

# DUNE LBL Sensitivities

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# Introduction

- Chris Backhouse ported a version of CAFAna, which is NOvA analysis software, to DUNE
- This software is a complete analysis package capable of detailed sensitivity projections with full systematics handling
- I've been working the past few weeks to validate the software, fix bugs from the port, and make DUNE sensitivity projections
- This is definitely still a work in progress

# Technical Details

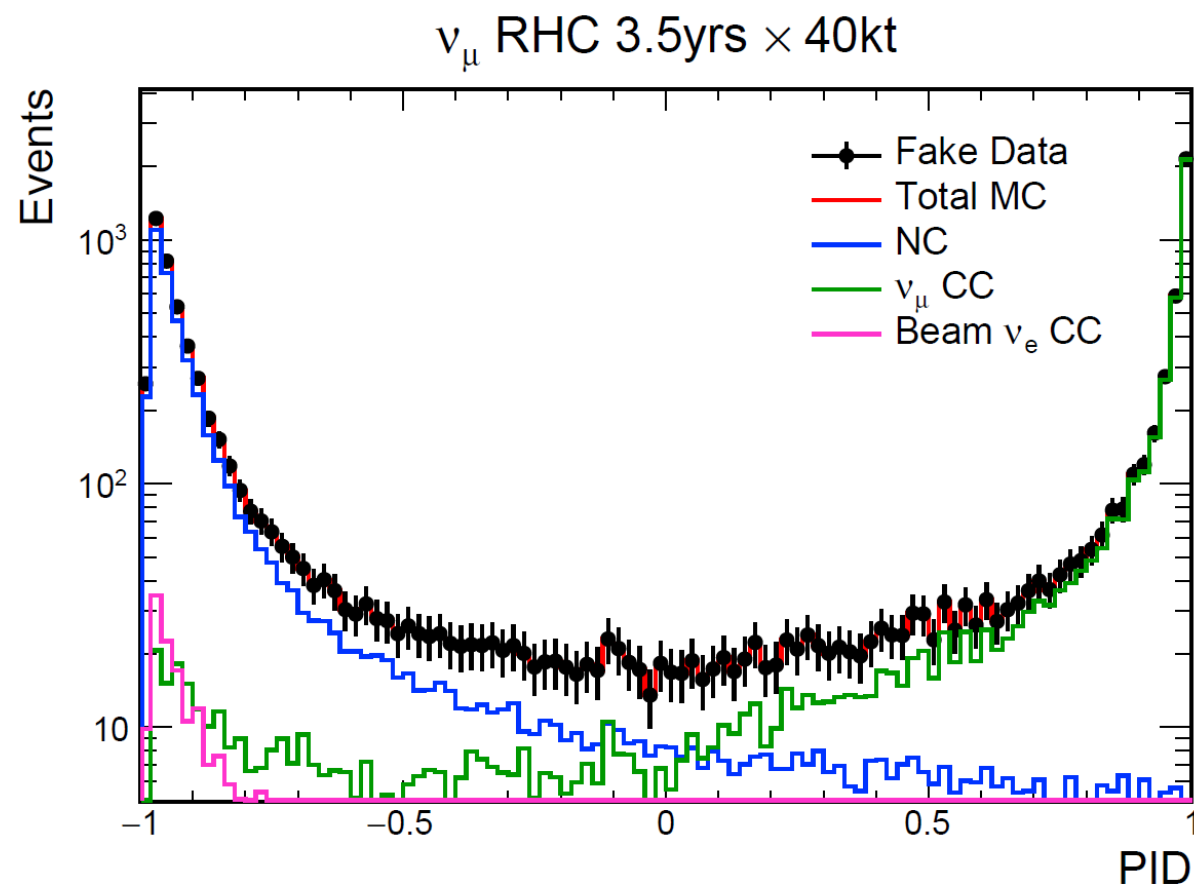
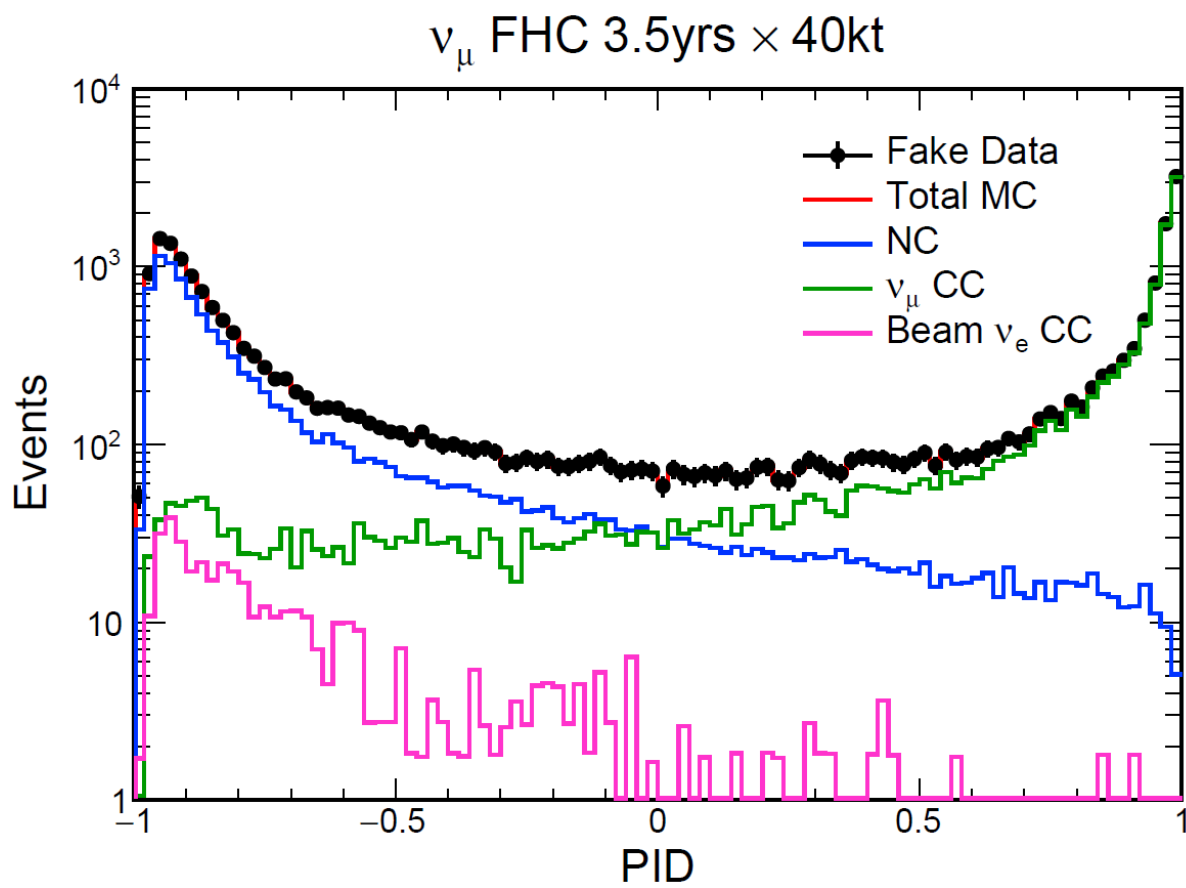
- Files:
  - /pnfs/dune/persistent/TaskForce\_AnaTree/far/train/v2.2/numutest.root
  - nuettest.root, anumutest.root, anuetest.root
- Assumptions:
  - $\theta_{12} = .5857$
  - $\theta_{13} = .148$
  - $\theta_{23} = .7854$  (max mixing)
  - $\Delta m^2_{21} = .000075$
  - $\Delta m^2_{32} = .2524 - .000075$
  - $L = 1300$  km
  - When not otherwise varied,  $\delta CP = 1.5 * \pi$
- Oscillation Parameter uncertainties:
  - Can marginalize oscillation parameters in fits
  - For most parameters, DUNE data will constrain sufficiently
  - For the solar parameters, requires outside data – not yet implemented, so these are not marginalized over yet

