PXD Testbeam 2018 DESY and first results

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PXD9 DESY Testbeam 29.10.18 - 25.11.18

Test beam environment

- 3 – 5 GeV electron source
- no magnetic field used
- EUDET telescope with 6 Mimosa26 sensors
- upstream scintillator triggers
- downstream FEI4 sensor for triggering and timing information

Devices under test

W11OF2

W40IF

- cut ladder modules W11OF2 and W40IF
- noisy ASIC pair 3 module W05OB1
- final ASICs Hybrid5 with 75 μm pixels

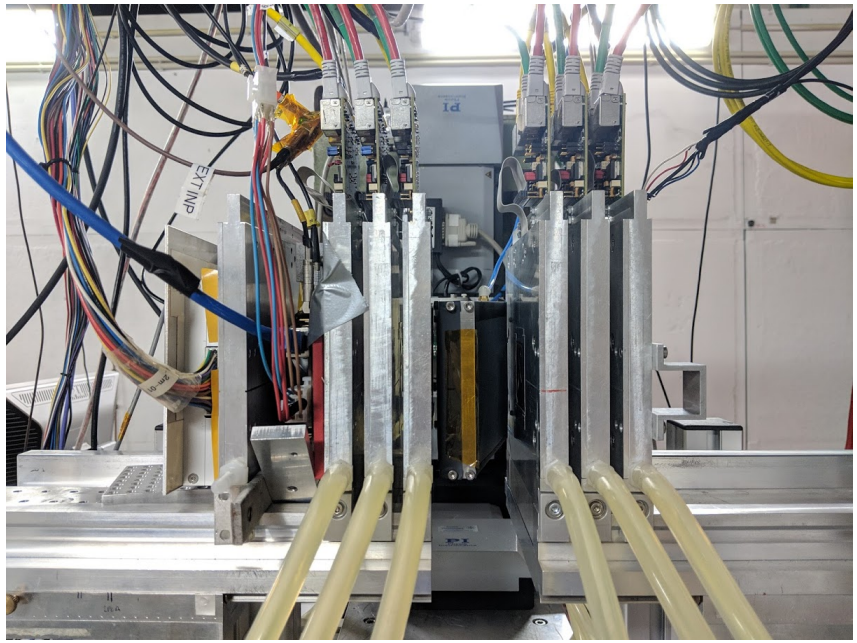
Backend and read-out

- mass-testing/lab setup equivalent
  - LMU-PS powered via HAMEG bench PS
  - lab power-breakout board
  - DHE on carrier board (no DHC)
  - mass-testing firmware 0x1183BDC (15:28 7.8.17)
  - lab patch panel

- read-out: DHE $\rightarrow$ BonnDAQ $\rightarrow$ EUDAQ + local data
- operated using UtilityIOC, CalibrationIOC and OnlineMonitor
- grounding: lab scheme $\rightarrow$ no forced ground connections
  - W11OF2 and W05OB2 could have bulk short to floating box, no effects observerd
  - W40IF isolated via kapton

Telescope setup

- from upstream to downstream
  - trigger scintillator
  - 3 Mimosa26 reference planes
  - PXD9 in light tight box
  - 3 Mimosa26 reference planes
  - FEI4 trigger and timing plane
  - Hybrid5
- Mimosa spacing
  - 2 cm for perp. incidence
  - 5 cm for angular scans



- trigger rates of 400-1.200 Hz
- PXD9 modules
  - mounted on laser cooling block (10 °C water cooled)
  - in open Alu box (light tight via tape)
  - flushed with N_2
  - on movable x-y-stage

Module conditions

- based on optimized configration from mass testing/lab with
  - ZP threshold 4
  - adjusted trigger latencies, etc.
- pedestals
  - stable, recalibrated at begin of new experiment
- HS links
  - unstable, periodically lost
  - link watchdog active
  - artificial hot 'active link pixels' for offline event check

Pre-measurements per module

- short runs with 'timing pixels'[1] for adjusting trigger delay settings
- ZP threshold scans
- x-y-alignment of sensor volume with sensitive scintillator, FEI4 and telescope planes

definitions:

- **run**: a set of $\approx 250,000$ consectutively recorded events
- **experiment**: a set of runs recorded under indentical conditions (configuration, sensor position, ...)

[1] one artificially hot pixel per gate

Optimal efficiency studies

- perpendicular incidence at small telecope spacing
- optimal matrix biasing conditions (from lab results)
- collect statistics for potential in-pixel studies
- several 'illumination windows' necessary for full sensor
- done on W11OF2, W40IF and Hybrid5

