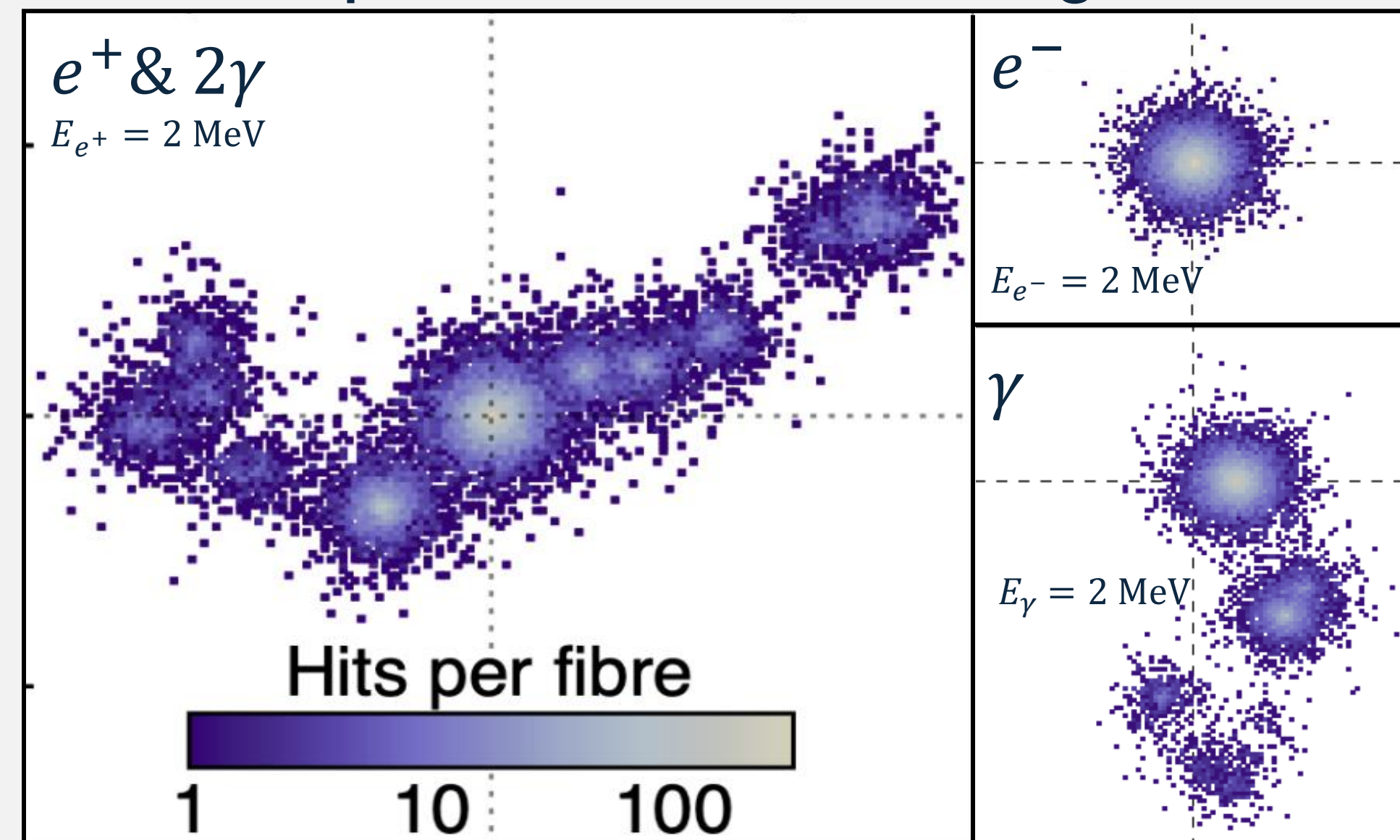


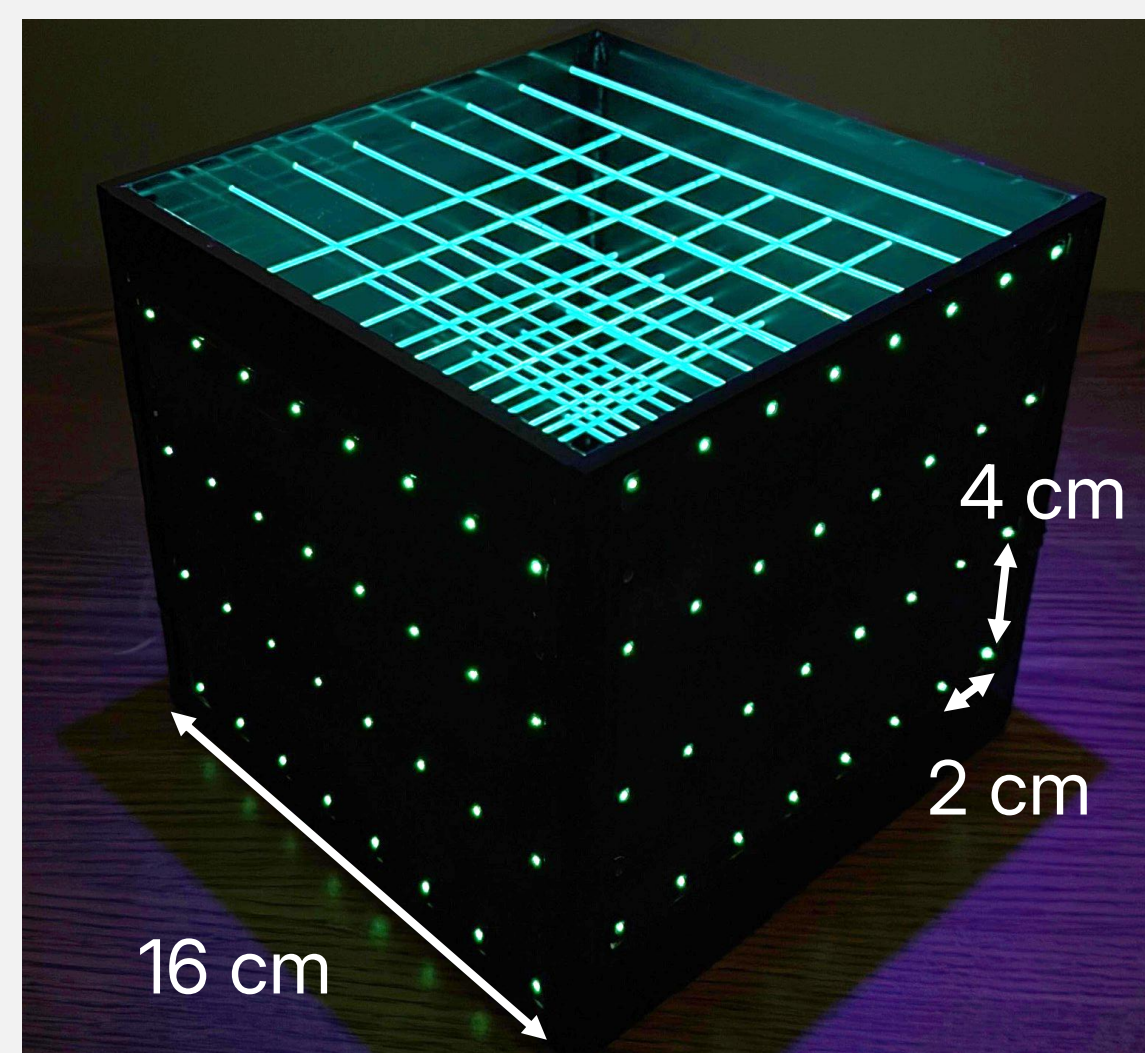
## BPULSE Experiment

### LiquidO Detection Paradigm:



Simulated LiquidO event displays. LiquidO combines an optically scattering scintillating target volume