



# FCFD - AC-LGAD Strip Readout

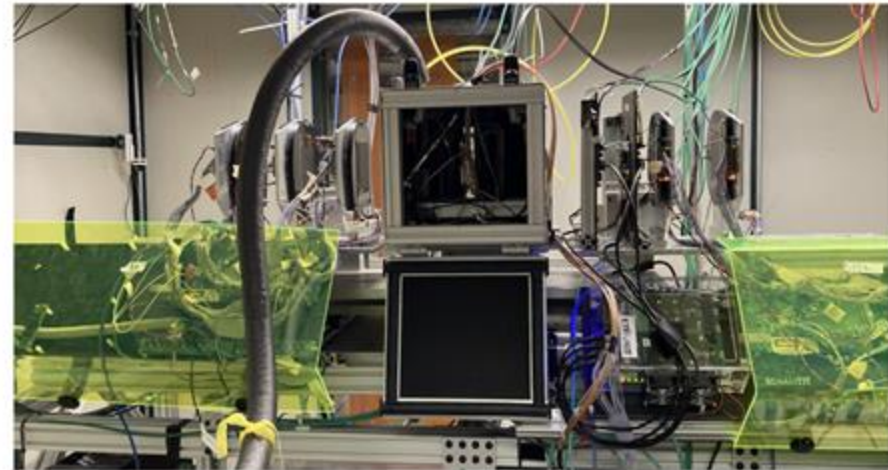
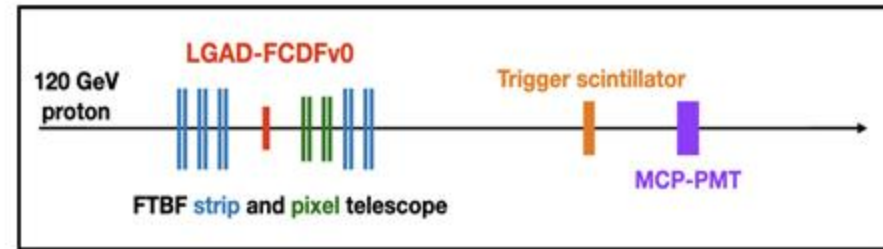
*Artur Apresyan*

*eRD109 Monthly Progress Reports*

*Aug 1, 2024*

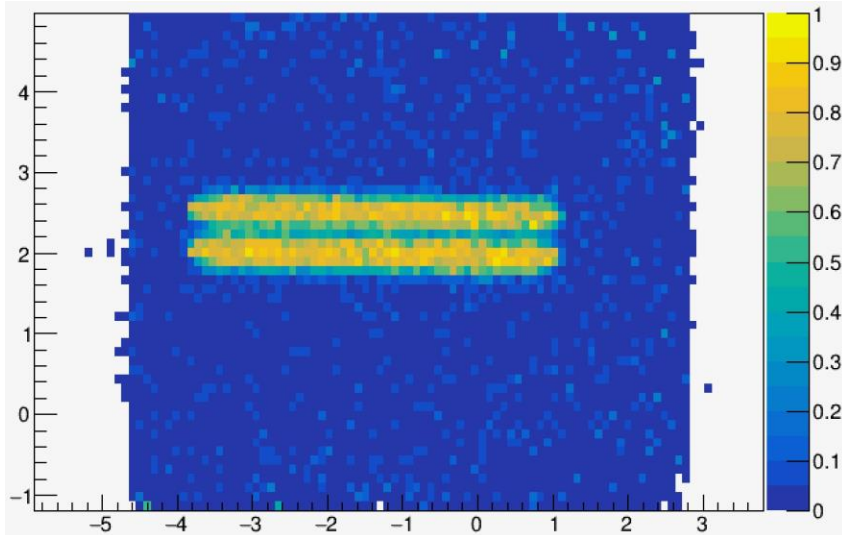
# Proton Beam Measurements

- Use Fermilab Testbeam Facility to test CFD chip with 120 GeV protons
- MCP-PMT used as time reference detector
- Temperature maintained at 20C
- Tracking telescope used to measure hit positions and efficiency

