Channel Labeling Scheme and Wire to Channel Mapping for LBNE in LArSoft.

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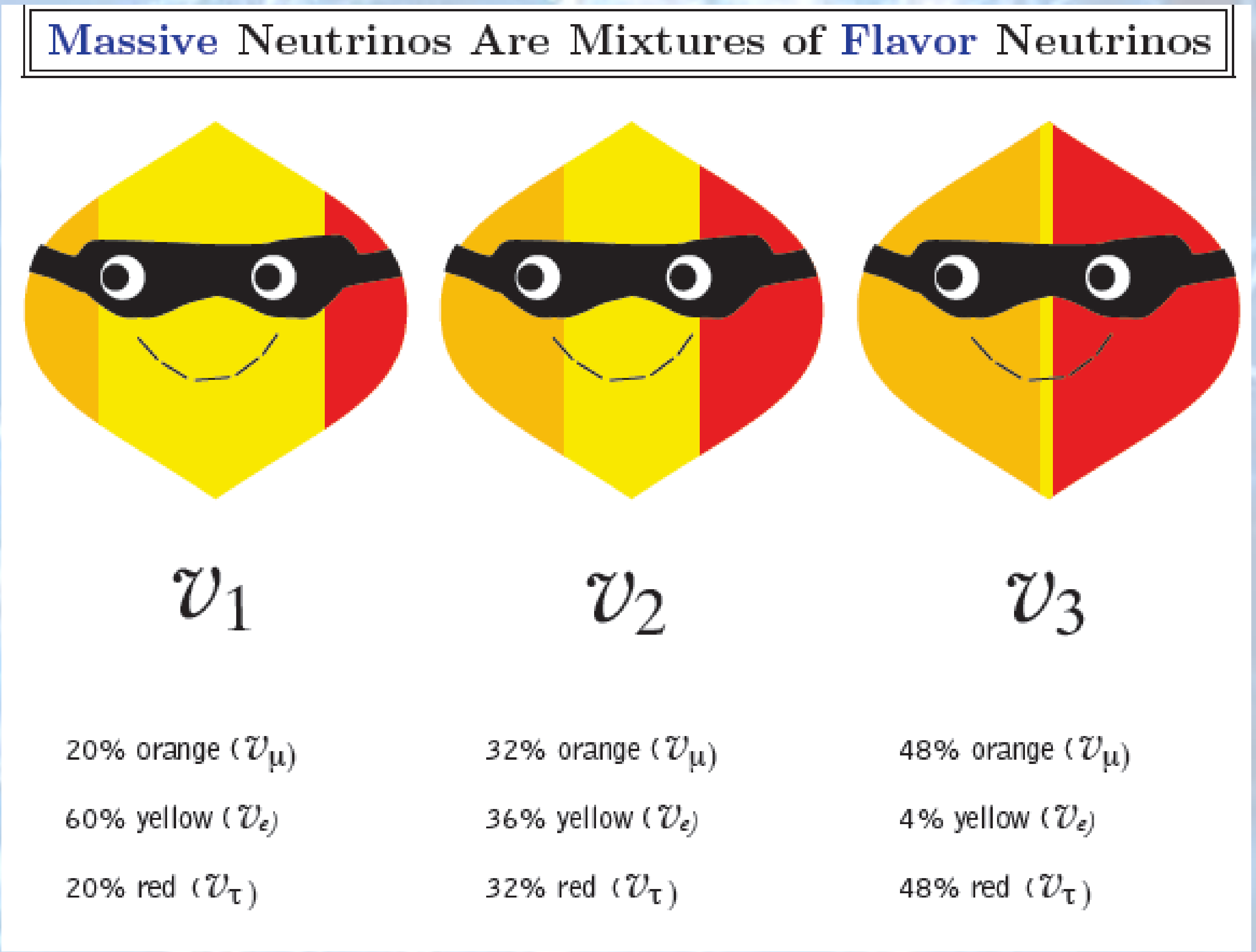
Outline

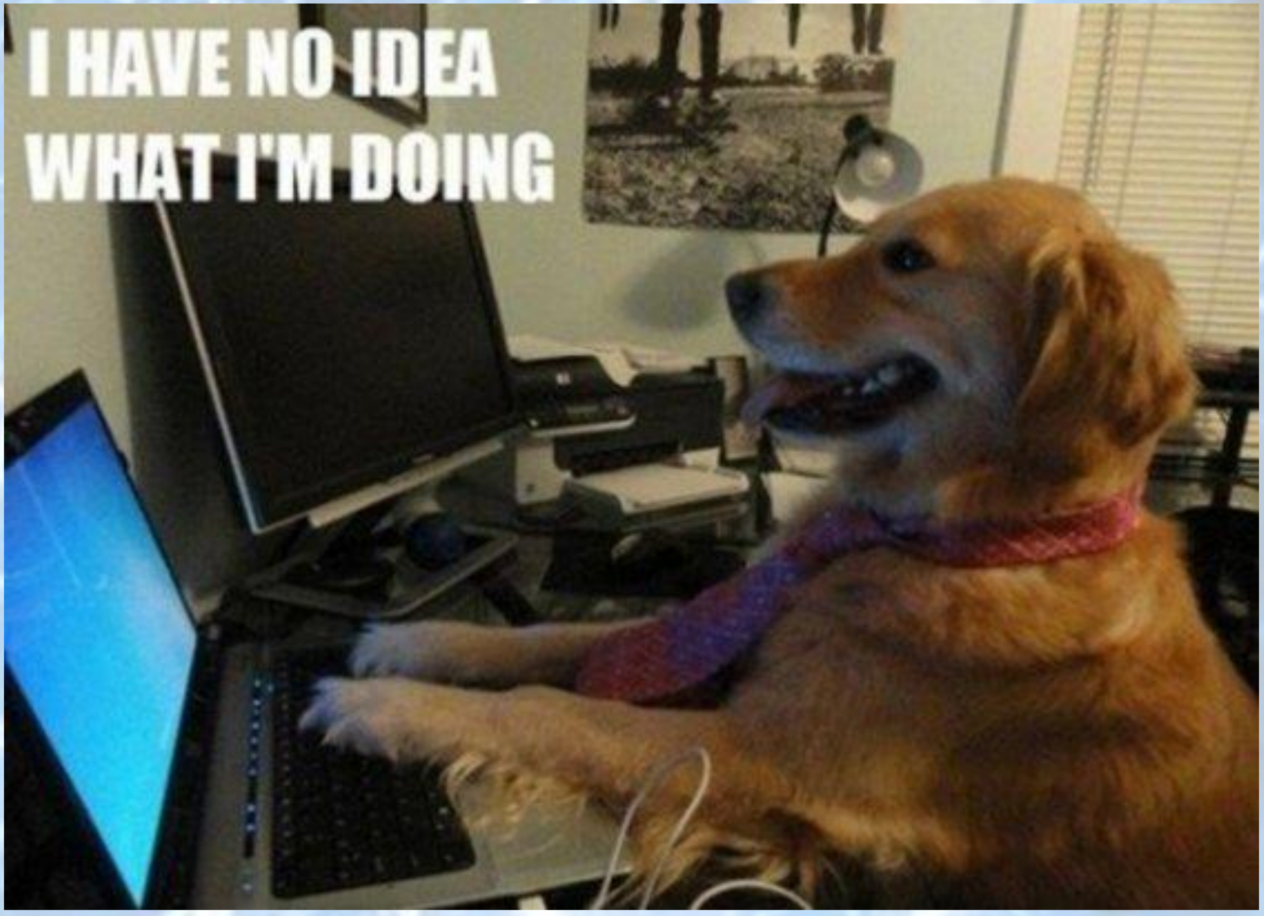
- Introduction
- Learning Curve
- Channel Labeling Scheme
- Wire to Channel Mapping