with wavelength shifting (WLS) fibers to produce event structure suitable for particle discrimination and tracking capabilities.

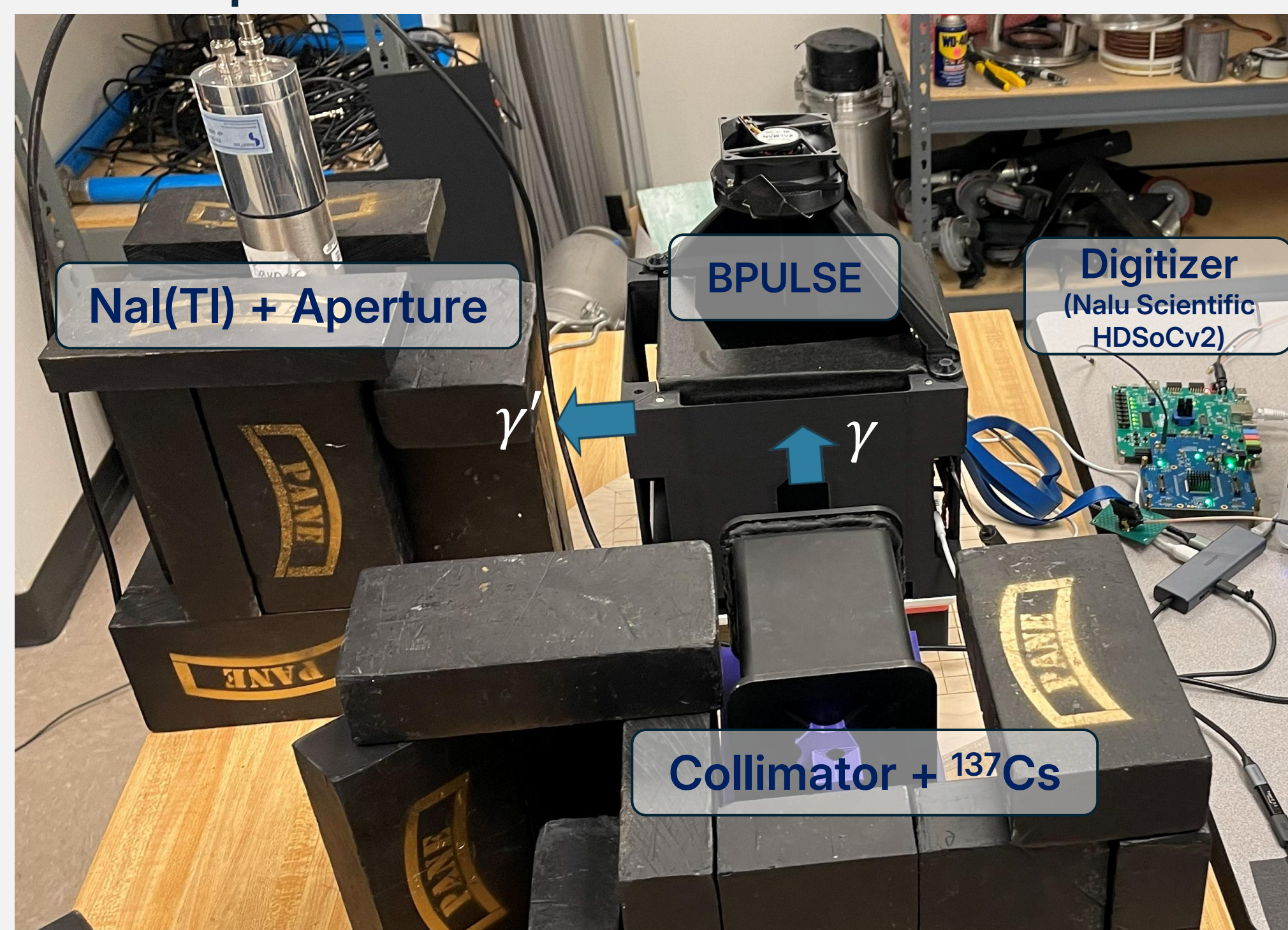
### BPULSE (Berkeley PennState Universities LiquidO Science Experiment):



