Calibrations for the DarkSide Experiment

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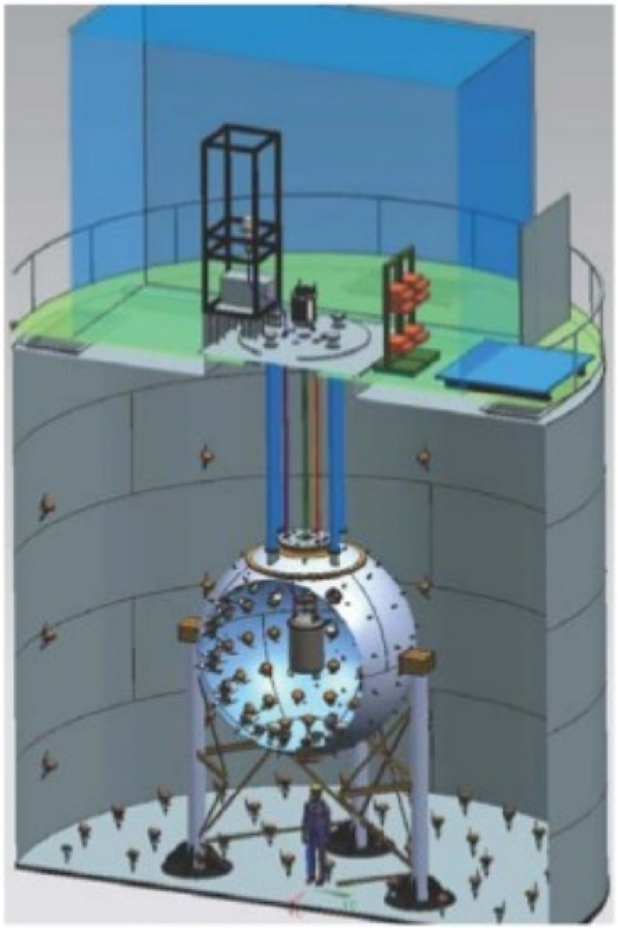
Outline

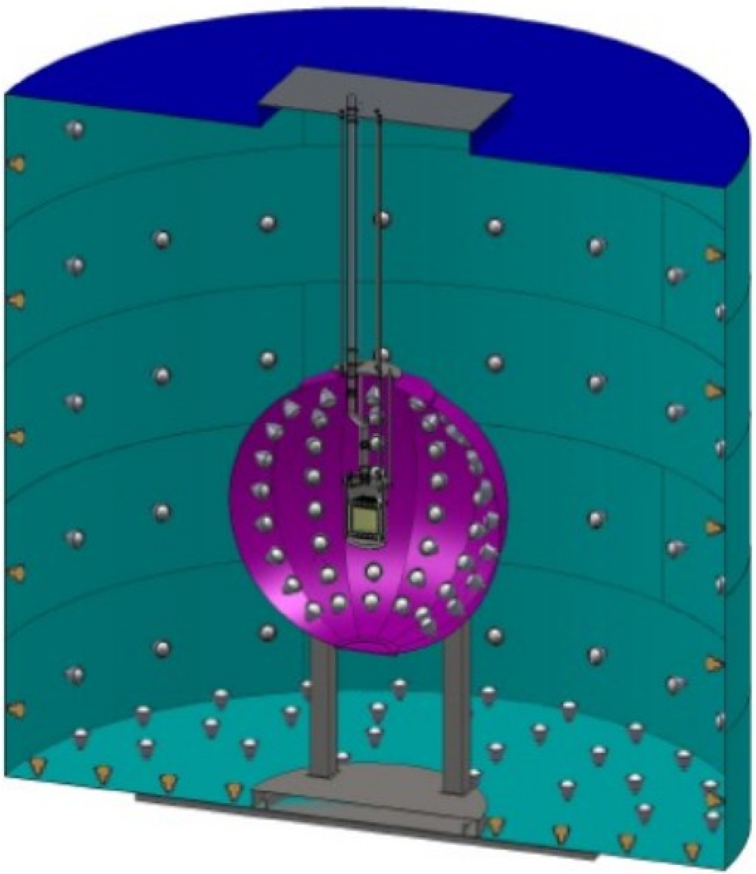
- Brief overview of DS-50
- Goals for Calibration
- Simulations
  - Gamma
  - Neutron
- CALIS (I & II)
- Articulated Arm
- Calibration Future

