LArIAT: Liquid Argon
In A Test Beam
Greg Pulliam, Syracuse University
on behalf of the LArIAT Collaboration
DPF 2017

“A small detector with a big heart”- Jonathan Asaadi

G. Pulliam Syracuse University

DPF August 2, 2017
LArIAT TPC

- TPC Dimension: 40cm x 47cm x 90cm
- Wire planes provide a finely resolved view (4mm) of charged particles
- Two readout planes, one shield plane
- Cold preamp ASICS, warm digitization
- 2 PMTs, 3 SiPMs collect light
LArIAT’s Event Display

Induction

May 29 2016: Run 9335 Spill 382 Event 39

Collection

π⁻ π⁻ π⁻ π⁻ p p
What Can LArIAT Do for You?

Using a LArTPC in a charged particle beam, study charged interactions in LAr as R&D for the broader LArTPC neutrino program. In particular:

- Energy reconstruction and PID of common charged particles ($\pi$, $\mu$, $p$, $K$, $e$)
- Distinguish electron-initiated showers from $\gamma$-initiated showers
- Study relationship between charge deposition to scintillation light yield (Mônica Nunes’s talk, Paweł Kryczyński’s poster, July 31)
- Compare results across different wire plane spacings (3mm vs 4mm vs 5mm)
LArIAT’s Own Physics Goals

- Provide the first $\pi$-LAr cross section measurements
  (Preliminary results this talk)

- $K^+/K^-$ cross section study
  (Next talk by Elena Gramellini. Dan Smith’s poster, Monday)

- Anti-proton annihilation studies (Following talk by Will Foreman)
The Beamline
Wire Chambers and TOF: Momentum and Time of Flight

- Time of Flight (TOF) provides a clock for how long a particle takes to travel through the beamline.
- As a charged particle passes through each wire chamber (WC), it induces a signal on a nearby wire in each chamber.
- Each pair provide a trajectory before and after the magnets. Combining these trajectories with the B field, the momentum is calculated.
- Also, choosing the polarity of the magnet chooses the charge of the particles we want to measure.

B Field (0.2-0.4 T)

\[ \theta_u \]

\[ \theta_d \]
Momentum + TOF = Mass Hypothesis
Beamline Composition

MC Percentage:

π: 48.4 %
e: 40.9 %
γ: 8.5 %
μ: 2.2 %
K: .035 %
\̅\(\bar{p}\): .007 %
Event Selection

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<thead>
<tr>
<th>Event Selection</th>
<th>Run-I Negative Polarity</th>
<th>Run-II Negative Polarity</th>
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<tbody>
<tr>
<td>Total Number of Beam Events</td>
<td>113,336</td>
<td>1,585,598</td>
<td>1,698,934</td>
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<tr>
<td>$\pi, \mu, e$ Mass Selection</td>
<td>20,653</td>
<td>493,455</td>
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<tr>
<td>20 ns $&lt;$ TOF $&lt;$ 27</td>
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<td>Requiring an upstream TPC Track within $z &lt; 2$ cm</td>
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<td>422,443</td>
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<td>$&lt; 4$ tracks in the first $z &lt; 14$ cm</td>
<td>12,910</td>
<td>316,451</td>
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<td>Electromagnetic shower rejection</td>
<td>9,824</td>
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<td>48.4%</td>
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<td>8.5%</td>
<td>2.2%</td>
<td>.035%</td>
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<td>Percent Passing Cuts</td>
<td>73.5%</td>
<td>14.2%</td>
<td>2.3%</td>
<td>73.4%</td>
<td>70.6%</td>
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<tr>
<td>Expected Percentage of Sample</td>
<td>81.9%</td>
<td>13.4%</td>
<td>.45%</td>
<td>3.7%</td>
<td>.56%</td>
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Measuring a Cross Section: Thin Slab Method

- Each wire spacing carves out a “thin slab” of argon.
- As particle enters each slab, we see if it interacts.
- NO INTERACTION: subtract off the energy deposited in the slab from the kinetic energy entering that slab. Fill an “incident” histogram with the KE. Move to next slab.
- INTERACTION HAPPENS: Calculate the KE and use it to fill an “interacting” and “incident” histogram.

\[ KE_{\text{interaction}} = KE_{\text{initial}} - \sum_{i}^{pts} \frac{dE_i}{dx} \times dx_i \]
**Incident**

**Interacting**
First $\pi$-LAr Cross Section

Run I/II (May-July 2015, Feb-July 2016)
Conclusion

- LArIAT liquid argon TPC programme informs design and operation of future LArTPC experiments:
  - Assessment and development of charged particle reconstruction and identification
  - Measure effect of various wire pitch options on PID
  - Light collection with reflectors & novel devices (see Mônica Nunes talk)
  - TPC performance

- First Run-I + Run-II π- interaction cross section analysis
  - Publication in preparation

- Additional hadron interaction cross section measurements (π+, K+/-, p, \(\bar{p}\)) coming soon
Kaon Analysis: In Progress

"Angry Face Kaon"

Identified over 1000 Kaon candidates
Analysis underway to create a K-LAr cross section
Aerogels Distinguish Pions From Muons

Between WC 3 and 4, we have two Aerogels Cherenkov detectors.

For a particular momentum range, both Aerogels will radiate light differently for muons and pions.

Before we even reach the TPC, we could know the incident momentum, charge, and have a particle ID hypothesis!
Muon Range Stack: PID of TPC-Escaping Particles

- Metal slabs with scintillator paddles between.
- TPC-escaping π will only penetrate 1-2 layers. μ will penetrate most of the length of the stack.
- Provides an estimate of momentum for stopping particles in stack.
- Four layers instrumented, each with 4 vertical paddles and 4 horizontal paddles (shown left).