TelePix2

A HV-CMOS sensor for Fast Timing and ROI Triggering

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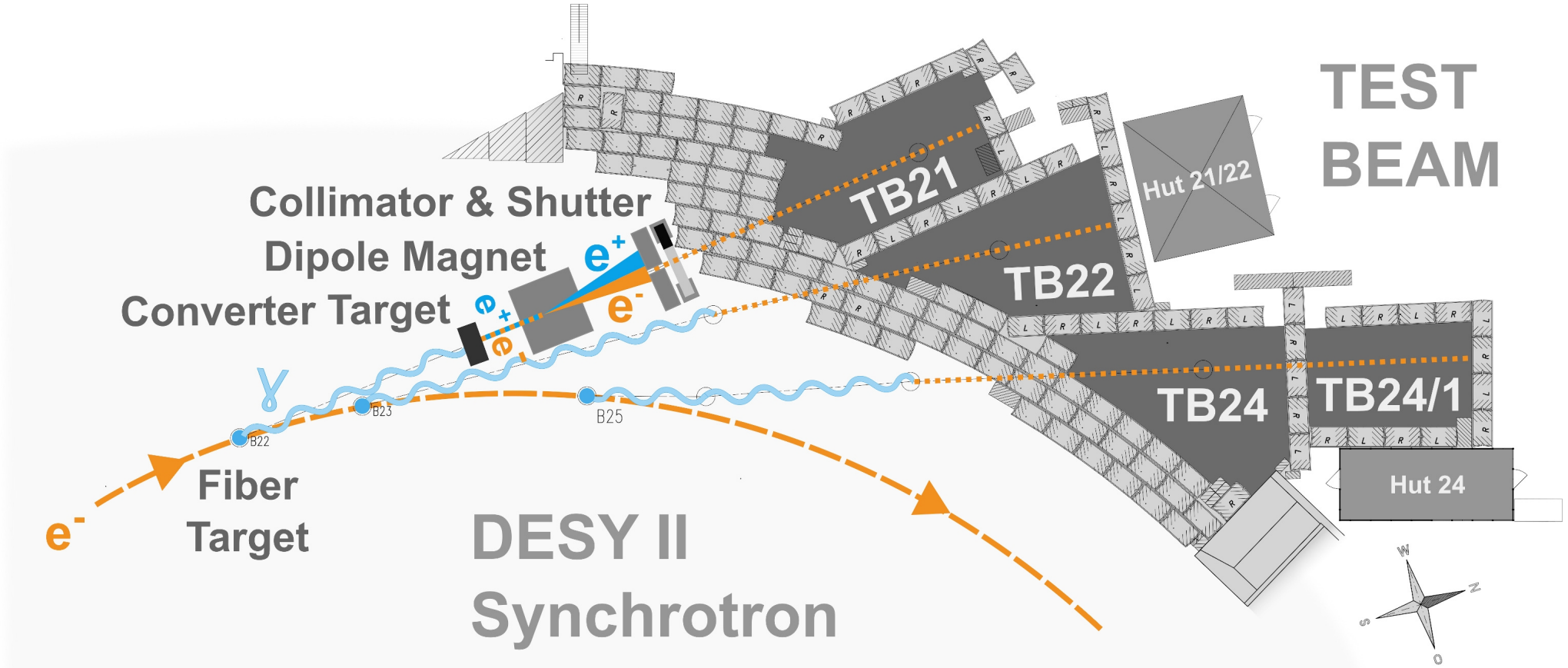
DESY.

