Diagnostics and bunch intensity control via Compton scattering

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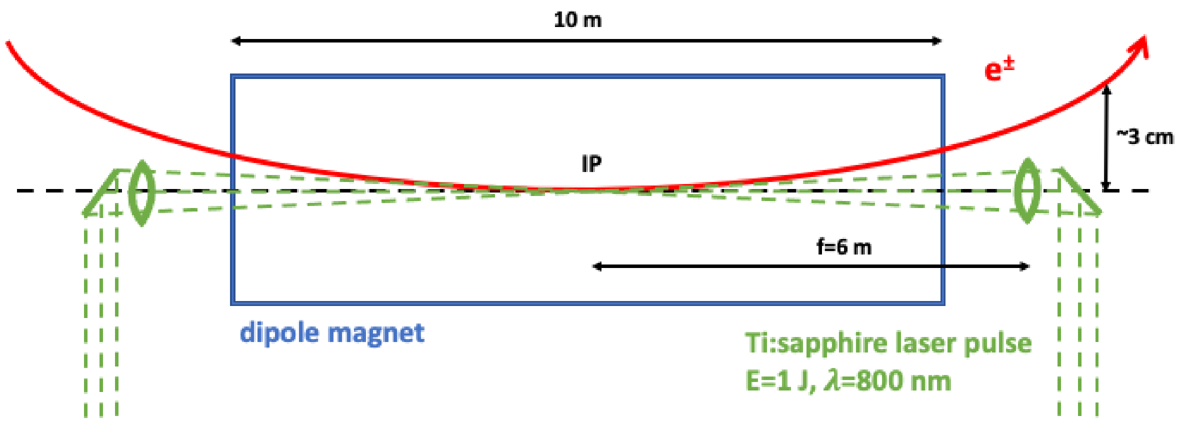
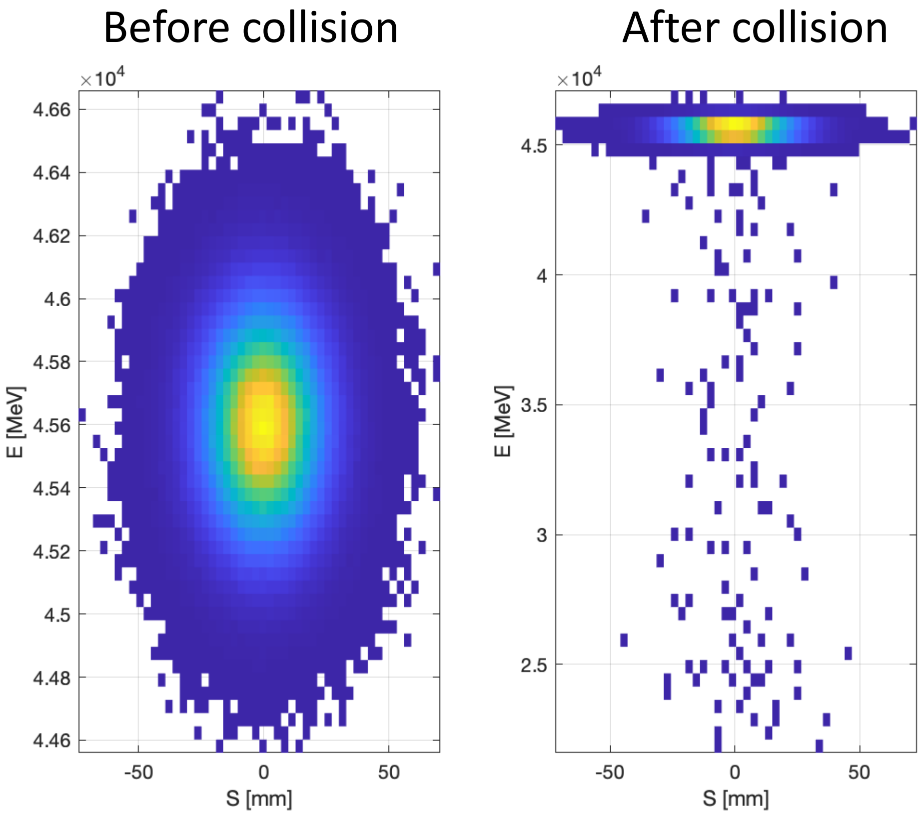
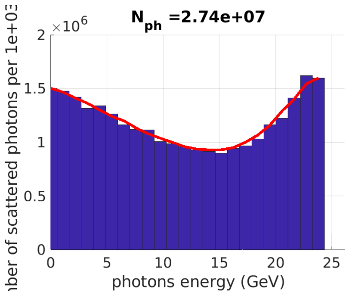
In the future circular electron-positron collider "FCC-ee", the intensity of colliding bunches must be tightly controlled, with a maximum charge imbalance between collision partner bunches of less than 3–5%. Laser Compton back scattering could be used to adjust and fine-tune the bunch intensity.



Sketch of the Compton collision inside a single 10 m long dipole.



Ne_{tot}=2.68e+11; Ne_{scat}=3.45e+07;



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For these initial studies, based on the laser parameter mentioned above, the initial conservative assumption was made that the bunch undergoes laser interaction every 3rd turn, corresponding to a laser frequency of 1 kHz and assuming a pulse energy of 1 J.

