Estimate The Radiation From A Sphere Dump Using FLUKA

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Project Description

There are the two simple device geometries to start with:
1) "Iron" (density 7.8 g/cm^3) sphere with the diameter of 300 cm, centered at (0,0,0), with the beam origin at (0, 0, -30 cm), to take into account, to some extent, the development of the cascade along 'z', and the need of more shielding in forward (z) direction.

2) a similar sphere but made of "Tungsten powder" (density of 15.6 g/cm^3) with the diameter 150 cm, centered at (0,0,0), and with the beam origin at (0, 0, -15 cm)

It would be nice if different groups could evaluate the prompt gamma and neutron dose rates in rem/h around these toy devices, either in the mesh in (z,y) with the limits on x: -15 cm < x < 15 cm, -1500 cm < y < 1500 cm, and -1500 cm < z < 1500 cm, with the bin size of 30 by 30 by 30 cm, or just at a distance of, say, 3 m from the center, function of theta polar angle, using the azimuthal symmetry of the problem (or may be just using a corresponding radial and polar angle binning).

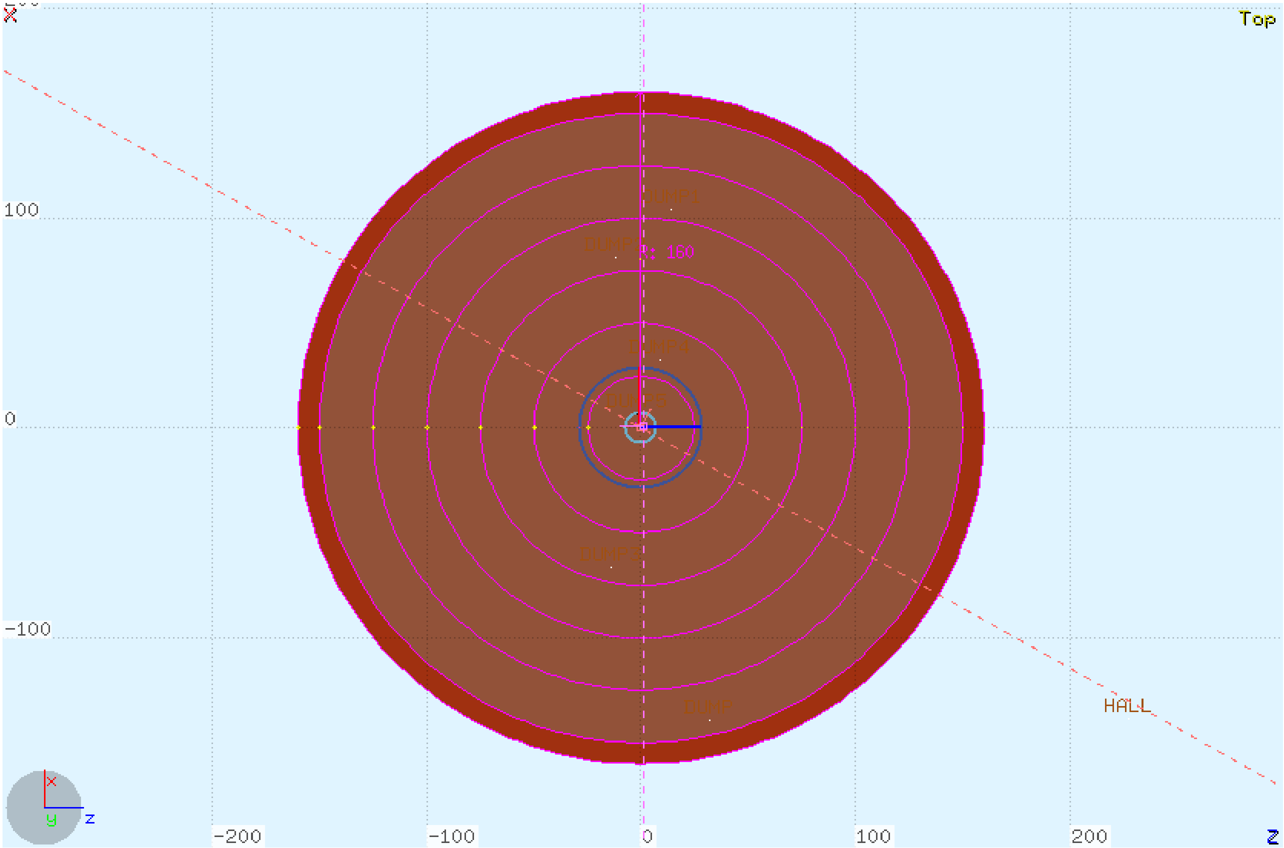
The second problem would be to evaluate the dose rates around these toy devices using the same mesh, after 1 hour, 24 hour, 7 days, and 30 days following the end of the 1000 hours run.

Geometry

Iron Sphere: R=150cm
Tungsten Sphere: R=75cm

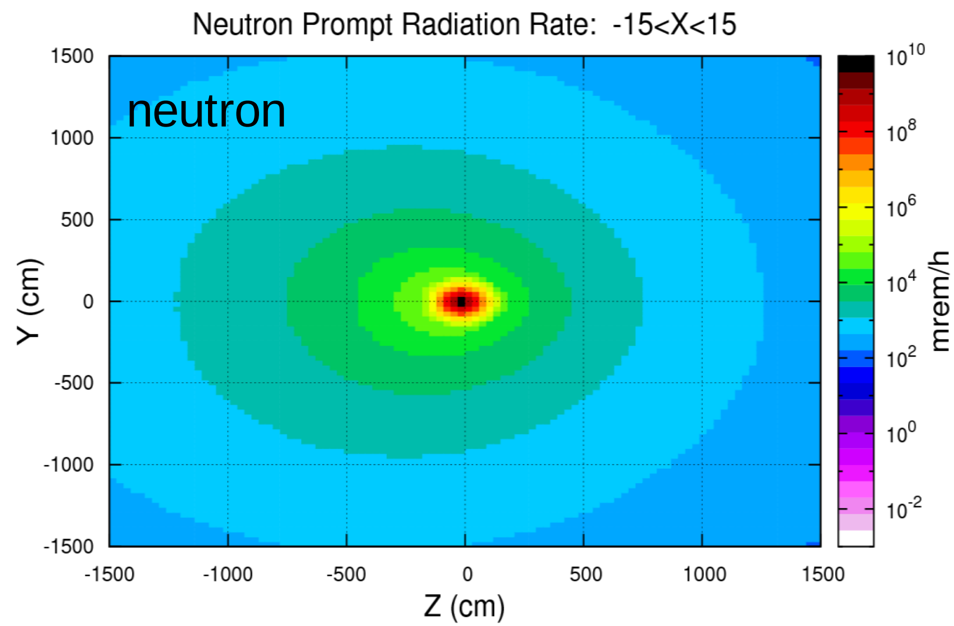
Create 6 layers of co-central spheres, all of them have the same thickness.

