VD CB PNS Data Analysis Update

Jun 5, 2024

Wei
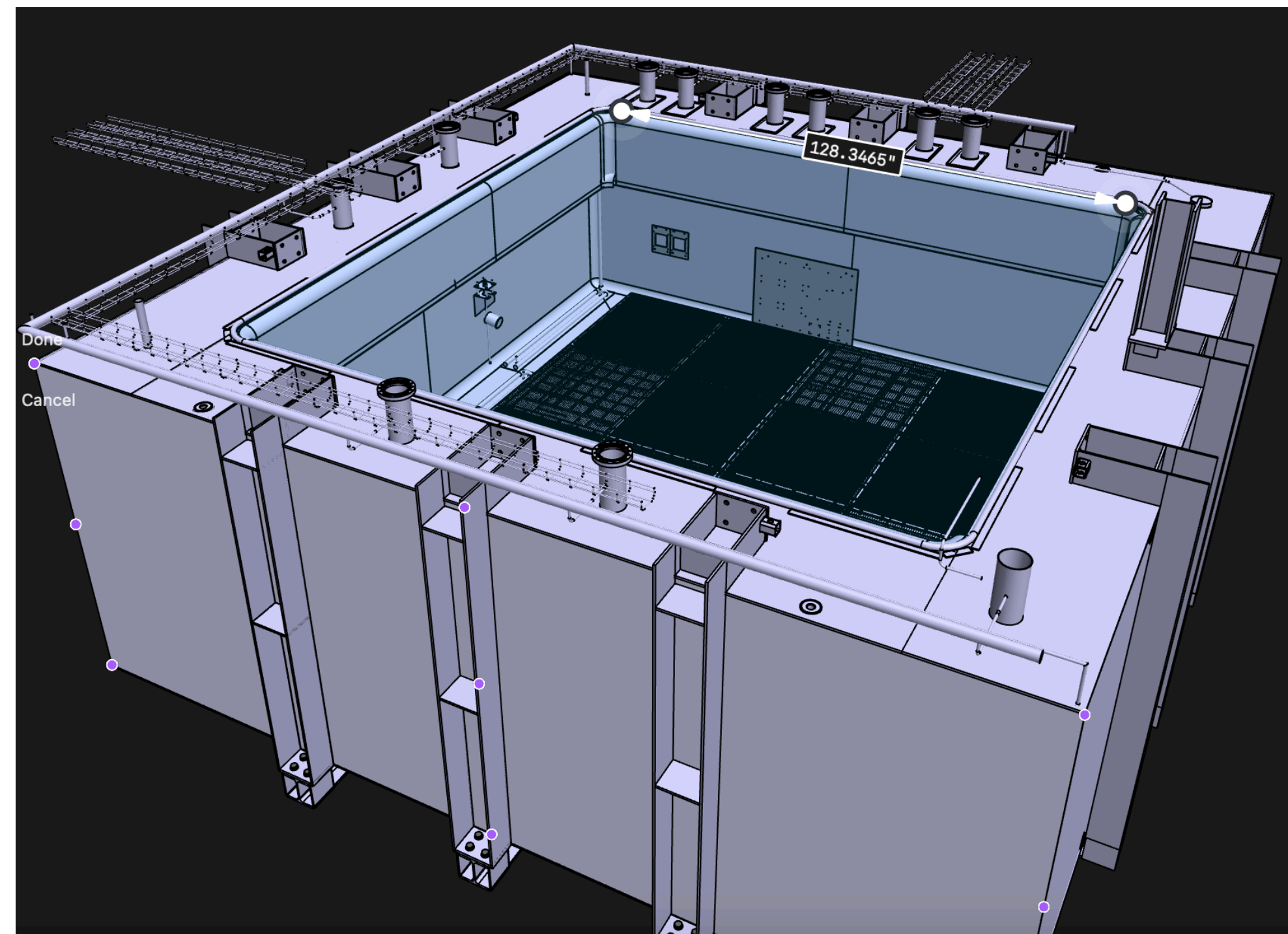
Simulated 4.7MeV γ in a LAr Bath (200m x 200m x 200m):
Pair production

Very localized deposits

e^+e^- **total KE: 3.68MeV (fixed)**

```
event 5
Marley events: assert info from file name
vertex @: (0.0, 0.0, 0.0) [mm]
    pdg     name trkId parId  acId       KE  selfDepo   allDepo
                                       [MeV]    [MeV]     [MeV]
---------------------------------------------------------------
     22    gamma     0    -1     0     4.70      0.00      4.70
     11       e-     1     0     0     1.60      1.60      1.60
    -11       e+     2     0     0     2.08      2.08      3.10
     22    gamma     3     2     0     0.51      0.10      0.51
     22    gamma     4     2     0     0.51      0.08      0.51
     11       e-     5     4     0     0.01      0.01      0.01
     11       e-     6     4     0     0.26      0.26      0.26
     11       e-     7     4     0     0.09      0.09      0.09
     11       e-     8     4     0     0.05      0.05      0.05
     11       e-     9     4     0     0.03      0.03      0.03
```
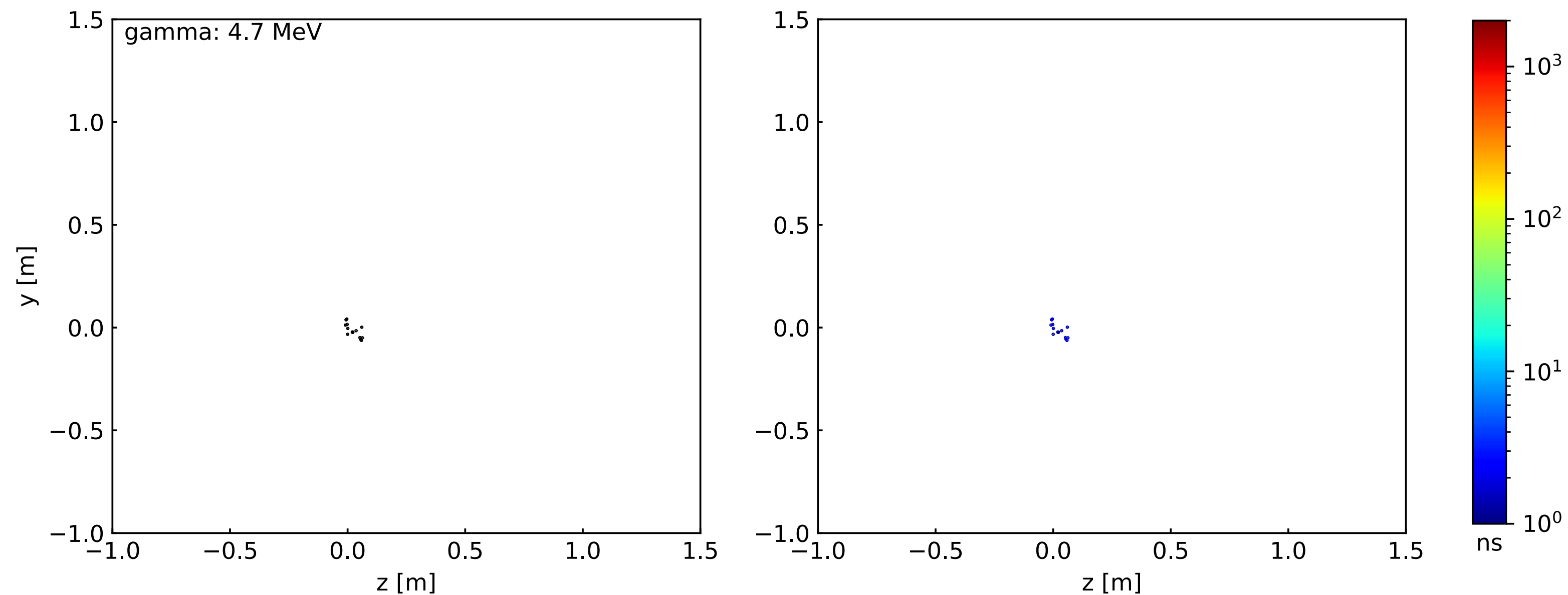

