Estimate the Radiation for TDIS Experiment Using FLUKA

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Introduction

1) **Proposal**: This project is to study the radiation for TDIS experiment in Hall A. TDIS requests a total of 22 days of beam time, with 10 days of production 50 μA beam on the hydrogen target, 5 days production on the deuterium target, 2 days for optics and detector commissioning, and an additional 5 days of 5 μA beam on the hydrogen target for background checks.

2) **Luminosity**: In this work, I assume 20 PAC days of **30uA** and 11 GeV beam on a 7.5ATM room temperature deuterium gaseous target.

3) **Target Straw**: 50 um Kapton, ID=1cm, and have **25um** thick aluminum end caps.

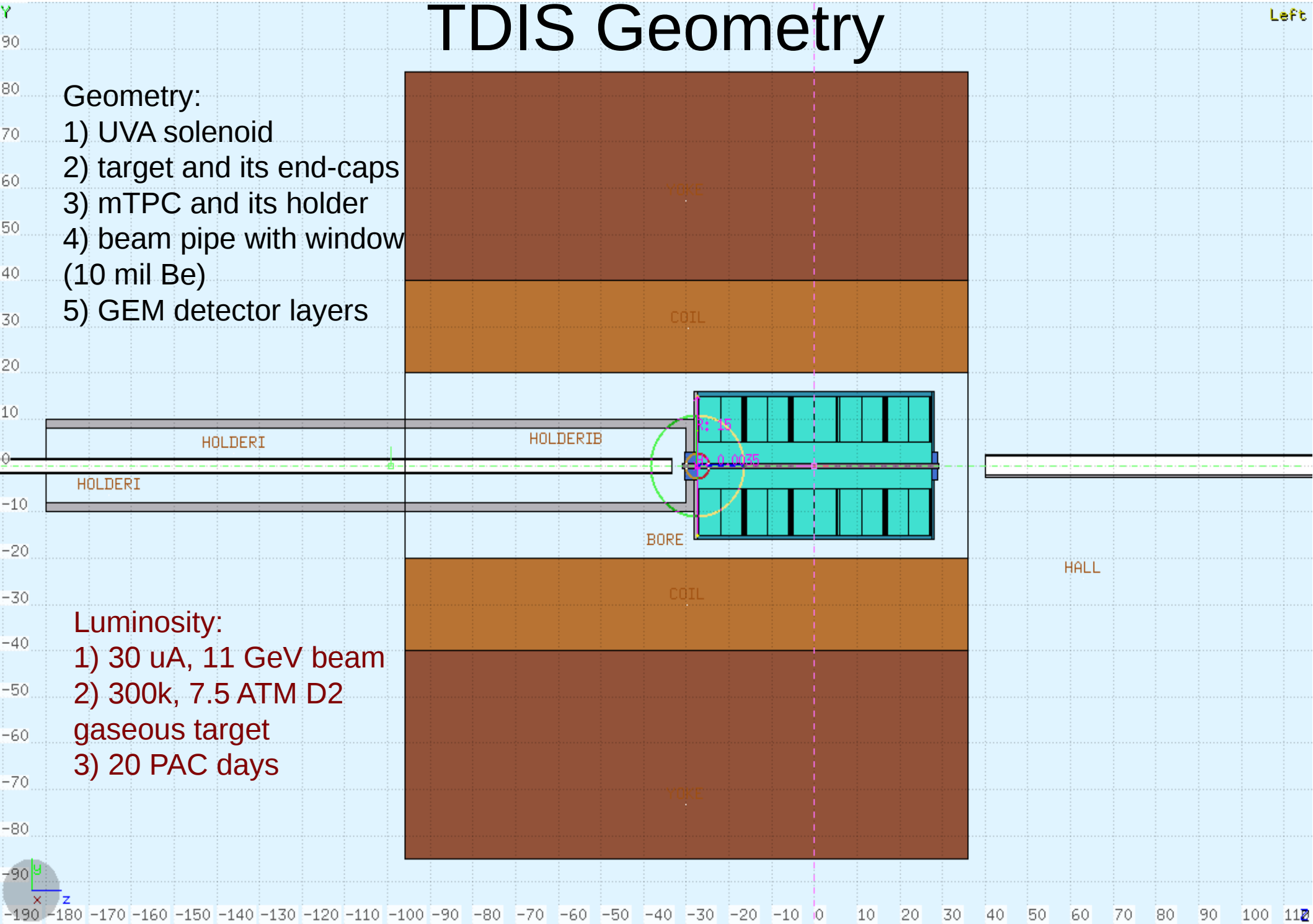
4) **mTPC**: **55cm** long, placed at the pivot. Also placed are a 0.4cm thick epoxy downstream end-plate, a 0.7cm aluminum upstream end-plate, and a 1.5cm equivalent thick PCB board cylinder shell. Its holder is an aluminum pipe (ID=16cm, OD=20cm). **10 GEM detector chambers** were placed. Each GEM detector contains 2 layer of Kapton(70um) and 1 layer of Copper(35um). The cathode layers are **10um** thick copper foils.

