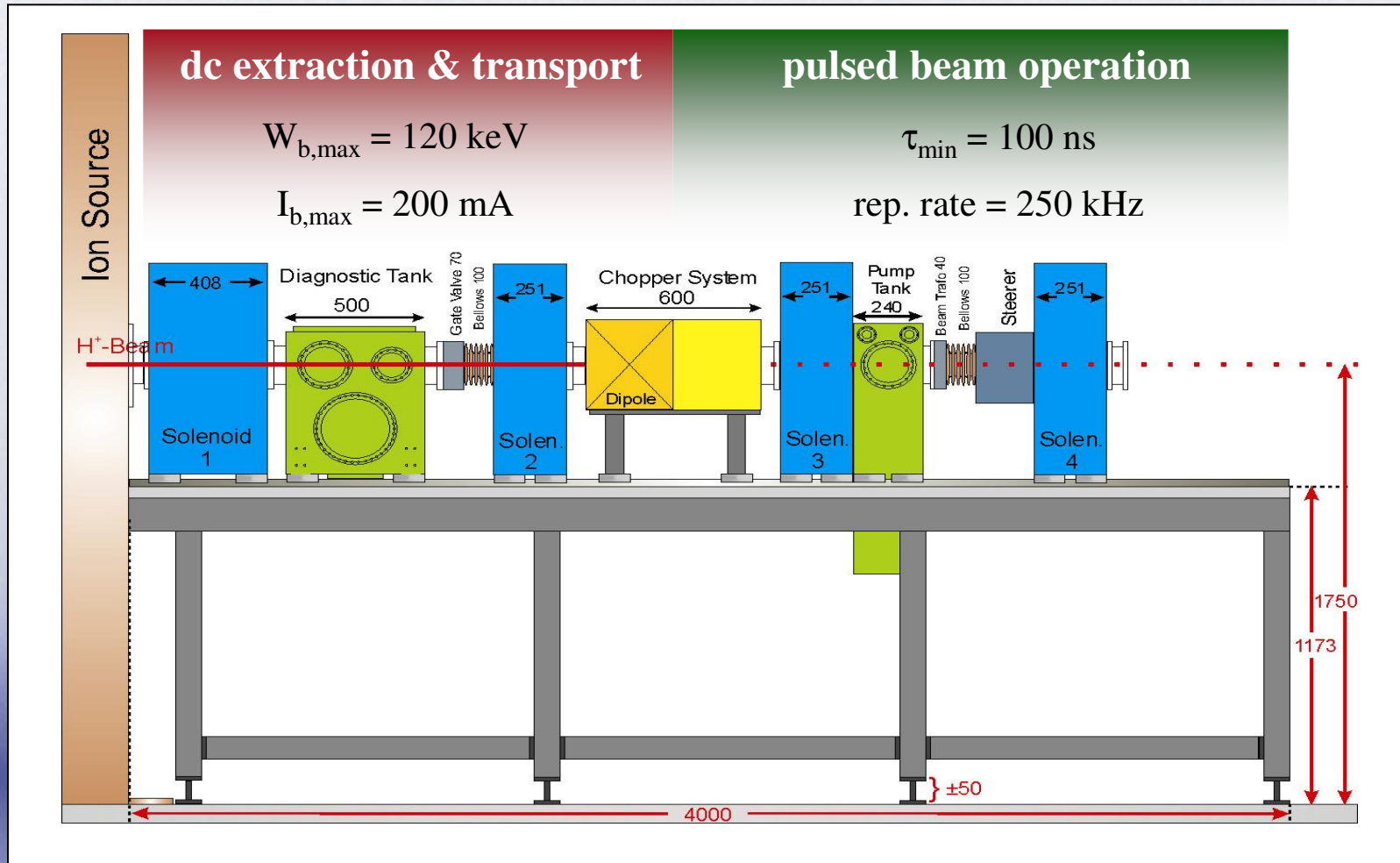


Diagnosics on Intense Proton Beams

Oliver Meusel

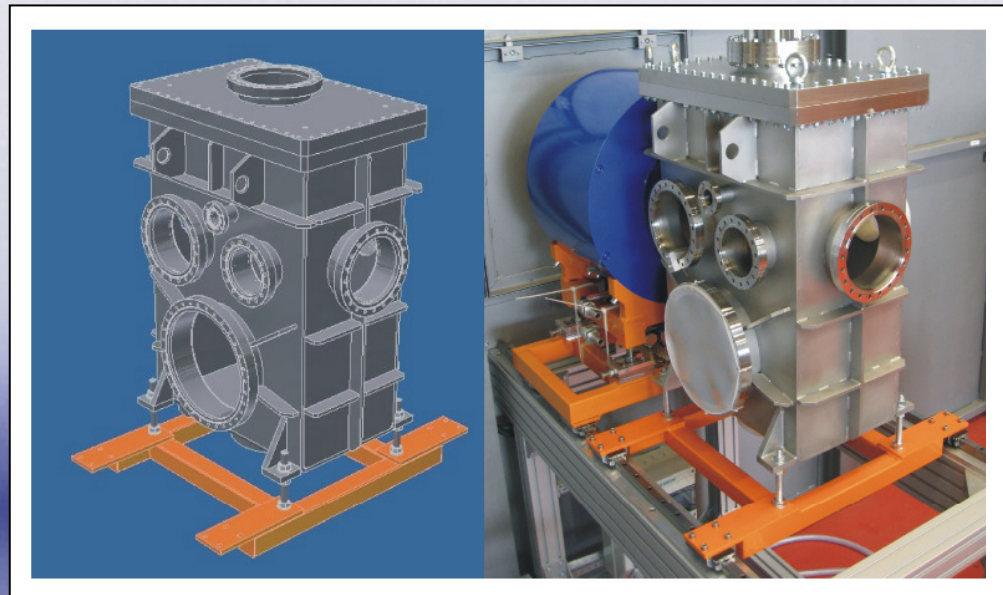
Riezlern 2009

Overview

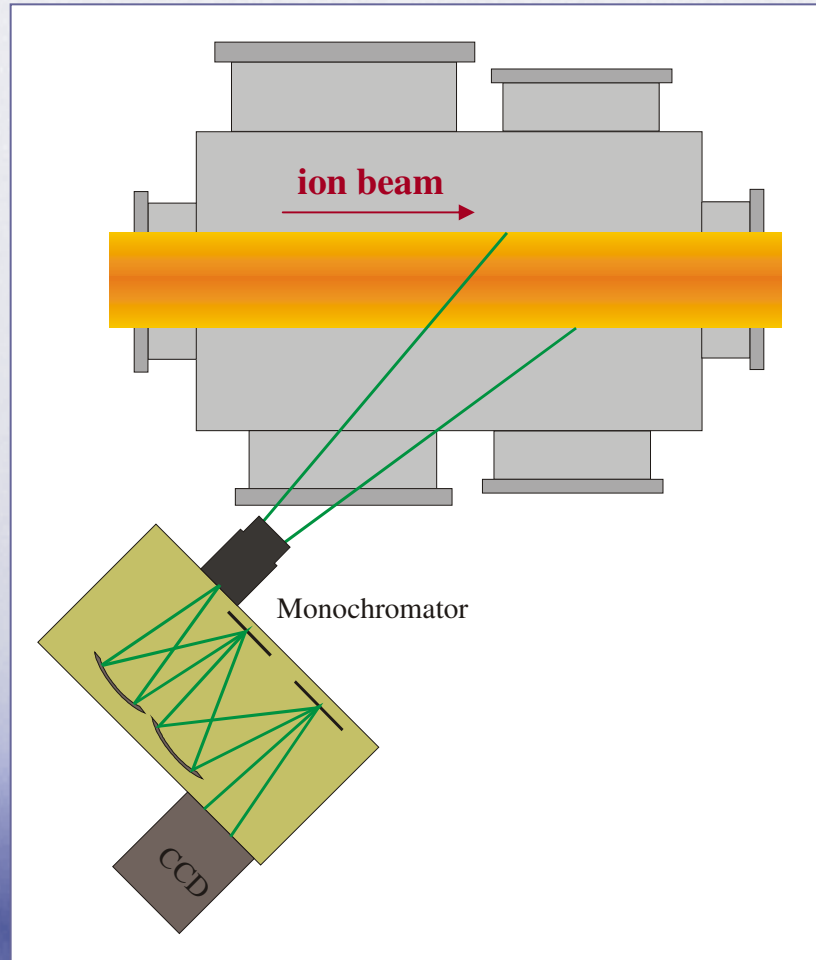


D1 Tank

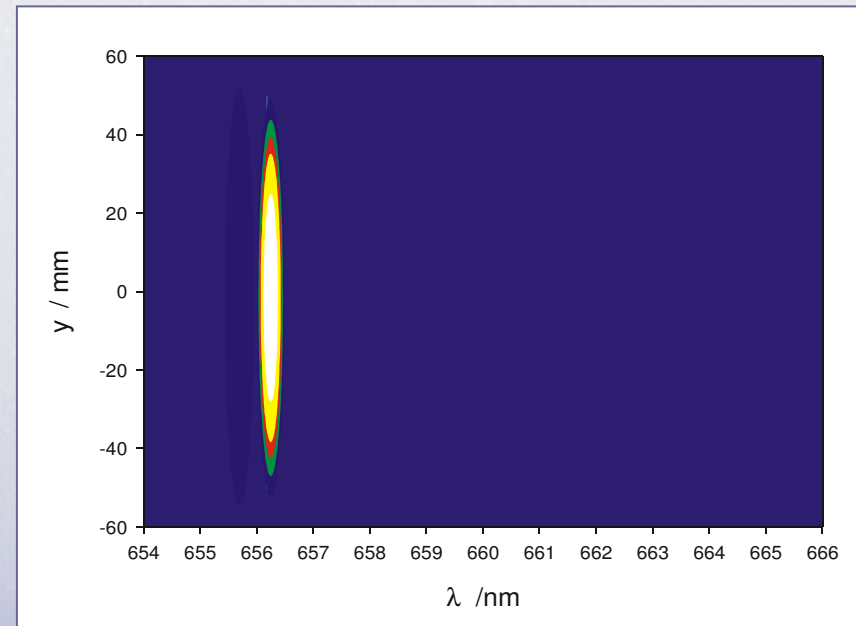
- 24kW Faraday cup ($I(t)$ / emergency beam dump)
- Pumping (2000 l/s)
- Pressure measurement and control



