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CERN

Different Versions of Cryogenic Current Comparators with Magnetic Core for Beam Current Measurements

Presenter: Jessica Golm
FSU Jena

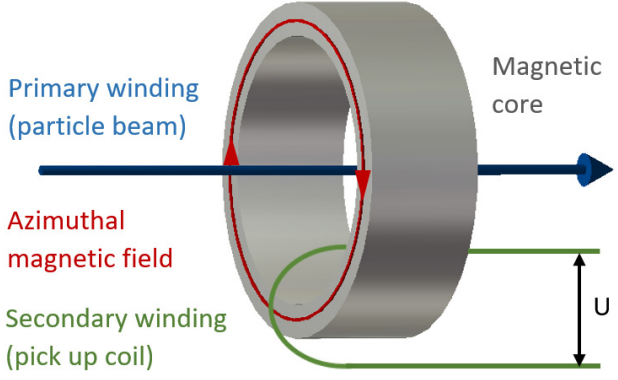
Content

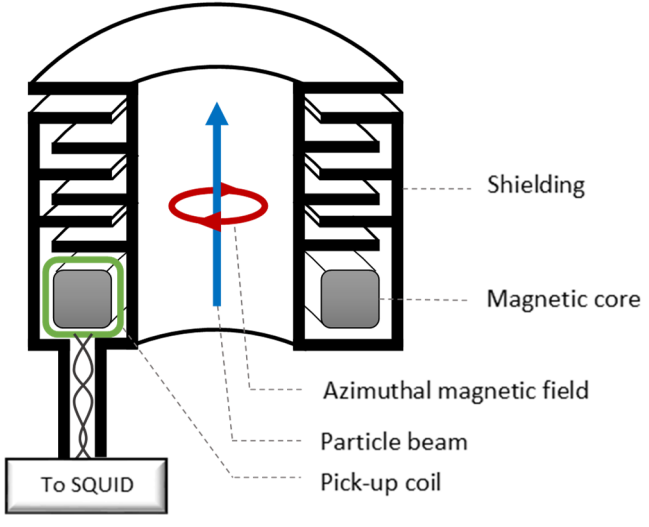
1. Operation principle and versions
    a. Core material
    b. Superconducting shielding
2. Experimental results
3. Summary and outlook

- Operation principle and versions -

Operation principle

non-destructive, low beam intensity measurements, absolute calibratable

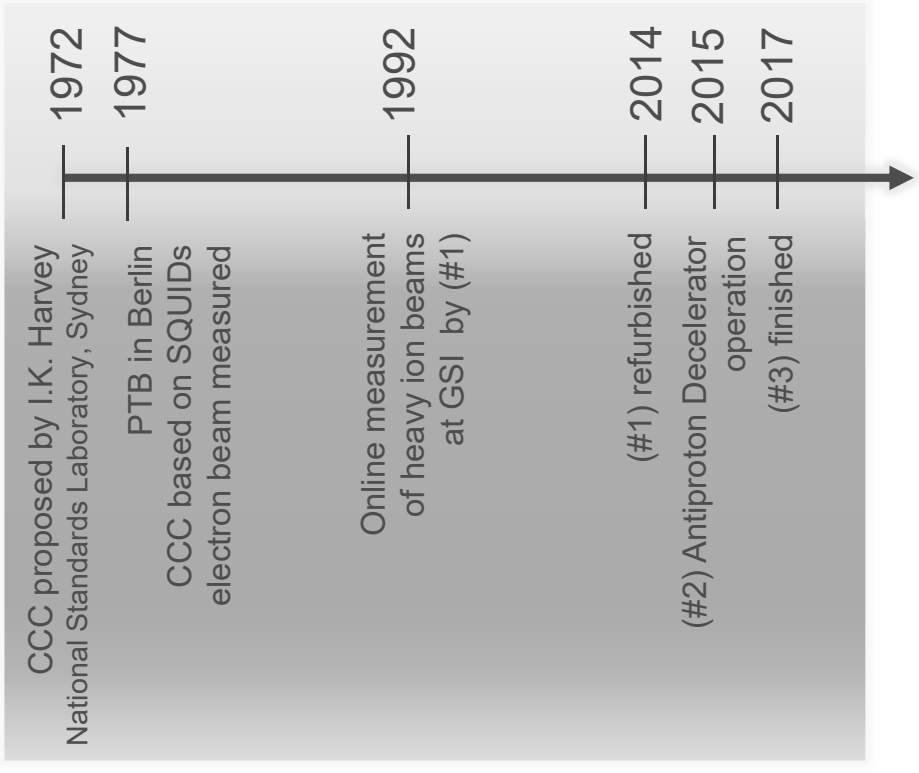




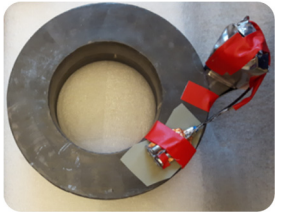
operation principle of an AC - current clamp →

