Ion injection into the precision Penning trap

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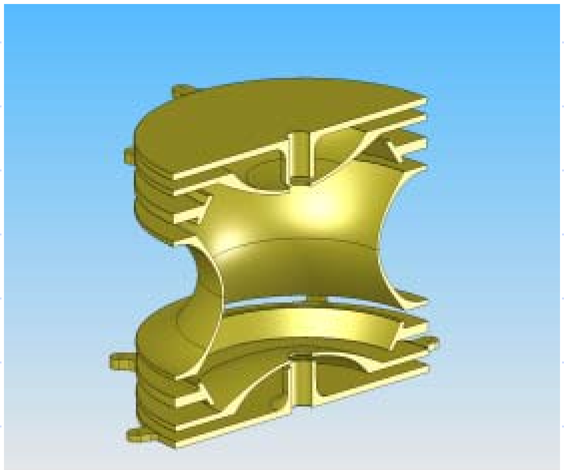
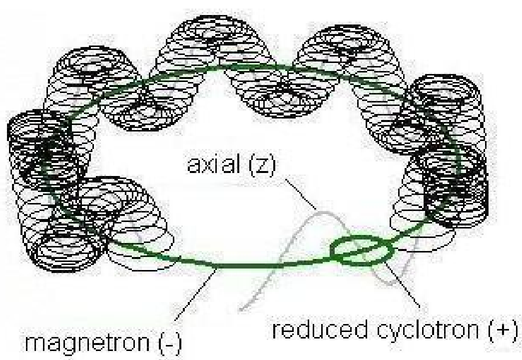
'05 TITAN collaboration meeting

Short review of TITAN Penning Trap





Three eigenmotions:
- Axial ν_z
- Reduced cyclotron ν_+
- Magnetron ν_-

$$\nu_- << \nu_z << \nu_+$$

Electrode Structure:
- Two end caps
- Ring electrode in one piece
- Split ring electrode
- Two end cap electrodes to correct field inhomogeneities

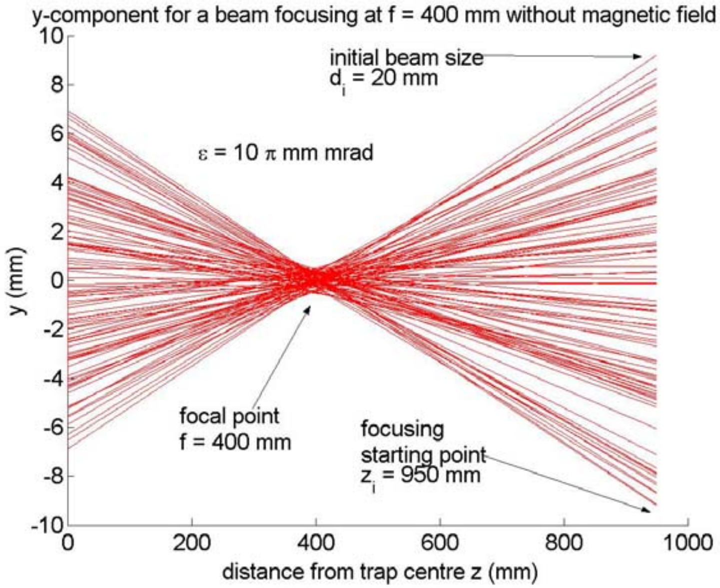
Mass measurement:
- Ideally, all ions start in the magnetron mode
- The RF-potential applied on the correction electrode couple (-) and (+) modes.
- Depending on the frequency of the RF-field, ion can finish in complete reduced cyclotron mode

Injection optimization goal

There are two parameters that need to be minimized as the beam enters the Penning trap:

- The final beam size. The beam entering the trap will need to be radially shifted in order to start the excitation in a complete magnetron mode of well define amplitude. Therefore, one wants to minimize the beam diameter since small beam sizes are easier to manipulate.
- The radial kinetic energy. In the strong magnetic field region, the ion undergoes a cyclotron motion around the field lines. For a proper mass measurement, one needs to minimize this cyclotron motion (the presence of an initial cyclotron motion increases the uncertainty on the TOF spectra).