Optical Spectroscopy



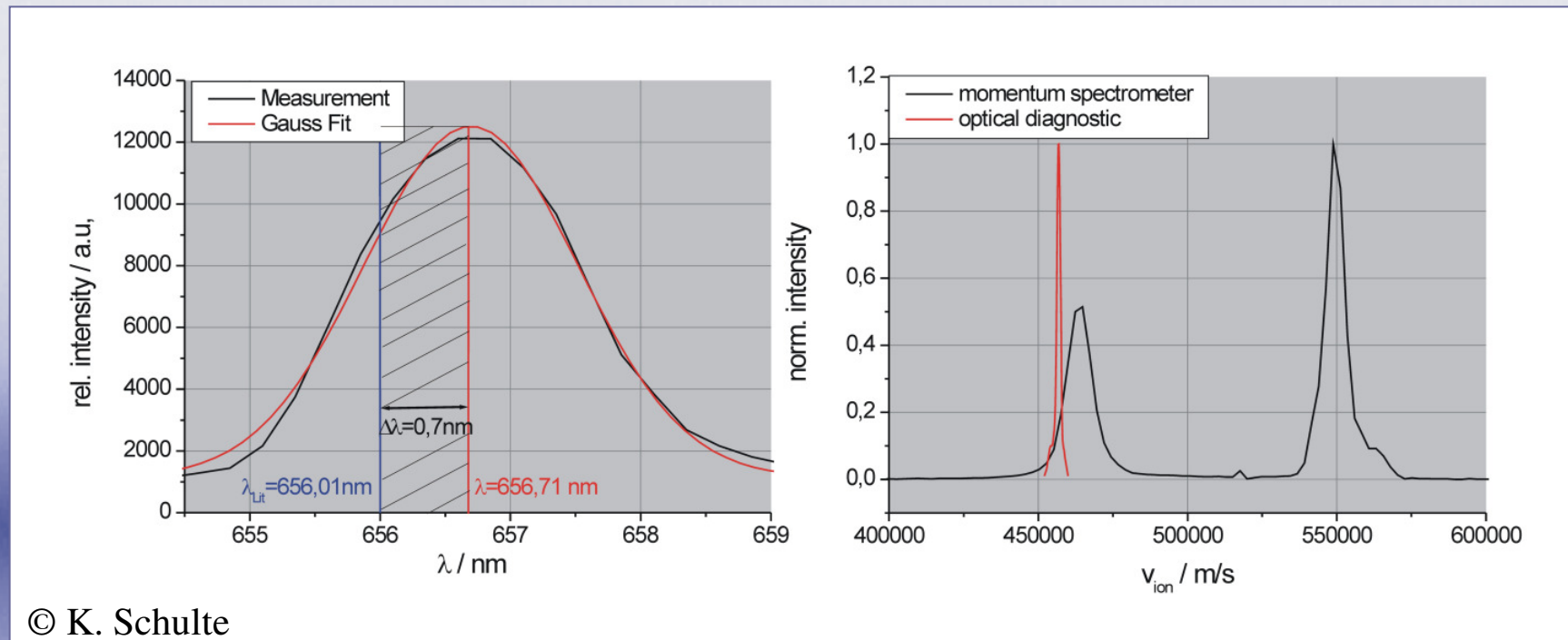
residual gas luminescence H_{α}



Optical Spectroscopy

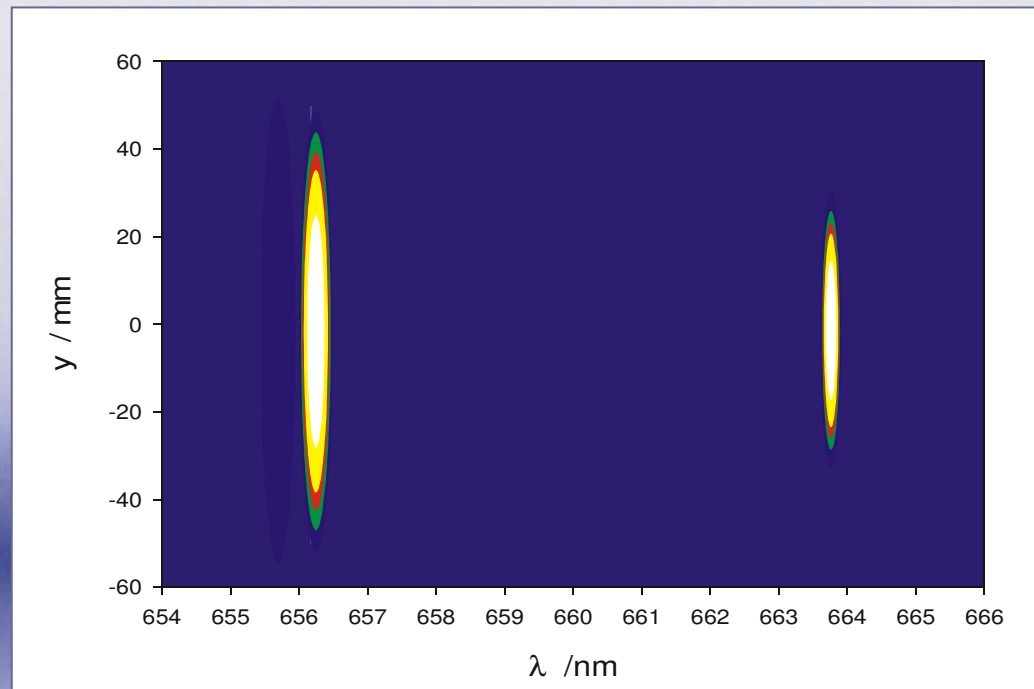
Example: He⁺ - comparison of Doppler shift measurement and momentum spectroscopy

$$v_i = \frac{\Delta\lambda c}{\lambda_0 \cos \theta}$$

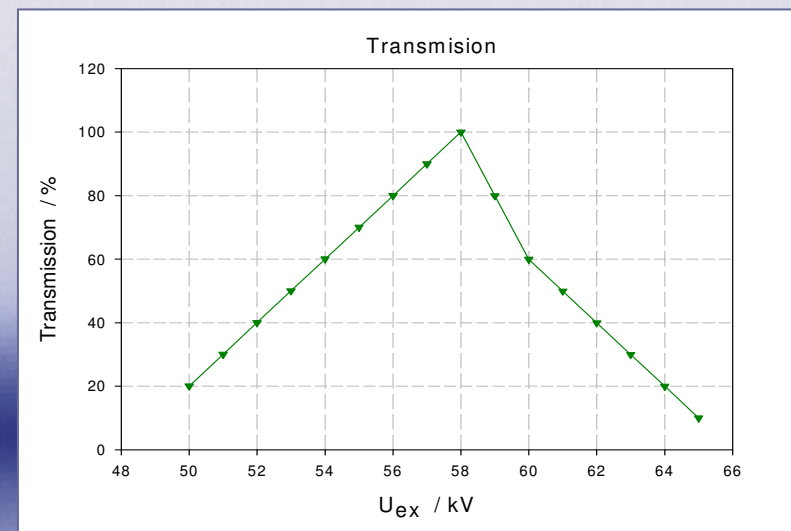
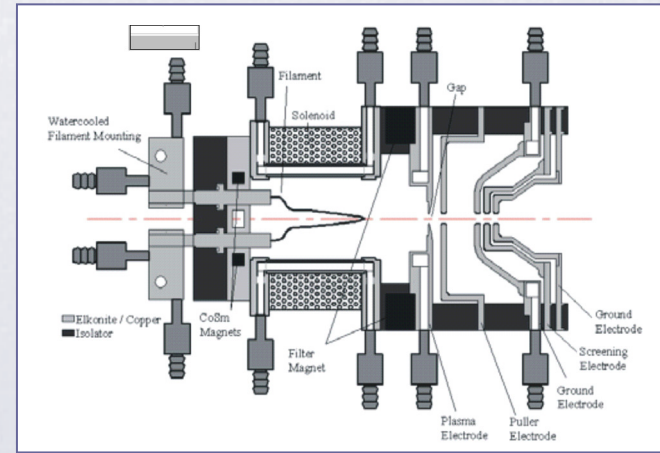
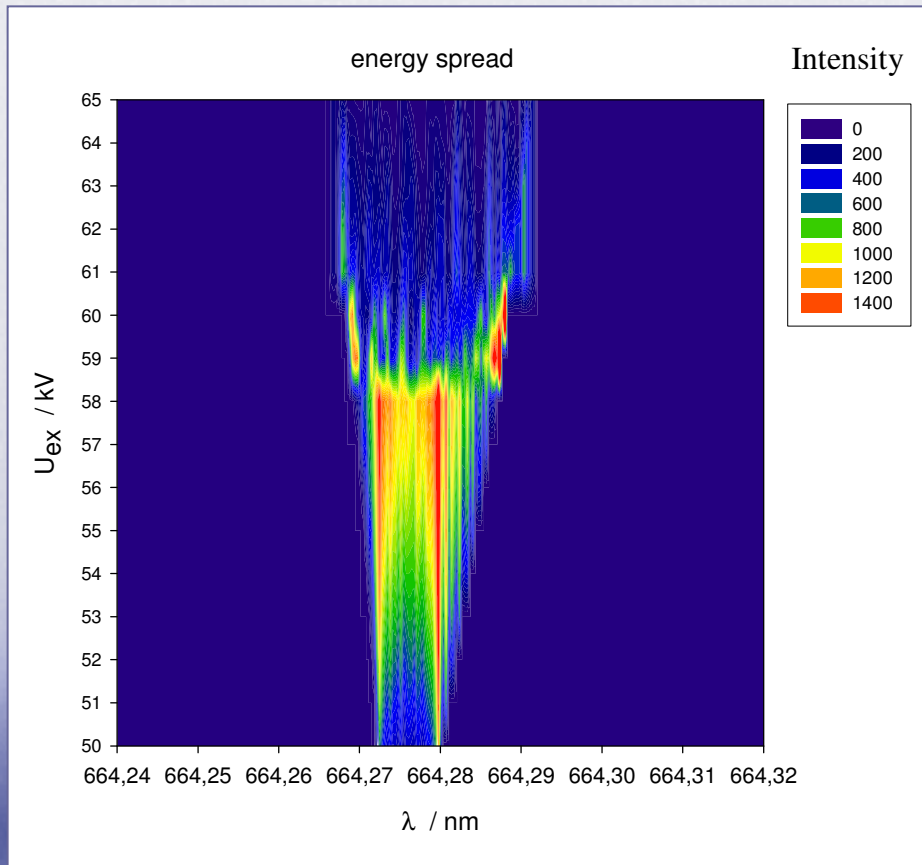


