MuPix8 Status and Testbeam Results

– PANDA Collaboration Meeting 2020/2 –
Luminosity Detector Session

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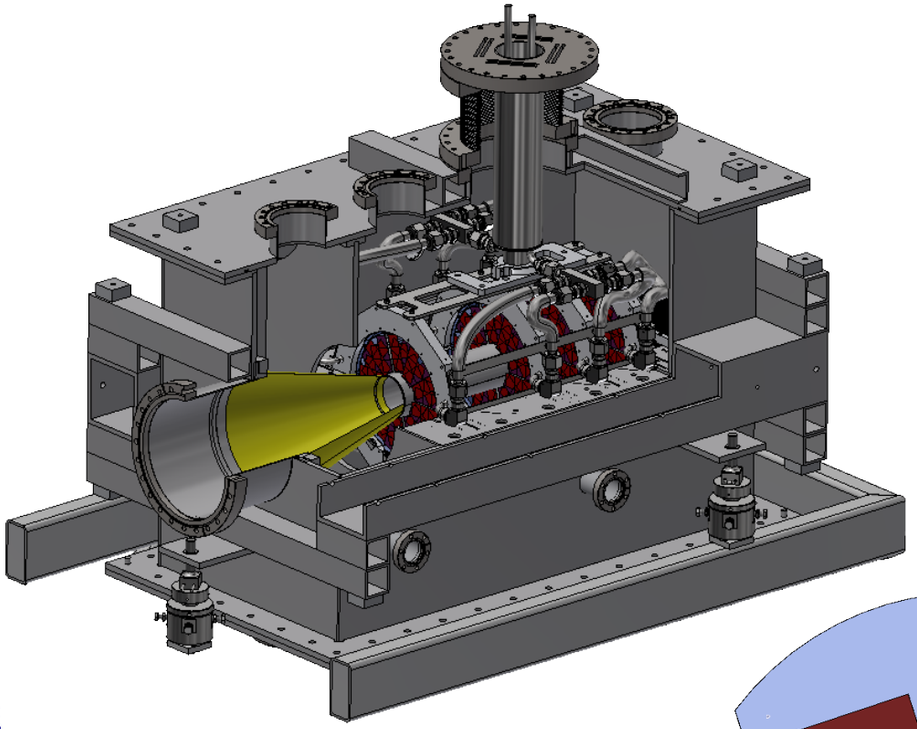
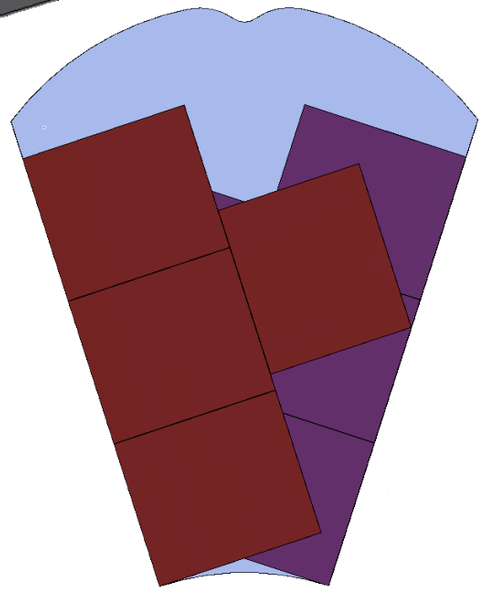
Luminosity Detector (LMD)

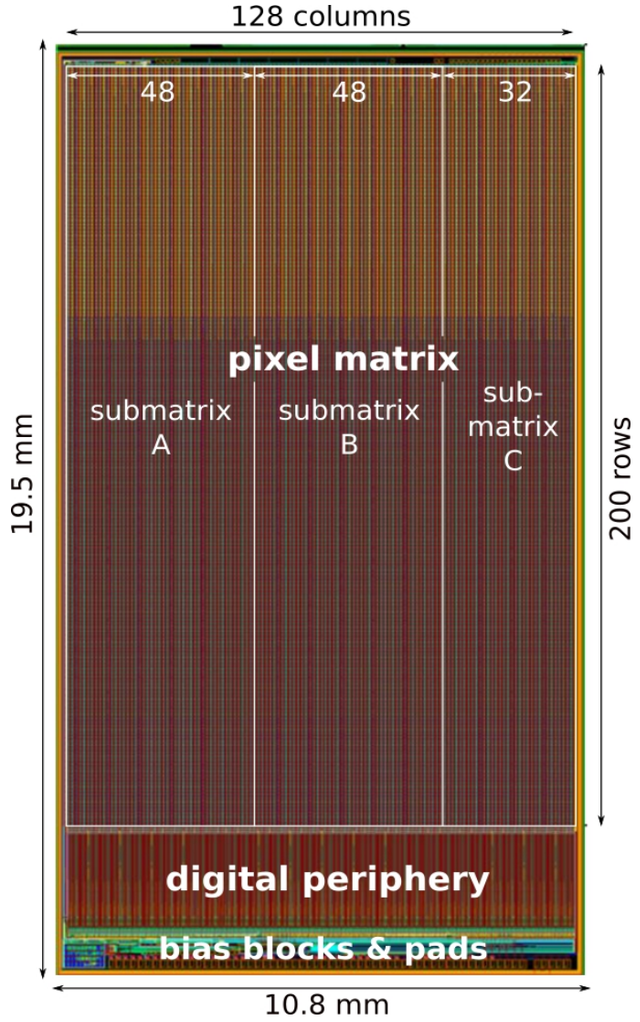
- 11 m behind IP
- Measure tracks of elastically scattered anti-protons
- Anti-protons enter detector vacuum through transition cone
- 4 detector layers with HV-MAPS on both sides
- 10 sensor modules per layer
- Aluminum holding structure with embedded steel pipe for cooling (coolant: -20°C ethanol)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





