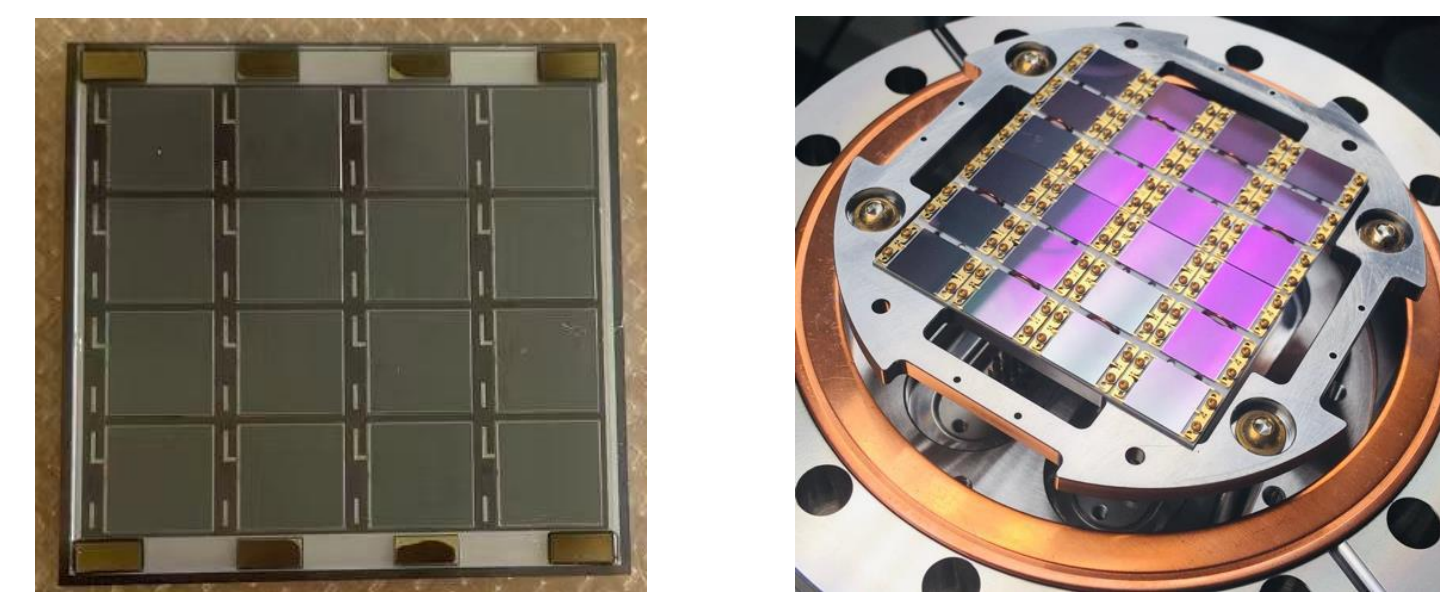


Zepeng Li¹, Liang Yang²

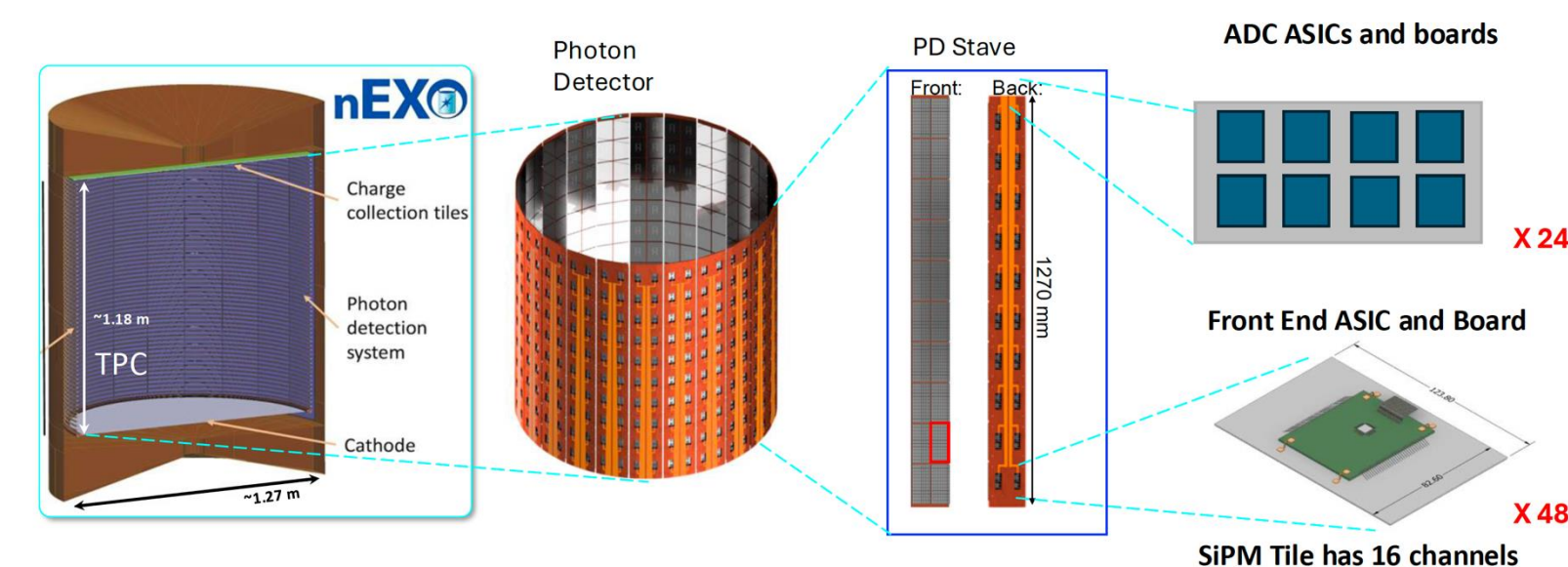
¹ University of Hawai'i at Mānoa | ² University of California San Diego | NEUTRINO 2026

1 MOTIVATION

- SiPMs are attractive for cryogenic photon detection because of high quantum efficiency, single-photon resolution, low operating voltage, high gain, compact size, and magnetic-field insensitivity.
- Main challenges: dark count rate, afterpulsing, optical cross-talk, and large capacitance.
- In nEXO, signals are collected by SiPMs, amplified, digitized, and transmitted to the DAQ. The system has about 7,680 channels.
- Low-power, low radioactivity, low noise, and compact SiPM readout electronics are essential for cryogenic experiments using large SiPM arrays.

