CCC Mini Workshop, CERN, 18th June 2024

Thomas Sieber

CCC Perspective at GSI/FAIR

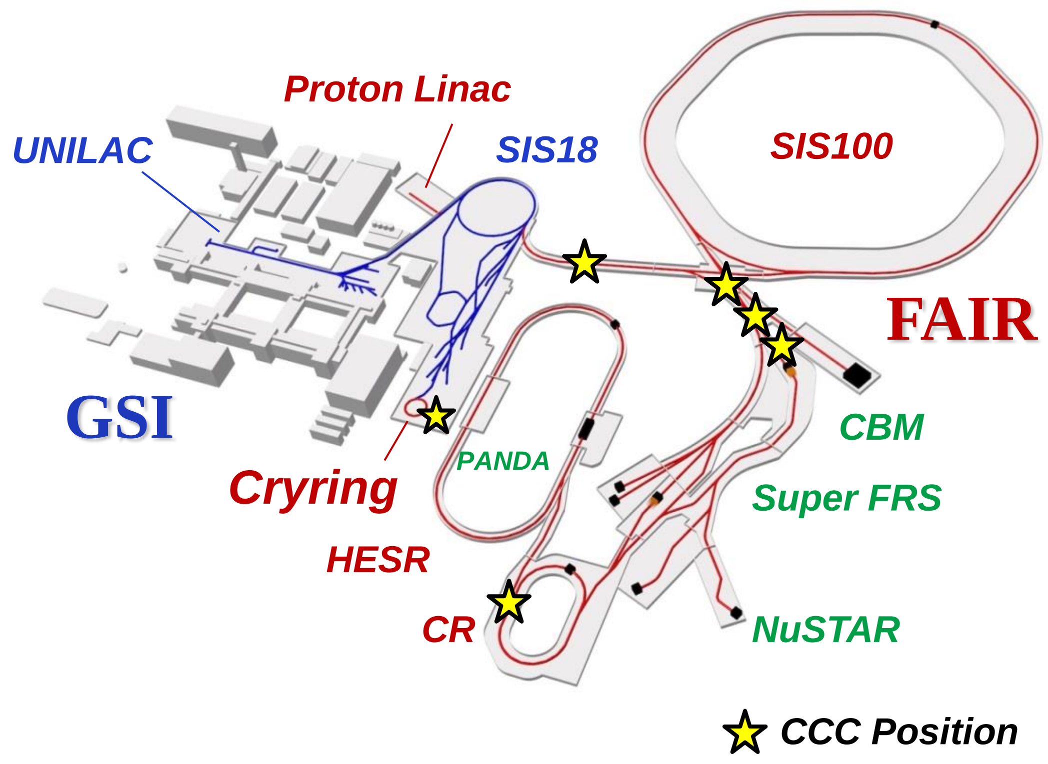
Outline

CCC time schedule for FAIR

Current status

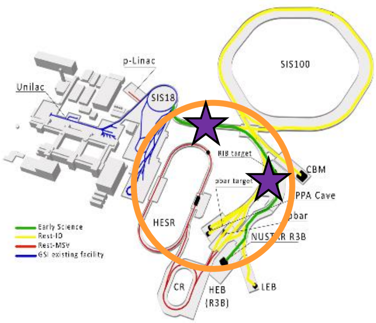
Pending tasks / developments

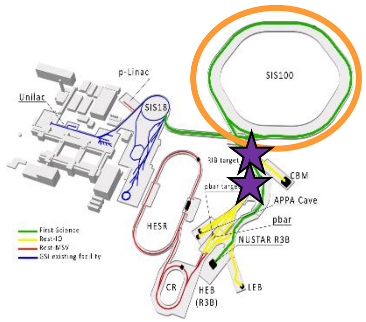
CCC Installation Points at FAIR

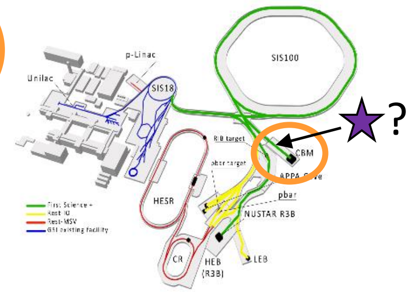


FAIR council decision: 4 x HEBT, (1 x storage ring), 1 x prototype in CRYRING → compact CCC