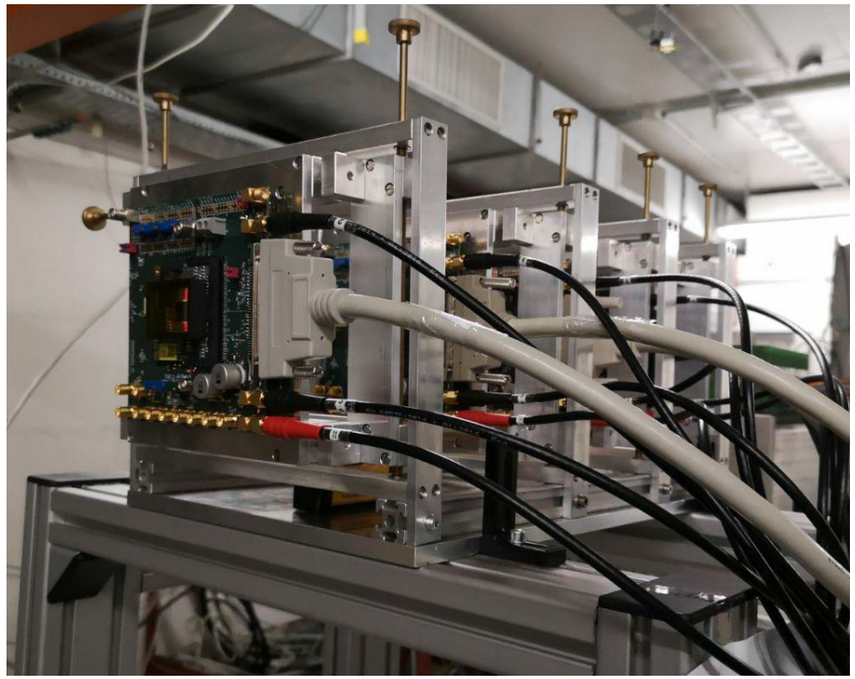
The MuPix8 Chip

- 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)



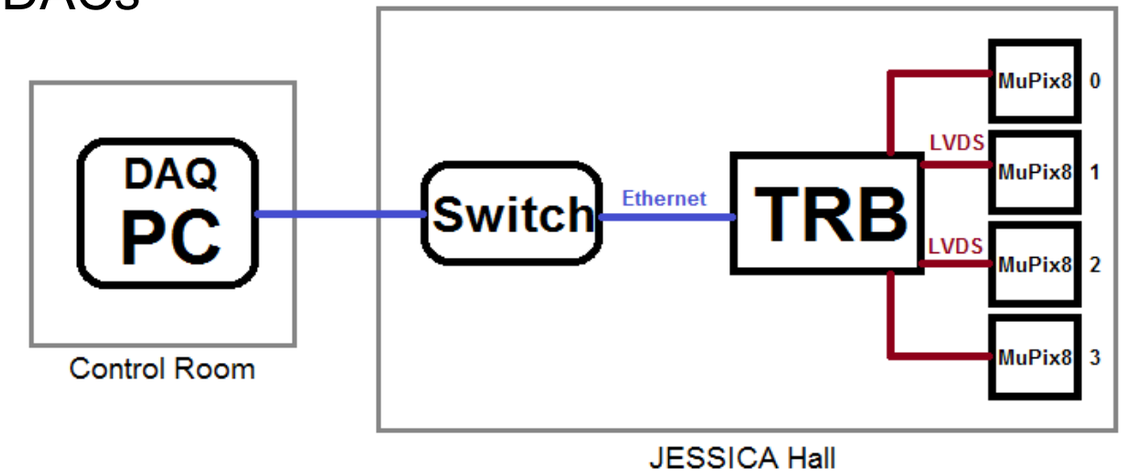
March 2020 Testbeam at COSY

- Same setup as previous testbeam (September 2019):
  - Four layers of MuPix8 sensors
  - All 3 submatrices active
  - Readout via TRBv3



- Change in sensor configuration:
  - Detection thresholds and baselines set via internal DACs

