MuPix8 Status

– PANDA Collaboration Meeting 2019/2 –
Luminosity Detector Session

René Hagdorn
Ruhr-Universität Bochum

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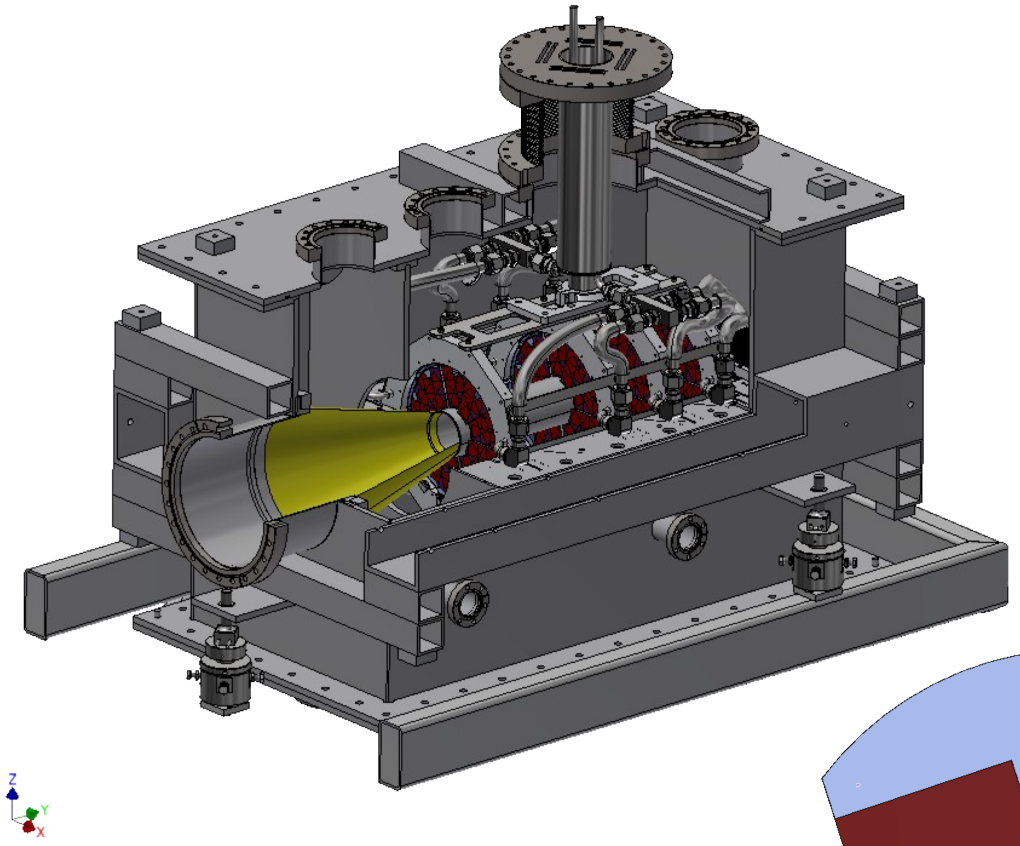
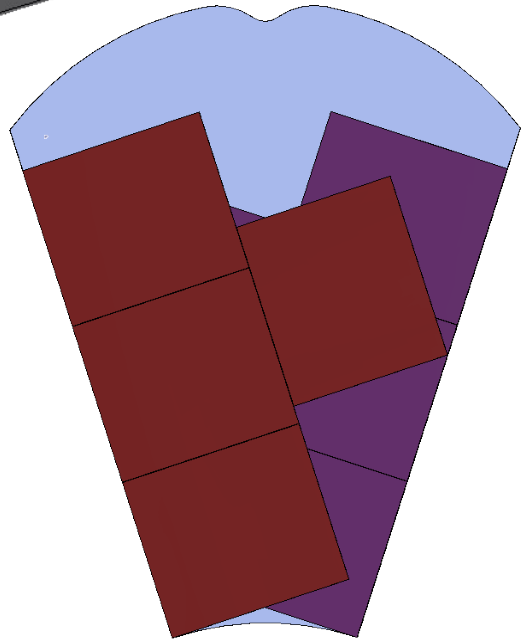
Luminosity Detector (LMD)

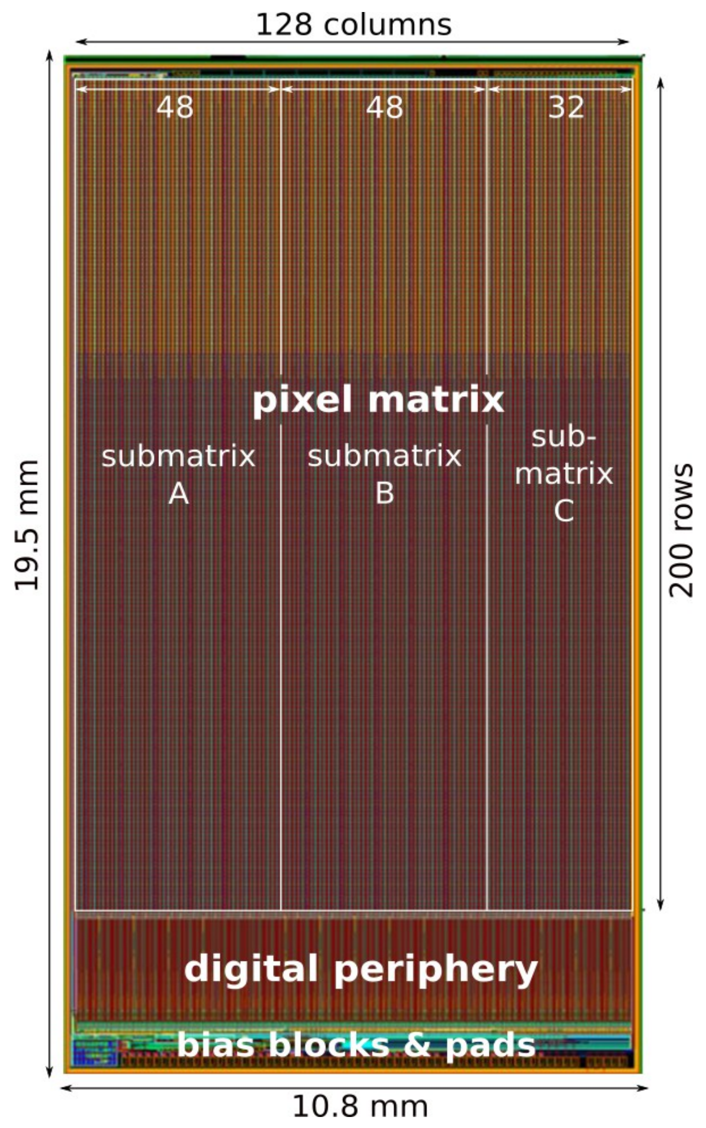
- 11 m behind IP
- Measure tracks of elastically scattered anti-protons
- Anti-protons enter detector vacuum through transition cone
- 4 detector layers with HV-MAPS on both sides
- CVD diamond carriers (10 per layer)
- Aluminum holding structure with embedded steel pipe for cooling (coolant: -20°C ethanol)
- Total number of sensors: 320
- Active area of one sensor: 2 × 2 cm²
- Pixel size: 80 × 80 µm²





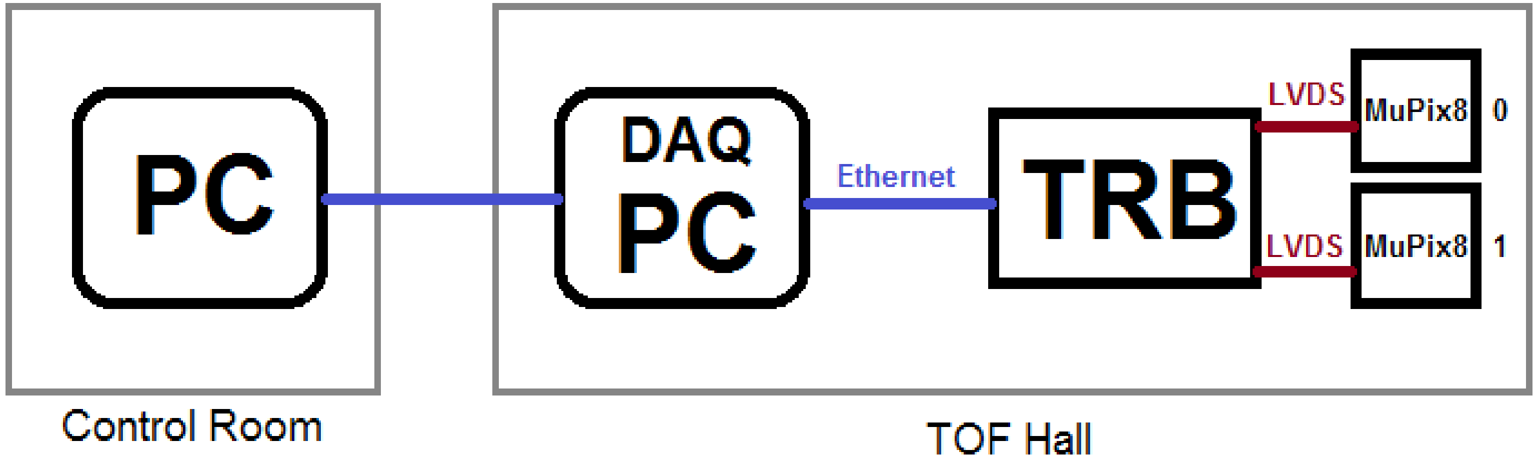
The MuPix8 Chip

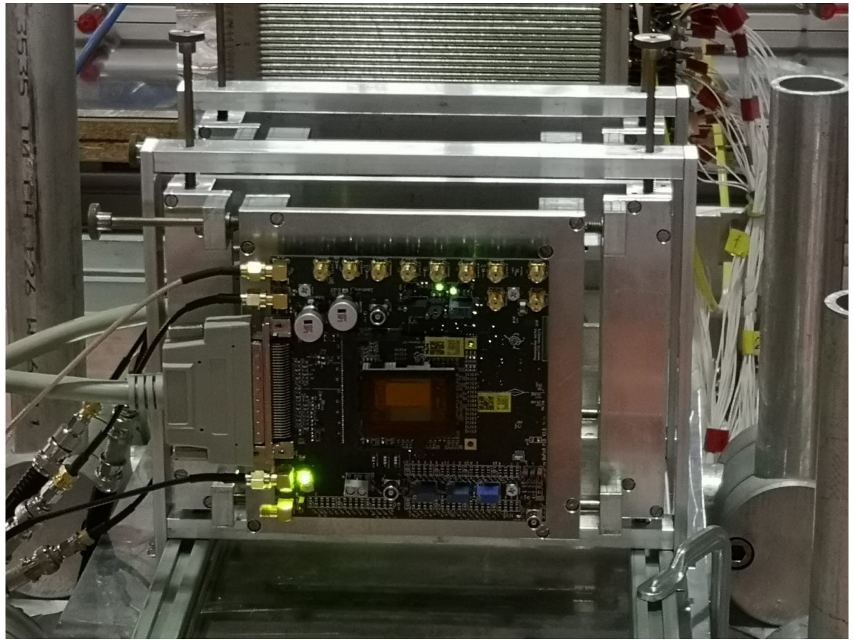
- Originally developped for Mu3e
- Physical size: 10.8 × 19.5 mm²
- Active area: ~ 10.2 × 16.2 mm²
- Matrix: 128 × 200 Pixels, three Submatrices
  MatA: source follower
  MatB/C: current mode
- Pixel: 80 × 81 μm²
- Charge sensitive amplifier in each pixel
- Two comparators in each periferal cell (timewalk compensation)
- 4 LVDS links (each submatrix + select/mux)
- Analog readout of Hitbus (ToT information) and amplifier output (for leftmost column only)