BPULSE prototype, shown pre-scintillator fill, characterizes  $\mathcal{O}(\text{MeV})$  interactions relevant for reactor  $\bar{\nu}_e$  (CLOUD) and  $0\nu\beta^+\beta^+$  (NuDoubt++).

- BPULSE Specs:
- 4L LAB+ PPO+ BisMSB+ Wax (NoWaSH - S. Schoppmann)
  - 64 1 mm  $\varnothing$  Y-11 WLS fibers
  - 64 SiPMs
  - 64 1-GSPS Digitizer

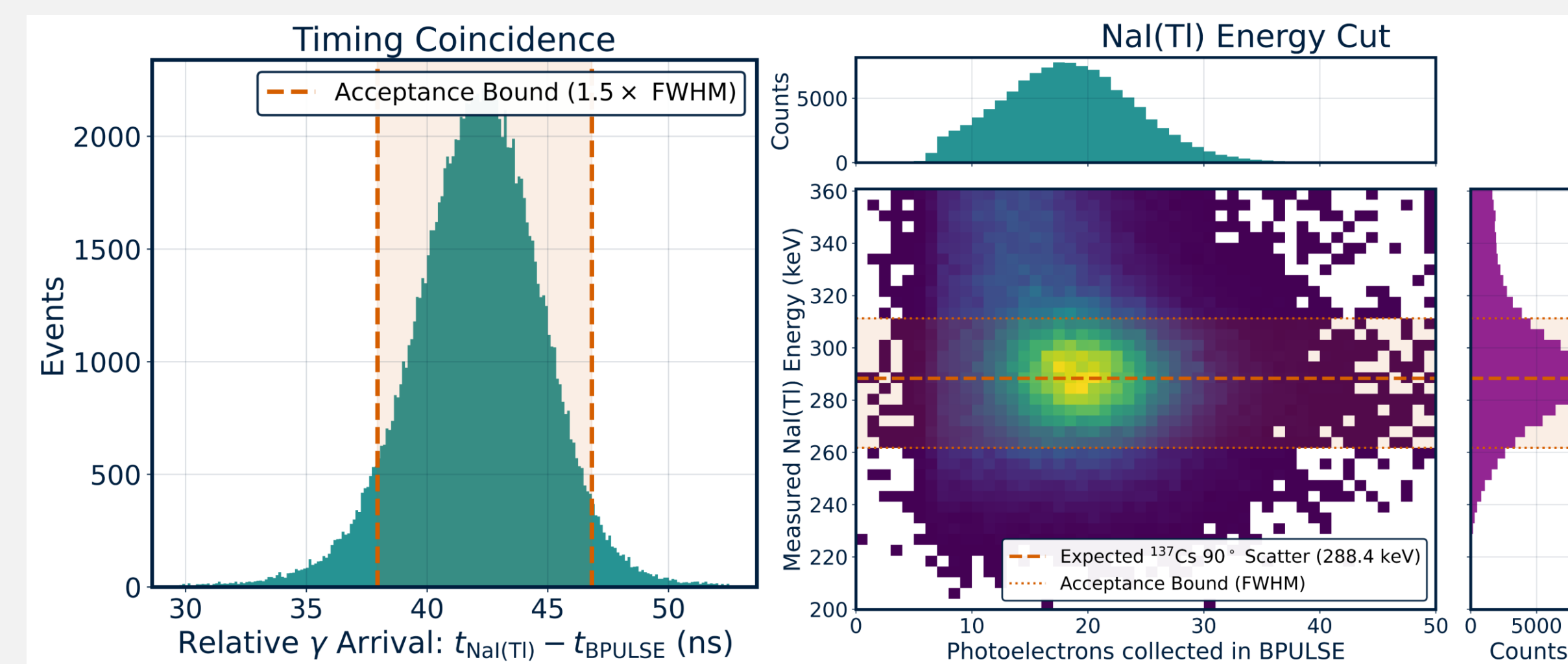
### Compton Coincidence Characterization:



Energy deposition in BPULSE via Compton scattering using a  $^{137}\text{Cs}$  source ( $E_\gamma=662\text{keV}$ ) collimated to a 2 cm diameter beam with the 1.2 cm field of view of a NaI(Tl) detector; deposited energy constrained by scattering angle.

## Event Selection

### NaI(Tl) Event Selection:

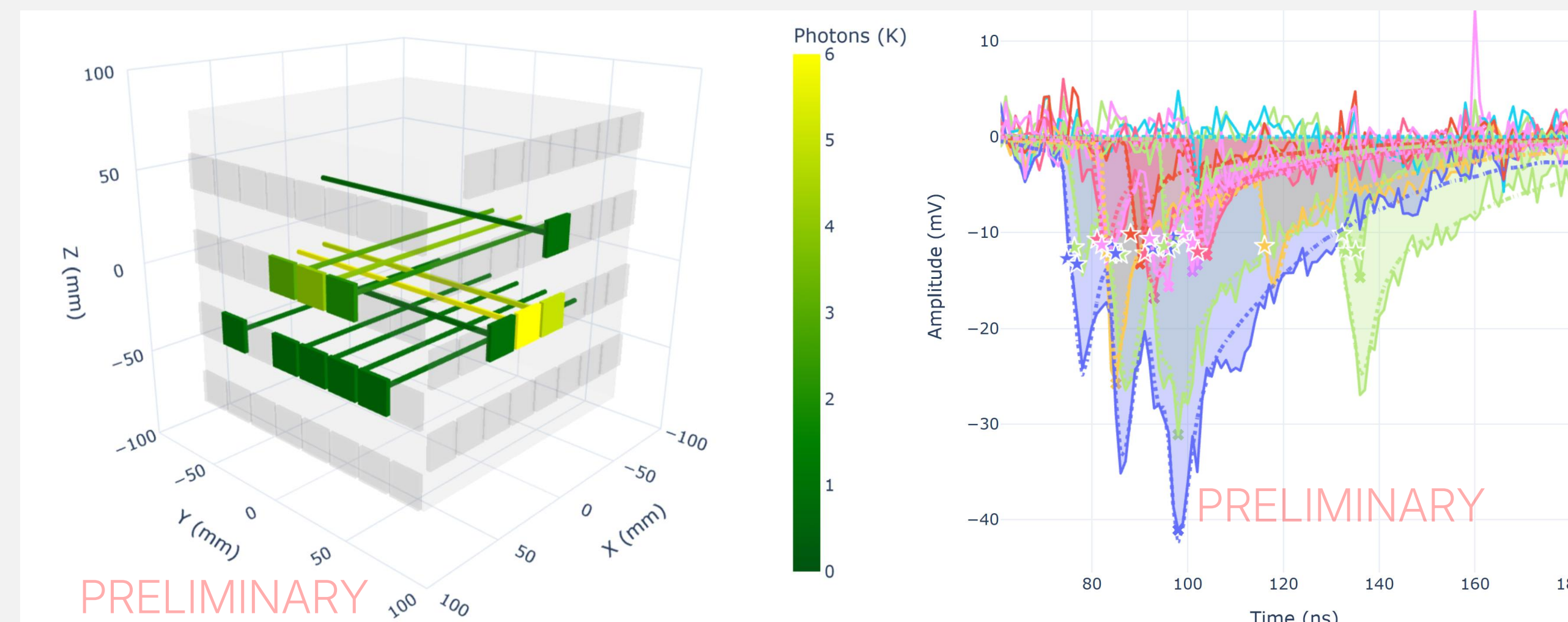


Compton scatter signal coincidence with BPULSE and NaI(Tl).

Left: Temporal coincidence demonstrates high event purity.

Right: Energy coincidence centers at 288 keV in the NaI(Tl) detector from a  $90^\circ$   $\gamma$  scatter.

