Source Performance Modelling

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Outline

Introduction

- Layout of positron source
- Photon production
- Positron production

Positron transport

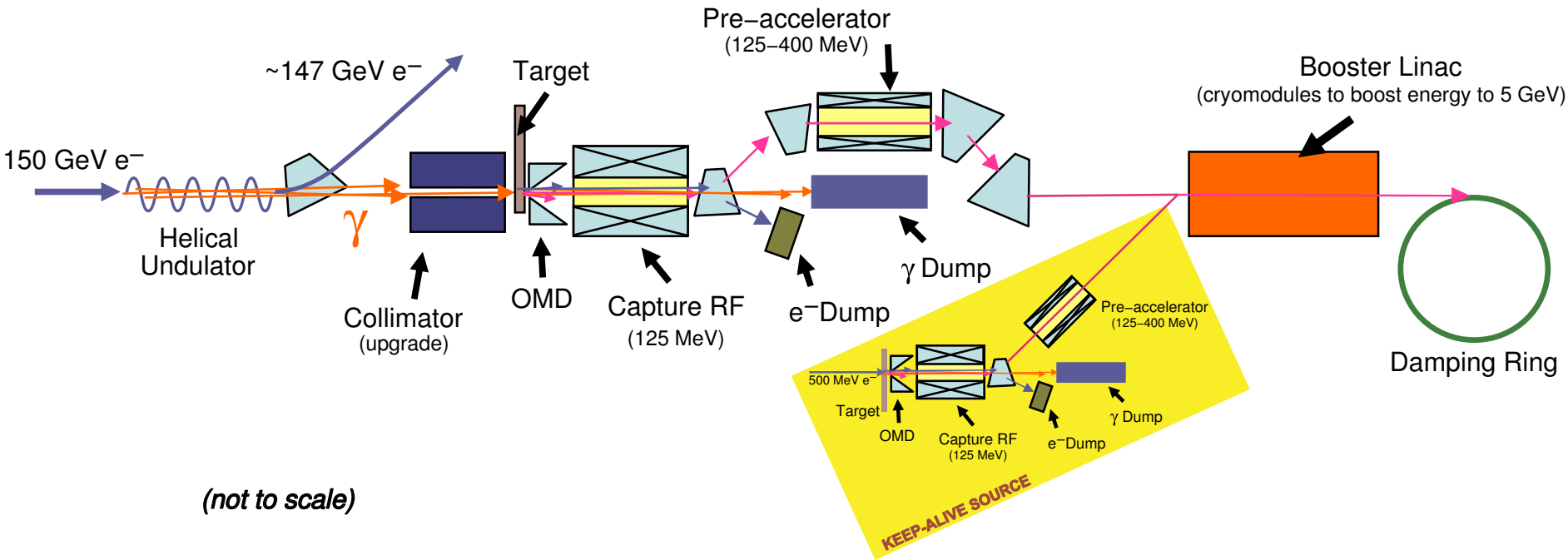
- Positron capturing
- Spin transport

Design issues

- Energy deposition
- Radiation damage
- Source activation

Outlook

Layout of Positron Source



ILC nominal positron source parameters

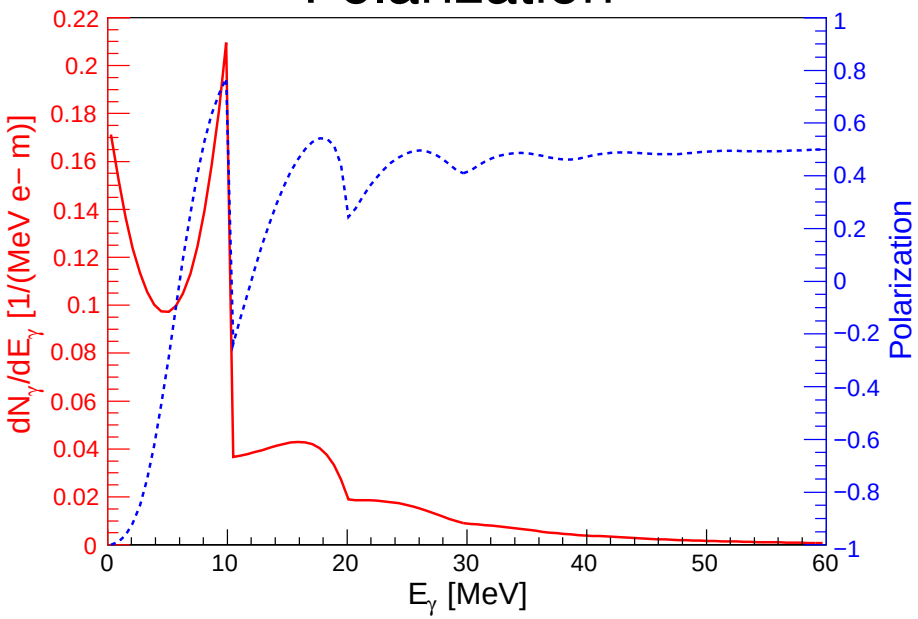
e^- drive beam energy, GeV	150
e^+ per bunch at the end of pre-accelerator	$3 \cdot 10^{10}$
Bunches per pulse	2625
Pulse repetition rate, Hz	5
e^+ polarization	30 (60)

Photon Production

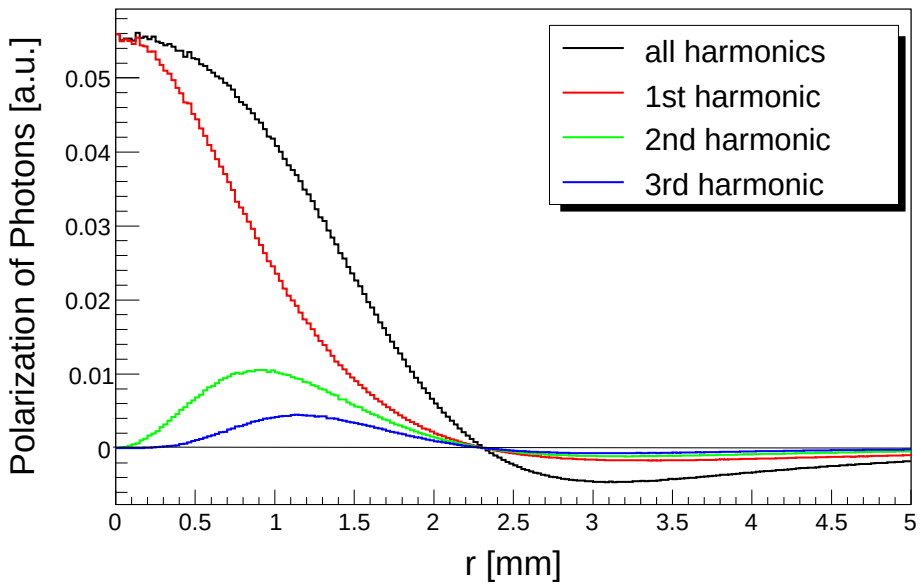
Undulator Parameters

Undulator K-value	0.92
Undulator period, cm	1.15
Number of photons, $\gamma/(e^- m)$	1.95
Energy of 1^{st} harmonic cutoff, MeV	10.06
Undulator-target distance, m	500