Previously: Two-Layer MuPix8 Setup at COSY

- Testbeam in February 2019 (FT Testbeam)
- Two chips in beam (TOF hall)
- x-y-adjustable holding frames and positioning rail from HIM
- Goals: Test parallel readout of two chips and observe position and time correlations in hits

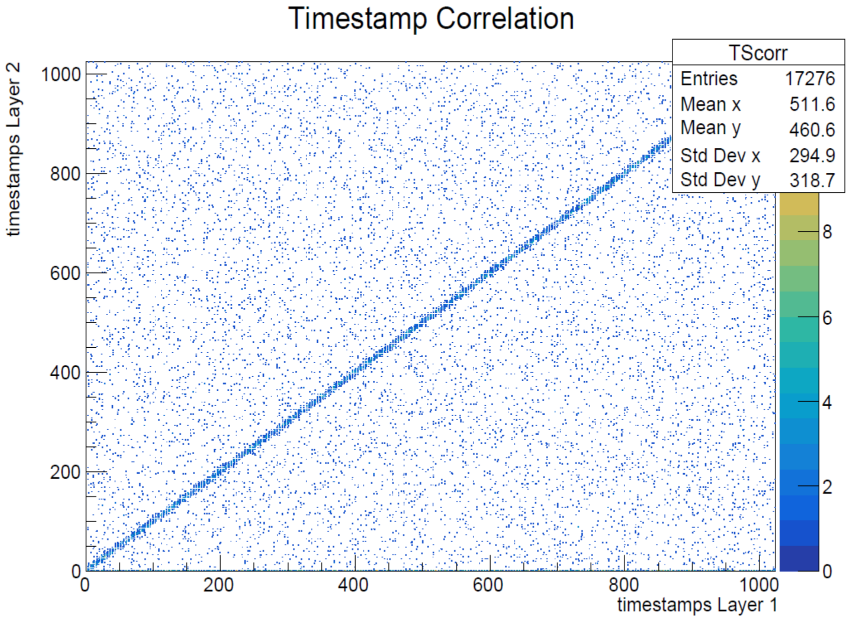


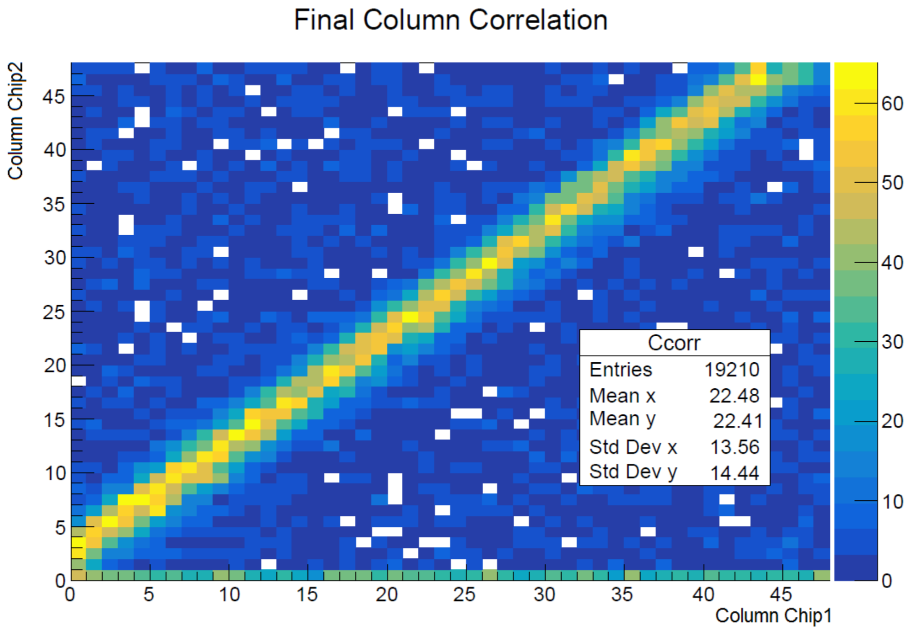


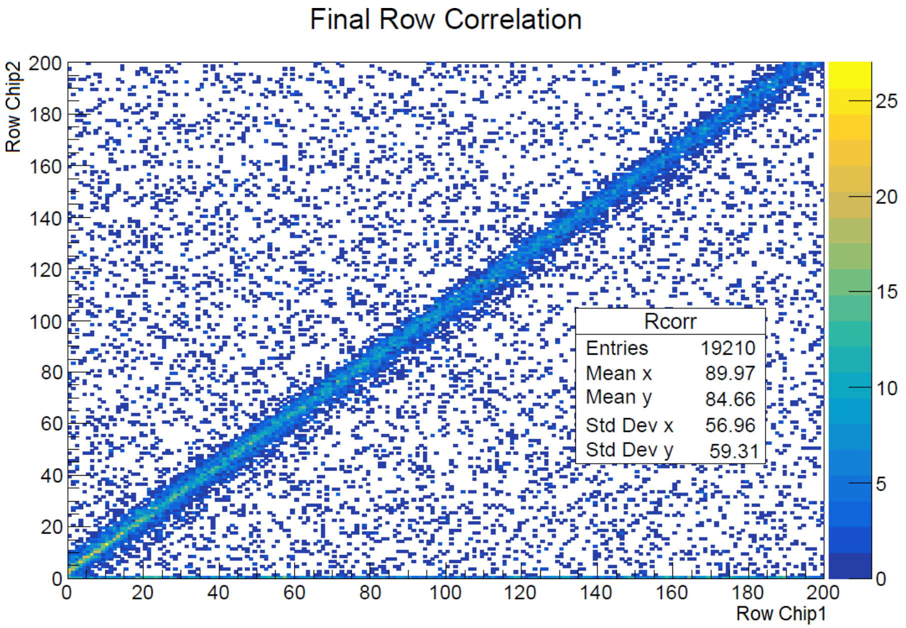
Previously: Two-Layer MuPix8 Setup at COSY

- Results (as shown at previous meeting 2019/1):
  - Synchronous timestamps
  - Correlations in column and row positions of two layers

  → Parallel readout of several layersis working
- Next step: Four-layer telescope for tracking and efficiency studies