Neutrinos

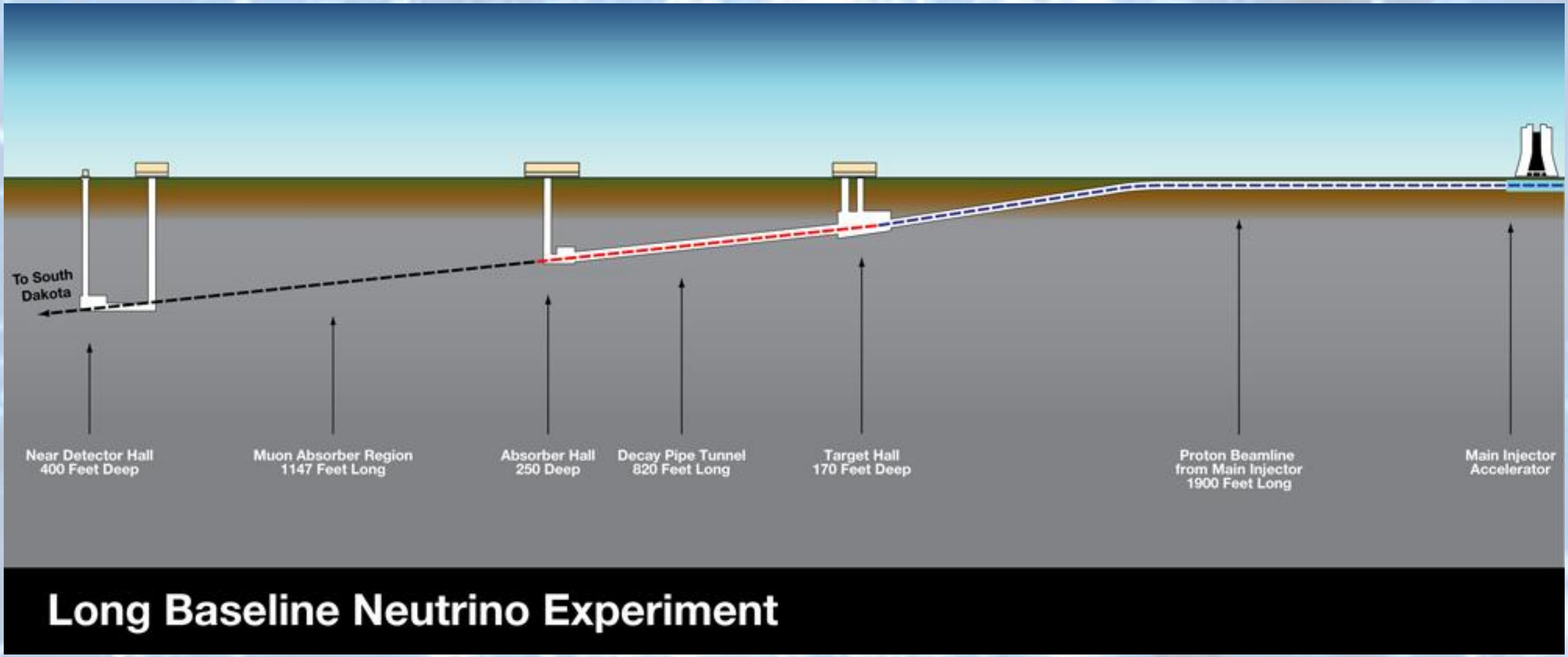
Neutrino Mixing



Learning Curve



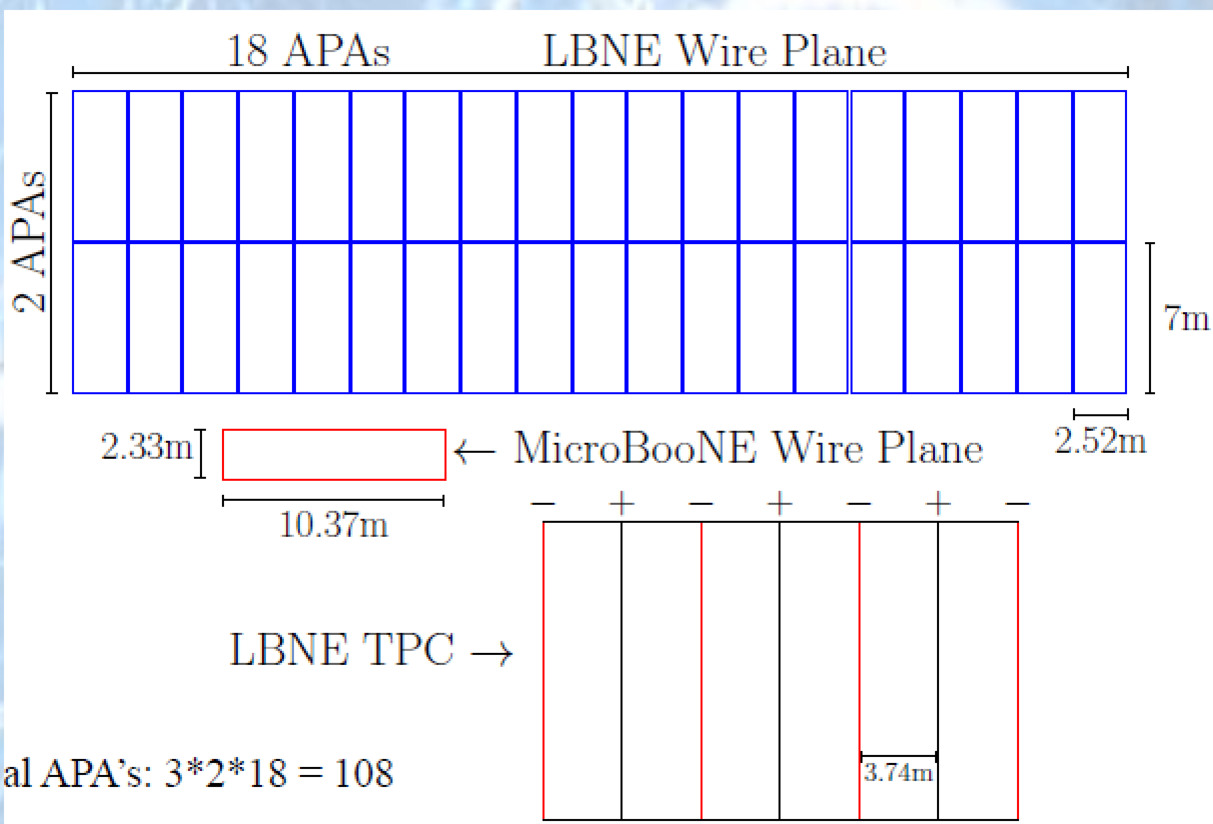
Long Base-Line Neutrino Experiment (LBNE)



