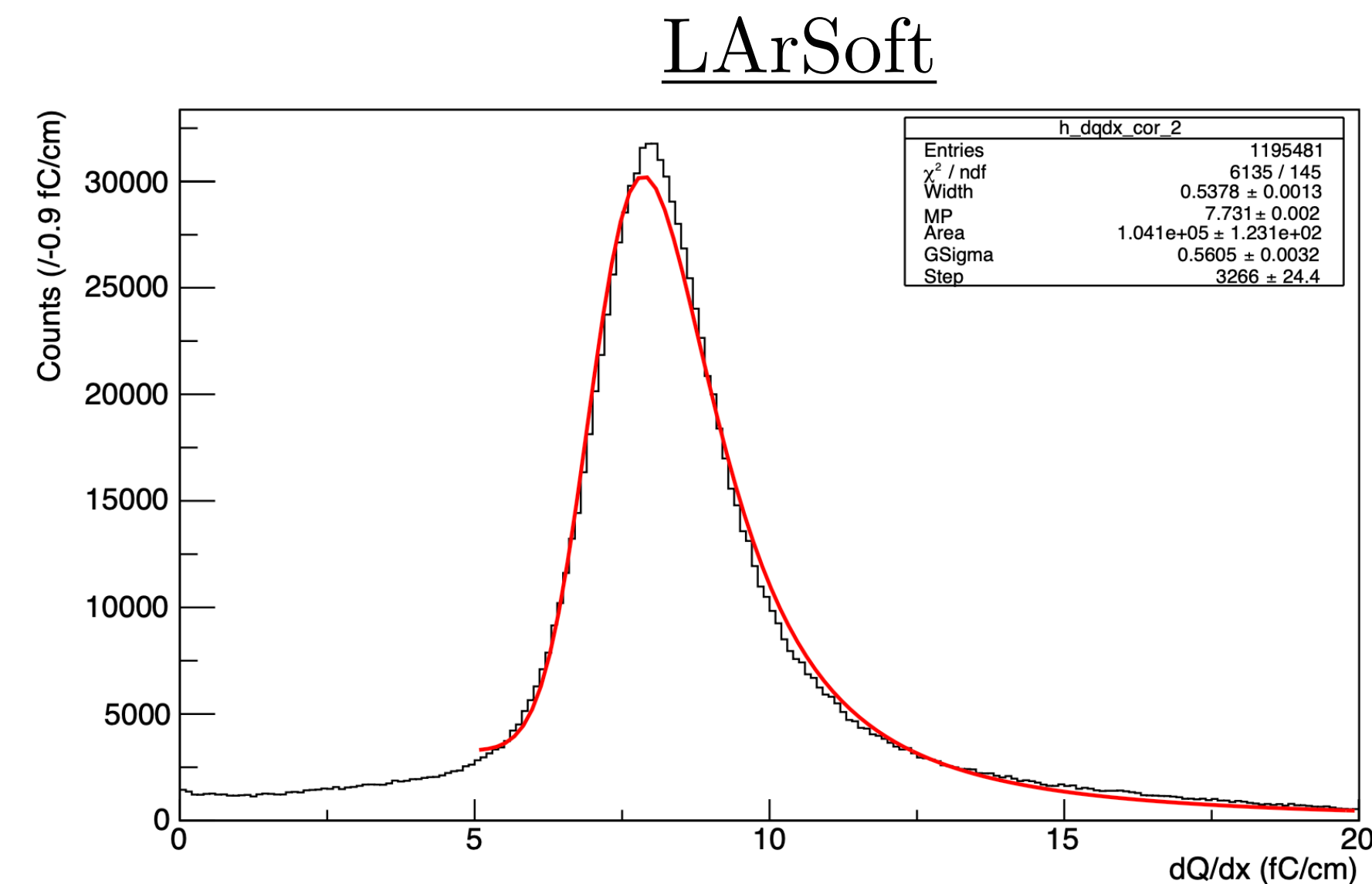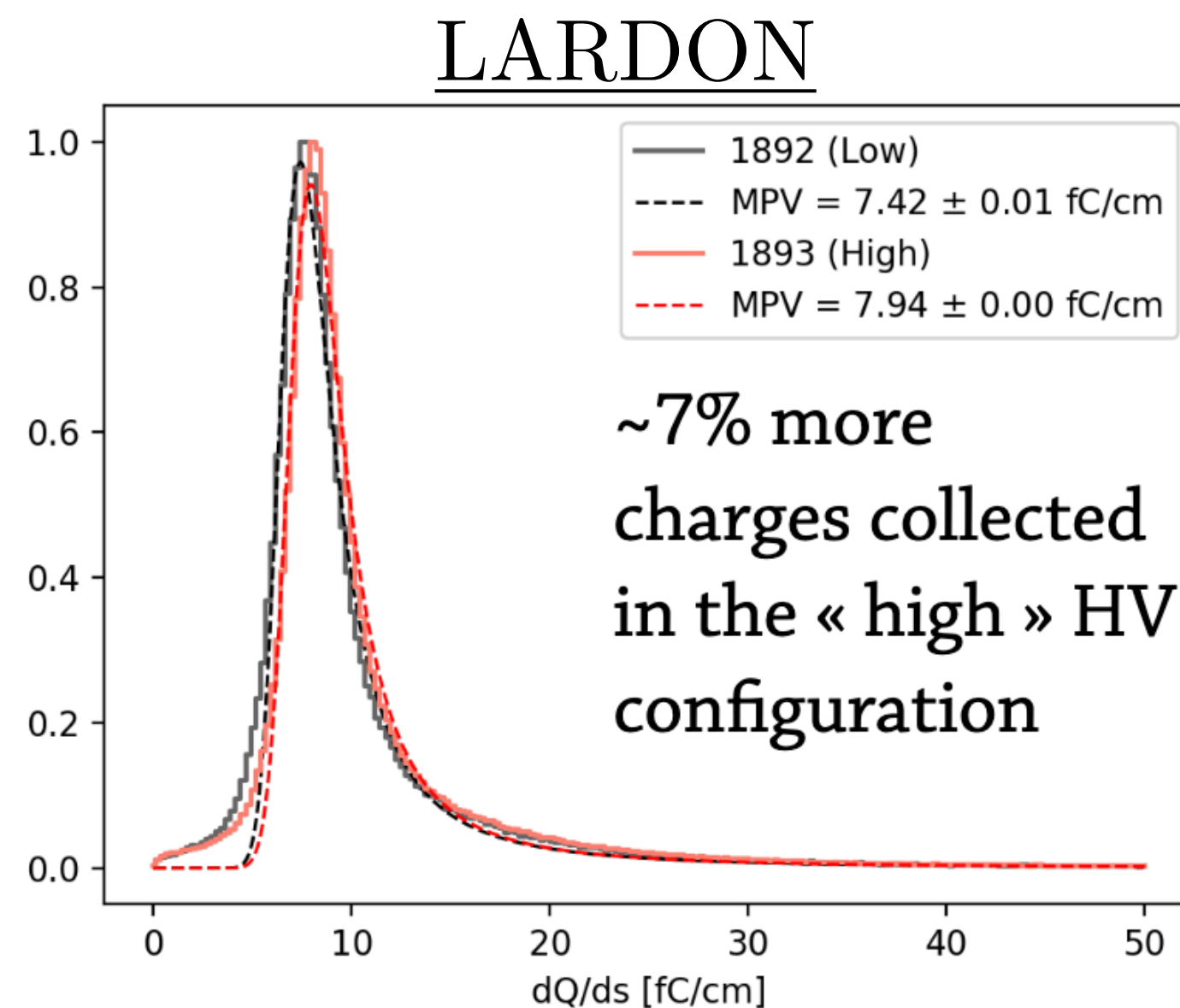# Calorimetry in the coldbox-VD with LArSoft

