Flux Inputs for T2HK Studies

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2 km Flux

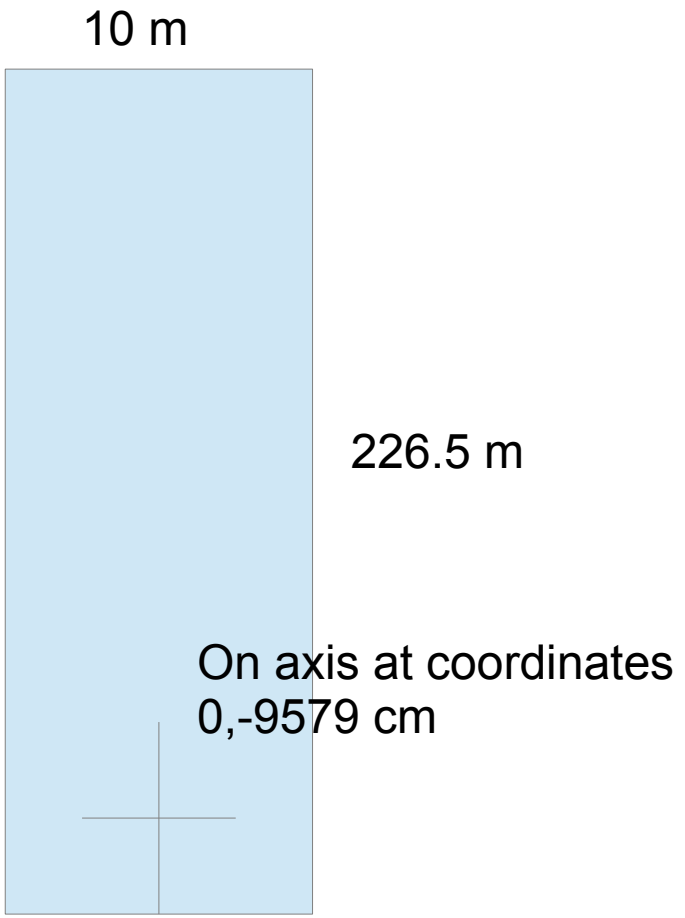
2 km neutrino mode flux files have been generated for the studies of the long WC detector

- GFLUKA used for hadron interactions
- Cover range of -0.5 to 6 degrees of off-axis angle
- 200 million triggers
- 250 kA horn currents

Ntuple variable definitions can be found at:
http://www.t2k.org/beam/NuFlux/FluxRelease/11arelease/ntpdef.

Files are stored on the iRODS server at QMUL at:
/QMULZone1/home/hyperk/flux_2km/

Instructions Francesca on accessing iRODS



2 km File Types

oa_study_250ka_2km_*root: standard T2K format flux files

- http://www.t2k.org/beam/NuFlux/FluxRelease/11arelease/ntpdef.
- 2 km flux is stored in the h3002 tree
- SK flux is also included

