LANL Detector Physics Options

New Mexico Liquid Argon Meeting

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Physics Goals

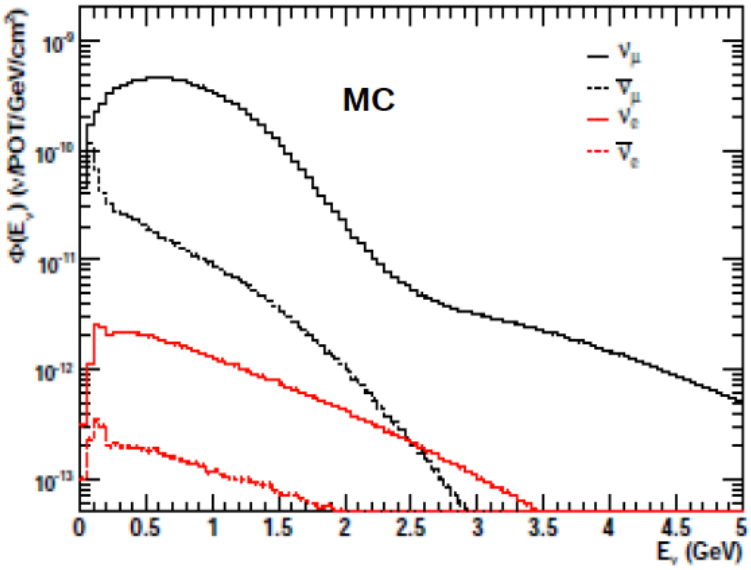
- Within scope of LDRD
  - discriminating between neutrino and antineutrinos using μ-decay and μ-capture
  - allows CP violation studies
  - study spallation backgrounds due to cosmic rays
  - study low energy β-γ separation
- Beyond scope of LDRD
  - neutron beam at LANL
  - SNS neutrino running
  - **NuMI neutrino running**

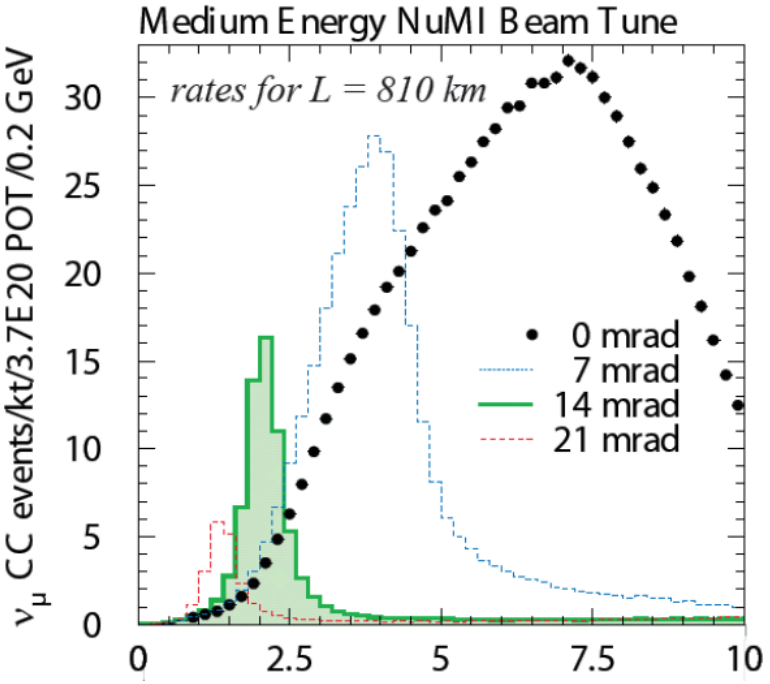
NuMi neutrino running

- neutrino energy reconstruction
- explore neutrino interactions in resonance and DIS regions
- calibrate detector with charged particle beam