- Test of new DAQ with Kintex board postponed

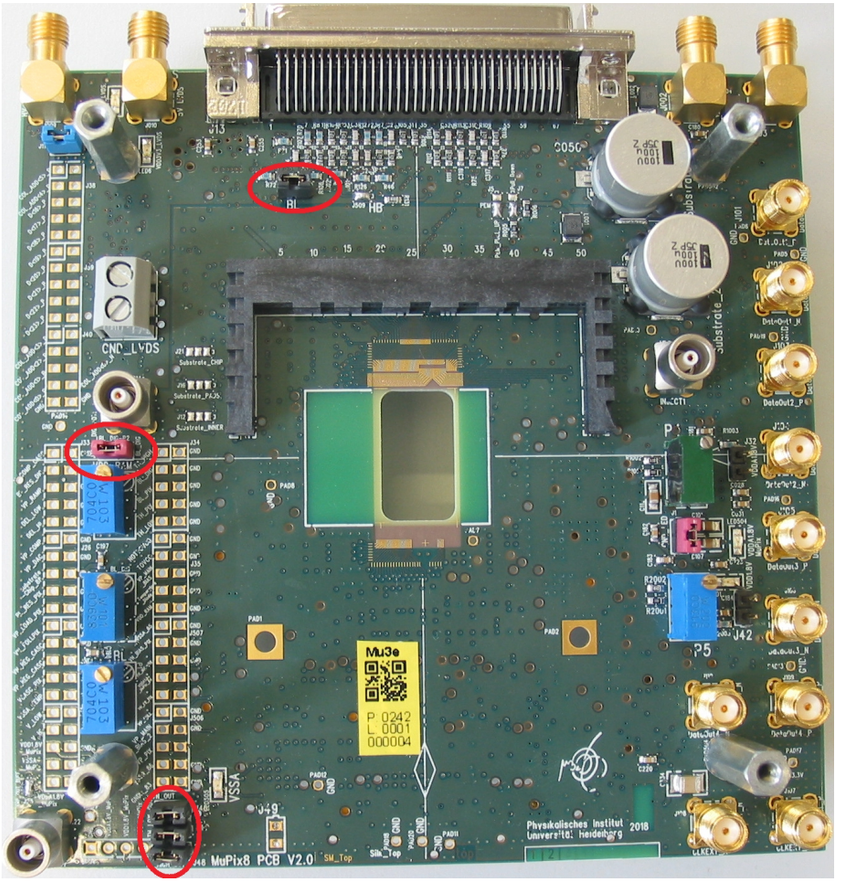


Internal threshold DACs

- Previously: Using sensorboard DACs to set voltages:
  - 14 bit values for thresholds
    (1900 mV sampled at 16383 steps ⇒ 0.116 mV/step)
  - Baseline voltages regulated by two potentiometers

- Internal voltage and threshold DACs (VDACs):
  - Implemented on the chip
  - 10 bit values
    (1900 mV sampled at 1023 steps ⇒ 1.857 mV/step)
  - Always set during chip configuration
    but overridden by board DACs

