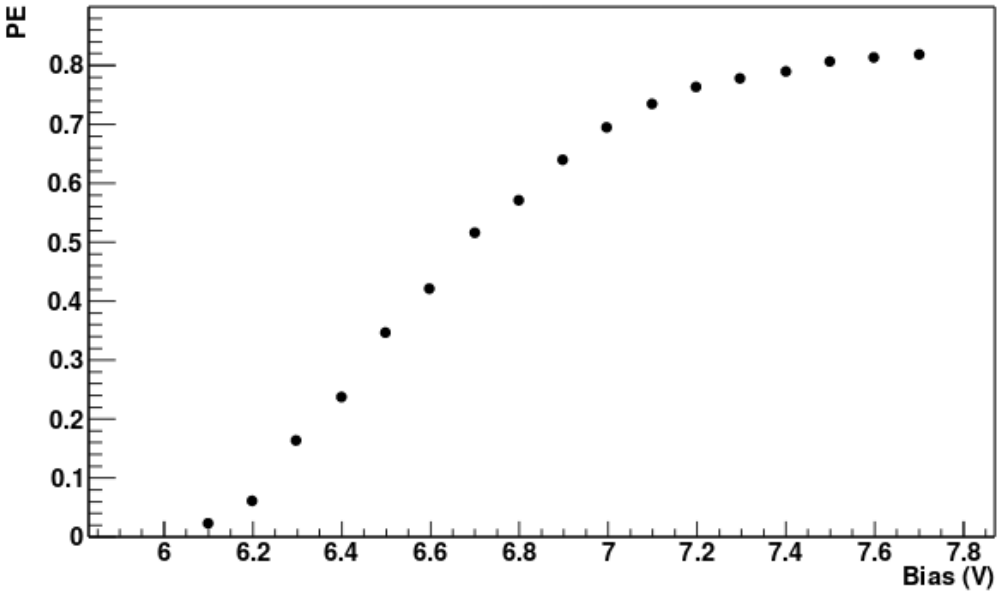
(Signal) and Noise Handling

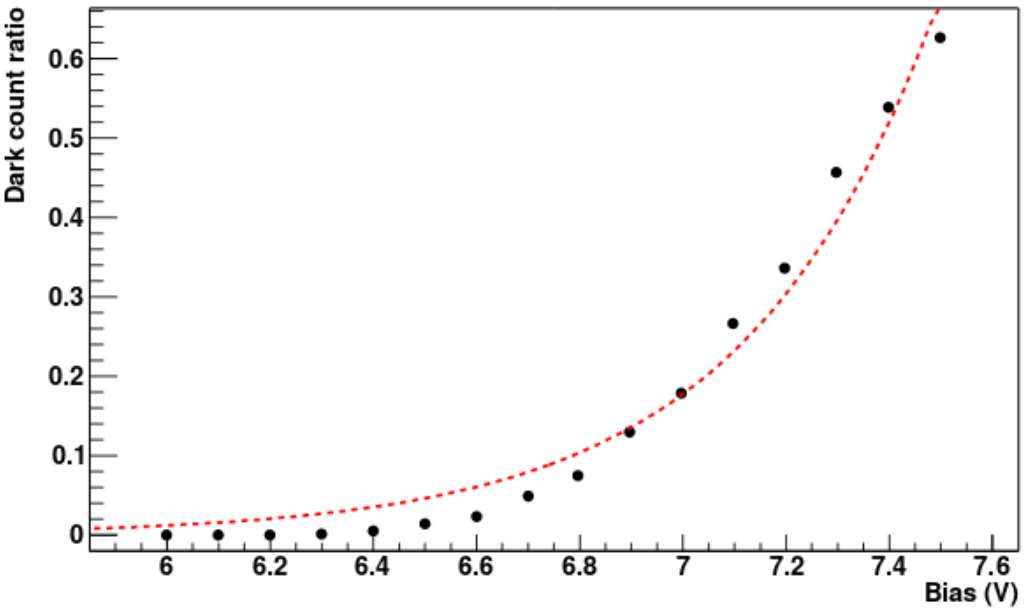
- Photo-Detection (VLPC) Characteristic & Operation
- Light Yield
- Space point generation (with noise)

VLPC Characteristics

We use Visible Light Photon Counters from DØ to detect light from the fiber tracker. These devices:

- Operate at 9-10K
- Have a high quantum efficiency (0.8)
- Have a High singles rate (100kHz)



