Supernova sensitivity
- *or* -
How BGs impact the Supernova Triggering

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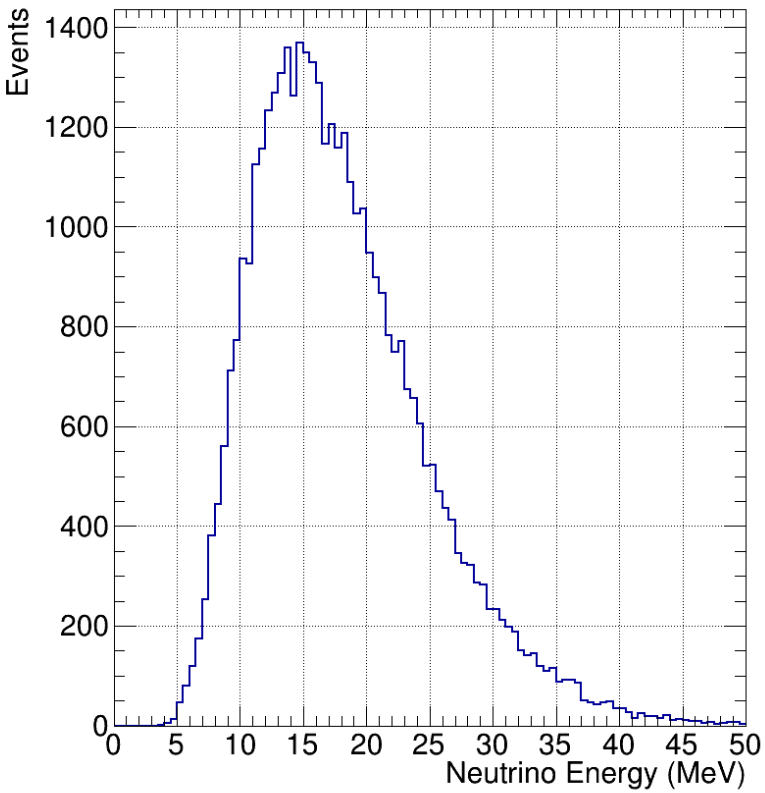
Basics for Supernova Triggering

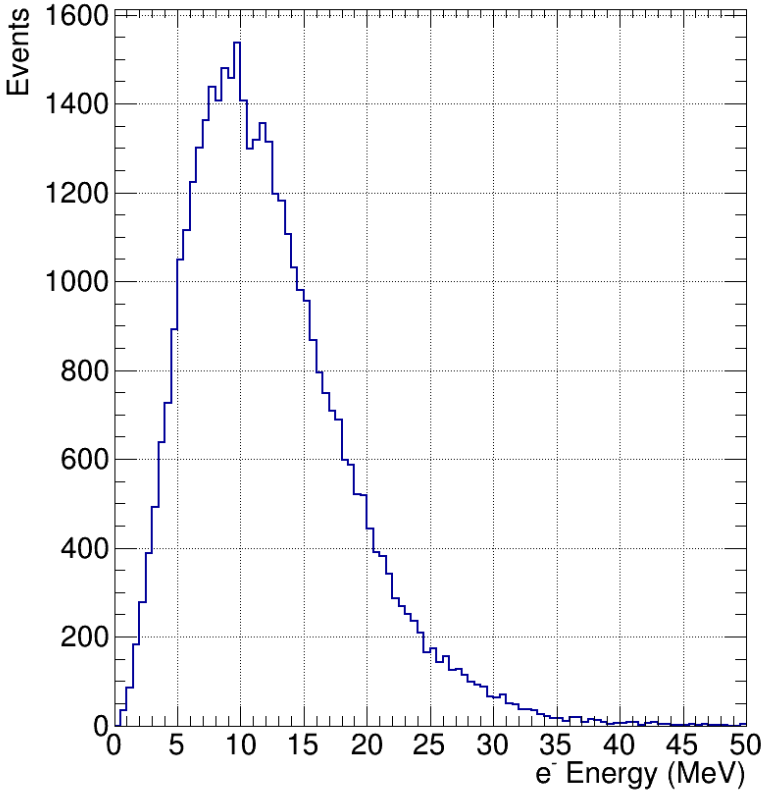
1. Need to estimate signal event rate ($\sim$10 sec)
   - How to design the DAQ to handle it
   - Or, what will be the DAQ limitations in a SN event?
2. Need to know BG rates
   - Minimize it to avoid fake triggers (SNEWS)
   - Also minimizes buffering/storage needs
     (1 SN trigger $\rightarrow$ 100 sec full detector readout)
3. Looking at the trigger since available info is less and worse energy resolution. If all works at this level, much easier to handle off-line.

Supernova Basics

Basics of Supernova at DUNE (I)

