Activities at UCSB

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UC Santa Barbara
AAD kickoff workshop
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Outline

- Summary of UCSB capabilities and past work
- Overview of our planned work
- Examples of ongoing measurements

UCSB's capabilities and past work

UCSB has focused on silicon detector projects (CLEO, CDF, BaBar, CMS).

We are now involved in silicon-based CMS upgrades:

- HGCal = fine granularity and thin sampling endcap calorimeter
- ETL = endcap layers of LGADs for 30 ps timing on each track

Infrastructure:

Cleanroom (gantry, bonding, inspection, testing)

Dark/cold boxes, Keithleys, DRS-based DAQ, picosecond IR laser.

ETL work and AAD synergies

Significant fraction of our time is devoted to the ETL project:

- Management, module design, and LGAD stability studies

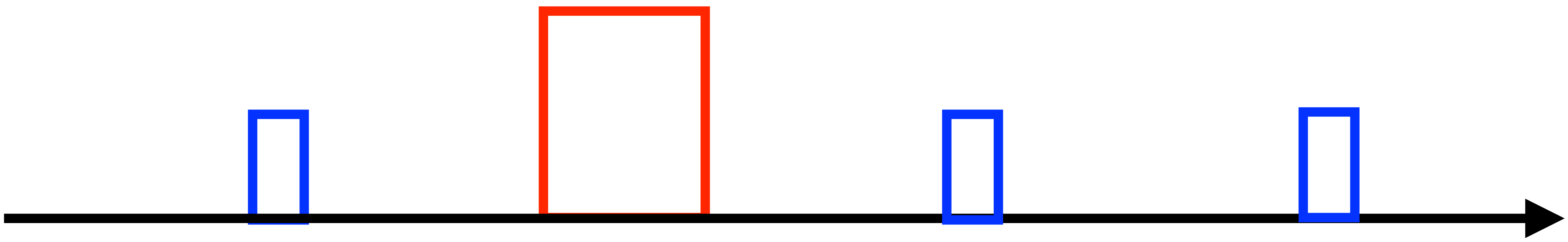
LGAD stability studies will be synergistic with AAD studies.

- Will study a variety of sensors both pre- and post-irradiation
  - LGADs and PIN diodes, with varied doping and gain layer configs.
- Using IR LED for simple, controllable charge injection.
- Will use IR laser for probing fine position dependence.
- Goals are to:
  - quickly characterize many sensors,
  - understand uniformity,
  - verify long term stability, and
  - develop full, verified simulation model for LGADs.

Synergies with AAD work are in exploring the rate & dynamic range extremes

Exploring extremes of rate & dynamic range

Planning pump-probe measurements using IR LED and/or IR laser



Should provide full control over timing of dynamic range effects.

-Varying the size of the pump pulse to explore saturation effects.

-Vary size and timing of probe pulses to measure time structure of saturation.

-Vary LGAD gain, & use PIN diodes, to disentangle bulk & avalanche effects.

-Use separate LEDs to avoid source saturation effects.

-Use both wide beam IR LED and IR laser spot to study local vs global effects.

Then move to beam + IR and IR+beam to understand effects of IR vs beam induced charge.

Exploring extremes of rate & dynamic range

Plan to study spatial dependence with IR laser scanning.

- Motion stages would work, but slow.
- Interested in exploring use of a MEMS mirror.

Then move to pump + probe with beam + IR and IR + beam to understand effects of IR vs beam induced charge.

Repeat this with varied doping and gain layer characteristics and after irradiation.

Feed into improvement of simulation.