DarkSide-50



- located at Gran Sasso National Laboratory (LNGS) at a depth of 3400 m w.e.
- 3 year background free running
- projected sensitivity of 10^{-45} cm^2 for a WIMP mass of ~80-100GeV
- 50kg mass with a 33kg fiducial mass
- uses a two-phase argon time projection chamber with underground argon

Muon Veto



- Water Cerenkov detector
- cylindrical tank: 10m diameter, 11m high
- filled with high purity water
- sides and bottom have 80 8in PMTs

Neutron Veto

- 4m diameter stainless steel sphere
- filled with 30ton of borated liquid scintillator
- scintillator is a mixture of equal parts tri-methyl borate (TMB) and pseudocumene (PC)
- has an array of 110 8in PMTs
- > 99.5% efficiency for radiogenic neutrons
- > 95% efficiency for cosmogenic neutrons

Goals for Calibration DS-50

TPC and Neutron Veto

- relative and absolute efficiency in detecting neutrons
- energy scale
- laser runs used for PMT gain and timing calibration
- use of LEDs in the veto for PMT gain calibration

Sources for Calibration

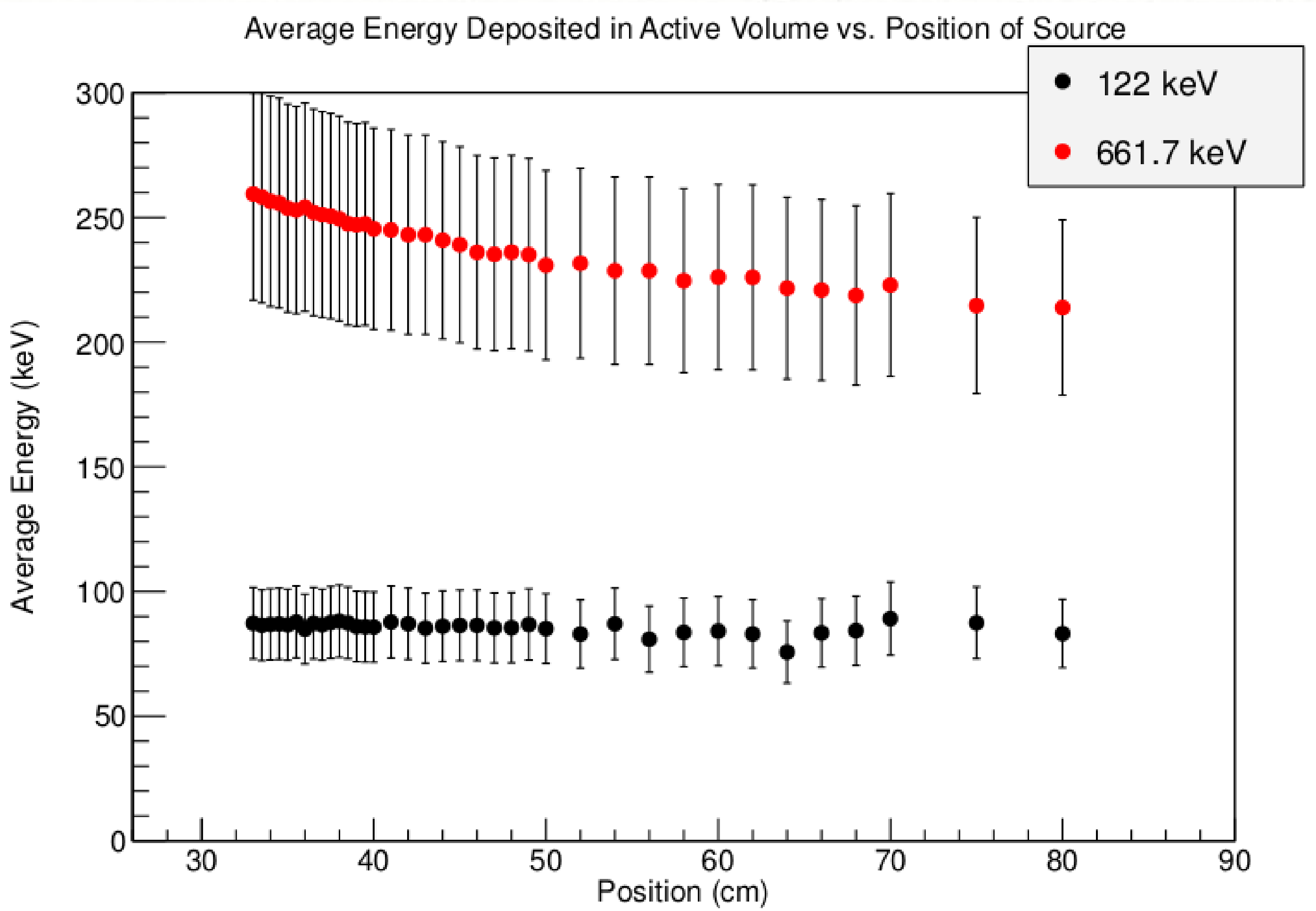
- radioactive: ^{57}Co, ^{137}Cs, AmBe
- neutron generator
- distributed source: ^{83m}Kr