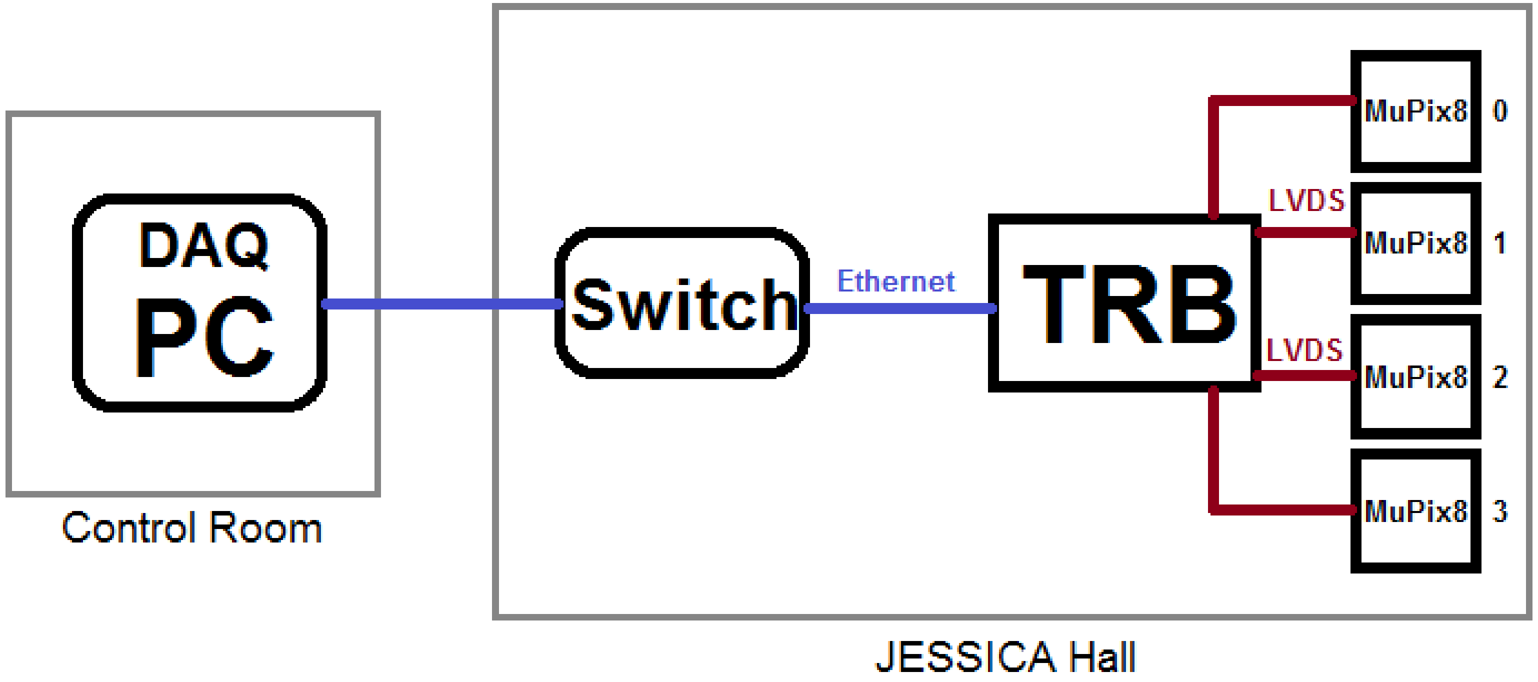


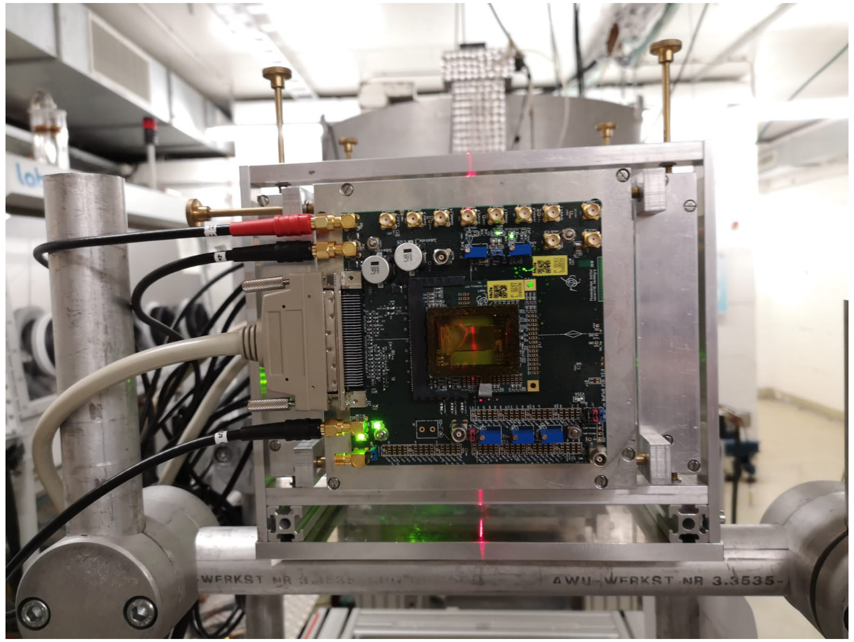




Now: Full Four-Layer MuPix8 Telescope

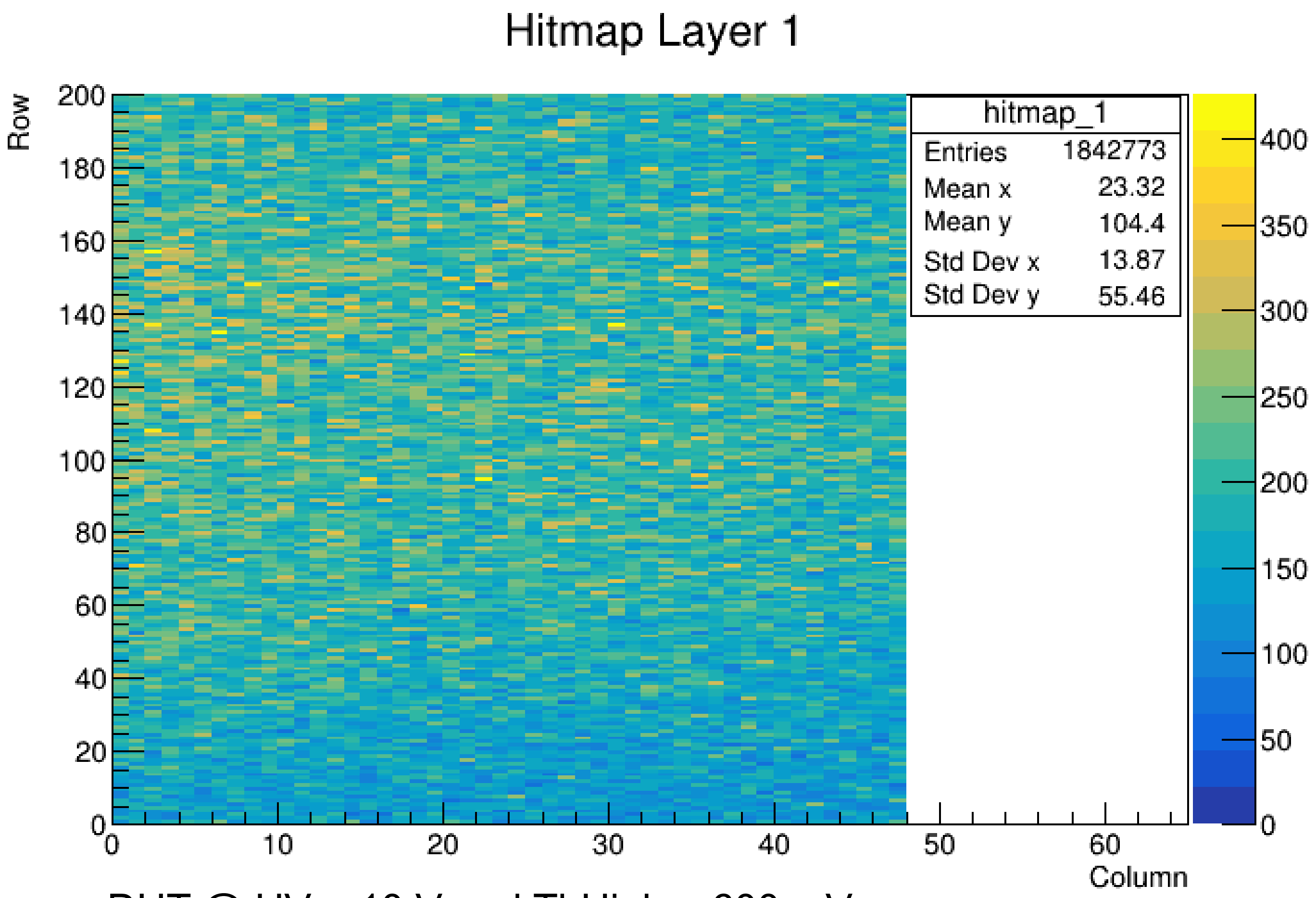
- CBM Testbeam at COSY (May 2019)
- 4 MuPix Layers on one TRB (1 per corner-FPGA)
- Goals: Test parallel readout of four chips and observe position and time correlations in hits + determine efficiency of DUT (layer 1) using layers 0, 2, 3 for track reconstruction



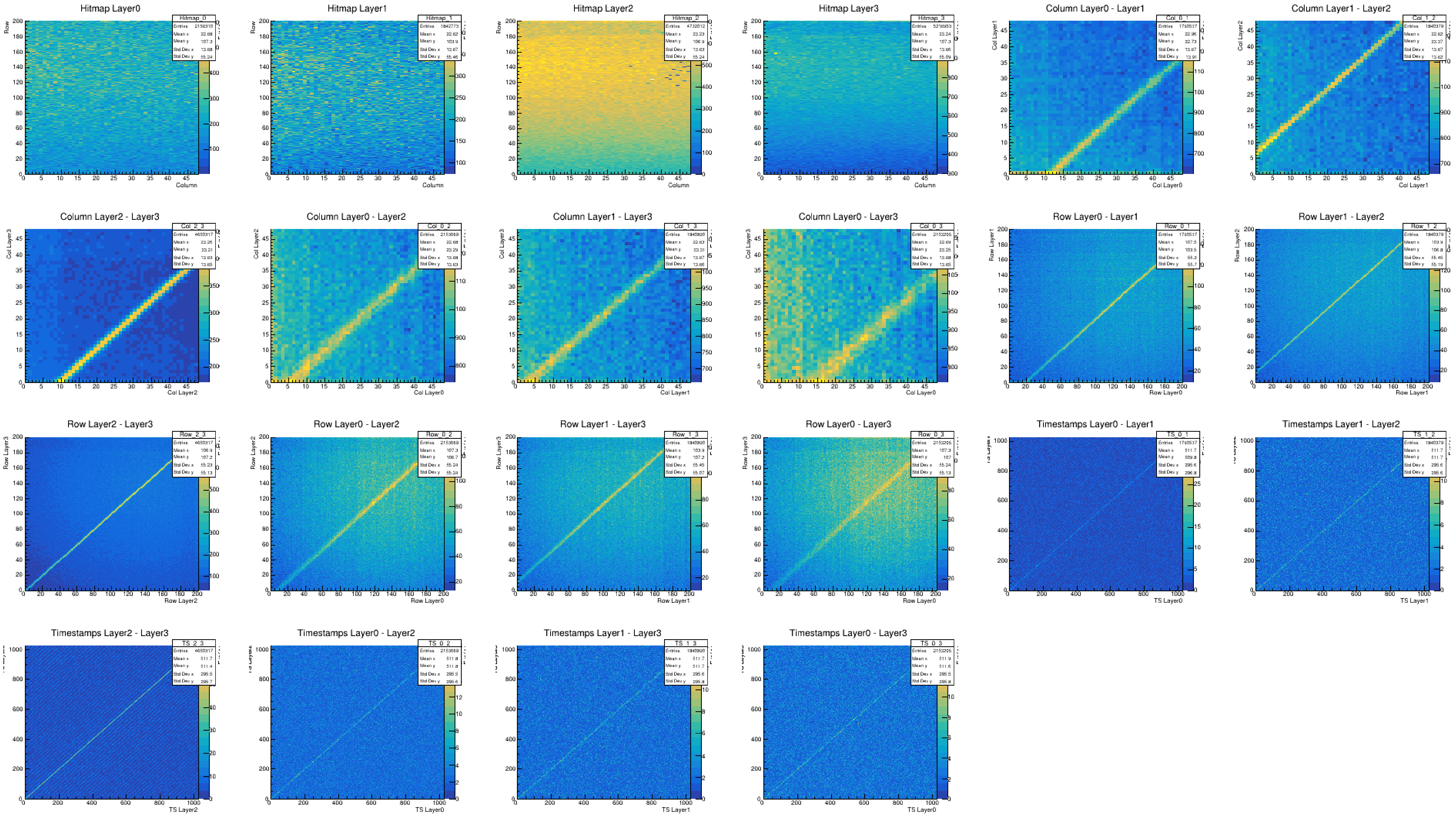


First Run

- Inserted ionization chamber in beam
  → lower rate per pixel and homogeneous illumination of the whole chip
- Fixed thresholds and HV for tracking layers
- Varying ThHigh (550 – 650 mV) and HV (10 – 50 V) for DUT



