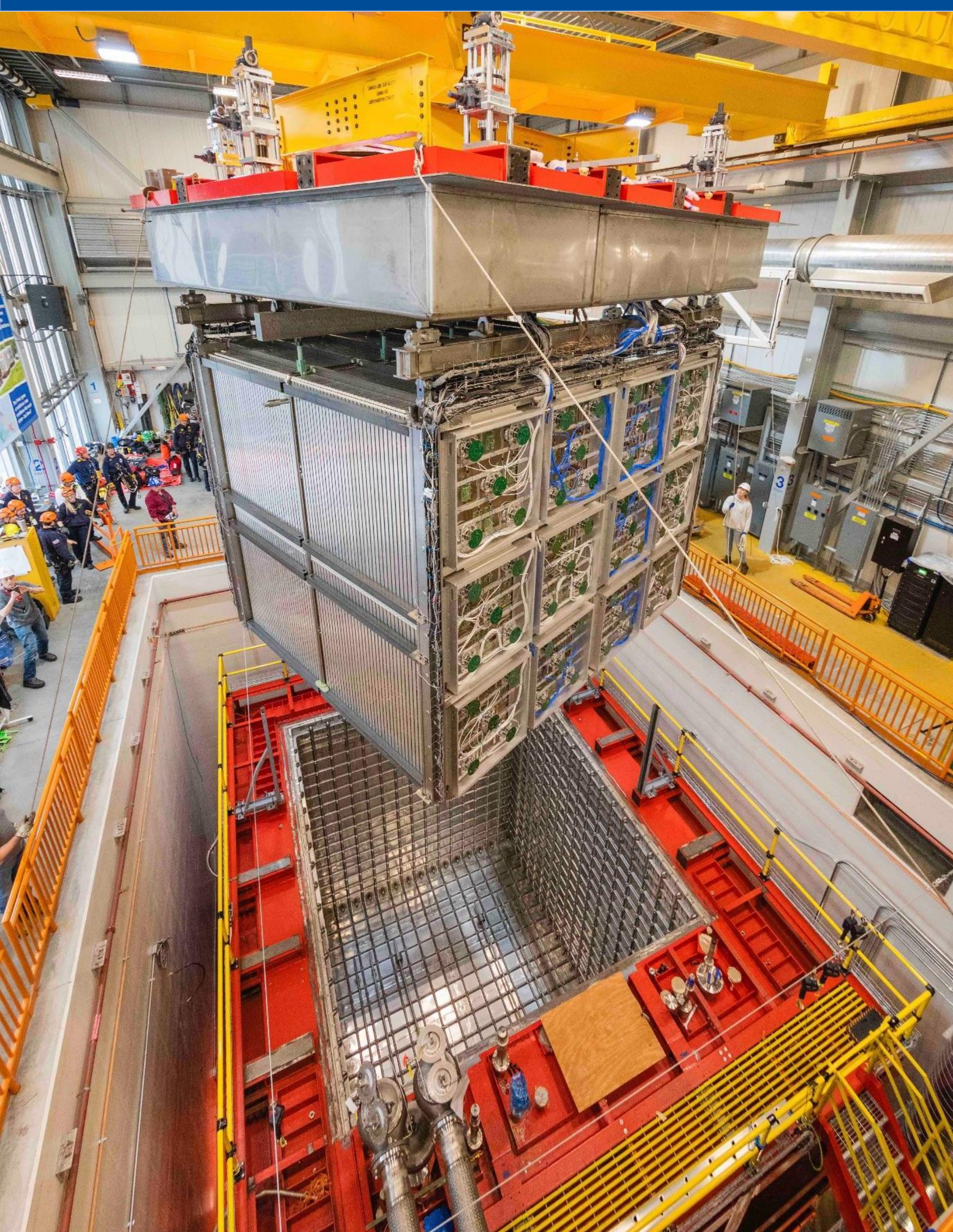




X-ARAPUCA Photon Detectors in SBND

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Photon Detection in SBND

Particle interactions in the liquid argon of the Short-Baseline Near Detector (SBND) produce VUV scintillation light of 127 nm photons.

