Study of Run2 electron beam injection

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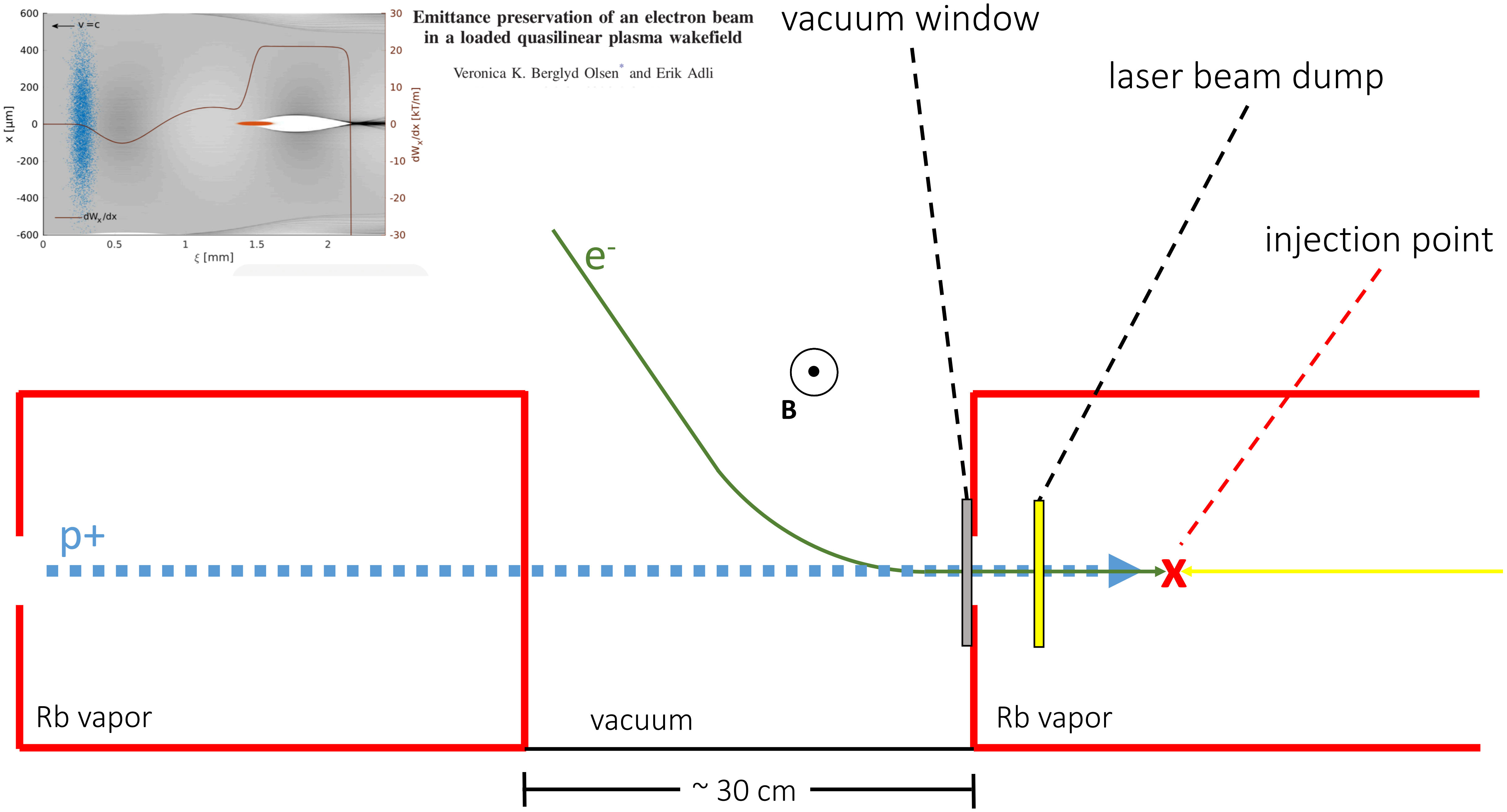
24.05.2019

MPP Group Meeting


Emittance preservation of an electron beam in a loaded quasilinear plasma wakefield
Veronica K. Berglyd Olsen* and Erik Adli
v = c
dW_x/dx
x [µm]
ξ [mm]
dW_x/dx [kT/m]
vacuum window
laser beam dump
injection point
e-
B
p+
Rb vapor
vacuum
Rb vapor
~ 30 cm

Beam parameters

Protons:

- 400 GeV/c
- ~ 3E+11 particles per bunch
- ε_N = 2μrad, σ_r = 200 μm
- Modulated

Electrons:

- 165 MeV/c
- 100 pC
- **Matched with plasma ($n_e = 2*10^{14}$ cm$^{-3)}$ at the injection: β ~ 9.5 mm, ε_N ~ 20μrad**

