Estimate the Radiation for TDIS Experiment Using FLUKA

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Introduction

1) 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 μ A beam on the hydrogen target for background checks.

2) In this work, I assume 20 PAC days with 2.0E36 luminosity (20uA beam current on
7.5ATM room temperature gaseous target).

3) The target is 7.5 atm gaseous deuterium at 300k, 40 cm long. The target container is made of kapton, has a diameter of 1 cm, and has 15um aluminum end caps.

4) A mTPC is placed at the pivot, in the center of the UVA solenoid. I also place 0.4cm thick epoxy down end-plates, 0.7cm aluminum up end-plate, 1.5cm equivalent thick PCB readout board. Its holder is an aluminum pipe (ID=16cm, OD=20cm). At 1.8m upstream I place
a box to hold DAQ electronics. I fill this box with pure silicon.

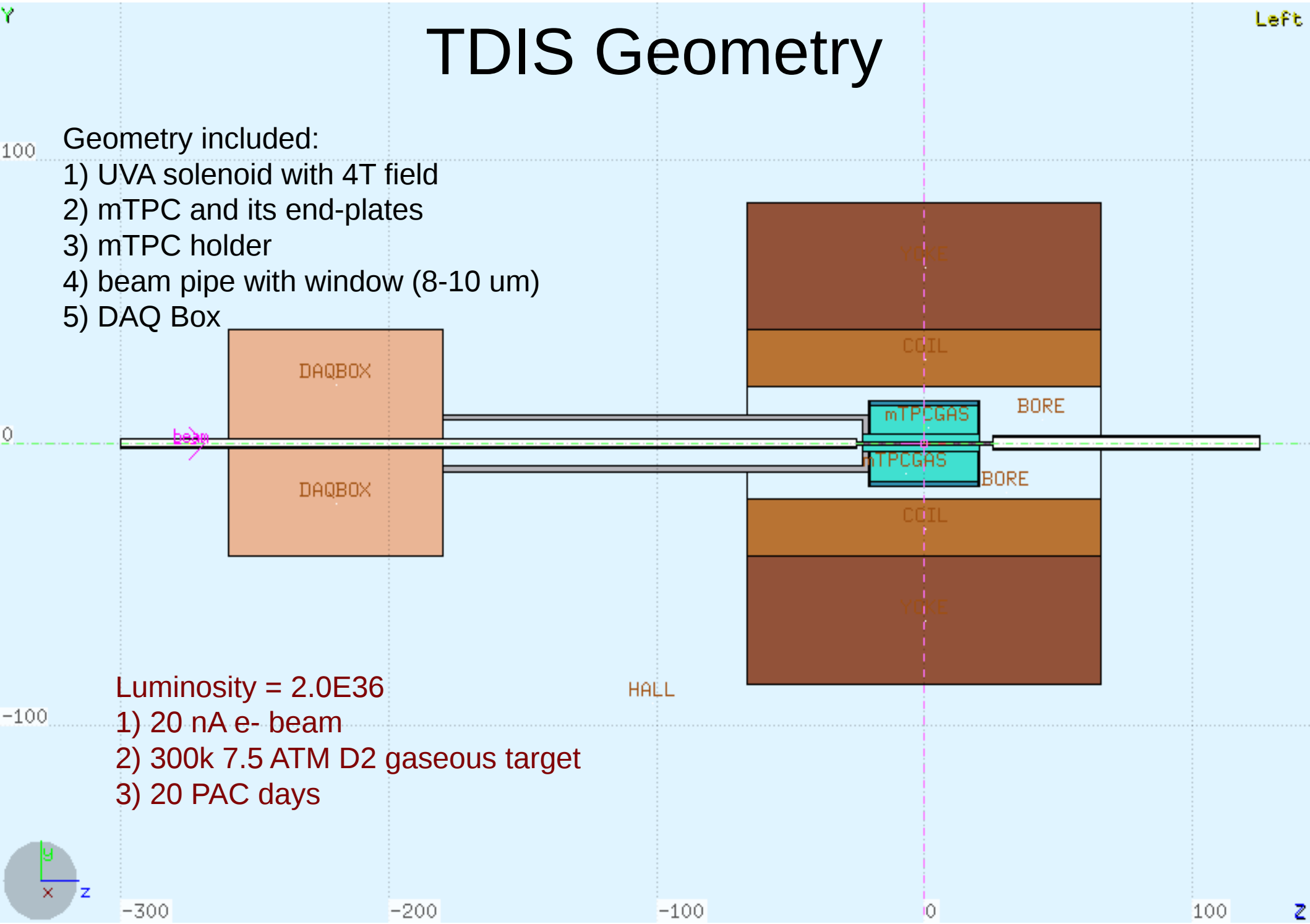
5)The UVA solenoid will provide 4.0 tesla magnetic field pointing upstream.
The size of the yoke is: 1.70m OD x 0.80m ID x 1.32m long, made of silicon steel.
The size of the coil is: 0.80m OD x 0.40m ID x 1.32m long.