Updated FAIR Planning

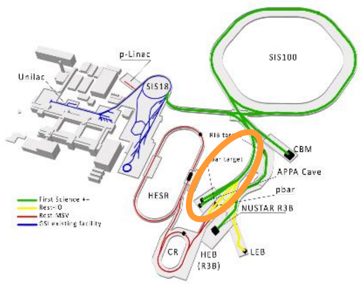


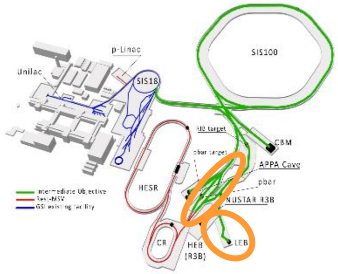


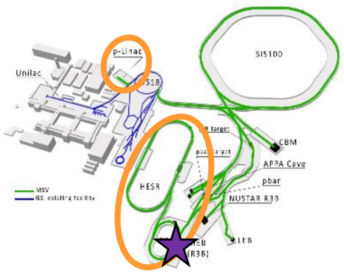


★ *CCC Position*

Early Science	First Science	First Science +
2026	2028	2028







tbd → First Science ++ → Intermediate Objective → Modulare Startversion

Time schedule, next steps, costs

- 25 l/d liquefier 2023/2024 (current purchase: 150 k€) will arrive next month

- Next steps (ES scenario):
  - 1x cryostat with SPS based slow controls (ILK, 250 k€, Q3/2024)
  - 1x liquefier (150 k€, Q3/2024) → TransMit company
  - 1x CCC detector + electronics (50 k€, Q3/2024)

  → 2 full CCC detector systems for ES 2024+2025

- Following steps (FS scenario):
  - order 2 systems together 2026/2027 (~900 k€)

- Separate planning for CRYRING

System costs (2019)

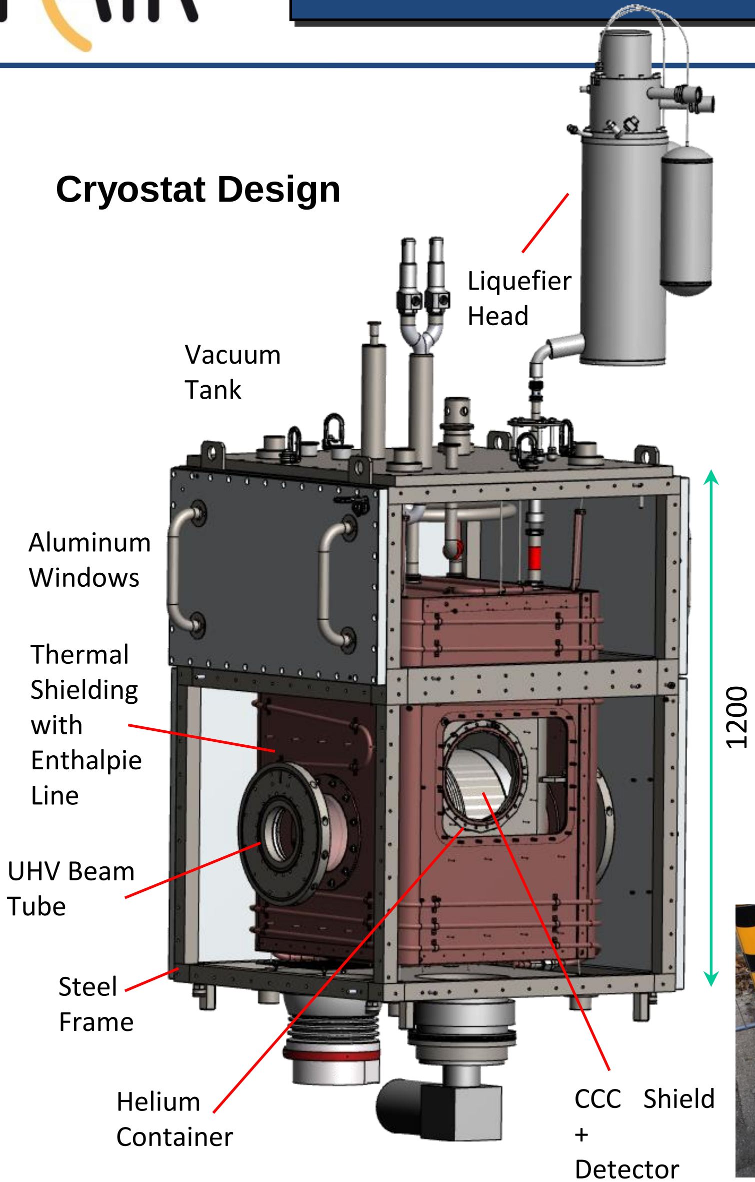
Nb CCC	150 k€
Cryostat	200 k€
Liquefier	80 k€
SQUID + electronics	10 k€
DAQ	10 k€
Support	5 k€
Total	**~ 450 k€**