# Systematics:

Background	Normalization Uncertainty	Correlations
For $\nu_e/\bar{\nu}_e$ appearance:		
Beam $\nu_e$	5%	Uncorrelated in $\nu_e$ and $\bar{\nu}_e$ samples
NC	5%	Correlated in $\nu_e$ and $\bar{\nu}_e$ samples
$\nu_\mu$ CC	5%	Correlated to NC
$\nu_\tau$ CC	20%	Correlated in $\nu_e$ and $\bar{\nu}_e$ samples
For $\nu_\mu/\bar{\nu}_\mu$ disappearance:		
NC	5%	Uncorrelated to $\nu_e/\bar{\nu}_e$ NC background
$\nu_\tau$	20%	Correlated to $\nu_e/\bar{\nu}_e$ $\nu_\tau$ background

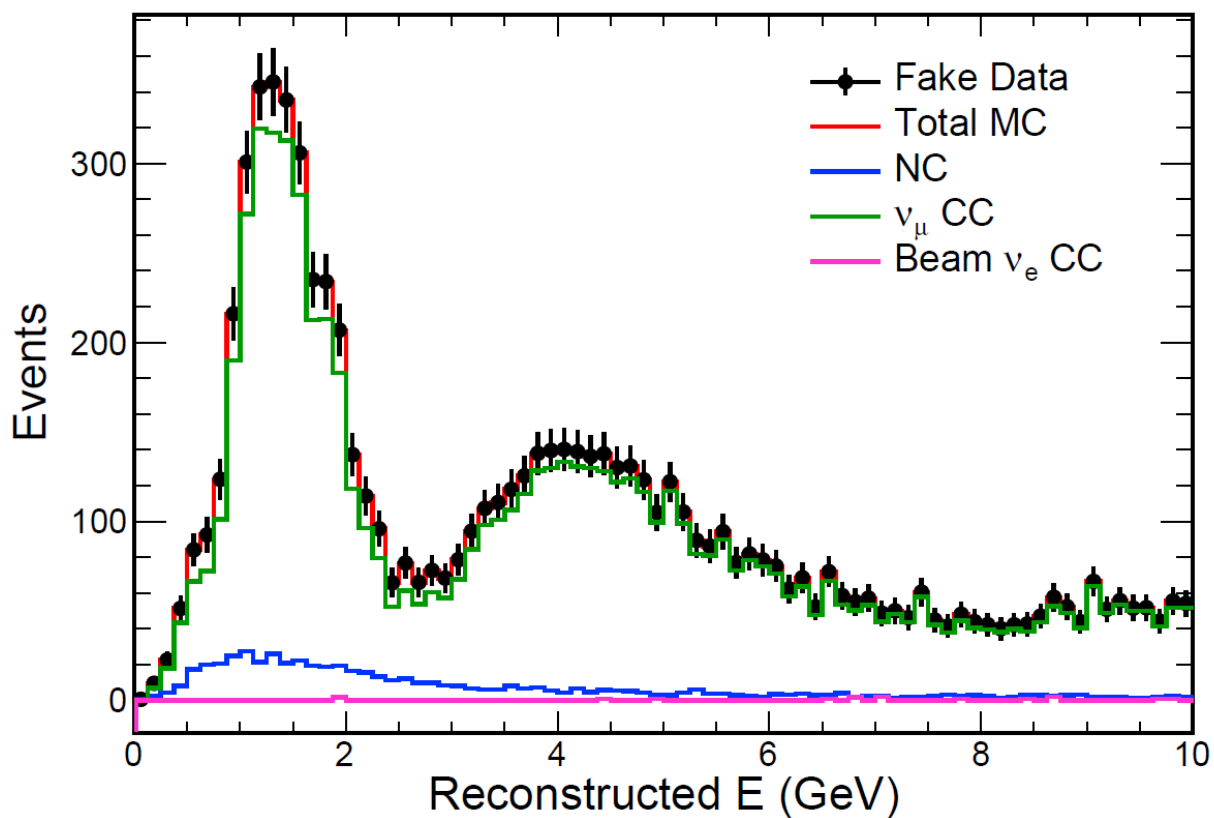
- There is an established set of systematics being used as a baseline
  - All normalization systematics
- I implemented all these, except I don't use the numu CC 5% normalization for nue, because the CAFAna framework would apply that systematic to the numu analysis too when combining experiments. I'll need to be a little clever to implement
- Also I suspected energy scale and resolution systematics would be pertinent, so I implemented a 2% scale and 6% resolution systematic

