

LBNE Beam Flux Predictions

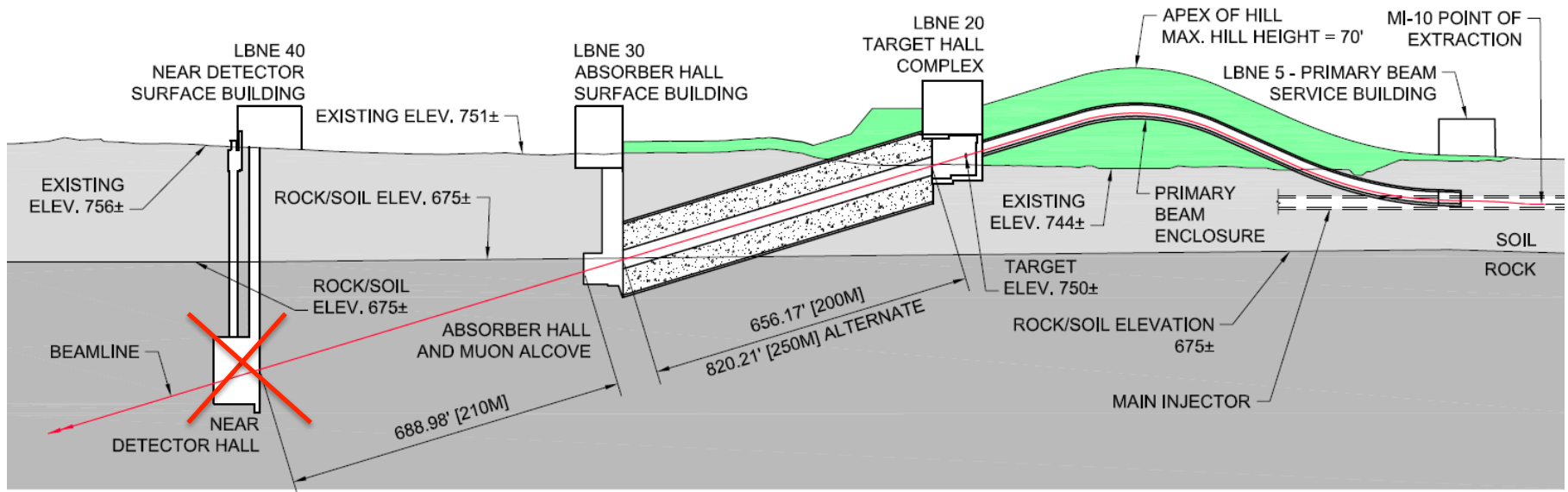
Kevin Yarritu, LANL

University of Pittsburgh, Dec. 8th 2012

Outline

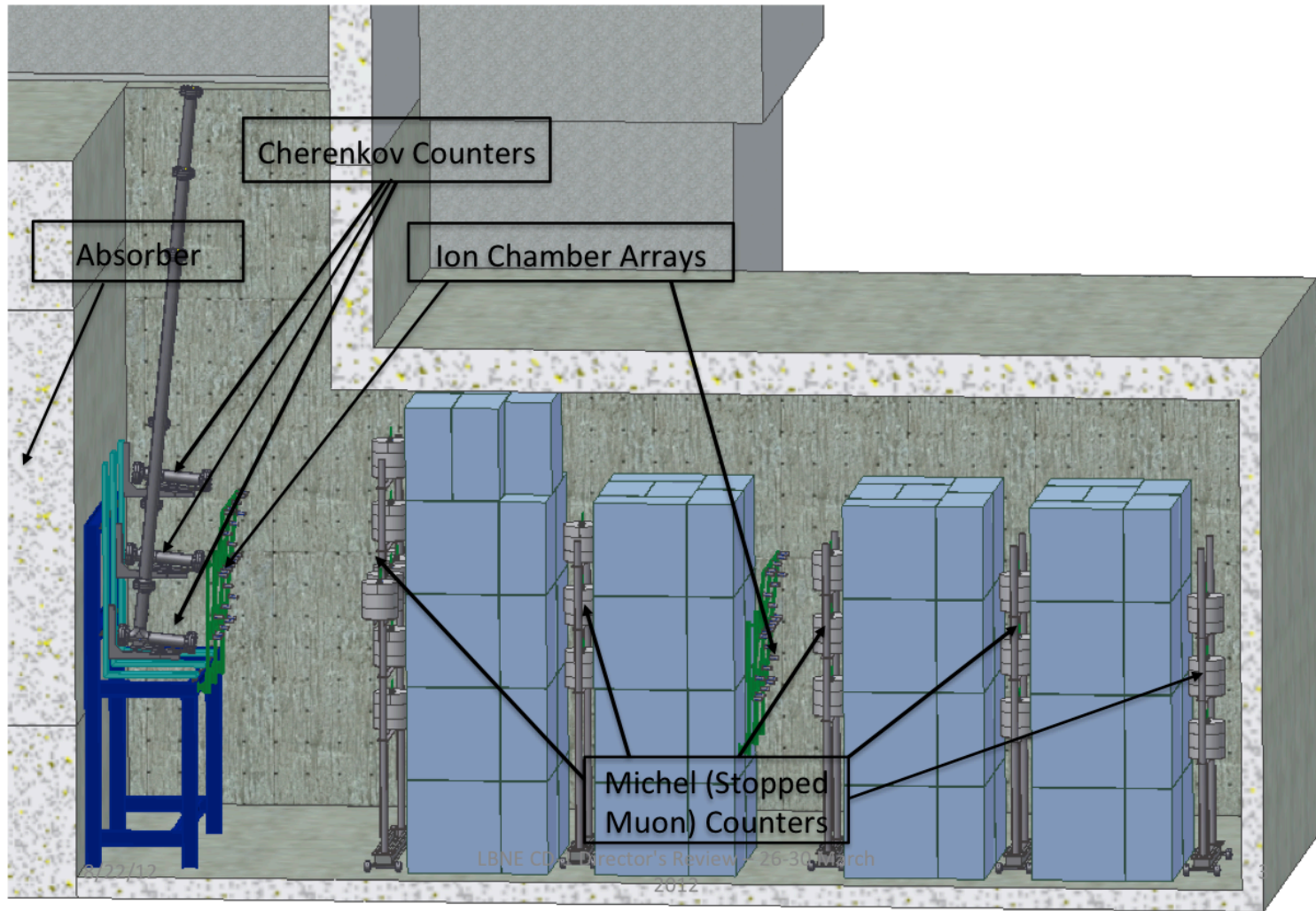
- overview of LBNE
- LBNE Geant4
- NA61 hadroproduction
- constraining the neutrino flux with muon monitors
- current muon monitor prototyping effort

insert pretty picture of LBNE here



- no near detector

more pretty pictures (muon monitors)



