FERMILAB-SLIDES-24-0156-PPD

ANNIE in 10 minutes

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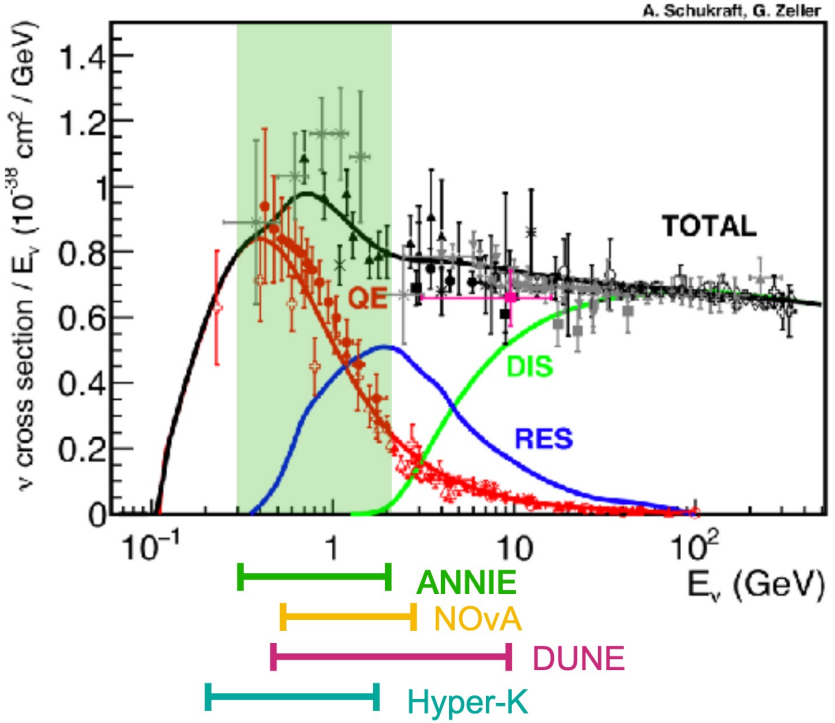
On behalf of the ANNIE collaboration

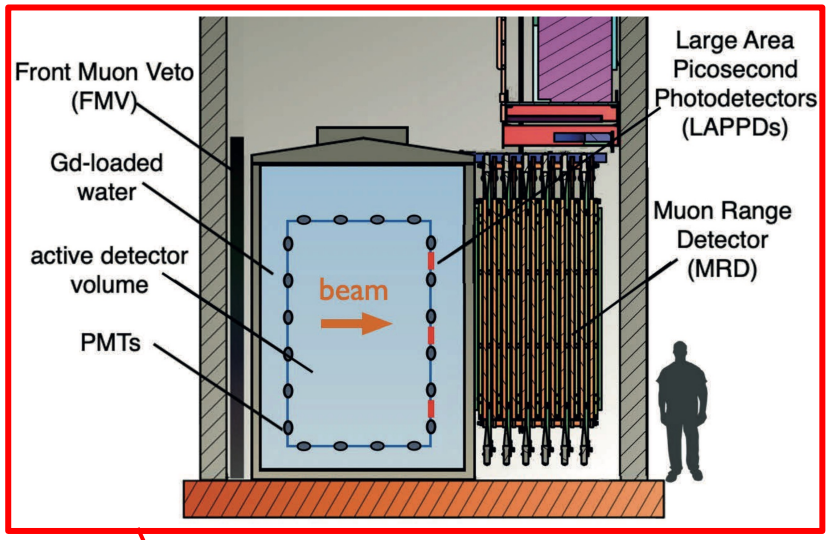
New Perspectives, July 8th 2024

Accelerator Neutrino Neutron Interaction Experiment

annie

- ANNIE is a 26-tonne Gd-loaded water Cherenkov neutrino detector
- Sits in Booster Neutrino Beam (BNB)