→ Incoming beam characteristics depend on the foils

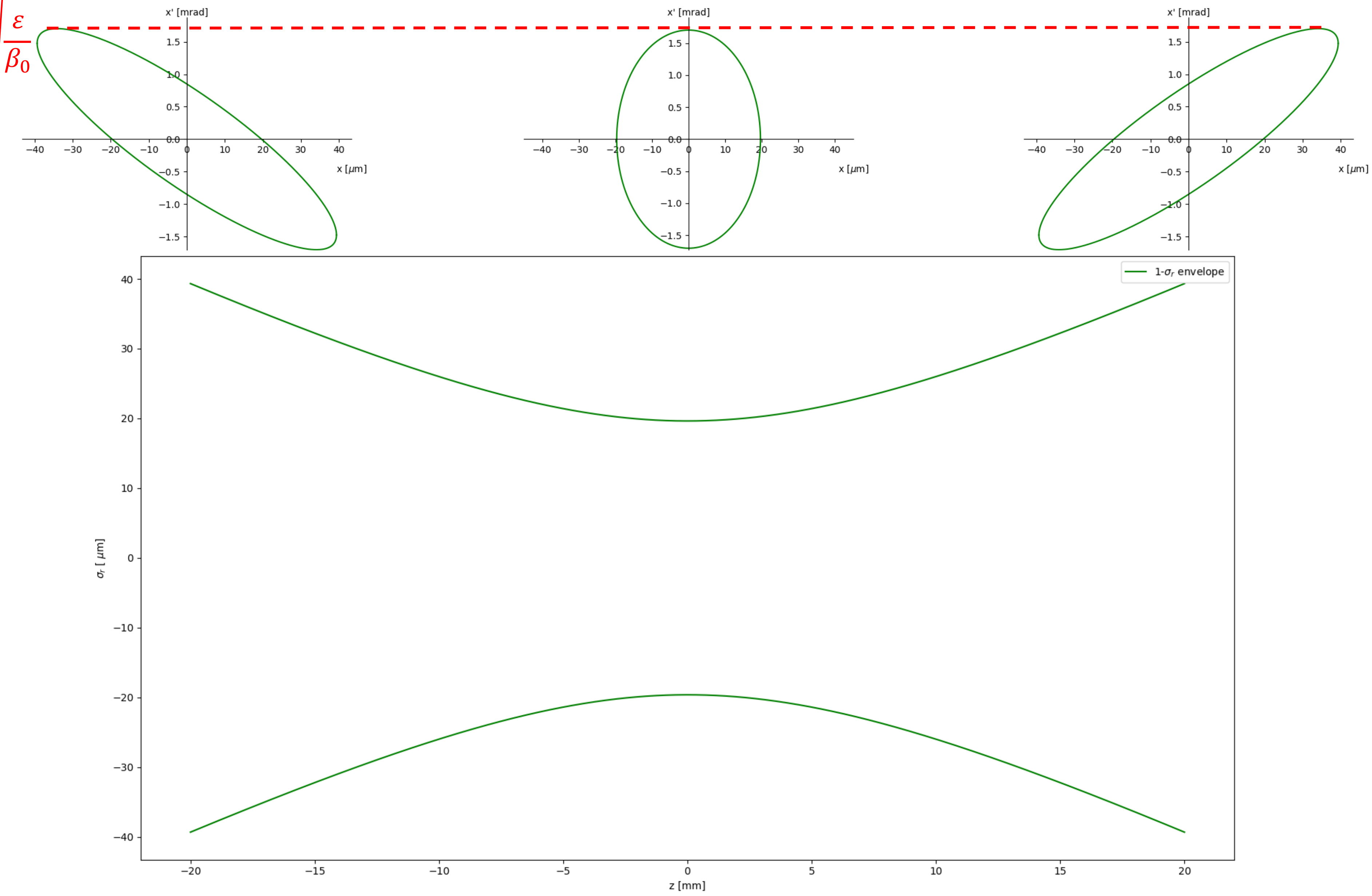
Plasma parameters

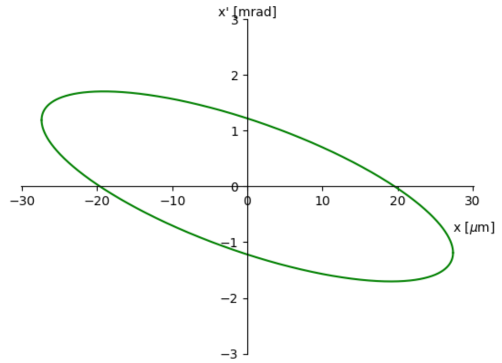
Rubidium vapor

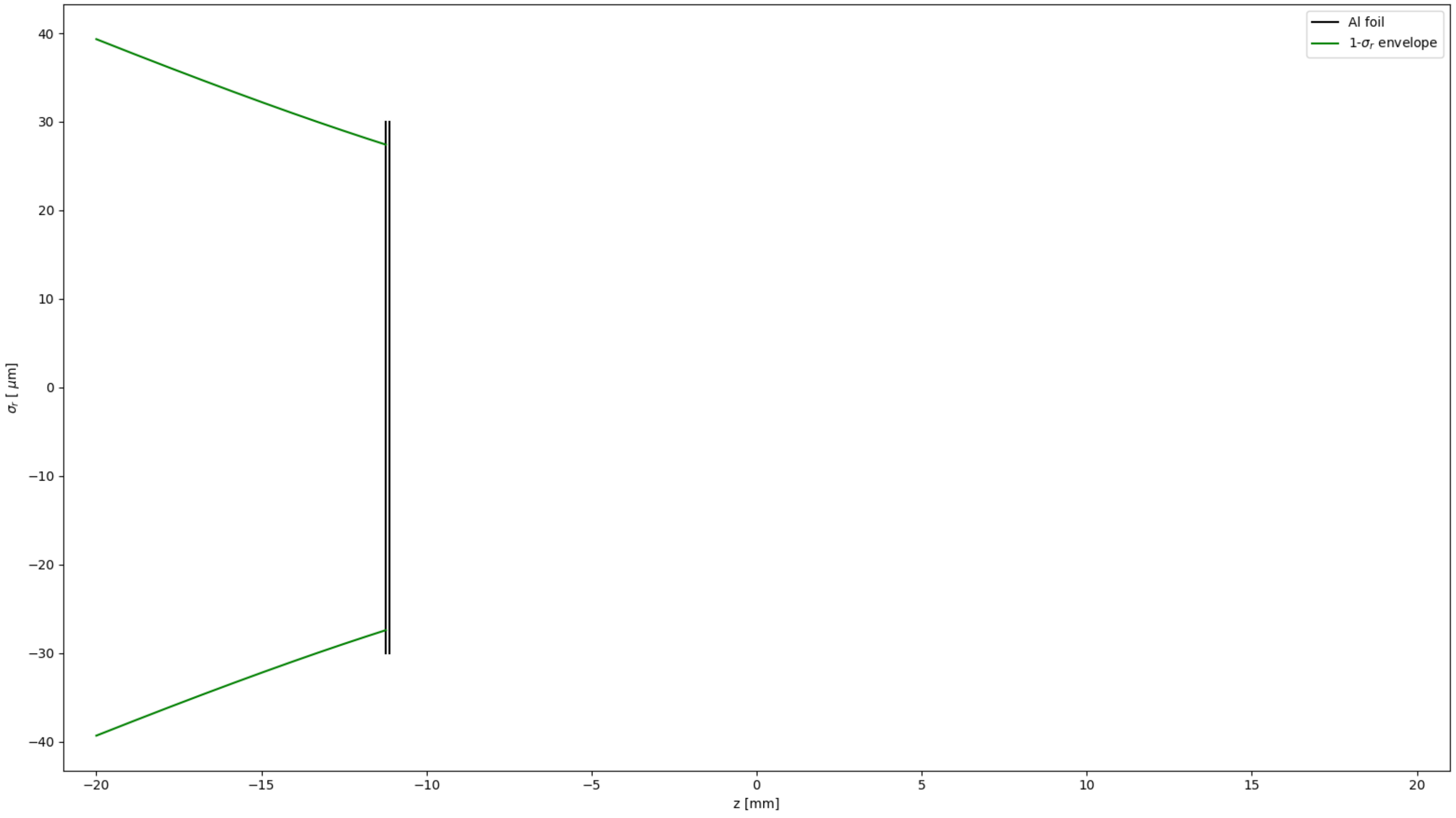
- T = (180 – 230) °C
- $n_e = (1 – 7)*10^{14}$ cm^{-3}

Beam optics recap

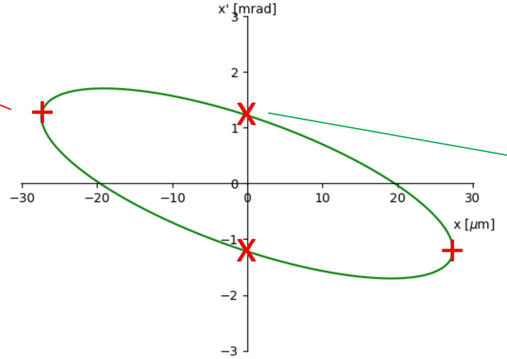
$$x'_{max} = \sqrt{\gamma\varepsilon} = \sqrt{\frac{\varepsilon}{\beta_0}}$$



