CBC3.1 status and CBC3 beam tests at H8

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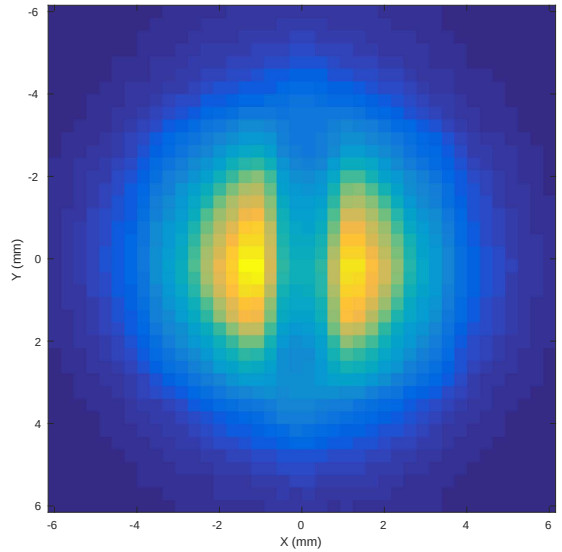
with thanks to:
Duncan Parker and Maria Khaleeq
(assembly of the modules used for these tests)
the UA9 collaboration
(particles)

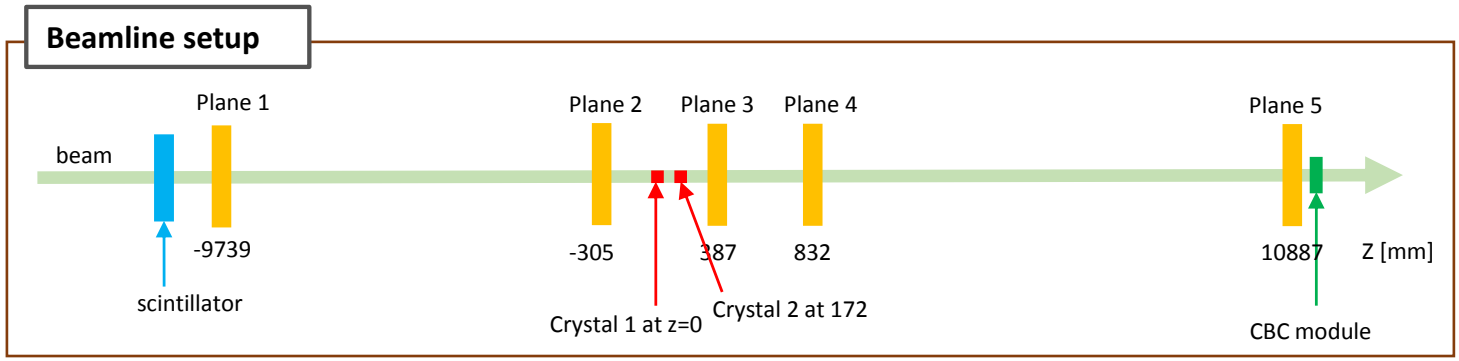
CBC3.1

- All planned changes implemented:
  - L1 data corruption at some DLL settings
  - Stub decoding
  - Reset signal synchronization
  - Interchip test logic
  - Interchip swapping logic
  - Reduced power consumption at power-up
  - Fuse supply pullup
  - Improved SEU tolerance
- Top level simulations running
- Final design review December 19th
- Submission for manufacturing planned for January 2018

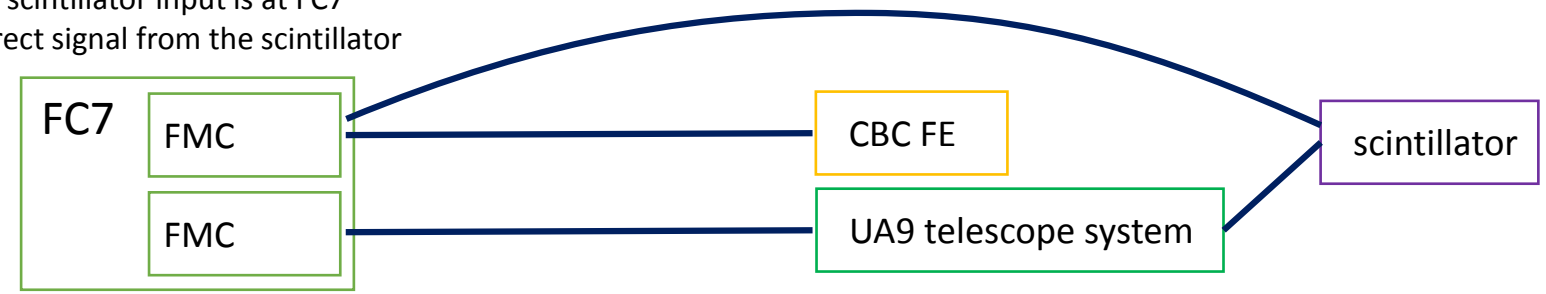
CBC3 Beamtest experiment setup



- Parasitic test after the UA9 experimen
  - 180 GeV Pion beam 21 – 23 Oct
  - 150 AGeV Xe beam 23 – 30 Oct.



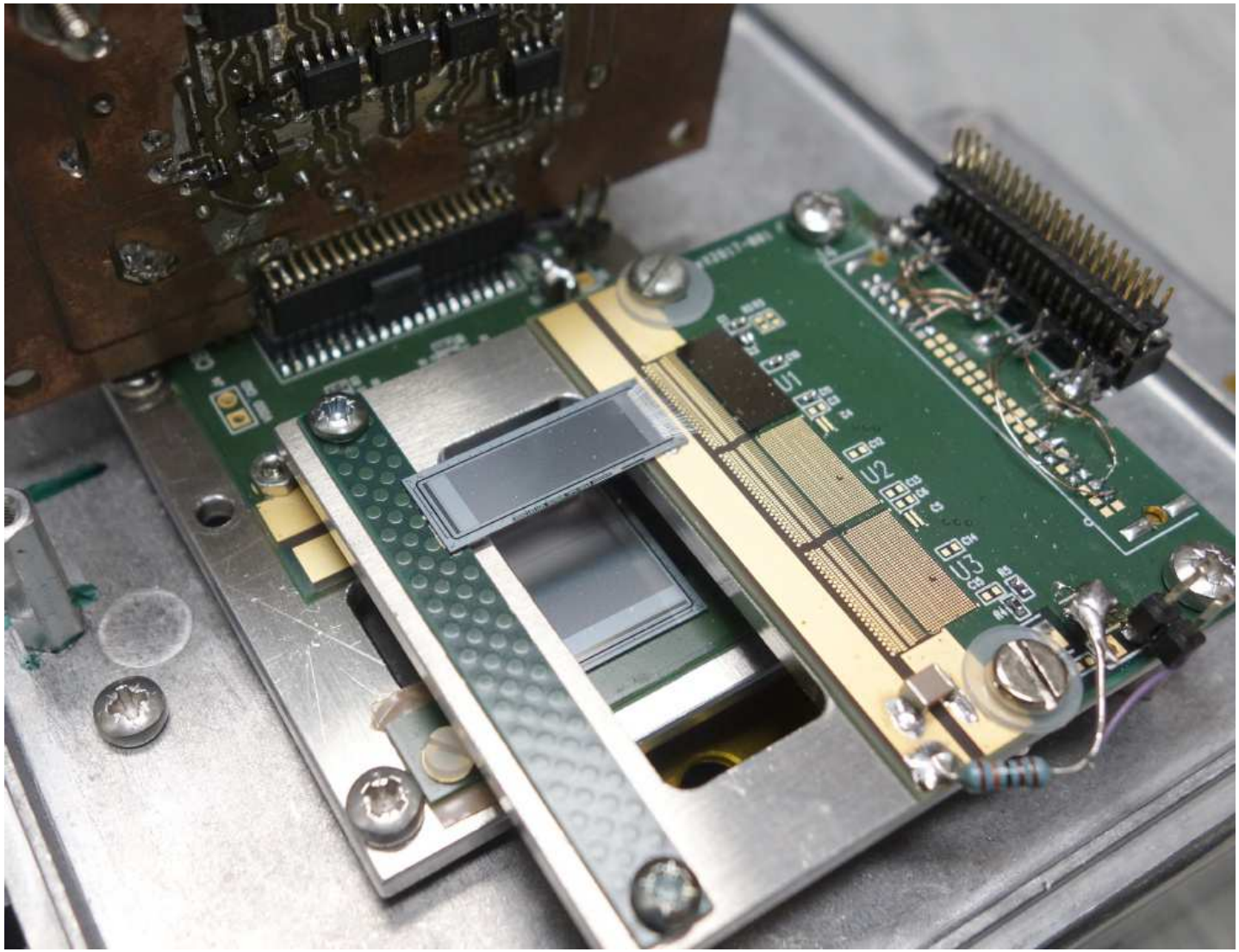
TDC for the scintillator input is at FC7
with the direct signal from the scintillator