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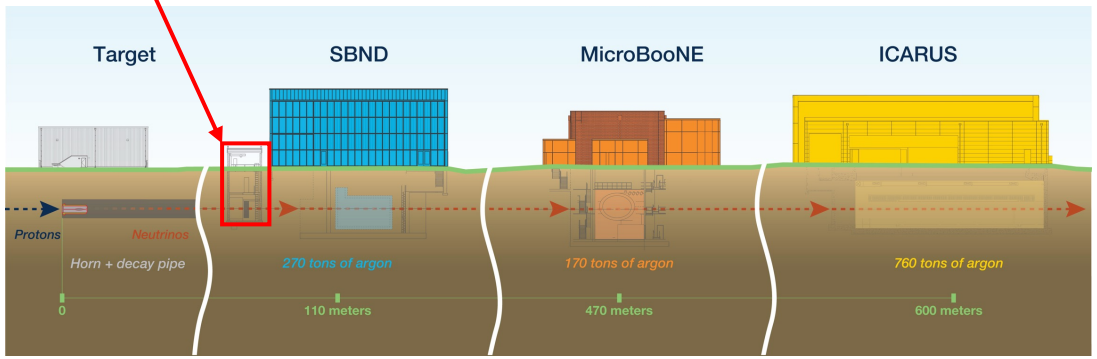
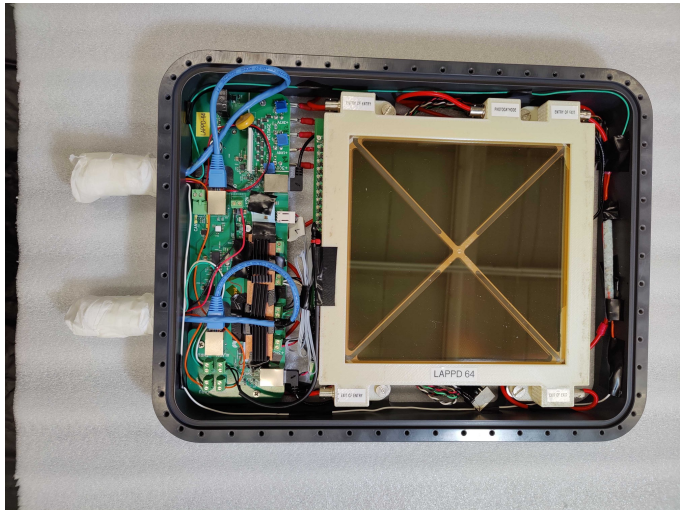
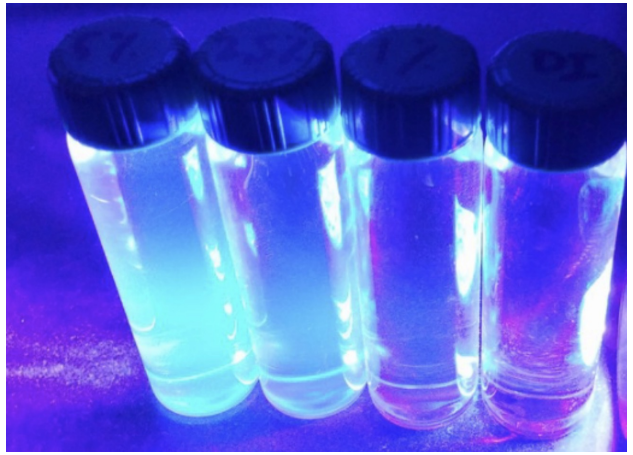


ANNIE goals

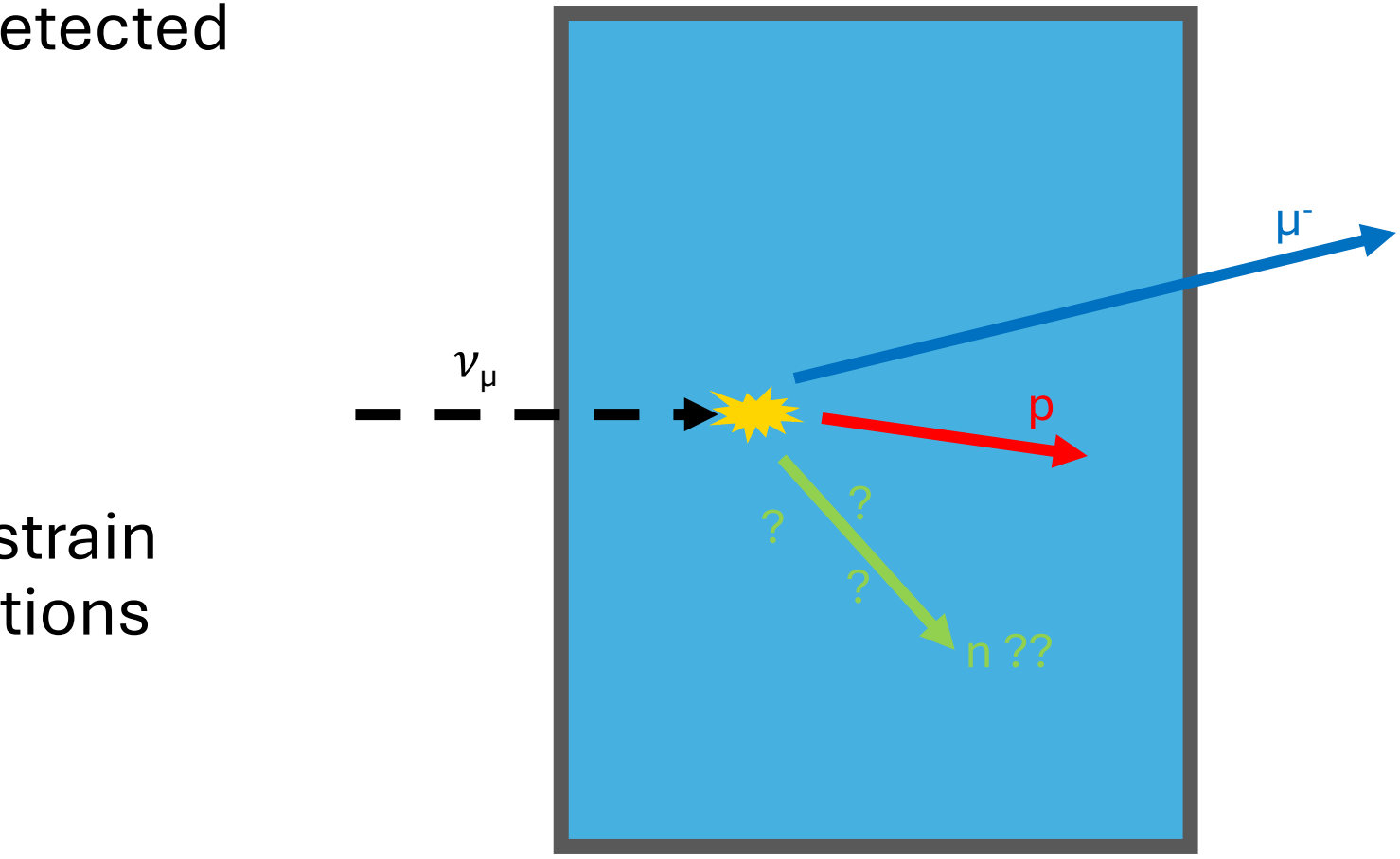
- Physics goals
  - Neutron yield measurement from beam neutrinos
  - Neutrino-nucleus cross-sections
    - Combine with SBN experiments for precision ^{40}Ar / H_2O cross-section comparisons
- R&D goals
  - Large Area Picosecond Photodetectors (LAPPDs)
  - Water-based Liquid Scintillator (WbLS)
  - Use of Gd-loaded water for neutron detection