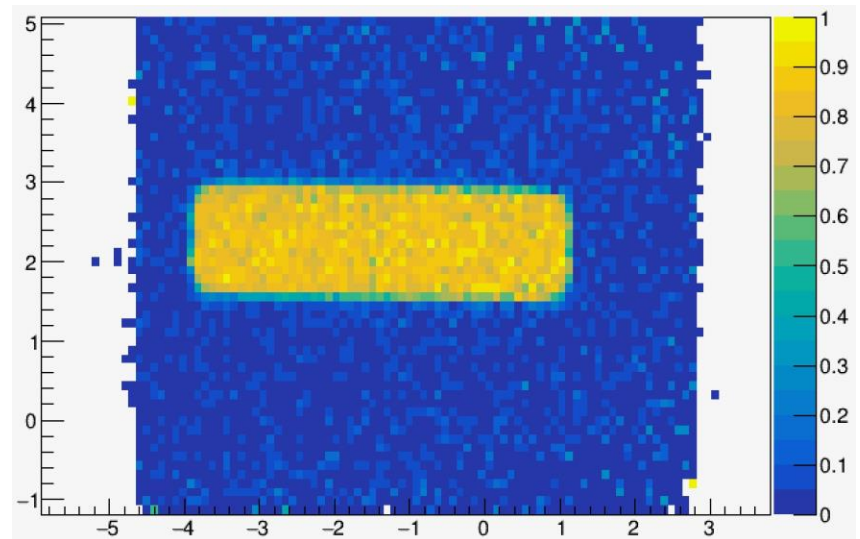


# FCFDv1 test beam in May

- Testing in the Fermilab beam in May 2024
  - Connected to a 5 mm strip AC-LGAD sensor, 500  $\mu\text{m}$  pitch, 50  $\mu\text{m}$  thick
- Optimizing the readout board grounding, power supplies, noise
  - Two-strip efficiency demonstrated to be 100%
  - The noise was observed to be too high, causing the comparator to fire too frequently, causing *fake hits*



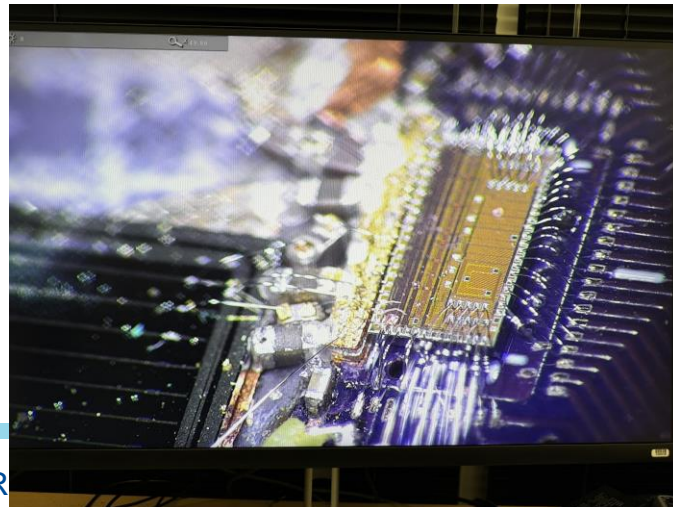
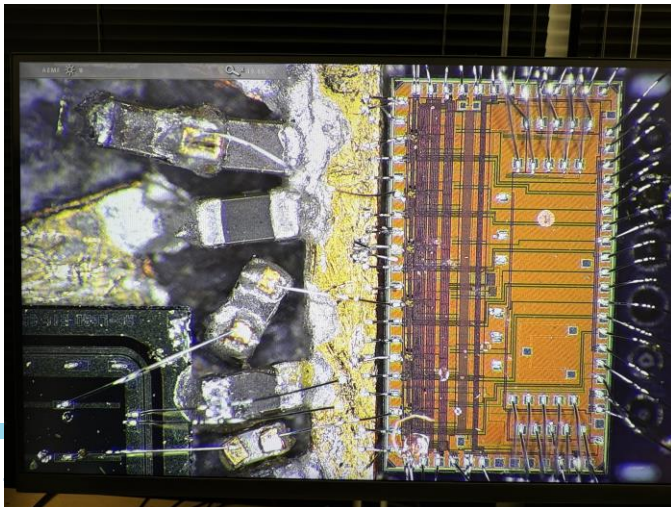
Efficiency with 2-strips read out separately