- shielding from external time-varying magnetic fields
- sc pick-up coil → flux conservation in sc loops → DC beams
- SQUID an extremely sensitive DC- and AC-ampere meter

Cryogenic Current Comparator (CCC) versions

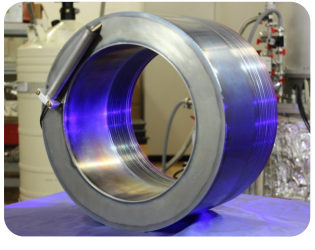


(#1) GSI-Pb-CCC

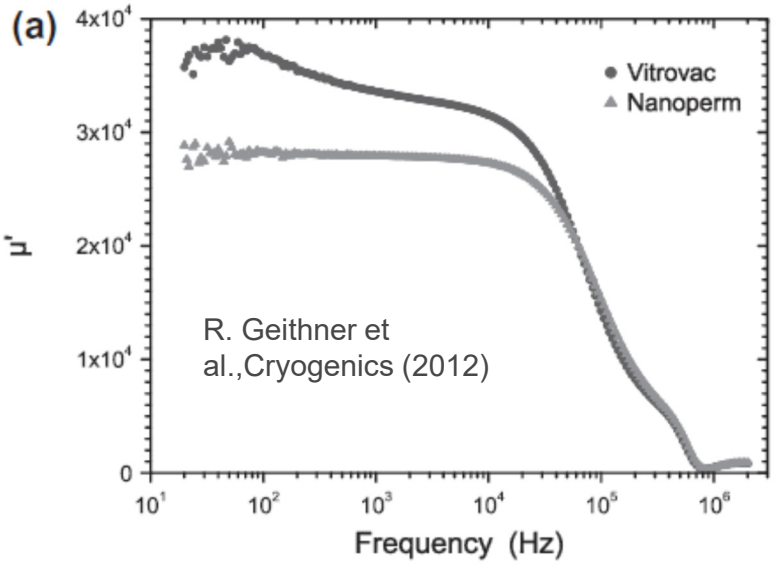


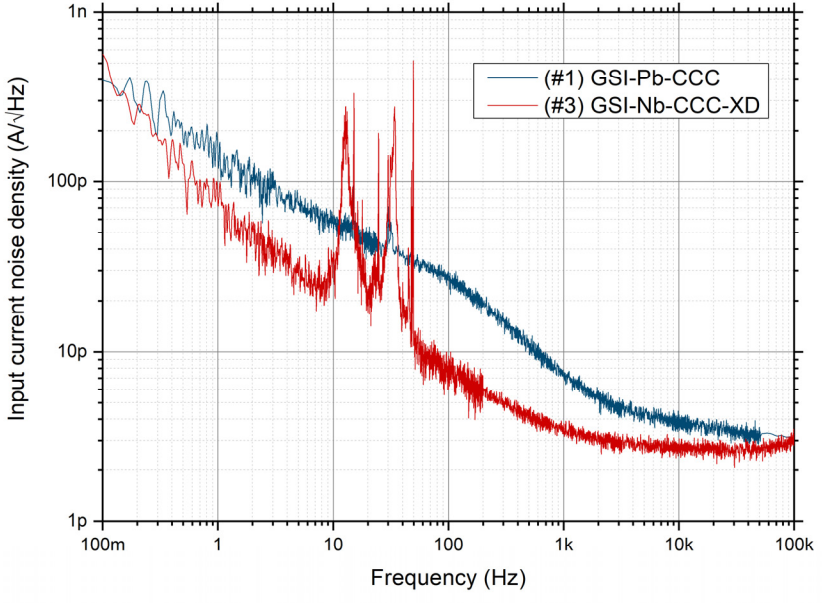
(#2) CERN-Nb-CCC

(#3) GSI-Nb-CCC-XD



Core material





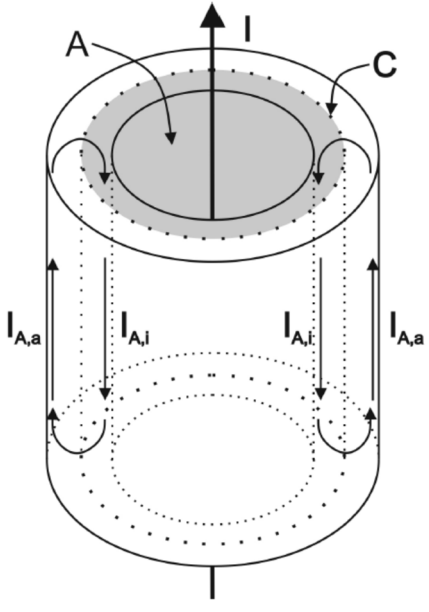
(# 1) amorphous Co-based Vitrovac 6025 → higher relative permeability

(# 2) nanocrystalline Fe-based Nanoperm M764

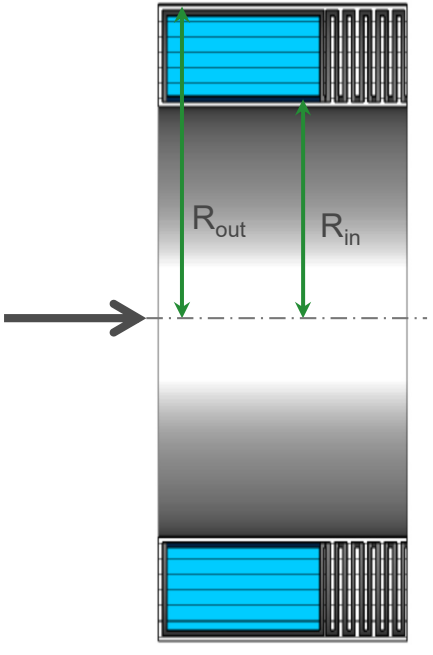
(# 3) nanocrystalline Fe-based Nanoperm 328 plus