pion_throws_2km_*.root: Reduced number of variables stored in the tree

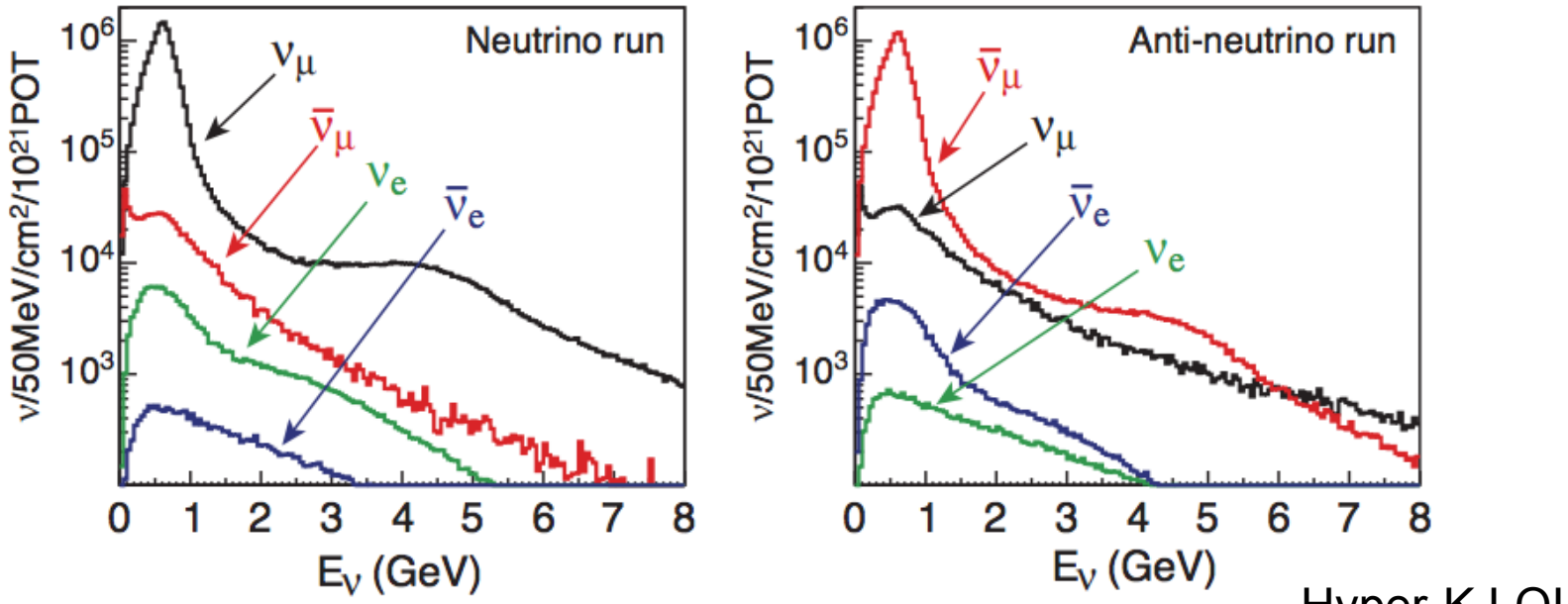
- Variable names are unchanged from T2K format
- Added TVectorD piWeights to the tree
  - Stores 100 weights corresponding to throws of the NA61 systematic errors within uncertainties

Plan for Flux Inputs

- Will begin production of antineutrino mode 2 km flux, 2 km fluxes at 320 kA horn current
- Considering evaluation of systematic errors at 2 km flux
  - Hadron production, proton beam errors by reweighting
  - Off-axis angle errors by shifting coordinate definition
  - Neglect other errors for now?
- Antineutrino mode flux errors at 280 m are now under study by T2K (R. Terri at QMUL)
- Options for format of modeling uncertainties:
  - Summary tree with weights for different “throws” of the systematic parameters
  - Covariance matrix with errors as a neutrino energy/flavor
- Any requests for flux inputs for studies?

Flux Optimization for CP Violation

Consider the difference in neutrino and antineutrino fluxes and cross sections:

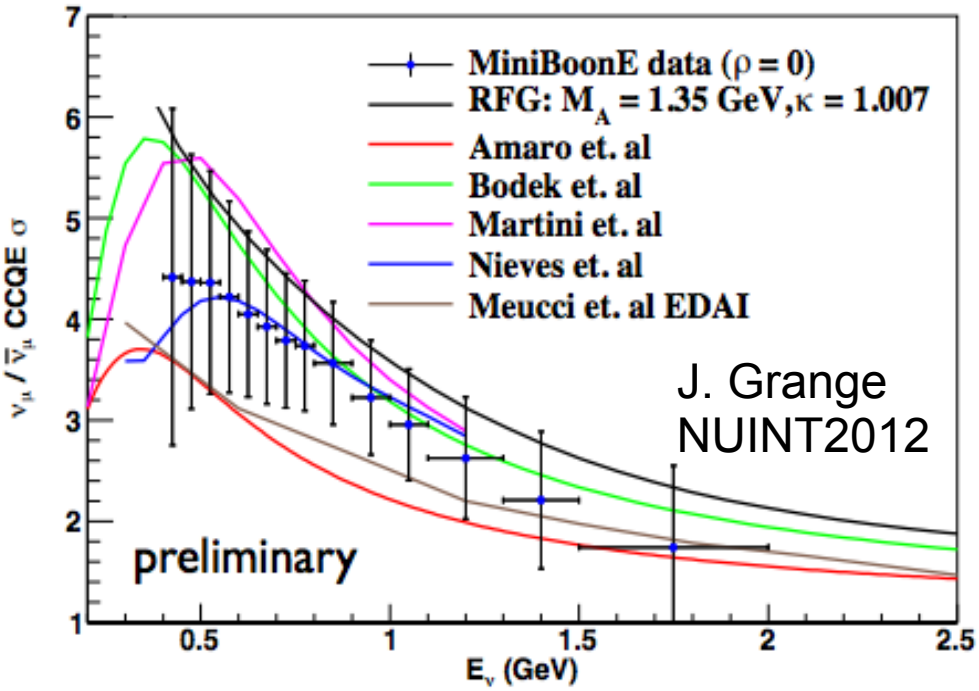


Hyper-K LOI

In anti-neutrino running the right sign flux is reduced, but fraction in high energy tail is also reduced

Wrong sign contamination is is increased, especially at high energy

Antineutrino Cross Section

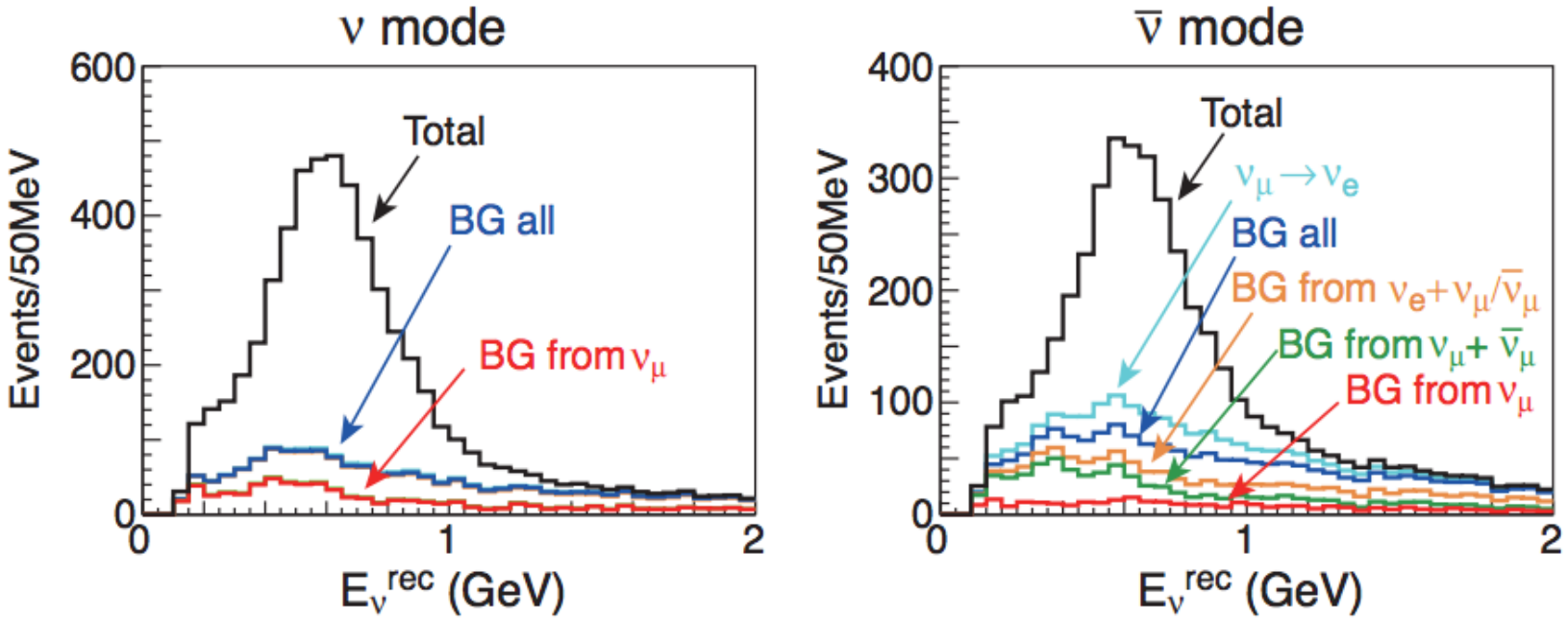


The antineutrino CCQE cross section is suppressed by factor of ~4 near peak

Suppression is less at high energy

Optimization to reduce the high energy tail of the antineutrino mode flux may improve S/B

