Timing Studies with Carbon in the CAL

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Motivation

- **Without the beam test we had limited tests of trigger timing for CAL triggers (low and high energy) because**
  - **surface cosmic ray distribution peaks at low energies**
  - **timing settings used for charge injection are different from those used during normal physics acquisitions**

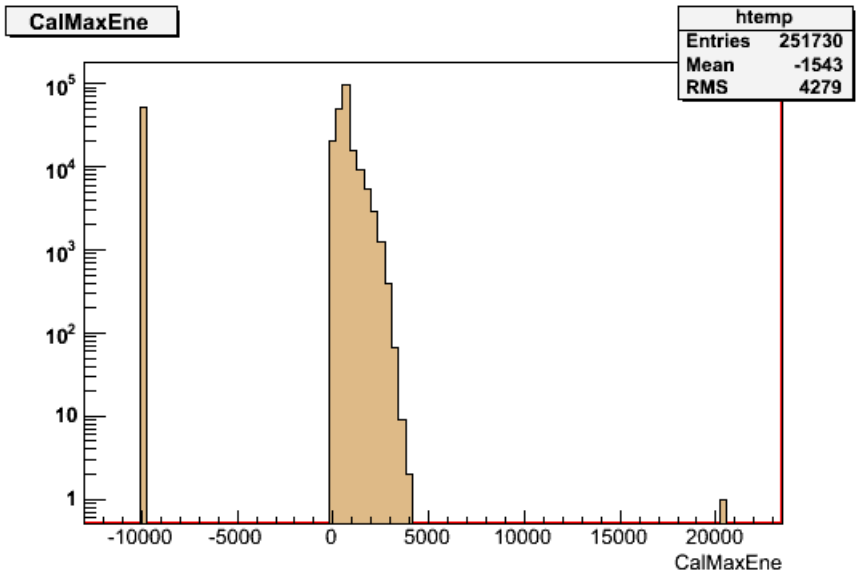
- **Data from the GSI beam test can be used to test the CAL trigger timing for high energy deposition (CNO)**
  - **This analysis will evolve into analysis needed during L&EO**
  - **This preliminary talk we will only address Carbon events**

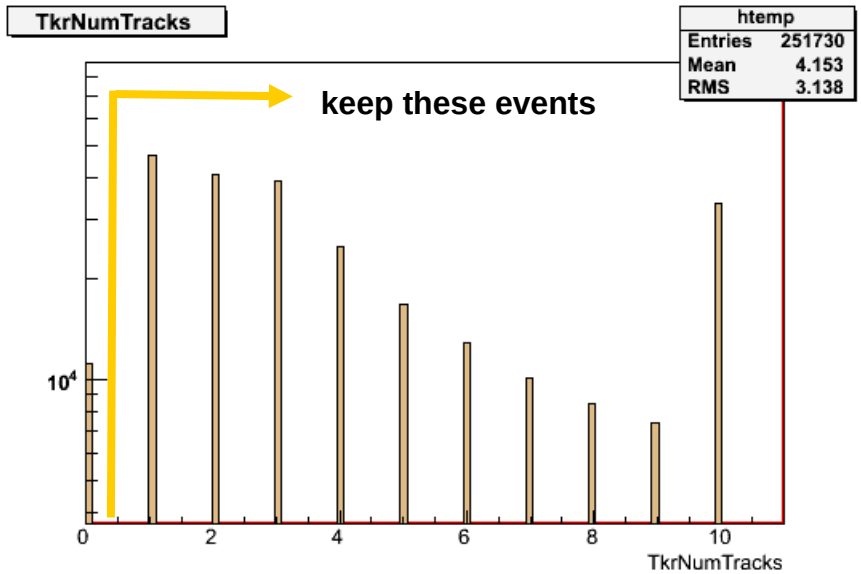
- **Question to be answered**
  - **Does the CAL_HE and CAL_LE Triggers behave as expected for Carbon events?**

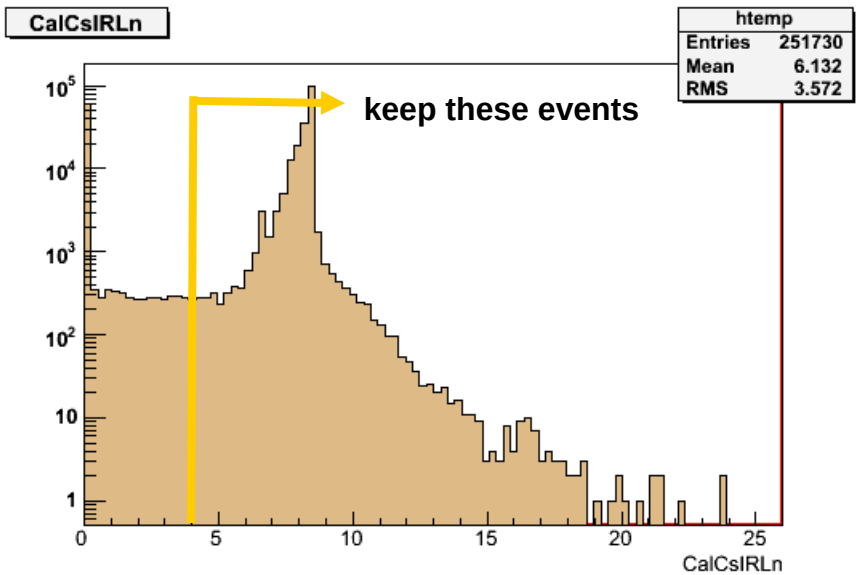
Selected Run

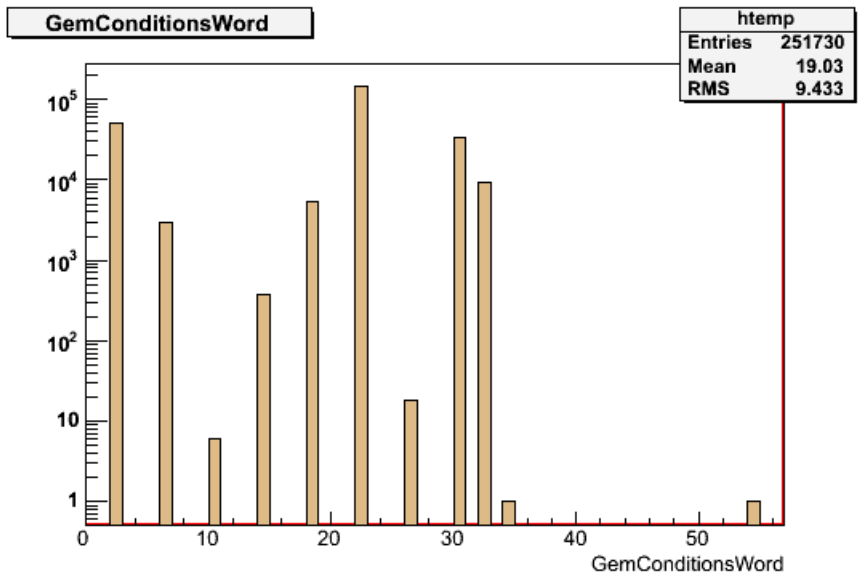
- Run ID 70002572
  - selected from the list of good runs
  - 1.5 GeV/nucleon Carbon
- Duration
  - 1901 seconds
- Number of Events:
  - 251,732
- Beam Position:
  - Vertically incident on tower 2 (TKR FM16 and CAL FM119)
  - X = 108 mm, Y = - 40 mm, Z = 0 mm
- Configuration
  - BT3 (all nominal settings)
    - only TKR is allowed to <u>open</u> the trigger window
      - » but CAL and ACD can also trigger !