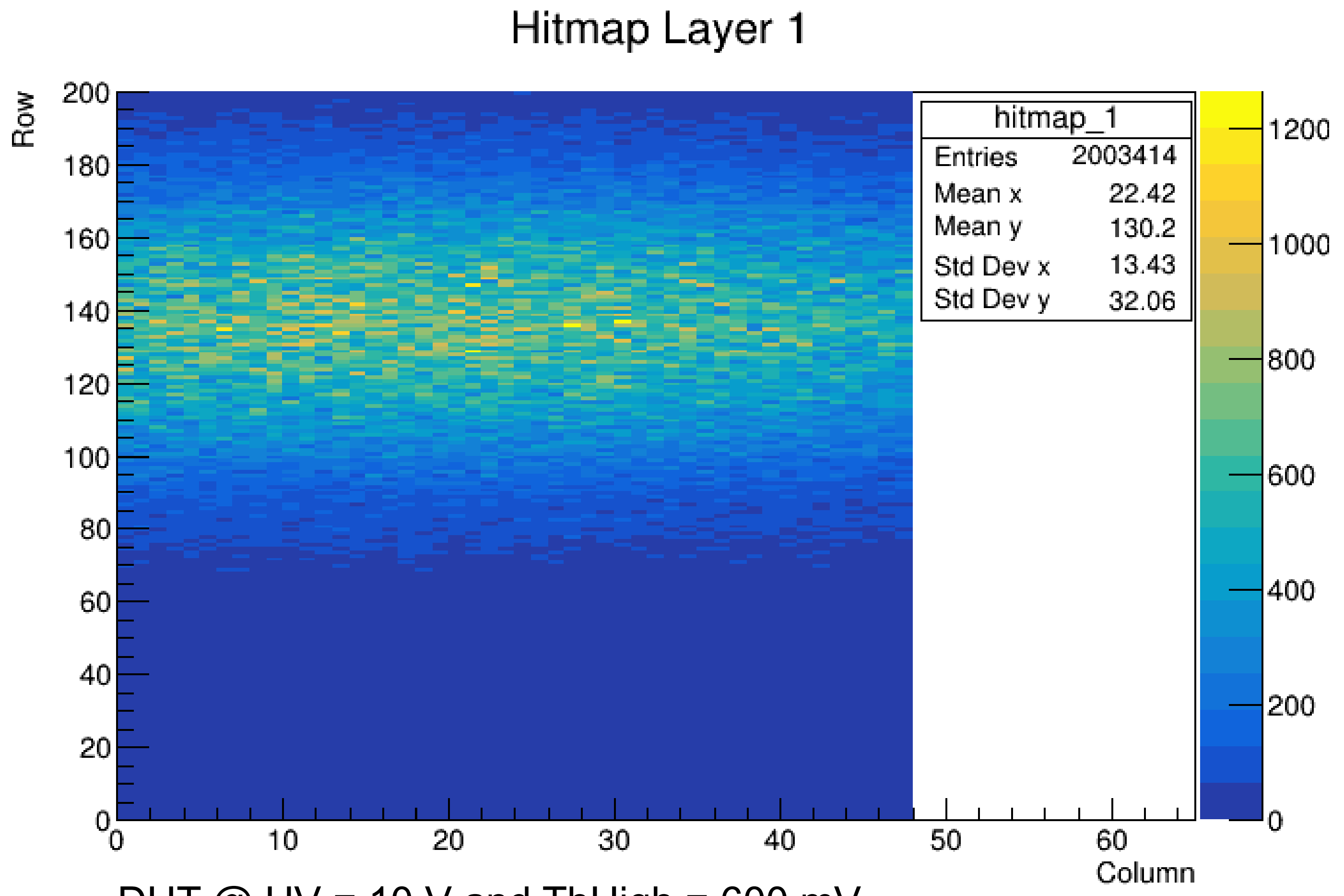
DUT @ HV = 10 V and ThHigh = 600 mV



Hitmap Layer0
Hitmap Layer1
Hitmap Layer2
Hitmap Layer3
Column Layer0 - Layer1
Column Layer1 - Layer2
Column Layer2 - Layer3
Column Layer0 - Layer2
Column Layer1 - Layer3
Column Layer0 - Layer3
Row Layer0 - Layer1
Row Layer1 - Layer2
Row Layer2 - Layer3
Row Layer0 - Layer2
Row Layer1 - Layer3
Row Layer0 - Layer3
Timestamps Layer0 - Layer1
Timestamps Layer1 - Layer2
Timestamps Layer2 - Layer3
Timestamps Layer0 - Layer2
Timestamps Layer1 - Layer3
Timestamps Layer0 - Layer3
Row
Column
Col Layer0
Col Layer1
Col Layer2
Row Layer0
Row Layer1
Row Layer2
TS Layer0
TS Layer1
TS Layer2

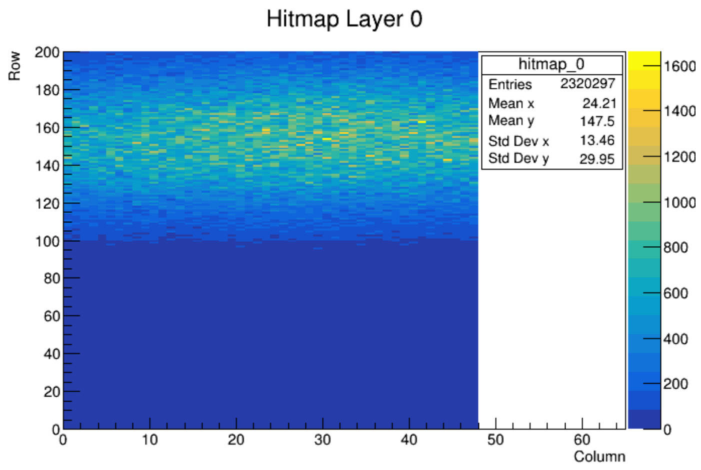
Second Run

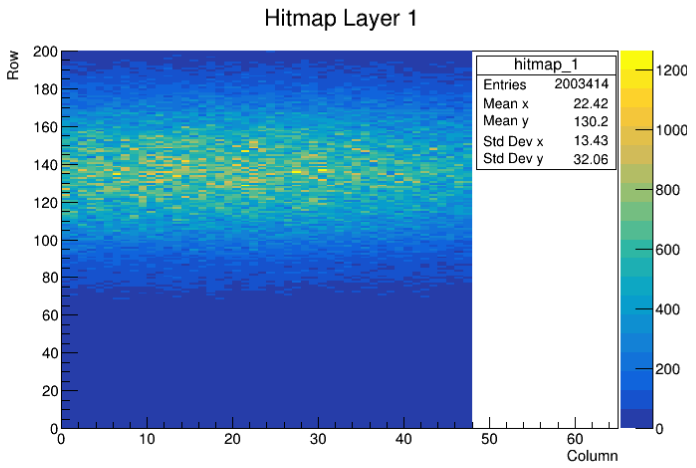
- All measurements had to be repeated, due to mixed up cables
- Ionization chamber was removed
  → narrower beam and higher rates
- Same threshold and HV settings as before

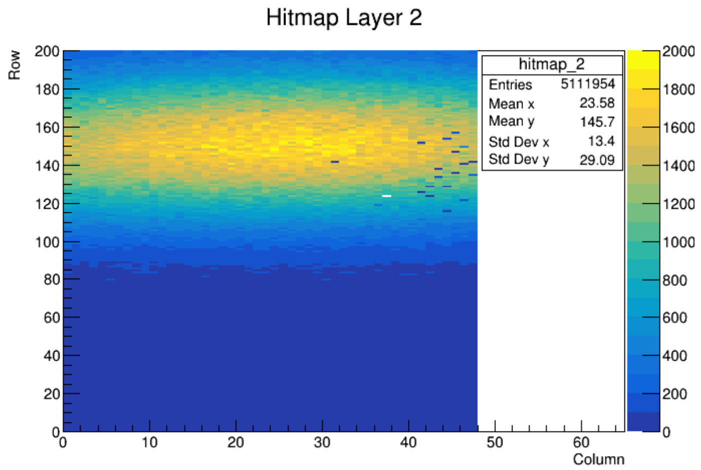


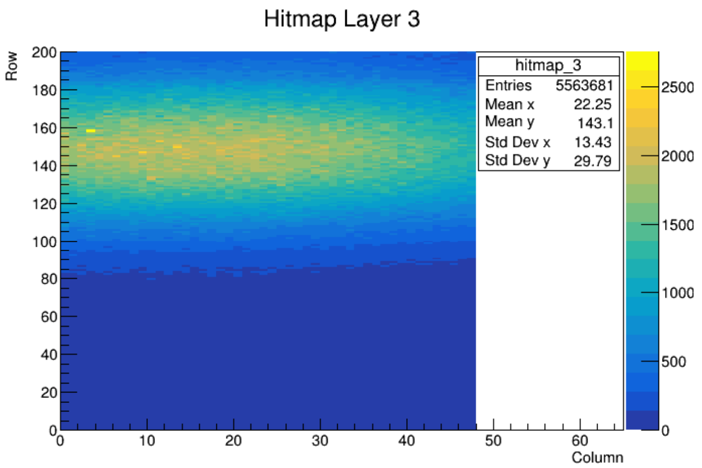
DUT @ HV = 10 V and ThHigh = 600 mV

- Observations:
  - Beam spot visible in hitmaps
  - Spot is moving
    (confirmed by COSY control room)









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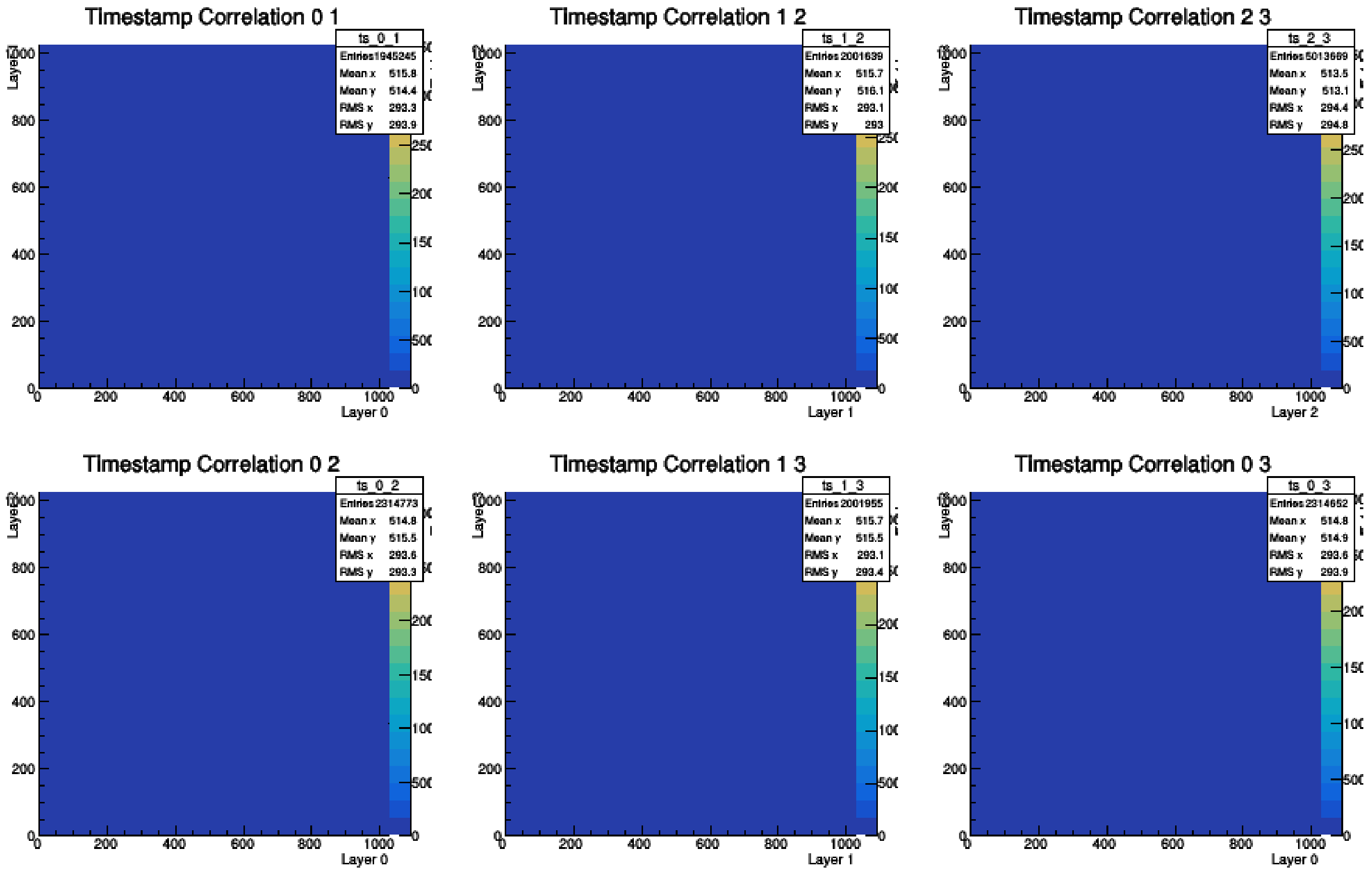
  - Timestamps behavior is as before