Neutrino energy spectrum

Booster Neutrino Beamline

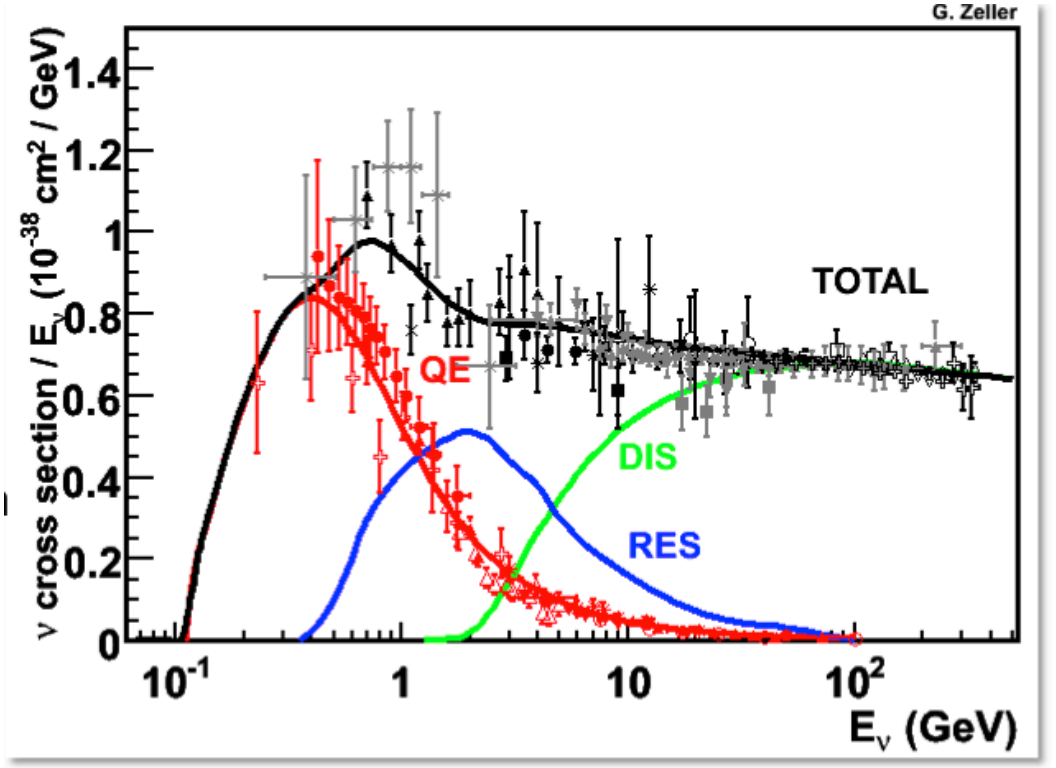


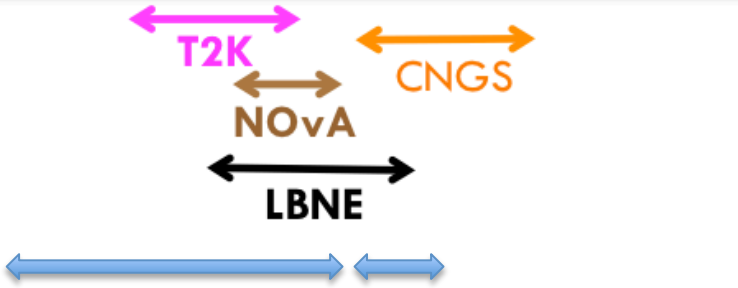


- compare booster beamline spectrum with medium energy tune on-axis

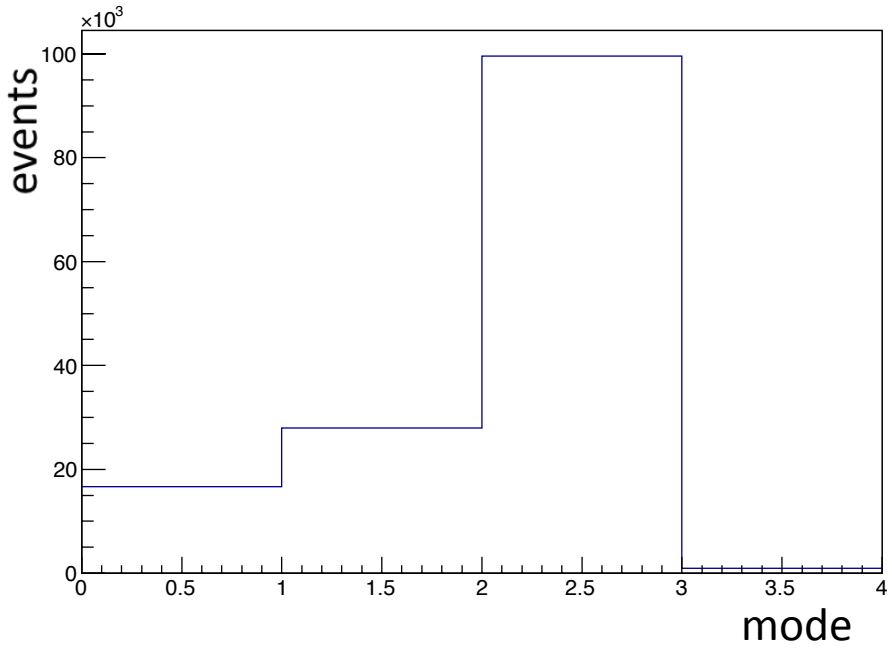
Energy Regime

- contributions from different regimes for each experiment
- quasi-elastic scattering gives an outgoing nucleon
- the resonant region can give multiple hadrons