Leïla Haegel / *IP2I Lyon*

Analysis

○ **Look at calorimetry information of going-through muons in the coldbox-VD (CB-VD):**

- Performed by LARDON (by Laura Zambelli)
- Checked with LArSoft with hand-written calorimetry module (by Yoann Kermaïdic)
- This work: reproducing with LArSoft GnocchiCalorimetry module

Inputs

- **Data**

  - Using run 1727
    (recorded in October 2022)

  - Cosmic ray tracks

  - CRP3 installed

- **Event**

  - defined by $t_\sqcap = 4\ ms$ read-out window

  - x-coordinate: $x_c\ =\ t_c\ v_{drift}$
    with $v_{drift} = 1.6\ mm/\mu s$

- **Selection of through-going tracks**

  - track starts inside of coldbox in y and z

  - track x-length is between $[0.95\ L_x,\ 1.0\ L_x]$


```
FD2-VD COLDBOX
[units in cm]
```
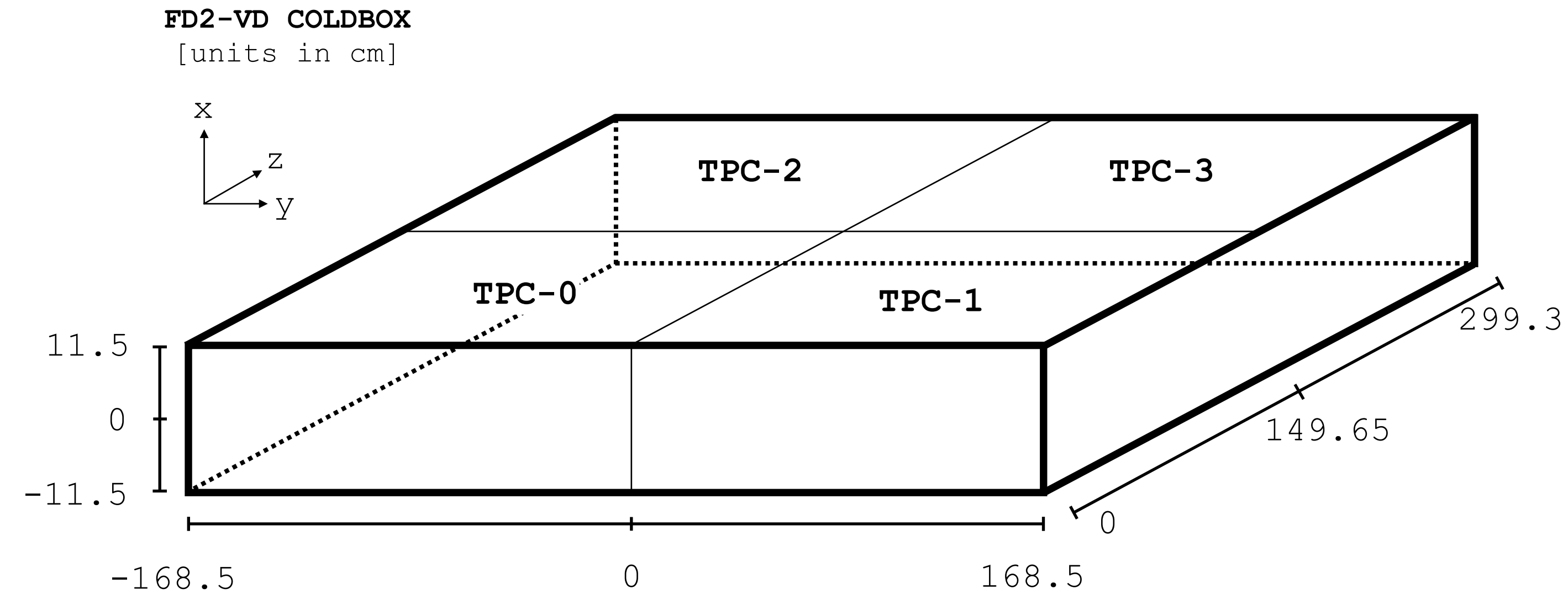
```
ON DUNEGPVM:

▸  INPUT:
   /pnfs/dune/tape_backed/dunepro/vd-coldbox-top/raw/2022/detector/study/None/
   00/00/17/27/1727_100_b_cb.test

▸  MODULE:
   /exp/dune/app/users/lhaegel/larsoft/v09_82_02d01/srcs/protoduneana/
   protoduneana/verticaldrift/checks/ColdboxThroughGoingTracks_module.cc
```

