Gamma-X Event detection

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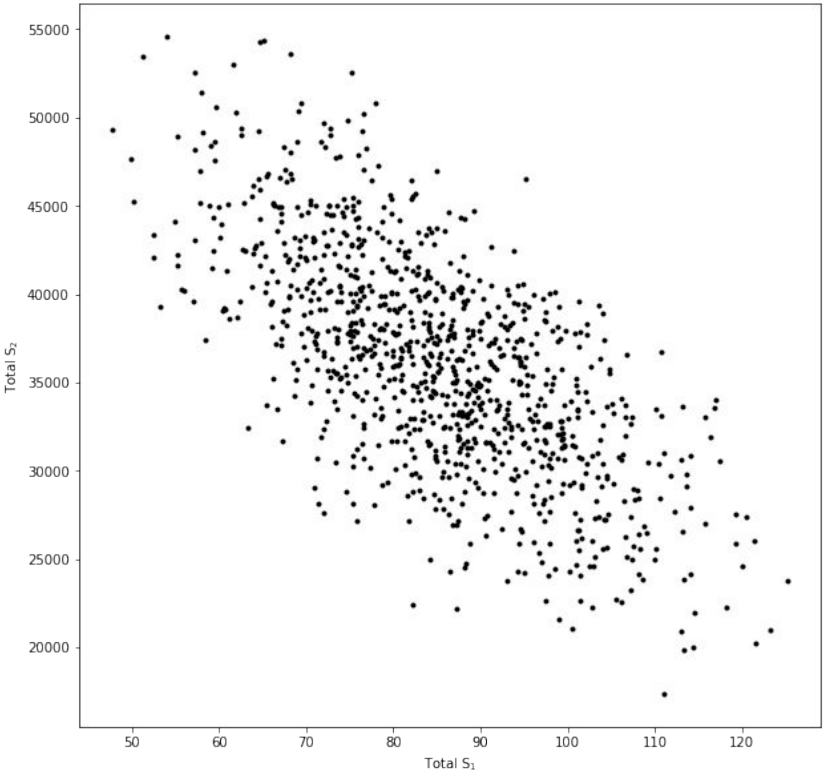
I am attempting to understand a potential background in the LZ detector, called Gamma-X events by analyzing simulations of background events.

Today's update starts on slide 11

Running BACCARAT

- Ran test Sims in latest version of BACCARAT (1.0.0)
- Will modify scripts to look for Gamma-X events
- Currently using simple rootpy analysis
- Plan to emulate Bhawna's Gamma-X study