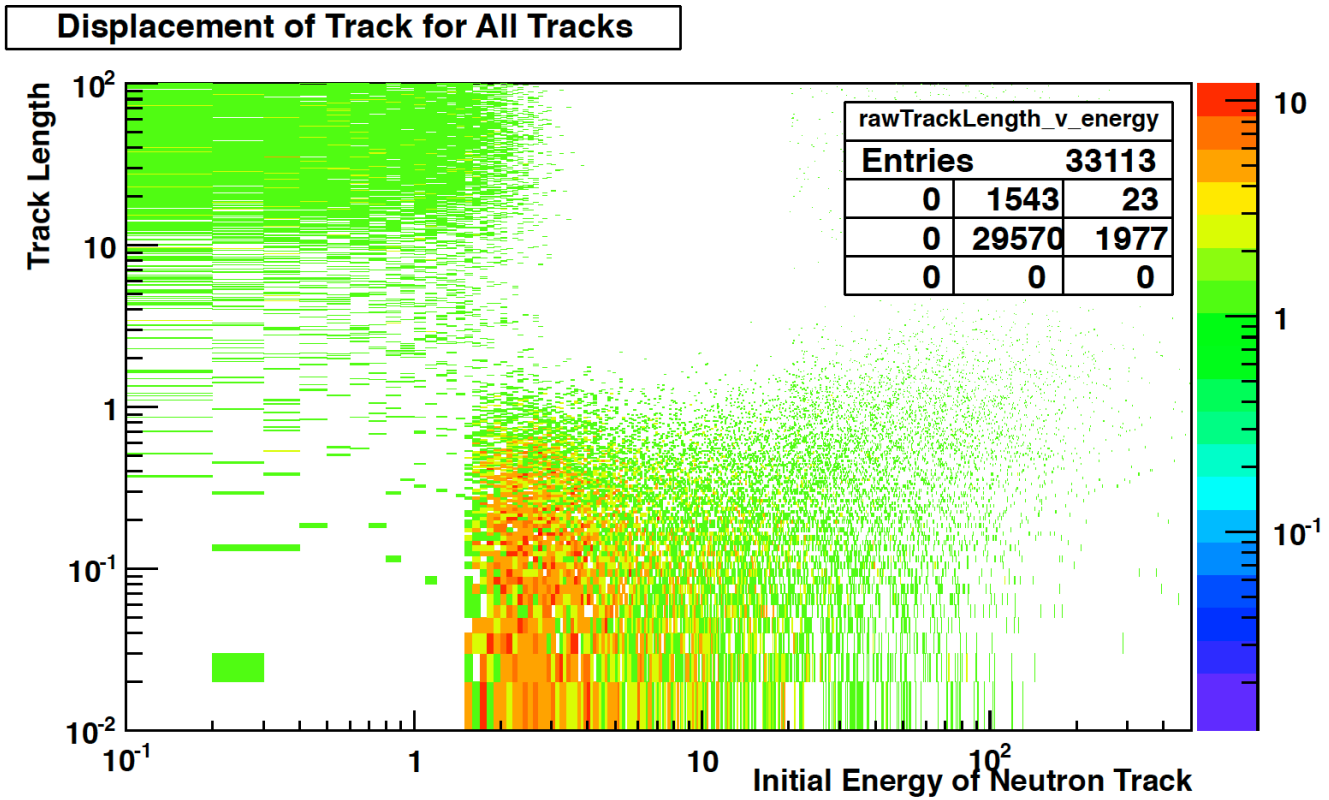


Medium Energy Tune



- a mode is an integer corresponding to a particular neutrino process
- 0 = quasi-elastic
  1 = resonance production
  2 = deep inelastic scattering
  3 = coherent scattering
- figure shows the distribution of modes corresponding to the neutrino events

Neutron displacements



- 2 dimensional distribution of track length vs initial energy of a neutron in liquid argon
- bottom right-hand points show the distance from the creation point of the neutron to first inelastic scatter location
- top left-hand points show the distance from the creation point of the neutron to the neutron capture location