DAQ

- FC7-based DAQ based on Kirika's firmware, operated independently from telescope DAQ
- Telescope reference clock, trigger and trigger counter reset by TTC fiber
- CBC3<->Telescope event matching by trigger count (off-line)
- Firmware-based 0.78ns resolution TDC connected to Scintillator
- 1-4 CBC3s using Mark Raymond's interface boards, new FMC breakout boards
- X(Y)-stage

Single-sided CBC3 modules



We are most grateful to Marko Dragicevic, Alex König and Marius Metzler for supplying sensors

180 GeV test

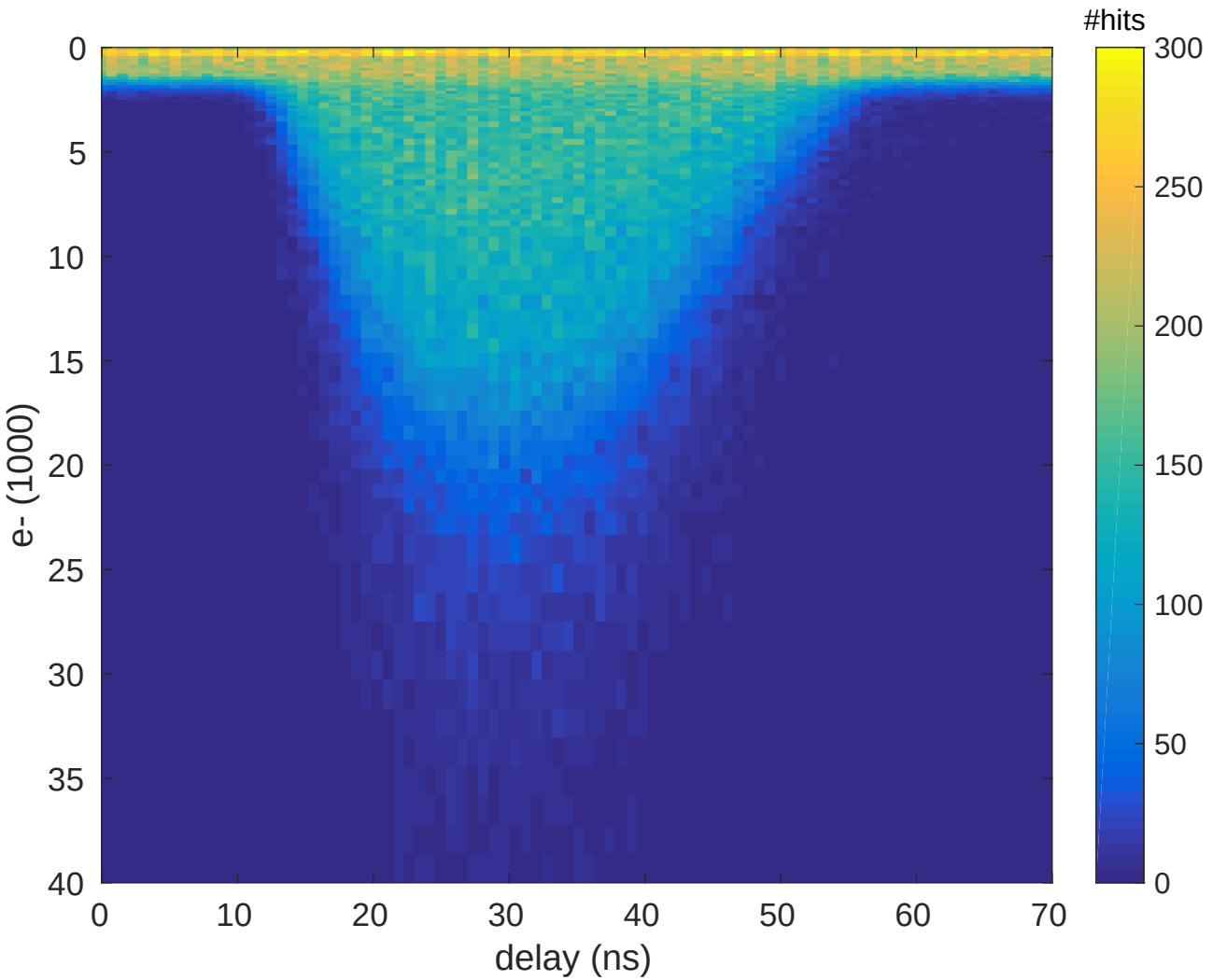
- 21-23 Oct:
  Single module with radiation test sensor (64 strips, 2cm).
  Measurements:
  - Stability
  - Resolution
  - Efficiency
  - Shaper response
  - HIPs

Pedestal stability

	Run number	Mean	sigma
21 Oct 2017 13:12:04 CEST	2424	584.42 +/- 0.74	5.65 +/- 0.56
21 Oct 2017 15:27:13 CEST	2606	583.35 +/- 0.82	5.67 +/- 0.56
22 Oct 2017 21:39:16 CEST	3427	583.26 +/- 0.75	5.66 +/- 0.55
23 Oct 2017 01:26:54 CEST	3448	583.35 +/- 0.79	5.58 +/- 0.56
		583.60 +/- 0.48	5.64 +/- 0.04