} lower current noise contribution and frequency dependence of the permeability

Superconducting shielding



R. Geithner, PhD Thesis (2013)



N. Marsic et al., Nucl. Intrum. Methods (2018)

- long tube open on both sides
  → screening current flow on the tube surface
- space constrains → meander shape
- damping is function of radius ratio (R_{out} / R_{in}) and number of meanders (N)
- meander structure damps magnet field components (~ 72 dB) except the azimuthal one

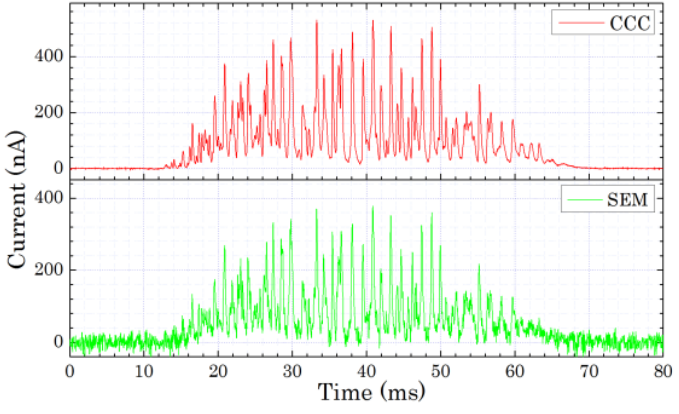
(# 1)	R_{out} / R_{in} = 125/75	~ 1.7	N = 8	Pb
(# 2)	R_{out} / R_{in} = 140/92.5	~ 1.5	N = 10	Nb
(# 3)	R_{out} / R_{in} = 170/120	~ 1.4	N = 12	Nb

