TelePix

A fast region of interest trigger and timing layer for the EUDET Telescopes

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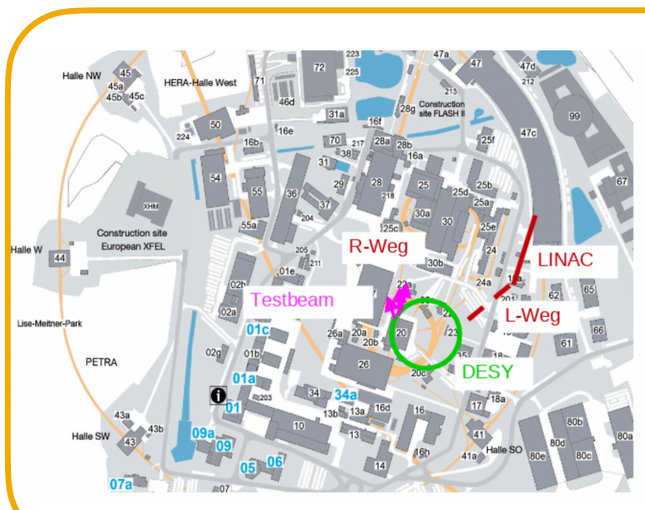
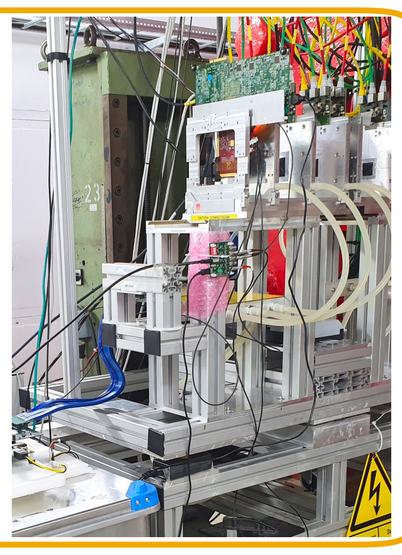
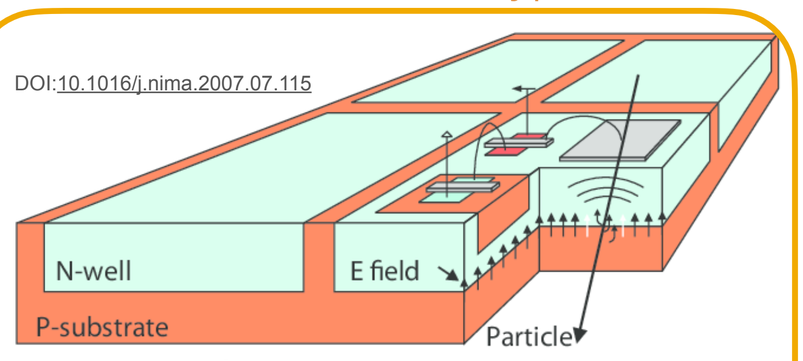


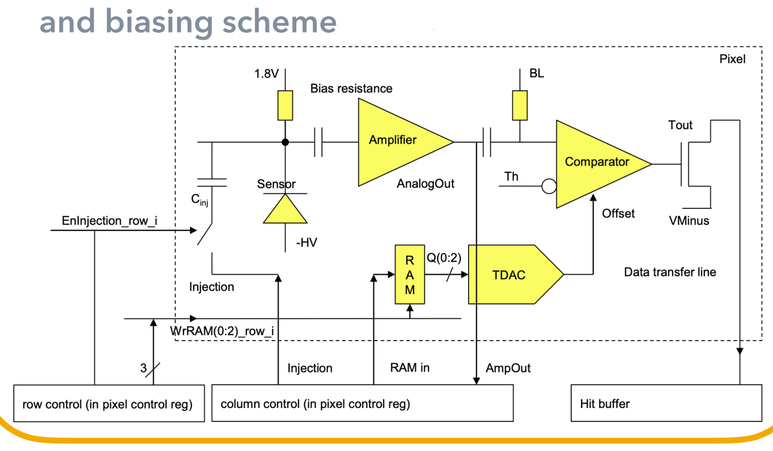
Test beams are essential for detector R&D to test developments as close as possible to a final experiment. Tracking telescopes are used as a reference system in time and space to pinpoint a particle's trajectory enabling studies on devices under test. The DESY II test beam [0] areas provide multiple 10 kHz particle rate and are equipped with three EUDET-style telescopes [1], based on MIMOSA26 sensors [2]. They provide excellent spatial resolution, but up to 230 µs integration time, leading to events with multiple track per trigger. These ambiguities can be resolved with a trigger and timing layer. An HV-MAPS based layer with region of interest trigger with <50 ns delay and a jitter < 5 ns is proposed, studied and qualified for the usage at the DESY II test beam.



