# Initial look at CNO-events

Instrument Analysis Group

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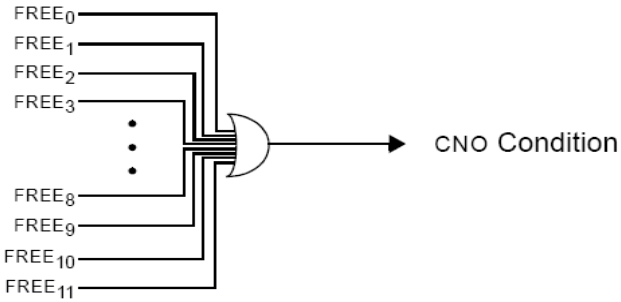
# Introduction (from LAT-TD-01545)

inputs from the ACD fall into two categories:

- **Vetos:**
  A discriminated signal from each of the 97 tiles of the ACD, used to (potentially) veto tracker triggers originating in any one of the sixteen towers.
- **CNO:**
  A discriminate signal representing highly ionizing particles from heavy nuclei (Carbon-Nitrogen-Oxygen). This input is used as a trigger.

- Each GAFE splits the light output of its PMTs into two signals: a veto signal and a CNO (or High Level Discriminator) signal. Both signals are separately amplified, shaped and discriminated.

- The CNO signals from (tile, pmt) channel are “wire ORed” on each FREE board. Thus, there is one CNO signal per FREE board, for a total of twelve (12) CNO inputs delivered to the GEM. These 12 signals are “ORed” to form the CNO condition.



# The Data we used

MonteCarlo (EngineeringModel v6r070329p16):

surfacemuons_4M_merit.root
surfacemuons_4M_svac.root

Data @ SLAC:

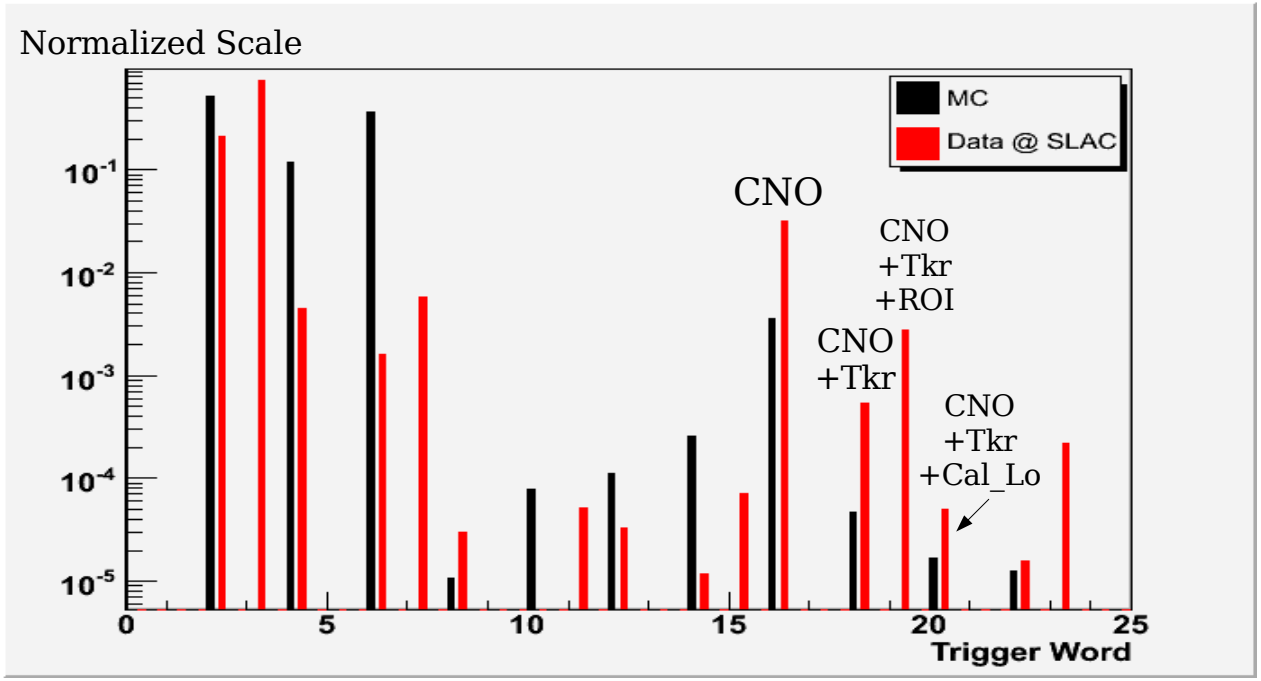
| | | | |
|---|---|---|---|
| run 77004472 | 945045 events | 1880 s | Lat Vertical |
| run 77004473 | 947899 events | 1880 s | Lat Vertical |

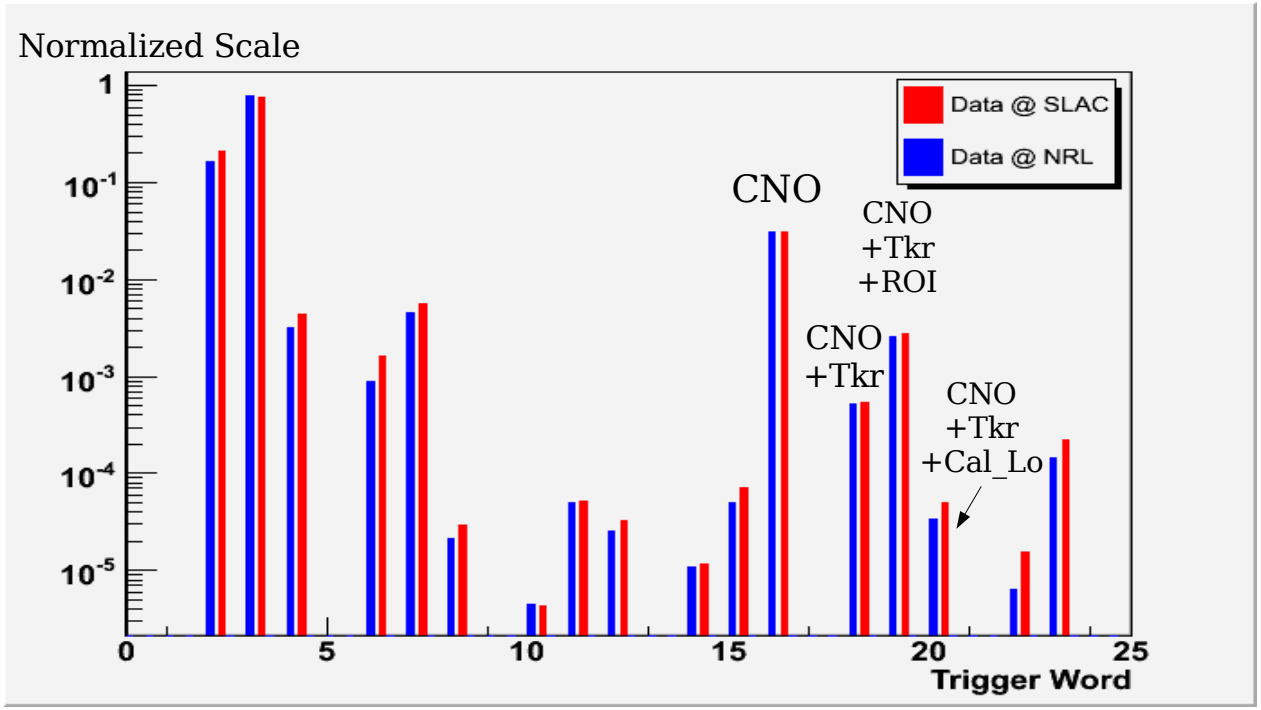
Data @ NRL:

| | | | |
|---|---|---|---|
| run 77005067 | 804269 events | 1880 s | Lat Vertical |
| run 77005068 | 805283 events | 1877 s | Lat Vertical |

Caveat:
MC simulations only have muons. Real data has complex showers, which are very relevant for CNO-triggered events. Serious comparisons are (kind of) meaningless.