Basic Distributions

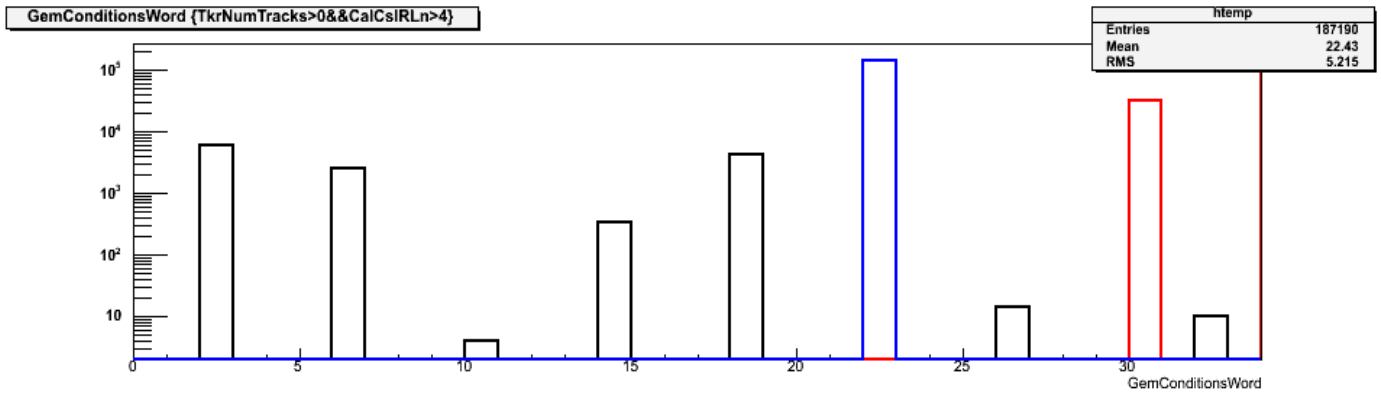






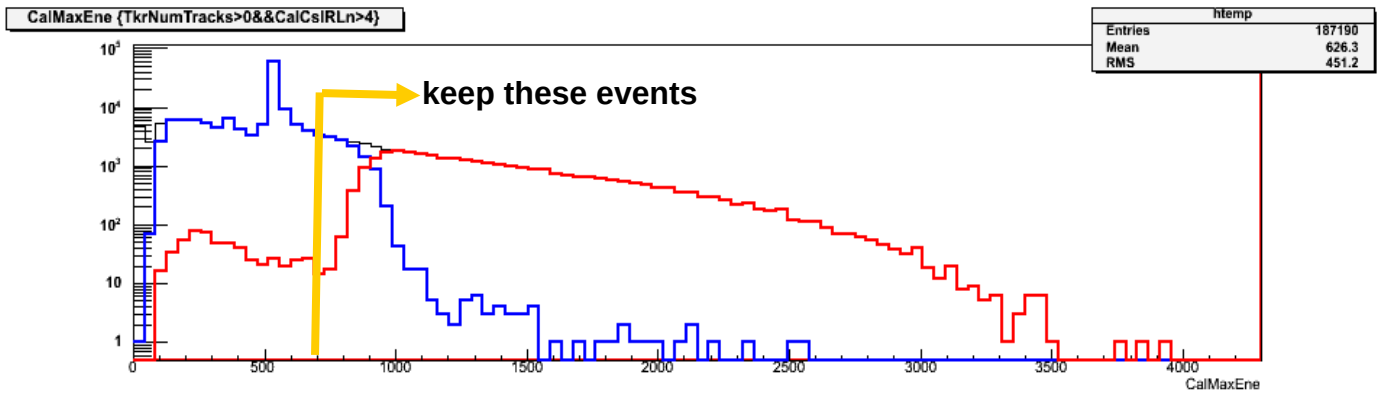


Study the two most frequent types of trigger

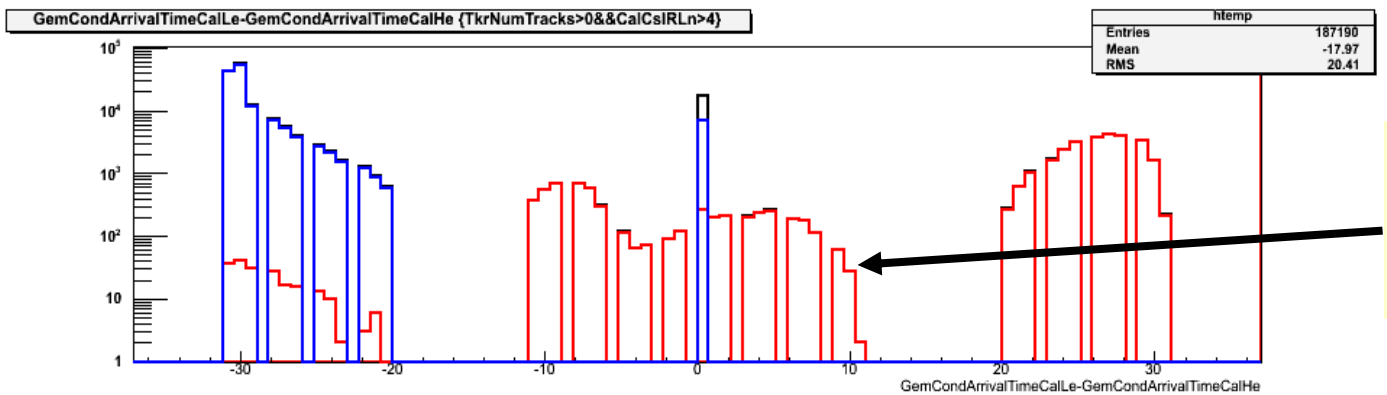


GemConditionsWord = 22
TKR
CAL_LE
CAL_HE
CNO

GemConditionsWord = 30
TKR
CAL_LE
CNO



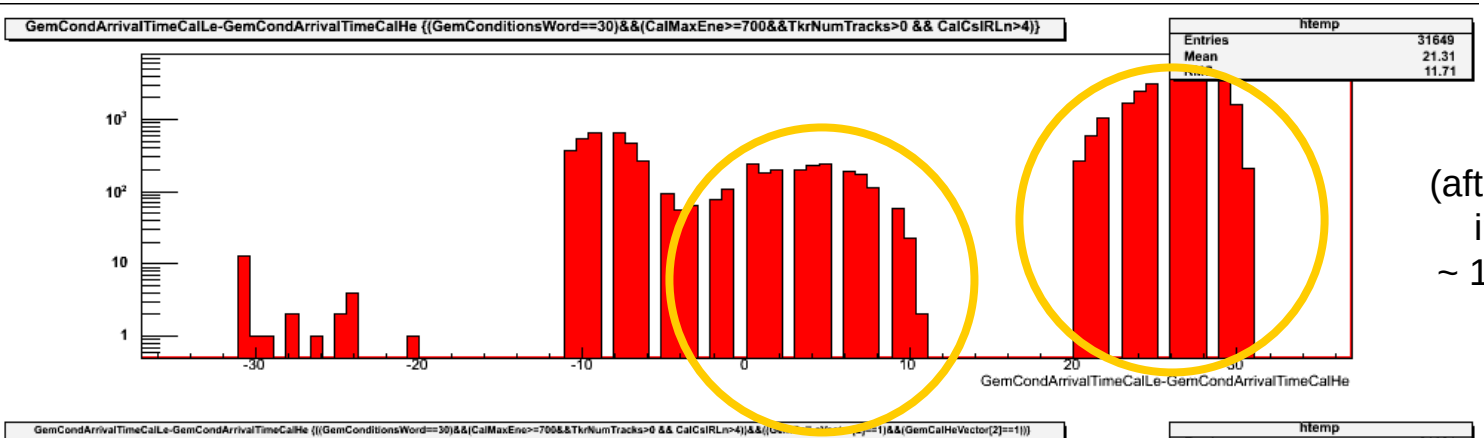
