

Simulation Study on Transporting, Focusing & Energy Selection of TNSA Protons by a Pulsed Solenoid

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Beam physics for FAIR 2012

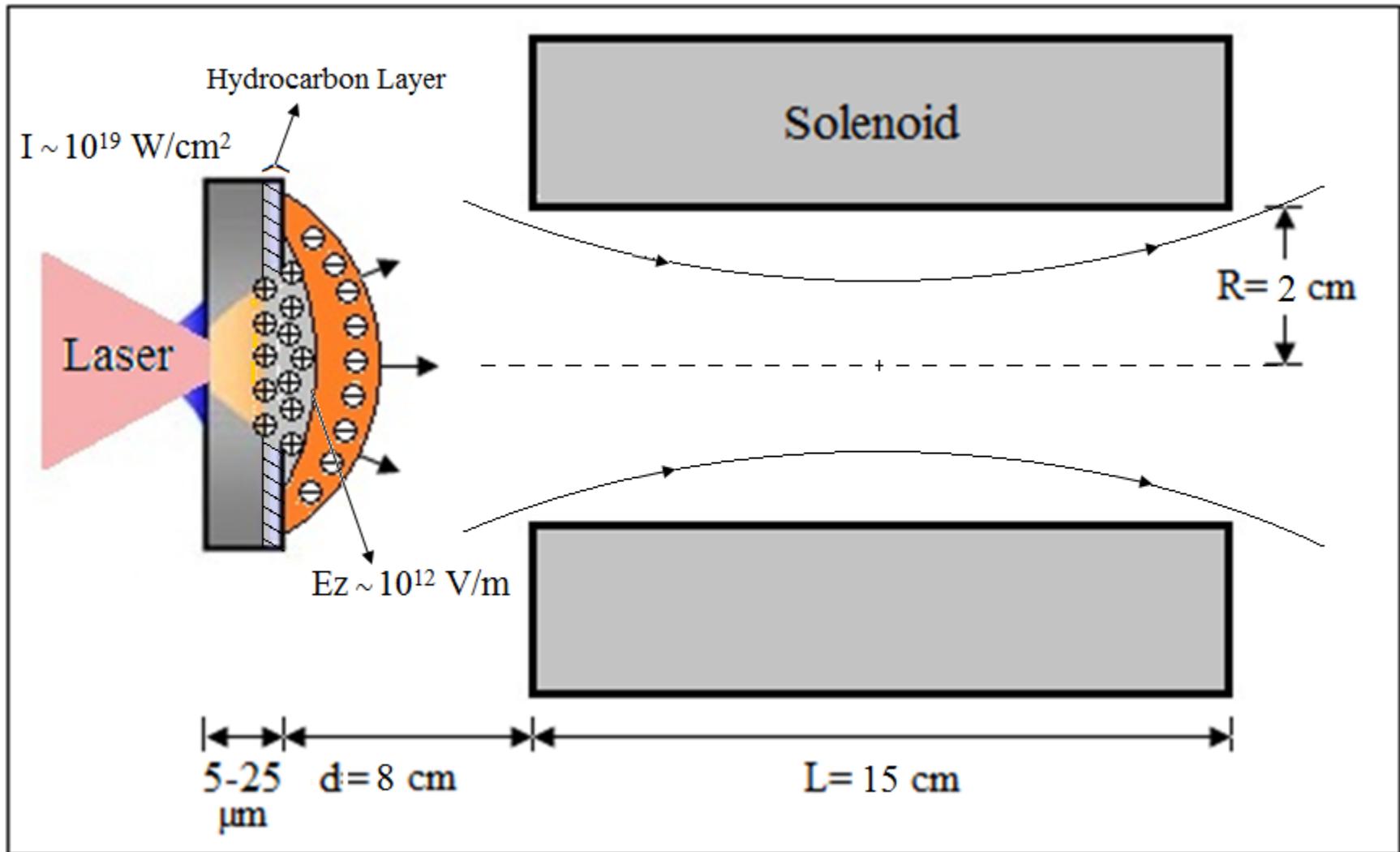
May 10th – 11th 2012

Mossautal-Gütersbach

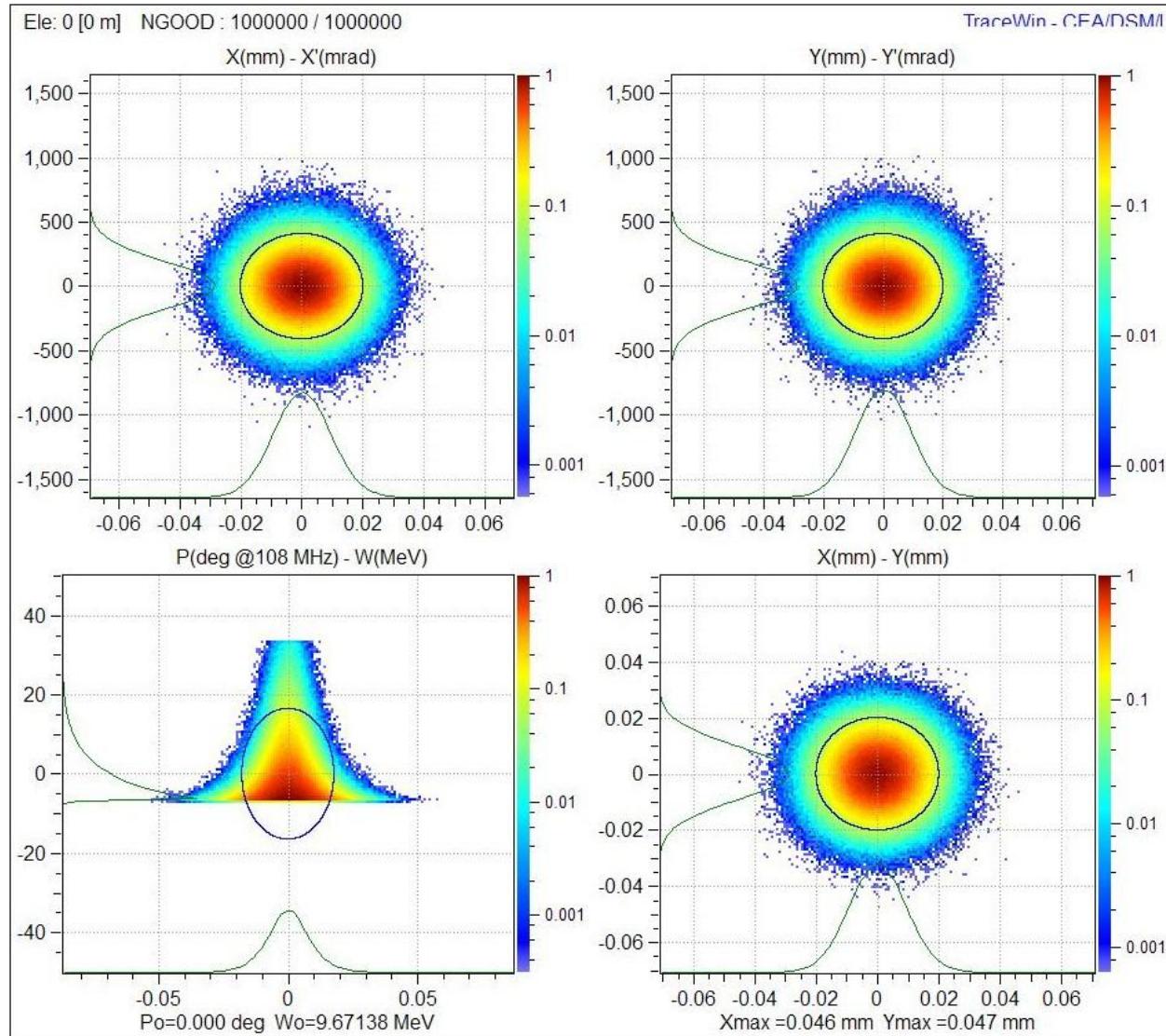
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- Solenoid focal spot:
 - Energy spectrum
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 - Smoothing & energy de-correlation of beam profile
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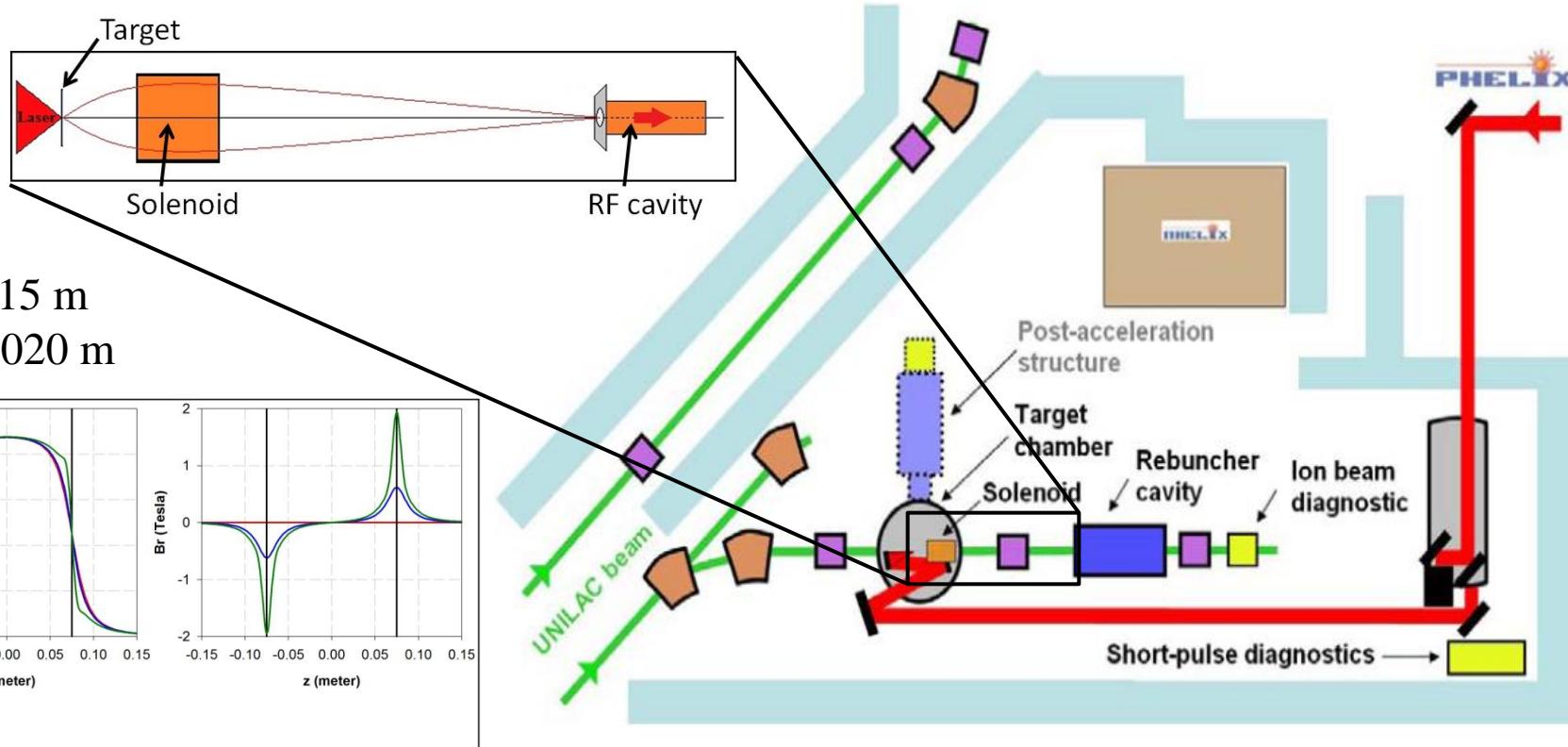
Target Normal Sheath Acceleration (TNSA)