Simulations

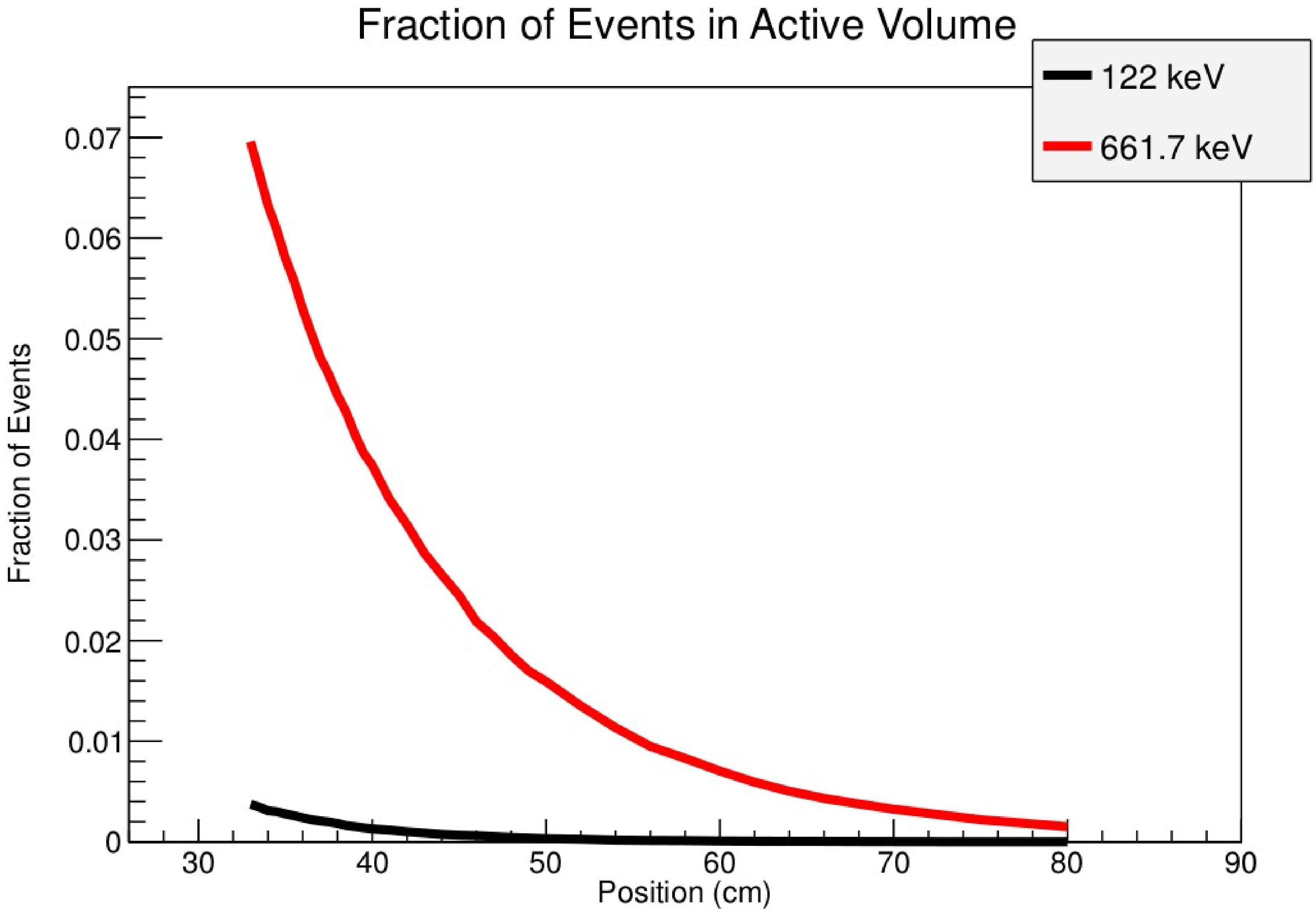
- using Geant4 Monte Carlo package with DS-50 geometry
- Goals of the simulations:
  - simulating sources for the calibration of the TPC
  - want to see where it is useful to position the source; how frequently and how close to the cryostat