TelePix HV-MAPS Prototype

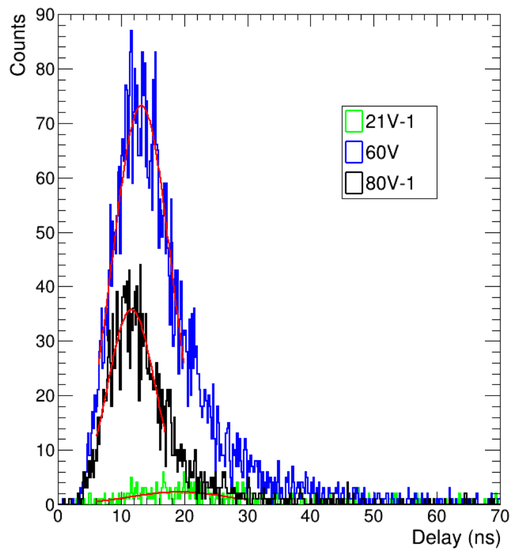


- 29x124 pixel with 165x25µm pitch, bias < -85V
- Based on previous developments [3]
- 180nm TSI HV-CMOS process
- Digital partner cell in periphery
- Timestamps with 4 ns precision and ToT
- Pixel masking/3bit threshold trimming
- Zero suppressed data driven readout
- Fast digital hit OR output for triggering
- In pixel amplifier (4 flavours) +comparator
- 4 Chips: Run2020 with P/N MOS amplifier and Run2021 with improved N-MOS/CMOS amplifier and biasing scheme



Region of Interest Trigger

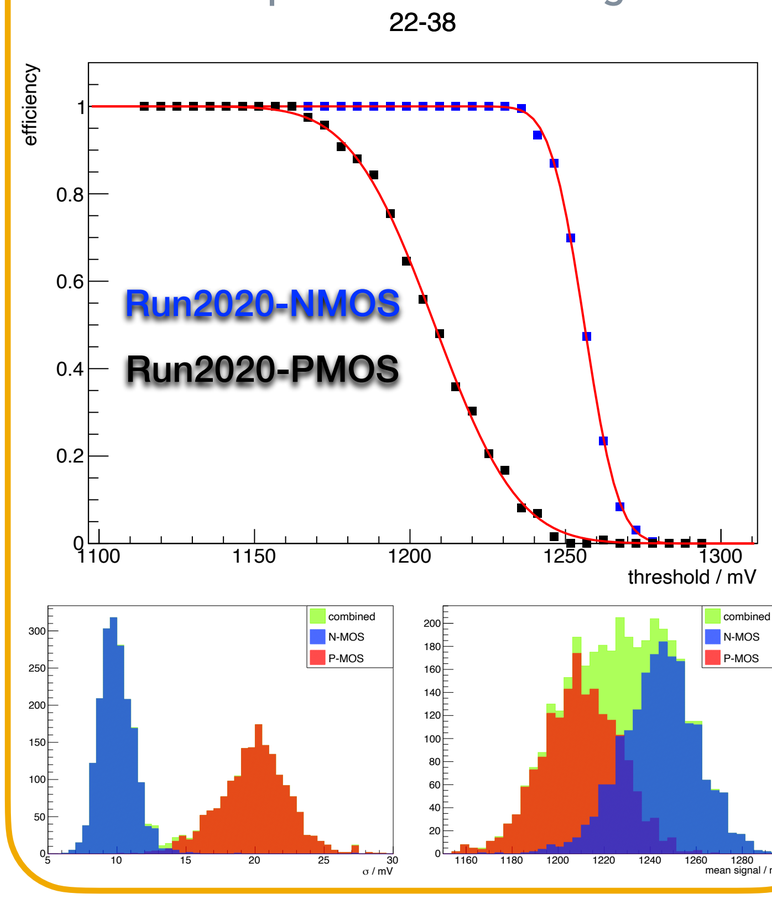
- Measured response of the fast hit OR for a full column of Run2020 NMOS
- 4 GeV electrons as MIP signal source
- Delay/ Jitter with respect to trigger scintillator for three bias voltages
- Reaching an absolute delay of below 22 ns and a jitter below 3.8 ns at thresholds without fake hits



