Potential PNS Setup for ProtoDUNE II

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PNS Working Group Meeting

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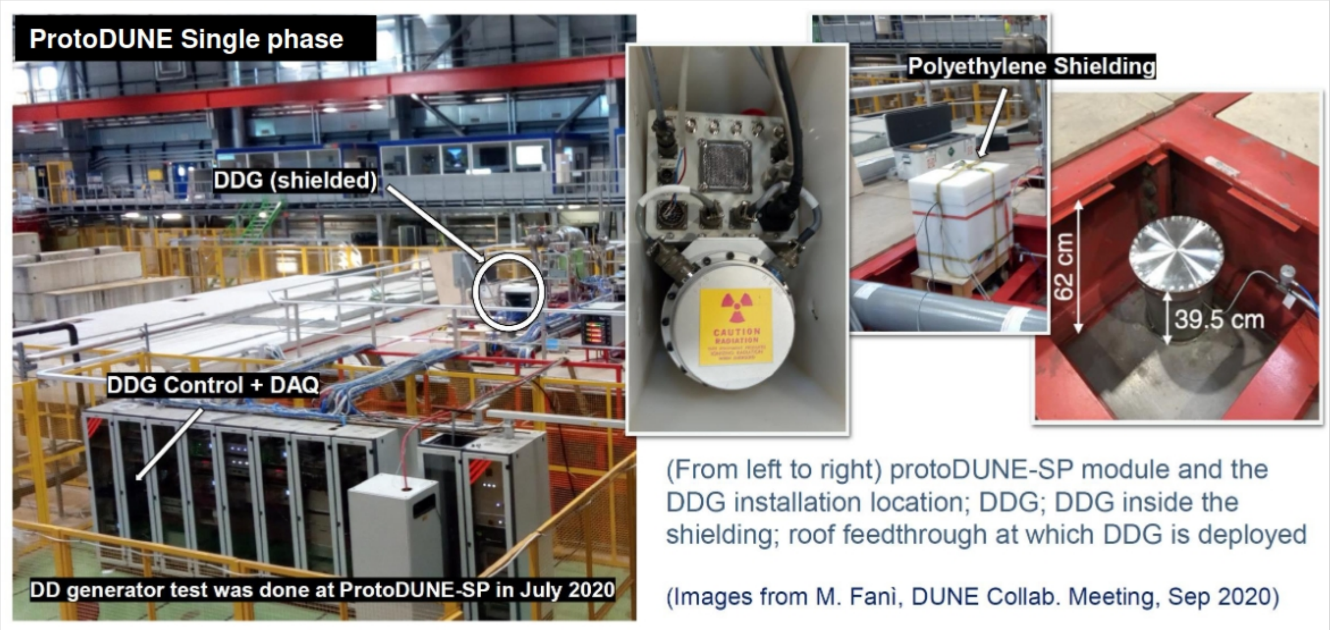
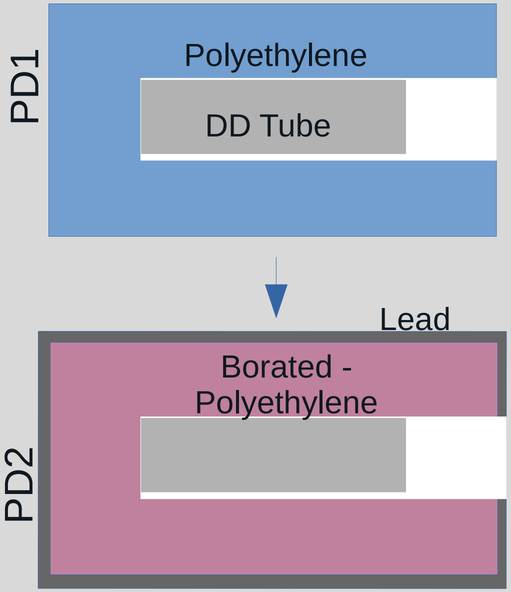
Reminder: ProtoDUNE I PNS Limitations