Realistic distribution fitted to PHELIX Data



Region of interest in LIGHT

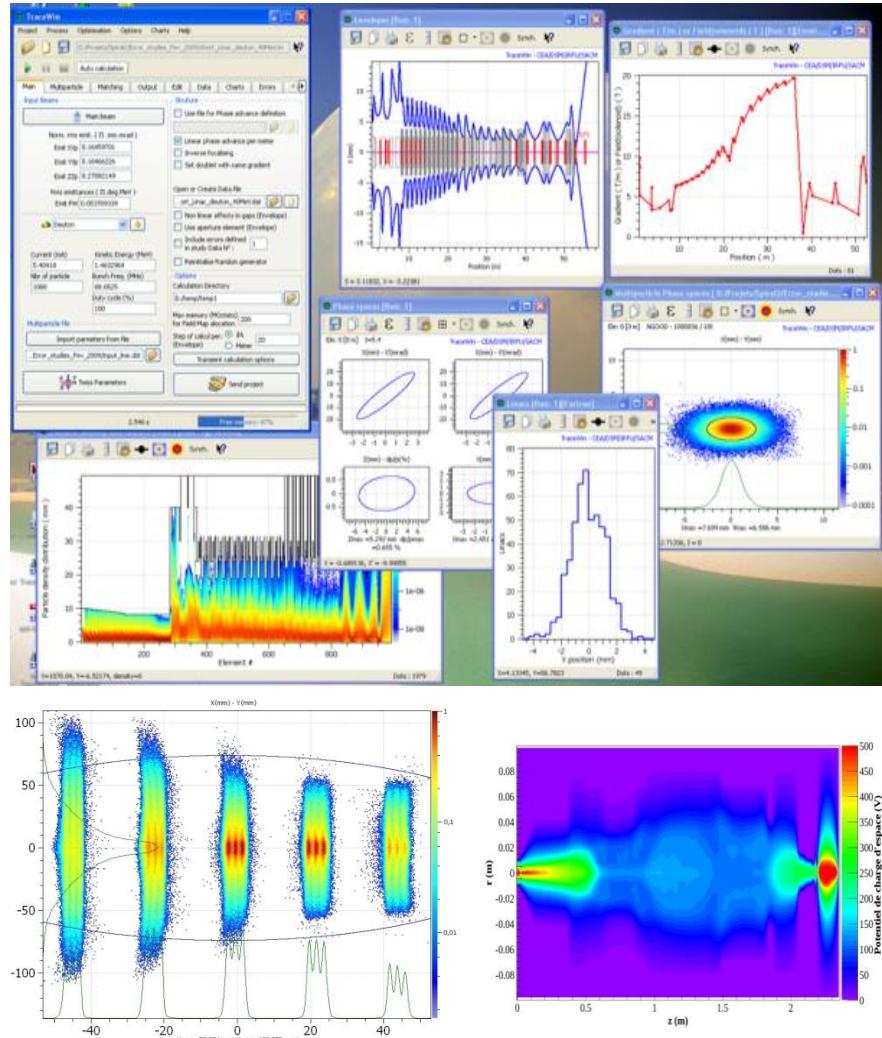


- $L = 0.15 \text{ m}$
- $R = 0.020 \text{ m}$

- The beam deviate from the expected focal spot due to: chromatic, geometric, space charge, diffraction, mechanical misalignment ...etc.
 - Chromatic: str. $E_{\text{Low}} >$ str. E_{High} (mono- Ω_i)
 - Geometric: str. $\Omega_L >$ str. Ω_S (mono- E_i)
- } Enlargement emittance

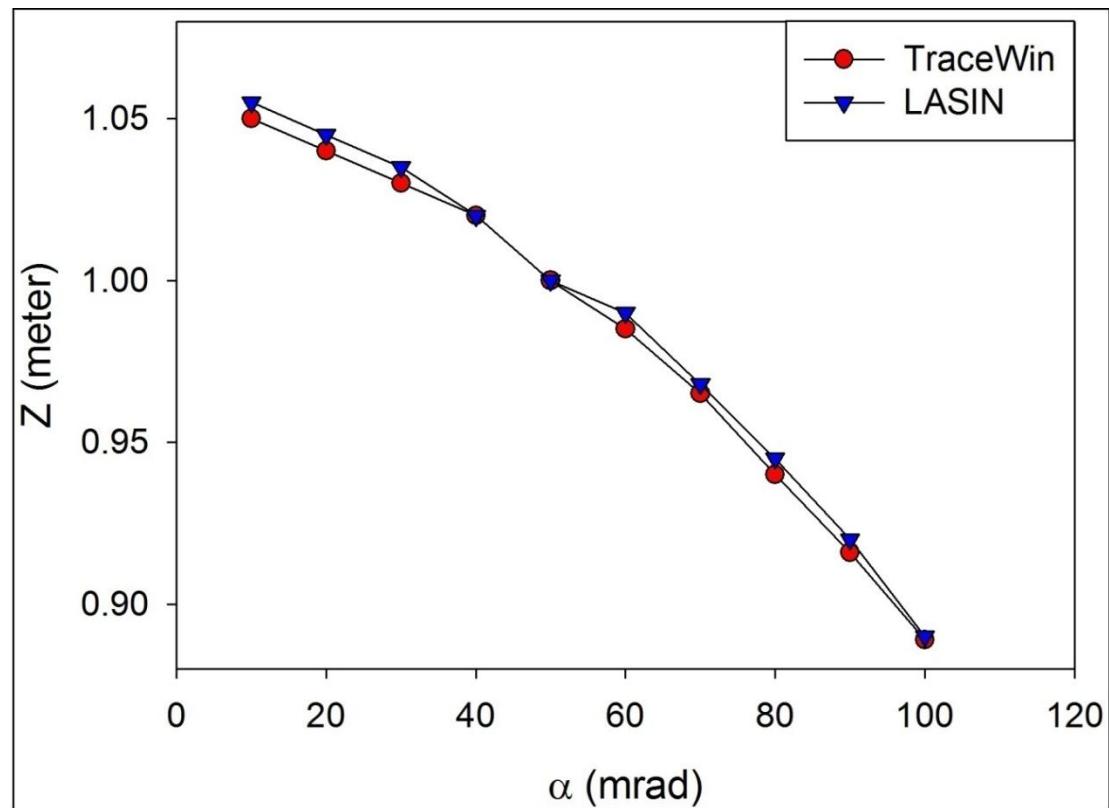
TraceWin Code

- Particle in cell code with envelope option (different elements of LINAC structure).
- Envelope, beam ellipses, emittances... etc.
- 3D space charge effect and space charge compensation or current map can be implemented (evolution of space charge and current in the longitudinal position).
- Standard and generated distribution.

