Concept of a polarized positron source at CEBAF

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December 2022

Plan

Positron injector Concept

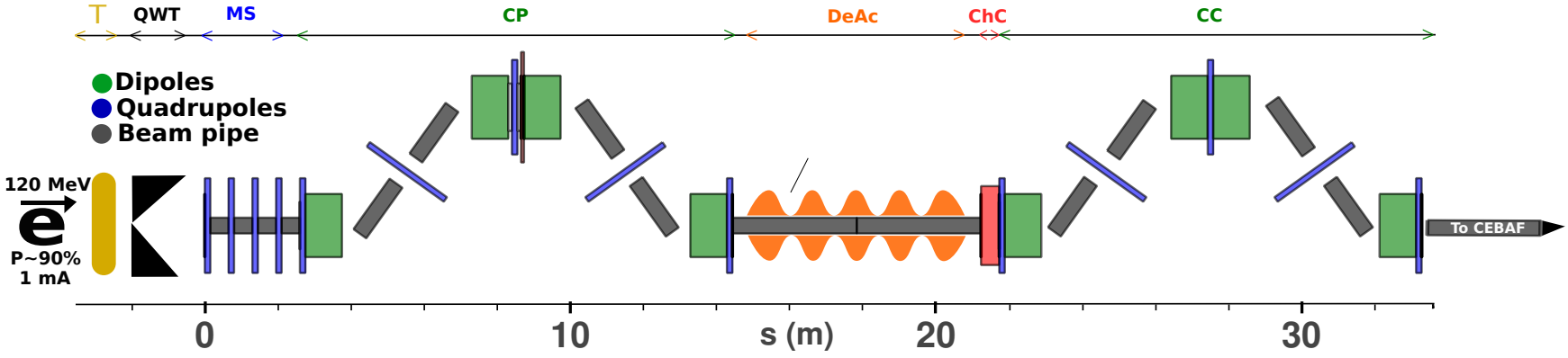


Figure: Conceptual layout of the positron injector for CEBAF.

T : Tungsten target

QWT : Quarter Wave Transformer

MS : Matching Section

CP : Magnetic Chicane

DeAc : Decelerating/Accelerating cavity

ChC : Chirping cavity

CC : Compression Chicane

Positron characteristics

- Efficiency : $\epsilon = \frac{N_{e^+}}{N_{e^-}} \longrightarrow$ **Unpolarized mode**.
- Figure-of-Merit FoM$=\epsilon P_{e^+}^2 \longrightarrow$ **Polarized mode**.