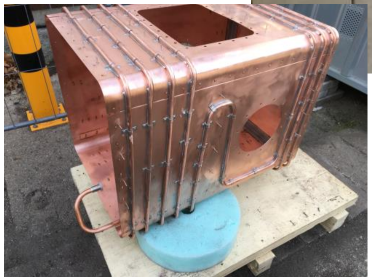
Current Activities

- Thermal shield modified for better He flow, test is ongoing
- 25 l/d liquefier ordered, arrives in July → tests
- Ring FESA class started (based on AD class), currently on hold, due to HEBT
- nonmagnetic He + UHV tube by NTG company, cryo test next week
- CCC-XD and DCCC beam test at SIS18 → evaluation → Lorenzo
- HEBT FESA class to be completed (SQUID controls)
- Filtering of periodic noise
- Implementation of CCC in spill optimzation feedback system (online spill correction)
- Slow controls, hardware specification, interface with UNICOS
- Optimization of DCCC (→ Volker)
- [Optimization of SQUID electronics, FLL stability, radiation hardness – at the moment 0.0 ressources]

Modified Thermal Shield

Cryostat Design





7 m of 14 mm diameter enthalpy tube

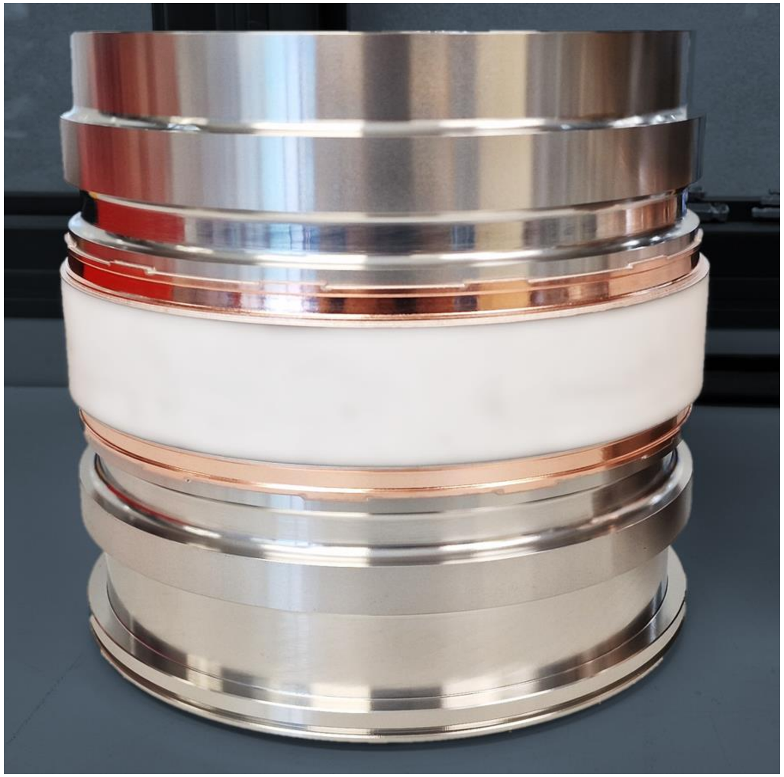
before: 15 m with 10 mm

much better manufacturing

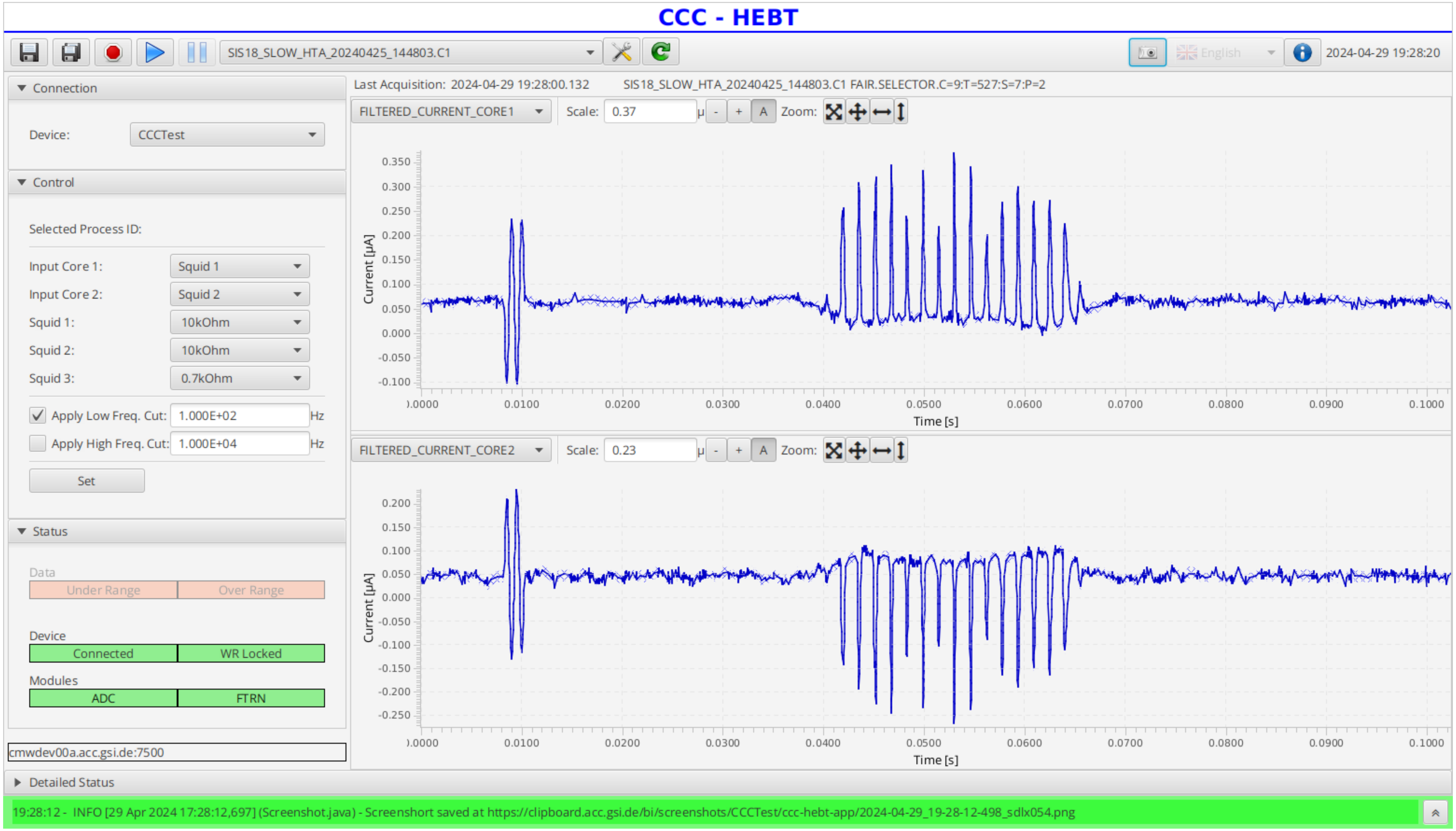
critical point: soldering

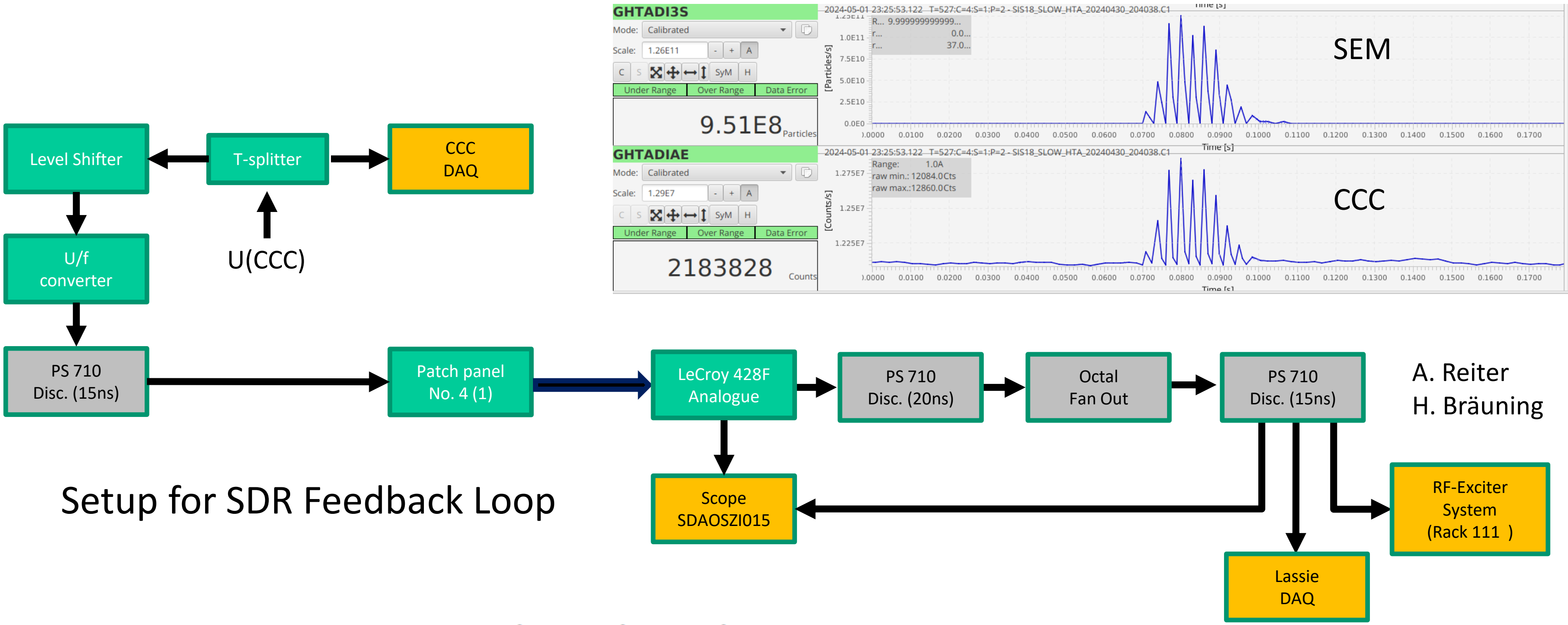
Nonmagnetic Gap

- Motivation: strong influence of inner parts on measurement
- common development GSI / NTG
- connection ceramics – copper – stainless steel
- temperature range 4 K – 600 K
- LN test with leakage testing on 24.06.
- if successfull → ordering of UHV tube