Study the impact of the hit ROI

○ **Hit finder:**

- The reconstruction finds hits above a certain threshold on the noise-filtered, deconvoluted signal
- The threshold defines a Region Of Interest (ROI) to look for hits
- For the top electronics, it is defined by:

```
$ less crpcb_top_process.fcl
...
crp2_july22_prod_config.gaushit.HitFinderToolVec.CandidateHitsPlane0.RoiThreshold: 1.0
crp2_july22_prod_config.gaushit.HitFinderToolVec.CandidateHitsPlane1.RoiThreshold: 1.0
crp2_july22_prod_config.gaushit.HitFinderToolVec.CandidateHitsPlane2.RoiThreshold: 1.0
```

- What is the impact of the hit candidate ROI level on calorimetric information?

Reconstruction options

- **(1) Official reconstructed files:**
  - DUNE software v09_72_00d00
  - Uses CandidateHitsPlane[0,1,2].RoiThreshold = 1

  Those are the files listed on the wiki

- **(2) My reconstructed files (low threshold)**
  - DUNE software v09_90_01d00
  - Uses CandidateHitsPlane[0,1,2].RoiThreshold = 1

  Newer version

- **(3) My reconstructed files (high threshold)**
  - DUNE software v09_90_01d00
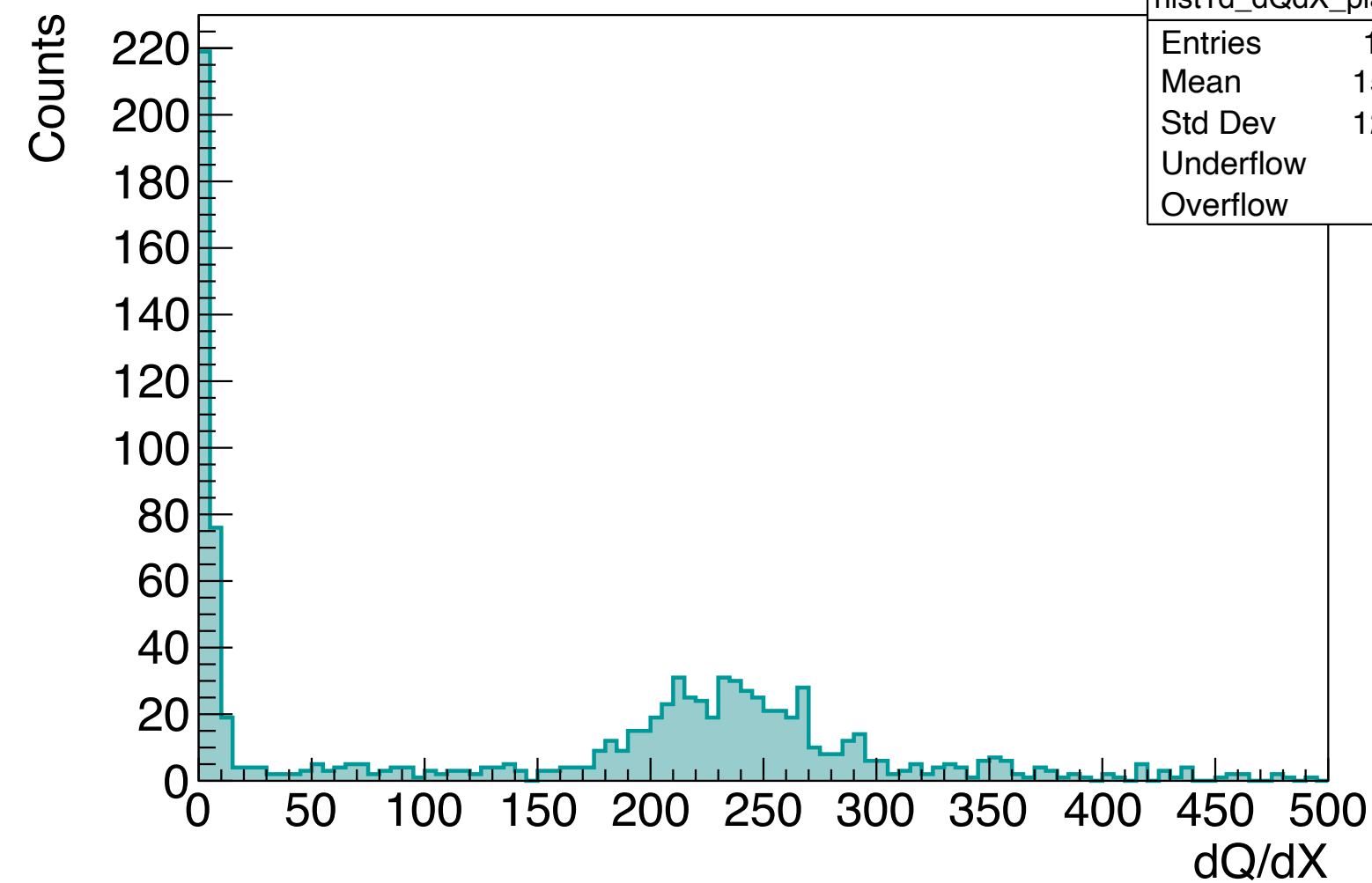 - Uses CandidateHitsPlane[0,1,2].RoiThreshold = 5

