Simulation Results on Cryostat with Neutron Absorbing Materials & Geometry Validation

DUNE Background Task Force Meeting
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Outline

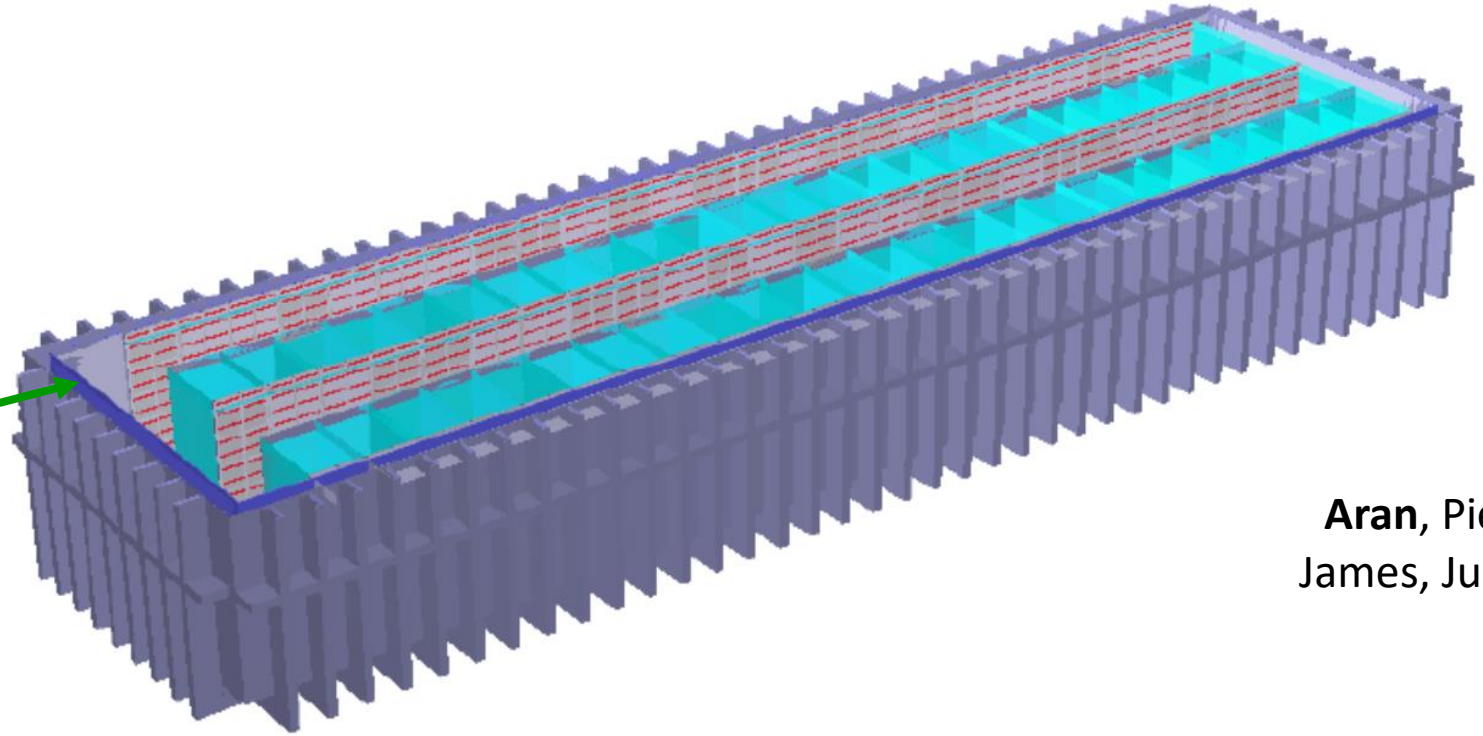
- Reducing neutron backgrounds
- Geometry and simulation
- Previous results
- Changes to geometry and simulation
- Results for all configurations
- Conclusions

