Nozzle effect on baem

J. Pasternak, special LhARA meeting, 13/01/2023

Introduction

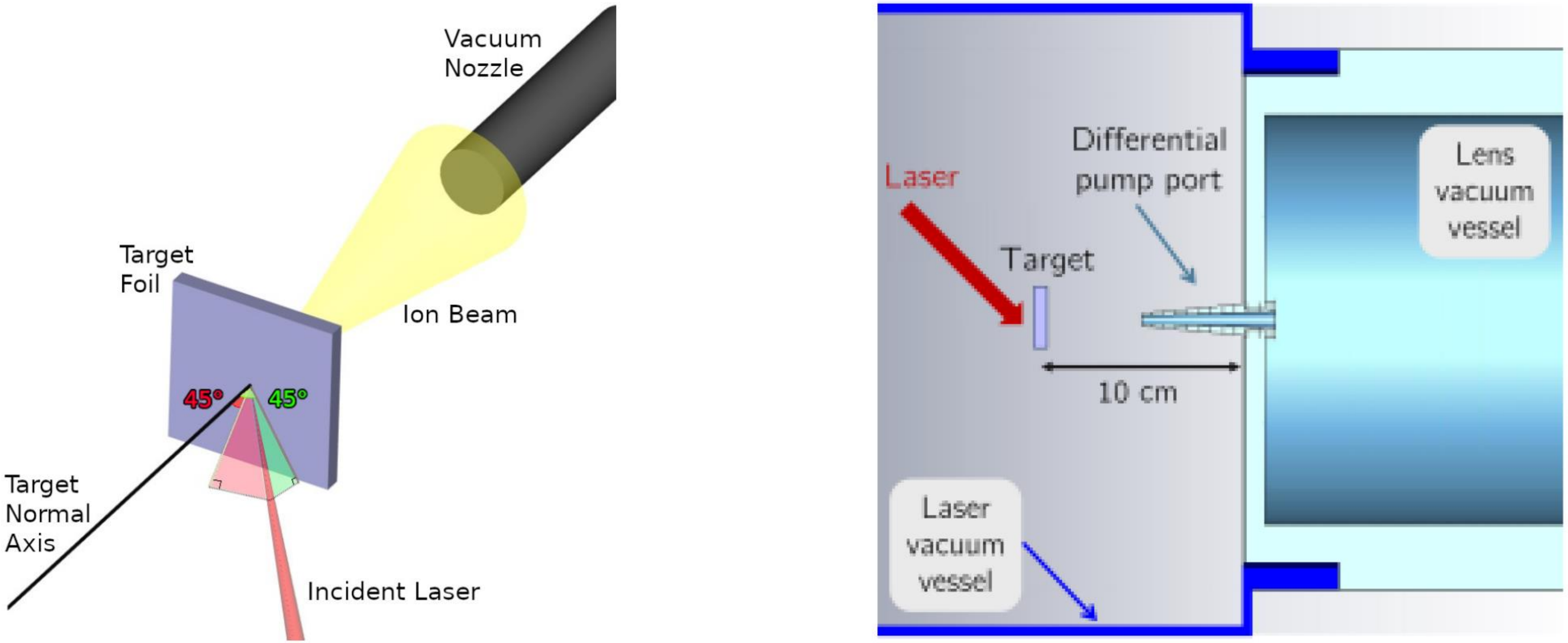


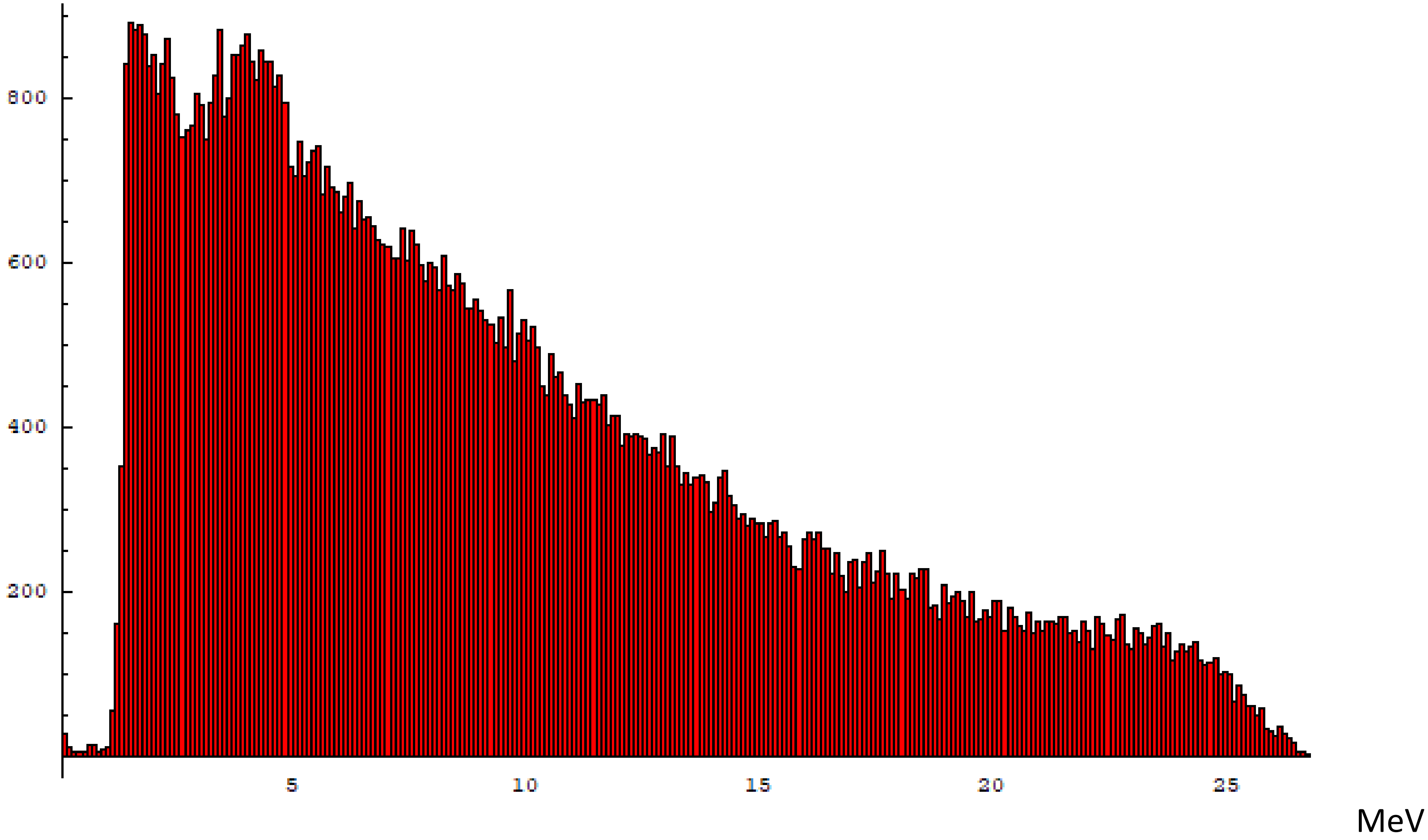
Figure 7.6: Schematic diagrams of the configuration between the laser target and the beam line, which includes the vacuum nozzle interface.