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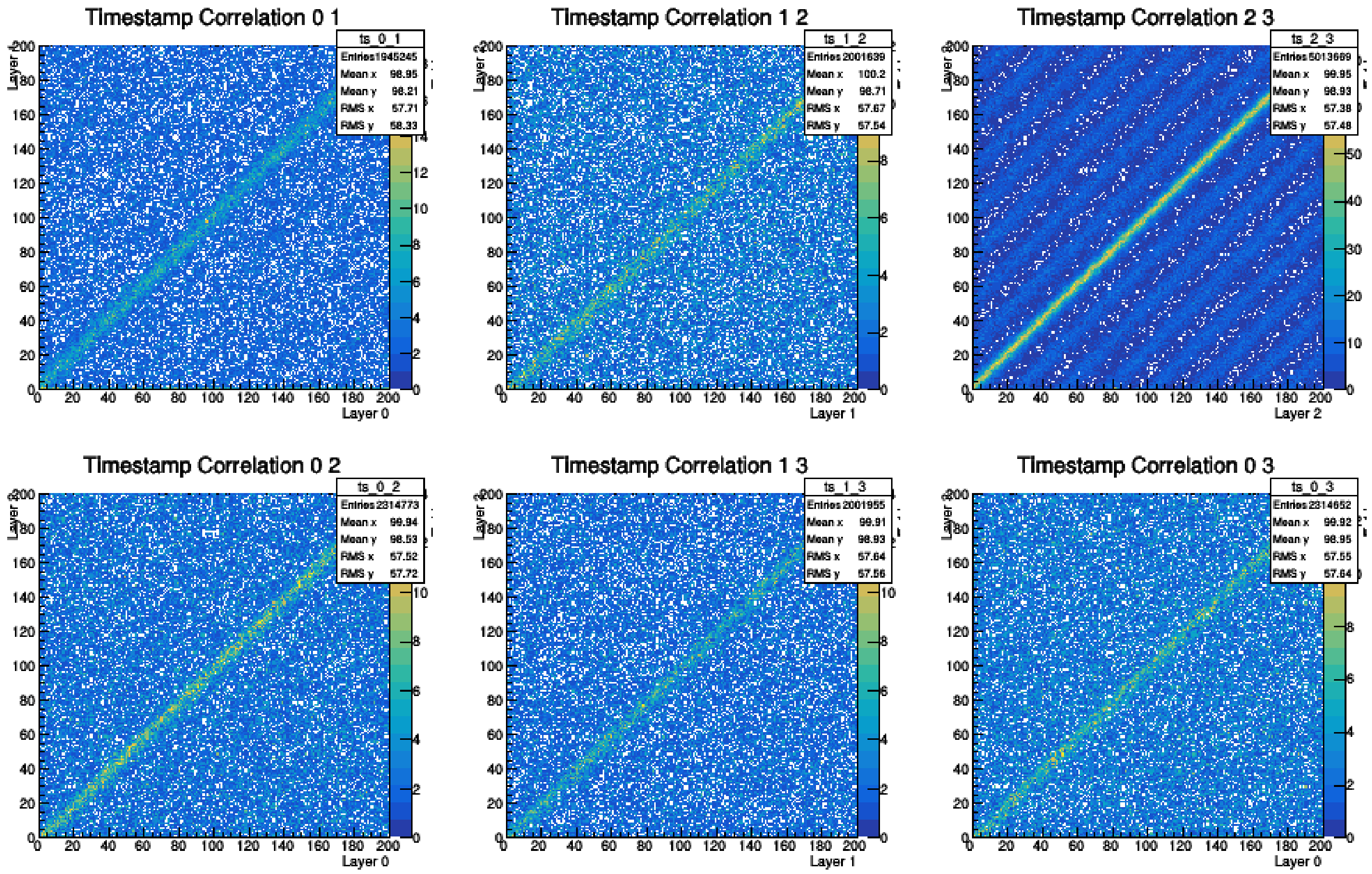
    (but only visible when zooming in)



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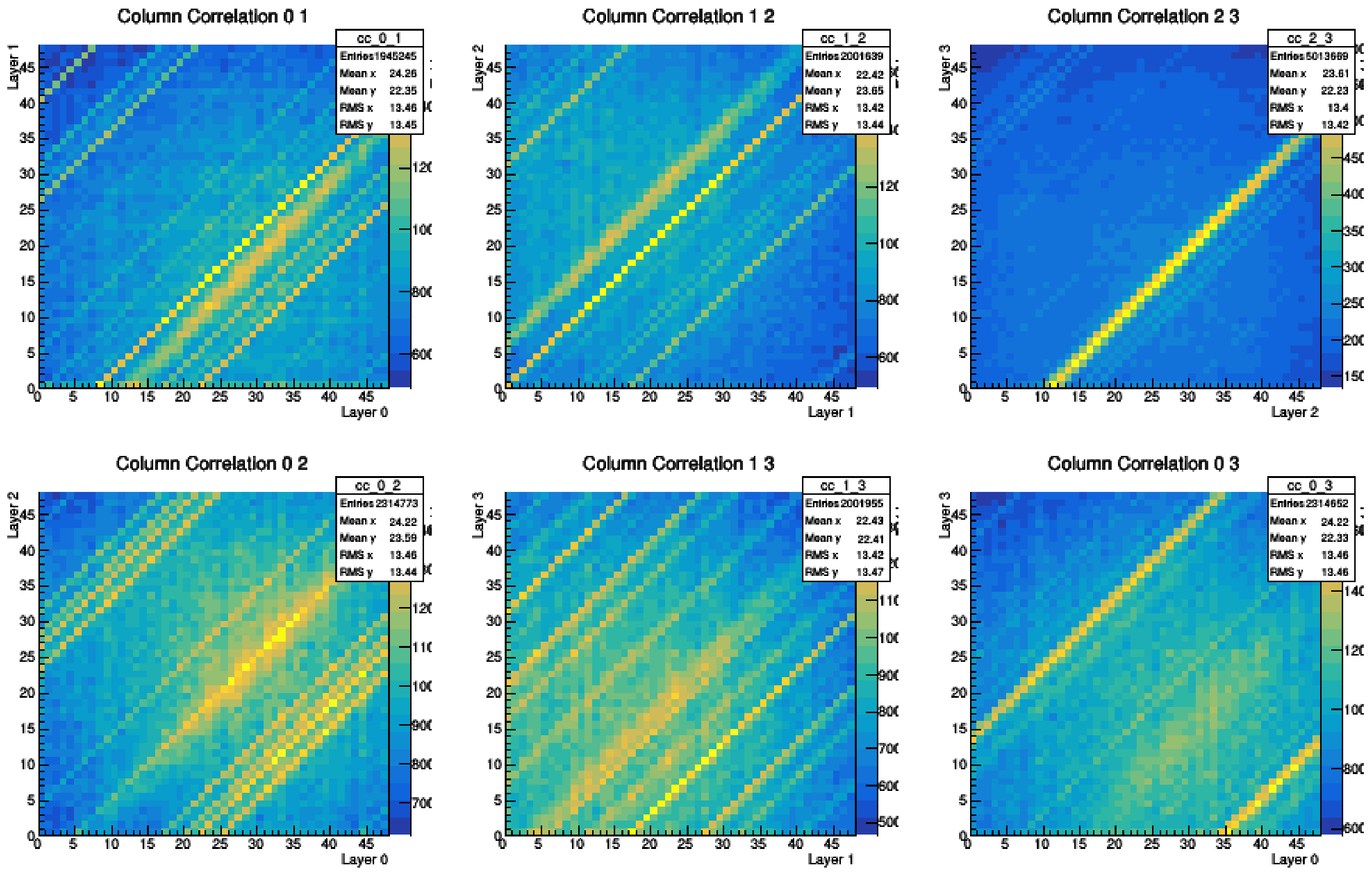
  - No clear column correlations anymore
    (parallel stripes)