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

TDIS Geometry

Geometry included:

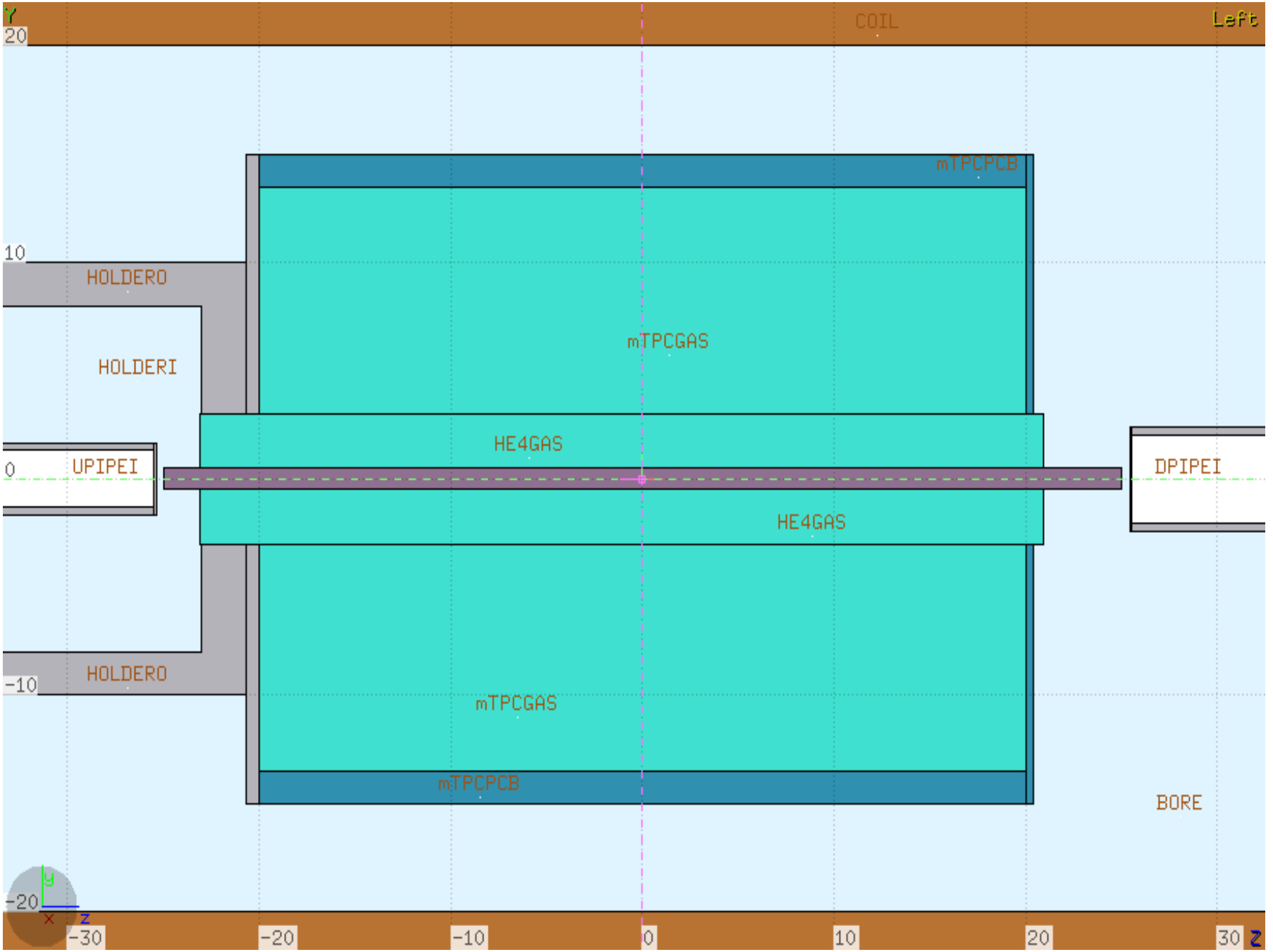
1) UVA solenoid with 4T field
2) mTPC and its end-plates
3) mTPC holder
4) beam pipe with window (8-10 um)
5) DAQ Box