From HT Lau's thesis

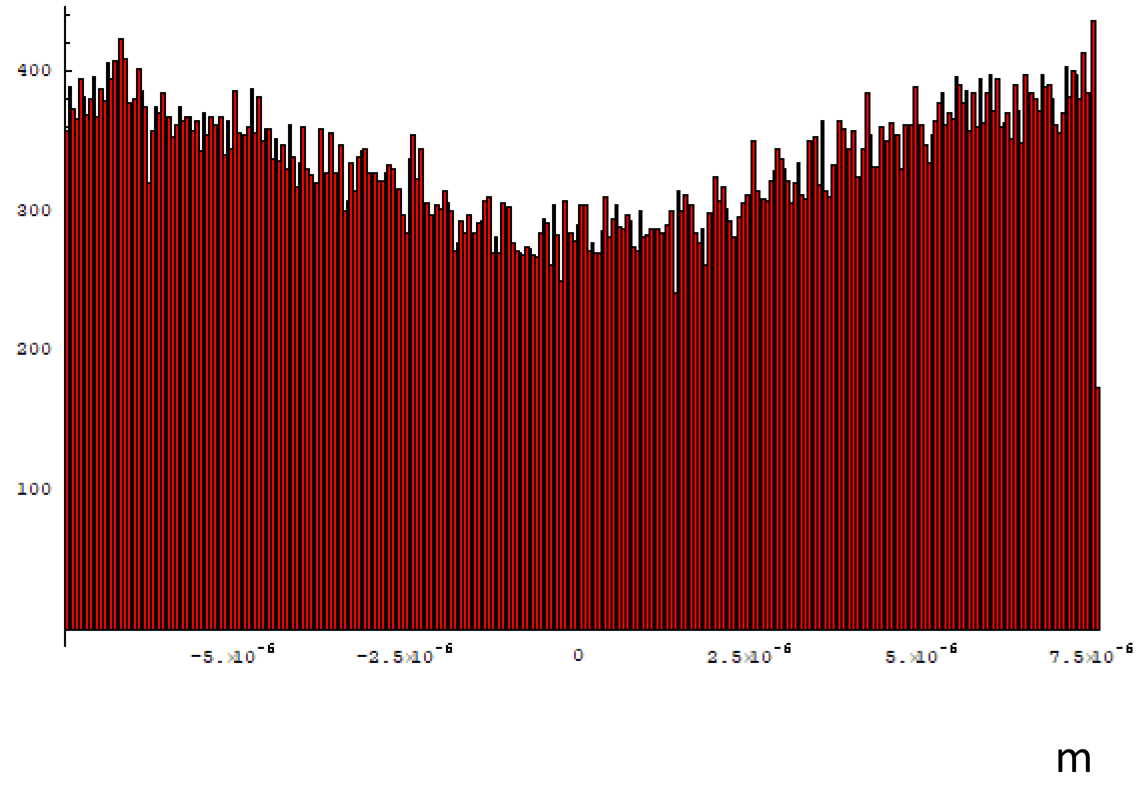
Introduction (2)

- Initial distribution of protons from 3D SCAPA simulation provided by E. Boella and presampled by T. Dascalu is studied
- As we still have no info on electron distribution, the old procedure is performed
  - Track for the first 5cm without space charge
  - Track for the next 5cm with space charge in GPT (thanks Will!)
    - Tracking without space charge for the second 5cm is also performed to investigate the strength of the space charge effect
  - The nozzle radial limitations are applied
  - Optical beam parameters are reproduced
- The results are compared with the HT’s distribution and some ideas how to move forward are proposed

