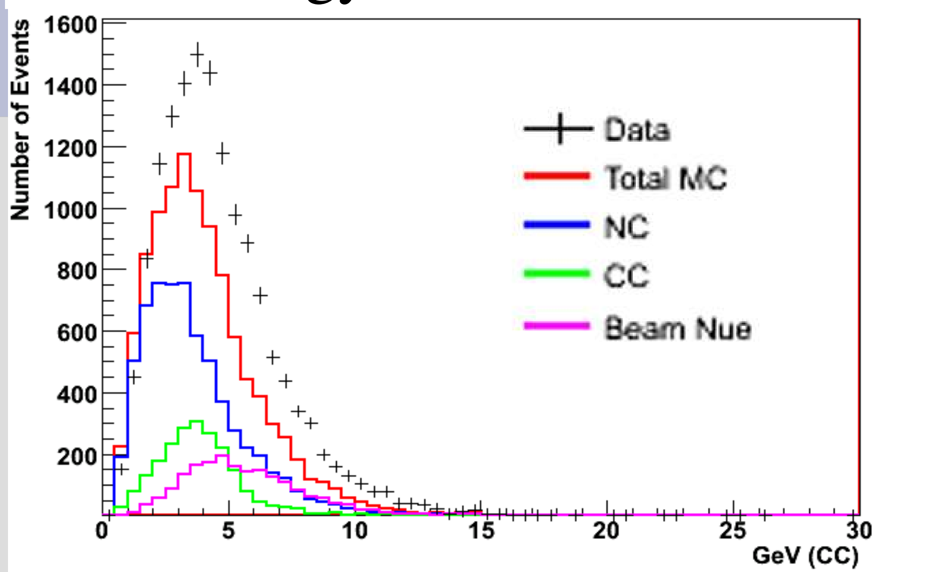
ND Data/MC Comparison

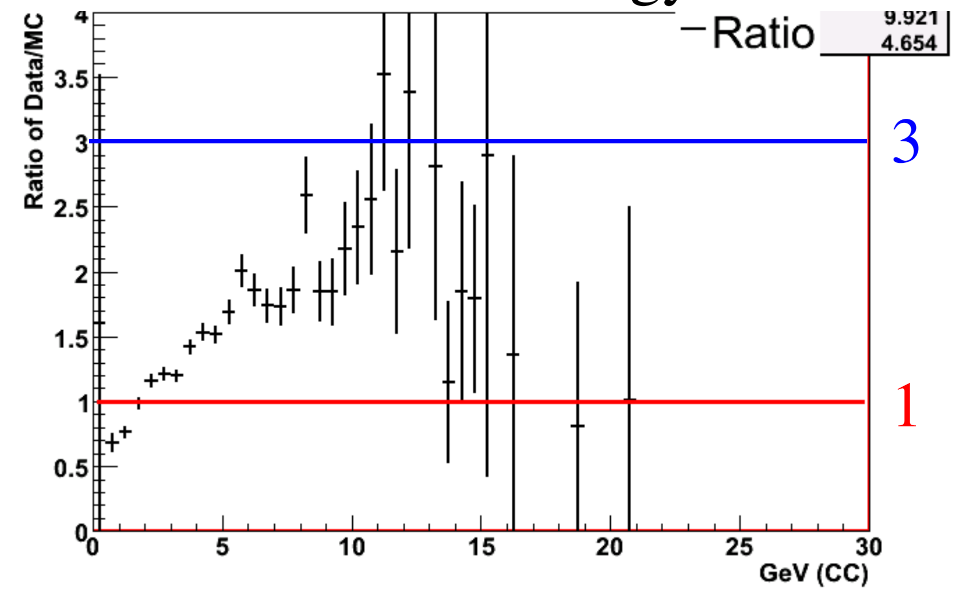
- Over the past several months we have clearly seen from several studies a large discrepancy between data and MC in the ND nue event sample
- Before this, differences in the shower development between data/mc had been seen
  - In this case the agreement was improved by reweighting events according to the true EMFrac of the event
- The nue selections enhance these deviations from the MC
  - Trying to compare the tails of distributions
- One aim of this meeting was to come up with a plan to address this

Data/MC Comparison

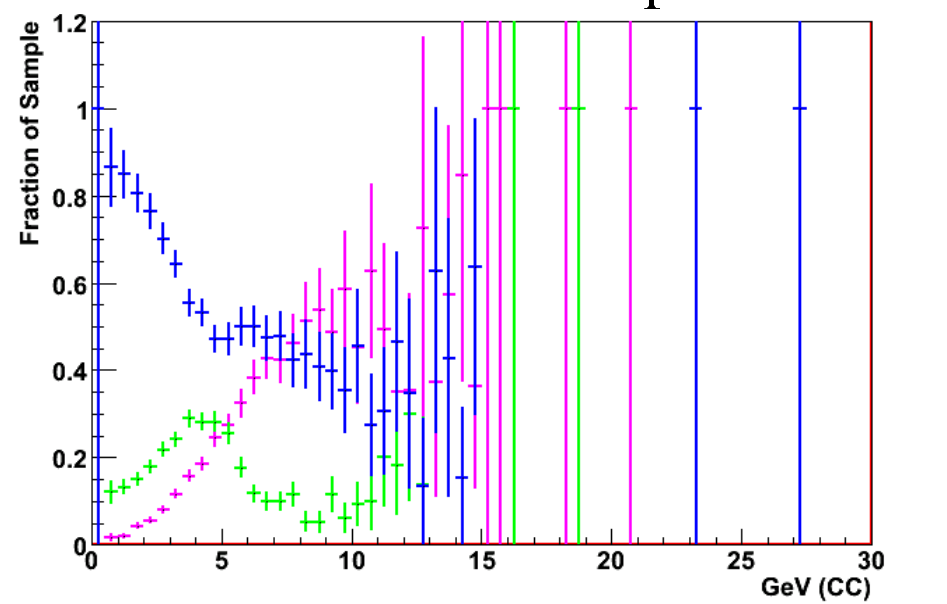
Reco Energy after ANN PID Cut



Data/MC Ratio Vs Energy



Fractional contributions per bin



Explanations:

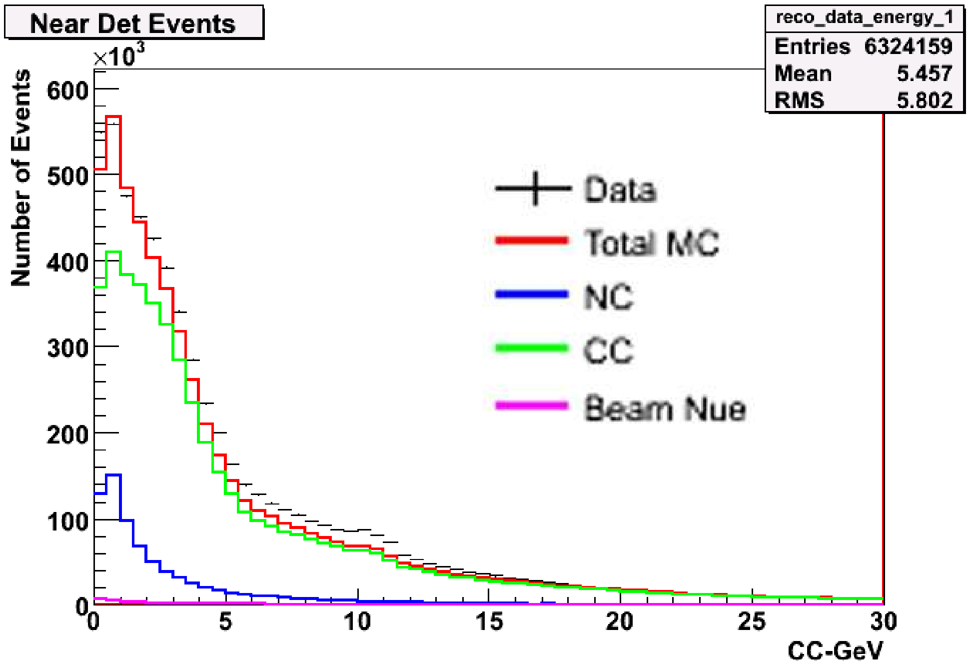
- We're making a mistake: can't count POTs?
- Poorly modeled hadronic system: incorrect pion multiplicities?
- Cross-section problem: QE too low?
- Beam modeling: not enough kaons?
- Signal!

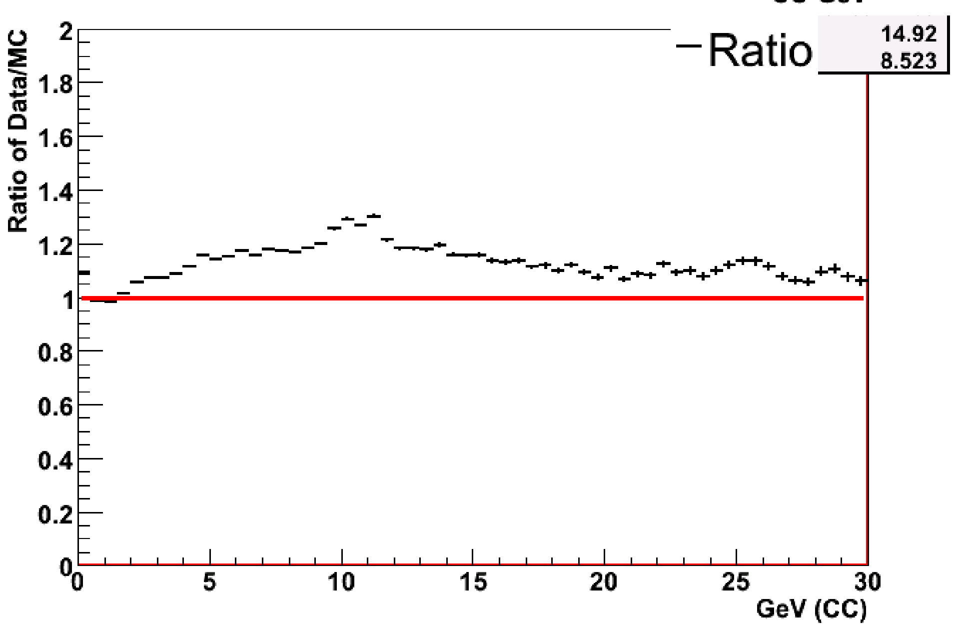
Josh Boehm

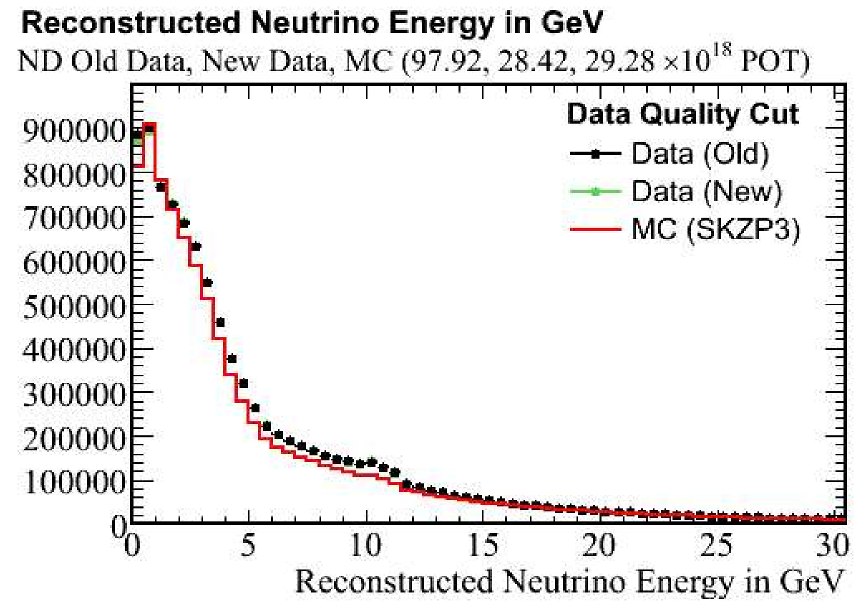
The CC Group Cuts

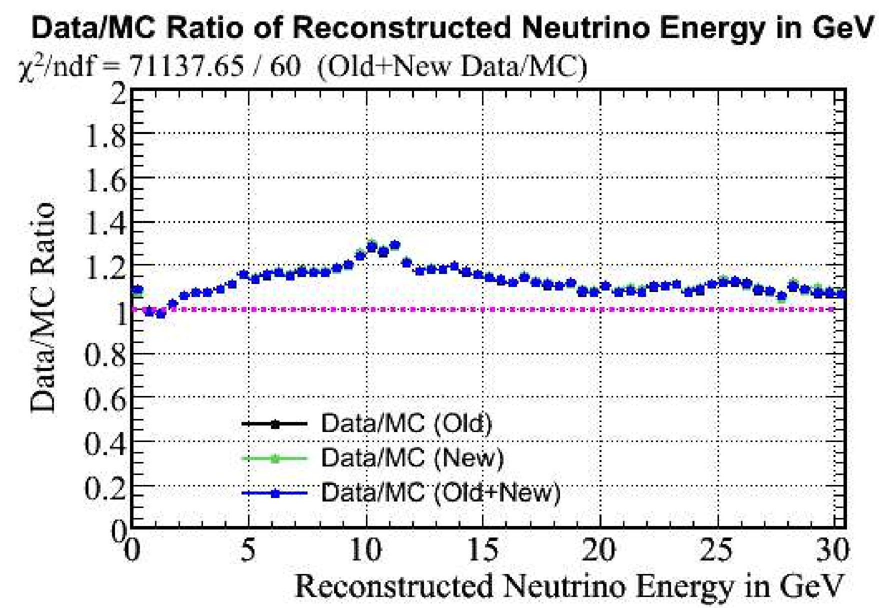
- Applied Cuts
  - DataQuality (goodBeam, coilcurrent, etc)
  - Fiducial volume cut (evt not trk though)
    - ND : $r < 1$ m & $1 < z < 5$ m
  - Number of Tracks > 0
  - Charge Sign Cut
  - Track passes fit (and track reclamation)

