Study of Run2 electron beam injection

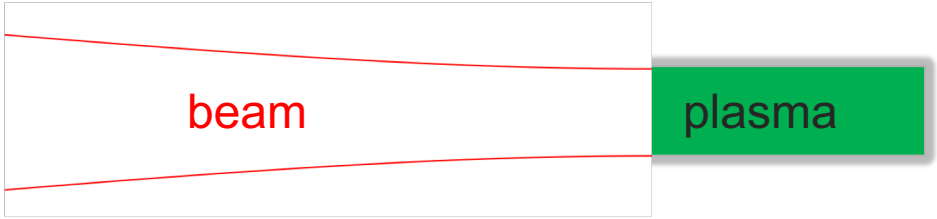
Livio Verra

26.04.2019

MPP Group Meeting

Goal: conserving beam size and emittance during the acceleration process

1) Matching the electron beam optics with the plasma at the injection point
   → Condition on the beta-function at the waist



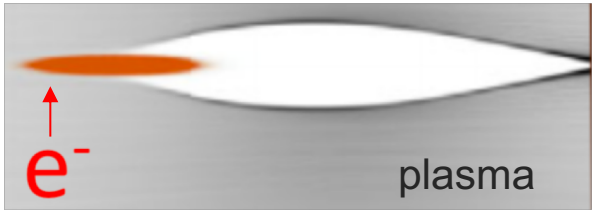
$$\beta_0 = \sqrt{\frac{2\,\epsilon_0\, m_e\, c^2\, \gamma}{n_e\, e^2}}$$

i.e: for E = 165 MeV and $n_e = 2 \cdot 10^{14}$ cm^{-3},
$\beta_0 \sim 9.6$ mm

Goal: conserving beam size and emittance during the acceleration process

2) Reaching the blowout condition ($n_b \gg n_e$))

→ Condition on the beam emittance

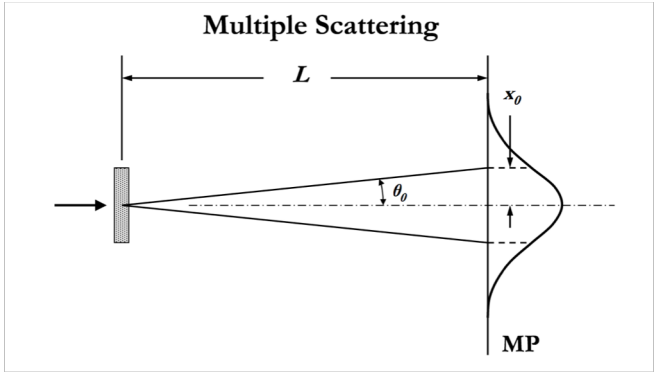


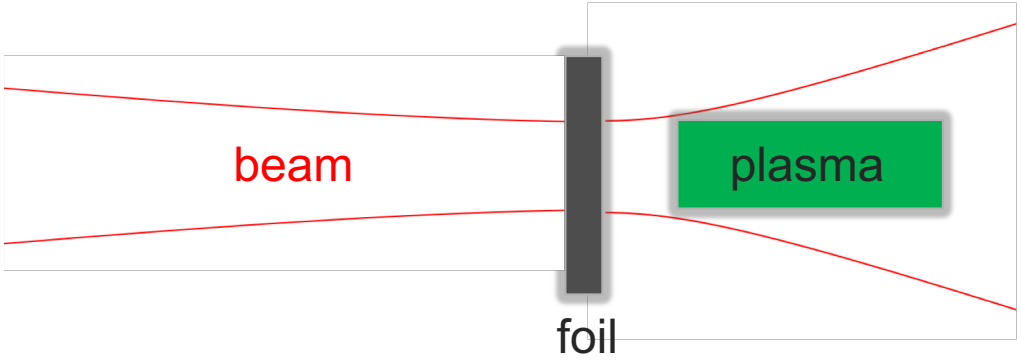
$$\epsilon_g \ll \frac{N}{(2\pi)^{3/2}\beta_0\sigma_z n_e}$$

