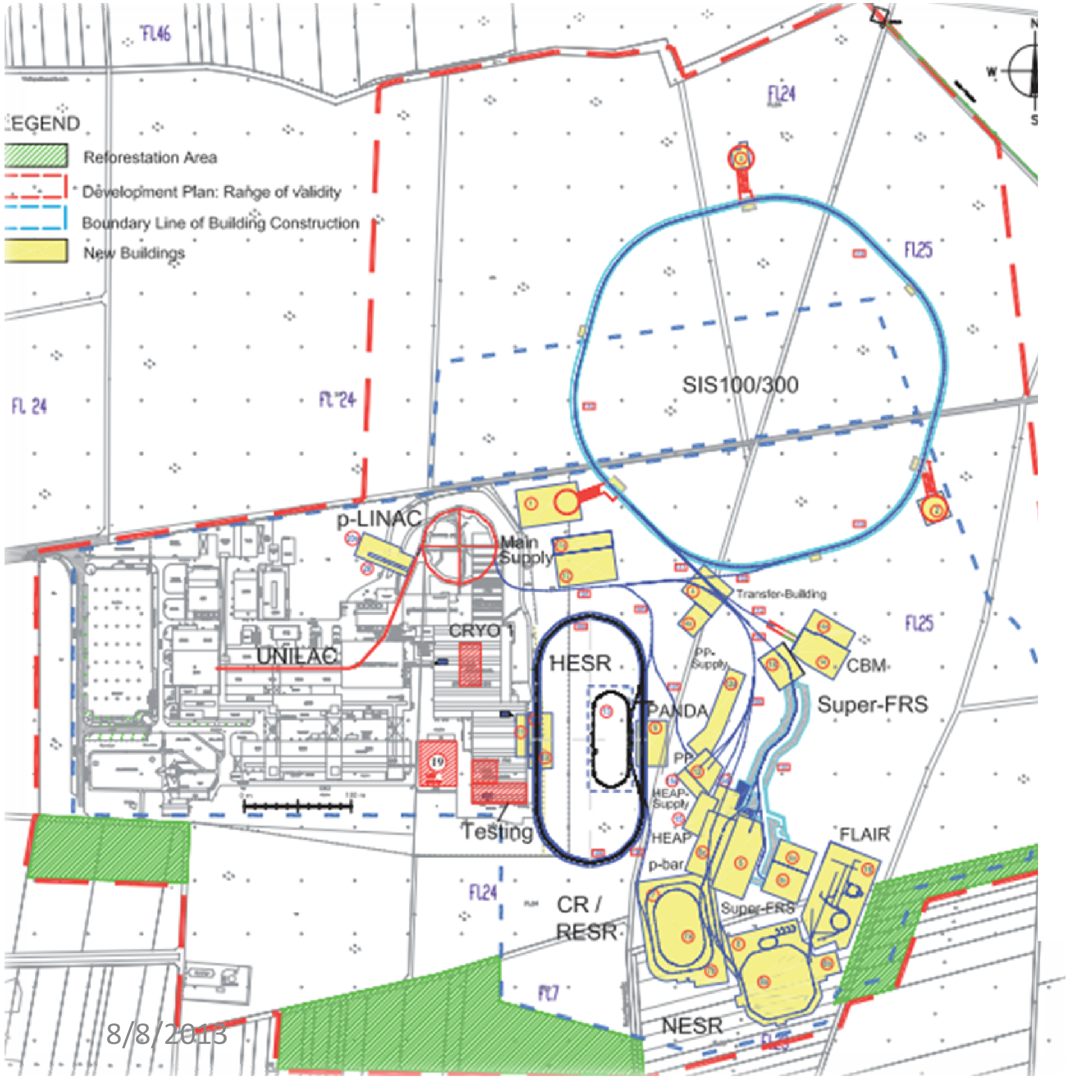
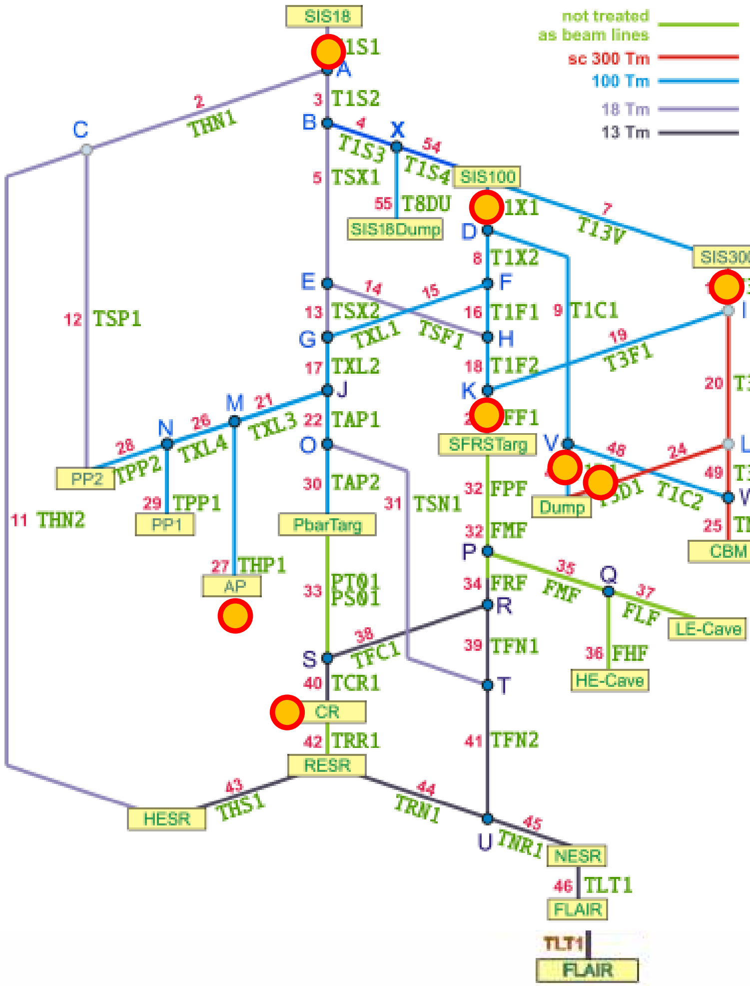
- Intensity measurements
- CCC principle of operation
- Simulation on the Field attenuation
- Test Measurement of simulated beam current
- Concepts for the FAIR installation
- Future works planned & Conclusion

FAIR- Layout


LEGEND
Reforestation Area
Development Plan: Range of validity
Boundary Line of Building Construction
New Buildings
SIS100/300
p-LINAC
Main Supply
UNILAC
CRYO 1
HESR
PANDA
Transfer-Building
CBM
Super-FRS
Testing
FLAIR
CR / RESR
NESR
Super-FRS


