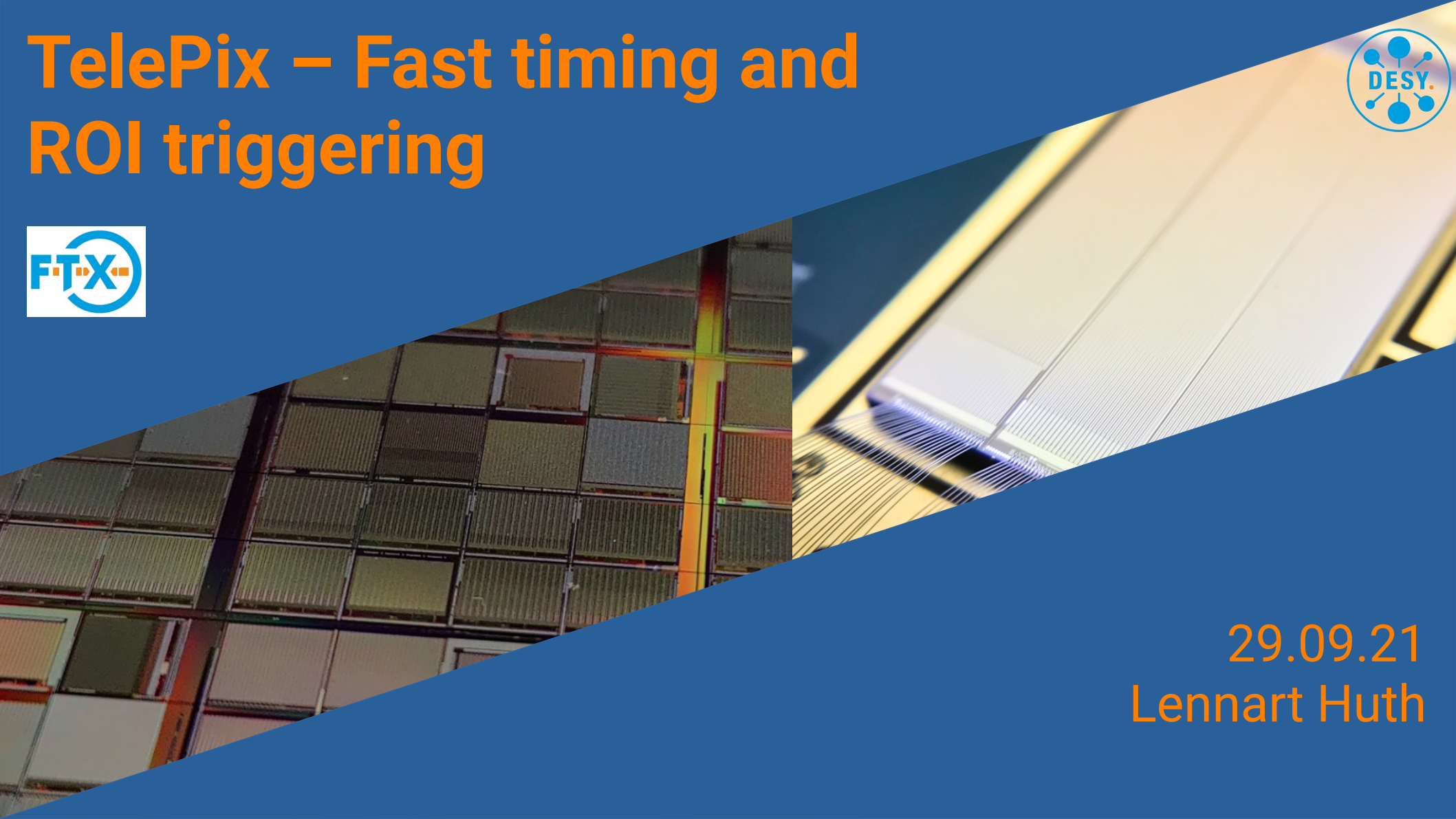
TelePix – Fast timing and ROI triggering

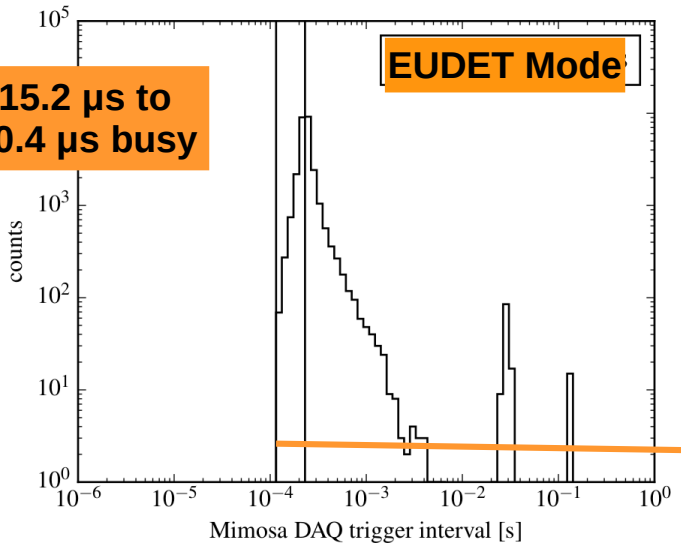


29.09.21

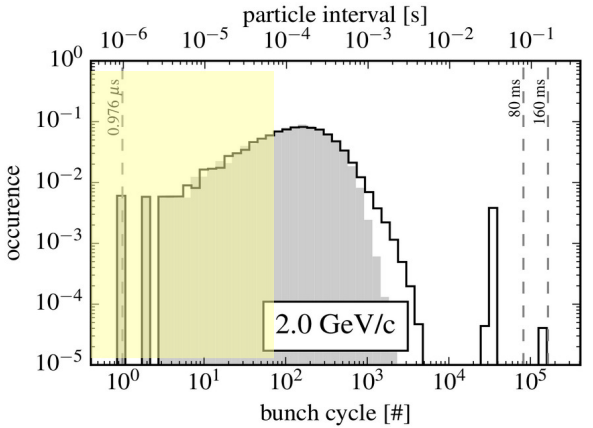
Lennart Huth

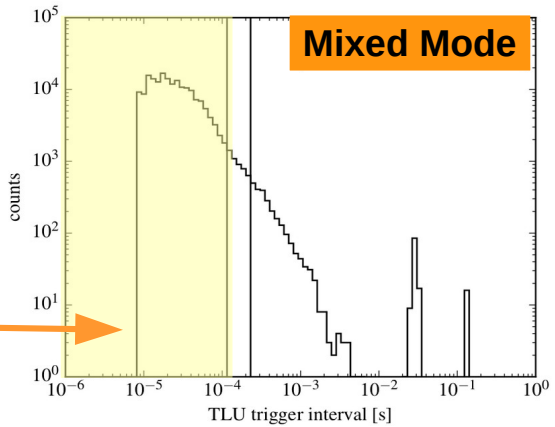
Improvements due to new trigger scheme

Ignoring the telescopes busy allows for higher rates, limited only by the time required to clock out the trigger numbers



Factor 10 higher trigger rates





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Coping with the increasing DESY-II rates