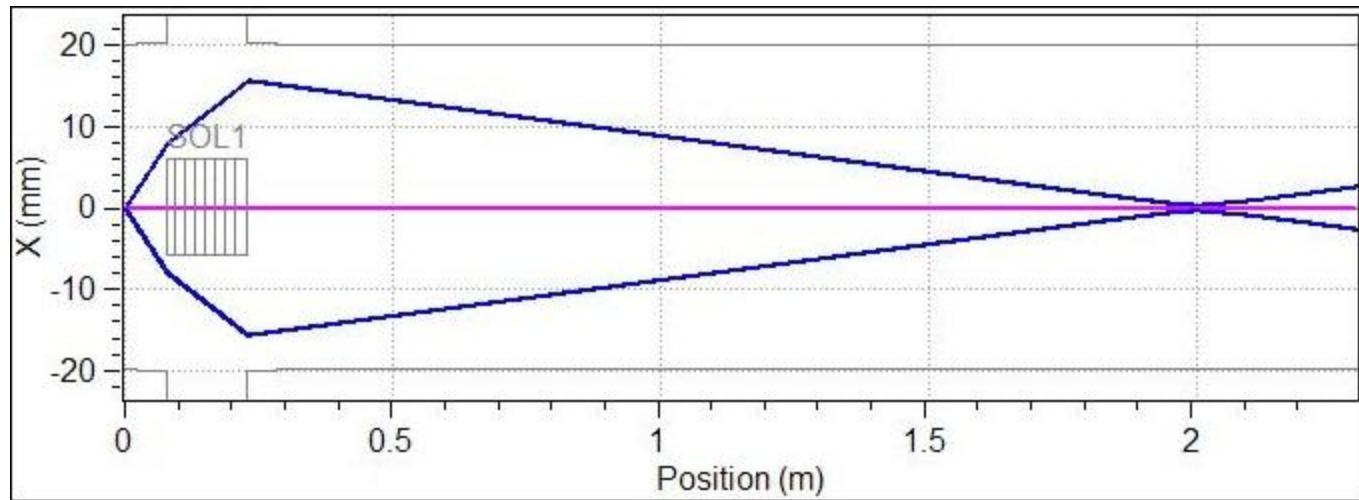
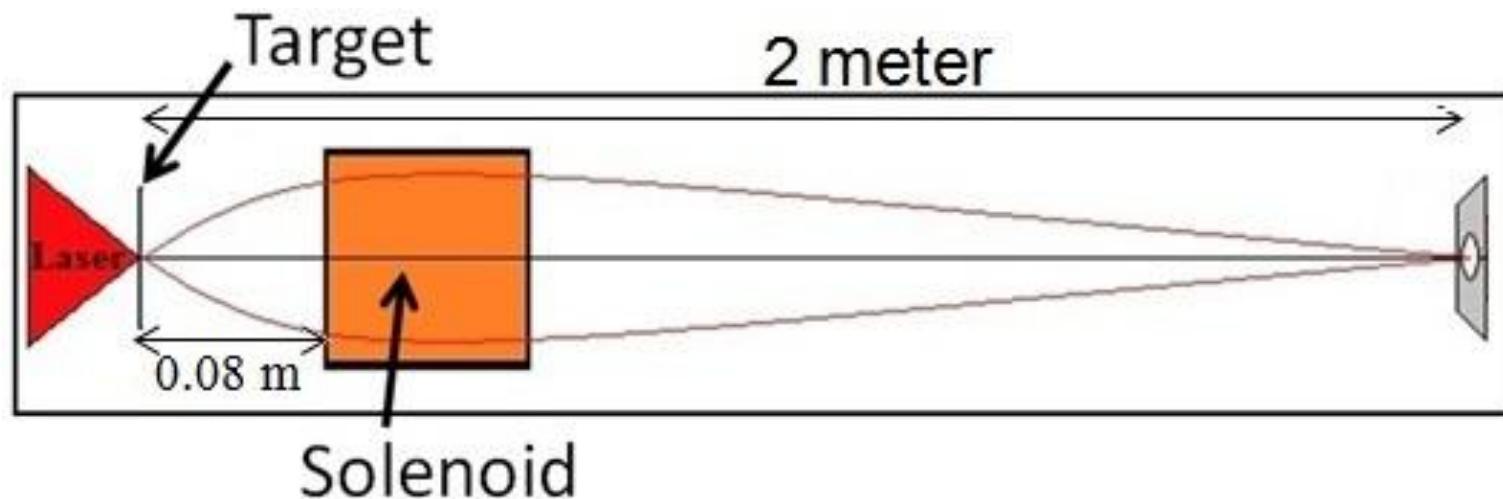


Comparison between TraceWin and LASIN Codes (geometrical aberration)

- Vanishing, 10MeV, Uniform
- FM:
 - TraceWin Code
 - LASIN Code
- Both codes give the same focal spot for different initial divergences

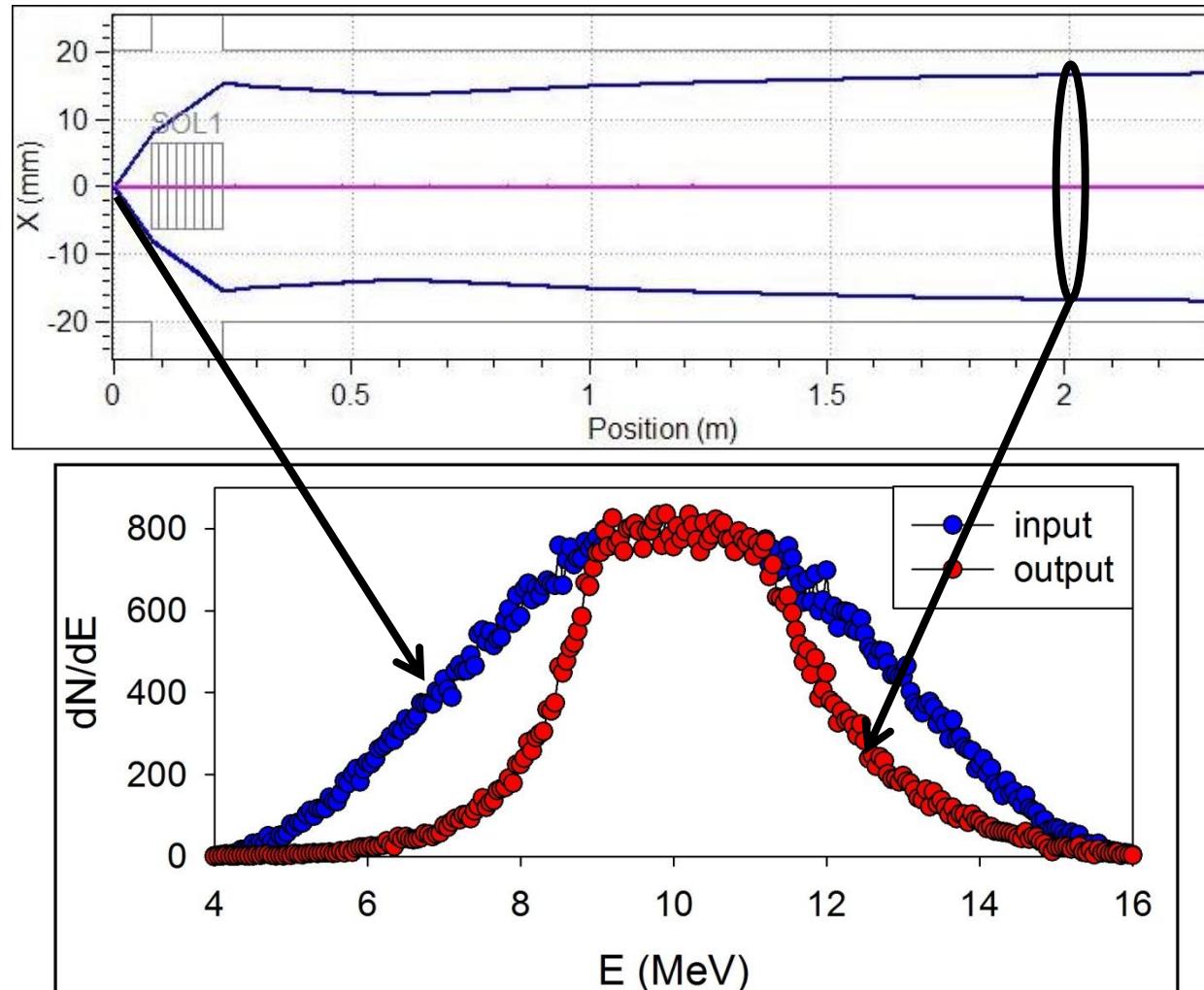


Solenoid focal spot



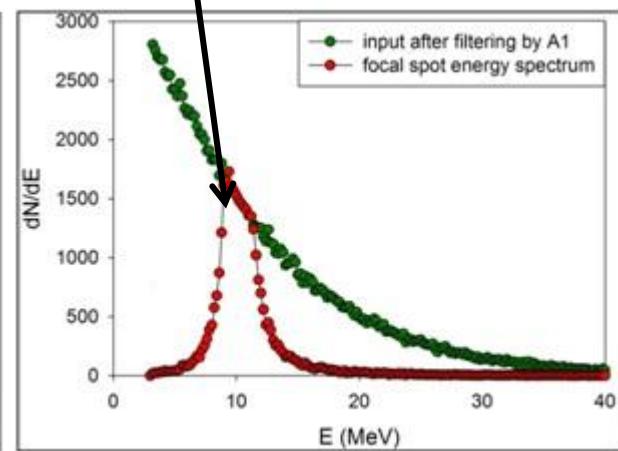
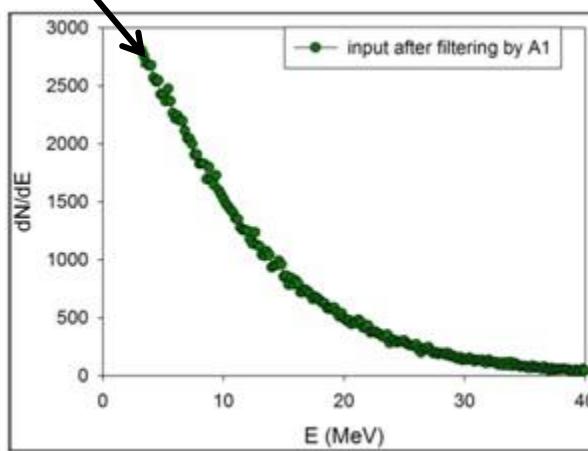
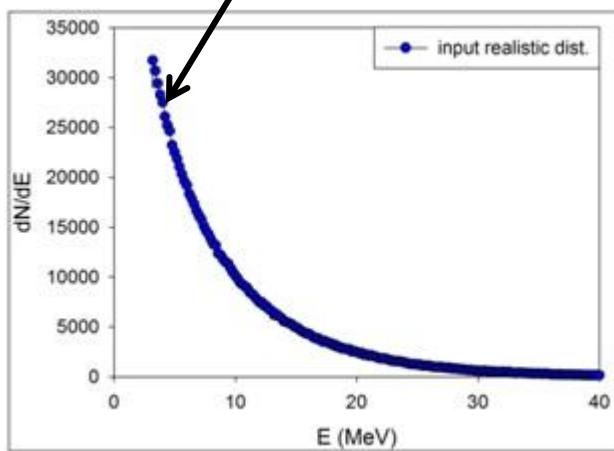
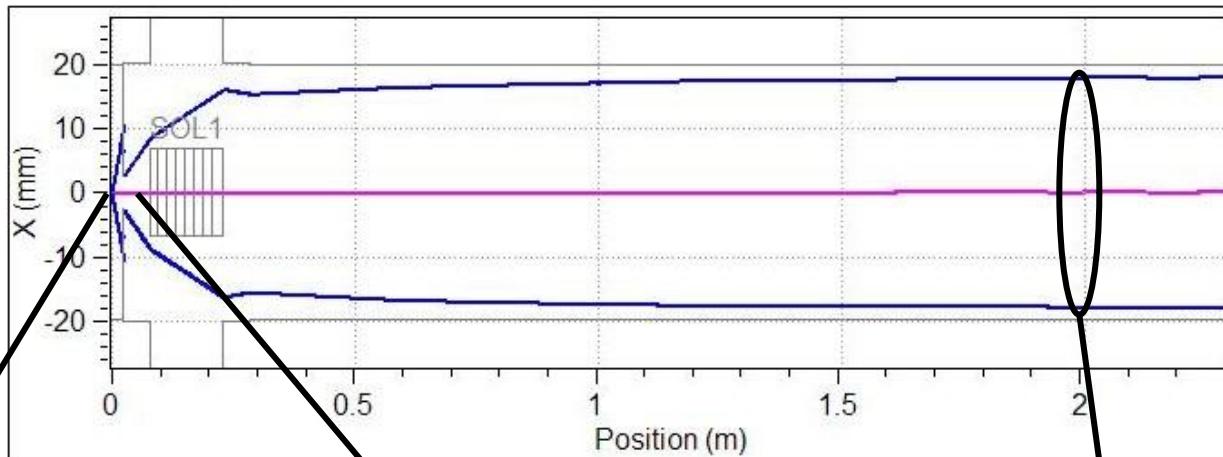
Energy spectrum (Uniform dist.)