SIS18
not treated as beam lines
sc 300 Tm
100 Tm
18 Tm
13 Tm
THN1
TSX1
T1S2
T1S3
T1S4
T8DU
SIS18Dump
SIS100
SIS300
T13V
T1X2
TSP1
TSX2
TXL1
TSF1
T1F1
T1C1
T3F1
TXL2
T1F2
T3C2
TAP1
TXL3
TXL4
TPP2
PP2
TPP1
PP1
THN2
TAP2
PbarTarg
TSN1
SFRSTarg
FPF
FMF
Dump
T1C2
T3C3
TNC1
CBM
THP1
AP
PT01
PS01
FRF
FMF
FLF
LE-Cave
FHF
HE-Cave
TFC1
TFN1
TCR1
CR
TRR1
RESR
TFN2
HESR
THS1
TRN1
TNR1
NESR
TLT1
FLAIR

CCC Locations in FAIR

T1S1 – Extraction line from SIS18

T1X1– Extraction line from SIS100

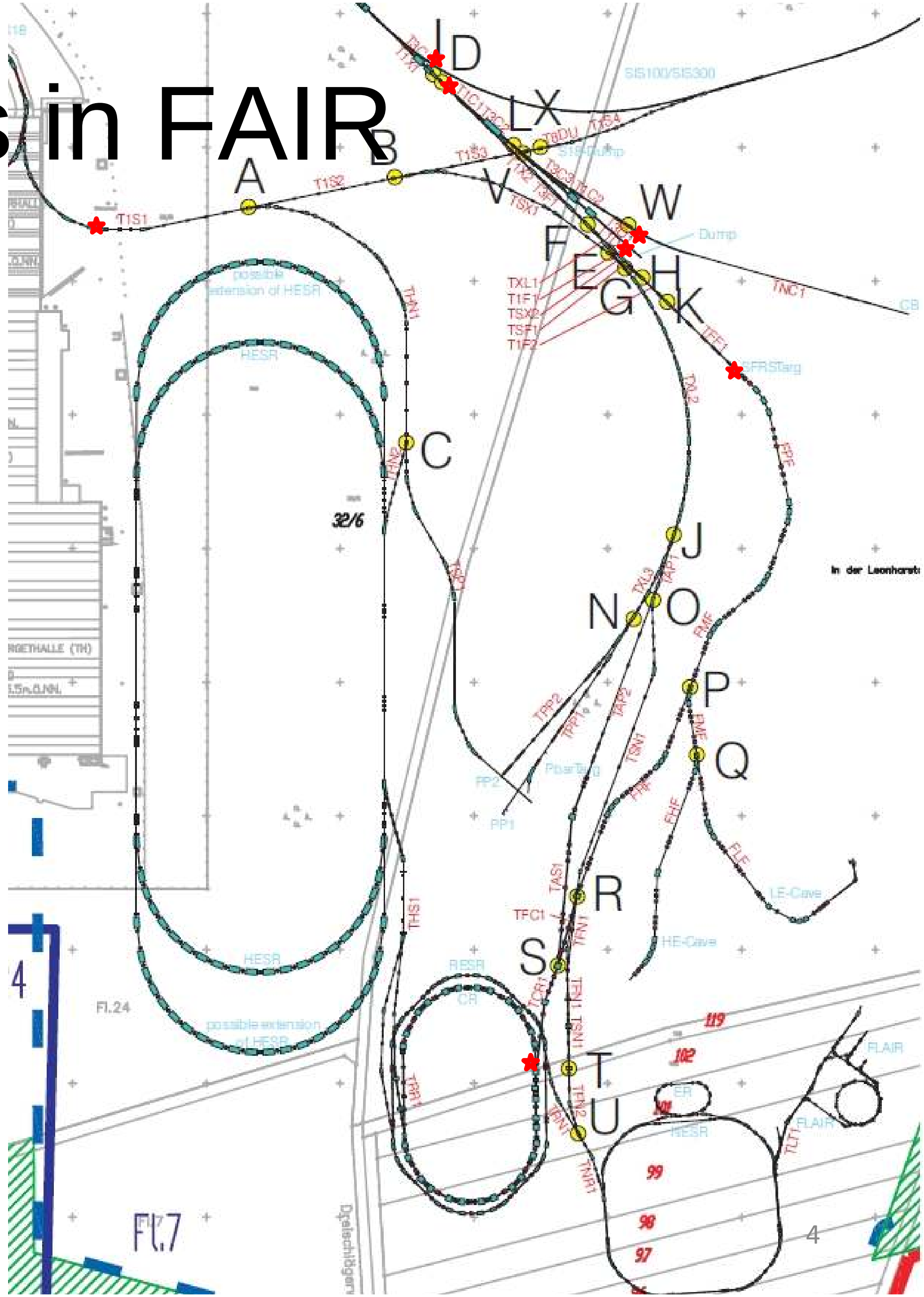
T3C1– Extraction line from SIS300

TFF1– In front of Super FRS

T1D1– Beam Dump from SIS100

T3D1– Beam Dump from SIS300

.. also inside the CRYRING and CR



Intensity Measurements for FAIR

For online monitoring of slowly extracted beams in

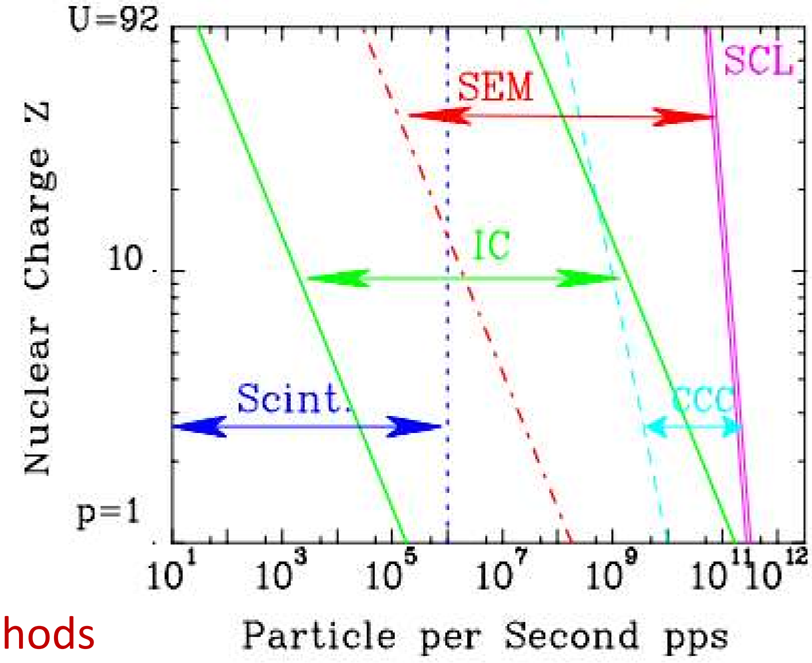
- Extraction lines of the synchrotrons (SIS18,SIS100, SIS300)
- In front of the beam dumps
- Experiments using slowly extracted beams (Super fragment separator -SFRS)