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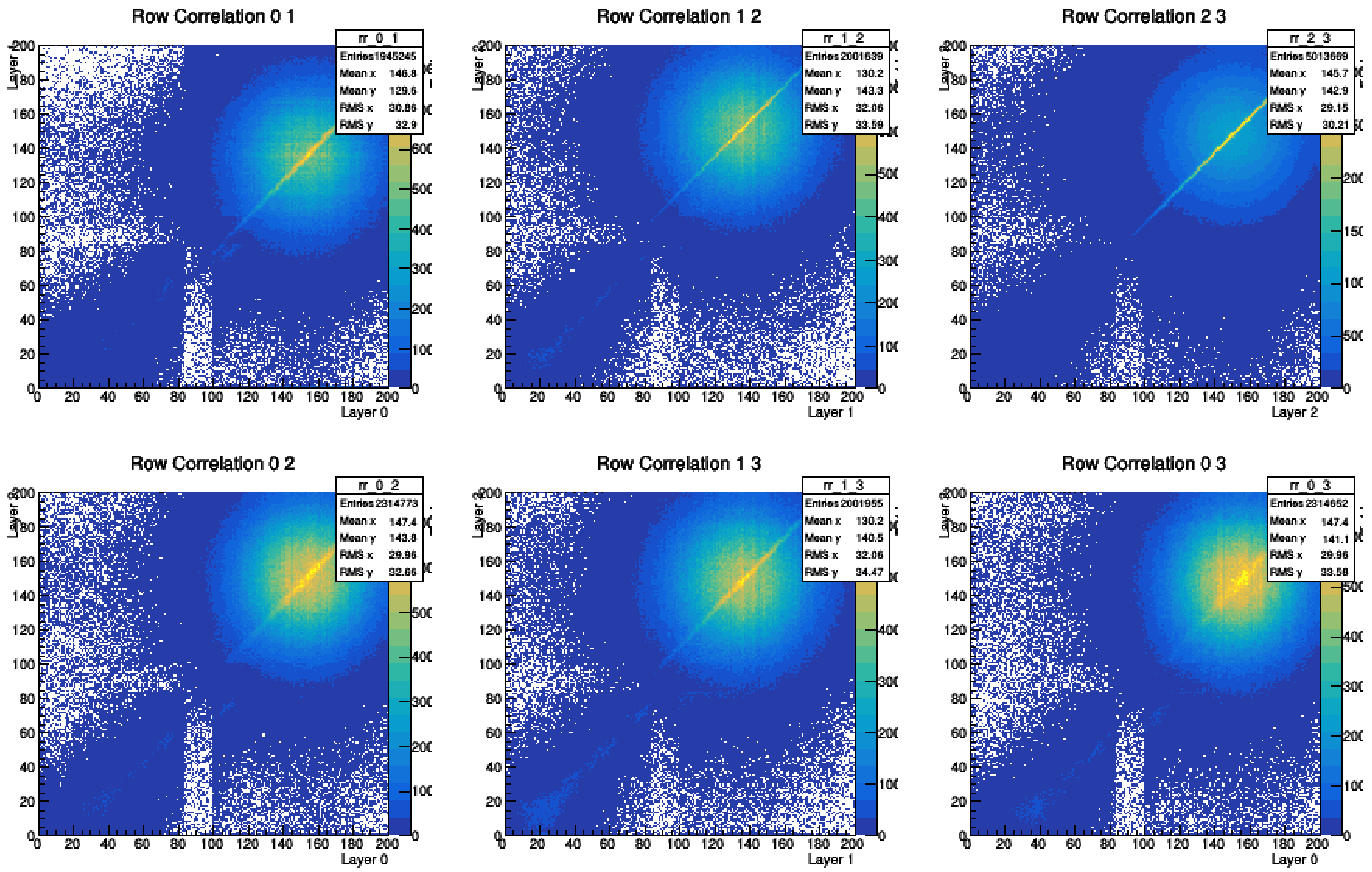
  - No clear column correlations anymore
    (parallel stripes)
  - "cross pattern" in row correlations
    (rates too high for correct readout)

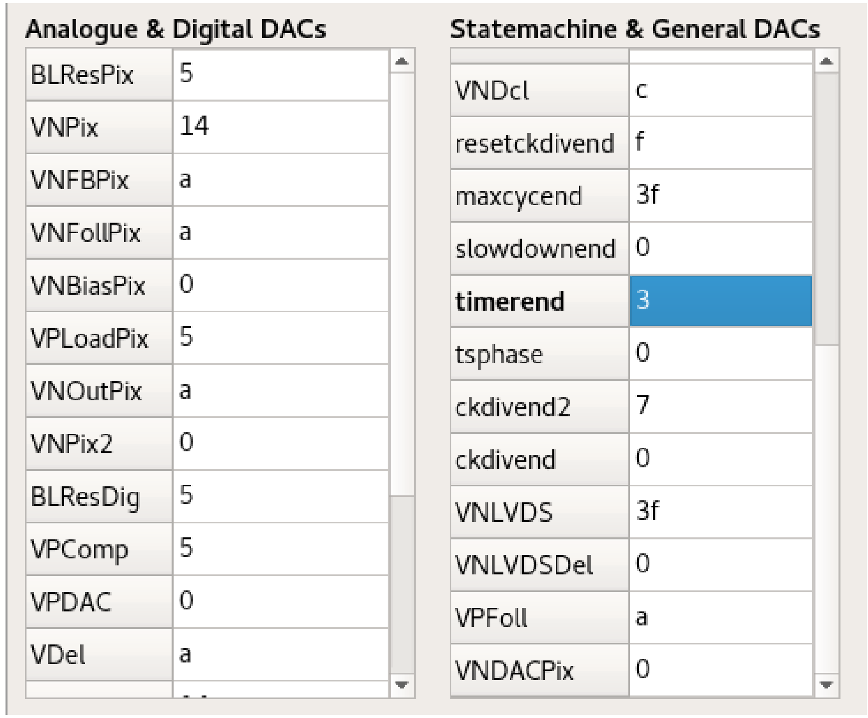


High Rate Problem

- Priority based readout of digital cells:
  Lower row addresses get read out first
- Physical rows 84 – 99 have highest digital addresses
- Hits get stuck in cells and are read out at a later cycle
  → pixels are insensitive to further hits during that time
- Current settings:
  ref_clock = 40 MHz and timerend = 3
  → approx. max hit rate: 2.3 MHz
- For future: set timerend = 0
  → max. hit rate ≈ 9.2 MHz

Digital Row Address	Pixel Row
0 – 55	——
56 – 139	0 – 83
140 – 239	100 – 199
240 – 255	84 – 99

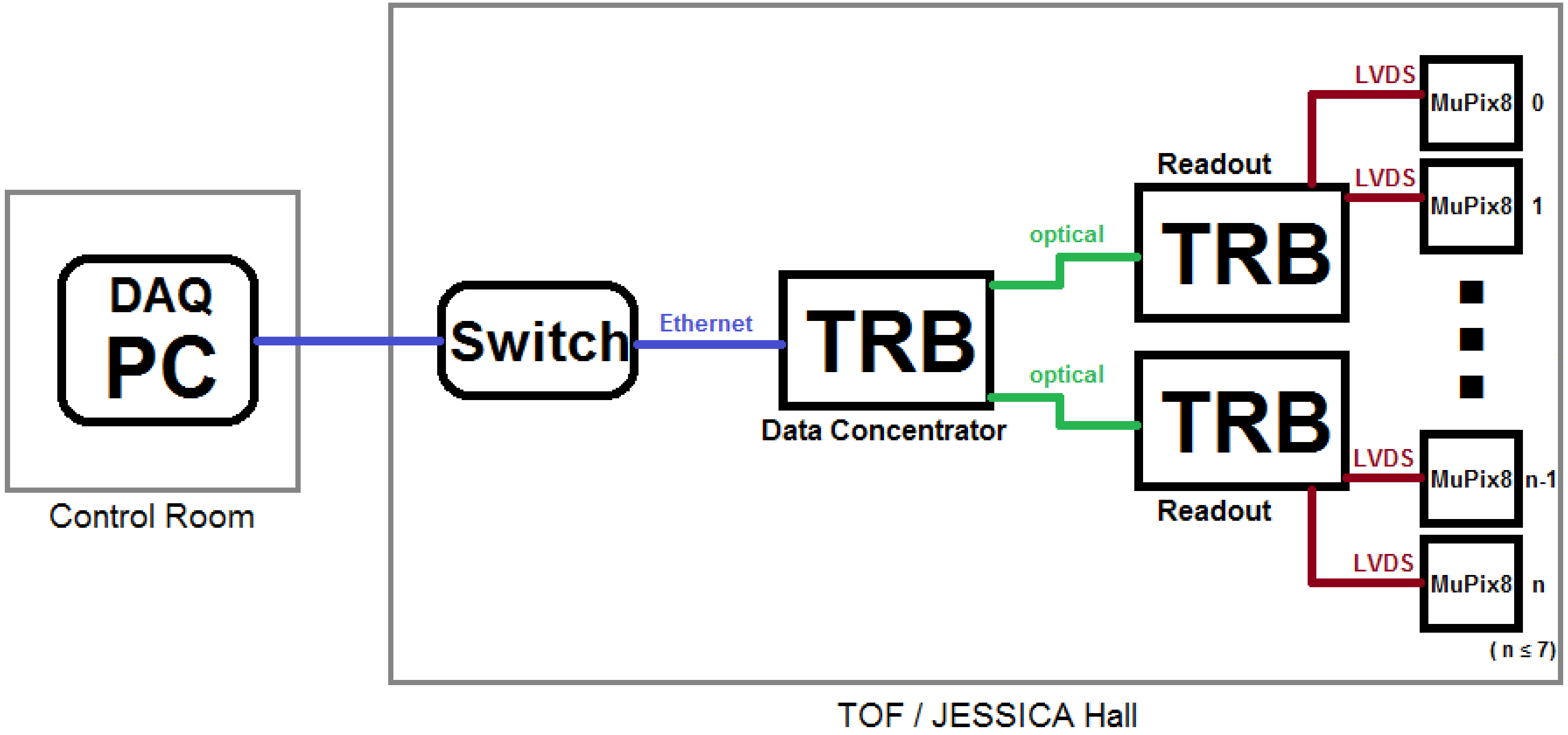
Row addresses of digital cells (8 bit)



Excerpt from chip config GUI. timerend sets a clock divider that reduces the speed of the readout FSM by (timerend + 1)

Future: Testbeam with several TRBs

- Next Testbeam: September 2019
- Use setup similar to final LMD readout scheme:
  - 2 TRBs to control / readout several MuPix chips
  - 1 TRB as data concentrator / single interface to DAQ