Data Quality Cut Comparison

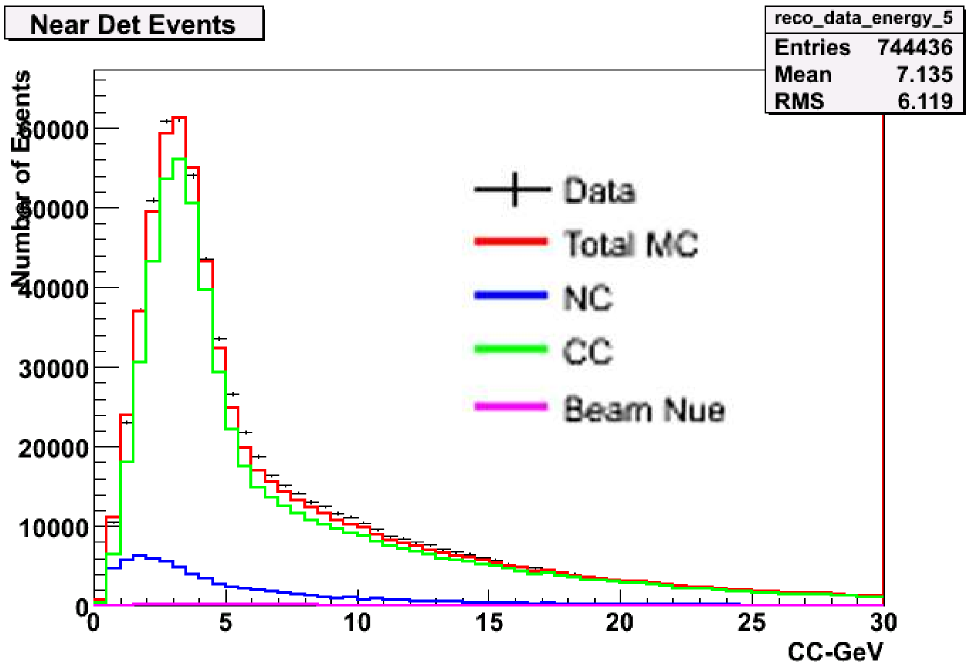


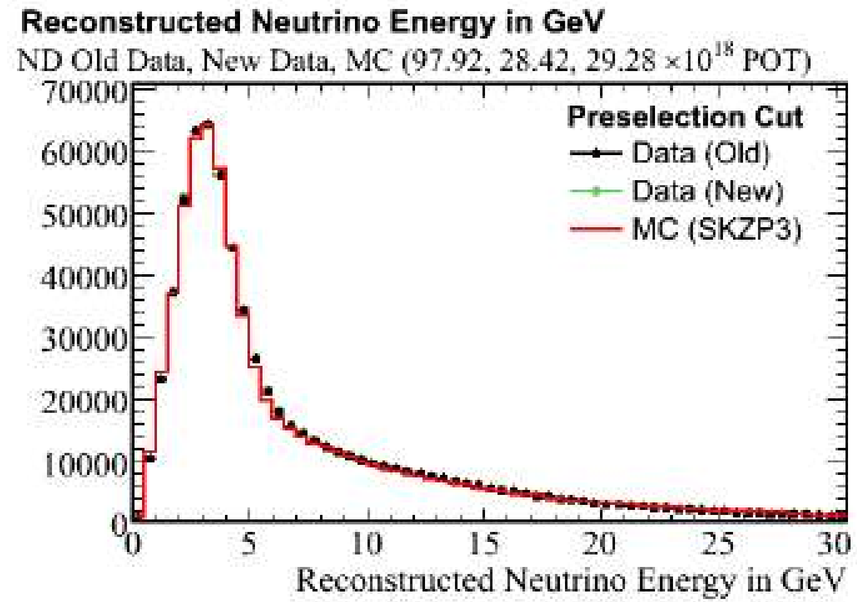


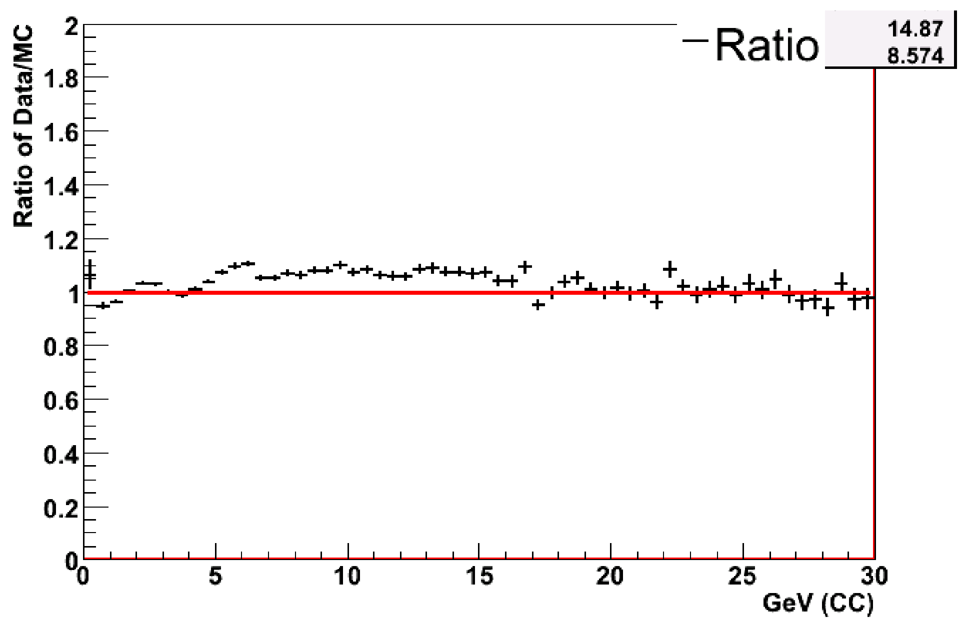


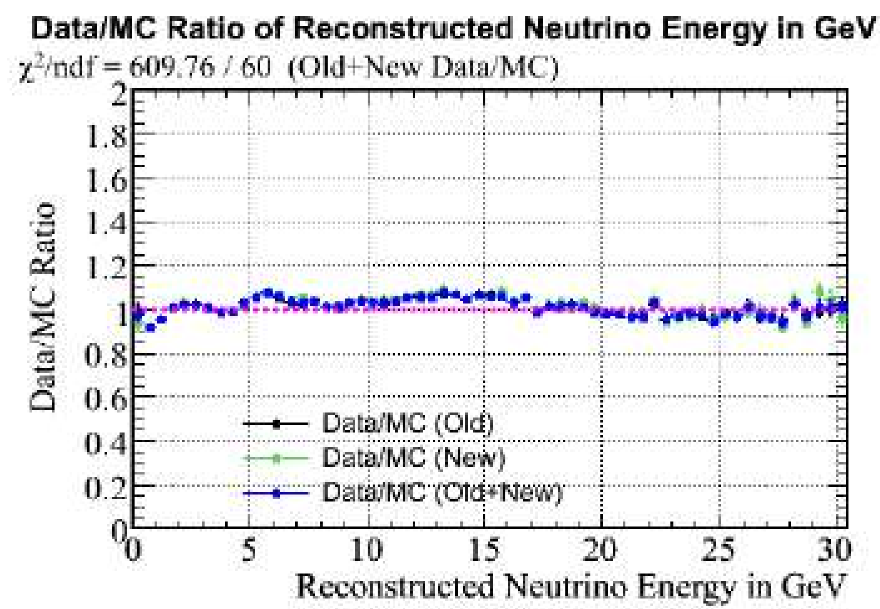


Preselection Cut Comparison

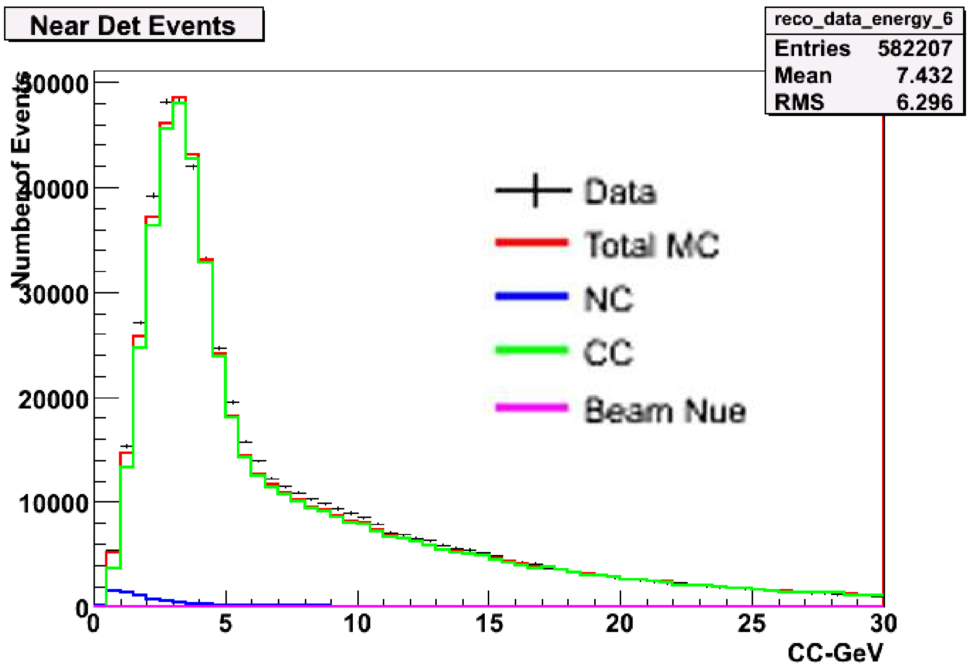


