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Database Development for the High Granularity Timing Detector

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Abstract

The large increase of pileup interactions is one of the main experimental challenges for the HL-LHC physics program. A powerful new way to mitigate the effects of pileup is to use high-precision timing information to distinguish between collisions occurring close in space but well-separated in time. A High-Granularity Timing Detector, based on low gain avalanche detector technology, is therefore proposed for the ATLAS Phase-II upgrade. The HGTD team needs to produce more than ten thousand modules during the production period, then our project is to develop a production database that will hold the history, quality control (QC) performance of components in each module, and the properties of the LGADs sensor.

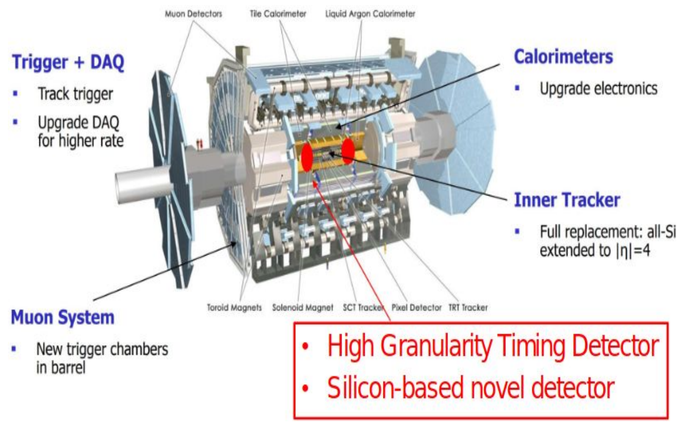
Keywords: ATLAS, Phase-II upgrade, HGTD, Module, Production Database

ATLAS Detector Phase-II upgrade for HL-LHC

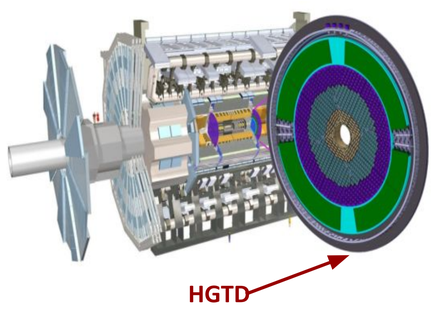
- The ATLAS detector is undergoing a significant upgrade program for all subsystems to operate in challenging HL-LHC conditions.

❑ **Luminosity up to 7.5x1034 cm-2s-1, pileup 200, irradiation level TID ~2MGy**

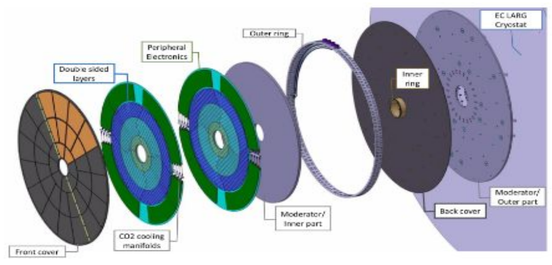
❑ **L1 trigger rate of 1 MHz. Additional 15 years of operation and maintenance**



High Granularity Timing Detector

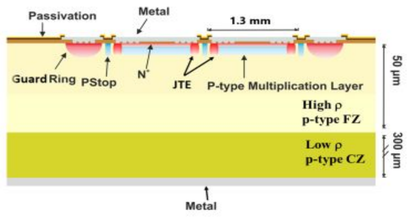


- ATLAS Phase-II upgrade detector.
- **Main goal:** improve the ATLAS functionality in the high-pileup environment provided by the HL-LHC.
- R: 120-640 mm, z: ±3.5m → 2.4<|η|<4
  7.5 cm space in z.



- Two disks on each side of the ATLAS interaction point.
- Target time resolution: **30-50 ps** per track up to **4000 fb-1.**

Sensor Technology: Low Gain Avalanche Detector

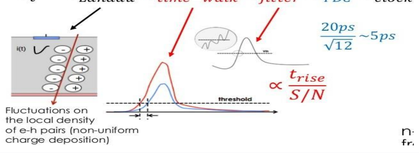


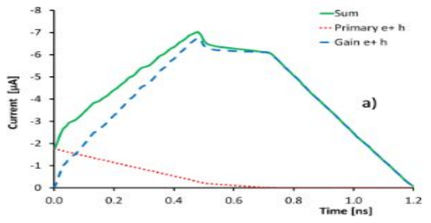
- Standard n-p Si detector with an additional p-type doped laying producing additional charge multiplication.
- Small rise time: **~0.5ns**, fast charge collection **~1 ns**.
- **50 µm** active thickness.
- Good timing requires a minimum collected charge of **4 fC/mip/hit.**

Time Resolution

$$\sigma_t^2 = \sigma_{Landau}^2 + \sigma_{time-walk}^2 + \sigma_{jitter}^2 + \sigma_{TDC}^2 + \sigma_{clock}^2$$

$$\frac{20ps}{\sqrt{12}} \sim 5ps \qquad \propto \frac{t_{rise}}{S/N}$$





Integrated Readout Chip (ALTIROC)