Operation mode	/	C̄C
Beam Energy [GeV]	45.6	182.5
n_G [nm]	0.71	1.49
n_H [pm]	1.42	2.98
f_G [mm] at IP	0.11	0.16
f_H [mm] at IP	0.02	0.04

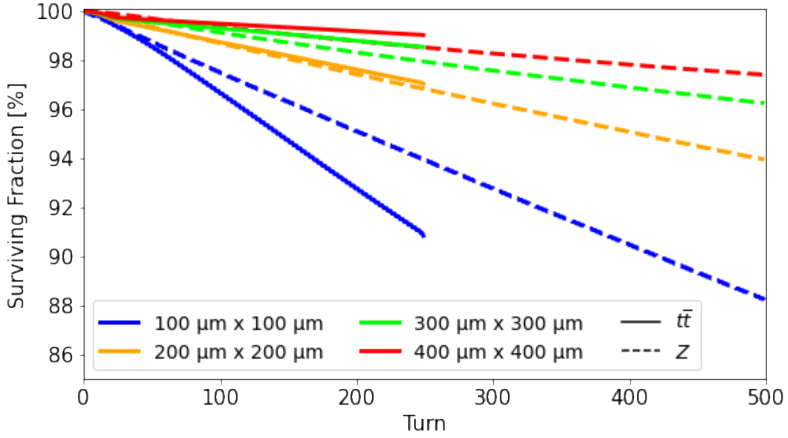


Figure 3: Surviving fraction of the initial particle bunch of 10^6 particles for different laser spot size. The dashed line indicates the results for the / operation mode, whereas the solid line is for tracking with C̄C parameters.

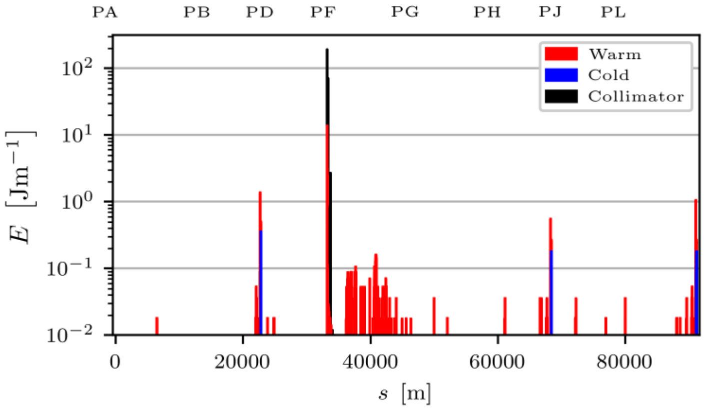


Figure 4: Single-bunch loss map after 500 turns with laser interaction for the Z operation mode and a laser spot size of 100 µm. Aperture losses in normal conducting magnets are shown in red, and losses on superconducting magnets are shown in blue.