Photon Energy Distribution and Polarization

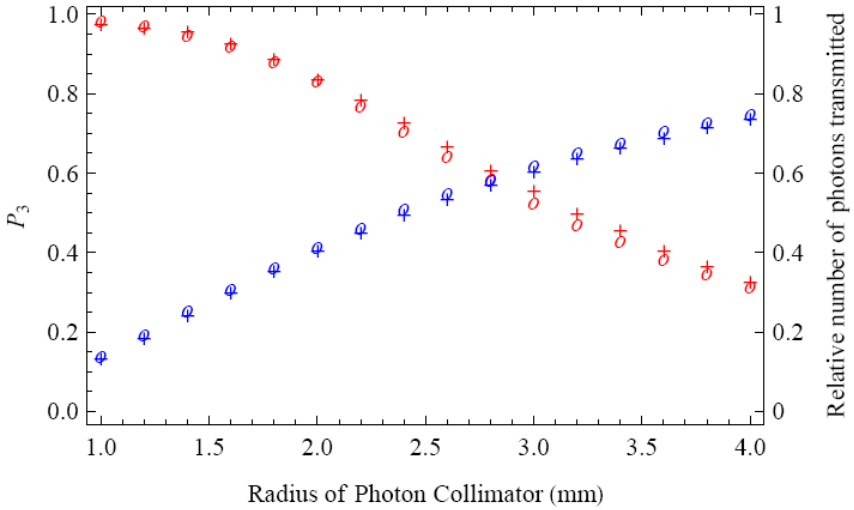


Photon Polarization at Target

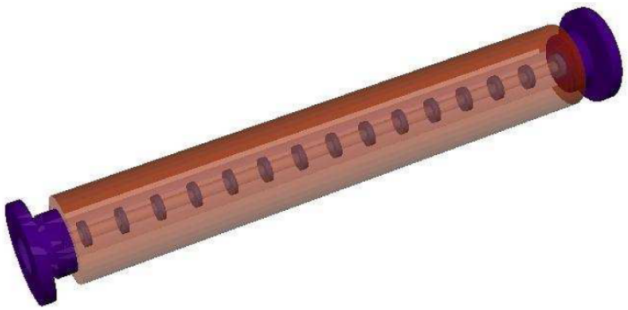


Photon Collimator (modelled by Zang Lei, Daresbury Lab)

Photon Polarization and Transmission vs Collimator Radius

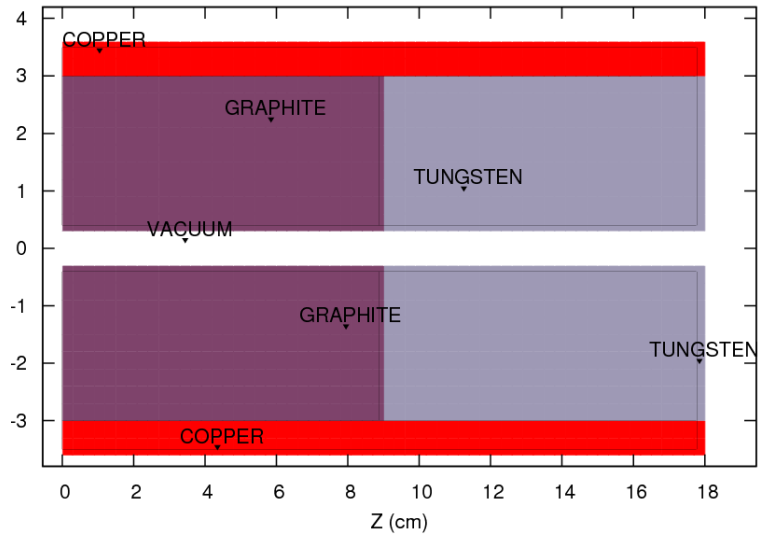


Model 1

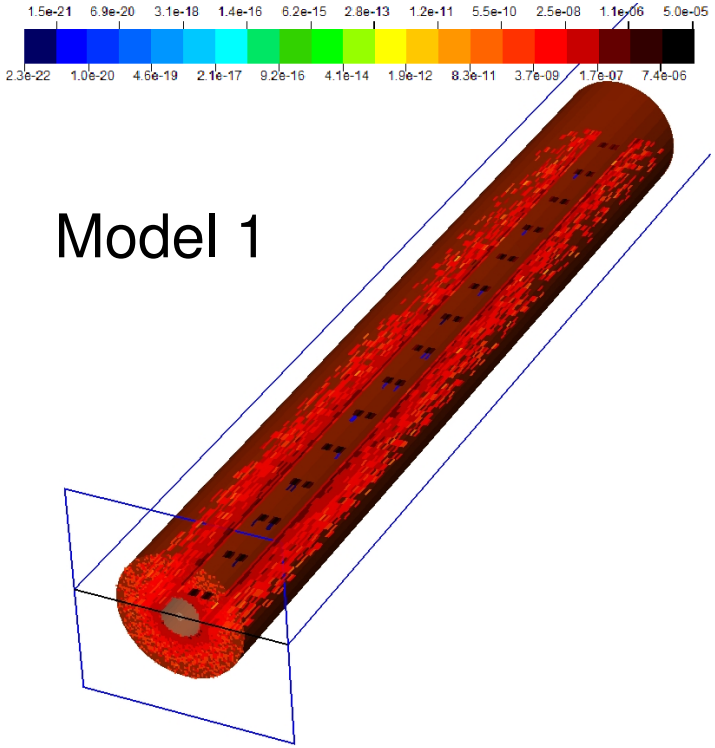


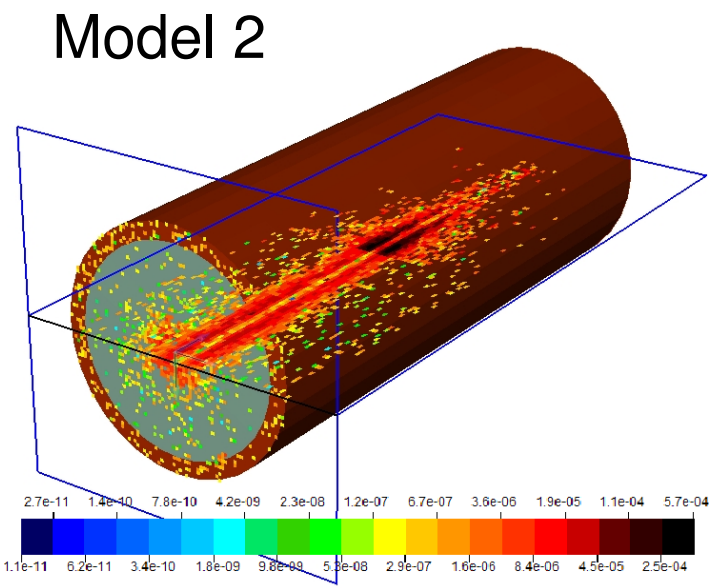
- Ti-spoilers, Cu-absorber
- Length is 90 cm, outer radius is 6 cm

Model 2 (A. Mikhailichenko, EPAC'06)



Energy Deposition in Photon Collimator (calculated by Zang Lei)