i.e: for β_0 = 9.6 mm, N=100 pC, σ_z = 60 μm, ε_g = 2.5 μrad

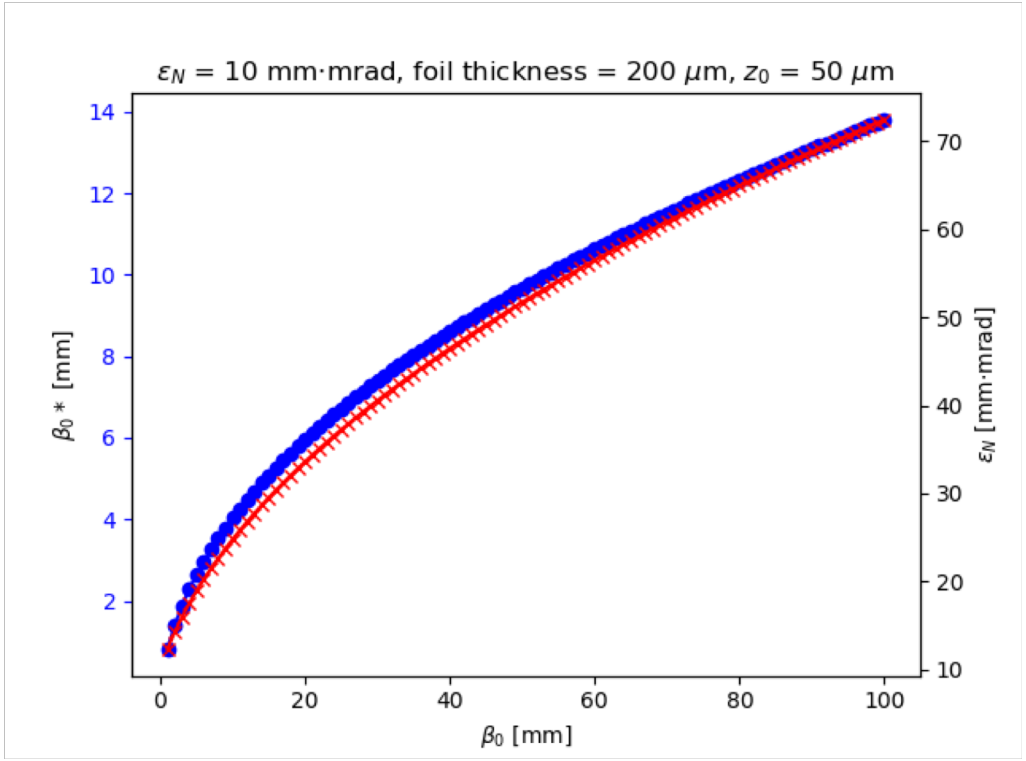
Problem: electrons must pass through (at least) 2 foils

Due to multiple Coulomb scattering, the electron beam divergence increases by an angle θ_0 → spoil beam characteristics