### BPULSE Data Event Display:



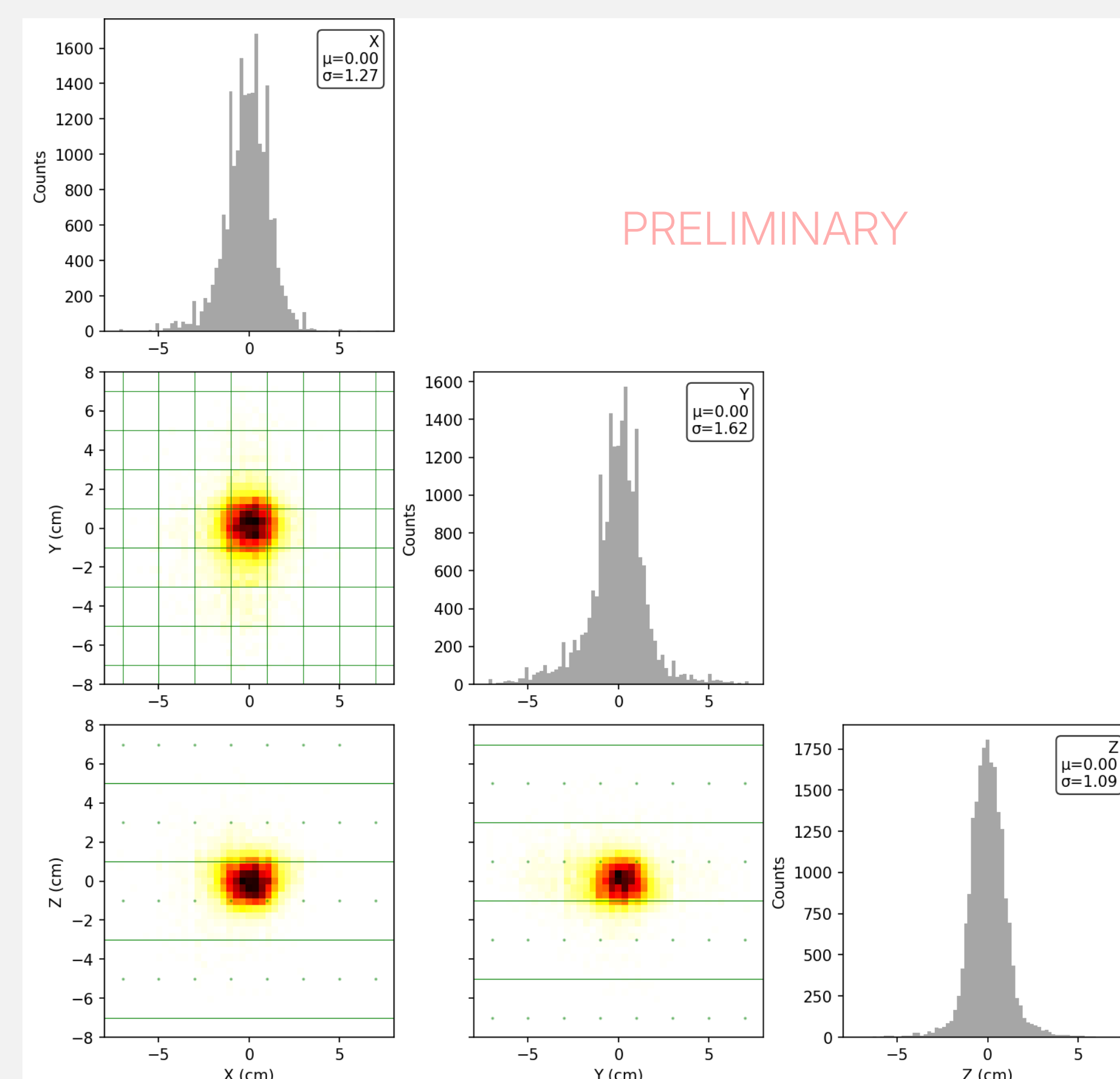
A 374 keV electron measured in BPULSE.

Left: 3D display of light collection profile indicating localization of light.

Right: digitized waveforms and fitted photon arrival times provide precise counting and timing characterization.

