Constraining The ME Flux

Wenting Tan

Hampton University
19th Nov 2012

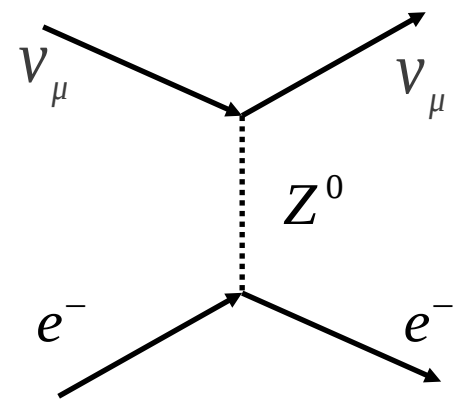
Neutrino Electron Elastic Scattering

Theoretical Prediction

$$\nu_\mu + e^- \rightarrow \nu_\mu + e^-$$

$$\frac{dN(T)}{dT} = \int dE_\nu \frac{d\Phi(E_\nu)}{dE_\nu} \frac{d\sigma(T, E_\nu)}{dT}$$

$$= Acceptance \times \sum_j \frac{d\Phi_j(E_\nu)}{dE_\nu} \Delta E_{\nu j} \times \frac{d\sigma(T, E_{\nu j})}{dT}$$



T: Scattered Electron Kinetic Energy

Absolute Event Rate

$for\ \nu_\mu$

Theoretically

$$Flux\left(\frac{Neutrinos}{m^2\times 12\times 10^{20}\,POT}\right)\times 0.15\times 10^{-43}\left(\frac{E_\nu}{10\,Mev}\right)cm^2\times 1.98\times 10^{30}$$

$$= \sum_1^{500}\left(\frac{Neutrinos\left(E_\nu\right)}{m^2}\right)\times 0.15\times 10^{-43}\left(\frac{E_\nu}{10\,Mev}\right)cm^2\times\Delta E_\nu\times 1.98\times 10^{30}\left(per\ 12\times 10^{20}\,POT\right)$$

= 2774 (per 20E20 POT)

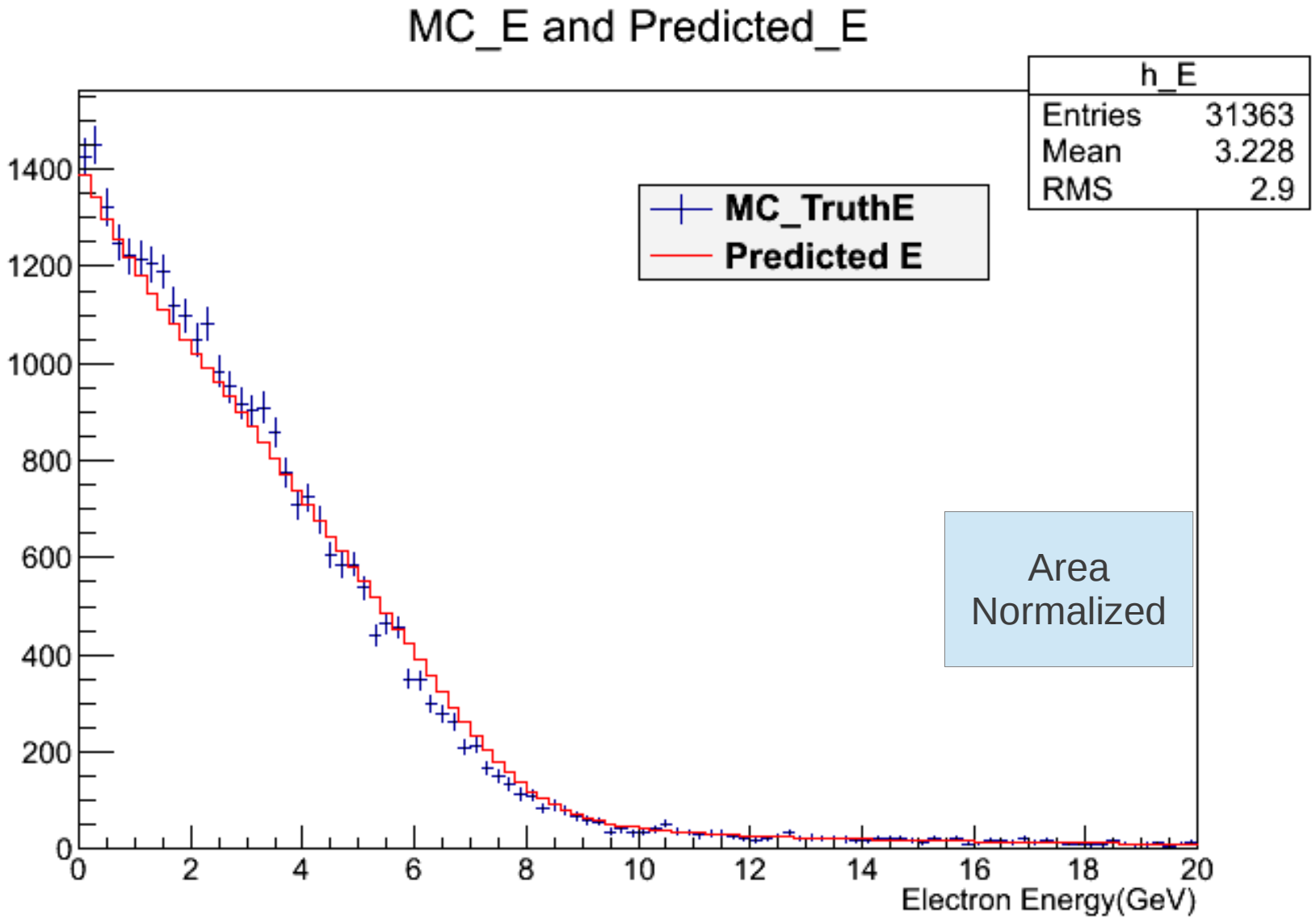
Monte Carlo

Full Chain Simulation: Genie->Cal->Reco->ANA->EMShower(Jaewon's reco tool)->
Event selected in Tracking Fiducial. Mod: 25-84

3136 (per 20E20 POT)

Reference : http://personalpages.to.infn.it/~kotzinia/lectures/pdf/l6-neutrino.pdf

Electron Energy Spectrum



Predicted E comes from the Theory(slides 2), details in previous talks:7899-v1(slides 5)

Difference Between MC and Prediction

- Flux version for theoretical prediction:

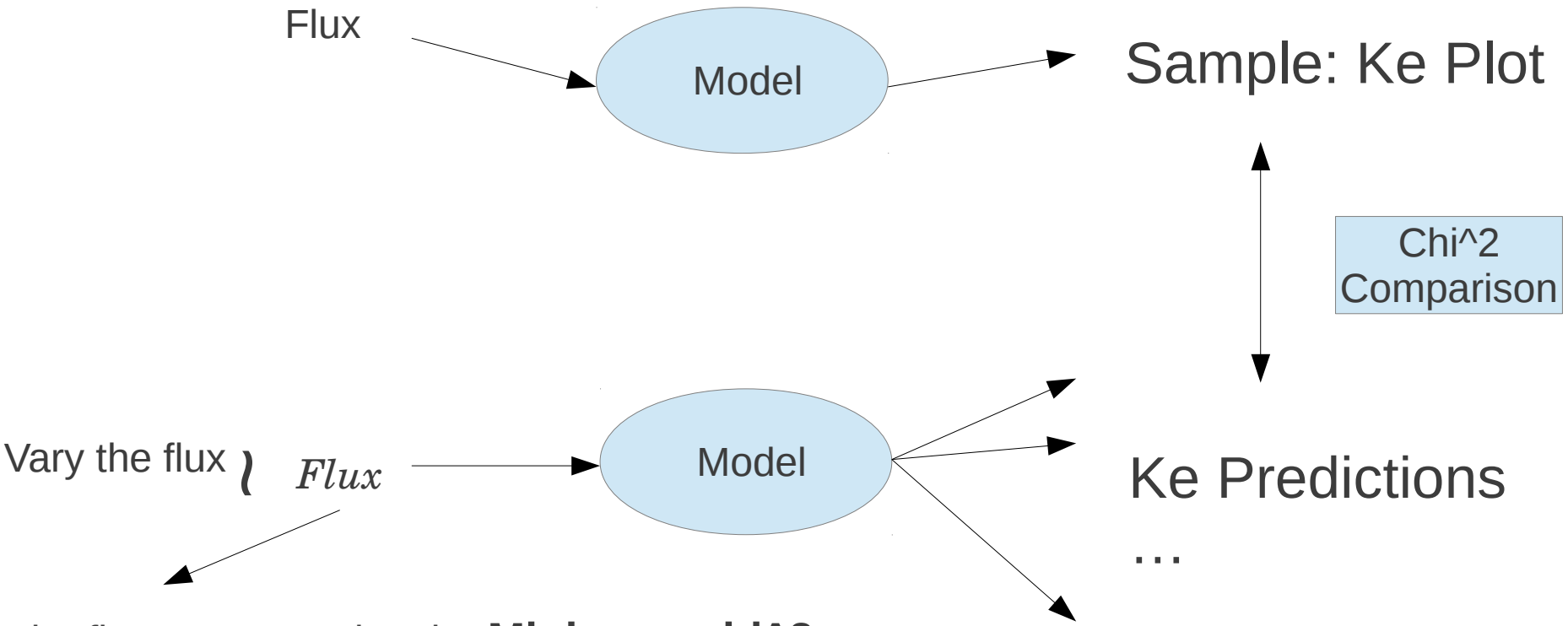
  Document : MINERvA-doc-2004-v3

- Flux in Genie is a different version:

  Leo is extracting the flux file

Later the plot of electron spectrum from the prediction(using Leo's new flux) and MC will be got, they are expected to be more consistent.

