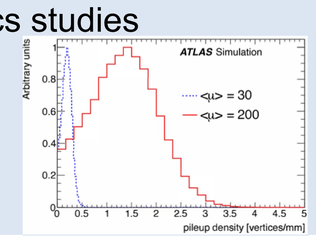
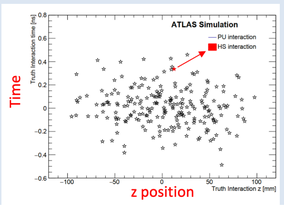
Test for Qualification control test structure in HGTD (High-Granularity Timing Detector)

The 9th Edition of the Chinese Large Hadron Collider Physics Conference,
November 16-20, 2023

HL-LHC upgrade

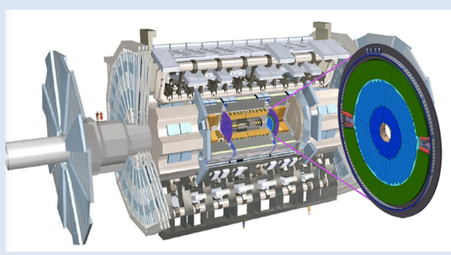
- Plan to start running in 2028
- Peak instantaneous luminosity: ~$7.5 \times 10^{34} \mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Integrated luminosity: ~4000 fb-1
- Average of 200 simultaneous p-p interaction(< μ>=200) per bunch crossing
- High vertex density leads to challenges in physics studies

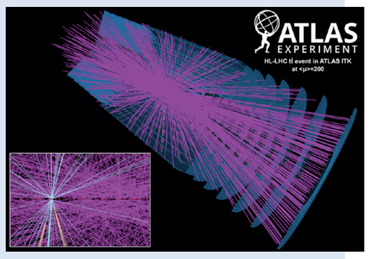




ATLAS HGTD project

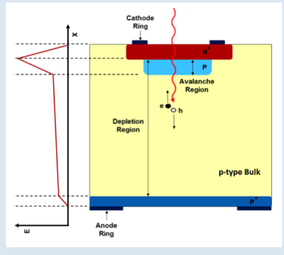
- The HGTD (High-Granularity Timing Detector) can provide time information
- High precision timing to mitigate pileup effects
- Coverage: 2.4 < |η| < 4.0
  110 mm < R < 1000 mm
- Time resolution per track: 30 ps
- Sensor technology: LGAD (Low-Gain Avalanche Detector)
- Potential LGAD vendors: CNM, FBK, BNL, HPK, IHEP-IME, USTC-IME...

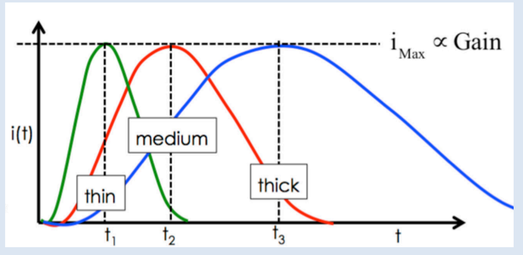




Design parameters of LGAD

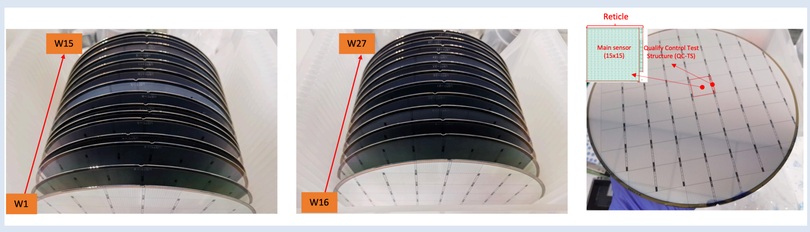
- N-in-p silicon detectors with an extra highly-doped gain layer
- High electric field in gain layer
- Active layer thickness: 50 μm
- Pad size: 1.3 x 1.3 mm^2
- Hit efficiency: > 95%
- Time resolution per hit: 35 ps (start), 70 ps after 1.5MGy (end of lifetime)
- Radiation tolerance: 1.5MGy $2.5 \times 10^{15} \mathrm{n_{eq}cm}^{-2}$

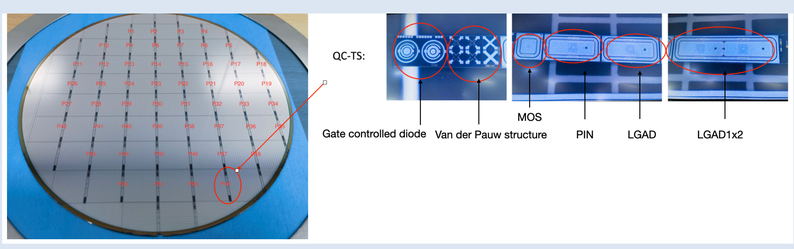




Qualification control test structure(QCTS)