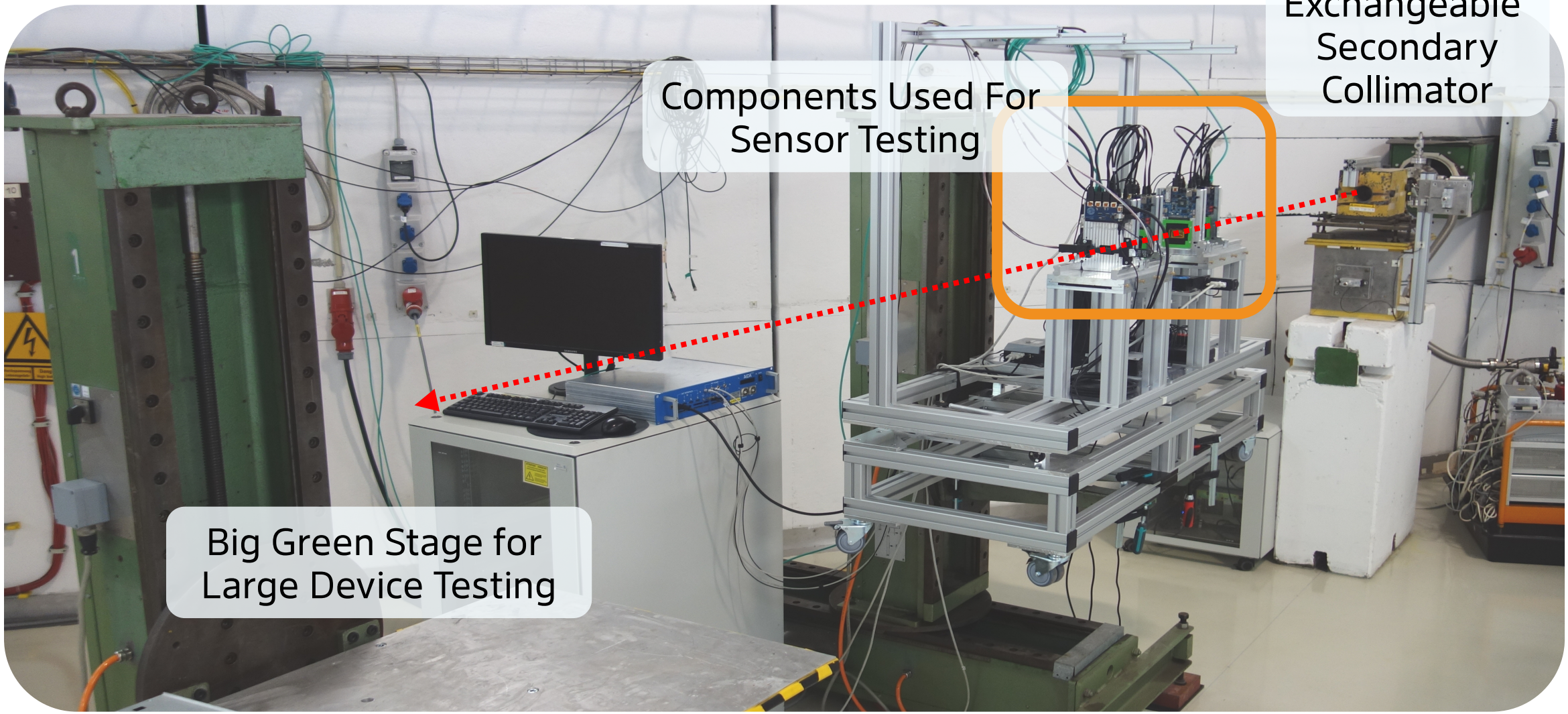
The DESY II Test Beam Facility



→ detector characterisation

→ e^- or e^+ 1-6 GeV/c

Inside the Test Beam Area

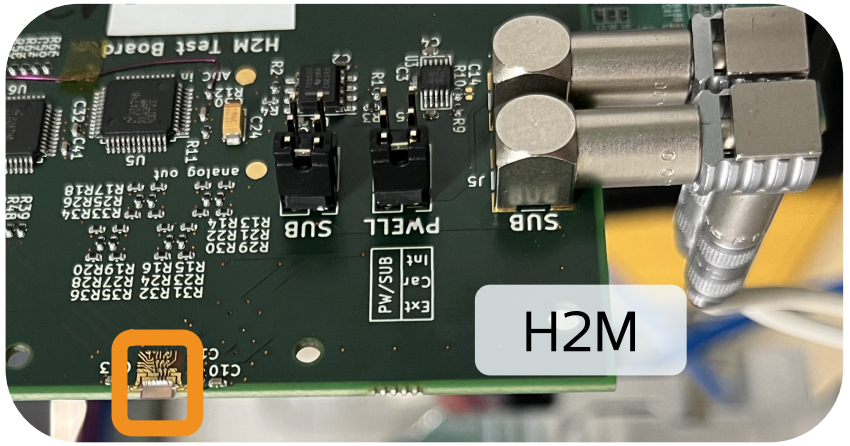


Test Beam Components

Device Under Test

Measurements include efficiency, spatial and timing resolution or calibration

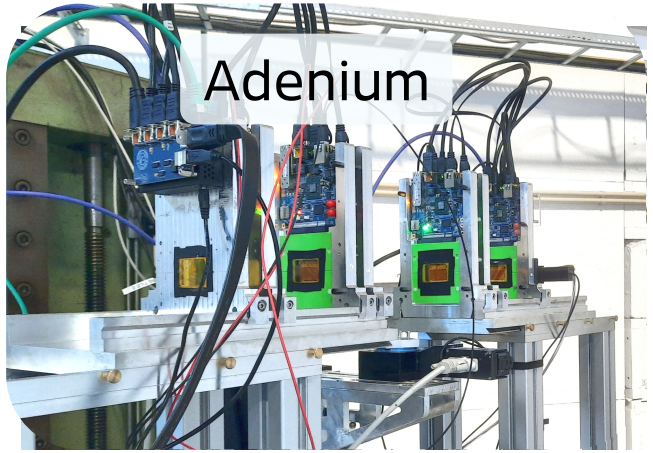
Range of different sizes under test

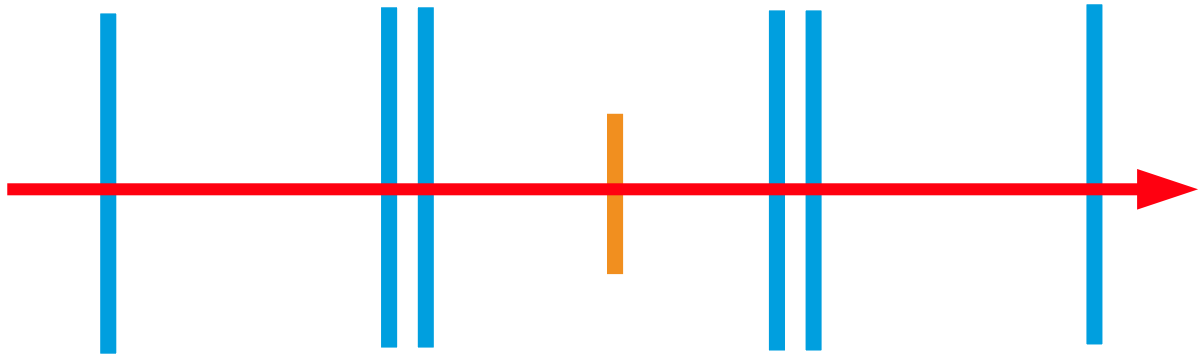


Electron Beam

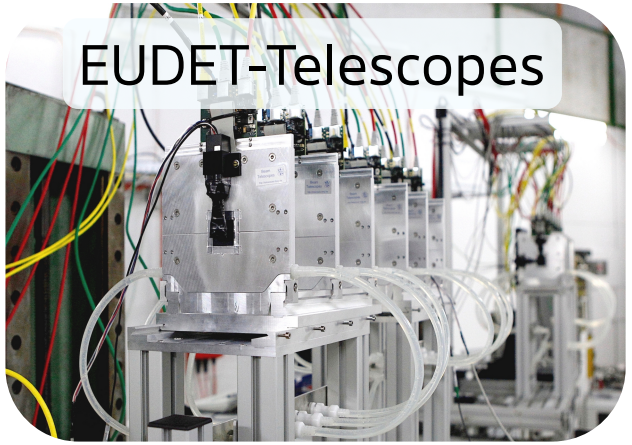
Test Beam Components

Telescope Planes
Multiple sensor planes
Allow precise track reconstruction



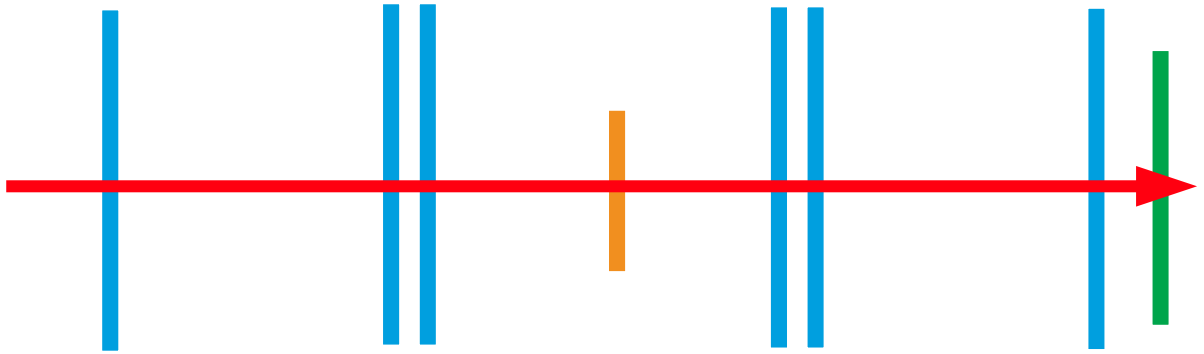


Device Under Test
Electron Beam

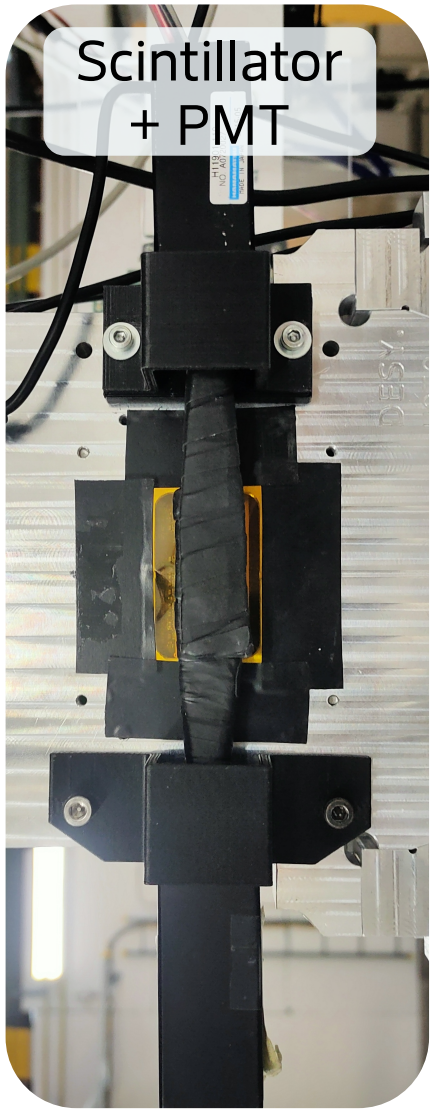


Test Beam Components

Trigger
Tag the presence of particles
Important for event based readout



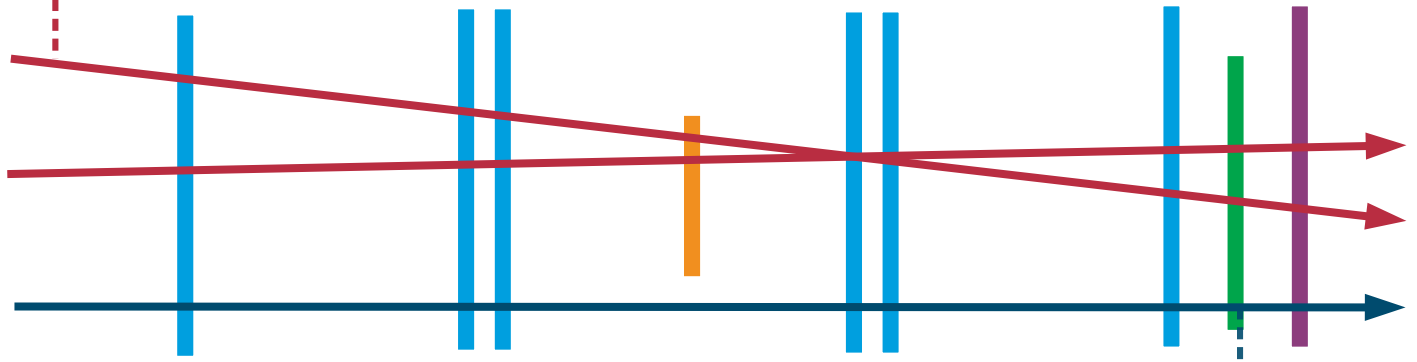
Telescope Planes
Device Under Test
Electron Beam



Timing and ROI Triggering Plane

Multiple electrons within readout frame
→ Timing plane needed

TelePix2
New user infrastructure



Telescope Planes
Device Under Test (DUT)
Trigger

Inefficient data taking
→ Configurable region of interest trigger needed

TelePix2

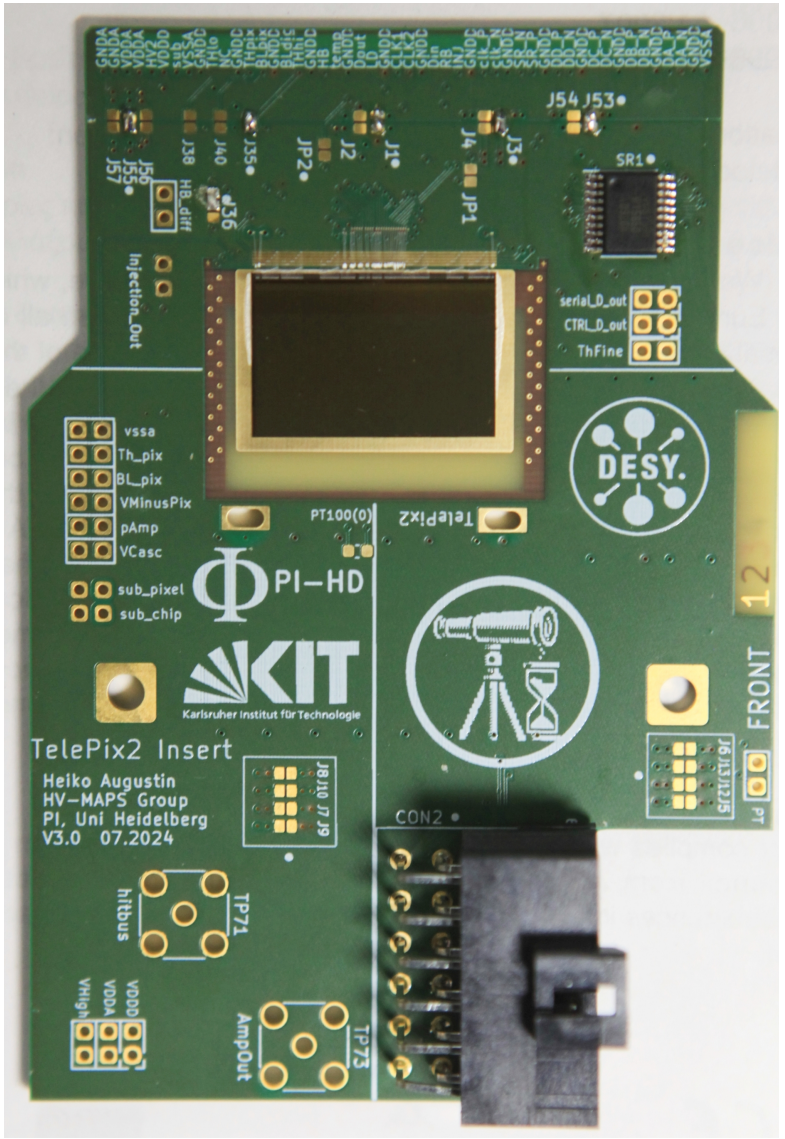
Key Features

- **180 nm HV-CMOS** process of TSI

1) Fast **user-configurable ROI trigger**
2) Hit position with a **4 ns timestamp**