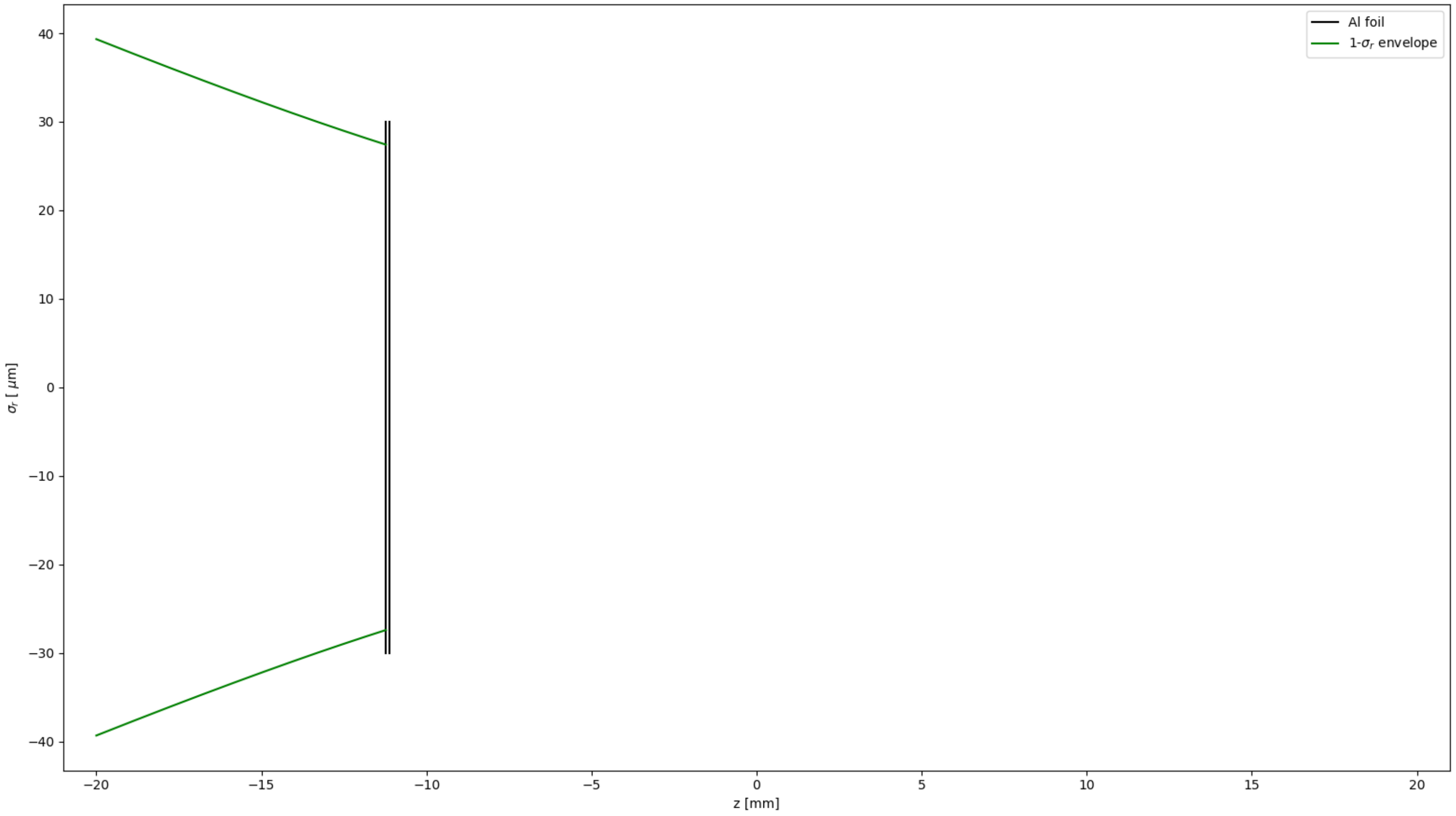

x' [mrad]
x [μm]

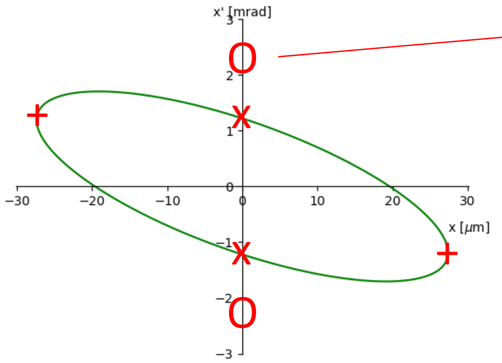

Al foil
1-σ_r envelope
σ_r [μm]
z [mm]

$$\sigma = \sqrt{\varepsilon\,\beta}$$



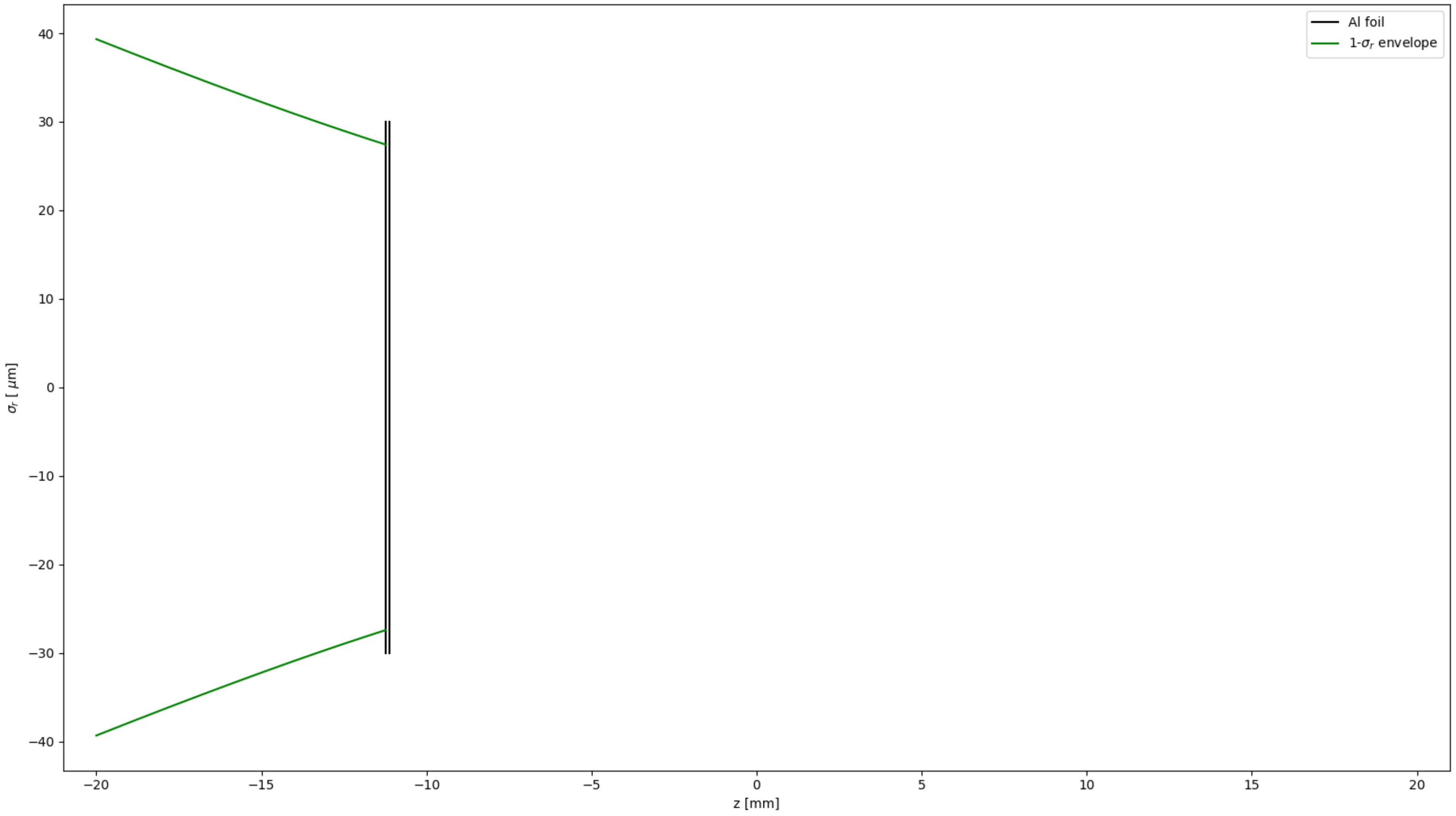
$$x'_i = \sqrt{\frac{\varepsilon}{\beta}}$$