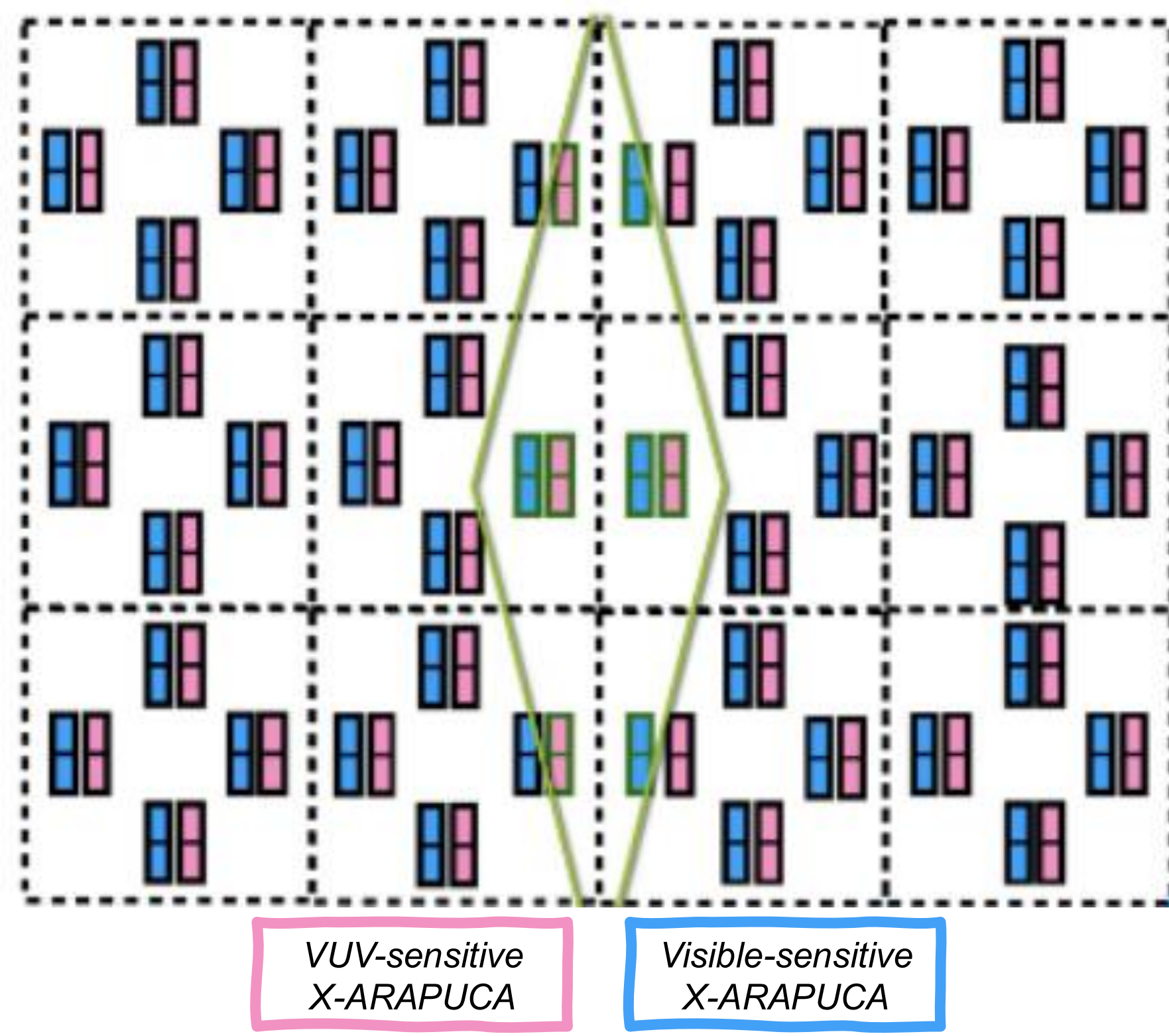
To collect the light of these interactions, SBND's photon detection system (PDS) consists of:

- 120 photomultiplier tubes (PMTs)
- 192 X-ARAPUCAs
- Reflective, wavelength-shifting foils on the cathode for increased light collection

The foils on the cathode shift the VUV wavelength into the visible range.