- Pitch: 165 x 25 µm²
- Pixels: 120 x 400
- Active Area: 2 x 1 cm²

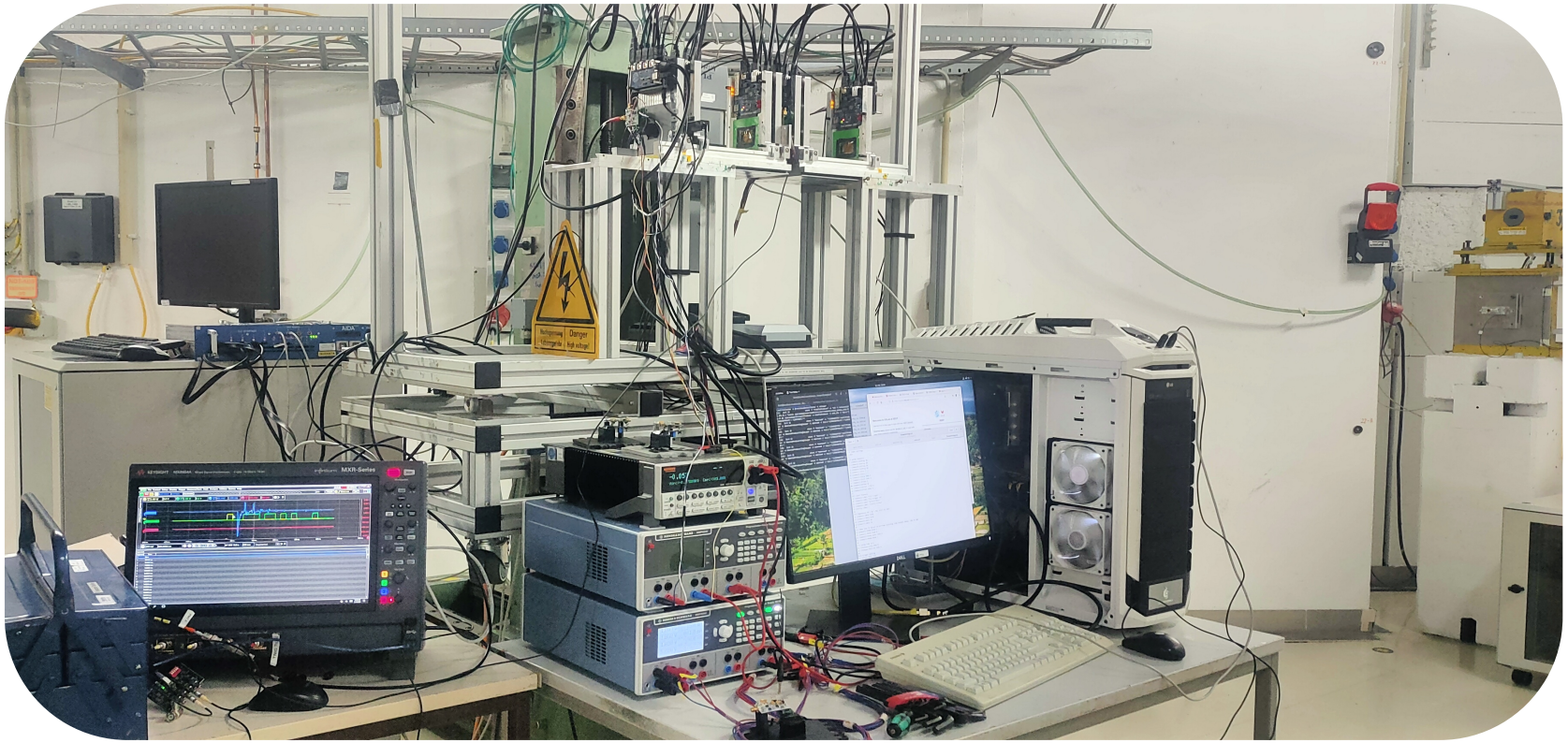
- TelePix2 reference paper on the arxiv



DESY Test Beam Campaign

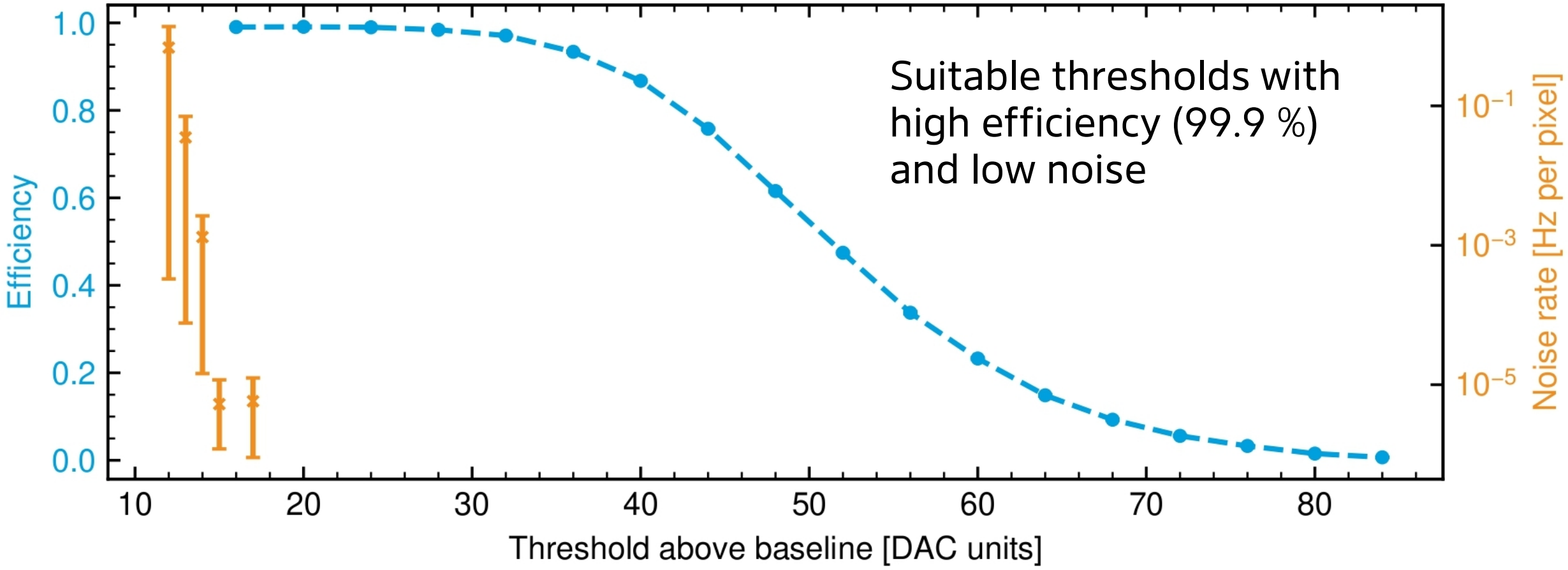
4 GeV electron beam

The TelePix2 sensor had a thickness ~ 740 µm.

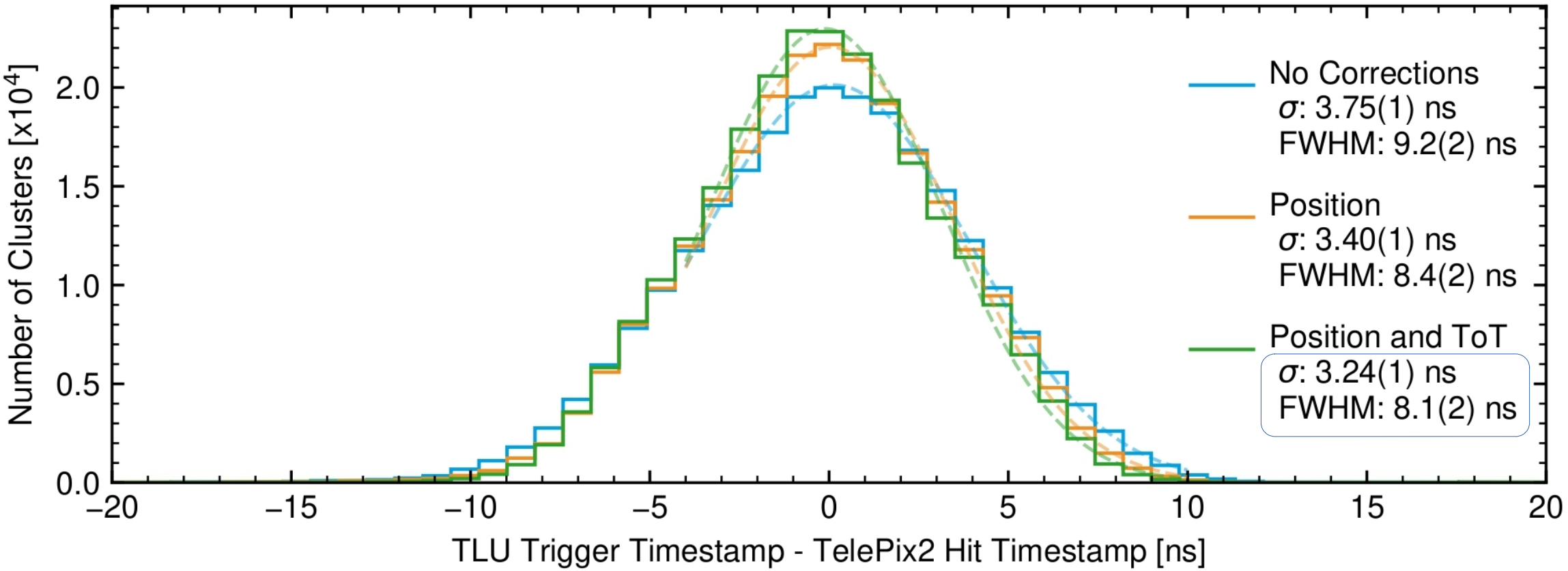


Analysis was carried out using the test beam reconstruction framework Corryvreckan.

