Studying TKR Trigger Arrival Time from with CAL Triggers in Flight Configuration

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Motivation

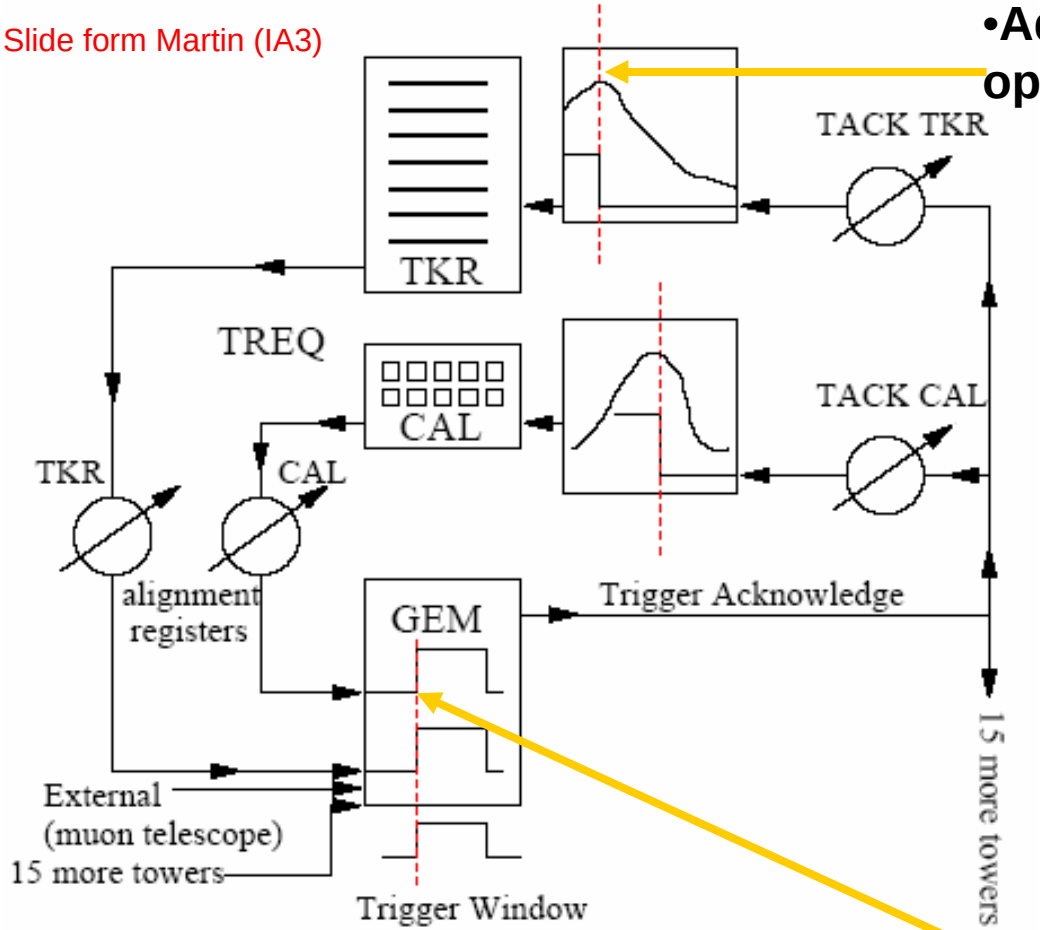
- So far the CAL low (CAL_LE_) and high (CAL_HE) energy triggers have been only tested with charge injection
  - because cosmic ray distribution peaks at low energies
- Can we use the CAL_LE and CAL_HE triggers in FLIGHT configuration to verify that the LAT is aligned in time?
  - need a lot of statistics since we rely on the tail of the cosmic ray distribution
    - we combined all LAT B/2 runs to obtain 10,320,000 events
      - » CAL_LE > 100 MeV
      - » CAL_HE > 1000 MeV
- Can we create samples of muon and photon candidates?
  - Yes, but we will define “loose” cuts to keep statistics to a reasonable level

Beware!!!!

- The next slides are a summary of my discussions
  - with Eric Sisskind
- I also stole some text from Martin's presentations
  - IA and/or trigger meetings
- Unfortunately I had no time to have them blessed by Mike Huffer (who designed the system!)
  - if there are mistakes, they reflect my ignorance about how the system works rather than a flaw in the design !
    - I could not find a timing diagram elsewhere…

How do we time in?

Slide form Martin (IA3)



- **Adjust Trigger Acknowledge delay for optimal data acquisition**
  - **goal is to sample at the peak**

It is not only about adjustable delays but there are also latencies in the system

Line up trigger primitives at GEM input

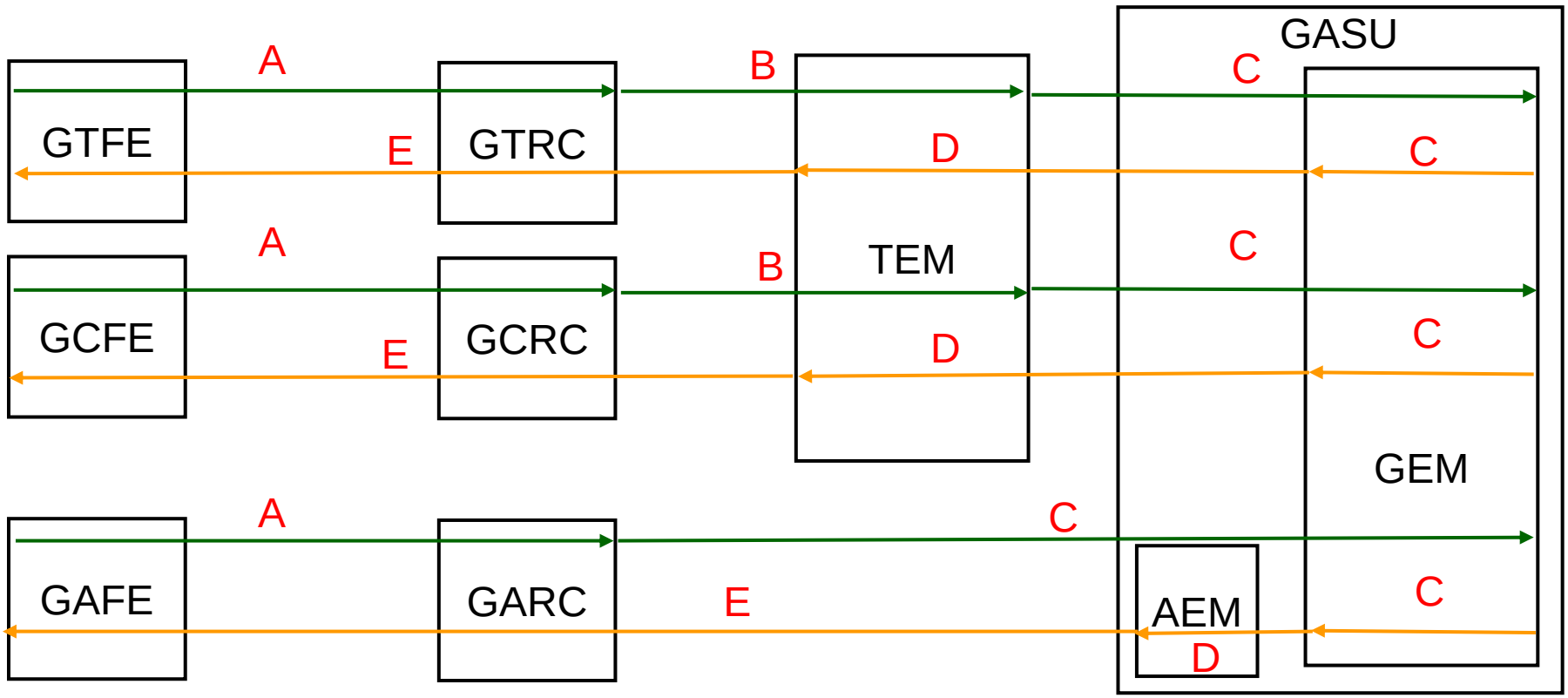
- **CAL is the slowest**
- **ACD is the fastest**
- **use trigger request delay lines to adjust arrival at TEM**

Trigger information (from Martin)

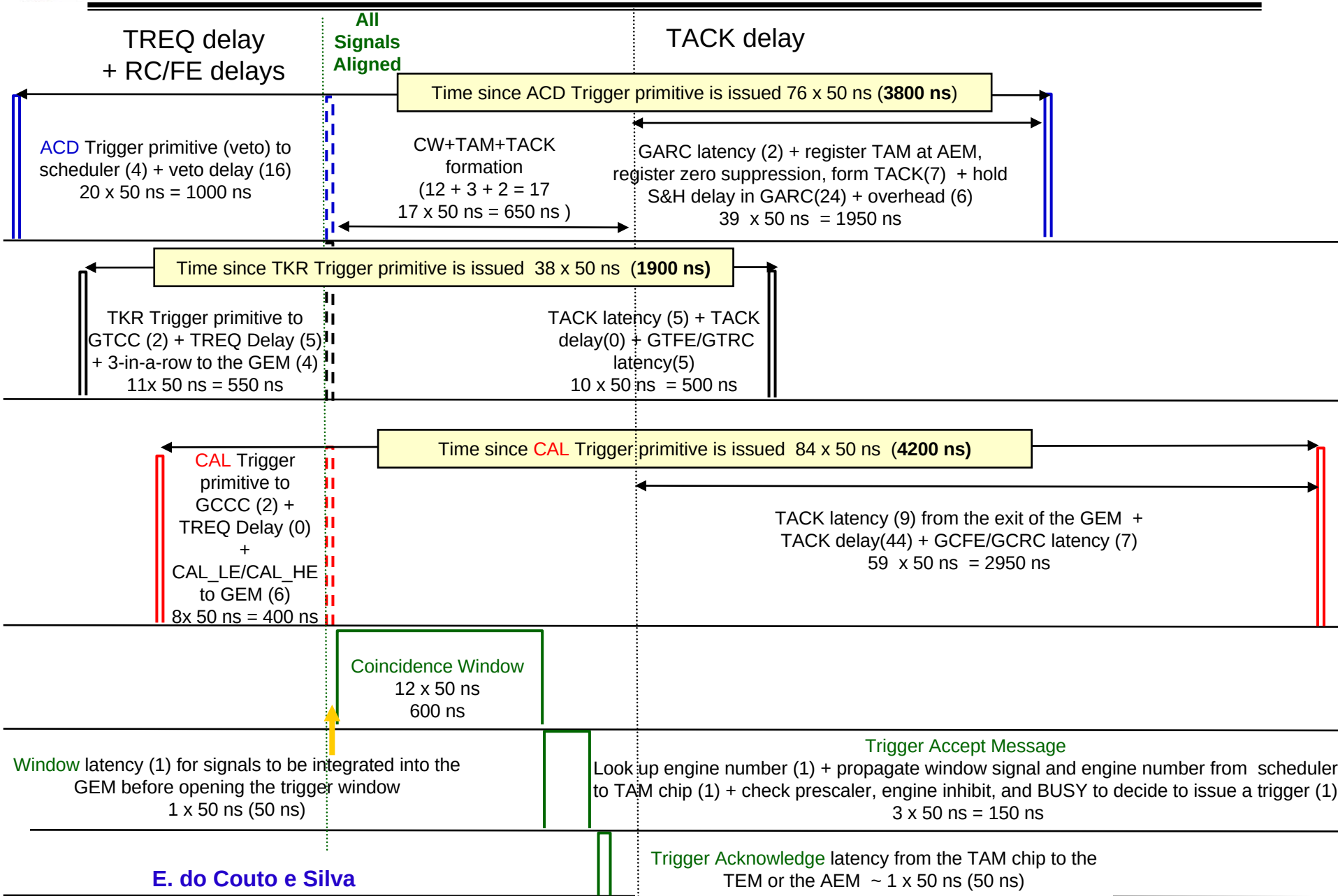
- If trigger window is too large
  - trigger efficiency high
  - data latching efficiency can be reduced
  - if window is 0 then max delay is 11 ticks
    - after that latching occurs before trigger !
- TKR trigger can be high
  - settable from 2 to 31 ticks or
  - during duration of signal
- LAT Timing was done at threshold above noise
  - CAL HI is difficult to time in with muons
    - used charge injection