Wrong Sign Background



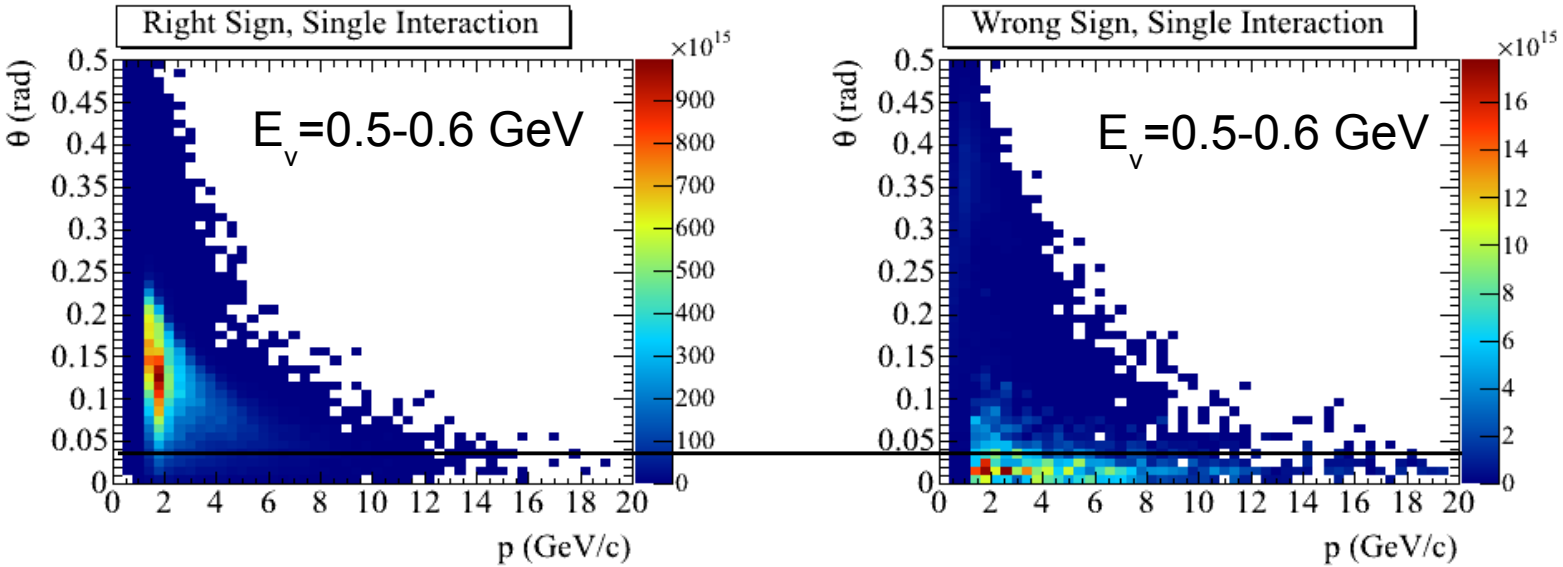
For antineutrino mode:

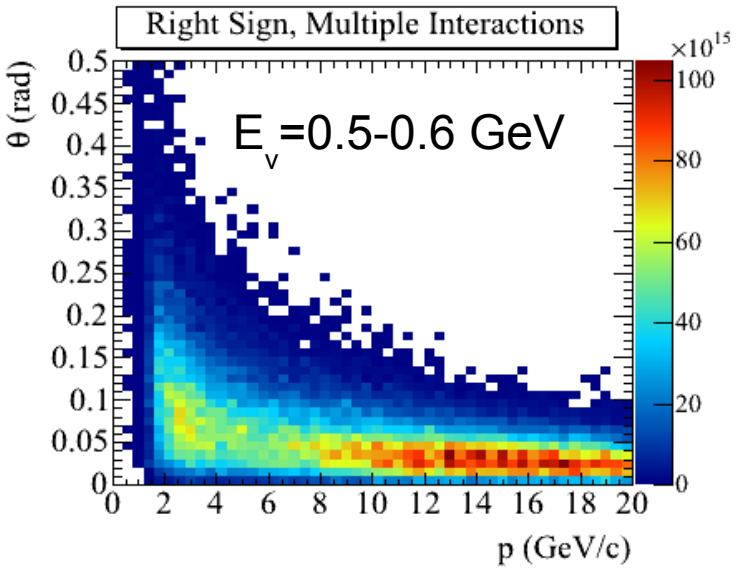
- Wrong sign signal is ~20% of right sign signal
- Right sign S/B = ~1.25 compared to ~2.3 for neutrino mode
  - Largely degraded by presence wrong sign backgrounds

