EUROPEAN SPALLATION SOURCE

Preliminary results of the nBLM DAQ test at Linac4

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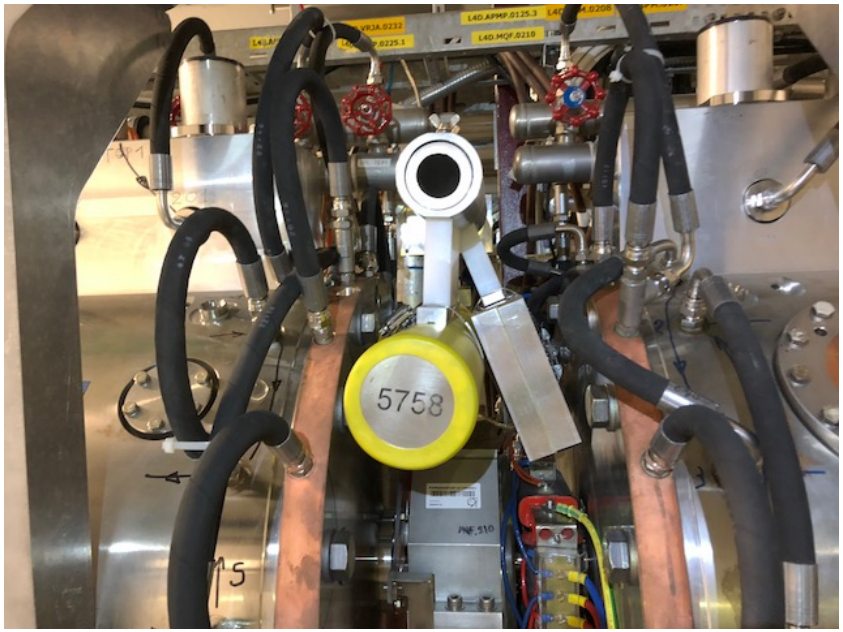
16. December 2018

Setup and collected data

Linac 4

- nBLM fast detector installed at the inter-tank region between DTL1 and DTL2 (12MeV, H^-)
- icBLM (ic17 – same production is the ESS ones) installed at the same location as well, not connected to BIS.



nBLM DAQ

- Both FW and SW (not EPICS based) provided by Lodz, data saved in HDF5 files
- Very early stage of prototype, not tuned for data taking – no external triggering possible, frequent reboots needed (platform stability issues)
- Strong support from Lodz to get at least some useful data in the end.

Setup and collected data

Nov. 2018:

- 3 runs of raw data (5 pulses) collected with the nBLM IFC1410 based DAQ by the CEA SW team, the rest with scope and other (modified IOxOS scope application – does not utilize the DDR).
- Detector voltages: to be checked
- Signal split between the scope and nbLM DAQ? To be checked.
- Due to the lack of time and unknown settings the results from this files are **not included** in this report.

Dec. 2018 – 1st day (5. Dec.):

- Signal split between
  - nBLM IFC1419 based DAQ and
  - scope or diamond DAQ (from CERN BLM section).
- Controlled losses available for us (2 x ~10-5min) just after installation.
- Data collected with the scope (Thomas) during controlled losses for 2 voltage settings. Results in [1,2].

Setup and collected data

Dec. 2018 – 1st day (5. Dec.):

- No useful data collected with the nBLM IFC1410 based DAQ during controlled losses
  - Need to set proper settings before meaningful processed data can be collected (at minimum: pedestal and event detection thresholds) - not possible to do that in time, therefore decide to collect the raw data.
  - Collected waveform shorter (~0.75s) than I set (2.5s) since processed data buffers were enabled.
  - A few files had zeros in collected data (reboot helps), but I noticed too late as I didn't have time to check this while the controlled losses were available.
  - In general: difficult to collect raw data as very frequent rests were needed (2 different sources causing the need to reboot)

Setup and collected data

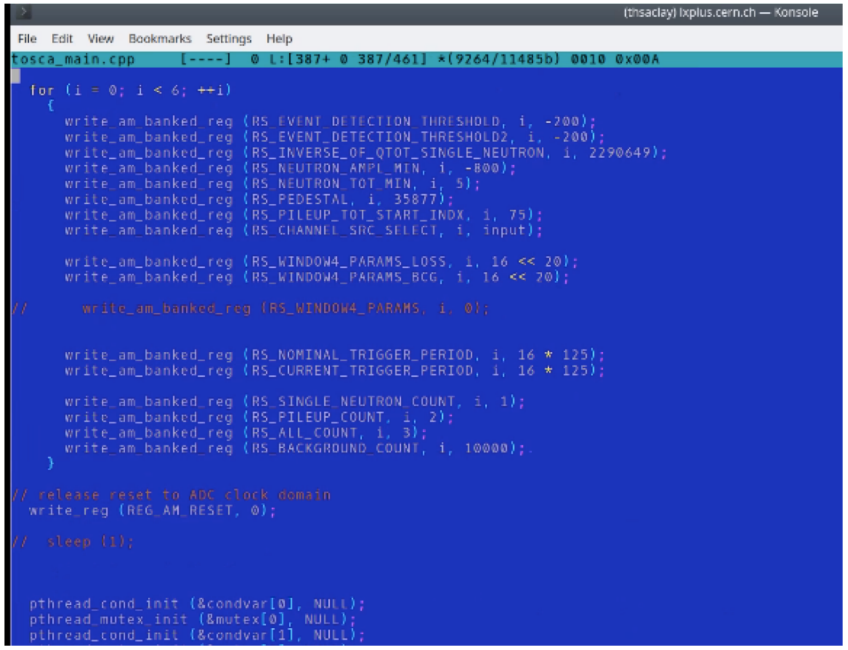
Dec. 2018 – 2nd day (6. Dec.):

- Signal not split - only either nBLM IFC1410 based or Struck based DAQ connected.
- Voltage settings: -550V (mesh), -1500V (drift)
- No controlled losses available.
- IFC1410 based DAQ:
  - Digitiser: IOxOS ADC3111 FMC
    - 250MS/s,
    - DC coupled
    - 16-bit, +/-0.5V range
  - Data collected with support by G. Jablonski:
    - help through remote connection
    - SW updated to newest version

Setup and collected data

Dec. 2018 – 2nd day (6. Dec.):

- IFC1410 based DAQ, collected data:
  - Run1 – 8, run26: raw data
  - Run9 – 28: *EventInfo* data
  - Run1, with settings as in screen
  - shot on the right
  - Run2– 11, settings changed to:
    - Pedestal=38819
    - Start event detection thr = -300
    - end event detection thr = -250
    - min neutron thr = -500
  - run12-13:
    - start event detection thr =-250
    - end event detection thr =-200
  - run14-28 (run 26 has raw data as well)
    - start event detection thr =-275
    - end event detection thr =-225



Setup and collected data

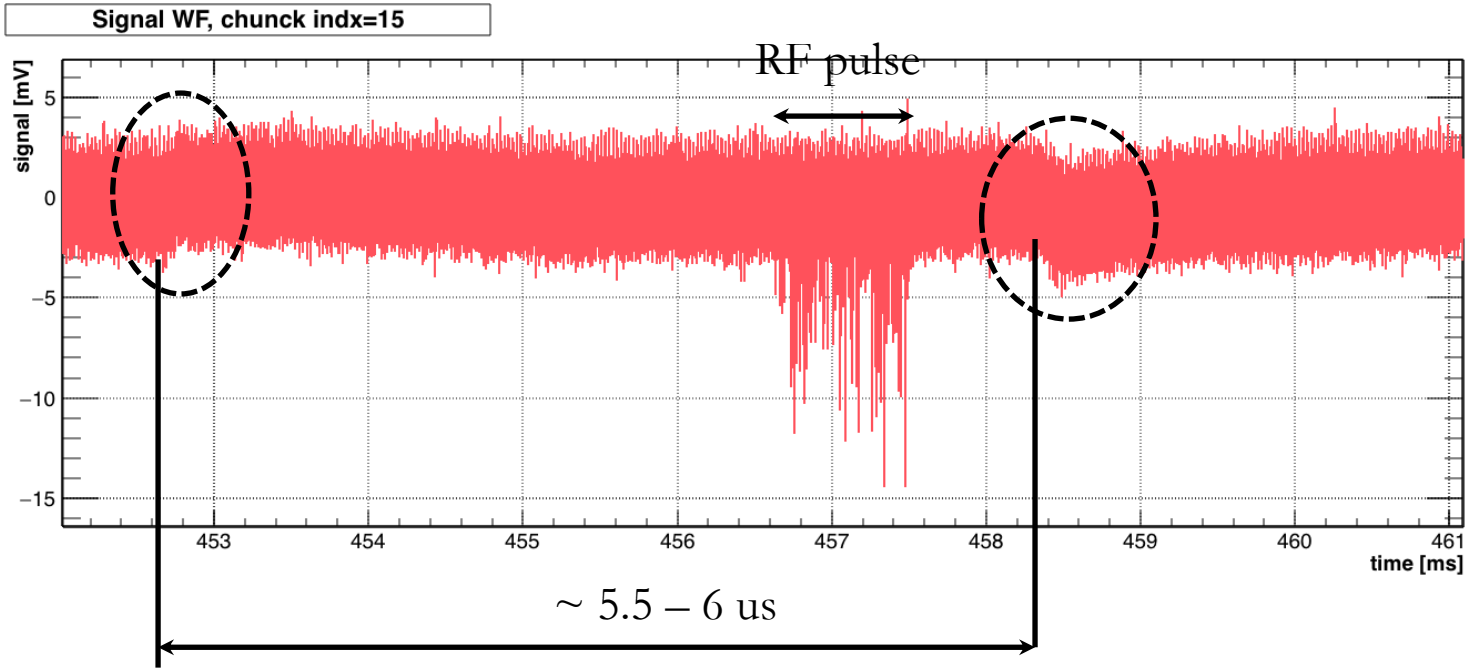
Dec. 2018 – 2nd day (6. Dec.):

- Struck based DAQ
  - SIS8300-L2 AMC
  - Digitiser: SIS8900 RTM
    - 125MS/s
    - +/-1V range, 16 bit
    - DC coupled
  - ~8s of data acquired on demand (no external trigger) – acq. Time (few seconds) significantly shorter compared IFC1410
  - Collected data: 5 files with ~8s of data