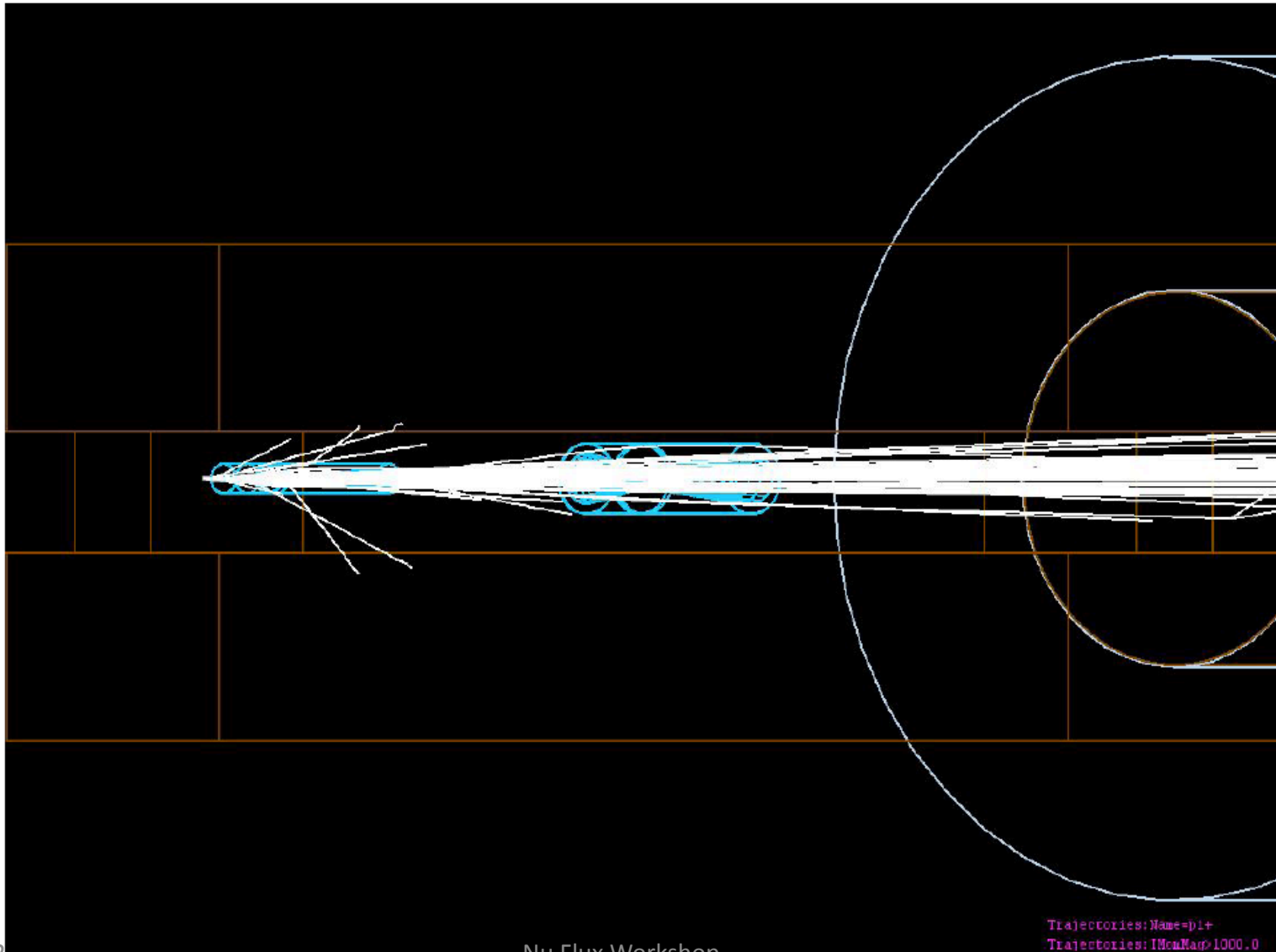
System Overview

- Michel (stopped muon) counters:
 - Determine the stopped muon rate at several absorber depths ($\sigma \sim 4-5\%$)
 - Separate μ^+ from μ^- decays ($\sigma \sim 4-5\%$)
- Ion chamber array:
 - Measure the muon profile and centroid after the absorber on a pulse-by-pulse basis ($\sigma \sim 5\text{cm}$)
- Muon Cherenkov counters:
 - Measure muon spectrum as a function of position across the rear of the absorber ($\sigma \sim 4-5\%$)

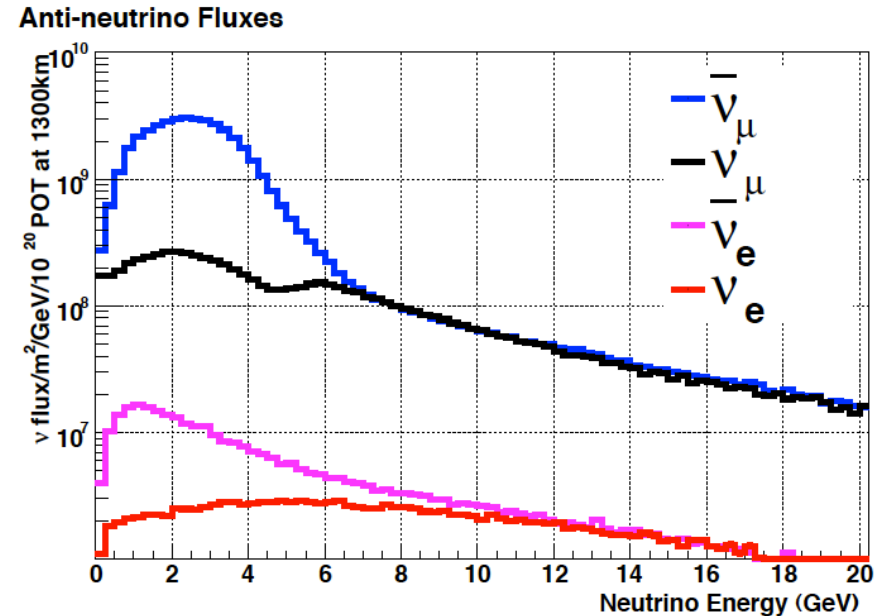
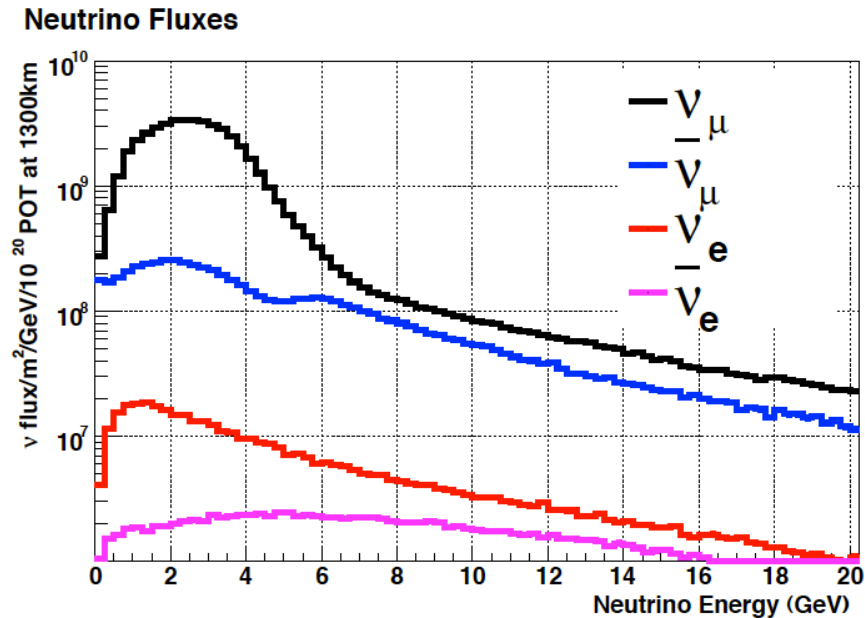
LBNE Geant4 simulation (G4LBNE)