dQ/dX from GnocchiCalorimetry

○ **dQ/dX in collection plane**

- Through-going tracks selected in 25 events

- Low ROI threshold leads to peak at very low dQ/dX

- Study shows that it is present for all selected tracks, not a subset of pathological ones
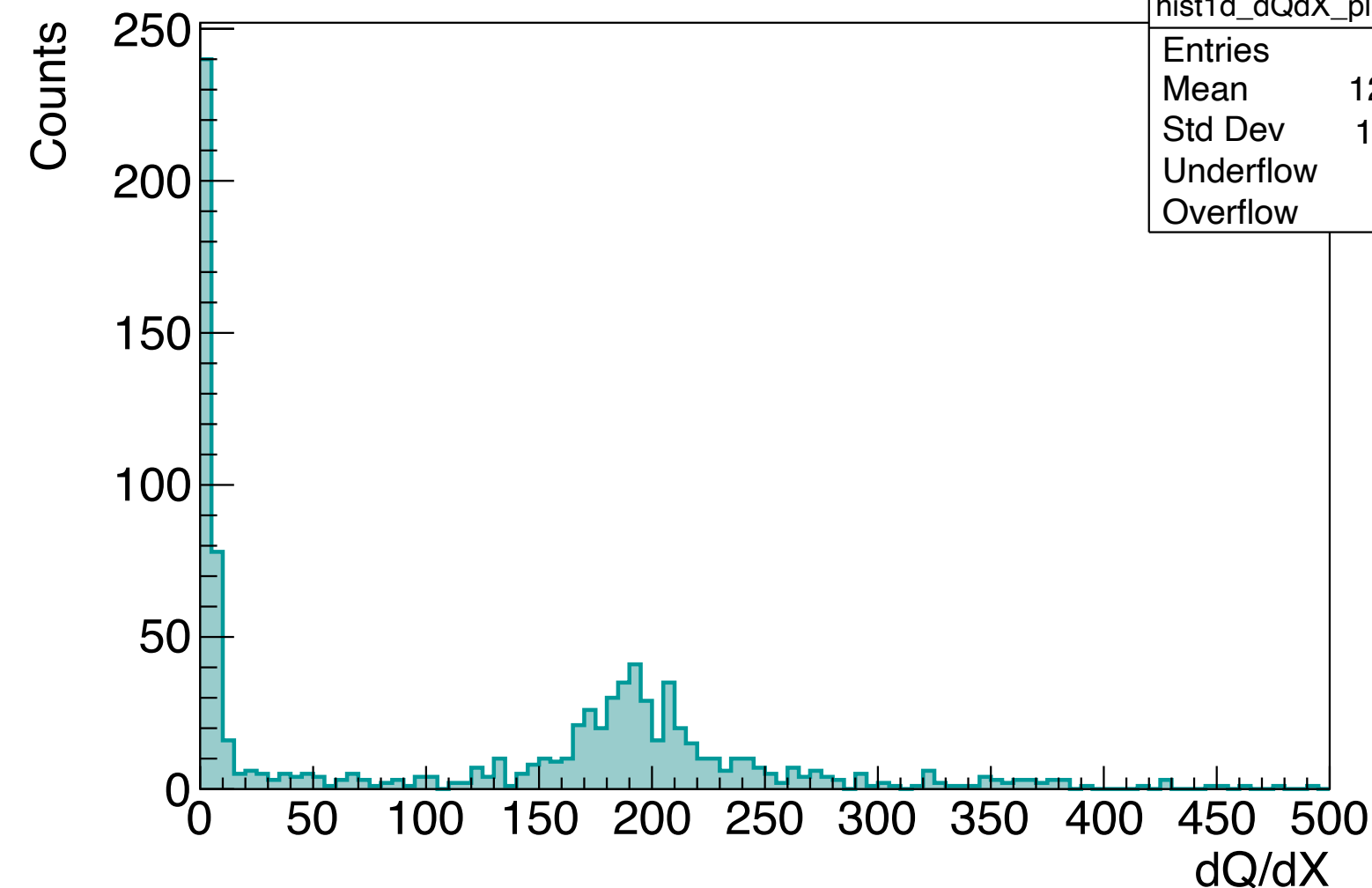
Number of hits

	v09_72_00d00 **Hit candidate RoI Threshold = 1**	**v09_90_01d00** **Hit candidate RoI Threshold = 1**	**v09_90_01d00** **Hit candidate RoI Threshold = 5**
event 23766	hits in event: 2390 hits associated to tracks: 1825	hits in event: 1374 hits associated to tracks: 839	hits in event: 698 hits associated to tracks: 560
event 23770	hits in event: 1536 hits associated to tracks: 910	hits in event: 1072 hits associated to tracks: 592	hits in event: 468 hits associated to tracks: 399
event 23774	hits in event: 873 hits associated to tracks: 482	hits in event: 759 hits associated to tracks: 361	hits in event: 267 hits associated to tracks: 193
event 23778	hits in event: 12258 hits associated to tracks: 1164	hits in event: 1182 hits associated to tracks: 833	hits in event: 492 hits associated to tracks: 365
event 23782	hits in event: 1828 hits associated to tracks: 1539	hits in event: 1152 hits associated to tracks: 736	hits in event: 505 hits associated to tracks: 406

