HINS Beam Absorber MARS15 Simulations

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HINS Beam Absorber Simulation Specs (B. Webber)

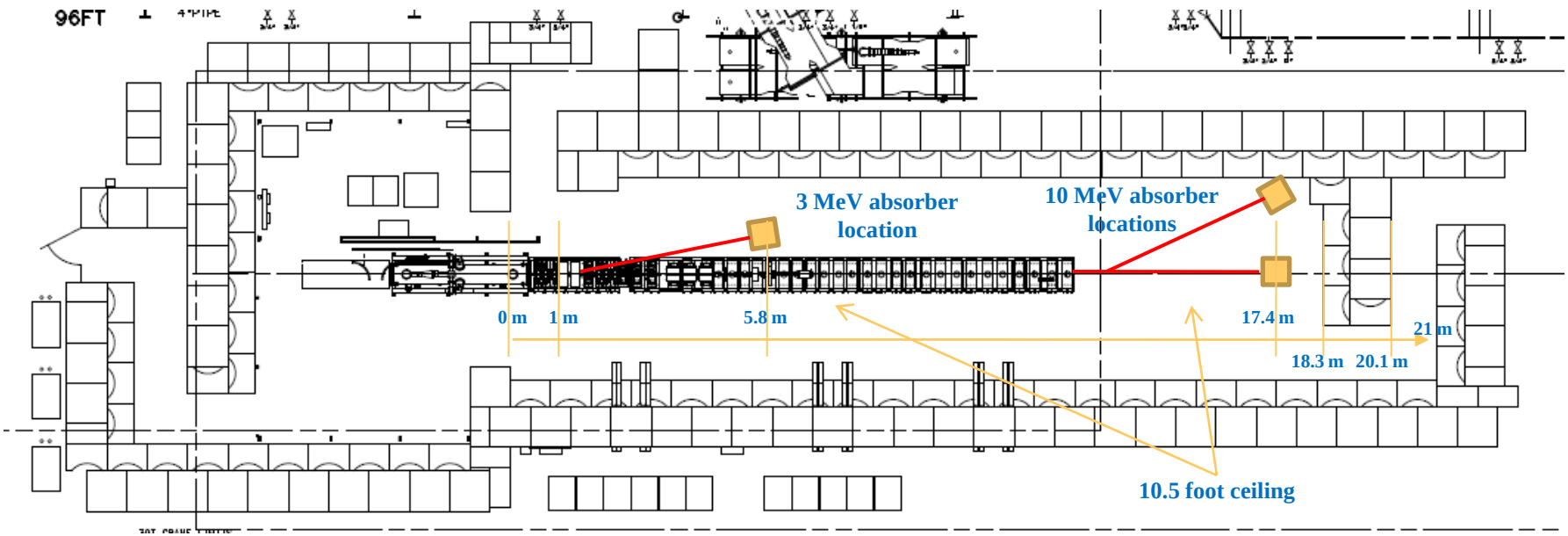
It is the SNS absorber housed in a rectangular steel box loaded with high-density (not borated) polyethylene beads (if it matters). The SNS absorber consists of a 1mm thick cone fabricated of pure nickel surrounded by a 1mm water cooling channel inside a 1.5mm stainless steel jacket. Assume the cooling water flow rate is 3 gpm. The absorber in the HINS beam enclosure is shown at one location for 3 MeV beam and and at two possible locations for 10 MeV beam.

The beam should be assumed to have symmetrical Gaussian transverse distribution with sigma-x = sigma-y = 10 mm.

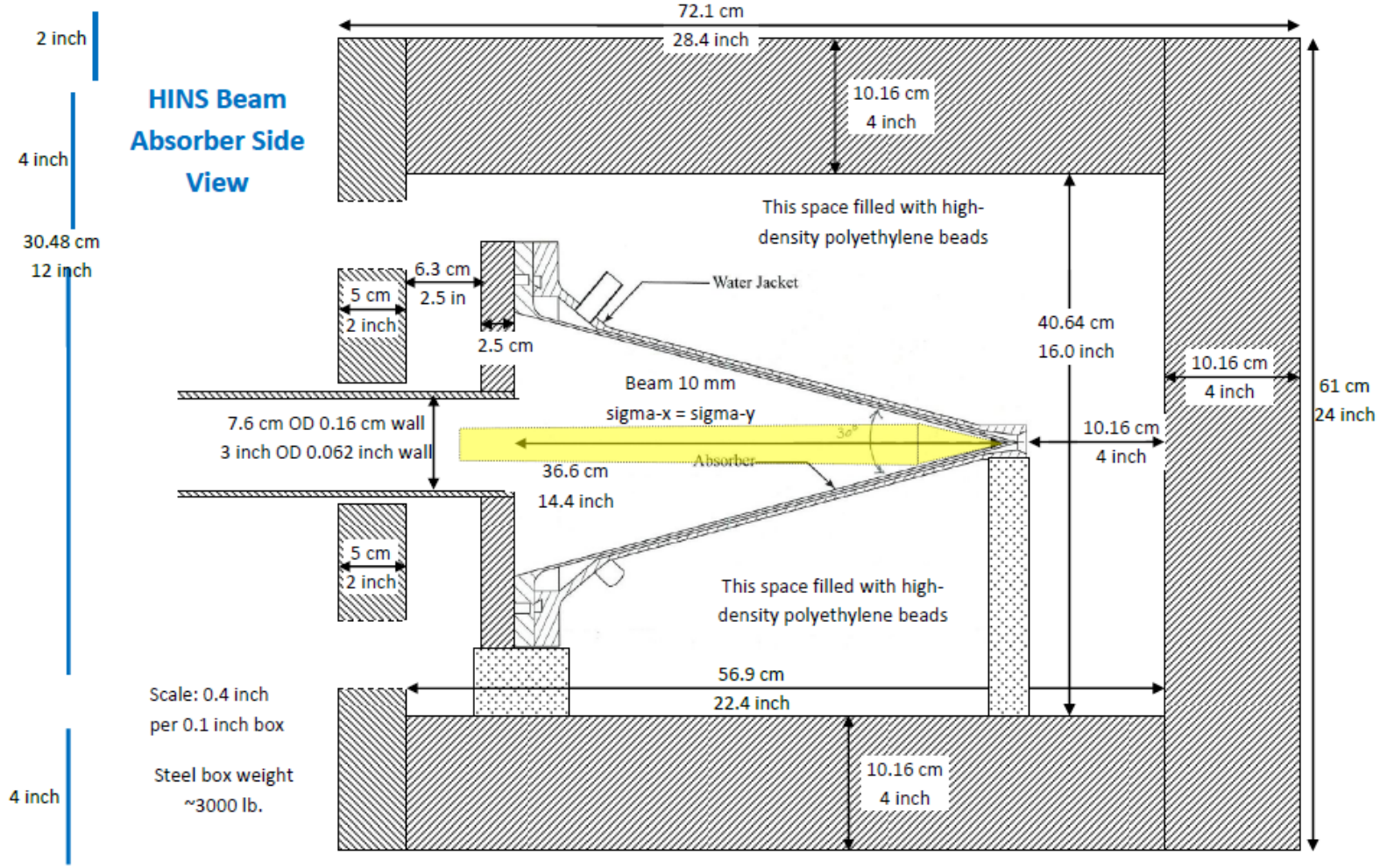
Beam intensity is 1% of 25 mA (5.6E18 pph) at 3 MeV (750W) and at 10 MeV (2.5kW).
Assume maximum 500 hours operation per year for 2.8E21 protons per year.

Absorber sits on steel-legged stand with beam center 128.5 cm above floor.

