First data quality check of 3x1x1 using LArSoft and QScan

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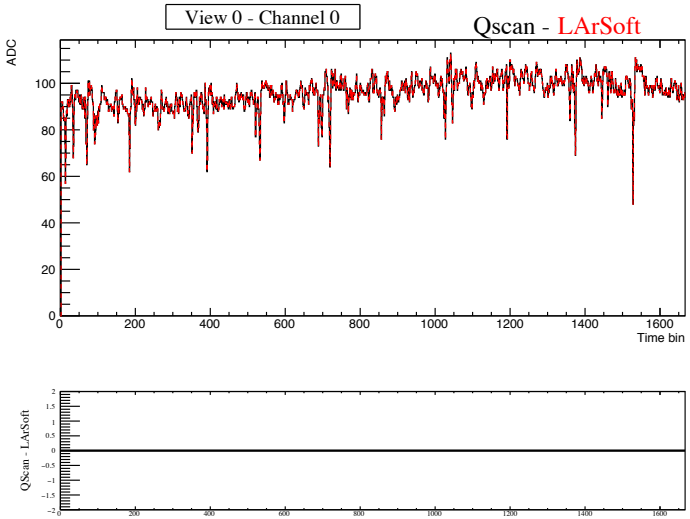
Summary of the data acquisitions

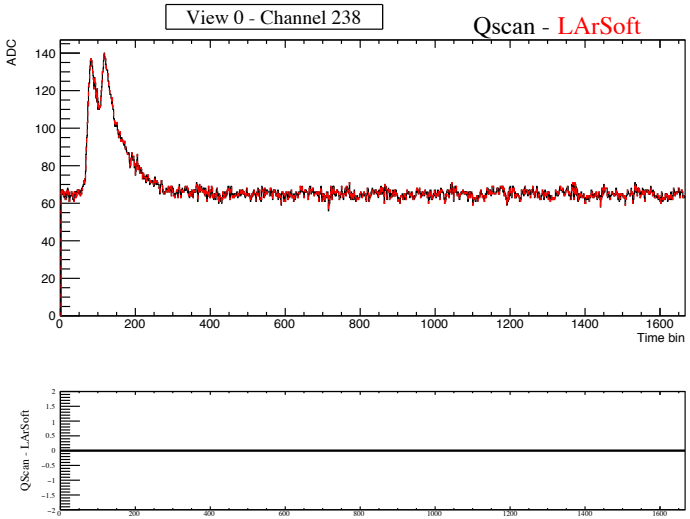
RUN	Liquid above grid	FFS V	Grid V	LEM V down	LEM V up	PMT status	PMT trigger
731	5 mm	5 kV	4 kV	3.0 kV[1]	0.2 kV	on	
732	5 mm	5 kV	4 kV	3.1 kV[1]	0.2 kV	on	
734 & 735	5.1 mm	5 kV	4 kV	3.1 kV[1]	0.2 kV	on	
739	9.4 mm	4.7 kV	3.7 kV	2.7 kV	0.2 kV	on*	
740	9.4 mm	4.7 kV	3.7 kV	2.7 kV	0.2 kV	on	
741	9.4mm	4.7 kV	3.7 kV	2.7 kV	0.2 kV	off	-
742	9.4 mm	4.9 kV	3.9 kV	2.8 kV	0.2 kV	off	-
743	9.4 mm	4.9 kV	3.9 kV	2.8 kV[2]	0.2 kV	off	-
744	9.4 mm	5 kV	4 kV	2.9 kV[3]	0.2 kV	on	
745	9.4 mm	5.1 kV	4.1 kV	2.9 kV[3]	0.2 kV	on	
746	9.4 mm	5.3 kV	4.2 kV	3.0 kV[4]	0.2 kV	on	
747	9.4 mm	5.3 kV	4.3 kV	3.0 kV[4]	0.2 kV	on	
748	9.4 mm	5.5 kV	4.5 kV	3.0 kV[4]	0.2 kV	on	
749	9.4 mm	4.9 kV	4.0 kV	3.0 kV	0.4 kV	on	
750	9.4 mm	4.9 kV	3.8 kV	3.1 kV	0.4 kV	on	
751	9.4 mm	4.1 kV	3.5 kV	2.9 kV[5]	0.2 kV	Positive PMT off	

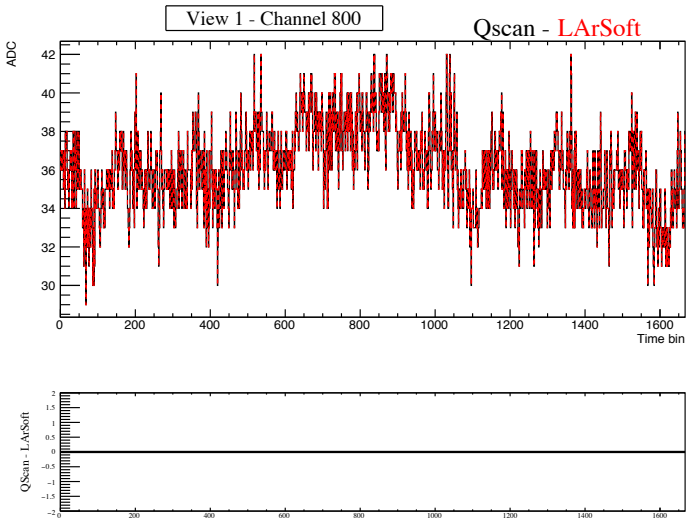
*) Cameras were on
1) 2.6 kV on all LEM except 5, 6, 7, 8 2) 2.6 kV on LEM 10 3) 2.8 kV LEM 1, 3, 12 and 2.6 kV LEM 10
4) 2.8 kV on LEM 1, 3, 12 and 2.7 kV on LEM 10 5) 2.0 kV on LEM 10

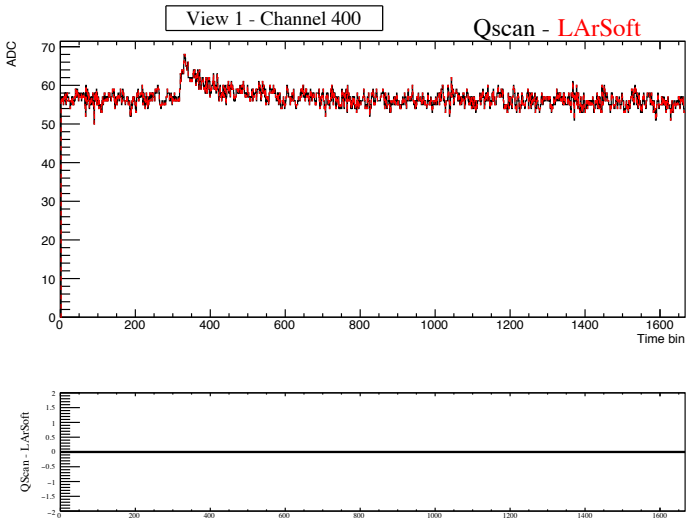
Direct LArSoft / QScan comparisons

Raw waveforms of run 748, event 0





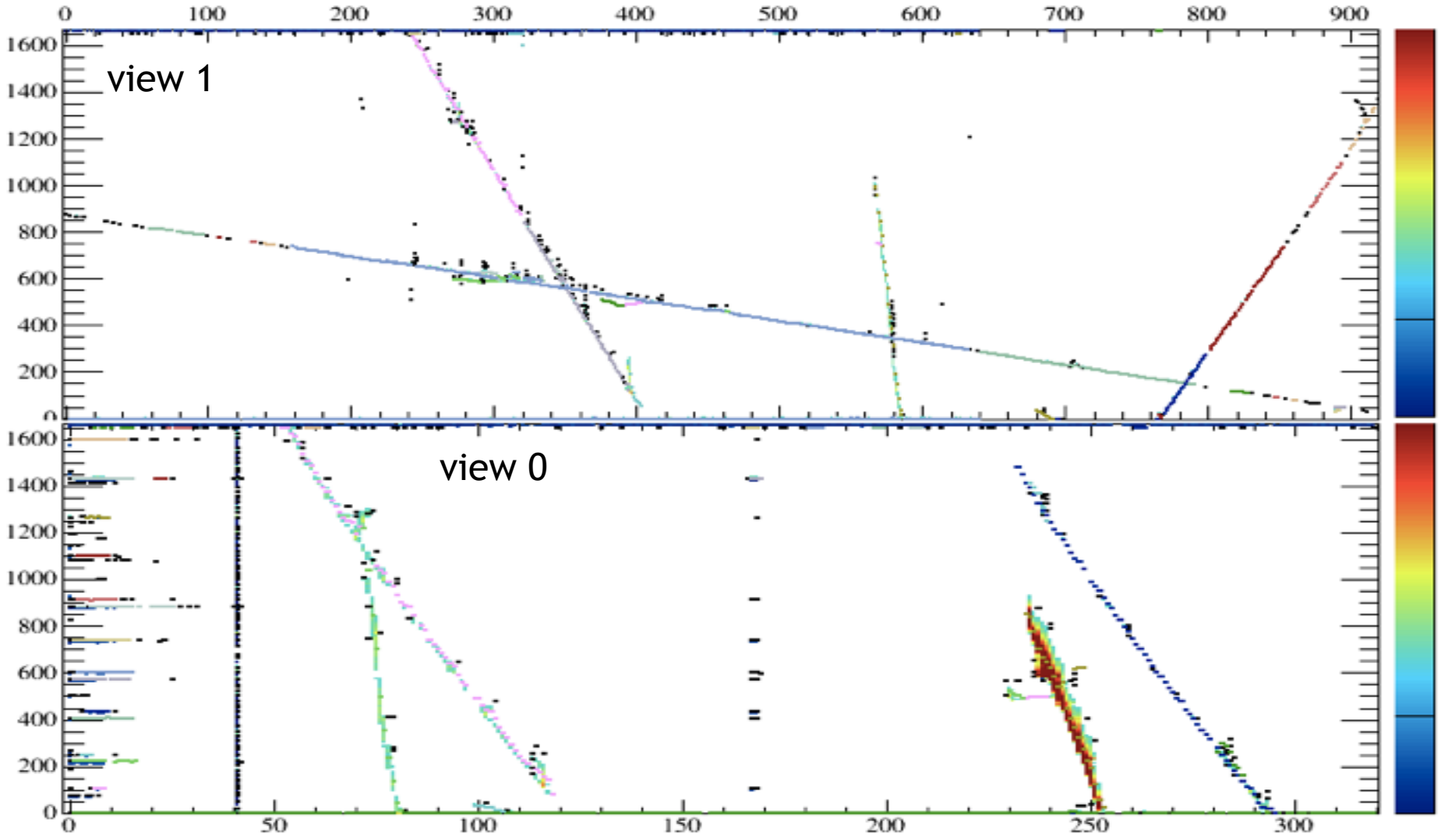




Direct LArSoft / QScan comparisons

Run 748, event 13

LarSoft Clustering output

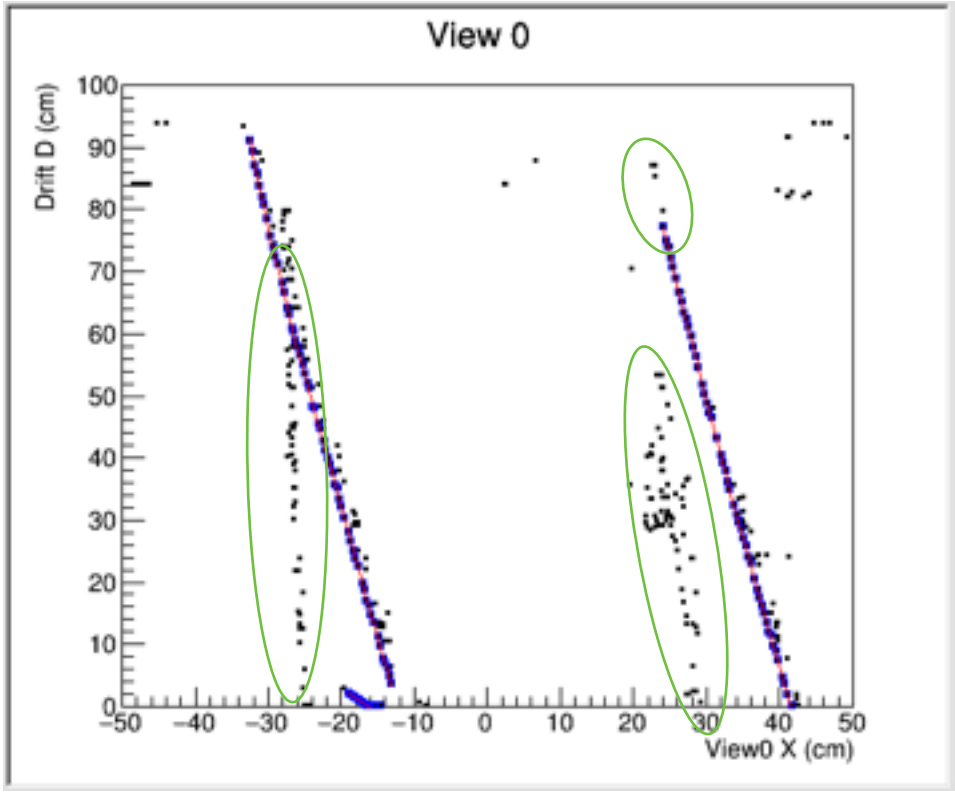


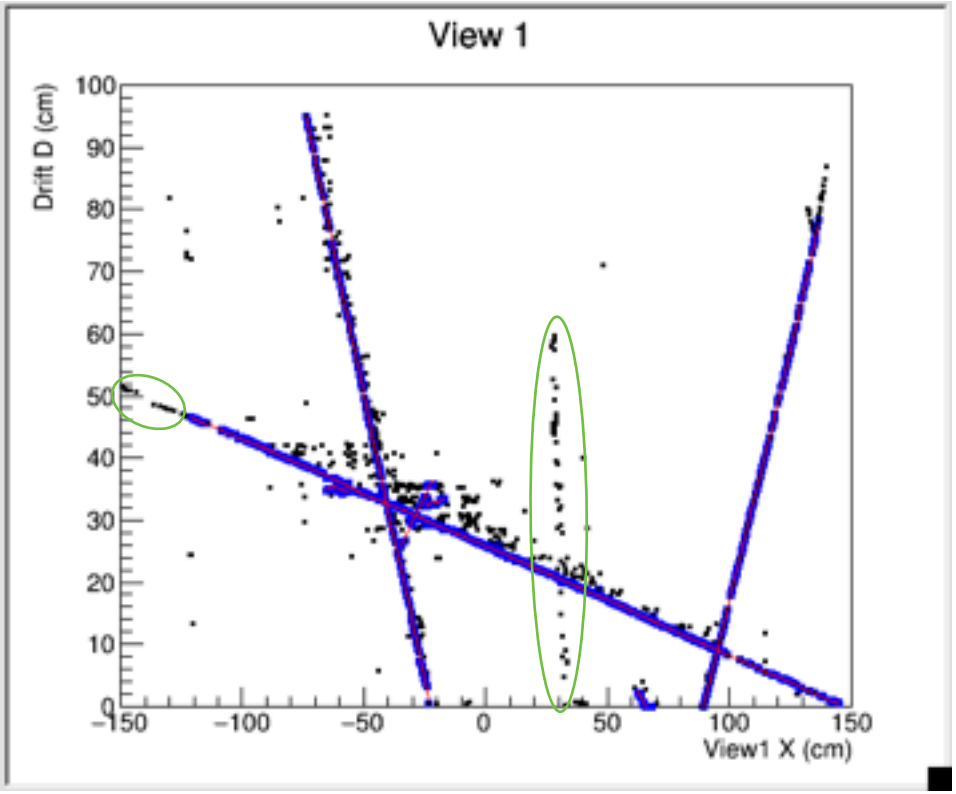
Direct LArSoft / QScan comparisons

Run 748, event 13

QScan ClusFilter output

red : found track
blue : hits associated to a track
black : un-associated hits





: Missing hits to fully reconstruct the track

Current Status in QScan

Status of the reconstruction in QScan

Hit Finding:

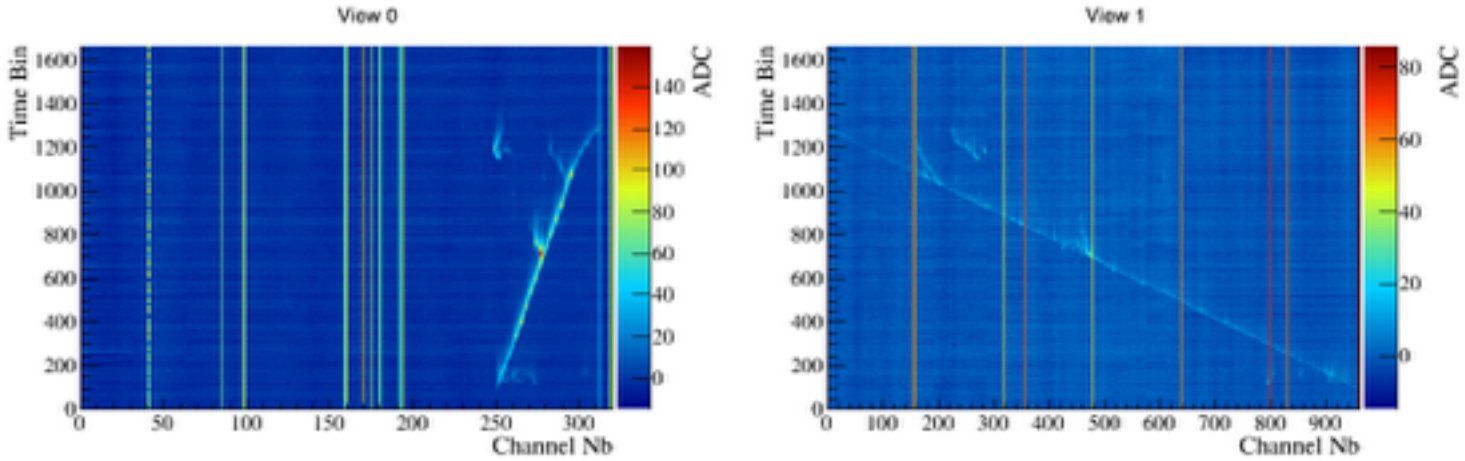
- Pedestals (mean, rms for each channel) taken from reference run (run 729)
- Problematic channels are masked
- Multi Hit algorithm used, threshold tuning was need (and could still be improved)
- FFT filtering could be foreseen as some specific frequencies noise can be seen
- Due to the noise, some hits are divided into multiple hits
- Due to the low gain, some of actual hits are not found and noise are considered as hits

Track finding:

- ClusFilter algorithm is used, with vertical track search enabled
- Parameter tuning was needed, as the default parameters was tuned from 6x6x6 simulation

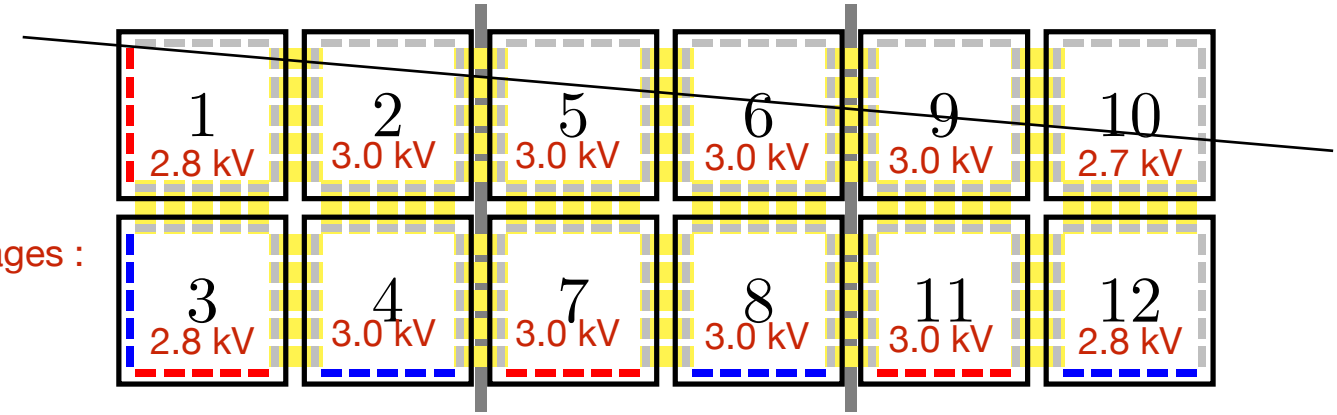
→ Parameters used in the recotask datacard are given in the backup

Example - run 748, event 366



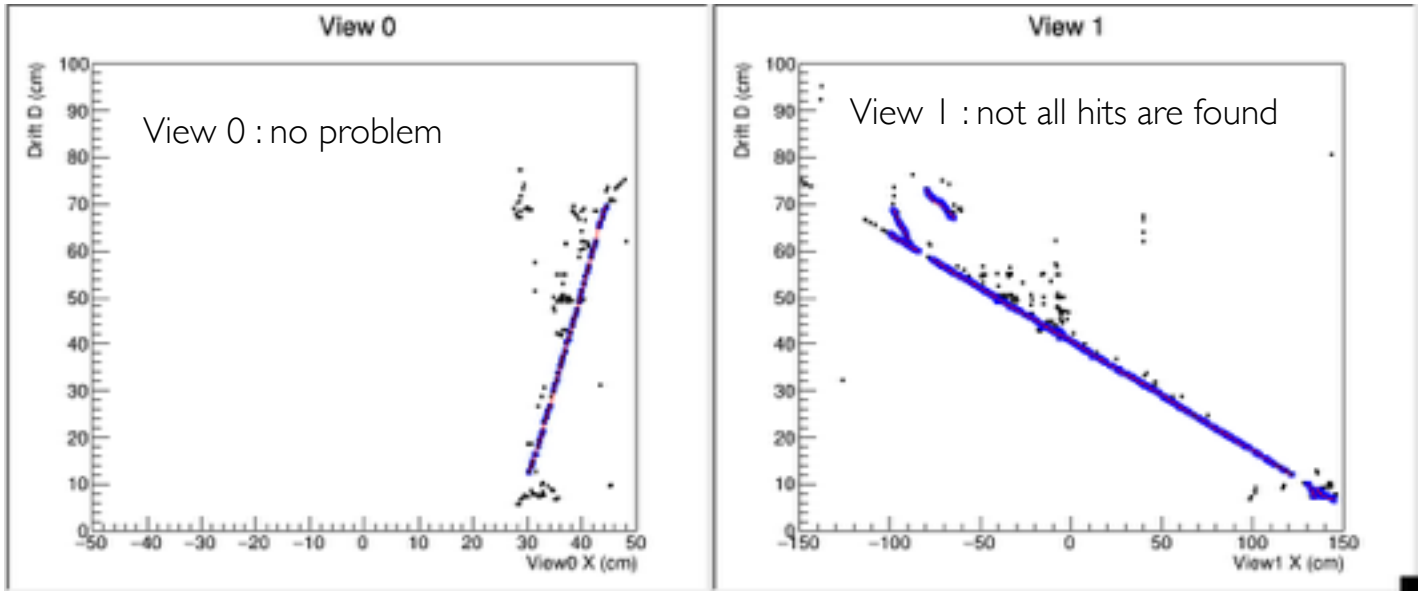
Nice because crossing only one side of the detector and all view 1 :