- Cancel override by unplugging certain jumper connections

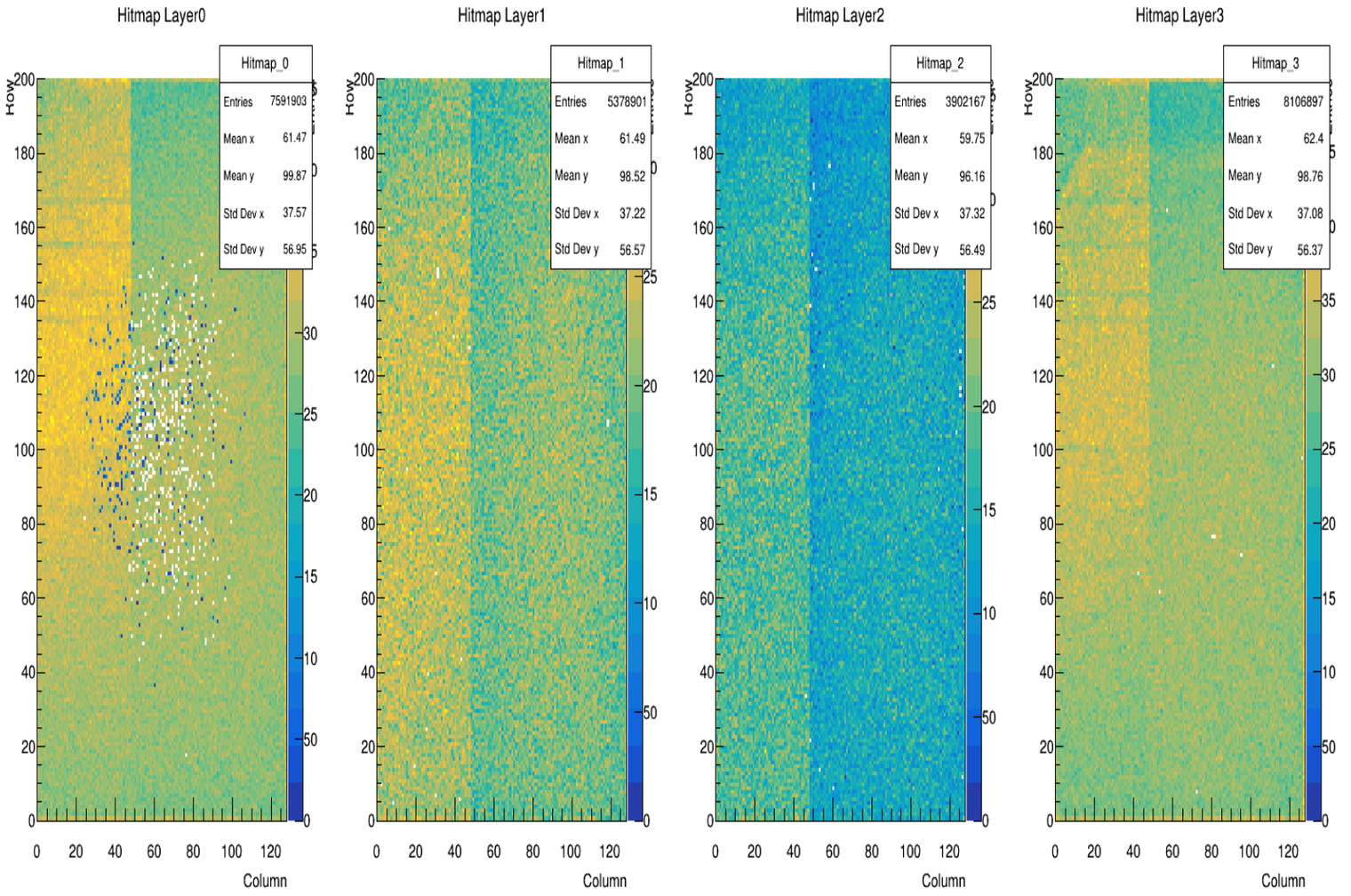


- Reasonanble match between the two settings (confirmed by manual measurement)

Hitmaps

Beam parameters:
p ~ 2.75 GeV/c
> 10^6 protons / s

- Homogeneous illumination of all sensors (wide beam)
- Sharp cut between Matrix A and B/C
- Started at very low intensities, increased rate several times during beamtime

