Aerogel Beam Line Cherenkov Detector for the LArIAT Experiment

Brandon Soubasis
Texas State University
Advisors: Jennifer Raaf, Will Flanagan, Karol Lang
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Liquid Argon Time Projection Chambers (LArTPCs)

LArIAT is a LArTPC at Fermilab Test Beam Facility that provides beams of known energies, selection of different particle types, and controlled environment in which to tune simulations and to develop tools for particle identification (PID), calorimetry, and event reconstruction without relying solely on simulation.
Particle ID

- We currently have 2 time of flight scintillator counters which give discrimination for particles but not for too close in mass such as $p/\pi$, but not $\pi/\mu$. 

Tues August 04, 2015

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![Particle ID Diagram](image-url)
Motivation

- How can we measure stopped muons and pions at LArIAT?
- Given simple assumptions, muons should stop within the LAr TPC with $p<280$ MeV and pions with $p<330$ MeV.
Motivation

- How can we separate stopped muons and pions at LArIAT?
- Can’t use a muon range stack since these muons will be stopping in the LAr TPC.
- Time of Flight (ToF) can be difficult since muon and pion masses only differ by 30%.
- What about a material with a small index of refraction (Aerogel)?
Aiming to separate muons and pions in a momentum range where muons emit Cherenkov radiation while pions do not.

- Different indices of refraction are sensitive to different momentum ranges.
- The combination of the two aerogel Cherenkov counter, pions and muons can be identified for $p<400\text{MeV/c}$

<table>
<thead>
<tr>
<th></th>
<th>$n=1.10$</th>
<th>$n=1.05$</th>
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<tbody>
<tr>
<td>$220&lt;p&lt;285$</td>
<td>$\mu$ ✓</td>
<td>$\times$</td>
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<tr>
<td></td>
<td>$\pi$ $\times$</td>
<td>$\times$</td>
</tr>
<tr>
<td>$300&lt;p&lt;400$</td>
<td>$\mu$ ✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>$\pi$ ✓</td>
<td>$\times$</td>
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</tbody>
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$$N_{DC} \approx 90 \times \sin^2 \theta_c \text{ where } \cos \theta_c = \frac{1}{\beta n}$$
We have our aerogel tiles horizontal instead of vertical.
This increases our thickness for particles to pass through from 6.5 to 7.4 inches
Currently using the EMI 9954B 2” PMT with another 3” PMT.
PMTs

- Calibrated PMTs using LED pulses.
- This allows us to translate from ADC counts to NPE

\[ n_0 \sim \left( \frac{\mu - ped}{\sigma_{0m}} \right)^2 \]
Due to the size of the new design(s), our counter is placed DS just after the KEK counter.
Can better understand our pile up from the aerogel counters?
**TOF vs Pulse Area – Positive Magnet Polarity Runs**

- **PMT Hamamatsu - Positive Polarity**
  - TOF [ns]
  - Pulse Area [mV/ns]

- **PMT Photonis - Positive Polarity**
  - TOF [ns]
  - Pulse Area [mV/ns]

- **PMT KEK1 - Positive Polarity**
  - TOF [ns]
  - Pulse Area [mV/ns]

- **PMT KEK2 - Positive Polarity**
  - TOF [ns]
  - Pulse Area [mV/ns]

- **Efficiency of detecting pion:**
  - HMMS PMT: 57%
  - PTN PMT: 41%
  - KEK1 PMT: 67%
  - KEK2 PMT: 82%

- **Efficiency of detecting proton:**
  - HMMS PMT: 22%
  - PTN PMT: 29%
  - KEK1 PMT: 5%
  - KEK2 PMT: 2%
- Efficiency of detecting pion
  - HMMS PMT: 52%
  - PTN PMT: 42%
  - KEK1 PMT: 69%
  - KEK2 PMT: 74%

- Efficiency of detecting proton
  - HMMS PMT10%
  - PTN PMT: 13%
  - KEK1 PMT: 9%
  - KEK2 PMT: 15%
Reference
E.H. Bellamy et al. NIM A339 (1994) 468-476
R. Godang et al. MUC-NOT-COOL-EXP-304
Other Involvement here at Fermilab

- US Wall Halo Scintillator Counter (HSC) Installation
- Modified Collimator Running and simulations
- Studies with Silicon photomultiplier (SiPMs)
Counters on the upstream wall!
- Measure any secondary beam halo.
- Help understand radiation field of MC7.
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- Help understand radiation field of MC7.
Wall halo counters are connected into the quad scalar and sent into acnet.

Plugged into a spare v1740 board.
We can see now the Halo Scintillator Counter’s reaction to the beam spill.
I have made changes to the event display to output all 6 wall HSCs.

Single tracks seem to quiet in the counters.
Notice the wall counter are lighting up when we have a lot of through the LArTPC.

Can we veto on the wall HSCs in the v1495.
We have noticed that HSC 4, HSC 5, and HSC 6 are seeing higher counts than HSC 1, HSC 2, and HSC 3.

~6E4 counts

~2E5 counts
As of June 29th the movable rack has also been installed.
I have made changes to the event display again adding the movable rack Halo Scintillator Counter’s channels.
Prepared steel plates and braces to narrow our downstream collimator.

 Been simulating the change in our observed momentum spectrum that these plates would give.

 Observing this change in our momentum spectrum would test both our beamline simulation and momentum reconstruction.
We have found some steel plates that have been tapped so that they can be placed inside the collimator to have the option of narrowing the beam. This will give us four options for the beam width.

I am working on the beam line simulation of these plates within the collimator.
Studies with SensL Silicon photomultiplier (SiPM) – 35 - 50μm microcells

- Compact!
- Inexpensive!
- Insensitive to magnetic field!
- Low operating voltage

I-V Curve

30-33v
ACKNOWLEDGEMENTS
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