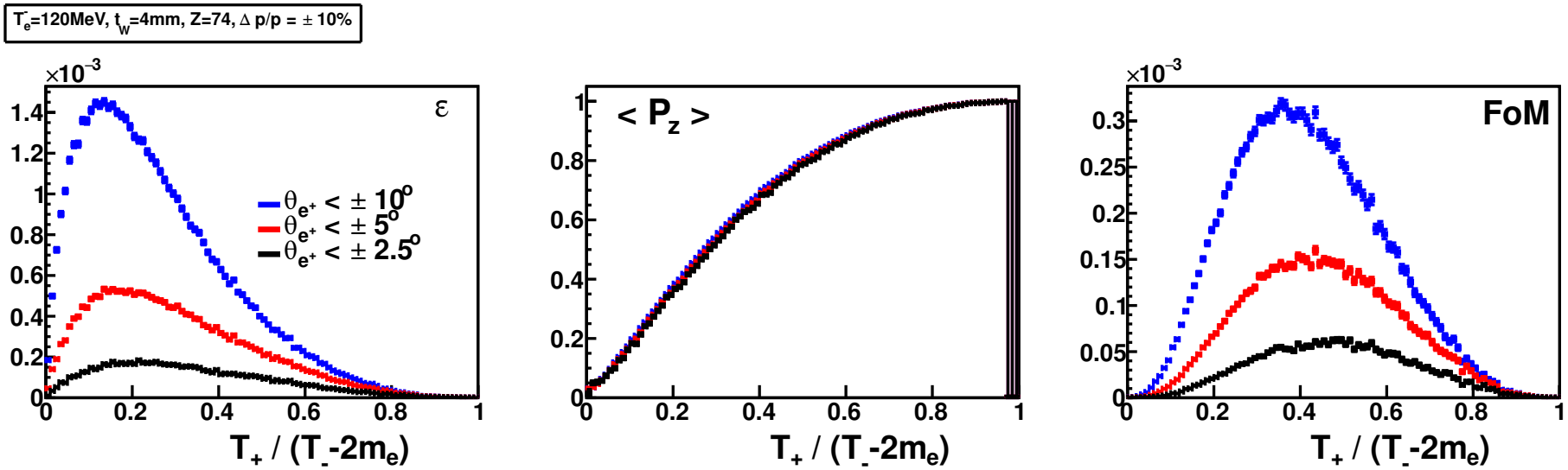
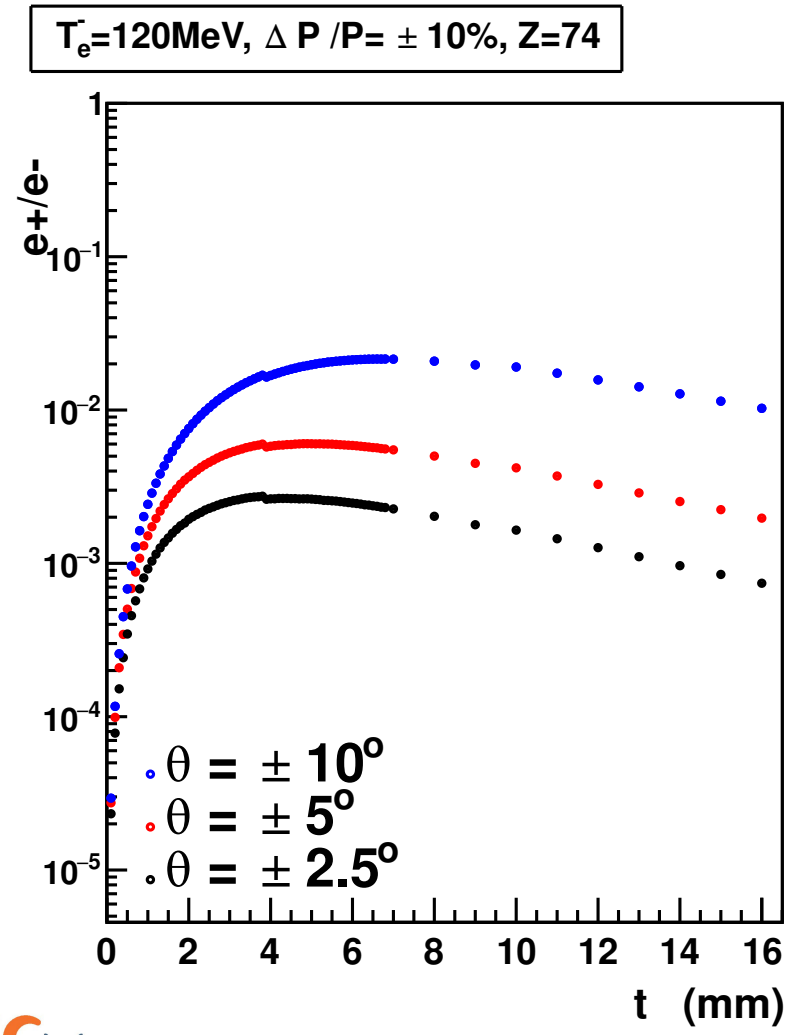