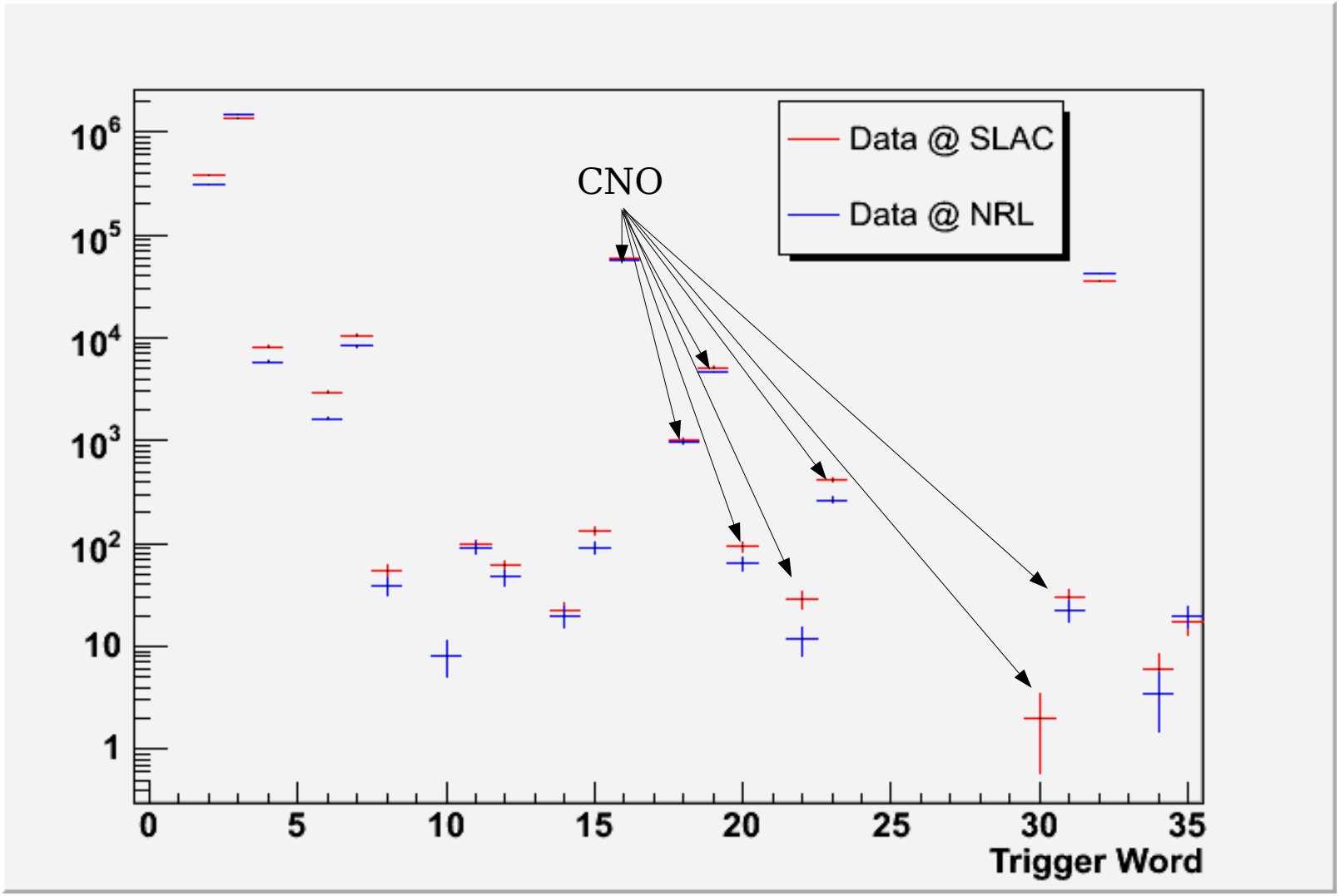
# Trigger Distributions




- In the GemConditionsWord, the CNO trigger is set on bit 4 (GemConditionsWord=16)
- For the MC simulations the ROI bit is never set (why?)
- Initially we were puzzled by events with triggerword=16 i.e. CNO events without veto trigger?
  Yes, because the ROI bit is set only if there is a Tkr trigger from the "shadowed" tower. (Therefore, some ROI triggers are ignored when setting the trigger word)
- There is one order of magnitude more CNO events in the data than expected from simulations
- The trigger distributions for data taken at SLAC and NRL look alike as it should be (more on next slide).

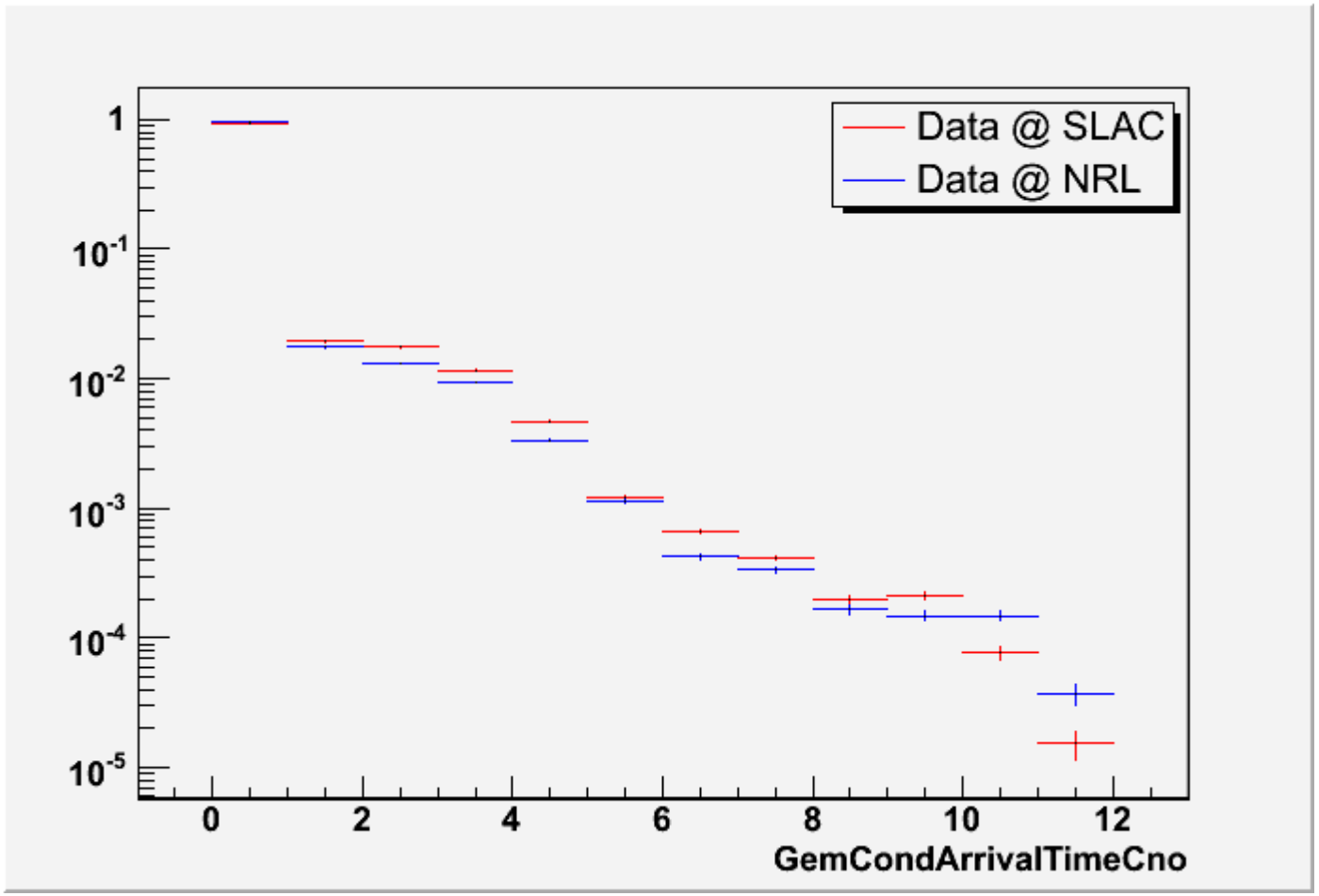
# Trigger Distributions: SLAC vs NRL




CNO events trigger rate: @ SLAC = ~ 18 Hz (3.8% of Tkr trigger rate)
@ NRL = ~ 15 Hz (3.5% of Tkr trigger rate)