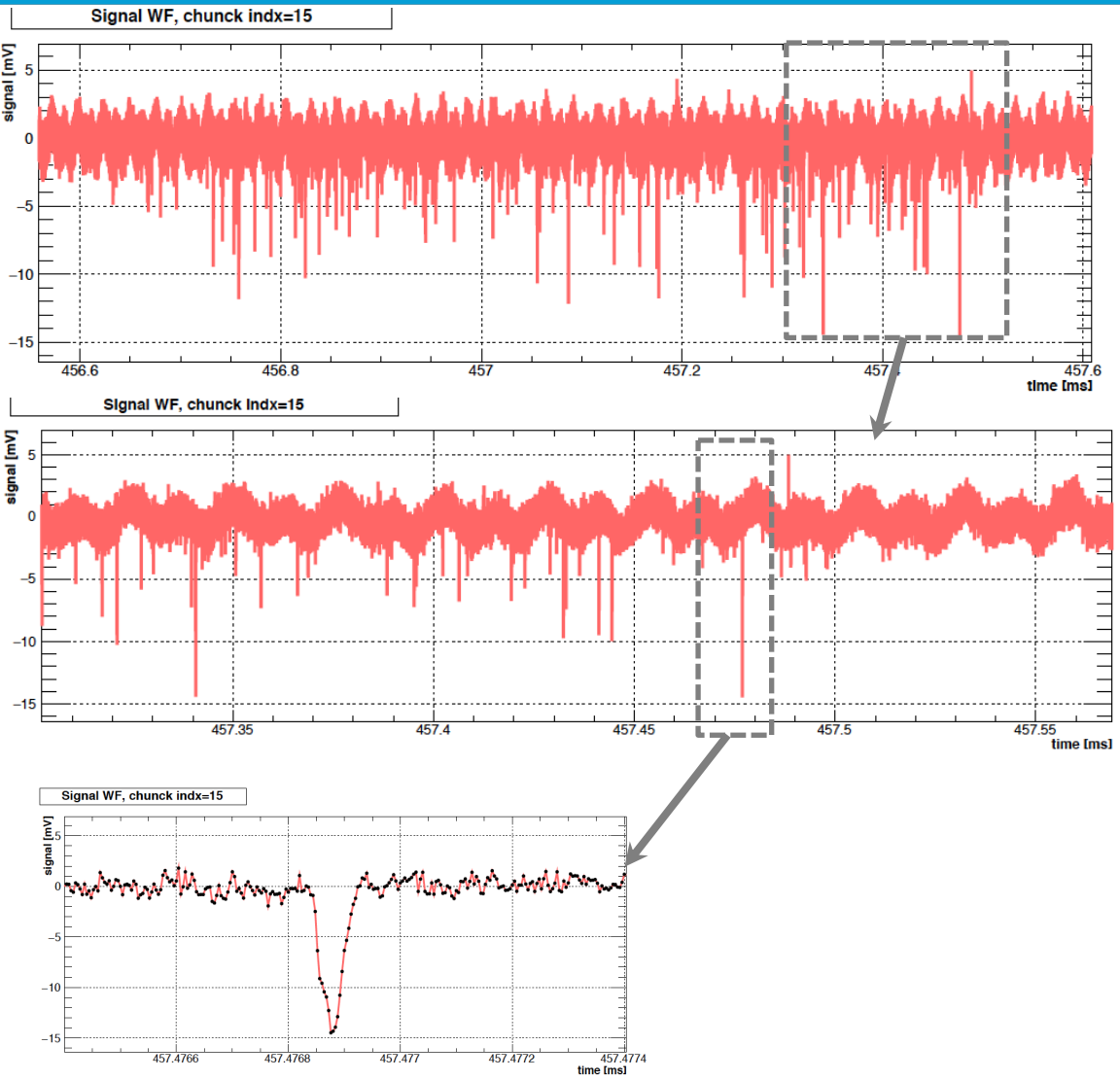
Raw data buffer – IFC1410

Raw data with subtracted pedestal

- Plot bellow: signal waveform with visible pulse (mostly gammas) during run7 (IFC1410)
- Observation:
  - ”Charging” and “discharging” structures with 5.5 -6 us distance always surrounding a pulse
  - Potential cause: pulsed magnets – to be verified



Raw data buffer – IFC1410

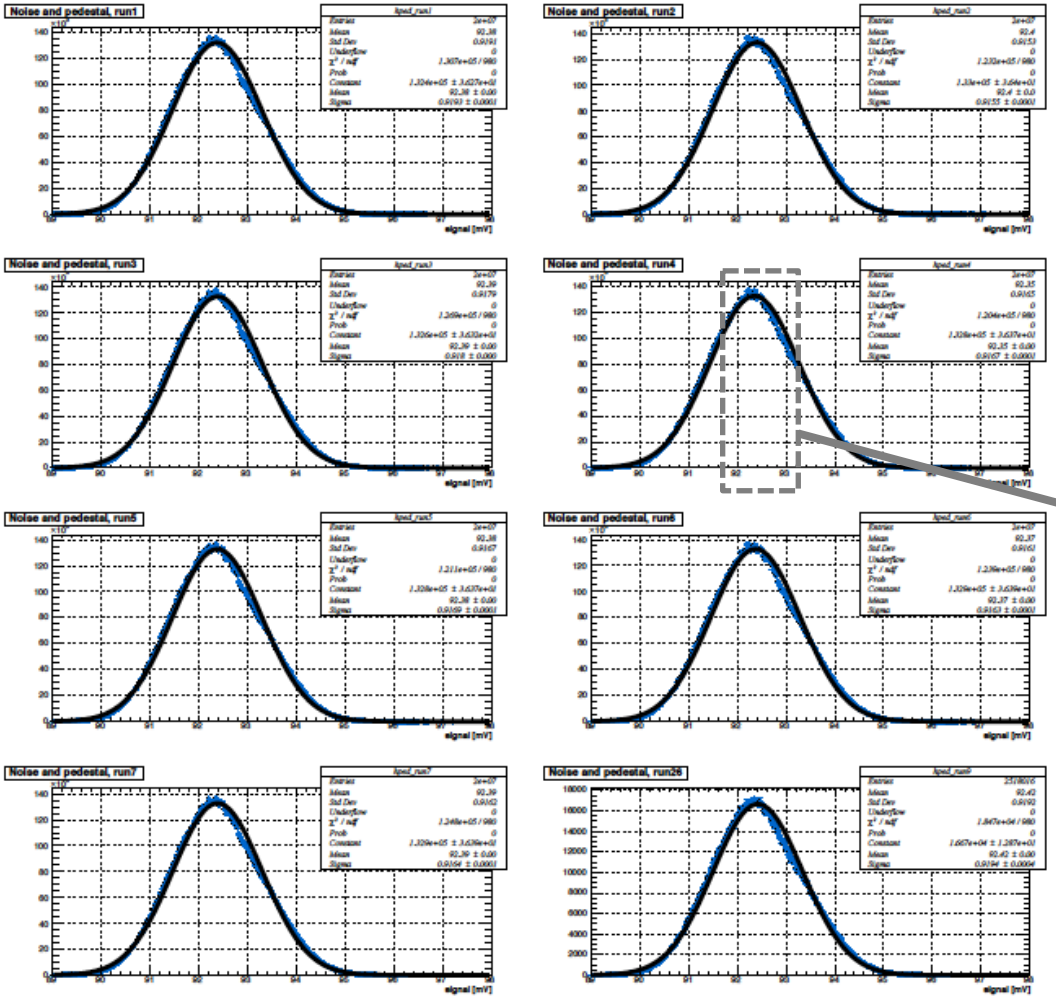


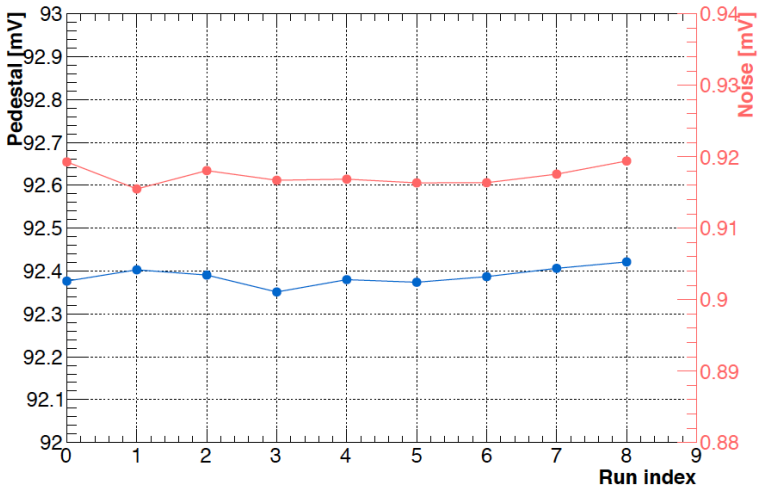
Raw data with subtracted pedestal

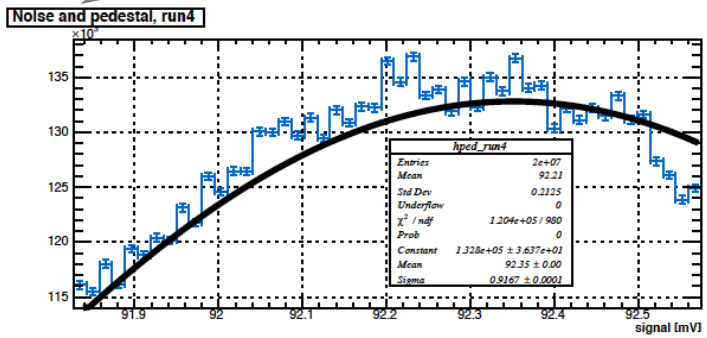
- Plots on the left: plot from the previous slide zoomed to
  - The RF pulse time window (top plot)
  - Last part of the RF time window (mid plot)
  - Last gamma signal in the RF time window (bottom plot)
- Observation: ~37kHz pickup