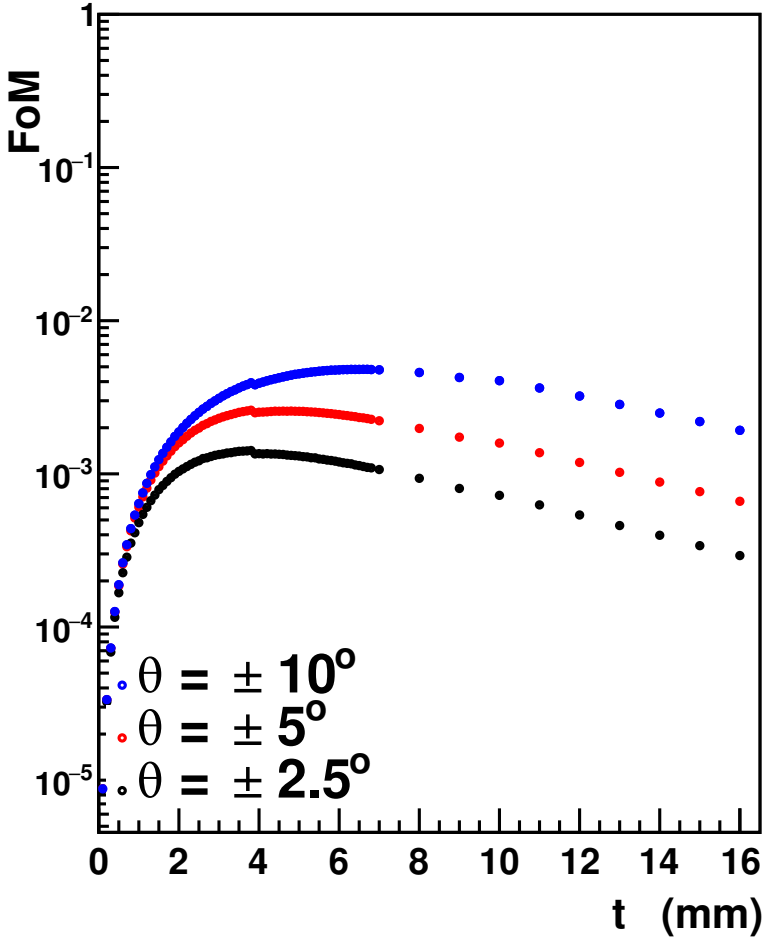
Figure: Positron production characteristics