LAT Alignment: Time Delays

Delay	TKR		CAL		ACD	
A	2	2	2	2	Veto_delay+4	20
B	TREQ_delay+4	9	TREQ_delay+6	6	null	0
C	Window_width+5	17	Window_width+5	17	Window_width+7	19
D	TACK_delay+5	5	TACK_delay+9	53	TACK_delay+7	7
E	5	5	7	6	hold_delay+6	30
Round trip time (system clock ticks)		38		84		76
Round trip time (ns)		1900		4200		3800
FEE Peaking time (ns)		1900-2000		>4000		4000



B2 Run: Timing Diagram?

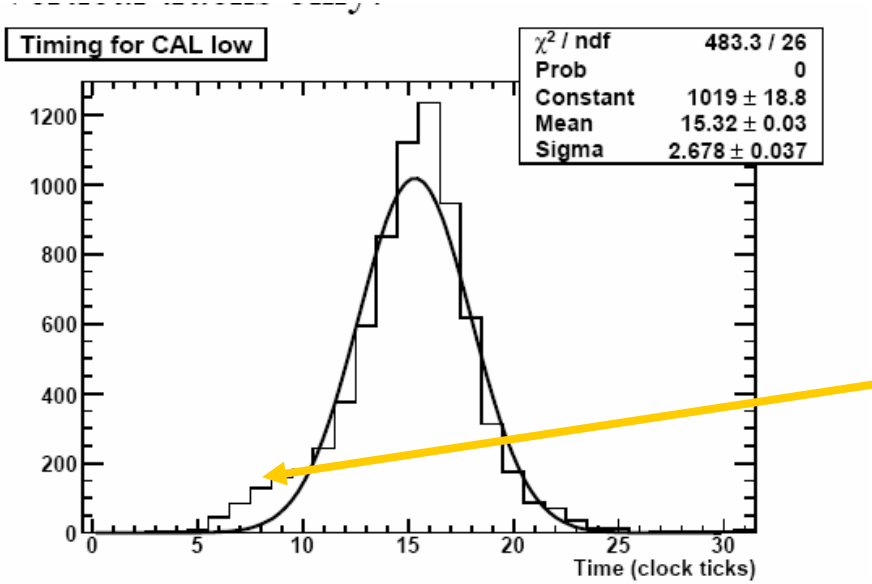


Summary of Timing

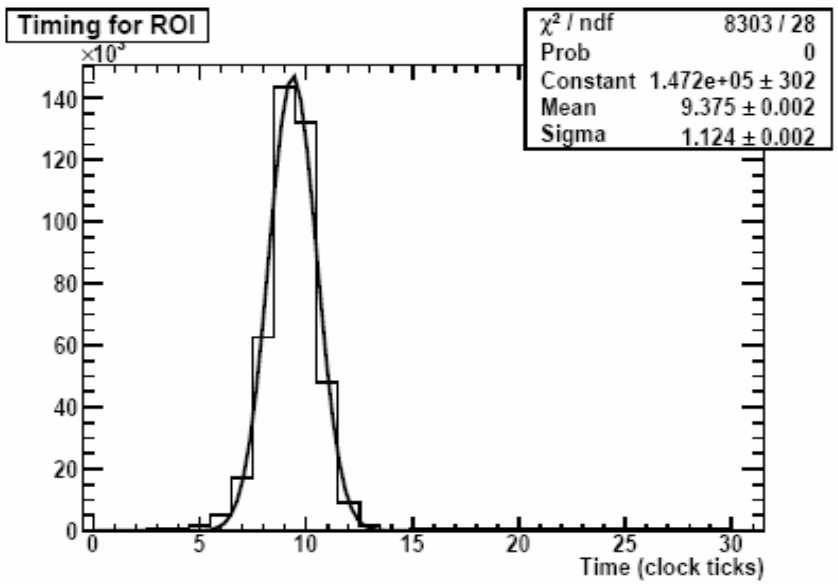
- We are latching the data at about
  - 3800 ns since ACD trigger primitive was issued
    - signal peaks at 4000 ns
  - 4250 ns since CAL trigger primitive was issued
    - signal peaks at >4000 ns?
  - 1900 ns since TKR trigger primitive was issued
    - signal peaks at 1900-2000 ns?

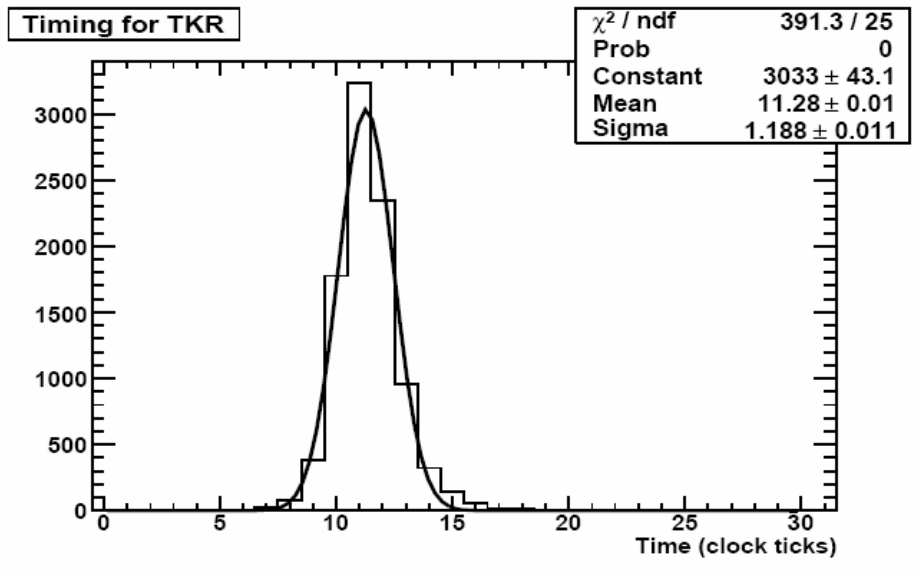
- Signal height variations imply in trigger jitter (see Martin's talk)
  - Trigger jitter is not large (ACD, CAL and TKR)
    - from 60 to 125 ns?
    - note that for "diode events" it can be as large as 500 ns !
      - » see next page

Trigger Jitter (from M. Kocian)



- **ACD Jitter**
  - σ = 1.2 x 50 ns = 60 ns
  - "box" ~ 10 x 50 ns = 500 ns
- **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)
    - see discussion in the next slide
- **TKR Jitter**
  - σ = 1.2 x 50 ns = 60 ns
  - "box" ~ 10 x 50 ns = 500 ns





The Cuts…

- **Muon candidates**
  - **select every tower, and only one tower at the time with**
    - **CAL_LE and TKR trigger fired**
      - » **GemTkrVector and GemCalLeVector set to 1**
    - **CAL_LE and TKR trigger and ROI bit set**
      - » **GemConditionsWord = 7**
    - **One track events**
      - » **TkrNumTracks =1**

replaces MC GltTower see Jane's talk (IA6)

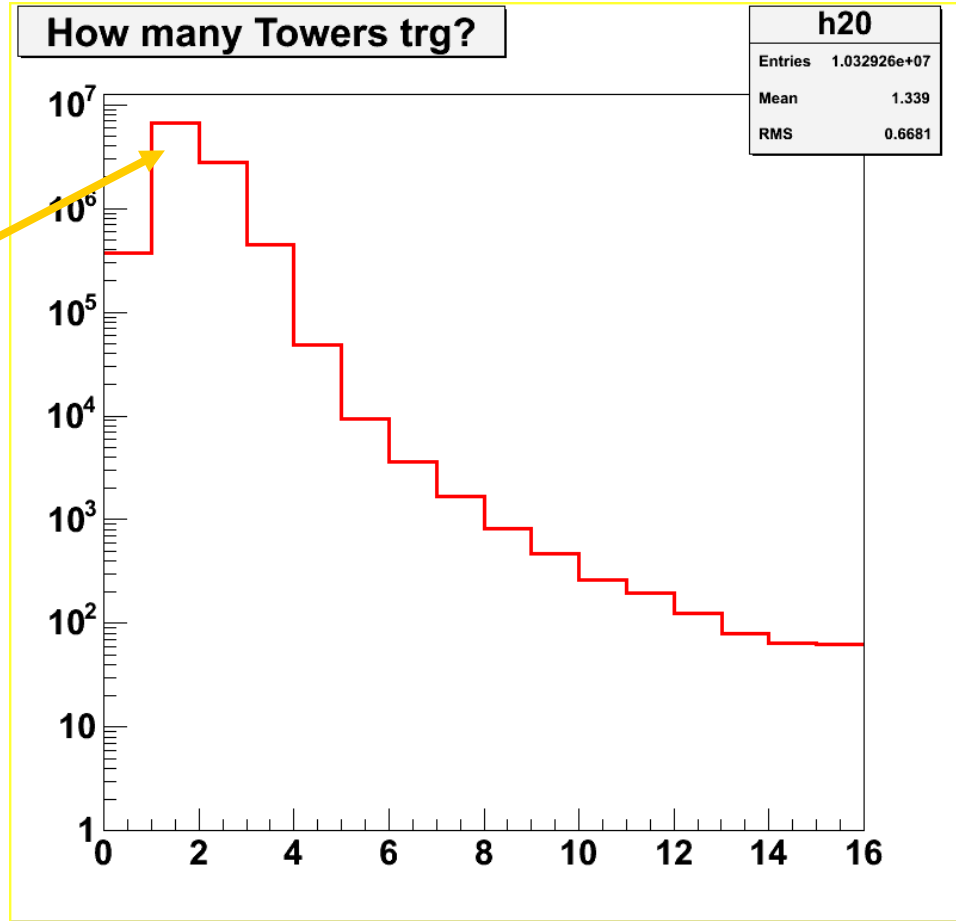
- **Photon candidates**
  - **select every tower, and only one tower at the time with**
    - **CAL_LE and TKR trigger fired**
      - » **GemTkrVector[TOWER] = 1 and GemCalLeVector[TOWER] = 1**
    - **CAL_LE and TKR trigger**
      - » **GemConditionsWord = 6**
    - **At least 1 track**
      - » **TkrNumTracks > 0**
    - **2 empty TKR planes above first TKR hit plane (use Si as a veto)**
      - » **TKR1SSDVeto>2**