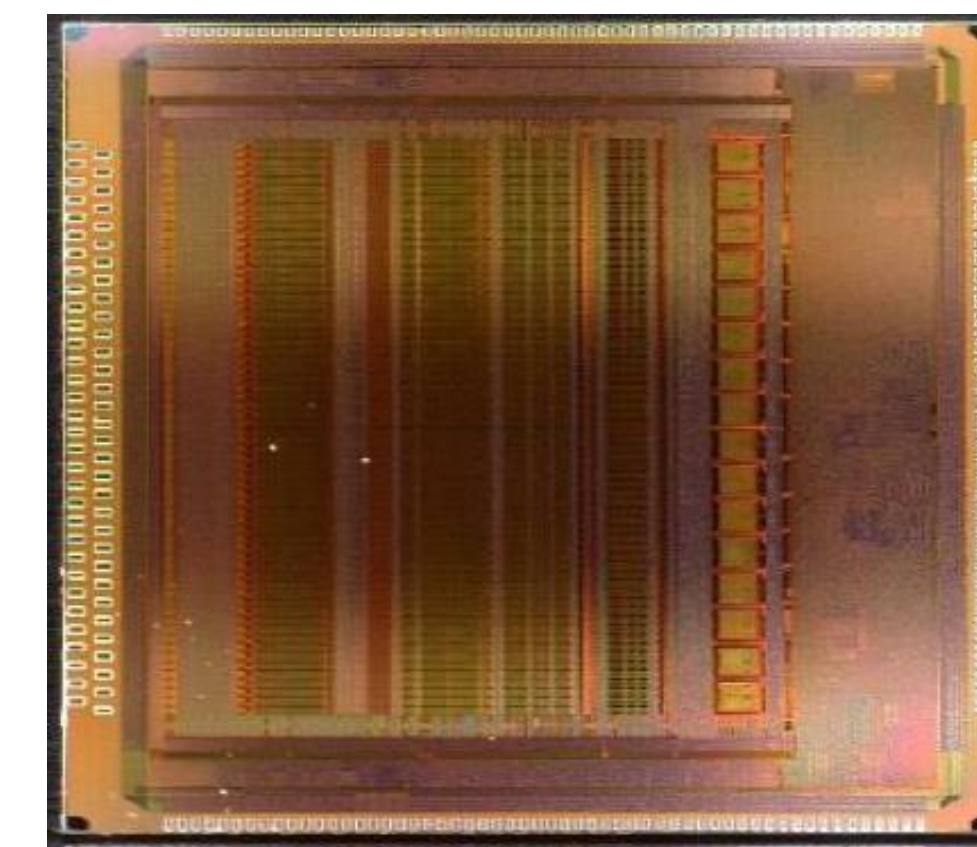


SiPM Arrays



nEXO Photon Readout System

2 CRYO ASIC DESIGN