- Mixed-mode: Ignore the BUSY of telescope
- Single particle trigger
- Still several tracks per Mimosa frame

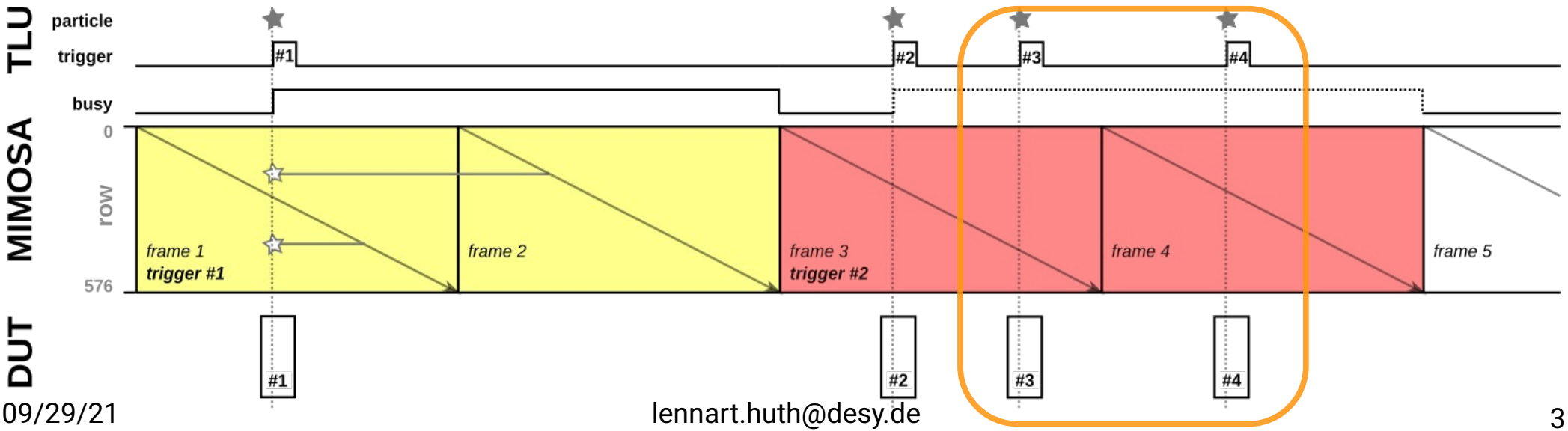
  → Assignments in software

Additional timing to link trigger to track

→ FEI4 plane (25ns ts and trigger)

→ Timepix3 (1.56 ns ts, no trigger)

→ **Any other device? TelePix**



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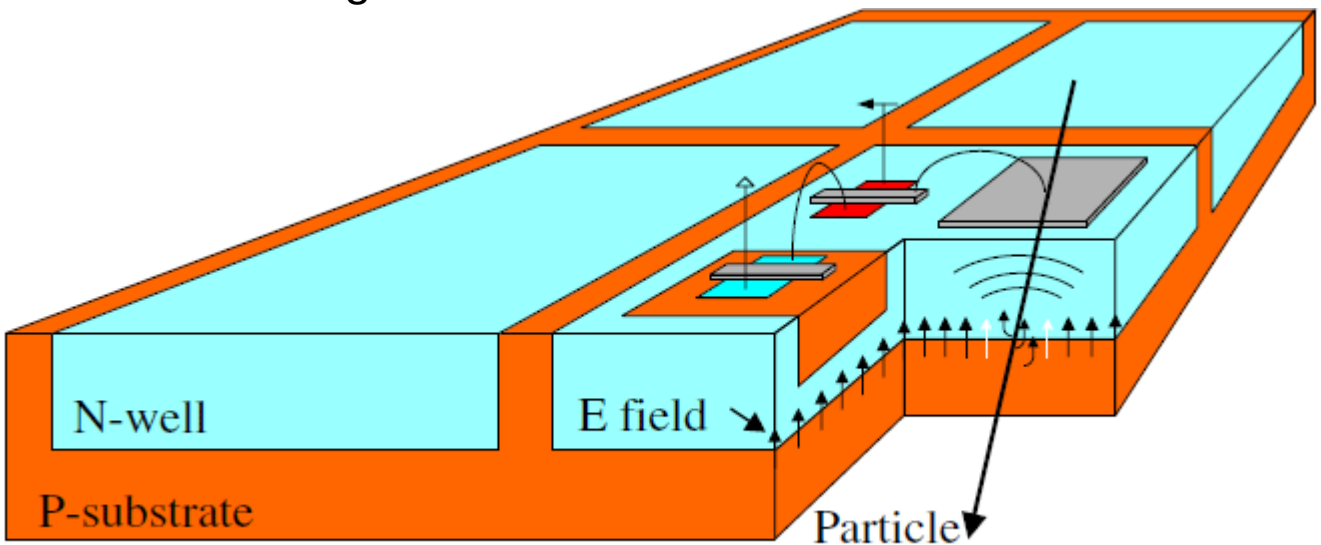
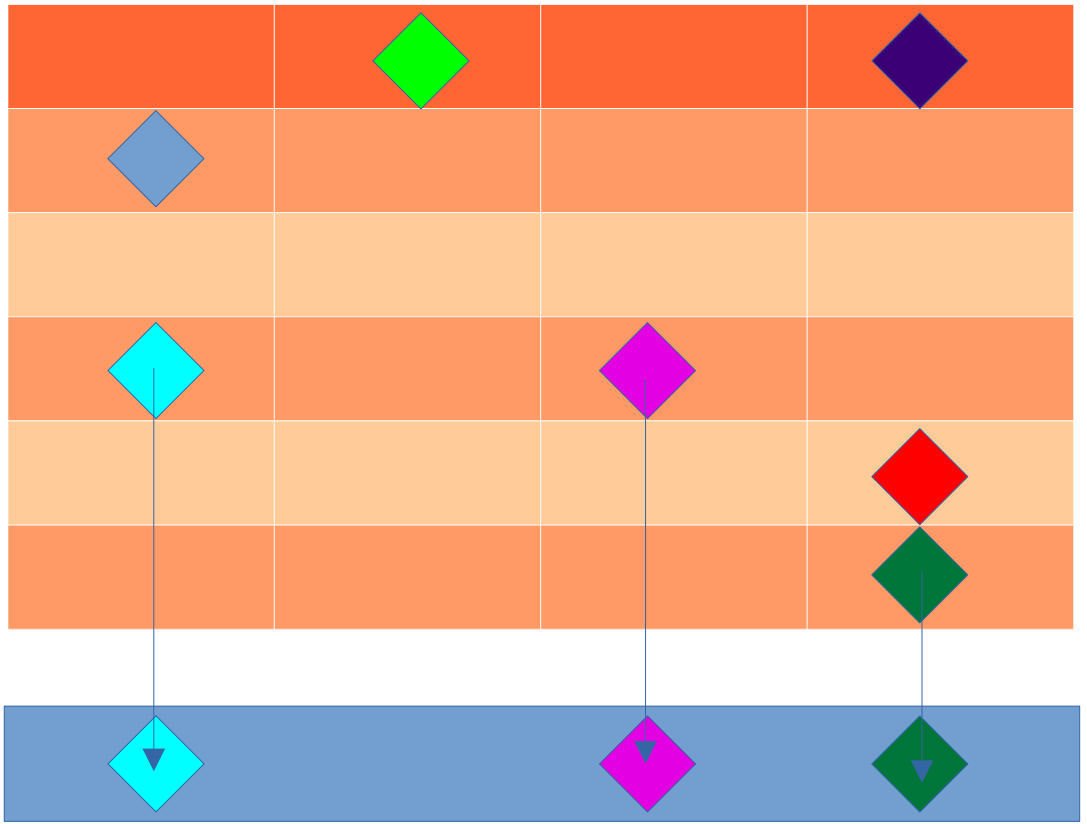
HV-CMOS

