Recent Updates (Gamma-X, SLAC work, MDC, etc.)

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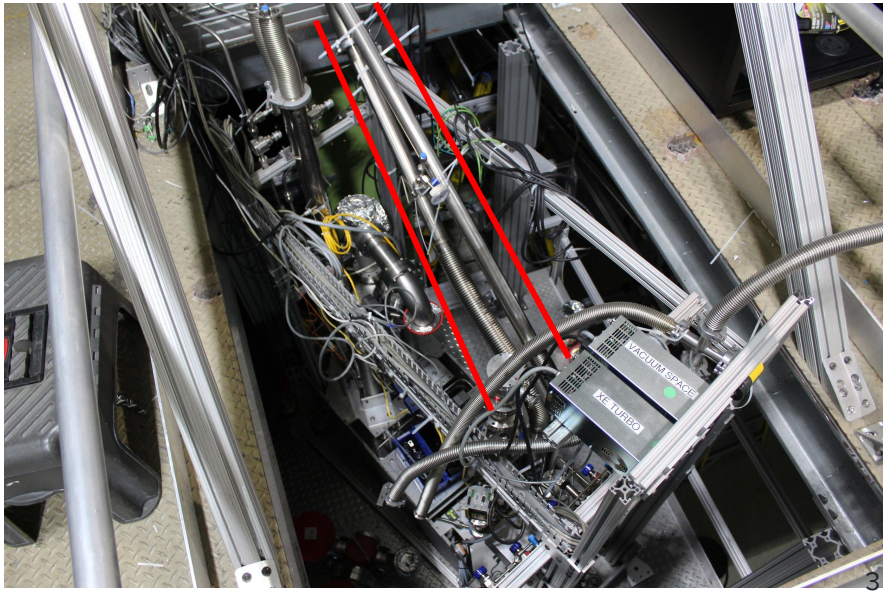
Today's update starts on slide 21

Summer in review

- “Finished” Gamma-X studies
  - More on this next
- Built Gas test and Phase 2 clean rooms
  - Gas test clean hood is currently in use
  - Phase 2 clean room is assembled but not cleaned
- Participated in MDC1
  - Calculated the electron lifetime for 30 days of simulated data which will hopefully look similar to real LZ data
  -

Thermosyphon lines

Replaced thermosyphon lines (marked in red) to make room for new Phase 1 breakout