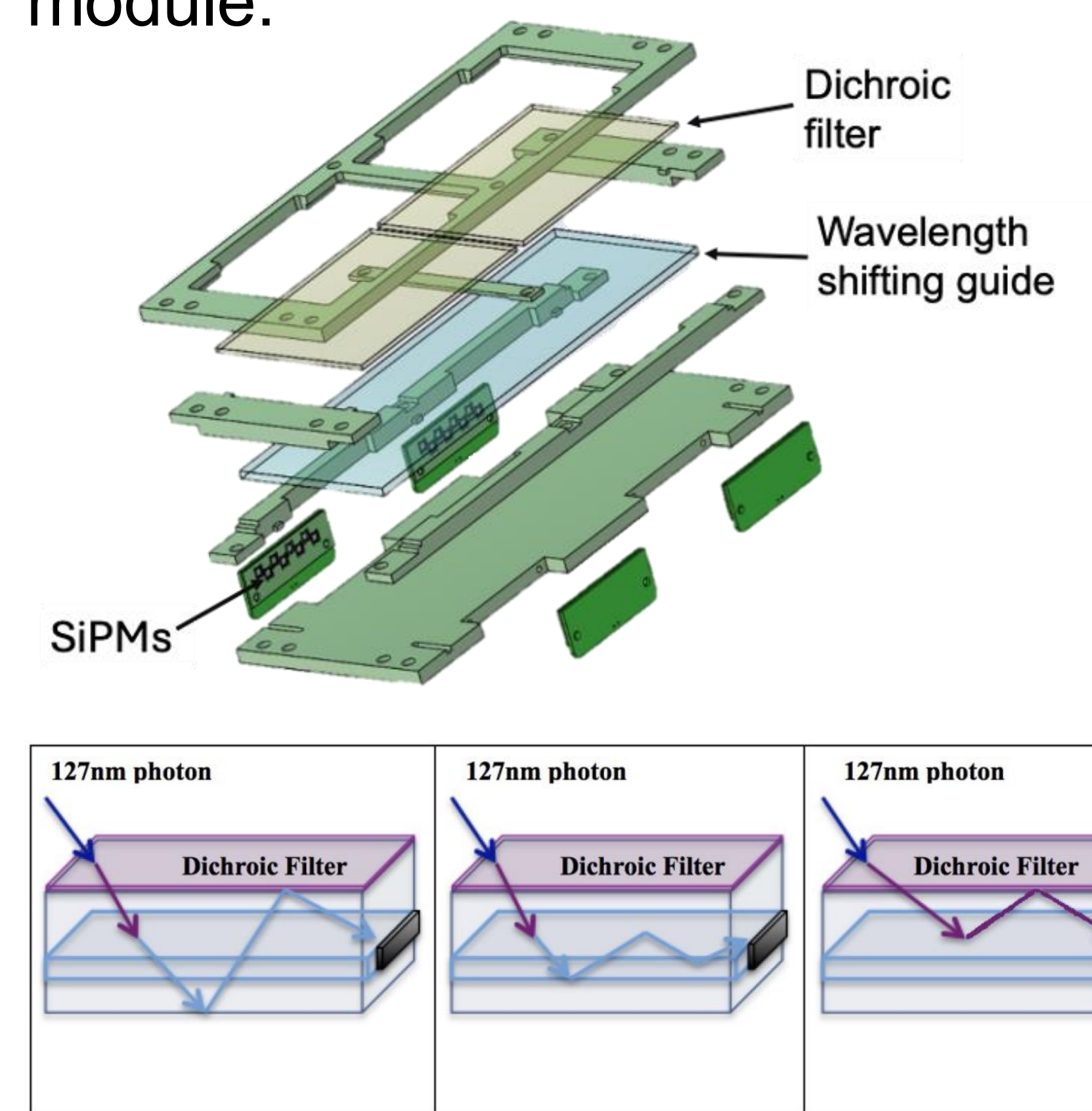
Wavelength sensitivity	VUV*	Visible
PMTs	80%	20%
X-ARAPUCAs	50%	50%

* VUV-sensitive devices also respond to visible photons



X-ARAPUCA Subsystems

Exploded view of an X-ARAPUCA module:



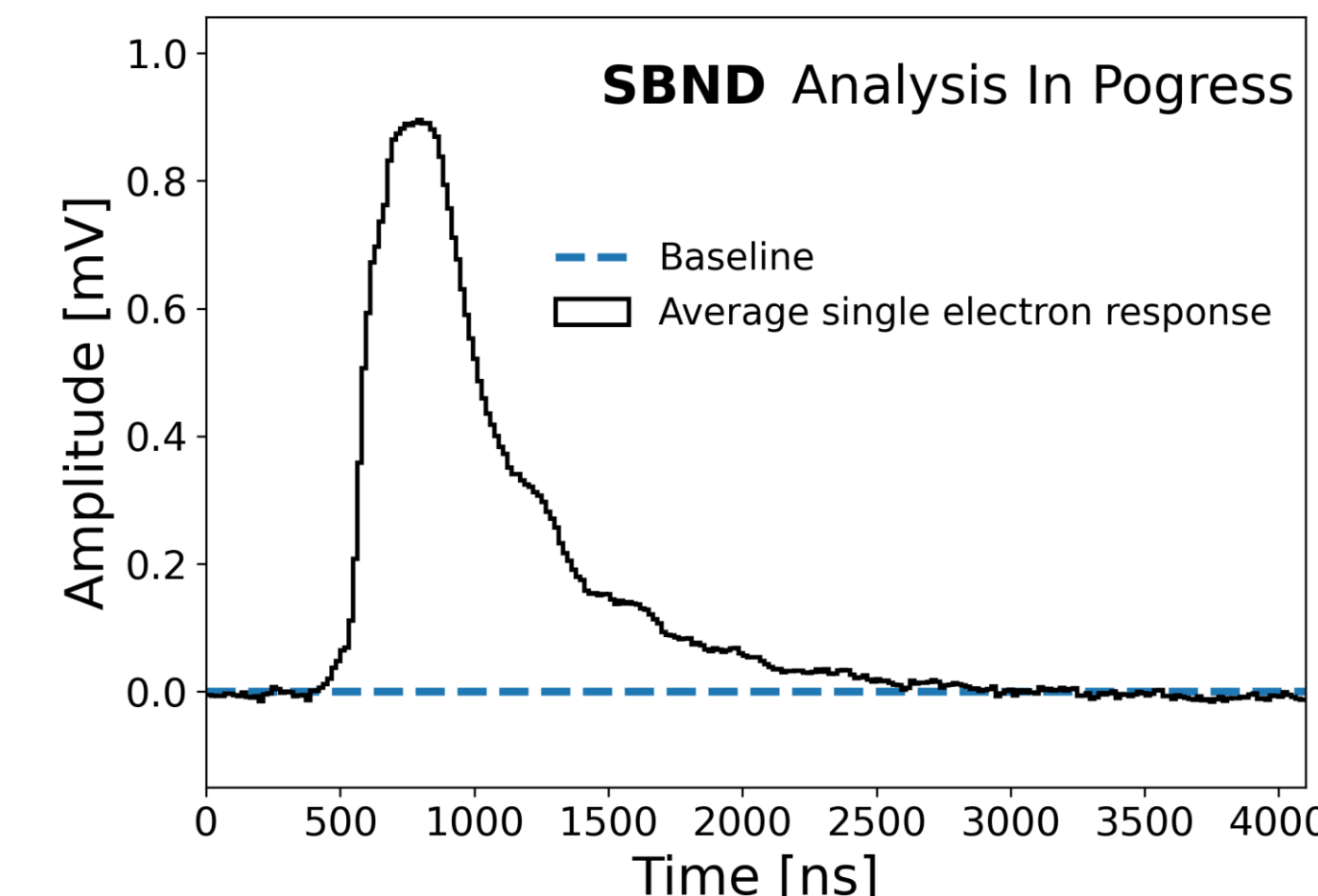
Modules are categorized by the amplifier and readout system used:

- Arapuca Power Supply And Input Amplifier (APSAIA)
- ARAPuca Readout Amplifier (ARARA)

Type	X-ARAPUCA			
	ARARA		APSAIA	
Dichroic filter cut off	OPTO 400 nm	OPTO 450 nm	OPTO 400 nm	OPTO 450 nm
wavelength-shifter	pTP	none	pTP	none
Light guide bar	EJ286 (blue)	EJ280 (green)	Glass to Power (blue)	Glass to Power (green)