5) **Solenoid**: the UVA solenoid provides **4.7 Tesla** magnetic field pointing upstream, **shifted to upstream by 30 cm** to enlarge acceptance. The dimension of the yoke are: 1.70m OD x 0.80m ID x 1.32m length, made of silicon steel. The dimension of the coil are: 0.80m OD x 0.40m ID x 1.32m length.

6) **Beam Pipe**: the incoming beam pipe at upstream is made of aluminum with 1.049 inches ID. Its wall thickness is 0.133 inches. Its window material is beryllium with a thickness of **10 mil** (0.0254cm). The exit beam pipe has 1.61 inches ID with wall thickness of 0.145 inches, whose window is also **10 mil** beryllium.

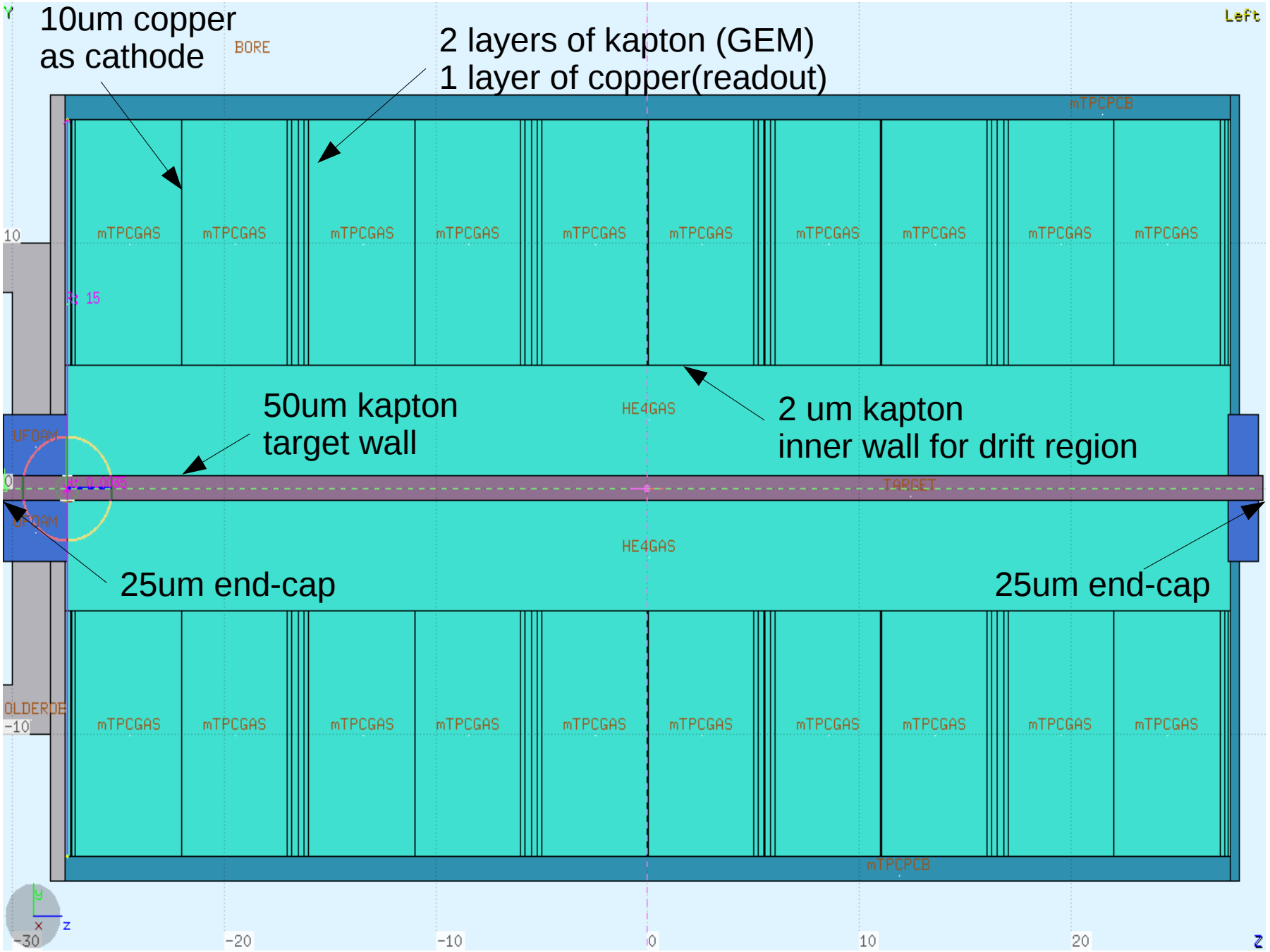
TDIS Geometry

Geometry:
1) UVA solenoid
2) target and its end-caps
3) mTPC and its holder
4) beam pipe with window (10 mil Be)
5) GEM detector layers