Fitting Tool Developing

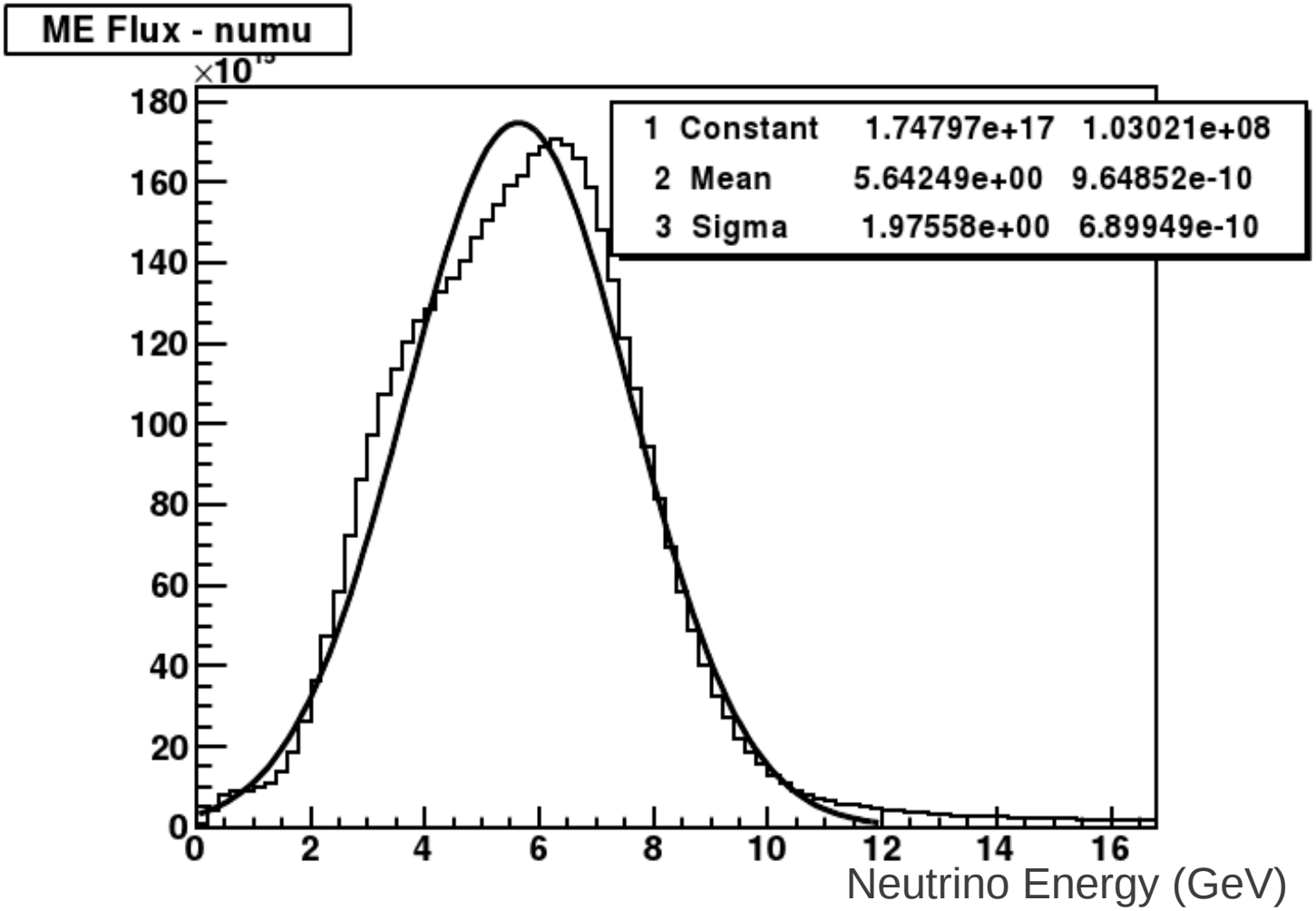


The flux correspond to the **Minimum chi^2** should be consistent with the flux we want to fit from the Ke data

Study on single Gaussian flux

Single Gaussian,
3 Parameters

Actual Triple
Gaussian Later



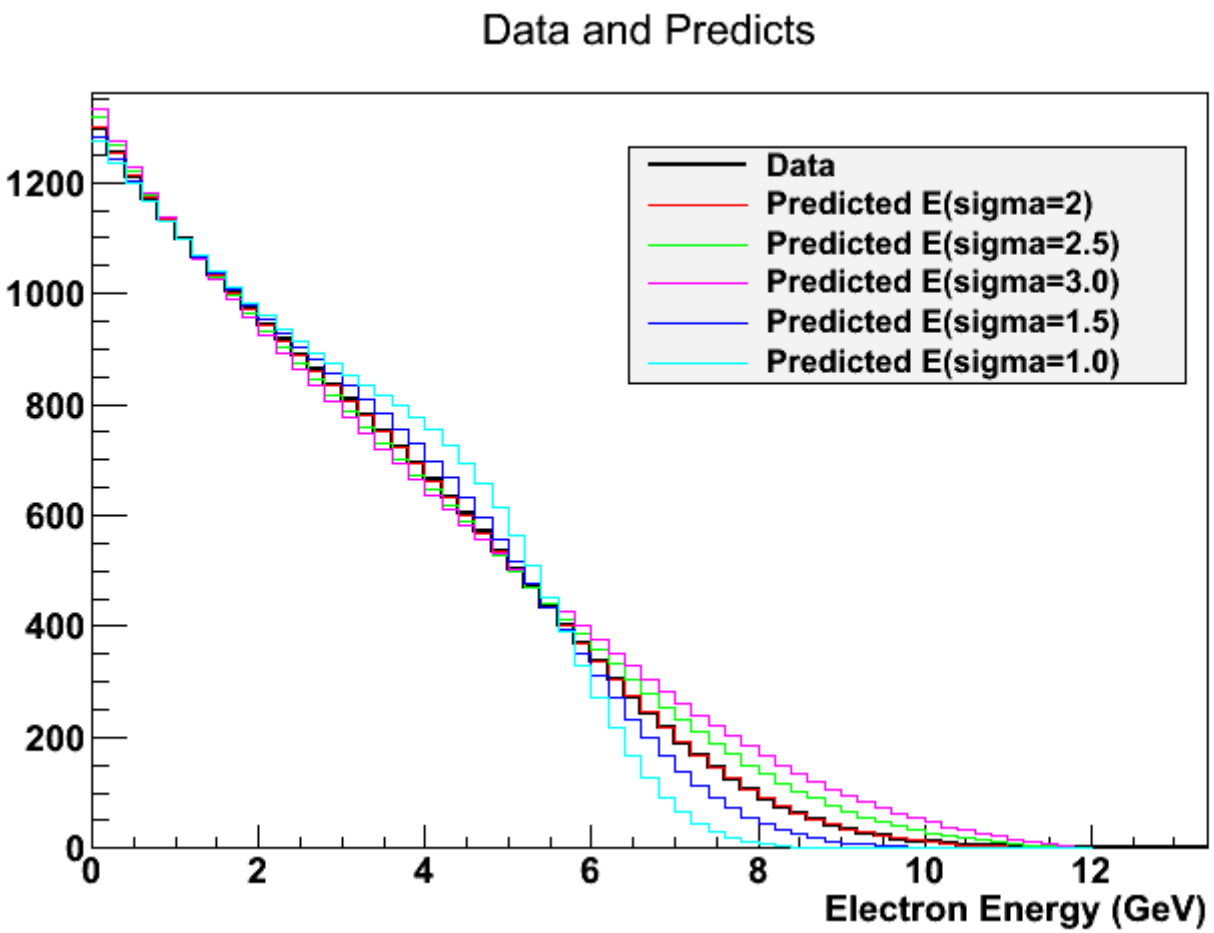
From this flux, we can generate a Ke plot → Ke Data

