

Characterization of ALTIROC-A modules for the ATLAS HGTD

TIDPAN 2026 - Taller de Instrumentación y Detectores en Física de Partículas, Astropartículas y Nuclear

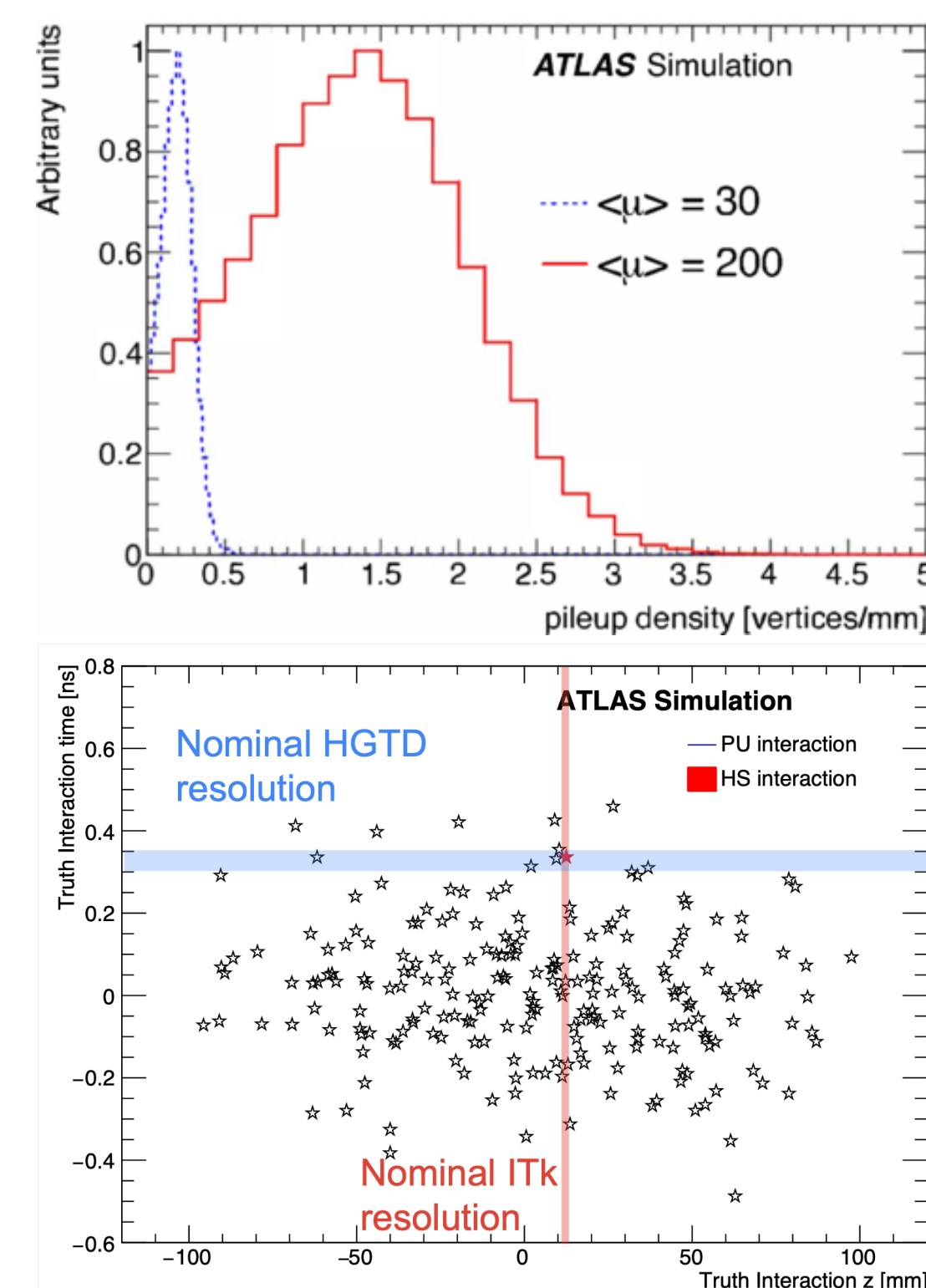
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High Luminosity LHC

HL-LHC main challenges:

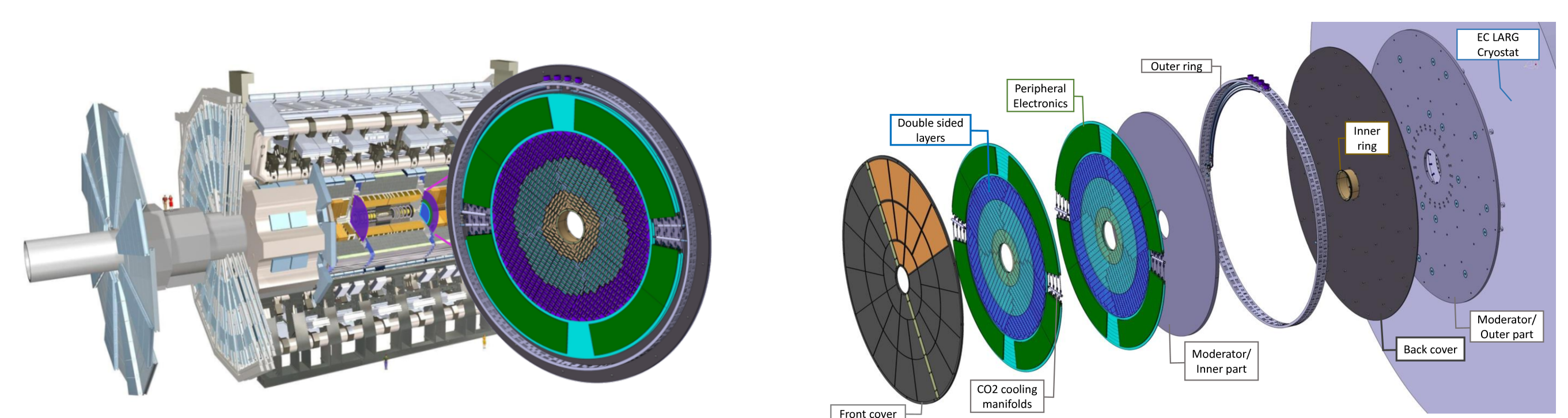
- Increase in instantaneous luminosity and pile-up
- Degraded longitudinal impact parameter resolution in forward region
- Reduced track-to-vertex association performance