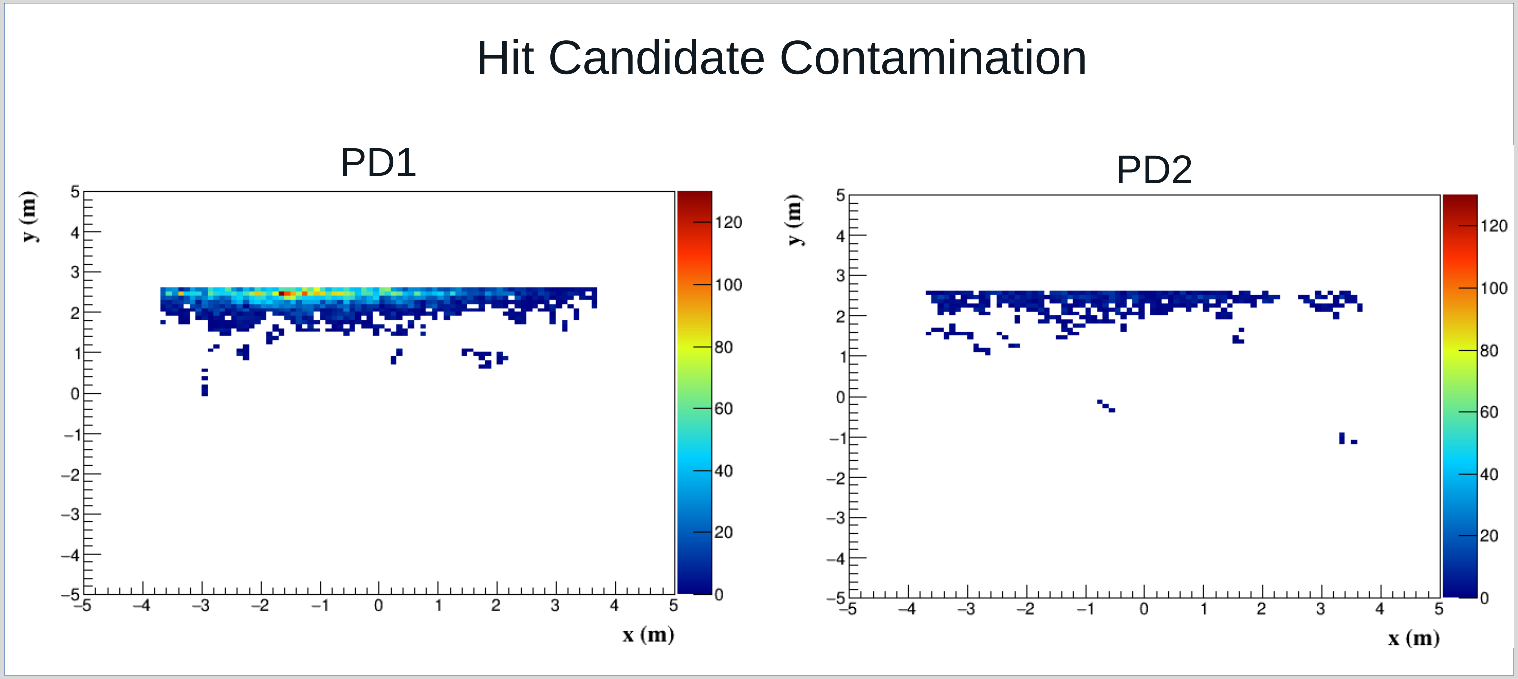
- DD Generator was placed on top of a ‘feedthrough’ type cryostat penetration
- DD generator was not capable of pulsing at the < 1hz required by the DAQ
  - Minimum operating frequency of 250hz
- A 15 cm polyethylene neutron shield was used
  - No gamma shield was in place