Amplitude: 1.74797e+17
Mean: 5.64
Sigma: 1.98 ->Free Par

Area Normalized

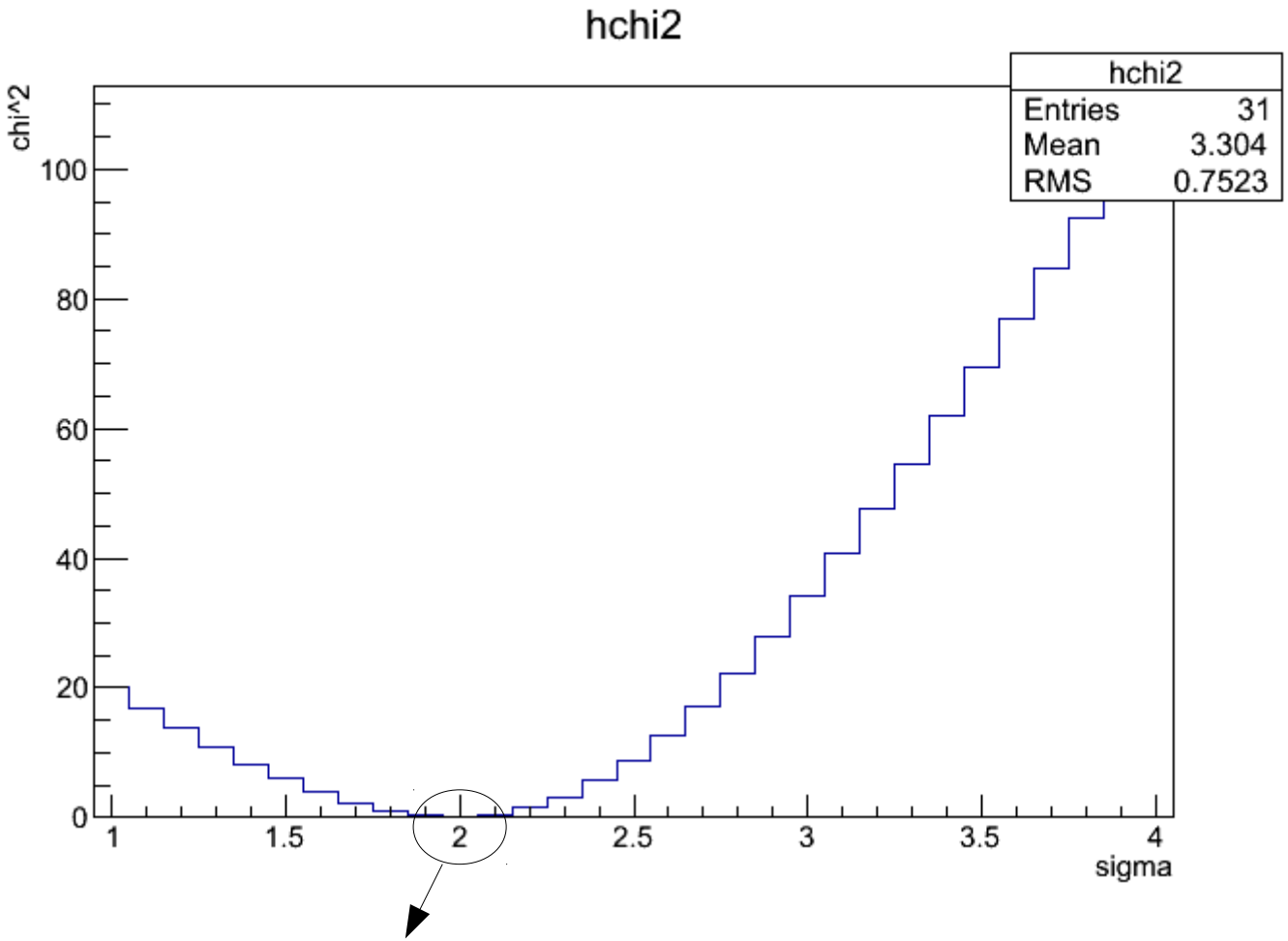
Vary Sigma from 1.0 to 4.0, Input disturbed fluxes into Model to get Ke predictions.

Then compare those with DATA



Fitting Manually

Chi^2 histogram of Data and Predicts

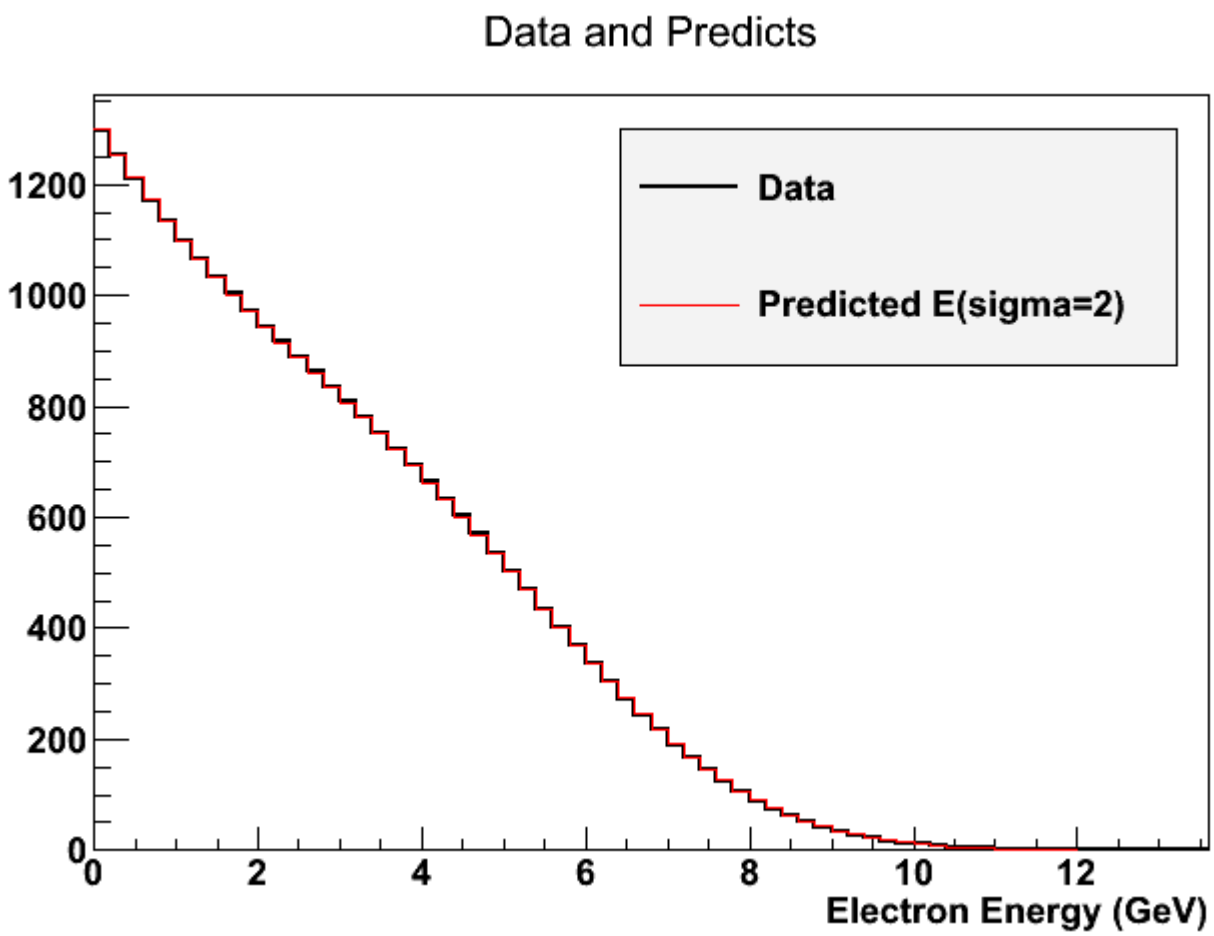


Fitted Sigma: 2

True Sigma: 1.98

For Visually Check

Plot Fitted Ke (w.r.t Sigma=2) and Data



Pretty Consistent

Fitting by TMINUIT in ROOT (Automatically)

Smooth Sample (area normalized)