Stability test setup

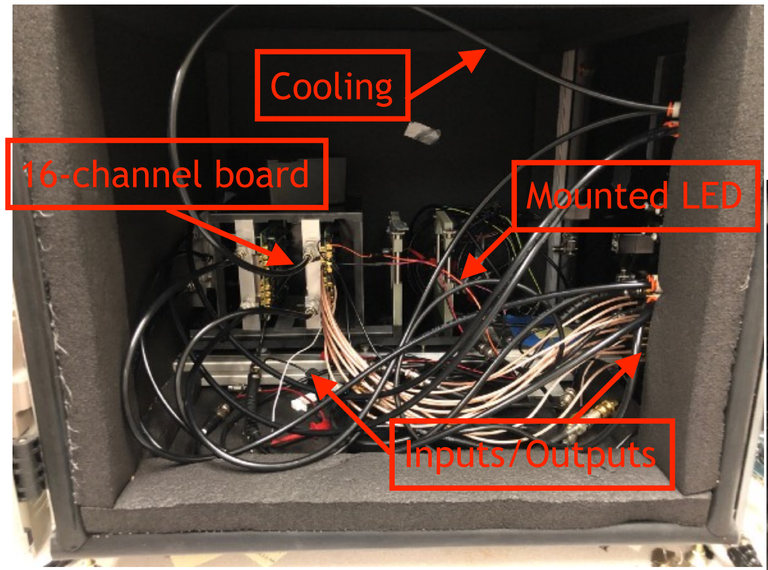
Our focus for MTD studies has been on long-term stability and gain uniformity, which he have done by studying LGAD response to an IR LED pulse, using this setup in lab

Readout board mounted onto metal plate, secured inside cold box

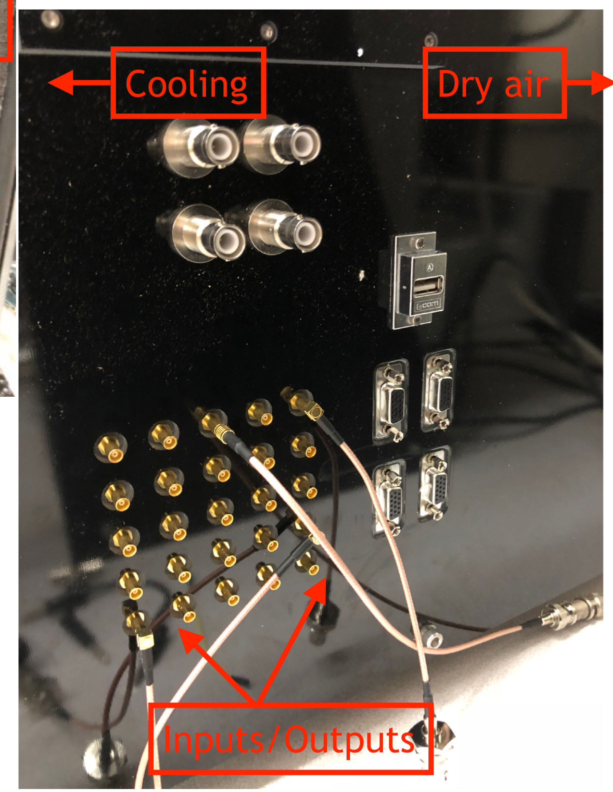
IR LED held in place ~10 cm away, flashes on for 20 ns once per second