Absorber Locations in HINS Beam Enclosure

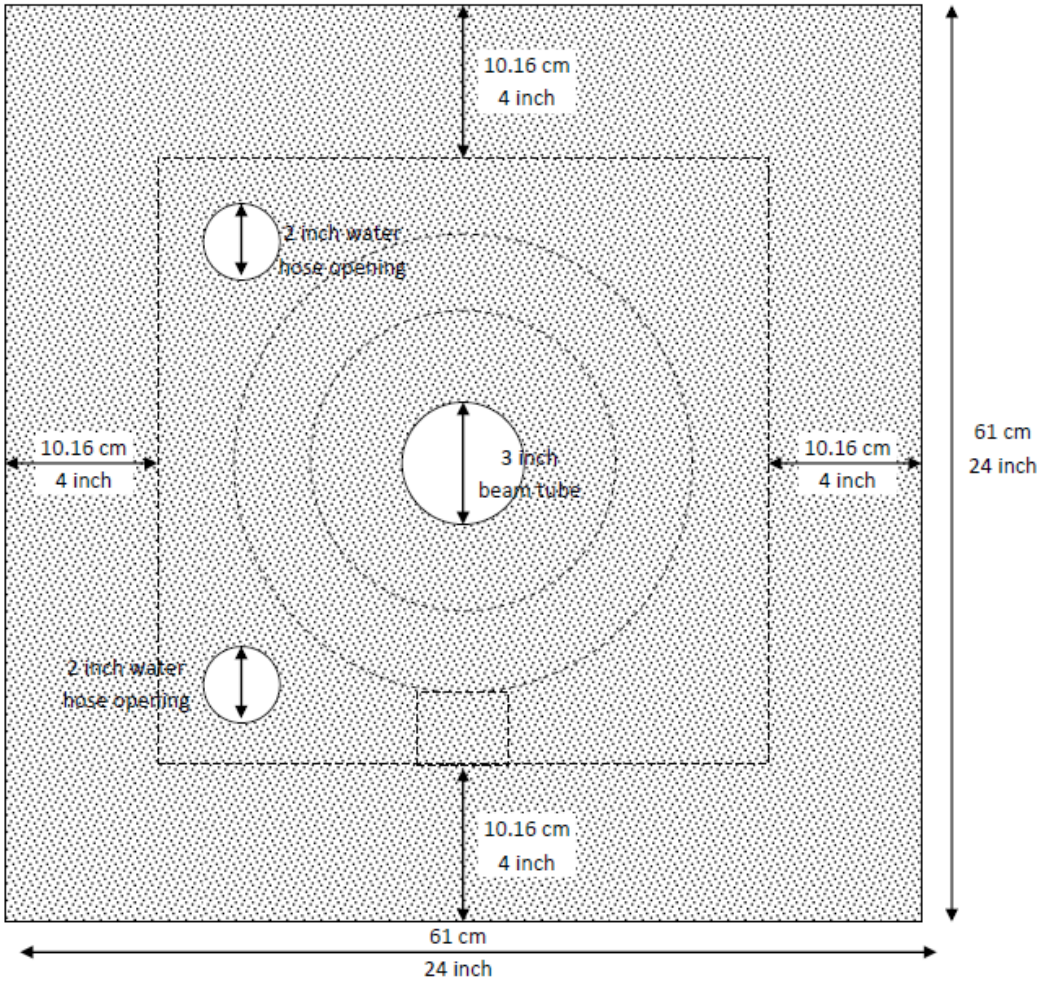


Physical Design of HINS Absorber



Absorber Front View

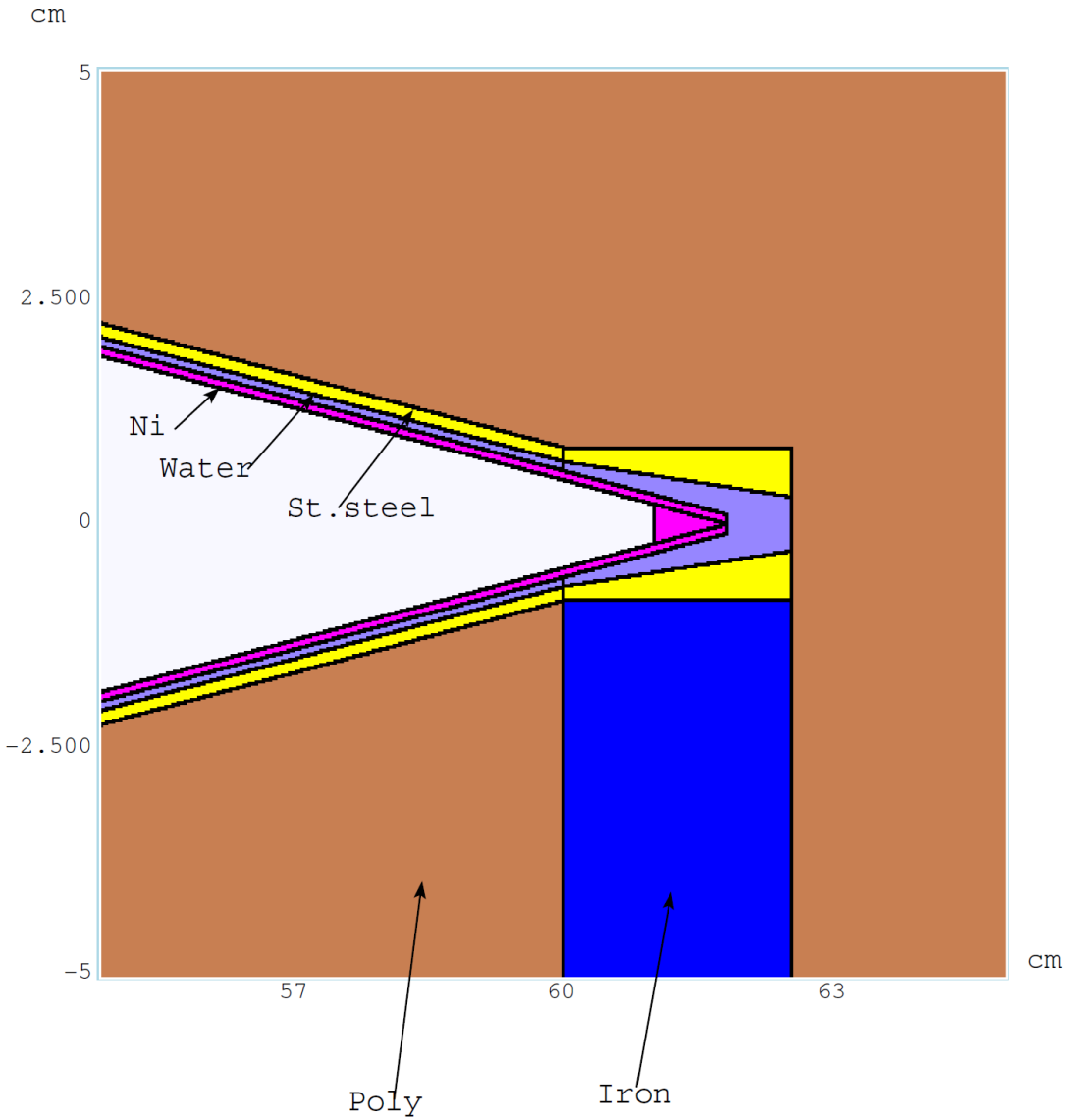
HINS Beam
Absorber Face



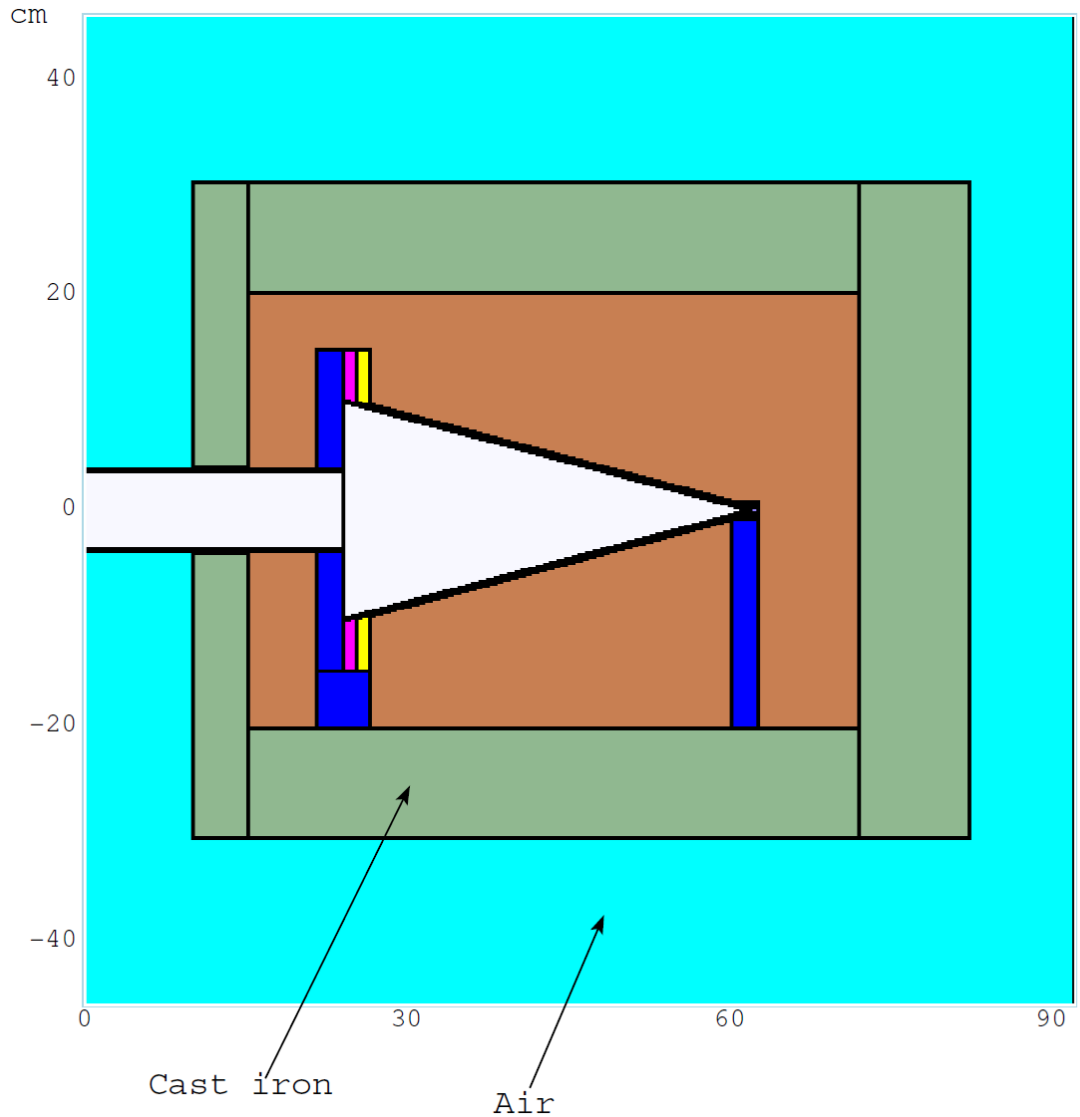
Questions for Study (B. Webber)

- What are prompt radiation dose rates outside the shielding box of the absorber and outside the shielding enclosure of the Linac for each of the possible beam energies and absorber locations?
- At what level, if any, is there concern for cooling water activation that would require a closed-loop radioactive-water cooling system?
- From a radiation shielding perspective, in what ways might the shielding box of the absorber be simplified or reduced in size or weight?