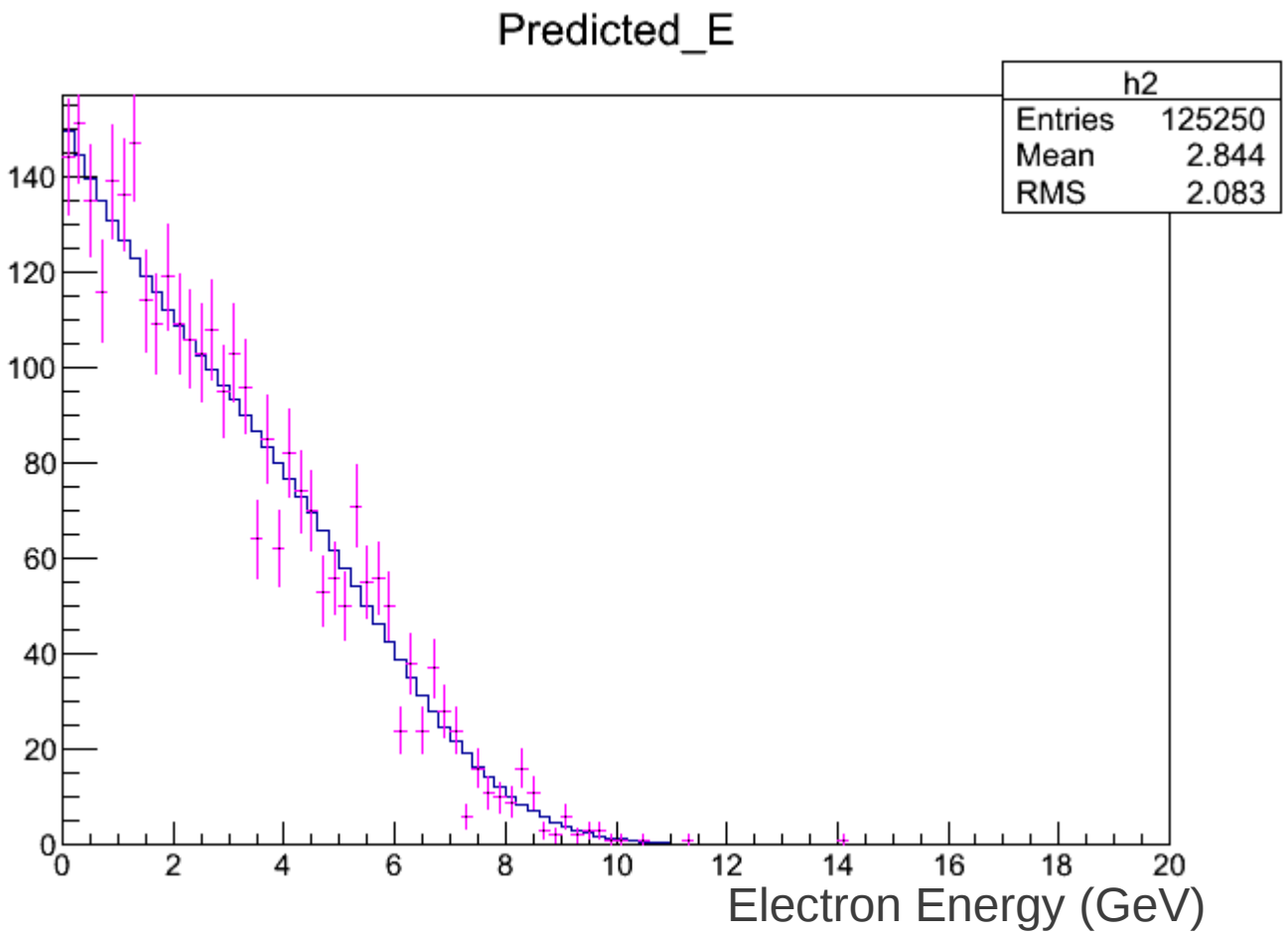
TruthSigma (Fixed m=5.6; a=17.480e16)	1.1	1.2	1.3	1.4	1.5
FitSigma	1.101	1.200	1.309	1.406	1.501

TruthMean (Fixed s=1.5; a=17.480e16)	5.6	5.7	5.8	5.9	6.0
FitMean	5.600	5.700	5.800	5.900	6.000

Fitting result looks consistent on smooth curve fitting

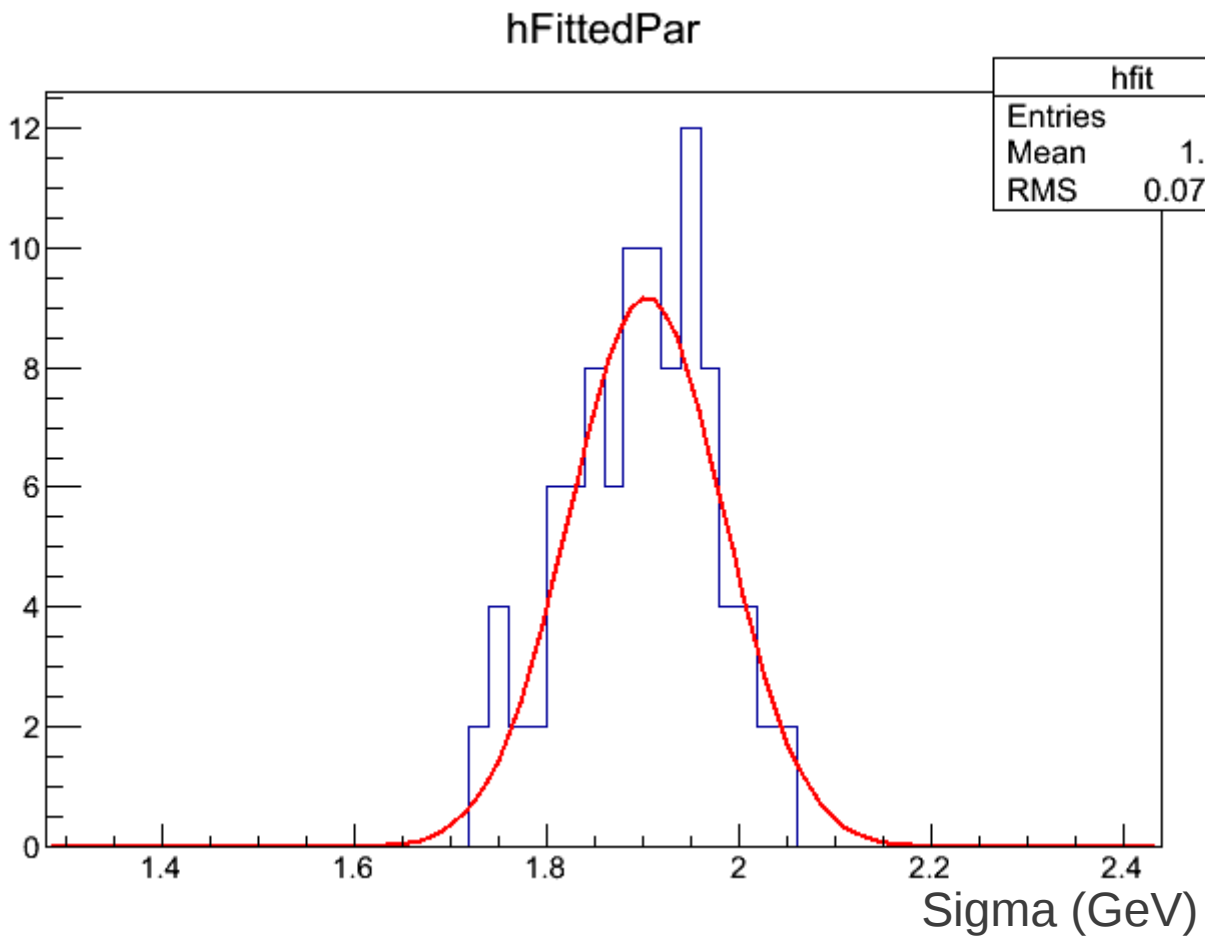
Fitting by TMINUIT in ROOT

To be more practical, we sampled a set of data from smooth Ke histogram,
with the Gaussian distributed error, then normalize it to 3136 events -- True Event rate



