PXD Phase 2 performance

Work in progress

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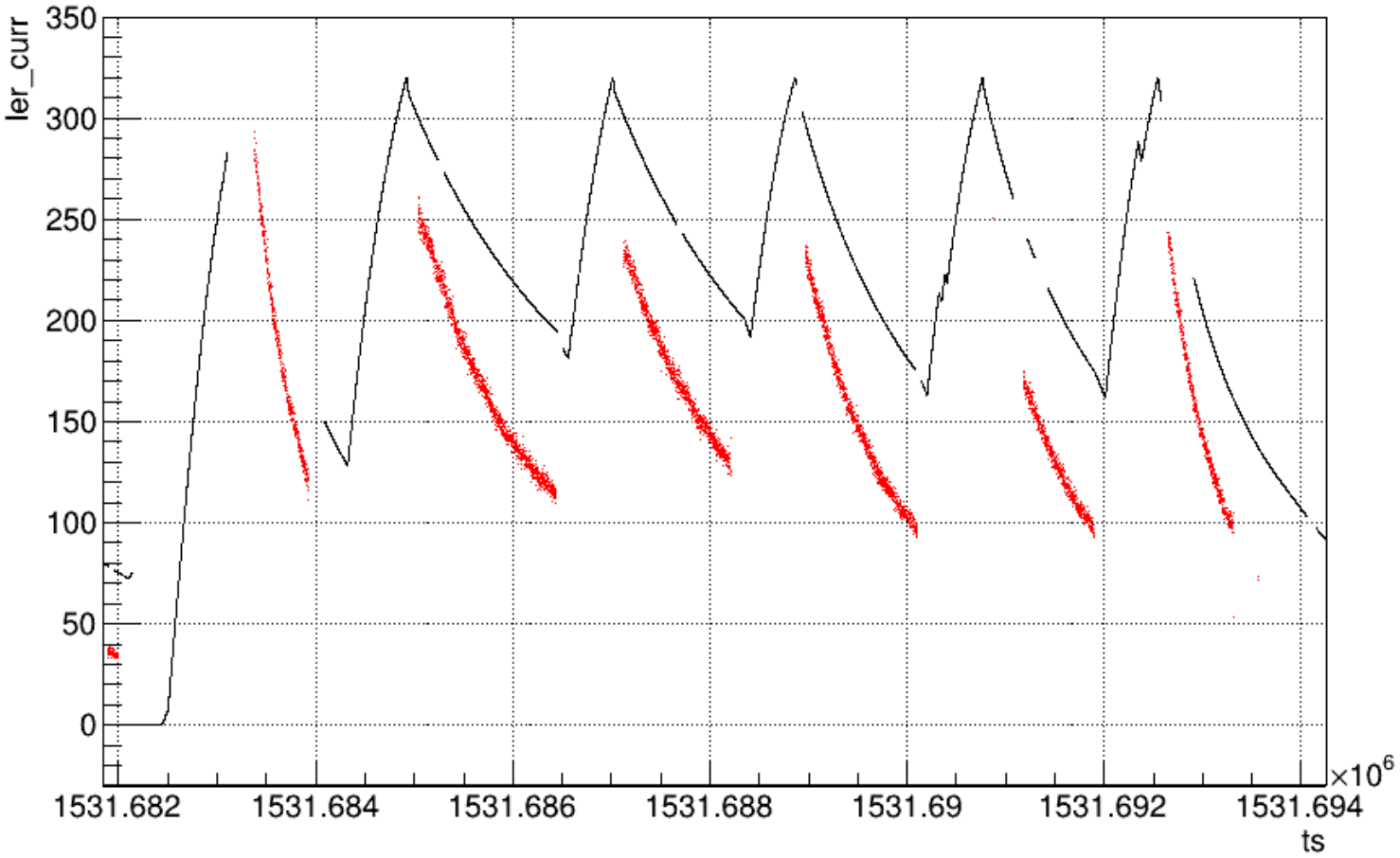
Motivation

- Beam backgrounds are limiting Belle 2 already
- We need to reach a clear, comprehensive understanding of beam backgrounds by October B2GM (also for BPAC!)
- Each subdetector is required to give a talk at B2GM
  - Benjamin has done most of the work for PXD already
  - Any help is appreciated

PXD Data for Beast tuples

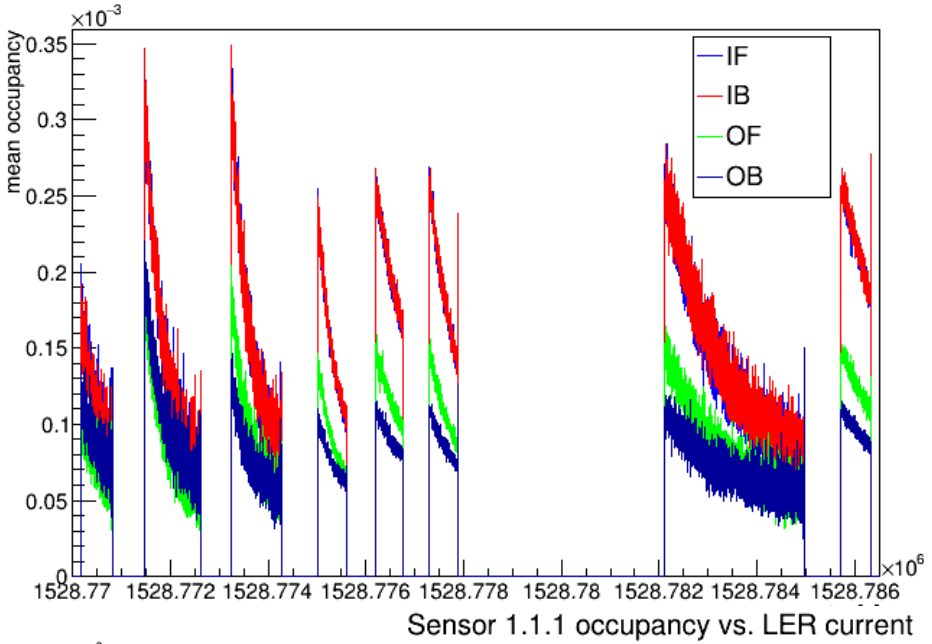
- Compute PXD variables at 1Hz from Belle II offline raw data files using basf2
  - Use global timestamps of Belle II events
  - Access to reconstructed data and offline calibrations (→ energy calibrations)
  - MC can be handled in almost the same way
  - Done for all BG studies and most lumi runs copied to KEKCC
- Integration of PXD tuples into global Beast tuples (many thanks to Luka Santeli)
  - Adding accelerator conditions and other Beast/Belle II detectors
  - Adding scaled MC data
  - Done for BG study on June 12

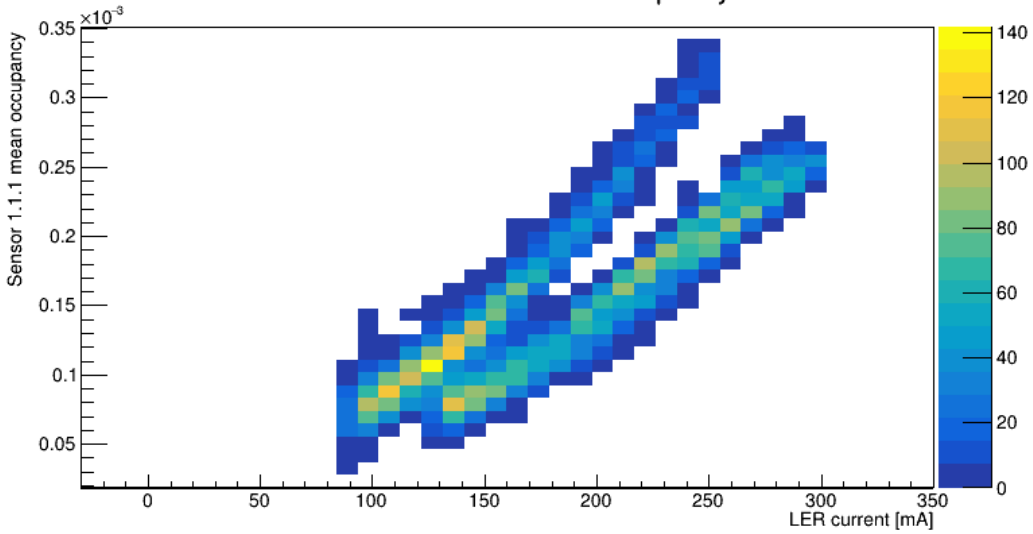
PXD Data for Beast tuples

- 

- Average PXD occupancy (red) vs. LER current (black)
- 1Hz timestamps derived from Belle II events seem consistent
- Availability of PXD tuples restricted to runs where PXD joined DAQ