- 180nm HV-CMOS process by TSI
- Large fill factor design
  → One deep N-Well as collection electrode
- Rather high capacity → lower SNR
- Short/constant drift length over pixel → less jitter and higher radiation tolerance



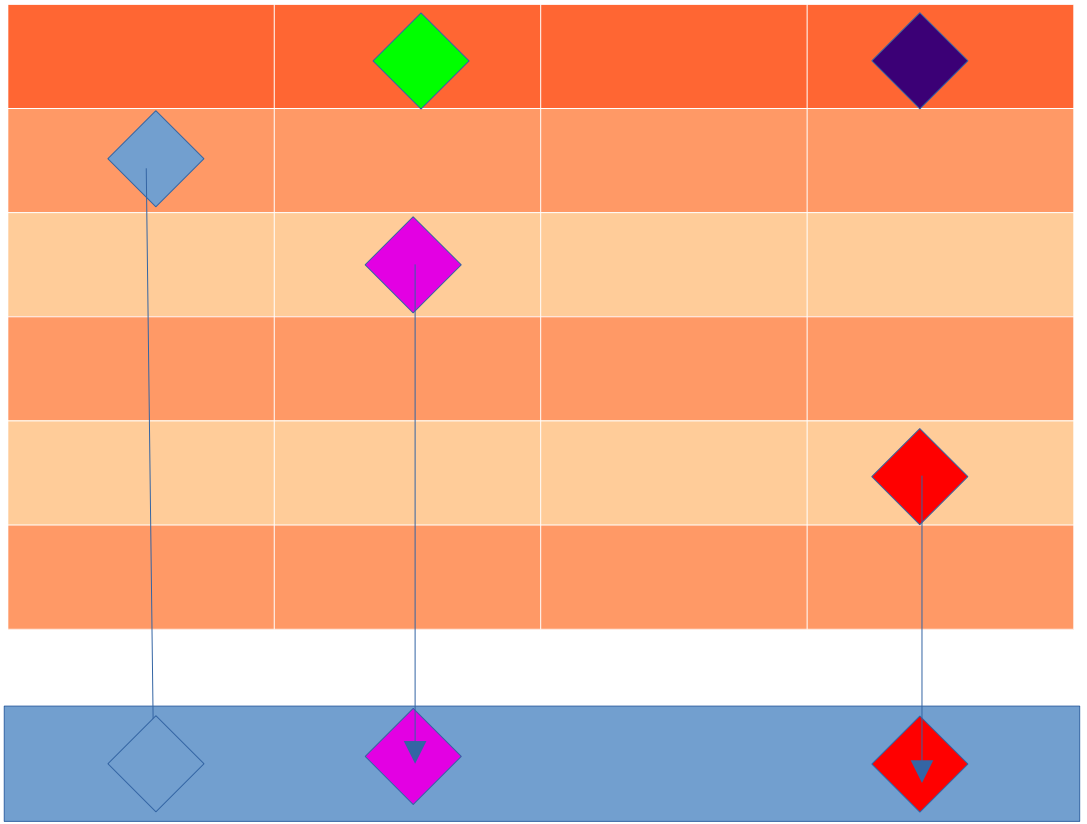
- In-pixel amplifier, discriminator, tune dacs and mask bit
- Digital partner cell for each pixel with
  - ToA measurement (10bit)
  - ToT measurement (6bit)
  - Pixel buffer
- State machine running at typically 125 MHz
- Up to four 1.25GBit/s differential data links
- Custom shift register for configuration
- Essentially everything configurable (30+ parameters)

Readout Scheme



- Column drain architecture without priority encoding
- One hit per column per readout cycle
- 24 bit counter of state machine in each frame

Readout Scheme



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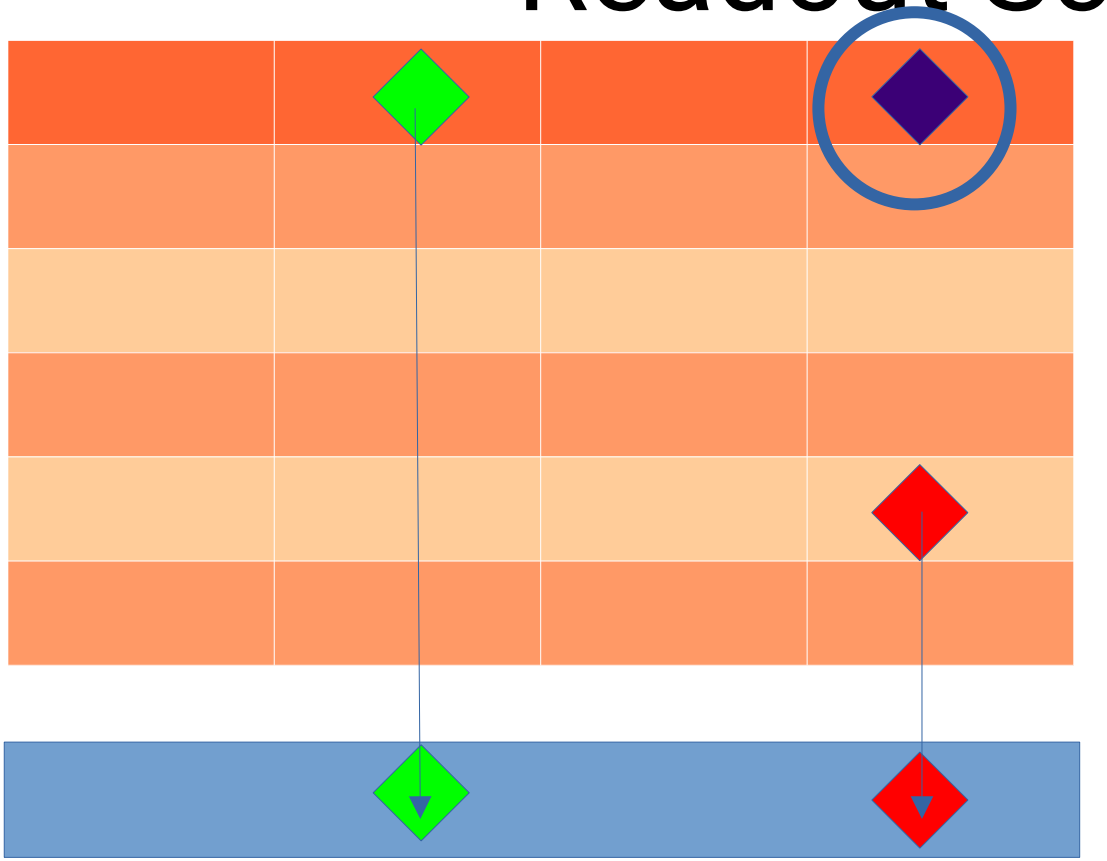
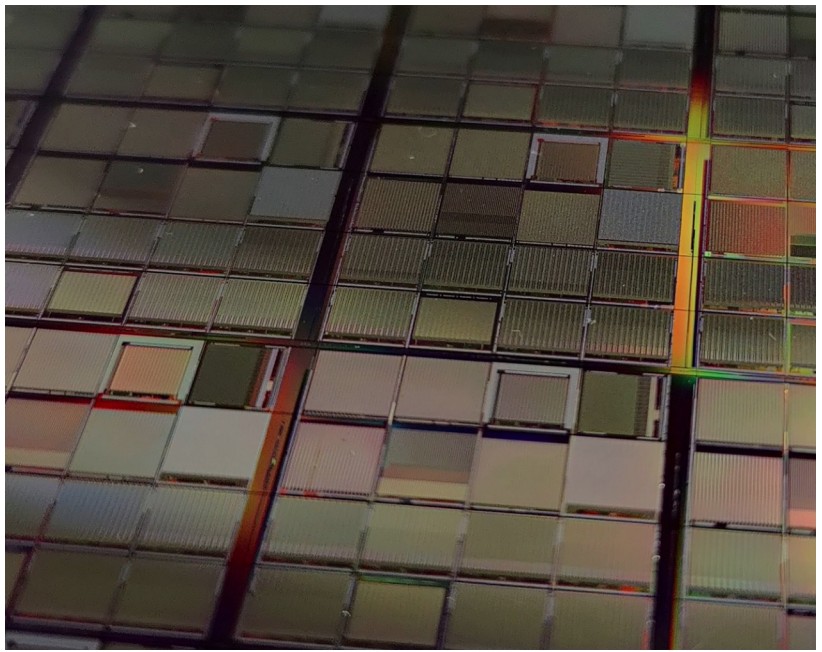
Readout Scheme