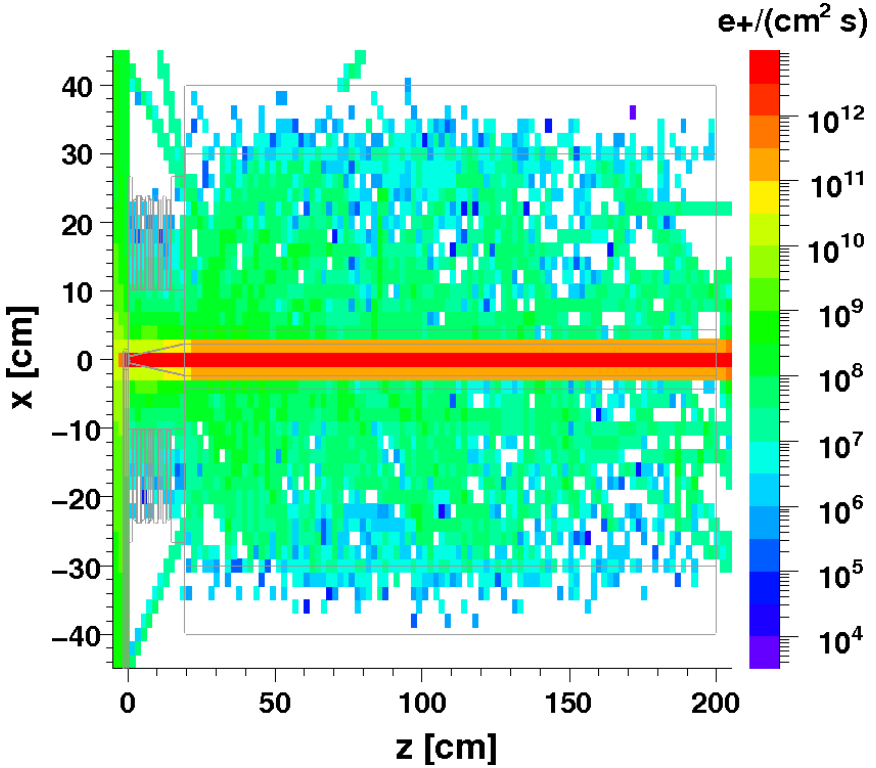




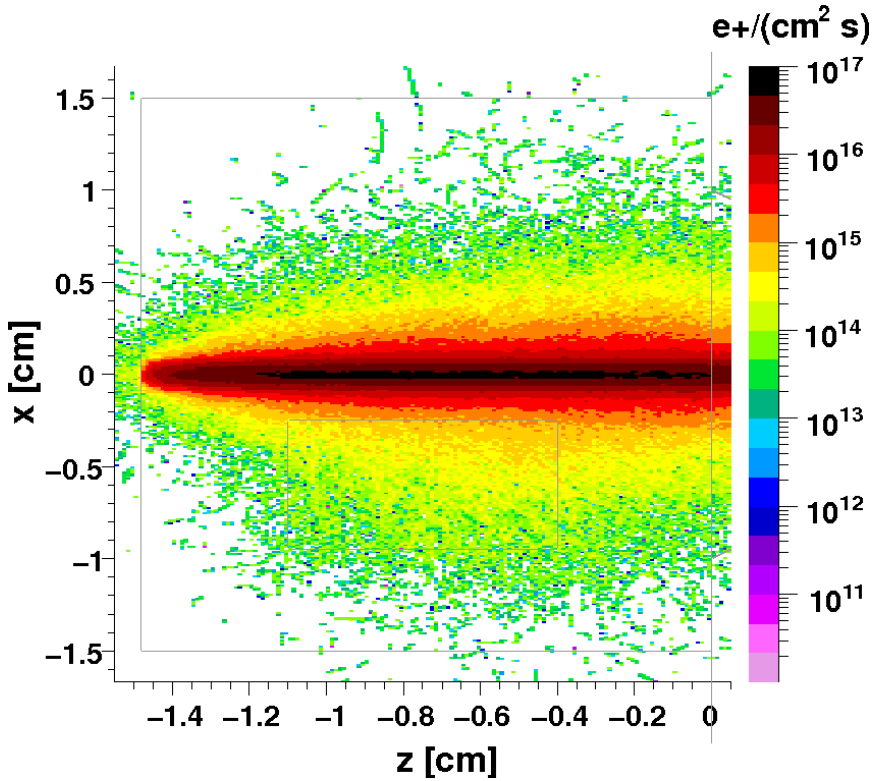
R_{col} [mm]	Trans. [%]	Pol. [%]	Model 1		Model 2		
			Deposited Energy [MeV/pr]				
			Ti	Cu	C	W	Cu
2	41	84	4.17 (34.7 %)		4.95 (41.1 %)		
			1.87	2.30	1.03	3.88	0.04
3	61	56	1.63 (13.6 %)		1.87 (15.6 %)		
			0.78	0.85	0.48	1.37	0.02
4	74	33	0.61 (5.1 %)		0.68 (5.7 %)		
			0.31	0.30	0.21	0.45	0.01

Positron Production. e+ Source without Photon Collimation

2D Projection of Positron Fluence



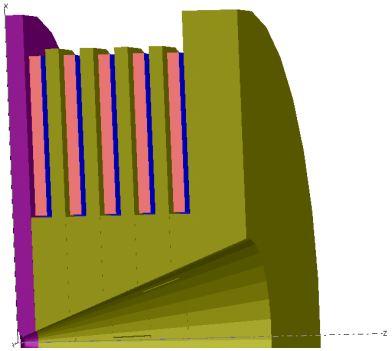
Positron Fluence in Target



Target Material	Ti6Al4V	W25Re
Positron Yield, e^+/γ	0.022	0.033
Polarization, %	26.7	24.8

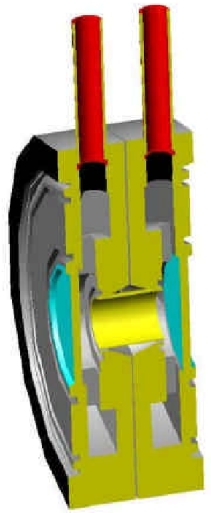
Pulsed Flux Concentrator

$$B_0(z) = \frac{B_{ini}}{1+gz}$$



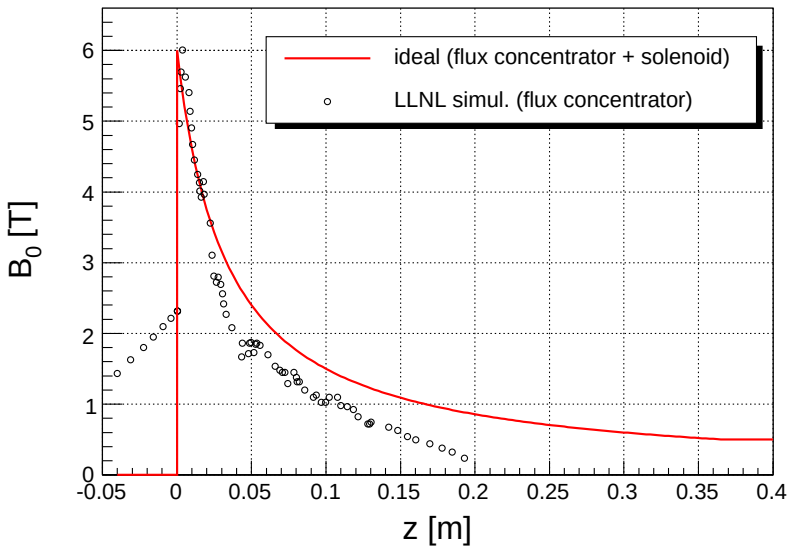
Li Lens

$$B_\theta(r) = \frac{\mu_0 I r}{2\pi a^2}$$

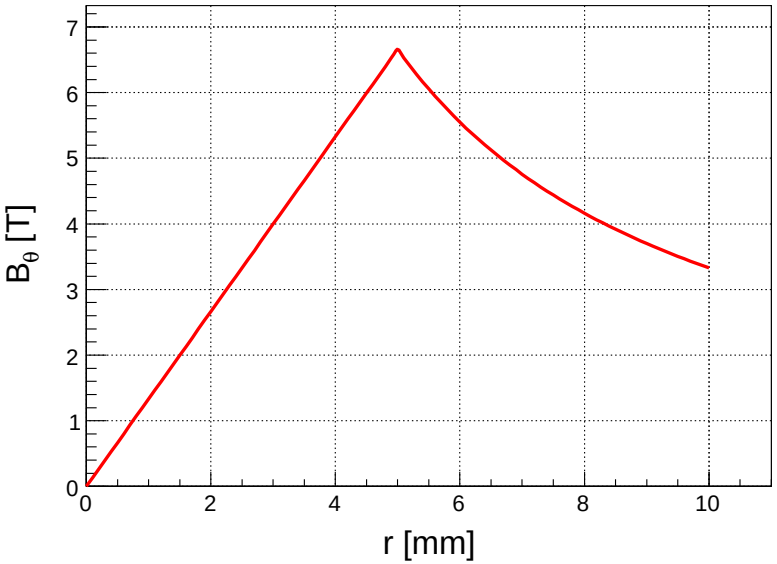


A.M.

