Polarized Positron for CEBAF

S. Habet[1,2] , Y. Roblin[2] , R.M. Bodenstein[2] , S.A. Bogacz[2] , L. Fanglei[2] , J. Grames[2], A. Hofler[2] , R. Kazimi[2], R. Suleiman[2] , A. Sy[2] , D. Turner[2], A. Ushakov1 , C.A. Valerio-Lizarraga[3] , E. Voutier[1]

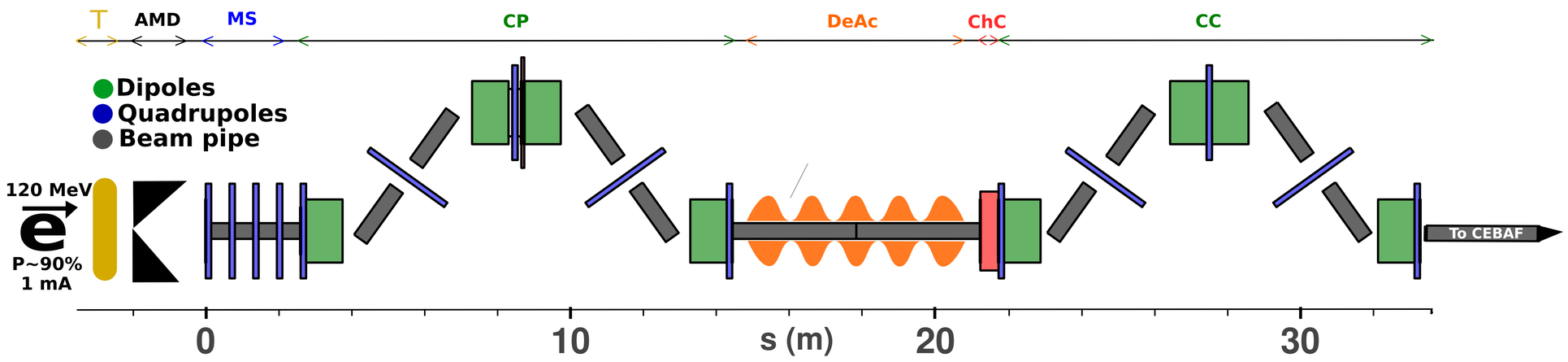
[1]Université Paris-Saclay, CNRS/IN2P3/IJCLab, 91405, Orsay, France,
[2]Thomas Jefferson National Accelerator Facility, Newport News, VA 23606,
[3]Universidad Autóboma de sinaloa, 80010 Culiacàan, México

Abstract

- The JLab positron source uses the Polarized Electrons for Polarized Positrons (PEPPo) technique to produce highly polarized positrons.
- Production of high polarization positron beam (I > 100 nA, P=60%), or a high intensity polarized poistron beam (I > 3 µA), from an intense highly polarized electron beam (I=1 mA, P=90%).
- The current design involve a new injector dedicated to positron production aty JLab.

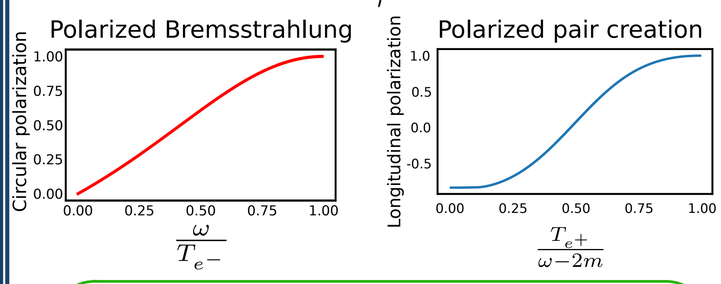
Legend

- T : Tungsten target.
- AMD : Adiabatic Matching Device
- MS : Matching Section
- CP : Magnetic Chicane
- DeAc : Decelerating/ Accelerating cavity
- ChC : Chirping cavity.
- CC : Compression Chicane



