Neutrons in LUX

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Outline

Previous LUX and LZ work on neutrons

Working towards an alpha, n pdf

      Bonus: initial work on neutron pdfs

How would we use an alpha, n pdf?

Predicting LUX run 4 neutron backgrounds

Which neutrons do we need to worry about?

LUX: Alpha, n from internal contamination of materials

 PMTs dominant (there is some B_2O_3)

 Titanium vessel subdominant

LUX: Alpha,n from Rn

 PTFE dominant

LZ: Similar to LUX, but also PMT bases, field shaping rings, more things outside of inner cryostat

Component	Material	Surface Area [m^2]	n/α (5.3 MeV)	(α,n) Production [n/day]
PMTs	Fe	2.4	6×10^{-7}	0.004
PTFE	CF$_2$	1.6	1×10^{-5}	0.04
Inner cryostat	Ti	6.4	7×10^{-9}	0.0001
Outer cryostat	Ti	11.3	7×10^{-9}	0.002
HDPE	CH$_2$	5.4	4×10^{-7}	0.006
Cu internals	Cu		–	–
Total				**0.05**

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Moving to a pdf: Neutrons from PMTs

Combined (a,n) & fission Spectrum

fPrimaryParEnergy_keV
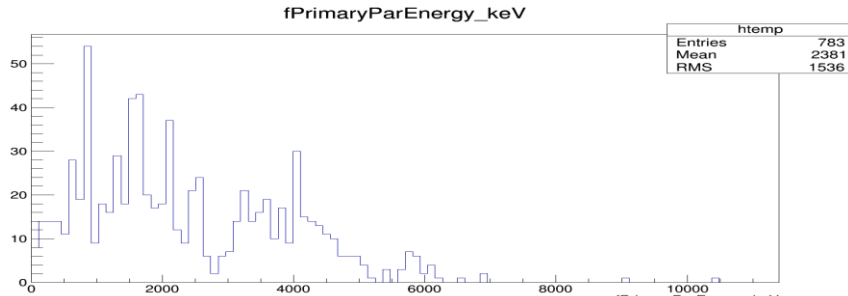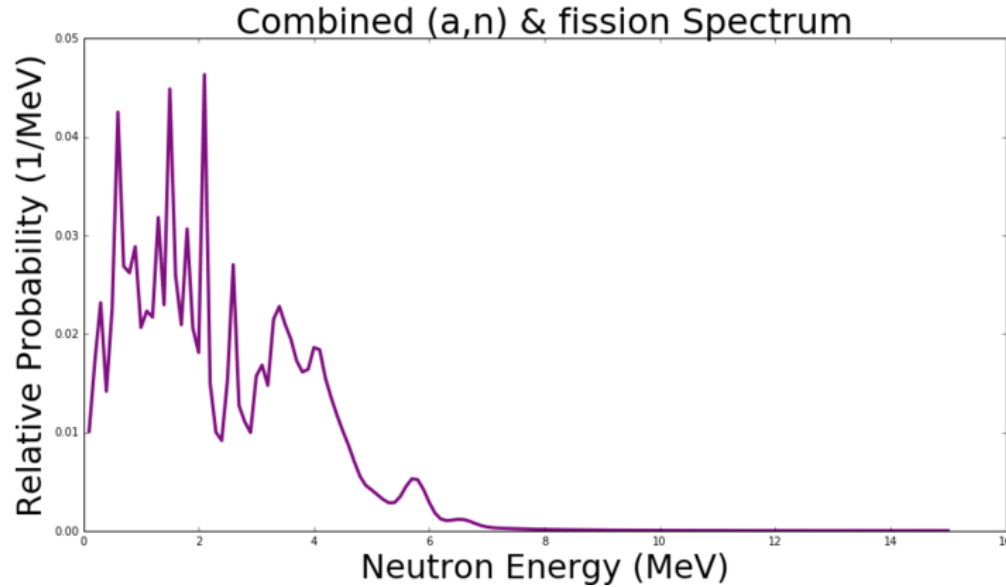
Macro 1: neutrons from PMTs