If happens on a XA, it should see all 4.7 MeV energy deposit
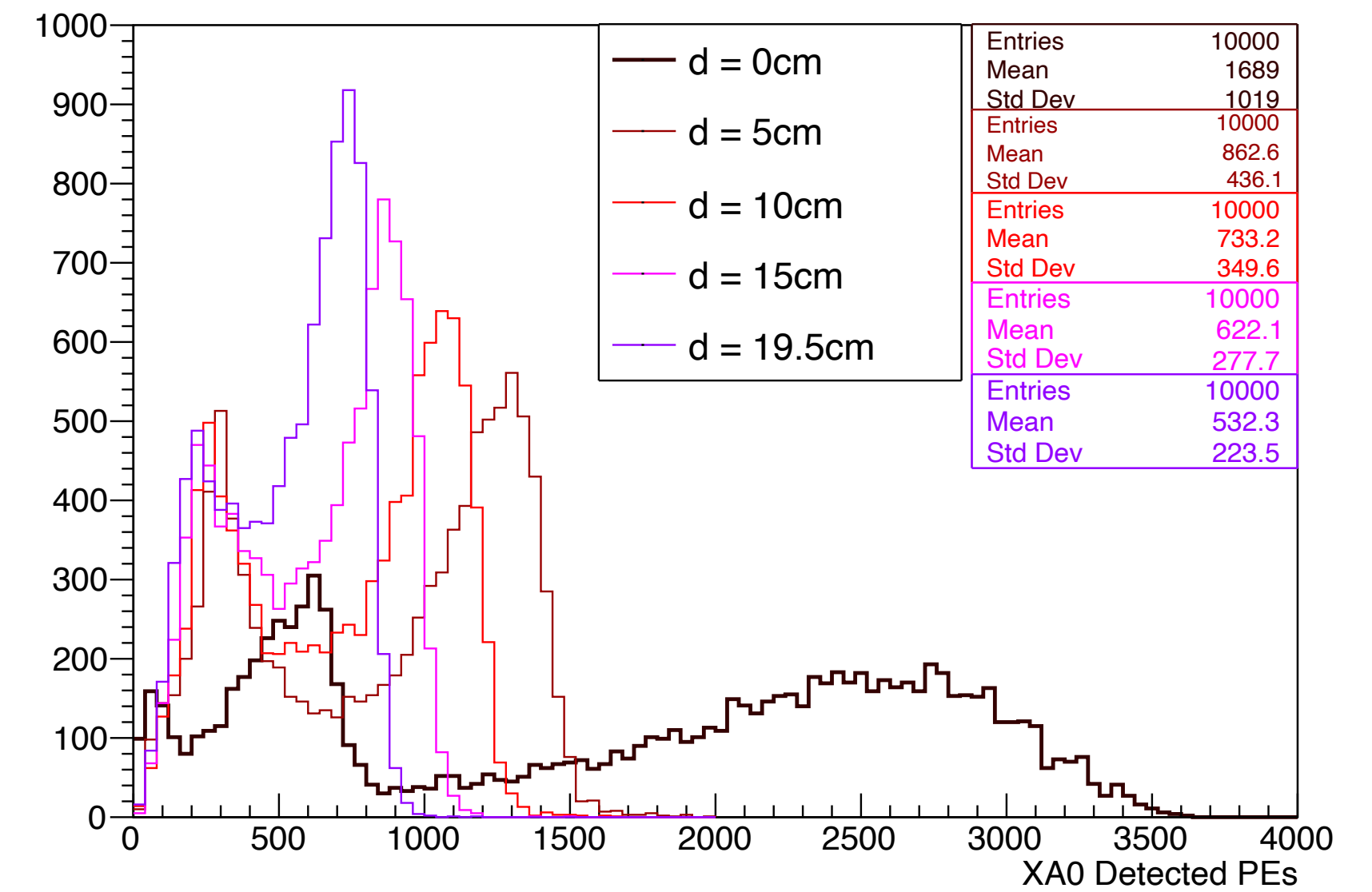**E deposit time scale is <10ns**