Efficiency and Noise (Cooled Operation)



Time Resolution After Corrections

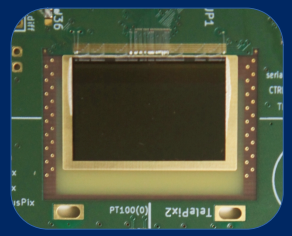


Fast Hit-OR Trigger and Masking Capabilities

TelePix2 Digital Trigger Mask

Pixels Off

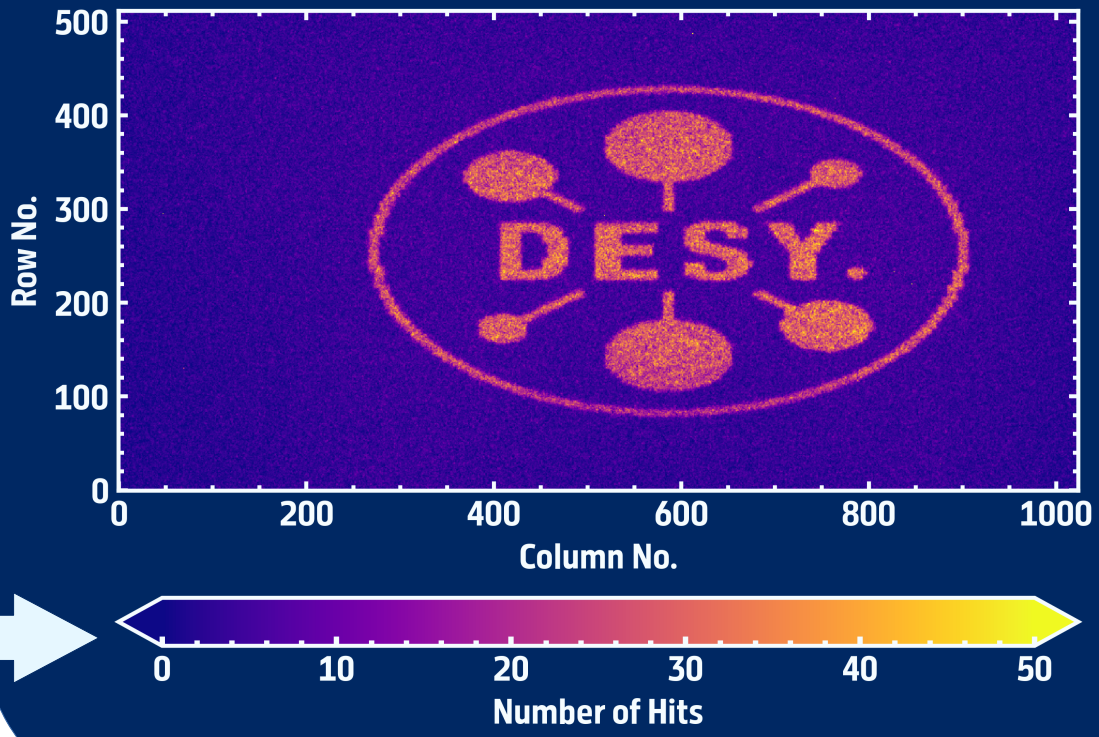
Pixels On



Trigger Signal
(generated on chip then fed externally)

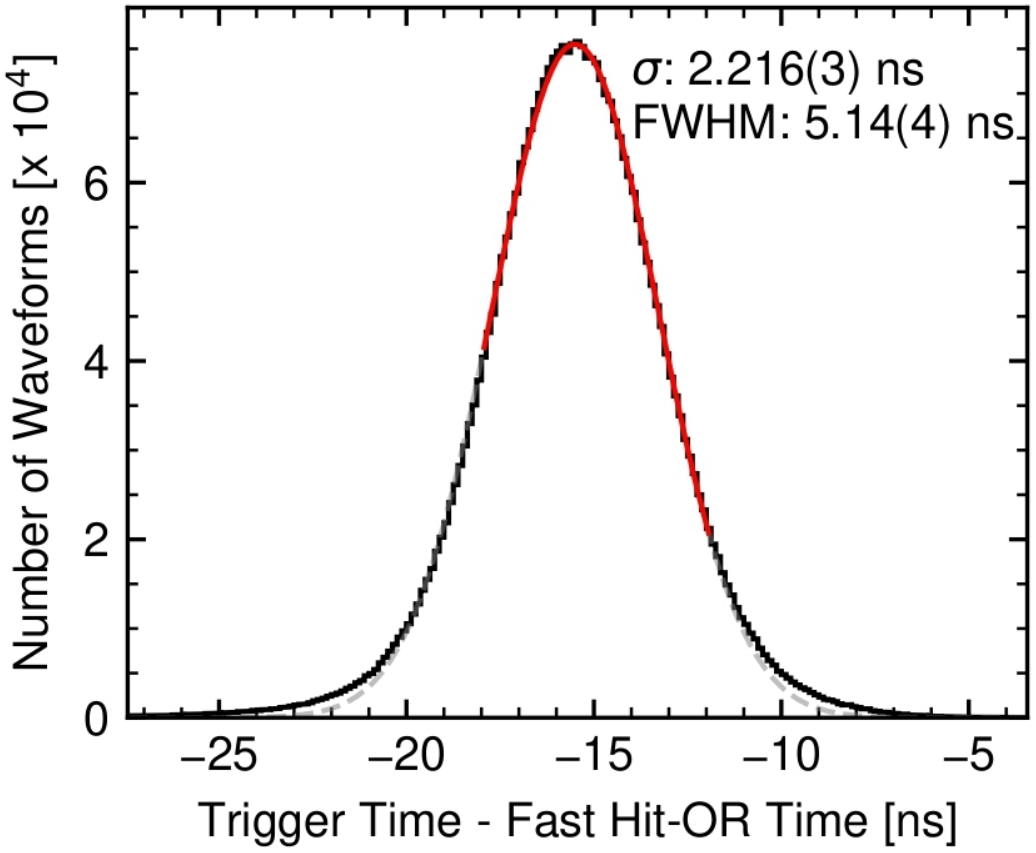
Rise time ~ 20 ns
Voltage ~ 1.4 V

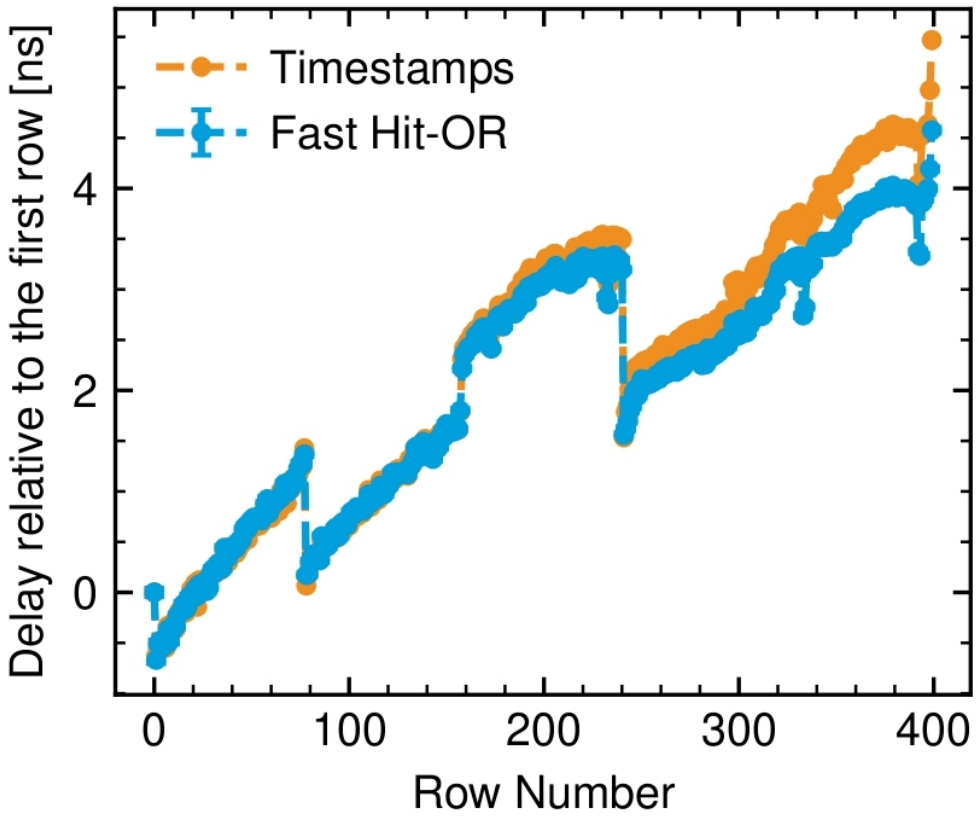
Triggered Telescope Hit Map



Fast Hit-OR Trigger Time Resolution

Timing Performance of the TelePix2 Trigger via Oscilloscope Waveforms



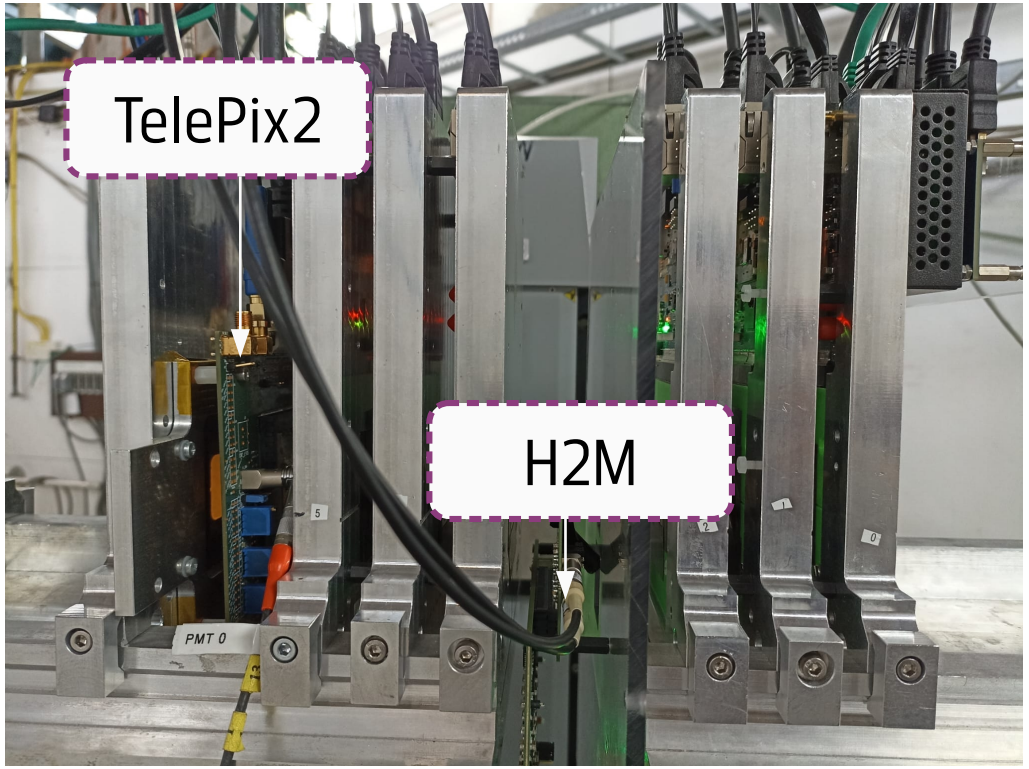


User Operation

New infrastructure at the DESY II Test Beam facility as **both** a ROI triggering and timing plane