B-field along beam axis

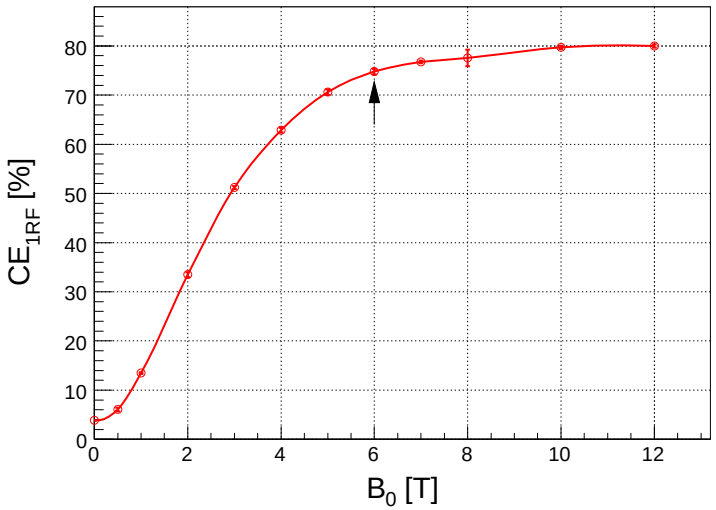


B-field vs radius (I = 166 kA)

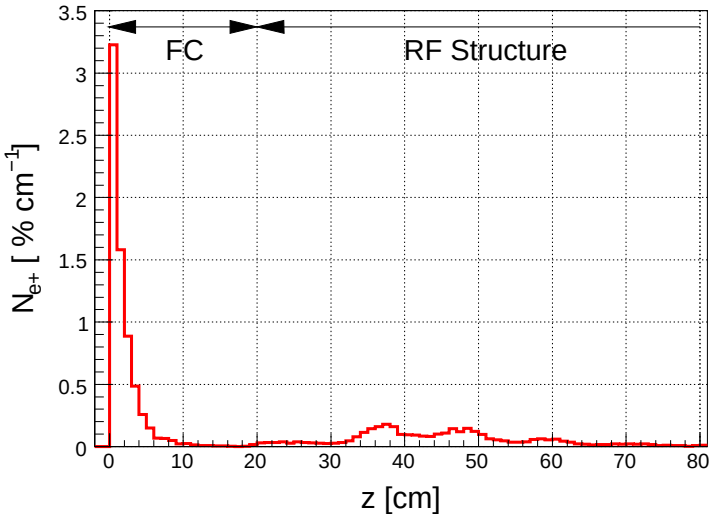


Capture Efficiency and Positron Losses

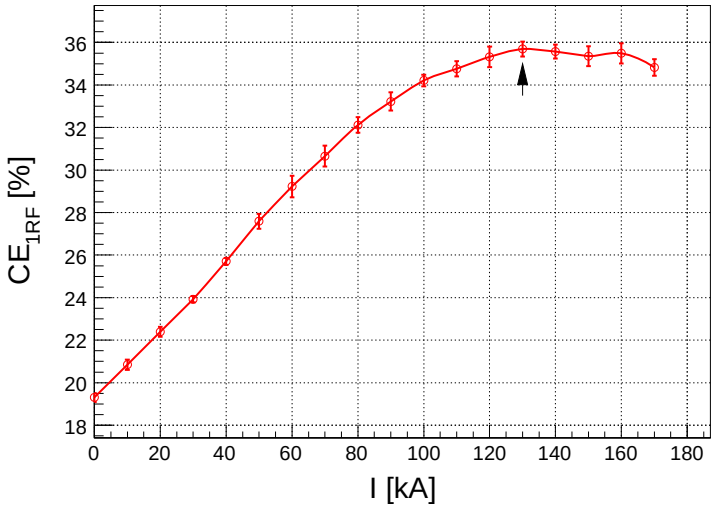
FC: CE after 1st RF Structure ($B_{sol} = 0.5$ T)



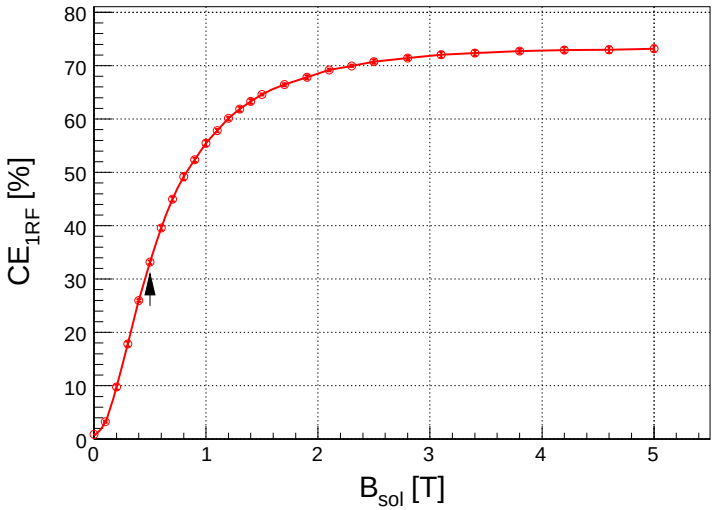
FC: Positron Losses



Li-Lens: CE vs Lens Current ($B_{sol} = 0.5$ T)

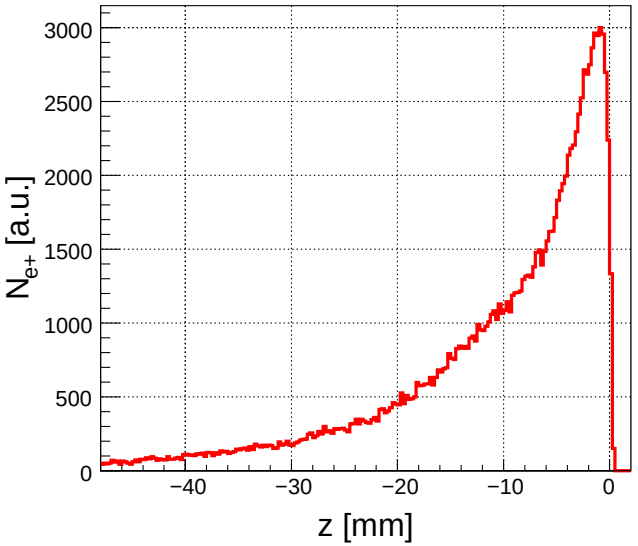


Li-Lens: CE vs Field of Solenoid

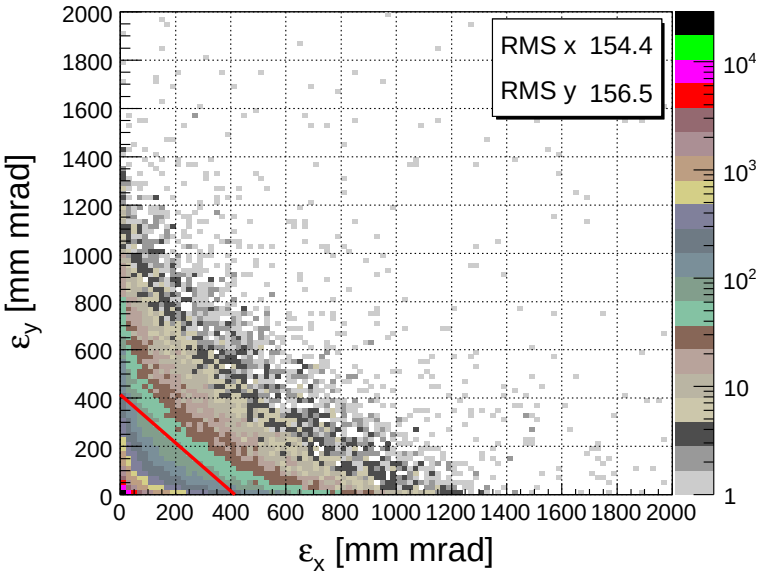


Longitudinal and Transverse Cuts at 125 MeV. DR Acceptance

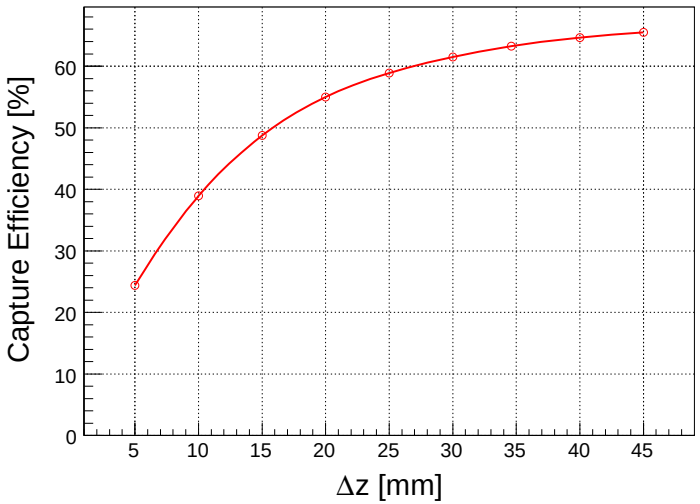
Longitudinal Profile of e^+ Beam



Emittance Cut



CE for different longitudinal cuts
($\varepsilon_{nx} + \varepsilon_{ny} < 0.09$ m rad)