Detected photons timing in simulated 3 γ released at 10cm drift distance from XA

For each n-capture, PD signal happens within 10us
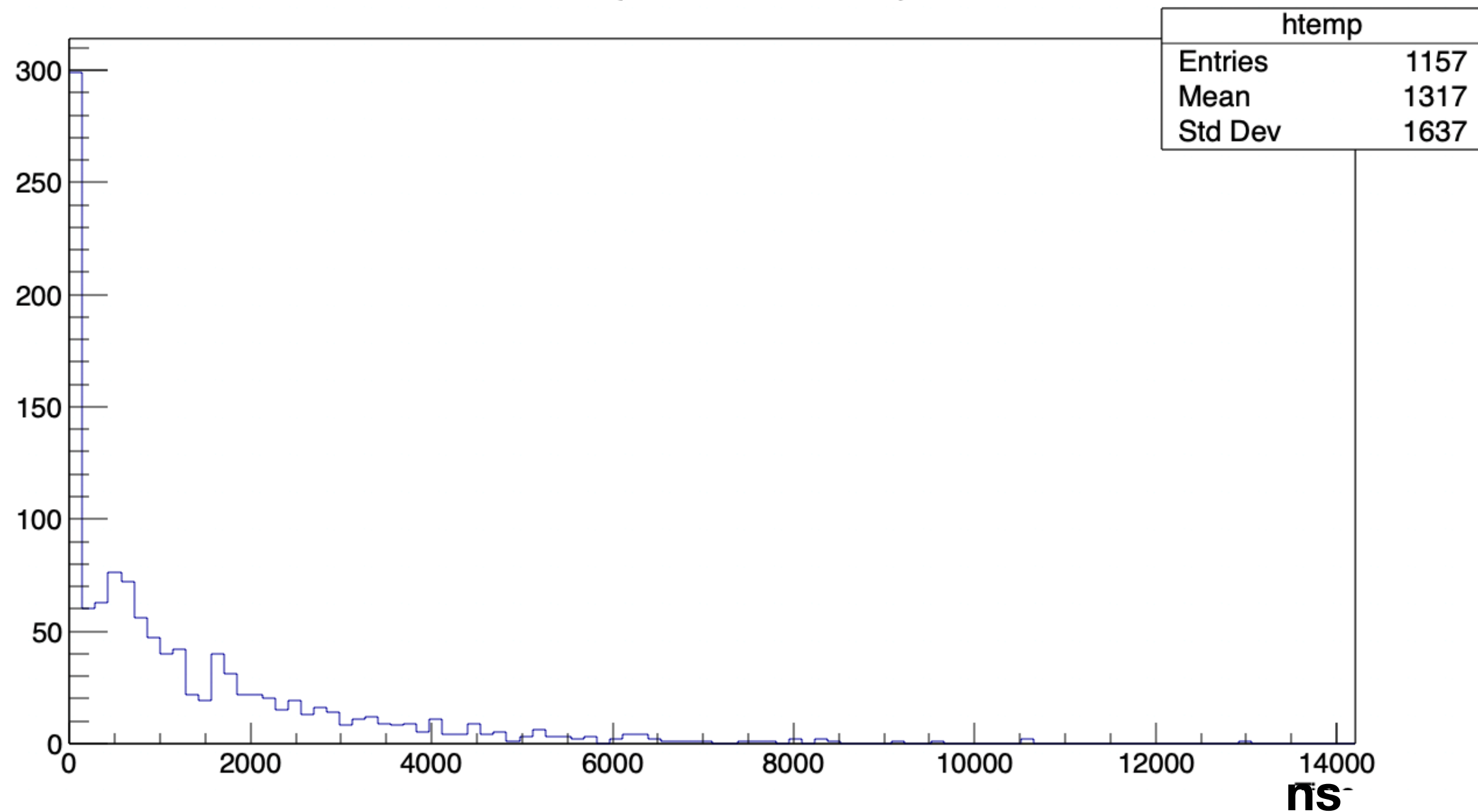*—> gamma release is prompt (ps?), gamma EM deposit time scale < 10ns*
—> 10us is primarily driven by the LAr slow component
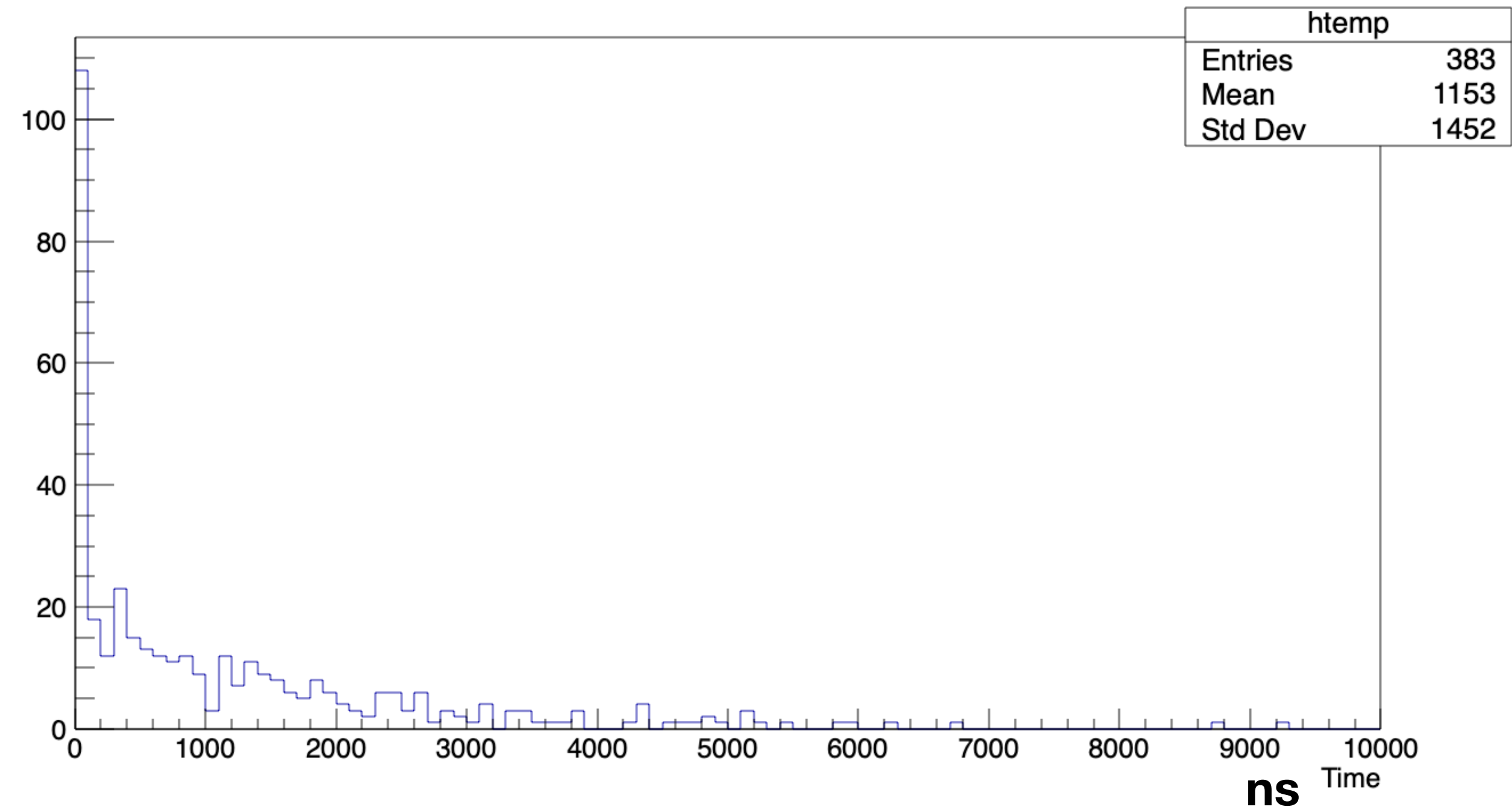
Based on this, define each n-cap signal has a large pd peak (>500PE) within a 10us window

	Entries	10000
	Mean	1689
	Std Dev	1019
	Entries	10000
	Mean	862.6
	Std Dev	436.1
	Entries	10000
	Mean	733.2
	Std Dev	349.6
	Entries	10000
	Mean	622.1
	Std Dev	277.7
	Entries	10000
	Mean	532.3
	Std Dev	223.5