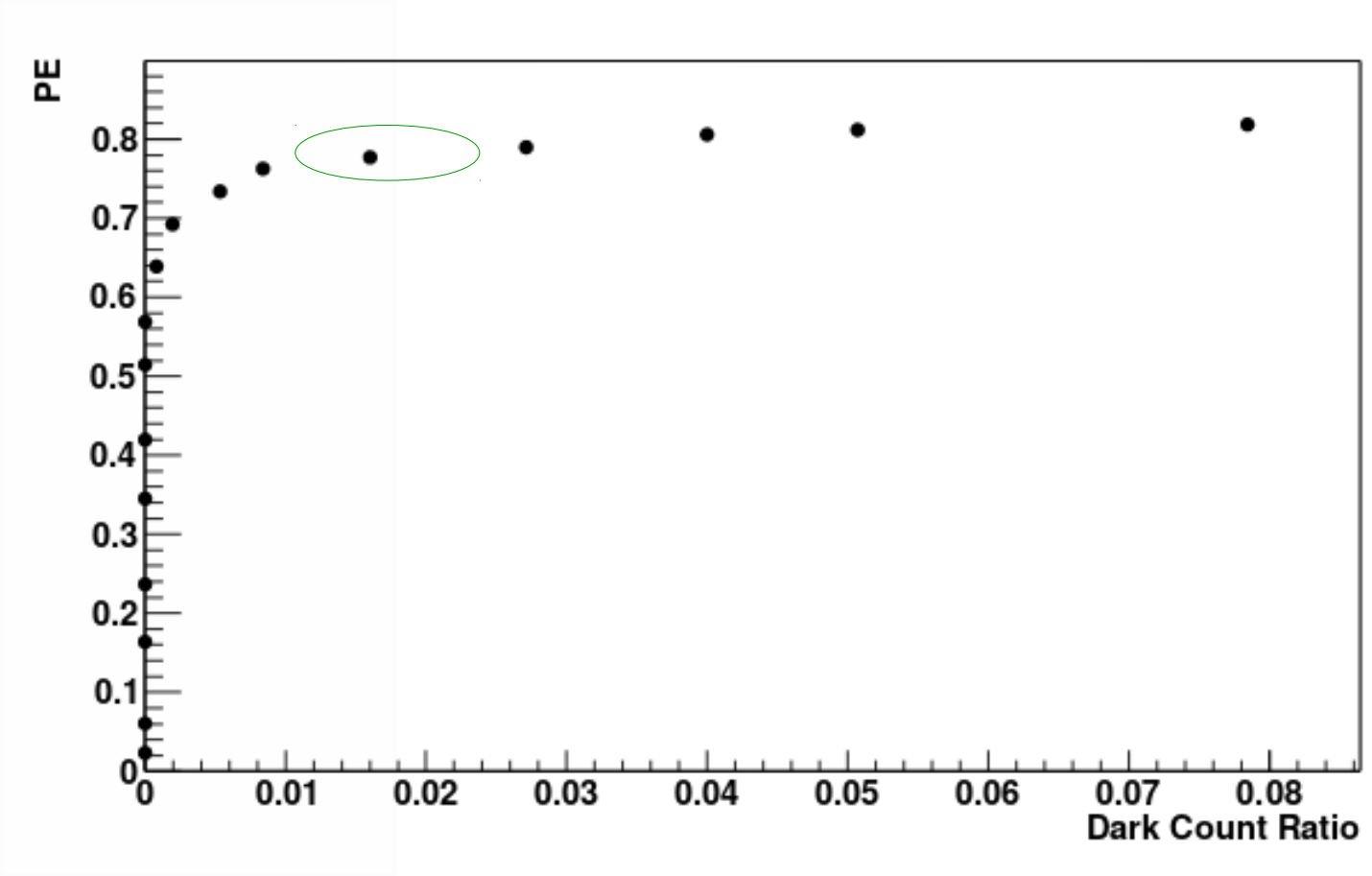


Note: Dark count ratio is the probability of finding a noise hit within a ~180ns gate.

Plots from D. Adey Thesis, p81

https://www2.warwick.ac.uk/fac/sci/physics/staff/academic/boyd/stuff/david_adey_phdthesis_librarycopy_2012.pdf

VLPC Operation

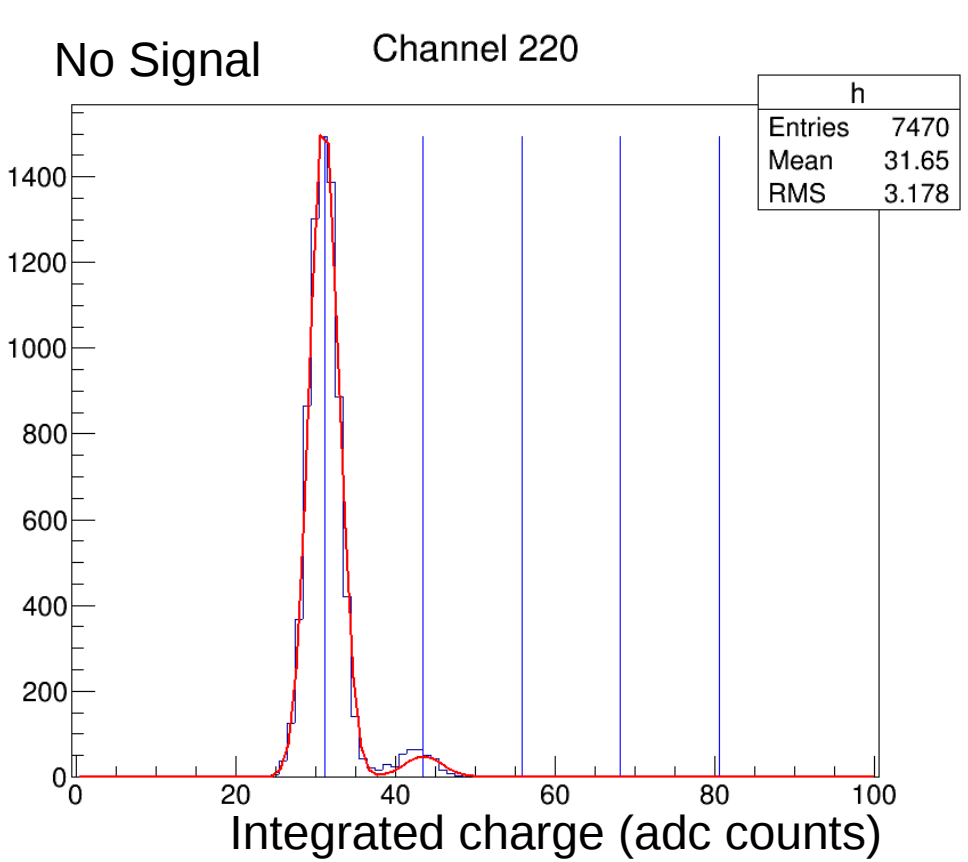


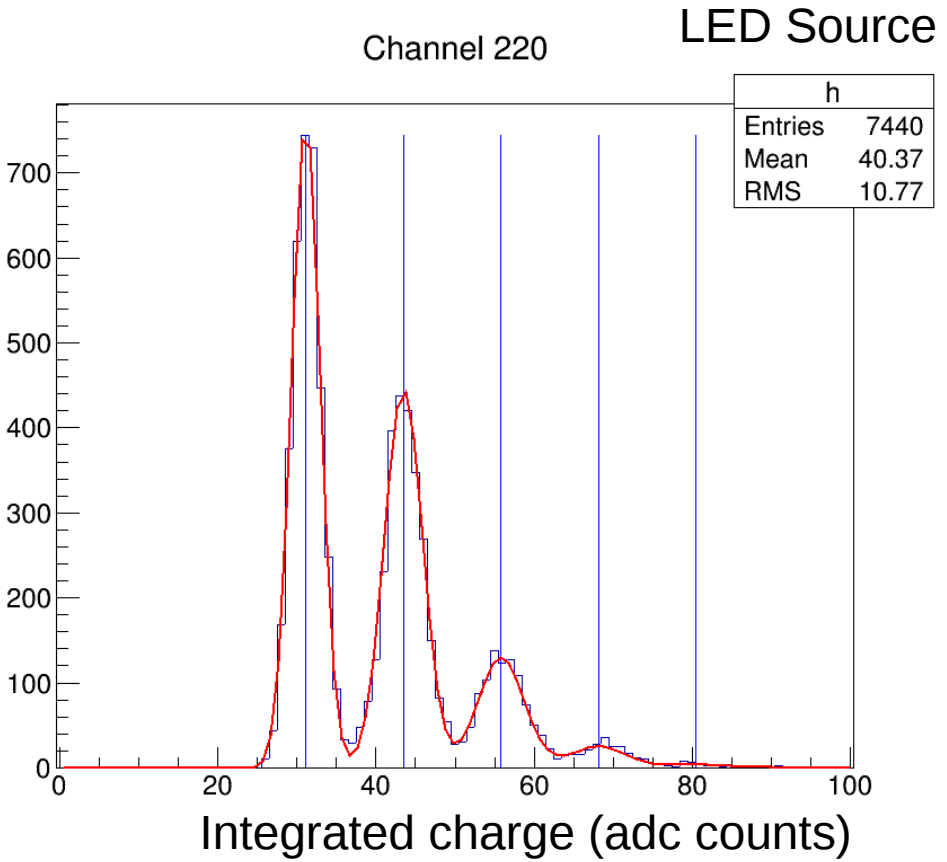
- Optimize bias so that we have a good Quantum Efficiency, with lowest noise
- It is a balancing game, and a lower noise would also lower efficiency.