- Column drain architecture without priority encoding
- One hit per column per readout cycle
- 24 bit counter of state machine in each frame
- Since always the lowest hit is read out, the hit stream is not time sorted (purple hit)
- If the red pixel is noisy – no pixels above are read out

TelePix I – Demonstrator Chip



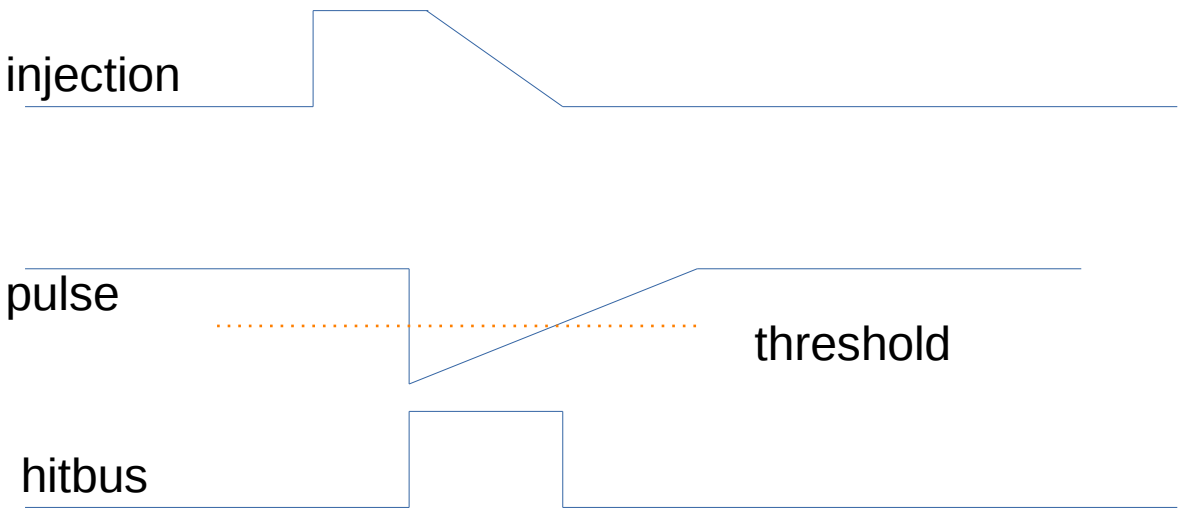
- 25um x 165um pixels
- 2 global thresholds for p/n mos amp parts
- 29x125 pixel
- 2x 10 bit TS sampled on falling and rising edge of clk
- Link speed 10x ts clk
- Column fast digital hit or for triggering
- Masking a pixel in hit or column disables trigger (feature to be fixed)
- Based on knowledge/expertise from large number of previous submissions

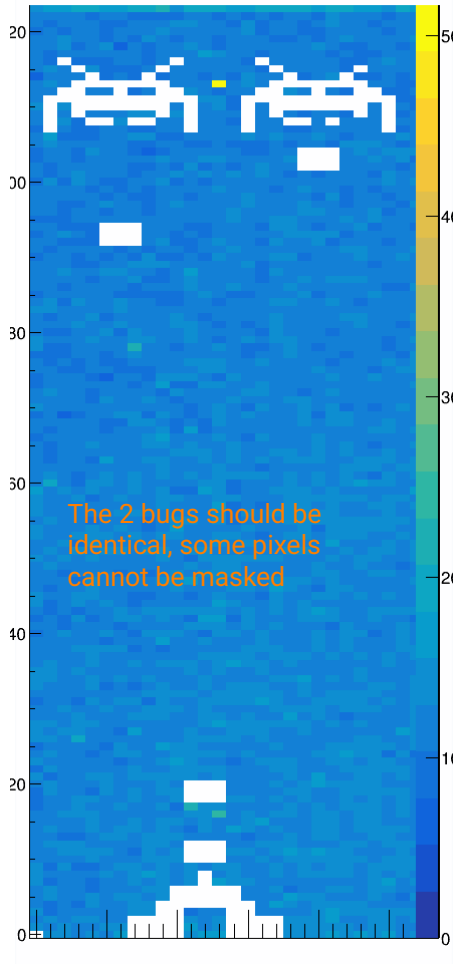
Laboratory Studies

Setup and Pixel Masking

Minimal lab setup:

→ Sensor on PCB
→ RO-PC
→ Oscilloscope to record waveforms
→ Efficiency measurement: #hitbus / #injections