AND SPECIFICATION

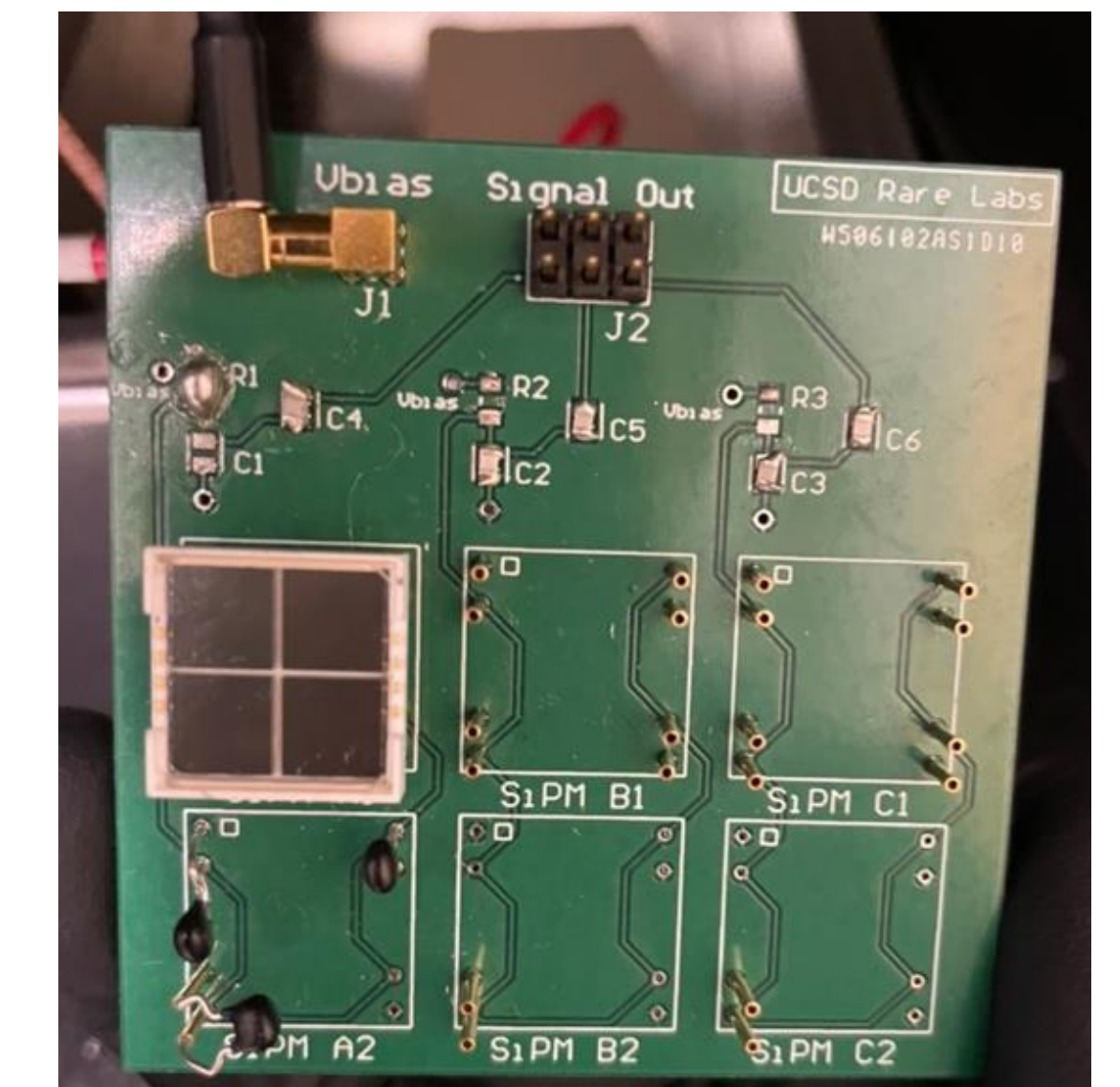
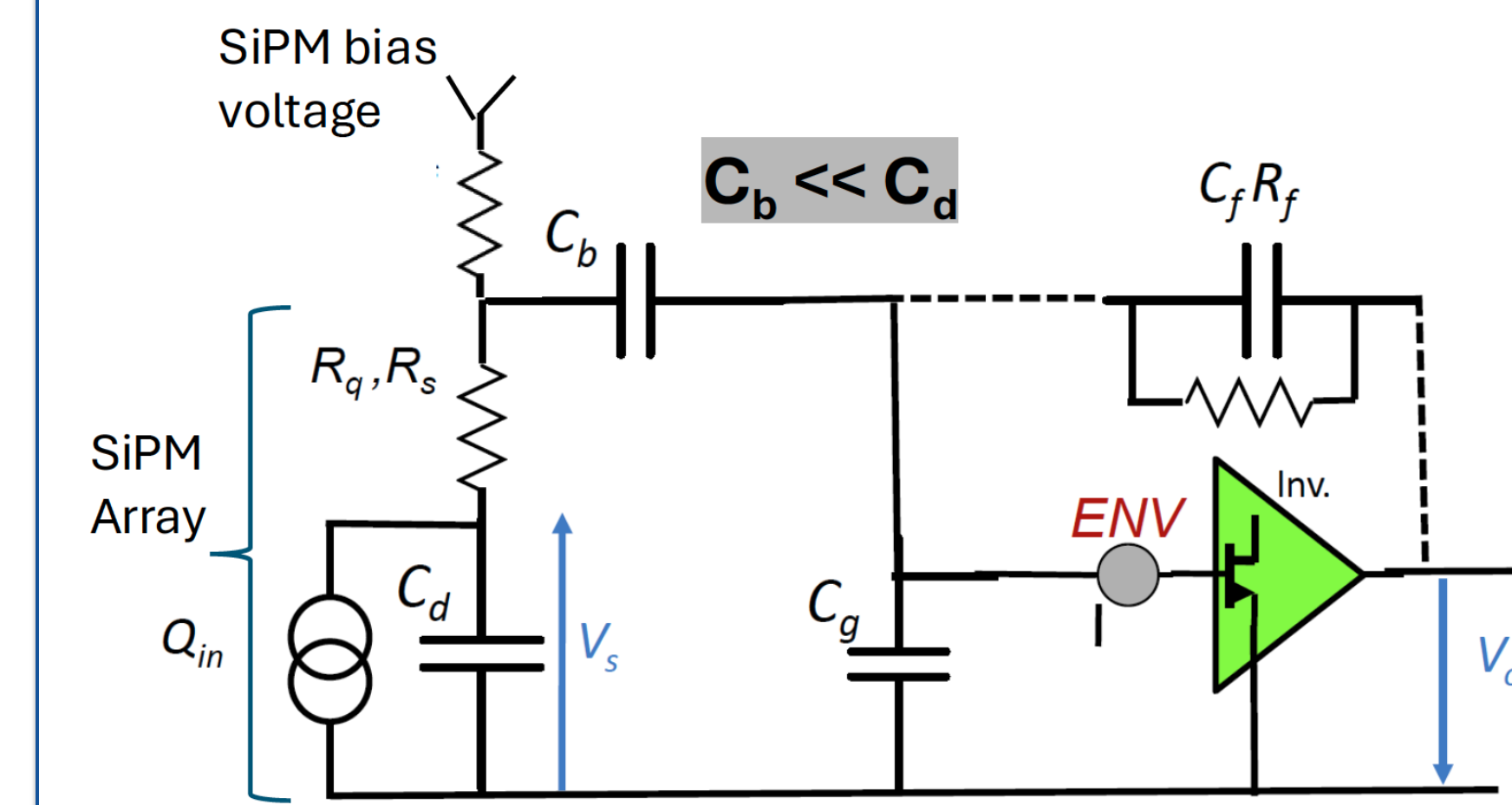