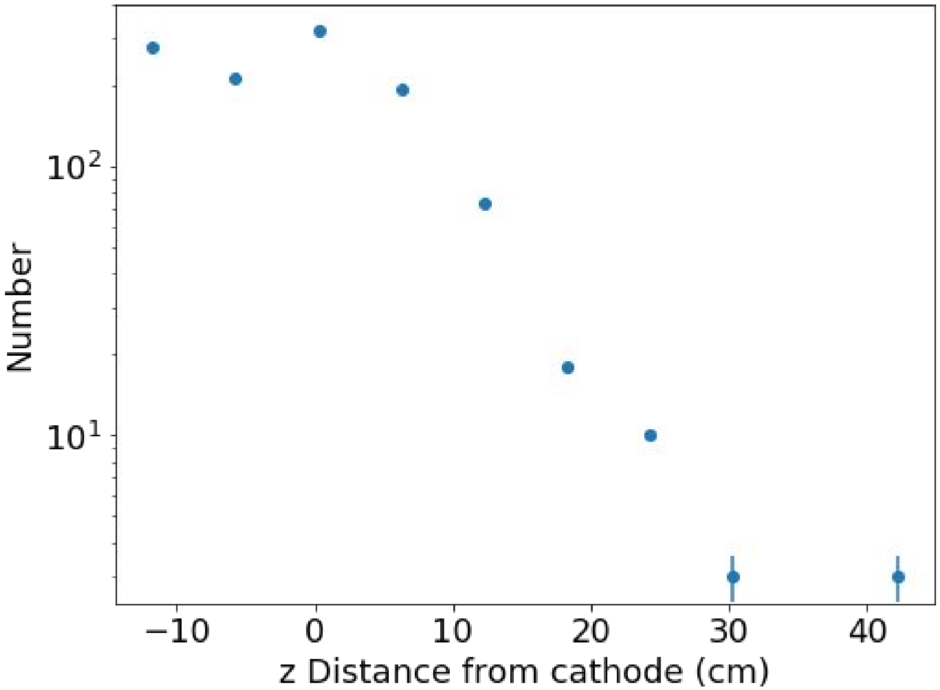
S1 vs. S2 from the BACCARAT test macro



More Gamma-X results

- 100,000 Th 232 Decay Chain Events
- Expected an exponential drop off (I see one if I don't require energy deposited)
-

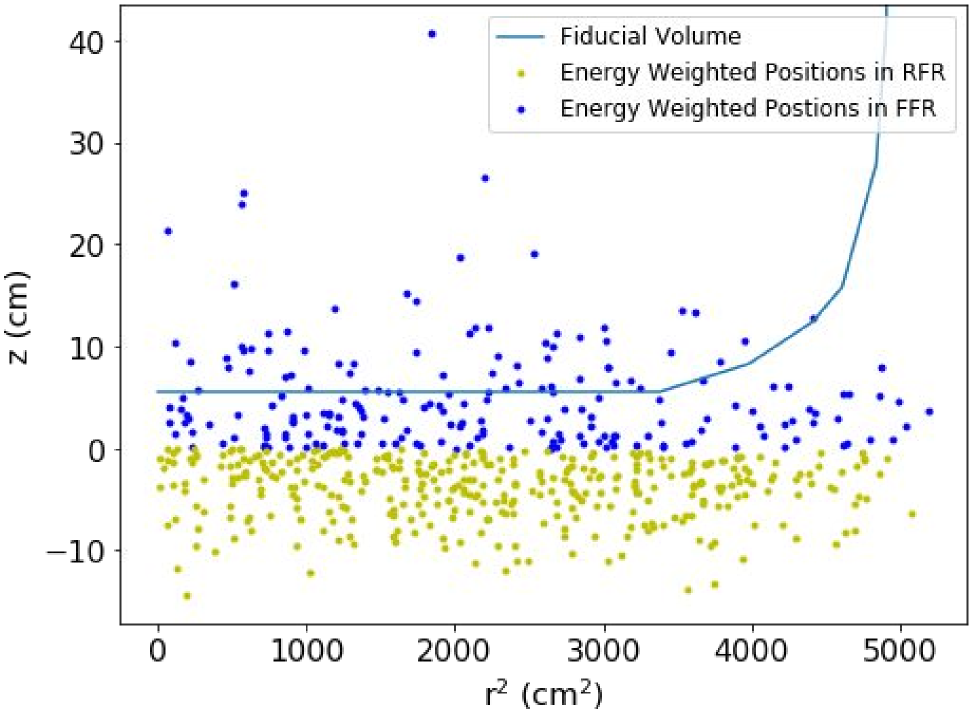
Events in both Forward and Reverse Field Regions



Gamma-X Update

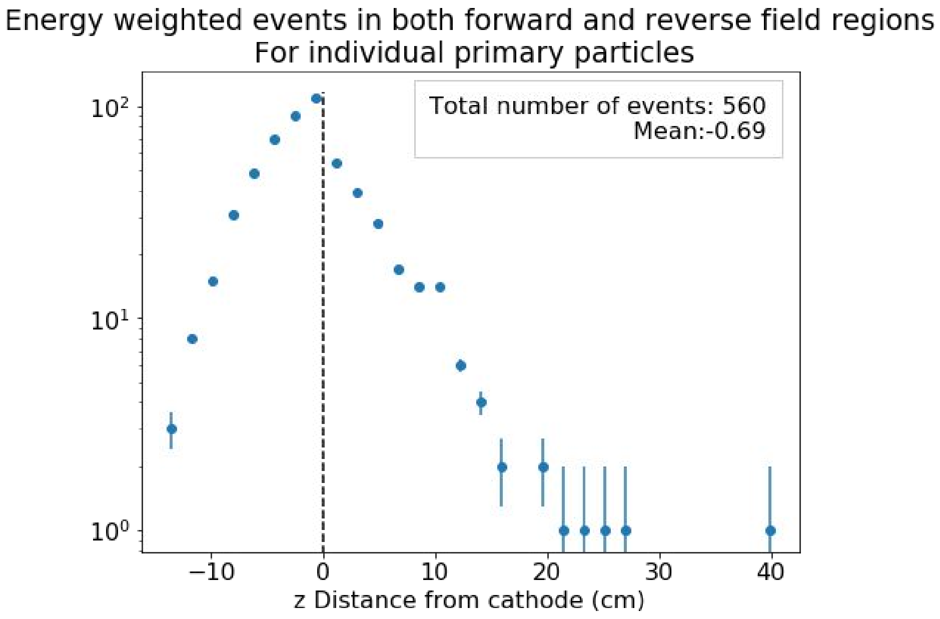
- Same 100,000 Events as last week
- Producing 560 events in both regions
- Now I add together events in forward and reverse field regions, then do the energy weighted sum
- There is now one dot for each decay event
- Issues getting S1 and S2
    - Needs libNEST
        - Needs Boost