- numu analysis
- PID = mvareresult
- For fits: 15 bins

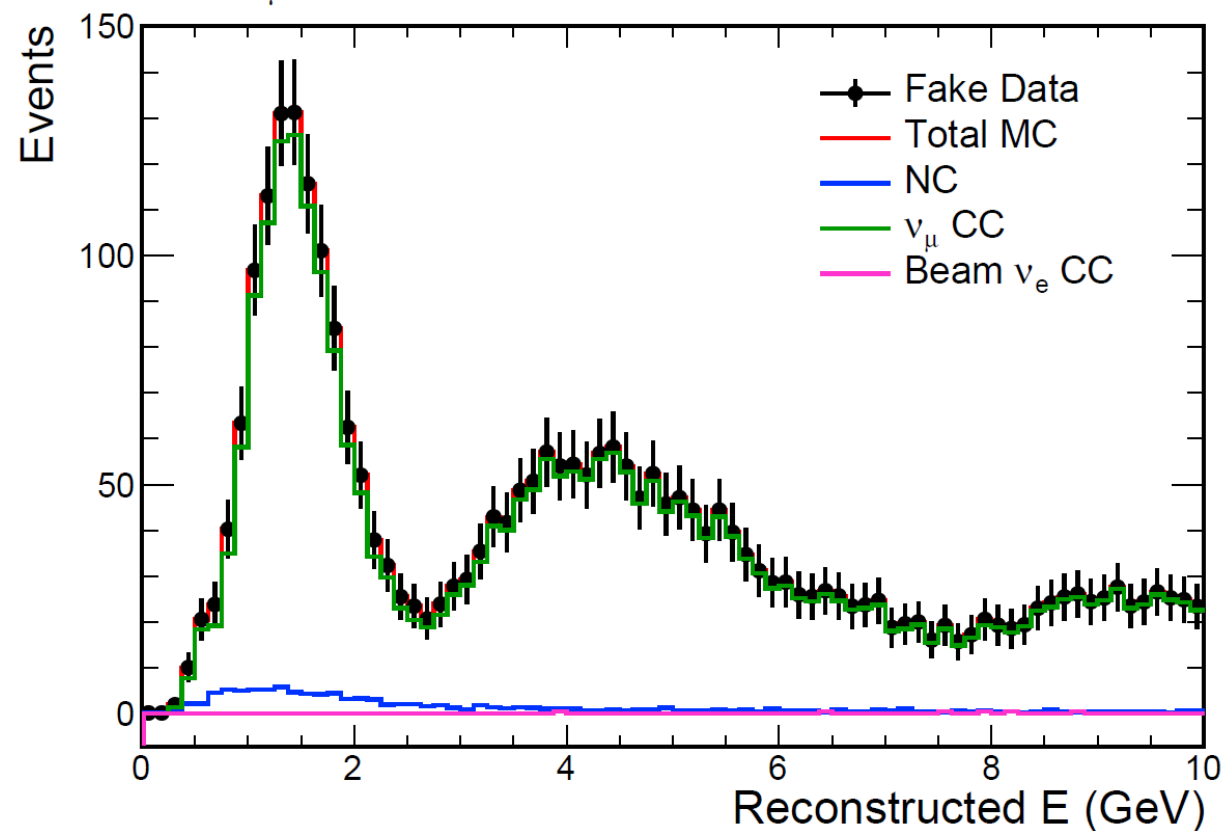


- numu analysis
- Cut on MVA to extract signal
