



The TwinEBIS test bench

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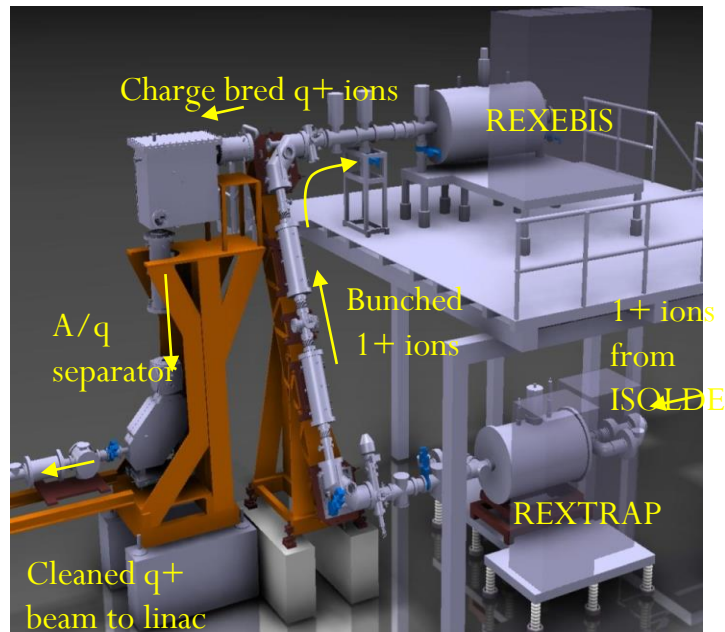
CERN BE-ABP-HSL / Ernst-Moritz-Arndt-Universität Greifswald

Robert Mertzig, Andrey Shornikov, Fredrik Wenander

CERN BE-ABP-HSL

- The test bench setup
- Record electron current
- Simulations = Measurements
- Ion extraction modulation
- New e^- gun design
- Extraction beam line

REX low energy



- Was bought by the Knut and Alice Wallenberg foundation (as REXEBIS) and given to ISOLDE
- Located in south hall build. 150

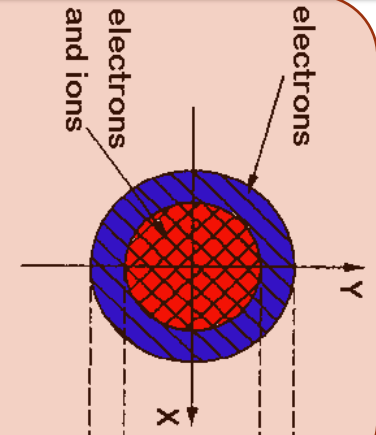
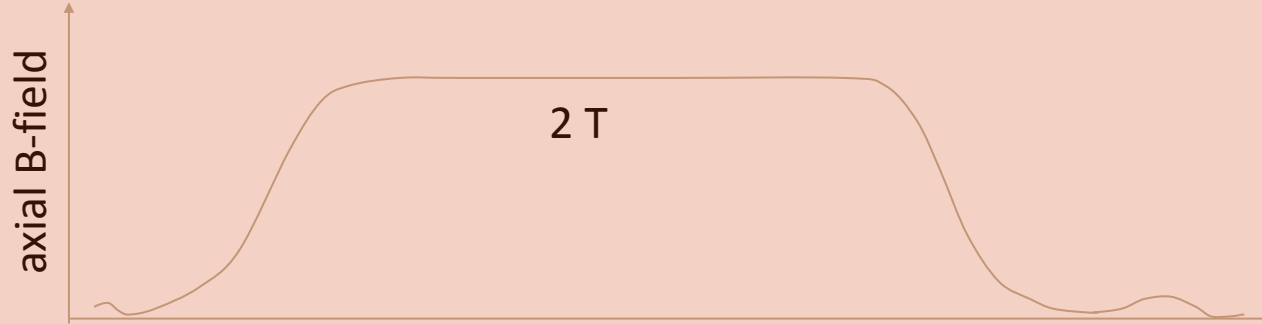
TwinEBIS purposes

1. Spare for **REXEBIS** (electron gun, drift-tube structure, collector and superconducting solenoid)
2. Test-bench for **increased electron beam** current and density.
3. Test-bench for **alternative cathode materials** and providers, as well as for cathode **poisoning** investigations.
4. Test-bench for **fast and slow ion-extraction** scenarios.
5. As **training** facility for students.

