

Fast-Timing Strip LGADs for Space-Weather Monitoring in Low Earth Orbit

Building & characterising a 32-channel large-area strip LGAD detector for charged-particle flux measurements

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down to ~30 ps

TIMING RESOLUTION LGADS REACH

7.7 × 46 mm

LARGE-AREA STRIP SENSOR

32 ch

READ-OUT CHANNELS

×10–30

LGAD INTERNAL GAIN

★ PHD ROADMAP · WHY THIS WORK, WHERE IT STANDS, AND THE GOAL ★

①

THE NEED

Timing for space tracking

Future missions (AMS-100, ALADInO, HERD) need <100 ps tracking, and prefer strip geometry.

②

THE APPROACH

A 32-ch SLAPP-2 strip

FBK pad-LGADs are proven (jitter ≈ 57–71 ps). I scale the same wafers to a 7.7 × 46 mm strip.

③

NOW

Build & commission the DAQ + TCT

Read-out boards + laser bench integrated; first signals, debugging ongoing.

④

THE GOAL

Space-compliant ToF layer

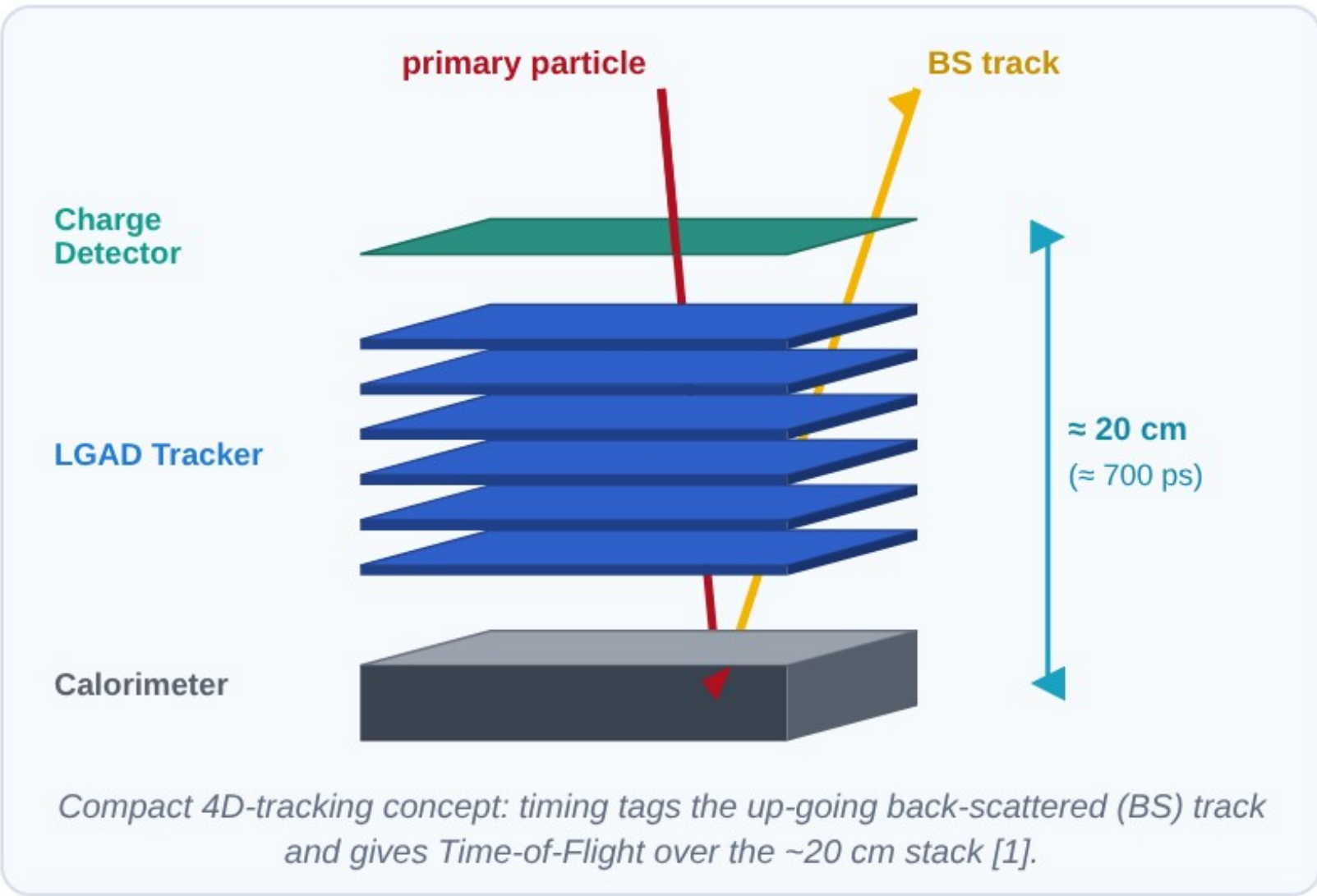
Position-resolved timing over 32 ch → toward a flyable LEO space-weather monitor.