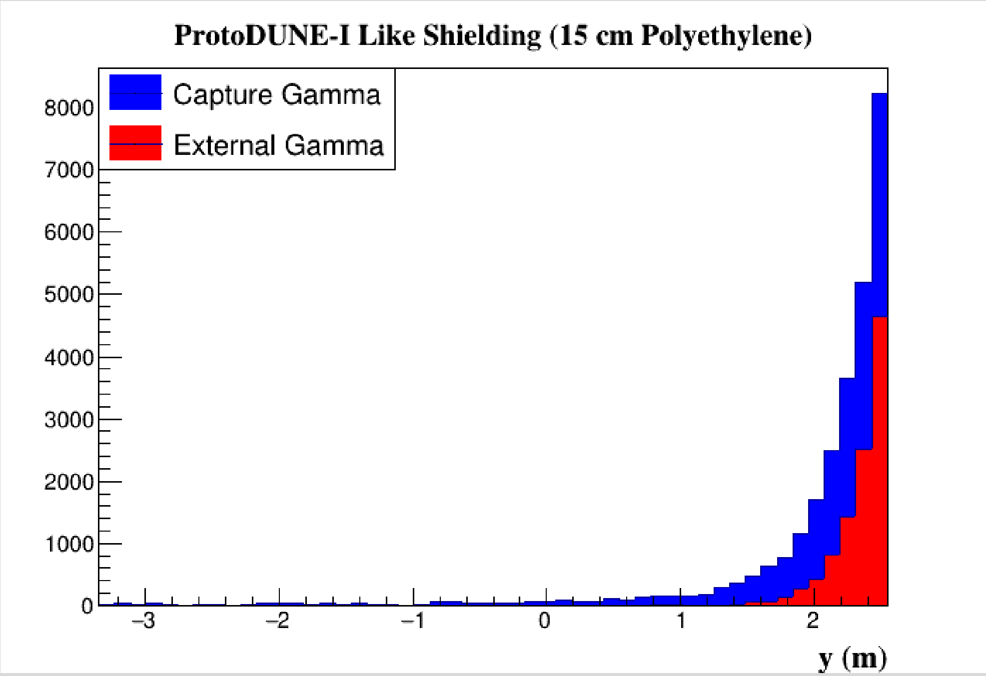
External Gamma Contamination

- Our simulations show a significant amount of external gammas in the active TPC
- This can be reduced by using borated-polyethylene, and including a lead gamma shield in the PNS design