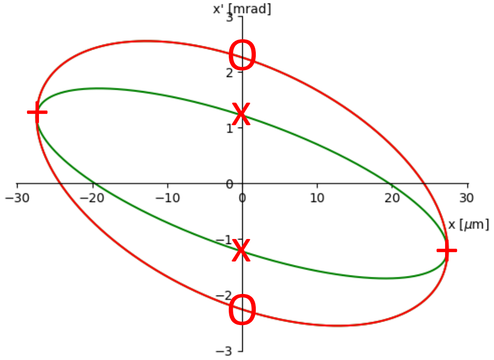




$$x'_f = \sqrt{x'^2_i + <\vartheta^2>}$$

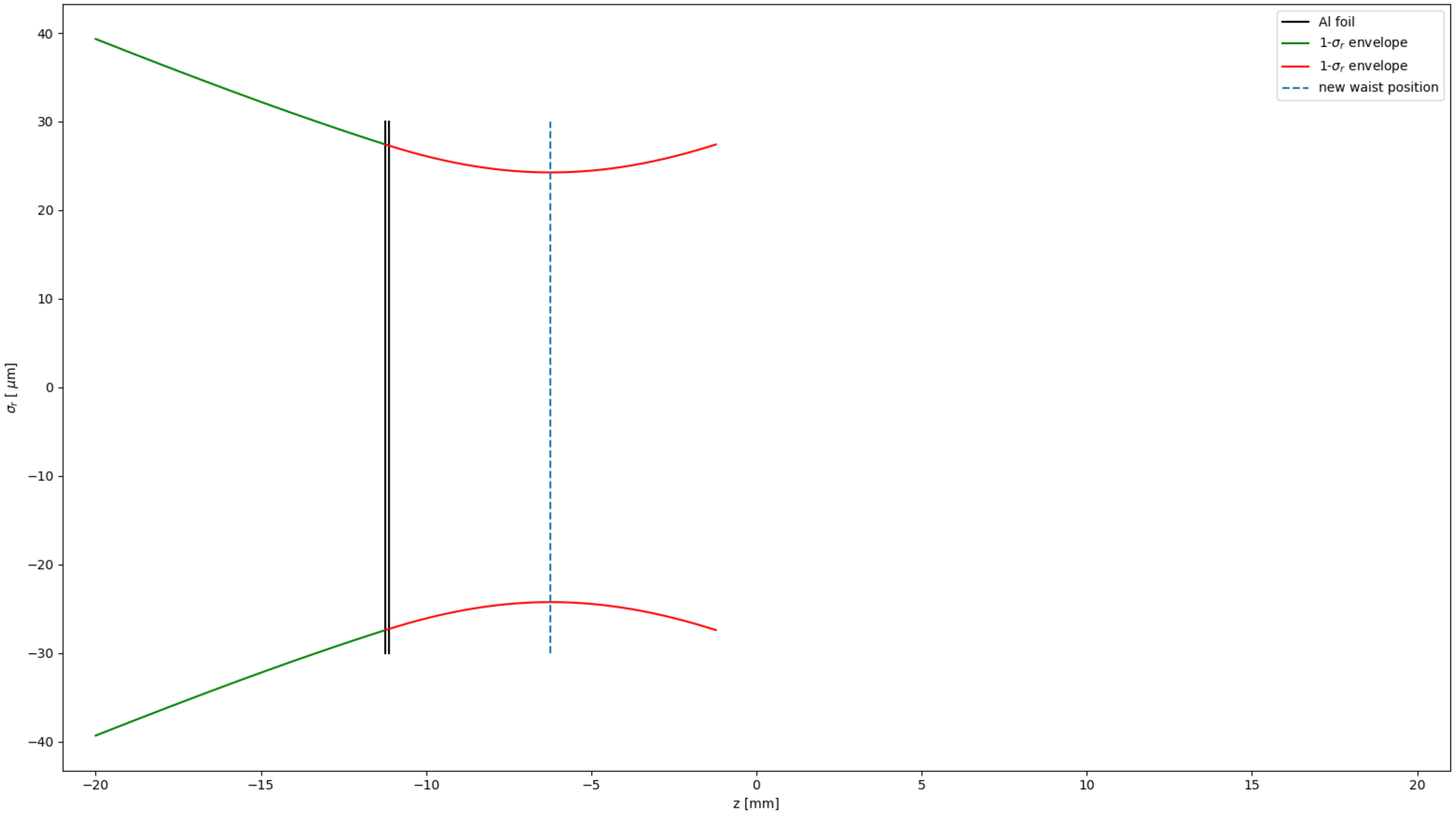
multiple scattering angle contribution

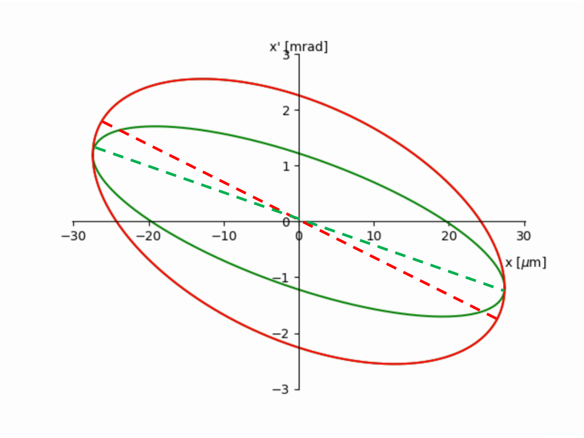




- Emittance growth
- Size conserved

