LGAD & AC-LGAD Testbeam Analysis Results at the ANL

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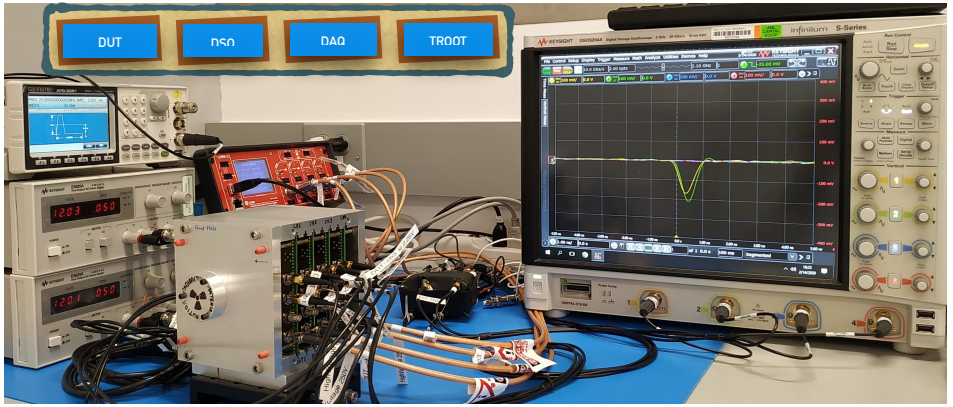
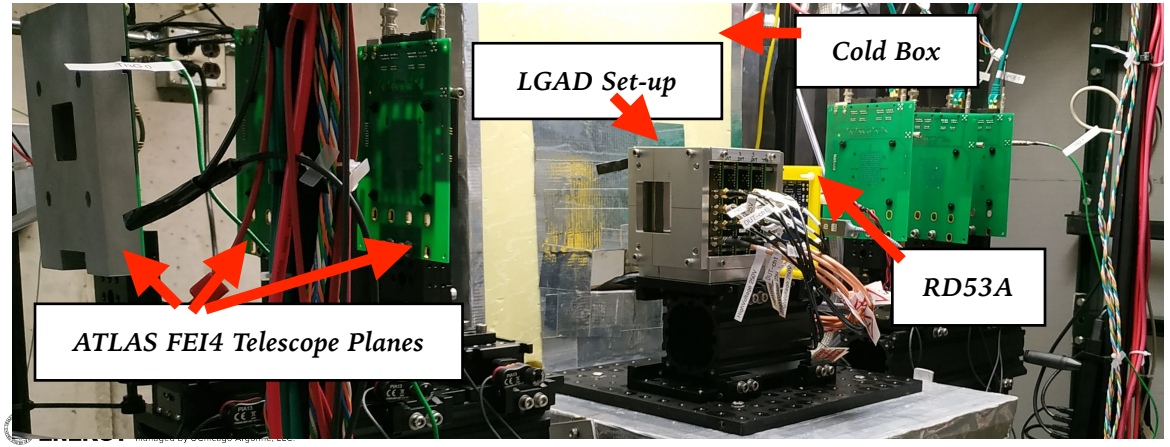
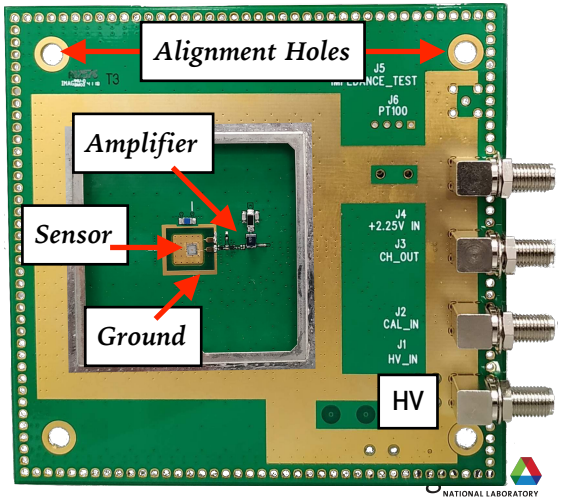
LGAD Testing Setup

- **Single channel readout board**
  - Tested HPK 1.2 and HPLK 3.1 (2020)
  - W2004 fabricated at BNL (2021)
- **AC-LGADs (BNL) + 16-Ch. Boards (FNAL)**
- **120 GeV Proton Beam at Fermilab**
  - Data were collected in spills of 4 sec
  - Trigger rate between 1 and 5 Hz