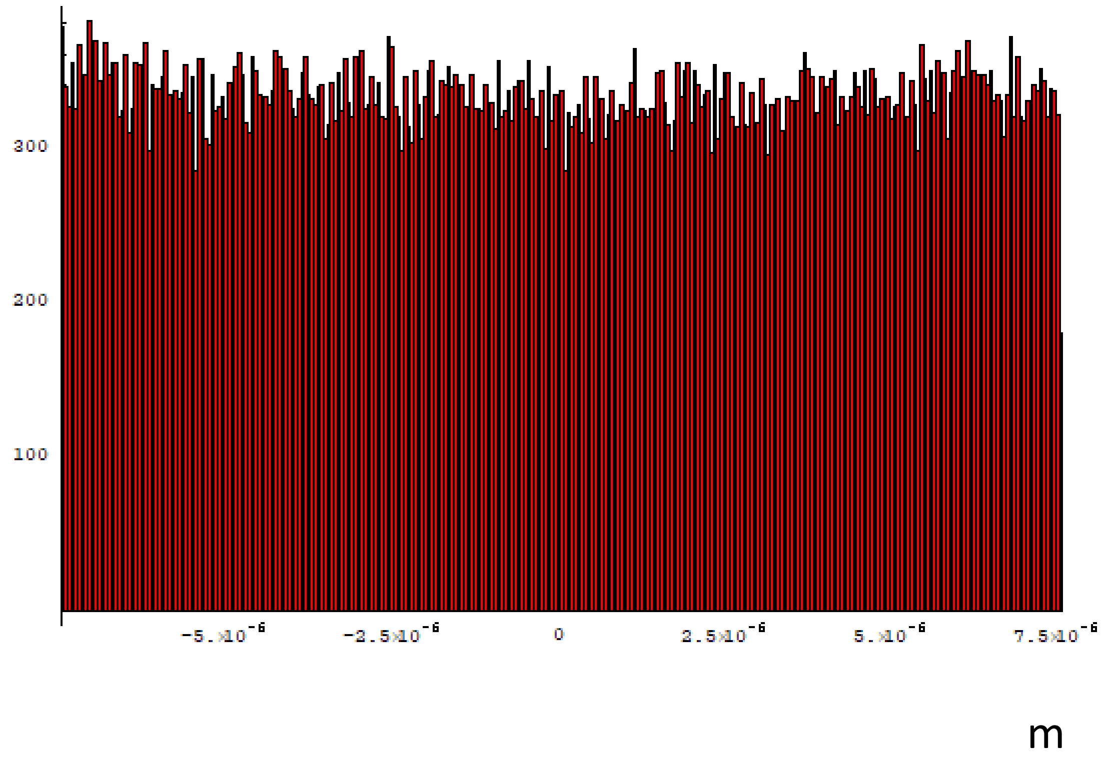
Spectrum



y distribution after the target (z=105um)