Summed spectrum of all PMT neutrons starting from PMT faces
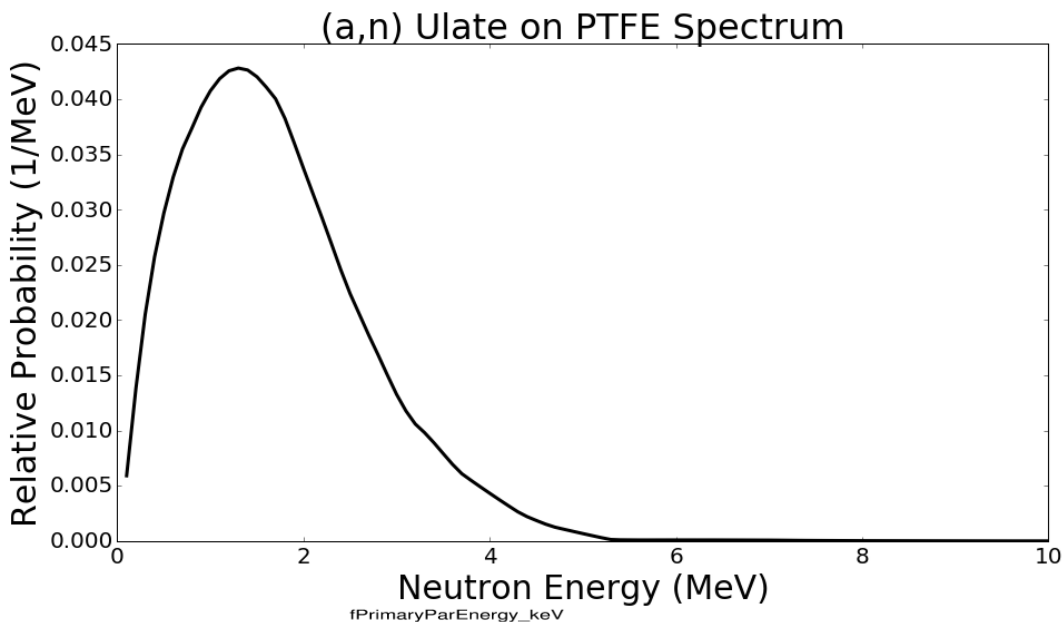
Used information from http://teacher.pas.rochester.edu:8080/wiki/pub/Lux/BackgroundMc/Malling_PMT_n_calcs.pdf to get these relative values

Used neutronyield.usd.edu + fission, assumes equilibrium of decay chains

Generally should cover neutrons

Moving to a pdf: Neutrons from PTFE
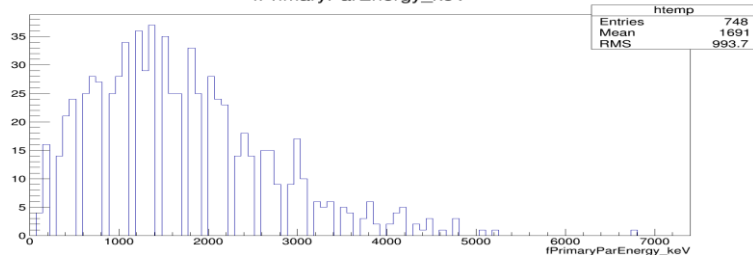

(a,n) Ulate on PTFE Spectrum

Macro 2: neutrons from PTFE

Neutrons from late chain for Rn

Used SOURCES 4C spectrum from LZ

Generally should cover neutrons coming from sides of detector

Moving to a pdf: Through simulations

Any open issues with macros?

> May not fully populate lowest energy events since neutrons are starting close to the detector, and those further away aren't directly simulated

Run energy deposition simulations

> Desire 100,000 golden events after fiducial cuts per Limits group

> But will start with whatever stats we can get

Run clustering code (slight mods on what already existed for other sims)

> Eliminate multiple scatters, esp inelastic scatters

Get S1 and S2 data from LibNEST and make pdf(s)

What do we do with a pdf?

