Summary Warp Simulations

By Frank Nürnberg, Mai 2010

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„Wenn Star Trek weiß wie ein Warp Antrieb gebaut wird, warum baut den dann keiner JETZT!?“

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Experiment Jan. 2010 @ Phelix

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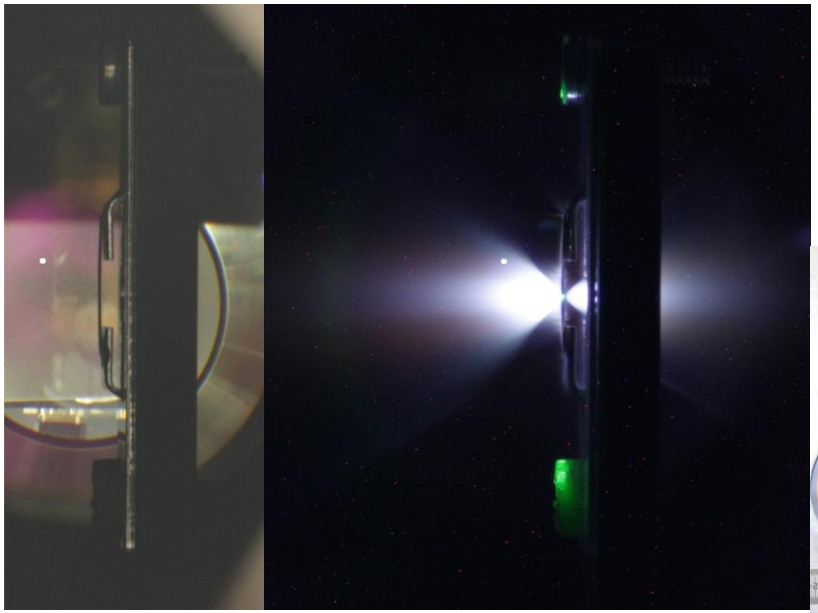

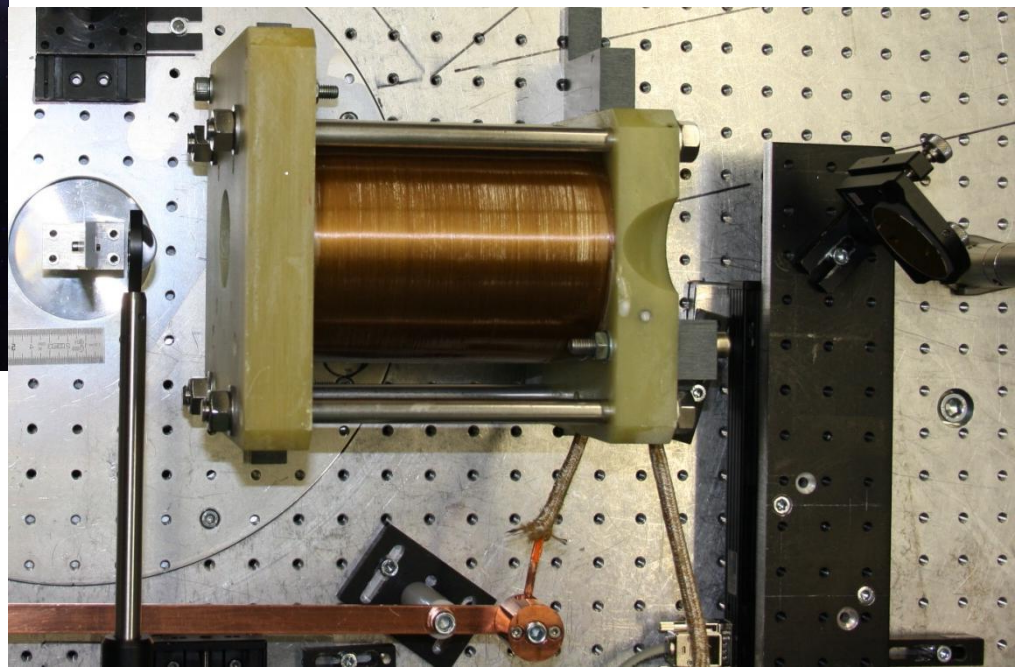

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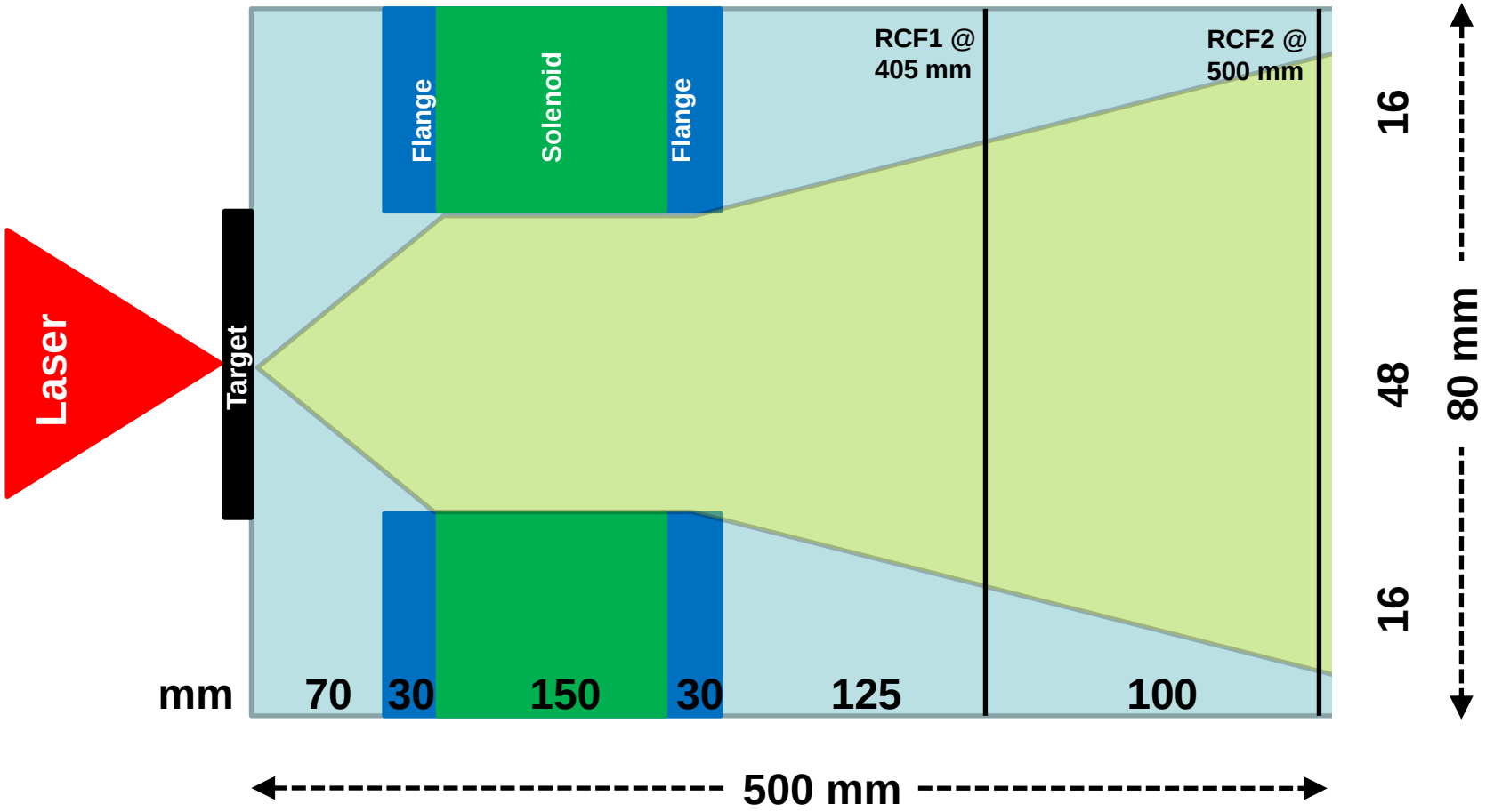
Warp Setup


Laser
Target
Flange
Solenoid
Flange
RCF1 @
405 mm
RCF2 @
500 mm
16
48
16
80 mm
mm
70
30
150
30
125
100
500 mm