Pedestal and noise: ifc1410 & ADC3111

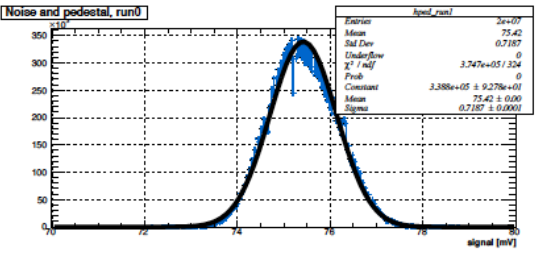
Pedestal and noise for each run with raw data (~ 10h between run1 and run26 start)

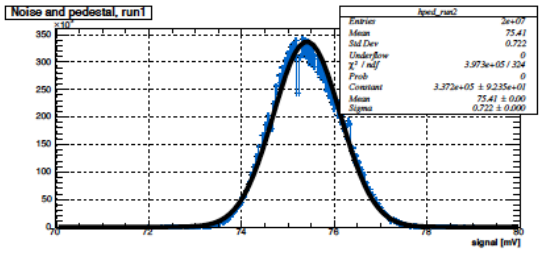


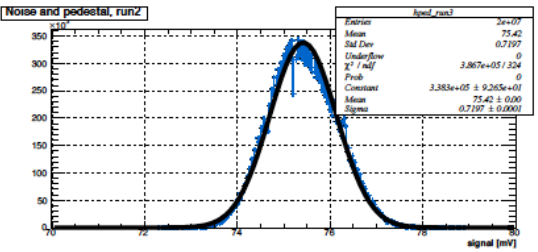


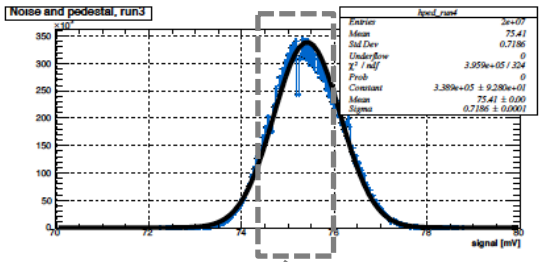


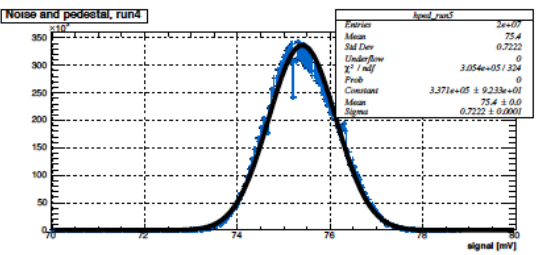
Pedestal and noise: Struck (with SIS 8900 RTM)

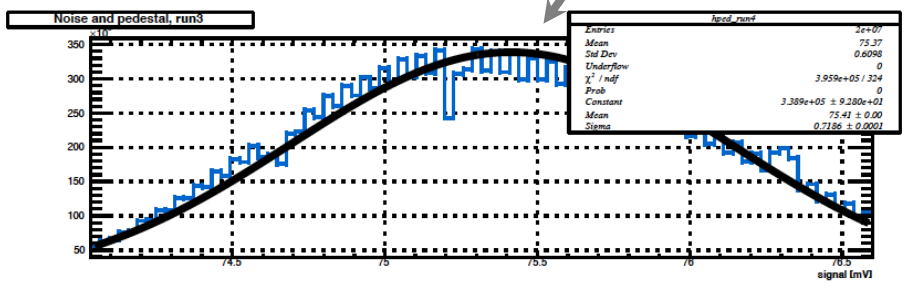






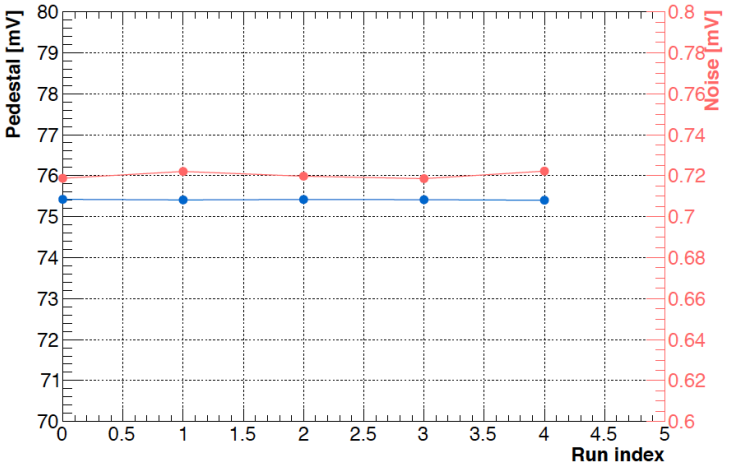






Pedestal and noise for each run

- Zig-zag: looks like binning/accuracy or bug inanalysis SW (decoding the bin data)
  - Analysis SW: no bugs found, checked also with sine wave from generator.
- Larger dip always on one bin
  - Potential cause: events included in calculation
  - Checked: no observable difference, if events included.
- Behaviour unclear. But not a significant concern due to effect on a level of few 0.1mV



Raw data - ifc1410 vs Struck: TOT & Amplitude

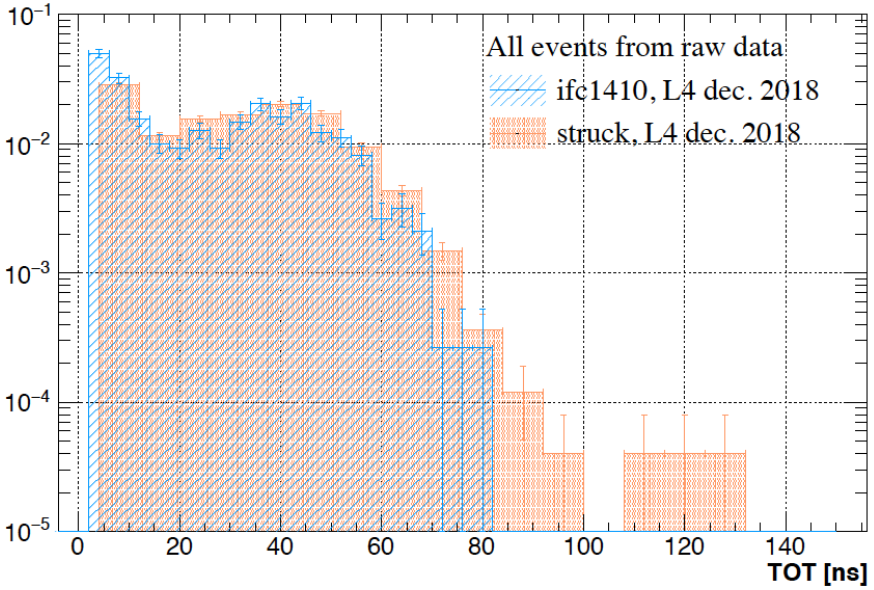
Various distributions for Events extracted from raw data - comparison between ifc140 (blue) and Struck (orange) data

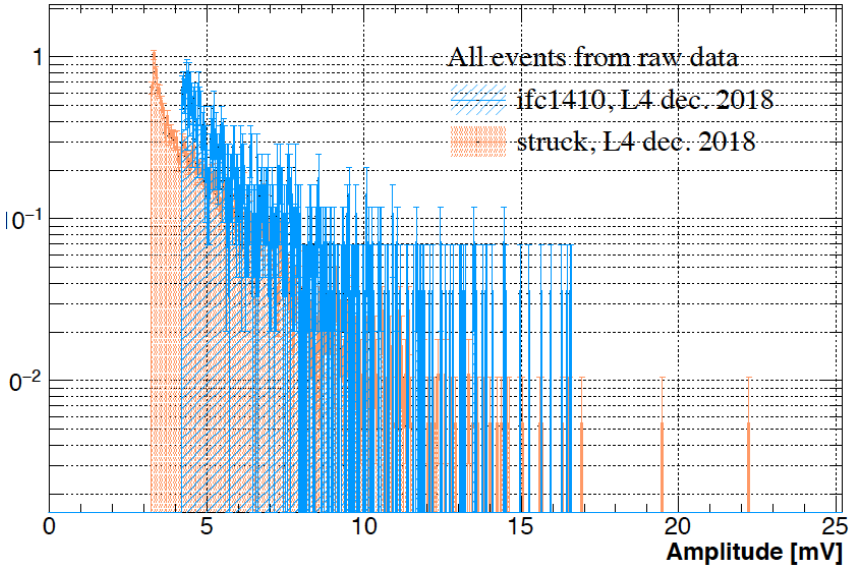
- Ifc1410 data has a cut on start time of event: only events inside a time window slightly larger than RF pulse are included in the histograms below
- Cut on start time of Struck data not included (yet…)
- Event detection settings for ifc140
  - Event start threshold = - 275 adc units
  - Event end threshold = -250 adc units
- Event detection settings for Struck
  - Settings for ifc1410 scaled to give the same Threshold/noise

Raw data - ifc1410 vs Struck: TOT & Amplitude

Various distributions for Events extracted from raw data - comparison between ifc140 (blue) and Struck (orange) data

- Plots below:
  - **TOT:** time window between events start and end
  - **Amplitude**: minimum signal in the TOT window
- Observation regarding the amplitude distribution:
  - 1st slop: spikes/noise
  - 2nd slope: gammas
  - Neutrons: after 15mV?, not enough statistics