Target thickness optimization

Unpolarized mode

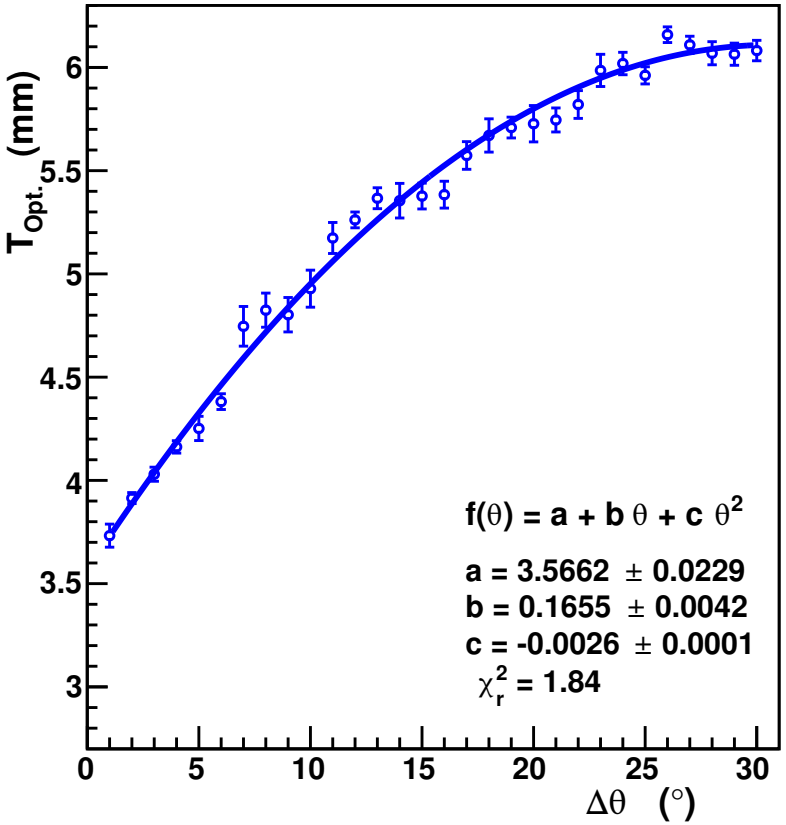


Polarized mode

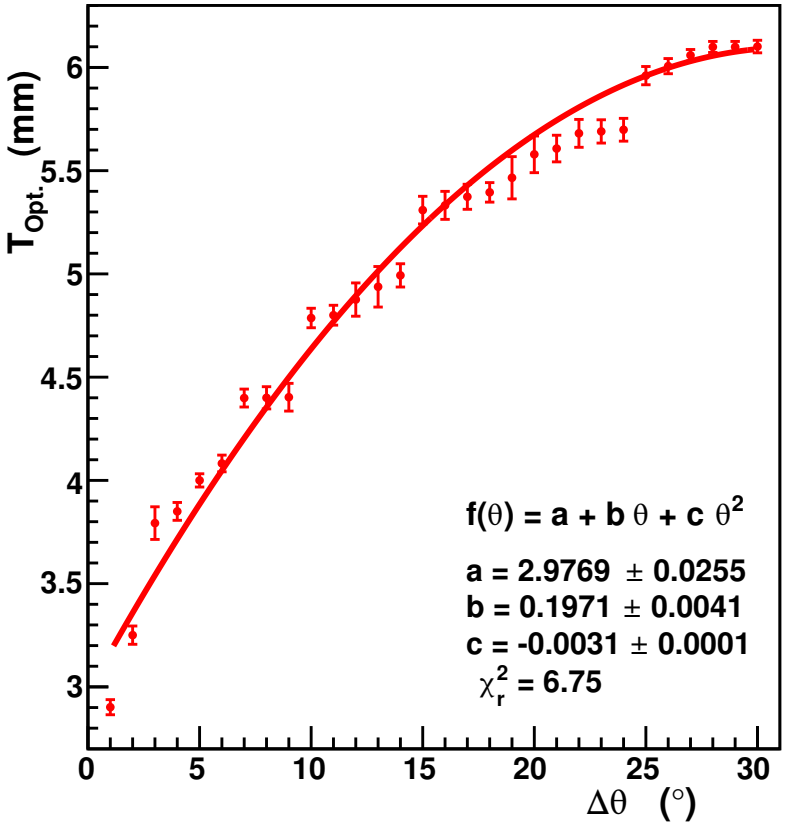


Optimum thickness VS Collection system aperture

Unpolarized mode



Polarized mode



- The optimum thickness of the e^+ production target is strongly sensitive to the angular acceptance of the collection system and depends on the operational mode of the source.

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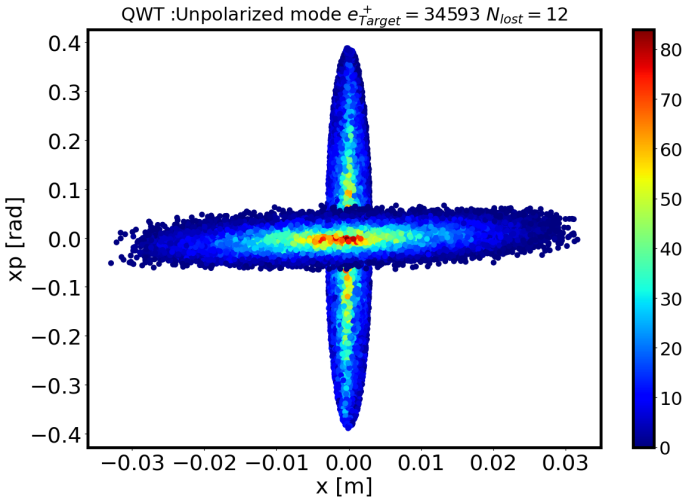
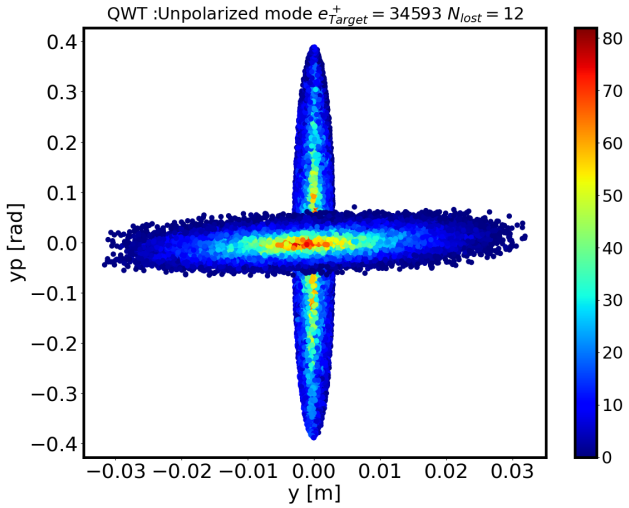
Quarter Wave Transformer

- Reduce the angular transverse spread $x_p = \frac{p_x}{p_z}$ and $y_p = \frac{p_y}{p_z}$.
- Rotate the transverse phase space (x, x_p) and (y, y_p) at the exit of the QWT.
- **Unpolarized mode**
  - $B_1 = 1.9\ T$
  - $B_2 = 0.2\ T$
  - $L_1 = 0.11\ m$
  - $L_2 = 4.9\ m$
- **Polarized mode**
  - $B_1 = 2.5\ T$
  - $B_2 = 0.5\ T$
  - $L_1 = 0.35\ m$
  - $L_2 = 5.1\ m$
- **Cavities configuration**
  - $f = 1497\ Mhz$
  - $E = 1\ MV/m$
  - $L_{cell} = 0.2\ m$





