MLLTRAP @ DESIR

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concept of MLLTRAP:

- measurement with Penning trap of highly-charged ions
- simultaneous relative measurement of individual ions in two precision traps
- sympathetic cooling of highly charged ions with laser-cooled Mg^+ ions inside Penning trap and Paul trap
- replacement of "classical" preparatory trap inside Penning set-up by A- and isobar-selecting devices outside Penning trap
- charge breeding with (commercial ?) EBIS

final goal: $\Delta m/m \approx 10^{-10}$

Perspectives for MLLTRAP facility

initial goals:

high-precision mass measurements of heavy, n-rich fusion products at radioactive beams from MAFF

development/commissioning phase:

coupling to Munich Tandem accelerator

- efficient gas stopping cell for reaction products available
- frequent access to beam time

physics perspectives:

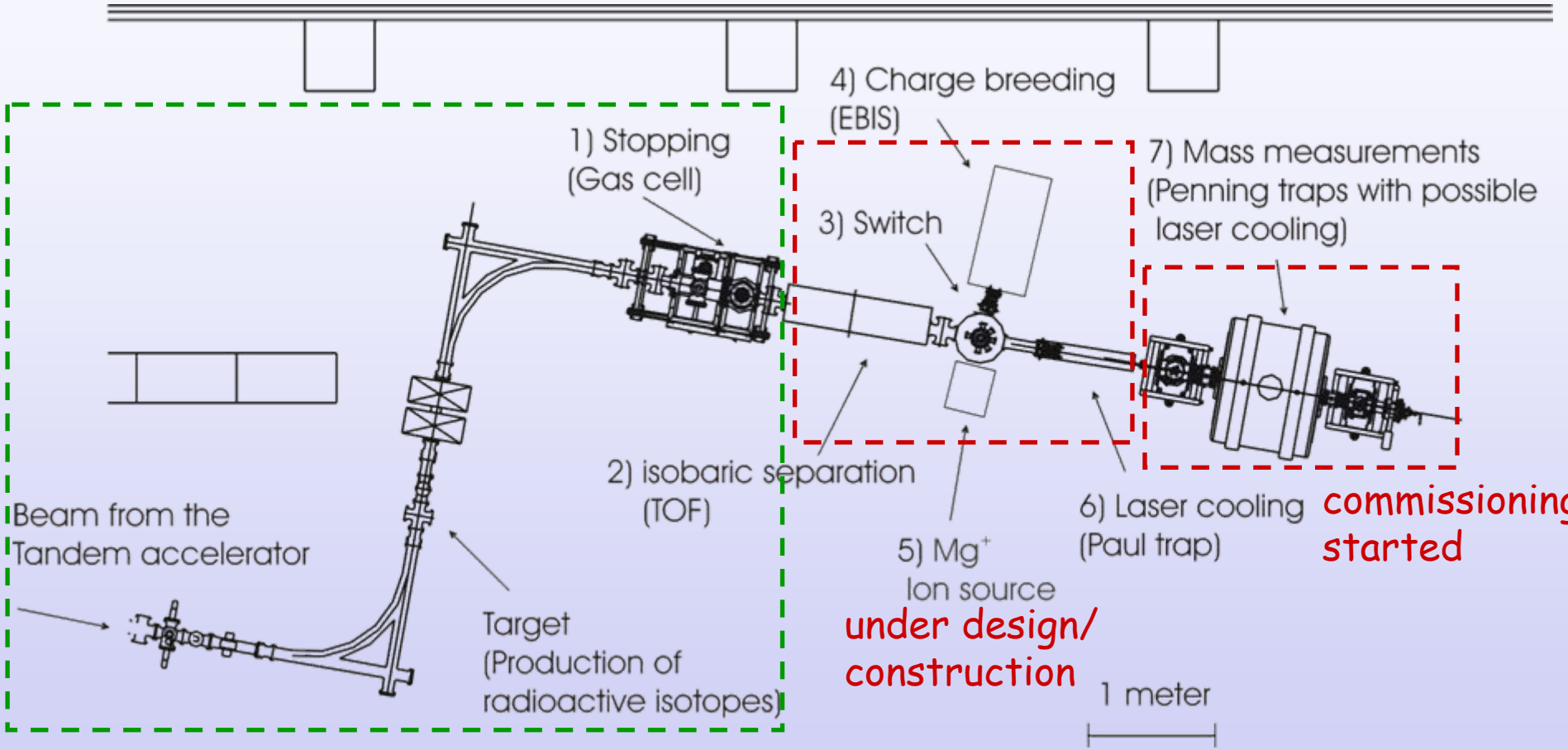
- radioactive ions at DESIR

time range:

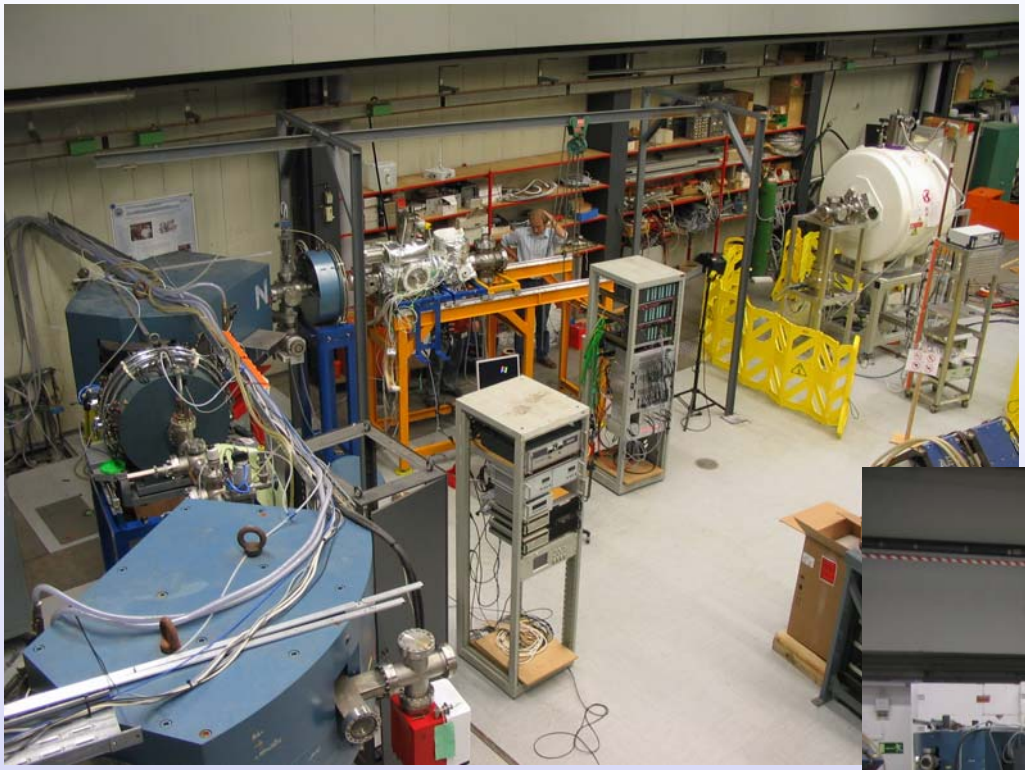
- construction and commissioning phase at MLL in Garching: ca. 3 years
- physics at MLL Tandem: ca. 1 - 2 years