we have extremely low intensity

For these beam lines (spill time 1 second),

- Minimum beam intensity of 10^4 pps
- Maximum beam intensity

of 10^{12} pps - Currents { proton: 160nA; Uranium^{28+} : 4.5µA }



For the beam current measurements

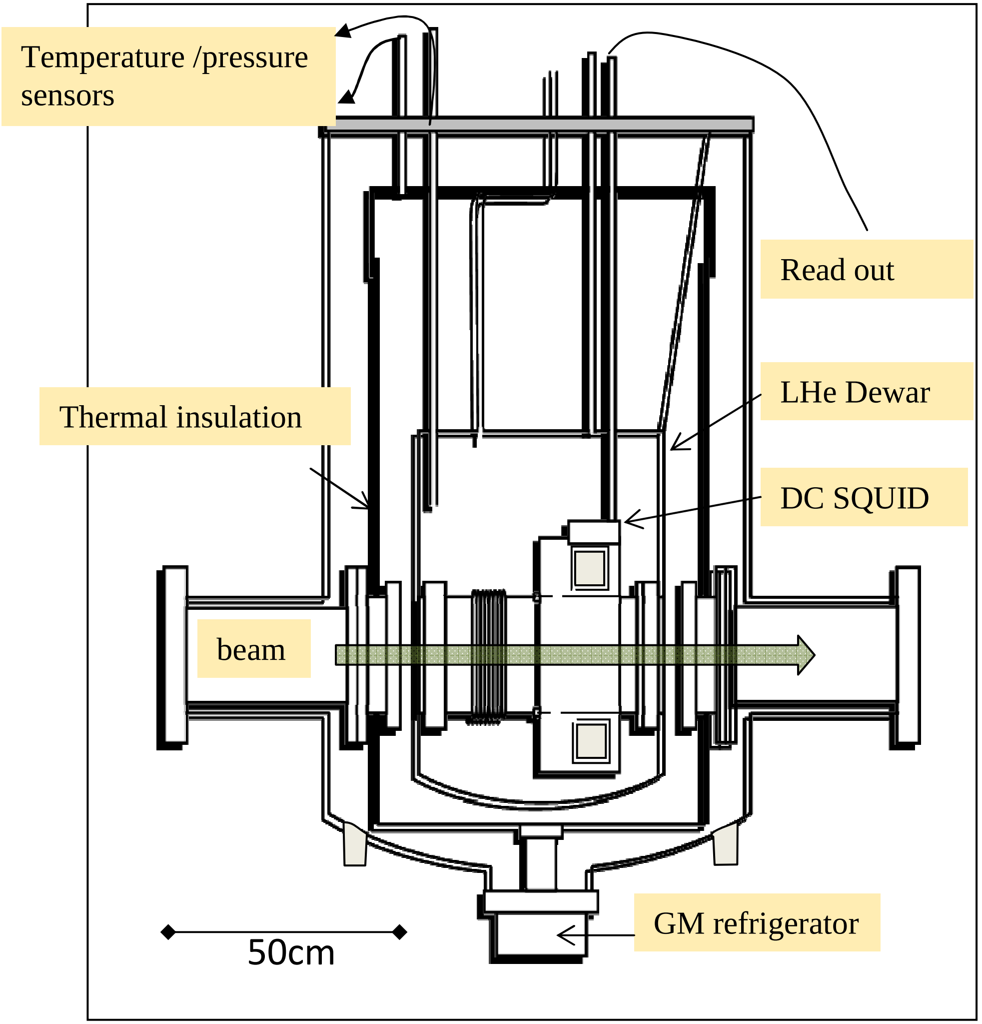
- Scintillators
- Secondary electron monitor
- Ionization chambers

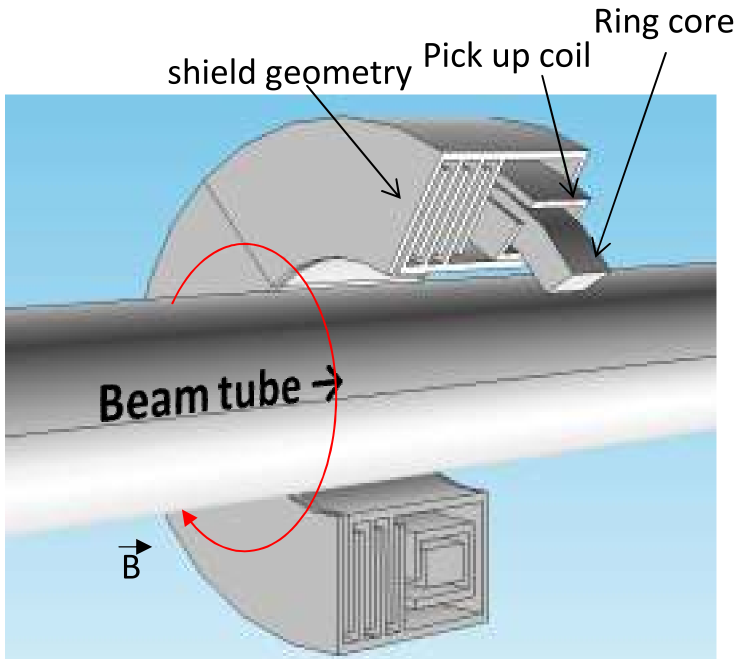
} Intercepting methods

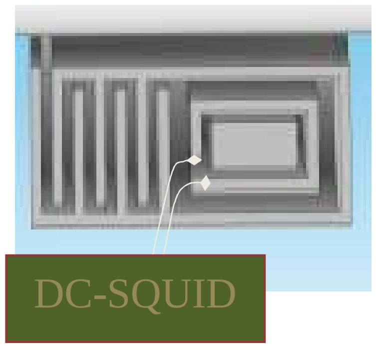
CCC- The only solution for Non-intercepting online measurement of beam current down to nA