June 12 study, looking at digits



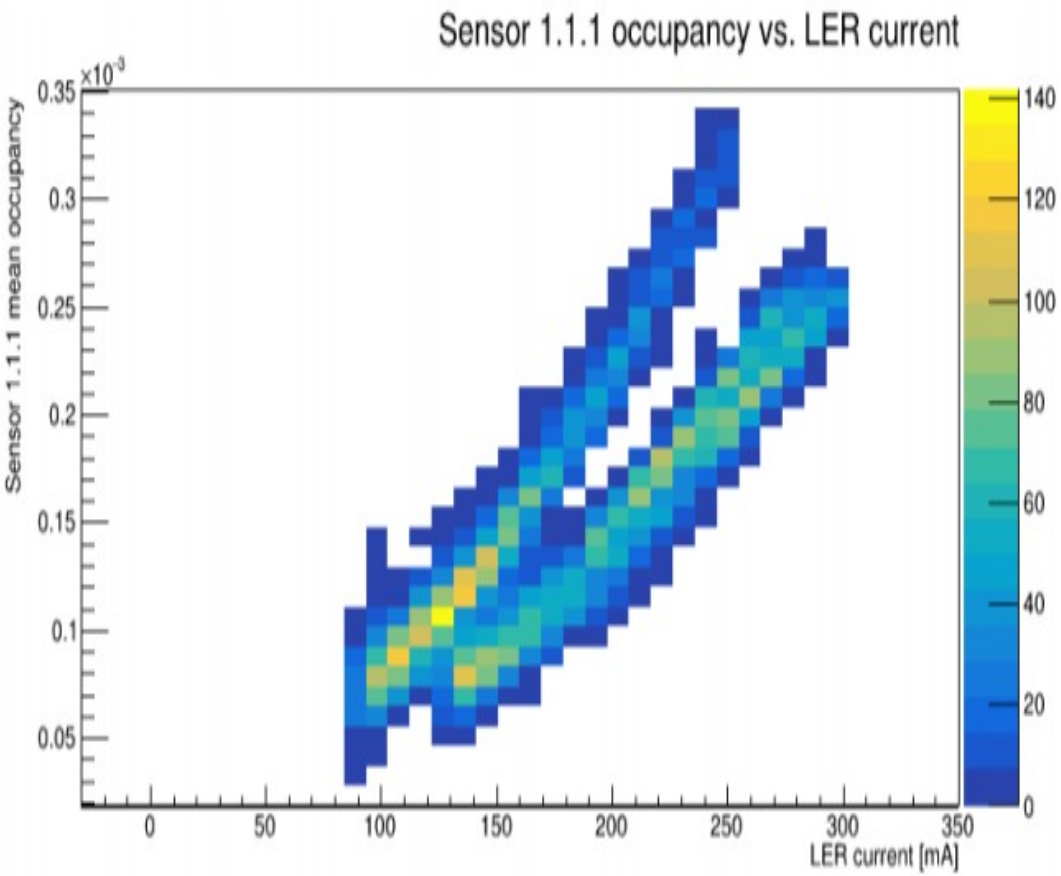


- June 12 with LER beam only
- Mean occupancy from all events per 1s window
- After filtering hot pixels
- Factors out dead/masked pixels

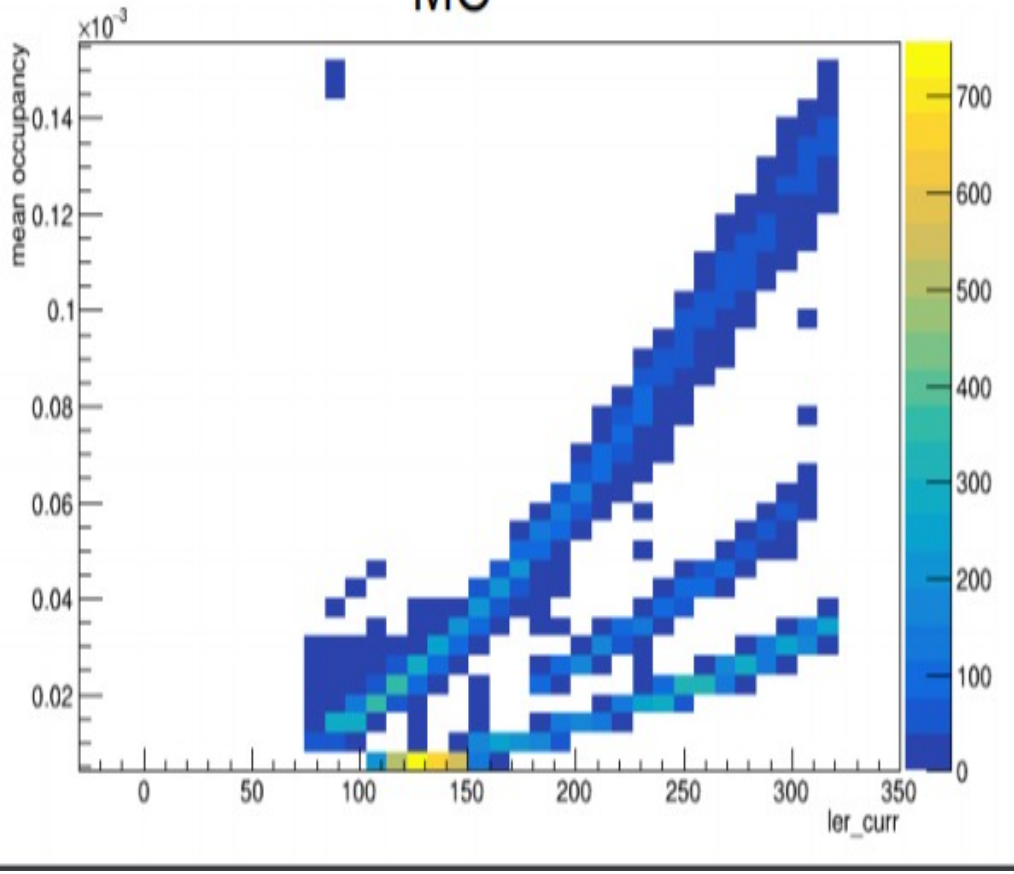
- Occcupancy vs. LER current
- Data shows **two** components
- Need to check which conditions changed