Absorber MARS Model (1)



Absorber MARS Model (2)

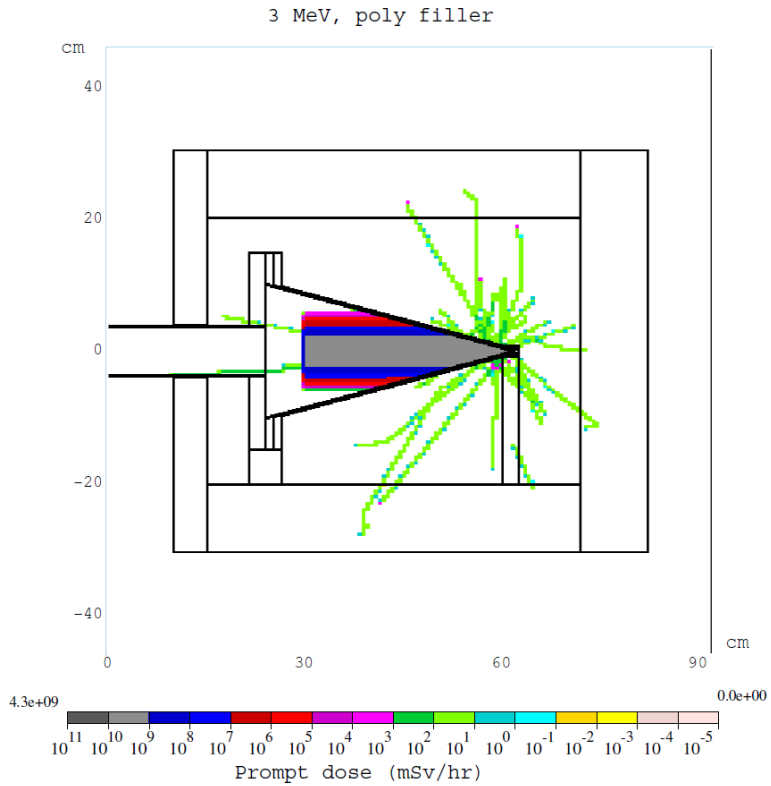


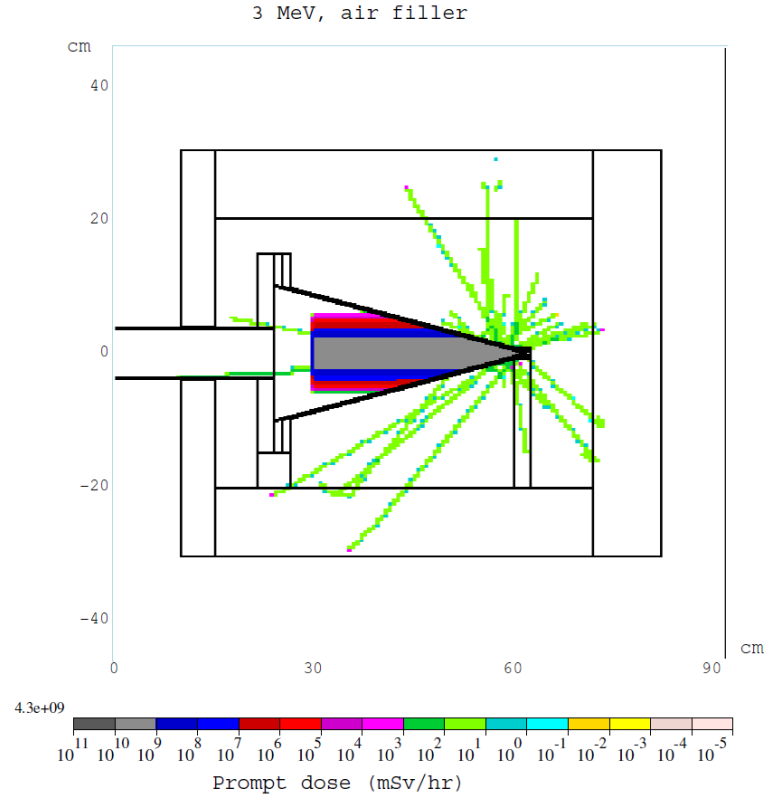
For 3 and 10 MeV beams at 1.556e15 p/s with and without poly filler <u>calculated:</u>

1. Prompt dose (mSv/hr)
2. Residual dose (mSv/hr) on contact for 30-day irradiation and 1-day cooling
3. Power density (mW/g)
4. Neutron and photon spectra

cm Note: 1 mSv/hr = 100 mrem/hr

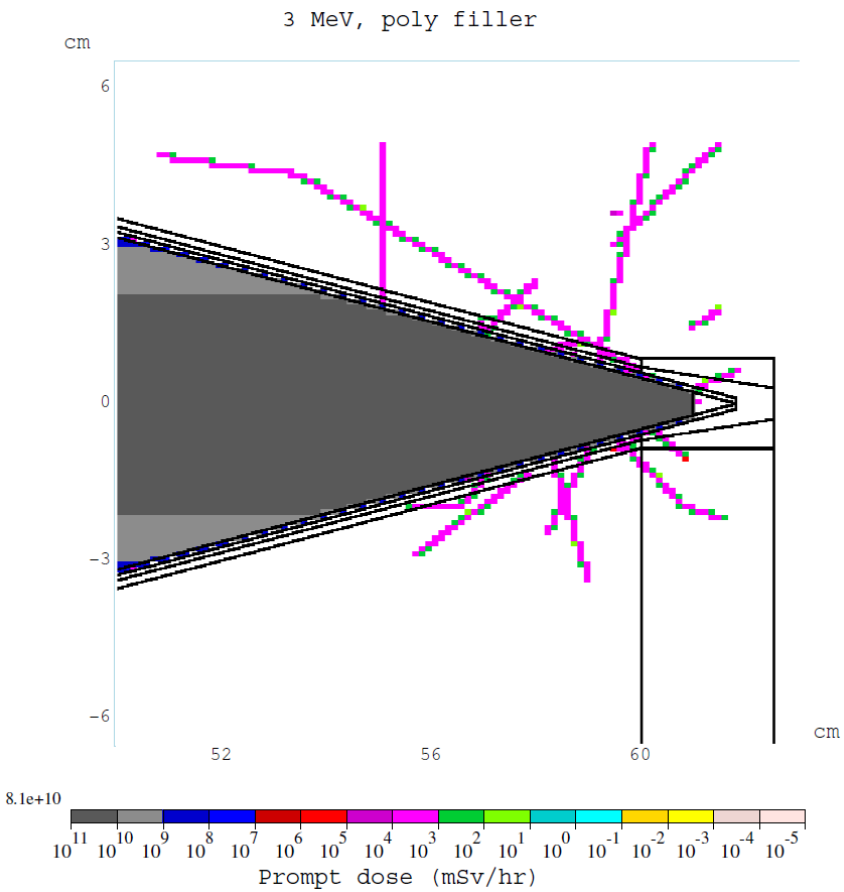
Prompt Dose at 3 MeV

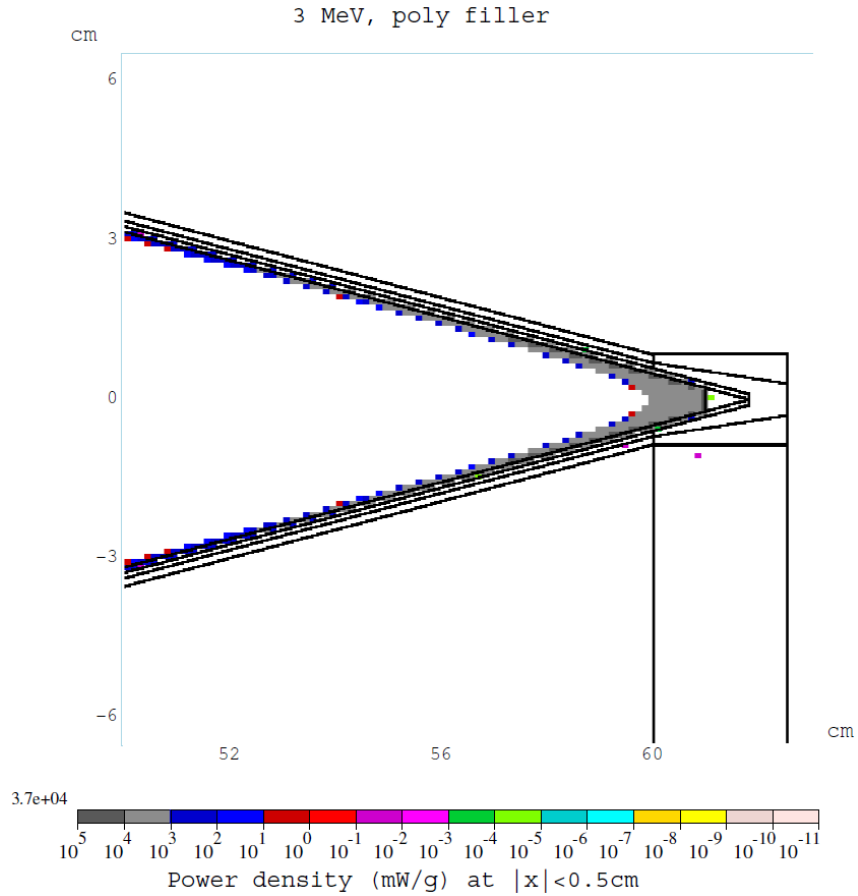




1. There is no neutron production at 3 MeV.
2. No activation.
3. No poly filler needed.
4. Iron shielding thickness can be reduced from 4" to 1" to take care of soft X-rays not included in this modeling.
5. Enlarge beam pipe OD or reduce beam size ?