- obtained from G4Numi
- modified so that it can have a flexible geometry
- uses Geant4 for production and transport
- has the ability to take Fluka as input for production

LBNE Beam Simulation

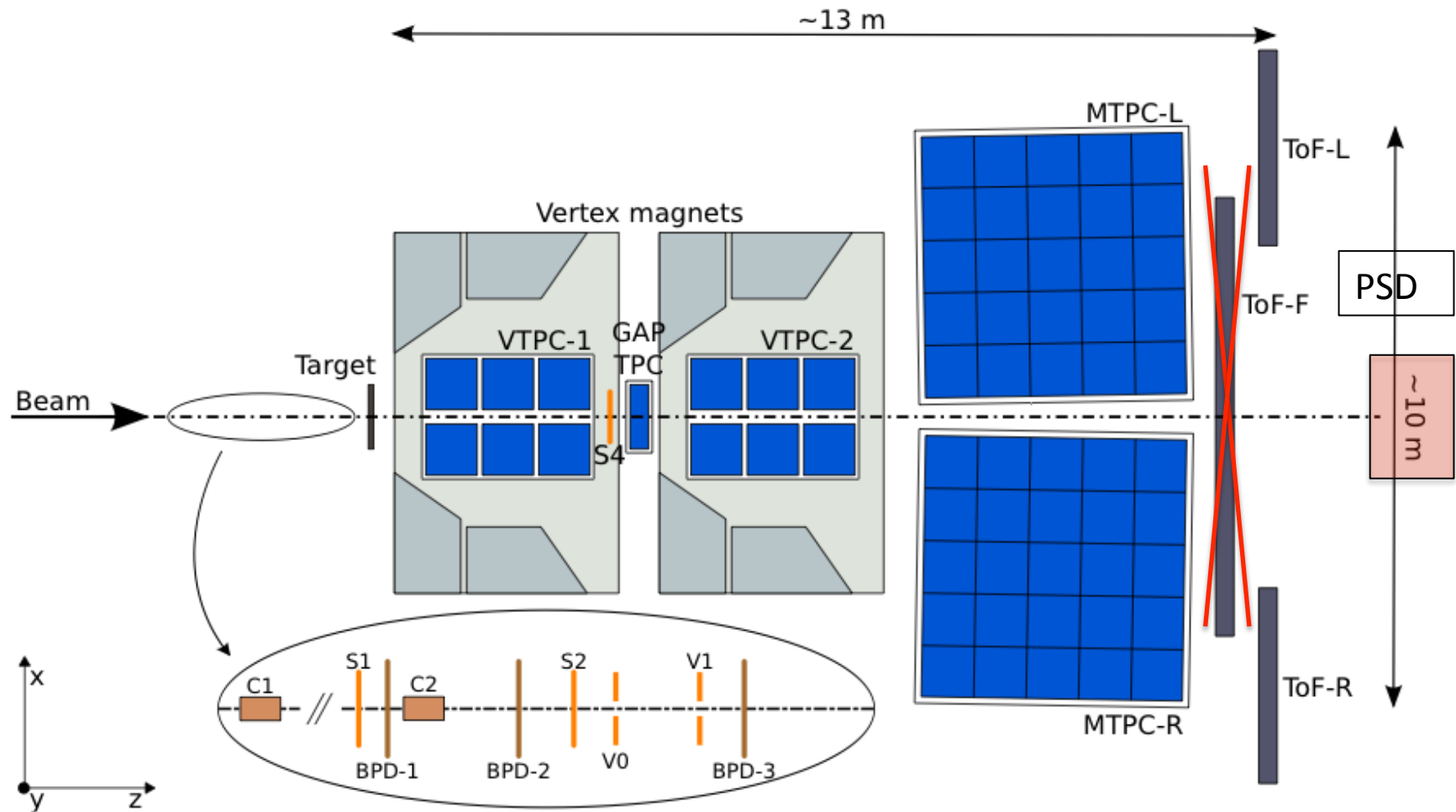


Neutrino fluxes at far detector



- current G4LBNE predictions
- these fluxes are being used as an input various toy Monte Carlo studies

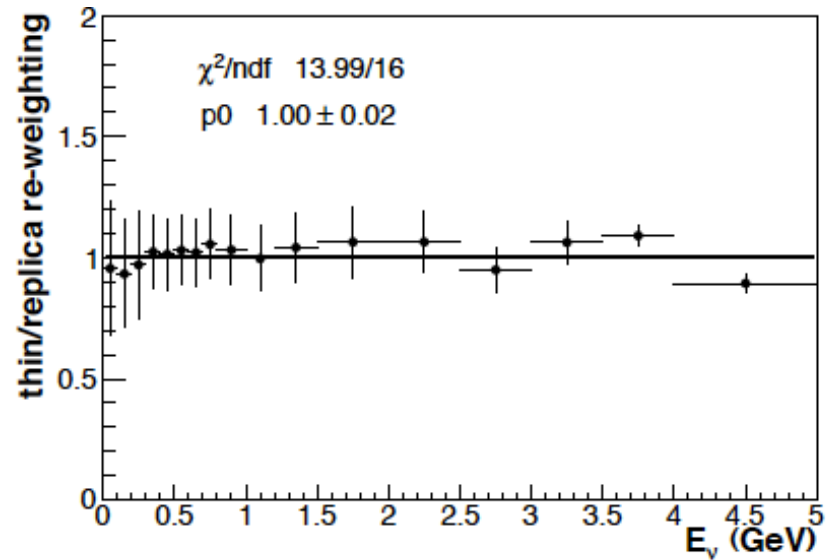
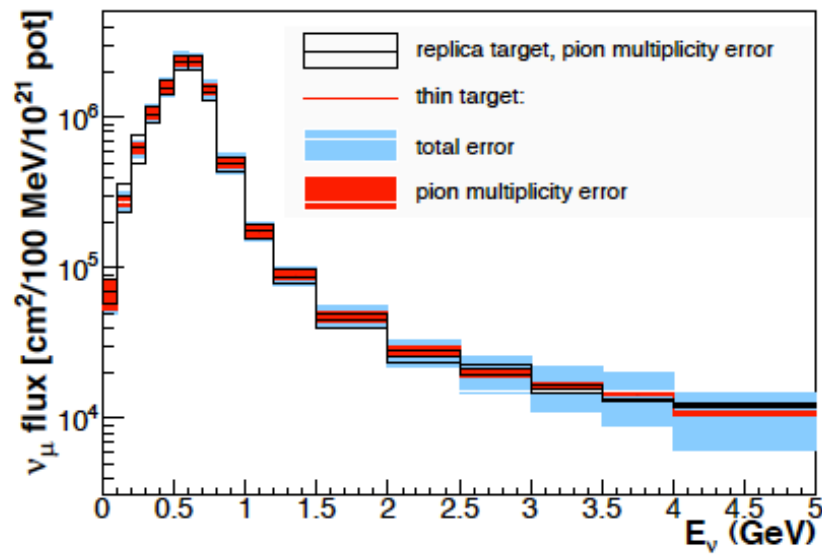
Overview of NA61 experiment



