Radiation and Target Aspects

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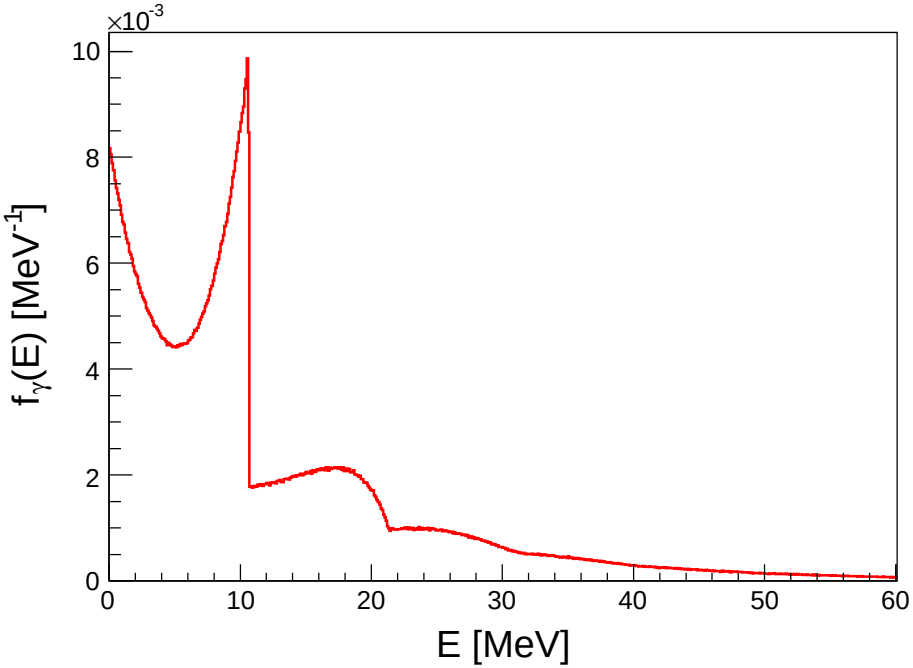
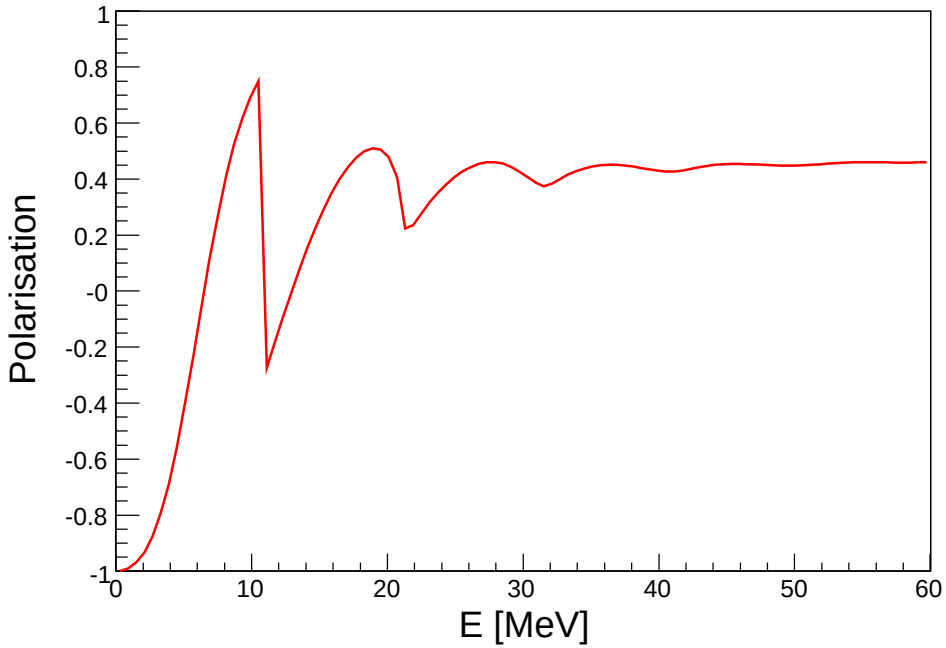
Undulator Based and Conventional Positron Sources

Conventional Source	**Undulator Based Source**
Drive Electron Beam	
6.2 GeV	150 GeV
Photon Production	
via bremsstrahlung in target	in undulator
	K-value 1
	Undulator period 1 cm
Target	
Compound 75W-25Re	Compound 90Ti-6Al-4V
Thickness 4.5 X_0	Thickness 0.4 X_0
Size of the Beam (impinging on the target)	
rms spot size 3.0 mm	rms spot size 0.7 mm