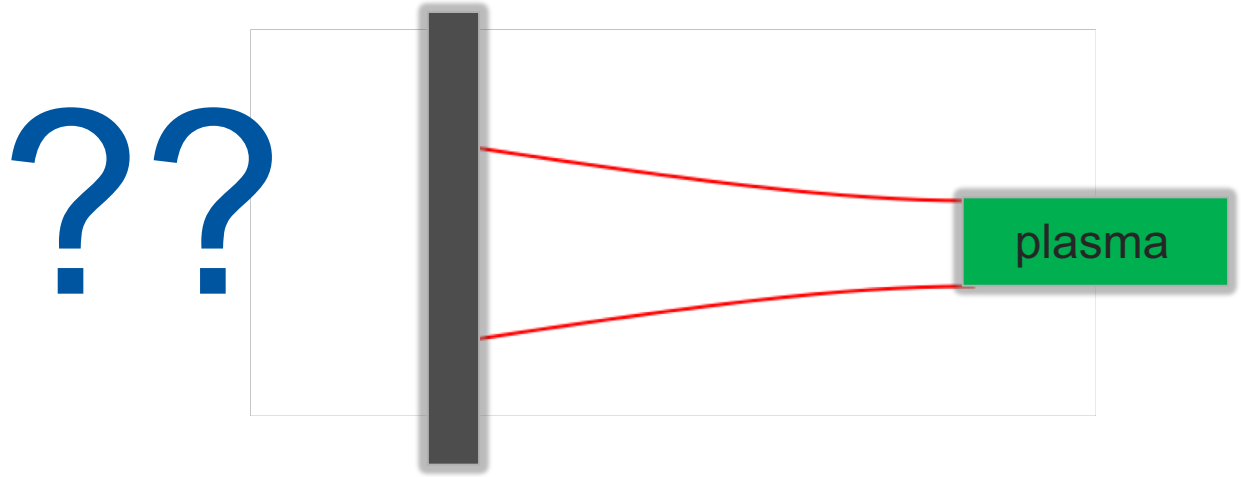




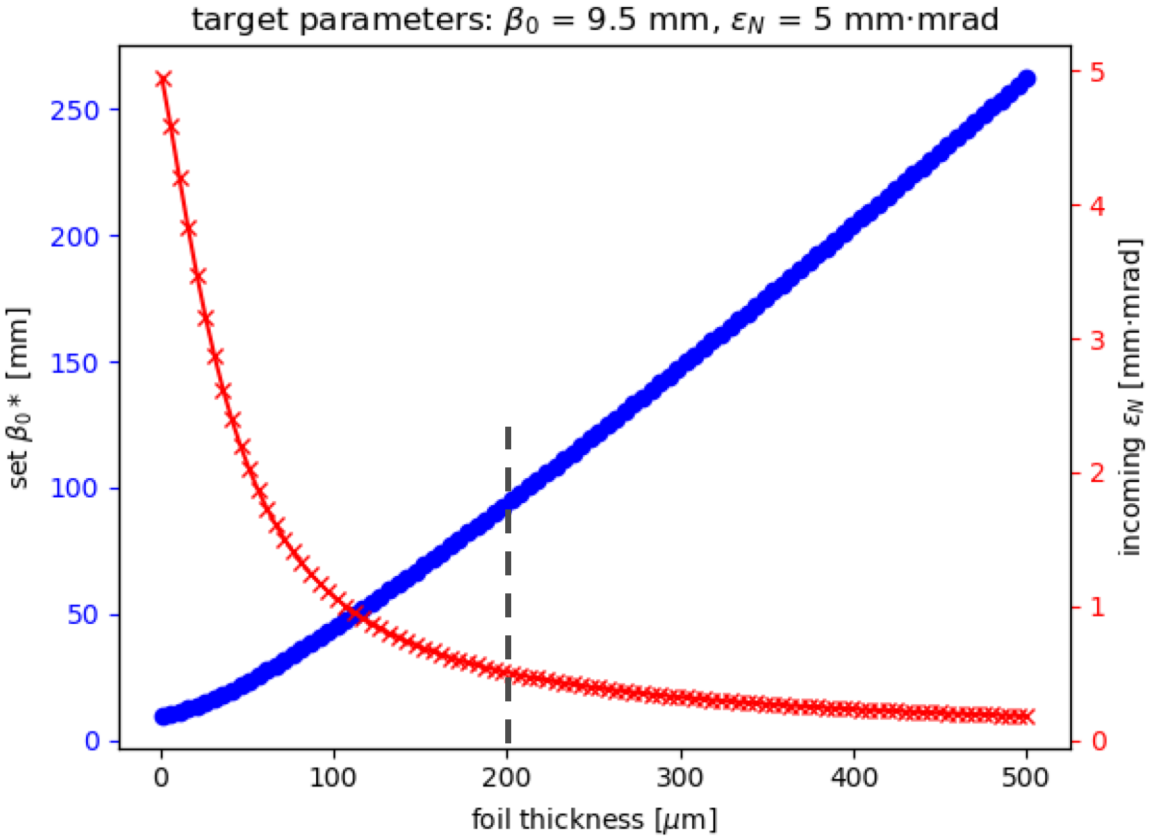
- Emittance increases
- Beta-function decreases
- Waist moves closer to the foil