NA61 collaboration

- see talk by Raphael Schroeter on Thursday
- produced thin target p+C data at 31 GeV
- very recently produced replica target data at 31 GeV
- reweighted the flux predictions of T2K at the far detector

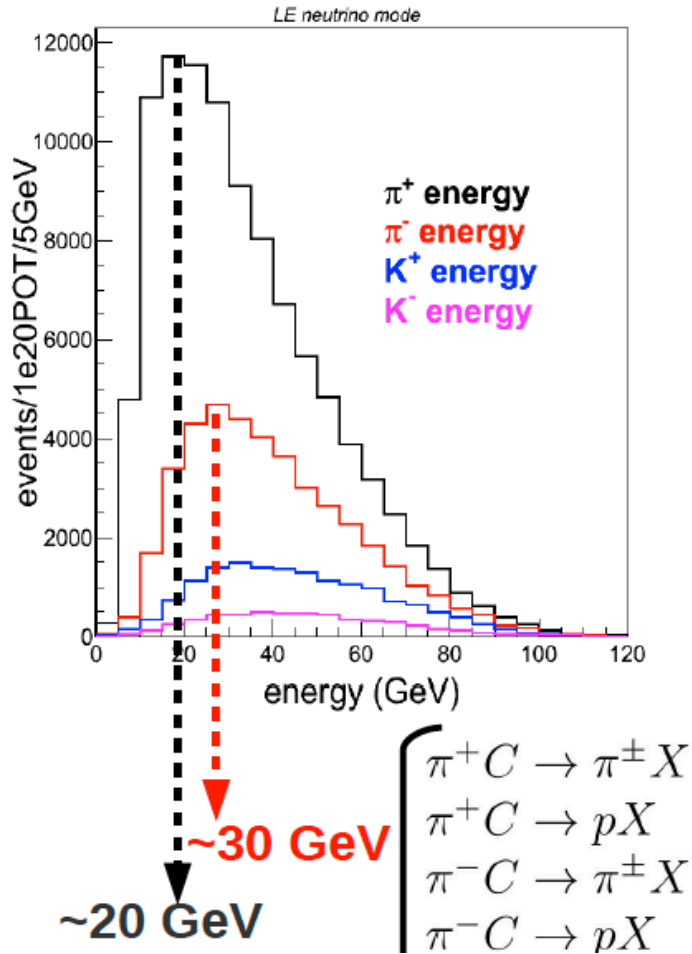
NA61 Collaboration



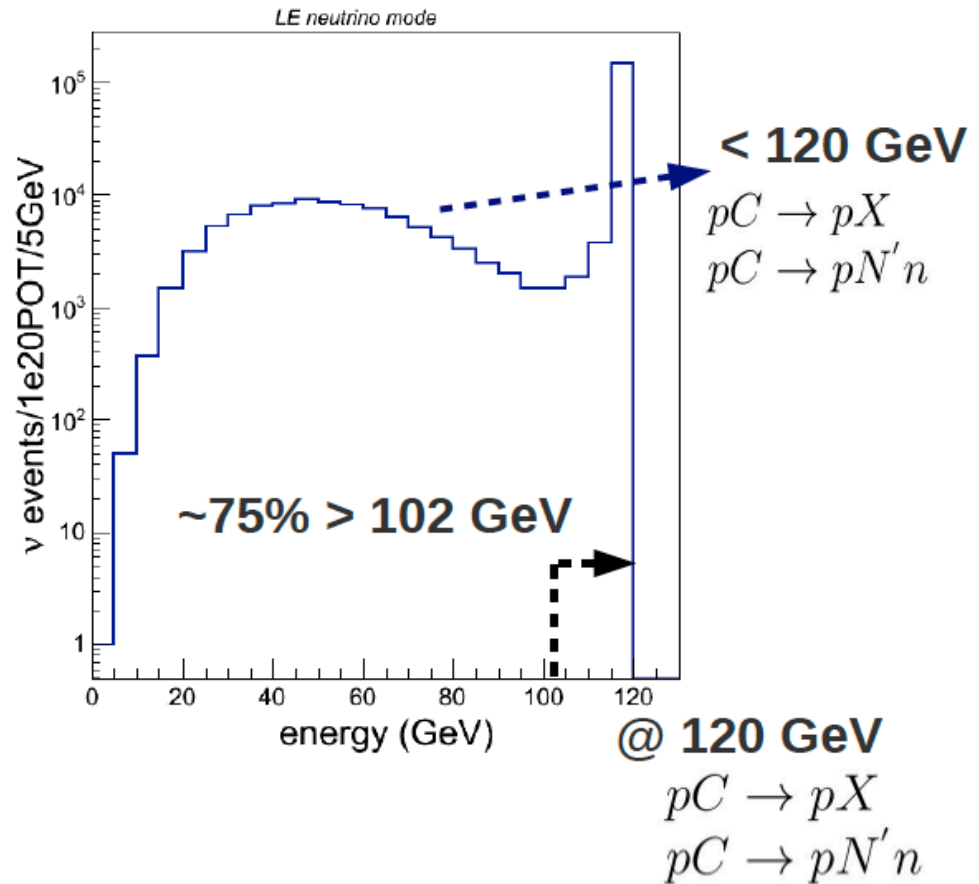
- comparison of thin and thick target data
- polynomial fit to ratio to two predictions