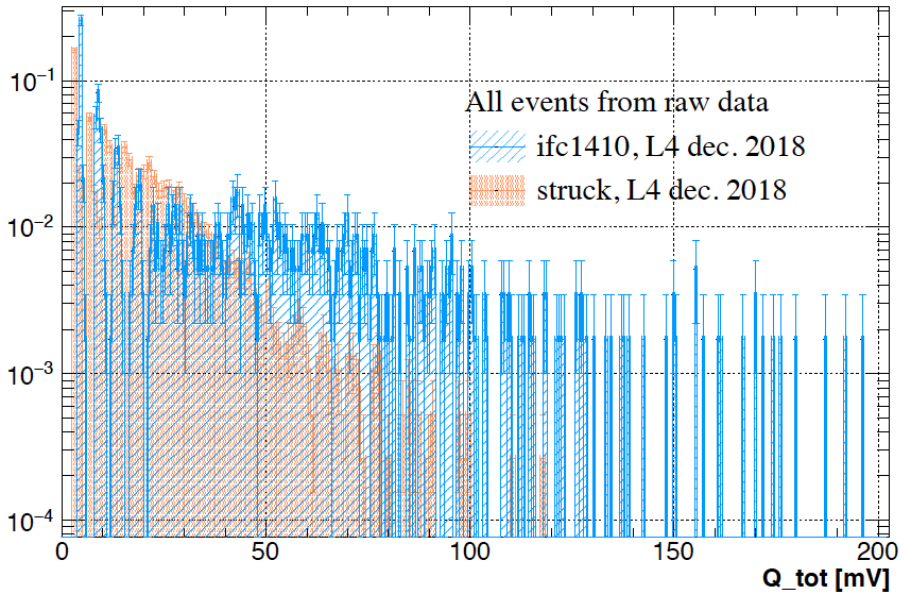


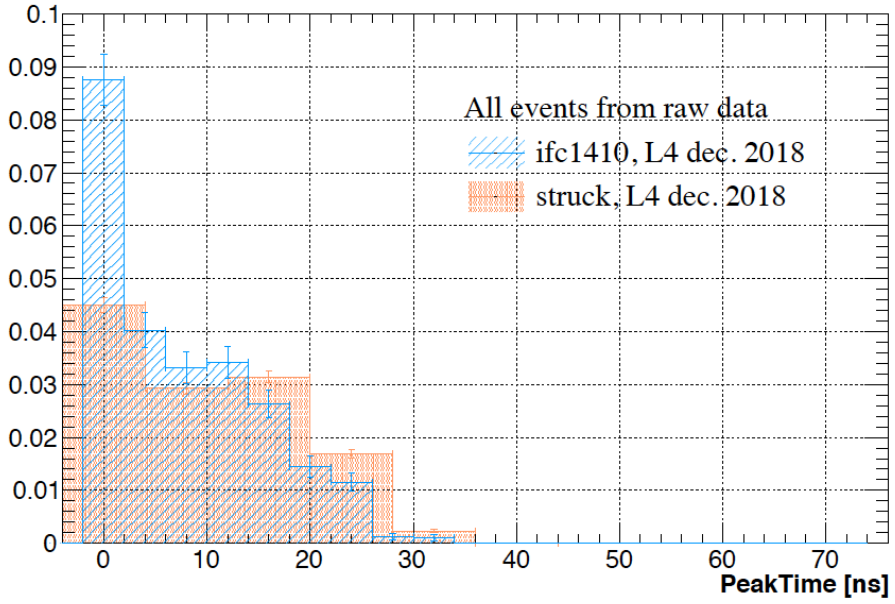


Raw data - ifc1410 vs Struck: TOT & Amplitude

Various distributions for Events extracted from raw data - comparison between ifc140 (blue) and Struck (orange) data

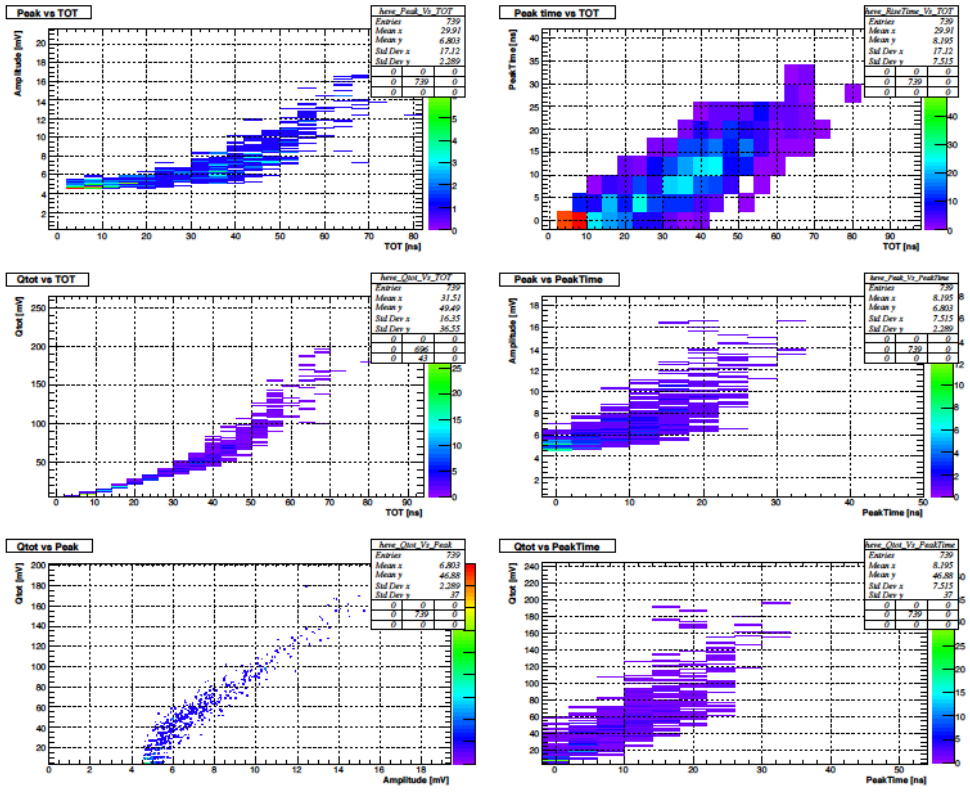
- Plots below:
  - **Qtot:** signal sum over the TOT window
  - **Peak time**: rise time, time difference between the minimum signal inside the TOT window and event start

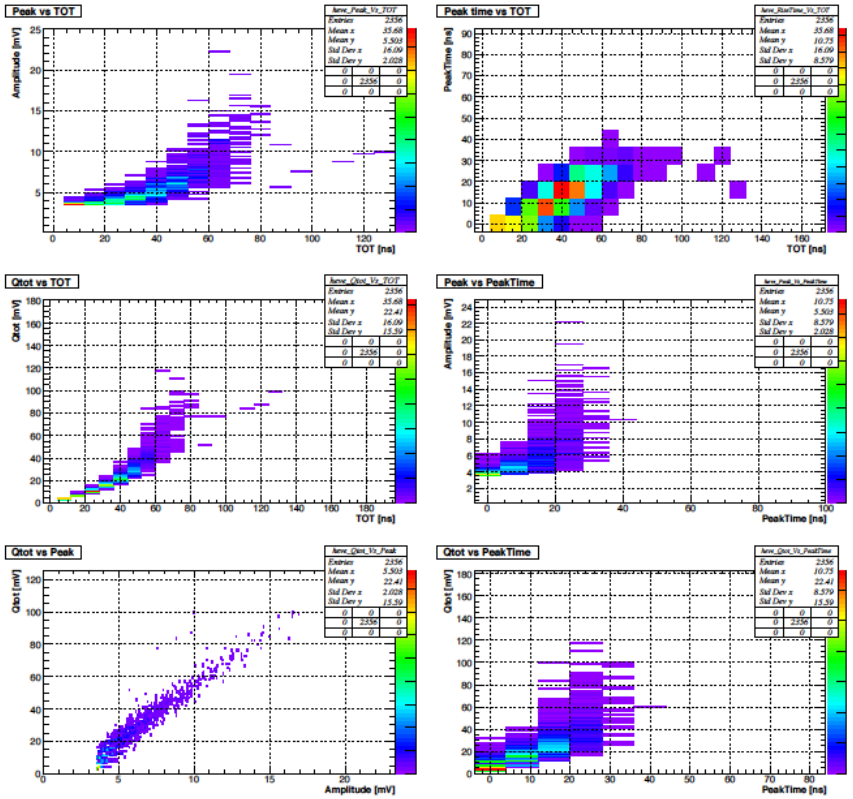




Raw data - ifc1410 vs Struck: TOT & Amplitude

Various distributions for Events extracted from raw data – correlation plots for ifc140 (left) and Struck (right) data



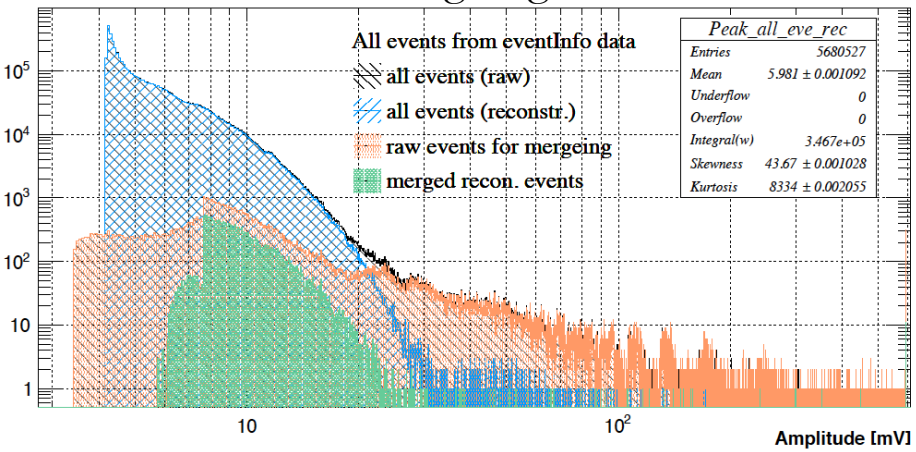


EventInfo data (run14 – run28)

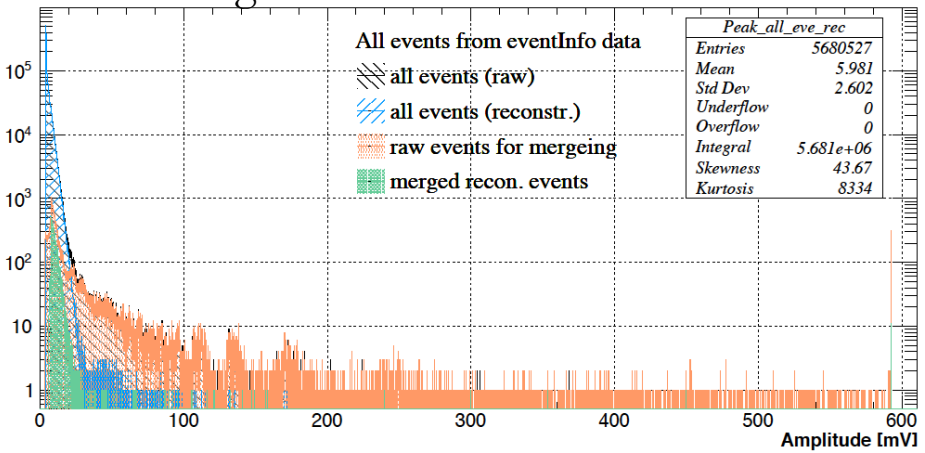
- Following slides show *Amplitude, TOT, peakTime* and *Q_TOT* extracted from the runs with *EventInfo* data (the ones with the same algo settings)
- 4 histograms on the same plot:
  - **Black**: values as read from the files
  - **Blue**: values after event reconstruction. Note: the real time data processing running on the FPGA is requires framing and cutting events in order to be able to report neutron counts per MTW (1us). Thus reconstruction of "true" events requires merging of events that were split.
  - **Orange**: events as read from file, but only those that are used for merging
  - **Green**: only merged events (ie. Events in orange histo after merging)
  - The statistics box is plotted for the blue histo to show overflows on original X scale (note: overflows are incorrect for zoomed in plots).