Cuts are less tight than Bill's (IA3) and Elisabetta's (IA5)

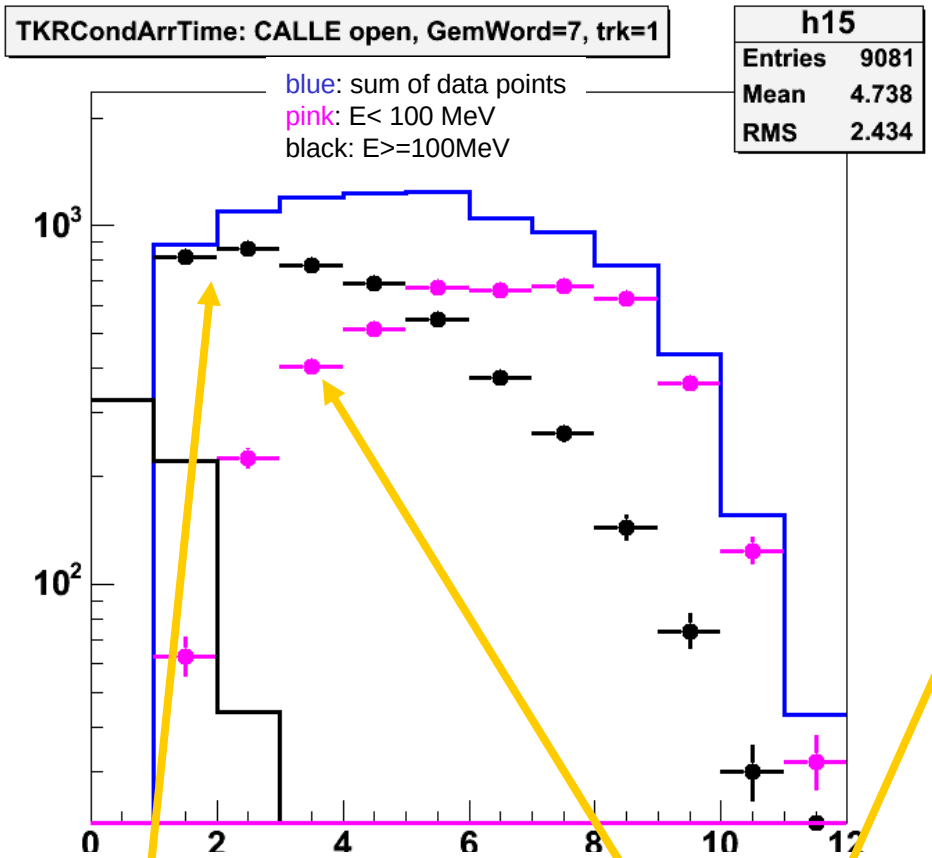
- **Final Results**
  - **Study arrival time of TKR for events with E>100 MeV and E<100 MeV**
    - **require CAL_LE to open the trigger window but TKR NOT**
    - **efficiency ~ 0.004% to 0.09% for CAL_LE**
    - **efficiency ~ 0.001% for CAL_HE**
      - » **depends on the cuts applied**

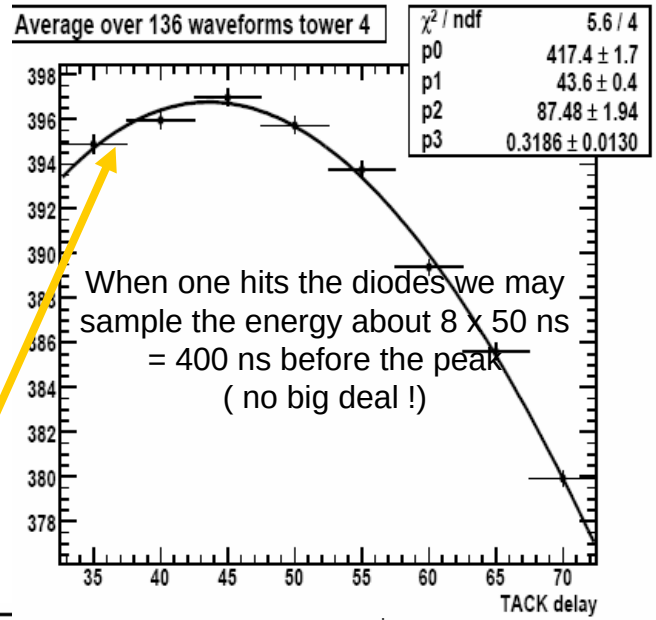
Number of Triggered Towers

- Select one Tower only
  - CAL_LE and TKR trigger fired
    - GemTkrVector[twr]=1
    - GemCalLeVector[twr] = 1

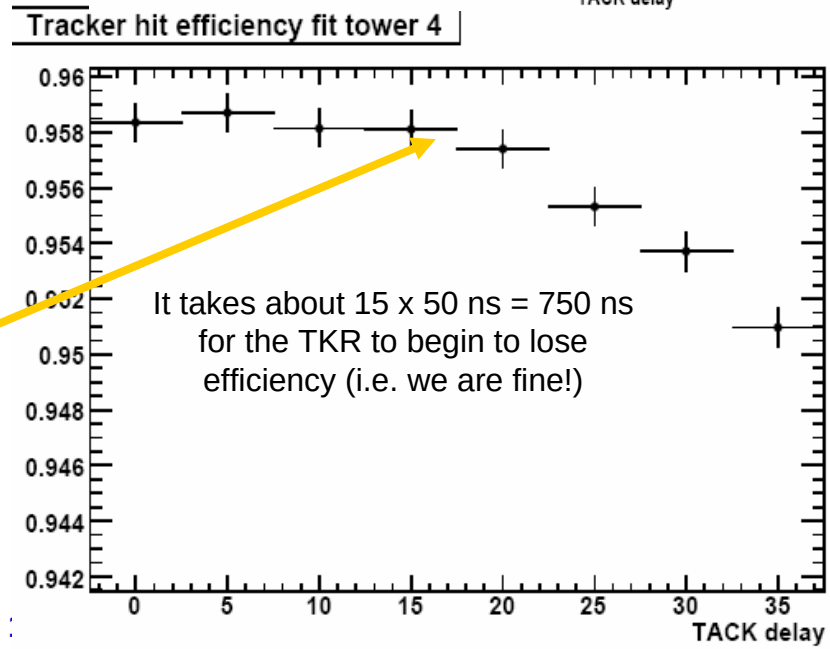


Our Main Results





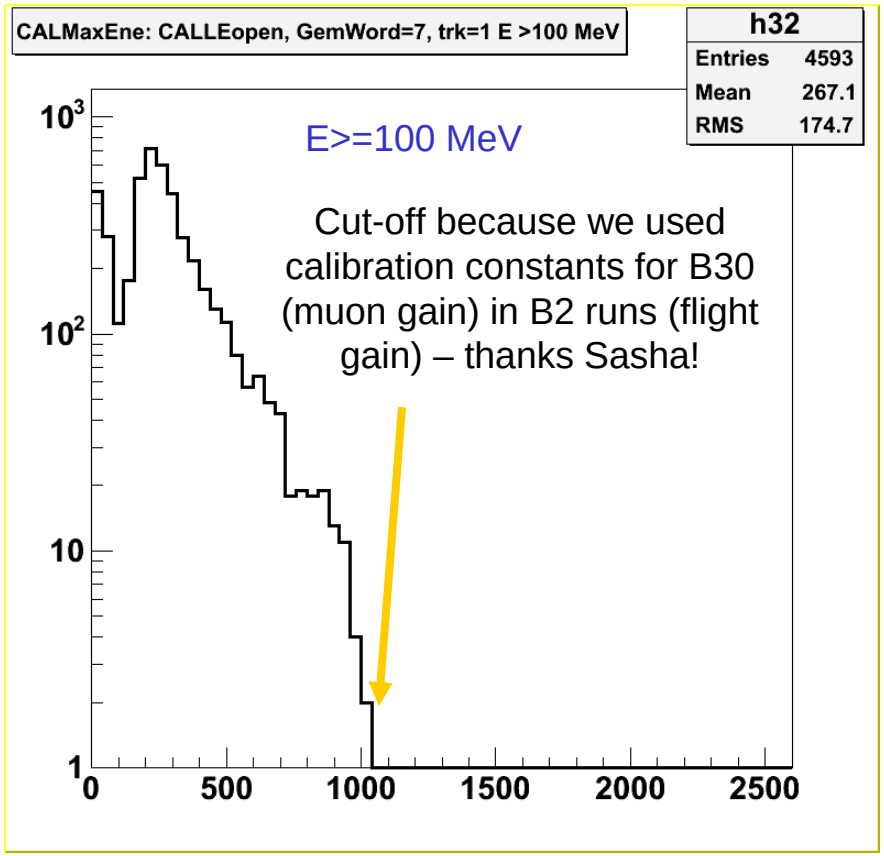
When one hits the diodes we may sample the energy about 8 x 50 ns = 400 ns before the peak (no big deal !)