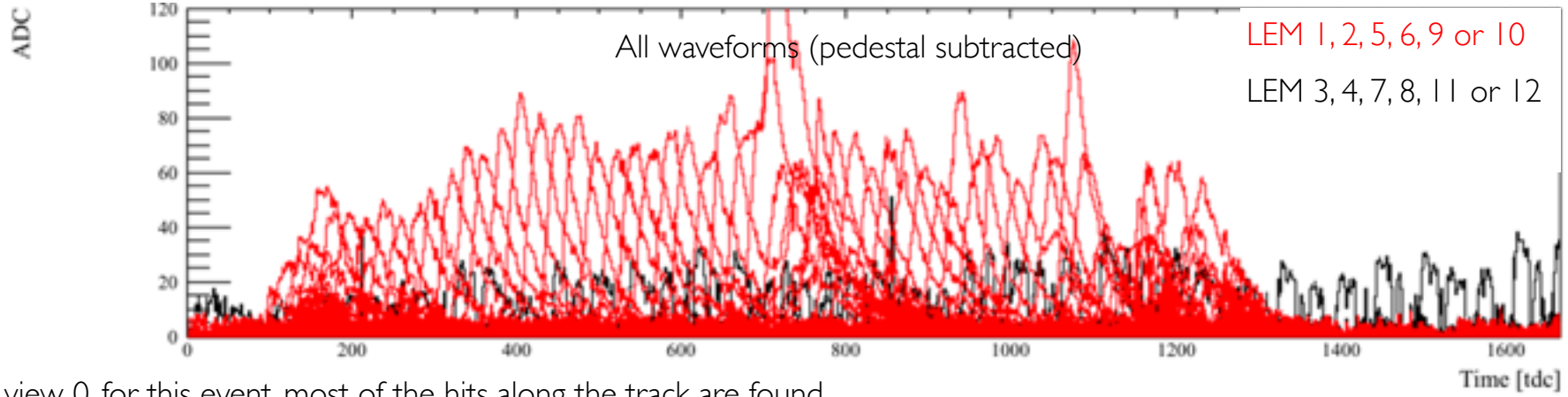
LEM down voltages :



Example - run 748, event 366 - view 0

red : found track
blue : hits associated to a track
black : un-associated hits





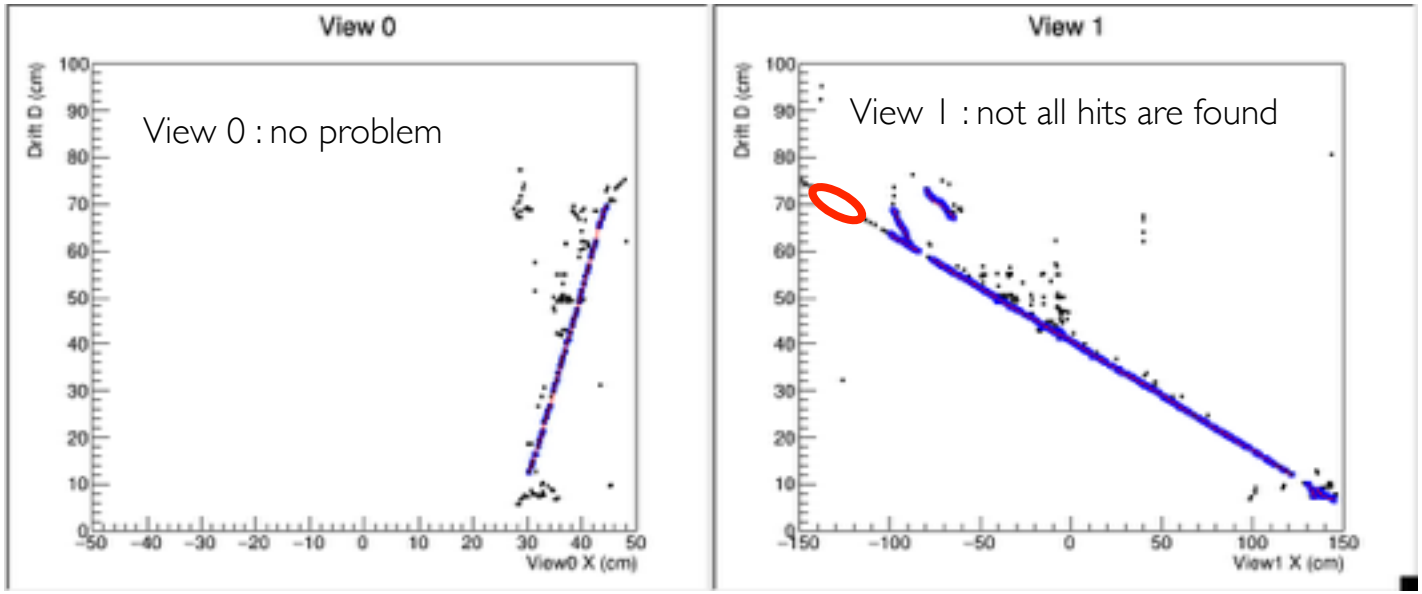
In view 0, for this event, most of the hits along the track are found.

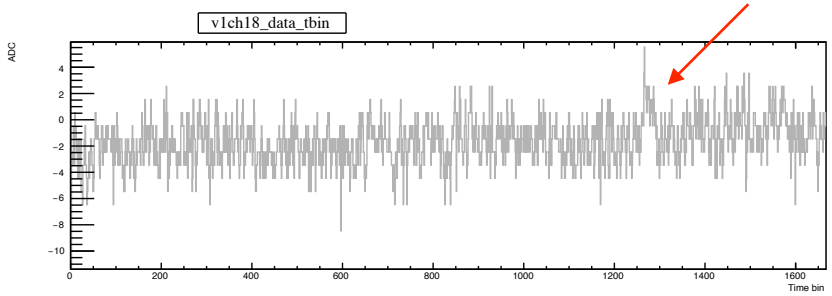
The shape of the waveforms do not follow the expected attenuation trend due to the different LEM configurations

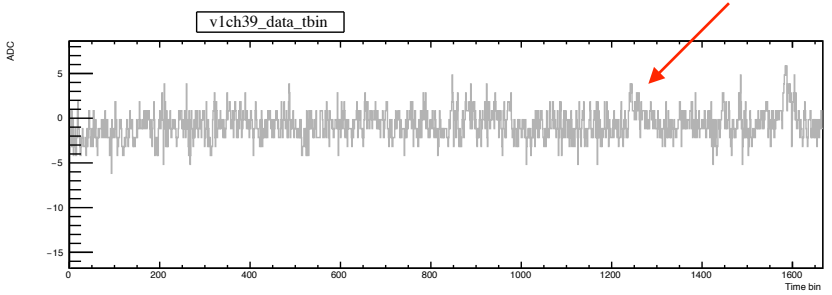
→At this moment, it is difficult to perform purity analysis, but it seems quite good

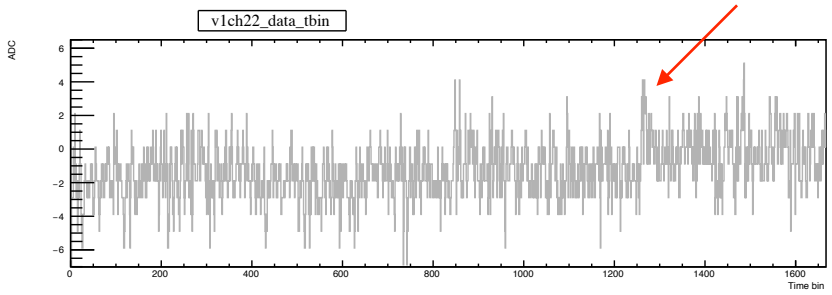
Example - run 748, event 366 - view 1

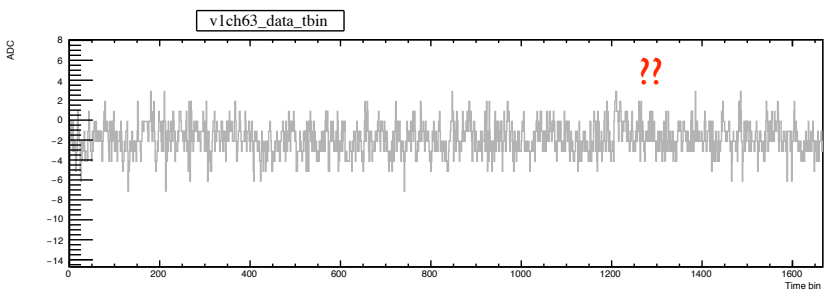
red : found track
blue : hits associated to a track
black : un-associated hits





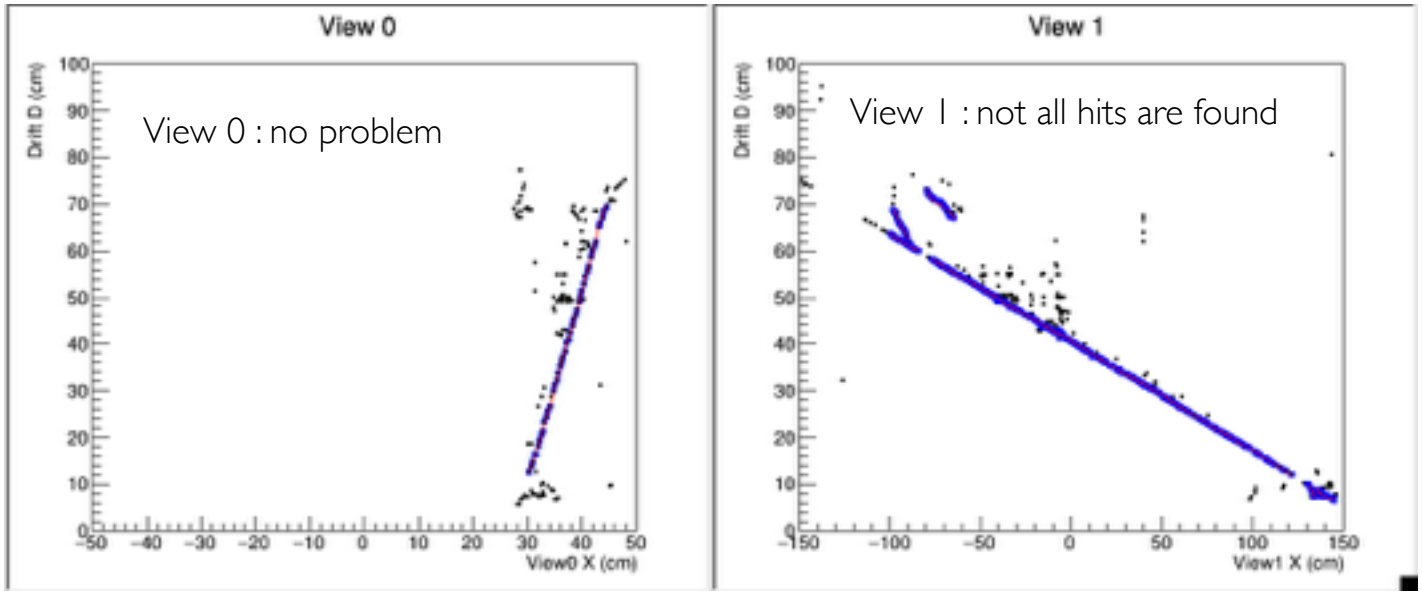


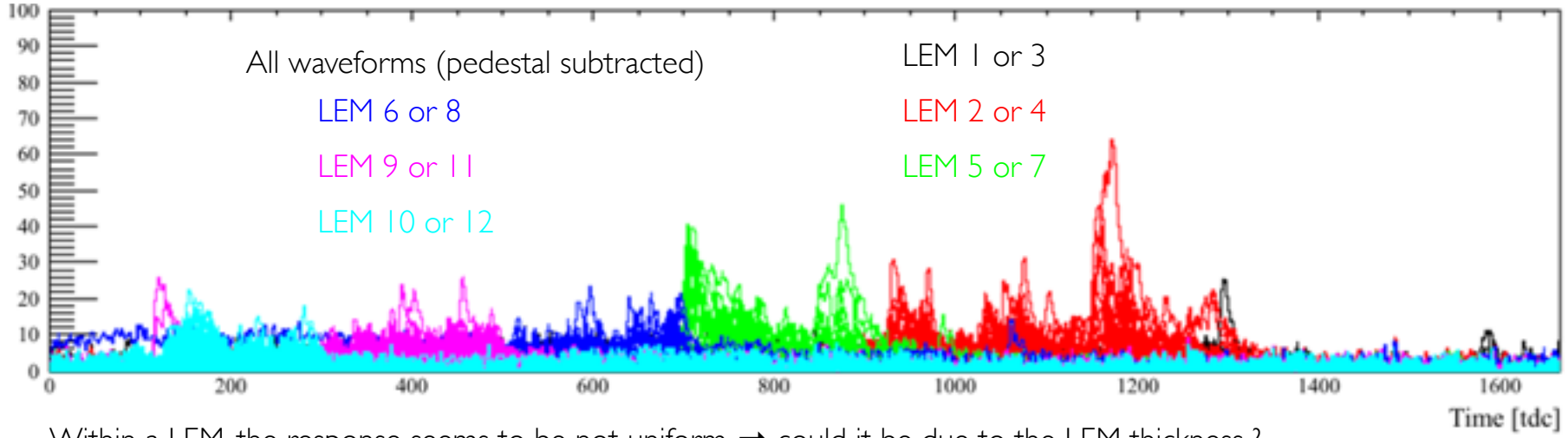




Example - run 748, event 366 - view 1

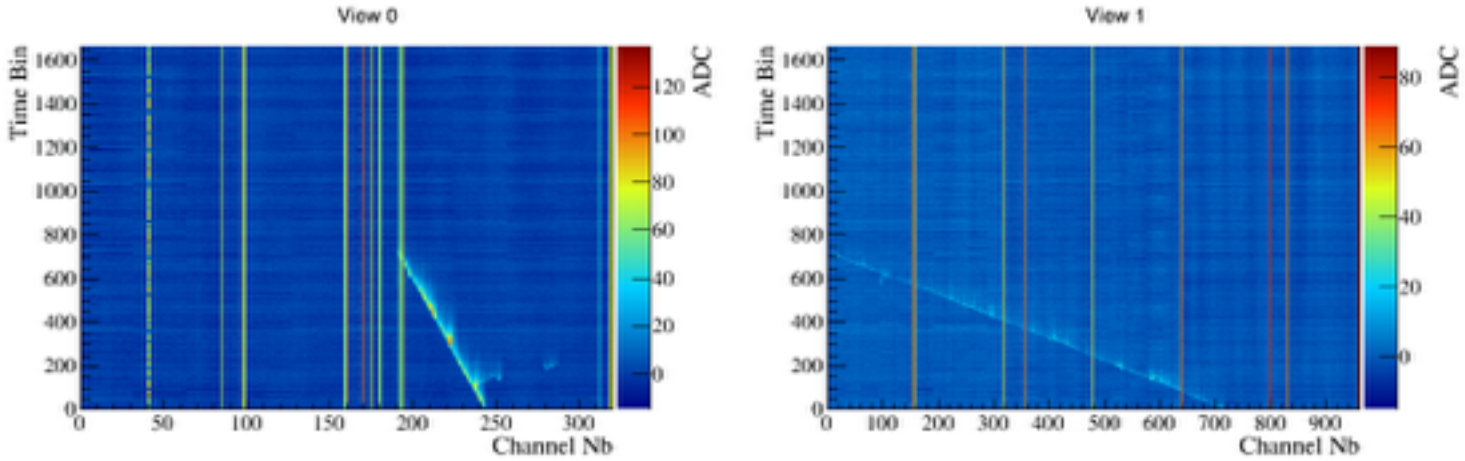
red : found track
blue : hits associated to a track
black : un-associated hits



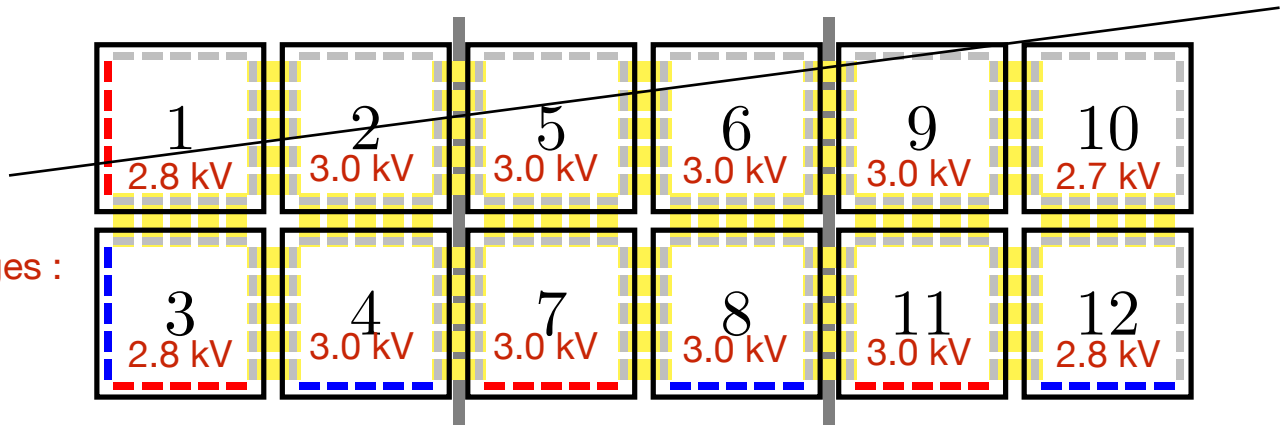


Within a LEM, the response seems to be not uniform → could it be due to the LEM thickness ?

Example - run 748, event 0



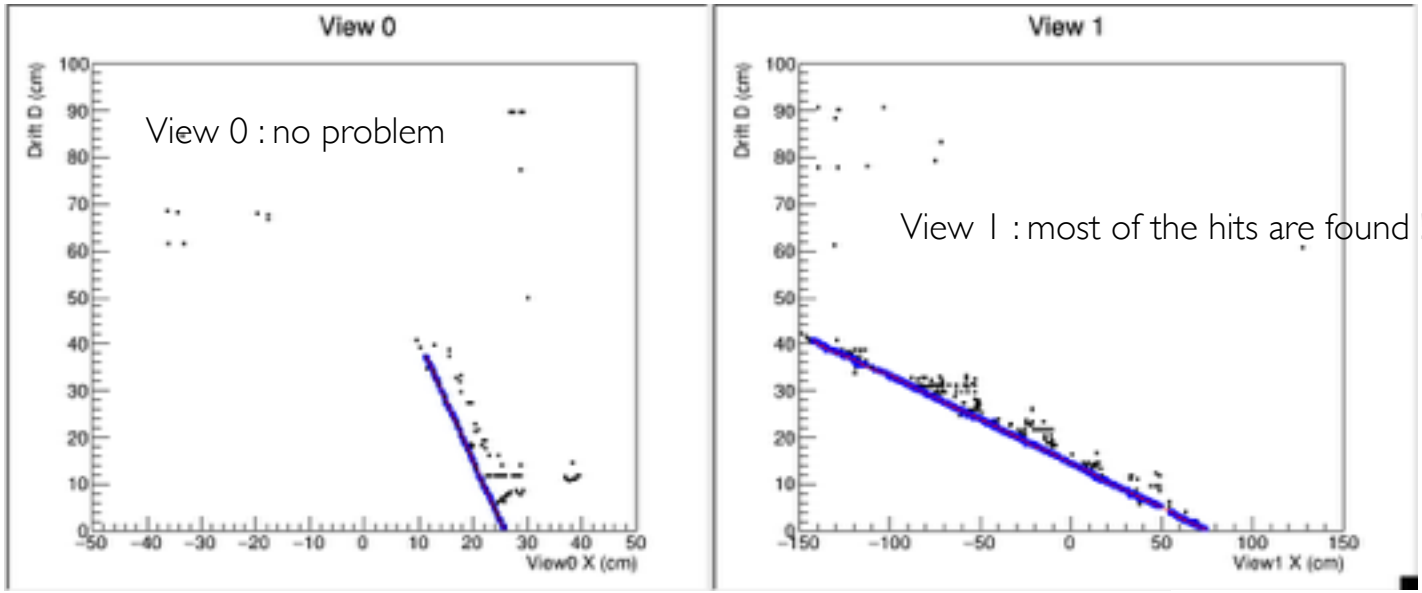
Other nice because it crosses only one side of the detector and part of view 1 :



LEM down voltages :

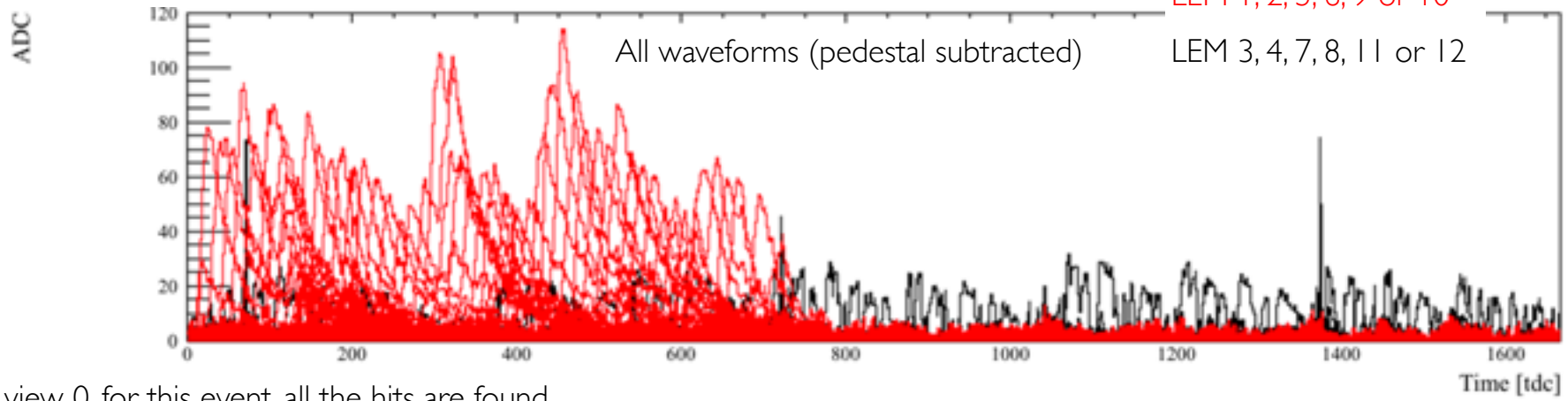
Example - run 748, event 0 - view 0

red : found track
blue : hits associated to a track
black : un-associated hits



LEM 1, 2, 5, 6, 9 or 10

LEM 3, 4, 7, 8, 11 or 12



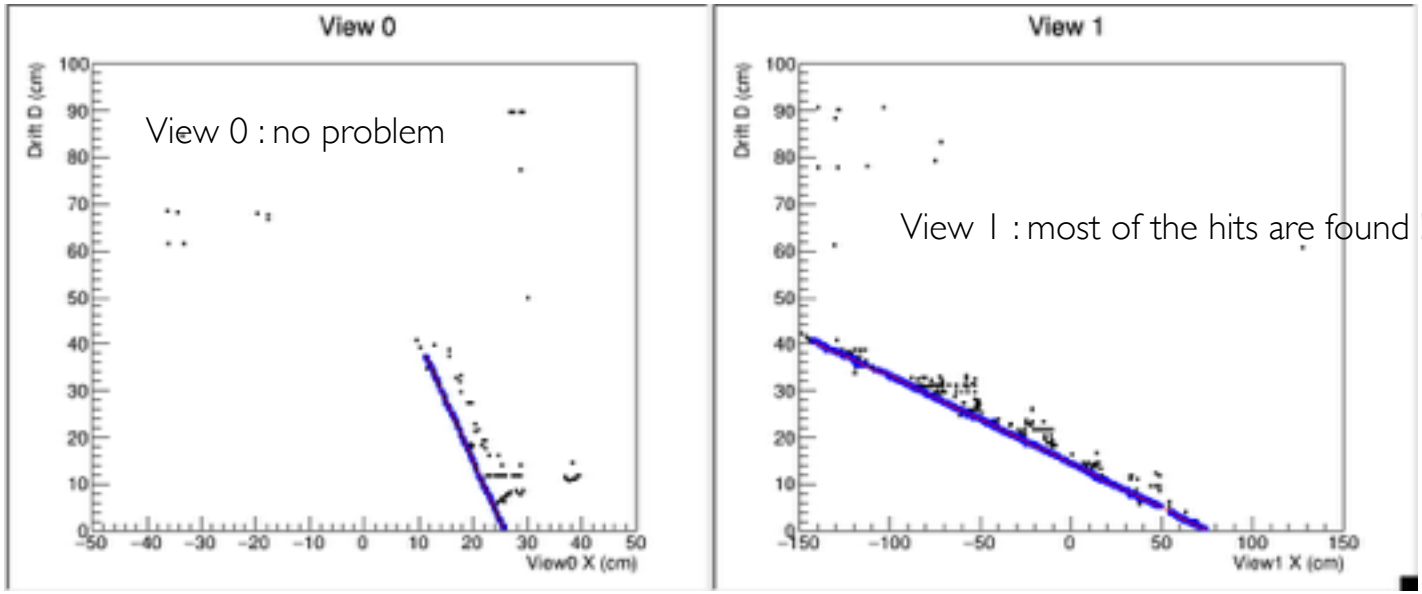
In view 0, for this event, all the hits are found.