Estimation of Beam Energy

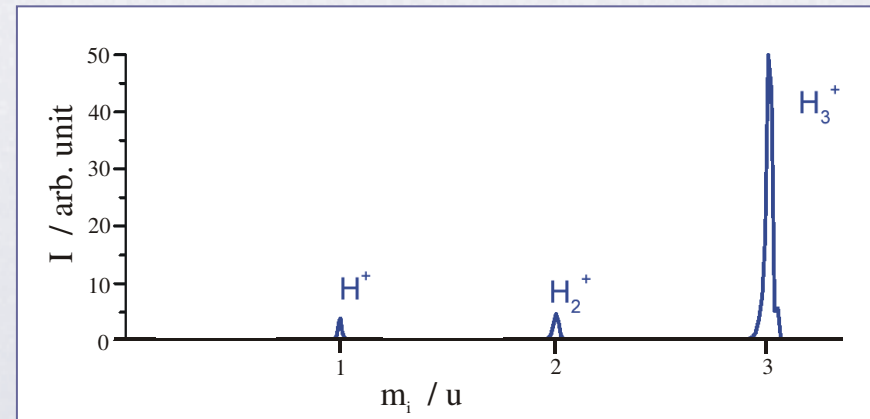
- investigation of charge exchange reaction
 - measurement of the beam energy
 - measurement of energy spread



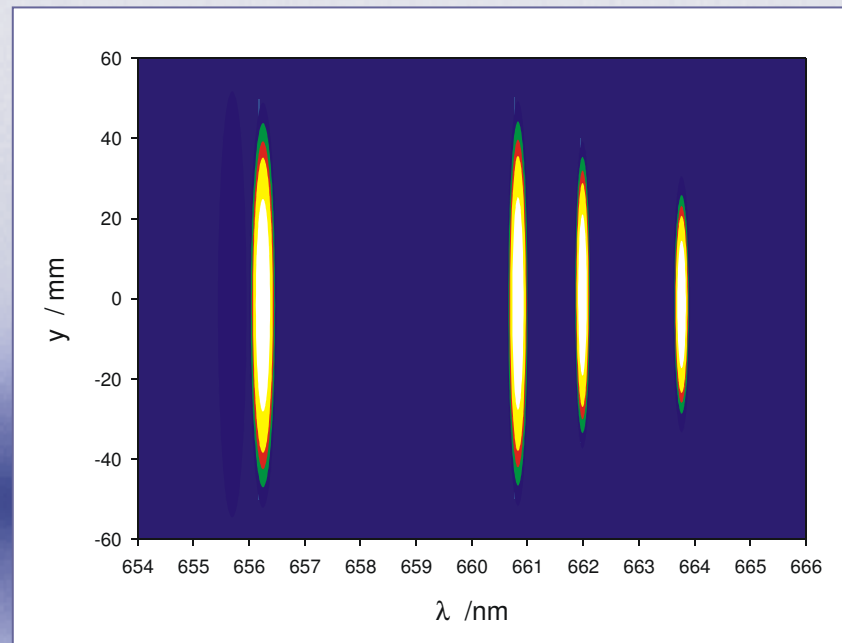
Estimation of Beam Energy Spread



Estimation of Beam Composition

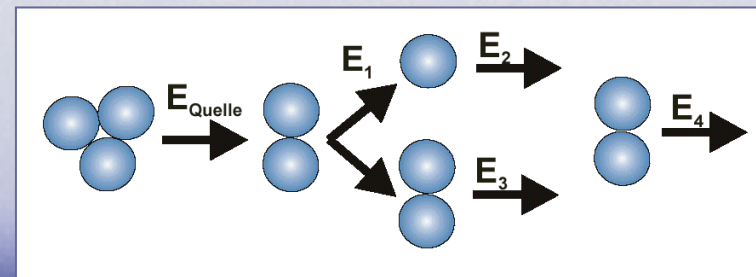
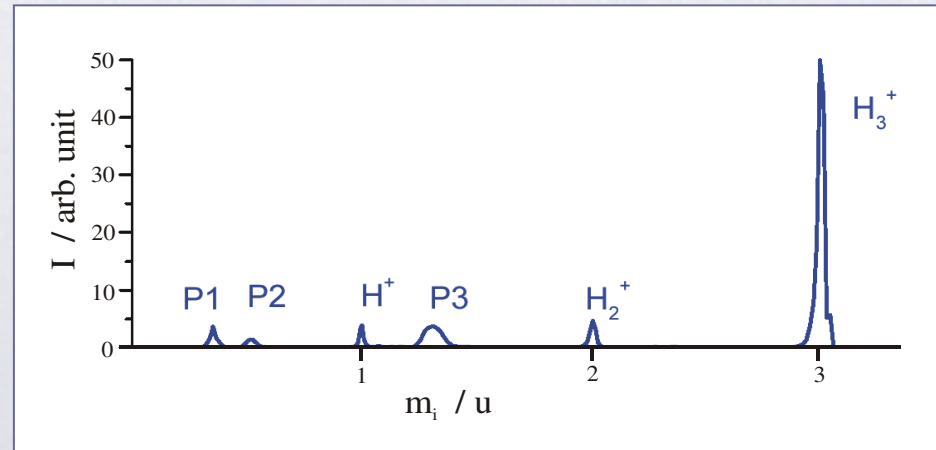
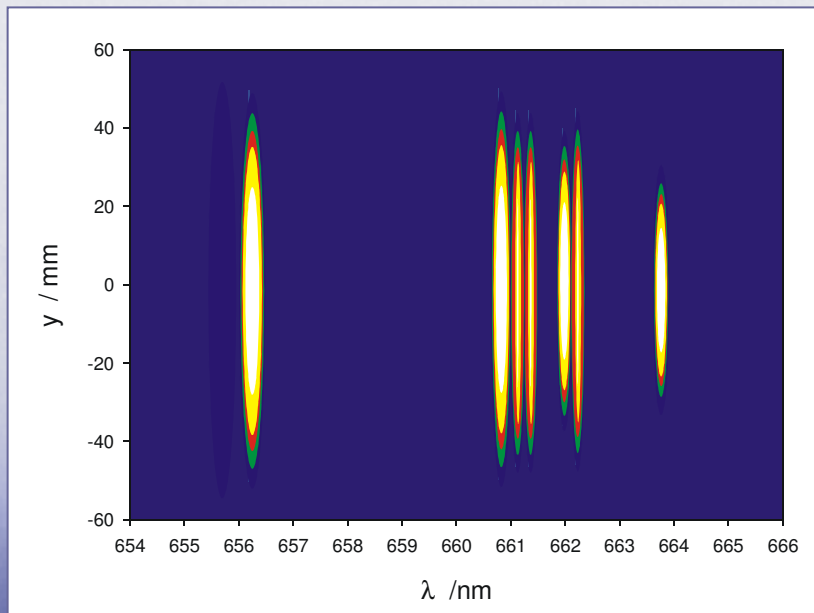