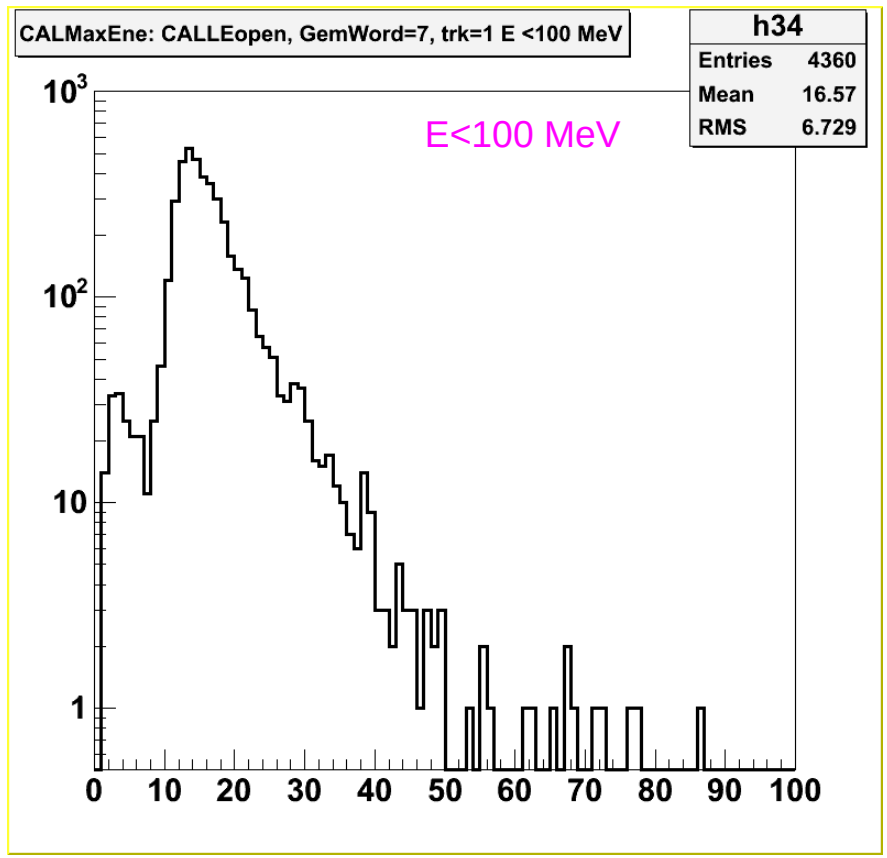


It takes about 15 x 50 ns = 750 ns for the TKR to begin to lose efficiency (i.e. we are fine!)

- **Our Results**
  - **Events with low energy in the crystals (but high Energy in the diodes E> 100 MeV)**
    - **TKR arrives on average 5 x 50 ns = 250 ns after CAL_LE opens the window**
  - **Events with High energy in the crystals (E> 100 MeV)**
    - **TKR arrives on average 3 x 50 ns = 150 ns after CAL_LE opens the window**

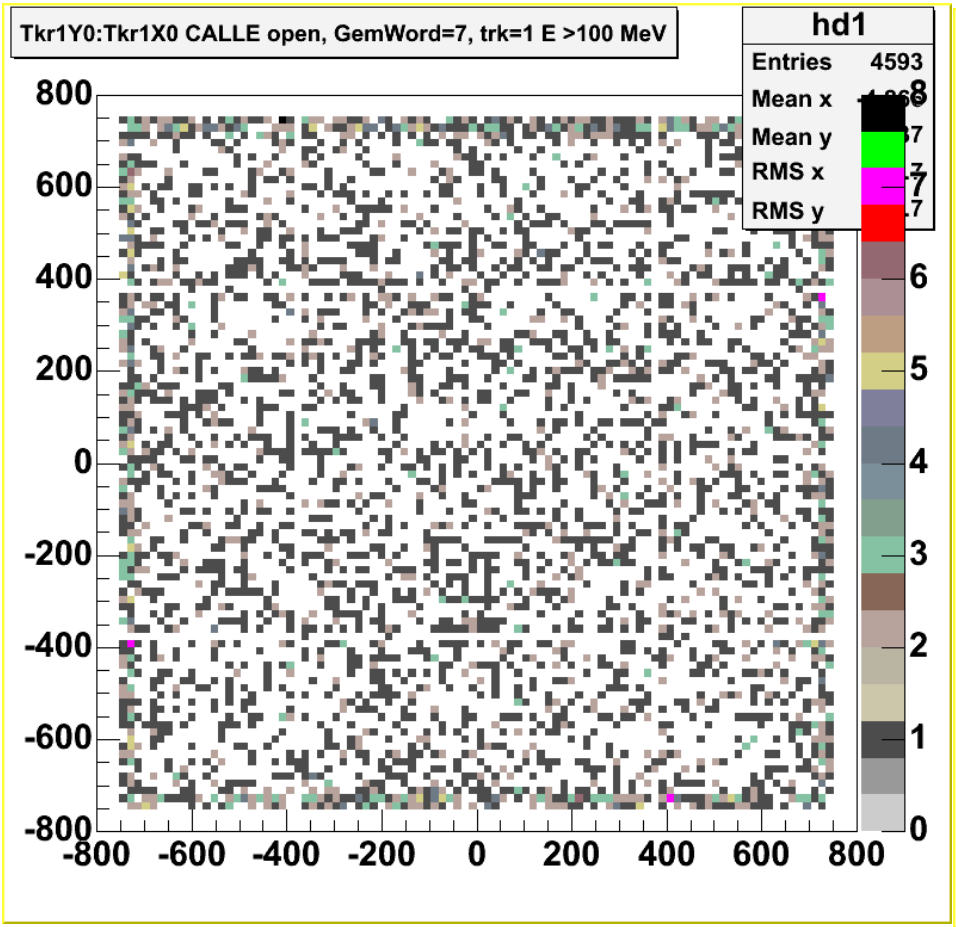
Maximum Energy in a Crystal

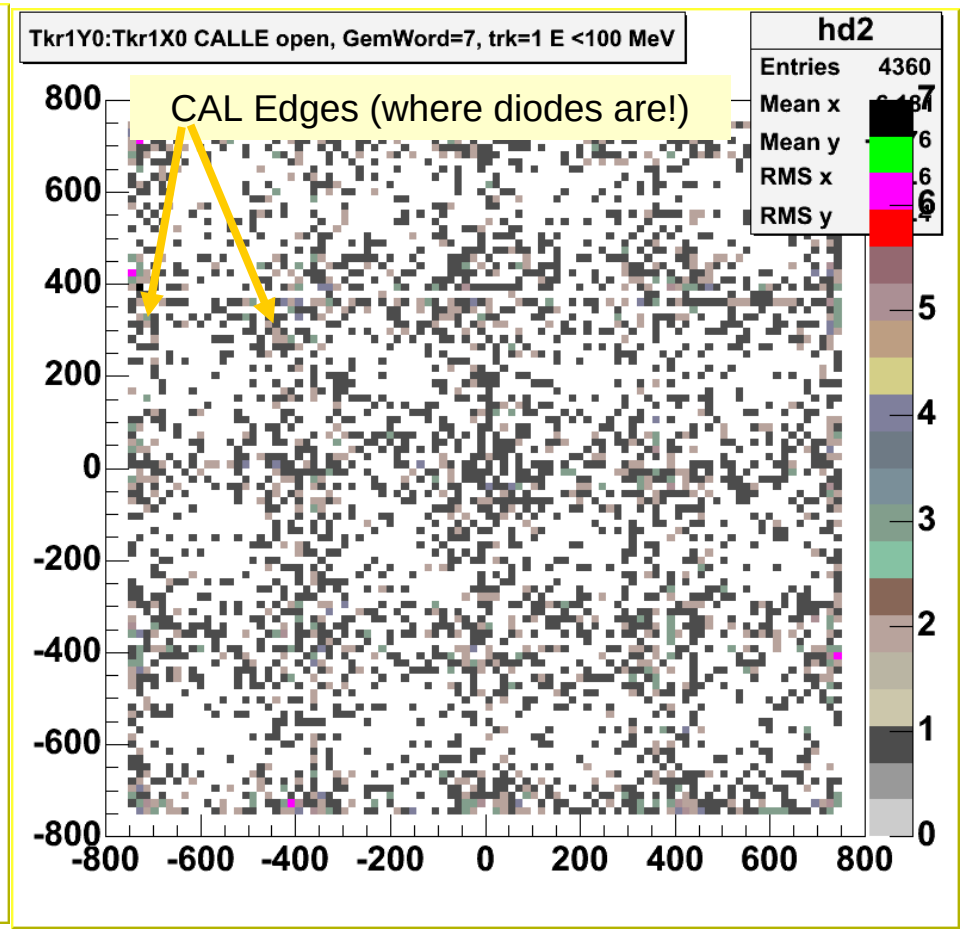




- **Muon candidates**
  - **Cuts**
    - **GemTkrVector[twr] =1 and GemCalLeVector[twr] = 1**
    - **GemConditionsWord = 7**
    - **TkrNumTracks =1**