Gamma Simulations

- gamma was placed close to the cryostat wall and then moved progressively farther out along the x-axis
- each simulation was run with 10^6 events
- energies used: 122keV (57Co) and 661.7keV (137Cs)



Energy threshold > 1 keV


Fraction of Events in Active Volume
122 keV
661.7 keV
Fraction of Events
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
30
40
50
60
70
80
90
Position (cm)

Neutron Simulations

- neutron was placed close to the cryostat wall and then moved progressively farther out along the x-axis
- each simulation was run with 10^5 events

AmBe Source

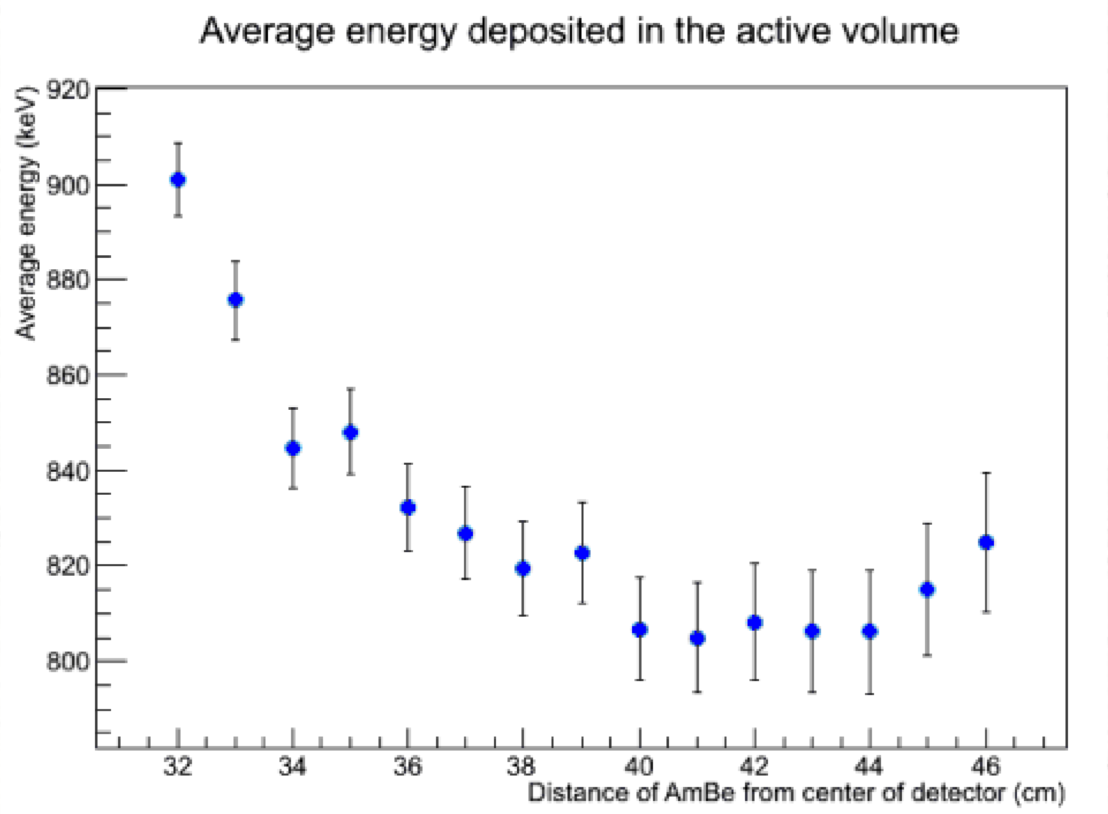


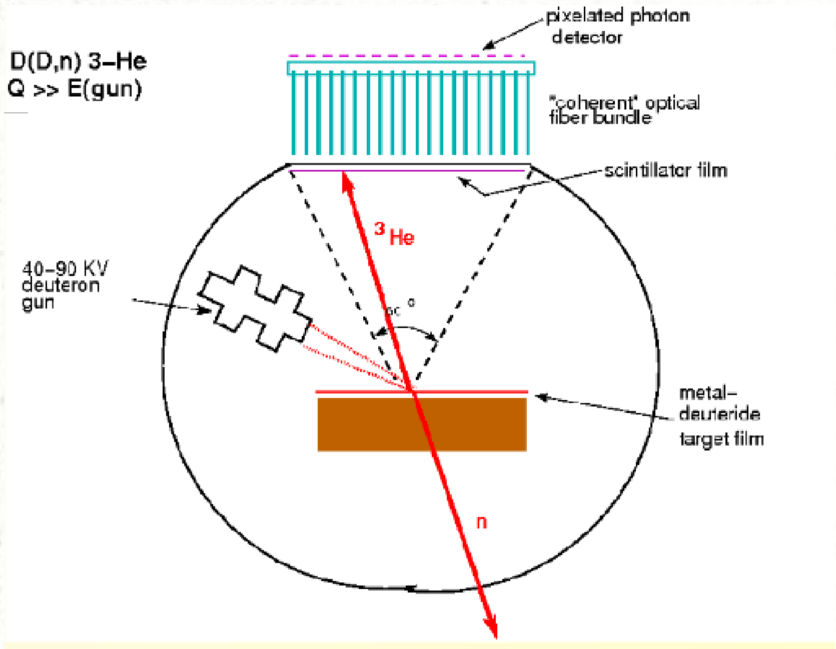
Image Credit: Erin E. Edkins

Neutron Generator

- want to use to calibrate TPC
- have a source of pure neutrons → no gammas
- clean test of detector with neutrons--excellent way of testing nuclear recoils in TPC

Neutron Generator

- using a triggerable neutron generator by ThermoFisher API-120
- neutrons generated by D-D fusion
- generator detects 3-He which gives neutron direction and timing
- max neutron yield < 10,000 neutrons/sec



Neutron Generator

- Simulate beam of 2.45MeV neutrons directed toward center of detector
- Positions ranged from 32cm to 42cm distant in the x direction
- 10^5 events were used for each position