BIAS / V	DELAY / NS	JITTER / NS
21	28+/-0.6	6.56+/-0.65
60	23.2+/-0.1	4.69+/-0.13
80	21.55+/-0.2	3.81+/-0.17

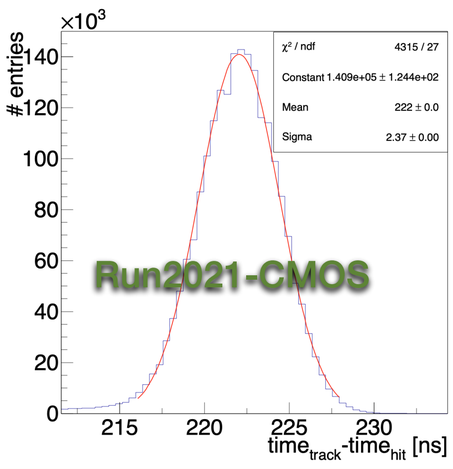
Injection based analog characterisation

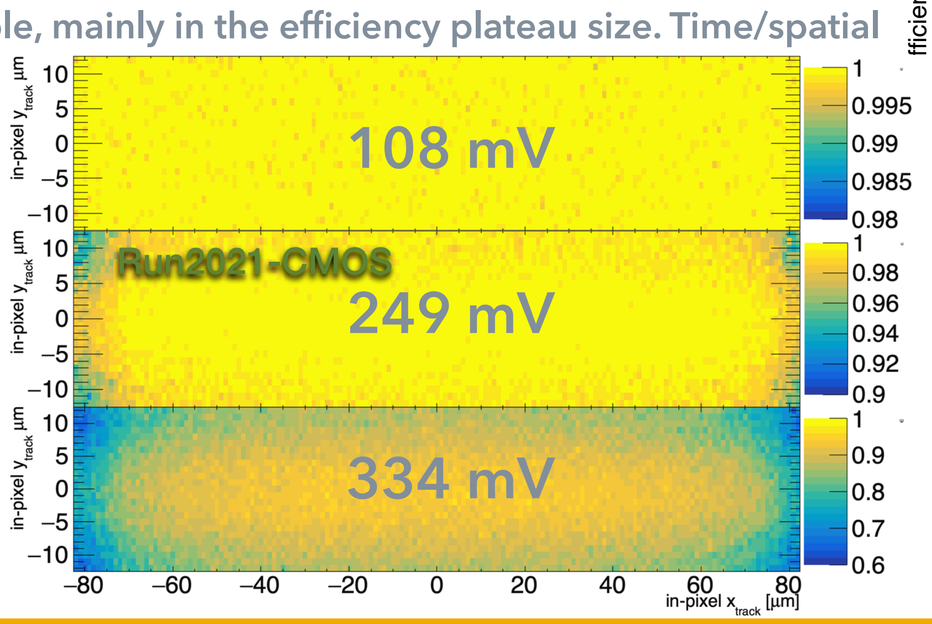
- Injecting fixed charge (400mV/8µs) into pixel cell
- Testing response on oscilloscope for different thresholds
- Extracting *s-curve* to determine average signal and noise
- Superior performance of Run2020-NMOS amplifier at used settings

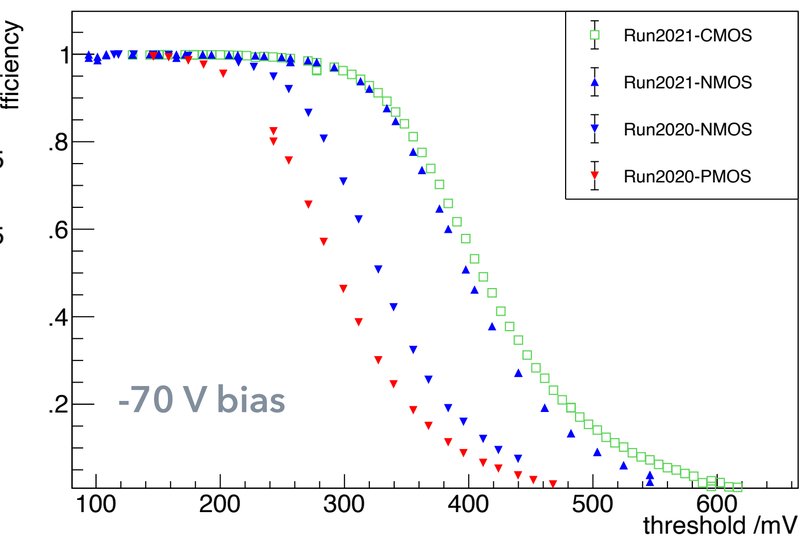


Test Beam Measurements

- Studied with a 4 GeV electron beam at DESY II, data reconstruction with Corryvreckan [4]
- Efficiencies of > 99.9 % at ~ 0.01 Hz noise (~2.5e-10 per bunch crossing at 40MHz)
- Efficiency decreases first in corners due to charge sharing
- Clear difference in the pixel designs visible, mainly in the efficiency plateau size. Time/spatial resolution, cluster size similar
- Time resolution of ~2.4 ns determined







Conclusions and Outlook

The TelePix prototype has shown, that it is capable to fulfil all requirements to serve as a fast timing and ROI trigger plane for the DESY telescopes. Compared to previous sensors, the signal amplitude has greatly improved and wide operational regions with efficiencies above 99 % are observed. In the process unprecedented time resolutions below 3 ns have been determined. A full scale sensor is already submitted, expected back later this year and will be put in user operation in the coming 12 months.

References and Contacts

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[4] D. Dannheim et al Corryvreckan: a modular 4d track reconstruction and analysis software for test beam data. *Journal of Instrumentation*, 16(03):P03008, mar 2021

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