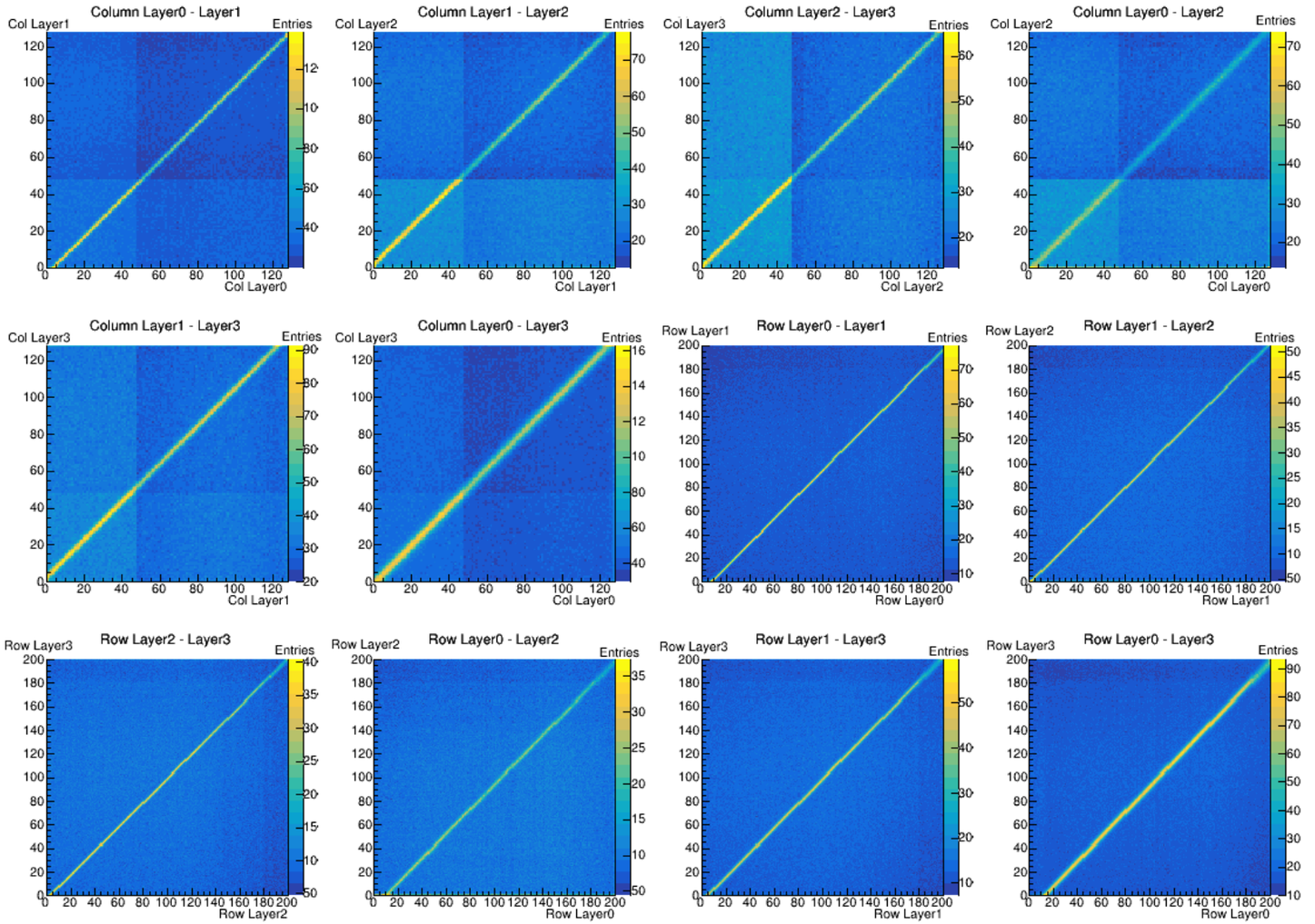


Hitmaps @ HV = 50 V and ThHigh = 600 mV

Hit Correlations

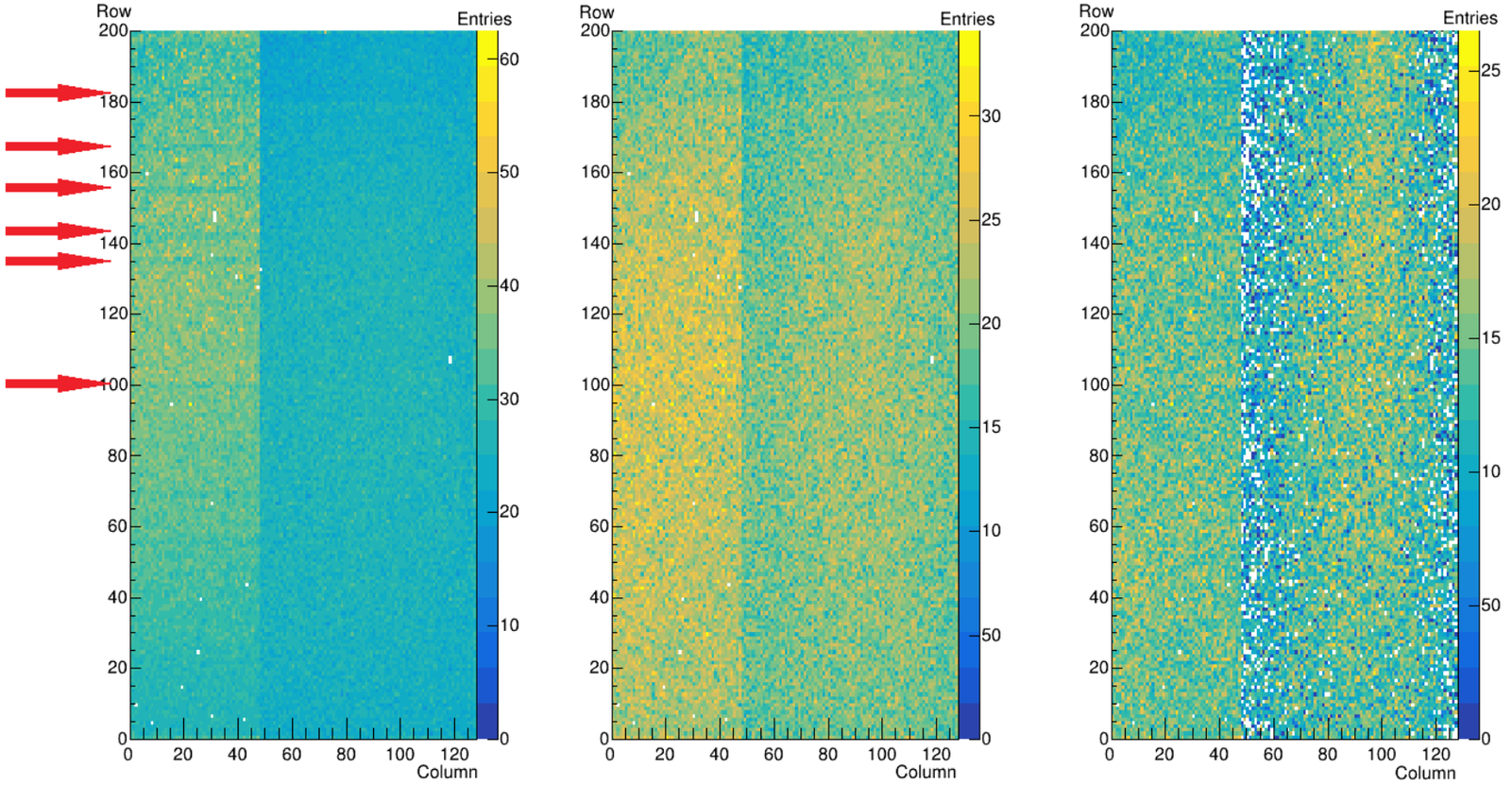
- Use Layer 1 as DUT with various HV and threshold settings
- Layer 0, Layer 2, and Layer 3 for tracking
- No rate problems due to beam intensity (usually seen in row correlations)
- Remaining offset can be corrected by software alignment

Column and Row Correlations for all matrices after alignment:
DUT: HV = 50 V and ThHigh = 600 mV



Differences in Submatrices

DUT @ HV = 50 V and ThHigh = 550 mV, 600 mV, 650 mV



- Different response from matrix A and B/C (sharp cut)
- Insensitivities for edges of matrices B/C at higher thresholds
- No difference in response between B and C

