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DEEP UNDERGROUND NEUTRINO EXPERIMENT

SN Trigger and the radiological backgrounds

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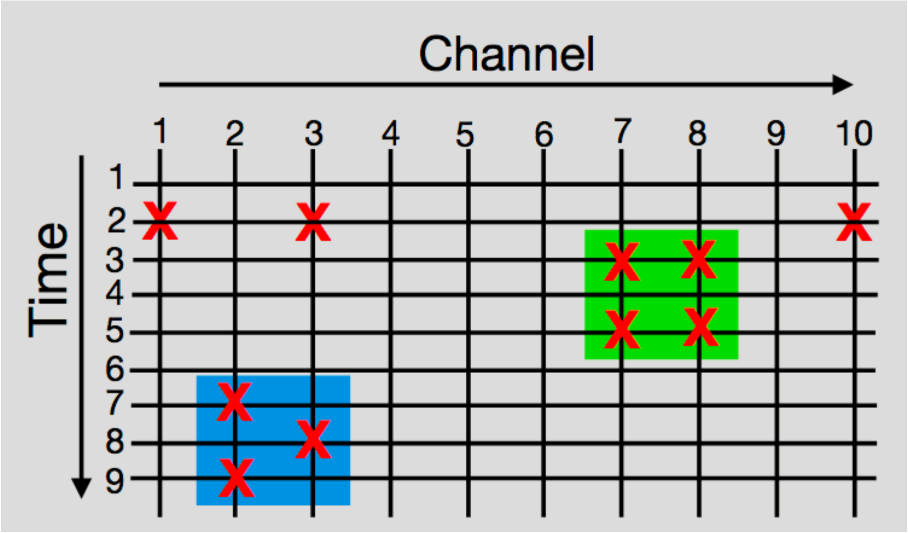
- Recap on the SN trigger
- Background efficiency
  - Argon 39, 42
  - Neutrons
- Background analysis for the SN triggers

SN Trigger recap

- Basic idea: use the fact that you get many interactions in a burst to trigger.
  - Create simple reconstructed objects that are sensitive to SN interactions (clusters).
  - Use only the collection wires for the TPC, typically runs on a fast hit finder algorithm.
  - Count them during for 10 seconds, if the number of clusters goes bigger than a certain threshold → issue a trigger.
- Cluster definition:

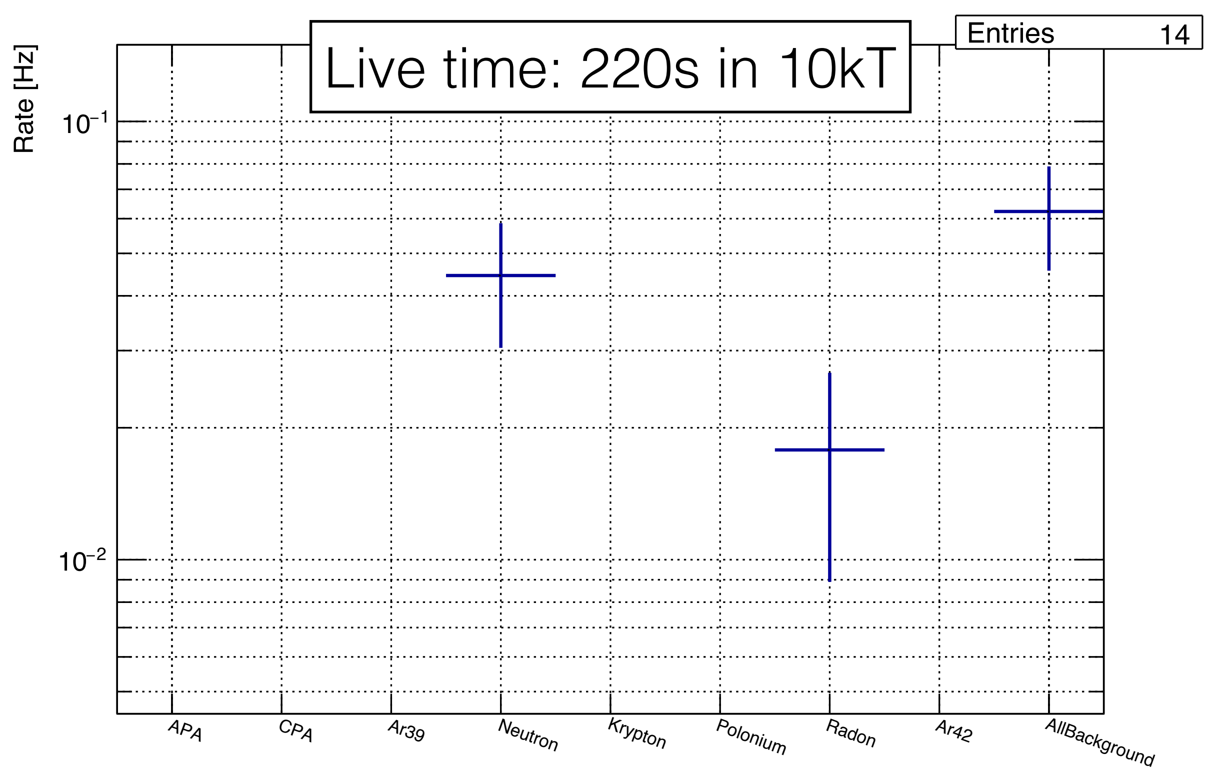


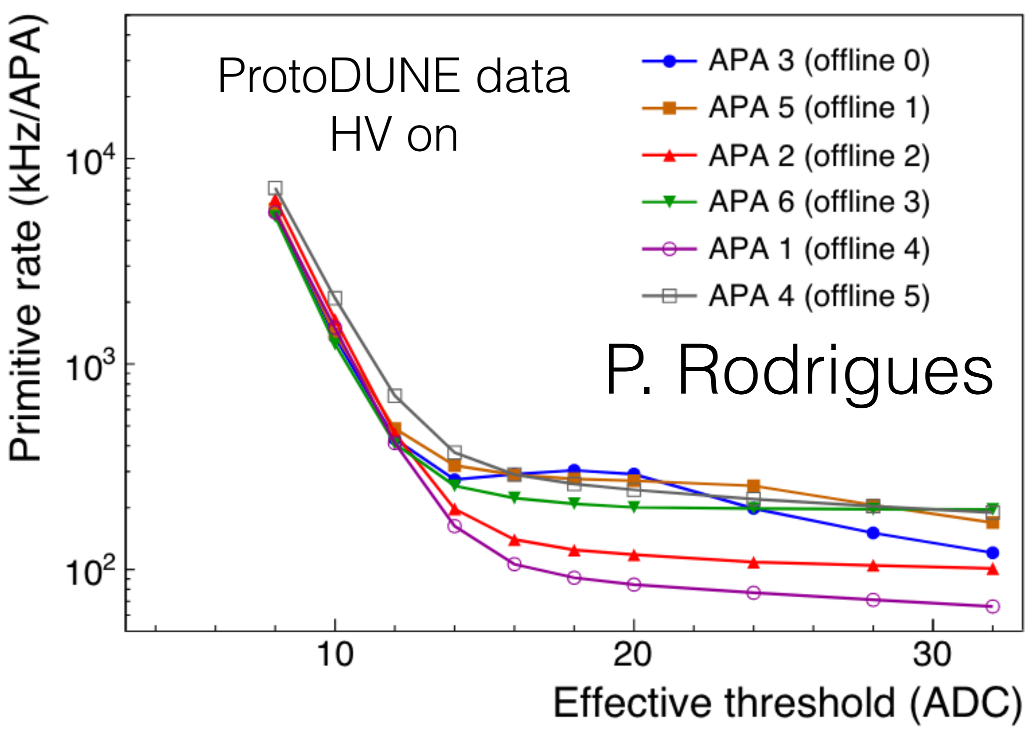
A. Booth

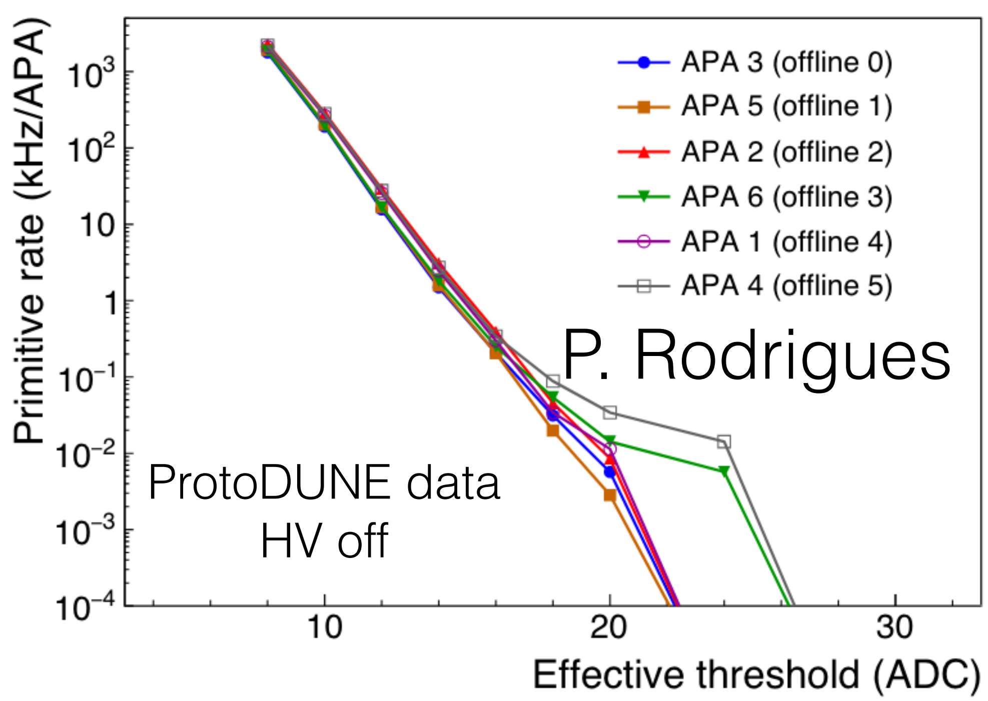
- Best configuration:
  - Grow the TPC clusters if:
    - Hits are no more than 2 channels appart
    - Hits are no more than 20μs appart
  - There is at least 2 channels which were hit
  - There is at least 6 hits in total

SN Trigger recap

- Using TripPrim hit finder with an ADC threshold of 20 ADC (more or less informed by ProtoDUNE)
- When this algorithm is applied, what actually survives?
    - 1/3 of the SN interactions*
    - Some remaining backgrounds:



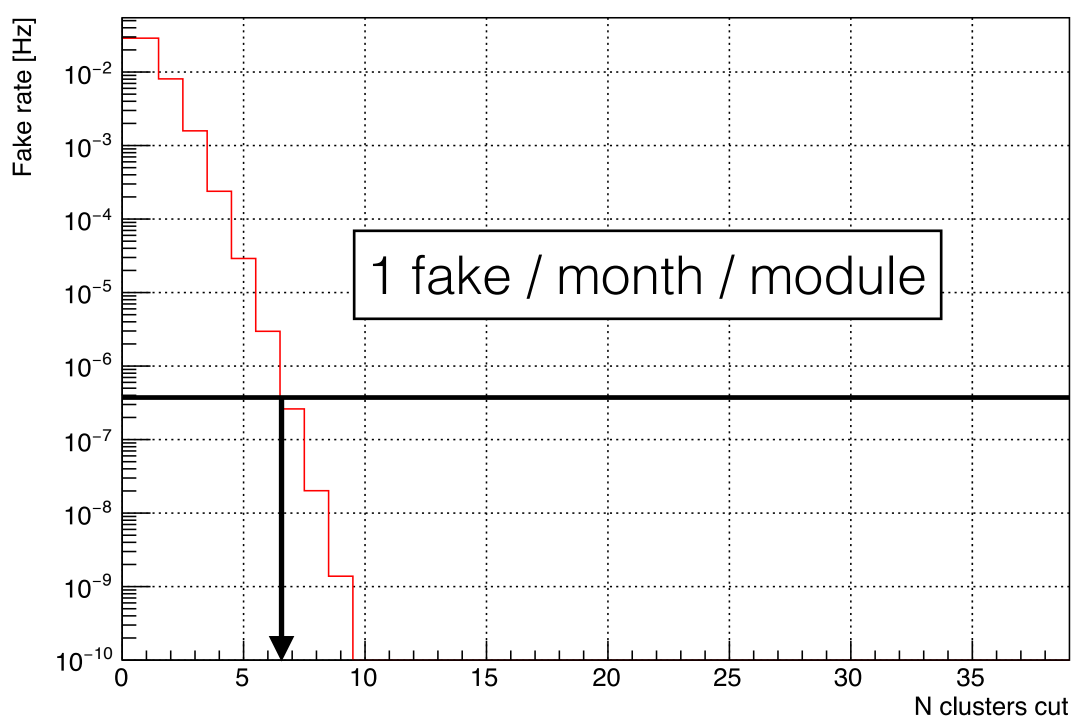




* I'll discuss this further

Sensitivity

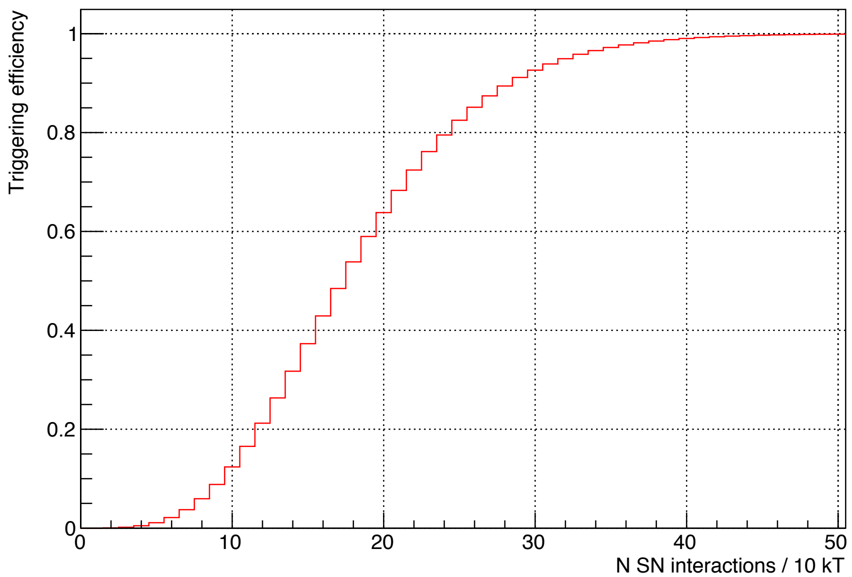
- Assume a 10 s window:
  - Number of events w/o SN: N = BR x 10 s (background rate x 10)
  - Number of events with SN: N = Burst x Eff + BR x 10 s
- We want to have 1 fake / month / module
  - FakeRate = $FR = BR \times \sum_{n=n_{\mathrm{Thr}}}^{\infty} \mathrm{Poisson}\left(\mu = T_{\mathrm{Integr}} \times BR, n\right)$
  - Find the thresholds which satisfies FR < 1 fake / month / module



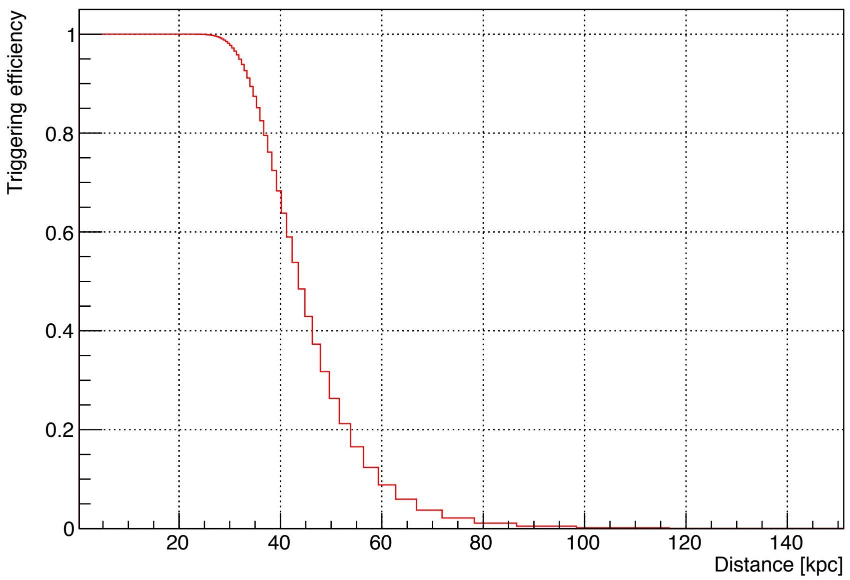
- Fake rate depends only on the background rate.

Sensitivity

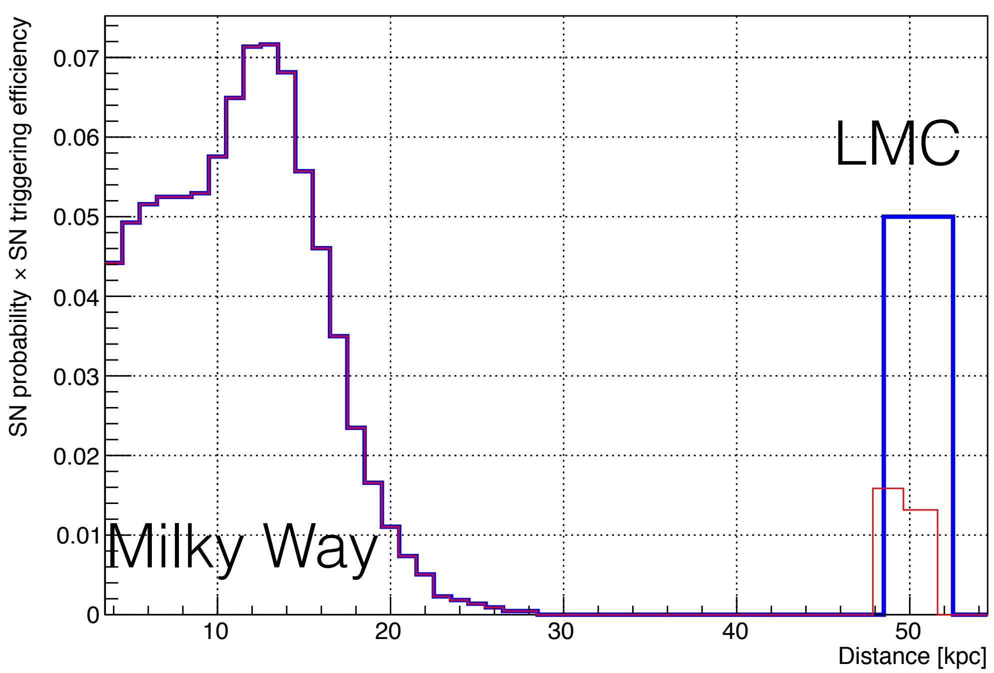
- Efficiency to trigger = $\epsilon_{\text{Trigger}} = \sum_{n=n_{\text{Thr}}}^{\infty} \text{Poisson}\left(\mu = n_{\text{detected clusters}}, n\right)$
- Depends on the burst (i.e the distance of the SN)