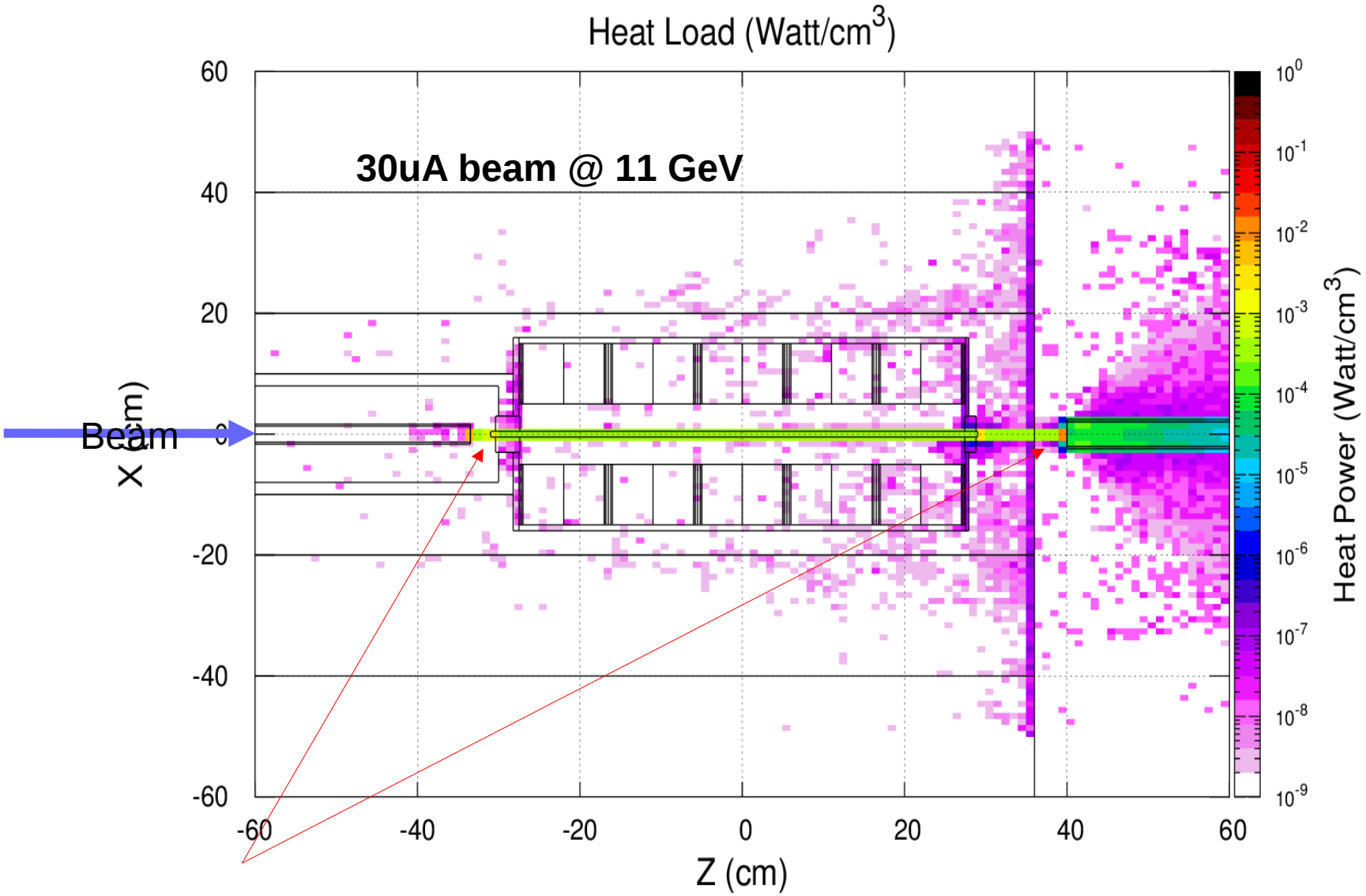


Luminosity:
1) 30 uA, 11 GeV beam
2) 300k, 7.5 ATM D2 gaseous target
3) 20 PAC days