Maximum Energy in a CAL Crystal (MeV)



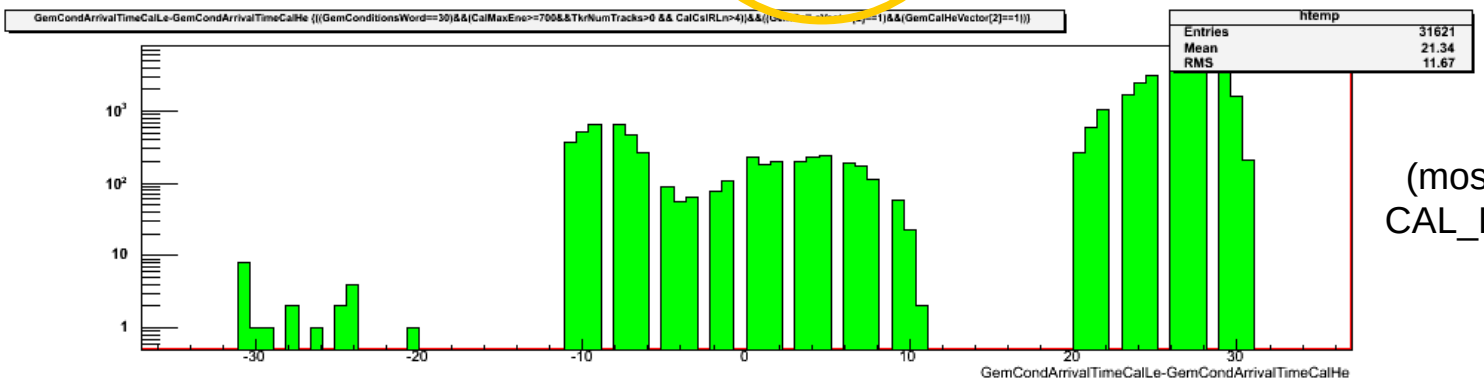
PROBLEM HERE!

How can CAL_LE arrive before CAL_HE?

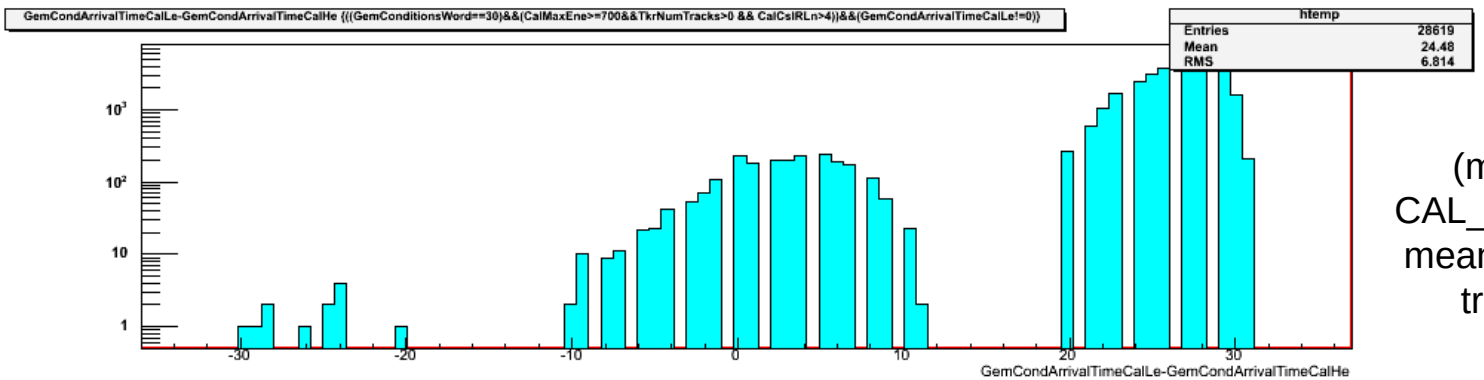
What else do we know about these events?



31649 events
(after initial cuts defined in previous pages)
~ 13% of initial triggers