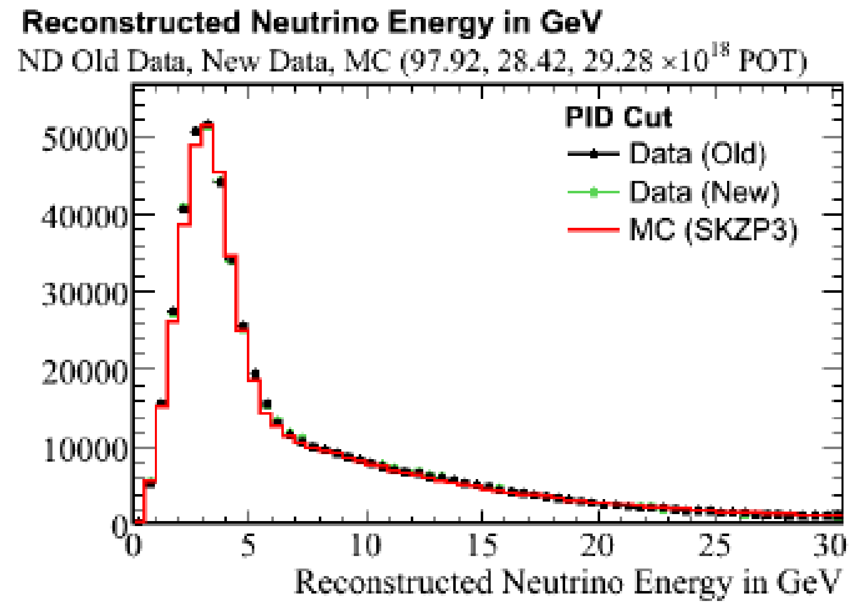


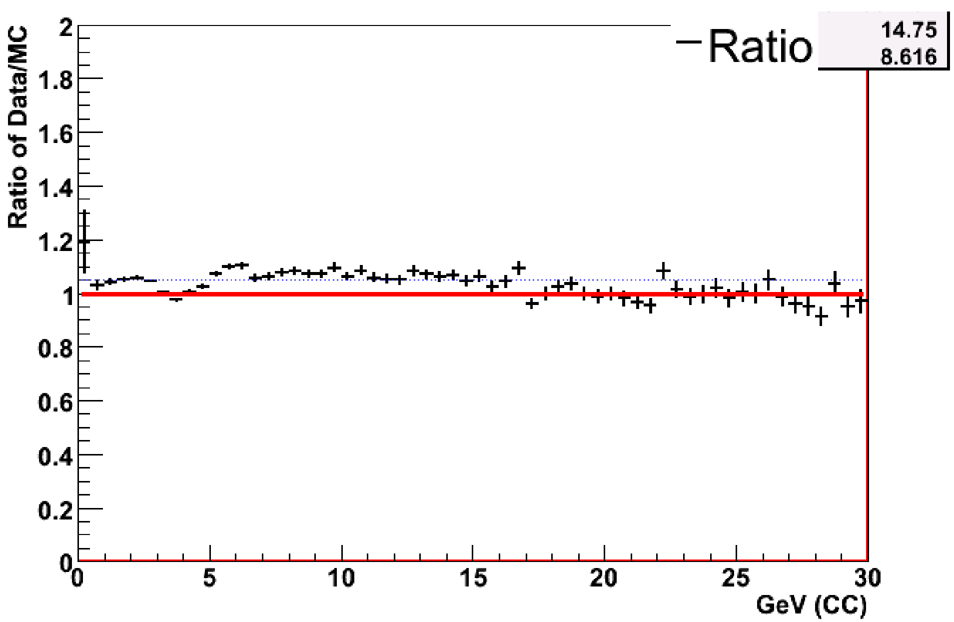


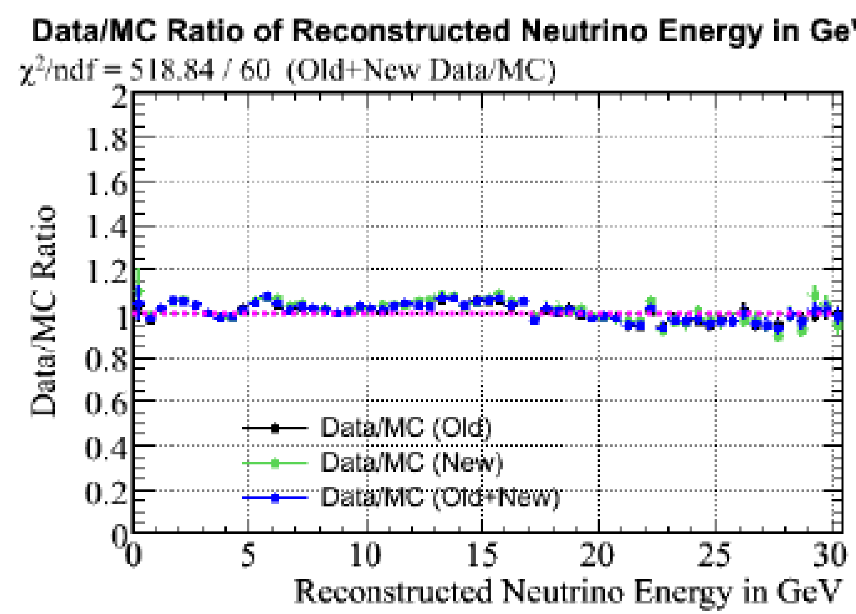


DP-PID Cut Comparison

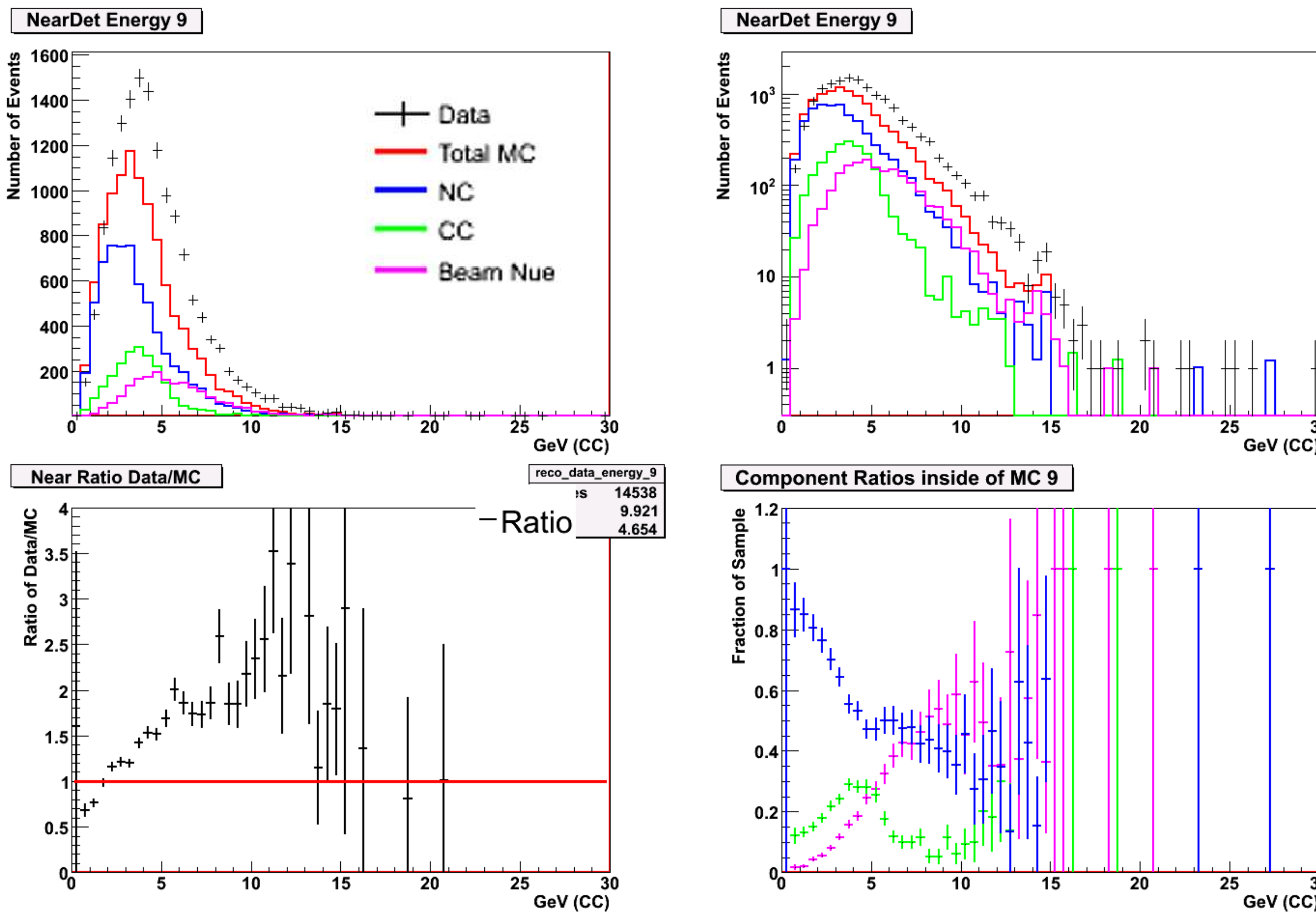




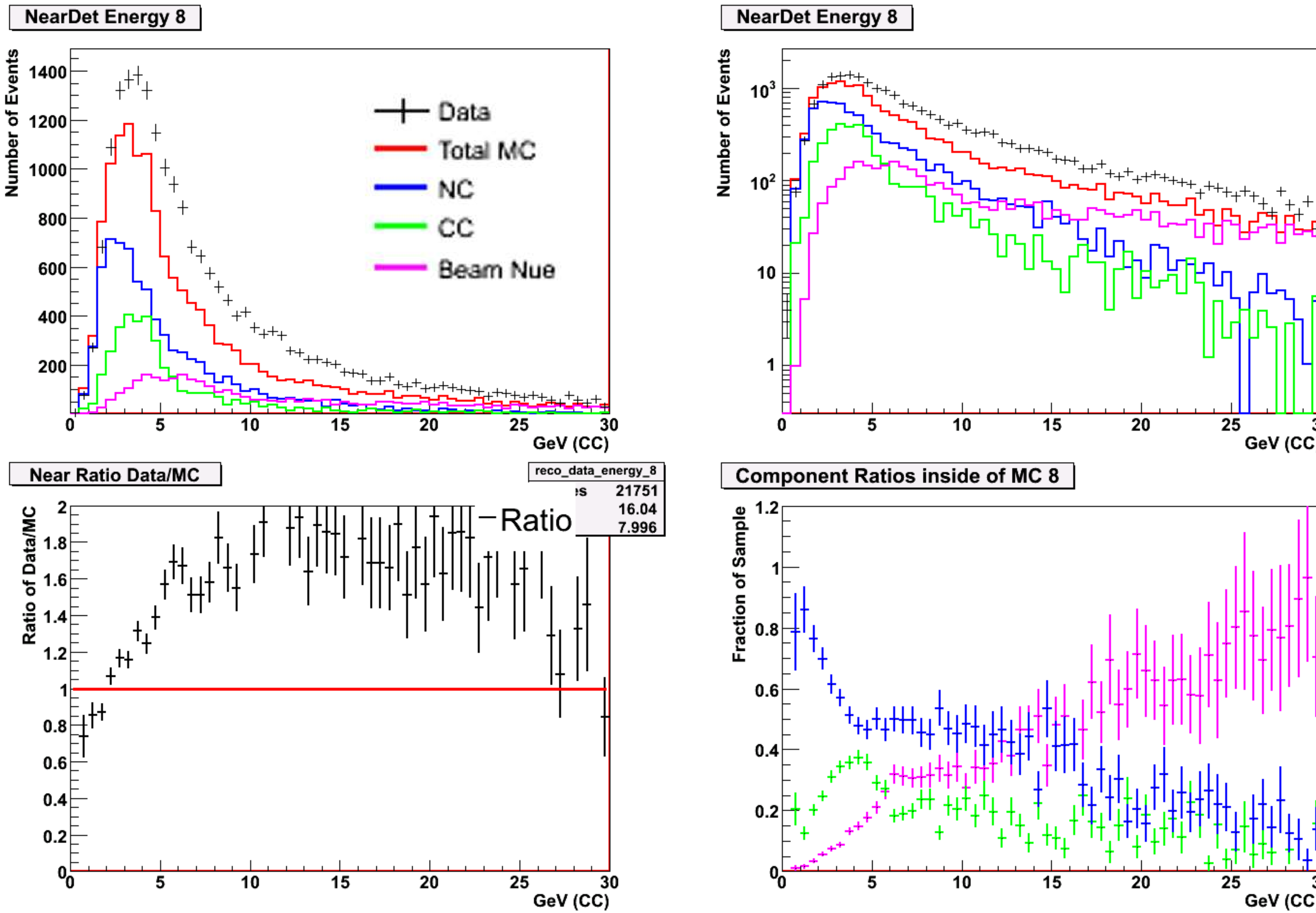