Plots from D. Adey Thesis, p81

https://www2.warwick.ac.uk/fac/sci/physics/staff/academic/boyd/stuff/david_adey_phdthesis_librarycopy_2012.pdf

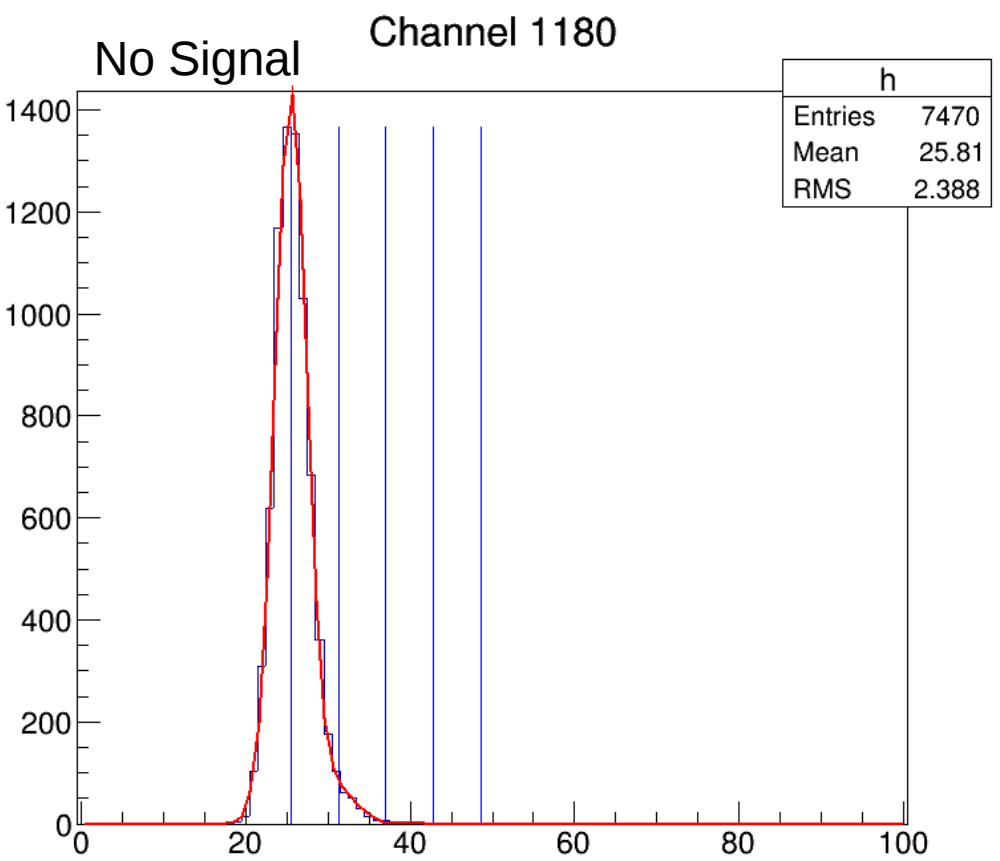
VLPC Operation

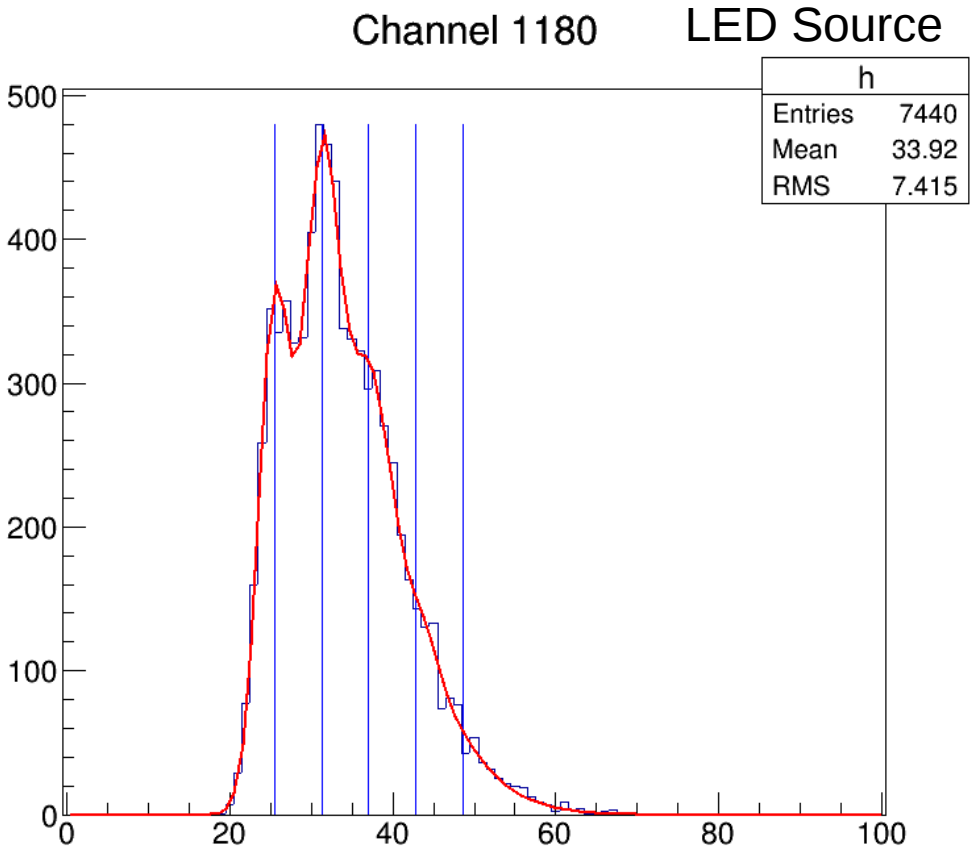




- VLPCs are calibrated using LED source

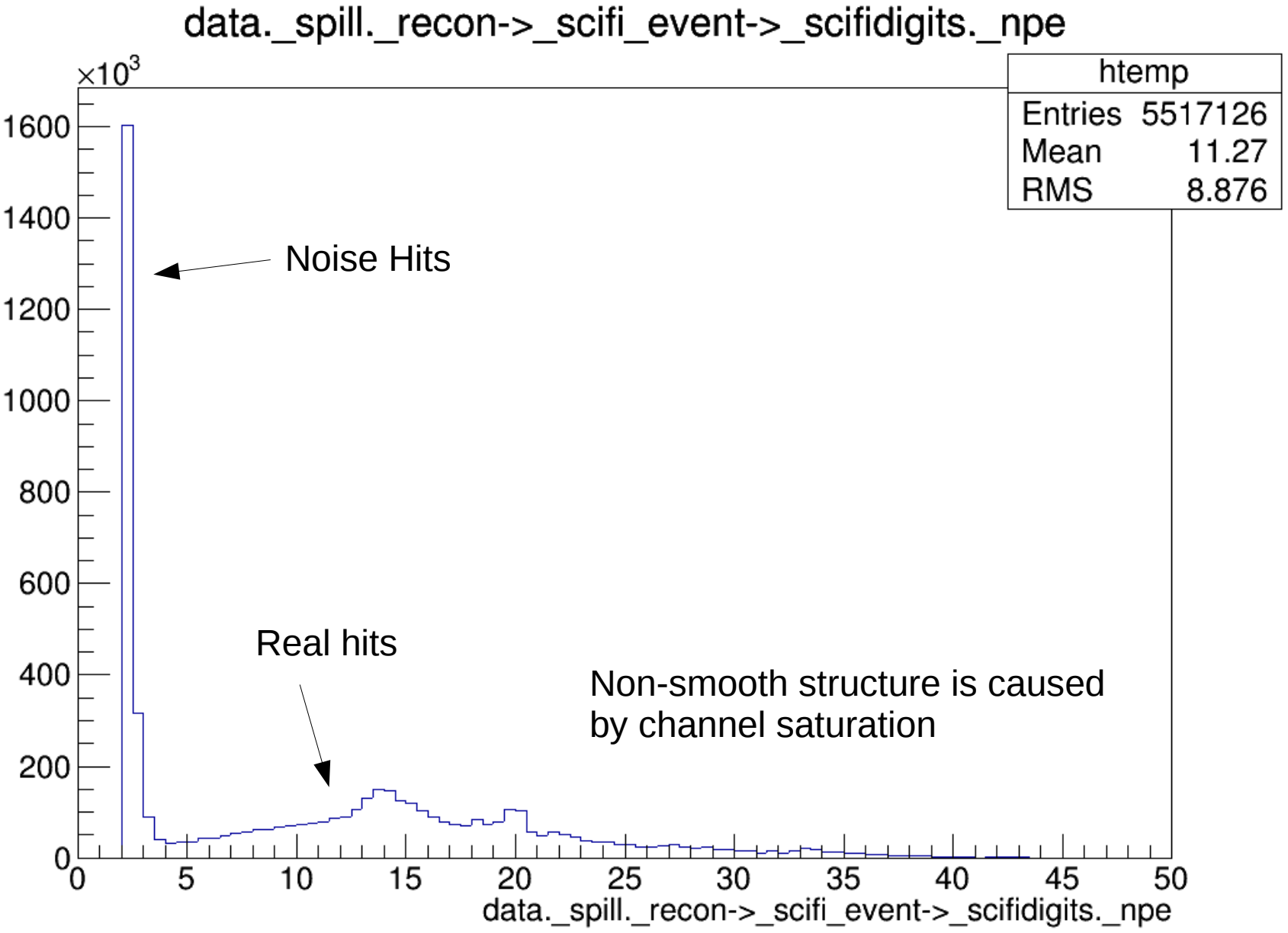
VLPC Operation





- Some channels are much lower gain, which makes calibration more difficult
- Fit function produces a high chi square when it fails, which allows efficient verification of the calibration.
- These low gain channels are probably more noisy, just from the peak widths.

Light Yield


data._spill._recon->_scifi_event->_scifidigits._npe