- Uniform distrib.(10 ± 5 MeV with div. up to 100 mrad)

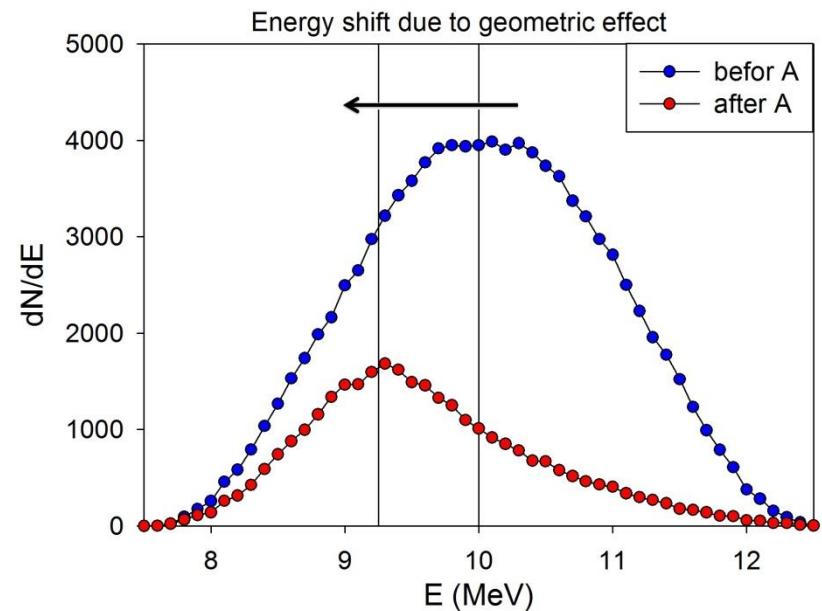
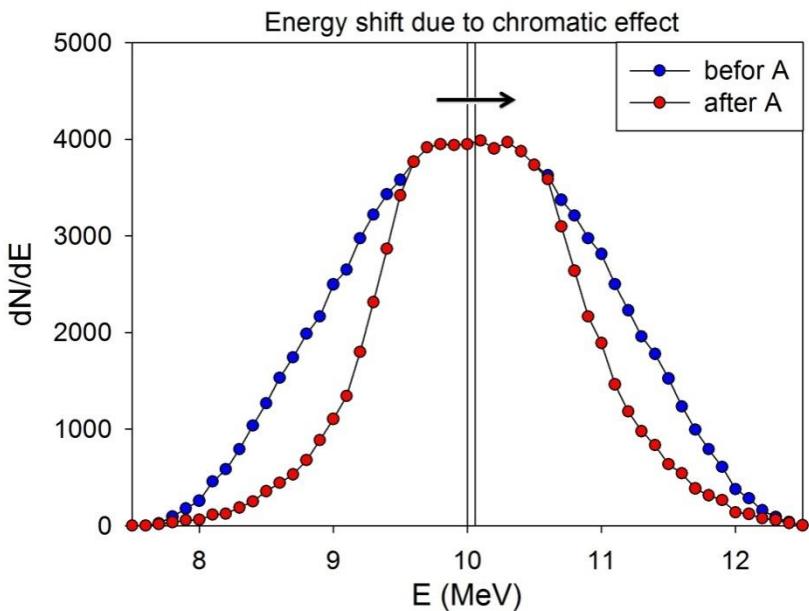
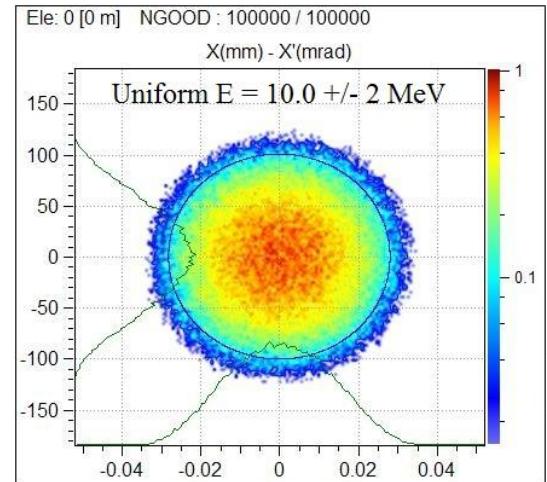
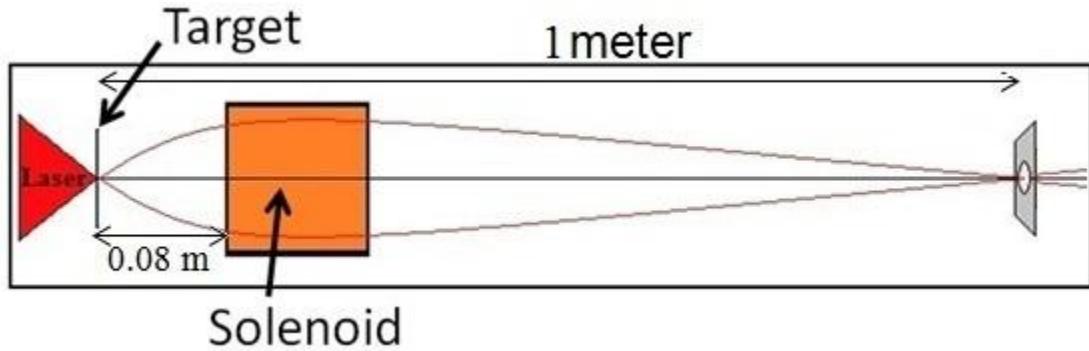


Energy spectrum (Uniform dist.)

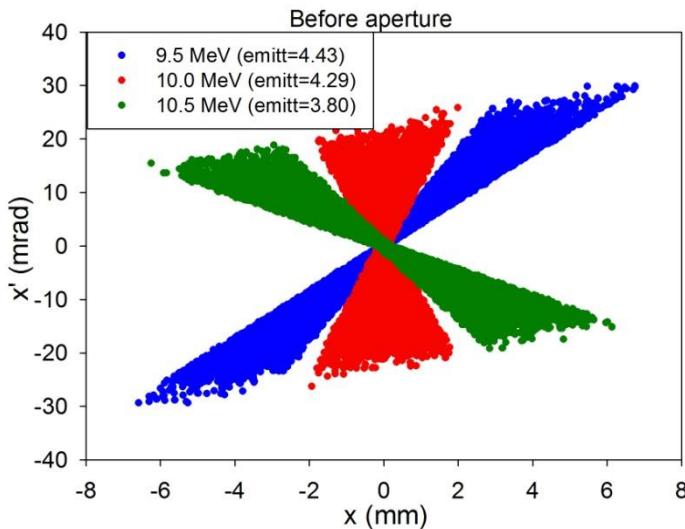
- Realistic distrib. (3-30 MeV with Aperture select div. up to 100 mrad)



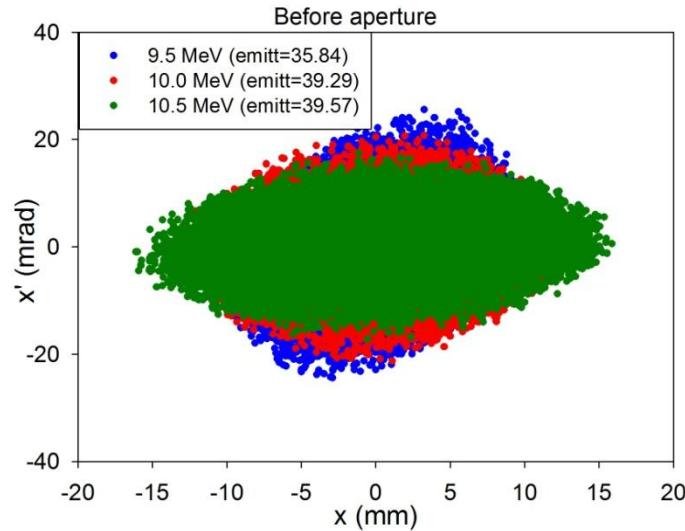
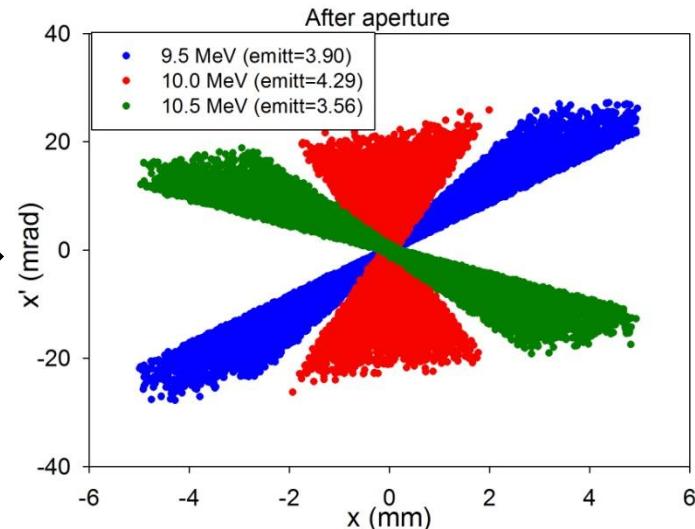
Energy spectrum shift after aperture due to chromatic & geometric aberration



