Performance of LGAD sensor for the ATLAS High-Granularity Timing Detector (HGTD)

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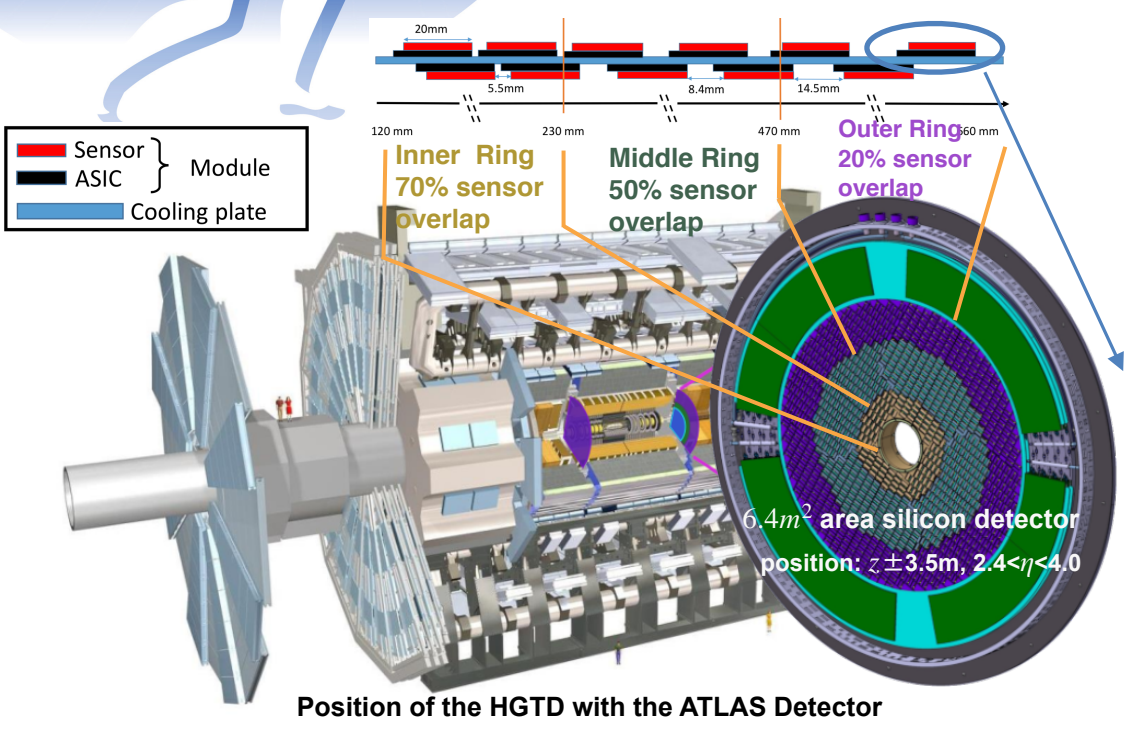
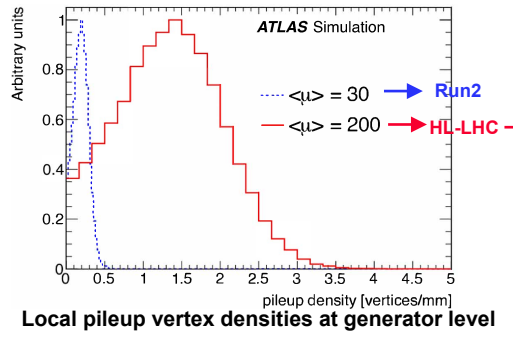
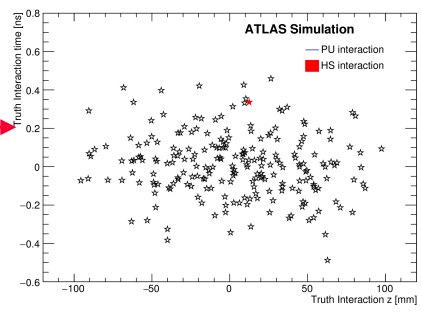
HGTD: 4-D tracking system



Position of the HGTD with the ATLAS Detector

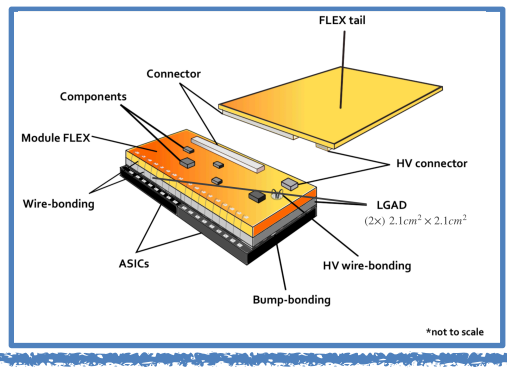


Local pileup vertex densities at generator level for two <μ>: 30 and 200



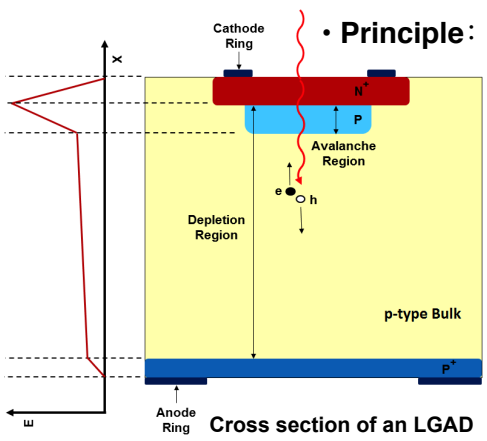
Visualization of the truth interaction in a single bunch crossing in the z-t plane