- For fits: 15 bins

$\nu_\mu$  FHC selection (MVA>0.25) 3.5yrs  $\times$  40kt

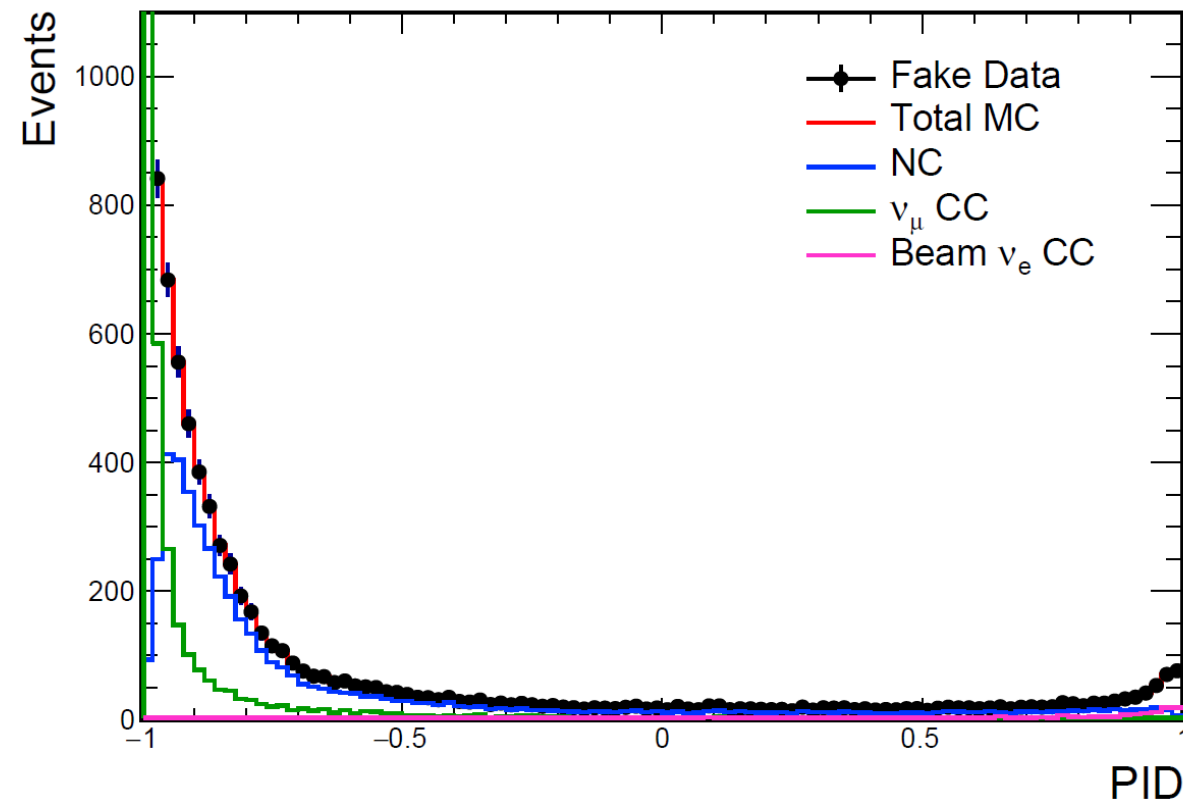
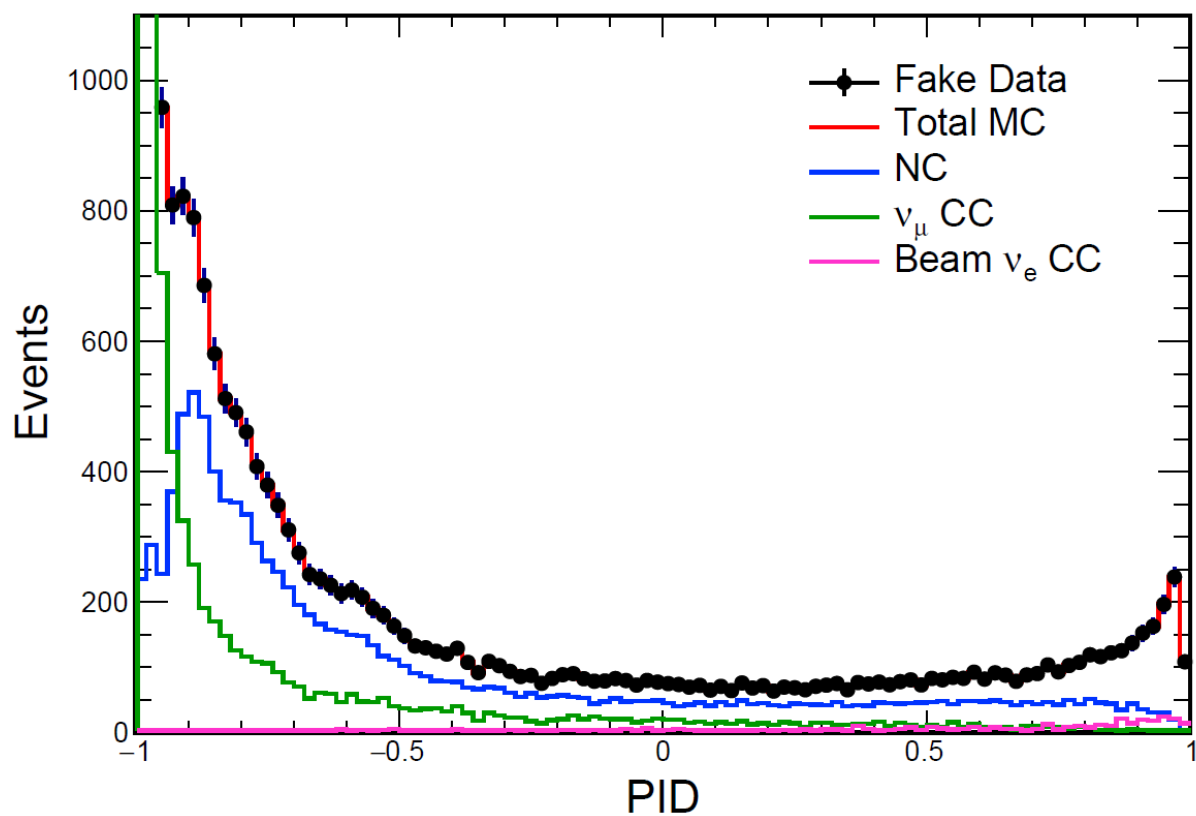