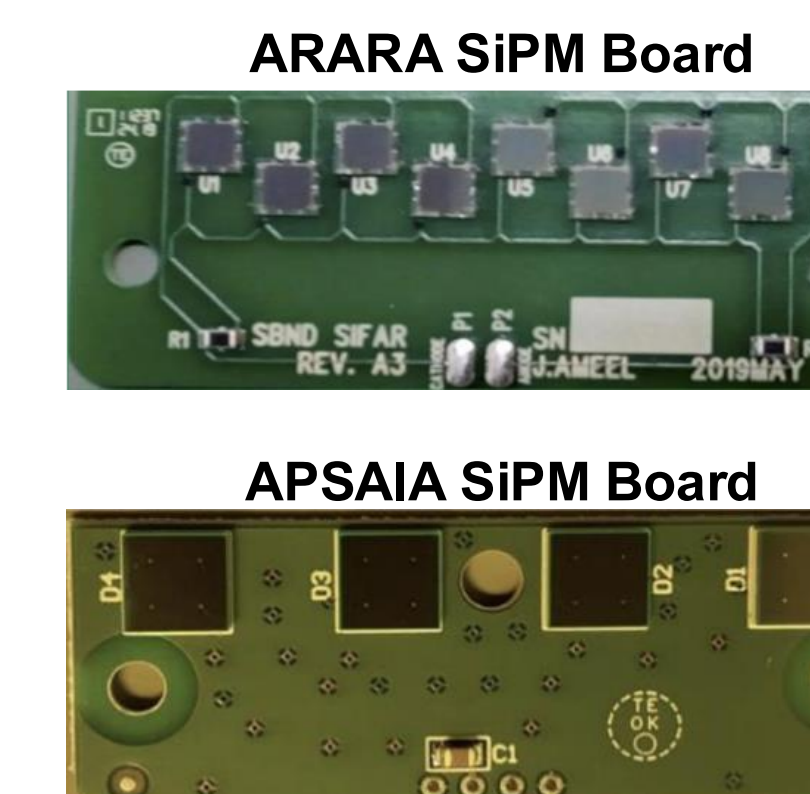
Multiple configurations for testing different components.

Average single electron response for APSAIA V1 X-ARAPUCAs.