Importance of neutrons

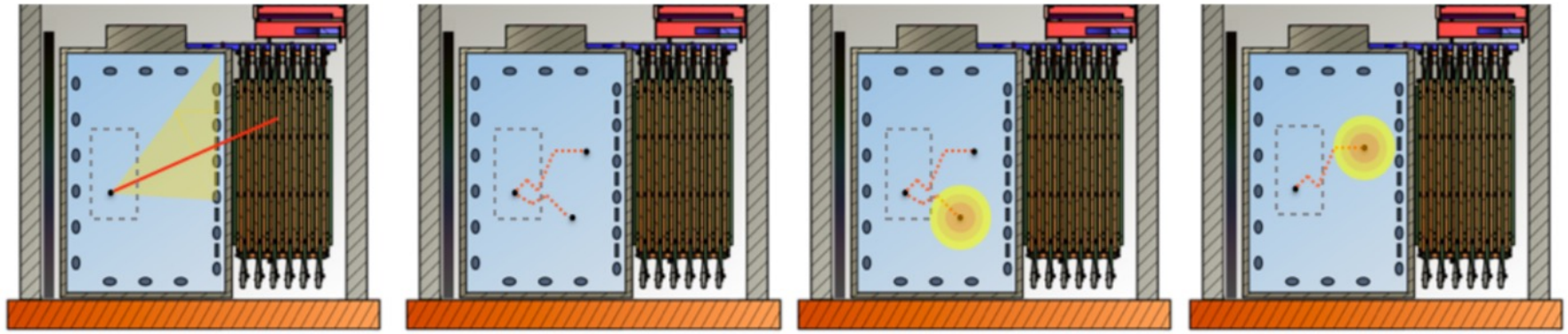
- Neutrons often go undetected in many experiments
- Must rely on generator predictions
  - Sizeable uncertainties
- ANNIE can make measurements to constrain event generator predictions