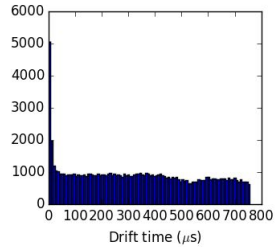
Clean rooms

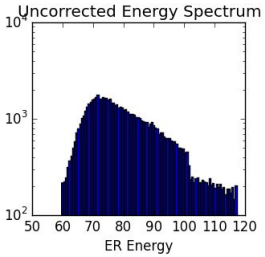
Gas test hood

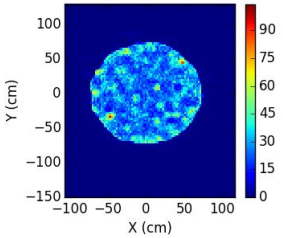
Phase 2 cleanroom

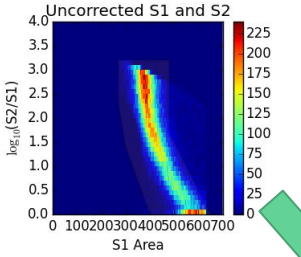
MDC 1

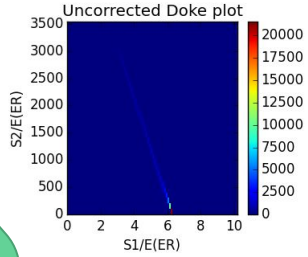
Day 1

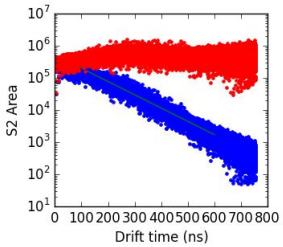


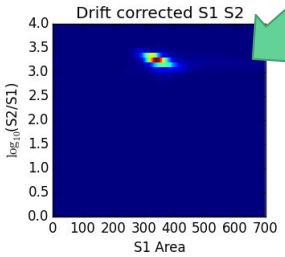


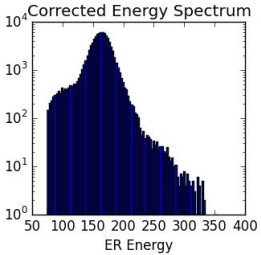




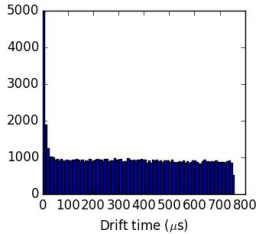


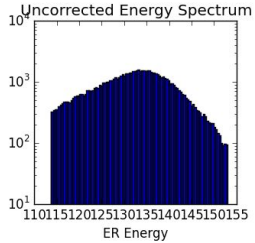


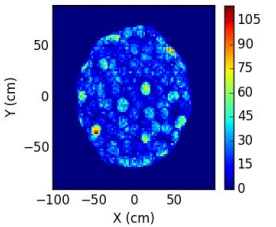


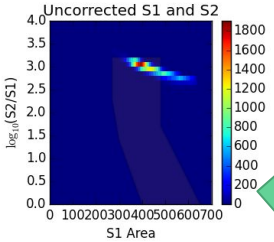


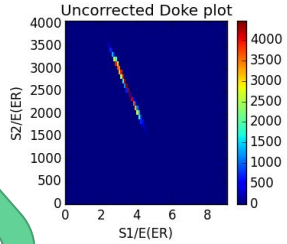
Day 30

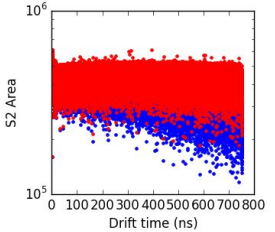


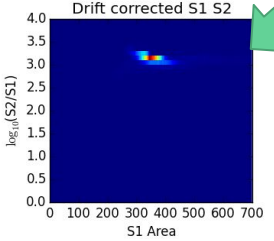


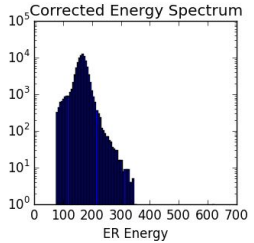




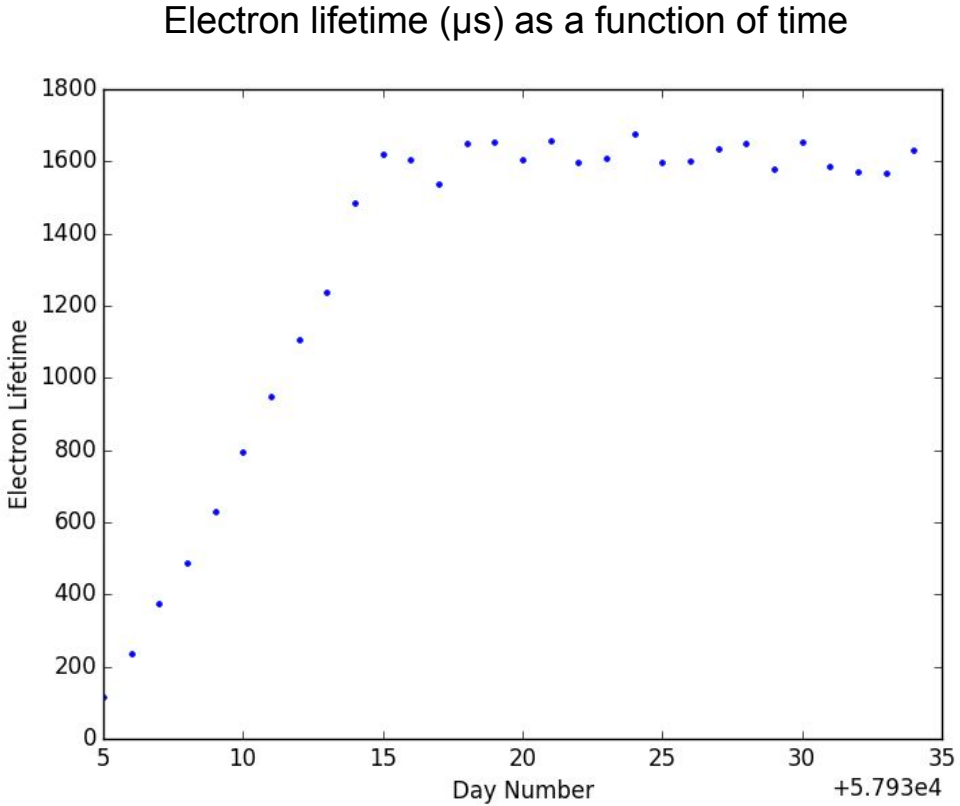








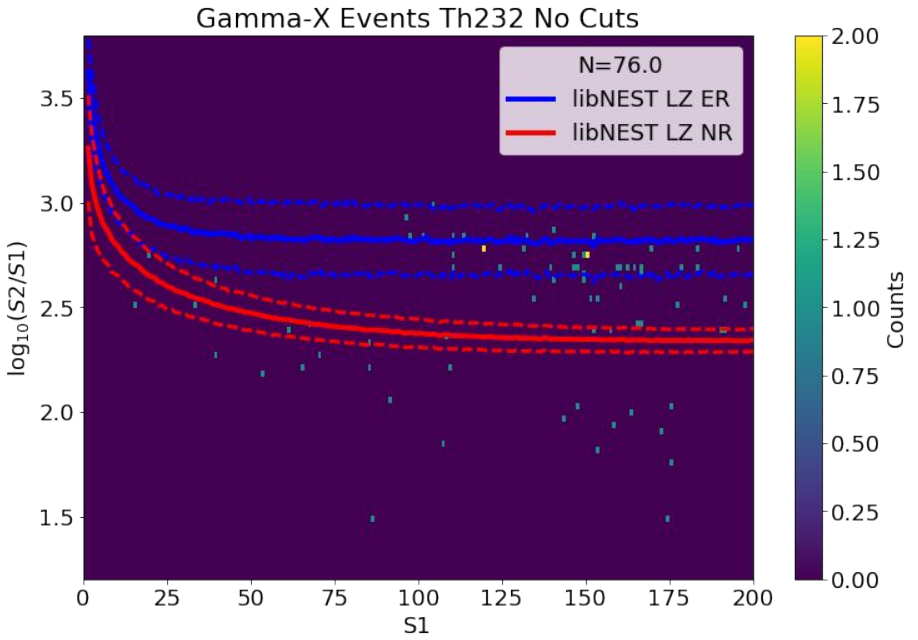
MDC 1 Electron Lifetime



Gamma-X

Wrote code to calculate the expected rate of Gamma-X events from the PMT windows.

Produced plots like the one on the right which show a large number of events in the WIMP search region (the left side of the red region)



Previous Gamma-X Results

Higher than all combined LZ backgrounds

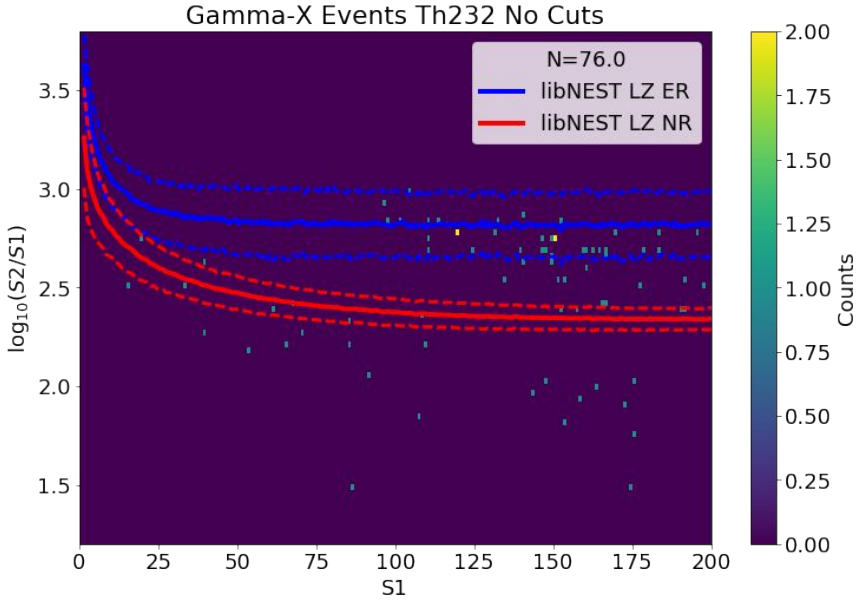
Source	Decays Simulated	Fraction which produce Gamma-X (all)	Fraction in WIMP search region (Depending on S1 S2 cut)	Approximate rate (assuming production from PMT windows and **no cuts**)
Th-232	14,900,000	0.012887 192507 Events	~ 4.0×10^{-7}	0.24 events per year
U-238	4,150,000	0.013739 57094 Events	~1.2×10^{-6}	3.83 events per year
Co-60	9,800,000	0.080683 790704 Events	~4.0×10^{-7}	0 (No Co60 in PMT windows)
K-40	9,400,000	0.004208 39559 Events	< 1.0×10^{-7}	< 0.13 events per year