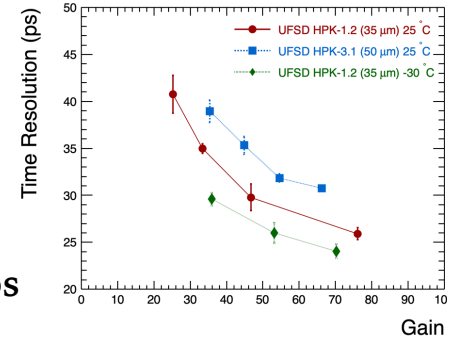


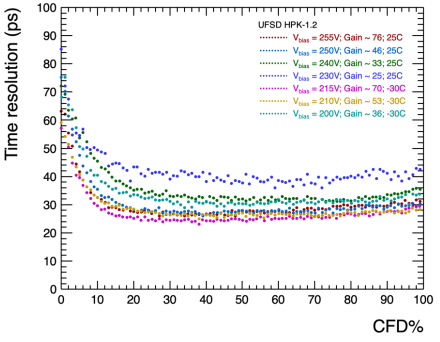


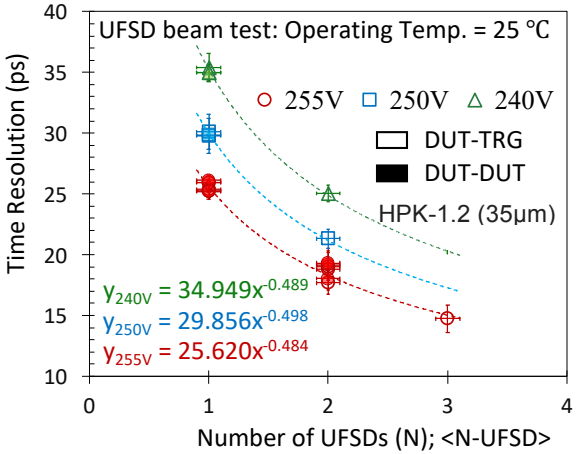


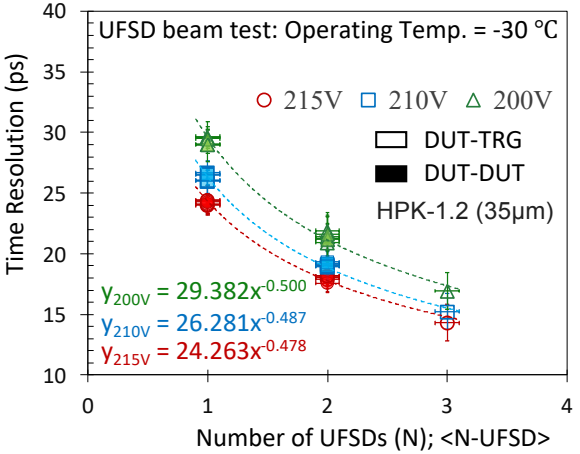
Testbeam Measurements Last Year (2020)

- Timing resolution for 3 layers of LGADs (HPK1.2)
- Timing resolution improves at low temperature but restricted by the lower breakdown voltage
- Very short rise time of ~350-400 ps were obtained
- M. Jadhav et al 2021 JINST 16 P06008, arXiv:2010.02499
  - Achieved **timing resolution of 14.31 ± 1.52 ps**
  - Fastest test beam measurements to date





