Experiments with a Fast Chopper System for Intense Ion Beams

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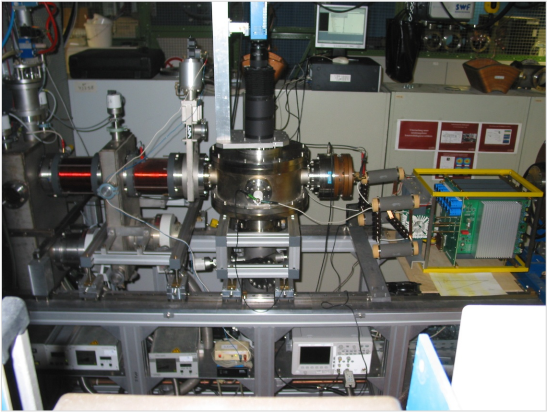
Overview

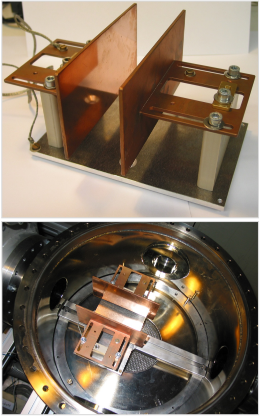
- Experiments at deflector test stand successfully completed
  - Static deflection: good agreement with analytical results and PIC simulation
  - Successful pulsed mode operation
- Next steps for the FRANZ chopper
  - Deflection plate mounting (protection against sputtering)
  - Electrical connection of the pulse generator

    → Transmission of the deflection pulse into the chopper chamber
  - Secondary particles?

Test Stand Layout



Beam line and High Voltage pulse generator.

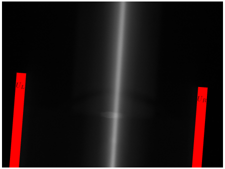


Deflection plates.

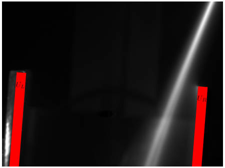
He^+ beam, $W_B = 20\,\mathrm{keV}$, $I_B = 1\,\mathrm{mA}$; plate distance $d = 7.6\,\mathrm{cm}$.

Static Deflection – Deflection Angle

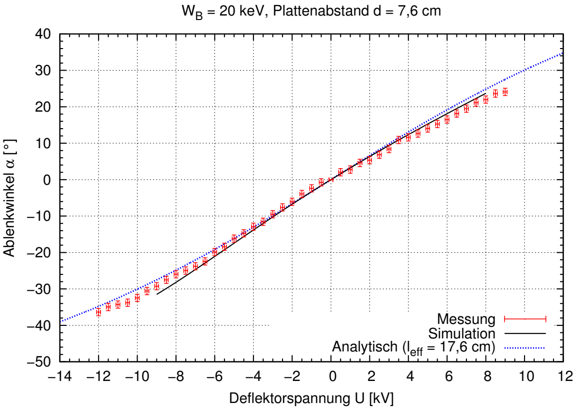
of a He^+ beam with the energy $W_B = 20\,\text{keV}$



$U_L = U_R = 0\,\text{kV}$



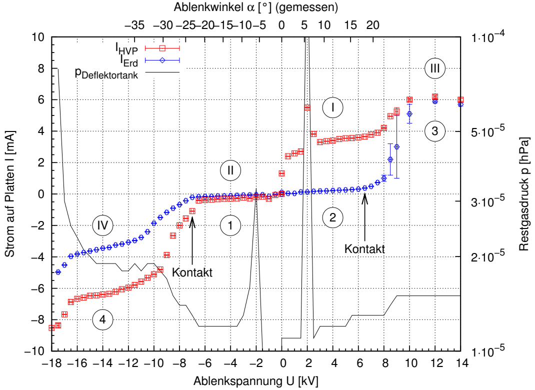
$U_L = +6{,}5\,\text{kV},\ U_R = 0\,\text{kV}$

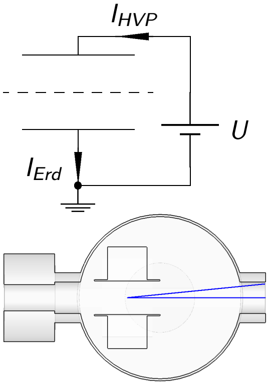


- Mismatch at the edges (beam close to the deflection plates)
- Asymmetry positive / negative → mapping characteristics