Reducing neutron backgrounds

- External neutrons are largest background to low-energy searches
- Juergen suggested shielding from neutrons by adding neutron absorbers to structures around detector
- Here we simulate effect of that

Full DUNE 10-kt geometry

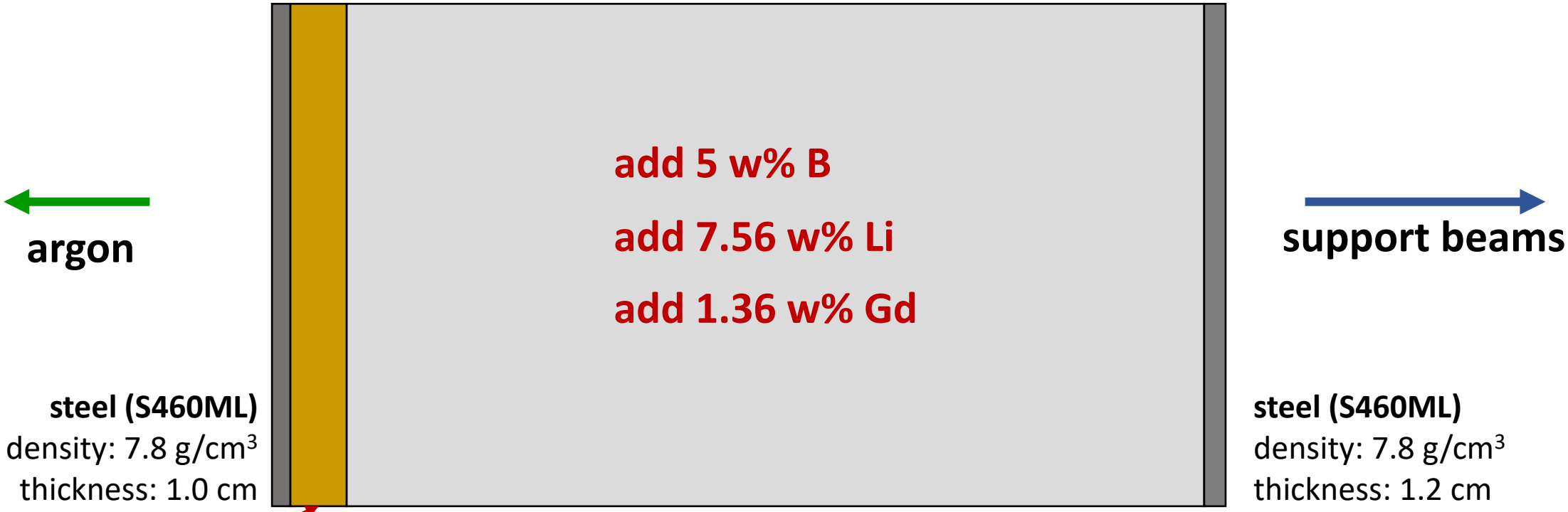
Adding neutron absorbers here



Aran, Pierre, James, Juergen

DUNE cryostat in LArSoft

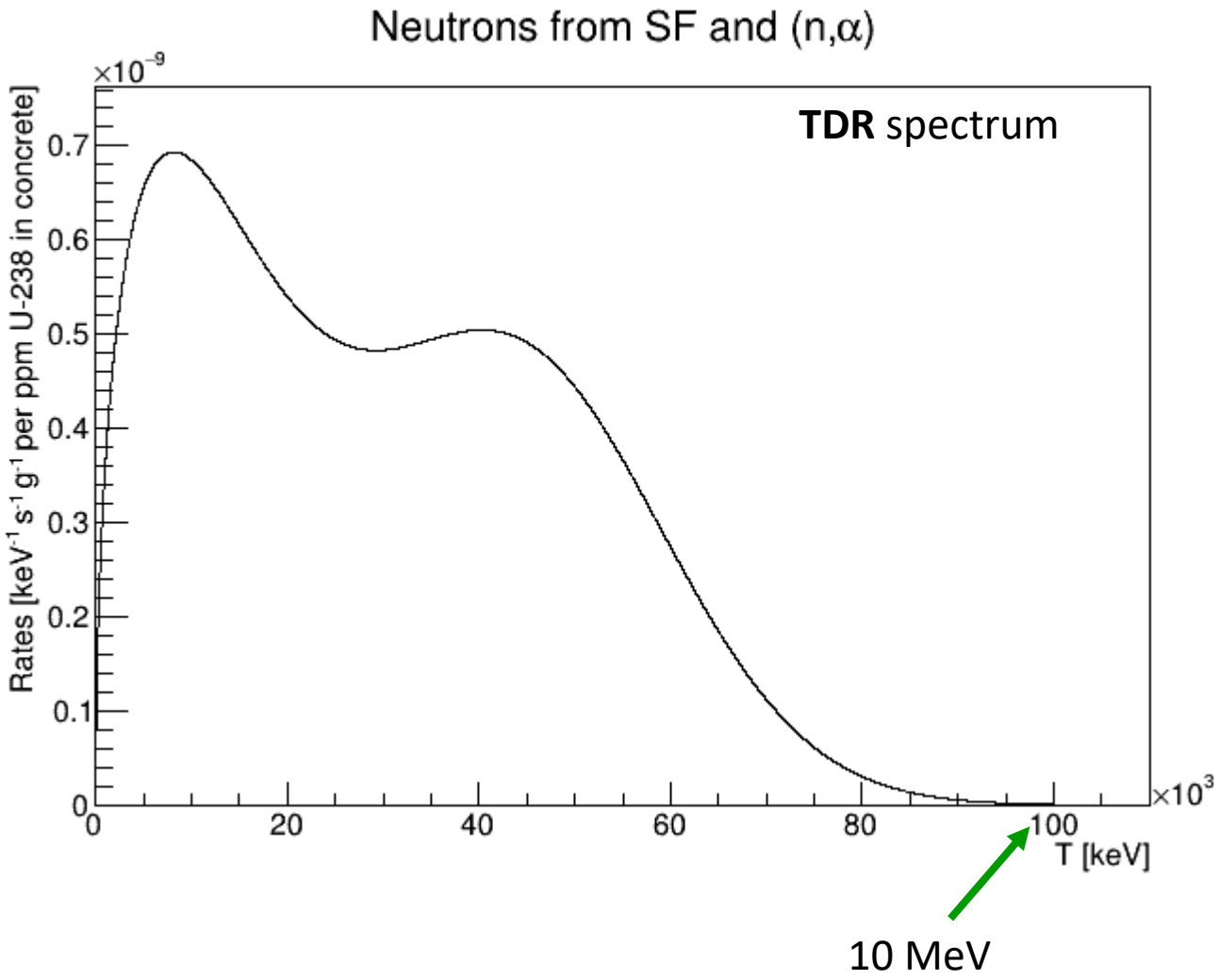
Neutron absorbers in DUNE cryostat



one per geometry

Simulation

- Full far-detector geometry
  - With different additions
  - DUNETPC v08_60_00
- Neutrons from 1-cm slabs around cryostat
- 10,000 events
- Look at first particles in detector that produce hits (eves)



Previous results

geometry	particles entering TPC
standard	584
5 w% B in PU foam	270
7.56 w% Li in PU foam	253
1.36 w% Gd in PU foam	1,125
replace wood with 7.56 w% Li in PE	0 (?)

Loading foam with B and Li reduces N particles

nothing gets inside detector

0 particles in simulation

- Several of following geometries included to understand this result
- Rerunning simulation produced 401 particles
- Reanalyzing existing simulation (96/100 files) resulted in 380 particles
  - Likely problem with copying files from dCache