Source parameters

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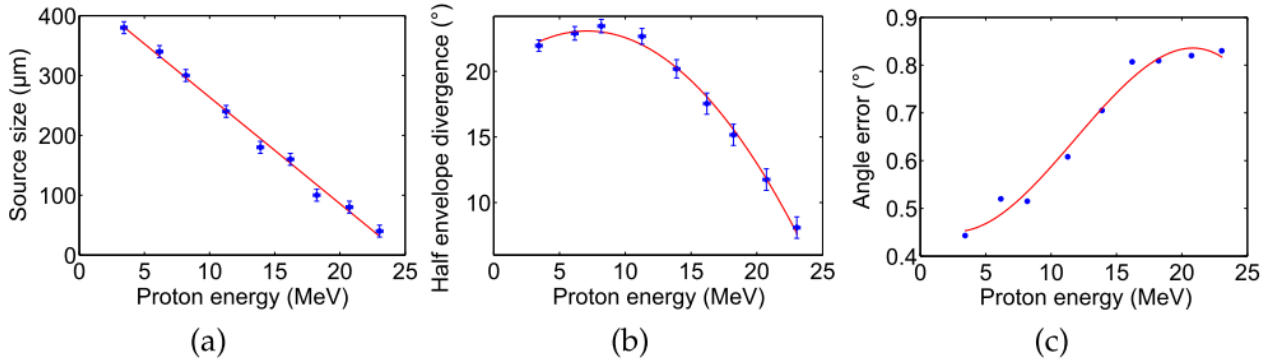
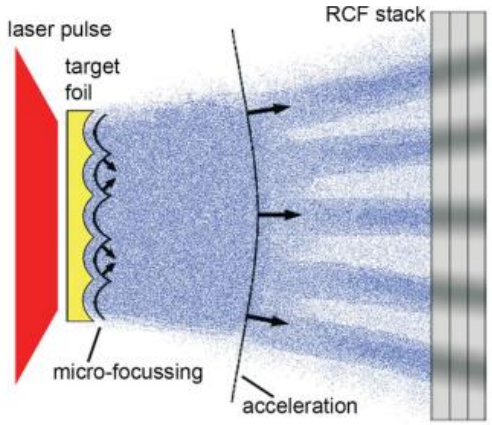
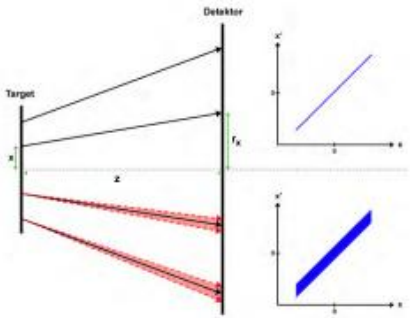
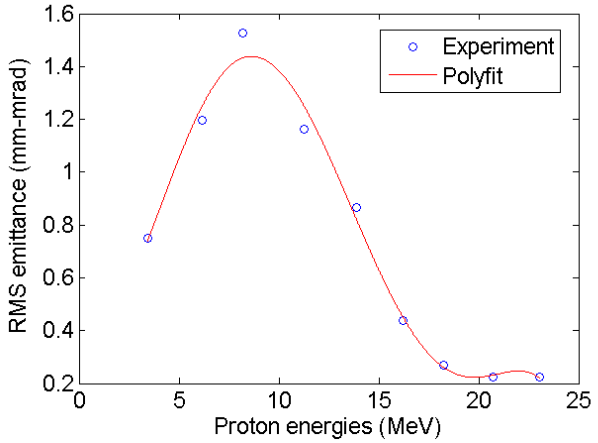


Figure 3: Proton beam parameters of the Phelix shot 18 for the Warp particle loader: experimental data (•) and polynomial fits (—) of the source size (a), the envelope divergence (b) and the angle error for the transverse beam emittance (c).







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Plasma and simulation criteria

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- Resolving **plasma frequency**: $\omega_p \cdot \Delta t < 1$
  → Volume source because of n_e
  → Δt = 75 fs (680 steps = 51 ps), Δt = 1 ps (21000 steps)

- **Courant criterion**:
  → Δt = 75 fs: $\Delta s(E_{p,max})$ = 5 µm, $\Delta s(E_e$=300 keV) = 17 µm
  → Δt = 1 ps: $\Delta s(E_{p,max})$ = 65 µm , $\Delta s(E_e$=300 keV) = 232 µm

- **Debye length**
  → grid
  → convergence check: 1000/500/250/100 µm

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Self fields: off (top) /on (bottom)

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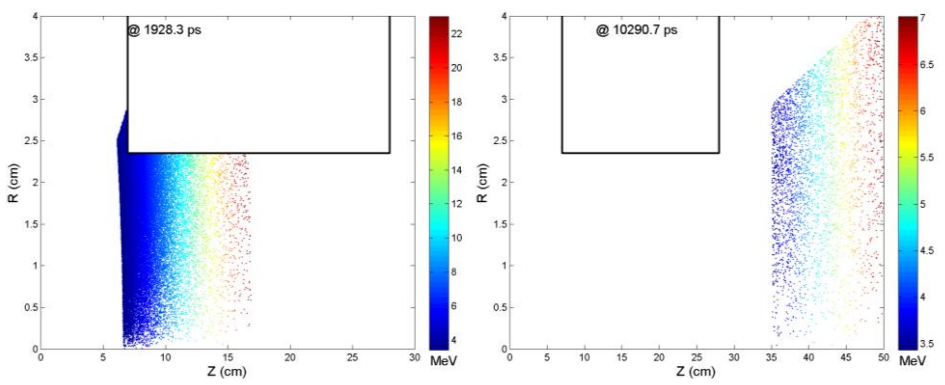
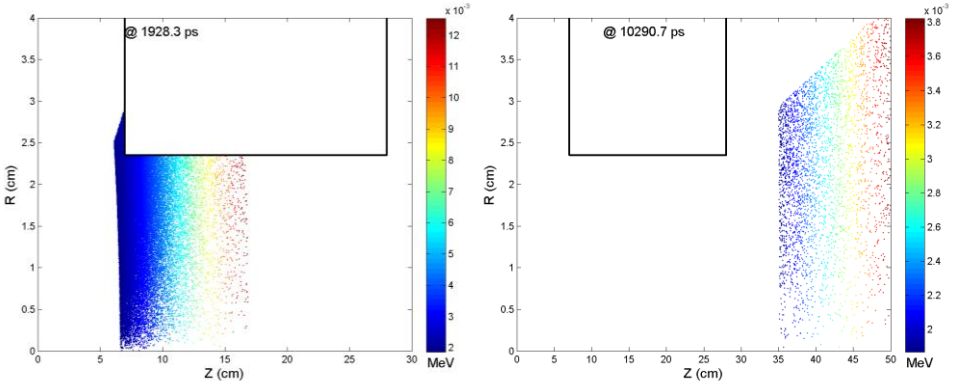
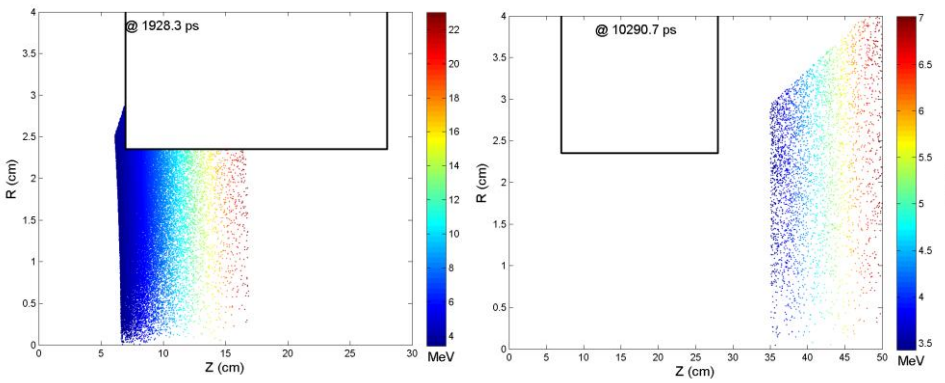
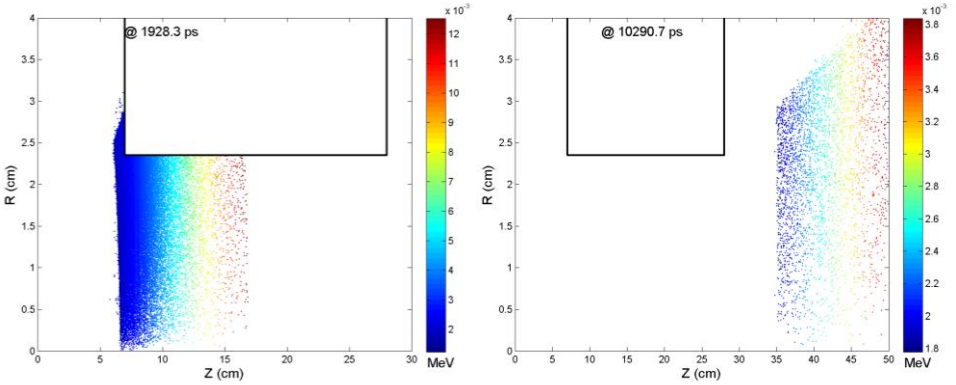
Protons (left), electrons (right)