CRYO ASIC chip

Specification	Value
CMOS process	130 nm
Supply voltage	2.5 V (2 V, 1 V internal)
Input capacitance	~220 pF
Anti-aliasing filter	5th order Bessel architecture
Peaking times	0.6, 1.2, 2.4, 3.6 μ s
Gain settings	6.0X/3.0X/1.5X/1.0X
Max. input charge	50/100/200/300 fC
Noise	~500 e ⁻ @ 3.0X and 1.2 μ s
Resolution	12 bit
INL and DNL	\pm 1 LSB
Sampling frequency	2 MSPS
Temperature	87 K (-186 °C)

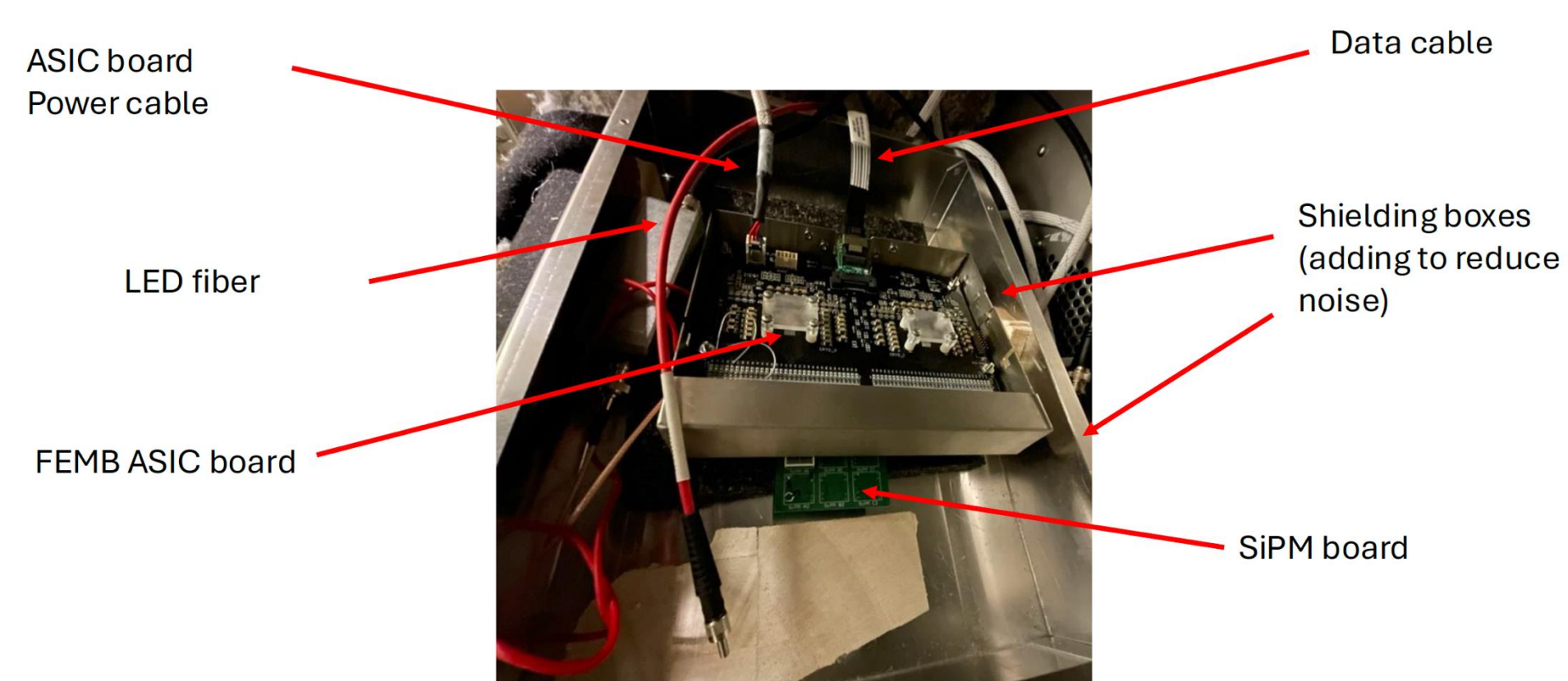
- System-on-chip integrates pre-amplification, channel multiplexing, waveform digitization, and data transmission in one chip.
- A single chip can read out 64 channels simultaneously.
- The CRYO ASIC has been extensively tested in LXe.