New (old) geometry cryostat

argon

support beams

SS304L (S460ML) steel
density: 8.0 (7.8) g/cm^3
thickness: 0.12 (1.0) cm

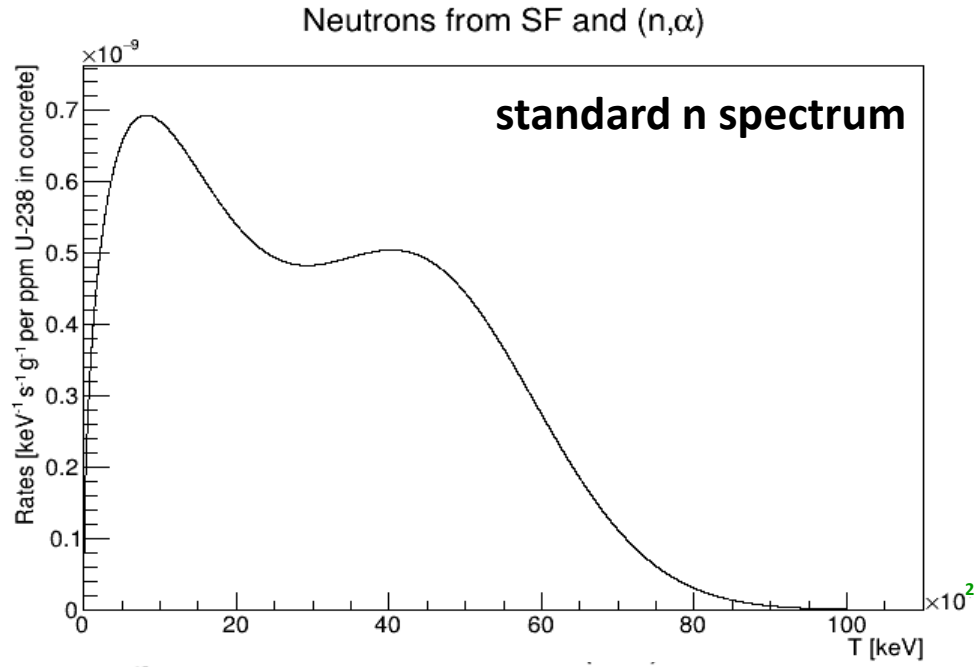
S460ML steel
density: 7.85 (7.8) g/cm^3
thickness: 1.2 cm

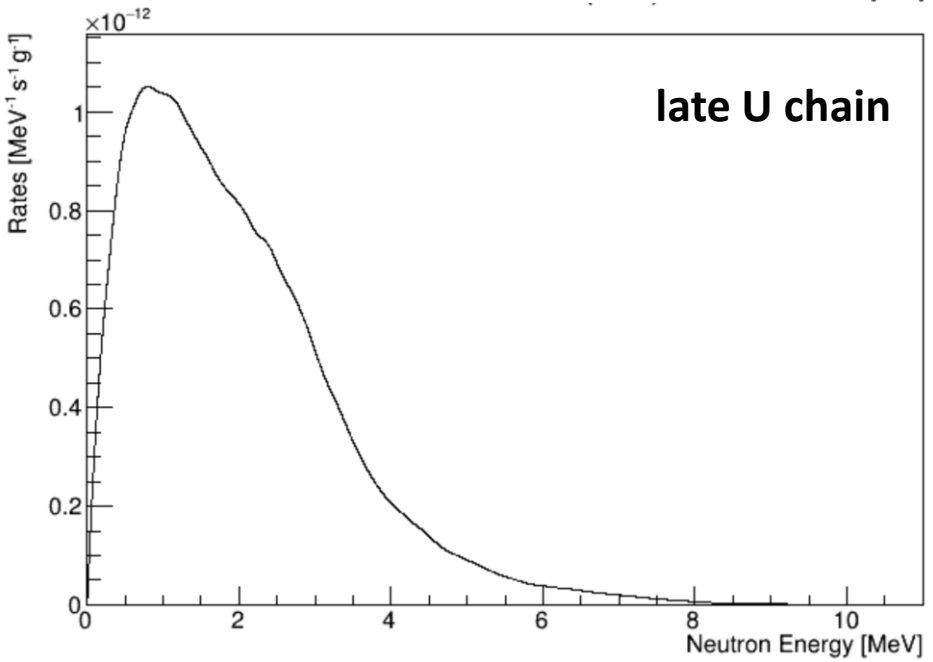
wood
density: 0.5 (0.54591) g/cm^3
thickness: 2.4 (4.5) cm
C:50, O:44, H:6 (C:6, O:5, H:10)

polyurethane foam
density: 0.09 (0.13) g/cm^3
thickness: 77.48 (74.5) cm

Neutron spectrum

- Neutron spectrum used is too high energy
  - Expect more neutrons to get inside
- Expect neutrons closer to late U chain spectrum
  - Included in simulation