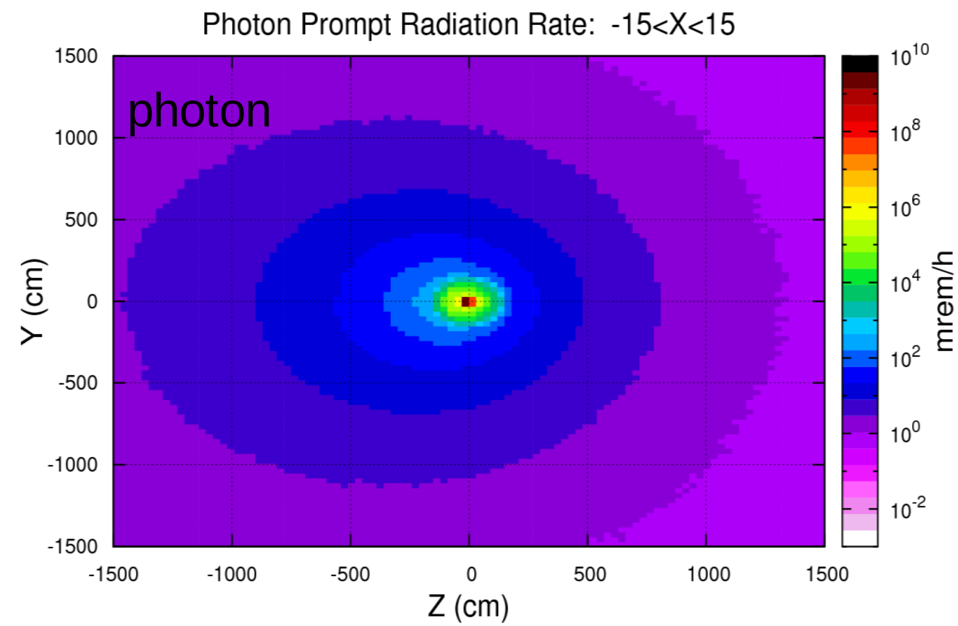
This will make it easy to:
1) apply biasing;
2) score neutron and photon flux at the boundary

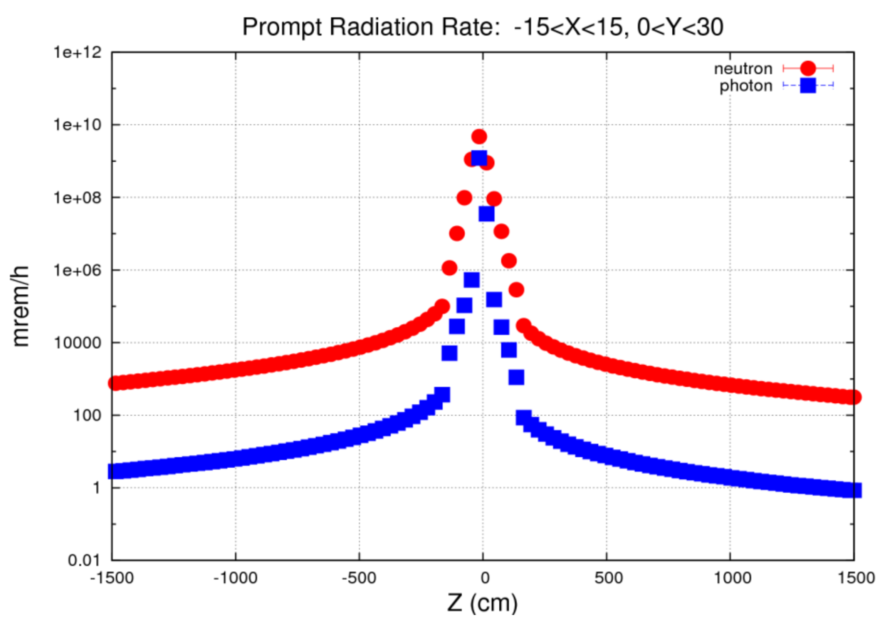


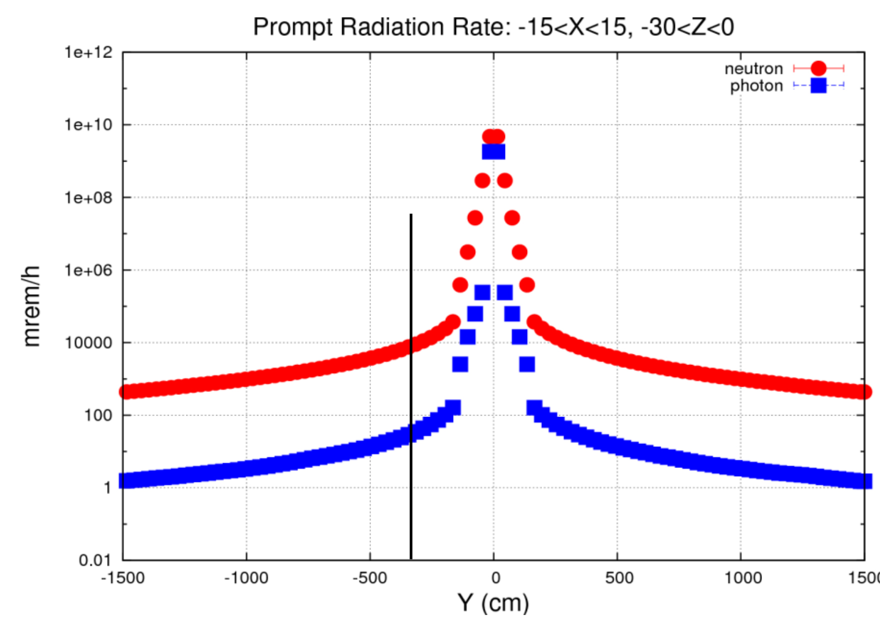
Run 4 projects:
1) Iron, R=150cm
2) Iron, R=150cm, with 10cm thick 5% borated plastic shell
3) Tungsten, R=75cm
4) Tungsten, R=75cm, with 10cm thick 5% borated plastic shell