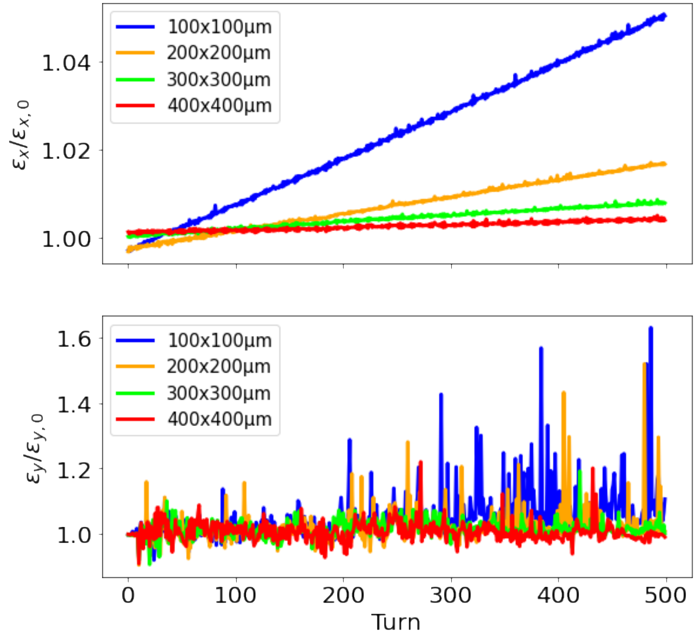
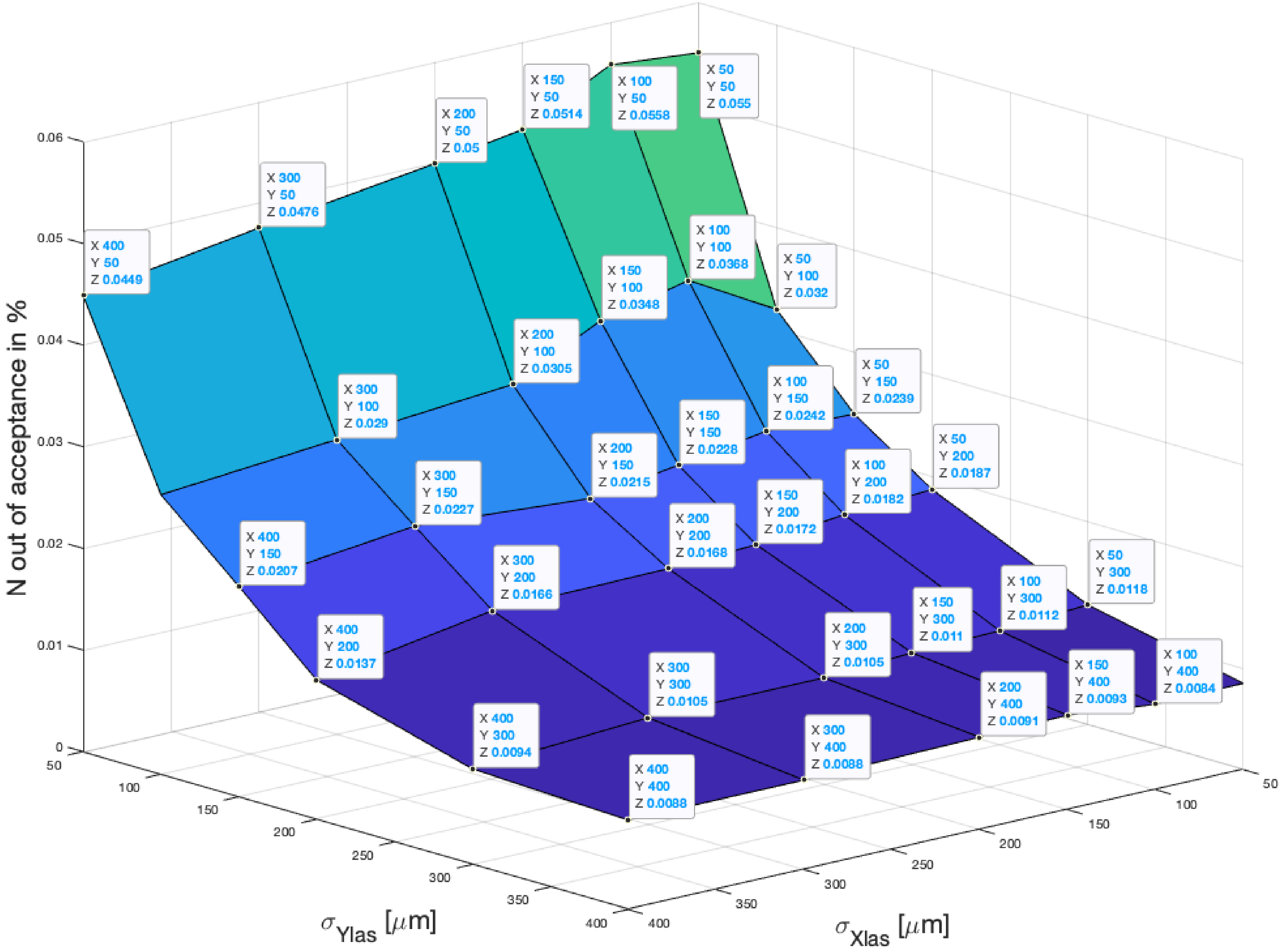


Figure 5: Emittance evolution of the particle bunch for different laser spot size and for the Z operation mode.