Results for all configurations

geometry	particles entering TPC			
	standard n spectrum		late U chain	
	old geometry	new geometry	old geometry	new geometry
standard	584	1,268	521	1,078
5 w% B in PU foam	270			
7.56 w% Li in PU foam	253			
1.36 w% Gd in PU foam	1,125			
replace wood with PE	453	848		
replace wood with 7.56 w% Li in PE	401	608		
replace wood with 7.56 w% Li in PE (2**x**density)		508		
replace wood with 7.56 w% Li in PE, corrugation thickness**x**3		584		
replace wood with PE, add 2-mm lithium between PE and PUF		721		
replace wood with 30.0 w% B in PE		614		569

Results for all configurations

new geometry: ~2x particles
late U chain: ~0.9x particles
n absorbers: ~0.5x particles

geometry	particles entering TPC			
	standard n spectrum		late U chain	
	old geometry	new geometry	old geometry	new geometry
standard	584	1,268	521	1,078
5 w% B in PU foam	270			
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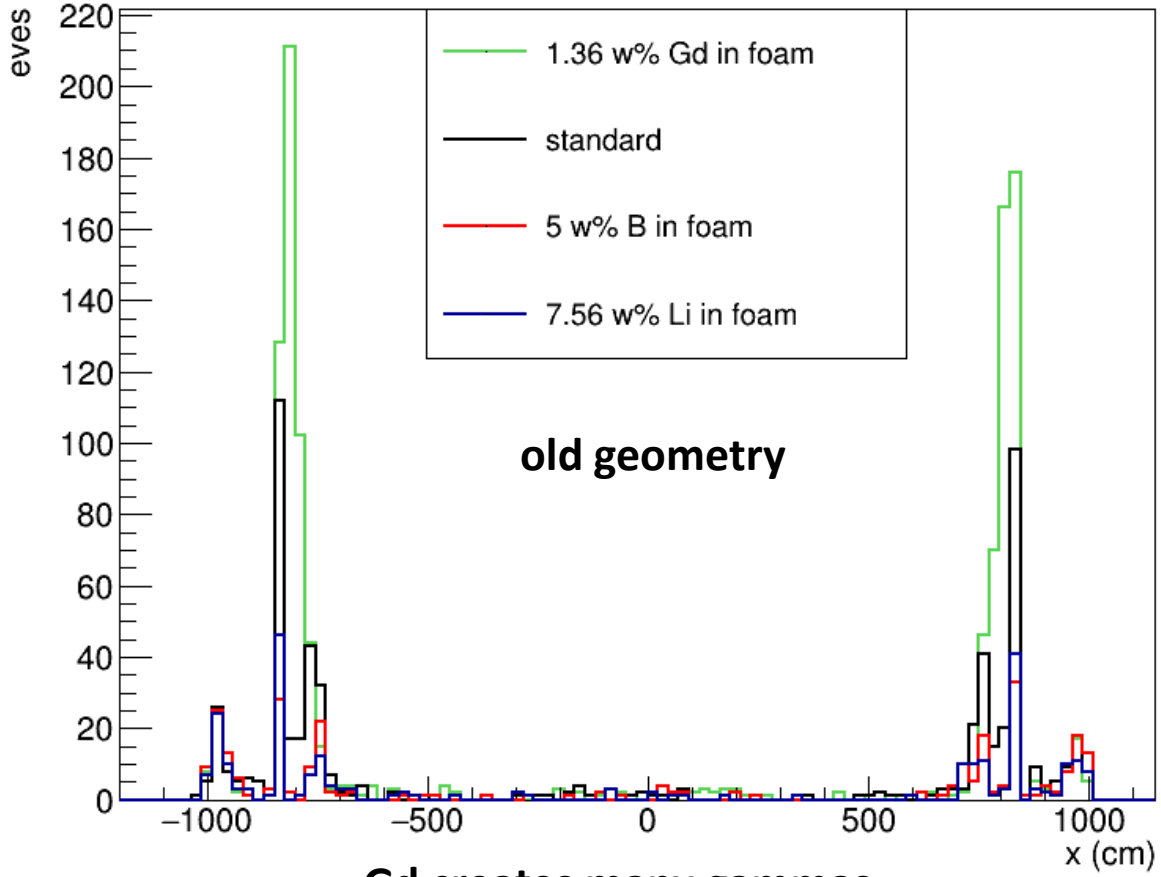
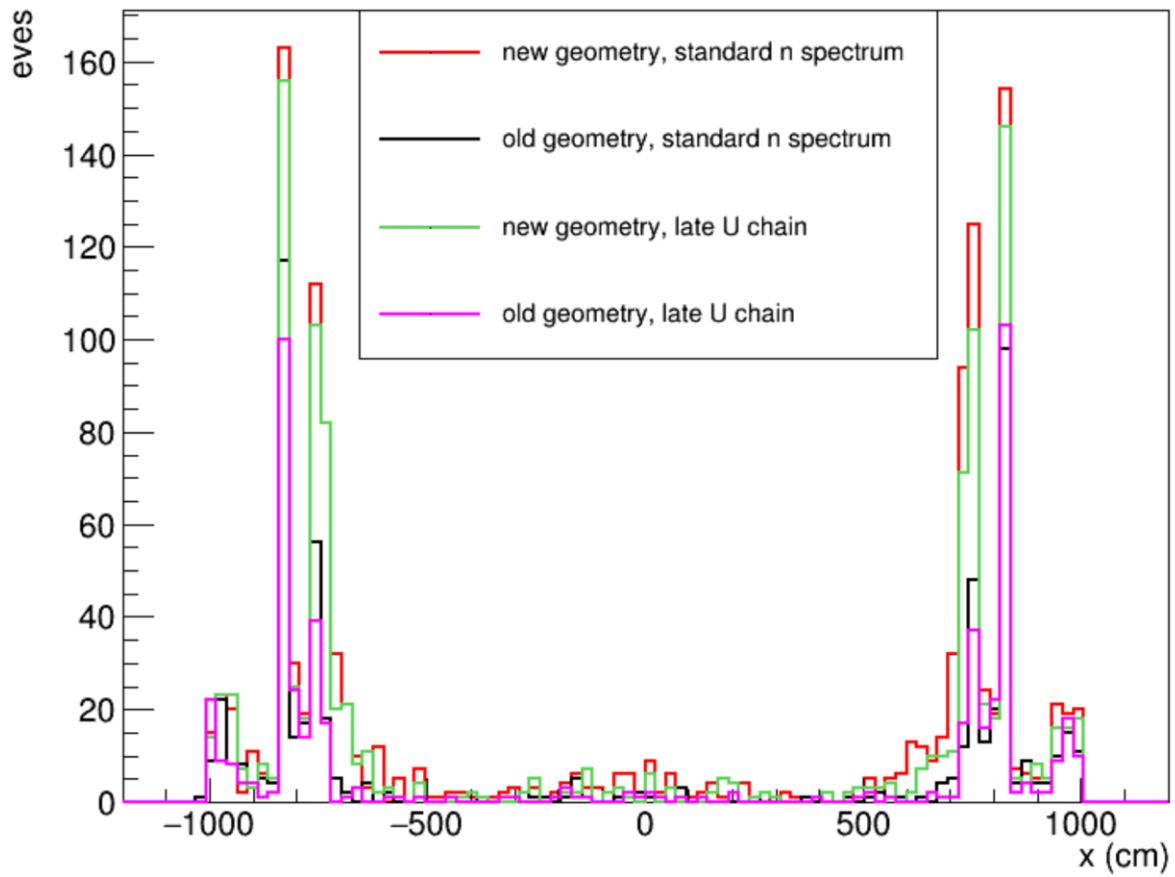
X origin of particles entering TPC