Iron Ball: Prompt Radiation Rate

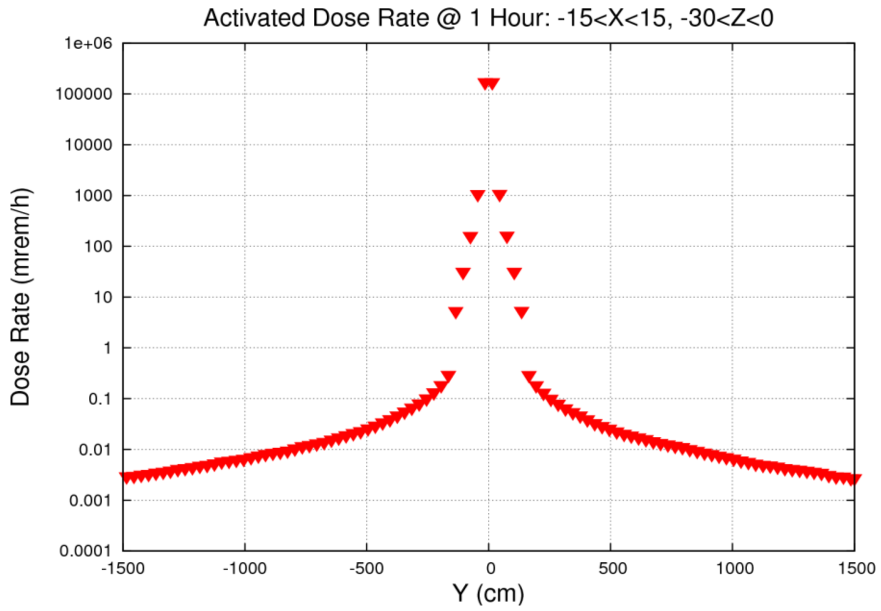


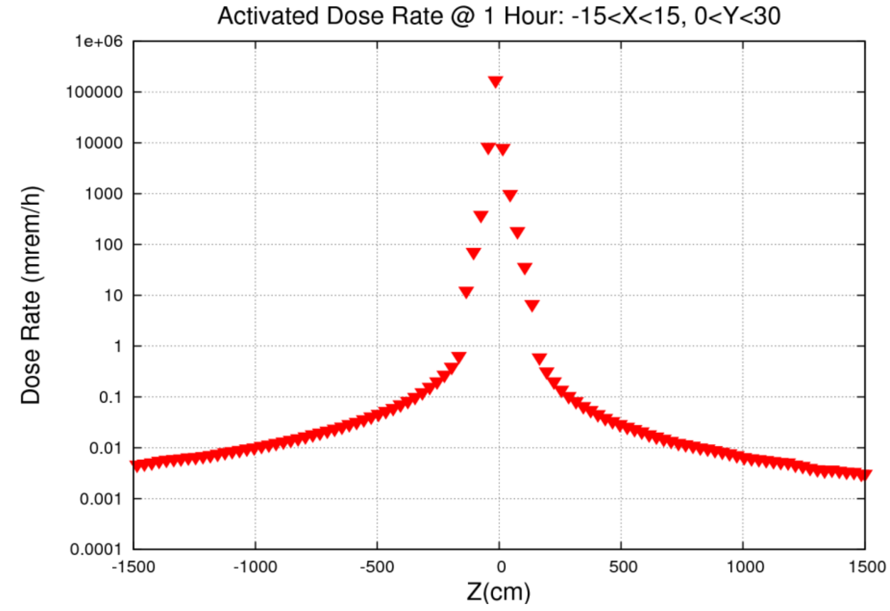


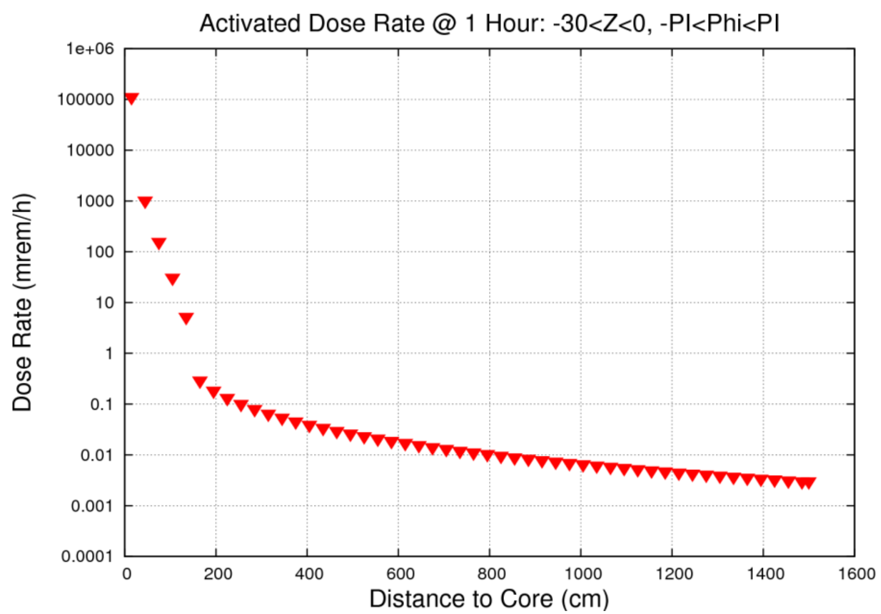




Iron Ball: Activated Dose Rate

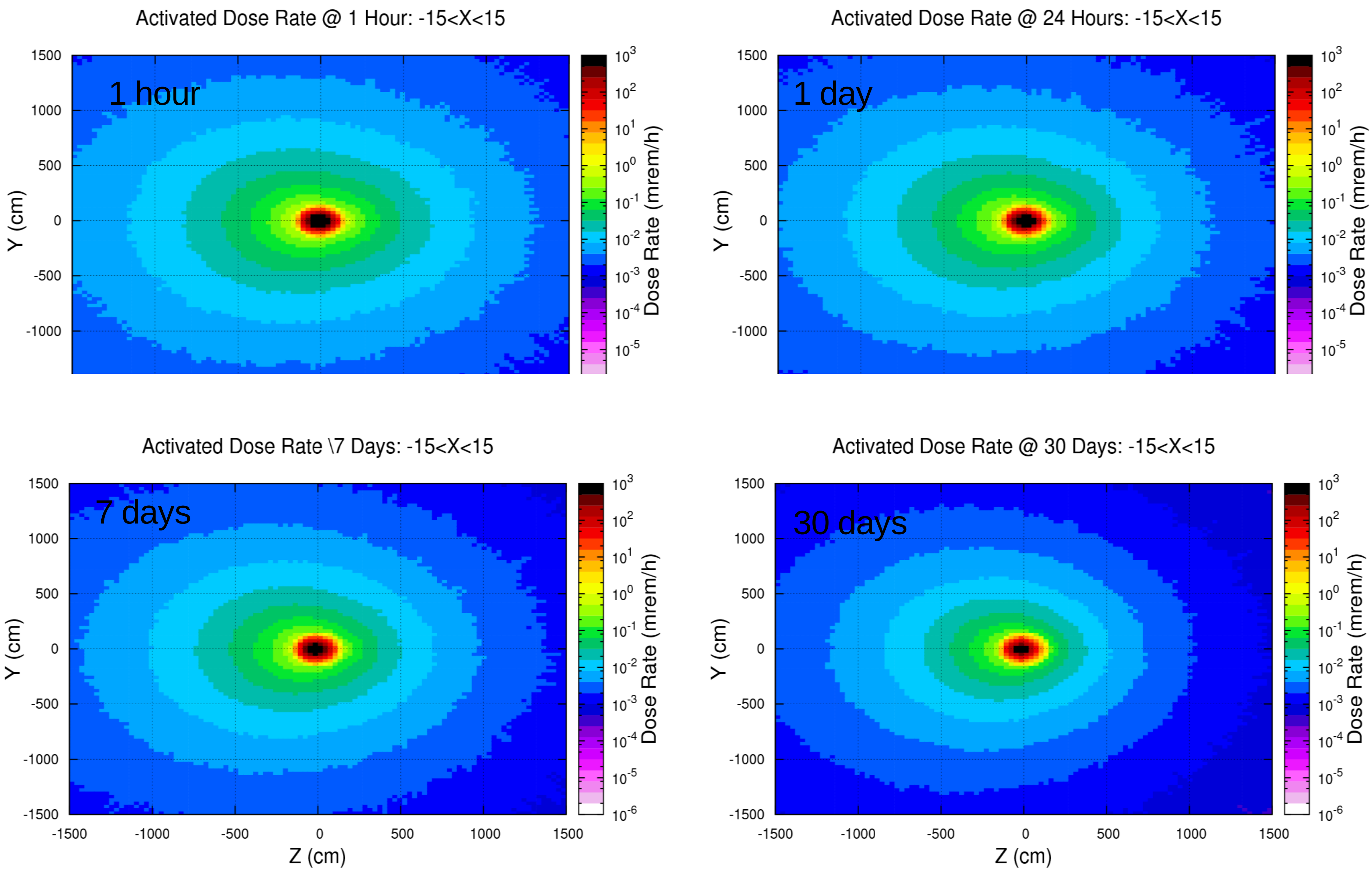




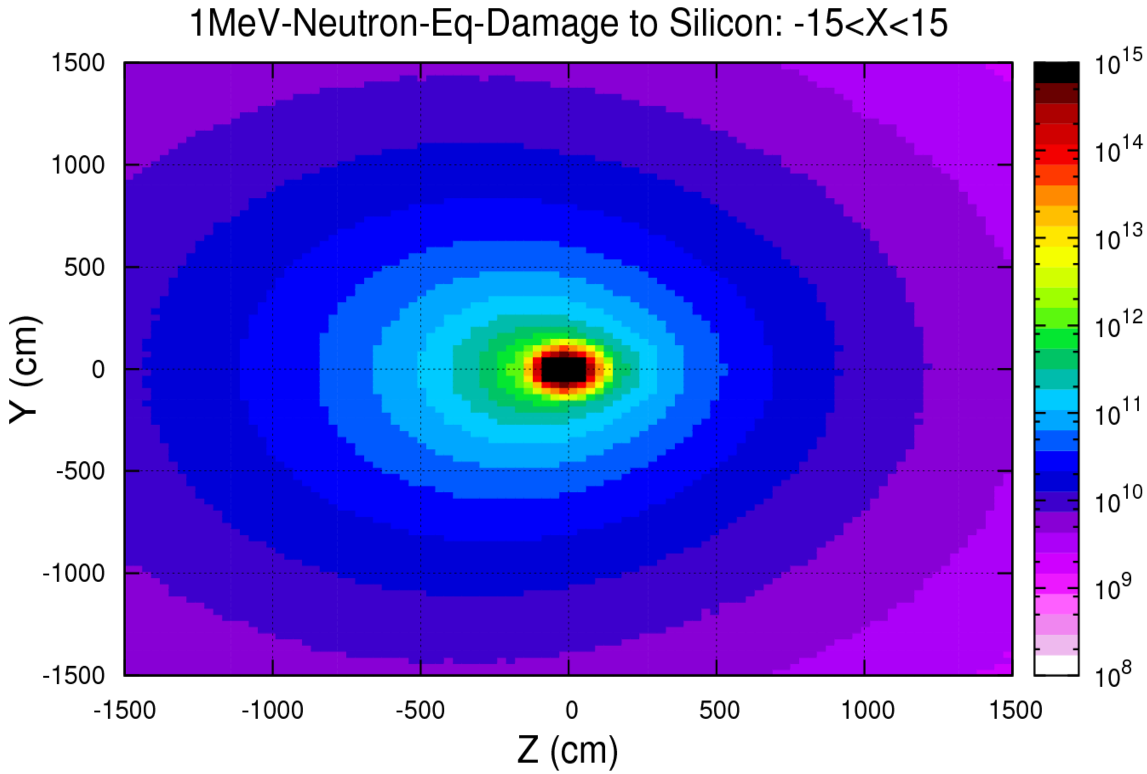


1000 hours 2.6uA beam @ 11.5 GeV

Iron Ball: Activated Dose Rate