Energy Ditribution Function and Polarization of Undulator Photons



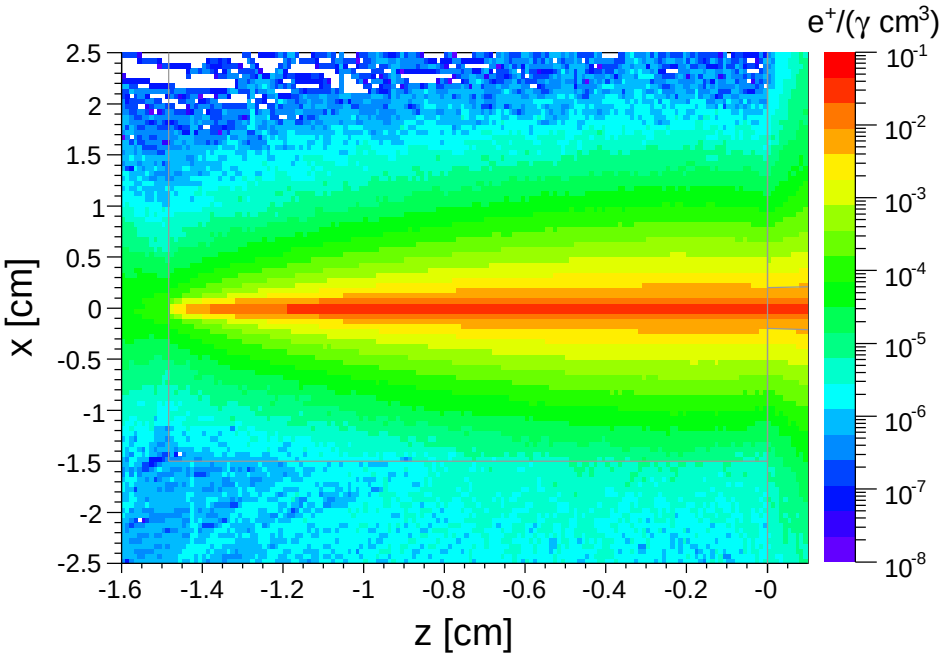


$$\int_0^\infty f_\gamma(E)dE = 1$$

E_1	10.69 MeV
$\langle E \rangle$	12.53 MeV

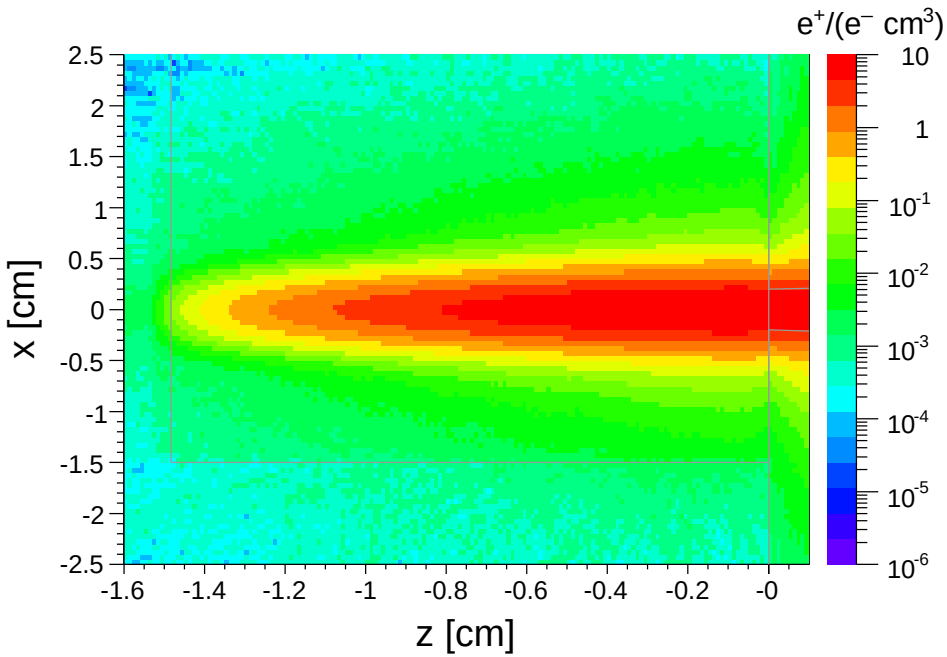
Positron Yield

Undulator based source



$$Y_{e^+} = 2.69 \cdot 10^{-2}\ \mathrm{e}^+/\gamma$$

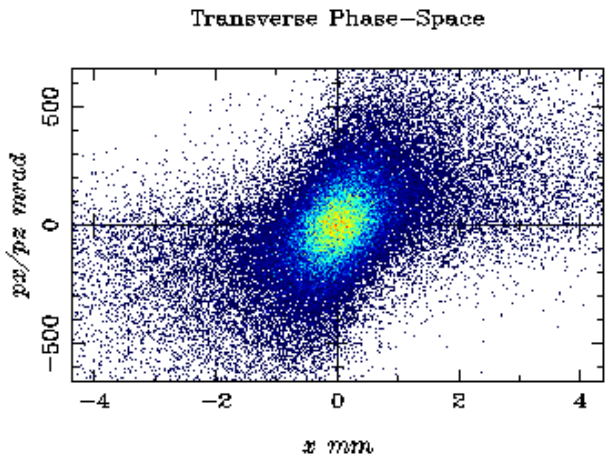
Conventional source

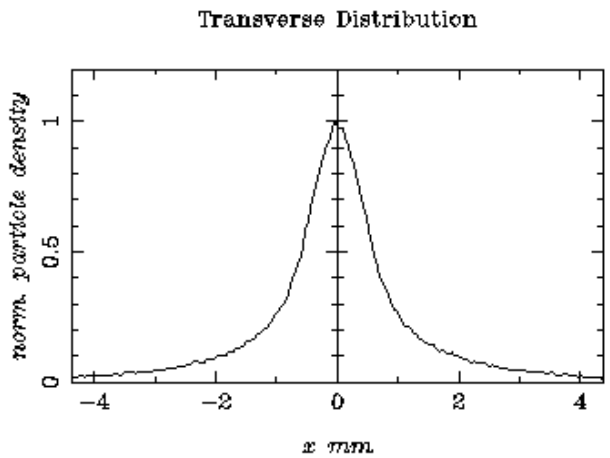


$$Y_{e^+} = 14.34\ \mathrm{e}^+ / \mathrm{e}^-$$

Positron Beam on Backside of the Target

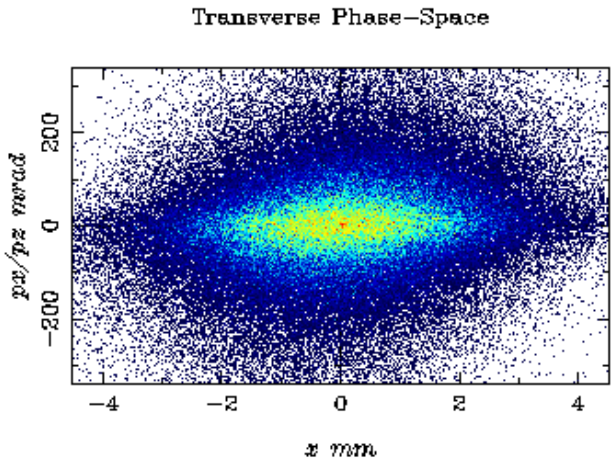
Undulator based source

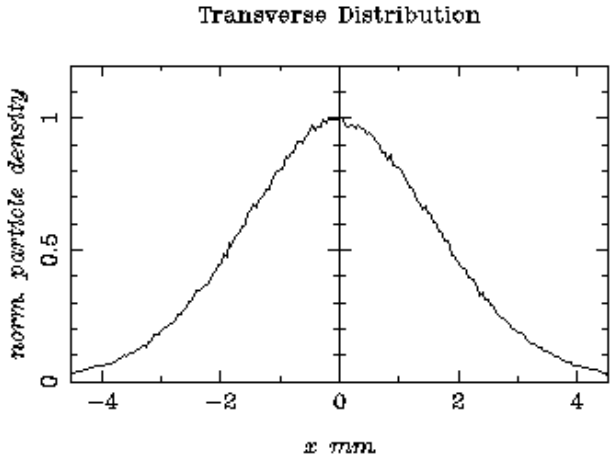




ϵ_X = 9665 π mm mrad

Conventional source





ϵ_X = 26879 π mm mrad

Positron Capture

Energy spread	1%
Longitudinal cut	> 10 cm
Transverse cut: $\epsilon_{i,x} + \epsilon_{i,y}$	> 0.04 rad m