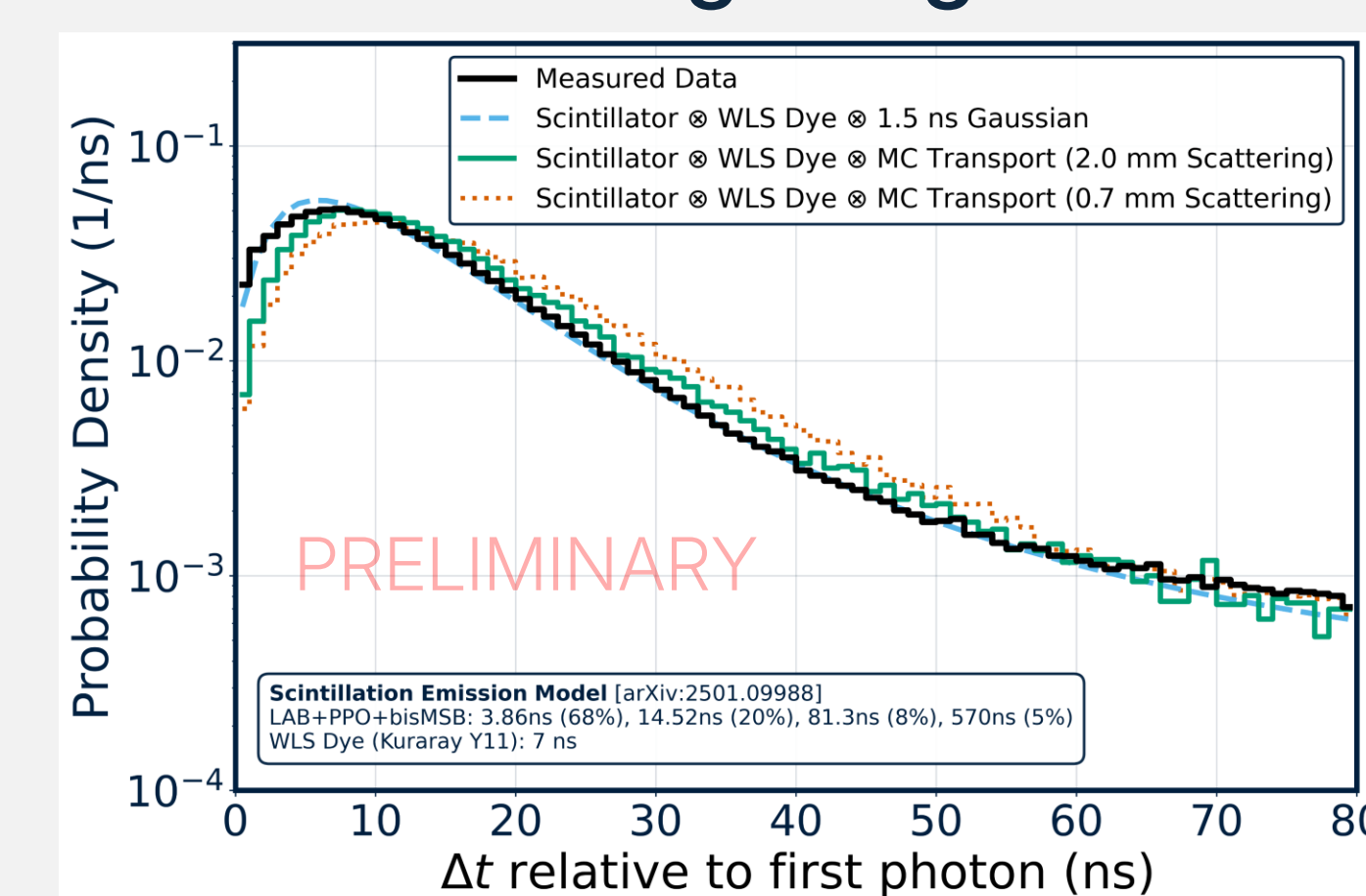
## Performance

### Vertex Reconstruction:

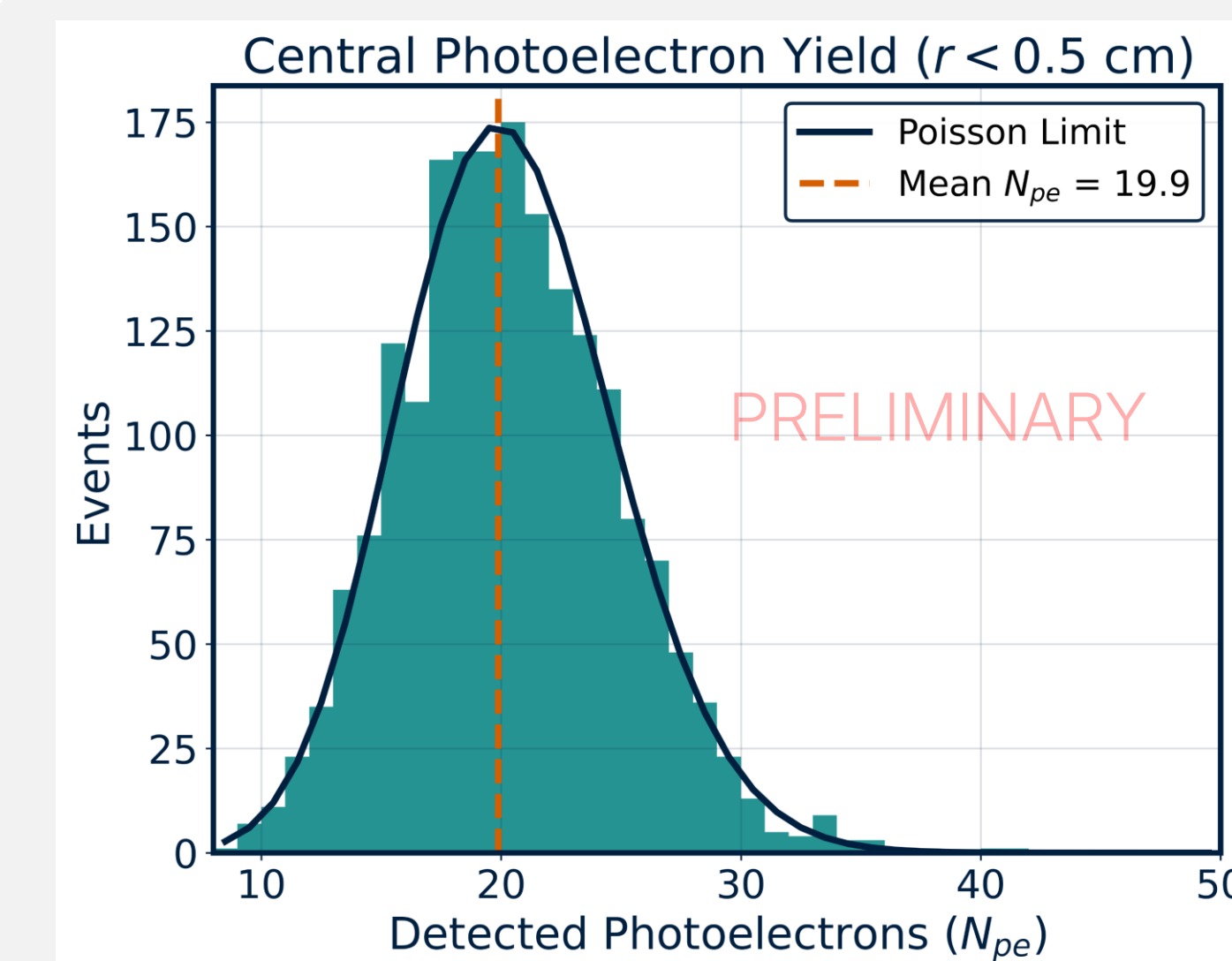


Reconstructed interaction position. Reported resolution of  $\sim 1$  cm dominated by beam spot size and multi-scatter events. Simulation