Working Principle- CCC

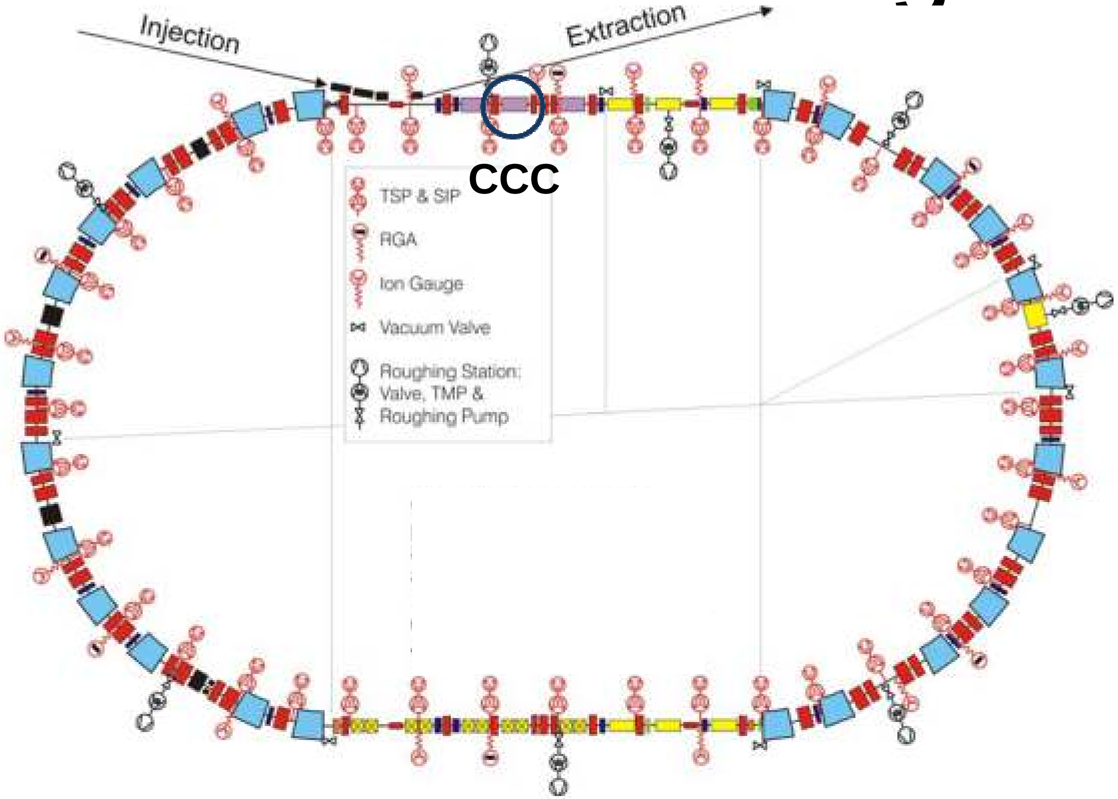
2D Schematic of the CCC prototype + Cryostat







Collector Ring



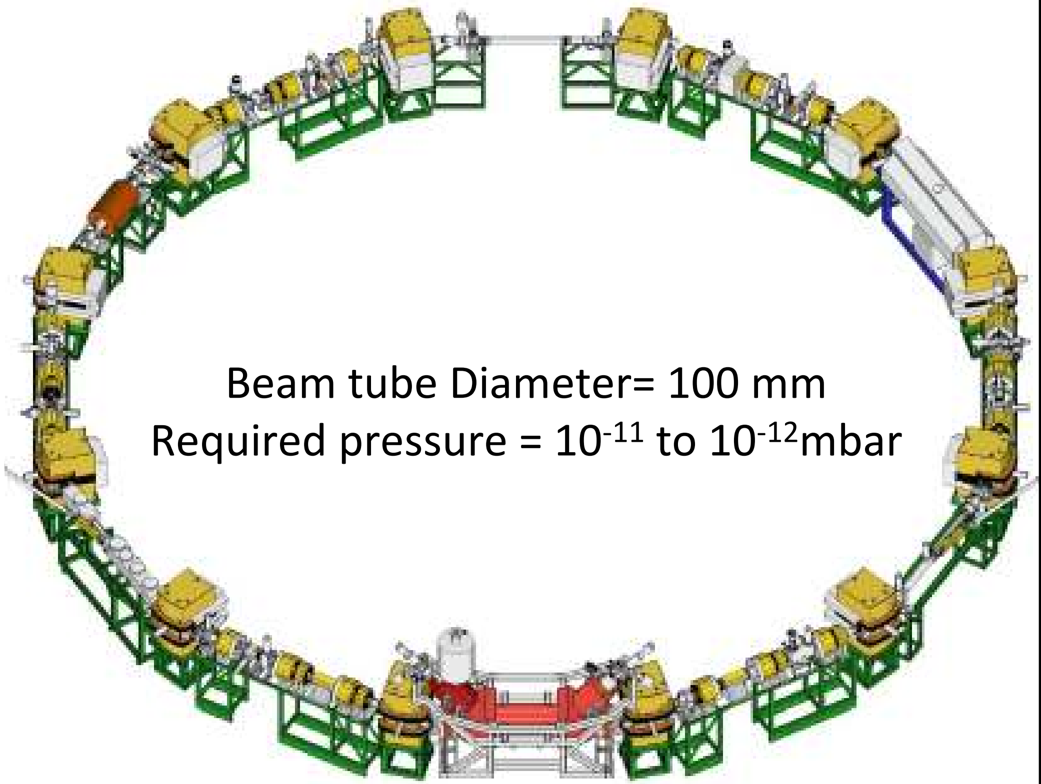
Circumference : 221.45 m
Beam Tube Diameter : 200 mm
Average Vacuum : 10^{-9} mbar
Max. No. of Particles
Antiprotons : 10^{8}
Rare Isotopes : 10^{9}

Kinetic Energy
Antiprotons : 3 GeV/u
Rare Isotopes : 740 MeV/u
Velocity
Antiprotons : 0.971v/c
Rare Isotopes : 0.83 v/c

CRYRING

With a detection threshold of CCC =2.3 nA

(Noise current resolution of 70pA/√Hz, Sampling rate of 1 kHz)

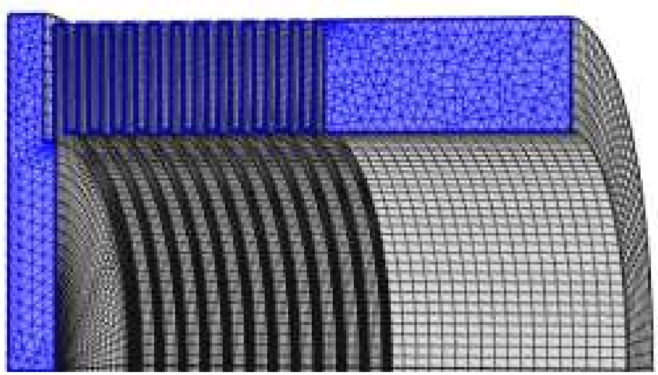


Type of the ion	E_{kin}	Current for 1 particle	Minimum number of ions
H^{+}	5 MeV	0.1pA	~23000
C^{12+}	5MeV	1.15pA	~2000
Ne^{10+}	5MeV	1pA	~2300
U^{92+}	5 MeV	8.814pA	~300

Simulation on the Field Attenuation

Goal: To estimate the field attenuation through the Magnetic shield geometry and various spatial dependences

