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GÖTTINGEN IN PUBLICA COMMODA SEIT 1737

Towards a novel silicon timing detector: ATLAS HGTD

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HEP Herbstschule

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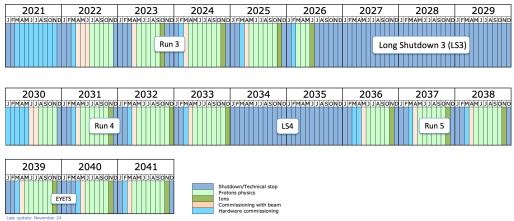
- Upgrade to HL-LHC
- HL-LHC starts with Run 4 in 2030
- Higher instantaneous luminosity by factor 5 - 7
- Targeted integrated luminosity of 3000 fb^{-1} over 10 years of operation
- Access rare events such as $H \to \mu^+\mu^-$
- Numerous hardware and technology upgrades
- New challenges for LHC experiments
- ATLAS upgraded in parallel



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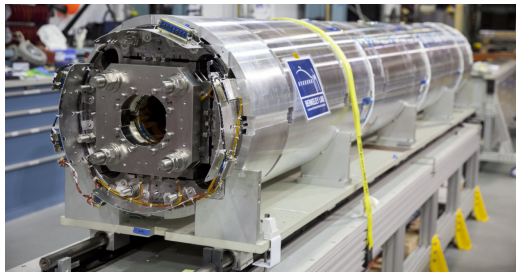

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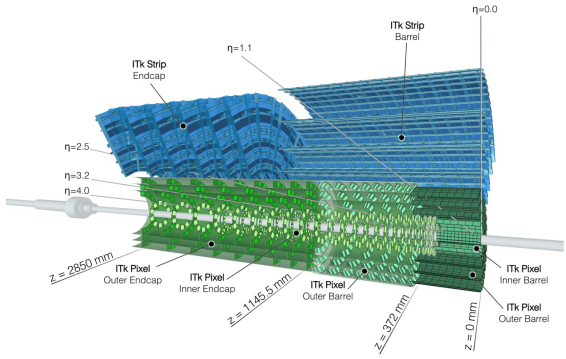
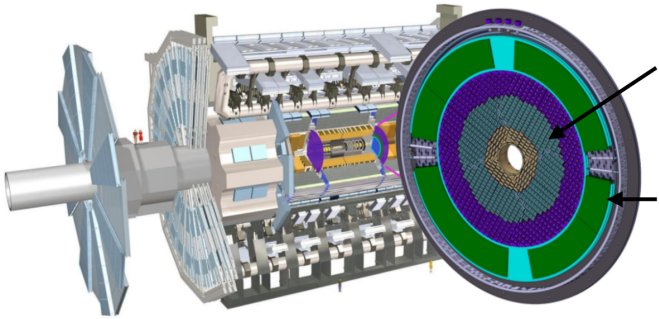
ATLAS upgrades include but are not limited to:

- Trigger + DAQ
- Electronics Upgrades
- Full silicon ITk
- **HGTD: Silicon Timing Detector**



HGTD

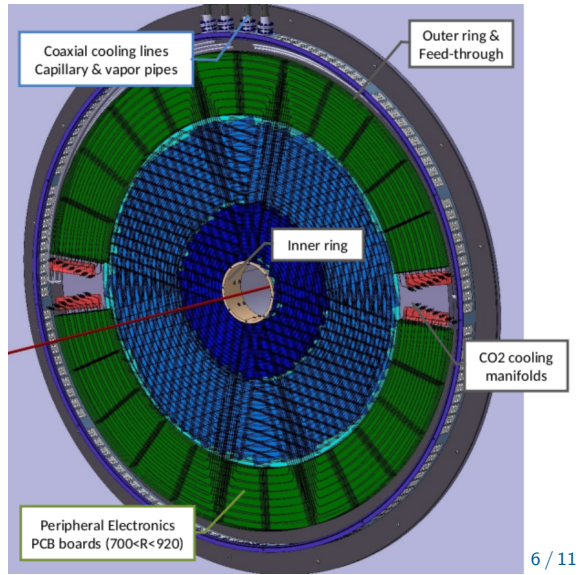
Hight Granularity Timing Detector



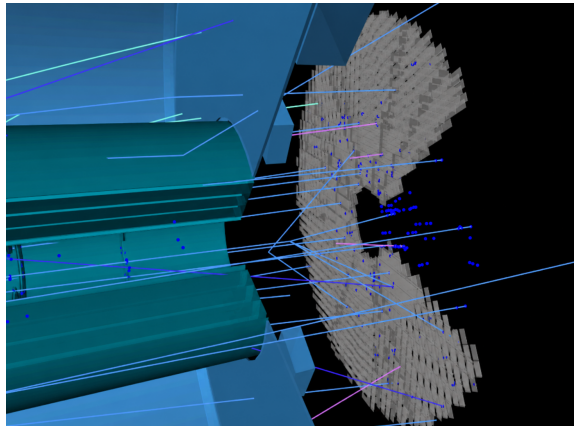
- 4D tracking hybrid Pixels
- 8032 modules
- Two instrumented double sided layers (mounted in 2 cooling disks)
- Rotated by 15°