Number of through-going tracks

	v09_72_00d00 **Hit candidate RoI Threshold = 1**	v09_90_01d00 **Hit candidate RoI Threshold = 1**	v09_90_01d00 **Hit candidate RoI Threshold = 5**
event 23766	total number of tracks: 15 through going: track 0 (368 hits) track 3 (227 hits)	total number of tracks: 24 through going: track 0 (144 hits) track 1 (109 hits) track 3 (92 hits)	total number of tracks: 15 through going: track 2 (82 hits)
event 23770	total number of tracks: 9 through going: -	total number of tracks: 14 through going: -	total number of tracks: 9 through going: track 0 (124 hits)
event 23774	total number of tracks: 9 through going: -	total number of tracks: 8 through going: -	total number of tracks: 6 through going: -
event 23778	total number of tracks: 9 through going: track 0 (269 hits) track 1 (229 hits)	total number of tracks: 17 through going: track 2 (165 hits)	total number of tracks: 10 through going: track 0 (98 hits) track 1 (80 hits)
event 23782	total number of tracks: 13 through going: track 3 (271 hits)	total number of tracks: 20 through going: -	total number of tracks: 12 through going: -

FHiCL-dump differences (for hit options)

- `crp2_july22_prod_config: {` **v09_90_01d00**
```
...

  gaushit: {
    LongMaxHits: [1,1,1]
    LongPulseWidth: [16,16,16] }
...

  pandoraShower: {
    ShowerFinderTools: {
      CalorimetryAlg: {
        CalAreaConstants: [5.346e-3,
                           5.339e-3,
                           5.292e-3] }
    }
    UseAllParticles: true}
}
...

  pandoraTrack: {
    UseAllParticles: true }
...

wclsdatanfsp: {
  configs: [
    "pgrapher/experiment/dunevd-crp2/
     wcls-sp.jsonnet"
    ]
}
```

- `crp2_july22_prod_config: {` **v09_72_00d00**
```
...

  gaushit: {
    LongMaxHits: [25,25,25]
    LongPulseWidth: [10,10,10] }
...

  pandoraShower: {
    ShowerFinderTools: {
      CalorimetryAlg: {
        CalAreaConstants: [5.129e-3,
                           5.189e-3,
                           5.029e-3] }
      }
    UseAllParticles: false}
}
...

  pandoraTrack: {
    UseAllParticles: false }
...

wclsdatanfsp: {
  configs: [
    "pgrapher/experiment/dunevd-crp2/
     wcls-nf-sp.jsonnet"
    ]
}
```

FHiCL files of interest

v09_90_01d00

- crp2_july22_prod_config: {
  ...

  gaushit: {
    LongMaxHits: [1,1,1]
    LongPulseWidth: [16,16,16]
  }
  ...

}
```
/cvmfs/larsoft.opensciencegrid.org/products/
larreco/v09_25_00/job/hitfindermodules.fcl
```

```
  wclsdatanfsp: {
    configs: [
      "pgrapher/experiment/dunevd-crp2/
       wcls-sp.jsonnet"
      ]
  }
```
/cvmfs/dune.opensciencegrid.org/products/dune/
dunereco/v09_90_01d00/fcl/wirecell_dune.fcl

Differences between WireCell options

v09_90_01d00

```
${WIRECELL_PATH}/pgrapher/experiment/
dunevd-crp2/wcls-sp.jsonnet
```

v09_72_00d00

```
${WIRECELL_PATH}/pgrapher/experiment/
dunevd-crp2/wcls-nf-sp.jsonnet
```

```
// The output of signal processing.  Note, there are two signal
// sets each created with its own filter.  The "gauss" one is best
// for charge reconstruction, the "wiener" is best for S/N
// separation.  Both are used in downstream WC code.
```

```
sp_signals: g.pnode({
  type: 'wclsFrameSaver',
  name: 'spsaver',
  data: {
    // anode: wc.tn(tools.anode),
    anode: wc.tn(mega_anode),
    digitize: false,
    frame_tags: ['gauss', 'wiener'],
    frame_scale: [0.005, 0.005],
    summary_tags: ['threshold'],
    summary_operator: {'threshold': 'set'},
    // nticks: params.daq.nticks,
    chanmaskmaps: [],
    nticks: -1,
  },
}, nin=1, nout=1, uses=[mega_anode]),
};
```

```
sp_signals: g.pnode({
  type: 'wclsFrameSaver',
  name: 'spsaver',
  data: {
    // anode: wc.tn(tools.anode),
    anode: wc.tn(mega_anode),
    digitize: false,
    frame_tags: ['gauss', 'wiener'],
    frame_scale: [0.005, 0.005],



    // nticks: params.daq.nticks,
    chanmaskmaps: [],
    nticks: -1,
  },
}, nin=1, nout=1, uses=[mega_anode]),
};
```