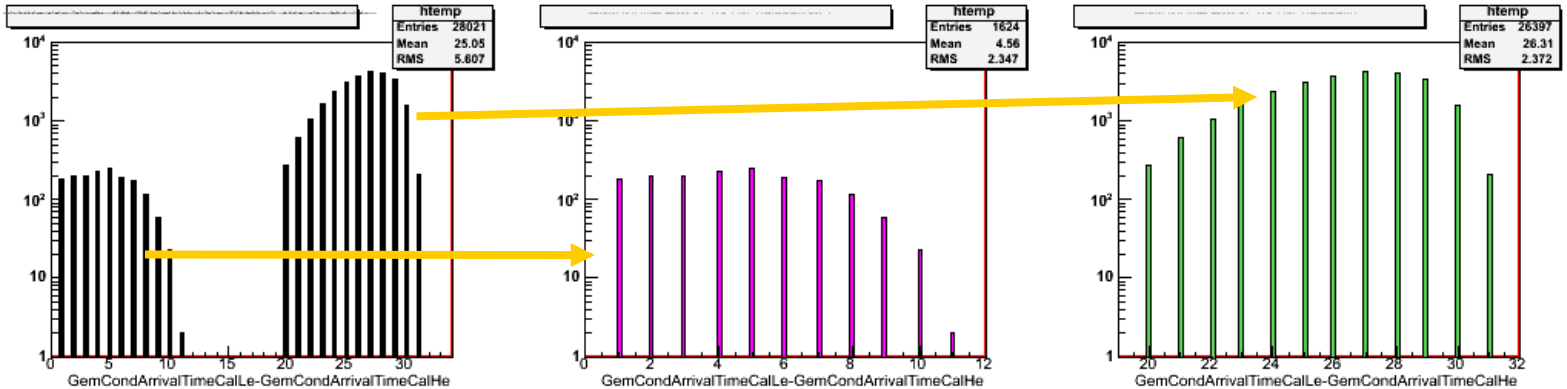


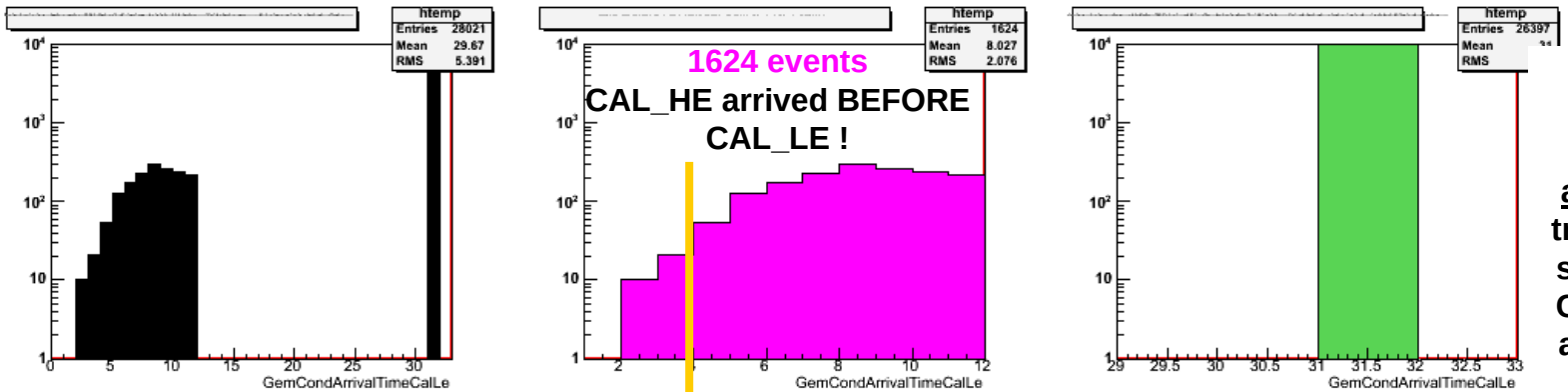
31621 events
(mostly in tower 2 and with CAL_LE and CALHE triggers)



28619 events
(most of the events the CAL_LE trigger was set to 31, meaning it did NOT open the trigger window, but…)

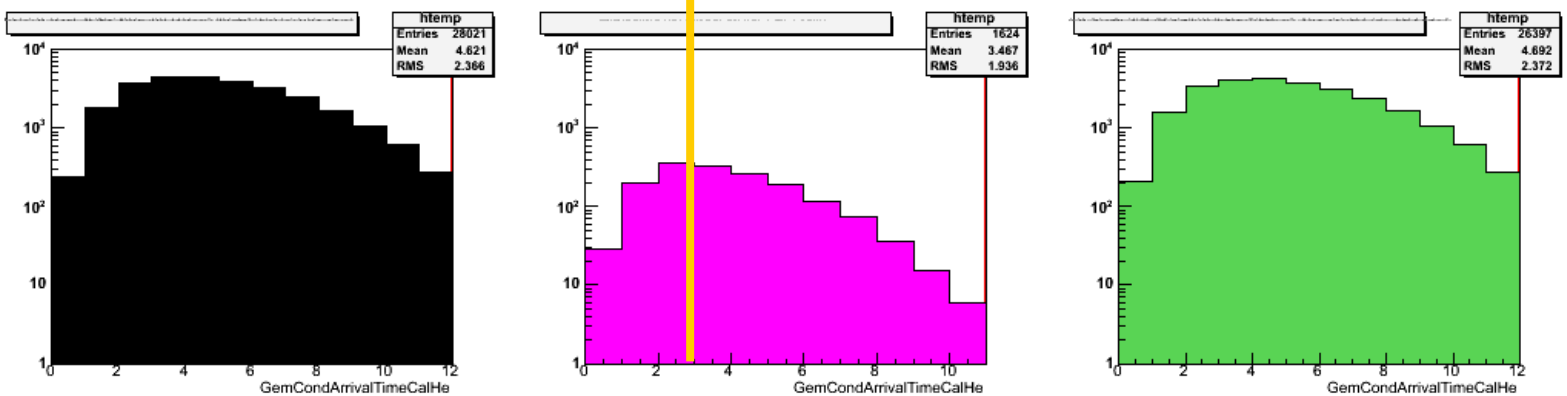
Inspecting the CAL_HE Distributions





1624 events

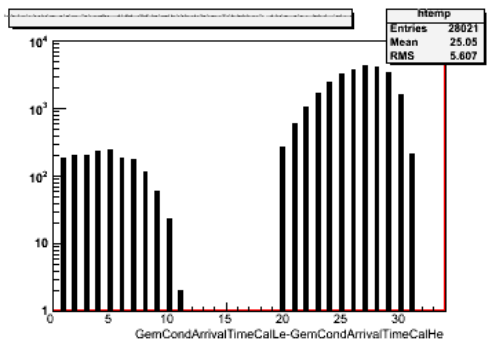
CAL_HE arrived BEFORE CAL_LE !

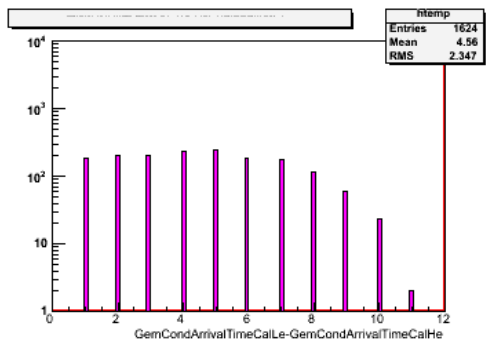


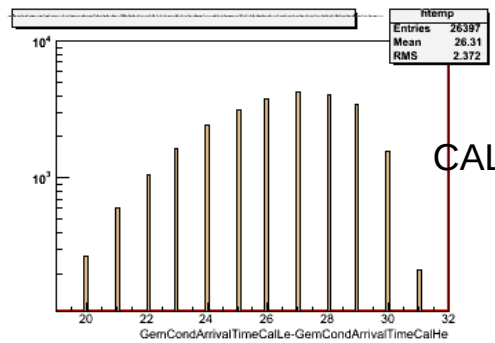
26397 events

CAL_LE fired early but it was <u>not allowed</u> to open the trigger window (BT3) so we never saw the CAL_LE distribution and CALHE triggers arrived later