MTPC Geometry

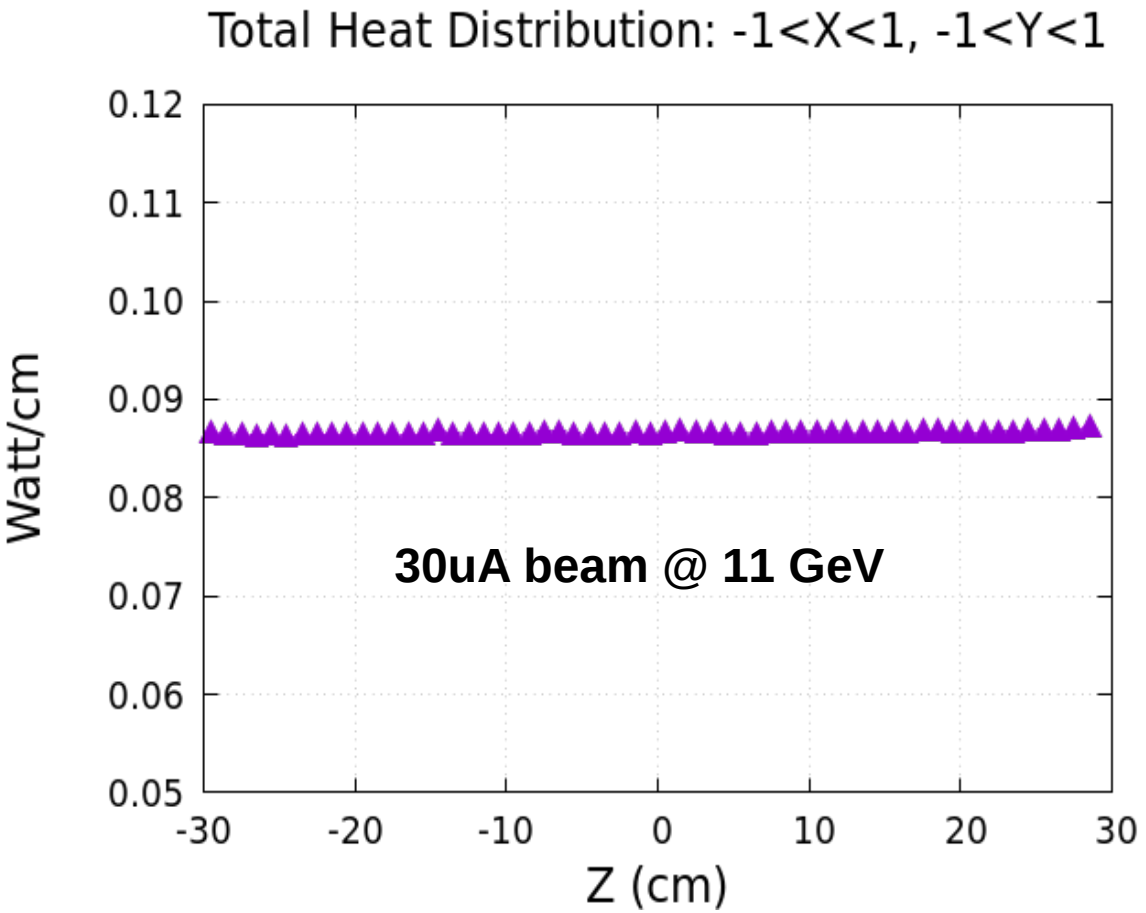


Energy Deposited in mTPC



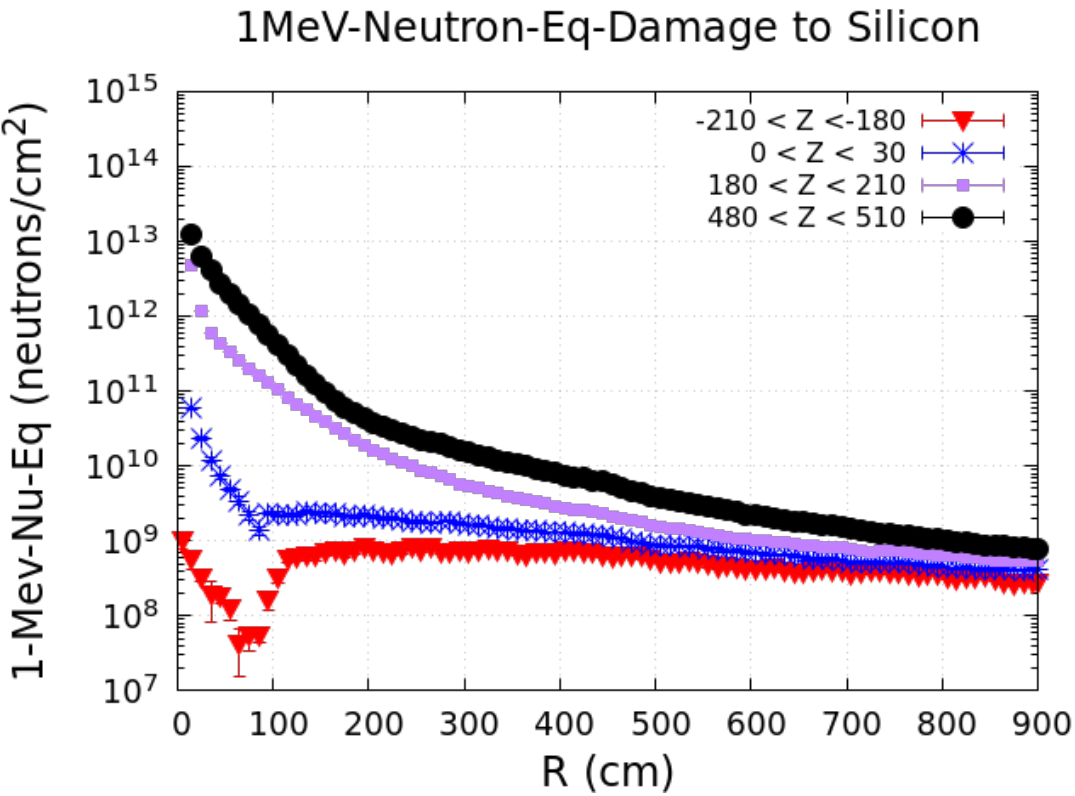
Most heat will be deposited at the two end caps of the target straw, and the beam pipe windows.