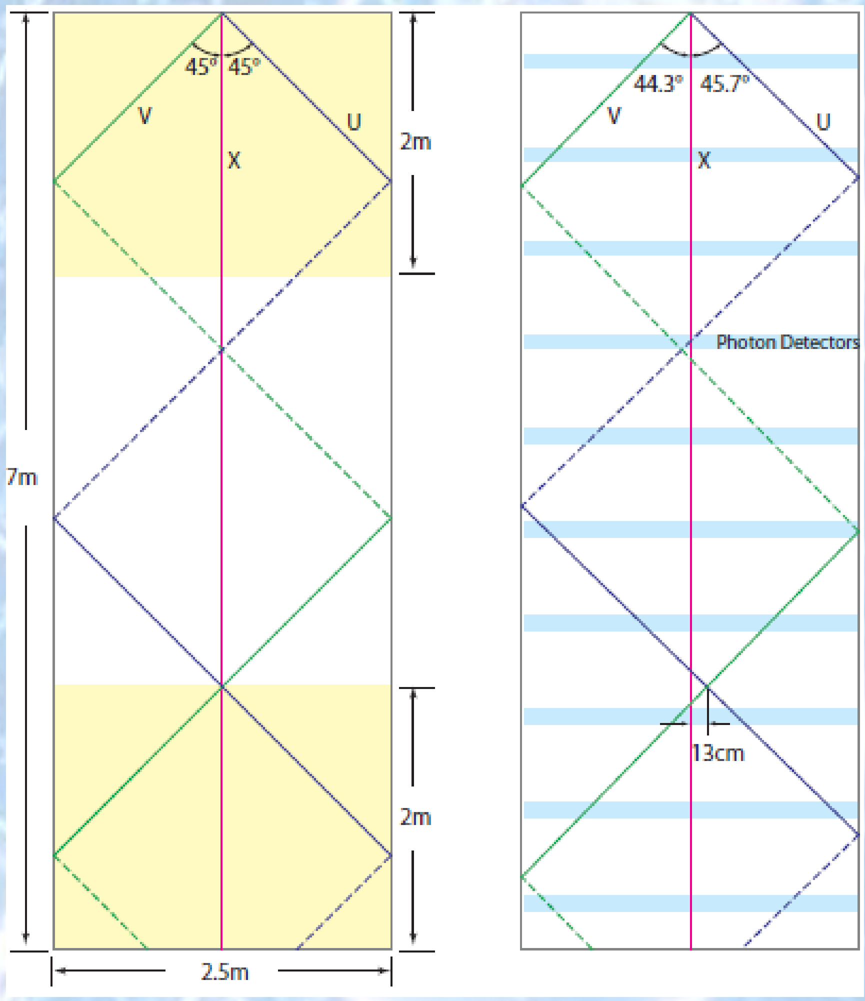
Differences between MicroBooNE and LBNE

MicroBooNE	LBNE
Wire Planes in one piece (2.33m high, 10.37m long in gdml) Catode plane in one piece	Wire Planes very large (about 14m high, 45.6m long) Anode Plane Assemblies (APAs) and Catode Plane Assemblies (CPAs)
One ~2.5m drift volume, one set of wires	Two 3.74m drift volumeson either side of assembled wire planes - Wrapped Wires
One Cryostat	Two Cyostats
U wire angle=+60° V wire angle=-60° Vertical Plane (Z plane) sometimes documented as Y	U wire angle=+45.7° V wire angle=-44.3° Vertical Plane (Z plane) sometimes documented as X

