The time resolution and position resolution of IHEP LGAD strip

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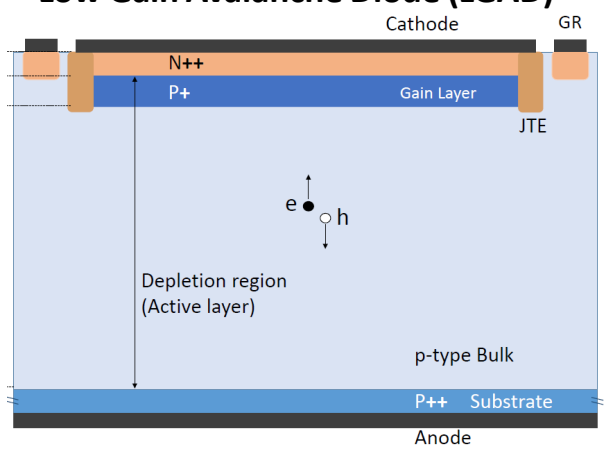
Low Gain Avalanche Diode (LGAD) has high-precision time performance, and the time resolution can reach 30 ps. The LGAD with a size of 1.3 mm × 1.3 mm was used for the upgrade of ATLAS and CMS time detectors to reduce the pile-up effect of High-Luminosity Large Hadron Collider (HL-LHC). Institute of High Energy Physics (IHEP, CAS) has designed a LGAD strip detector, which can be used as a time detector in electron colliders such as Circular Electron Positron Collider (CEPC) and Future Circular Collider (FCC-ee). The strip-shaped LGAD allows for a larger cell area, which reduces readout channel density, and provides position resolution with a double-ended readout method. The double-ended readout method can also correct the time delay caused by the difference in hit position, thereby improving time resolution.

Low Gain Avalanche Diode (LGAD)



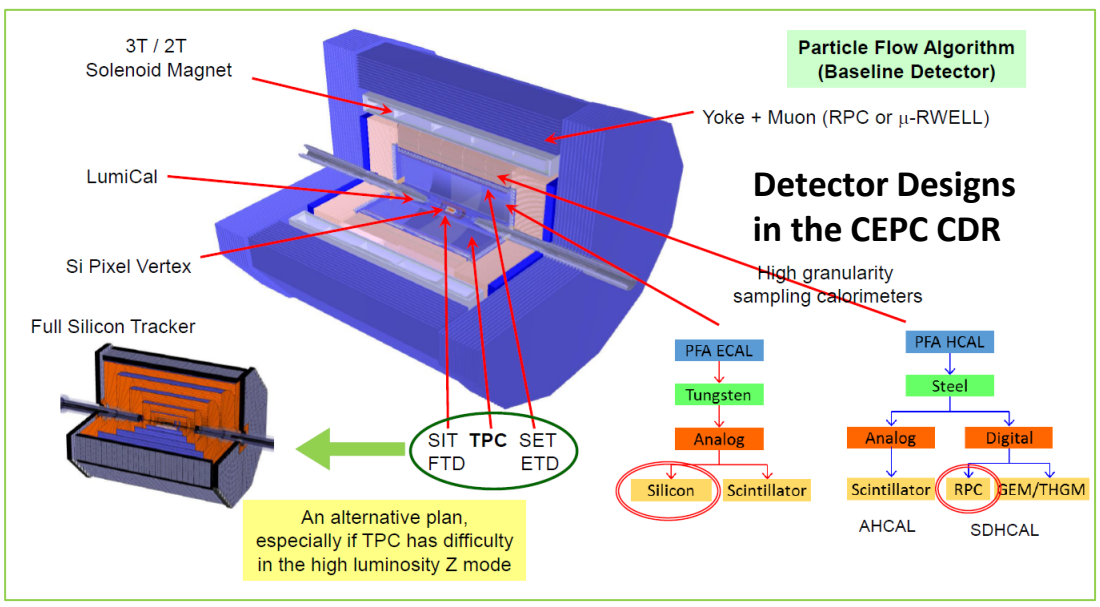
- Low gain: **10-50**
  - to improve signal slope but control noise
- Thin sensor: **~50 μm**
- Fasting timing: **~30 ps**
- Radiation hardness:
  - 2.5 × $10^{15}N_{eq}/cm^2$ and 2.0 Mgy