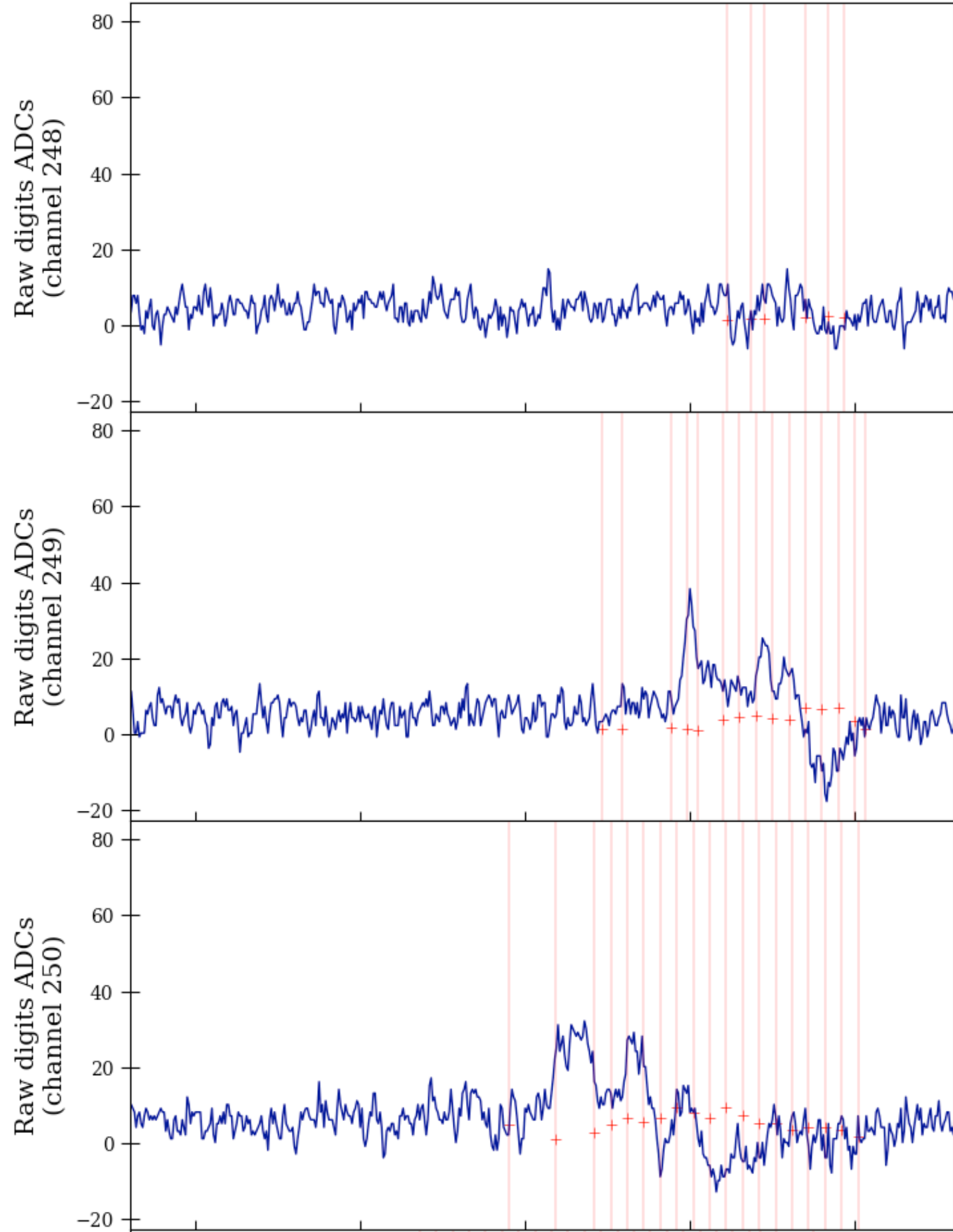# Track hits waveforms: collection planes

○ **Track hit time:** `recob::hit -> PeakTime()`

  • track hits distributed in [4612, 5006] ADC ticks

    • induction plane 1: [4629, 5006]

    • induction plane 2: [4921, 4998]

    • collection plane: [4612, 4999]

○ **Track hit amplitude:** `recob::hit -> PeakAmplitude()`

  • track hits distributed in [0.56, 17.96] ADC units

    • induction plane 1: [0.6, 11.9]

