



Bringing Back the Senses to LUX-ZEPLIN

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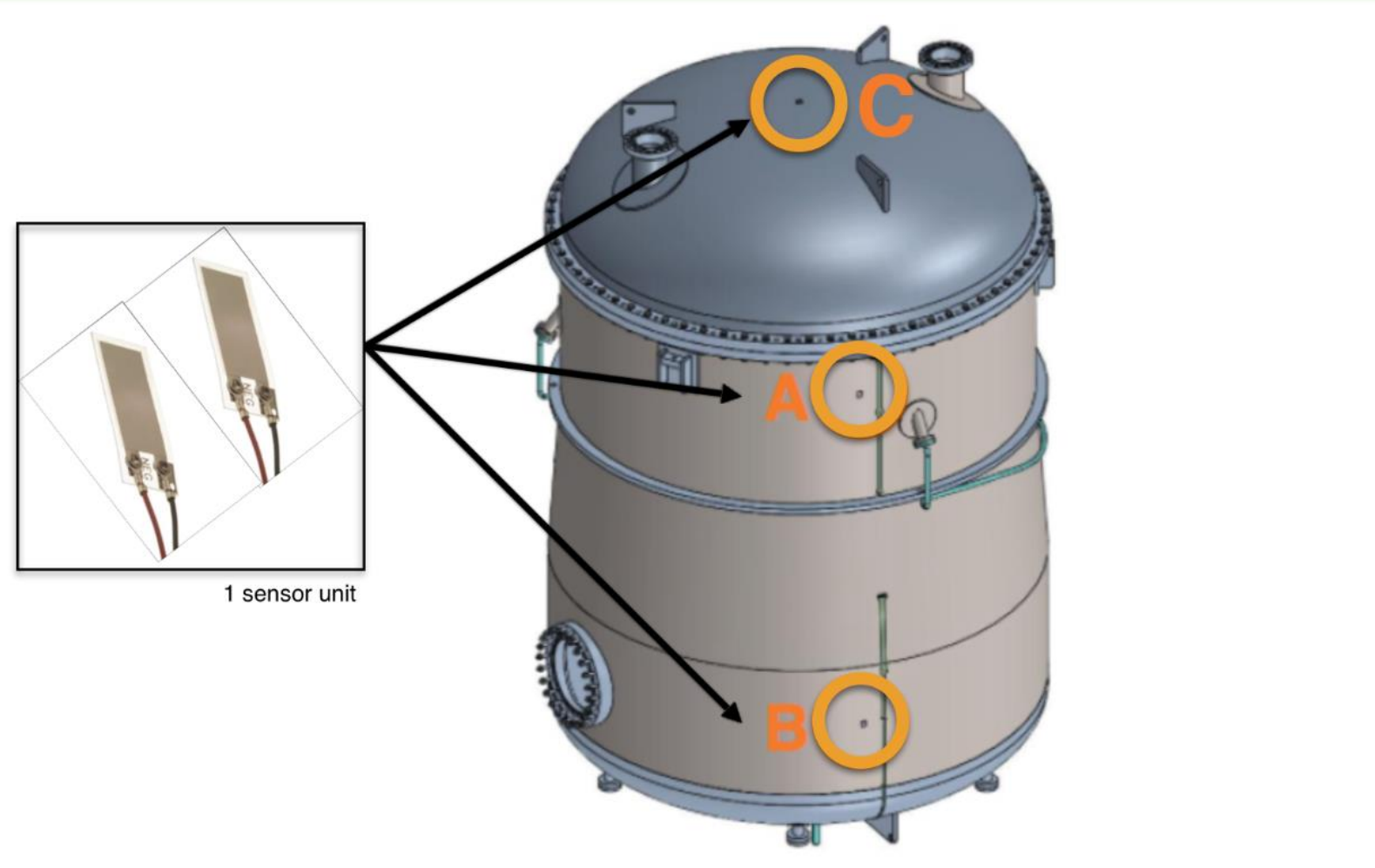


The LUX-ZEPLIN Experiment (1)