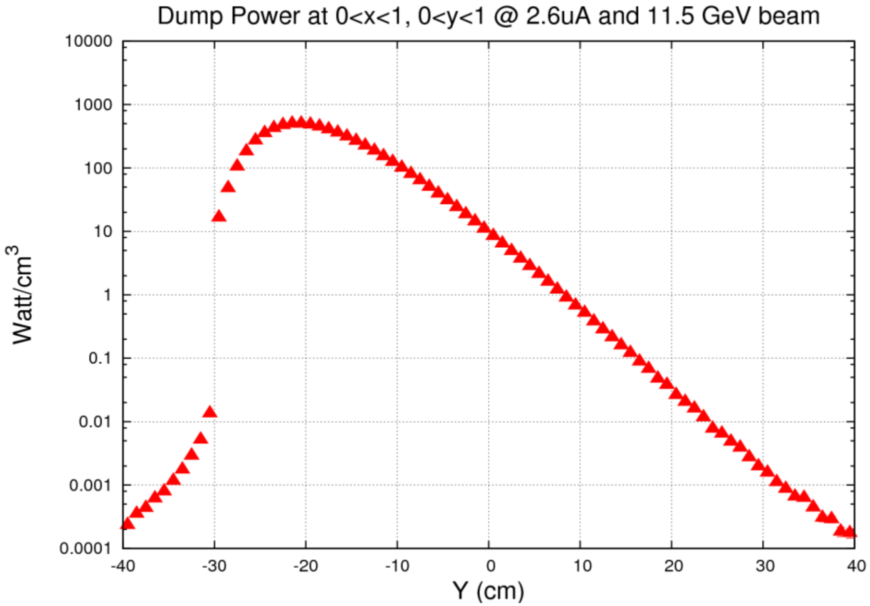


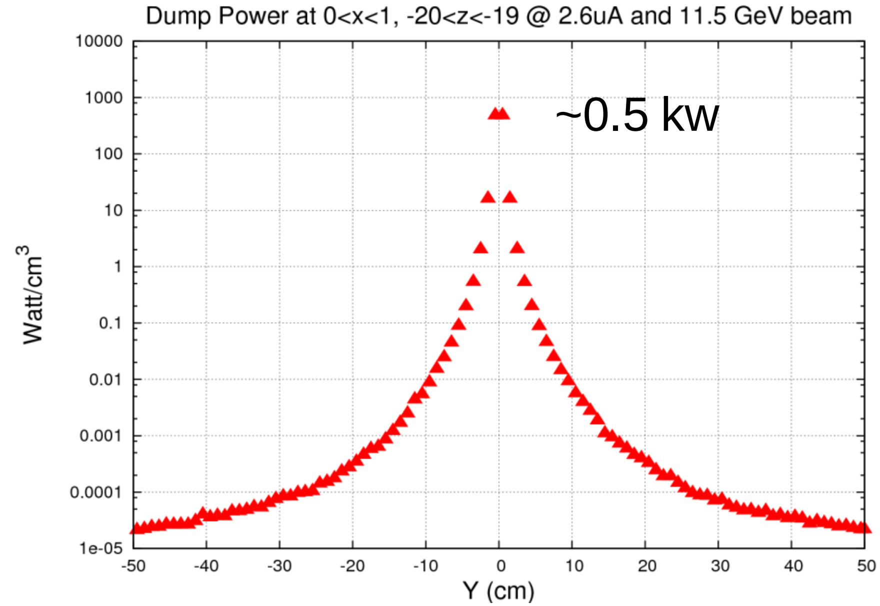
Iron Ball:1-MeV-N-Eq. Damage

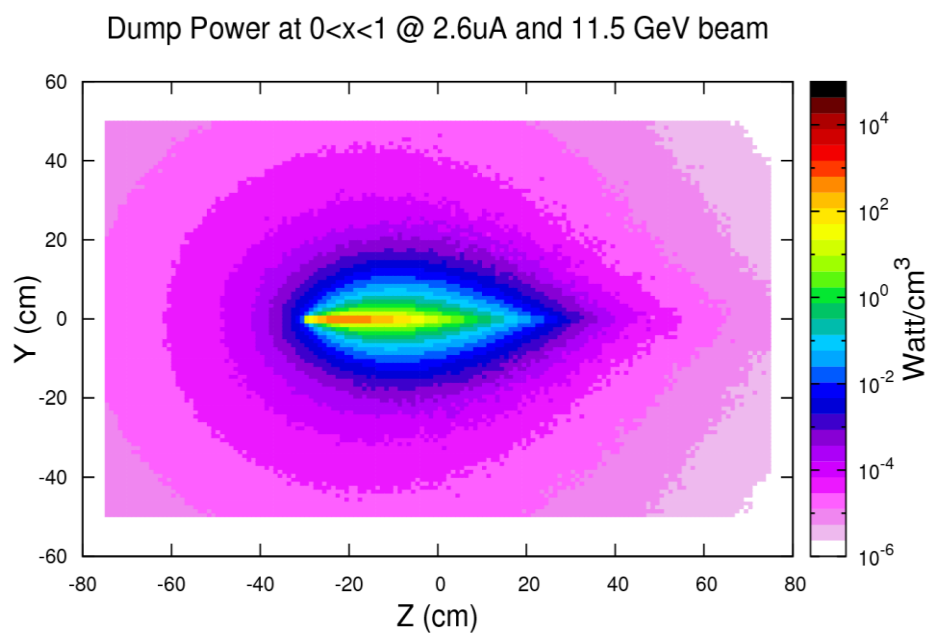


1000 hours 2.6uA beam @ 11.5 GeV

Iron Ball: Heat Power in The Dump

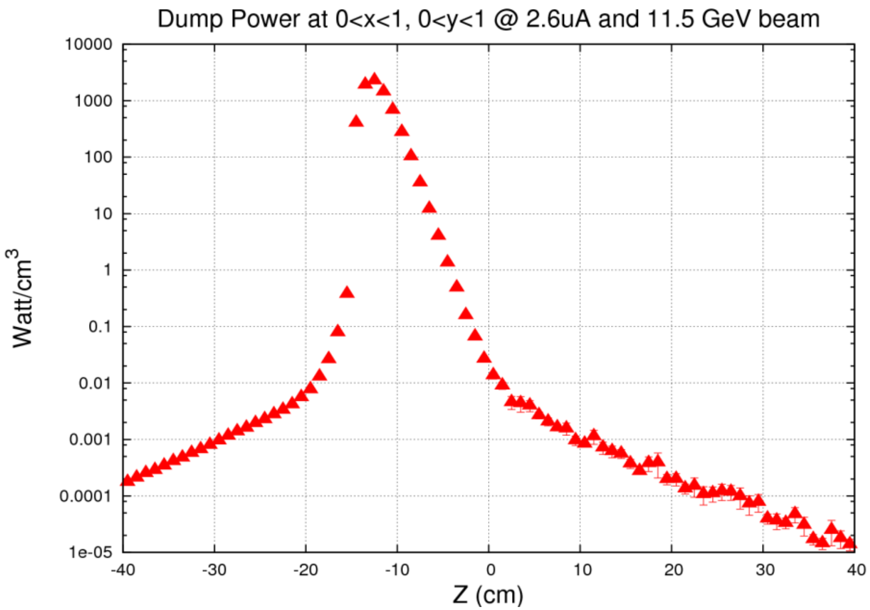


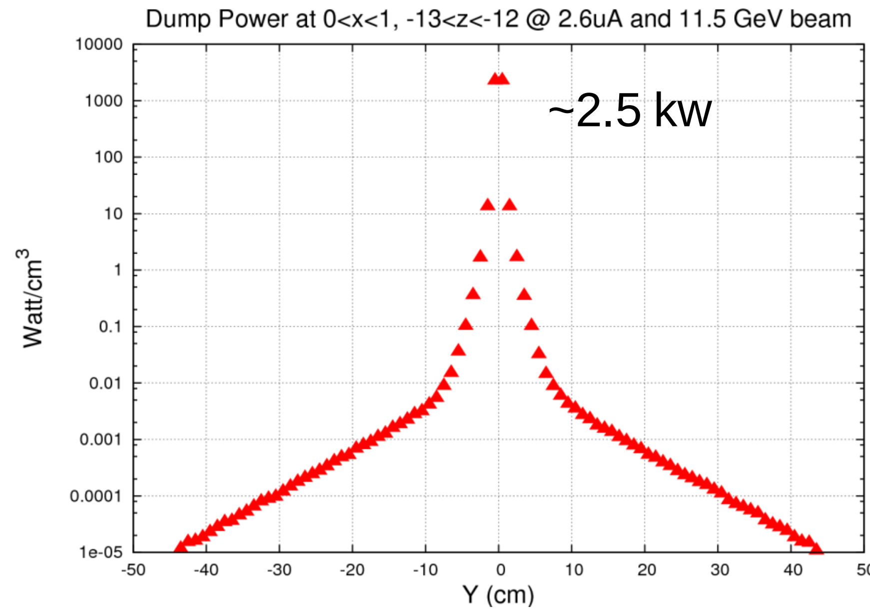