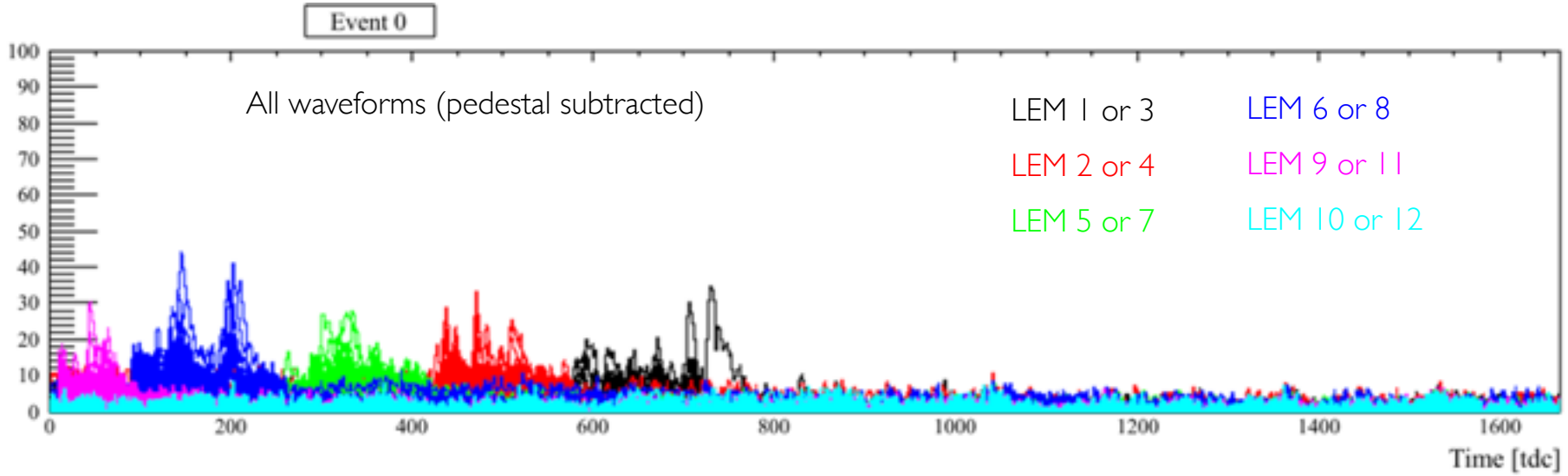
But the shape of the waveforms do not follow the expected attenuation trend due to the different LEM configuration

→At this moment, it is difficult to perform purity analysis but it seems quite good

Example - run 748, event 0 - view 1

red : found track
blue : hits associated to a track
black : un-associated hits





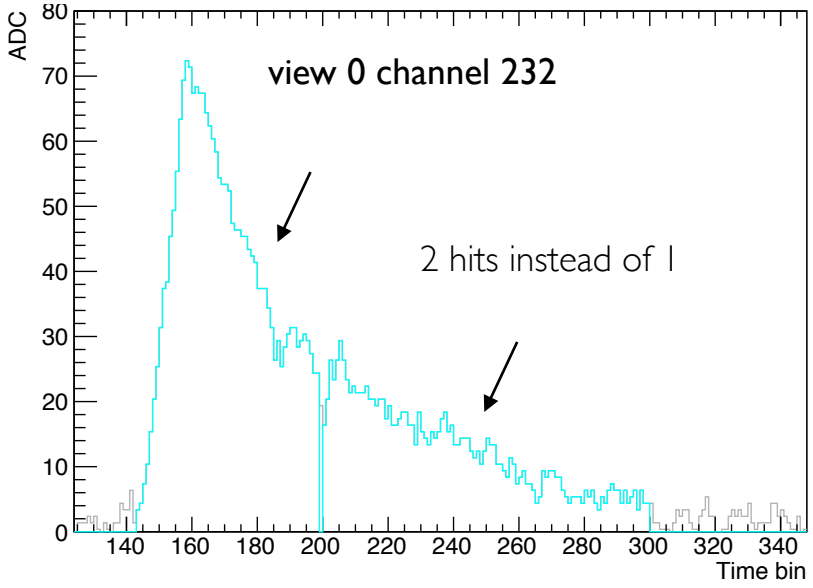
Within a LEM, the response seems to be not uniform → could it be due to the LEM thickness ?

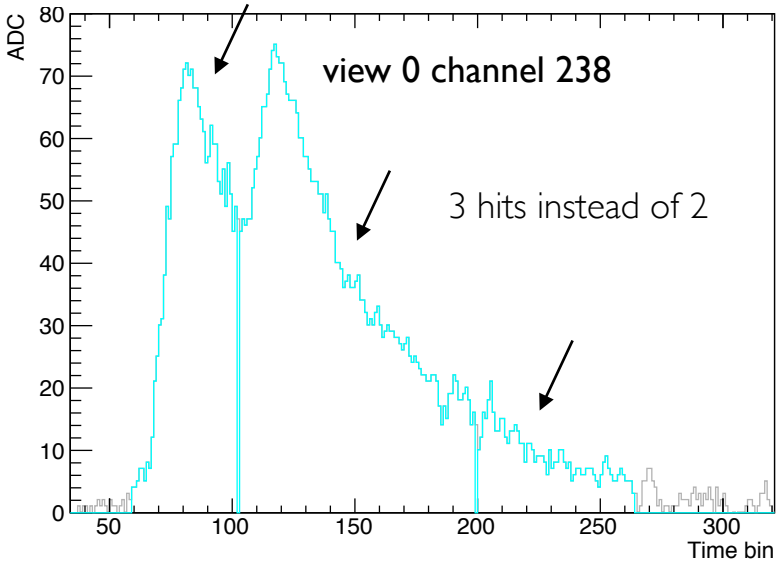
Example of the multi hit and noise problems

gray : waveform

blue : hits found

run 748, event 0



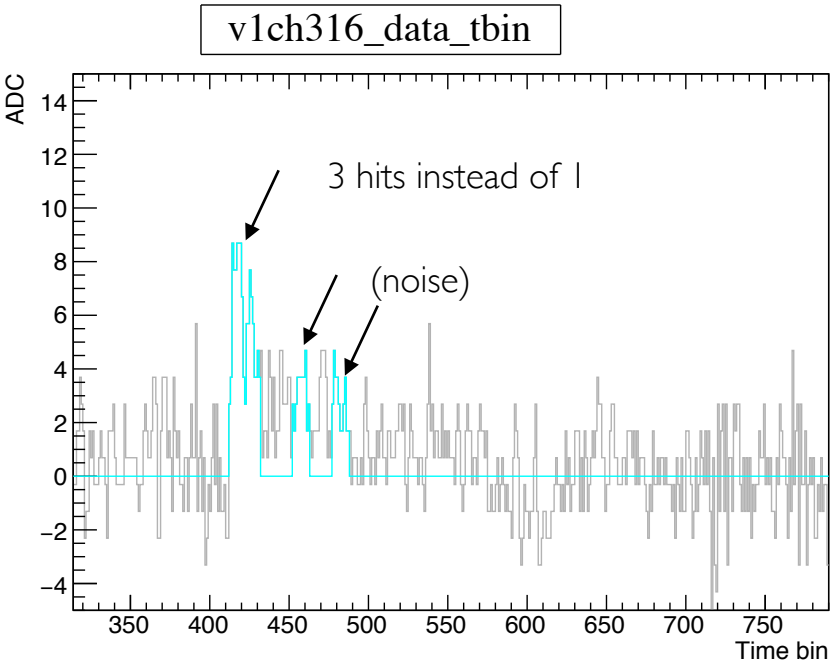


Due to the fluctuations, multiple hits are found

↳ Must be improve either with noise filtering

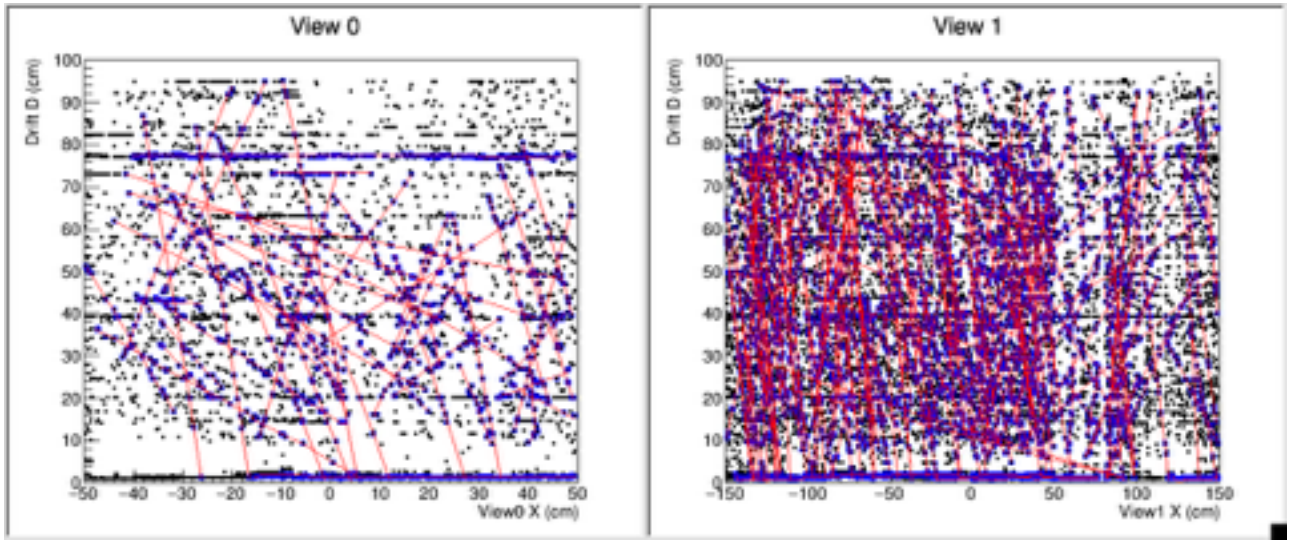
or with better hit finding constraints

One can also see the long tail of the hits due to the low extraction field.



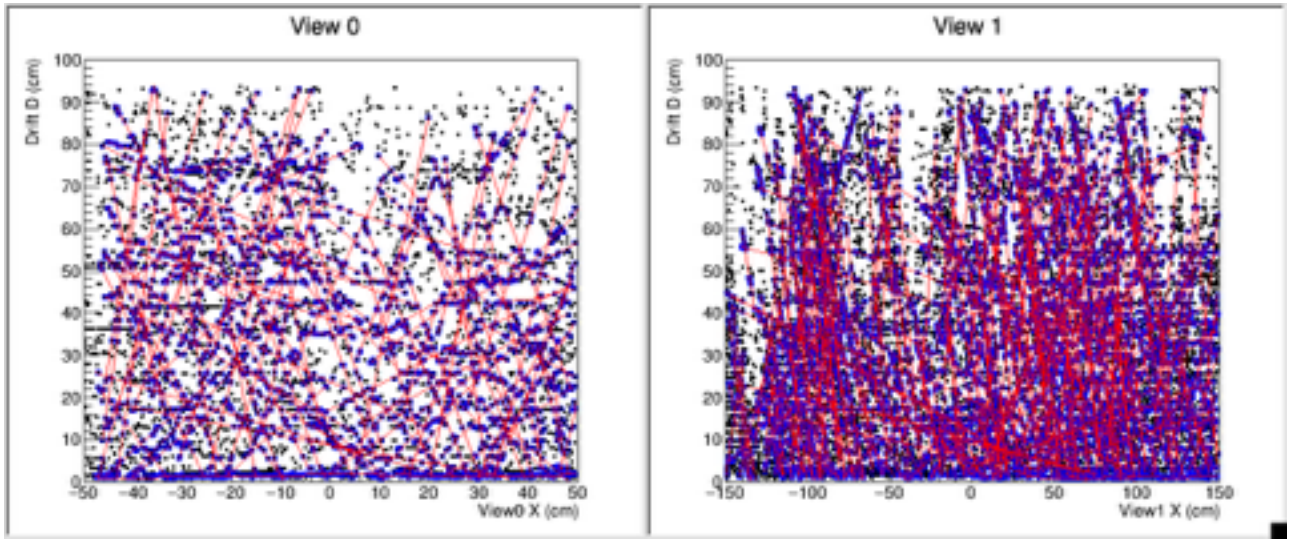
Some events with a lot of random tracks

In some events, more than 100 random tracks found in each views



run 750

Event 38

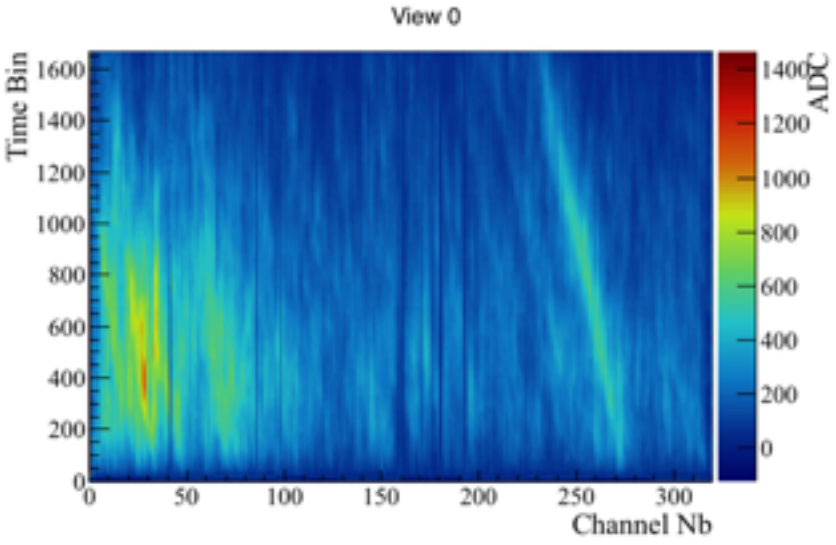


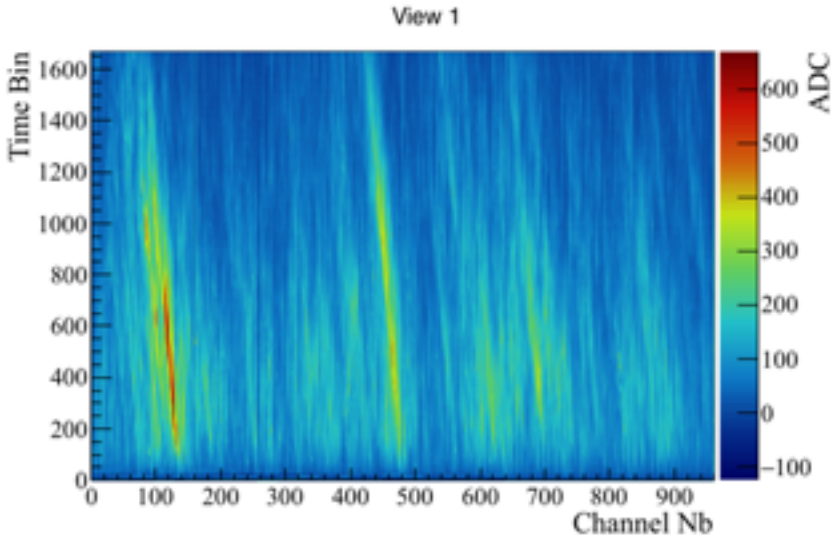
run 747

Event 12

Event display of those events

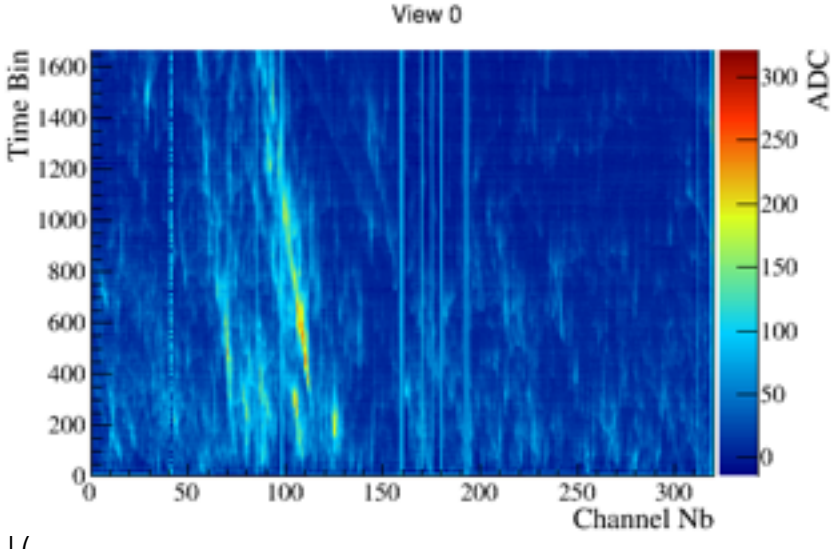
these events are very energetic, could be also some large cross talk

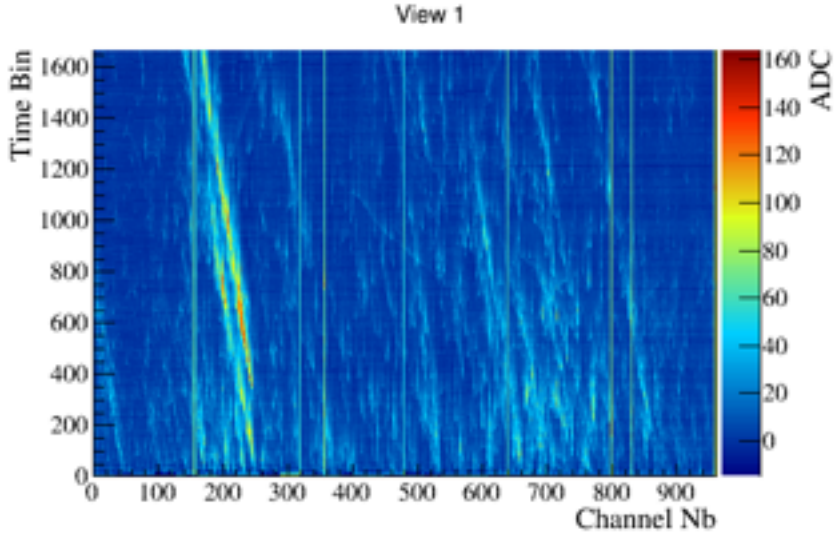




run 750

Event 38



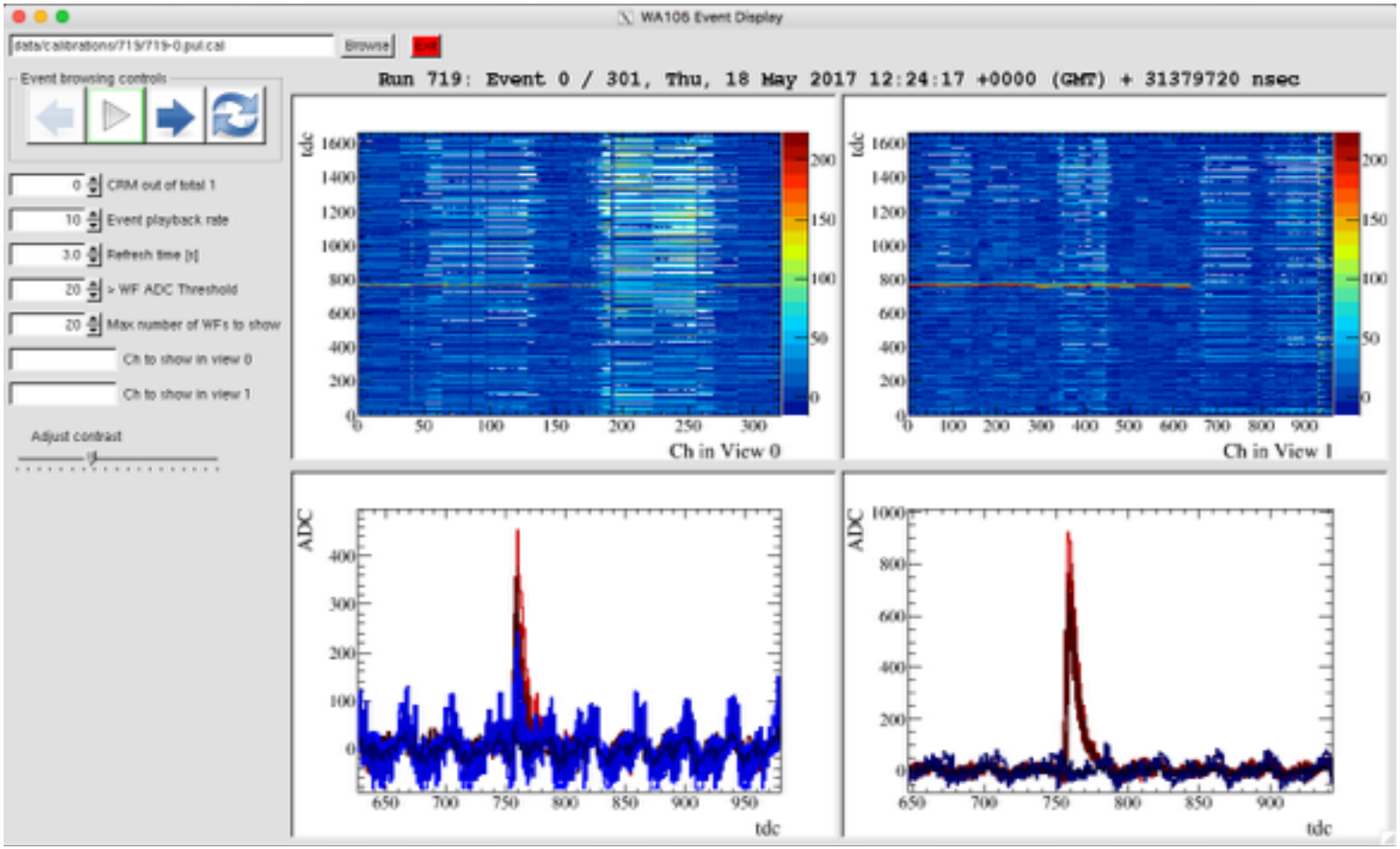


run 747

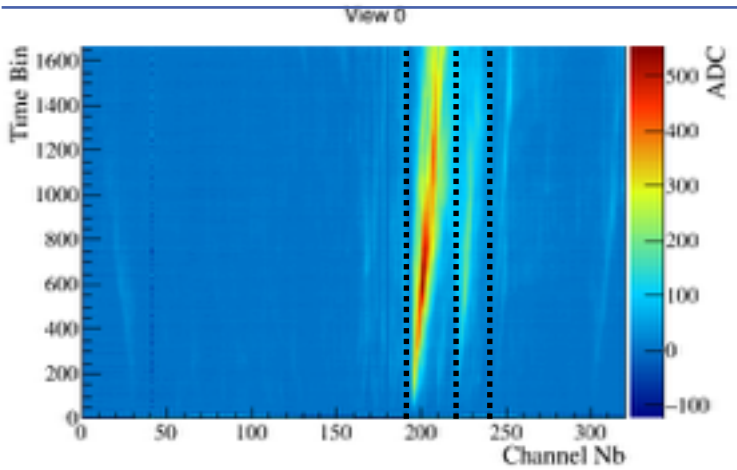
Event 12

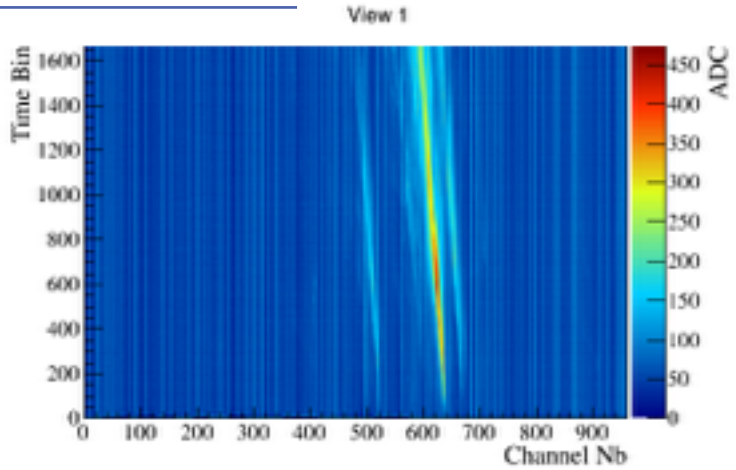
Looking at pulsing data (run 719)

pulsing SGFT 2 and 3 (view 1 channel 0 to 640) with 150 mV. Pulse maximum amplitude at ~ 800 ADC, signal (cross talk) in view 0 at around ~450 ADC → consistent with the previous event display