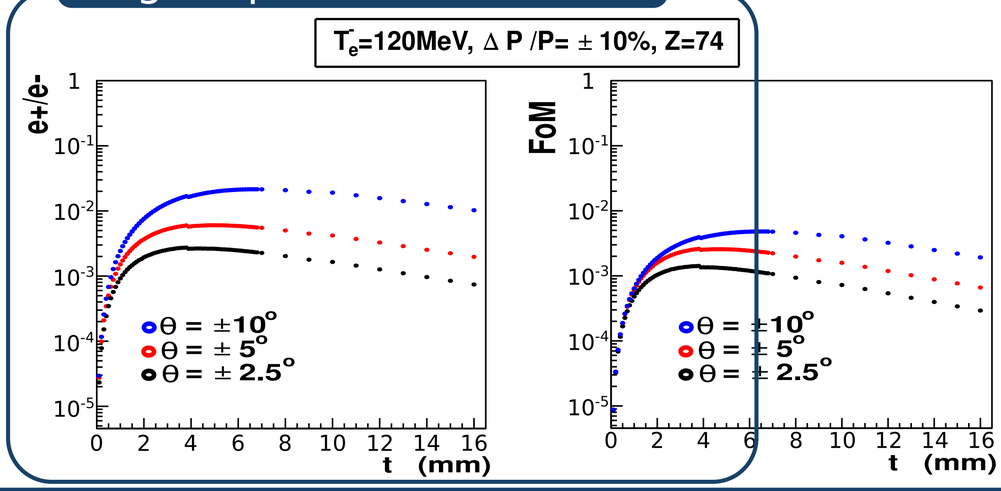
Polarization transfer

$$e^- \Longrightarrow \gamma \Longrightarrow e^+$$



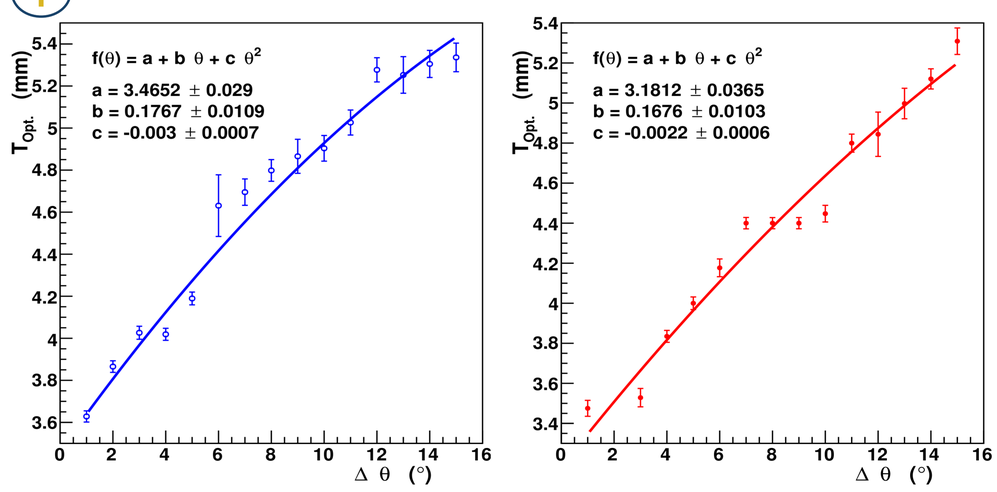
- Longitudinal polarized e⁻ produce circular polarized photons.
- Circular polarized photons produce longitudinal polarized e⁻ and e⁺ with no transverse polarization

Target optimization



- According to the unpolarized mode Ɛ the Optimum thickness is about 3.5 mm.
- The optimum target thicknes for the polarized mode is gotten around 4 mm.
- The efficiency and FoM decreases when the angular decrease.
- Two different modes involve two different targets

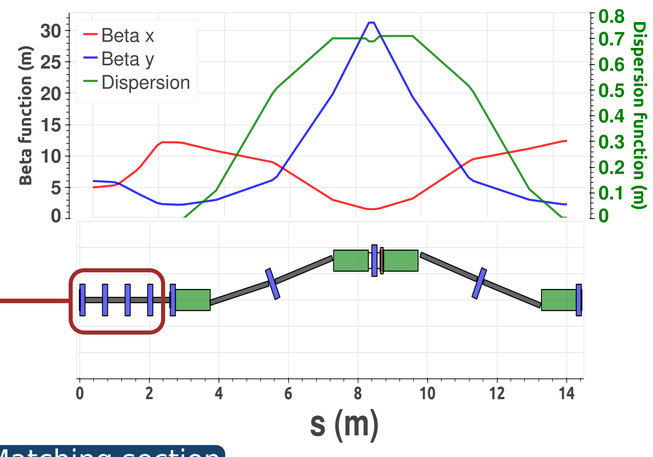
Optimum angular aperture



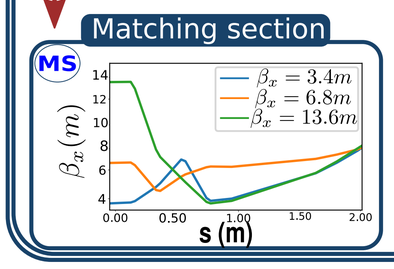
- Same optimum target thickness for both modes : polarized and unpolarized according to the angular aperture.
- Analysis shows an important dependency between the target thickness and the angular aperture.
- The optimum target thickness does not vary with the momentum bite $\Delta p/p$