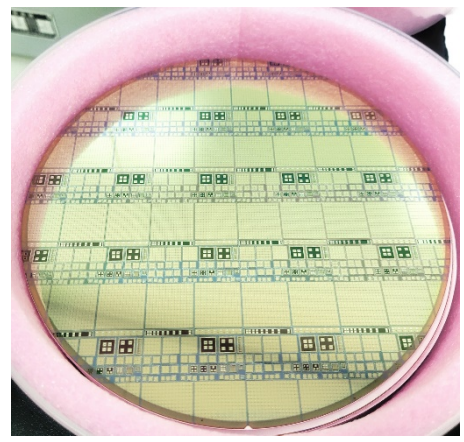
Institutions of LGAD R&D

- **IHEP(China)**
- NDL(China)
- USTC(China)
- CNM(Spain)
- HPK(Japan)
- FBK(Italy)
- BNL(America)

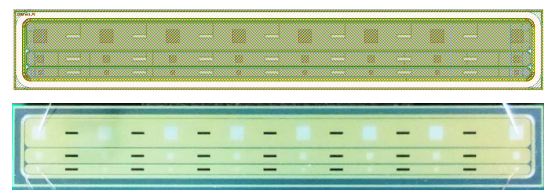
LGAD strip :

- Large area
- Low readout density
- Position information





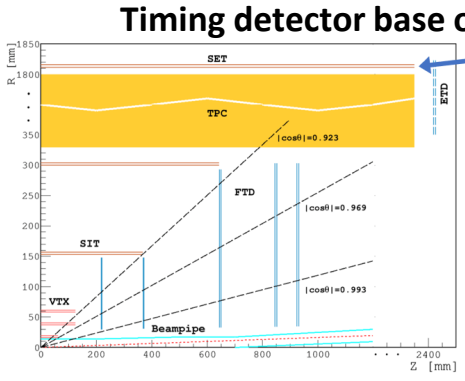
IHEP-IME LGAD wafer

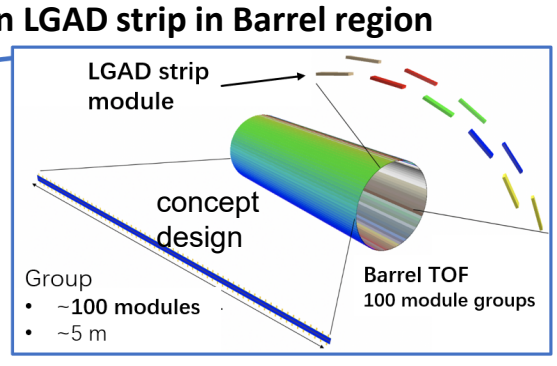


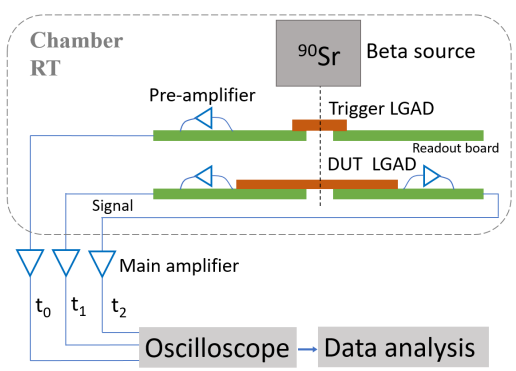
IHEP LGAD strips

- Wide：19mm×1mm
- Middle：19mm×0.5mm
- Narrow：19mm×0.3mm

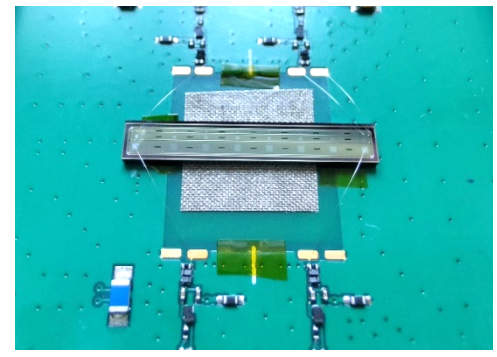
Timing detector base on LGAD strip in Barrel region