is the data we
want to use for fitting

100 Sets of Data(same randomly sampling): Fitted Sigma Histogram



Fitting Result

Mean: 1.904

True Mean: 1.98

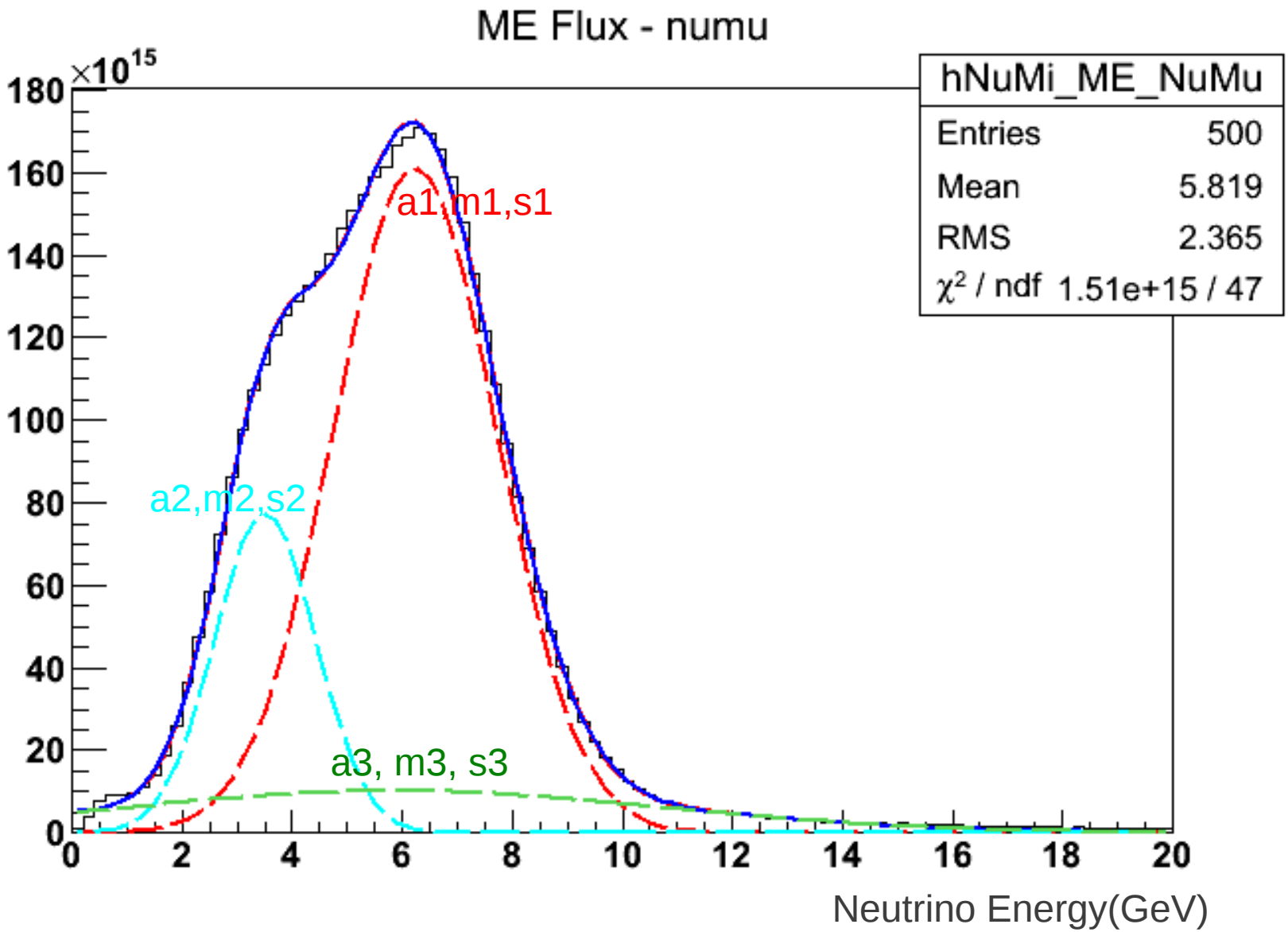
1Sigma: 0.080

Estimated error

Need to study on errors

Parameterize Flux

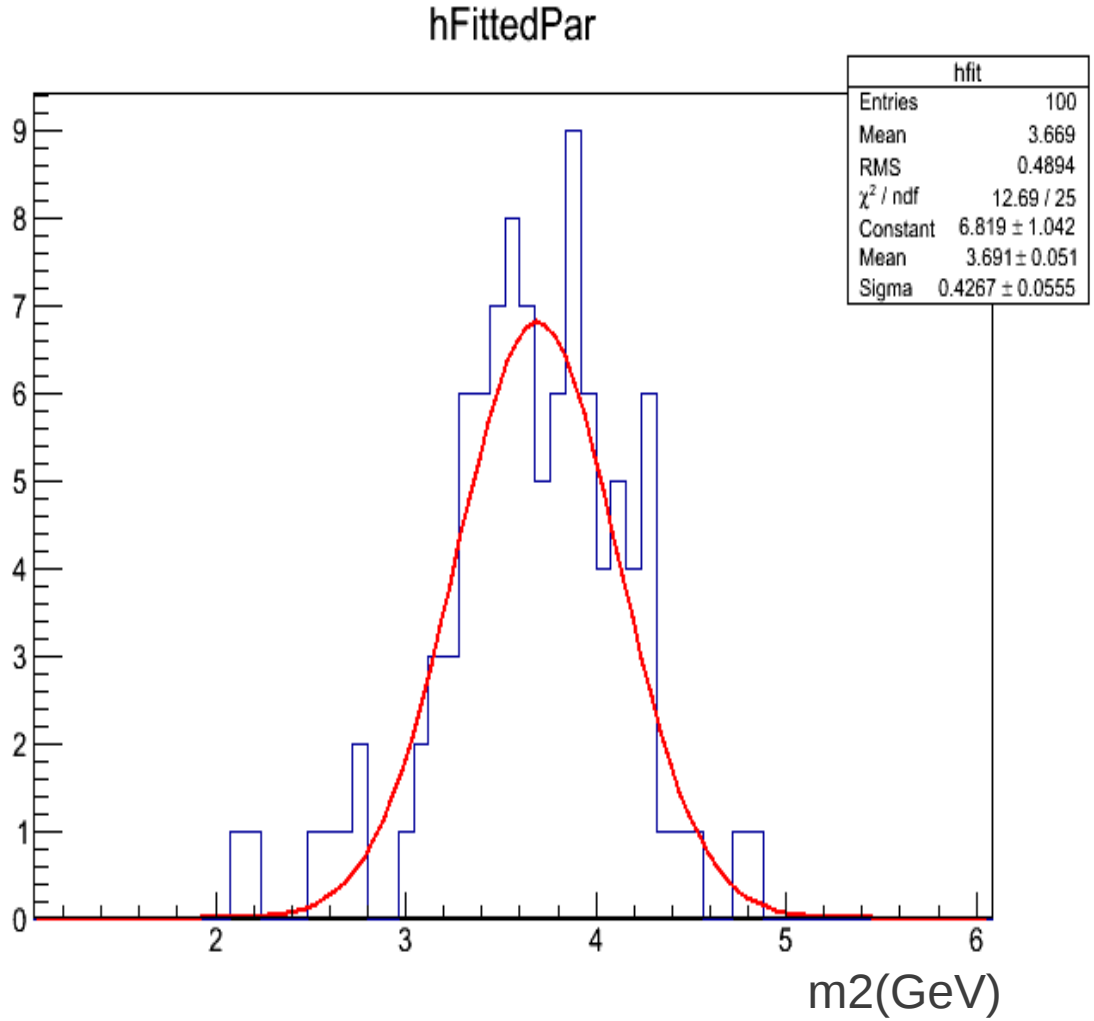
3 Gaussian,
9 Parameters



TMinuit Fitting Parameters

Ramdom Sample Size: 3136; 100 sets of sample

Name	Value	TMinuit Fitting Mean	Fitted Par Hist Gaus 1sigma
a1	1.610e+17	Fixed--	--
m1	6.229	6.116	0.137
s1	1.489	1.363	0.119
a2	7.731e+16	Fixed--	--
m2	3.502	3.691	0.428
s2	0.922	2.240	1.034
a3	1.021e+16	Fixed--	--
m3	5.847	5.344	0.935
s3	4.867	4.673	0.390



To fit parameters one by one, fix others when fitting a single one

MC Study on nu e Channel

ME nu e signal sample: 200E20 POT ~ 10 times of the real

Variables Jaewon's Rough Reco Cut:

Fiducial Events

truth_fiducial_evt (The event in MC is generated in the Tracking fiducial, Mod: 25-84)

To Remove Bad Reconstructions

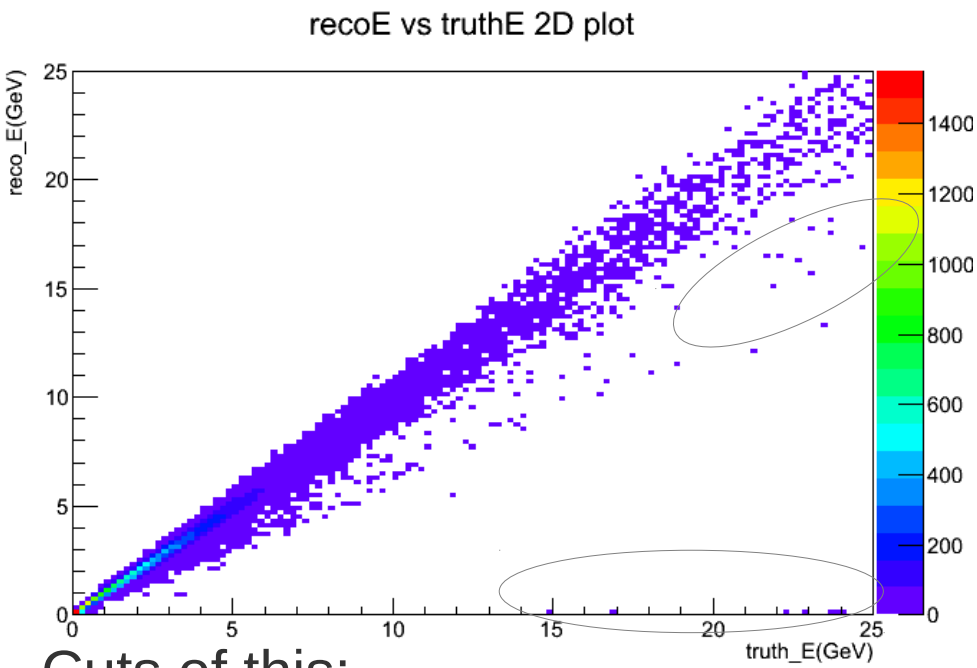
XzUzDiff XzVzDiff chi2PerDoF(Next Page)