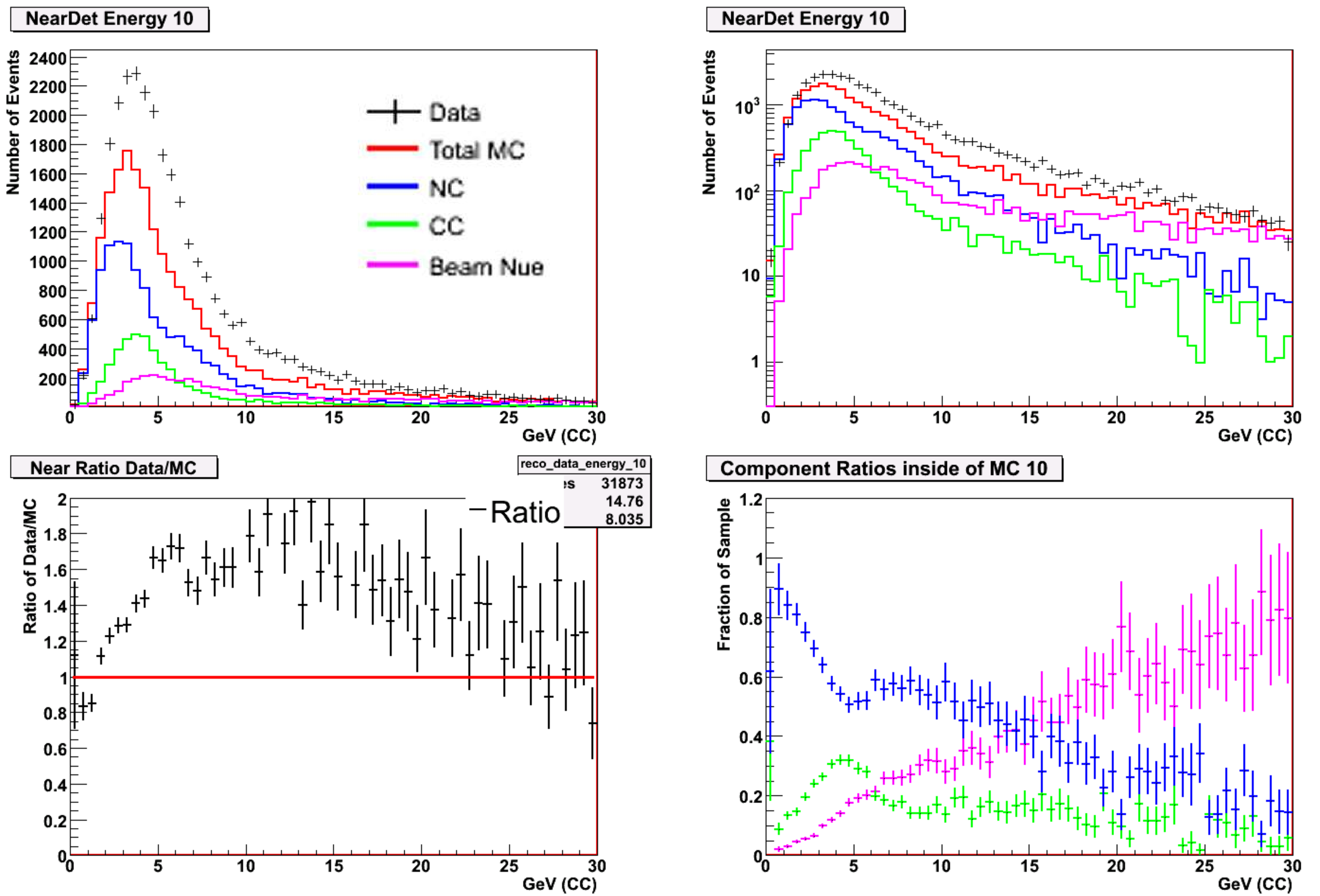
ANN PID Cut - Energy



Subshower PID Cut - Energy



MDA PID Cut - Energy

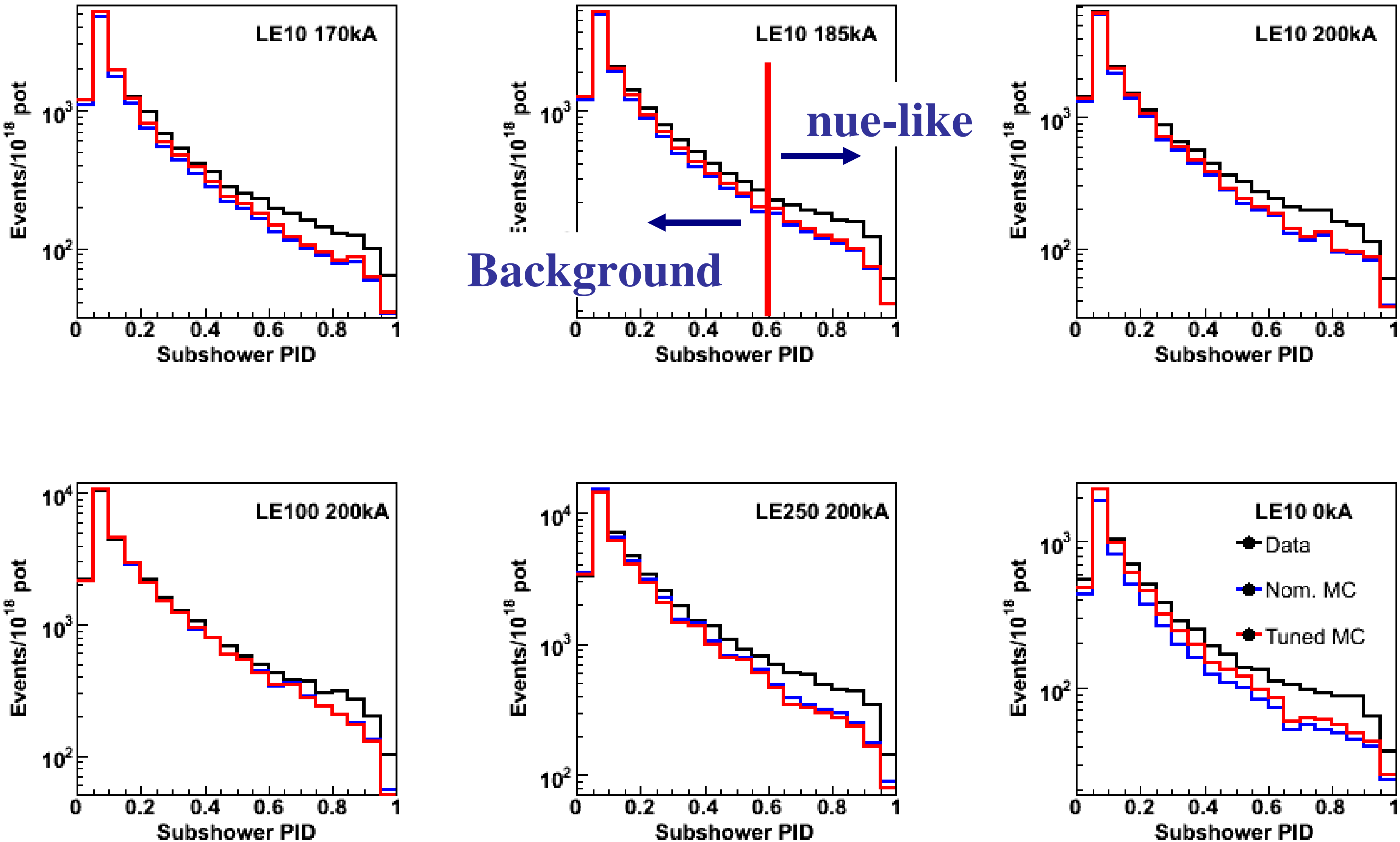


Beam Reweighting for NUE

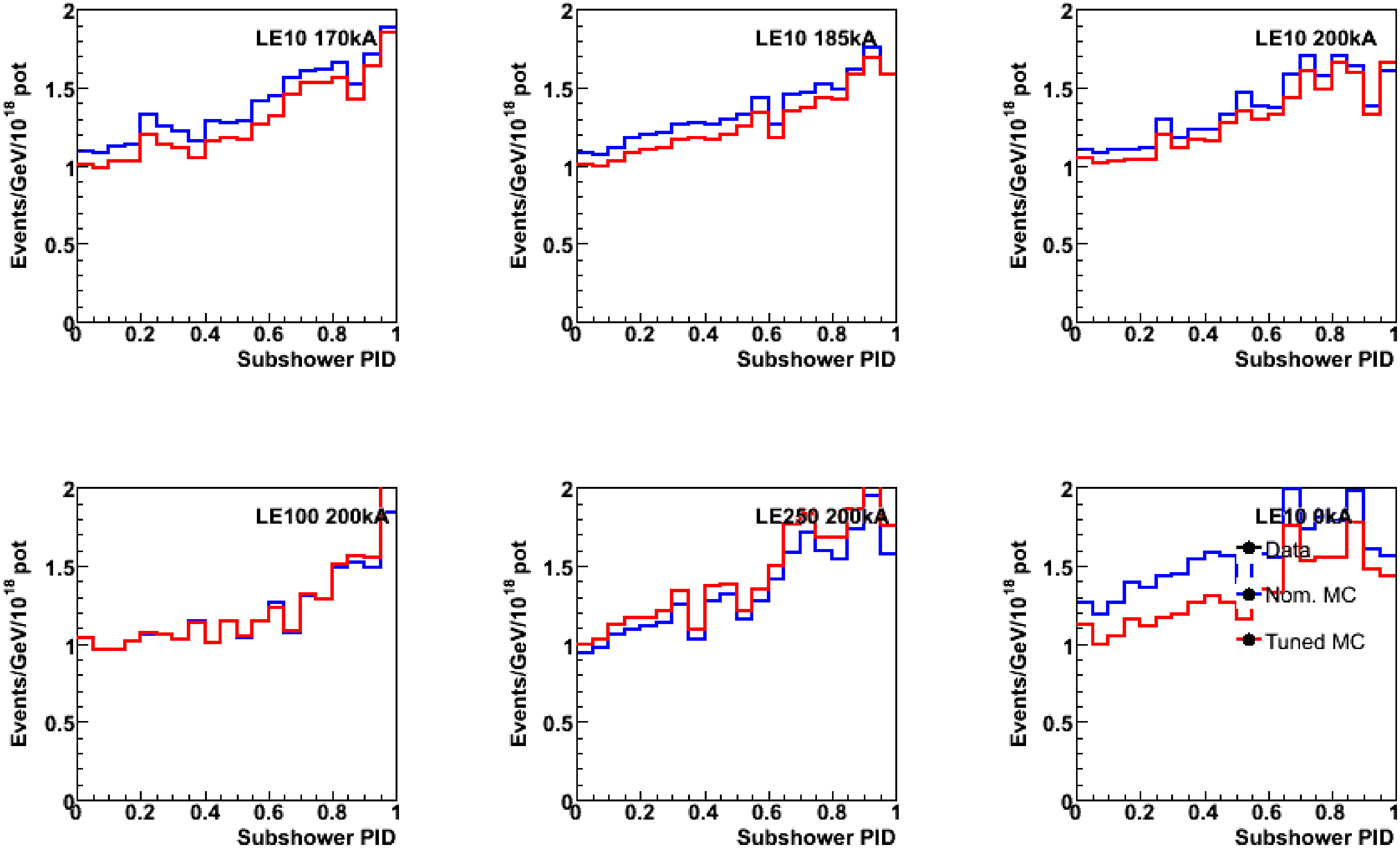
Patricia Vahle
University College London
June 5, 2006

