Measurement and Simulation of Cosmic Ray Background in LArTF for MicroBooNE

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MicroBooNE

- A Time Projection Chamber (TPC) is a liquid or gas filled volume that allows for three dimensional tracking of particles

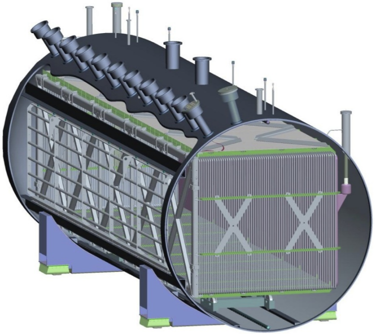


image: http://www-microboone.fnal.gov/

- MicroBooNE is a Liquid Argon TPC (LArTPC) designed to detect neutrino interactions
    - The liquid argon serves as a target for a neutrino beam
    - 80 ton active volume (170 ton total)
    - 2.6 m x 2.3 m x 10.4 m
    - Three wire planes on the TPC record the signals

- The first surface-level LArTPC of this size
    - The cosmic ray background needs to be measured at the location

Cosmic Rays

- Very high energy primary cosmic particles (mostly protons) interact with the Earth's atmosphere producing showers of secondary cosmic particles

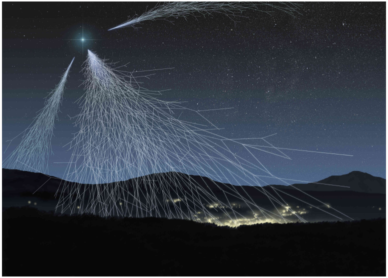
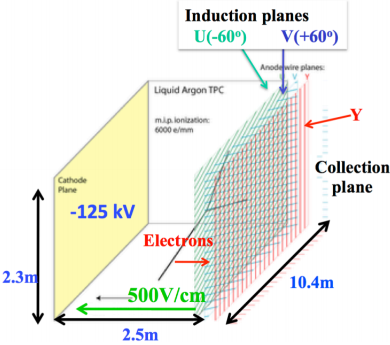


image: ASPERA/Novapix/L.Bret

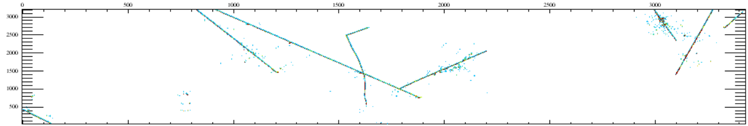
- Secondary pions and kaons can decay into muons.
  - These muons can reach and penetrate the Earth's surface
  - 3m of concrete would only absorb ∼30% of the muons
- The cosmic ray muon rate at Earth's surface is about 130 $\frac{muons}{m^2 s}$

Cosmic Rays in MicroBooNE

- It up to 1.6 ms for the electrons to reach the anode and for that information to be processed
- The estimated cosmic ray rate in MicroBooNE is between 4 and 8 kHz



- This gives a rate of ∼6 to ∼13 muons per readout frame



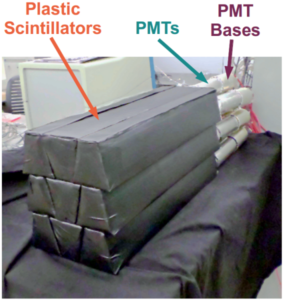
charged current neutrino interaction with cosmics

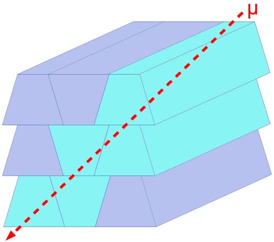
NMSU Cosmic Ray Detector

- Our group at NMSU has built a cosmic ray muon detector to measure the cosmic ray rate
- It is currently running in the Liquid Argon Test Facility (LArTF), where MicroBooNE will be located during its run
- The goal of the detector is to validate Monte Carlo studies of cosmic rays in MicrobooNE

NMSU Cosmic Ray Detector

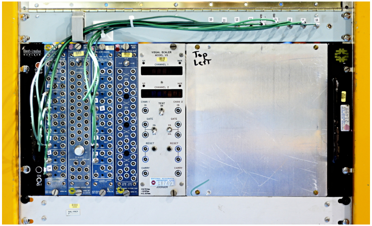
- The detector consists of 9 plastic scintillator bars stacked 3 x 3
- It measures 20cm x 24cm x 40cm