June 12 study, Data vs. MC

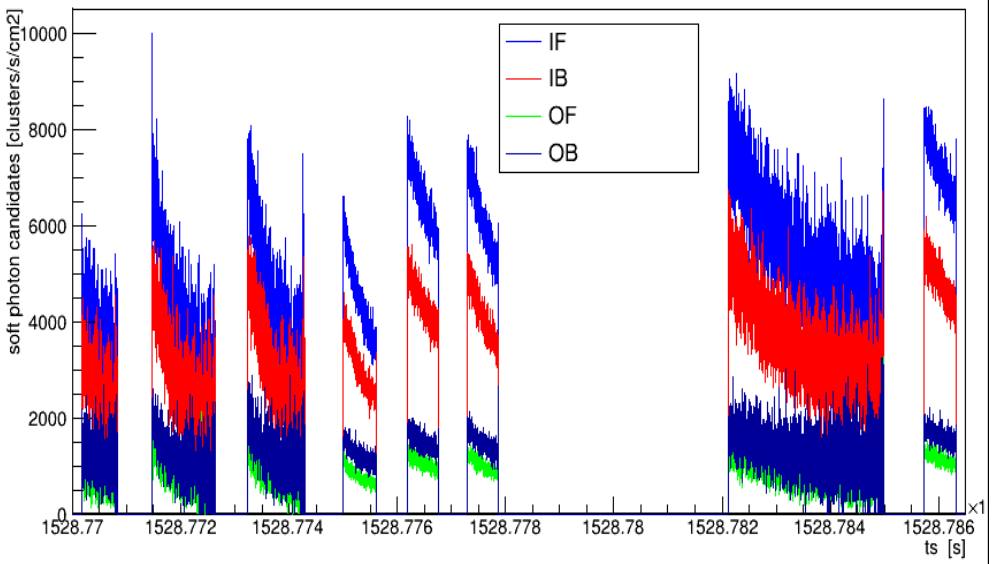
Data



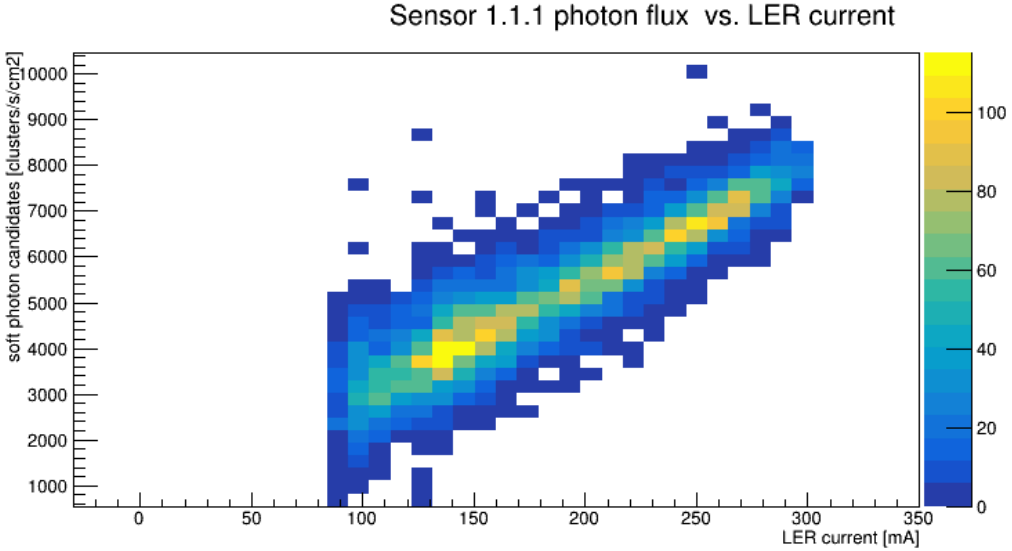
MC



June 12 study, looking at clusters

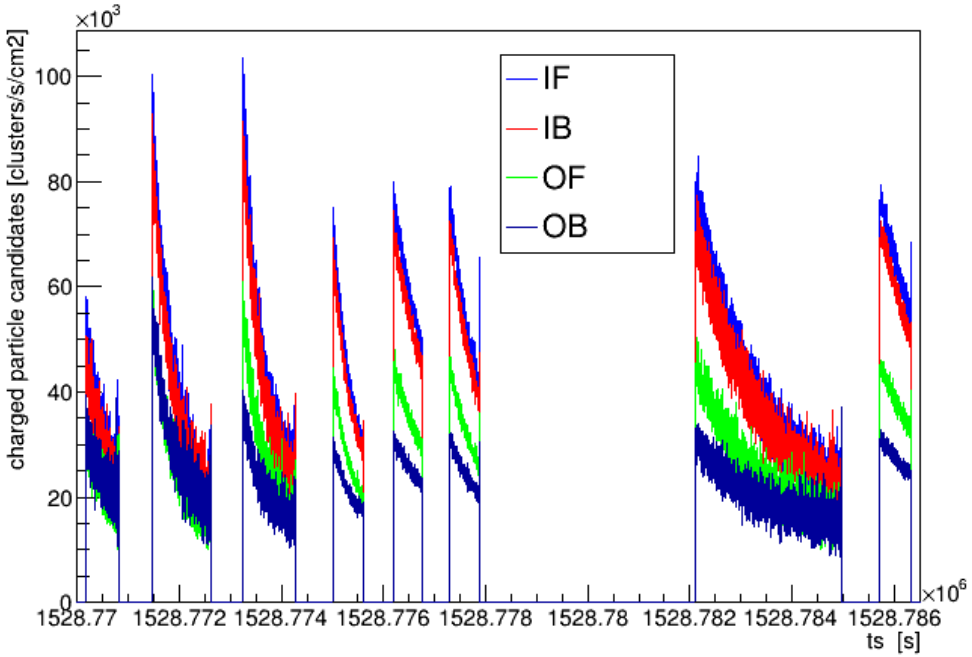


- June 12 with LER beam only
- Photon candidate clusters:
  - 1 pixel
  - 6 keV < Energy < 10 keV
- Normalized to ‘total integration time’ and ‘active area’

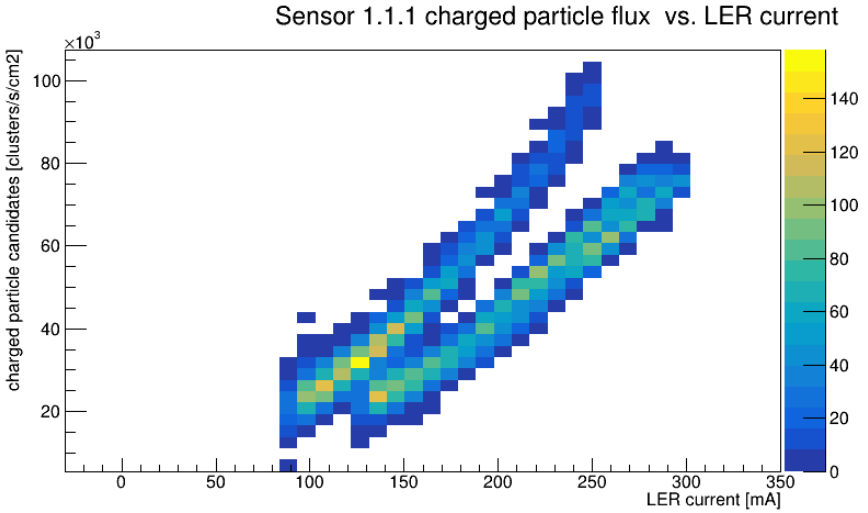


- Flux vs. LER current
- Data shows **one** component
- Currently Yuri‘s SR samples not available at KEKCC and not included into tuples

June 12 study, looking at clusters



- June 12 with LER beam only
- Charged particle candidates:
  - > 1 pixel
  - 10 keV < Energy
- Normalized to ‘total integration time’ and ‘active area’



- Flux vs. LER current
- Data shows **two** components
- Linear and Quadratic scaling accelerator current

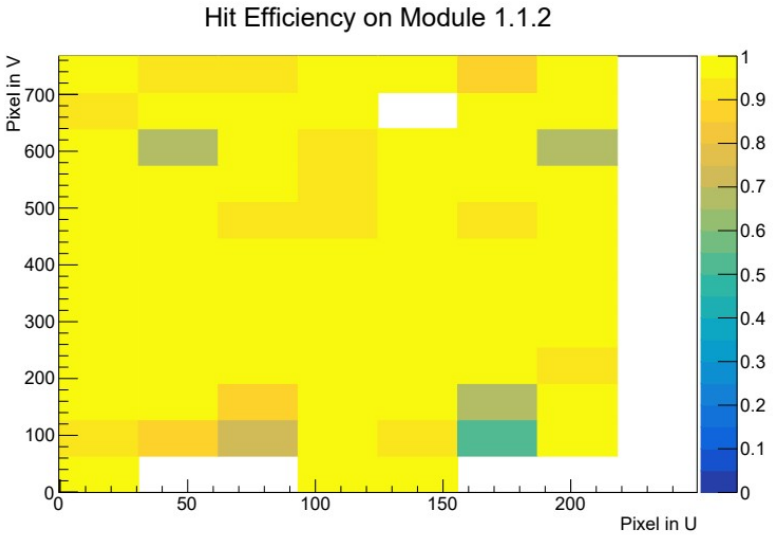
Summary

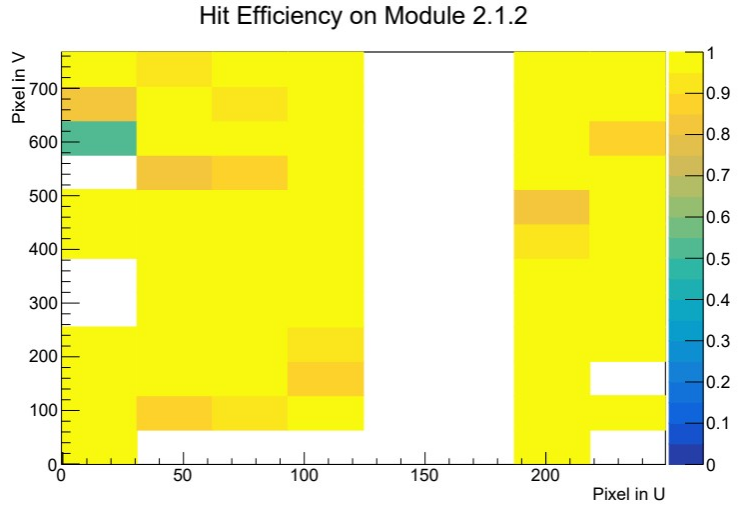
- PXD data integrated into Data/MC tuples
- SR samples from Yuri are still missing
  - Can be processed using same code, fast
- Analysis of Data/MC tuples has just started
  - Tuples confirm that soft photons component scales linear with LER current
  - Analysis of occupancy and flux data is ongoing
  - Data is available also with segmentation of ASIC/Switcher regions
  - Any help with the analysis is appreciated!

PXD efficiencies

- Efficiency calculation done by Uwe Gebauer
- Calculation:
  - Reconstruct tracks with ‚standard' settings and extrapolate to the PXD
  - Look for PXD clusters within 500µm
  - Efficiency = #Tracks with cluster/# All tracks
- Track cuts
  - Successful track fit
  - Within a radius of 10 pixel no noisy/dead pixel or sensor border
  - At least one SVD hit (no CDC only tracks)
  - Momentum > 4 GeV
  - P-value > 10^{-20}