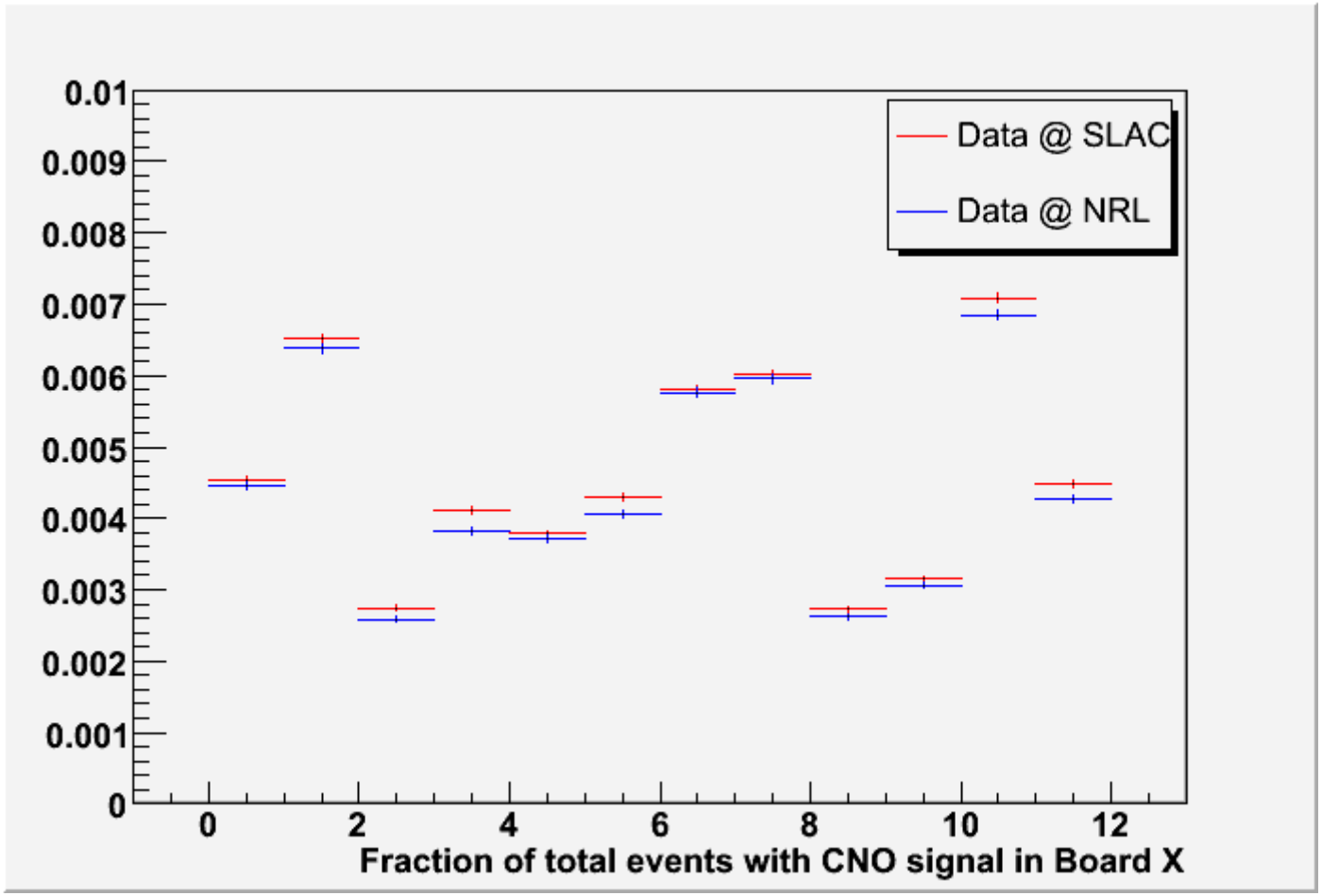
- NRL runs have lower trigger rate, due to missing low energy events (roof)
- This results in an overall different energy distribution (Cal_lo and Cal_hi rates changed)

# CNO Trigger Arrival Time: SLAC vs NRL



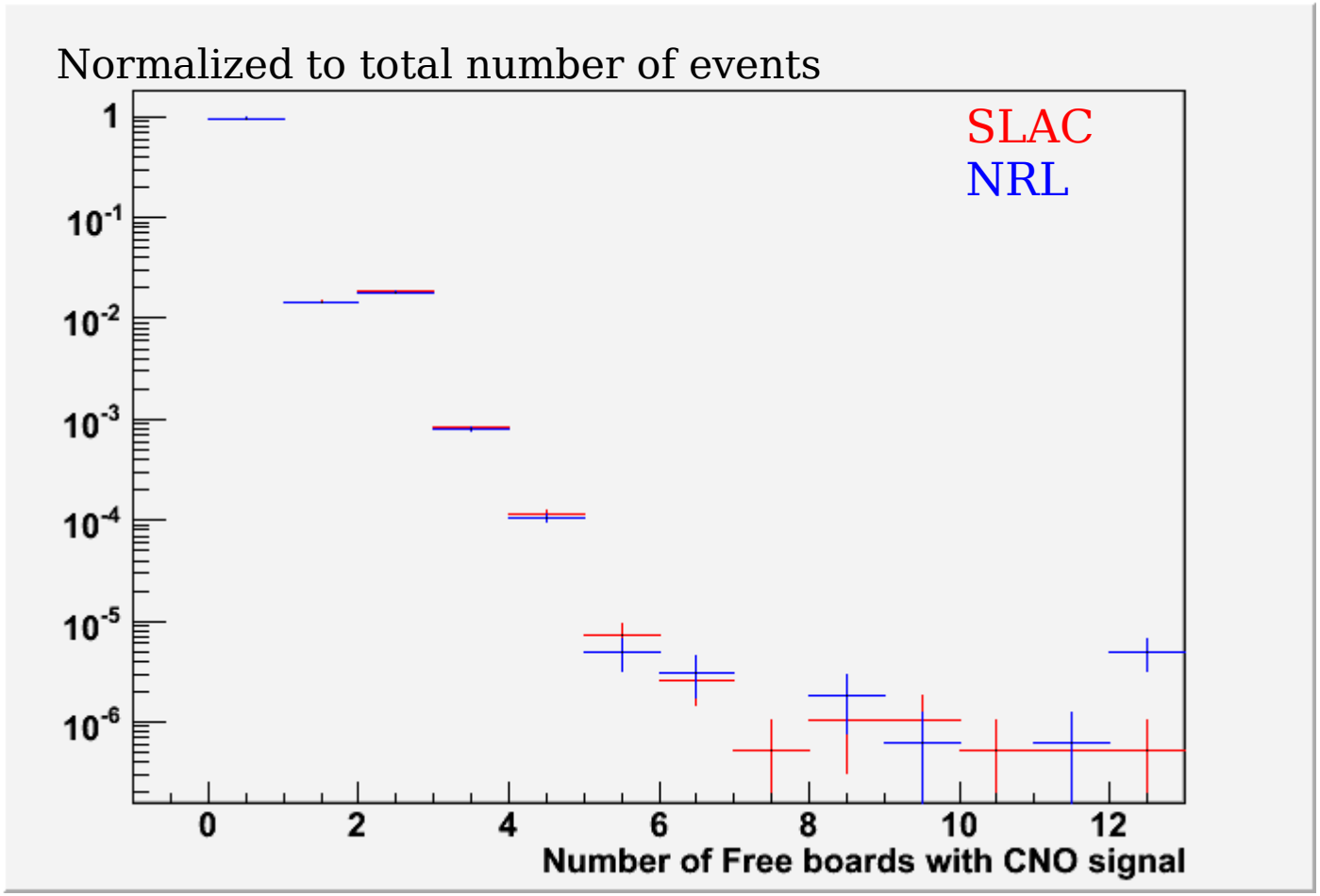

- The data from NRL seems to have a higher concentration of CNO triggers issued during the first clock tick...