Tkr1X0 vs Tkr1Y0





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  - **Cuts**
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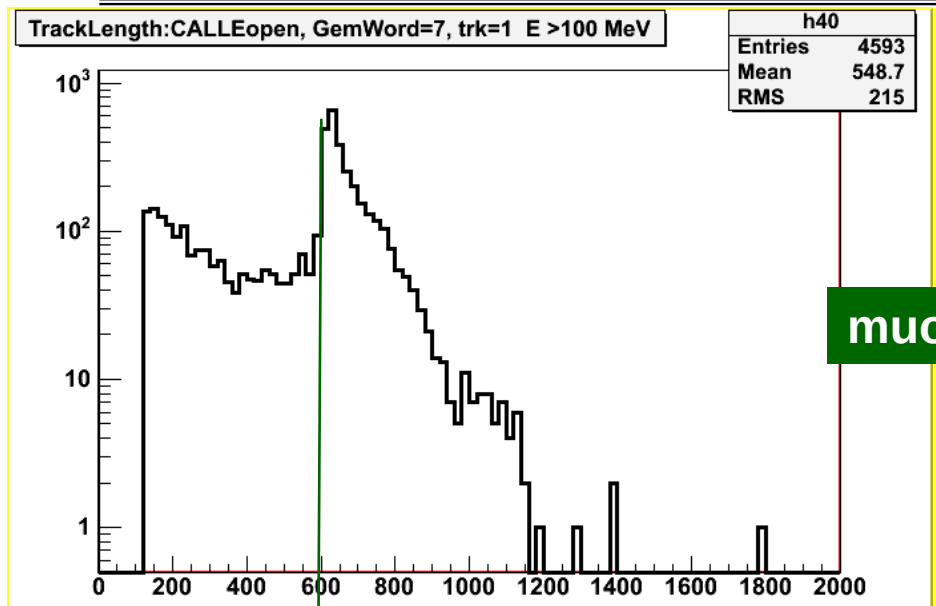
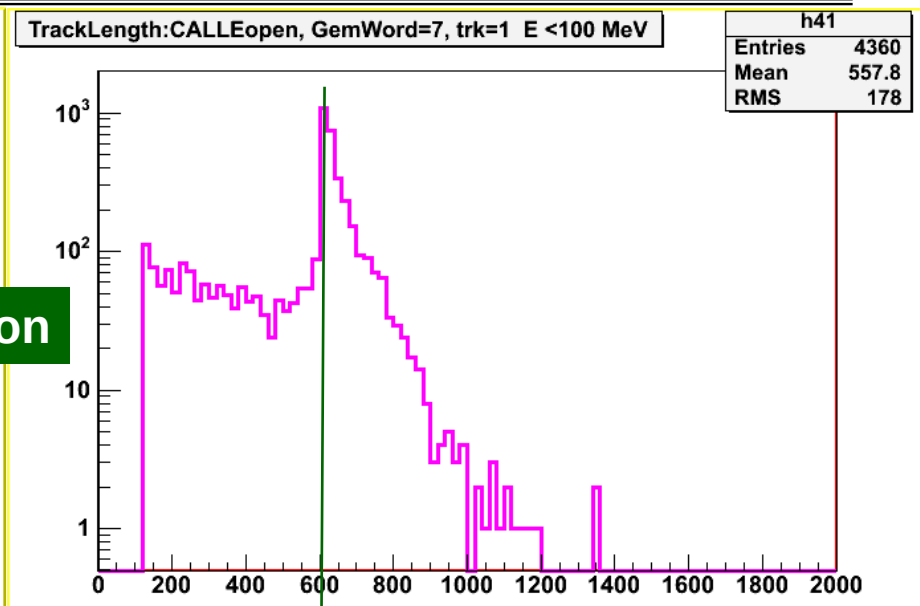
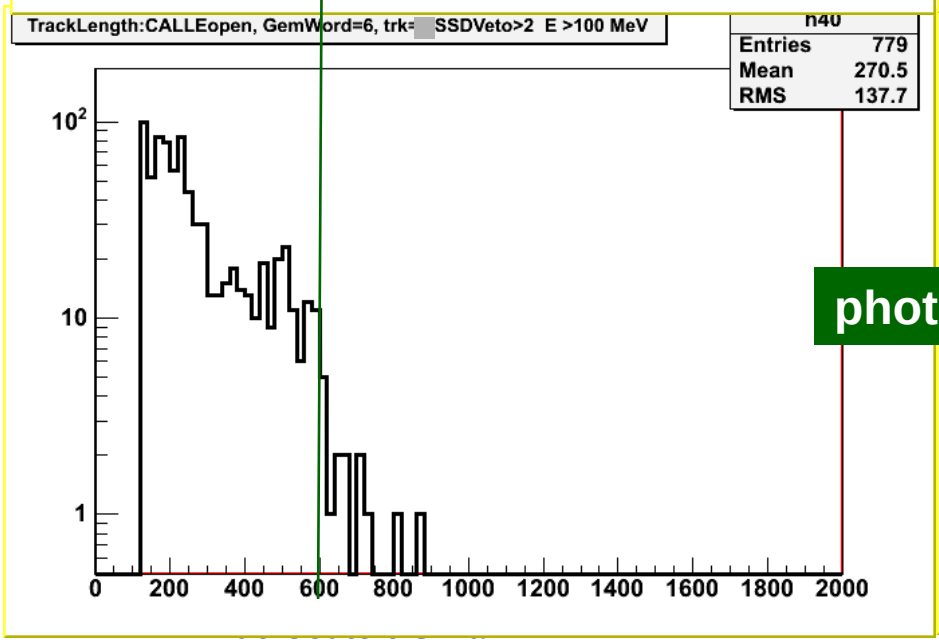
    - **GemConditionsWord = 7**
    - **TkrNumTracks =1**

