Working Toward a Precision Neutrino Beam

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In partnership with:
Introduction

• Working with Charles Lane on MARGARITA Cherenkov detector in the NuMI beamline

• Analysis of the existing NuMI muon monitors has been lacking and could provide important insights for various experiments utilizing the beam

• Working with Laura Fields to improve the offline analysis and develop a functioning g4numi simulation
Muon Alcoves

Muon Monitors

- 9x9 array of ionization chambers containing helium gas
- 2x2 m² total array coverage
- Originally installed c. 2005
Online Monitoring

- ACNET data from Nov 14, 2017 to Jan 2, 2018
- Plotted by Jim Hylen
- Only 2 of the 7 weeks of data produced monitoring to the 1% level
- Several issues that may be solved with offline analysis
Offline Analysis

• Improvements made by:
  – Adding a nonlinear correction to account for the response of charge collected in the ionization chambers with increasing beam current
  – Cutting data based on irregular helium gas calibration readings and large beam spot sizes

• Examined several periods of interest
  – Horn tilt in November 2015
  – Horn hanger water leak in March 2018
Horn tilt

![Graph showing signal after all corrections from November 2015 to February 2016 for MM1 and MM2.]
Introducing MARGARITA

- Prototype water Cherenkov detector
- Utilize difference in muon lifetimes to characterize NuMI beam
- Two small containers of fluid, each on top of a 2 inch PMT
- Contained within lightproof 5 gallon can
- High voltage input and oscilloscope output
Muon Lifetime

- $\tau^+ = 2.1969811 \pm 0.0000022 \ \mu$s
- $\tau^+ / \tau^- = 1.000024 \pm 0.0000078 \ \mu$s (vacuum)
- Negative muons have additional channels in matter
- Captured in an atomic orbital or by a proton
- Shorter lifetime

\[ \frac{1}{\tau^-_{\text{total}}} = \frac{1}{\tau^-_{\text{decay}}} + \frac{1}{\tau^-_{\text{capture}}} \]
MARGARITA Installed

- Muon Alcove 2 in NuMI beamline
- 5 GHz LeCroy 640Zi oscilloscope
- PMTs are gated to avoid initial beam pulse
- Expect $\sim 10^5$ stopped muons after each beam spill
MARGARITA Data

- High voltage off
- Use beam structure for gating timing

- High voltage on, single pulse
Continuing work

• Continue monitoring the muon monitor signals for any developing issues
• Develop a Geant4 simulation for the existing muon monitors using g4numi
• With the functioning simulation, model the previous beamline issues, and adapt the simulation for use with MARGARITA and future muon monitors
• Begin significant data collection and analysis with MARGARITA
• By providing additional tools to characterize a neutrino beamline, we hope to benefit any existing and future beamline experiments