Differences between LBNE and MicroBooNE

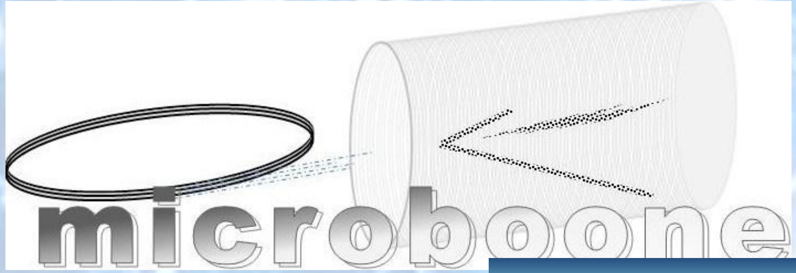


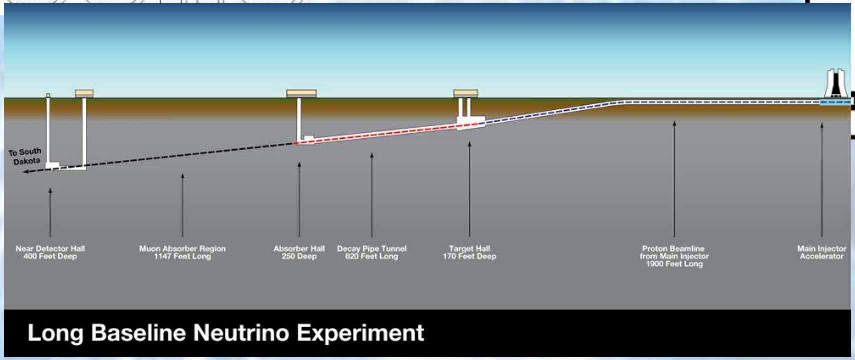
Ambiguity Problem



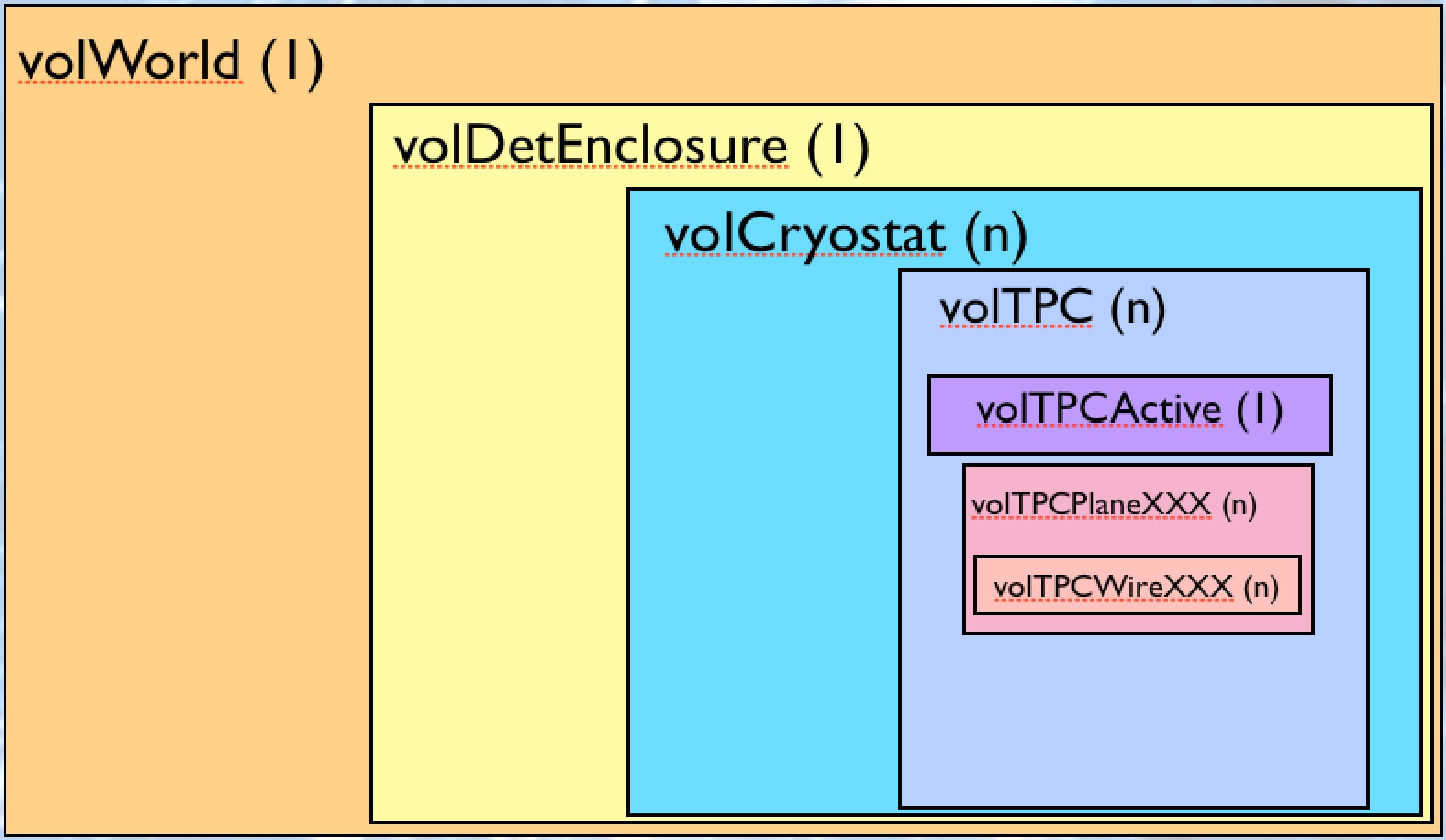
LArSoft

- The LArSoft software is designed to work for all planned and running liquid argon experiments at Fermilab. It is written in C++ and built on the ROOT data analysis software.





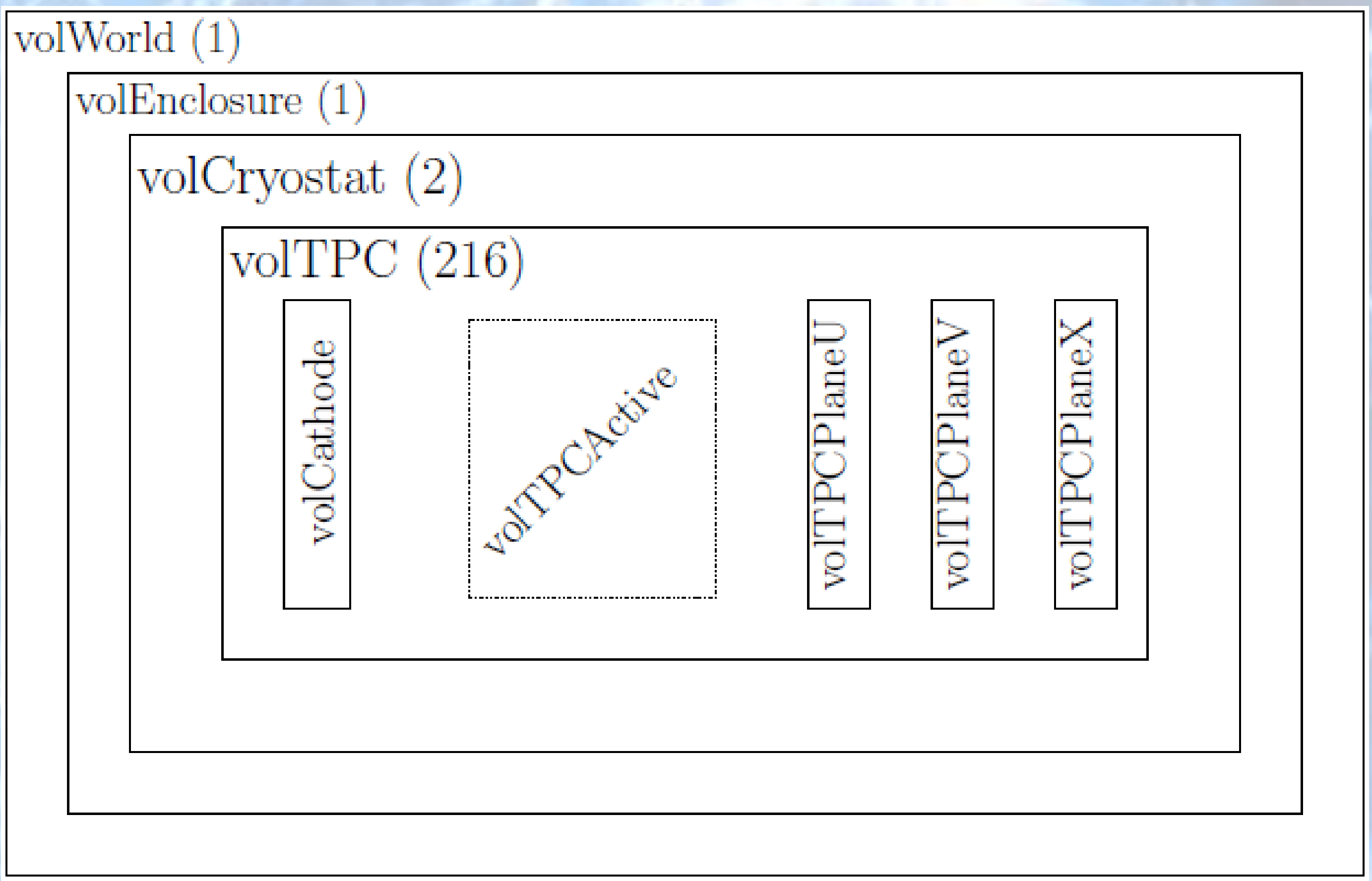
Hierarchy



volWorld (1)
volDetEnclosure (1)
volCryostat (n)
volTPC (n)
volTPCActive (1)
volTPCPlaneXXX (n)
volTPCWireXXX (n)