-> integration into DESIR

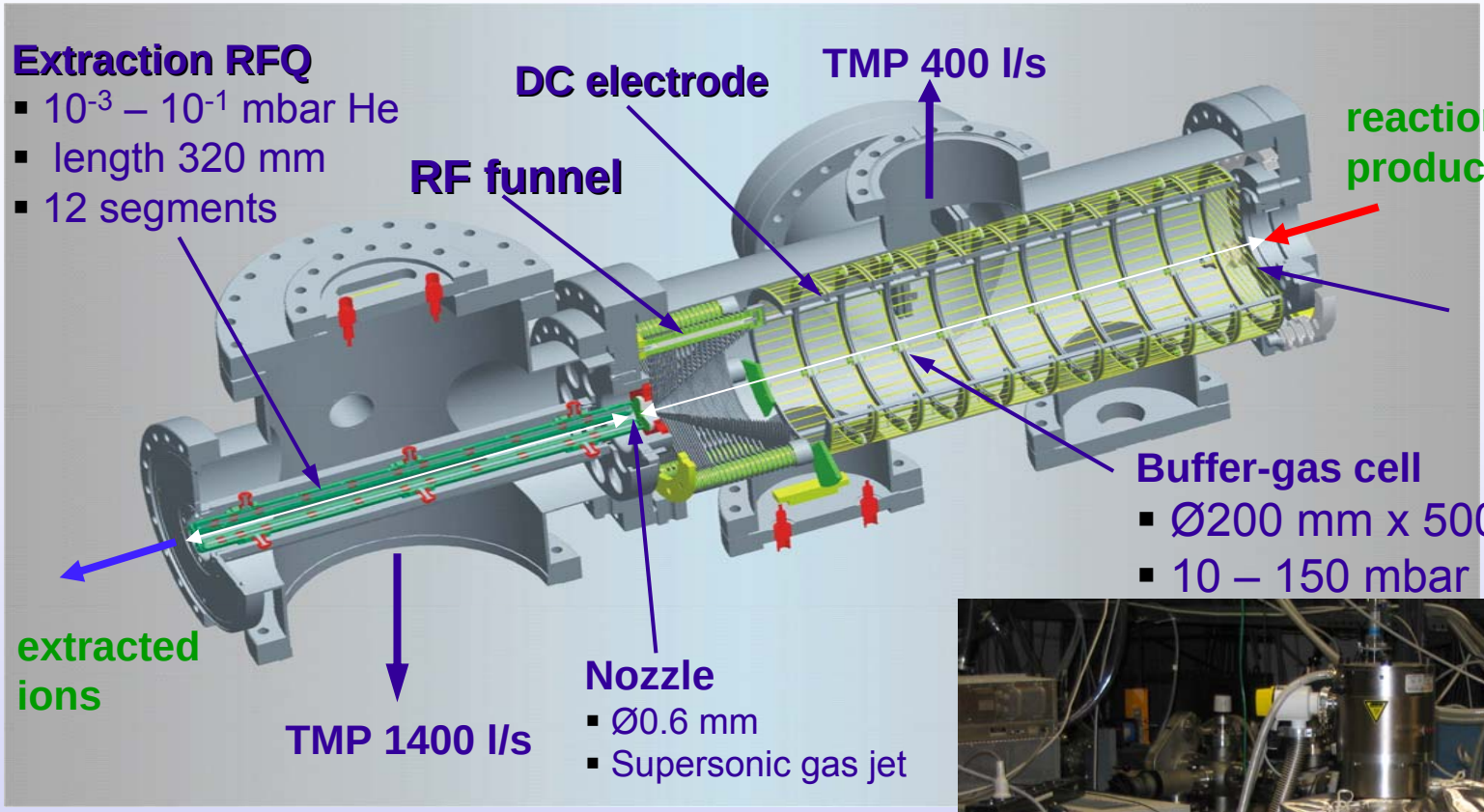
Layout of the present MLLTRAP area

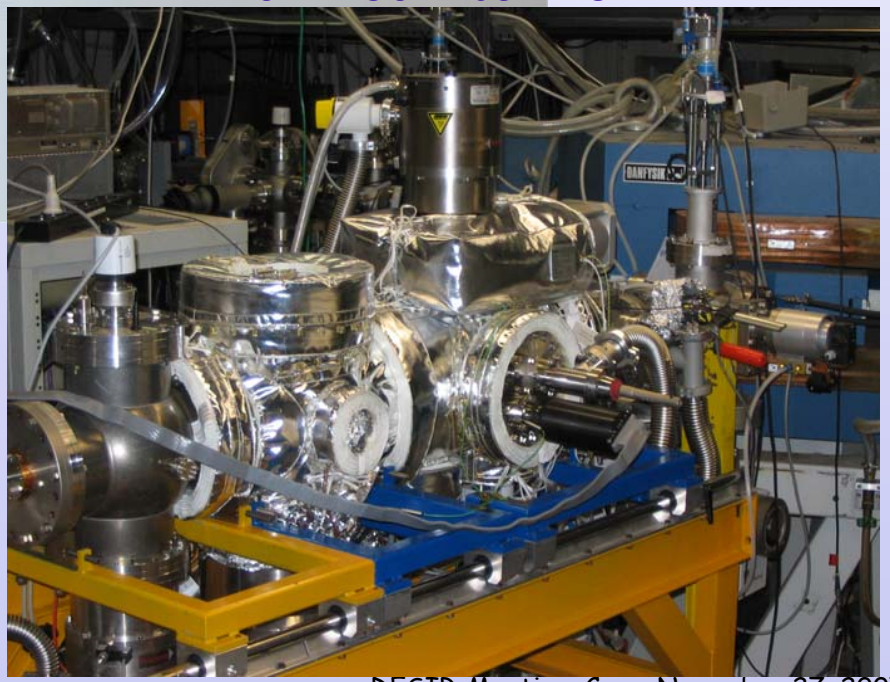


Present View of MLLTRAP



Buffer Gas Cell: MLL IonCatcher





maximum absolute efficiency (stopping + extraction): 16%

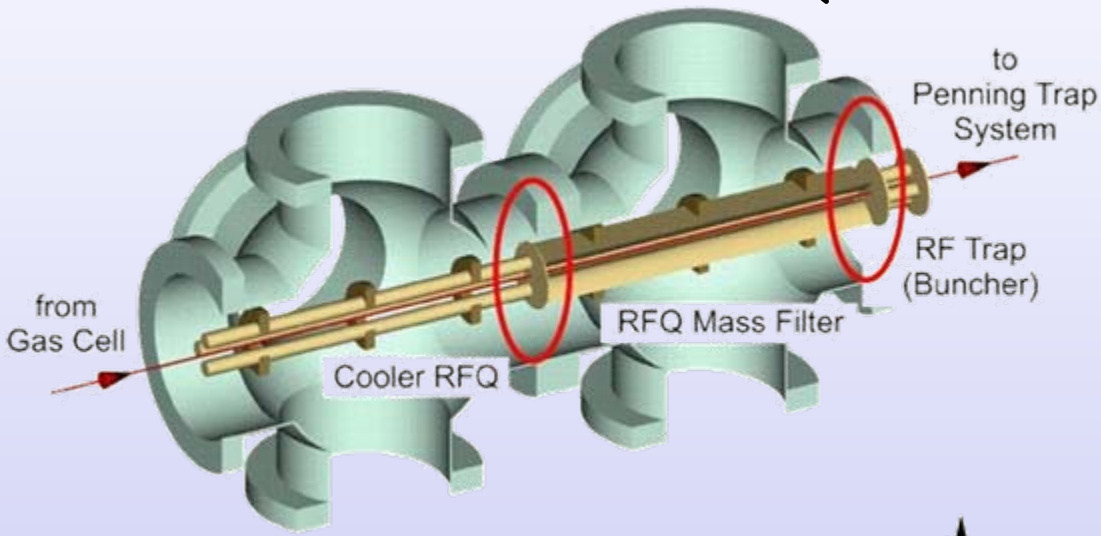
J.B. Neumayr, PT et al.,