Spill Measurement in FESA

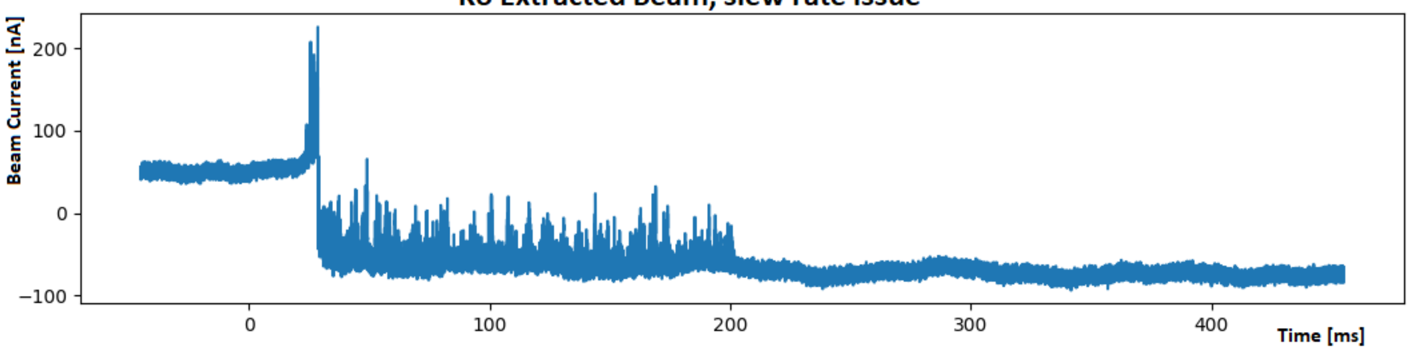




A. Reiter
H. Bräuning

Setup for SDR Feedback Loop

Ko Extracted Beam, slew rate issue



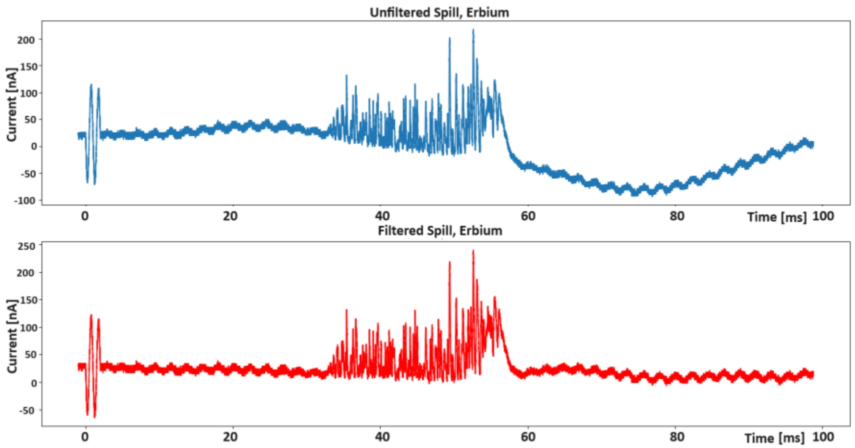
- Flux Jump occurred at both SQUIDS
- Due to spill properties at Ar beam or general problem?
- Once CCC works filtering in FESA will provide good signal

Situation at CRYRING

- CCC-XD (Niobium) successfully operated in storage ring, nA measurement could be demonstrated, support for Cryring experiments provided.
- strong influence of rf-background on V/Φ Curve when moving from lab to machine. Bias Current reduced, operation less stable than in laboratory
- unavoidable jump at injection, slew rate problems partly solved by damping the system
- magnetic ramp up to 30 nA → better magnetic shielding required
- filtering of periodic disturbances (liquefier, 30 nA) required, to be implemented in FESA class

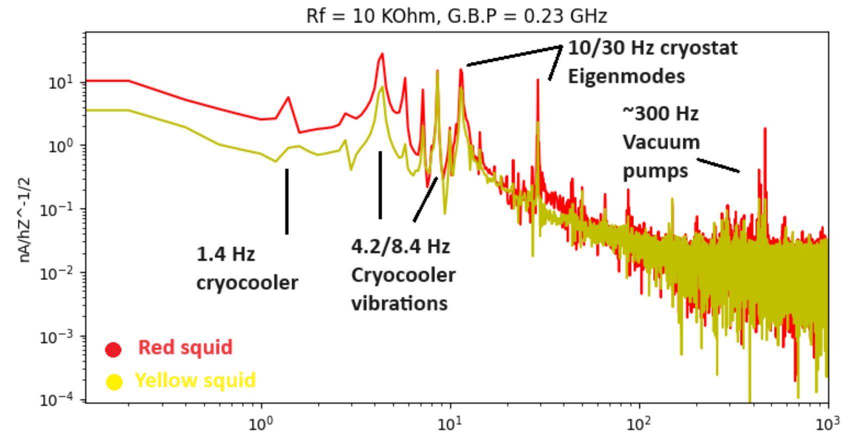
Todos:

- improve slew rate limitations (→ damping + modified eigenmodes by matching trafo)
- improve magnetic shielding (→ shield from axial CCC)
- longer standing time (→ new thermal shield, bigger liquefier)
- less expensive (→ lead shielding)
- better noise behavior, current resolution etc. (→ matching transformer design, Dual Core CCC)
- **space restrictions: compact 0.5 m CCC required – seems realistic with axial shielding**
- **→ project dependent on future modifications / experimental programme of CRYRING**



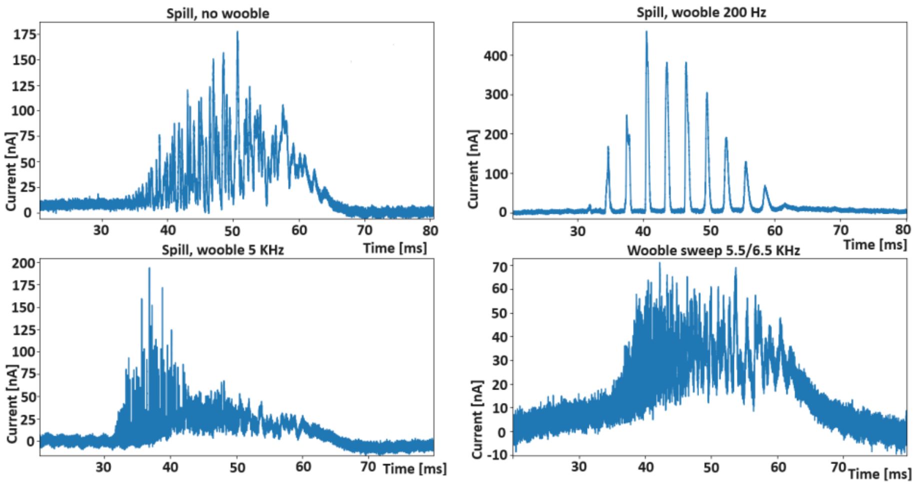
Beam: Er^{57+}, ~5*10^8pps, 400 MeV/u, t_{extr} 20 ms – 1 s

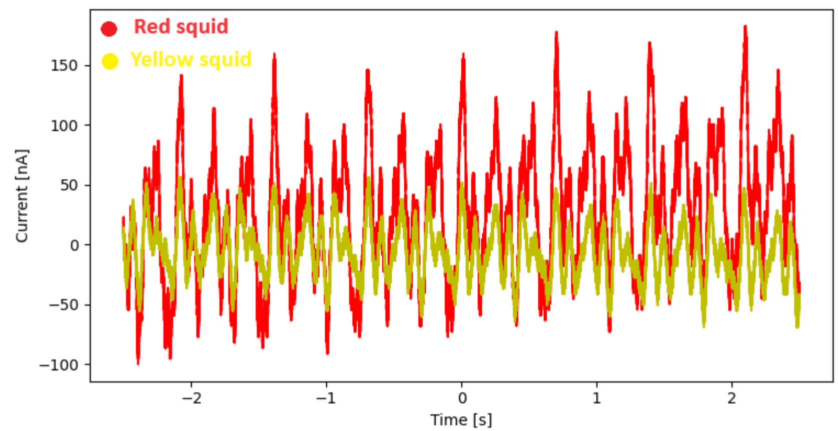
→ FFT from Er beam



Test of tune „wobbling“ with Ar beam

Beam: Ar^{18+}, ~3*10^9pps, 400 MeV/u, t_{extr} 50 ms – 2 s





Summary and Outlook

- CCC focus at FAIR changed from storage rings to transport sections → FAIR Early Science … FS, FS+ scenarios
- CCC-XD successfully operated in storage rings and transport lines, nA and spill measurement could be demonstrated, system fulfils FAIR requirements (almost)
- Beamtime in Dec. 2023 showed XD setup capability for online spill analysis
- Axial CCC type provides excellent magnetic shielding, but is extremely noise sensitive
- Dual core CCC combines advantages of both systems and will be the choice for FAIR
- DCCC successfully tested with beam, operation as detector for feedback system did not work out (so far)

Current activities:

- New thermal shield test (June 2024)
- Liquefier test (July 2024) → collaboration with TransMIT Gießen?
- FESA class development ongoing, including filtering, online data processing and SQUID controls (and input for spill optimization)
- **finalization of DCCC design**
- **collaboration with FH Jena for advanced signal processing**
- purchasing of cryostat for 2nd CCC end of 2024