Solution: precise timing in the forward region



High Granularity Timing Detector

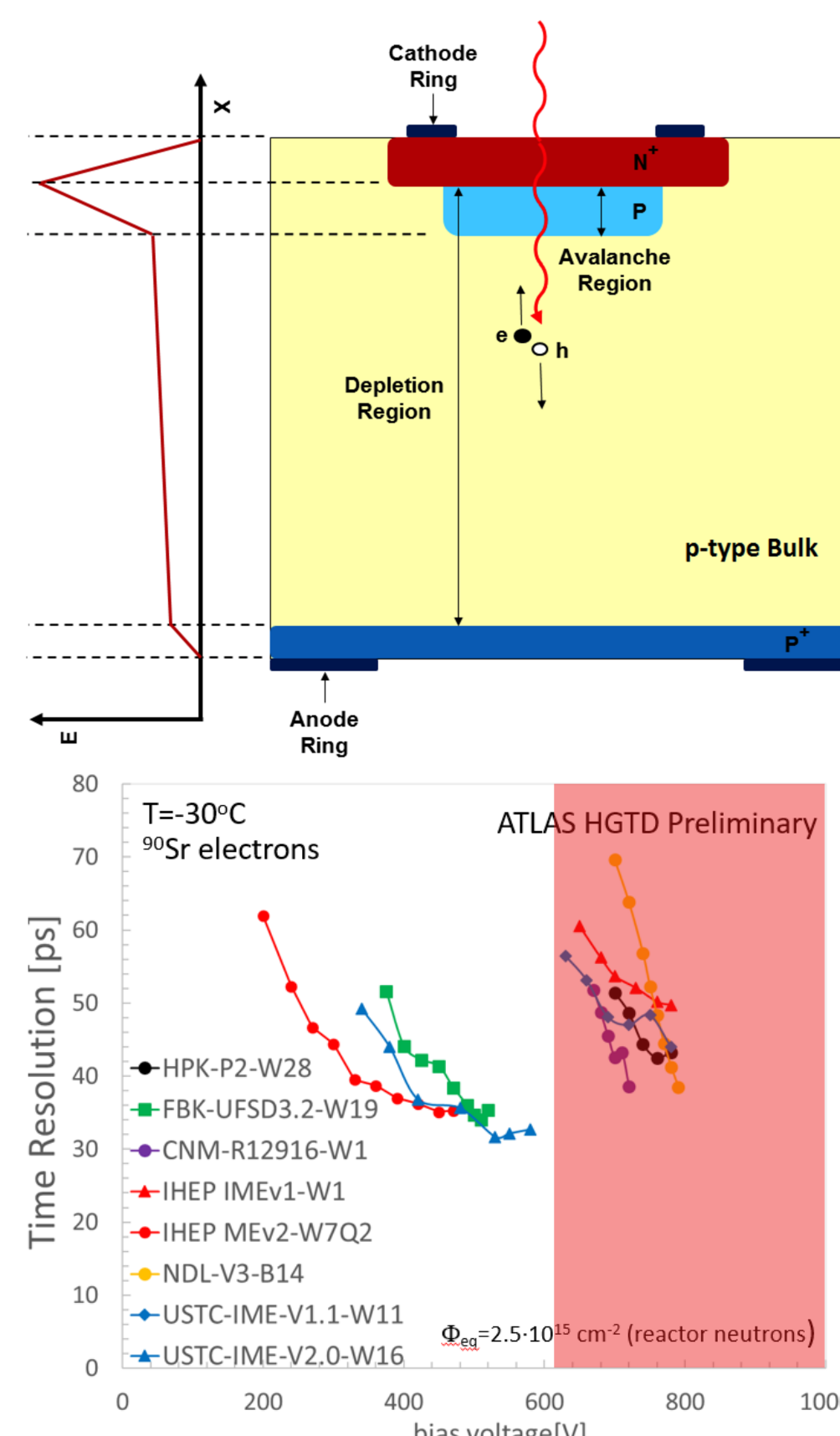
- Double-sided disks at ± 3.5 m from the interaction point
- Coverage: $2.4 < |\eta| < 4.0$, $120 \text{ mm} < r < 640 \text{ mm}$
- Radiation hard up to $2.5 \times 10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$ and 2 MGy
- **Time resolution:** 50 (70) ps per hit and 35 (50) ps per track at the start (end) of its lifetime [1]



HGTD Sensor and ASIC

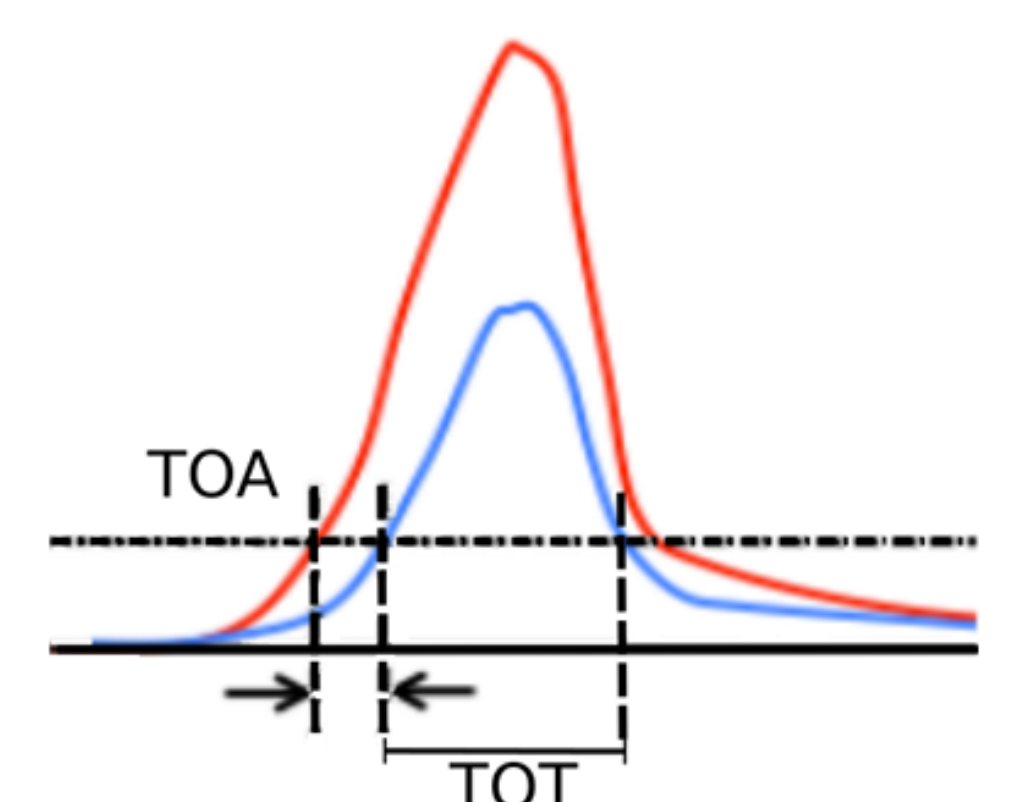
Low Gain Avalanche Detector (LGAD):