$\rightarrow$ determine sensor efficiency and resolution at optimized biasing

Biasing studies

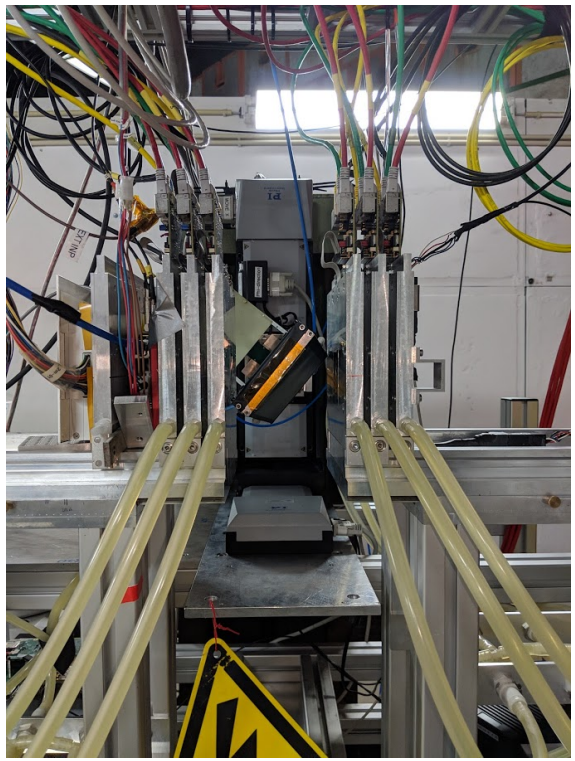
- perpendiclar incidence at small telescope spacing
- probing HV and drift/clear-off combinations $\rightarrow$ doping variation rings
- only one 'illumination window'
- done on W11OF2, W40IF and Hybrid5

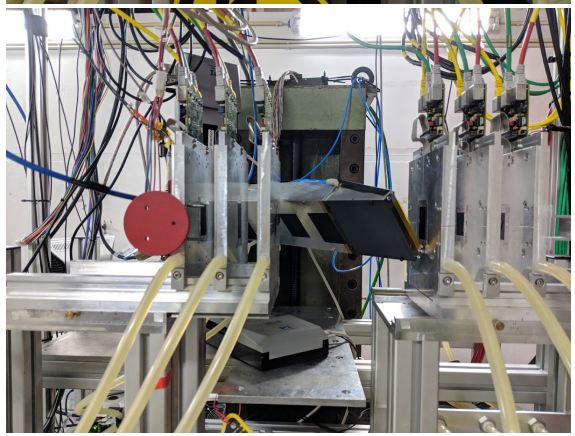
$\rightarrow$ study influence of doping variations (rings) on efficiency at varying biasing conditions

Angular scans

- inclined incidence in θ and ϕ
  - $\phi \in [0, 10, 20, 30, 40]$ deg
  - $\theta \in [0, 20, 30, 40, 50, 60]$ deg
- only one 'illumination window'
- done on W40IF and W05OB1

$\rightarrow$ determine resolution improvements for inclined tracks via charge sharing (cluster database algorithm)



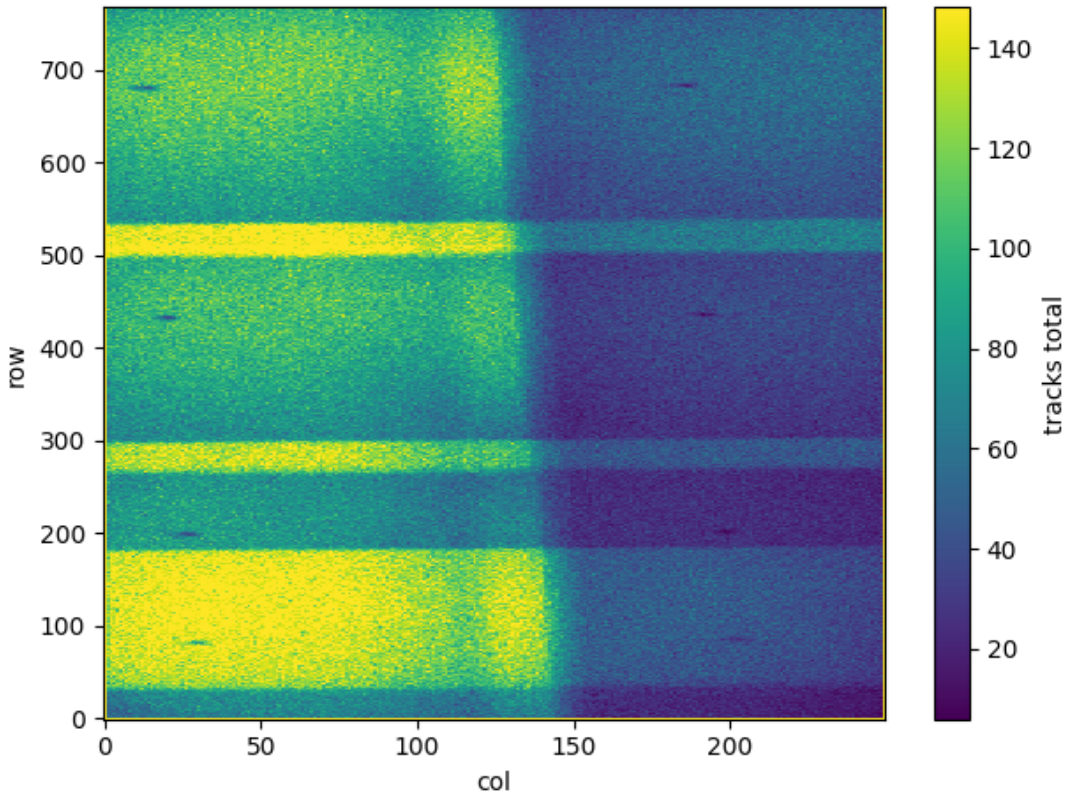


Preliminary results

- **preliminary** results for efficiencies at perp. incidence at optimal biasing
- using Benjamins testbeam analysis framework (TBSW)
  - calibration once per experiment (pixel masking, alignment, ...)