Bare module: **2 LGADs** and **2 ASICs**



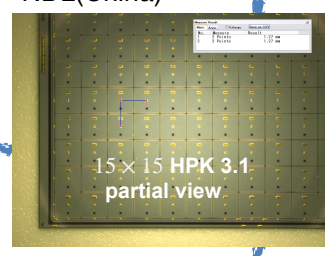
- HGTD for the **pile-up challenge** at **HL-LHC**
  - Timing resolution is required to be around 30 ps/track at beginning
  - ~3.7×10^6 channels with $1.3 \times 1.3 m^2$ readout channel
  - Radiation hardness: $2.5 \times 10^{15} N_{eq}/cm^2$ and 2.0 MGy

Sensor Technology: Low Gain Avalanche Diode (LGAD)



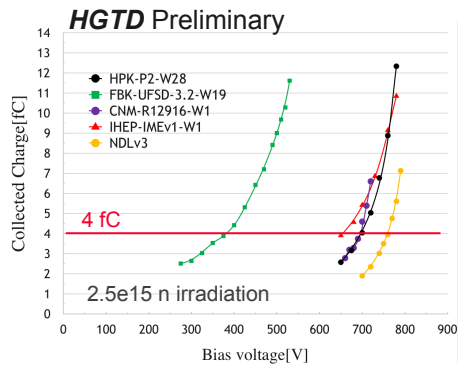
Cross section of an LGAD

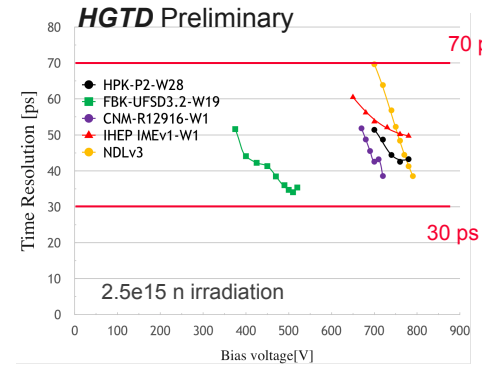
- **Principle**: **n on p** sensor with p-type multiplication layer
  - Low gain: **>10**
    - to improve signal slope but control noise
  - Thin sensor: **~50 um**
  - Fasting timing: **~30 ps** (pre-irradiation)
  - Several **prototypes** are being tested:
    - CNM(Spain), HPK(Japan), FBK(Italy), IME(China), NDL(China)



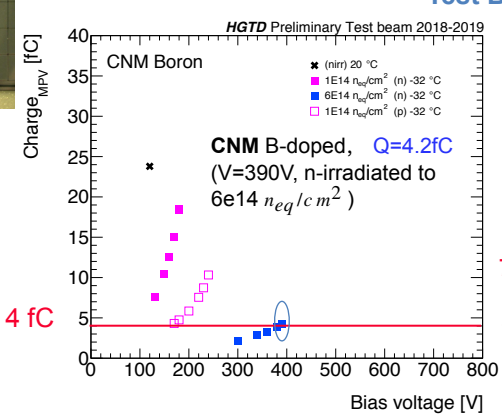
Laboratory and Test Beam Measurements for Irradiated LGADs

