Cryogenic Current Comparator Meeting @ GSI

5 August 2013

M. Schwickert
Linac & Operations – Beam Instrumentation (LOBI)

CCC-Meeting, 5 August 2013, GSI Darmstadt

Proposed Agenda

9:00	Welcome and a Short Introduction	M. Schwickert
9:20	A brief History of CCC Project at GSI	H. Reeg, C. Schröder, F. Kurian
9:40	CCC in the FAIR Facility	F. Kurian
10:00	Discussion on FAIR CCC	All
10:45	*Visit to the CCC system and GSI facility*	
12:00	*Lunch Break (colleagues from Jena will join)*	
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13:30	Questions / Discussion on Studies at Jena	All
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16:00	Summary & Next Steps	All

Version 2.0 of the CCC-Project at GSI

- 2007 Contract „Fremde FuE“ between Friedrich-Schiller Universität Jena (W. Vodel) and GSI (M. Schwickert)
- (Re-)Start of CCC-Collaboration: FSU Jena, MPI-K Heidelberg, HIT, GSI
- Start of phd works of A. Steppke and R. Geithner at Jena on novel CCC
- 2010 DITANET-Funding for phd of F. Kurian at GSI: ‚Development of a CCC for FAIR‘
- 2011 CCC gets project funding at Helmholtzinstitut Jena (Prof. Stöhlker, GSI)
- 2012 Start of CRYRING@ESR project, including 1 CCC
- 2013 FAIR Council approves CCC as part of German In-Kind delivery for FAIR

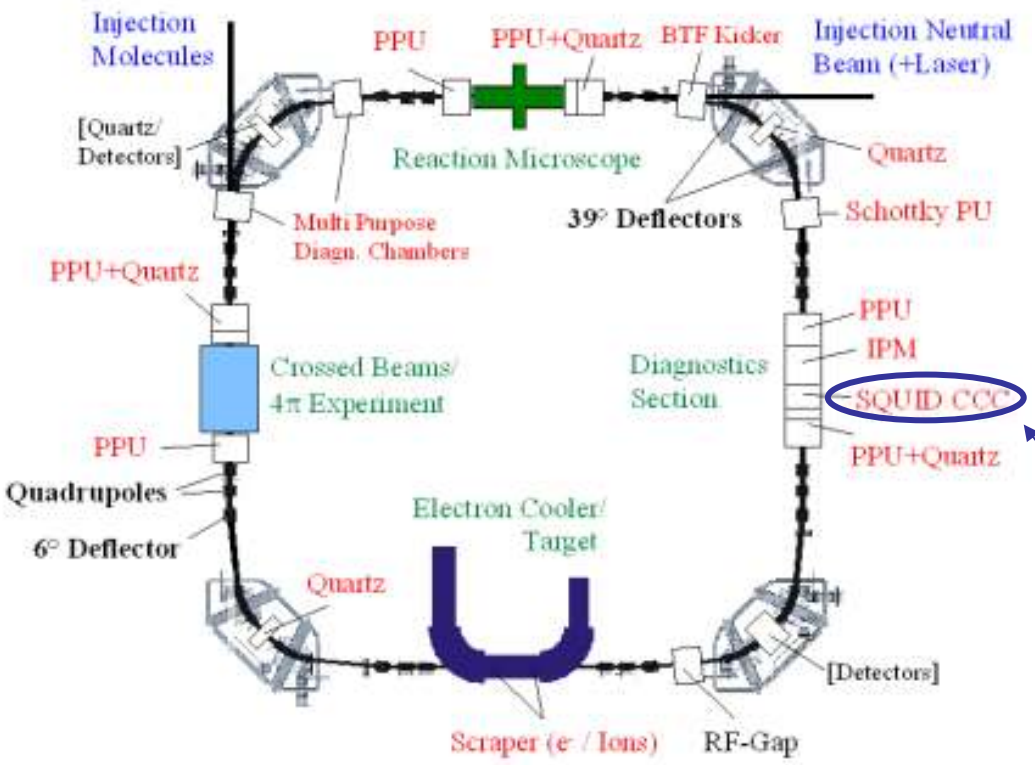
The people involved

- University Jena
  - Ralf Neubert (Electronics engineer, expert for SQUIDs and cryogenics)
- Helmholtz-Institute Jena
  - Dr. Wolfgang Vodel (formerly group leader SQUIDs at Institute for Low Temperature Physics, University Jena)
  - René Geithner (phd Student, Thesis just submitted)
- MPI Kernphysik Heidelberg
  - Dr. Robert von Hahn (project leader CSR, cryogenic storage ring)
  - [initially: Dr. Thomas Sieber, now SIEMENS, future: GSI]
- HIT: - Andreas Peters (CCC inventor ☺)
- GSI
  - Hansjörg Reeg - Dr. Piotr Kowina
  - Febin Kurian - Dr. Marcus Schwickert