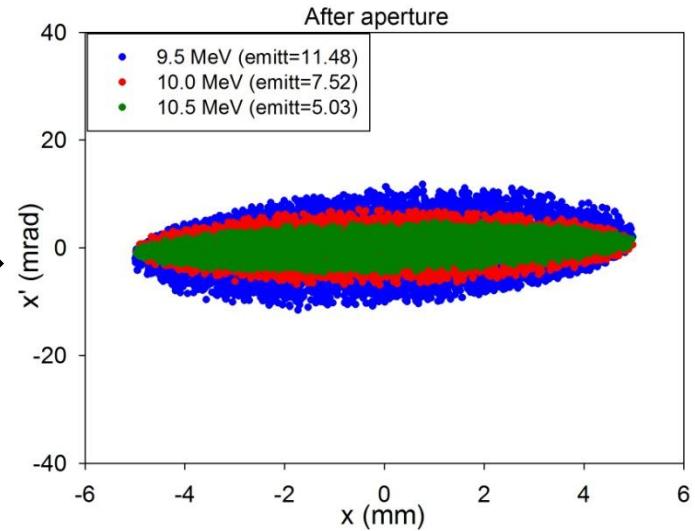
Emittance explanation for energy spectrum shift caused by chromatic & geometric aberration



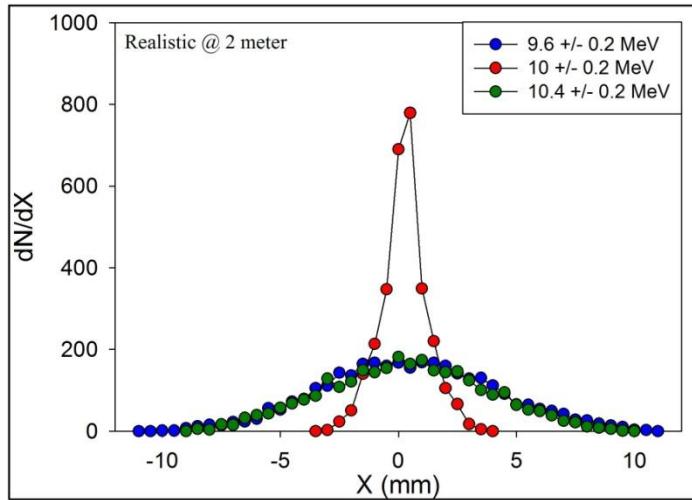
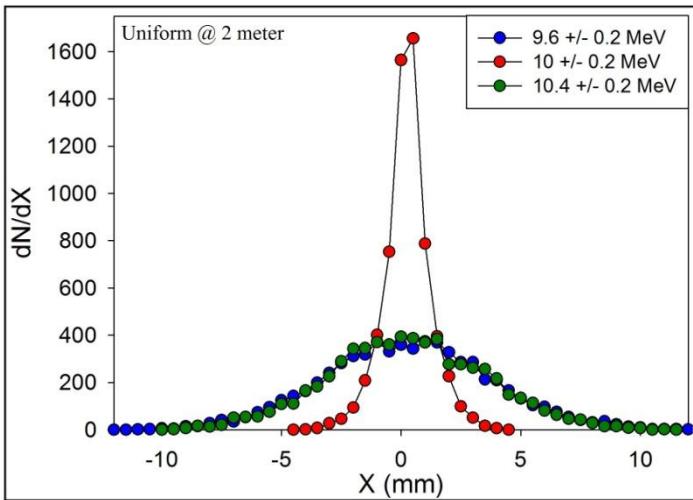
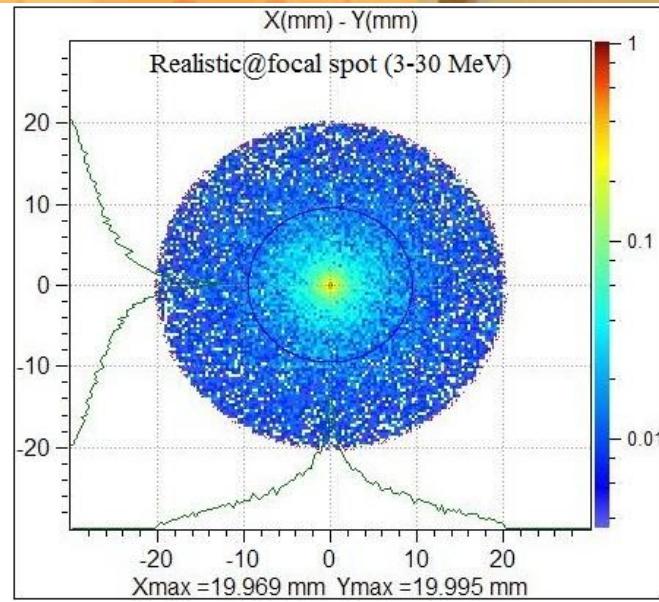
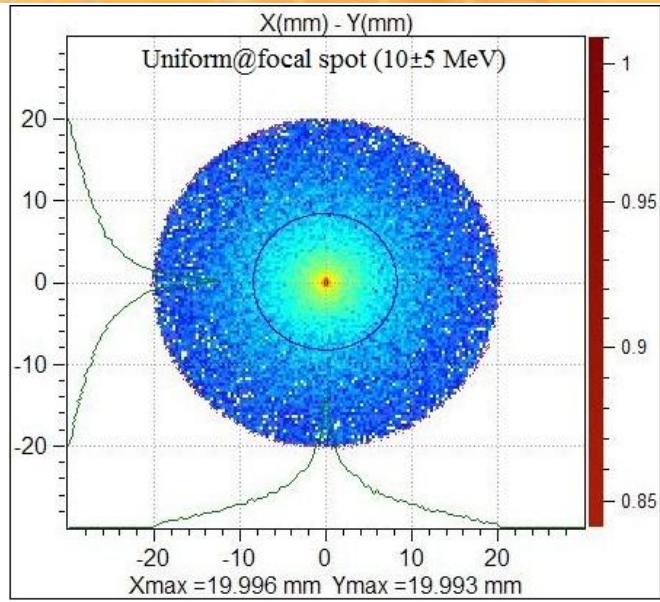
Aperture