Protons (left), electrons (right)







95 % of all protons get lost in the solenoid for both cases

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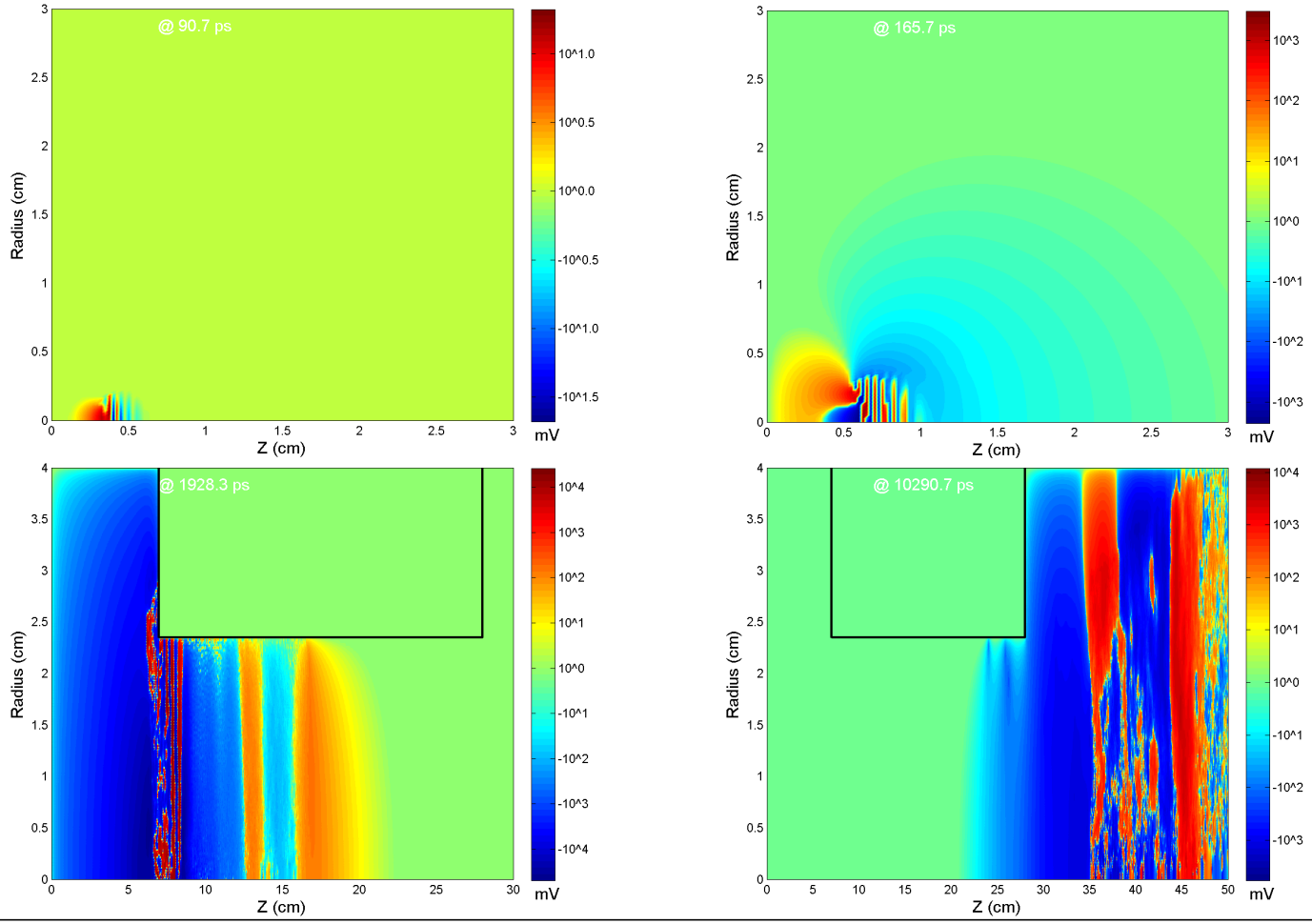
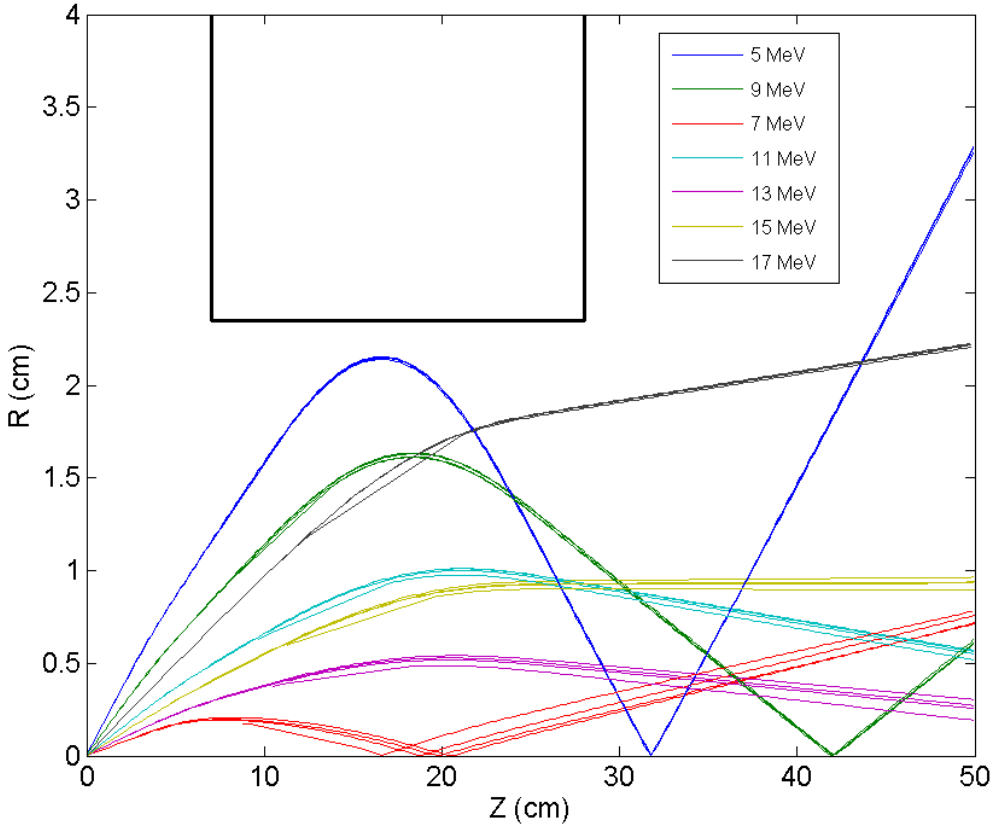
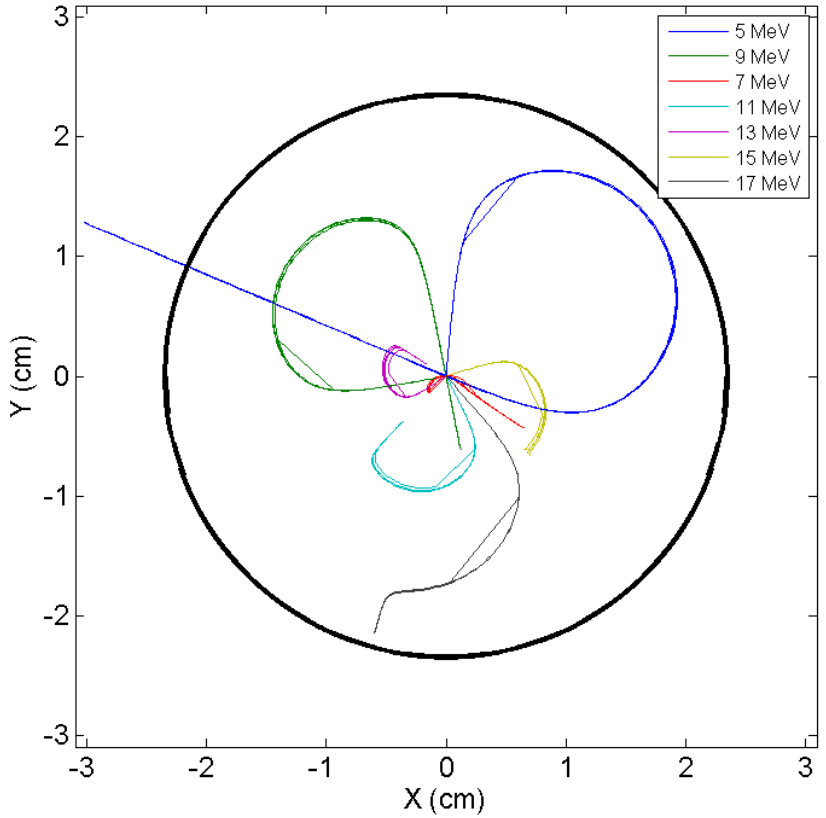
Beam neutrality: potential