To Remove Backgrounds

vtx_mod neighborhoodEnergy/recoE_s

Details in Jaewon's Talks

Reco E vs Truth E in Fiducial



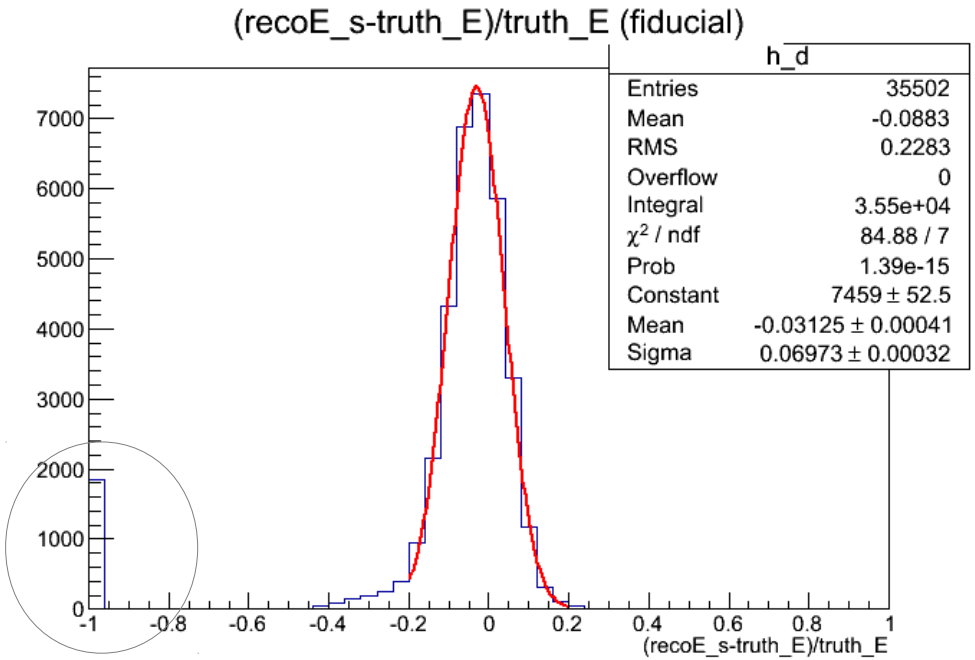
Cuts of this:

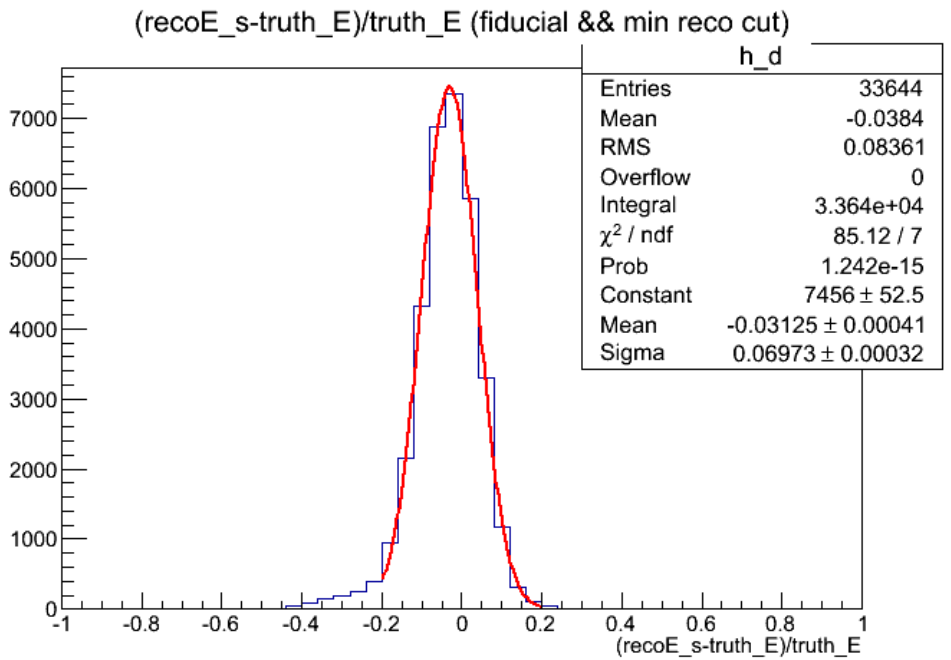
Not too big |XzUzDiff| (in z direction, X and U plane difference in Mod) and |XzVzDiff|

Reasonable chi2PerDoF (should be reasonable, bigger than 0)

Remove some outliers

Reco Energy Resolution in Fiducial





Cuts of this:

Not too big |XzUzDiff| |XzVzDiff|

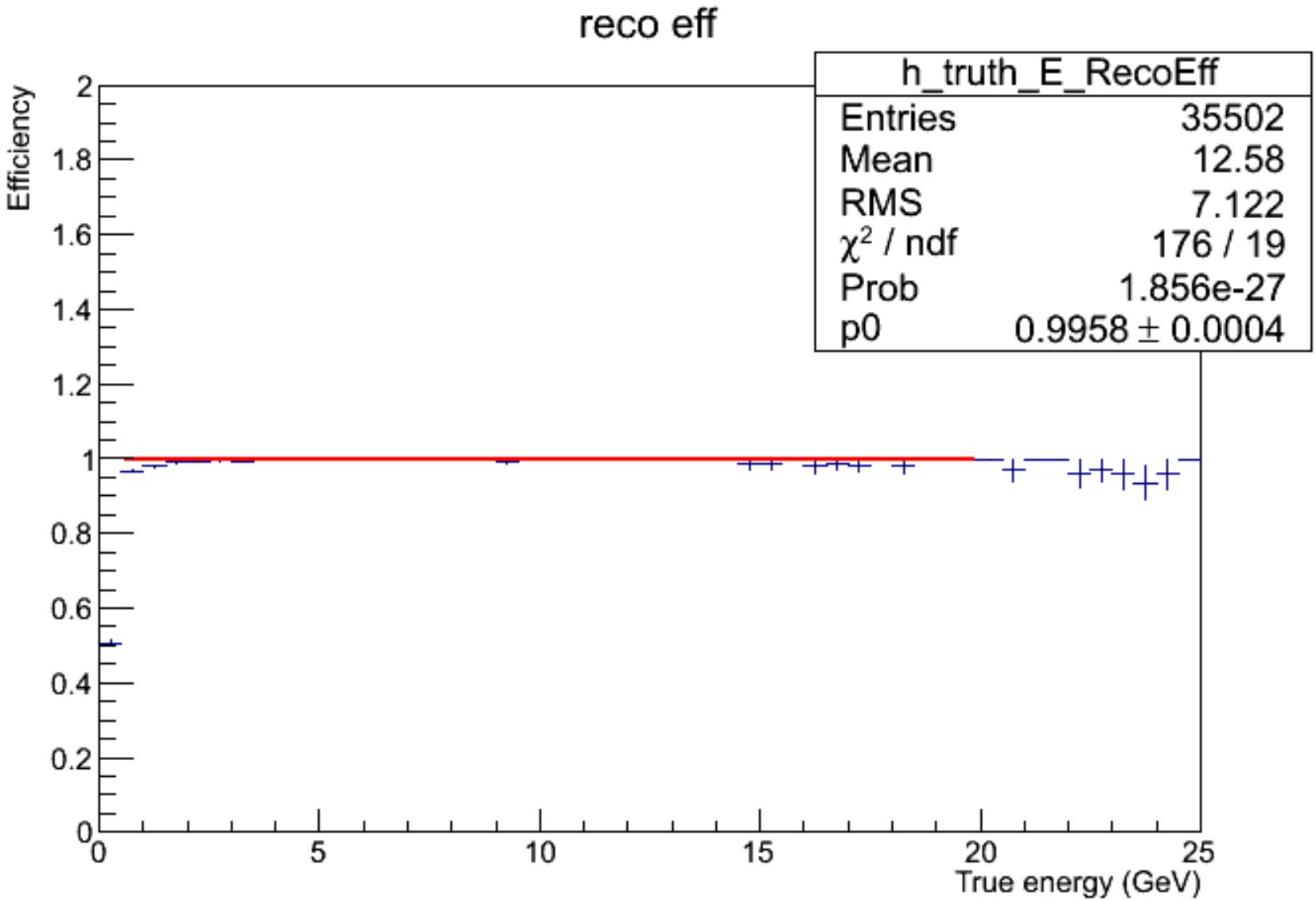
Reasonable chi2PerDoF

Remove failed reconstructions

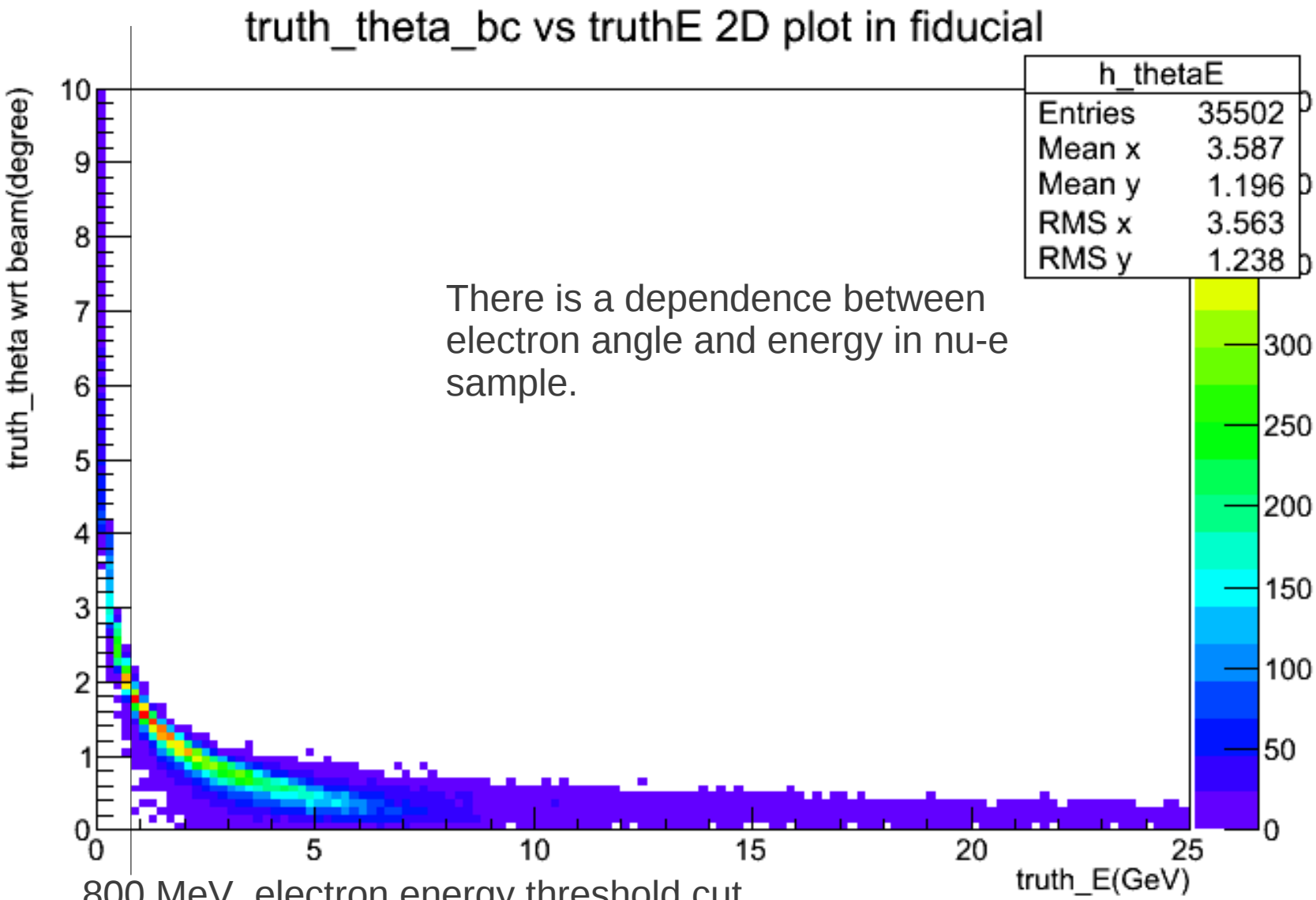
Reconstruction Efficiency in Fiducial

Fraction of two histograms in each bin: $$\frac{histo_{with\,reco\,cuts}}{histo_{origianl}}$$

Energy Efficiency:



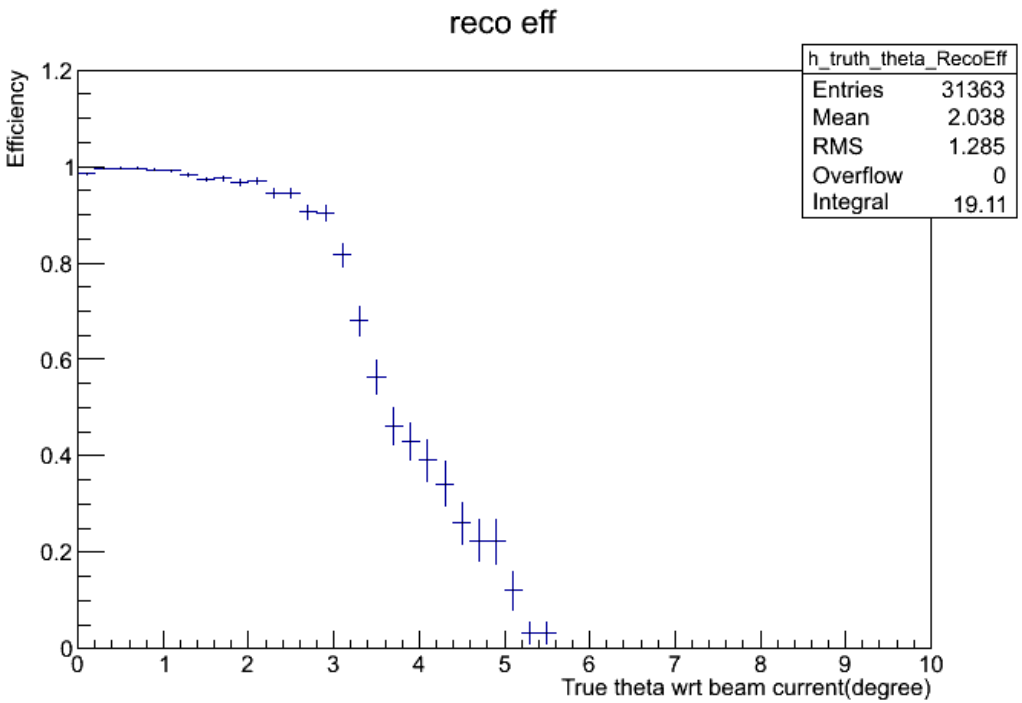
Related Angle and Energy, Truth_theta_bc vs Truth-E

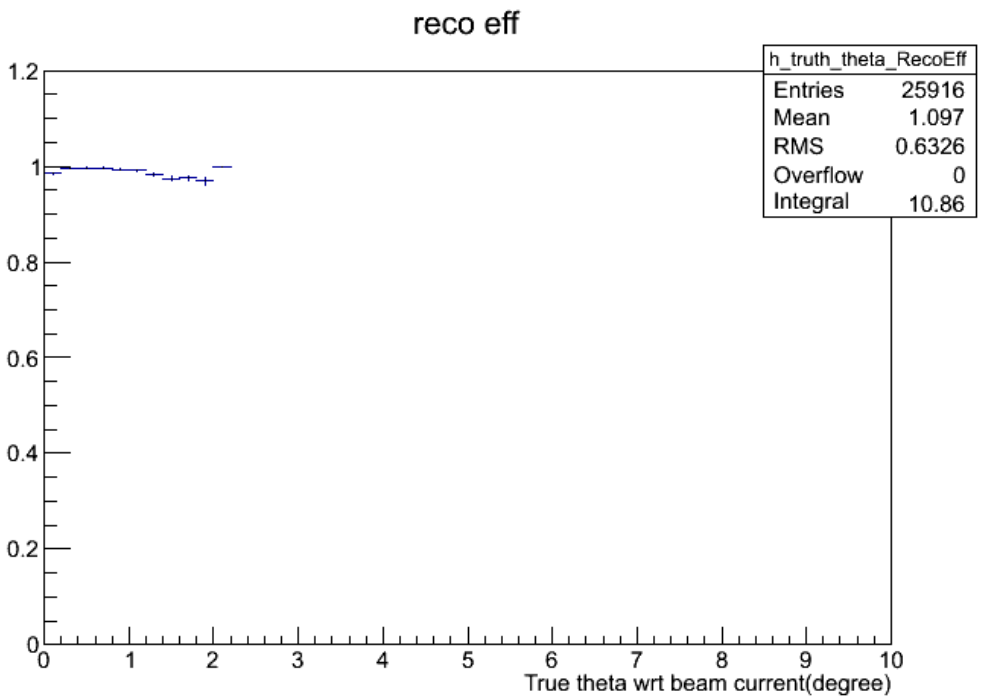


There is a dependence between electron angle and energy in nu-e sample.