Secondary Interactions

Energy Spectrum of Charged Pions and Kaons That Are Neutrino Ancestors



Energy Spectrum of Protons That Are Neutrino Ancestors



Plan for USNA61

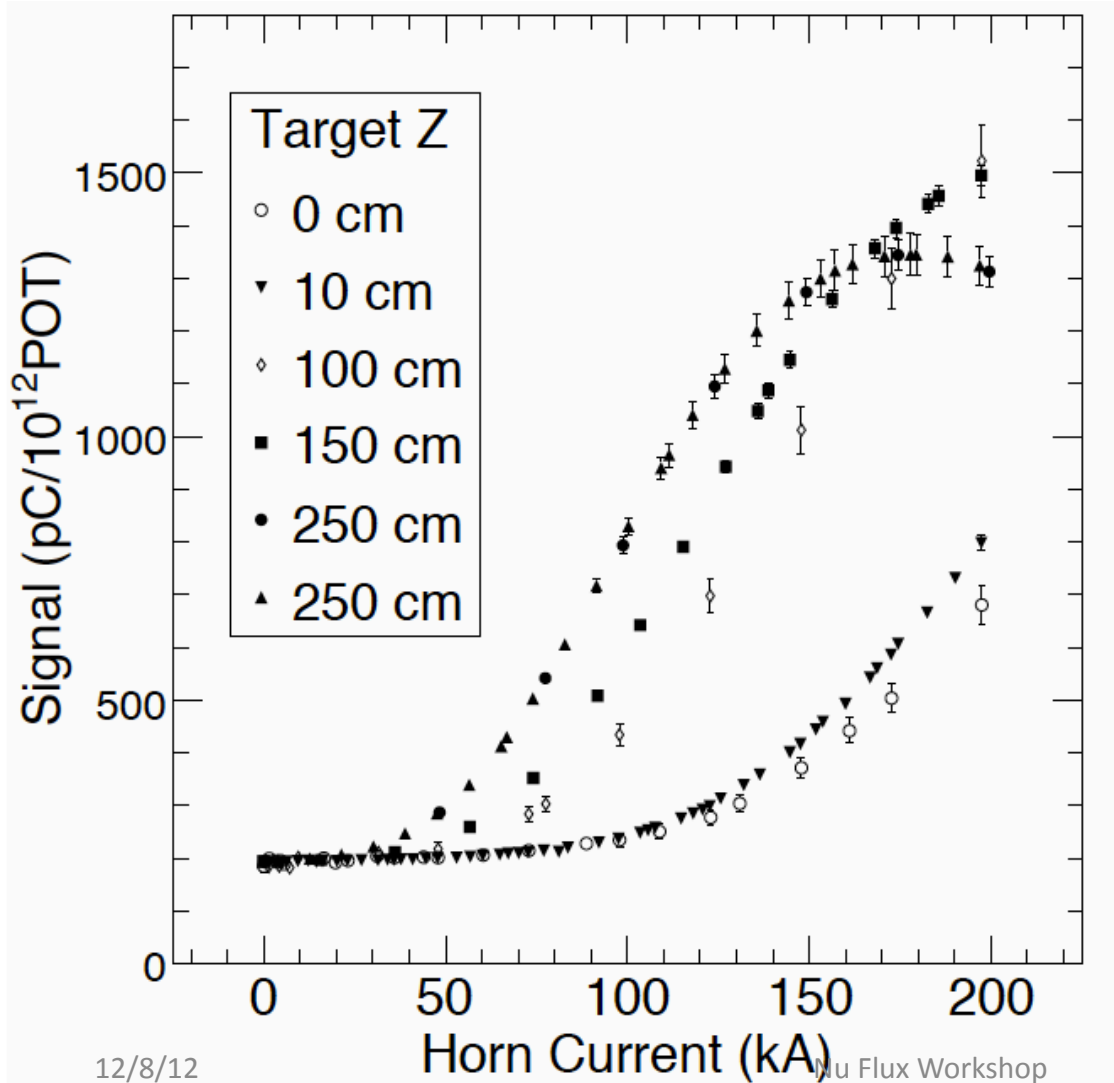
- data taken in June and July of this year with thin (4% interaction length) target
- problems with magnetic field
- letter of intent submitted in May that details a 4-5 year program to use NA61 as a hadroproduction measurement factory
- would begin in 2014

In situ measurements

how would LBNE use the muon monitors to constrain its own flux?

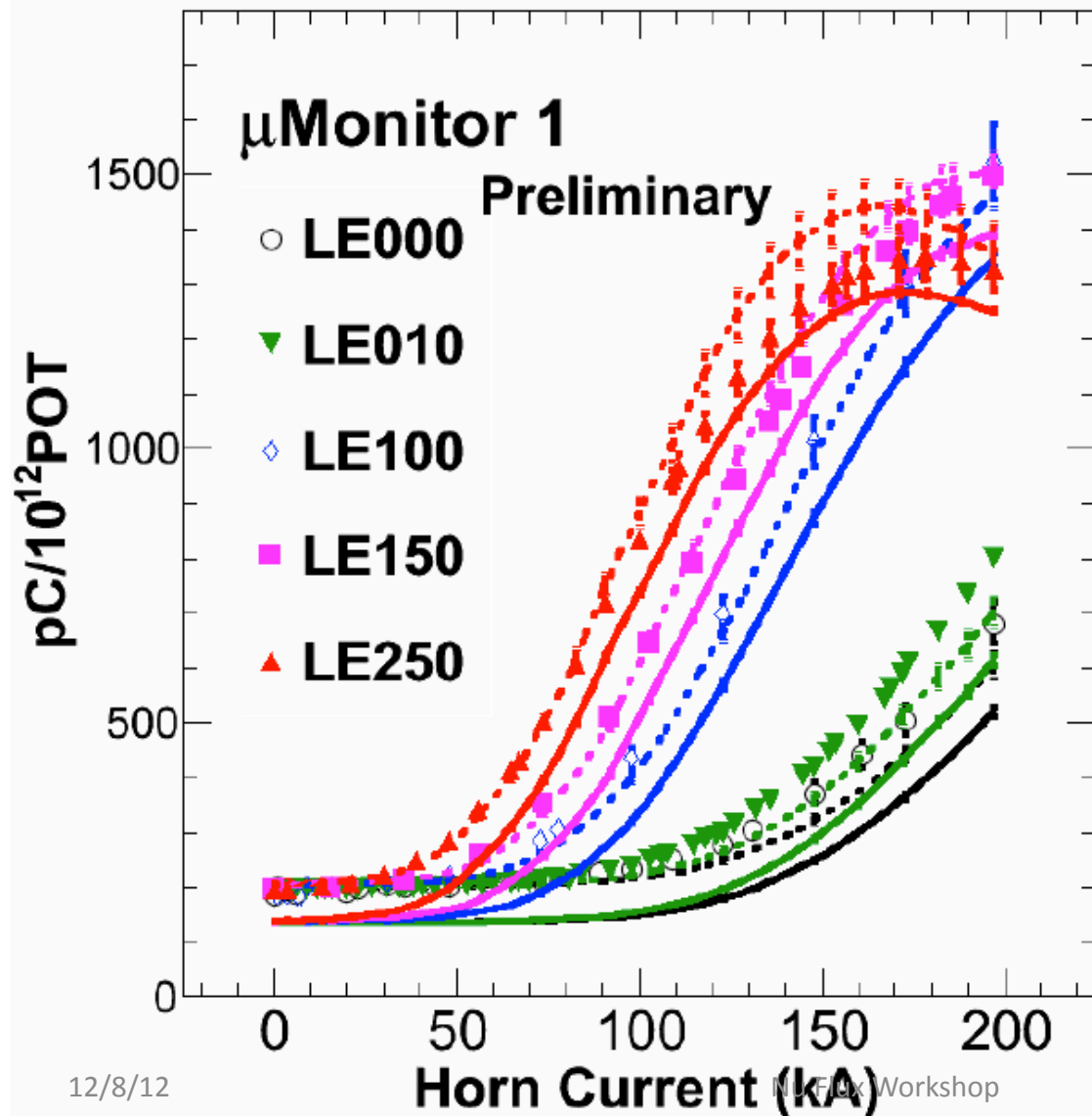
- Numi method
 - use 3 arrays of muon monitors
- scan in horn current (transverse momentum) and target position (longitudinal momentum)
- fit to horn current scan data by varying underlying (p_T, p_z) of parent mesons
- constrain π^+/π^- and K^+/π^- ratios to hadroproduction data