d = 0cm
d = 5cm
d = 10cm
d = 15cm
d = 19.5cm

XA0 Detected PEs

Time {EventID == 100}

htemp	
Entries	1157
Mean	1317
Std Dev	1637

ns

Time {EventID == 1}

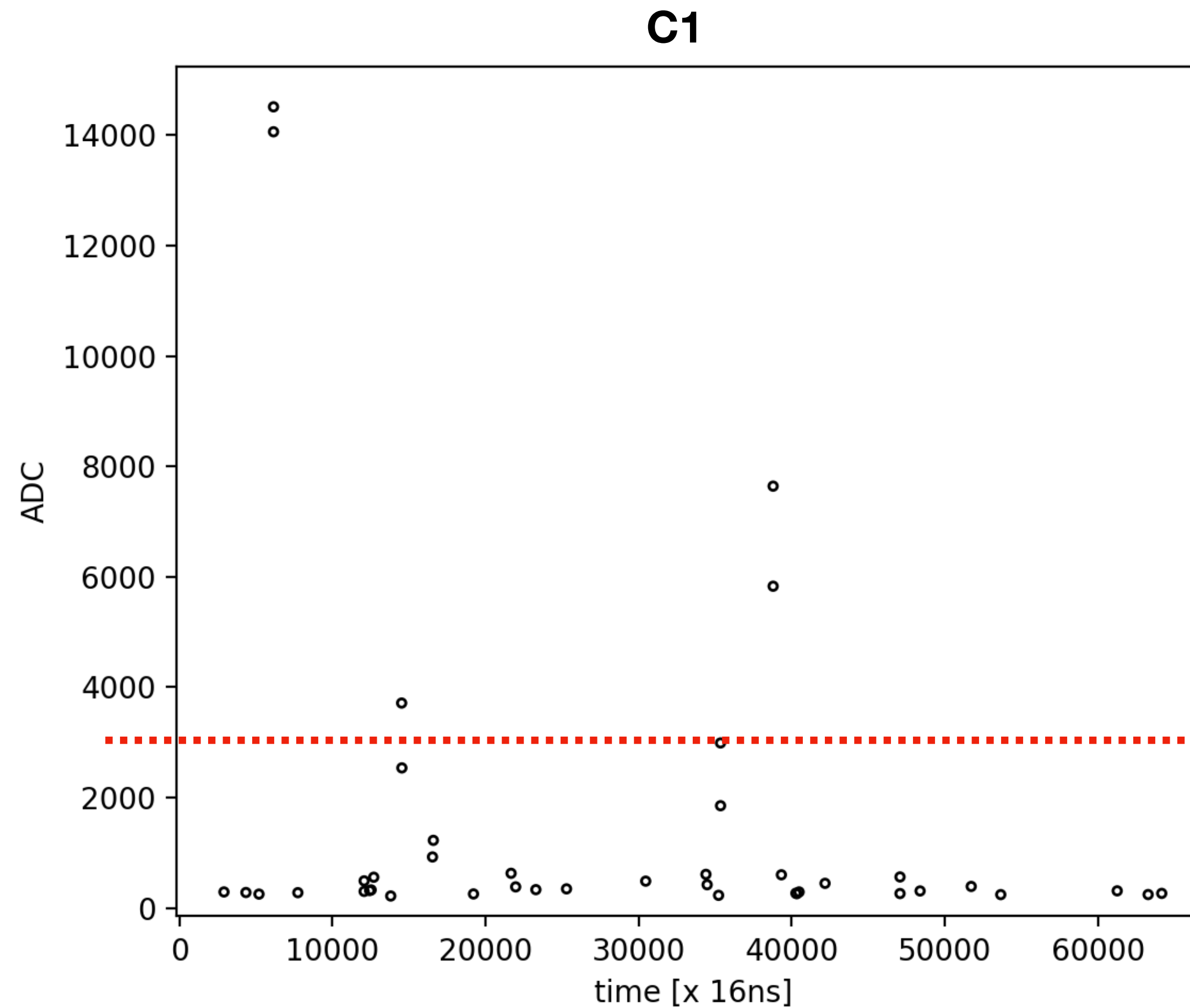| htemp	
Entries	383
Mean	1153
Std Dev	1452

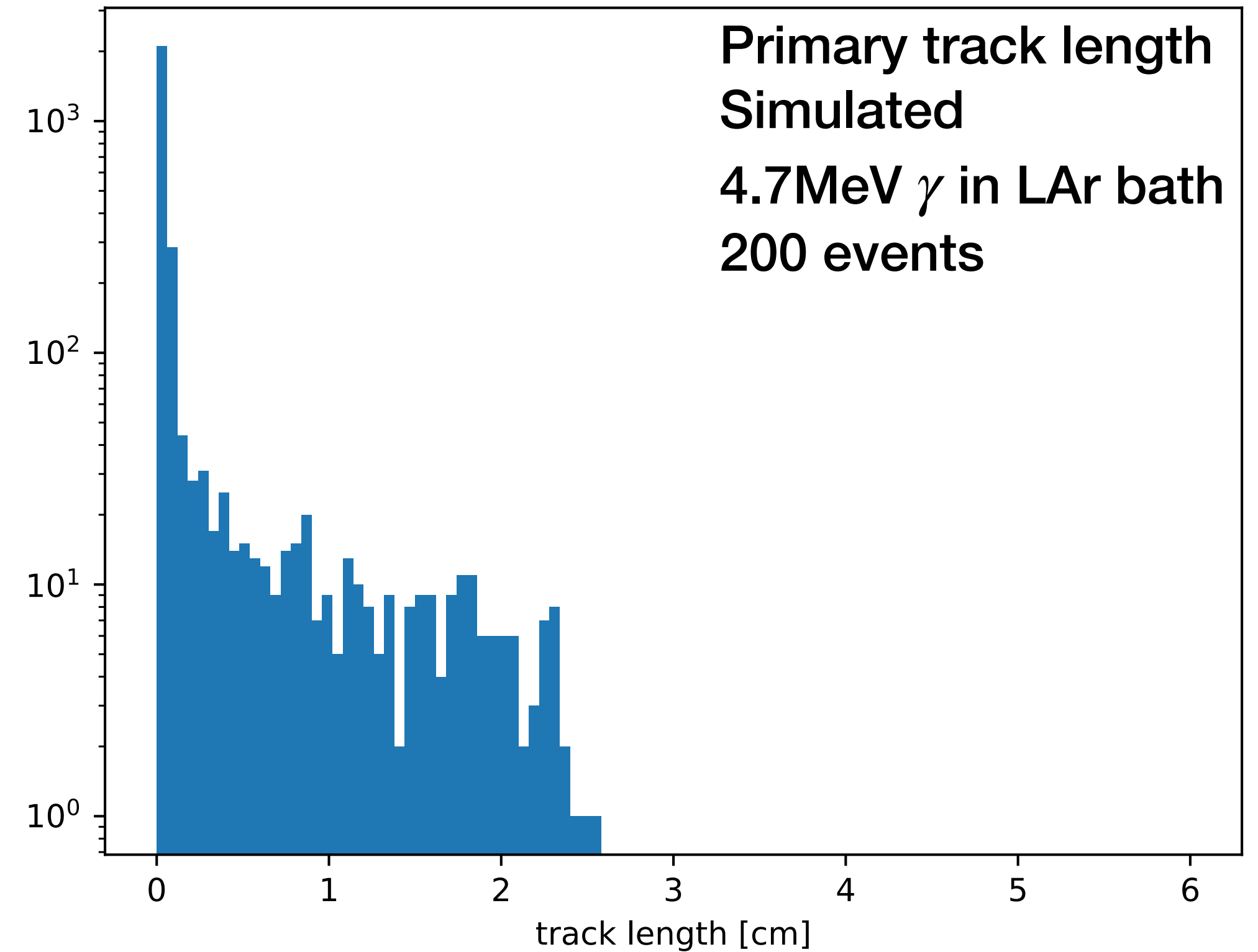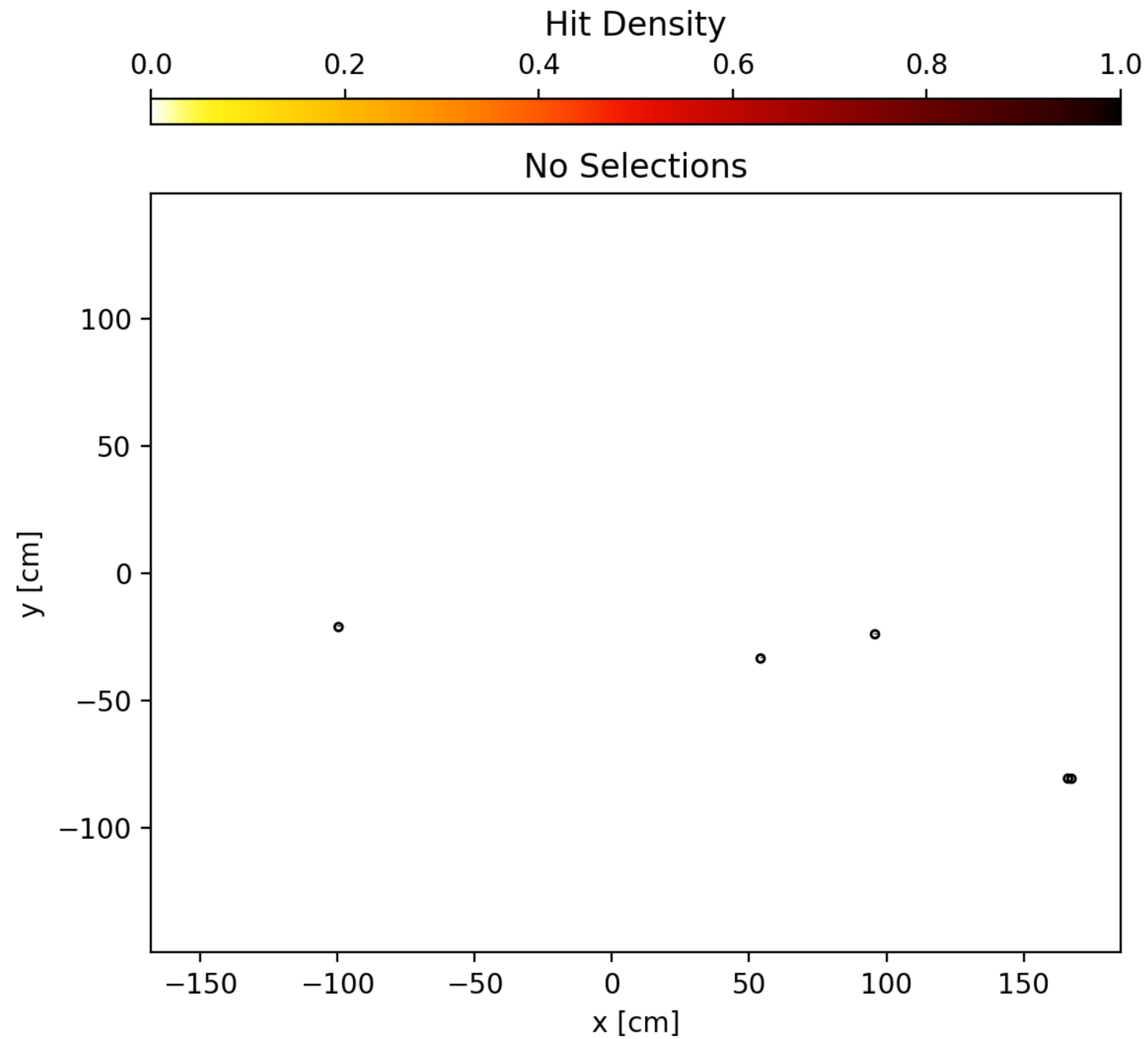ns Time