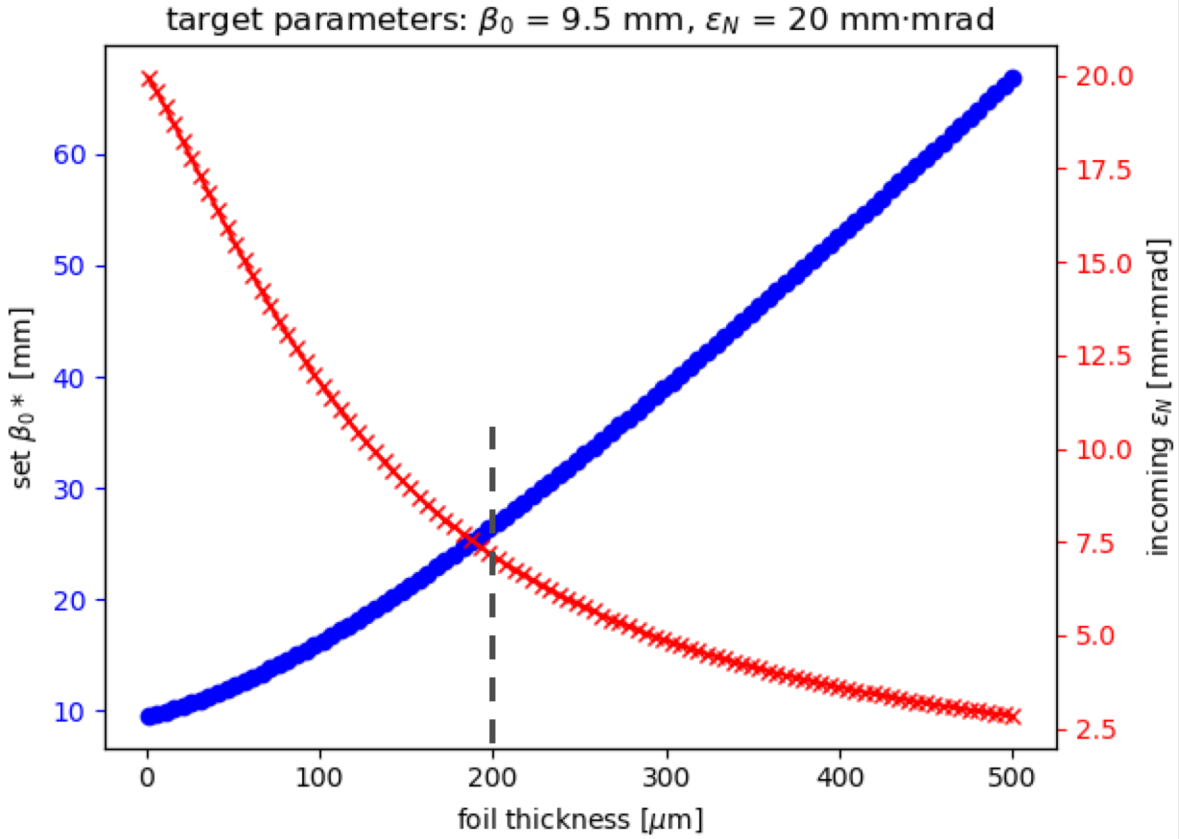
What are the characteristics of the beam before the foils, to satisfy the matching conditions at the injection?