Noise ~ 800 e (1 vcth ~ 142 e), pedestal is very stable

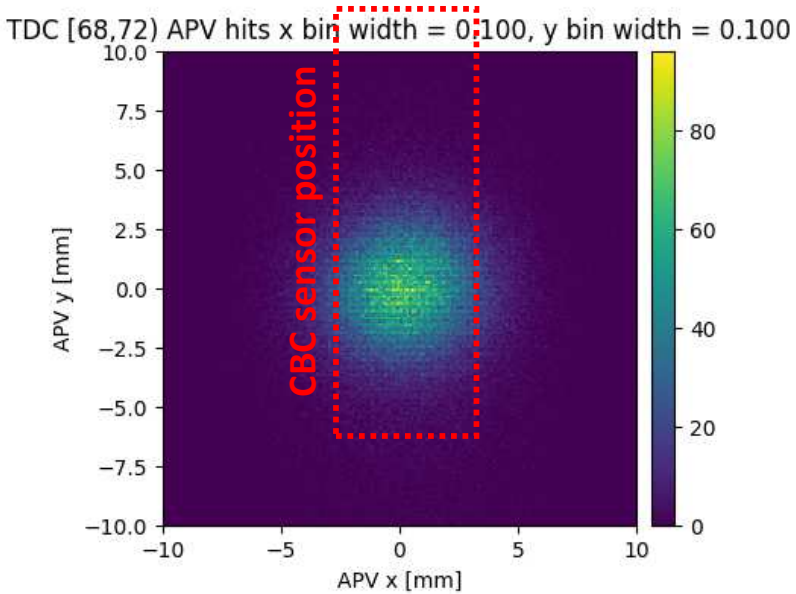
Shaper response, Sample mode

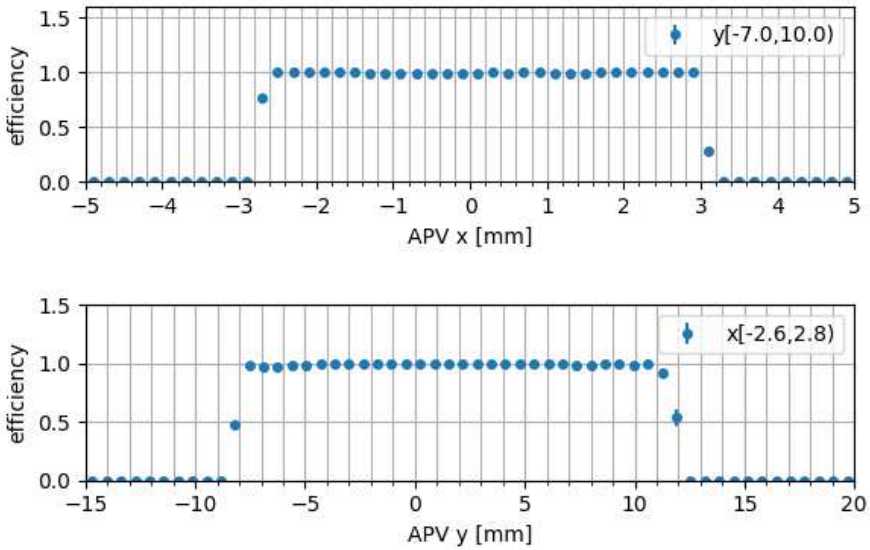


Works well for synchronized particles (or-mode may be preferable for asynchronous applications)

Efficiency

- The threshold was set to 5.96 sigma
- Events selected in 3.1 ns bin around maximum sensitivity, (25487 events)
- Efficiency of CBC hit with cluster position < 200 um from the track hit at closest Telescope plane
- eff. = 99.58 +/- 0.04





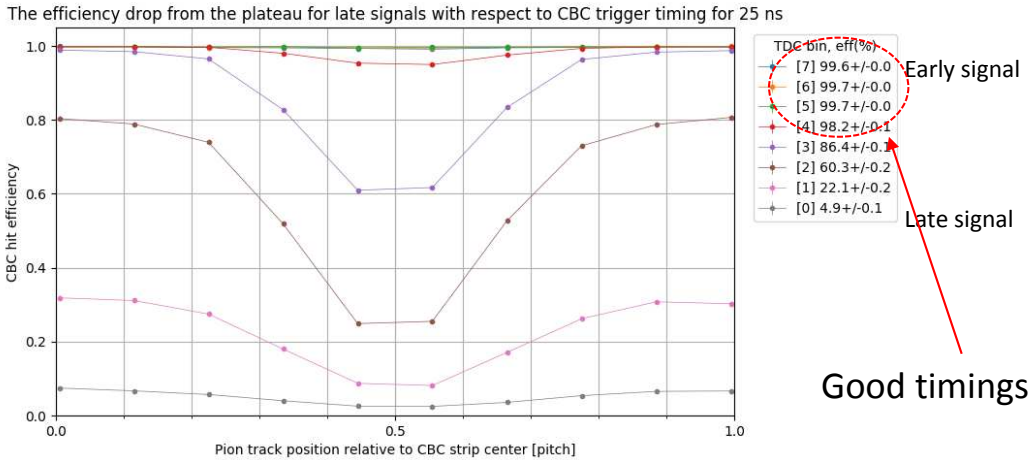
Efficiency

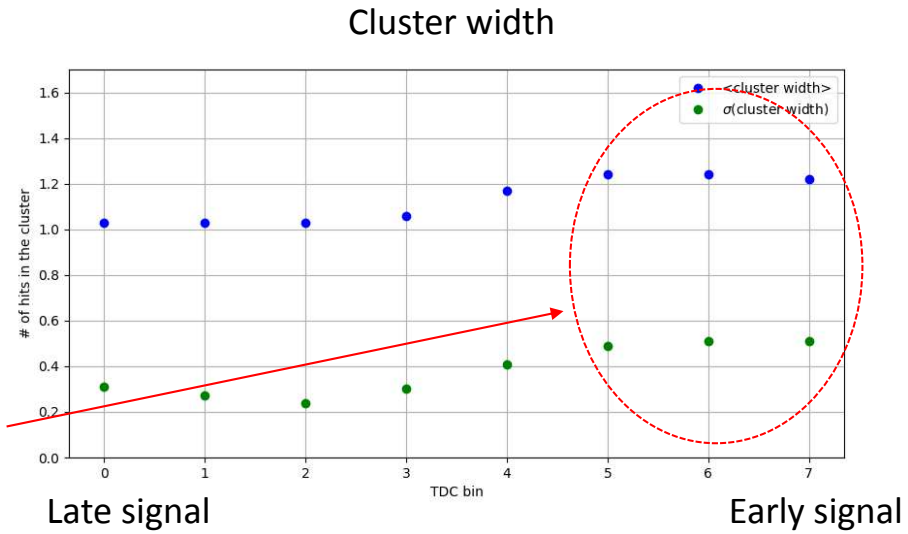
The threshold was set to 5.96 sigma

Efficiency of CBC hit with cluster position < 200 um from the track hit at closest Telescope plane

Efficiency goes down for the late signals.

3.125 ns TDC bins



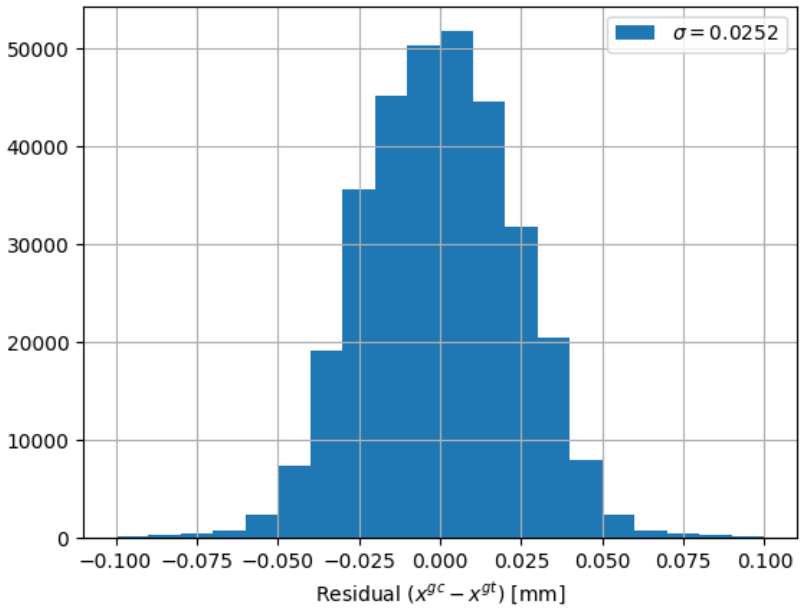


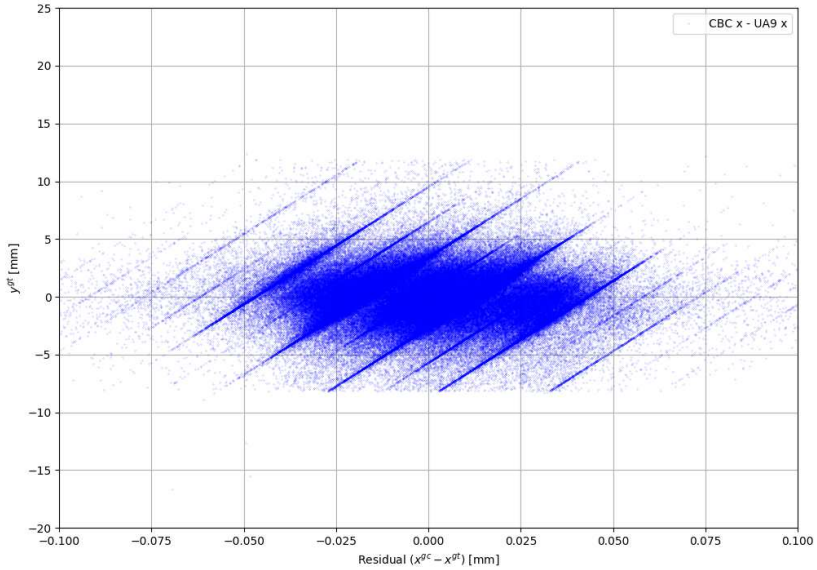
No loss of efficiency between strips if the particle arrives anywhere near the peak of the shaper response.