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Lardon: Single Event PD Peaks Example

Eyeball most events are like this:
Only 1-2 peaks above 3000 ADC/channel (where most useful PNS signals are expected)

C1

PNS Run 25068 - Apr18

Lardon: CRP Data - Event level Single Hits (tracks not plotted)

Hits not associated with 2D/3D/ghost track in default charge reconstruction
**(Could be further tuned for PNS signal)**

Event Selection/Matching

- **Implemented** (per trigger)
  - A large PD peak (total ADC >5000) on each cathode XA
    - Find pd peaks from **2 channels closest in time (*min_dt*), *min_dt* < 160ns** (10 ticks) - could be tuned
  - Each large PD peak has >=1 single hits in TPC *matched*
    - Single **hits** are those that are **not used in tracks** reconstruction (may need tuning in the future)
    - XA center **+/- 30cm** in x-y, time within **140us (one drift time)** of the PD peak
    - TPC single hit time: **tdc_max** on collection plane
    - Require collection Z plane hit time >= V induction plane hit time >= U induction plane hit time
  - Each large PD peak needs to separate from each other by at least **10us (i.e., +/-625 time ticks)**
    - If not, it's possible double/multiple captures, discard for the moment as it complicates ADC/PE calculation…
  - Matched TPC single hits are excluded in subsequent matching

- **Pending [to be understood, not yet implemented]**
  - *Exclude nearby hits of previously matched hits (define nearby)*
  - *Exclude hits nearby a track*
  - *Event size/voxel selection*
  - *Double/multiple n-captures*
  - *Cross check PD timing with TPC track timing using 3d tracks crossing anode*

Post TPC-matching PD Signal: total amplitude (ADC)

C1 tpc-matched pdpeaks: 5020
C2 tpc-matched pdpeaks: 149
C3 tpc-matched pdpeaks: 524
C4 tpc-matched pdpeaks: 4960