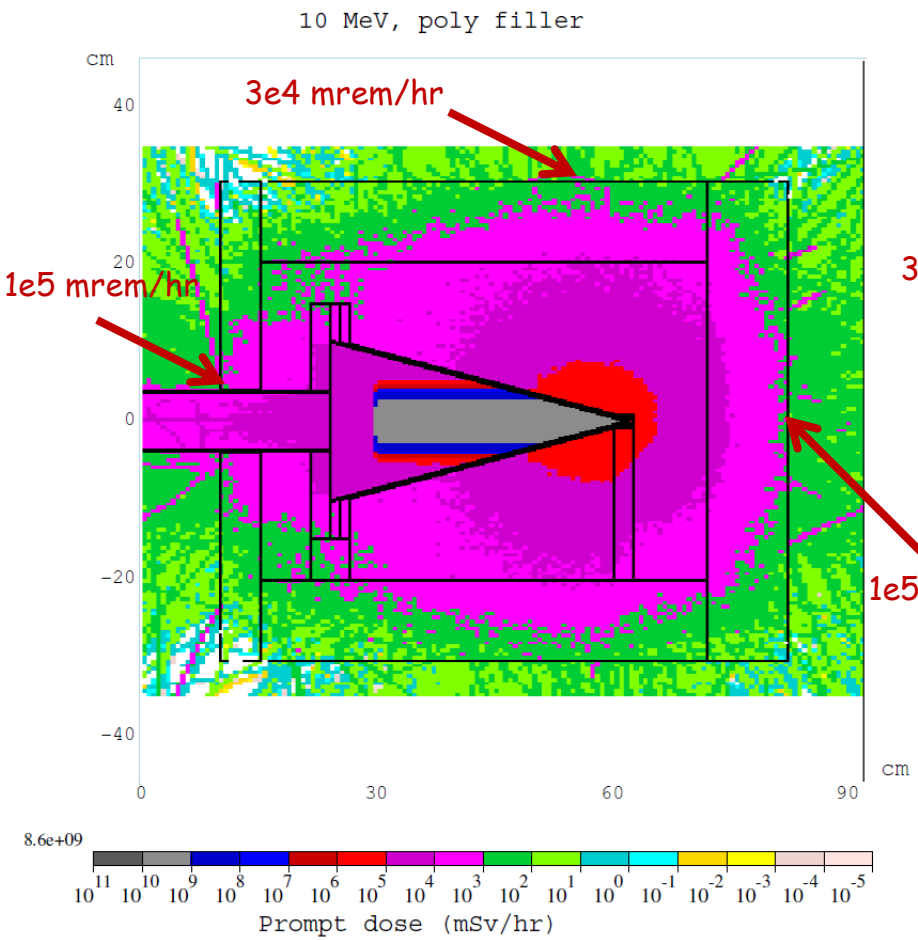
Prompt Dose and Power Density at 3 MeV

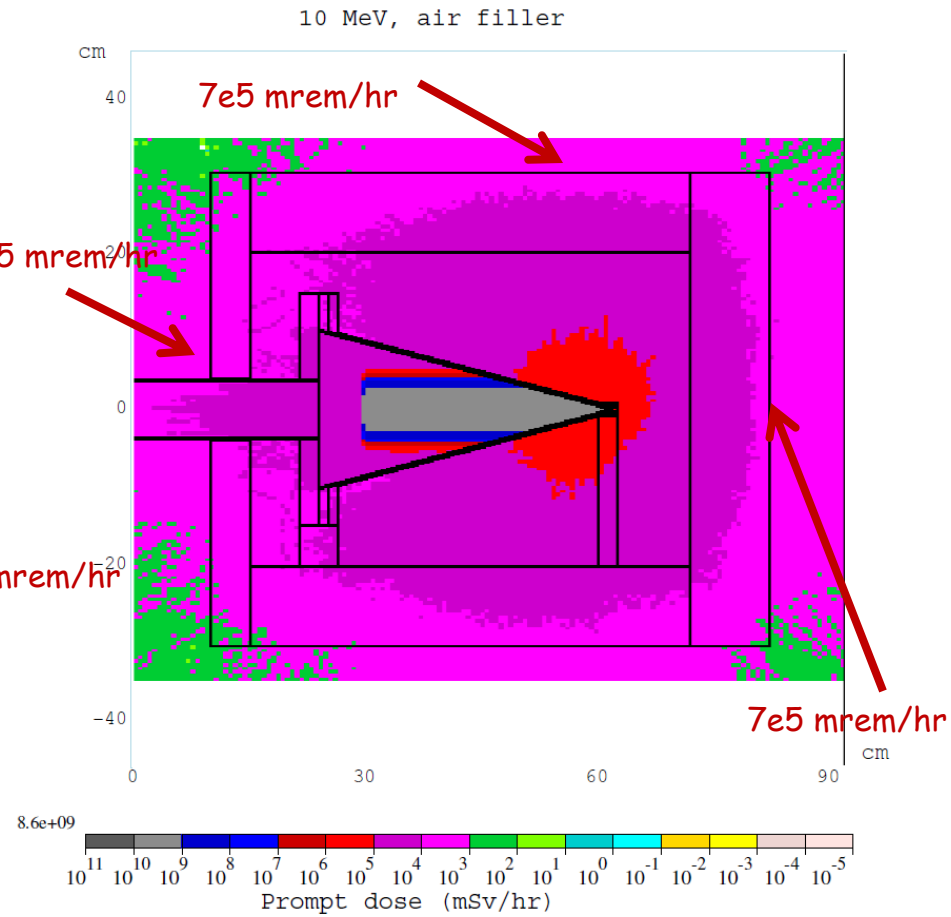




Max 37 W/g

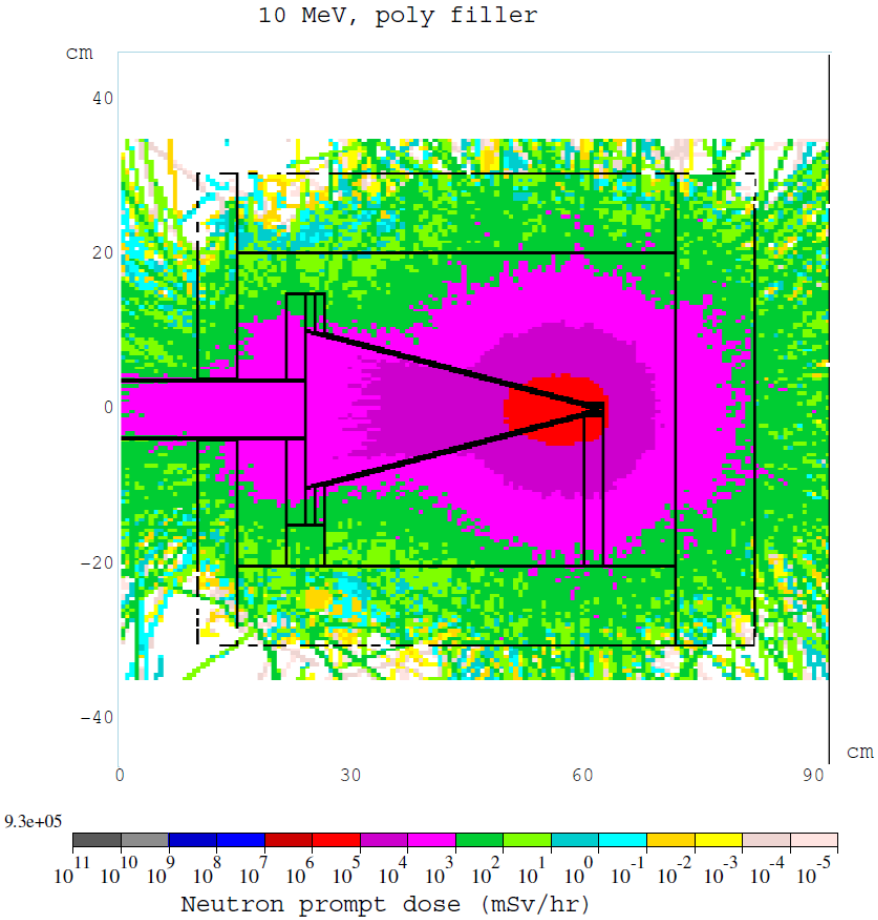
Prompt Dose at 10 MeV with and w/o Poly Filler

