

Un-Polarized mode

Conclusion 0000000000

Development of a Polarized Positron Source for CEBAF

Sami Habet

IJCLab & JLab

March 8, 2023

This research work is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under agreement STRONG - 2020 - No 824093









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Introduction

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J. Grames, E. Voutier et al., JLab Experiment E12-11-105 (2011)



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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode	Conclusion 0000000000
Plan					

- 2 Collection system
- Momentum collimation
- Longitudinal optimization
- **G** Un-Polarized mode



6 Conclusion

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Workshop, UVA, MARCH 7-8.	3 on 32

Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode	Conclusion 0000000000
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- 1 Target optimization
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- 4 Longitudinal optimization
- **G** Un-Polarized mode





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- 1 Target optimization
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6 Conclusion

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Target optimization ●000	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode	Conclusion 0000000000
Outline					

- 2 Collection system
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Unpolarized mode

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

Polarized mode

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



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Unpolarized mode

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Polarized mode

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Target optimization



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Target optimization Collection system Momentum collimation Longitudinal optimization Un-Polarized mode Con OOO CONTRACTOR OF CONTRACTOR CONTRA

- Reduce the angular transverse spread $x_p = \frac{p_x}{p}$ and $y_p = \frac{p_y}{p}$.
- Rotate the transverse phase space (x, x_p) and (y, y_p) at the exit of the QWT.
- Use a QWT as an energy filter.
- QWT acceptance :
 - Radial acceptance $r_0^{QWT} = \frac{B_2}{B_c} R$
 - Transverse acceptance $p_t^{QWT} = \frac{eB_1R}{2}$

- L₁:Short solenoid length
- B_1 : Magnetig field in L_1
- R: Accelerator aperture



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Quarter Wave Transformer

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Collection system

 Reduce the angular transverse spread
 x_n = Px/Px and y_n = Py

$$x_p = \frac{p_x}{p}$$
 and $y_p = \frac{p_y}{p}$

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Longitudinal optimization

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Collection system Longitudinal optimization 000 Quarter Wave Transformer

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Target optimization Collection system Momentum collimation Longitudinal optimization Un-Polarized mode Conclusion

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Quarter Wave Transformer

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Longitudinal optimization

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Goal

- Reduce the longitudinal energy spread of the accepted e⁺ at p = 60 MeV/c
- f = 1497 Mhz
- E = 1 MV/m
- L_{cell} = 0.2 cm
- $r_{cell} = 3 cm$



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Target optimization collection system Momentum collimation Longitudinal optimization Un-Polarized mode Conclusion

Accelerating warm section

Goal

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Beam size optimization



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Beam size optimization



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200

100





60 P [MeV/c]

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 $\beta_x(m)$

0.00 0.50

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Longitudinal optimization: Energy spread and bunch length

Longitudinal optimization

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• Compression factor = <u>Bunch length Entrance</u> <u>Bunch length Exit</u>

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

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

- Where:
 - R₅₆ : Longitudinal chicane element.
 - $k = 2\pi \frac{f}{c} [m^{-1}]$
 - f is the cavity frequency
 - eV₀ Cavity acceleration [MeV]
 - E₀ Central energy [MeV]
 - ϕ Cavity phase advance.



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Longitudinal optimization: Energy spread and bunch length

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Target optimization Collection system Momentum collimation Congitudinal optimization Un-Polarized mode Conclusion

Transmission and Current



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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode	Conclusion 0000000000
summarv					

Ce+BAF Parameter	e^+ model	Target value
σ _{dp/p} [%]	0.68	\pm 1%
$\sigma_{z}[ps]$	4	\leq 4
$\sigma_{x}[mm]$	6	\leq 3
N $\epsilon_n[mm mrad]$	140	\leq 40
Mean Momentum [MeV/c]	123	123
$e^+~(P>60\%)$	170 nA	50 nA

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Un-Polarized mode: Positron Capture

- Reduce the magnetic field in the first solenoid.
- Rotate the transverse phase space (x, x_p) and (y, y_p) at the exit of the QWT.
- Use the same QWT as an energy filter.
- QWT acceptance :
 - Radial acceptance $r_0^{QWT} = \frac{B_2}{B_1} R$
 - Transverse acceptance $p_t^{QWT} = \frac{eB_1R}{2}$

• $L_1 = 0.24 \ cm$:Short solenoid length

Un-Polarized mode

- $B_1 = 0.96 T$: Magnetig field over L_1
- $R = 3 \ cm$: Accelerator aperture

Longitudinal optimization



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Longitudinal optimization





Momentum collimation



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Longitudinal optimization

- The longitudinal energy spread dp/p is reduced by accelerating from 22 MeV/c to 123 MeV/c.
- The accelerating section is utilized to produce the required energy chirp.
- The same compression chicane is employed to effectively reduce bunch length.



Un-Polarized mode

Unpolarized mode: Transmission current



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Un-Polarized mode

Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode 00000●	Conclusion 0000000000
summary					

Ce+BAF Parameter	e ⁺ model	Target value
[%]	0.5	+ 1%
$\sigma_{ap/p}[\gamma\sigma]$	2	< 4
$\sigma_{\rm x}[mm]$	2	 ≤ 3
N $\epsilon_n[mm mrad]$	123	≤ 40
Mean Momentum [MeV/c]	123	123
$e^+~(P>20\%)$	700 nA	$1 \ \mu A$

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- The performance of the positron system is heavily dependent on the central momentum. To obtain 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 plays a crucial role in selecting the desired momentum and reducing the spread of transverse angles.
- The accelerating section significantly impacts the longitudinal plane, reducing the energy spread to meet the CEBAF requirement of $\sigma_{dp/p} = \pm 1\%$.
- It is possible to achieve a compromise between the energy spread and the bunch length to meet the appropriate longitudinal CEBAF requirement during the injection.
- Including the electron beam after the target could be an interesting way to test our layout.



This research work is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under agreement **STRONG - 2020 - No 824093**.









THANK YOU FOR YOUR ATTENTION!

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Target optimization	Collection system	Momentum collimation	Longitudinal optimization	Un-Polarized mode	Conclusion 0000000000
Beam size					



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Normalized emittance



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Transmission and current



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Momentum collimation



 $B_1 = 2.5 T B_2 = 0.05T$

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Angular distribution



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Transverse space



• 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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