    • induction plane 2: [0.6, 4.8]
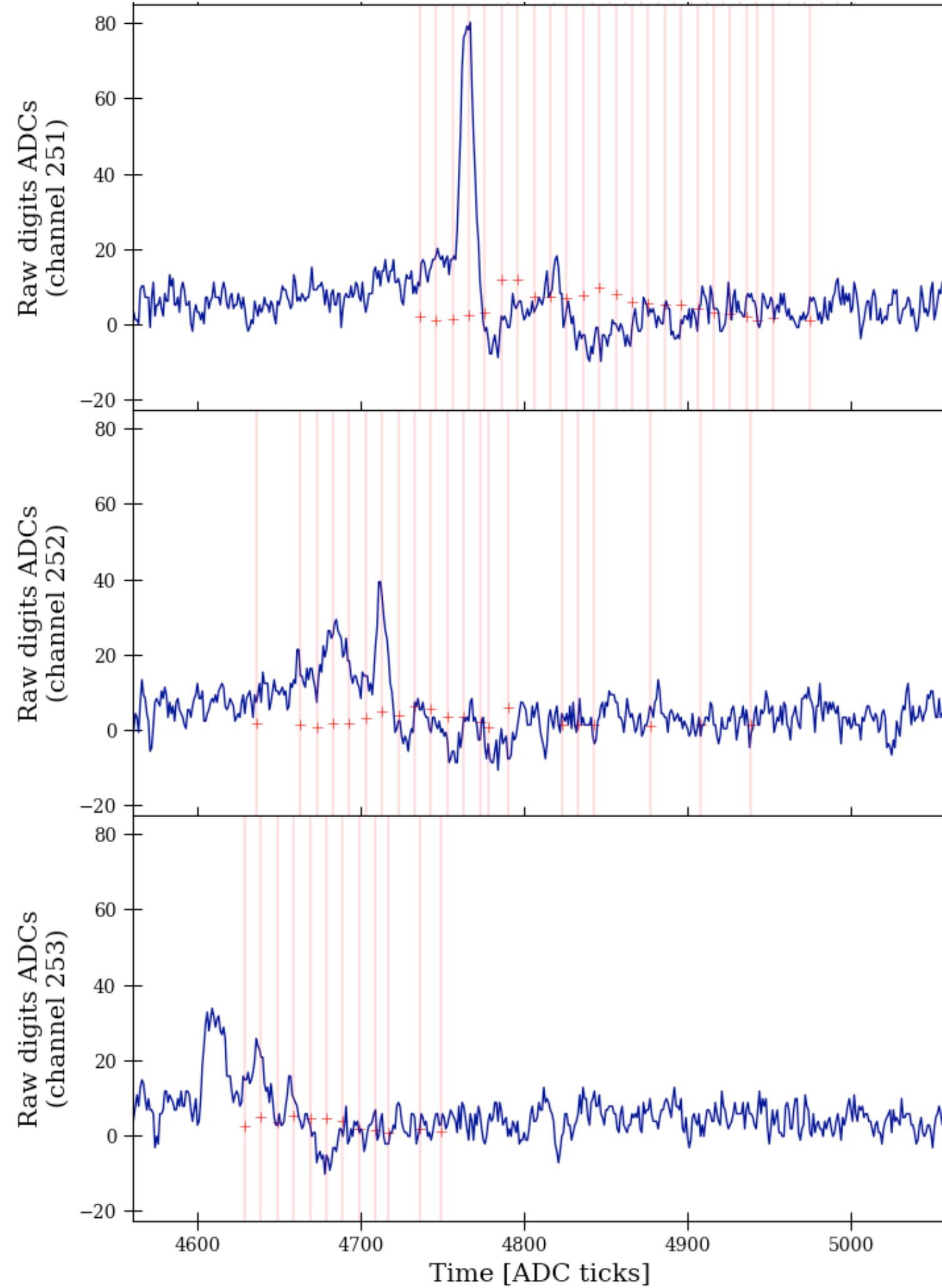
    • collection plane: [1.2, 17.9]
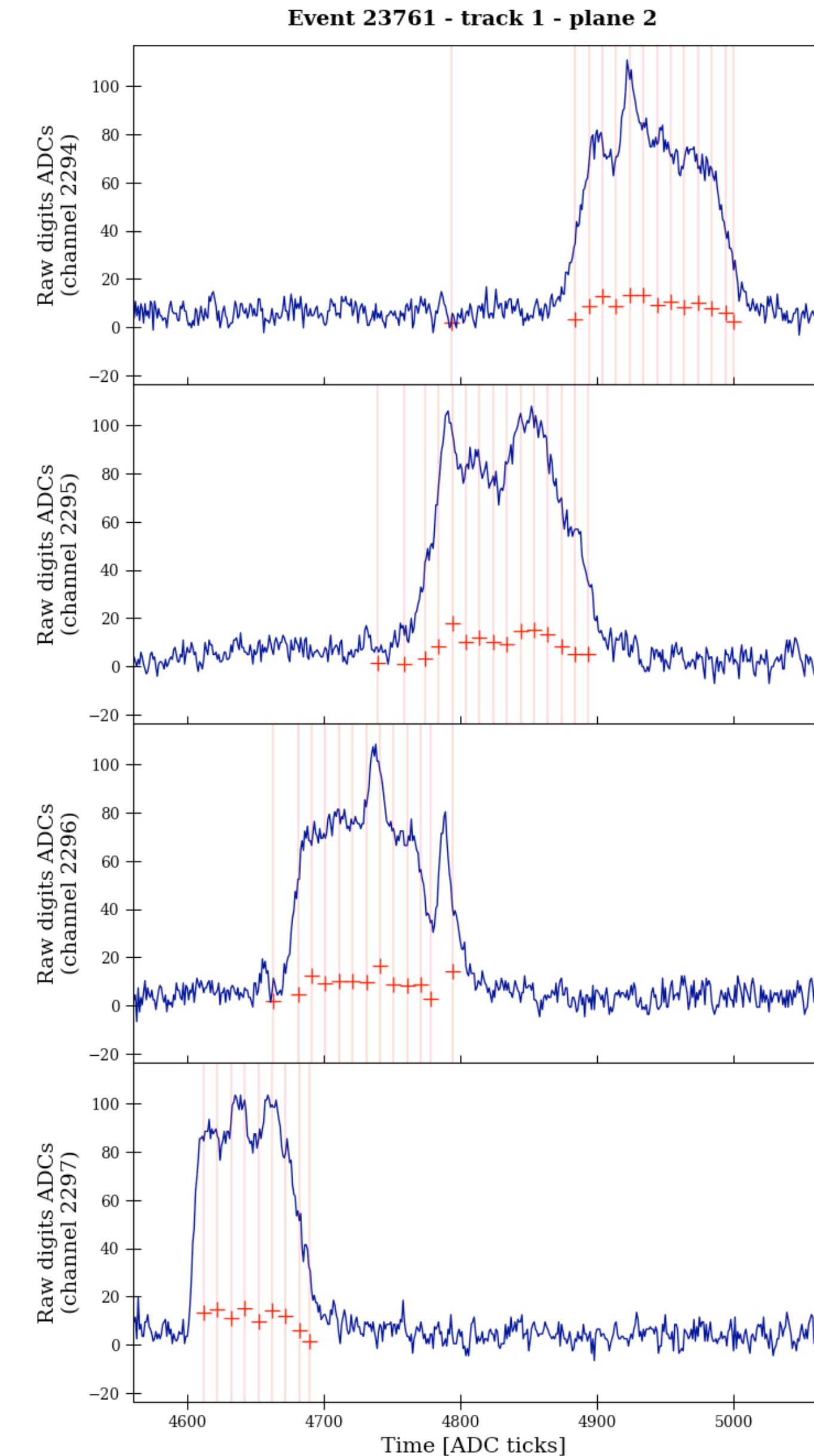
Event 23761 - track 1 - plane 2
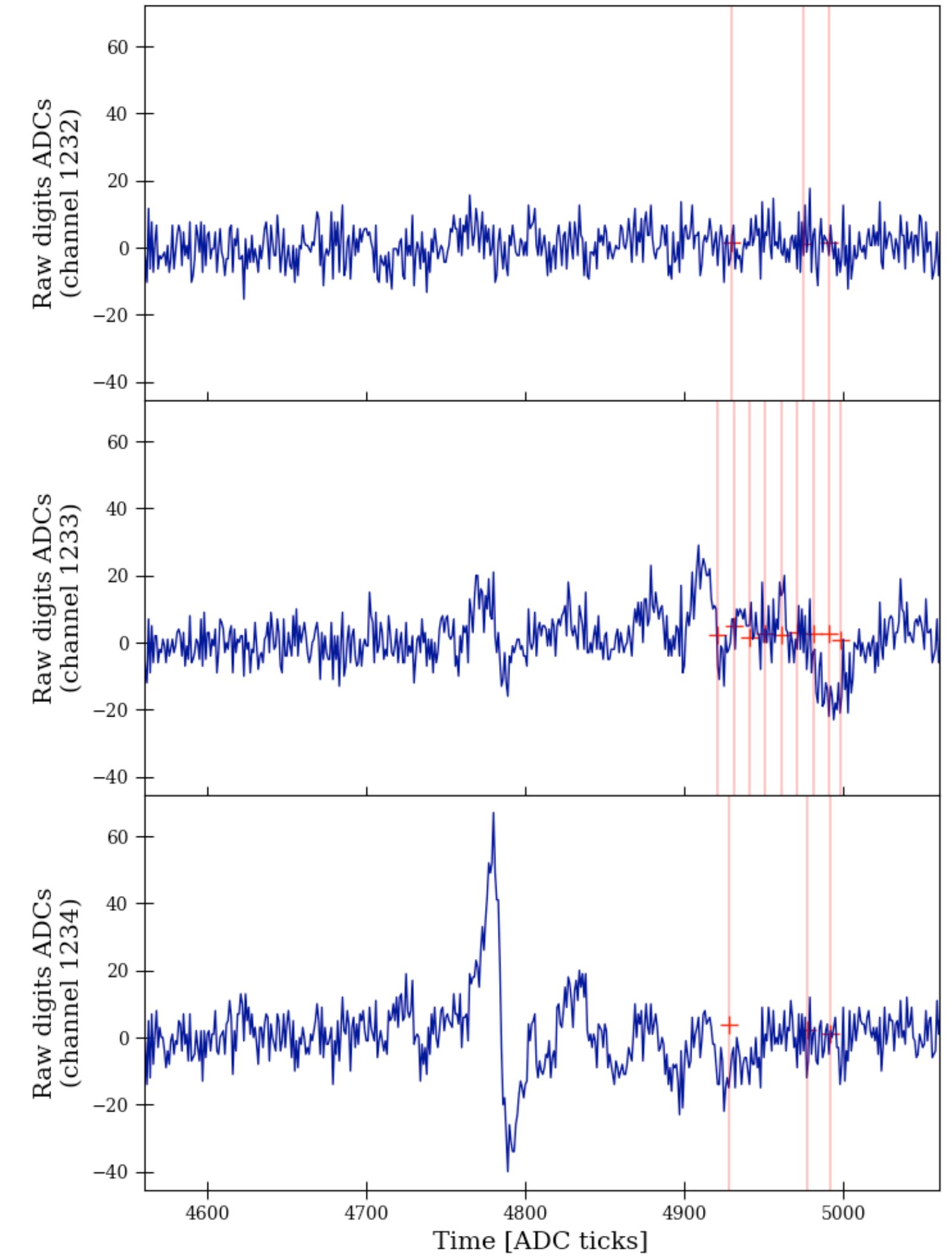
Next steps

○ **Reconstruction:**

- Set gaushit, pandoraTrack, wcls values to v09_72_00d00 to study their impact

- Look at the deconvoluted, filtered signal & hit finder output with different ROI threshold to see if noise is picked up

- Run on all run to see if GnocchiCalorimetry reproduces the LARDON results

This work was done with the help of Y. Kermaïdic, D. Autiero, S. Galymov, E. Pennacchio