Convergence check - protons





Convergence check - electrons

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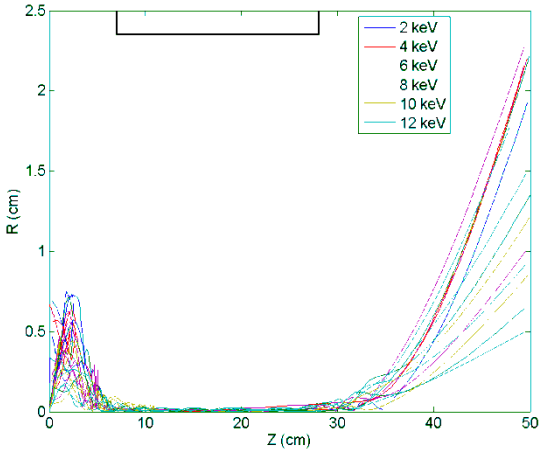

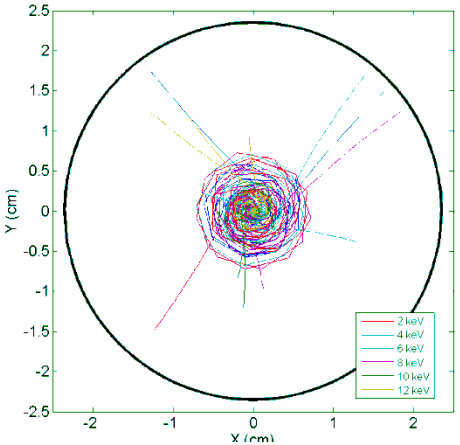

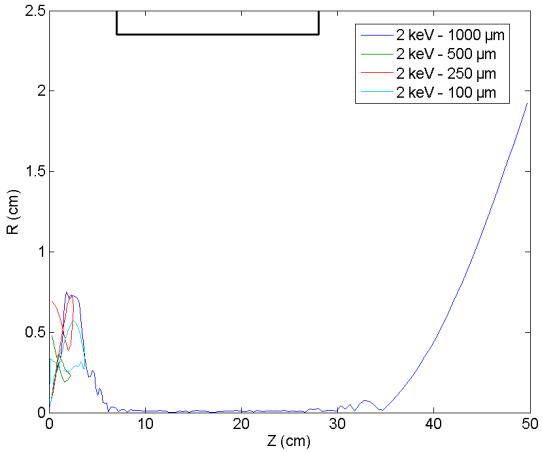

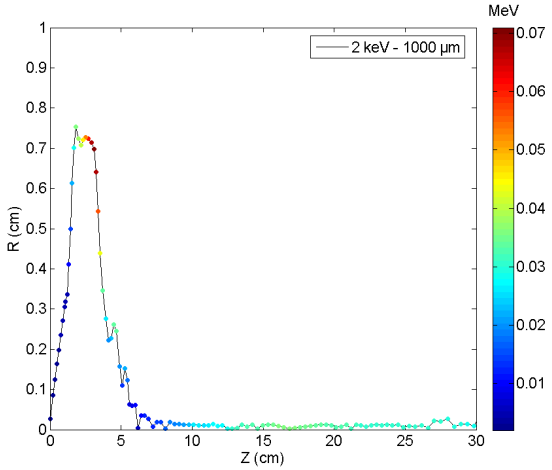

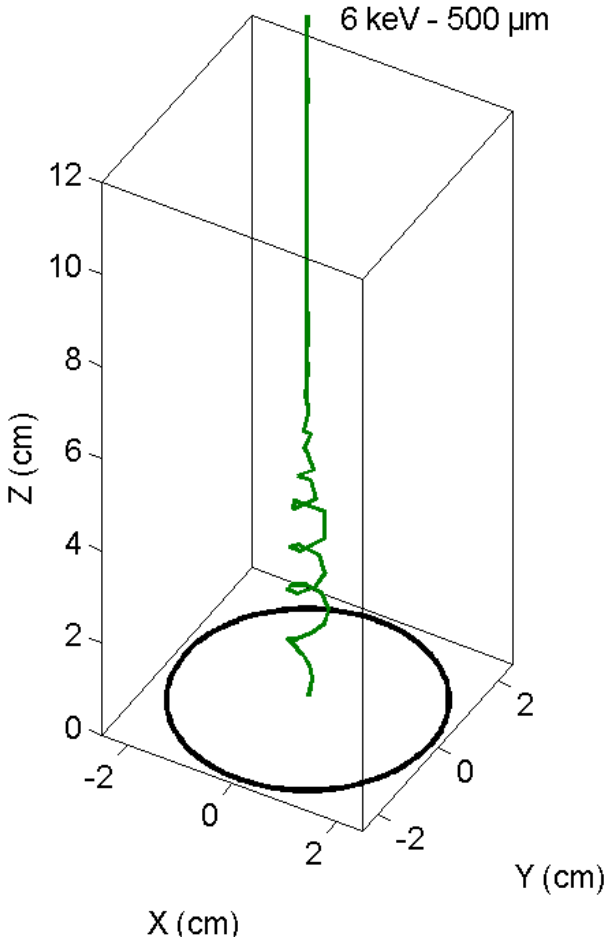

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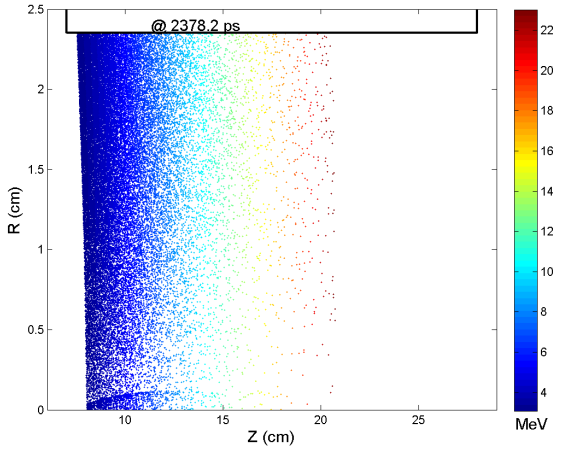
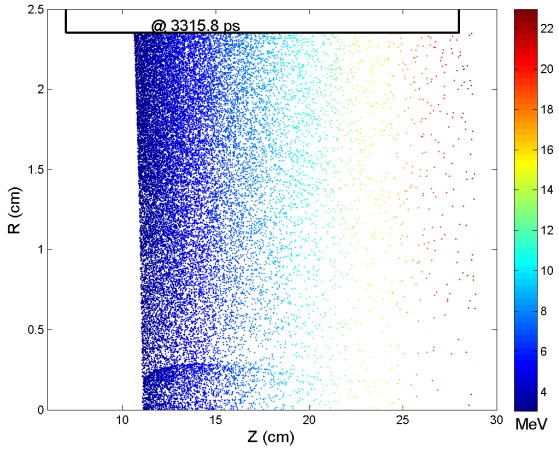
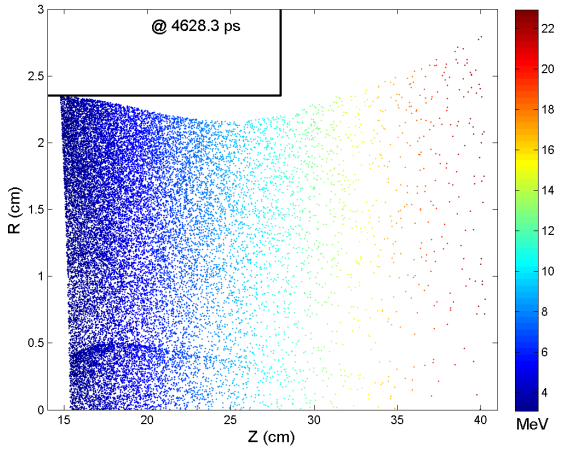
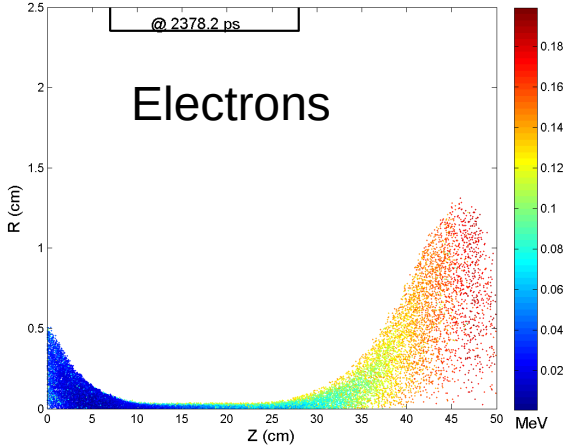
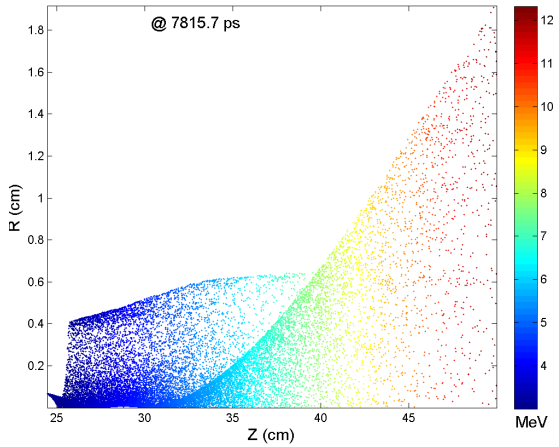
Proton aggregation