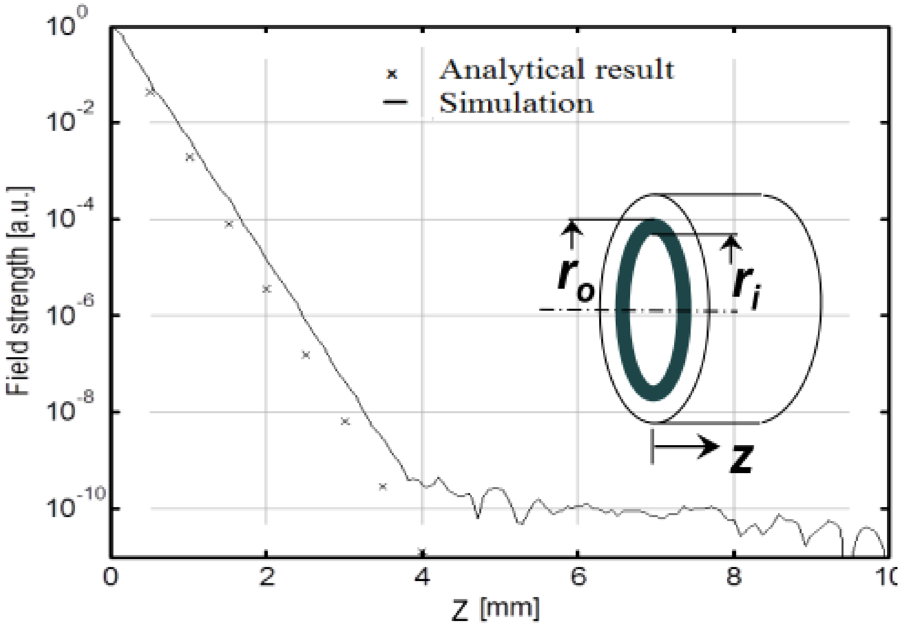
- Dependence on Gap width
- Number of meander structures

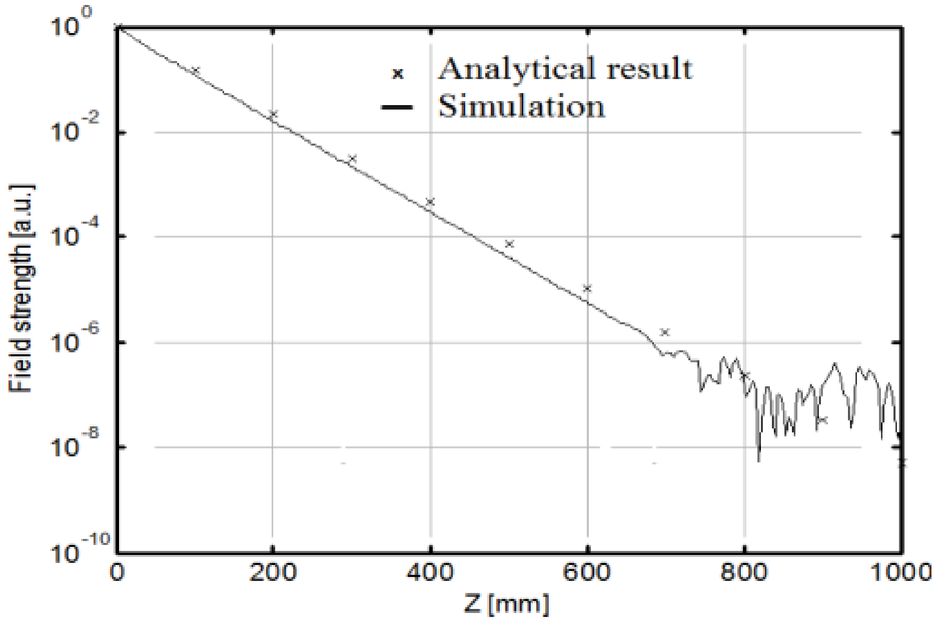


FEM Simulation Package: Comsol multiphysics ™

Accuracy of the 3D simulation

$$V(\rho,\emptyset,z) = \left(V_{trans}\exp\left\{\left(\frac{-2}{1+{}^{r_i}/_{r_o}}\right){}^{z}/_{r_o}\right\}\right) + \left(V_{long}\exp\left\{-\left(\frac{\pi}{1-{}^{r_i}/_{r_o}}\right){}^{z}/_{r_o}\right\}\right)$$



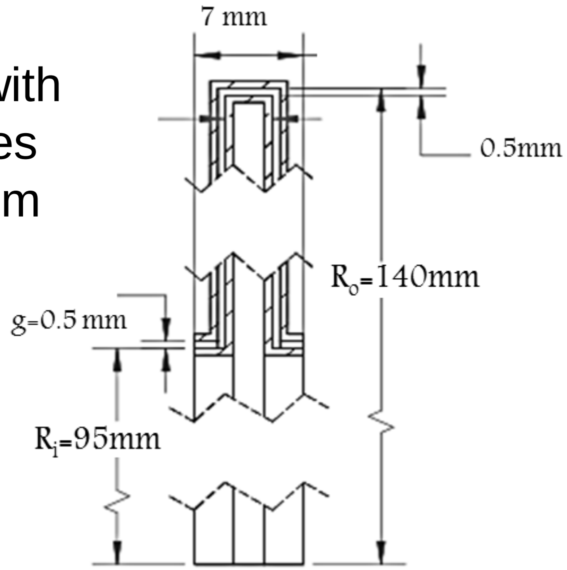


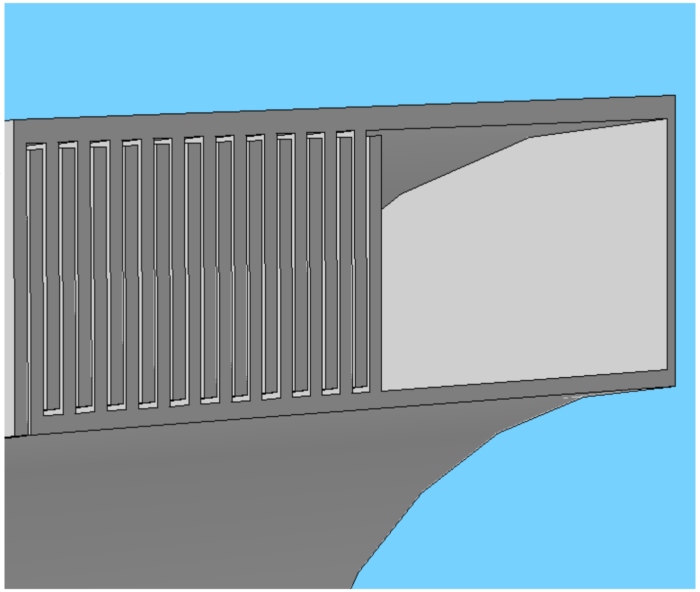
Comparison of the accuracy on the simulation of Field attenuation with analytical result . (Left) For the longitudinally applied field and (Right) Transverse applied field