Comparing Apples to Apples

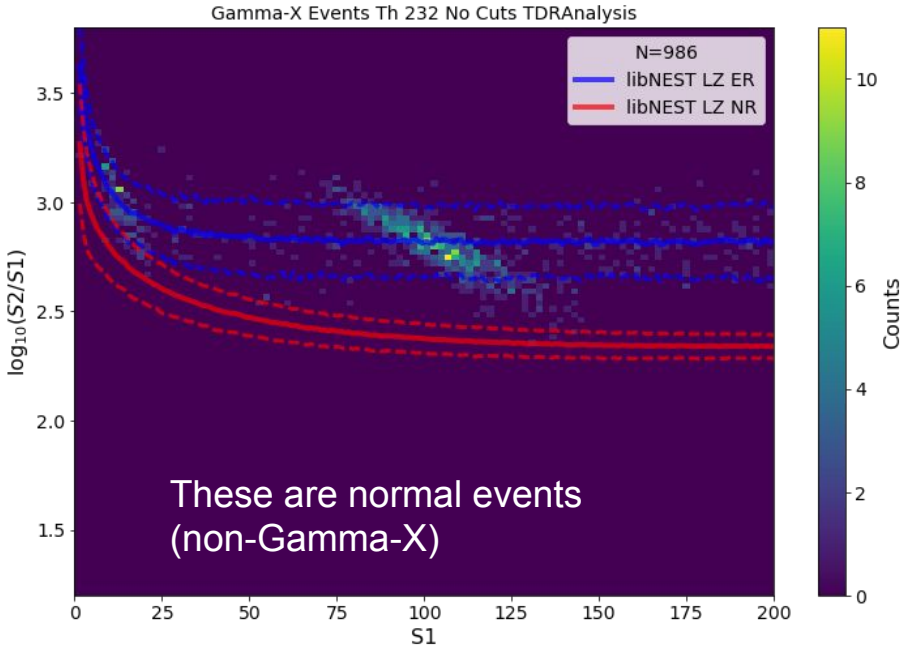
All of the LZ backgrounds are summarized in the backgrounds control table which follows a very specific procedure to generate background rates.
I was doing something similar but not exactly the same.
To see how well my rates compare with the total rates I modified the control table to work with gamma-x events.

Source	Mass (g/unit)	Mass (g)	Activity (mBq/kg)	Livetime equivalent	# beamOn	# beamOn E-scaled	# Surv. All	R-factor	Surviving 1000 days	Events Per year
U early (γ)	38.0	9158	13.21	1.39E+01	1.00E+07	1.45E+08	17.00	1.68E-08	1.75E-01	6.41E-02
U late (γ)	38.0	9158	0.75	2.43E+02	1.00E+07	1.45E+08	17.00	1.17E-07	6.98E-02	2.55E-02
Th (γ)	38.0	9158	1.01	1.85E+02	1.02E+07	1.48E+08	36.00	2.43E-07	1.94E-01	7.09E-02

