Shielding in Target Area of Conventional Positron Source

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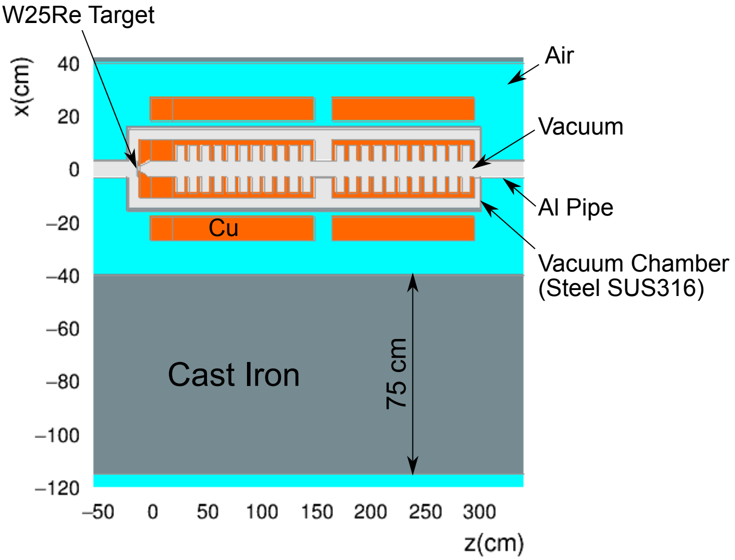
Outline

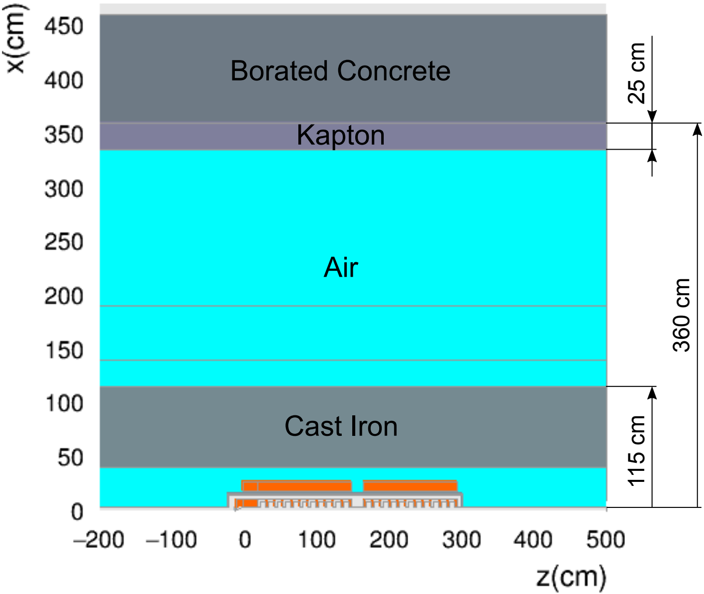
- Geometry and materials in target area, source parameters
- Radiation during source operation
- Radiation after 5000 hours of operation and different cooling time
- Shielding material and thickness

Geometry and Materials

Model is based on suggestions of M. Kuriki, T. Takahashi, T. Omori and P. Sievers



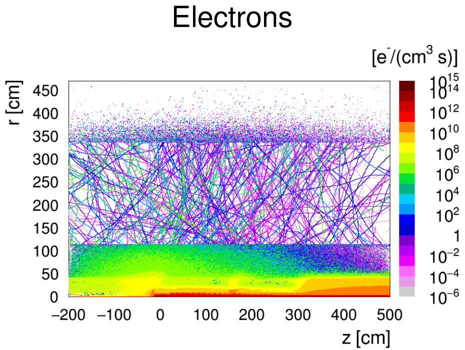
Geometry and Materials

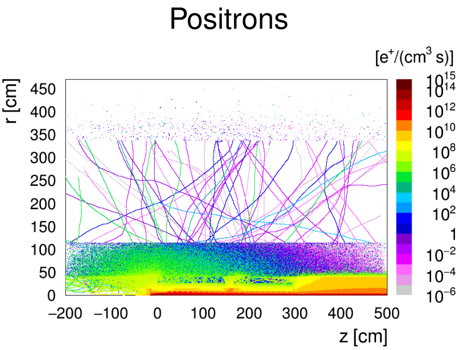


Source Parameters

- 3 GeV e^- beam, 1312 bunches/pulse, 2.4 nC bunch change.
- 2 mm rms beam spot radius on target.
- 16 mm W25Re target thickness.
- 5 mm space from target to Flux Concentrator (FC).
- 5 T pulsed FC with smallest aperture size of 16 mm at the beginning and 10 cm length.
- 20 cm length “collimator” (Cu-pipe) and 3 cm inner radius .
- Two 1.27 m accelerator sections with aperture radius of 3 cm surrounded by 0.5 T solenoids.
- Al beam pipes with inner radius of 3 cm and 2 mm wall thickness.
- Stainless steel (SUS316) vacuum chamber with 1 cm wall thickness.