Heat Load in Target Straw

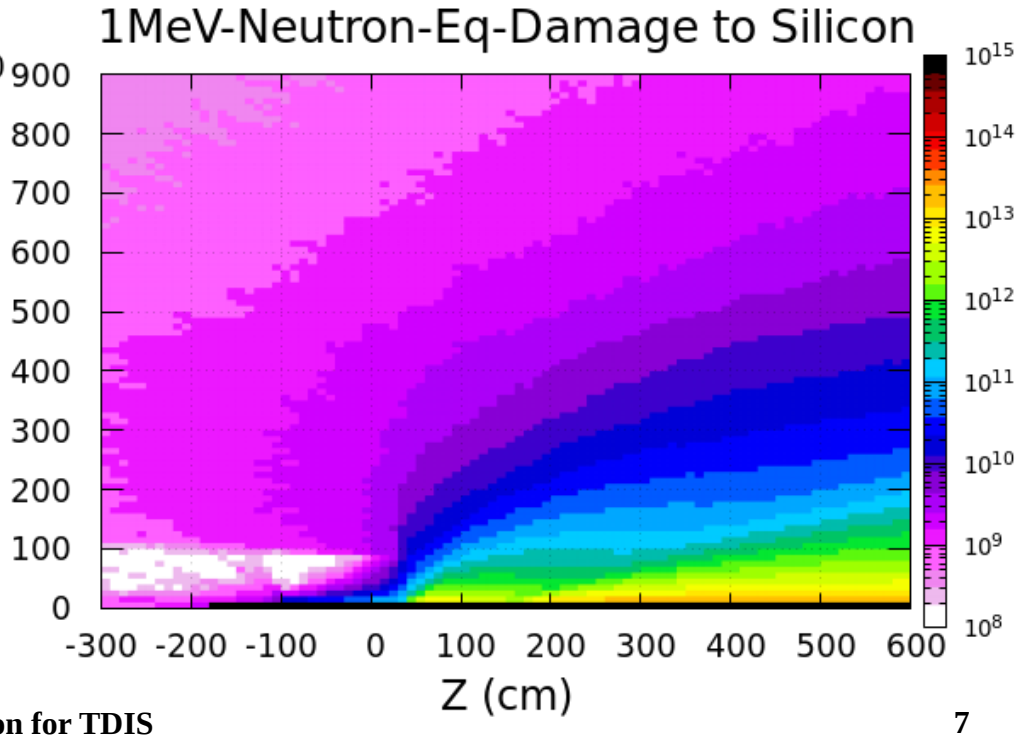


Conclusion:
The total heat power in target (include target wall) is 0.086 x 55 ~= 4.7 watts