"Performance of the MLL IonCatcher",
Rev. Sci. Instr. **77** (2006) 065109

Isobaric Purification outside the Penning Traps

highly-charged ions exclude isobaric purification in first Penning trap
→ external A- and Z-selection required

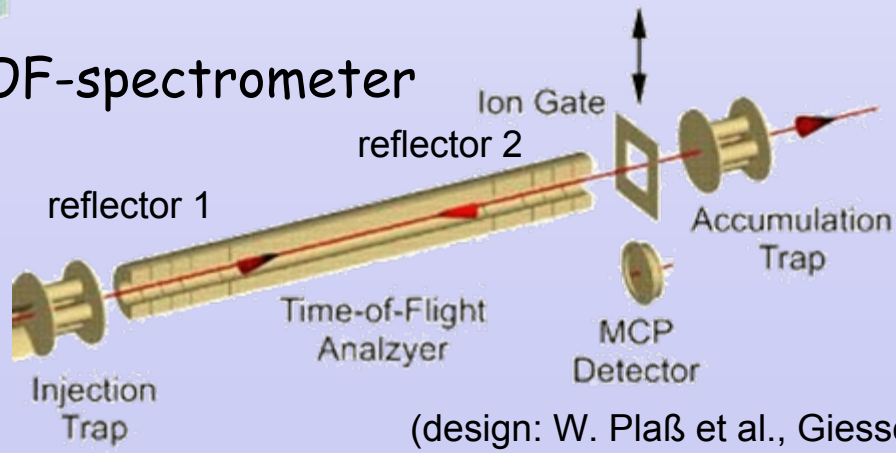
1. A selection: RFQ mass filter behind extraction-RFQ