EventInfo data (run14 – run28)

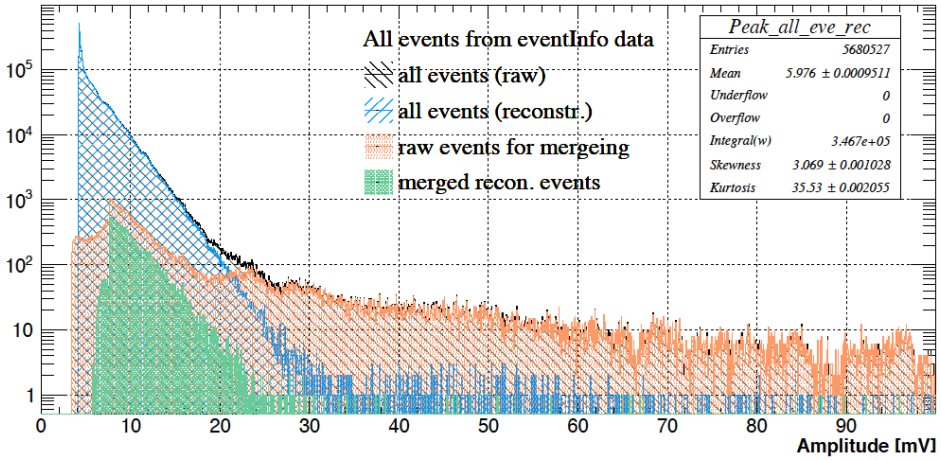
Log -log



Original X scale



Zoom on X scale

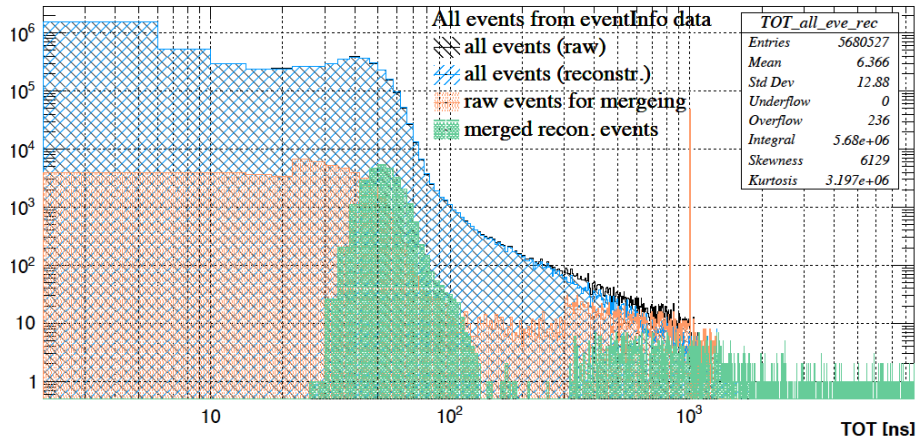


Amplitude:

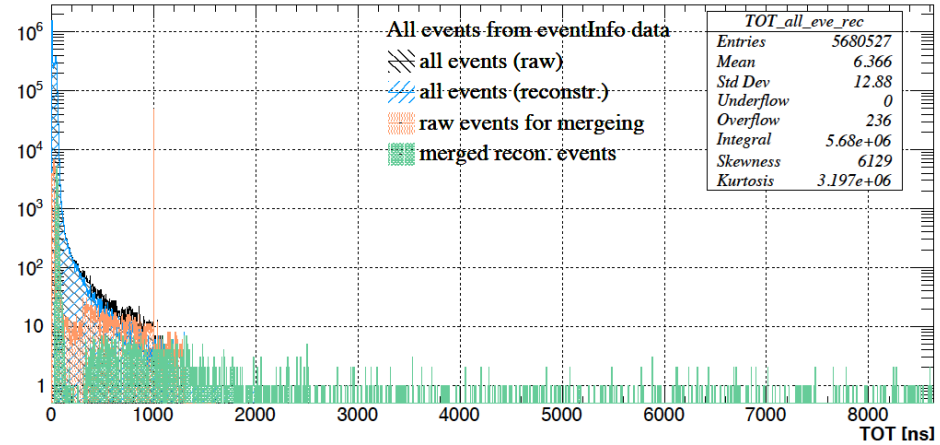
- Neutrons above ~ 30mV
- **Todo**: cut on the event start to include only events inside the RF pulse

EventInfo data (run14 – run28)

Log -log



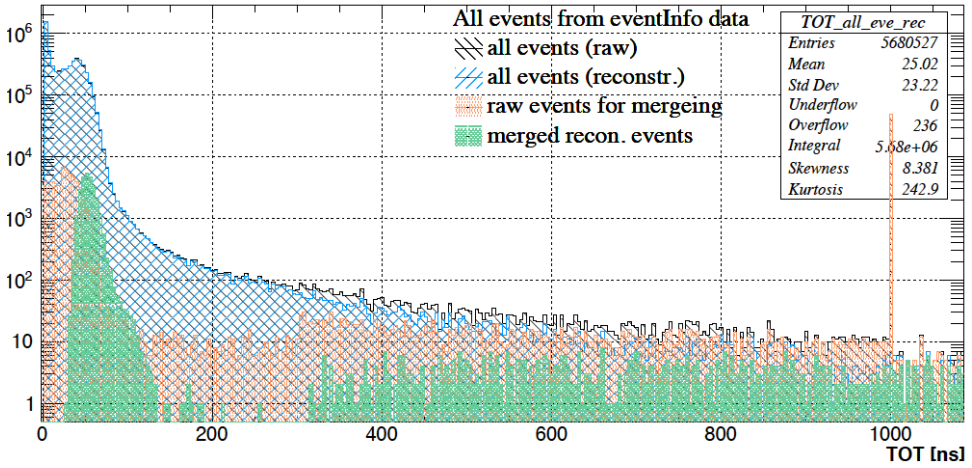
Original X scale



TOT:

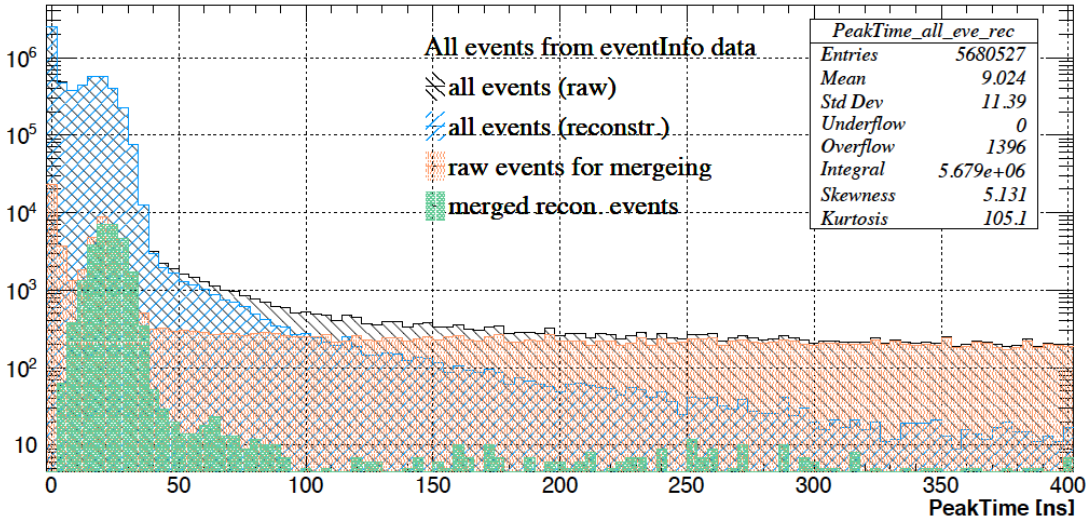
- ”pulses” extending over several us present – baselins shifts (see correlation plot Amplitude vs TOT).
- **Todo**: exclude long events with too low amplitude.
  - Note that this is effectively done online in FW as well,
  - But the amplitude cut for neutron is fixed and was not set optimally as one needs first to have the plots here to be able to set the cut appropriately.