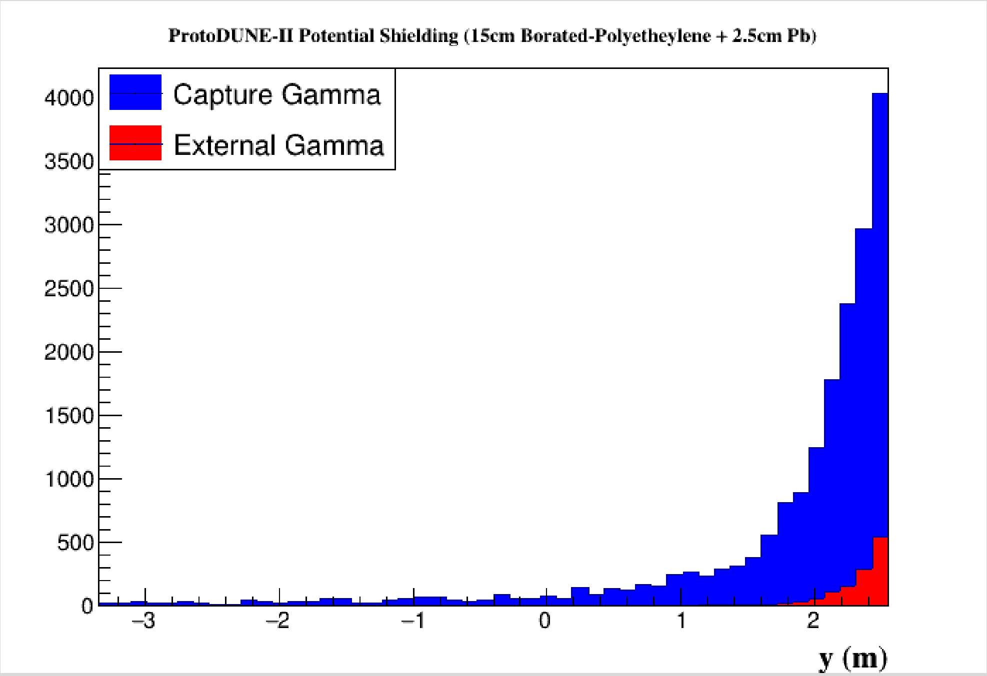




Hit Candidate Positions by Gamma Origin



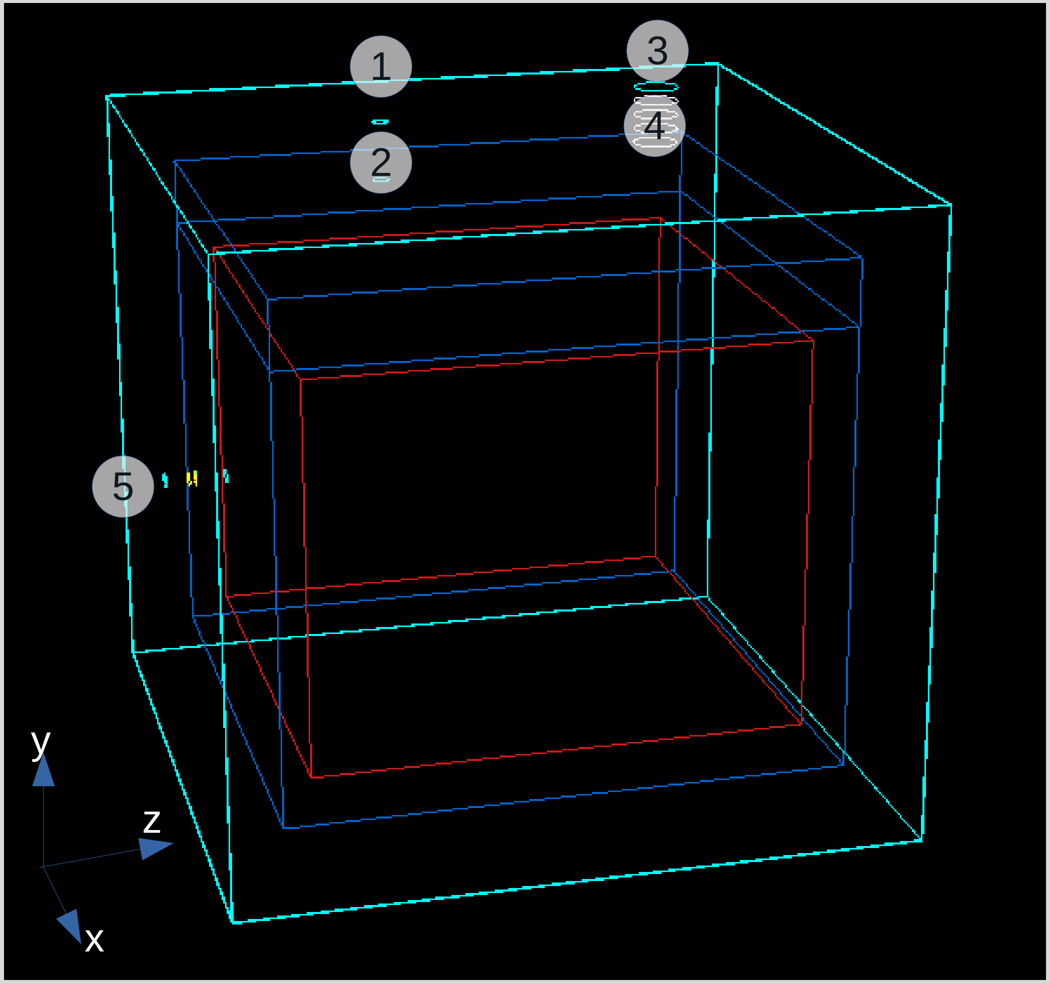
Hit Candidate Contamination: **38.8%**



Hit Candidate Contamination: **6.91%**

