LBNF Muon Monitor System

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LBNF Muon Systems

- 3 Systems
  - Threshold Gas Cherenkov
  - Ionization Array
  - Stopped Muon Counters

- Prototypes for all 3 are currently in the NuMI alcoves, or are being developed.
- Goals: Monitor stability, determine the energy/momentum spectrum of muons
Ionization Detectors

• Looking into an array of diamond or silicon detectors to continuously monitor beam shape, intensity and profile.

• Silicon detectors
  ‣ Purchased 2 Si PINs from Hamamatsu. Same devices as used for T2K muon monitors.

• Diamond Detectors
  ‣ ~8 times more rad hard than silicon; Smaller signal than Si, but very fast timing
  ‣ 3 used detectors on loan from CNGS in NuMI alcove 2 right now. Do shown some drifting on a ~3 week timescale when first turned on.
  ‣ Colorado Purchased and metalized a small polycrystal CVD diamond. Developing a circuit/box to house it and read it out

• See Nick’s talk later in this session!
Threshold Gas Cherenkov Detectors

• L-shaped pipe filled with argon gas. A PMT sits about 5 m away, just outside a quartz window.
  ‣ Density of argon can be varied.
  ‣ Motorized actuators can remotely adjust the pitch and yaw of the detector
• Will measure muon 2D distribution in p,θ
• Full-scale prototype in alcove 2 has collected neutrino and anti-neutrino data.
• See Max’s talk next
Stopped Muon Counters

- Looks for muon decay electrons after the beam pulse
- Using oil to also look for $^{12}$B decay ($E=13.4$ MeV, $\tau=30$ msec)
- Inner mineral oil volume with 4 PMTs to look for Cherenkov light from decay electrons
- Outer liquid scintillator veto with 4 PMTs
- PMTs will be gated off during the beam pulse
Diamond signal rise studies

Picked 20 day period immediately after diamonds were turned on. Diamonds had been off for multiple months in each case. Beam had been running for weeks before.
Comparing diamonds to muon monitor 2

March 24-31

Beam was off for a few hours and then came back on, causing a signal spike.
Comparing diamonds to muon monitor 2

March 24-31

Muon monitor 2 and the averaged diamond signal are highly correlated as expected. They are both measuring results of PoT.