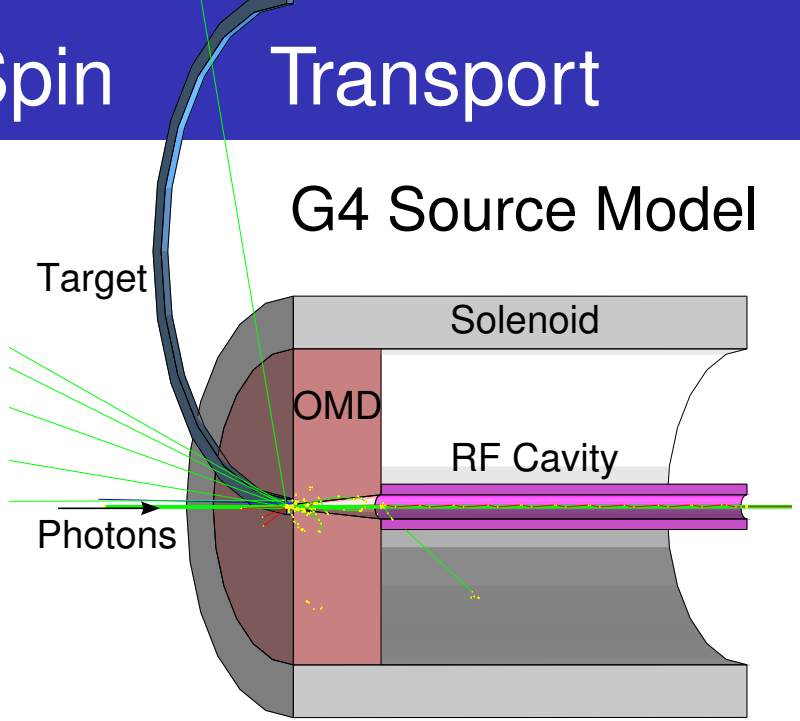
DR Acceptance

- DR transverse acceptance: 0.09 m rad
- DR longitudinal acceptance: $\pm$ 3.4 cm $\times$25 MeV

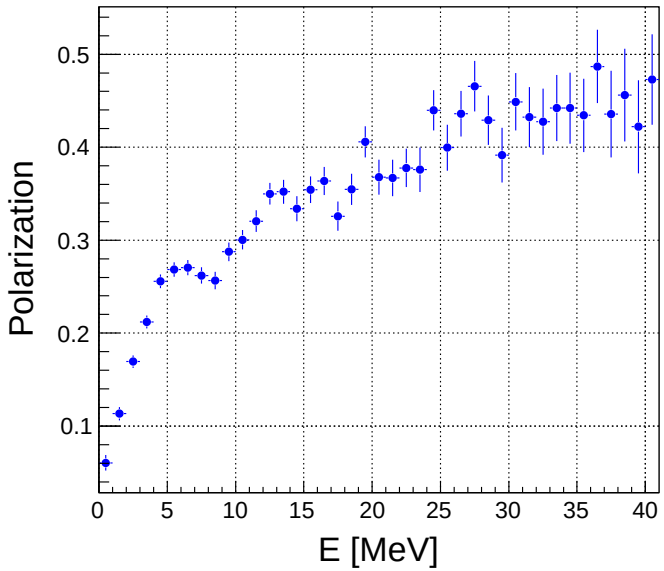
Capture Efficiency

Longitudinal Cut	CE [%]
Δz = 10 mm	39
Δz = 34 mm	63

G4 Source Model



e^+ Polarization after Target

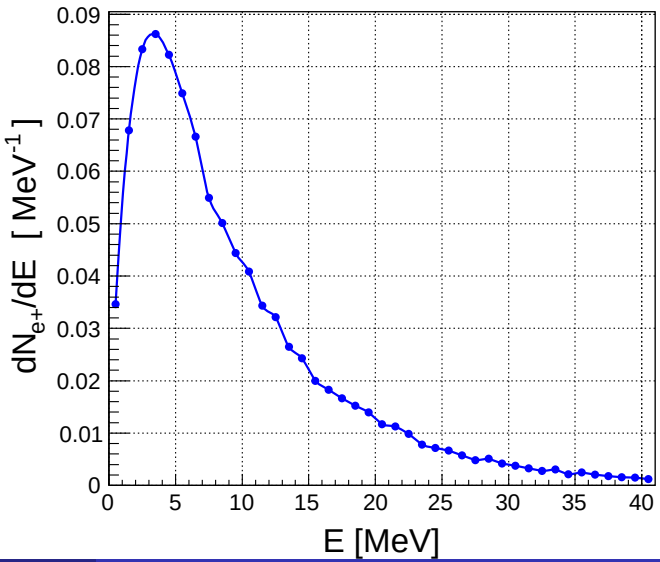


e^+ Polarization

	Base Line Design	with **Ph. Col.** R_{col} = 2.3 mm
after Target	**26.7**	44.2
after Pre-Accelerator*	**38.6**	48.4