htemp
Entries 5517126
Mean 11.27
RMS 8.876
×10^3
1600
1400
1200
1000
800
600
400
200
0
Noise Hits
Real hits
Non-smooth structure is caused
by channel saturation
0
5
10
15
20
25
30
35
40
45
50
data._spill._recon->_scifi_event->_scifidigits._npe

Space point generation

- Digits:
  - Generated if >2.0 pe is seen in the channel
  - Probability for hit from noise is 0.1 per plane per trigger

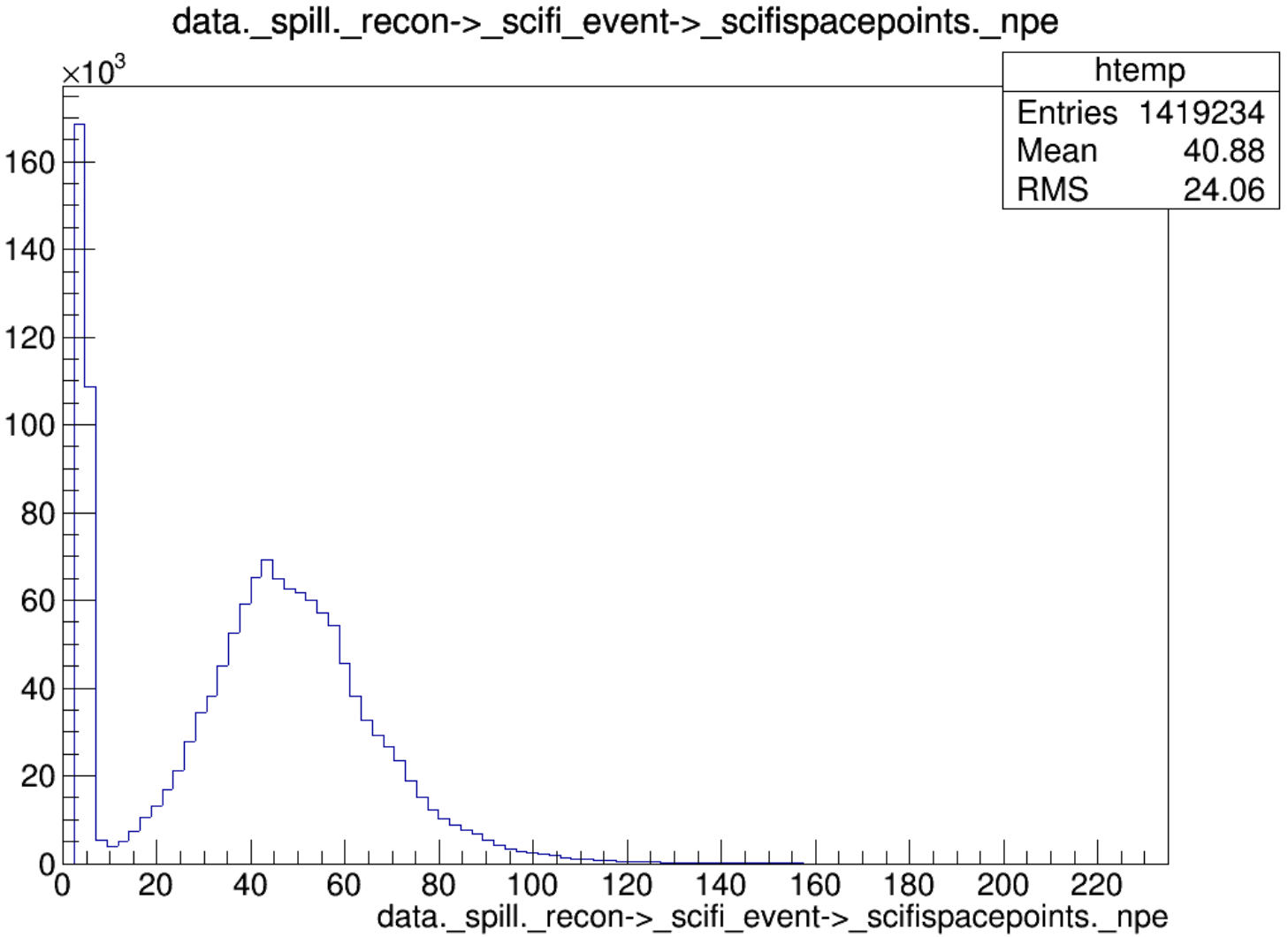
- Clusters:
  - Combine neighboring digits.

- Spacepoints:
  - First: attempt to assemble triplet space points, from 3 intersecting planes.
    - Probability for ‘fake’ from noise is 7E-6 per station per trigger.