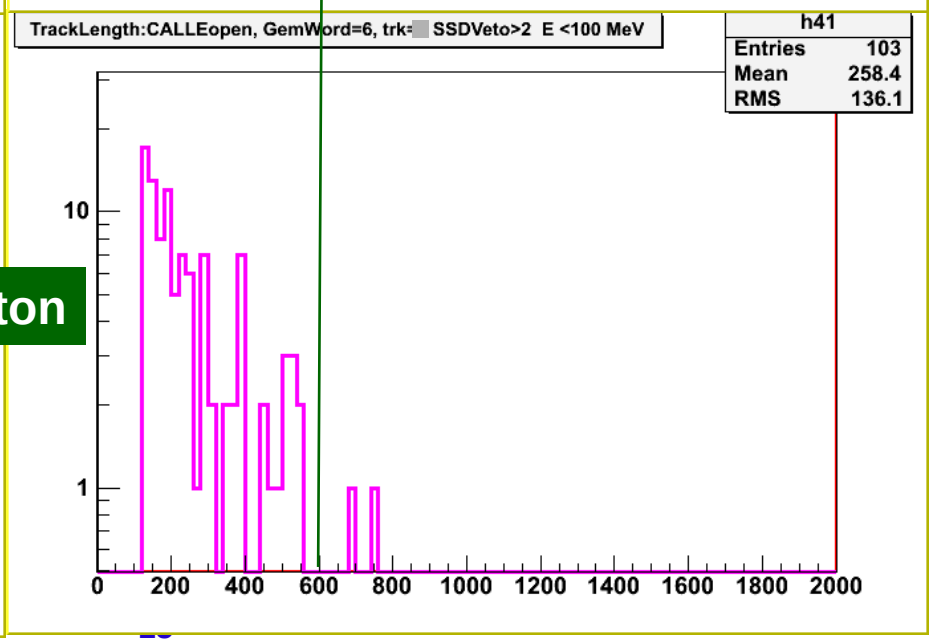
Length of the Track





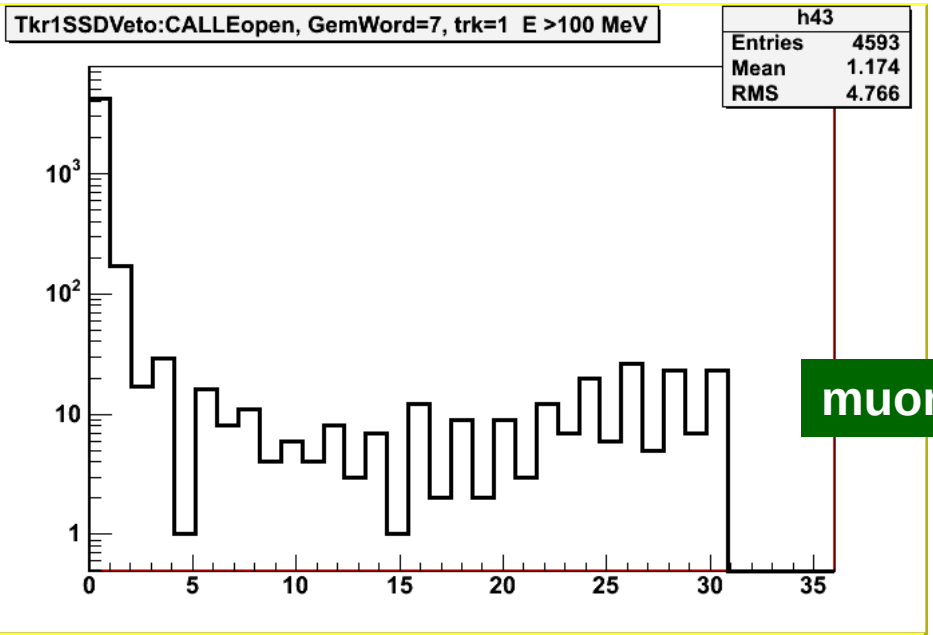
muon



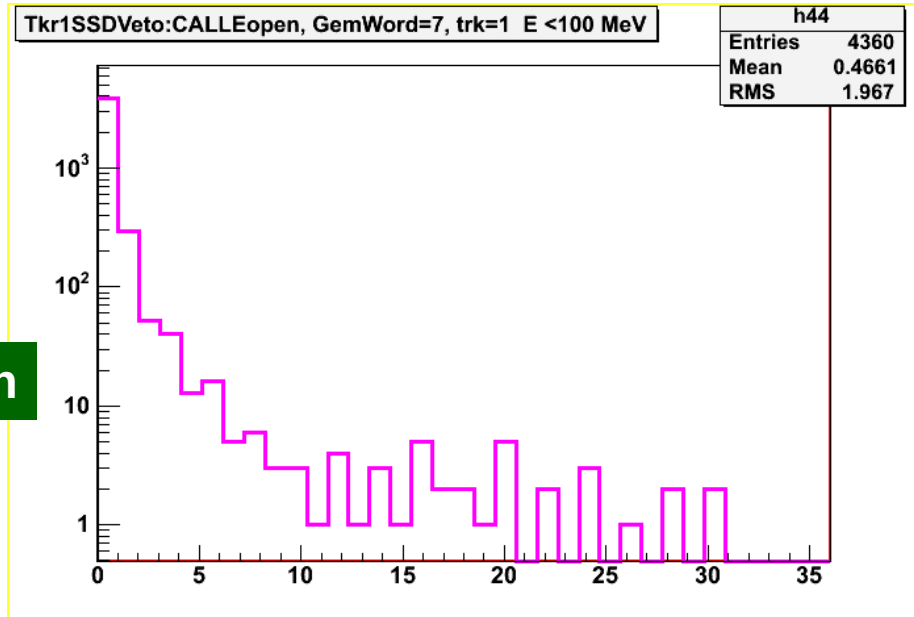


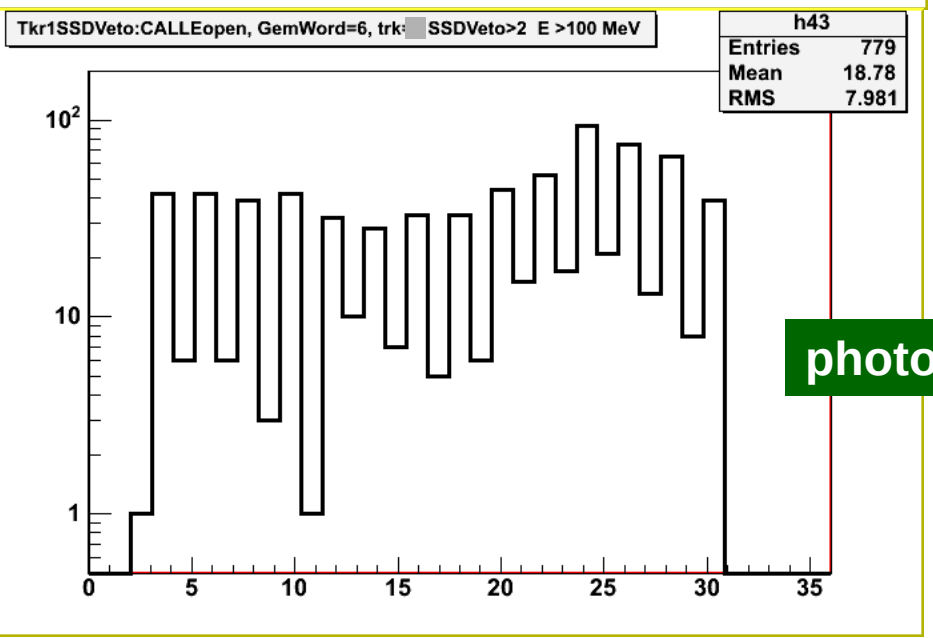
photon

Tkr1SSDVeto

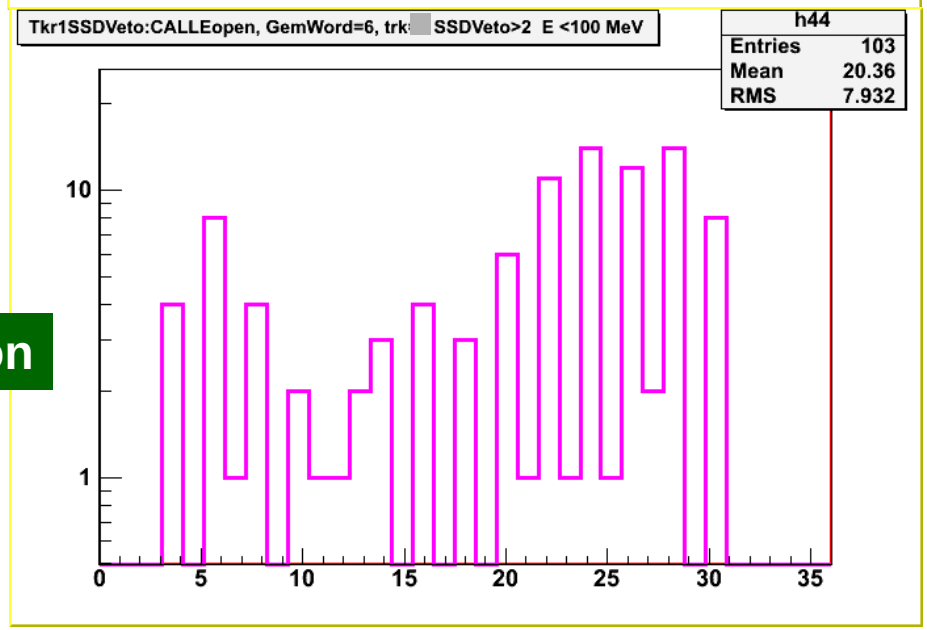


muon

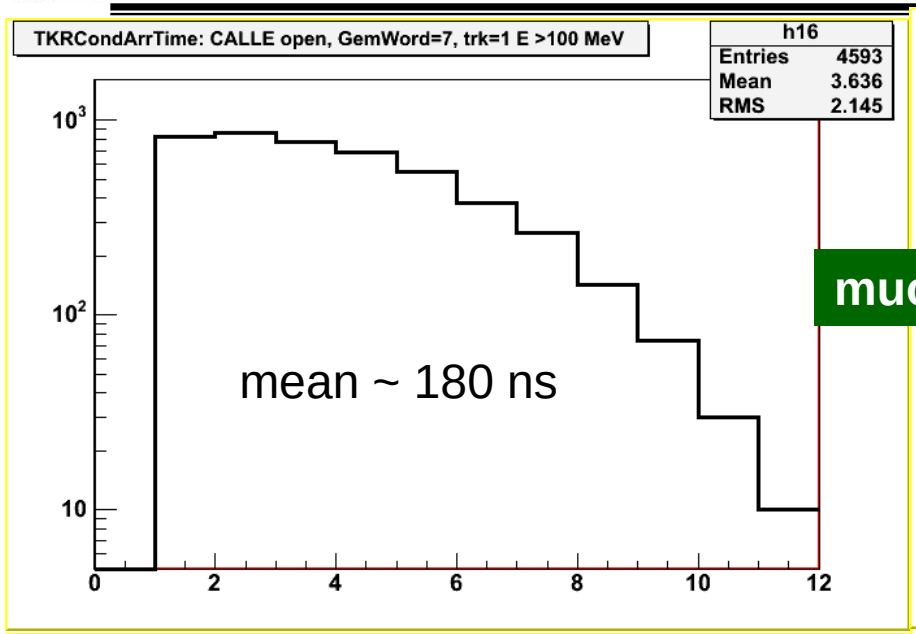


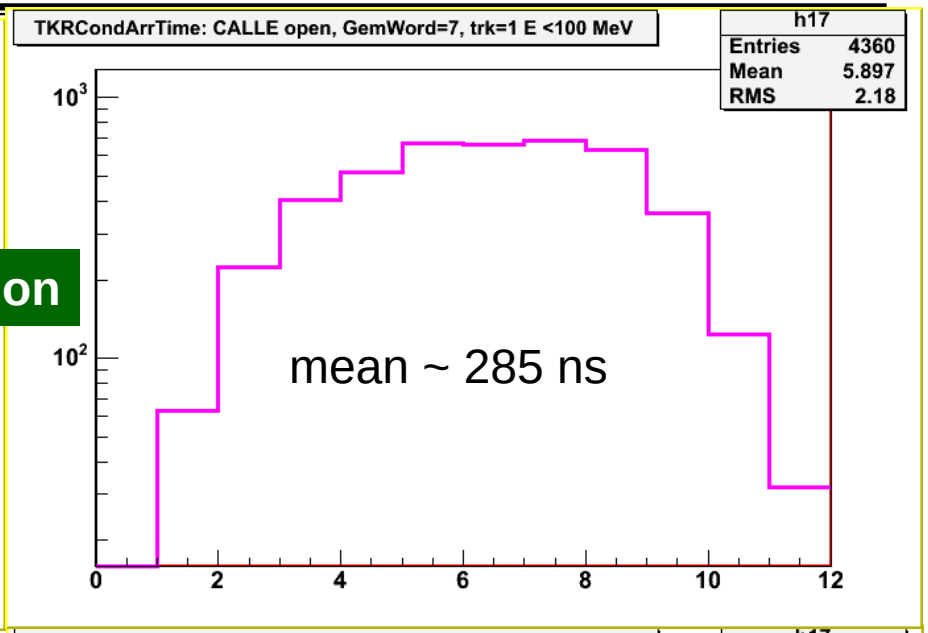


photon

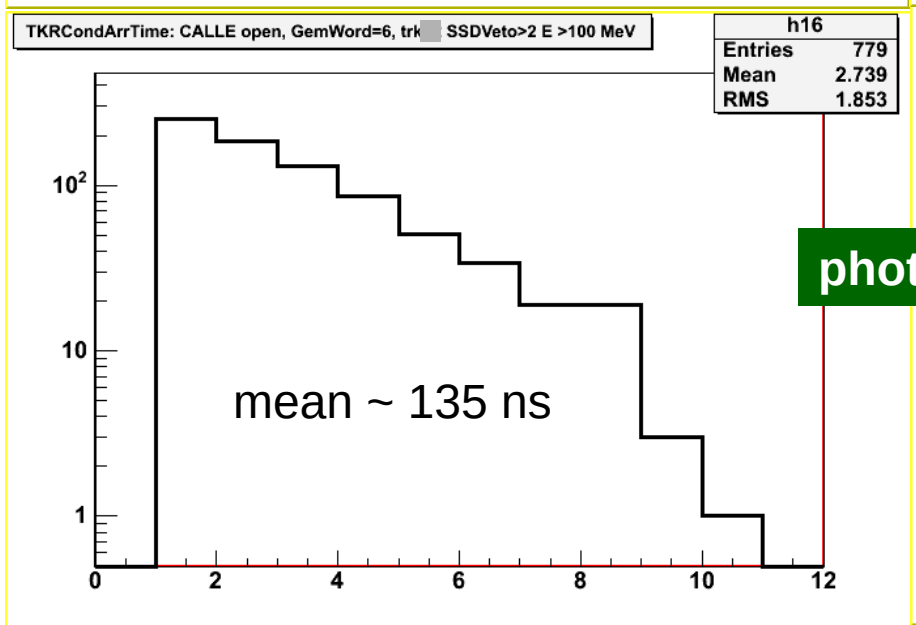


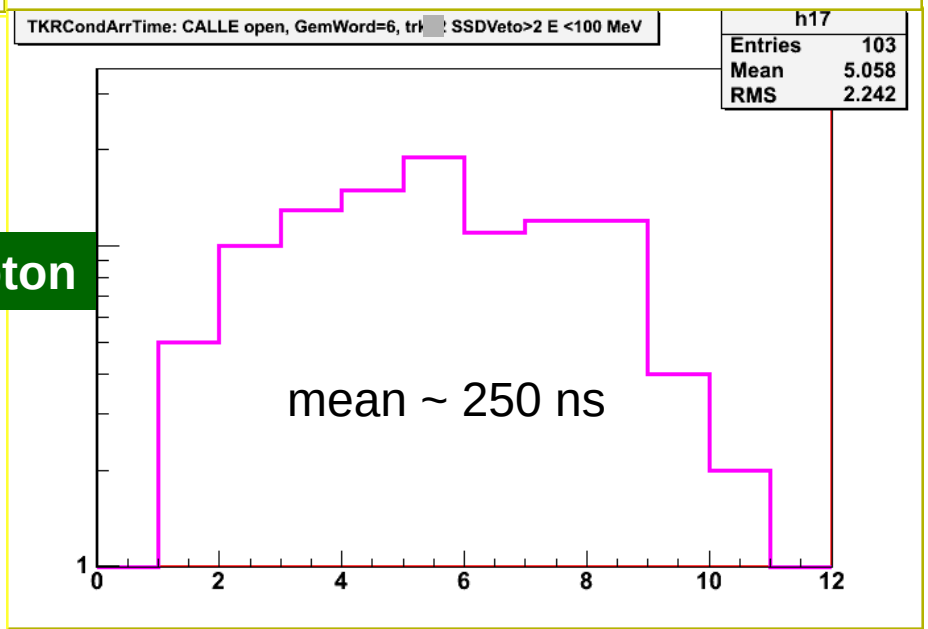
TKR Arrival Time with CAL LE Opens Window