of a point source indicates 0.5 cm resolution in x & y, 0.3 cm in z.

### BPULSE Timing & Light Collection:



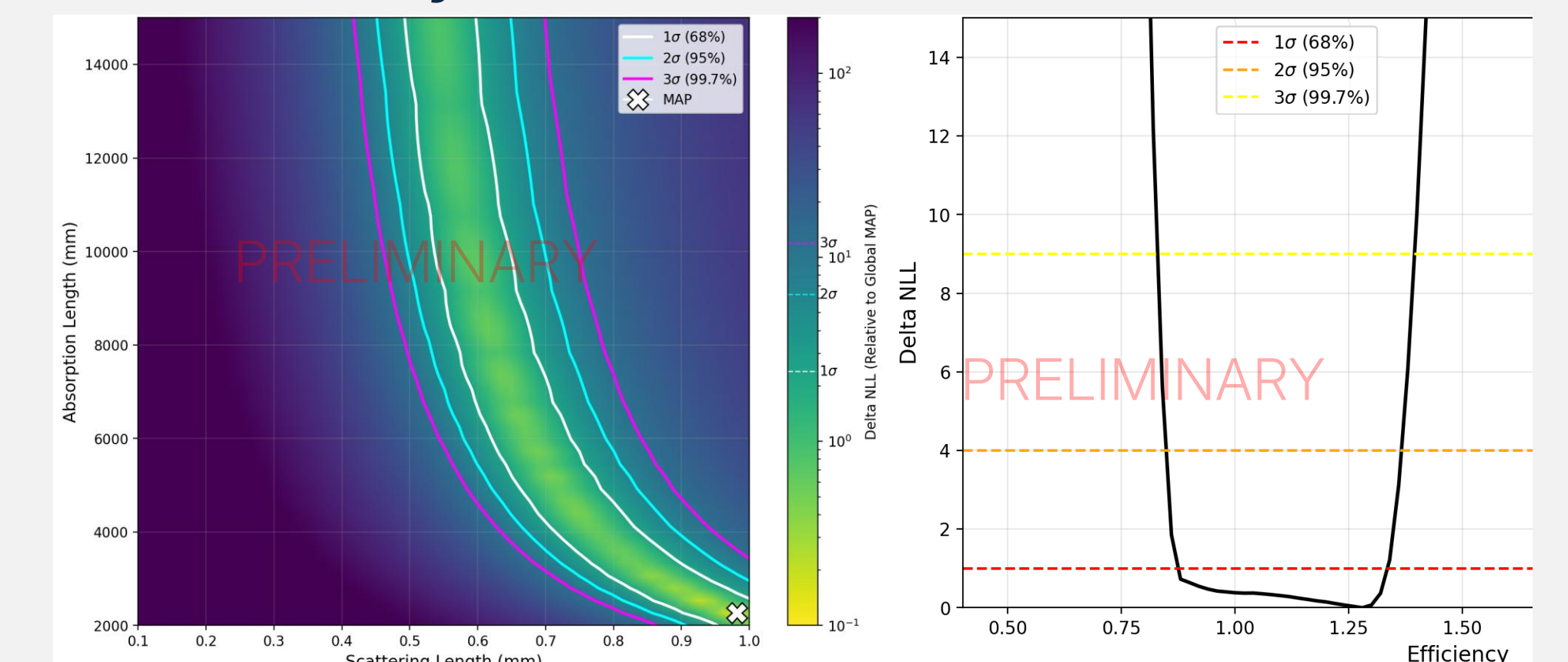
Photon arrival times, dominated by fiber properties, perturbed by optical scattering in opaque scintillator.