- Direct Dark Matter (WIMPs) Detector located ~1.5km underground at the Sanford Underground Research Facility (SURF) South Dakota
- Utilises a dual phase liquid Xenon time projection chamber (TPC) with 7 tonnes of active Xenon
- Published world leading sensitivities to spin independent WIMP-nucleon interactions in 2022 (1)
- Sensitive to 40GeV/c² WIMP cross section of 1.4x10⁻⁴⁸cm² with 1000 live days of data (2,3)

Acoustic Sensors (4)

- Measures spurious vibrations which can contribute backgrounds e.g. cavitation of bubbles
- Piezoelectric polymer film (PVDF)
- Installed on the inner cryostat vessel (ICV)
 - 8 total, 1 on top, 1 on bottom, 6 evenly spaced around the ICV



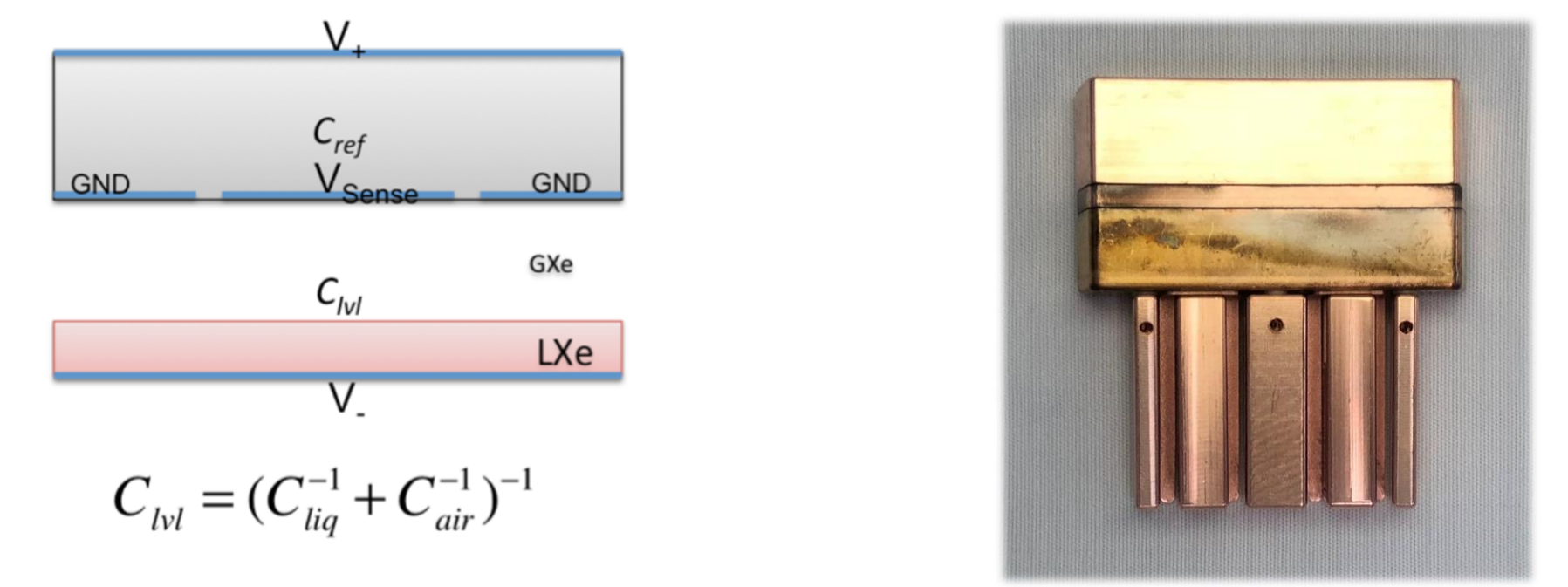
Incoming particle

Slow and Fast Control (2)

- LZ's Xe detector is monitored by many sensors such as thermometers, pressure transducers, barometers, acoustic sensors, loop antenna and level sensors (4)
- Data acquisition split into fast and slow control,
 - Slow control is used to monitor for long term changes by operators of the detector (1Hz sampling)
 - Fast control is triggered in a 2.5ms window on the S2 of events, data is only taken from the Acoustic Sensors, Loop Antenna and, Weir Precision Sensors (100kHz sampling)