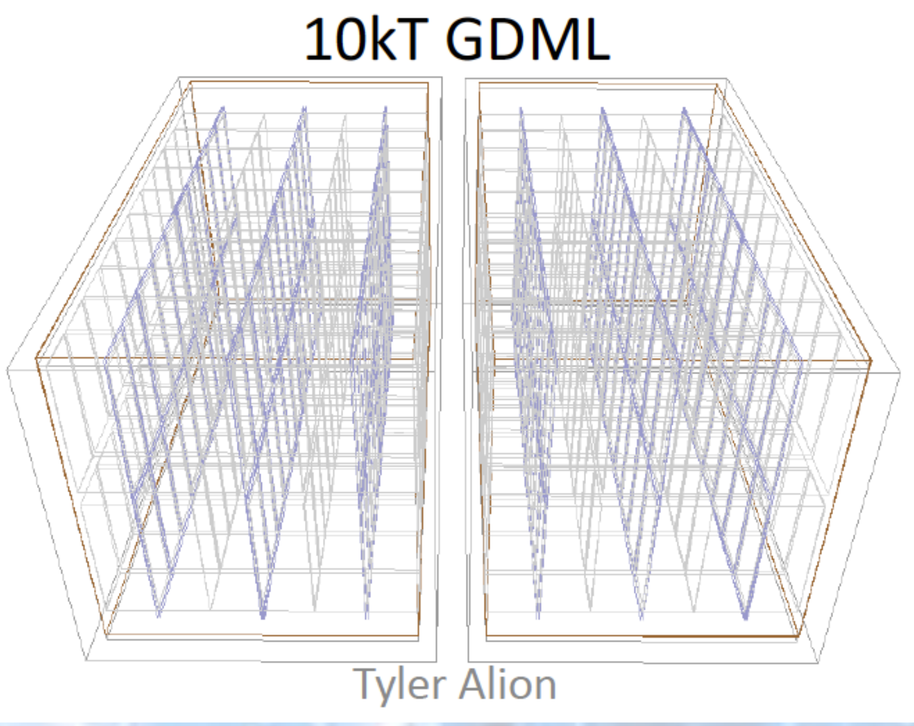
The New LBNE GDML

Object Hierarchy



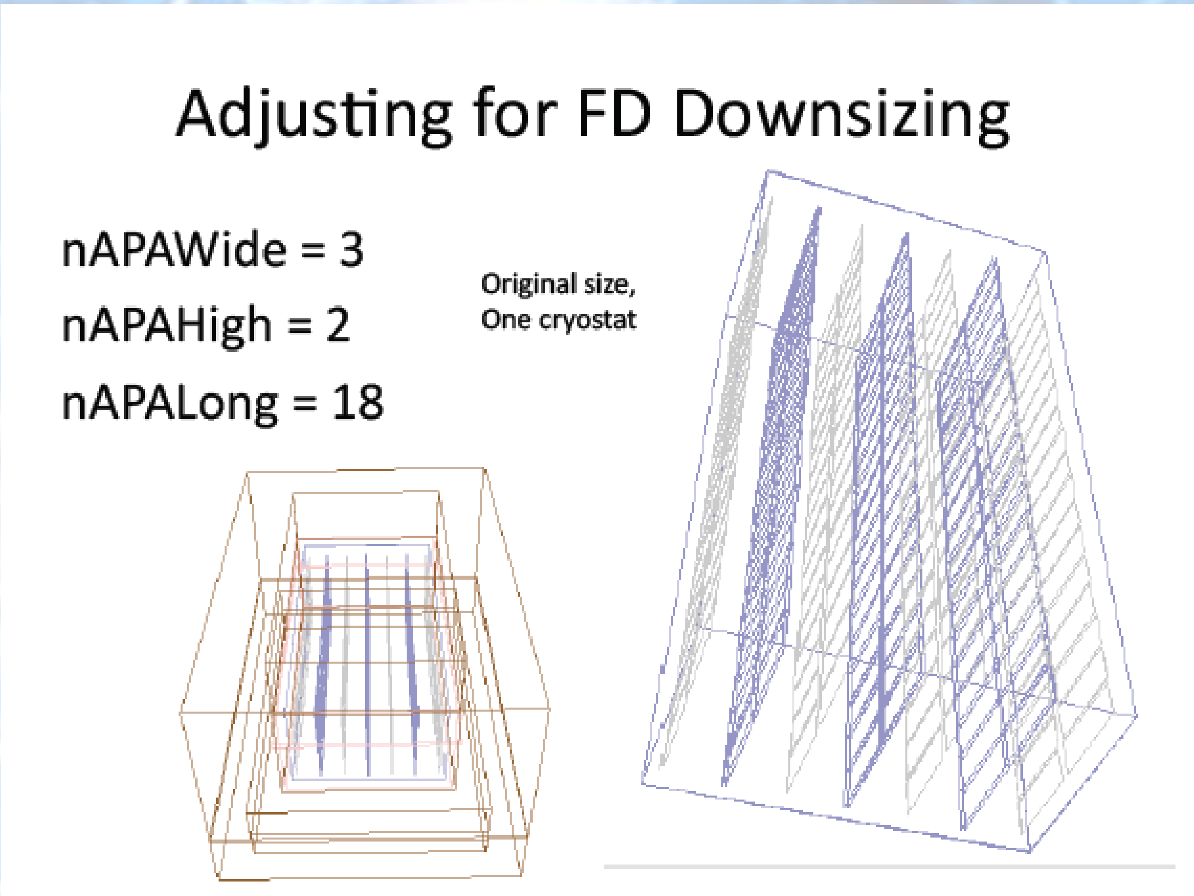
How to quickly build a detector

- The APA designs appears to be stable (2.5m x 7m)
- Want to quickly build up gdml files for different cryostat configurations
- South Carolina group has written perl scripts along with xml files for LBNE within LArSoft



Design Parameters

- nCryostats
- nAPAs and geometry
- CPAs
- Drift distance
- Almost all geometry



Design Parameters

- nCryostats
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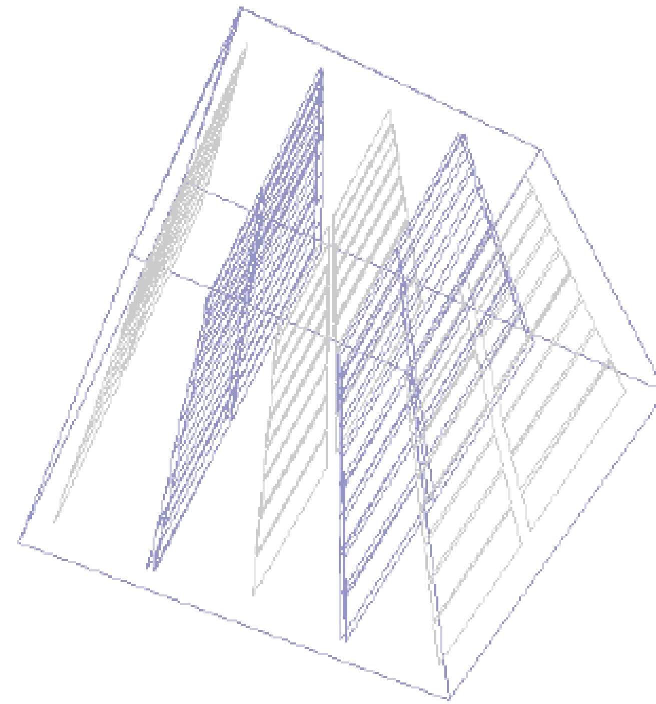
Adjusting for FD Downsizing

nAPAWide = 2

nAPAHigh = 2

nAPALong = 9

These are just drawings of the volCryostat →



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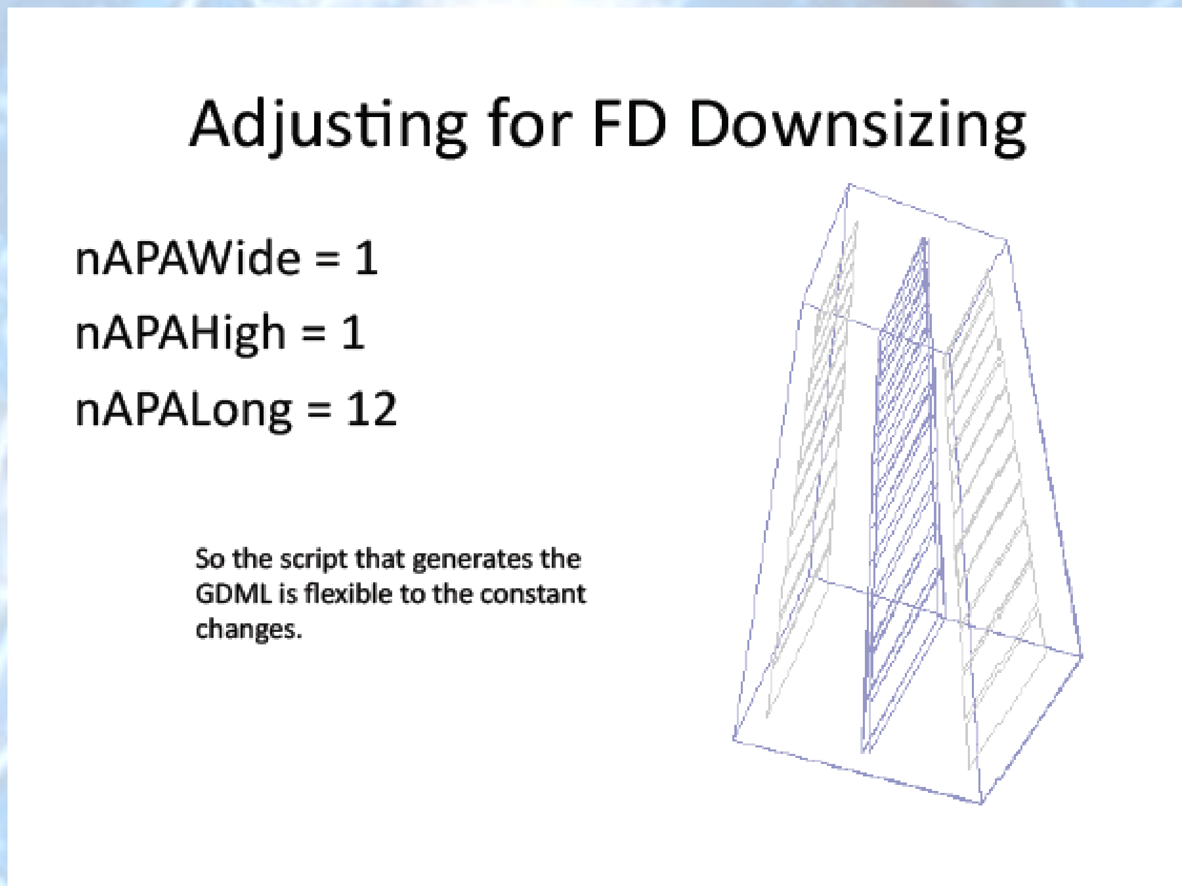