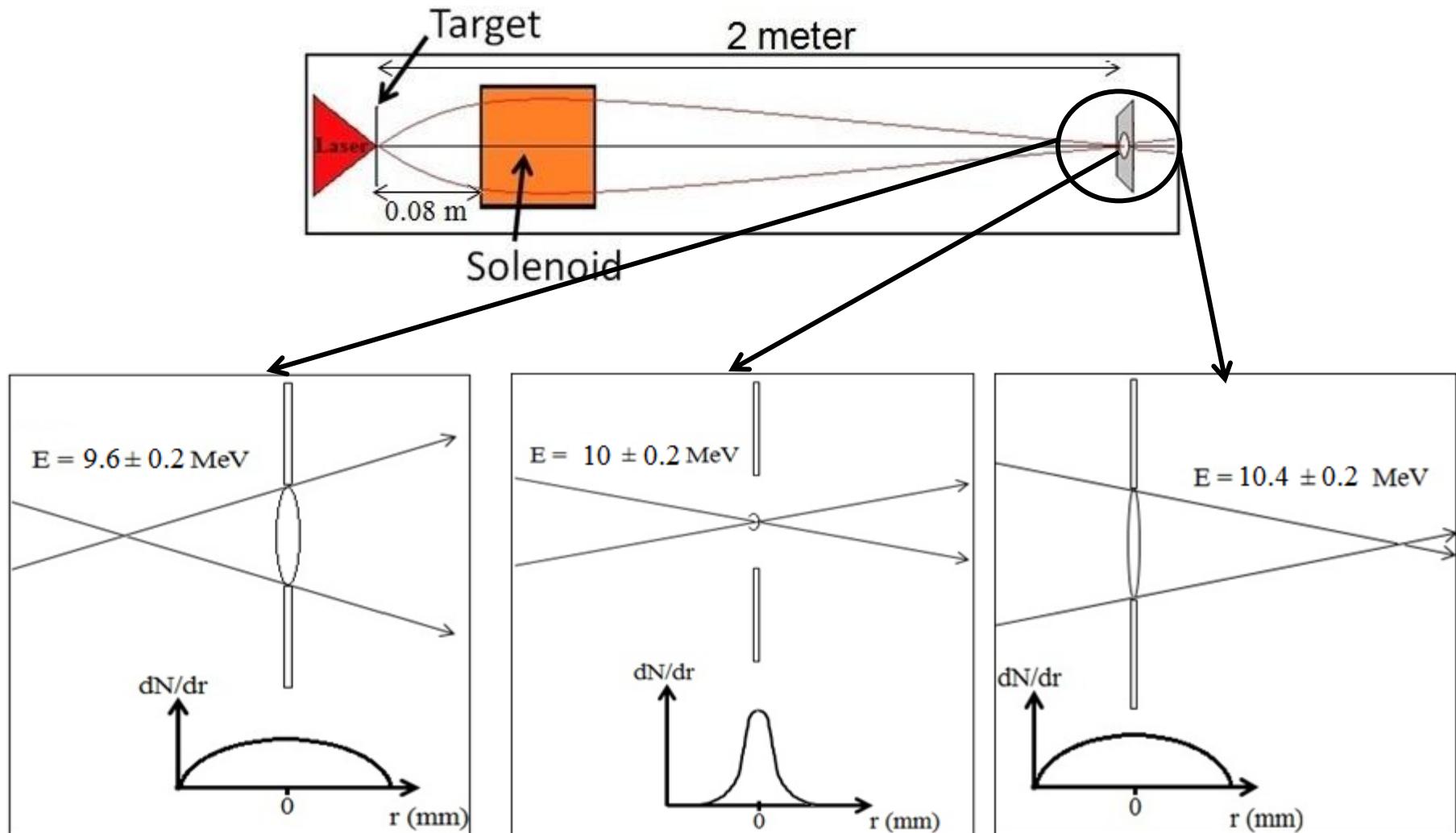
Aperture



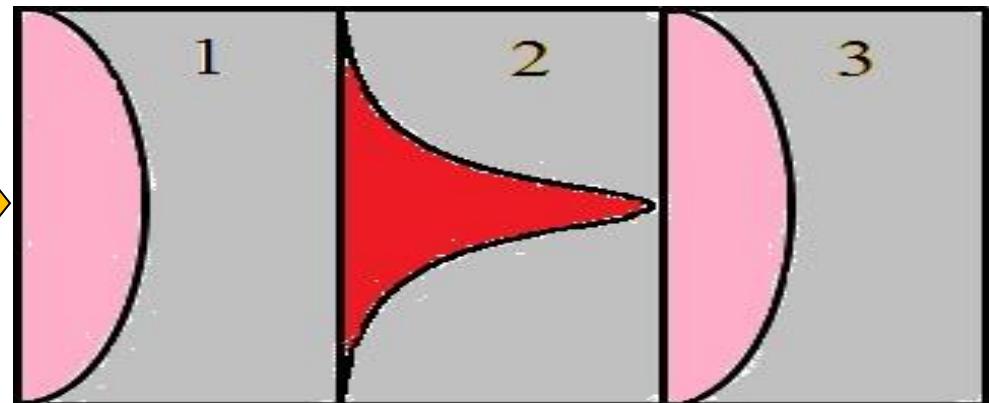
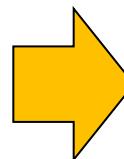
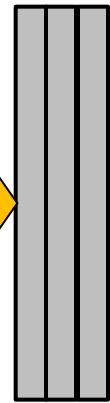
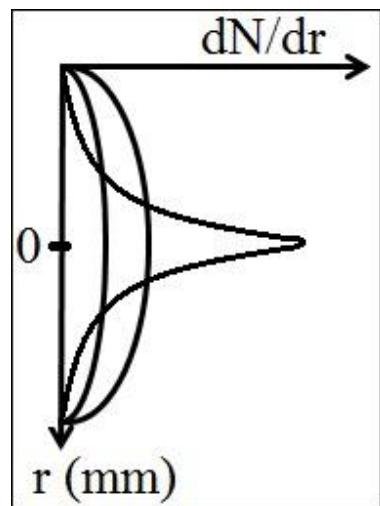
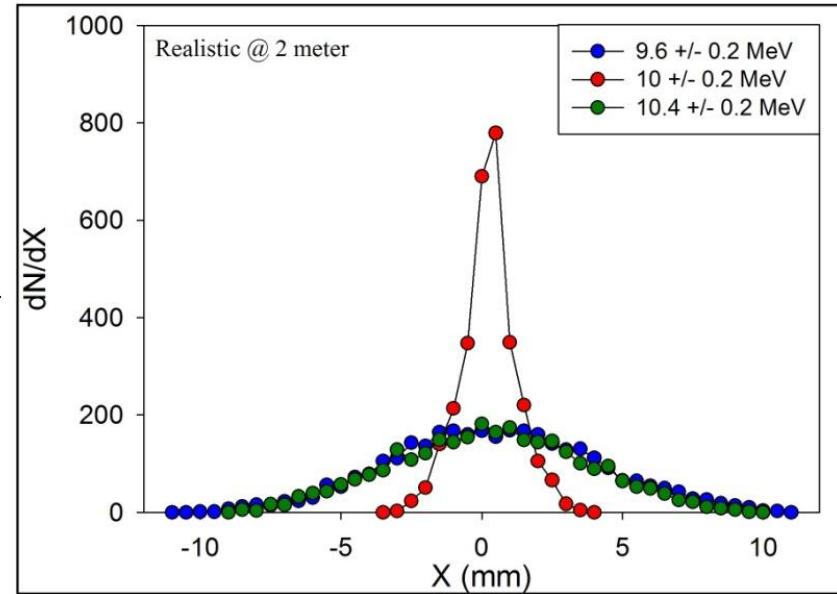
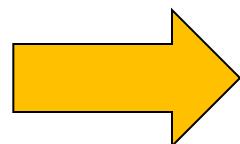
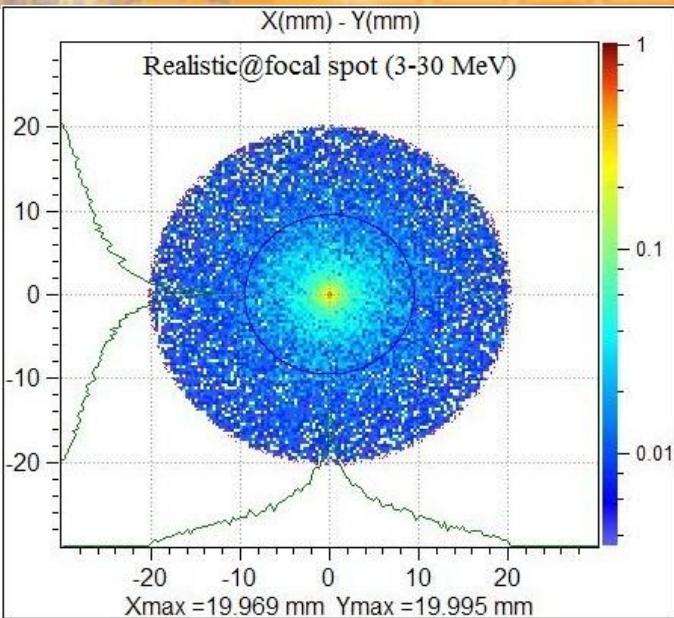
Energy correlation of beam profile



Energy correlation of beam profile caused by chromatic effect

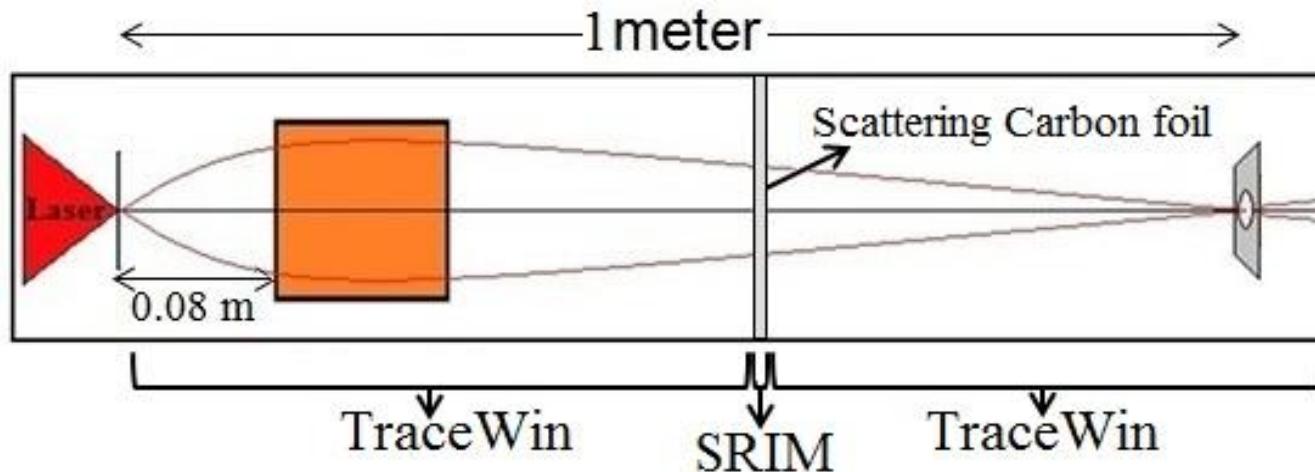


Focal spot deposition in layers



Smoothing & energy de-correlation of beam profile

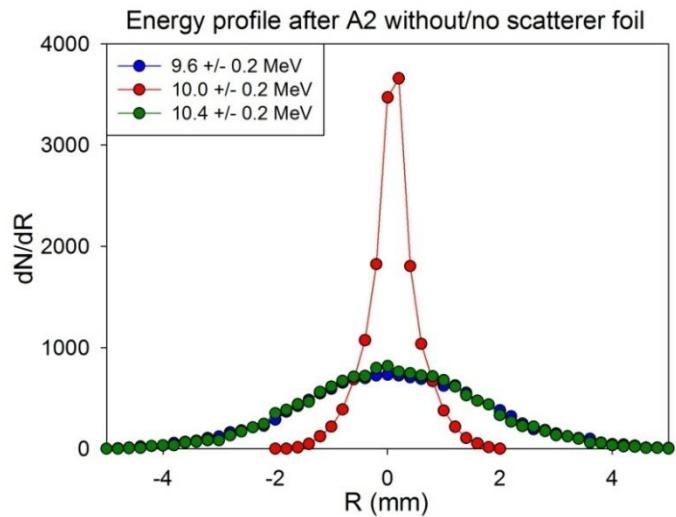
- scattering carbon foil: angular divergence & energy straggling that reproduce the central transverse density



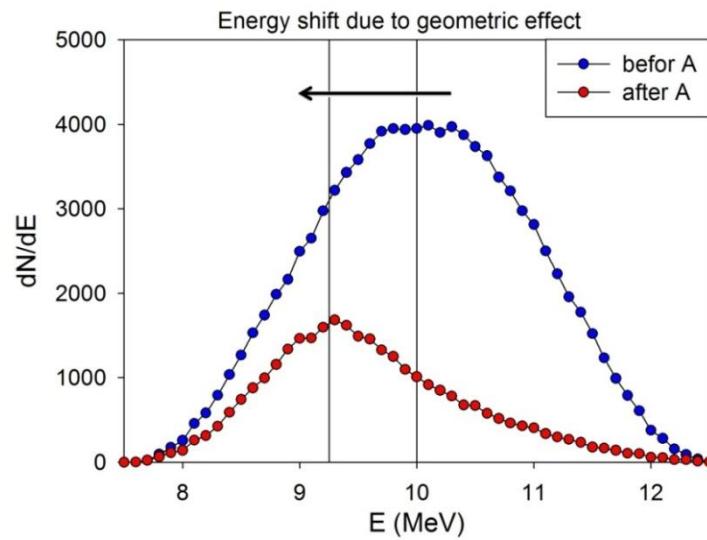
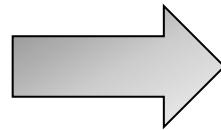
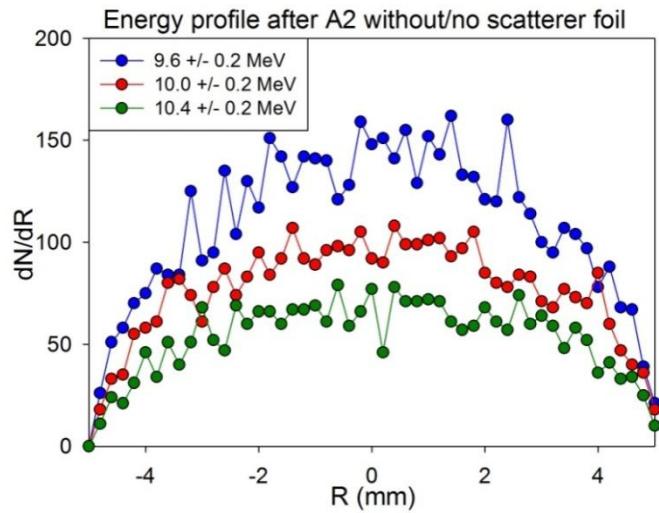
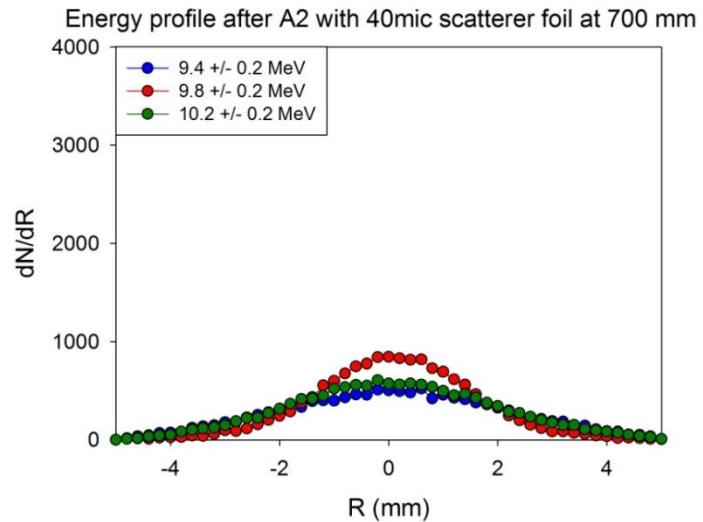
- 700 mm from target and focal spot at 1 meter
- Atima code: needed thickness (8.4 mg/cm²)