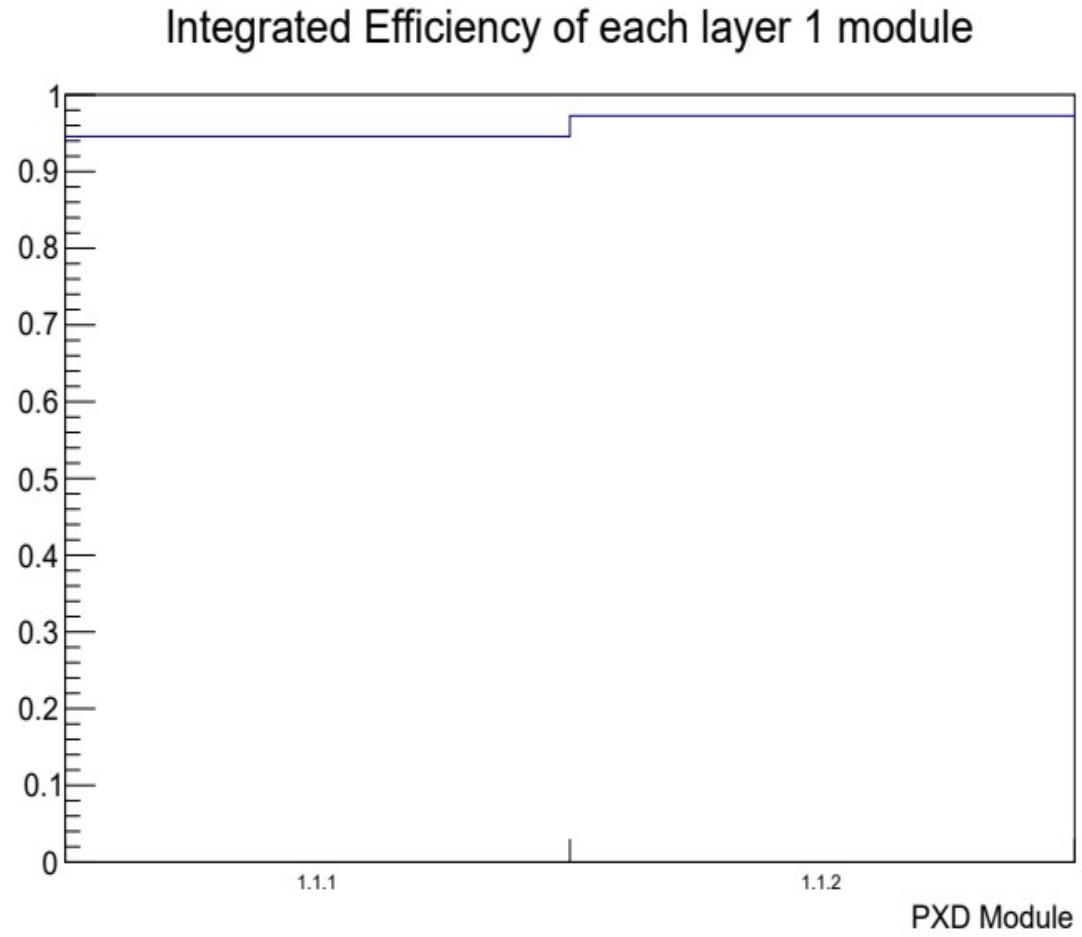
PXD efficiencies

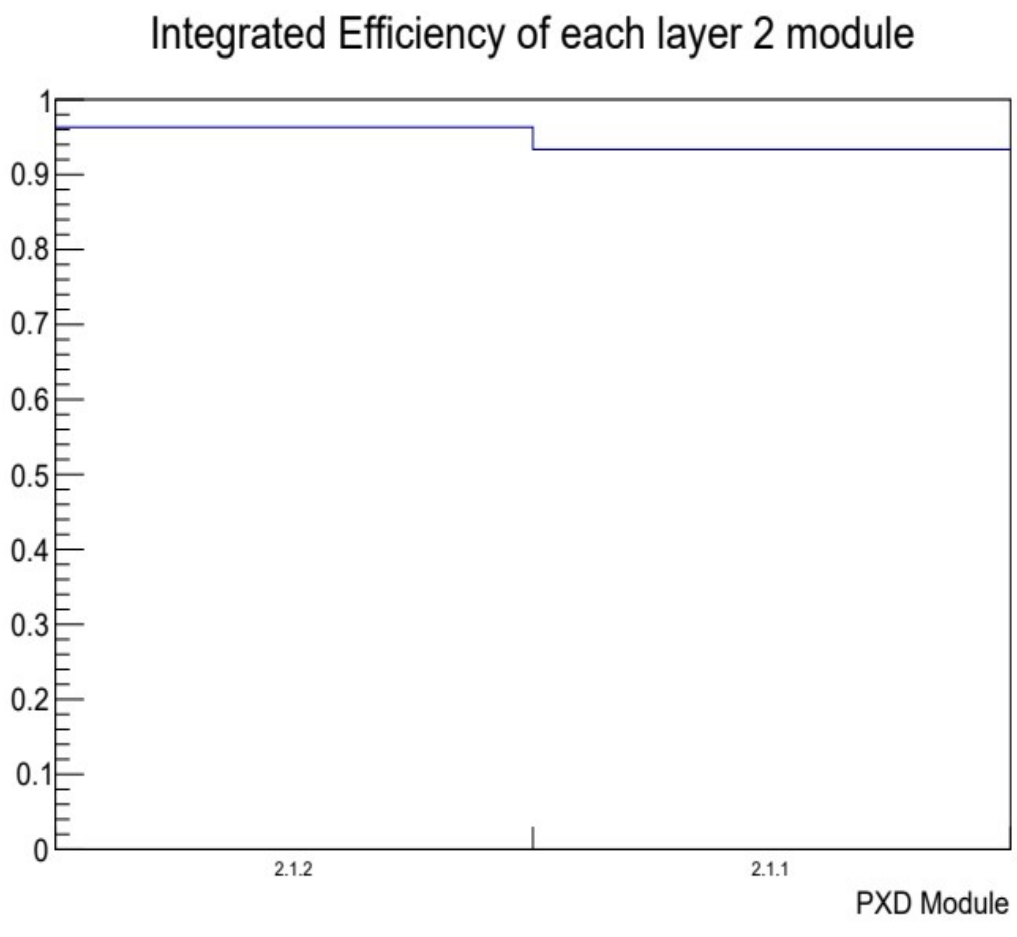




PXD efficiencies

- Overall PXD efficiency ~96%
- Work in progress, more at B2GM





PXD radiation effects

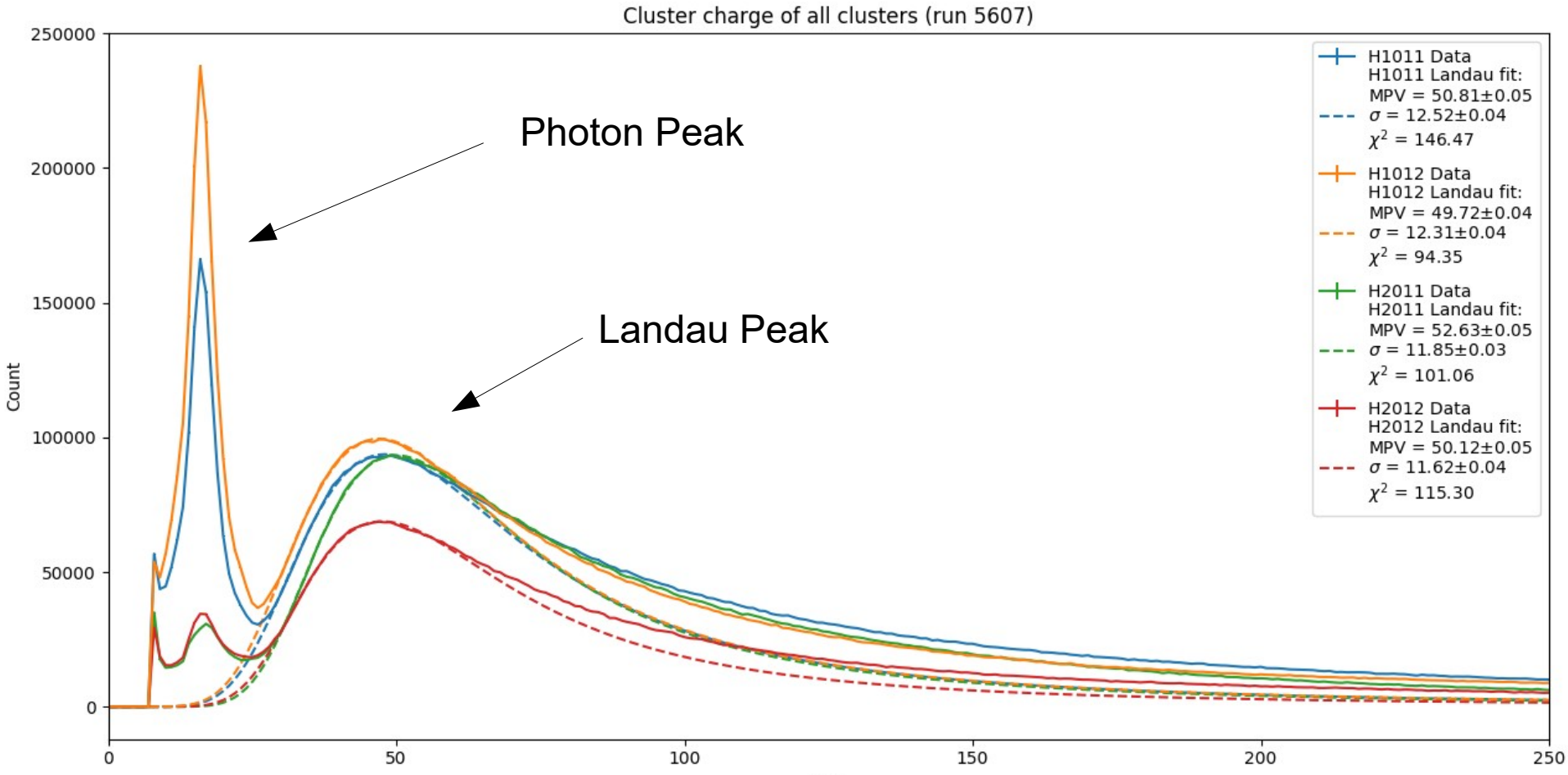
- PXD DEPFETs sensitive to radiation effects
- Through radiation the 'threshold voltage' $U_{Threshold}$
- of the DEPFETs is shifted, which leads to a different drain current I_D and a different self amplification g_q in the transistor

$$MPV \sim g_q \sim \sqrt{I_D} \sim \left(U_{Gate} - U_{Threshold}\right) \qquad (1)$$