Accumulated Damage to Silicon

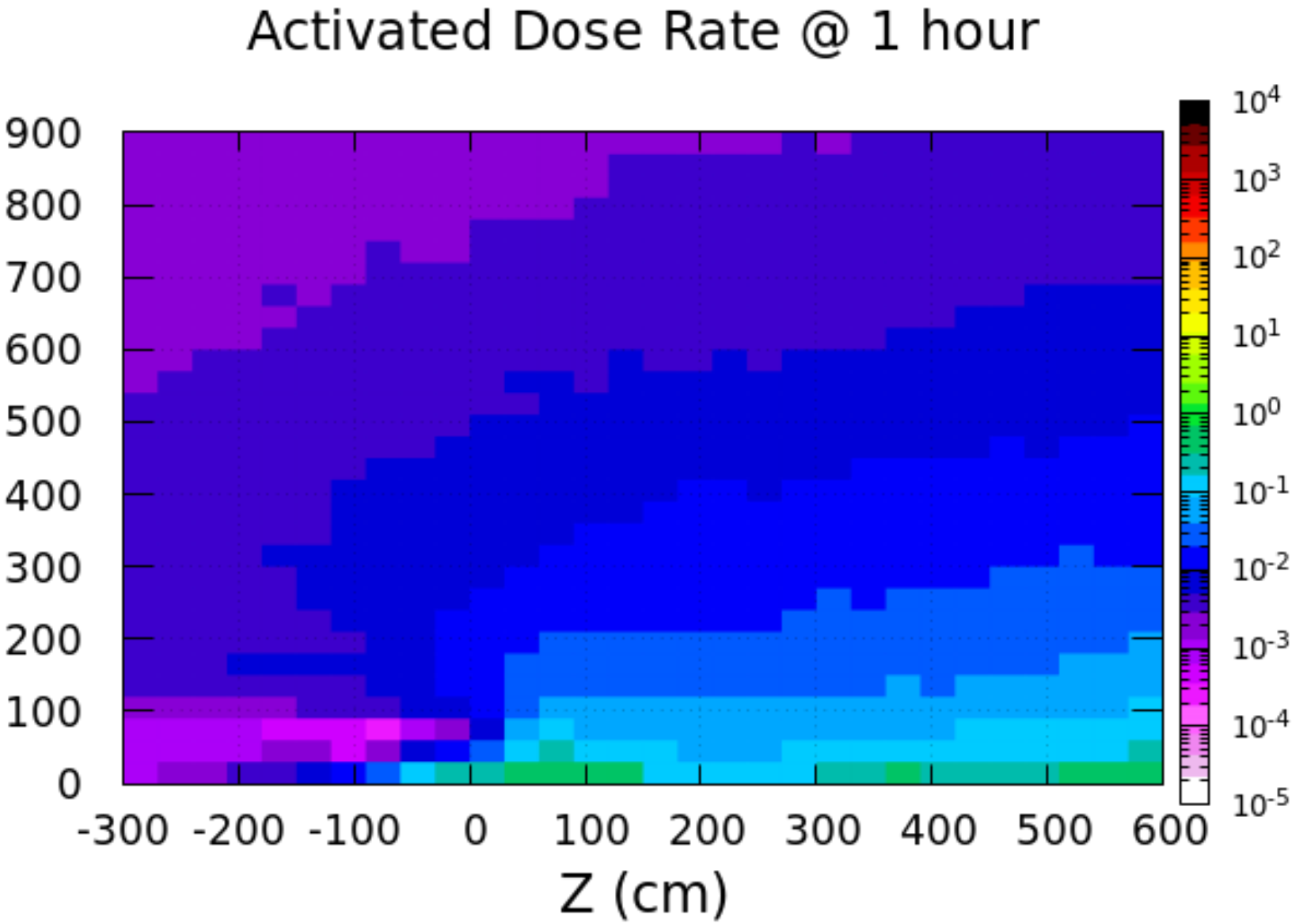


20 days, 30uA electron beam @ 11 GeV



Conclusion:
It is safe to place detectors at any location upstream, but not downstream with R<10 cm.

Activation Map @ 1 hour (2D)