◀ WE ARE HERE

1 Why timing detectors for space?

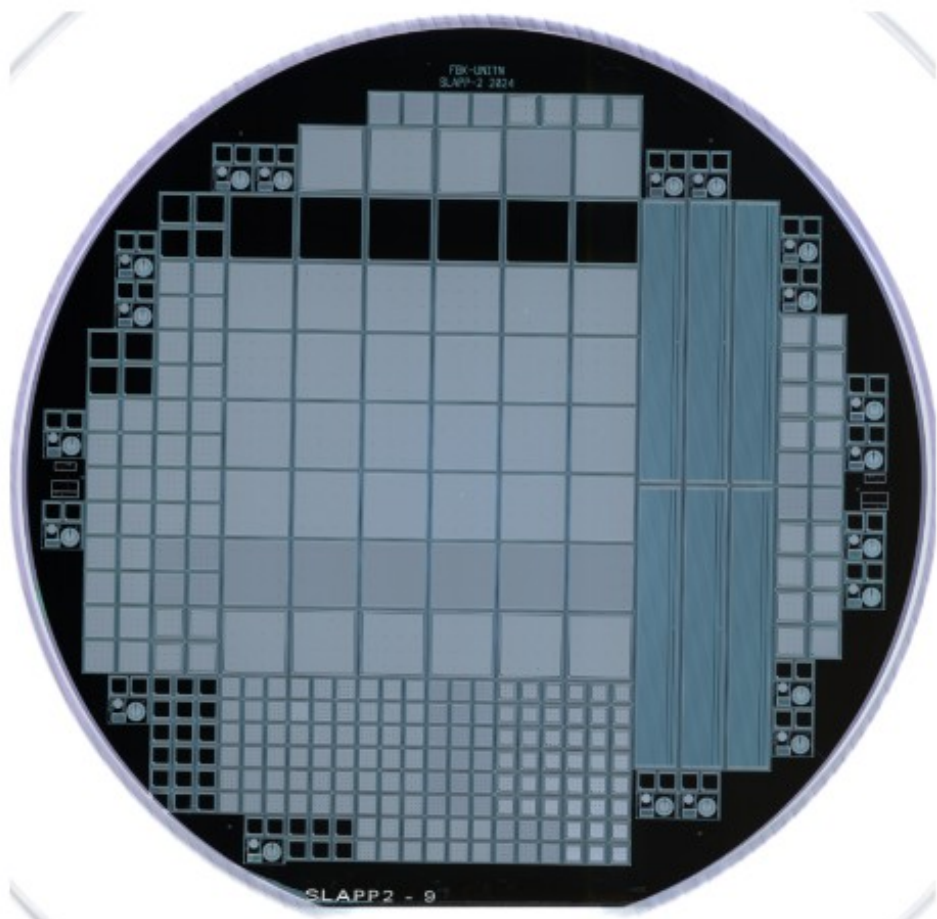
Charged-particle fluxes in **Low Earth Orbit** are a primary **space-weather** observable. Conventionally their charge & momentum need a bulky **magnetic spectrometer**; instead, **fast timing** (<100 ps) added to a compact tracker enables **4D tracking** at low mass & power, ideal for **CubeSat-scale** missions:

- ▶ Reject **back-scattered hits** from the calorimeter
- ▶ **Time-of-Flight** → velocity & particle-mass ID, with **no magnet**
- ▶ **e/p identification** (slow hadronic vs. fast EM secondaries)
- ▶ Resolve **pile-up & ghost hits** at high flux



2 LGADs & the SLAPP-2 strip sensor

- ▶ An **LGAD** = thin (45–150 μm) silicon sensor with a **gain layer** → avalanche multiplication (×10–30) → large, fast pulses; thin sensors reach **~30 ps**
- ▶ **SLAPP / SLAPP-2** (FBK + INFN): space-dedicated LGADs; pad sensors give **jitter ≈ 57 ps** (150 μm) / **71 ps** (100 μm) [1]
- ▶ SLAPP-2 also produced **strip sensors** (200 μm pitch, 4.5 cm): "the preferred geometry in space trackers"
- ▶ **My device**: a **7.7 × 46 mm, 32-channel strip** from the same wafers. Does large-area strip geometry keep the pad timing?



A SLAPP-2 wafer after production at FBK; the 32-channel strip sensors come from this batch [1].

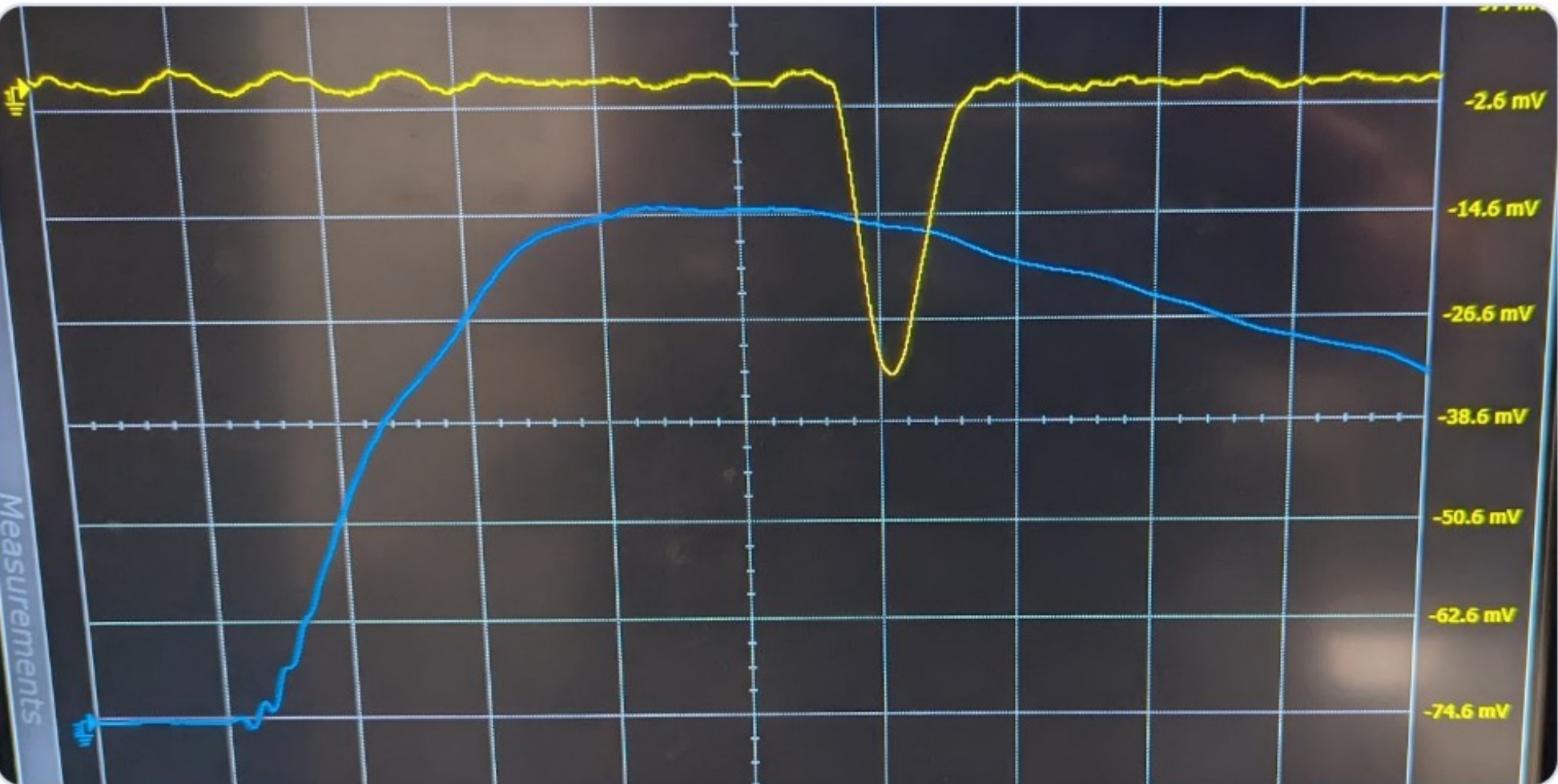
3 Read-out system & status

- ▶ **Amplification board** (INFN-PG / Fermilab): 32-channel, 2-stage transimpedance amplifier
- ▶ **Daughter board** (UnitN): hosts & wire-bonds the sensor, routes signal + HV
- ▶ **3D-printed support**: TCT adapter @FBK + source / test-beam cutout
- ▶ HV up to ±1100 V · LabVIEW DAQ, 256-waveform averaging

Signal generation confirmed **qualitatively** on this brand-new chain (IV, cosmics, ⁹⁰Sr).

Done: a mini-LGAD was tested directly on the amplification board → read-out chain works with no issue.

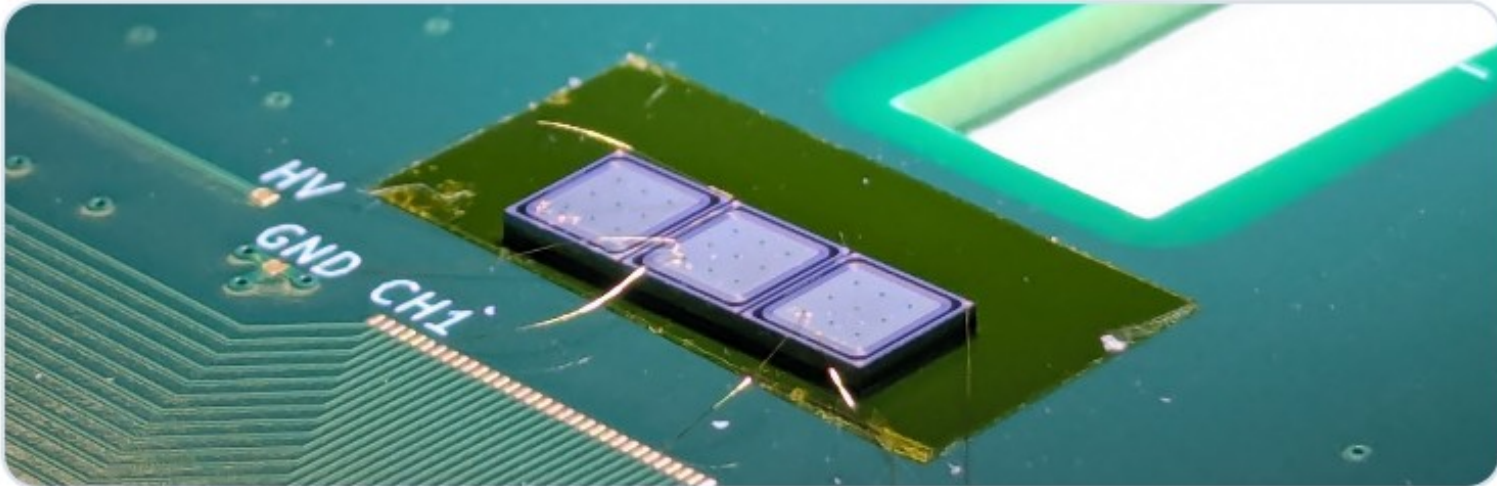
Ongoing: mini-LGAD characterisation on the completely new daughter board, to verify functionality before moving to the large-area LGAD strip.