$$\nu_e + Ar \rightarrow e^- + K^*$$

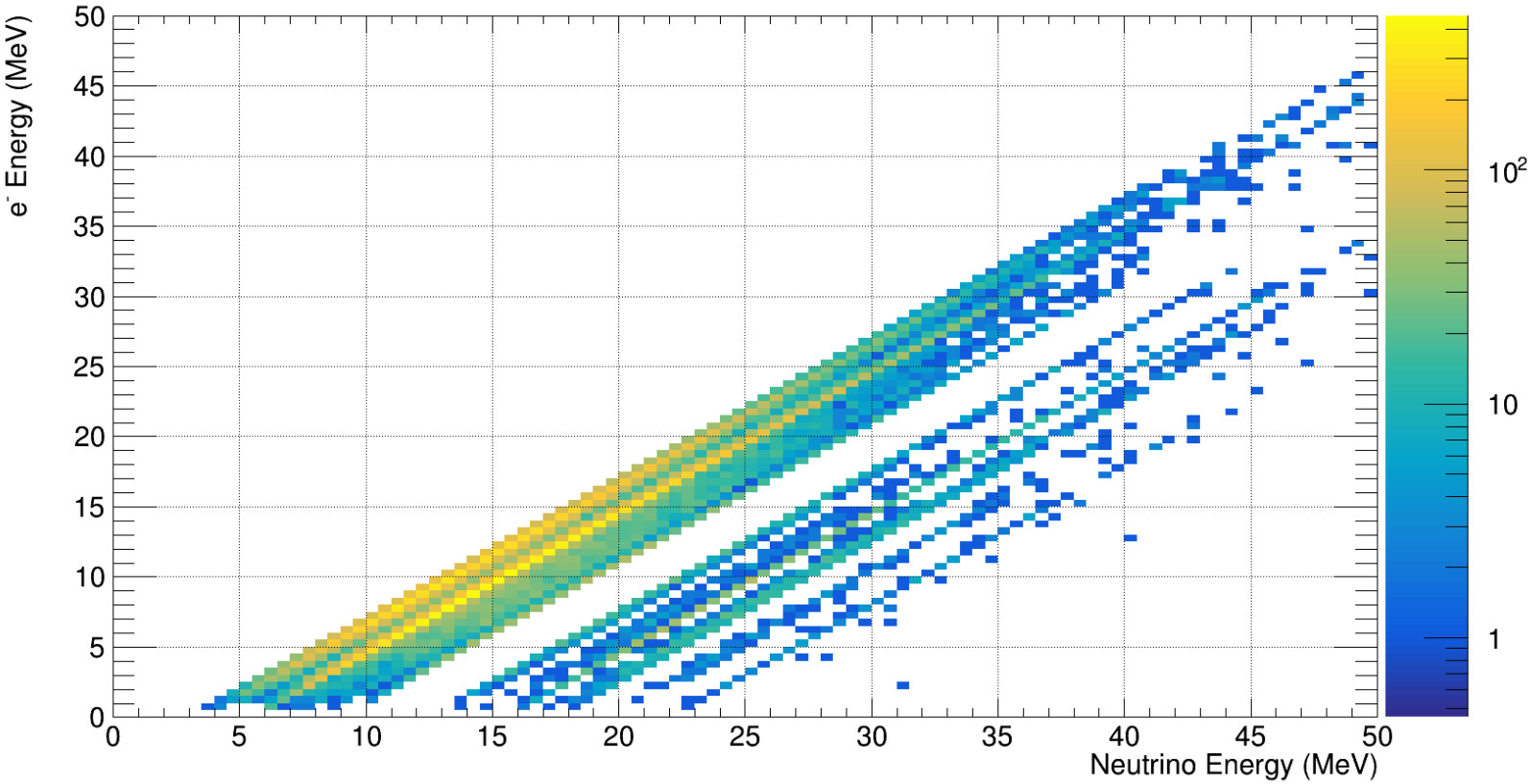




MARELY events

Basics of Supernova at DUNE (II)

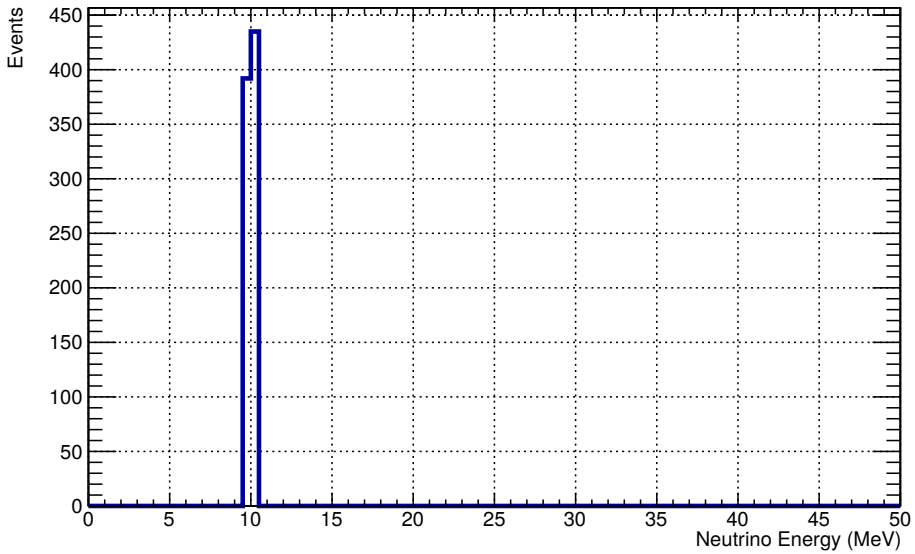
$$\nu_e + Ar \rightarrow e^- + K^*$$

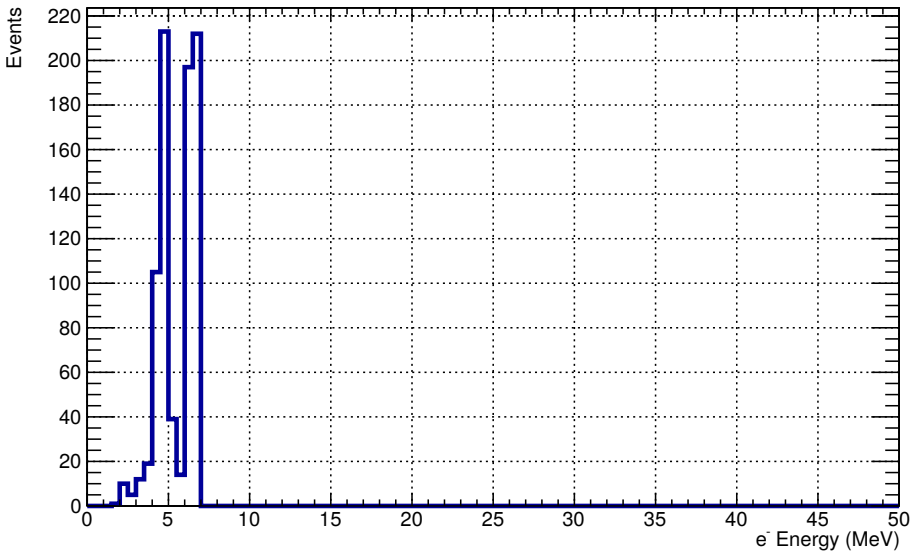


Distribution features due to nature of CC interaction

Basics of Supernova at DUNE (III)

$$\nu_e + Ar \rightarrow e^- + K^*$$





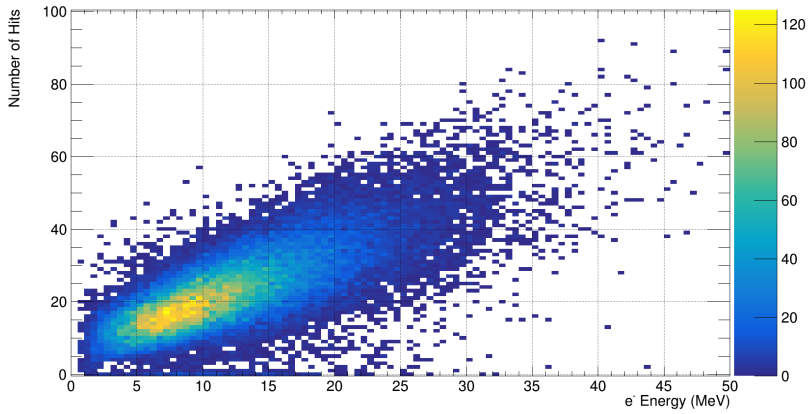
Distribution features due to nature of CC interaction

Supernova Observables @ DUNE

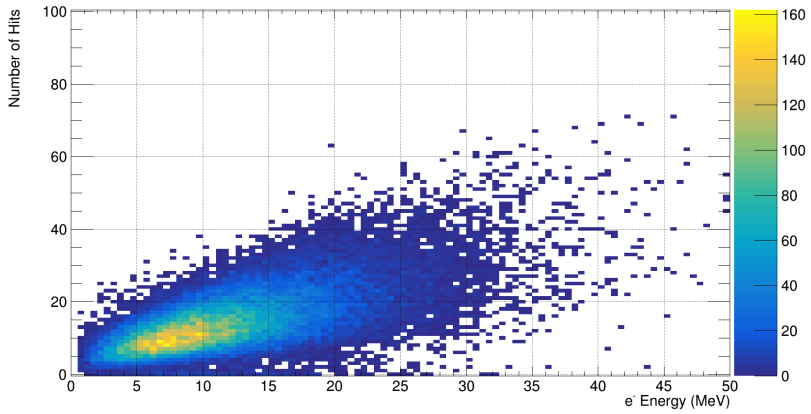
What's the observable for SN triggering?

$\rightarrow$ TP (or hits)!