Zoom on X scale

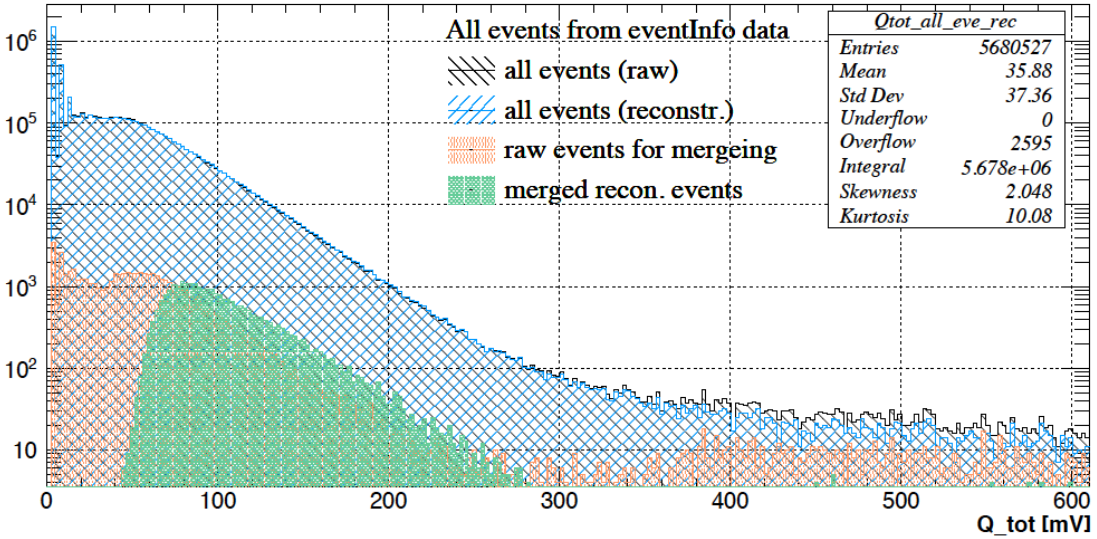


EventInfo data (run14 – run28)

Rise time

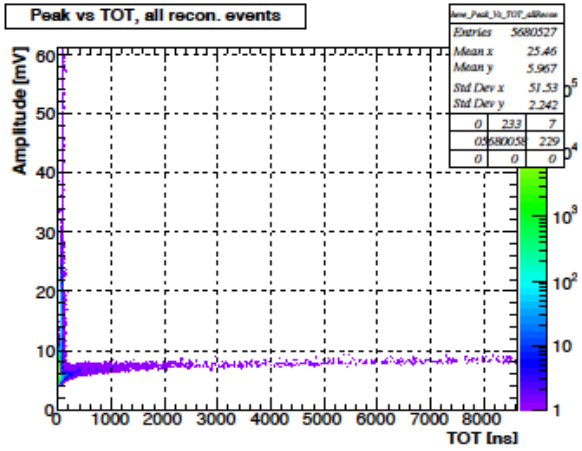


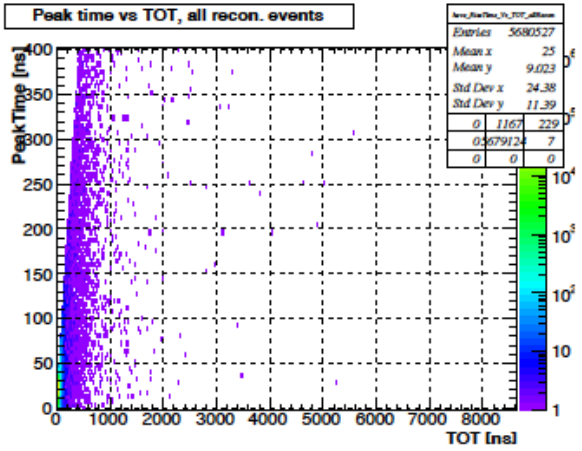
Qtot

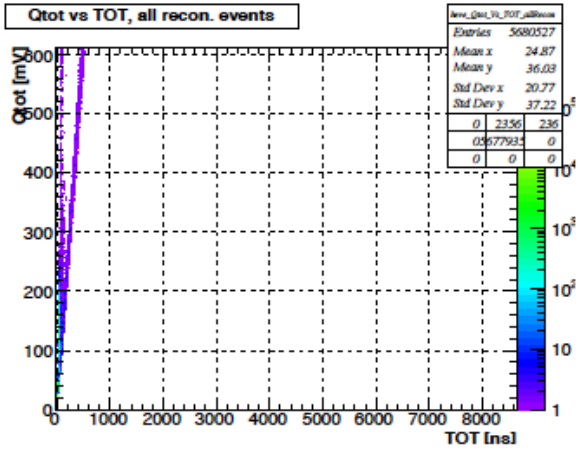


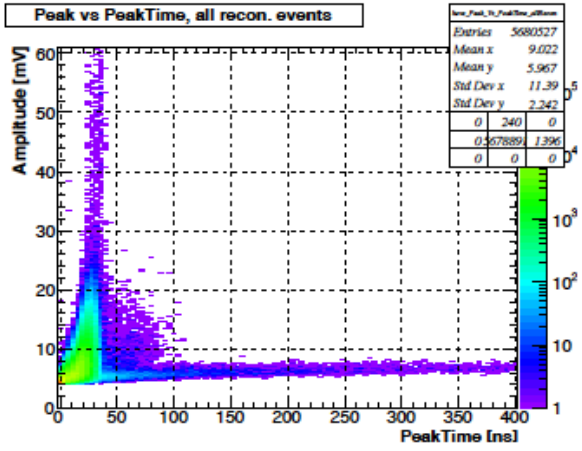
EventInfo data (run14 – run28)

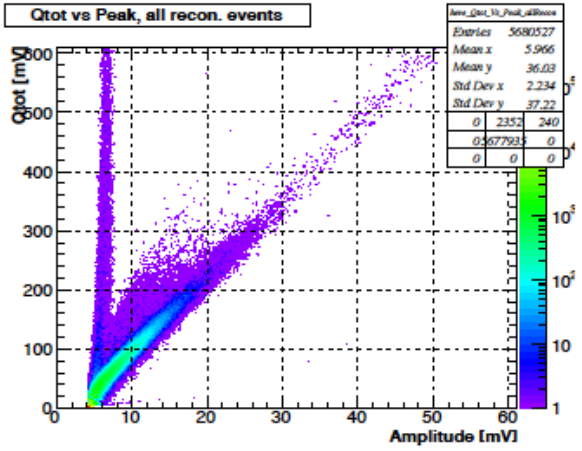
Correlation plots: reconstructed events

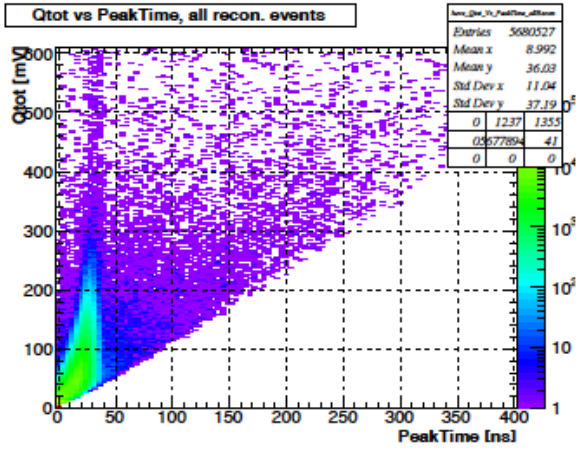






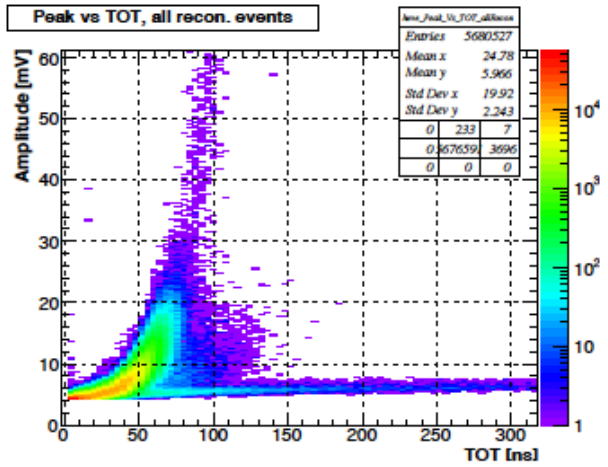


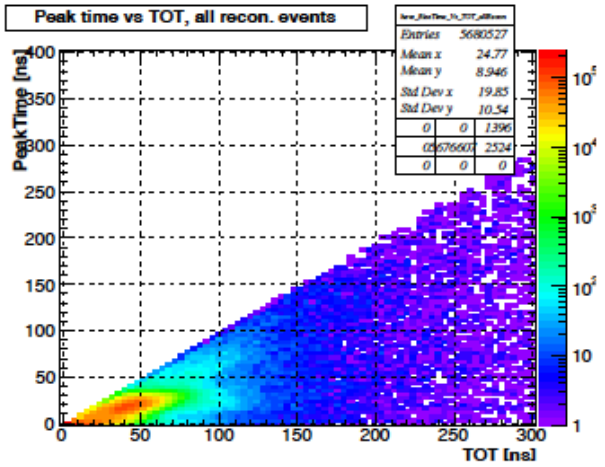


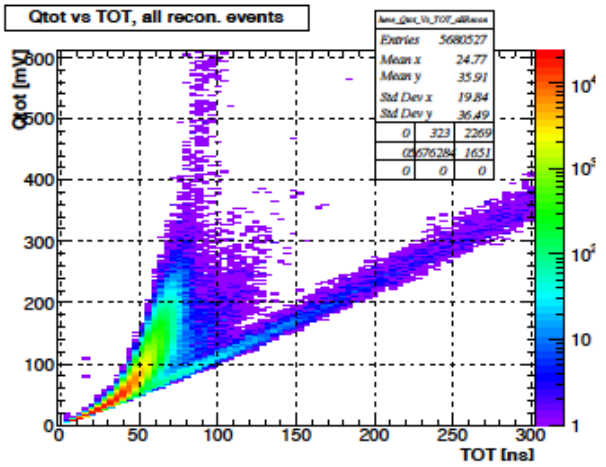


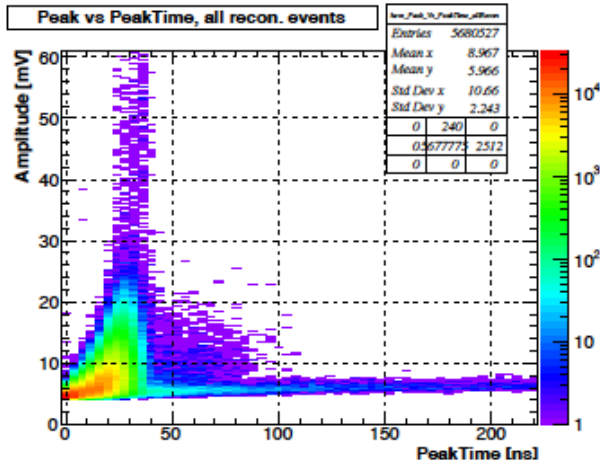
EventInfo data (run14 – run28)