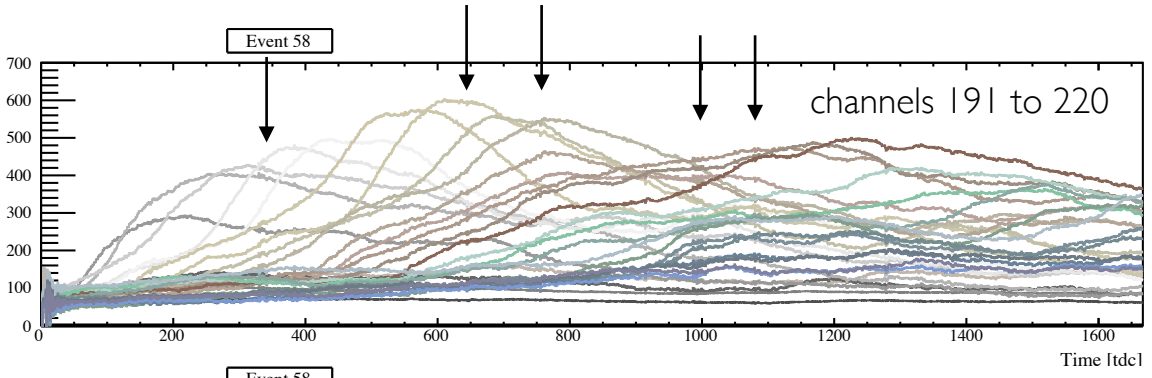
Waveforms of run 751 event 58 (view 0)

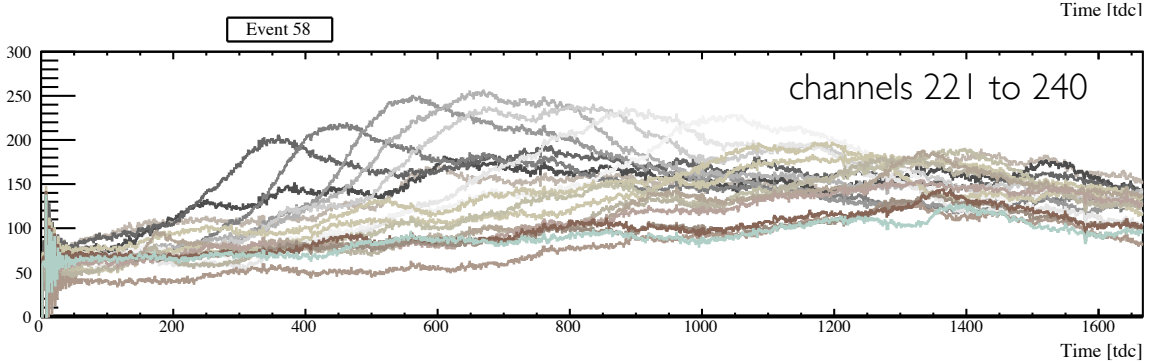




Looking at the waveforms of the 2 tracks in view 0 :

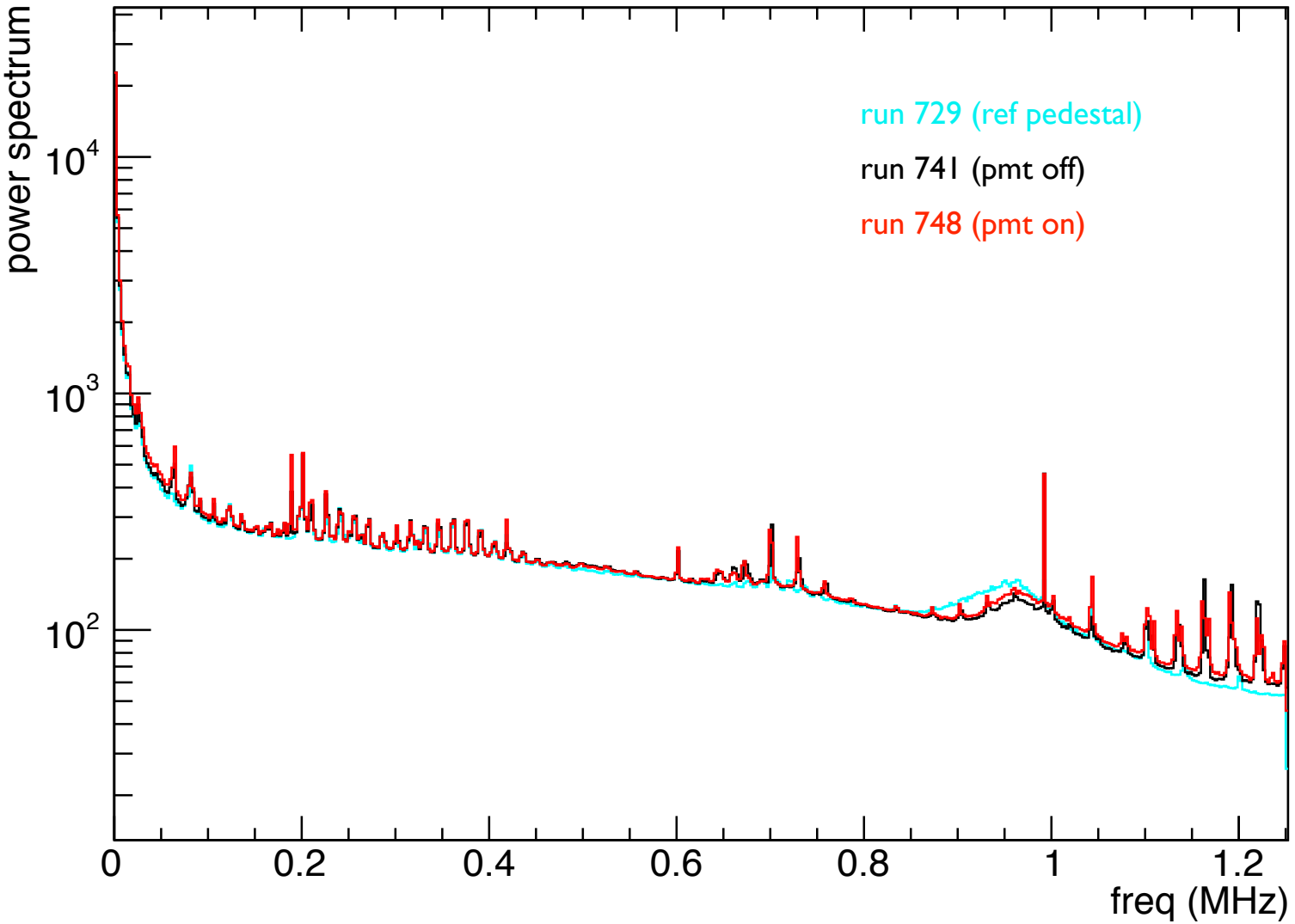
All waveforms see some fluctuations at the same time, there is some noise that could be removed :





Noise Spectrum

All channels together, seems that we are picking specific noise frequencies



(removing highly energetic events)

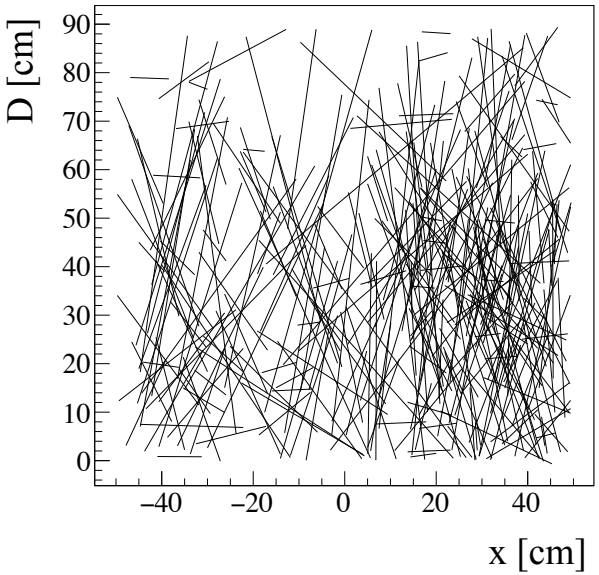
Run 743 - all tracks found superimposed

Cathode : 36.0 kV, Grid : 3.9 kV, LEM Bottom ~ 2.8 kV

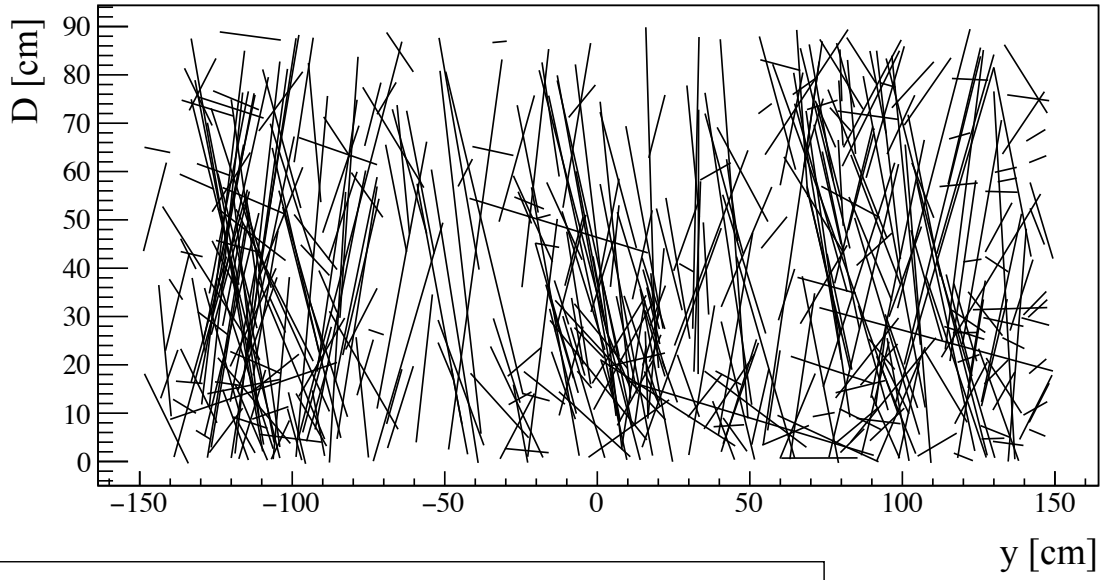
Reconstructed tracks in view 0 are not uniformly distributed

No crossing muons reconstructed

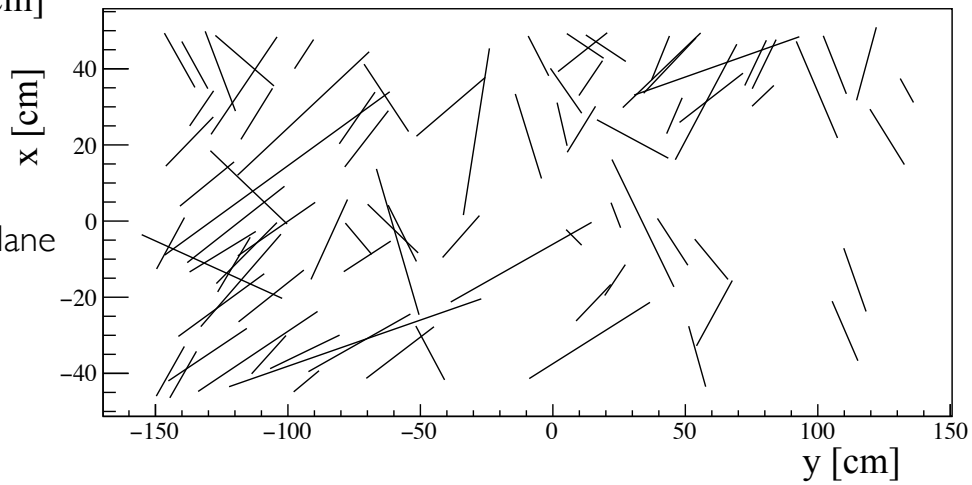
View 0



View 1



3D matching tracks projected on x-y plane

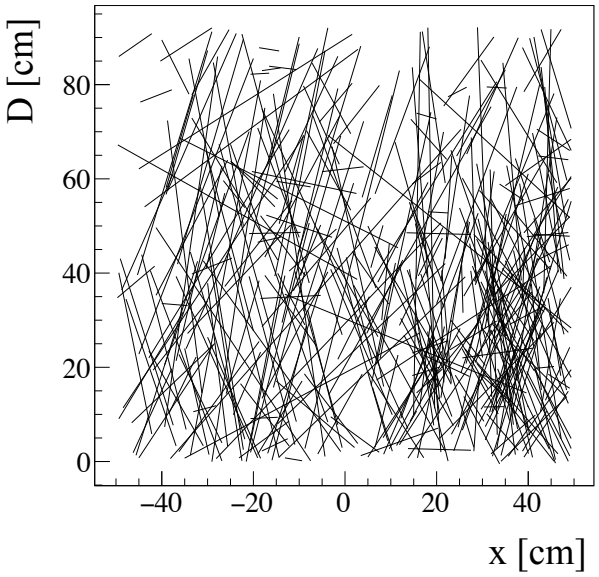


(removing highly energetic events)

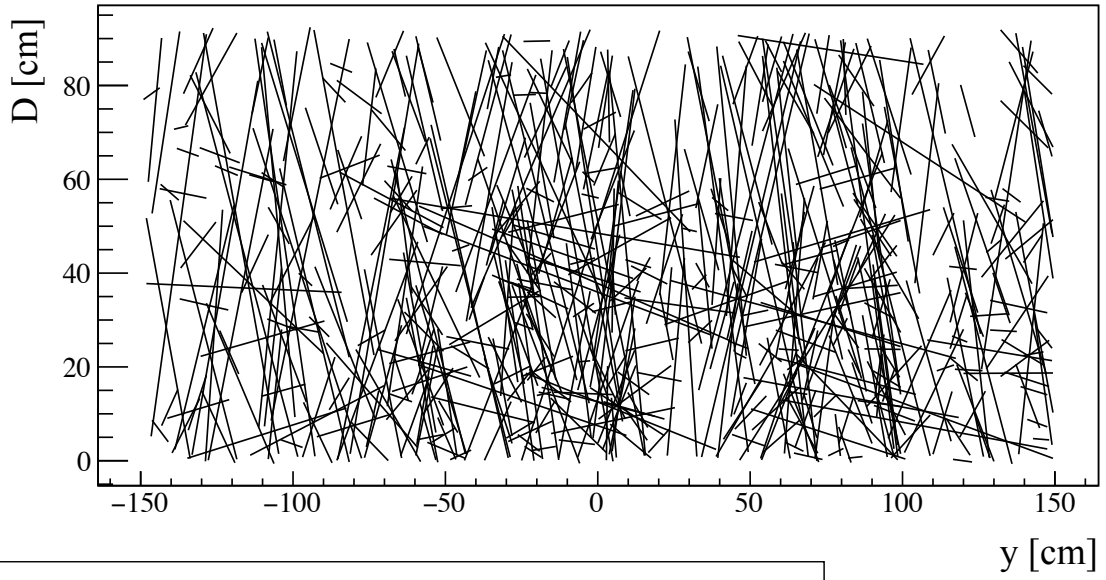
Run 745 - all tracks found superimposed

Cathode : 38.0 kV, Grid : 4.1 kV, LEM Bottom ~ 2.9 kV

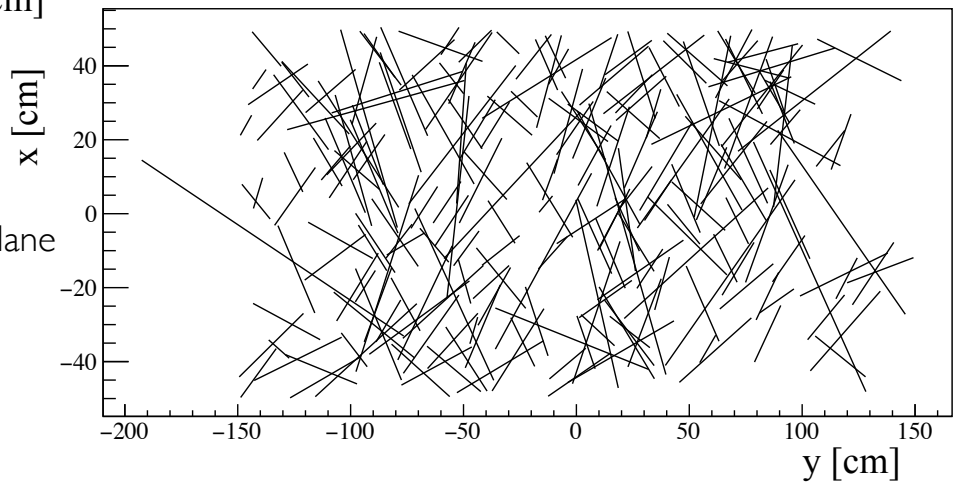
View 0



View 1



3D matching tracks projected on x-y plane

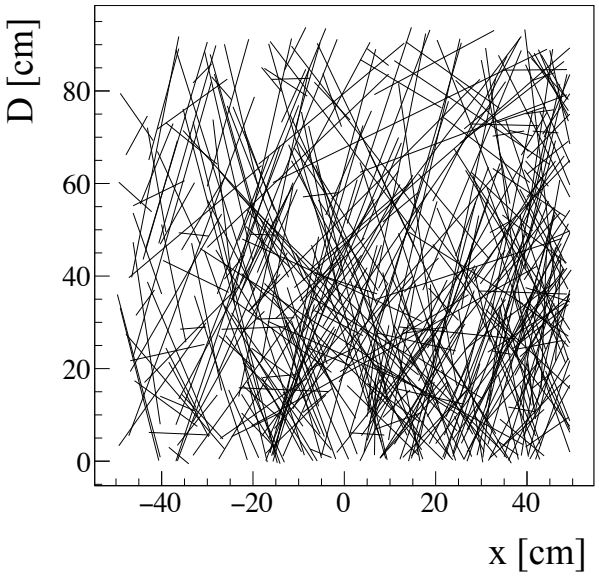


(removing highly energetic events)

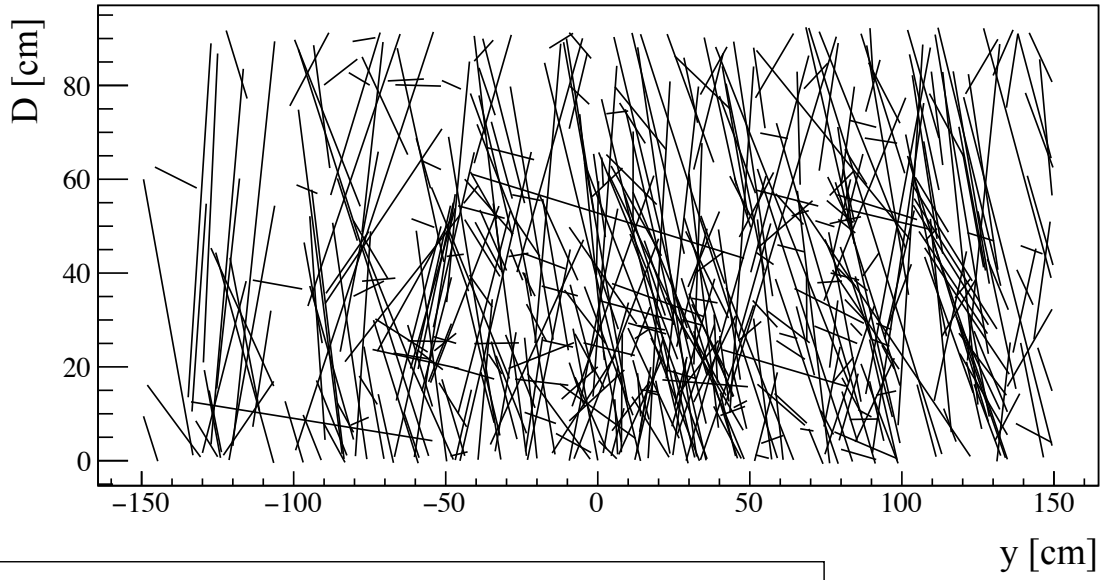
Run 747- all tracks found superimposed

Cathode : 39.0 kV, Grid : 4.3 kV, LEM Bottom ~ 3.0 kV

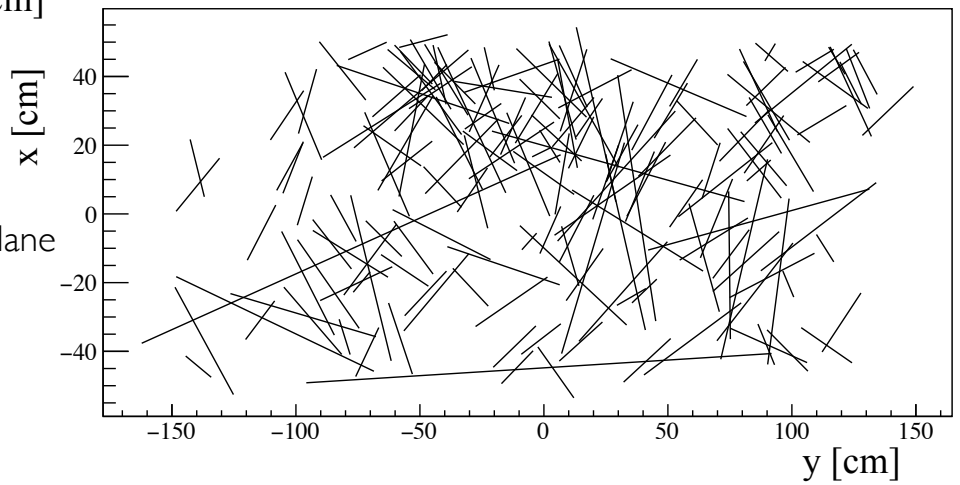
View 0



View 1



3D matching tracks projected on x-y plane



(removing highly energetic events)

