FCFD design status and specifications for AC-LGAD strip sensors for barrel TOF

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FCFDv1.1 design status

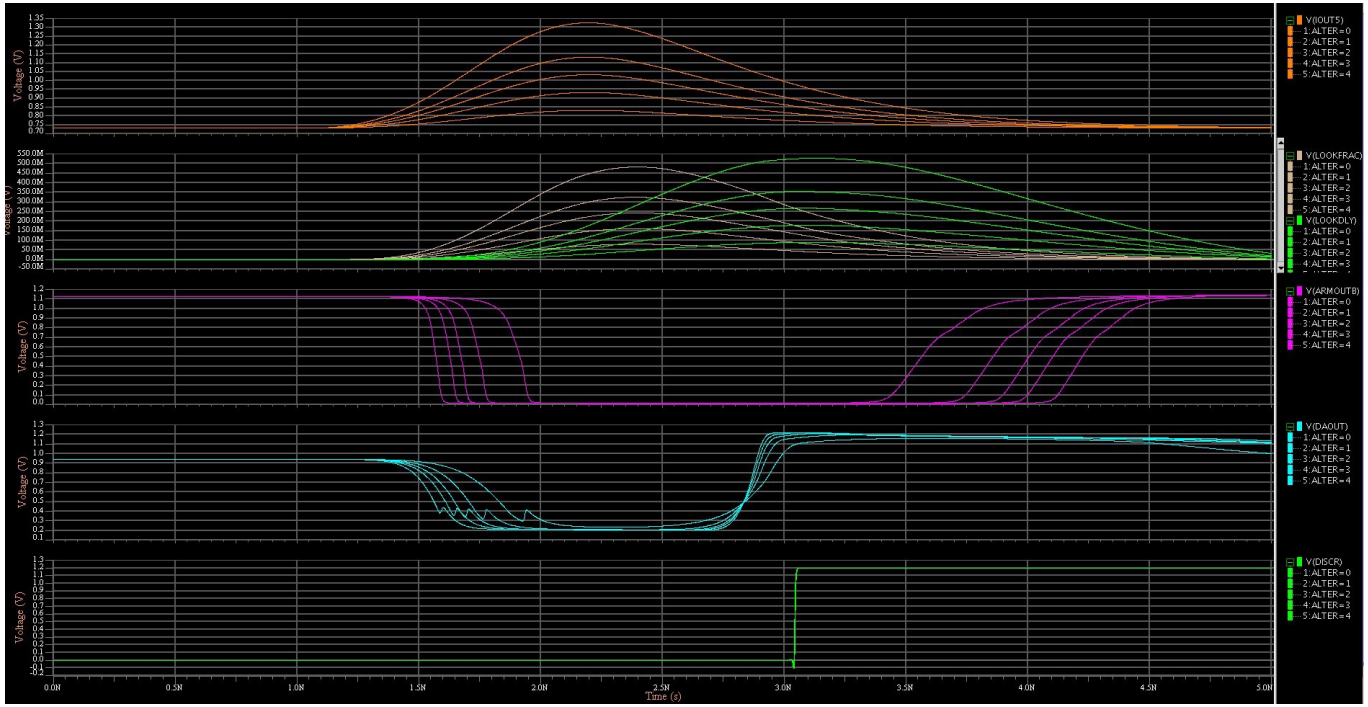
- Work is progressing well
  - The front-end redesign is complete, implemented a dual-stage amp
- Performance evaluated with simulated LGAD signals
  - Use 1000 LGAD pulses generated with Wakefiled2 program and signals re-scaled to amplitude so that the MPV is ~20 fC
  - For simulation of one FCFDv1.1 channel, we used the AC-LGAD sensor RC-network model we presented last time
  - One of the 10 strips in the model is connected to the ASIC channel input.

Simulatio results

- Two power settings tried:
  - In high power mode:
    - Using a "noiseless" simulation of 1000 runs with the 1000 LGAD pulses gives 28.6 ps jitter (expected, this is inherent signal jitter).
    - Using a "perfect" LGAD pulse of 20 fC and doing transient noise runs on the circuit gives a circuit jitter of 15.7 pS.
    - Doing transient noise runs with the 1000 LGAD pulses gives a final jitter of 31.9 pS, which is basically the LGAD inherent noise and the circuit noise summed in quadrature
  - In low power mode:
    - Transient noise runs with the 1000 LGAD pulses gives a final jitter of 34.6 pS

FCFDv1.1 design status

- The simulation is shown for a range of input charges of 15, 30, 45, 60, and 90 fC
  - Discriminator output shows that it moves only a few pS over this range of signals