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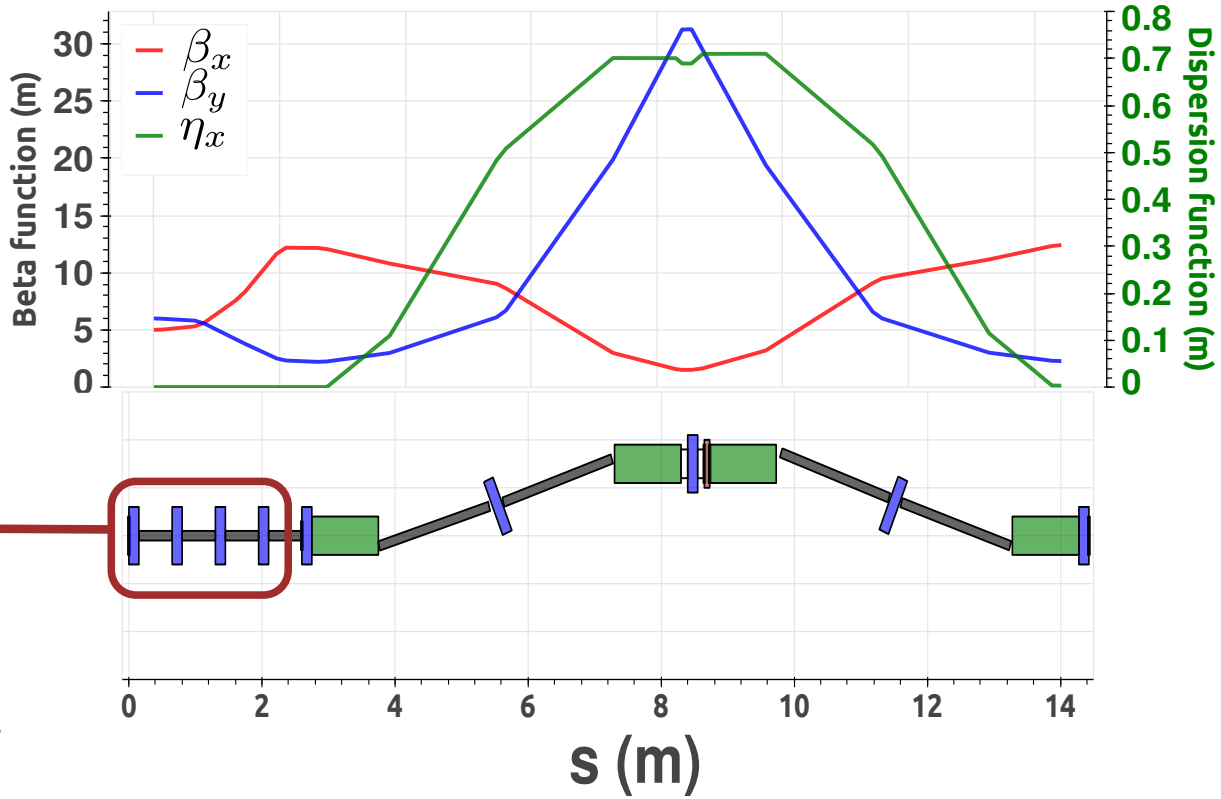
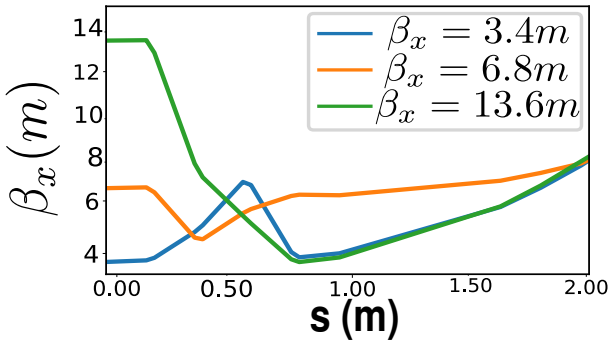
Beam size optimization