Run 748 - all tracks found superimposed

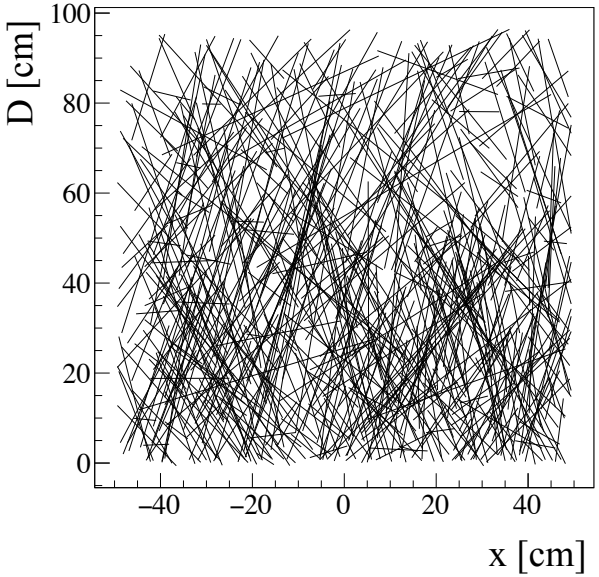
Cathode : 41.0 kV, Grid : 4.5 kV, LEM B ~ 3.0 kV, LEM T 0.2 kV

Closest to nominal configuration run

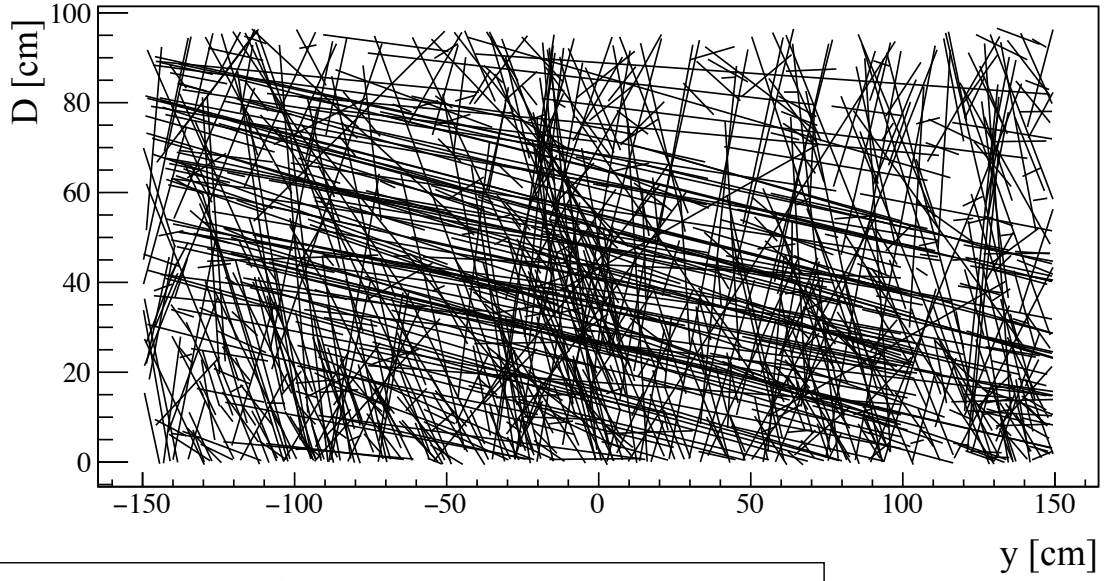
we can reconstruct much more crossing muons in view 1 !

Only one crossing muon direction ?

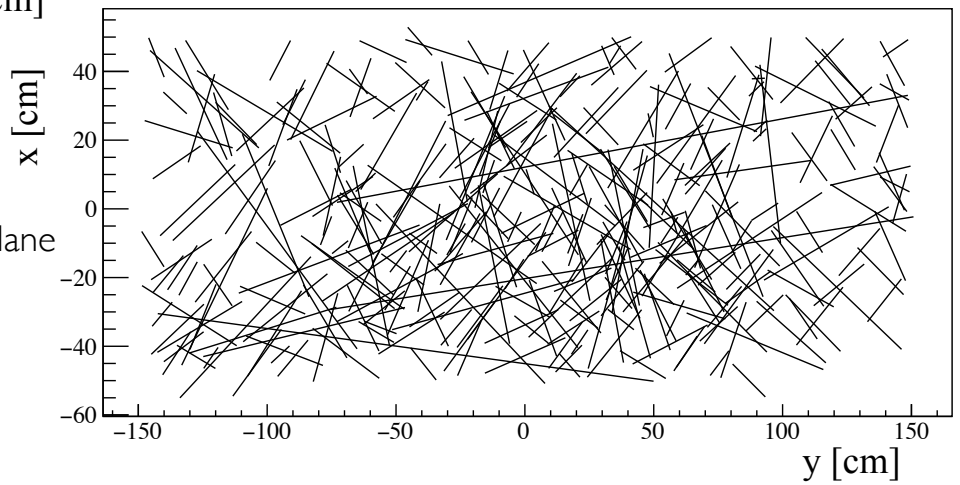
View 0



View 1



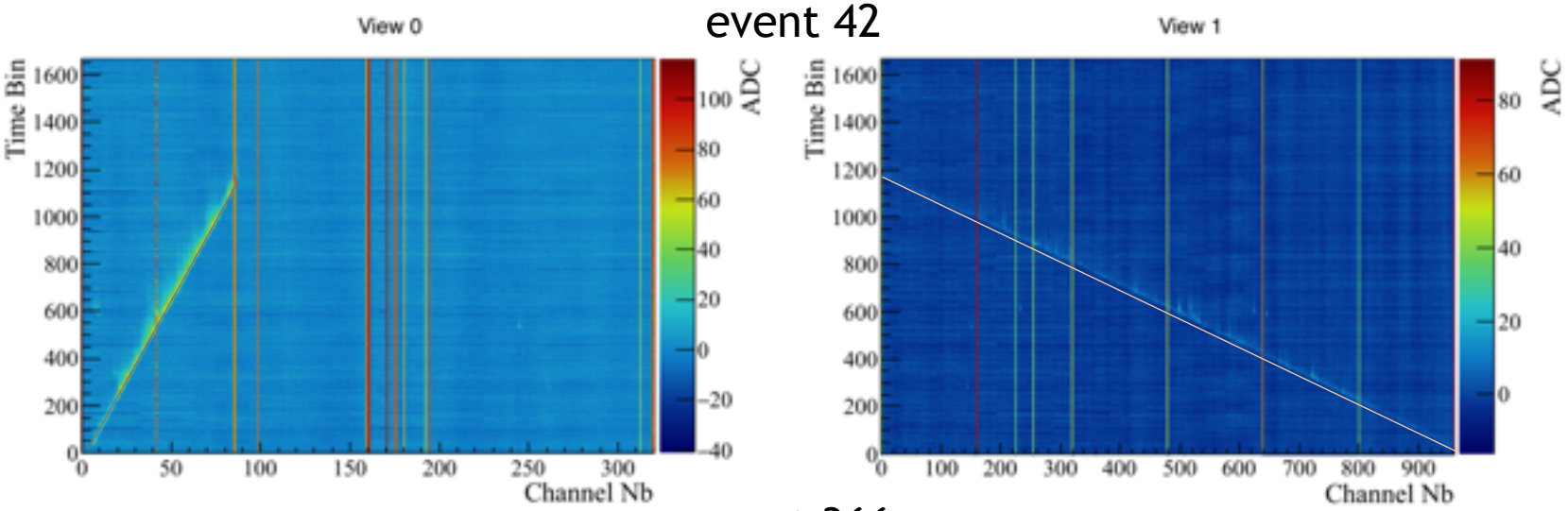
3D matching tracks projected on x-y plane



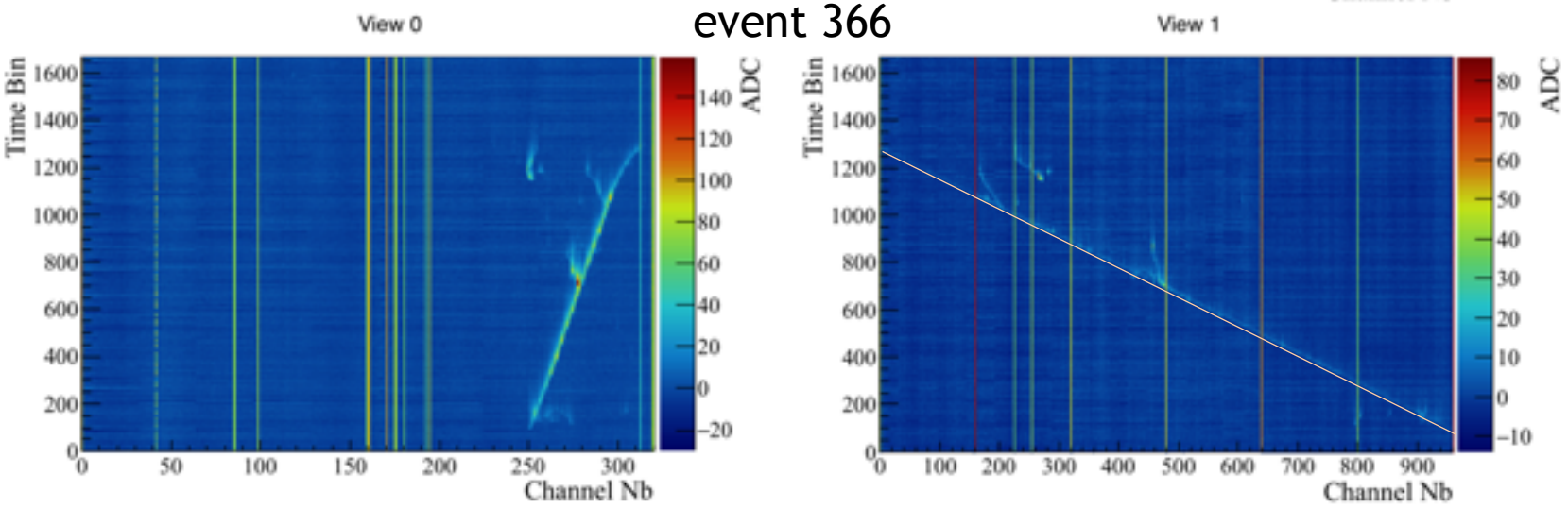
Only a few crossing muons are 3D matched at the moment

Track distorsion - run 748

event 42



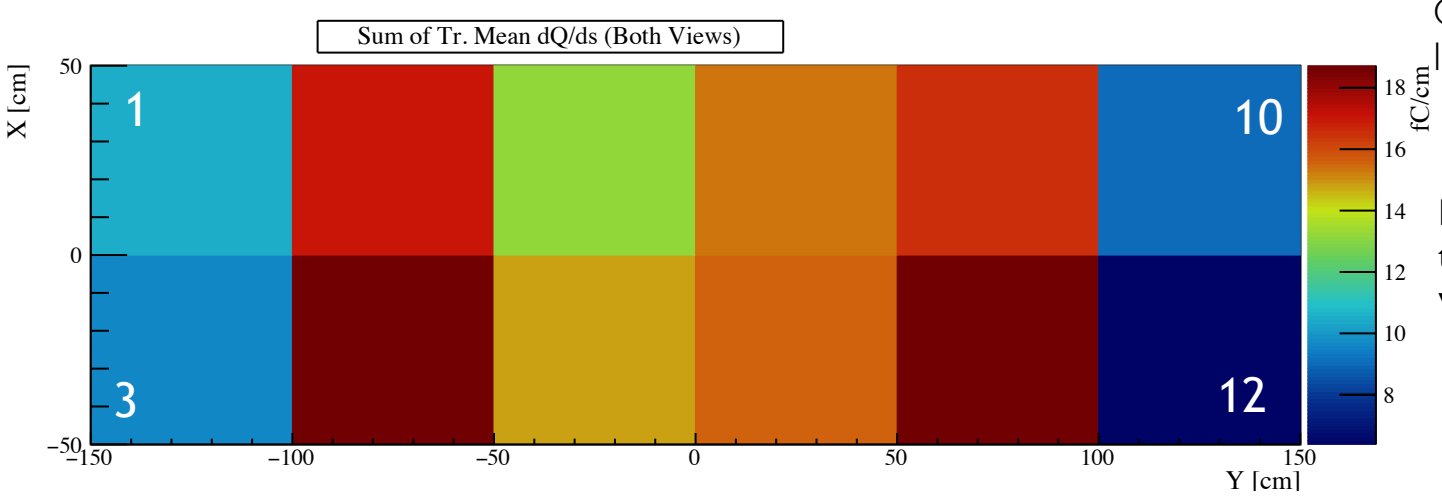
event 366



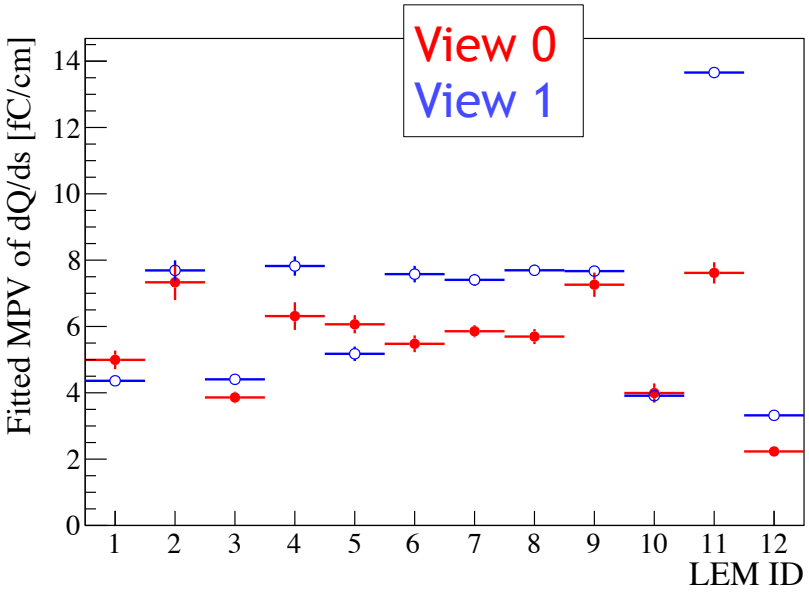
Bending of track wrt a straight line could highlight space charge effect, although we have to be careful due to the grid voltage, LEM voltage and potential CRP deformation

run 748 dQ/ds

HV settings :
LEM 1, 3 and 12 at 26 kV/cm
LEM 10 at 25 kV/cm
Other LEMs at 28 kV/cm
Grid at 4.5 kV
Induction at 1 kV/cm



Events with more than 20 2D tracks reconstructed in either views are removed

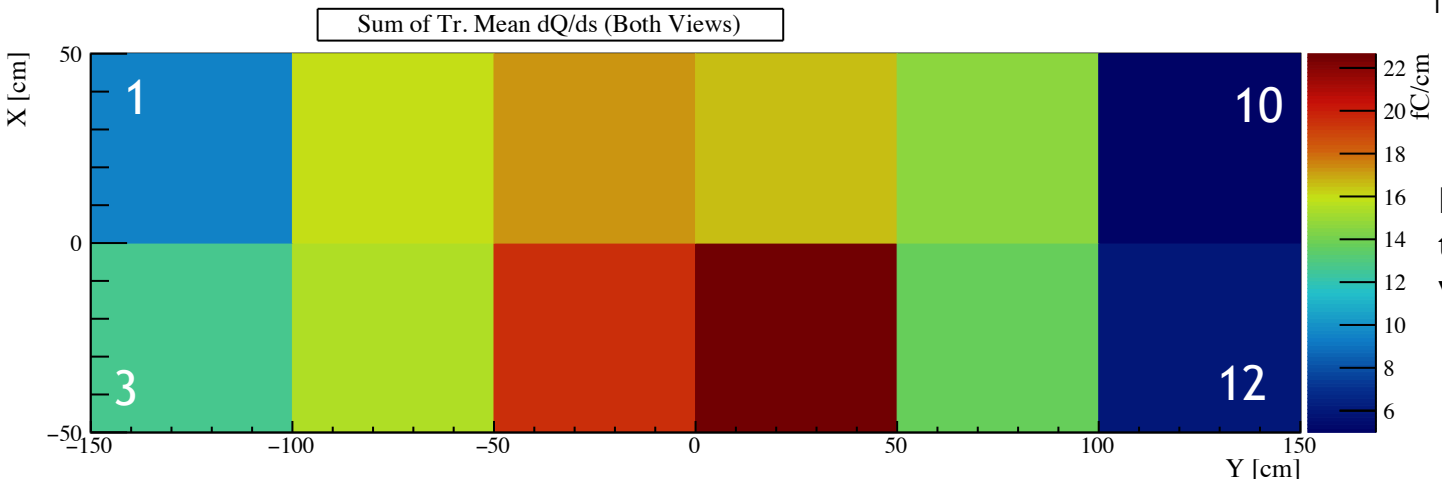


- Lower gain in corners LEMs

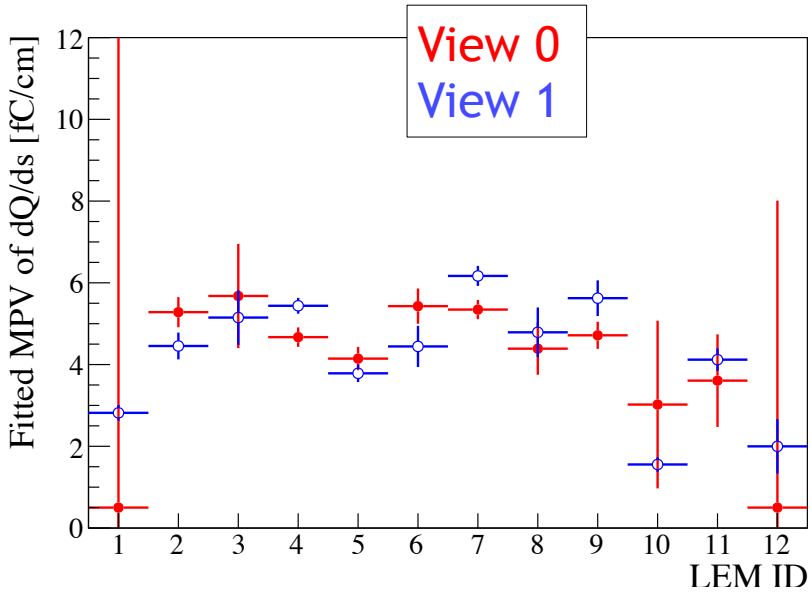
- Higher gain for LEM 2, 4 and 11
- MPV dQ/ds in View 1 > View 0
  ↳ differs from Slavic's results

run 766 dQ/ds [PMT trigger]

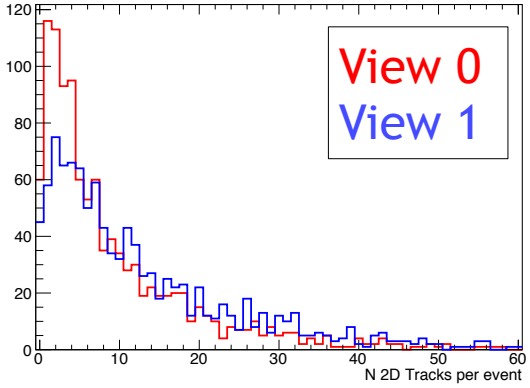
HV settings :
LEM 1, 3, 10, 12 at 24 kV/cm
Other LEMs at 28 kV/cm
Grid at 4. kV
Induction at 1. kV/cm



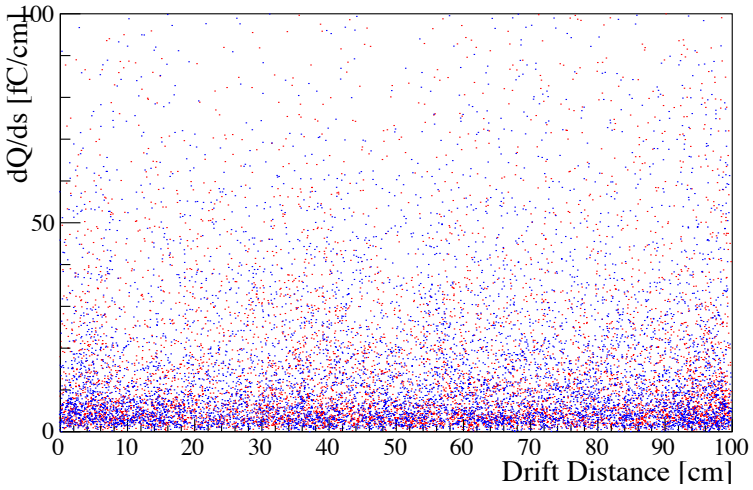
Events with more than 20 2D tracks reconstructed in either views are removed



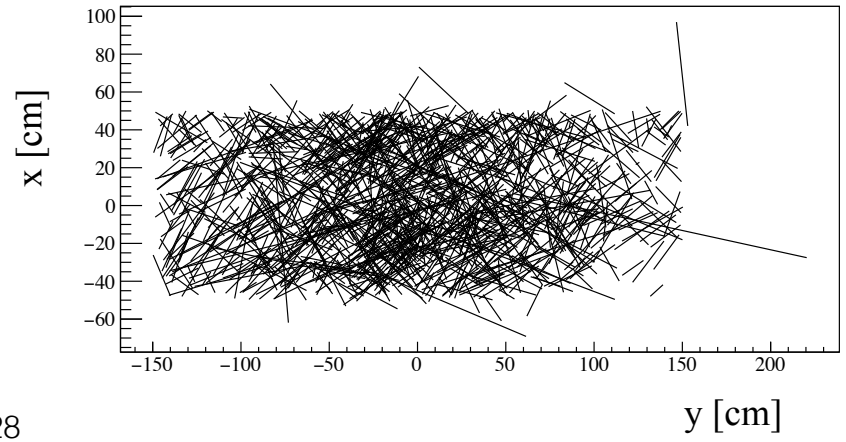
- Different gain pattern wrt to run 748
- Tracks are different (PMT Trigger), they are more vertical and more energetic
- Very preliminary result, as some fake 2D and 3D tracks might be found out of the energetic events



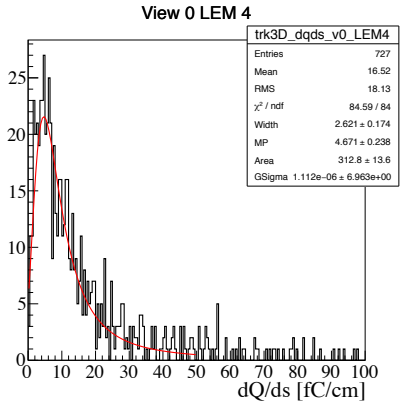
run 766 dQ/ds [PMT trigger]