$\xrightarrow{1/R^2}$

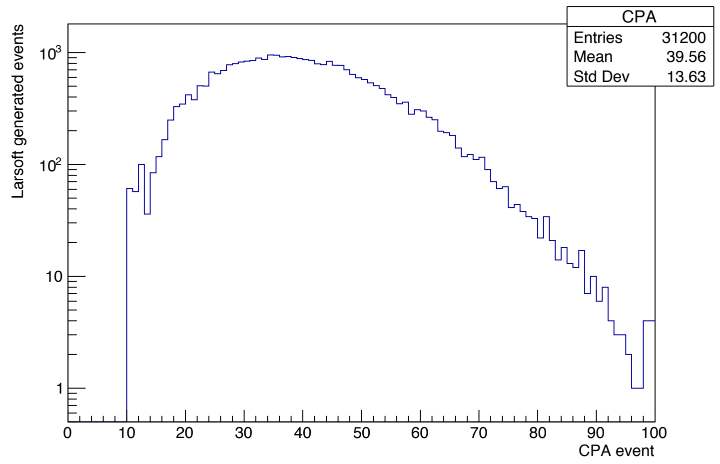


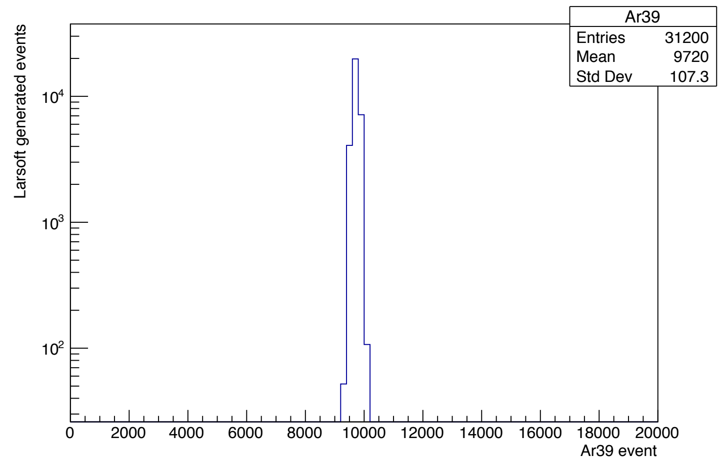
- Efficiency to trigger over the Milky Way is very good.
- LMC is more challenging.

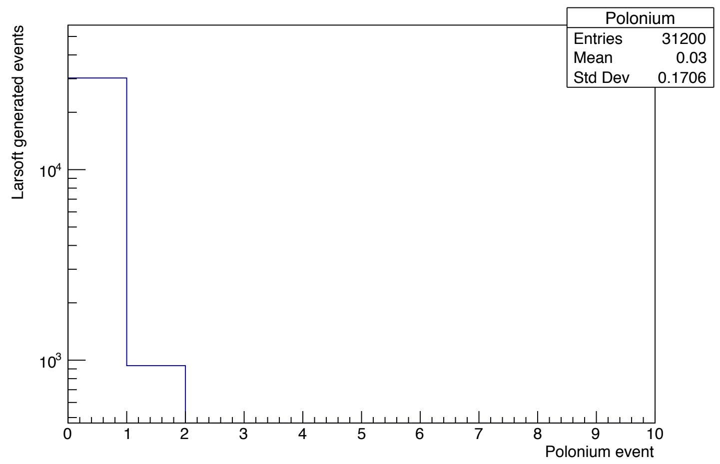


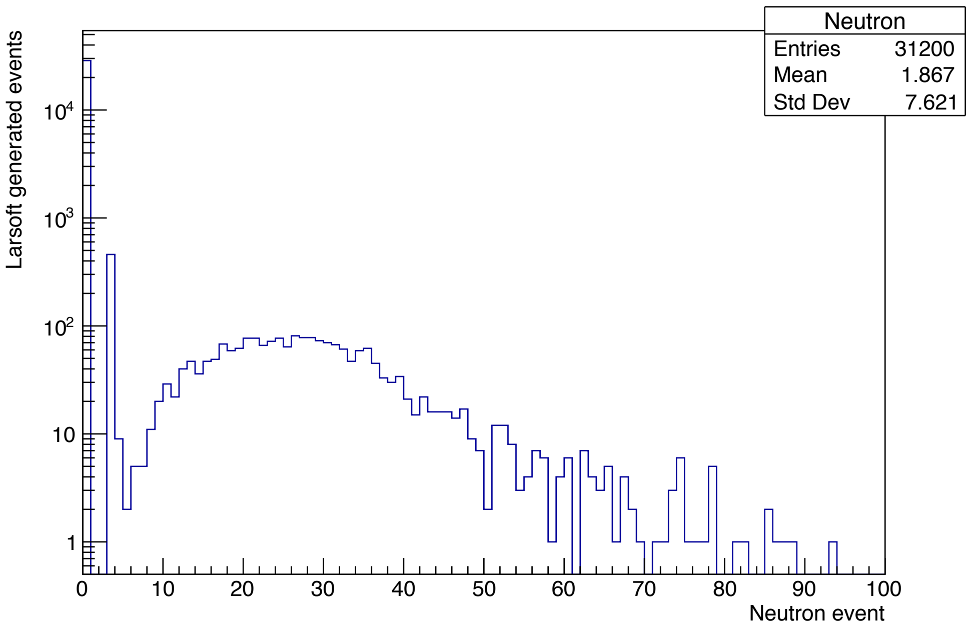
Background generation
Just double checking…