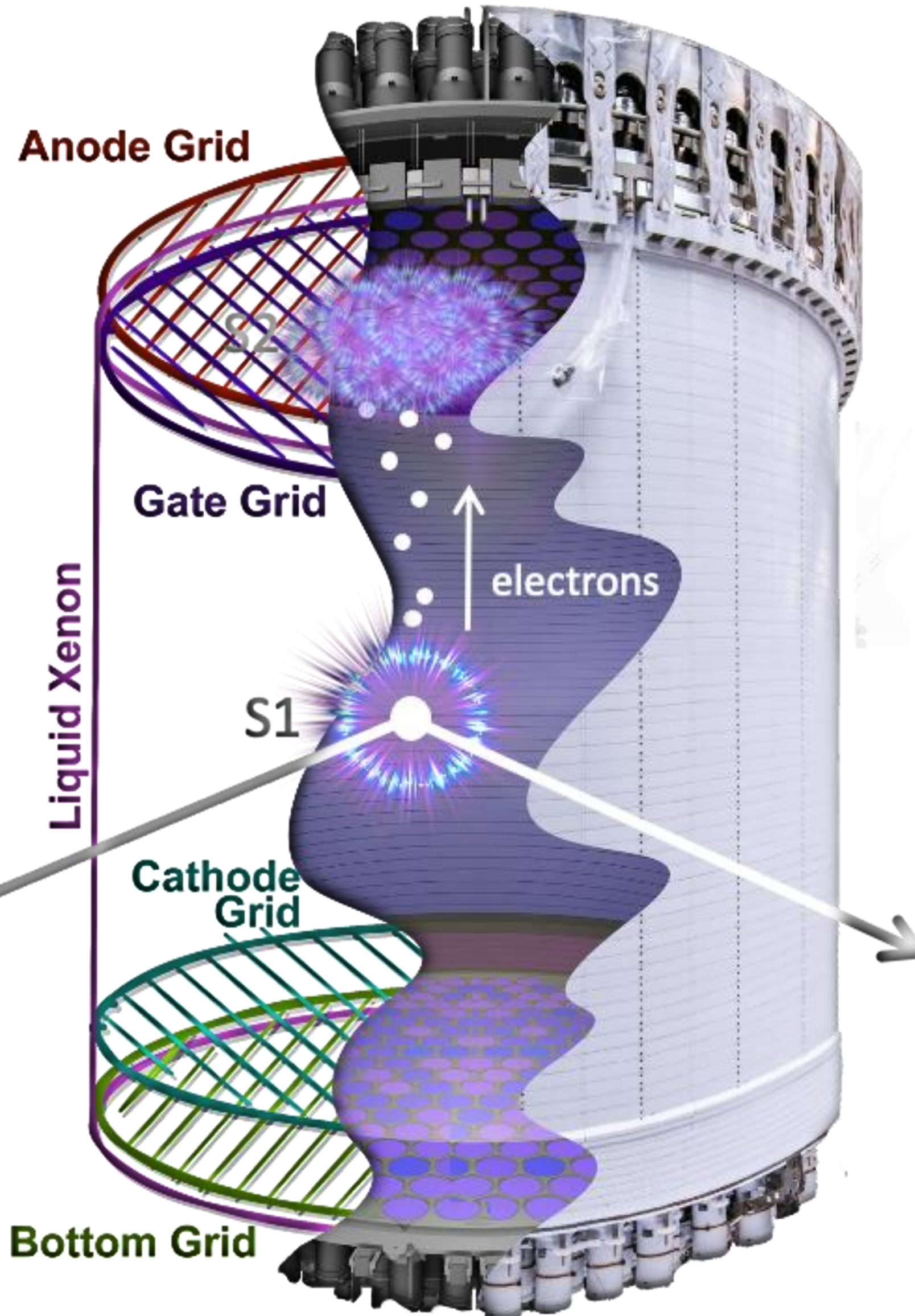