Output to 4 DRS digital oscilloscopes

Bias set and programmable using Keithley power supply



Inside cold box



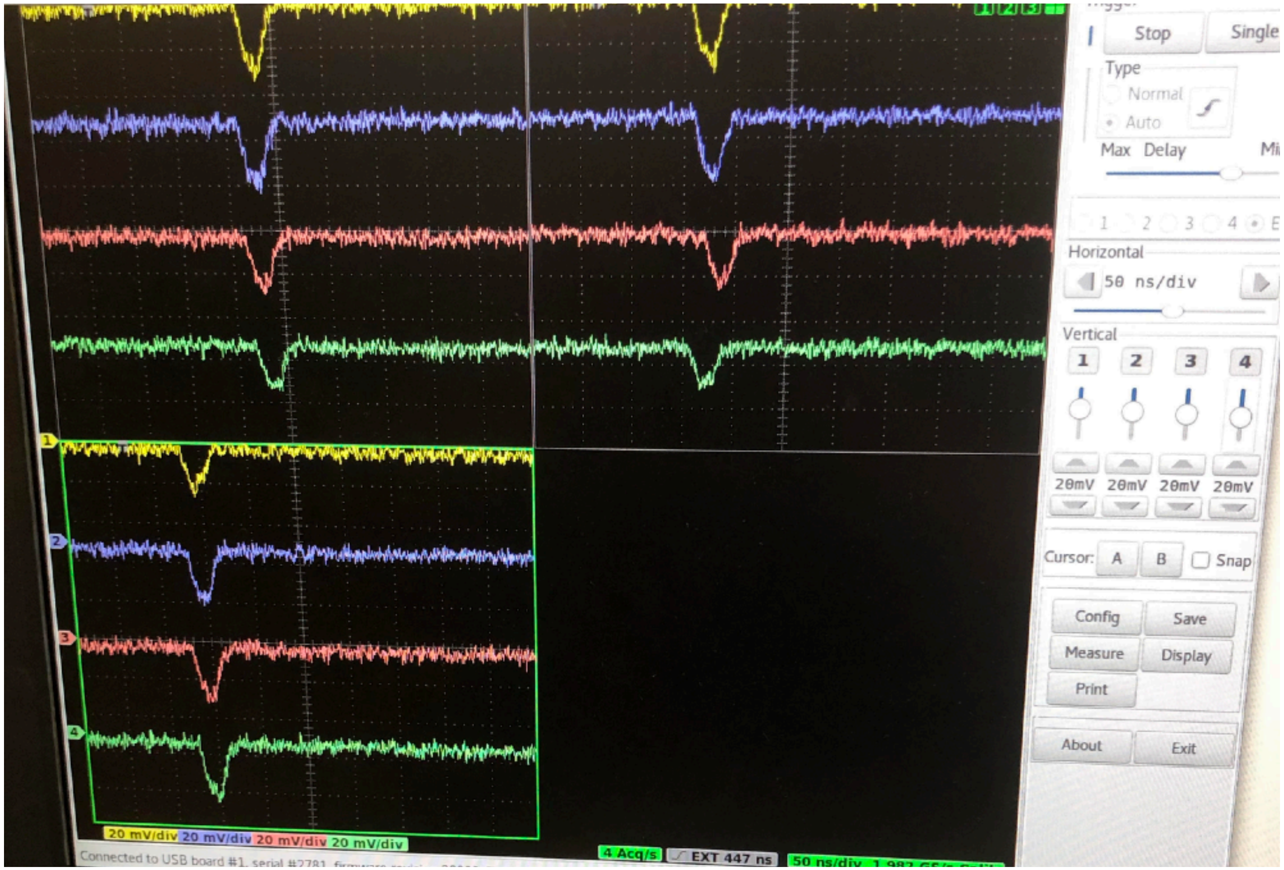
Outside cold box

Data taking and analysis procedure

We have 4 DRS digital oscilloscopes for data-taking (traces from 3 shown)

Analyze the DRS data to study response height, area, noise, etc.

Save voltage + current data from Keithley to match with DRS data and make I-V curves



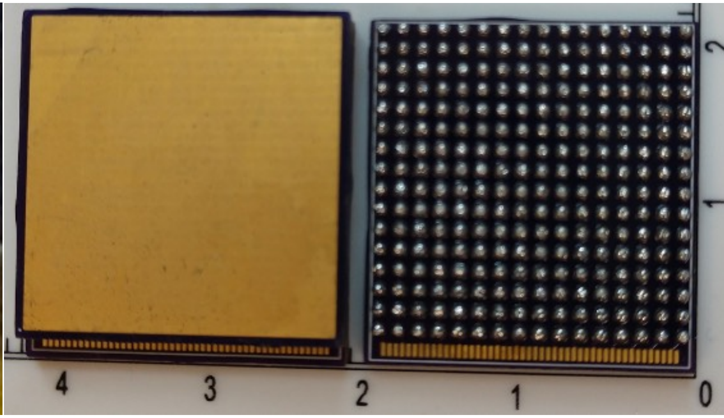
Bump-bonding sensors at UCSB

Plans for the final ETL ASIC bump bonding and module construction process are not yet finalized