3 WEAK-COUPLING READOUT CONCEPT



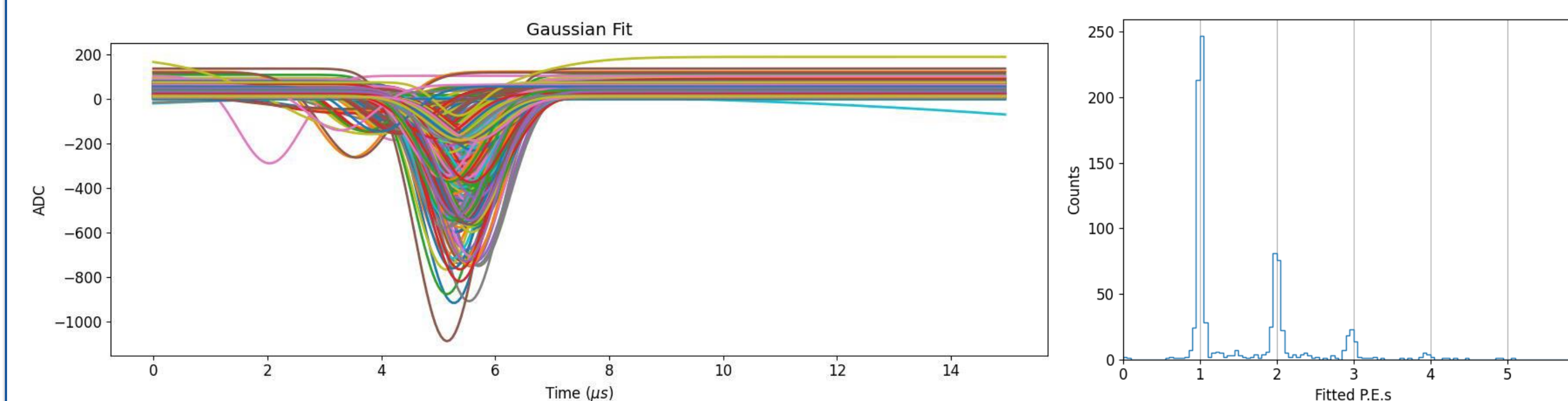
- Large-area SiPM arrays have capacitance C_d of several nF to tens of nF.
- $C_d \gg C_b \gg C_g$.
- PCB board connects multiple Hamamatsu VUV4 2x2 SiPMs to the readout.
- SiPM capacitance is ~1.3 nF.
- 3.3 nF capacitors in parallel simulate a total capacitance of 4.6 nF.
- Weak coupling capacitor is 0.2 nF.

4 CRYOGENIC TEST SETUP



- CRYO ASIC FEMB board reads out the SiPM board.
- Entire setup installed in an environmental chamber and cooled with nitrogen gas to 160 K.
- LED coupled with a fiber injects photons.
- Shielding boxes added to reduce noise.

5 Cryogenic Test Results



- CRYO ASIC configured for 1.2 μ s peaking time and 4.8 mV/fC gain.
- 50 V bias for Hamamatsu VUV4 SiPM and 0.2 nF coupling capacitor.
- LED light injection and random trigger.
- Single p.e. magnitude ~200 ADC.
- Noise level ~4 ADC (2100 e⁻). Signal-to-noise ratio ~50.
- Improved grounding may further reduce noise.

6 Summary

- CRYO ASIC is a versatile cryogenic readout ASIC integrating signal amplification, waveform digitization, and data transmission in a single chip.
- The weak-coupling concept effectively matches the large capacitance of SiPM arrays.
- CRYO ASIC has been successfully tested with SiPM arrays at 160 K, demonstrating low noise, excellent single-photon resolution, and robust performance.

Contact Information

- Dr. Zepeng Li, (zpengli@hawaii.edu)
- Dr. Liang Yang, (liyang@physics.ucsd.edu)