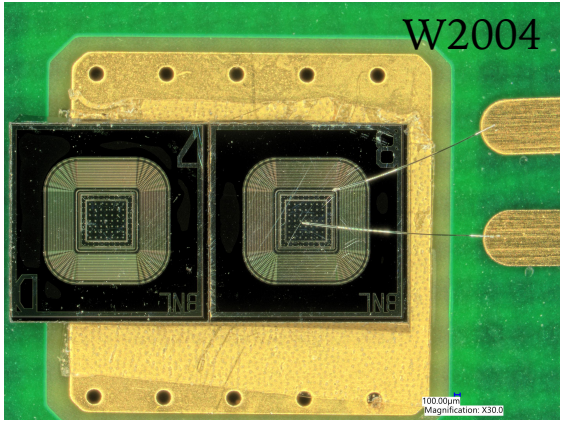


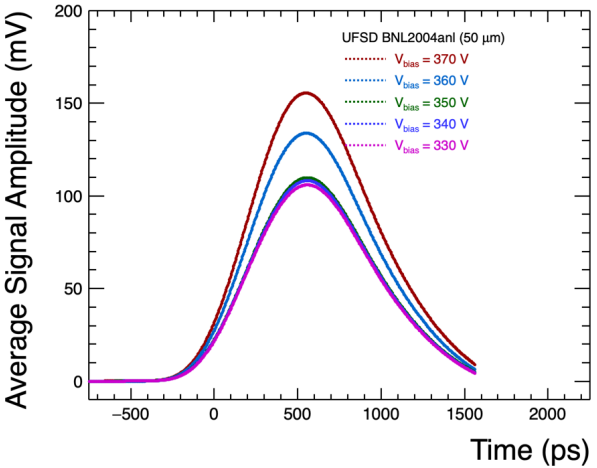


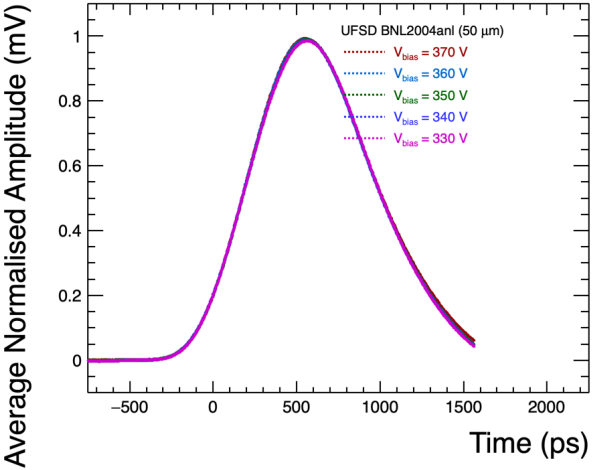
LGAD Testing for W2004 BNL sensor

Test beam campaign for LGADs (2021)

- Sensor LGAD W2004
- Single channel readout board (SCIPP)
- Pad size 1 mm × 1 mm; BreakDown ~ -350V
- Tests performed at room temperature and at -30 °C
- Data taken at different bias voltages