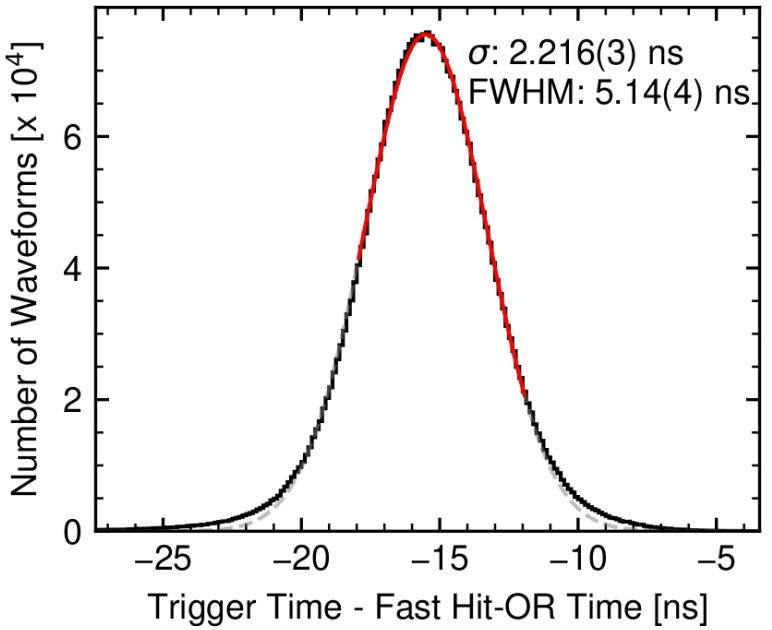
User groups including RD50-MPW4, Atlas-ITK and Tangerine

Existing module within Corryvreckan for easy integration into analysis workflows



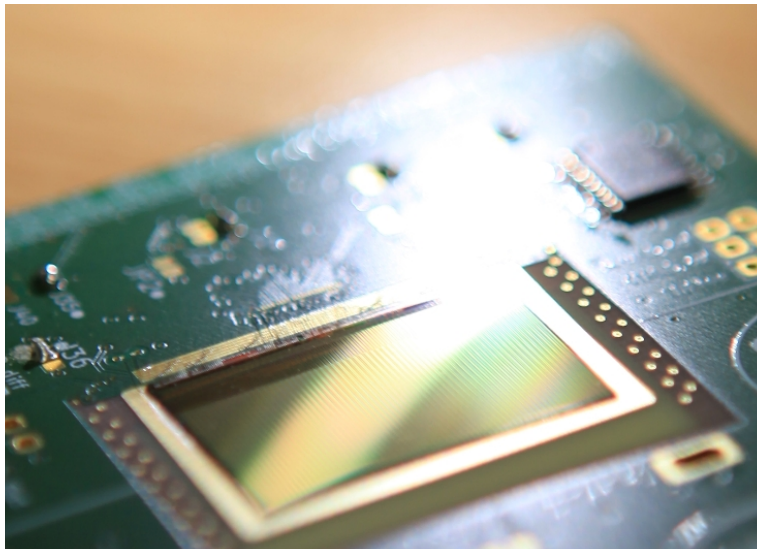
Summary

- TelePix2 developed for the DESY II Test Beam Facility
- Efficiency above 99 %
- Time resolution below 4 ns
- Trigger time resolution below 3 ns



Outlook

- Trimming performance currently being evaluated
- Aiming to equip all beamlines



The measurements leading to these results have been performed at the Test Beam Facility at DESY Hamburg (Germany), a member of the Helmholtz Association (HGF)

Appendix

TelePix2

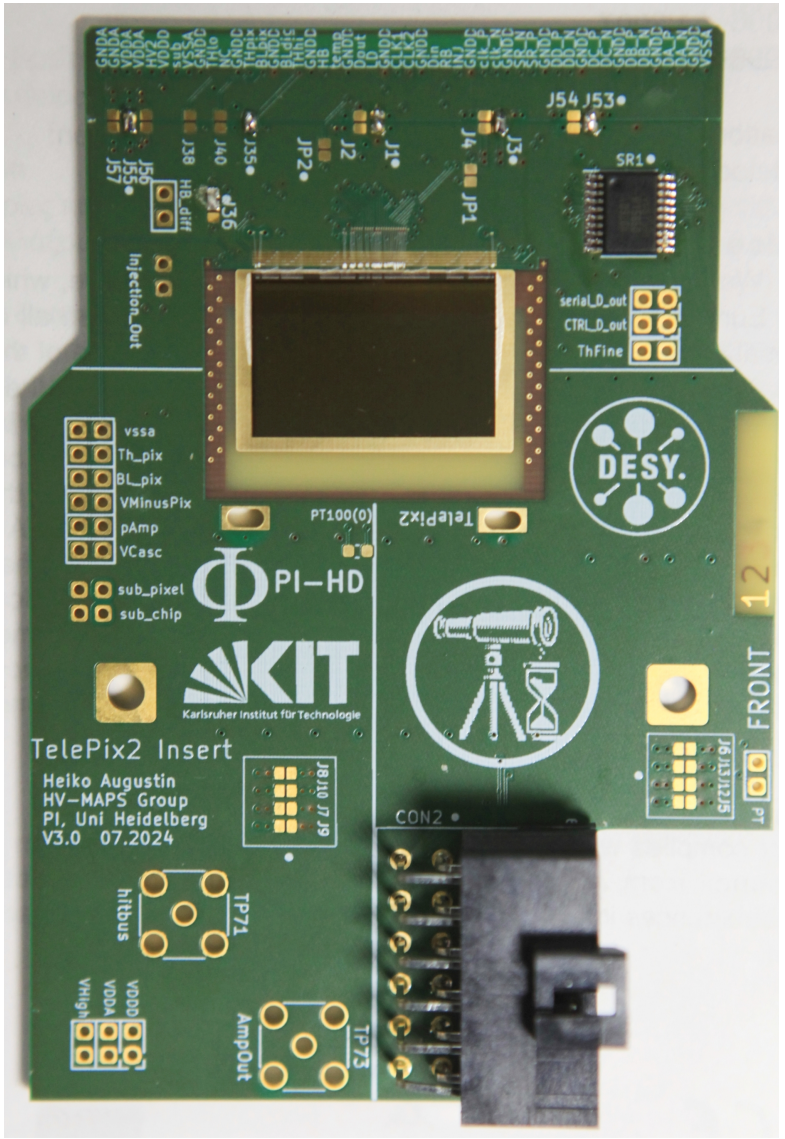
Key Features

- **180 nm HV-CMOS** process of TSI
- Fast **user-configurable ROI trigger**
- **4 ns timestamp**

- A low material budget compared to hybrid sensors
- 3-bit trimming
- Amplifier and comparator within pixel
- Self-triggered readout with zero suppression

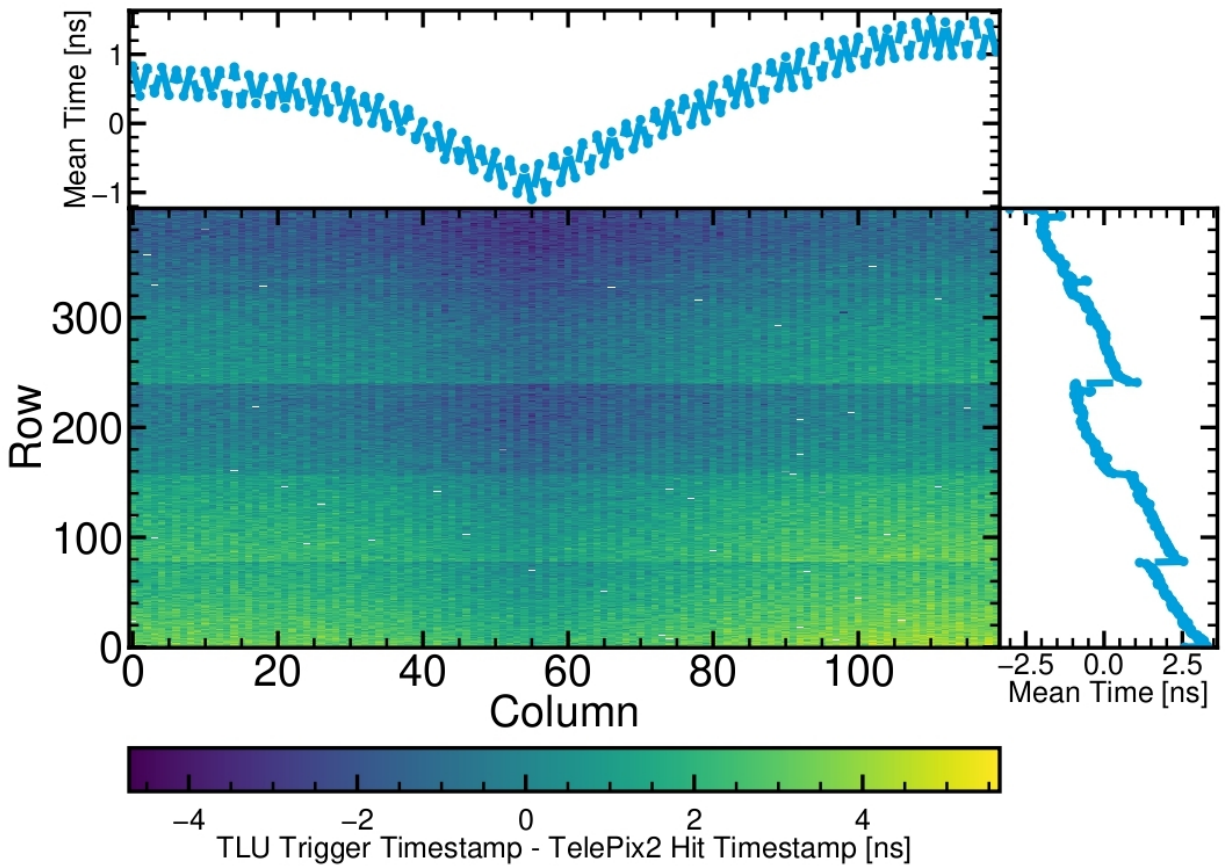
- Pitch: 165 x 25 μm^2
- Pixels: 120 x 400
- Active Area: 2 x 1 cm^2

