The CAPTAIN Experiment

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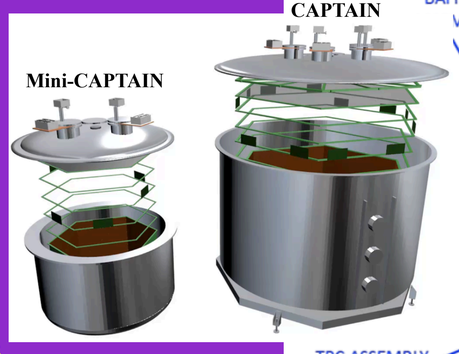
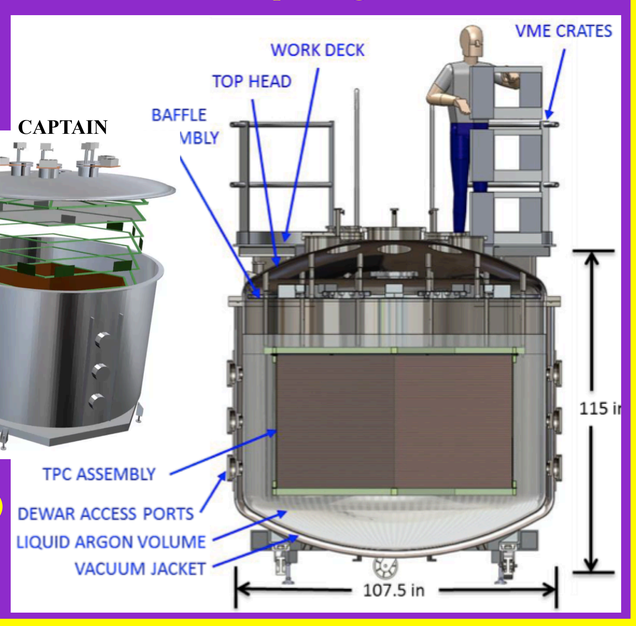
Cryogenic Apparatus for Precision Tests of Argon Interactions with Neutrinos (CAPTAIN)

- The CAPTAIN experiment began as part of a Los Alamos National Laboratory (LANL) Laboratory Directed Research and Development (LDRD) project and has evolved into a multi-institutional collaboration.
- Study interactions in liquid argon with neutron sources and neutrino sources for neutron reconstruction and low energy supernova neutrino identification in liquid argon TPC
- Two Liquid Argon Time Projection Chamber (LArTPC) detectors: CAPTAIN and Mini-CAPTAIN

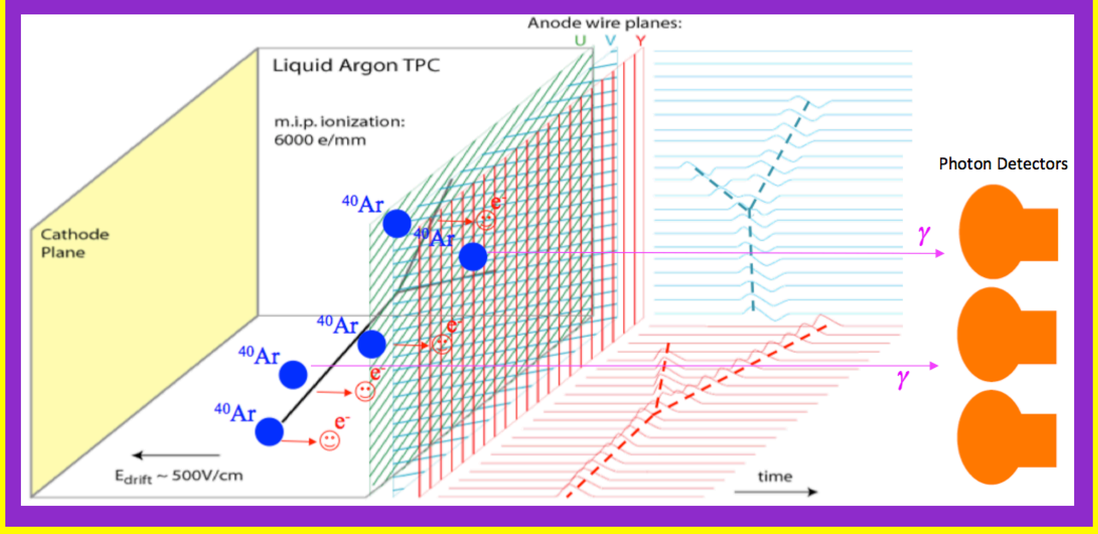


The CAPTAIN detector
- 7700L cryostat
- 1 meter drift
- 5-ton fiducial mass
- 500 V/cm drift field
- 3-mm wire spacing
- MicroBooNE electronics
- Photon detection system PDS (Ar scintillation)
- Laser Calibration System (LCS) (tracks)
- Purity System (Ar purity)