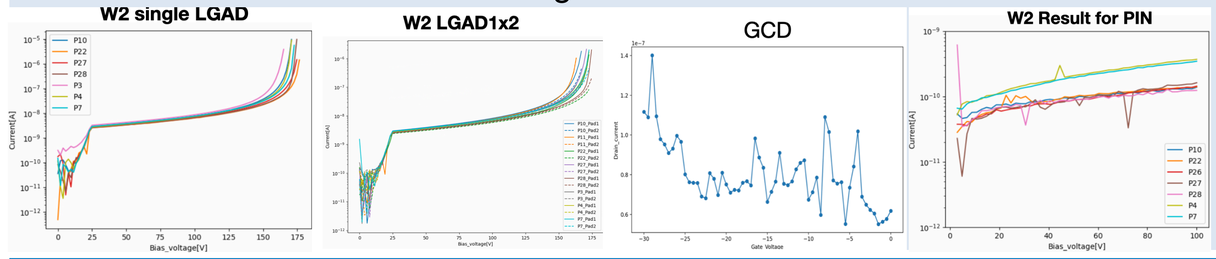
- QCTS will be used by CERN to monitor the production process and perform quality assurance measurements on the Supply for LGAD
- LGAD test Sensors with the same gain layer design properties as the Sensors organized as:
  - single pad LGAD
  - 1×2 LGAD
- Process control test structure that will provide diagnostic capability. It shall be composed of:
  - PIN diode
  - MOS capacitor
  - Gated diodes
  - Van der Pau structures





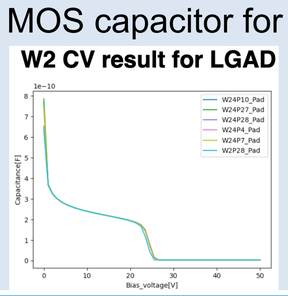
IV Test in QCTS

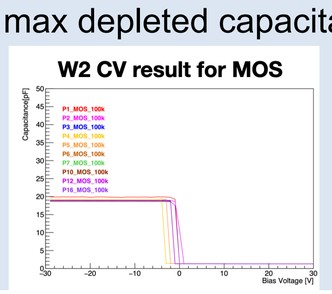
- IV Test for LGAD and LGAD 1×2 to calculate the break down voltage
- IV Test for gate controlled diode to calculate surface current
- IV Test for PIN to calculate the gain in LGAD



CV Test in QCTS

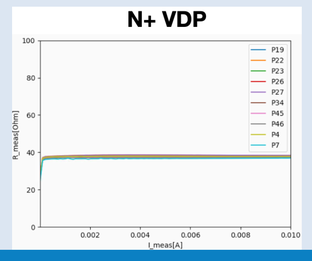
- CV Test for LGAD to calculate Gain Layer depletion voltage
- CV Test for MOS capacitor for max depleted capacitance and thickness of oxide

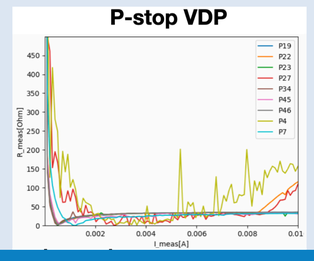




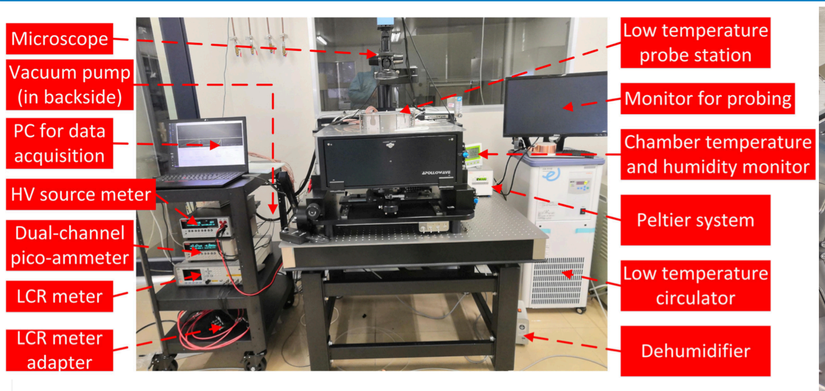
Resistance Test in QCTS

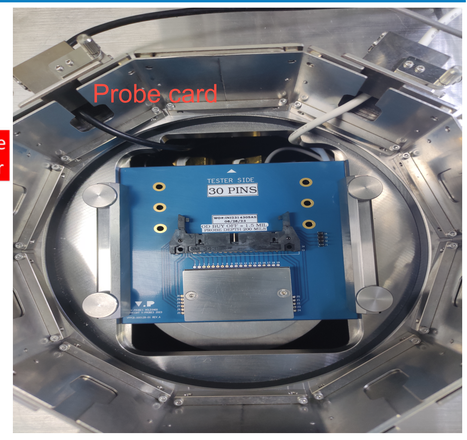
- Resistance Test for Van der Pau structures

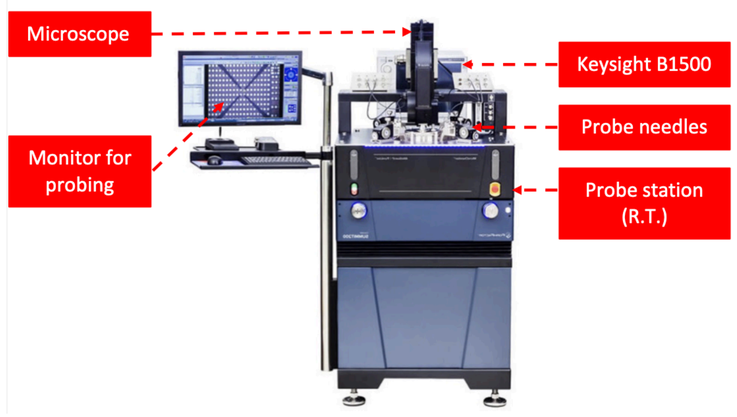




HGTD test Setup in USTC







Conclusion

- QCTS will provide diagnostic capability to production process and perform quality assurance measurements for LGAD
- We have set up test system with capability to conduct large-scale testing of samples.
- From now on, most of the test result are in our expected range but some result still needs to be understood

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On behalf of ATLAS HGTD Collaboration