Radiation Damage and Activation of ILC Positron Source Target

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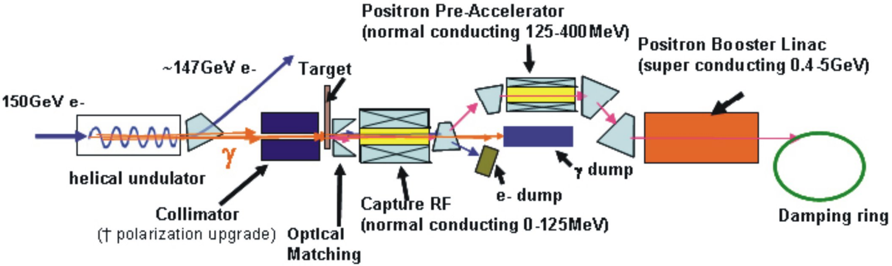
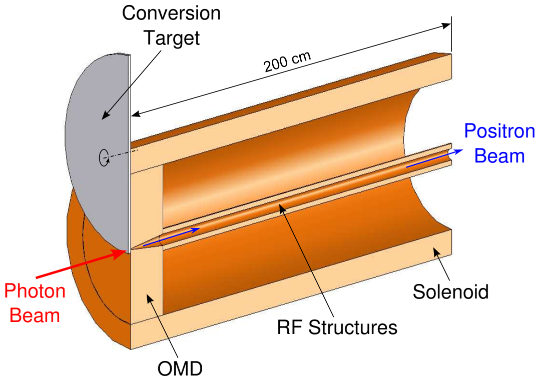
ILC Positron Source Scheme



Helical Undulator. Source Model. Target Issues.

Undulator parameter	for study	baseline
E_{e^-}, GeV	150	150
K-value	1	0.92
Undulator period, mm	10	11.5
Magnetic field, T	1.07	0.86
E_1, MeV	10.7	10.1

Target compound	Ti6Al4V
Target thickness, X_0	0.4
rms size of photon beam, mm	0.7



Positron Beam at IP
$2 \cdot 10^{10}$ e^+/bunch
2820 bunch/pulse
5 Hz

Photon Beam
$\sim$ 150 kW

Energy Deposited in Target
$\sim$ 10 kW

Target Issues:

- Thermal Damage
- Radiation Damage
- Activation

Simulation Outline and Used Tools

Fixed for simulations: electron drive beam energy, target compound and thickness, optical matching device.

Varied:

- undulator K value between 0.2 and 1.4 ($\lambda_u = 1$ cm)
- undulator period λ_u between 0.1 and 1.4 cm ($K = 1$)

Tools

Positron yield, energy deposited in target, target activation have been calculated by

- FLUKA

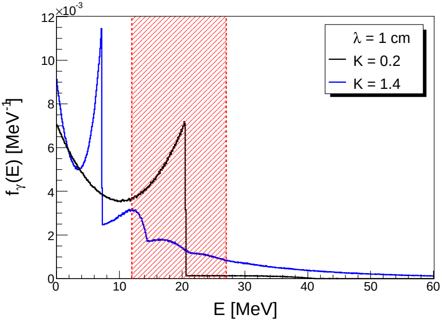
Positron capture has been calculated by

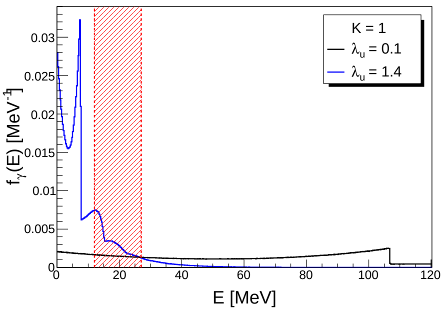
- ASTRA

Target damage (dpa) has been estimated by combining of

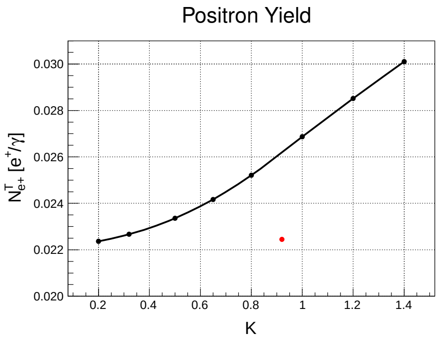
- FLUKA (neutron fluence and energy distribution) and
- SPECTER (**displacement cross sections**)

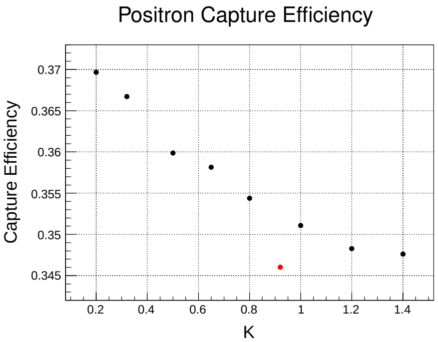
Photon Energy Distribution





Positron Yield and Capture Efficiency ($\lambda_u = 1$ cm)
Varying of K





Note:

Red point is for the present baseline undulator parameters

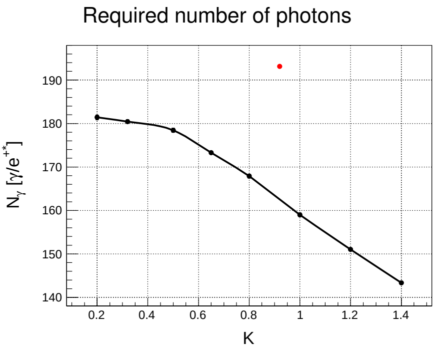
Longitudinal Cut:

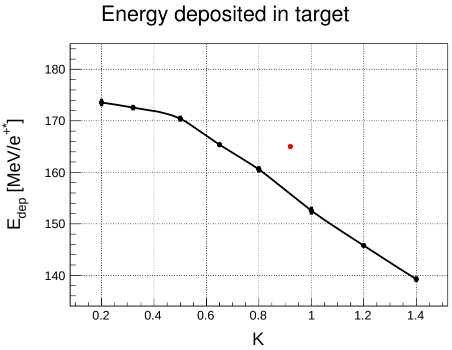
Energy Spread is 1%

Tranverse Cut:

$\epsilon_{i,x} + \epsilon_{i,y} < 0.04\pi$ m rad

Required Number of Photons and Energy Deposited in Target (per Positron at IP). $\lambda_u = 1$ cm





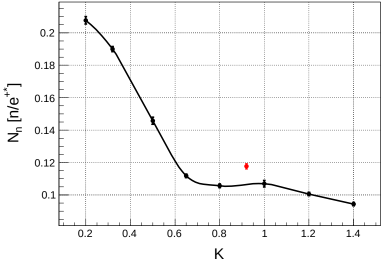
Present Baseline Design

Photon Beam Power
93.1 kW

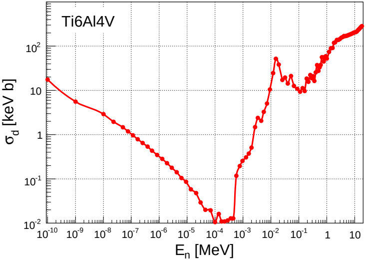
Power Deposited in Target
7.45 kW

Neutron Production and Target Damage ($\lambda_u = 1$ cm)

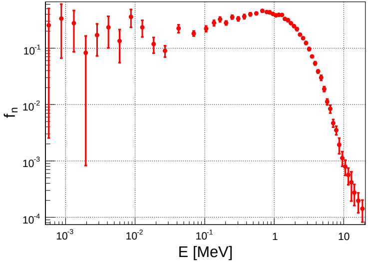
Neutron Yield



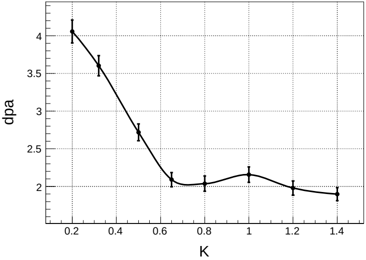
Displacement Cross Section (SPECTER)



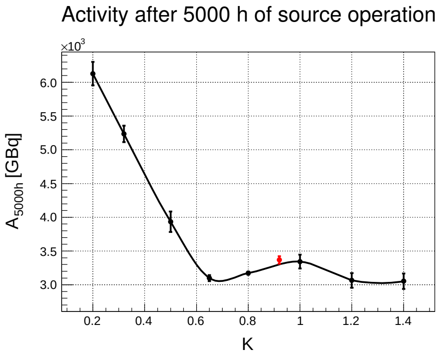
Example of Neutron Energy Distribution Function

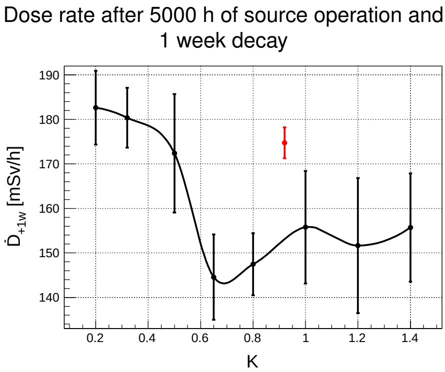


Target Damage by Neutrons after 5000 Hours of Target Irradiation



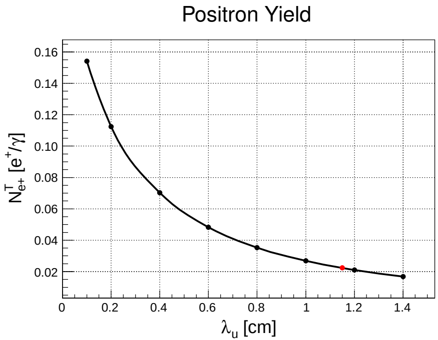
Target Activity and Dose Rate ($\lambda_u = 1$ cm)