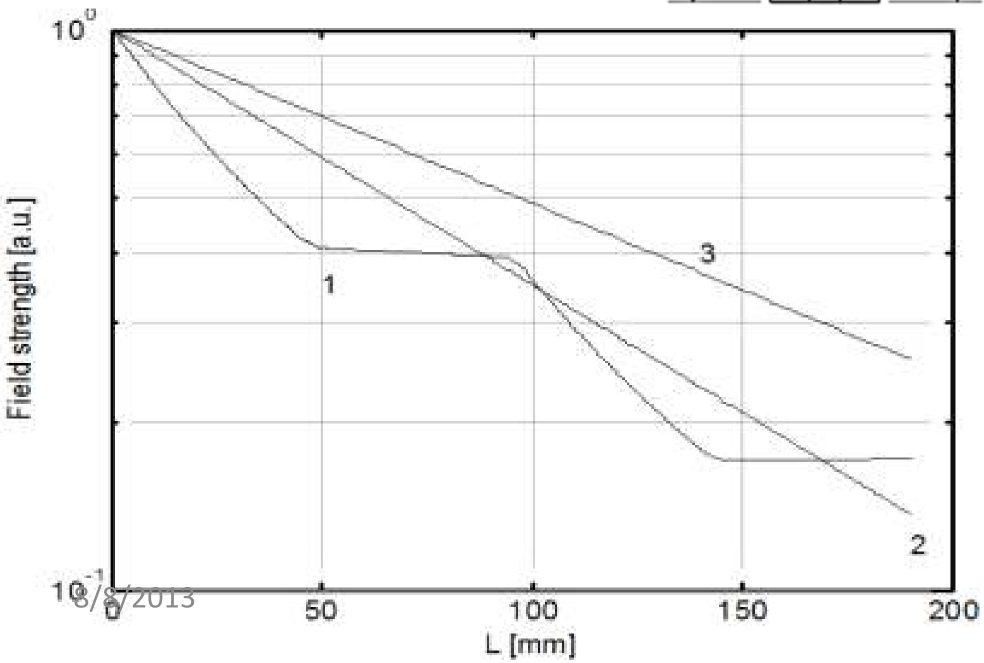
Simulation on the Field Attenuation

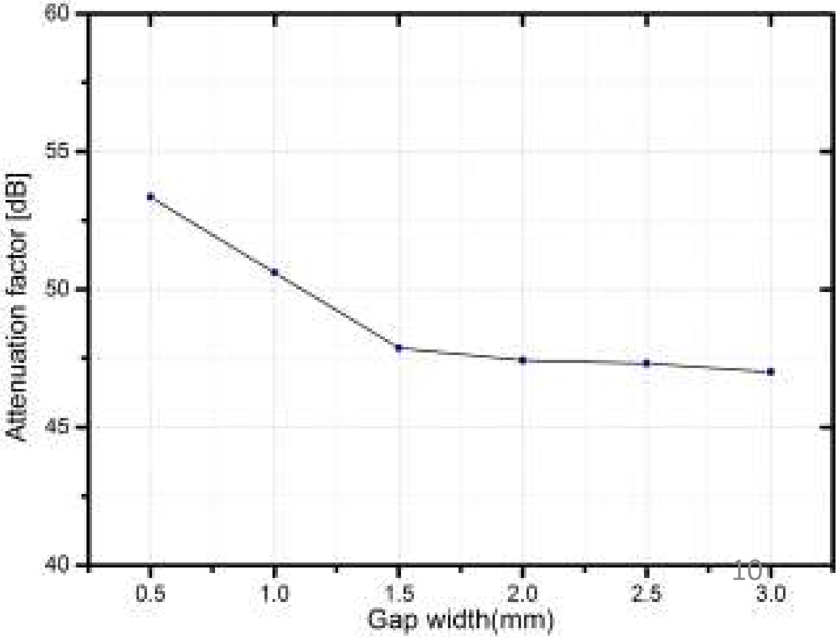
For the given geometry with 14 meander shaped plates with a gap width of 0.5 mm between them

Attenuation factor = 155 dB









Field attenuation-Experimental determination

External magnetic field is applied in desired direction by Helmholtz's coil and the corresponding SQUID signal is read and converted to equivalent magnetic field

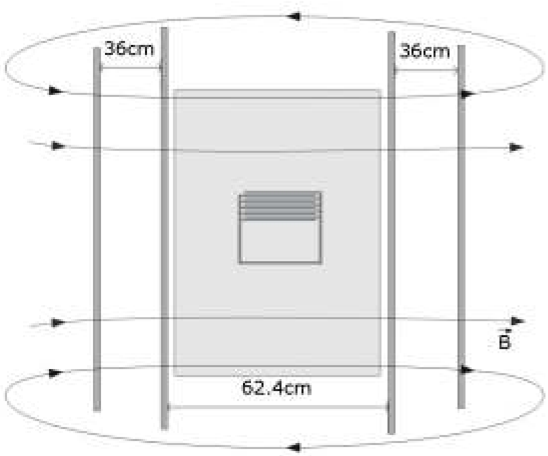
$$B = \Phi / A = \frac{L \cdot I}{A}$$

L: Inductance of the pick up coil

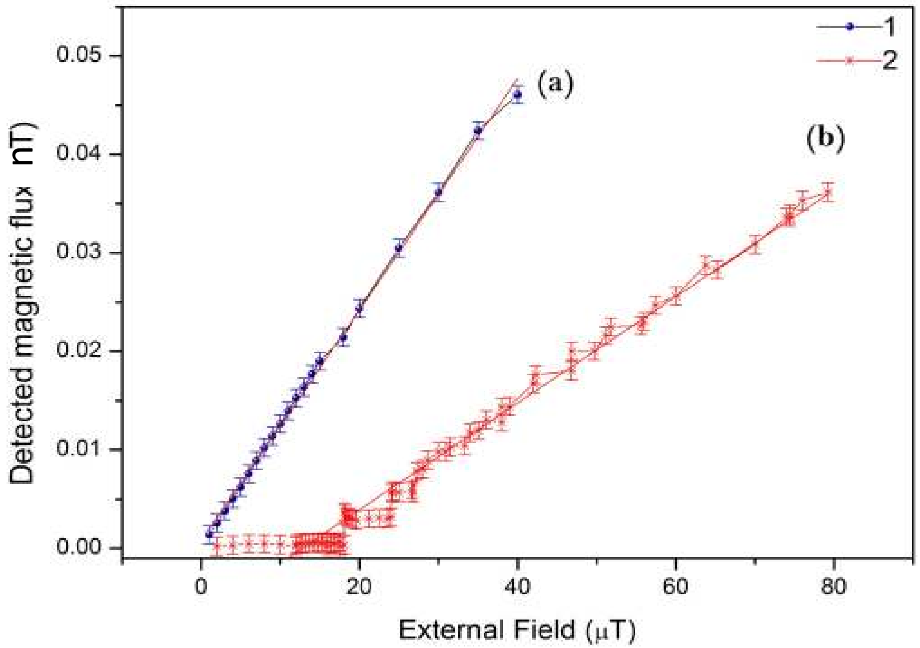
A: Area of cross section

I : Current measured by the SQUID

Attenuation factor in the transverse applied magnetic field= 148 dB



Helmholtz's coils arranged in transverse direction to the axis of the shield



Magnetic field attenuation (a) in the transverse direction and (b) in the axial direction