- Detector installed on calorimeter extended barrels
- Different pixel modules designs for the different regions
- Total thickness: $< 13\,\text{cm}$

- Time measurements for objects in the forward regions of ATLAS
- $2.4 < |\eta| < 4.0$
- Active area $6.3\,\mathrm{m}^2$ (total)
- Design based on $1.3 \times 1.3\,\mathrm{mm}^2$ silicon Pixels ($2 \times 4\,\mathrm{cm}^2$ sensors)
- Operation temperature: -30°C bi-phase CO_2 cooling
- Radiation hardness up to $5.1 \times 10^{15}\ n_{\mathrm{eq}}/\mathrm{cm}^2$ and $4.7\,\mathrm{MGy}$
- Chip: ALTIROC ASIC: ATLAS LGAD Timing Integrated ReadOut Chip (CMOS)



- Resolve close-by vertices
  - precise timing measurements (resolution of 30-50 ps)
- Instantaneous and unbiased luminosity measurement
- Jet pile up rejection
- Lepton isolation with time stamp



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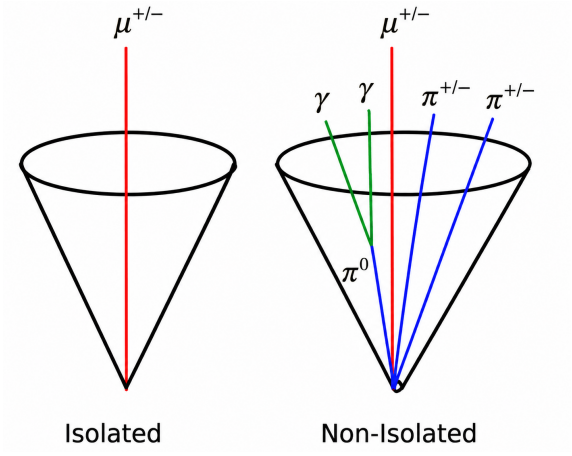
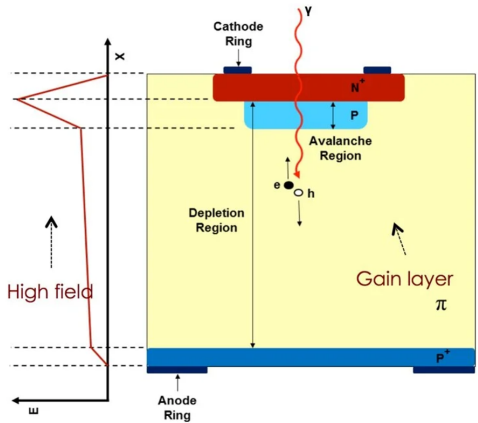


LGAD

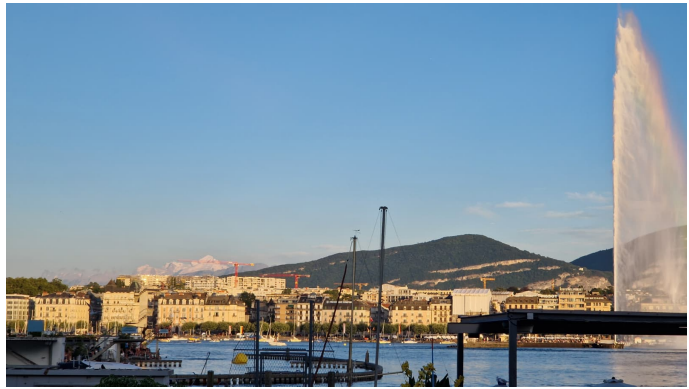
Low Gain Avalanche Detector

- Silicon sensor with highly doped gain layer
- Creates strong electric field ($\sim 300\,\mathrm{kV/cm}$)
- Controlled charge carriers avalanche multiplication
- Internal gain typically 10–30
- Increased signal-to-noise ratio
- Enables precise timing measurements with a resolution of 30–50 ps



Outlook

- Full HGTD integration at CERN 2027-2029
- Testing of modules and detector units during assembly
- Development of full quality-assurance procedure for surface assembly
- Final quality checks at cool
- Full system tests of the electronics and readout chain
- Commissioning of the HGTD within ATLAS and integration with the trigger and data-acquisition system during LS3

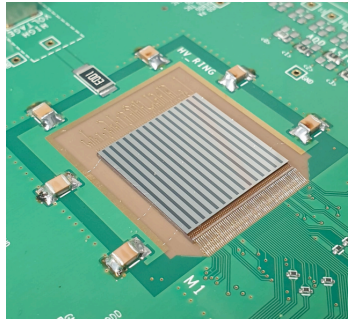


Thank you for your attention.

Backup

ALTIROC ASIC

The Chip



- Custom front-end ASIC developed for ATLAS HGTD
- 15×15 matrix of LGAD pads (225 channels)
- Measures Time-of-Arrival (ToA) and Time-over-Threshold (ToT)
- Two integrated TDCs with ~ 20 ps precision
- Low-jitter preamplifier and discriminator chain
- Power consumption <4.5 mW per channel
- Designed for operation in the HL-LHC radiation environment
- Enables a combined timing resolution of 30–65 ps per hit with LGAD sensors