High Luminosity LHC (HL-LHC): ATLAS Phase-II upgrade from 3-0 to 4-D tracking system (ITK+HGTDT)

- HL-LHC is foreseen to start running in ~ 2028.
- Instantaneous Luminosity: $L \approx 7.5 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$
- Integrated Luminosity (10 years): $L \approx 4000 \text{fb}^{-1}$
- Up to 200 p-p interactions per bunch crossing.

To mitigate the high pileup effect, the ATLAS detector will be upgraded: ITK+HGTDT

- Extended pseudorapidity: $|\eta| < 4.0$
- Better position resolution $\sigma_z$ on tracks in the central region.
- Two instrumented double-sided layers, silicon-based technology, 75 mm thick, built in three ring Lay-out mounted in two cooling boxes in the gap between the barrel and the end-cap calorimeter at $z \approx \pm 3.3 \text{ m}$ from the interaction point
- High precision time measurement: $30 - 50 \text{ ps}$ time resolution per track
- Assign time to each track in the forward region: $2.4 < \eta < 4.0$
- Improve pileup rejection by a factor of 6 and correct track-to-vertex association.

Performance measurements of LGAD sensors

- Data collected in 2018-2019 with 120 GeV pion beam (CBR SP) and 5 GeV electron beam (DESY)
- EUDET type telescope used for position-dependent measurements
- EUDET Trigger Logic Unit: synchronize the telescope with HGTDT DAE
- Operation inside a cooling box ($< -20 ^\circ \text{C}$).
- High-precision time measurement: $30 - 50 \text{ ps}$ time resolution per track in the forward region: $2.4 < \eta < 4.0$.
- Better than 70 ps time resolution is obtained at 4 IC for both HPK and FBK sensors at different fluences.
- HIT efficiency $> 95 \%$ at the end of lifetime (70 ps).
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HGTDT Front-End Electronics

- HIT efficiency $> 95 \%$ at the end of lifetime (70 ps).
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Low Gain Avalanche Diode (LGAD)

- Originally developed by CNM and RD50, 9- p-p detector with an additional thin ($\sim 5 \mu \text{m}$) and highly doped 10 $\mu \text{m}$ p-type multiplication layer with a high E-field.
- Internal gain $\sim 20$ (h before (a) different) $\sigma_{hit}(0.8 \%)$.
- HIT efficiency $95 \%$ at the end of lifetime.
- Excellent time resolution: $<30 \text{ ps}$ before irradiation.
- HGTDT prototypes are produced by CNM (Spain), HPK (Japan), FBK (Italy) and NDL (China).

Radiation Hardness

- Radiation tolerance: $2.5 \times 10^{17} \text{n}_\text{eq}/\text{cm}^2 \cdot \text{Mgy}$
- The operating voltage in each HGTDT section has to be increased to compensate for the radiation damage.


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