Energy weighted depositions combining both the forward and reverse field regions



Fixed Histogram

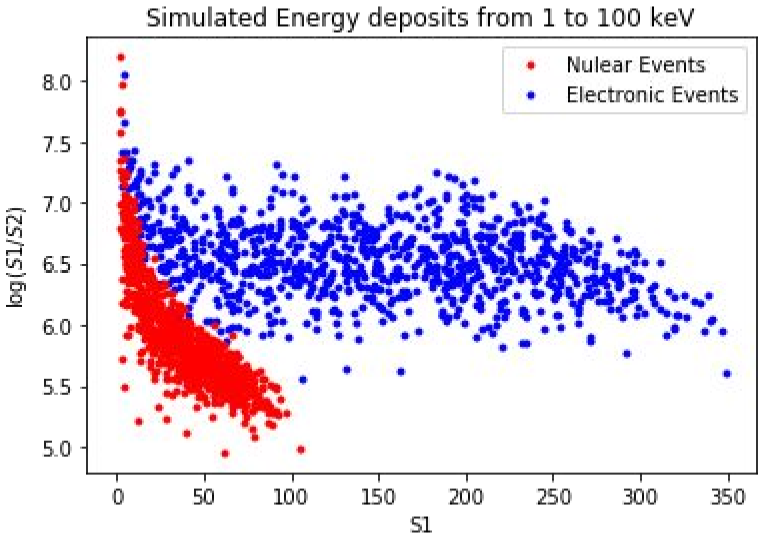
- This is a histogram of the data on the last slide as a function of z
- The RFR looks almost linear and the FFR looks exponential



fastNEST is up and running

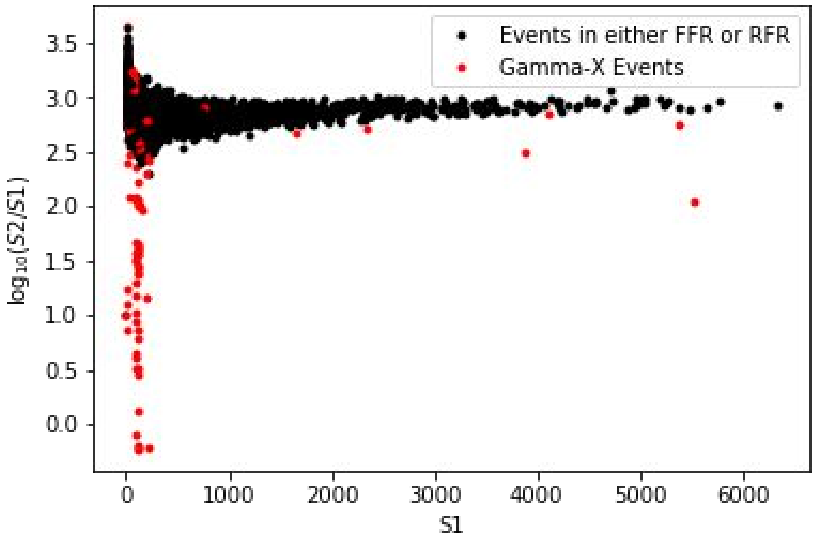
I’m able to get S1 and S2s

The plot on the right is just an example of S1 and S2 for Nuclear and Electronic events. They are for random energy depositions of 1 to 100 keV with no specification on location.