Gamma-X Plots With New TDRAnalysis Method

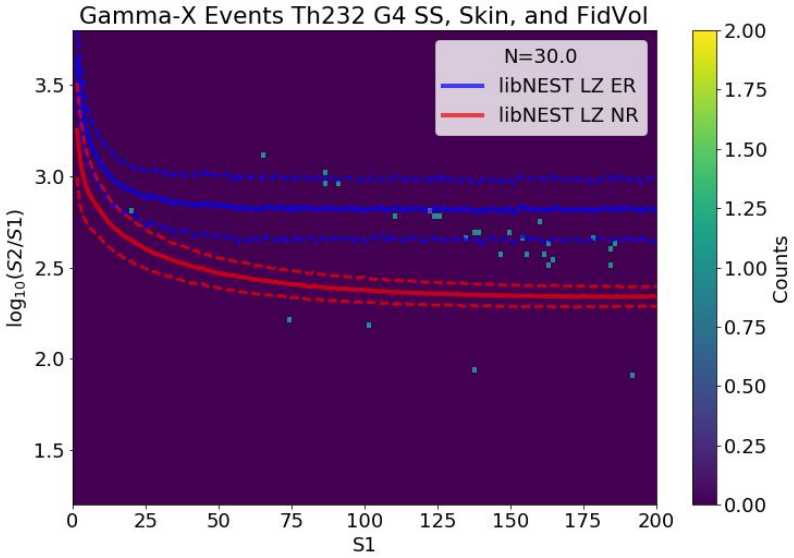


Old Method

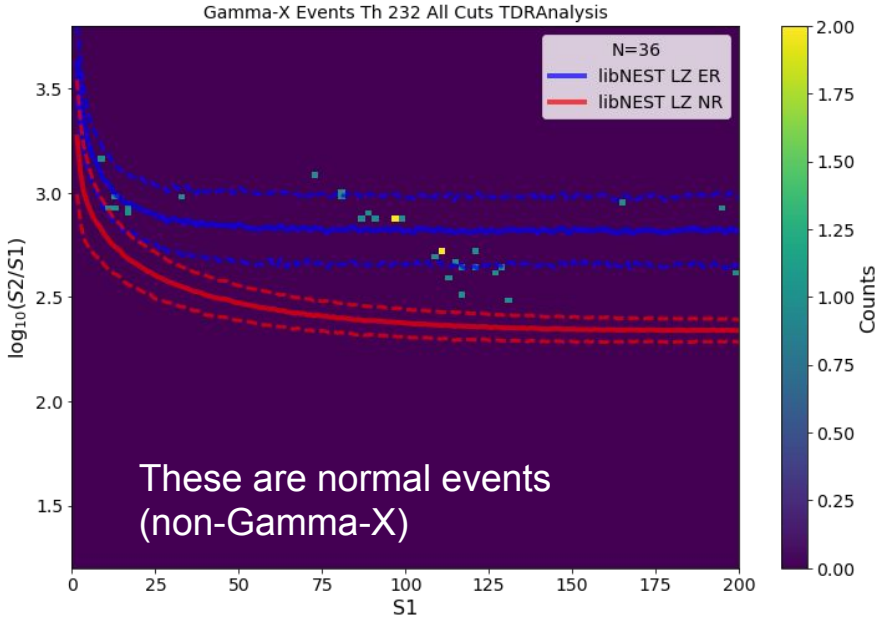


New Method

Gamma-X Plots With New TDRAnalysis Method W/ Cuts



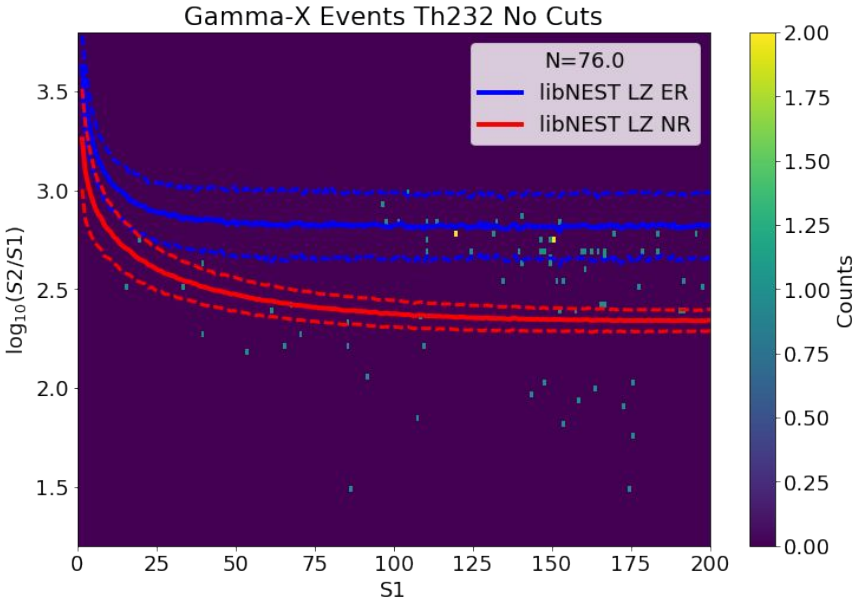
Old Method



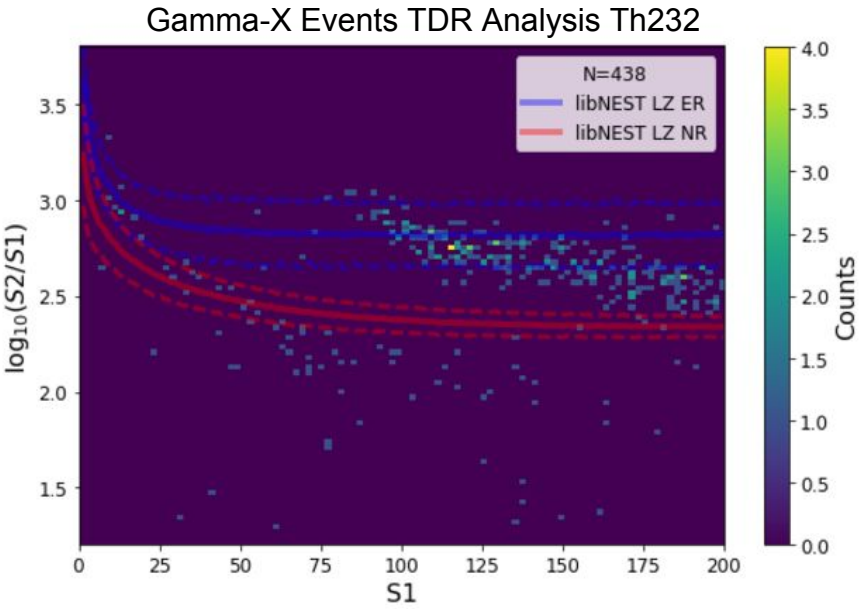
New Method

Latest Gamma-X Update

- Plots shown last week were only “normal” events



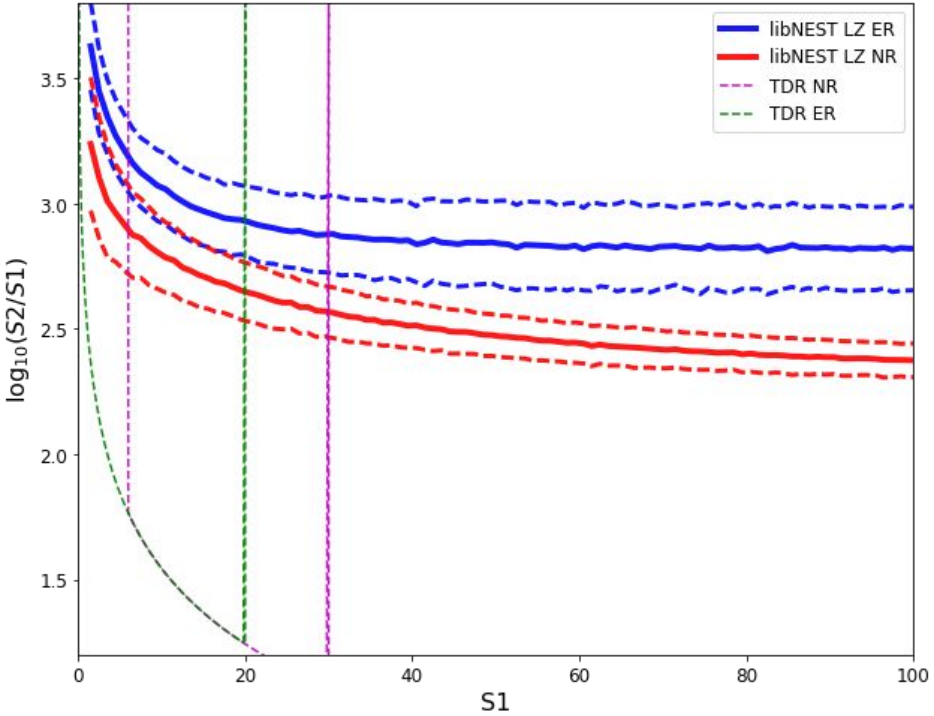
Old Method



New Method

TDR vs. My Cuts

- The TDR Analysis assumes that when ER events are produced that only ER events are seen. With that assumption it can make a more rough cut on S1 and S2. This only works for normal events, but not Gamma-X events.
- I will use all 4 cuts to be able to compare my rate to the TDR as well as provide a more accurate estimate of the rate



Fall 2017 Plan

- Gamma-X
  - Continue to improve and compare the Gamma-X result with those of others
  - Look for Gamma-X events in the MDC 1 data then see if there is some way to discriminate against them.
- Cable making
  - Will soon begin clearing out the server room
- Phase 1 Data Analysis
  - Assist with the Phase 1 analysis in run 7
- Cameras
  - Possibly work on cameras that would be able to run in cold gas or liquid xenon. These would likely need to be different than those used in Phase 2.