Neutron detection ability

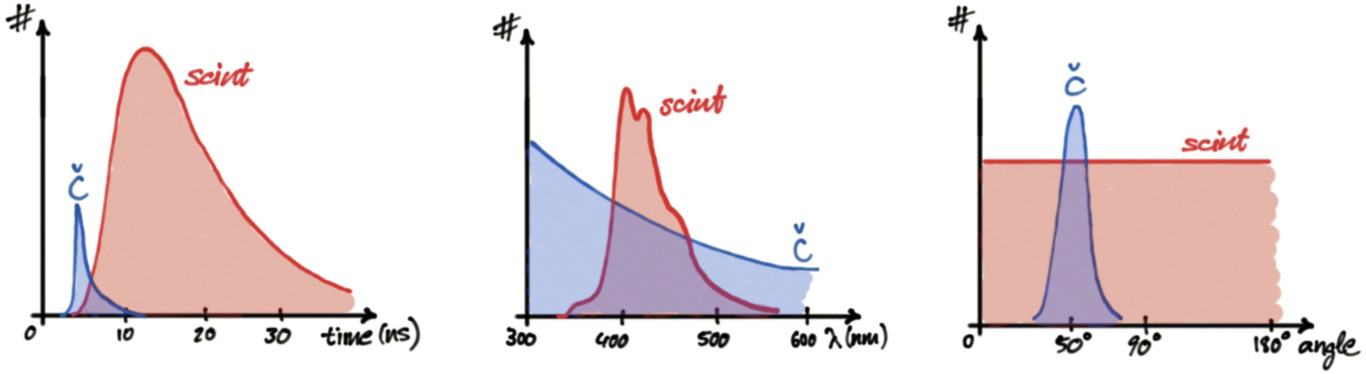
- ANNIE is the first experiment to detect beam neutrinos in Gd-loaded water!
- 0.1% Gd by mass
  - Greatly improves neutron detection ability

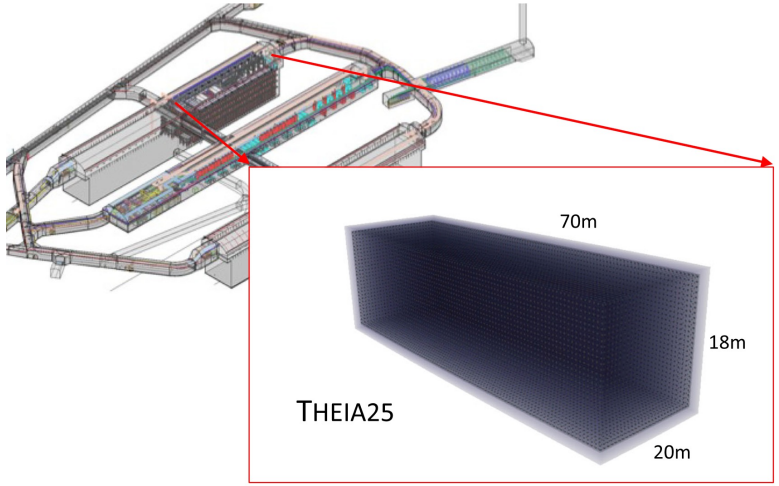
	Without Gd	With Gd
Neutron capture time constant (μs)	~200	~30
ɣ-ray cascade energy (MeV)	2.2	~8



Water-based Liquid Scintillator

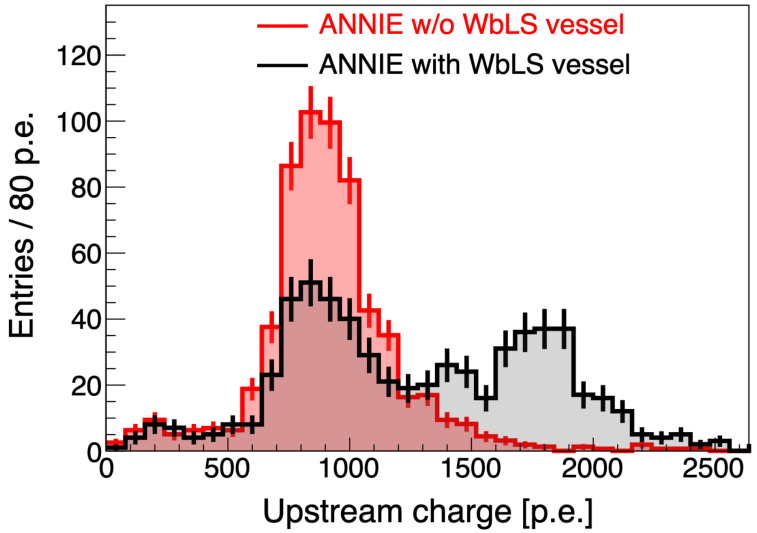
- ANNIE is the first experiment to detect beam neutrinos in WbLS!
- WbLS allows hybrid detection of scintillation and Cherenkov light
  - Good energy resolution
  - Directionality
- WbLS scintillates, and is transparent enough to allow light to propagate
- WbLS THEIA is option for DUNE FD4

