

Performance study of ultrathin sensor planes for a highly compact and granular electromagnetic calorimeter of the LUXE experiment

Laser und XFEL Experiment

- Collision of 1 Hz high-power laser and 10 Hz high-energy electron beams to study the strong-field QED
- Opportunity for a beam-dump ALP survey
- Two parallel talks at EPS-HEP 2025



LUXE parallel talk



LUXE NPOD



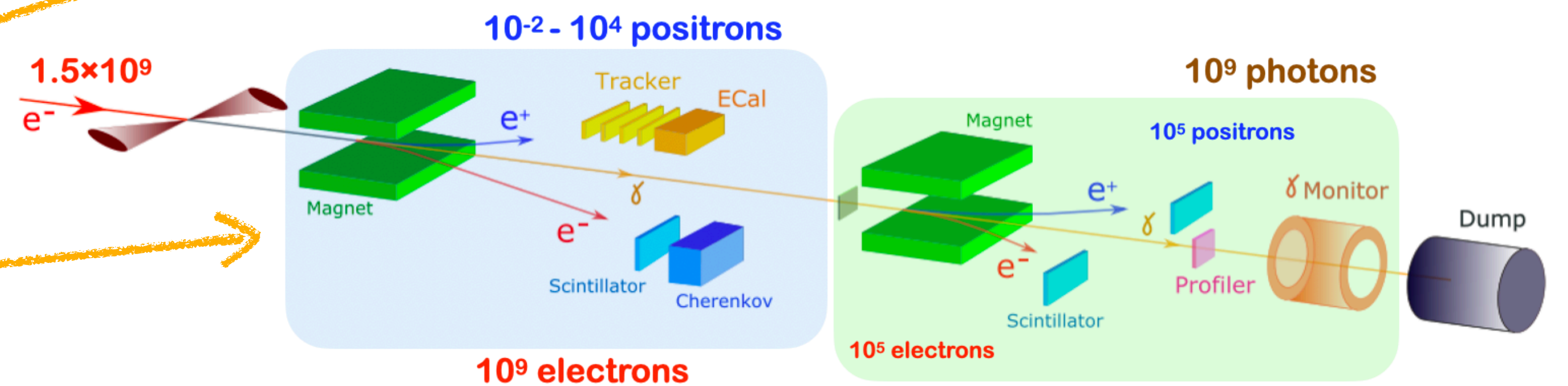
EPJC 85 684

- Detection system similar to fixed-target experiments with detectors for electrons, positrons, and photons

Electromagnetic calorimeter for positrons

A spectrometer with good (1) energy and (2) position resolutions and the ability to (3) subtract background and to handle (4) a wide positron rate range from 10^{-2} to 10^4 /BX calls for both **high compactness and high granularity**, which requires