LGAD signal (yellow) on the laser-trigger reference (blue), read out on the 2.5 GHz oscilloscope.



Full read-out chain: UnitN daughter board + INFN-PG / Fermilab 32-channel amplification board in the 3D-printed holder.



Mini-LGAD (3 pads) wire-bonded on the daughter board (HV / GND / CH1).

4 Measurement plan

➔

Mini-LGAD on amplification board

Amplification chain verified: cosmics + ⁹⁰Sr @TIFPA, laser @FBK TCT.
DONE

◆

32-channel LGAD strip

Bond 32 channels (with expert); 5 open-metal channels TCT-capable; CCE, gain-uniformity & timing in TCT.
NEXT

➔

Mini-LGAD on daughter board

Verify bonding & daughter → DAQ chain; 2 channels read out; read-out chain debugging on this new setup.
ONGOING

★

Sources + test beam

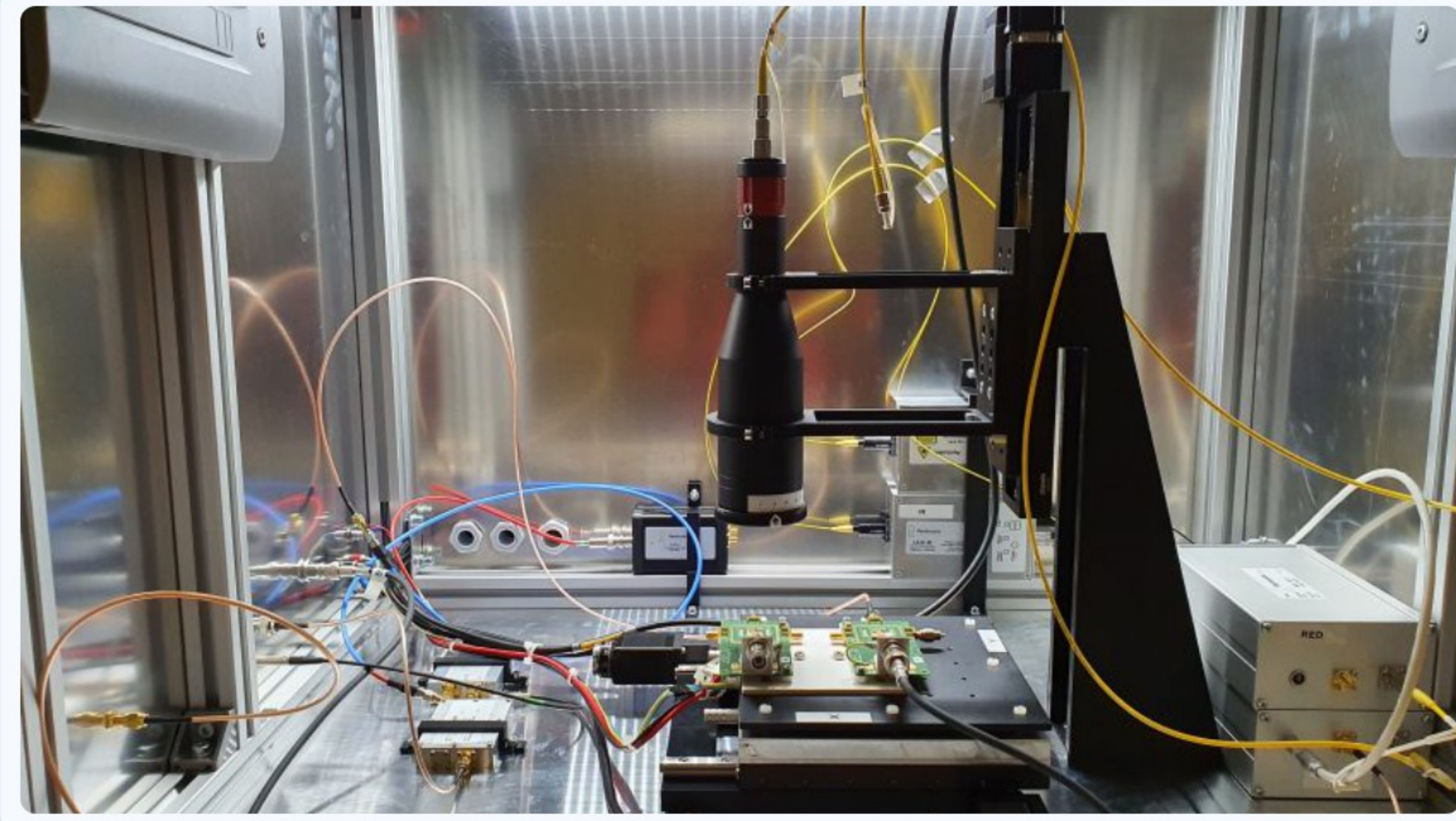
Full sensor characterisation → space-compliant ToF demonstrator.
GOAL

★ THE METHOD · MEASURING WITH LIGHT

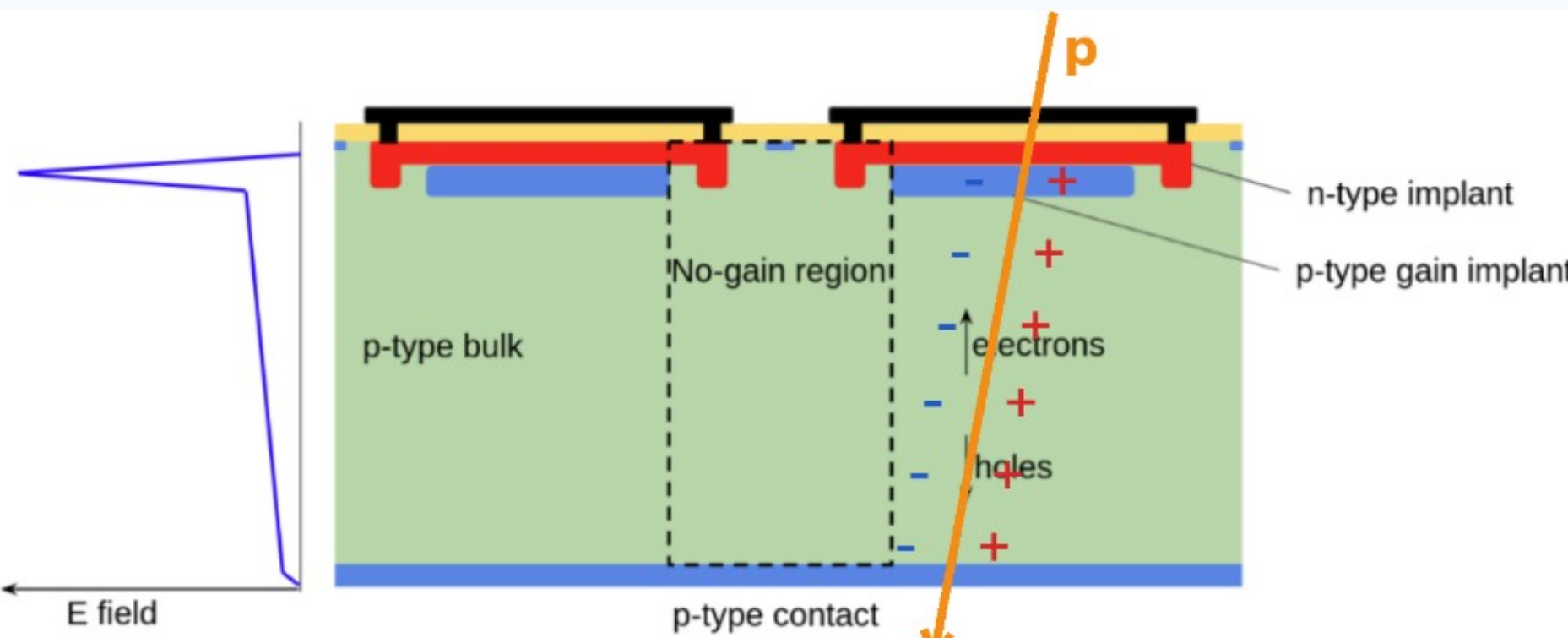
From a Laser Pulse to a Timing Measurement