In the meantime, a UCSB undergrad, Daniel Fernandez, has been working on using ball-grid array technology to build large sensor arrays fairly quickly and easily for initial tests

We obtained a BGA setup — jig, stencils, solder balls — and started practicing on 16x16 PCB mockups

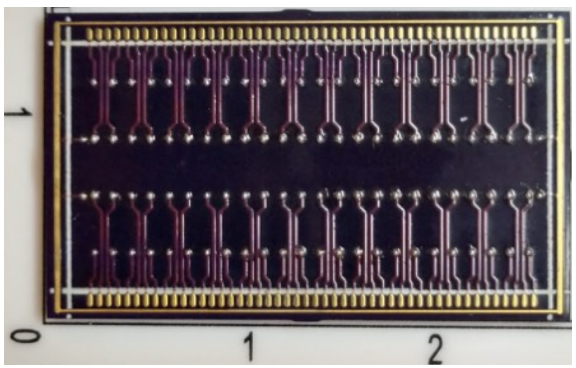
Used traces to check continuity of all bump bonds

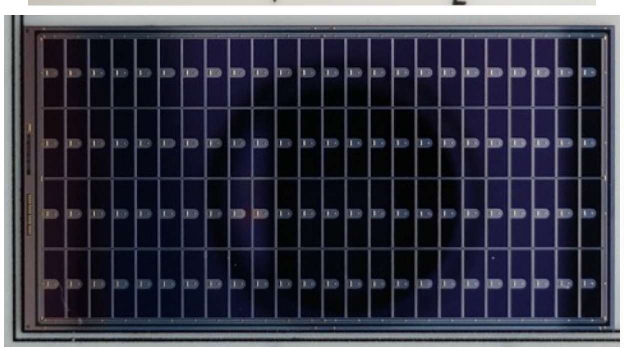


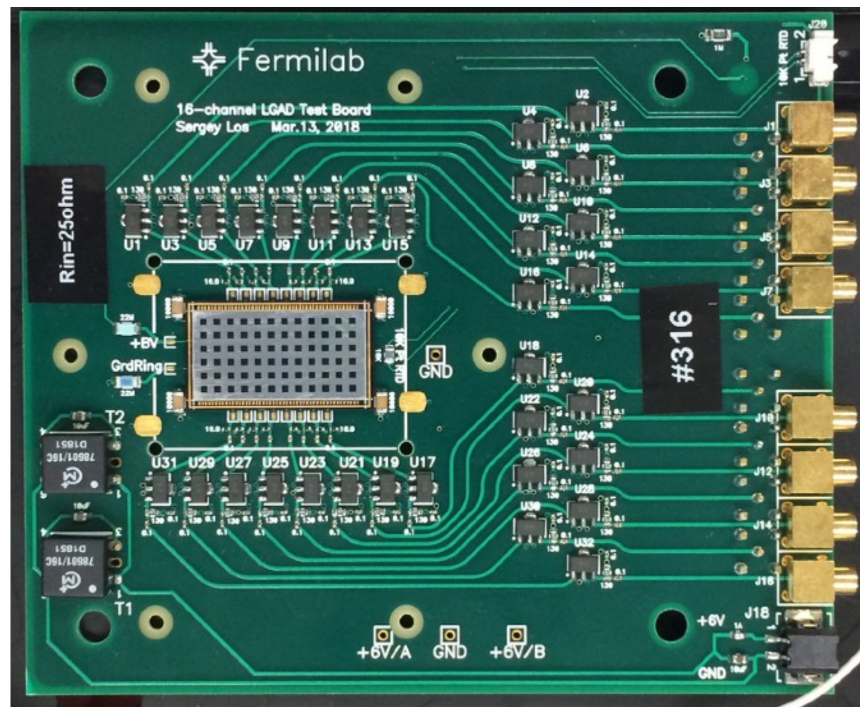
Bump-bonding sensors at UCSB

Initially studying 4x24 and 5x5 sensor arrays bonded to interposers

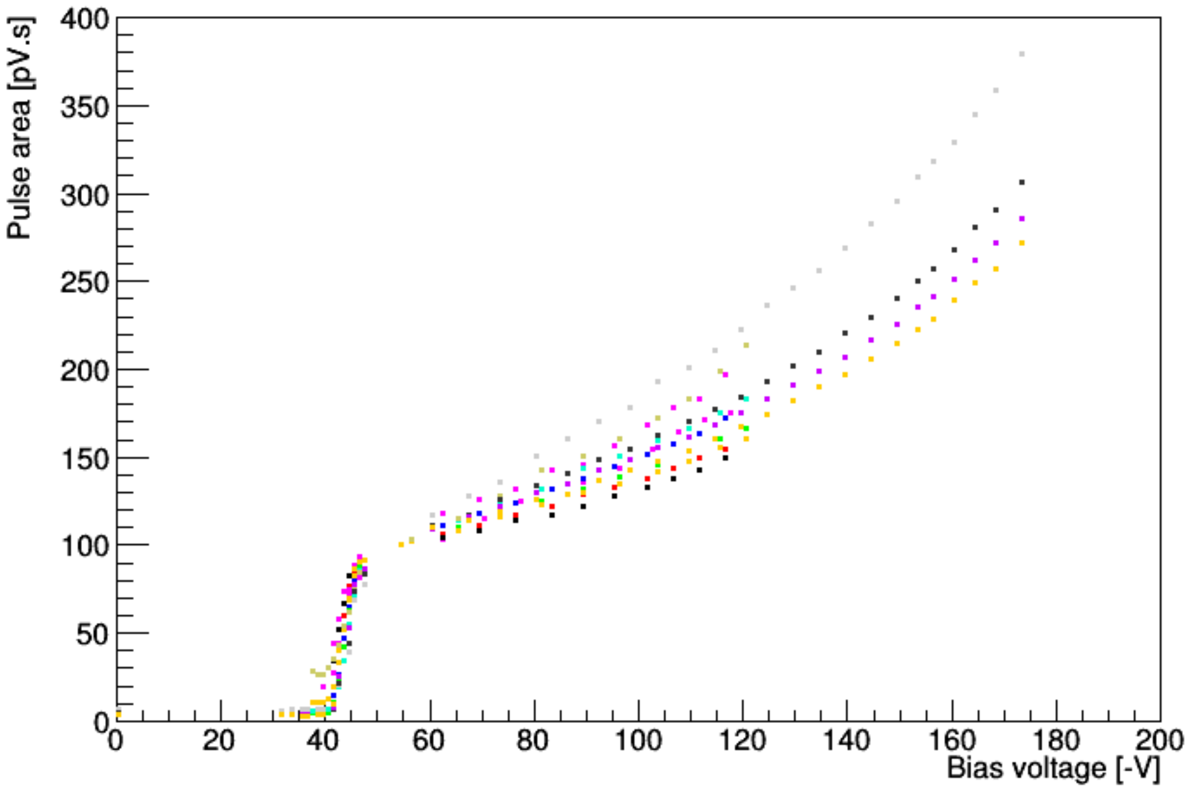
Attached to 16-channel readout board
- Combination of single channel outputs plus 2,4,8,16 ganged channels
- Checkerboard metallization on back of sensor allows testing with IR LED