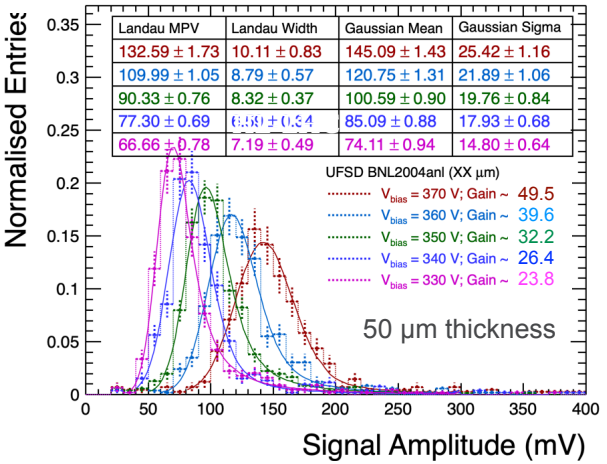


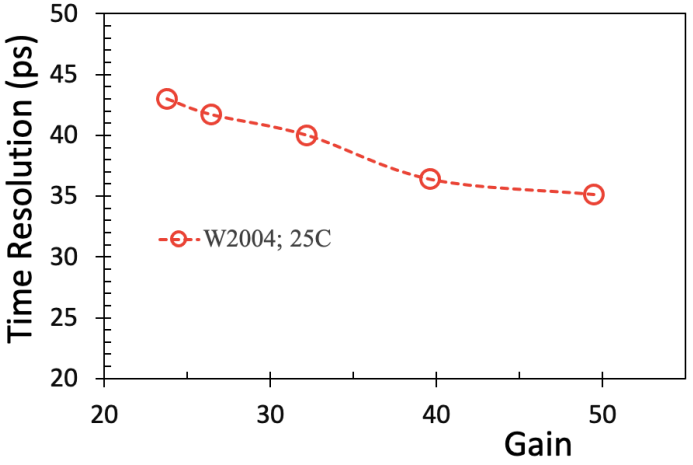


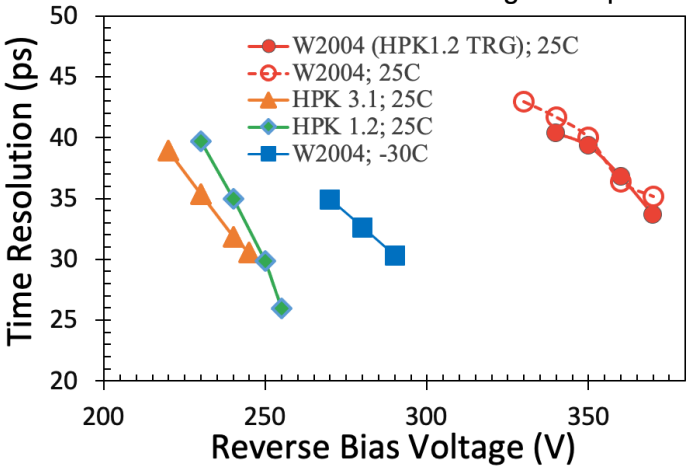
LGAD Testing for W2004 BNL sensor

Test beam campaign for LGADs (2021)

- Sensor LGAD W2004
- Pulse amplitude (Landau + Gaussian)
- Time Resolution vs. gain (and reverse bias)
- BNL's LGADs show performance comparable to HPK
  - Leakage current <1nA; High gain, up to ~50



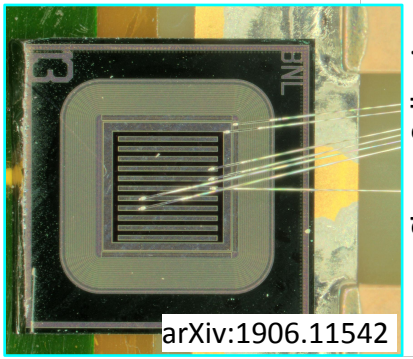


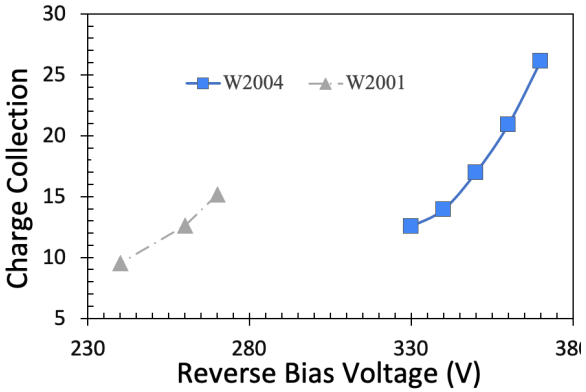


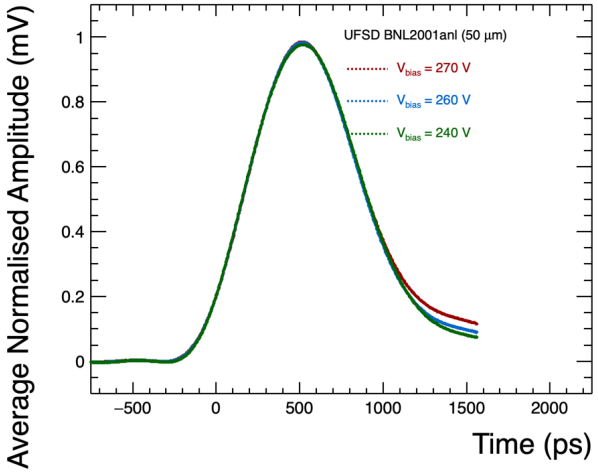
LGAD Testing for W2001 BNL sensor

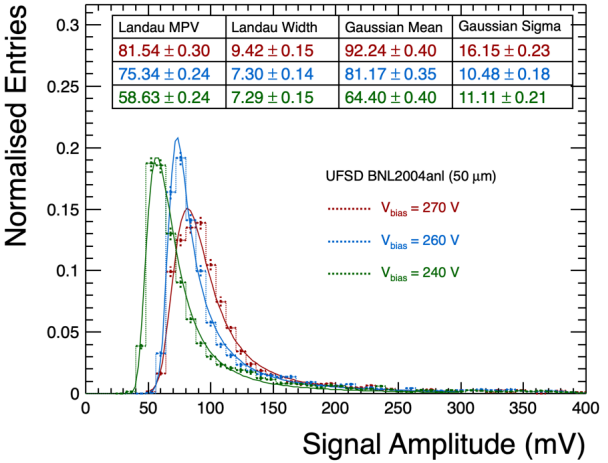
Test beam campaign for LGADs (2021)