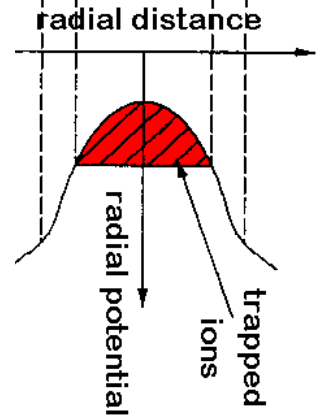
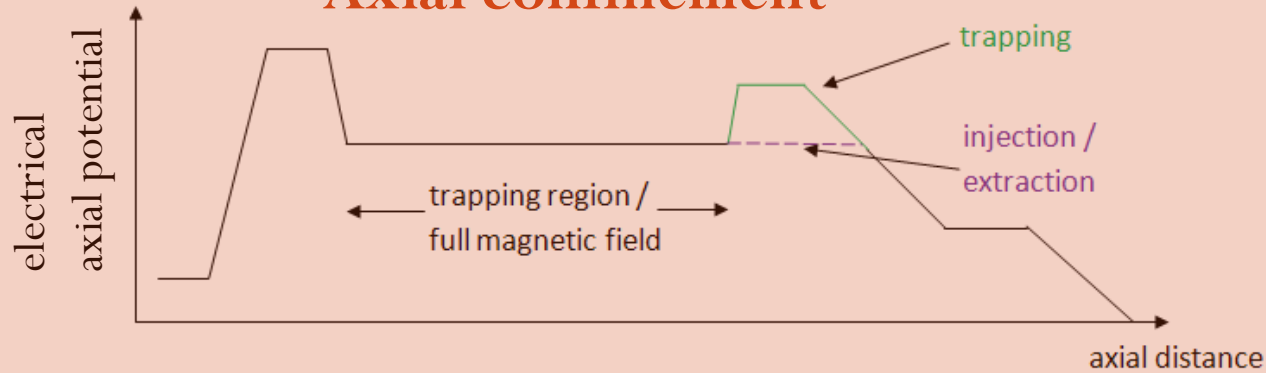