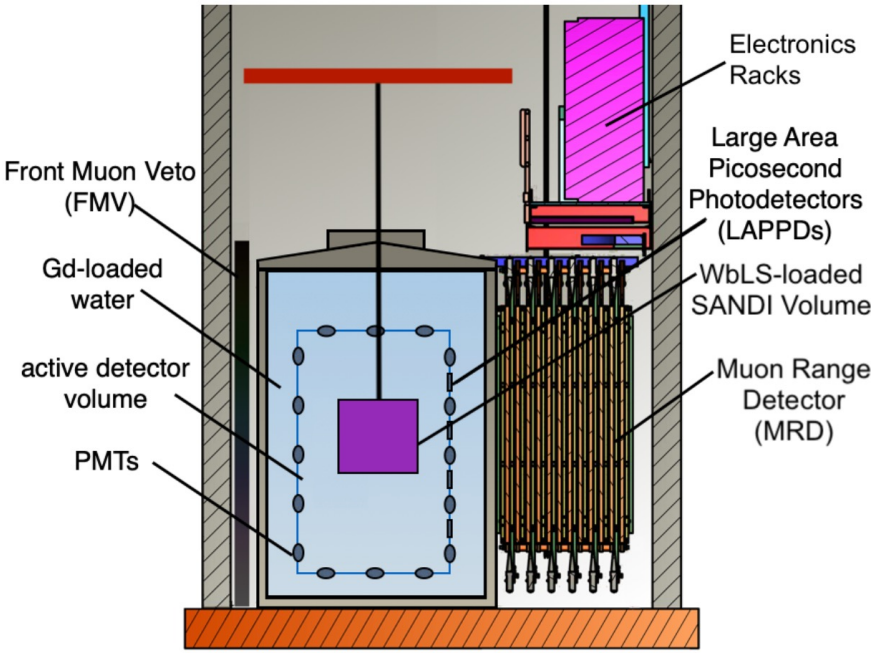


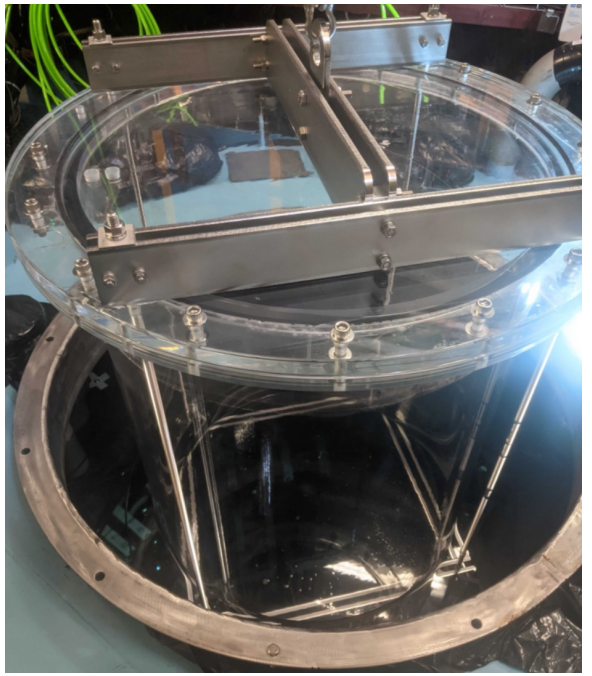


Detection of neutrinos using WbLS

- Deployed WbLS vessel inside ANNIE tank during March-May 2023
- Paper at arxiv:2312:09335, accepted to JINST