Before match   **After match**   **Before match**   **After match**
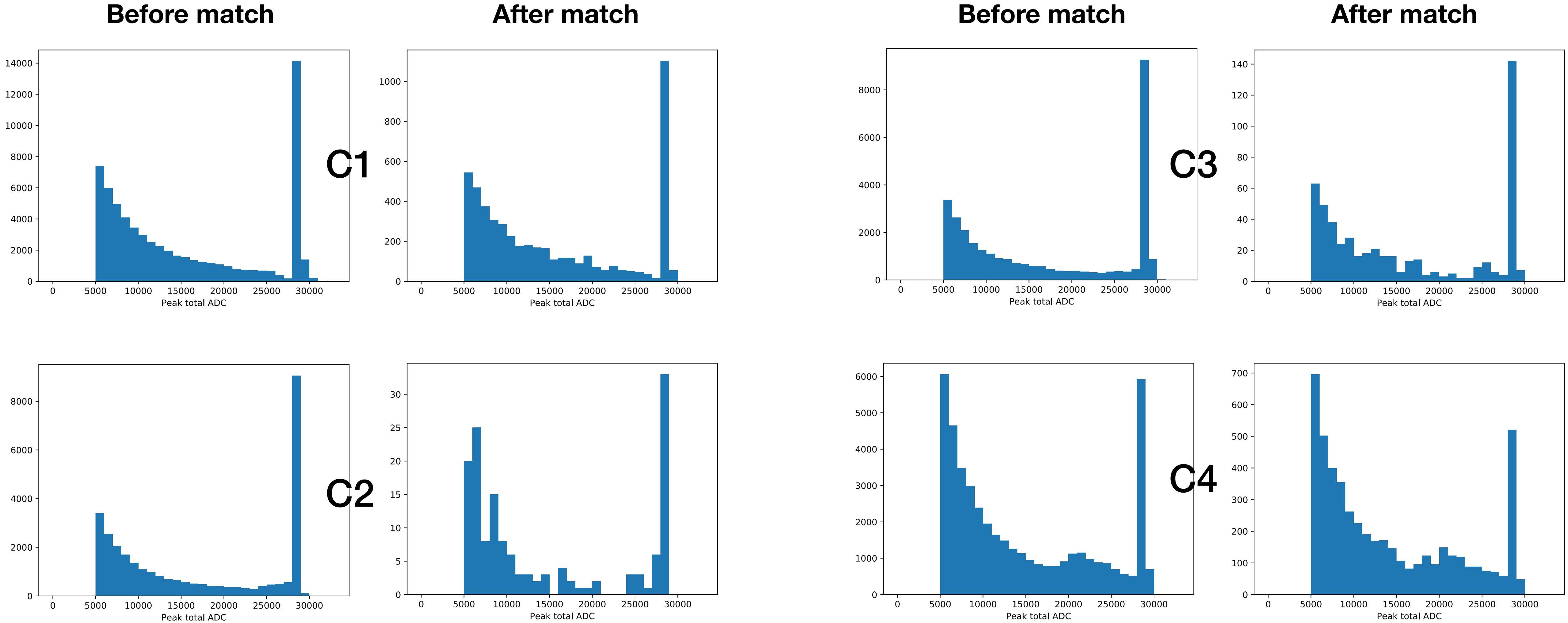
All make sense, but not helpful for calibration
—> need to apply voxel selection, improve matching, understand CRP + PD reco
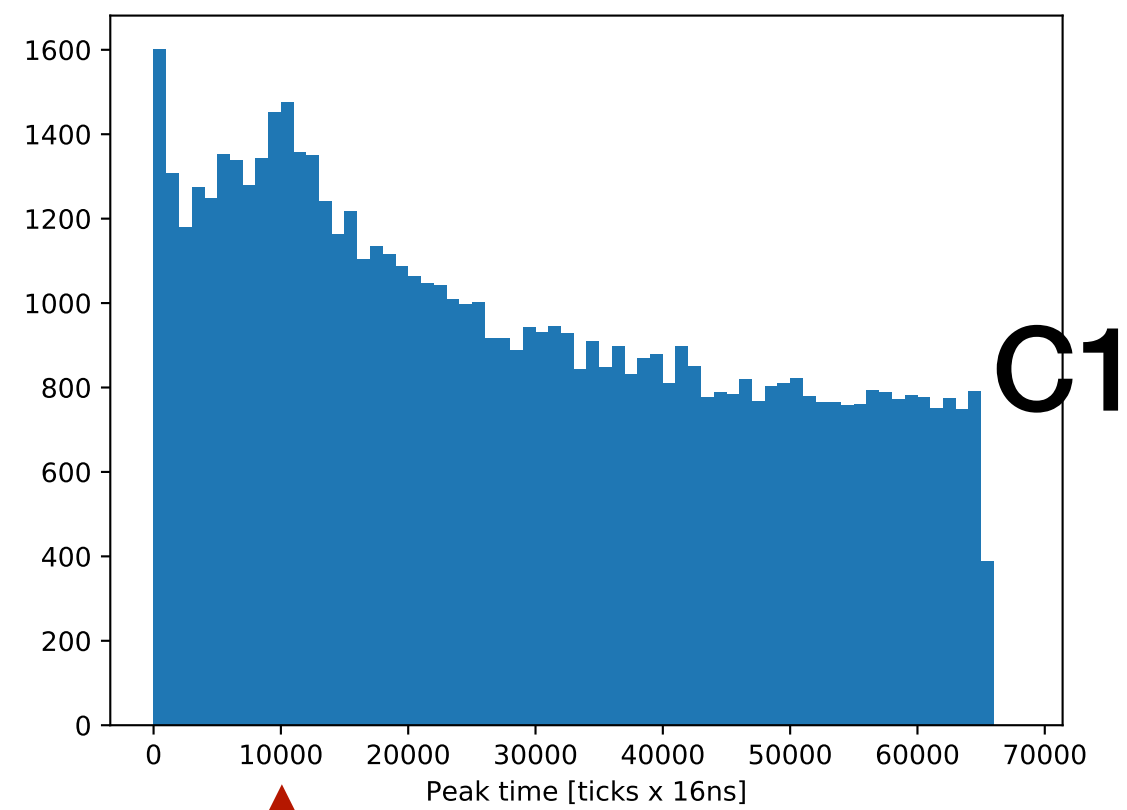**—> compare with cosmic run.**
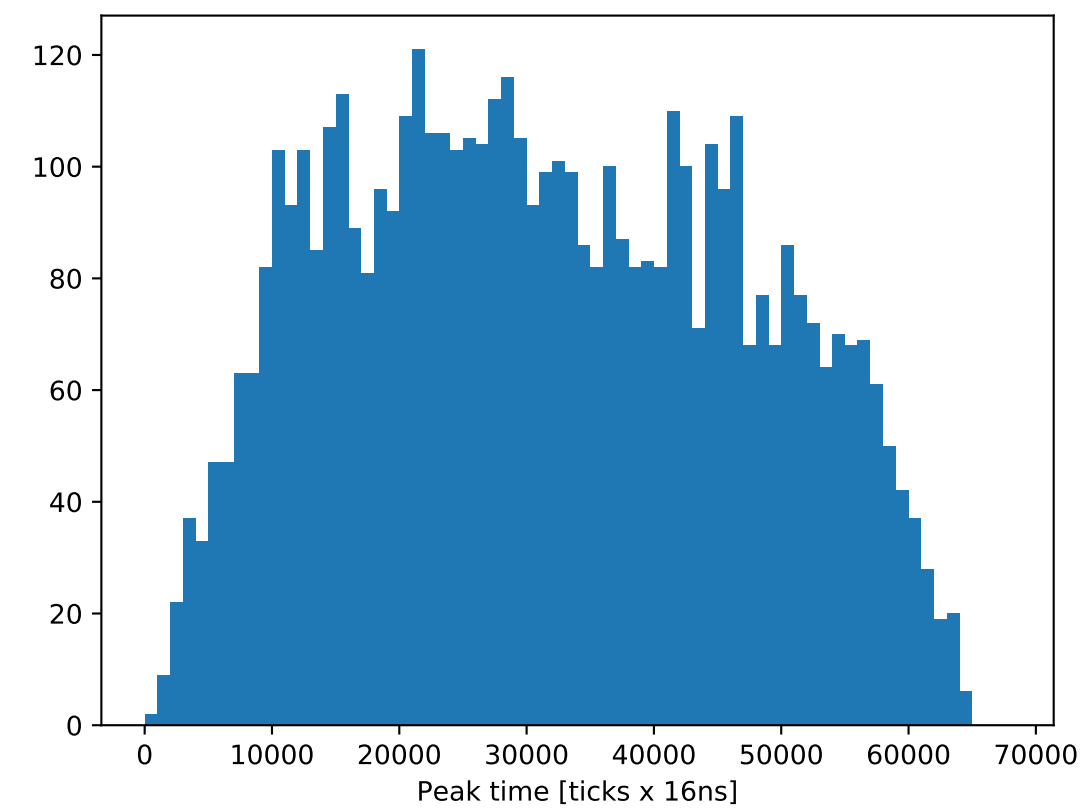
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Post TPC-matching PD Signal: peak time

```
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```