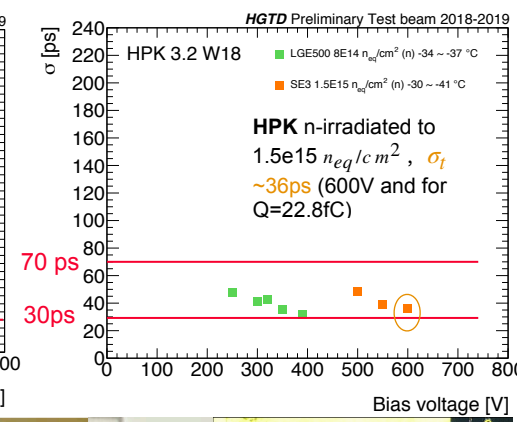
Laboratory



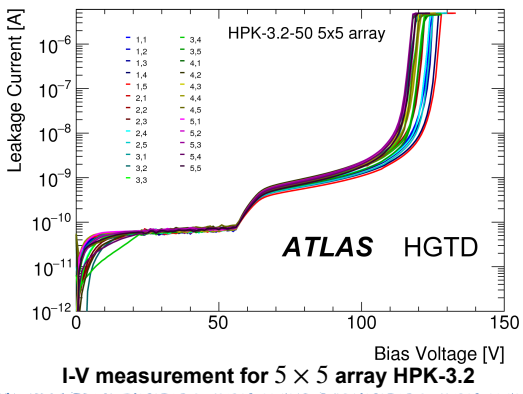


Test Beam

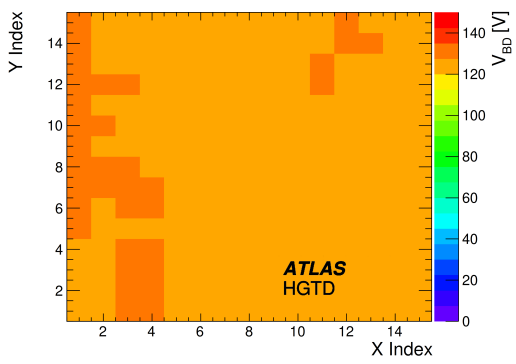




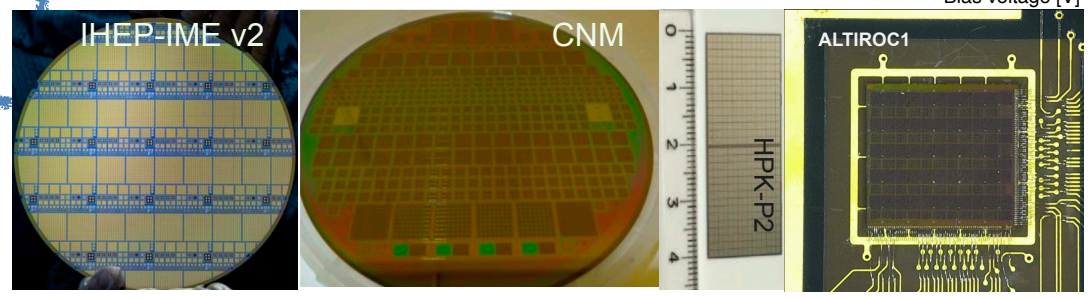
Non-Irradiated $n \times n$ LGADs Measurement in Lab



I-V measurement for 5×5 array HPK-3.2

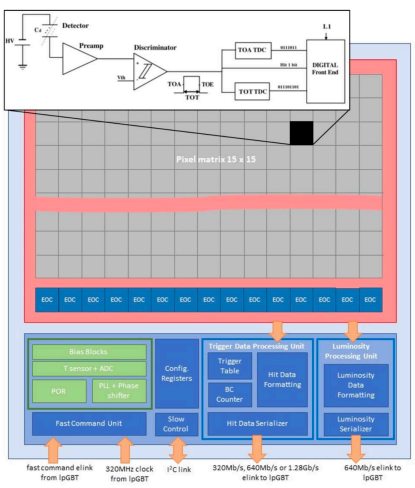


V_{BD} map of 15×15 array HPK-3.2



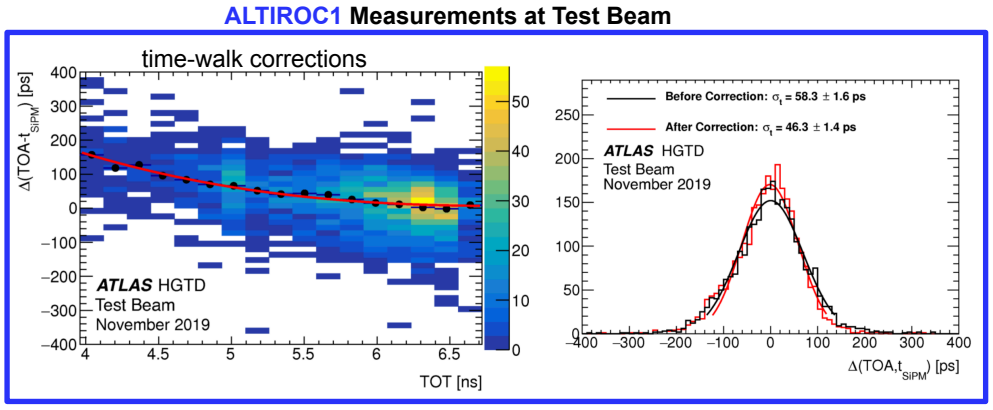
ALTIROC: ATLAS LGAD Timing Integrated ReadOut Chip

- **Ongoing** development **ALTIROC**
  - 15×15 readout channel
- **ALTIROC1**: 25 channels in 5×5 array
- Pre-amplifier, TOA,TOT
- Achieve ~25ps jitter at 4fC input charge



Global architecture of the ALTIROC ASIC

ALTIROC1 Measurements at Test Beam



- Fit TOA variation as a function of TOT for time-walk corrections
- σ_t~46ps including landau term(~25ps) with time walk correction, so jitter ~39ps
- Improved DAQ should improve jitter resolution by ~35% to achieve jitter ~25 ps

Summary

The HGTD will play a key role to mitigate the impact of pile-up at HL-LHC. LGAD technology and layout for HGTD are optimized to reach resolution better than 50 ps/track up to the end of the detector lifetime. Irradiated LGADs were tested and have shown to be able to reach the required performance.