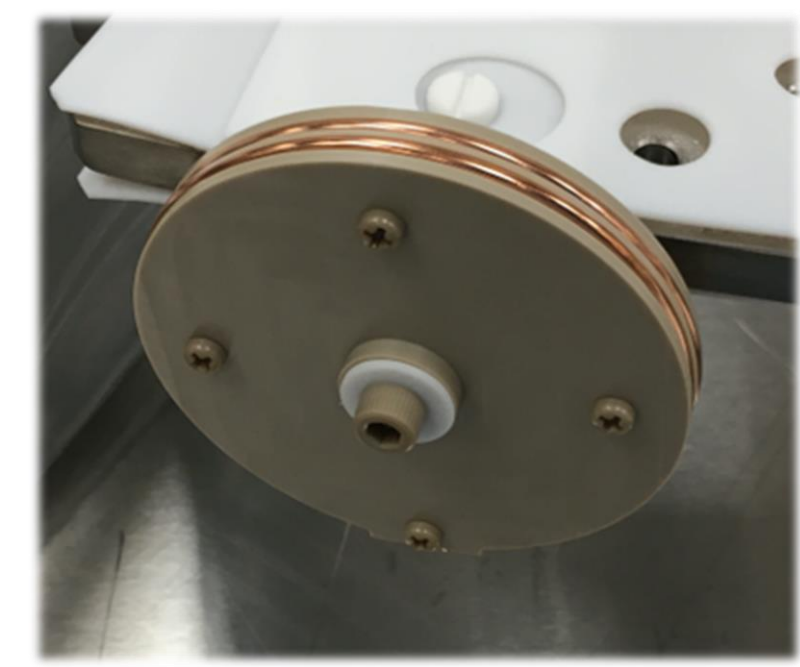
Weir Precision Sensors (3)