Track selection

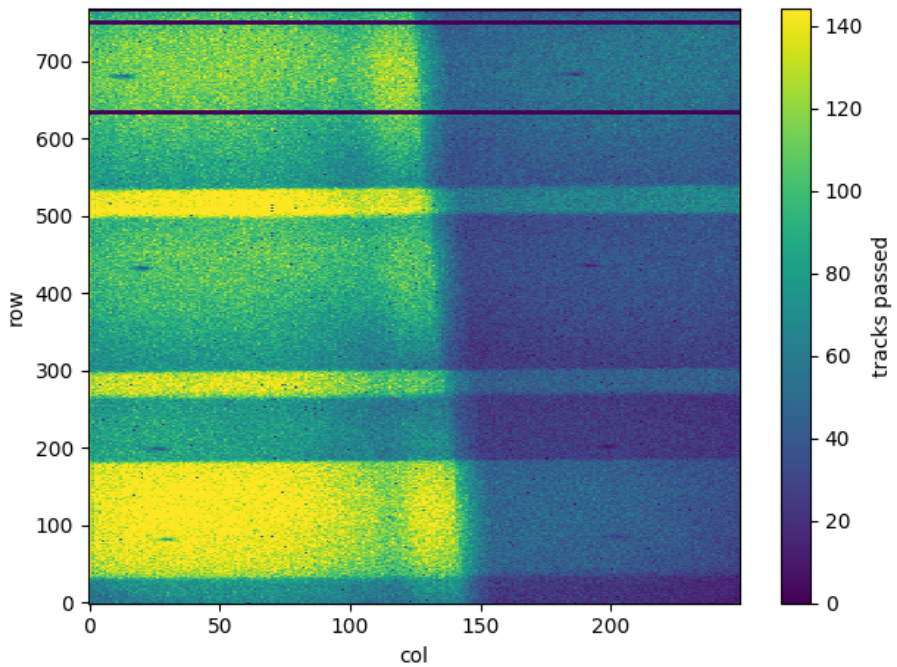
- select tracks with a hit on the reference/timing plane (FEI4)
- select only tracks in events with all 'active link' pixels present on PXD9



W40IF total track selection

Track matching

- select subset of tracks with a matched[2] hit on PXD9
- dead gates and pixels visible