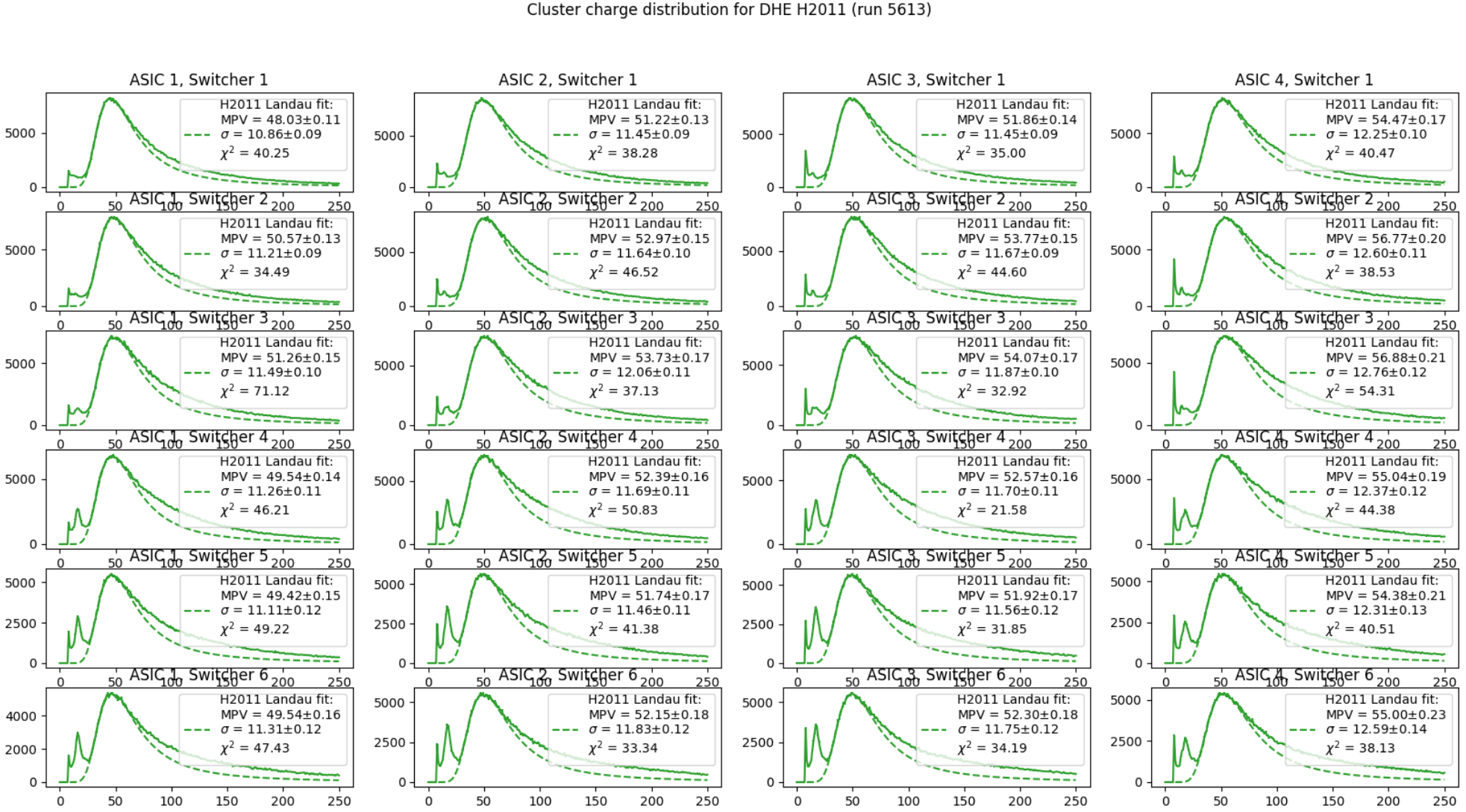
- The change in the self amplification is visible in the **MPV** of the Landau distribution
- During phase 2 the Gate-On voltage U_{gate} was adjusted to compensate for this effect
- Following analysis based on BonnDAQ data

MPV

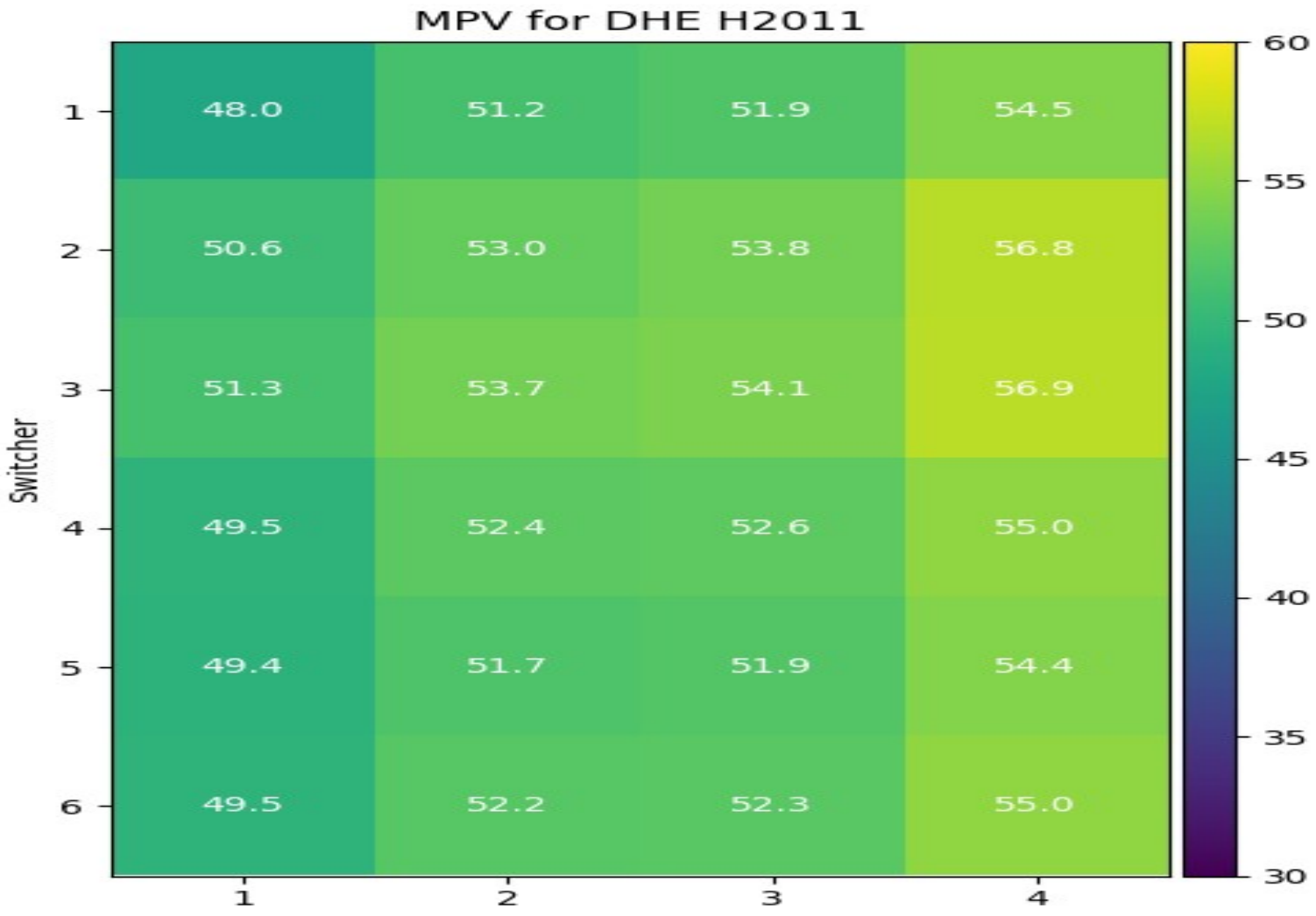
- Langau distribution fitted to cluster charge histogram for each module and each run from which the MPV is extracted
- Using pyRoot instead of pyplot (better error estimation)