Objective

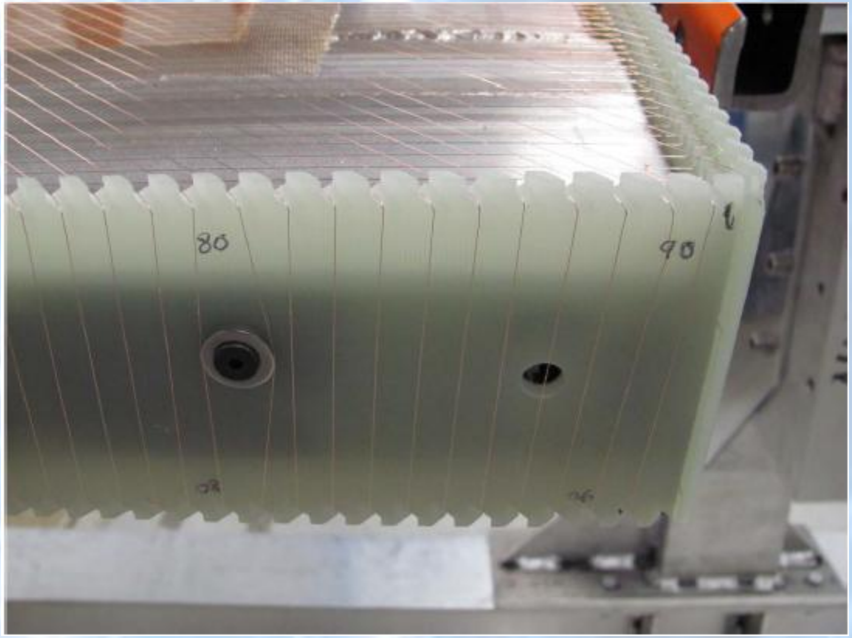
- To define a convention for the channel labeling for LArSoft focusing in the special characteristics of the Long Base-Line Neutrino Experiment (LBNE). Additionally, to write a module for LArSoft capable of interpret the labeling mentioned previously.

Motivation

- Parameters are based on non-detailed simulations.
- Simulations are based on a black box detector or in Microboone.
- The study of wrapped APA's will allow to have actual simulations.

Wrapped APAs

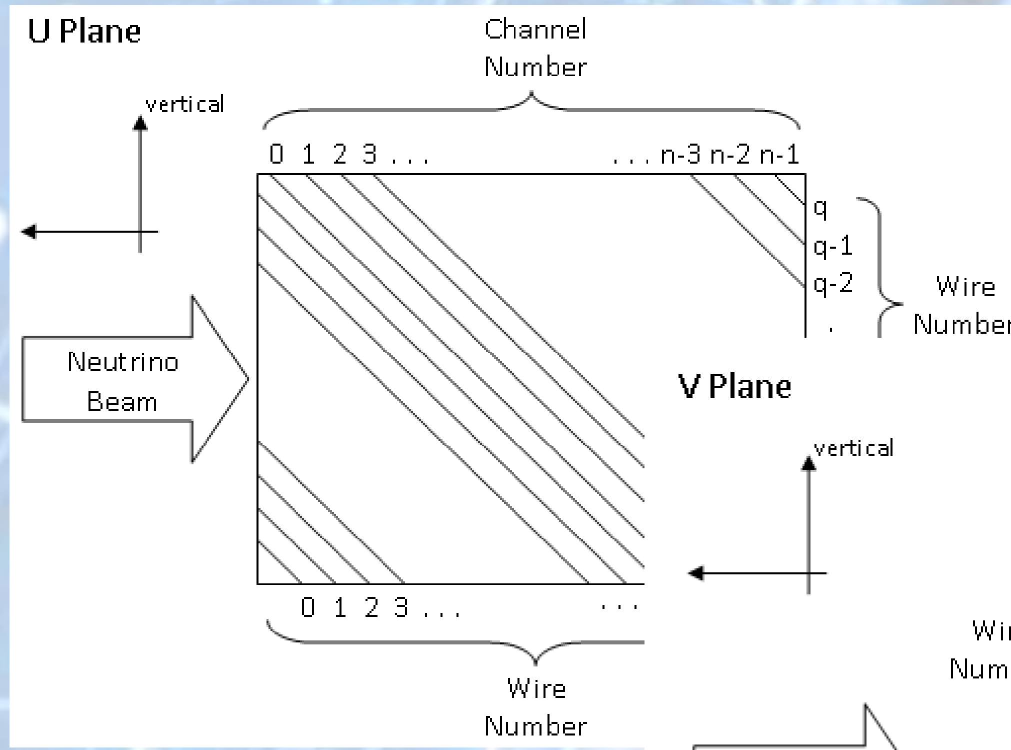
- Very nice way to save money in cold electronics.
- Leads to mapping up to 4 wire segments to one readout channel for 150+ channels.