$\sigma = \sqrt{\varepsilon \, \beta}$ → Beta decreases



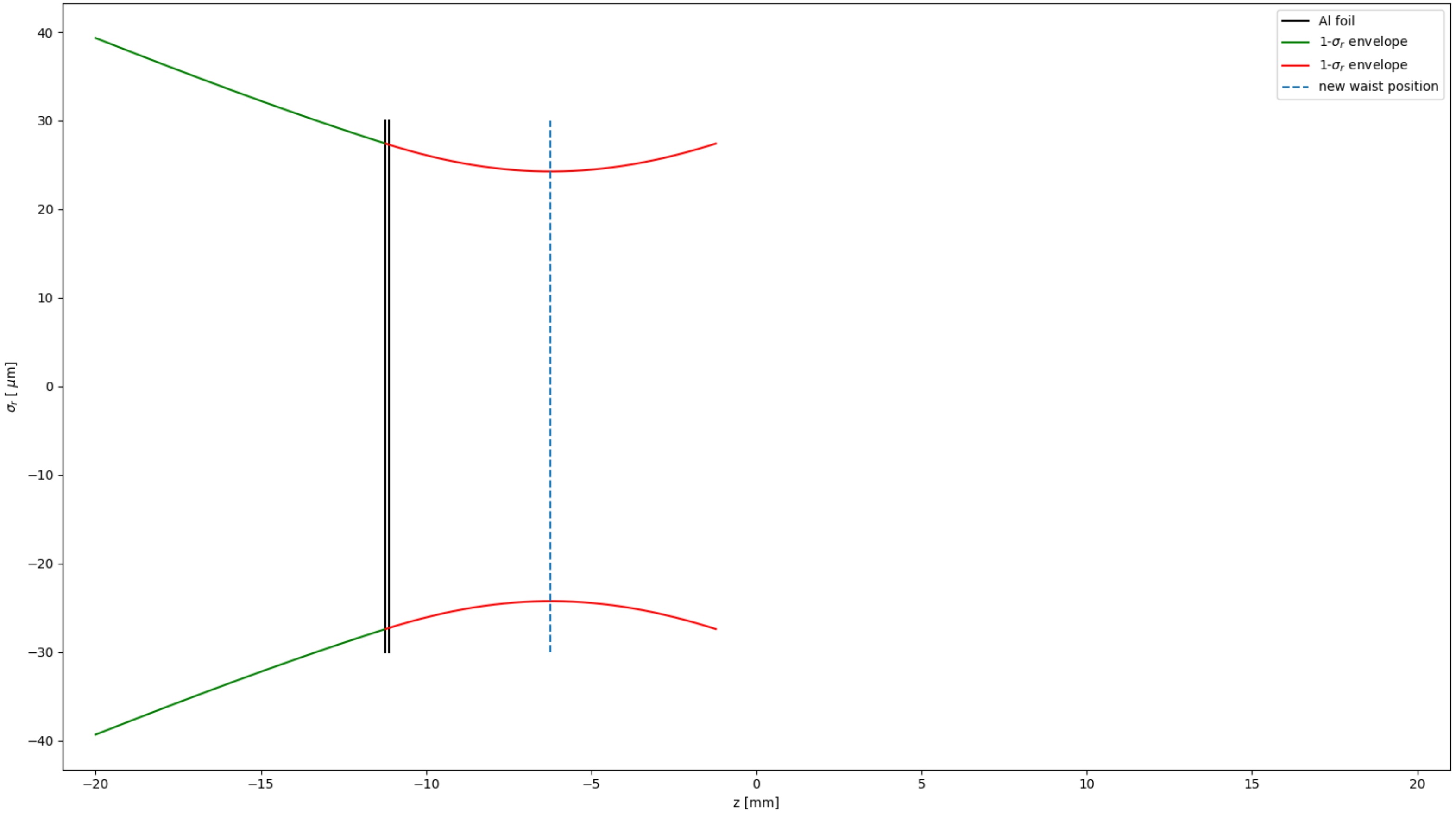


Ellipses is rotated towards the waist

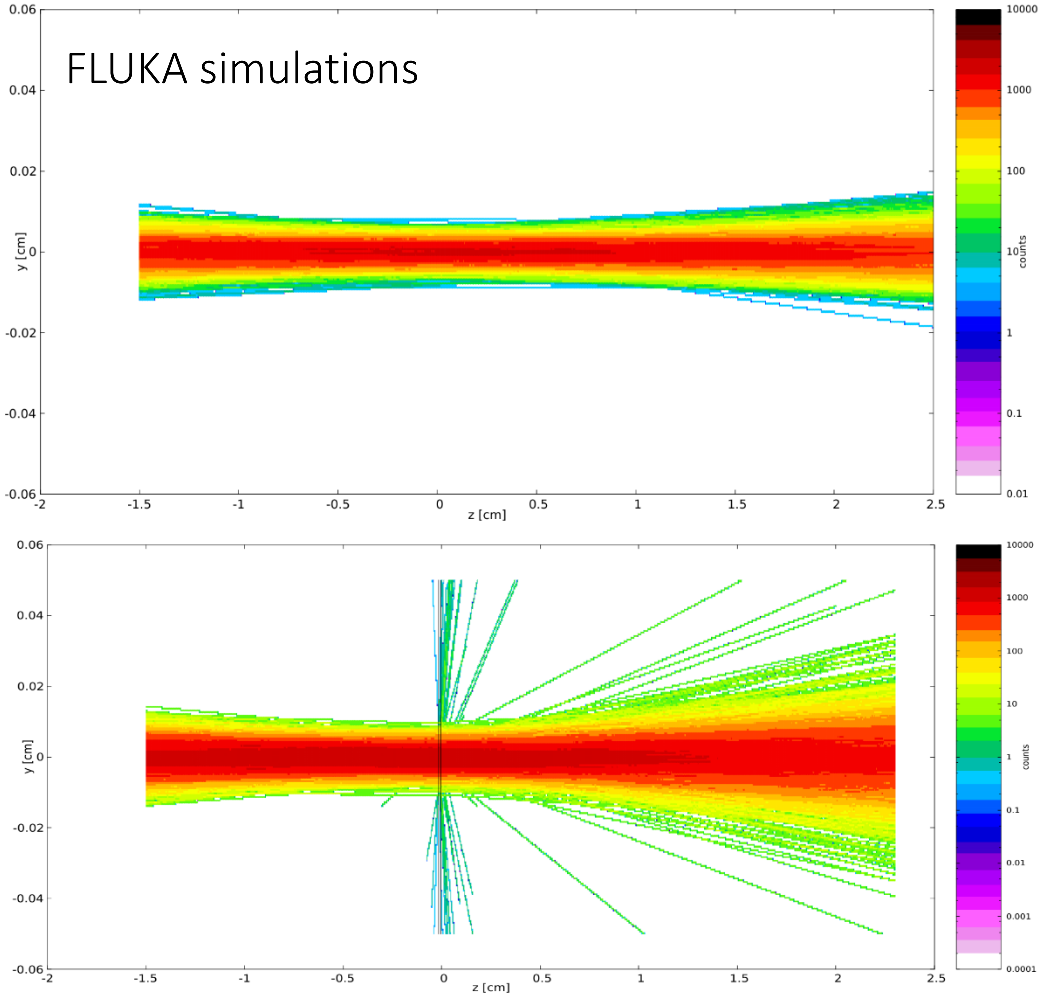
→ Beta function not only defines the size (with ε) , but also the envelope evolution:

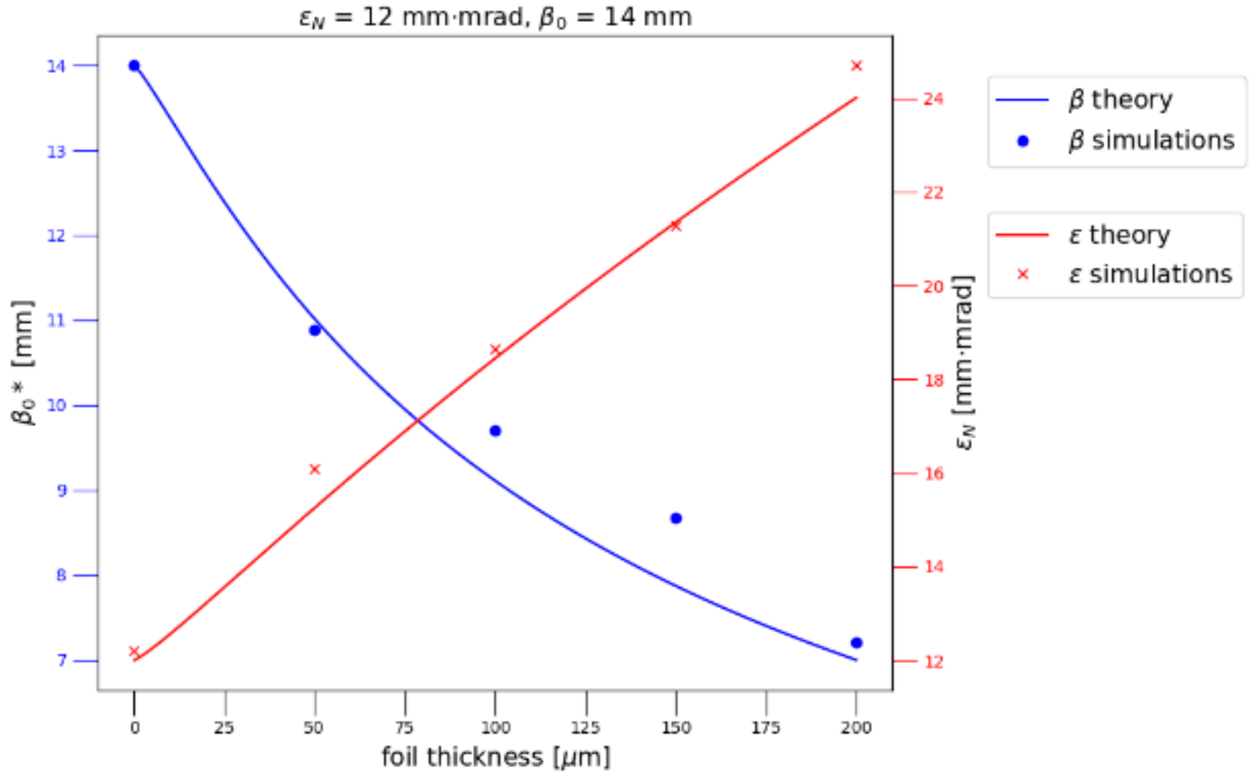
$$\sigma = \sqrt{\sigma_0^2 + \frac{z^2 \varepsilon}{\beta}} \xrightarrow{z\,=\,\beta} \sigma = \sqrt{2}\,\sigma_0$$

→ The waist moves closer to the foil



To check the model: forward calculation
→set incoming beam characteristics and
propagate them after the foil





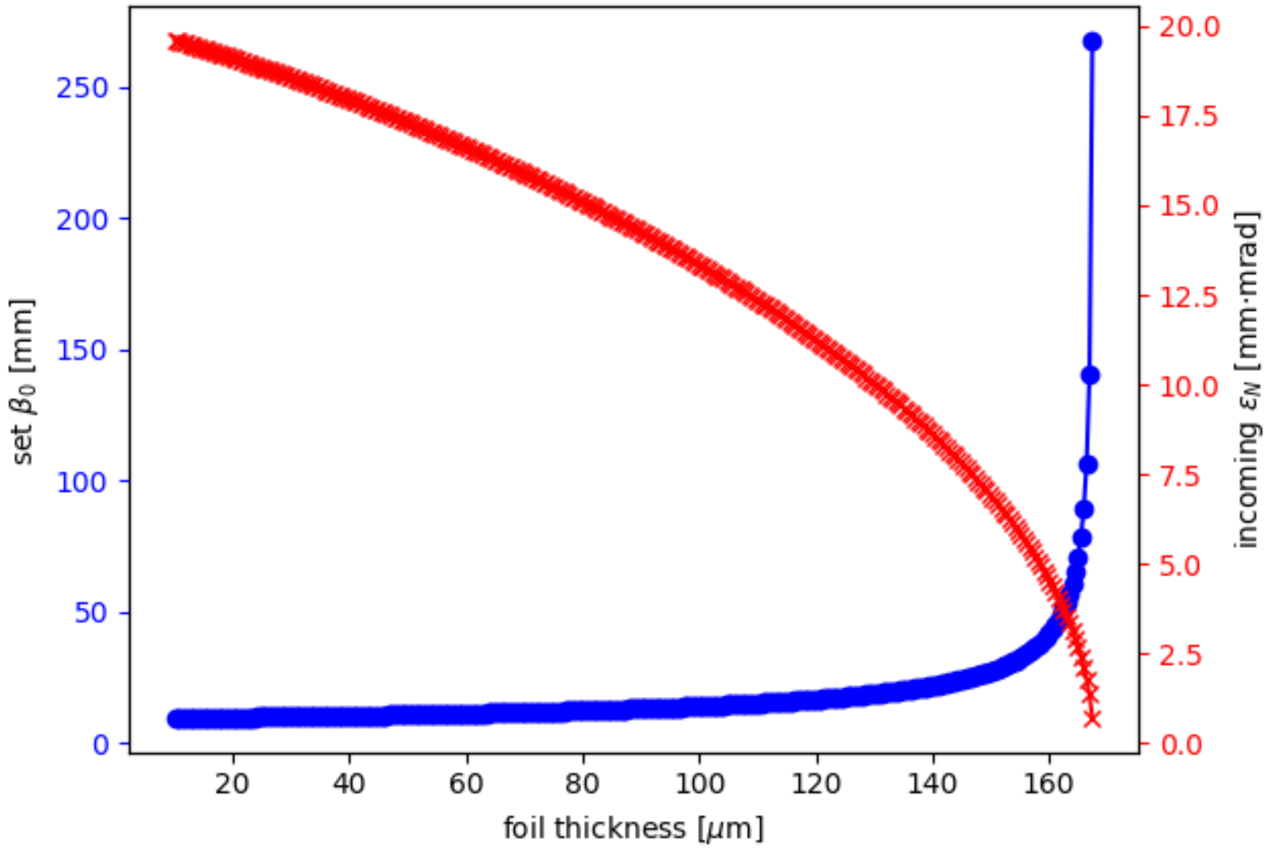
Working backward

Set:

- desired beta function at the waist (9.5 mm)
- desired emittance (20 mm mrad)
- distance waist – laser beam dump

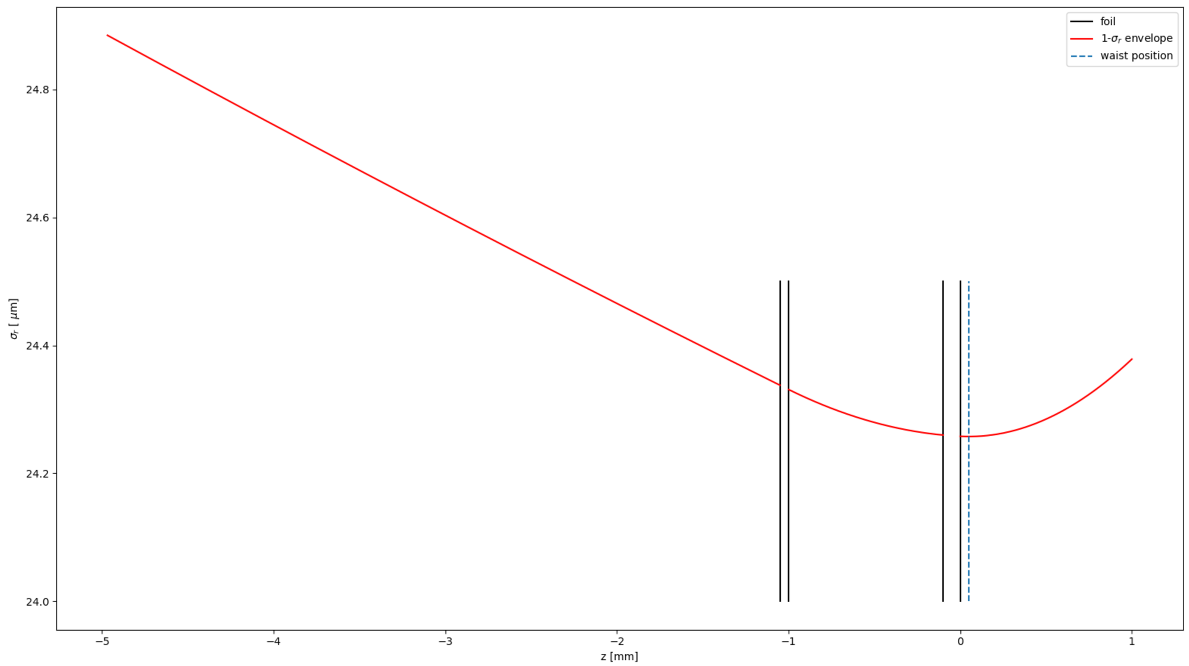
Return, as a function of foil thickness:

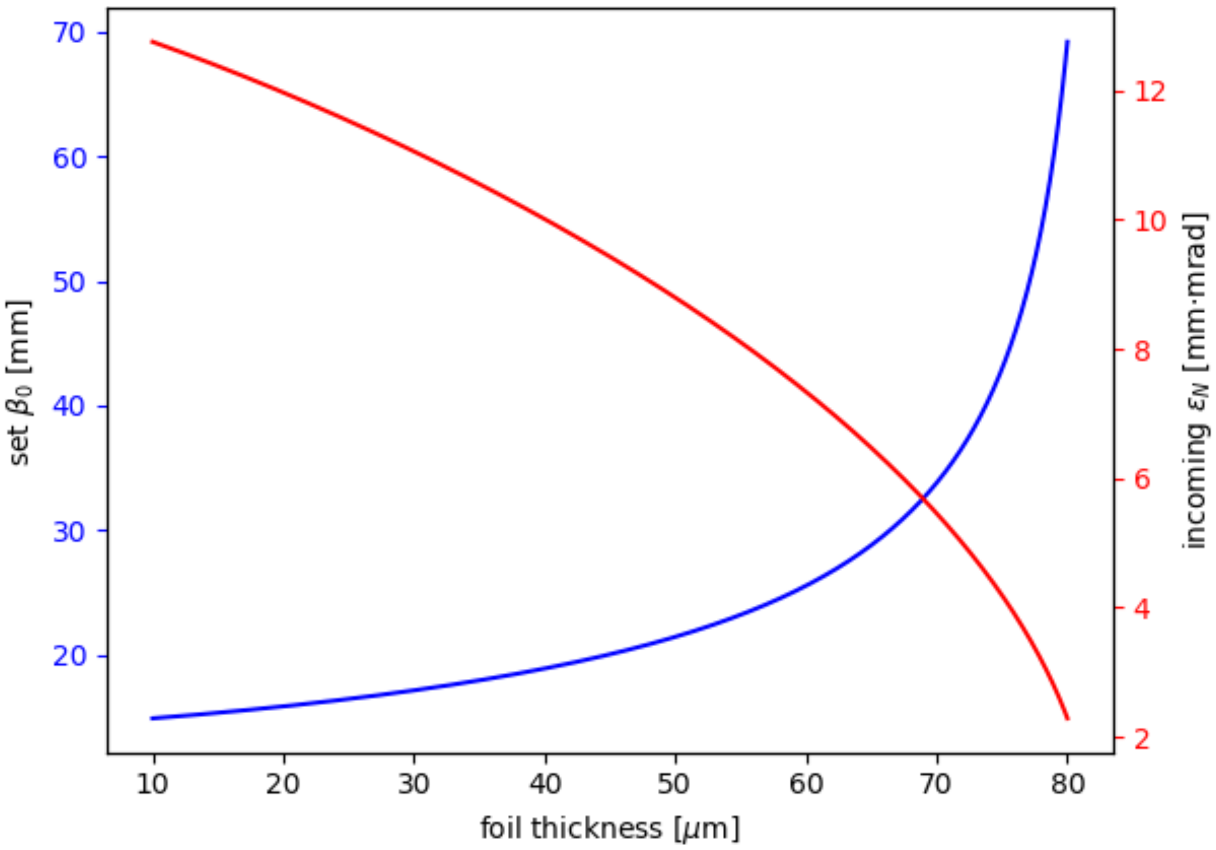
- beta function at the waist
- incoming emittance
- new waist position