Gamma-X rates

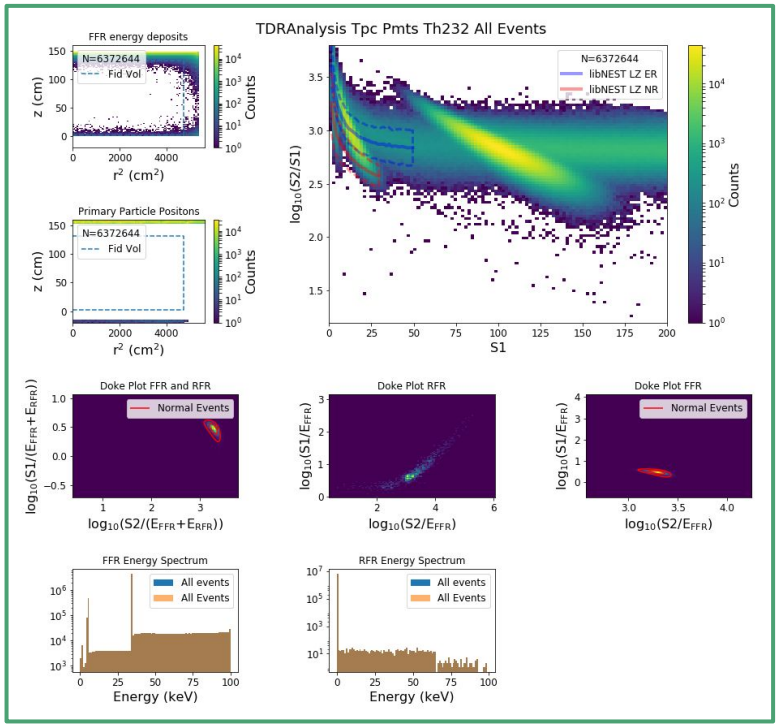
I ran the TDR Analysis which outputs whether or not an event is a Gamma-X

I did the same thing for a few sources (Full PMTs, Bottom Grid, Anode Grid, Cathode Grid, Field Rings, and Vessels)

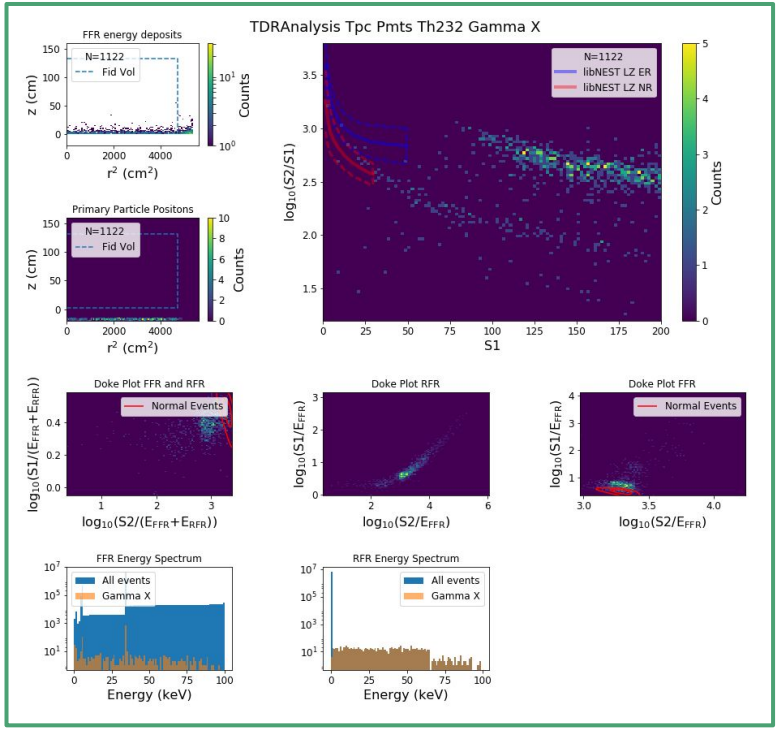
Compare the rates expected after making the three different energy cuts (the TDR ER cut, libNEST ER band cut, libNEST NR band cut)

Gamma X Update

Full PMTs with no cuts

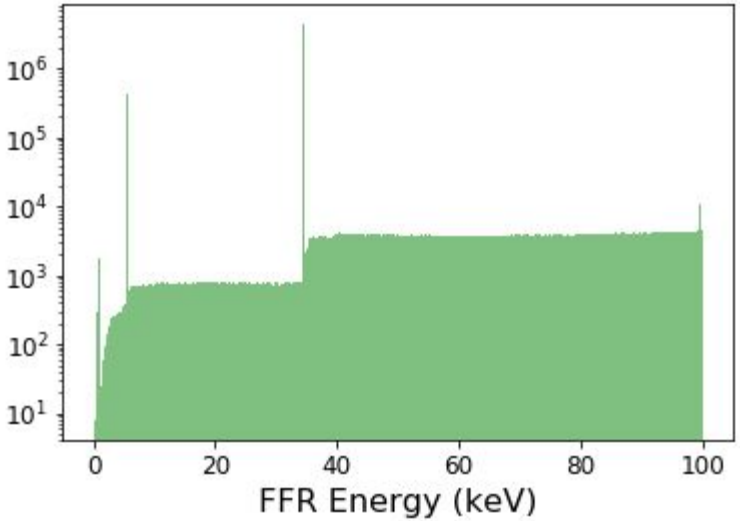


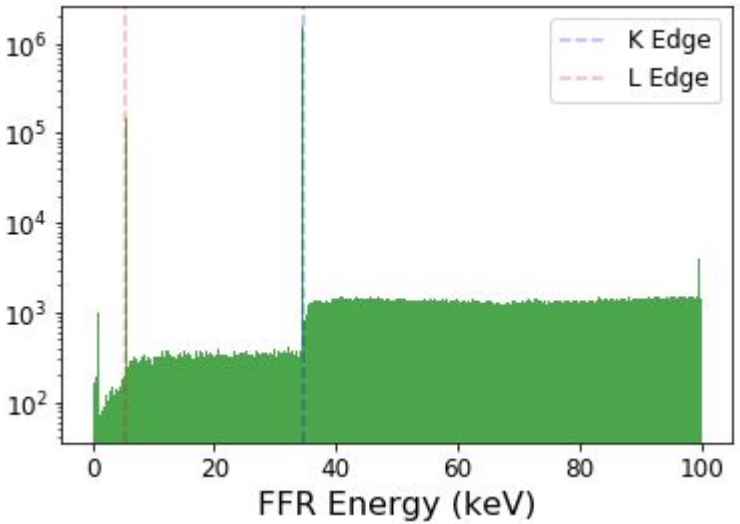
All events (Gamma-X and Normal)



Gamma-X events only

Lines in Energy





Lines in energy deposition correspond to Xenon energy levels. Not sure why this is happening. I would not have expected the energy depositions to be so discrete.