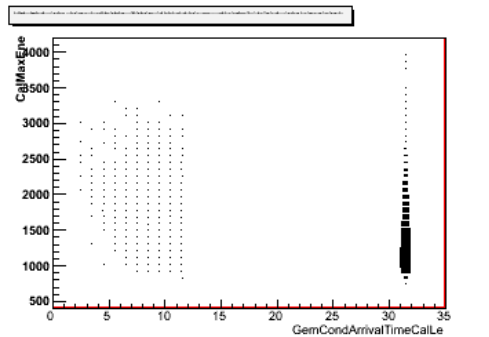
Correlations with the Max Energy in a Crystal

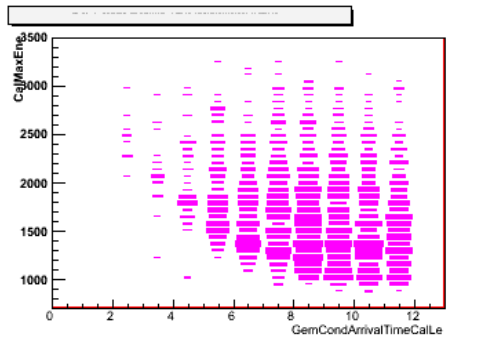


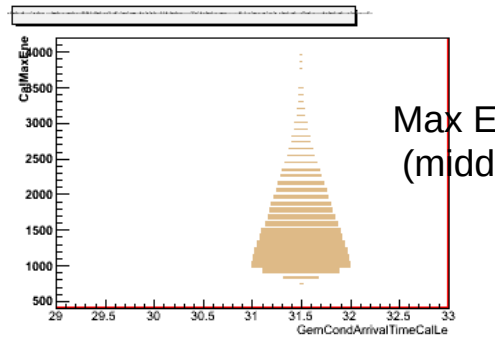




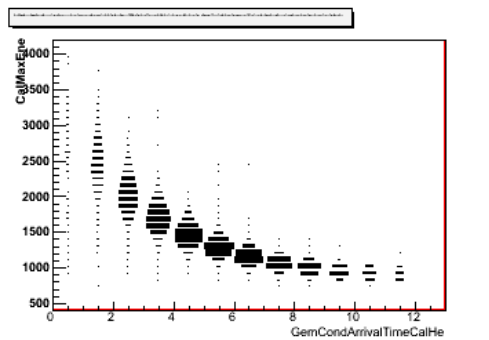
CAL_LE – CAL HE

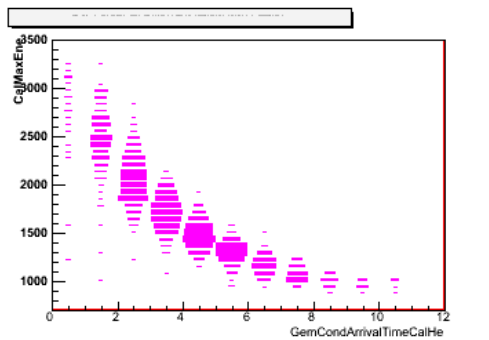


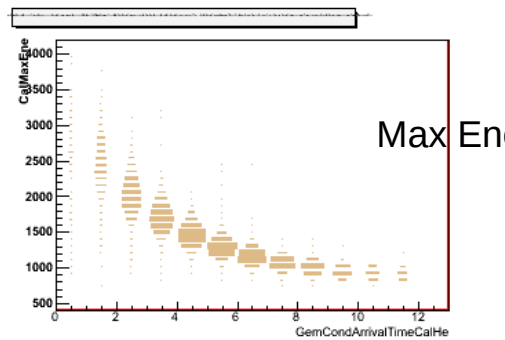




Max Energy vs CAL_LE
(middle plot is strange)

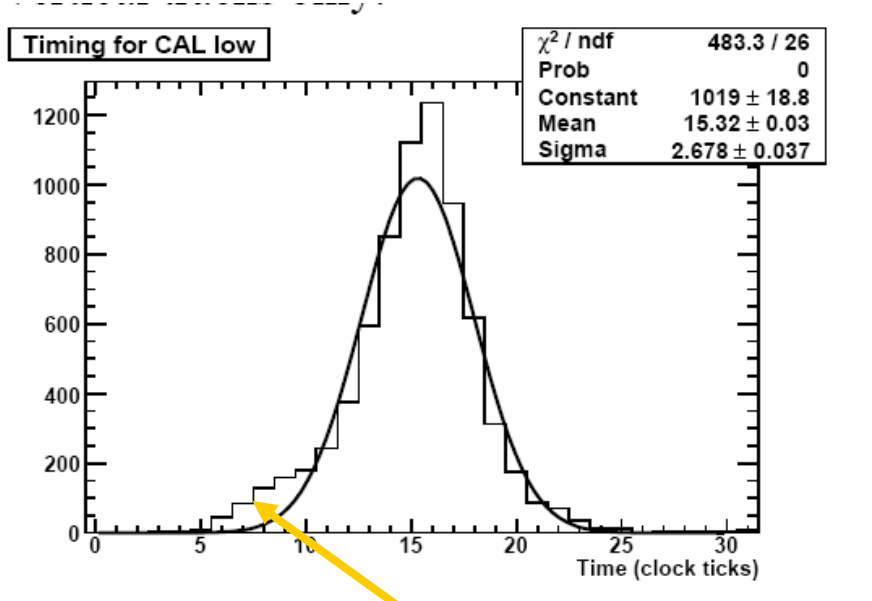






Max Energy vs CAL_HE
(OK)