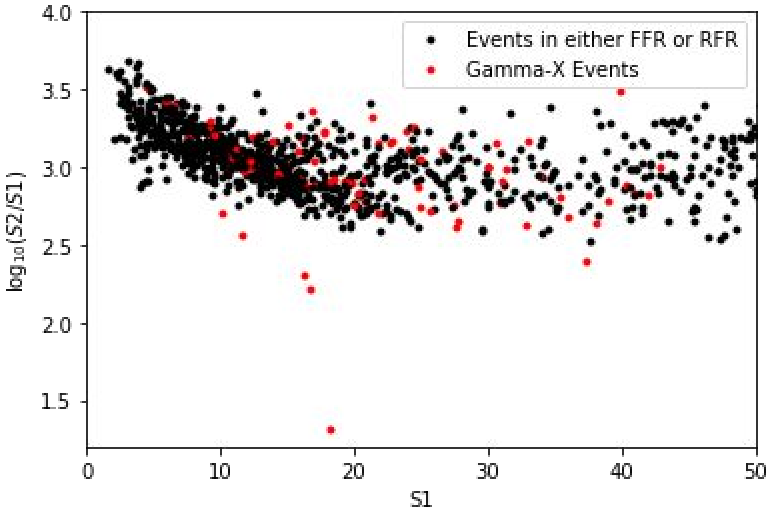
Real Gamma-X events in S1 and S2

- Gamma events create a lot of light compared to WIMP events
- See up to 6000 S1 but the WIMP search is only up to 50 S1
- See the expected suppression of S2



Just WIMP search region

- Same data, now only showing the WIMP search region defined in the TDR
- See ~5 events that appear to be closer to nuclear rather than electronic events.
- Need more statistics, this is with 100,000 decay events I can easily scale this up to a few million events



Search Region from TDR

This is the plot which I used to compare the normal and Gamma-X events to.