- TelePix2 reference paper on the arxiv

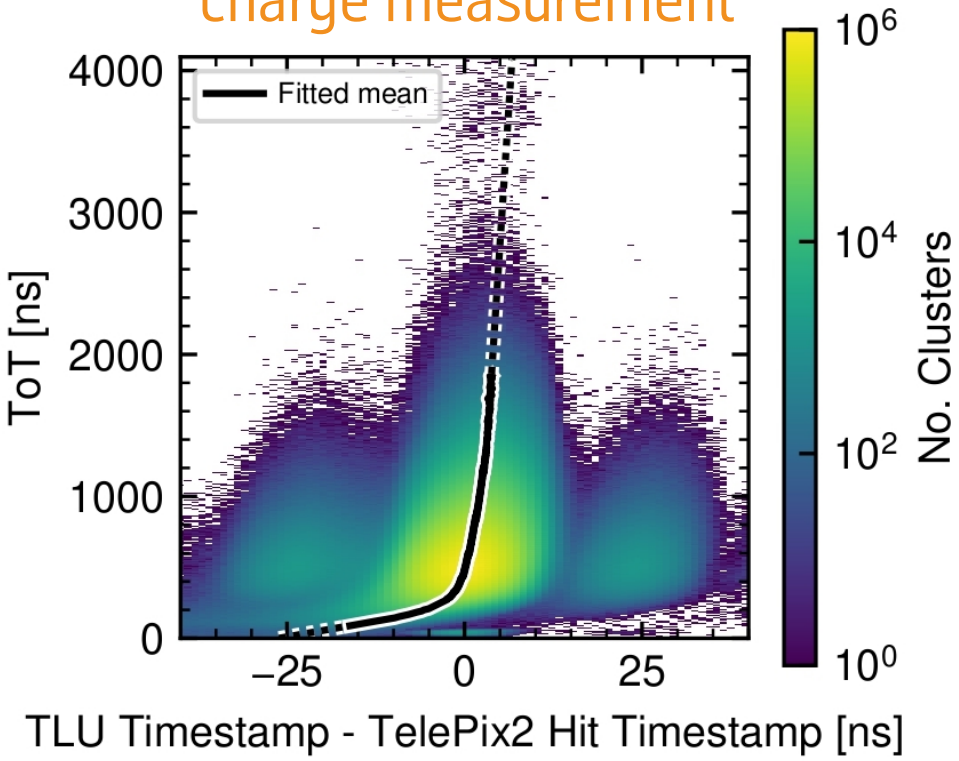


Position and Charge Time Delay

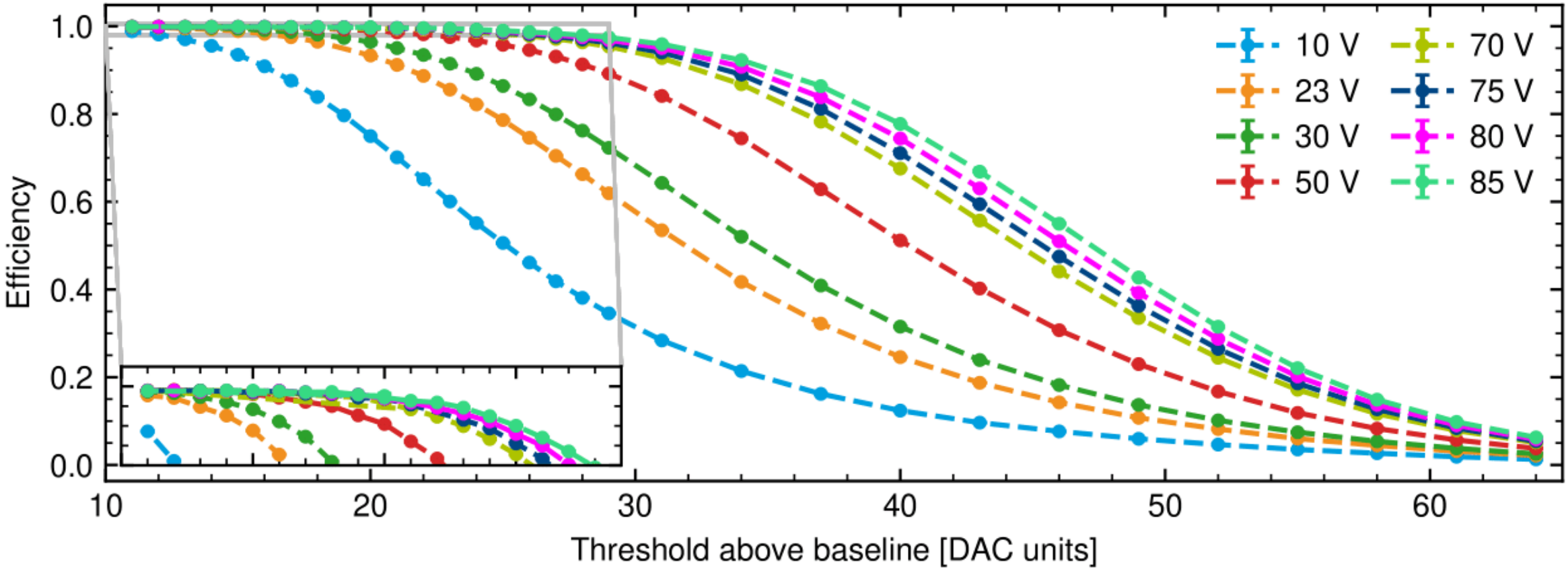
Time Delay per Pixel



Time Delay for corresponding charge measurement



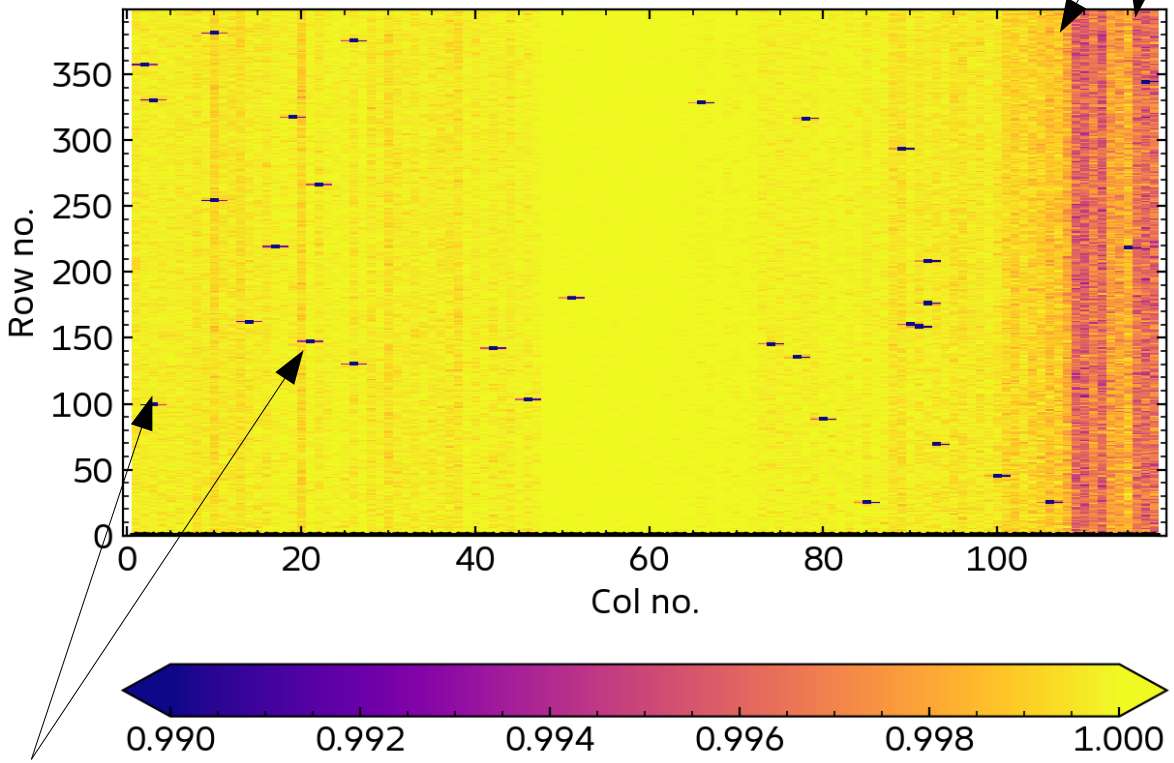
Efficiency vs Threshold



Efficiency

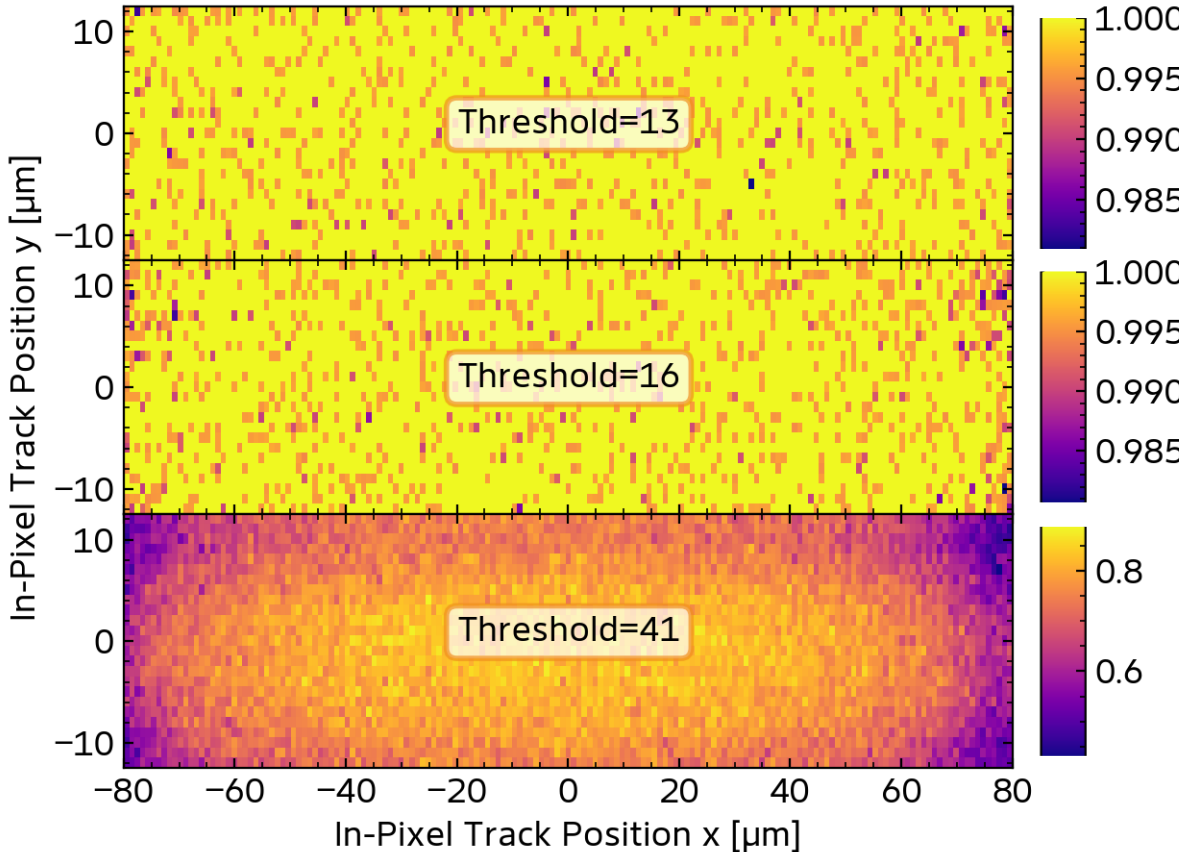
Slightly lower efficiency (< 1 %) columns still under investigation