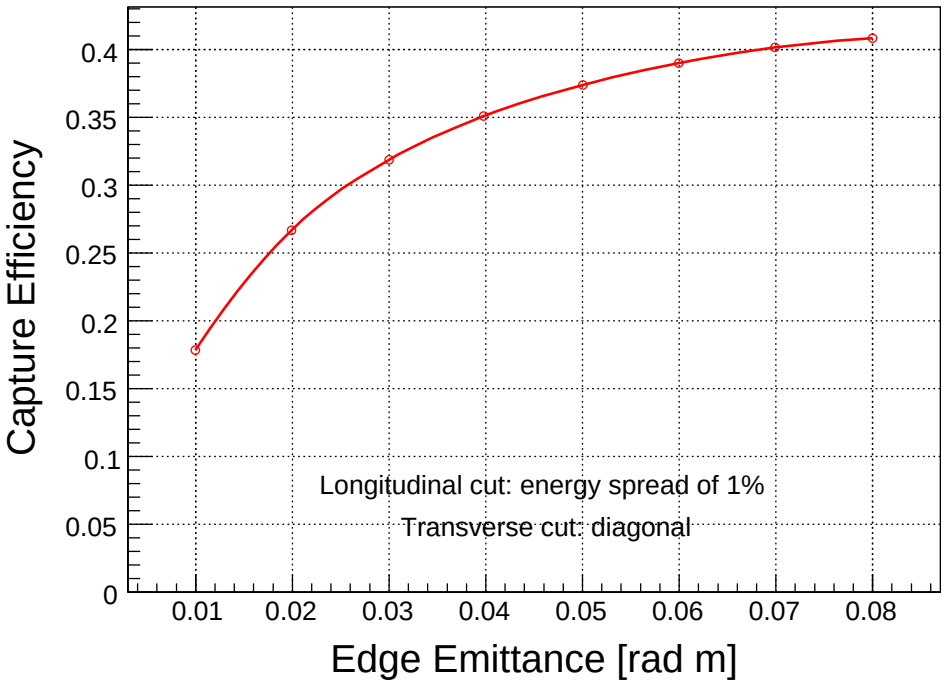
Capture Efficiency

Undulator Based Source

0.35

Conventional Source

0.115



Required Number of Photons/Electrons

Source Type	Undulator	Conventional
IP	1 e^+	1 e^+
DR	1.5 e^+	1.5 e^+
after Target	4.27 e^+	13.04 e^+
before Target	159.08 γ	0.91 e^-

Positron Beam Time Structure

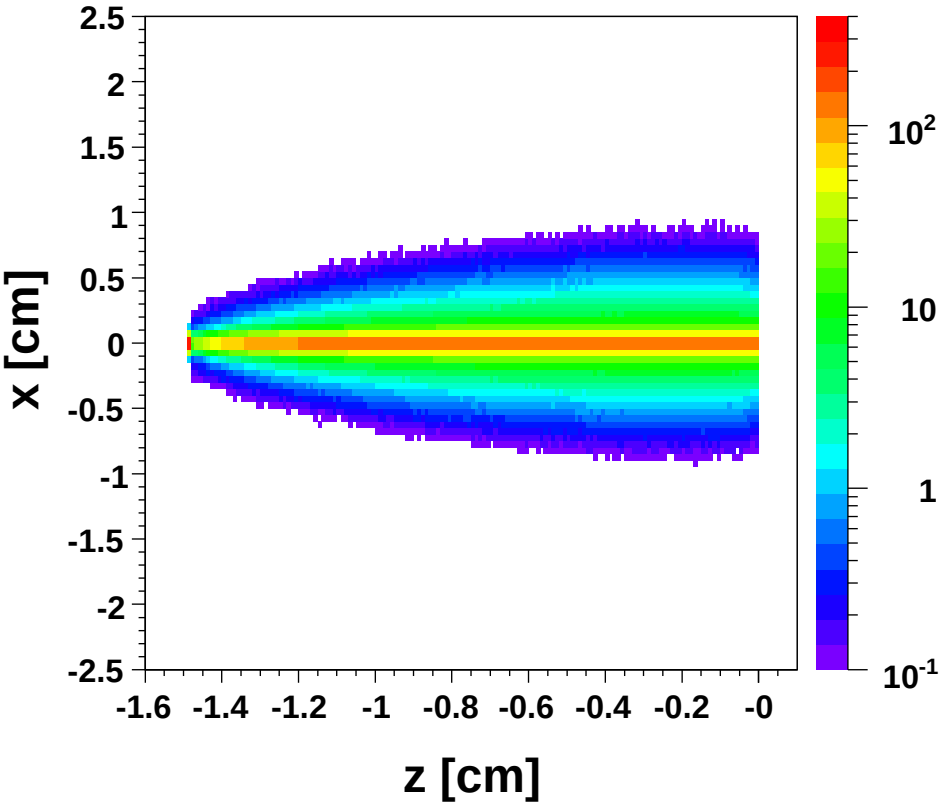
$2 \cdot 10^{10}$ e^+/bunch, 2820 bunch/pulse, 5 Hz

Required Number of Photons/Electrons

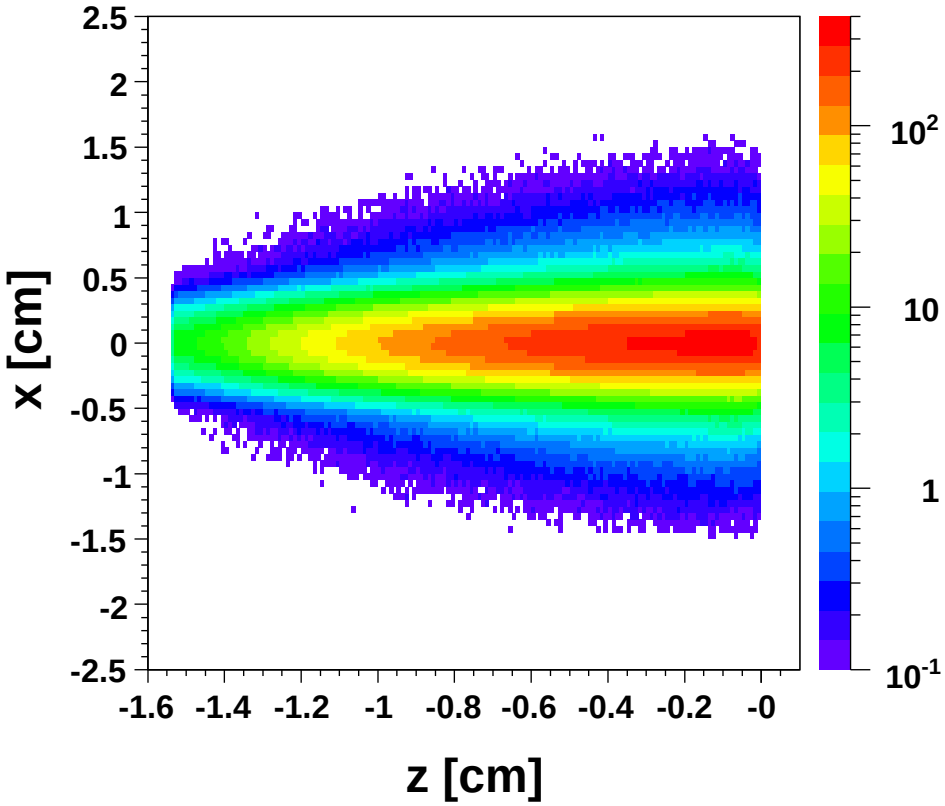
Source Type	Undulator	Conventional
Beam Intensity	$4.49 \cdot 10^{16}$ γ/s	$2.56 \cdot 10^{14}$ e^-/s