8 ADC threshold

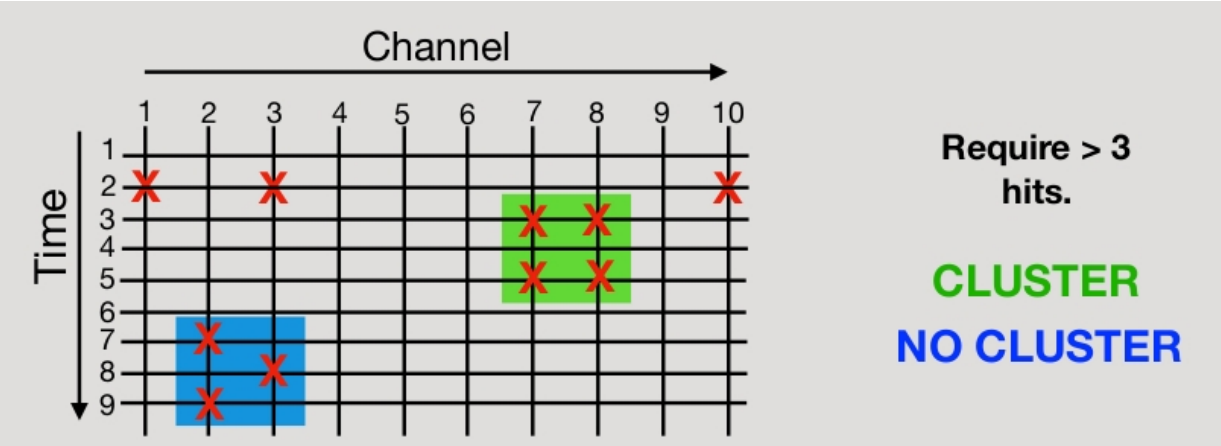


32 ADC threshold



How to select candidates events from SN?

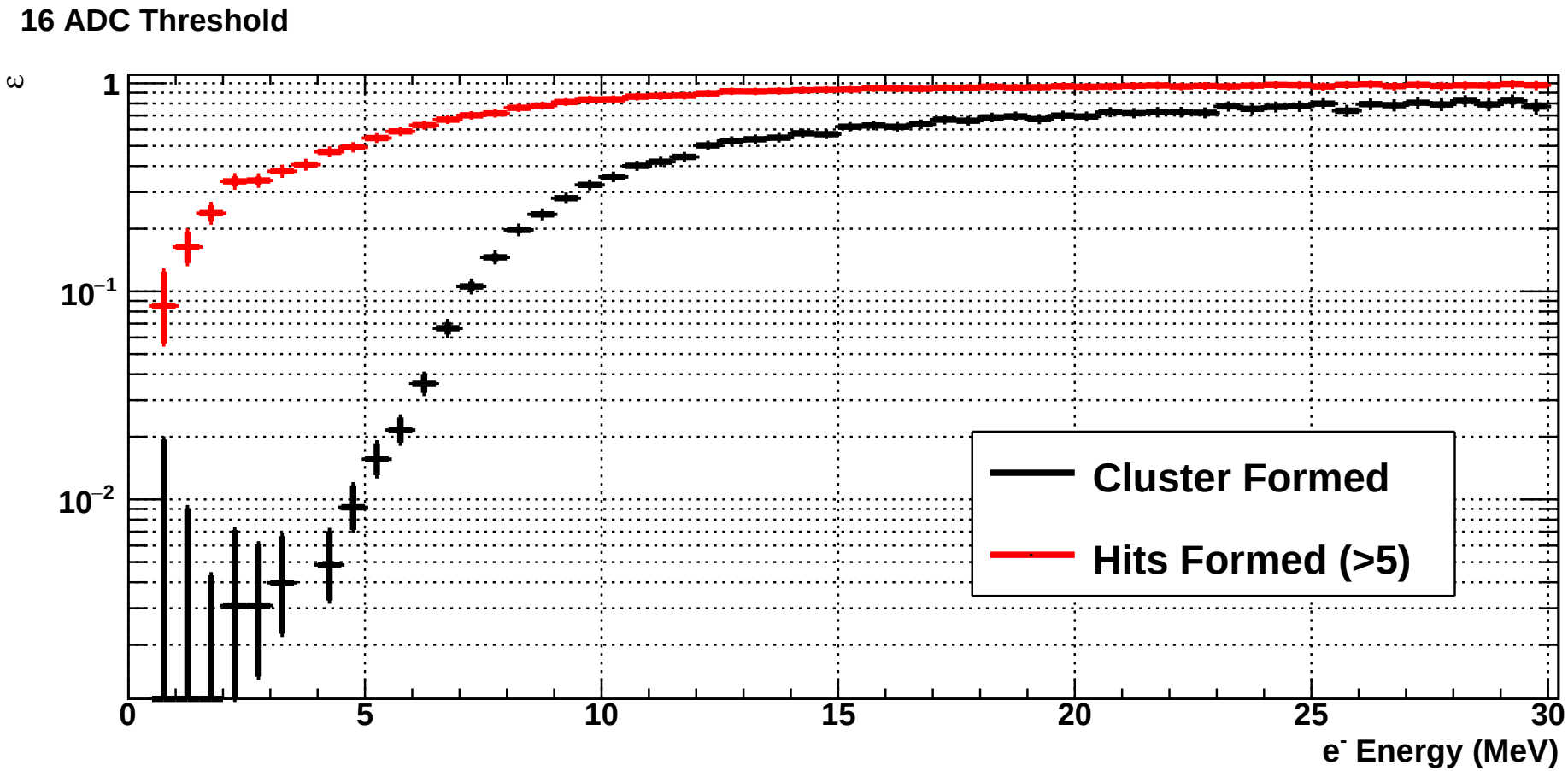
Clustering of TP (hits)!