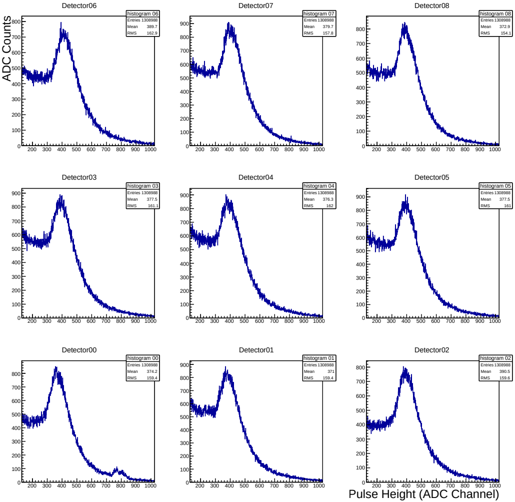
- Each scintillator is connected to one of nine 2" photomultiplier tubes (PMTs)

- The data acquisition was done using a combination of NIM and CAMAC electronics



- A NIM discriminator and logic unit were used to create a gate and trigger for a CAMAC analog to digital converter (ADC)

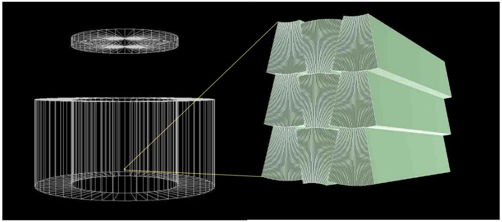
- We required a coincidence of two or more detectors with a signal height greater than 30 mV
- The PMT signals are sent to the CAMAC ADC to be converted and recorded into the computer



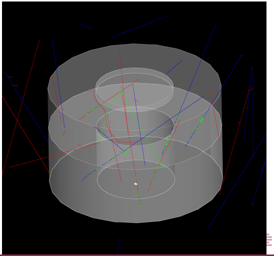
- Pulse height spectra of the incoming signals from the nine detectors
- The pulse height peaks correspond to the energy deposited by vertical muons traveling straight through the detectors

CRY and Geant4 Simulation

- Monte Carlo simulation of our detector in LArTF

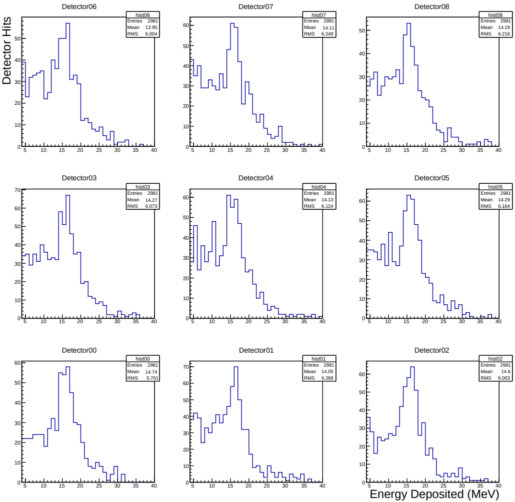


- Geometry and tracking was done using Geant4
http://geant4.cern.ch/



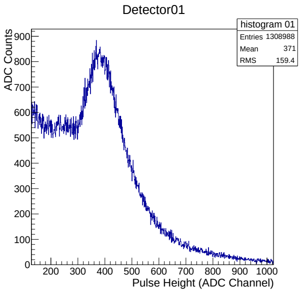
- Cosmic rays were generated using the Cosmic-Ray Shower Generator (CRY)
http://nuclear.llnl.gov/simulation/main.html

Monte Carlo Simulation
Preliminary Results



- Energy spectra of the incoming signals from the nine detectors

- Energies can be determined by comparing the peak locations of our detector and simulation
- We can then rescale the pulse height spectra into units of energy



Histogram of Detector01 pulse heights

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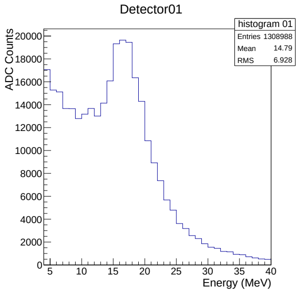
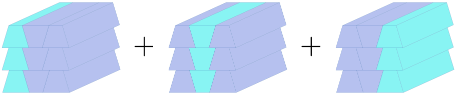


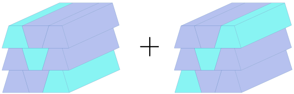
Same histogram rescaled to units of energy (MeV)

- Now that our detector data is on the same scale as our simulation data, we can compare the rates using the same threshold (5 MeV)

	Total Rate	Vertical Rate	Diagonal Rate
Detector Rate (s^{-1})	15.15	2.00	0.14
Simulation Rate (s^{-1})	11.10	1.44	0.08



- Vertical Rate



- Diagonal Rate

Conclusions and Further Work

- A combination of measurements in LArTF and a Monte Carlo simulation will further help our understanding of the cosmic ray rate in MicroBooNE.
- We are currently conducting a more detailed analysis of the angle dependence of the rate.

Thank you!