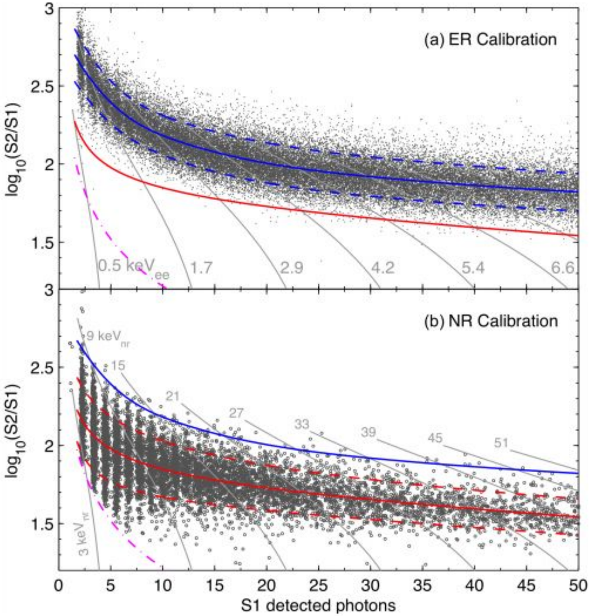


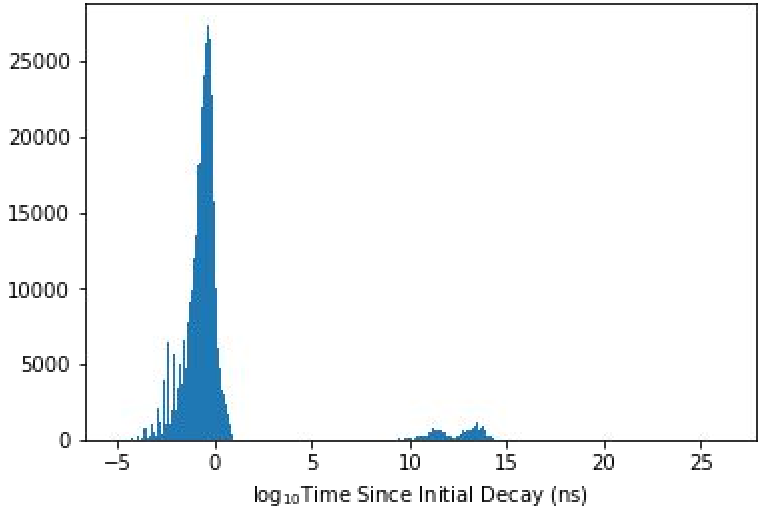
Figure 1.3.11: Discrimination parameter $\log_{10}(S2/S1)$ as a function of S1 signal obtained with LUX calibration [58]. (a) ER band calibrated with beta decays from a dispersed ^3H source; the median is shown in blue, with 80 % population contours indicated by the dashed blue lines. (b) NR band populated by elastic neutron scattering from a D-D pulsed neutron source; the median (solid) and 80 % band width (dotted) are indicated in blue and red, respectively. The mostly vertical gray lines are contours of constant energy deposition. For more information, see Chapter 7.

Time resolution

I wanted to make sure that all of the events occur within the timeframe of one event in the detector

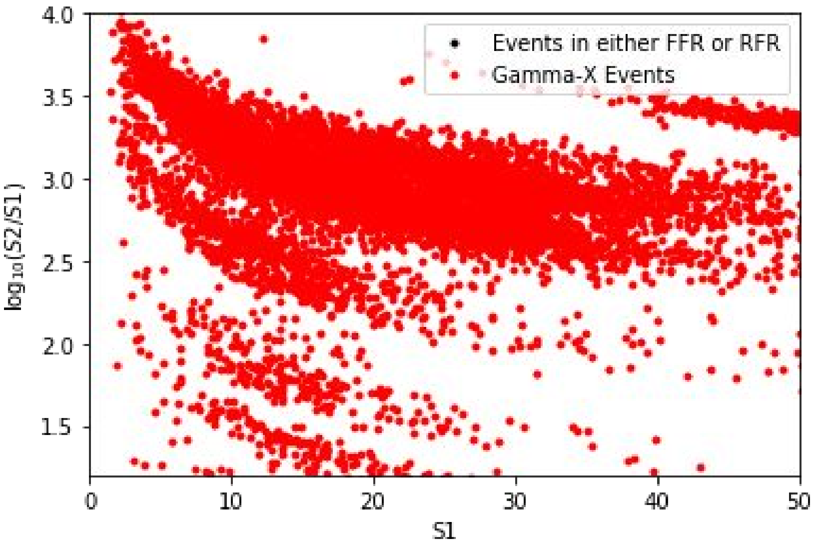
Almost all events occur within a few nanoseconds of the initial decay.

There is a much smaller population of secondary events which are handled separately from the primary events.



High statistics run

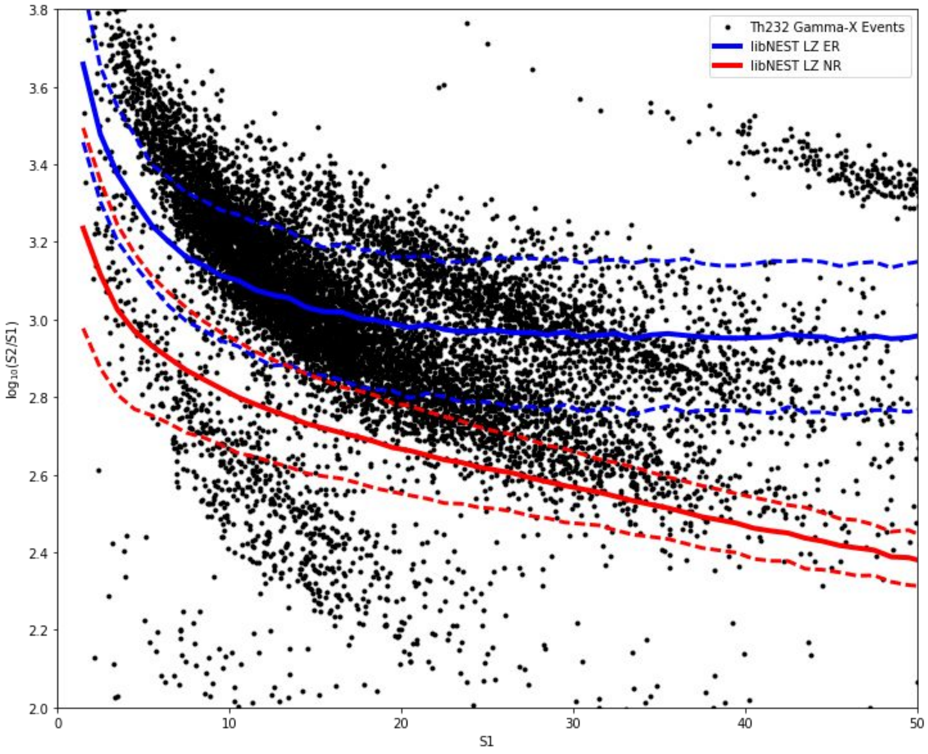
- Went from 100,000 decays to 10,000,000 decays in this data set
- There are band like structures in the S1 vs log(S2/S1) plot (shown right)
- I am only focusing on the WIMP search region
- There are ~12,000 Gamma-X events in this region