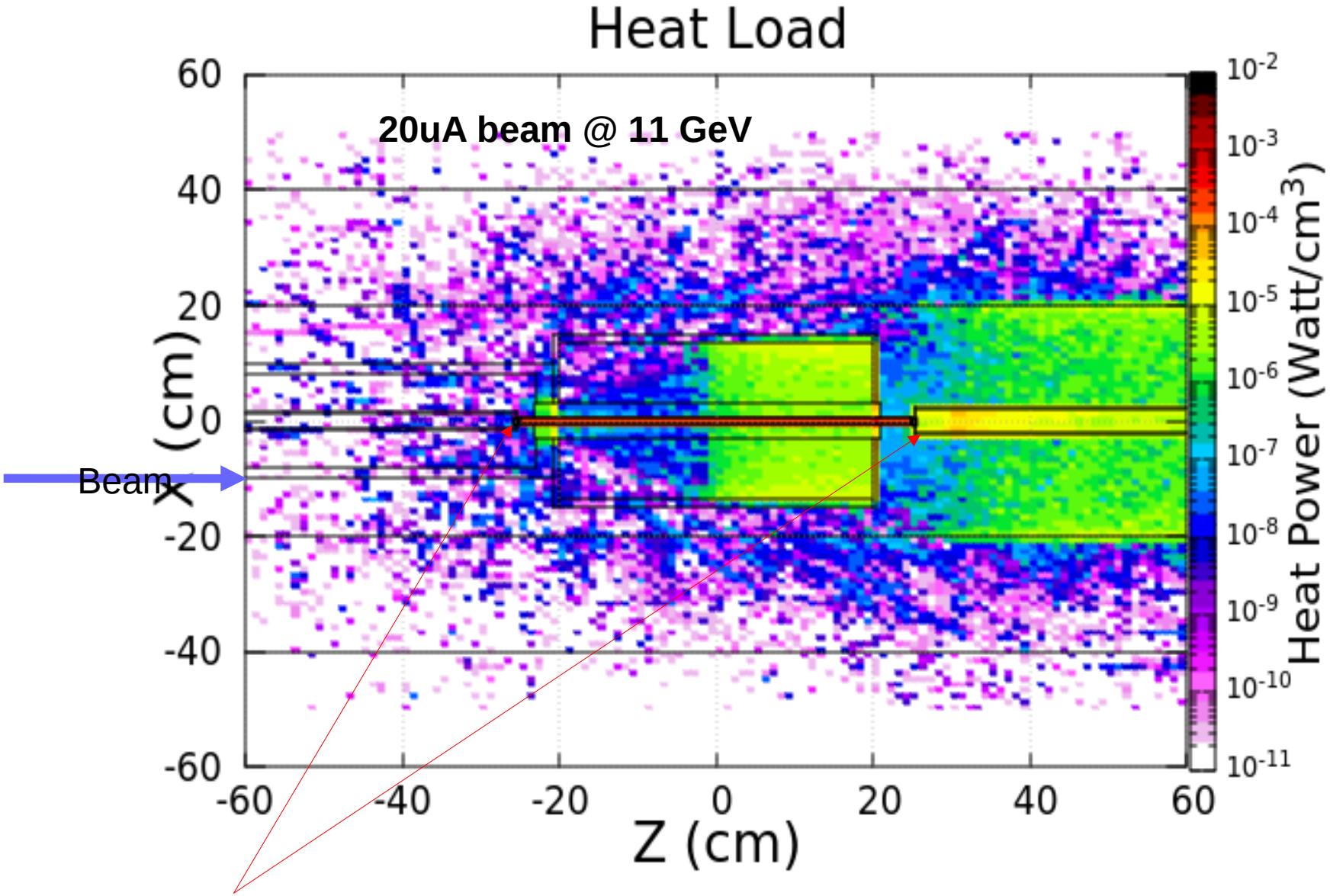
Luminosity = 2.0E36

1) 20 nA e- beam
2) 300k 7.5 ATM D2 gaseous target
3) 20 PAC days