Curt/Limits group tell us how much better our limit could be if this background were included, but also how many neutron backgrounds would be predicted

We included ^{8}B pdf at 0.15 events and if alpha,n neutrons are in the 0.1-0.3 event range then inclusion perhaps makes sense

Have to decide if this is in line with our predicted number of neutron events anyway

Additional analyses of multi-scatters?

Is this just for our knowledge/being able to answer questions during talks, or does it go into publication? (initial arXiv, vs journal submission)?

How many alpha, n neutrons would we predict?

Aaron's table

Background source	Expected number below NR median
External gamma rays	1.51 ± 0.19
Internal betas	1.2 ± 0.06
Rn plate out (wall background)	8.7 ± 3.5
Accidental S1-S2 coincidences	0.34 ± 0.10
Solar ^{8}B neutrinos (CNNS)	0.15 ± 0.02
Neutrons	0.3 ± 0.03

Older LUX predictions

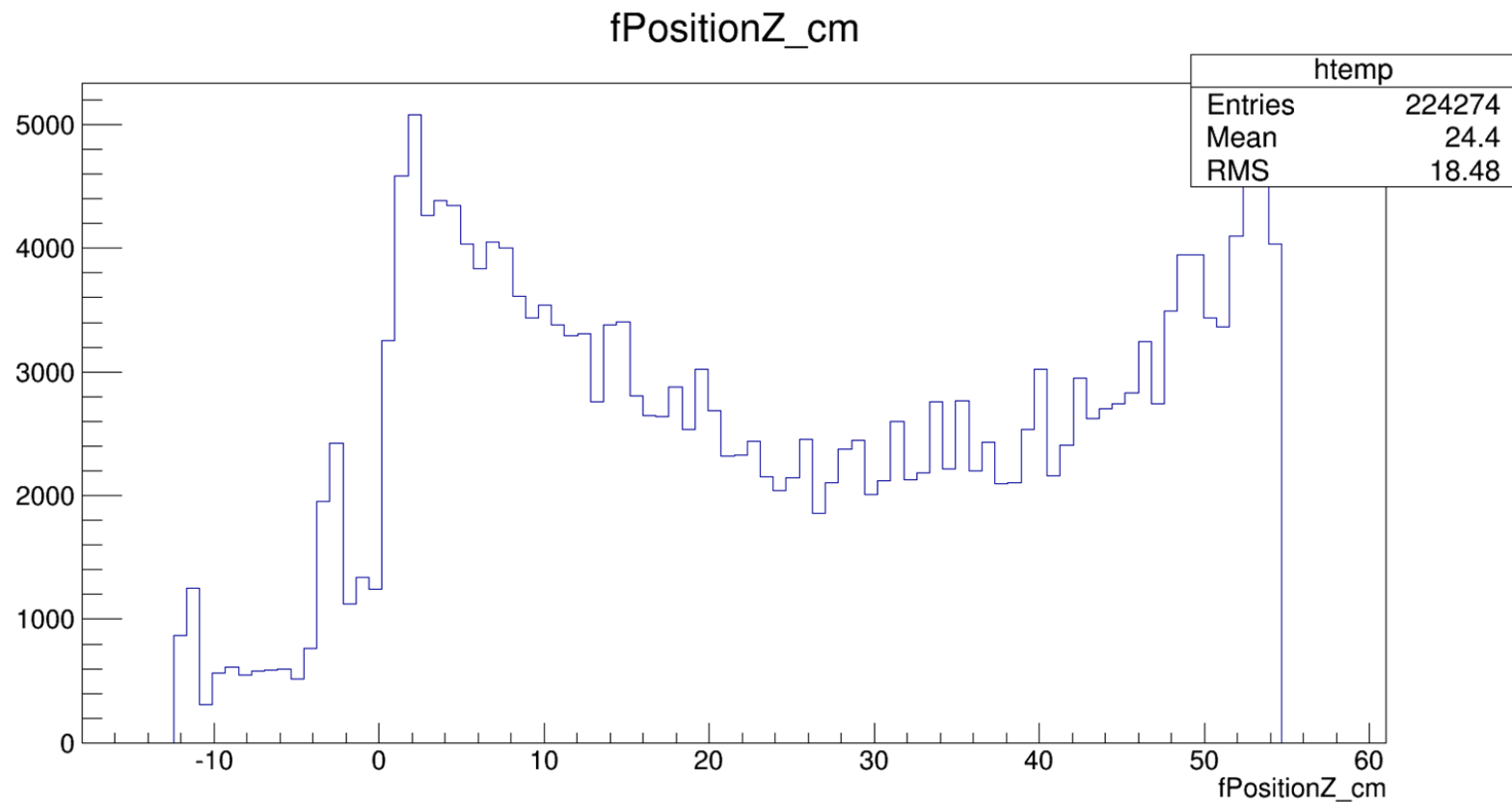Backgrounds paper https://arxiv.org/pdf/1403.1299v1.pdf

