Innovations in silicon detector technologies for next-generation experiments: improving timing precision of LGADs for ALICE 3

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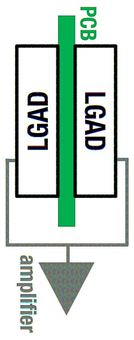
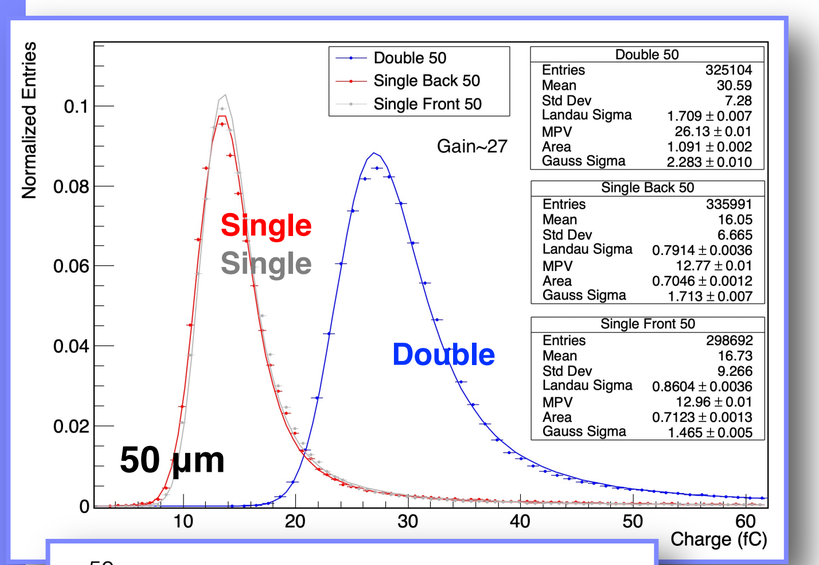
Double-LGAD concept

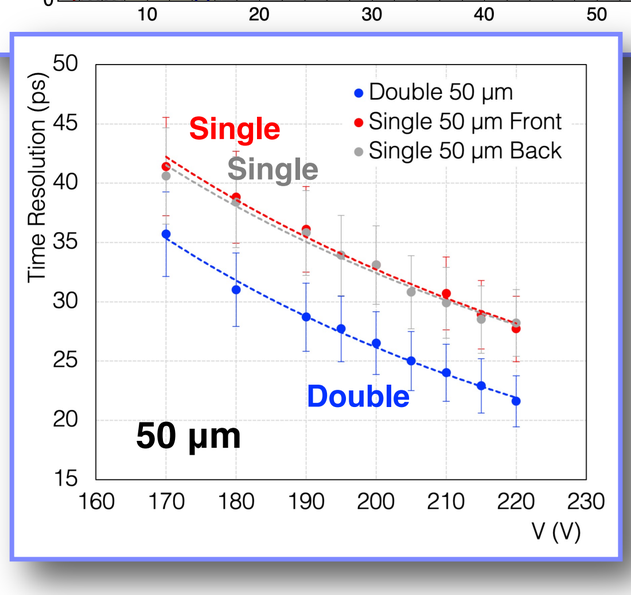
The new double-LGAD concept was introduced and tested for the first time.



It consists of summing up the signals generated by two layers of LGAD using a single front-end amplifier.

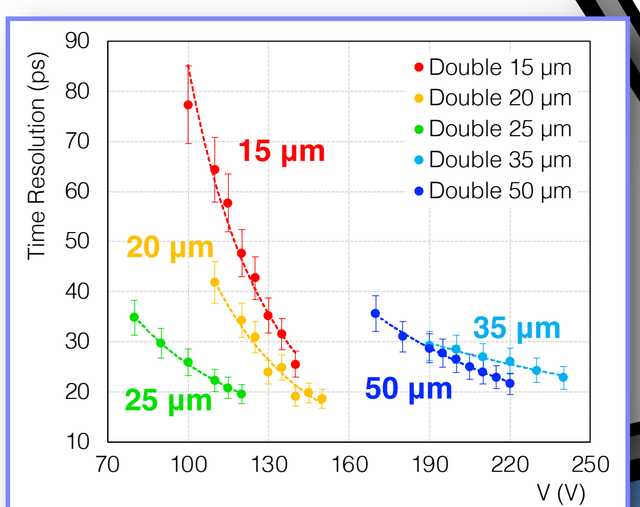
→ **higher** (doubled) **charge at the input of the amplifier** for all the thicknesses



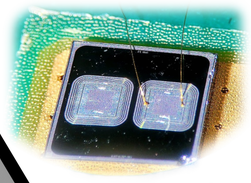


Studies then done on even thinner LGADs **(15 & 20 µm):**

→ Time resolution of **~20 ps for all thicknesses** (15 to 50 µm) and below ~20 ps for 20 µm