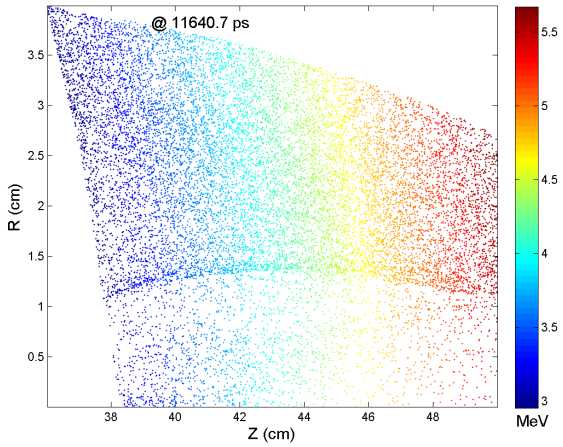




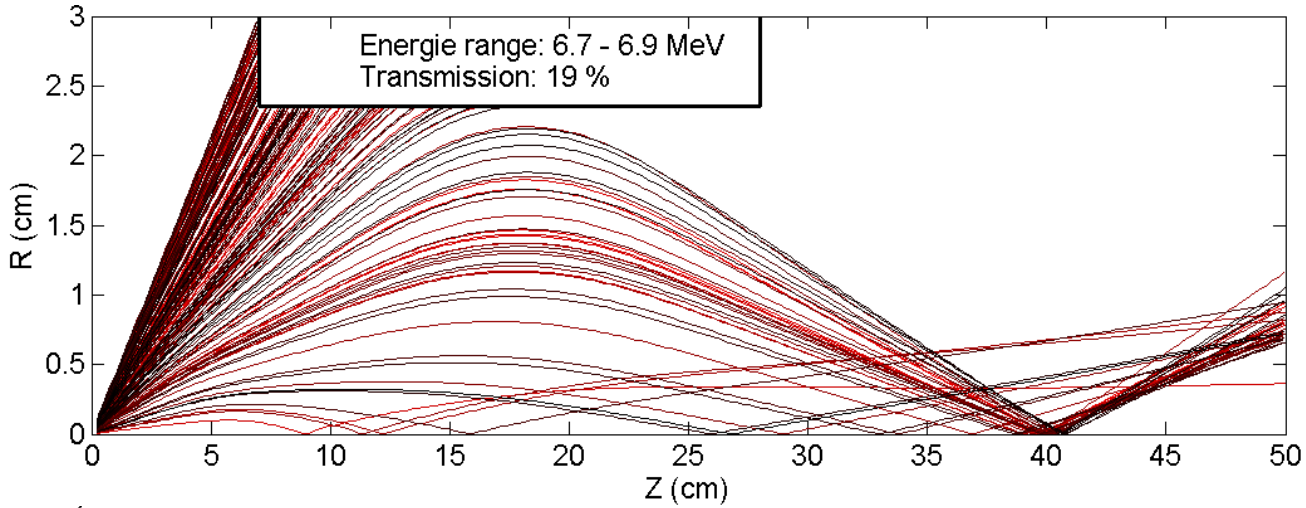




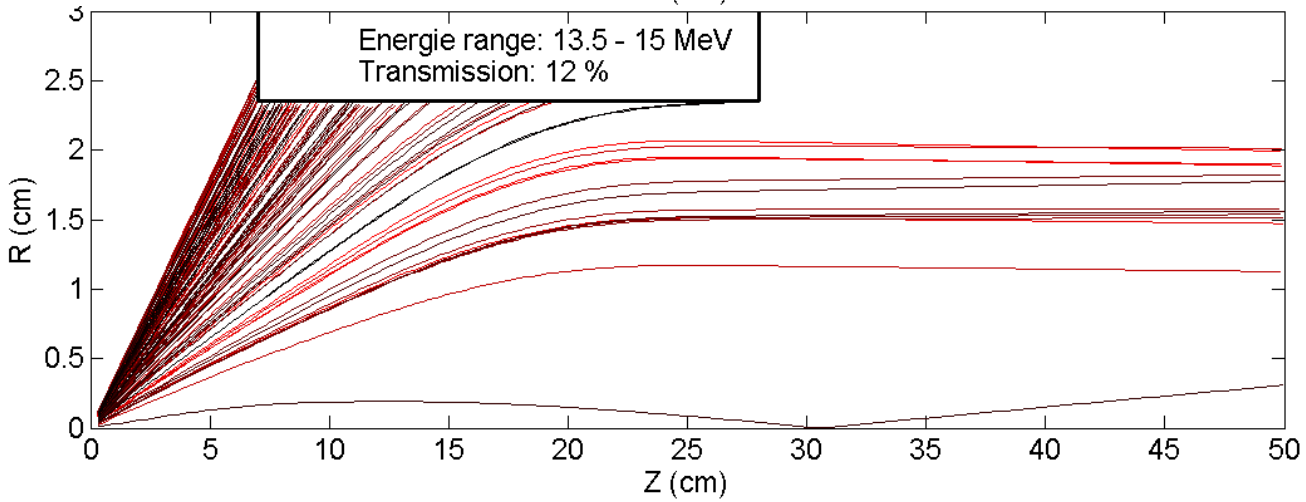




Focus and collimation



7.1e+9 protons



2.7e+9 protons

Emittance growth

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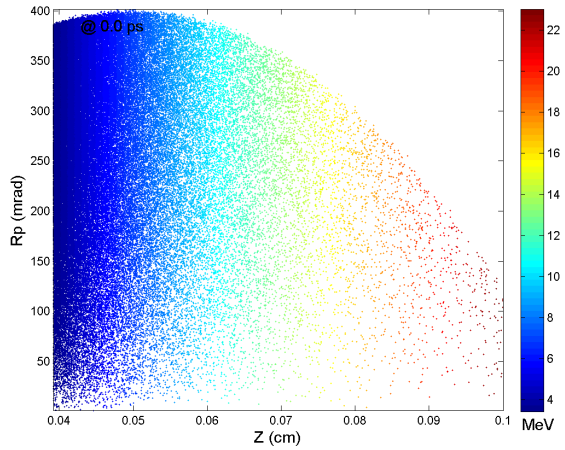