Tracking residual (resolution)

- 323927 single track with CBC single cluster hit events are selected. (these were not used for the alignment)
  - Residual σ = 0.02521 ± 0.00003 mm

  where expected σ = 0.02598 mm(0.090/sqrt(12) for CBC sensor, telescope hit resolution = 0.007 mm



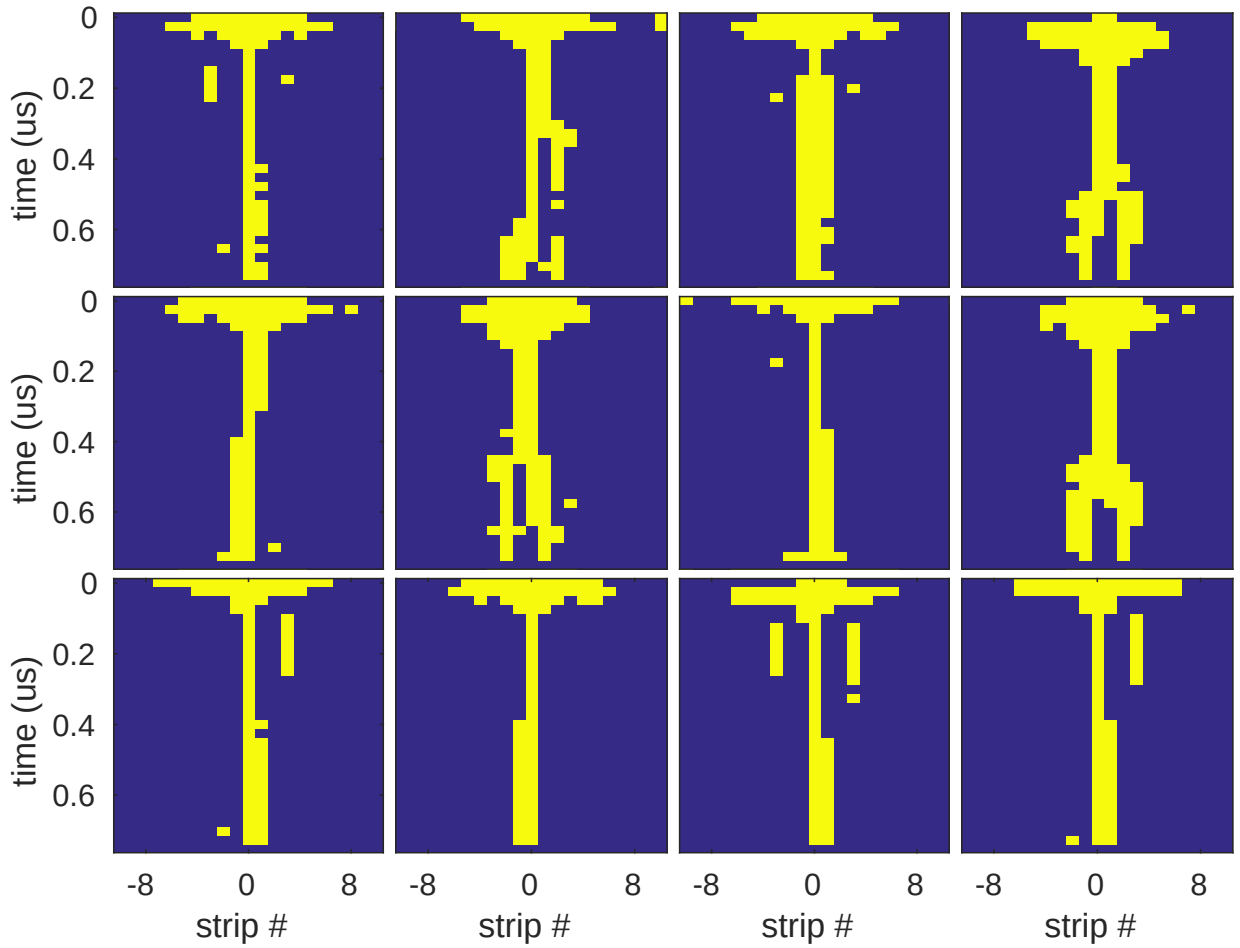


150 AGeV Xenon test

23-30 Oct:
Single module with radiation test sensor (64 strips, 2cm)

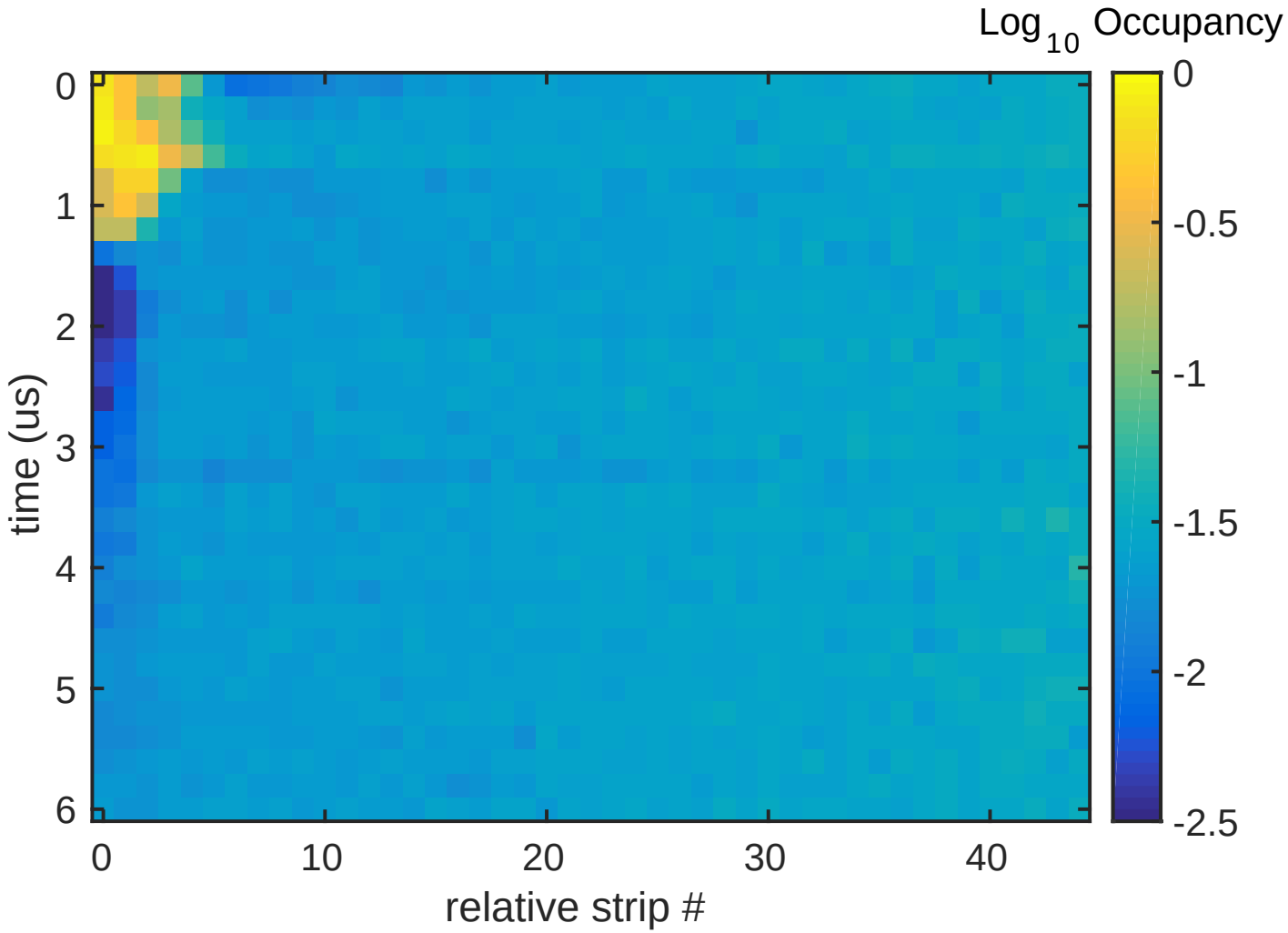
- Large signal response study
  - Xe^{+54} deposits about 3000 MIP at full bias
  - Sensor operated at reduced bias to reduce overload
  - Q $\approx$ 600 MIP at V_b=-8V if Q $\propto$ depletion $\propto \sqrt{V_b}$
  - Q $\approx$ 1700 MIP at V_b=-64V, just over 4 pC (worst-case HIP)
- Study of settings for Ion telescope operation