# CNO Trigger Occupancy per Board
# SLAC vs NRL



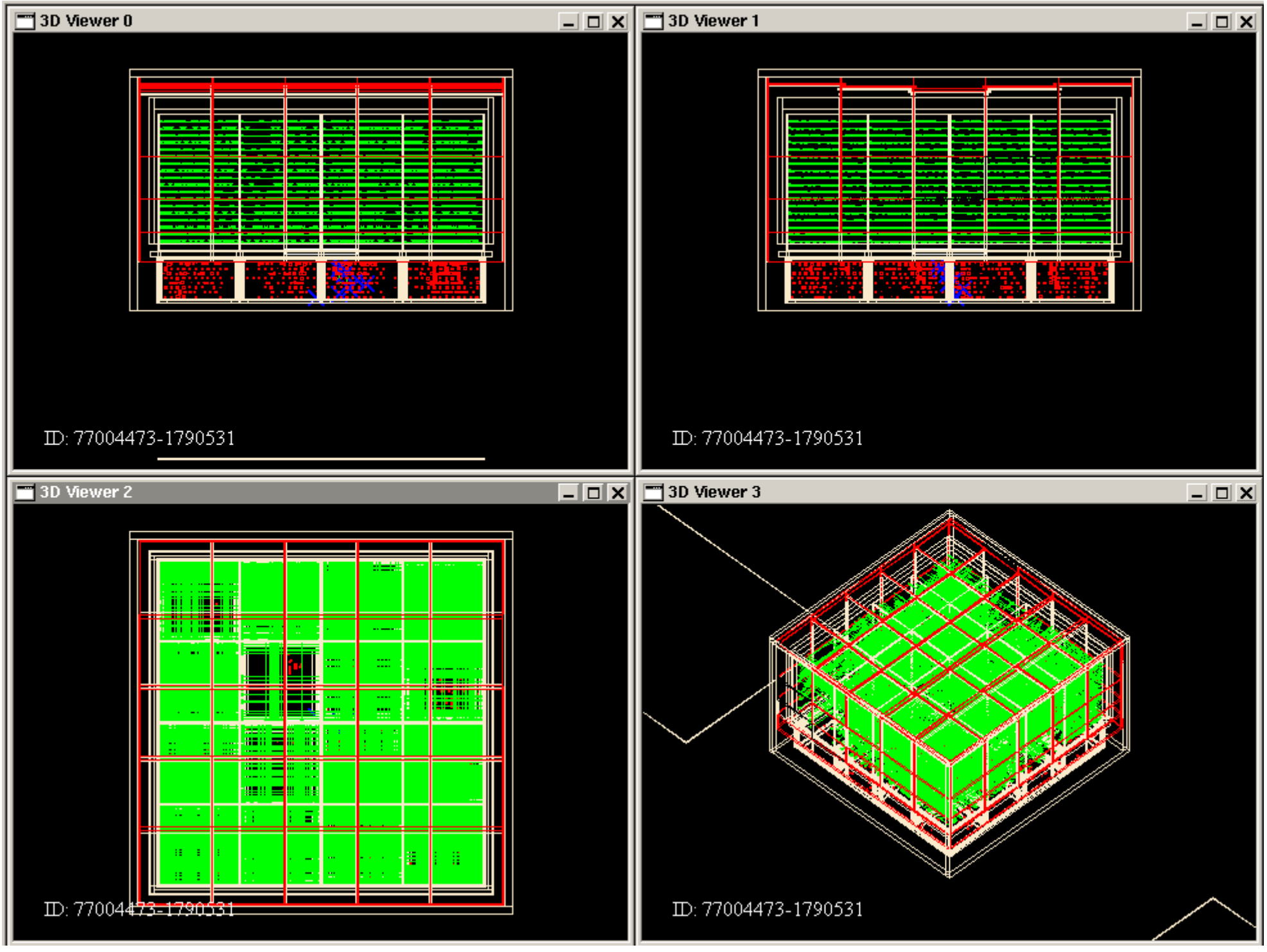

- Events at NRL have a lower CNO trigger rate as mentioned before.
- ~3% of events have CNO trigger. Since there are 12 free boards, one would expect roughly ~ >0.3% of the events would have a trigger in a particular board.
- The number and location of “actual” tiles per free board should be used to scale the plot above (some boards have empty channels, top tiles have more hits, etc.). This could explain why some boards are more likely to issue a CNO trigger

# Number of Free boards issuing a CNO trigger

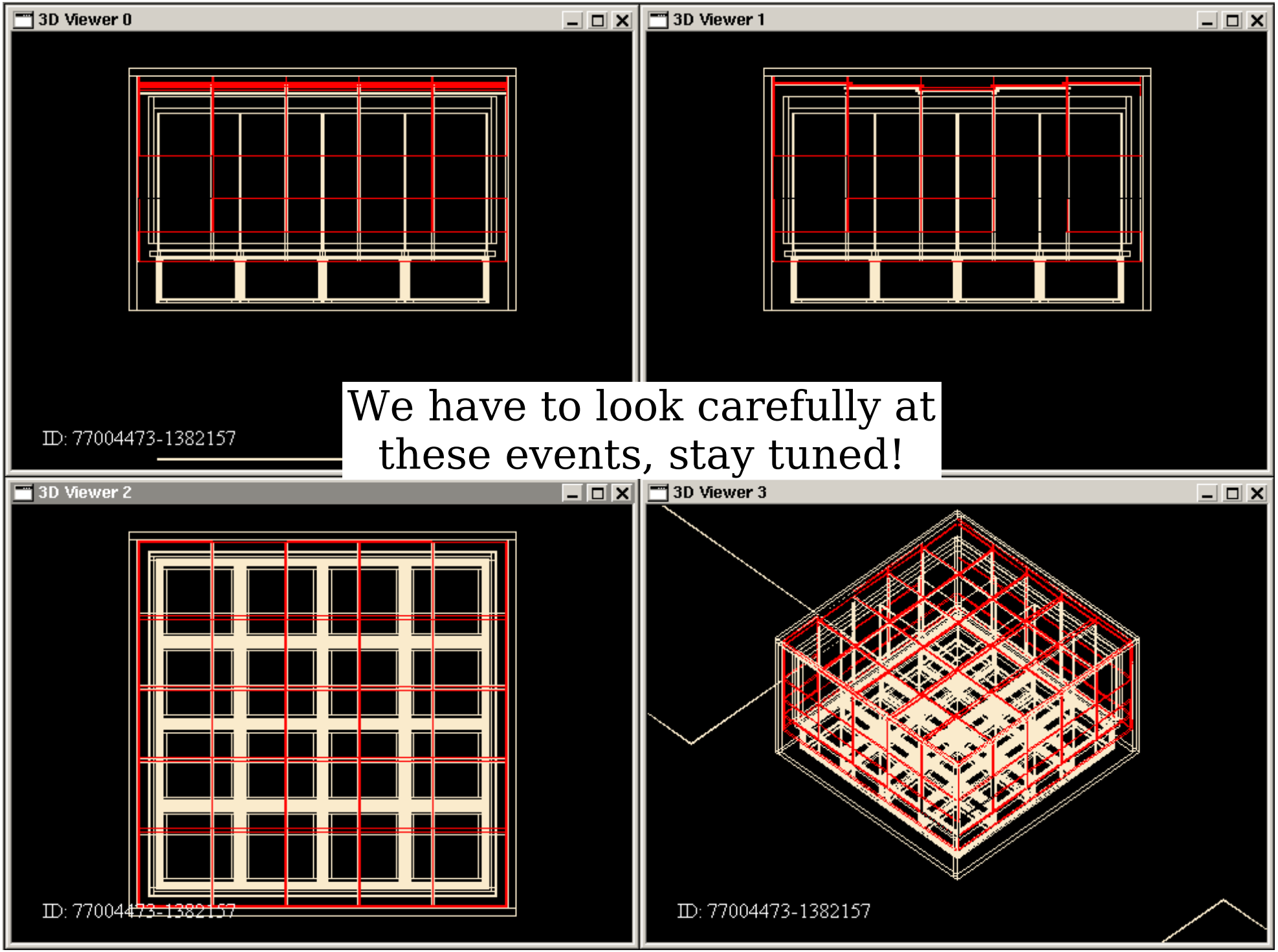



- Most of the events don't have CNO trigger (0 boards).
- There are more events with 2 boards issuing a CNO trigger than just one board (???)