Principle of an EBIS

Radial confinement



Axial confinement

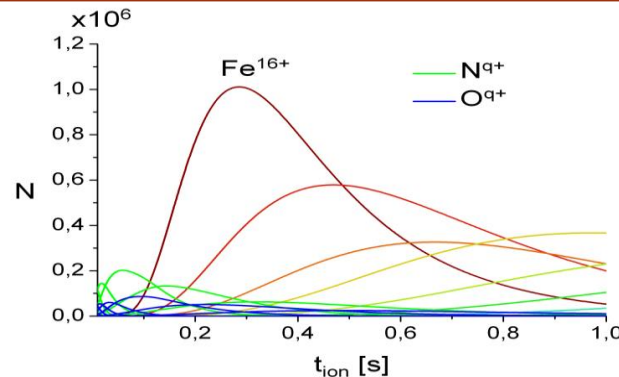


$$q \propto j_e \cdot \tau$$

q = final ion charge

j_e = electron current density

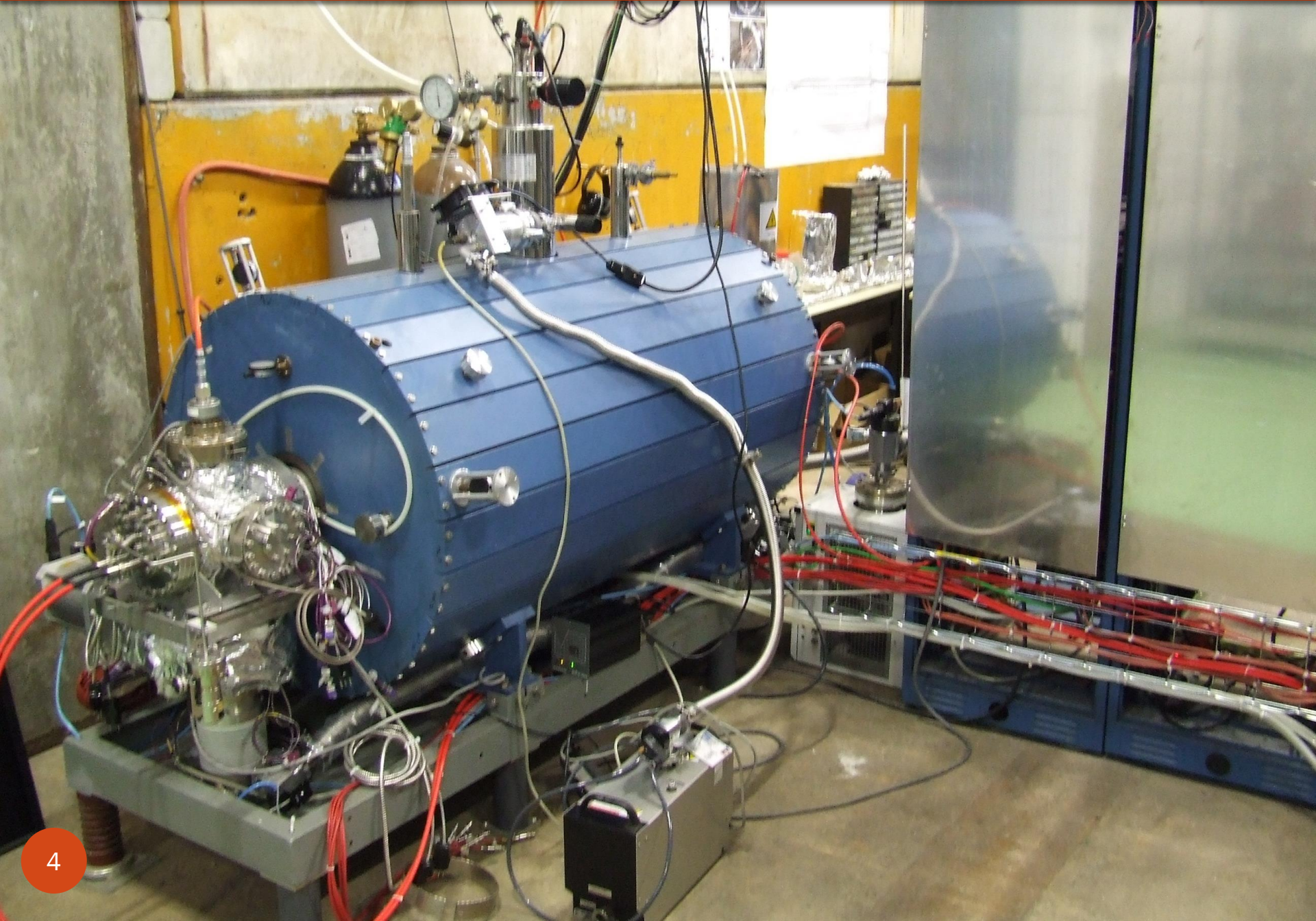
τ = confinement time



Charge breeding time and space charge limit are a function of e^- density

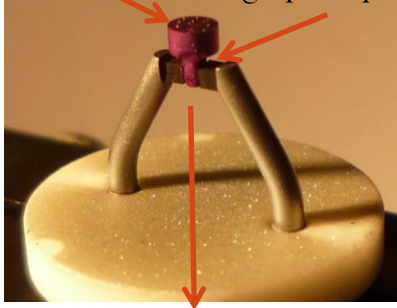
Max. charge state depends on e^- energy

TwinEBIS setup

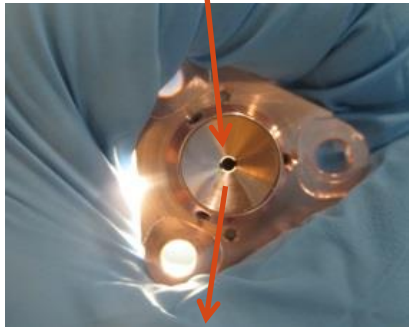


The crystal issue (LaB_6 $\langle 100 \rangle$ vs $\langle 310 \rangle$)

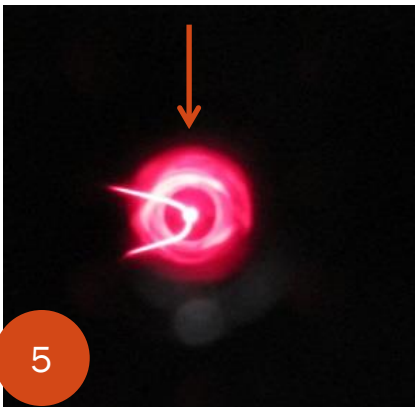
crystal
graphite pad



Installation into
Wehnelt electrode



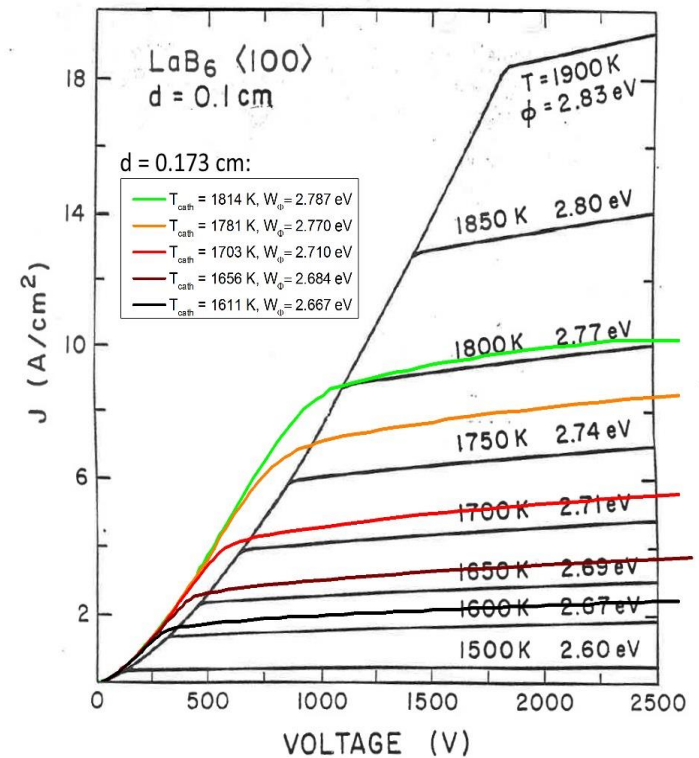
Heating



Challenge:

It was impossible to reach the specified values for extracted e- current
AND
have the specified cathode life time

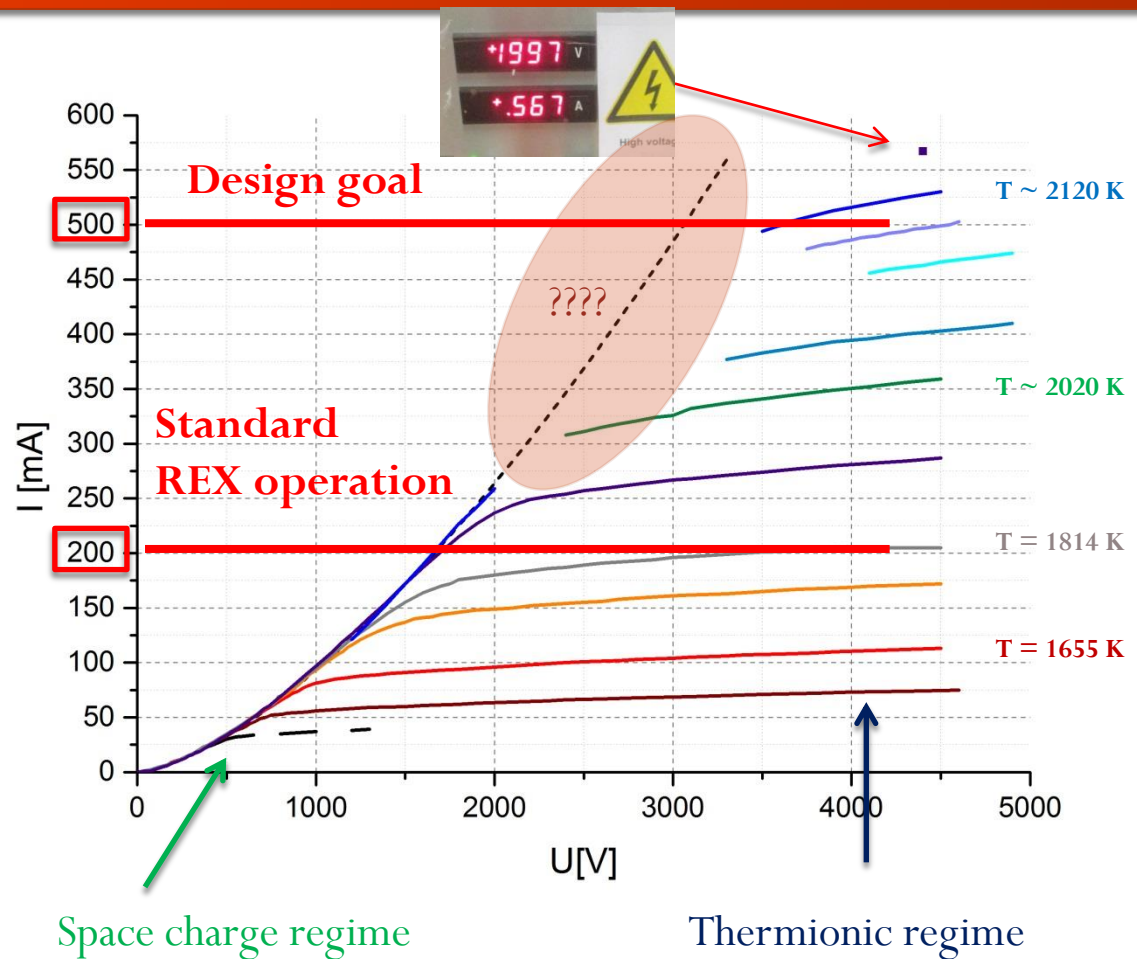
- ✓ Cathode temperature measurement calibration (heating power vs temperature) from manufacturer confirmed
- ✓ “Plateau” defines the work function for a given temperature
- ➔ Our crystal follow work function of $\langle 100 \rangle$ rather than $\langle 310 \rangle$
- ➔ **Still: shorter life time OR lower current**



Pushing the limit of the e-beam current

- REXEBIS was designed for 500mA using a 2D space-charge limited simulation
- Operation current at REX is limited to ~ 200 mA:
 - Cathode life time
 - Stability
- Recommended maximal operation 1900 K (expected lifetime for 500mA only a couple of weeks)

→ Why did we manage at TwinEBIS: Because it is a test bench. Since 1999 REXEBIS is operated with the aim of stability, thus not a lot of development happened!