Xenon Ion response, V_b=-8V



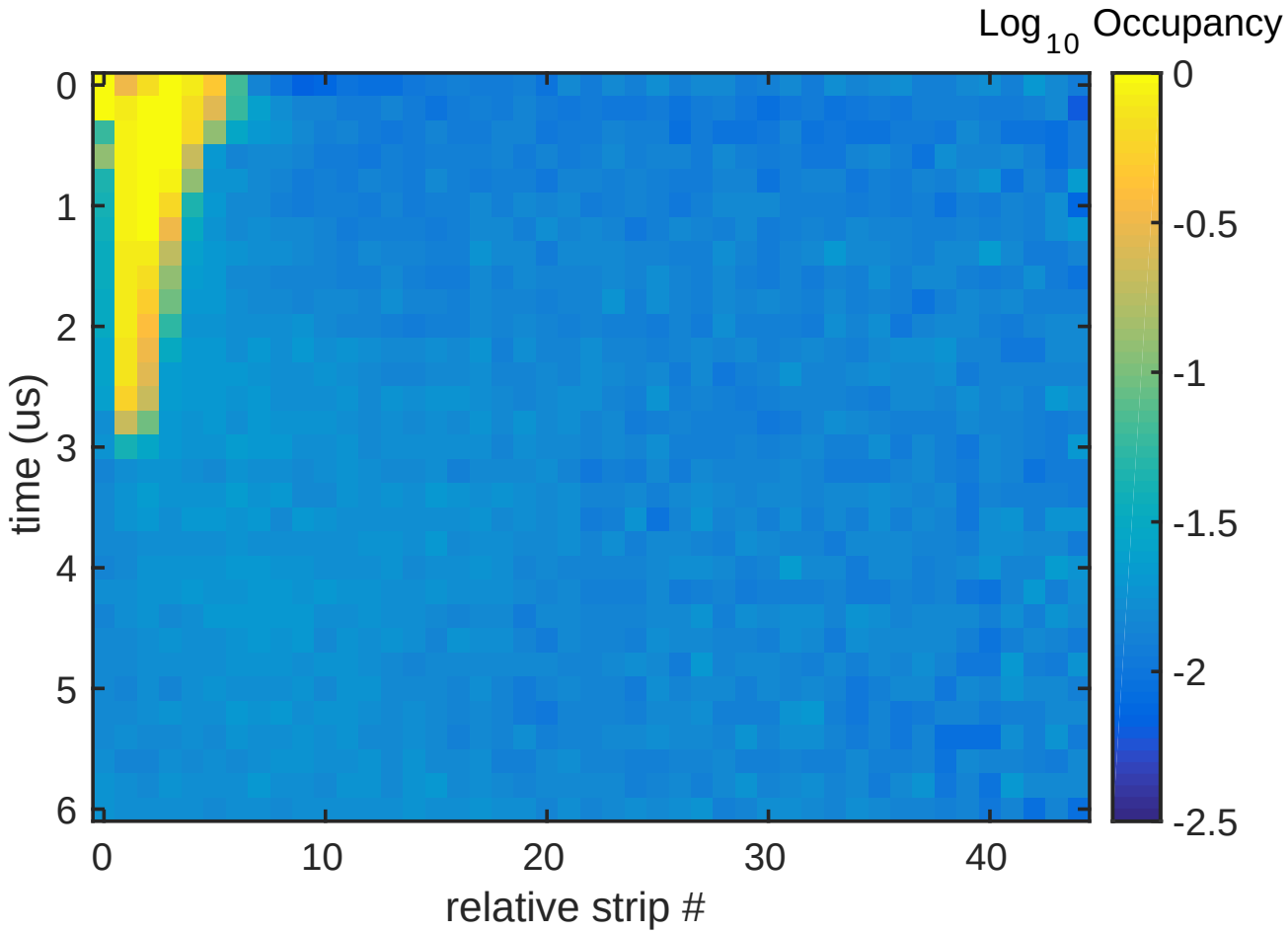
For simulations and lab measurements of HIP response see:
http://www.hep.ph.ic.ac.uk/ASIC/dmray/CBC_documentation/CBC3_FE_measurements.pdf

Effects of Xenon Ions on pedestal, V_b = -8V



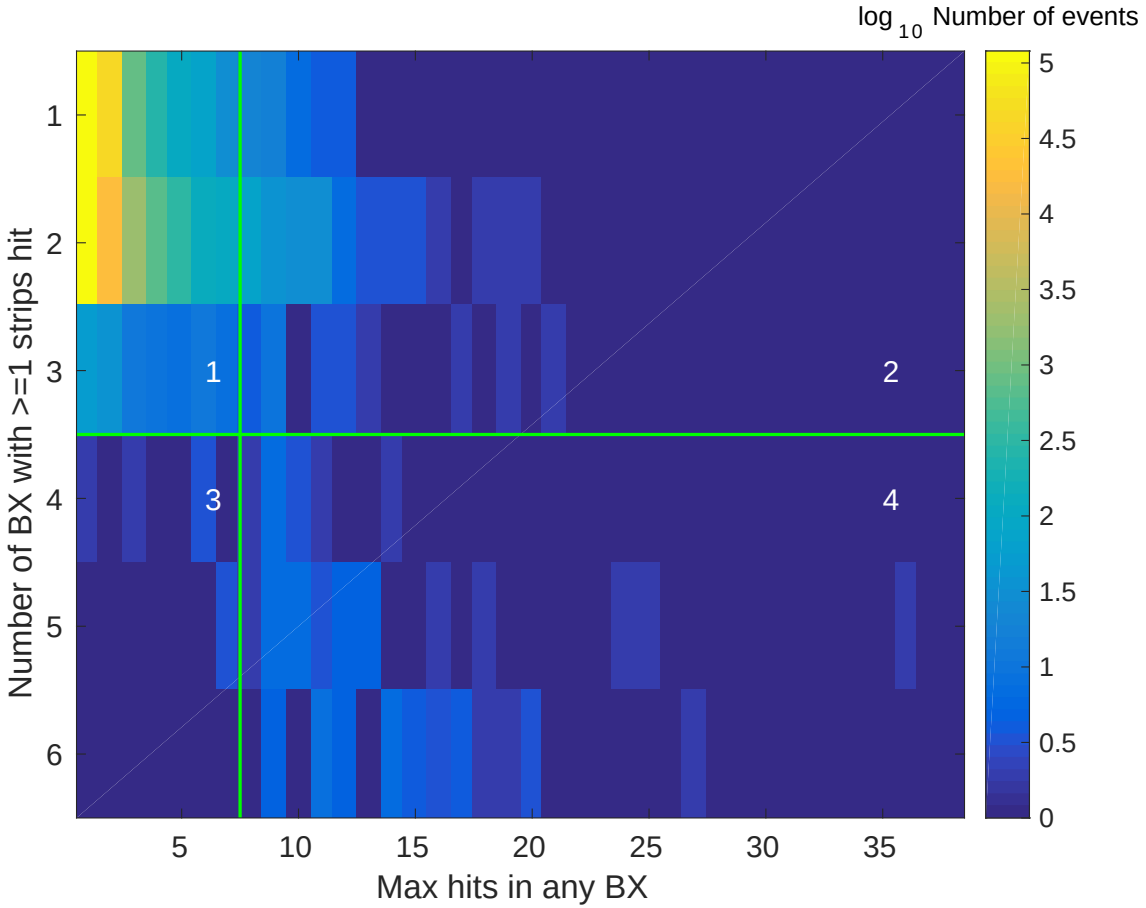
Threshold set close to pedestal (Vcth=570) to observe changes in noise. Trigger every 8 BX. Some undershoot but no obvious global long-term effect on pedestal.