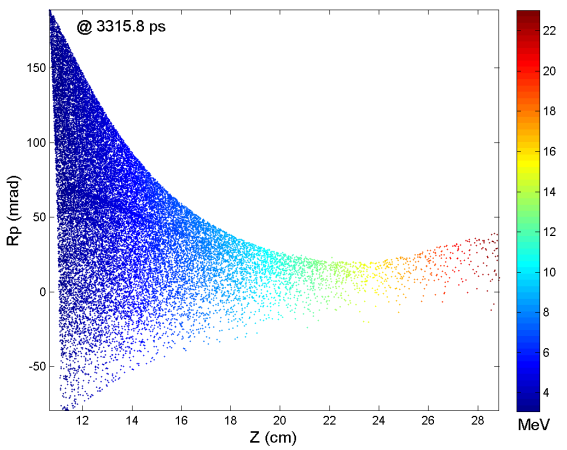

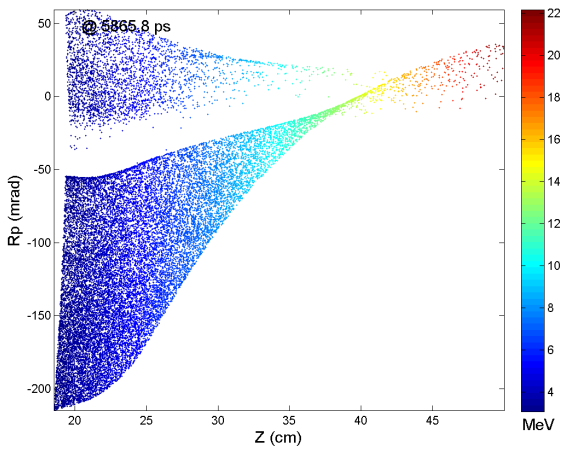

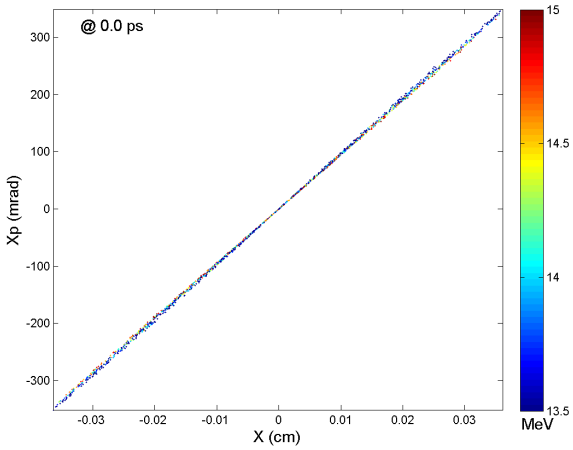

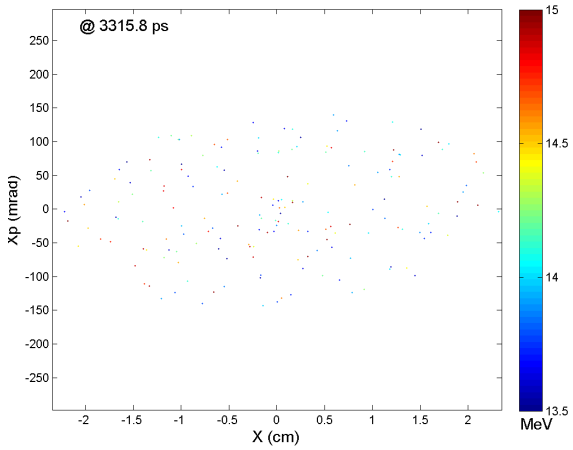

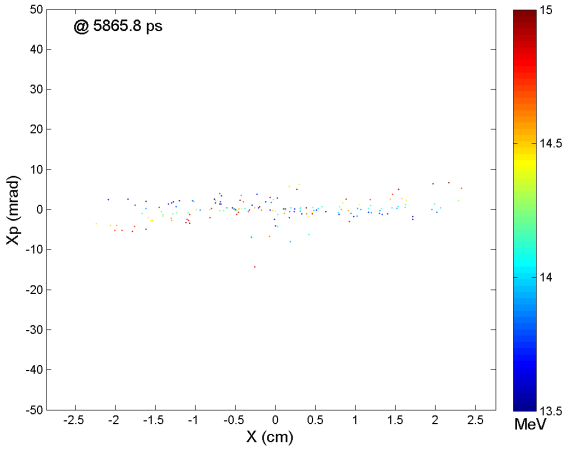

10 mrad x 0.7 mm = 0.7 mm-mrad

200 mrad x 40 mm = 8000 mm-mrad

10 mrad x 40 mm = 400 mm-mrad

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RCF stacks: with B and without B

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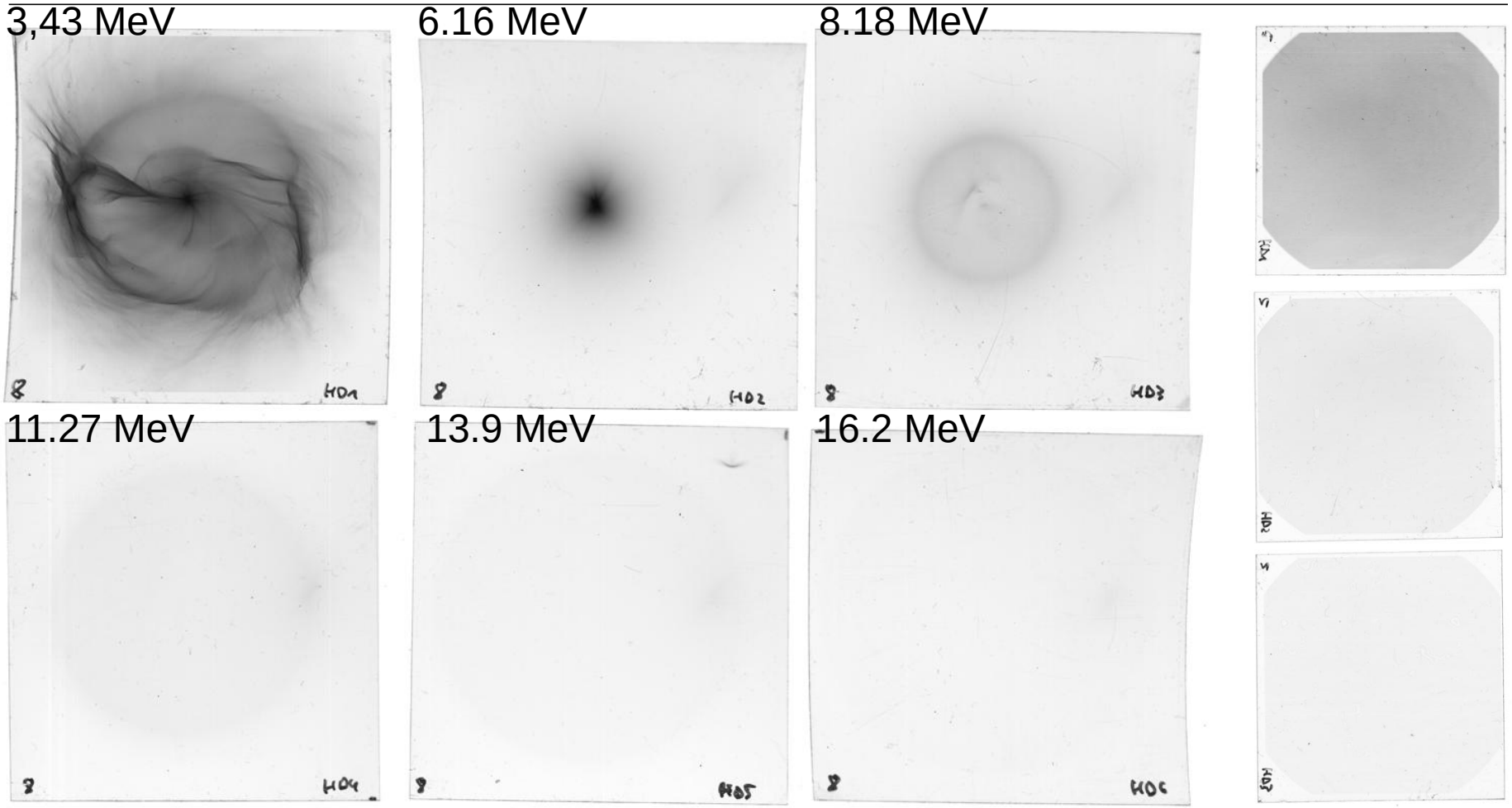

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Warp simulation: RCF stack

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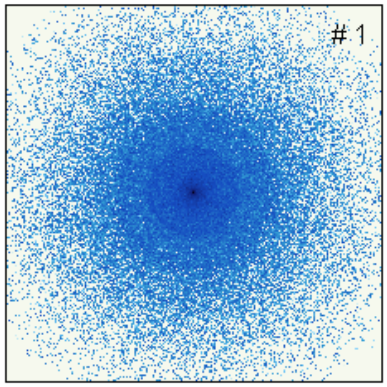
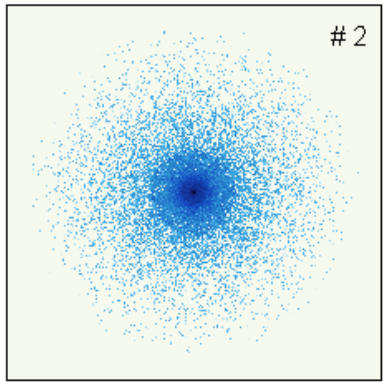
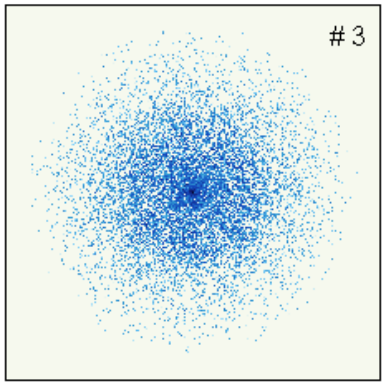