CCC-Application: Cryogenic Storage Ring of MPI-K

Cryogenic Storage Ring CSR presently under construction at Max-Planck-Institute für Kernphysik / Heidelberg

(-> presentations of R. v. Hahn, M. Grieser, F. Laux)



(Figure courtesy T. Sieber, MPI-K Heidelberg)

CSR Key Features:

- Electrostatic ring
- 35 m circumference
- XHV vacuum system ~1E-13 mbar
- Operational temperature <10 K
- Particle energy: 10 - 300 keV
- Beam intensity: 1 nA – 1 µA

Current measurement device for:

- Lifetime measurements
- Determination of reaction rates / cross sections
- Pickup calibration

⇩

Below the sensitivity threshold of standard DC-Current transformers

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Common development MPI-K / FSU Jena / GSI:

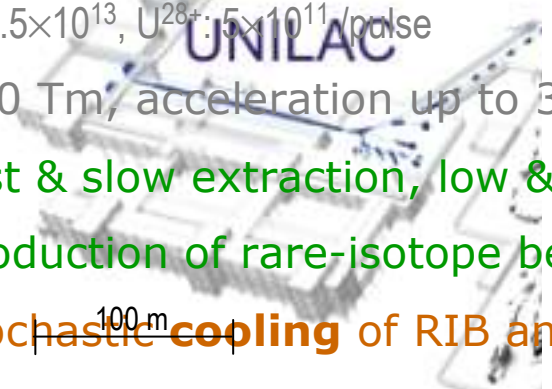
A CCC for the Cryogenic Storage Ring as **prototype for FAIR CCC**

GSI and the FAIR Project

Existing GSI facility:
UNILAC & **SIS18** as injectors

p-LINAC: high current 70 mA, 70 MeV
Length: 120 m

SIS100: Superconducting, 100 Tm,
Energy: 11 MeV/u 1-29 GeV/u, **high current operation p to U**
p: 2.5×10^{13}, U^{28+}: 5×10^{11}/pulse



SIS300: 300 Tm, acceleration up to 30 GeV/u

HEBT: fast & slow extraction, low & high currents

S-FRS: production of rare-isotope beams (RIB)

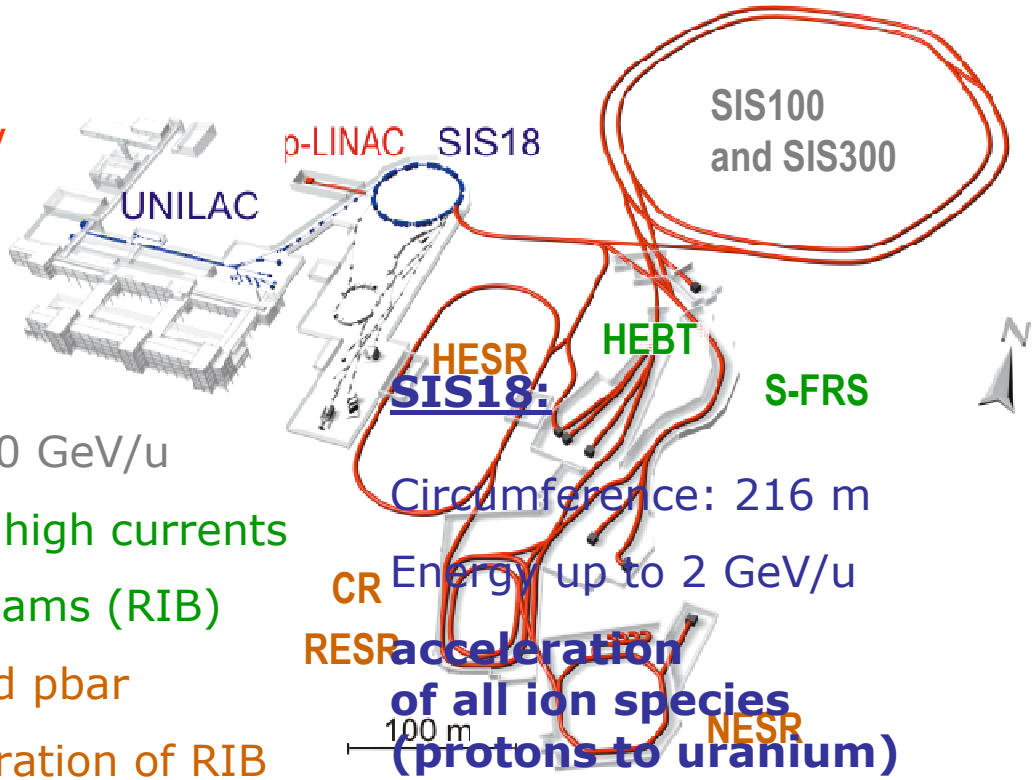
CR: stochastic **cooling** of RIB and pbar