- Signal from each LGAD sensor will be read out using the ALTIROC chip.
  - ★ Pre-amplifier followed by TOA and TOT.
  - ★ TSMC CMOS 130nm technology. Total of 225 readout channels (15x15).
- Two prototypes of ALTIROC chips produced and tested:

★ ALTIROC0: 2016
four channels in a 2x2 array. Each channel 200x100 µm 2 = Preamplifiers + TOT and CFD

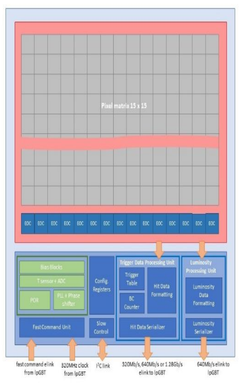
★ ALTIROC1: 2018
25 channels in 5x5 array
Preamplifiers,TOT, CFD + digital components

Ongoing development

★ ALTIROC2: 2020-2021

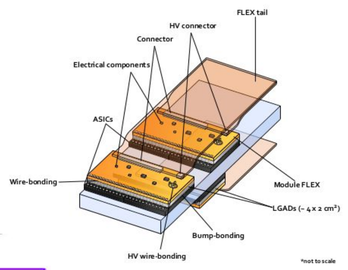
225 channels. All functionalities of final ASIC

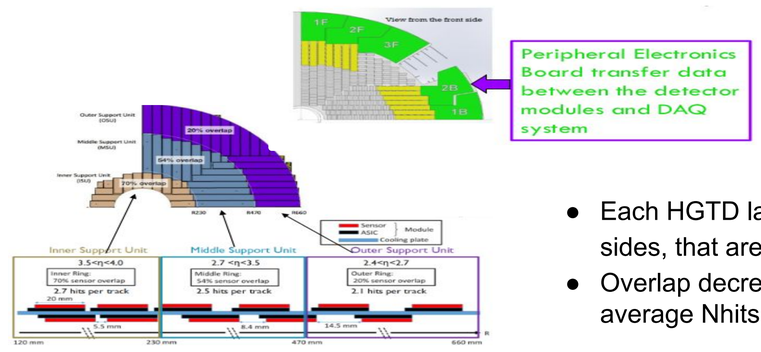
★ ALTIROC3:
Radiation hard version of ALTIROC2



HGTD Module

- Bare modules: sensor + 2 ASICs
  - ➢ Sensor: 15x30 pixels of 1.3x1.3 mm2.
  - ➢ Each sensor is bump-bonded to 2 ALTIROC chips.
- Bare module glued to flex PCB, connected to flex cable.
- Flexible tail to outer radius electronics.





- Each HGTD layer has modules on both sides, that are partially overlapping .
- Overlap decreases with R tomaintain average Nhits per track ≳2.

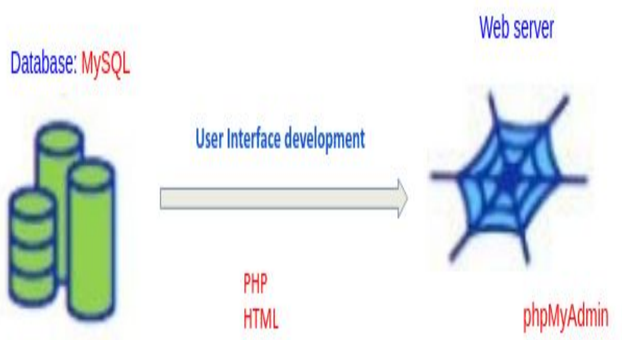
HGTD PRODUCTION DATABASE

Production Database

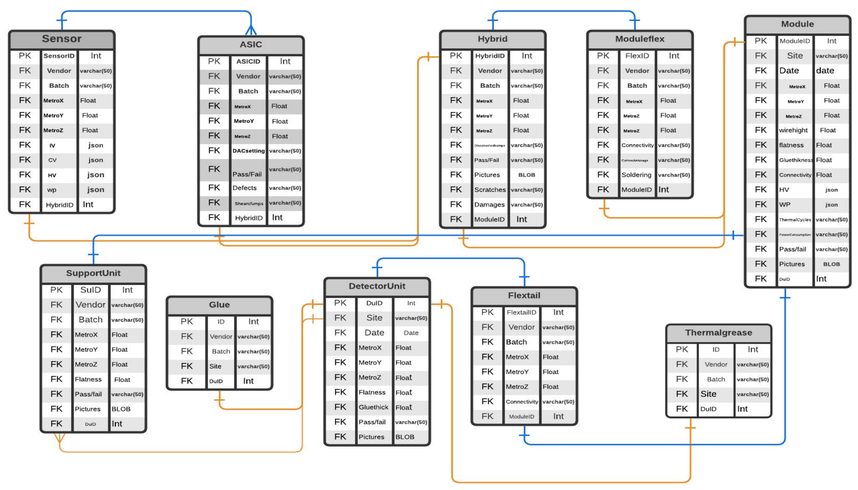
- The database is an important tool to manage the production process.
- It holds details of modules information, production quality and tests results.

Methdology

- To develop this database many technologies are used:



Database Framework



User Interface

Main Reference

[1] ATLAS Collaboration. Technical design report: A high-granularity timing detector for the atlas phase-II upgrade, CERN-LHCC-2020-007, CERN, 2020.