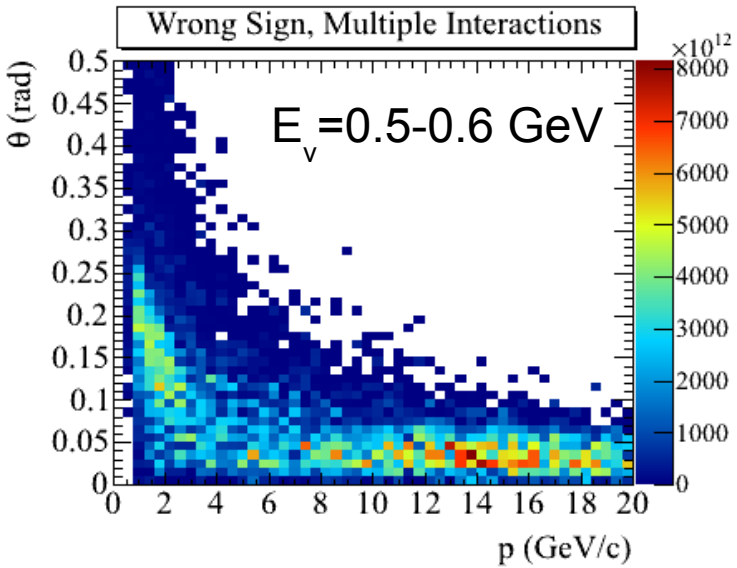
Can we reduce the neutrino flux when operating in antineutrino mode?

First Scatter Phase Space 0.5-0.6 GeV

Angle and momentum of first scattered meson in chains producing SK antineutrinos (left) and neutrinos (right). Chains with single interaction (top) or multiple (bottom)