Nue Event Selection – All beams

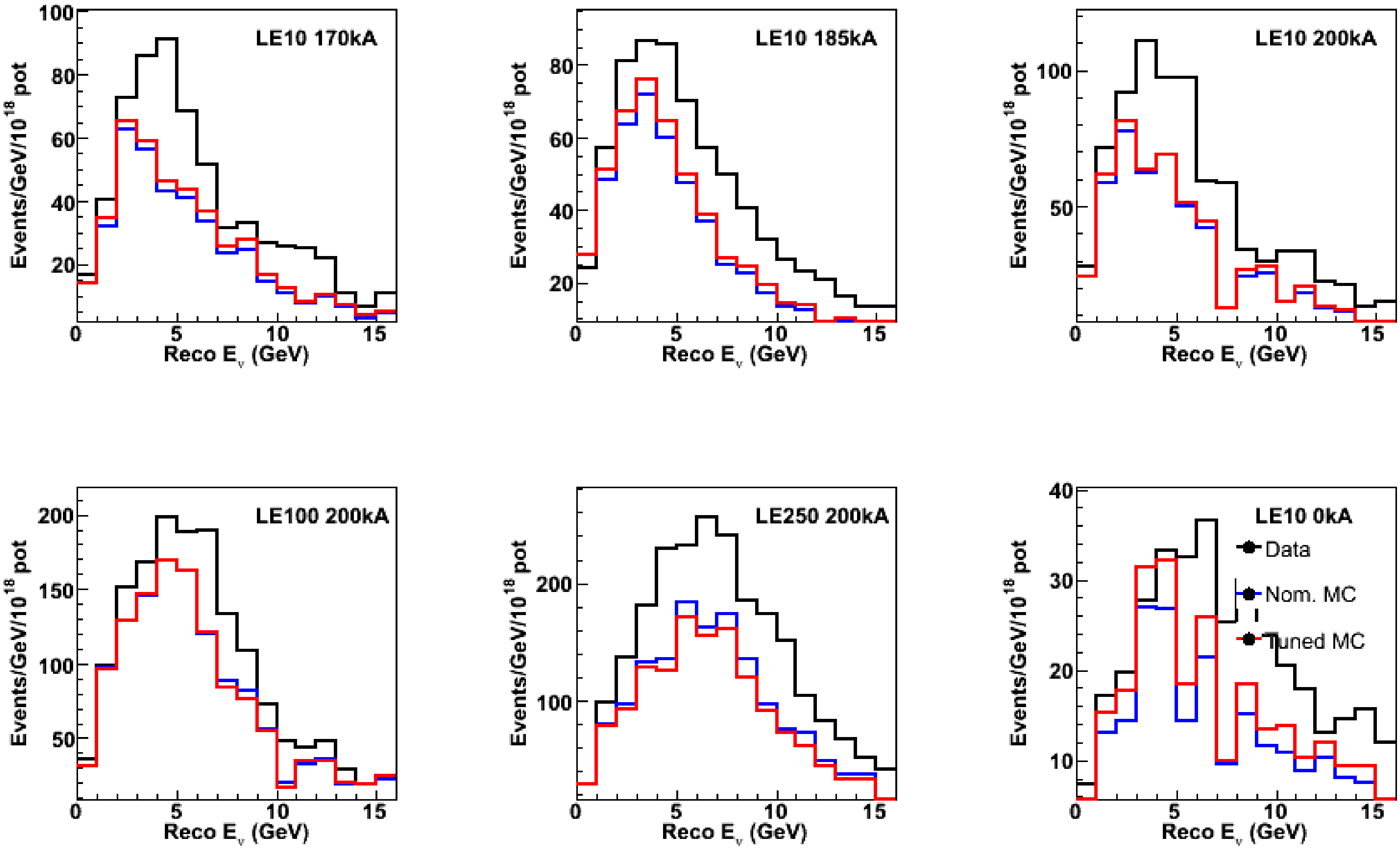
- **Fiducial Volume cut**
- **Select events with track length<25 planes**
- **Number of track like planes<16**



Data/MC PID distribution



Data vs. MC

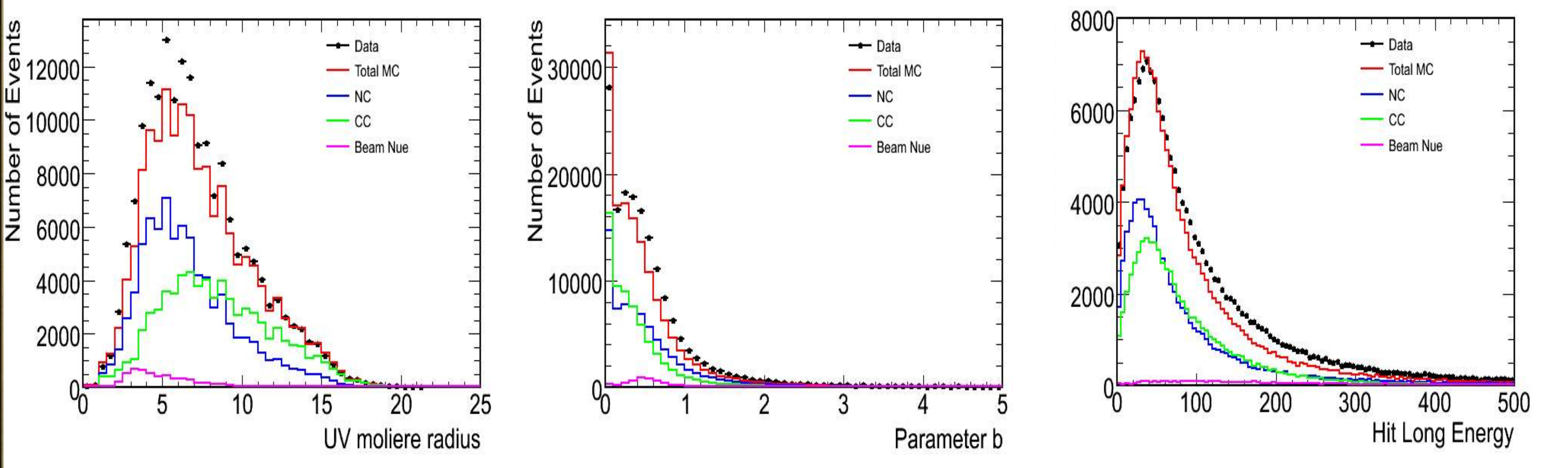

LE10 170kA
LE10 185kA
LE10 200kA
LE100 200kA
LE250 200kA
LE10 0kA
Data
Nom. MC
Tuned MC
Events/GeV/10^{18} pot
Reco E_ν (GeV)

Mayly Sanchez

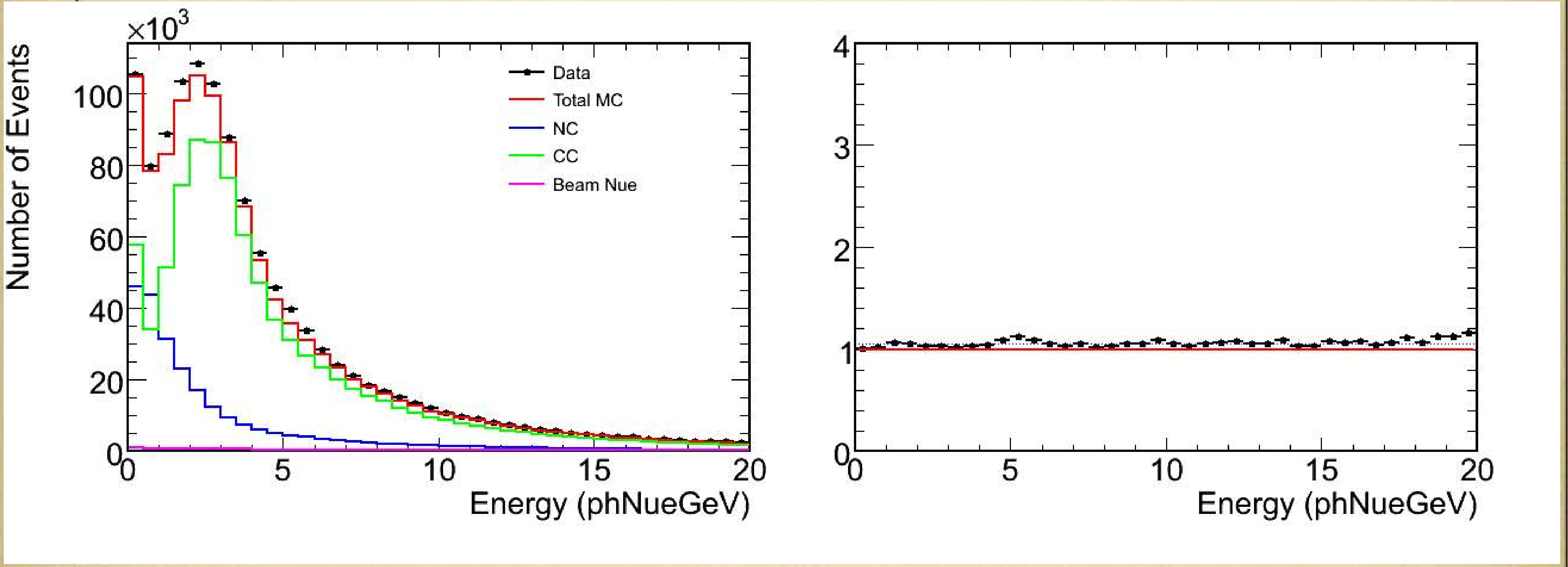
Cut PID

FOM=0.86

DataQuality && inFiducial
srtrack.planes < 25 && trklikeplanes < 16
srshower.phNueGeV > 1
1 < srevent.planes < 16
42.8 < hitcalc.fHitLongEnergy < 315
0.7 < shwfit.uv_molrad_vert < 5.13
0.26 < shwfit.par_b < 2.4

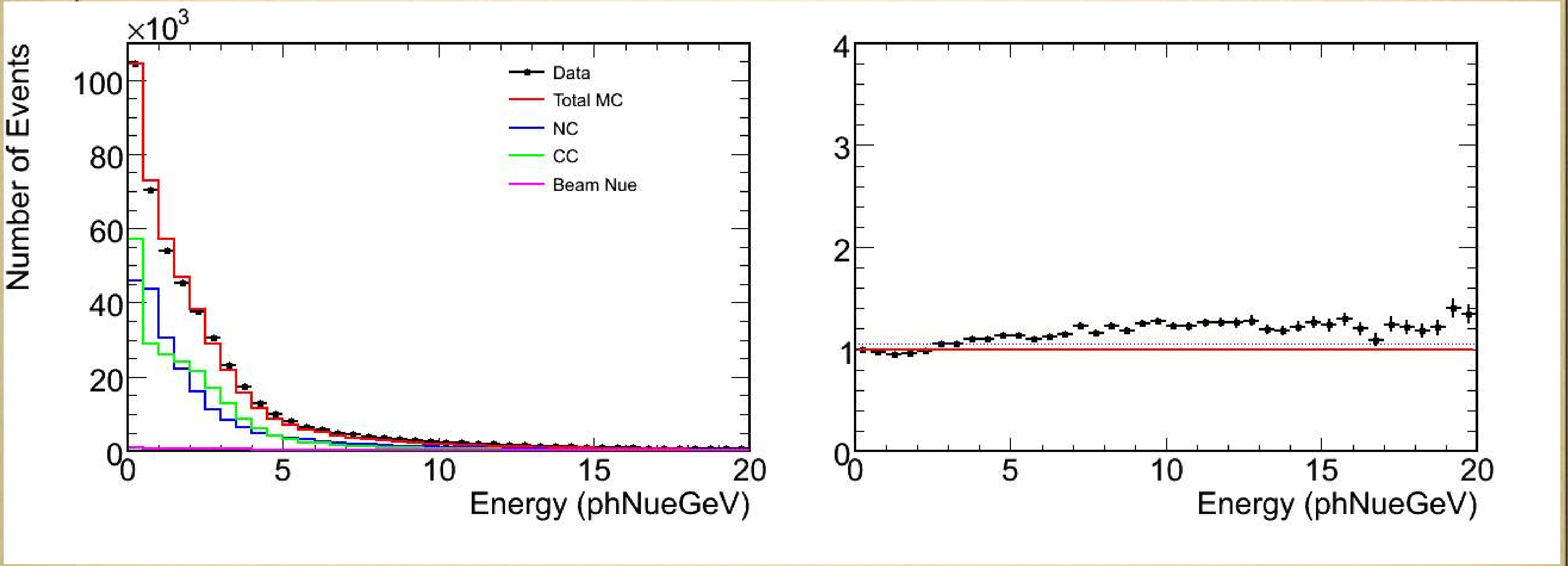


Data Quality + Fiducial Cuts



~few% discrepancy @ 5 GeV

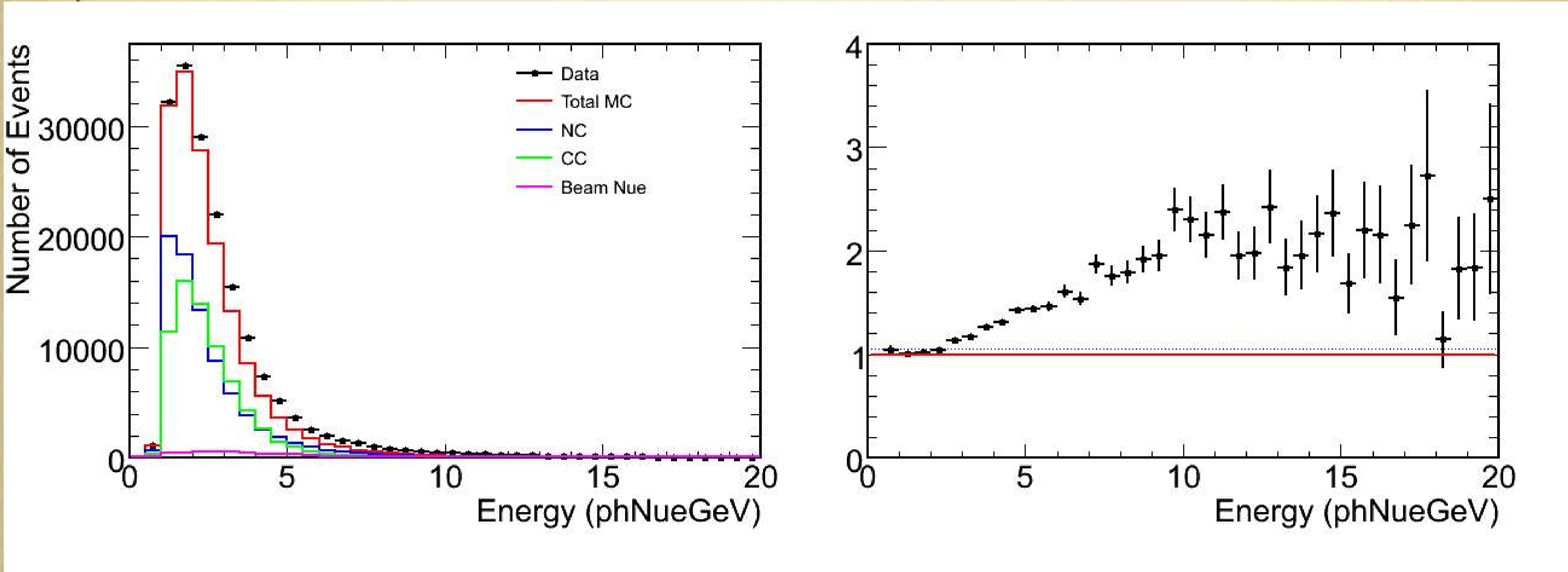
Track length > 25 planes
Track-like Planes > 16