….. slow controls (Simatic) for cryostat + optimization of commercial electronics → whenever ressources available

- FESA class for storage rings
- FESA class for HEBT (→ merge)
- DCCC optimization and tests at GSI / CERN → FAIR + SPS
- Slow controls for cryogenic/vacuum system with UNICOS
- Liquefier development (beyond Cryomech)
- Dry cryostat (FAIR dimensions + time schedule?)
- Improved filtering of periodic disturbances
- CCC as detector for spill optimization feedback system
- Nonmagnetic ceramic gaps
- Optimization of SQUID electronics (FLL stability, radiation)

CCC Collaboration 2015-2024

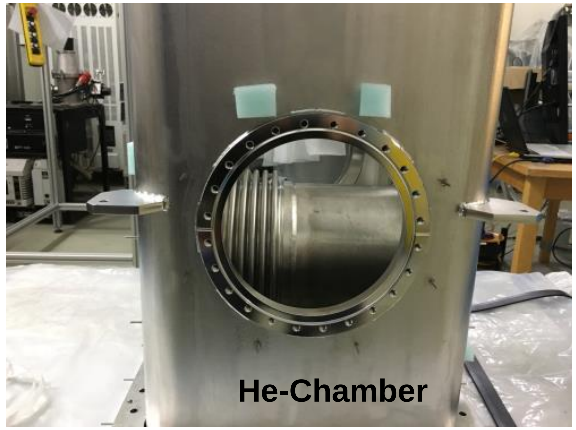
- **HI Jena**: Laboratory tests, shielding and SQUID circuit design, SPICE models
  → signal processing
- **FSU Jena**: Laboratories (cold lab, EMV shielded), administration (BMBF appl.)
- **IPHT Jena**: SQUID development and production, SQUID electronics, magn. shield
- **TEMF**: Simulations, shielding factors, electrical and mechanical eigenmodes and stability
- **CERN**: Cryostat development, FESA, beamline tests (ring) (1 PhD thesis)
- **GSI**: Cryostat, beam test (HEBT/ring), detector development (2 PhD thesis), FESA, electronics optimization

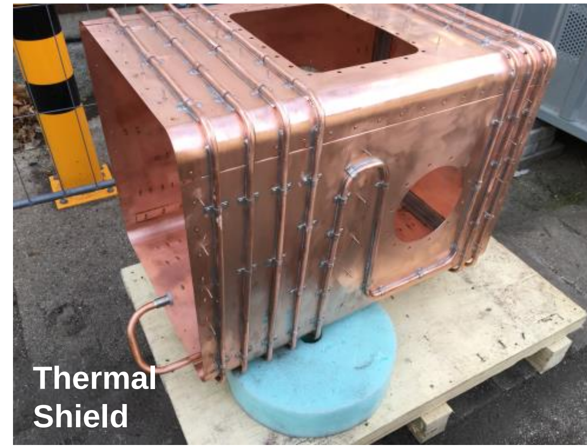
… AND

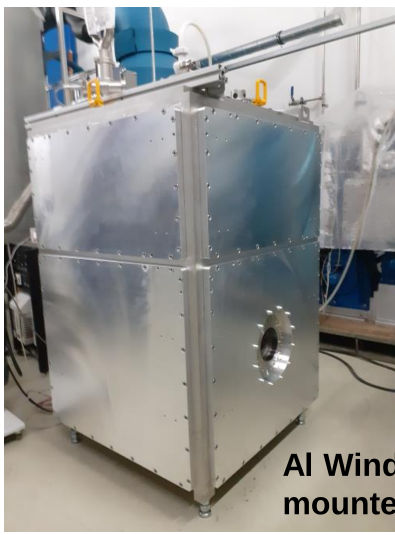
- **Magnicon**: SQUID electronics, expertise, radiation test; **FH Jena:** Signal processing

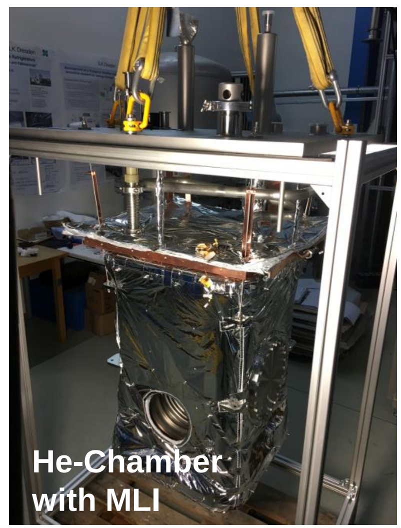
Thank you for your attention !