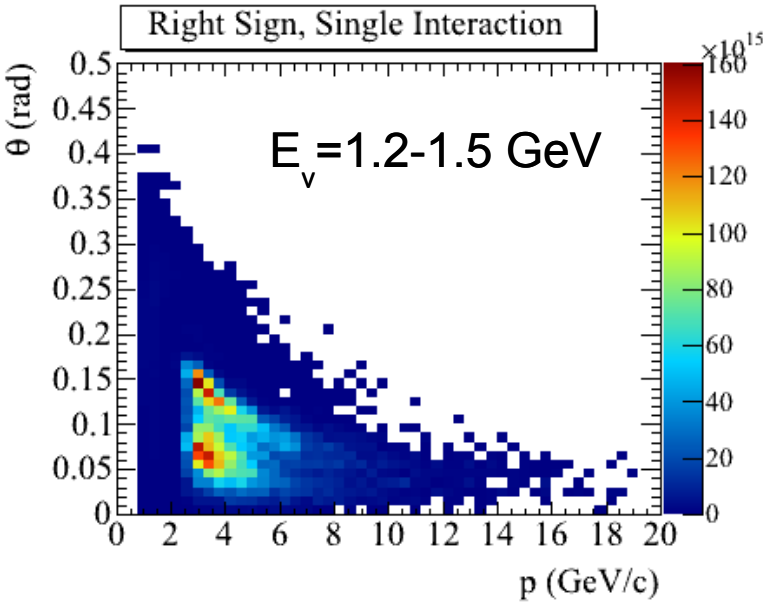


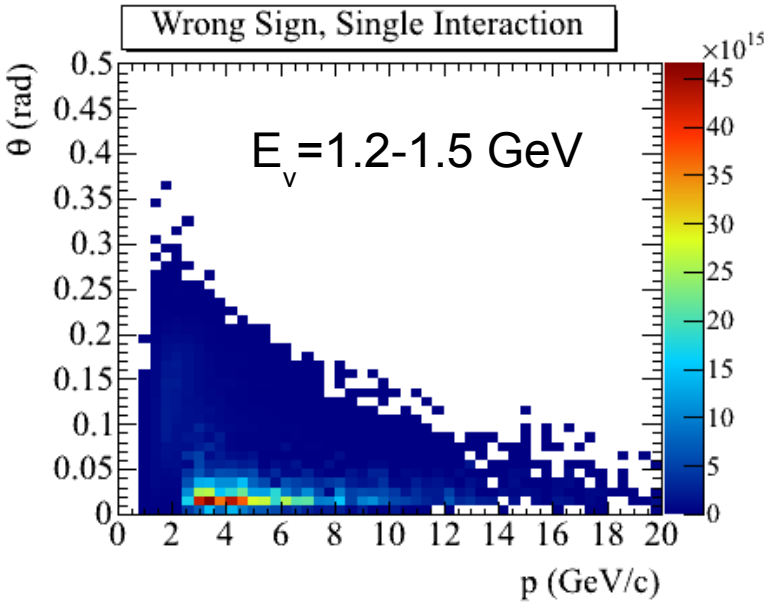


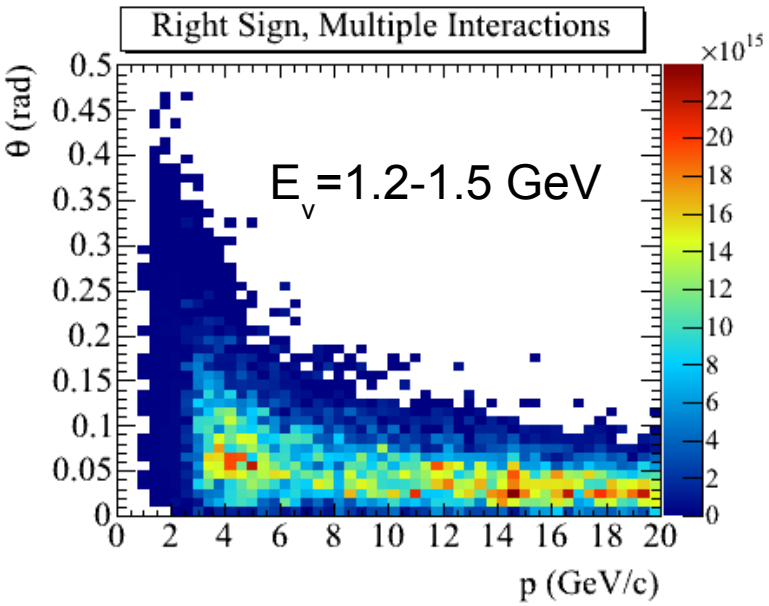


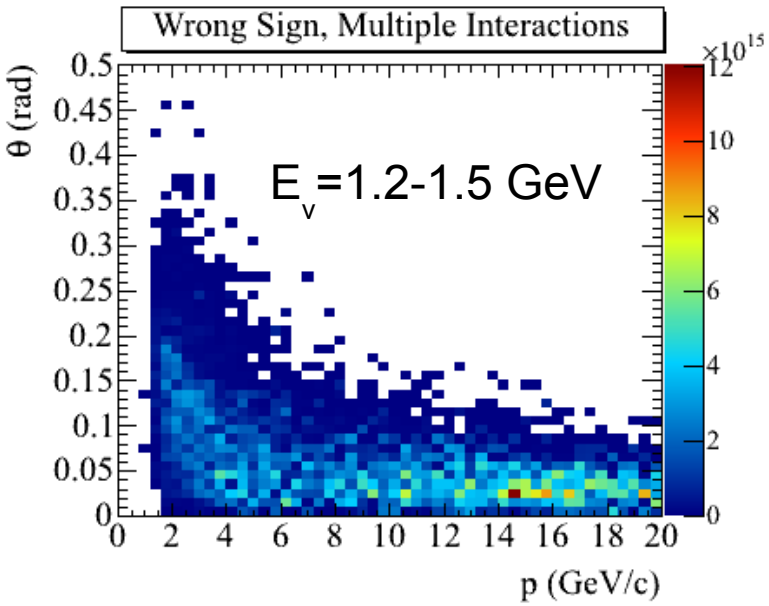
Much of the wrong sign flux from single interaction is very forward

First Scatter Phase Space 1.2-1.5 GeV









Flux Optimization

- Much of the wrong sign flux comes from forward produced hadrons
- Can we reduce this flux?
  - Longer target
  - Absorber downstream of the target
  - Optimized horn design
- Have started some basic studies, results not ready yet