$$v = \sqrt{\frac{2eU_{ex}}{m_i}}$$



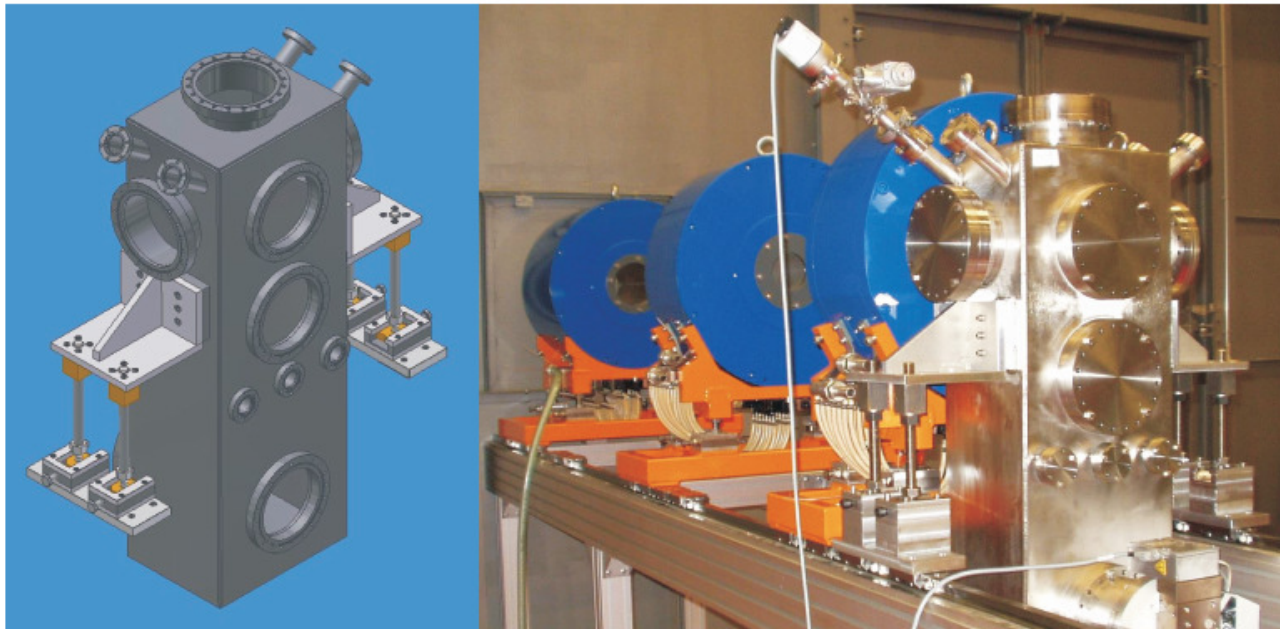
Estimation of Beam Composition

fragmentation of charged molecules



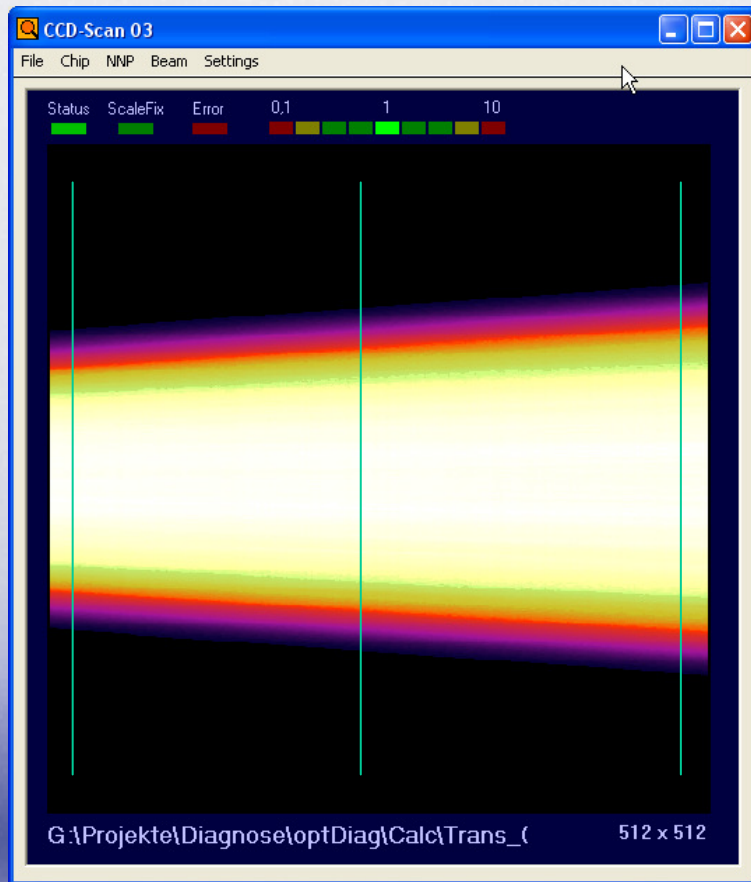
D2 Tank

- time resolved measurement of beam profile
- time resolved measurement of beam potential
- pressure measurement and control

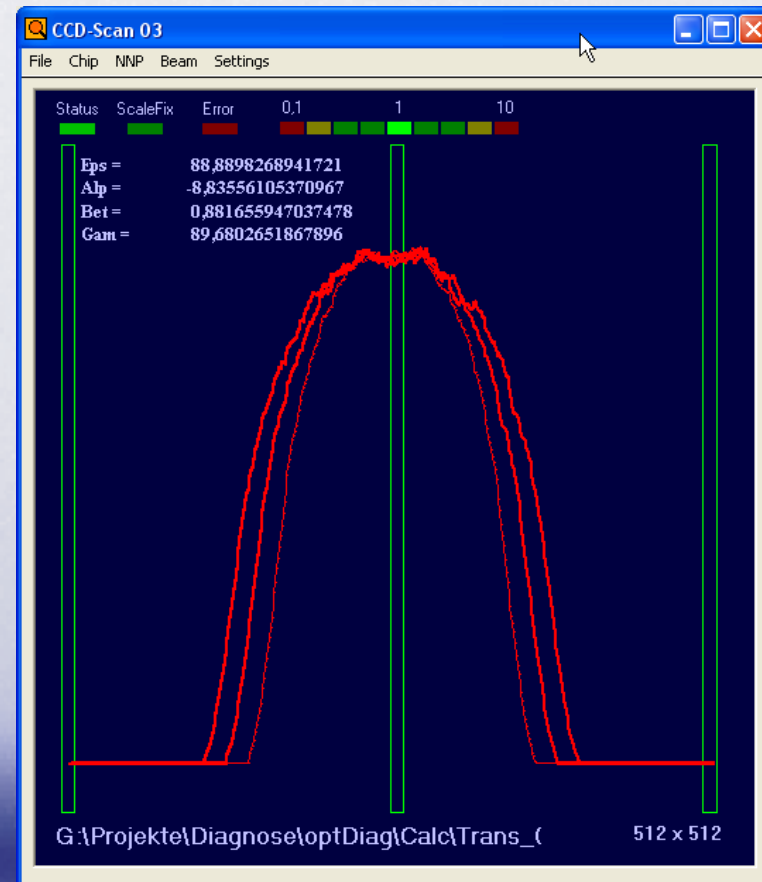


Estimation of Beam Profiles

determination of twiss parameters



resolution 0,078 mm/Pixel

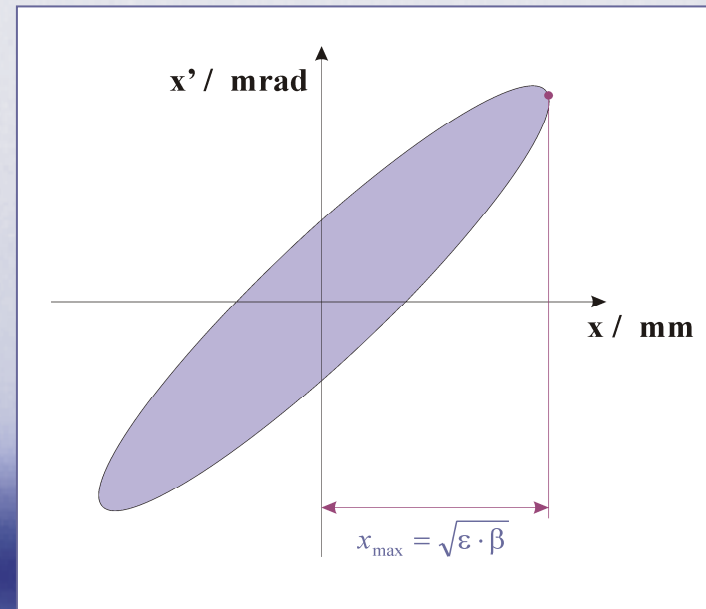
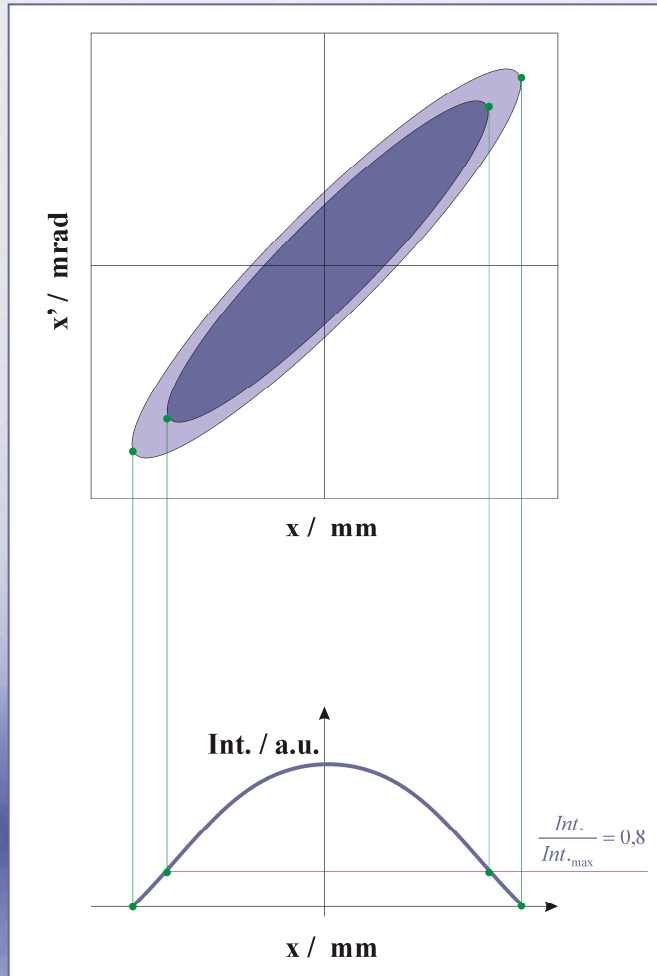