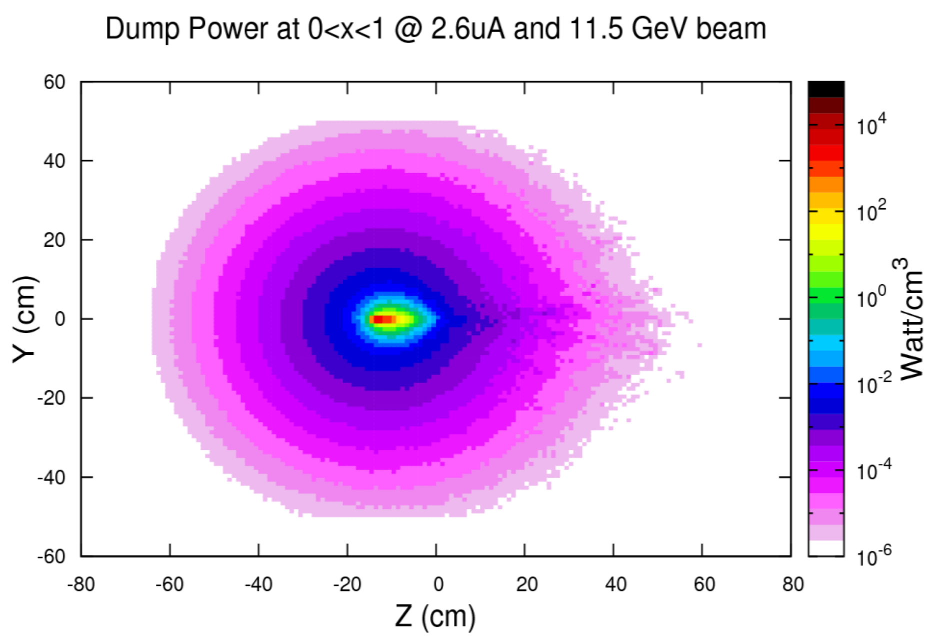


2.6uA @ 11.5 GeV

Tungsten Ball: Heat Power in The Dump

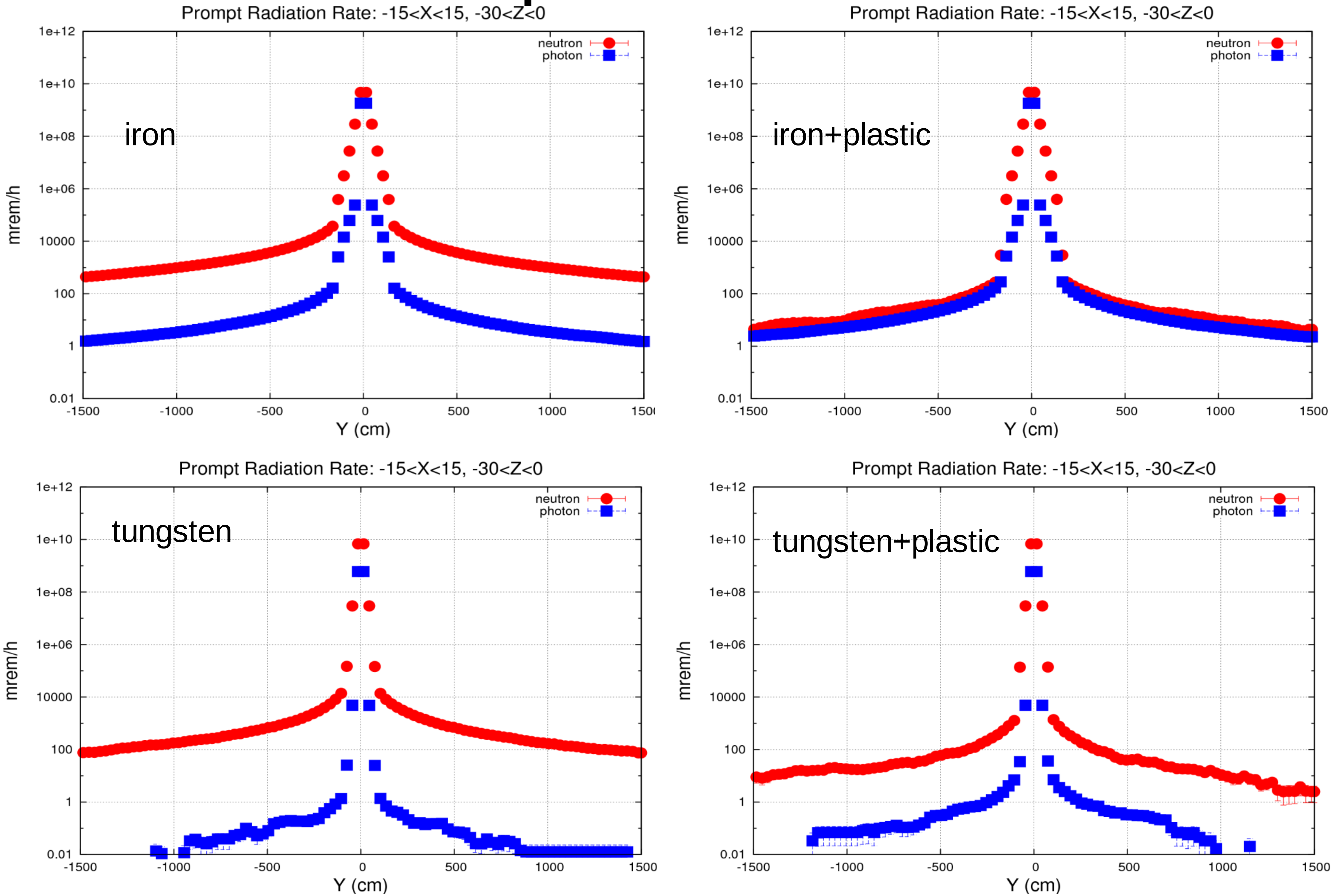






2.6uA @ 11.5 GeV

Prompt Dose Rate



Compare Prompt Dose Rates

Prompt Dose Rate (rem/h)

material	source	No plastic	No plastic	No plastic	No plastic	With 10cm plastic	With 10cm plastic
		Pavel	Jixie	Igor	George	Pavel	Jixie