- differential pumping
- setup in progress



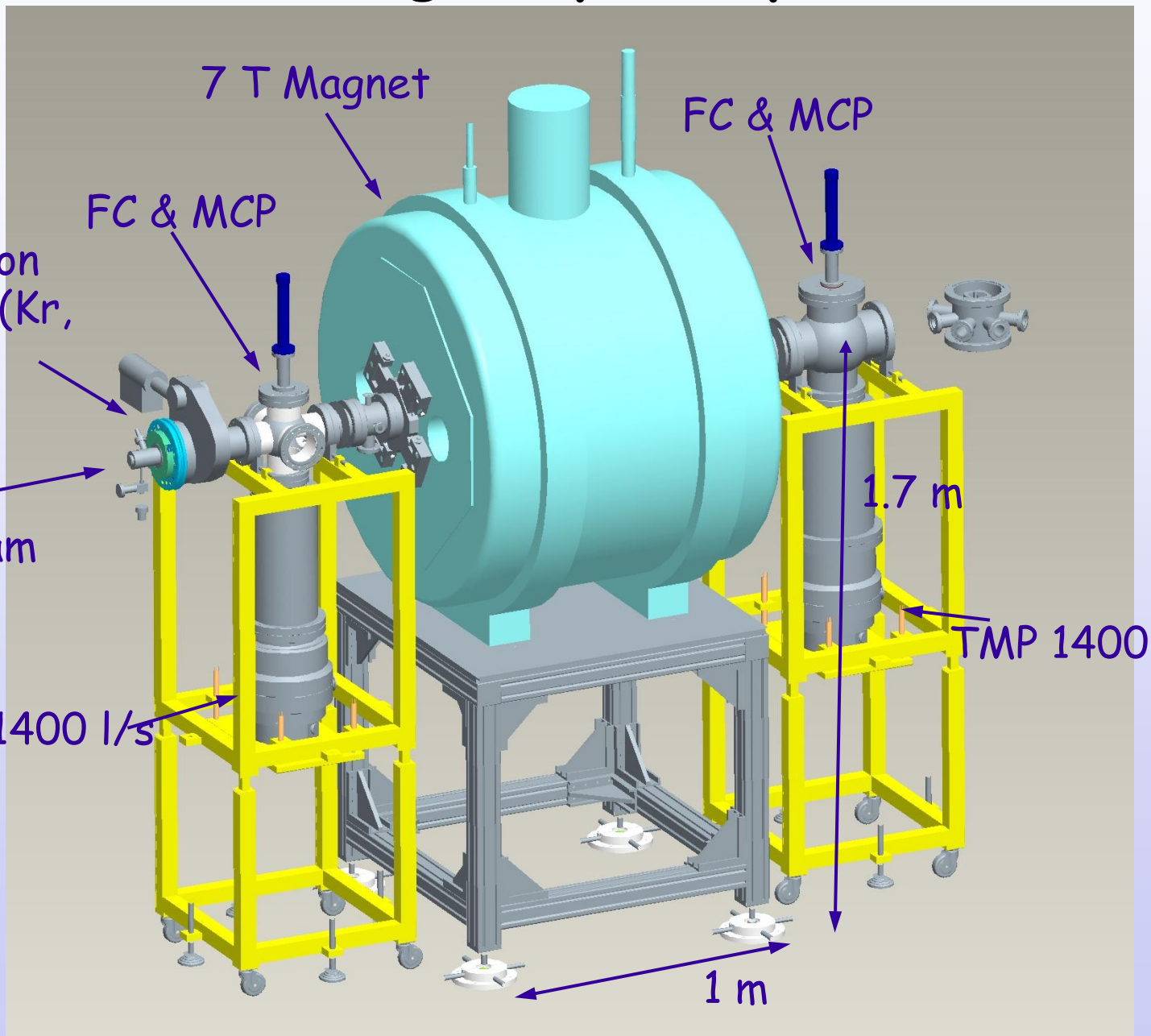
2. Z selection: Multi-reflection TOF-spectrometer

- analyzer with 2 electrostatic reflectors
- Z selection: Bradbury-Nielsen ion gate
- length: ca. 0.5 m, short TOF: ~ 1 ms
- ca. 100 turns: $\Delta m/m \sim 10^5$ achievable
- efficiency ca. 50%
- setup in collaboration with Giessen team

