Double Phase LArTPCs

Construction, Testing, and Analysis

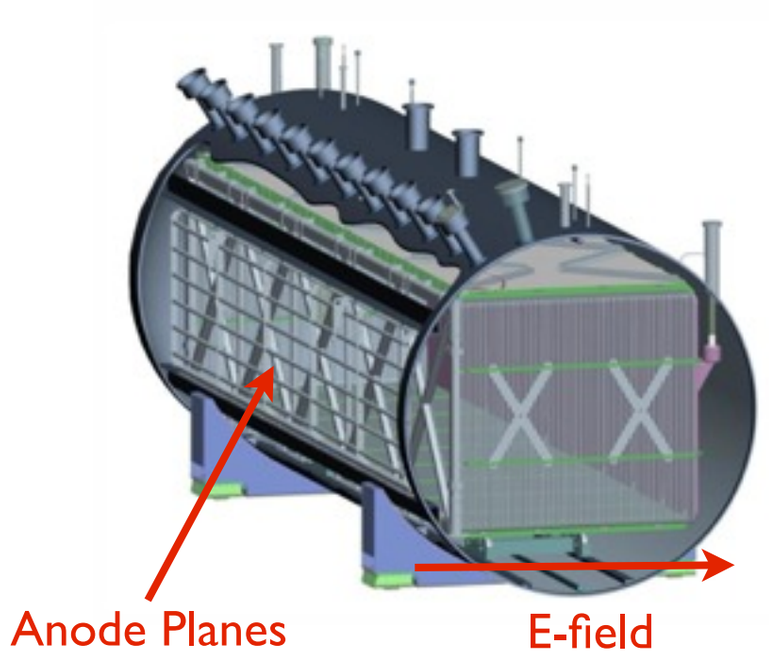
What are LArTPCs?

LArTPC stands for "Liquid Argon Time Projection Chamber."

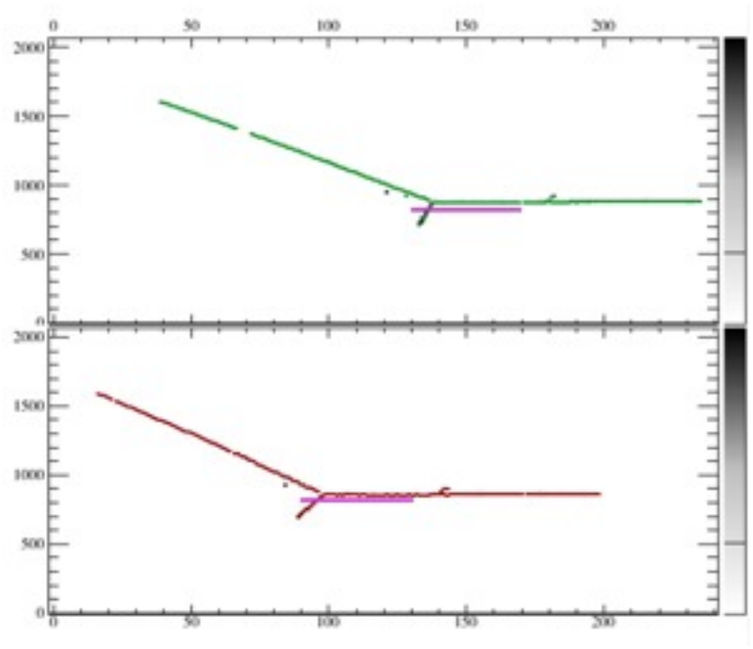
- This is a particle detector that employs the properties of liquid argon to track particle trajectories.

- Basic principles of operation:
  1. An electric field is established across the chamber.
  2. A passing particle ionizes the liquid argon.
  3. Electrons drift to an anode and produce a signal.

- These produce a 2-D image of the particle path, and a 3-D image can be formed by examining the drift time of the electrons.