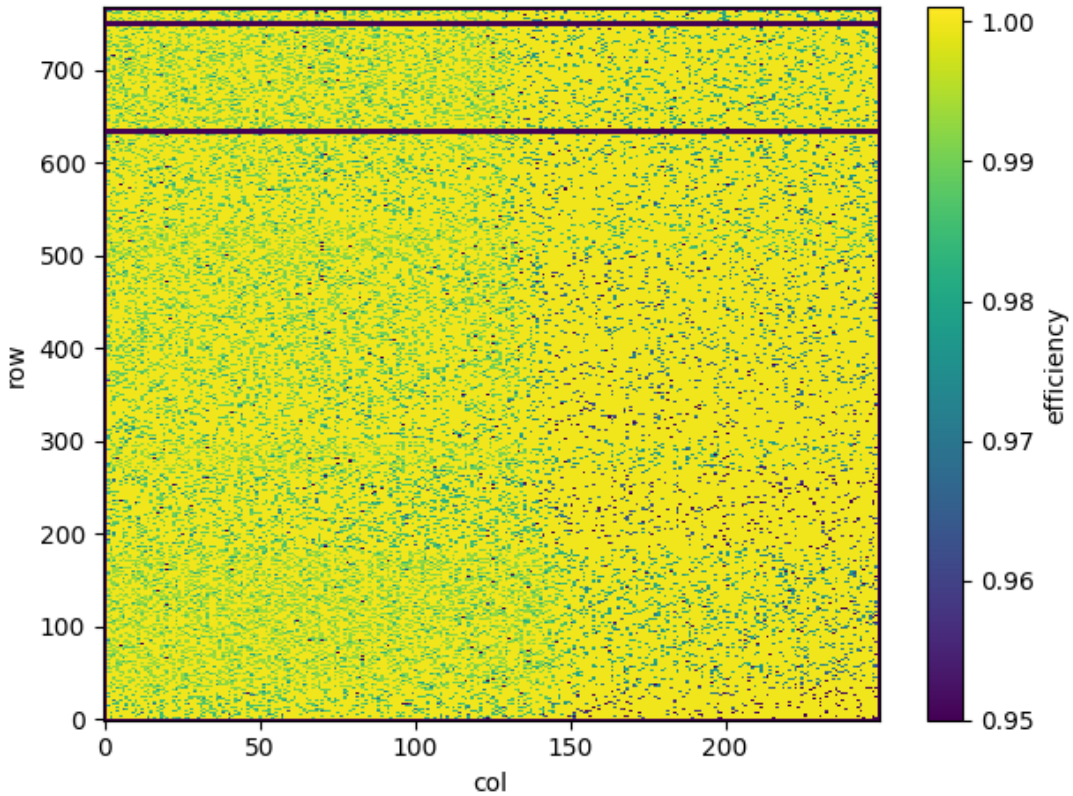


W40IF matched track selection

[2] within 200 μm $\times$ 200 μm square around extrapolated track position

Sensor efficiency

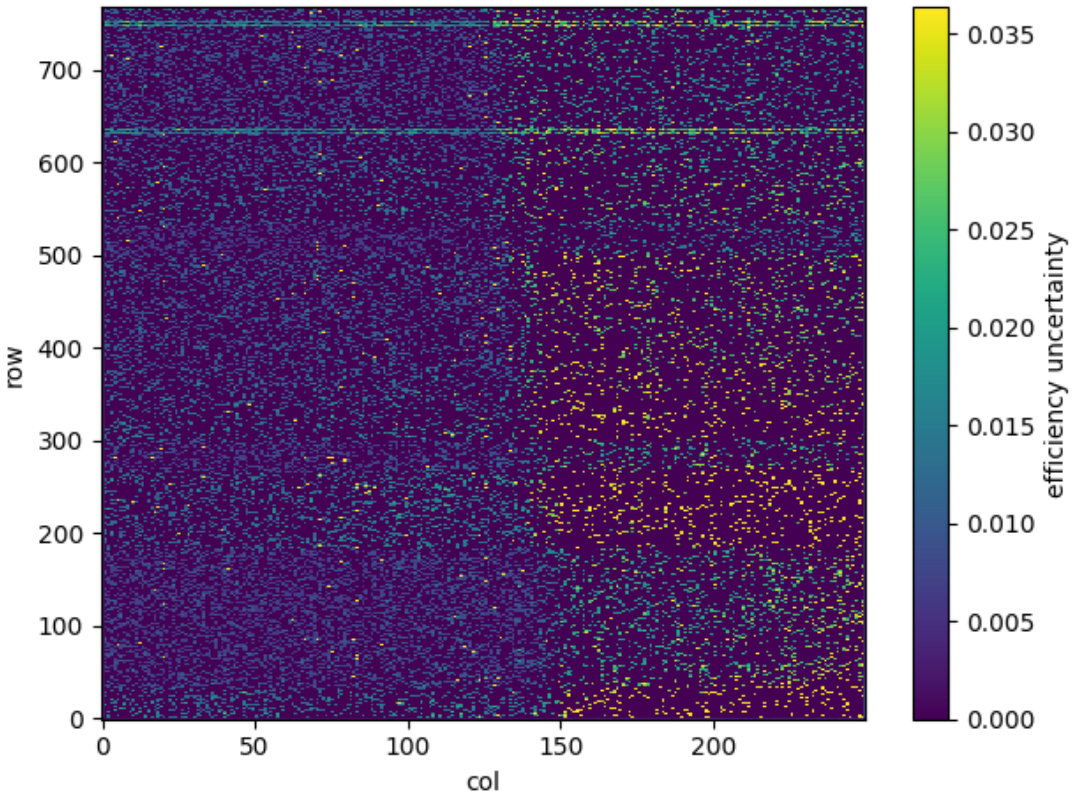
- ratio of matched to total tracks gives efficiency ϵ
- average excluding dead pixels: $\approx 99.6 \pm 1.4\,\%$



W40IF efficiency

Efficiency uncertainty

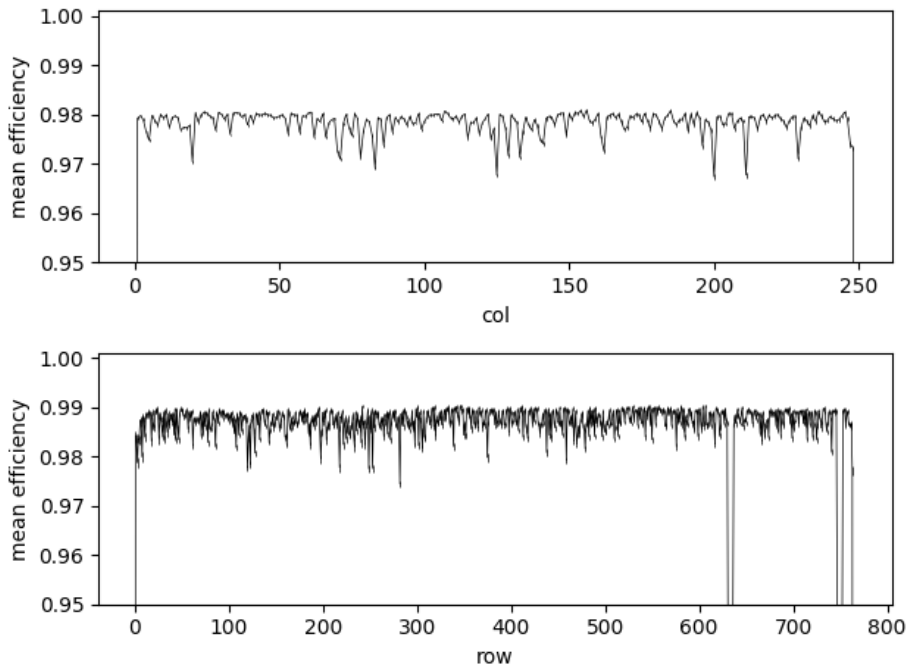
- uncertainty on ϵ via binomial counting uncertainty
- for high statistics region $< 1\,\%$
- for single pixels in the order of up to $10\,\%$



W40IF efficiency

Efficiency projections

- projections on cols and rows
- reduced due to dead gates and binning effects at borders
- fluctuations due to 'stitching' of individually calibrated experiments (pixel masks)?