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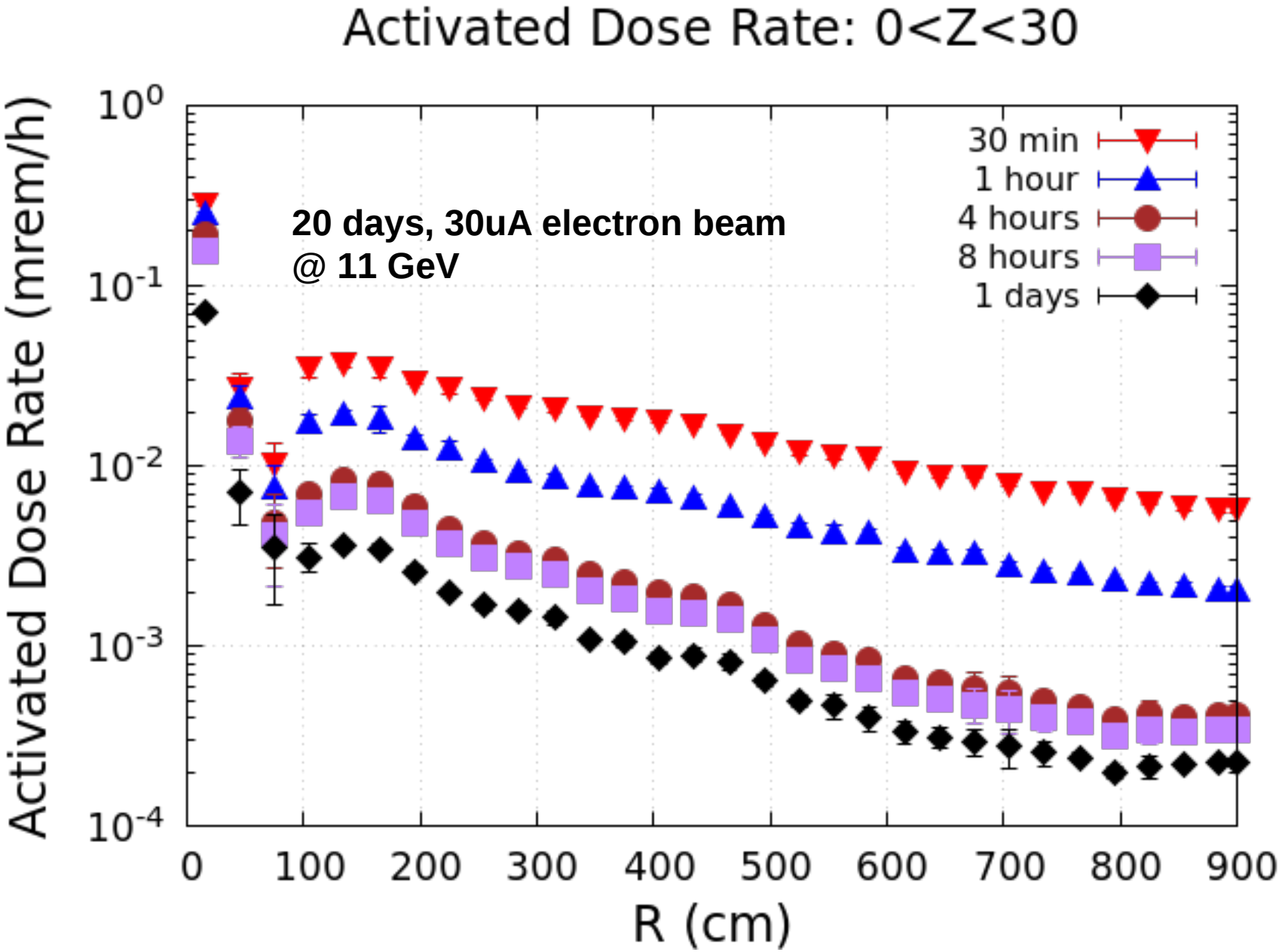
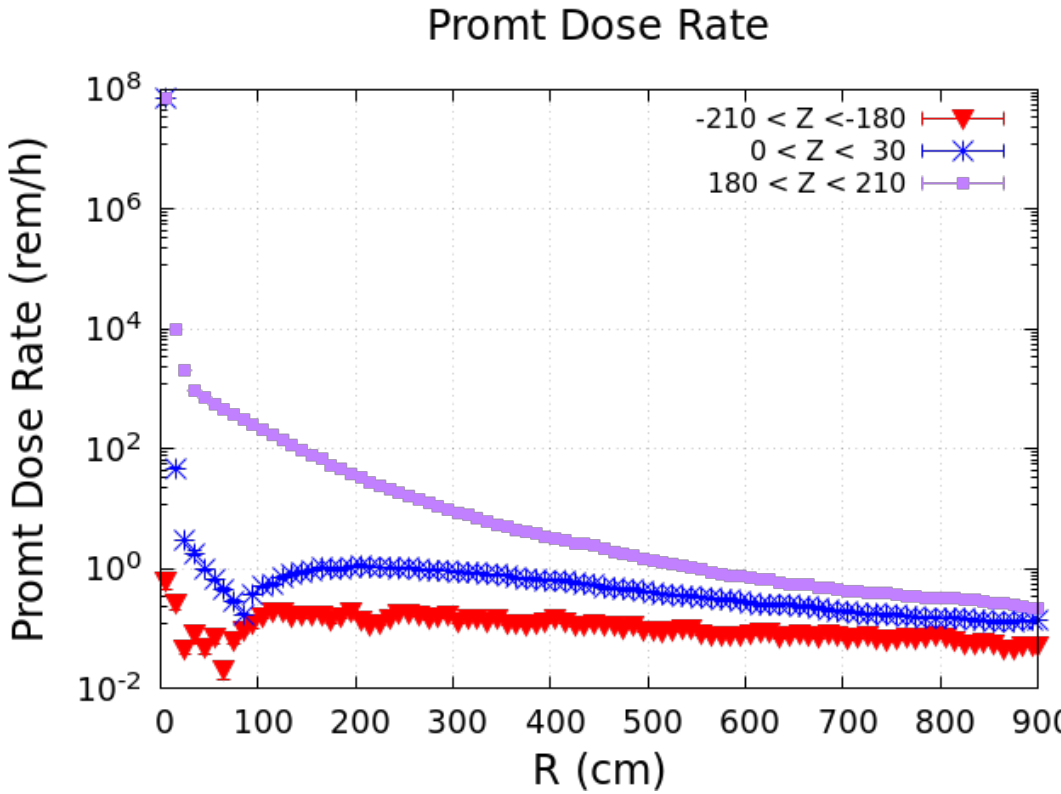
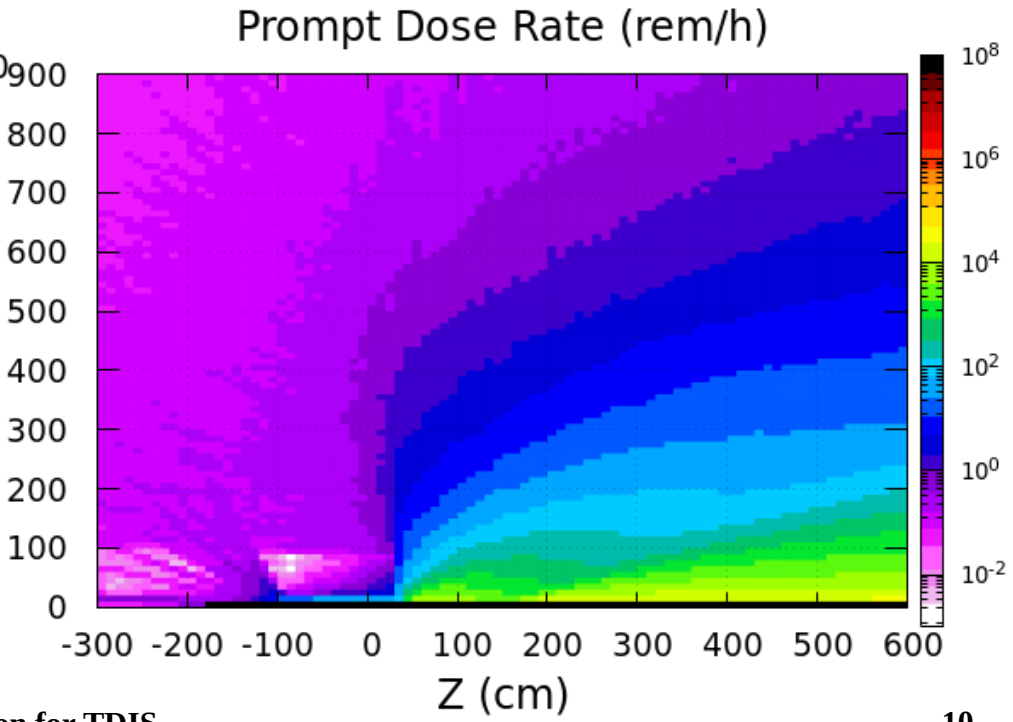
Dose Rate from Activation at Target



Prompt Dose Rate



30uA, 11 GeV beam



Conclusion:
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Summary

1) FLUKA simulation has been performed for TDIS experiment assuming 30 uA 11 GeV electron beam for 20 days.