- Detects changes in height of the liquid xenon
 - E.g. long-term changes / surface waves & ripples from possibly bubbles and circulation changes
- Parallel plate capacitors
 - The liquid surface sits between the plates
- 6 WPS are spread evenly about the surface of the LXe



Loop Antenna (5)

- Monitors the EM environment of the TPC
 - Can provide a quick shut down to the HV supply if sparking from the HV grids occur
- 2 stacked OFHC copper wire rings
 - Held in place by a polyether ether ketone casing (PEEK)
- Installed on the PMT trusses
 - 4 located on the top PMT trusses, 4 located on the bottom PMT trusses



Physics event with low sensor noise

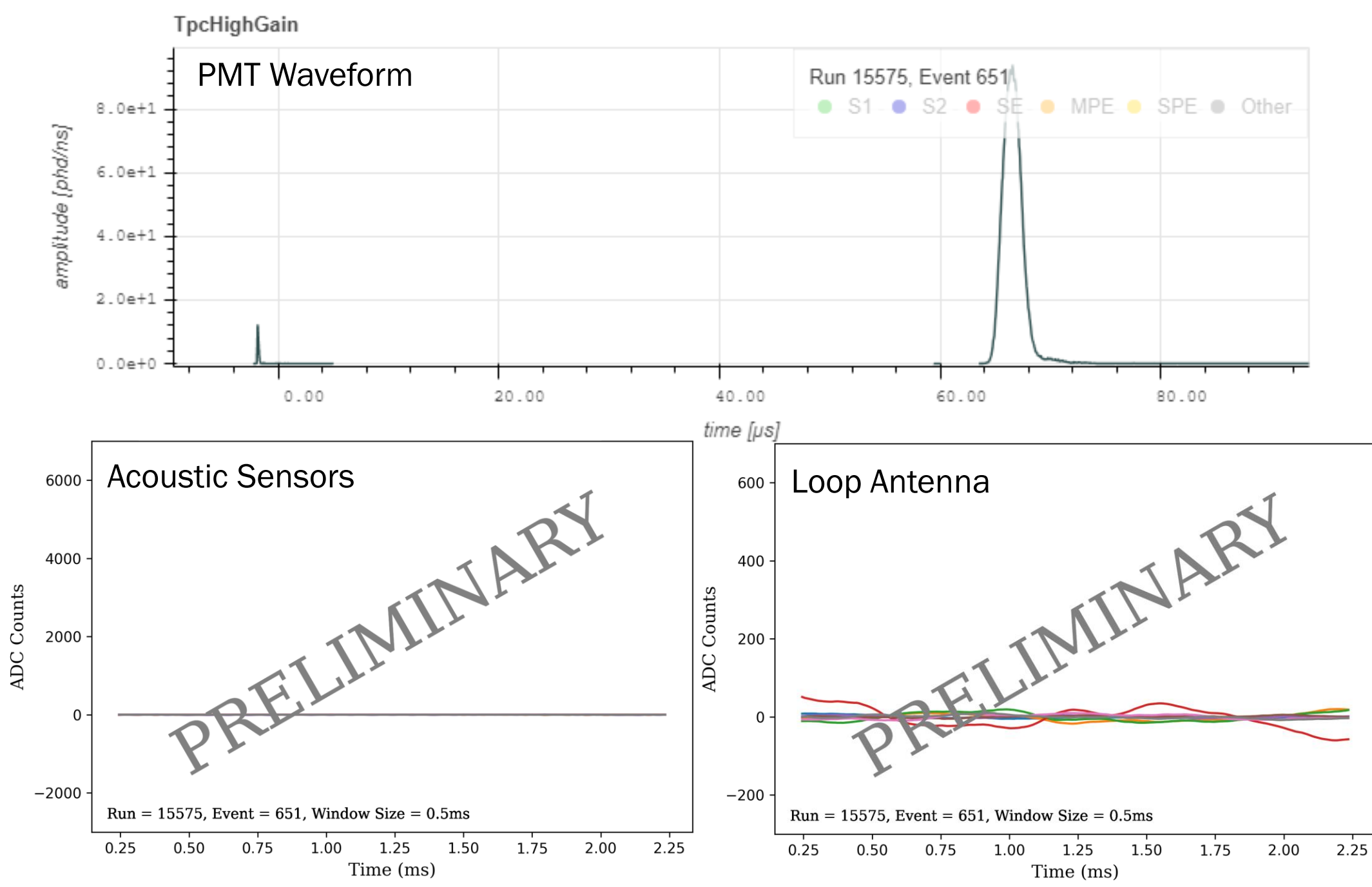


Figure 2: A good physics event where only noise is observed in the sensors. The PMT waveform indicates a clean high energy single scatter near the wall, likely from a radiogenic origin.