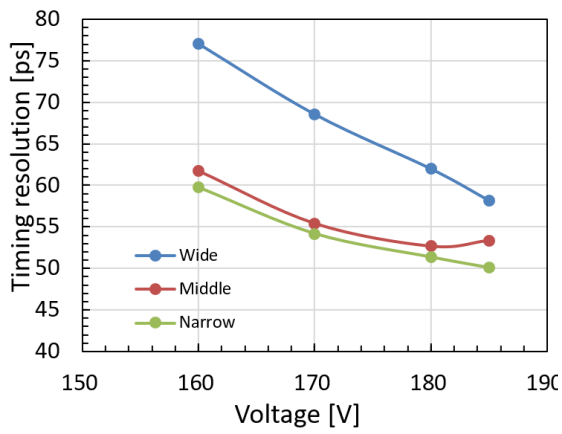


Beta source test setup

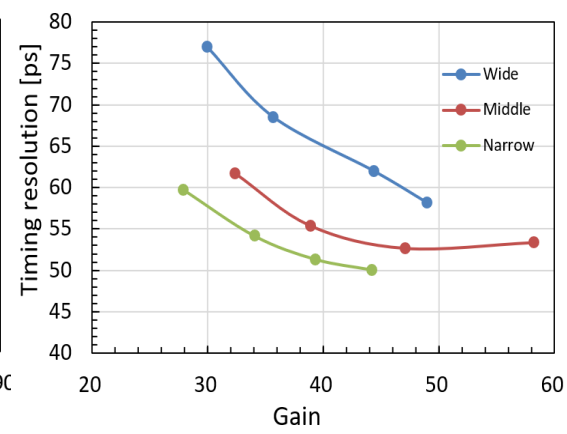


LGAD strip bonded to readout board

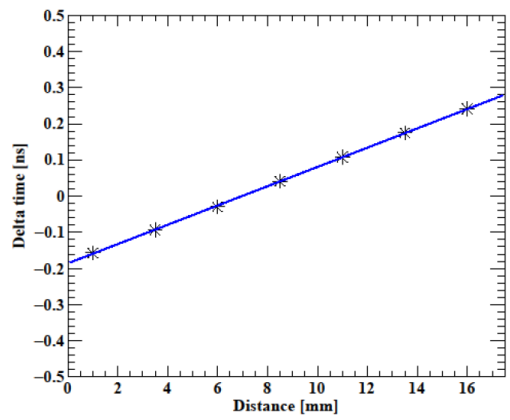
Time resolution $\sigma_t^2 = \sigma_{(t1+t2)/2}^2 - \sigma_{t0}^2$



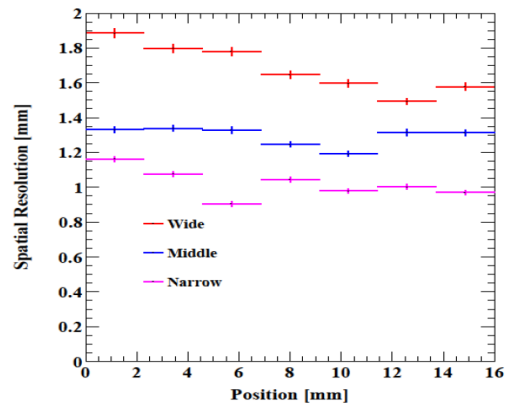
Time resolution vs. Gain



Delay time vs. hit position



Position resolution



According to the beta test and laser test, the LGAD strip with a small width has good time resolution and position resolution. The use double-ended readout method shows that narrow devices have better performance, with an optimal time resolution of 50 ps and a position resolution of approximately 1 mm. The next step is to remove the full coverage metal electrodes and place metal pads only on the ends of the strip. Increase the resistivity of the N+ layer to increase the signal difference at both ends and improve the position resolution.

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