$\nu_\mu$  RHC selection (MVA>0.5) 3.5yrs  $\times$  40kt



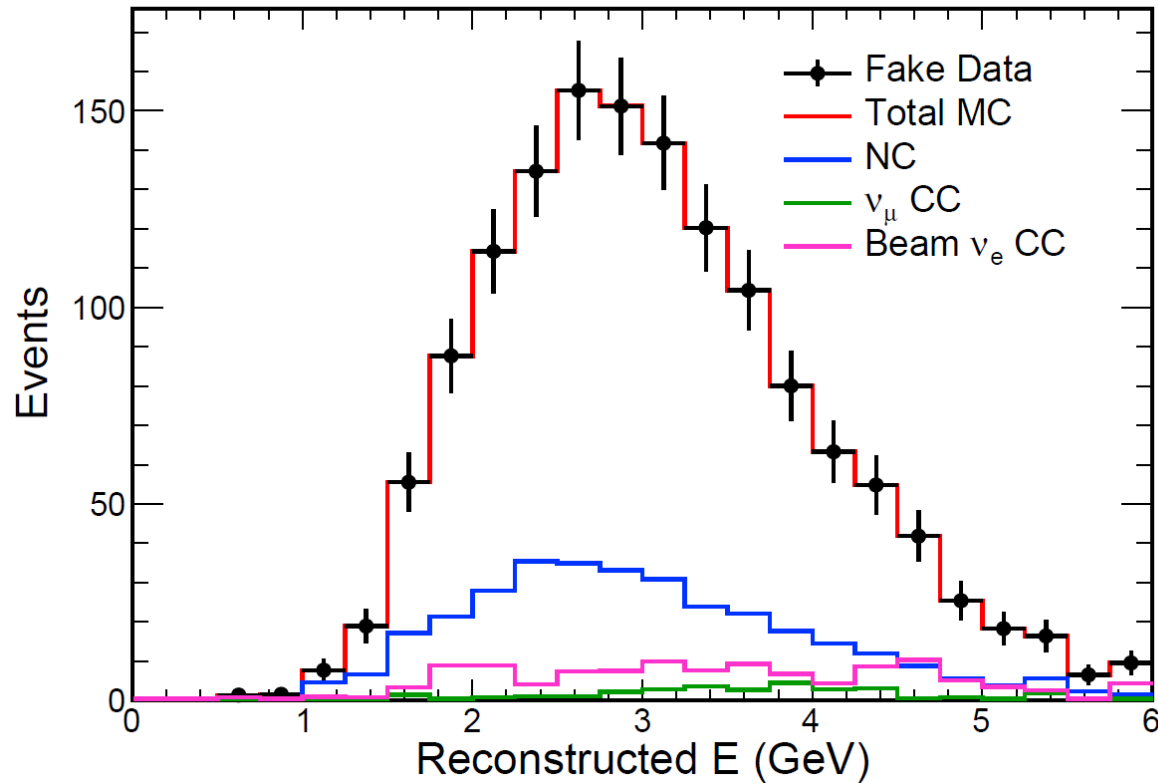
- nue analysis
- PID = mvareresult
- For fits: 20 bins