Solenoid Valve actuation in PMT waveforms and multiple sensors

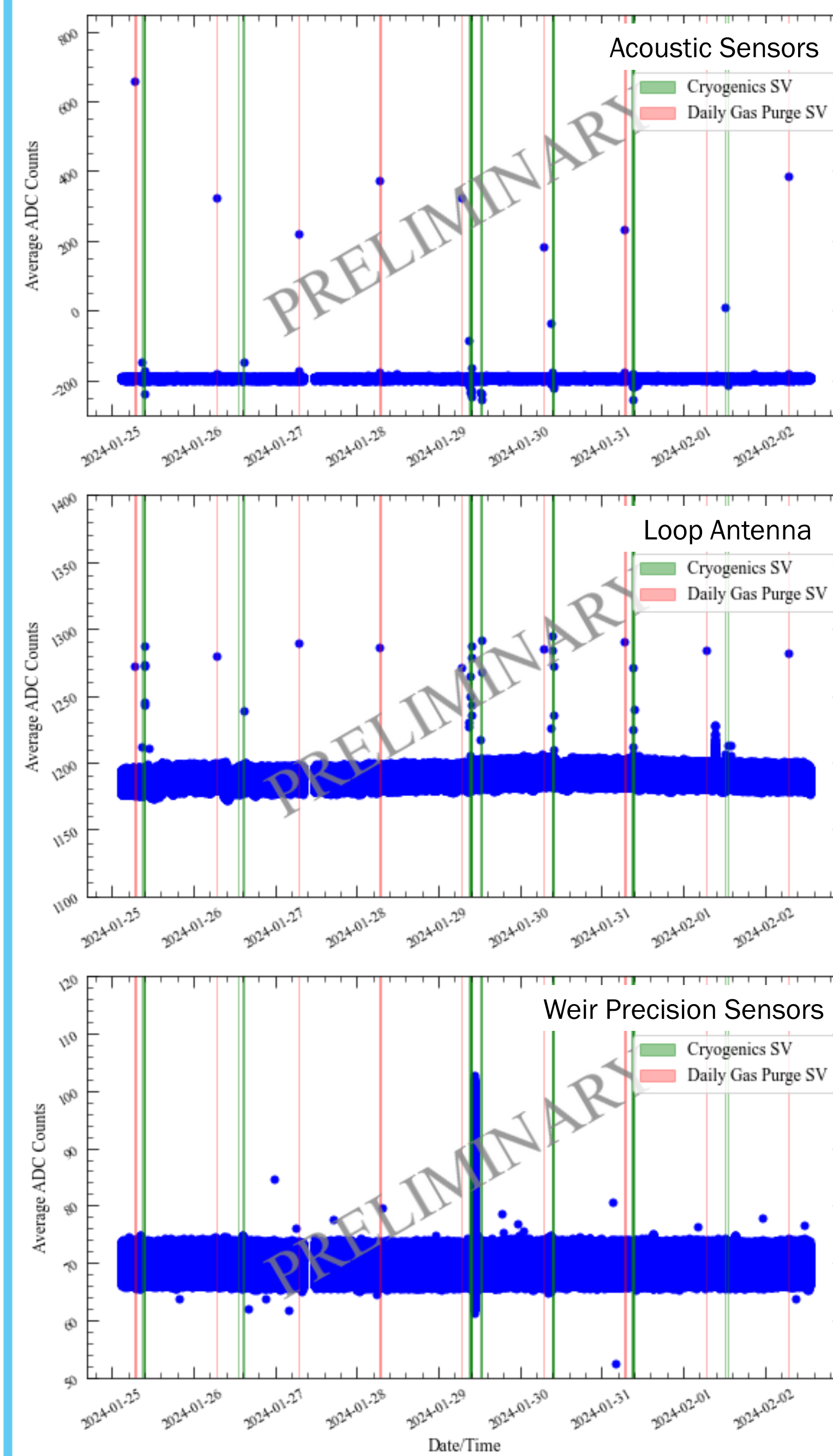


Figure 1: Acoustic sensors, loop antenna and weir precision sensors average ADC counts over ~8 days. Average ADC counts being the average value for an event, averaged over all sensors for each sensor type. Each point is one event. Solenoid valve actuations seen in the AS and LA are highlighted in red and green. The large spike in the WPS is from a change of cryocooler.