- Sensor LGAD W2001
- Pad size 2 mm × 2 mm; Pitch 150 µm
- BreakDown ~ -270V
- Single strip it connected to the Board
- Neighboring guard rings grounded







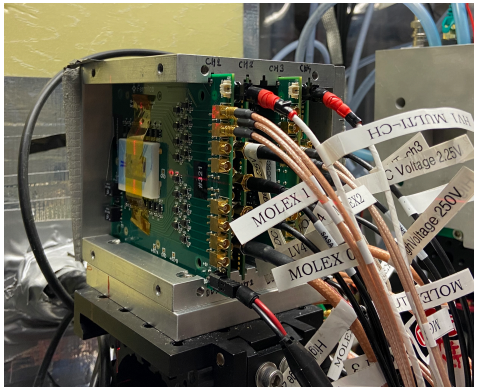


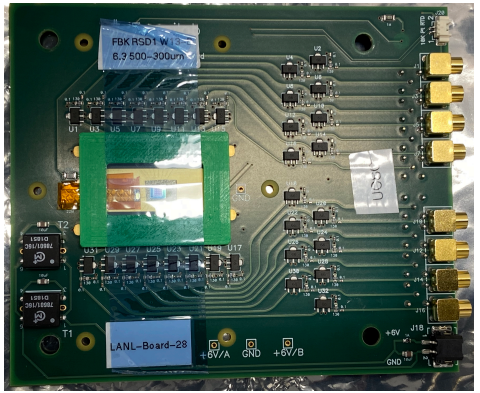
Landau MPV	Landau Width	Gaussian Mean	Gaussian Sigma
81.54 ± 0.30	9.42 ± 0.15	92.24 ± 0.40	16.15 ± 0.23
75.34 ± 0.24	7.30 ± 0.14	81.17 ± 0.35	10.48 ± 0.18
58.63 ± 0.24	7.29 ± 0.15	64.40 ± 0.40	11.11 ± 0.21

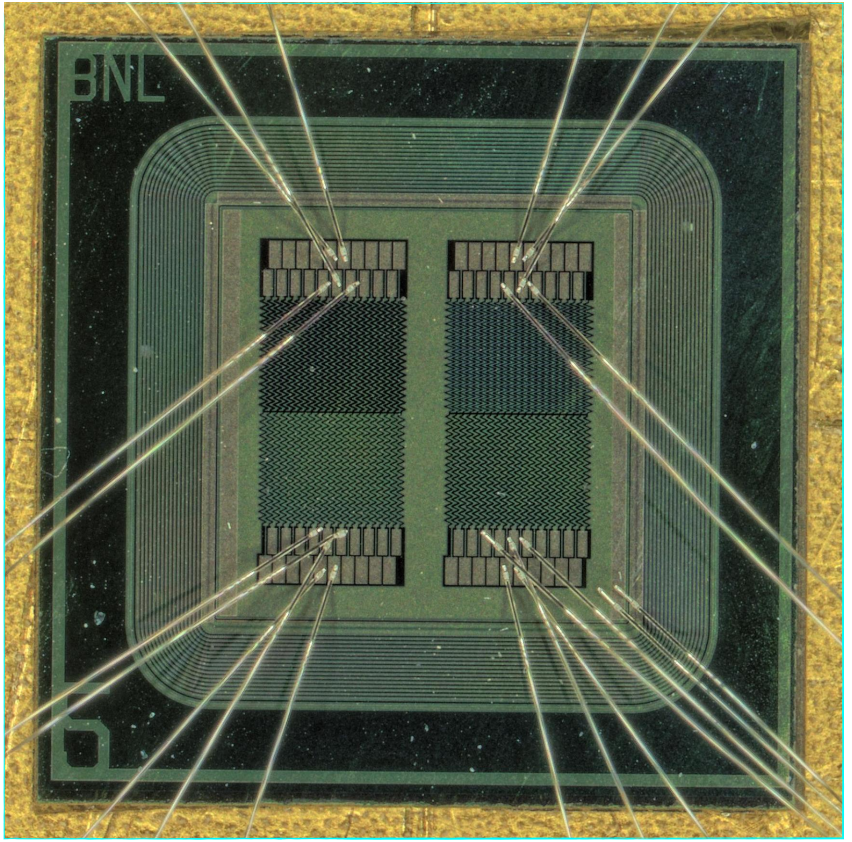
LGAD Testing for W2005 BNL Zigzag sensor