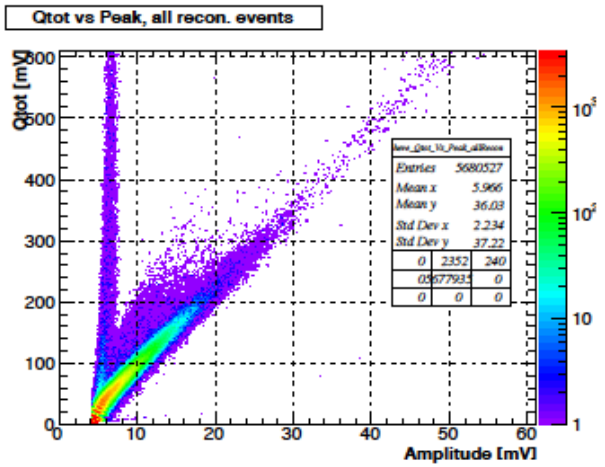
Correlation plots: reconstructed events – zoom in

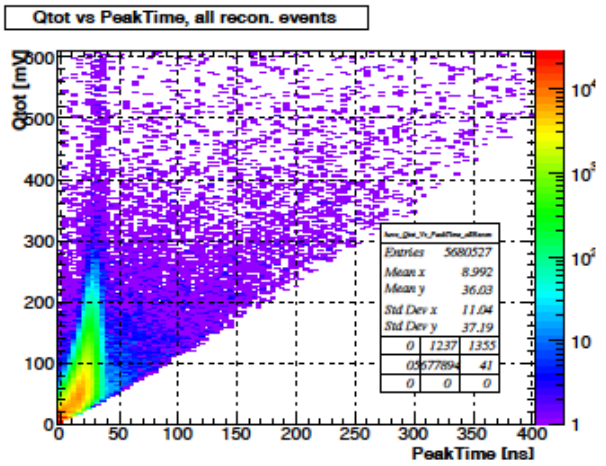








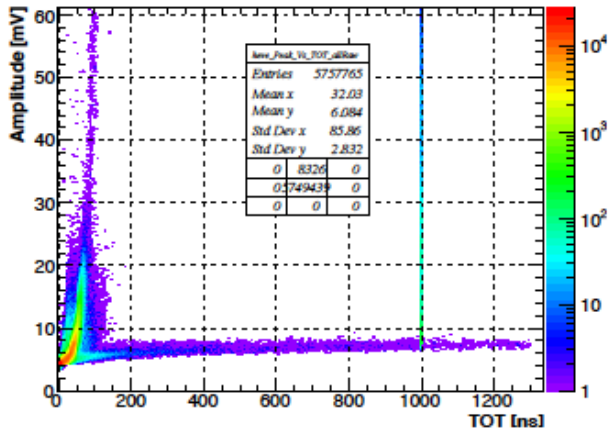




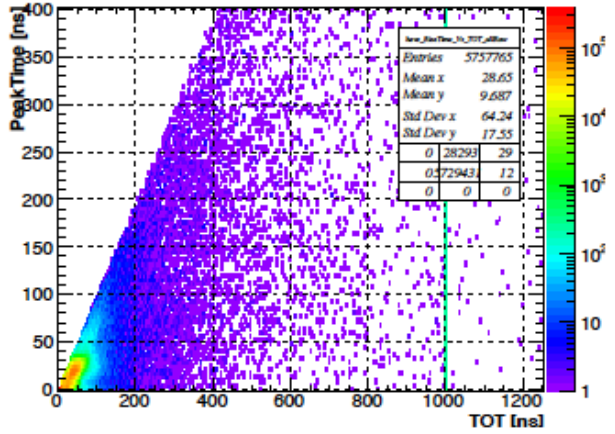
EventInfo data (run14 – run28)