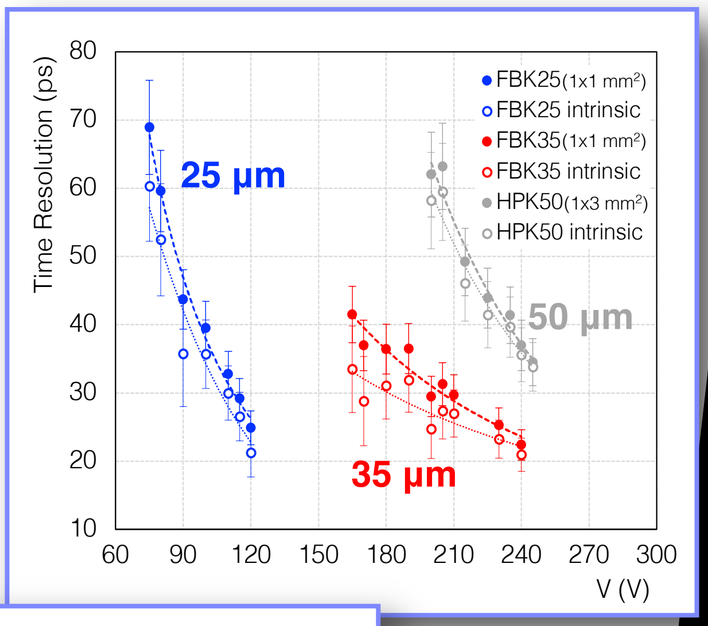
Very thin LGADs (25 & 35 µm)

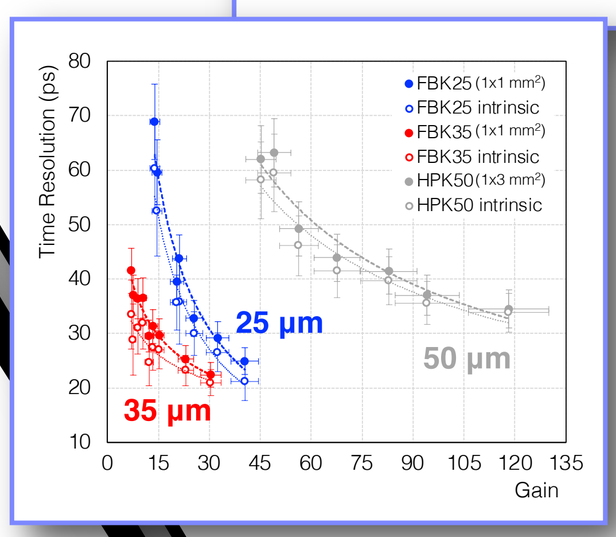


were tested for the first time in a test beam setup.

→ **Improvement of the time resolution by** going to a **thinner LGAD** design

https://doi.org/10.1140/epjp/s13360-022-03619-1





25 µm (120 V) → **25 ps**

35 µm (240 V) → **22 ps**

(different doping concentrations in the two thicknesses)

https://doi.org/10.1140/epjp/s13360-023-04621-x

→ advantage for the electronics

→ consistent **improvement of the time resolution for the d-LGAD** compared to the single LGADs

Ongoing

- Studies of the time resolution with an electronics chain with **LIROC + picoTDC**
- Studies on **CMOS-LGADs**

R&D on very thin LGADs

LGADs are silicon detectors developed to **detect charged particles.**

→ They are an evolution of *n*-on-*p* (PIN) sensors, obtained by implanting an additional **highly doped gain layer** just below the *p-n* junction.