- Number of events generated from each background:









- Is this expected for the neutrons?
  - Most of the time **no neutrons**,
  - sometimes ~**30 neutrons**

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Background efficiency
Argon 39

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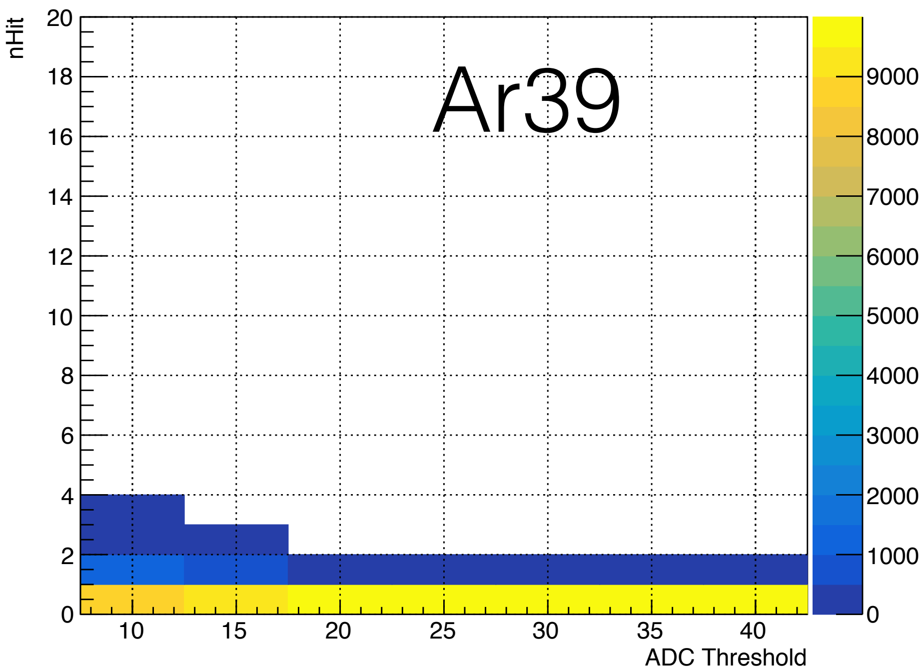
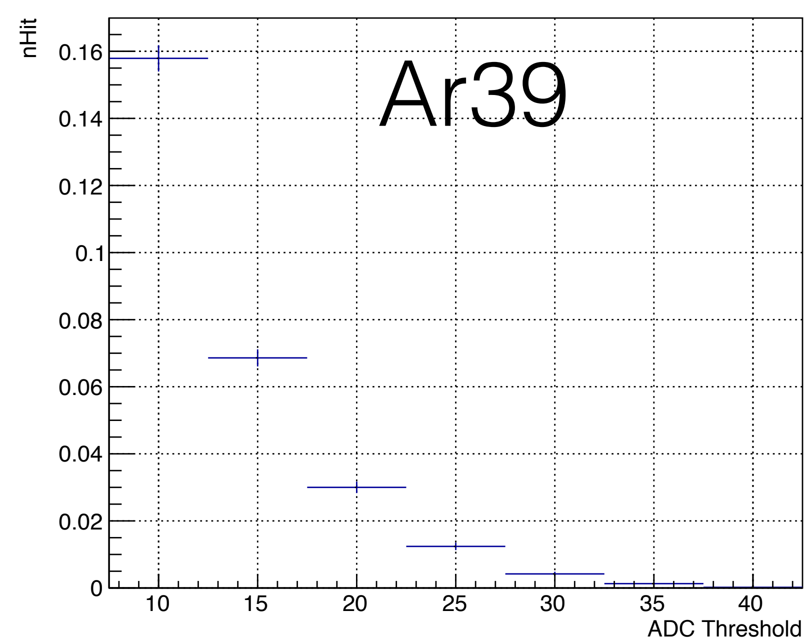
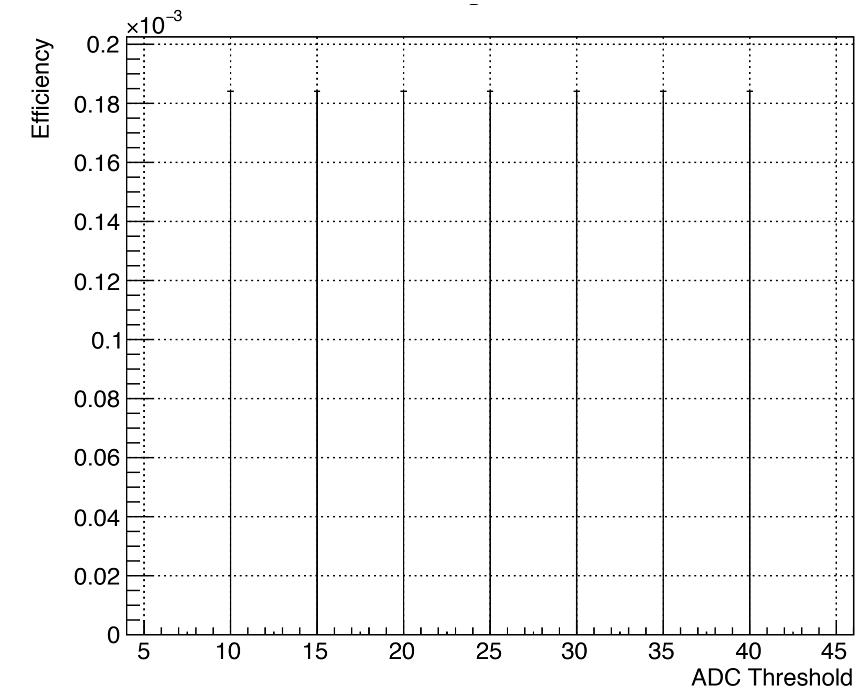
- Generated single neutrons with same background characteristics (place, energy).
  - Completed that for the Ar39, Ar42, neutrons.