Simulation

- dE/dx of liquid argon: 2.1 MeV/cm

  - a 3 GeV muon needs about 14 meters to be contained

- neutrons have about 1 barn of total cross section to interact in 1 meter
- eliminate primary lepton and all neutrons from event

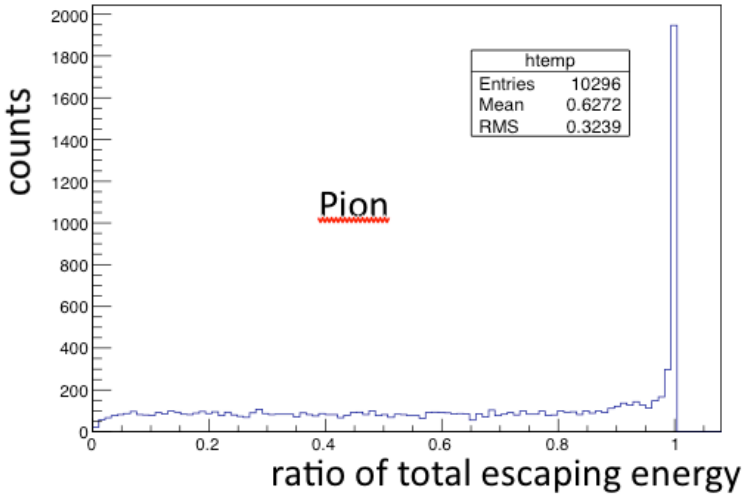
how many events can we get?

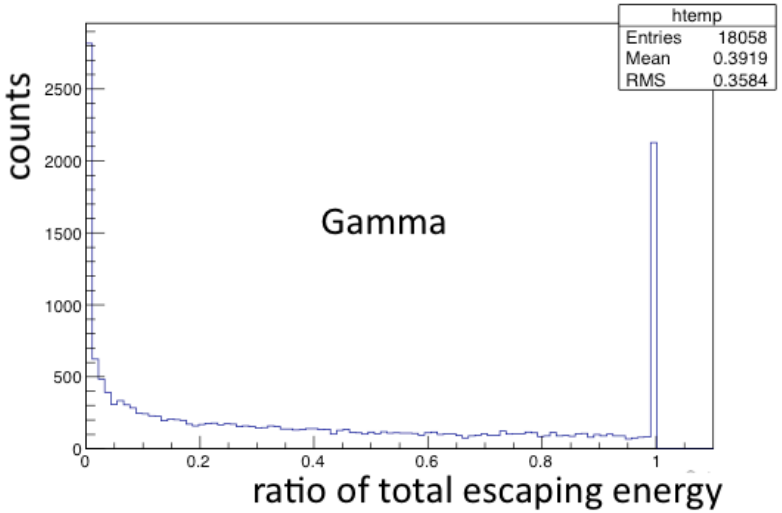
- using a geometry of 1m radius and approximately 1m in height
- using LArSoft
  - $4x10^{20}$ POT (NuMI beamline per year) produces $4x10^{6}$ neutrino interactions in the TPC
- 75% of these are charged current events => 10% are fully contained
- 300,000 fully contained CC events