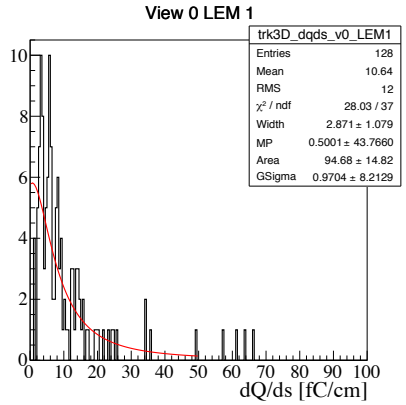


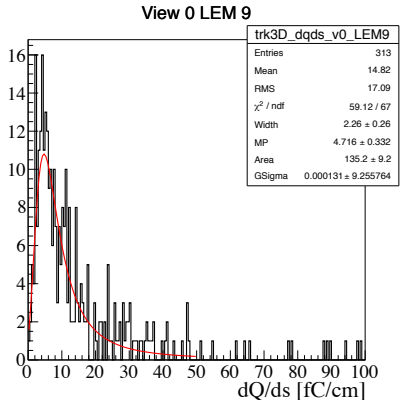
3D tracks

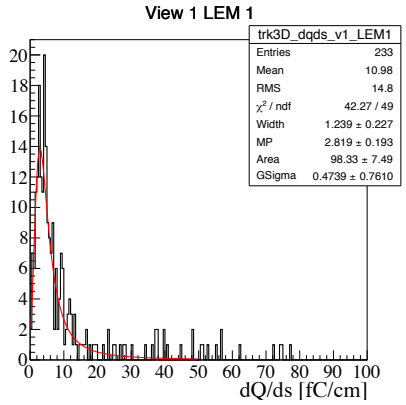


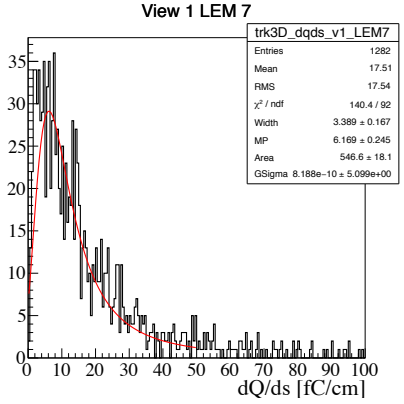
some of the dQ/ds fits

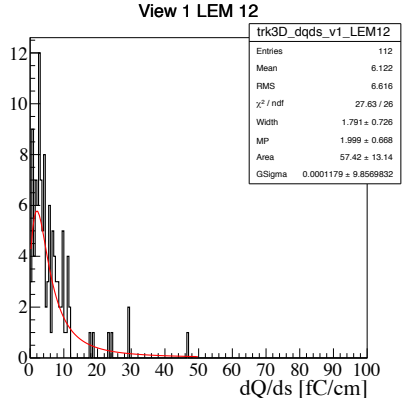










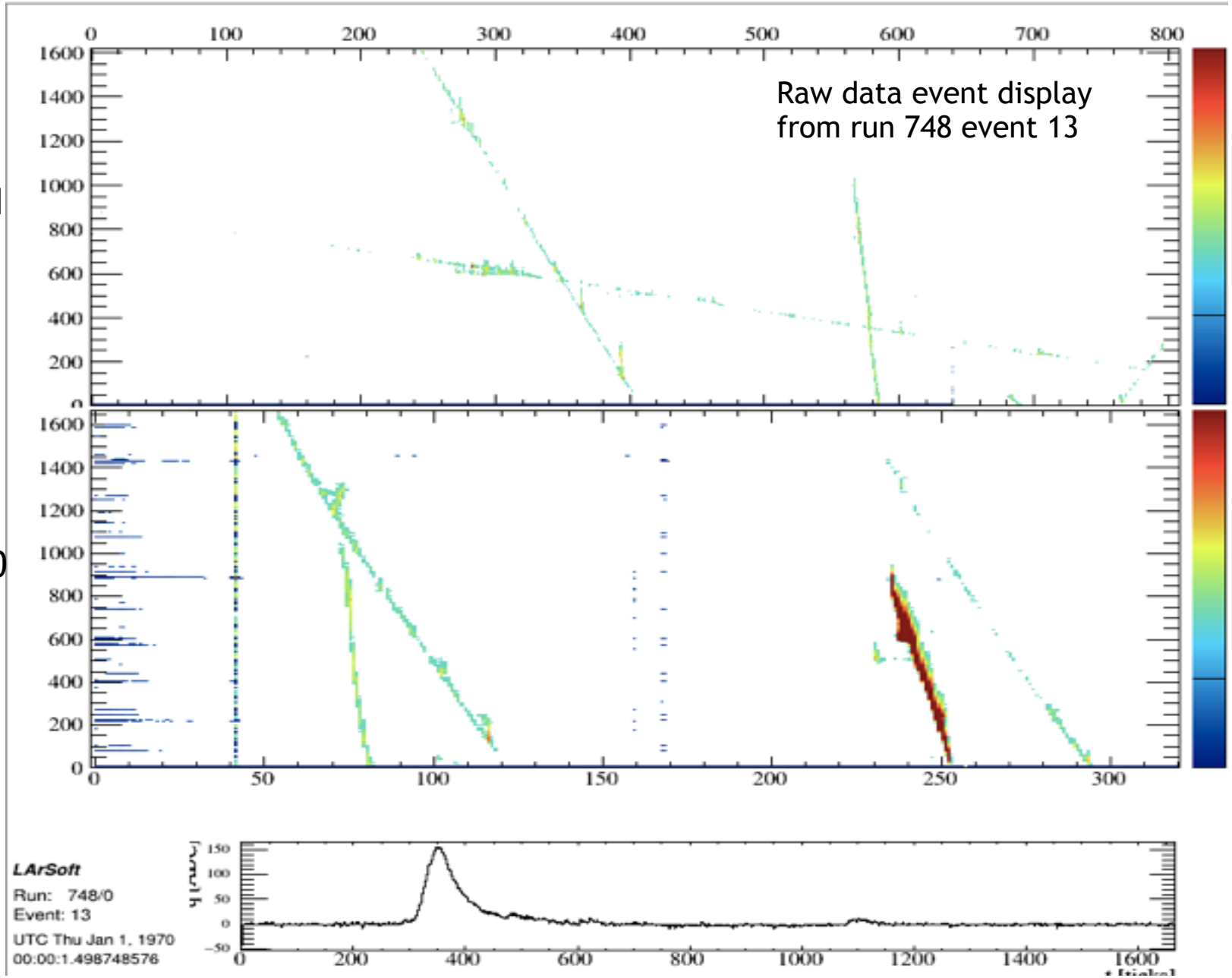


Current Status in LArSoft

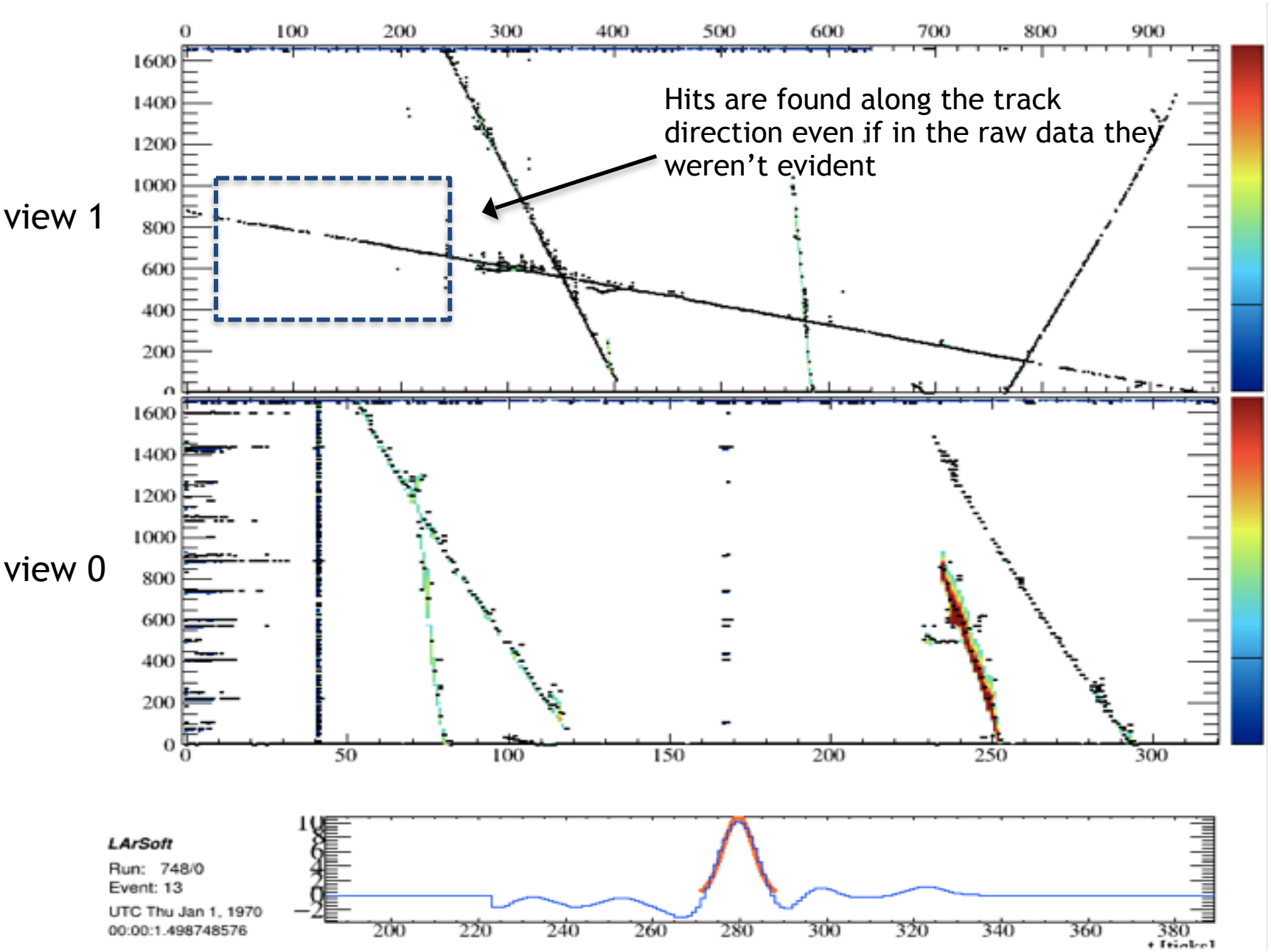
First try using LArSoft in the 3x1x1 configuration

- Data can be imported and converted to LArSoft friendly format.
- Standard LArSoft reconstruction is in place, alternative reconstruction tools for dual phase are under developments.
- Standard reconstruction can be run on real data: quality criteria must yet be defined. Gain and purity measurements requires ad-hoc tools not yet existing
- For this presentation, used LArSoft out the box without tuning reconstruction parameters
  - Deconvolution and "noise filtering" applied

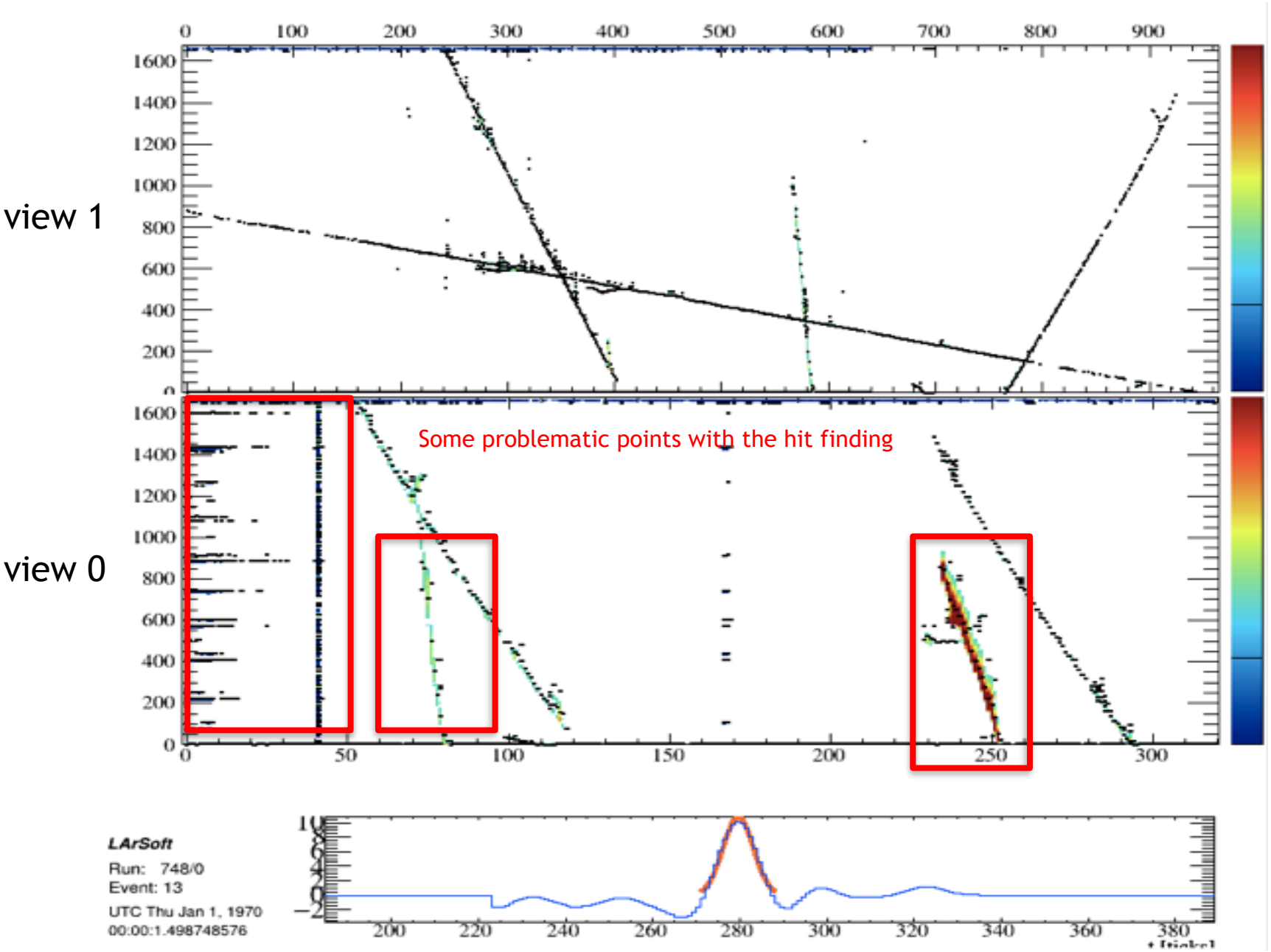
Raw data event display



Hit finding

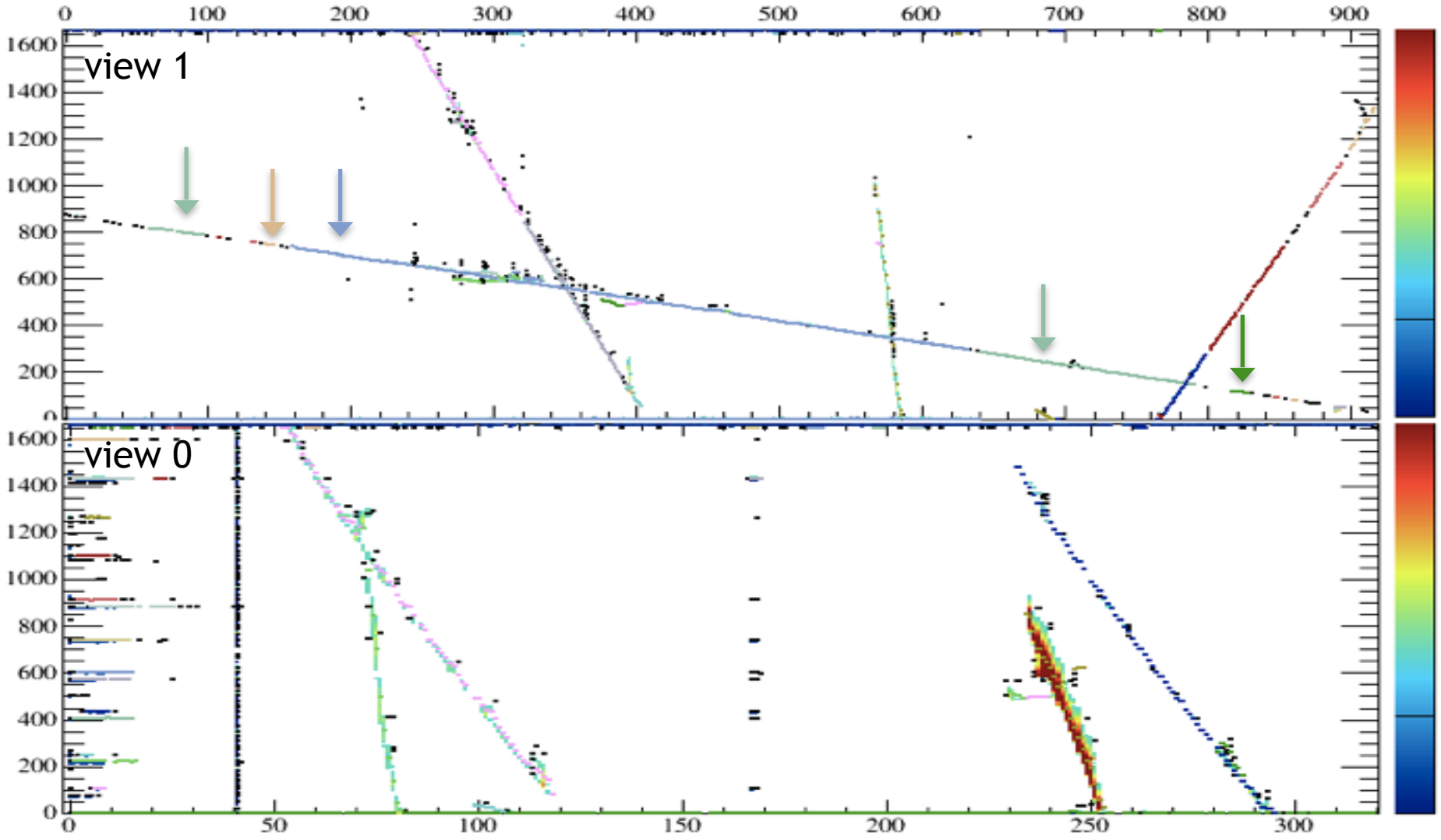

view 1
view 0
Hits are found along the track direction even if in the raw data they weren't evident
LArSoft
Run: 748/0
Event: 13
UTC Thu Jan 1, 1970
00:00:1.498748576

Hit finding – Issues

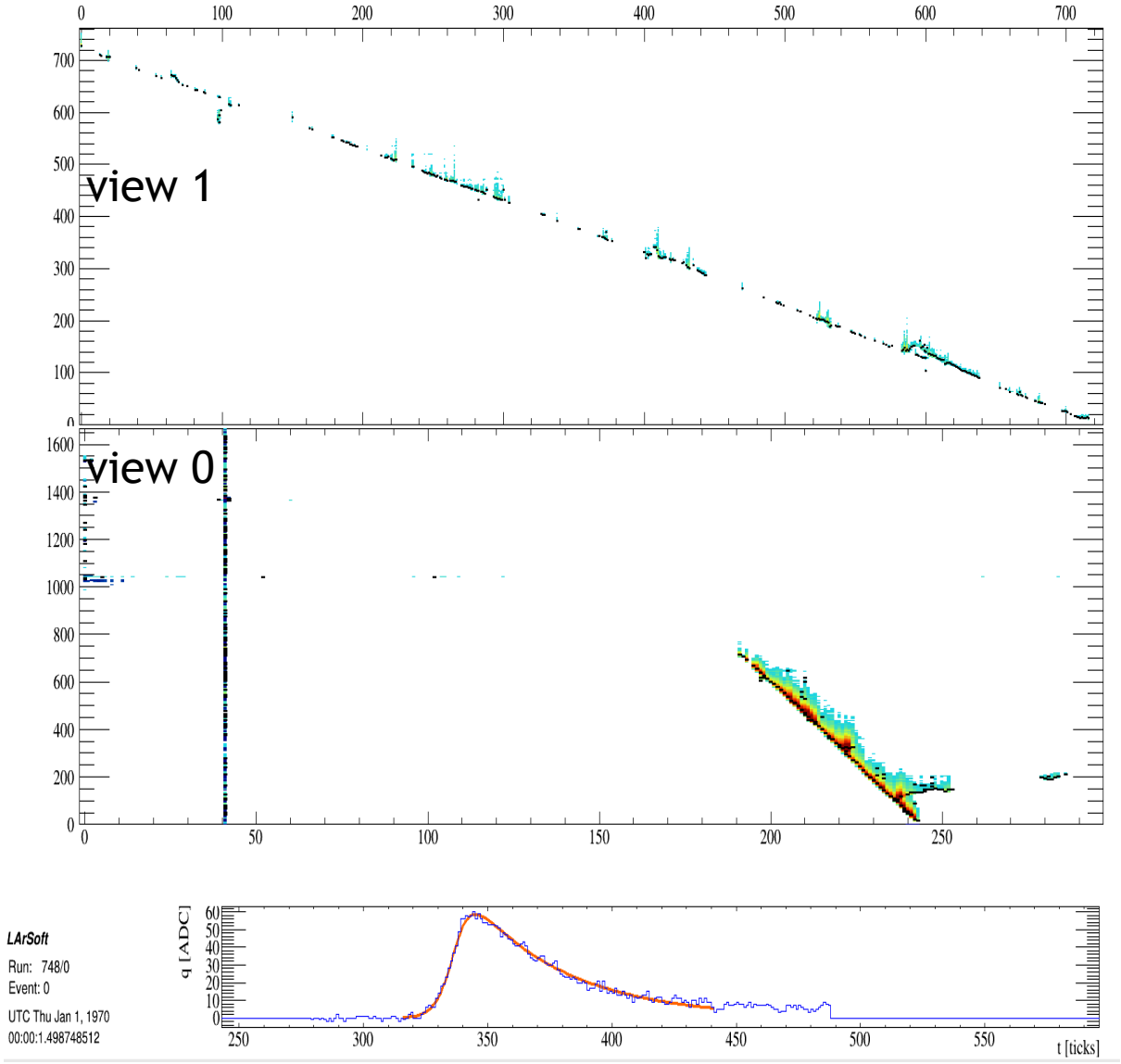


Cluster finding

Cluster finding results is quite good, although missing splits tracks into several clusters



Raw hit finding



Here threshold for fitting: 10 ADC counts.

Raw hit finding works on non convoluted signals.

- No noise filtering applied yet.
- Cleaner wire signal.
- No artifact from deconvolution.

- Key parameters to tune to avoid fitting noise hits:
  - ADC count threshold.
  - ADC sum of hit.
  - Length of hit.