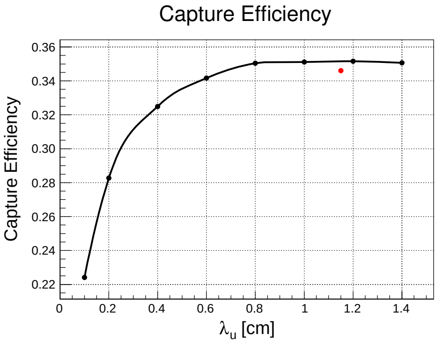




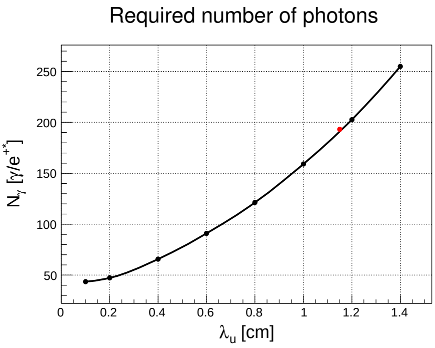
Positron Yield and Capture Efficiency ($K = 1$)

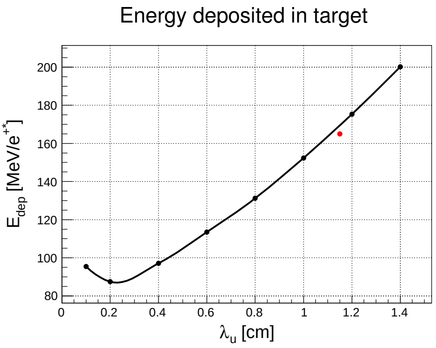
Varying of λ



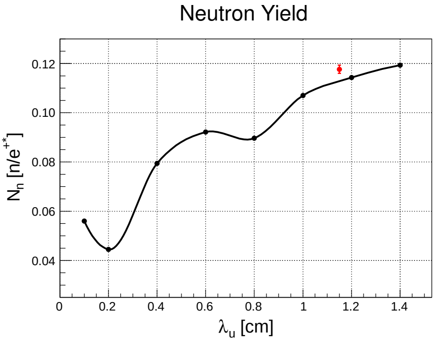


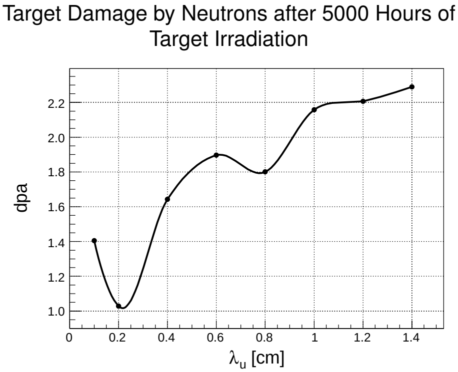
Required Number of Photons and Energy Deposited in Target (per Positron at IP). $K = 1$





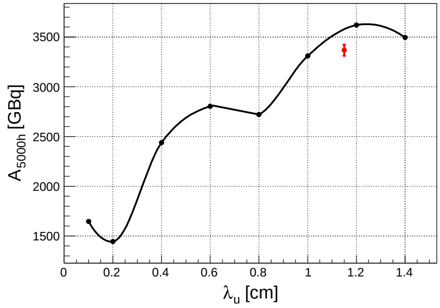
Neutron Production and Target Damage ($K = 1$)



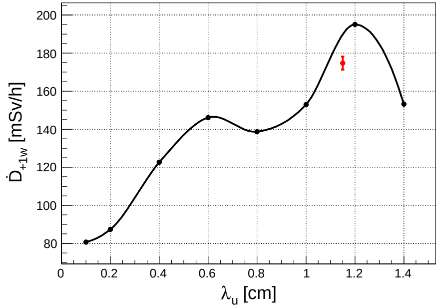


Target Activity and Dose Rate ($K = 1$)

Activity after 5000 h of source operation



Dose rate after 5000 h of source operation and 1 week decay



Summary and Outlook

- Undulator K value above 0.6 is recommended to use (higher K is better for the target heat load).
- Smaller undulator period is more effective.

Future plan

- Beam time structure will be taken into account.
- Polarization of beam will be considered.