# Event with 11 boards issuing a CNO trigger

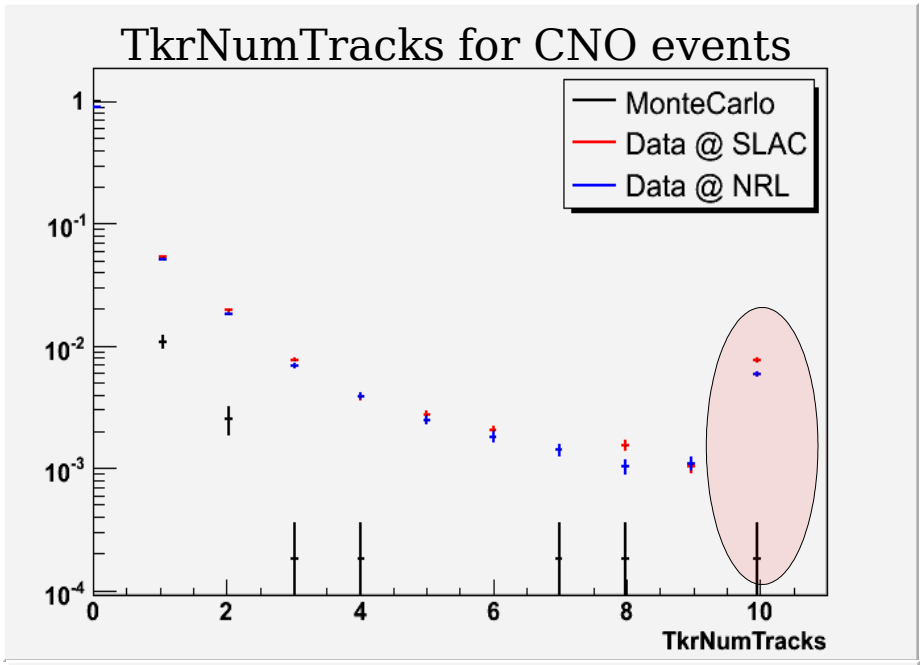


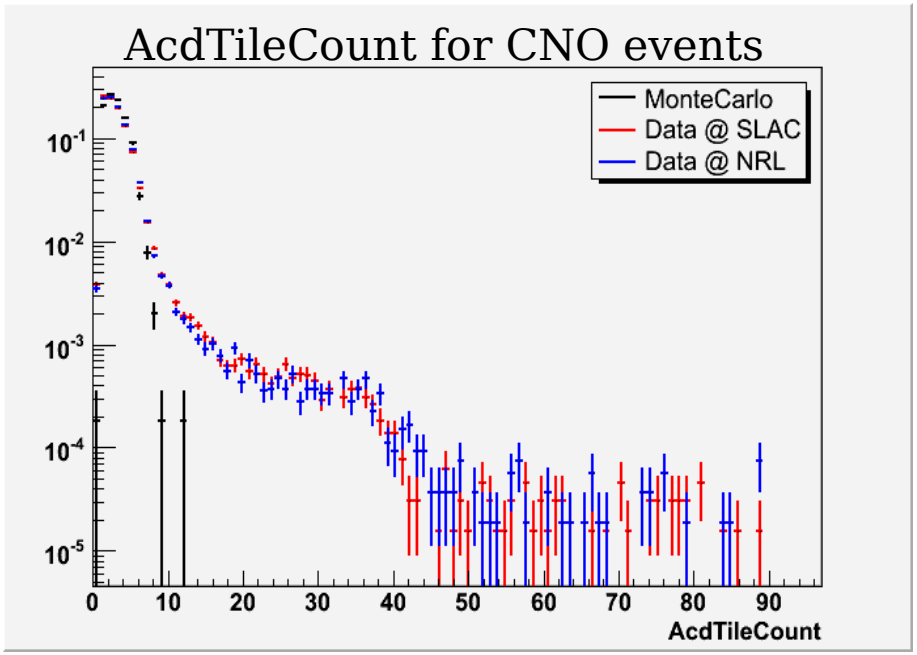
# Event with 10 boards issuing a CNO trigger (???)

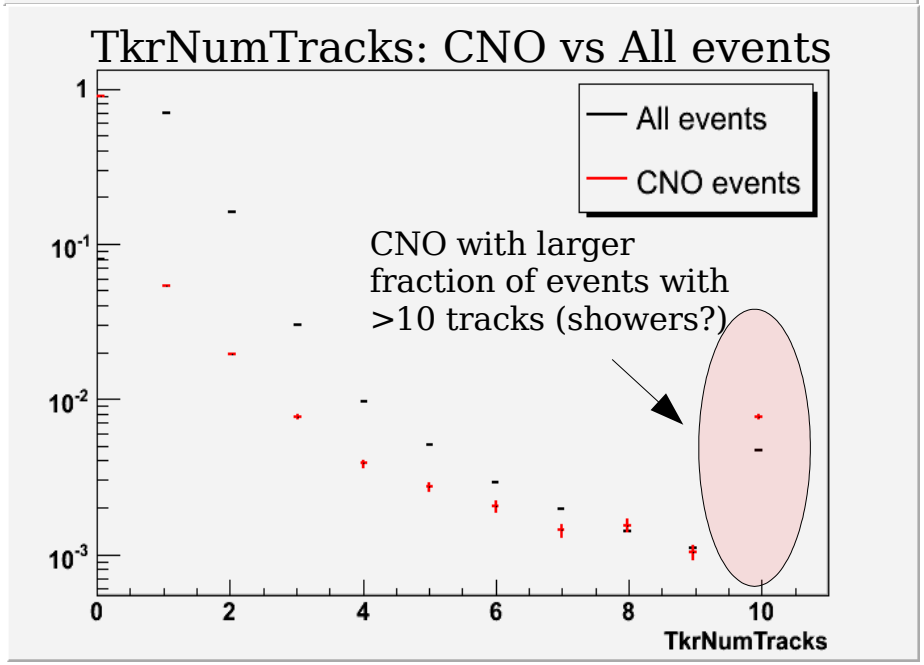


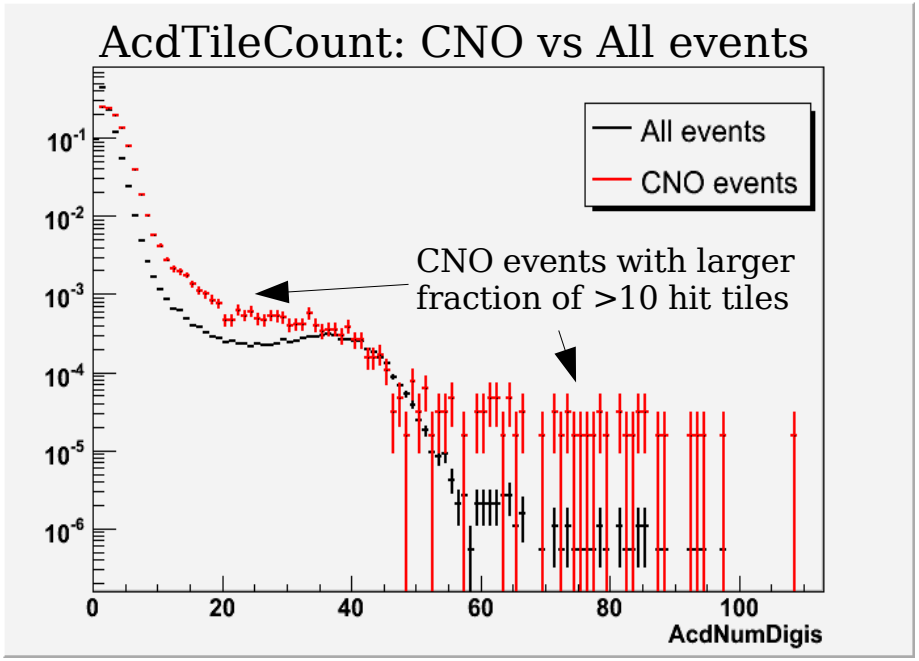

We have to look carefully at these events, stay tuned!

# Looking at Distributions



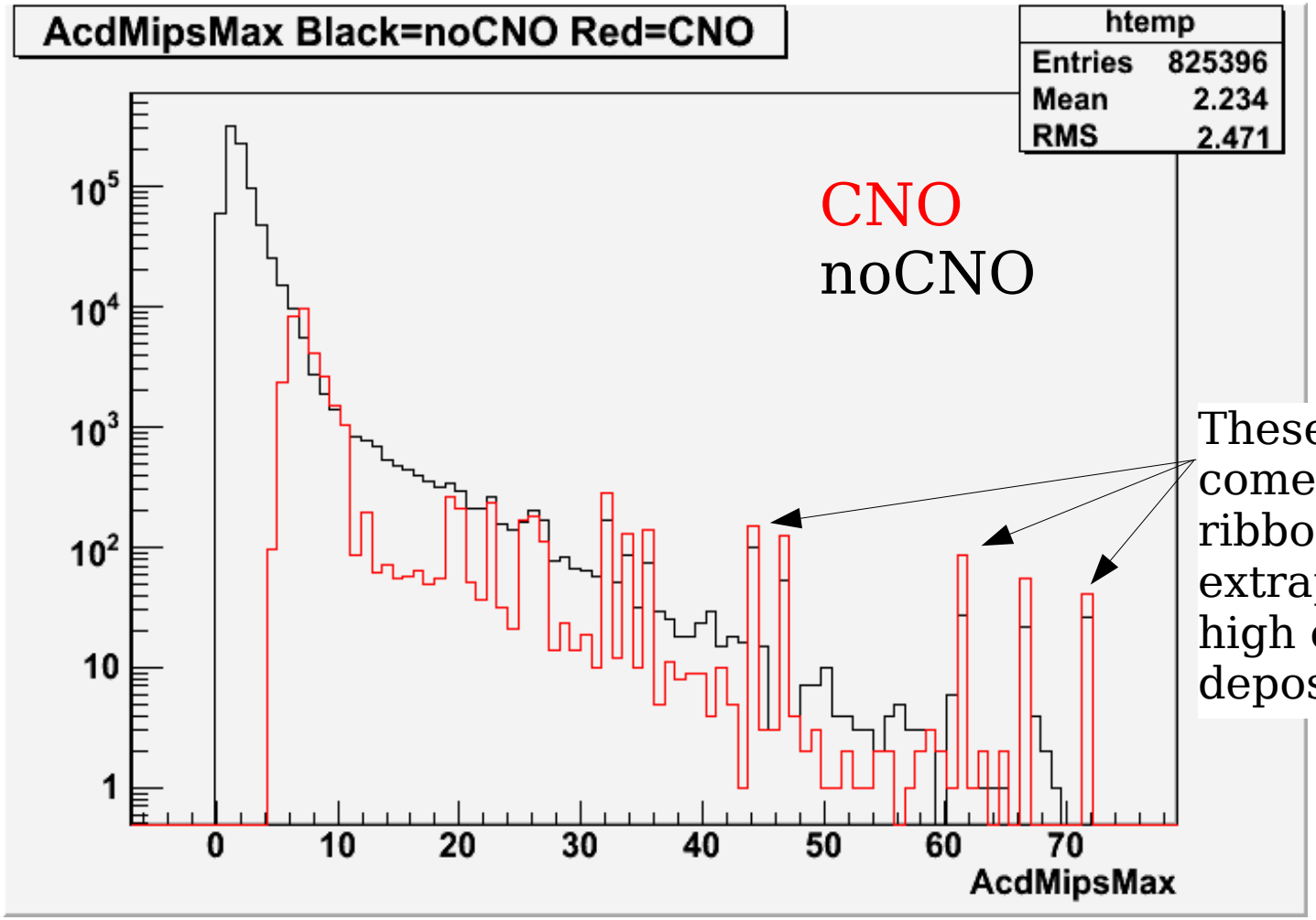




AcdNumDigis, GemDeltaEventTime, TkrTotalHits, CalEnergySum and other distributions in the last slides