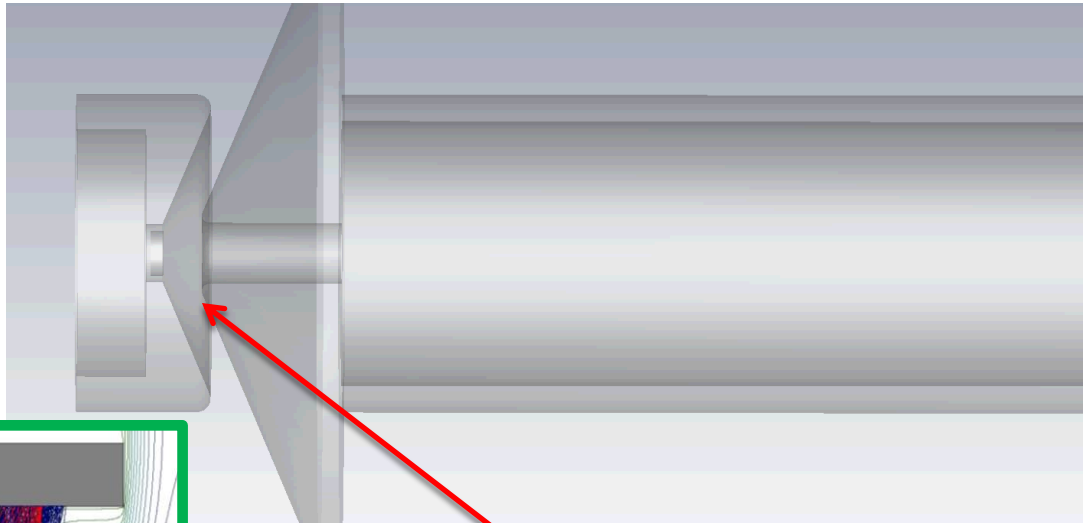
Challenges:

- High current = high temperature → cathode aging
- Explanation of "broken diagram" → Simulations

Understanding the setup: Simulations vs Measurements

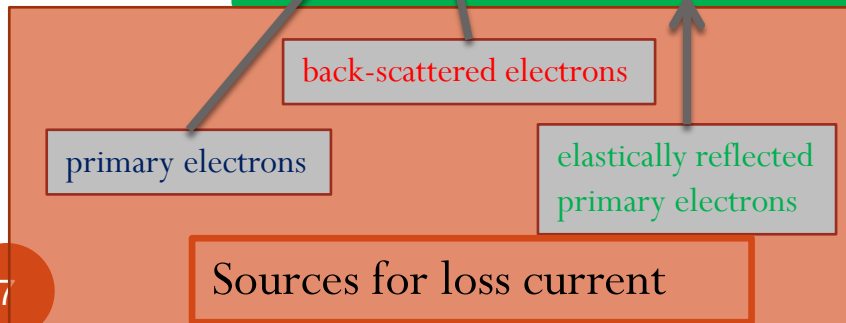
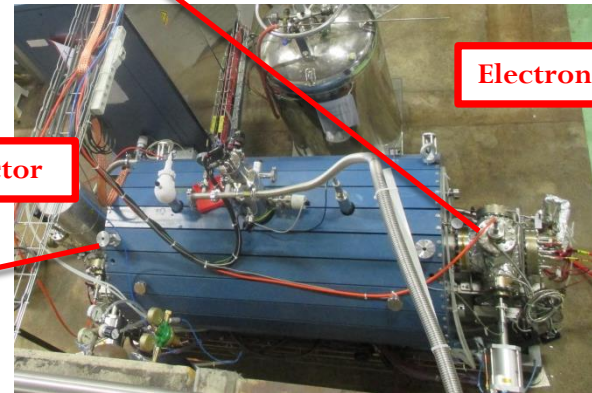
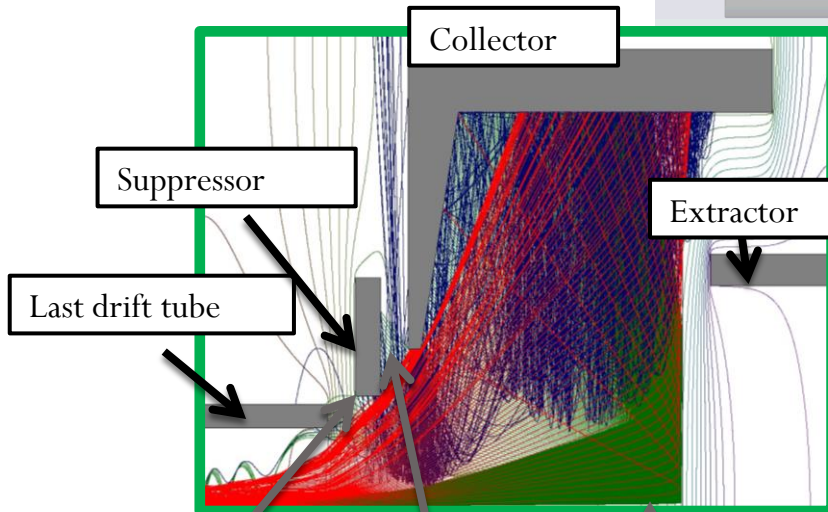
Motivation:

- Loss currents occurring at certain EBIS-operation settings have to be understood



Tools:

- Tricomp: Field precision for first 2D investigation
- Microwave Studio CST for 3D fine tuning (tilt angles, non concentric shifts)



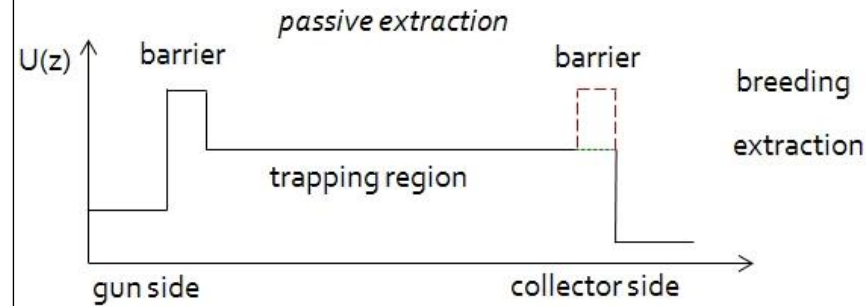
Results:

- ✓ Understanding emission properties of the gun
- ✓ Suggestions for improving the geometry

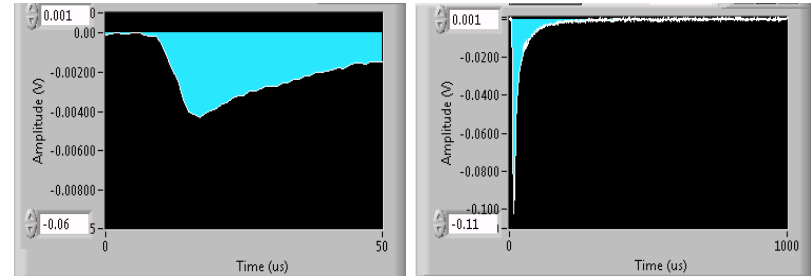
See the poster of Robert Mertzig!

Pulse shape modulation

New control hardware (PXI real time) and program (LabVIEW) by L. Hedlund (technical student):
Drift tubes and barriers can be addressed separately with different $U(t)$.



Signal intensity / a.u.