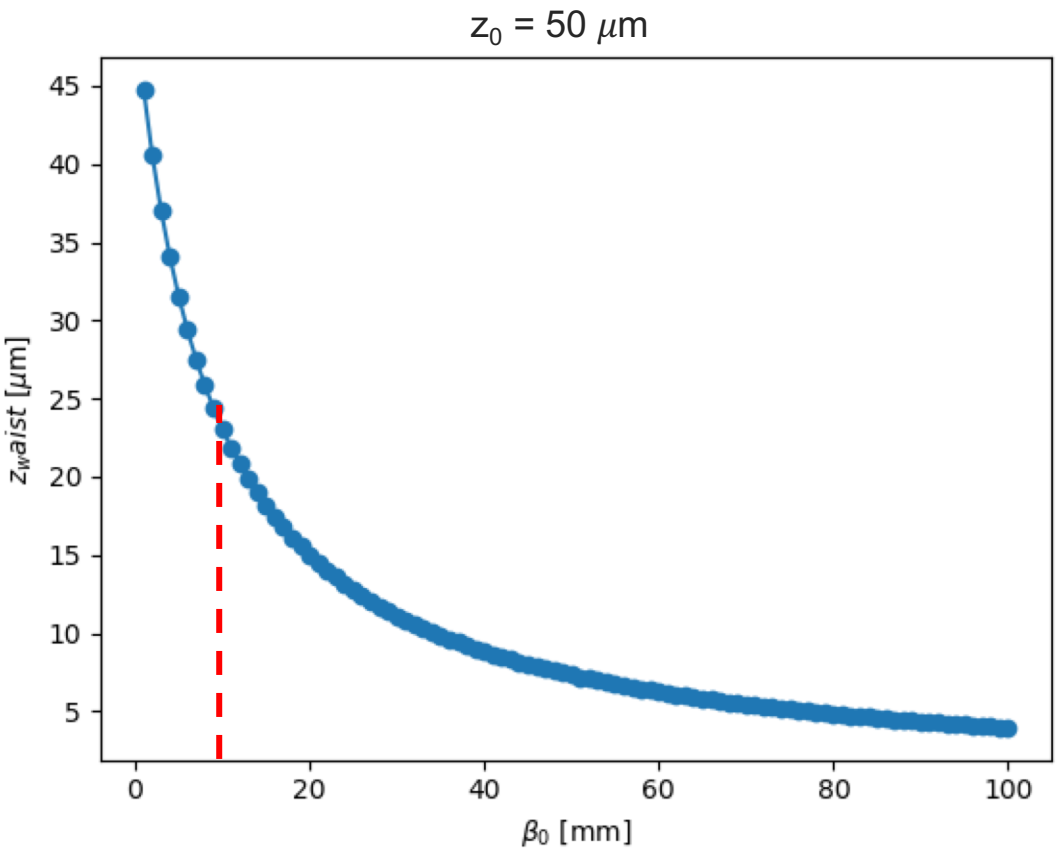
Target $\sigma_w = 12\ \mu m$

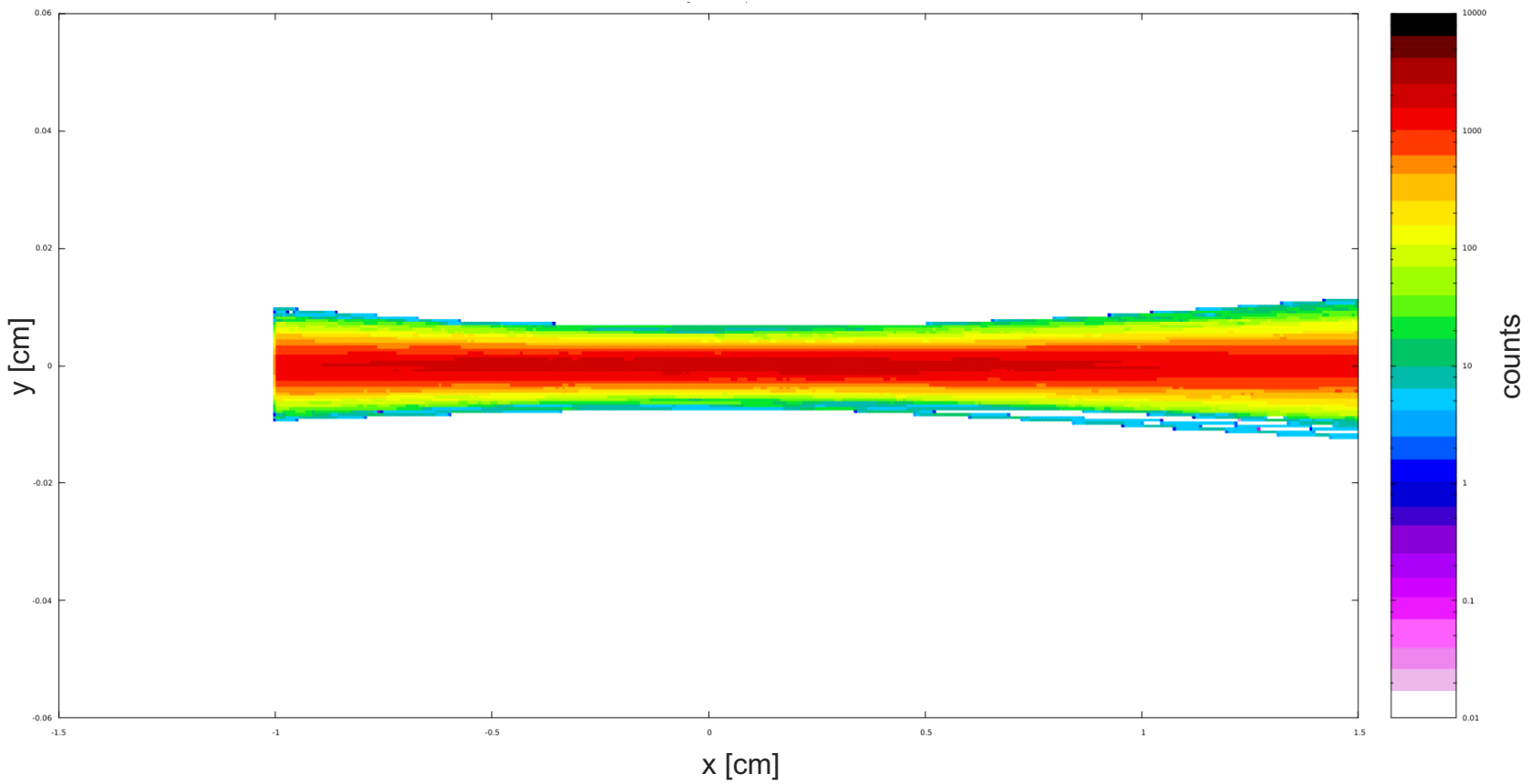


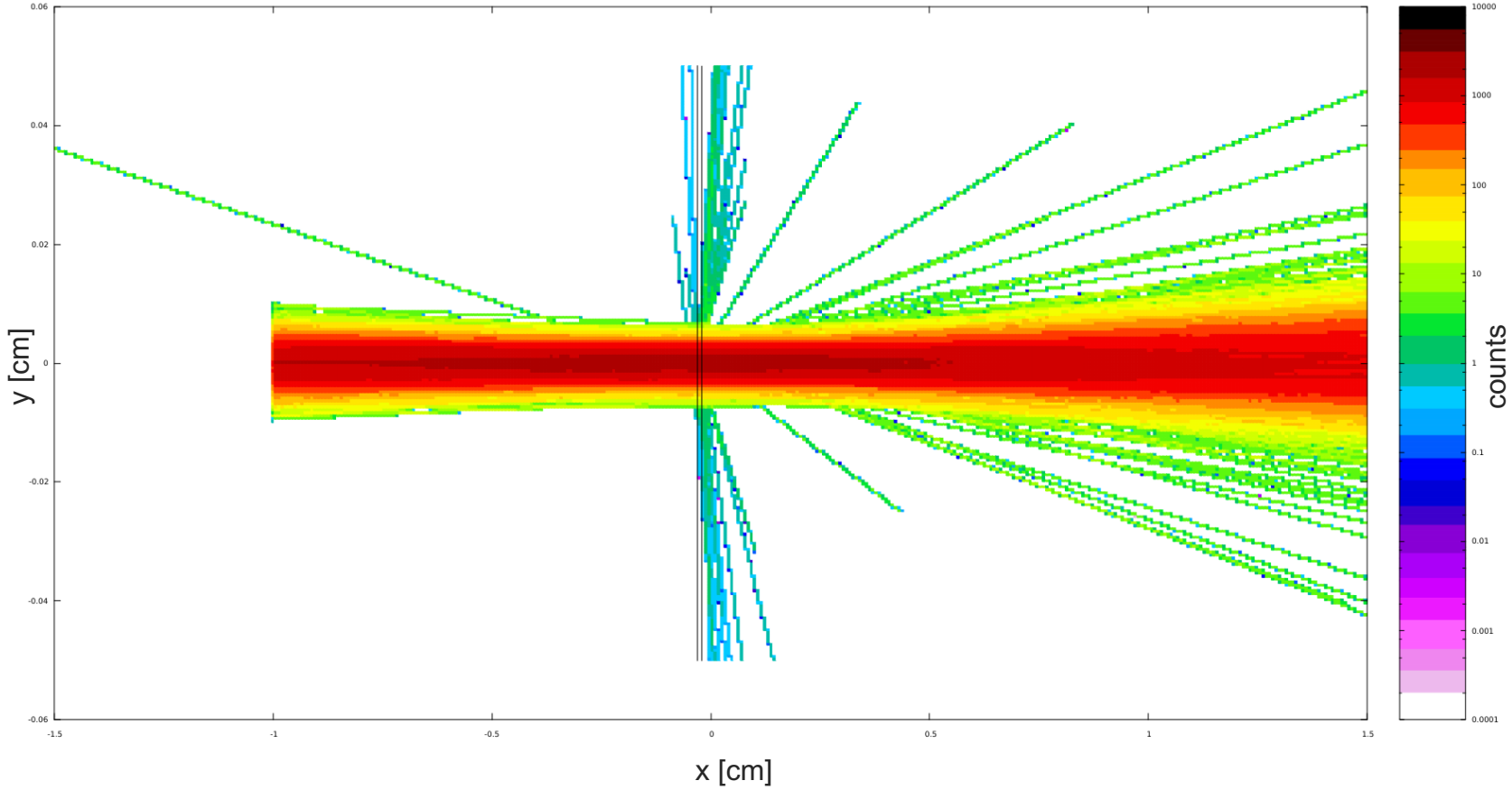
Target $\sigma_w = 24\ \mu m$



Waist moves 25 μm closer to the foil → Δt ~0.08 ps




0.06
0.04
0.02
0
-0.02
-0.04
-0.06
y [cm]
-1.5
-1
-0.5
0
0.5
1
1.5
x [cm]
10000
1000
100
10
1
0.1
0.01
counts


y [cm]
x [cm]
counts
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-1.5
-1
-0.5
0
0.5
1
1.5
10000
1000
100
10
1
0.1
0.01
0.001
0.0001

Next steps:

- study the feasibility for one foil (thickness, material, ecc..)
- cross-check with simulations
- repeat for the second foil
- experimental tests (CLEAR??)
- ….