Preliminary model of the new CCC

Features

•Length: Less than 1 m

•Isolated vacuum chamber

•Local recycling Helium Liquefaction unit

•Longitudinal design

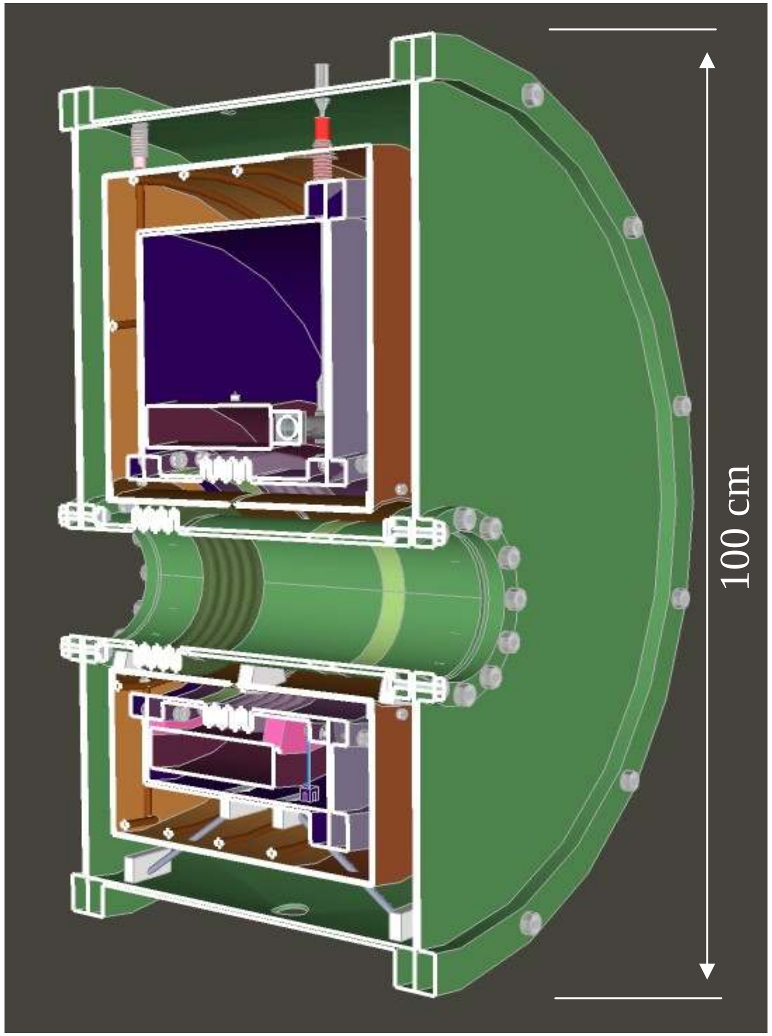
Upgrades:

•New Nb shield geometry

•New Ring core (Nanoperm)

•New SQUID unit from Supracon

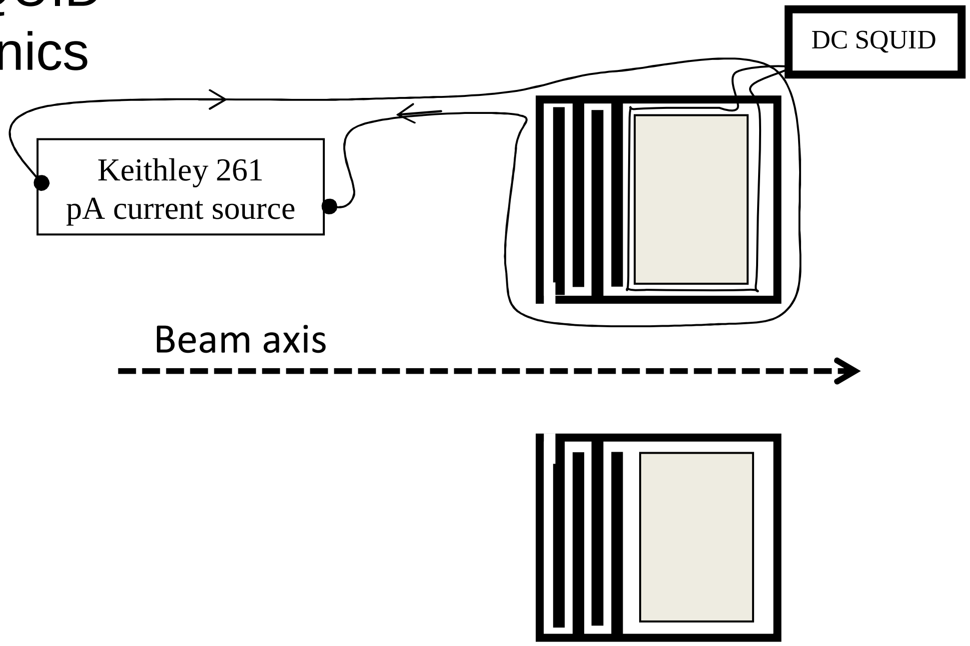
•New SQUID controller from Magnicon



Test Measurements using GSI CCC

Goal of the refurbishment:

1. Experience in vacuum techniques, cryogenics and SQUID measurements
2. Cryostat is needed to test the SQUID
3. Test the new SQUID and electronics



Took into operation after refurbishing

1. Vacuum systems and components
2. GM refrigerator
3. SQUID cartridge and feed-through
4. Readout systems

Next step is to introduce

1. Supracon SQUID systems
2. Magnicon electronics

Hence to establish as a prototype for the new system and to provide a resolution standard with the new components.

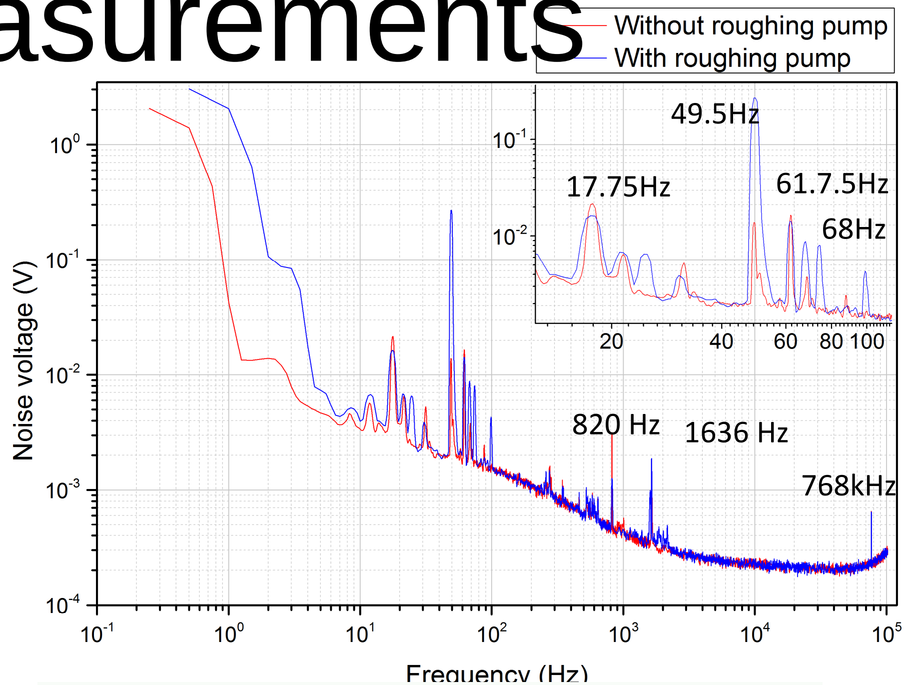
Goal of the test : Apply a known nA current to a wire loop surrounding the pickup coil and measure it using SQUID sensor.