Solenoid Valve actuation in PMT waveforms and multiple sensors

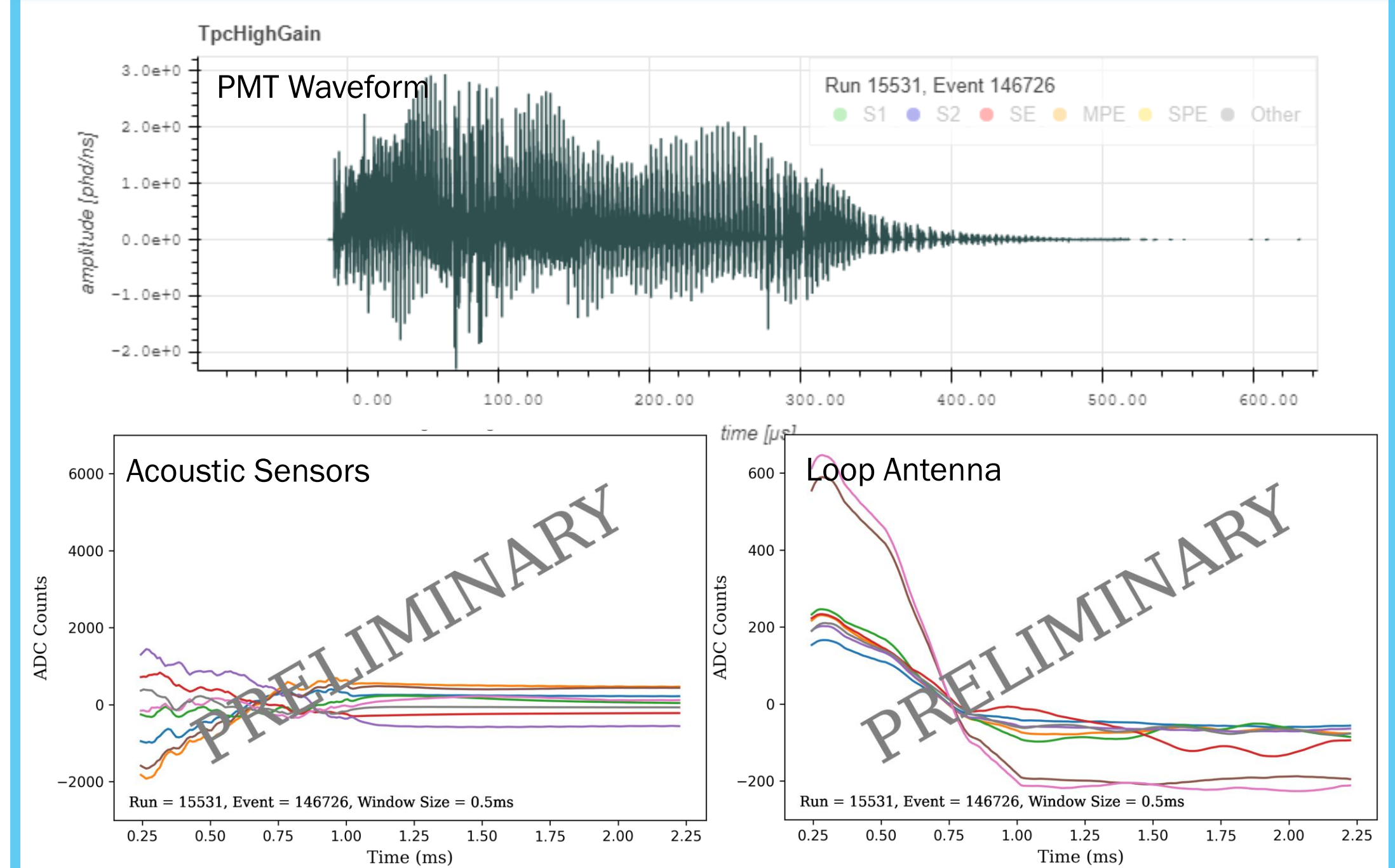


Figure 2: An event where a solenoid valve is actuating. Signals are seen in the loop antenna and acoustic sensors. The PMT waveform shows interference; this is also observed in the outer detector.