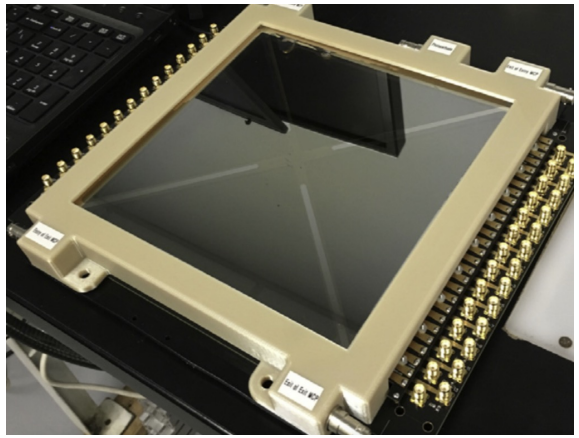


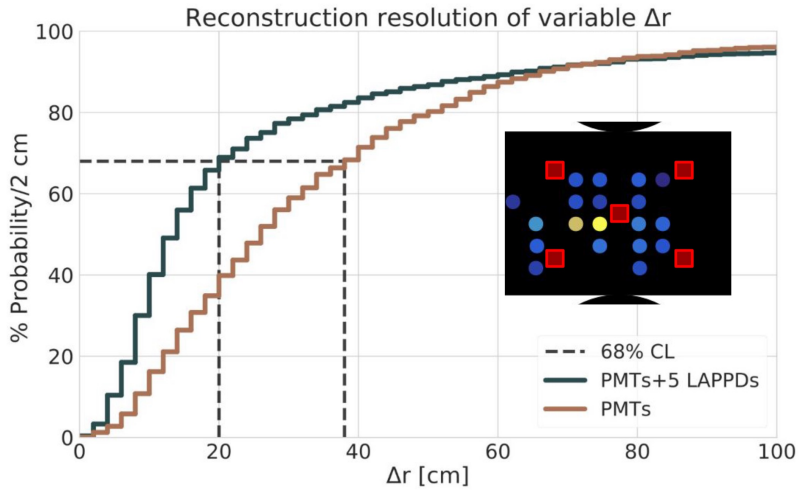


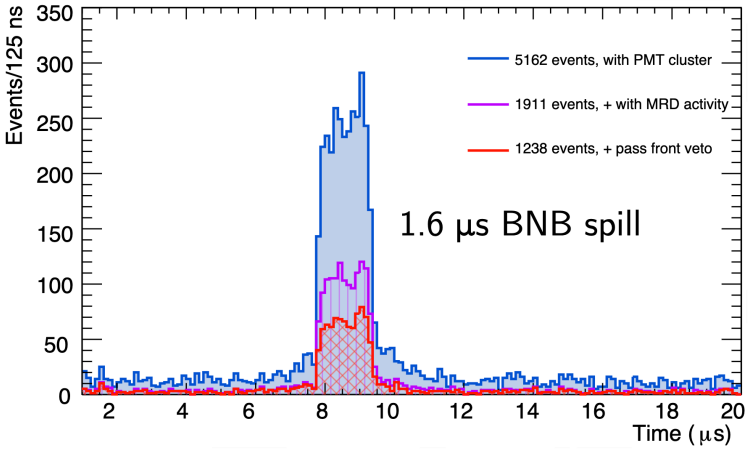


Large Area Picosecond Photodetectors

- LAPPDs are cutting edge photosensors
  - 20cm x 20cm device
  - Timing resolution < 100 ps
  - Dark rate < 1 Hz/mm^2 at room temperature
  - ~ 1 cm spatial resolution
- ANNIE is first experiment to ever detect beam neutrinos using LAPPDs!

