# Development of a Polarized Positron Source for CEBAF Beam dynamics: Design and optimization

### Sami Habet

IJCLab & JLab

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Sami Habet

Development of a Polarized Positron Source for CEBAF

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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Plan				

### 1 Target optimization

- Ollection system
- 6 Momentum collimation
- 4 Longitudinal optimization

G Conclusion



Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Plan				

### 1 Target optimization

- 2 Collection system
- 8 Momentum collimation
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G Conclusion



Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Plan				

- 1 Target optimization
- 2 Collection system
- **3** Momentum collimation
- 4 Longitudinal optimization

Conclusion



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Plan				

- 1 Target optimization
- 2 Collection system
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Conclusion



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- 1 Target optimization
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- **3** Momentum collimation
- 4 Longitudinal optimization

**5** Conclusion



Target optimization ●00	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Outline				

### 1 Target optimization

- Ollection system
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Target optimization ○●○	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Positron char	acterization			

### Unpolarized mode

• Efficiency : 
$$\epsilon = \frac{N_{e^+}}{N_{e^-}}$$

### Polarized mode

• Figure-of-Merit FoM=
$$\epsilon P_{e^+}^2$$



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Target optimization

### Target thickness optimization



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- 1 Target optimization
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- 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<sub>p</sub>) and (y, y<sub>p</sub>) at the exit of the QWT.
- Use a QWT as an energy filter.

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- Reduce the angular transverse spread  $x_p = \frac{p_x}{p_2}$  and  $y_p = \frac{p_y}{p_2}$ .
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### Quarter Waves Transformer

- Reduce the angular transverse spread  $x_p = \frac{p_x}{p_z}$  and  $y_p = \frac{p_y}{p_z}$ .
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### Goal

- Reduce the energy spread of the accepted e<sup>+</sup> @ p = 60 MeV/c
- f = 1497 Mhz
- E = 1 MV/m
- L<sub>cell</sub> = 0.2 cm
- $r_{cell} = 3 cm$



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Target optimization	Collection system 00●	Momentum collimation	Longitudinal optimization	Conclusion 000000000
Accelerating	warm section			

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Target optimization	Collection system	Momentum collimation ○●	Longitudinal optimization	Conclusion

### Beam size optimization



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Momentum collimation

Longitudinal optimization

Conclusion 000000000

### Beam size optimization





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Target optimizationCollection systemMoment00000000	um collimation
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Longitudinal optimization

### Beam size optimization







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• Compression factor = Bunch length Entrance Bunch length Exit

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

- $\kappa = \frac{d\delta_p}{dz} = \frac{-keV_0}{E0 + eV0\cos\phi}\sin\phi$
- Where:
  - R<sub>56</sub> : Longitudinal chicane element.
  - $k = 2\pi \frac{f}{c} [m^{-1}]$
  - f is the cavity frequency
  - eV<sub>0</sub> Cavity acceleration [MeV]
  - *E*<sub>0</sub> Central energy [MeV
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Target optimization<br/>ocoCollection system<br/>ocoMomentum collimation<br/>ocoLongitudinal optimization<br/>ocoConclusion<br/>ocoLongitudinal optimization:Energy spread and bunch length

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Longitudinal optimization <u>\_\_\_</u>

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 Constructional optimization:
 Energy spread and bunch length

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Before compression

-0.03



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Summury				

Params	$e^-$ beam	Target Exit one period	Exit
σ <sub>dp/p</sub> [%]		1.3870	0.68
$\sigma_{z}[m]$		0.0002	0.0016
$\sigma_{x}[m]$	0.0005	0.0028	0.0081
$\sigma_{xp}$ [rad]	pencil beam	0.0021	0.0007
$N  \epsilon_x[mrad]$		0.019	0.0014
N $\epsilon_y$ [m rad]		0.02	0.0014
p Central [MeV/c]	120	60	123
e <sup>+</sup>	1 <i>mA</i>	2482 nA	170 nA

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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion 000000000
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- The performance of the positron system is heavily influenced by the central momentum. For a high yield of positrons, the central momentum should be set to 15 MeV/c, while a high polarization requires a central momentum of 60 MeV/c.
- The QWT helps the selection of the desired momentum and reduces the spread of transverse angles.
- The accelerating section exerts significant influence on the longitudinal plane, thereby reducing the energy spread to meet the CEBAF requirement of  $\sigma_{dp/p} = \pm 1\%$ .
- For improved compression, the energy spread at the exit of the C100 must be at least five times smaller.
- Expecting higher current for the unpolarized mode P=15 MeV/c.

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Twiss function	s			



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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion
Beam size				



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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Conclusion ○○○○○○●○○
Momentum co	ollimation			



 $B_1 = 2.5 T B_2 = 0.05T$ 

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Angular distr	ibution			
0.0035		40 9 33 30 25	/T Polarized 2023 30Million e <sup>-</sup> θ <sub>2</sub> = 0.057	



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0.0025

0.0015

0.0010 0.0005

<sup>لي</sup> 0.0020

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Transverse sp	ace			



• The transmitted positrons are within the acceptance of the QWT

• 
$$p_t^{QWT} = \frac{eB_1R}{2}$$
. = 10.31°

• 
$$r_0^{QWT} = \frac{B_2}{B_1}R = 0.6 mm$$

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