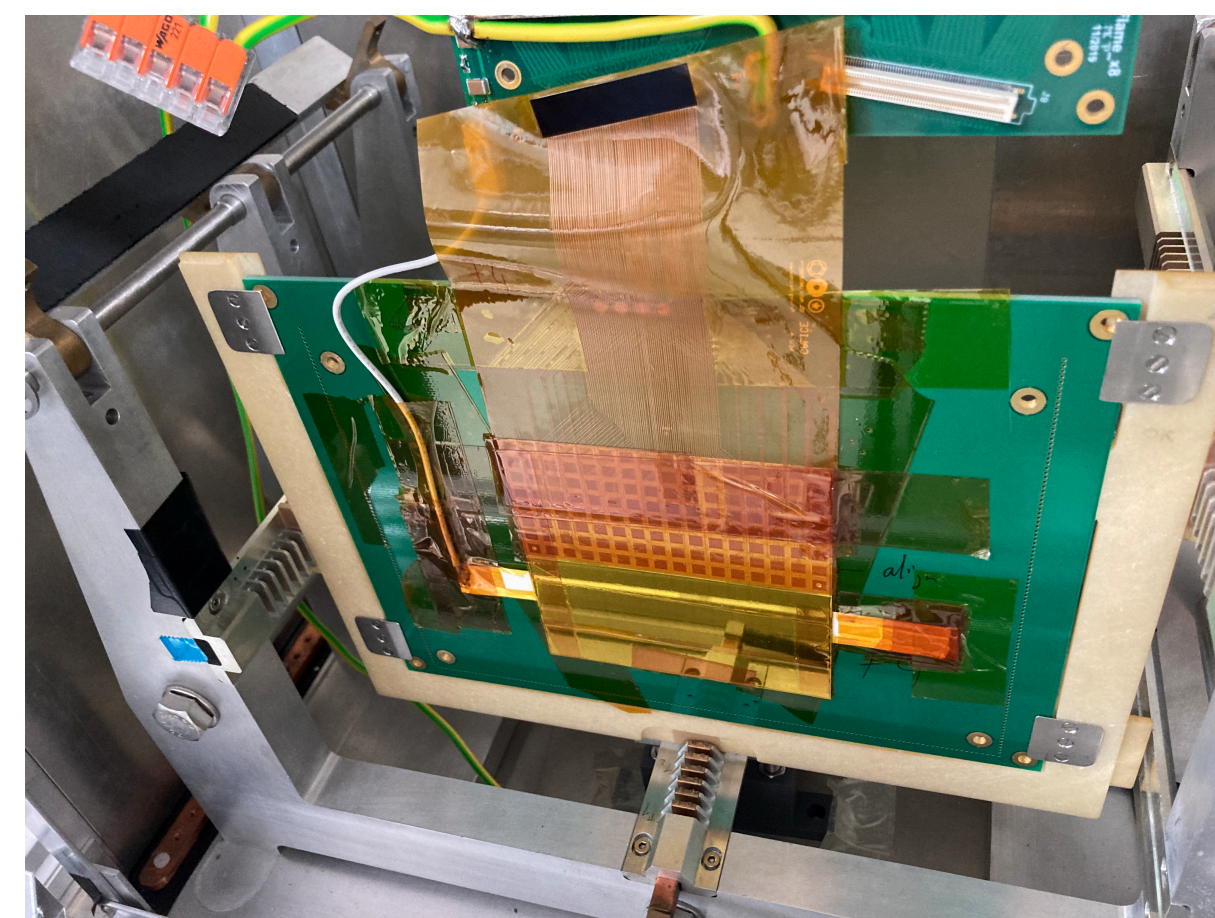
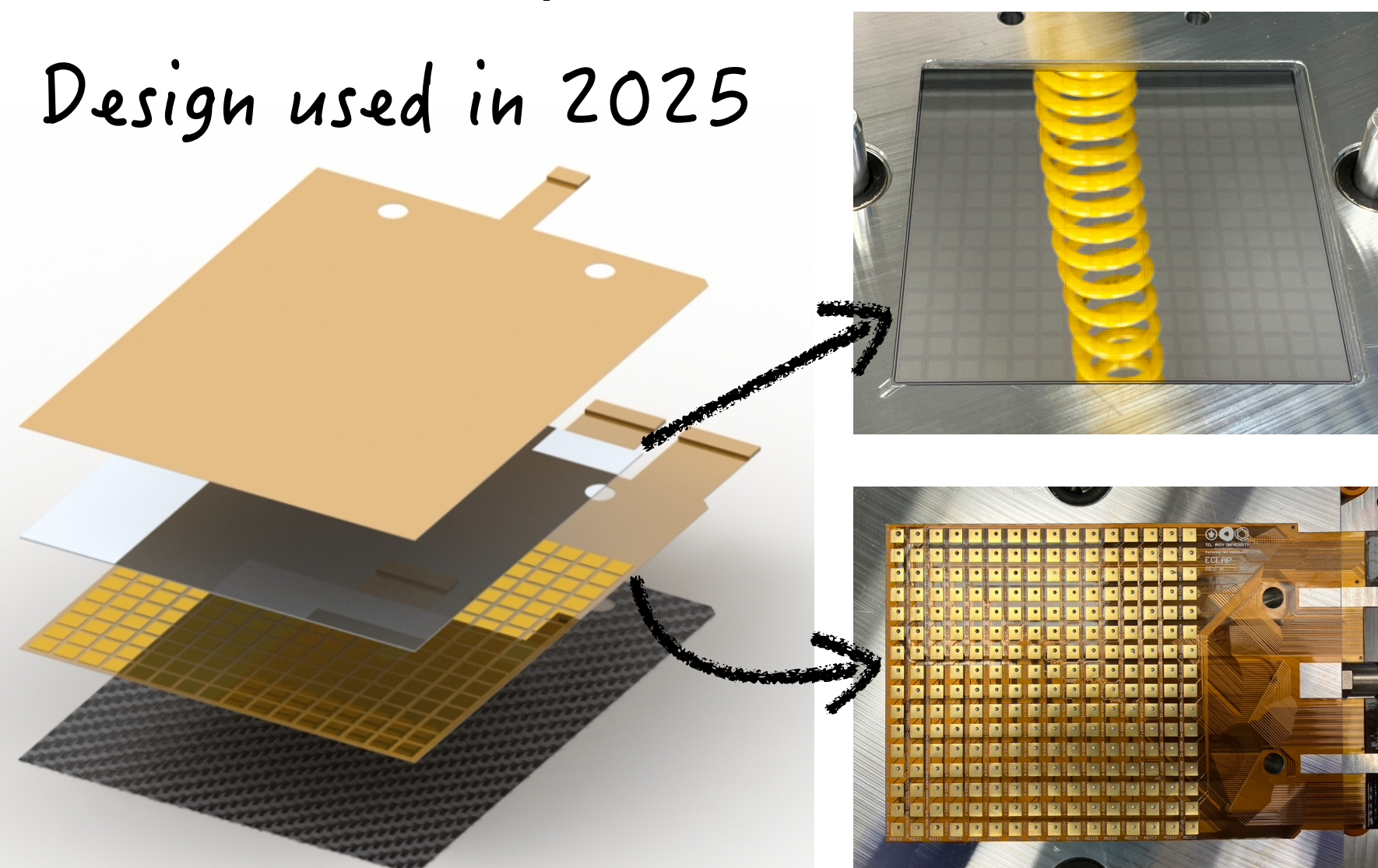
- Dense absorber with small Molière radius
- Ultrathin sensor planes with many small readout pads