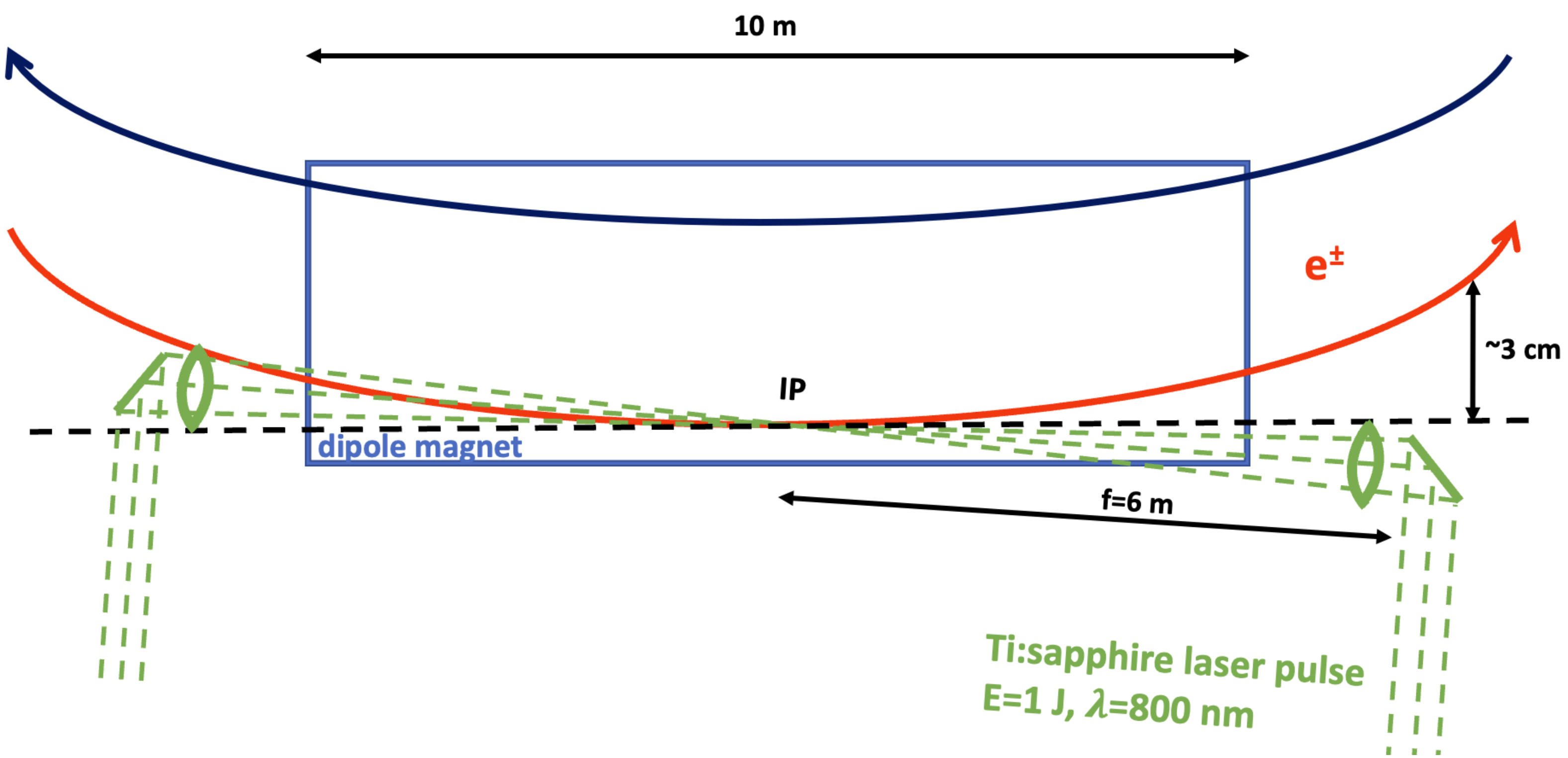
Varying laser focusing at IP



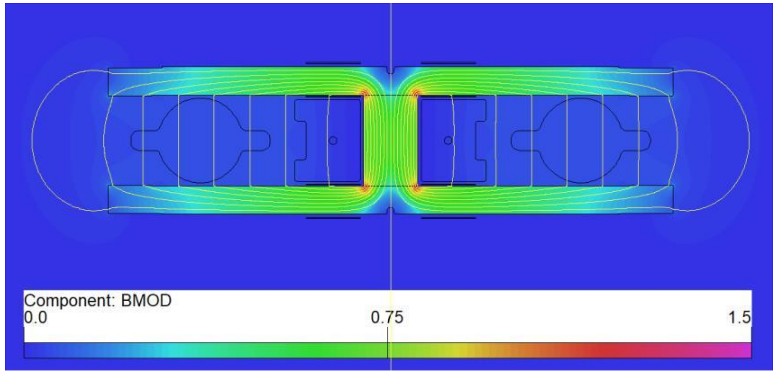
List ToDo:

- Improve IP inside banding magnet

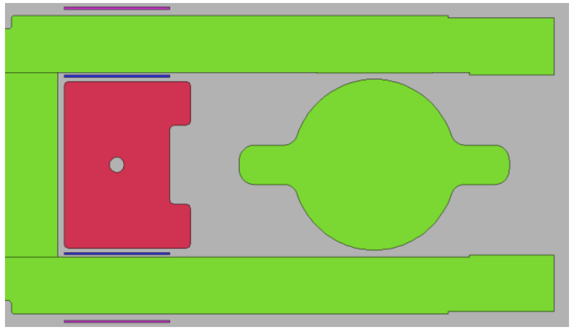
- Find optimum between reducing bunch charge to exclude flip-flop instability and emittance groving
- Study possibility to optimise energy distribution e^- e^+ using dispersion inside bending magnet
- Study possibility to reduce beam halo using Donuts-shaped laser beam
- Study polarisation of scattered photons for diagnostic
- Find application and users for 25 and 150 GeV photon beam 🖖