Injection parameter



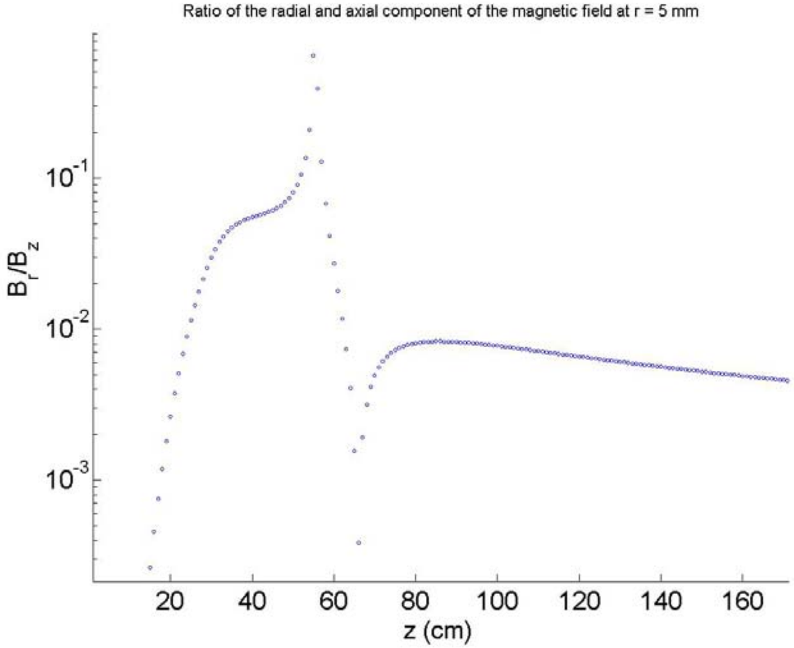
The final beam size is minimized according to three parameters before adding any optical elements:

- Initial beam size d_i
- Focal point position f
- Focusing starting point (einzel lens position) z_i

Other initial beam characteristics:

- Initial axial energy E_r = 5 keV
- Axial energy spread: ΔE = 5 eV
- m/q ratio = 2-3 amu/e
- Emittance $\varepsilon = 10\pi$ mm mrad