MPV per Switcher/ASIC region

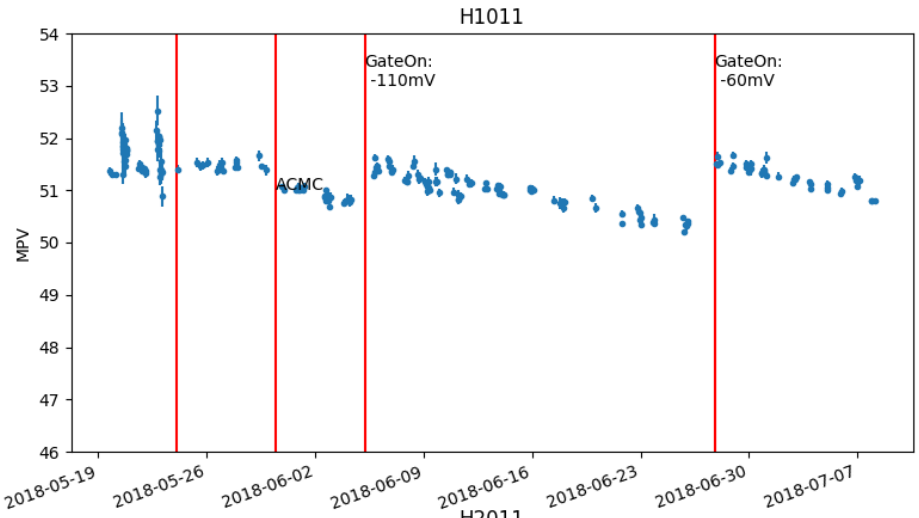


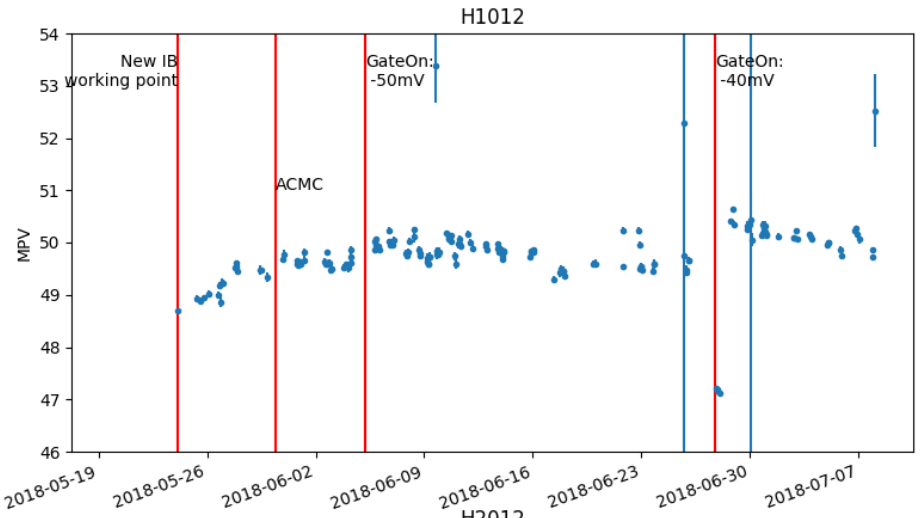
MPV per Switcher/ASIC region

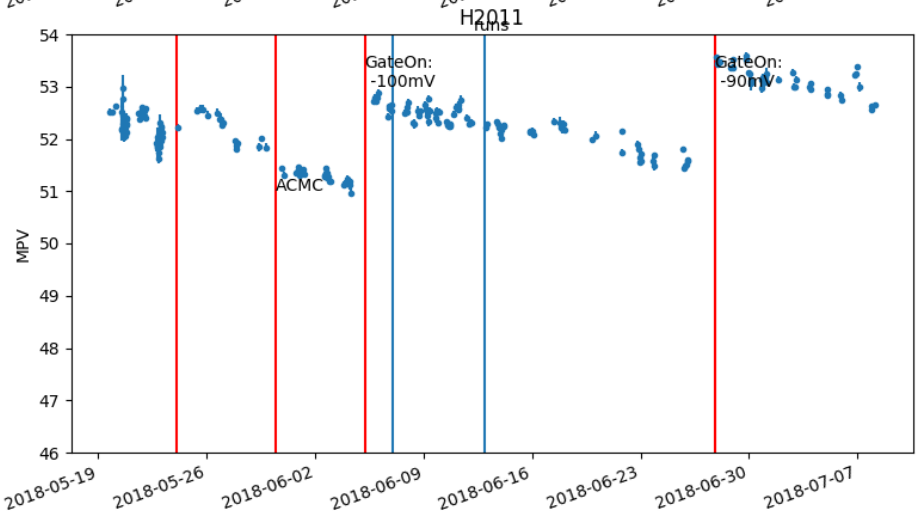


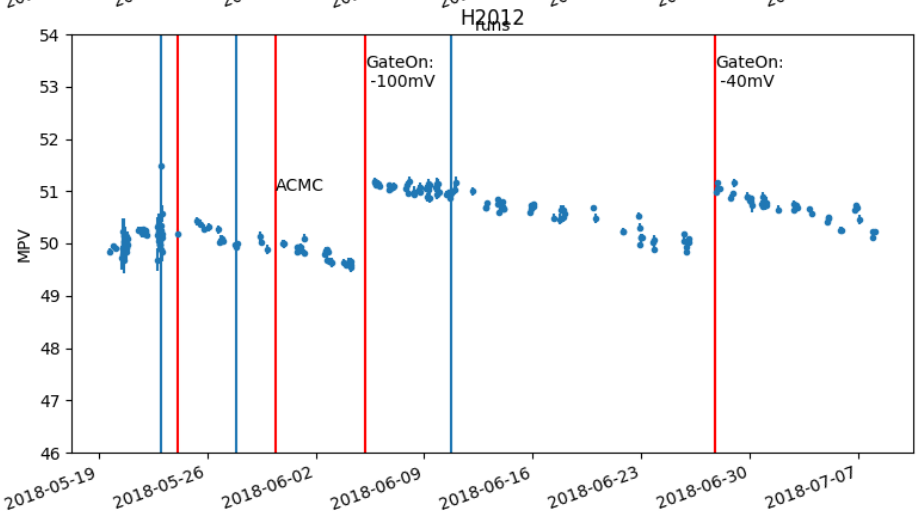
MPV Evolution

Cluster charge
MPV of runs 2009 to 5613, only runs with more than 400000 events shown.

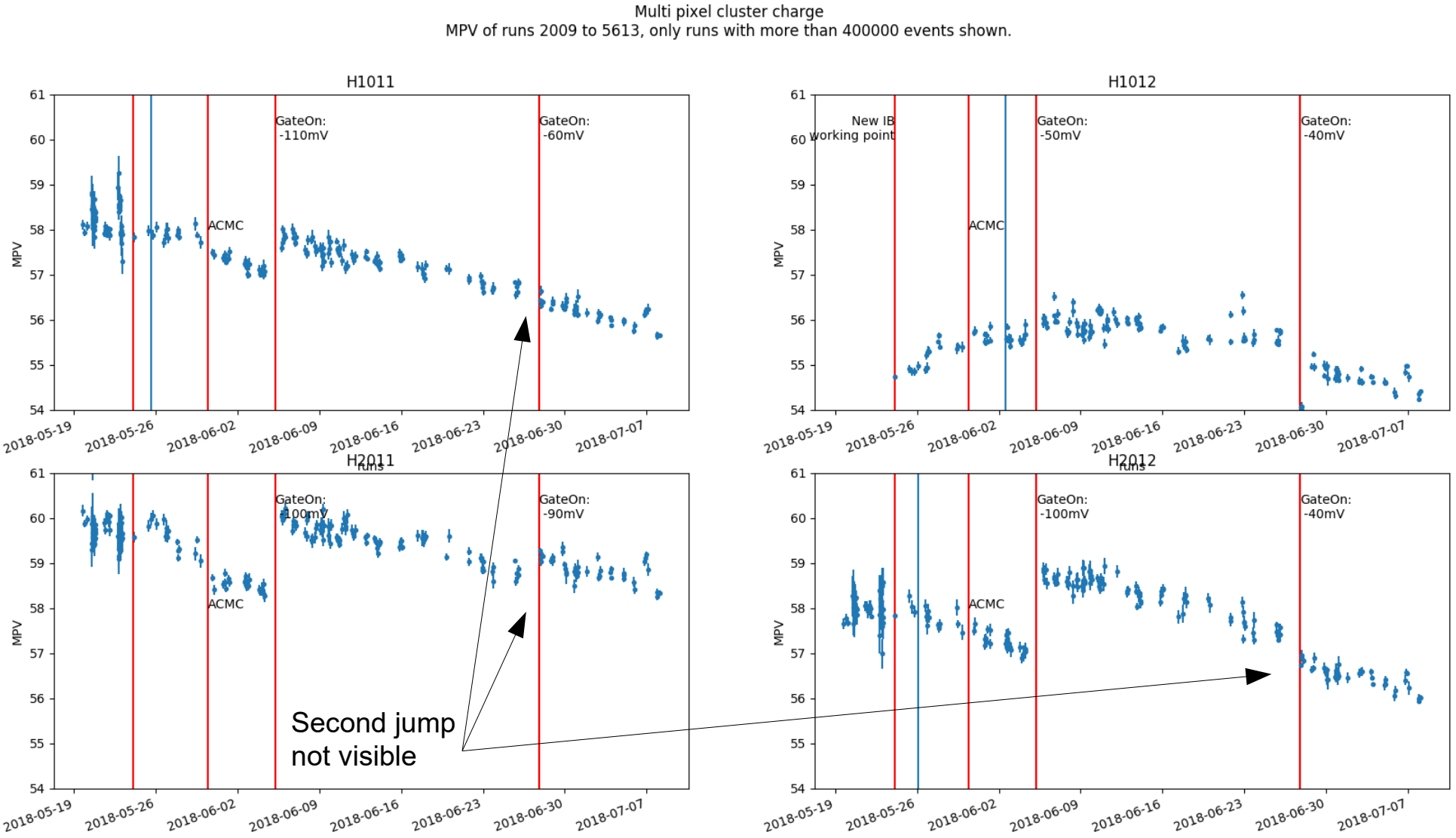








MPV Evolution (2)