2) The accumulated 1MeV neutron equivalent damage to silicon for target and its upstream is less than 3x10^11. It is very safe to place electronics upstream of the target. But it is not safe for downstream at R<10 cm.

3) Total heat load in the whole target straw is about 4.7 watts.

4) At target area, the dose rate from activation after beam is shut down for 1 hour are:
~= 0.4 mrem/h inside the solenoid bore, and
< 0.1 mrem/h outside the solenoid.

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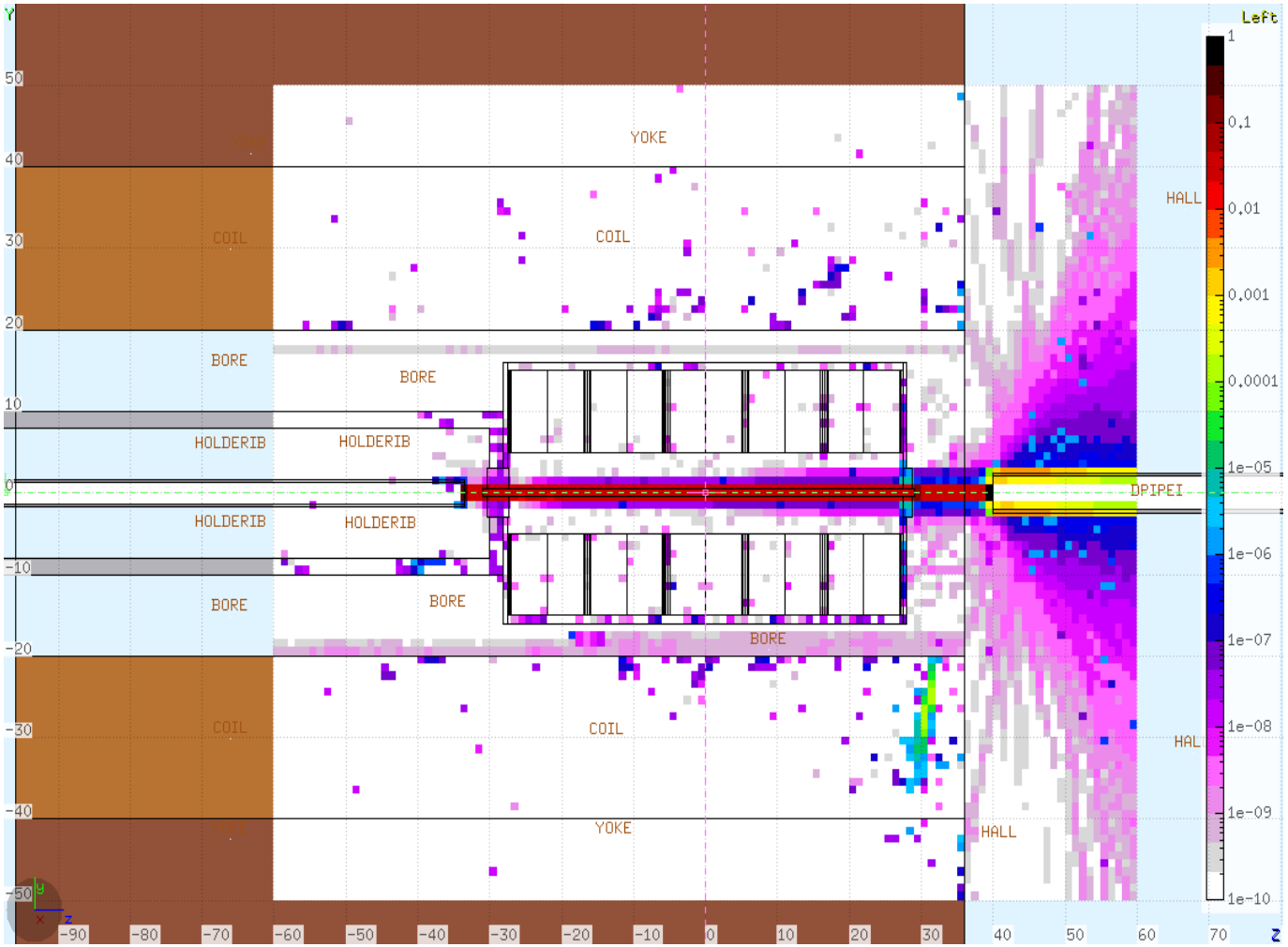

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