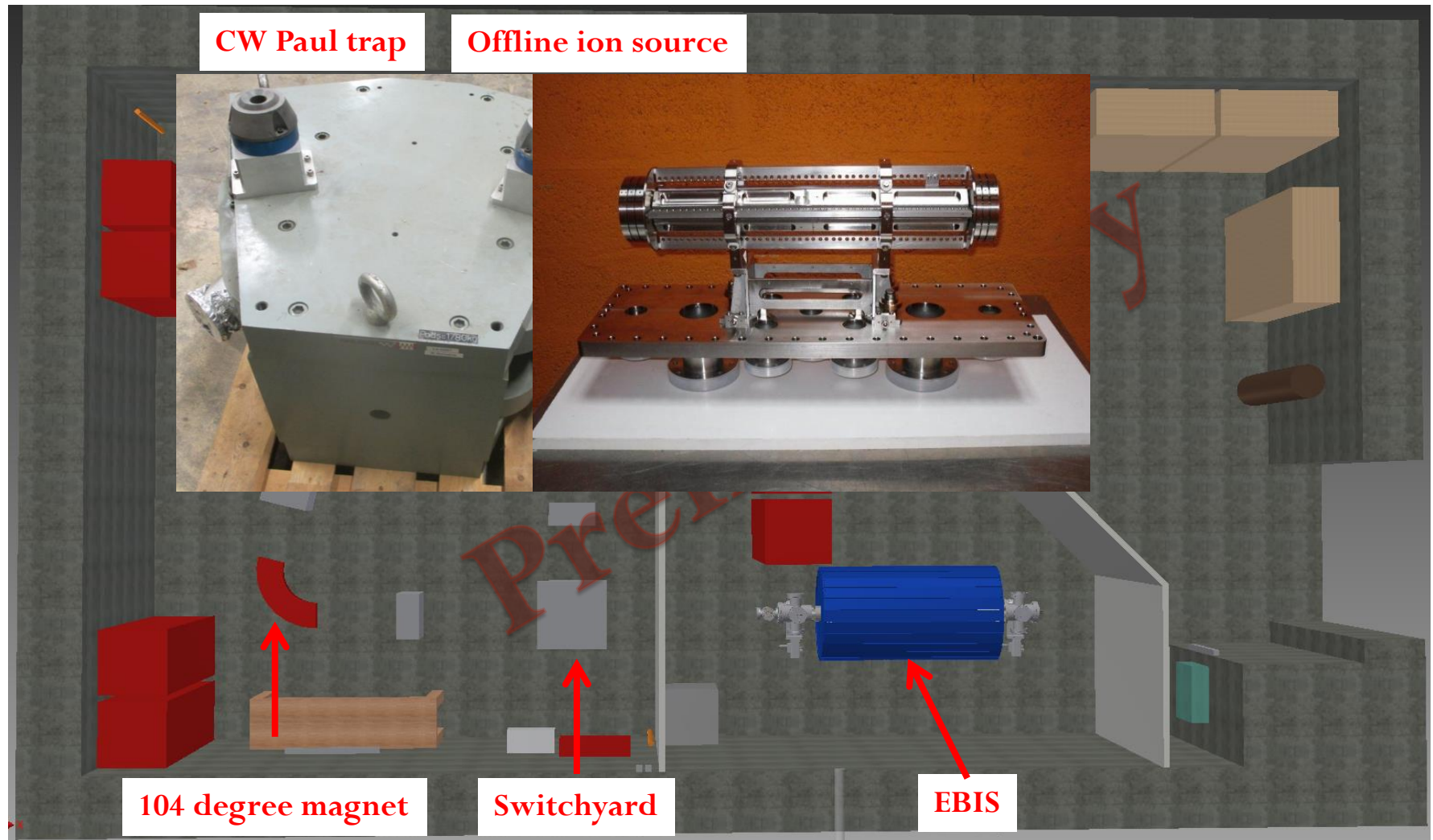


FWHM
 $\sim 50\mu\text{s}$

Barrier control to be implemented in new REXEBIS controls 2015

→ customized ion distribution as function of time

Extraction time/ us.



Finalizing Phase1 after only a few months

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Move of the test bench → Increased available surface from 24m^2 to $\sim 60\text{m}^2$

TwinEBIS: new gun design

- we learnt a lot during our systematic investigations at TwinEBIS
 - the considerations and test for HEC² (see talk of **Andrey Shornikov**) gave us some design ideas
- We should try to build a new e⁻-gun at ISOLDE!



It will be compatible with TwinEBIS and REXEBIS electrode structure
It is also in the regime of an ion source for the 2nd generation IBT facilities

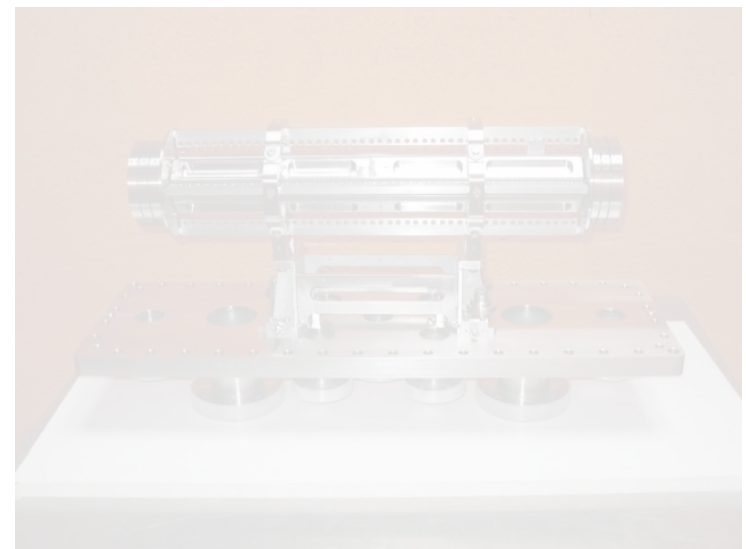
PENDING RESOURCES

TwinEBIS: extraction beam line

- Requires the EBIS to be on High Voltage (30kV)
- 104 degree separator magnet to distinguish charge states
- Required for electron density measurements
- and for study of molecular break up reaction (efficiency vs breeding time), includes the implementation of an offline source
- Possibility: Test of cw Paul trap for EM