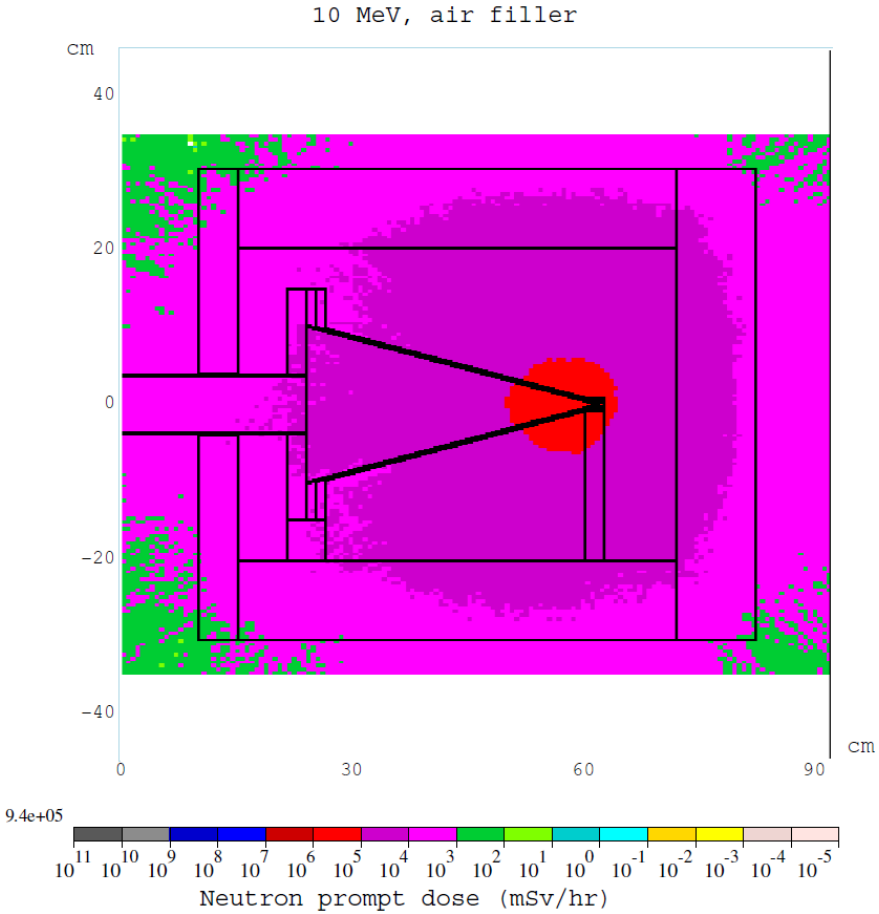




Enlarge beam pipe OD or reduce beam size ?

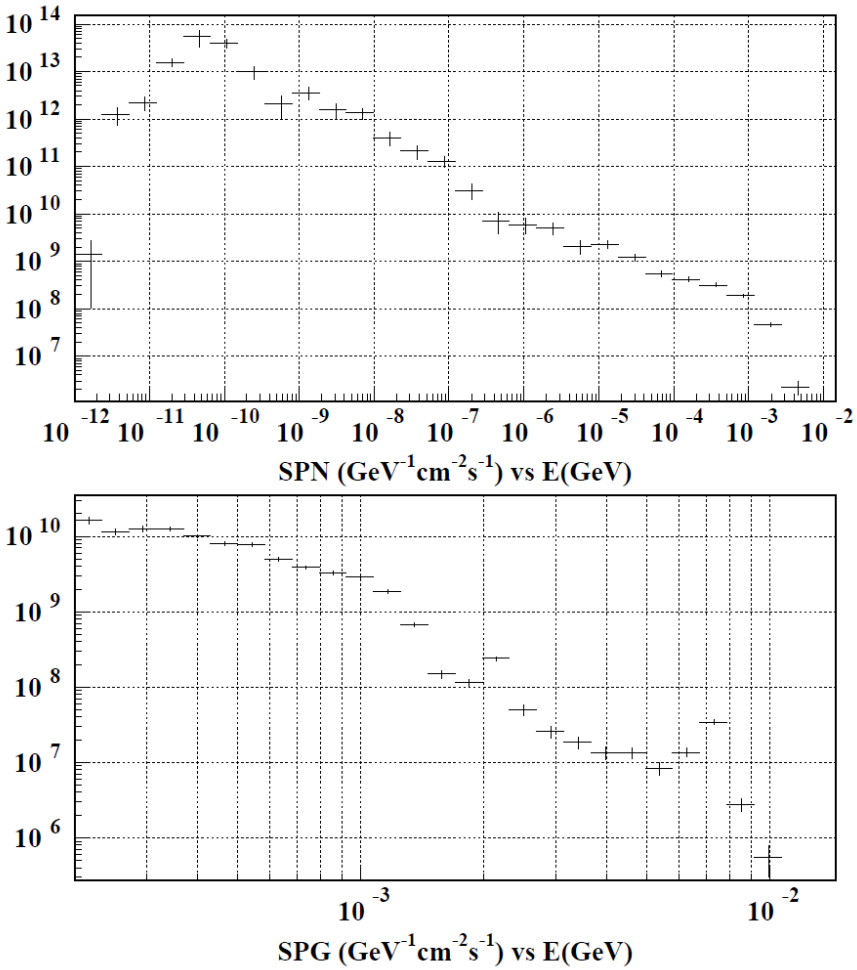
Neutron Dose at 10 MeV with and w/o Poly Filler