Matching section



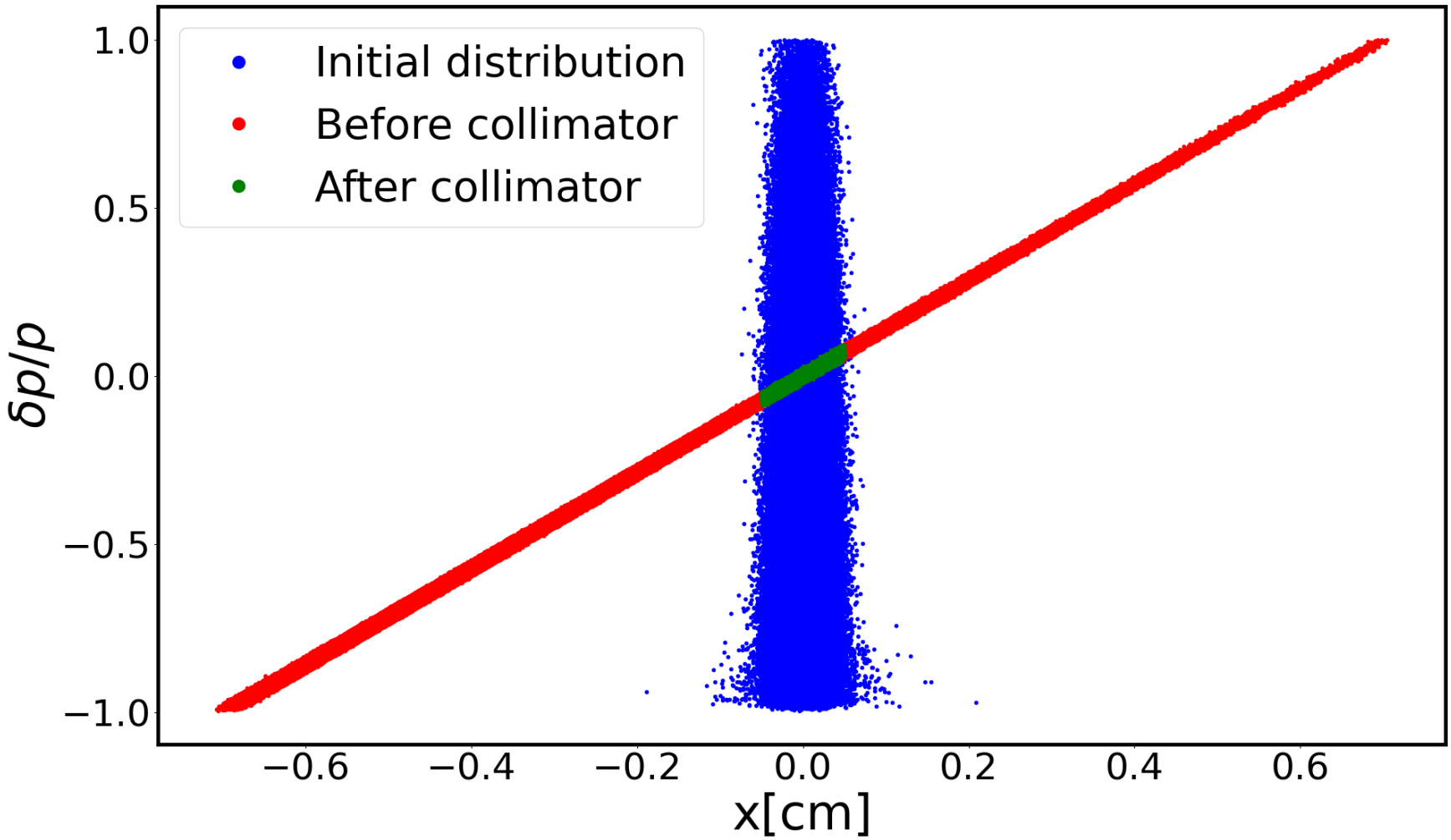
- **Periodic Twiss in FODO:**

$$\beta_{x,y_{in}} = \beta_{x,y_{out}}$$

- **Minimum beam size condition:**

$$\beta_x = \beta_{x_{MIN}} \longrightarrow \alpha_x = 0$$

Momentum collimation: At the middle of the chicane



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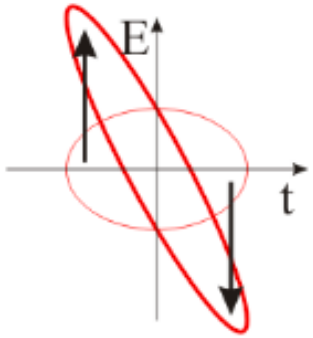
Longitudinal beam chirp