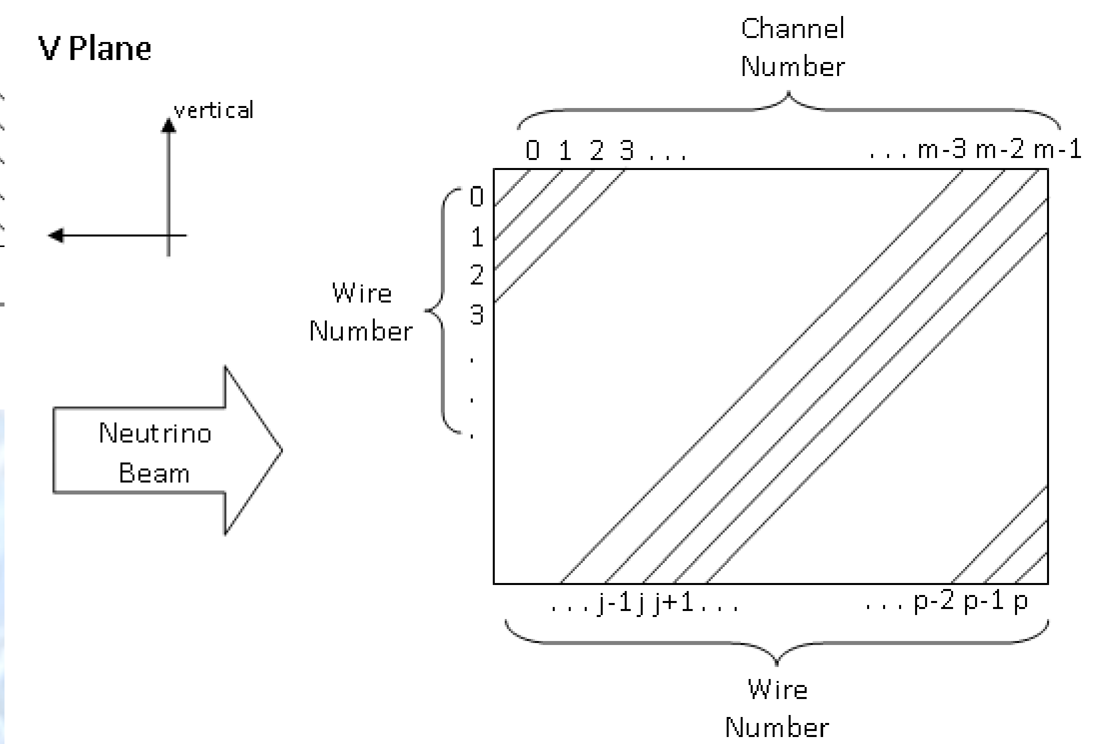


Definitions

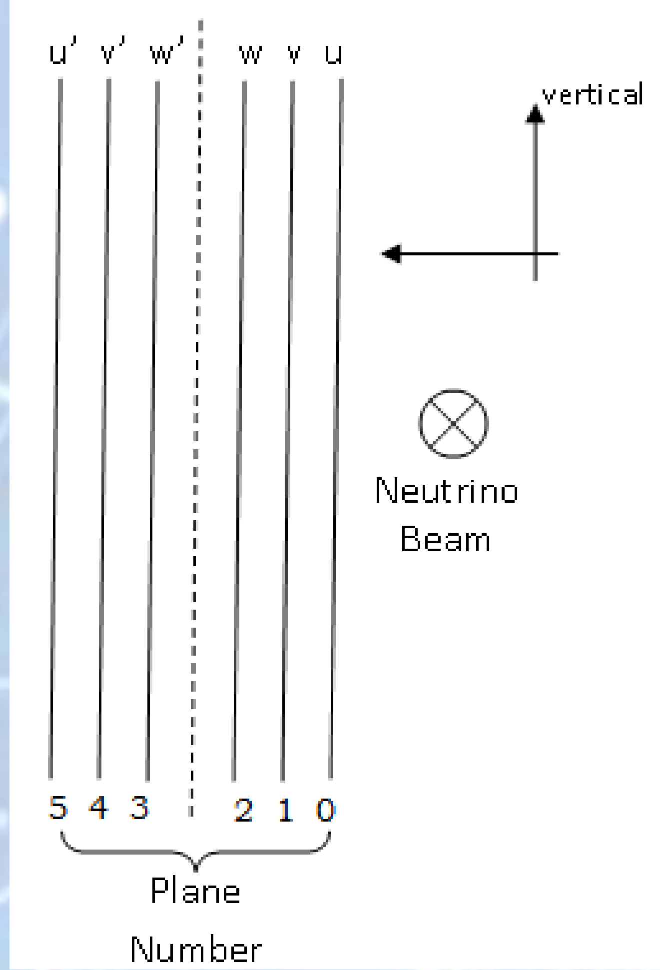
- Channel: Where the readout electronics are located. The signals registered in it are then transmitted to the Data Acquisition System.
- Wire: A physical wire where a charged particle will be registered and then the signal is read out at the channel associated to the wire.

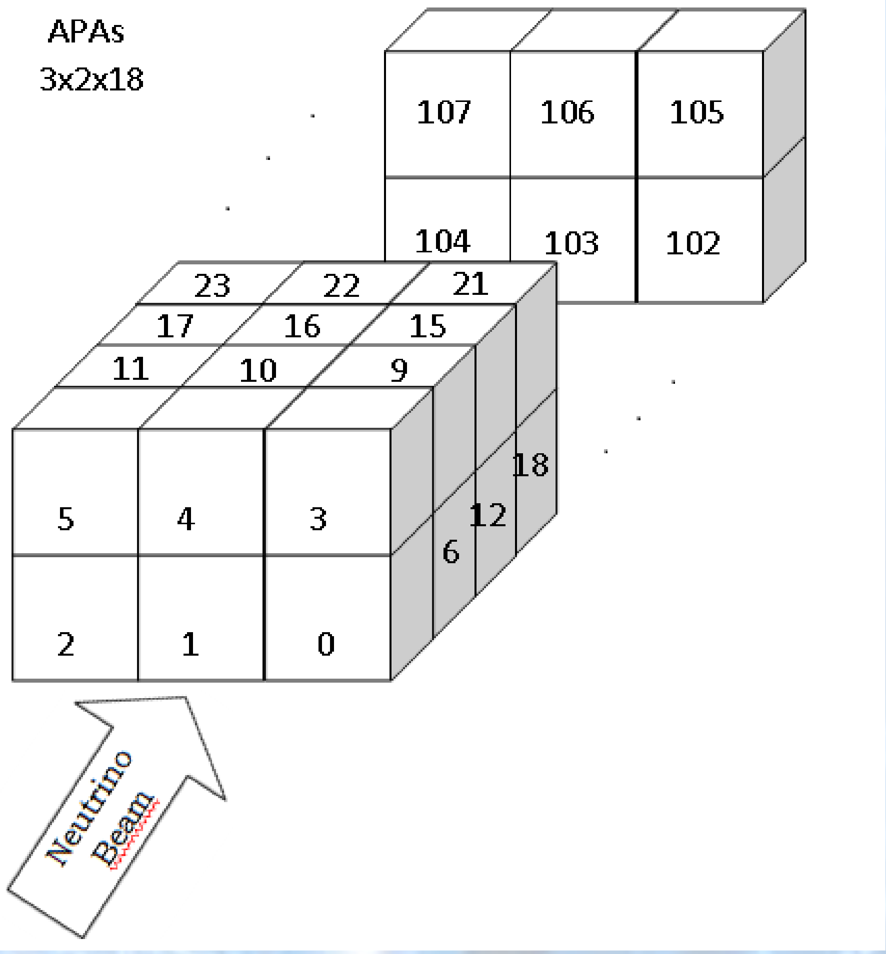
Counting Channels & Wires



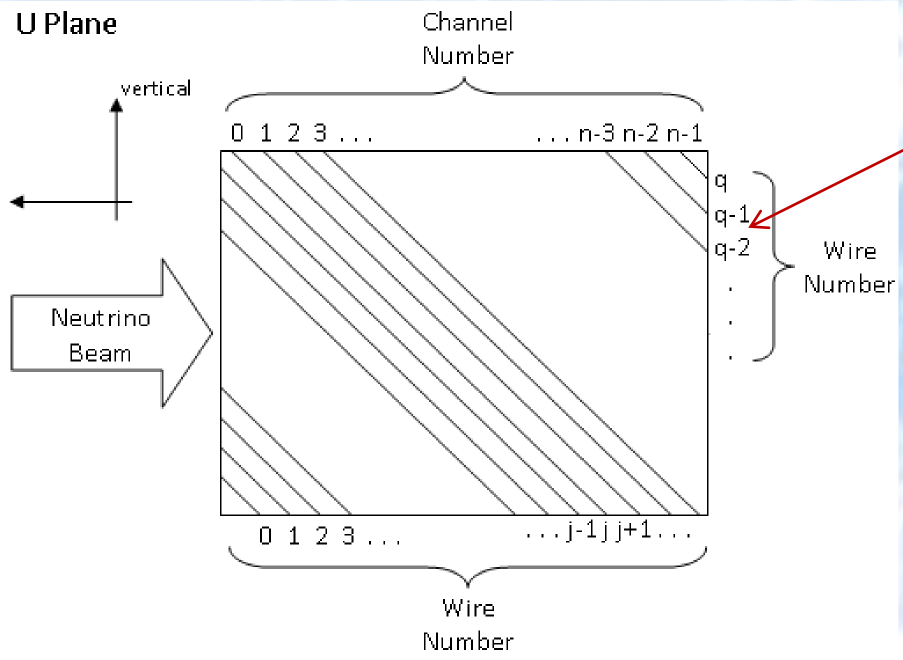


Counting Planes & APAs





For Example



- We want to label the wire q-1.
- Look for the APA the wire is, the plane where it is contained and finally, the channel associated to that wire.