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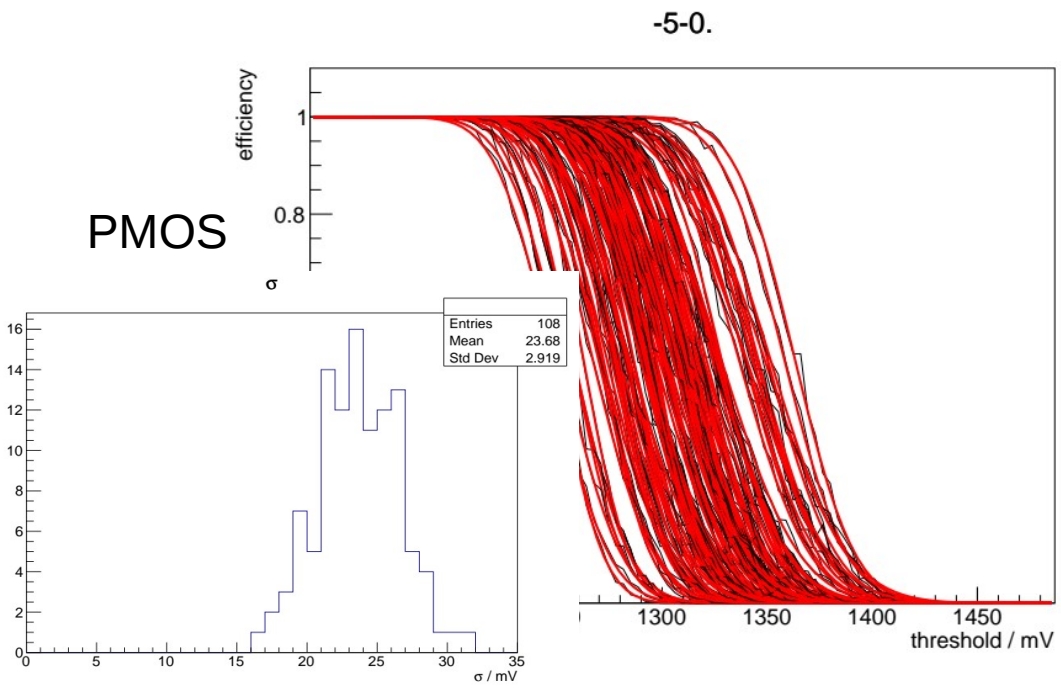
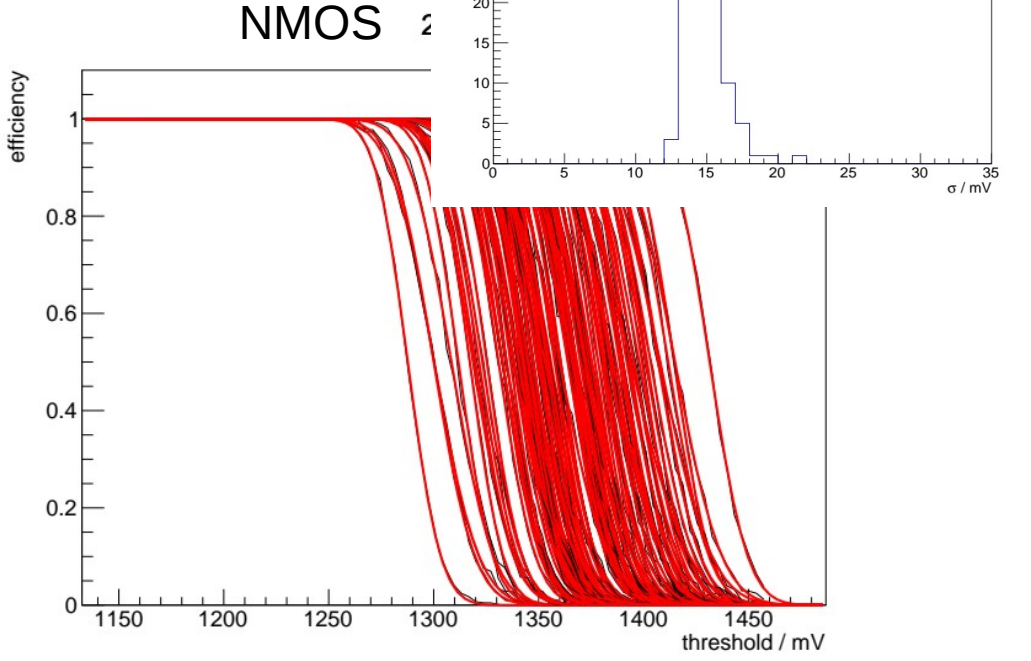
Injection scan 0.8V & 100ns

NMOS amplifier outperforms the PMOS. Higher signal, less noise

PMOS



NMOS



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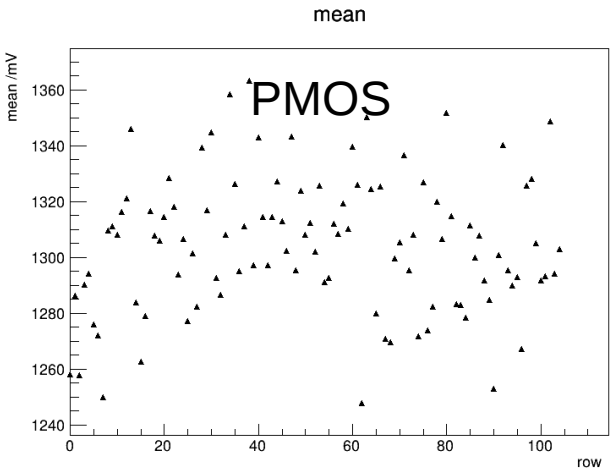
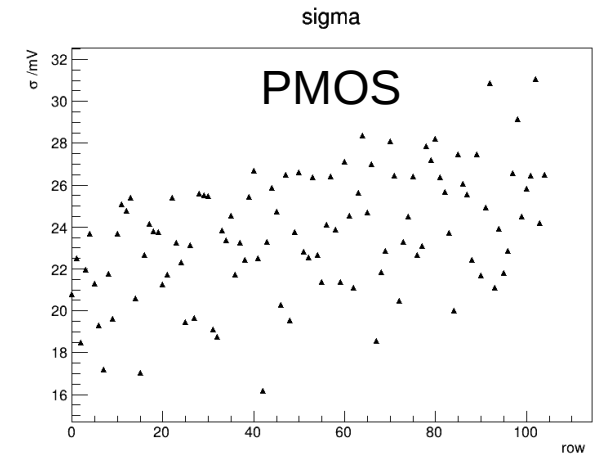
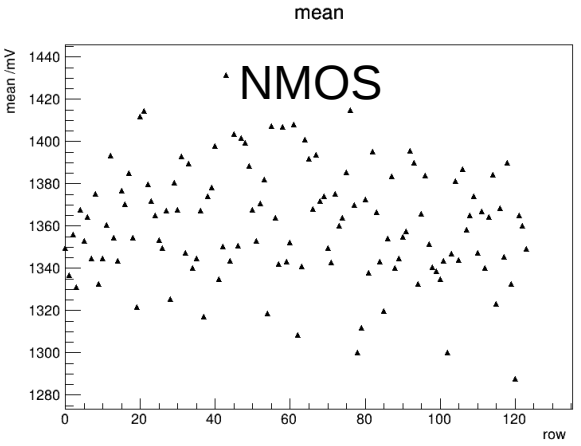
Projection of Injection Scans