Gamma-X rates All PMTs (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	16.80	0.14%	1.46	1055%
	My ER ROI	15.36	0.00%		954%
	My NR ROI	2.14	9.87%		63%
Gamma-X Events	TDR ROI	0.02			
	My ER ROI	0.00			
	My NR ROI	0.23			

Gamma-X rates Anode Grid (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	0.50	0.00%	Not Calculated	Not Calculated
	My ER ROI	0.46	0.00%		Not Calculated
	My NR ROI	0.06	0.00%		Not Calculated
Gamma-X Events	TDR ROI	0.00			
	My ER ROI	0.00			
	My NR ROI	0.00			

Gamma-X rates Bottom Grid (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	0.132	4.84%	Not Calculated	Not Calculated
	My ER ROI	0.105	4.39%		Not Calculated
	My NR ROI	0.015	42.62%		Not Calculated
Gamma-X Events	TDR ROI	0.007			
	My ER ROI	0.005			
	My NR ROI	0.011			

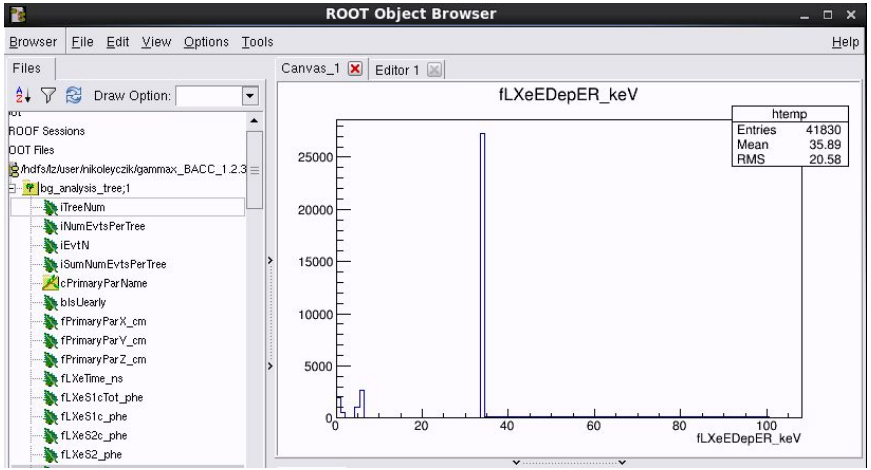
The problem with BACCARAT

I had been using an outdated version of BACCARAT (1.2.3) and the most recent version (2.4.0) appears to have changed some properties at low energies.

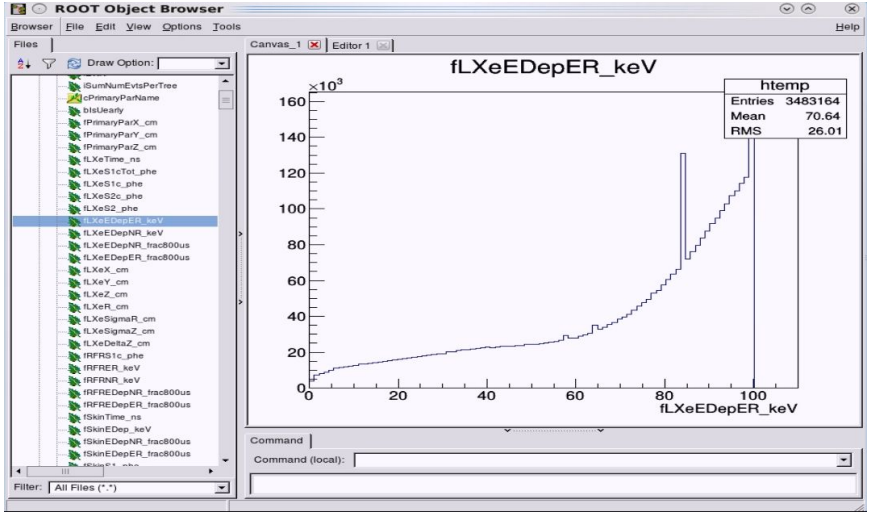
Instead of rerunning the sims local I used the latest results for the backgrounds review which were run using BACCARAT 2.4.0 and reduced using TDRAnalysis 5.3.0
Note that these sims only include:

- Conduit Feedthrough
- HV conduit
- **PMTs (Focused on these so far)**
- PTFE Walls
- Vessels

The Difference Between 1.2.3 and 2.4.0 Energy Dep

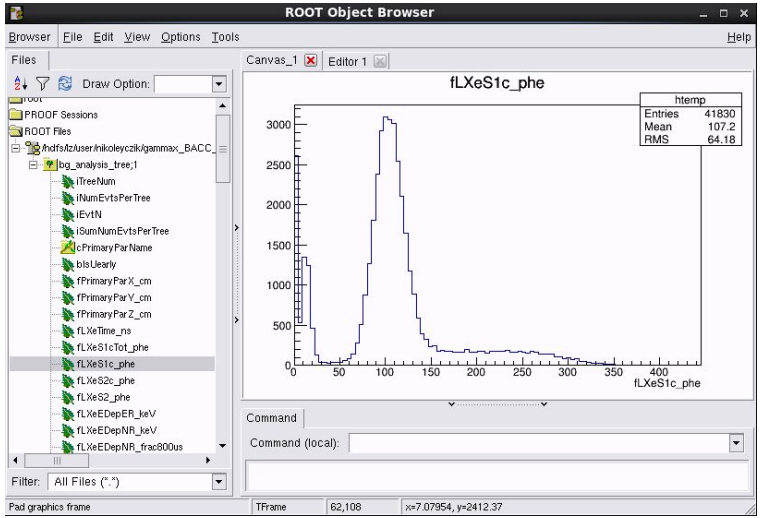


My output: BACC 1.2.3 and TDR ~5.2.1 (slightly modified)