Figure: Dipl. thesis R. Mertzig



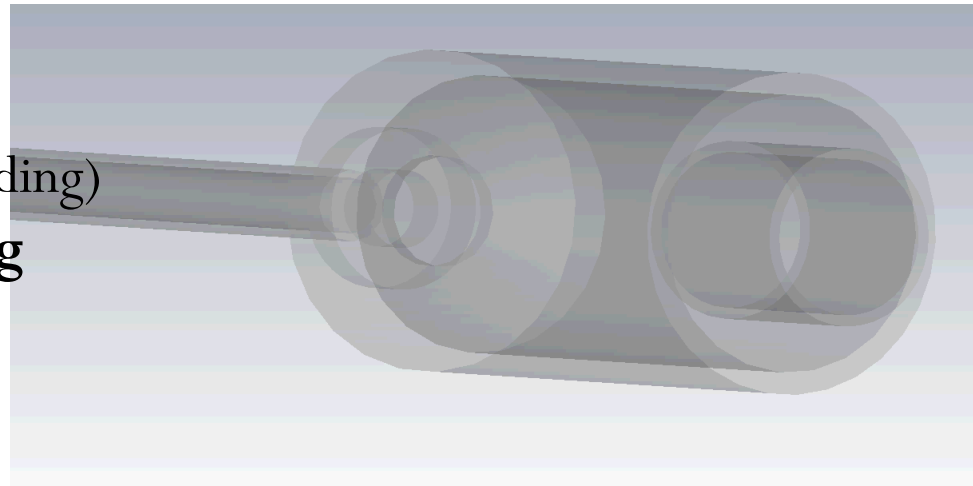
Picture from the web

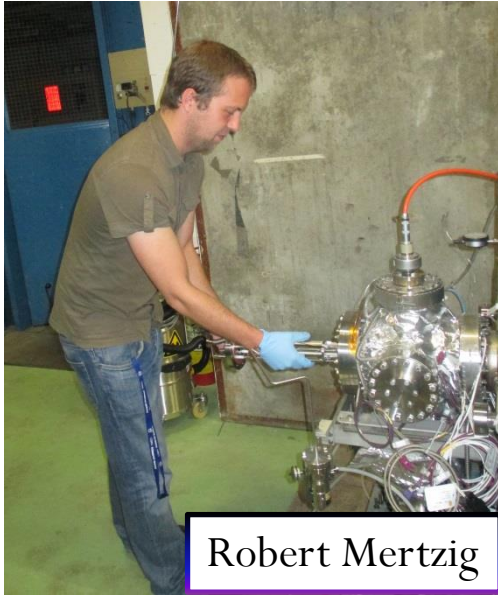
Good first year:

- ✓ Test bench **commissioned** (end of Phase 1)
- ✓ First high electron current results (**>500mA**) as compared to 200mA standard REXEBIS operation
- ✓ Comparison of **measurements to simulations** (poster **R. Mertzig**).
- ✓ Modulated the **extraction pulses**
- ✓ Moved the setup to a new **more spacious area**

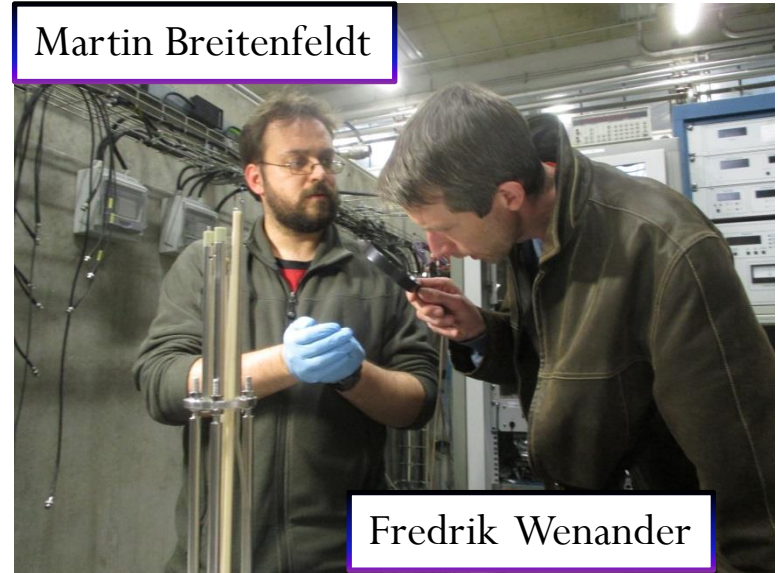
More to come:

- Start designing a **new e⁻-gun**
- Extraction beam line (pending the funding)
- Of course, **continue characterizing** the current e⁻ beam by measurements and simulations





Robert Mertzig



Martin Breitenfeldt

Fredrik Wenander



Andrey Shornikov



Lars Hedlund

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