Xenon Ions, V_b=-64V



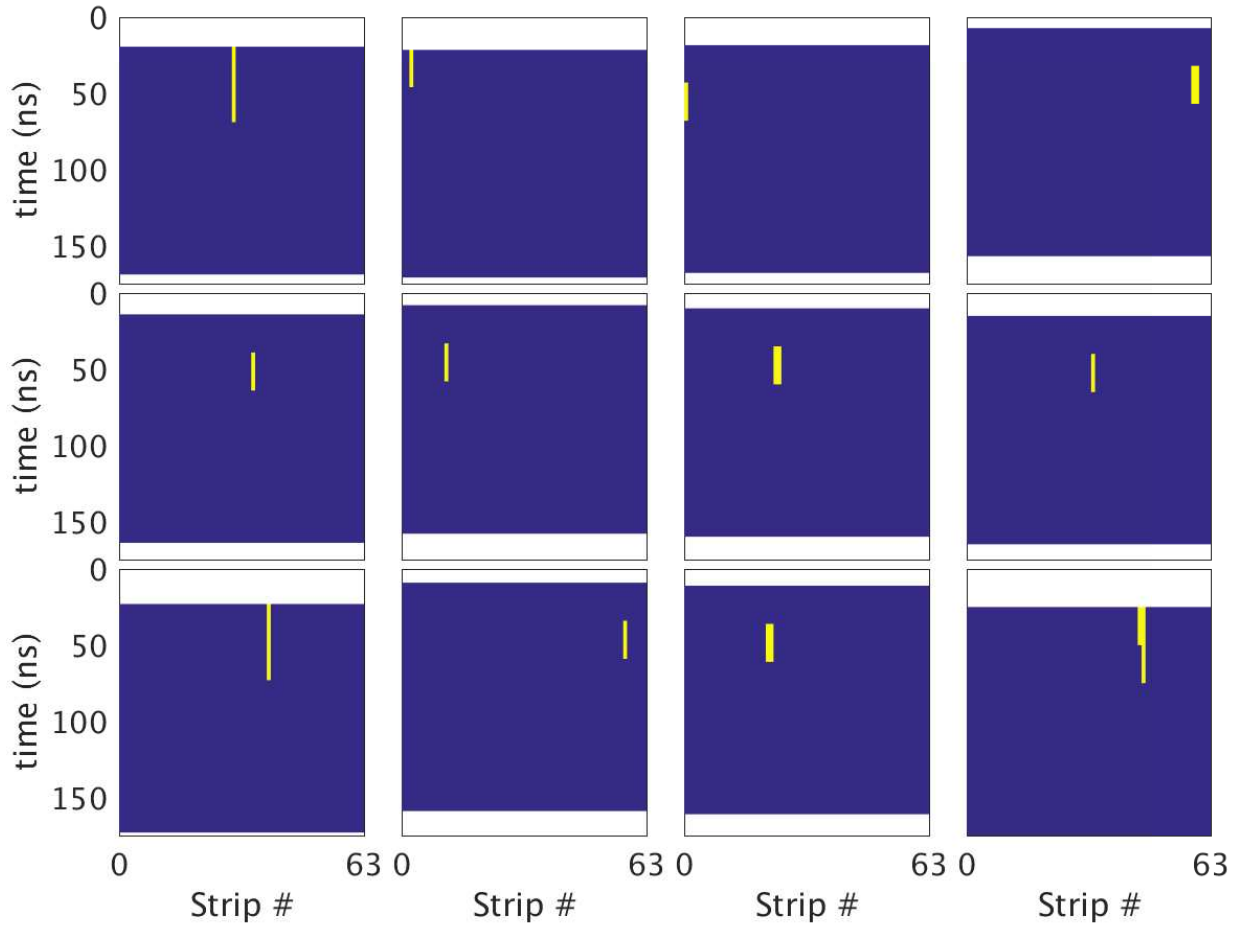
Wider event, longer recovery but no undershoot.

Ion-like events observed in the Pion beam data



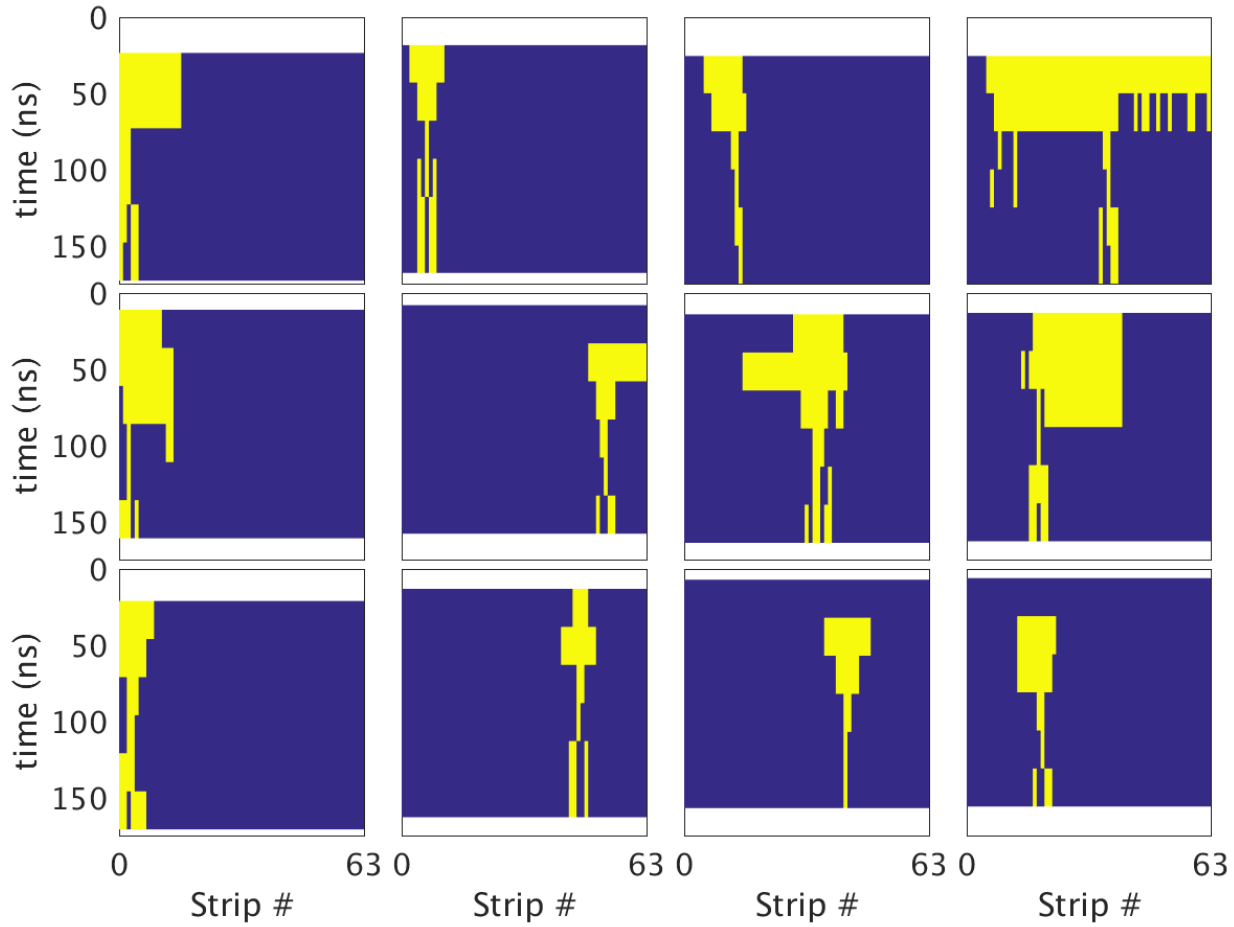
Fairly long tail in the distribution of number of hits, and an almost isolated distribution of events with deposits in many BX.

Randomly selected “Normal” Pion events (region 1)



Mostly 1-2 channels hit for 1-2 BX as expected for MIP-like particles.