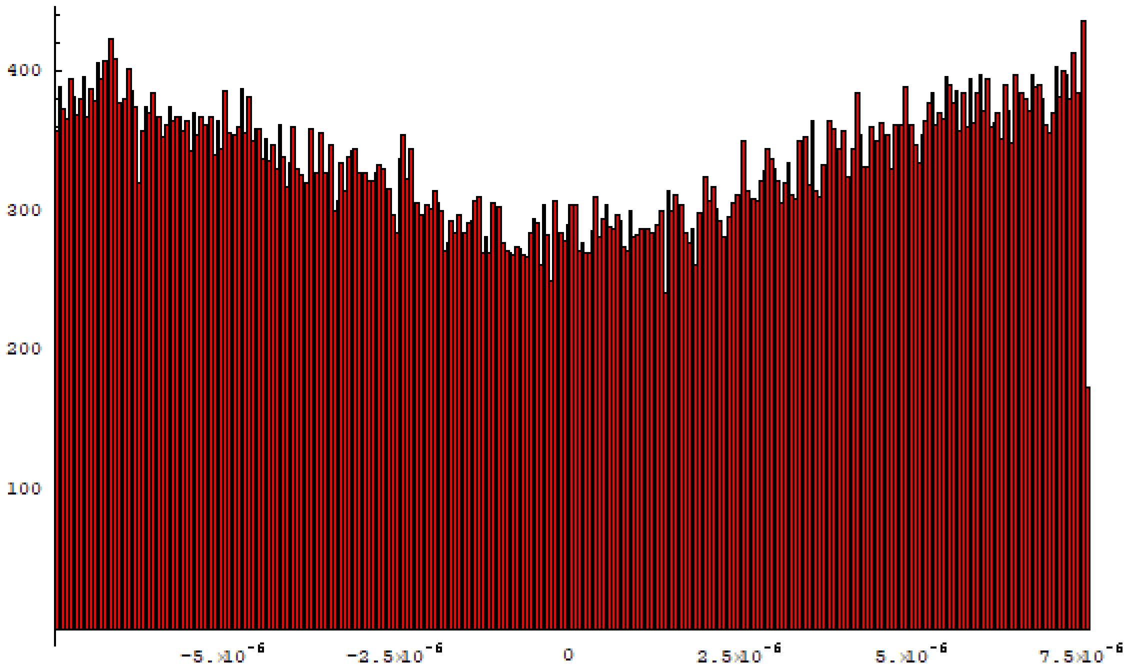


15MeV ±2%



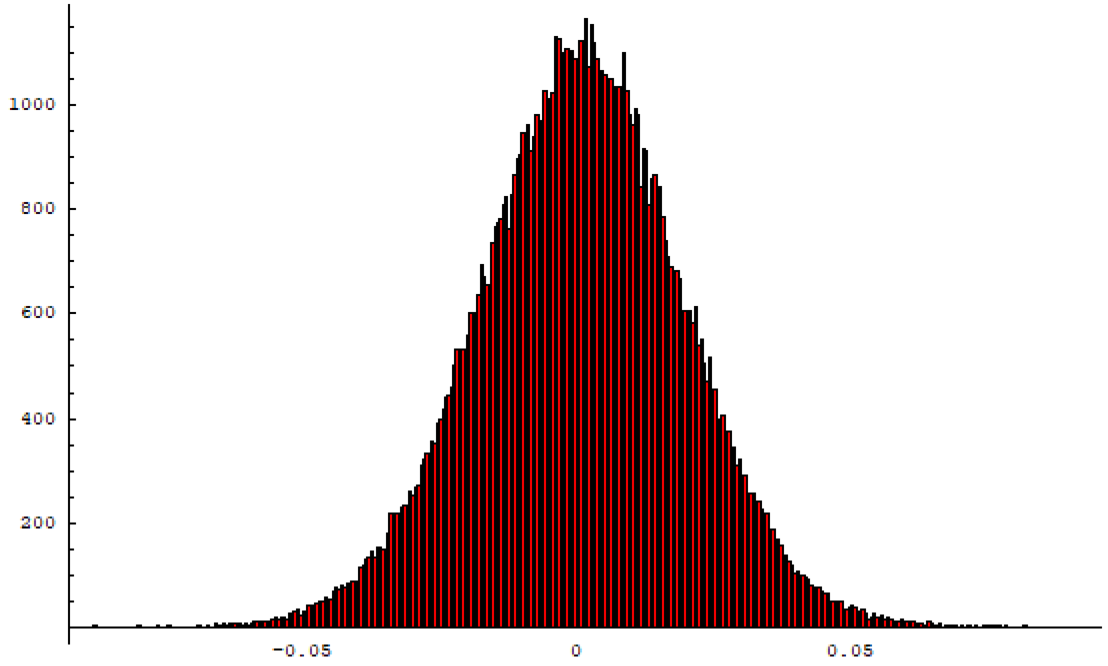
Full spectrum

y, y’ distributions after the target (z=105um, 15MeV ±2%)