# PHA (mips) distributions

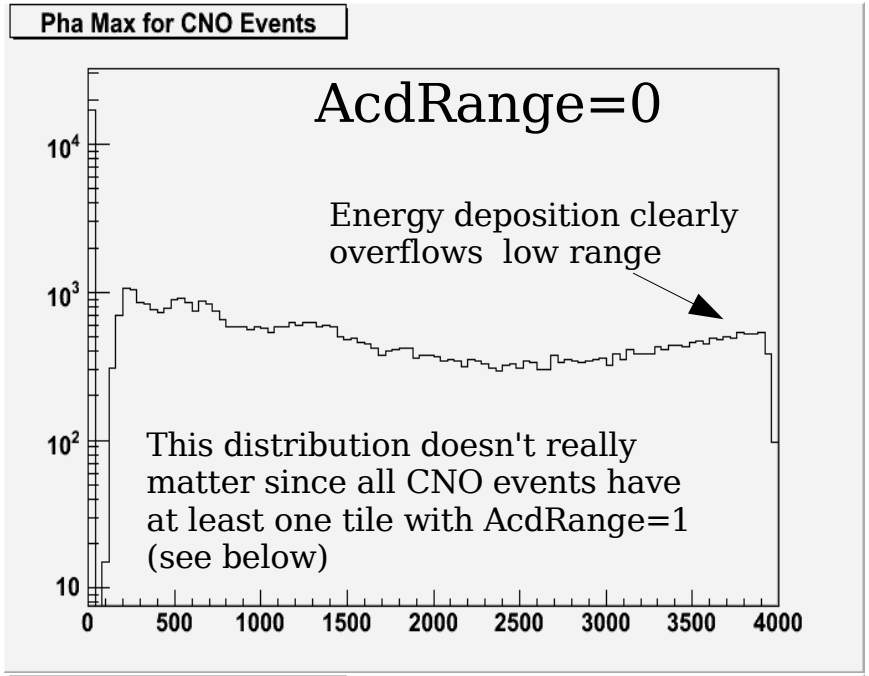
- What is the PHA(mips) distribution for CNO events?
- CNO threshold is supposed to be 20 MIPS
- Life gets difficult since we don't know exactly which tile fired above CNO threshold.
- After looking at AcdRecon and talking to Eric Charles we know that the PHA->mips conversion is not properly implemented yet for events with high-range gain

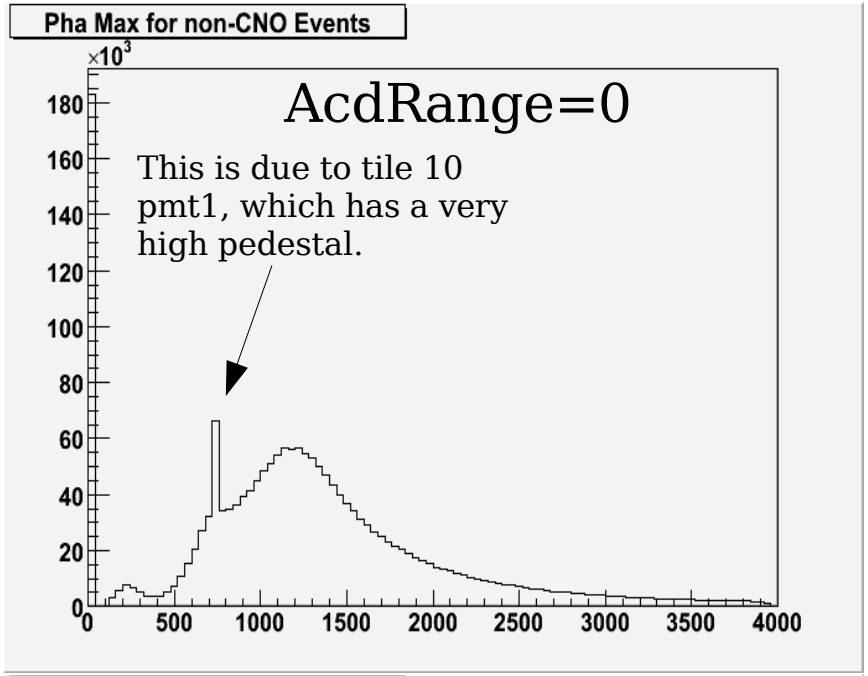


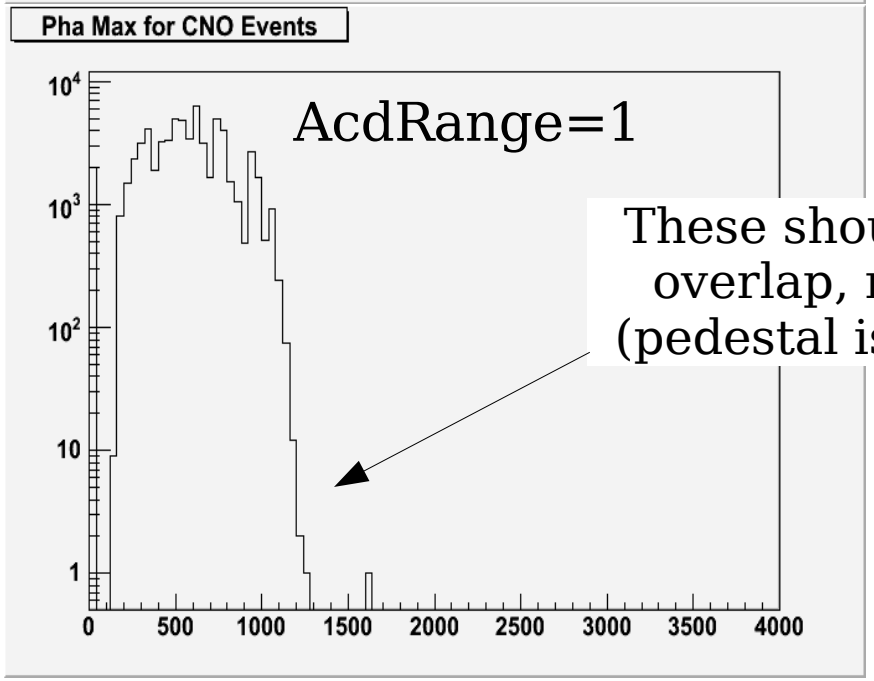

These peaks come from the ribbons (poor extrapolation for high energy deposition?)

# PHA (mips) distributions

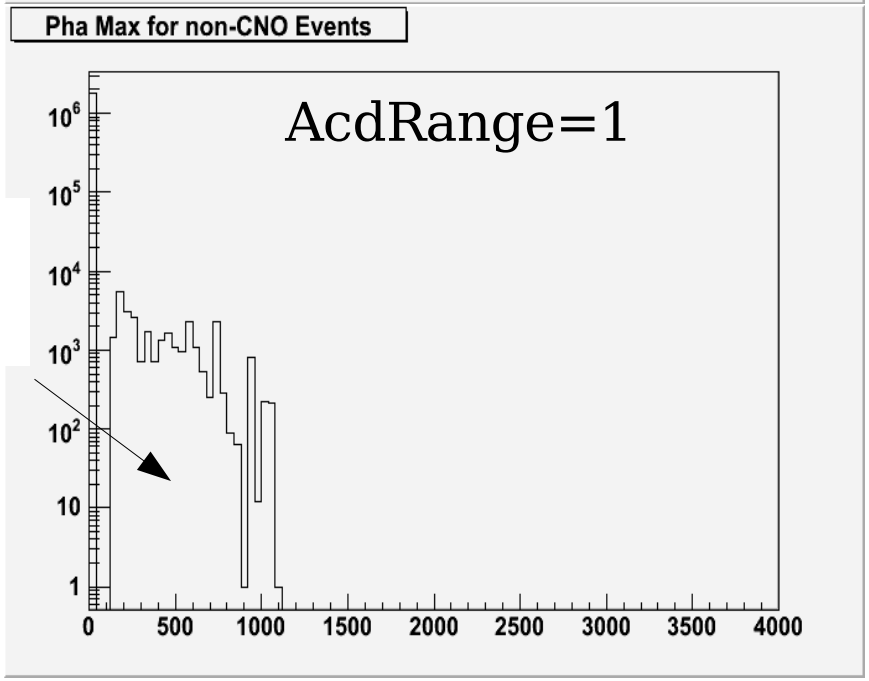
Let's look then at the maximum PHA value in any tile for every event:




These should not overlap, right? (pedestal issues?)



