Optimal Converter Thickness
Rod Targets

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Outline

- Analytical estimations of optimal thickness of the gammas–to–positrons conversion target
- Proposal and estimations of a rod target

Optimal thickness and yield

Analytic estimations

Model:

- Each gamma produces κ pairs per radiation length (r.l.)
- λ positrons lost on the pass length of 1 r.l.
  — linear (ionization) losses are supposed

Maximal yield of positrons at the rear face of target (per the gamma)

$$N_{\max} = 1 - \frac{\lambda}{\kappa} \log\left(1 + \frac{\kappa}{\lambda}\right) \quad \text{of} \quad N_{\max}^{(\mathrm{tot})} = \frac{\kappa}{\kappa + \lambda} \ .$$

Optimal thickness of target [r.l.] reads

$$L_m = \frac{1}{\kappa} \log\left(\frac{\kappa + \lambda}{\lambda}\right) \ .$$

Optimal thickness and yield

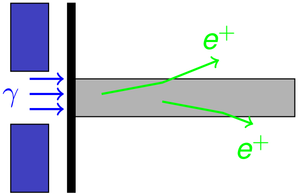
Calculations

Table: Maximal yields of positrons from the titanium and the tungsten targets at optimal thickness

Mat	$E_{\max}$, MeV	κ	λ	L_m	$N_{\max}^{(\mathrm{tot})}$	$N_{\max}$
Ti	10	1/4	3.78	0.26	0.06	0.03
	20	1/3	1.79	0.51	0.16	0.08
	30	1/3	1.17	0.75	0.22	0.12
	58	1/2	0.60	1.22	0.45	0.17
W	10	1/4	1.42	0.65	0.15	0.08
	20	1/3	0.67	1.21	0.33	0.19
	30	1/3	0.44	1.69	0.43	0.26
	58	1/2	0.22	2.34	0.69	0.47

Rod Converting Target

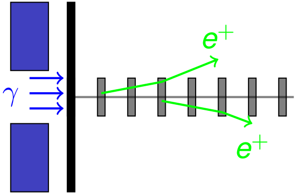
Rod target was proposed by Lapko and Shulga, 2006



- Path length of positrons much shorter than of gammas
  - increases yield of positrons
  - reduces emittance of positron beam
  - decreases target heat load (losses)
- Obstacles:
  - 1.3 GeV, 40 m CP–to–target distance $\rightarrow R_{\text{spot}} = 16$ mm
  - spot radius
    $16\,\text{mm} \approx 5 \times 3.3\,\text{mm}$
    5 rad.length of tungsten

Sliced Rod Converter

Allows to construct a long rod with shorter positrons path length



Losses decreased by a factor

$$\zeta = \frac{1}{2}\left(\frac{3\alpha_f}{\pi}\right)^{1/3}\left(\frac{\gamma R L_{\mathrm{r.l.}}}{l_{\mathrm{rod}}}\right)^{2/3}$$

- where

  R the disk radius,
  l_{rod} the rod height,
  $L_{\mathrm{r.l.}}$ the rod height [rad.length].

(Method of [Rossi] was used)

Estimations for tungsten, 30 MeV

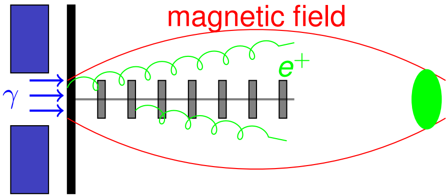
- the length of "rod" 80 cm
- the radius of rod 15 mm
- (r.l. 3.3 mm $= 20 \times 165\,\mu$m)

Table: Yields of positrons from the tungsten targets

Type	height [r.l.]	$N^{(\mathrm{tot})}$	N_{yield}
Solid	0.4	0.125	0.114
Solid	1	0.28	0.22
Solid	1.69	0.43	0.255
Solid	2	0.49	0.248
Rod 80 cm	0.4	0.125	0.124
Rod 80 cm	1	0.28	0.279
Rod 80 cm	1.69	0.43	0.41
Rod 80 cm	2	0.49	0.42
Undul (Ti, 10 MeV)	0.4	0.095	0.022

Sliced Rod Converter + Magnetic Field

Strong Longitudinal Field – Radius of Gyration ≪ Rod's Radius



- Specifics:
  - Number of disk crossings controlled by the field strength and pattern
  - Focusing: emittance increases 2 times slower
  - The positron beam can be focused afterwards
- Drawbacks
  - needed the field of 4 . . . 7 Tesla (superconducting solenoid)

Heat Load in Rod Target

Insulated Solid Target

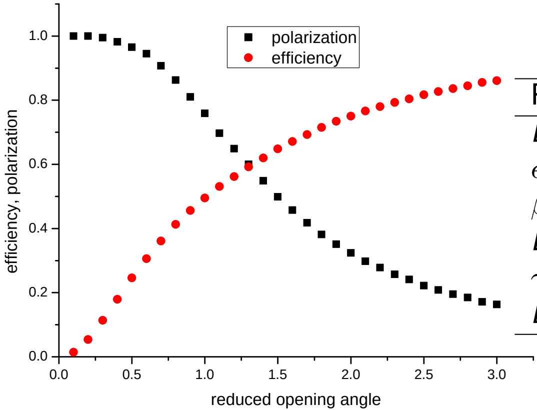
- Heat deposits into target due to ionization losses from electron–positron pairs,
- Rod target insulated – no heat conductance and thus diffusion,
- The 0.4 r.l. target got deposited of 40 J/g per pulse (200 ms) which increases of tungsten target temperature by 300 C.

Summary and Outlook

- Optimal Compton target can be thicker and more effective
- Target should be replaced 5 times per second
- Rod–target scheme enhances yield and decreases heat load
- Modified rod–target scheme enhances yield and emittance
- Further optimization should include both the target and capturing section

Appendix: Efficiency vs. Polarization

ERL Model, Simulation



Par	unit	value
E_{el}	GeV	1.301
$\epsilon_{x,z}$	rad nm	0.625
β_{cp}	m	0.16
$E_\gamma^{\max}$	MeV	30.18
$\gamma\psi_{\max}$		3
$E_\gamma(\psi_{\max})$	$1/E_{\max}$	0.1