Testbeam Analysis

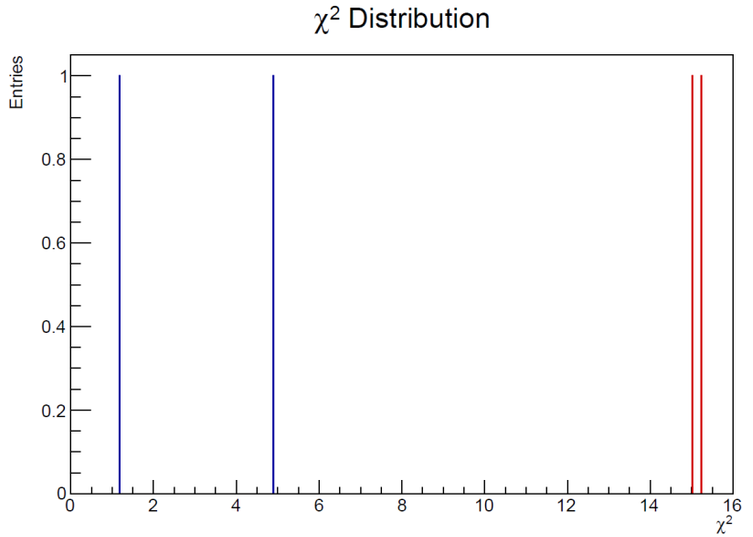
Currently investigating code of MuPix6 analysis algorithm and adapting it for MuPix8 data:

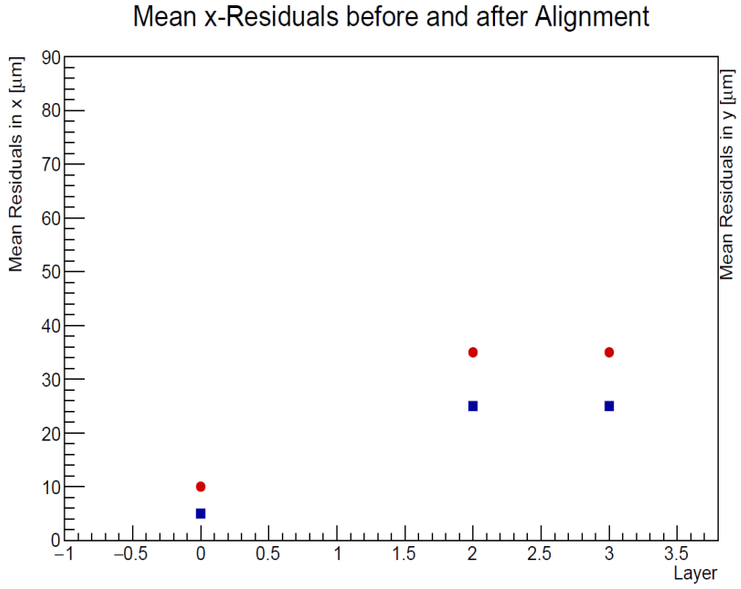
- Coordinate transformation to x-, y-, z-coordinates (✓)
- Software alignment of layers (✓)
- Cluster finder (✓)
- Tracking algorithm based on cellular automaton (✓/✗)
- Efficiency calculation for DUT, etc. (✗)

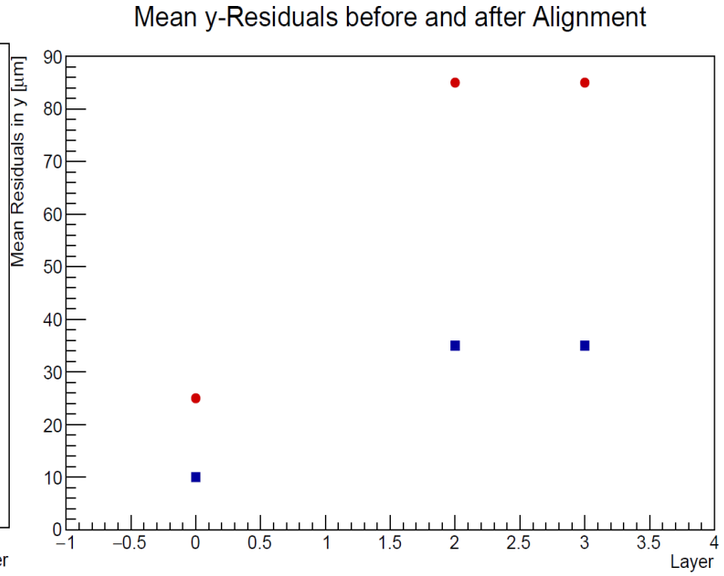
First Test Results

- Test of Tracking algorithm with two events from testbeam data set
- Each event containing a single hit in layers 0, 2, and 3
- Tested tracking with and without software alignment

- TODO / Improvements:
  - Replace current tracking algorithm with simplified version (originally designed for GPU or FPGA tracking)
  - Iterative alignment improvements after tracking