m

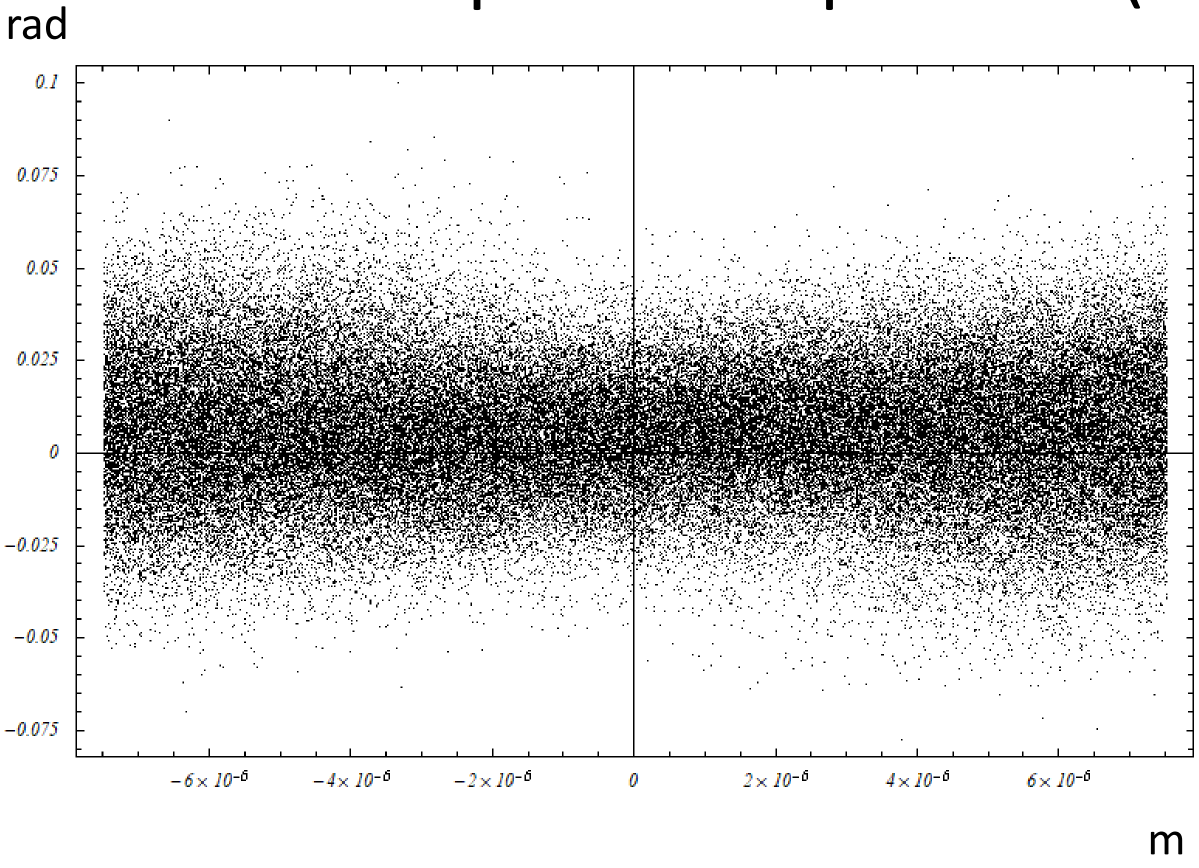
Y



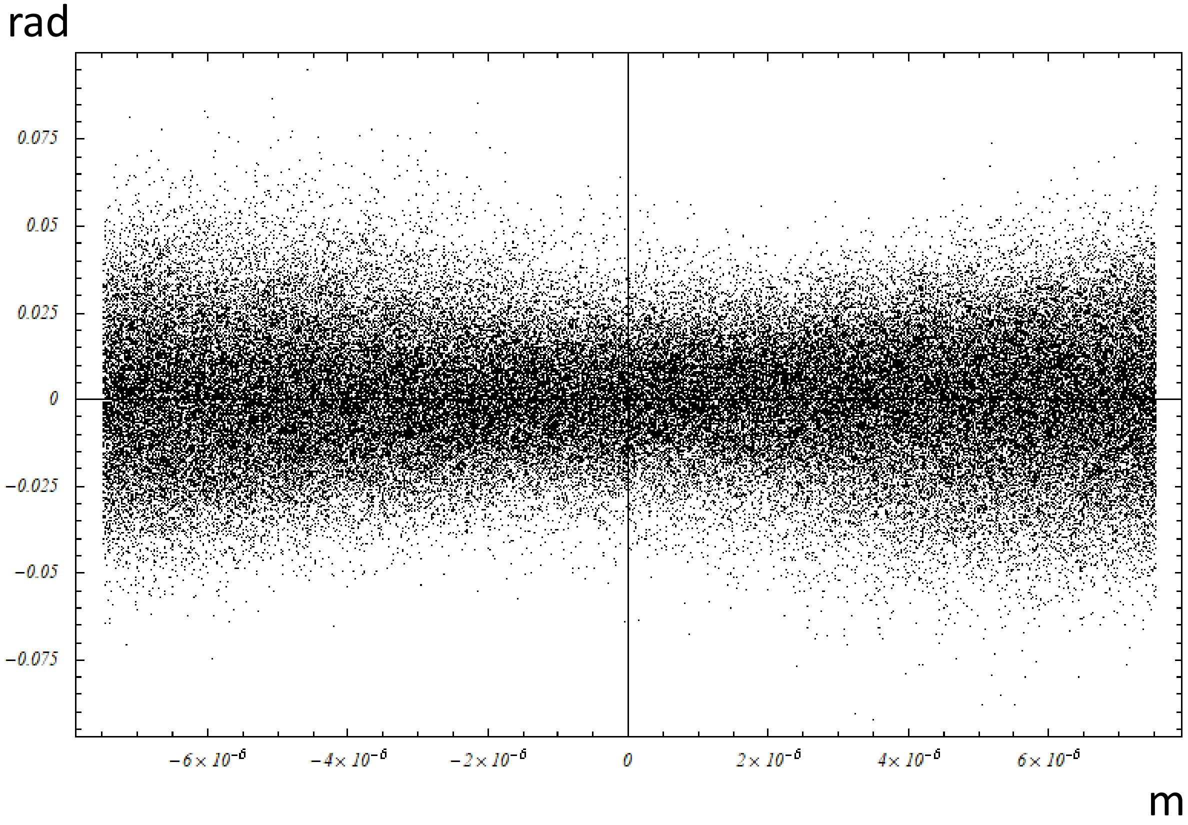
rad

Y’

Initial phase spaces (z=105um, 15MeV ±2%)



(x, x’)



(y, y’)

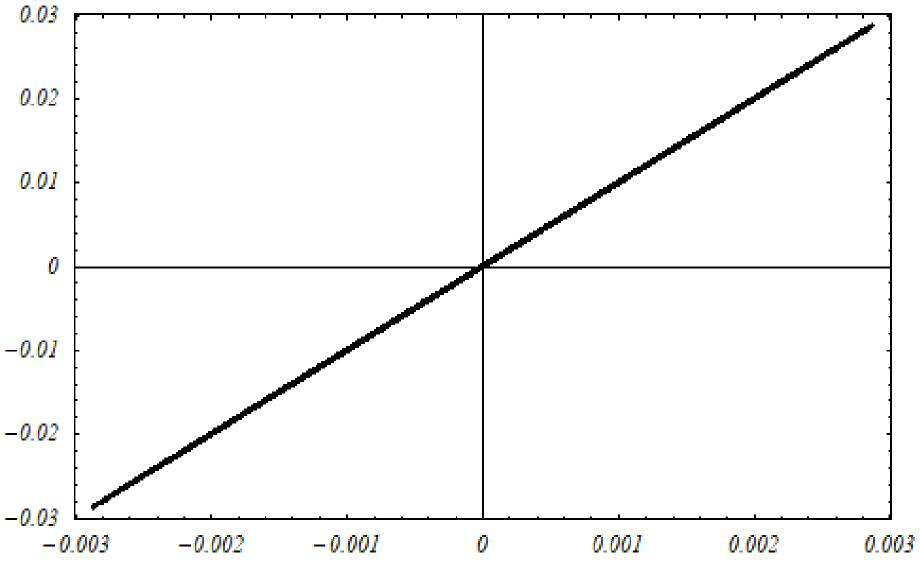
Nozzle effect - transmission

- 71.8% of particles within the energy range (15MeV $\pm$2%) survives the entrance nozzle cut (r=2mm)
- 35.6% of particles within the energy range (15MeV $\pm$2%) survives the exit nozzle cut (r=2.87mm)
  - 40.1% of particles within the energy range (15MeV $\pm$2%) survives the exit nozzle cut (r=2.87mm) if space charge is ignored