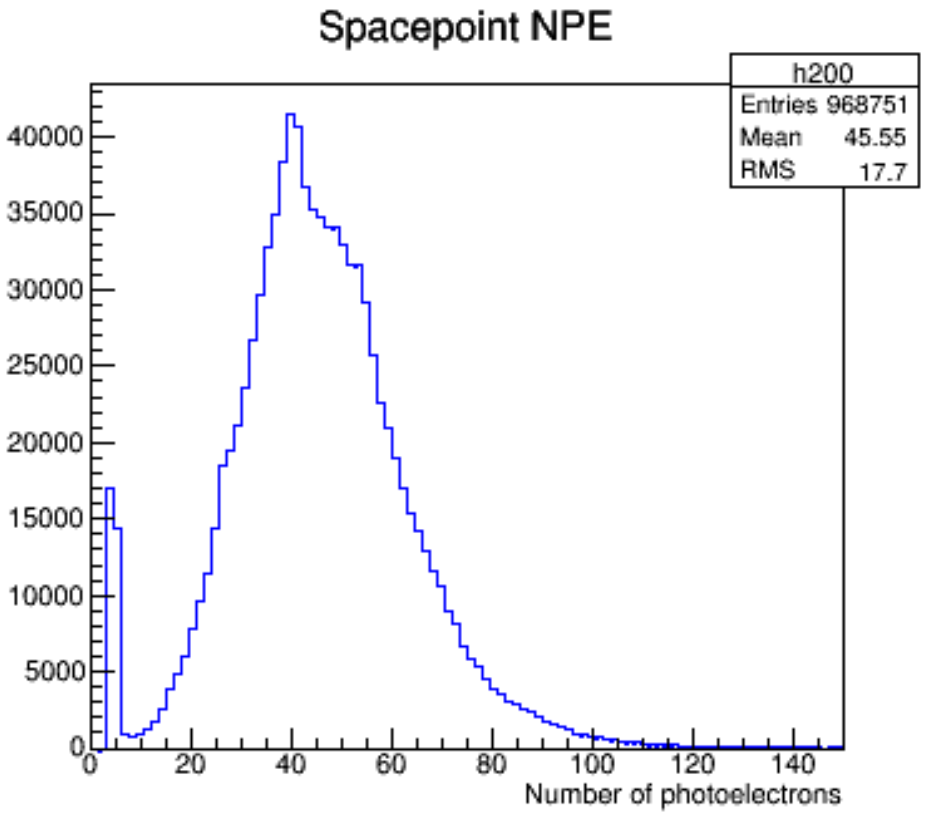
  - Second: attempt to make doublet spacepoints, from 2 intersecting planes.
    - Probability for ‘fake’ from noise is quite high: 3.6E-2 per station per trigger.
    - Noise can cause the ‘real’ hit to be generated in the wrong place:
      - Mitigated by first using digits in descending light yield order.

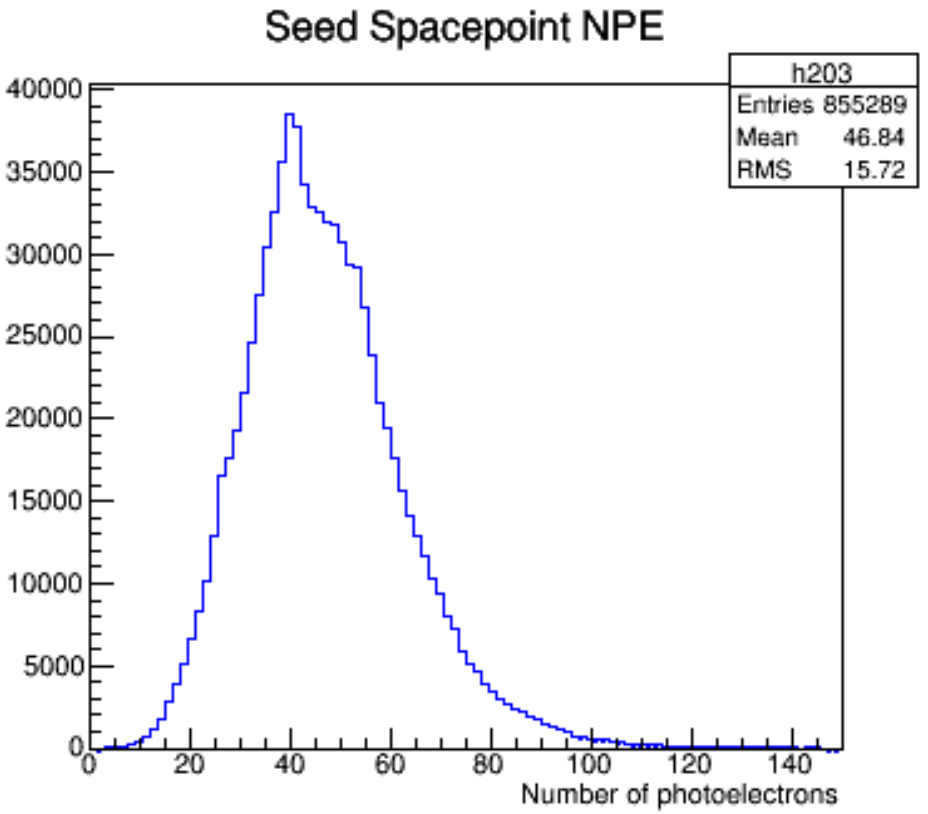
Light Yield

- For space points
- Note the noise suppression due to space point selection



Light Yield: Tracks





- Seed space point is the space points used in tracks
- The final step of noise rejection is able to completely remove the detector noise

Plots from M. Uchida run summary web pages.

http://www.hep.ph.ic.ac.uk/~mgeorge/Files/2016MICEData/MAUS2.8.2/8681/

Conclusion

- Noise is central to the detector:
  - Can’t live without it
  - Need to balance cuts / reconstruction algorithms to reduce the impact of noise.
    - Setting high p.e. cuts removes noise, but also decreases efficiency!

- Noise introduces ambiguity when generating ‘doublet’ space points
  - Ambiguity is reduced by using pulse height information
    - Still possible to move a space point with noise (inefficiency!)

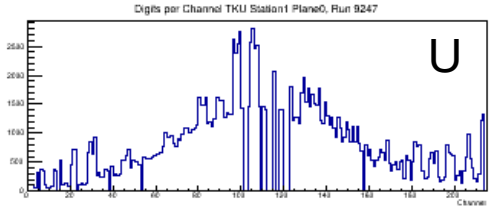
- Pattern recognition delivers ‘final’ noise rejection.
  - Works very well, noise is not visibly propagated to final track fits.

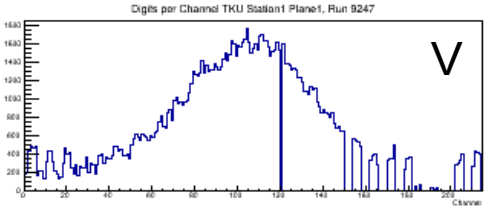
Back up slides on dead channels/digits...

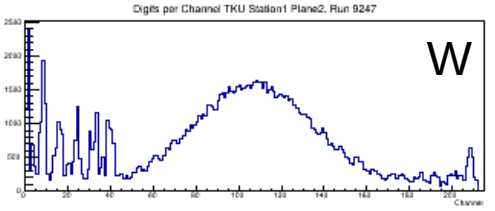
- If you don’t want to go through these yet, that's fine.