~10% discrepancy @ 5 GeV

~20% discrepancy @10 GeV

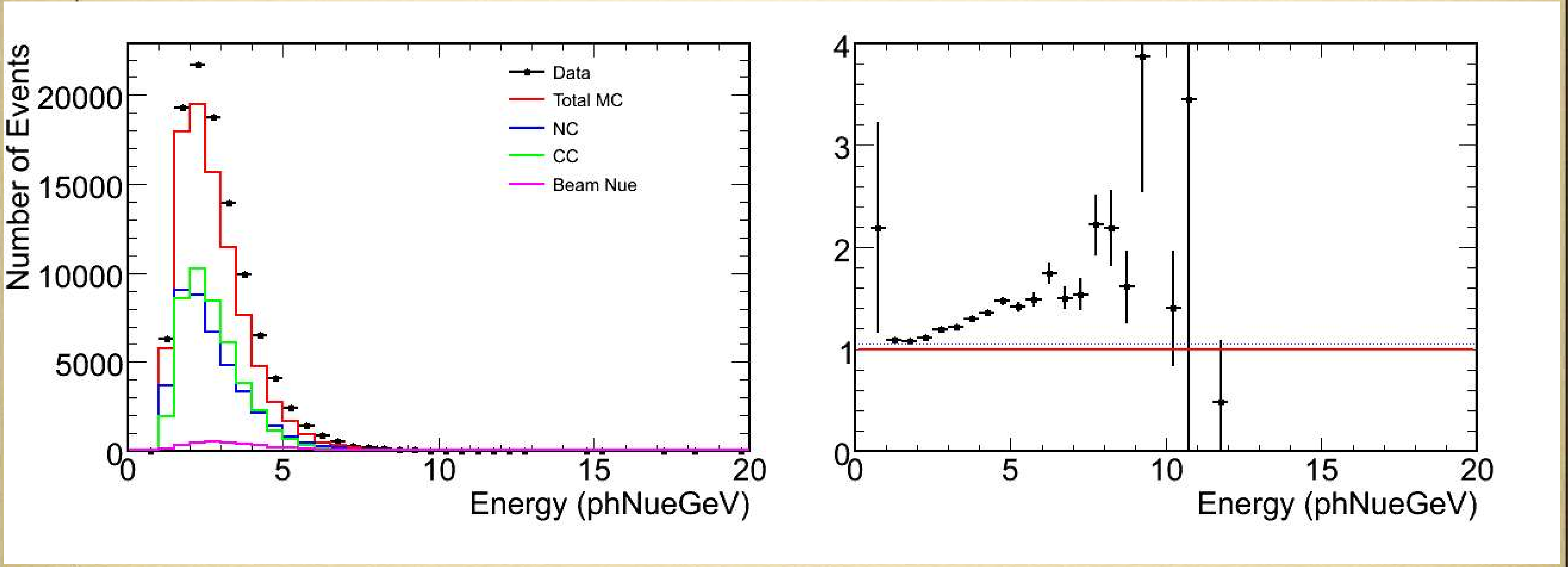
1 < Event Length < 16 (Planes)