Combined two-strip efficiency

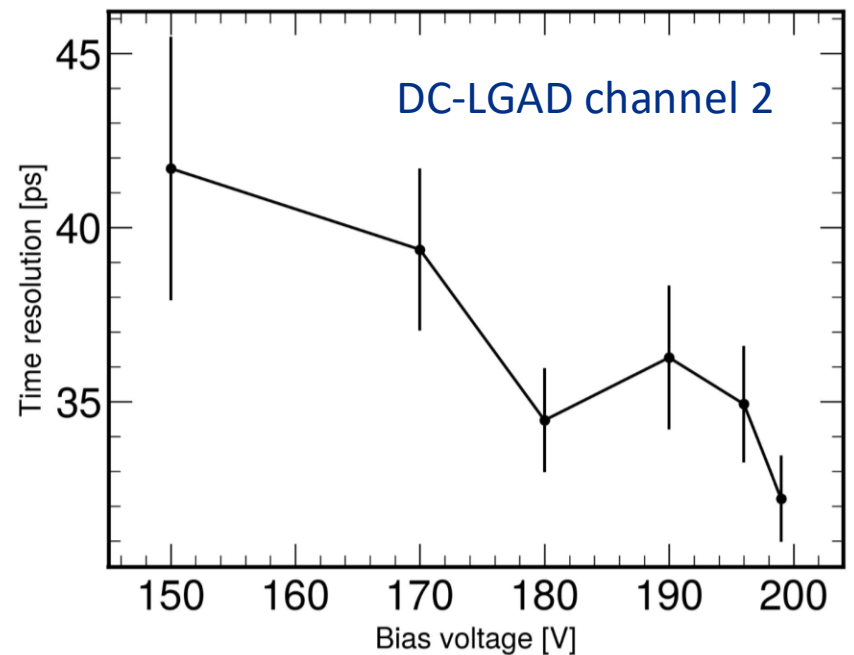
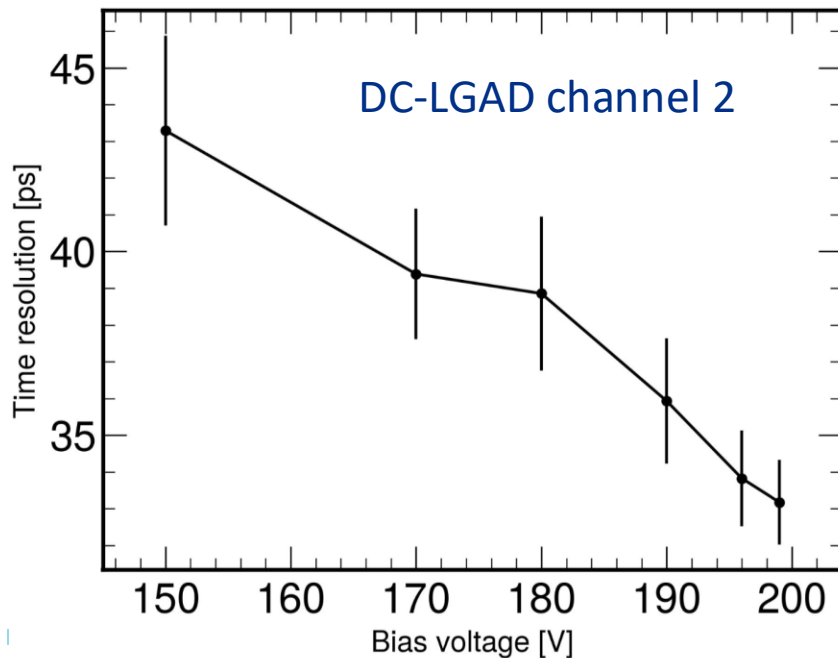
# FCFDv1 test beam in June

- Modified the board for test beam in June
  - Mounted on a specially designed low-noise readout board, improved layout and optimized components
  - Added a 7-pF capacitor in series to the AC-LGAD sensor, to reduce the noise and avoid fake hits, and reduce input capacitance
    - Fake hits are reduced, at the cost of **~1/2 of signal size** to the chip input
- Mounted a DC-LGAD with 2 pixels ( $1.3 \times 1.3 \text{ mm}^2$ ) connected
  - The DC-LGAD sensors would allow to test and characterize the performance of the chip, without the RC-network effects