Single phase liquid argon TPC
MicroBoone, at Fermilab



Sample event display of a TPC

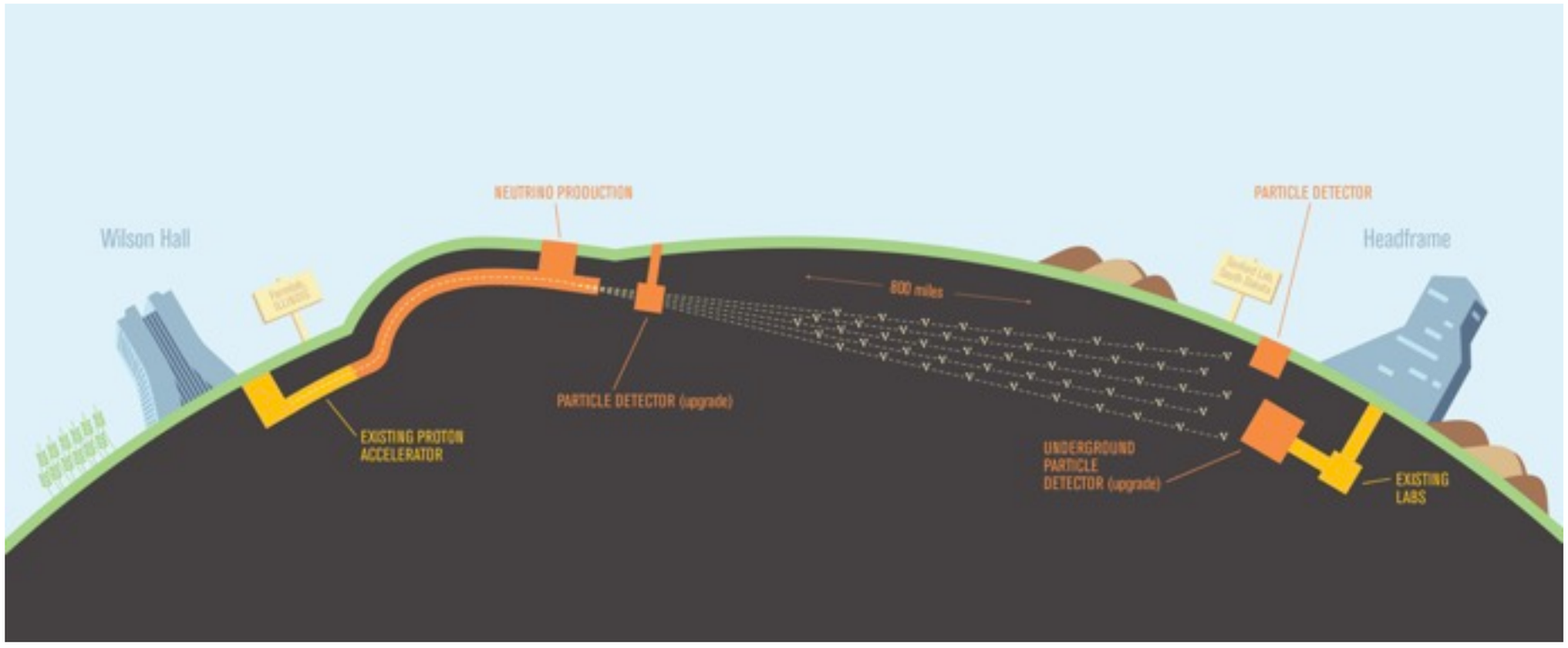
Photo Credit: http://www-microboone.fnal.gov/public/aboutdetector.html

Why Use LArTPCs?

A major reason for LArTPC use is in neutrino studies.

- Neutrinos exhibit strange behavior, where they tend to "oscillate" from flavor to flavor, and we want to detect several parameters related to this oscillation.

- However, neutrinos are elusive, and therefore require a lot of target mass to be detected.



Liquid argon is relatively cheap, and thus is a good candidate for large neutrino detectors, like the Long Baseline Neutrino Experiment (left).