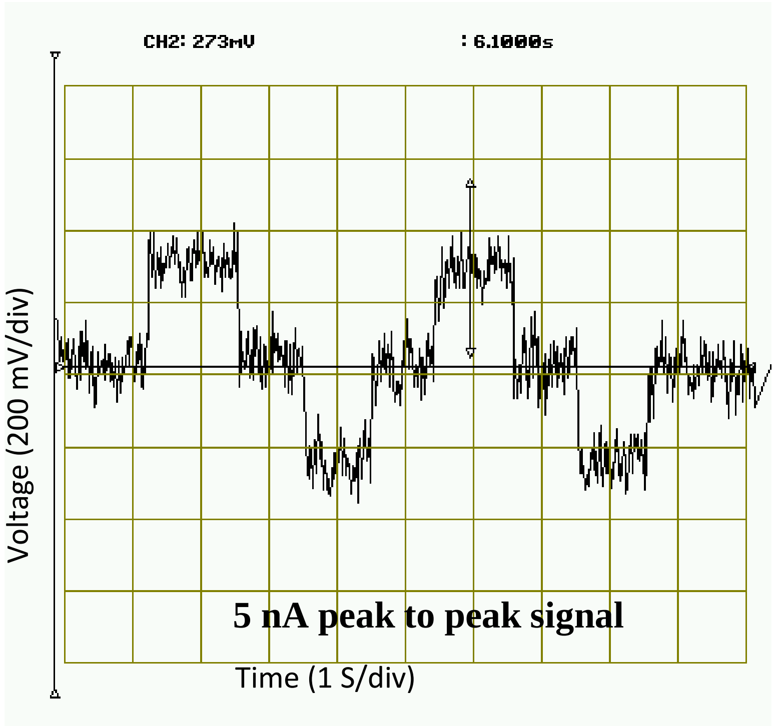
Current Measurements

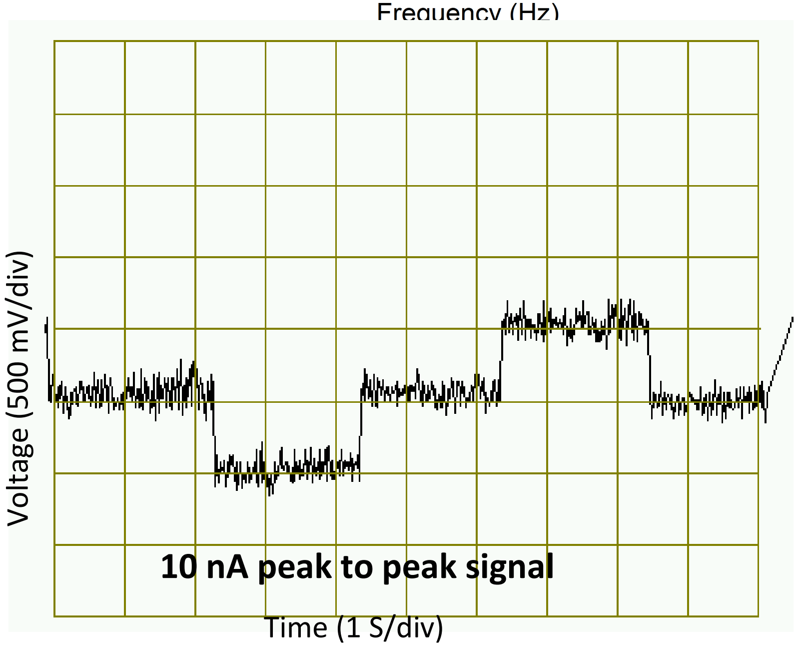
The SQUID sensor is calibrated to $10V/\Phi_0$ V_{out}

Current sensitivity of the SQUID = $175\ nA/\Phi_0$

The noise limited current resolution
at low frequency = 70 pA/√Hz



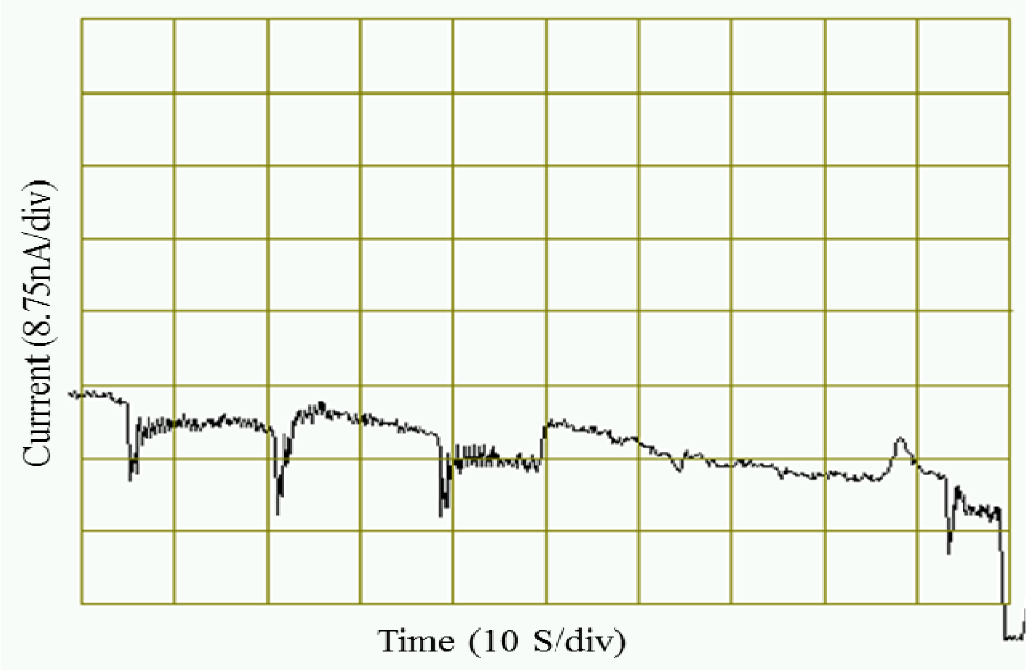




Measurements Challenges

Zero Current Drift:

Extremely sensitive to the temperature stability of LHe Cryostat



Further investigations are required on the dependence of zero current drifts on mechanical stability

Future Plans and Conclusions

1. New SQUID system from Supracon is under installation and will be installed inside the GSI CCC to measure the simulated beam current

2 . New SQUID electronics from Magnicon will be used for the signal read-out and will also be tested with GSI CCC system.

3. The GSI CCC system with new upgraded parts will be taken to the beam line to measure the beam current.

4. Vibration analysis of the complete system

5. Further investigations on the noise sources

6. Design drawing of the new CCC unit will be finalized soon.

Acknowledgements

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Thank you for your attention