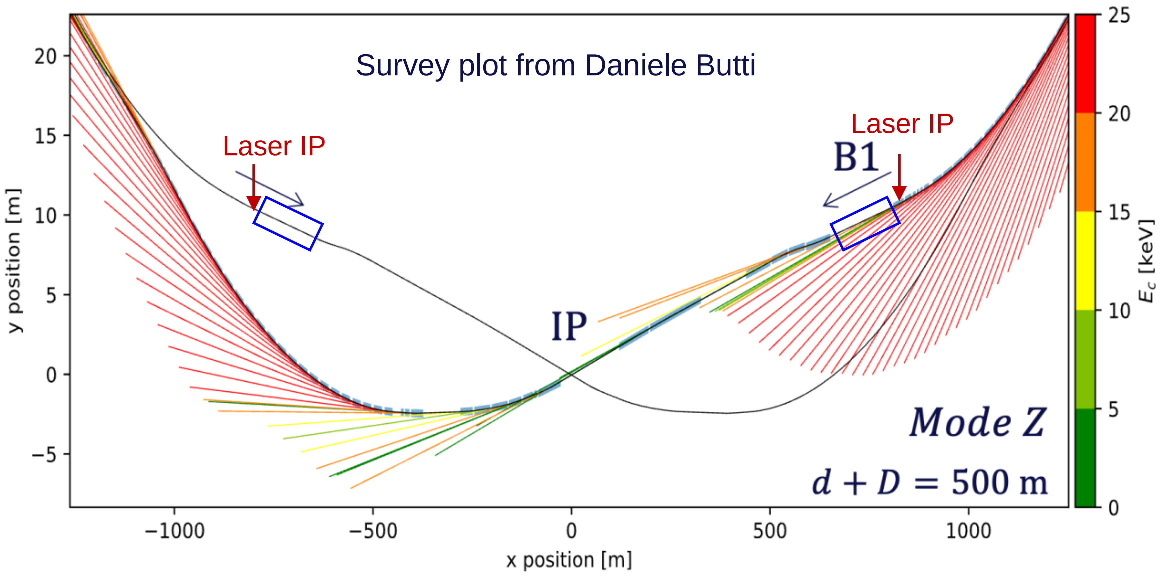
Magnet correction circuits, *J. Bauche, C. Eriksson, F. Saeidi*



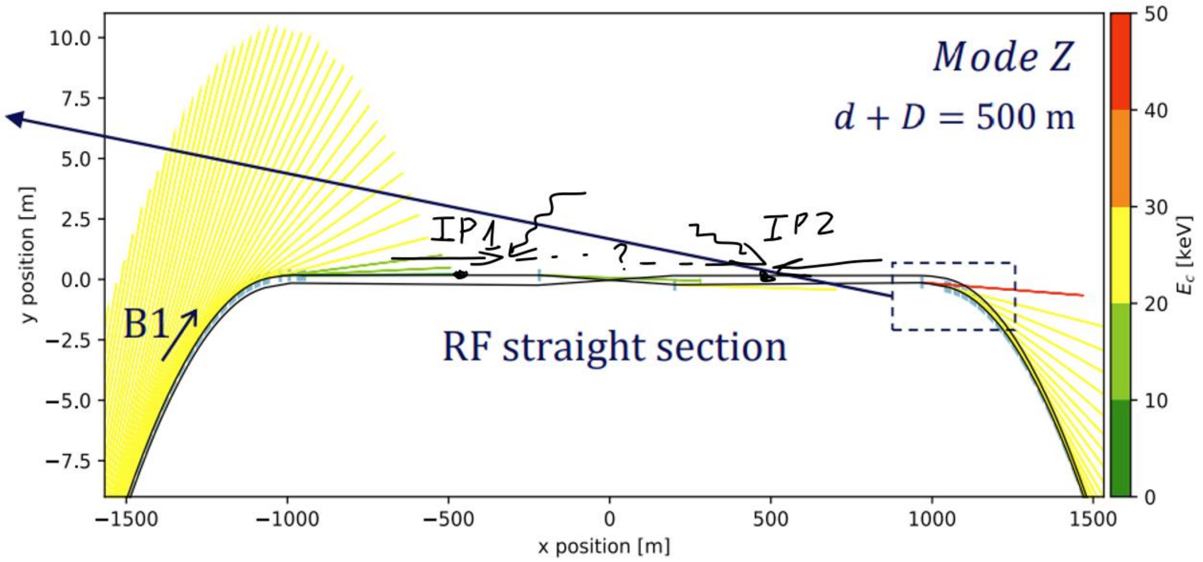
Magnetic model cross-section (tt_{bar} excitation, B = 61 mT)