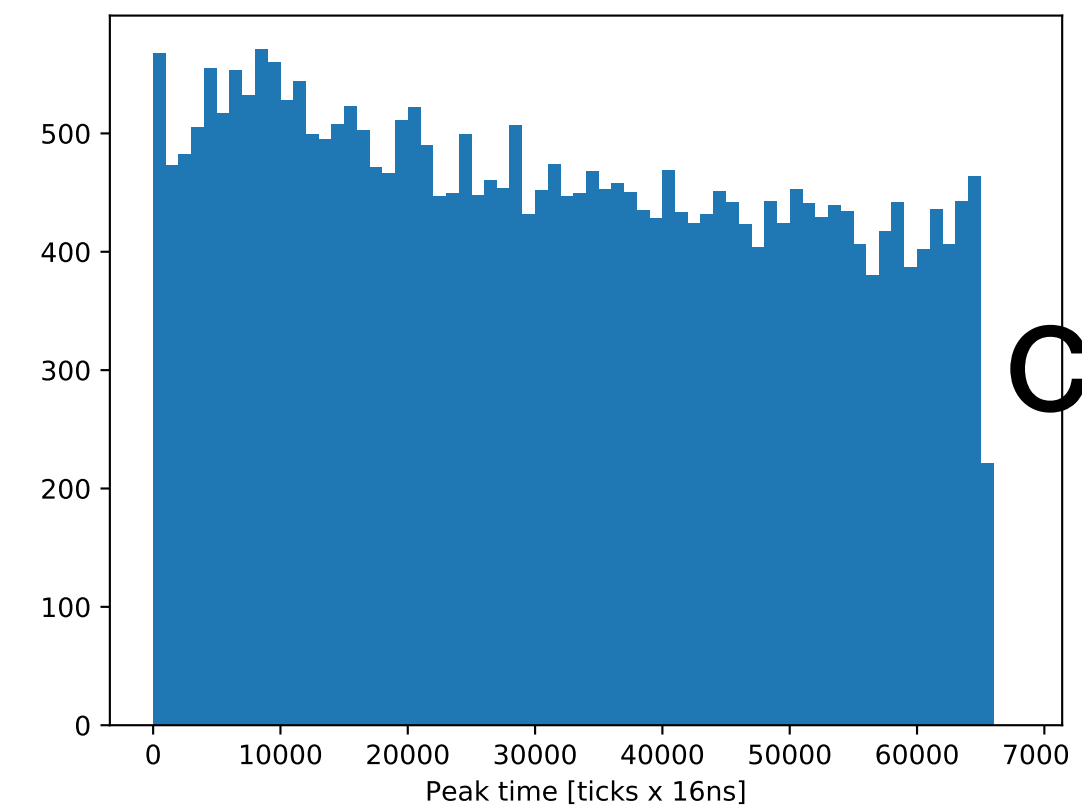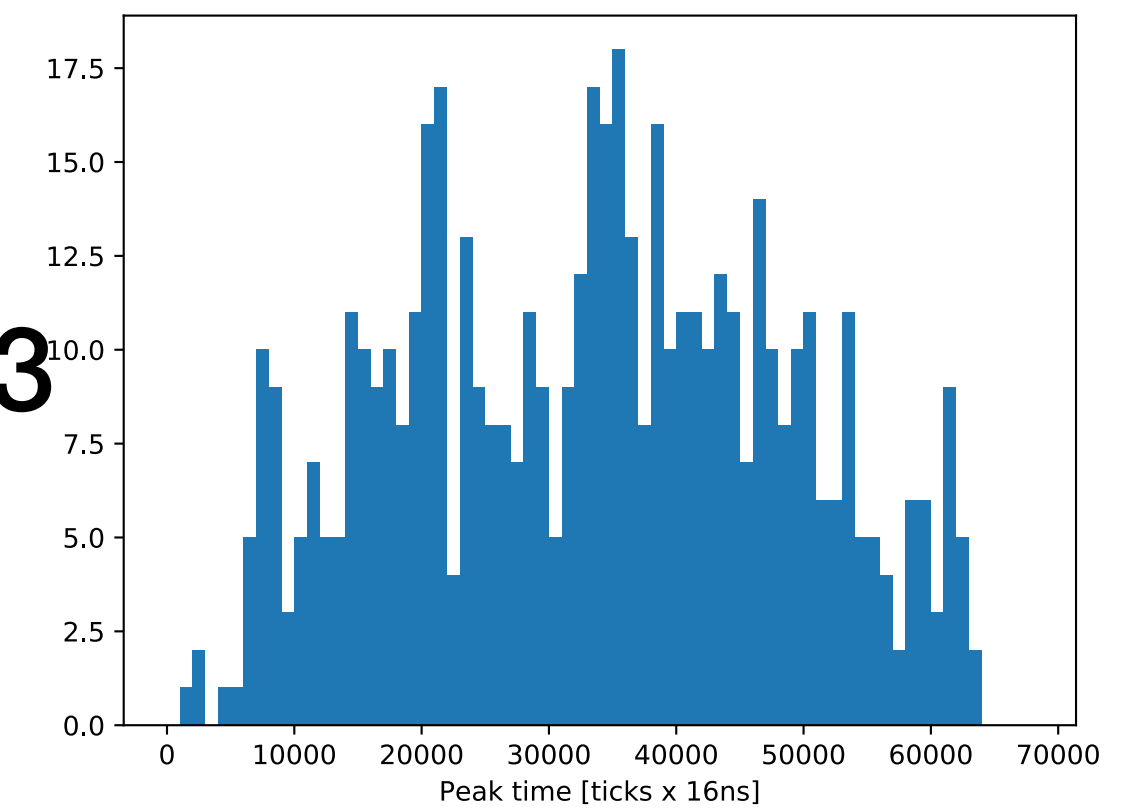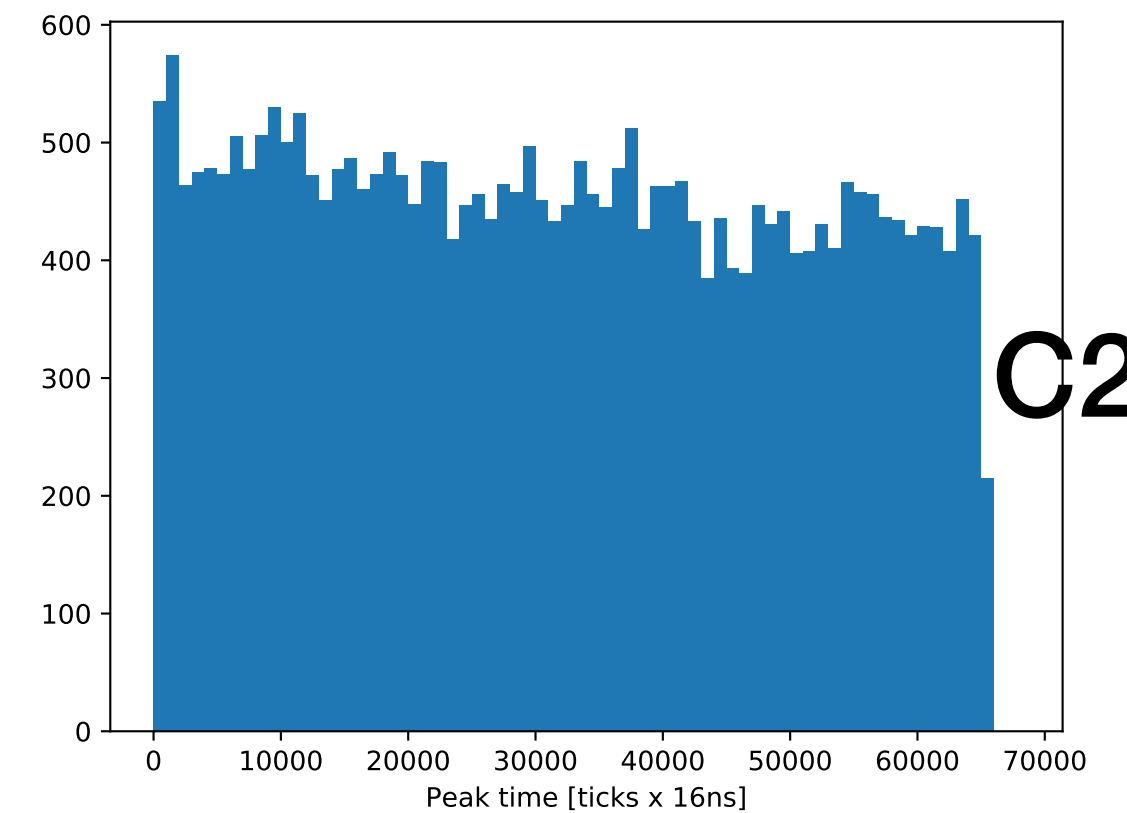
Peak timing

Capture statistics from simulation:
1 capture/evt

20cm x 20cm x 20cm voxel: Scale down by 9
10cm x 20cm x 20cm voxel: Scale down by 18
10cm x 10cm x 10cm voxel: Scale down by 72
2cm x 20cm x 20cm voxel: Scale down by 90
1cm x 20cm x 20cm voxel: Scale down by 180
If we want 10x10x10cm^3 voxel,
would be nice if we can get 6M stats (CRP+PDS)

Full 20cm drift in x:
20cm x 60cm x 60cm voxel