The Transient-Current Technique (TCT) at FBK: a picosecond laser stands in for a particle, so we map gain & timing across the whole sensor with no beam.

1 Two correlated pulses – DUT

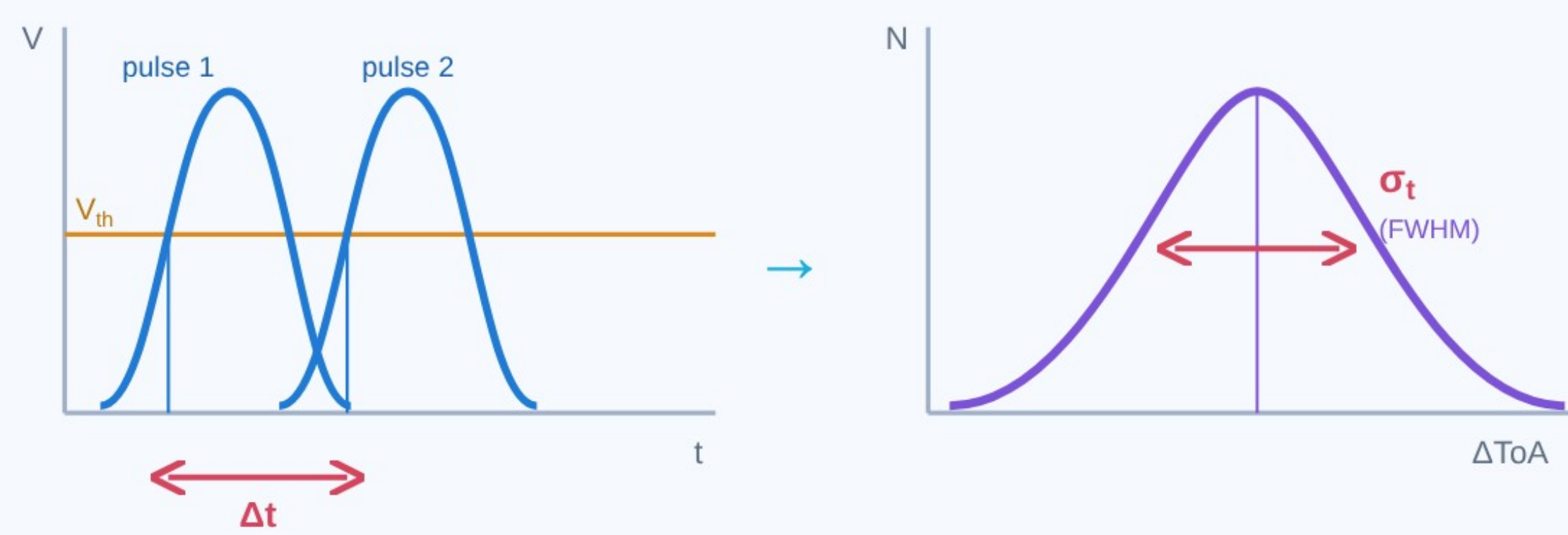


2 Charge generation inside the LGAD



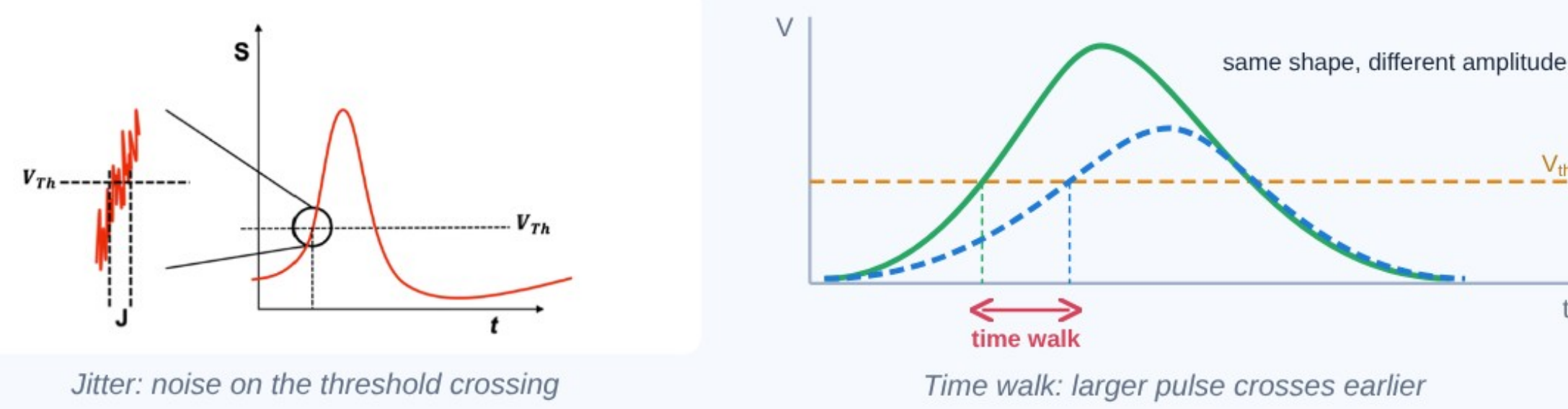
A charged particle (or the IR laser, through **openings in the metal**) frees e⁻h⁺ pairs; electrons drift up and are **multiplied in the gain layer**. An **X/Y/Z stage** scans the whole active area. [1]

3 Measuring σ_t: the two-pulse method



Each event records **two pulses** a fixed Δt apart. Over many events the spread of their arrival-time difference (ΔToA) is **Gaussian**; its width gives the timing resolution σ_t (after ÷√2).

4 Extract σ_t: why it is hard



$$\sigma_t^2 = \sigma_{\text{jitter}}^2 + \sigma_{\text{Landau}}^2 + \sigma_{\text{time walk}}^2$$

The two correlated pulses share the laser/scope jitter → fit their **ToA-difference** and divide by √2 to isolate the sensor σ_t.

Jitter ∝ noise / slew-rate → more gain, less noise

Landau noise: stochastic deposition → thin sensors

Time walk: amplitude-dependent crossing → CFD correction

Non-uniformity over large area → ±30 ps · **key challenge** for LGAD strip sensors