Daily Solenoid Valve Actuation

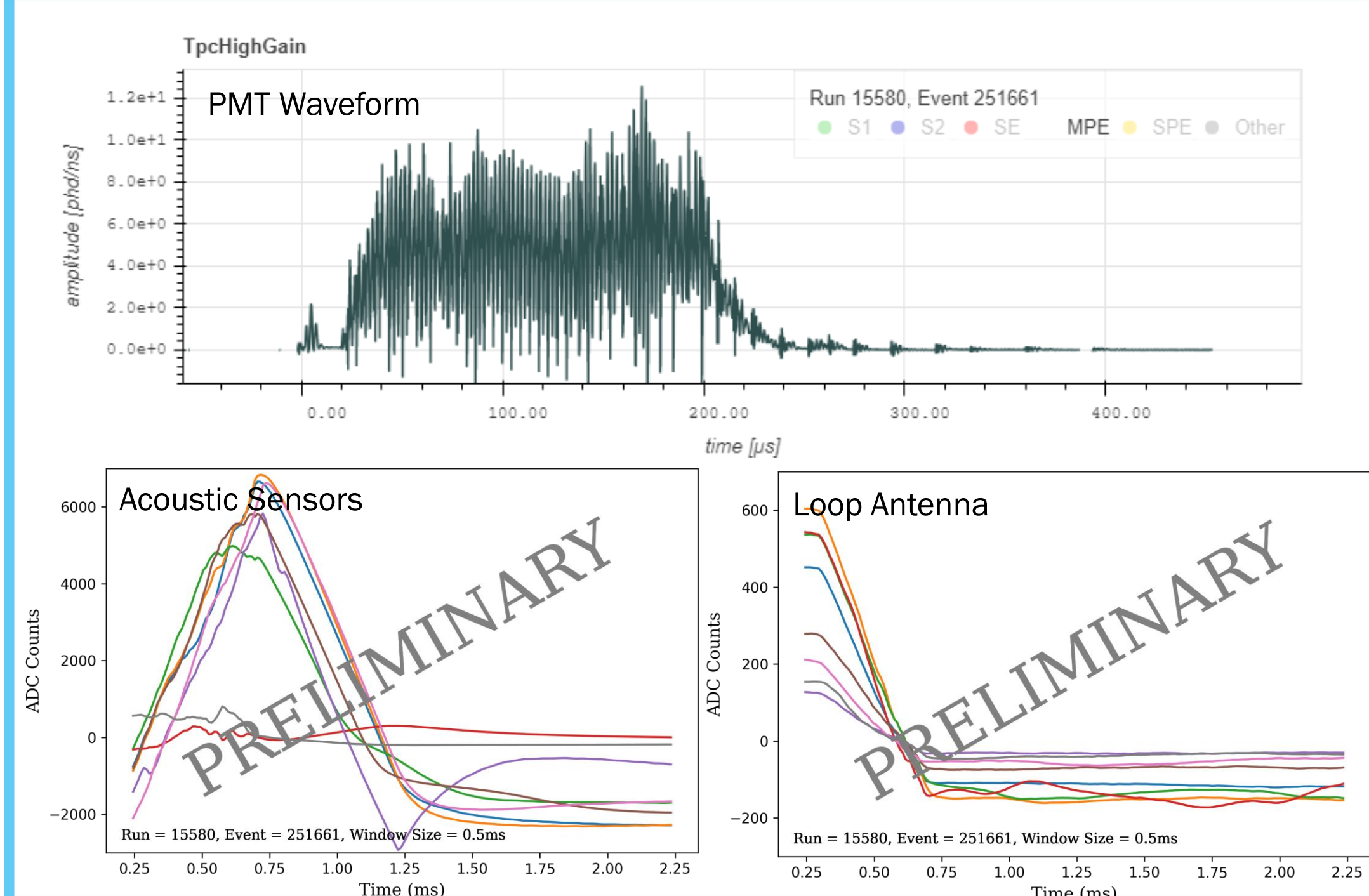


Figure 3: A daily event seen when a solenoid valve actuates at 0651MT. The PMT waveform shows interference; this is also observed in the outer detector.

Conclusion & Results (6)

- First exploratory study into on-event sensor data of LZ
- The sensors were anticipated to help understand the detector and help with debugging in case of problems; this hasn't been required - this is an exploratory study
- Signals are observed in the fast data for the sensors
- The signals observed in the acoustic sensors and loop antenna are well characterised through solenoid valve actuations in the cryogenics system

References:

1. Aalbers, Jelle, et al. "First dark matter search results from the LUX-ZEPLIN (LZ) experiment." *Physical review letters* 131.4 (2023): 041002.
2. Akerib, D. S., et al. "Projected WIMP sensitivity of the LUX-ZEPLIN dark matter experiment." *Physical Review D* 101.5 (2020): 052002.#
3. Akerib, D. S., et al. "The lux-zeplin (lz) experiment." *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment* 953 (2020): 163047.
4. Mount, B. J. LUX-ZEPLIN (LZ) technical design report. No. LBNL-1007256; FERMI LAB-TM-2653-AE-E-PPD; arXiv: 1703.09144.

