COSMIC MUON CHARACTERISATION IN LARTPCS

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Physics Goals

* Liquid Argon Time Projection Chamber (LArTPC) R&D.
* Address electromagnetic **low-energy excess** observed by MiniBooNE.
* **Cross-section** measurements on argon.
* First step in the **Fermilab short baseline neutrino program**.
LIQUID ARGON TIME PROJECTION CHAMBER

- Cathode Plane
- Incoming Neutrino
- Charged Particles
- Liquid Argon TPC
- Sense Wires
- $E_{\text{drift}}$
- 3 Planes, 8192 Wires, 3 mm wire spacing
LIQUID ARGON TIME PROJECTION CHAMBER

Cathode Plane

Incoming Neutrino

Scintillation light

Liquid Argon TPC

Sense Wires
U V Y

Fast light signal captured by 32 PMTs
LIQUID ARGON TIME PROJECTION CHAMBER

Liquid Argon TPC

Cathode Plane

Incoming Neutrino

$E_{\text{drift}}$

Ionization electrons

Sense Wires

U V Y

V wire plane waveforms

TPC readout:
Order milliseconds

Y wire plane waveforms

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Run 5906, Subrun 74, Event 3710
MicroBooNE Data

Plane 0: Induction

Plane 1: Induction

Plane 2: Collection
MICROBOOONE DATA EVENT

Colour ~ Deposited charge

Plane 0: Induction

Plane 1: Induction

Plane 2: Collection

Run 5906, Subrun 74, Event 3710
MicroBooNE Data

Incoming neutrino

Time
Wires
MICROBOONE DATA EVENT

Run 5906, Subrun 74, Event 3710
MicroBooNE Data

Plane 0: Induction

Run 5906, Subrun 74, Event 3710
MicroBooNE Data

Electromagnetic Shower

Plane 1: Induction

Run 5906, Subrun 74, Event 3710
MicroBooNE Data

Proton Track

Plane 2: Collection

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BACK TO REALITY: EVENTS CONTAIN A LOT OF COSMIC CHARGE DEPOSITS

Run 1463 Event 28. August 15th 2015 10:37
MicroBooNE is a surface detector.

- 5 kHz cosmic muon rate.
- Approximately 24 muons per triggered event

→ Cosmic activity is the dominant background!
MICROBOOНЕ DETECTOR SUBSYSTEMS

**TPC**
Cosmic muons produce tracks which are automatically reconstructed.

**PMT**
32 PMT's record the light emitted by ionised argon due to cosmic activity with nanosecond precision.

**Cosmic Ray Tagger**
MicroBooNE is equipped with a scintillator based cosmic tagger system that has a coverage of 85%.
MICROBOOONE DETECTOR SUBSYSTEMS

Fast simple signals from the photo-multiplier (PMT) system and the cosmic ray taggers in combination with detailed but slow energy deposits from the TPC.

→ Cosmic studies benefit from using all parts of MicroBooNE!
### Goals and Results

- Independent **rate measurement** using the different subsystems.
- Track reconstruction **resolution in the TPC**.
- Modelling the distortion of the electric field due to build-up of slow drifting ions (**Space-charge**).
- Validation of different **input flux models** for CORSIKA.
- Data **stability** testing over different **data-taking** periods.
We are able to reconstruct muon tracks entering the TPC with an efficiency above 98% and a purity of $\approx 98\%$.

Reconstruction resolution: $O(\text{cm})$ for the length and below $1^\circ$ for the angles.

$\rightarrow$ Fully automated track reconstruction in LArTPC with high granularity.
• Evaluations with both CRY and CORSIKA, the latter being our default.
• Evaluations using different CORSIKA input models; Found good agreement using proton primaries

The intensity of primary nucleons is approximated by:

\[ \Phi(E) = 1.8 \times 10^4 (E[\text{GeV}])^{-2.7} \text{ nucleons/m}^2 \text{s sr GeV} \]

Measured muon flux at Fermilab, integrated over energy and solid angle:

\[ 129.5 \pm 0.5 \text{ (stat.)} ^{+4.0}_{-2.8} \text{ (syst.) Hz/m}^2 \]
Agreement between CORSIKA configuration, TPC and PMT measurement. Measurement using the CRT in progress.
THANK YOU!
& Questions