LArIAT Light Readout
A. Szelc for the LArIAT Collaboration

Light Collection team:
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Introduction

- Most Neutrino detectors use LAr Scintillation light as an indication of $t_0$ and as a hint of the track location.
- There is a lot of information in there, that we are leaving behind.
- Dark Matter detectors use scintillation for calorimetric reconstruction.
- Could we combine that measurement with that usually obtained by TPC?
- LArIAT is a TESTbeam experiment, so we can try to see what can be done.
The LArIAT program @ FNAL

Setting up a test facility to calibrate and test LArTPCs and their components using a beam of charged particles

**Phase-I:** Reuse the ArgoNeuT detector with small modifications – *should allow relatively quick operation* – planned start of data taking: spring 2014

**Phase-II:** Larger LarTPC - *Design facility for broader, longer-term use*

One unique cryogenic/purification facility at FNAL designed to operate for both phases and to allow future tests of LAr detectors
LArIAT will run in MCenter – allows almost permanent occupation (as opposed to MTest).

We will use a Tertiary beam (identical to MINERvA beam test)

We are in the process of optimizing the beam configuration to obtain a spectrum of charged particles closely resembling that of future neutrino experiments.
Motivation

**Calibration** is one of the critical steps to understanding the response of any detector.

The LArTPC is becoming the go-to experiment in neutrino physics.

Surprisingly, there haven't been many dedicated calibrations of LArTPCs.

Understanding parameters like energy resolution and particle ID capabilities of this technology will allow future experiments to lower their systematic errors which may prove essential in precision measurements down the road.
LArIAT physics goals

• Optimizing the particle ID
  • For protons, kaons and pions measuring the recombination factors.
  • For electrons and gammas measuring the dE/dx separation

• Non-magnetic muon sign determination

• anti-proton event studies

• Phase 2: EM and hadronic shower containment studies

• Testing new technologies!
The Light Readout System in LArIAT

- ArgoNeuT planned to install PMTs in its second run.
- LArIAT has inherited the Cryostat and TPC and so we can work with what was designed for that system.
- The TPC frame is constructed in such a way that we can cover large parts of it with Wavelength Shifter + reflector foils increasing the uniformity of Light Collection.
- We want to collect much more light than typical neutrino experiments and digitize it fast enough to differentiate fast and slow light.
The System

- 2 PMTs, operating at cryogenic temperature, (considering adding 2 SiPMs)
- Highly reflecting foils (VIKUITY) coated by a thin TPB film on the inner surfaces of the field cage
- In this setup the scintillation VUV photons are wavelength-shifted into visible photons when hitting the TPB and then reflected from the mirror surfaces beneath, up to collection by the PMTs.
Mounting the PMTs
DAQ + readout

- Readout using a CAEN V1751 fast ADC
- Have used a board like this and have code ready.
- Extracting single phels from the tail of the signals
Tests With a Small Chamber

• Before we put this setup into the LArIAT cryostat we would like to make sure it works.
• Will test the components with a smaller chamber at University of Chicago.
• Building a small mock-”TPC” out of the G10 used to construct the actual ArgoNeuT/LArIAT TPC.
• Test will serve to make sure that the system is plug-and-play when we install it in M-Center.
• And constrain some of the parameters of our MC simulation.
The Components(1)

- PMTs inside a vacuum pumped dewar
- Cooling via external bath
- Constructed G10 box, which will be covered with TPB covered foils.
- External Muon paddles as trigger.
- Can trigger internally on coincidence.
The Components (2)

TPB evaporated foil (this is for the LArIAT TPC)

Mock “TPC”

W. Foreman
Temporary Lab Setup

- New lab space available.
- We now have the digitizer.
- We will be adding SiPMs to setup.
MC Simulations

- Light Yield is often hard to estimate and simulate.
- First try using analytic method: *Ettore Segreto, 2012 JINST 7 P05008 (Secret Law)*
- Gives ~50 phel/MeV for LArIAT ph 1 TPC.
- For the small box, the LY is an order of magnitude more (0.7phel/keV).
- Varying the TPB coverage to arrive at a reasonable yield.

P. Kryczynski
Stand-alone simulation in Geant4

preliminary estimate: 0.5 phe/ keV
Improving the simulation: measurements of G10 reflectivity

- One of the unknowns in the simulation is the reflectivity of G10.
- There is a possibility to measure it using an integrating sphere at the Cracow University of Technology.
- A relatively simple measurement could help constrain the MC results.
- First measurements done and implemented in the simulation.
- Refining and other measurements of other components upcoming
The problem of plenty

- Other recent developments include introducing the PMT response into the simulation.
- We have the reverse problem of Dark Matter experiments – we see almost too much light.
- We could tweak the TPB coverage depending on what we want to focus on.
- Or degrade the TPB (relatively easy, as we've found out at this workshop).

P. Kryczynski

Preliminary 2GeV muon

signal @ Hmm
Conclusions

- LArIAT will have a “Dark Matter-like” light readout system. We expect a LY of the order of 50 phel/MeV (@ zero field)
- This should give us the capability to enhance our calorimetric reconstruction and look at pulse shape discrimination.
- The system is constructed of components that we've used already, so should be straightforward to run.
- The tests with the prototype at UChicago should start in about a month and should clarify the design and allow refining of our simulation for the full detector.
Back-up Slides
Implemented in the MC Simulation

- Emission/absorption spectrum of LAr (+fano factor, fast/slow component)
- WLS spectra of TPB and surface properties of copper, photocathodes, g10
- PMTs efficiency
- Energy spectrum of incident electrons/mouns smeared via the gauss distribution
- Smearing of the momentum x.y component, changing starting position of incident particles to study LY vs track length
- Considering different physics lists
- Considering backpainted surface instead of current "fake shifter " approach (F. Di Pompeo)
- varying TPB coverage
- --g10 reflectivity implemented