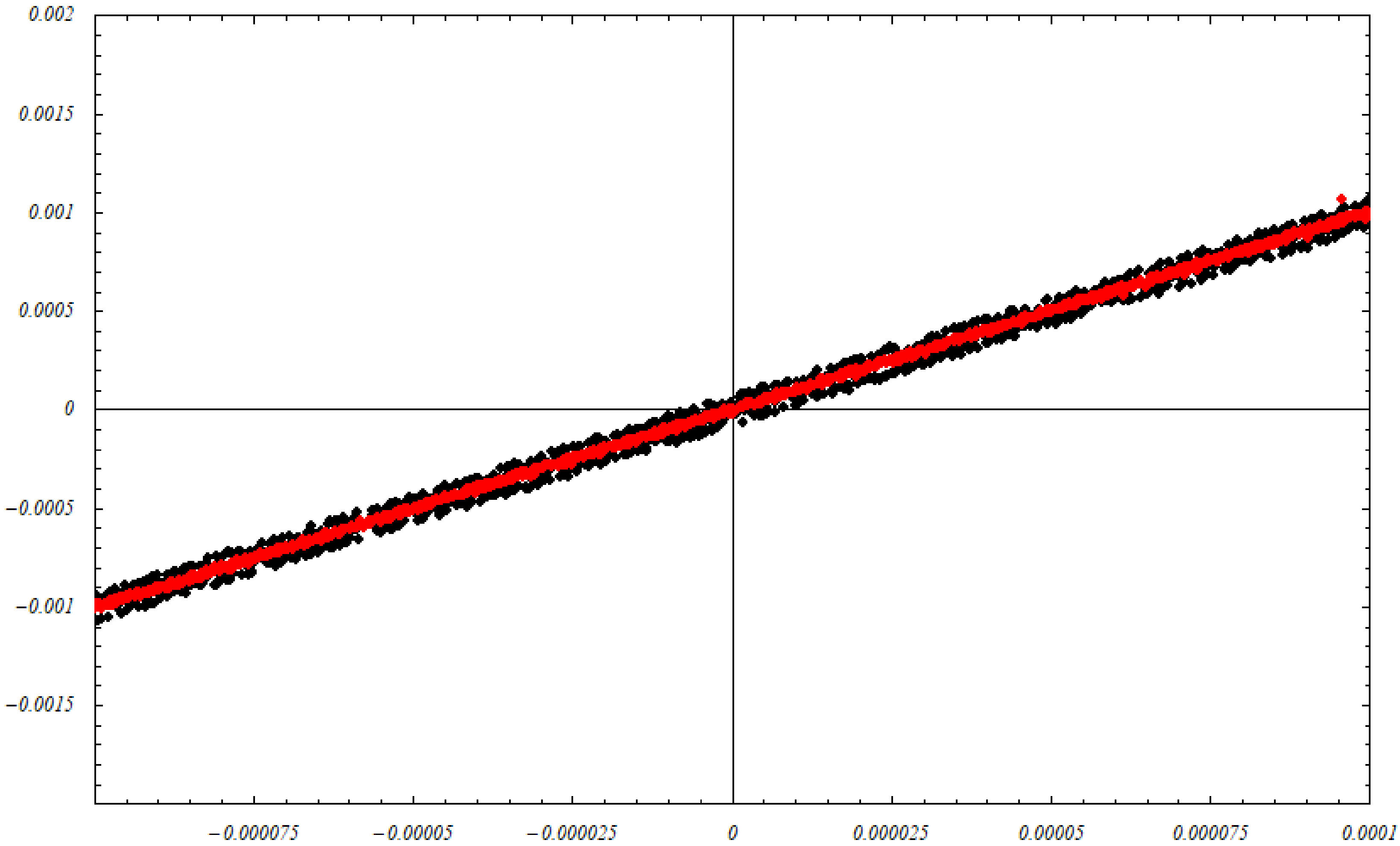
Nozzle effect (beam parameters)

	HT's distribution	SCAPA distribution	SCAPA distribution no-SC
Mean RMS emittance [m]	1.43×10^{-8}	1.26×10^{-7}	5.5×10^{-8}
Mean beta [m]	141.34	12.82	28.8
Mean alpha	-1418.43	-129.79	-288.03

Phase space at the exit of the nozzle (x,x’) [m,rad]