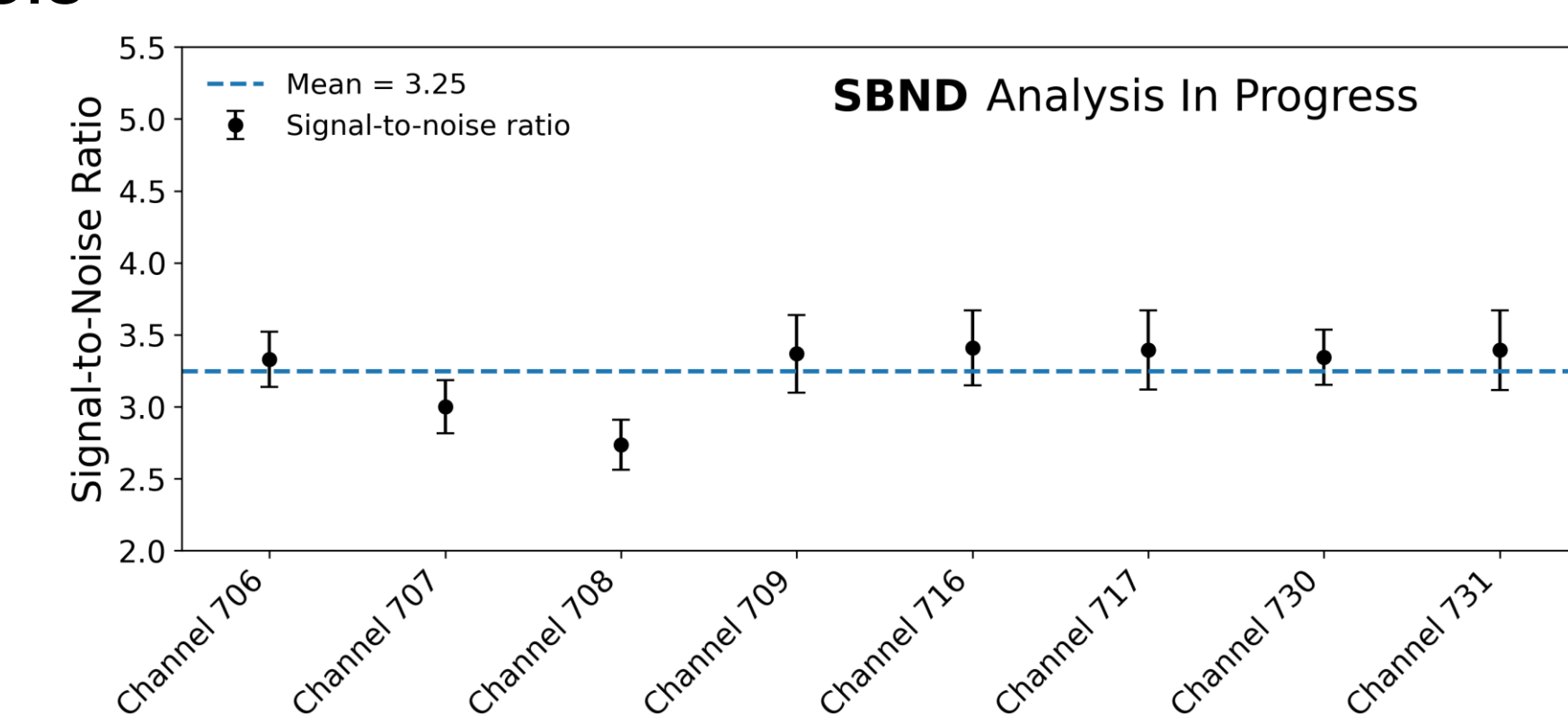
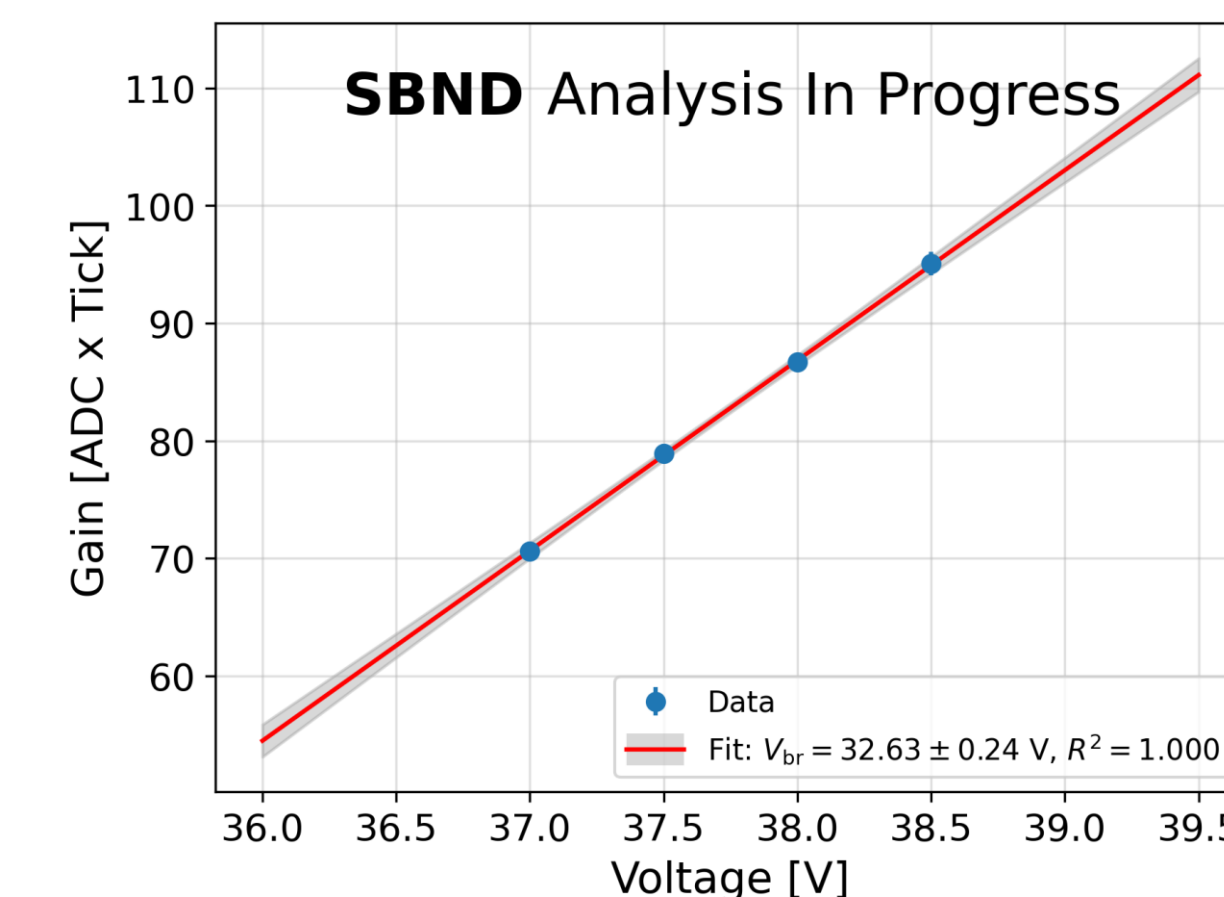