# Summary

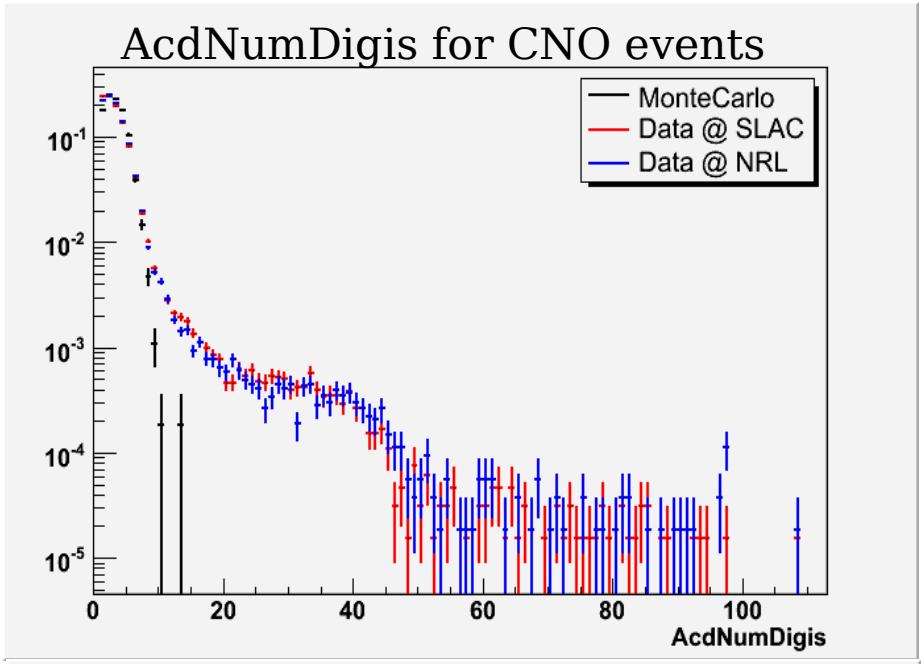
From this look at CNO events we learned:

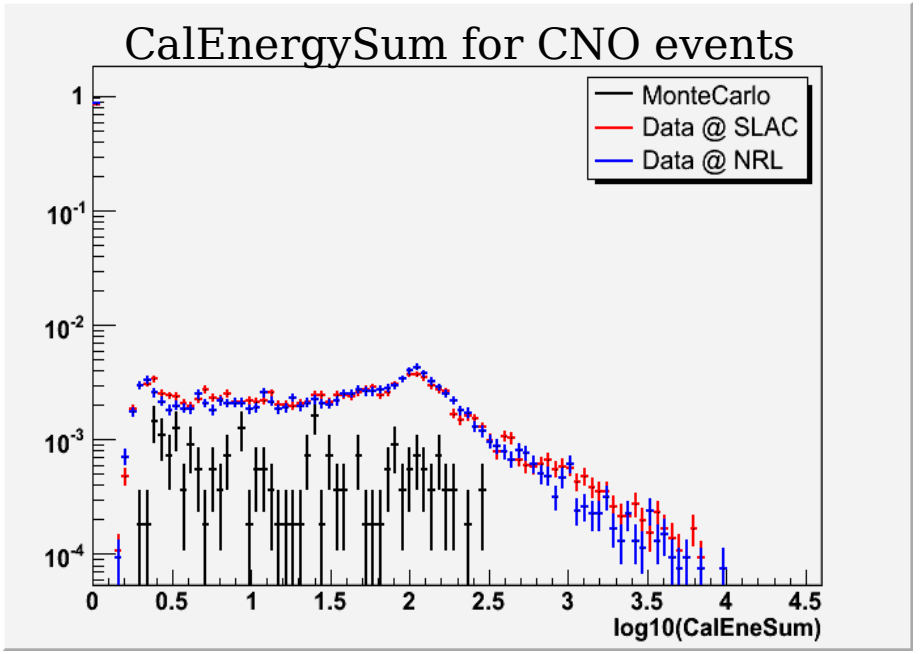
- That some events result in a CNOI signal from many (~10) free boards even though there is no energy deposition or Tkr hits.

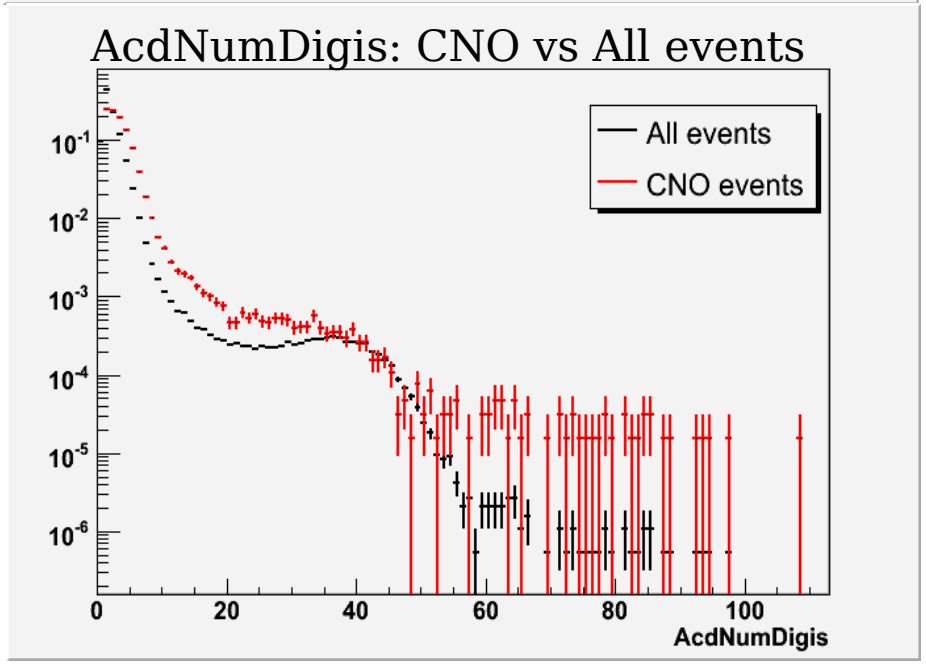
- That the conversion from PHA to mips for signals with high-range gain is not yet implemented. (Eric Charles knows about this, in the to-do list)

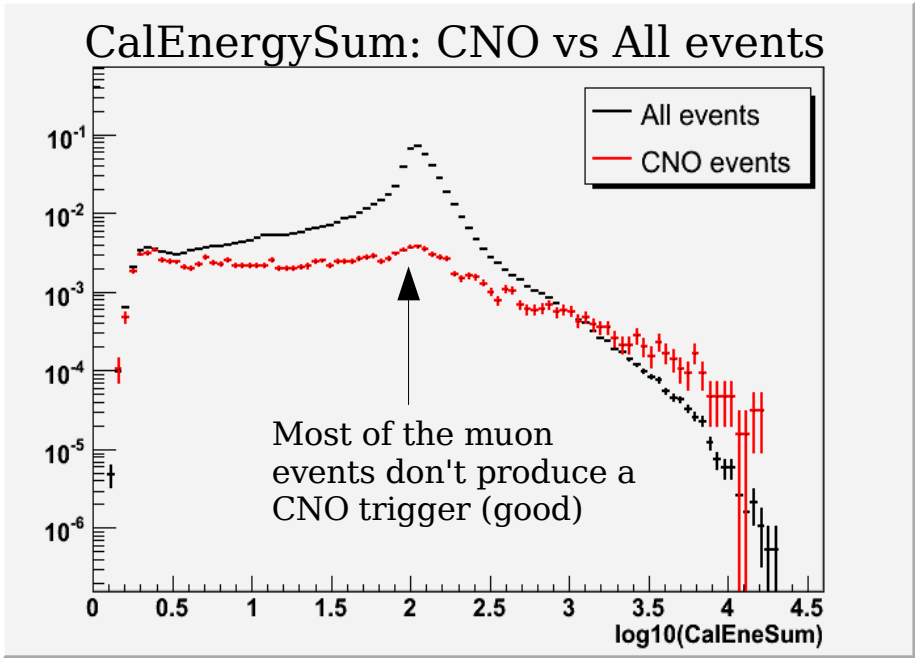
- That surface_muons MonteCarlo does not provide a baseline to study CNO events.