Picture credit: http://lbne.fnal.gov/how-work.shtml

Motivation for Double-Phase LAr-LEM TPCs

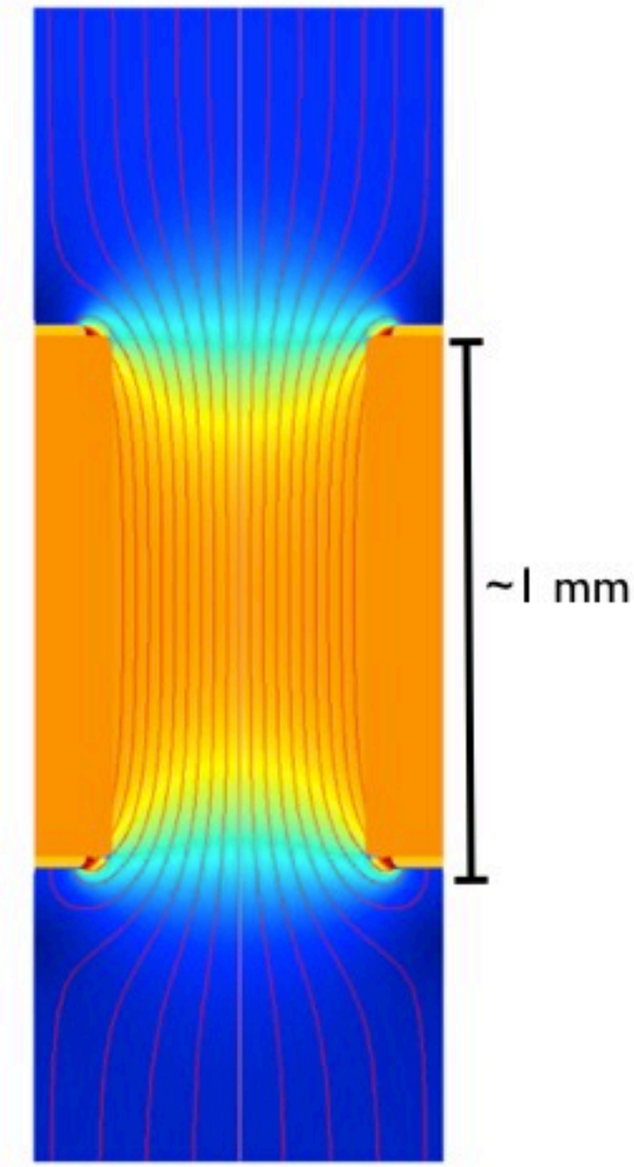
Introduced to improve on some of the aspects of single phase LAr TPC's

- Signal to Noise Ratio

- Low energy event detection (events involving fewer instances of ionization)

- Signal degradation during electron drift

The double phase TPC employs a charge amplification region in gaseous argon to increase sensitivity to low electron levels: the LEM (Large Electron Multiplier).



Picture credit: "Modeling, design and first operation of the novel double phase LAr LEM-TPC detector" by Filippo Resnati

Basic Design/Operation Principles

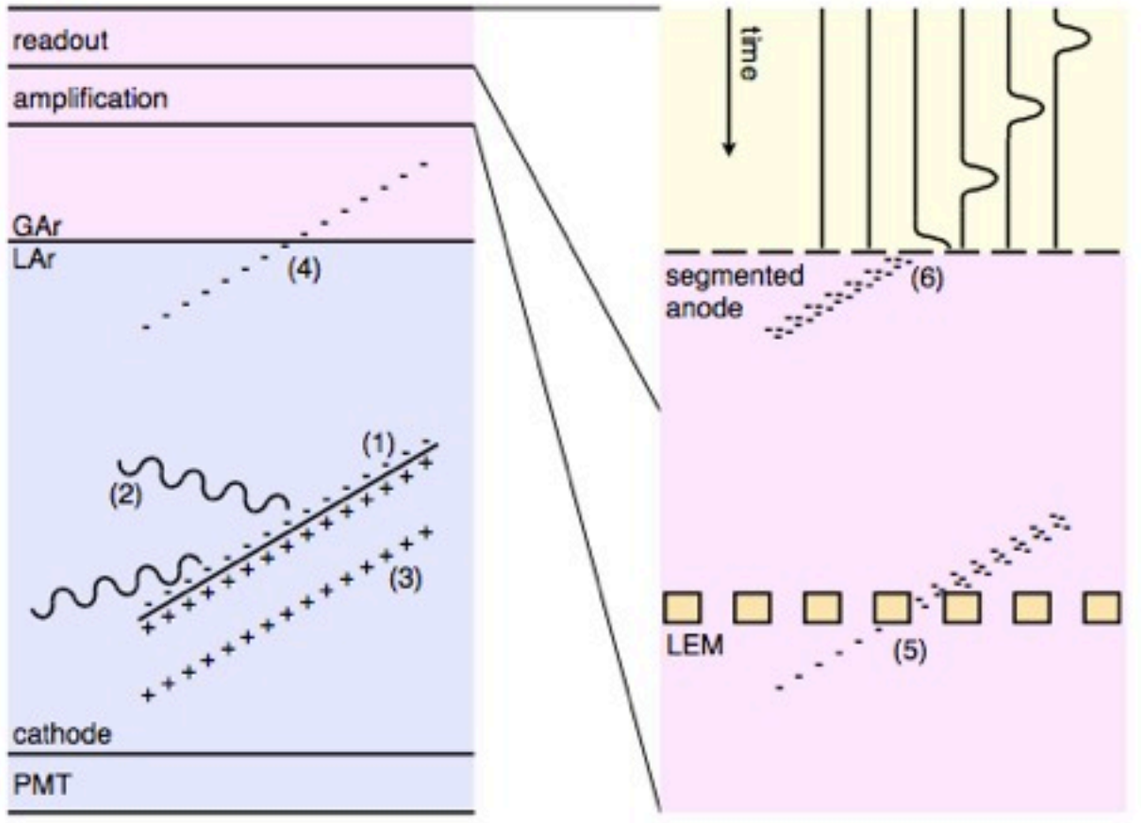
These operate on the same principles that single phase TPCs employ, with a few marked differences.