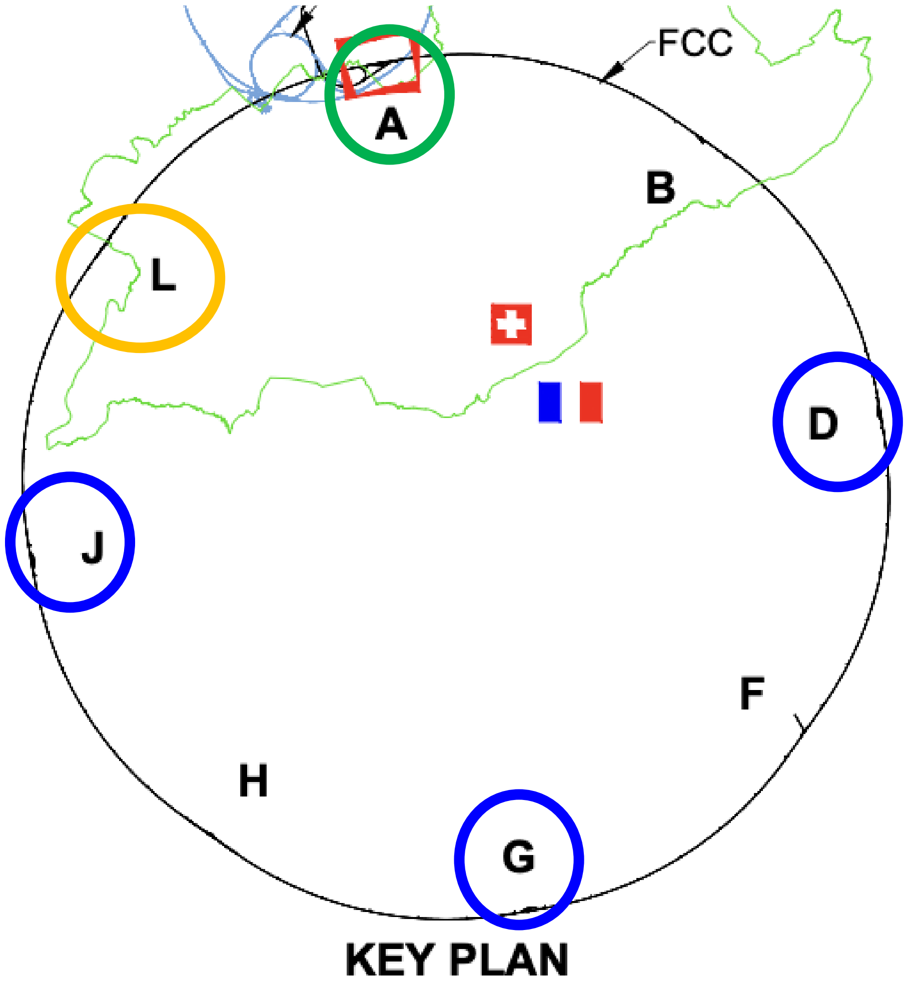


Trim coils wrapped around top and bottom poles

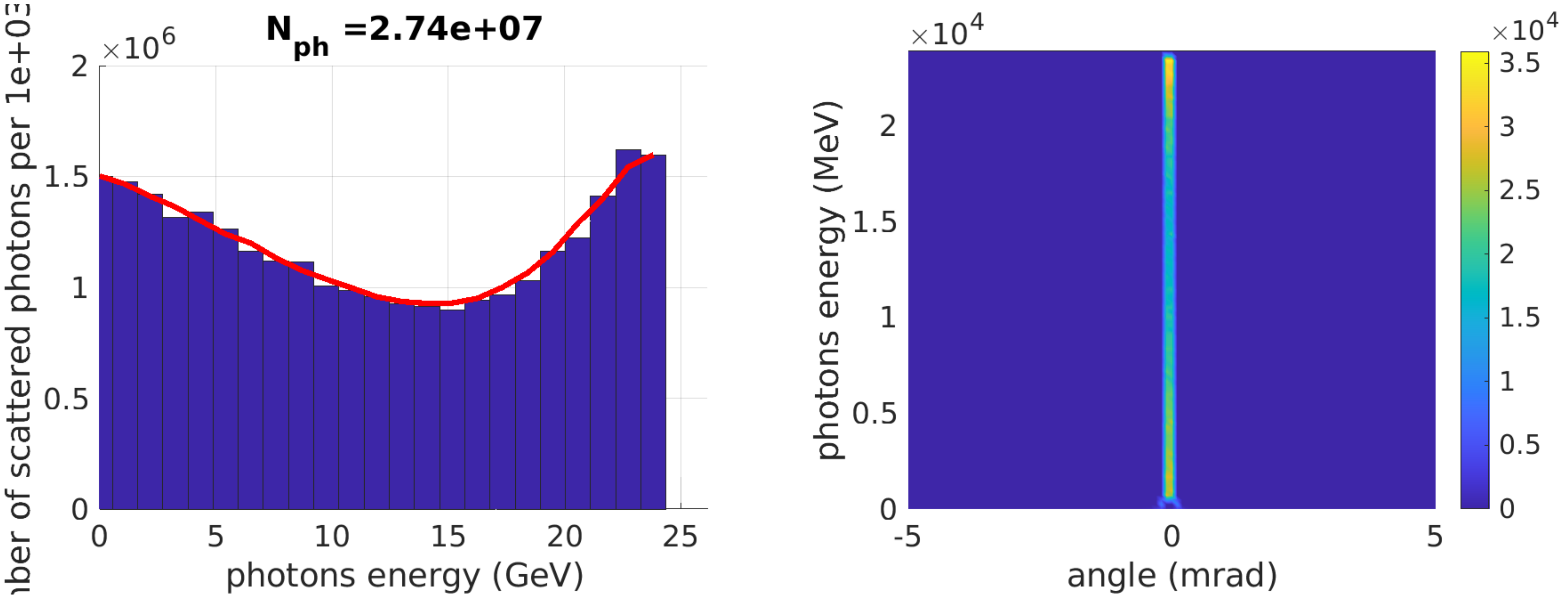


Synchrotron Radiation fan shows a potentially strong contamination from SR in the compton gammas extraction line.