New observable formation: Clusters of TPs

Hit and Clustering Formation Efficiency

$\varepsilon_{det} = \varepsilon_{hit} \times \varepsilon_{clustering}$

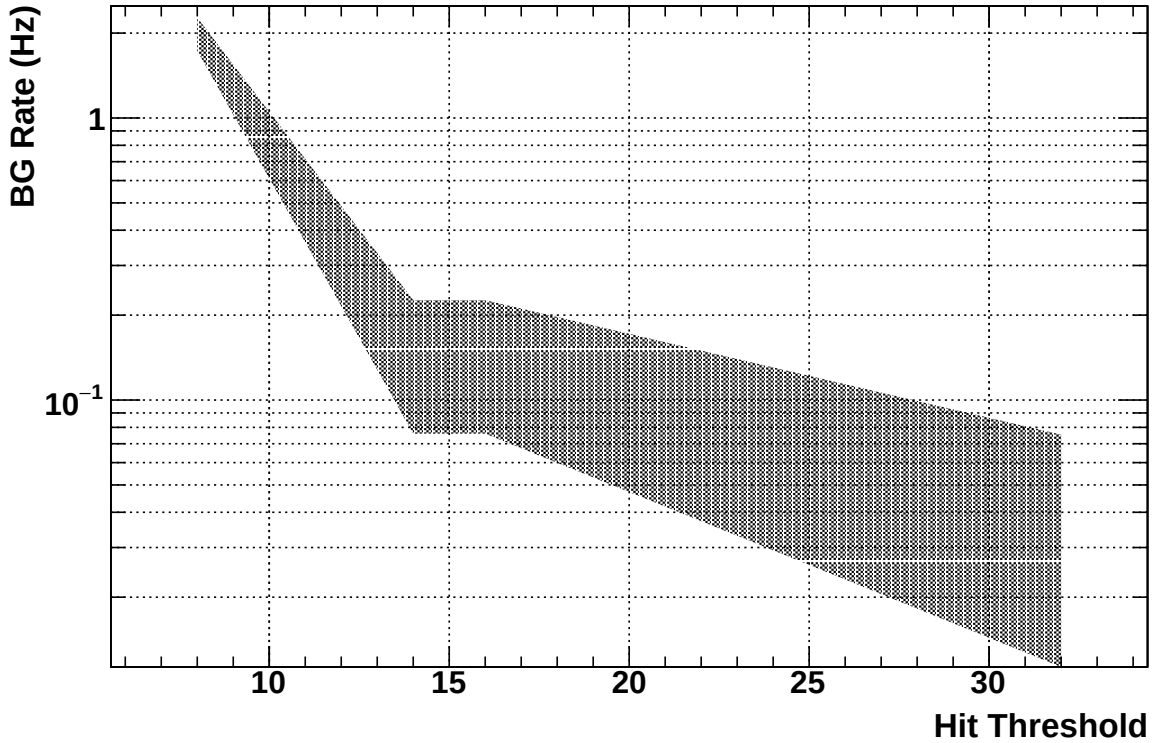


Collection wires only!

Backgrounds on Supernova Triggering

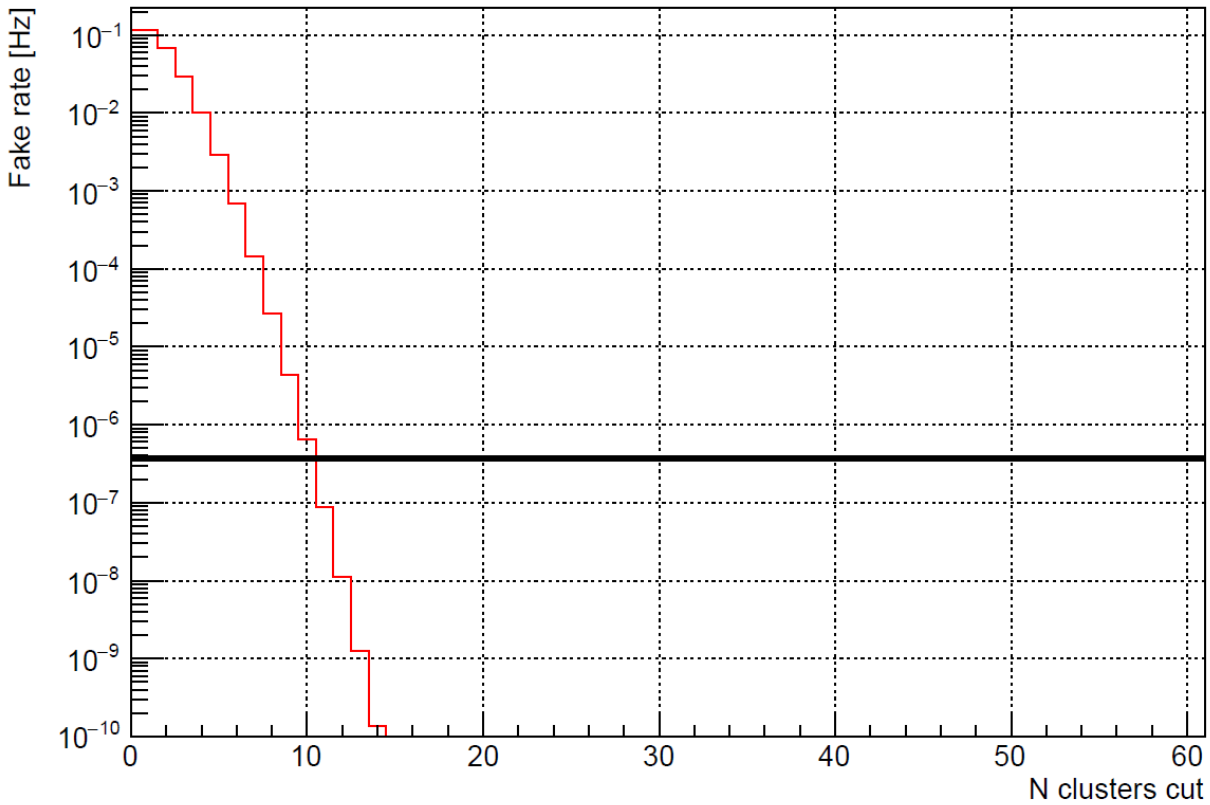
Clusters Rate from BG (MCC11)

100k MARLEY Events
Cluster definition: At least 6 hits and 1 ch



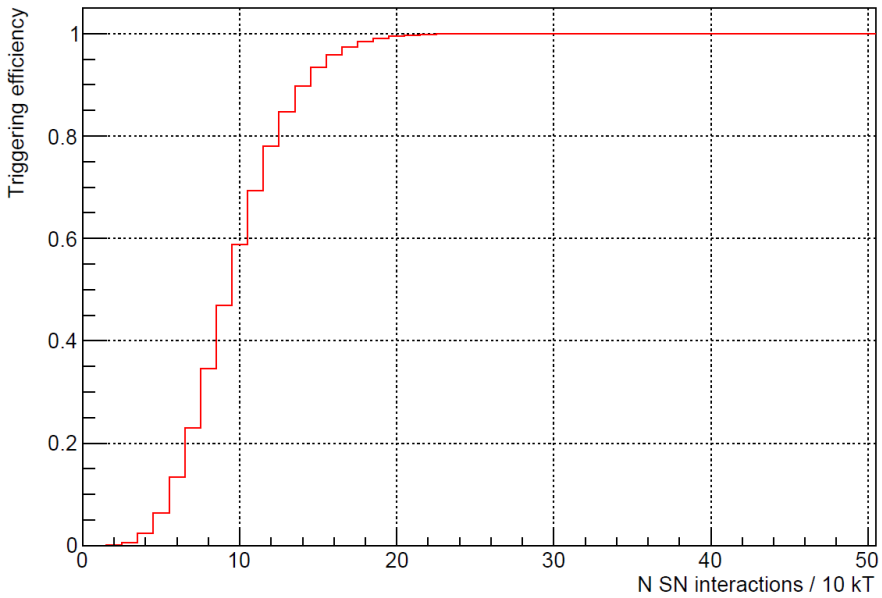
Fake SN Triggers with 100k MARLEY Events (MCC11)