374 keV electron recoils in the center of BPULSE generate 20 photons at readout on average.

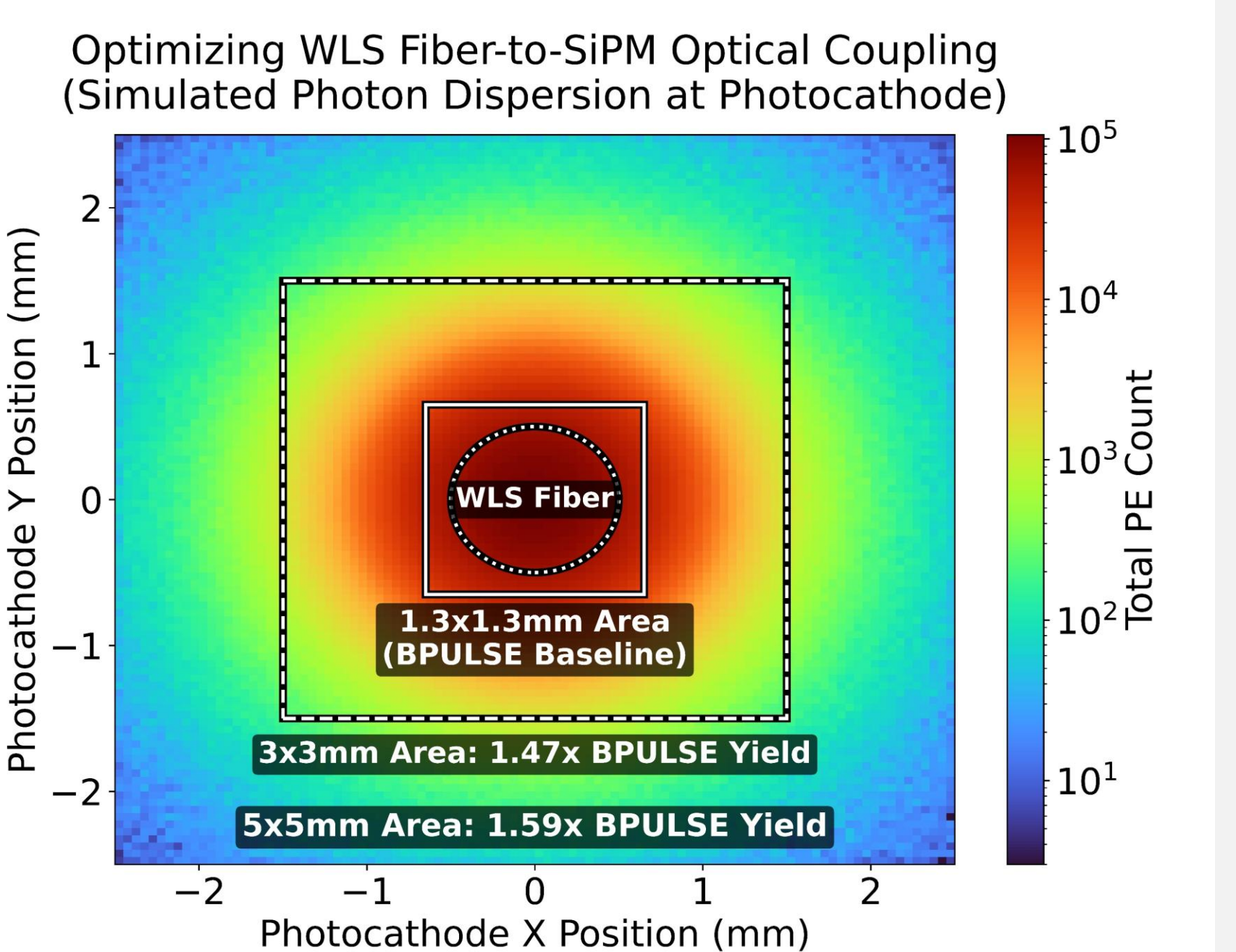
## Implications

### Systematics & Simulation:



Simulated degeneracy between scintillator absorption and scattering length with detector efficiency, the largest current uncertainty in our measurement.

### Optimization:



Simulation of photon collection at SiPM photocathode suggests larger surface could increase collection efficiency  $>1.5\times$ .

Optimizing detection setup assuming SiPMs at both fiber ends (128 total) and larger photocathode area:

$$\frac{20 \text{ photons}}{374\text{keV}} * \frac{2 \text{ SiPM}}{\text{fiber}} * 1.5 = \frac{160 \text{ photons}}{\text{MeV}}$$

### Outlook:

Current BPULSE can resolve electron energy depositions suitable for measuring  $\beta^+$  annihilation  $\gamma$ 's with position resolution competitive with voxelized detectors (SuperFGD).

Refine optical models and track remaining systematics to build a foundational response function for LiquidO.

Test additional scintillator targets (emulsion based oWbLS from Brookhaven National Lab) and measure higher energy gamma emissions ( $^{60}\text{Co}$ ).