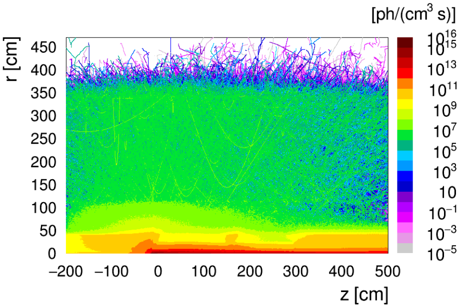
e^- and e^+ Distributions during Source Operation



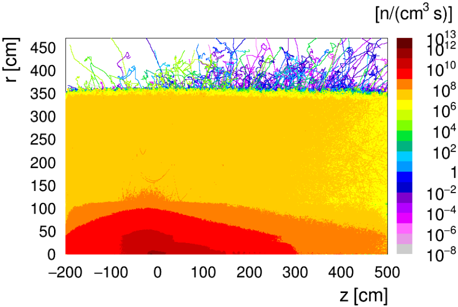


γ and n Distributions during Source Operation

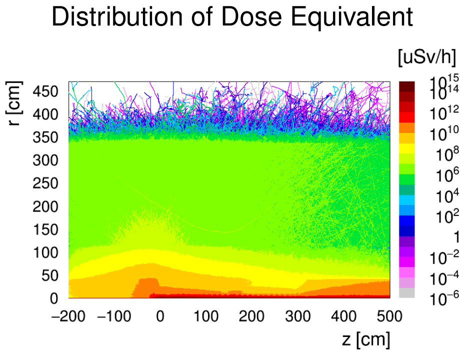
Photons

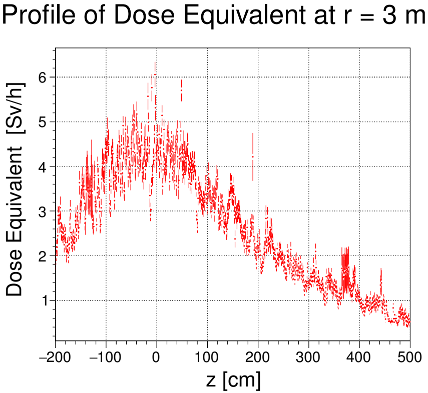


Neutrons



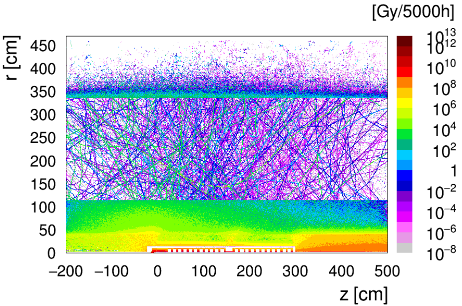
Dose Equivalent during Source Operation



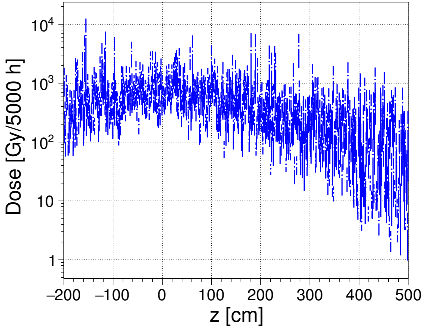


Absorbed Dose after 5000 h of Source Operation

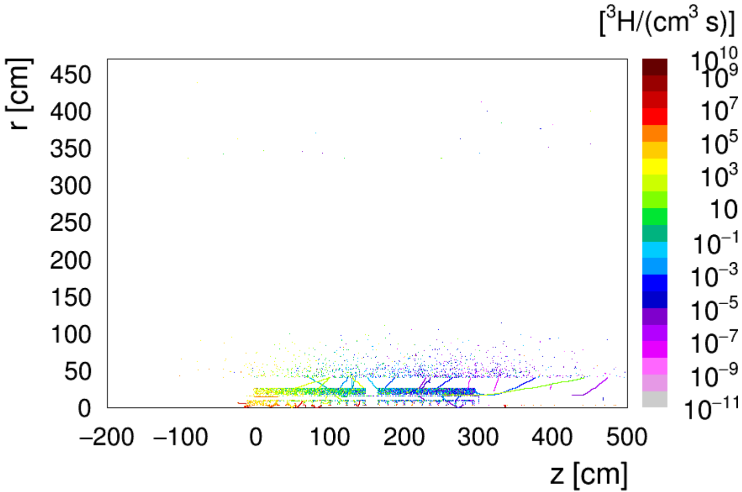
Distribution of Absorbed Dose



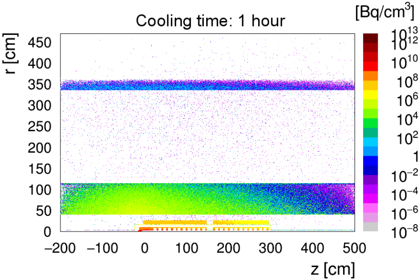
Absorbed Dose in Kapton (r $\approx$ 3.4 m)

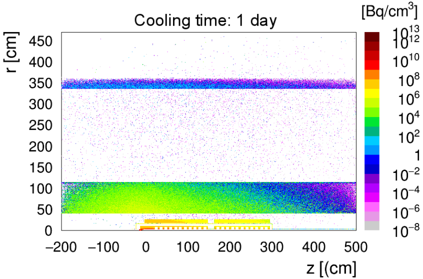


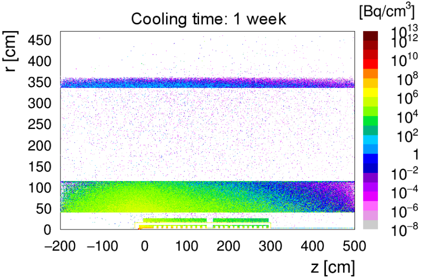
Tritium Production Rate



Total Yield is $(1.8 \pm 0.2) \cdot 10^{-3}$ ^{3}H/e$^-$


Cooling time: 1 hour
[Bq/cm^3]
r [cm]
450
400
350
300
250
200
150
100
50
0
–200 –100 0 100 200 300 400 500
z [cm]