CAL_HE could arrive earlier



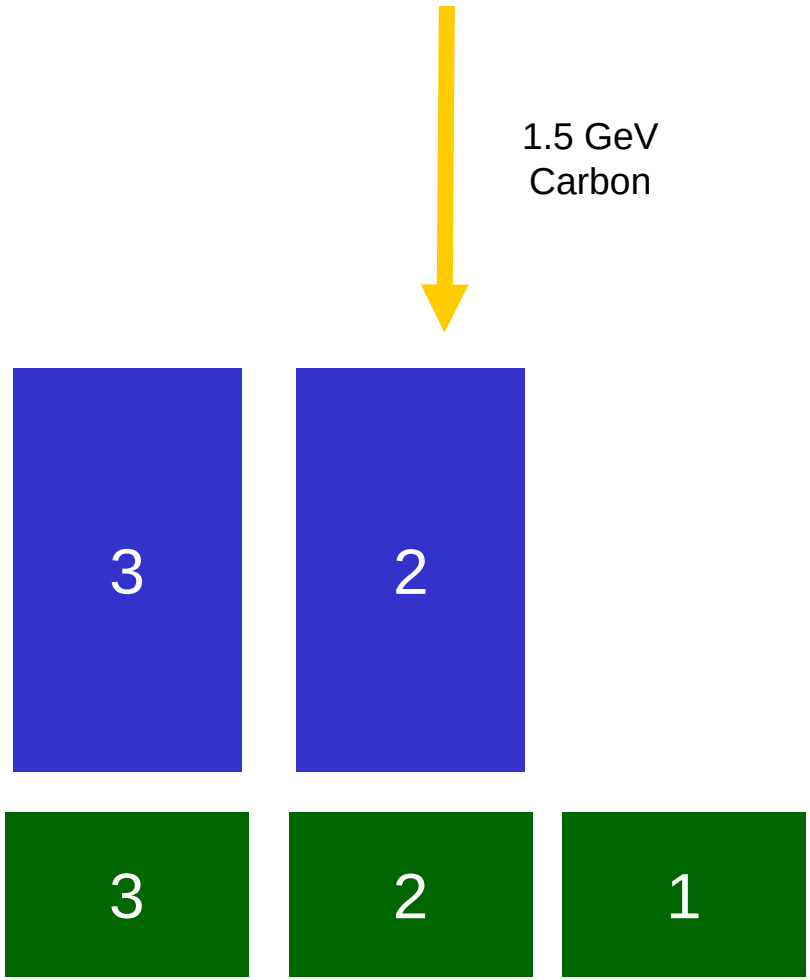
- **CAL_LE Jitter**
  - **σ = 2.5 x 50 ns = 125 ns**
  - **"box" ~ 20 x 50 ns = 1000 ns**
  - **low values are Diode depositions**
    - **arrive about 5 to 8 x 50 ns earlier (250 to 400 ns)**

The plot shows the high energy depositions arriving early due to diode hits.
(CAL_LE measurements by Martin during I&T testing using surface muons)

We can infer that the same can happen for CAL_HE

Let's test this hypothesis…

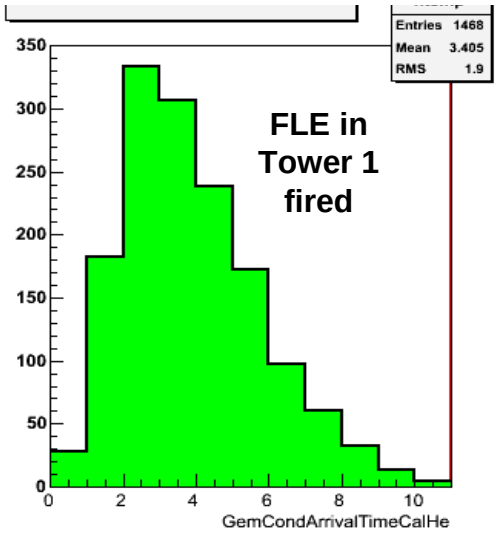
BT Geometry at GSI

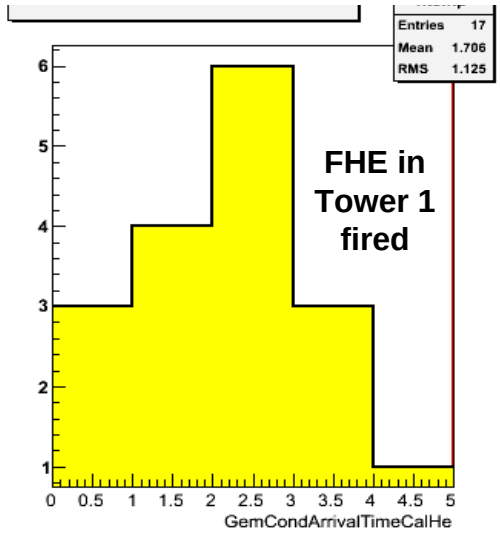


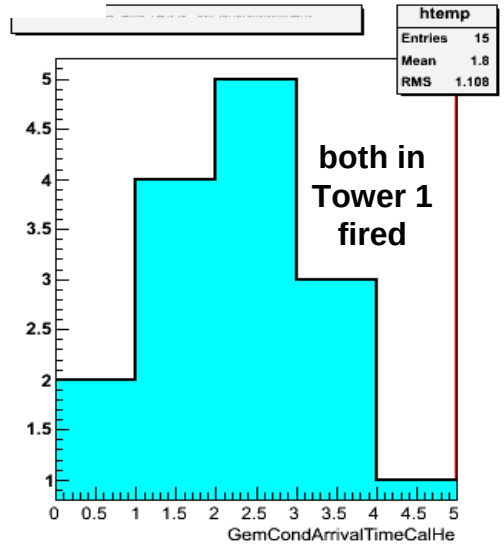
If these events are from diode depositions we should not see too much activity on the neighboring CAL modules

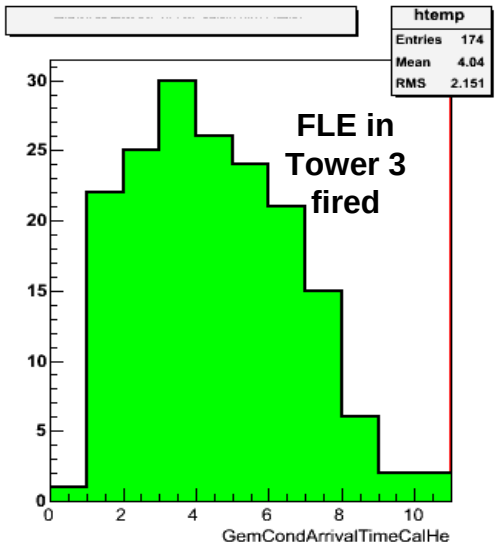
Tower 2 was not the only one with CAL triggers…

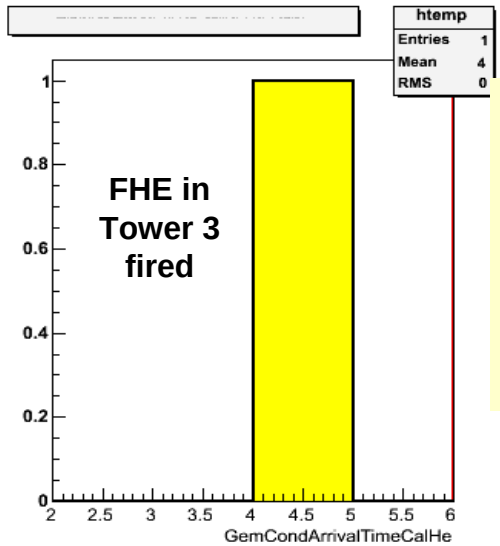
90% of the selected events in tower 2 also fired CAL_LE in tower 1