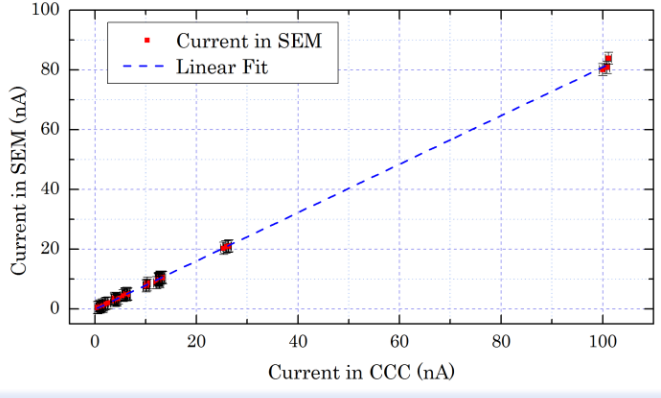
- Experimental Results -

(#1) beam measurements

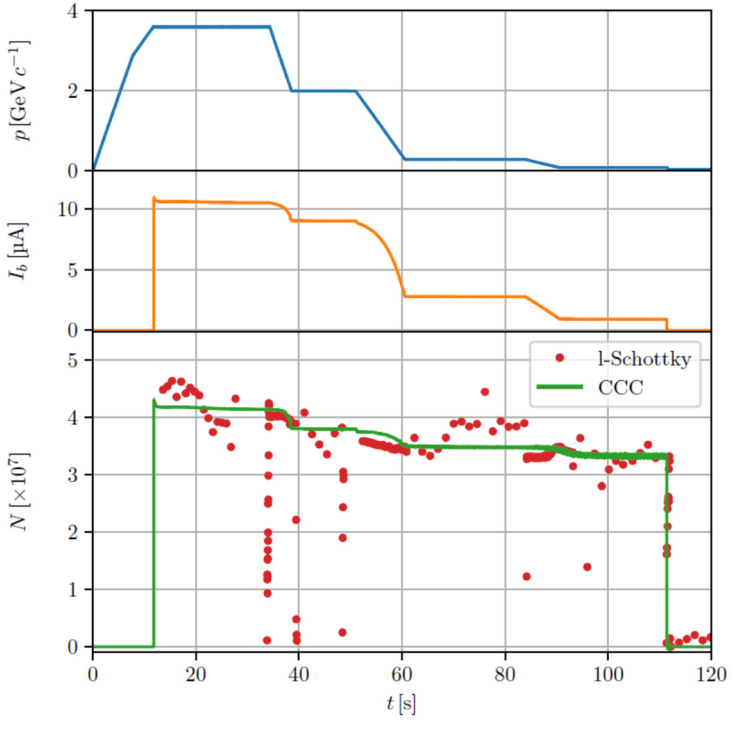
- spill structure: 1.6 x 10^9 Ni^{26+} ions extracted over 64 ms
- comparison CCC and SEM (Secondary Electron Monitor) at HTP
- beam parameters: 600 MeV/u Ni^{26+}

T. Sieber et al., Pro.IBIC'16, (2016), and F. Kurian PhD thesis (2016)





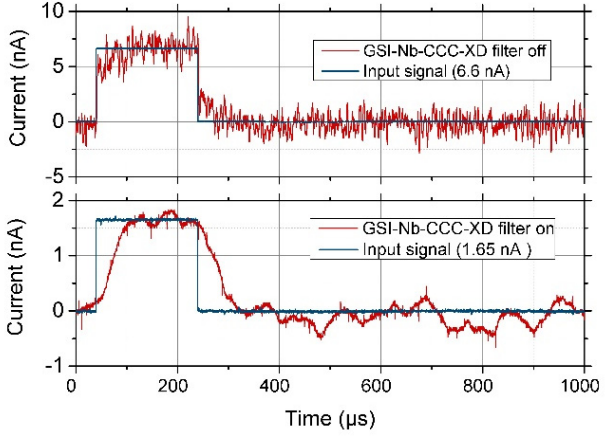
(#2) beam measurements



- CERN AD ring with injection momentum 3.57 GeV/c and extraction momentum of 0.1 GeV/c
- resolution of 3 nA and maximum long-term drift of 25 nA over a cycle of ~100s

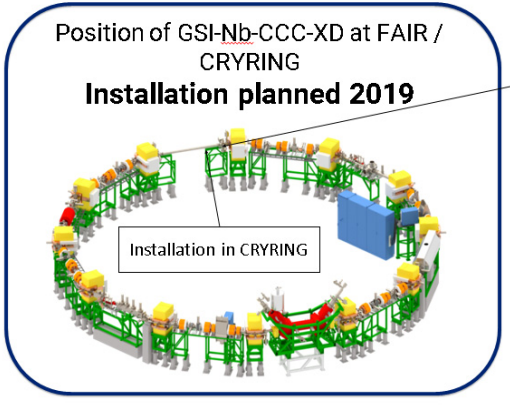
M. Fernandes et al.'Superconductor Science and Technology, Volume 30, Number 1 (2017), and PhDThesis (2018)