- n-on-p structure with additional p-type gain layer
- Low gain for fast signal rise time and enhanced S/N ratio
- 15×15 pads ($1.3 \times 1.3 \text{ mm}^2$ each), thickness $775 \mu\text{m}$ (active thickness $50 \mu\text{m}$)
- Carbon enriched gain layer for radiation hardness
- **Collected charge:** 10 fC (start) - 4 fC (end)
- **Hit efficiency (gain region):** 97% (start) - 95% (end)



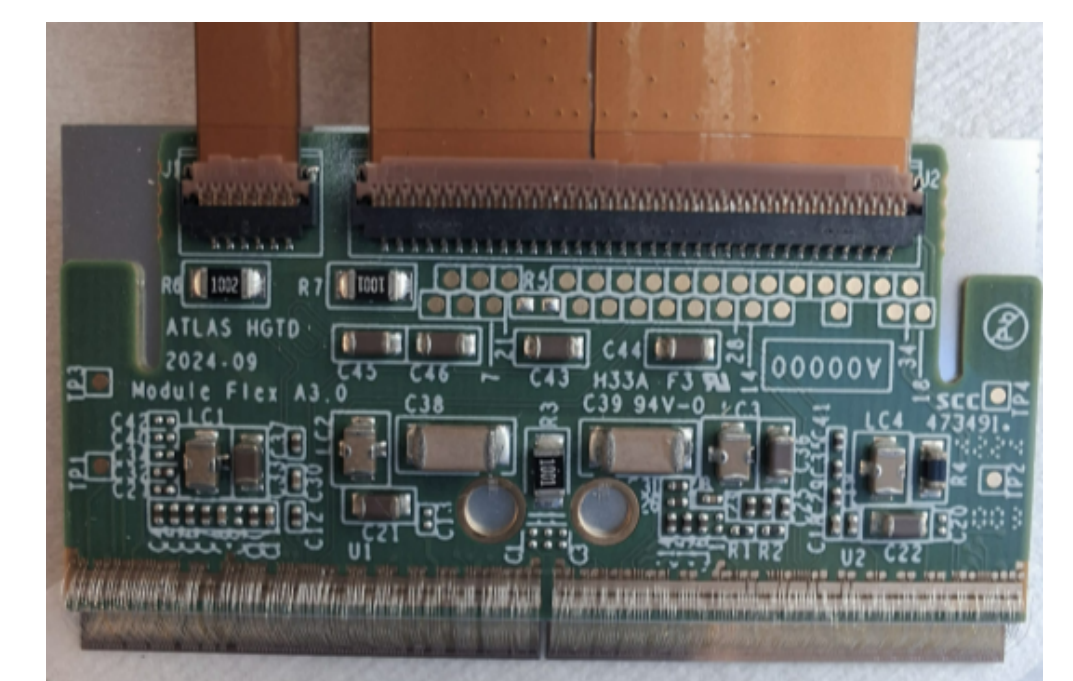
ALTIROC ASIC:

- Provides **Time-of-Arrival (ToA)** and **Time-over-Threshold (ToT)** measurements
- Per-bunch luminosity measurements
- Final version: ALTIROC-A