W40IF efficiency projections

Efficiency projections - zoomed

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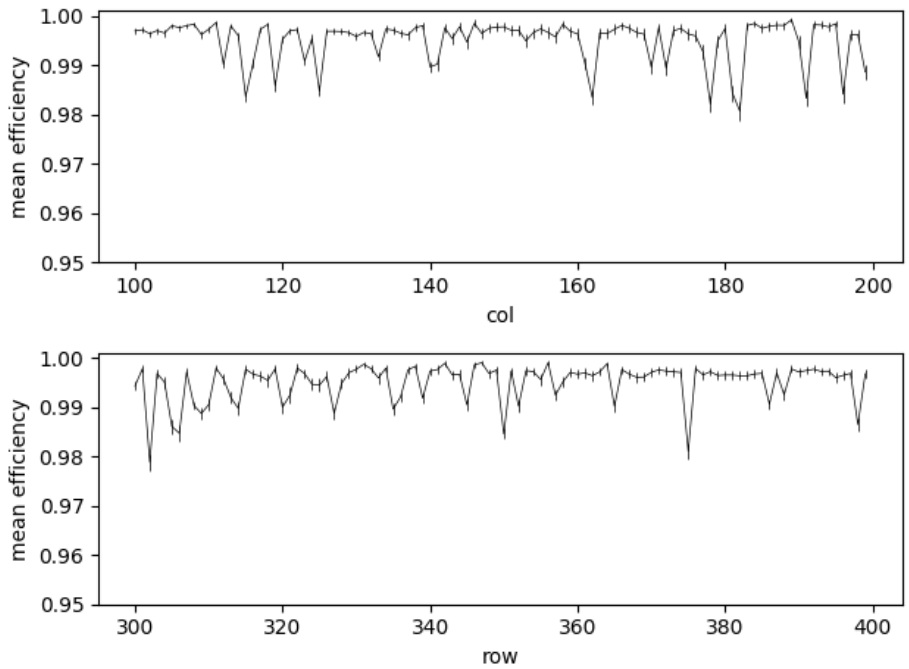
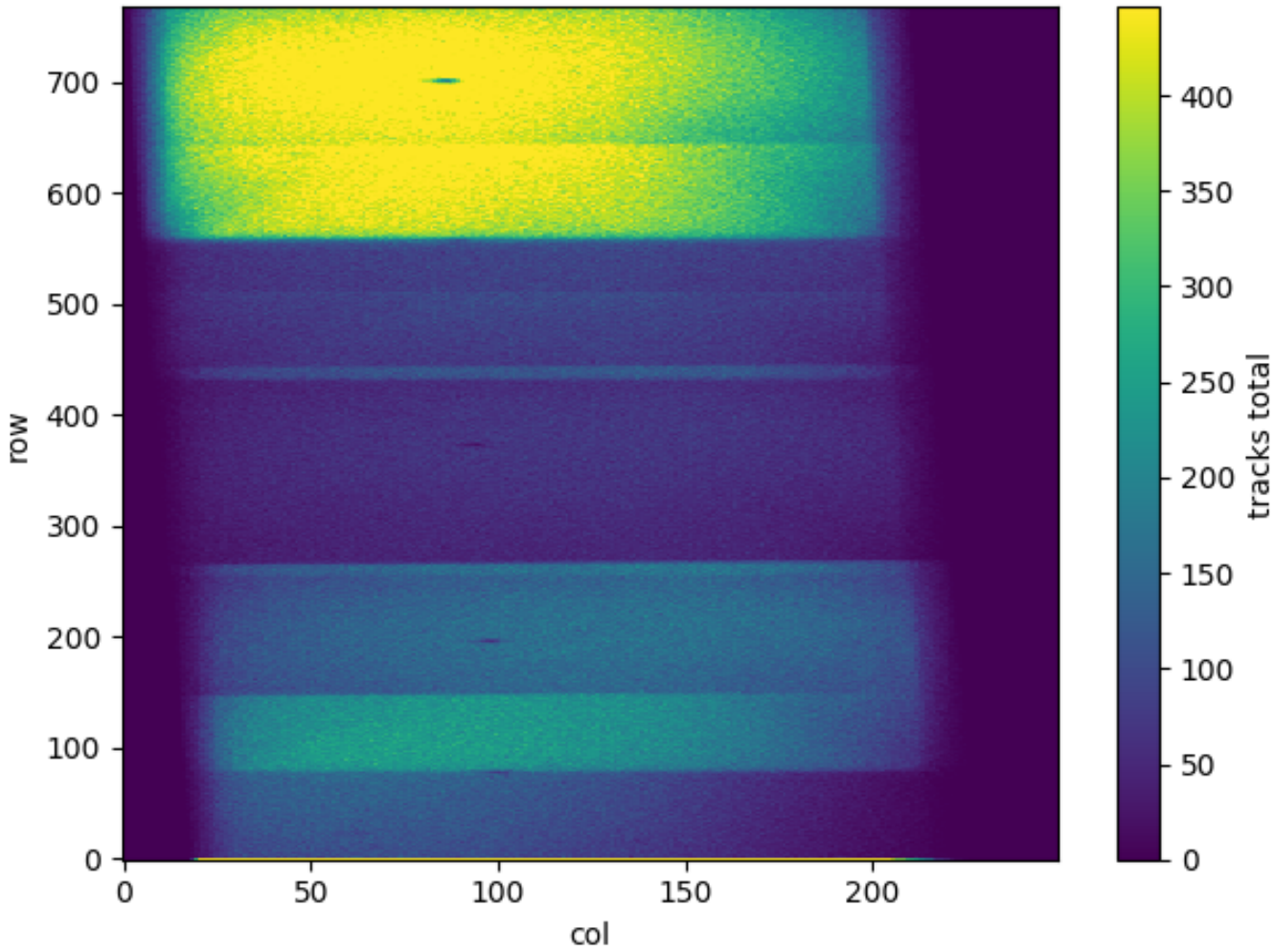
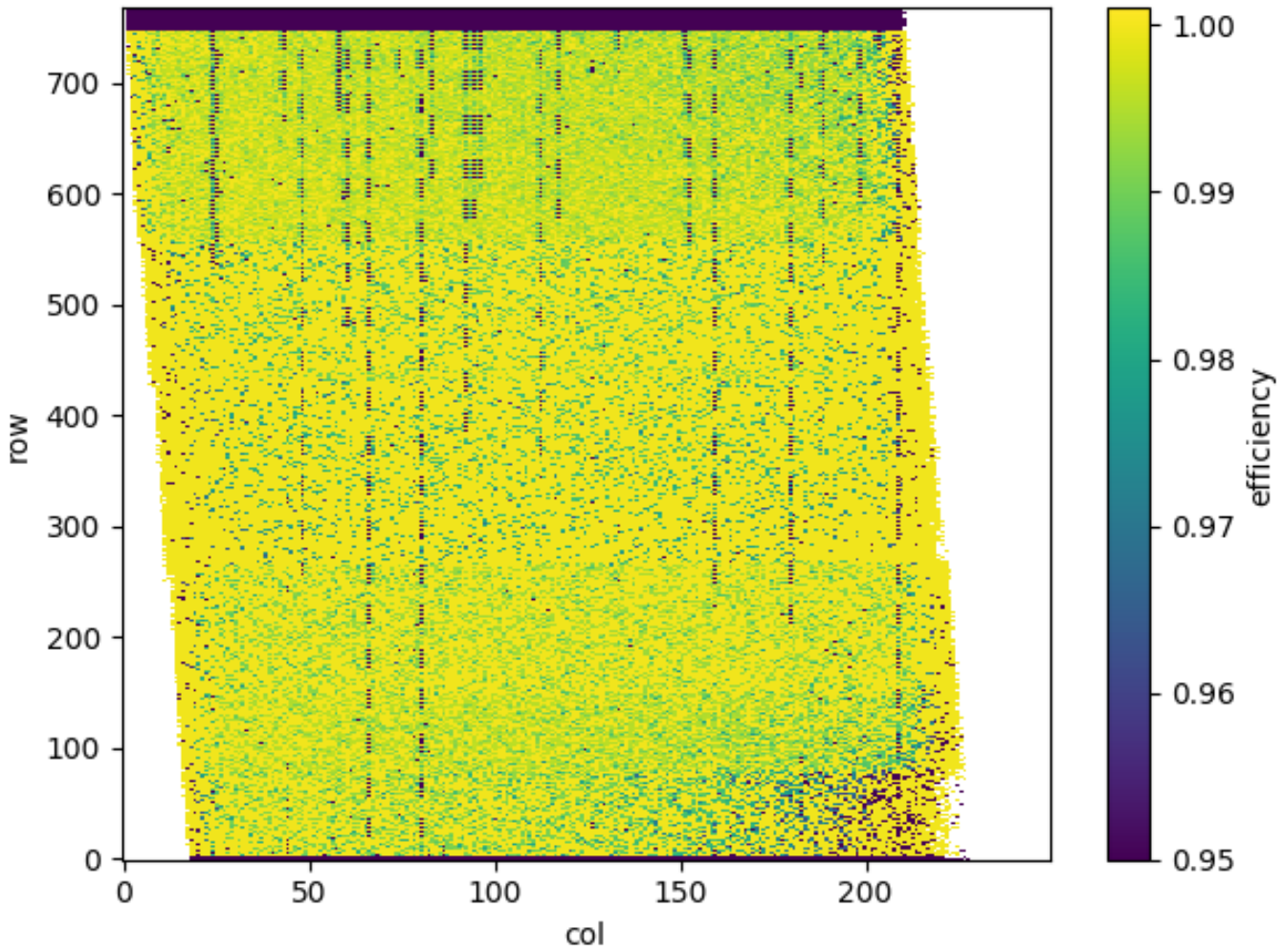