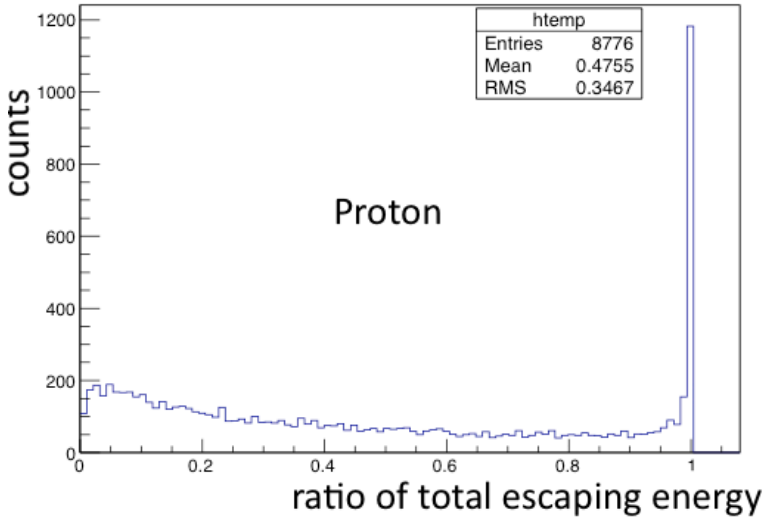
Containment as a function of geometry

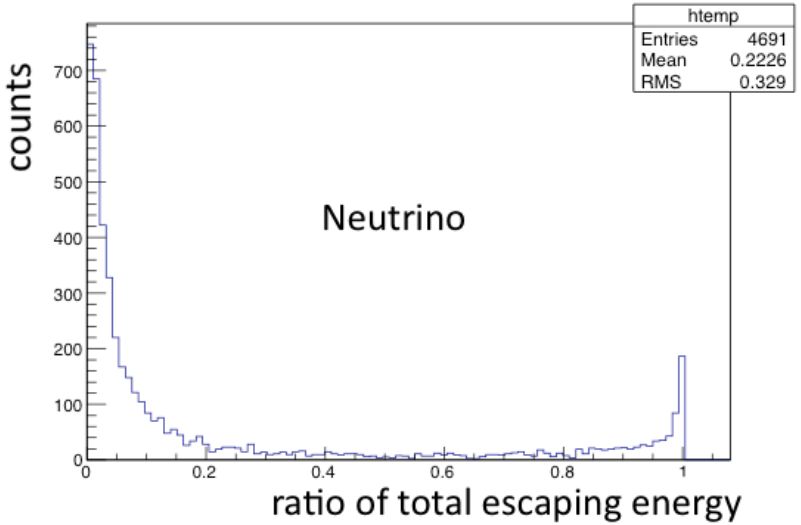
radius (cm)	height (cm)	% contained
100	100	11.5
125	100	12.0
150	100	12.3
100	140	12.1
125	140	12.9
150	140	13.5
100	200	13.0
125	200	14.1
150	200	15.1
100	270	13.6
125	270	15.0
150	270	16.3