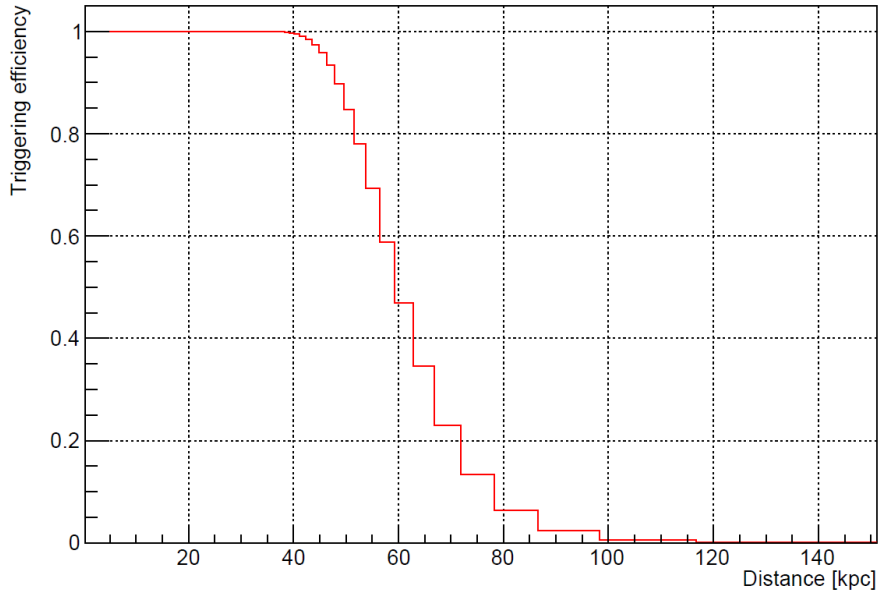
Background rate in 10kt $\rightarrow$ 0.151 $\pm$ 0.076 Hz



10 BG coincident clusters $\rightarrow$ once every month

How efficient we are with 10 clusters from a SN?

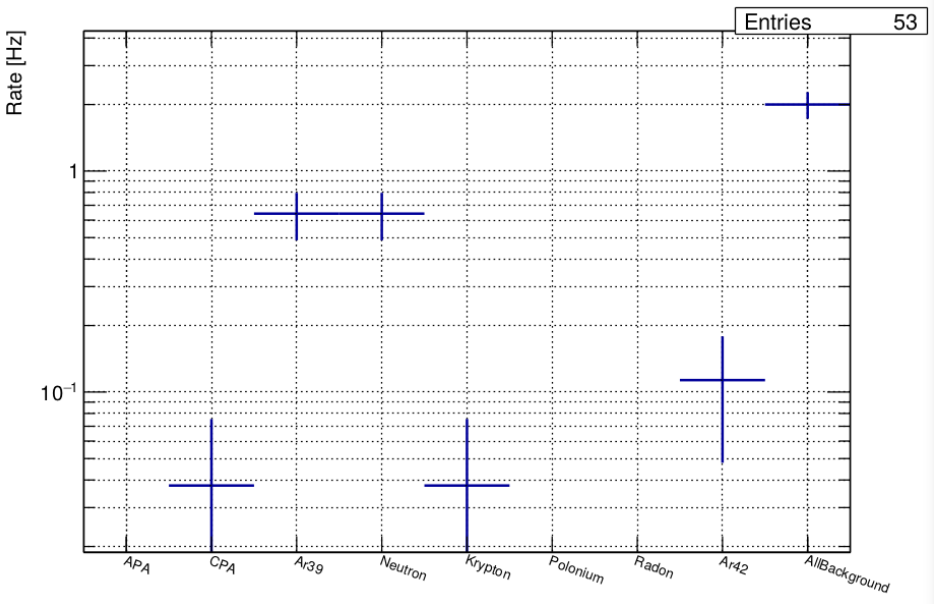




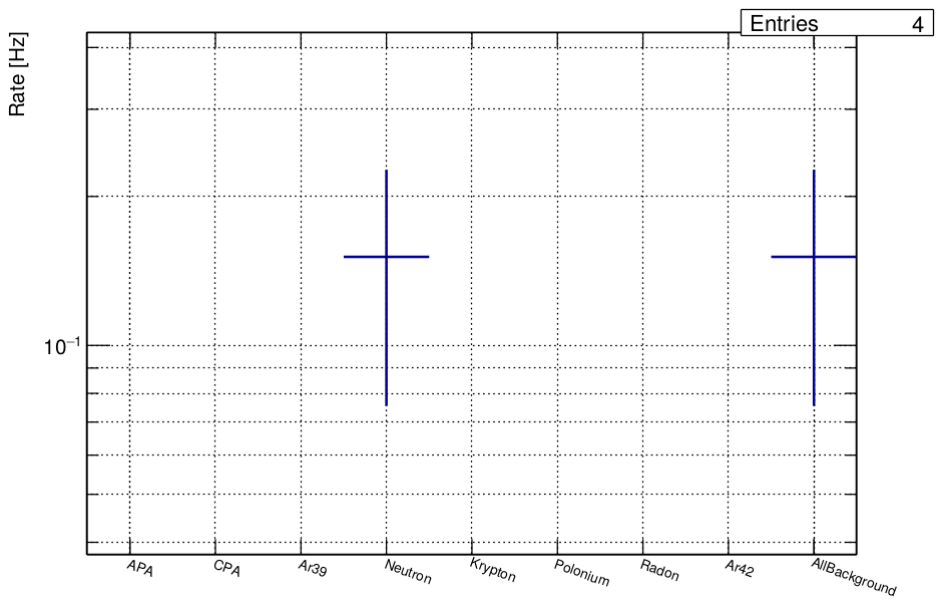
60% (meaning distance of $\sim$60 kpc, LMC covered, model dependent)