3 Profile with $\Delta z = 20$ mm

Estimation of Beam Profiles

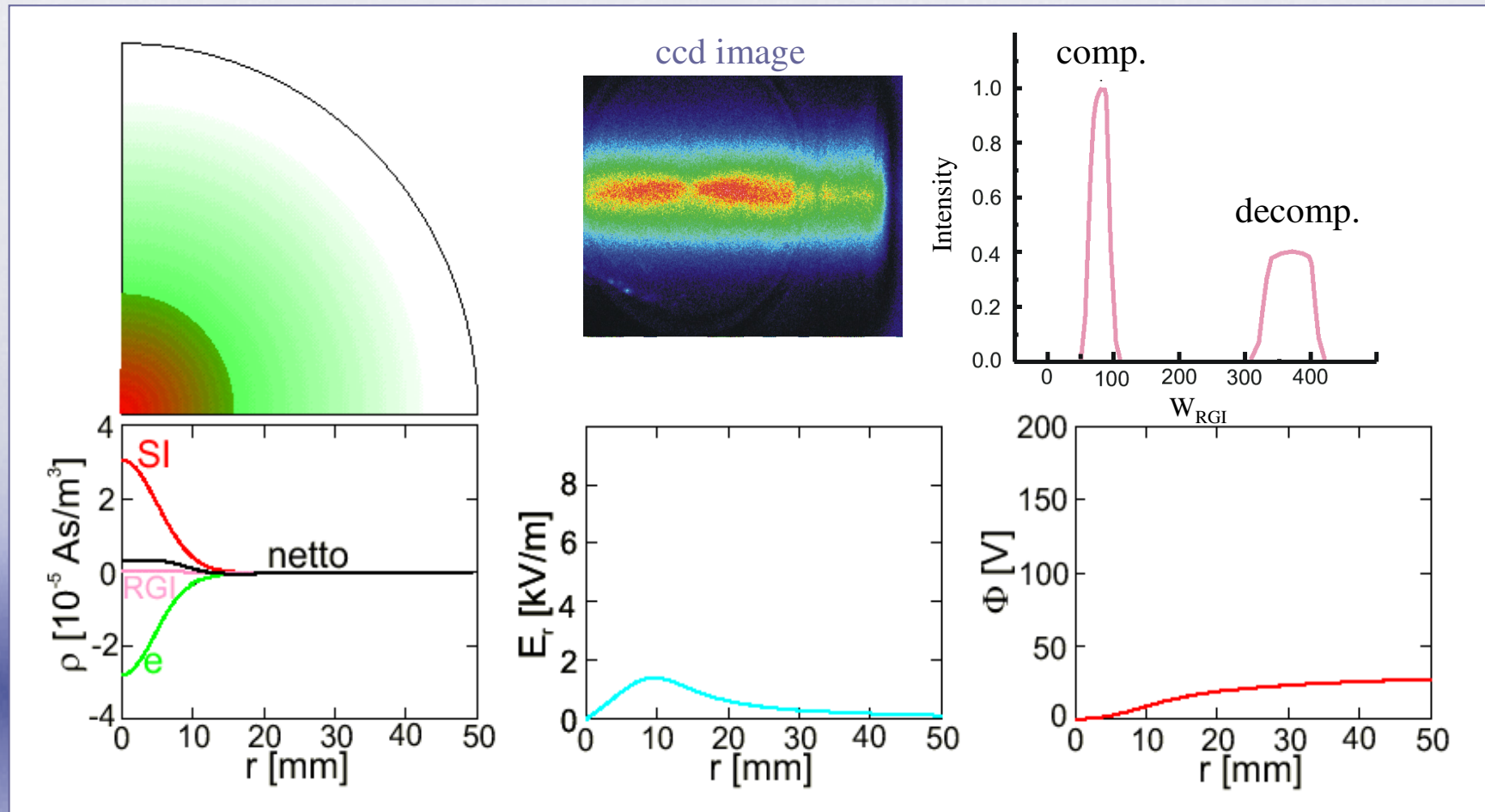
estimation of beam emittance for cylinder
symmetrical beams

$$x_{\text{Profil}} = 2x_{\text{max}} = 2\sqrt{\varepsilon \cdot \beta}$$

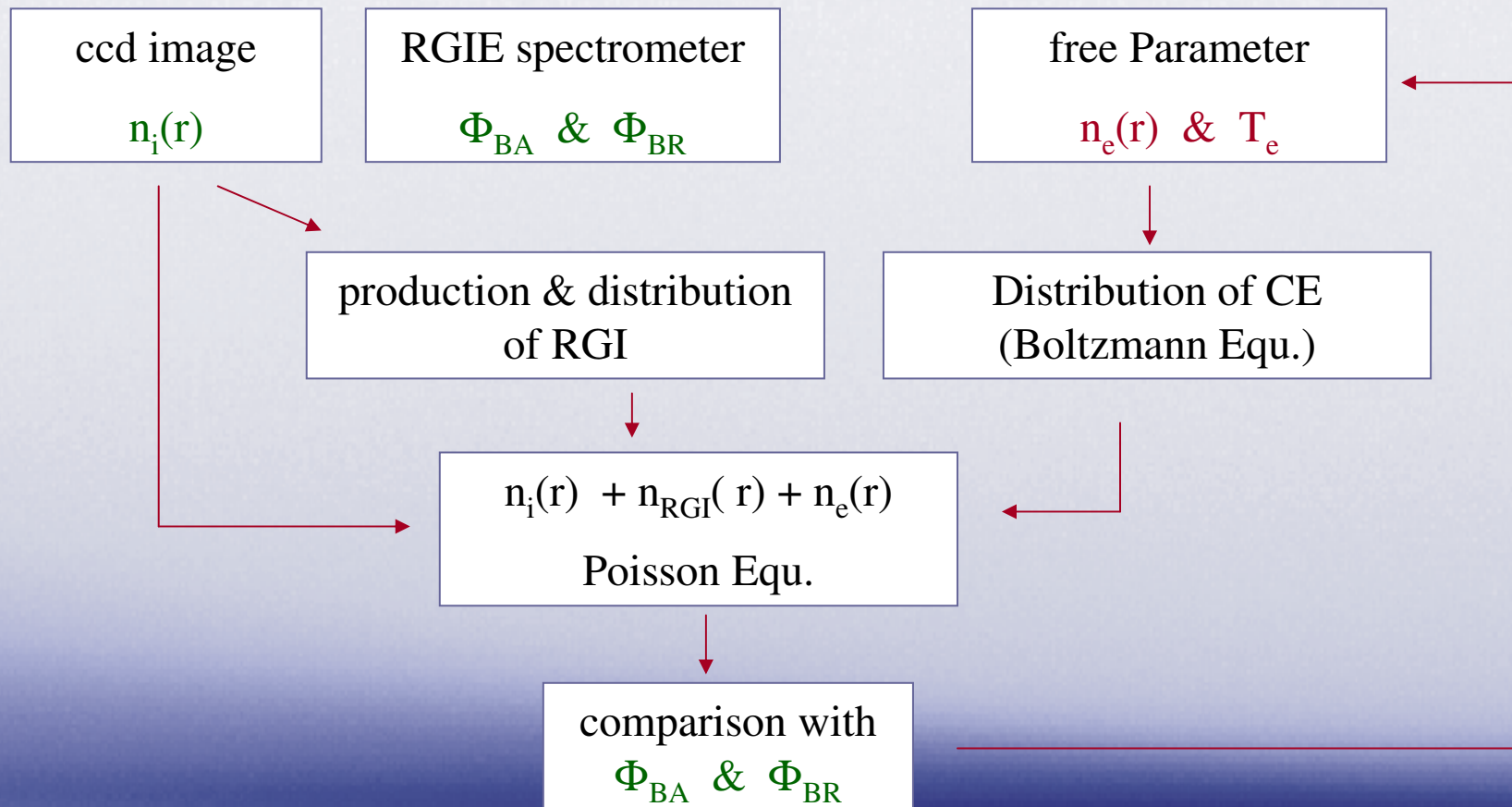


Space Charge Compensation

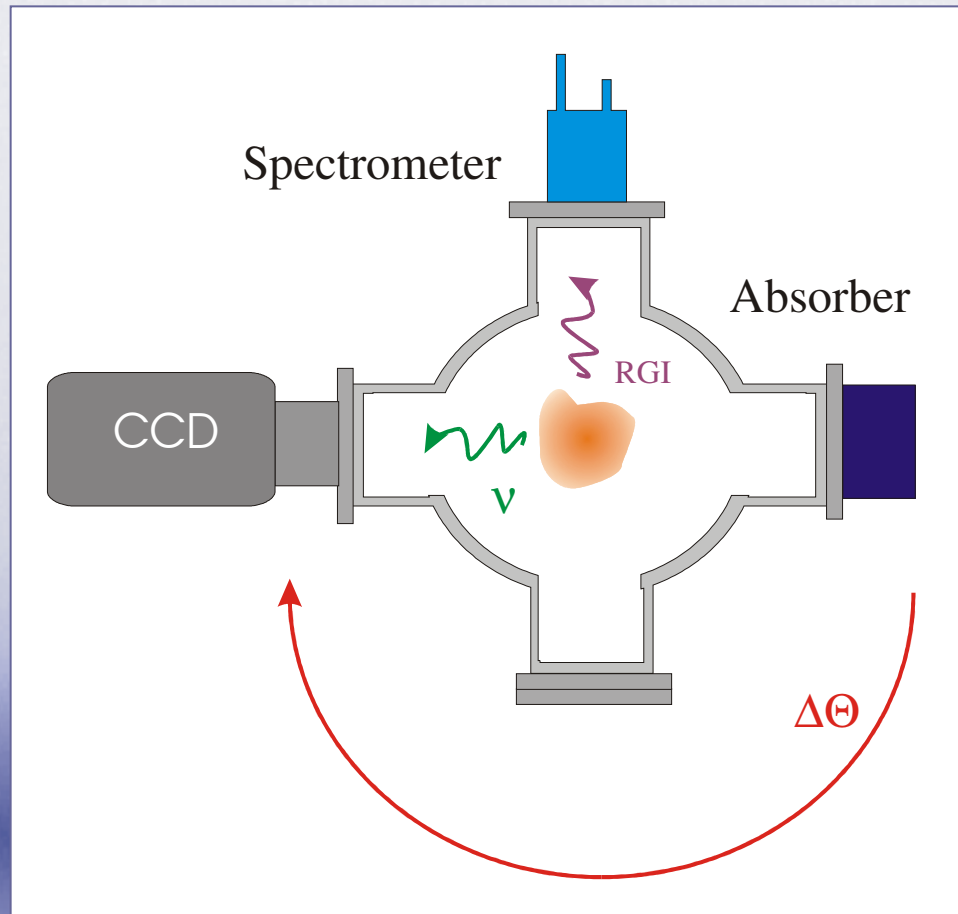
estimation of electron density distribution