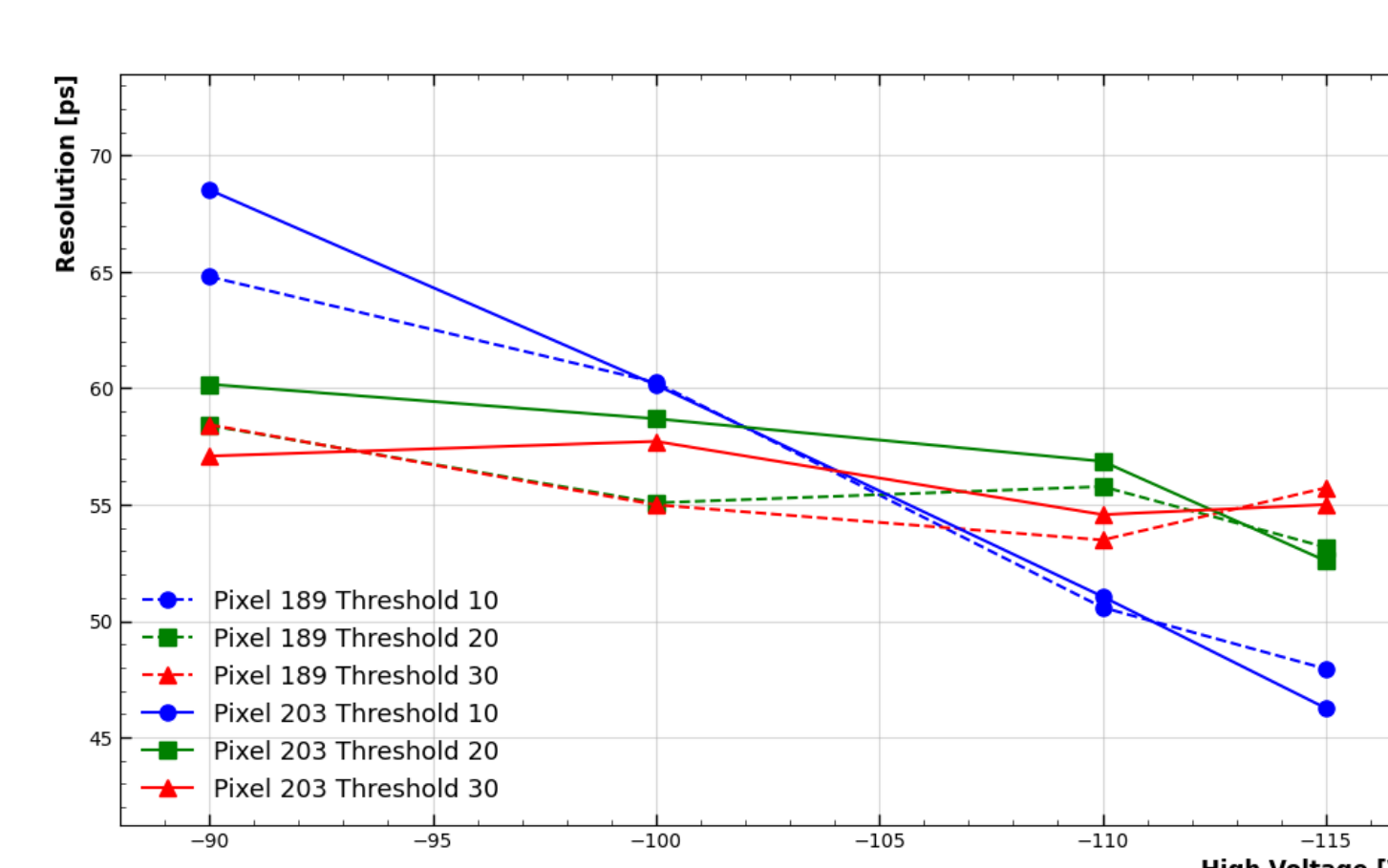
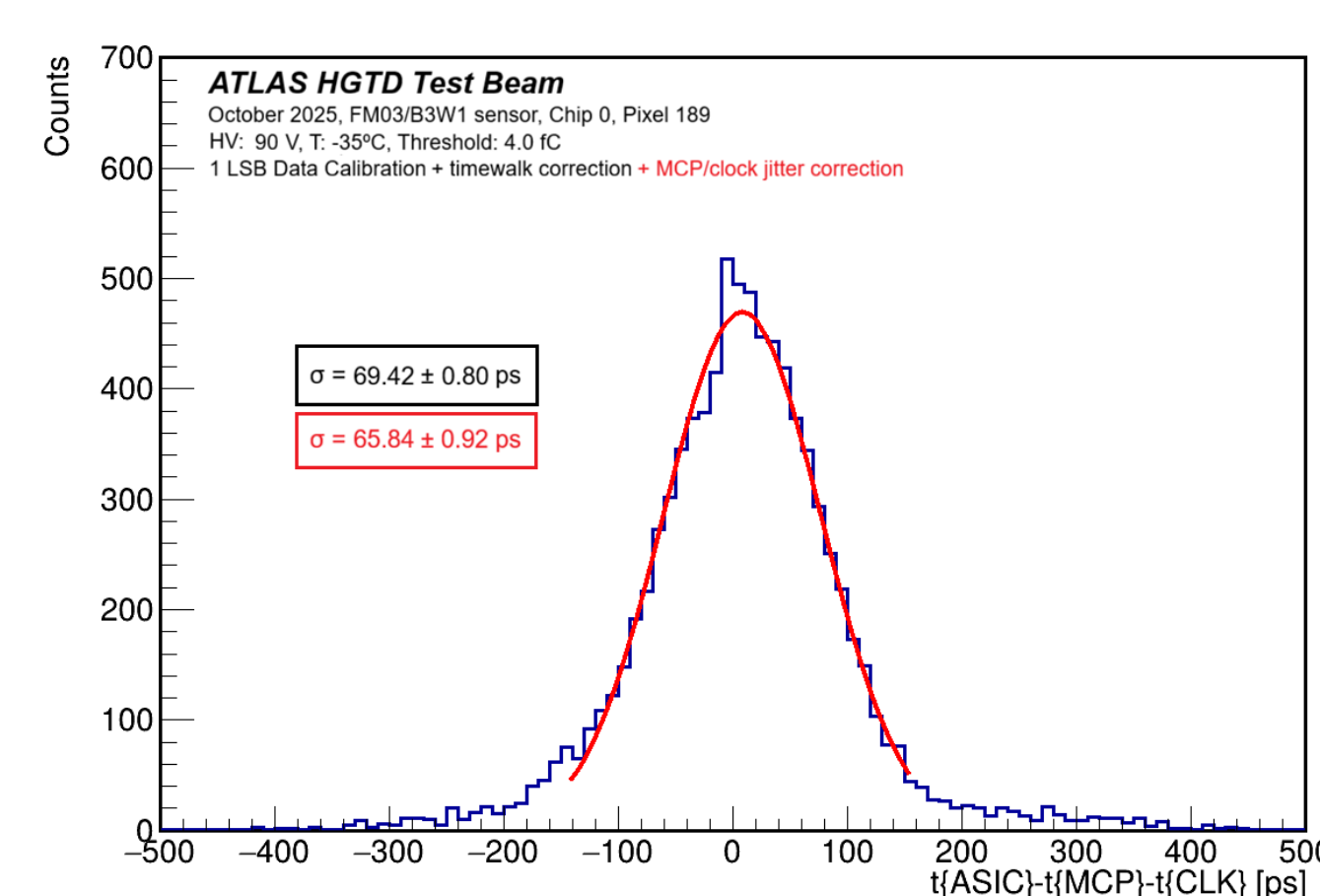
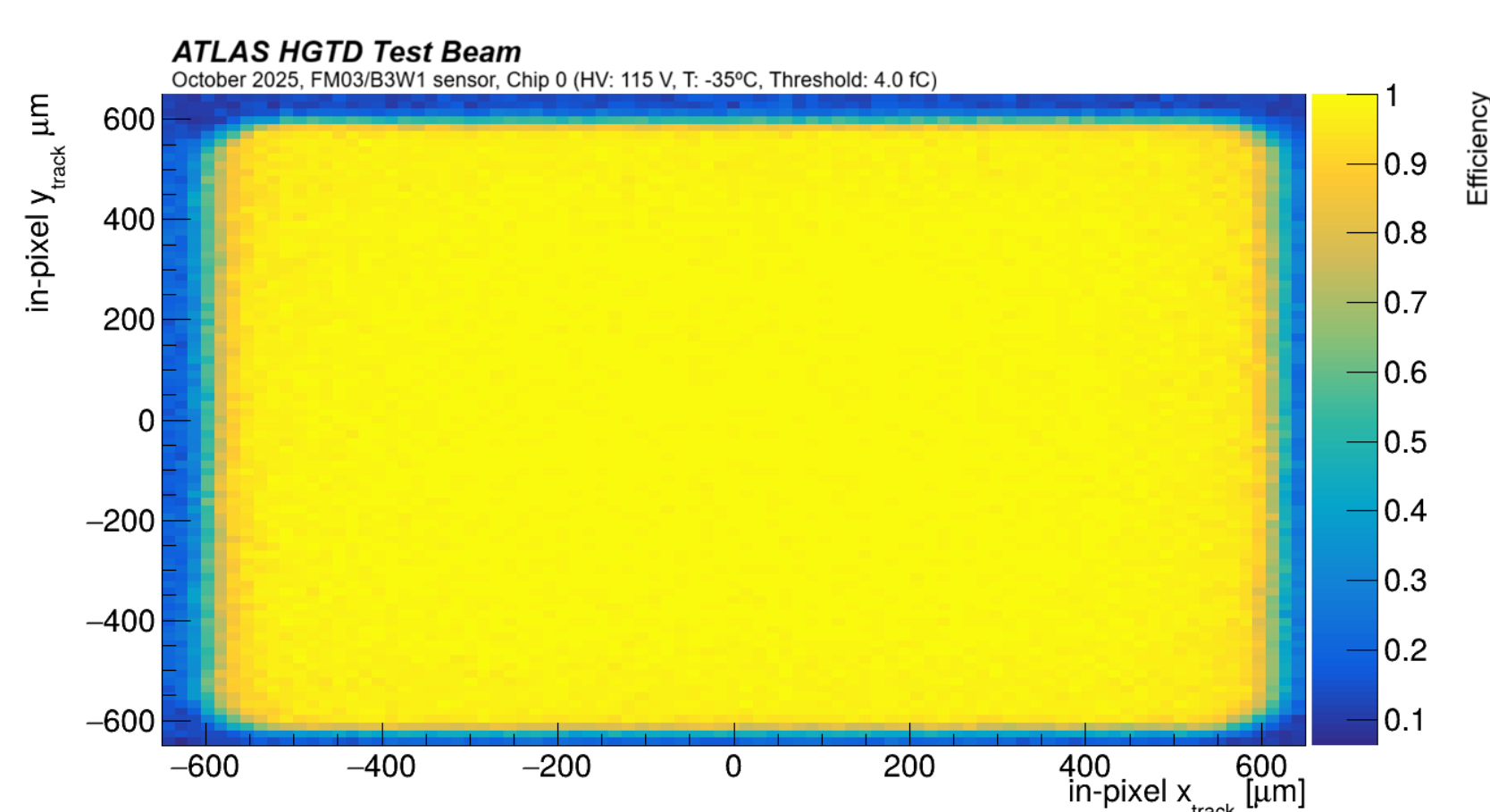
HGTD module:

- Two LGAD sensors bump-bonded to two ALTIROC ASICs
- 8032 modules to be produced



Test beam results

- Test beam measurements with AIVin software on ALTIROC-A modules at CERN SPS and DESY
- Module tuned at -30°C at thresholds from 4 fC to 12 fC and with bias voltages from -90 V to -115 V
- Hit efficiency above 98% in the gain region
- Time resolution below 50 ps for highest bias voltage point
 - Resolution after timewalk and clock jitter corrections



Conclusions

- HGTD will mitigate the pile-up effects for the HL-LHC
- Module assembly and testing pre-production ongoing
- Full ALTIROC-A modules tested at test beam with time resolution below 50 ps
- Plans to test irradiated modules at test beam

References

- [1] Technical Design Report: A High-Granularity Timing Detector for the ATLAS Phase-II Upgrade. Technical report, CERN, Geneva, 2020.

Aknowledgments

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