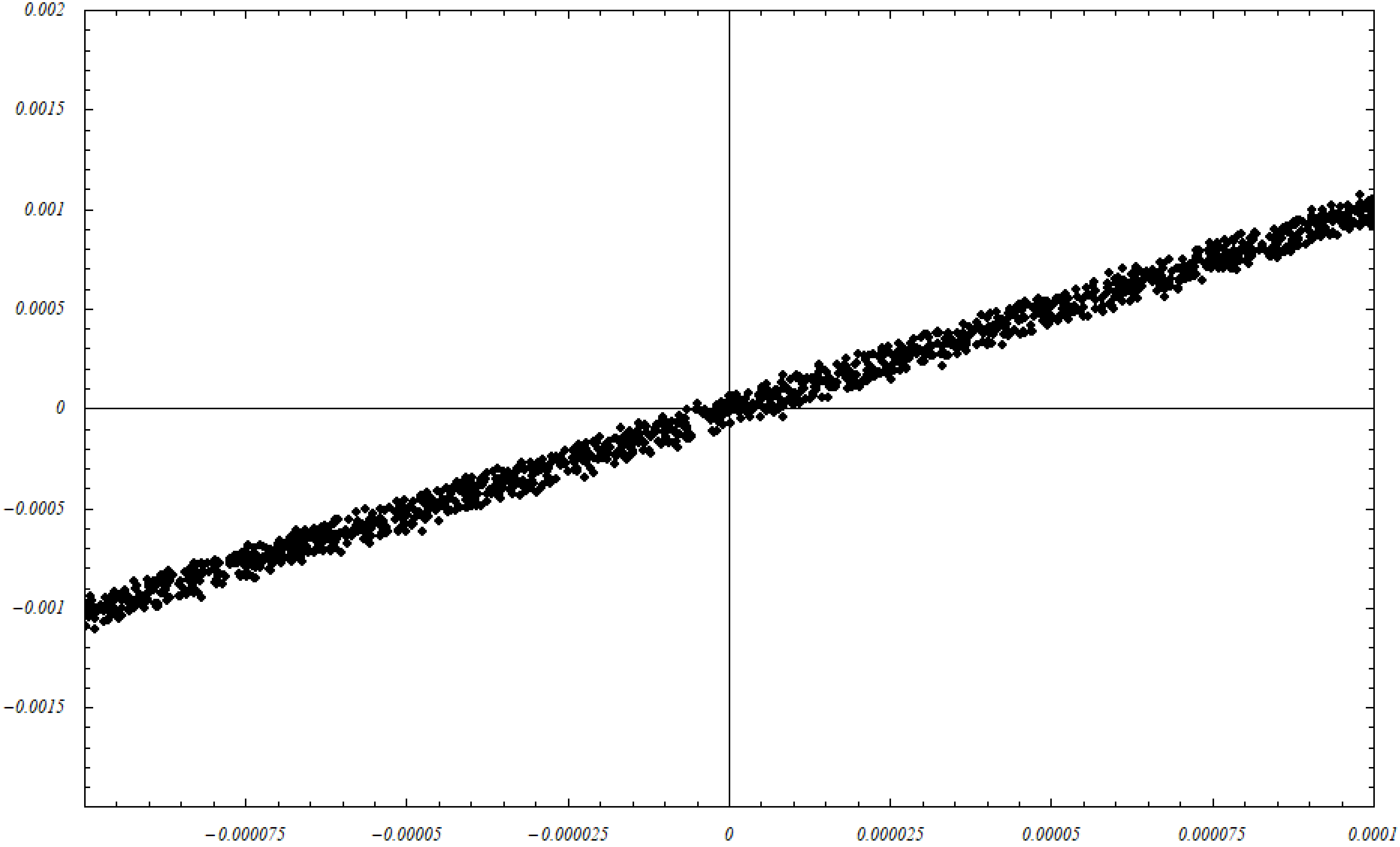


Full

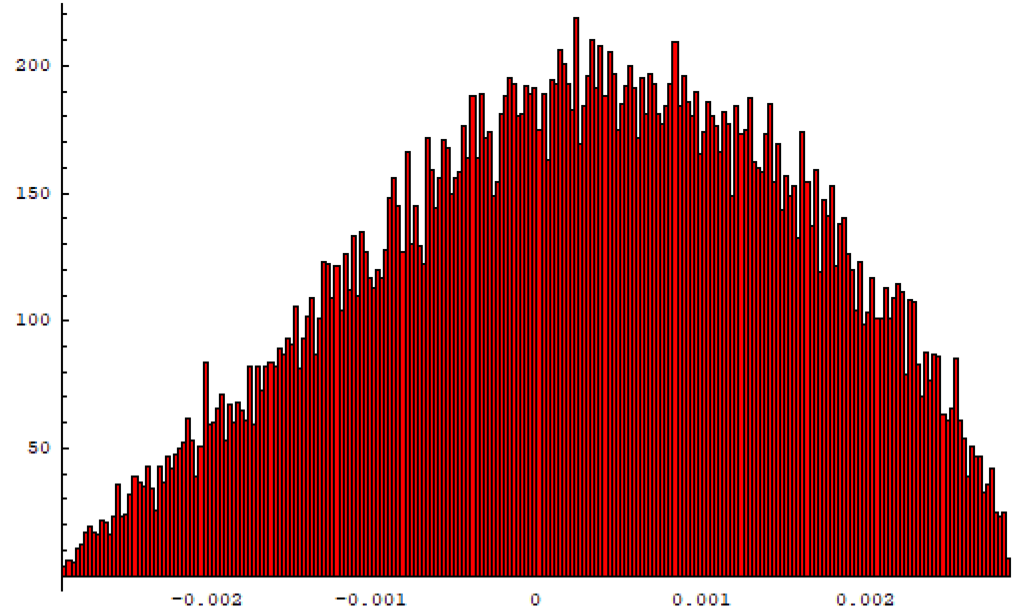


Zoom: black – SCAPA w/o SC, red – HT’s

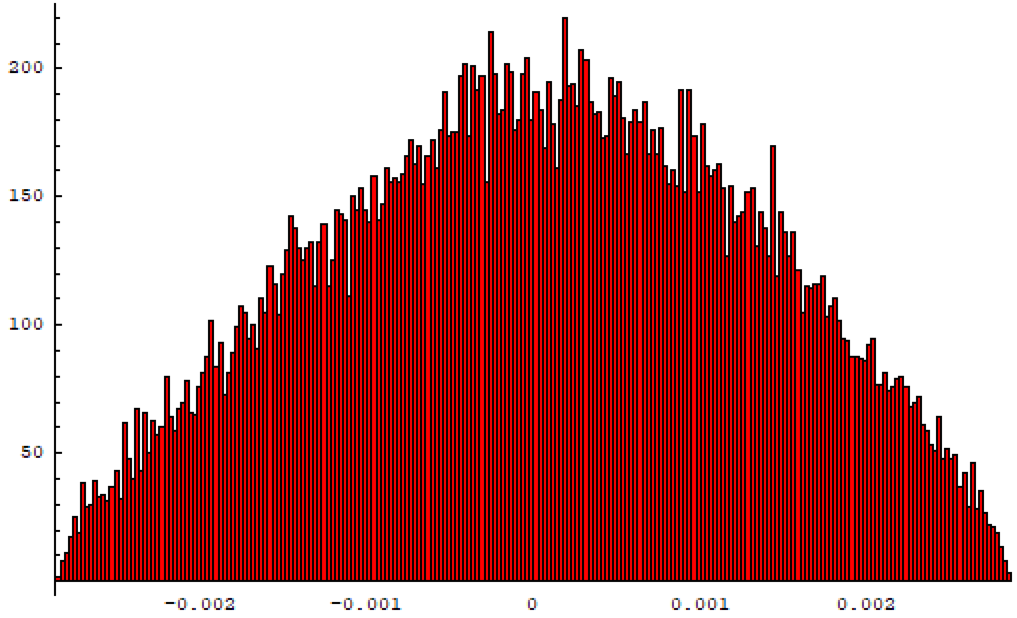
Phase space at the exit of the nozzle (x,x’) [m,rad], SCAPA with SC



x,y distributions at the exit of the nozzle (SCAPA-no SC) [m]

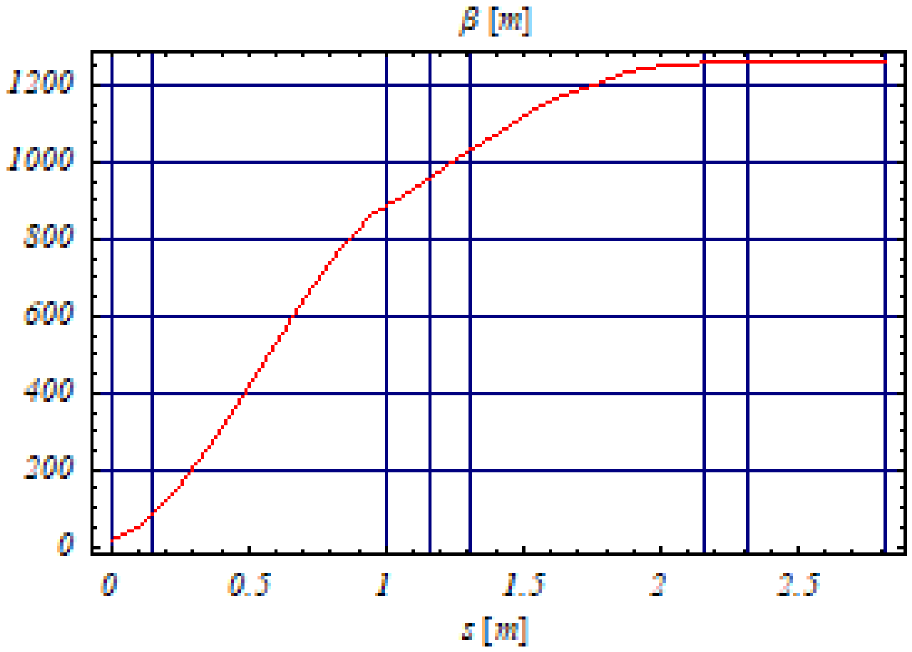


x



y

Beam size in the capture section



- Beam size at the nozzle exit (2.87mm) -2.26σ
- Beam size at the exit of the second GL with 2.26σ is 28.4mm (77.8% of the cathode radius)
  - What is the max radius of the electron cloud we can use?
  - With the solenoid with the aperture of 36.5mm we could accept the beam up to 2.9σ

Some preliminary conclusions and ideas

- Interesting findings on the SCAPA distribution
  - Sharp cut-off in real space
  - No very large divergence particles
  - hole in the middle for our energy (real space)
  - x/y asymmetry
- Interesting findings on the nozzle effect
  - Phase space inclination and the lab size completely defined by the geometry
  - The difference is in the angular spread spread(SCAPA)/spread(HT)~10
  - SCAPA with SC closer to the preCDR distribution
  - Maximum radius of the beam in the capture section defines, if we need to modify the nozzle or not