Static Deflection – Secondary Particles

measurement with a He^+ beam at the energy $W_B = 20\,\text{keV}$

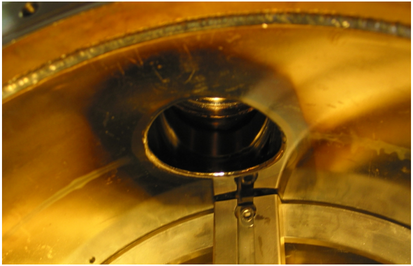


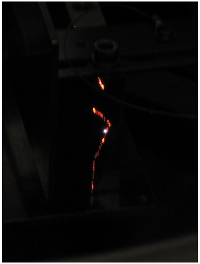


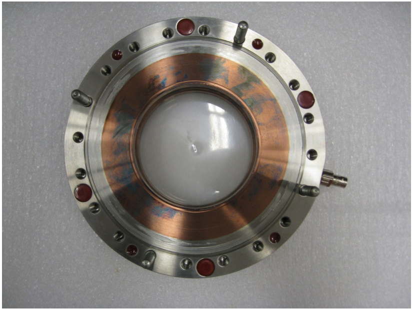
Peak in the residual gas pressure at $\alpha = 5.7°$ → lower right image

Sputtering

Beam hits plates and walls, releases metal ions → deposition on insulator surfaces



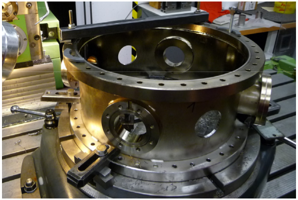




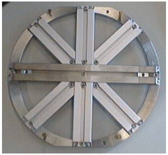
→ High Voltage breakdowns

- Plans: new plate mounting
  - Shadowing
  - Meandering
- New plate material?

New 45 Degree Deflection Ports

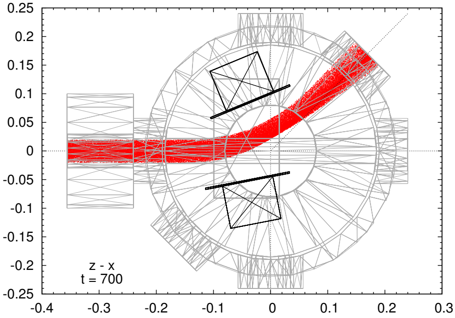


Assembly in the workshop.



Wheel ion-optical bench.

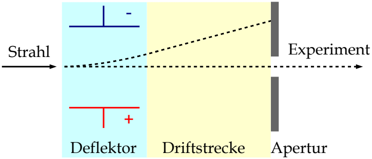
First beam dynamics simulations using the new setup (preliminary):



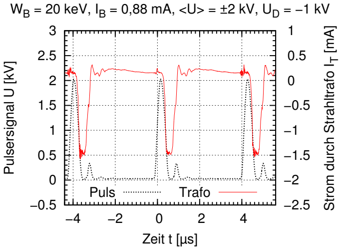
$U_L = -13\,\text{kV}$, $U_R = +12\,\text{kV}$, $W_B = 20\,\text{keV}$

Redistribution: mapping characteristics

Pulsed Mode Operation



Experimental setup.

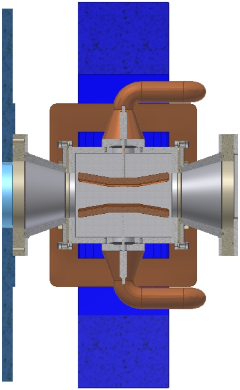


Pulse (black), resulting beam current behind aperture (red).

Pulsing the deflection voltage at $f_0 = 250\,\mathrm{kHz}$, up to $U = \pm 5.6\,\mathrm{kV}$

- Symmetrical wiring of deflection plates, minimising capacitance and voltage breakdowns
- Measuring time of flight and plateau length while varying pulse amplitude, beam energy
- Influence of secondary particles on the system
  - Dump on potential
  - Solution: secondary electron suppression
- Emission of pulse signal

Transmission of Pulse Signal



Cross-sectional view,
actual cable design.

Large influence of pulse signal on a radio at 4 m distance

- Shielding the environment from pulse signal necessary
- Protection of the cable against external disturbances

→ Coaxial build-up (copper tube)

Parasitic capacitance $C_K = \frac{2\pi\varepsilon_0\varepsilon_r l}{\ln(\frac{R}{r})}$

- Air as dielectric ($\varepsilon_r = 1$)
- Short transmission distance l
- Large radius ratio $\frac{R}{r}$

Outlook

- Wiring between pulse generator and chopper chamber
- Parasitic capacitances in acceptable range
- Consideration of sputtering in beam dynamics calculations
- Consequences for the design of the chopper chamber
  - Plate mounting
  - Plate material
  - Secondary electron suppression
- Emittance measurements of deflected beam

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Thank you for your attention!