Tracker: Upstream Digits

1







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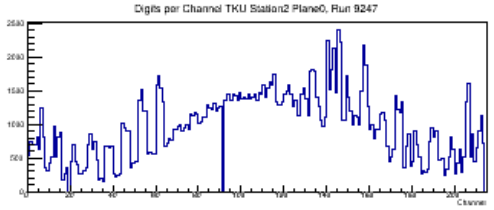

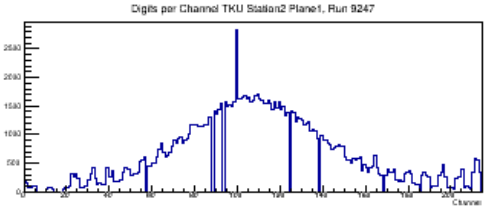

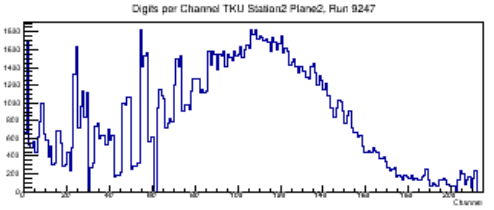

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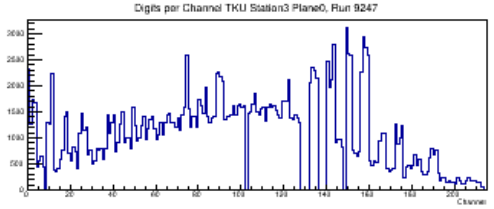

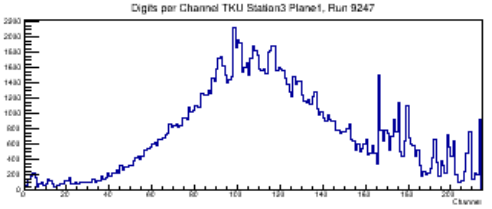

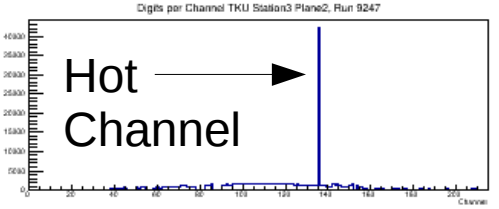

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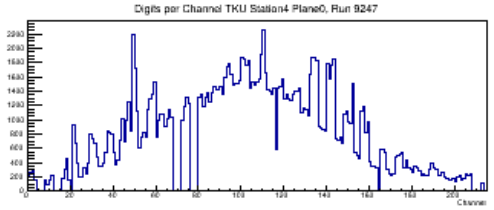

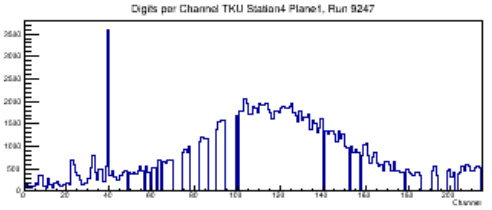

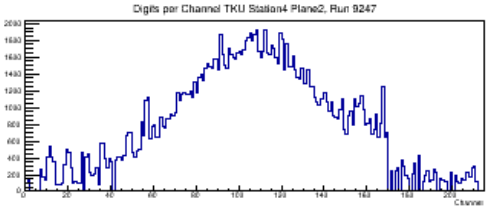

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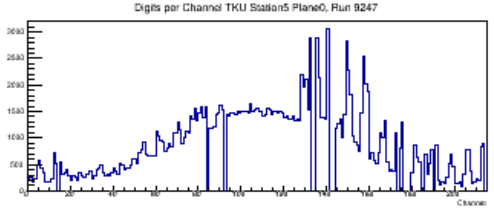
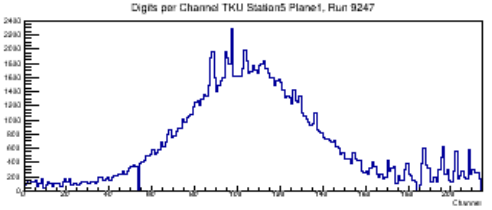
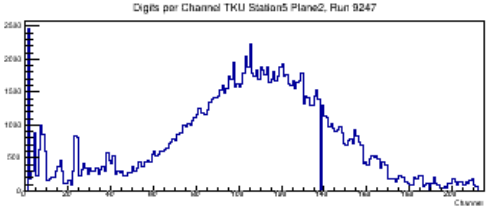
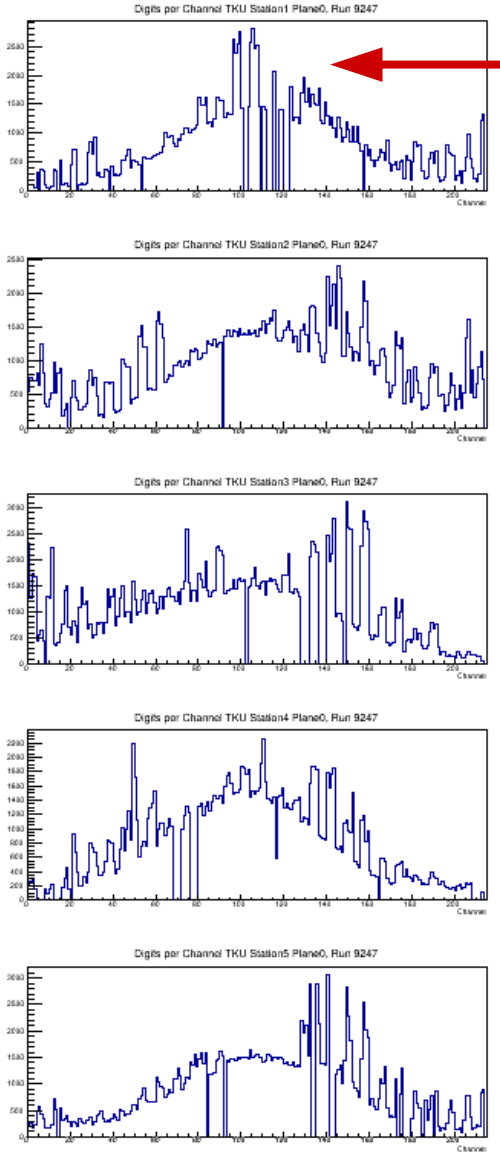
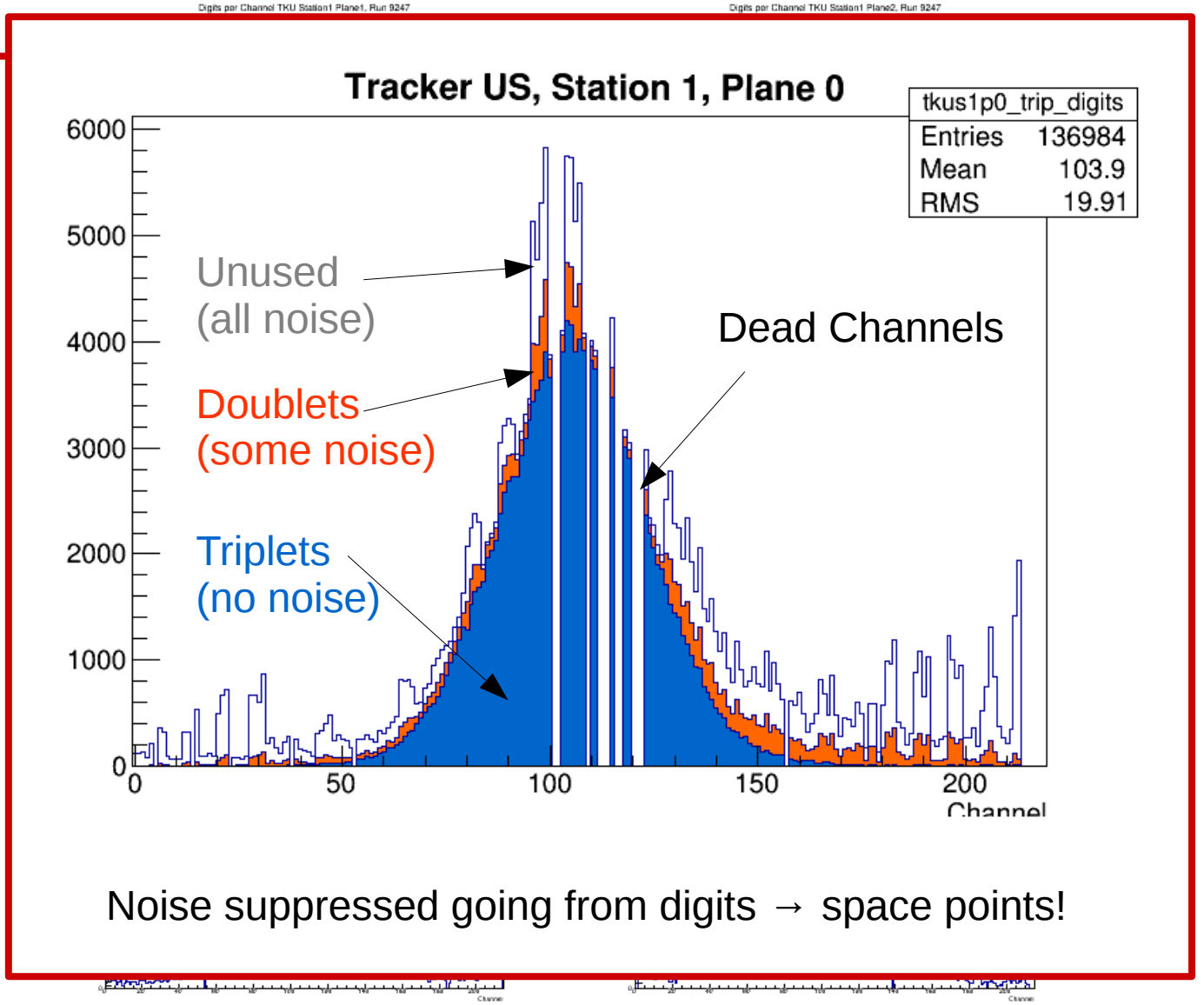