iron	neutron	146	10.0 +/- 0.1%	11.5 +/- 6%	9.5 +/- 0.3%	0.8	0.11 +/- 3.4%
iron	photon	0.44	0.039 +/- 0.6%	0.158 +/- 29%	0.025 +/- 0.9%	2.8	0.063 +/- 0.7%
tungsten	neutron	13.0	1.7 +/- 2.5%	4.4 +/- 11%	N/A	2.7	0.15 +/- 10%
tungsten	photon	0.06	0.0002 +/- 39%	0.0002	N/A	0.003	0.0007 +/- 24%

Summary

1) FLUKA simulation has been performed for 4 geometry settings.
In order to achieve reasonable statistics, “importance biasing” have to be applied.

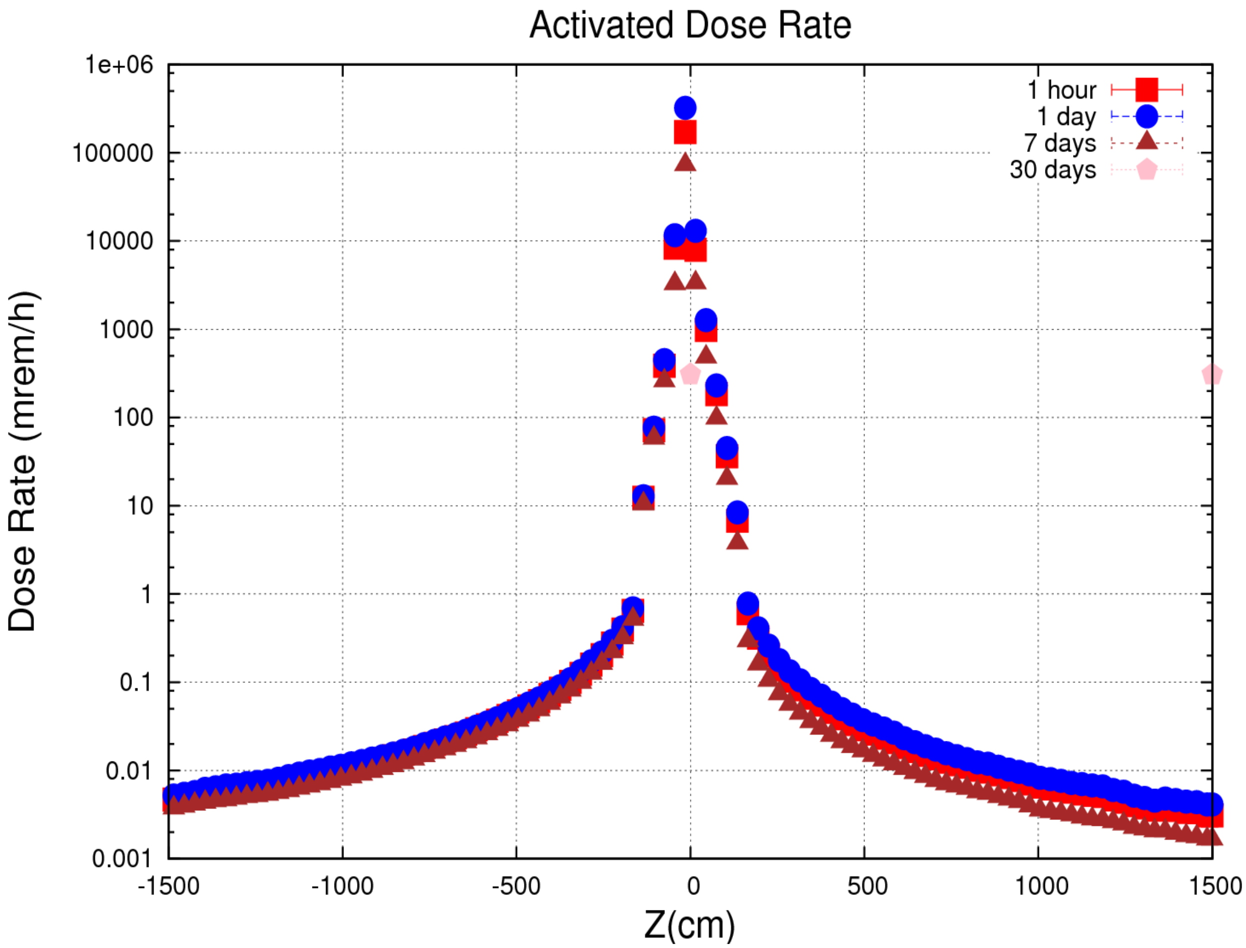
2) With 150 cm radius iron sphere ball, the 1-MeV-Nu-Eq. damage for 1000 hours of 11.5 GeV and 2.6 uA electron beam at R=150 is 2.6E12. This is the worst case among 4 settings.