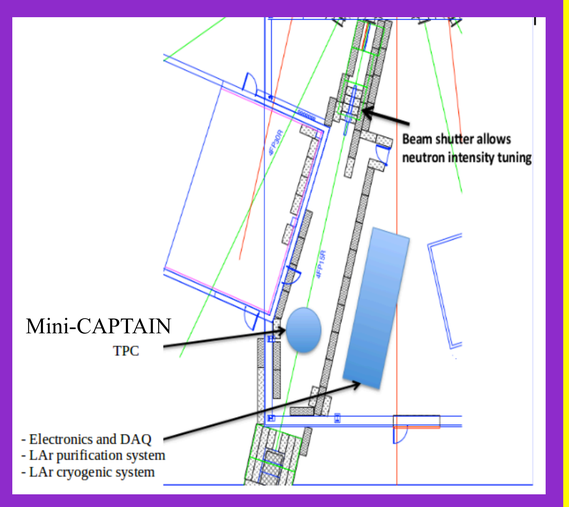
Liquid Argon Time Projection Chamber (LArTPC)

- Charged particle tracks ionize Argon atoms, ionized electrons are drifted to anode wires (~ms)
- Electrons near the wires are collected first, and electrons far from the wires are collected last, so drift coordinate information is converted to electron drift time (time is projected)
- Argon scintillation light (~ns) is detected by photon detectors at same time

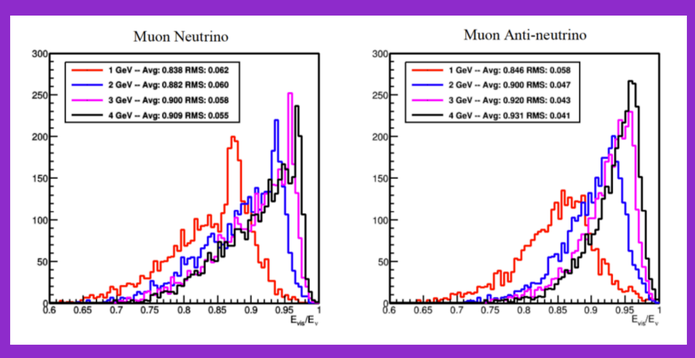


Neutron Studies at the Weapon Neutron Research Facility (WNR), Los Alamos

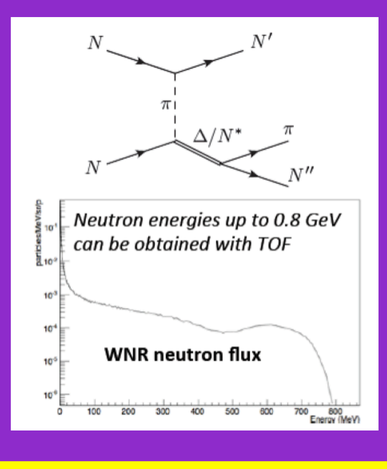
- Study neutron interaction signature for high energy neutrons for DUNE
- Study low energy nAr→nAr interaction for NC from supernovae neutrinos
- Mini-CAPTAIN has been run in the WNR neutron beam at Los Alamos Neutron Science Center (LANSCE)
- WNR provides a high flux neutron beam with a broad energy spectrum
- Neutron energy is determined by time of flight



Mini-CAPTAIN in WNR



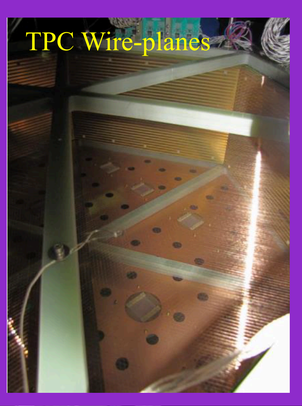
Simulated ratio of visible to true energy for muon neutrinos and anti neutrinos in LArTPC. Missing energy is caused by neutrons (from Clark McGrew)

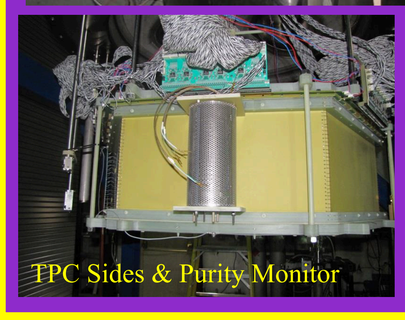


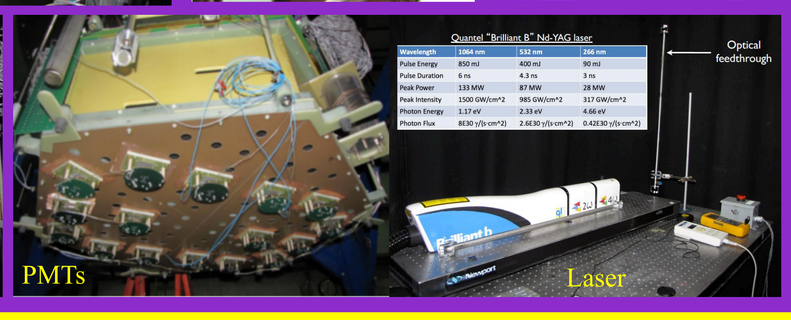
Mini-CAPTAIN Commissioned and Run for Neutron Measurements