BG Composition of Selected Clusters

100k MARLEY Events. Cluster definition: At least 6 hits and 1 ch



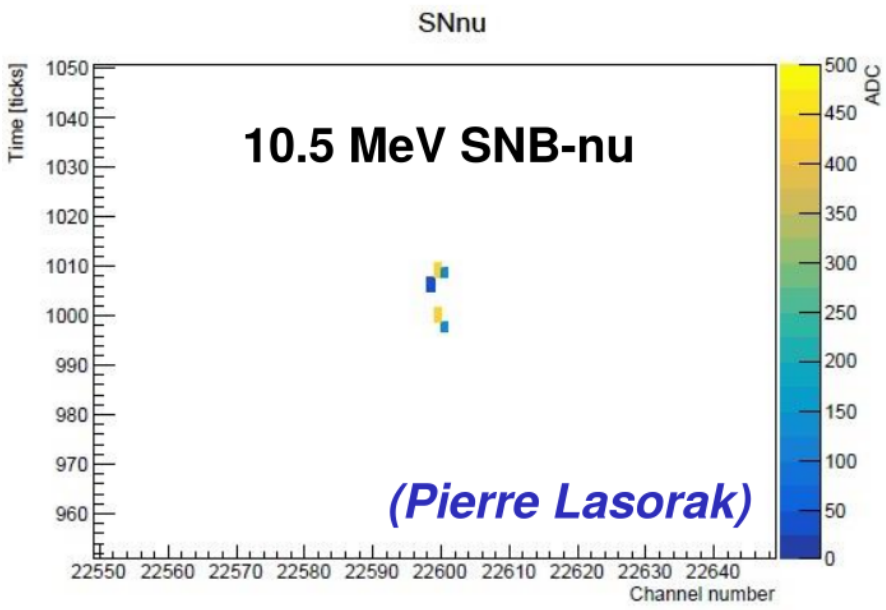
thr. = 8 ADC

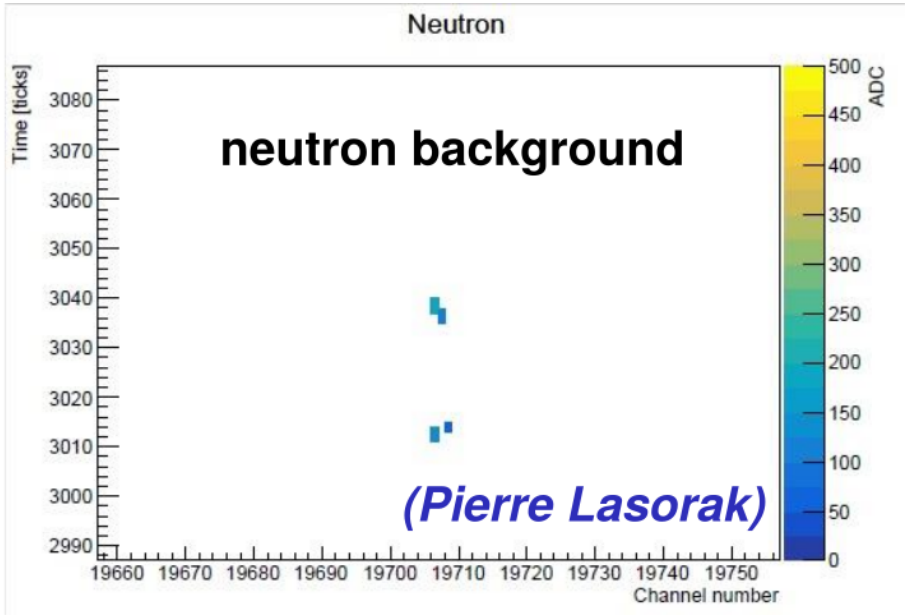


thr. = 16 ADC

- Only Neutrons remains at hit thr. of 16 ADC
- Understanding them is *a must*
- This rate (TDR status) inaccurately estimated:
  - small $1 \times 2 \times 6$ MC detector
  - Materials
  - neutron Energies

Another reason to understand neutrons

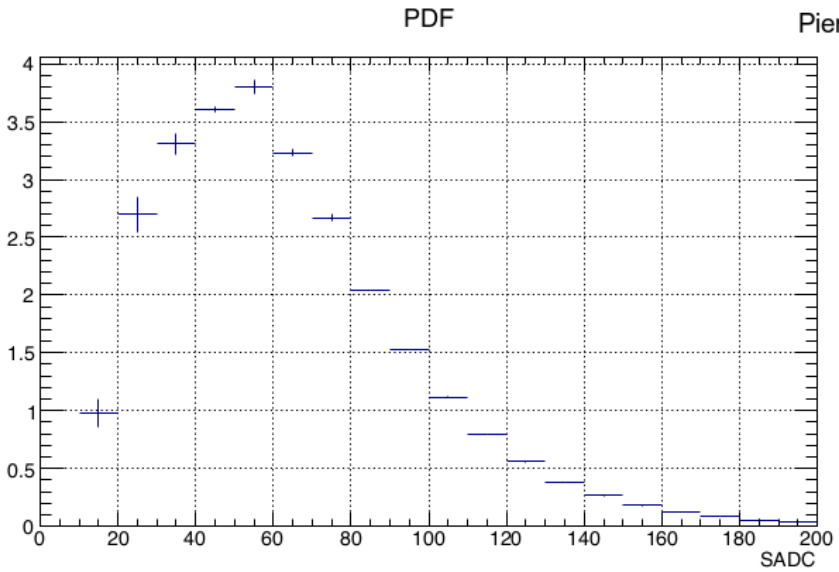




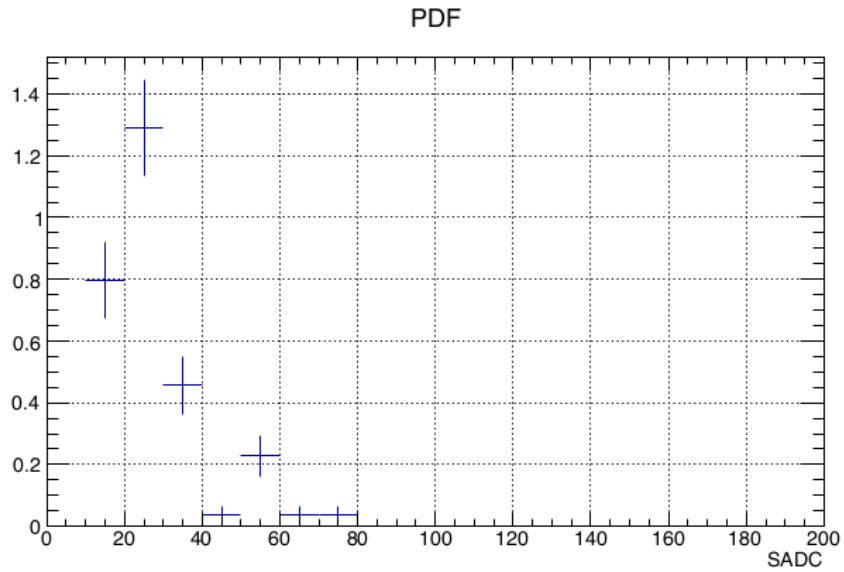
Prospects

Shape SN trigger (I)

→ Counting events so far (integrated number of Clusters), but ADC and cluster size also available.
E.g. Use ADC to discriminate SN from BG:



Signal+Background



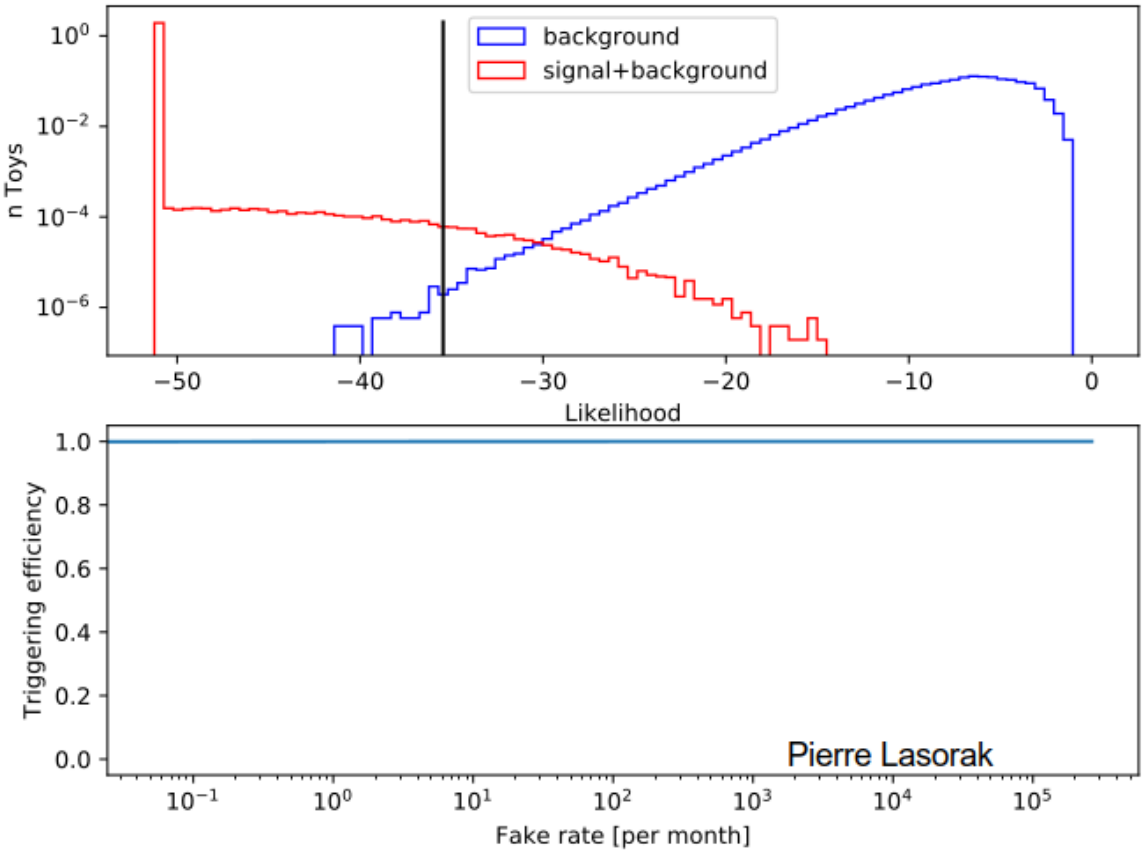
Background only

Shape SN trigger (II)