- The detector is only partially filled with LAr. The rest is filled with gaseous argon.

- When drift electrons in the LAr reach this boundary, they are extracted from the liquid into the gas. (4)

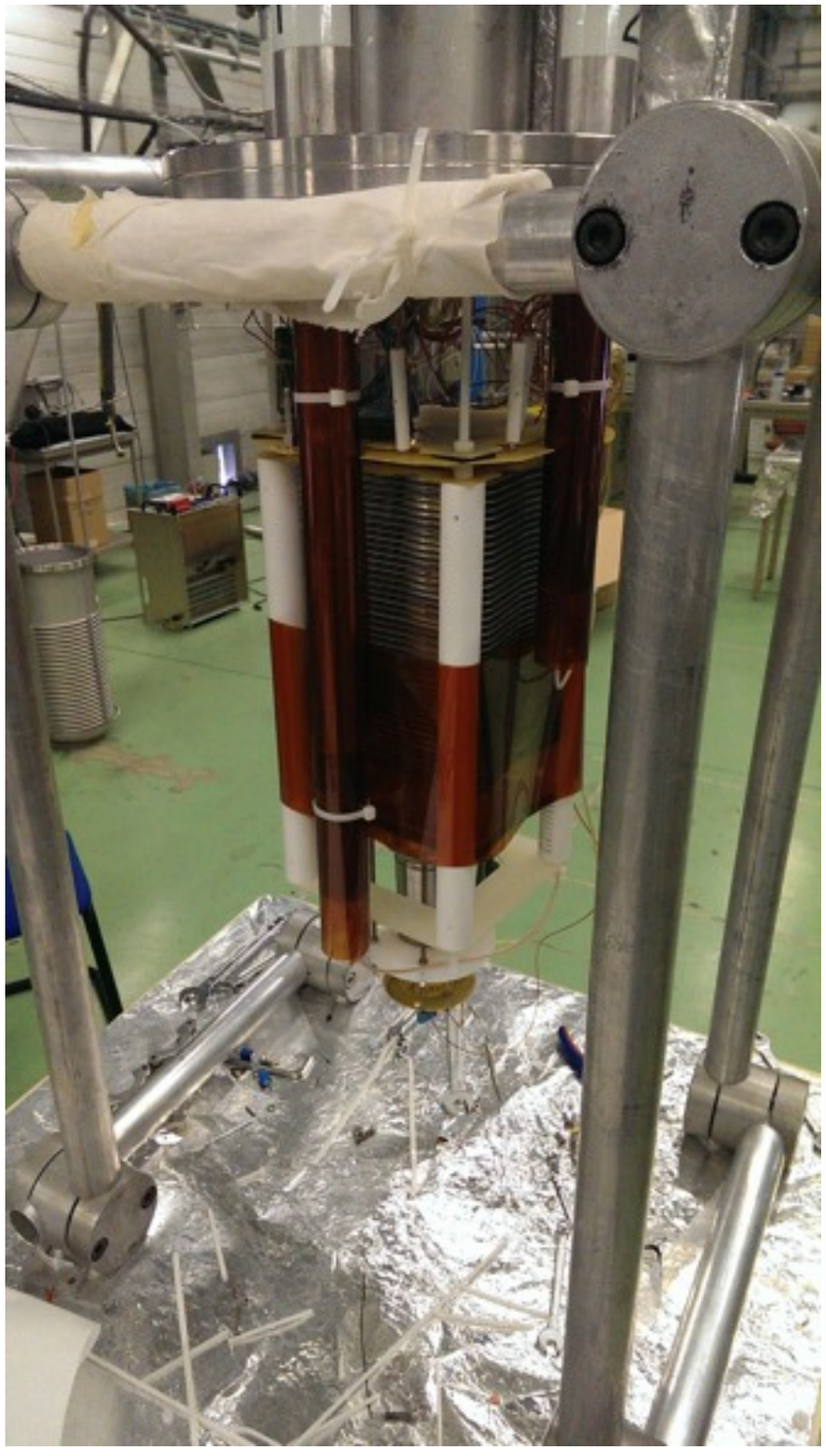
- These electrons then undergo amplification in the LEMs via Townsend avalanche. (5)