Reality	HEX
#APA=12	0C
plane U	0
#wire=200 → #channel=200	0C8

We would label it as: 0C00C8

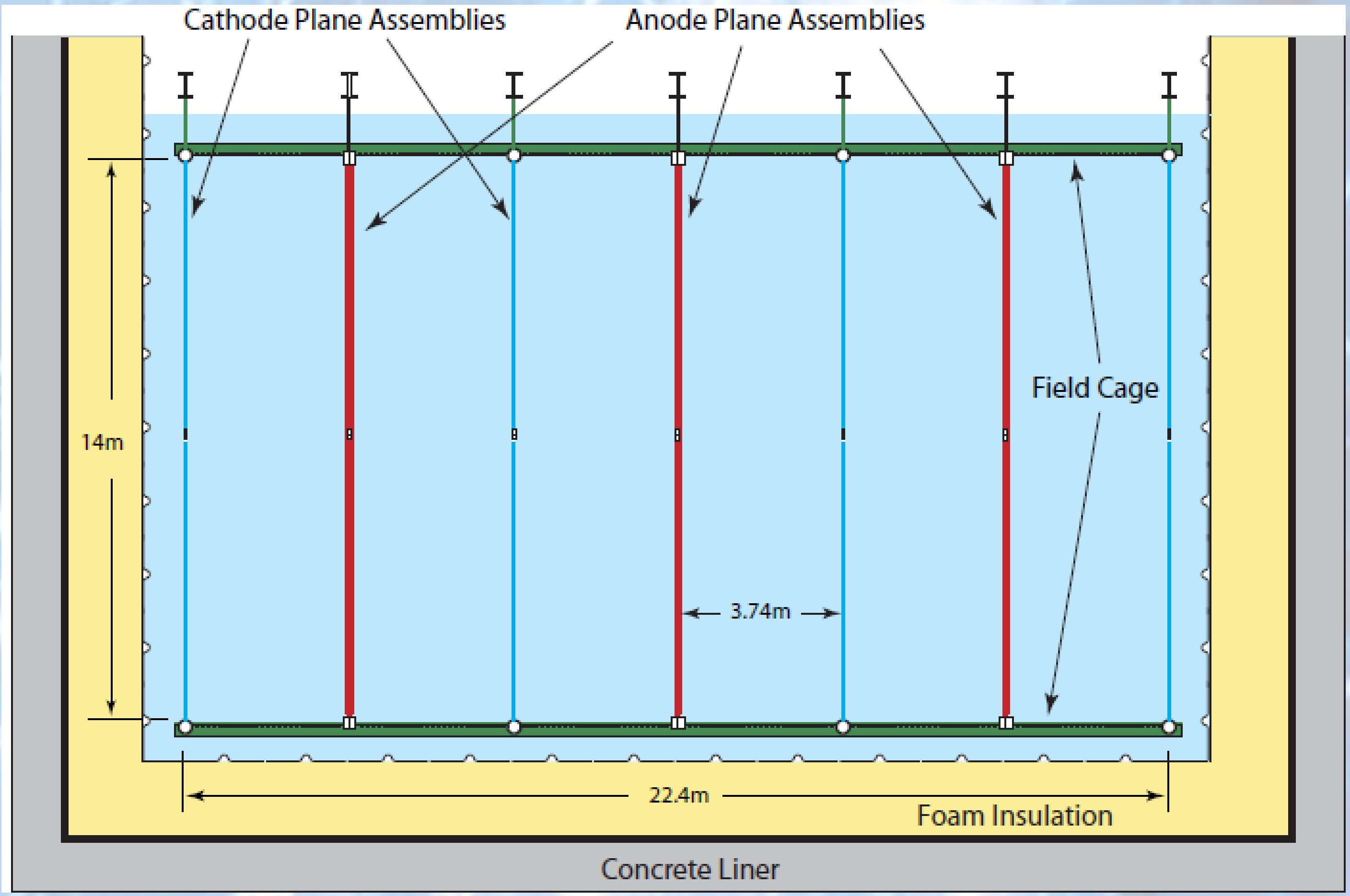
What is Next?

- Finish the channel mapping
  - Allow begin working on hit disambiguation studies
- Incorporate the new geometry into the event display within LArSoft
- Begin generation of single particle MC for proof of principle studies


KEEP
CALM
AND
ACT LIKE YOU KNOW
WHAT YOU'RE DOING

Backup Slides

Cross section of the TPC inside the cryostat



Mass-Induced Neutrino Flavor Oscillations

Neutrino Flavor change can arise out of several different mechanisms. The simplest one is to appreciate that, once neutrinos have mass, leptons can mix. If neutrinos have mass, there are two different ways to define

the different neutrino states.

(1) Neutrinos with a well defined mass:

$\nu_1 , \nu_2 , \nu_3 , \ldots$ with masses $m_1 , m_2 , m_3 , \ldots$

(2) Neutrinos with a well defined flavor:

$$\nu_e , \nu_\mu , \nu_\tau$$

These are related by a unitary transformation:

$$\nu_\alpha = U_{\alpha i} \nu_i \quad \alpha = e, \mu, \tau, \; i = 1, 2, 3$$

U is a unitary mixing matrix.

The Propagation of Massive Neutrinos

Neutrino mass eigenstates are eigenstates of the free-particle Hamiltonian:

$$|\nu_i\rangle = e^{-i(E_i t - \vec{p_i}\cdot\vec{x})}|\nu_i\rangle, \qquad E_i^2 - |\vec{p}_i|^2 = m_i^2$$

The neutrino flavor eigenstates are linear combinations of ν_i's, say:

$$\begin{aligned} |\nu_e\rangle &= \cos\theta|\nu_1\rangle + \sin\theta|\nu_2\rangle. \\ |\nu_\mu\rangle &= -\sin\theta|\nu_1\rangle + \cos\theta|\nu_2\rangle. \end{aligned}$$

If this is the case, a state produced as a ν_e evolves in vacuum into

$$|\nu(t,\vec{x})\rangle = \cos\theta e^{-ip_1x}|\nu_1\rangle + \sin\theta e^{-ip_2x}|\nu_2\rangle.$$

It is trivial to compute $P_{e\mu}(L) \equiv |\langle\nu_\mu|\nu(t,z=L)\rangle|^2$. It is just like a two-level system from basic undergraduate quantum mechanics! In the ultrarelativistic limit (always a good bet), $t \simeq L$, $E_i - p_{z,i} \simeq (m_i^2)/2E_i$, and

$$\boxed{P_{e\mu}(L) = \sin^2 2\theta \sin^2\left(\frac{\Delta m^2 L}{4E_\nu}\right)}$$