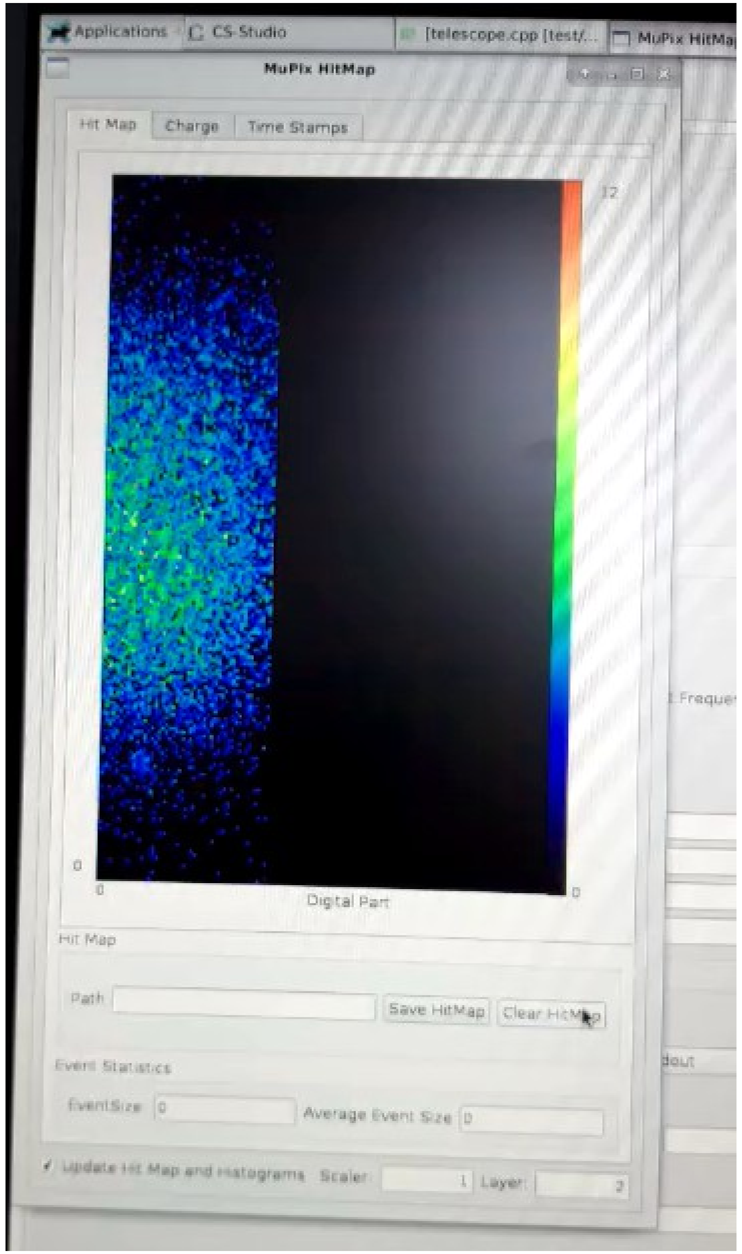
Future: Testbeam with several TRBs

- Goals:
  - Test new readout scheme
  - correlations and efficiency
  - additional layer(s) of fast scintillators for precise rate determination and timing tests
  - Increase readout rate by using new statemachine settings
  - Also use matrices B and C of MuPix8
  - Use SODA for synchronization

Future: Testbeam with several TRBs

- Changes in redout / control software:
  - Set IP and Endpoint addresses from outside (currently hardcoded in telescope software)
  - Chip config and measurement parameters should be set via contol system (using EPICS)
  - Also use CS to perform automated measurement scans
  - New online monitor for hitmaps and TS- and ToT-distributions.
    (high ammounts of lag with current setup)

- Firmware changes necessary to use TRB chain
- New testbeam stand for telescope



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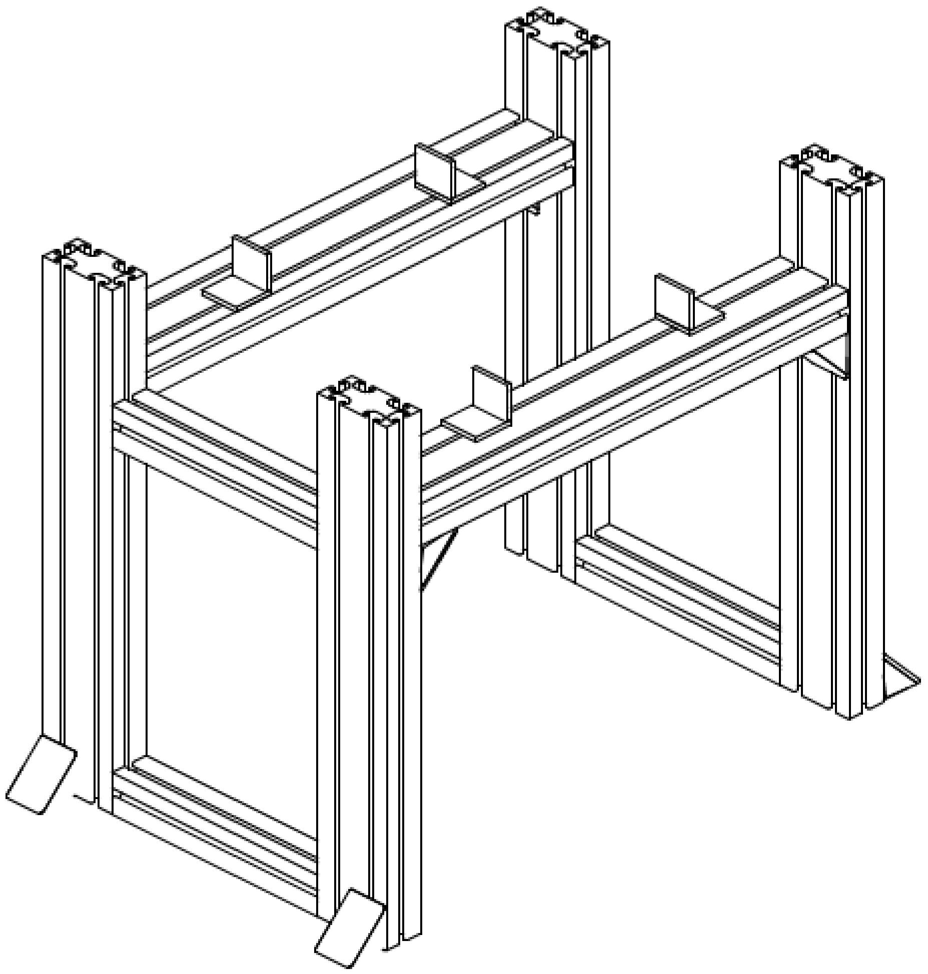


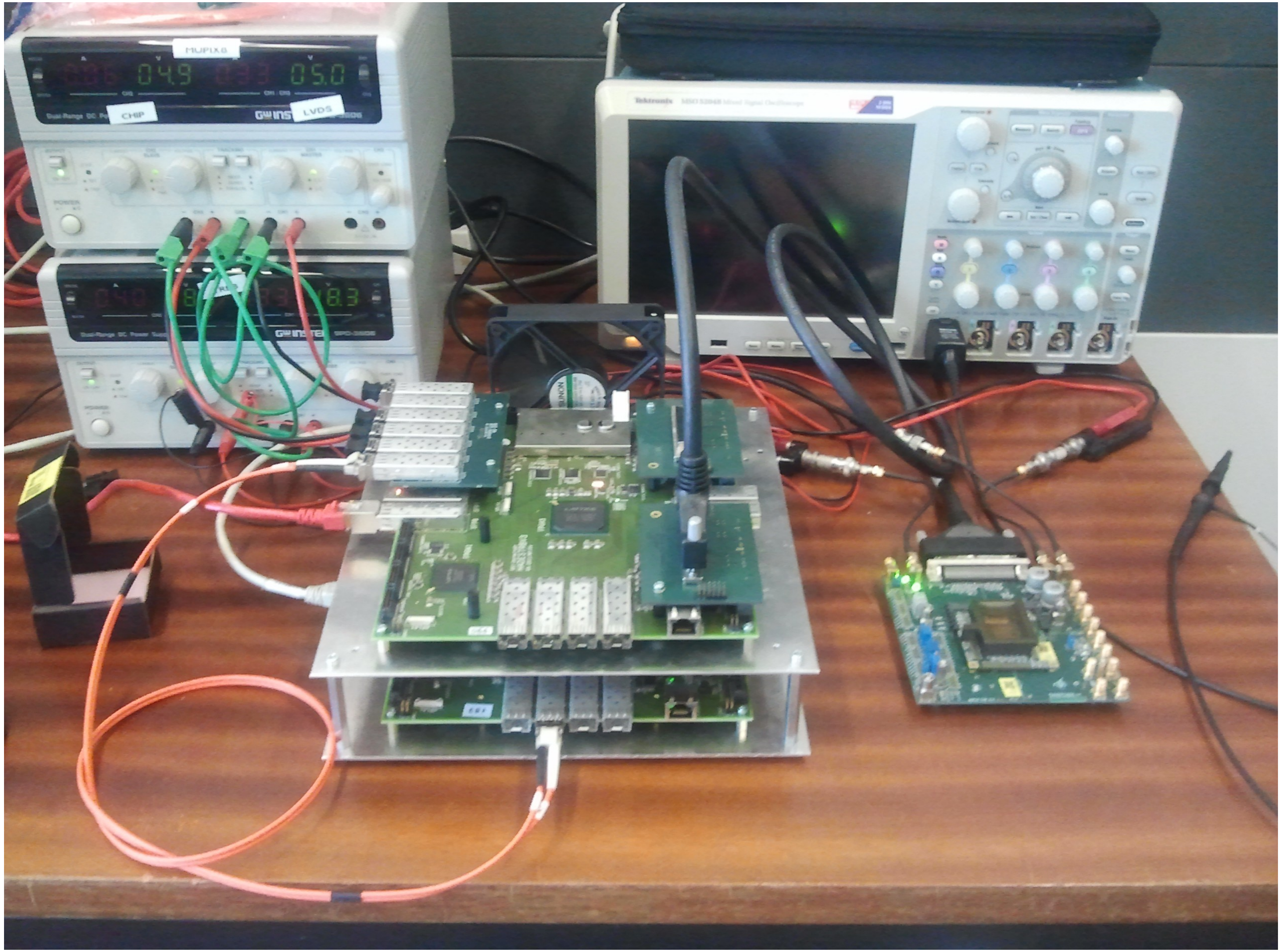
Summary

- Testbeam with four layer telescope
  - Observed correlations in rows and columns
  - Redout errors at high rates, readout statemachine too slow
  - Efficiency studies are WIP

- Plans for next testbeam
  - TRB chain with readout units and data concentrator
  - Reworking of DAQ software and TRB firmware
  - New telescope stand designed