$\nu_e$  FHC 3.5yrs  $\times$  40kt

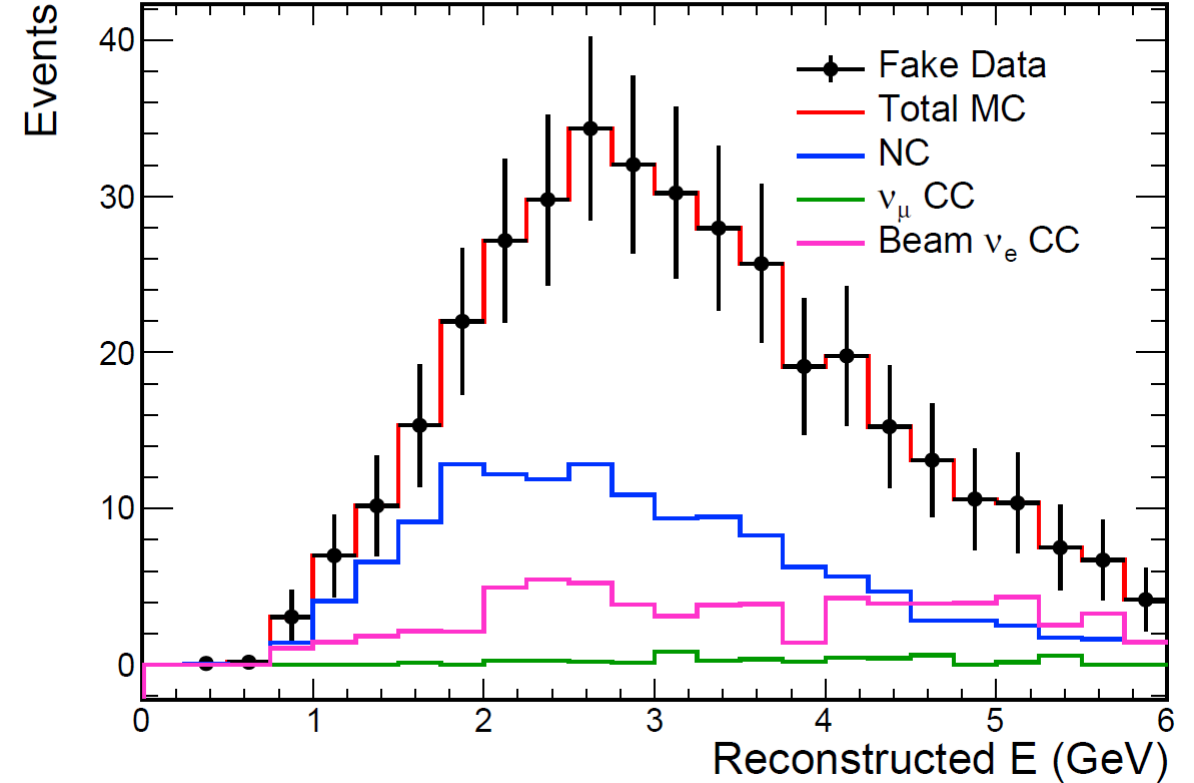


- nue analysis
- Cut on MVA to extract signal
- For fits: 15 bins

$\nu_e$  FHC selection (MVA>0.8 ) 3.5yrs  $\times$  40kt



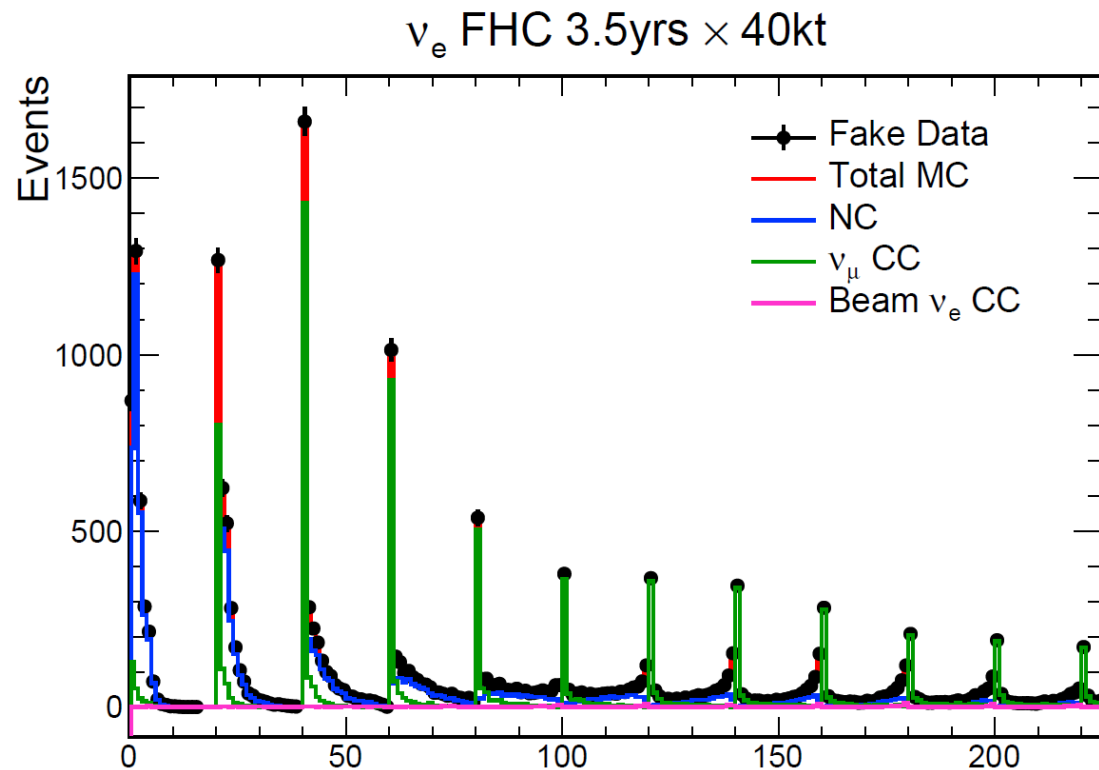
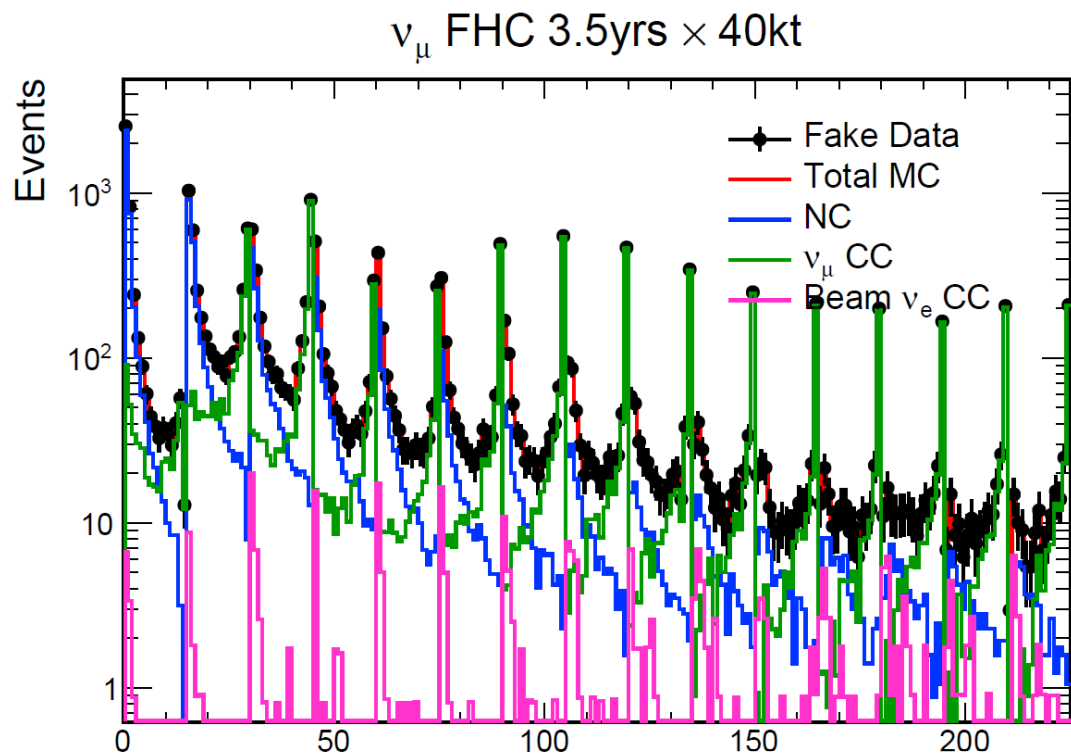
$\nu_e$  RHC selection (MVA>0.8) 3.5yrs  $\times$  40kt