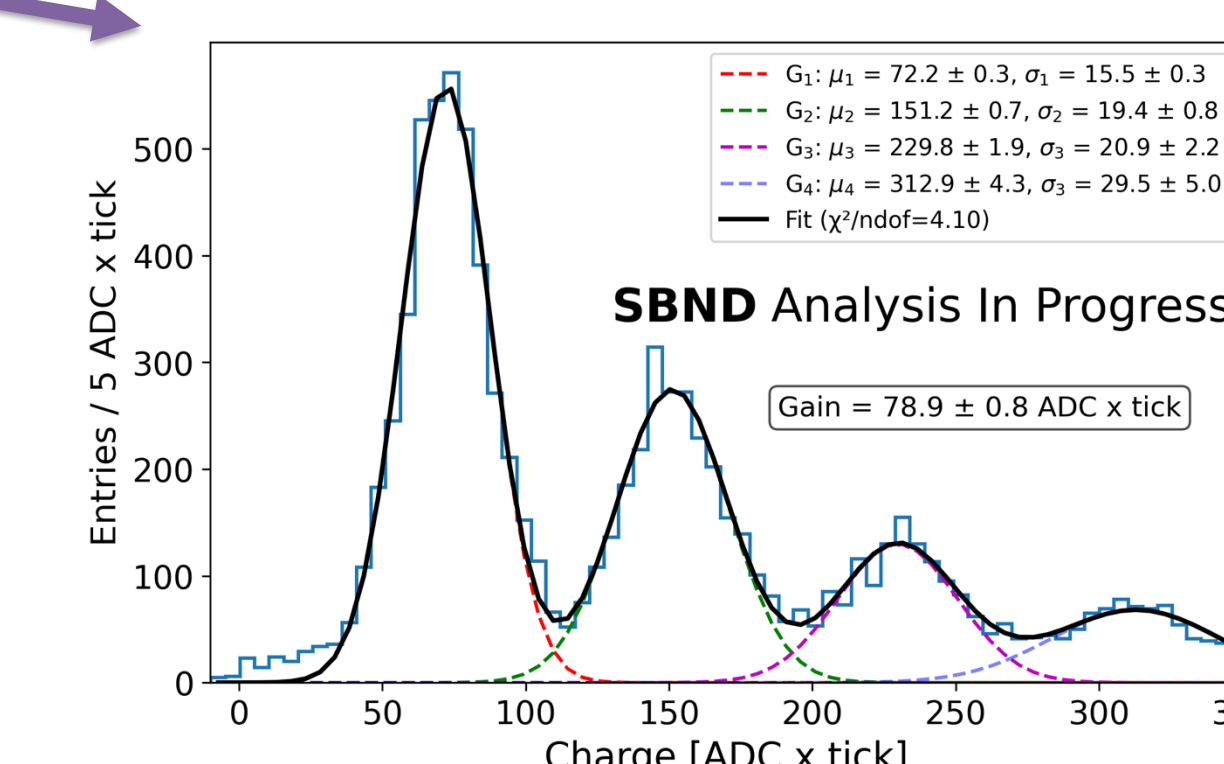
Status and Calibration