The Mini-CAPTAIN detector
- A Cryostat – 1700 L of liquid argon.
- TPC has 1000 wires (3planes) and a max. drift length of 32 cm (1 m diameter)
- 16-1" PMTs facing the TPC volume
- Purity monitor attached to the side of the TPC

Commissioning of Mini-CAPTAIN



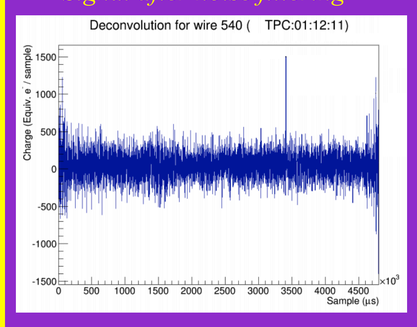




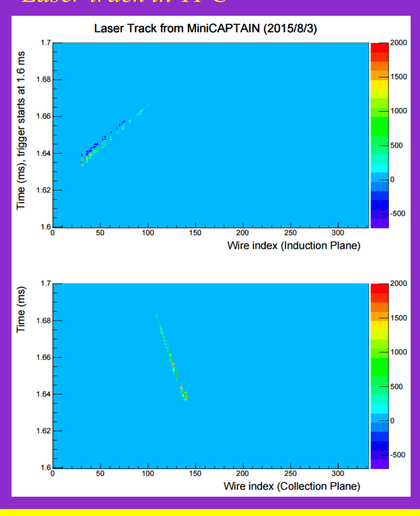
Mini-CAPTAIN Data

- Engineering runs in 2015 and first physics run in 2016
- First laser and neutron data has been collected and under analyzing
- Planning 2nd neutron running in WNR in summer, 2017

Signal after noise filtering



Laser track in TPC



PMT Data

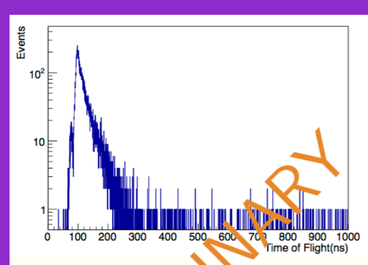


Figure 7. Time of flight of neutron in ns.

From B. Bhandari

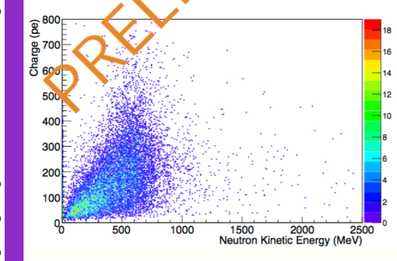
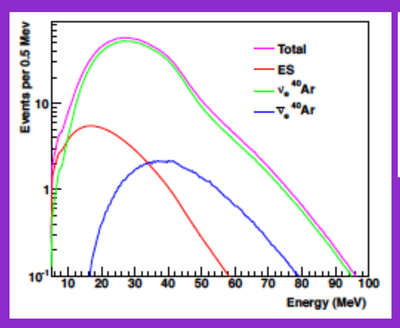


Figure 8. The relationship between charge (pe) and incoming neutrons energy(MeV). Charge looks like linearly dependent on energy up to 500 MeV.

The CAPTAIN Detector

- Will study low energy neutrinos for DUNE supernova physics program: E_ν<100MeV, never done before
- Considering low energy neutrino sources at SNS, LANL or JPARC

Neutrino interactions in a 10kt LArTPC for a supernova 10kpc from Earth



Reaction Type	Events / 10 kt
(CC) $\nu_e + {}^{40}\mathrm{Ar} \rightarrow e^- + {}^{40}\mathrm{K}^*$	~700 [1]
(CC) $\bar{\nu}_e + {}^{40}\mathrm{Ar} \rightarrow e^+ + {}^{40}\mathrm{Cl}^*$	~60 [1]
(ES) $\nu_x + e^- \rightarrow \nu_x + e^-$	~85 [1]
(NC) $\nu_x + {}^{40}\mathrm{Ar} \rightarrow \nu_x + {}^{40}\mathrm{Ar}^*$	~90 [2]

[1] K. Scholberg
[2]A. Hayes

Status:
- Cryostat in hand, pressure tested
- All electronics are in hand and tested
- LAr recirculation system in hand
- TPC wiring ongoing
- Motorized laser controls OK

Los Alamos NATIONAL LABORATORY EST.1943

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