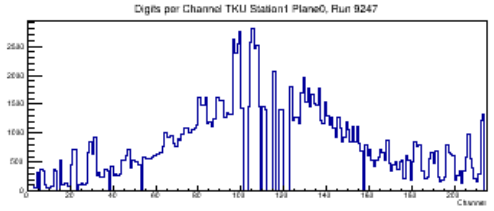
Tracker: Digit use & Noise

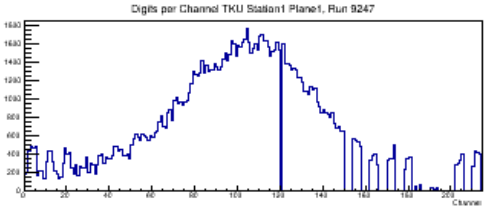


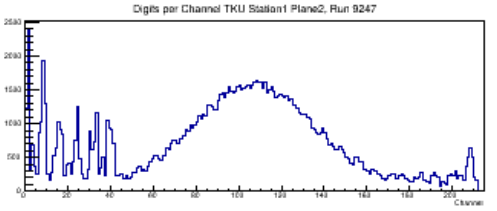


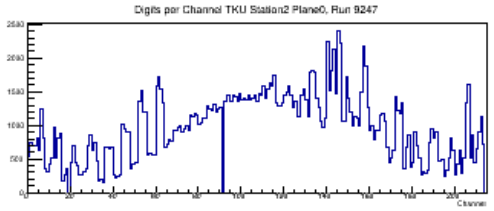
Noise suppressed going from digits → space points!