Location Change

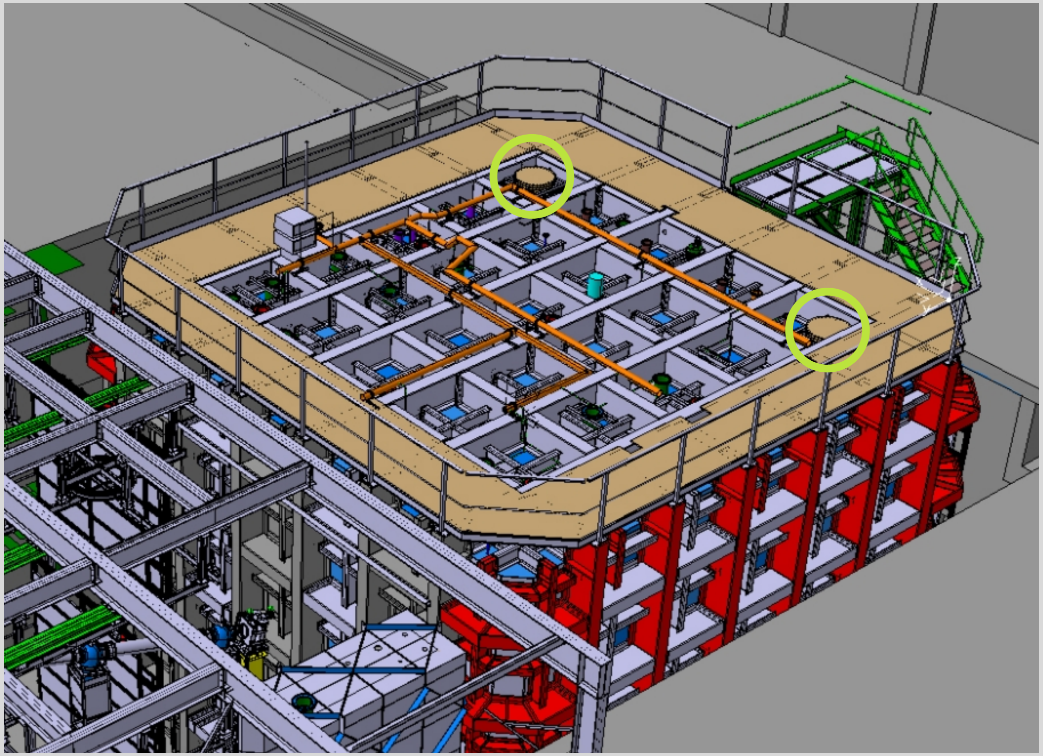
- Five potential locations to compare
  1) On top of feedthrough (PDI-like)
  2) Inside of feedthrough
  3) On top of manhole
  4) Inside manhole
  5) Beam plug