W40IF efficiency projections

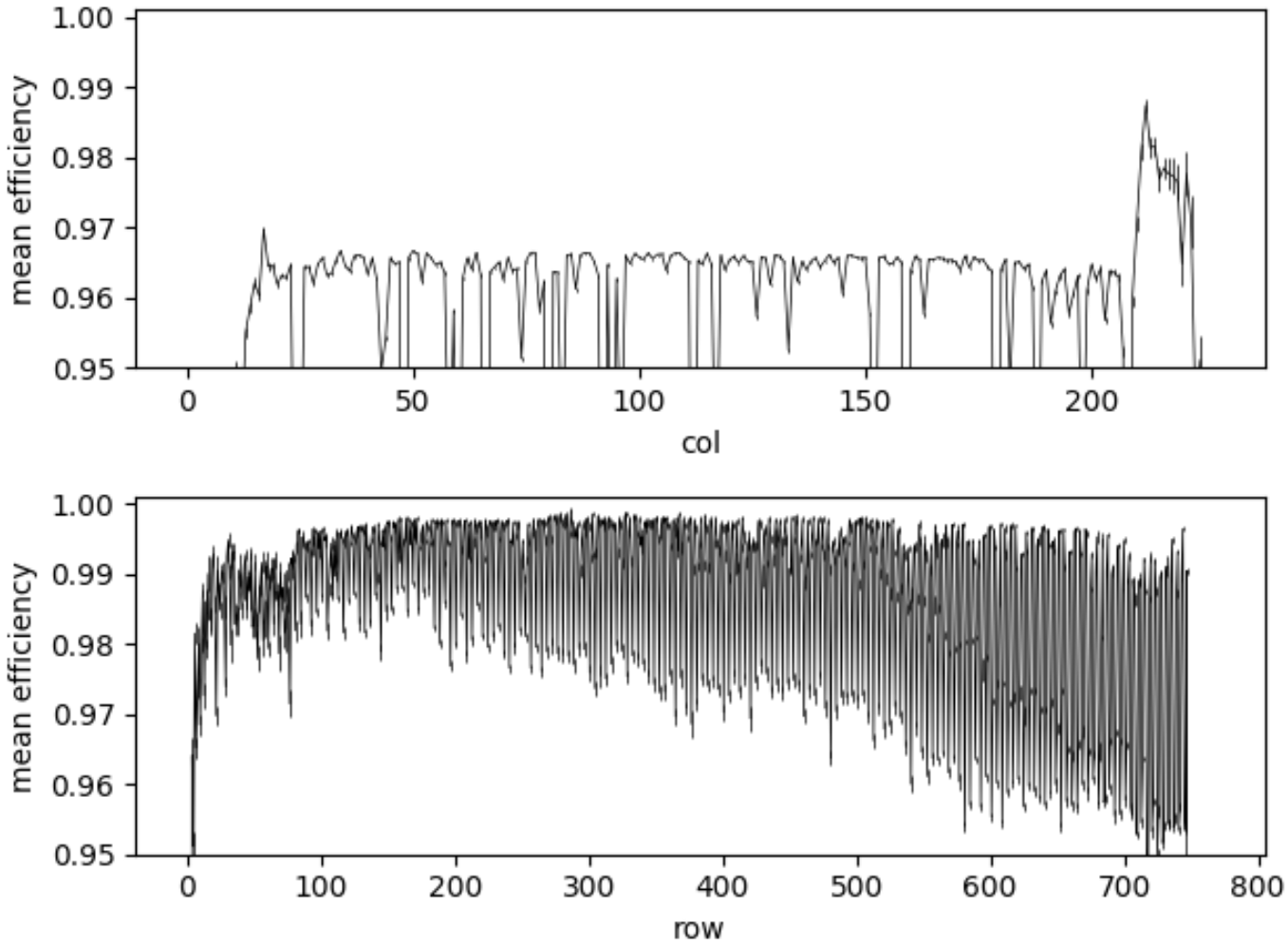
Track selection - W11OF2



Efficiency - W11OF2

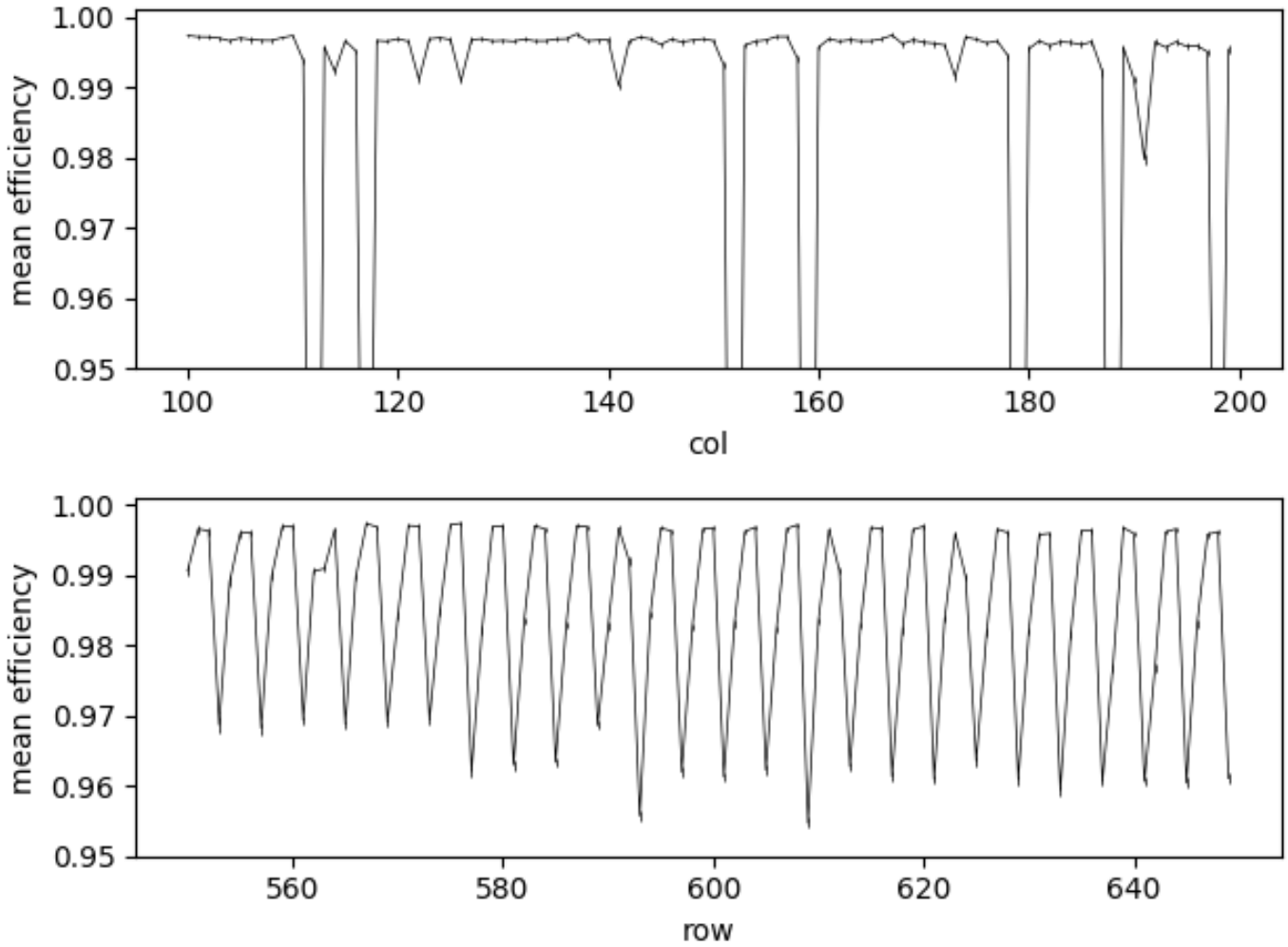


Efficiency projections- W11OF2



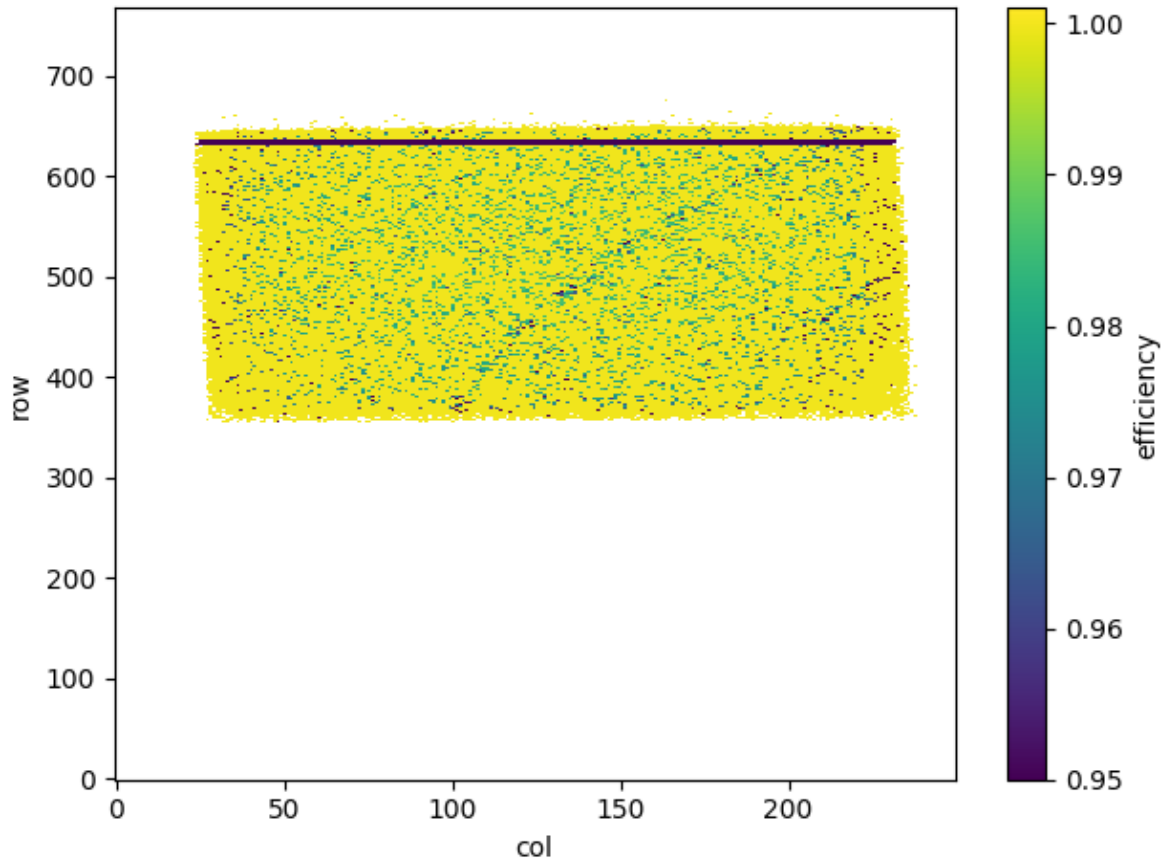
- bad 4th row pattern due to broken drain lines

Efficiency projections- W11OF2 - zoomed



- bad 4th row pattern due to broken drain lines

Preview: biasing studies



W40IF efficiency at non-optimal biasing

- bad biasing shows ring-shaped inefficiencies

Conclusion

- successful testbeam campaign with data from three PXD9 modules at different biasings, angles and high statistics
- not understood link instability issue
- DAQ issues result in some runs having a trigger mismatch
  - offline mismatch correction under investigation
- first results show promising efficiencies on L1 and L2 module

Outlook

- efficiency analysis:
  - correct for dead pixels and gates and border binning
  - high number of single dead pixels, check hot pixel masking
- resolution analysis
- cross-check with pedestal calibration and noisy pixel masking
- study signal-to-noise behaviour
- biasing studies:
  - correlate efficiency loss to doping variation analysis
  - determine stability of optimal biasing
- angular scans:
  - study effect of charge sharing on resolution
  - study different cluster-to-hit algorithms

Backup