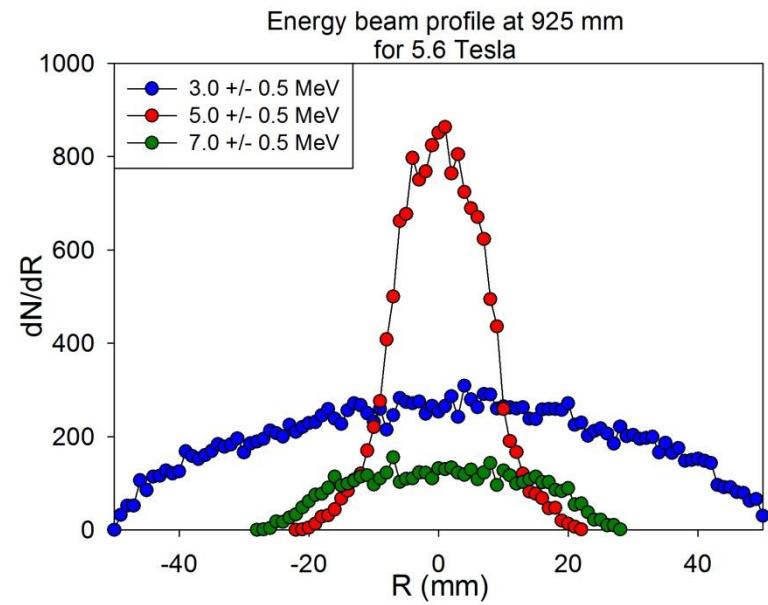
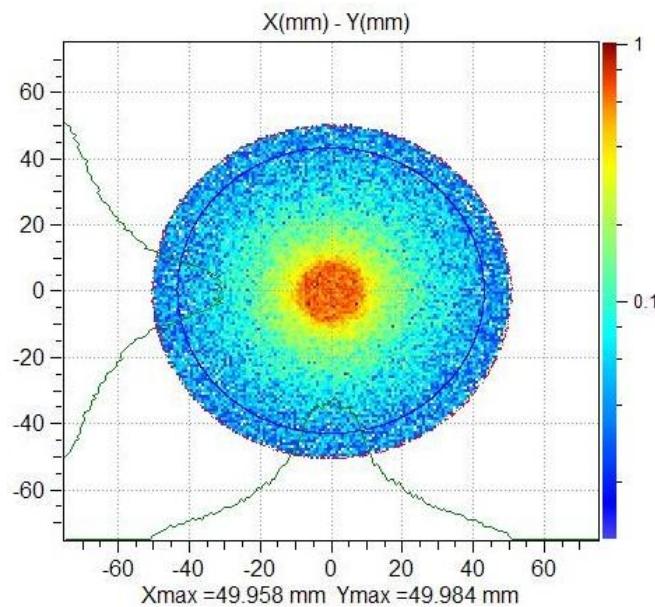
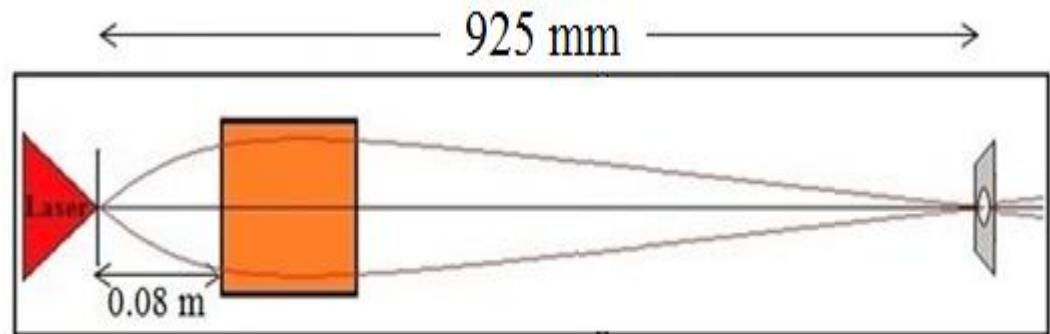
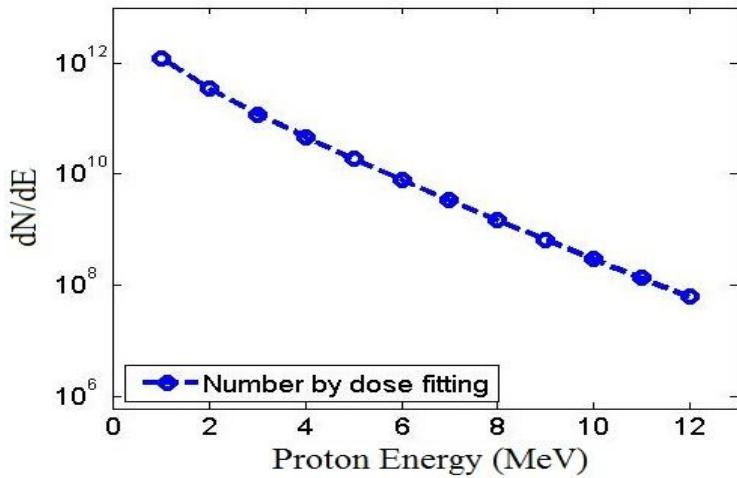
Radial spectrum at focal spot with & without scatterereing



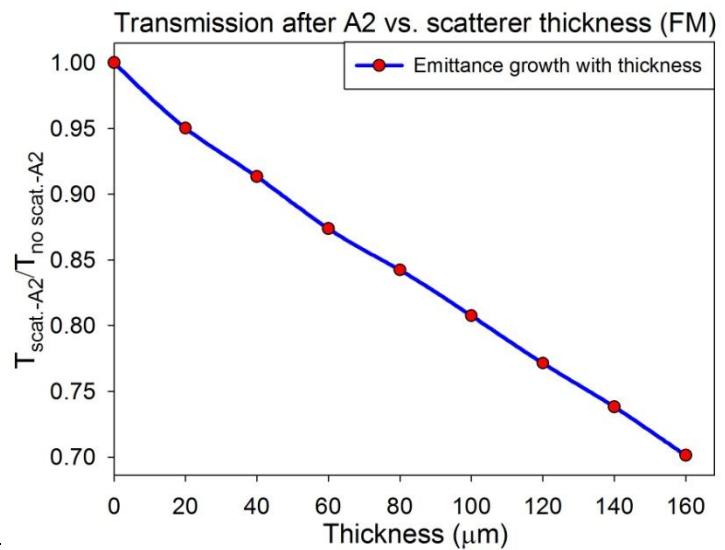
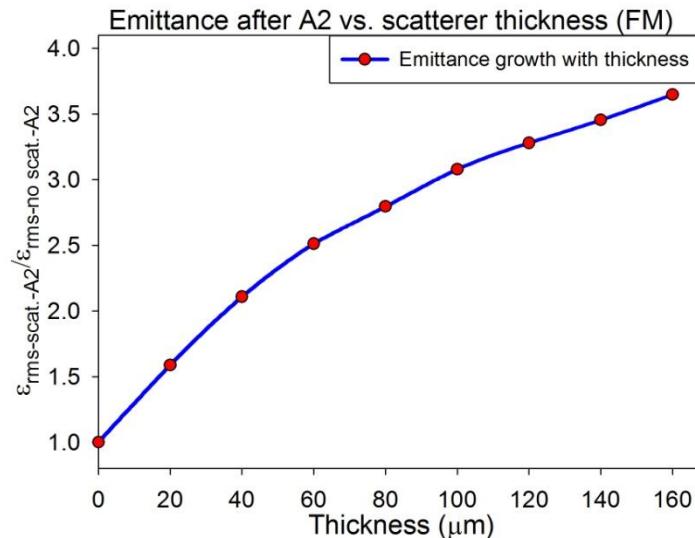
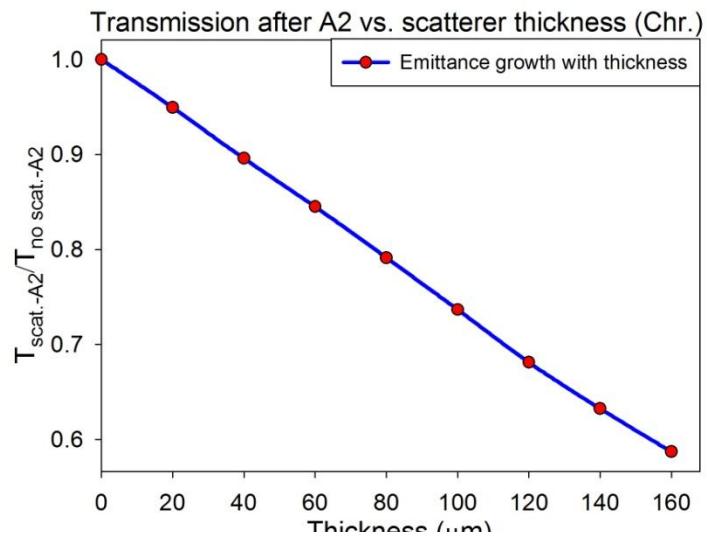
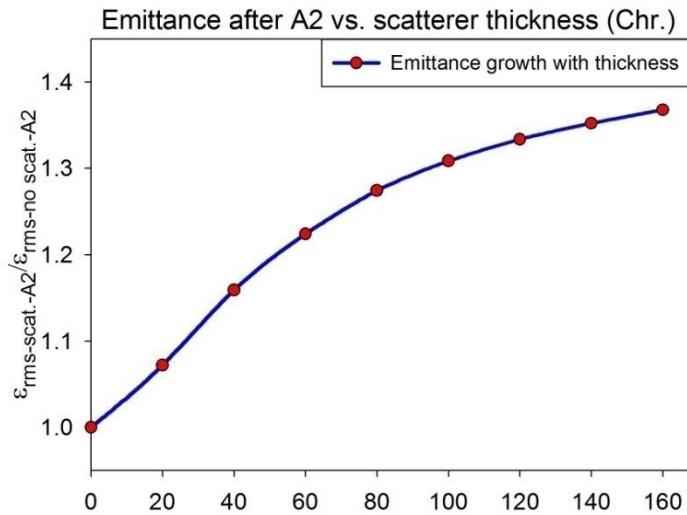
Scatr. foil