Feedthrough

- The feedthrough cryostat penetrations have a stainless steel pipe that extends 39.5 cm from the cryostat membrane
- The diameter of the opening is 25 cm
- Is it possible to place the DD tube into the feedthrough?
  - Need insulation; the DD generator cannot operate under -20°C
  - Small radius does not permit shielding

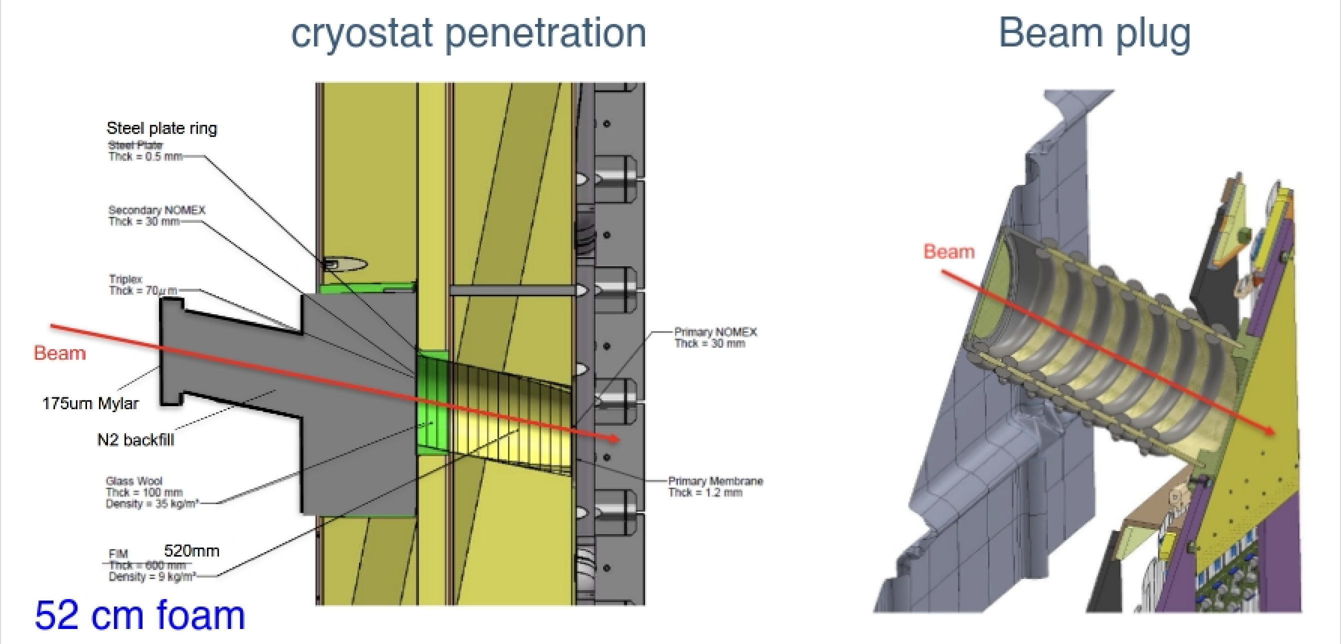
Manhole



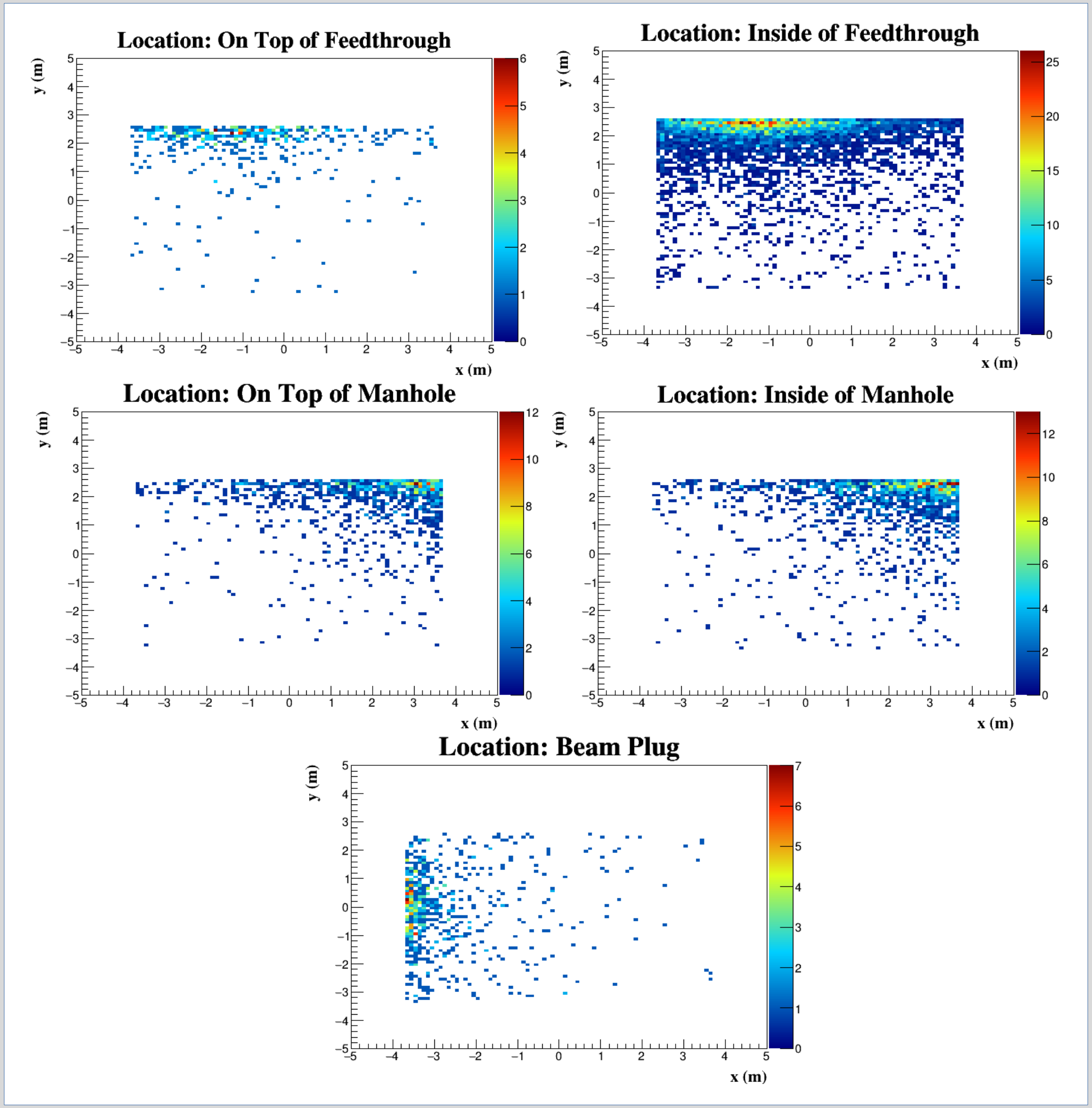
- The manhole cryostat penetrations have a much larger diameter of 71 cm
- The DD Generator can be placed on top of the manhole flange
- We have begun discussions about the possibility of placing the generator inside the manhole and using a vacuum chamber for insulation
  - Plenty of room to construct shielding around the source

Beam Plug

- Located on the side of the detector unlike the other cryostat penetrations discussed
- Uses a beam plug to bypass the liquid argon buffer