Self-Consistent Calculation of Compensation



Time Resolved Beam Tomography

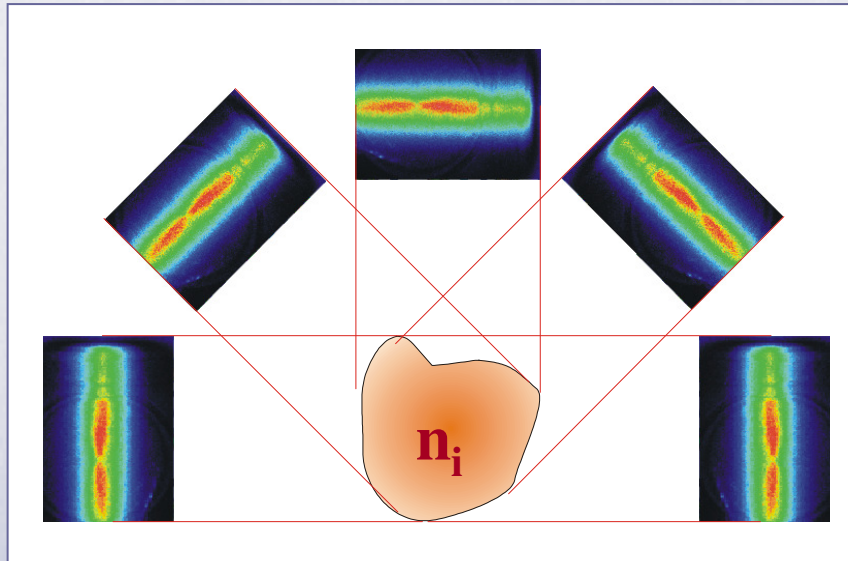


estimation of rms emittance
(MaxEntropy)

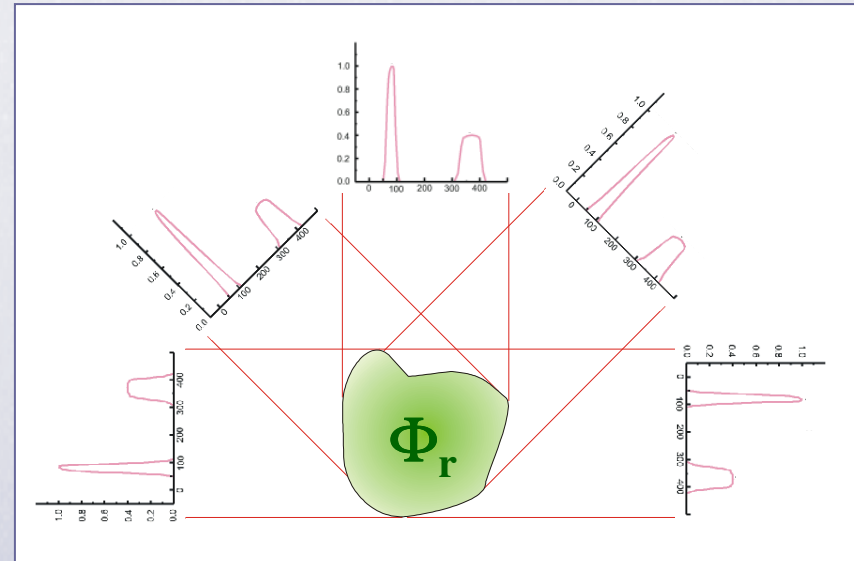
Estimation of local space charge
compensation

Beam Tomography

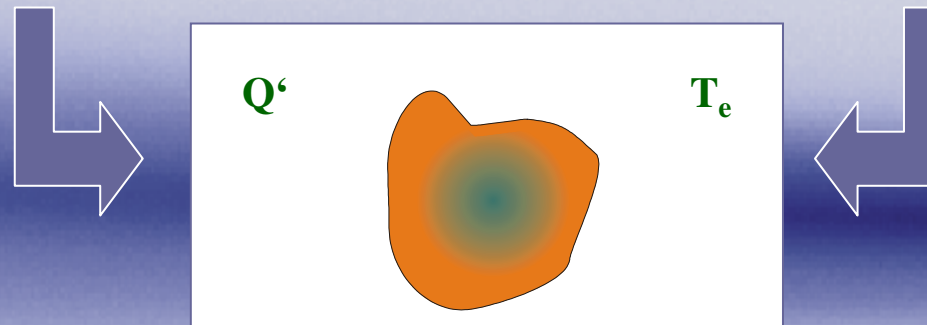
optical profiles



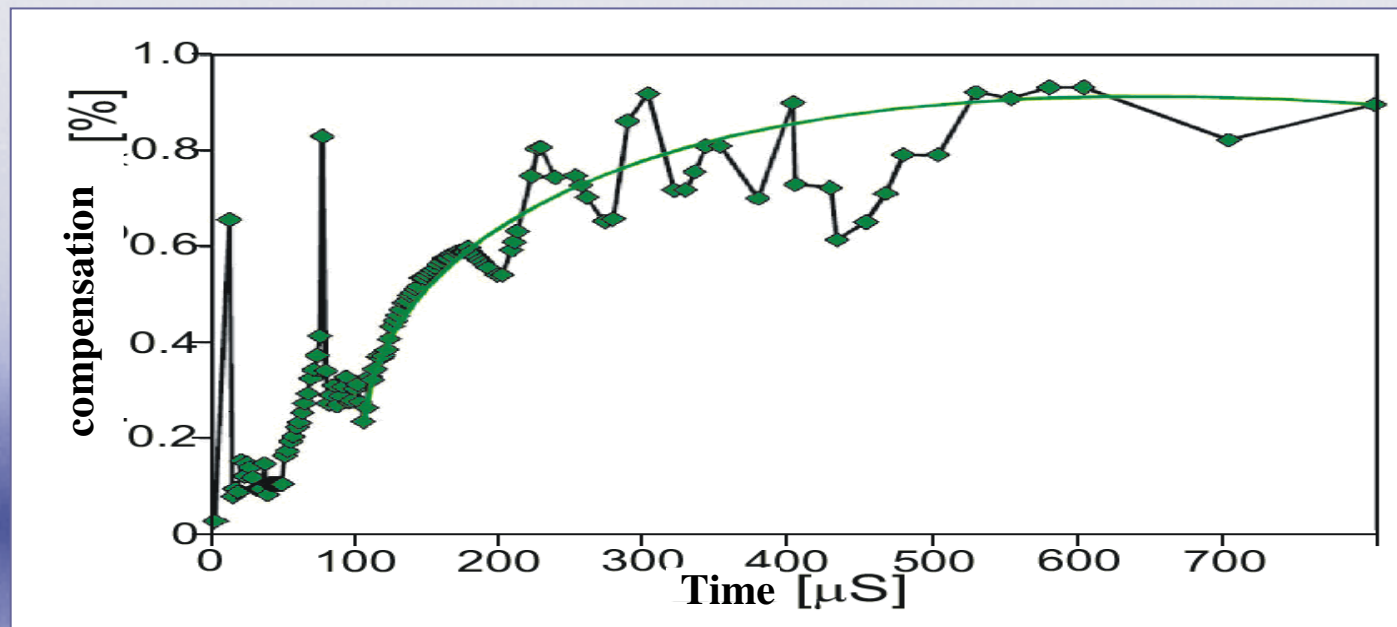
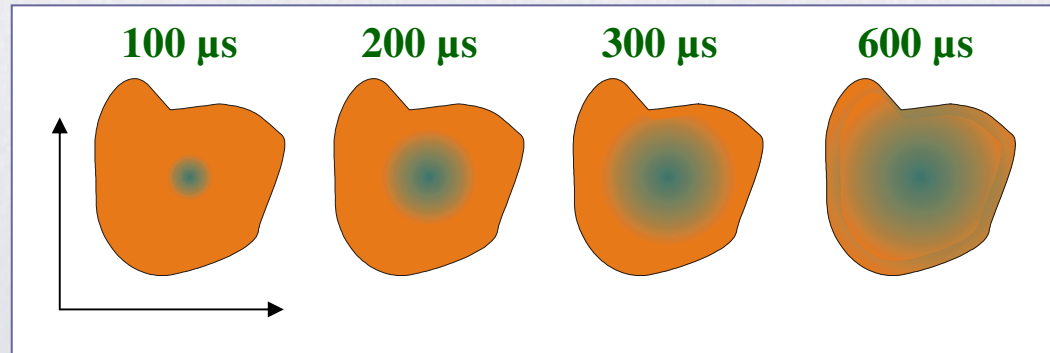
potential distribution