Deposited Energy

Undulator based source



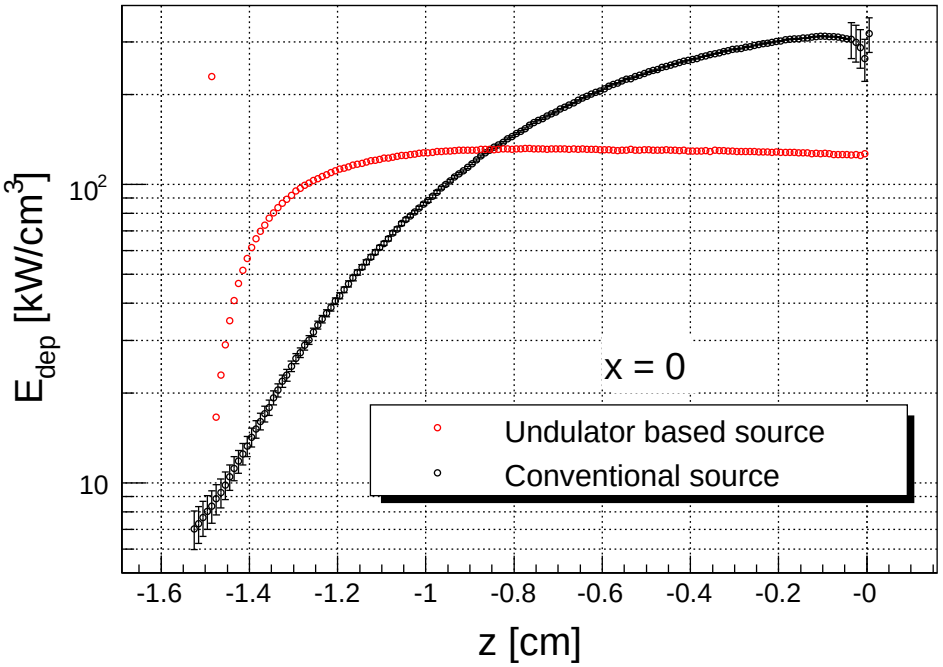
Conventional source

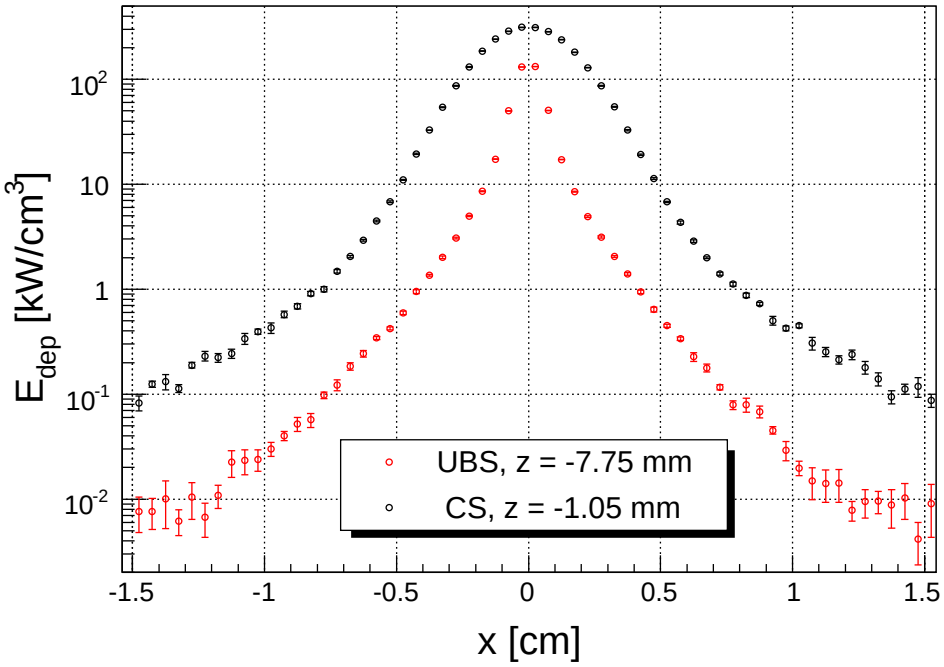


Total Energy Deposition

6.89 kW **47.44 kW**

Maximal Deposited Energy





Undulator based source

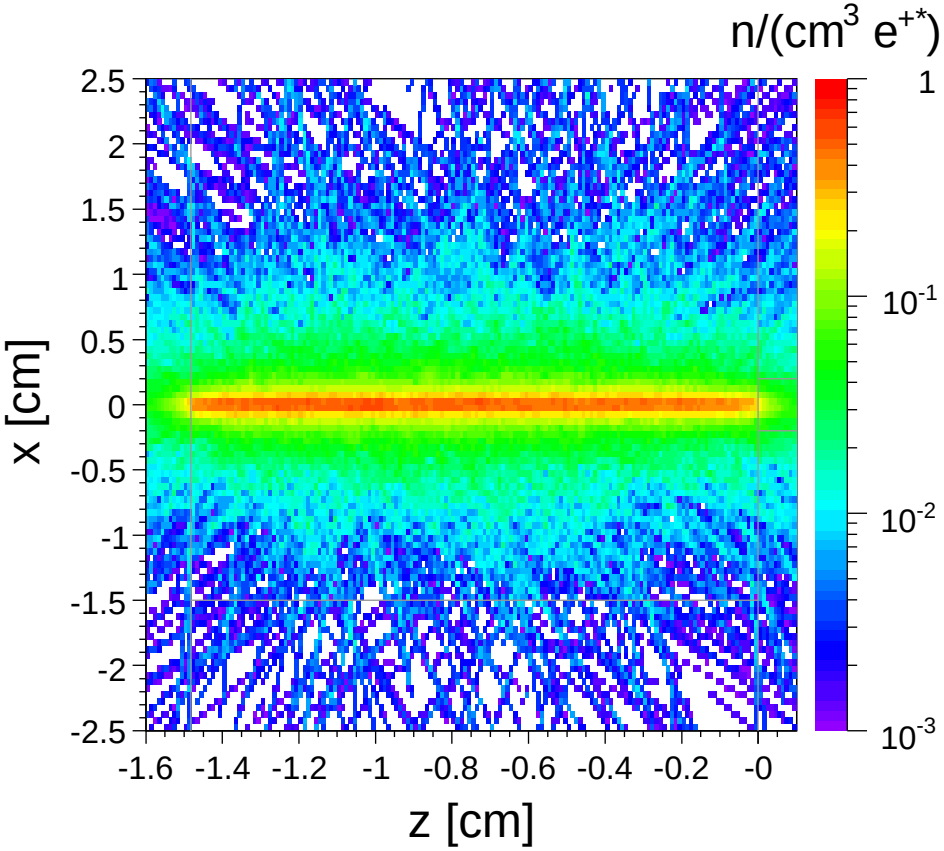
145.4 kW/cm^3

Conventional source