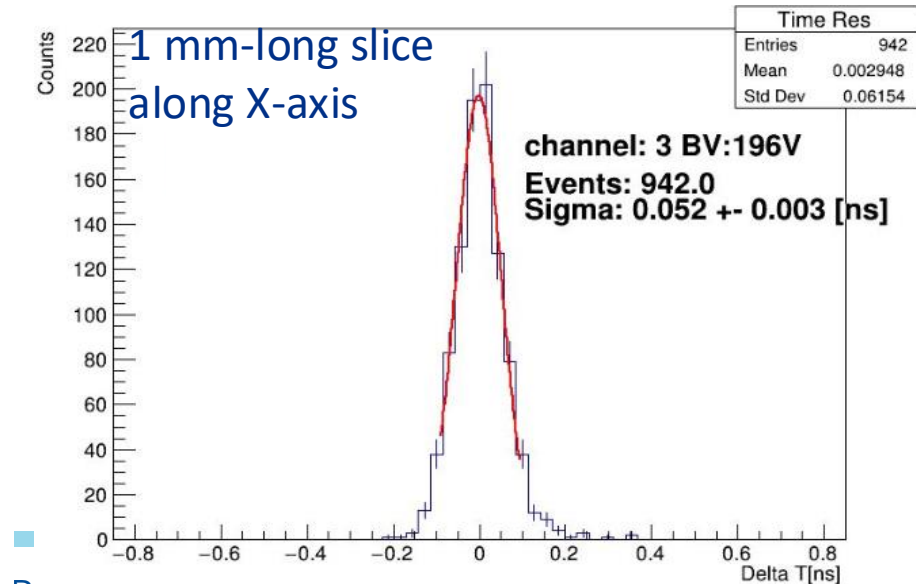
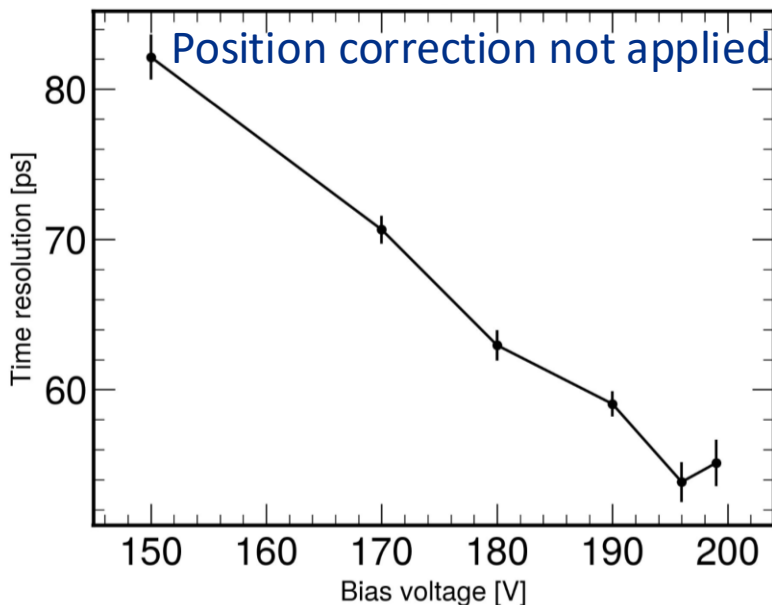
# FCFDv1 test beam in June: DC-LGAD results

- Performed bias scan BV = 150V, 170V, 180V, 190V, 196V and 199V (breakdown above 200 V)
- Achieve time resolution around 32 ps
  - No time-walk observed, no time-walk correction applied
  - Signal amplitudes around 300 mV
  - Chip performs well for sensors with expected characteristics



# FCFDv1 test beam in June: AC-LGAD results

- Time resolution on the AC-LGAD channel achieves around 55 ps
  - Due to series capacitor, MPV signal size of strip **reduced by more than half**: ~130 mV (AC-LGAD ) compared to 300 mV (DC-LGAD)
  - Time resolution for the whole strip **55 ps** (without correcting for position)
  - Time resolution in 1mm slices along strip: **52 ps** (will implement correction)
- $\sigma_T$  for DC-LGADs with 130 mV signals ~ 50 ps
  - Indicates that AC-LGAD should get  $\sigma_T$  ~35 ps with improved comparator



# Development plans in 2024 and 2025

- Finalize testing of FCFDv1
  - Test with IR-laser to study the effect of increased signal from AC-LGADs on time resolution
  - Re-optimize the chip with the final-spec AC-LGAD parameters as tested with FCFDv1 version, for a minor revision FCFDv1.1
- Next focus on the full chip: full-size FCFD v2 end of 2025
  - Finalize the geometry and sensor key parameters (strip length, sheet resistance and thickness)
  - Complete ASIC with readout that would interface with the EIC experimental DAQ
  - Implement the interfaces with RDO
- The final ASIC (v3) to be produced end of 2026