XA0: 708.5/9901
XA1: 344/9901
XA2: 311/9901
XA3: 229.5/9901

XA0: 18k/250k
XA1: 8k/250k
XA2: 7.5k/250k
XA3: 5.8k/250k

h_YZX_xy	
Entries	9901
Mean x	183.6
Mean y	−7.788
Std Dev x	82.94
Std Dev y	95.73

Plot axes: Y (cm) vs Z (cm), labeled regions XA0, XA1, XA2, XA3.
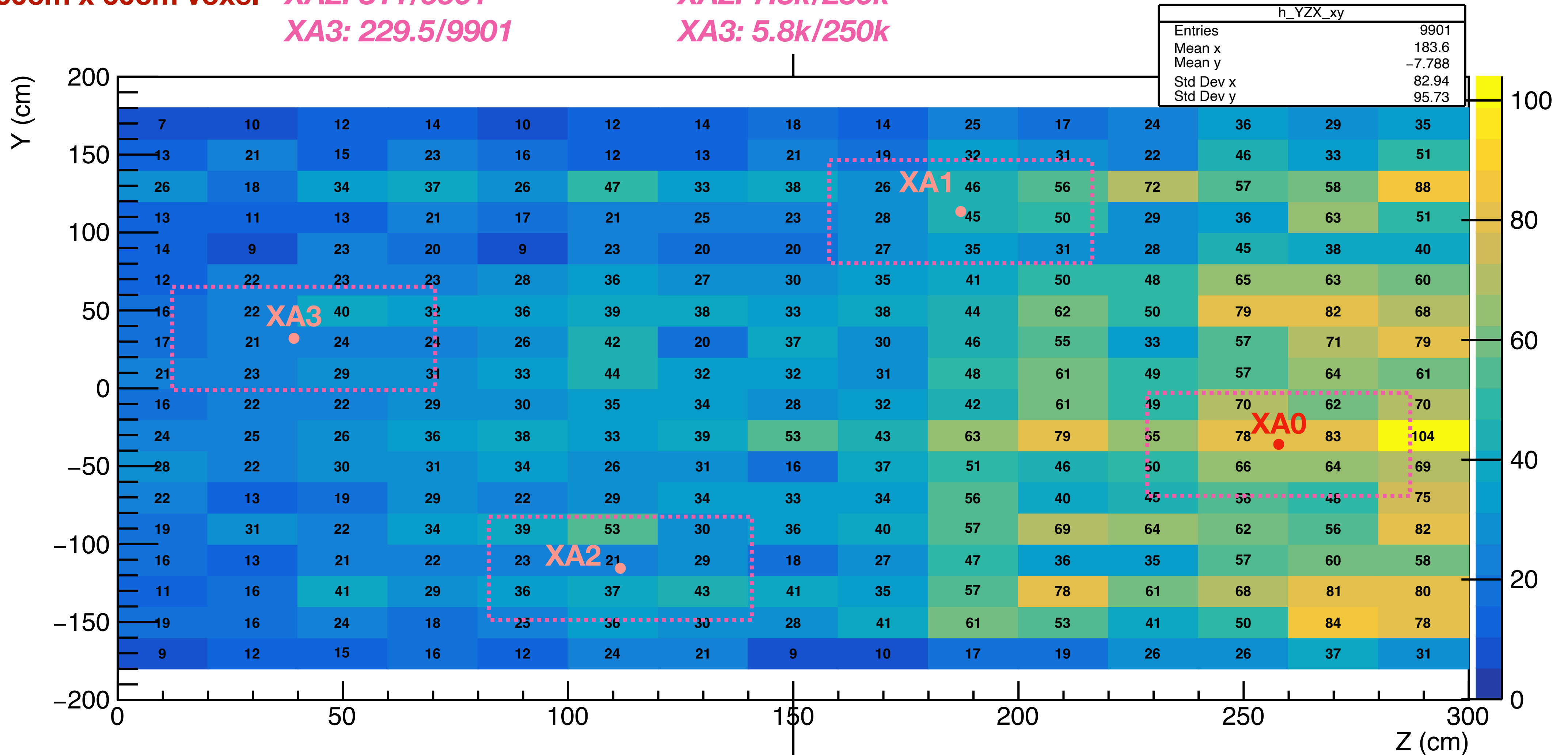
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```
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```

DATA: 5k tpc-matched pd peaks from ~50k events

Roughly match Sim stats