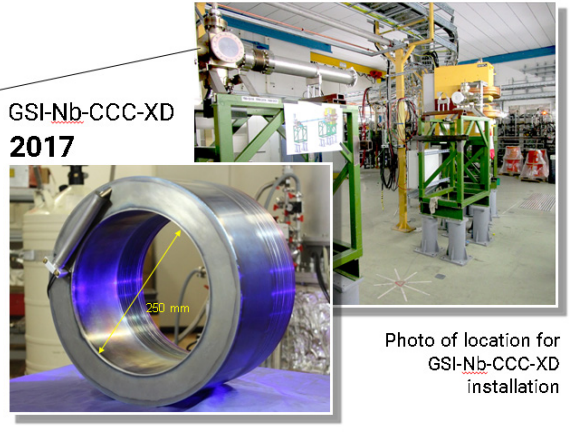
(#3) lab measurements



- Pulse response measurements with wire wound around pick-up coil
- Measurement without (top) and with (bottom) 10 kHz filter
- Pulse form (bottom graph) is distorted due to the low-pass filter

- (#3) is finished
- Cryostat for CRYRING installation is in preparation





- Summary and Outlook -

Summary

CCC Sensor		(#1)	(#2)	(#3)
Diameter	inner/outer (mm)	147/ 260	185 / 280	250 / 350
Length (mm)		95	193	207
Shielding	material meander number attenuation (dB)	Pb 8 ~ 72 dB	Nb 10 ~ 72 dB	Nb 12 ~ 72 dB
SQUID	 electronics	Supracon Magnicon XXF-1	Magnicon Magnicon XXF-1	Supracon/IPHT Supracon/IPHT
Core material		Vitrovac	Nanoperm	Nanoperm
Current noise density (pA/√Hz) 100 Hz 1 – 10 kHz		 ~ 30 ~ 3-7	 ~10 ~ 5	 ~ 7 ~ 3

Summary and Outlook

1972 CCC proposed by I.K. Harvey National Standards Laboratory, Sydney

1977 PTB in Berlin CCC based on SQUIDs electron beam measured

1992 Online measurement of heavy ion beams at GSI by (#1)

2014 (#1) refurbished

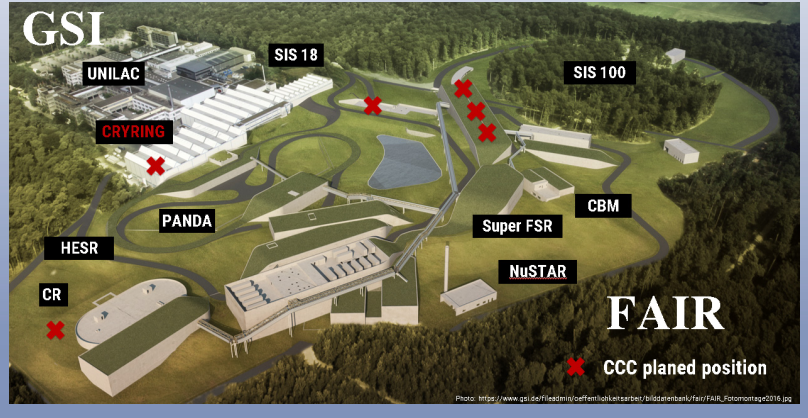
2015 (#2) AD operation

2017 (#3) finished

2018 First tests with coreless CCC

2020 CRYRING measurements

2021 ELENA installation ?



https://www.gsi.de/fileadmin/oeffentlichkeitsarbeit/bilddatenbank/fair/FAIR_Fotomontage2016.jpg

Thank you for your attention !

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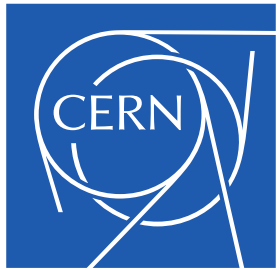

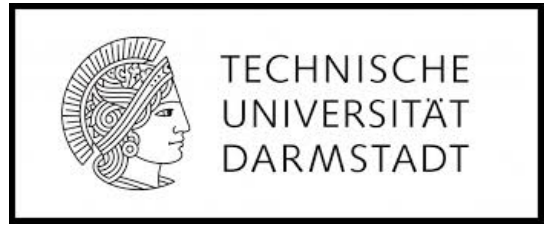

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