Silicon sensor plane

- CALICE-style, produced by Hamamatsu
- 320/500 μm thick; 90 x 90 mm^2 area
- 16 x 16 readout pads (5.5 x 5.5 mm^2 per pad)
- Glued to Kapton film with embedded Cu readout traces

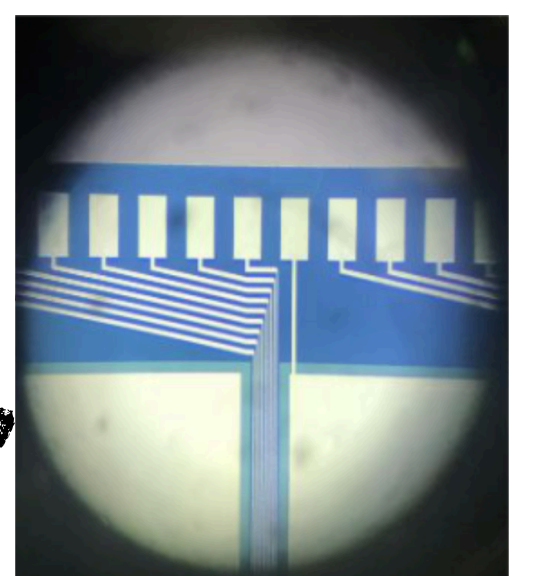
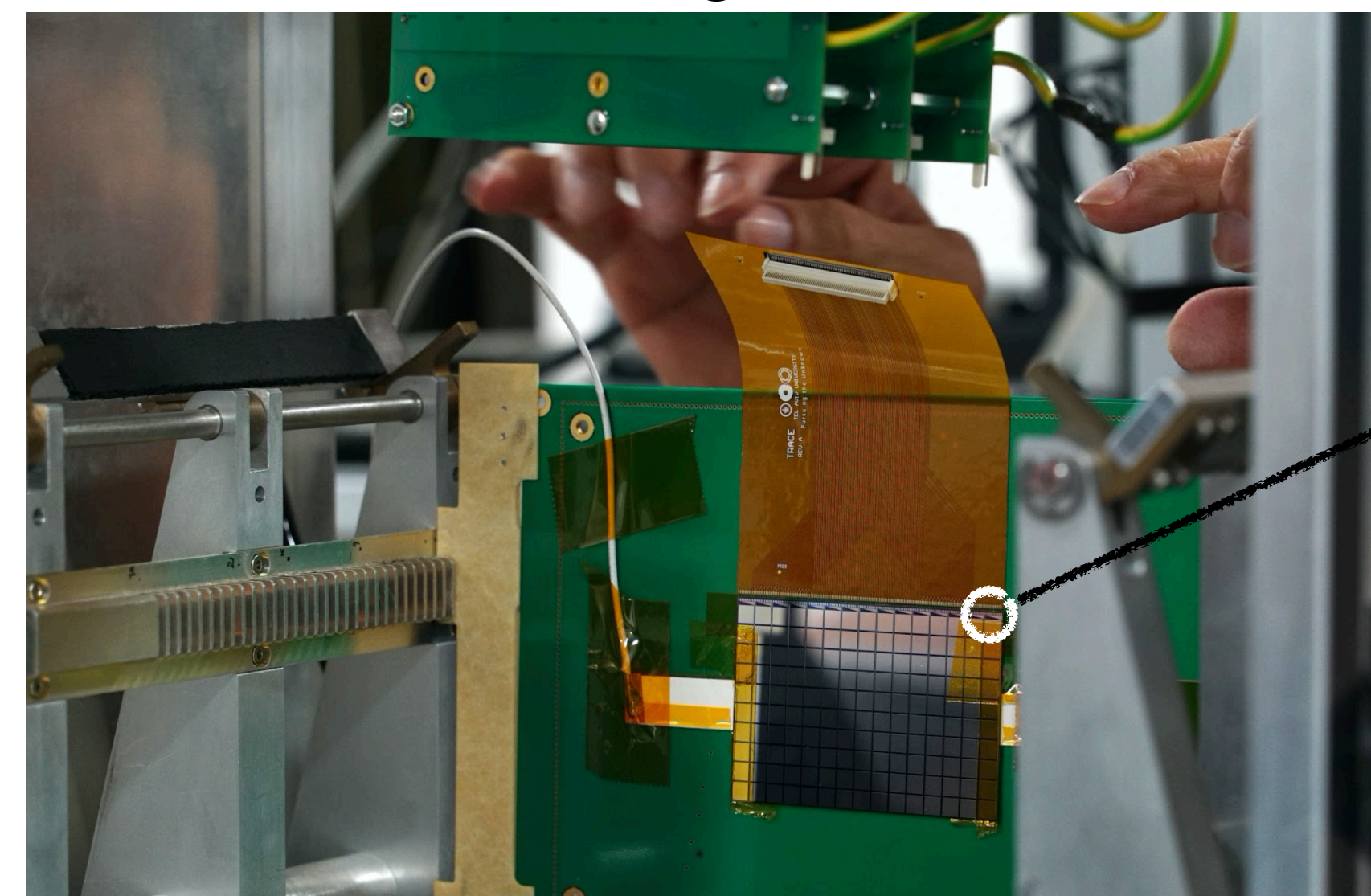
Design used in 2025