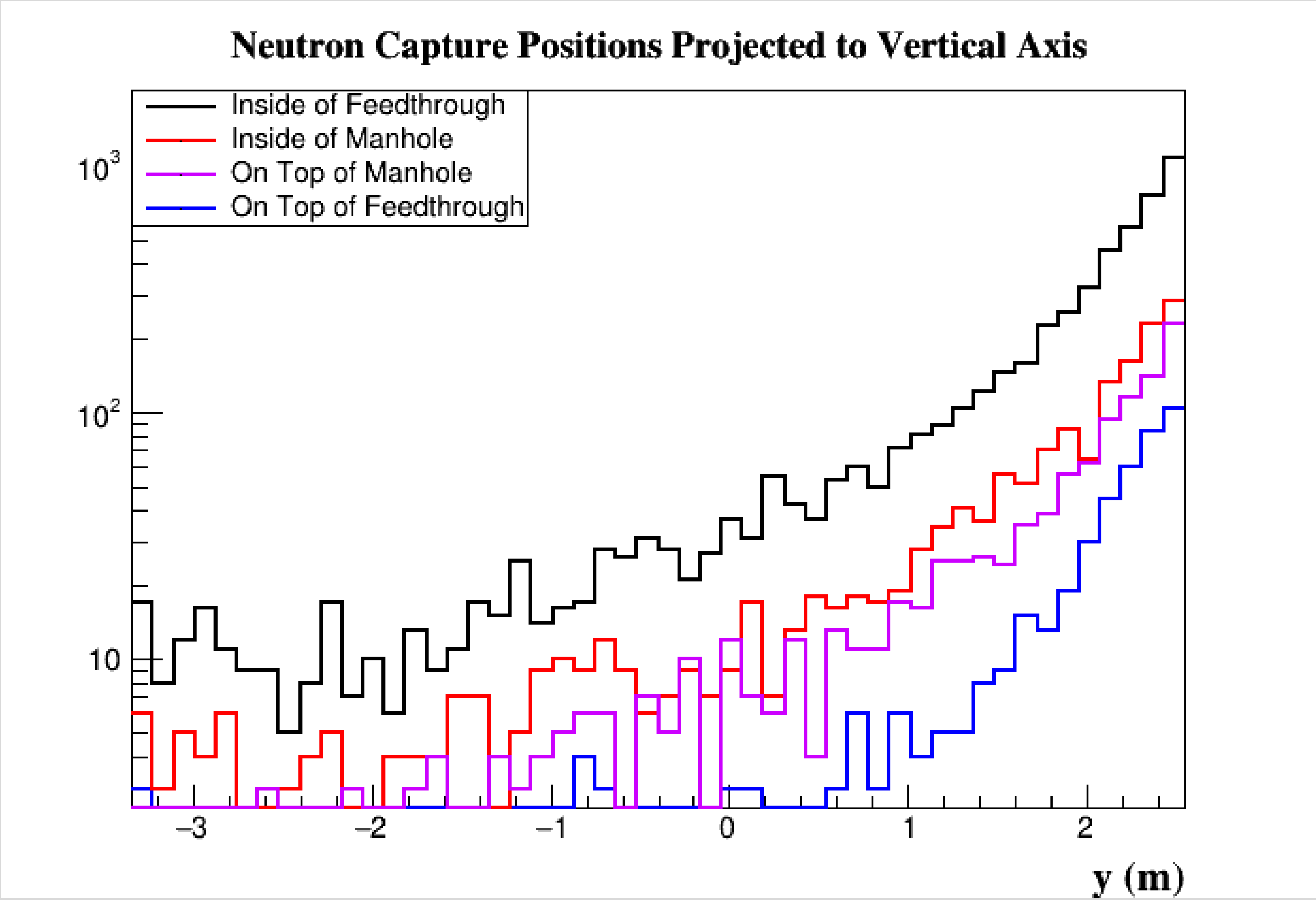


Neutron Captures In Active TPC



- Positions of neutron captures in the active volume projected to the x-y plane
- Total number of neutron captures in the active volume is counted
- Capture yield is the number of neutrons captured in the active volume divided by the number of neutrons produced (10^5 in these simulations)