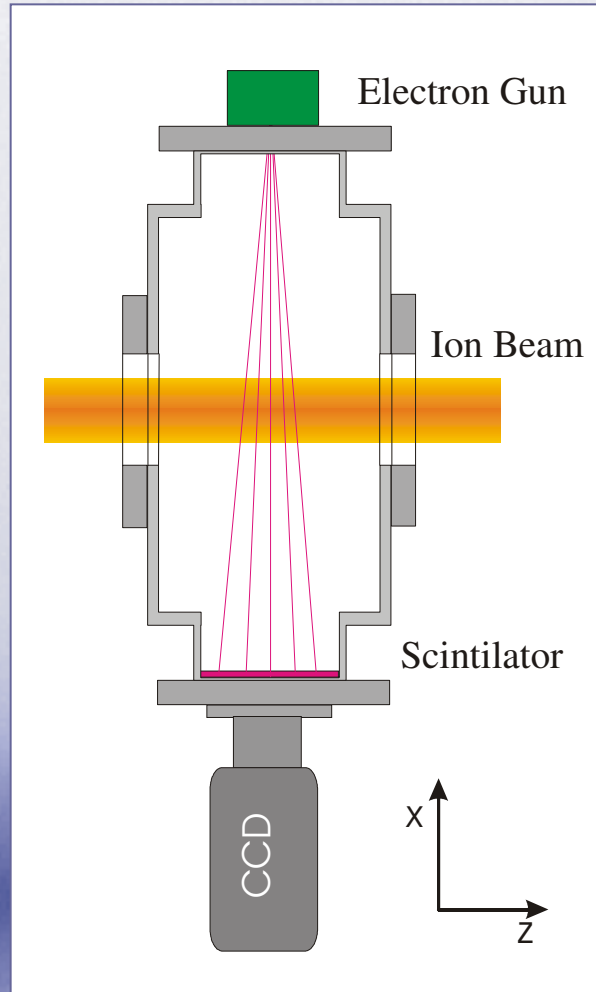
local compensation electron distribution



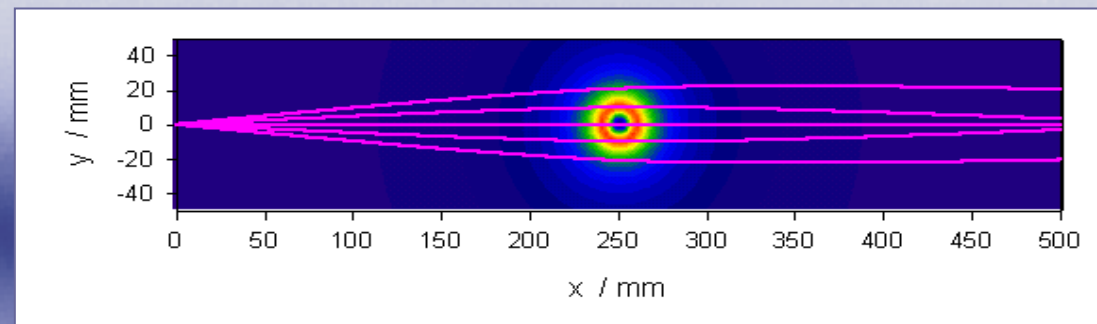
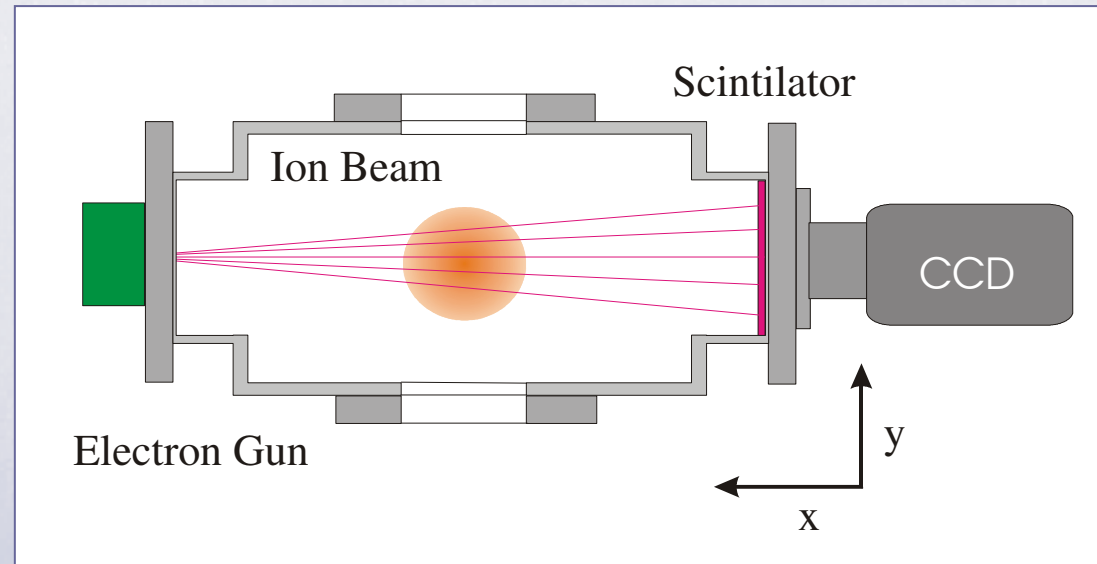
Dynamics of Space Charge Compensation