Full Chip Efficiency
(1 threshold unit below user operation)

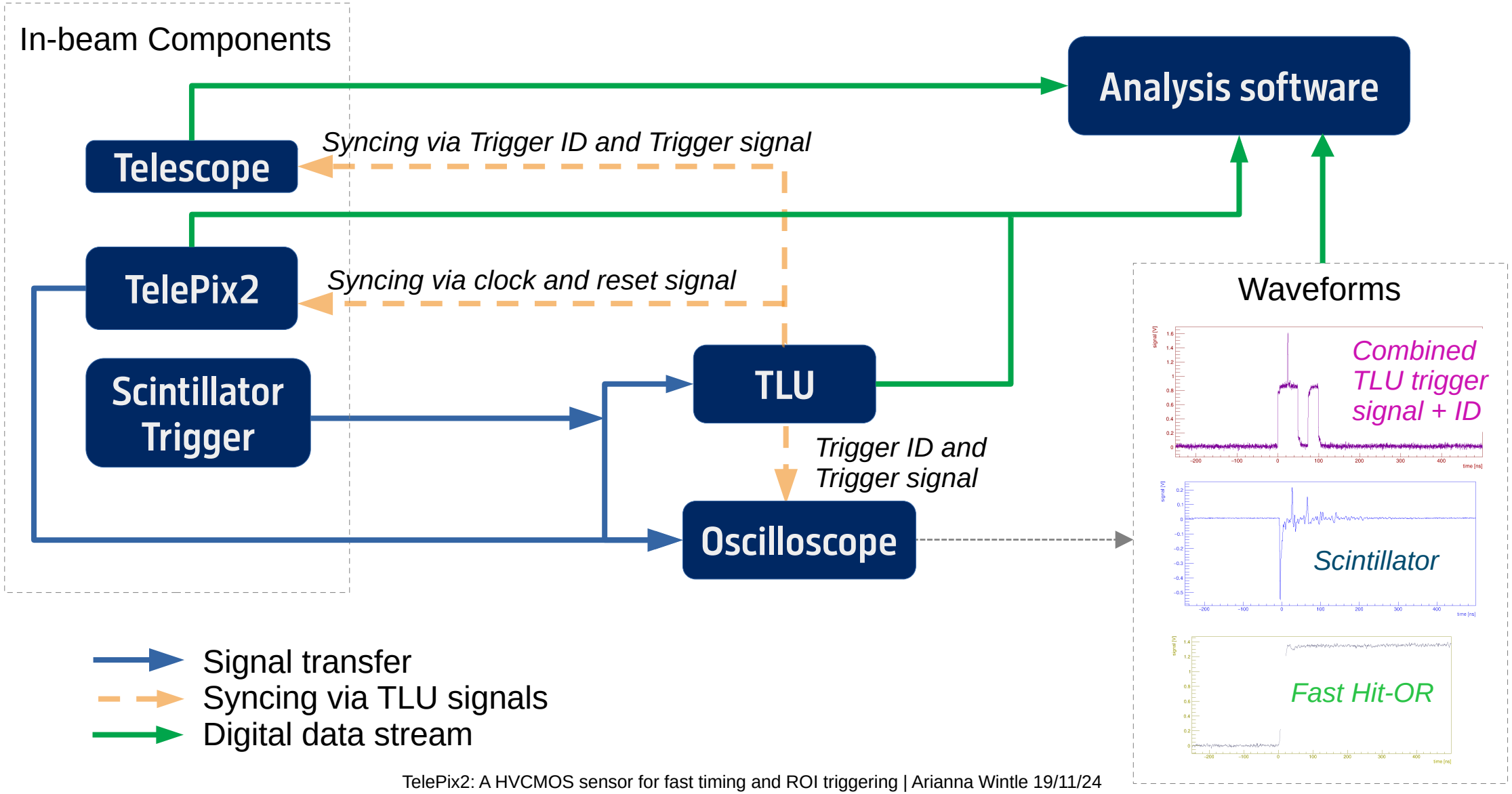


Noisy pixels masked online

In-Pixel Efficiency

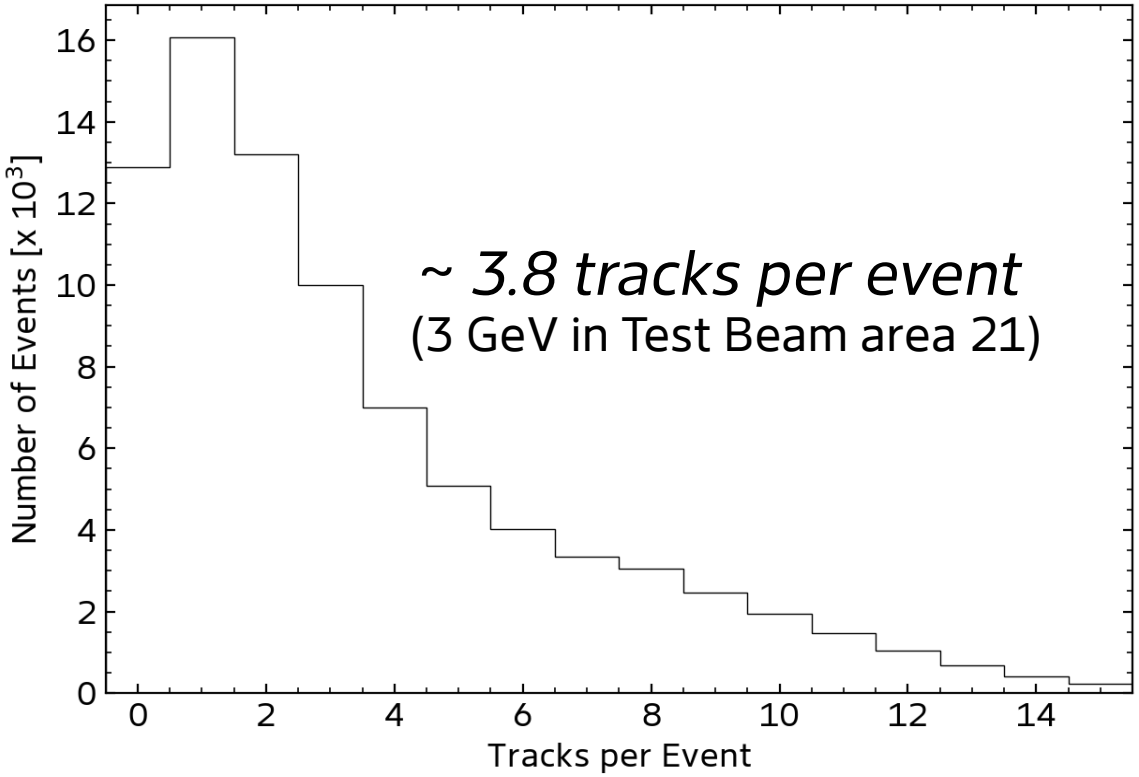


Data Collection

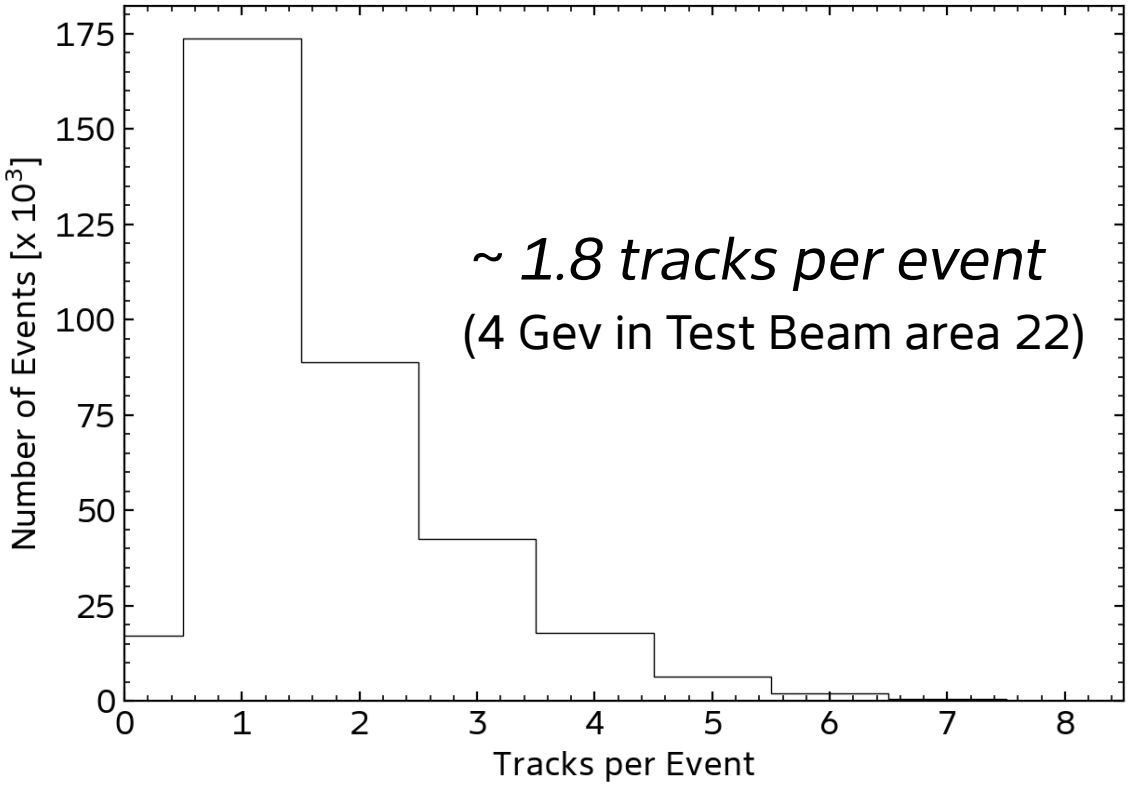


Track Multiplicity

Mimosa Track Multiplicity



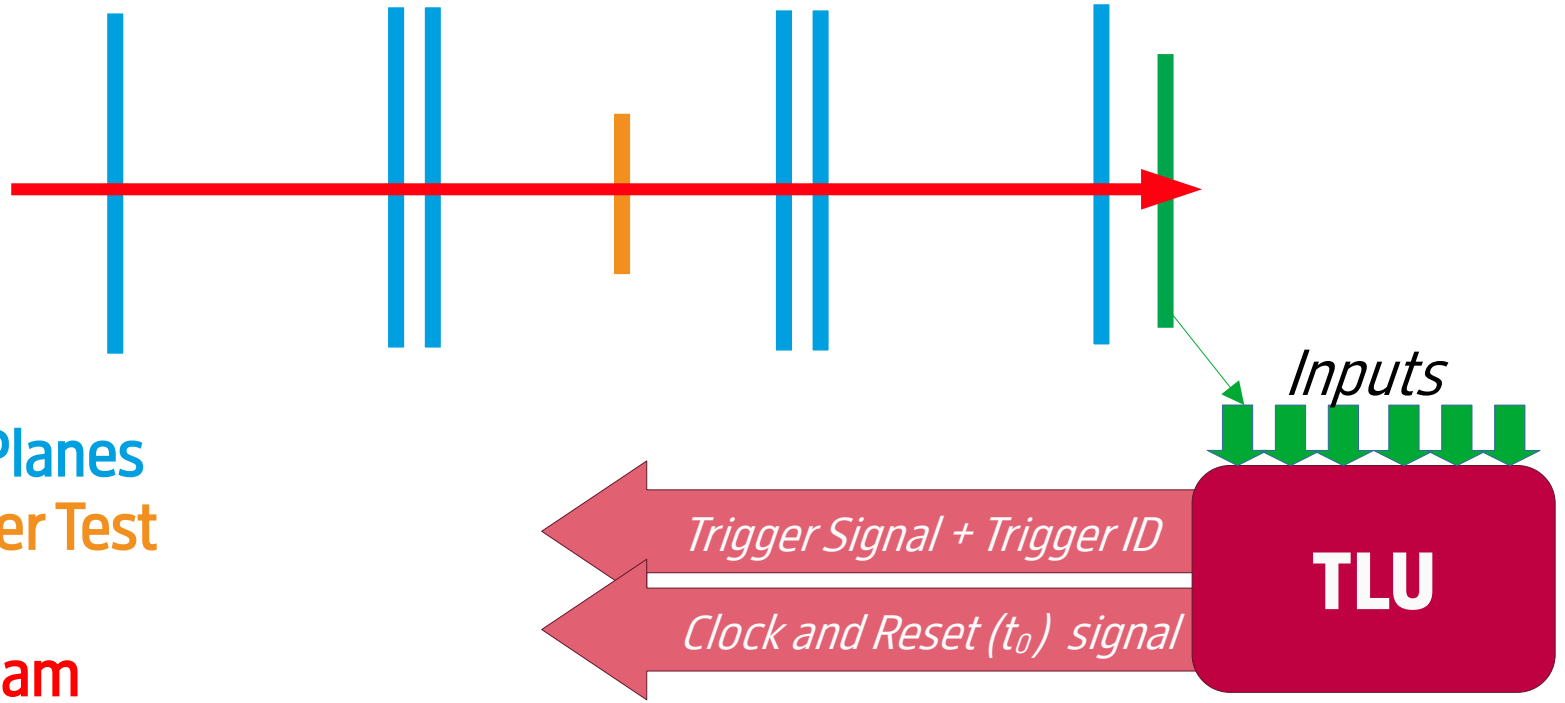
Adenium Track Multiplicity



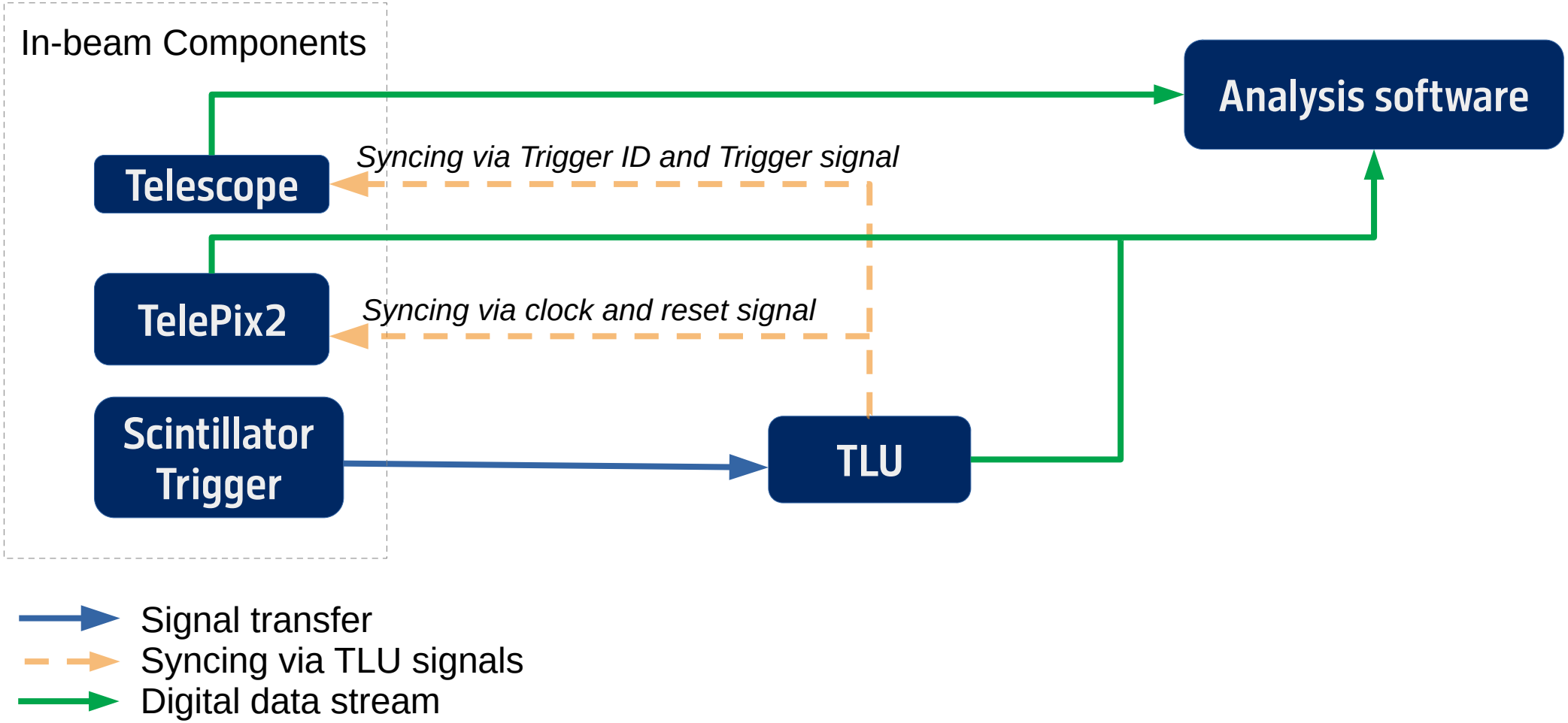
Rate varies dependent on factors such as:
which beamline is in use, selected energy and target position
The plots above should only be taken as a rough guide

Test Beam Components

Trigger Logic Unit (TLU)
Trigger on an arbitrary logical combination of 6 triggering inputs
Synchronisation of multiple devices