RESR: accumulation of pbar, deceleration of RIB

NESR: versatile experimental ring for stable ions, RIB, pbar cooling, gas-target, e-A collider

HESR: storage and acceleration of pbar to 15 GeV/u

FAIR: Facility for Antiproton and Ion Research



SIS18:

Circumference: 216 m

Energy: up to 2 GeV/u

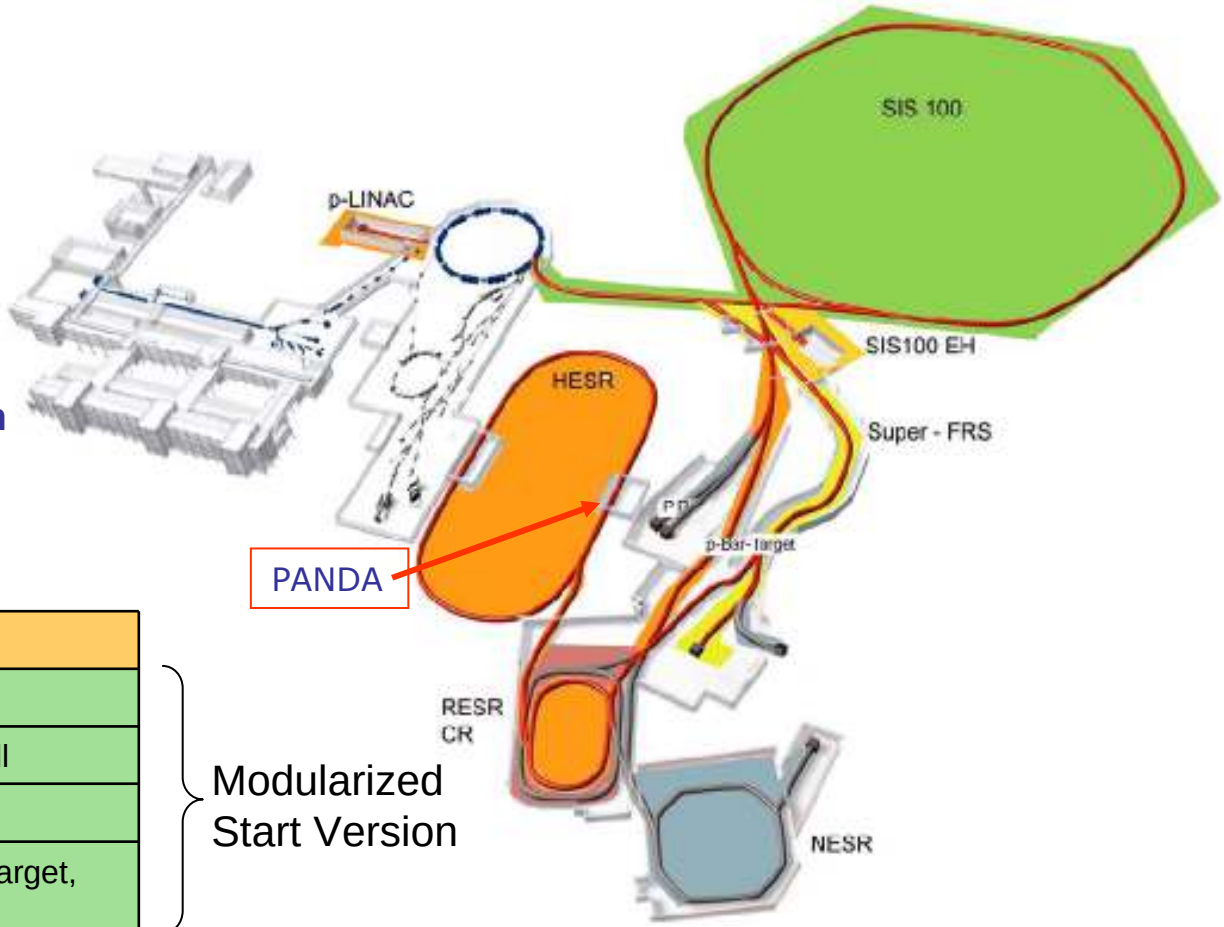
acceleration of all ion species (protons to uranium)