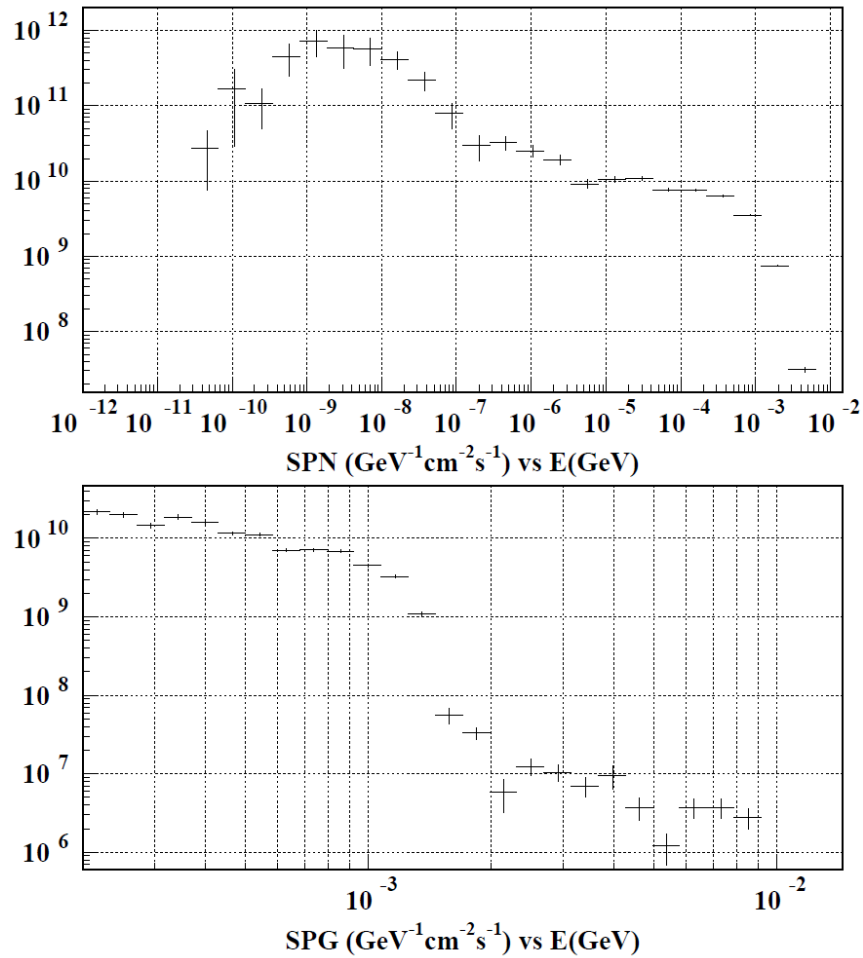


1. Poly filler works nicely.
2. Add poly or concrete on iron outside.

Neutron (SPN) and Photon (SPG) Spectra Downstream of the Shielding Box

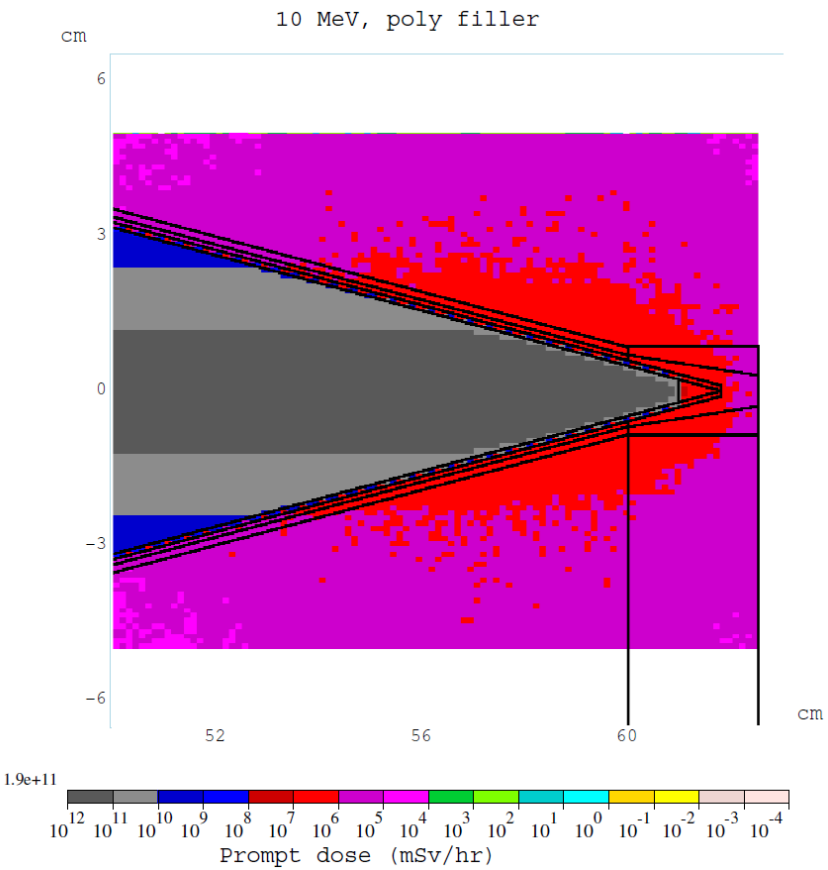


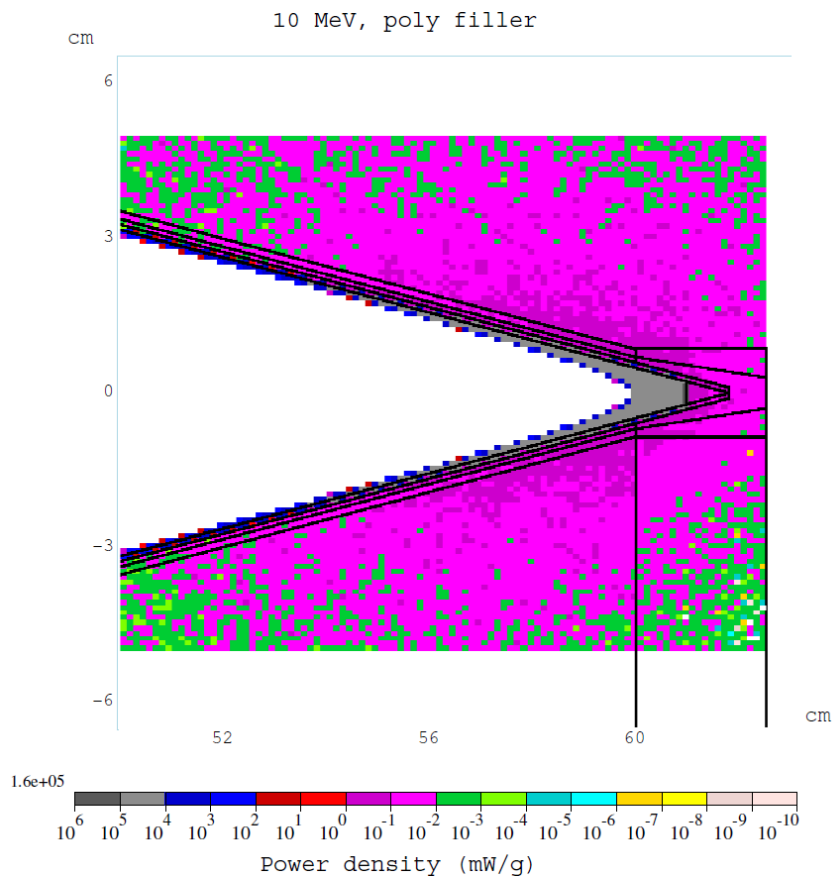
With poly filler



Without poly filler

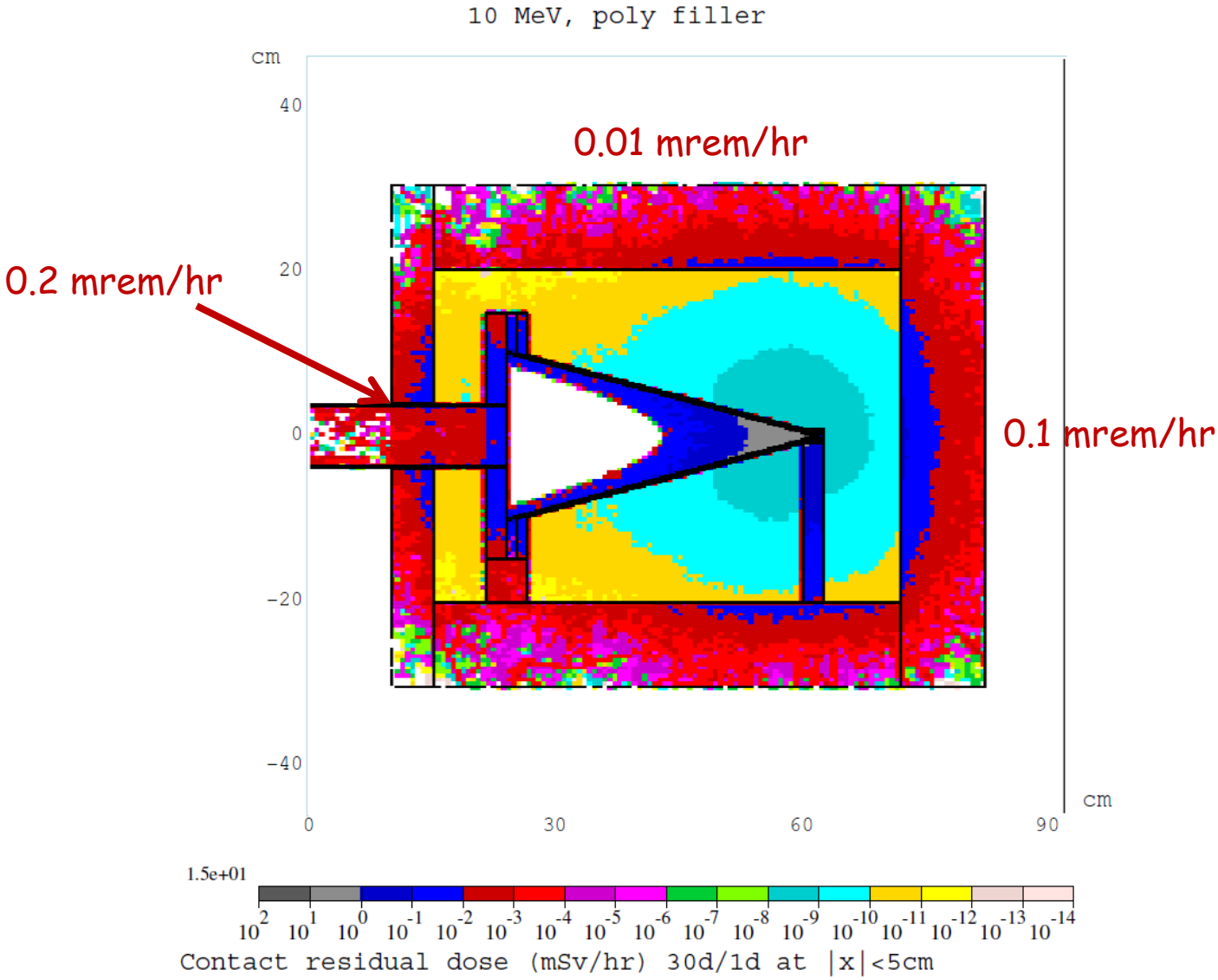
Prompt Dose and Power Density at 10 MeV





Max 160 W/g

Contact Residual Dose at 10 MeV

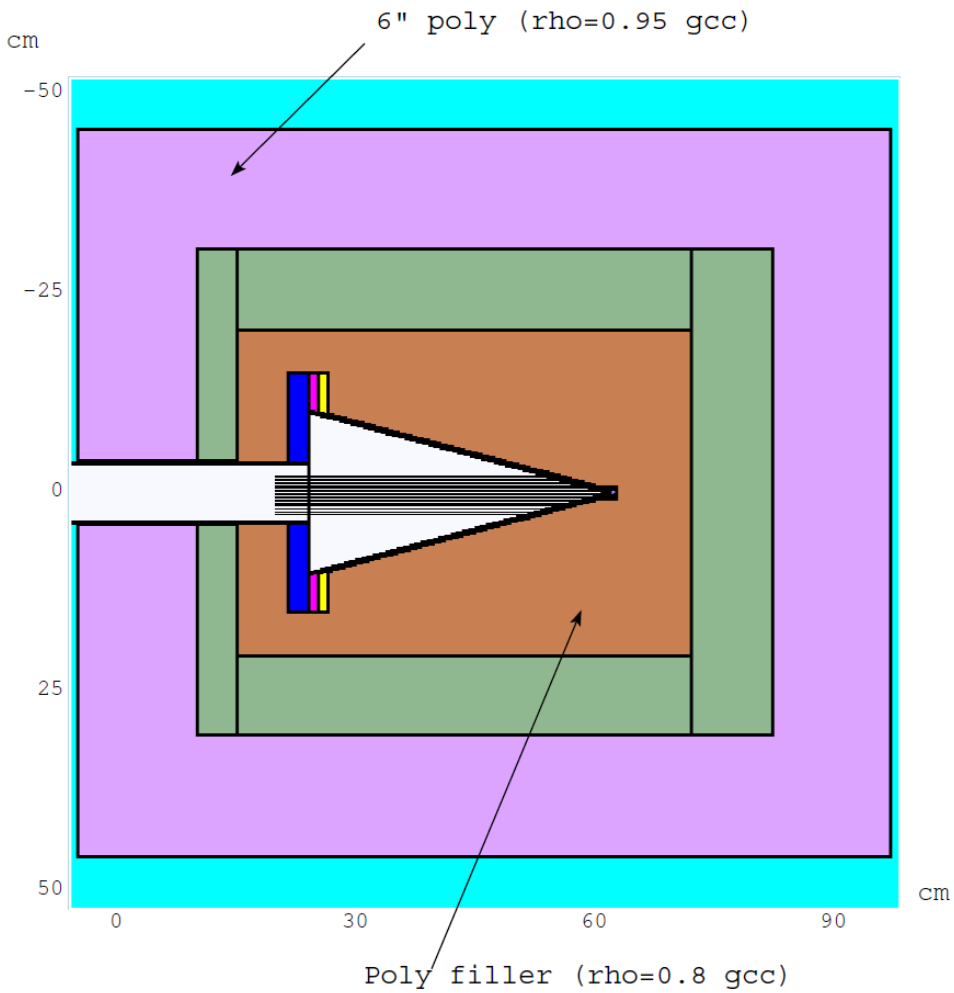


OK!

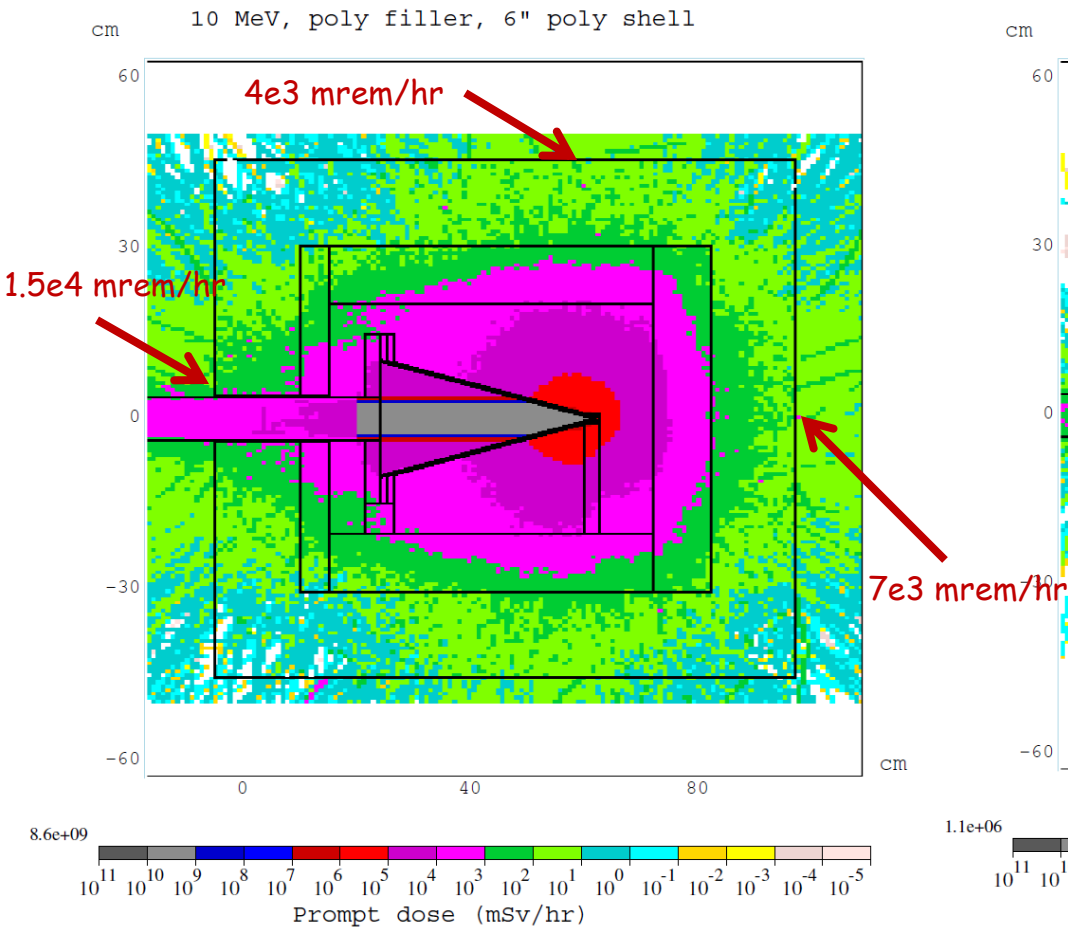