Including ER and NR bands

The Gamma-X events do not exactly follow the ER and NR bands. There is suppression of S2 at constant S1.

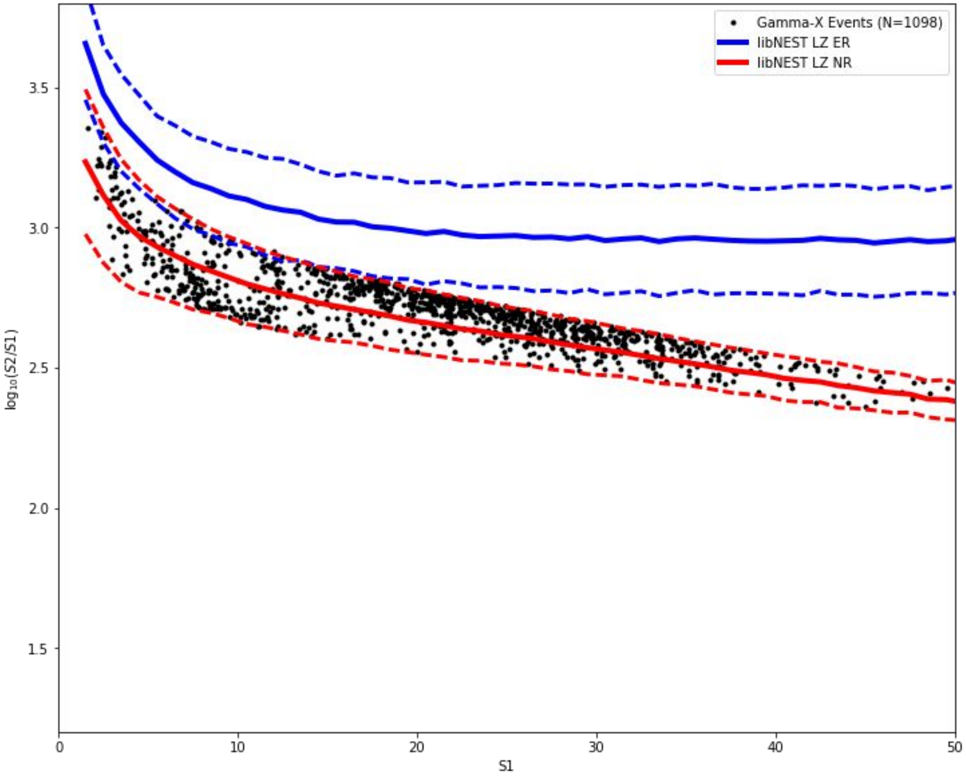
The bands shown here are the 90% bands.



Focusing just on the NR band

There are 1098 events that fall in this band.

So about 0.01% of Th232 decays from the PMT windows will be likely to cause Gamma-X events



Next Steps

- More high statistics runs of other radioactive sources. Likely Uranium as it also has a high rate from the PMT windows.
- Detailed analysis of these events. Likely just to determine the tracks and angles which create these events (Are they more likely in the edge or the center etc.).
- Determine the actual rate in cts/kg/day. This is likely to be an underestimation as there are more background sources than the PMT windows