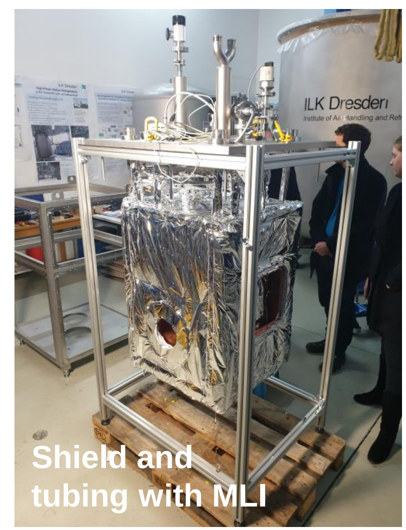
Production of the CRYRING Cryostat

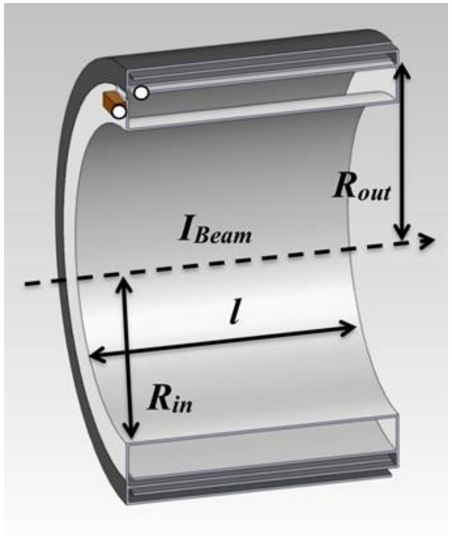












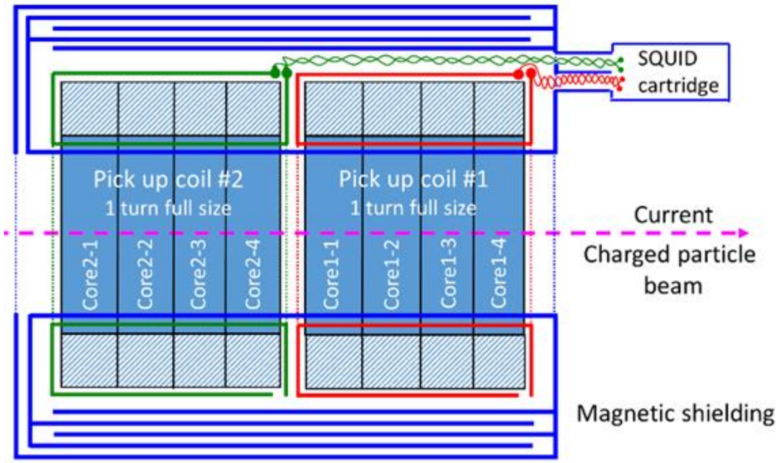
Axial/Coreless-CCC

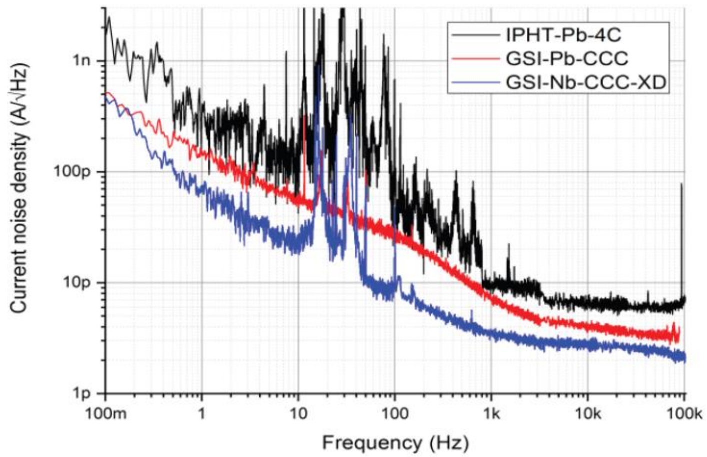
Pros

- magn. shielding (-150 dB instead of -75 dB)
- lead / costs
- easy manufacturing
- [two stage SQUID]

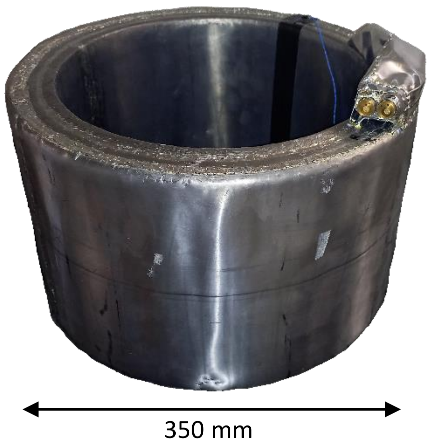
Cons

- weak coupling (beam)
- excessive noise





Noise figures for classical and axial CCC



Dual-CCC

Pros

- magn. shielding (150 dB instead of 75 dB)
- lead / costs
- easy manufacturing
- [two stage SQUID]
- strong coupling
- low noise background
- redundancy