MTPC Geometry

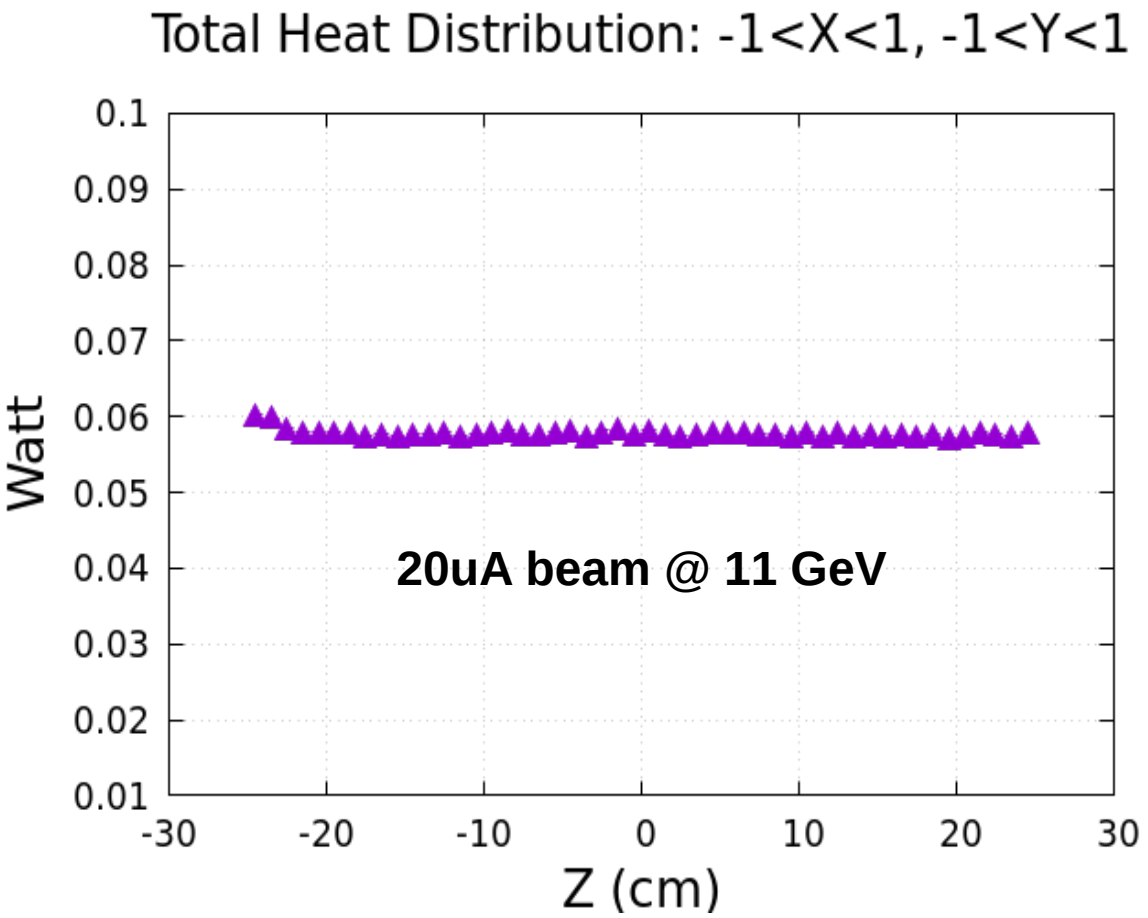


Energy Deposited in mTPC



Most heat will be deposited at the two end caps of the target straw