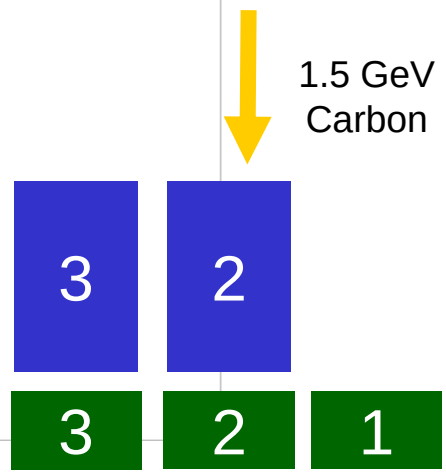




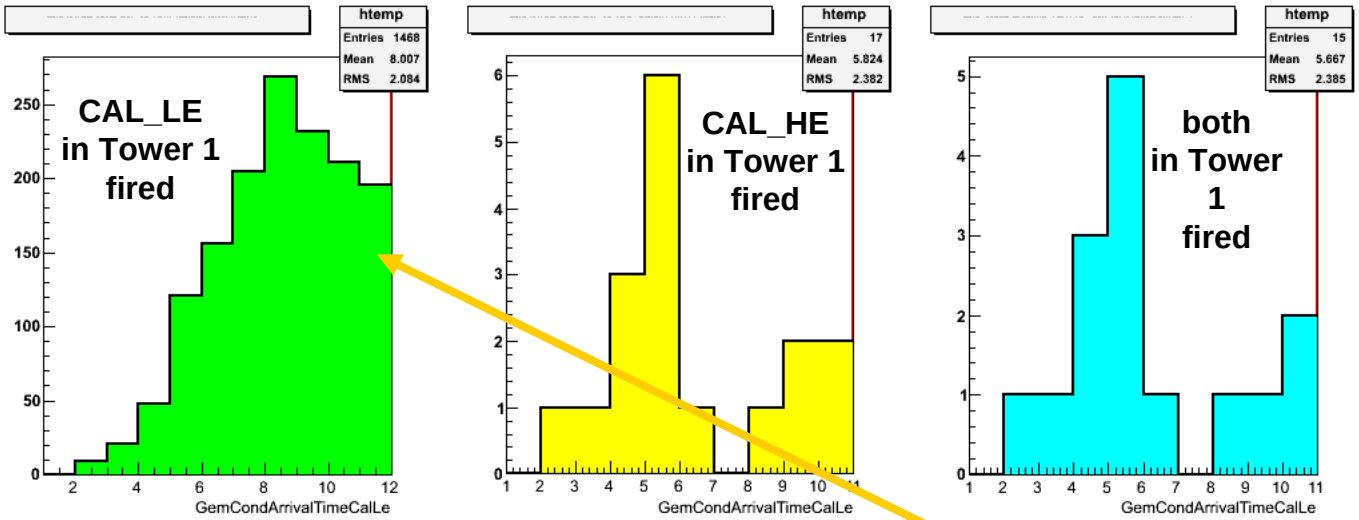


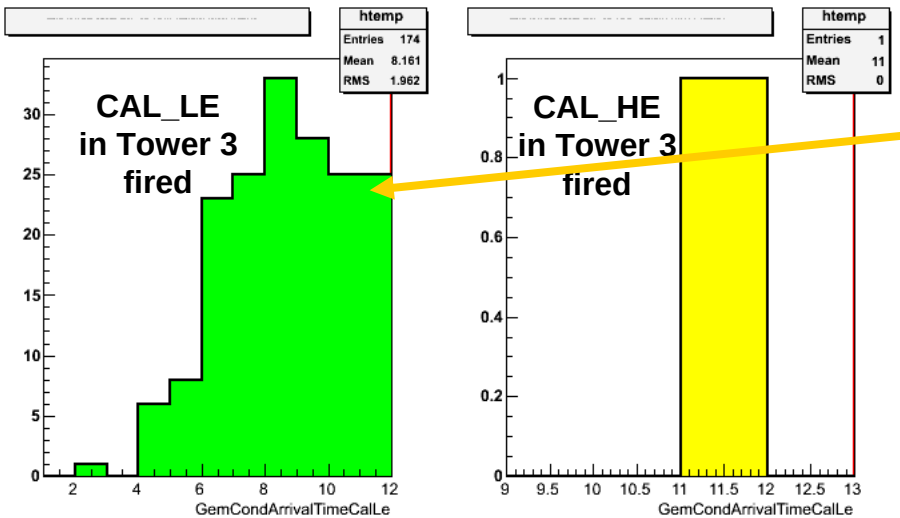


CAL_HE distributions requiring either CAL_LE, CAL_HE or both to fire in adjacent towers



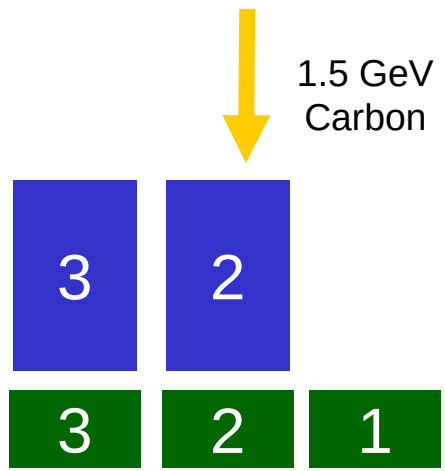
Tower 2 was not the only one with CAL triggers…