Low Gain Avalanche Detectors

Based on internal low-gain (10-70) multiplication mechanism

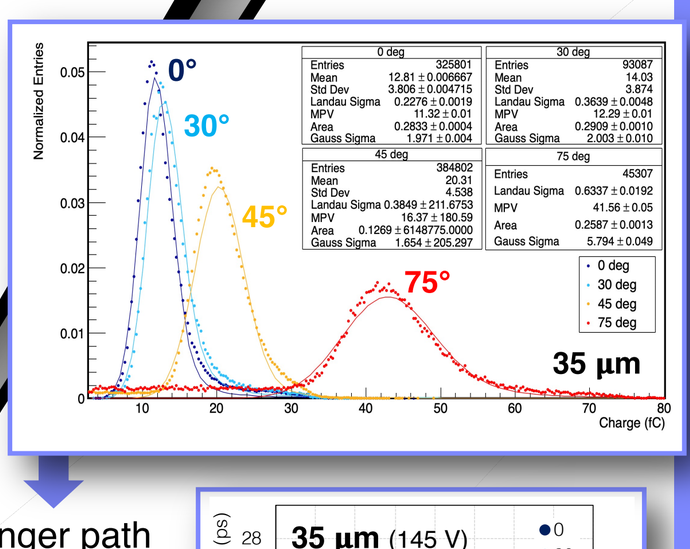
Large and fast signals

Improved S/N

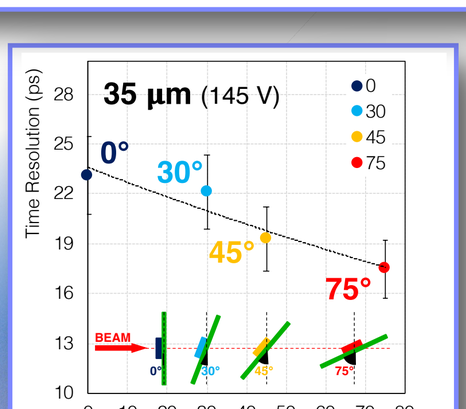
Excellent timing performance

→ Most mature silicon detector technology for timing applications

Time resolution VS **incident angles**



Longer path inside the LGAD → **Higher charge realized**



The **time resolution** slightly **improves** going to **higher** impinging **Angles.**

Tilted LGADs

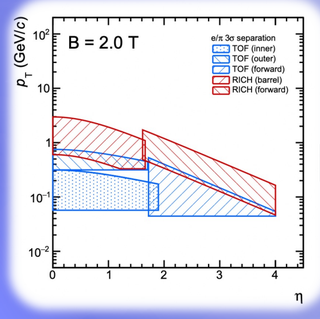
ALICE 3 - A next generation heavy ion experiment

TIME OF FLIGHT (TOF) DETECTOR

- outer TOF R ≈ 85 cm
- inner TOF R ≈ 19 cm
- forward TOF z ≈ ±375 cm

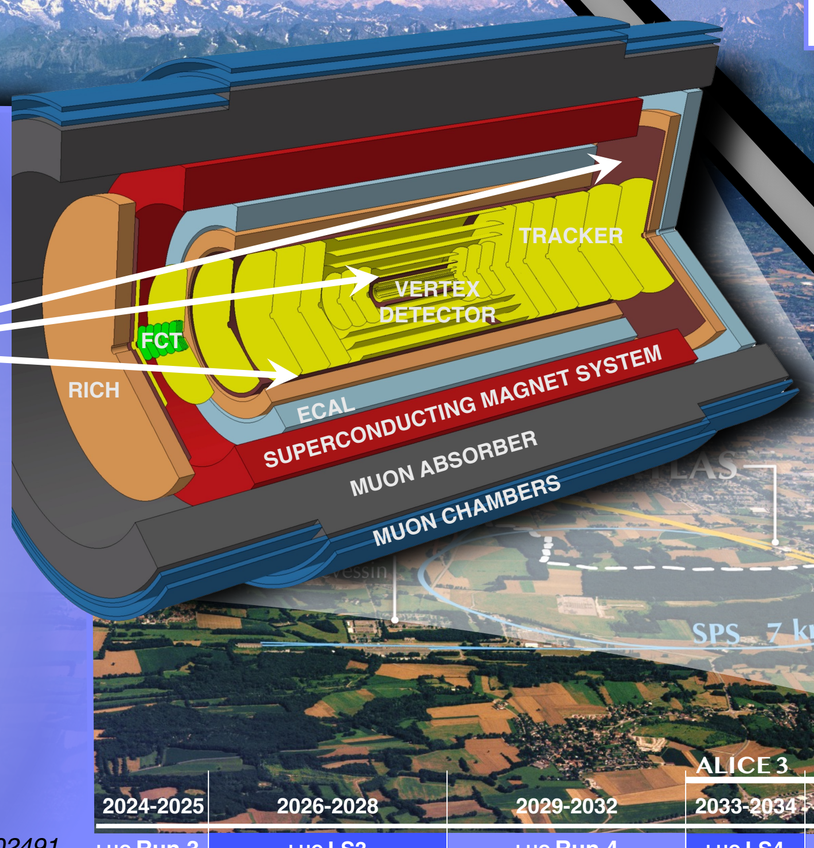
Requirements:

- Rad. hardness
  - outer TOF: NIEL ~ $9 \cdot 10^{11}$ MeV n_{eq} /cm²
  - inner TOF: NIEL ~ $6.1 \cdot 10^{12}$ MeV n_{eq} /cm²
  - forward TOF: NIEL ~ $8.5 \cdot 10^{12}$ MeV n_{eq} /cm²



- Time resolution of **20 ps**

Extensive R&D on the most advanced silicon technologies: ***LGADs, SiPMs, CMOS LGADs***



ALICE 3 LoI: *https://arxiv.org/abs/2211.02491*