PMT neutron generation 1.2 n/PMT/ yr

3.4-25 keVnr, 118 kg, 85.3 livedays+ 0.06 single scatter events (only top and bottom PMT arrays)

1 year, 100 kg, predict 0.1, but upper limit <0.72 events

Tied to counting 13 MS to SS events

Just a look at the leakage from the PMTs in Z

Alpha-n Neutron PDF? (old slides from Sims call)

Kim + Shaun

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What would be needed?

Source spectra: incident alphas (from bulk U and Th, K chains or surface Rn) and the materials they impact (overall normalization not important)

From SOURCES or TALYS or in a hurry http://neutronyield.usd.edu/ for decay chains, may have already in LUXSim or LZ version

Macros to start these neutron spectra in appropriate places

Energy deposition sims from these neutrons

What stats do we need?

A way to get RQs from these sims

Clustering algorithms to go into LibNEST

Current resources

http://teacher.pas.rochester.edu:8080/wiki/pub/Lux/LuxDB00000041/LuxDB000
00041_130128_LUX_a_n_BG_v1.pdf

0.5 n/day produced throughout detector b/c of Po210 (factor of 2 difference from quotes PMT
result of 1.2 n/all PMTs/ day)

http://teacher.pas.rochester.edu:8080/wiki/pub/Lux/BackgroundMc/Malling_PMT
_n_calcs.pdf

1.2 n/PMT/yr produced in PMTs from U and Th chains

http://teacher.pas.rochester.edu:8080/wiki/pub/Lux/LuxRequiredReading/Mallin
g_thesis_2013.pdf

baseline neutron yield from LUX PMTs is 1.2 n PMT-1 yr-1

More resources

Backgrounds paper https://arxiv.org/pdf/1403.1299v1.pdf

For a one-year run using a 100 kg fiducial, the upper limit is <0.72 events, with an expectation of 0.1

Where are we: Source spectra

-Presumably contained in LZbkgNeutronEnergies_all_new.dat (LUXSim/generator/src/) Though have not figured out how to extract the info yet and is all pieces combined and for LZ. Would need to figure out how to relate to LUX.

-Information came from Paolo originally, so could talk to him

Where are we: Macros and Energy deposit stats

- No macros in LUXSim or LZSim that look like just what we want at first glance.

    - Thought was perhaps to create a neutron generator with an adjustable spectrum, place on the correct locations (PMTs, PTFE, and Cryostats seem to be dominant)

    - Collect stats for each, then combine with the proper ratio of rates found elsewhere

Where are we: Clustering-LibNEST Vs LUXSim-DPF

- Still trying to find what generator to use, or the energy spectra to create one for LUXSim

- Might already have clustering to go to LibNEST from ER background studies