Randomly selected long&large events (region 4)



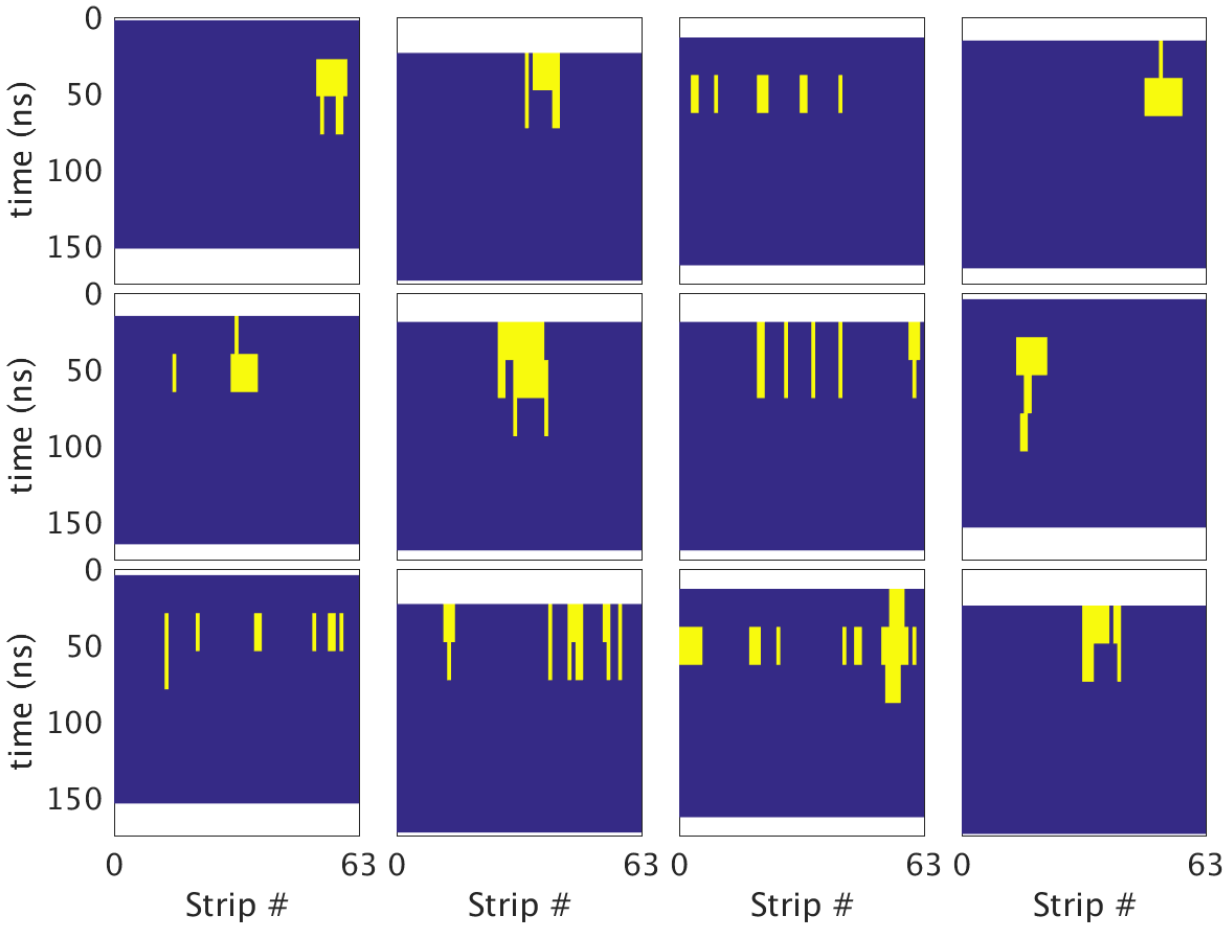
Long tail -> large charge deposit in small number of channels, quite similar to ions, but sometimes very large initial deposit.
Nuclear interaction in sensor? Rate: 4.1 in 10000 events.

40 AGeV Xenon ions

- 5-7 Dec: Xenon SEU test
  - 1 CBC3 centered in the beam
  - 2 CBC3s used for reading out KIT test sensor (127 vertical strips)
  - 1 CBC3 used for reading out radiation test sensor (64 horizontal strips)
  - Result: Improved SEU statistics (100 events in total), may let us draw further conclusions regarding relative reset/write node sensitivity.
  - Analysis ongoing

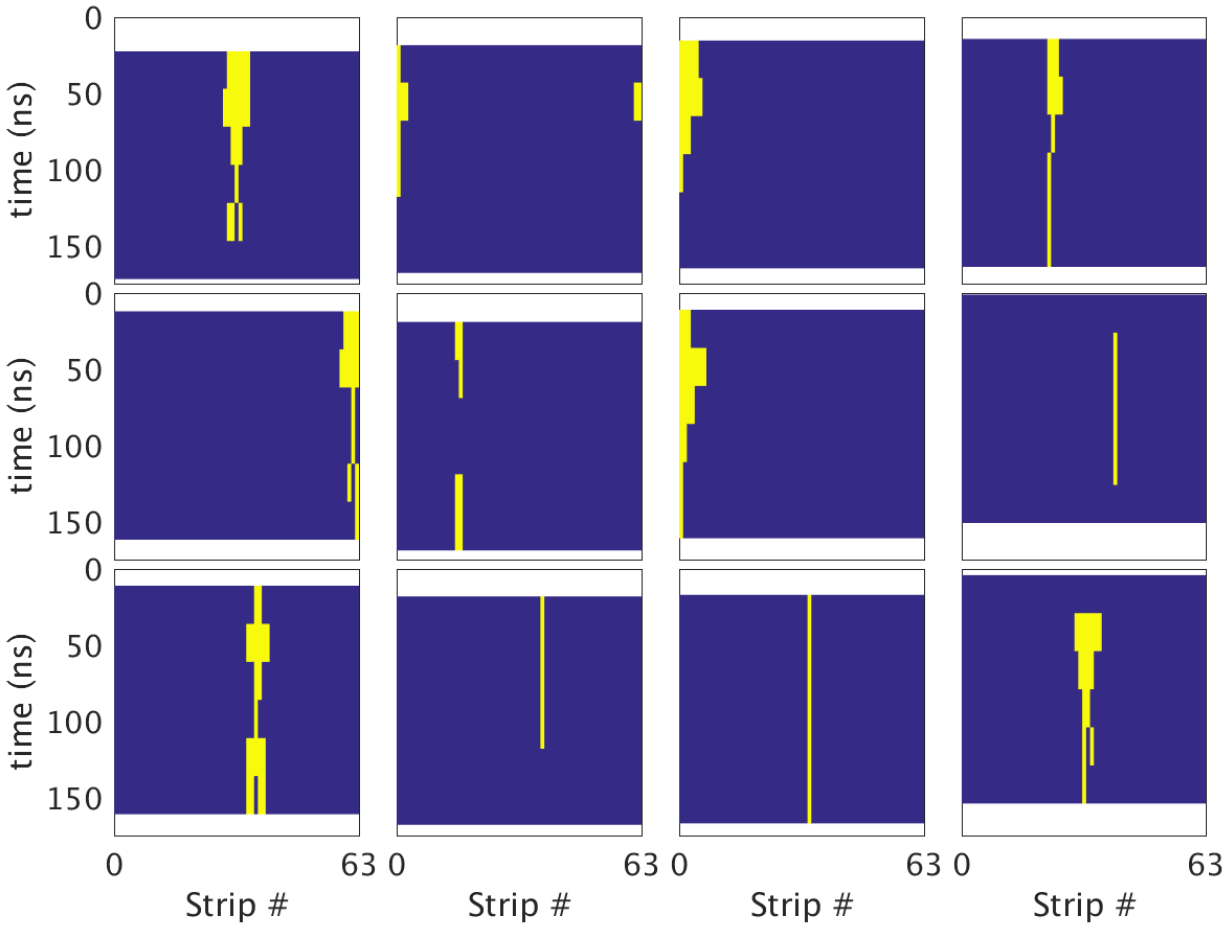
Backup

Short events with many hits (region 2)



Isolated hits could be upstream nuclear interactions. Fast recovery indicates small individual deposits. Rate: $\approx$ 1 in 1000 events.