Numi horn current scan



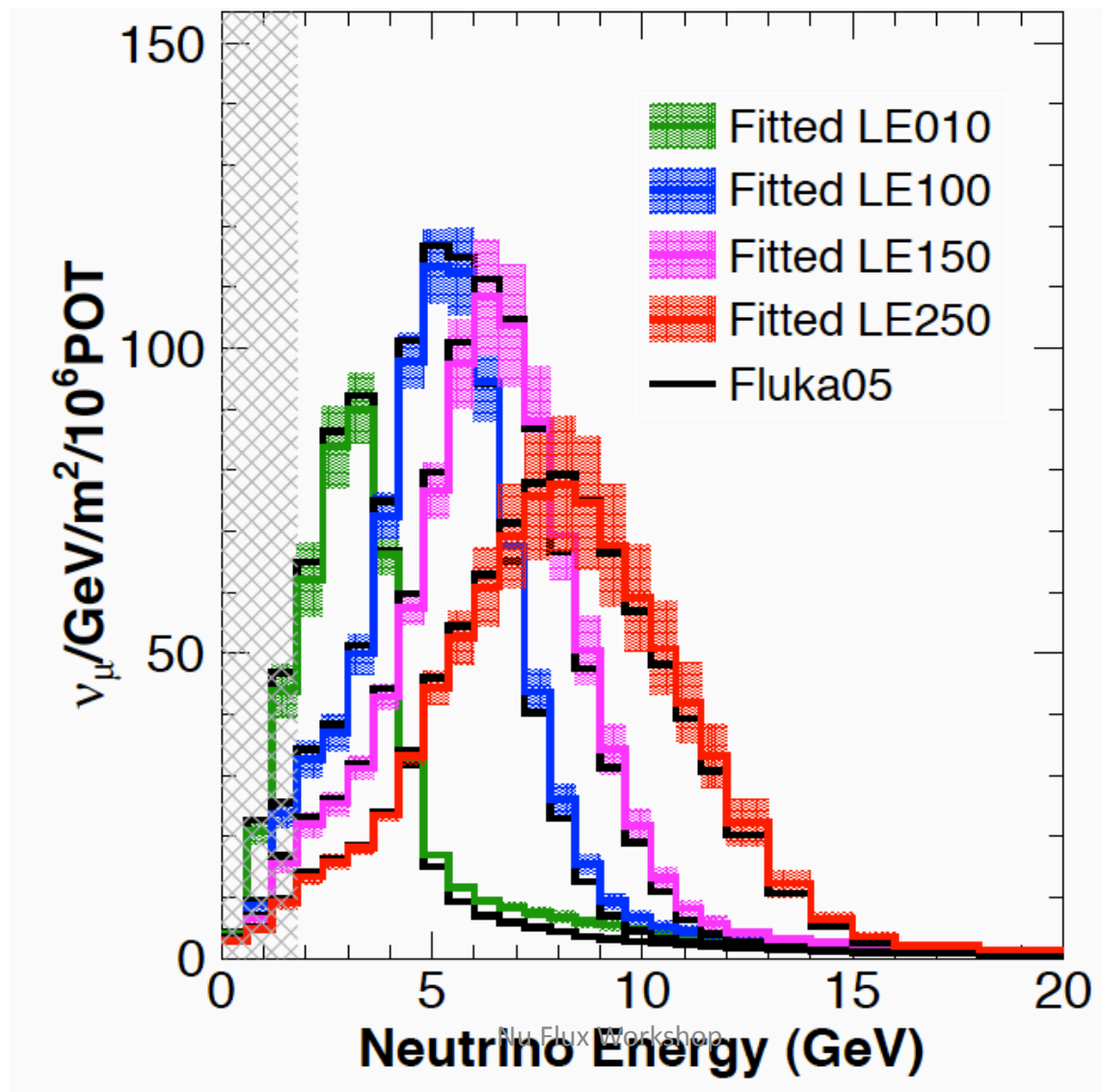
- corrected for ambient temperature, pressure, gas quality...

Tuned Monte Carlo after fit



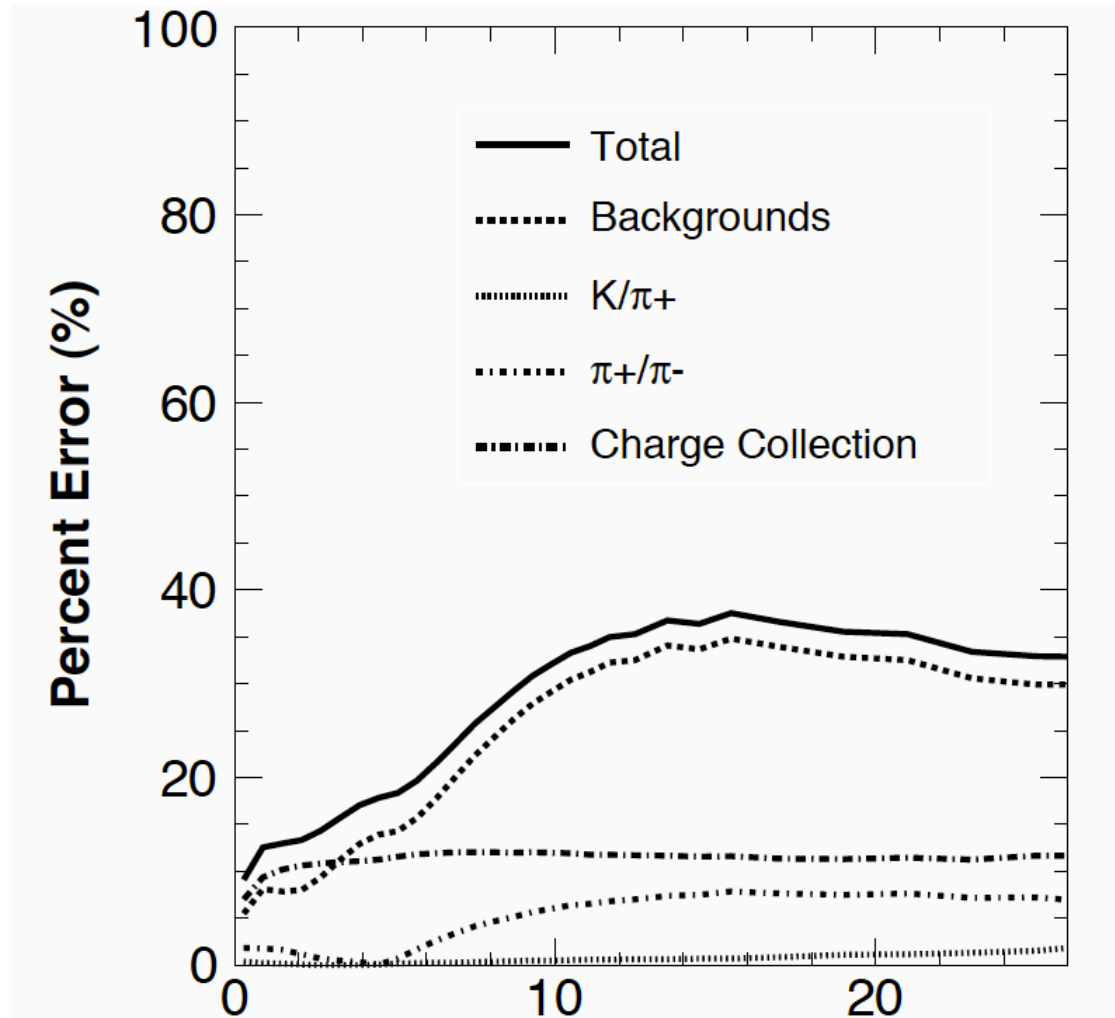
- dots = data
- dashed line = tuned MC
- solid line = untuned MC