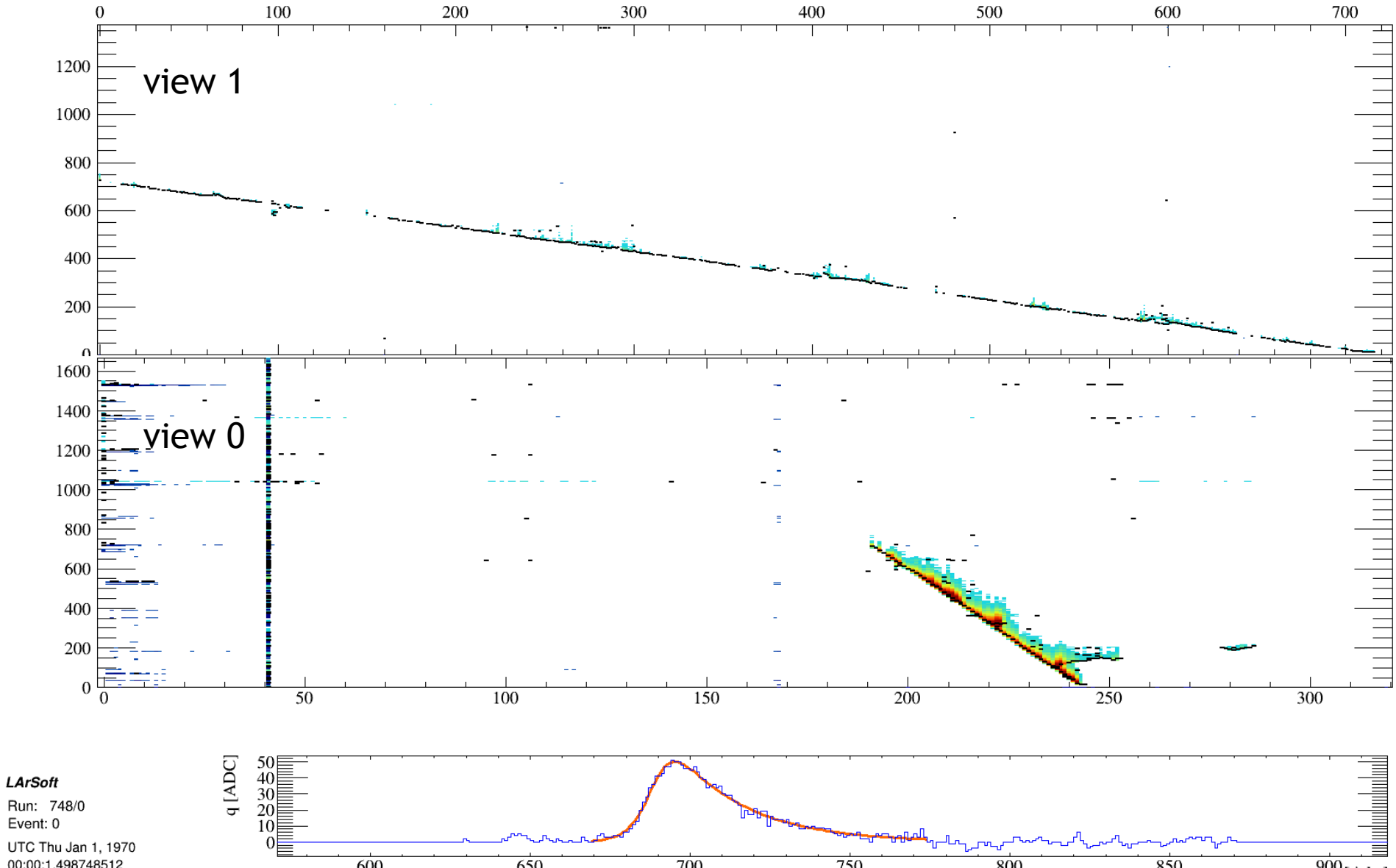
  More time still needed for tuning.

→ Under development

Raw hit finding

Threshold for fitting: 5 ADC counts.

More noise is fitted but tuning of other parameters (see previous slide) and noise filtering should get rid of this.



Plans

At the software level :

-With the current high voltage settings, the main problem is the hit finding as the gain is low :

- Investigate the noise reduction
- Could fitting hits help in Qscan ? (largely increase the reconstruction time)

-Investigate the highly energetic events in terms of cross talk

In QScan track finding code seems to be work fairly well. LArSoft reconstruction developments are on-going.

3D matching needs a better track reconstruction, in particular at the start and ending points.

At the data level :

- Take pulsing data to :
  - try to better understand the cross talk
  - Intercalibrate each channels
- We can clearly see the effect in terms of track reconstruction of the grid & LEM increasing voltage

Backup

Parameters used for the reconstruction so far

in Qscan/WA105_rectasks.config

Hit Finding :

```
PARA_CALI [1, 1, 0]
# adcThr sigThr siglow1 siglow2 padLeft padRight
PARA_ROI [5., 2.0, 0.5, -0.1, 5, 10]       #ROI
# relTh1 relTh2 absTh1 abs_Th2 dt(us) padLeft padRight  //
PARA_HIT [1., 4., 9999, 9999, 5.0, 10, 20]
```

Track Finding :

```
PARA_CLUSFILTER [12, 5., 3., 15, 0.256, 3., 6]
#To use the ClusFilter algorithm - General Tracks:
#parameters:
# 1: Min nb of point to make a track
# 2: Distance in x or y to search for new hit (in cm)
# 3: Distance in z to search for new hit (in cm)
# 4: Chi2 cut
# 5: uncertainty on hit position along drift (in cm)
# 6: pbeta guess to compute MS error (the lower the more conservative) (in GeV)
# 7: Nb of point for d-ray
#-------------------------------------------------------
PARA_CLUSVERT [5., 3., 0.3125]
#Optional - to look for vertical tracks
#The set of point are rotated by 90° (x/y becomes z and z becomes x/y)
#paramters
# 1: Distance in "x/y" to search for new hit (in cm)
# 2: Distance in "z" to search for new hit (in cm)
# 3: Uncertainty on hit position along "z" (in cm)
```

3D matching :

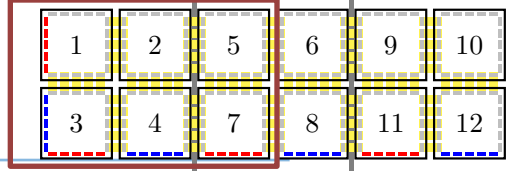
```
# 1: max endpoint Z difference between two views in cm
# 2: max charge balance difference between two views
# 3: time cut on association with T0 from PMT data in us
# 4: flag for T0 reco
#    -1 skip T0 reco
#     0 reco T0 from track position only
#     1 reco T0 and match with PMT data match
#     1 reco T0 and match with MC
PARA_TRKOANA [5.0, 0.4, 5.0, 0 ]
```

Standard reconstruction in LArSoft

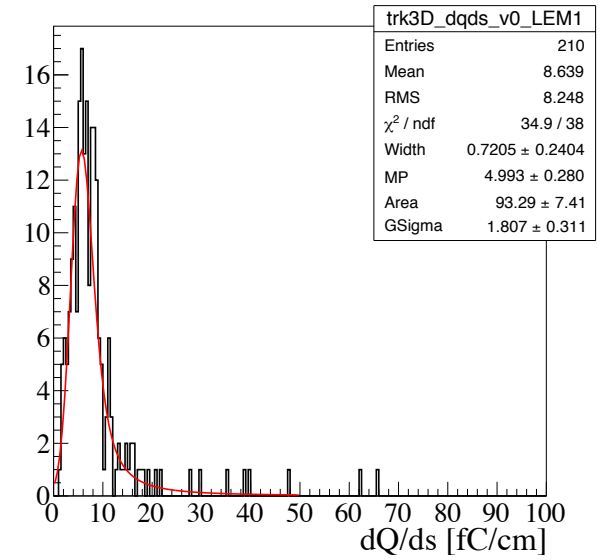
LArSoft module name	Reconstruction task	Used on real data
DataPrep	Creation of calibrated signals on wires: • Pedestal subtraction* • Deconvolution • FFT and noise corrections …	Yes
Gaushit	Standard hit finding fitting a gaussian function	Yes
Linecluster	Clustering the hits in straight lines. Used as starting point for track reconstruction	Yes
Pmtrack	3D track reconstruction	No
Blurred cluster and emshower	Clustering to find 2D shower and 3D shower reconstruction	No

*Not yet done at this level currently, but something already exists, just need to put it in place