First chicane

Beam size

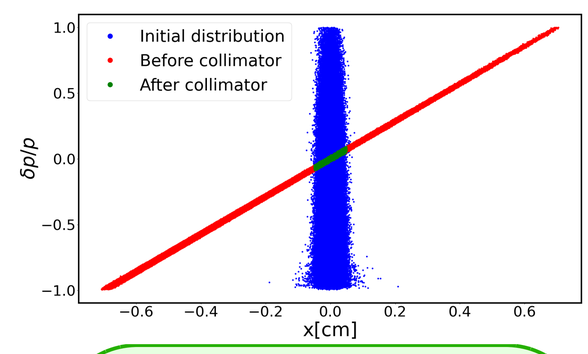


Matching section



- Fodo periodic Twiss parameters: $\beta_{x,y_{in}} = \beta_{x,y_{out}}$
- Minima beam size condition: $\beta_x = \beta_{x_{MIN}} \longrightarrow \alpha_x = 0$

Momentum selection



- Momentum selection is chosen at the peak value of the or the FoM
- Momentum collimation at the middle of the first chicane where the dispersion is maximale and the beam size is minima
- Dogleg intrduce a correlation in the longitudinal plane dp/p, z, using dispersion generated by dipoles difined as [2]:

$$D(s) = S(s)\int_0^s \frac{1}{\rho}\, C(t)\, dt \; - \; C(s)\int_0^s \frac{1}{\rho}\, S(t)\, dt$$

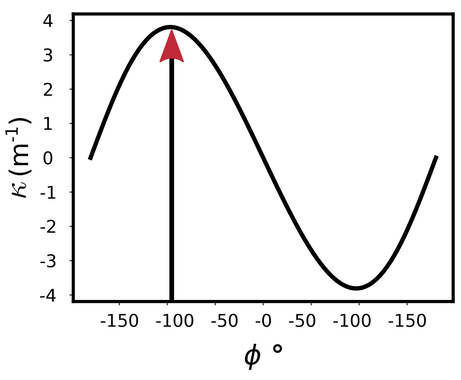
Compression chicane

Chirping cavity

- An Rf cavity is used to create a carrelation between dp/p and z
- The beam chirp is expressed as :

$$\kappa = \frac{d}{dz}\left[\frac{\delta p}{p}\right] = \frac{2\pi f}{c}\,\frac{eV_0}{E_0 + eV_0\cos\phi}\sin\phi$$

- Full compression achieved @ ϕ = 96.6 ° for M_{56} = -24 cm
- Cavity characteristics:
  - Frequency = 1500 MHz
  - Acceleration (eV_0) = 6 MeV
  - E_0 = 60 MeV



Compression optimization

- The beam size at the exit of the compression chicane is defined as:

$$\sigma_{z,f} = \sqrt{(1+\kappa R_{56})^2\,\sigma_{z,i}^2 + R_{56}^2\sigma_{\delta,i}^2\frac{E0^2}{E^2}}$$

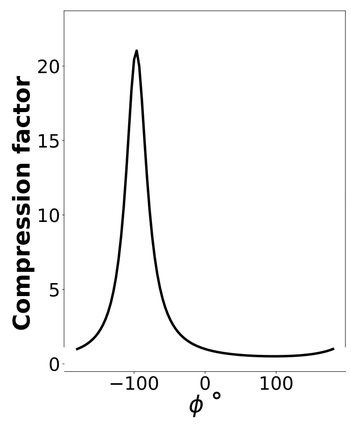
- For a Full compression :

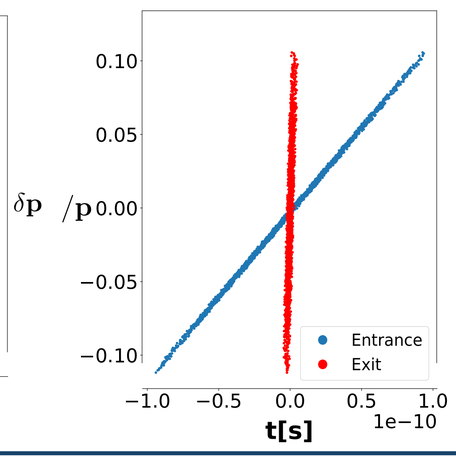
$$\sigma_{z,f_{Min}} \rightarrow \frac{d\sigma_{z,f}}{d\kappa} = 0$$

$$\kappa = -\frac{1}{R_{56}}$$

- The compression factor for small momentum spread is defined:

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





CEBAF requirements

Parameters	Unit	Value
Mean Energy	Mev	123
$\delta p/p$	%	± 2%
Emittance ϵ	mm-mrad	≤ 40 mm-mrad
Bunch length	s	≤ 4 ps
Transverse rms	mm	≤ 3 mm

Conclusion

- The CEBAF requirments makes the positron project very challenging.
- A new positron injector may be assembled at the Low Energy Recirculator Facility (LERF) and may be connected to the CEBAF accelerator through an arc.
- One of the futur challenge is to decrease the positron momentum dispersion from from $\delta p/p$=±10% to ±2%, a set of cavities will serve this purpose.
- One of the future possibilities for beam compression is the CEBAF arcs, which could be used for a compression with an appropriate chirping cavity.

References

[2] H. Wiedemann. Particle Accelerator Physics. Springer- Link: Springer e-Books. Springer Berlin Heidelberg 2007. isbn: 9783540490456.