Test beam campaign for LGADs (2021)

- Sensor LGAD W2005
- Pad size 3 mm × 3 mm; Pitch 50 μm; ZigZag strips
- BreakDown ~ -350V
- Multichannel readout board (FNAL)
- Readout 3 strips at a time through DSO
- Data will be studied for timing resolutions

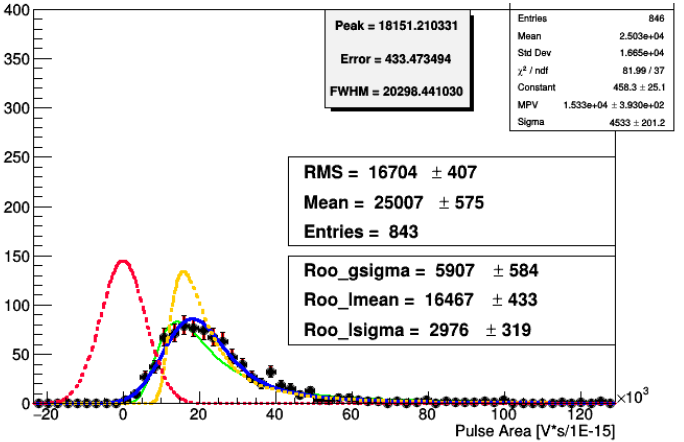


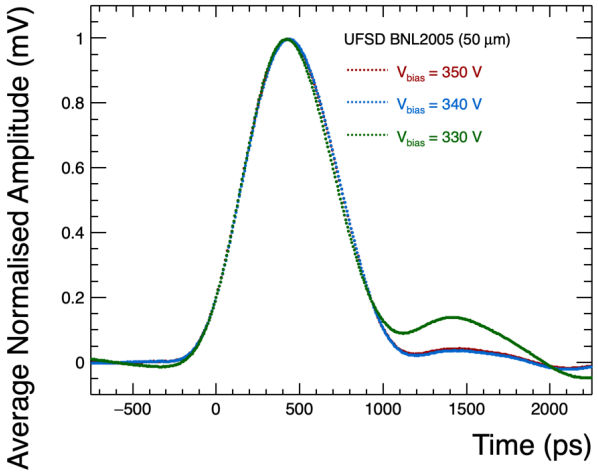


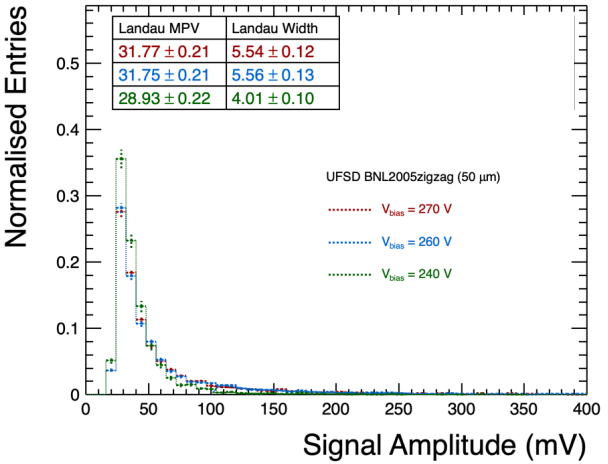


W2005 Zig-zag

- Sensor LGAD W2001
- Pad size 2 mm × 2 mm; Pitch 150 µm
- BreakDown ~ -270V
- Single strip it connected to the Board
- Neighboring guard rings grounded







Pulse Area

Summary

- Tested BNL fabricated LGADS and AC-LGADs
- Performance of LGAD (W2004) is comparable to that of HPK3.1 (same thickness)
- The other parameters like risetime, jitter, noise, gain, charge collection and SNR are under study
- The test beam data for AC-LGADs are under study
- Future plans for incorporate Digitizer to read more that 3 channels
- Incorporate the LGAD setup with ATLAS telescope