10^{13}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}

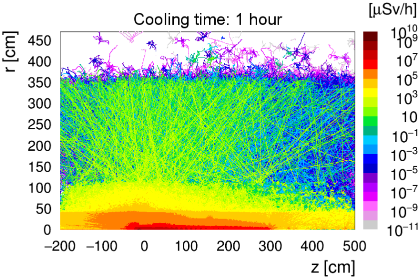

Cooling time: 1 day
[Bq/cm^3]
r [cm]
450
400
350
300
250
200
150
100
50
0
–200 –100 0 100 200 300 400 500
z [(cm]
10^{13}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}

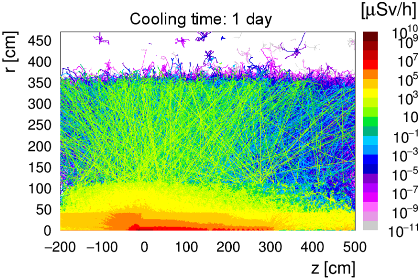

Cooling time: 1 week
[Bq/cm^3]
r [cm]
450
400
350
300
250
200
150
100
50
0
–200 –100 0 100 200 300 400 500
z [cm]
10^{13}
10^{12}
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}

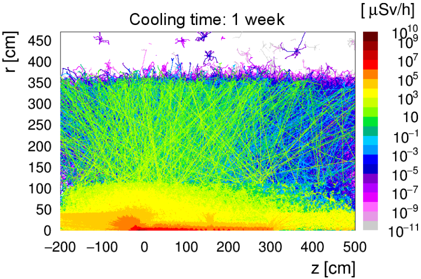
Residual Activity after 1 Hour of Cooling

	Activity [Bq]
Target	8.2E+12
Flux Concentrator	2.0E+12
Collimator	4.1E+12
Solenoid 0	1.6E+12
Accelerator Section 1	6.4E+12
Solenoid 1	5.7E+12
Accelerator Section 2	1.5E+12
Solenoid 2	1.3E+12
Cast Iron Shielding	8.8E+11
Kapton	1.5E+08
Borated Concrete Tunnel Wall	3.1E+08
Air in Positron Line	4.0E+07
Air in BDS/RTML Line	6.5E+06