Neutron Generator

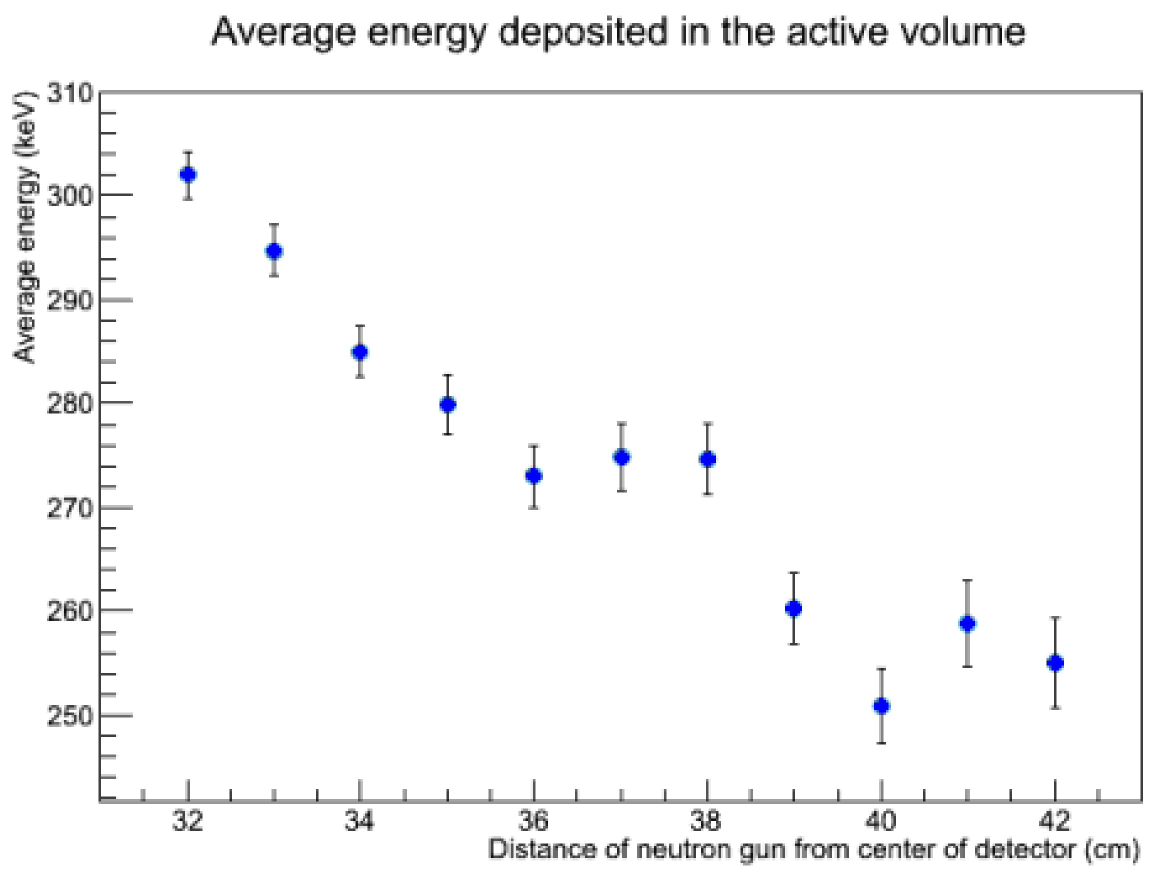


Image Credit: Erin E. Edkins, UHM

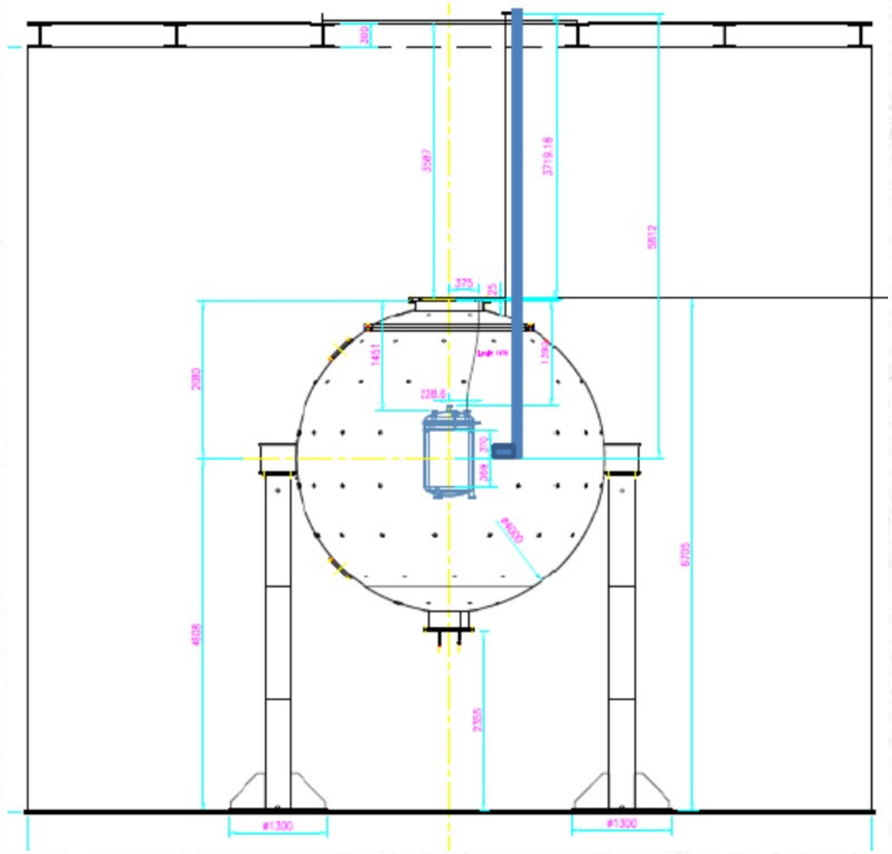
CALIS

(CALibration Insertion System)