3) Activated radiation level in the hall is negligible for all these 4 settings.

4) Comparing to neutron prompt radiation, photon prompt radiation is negligible. Jixie's fluka result is one order smaller than Pavel's result, but agree well with George's and Igor's result.

5) For tungsten sphere, the peak heat power is 2.5kw per cm^3, which make the cooling design very challenging.

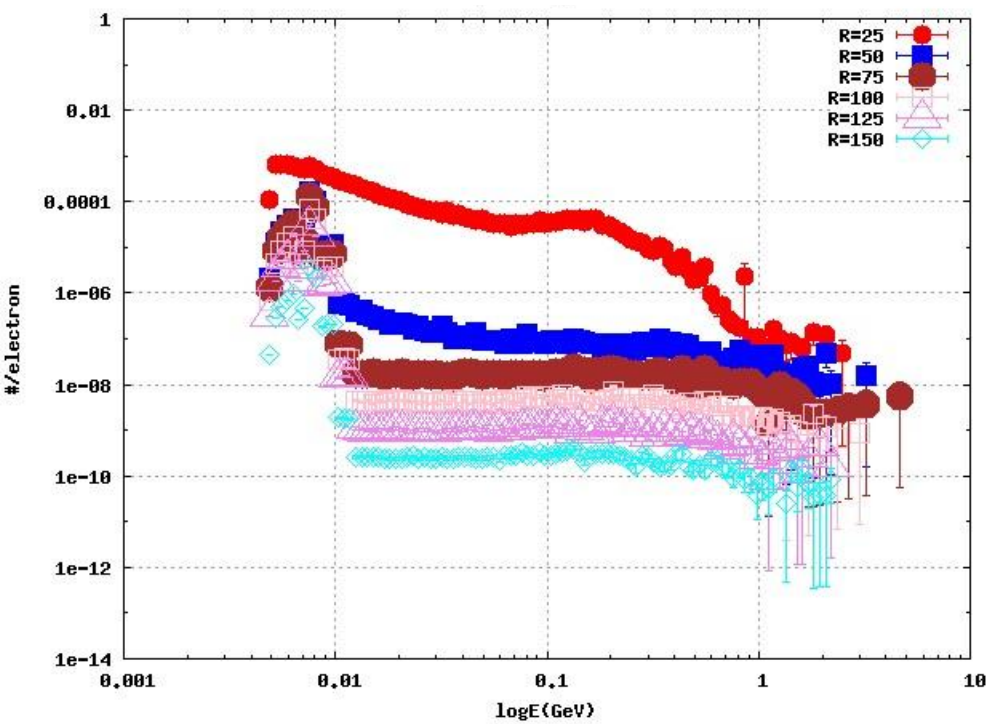
Iron Ball: Activated Dose Rate



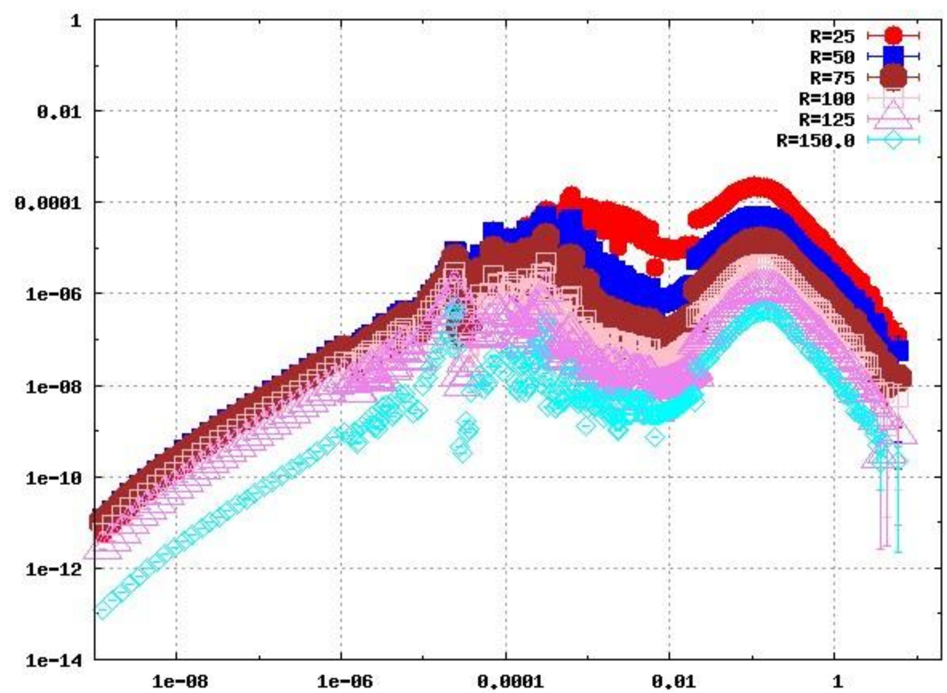
1000 hours 2.6uA beam @ 11.5 GeV

Iron Ball: Neutron And Photon Flux

Photon Yield



Neutron Yield



2.6uA @ 11.5 GeV

1-MeV-N-Eq. Damage