Searching range

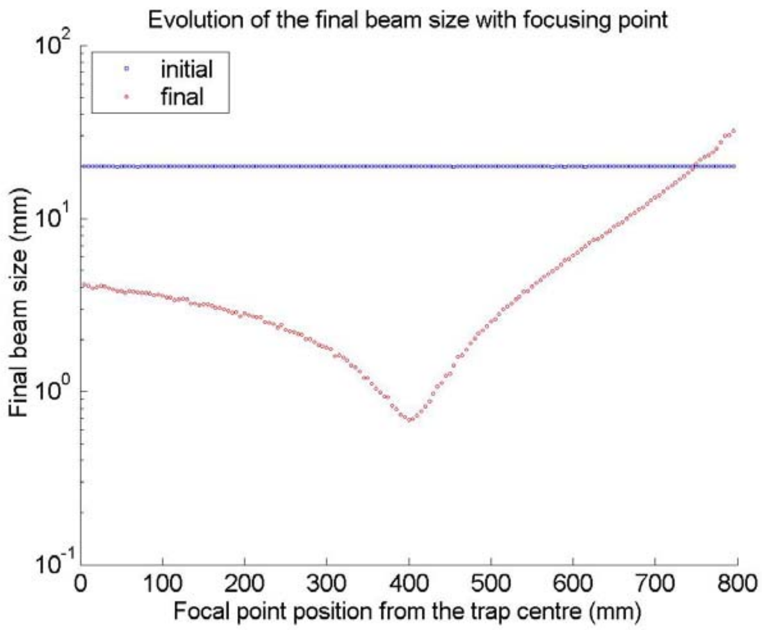


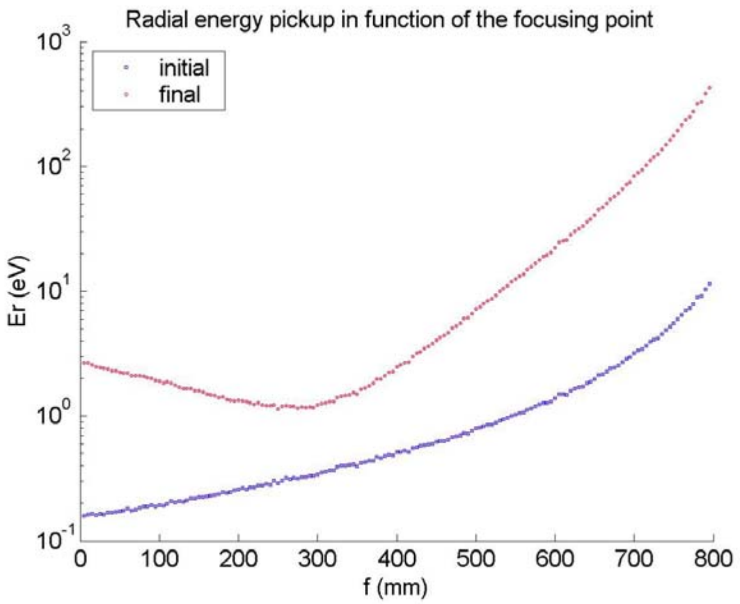
The magnetic field behavior reduces searching range:

- Shouldn't start to focus the beam for $z_i < 70$ cm, since the high Br/Bz value will blow up the beam
- For practical purpose, don't want to big initial beam: $d_i < 50$ mm

Parameter variation

- For f variation, set z_i = 900 mm, d_i = 20 mm
- Position where df is minimal: f_{min} = 400 mm
- After, keeping this value, d_i and z_i are varied separately
- Note: for each parameter's variation, E_r and d_f presents only one minimum. Not a local minimum.

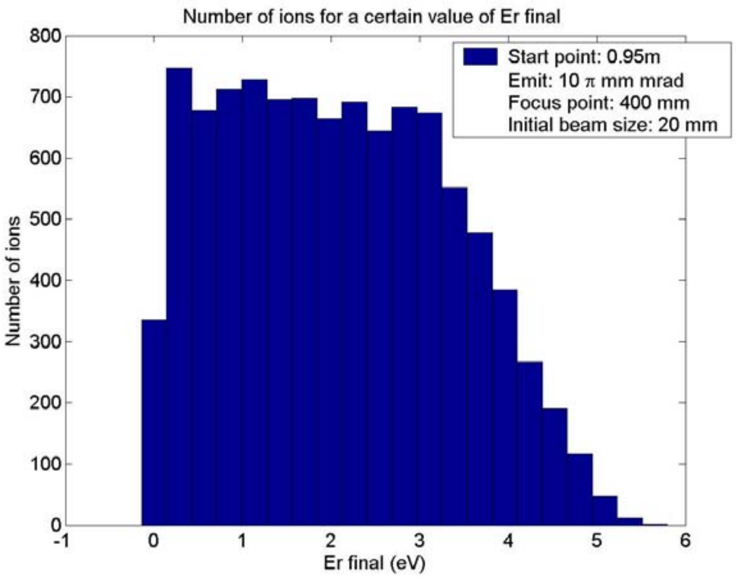




Beam characteristics

- Simulations uses initial flat beam of 10 π mm mrad emittance.
- To reduces uncertainty, the cyclotron motion is taken out of the determination of d_f.
- Results:

Miniamal beam size caracteristics	
Emittance	10 π mm mrad
Initial beam diameter	20 mm
Lens position	950 mm
Focal point	400 mm
Average Er at df min	2.1 eV
Radial energy spread	5 eV