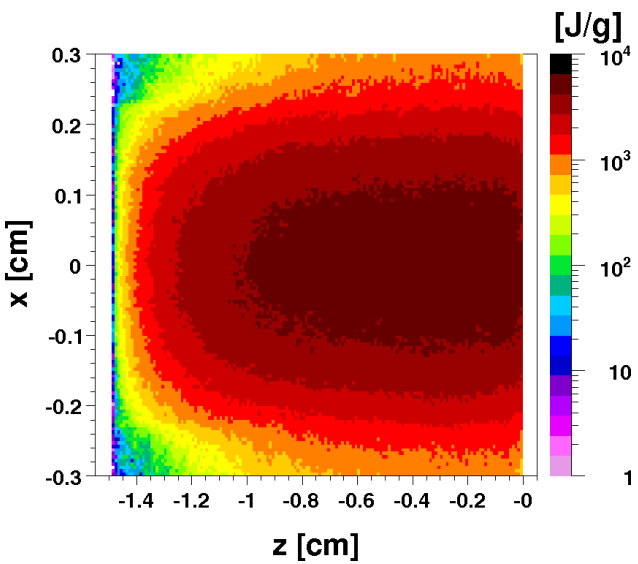
* calculated using ASTRA code

e^+ Energy after Target

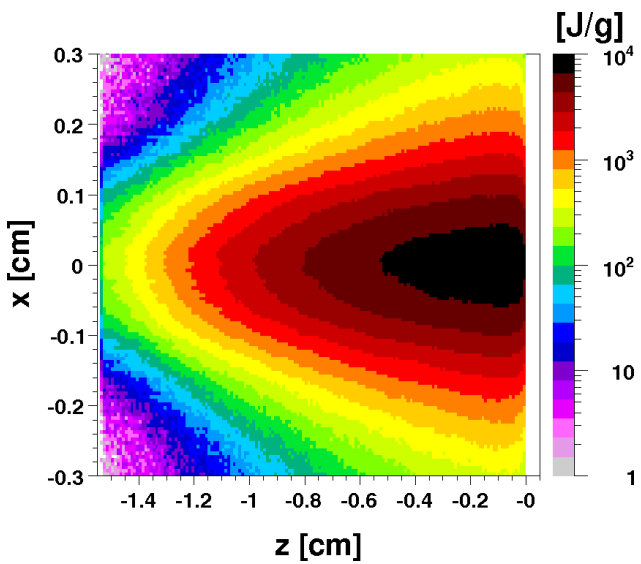


Energy Deposition

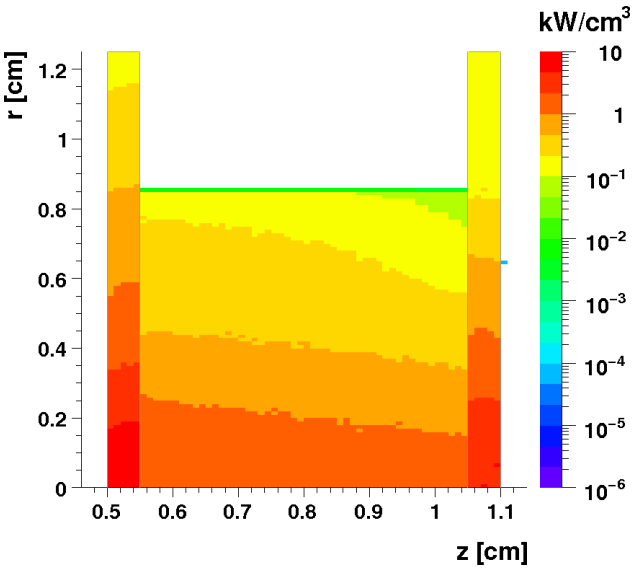
Target of UBS



Target of Conventional Source



Li-Lens

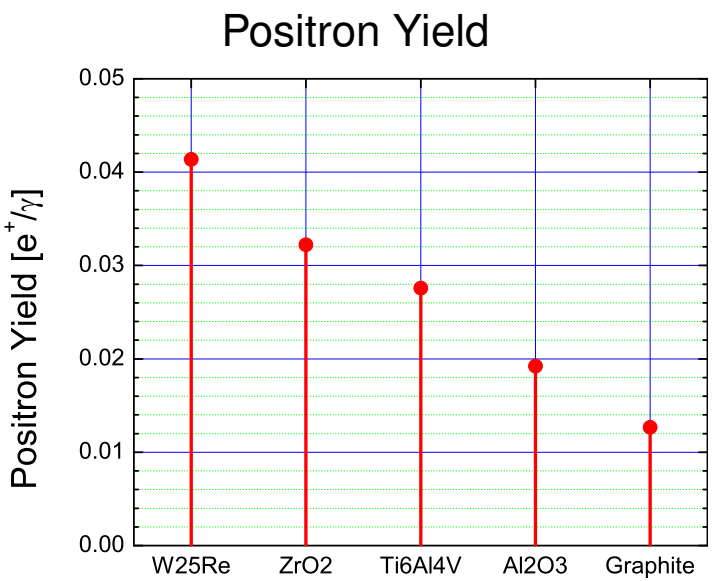


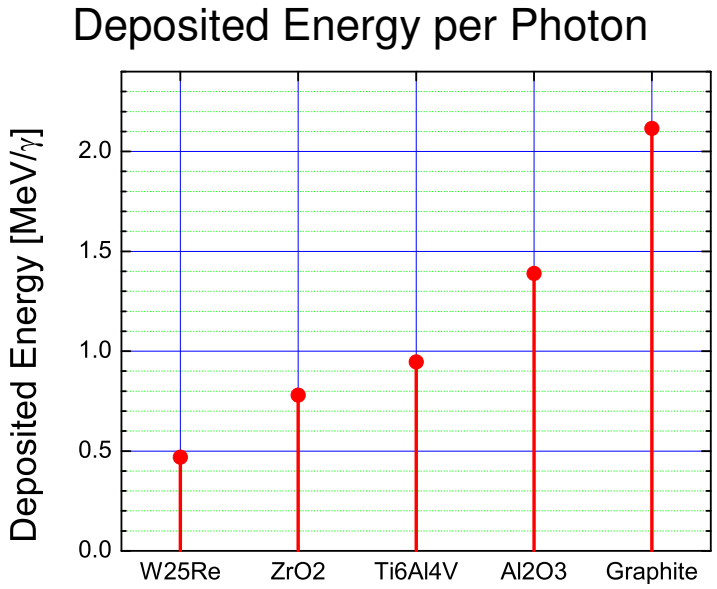
	UBS K = 0.92 λ = 11.5 mm 0.4 X_0 Ti6Al4V	CS 6.2 GeV σ = 1.5 mm 4.5 X_0 W25Re
Target Radius, cm	50	100
Revolution Rate, rpm	1920	3400
Max. ΔT, K	**63**	**137**
Max. Thermal Stress, MPa	**90**	**390**

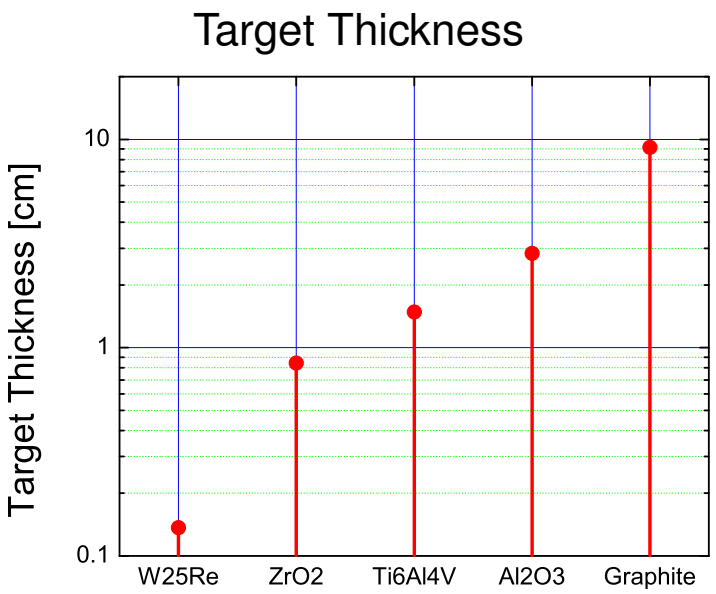
Surviving of Li-Lens Windows?

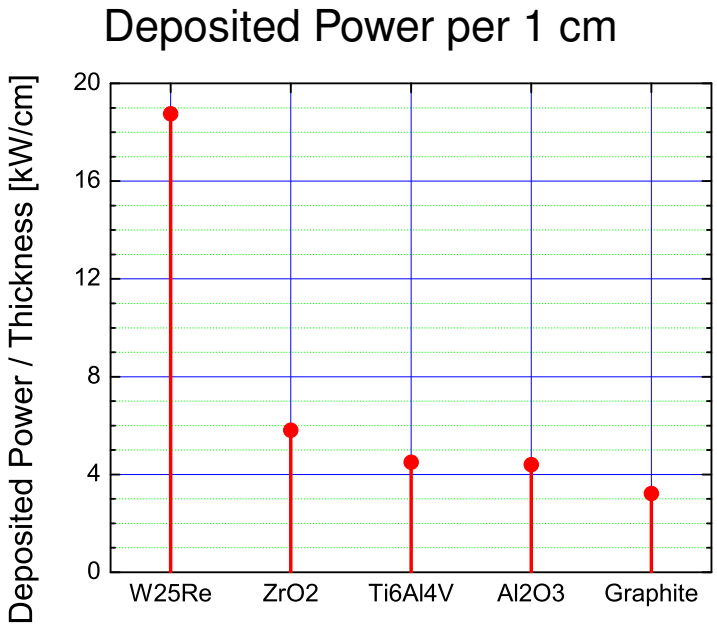
Different Target Materials

(K = 1, λ = 1 cm; 0.4 X_0)