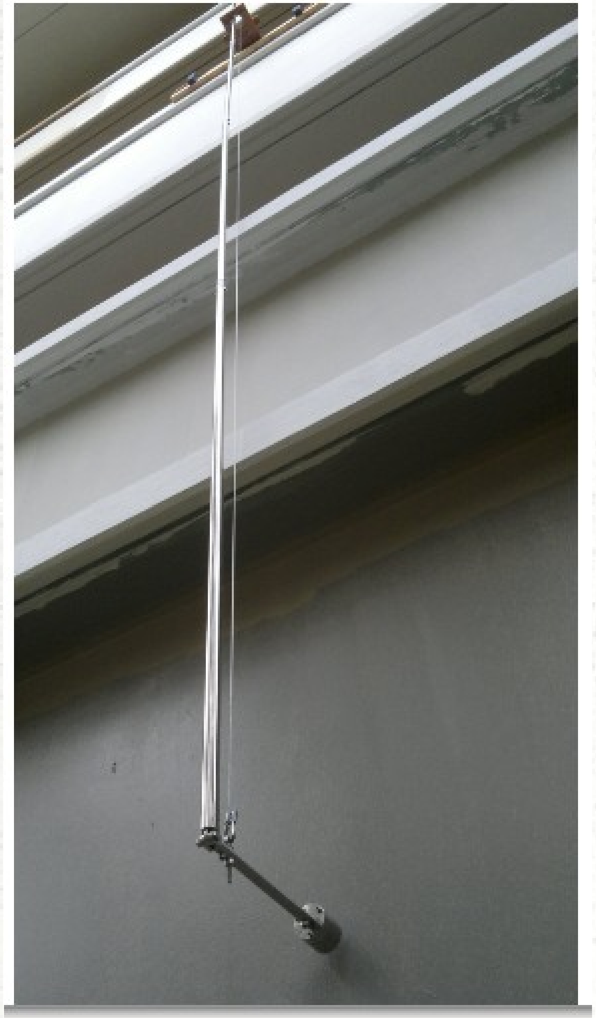
- Spring 2013--TPC filled with atmospheric Ar and lowered into neutron veto
- wanted to commission the TPC with the neutron veto filled with air
- development of CALIS I