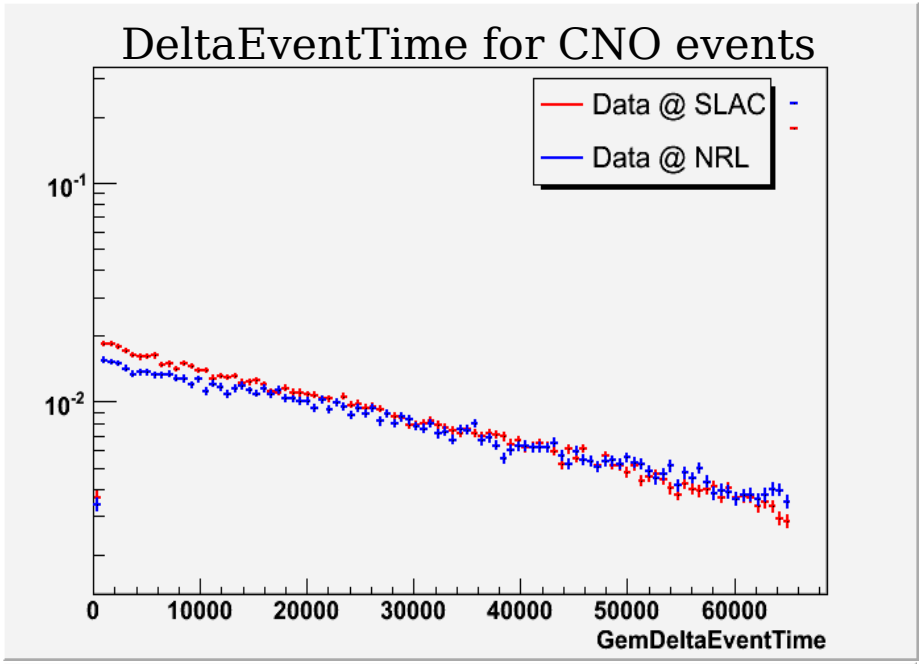
# OTHER DISTRIBUTIONS

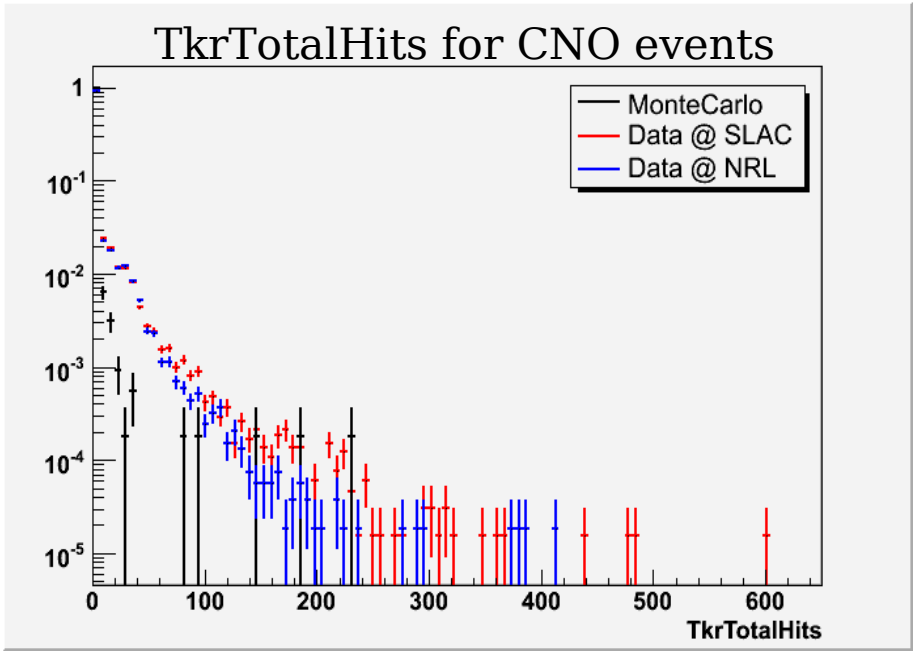

AcdNumDigis for CNO events
MonteCarlo
Data @ SLAC
Data @ NRL
AcdNumDigis

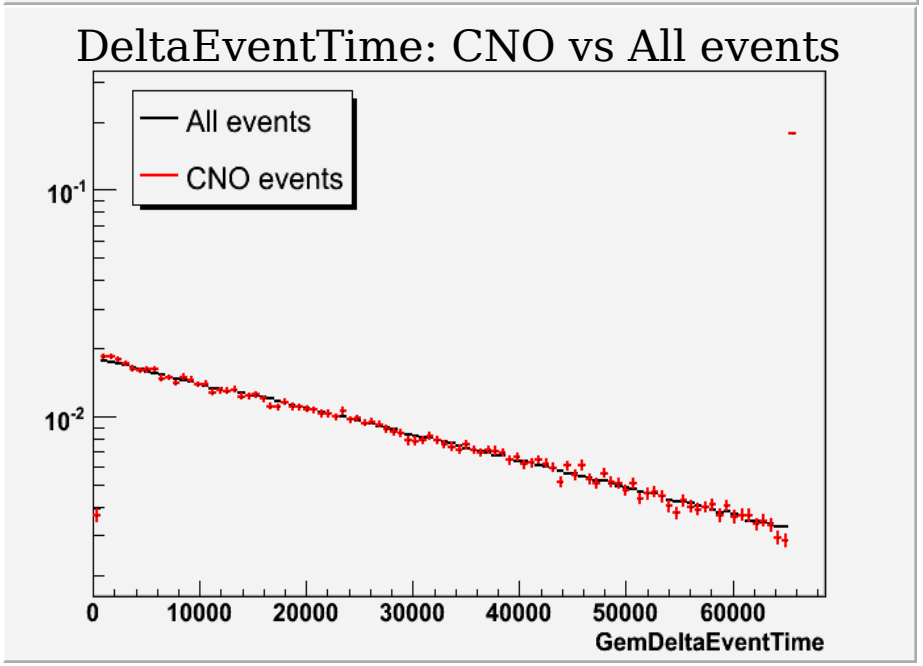

CalEnergySum for CNO events
MonteCarlo
Data @ SLAC
Data @ NRL
log10(CalEneSum)

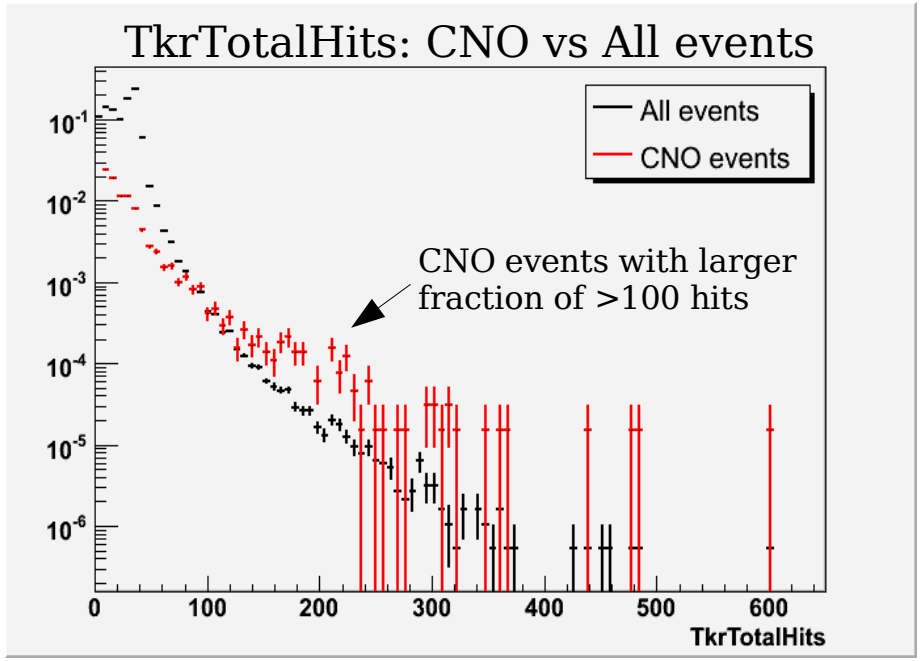

AcdNumDigis: CNO vs All events
All events
CNO events
AcdNumDigis


CalEnergySum: CNO vs All events
All events
CNO events
Most of the muon events don't produce a CNO trigger (good)
log10(CalEneSum)


DeltaEventTime for CNO events
Data @ SLAC
Data @ NRL
GemDeltaEventTime


TkrTotalHits for CNO events
MonteCarlo
Data @ SLAC
Data @ NRL
TkrTotalHits


DeltaEventTime: CNO vs All events
All events
CNO events
GemDeltaEventTime


TkrTotalHits: CNO vs All events
All events
CNO events
CNO events with larger fraction of >100 hits
TkrTotalHits