Data Collection



High-Voltage Monolithic Active Pixel Sensors

HV-MAPS

- **Hybrid** sensors bump bond a separate readout and sensor chip together
  - Can be **costly** to manufacture and have a **high material budget**

- **Monolithic** sensors integrate readout and sensor onto one chip:
  - But charge collection **via diffusion** → **too slow** for high rate applications

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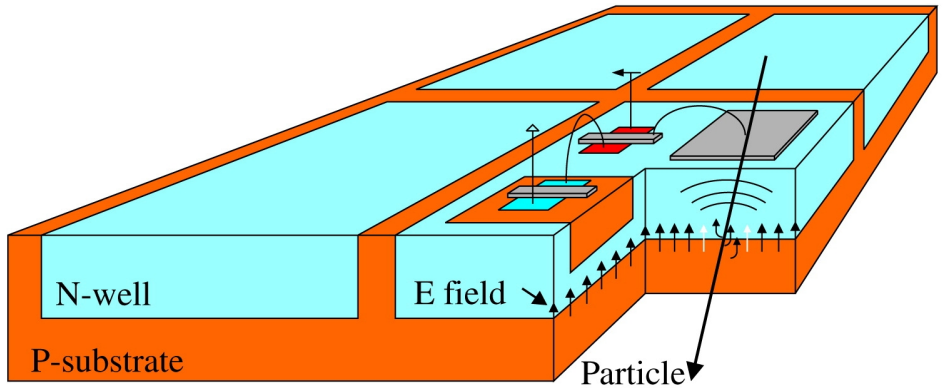
HV-MAPS embed readout inside pixel electrode

- **Higher biasing voltage** → collection **via drift (faster)**
- Can result in improved:
  - → Signal amplitude
  - → Charge collection speed
  - → Radiation tolerance



Ivan Perić, NIM 582 (2007) 876-885