Neutrino Energy spectrum



Systematic error contribution

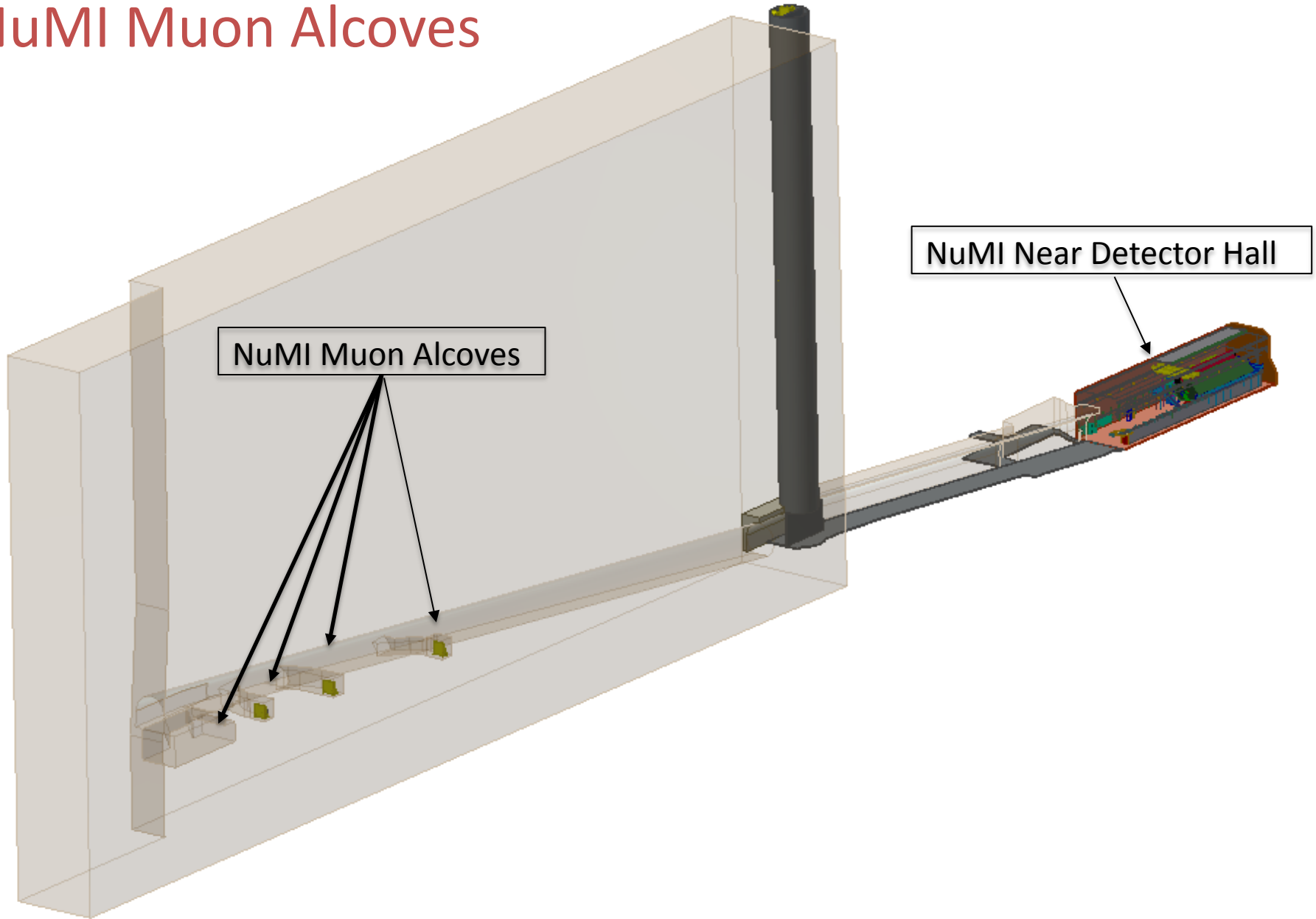
- delta ray contribution in muon monitors dominates the systematic error
- ionization scale of muon monitors is second