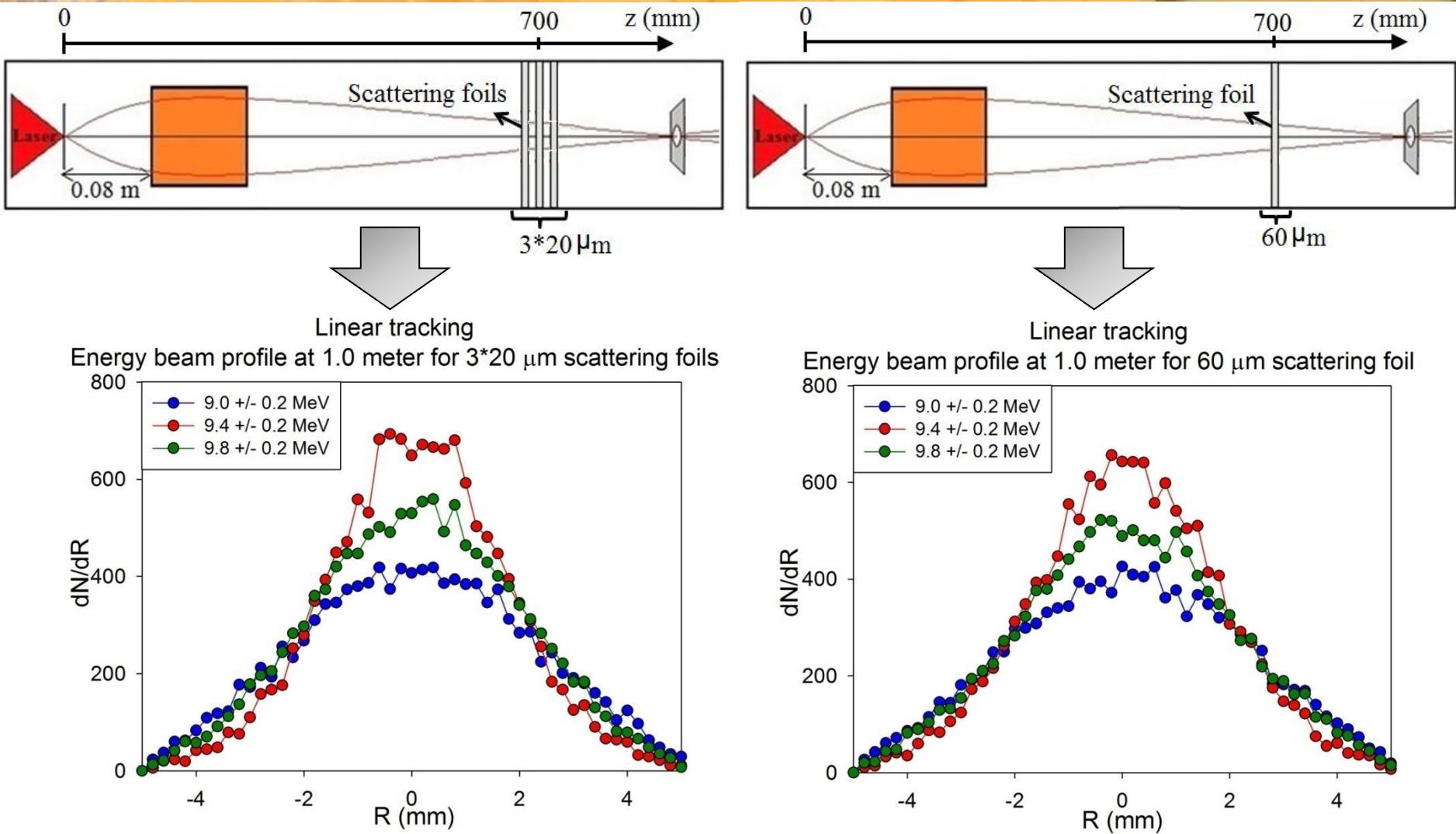
Non-linear tracking of realistic distribution



Emittance & transmission dependence on scattering foil thickness

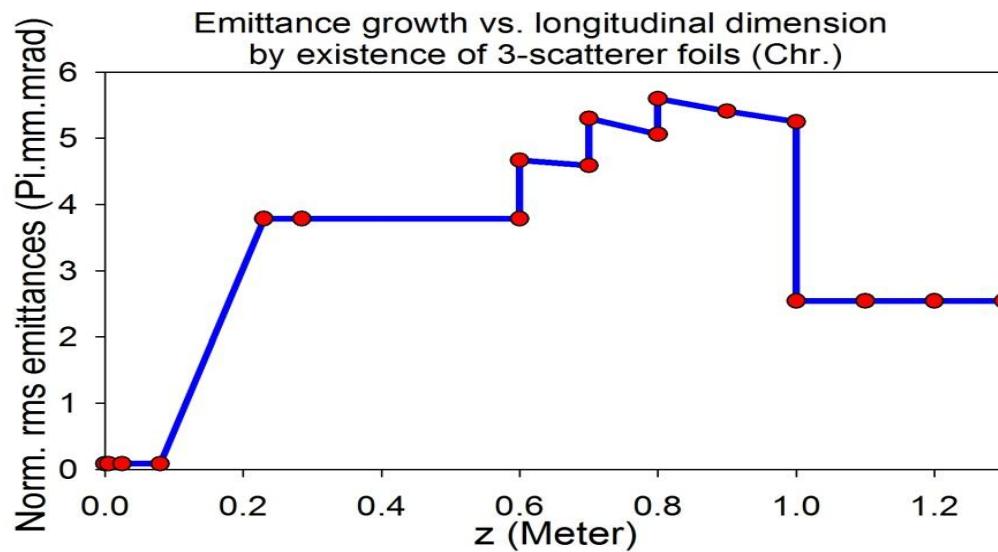


Using many scattering foils instead of one foil

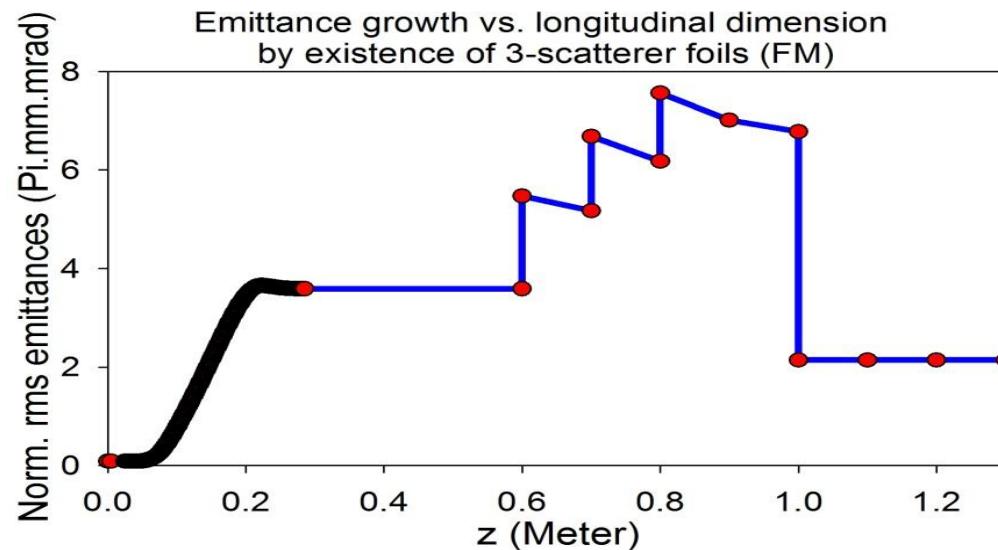


Transverse emittance growth in z-direction

Linear Tracking:



Non-Linear
Tracking:



Conclusion and outlook

- The energy spectrum is filtered by energy spread\chromatic aberration and beam pipe
- TraceWin treated geometrical effect the same as LASIN Code.
- The energy correlation of beam profile is due to chromatic effect .
- Low energy region at focal spot is more affected by chromatic aberration while high energy region is dominated by geometrical aberration.
- Further simulation to compare simulated energy beam profile with imprint energies at RCF sticks in the last beam time at GSI.

References

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- I. Hofmann et al., HIAT 09, Venice, Italy, 2009
- I. Hofmann et al., Nucl. Instr. Meth. 681, 44-54 (2012)
- GSI Internal report, <https://www.gsi.de/documents/DOC-2010-Nov-36-1.pdf>
- D. Uriot, TraceWin documentation, <http://irfu.cea.fr/Sacm/logiciels/index3.php>
- SRIM Code: <http://www.srim.org/>
- Atima Code: <http://www-linux.gsi.de/~weick/atima/>



Thank You