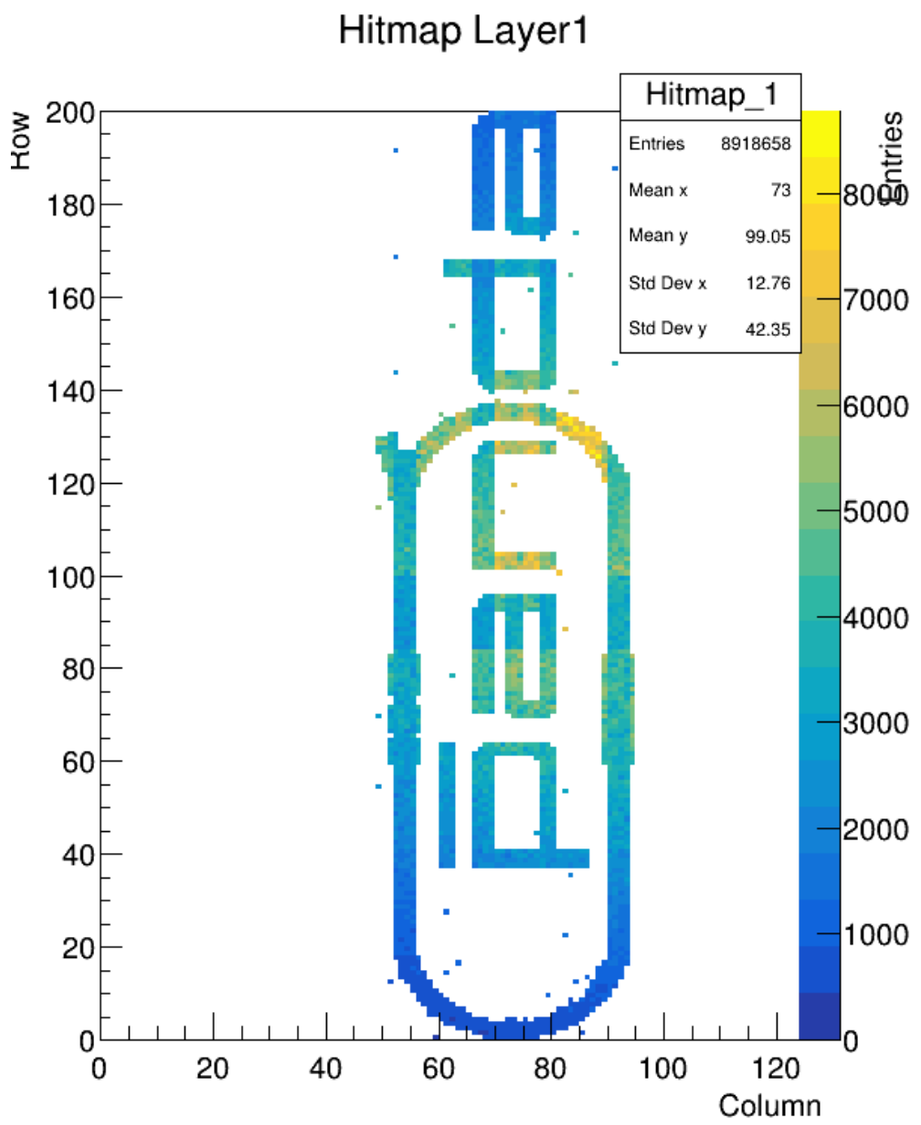






Summary

- Testbeam at COSY with four layer telescope
  - Chip configuration using VDACs
  - All submatrices read out simultaneously
  - No readout errors observed due to beam intensity
- Testbeam data analysis based on cellular automaton algorithm used for MuPix6
  - First test with MuPix8 beam data seems promising
- Possibility to use simplified tracking algorithm is being investigated