Comparing gain of different channels

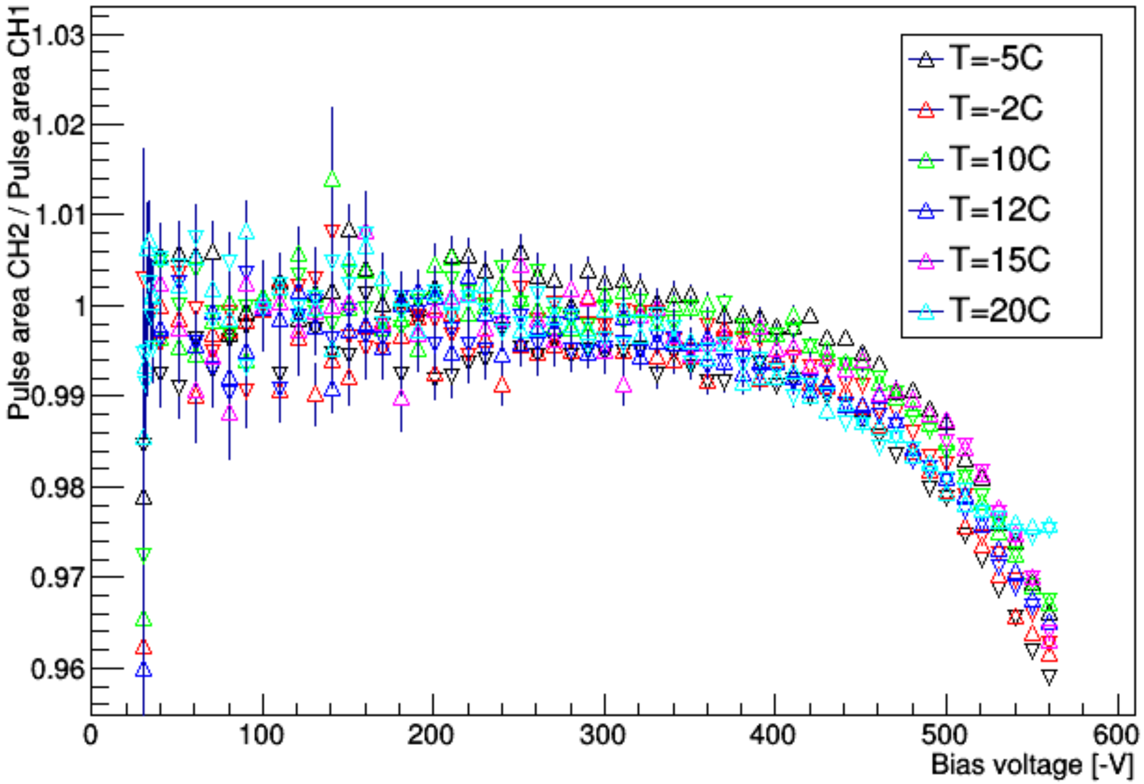


Pulse area as a function of bias for 16 single channel outputs (different colors)

- Collect data for 10 minutes at each bias
- Normalize to match at -55V to correct for LED exposure differences
- 12 channels scanned to -120V, 4 scanned to -180V

Wide spread in gain across these 16 channels — study all 96, map out gain non-uniformity