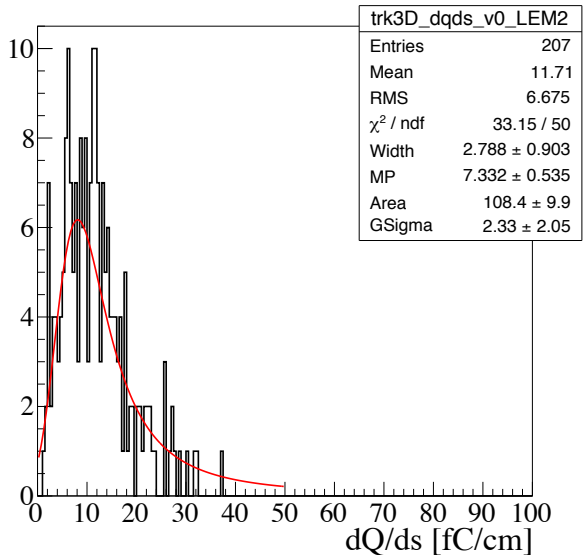
run 748 dQ/ds fits view 0



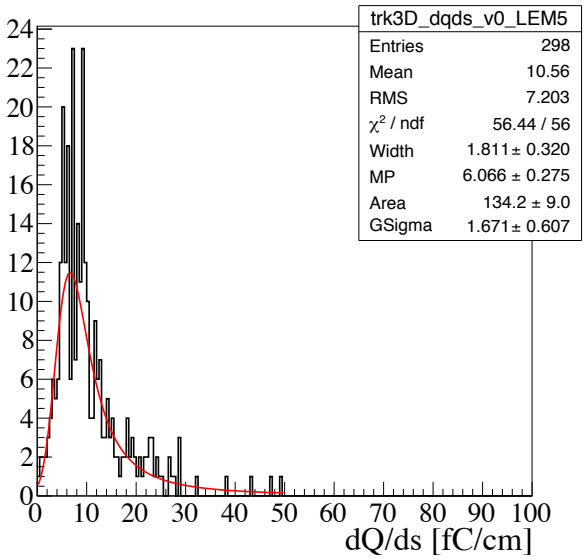
View 0 LEM 1



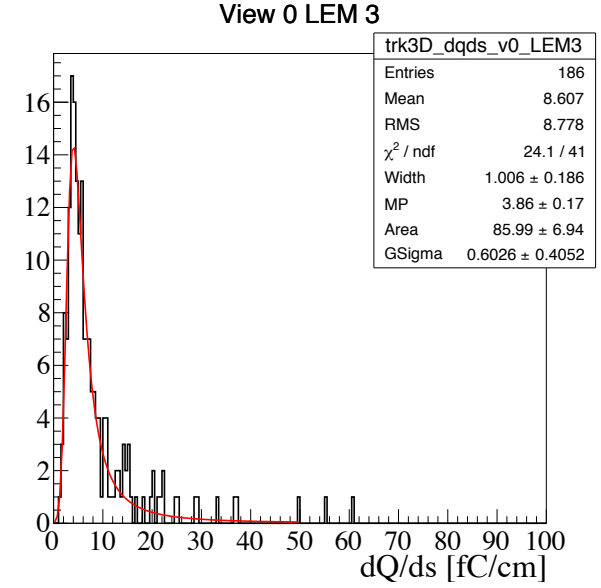
View 0 LEM 2



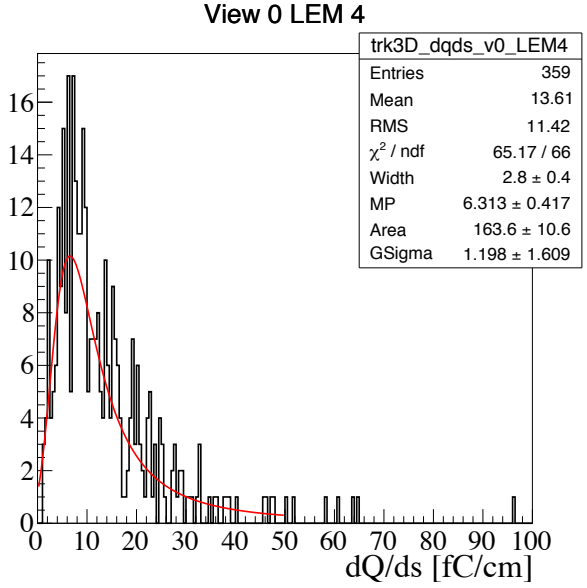
View 0 LEM 5



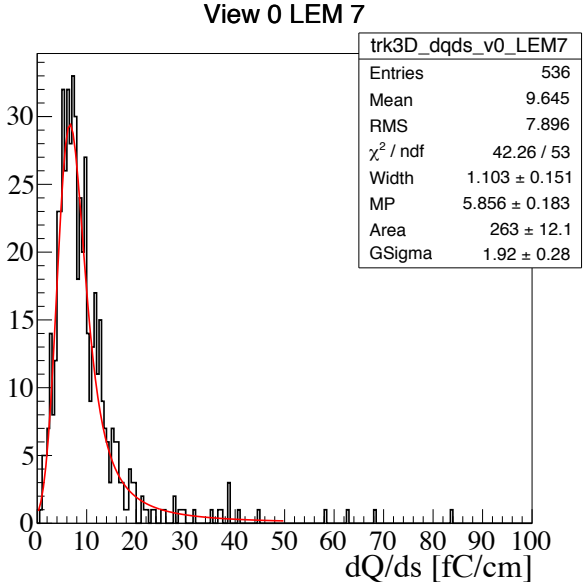
View 0 LEM 3



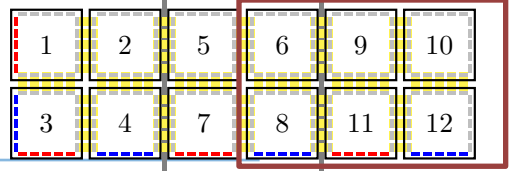
View 0 LEM 4



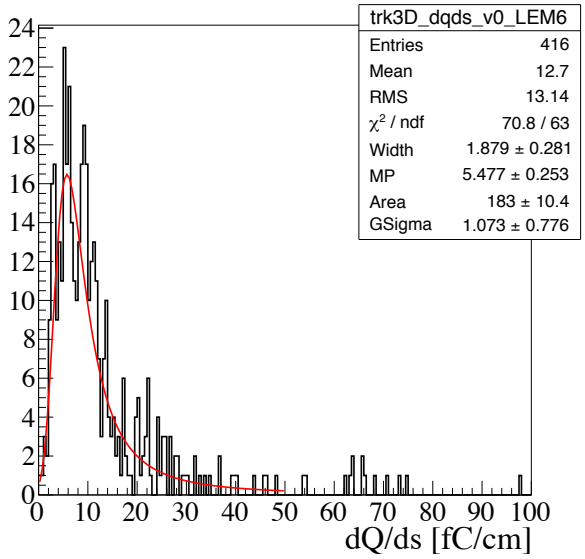
View 0 LEM 7



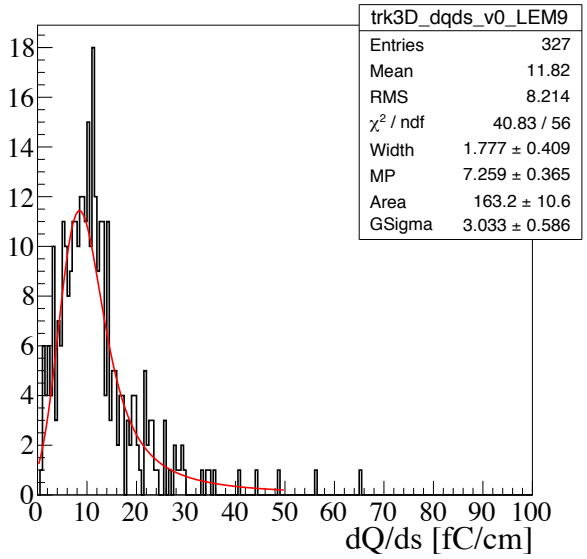
run 748 dQ/ds fits view 0



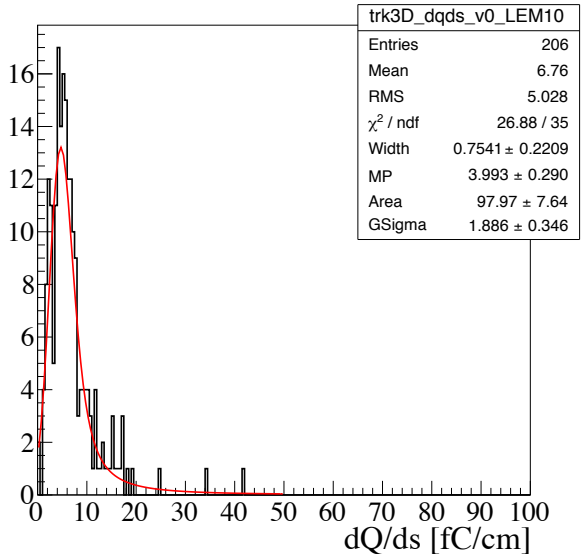
View 0 LEM 6



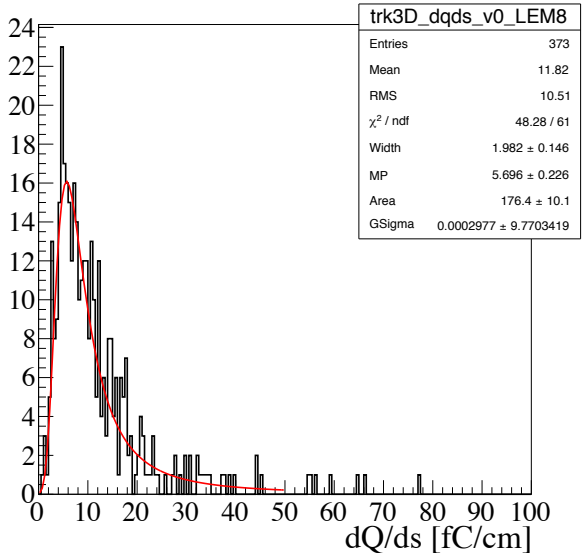
View 0 LEM 9



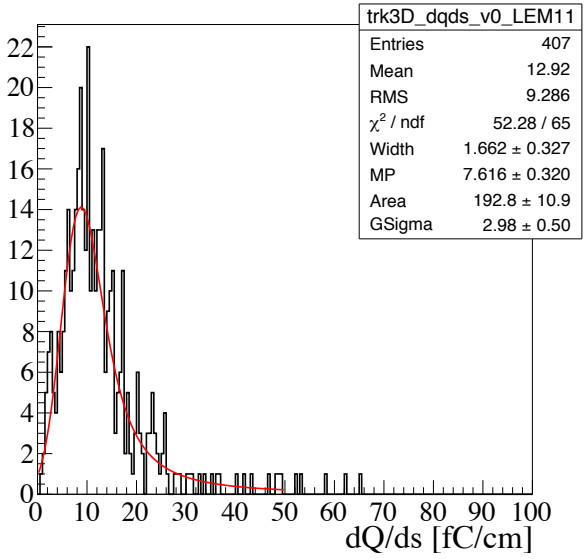
View 0 LEM 10



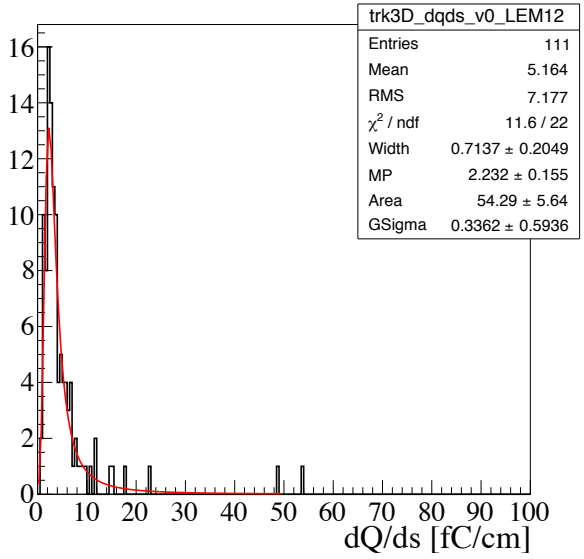
View 0 LEM 8



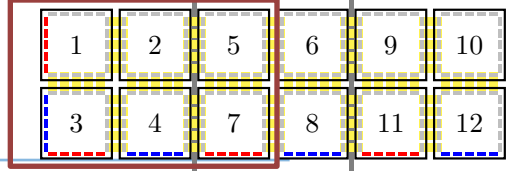
View 0 LEM 11



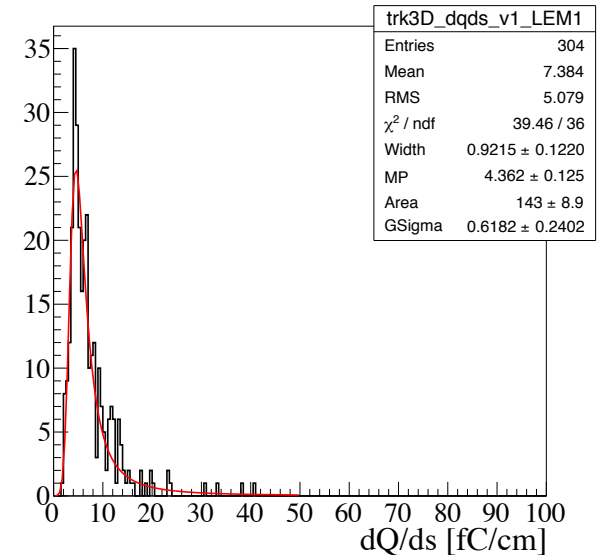
View 0 LEM 12



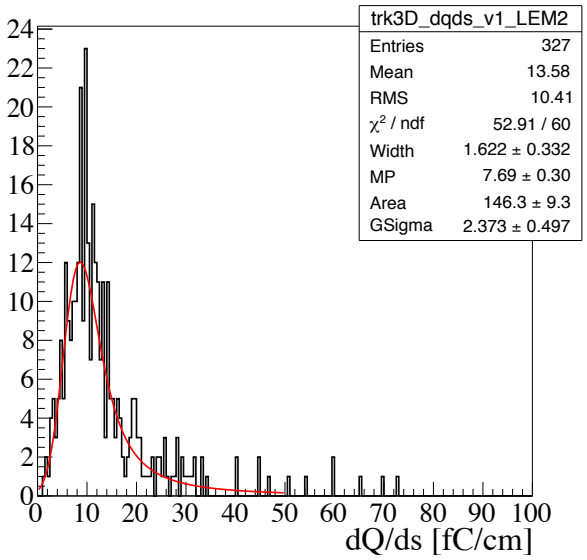
run 748 dQ/ds fits view 1



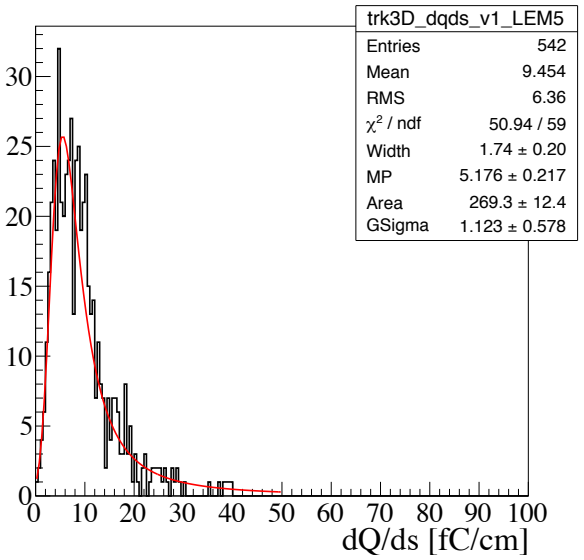
View 1 LEM 1



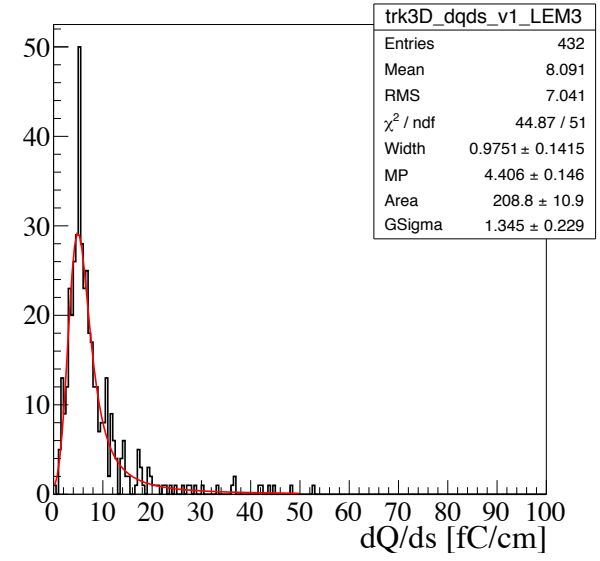
View 1 LEM 2



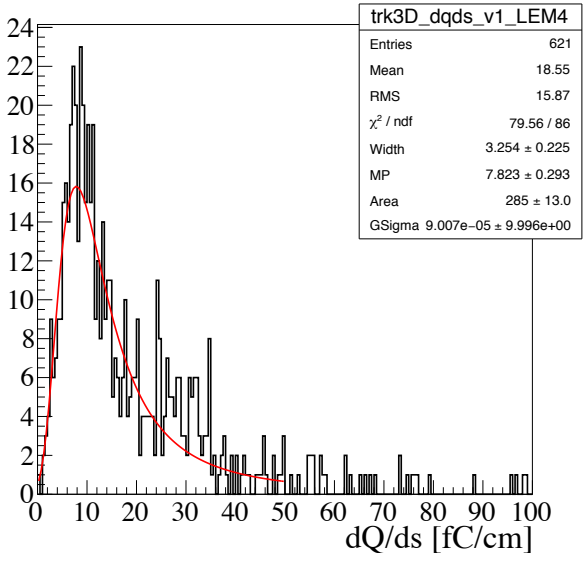
View 1 LEM 5



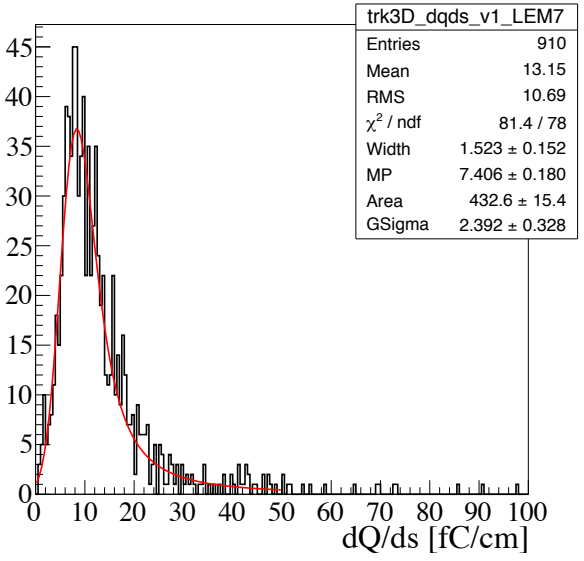
View 1 LEM 3



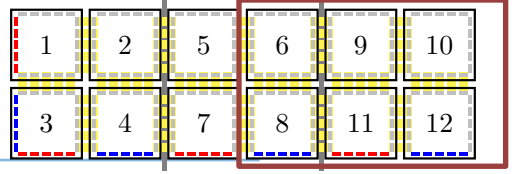
View 1 LEM 4



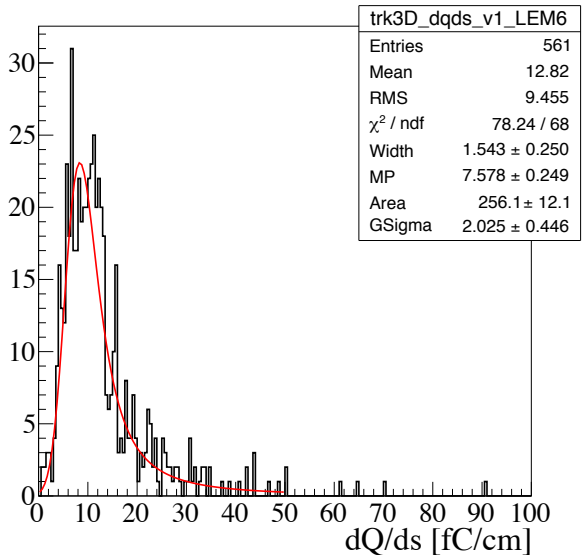
View 1 LEM 7



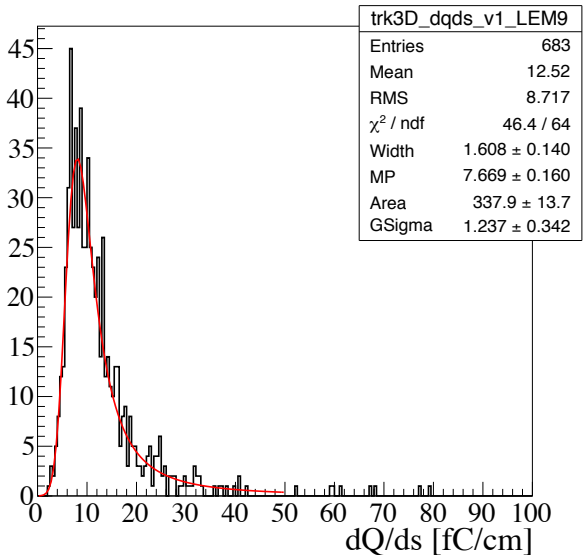
run 748 dQ/ds fits view 1



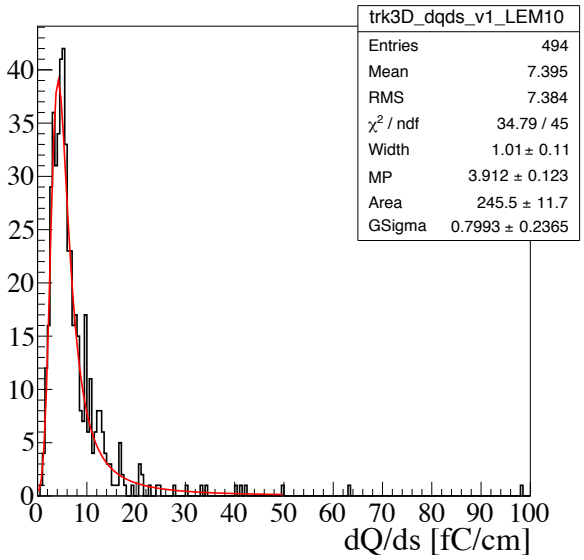
View 1 LEM 6



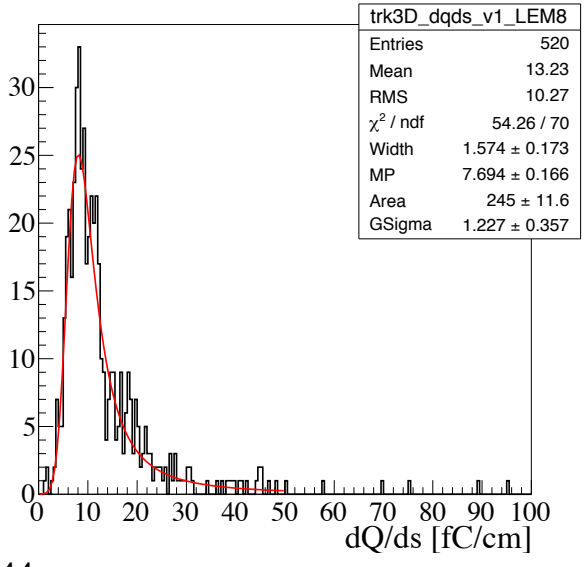
View 1 LEM 9



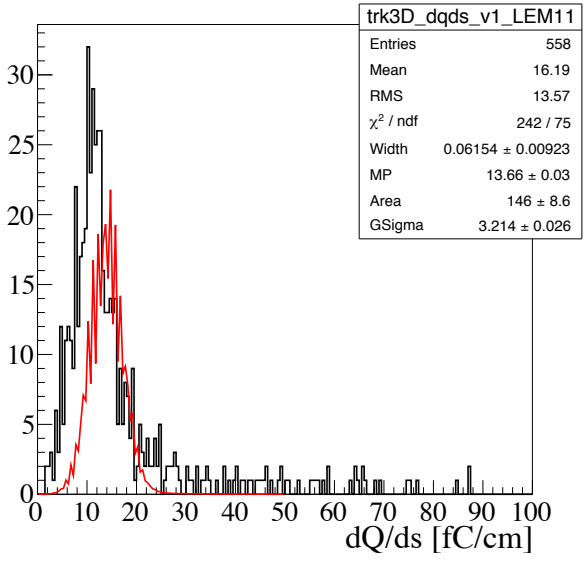
View 1 LEM 10



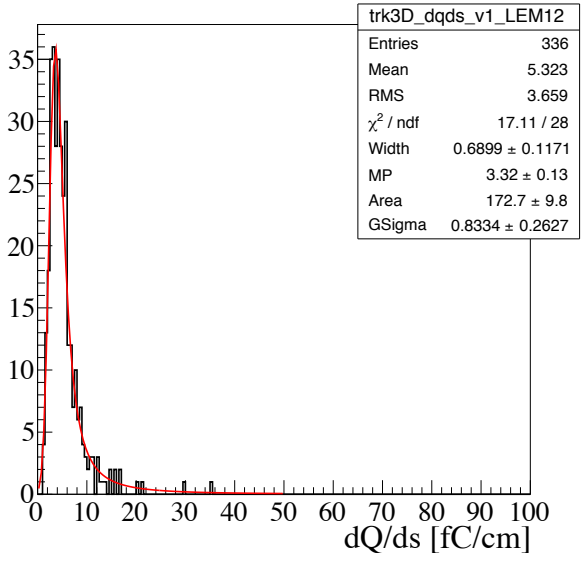
View 1 LEM 8



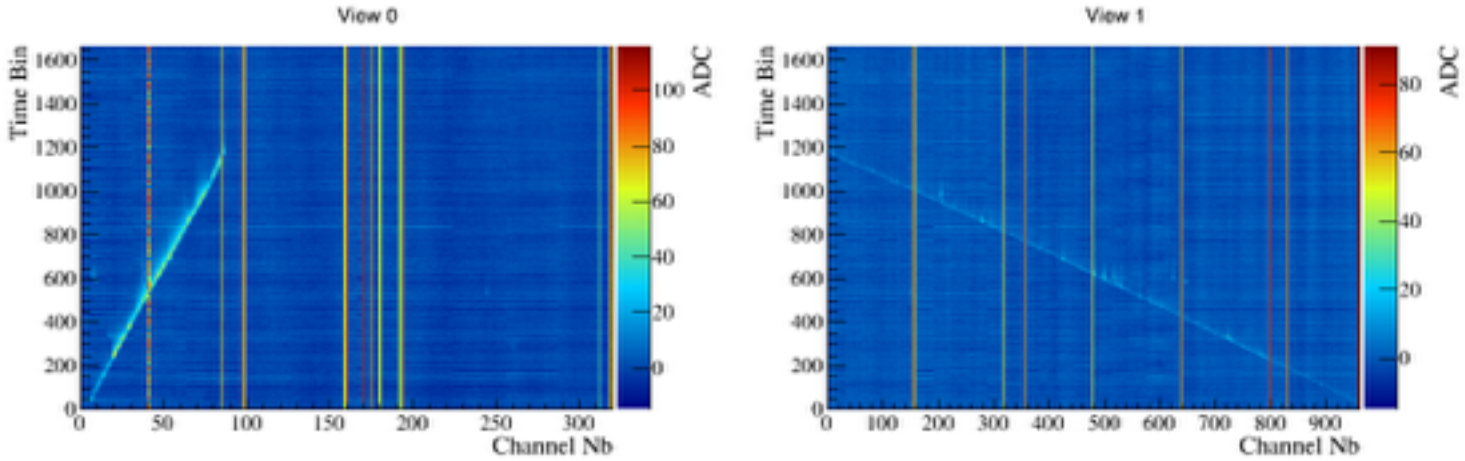
View 1 LEM 11



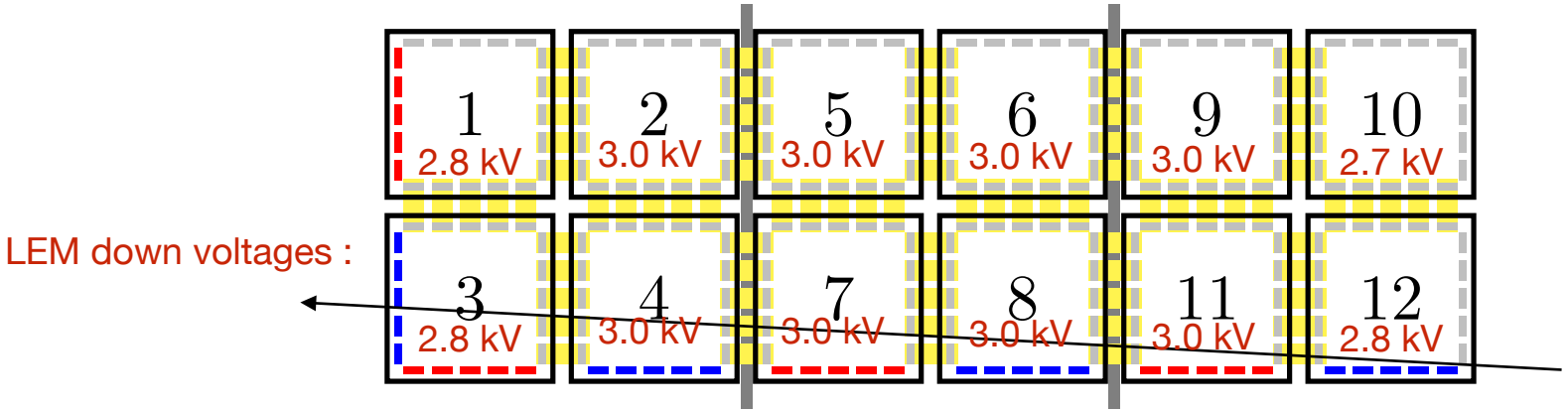
View 1 LEM 12



Example - run 748, event 42

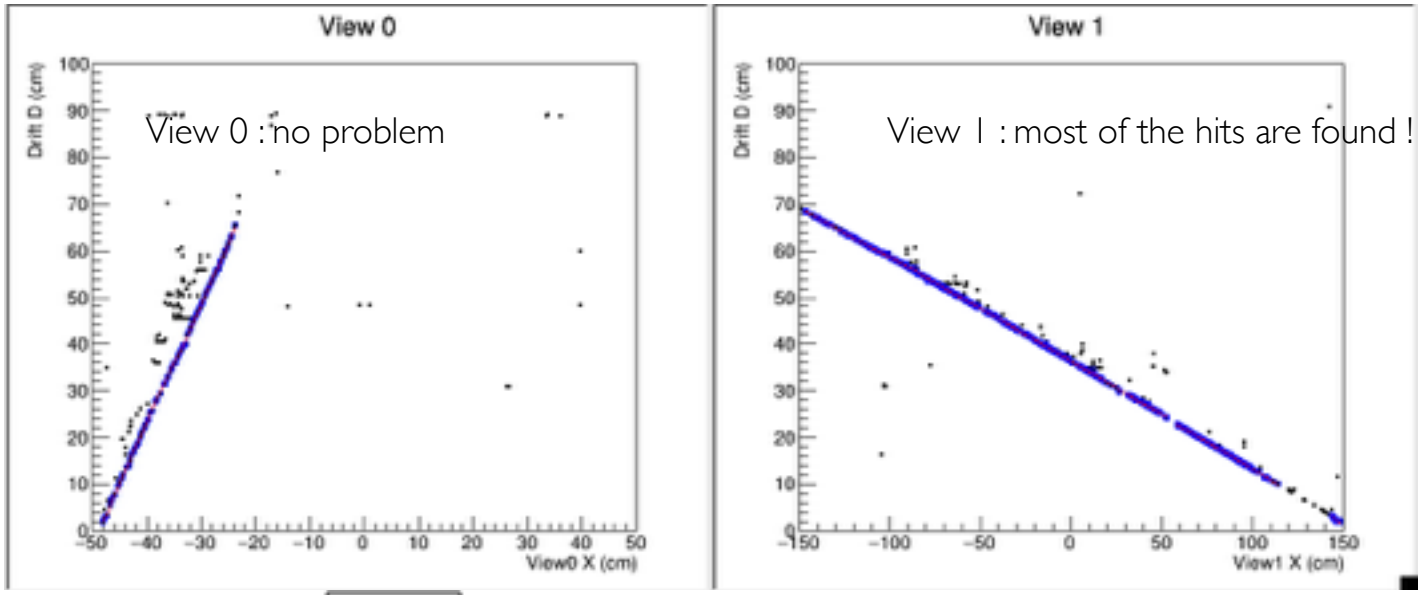


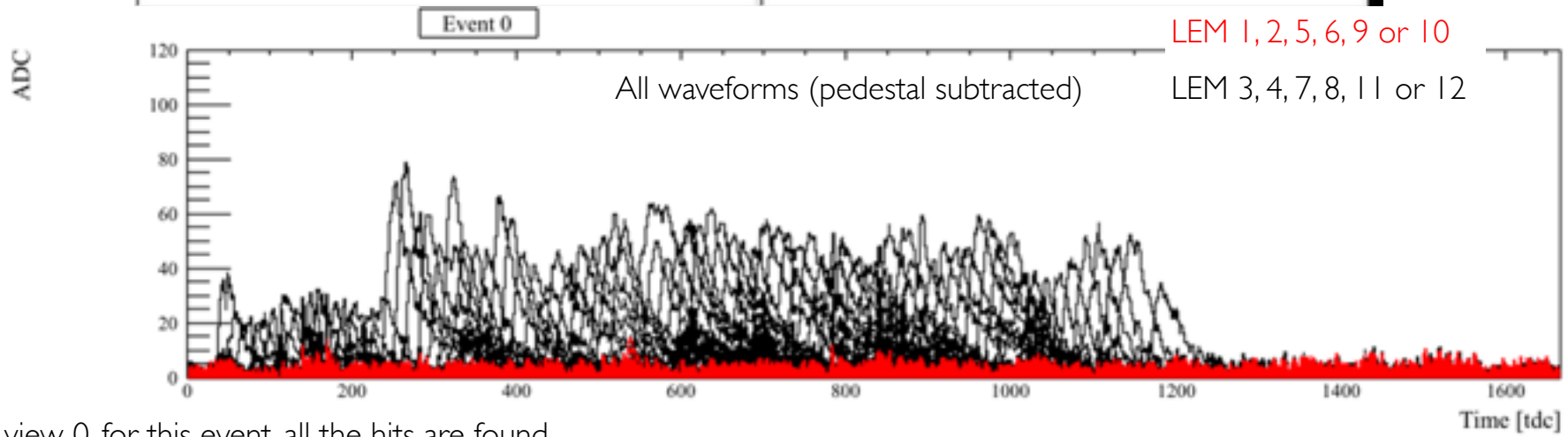
Other nice because it crosses only one side of the detector and part of view 1 :



Example - run 748, event 42 - view 0

red : found track
blue : hits associated to a track
black : un-associated hits





LEM 1, 2, 5, 6, 9 or 10

LEM 3, 4, 7, 8, 11 or 12

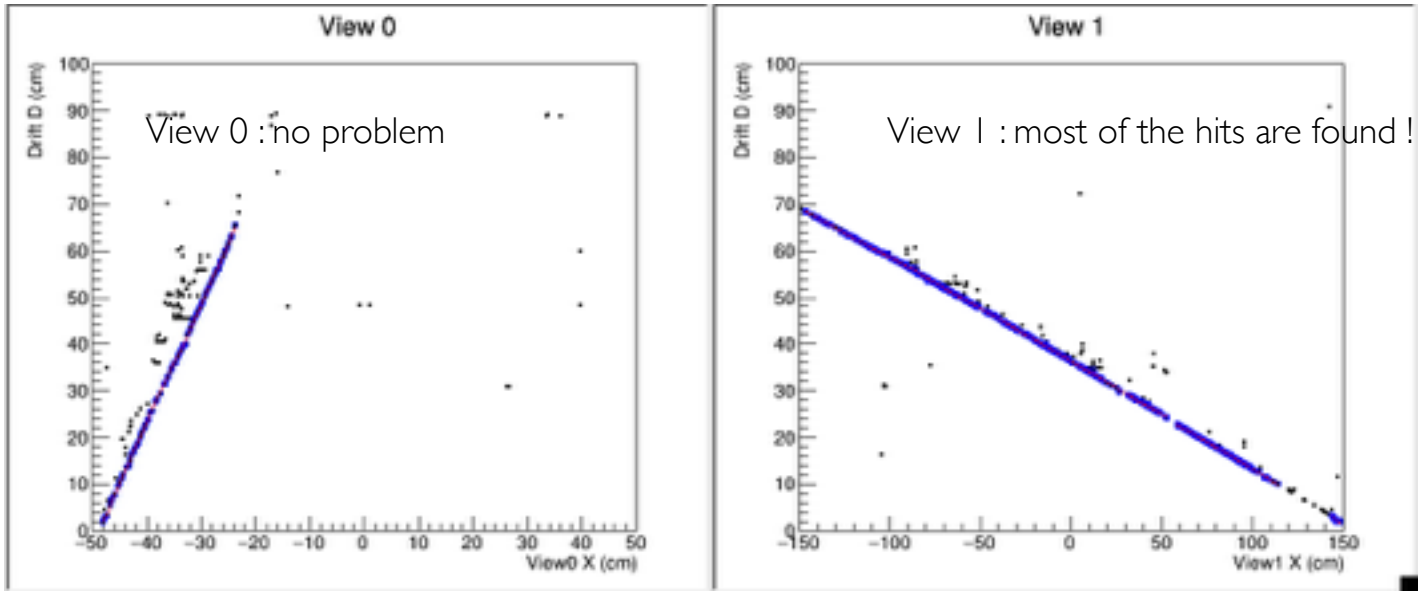
In view 0, for this event, all the hits are found.

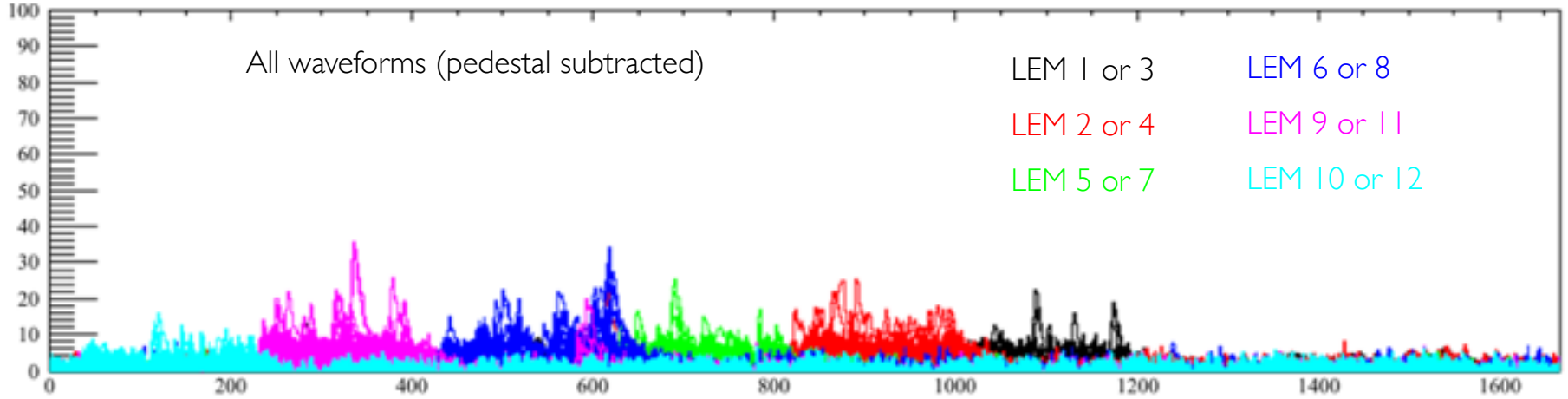
But the shape of the waveforms do not follow the expected attenuation trend due to the different LEM configuration

→At this moment, it is difficult to perform purity analysis

Example - run 748, event 42 - view 1

red : found track
blue : hits associated to a track
black : un-associated hits





Within a LEM, the response seems to be not uniform → could it be due to the LEM thickness ?

we can clearly see the difference in voltages applied in LEM 3 and 12 wrt to the others