Correlation plots: raw events

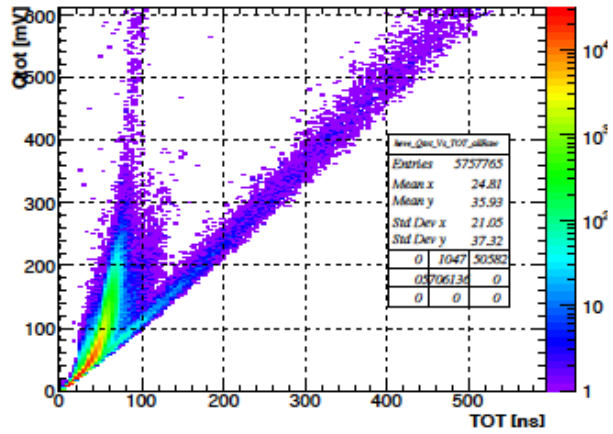
Peak vs TOT, all raw events



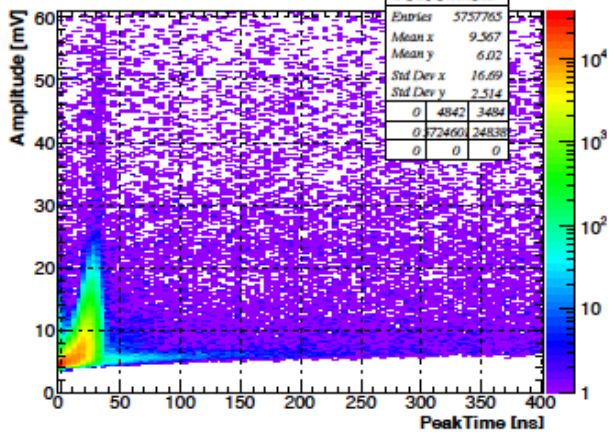
Peak time vs TOT, all raw events



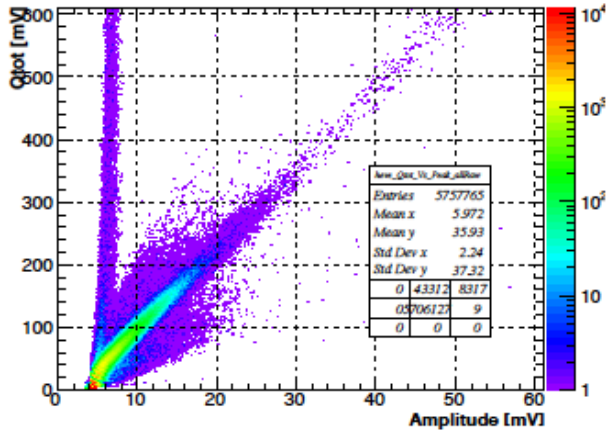
Qtot vs TOT, all raw events



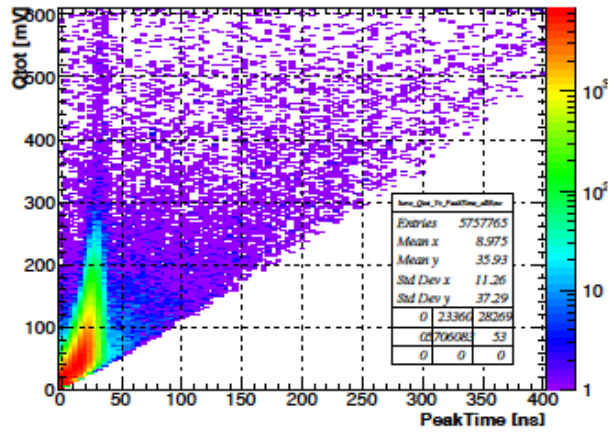
Peak vs PeakTime, all raw events



Qtot vs Peak, all raw events

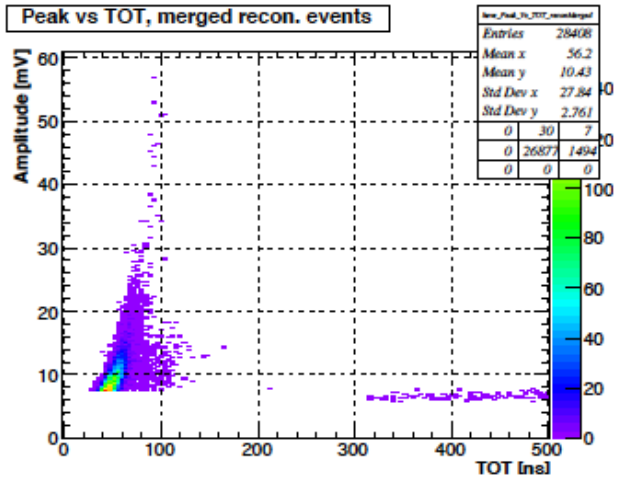


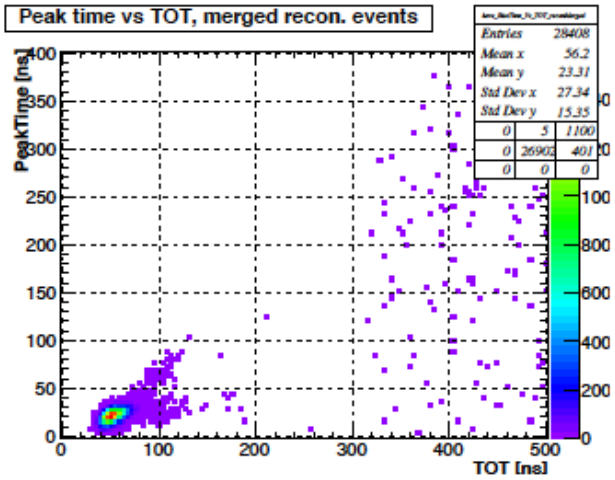
Qtot vs PeakTime, all raw events

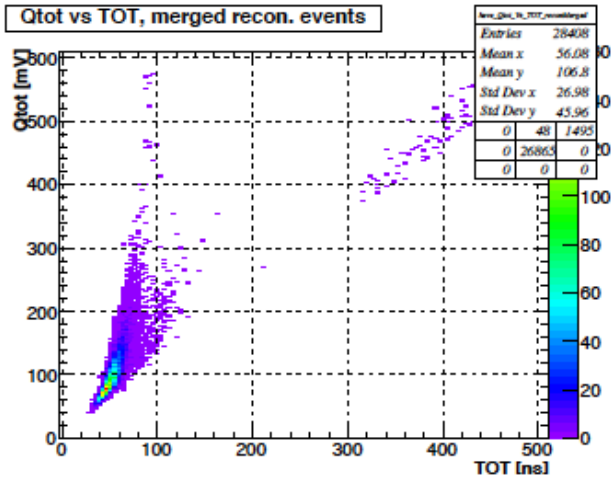


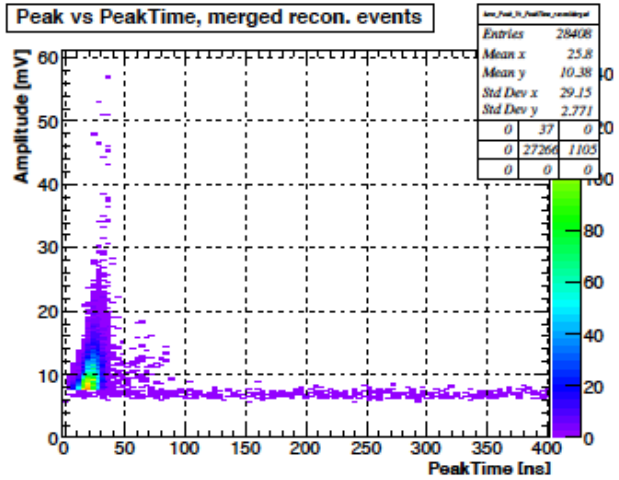
EventInfo data (run14 – run28)

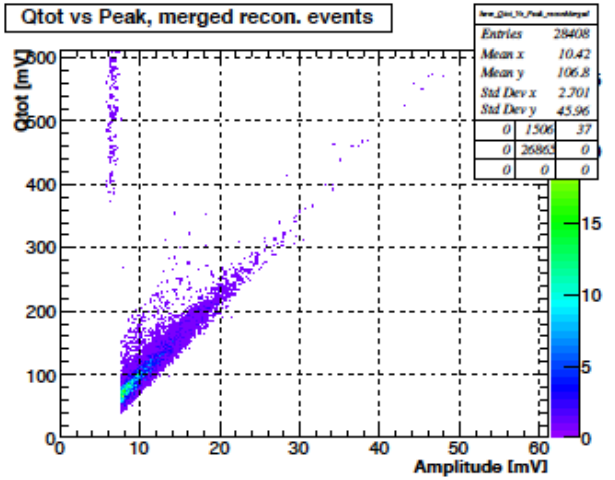
Correlation plots: only reconstructed events

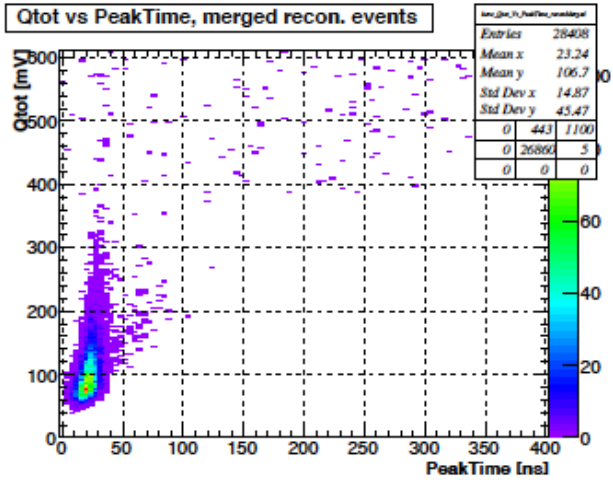








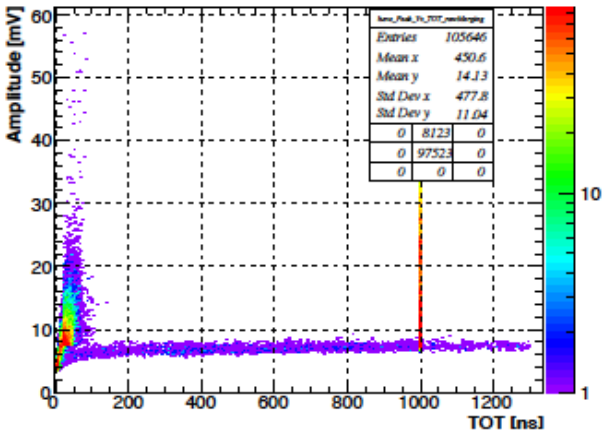




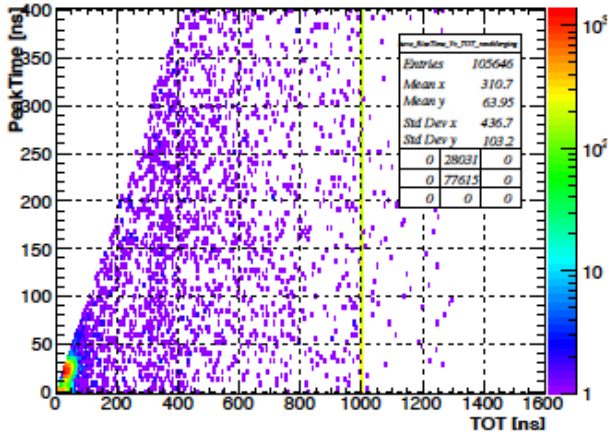
EventInfo data (run14 – run28)

Correlation plots: events as read from file – only those used in merging

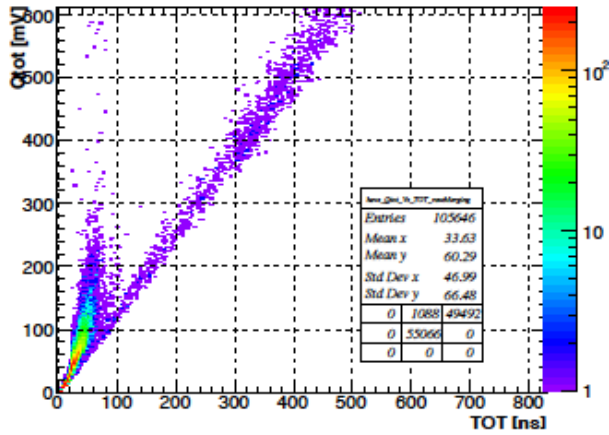
Peak vs TOT, raw events for merging



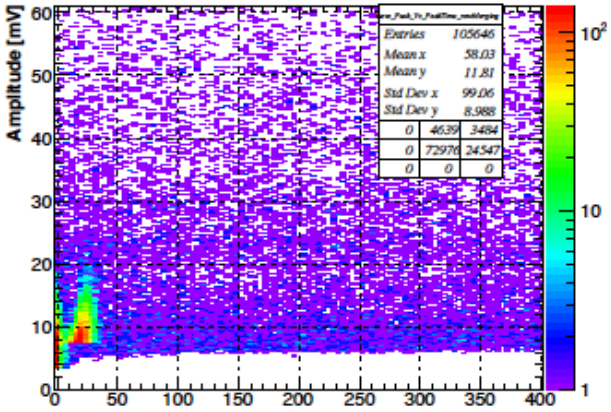
Peak time vs TOT, raw events for merging



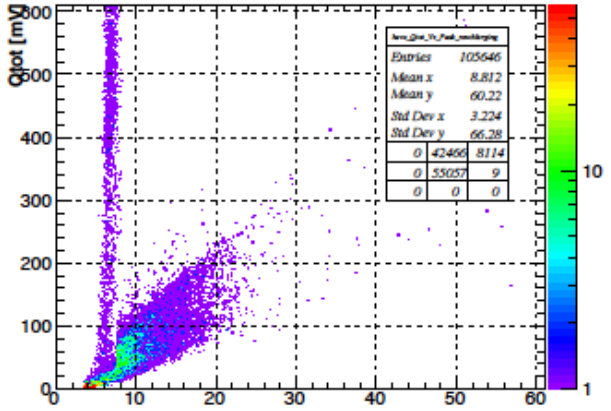
Qtot vs TOT, raw events for merging



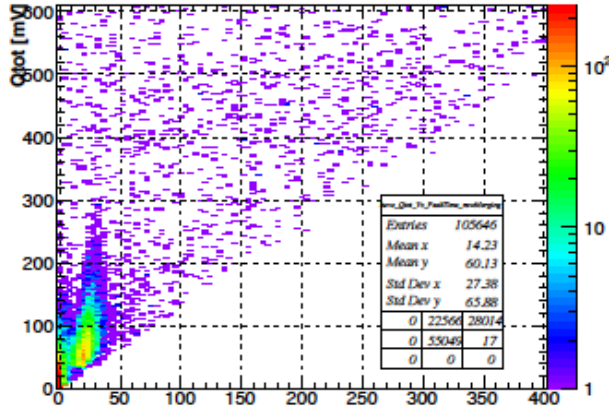
Peak vs PeakTime, raw events for merging



Qtot vs Peak, raw events for merging



Qtot vs PeakTime, raw events for merging



To-dos

- Raw data
  - Check Struck data and readout sw
  - Use cut on start time of events for stuck data in TOT, Amplitude, etc distributions
  - Check persistency plot for identified events
  - Check split events – extract and estimate probabilities (from avrg. signal) for max. on each side
  - Compare with data collected in Nov. by CEA
- EventInfo data
  - Use cut on start time of events in analysis
  - Check time evolution and identify RF pulses
  - Check start time of baseline shift events
  - Persistency plot & event histograms over the RF pulses
- Compare results with the scope data collect by Thomas Papaevangelou – if possible (settings might be different, different analysis).
- Check bandwidths for Stuck RTM and adc3111.
- Estimate detected cosmic neutron rates.
- Check voltage settings during the data collected in Nov. by CEA

References

[1] L. Segui, "*nBLM project report, Experimental Tests, CDR12 final*" report for nBLM CDR3, Feb. 2018, available at https://indico.esss.lu.se/event/1173/

[2] L. Segui, "*nBLM detectors*", presentation at nBLM CDR3, available at https://indico.esss.lu.se/event/1173/