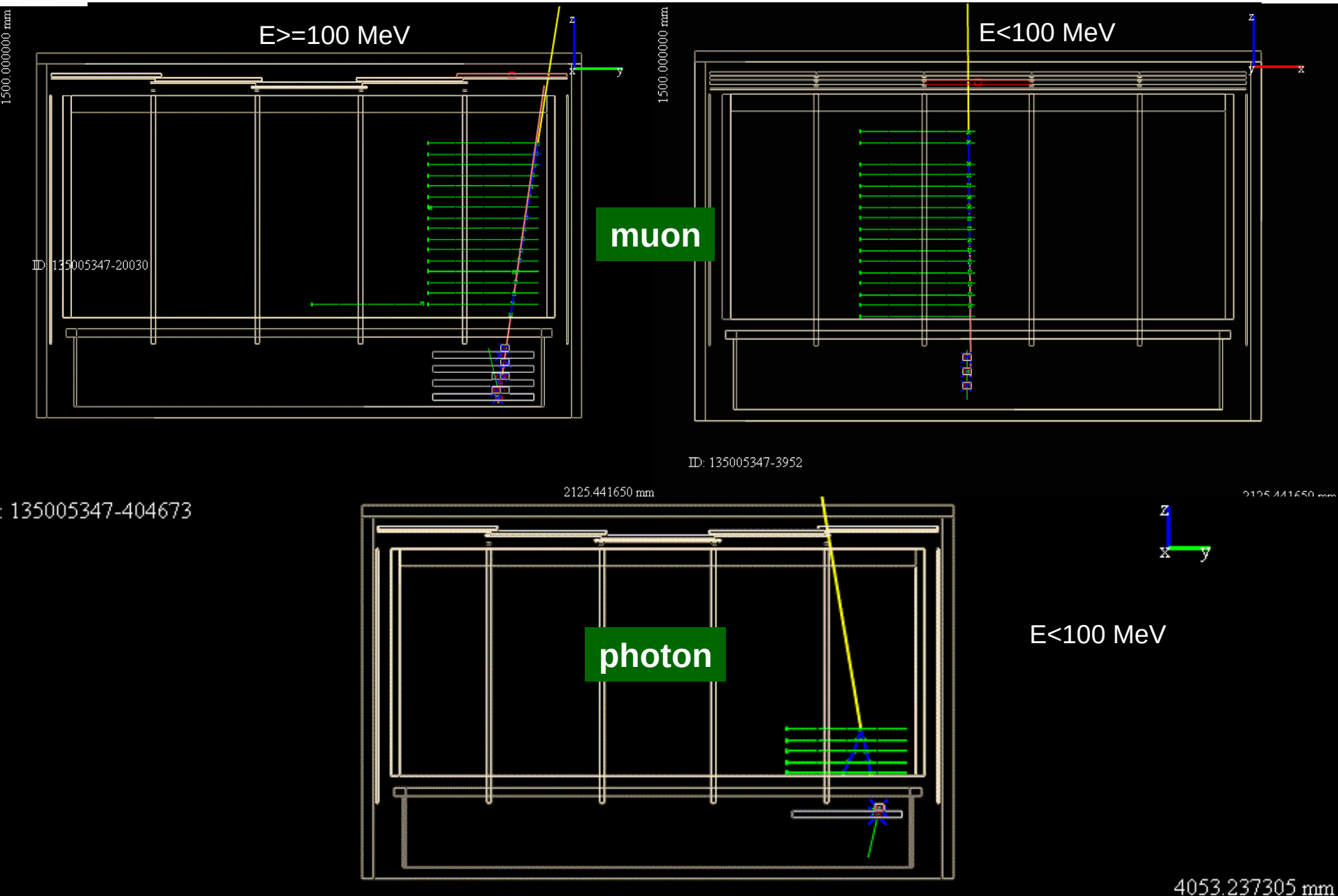
muon



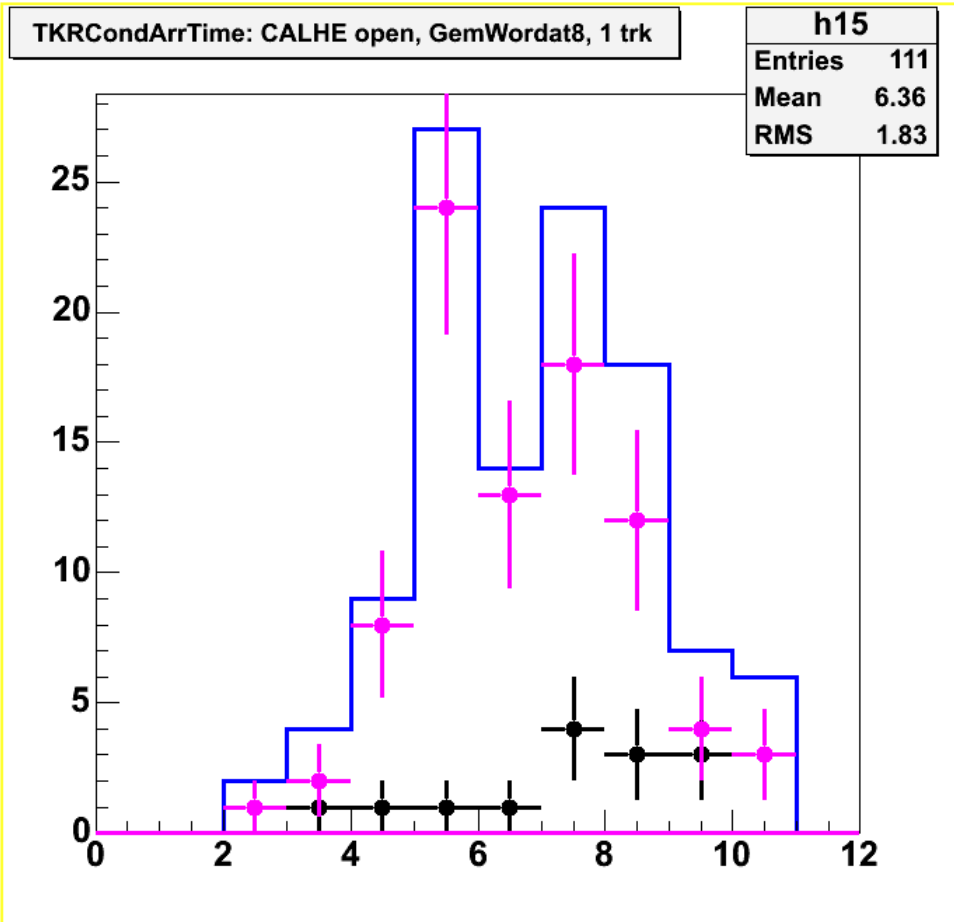


photon

Muons and Photons



CAL HI Triggers with Muons !

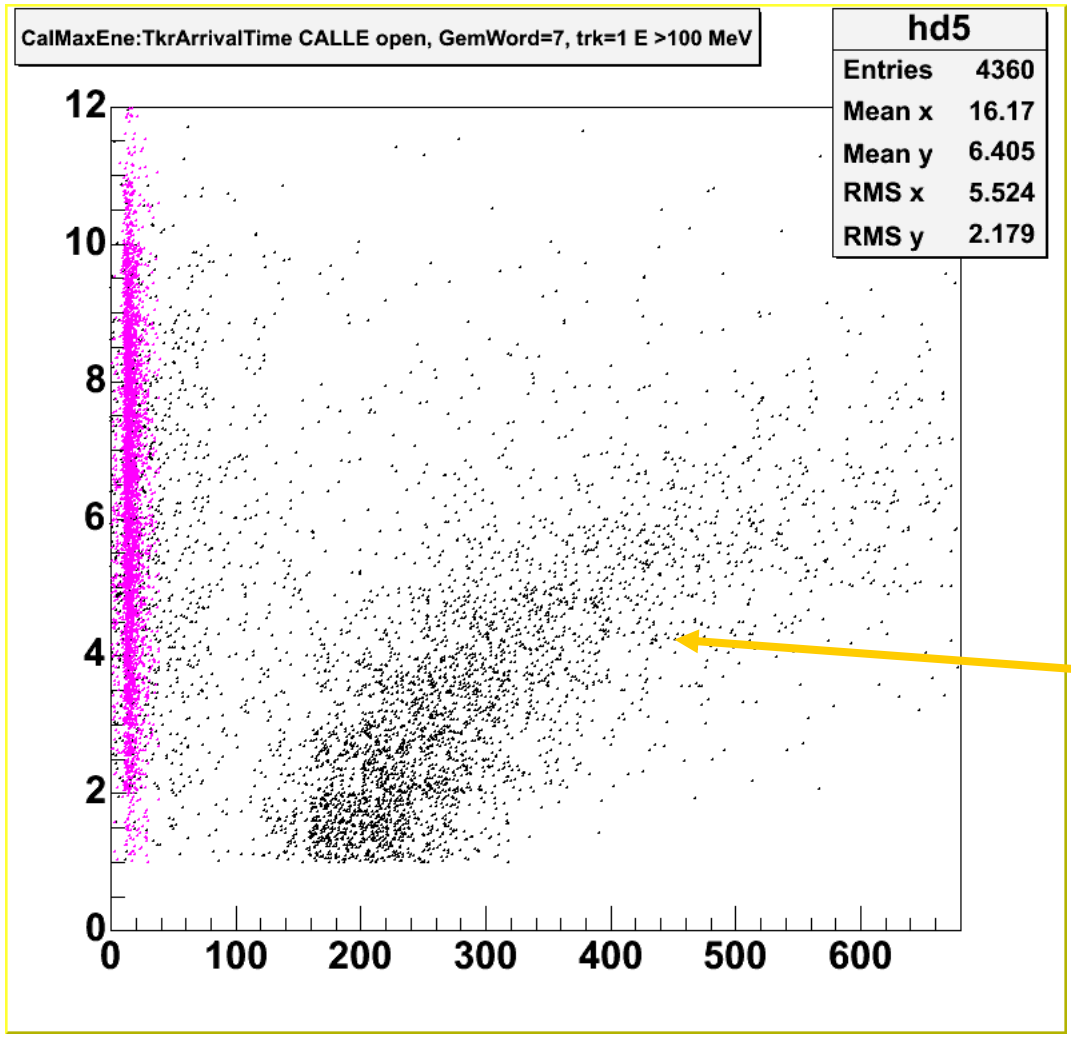


- CAL_HE triggers
  - 0.001% efficiency
  - expect a factor of 10 higher statistics for the final LAT runs!
- Not enough statistics to say anything
  - distribution does fall off !
    - this is good!