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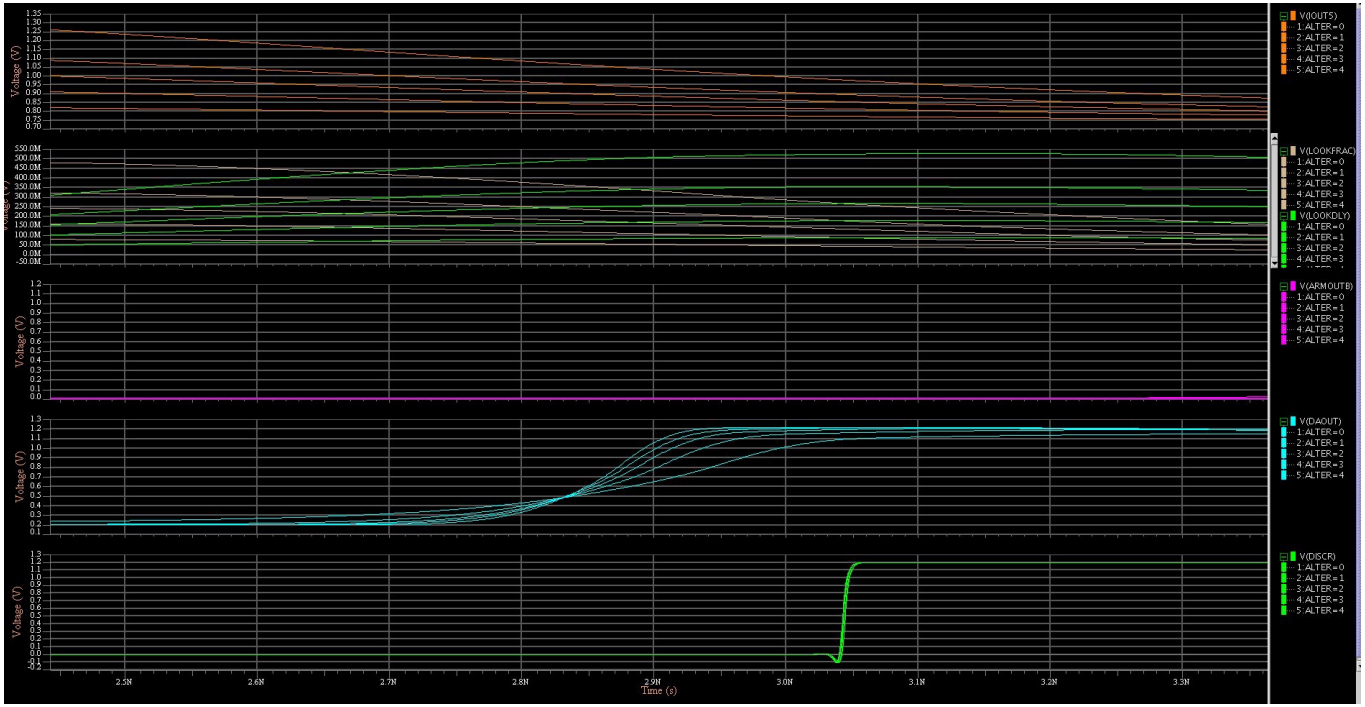


Amplifier output signals

Fraction and Delayed signals

Arm Comparator output

High Gain Diffamp output

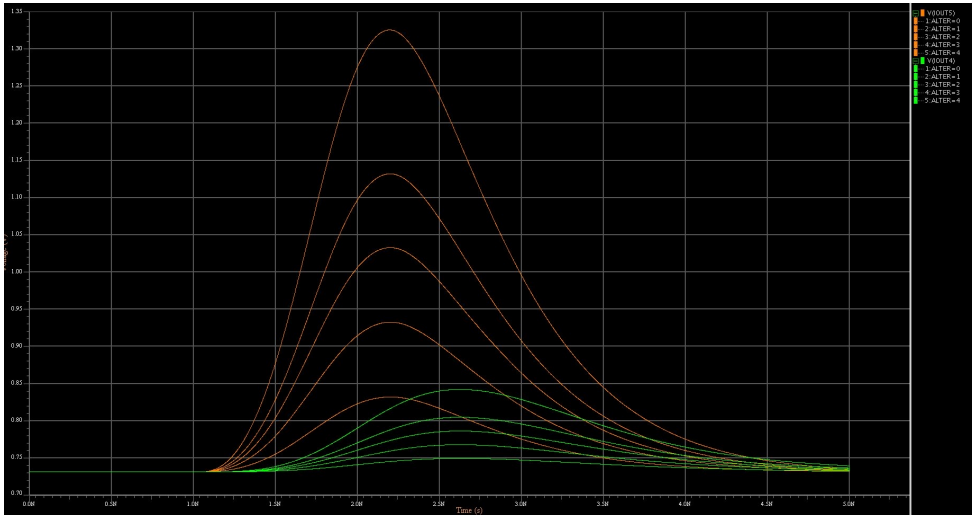
Discriminator output

Zoomed-in version

Fermilab

FCFDv1.1 design status

- Currently working on updates to the arming comparator and readout
  - Configurable threshold to trigger the comparator
  - If the signal is above ~7-10 fC → trigger readout of that strip, and the neighbor on each side (the threshold is configurable)



- Stage-1 output along with the output of the neighbor channel.
  - Note that the neighbor channel signal is smeared (delayed) somewhat due to the RC components in the AC-LGAD
  - The neighbor amplitude is ~20% of the main channel.

Next steps

- Currently finalizing the design, expect to start the layout in the next few weeks, with submission in either Jan or Feb TSMC run
- Working on reserving the mini@sic run with TSMC
- No test beams in FNAL in FY25
  - We are working on several options to quickly perform characterization of the chip asap
  - Initial characterization with charge-injection and beta-source and laser will be performed once received from foundry
  - Reserved a slot in DESY test beam in July 2024, trying to book a slot in SLAC