800 MeV electron energy threshold cut

Angle(w.r.t beam) Efficiency before and after 800 MeV energy threshold cut:

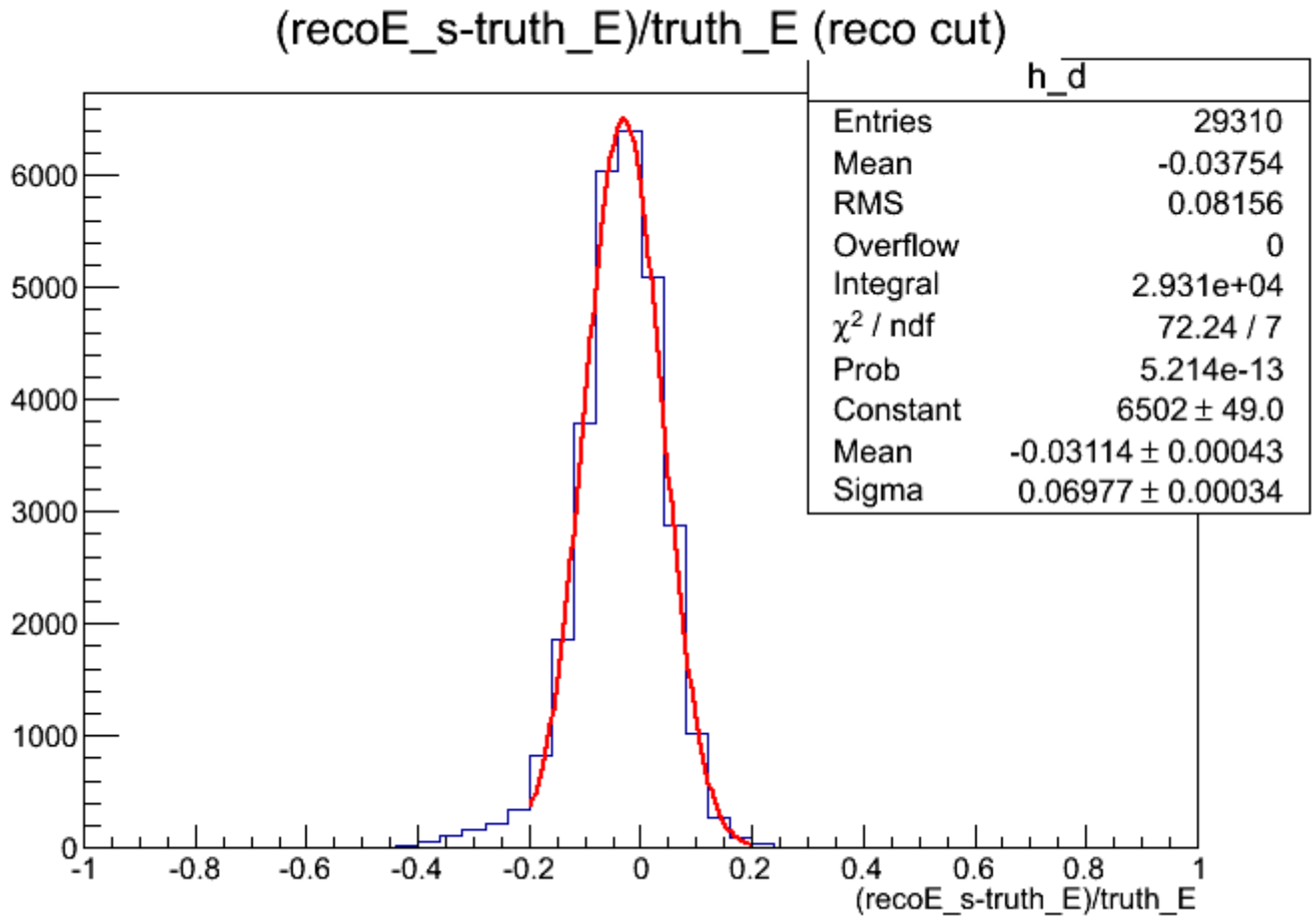




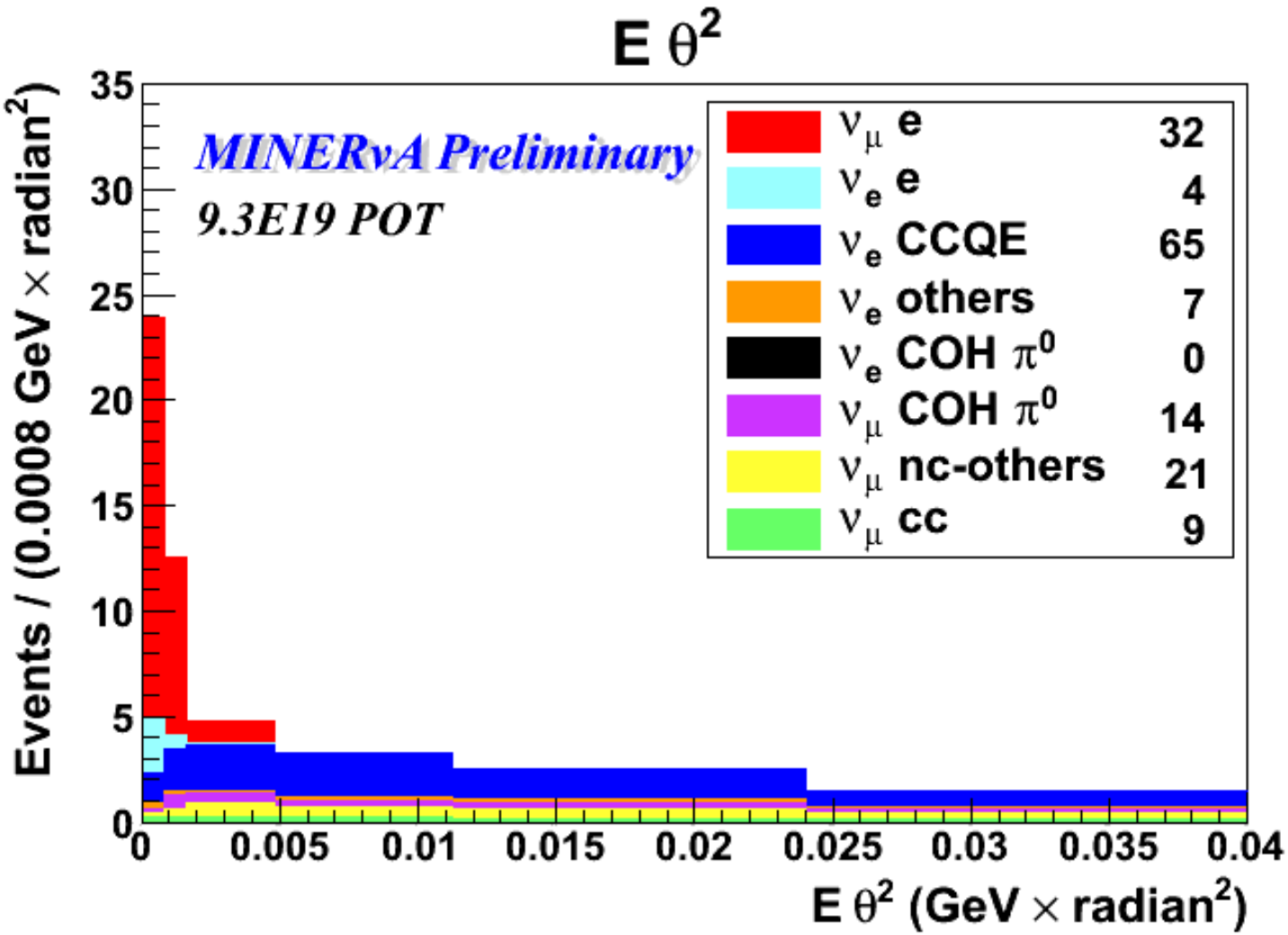
Before (drops at high angle)

After (around 1)

Energy Resolution with reco cut plus threshold cut in fiducial



Need to consider side Ecal correction later.

MC Study On Backgrounds(to do)

Use Jaewon's Developed Reco Cut on ME sample, to reject backgrounds and reproduce the following plot