→ Likelihood to compare cluster's ADC shape (10 sec) between BG only and signal+BG

→ H.E. events shape very different from BGs (are we confident of them?)

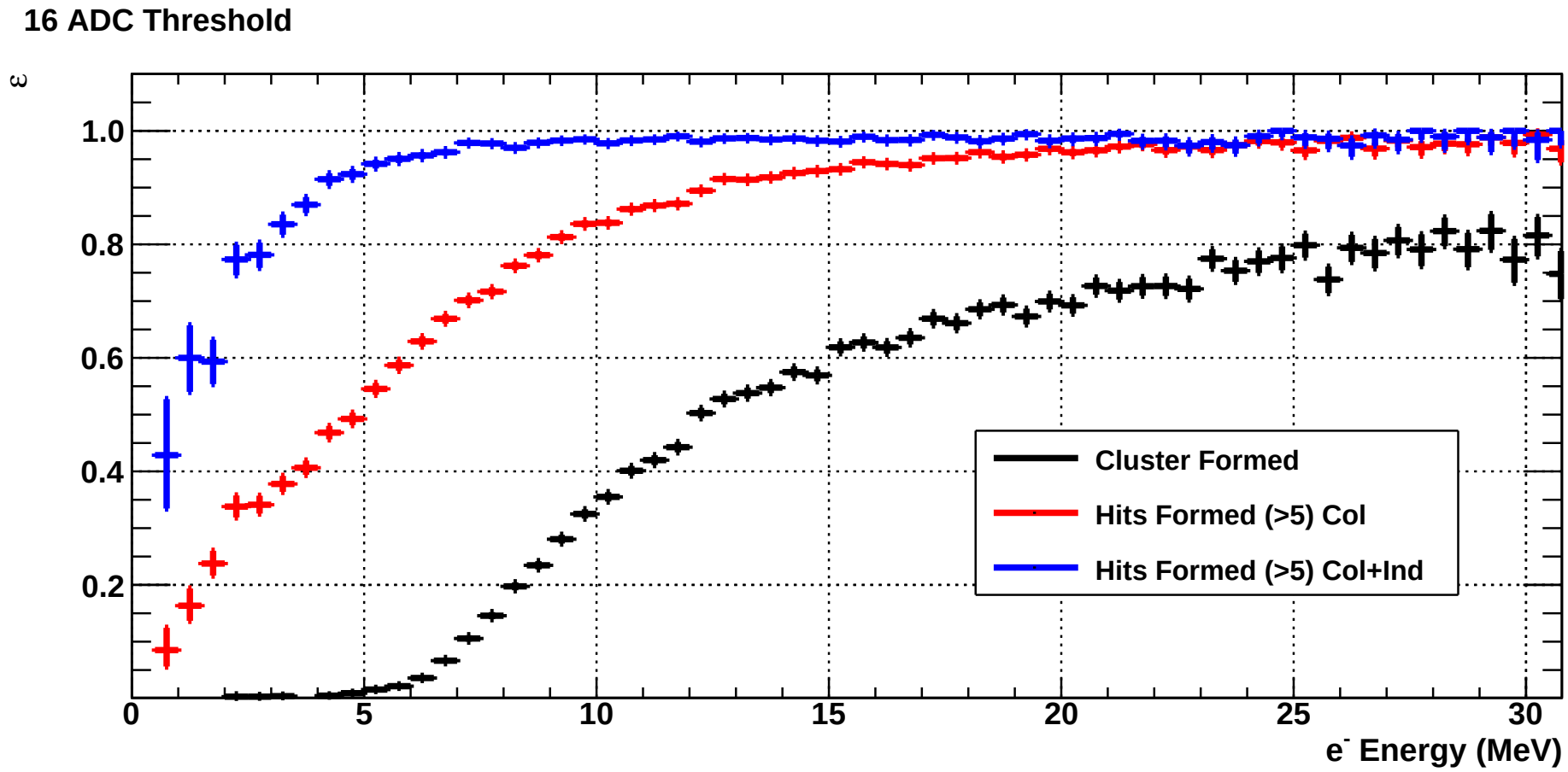
→ BGs shape can be measured "locally"



Induction Wires (I)

More TP available at Induction Wires $\rightarrow$ increased efficiency

$\varepsilon_{det} = \varepsilon_{hit} \times \varepsilon_{clustering}$



Induction Wires (II)

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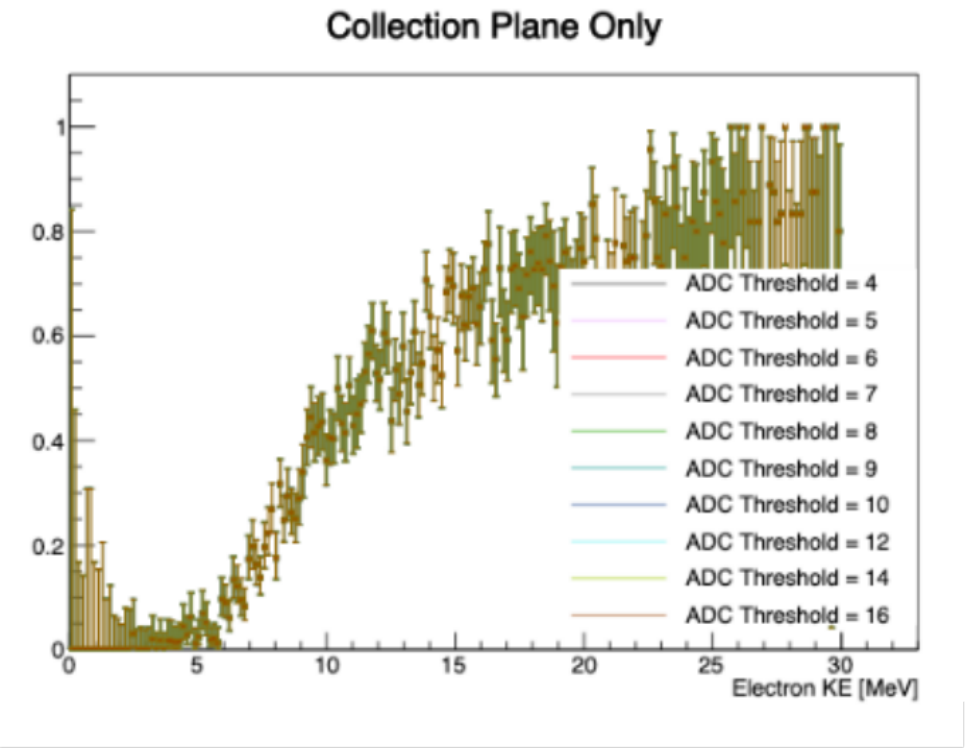