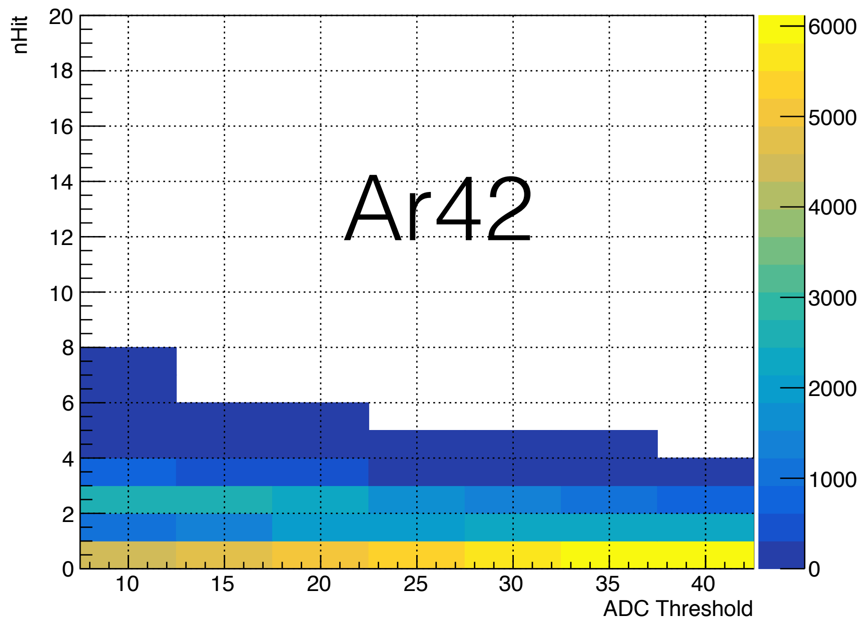


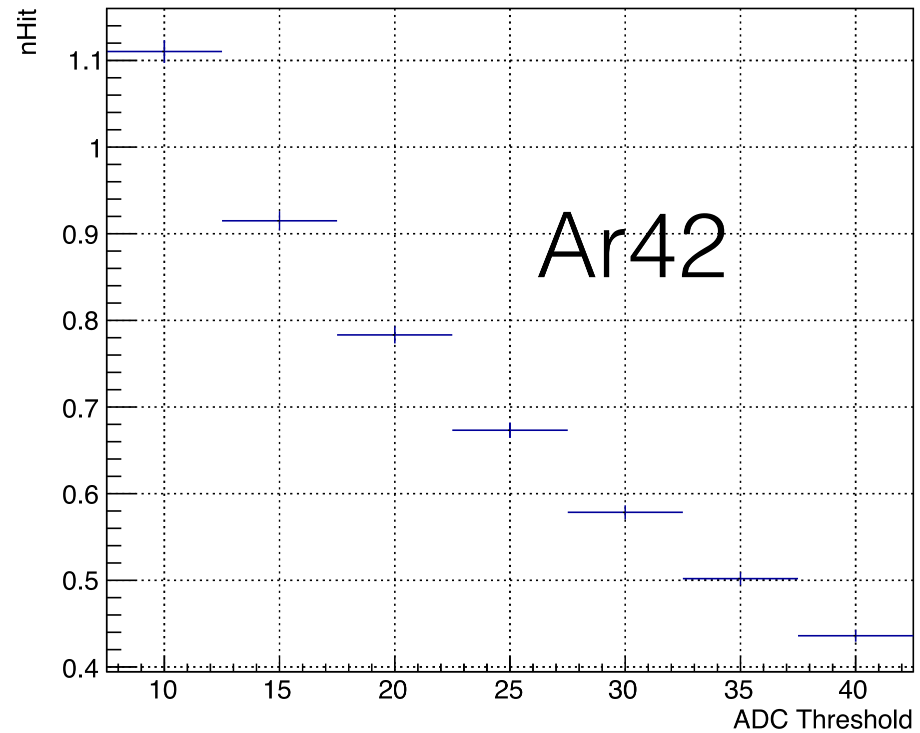


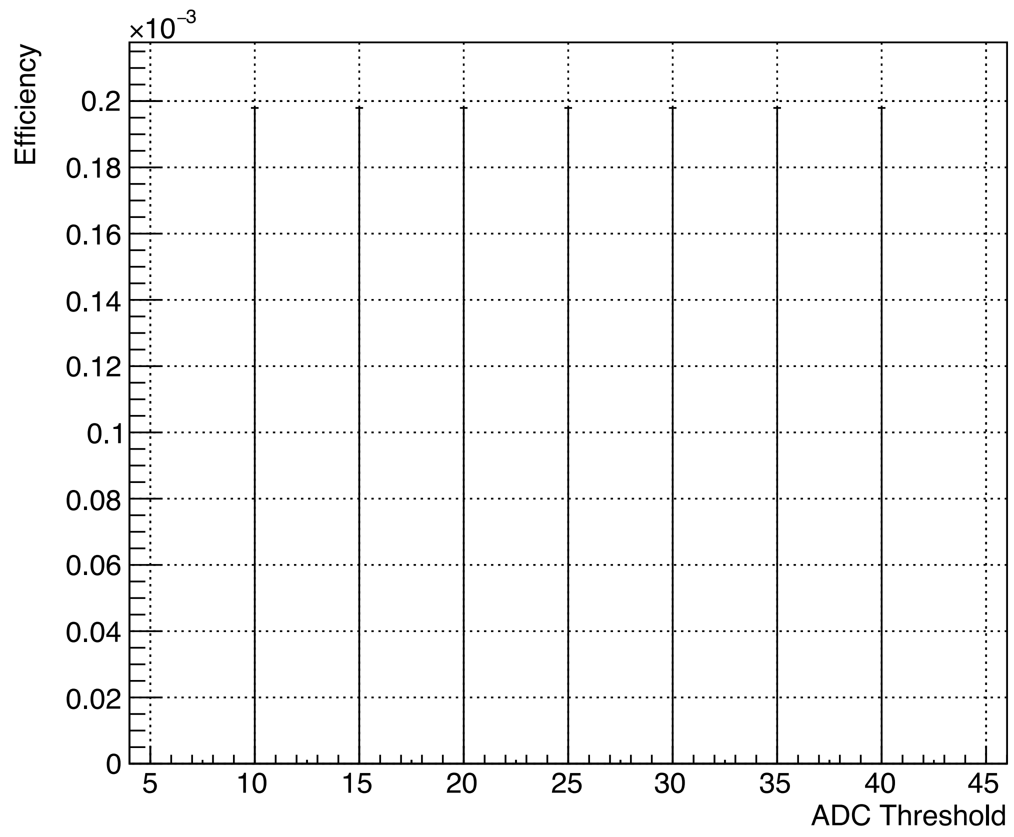


- Essentially, any sensible threshold you put for the ADC kills most of the Ar39 hits → it's impossible to trigger with Argon 39!
- The only way is pile up, some back of envelope calculation was made by Brett (I think) → still doesn't matter