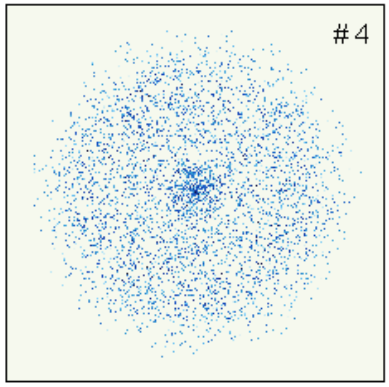
3,43 MeV
11.27 MeV

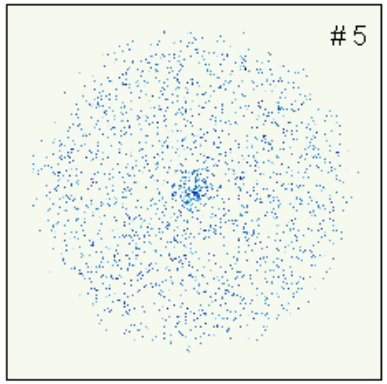


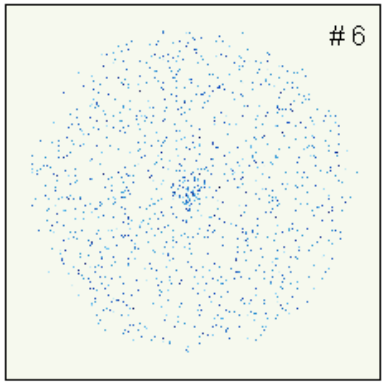
6.16 MeV
13.9 MeV



8.18 MeV
16.2 MeV







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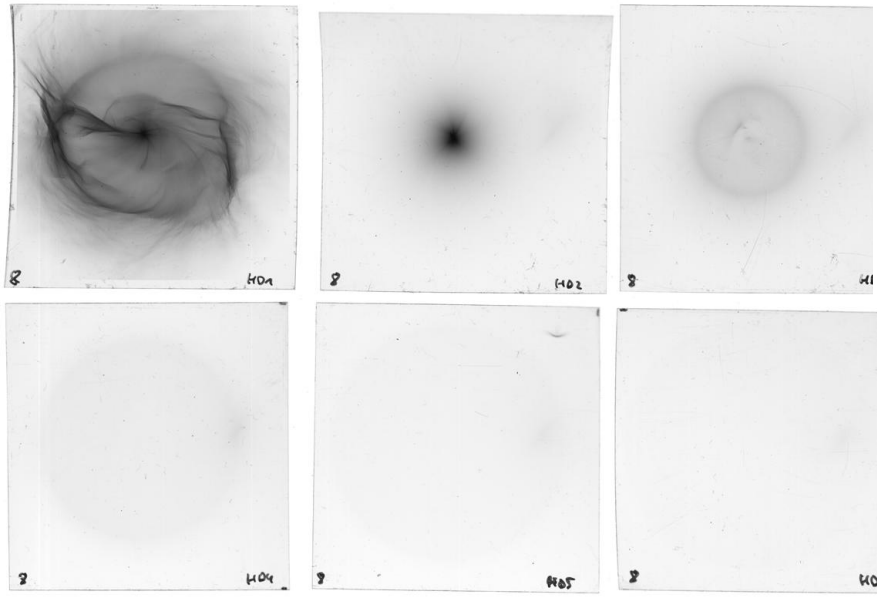
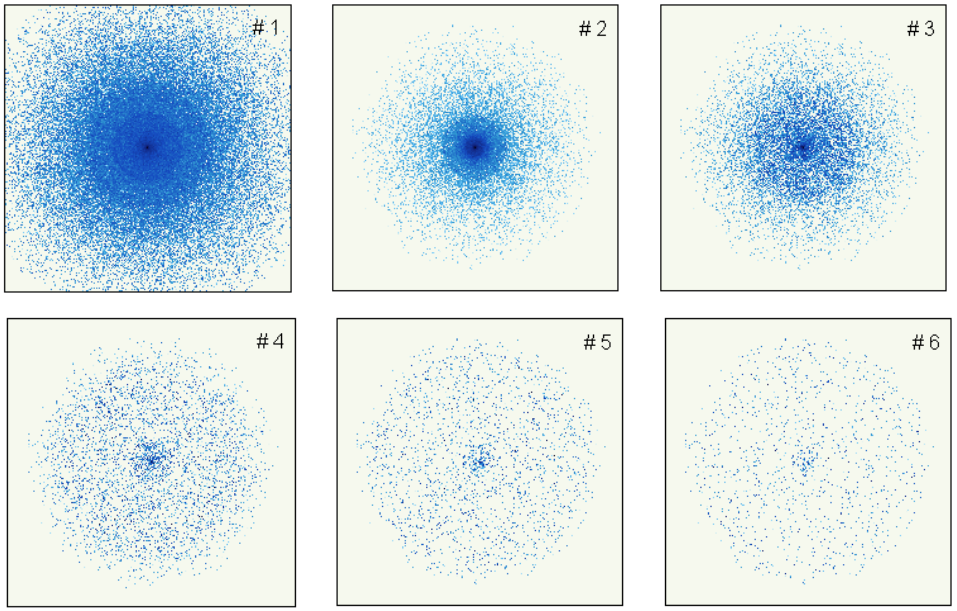
Comparison

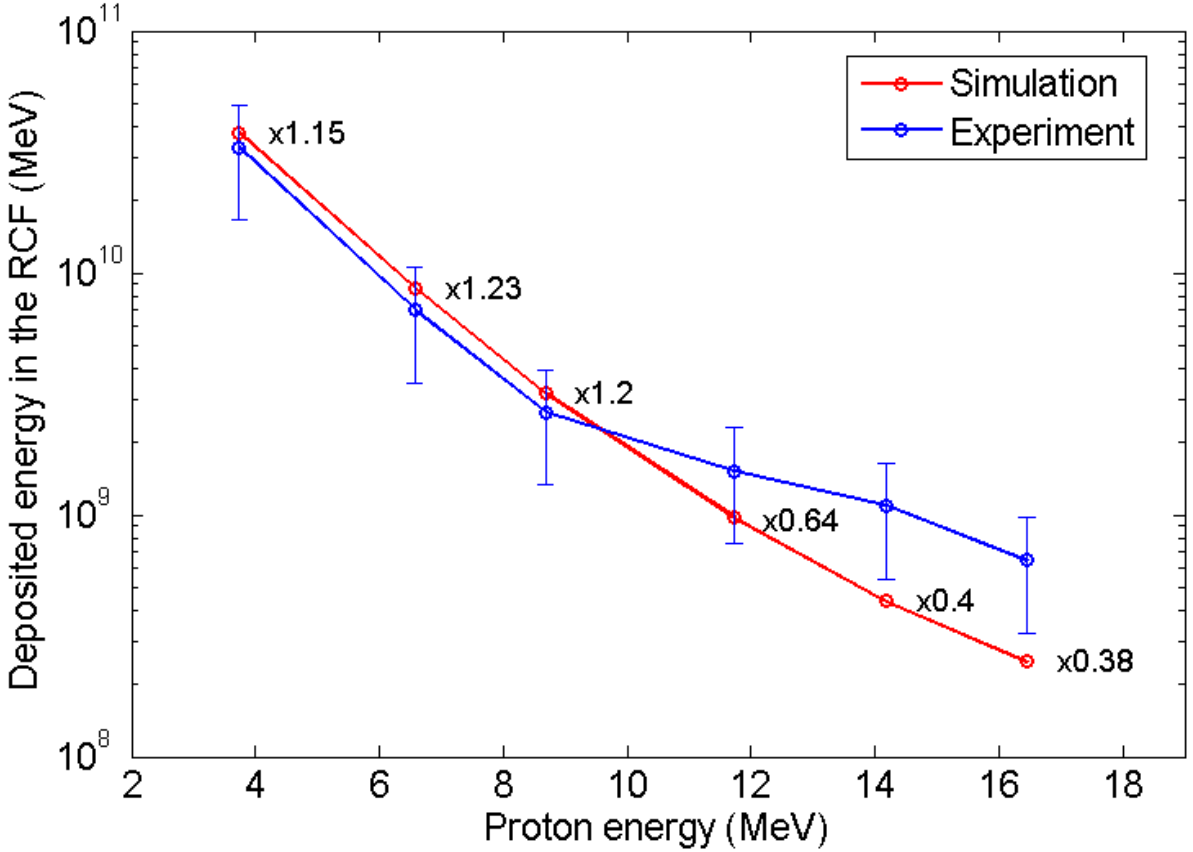




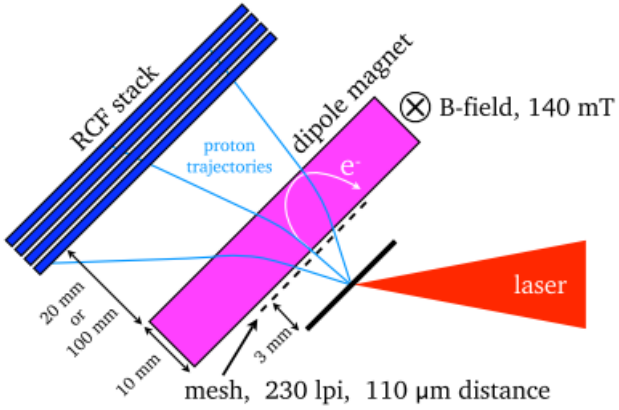
#1: outer ring / inner ring / spot r = 21/9/2 mm
#2: halo / spot r = 6/2.5 mm
#3: ring: outer/inner r = 13.5/10 mm
#4: r = 23.5 mm
#5: r = 26.5 mm
#6: r = 28.5 mm