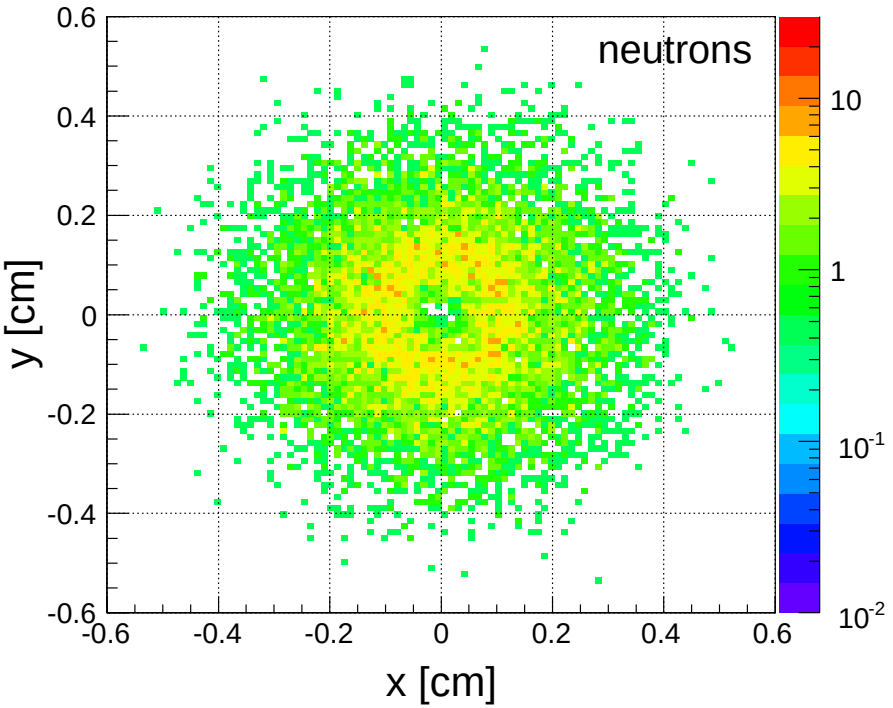




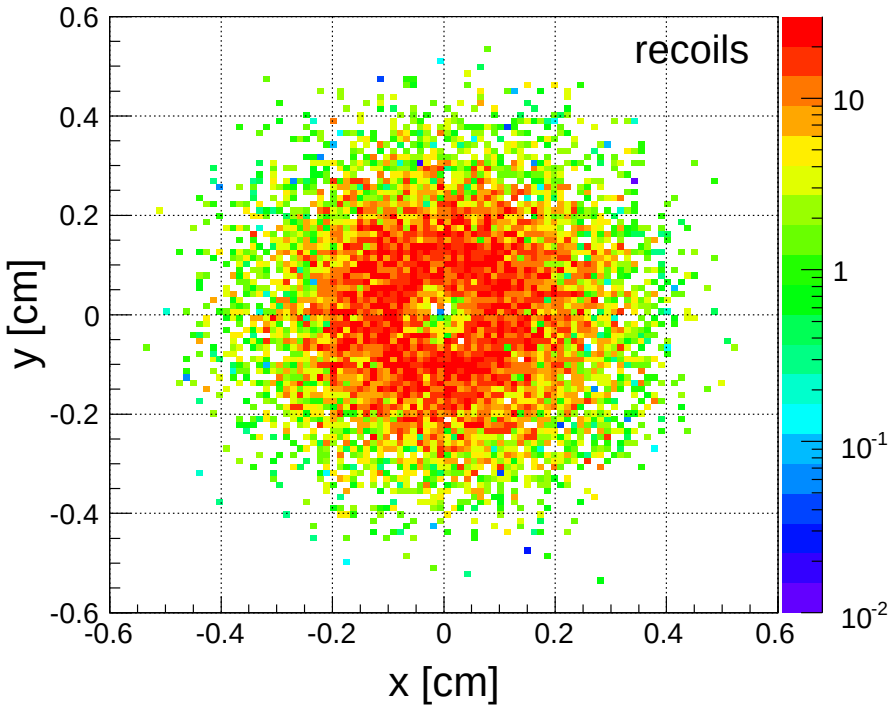


Radiation Damage (FLUKA & SPECTER)

Damage by Neutrons



Damage by Recoils



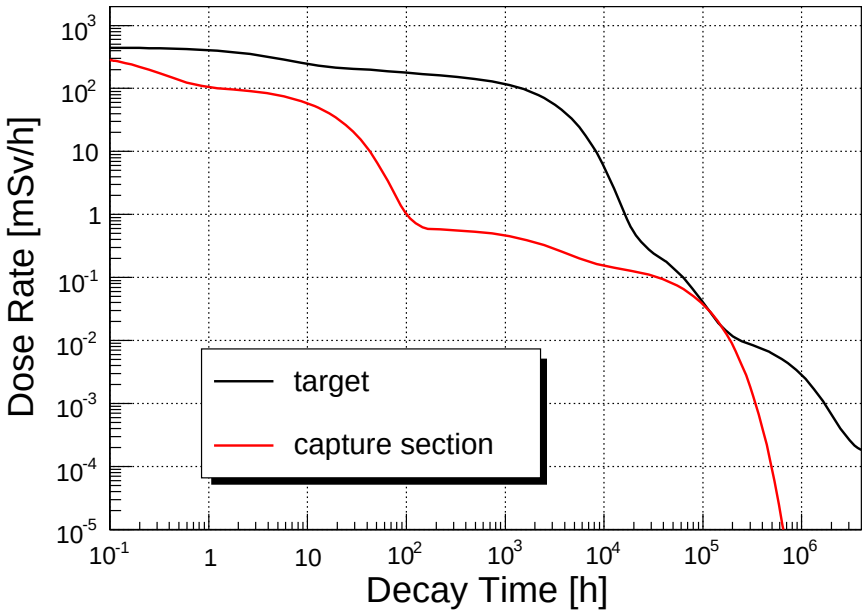
Damage of Ti6Al4V target after 5k hours of irradiation:

$\sim$ **7 dpa** (12.5% by neutrons) for stationary target

or $\sim$ 0.05 dpa for rotating target with r = 50 cm

Source Activation

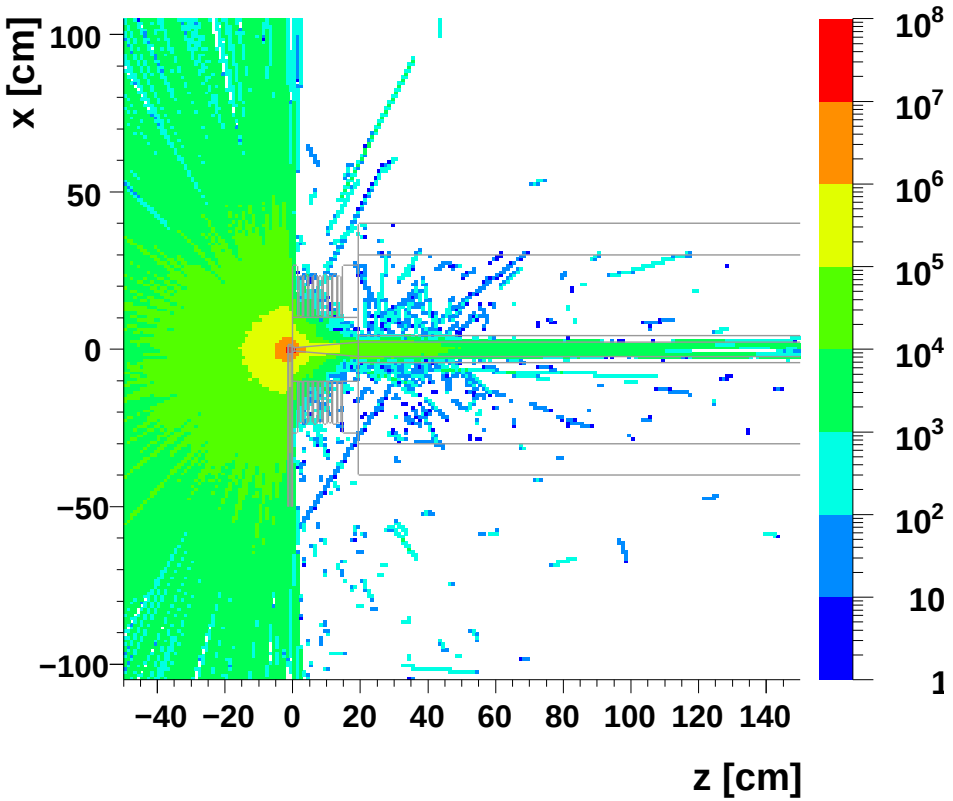
Ambient Dose Rate Equivalent vs Decay Time



Nuclei	A	$T_{1/2}$, h	$\dot{D}_{+1h}$, mSv/h	%
Ti	45	3.1	104.4	42.09
Sc	46	**2011.9**	86.7	34.96
Sc	44	3.9	21.3	8.59
Sc	48	43.7	19.1	7.71
Sc	47	80.4	13.6	5.47

Effective Dose Rate [mSv/h]