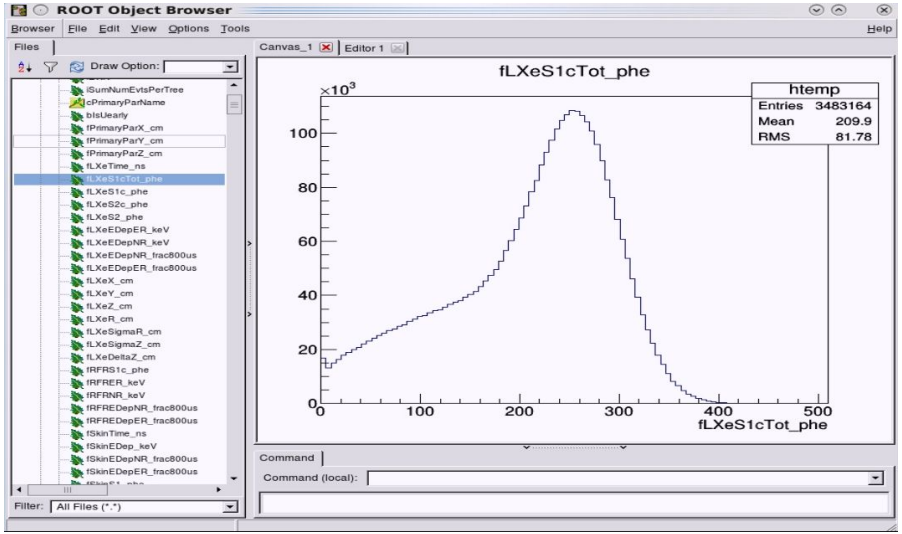


PDSF output: BACC 2.4.0 and TDR 5.3.0

The Difference Between 1.2.3 and 2.4.0 S1



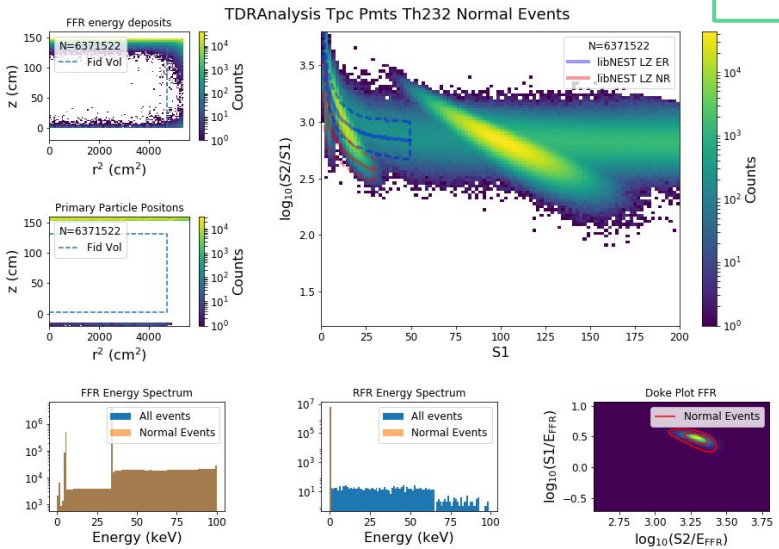
My output: BACC 1.2.3 and TDR ~5.2.1 (slightly modified)

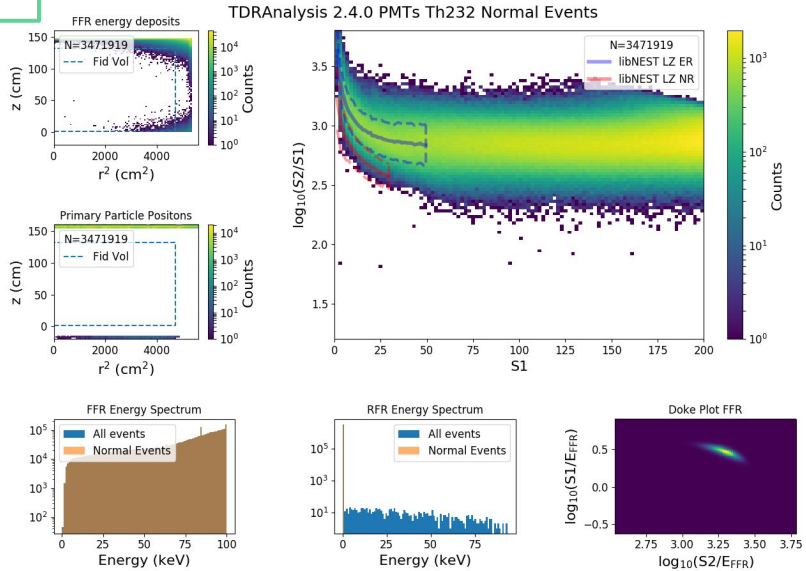


PDSF output: BACC 2.4.0 and TDR 5.3.0

The Difference Between 1.2.3 and 2.4.0 Normal Events

NO CUTS

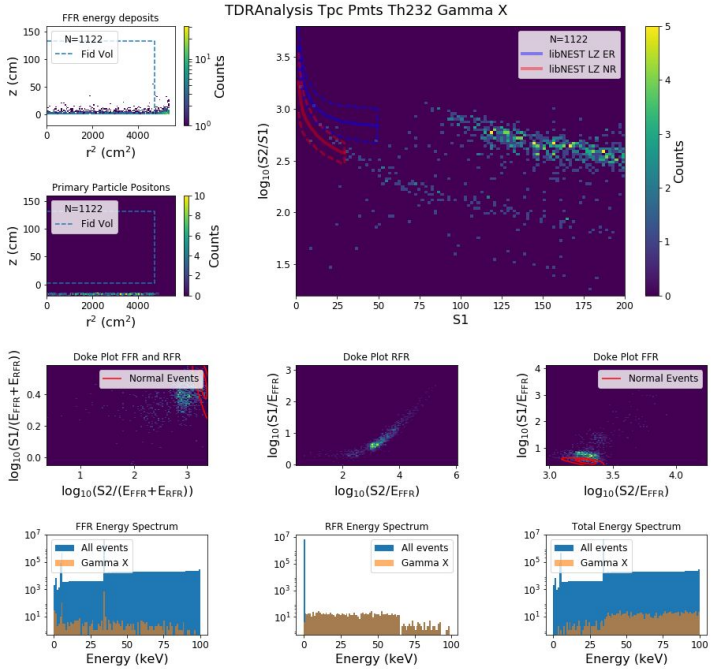




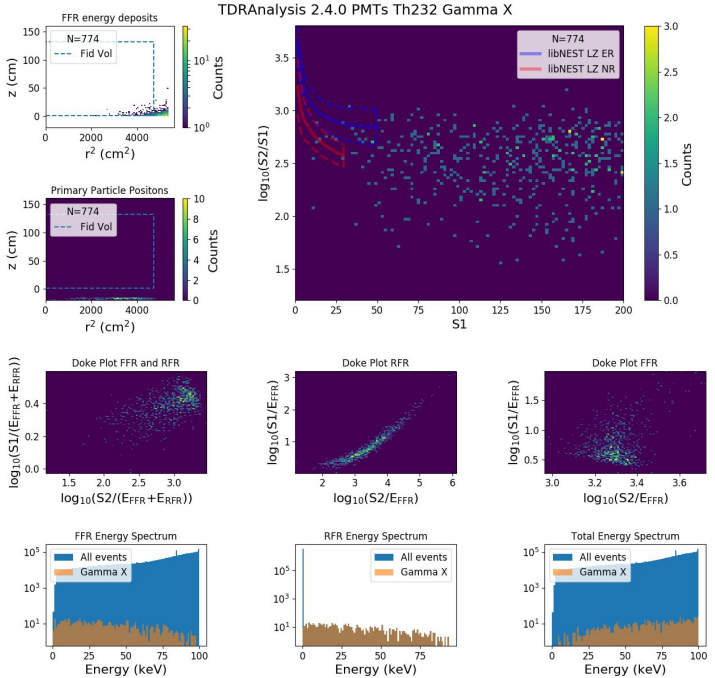
My output: BACC 1.2.3 and TDR ~5.2.1 (slightly modified), libNEST 3.0.2