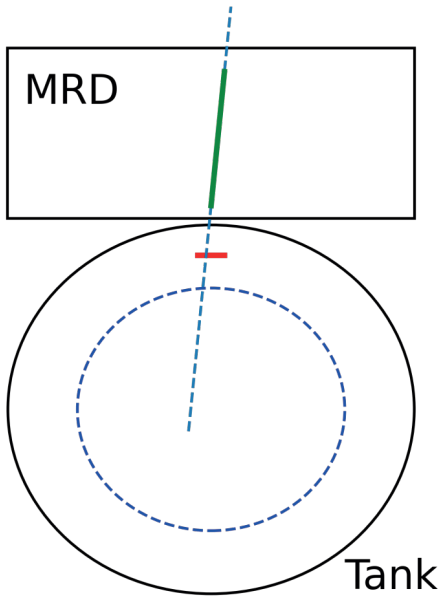


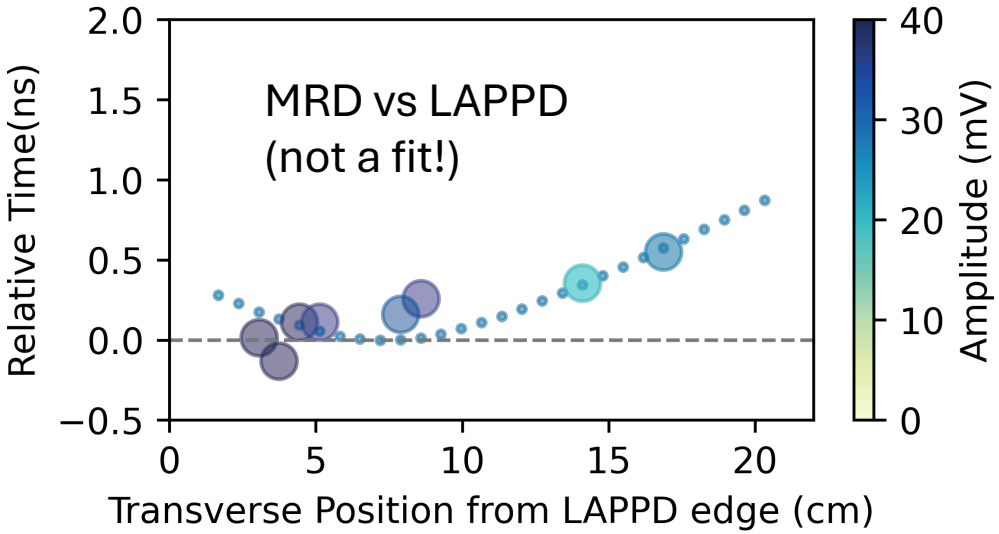




Tracking with a single LAPPD

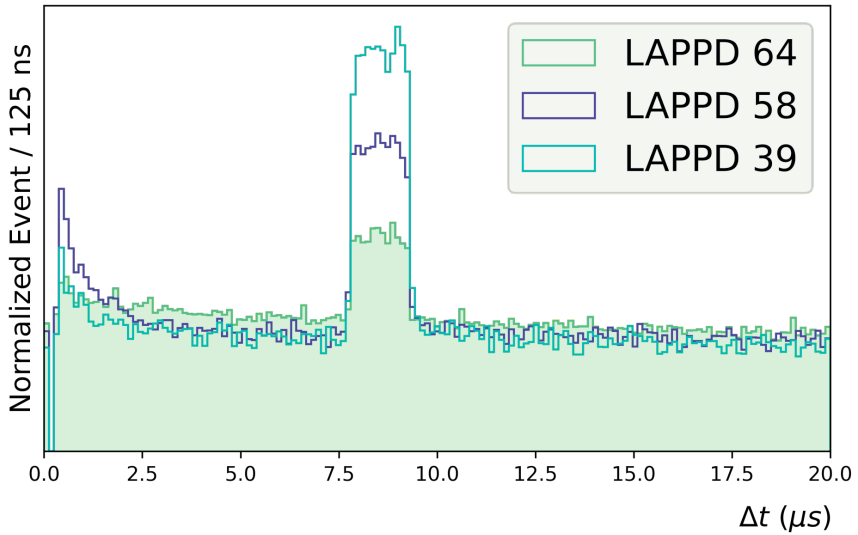
- It is possible to constrain muon track parameters using a *single* LAPPD!
  - Possible due to sub-ns timing resolution
- Use MRD muon track reconstruction to predict arrival time of pulses on LAPPD striplines

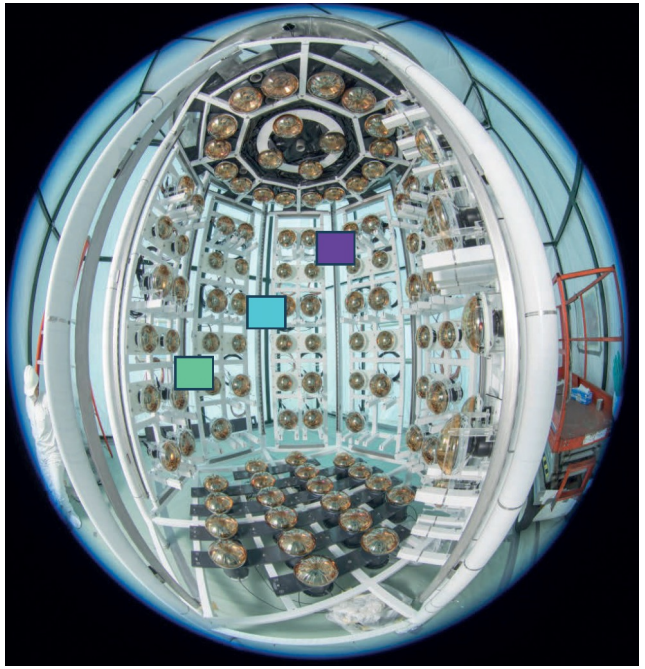




Large Area Picosecond Photodetectors

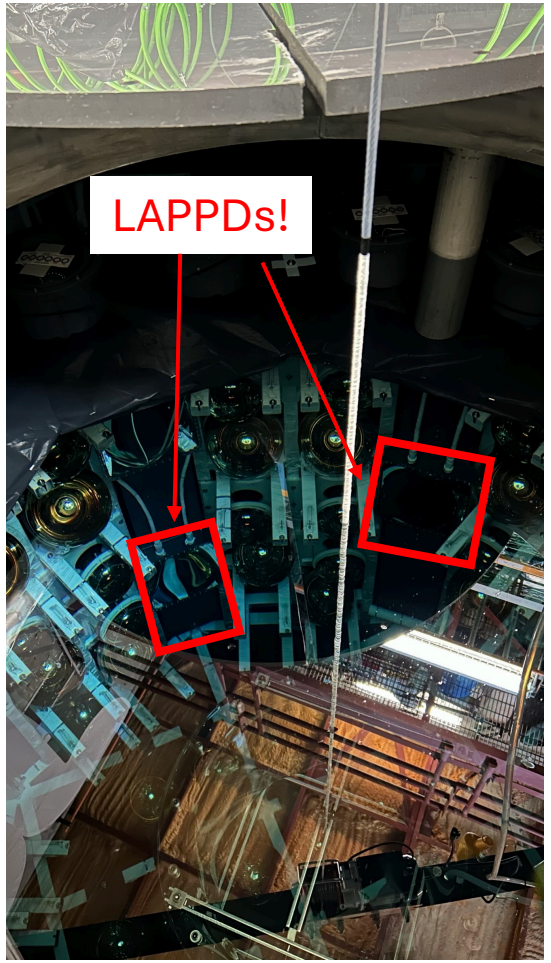
- Currently have multiple LAPPDs deployed inside tank