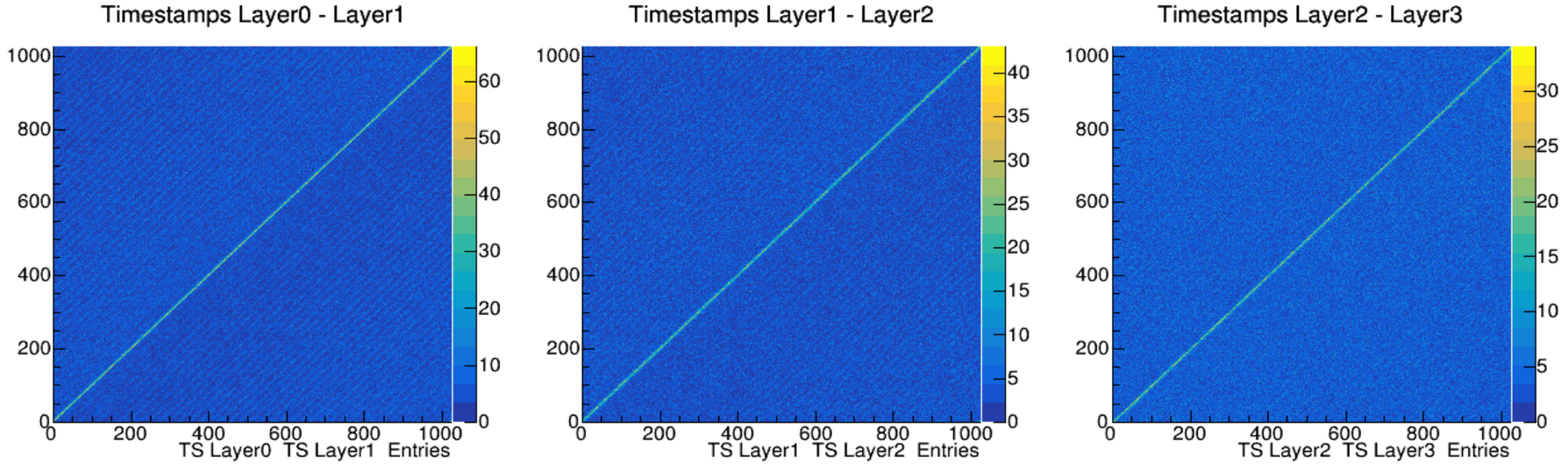


Matrix B of MuPix8 with PANDA Mask

– Backup –

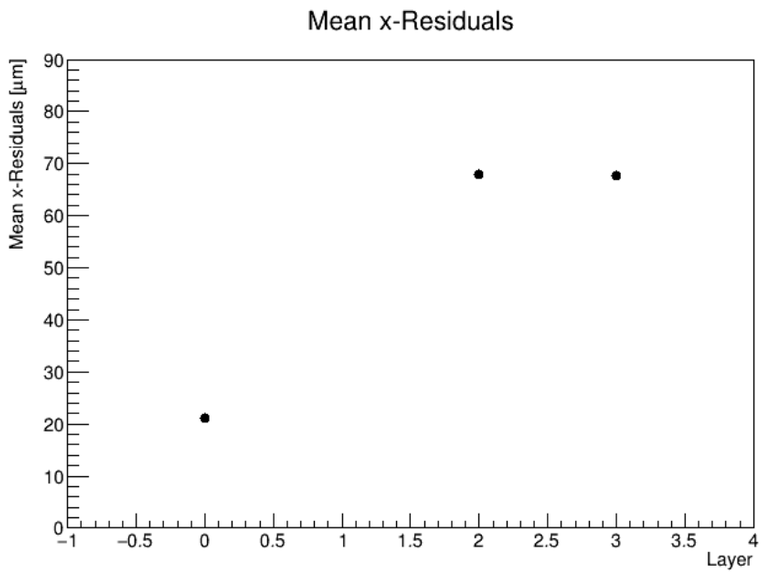
Timestamp Correlations

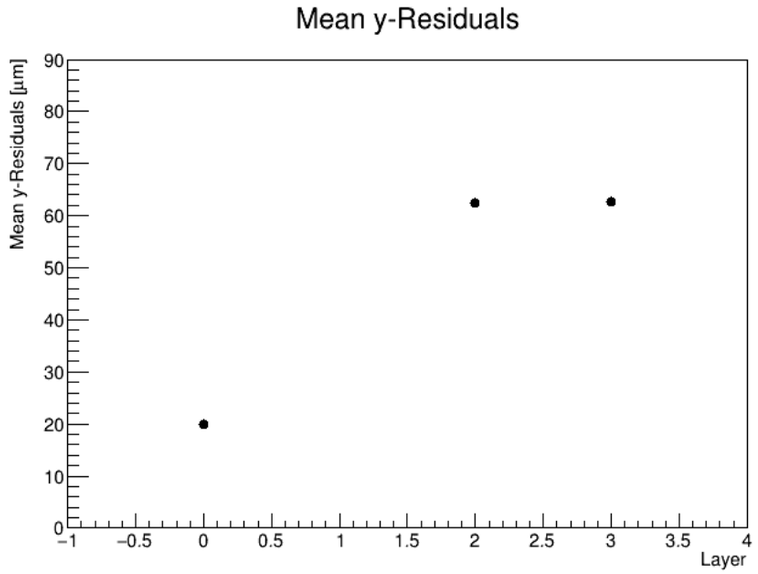
- All 4 Layers synchronized

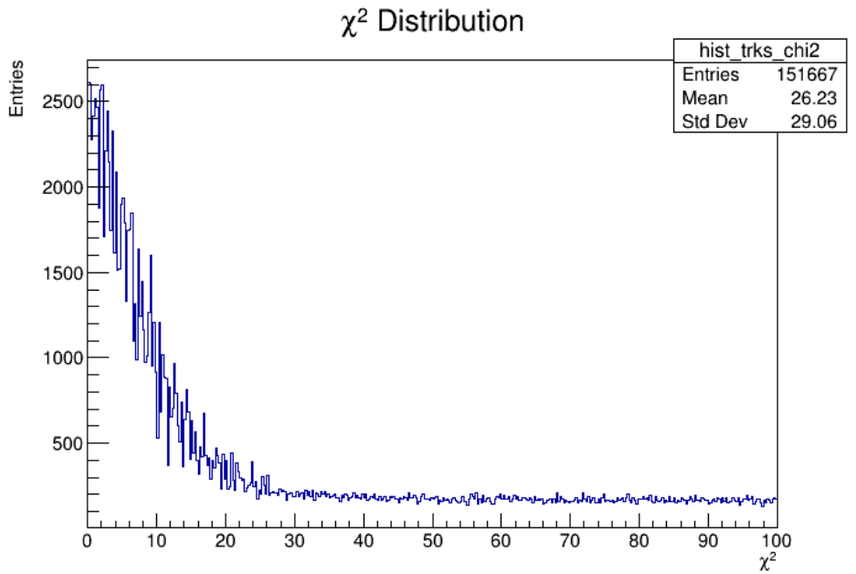


Tracking Test with Full Run

- Test of tracking algorithm with one full run (settings: HV = 30V, ThHigh = 600mV):







Note: After software alignment, **no** cluster correction