~40% discrepancy @ 5 GeV

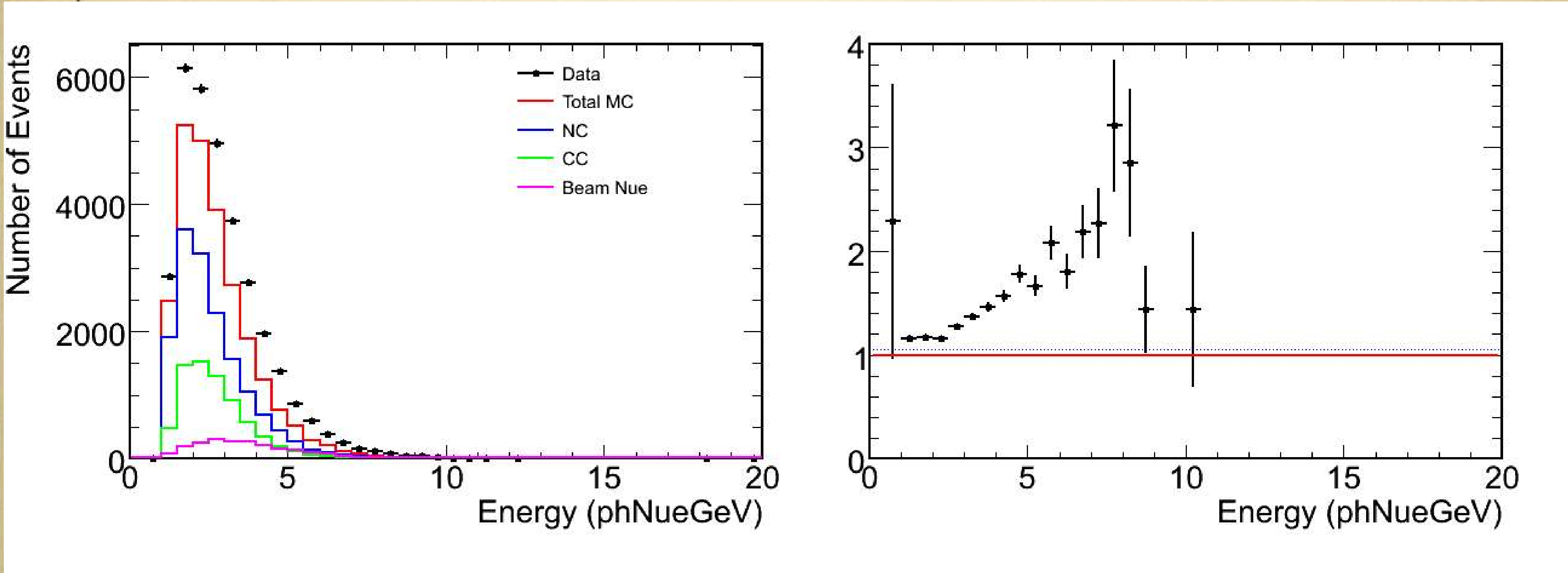
~100% discrepancy @10 GeV

42.8 < e hit long < 315



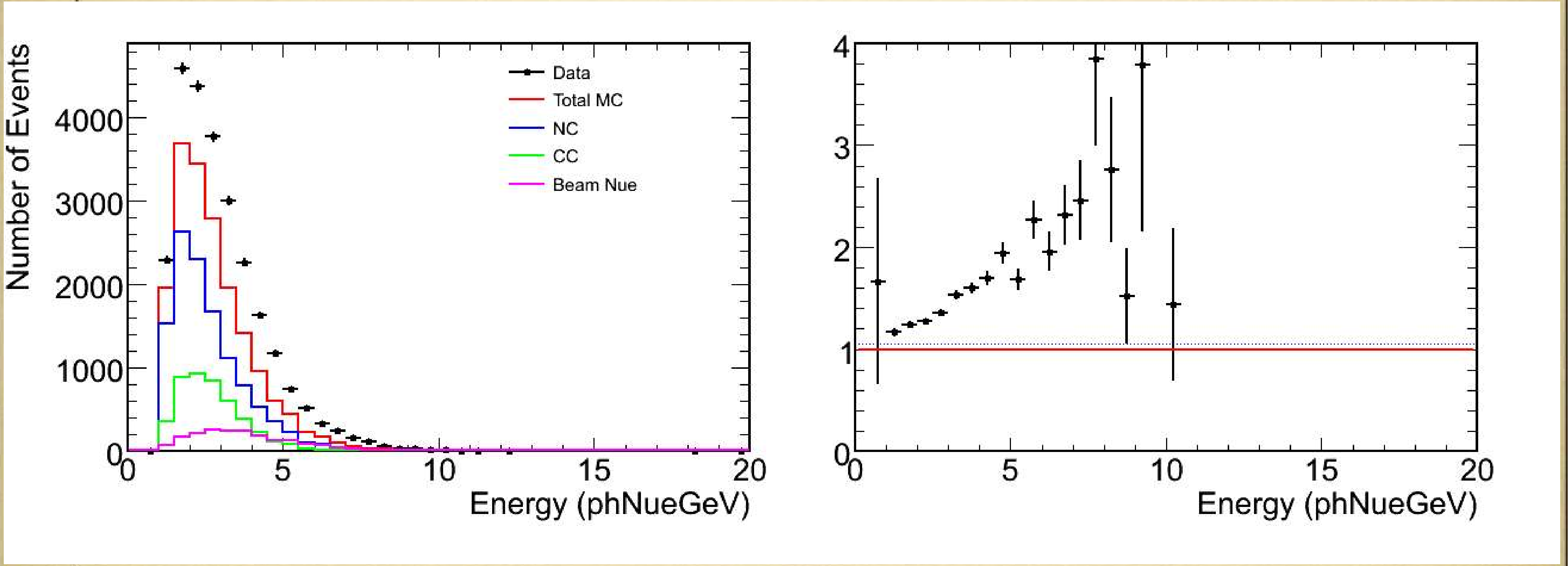
~40% discrepancy @ 5 GeV

0.7 < uv mol rad < 5.13



~60% discrepancy @ 5 GeV

0.5 < par b < 2.4



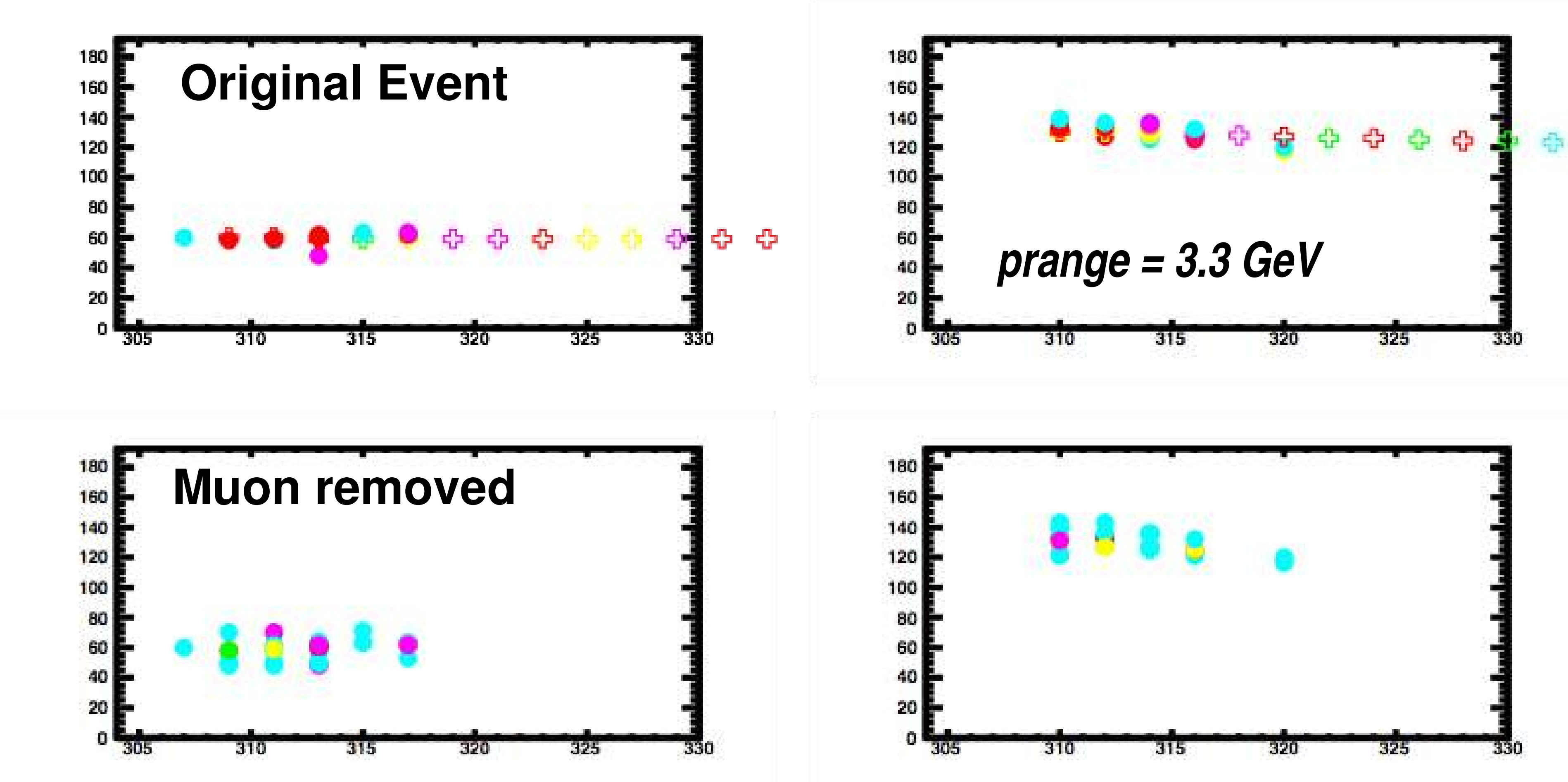
~70% discrepancy @ 5 GeV

Factor 3 @ 10 GeV

Muon Removal

Caius Howcroft

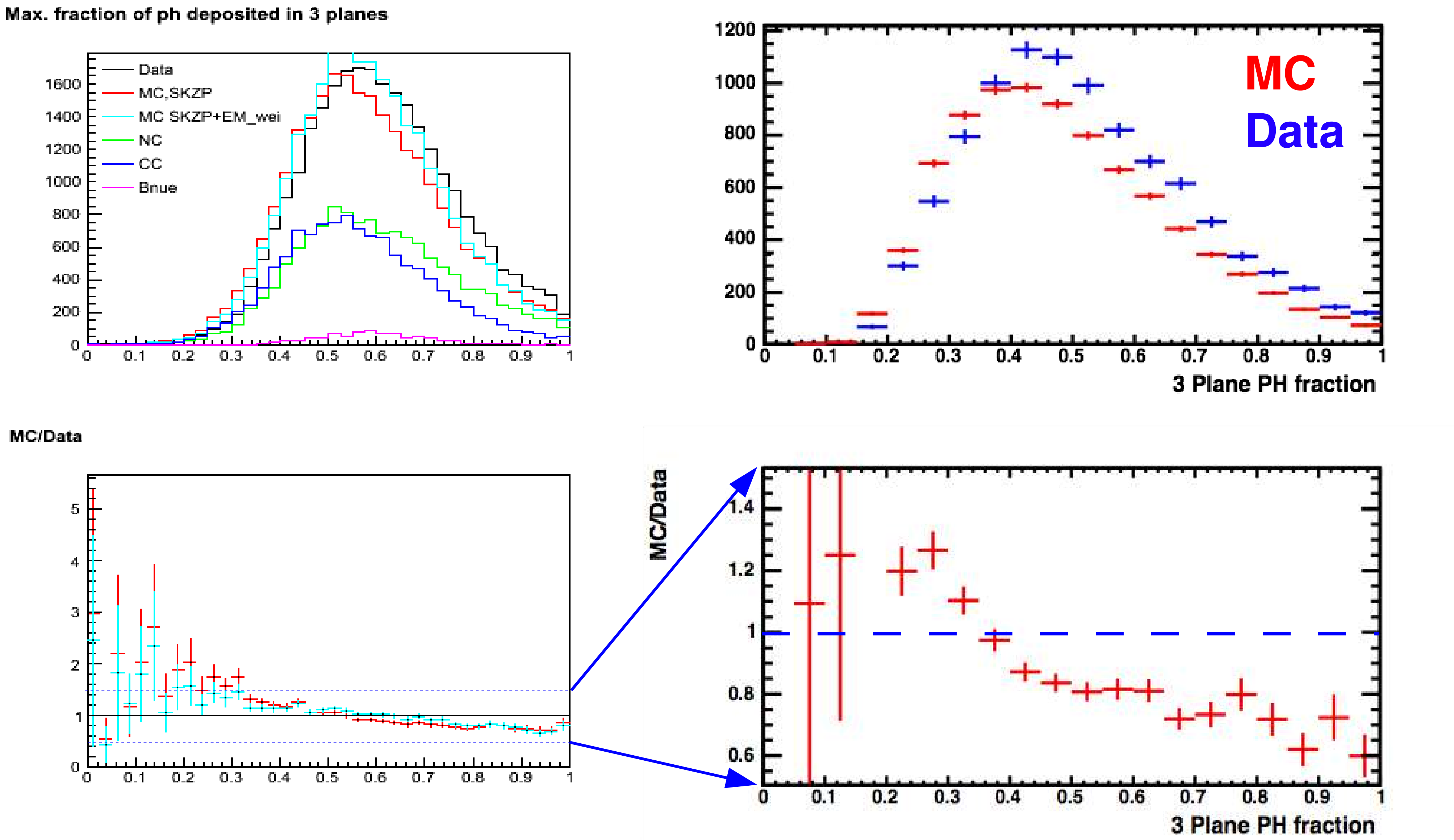
- **Select CC events, identify & remove mu -> NC-like shower**
- **Code for both detectors is available**
- **Far Detector data set ~1e20 POT.**
- **Near Det data set 5e18 POT**



EMFrac Problem

LE10 DATA & MC

MRCC DATA & MC



Effects of generator parameters on EM shower fraction

Tingjun Yang
Stanford University
Nue phone meeting, 05/09/06

- It's been demonstrated that the EM shower fraction in the MC needs to be enhanced to match the data.
- Hugh gave us 4 NEUGEN knobs to play with:
    - RHONUC – nuclear density in INTRANUKE
    - NUCRAD – coefficient r_o to determine nuclear radius according to r = r_o * A**(1/3)
    - NUCCEXFAC – the scale factor of the charge exchange probability for an intranuclear scattering interaction
    - PIZEROS – the scale factor for the pi0 generation in DIS hadronization. Doubling this doubles the probability that you get a pi0-pi0 pair relative to a pi+ - pi- pair when a charge-neutral pair of particles is produced.

I took some mc ntuples and dumped the energy of all the neutrino interactions (CC+NC) in the fiducial volume to a text file. I read in those energy values in the program and call neugen to generate neutrino interaction:

call generate_nu_event(14,e_nu,56,26)

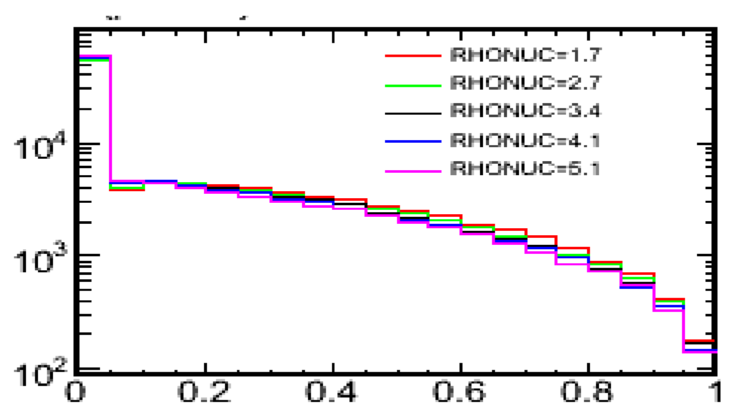
The shower energy is defined as $E\_shw = E_p + E_n + E_{p+} + E_{p-} + E_{pi0} + E_K$

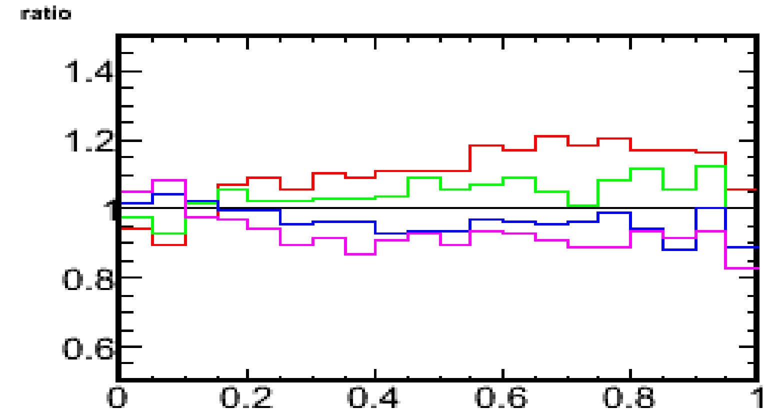
The EM shower energy is defined as $E\_em = E_{pi0}$

em_frac = E_em/E_shw

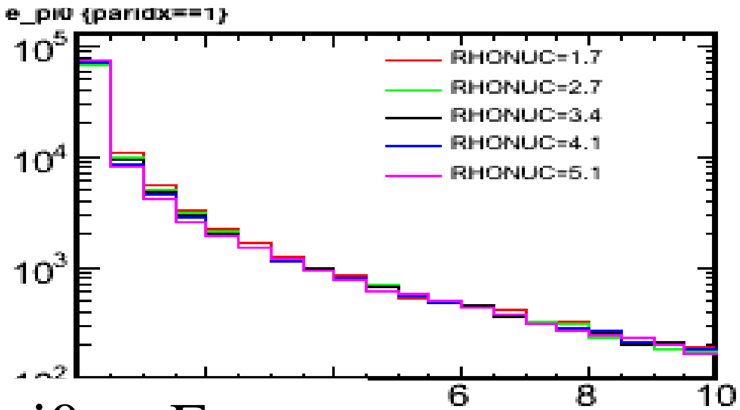
For each parameter, I tried four different values: 0.5par, 0.8par, par, 1.2par, 1.5par. (par is the default value) and I plotted three distributions with different values: em_frac, E_pi0, N_pi0 vs E_nu