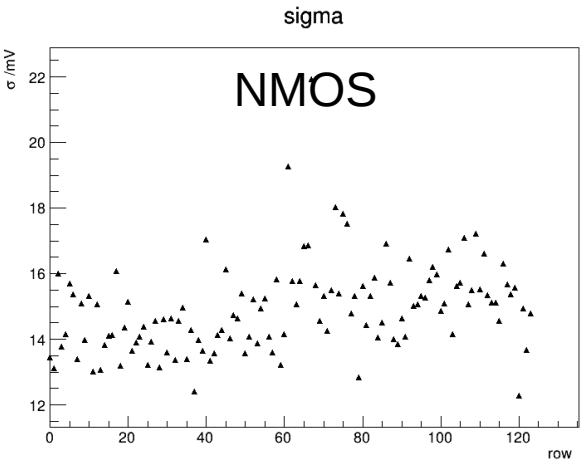




Only small effects along the row address, rather large pixel to pixel fluctuations

Hard to judge if this is the injection itself or the pixel





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Testbeam Results

All results are preliminary

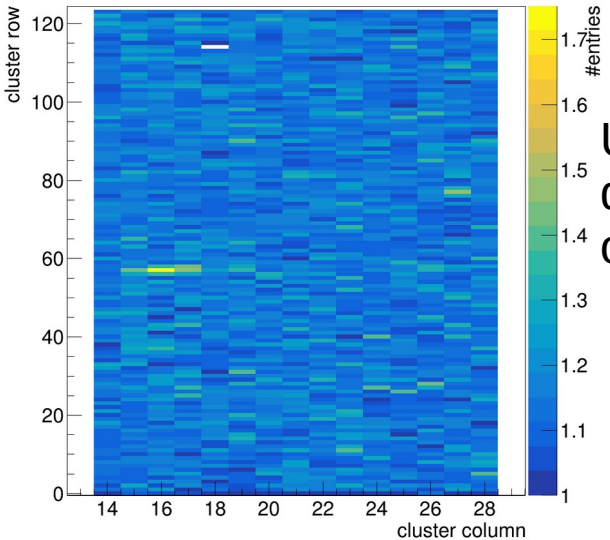
Testbeam Setup/Analysis Flow

- Reference Telescope
- Coincidence of two scintillators
- AIDA TLU
- TelePix operating in AIDA mode
  → 125MHz reference clock from TLU
  → T_0 signal to reset counters
  → Trigger signals sampled with 500 MHz
- LVDS receivers have some issues, chip core clock set to be 120MHz

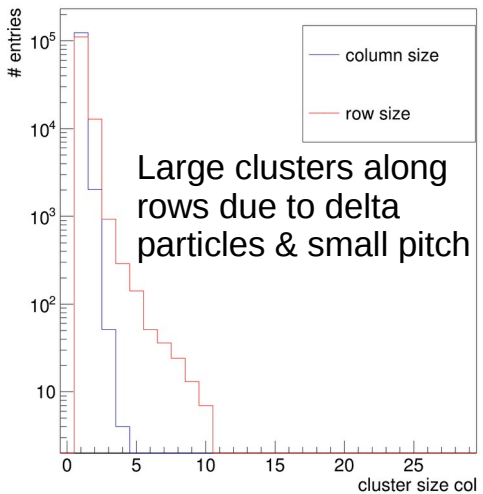
Analysis based on corryvreckan

- Chi2/ndof max 5
- Time cut covers the full frame
- Maximum of one track per frame