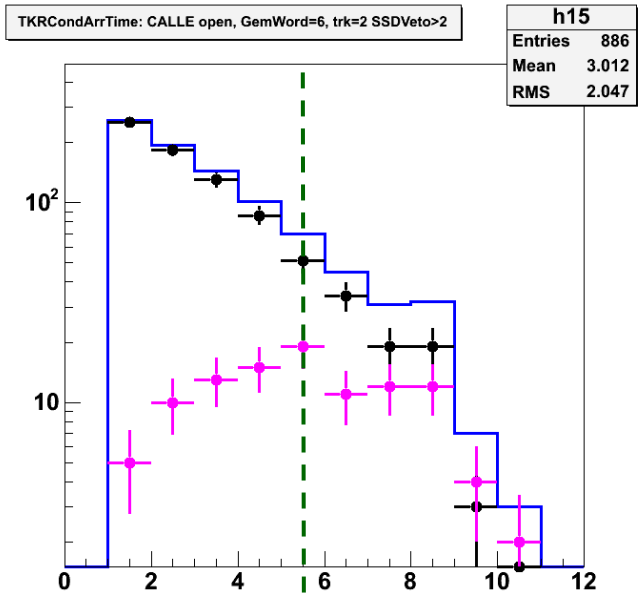
Conclusion

- We were able to study time properties of the CAL Low Energy Trigger with ground data
  - from a sample of about 10M LAT L1 triggers (~6 hours)
- There are no obvious problems with the TKR arrival time of the events
  - distribution is well contained within the Trigger window
    - for muons and photon candidates
- There is a class of events that trigger on CAL diodes but deposit little energy in the CAL which exhibits different timing properties
  - all consistent with expectations
- LAT seems to be timed in properly
- We should have more statistics for the final runs
  - also remember we will orient the LAT horizontally!

Muon Candidates



correlation for E>=100 MeV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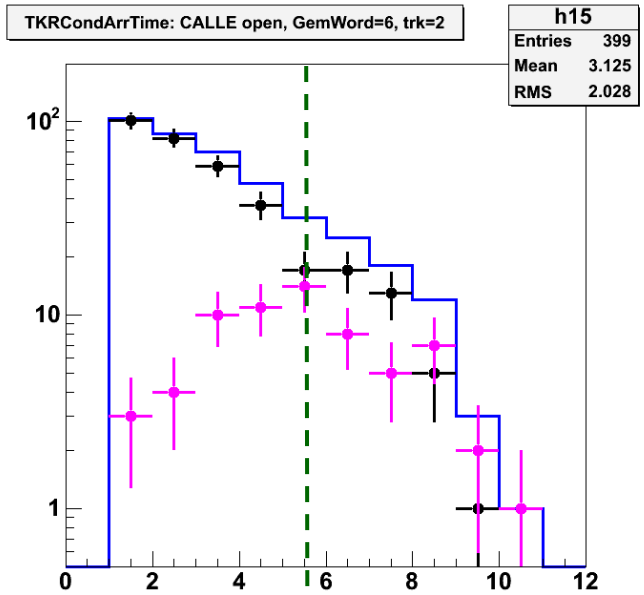
h15
Entries 886
Mean 3.012
RMS 2.047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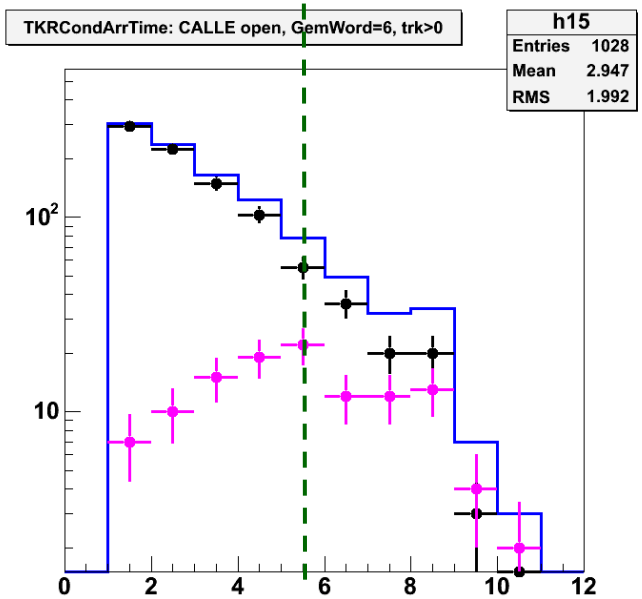
h15
Entries 399
Mean 3.125
RMS 2.028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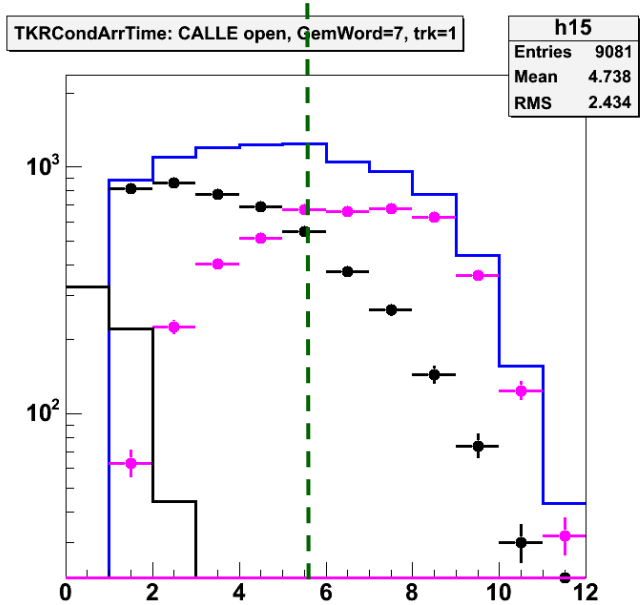
h15
Entries 1028
Mean 2.947
RMS 1.992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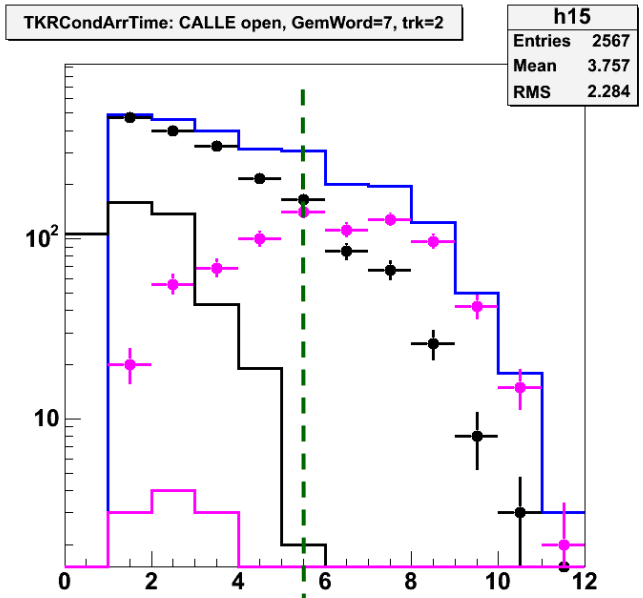
h15
Entries 9081
Mean 4.738
RMS 2.434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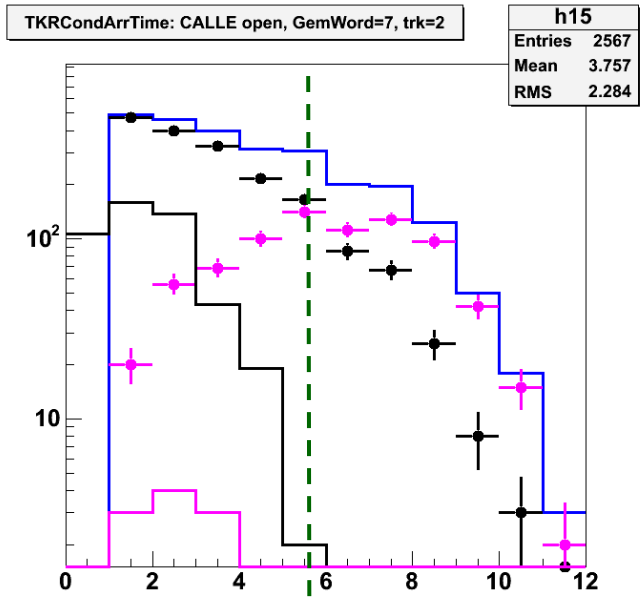
h15
Entries 2567
Mean 3.757
RMS 2.284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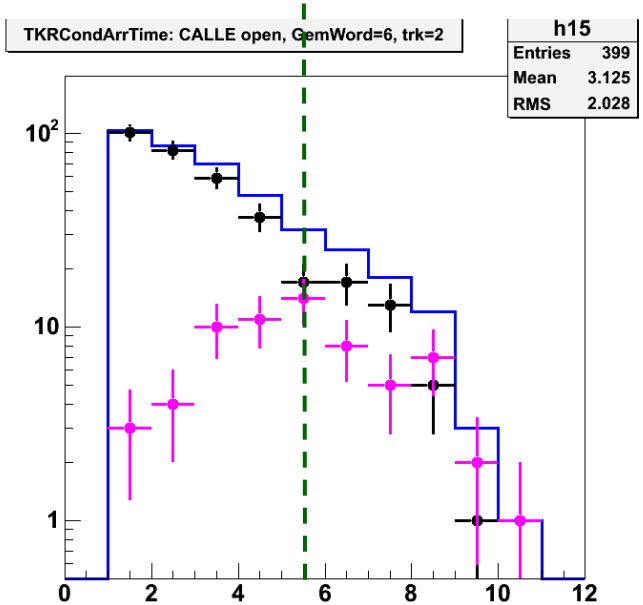
h15
Entries 2567
Mean 3.757
RMS 2.284


TKRCondArrTime: CALLE open, GemWord=6, trk=2
h15
Entries 399
Mean 3.125
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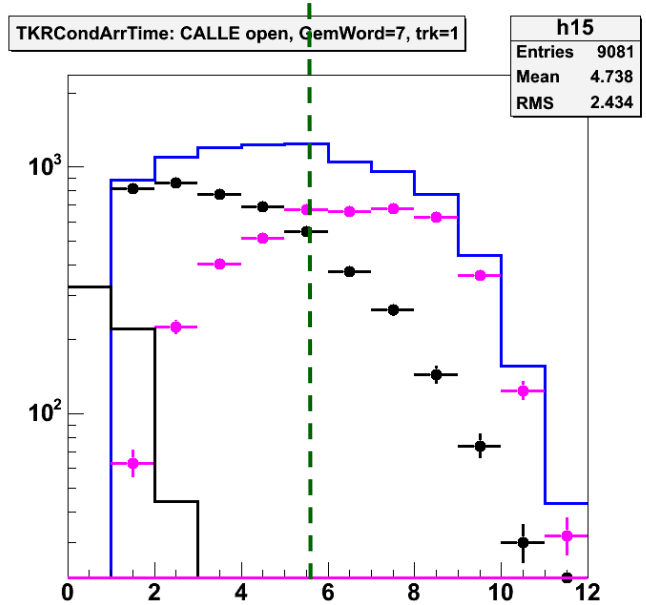
TKRCondArrTime: CALLE open, GemWord=7, trk=1
h15
Entries 9081
Mean 4.738
RMS 2.434

Number of ACD Digis: muons