- The amplified signal is then collected on the anode. (6)

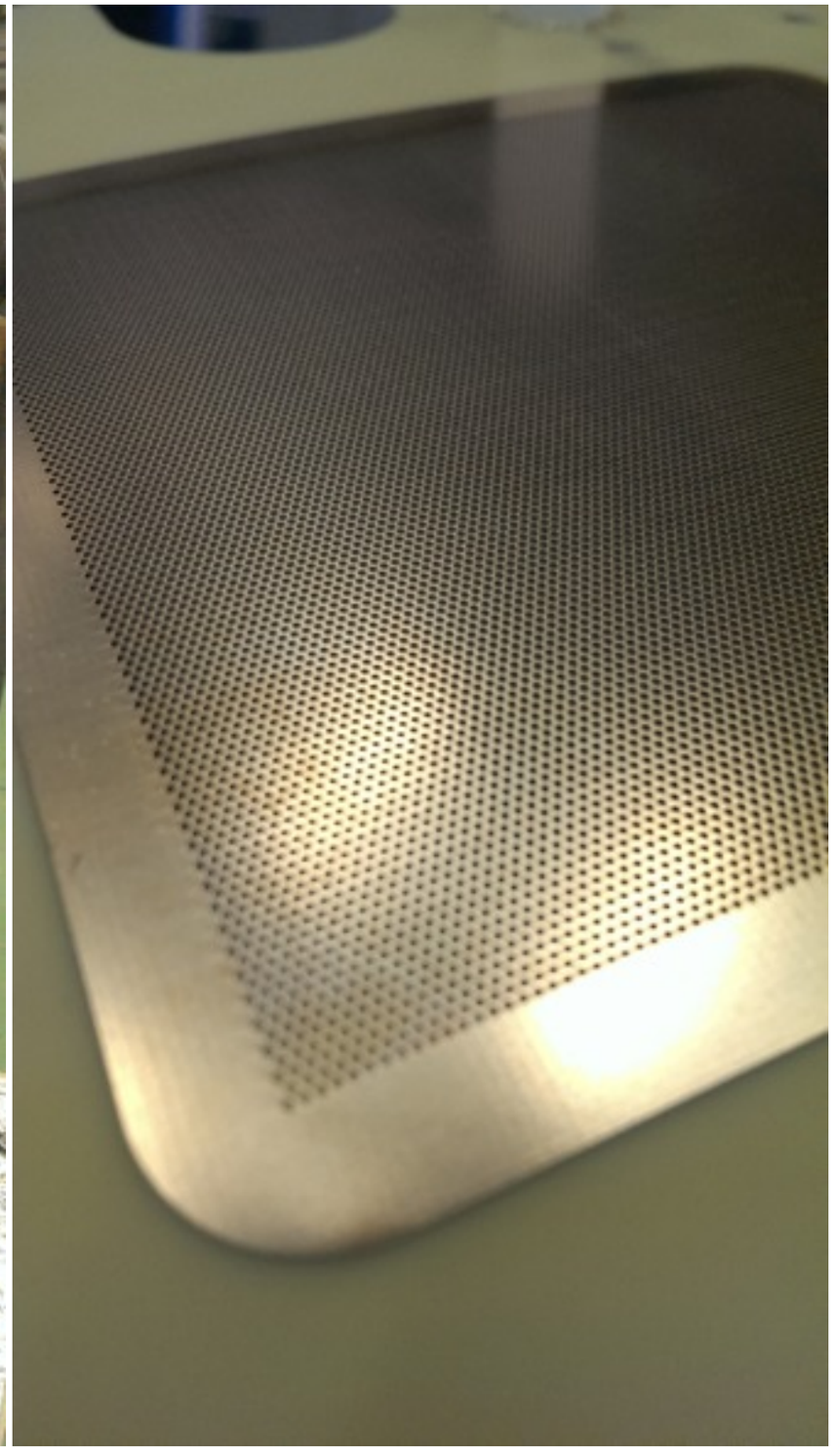


Picture credit: "Modeling, design and first operation of the novel double phase LAr LEM-TPC detector" by Filippo Resnati