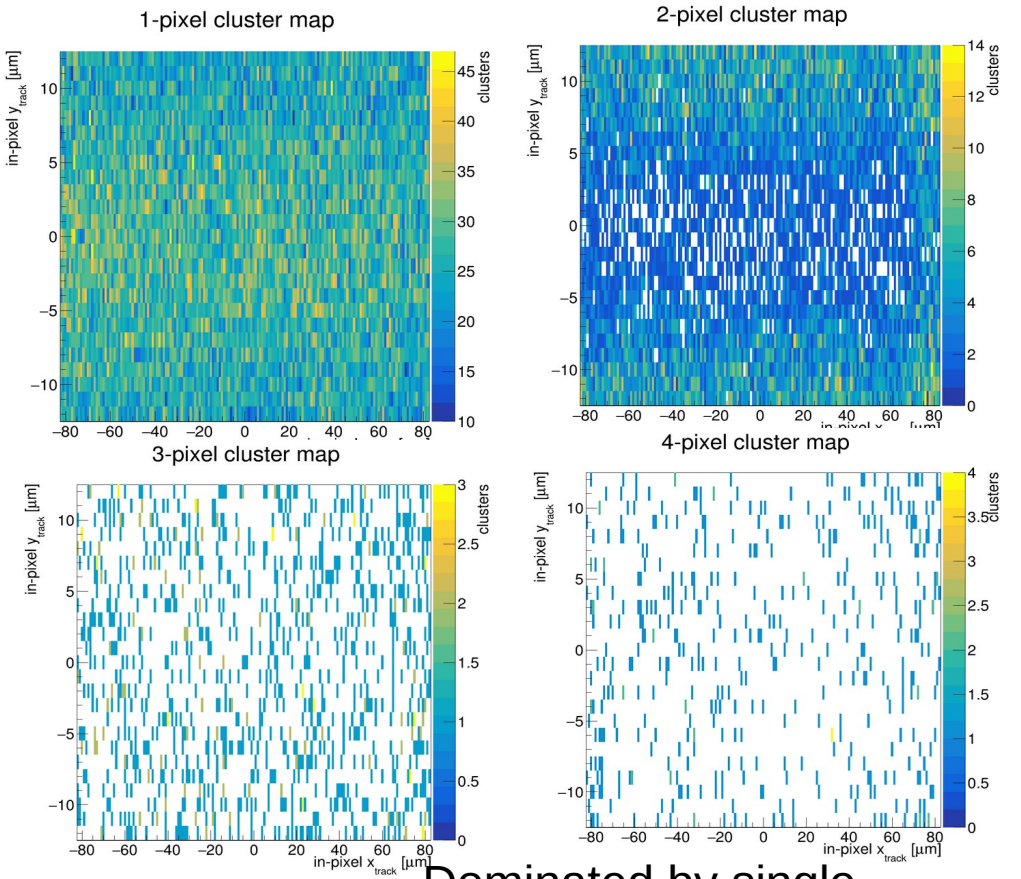
Cluster size studies



Uniform distribution on chip



Large clusters along rows due to delta particles & small pitch



Dominated by single cluster
Few 3,4 hit clusters

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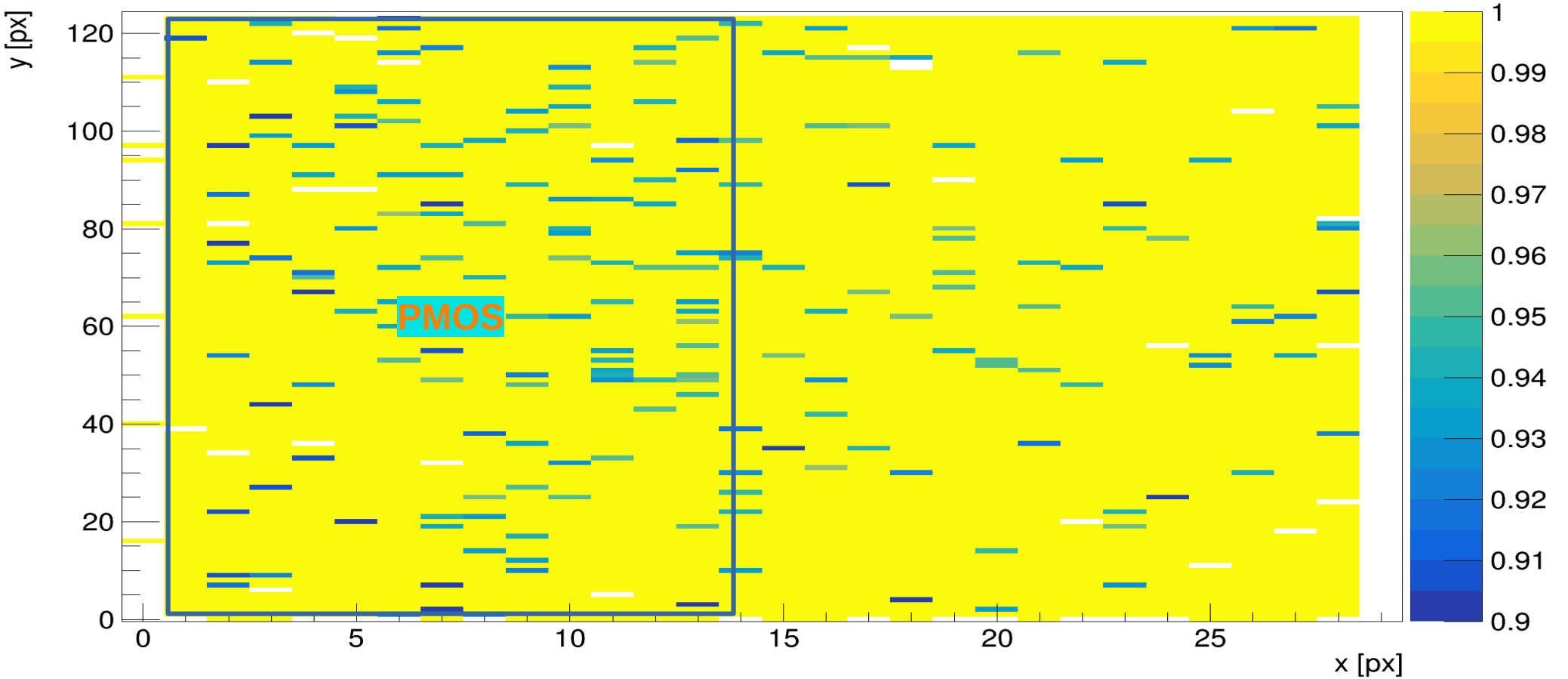
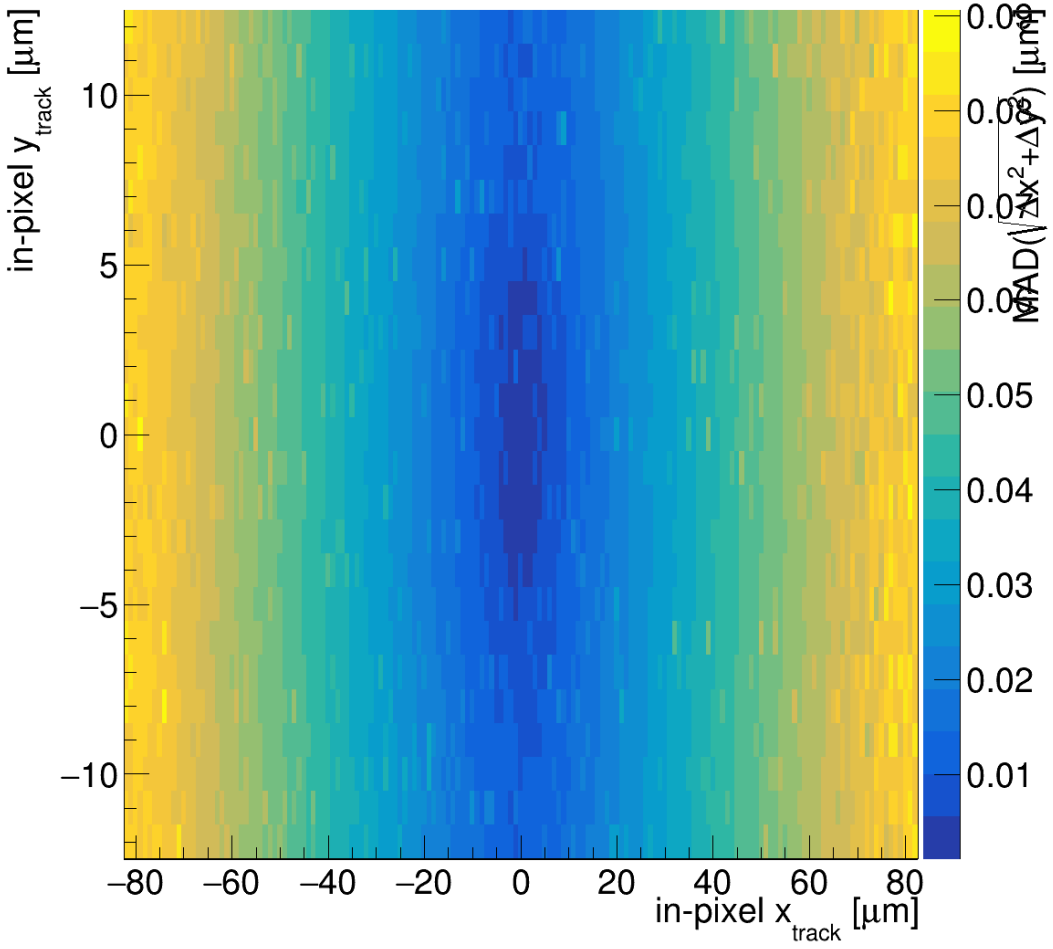
Efficiency