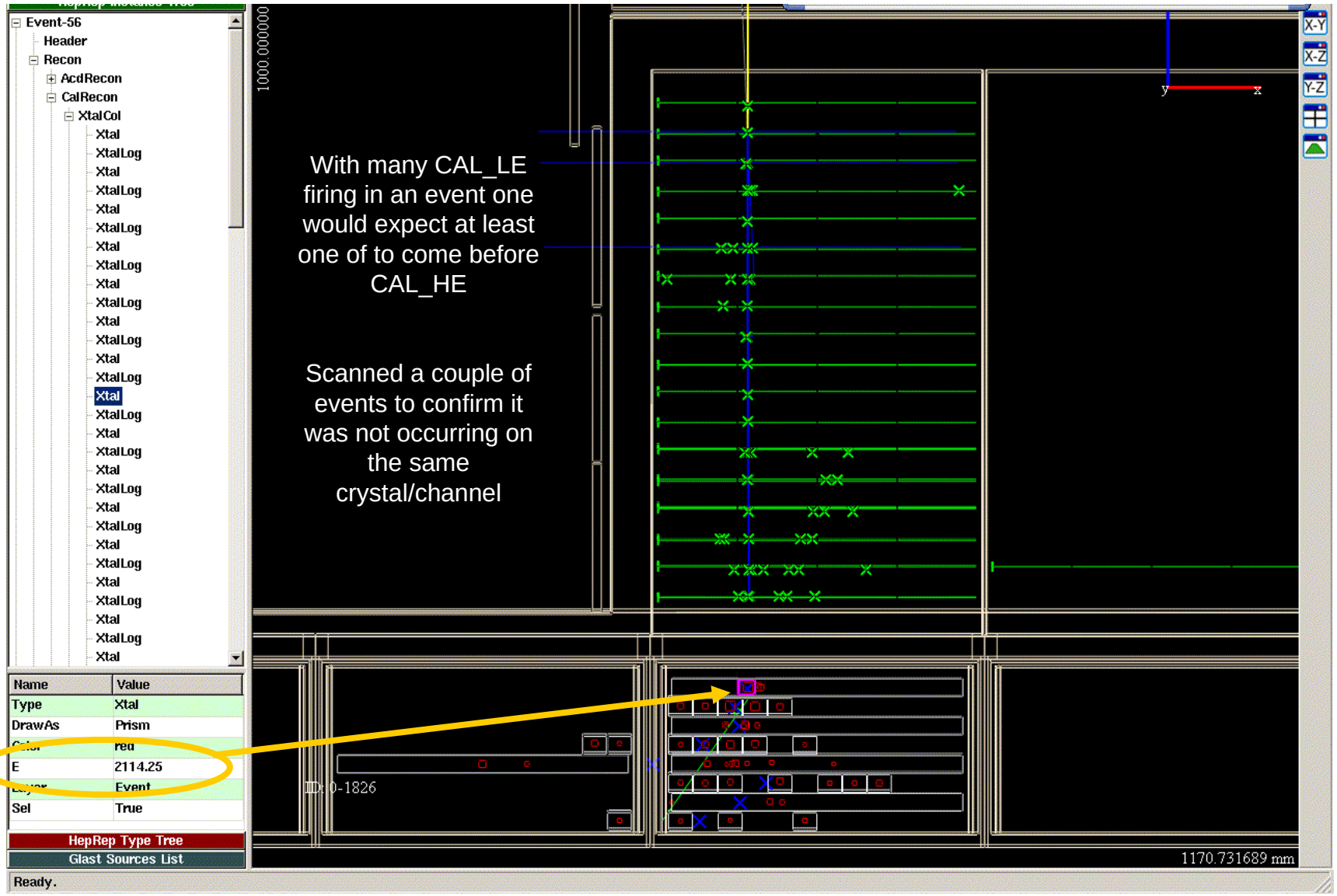


CAL_LE distributions requiring either CAL_LE, CAL_HE or both to fire in adjacent towers

Should fall faster (see previous slide)



What does FRED tell us?



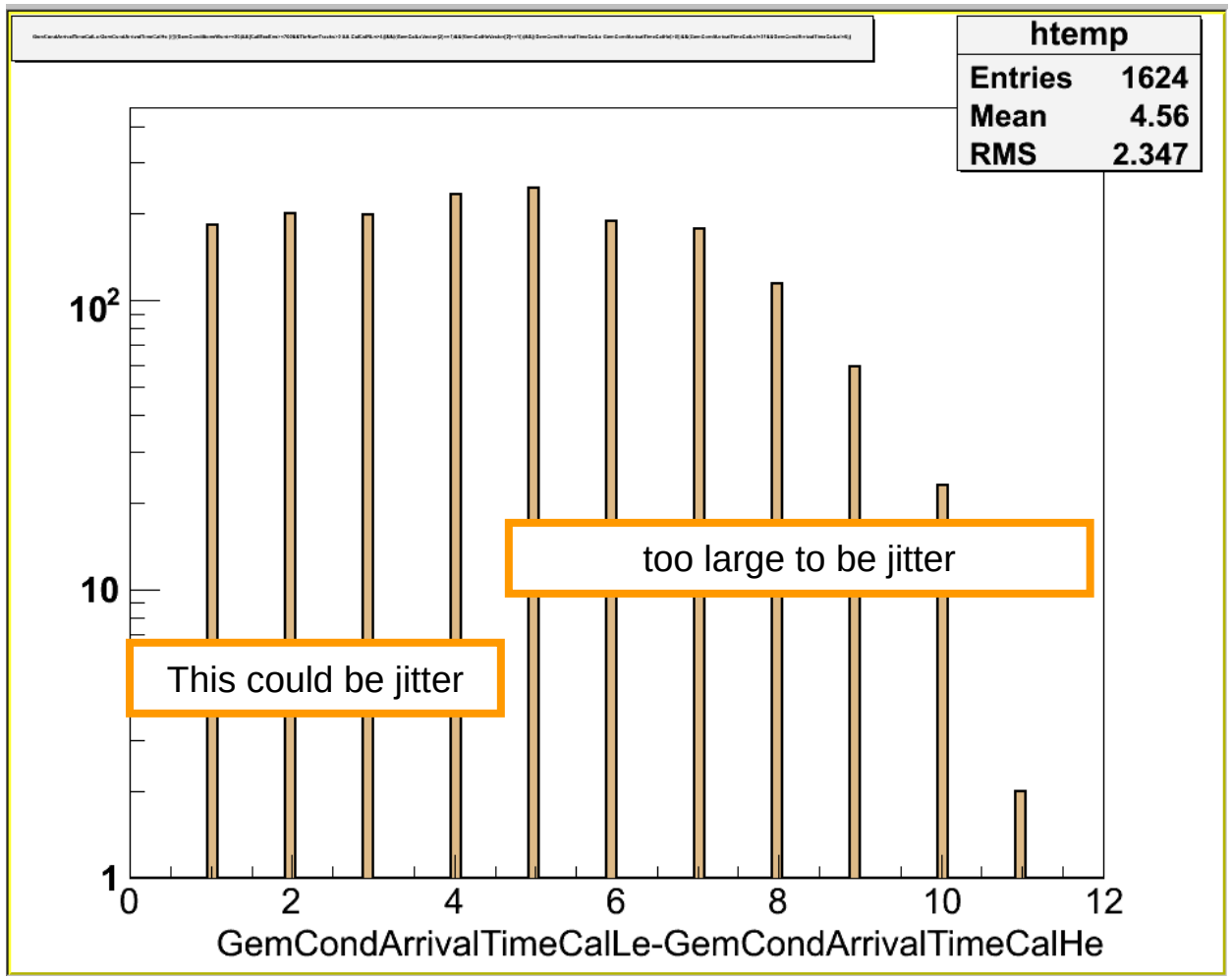
With many CAL_LE firing in an event one would expect at least one of to come before CAL_HE

Scanned a couple of events to confirm it was not occurring on the same crystal/channel

Are you sure these are not diode hits? Yes

- **Verified that the energy was NOT too low in the crystal in which the CAL_HE trigger fired**

Could it be jitter? Not for all events



Summary

- For a fraction of about 1% of initial triggers we found CAL_HE trigger fires before CAL_LE
  - we can't explain why
    - do we care since it is ~ 1%?
- We excluded the following explanations
  - Direct deposition in diode
  - jitter in the electronics
  - systematic effect from a particular crystal/channel
- Experts are looking into it
  - sent the talk to Sasha et al and we are waiting for their feedback