Design used in 2022

GaAs sensor plane

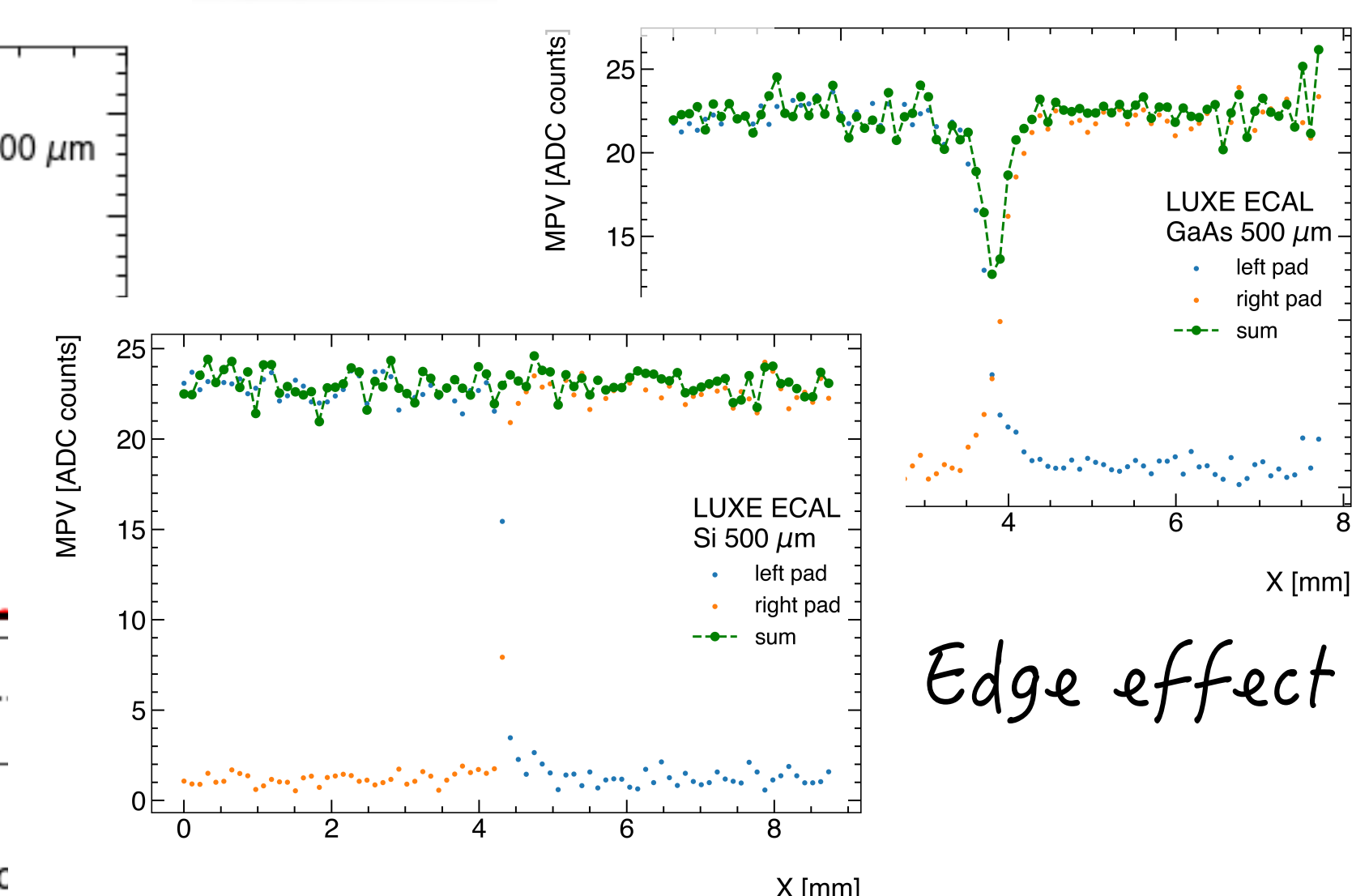
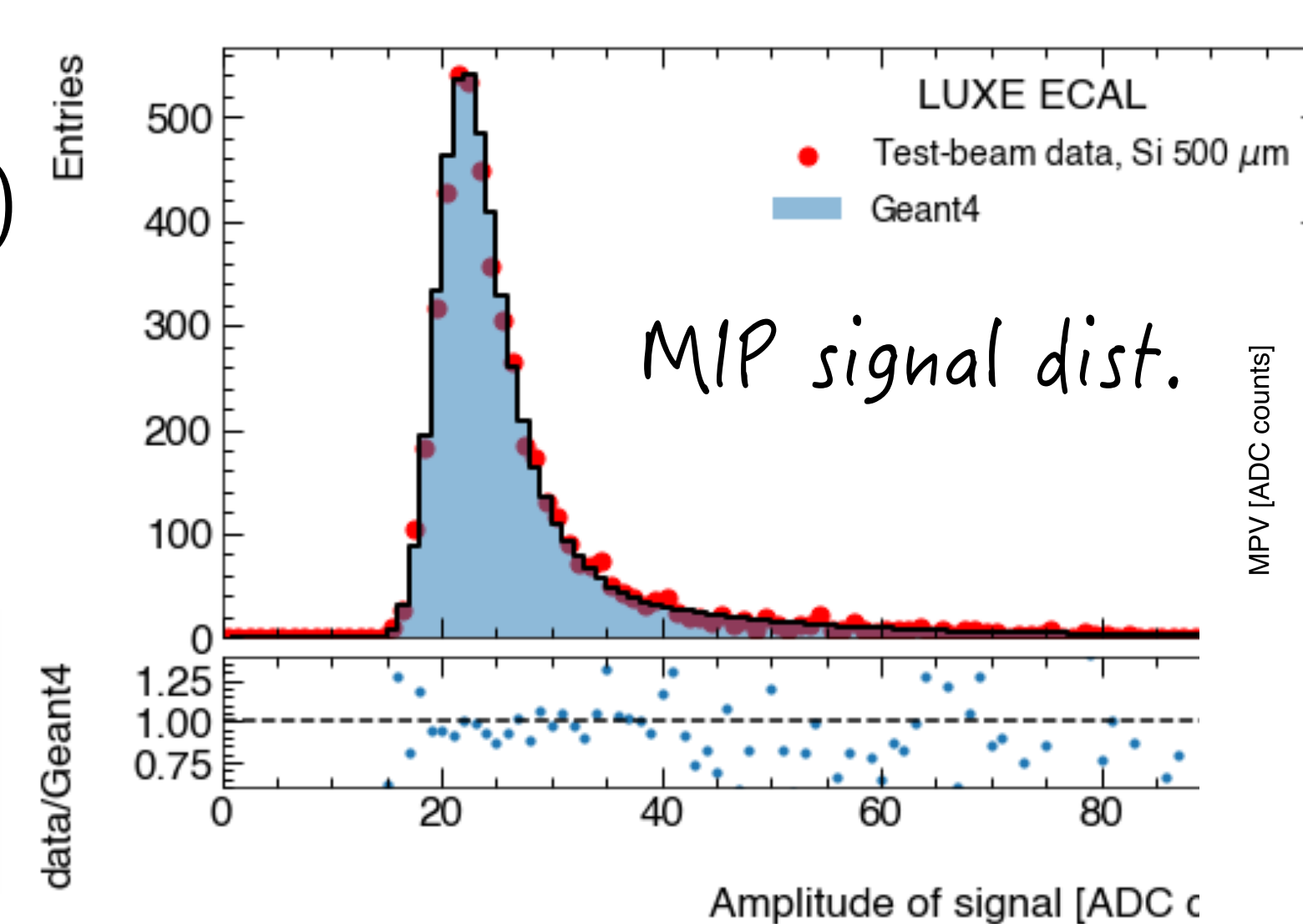
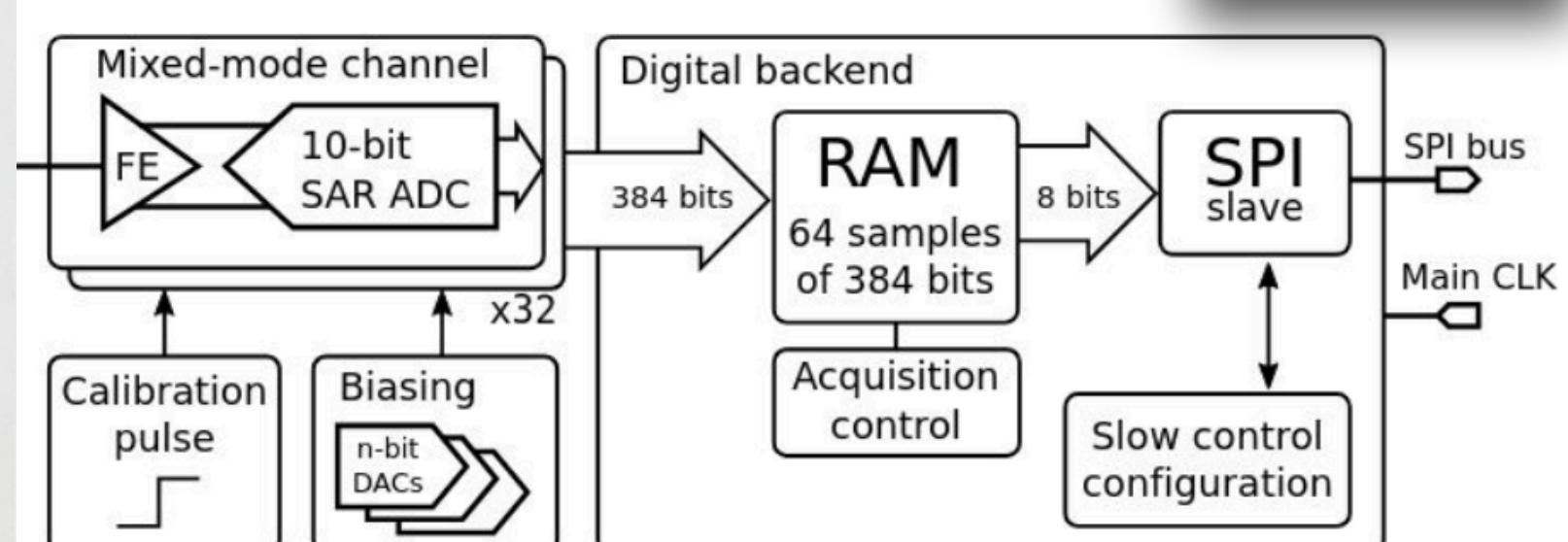
- Produced by Tomsk State University
- 500 μm thick; 50 x 75 mm^2 area
- 10 x 15 readout pads (4.7 x 4.7 mm^2 per pad)
- Al readout traces integrated on the sensor



The traces are put in the 0.3-mm gaps between pads

Prototype testing in 2022 and 2025

- Sensor and detector prototypes are tested with e^- beam at DESY
- TB-2022 with two sensor prototypes of each kind (500 μm thick)
- TB-2025 with 20 silicon sensor modules inside the full structure FLAME/FLAXE ASICs
- ASICs with 32-channel and 50 ns shaping time
- Packed inside front-end boards, which are connected to readout FPGA
- Coordinated by the TLU
- Mechanical structure
- High precision combs to hold super-flat W planes
- (new in 2025) T-frames to hang sensors and FEBs



Edge effect

Takeaway messages

- Ultrathin sensor samples with new technologies of fanout- and sensor-embedded traces are tested in an electron beam and show successes
- They are crucial for highly compact detectors which are essential for future experiments
- Spread of response of the readout within 3%
- GaAs sensor samples show edge effects of 40% (w/ traces) and 10% (w/o traces) loss at gaps
- LUXE ECAL-P prototype with 20 Si sensors was assembled and tested at DESY in 2025
- Analysis ongoing, stay tuned!