Signal to Noise calculation

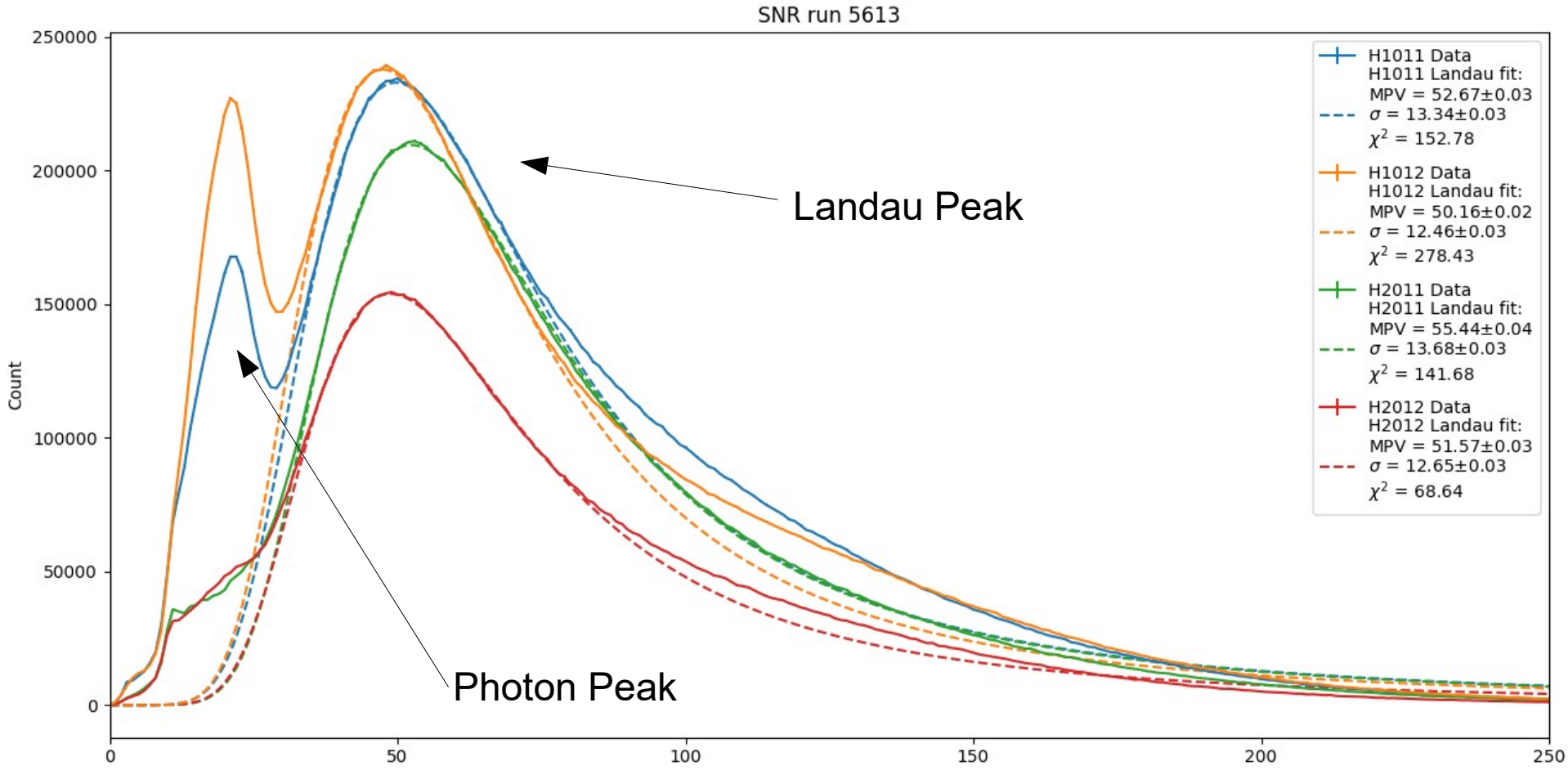
- From run 3698 to 6379 we have automatically recorded pedestals --> Can be used to calculate noise of the modules
- For each cluster we define a local signal to noise ratio as:

$$SNR = \frac{Clustercharge}{\sqrt{Clustersize} * Seednoise}$$

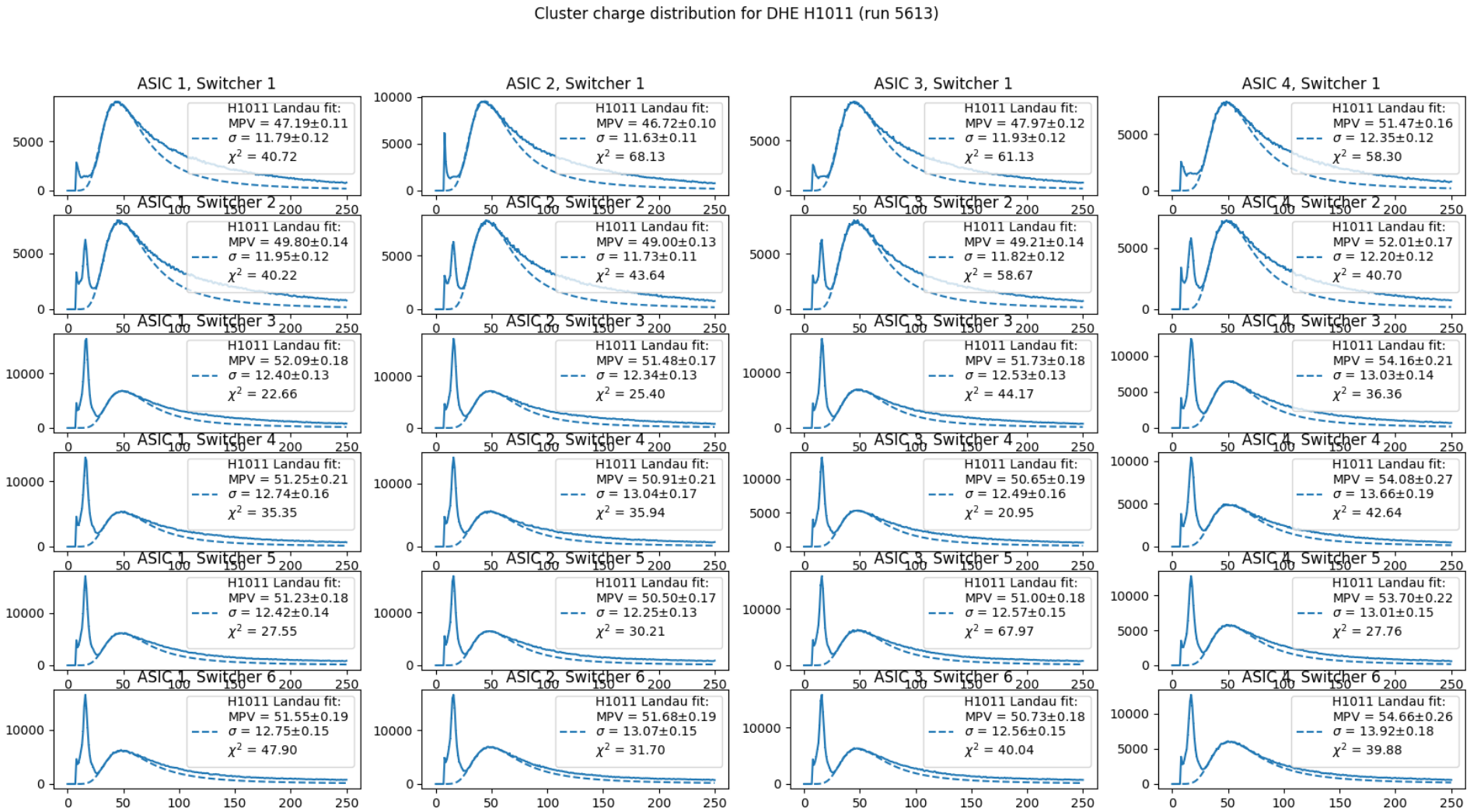
- The SNR values of all clusters are filled into a histogram, which gives a Landau shape from which the MPV is extracted using a Langau fit