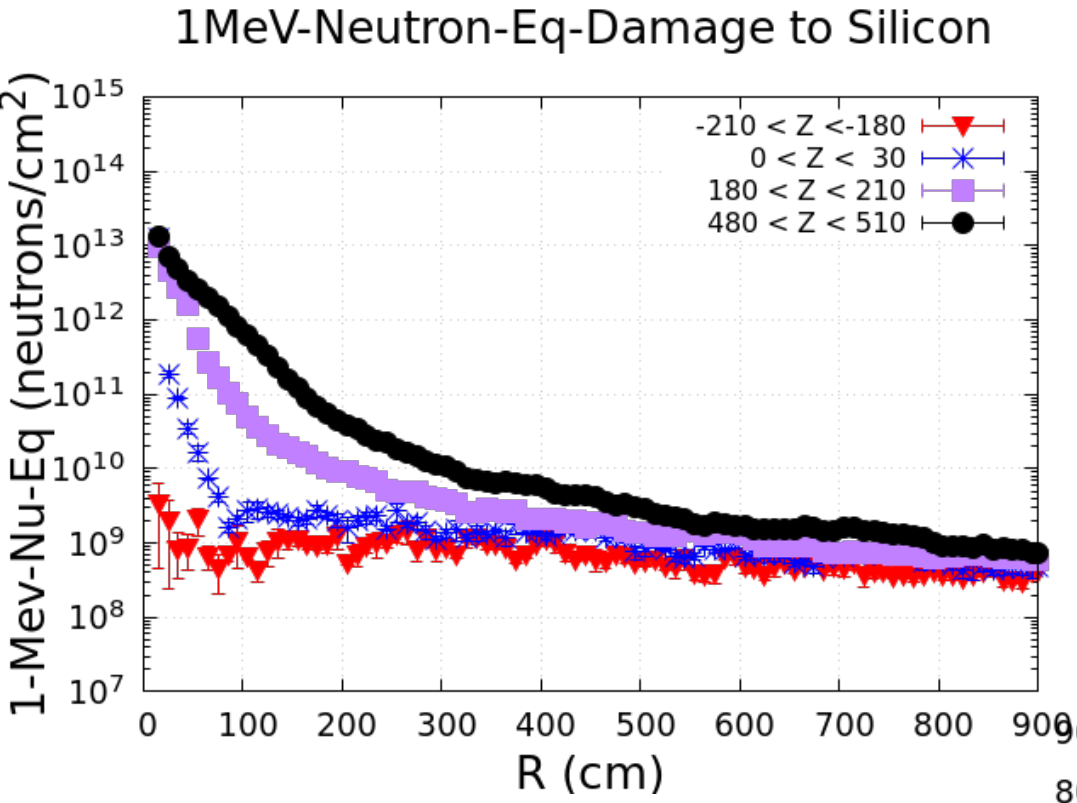
Heat Load in Target Straw

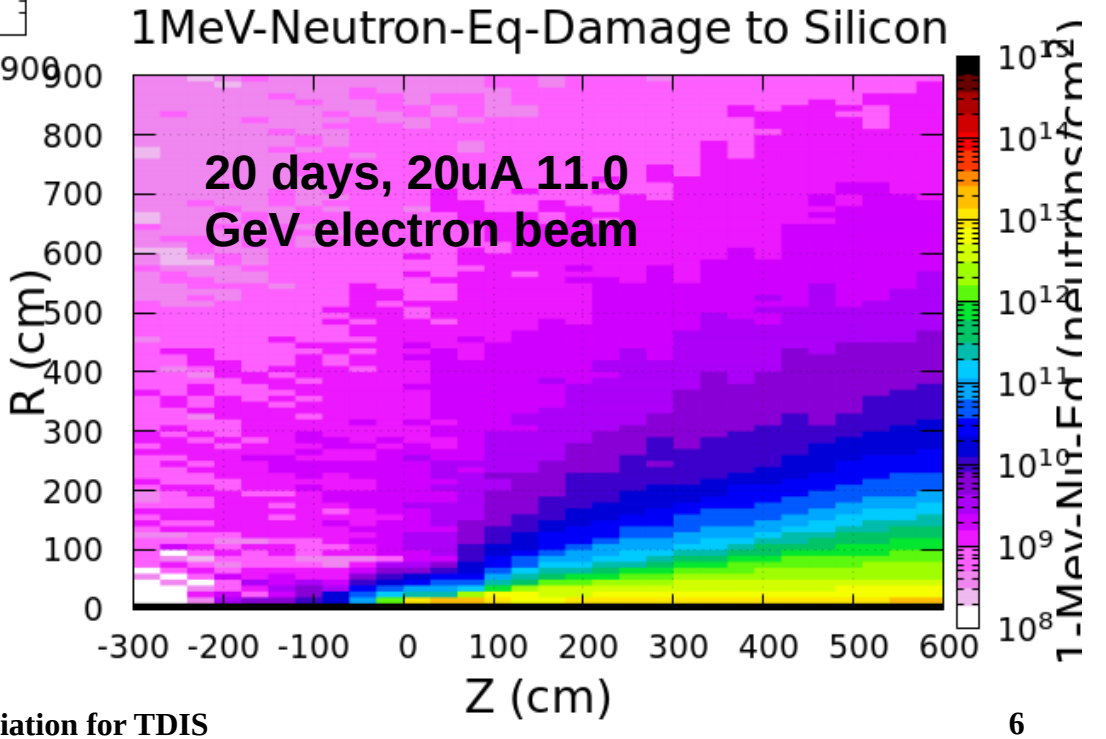


Conclusion:

The total heat power in target (include target wall) is 0.06 x 40 = 2.4 watt

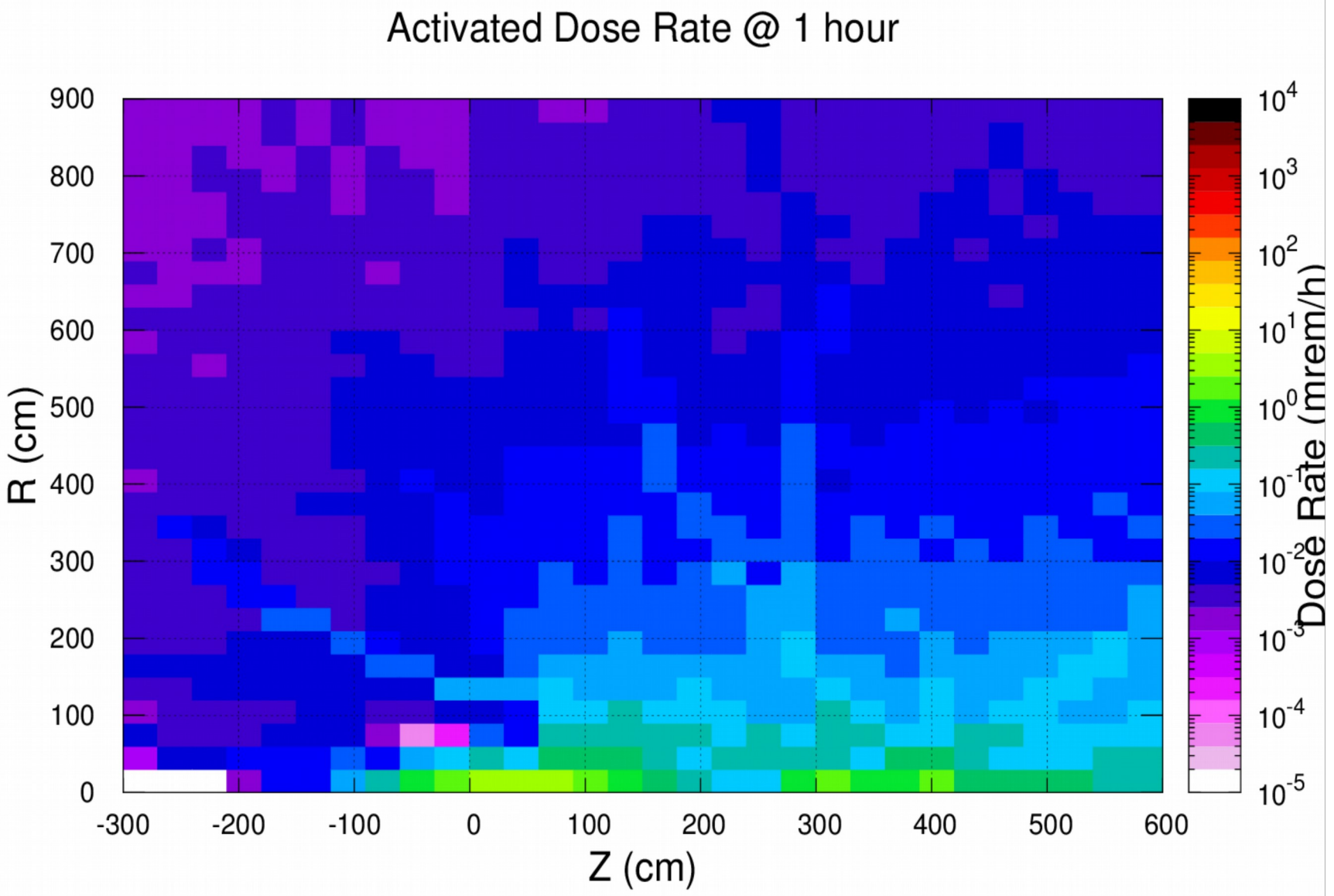
Accumulated Damage to Silicon



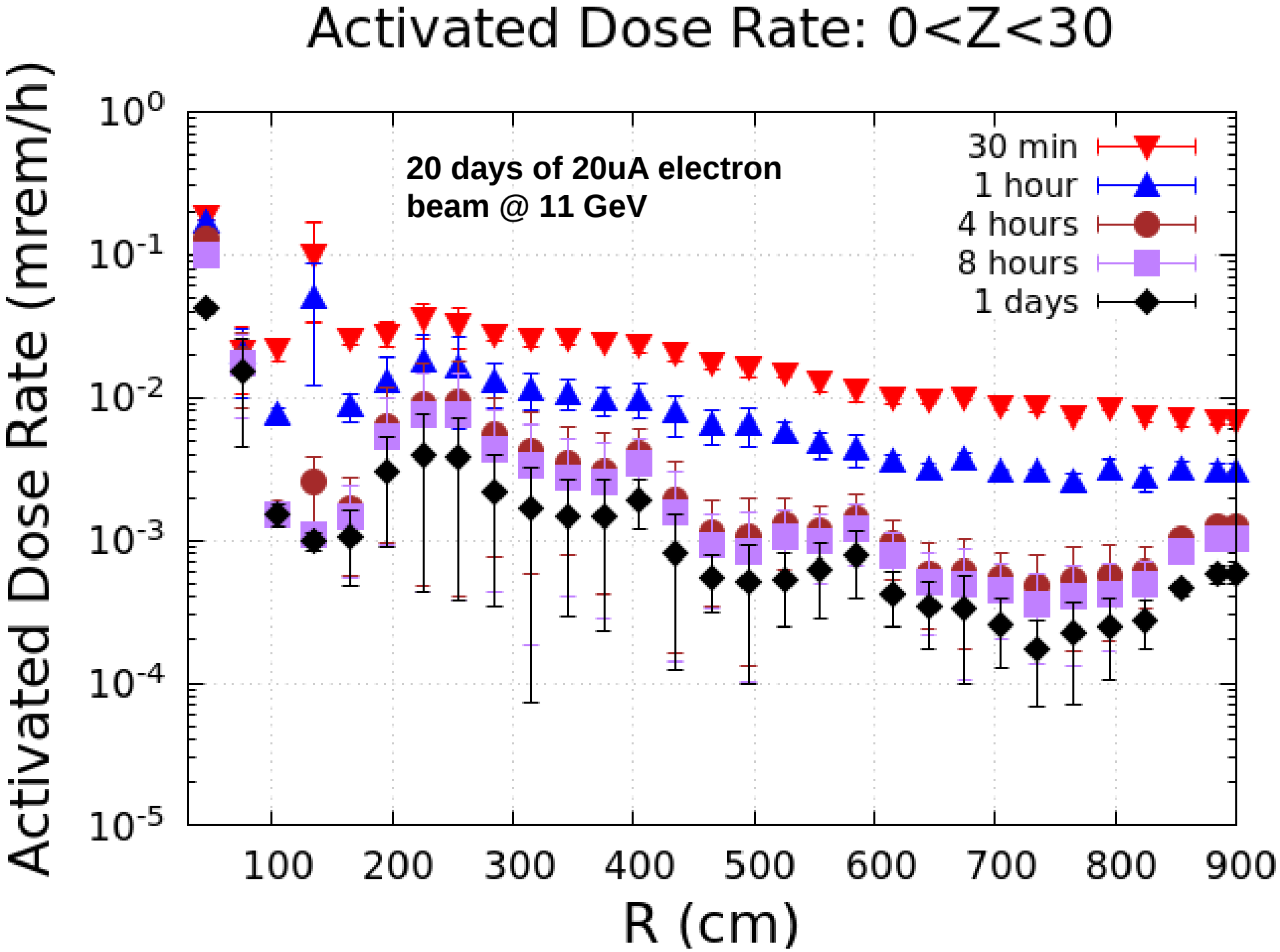