346.8 kW/cm^3

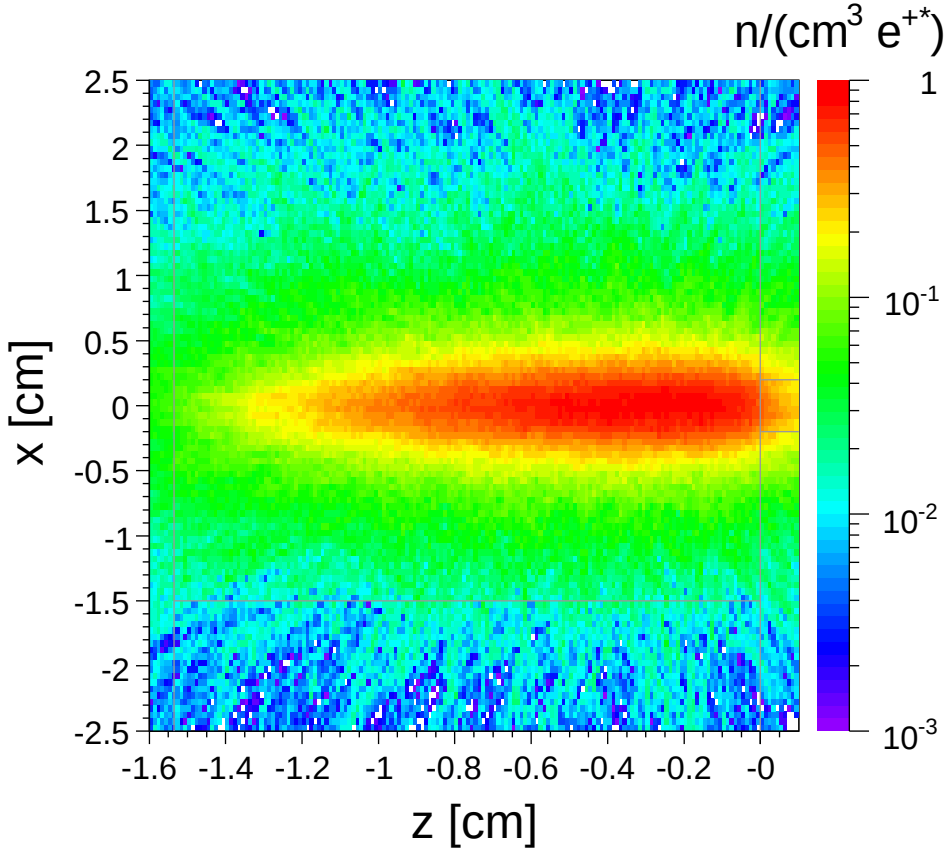
Neutron Density

Undulator based source



0.107 n/(cm^3 e^{+*})

Conventional source

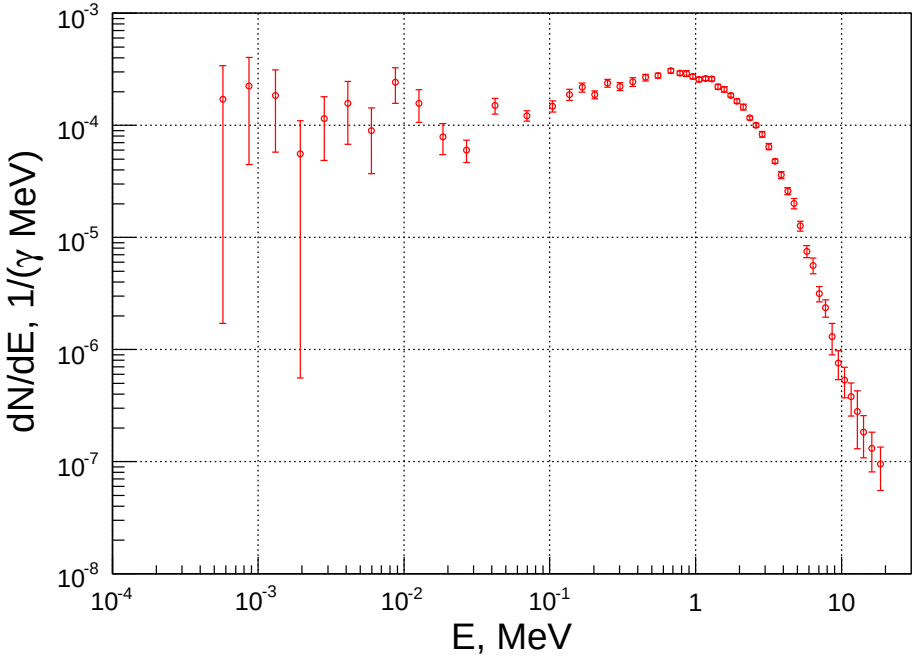


0.498 n/(cm^3 e^{+*})

e^{+*} is the positron at IP

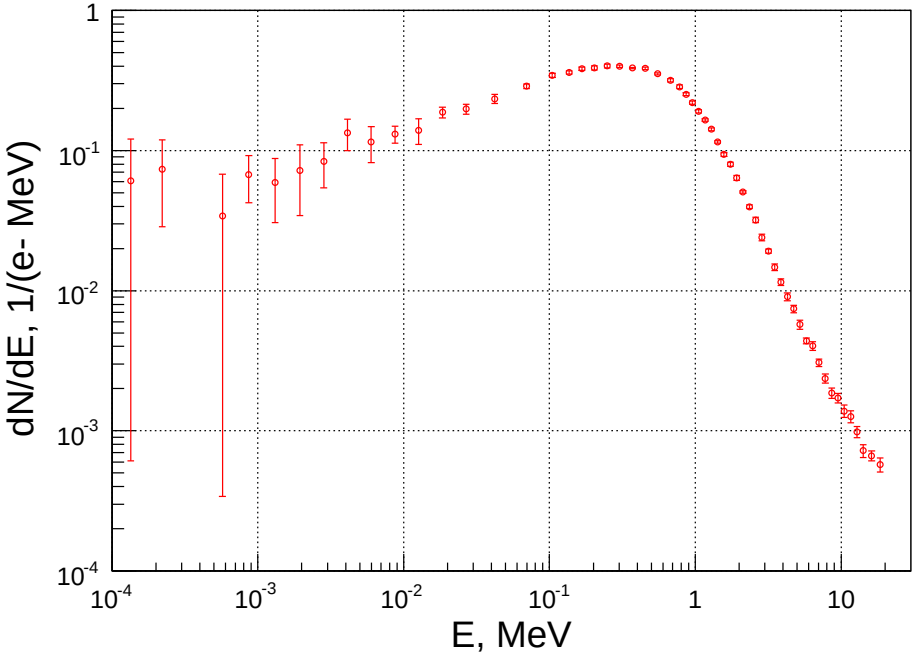
Energy Distribution Function of Neutrons