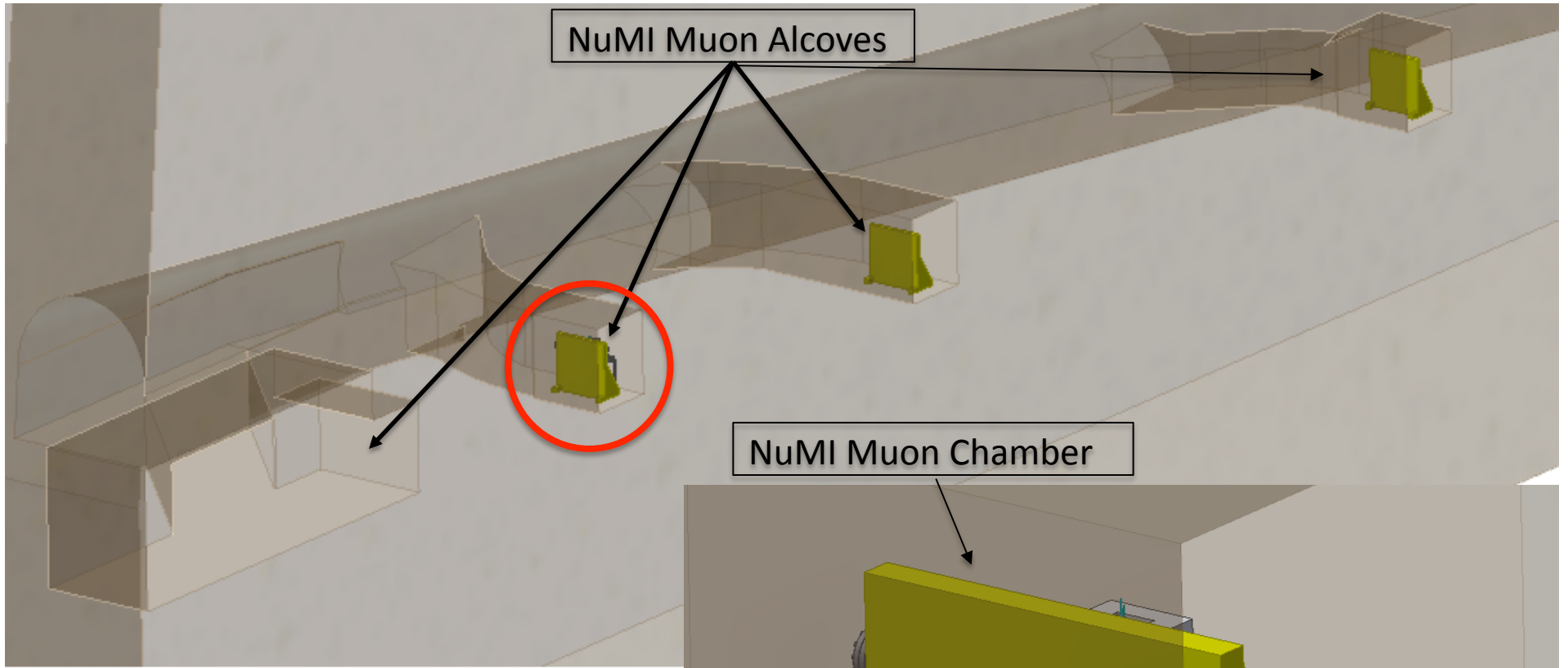


how well did numi do?

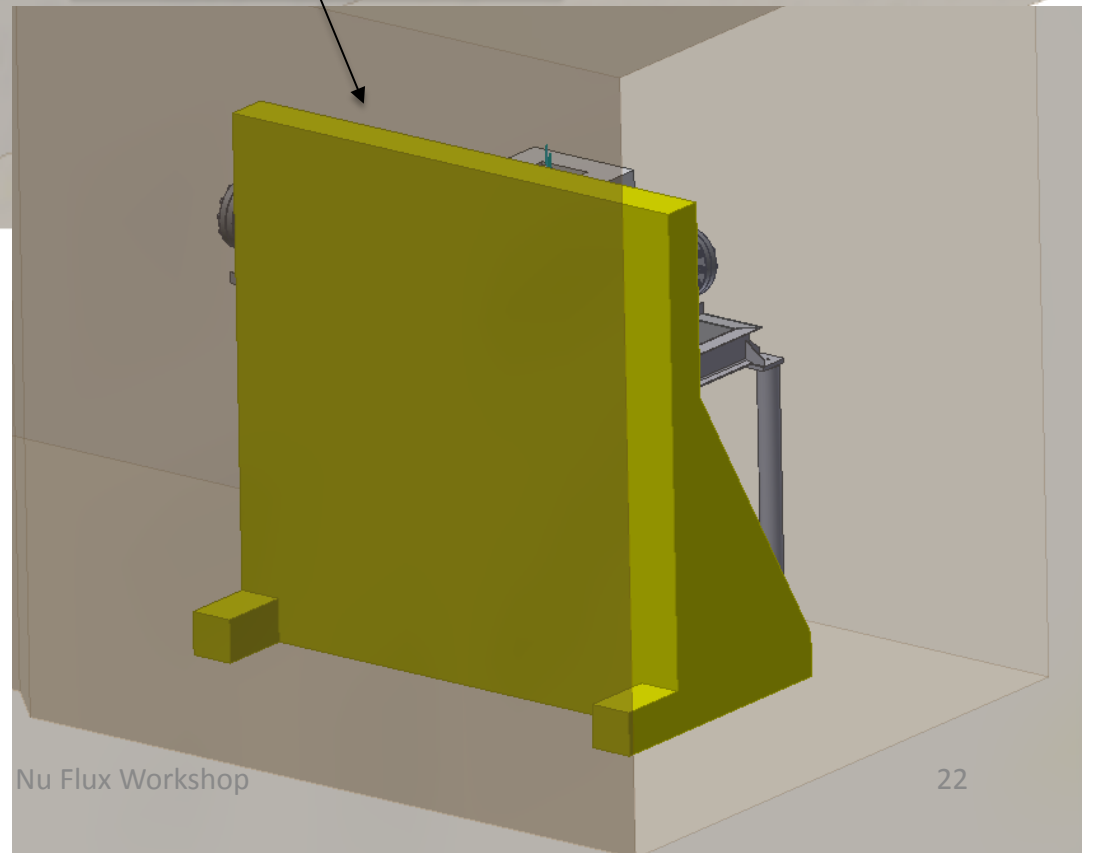
E bin (GeV)	ν_μ Flux Neutrinos/GeV/m ² /10 ⁶ POT	Error	Percentage Error (%)
0.0-0.6	3.92	0.52	13.3
0.6-1.2	20.9	2.2	10.4
1.2-1.8	43.8	4.4	10.1
1.8-2.4	62.1	5.9	9.6
2.4-3.0	83.8	6.8	8.2
3.0-3.6	90.1	5.8	6.4
3.6-4.2	66.1	3.2	4.8
4.2-4.8	32.8	1.1	3.3
4.8-5.4	16.9	0.5	2.8
5.4-6.0	11.5	0.4	3.5
6.0-6.6	9.48	0.50	5.2
6.6-7.2	8.41	0.63	7.6
7.2-7.8	7.54	0.76	10.0
7.8-8.4	6.82	0.83	12.2
8.4-9.0	5.92	0.85	14.3
9.0-9.6	5.45	0.89	16.3
9.6-10.2	4.88	0.87	17.8

NuMI Muon Alcoves





Current idea to use second alcove



Current Plan

- Develop services for prototype detectors prior to beam start up in March
 - Power, signal/HV cables, stand, gas lines, racks, ACNET(?), etc.
- Will work to produce prototype modules for February installation, but...
 - Tight schedule: might not be ready for installation until summer (2013)
 - Would require short (1 day?) shutdown for alcove access if alcoves are prepped properly

Conclusions

- LBNE simulation still being developed
- Hadroproduction scenario looks promising for future neutrino experiments
- constraining the neutrino flux is still a challenge using only muon monitors
- muon monitor development is currently underway