Mitigating 10-MeV Case: Adding 6" Poly (04/28/10)

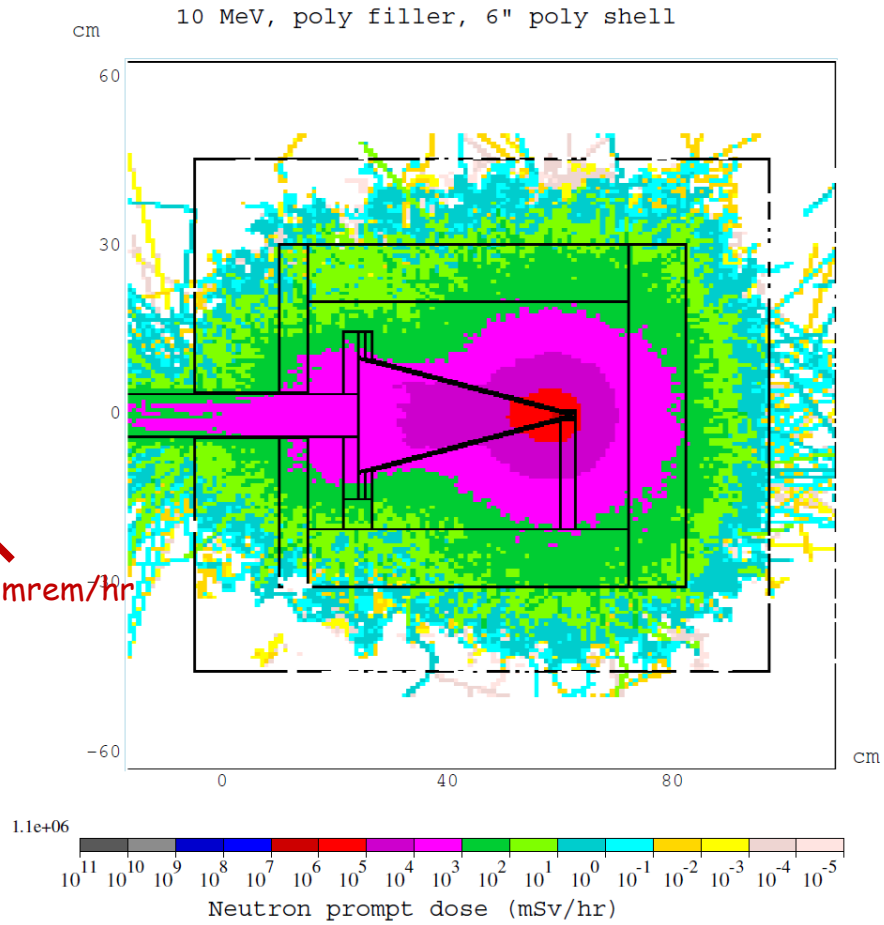
1. Prompt dose on the outside of the 4" thick iron shielding box is too high at 10 MeV, ~3e4 mrem/hr, and 70% is due to neutrons.
Solution: add 6" poly shell.

2. Beam pipe (3" OD, 0.062" wall) is too tight for the 10-mm sigma proton beam.
Solution: reduce RMS beam spot size to $\sigma_x = \sigma_y = 8.5$ mm.
It results in increase of maximum power density in Ni absorber from 160 W/g to 220 W/g.