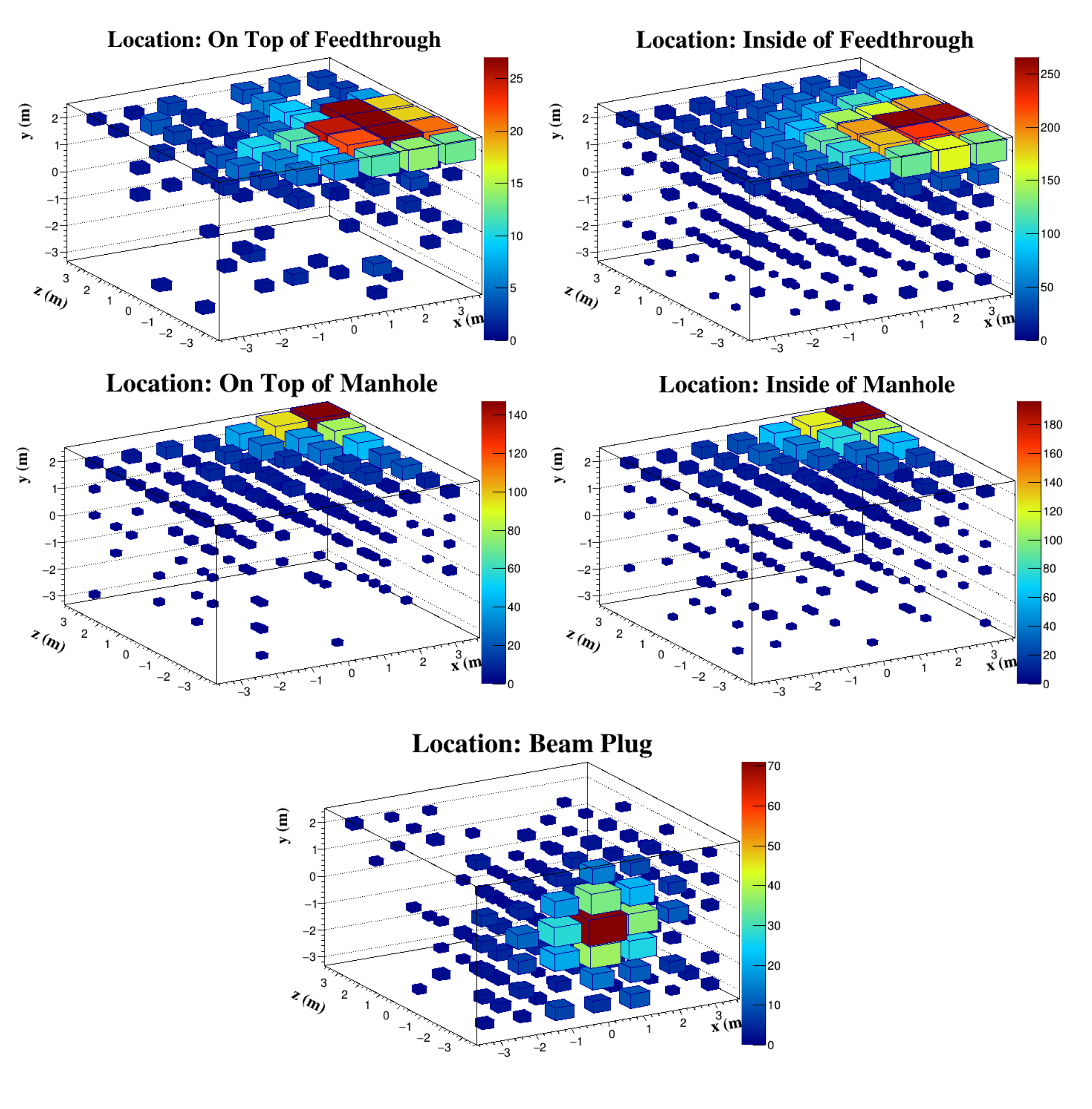
Location	Capture Yield
On Top of Feedthrough	0.470%
Inside of Feedthrough	5.217%
On Top of Manhole	1.065%
Inside of Manhole	1.560%
Beamplug	0.675%


Neutron Capture Positions Projected to Vertical Axis
Inside of Feedthrough
Inside of Manhole
On Top of Manhole
On Top of Feedthrough
10^3
10^2
10
−3
−2
−1
0
1
2
y (m)

Coverage Comparison

- The active TPC is divided into ~1m x 1m x 1m voxels, presented as 3d histogram bins
- The number of voxels with at least one neutron capture is counted
- Coverage is the percentage of voxels containing at least one neutron capture

Location	Voxels With Captures	Coverage
On Top of Feedthrough	106	36.1%
Inside of Feedthrough	269	91.5%
On Top of Manhole	161	54.8%
Inside of Manhole	186	63.3%
Beamplug	150	51.0%



Preferred PDII Setup

- Any of the following three locations provide significant improvements in capture yield and coverage over the feedthrough location
  - On top of the manhole
  - Inside of the manhole
  - Inside of the feedthrough
- Where shielding is permitted using the borated-polyethelyne and lead design reduces the hit candidate contamination significantly (~ a factor of 5)
- Choice of location will depend on what is available, as well as our ability to control the temperature within the cryostat penetrations

Next Steps

Further develop the simulations (energy deposition of external vs. capture gammas)

↓

Receive the DD generator & setup the neutron source lab

↓

Have necessary modifications done to the DD generator by the manufacturer

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Test external triggering, and perform dose rate measurements

↓

Optimize the generator setup for the preffered location

Questions & Comments