– Backup –

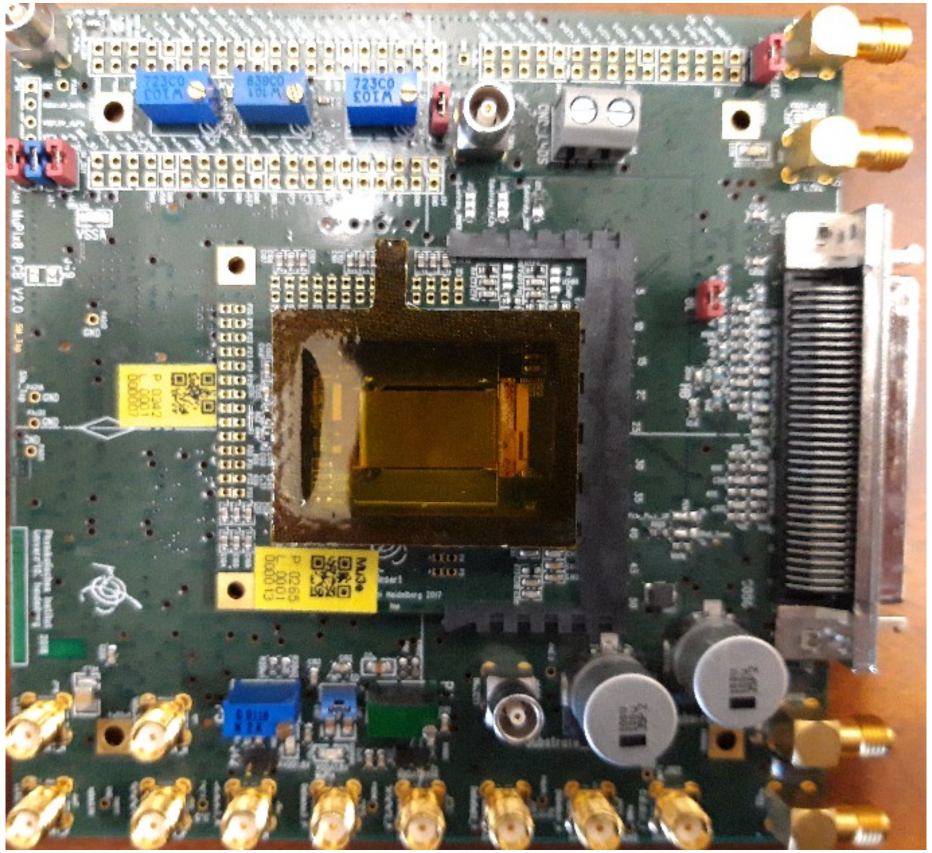
Lab Setup



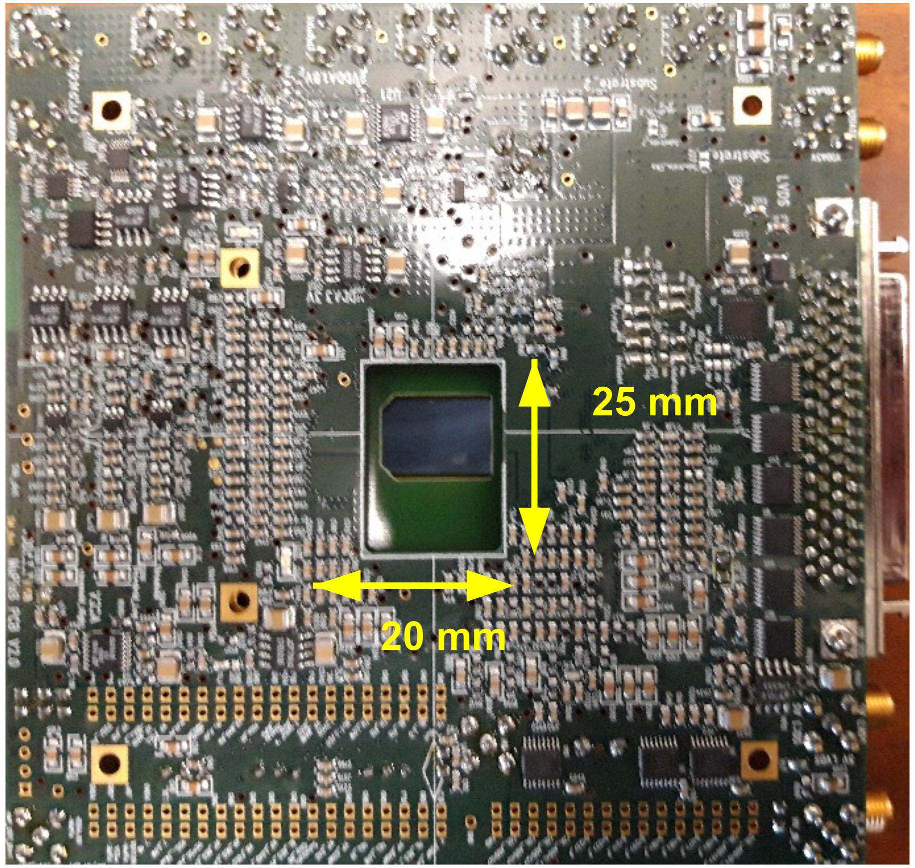
New Chips and Sensorbords in Bochum

- Different substrate resistivities (80 Ωcm and 200 Ωcm)
- New Sensorboards with adjustable VDD
  (1.9 V for more stable working point)
- PCB cutout → ideal for usage in telescope setup

Front side

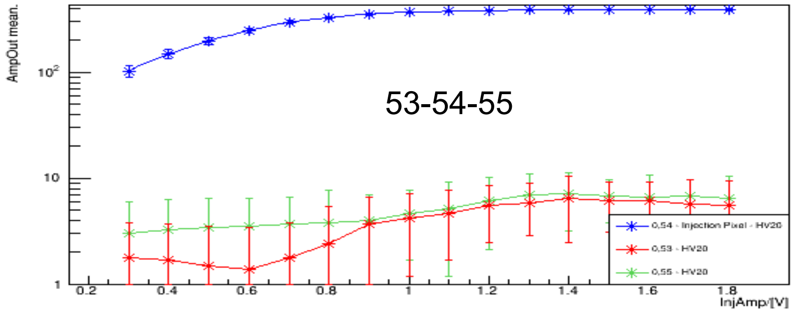


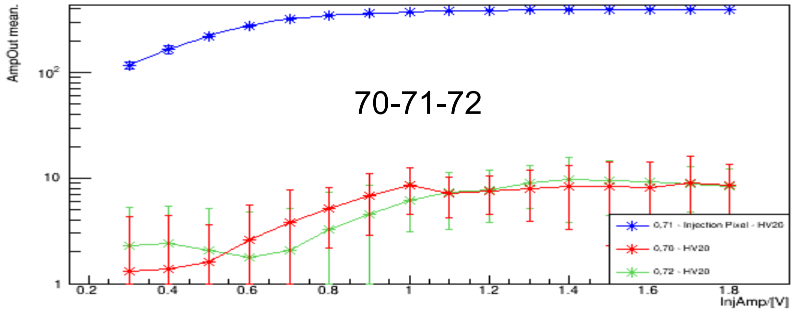
Back side

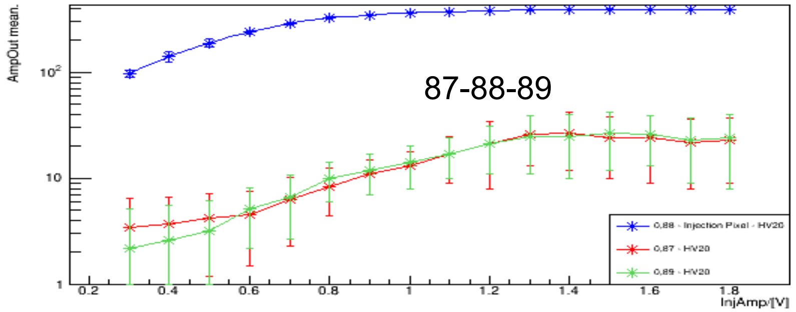


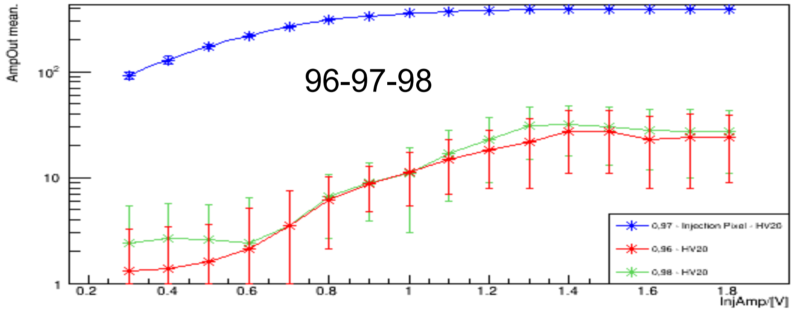
Crosstalk

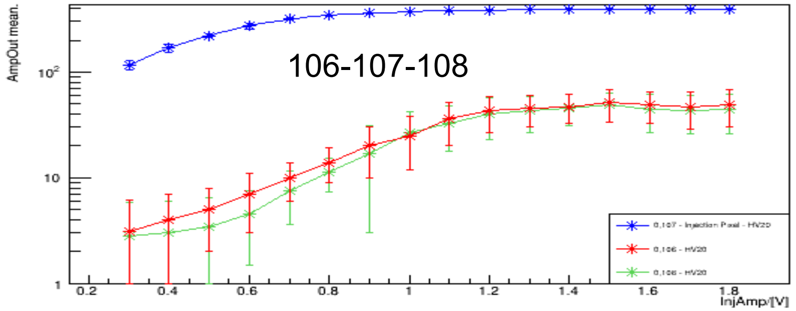
- Row dependence of crosstalk in Matrix A
- Using analog amplifier readout
- Injected pixel (blue) and neighboring pixels (red/green)

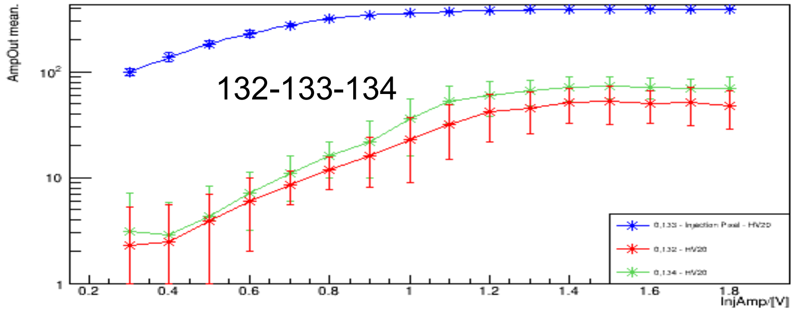


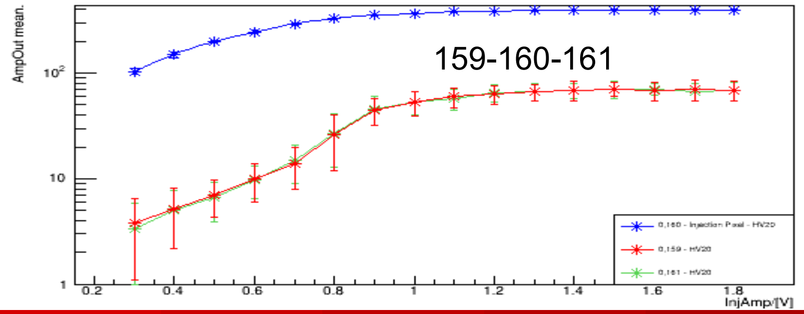












Recap: Last November

- Cluster analysis of testbeam data (MAMI october 2018)
- Different cluster sizes show different distributions
- Multi clusters (three or more pixels) show pattern related to crosstalk