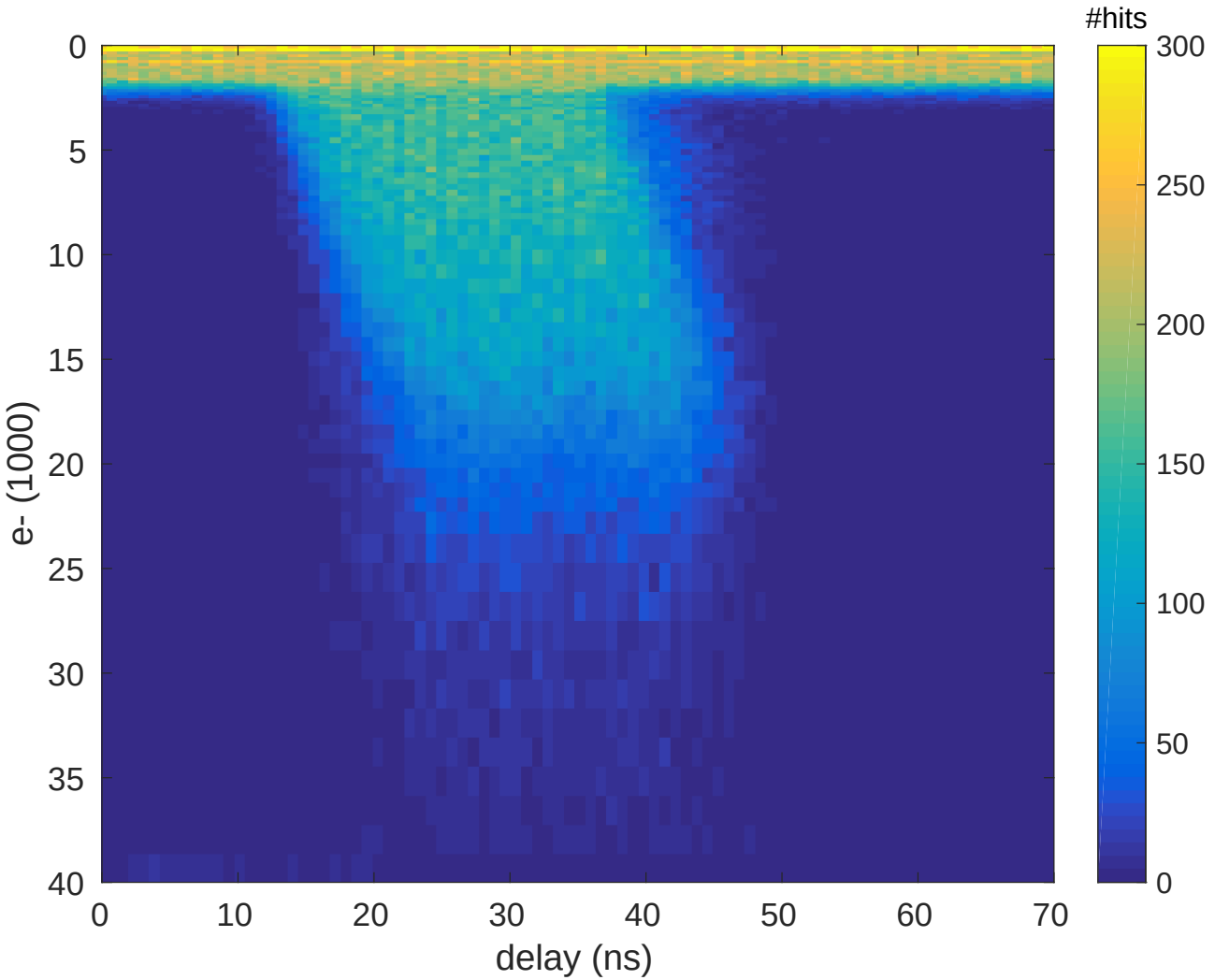
Long hits but few hits (region 3)



Mostly similar to type 4 events but with small deposit or at an edge. Rate: ≈

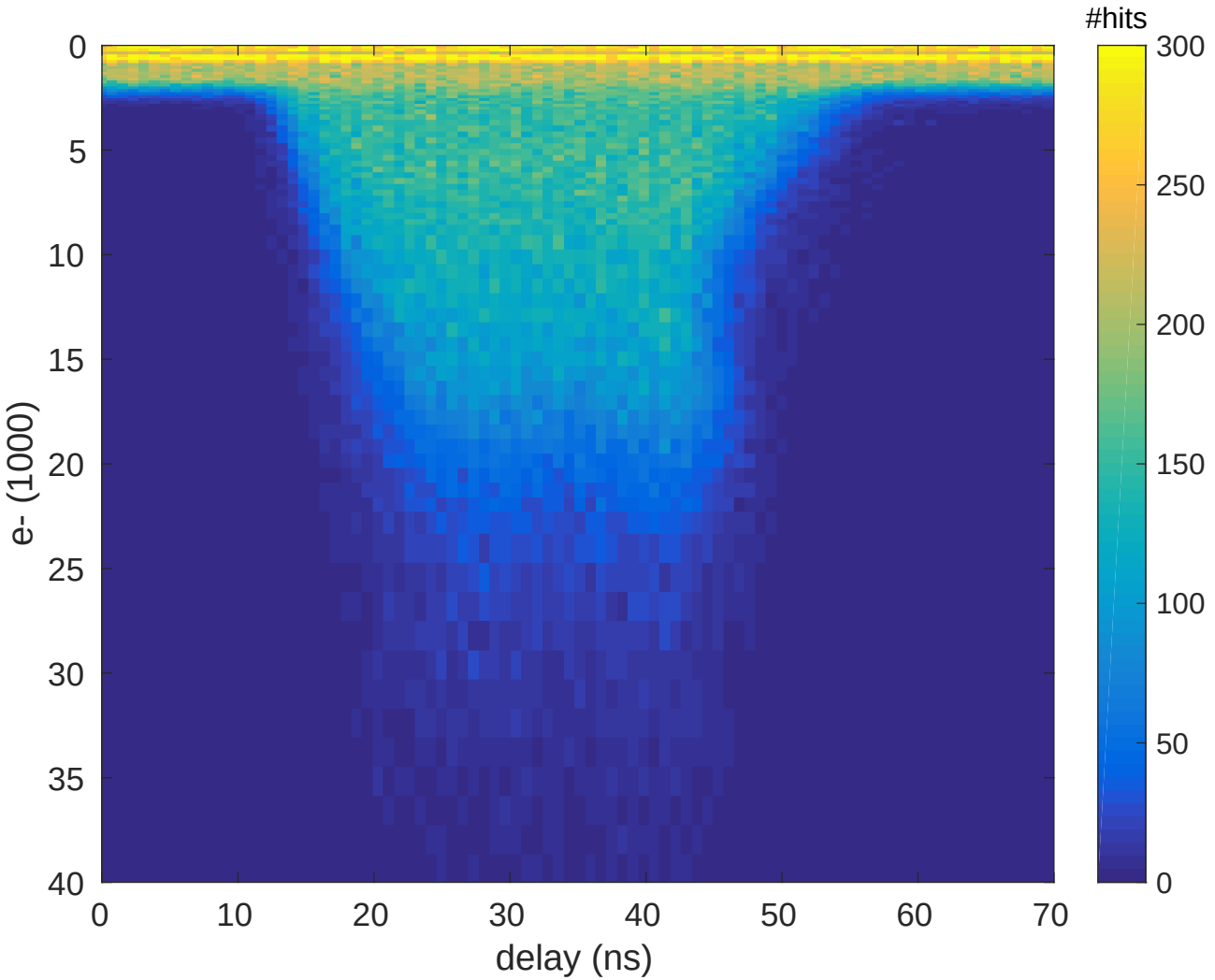
5 in 100000 events.

Shaper response, Fixed pulse width mode



Clear time-walk, not obviously superior to sample mode?

Shaper response, OR mode



Extended sensitivity to Possibly somewhat better sensitivity to small charge