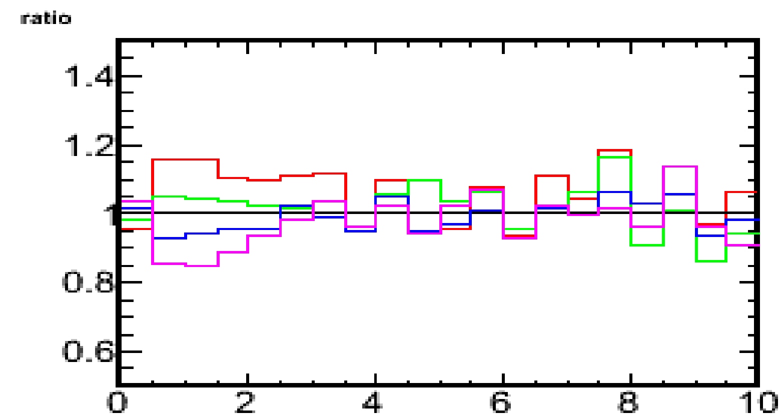
em_fract



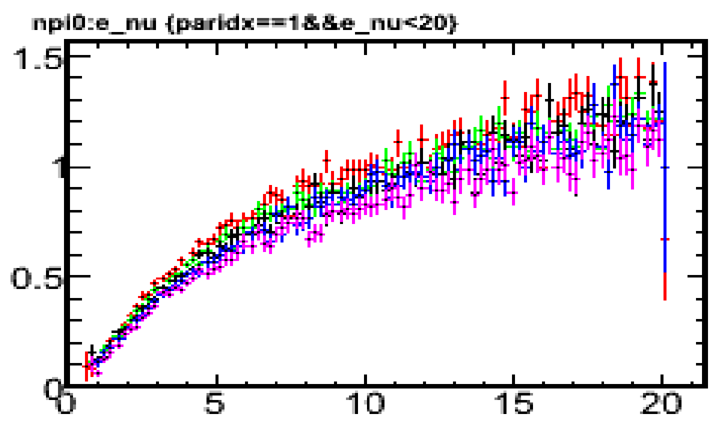


E_pi0



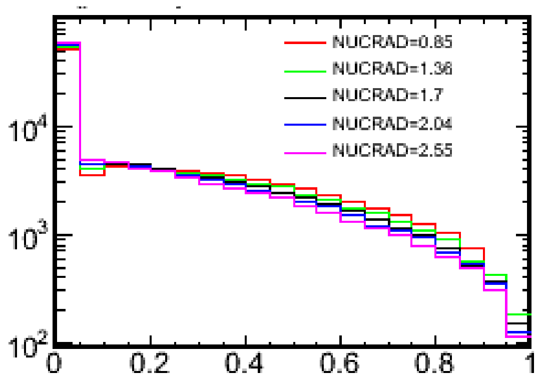


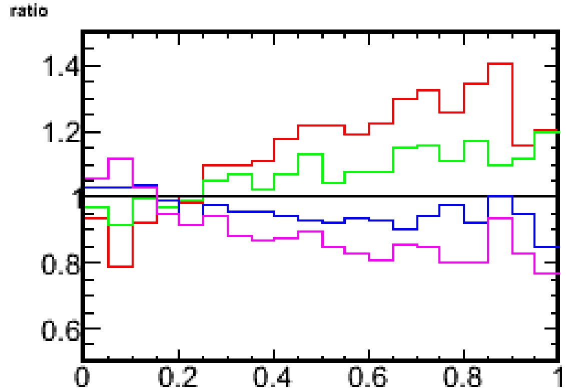
N_pi0 vs E_nu



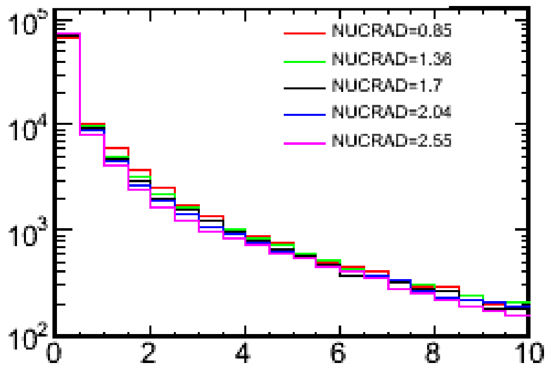
RHONUC – nuclear density in INTRANUKE

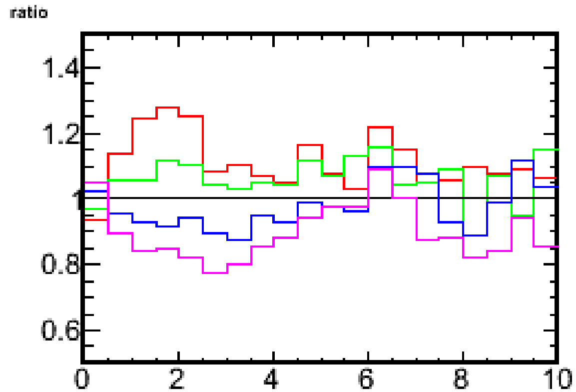
em_fract



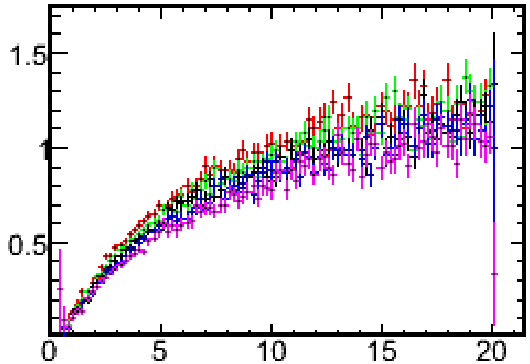


E_pi0



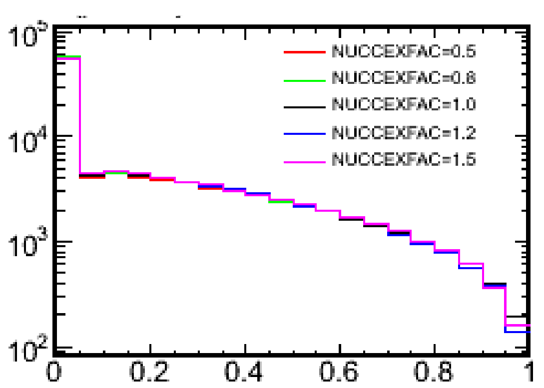


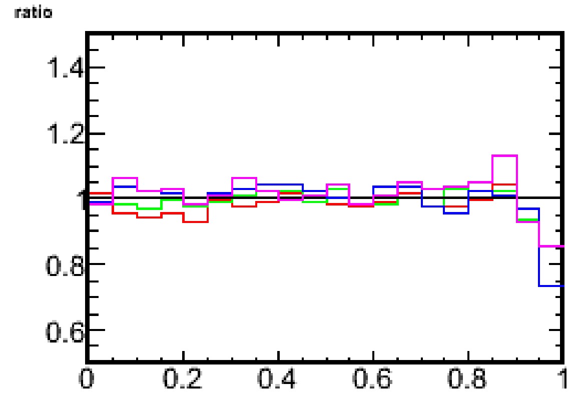
N_pi0 vs E_nu



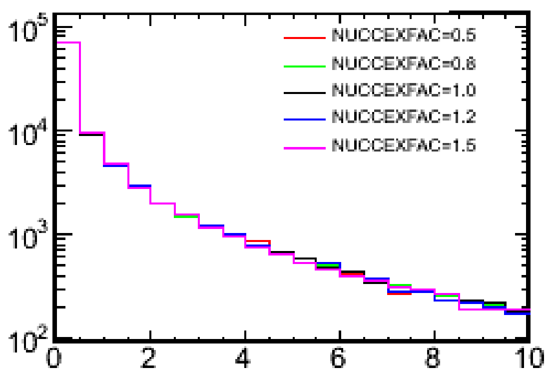
NUCRAD – coefficient r_o to determine nuclear radius according to r = r_o * A** (1/3)

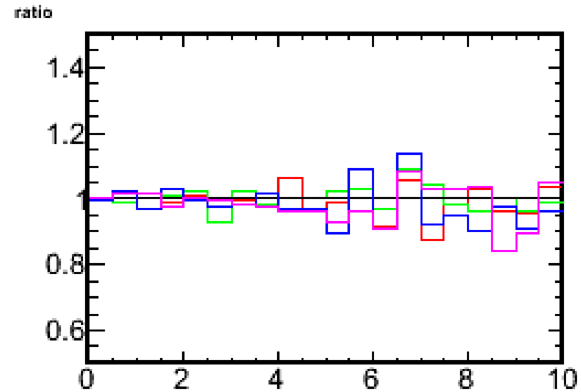
em_fract



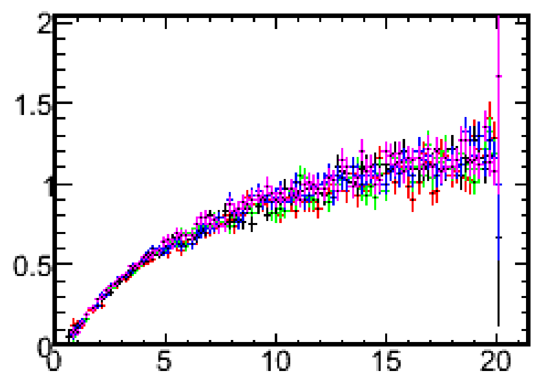


E_pi0





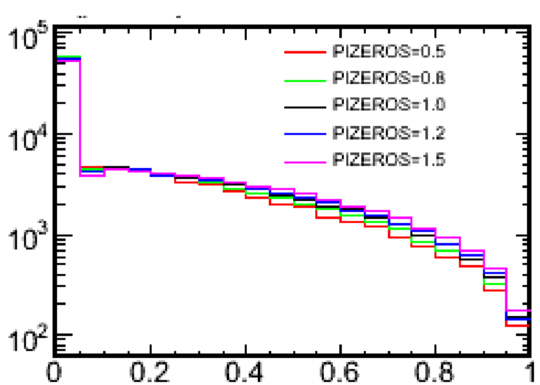
N_pi0 vs E_nu

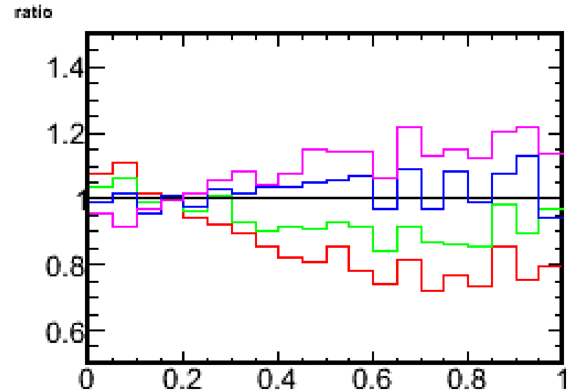


NUCCEXFAC – the scale factor of the charge exchange probability for an intranuclear scattering interaction

No effect

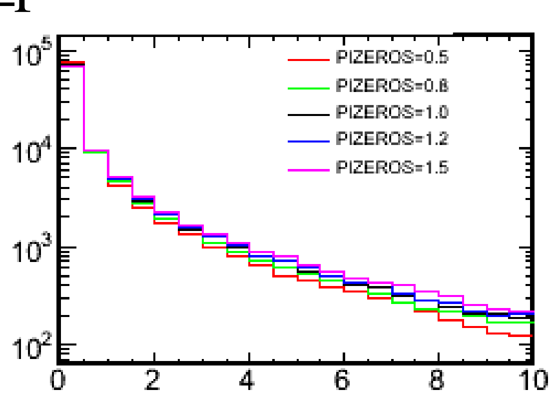
em_fract

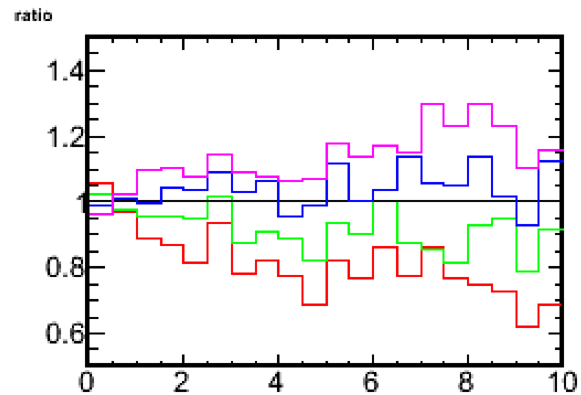




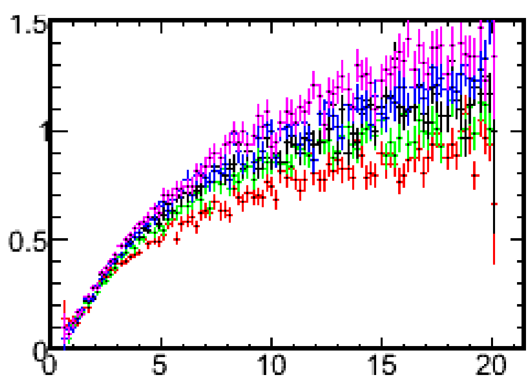
From Trish's presentation yesterday (MINOS-doc-1940), it seems that we are lacking high energy nue candidates. Tuning this parameter could give us more nue candidates in the MC.

E_pi0





N_pi0 vs E_nu



- PIZEROS – the scale factor for the pi0 generation in DIS hadronization. Doubling this doubles the probability that you get a pi0-pi0 pair relative to a pi+ - pi- pair when a charge-neutral pair of particles is produced.

Summary

- There is a large data/MC discrepancy in the energy spectrum of shower-like events
  - This discrepancy can be enhanced by selecting em-like showers
  - A similar effect can be seen in the hadronic showers of numu CC events (as highlighted by the MRCC)
  - At higher energies, beam nue purity of nue selected sample becomes much higher and data/MC discrepancy reduces
  - Points to problems in the hadronization model and in particular pi zero production

The Plan

- Implement new event selections which have different background contributions (0 pi0, 1pi0, multi-pi events, etc) to try to pin down the EMFrac discrepancy
- Study showers in numu CC events and characterize developmental differences
  - Select high purity sample
  - Have handle on kinematic quantities
- Generate new MC sample with some of the pi0 related tweaks