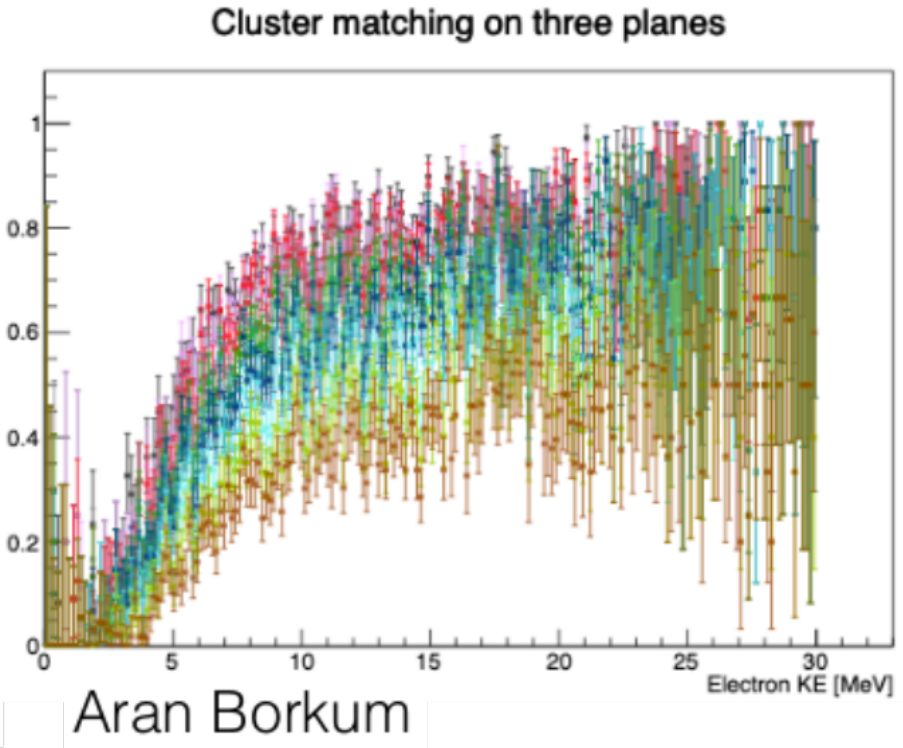

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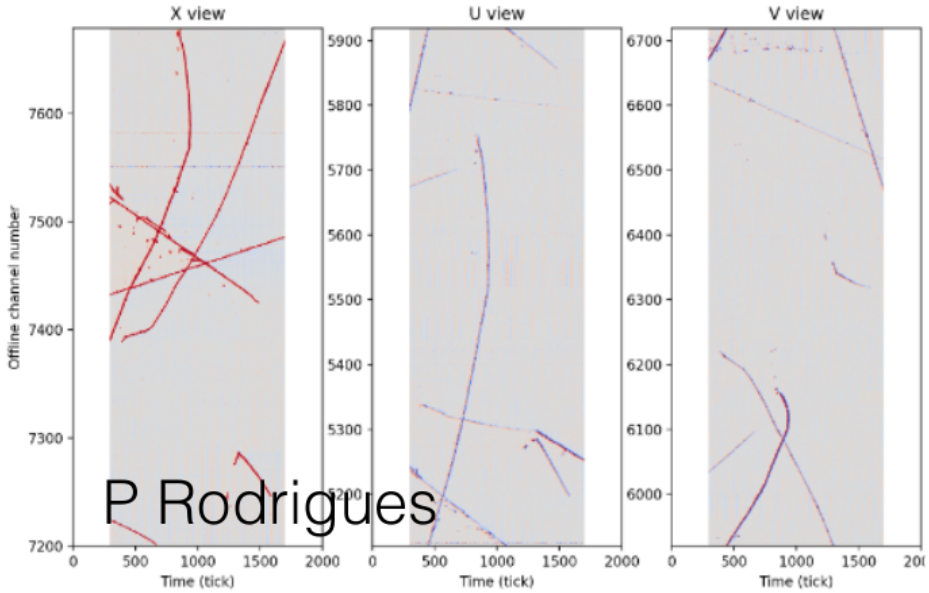
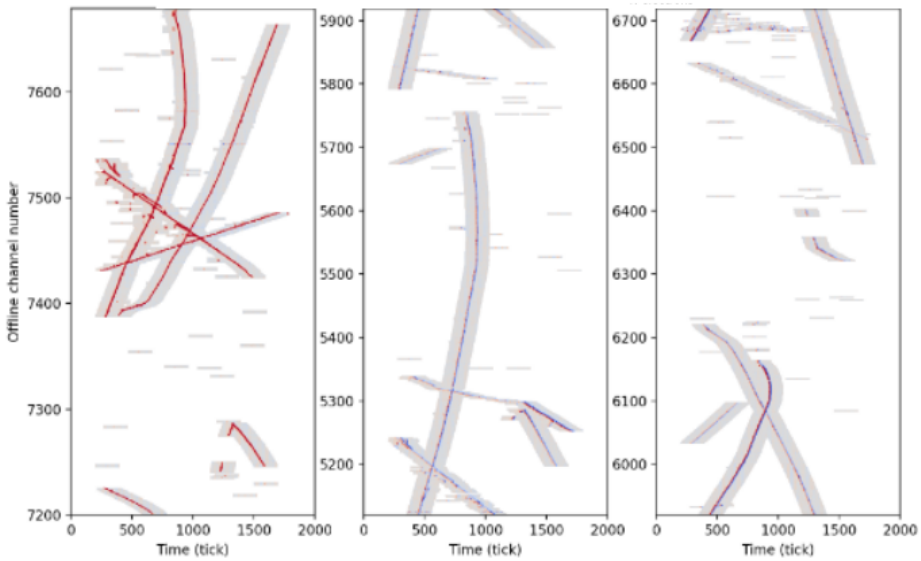
Room for Improvement (III)

More TP available at Induction Wires $\rightarrow$ increased efficiency
Possibility for ROI triggering (and less data to be stored)





Summary

- DUNE will record SN events if one happens in our Galaxy (or Magellanic Clouds)
- Main detection channel: $\nu_e + Ar \rightarrow e^- + K^*$
- Main BG source: neutrons (radiogenic and spallation)
- One fake SN trigger per month achieved, needs updates (neutrons!)
- Still room for improvement (Induction, ROI, shape information)

Backup Slides

Supernova Triggering at TDR

→ Requirements at SP TDR:

"For planning, the DAQ will allot an average SNB trigger rate of one per month. Given current understanding of **rates and the >95% expected efficiency for a SNB with at least 60 interactions each of minimum 10 MeV** *in true neutrino energy, most such triggers will be due to fluctuations of low energy radiological backgrounds and, potentially, excess noise. Such triggers will prompt 100 s of data from the entire module to be read out. At this average rate and if saved to offline storage, the SNB triggers will produce 1.8 PB/year uncompressed from one single-phase module. There is, however, no requirement to permanently store SNB data that is deemed, after further offline analysis, to be due to fake triggers."*