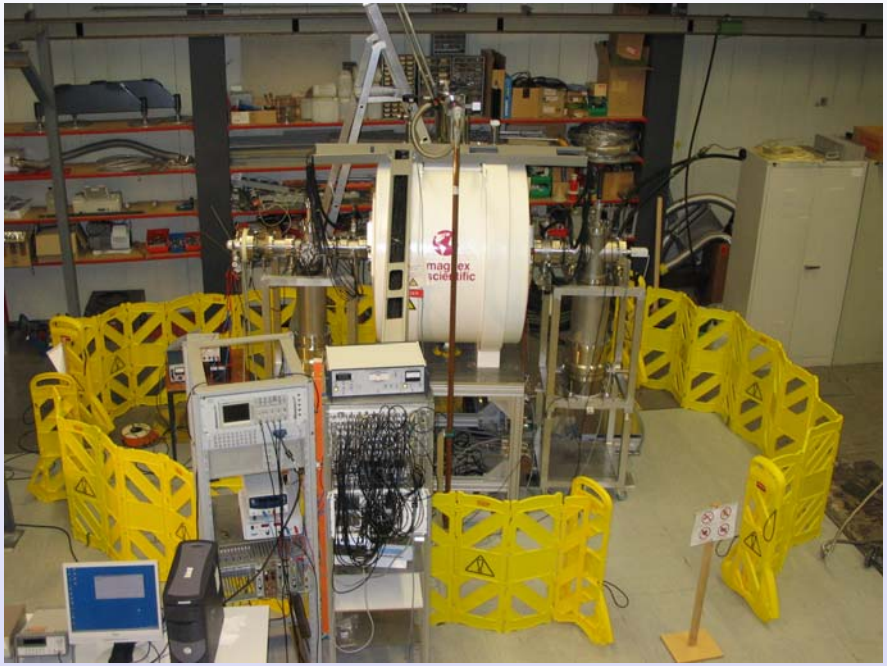


(design: W. Plaß et al., Giessen)

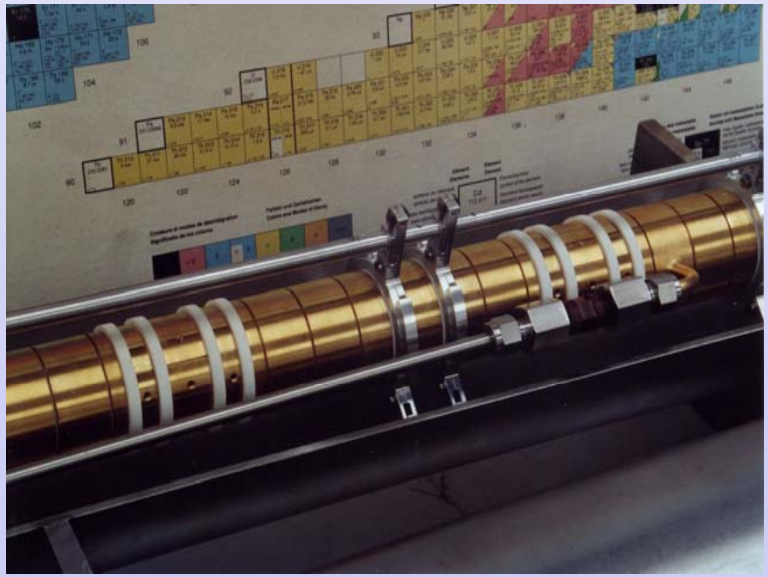
Penning Trap Setup



Status of Penning trap system



- 7.0 T, superconducting magnet from Magnex Scientific Ltd (UK): identical to magnet of SHIPTRAP, JYFLTRAP
- (warm) bore diameter: 155 mm
- 2 homogeneous centers, shimmed both to 0.3ppm



- trap electrodes mounted
- (magnetic) alignment performed
- commissioning started

Highly charged ions

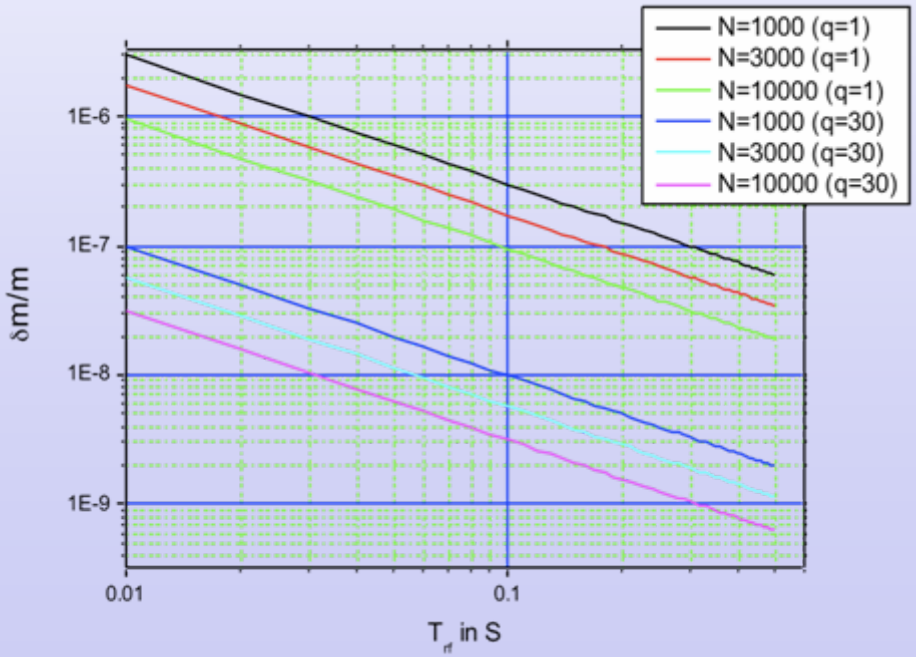
- why:

$$\frac{\delta m}{m} \propto \frac{m}{T_{rf} q B \sqrt{N}}$$

- how:

EBIS:
- commercially available
- room-temperature (permanent magnets)

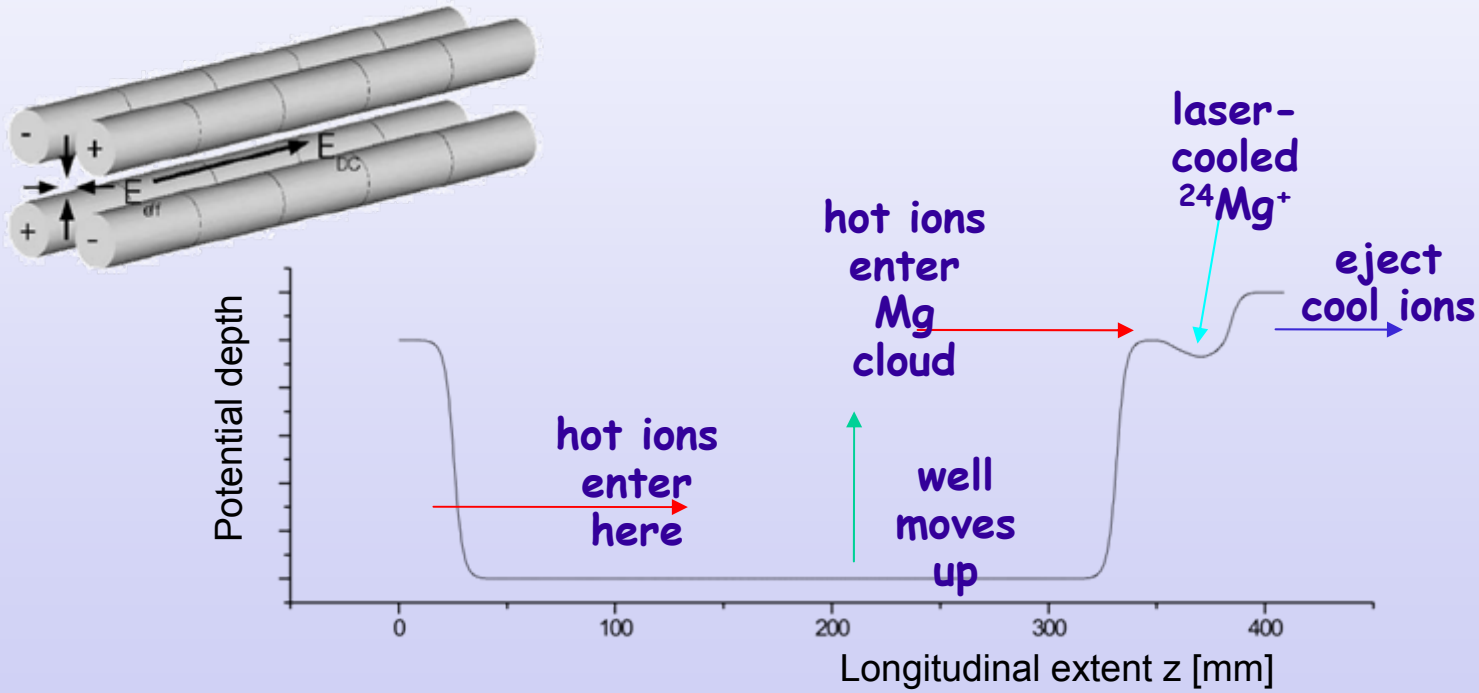
A=100, B=7.0 T:



Sympathetic Laser Cooling

idea: In-trap preparation of highly charged ions by cooling in a strongly coupled plasma of laser-cooled $^{24}Mg^{+}$
(M. Bussmann et al, Int. J. Mass Spectrom. 251 2-3 (2006) 179-189)

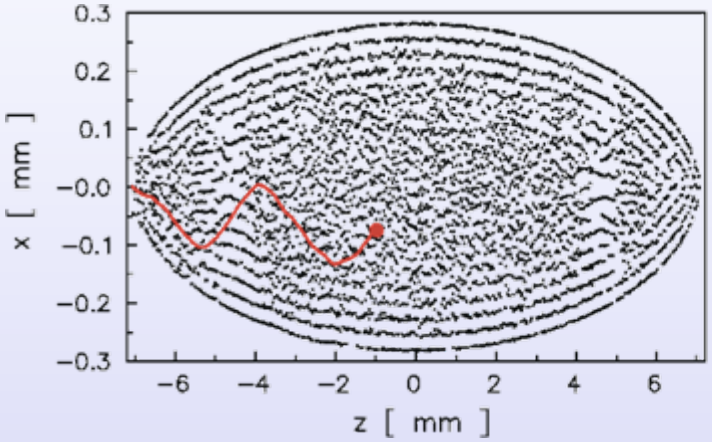
linear Paul trap:

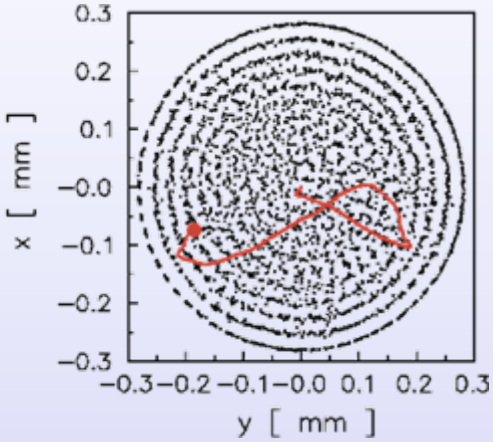


goal: fast cooling to mK temperatures
⊂ precise localization of ion cloud in trap center

Properties of Sympathetic Cooling

- studied in extensive simulations of stopping in strongly-coupled plasma
  (massive-parallel code by M. Bussmann)

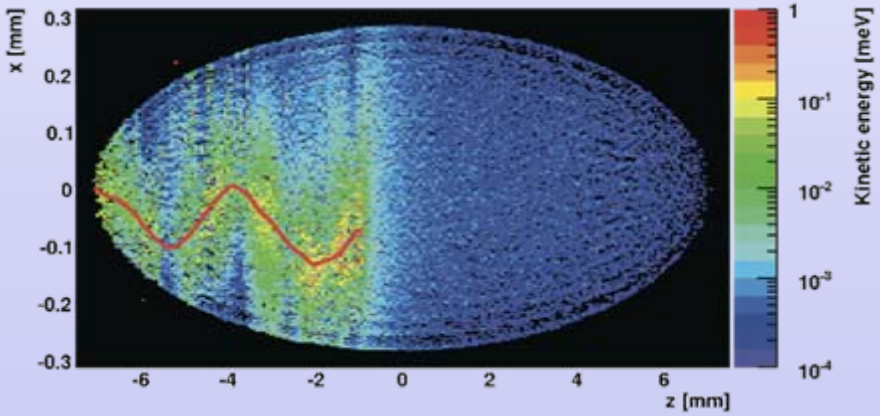




Properties of cooling process:

1. fast cooling (~10 μs)
2. $^{24}Mg^+$ crystal is not destroyed
3. cooling possible without laser scanning

large Mg^+ Coulomb crystal:



→ laser system has been ordered

→ first tests will start with existing Paul ring trap PALLAS

Physics with MLLTRAP

- exploit high mass accuracy to focus on unique physics cases
- exploit rare ion beams available at DESIR

in-trap spectroscopy
- conversion electron and α spectroscopy
- ‚shake-off' electrons (2^+ lifetimes, Q moments)

trap-assisted spectroscopy

high-precision mass measurements
- unitarity of CKM matrix (V_{ud})
- precision studies on fundamental constants

→ connecting beamline with S^3 highly desirable !