Escaping energy

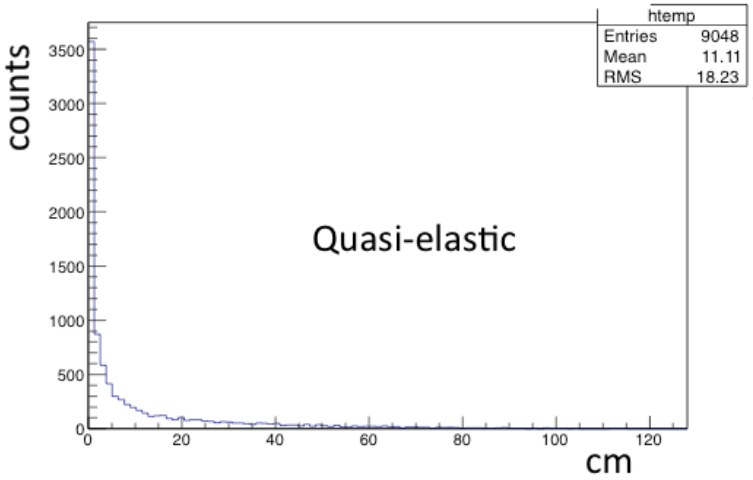


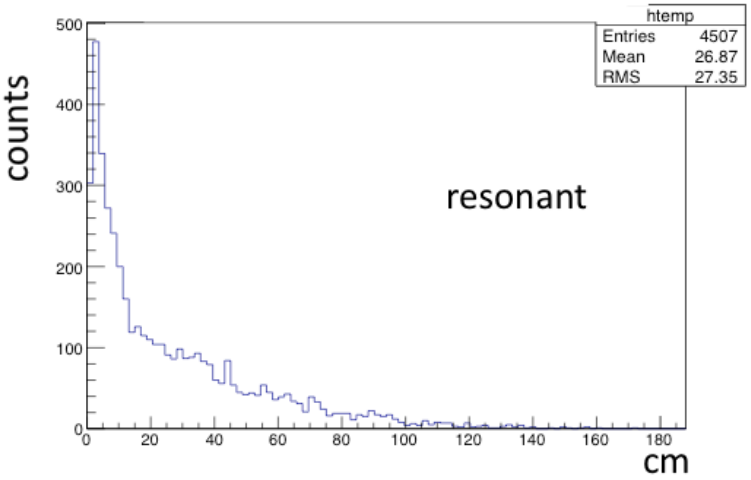


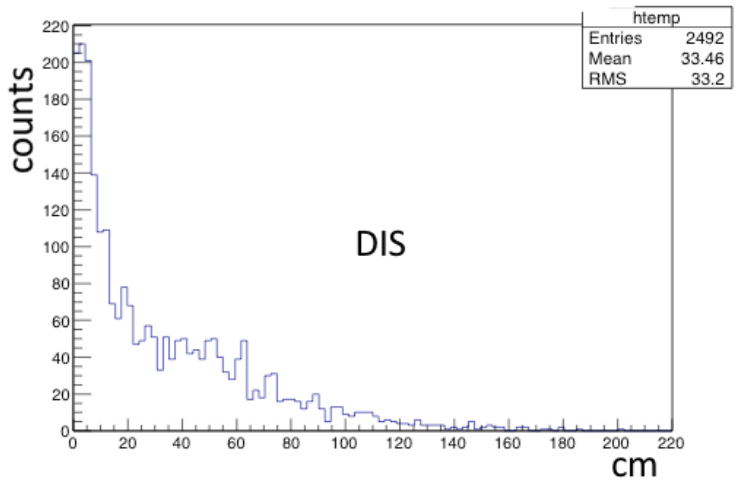




Characterization of event size

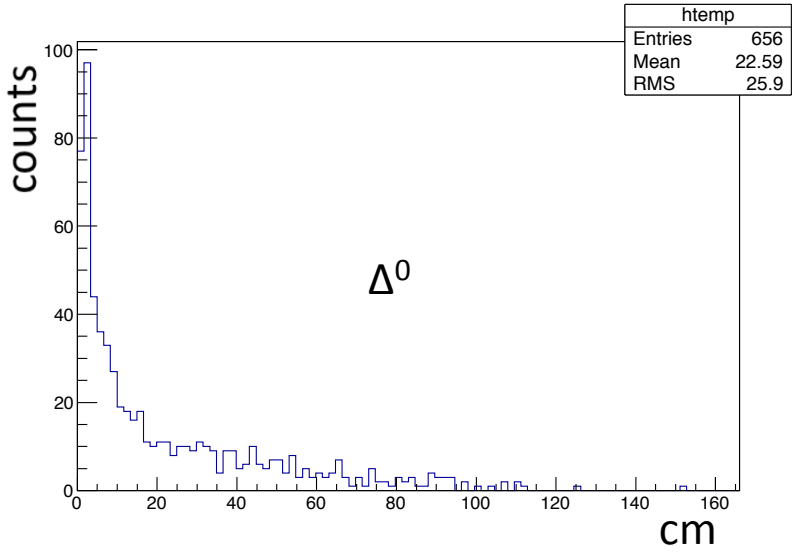


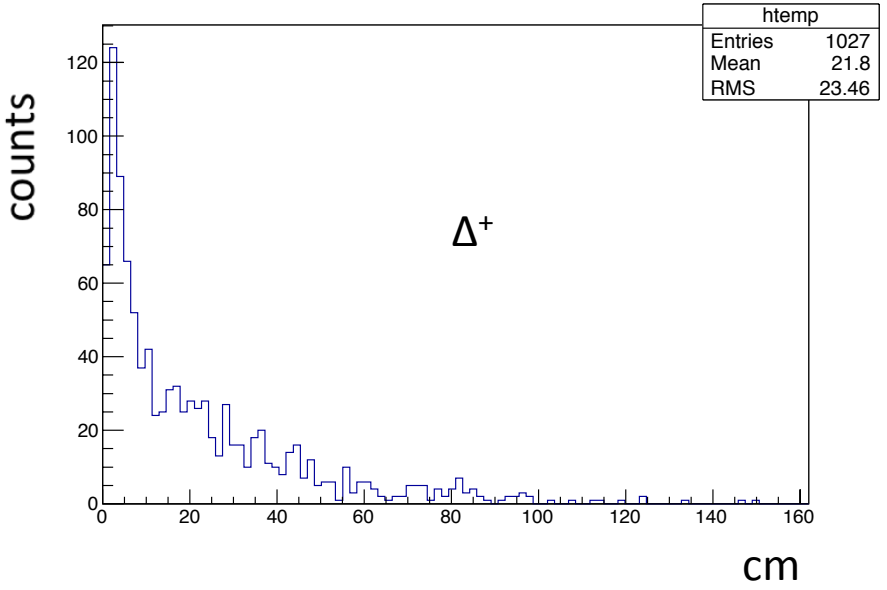


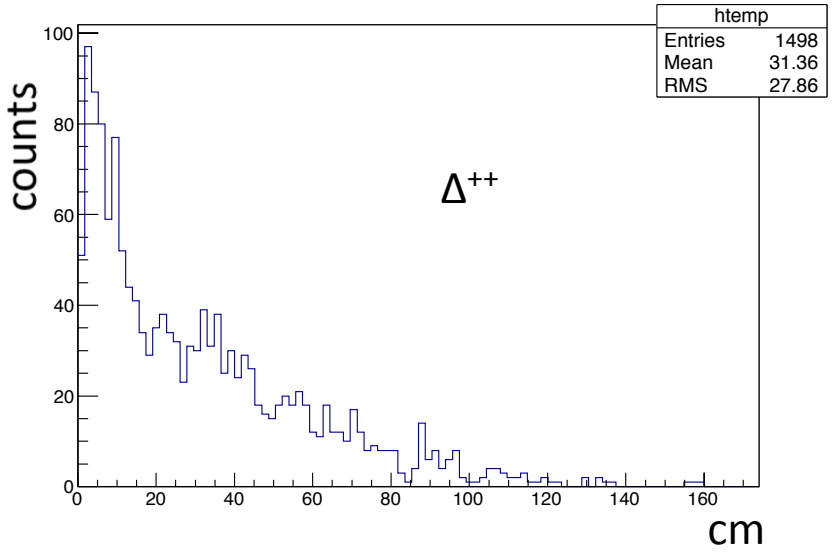


- distance shown is the endpoint of the furthest track from the event vertex for fully contained events
- geometry is 100 cm radius and height

Event size by resonance







- uses same definition of event size as on previous slide
- break down resonance region into primary resonances

Neutrino energy reconstruction

- now that we have a viable TPC, all we have to do is reconstruct the neutrino energy…..

Summary

- LANL TPC will explore the neutrinos in the medium energy tune, thus complementing the booster beamline
- Able to contain a significant amount of events

  caveat: primary lepton must be identified by an external source, neutrons escape