SNR

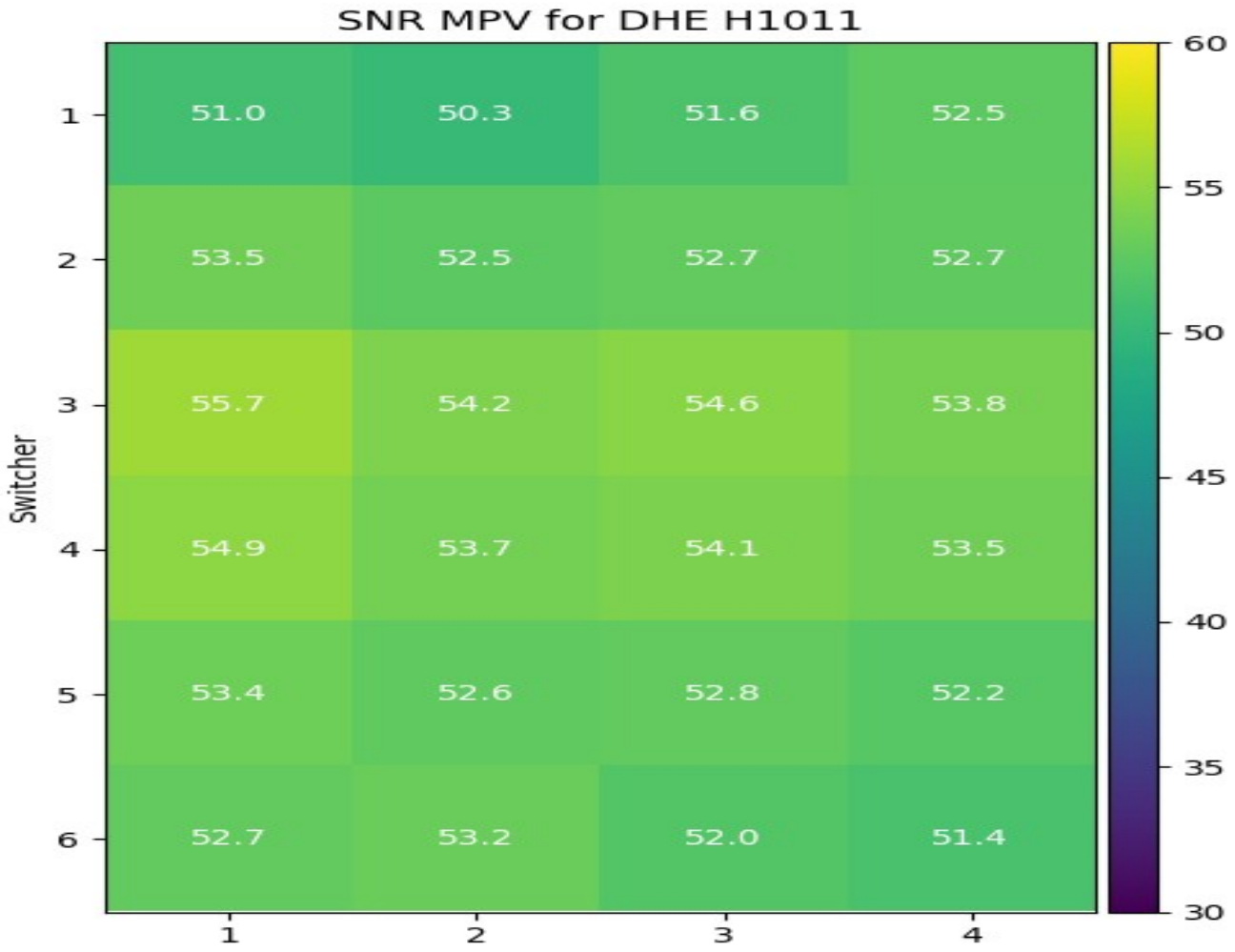
- Langau distribution fitted to cluster charge histogram for each module and each run from which the MPV is extracted



SNR per Switcher/ASIC region

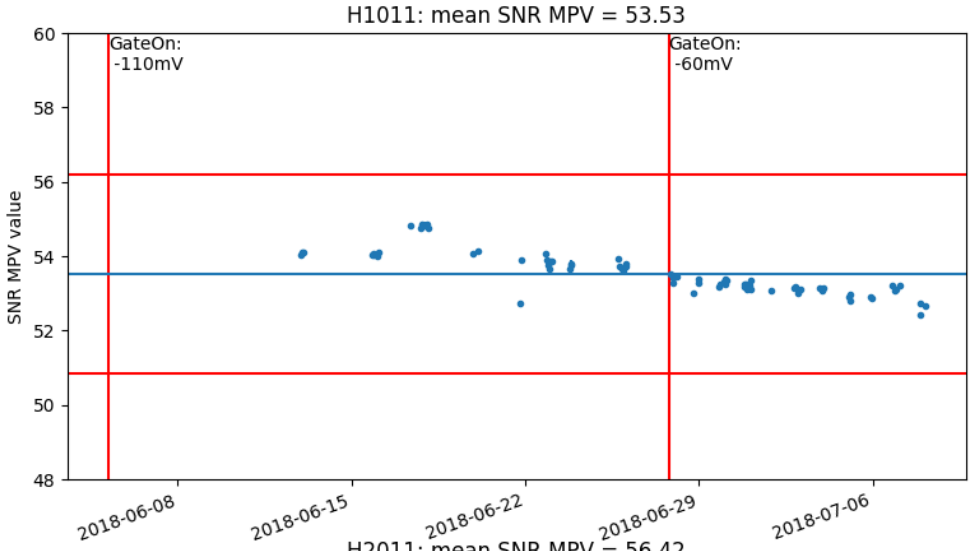


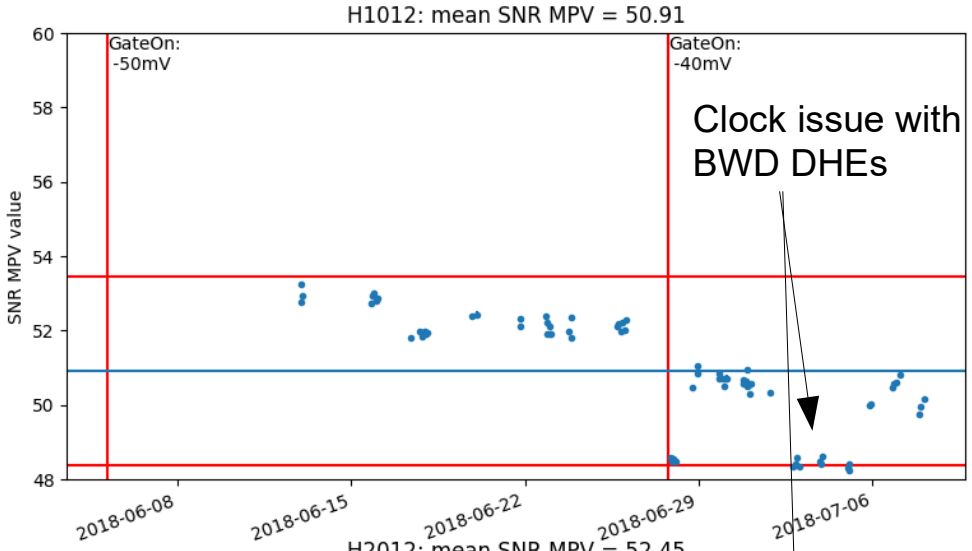
SNR per Switcher/ASIC region

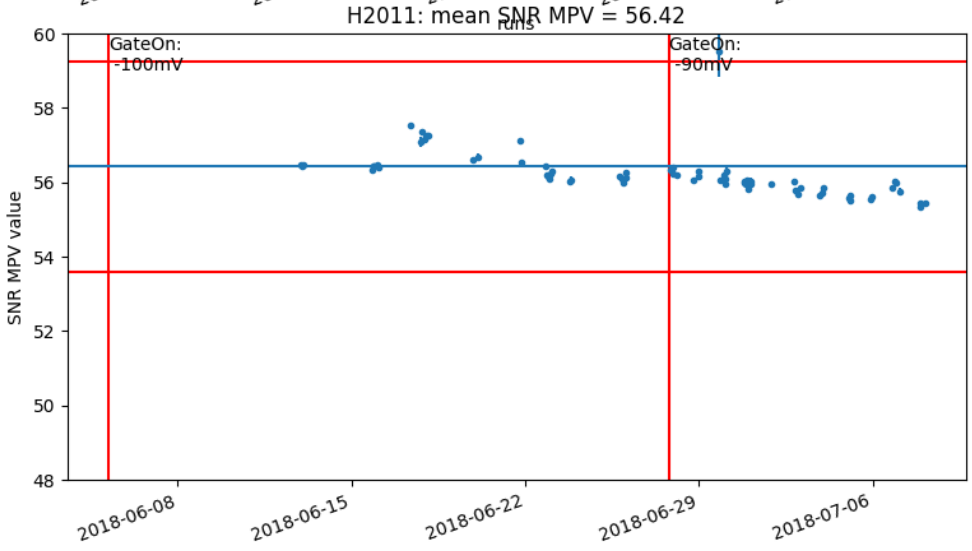


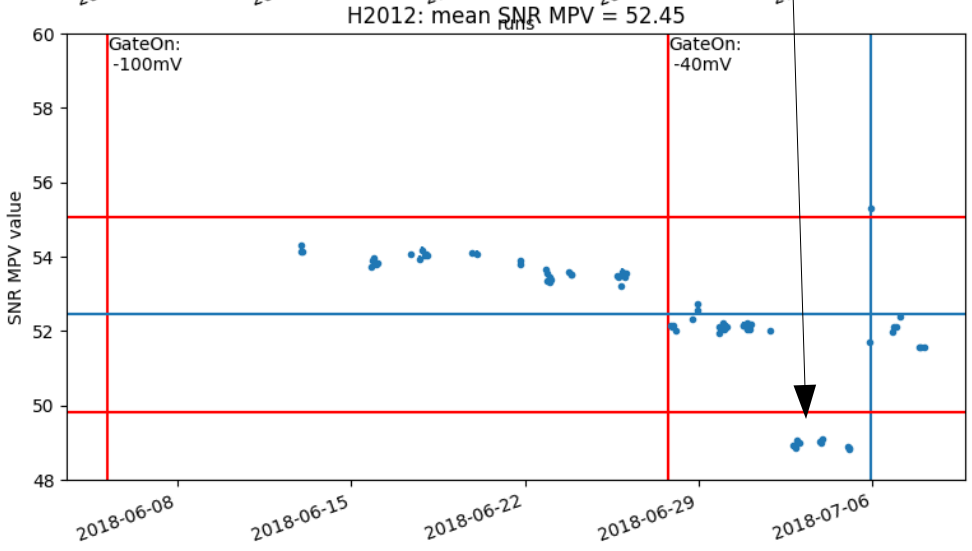
SNR Evolution

SNR MPV with mean value and +-5% interval.









Summary

- Gate-On variations and radiation damge can be clearly seen in the MPV of the Landau
  - Multi pixel cluster show a different not yet understood behaviour

- The four Phase 2 modules show a SNR of ~52
  - The SNR seems to slowly decrease over time, has to be investigated further