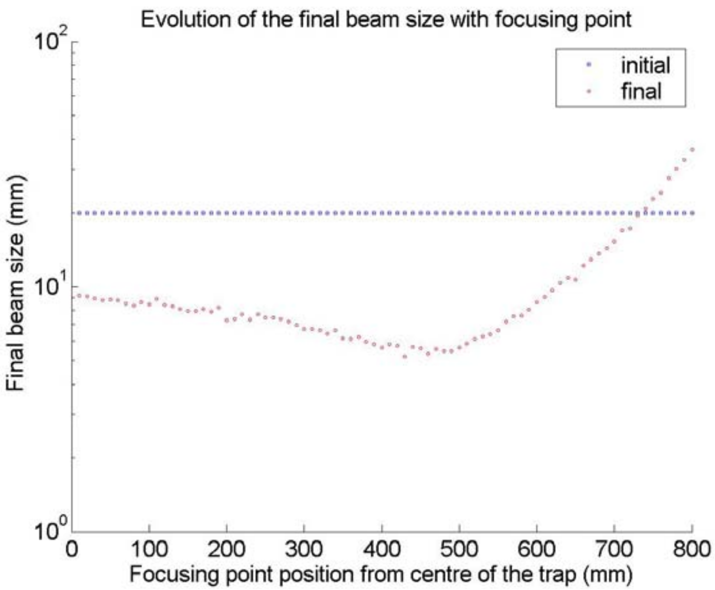


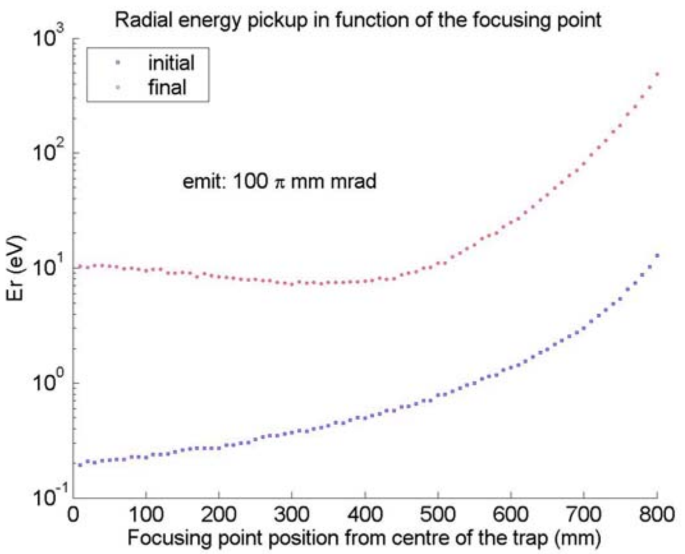
100 π beam

- For a 100 π mm mrad emittance beam, the minimal final beam size found is

  d_f = 5 mm.
- The fianl radial kinetic energy: E_r = 7.4 eV. This correspond to a cyclotron radius 2 times larger then for a 10 π beam.

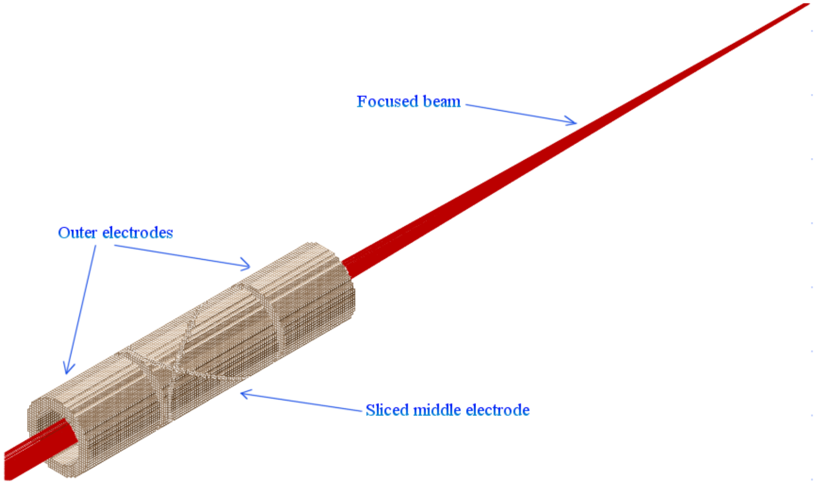
  And ΔE = 25 eV
- Important to have a low emittance beam





Adding the Einzel lens

- An Einzel lens has been add to the simulation.
- The z_i value correspond to the beginning of the second grounded electrode
- Due to finite size of the Einzel lens, beam doesn't focus a dimensionless point.
- Potential difference V = 1800 V applied on the central electrode.
- Final beam size of 1 mm.



Conclusion

- The optimal position of the Einzel lens is: z_l = 950 mm from the trap centre.
- One needs to apply a potential difference of 1800 V between the outer and central electrode in order to focus the beam at 400 mm from the trap centre.
- The use of a Lorentz steerer is proposed in order to reduce the final radial energy spread.
- Further study of the steering & deflecting effect of the sliced Einzel lens will be made.

Acknowledgement

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