Undulator based source



$6.71 \cdot 10^{-4}$ n/γ

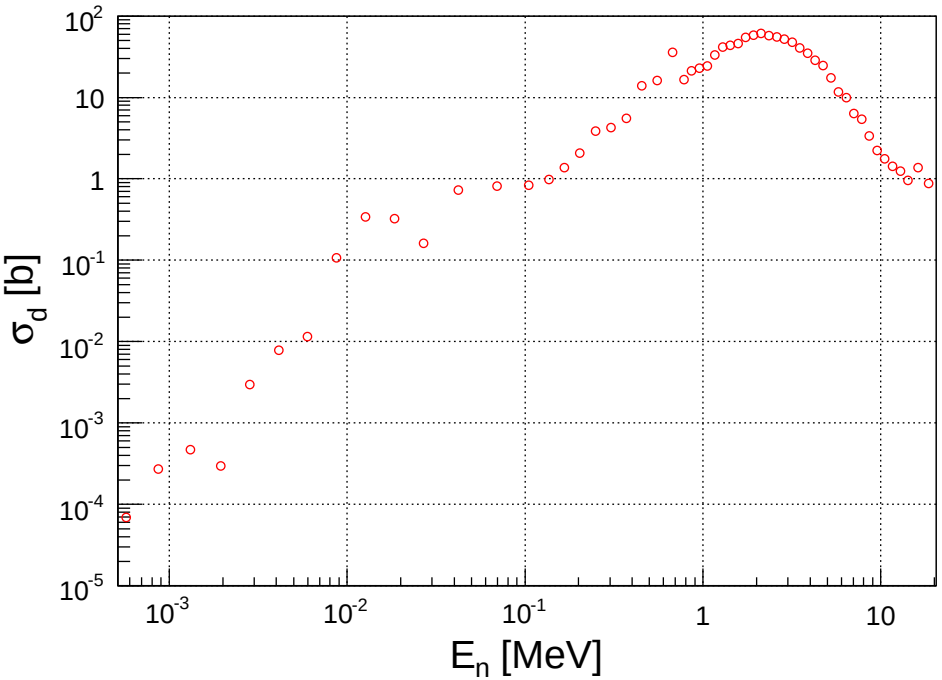
Conventional source



$5.22 \cdot 10^{-1}$ n/e$^-$

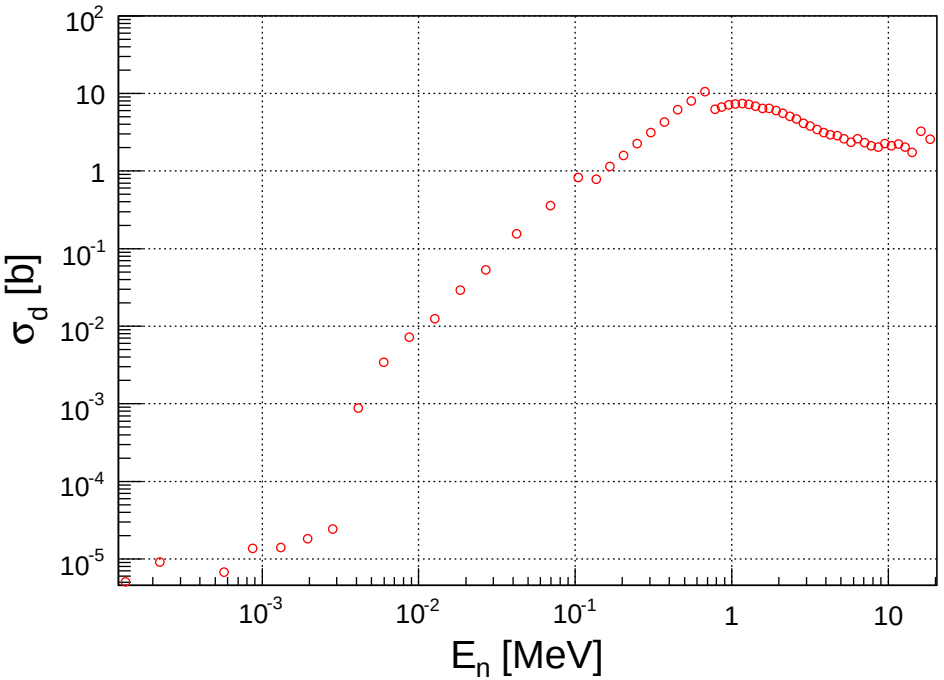
Displacement Cross Section (SPECTER)

Undulator based source
Ti6Al4V



915.5 b/neutron

Conventional source
Natural W*



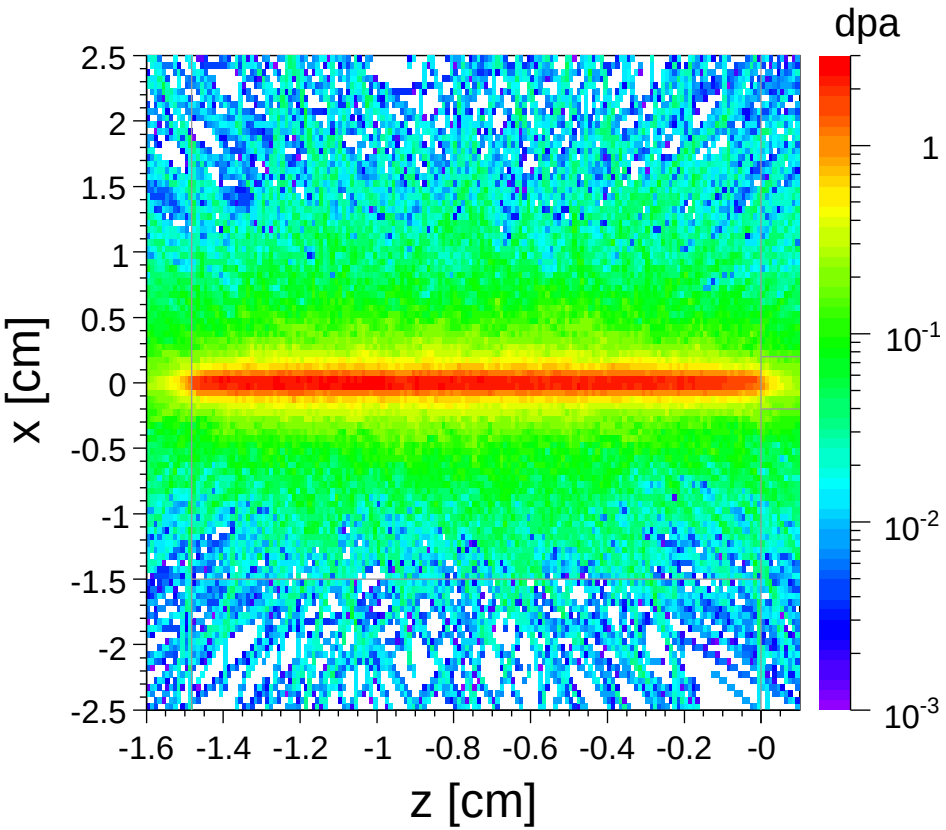
172.6 b/neutron

* Tungsten isotopes:

^{182}W – 26.43%
^{183}W – 14.30%
^{184}W – 30.67%
^{186}W – 28.60%

Radiation Damage

Undulator based source

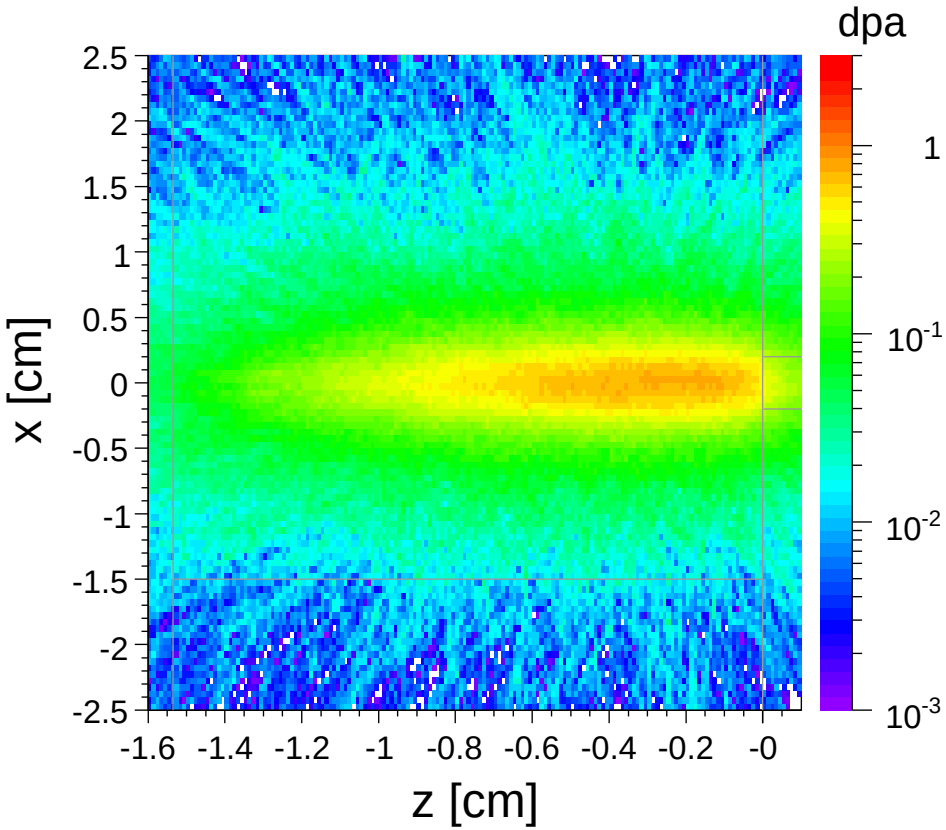


max: **2.68 dpa**

dpa averaged over z (full depth): 2.16 dpa

dpa averaged over x (-1.5;2.5): 0.158 dpa

Conventional source



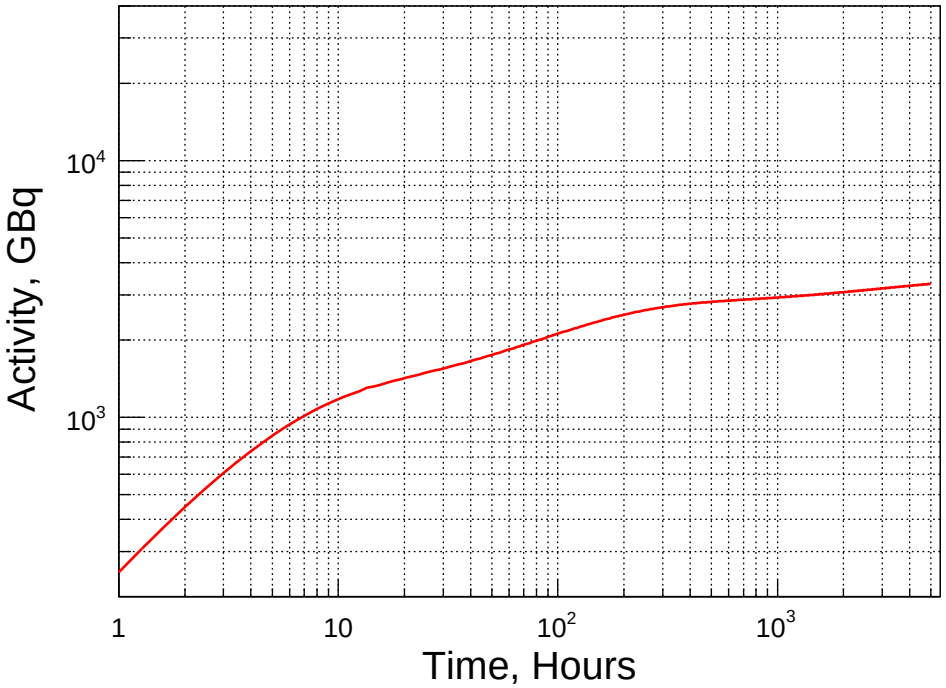
max: **0.85 dpa**

dpa averaged over z (full depth): 0.46 dpa

dpa averaged over x (-1.5;2.5): 0.089 dpa

Activation

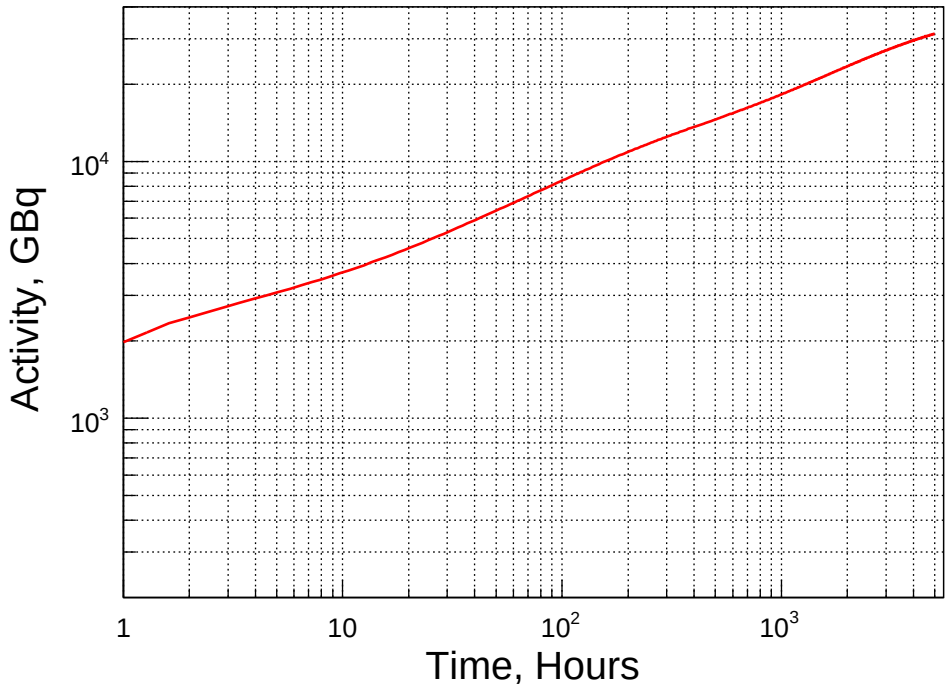
Undulator based source



A_{5000h} = **3344 GBq**

Nuclei	A	$T_{1/2}$, h	A_{5000h}, GBq
Sc	47	80.4	1462
Ti	45	3.1	924
Sc	46	2011.9	501
...	...	...	...

Conventional source

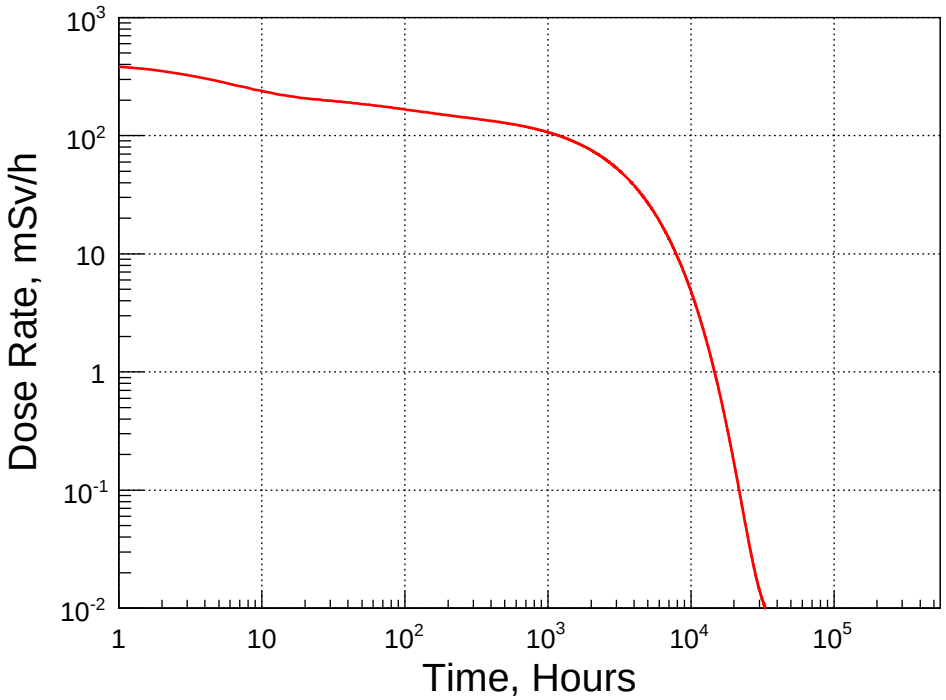


A_{5000h} = **31302 GBq**

Nuclei	A	$T_{1/2}$, h	A_{5000h}, GBq