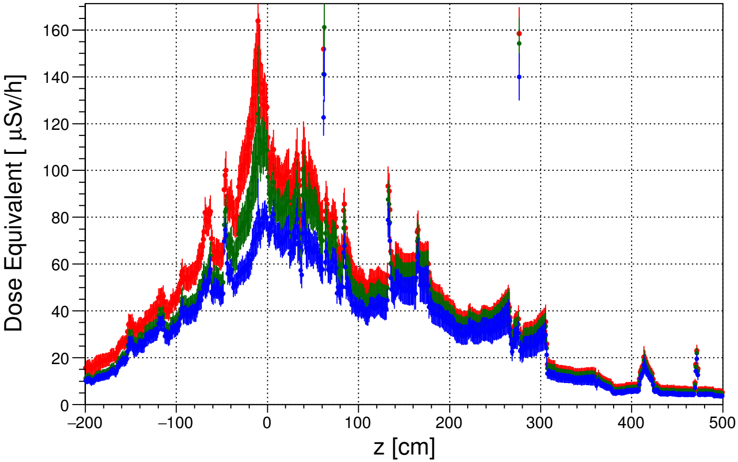
Residual Dose after 5000 h of Source Operation







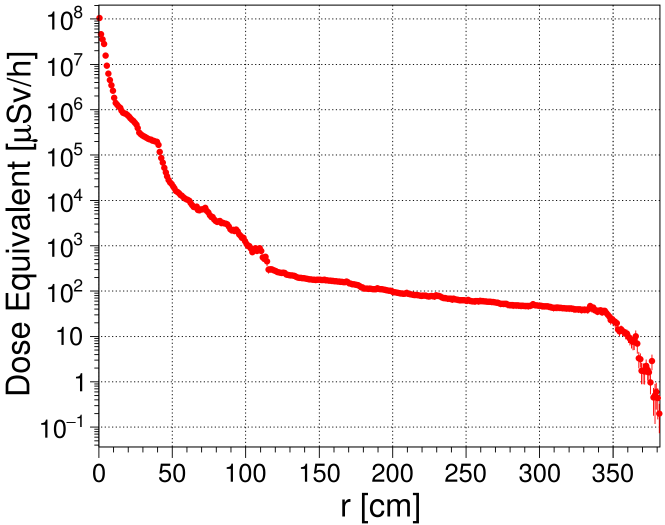
Average Residual Dose Equivalent in BDS/RTML Line Gallery



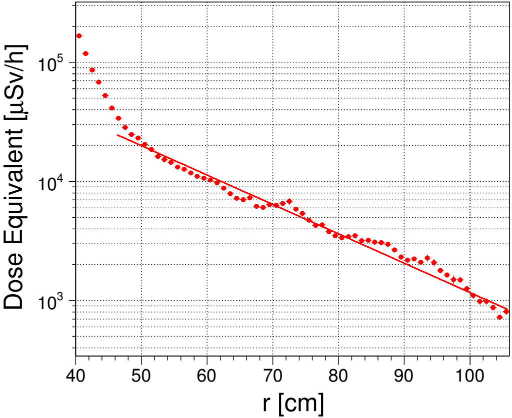
red: 1 hour of cooling time; green: 1 day; blue: 1 week
Average over radii in range [115 cm; 335 cm]

Radial Profile of Residual Dose Equivalent after 1 Hour of Cooling

averaged over 1 m in z-direction [-47 cm; 53 cm]



Dose Equivalent after 1 Hour of Cooling vs R in Cast Iron

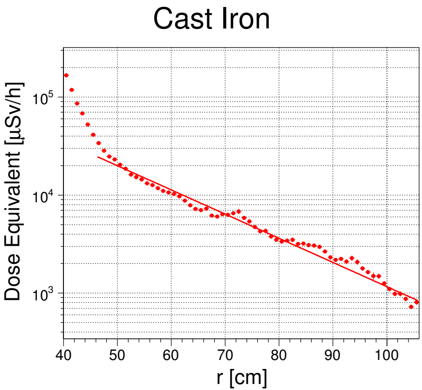


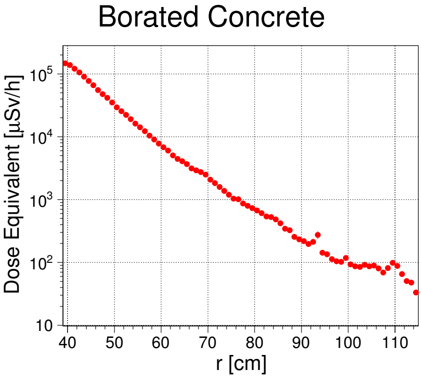
40 cm cast iron reduces dose rate of 10 times.

≈**115 cm** thickness of cast iron is needed to reduce the dose rate averaged over radius in BDS/RTML-gallery to 20 μSv/h.

≈**130 cm** thickness of cast iron is required to have 20 μSv/h just behind shielding.

Borated Concrete vs Cast Iron





Borated concrete with **75 cm** thickness reduces rate of dose equivalent (averaged over 1 m in z-direction) to **30 μSv/h** after 5000 hours of source operation and 1 hour cooling

My suggestion is to use 1 m borated concrete to have some safety margin.