Background efficiency
Argon 42

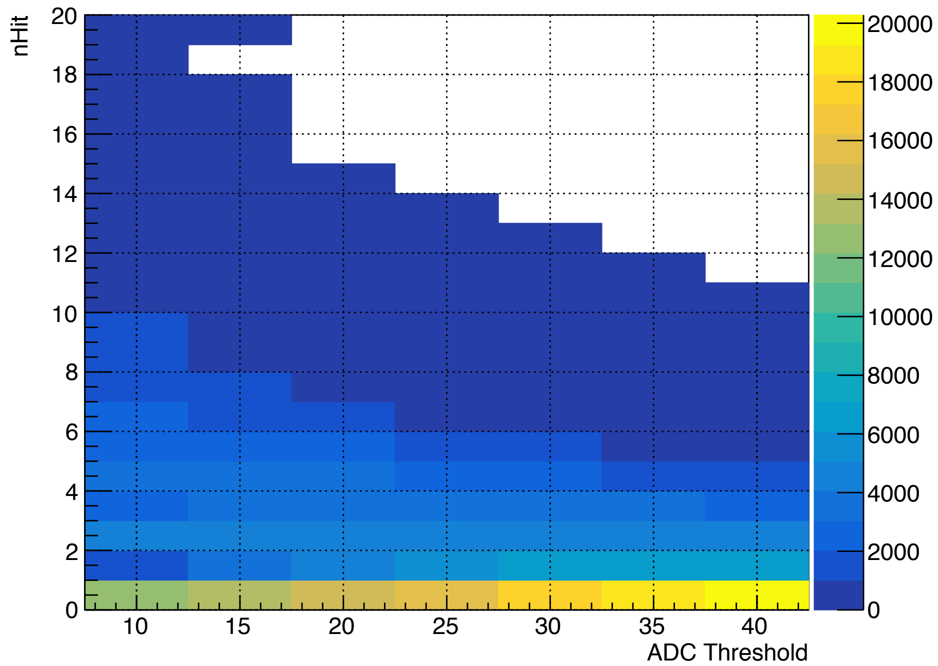


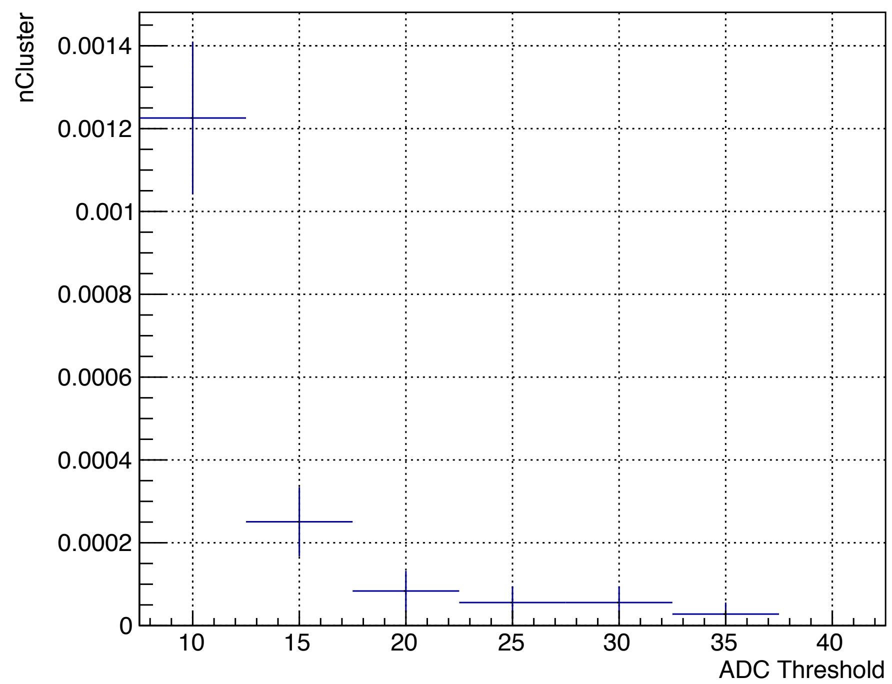




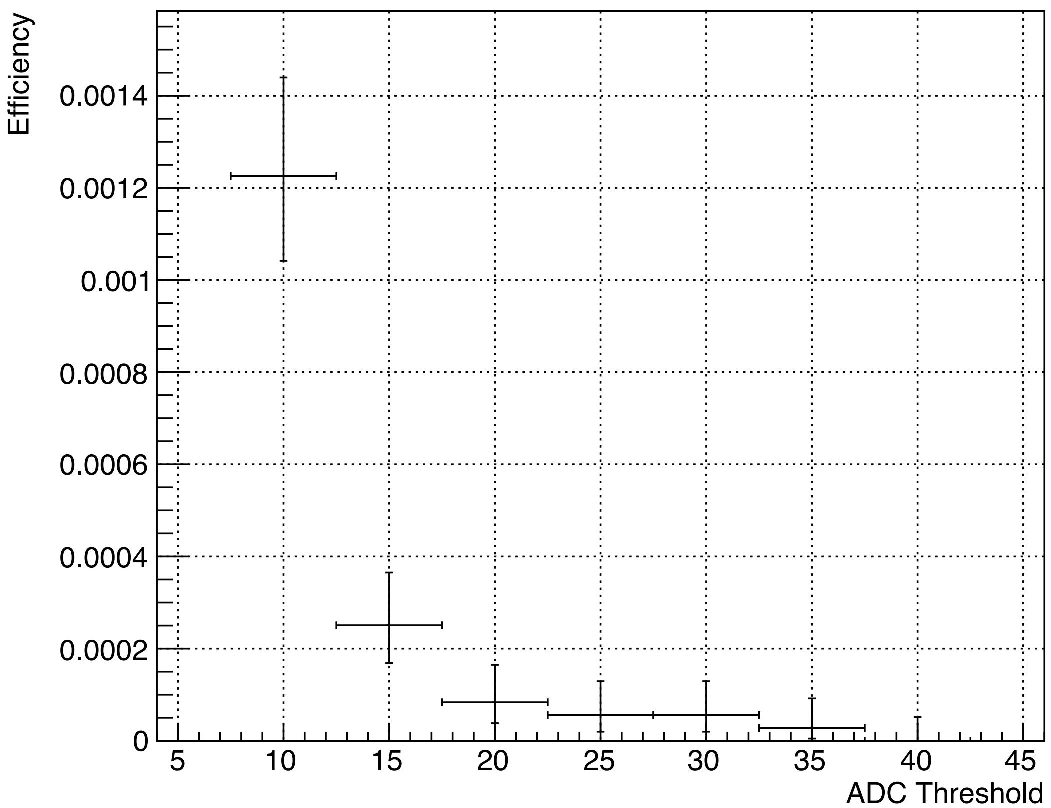
- Argon 42 is essentially just below the threshold!
- More studies are required

Background efficiencies
Neutrons



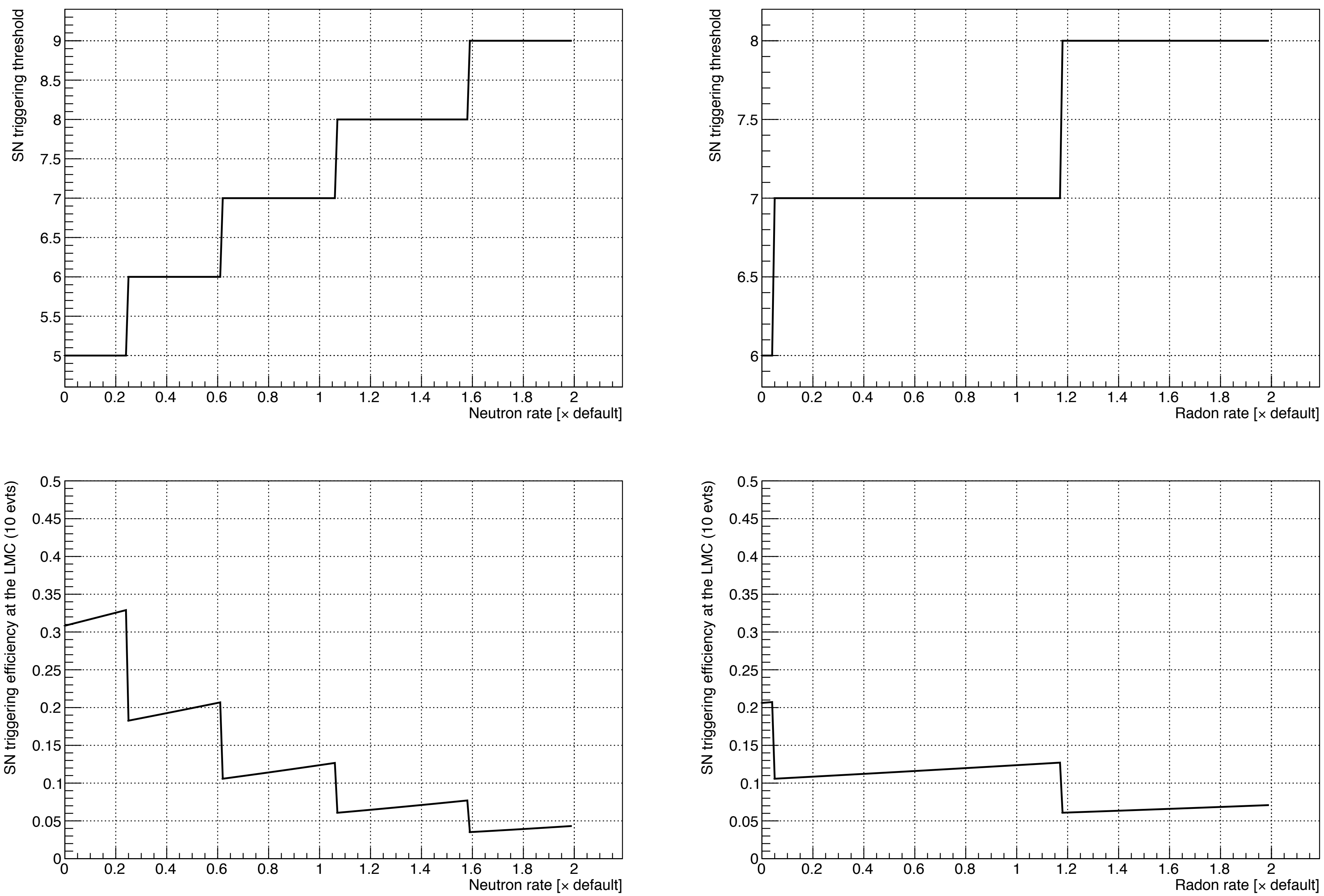


- Unlike for the Argon 42 case, well above the threshold.
- Geometrical effects are non trivial for the efficiency calculation (most of the neutrons don't actually make it inside the detector)
    - Student looking at this (Aran Borkum)
- Low efficiency probably means we don't need to worry about the pile up?
    - Uranium spontaneous decay (multiple neutrons).



Background analysis

- What do we get if we reduce backgrounds:
  - Argon 39 → quite clear that we don't get any sensitivity (maybe sparing space on disk)
  - Neutron
  - Radon



- If we manage to reduce the background neutron background, increase of the sensitivity at the LMC
- Radon contribution is also here.

Conclusion

- Main backgrounds for triggering low E are neutrons and radons:
  - Managing to get rid of this makes the SN trigger more efficient.
  - Neutron pile up seems okay?
- Argon 39 doesn't impact triggering.
- Argon 42 is not very far from the threshold, need to be careful.