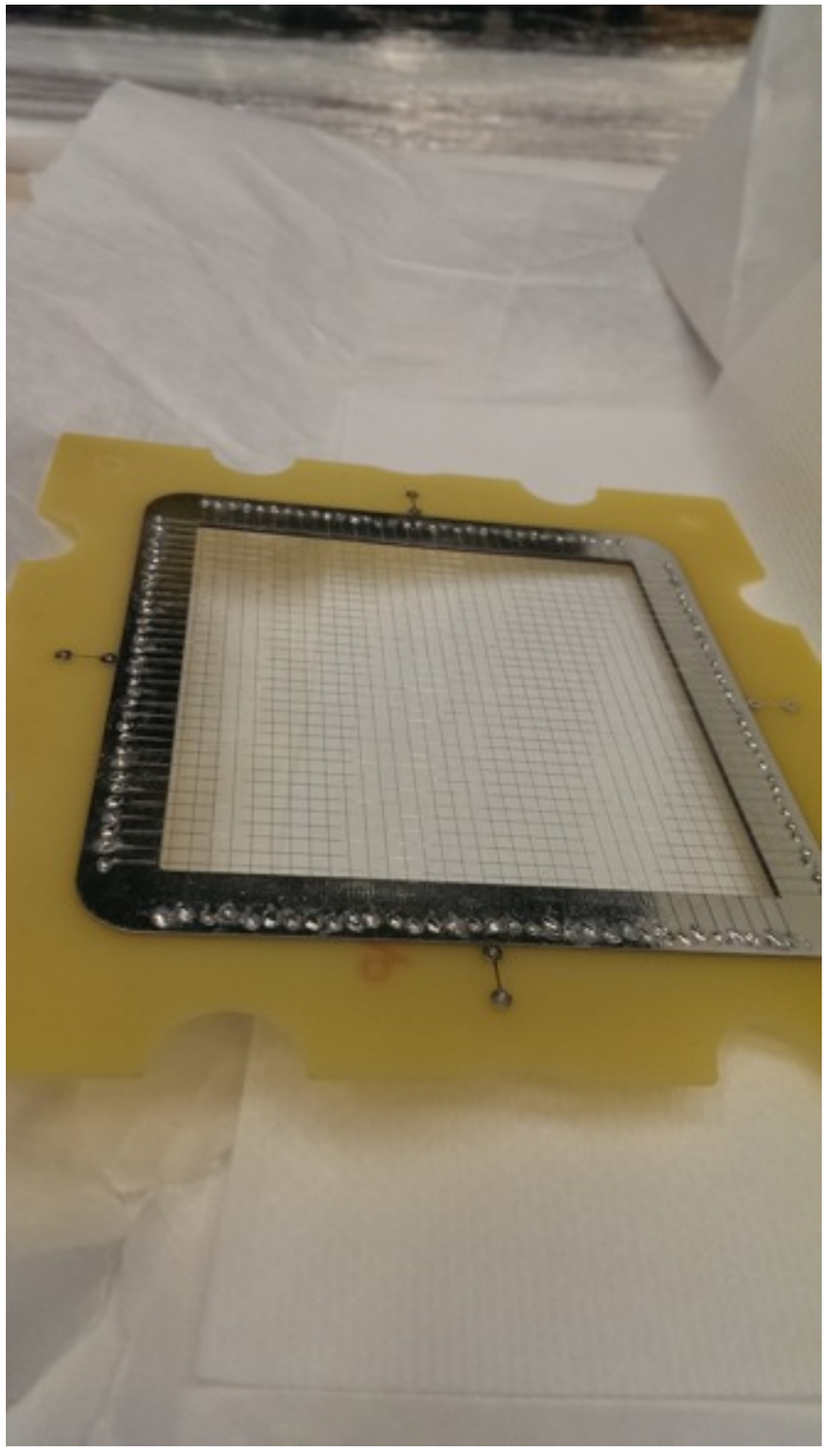
Some Detector Components



The 3 liter detector, with all components added

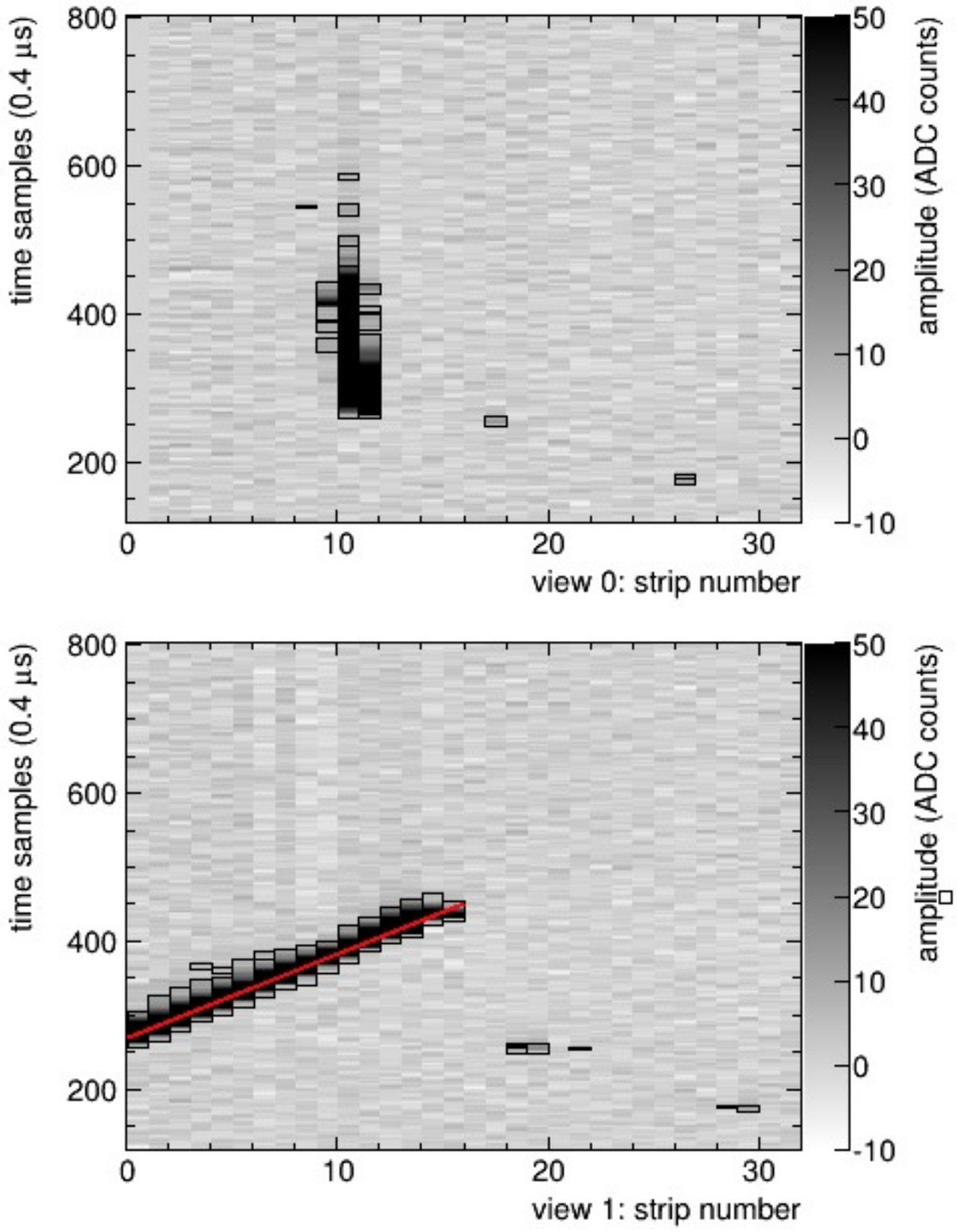


The LEM



The extraction grid

My Project



Qscan event display and track fitting

My project this semester is composed of several parts:

- I will help test the gain of LEMs of various geometries to optimize them for use in larger detectors

- I will work with a software package called Qscan that reconstructs and displays particle interactions in liquid argon.

- Some fitting and track analysis elements of this software are a bit faulty (left), so I will attempt to understand what causes the problems and fix the issues.