	X-ARAPUCA		
	ARARA	APSAIA V1	APSAIA V2
Manufacturer	SensL	Hamamatsu	Hamamatsu
Sensor name	MICROFC-30050	S14160-6050-HS	S13360-6050-VE
Number of channels (sensors)	176 (5632)	8 (64)	24 (192)



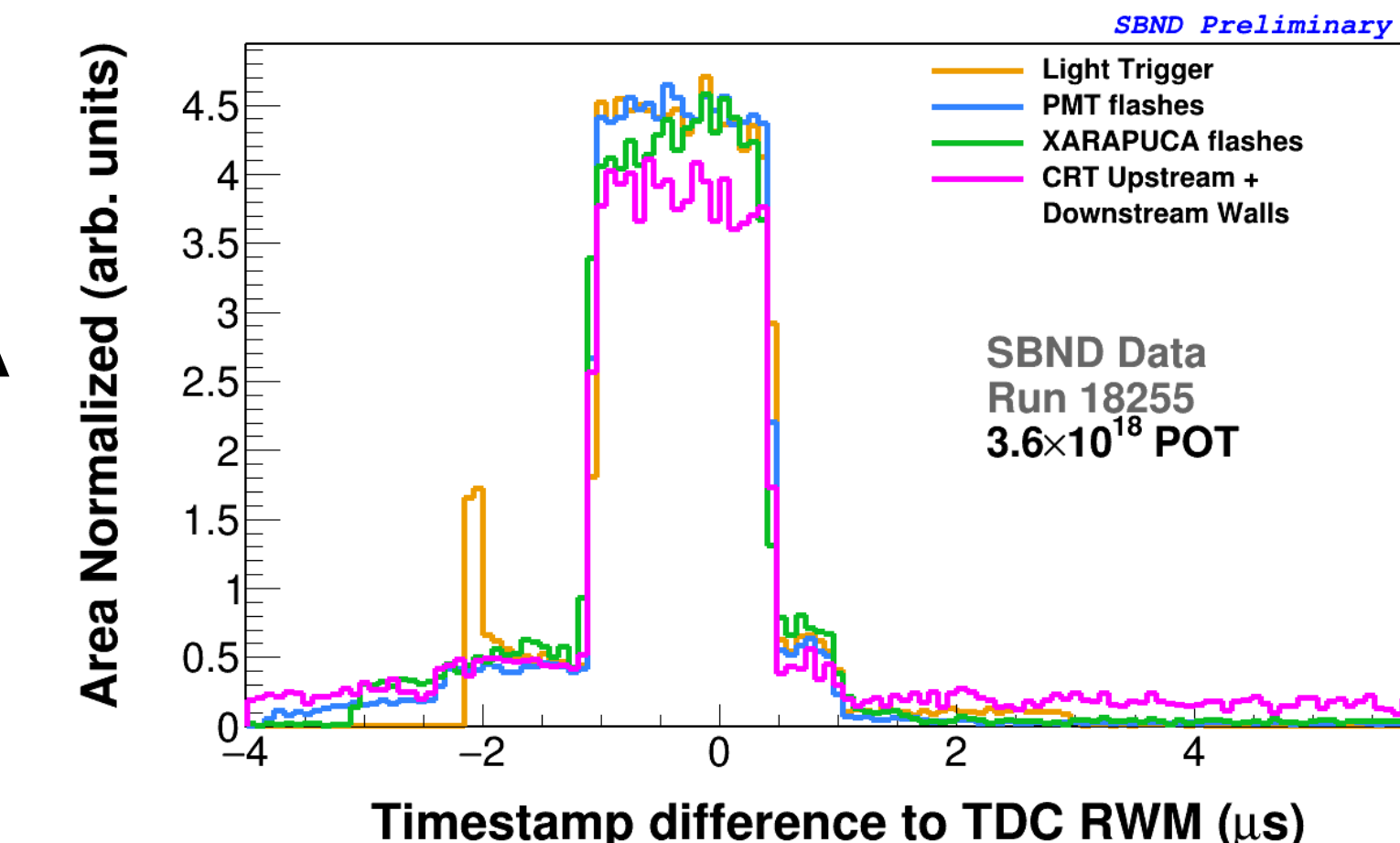
The calibration method is the same for all X-ARAPUCAs in SBND:

1. Collect low-light signals and fit the individual peaks corresponding to single-, double-, triple-photoelectron signals
 - ❖ Gain is the measured difference between the peaks
2. Repeat for multiple bias voltages and obtain the gain as a function of bias voltage
3. Set the voltages to match the gain across channels
4. Evaluate the signal-to-noise ratio (SNR)
 - ❖ APSAIA V1 SNR is 3.25
 - ❖ Compared to PMT's SNR is 4.7



Conclusion

SBND is the only experiment currently testing X-ARAPUCA technology in a neutrino beam and will provide critical information for deployment in future detectors like DUNE.



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[1] A. Machado, E. Segreto, D. Warner, A. Fauth, B. Gelli, A. P. R. Maximo, L. Paulucci, , and F. Marinho, "The X-ARAPUCA: An improvement of the ARAPUCA device," arXiv , 1–9 (2018), <https://arxiv.org/pdf/1804.01407>.

[2] SBND Collaboration. Scintillation light in SBND: simulation, reconstruction, and expected performance of the photon detection system. *Eur. Phys. J. C* 84, 1046 (2024). <https://doi.org/10.1140/epjc/s10052-024-13306-3>