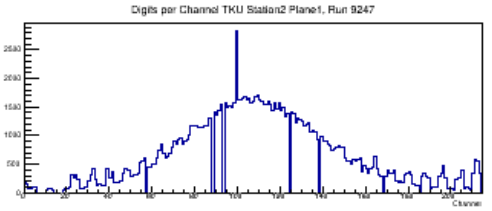
Tracker: Upstream Digits

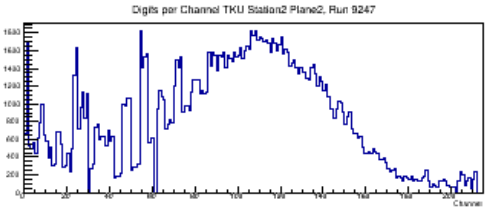


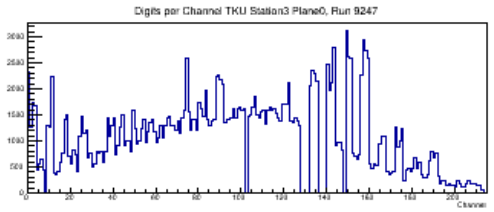


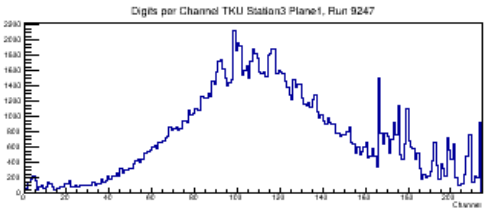


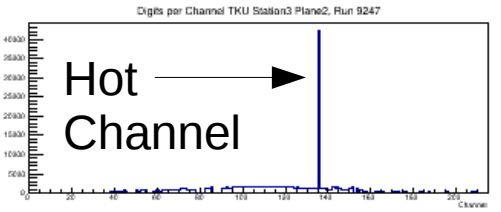


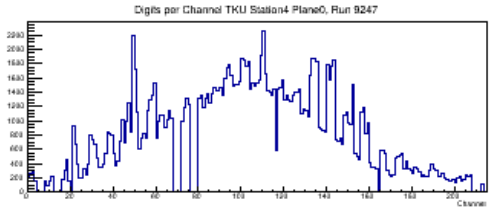


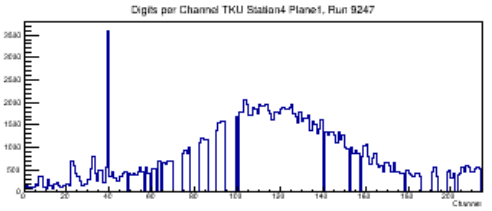


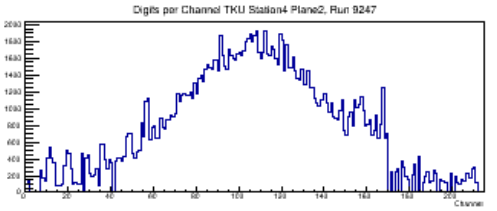


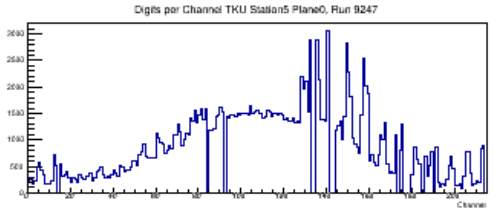


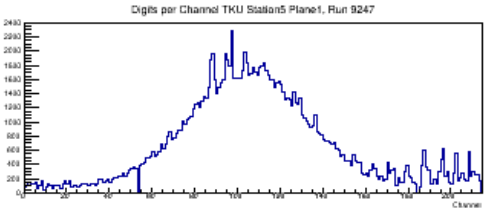


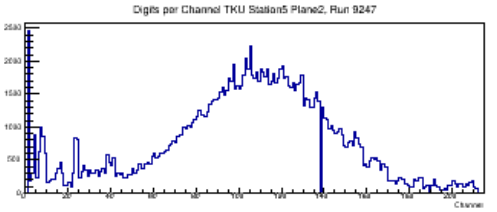




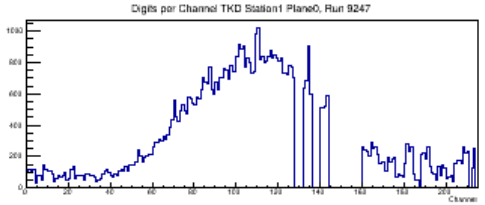


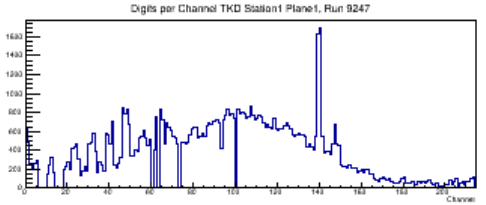


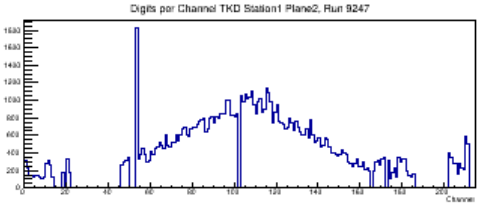


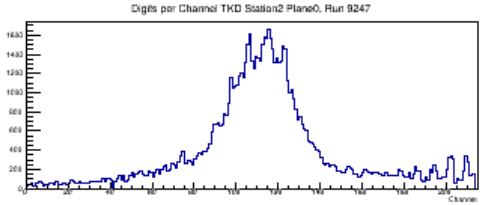


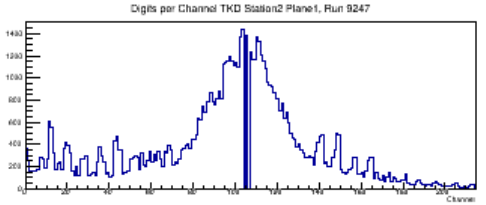
Tracker: Downstream Digits

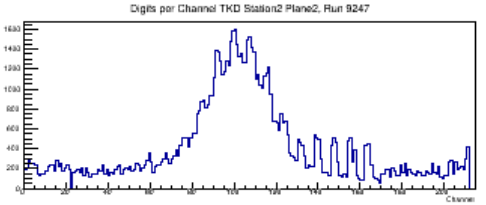


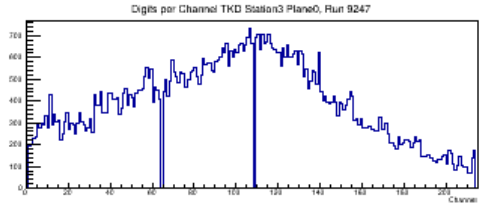


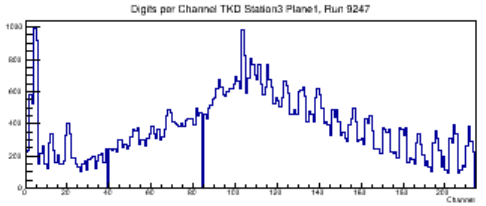


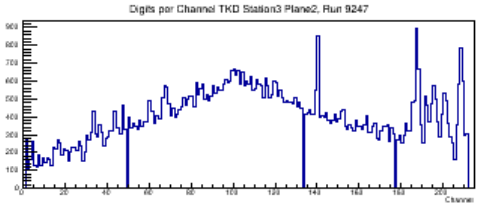


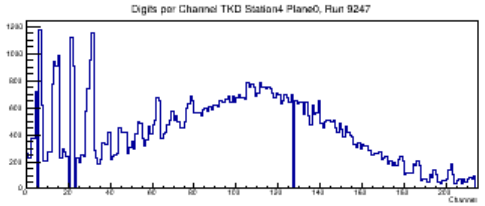


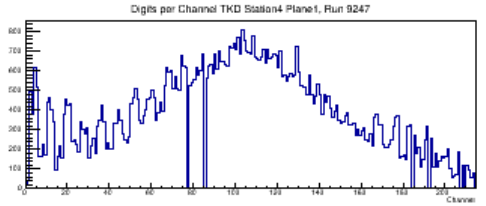


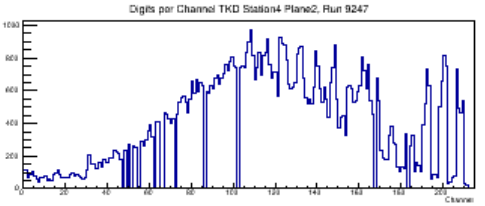


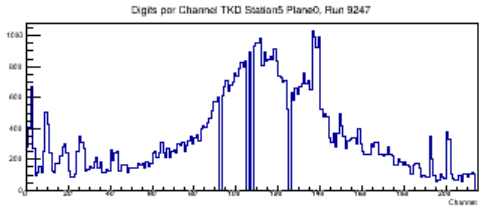


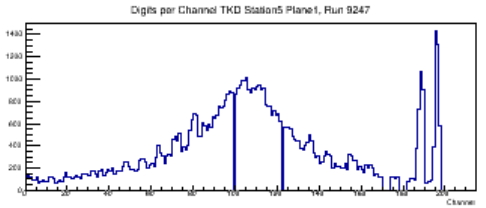


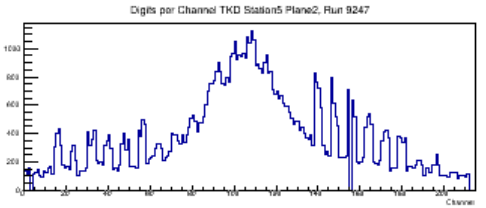












Tracker: Space-point finding efficiency

- Efficiency here is the probability of finding a 'real' space point at each tracker station, after seeing a coincidence in TOF1-2.
- A 'real' space point include both doublet and triplet space points and substantial effort is taken to remove noise space points, using recorded light yields.
- This does not rely on track finding, and gives an 'ideal' baseline for the detector.
- Efficiency is not ideal at all stations, and is caused by dead VLPC channels within the cryostat.
- Currently in the process of reviewing wave guide connectors to find more optimal connections.