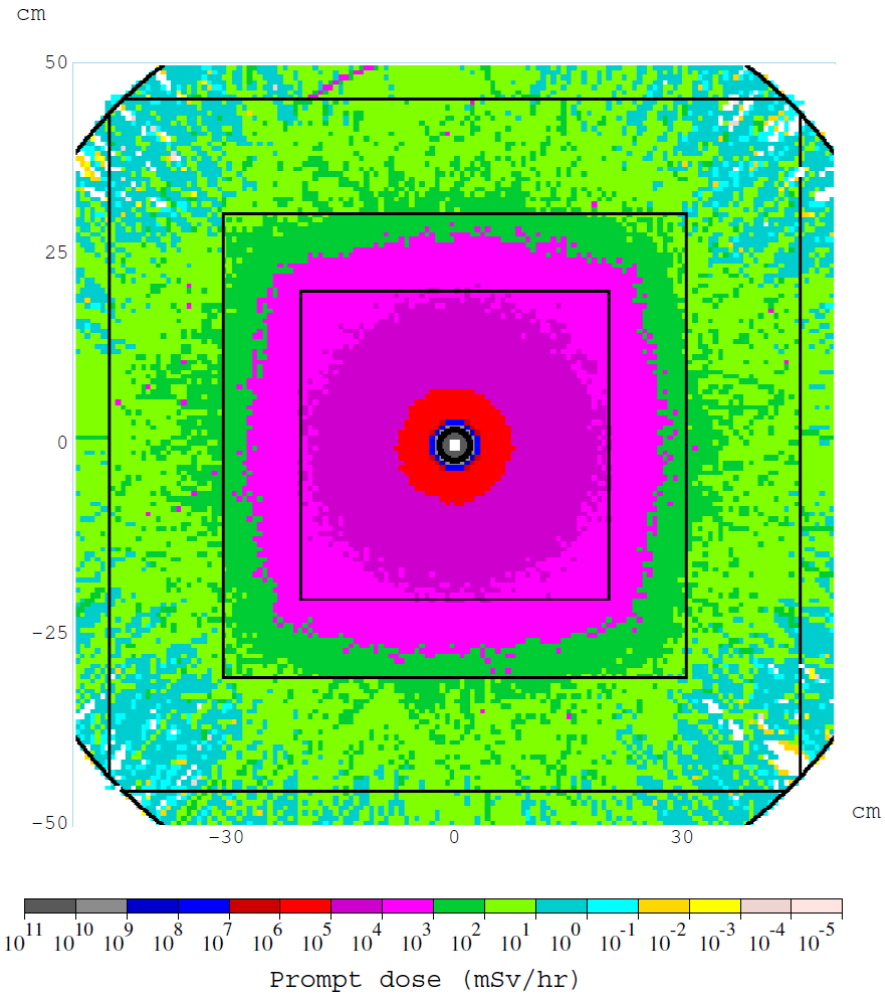
Prompt Dose at 10 MeV in the Extended Model

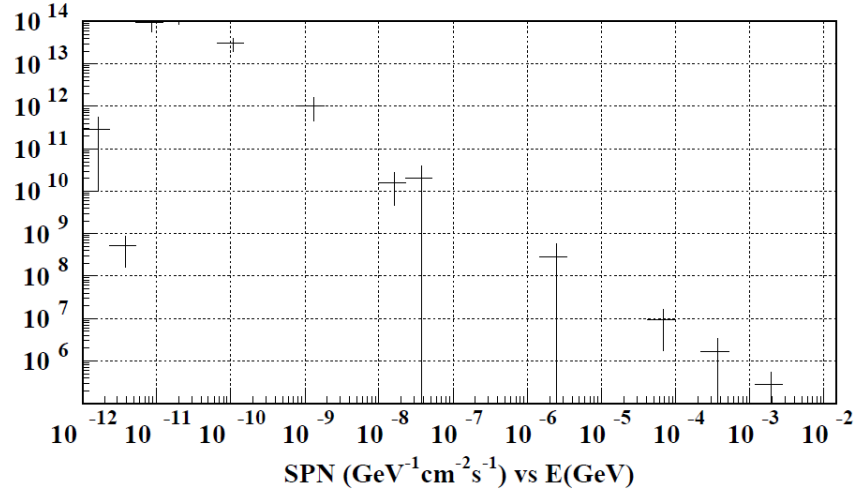


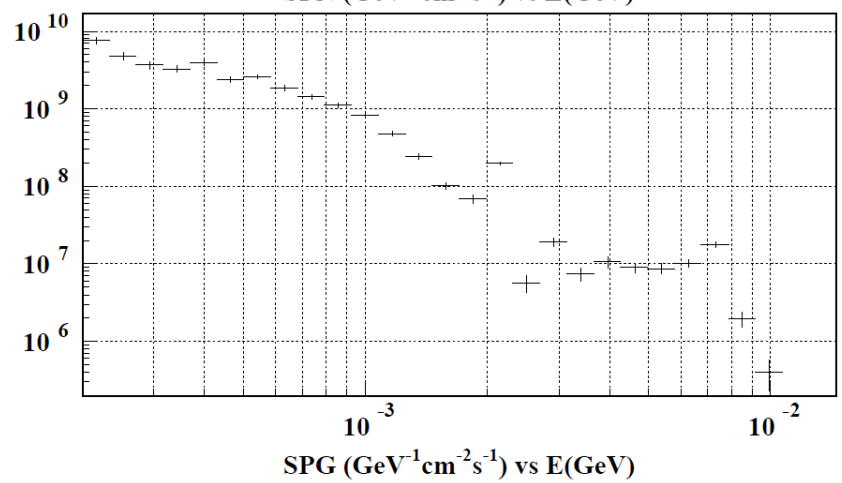


Total dose outside is down by about an order of magnitude

Prompt Dose at z~55 cm and Spectra Downstream of the Shielding Box

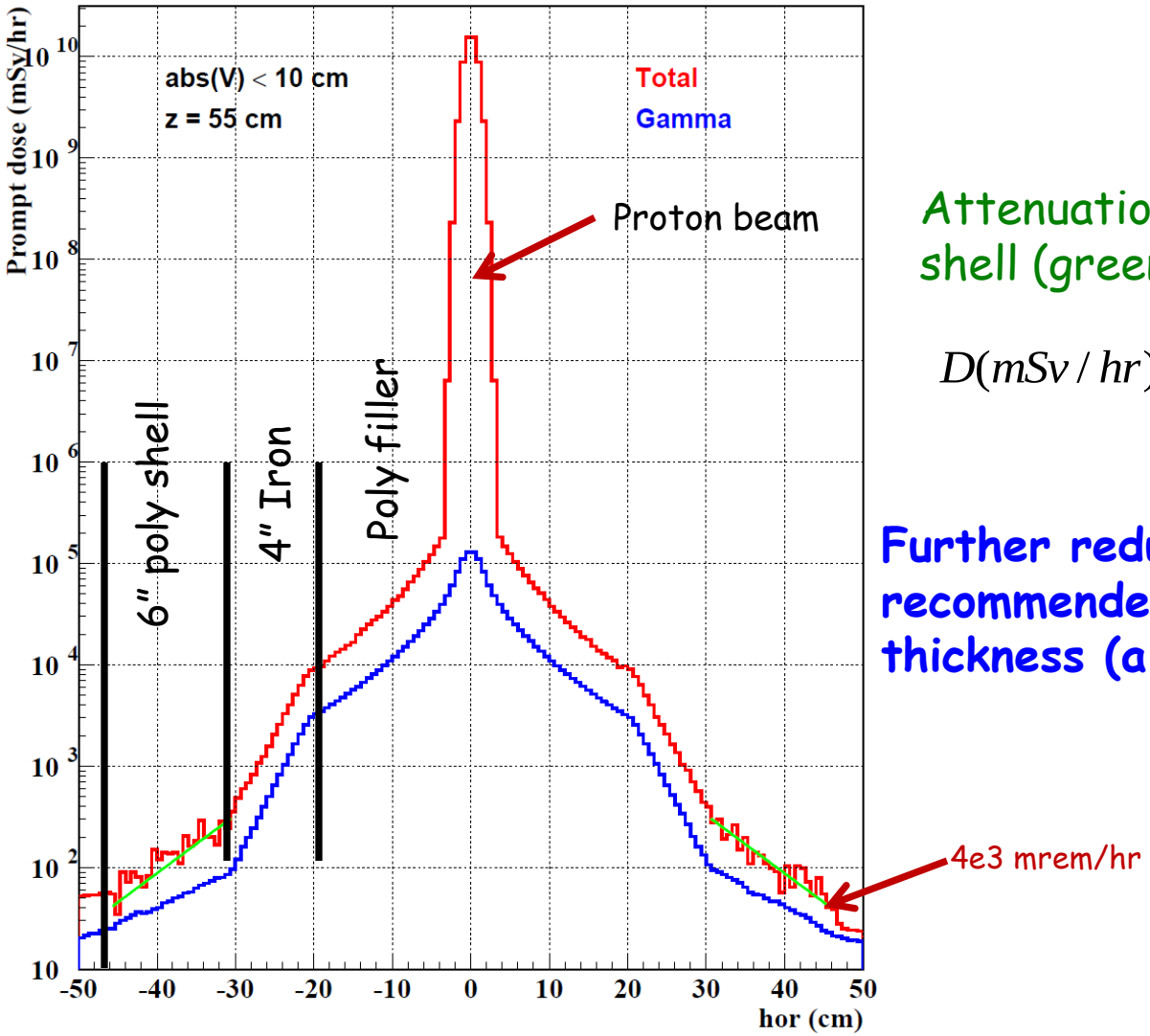






Most of energetic neutrons are cut by poly shell

Prompt Dose at Longitidinal Maximum z~55 cm



Attenuation of total dose in 6" poly shell (green line fit) with x in *cm*:

$$D(mSv/hr) = 309\exp[-0.13223(x-30.5)]$$

Further reduction – if needed – is recommended by increasing the iron thickness (a factor of 30 per 4 inches)