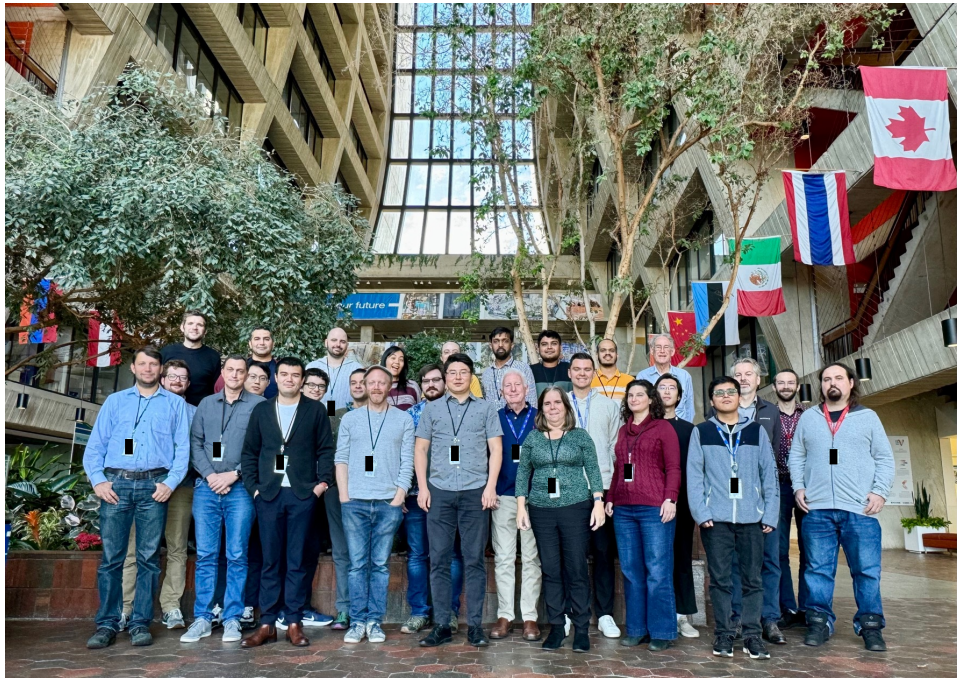


Summary

- ANNIE has already achieved significant milestones
  - First detection of beam neutrinos in Gd-loaded water
  - First detection of beam neutrinos using LAPPDs
  - First detection of beam neutrinos in WbLS
- Plenty more to look forward to
  - Cross-section measurements
  - Neutron multiplicity
  - Multi-LAPPD reconstruction
  - Future WbLS deployments



Thank you

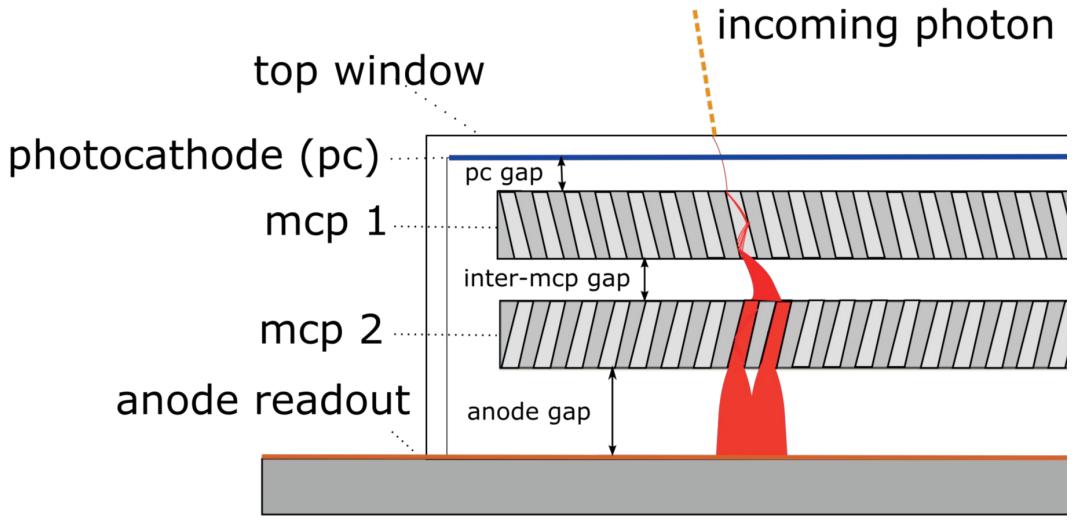


Questions?

BACKUP

LAPPD structure

- Stack of two microchannel plates (MCP)
- Each MCP contains millions of coated pores
  - Each pore ≈ 1 PMT
- 28 anode striplines for readout



LAPPD reconstruction

- Longitudinal reconstruction from timing difference
- Coarse transverse reco using stripline position
  - Could be refined through model of charge sharing across striplines