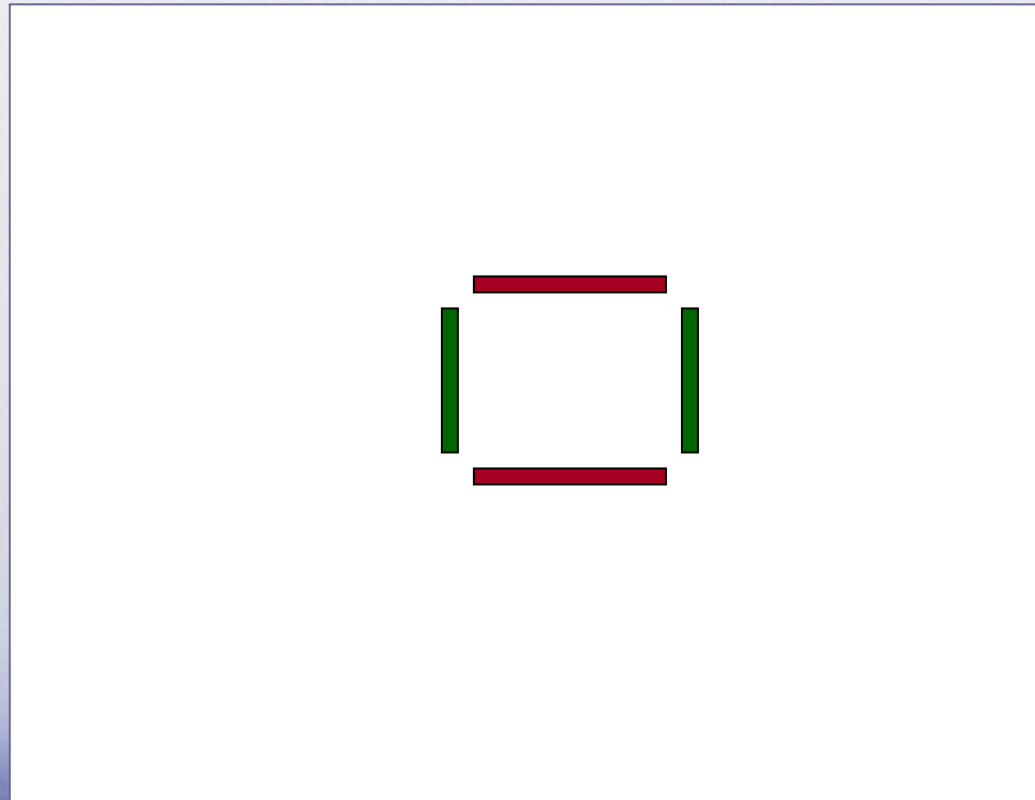
Electron Beam Probe



independent of residual gas pressure

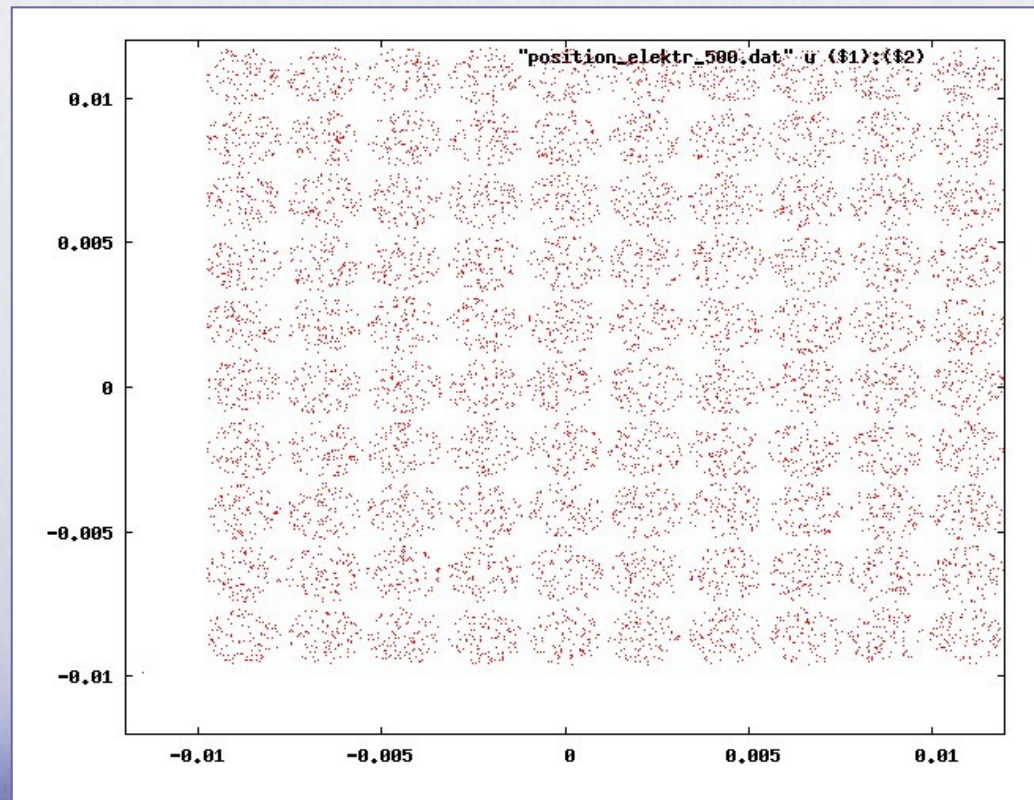


Electron Beam Probe



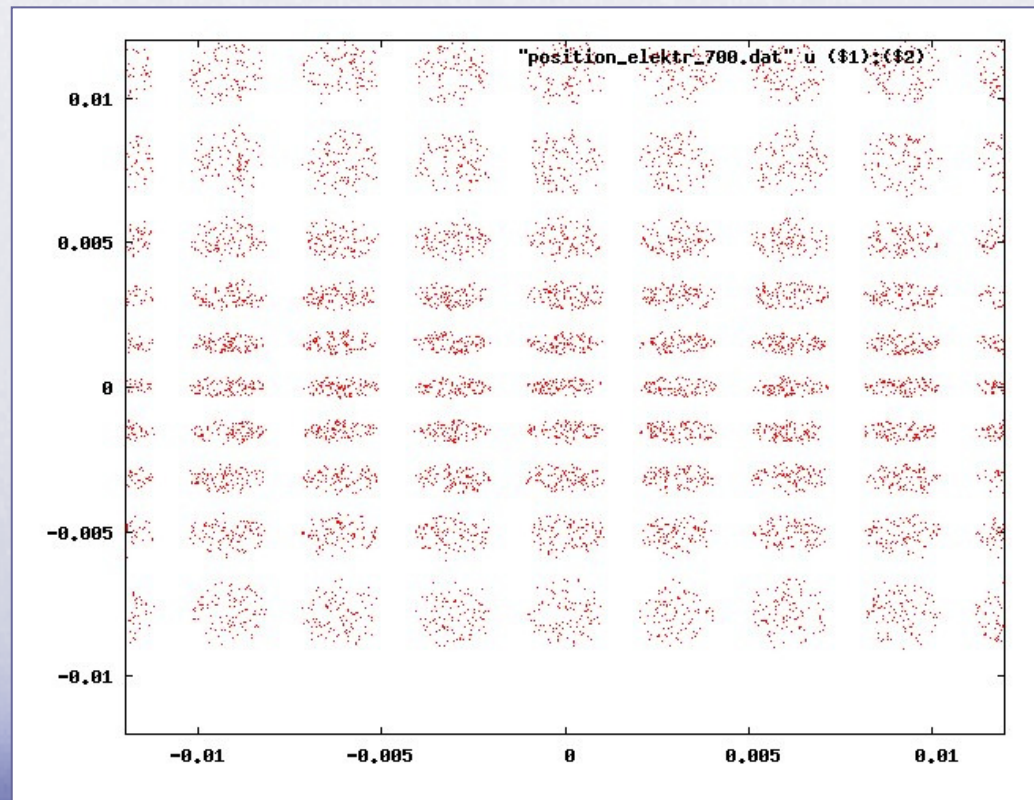
gun with deflector

Electron Beam Probe



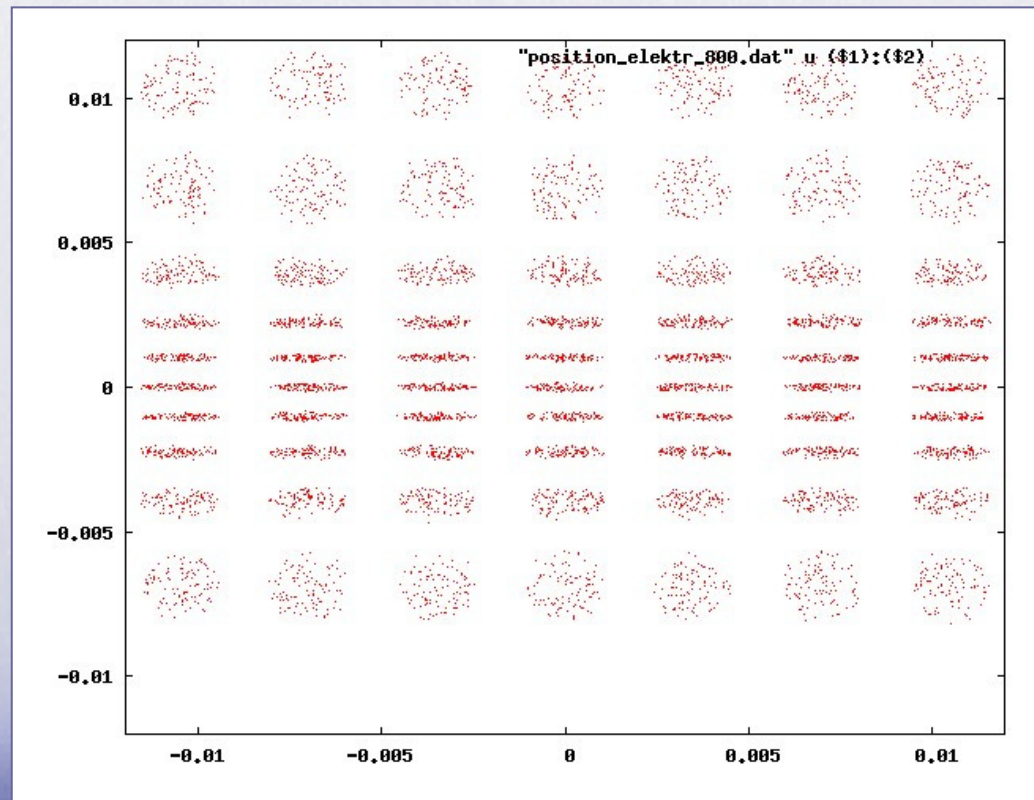
250 mm

Electron Beam Probe



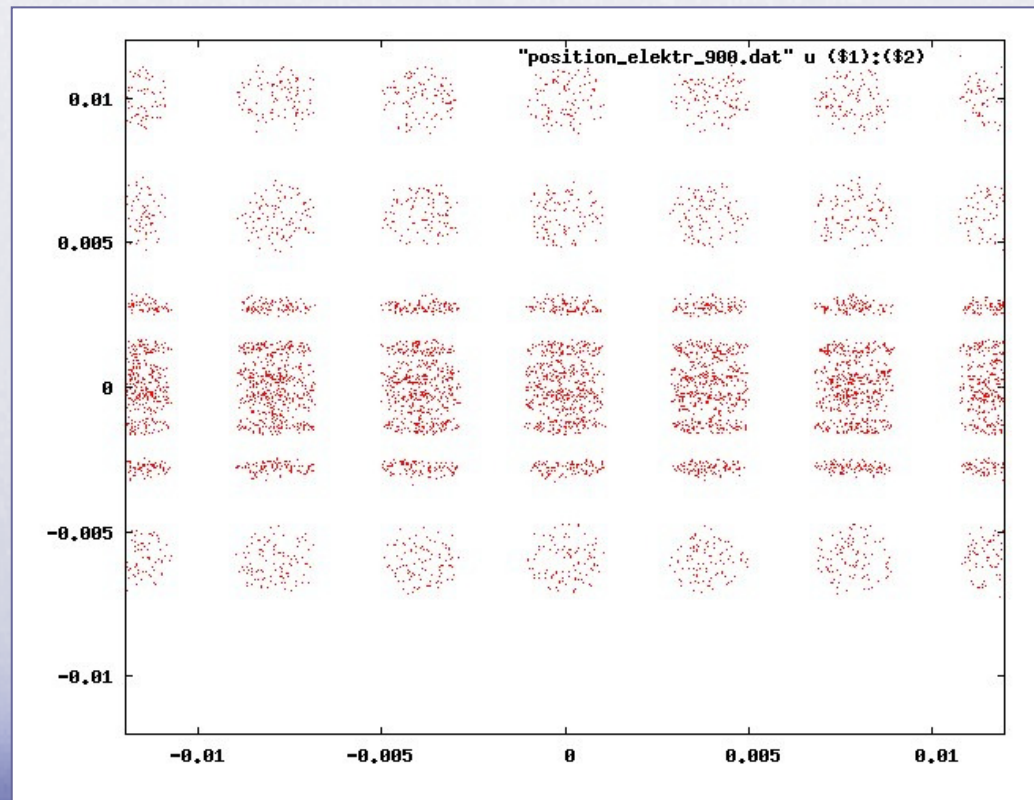
350 mm

Electron Beam Probe



400 mm

Electron Beam Probe



450 mm

Conclusion

FRANZ is a test bench for beam diagnostic instrumentation

- estimation of rms emittance from density profiles
- beam instabilities (electron- ion two stream instability)
- symmetry breaking
- compensation process

measurement with high time resolution !



beam thermodynamics

Strucki ?

Acknowledgement

- diagnostic on nnp - K. Schulte
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- beam preparation and ion optics - Ch. Wiesner
- and behind - P. Nonn / F. Plag

<http://franz.physik.uni-frankfurt.de>

<http://nnp.physik.uni-frankfurt.de>