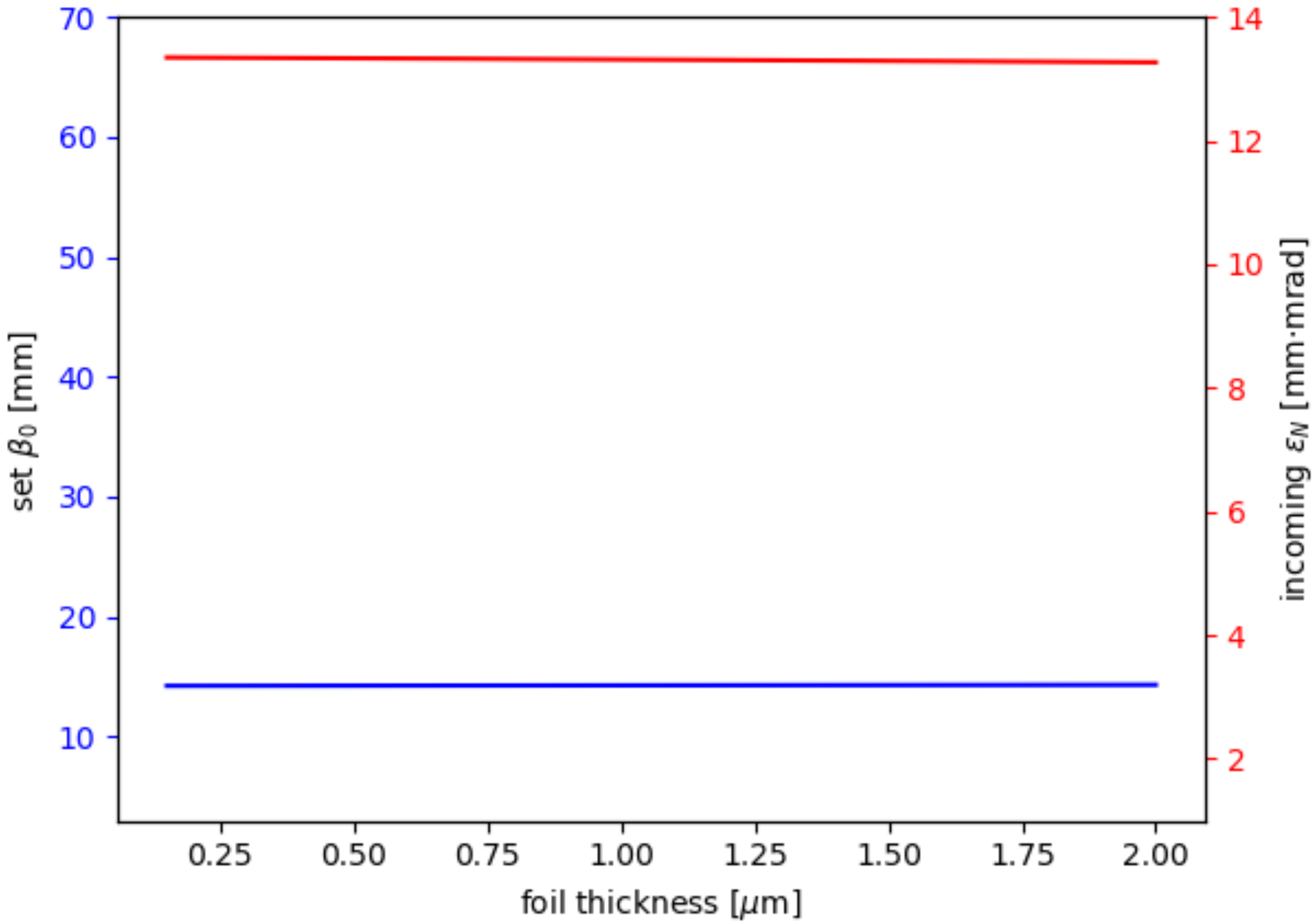
Reiterate for the vacuum window

- 100 μm thick LBDP
- Al window

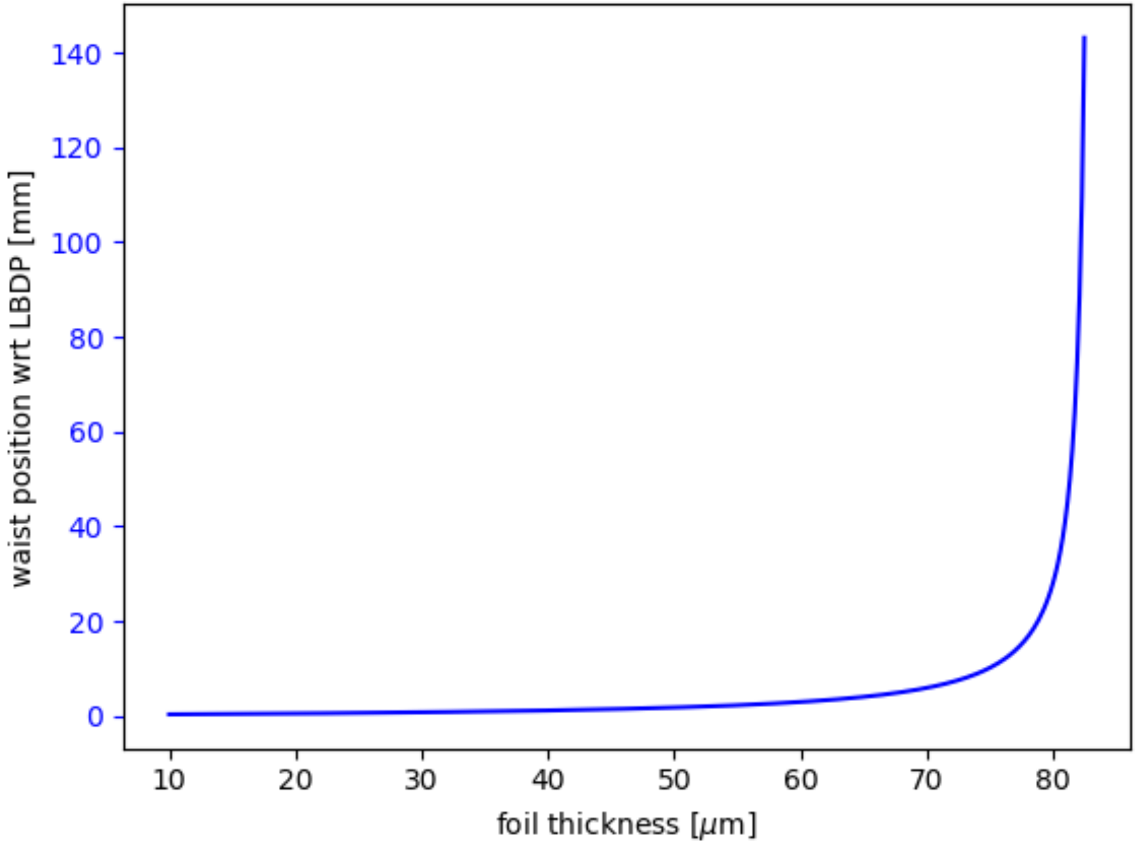




As the pressure differential is small, we could use a very thin Silicon membrane (down to 200 nm)
→ almost transparent for the beam
→ we could afford a thicker LBDP



To set the waist 100 µm downstream LBDP,
we have to focus further downstream



Do we need to consider energy deposited in the LBDP by the proton bunch?

→ simulated proton bunch through 150 µm Al foil