99.5% overall



Resolution

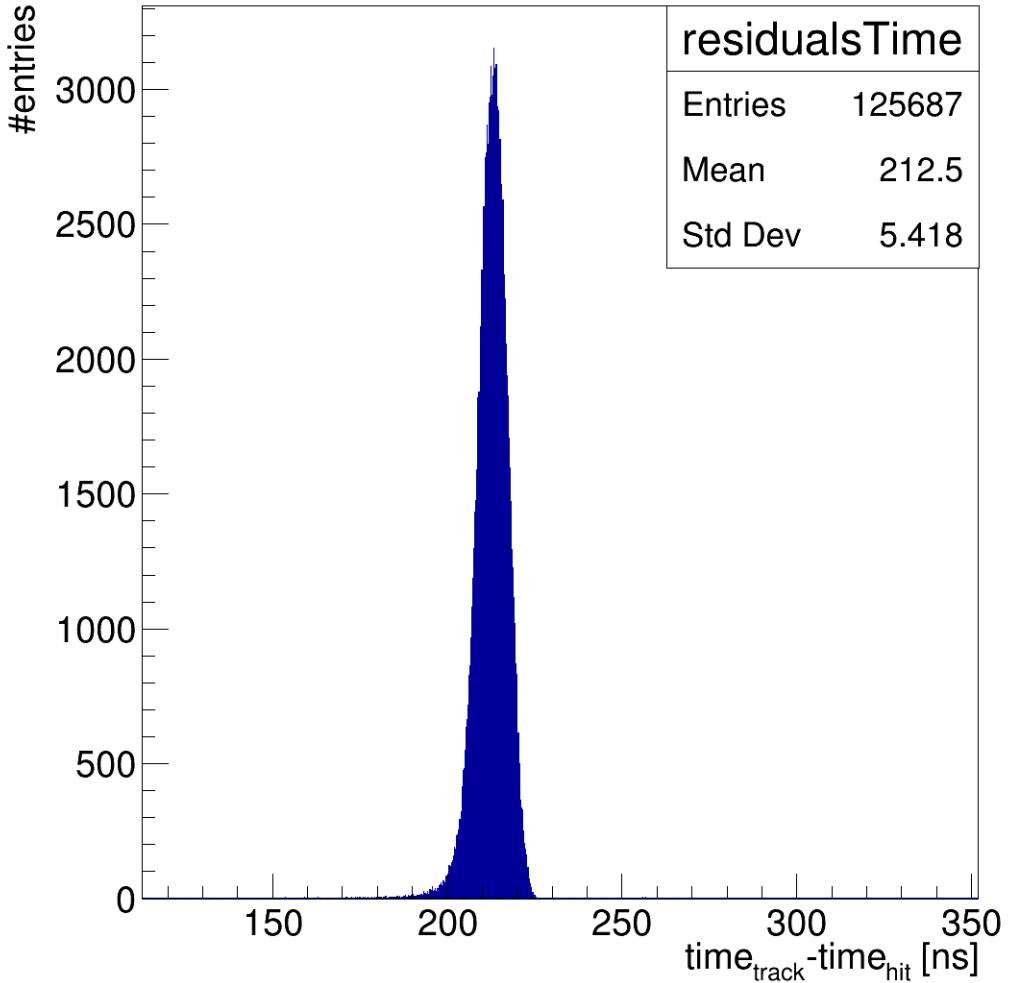


Resolution along x/y significantly different due to pixel size

Y: 165um pitch and **47.0um** resolution
X: 025um pitch and **09.5um** resolution

Resolution along x is below expectation of <7.2um. Likely due to telescope pointing resolution – needs to be verified

Timing



N-Mos part only, 8.3ns ts binning

Time walk correction still missing

Gaussian fit to core leads to 4.8ns

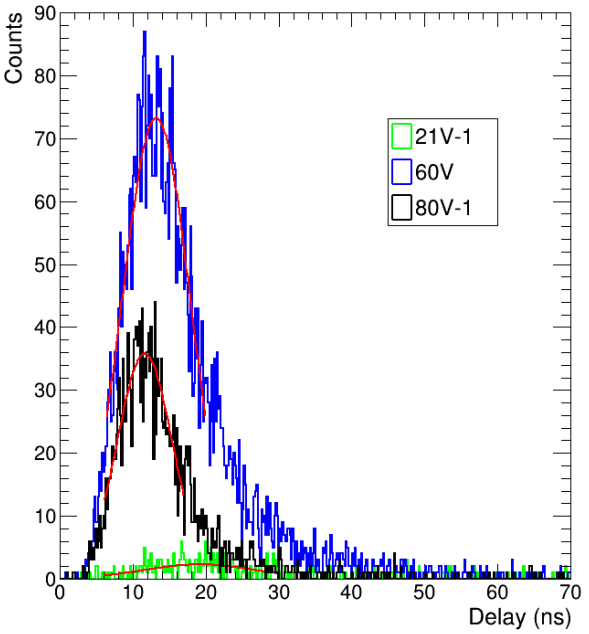
PMOS part: Seems to be a bit faster

HB Timing

- Most relevant measurement for us
- Delay/Jitter between hitbus and trigger scintillators, measured with oscilloscope
- Only one column activated, no pixels masked and a rather high threshold
- For a bias of 80V, resolutions below 5ns measured, with significant influence of reference jitter

  → Fulfilling requirements
- Delay is also rather low (slight cable length difference, need to add ca 10ns)

Plots from Adriana



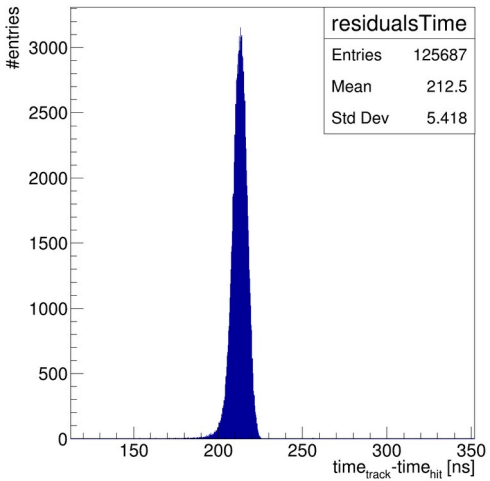
Spectrum	Mean (ns)	Mean Er (ns)	Sigma (ns)	Sigma Er (ns)
21V-1	18.04	0.59	6.56	0.65
60V	13.17	0.10	4.69	0.13
80V-1	11.55	0.13	3.81	0.17

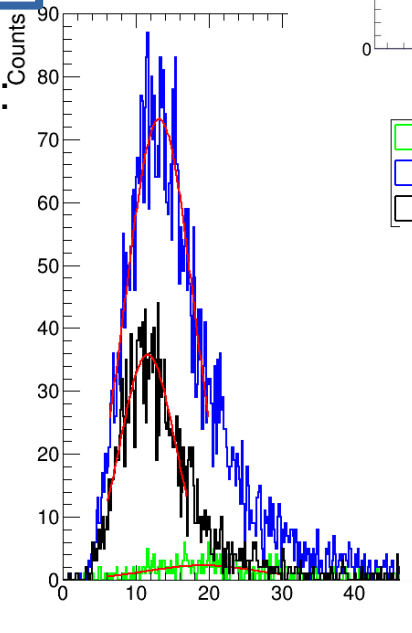
Summary/Outlook

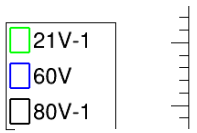
- Efficiency 99.5%+
- Time resolution <5ns, timewalk correction missing
- Masking functional
- Fast hit or functional

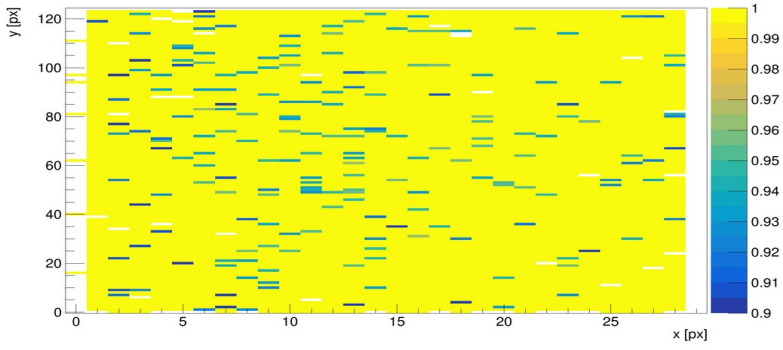
Upcoming submission this year:

- 1x2cm
- Bonded from one side only
- Full ROI selection
- Masking not interfering with hit or









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