- **Compression factor** $= \frac{Bunch\ \ length_{\ \textbf{Entrance}}}{Bunch\ \ length_{\ \textbf{Exit}}}$

$$C = \frac{1}{1 + [R_{56} \times \kappa]}$$

- **Using z & $\frac{\delta P}{P}$ space, we have:**

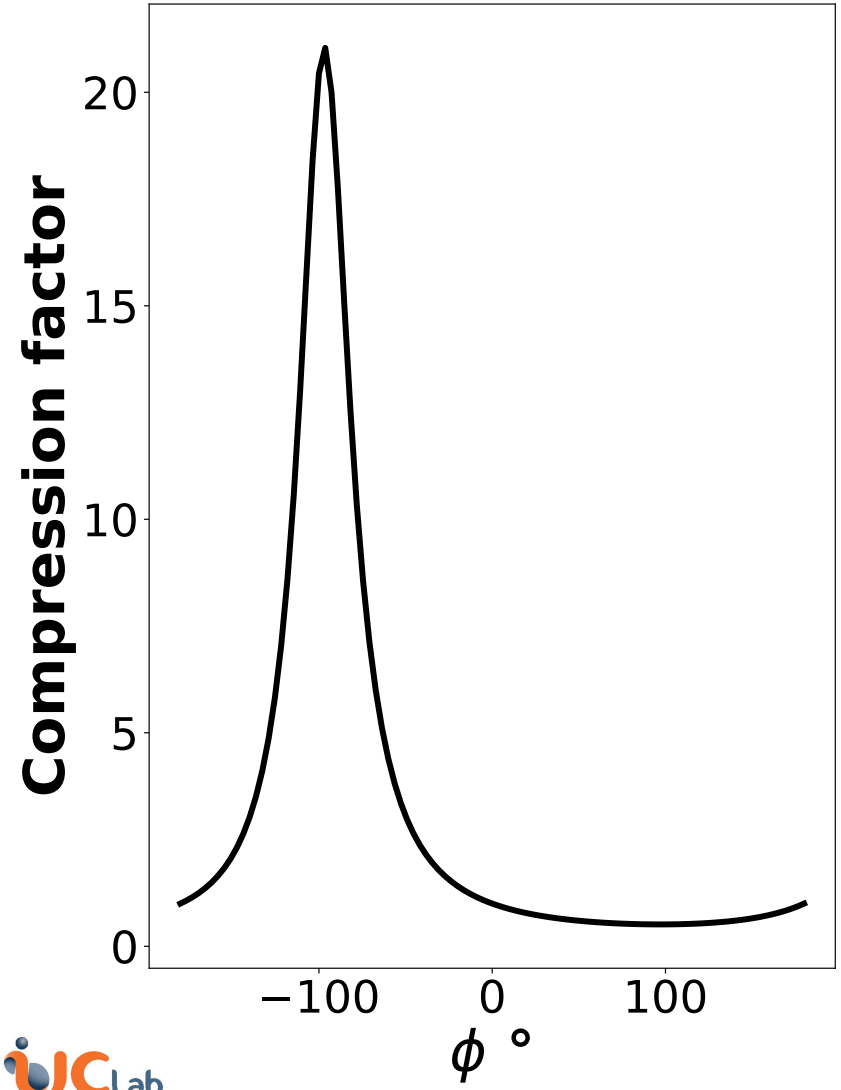


$$\kappa = \frac{d\delta_p}{dz} = \frac{-keV_0}{E0 + eV0\cos\phi}\sin\phi$$

- $k = 2\pi\frac{f}{c}\ [m^{-1}]$
- f is the cavity frequency
- eV_0 Cavity acceleration [MeV]
- E_0 Central energy [MeV]
- ϕ Cavity phase advance.

$$\longrightarrow\ C = \frac{1}{1+\left[R_{56}\times\frac{-keV_0}{E0+eV0\cos\phi}\sin\phi\right]}$$