Gd creates many gammas
other absorbers reduce number of particles



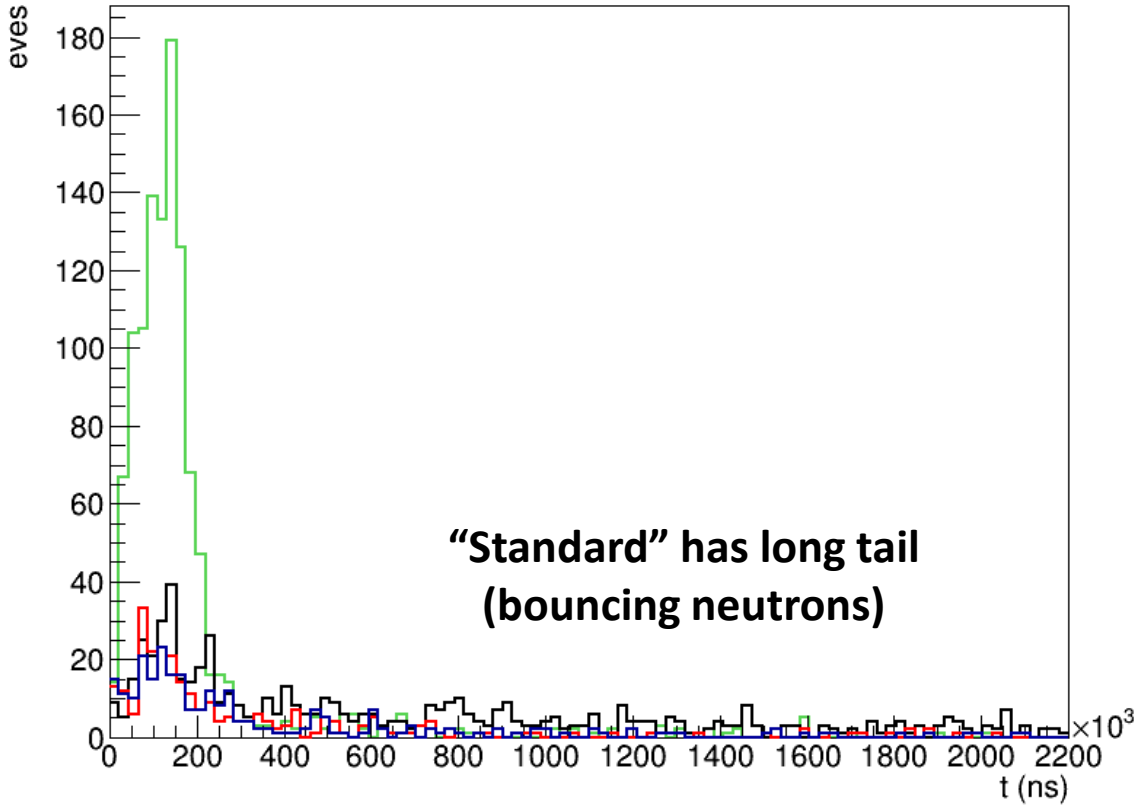
new geometry: particles created closer to TPC
late U chain: particles created further from TPC

Conclusions

- Adding neutron absorbers to infrastructure around detector looks promising for reducing backgrounds
  - Previous incredible result for Li-loaded polyethylene was erroneous
- More realistic geometry results in worse (~2x) backgrounds
- Expect more realistic n spectrum to improve backgrounds

Backup slides

Eve distributions



Loading foam with neutron absorbers significantly reduces number of neutrons entering detector but generates numerous gammas