#1: outer ring / inner ring / spot r = 14/8/1.5 mm
#2: halo / spot r = 7/2.5 mm
#3: ring: outer/inner r = 11.8/7.4 mm
#4: r = 25 mm
#5: r = 26.8 mm
#6: r = 27.5 mm

Warp simulation: comparison



Dipole



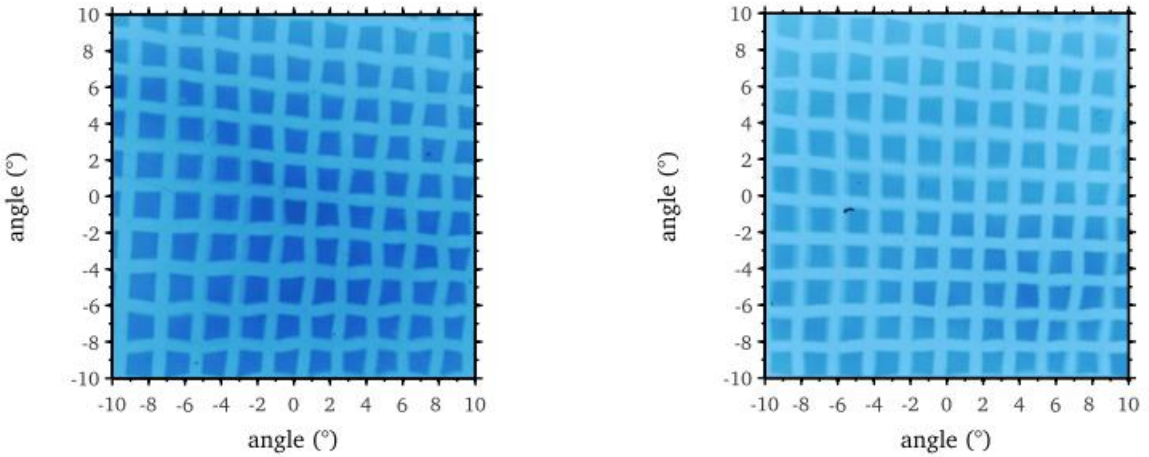
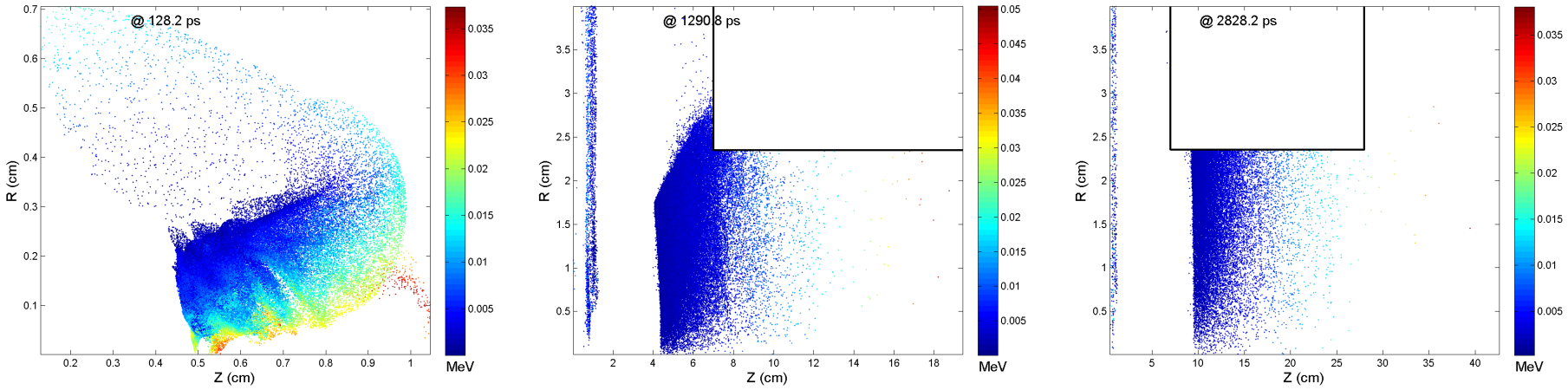


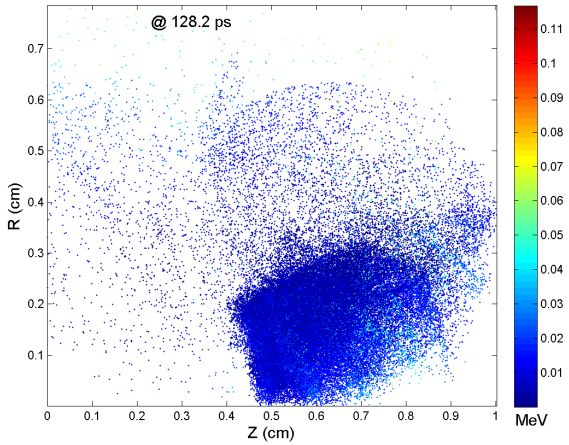
Figure 4.18: Mesh imprint for 8 MeV protons 2 cm (left) and 10 cm (right) behind the dipole.

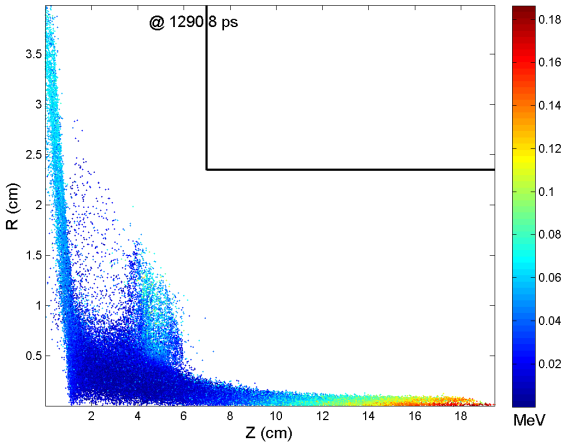
Dipole 140 mT, no solenoid

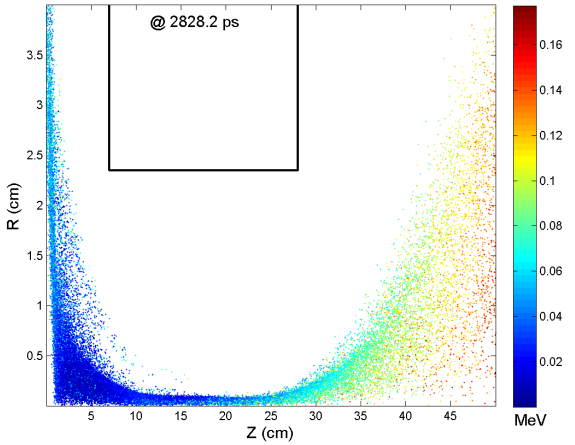


Transmission of electrons through the solenoid:
Without dipole: 4.7 % - with dipole: 4 %
With dipole and solenoid: 20.3 %

Dipole 280 mT with solenoid







Transmission of electrons through the solenoid:
With dipole 140 mT and solenoid: 20.3 %
With dipole 280 mT and solenoid: 21.2 %

Outlook

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- Optimizing setup for transmission
- Dipole
- Energyselection using 2 solenoids
- Solenoid-drift-compression-focussing
- Quadrupol triplett
- 1-D parameter

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Results/ideas meeting

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- Check detector image if self-fields/solenoid-field off
- Check initial expansion: potential, particles per cell, grid
- Convergence check: decrease gid size AND increase particle number
- Concentrate on energy window for collimation and focussing (save only particles in this window)
- Energy conservation
- Different initial electron distribution to avoid oscillations

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