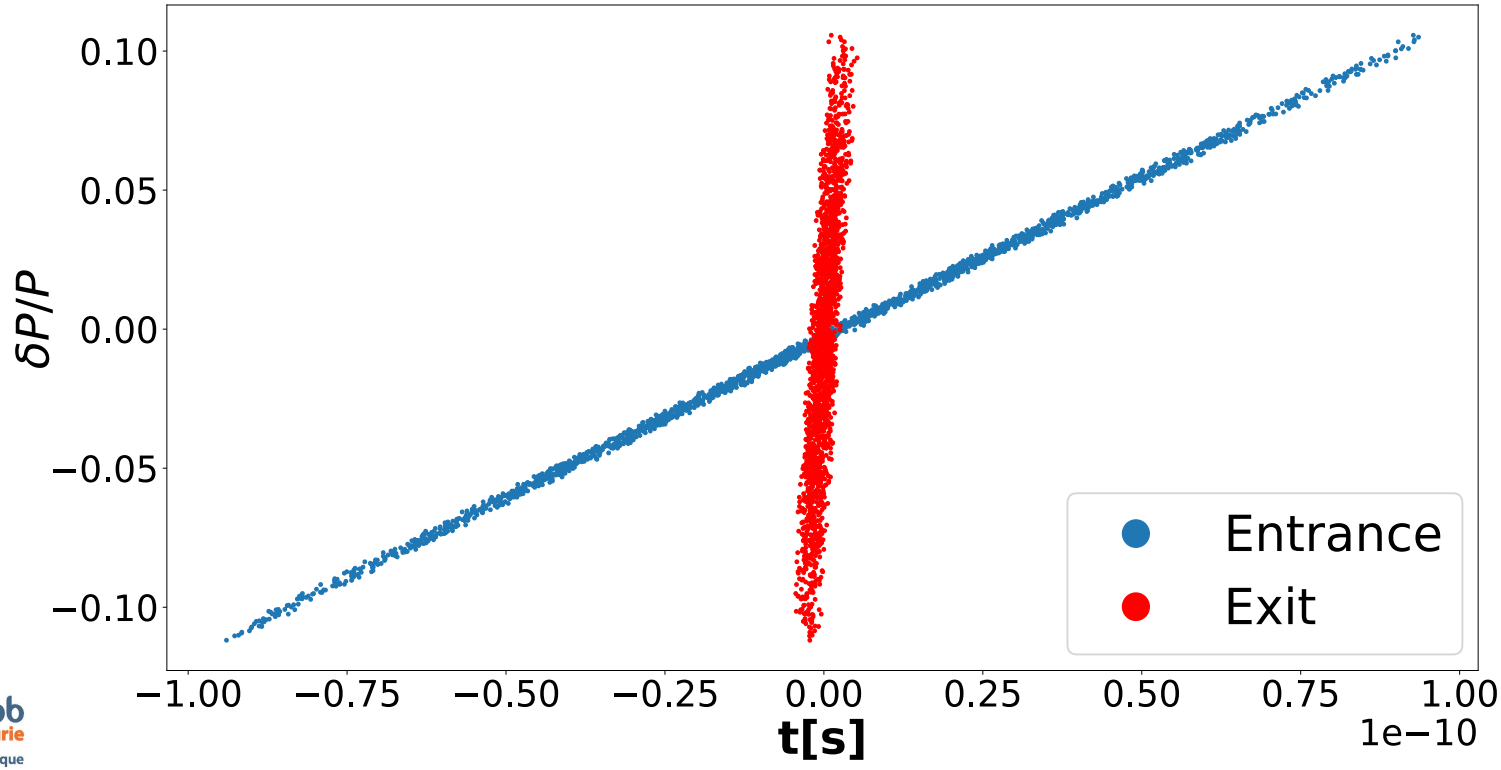
Compression factor



- $R_{56} = -0.25$ m
- Optimal chirp @ $\kappa = 3.81\ m^{-1}$
- Optimal cavity phase advance $\phi_0 = -96.6°$
- Cavity frequency $f = 1500\ Mhz$

Longitudinal compression

- $R_{56} = -25\ cm$
- Chirp : $\kappa = 3.81\ m^{-1}$
- Full compresion factor : $C = \frac{1}{1+\kappa \times R_{56}} = 23.3$



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Next challenges

- A new injector is under study for possible assembly at the LERF.
- The positron injector layout is going to evolve (Collection system, RF cavities...).
- The collection system optimization is very challenging; a comparison between a flux concentrator and the quarter wave transformer is under investigation.
- Due to the CEBAF requirements, the energy spread, and the bunch length have to be as small as possible.
- Among potential options for future studies is the possibility of further compressing the beam using the CEBAF arcs and an appropriate chirp in the linacs.