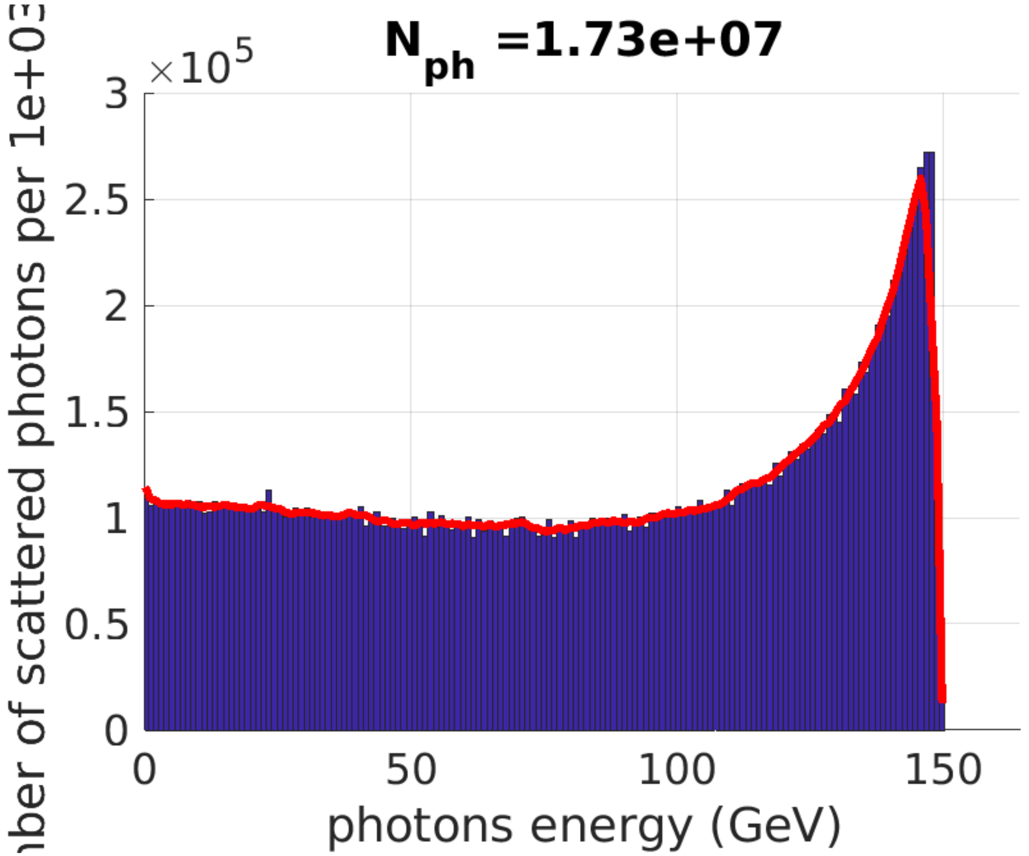




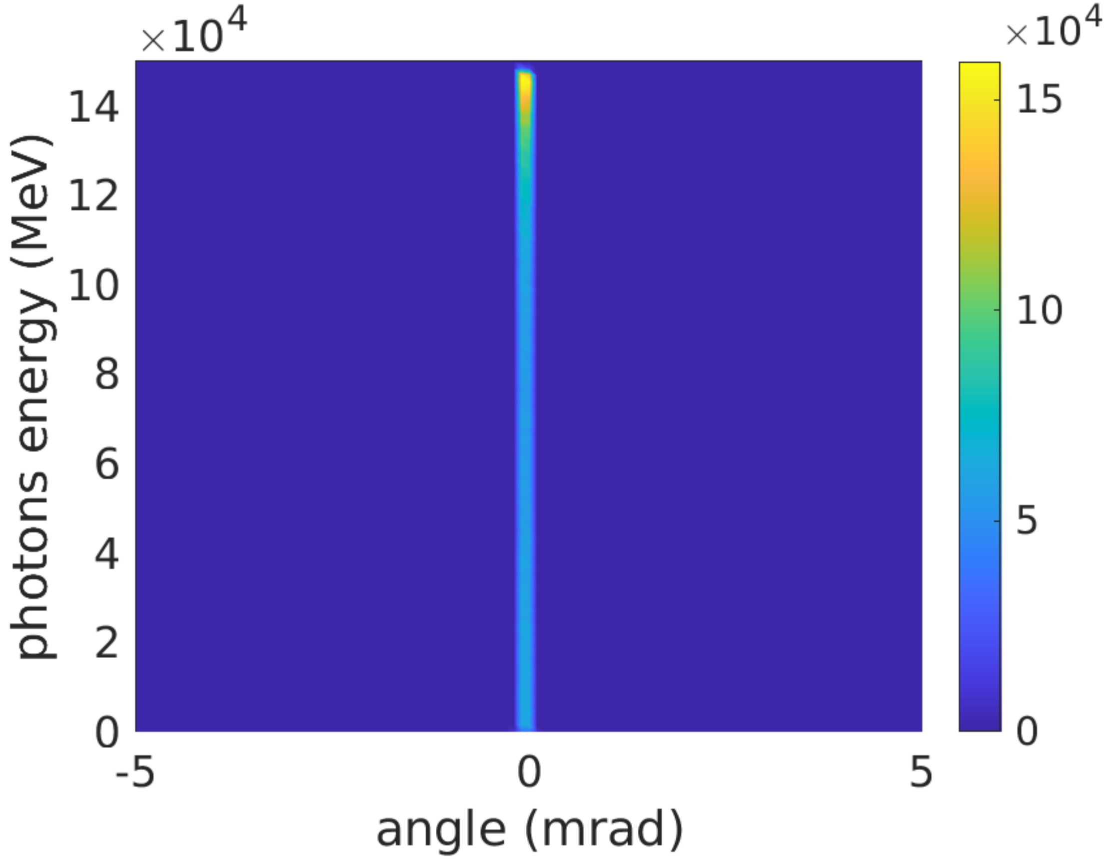
Beam from xsuit z



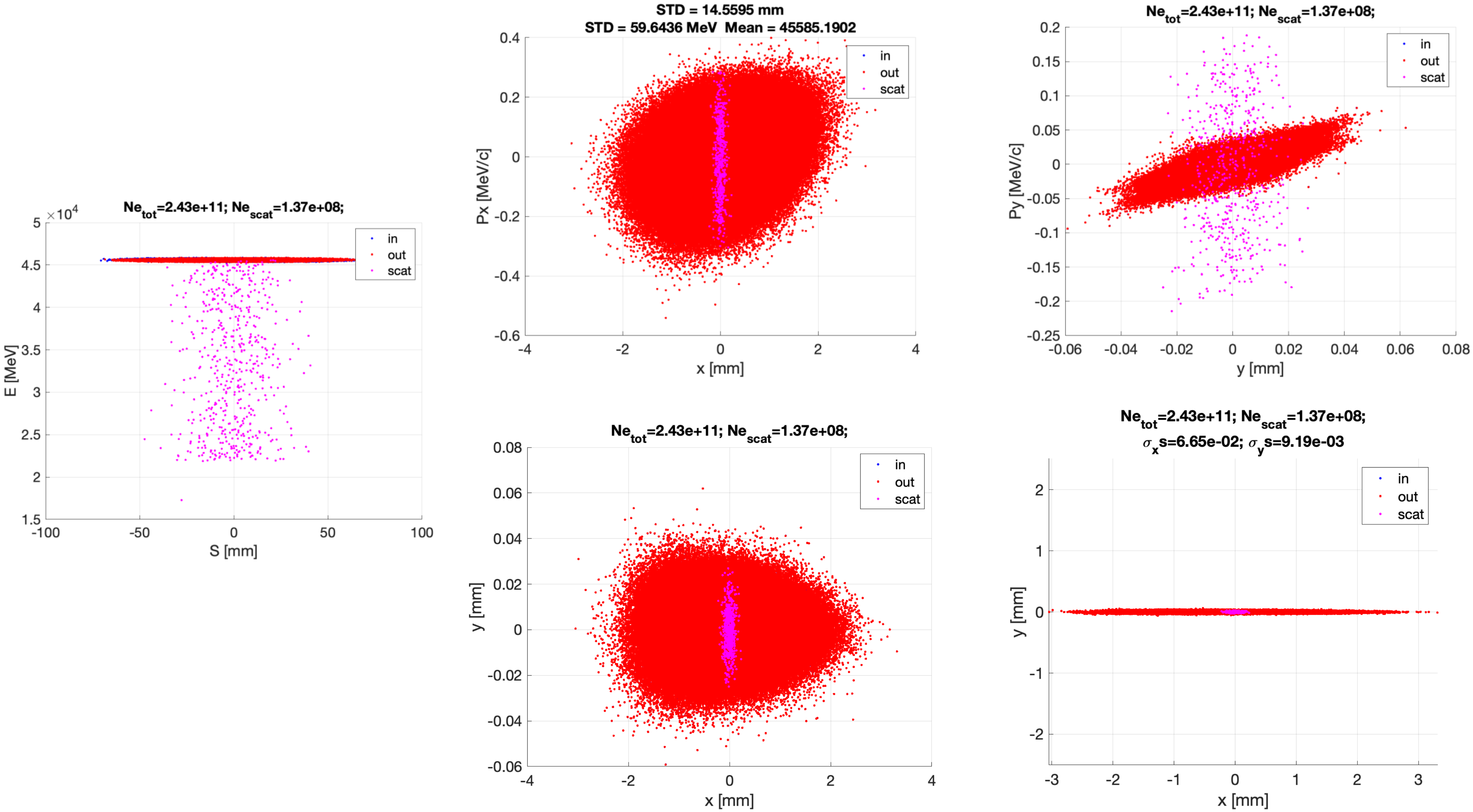
TT BAR



N_{ph} =1.73e+07
×10^5
3
2.5
2
1.5
1
0.5
0
0
50
100
150
photons energy (GeV)
nber of scattered photons per 1e+03



×10^4
14
12
10
8
6
4
2
0
-5
0
5
angle (mrad)
photons energy (MeV)
×10^4
15
10
5
0



Ne_tot=2.43e+11; Ne_scat=1.37e+08;
E [MeV]
S [mm]
×10^4
in
out
scat
STD = 14.5595 mm
STD = 59.6436 MeV Mean = 45585.1902
Px [MeV/c]
x [mm]
Ne_tot=2.43e+11; Ne_scat=1.37e+08;
Py [MeV/c]
y [mm]
Ne_tot=2.43e+11; Ne_scat=1.37e+08;
y [mm]
x [mm]
Ne_tot=2.43e+11; Ne_scat=1.37e+08;
σ_x s=6.65e-02; σ_y s=9.19e-03
y [mm]
x [mm]