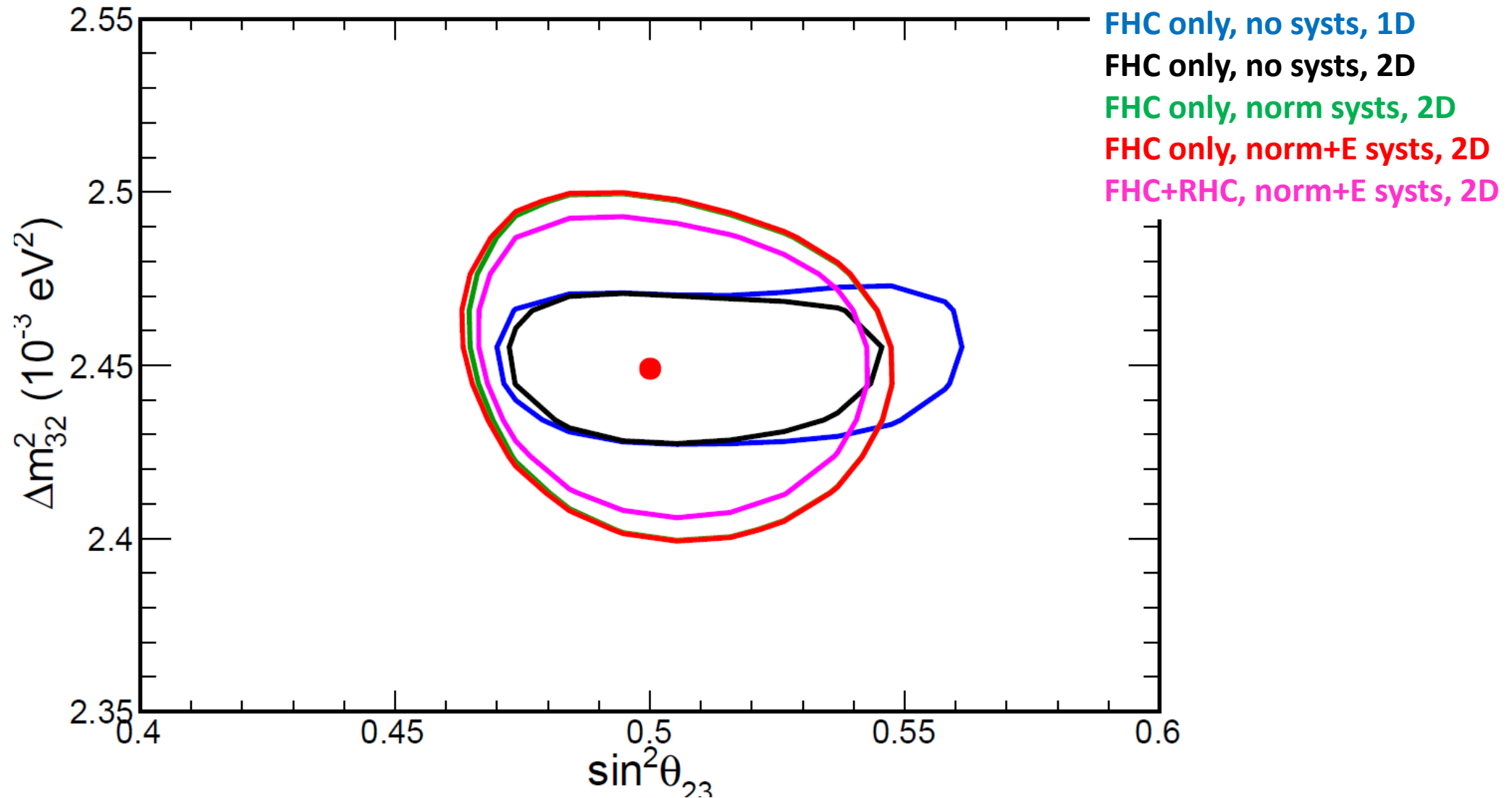


2d

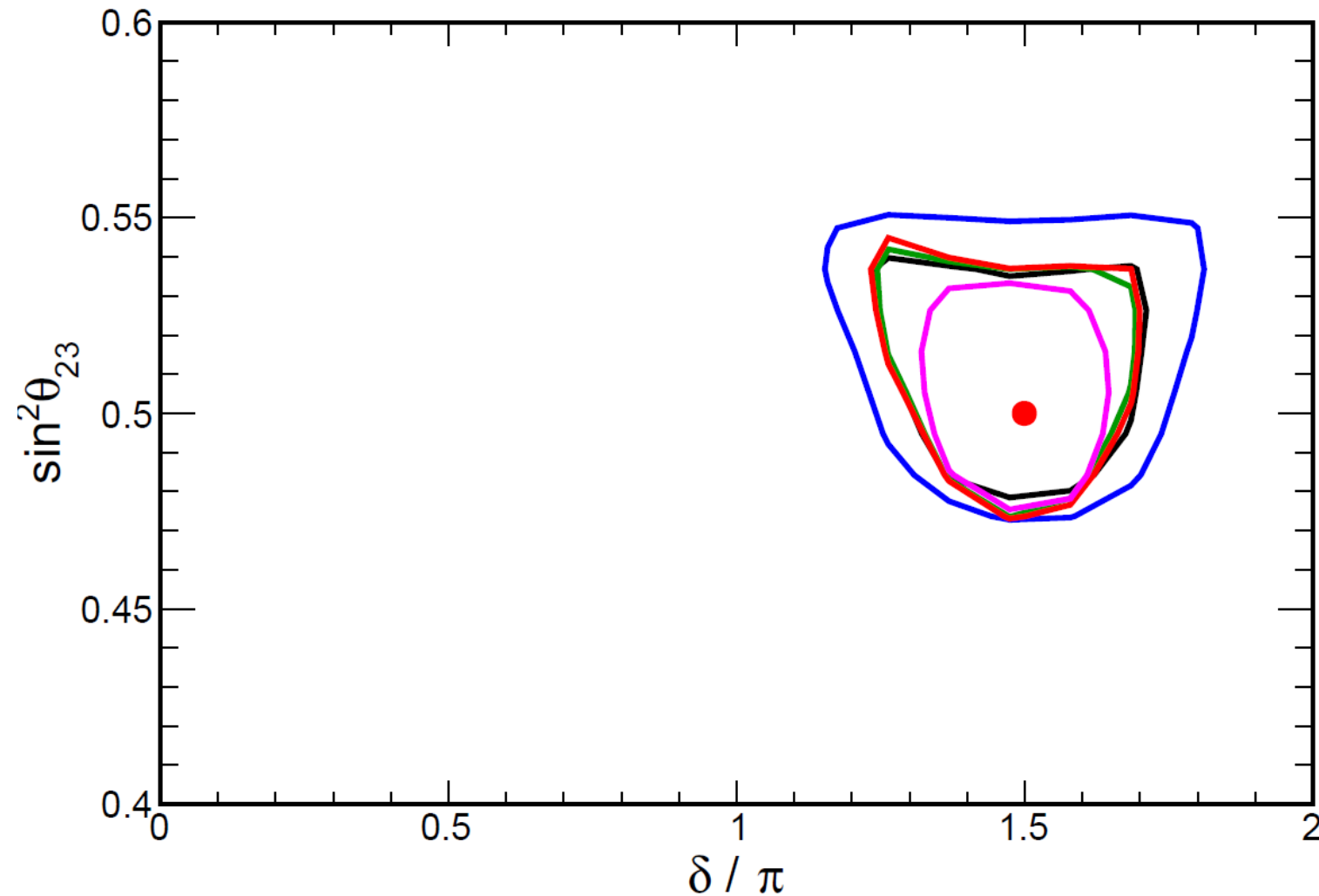
- CAFAna allows us fit in 2D (ie E and PID simultaneously) by making the 2D histogram into a 1D histogram
- Then no longer cutting on mva, but using all the information available