PDSF output: BACC 2.4.0 and TDR 5.3.0, libNEST 4.2.0

The Difference Between 1.2.3 and 2.4.0 Gamma-X Events



NO CUTS



My output: BACC 1.2.3 and TDR ~5.2.1 (slightly modified), libNEST 3.0.2

PDSF output: BACC 2.4.0 and TDR 5.3.0, libNEST 4.2.0

Gamma-X rates 2.4.0 PMTs (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	0.06	0.00%	1.46	-96%
	My ER ROI	0.14	0.00%		-90%
	My NR ROI	0.02	0.00%		-99%
Gamma-X Events	TDR ROI	0.00			
	My ER ROI	0.00			
	My NR ROI	0.00			

Gamma-X rates 2.4.0 PMTs (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	0.06	0.00%	1.46	-96%
	My ER ROI	0.14	0.00%		-90%
	My NR ROI	0.02	0.00%		-99%
Gamma-X Events	TDR ROI	0.00			
	My ER ROI	0.00			
	My NR ROI	0.00			

There was one K40 event that got classified by my NR band (within the 90% bands for libNEST NR energy deposits)

Gamma-X rates 2.4.0 PMTs (including all cuts)

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Normal Events	TDR ROI	0.06	0.00%	1.46	-96%
	My ER ROI	0.14	0.00%		-90%
	My NR ROI	0.02	0.00%		-99%
Gamma-X Events	TDR ROI	0.00			
	My ER ROI	0.00			
	My NR ROI	0.00			

No Gamma-X events pass all cuts in ~4e8 events
But Gamma-X events are ~1e-4 of all events

Gamma-X rates 2.4.0 PMTs (including all cuts)

Type of Events	Energy Cut	Events per 1000 days	Fraction of all events that are Gamma-X	BG Table Rate (per 1000 days)	Difference between my results and BG table
Normal Events	TDR ROI	0.06	0.00%	1.46	-96%
	My ER ROI	0.14	0.00%		-90%
	My NR ROI	0.02	0.00%		-99%
Gamma-X Events	TDR ROI	0.00			
	My ER ROI	0.00			
	My NR ROI	0.00			

My numbers are ~10% lower than the backgrounds control table but many sims saw 0 events pass all cuts. If we use upper limits instead my numbers are only ~50% lower

Backup (Raw Data)

Simulation name	N files	N beamOn	ROI	+SS	+Skin	+OD	+Skin+OD	+5.6t FV	U_early	U_late	R-factor
2.4.0_tpc_pmts_Th232_NormalTDRROI	3.94E+02	3.94E+08	49395	49162	41455	36039	30694	7			1.22E-09
2.4.0_tpc_pmts_Th232_NormalMyERROI	3.94E+02	3.94E+08	133593	132756	114674	98664	86065	15			2.62E-09
2.4.0_tpc_pmts_Th232_NormalMyNRROI	3.94E+02	3.94E+08	7563	7557	6300	5507	4628	0			0.00E+00
2.4.0_tpc_pmts_Th232_GammaXTDRROI	3.94E+02	3.94E+08	6	6	1	6	1	0			0.00E+00
2.4.0_tpc_pmts_Th232_GammaXMyERROI	3.94E+02	3.94E+08	10	10	1	10	1	0			0.00E+00
2.4.0_tpc_pmts_Th232_GammaXMyNRROI	3.94E+02	3.94E+08	8	8	0	6	0	0			0.00E+00
2.4.0_tpc_pmts_U238_NormalTDRROI	3.78E+02	3.78E+08	40593	40399	34040	30650	26220	3	0	3	5.46E-10
2.4.0_tpc_pmts_U238_NormalMyERROI	3.78E+02	3.78E+08	108202	107428	92691	82066	71792	10	0	10	1.82E-09
2.4.0_tpc_pmts_U238_NormalMyNRROI	3.78E+02	3.78E+08	6323	6322	5308	4845	4129	0	0	0	0.00E+00
2.4.0_tpc_pmts_U238_GammaXTDRROI	3.78E+02	3.78E+08	0	0	0	0	0	0	0	0	0.00E+00
2.4.0_tpc_pmts_U238_GammaXMyERROI	3.78E+02	3.78E+08	3	3	0	3	0	0	0	0	0.00E+00
2.4.0_tpc_pmts_U238_GammaXMyNRROI	3.78E+02	3.78E+08	1	1	0	1	0	0	0	0	0.00E+00
2.4.0_tpc_pmts_K40_NormalTDRROI	4.00E+02	4.00E+08	2378	2376	1893	1868	1462	0			0.00E+00
2.4.0_tpc_pmts_K40_NormalMyERROI	4.00E+02	4.00E+08	6338	6314	5035	5056	3987	0			0.00E+00
2.4.0_tpc_pmts_K40_NormalMyNRROI	4.00E+02	4.00E+08	386	386	322	310	254	1			1.72E-10
2.4.0_tpc_pmts_K40_GammaXTDRROI	4.00E+02	4.00E+08	1	1	0	1	0	0			0.00E+00
2.4.0_tpc_pmts_K40_GammaXMyERROI	4.00E+02	4.00E+08	0	0	0	0	0	0			0.00E+00
2.4.0_tpc_pmts_K40_GammaXMyNRROI	4.00E+02	4.00E+08	2	2	0	2	0	0			0.00E+00
2.4.0_tpc_pmts_Co60_NormalTDRROI	3.97E+02	3.97E+08	25186	25077	17688	9526	6243	3			5.20E-10
2.4.0_tpc_pmts_Co60_NormalMyERROI	3.97E+02	3.97E+08	65342	64941	47499	24706	16947	8			1.39E-09
2.4.0_tpc_pmts_Co60_NormalMyNRROI	3.97E+02	3.97E+08	4066	4066	2838	1588	1031	0			0.00E+00
2.4.0_tpc_pmts_Co60_GammaXTDRROI	3.97E+02	3.97E+08	6	6	0	4	0	0			0.00E+00
2.4.0_tpc_pmts_Co60_GammaXMyERROI	3.97E+02	3.97E+08	10	10	0	9	0	0			0.00E+00
2.4.0_tpc_pmts_Co60_GammaXMyNRROI	3.97E+02	3.97E+08	7	7	0	7	0	0			0.00E+00