W	181	2908	8888
W	185	1803	7111
Re	186	91	5774
...	...	...	...

Dose Rate

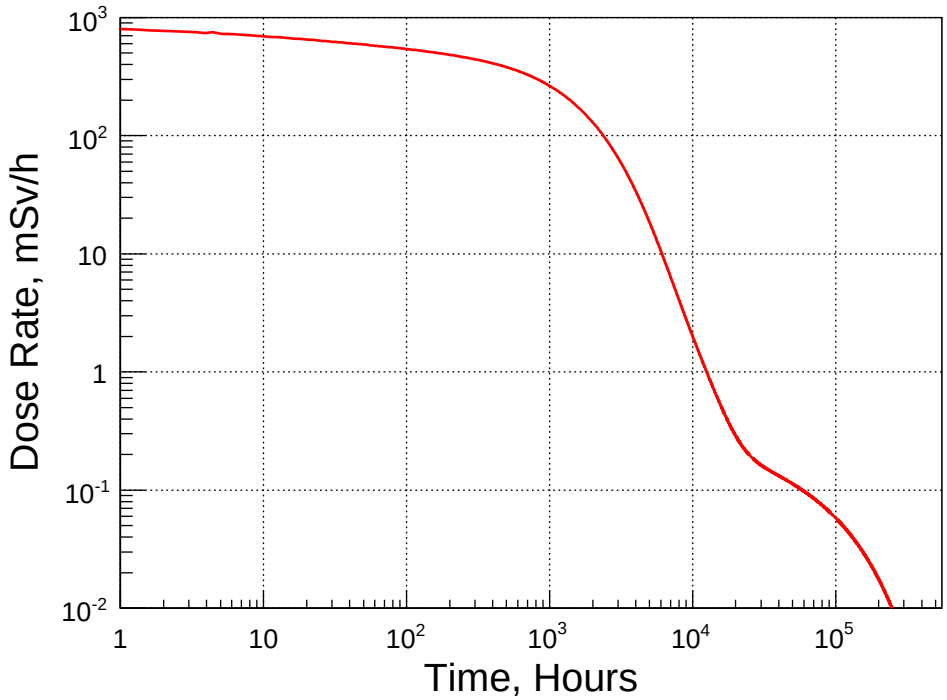
Undulator based source



$\dot{D}_{+1w}$ = **155.8 mSv/h**

Nuclei	A	$T_{1/2}$, h	$\dot{D}_{+1w}$, mSv/h
Sc	46	2011.9	141.4
Sc	47	80.4	5.8
Sc	48	43.7	2.8
...	...	...	...

Conventional source



$\dot{D}_{+1w}$ = **489.7 mSv/h**

Nuclei	A	$T_{1/2}$, h	$\dot{D}_{+1w}$, mSv/h
Re	184	911.9	450.3
Re	183	1680.0	14.7
Ta	182	2746.3	12.8
...	...	...	...

Summary

Source type	UBS	CS
Total energy deposition, kW	6.89	47.44
Maximal energy deposition density, kW/cm^3	145.4	346.8
Maximal dpa (by neutrons, after 5000h), dpa/cm^3	2.68	0.85
Target activation after 5000 h, GBq	3344	31302
Dose rate after 1 week shutdown, mSv/h	155.8	489.7