# Numu contour

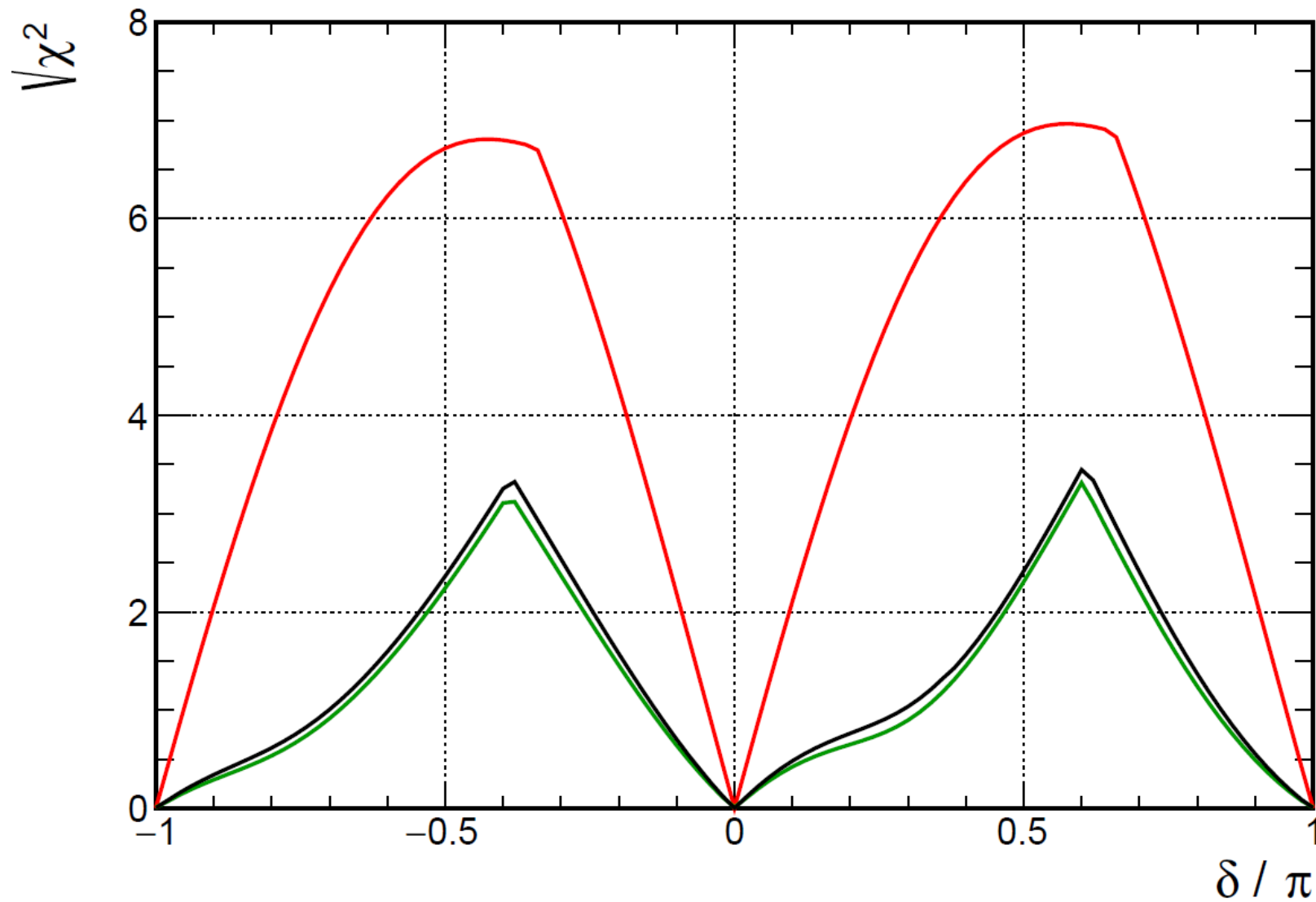


# Nue contour



- FHC only, no systs, 1D
- FHC only, no systs, 2D
- FHC only, norm systs, 2D
- FHC only, norm+E systs, 2D
- FHC+RHC, norm+E systs, 2D

3.5yrs  $\times$  40kt, stats only



**FHC only, no Systs, 2D**

**FHC only, all systs, 2D**

**FHC + RHC, all systs, 2D**

# Next:

- Double check everything
- Incorporate oscillation uncertainties for solar parameters
- Incorporate the numu CC systematic for the nue analysis
- Investigate why systematics affecting numu so much, not so much nue
- Different exposures, non-max mixing, etc