- Summer 2013--TPC removed from neutron veto for PMT upgrade and then redeployed
- need to commission TPC with neutron veto filled with liquid scintillator
- development of CALIS II

CALIS I



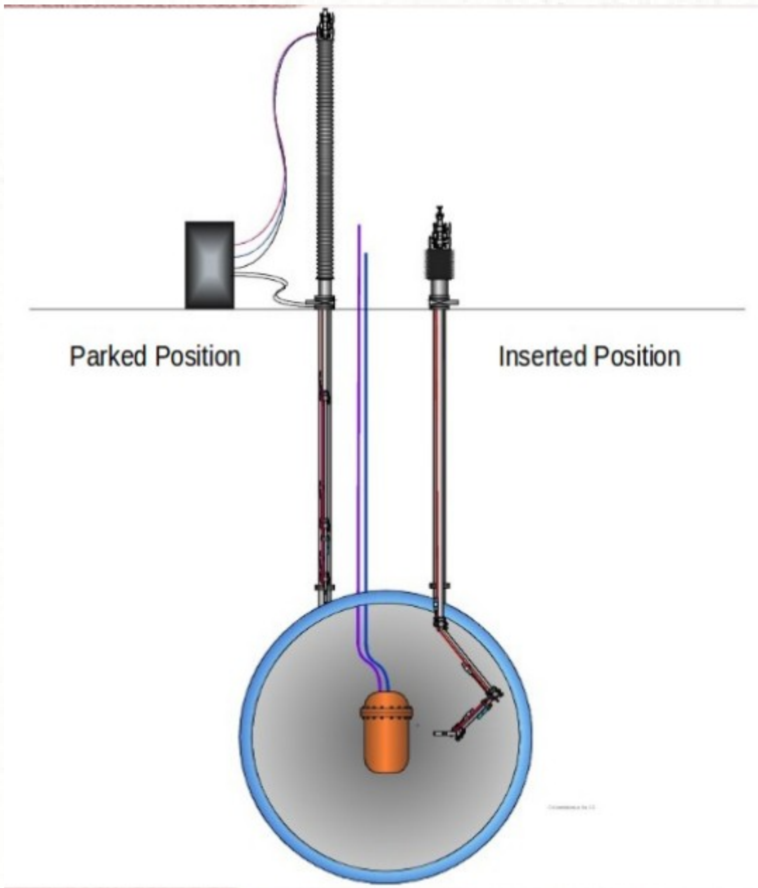
- developed and built at UH Manoa
- used in the first DS-50 TPC deployment at LNGS, no liquid scintillator was in the neutron veto
- consists of 4 6 foot long stainless steel tubes, 3 horizontal tubes of varying lengths (15in, 9in, 2.5in) and a collimator
- bottom tube has pivot point to allow the source to be raised to a horizontal position



CALIS II

- developed and built at UH Manoa
- developed for use in liquid scintillator
- consists of 4 6ft long vertical tubes,1 vertical tube 5.5ft long; each tube 2in diameter, 1/16 in thickness
- has an inner chimney for guidance and outer chimney to connect to organ pipe above neutron veto

Articulated Arm



- to be used in the LSV
- want to deploy sources and neutron gun 4pi around the TPC
- proposed 6 axis arm
- in the initial stages of design

Calibration Future

- Calibration is integral to achieving the 3 year background free running and convincing potential claim of WIMP detection
- Calibration plans include calibration of the TPC and the active neutron veto
- Laser and LED PMT calibrations have been preformed
- Source runs are planned for early next year after needed modifications are done for CALIS II
- Articulated arm will enable extensive calibration of the TPC and neutron veto with both radioactive sources and the neutron generator