5000 h irradiation and 1 week of cooling time



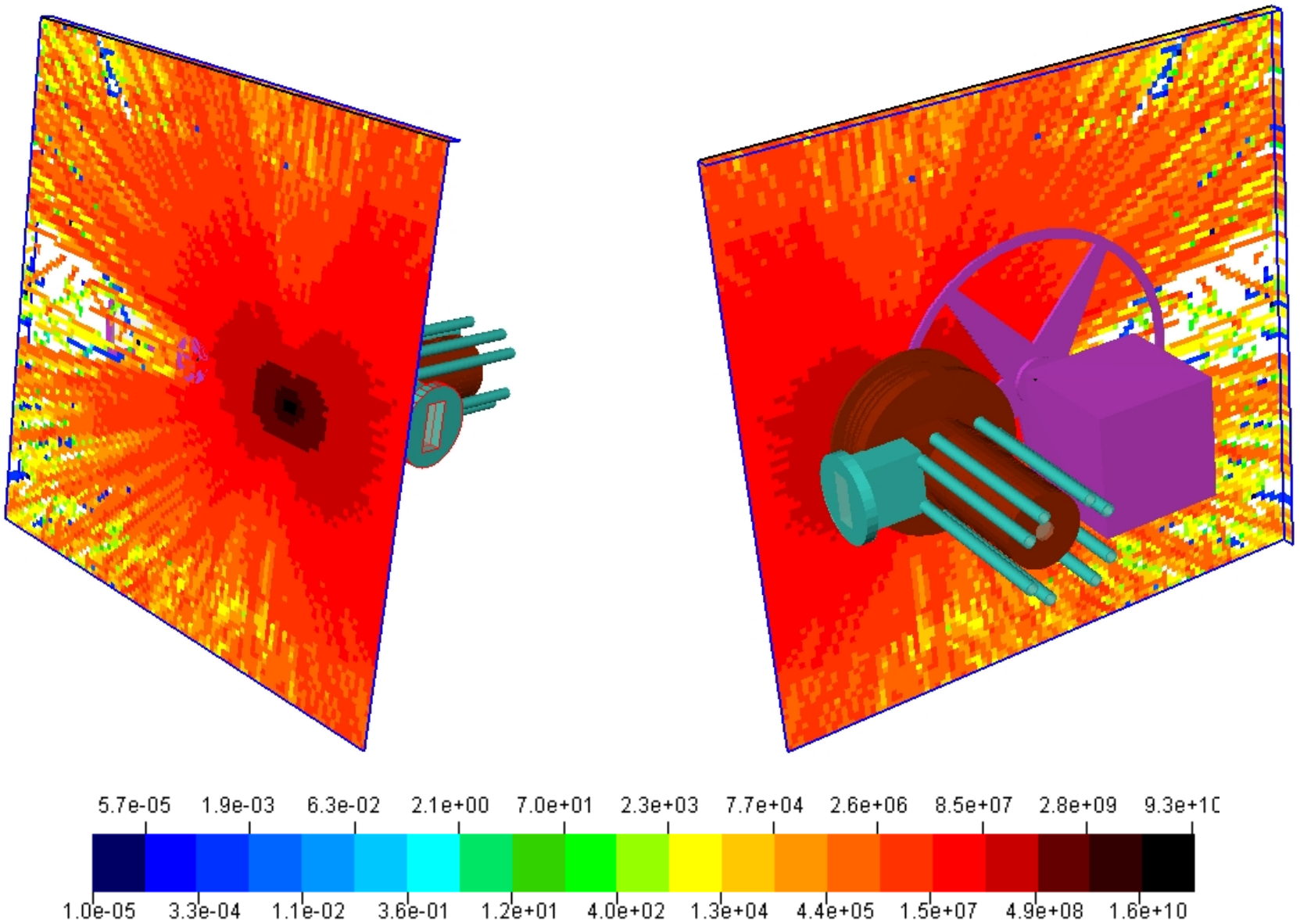
Materials

Target: Ti6Al4V

Capture Section: Cu

Dose Rates [pSv/s]. 1 Hour after 8 Hours of Irradiation

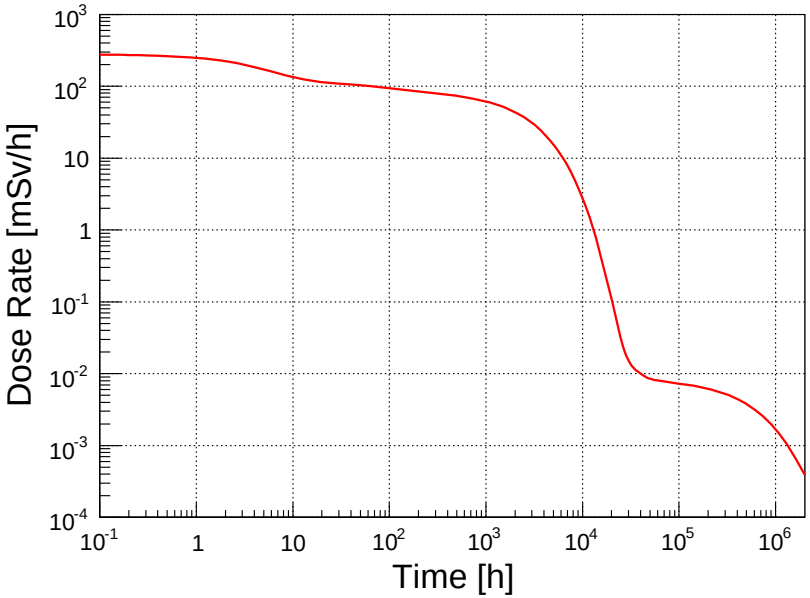
(calculated by L. Fernandez-Hernando, Daresbury Lab)



Activation of Target

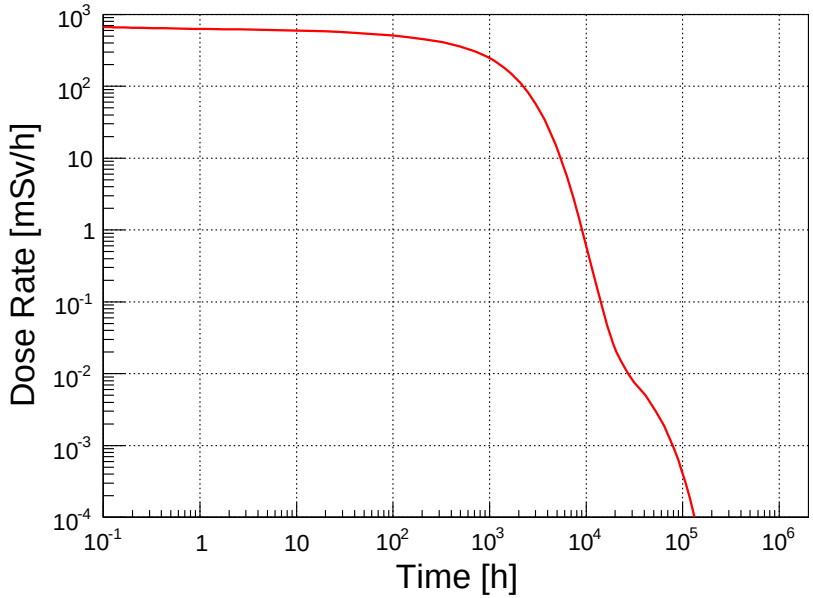
Undulator Based Source

0.4 X_0, Ti6Al4V Target; R_{col} = 2.3 mm



Conventional Source

4.5 X_0, W25Re Target



Dose Rate [mSv/h]

	Undulator Based	Conventional
after Source Switch-Off	280	700
after 1 hour	248	628
after 1 day	111	574
after 1 week	86	469

Summary and Outlook

- Positron production has been calculated for undulator-based and conventional positron sources
- Positron yield and polarization have been calculated for the different undulator parameters and target materials
- Positron capturing has been simulated for different schemes of OMD (pulsed flux concentrator and Li-lens)
- Spin transport through source has been simulated
- Energy deposition in source parts has been determined
- Radiation damage of target has been estimated
- Source activation has been calculated

- Report is coming soon