Modularized FAIR Version

FAIR Joint Core Team and Scientific and Technical Issues Working Group

were mandated to prepare a proposal for

a start version accounting for recent cost estimates and firm funding commitments



Module	Color	Machine
0	green	SIS100
1	ochre	Experimental hall
2	yellow	Super-FRS
3	orange	p-Linac, p-Bar-Target, CR, HESR
4	blue-gray	NESR, experiment stations
5	red-brown	RESR

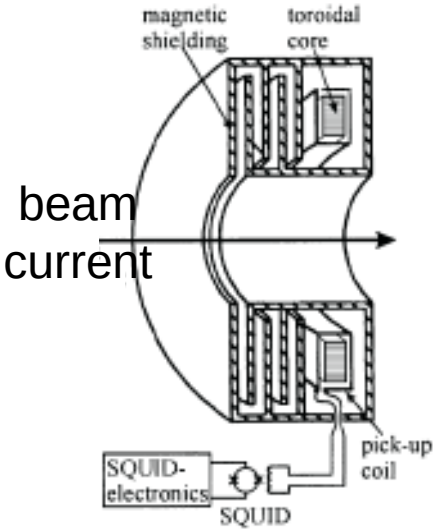
Modularized Start Version

Final Stage

Cryogenic Current Comparator (HEBT, CR)

HEBT: 6 Devices (PSP 2.3.6.2.1),
CR: 1 Device (PSP 2.5.6.1.3)

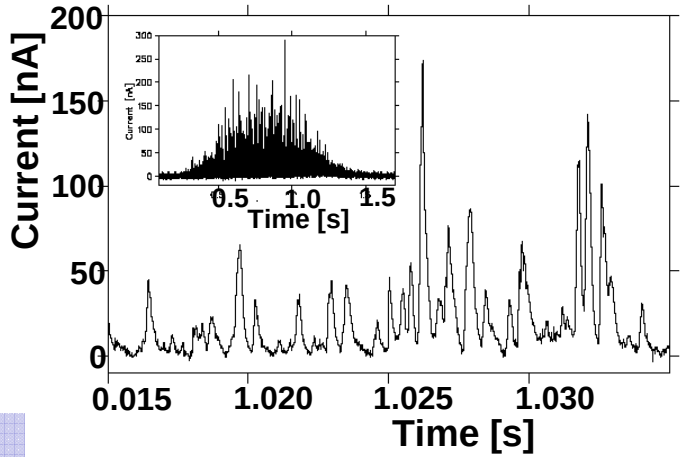
- online current monitoring for slow extraction (HEBT), intensity monitoring for circulating beam (CR)
- beam current below threshold of regular transformers



- high-resolution detection of the **beam's magnetic field**
- **superconducting pick-up coil** with ferromagnetic core
- **SQUID** for sensitive detection of coil magnetic field
- collaboration: Univ. Jena, MPI-K Heidelberg, HIT Heidelberg, GSI
- resolution improvement by optimal **selection of core material**

Existing GSI Prototype:

7×10^9 Ar^{11+} at 300 MeV/u within 1.2 s, readout 20 µs:



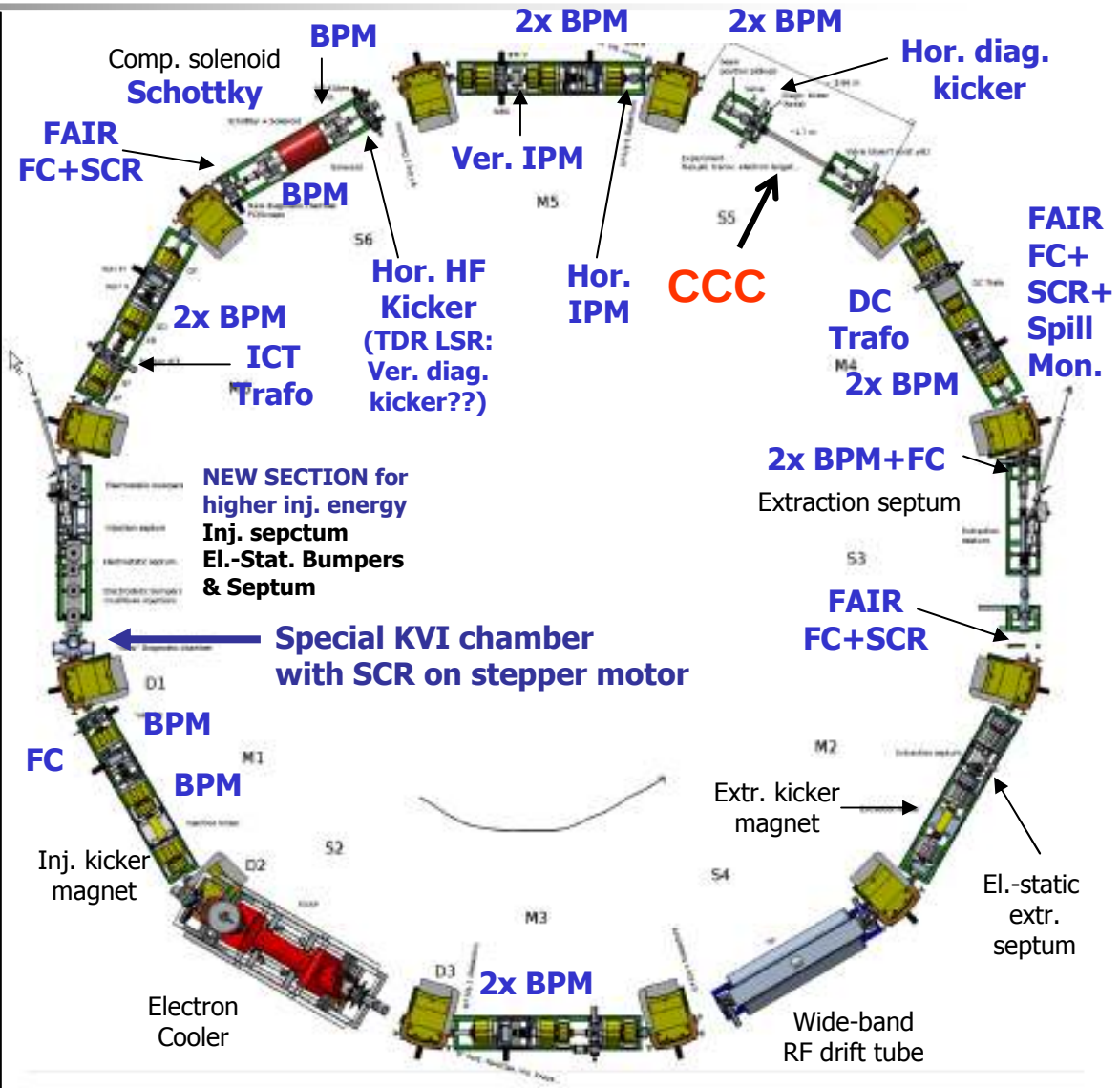
- GSI prototype resolution: **8 nA (1 kHz readout) ⟶ 2×10^9 U^{28+}/s**

CRYRING@ESR
Parameters & New Layout

- **New Layout 4th Oct. 2012**
- New circumference C:
- C(CRYRING) = 54.2 m = C(ESR)/2
- RFQ for ions with q/A > 0.25
- Inj. energy: 40 keV (RFQ off)
  300 keV/u (RFQ on)

4<E<30 MeV/u (ESR)

- Inj. type: multi-turn (source, 50 µs)
  fast (ESR)
- Max. energy: E_{max}= 96 $(q/A)^2$ MeV/u
  - p, pBar: 30.0 MeV (inj. limit)
  - C^{6+} : 24.7 MeV/u
  - U^{92+} : 14.8 MeV/u
- Mag. rigidity: 0.054 – 1.44 Tm
- Revolution frequency: 40 kHz–2.5 MHz
- RF frequency: 40 kHz–1.5 MHz (h=1)
- Bunch structure:
  - **Width: 100 ns – 15 µs**
  - **Duty cycle: 20 - 60%**



CCC: Important Aspects

- **Note: The resolution of the CCC system is noise limited !**

- Our steps towards an improved CCC:
  - Optimization of the high-μ_r toroid / flux concentrator
    → finished (Vodel, Geithner, Neubert)
  - Enhanced magnetic shielding:
    → em-simulations and tests performed (Kurian / Geithner)
    → production of Nb-shield protoype finished (Neubert / Geithner)
  - Improved SQUID+readout electronics
    → market survey and performance tests (Neubert / Geithner / Vodel)
  - re-commissioning of the CCC-prototype for tests (Kurian)
    → finished, beam tests planned for 2014
  - design concept for novel CCC cryostat (all partners)

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