Conclusion:
It is safe to place detector at any location upstream, but not downstream with R<30 cm.

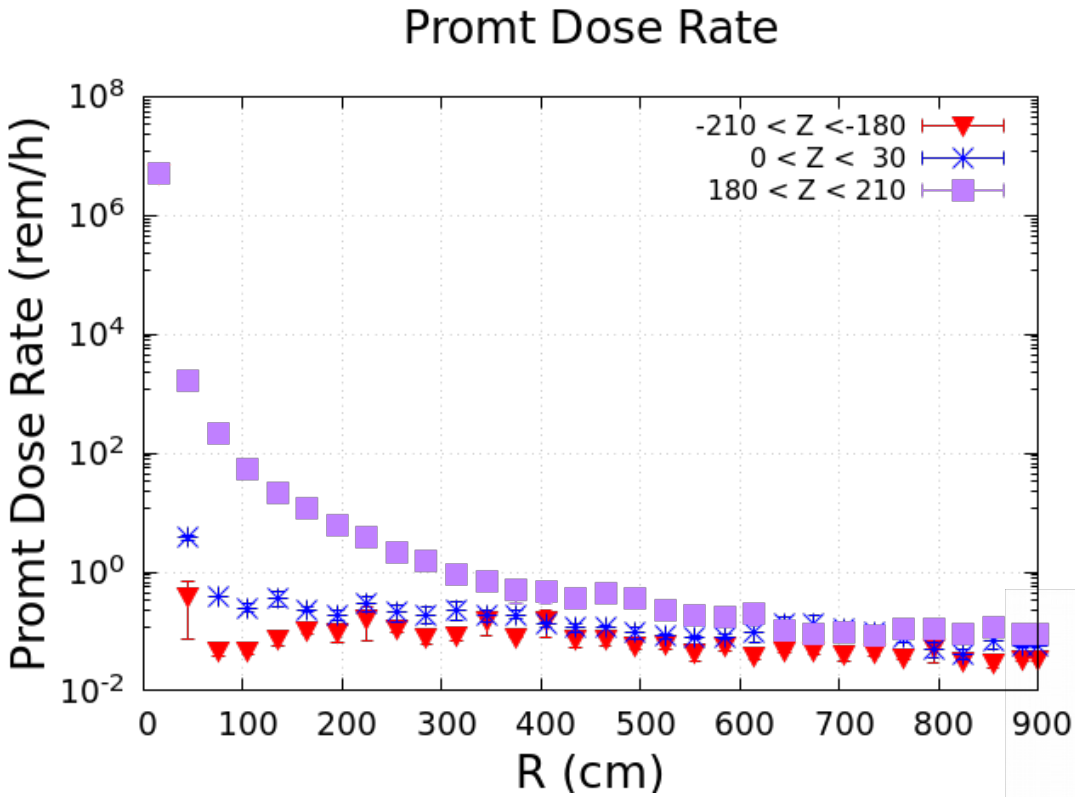
Activation Map @ 1 hour (2D)