Comparing gain of different channels

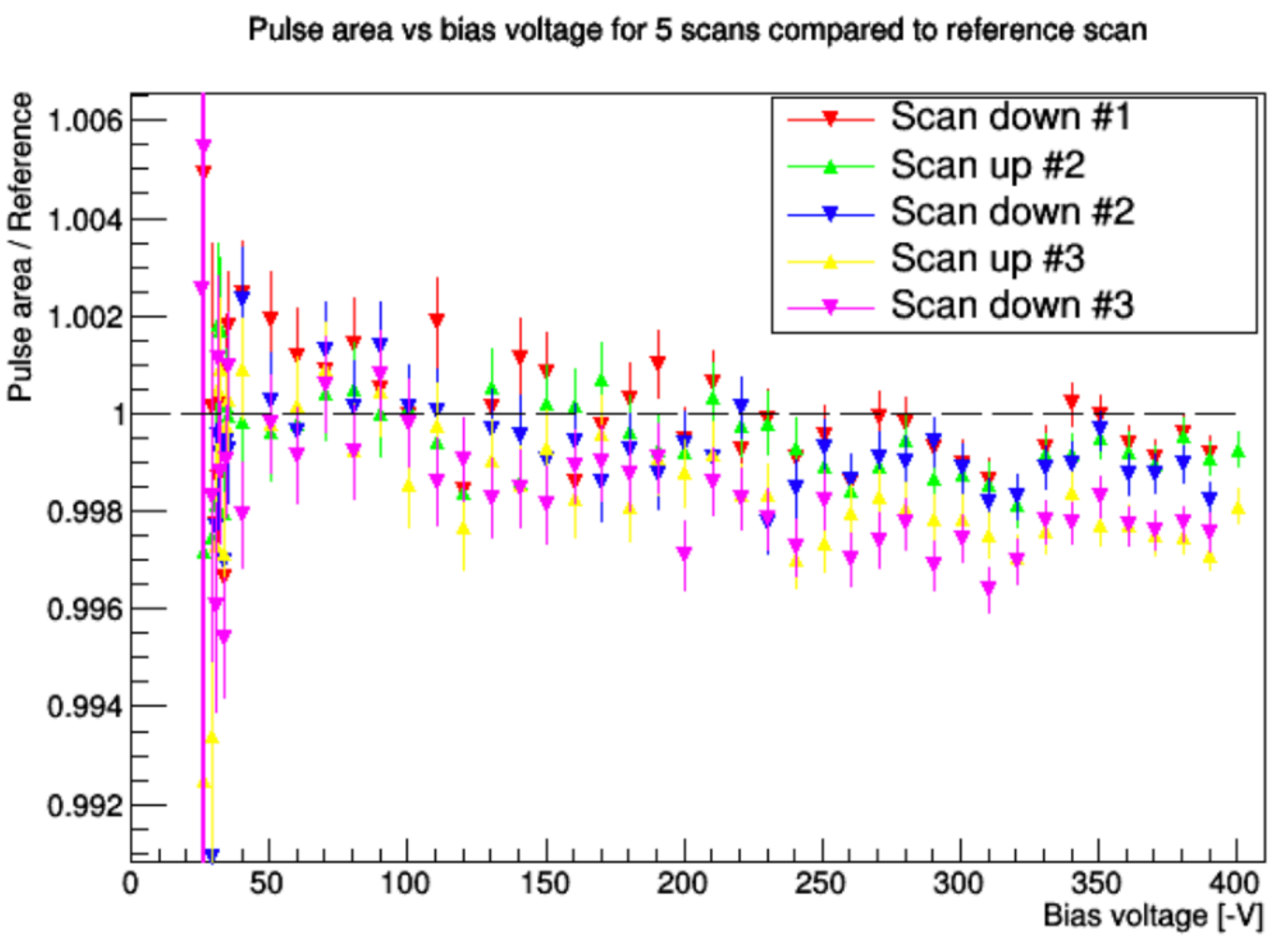


Ratio of pulse area for 2 channels shows gain differences more precisely

Here different colors are for different temperatures set by chiller

Study consistency of any non-uniformity over many scans over many different temperatures and long time scale

Comparing gain of single channel



Compare all gain curves for one channel to each other, by dividing by "reference" scan

Have seen agreement at 0.1% to 10% level for different sensors

Can be studied for time dependence, temperature effects, etc.

Summary and discussion

LGAD stability studies at UCSB will be synergistic with AAD studies

- A suite of tests have been developed that will be performed on sensors with various doping, gain layers, radiation exposure

IR LED can be used for programmable charge injection across entire sensor, while laser can probe more finely

- By using pump-probe method with varied pulse sizes and frequencies, we can begin to study the rate and dynamic range extremes of these sensors