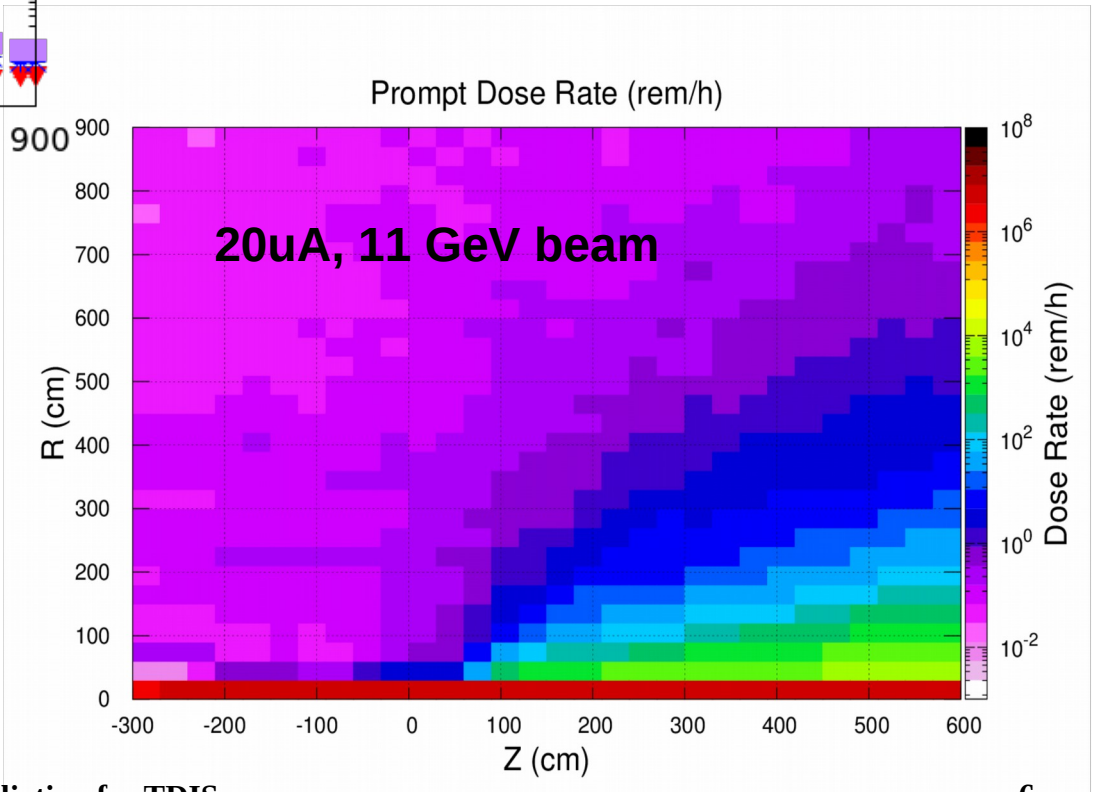


20 days, 20uA electron beam @ 11 GeV


Activated Dose Rate: 0<Z<30
Activated Dose Rate (mrem/h)
R (cm)
20 days of 20uA electron beam @ 11 GeV
30 min
1 hour
4 hours
8 hours
1 days
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
100
200
300
400
500
600
700
800
900

Prompt Dose Rate





Conclusion:
It is safe to place detector at any location upstream, but not downstream with R<30 cm.

Summary

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

2) The accumulated 1MeV neutron equivalent damage to silicon for upstream is less than 3x10^11. It is very safe to place electronics upstream of the target. But it is not safe for R<30 cm downstream.

3) Heat load density in the whole target straw is about 2.4 watt.

4) Dose rate from activation after beam is shut down for 1 hour:
 at target area (R<30cm) is about ~3 mrem/h, less than 0.1 mrem/h for R> 100 cm, where R is the distance from beam line.