

# Updates on Constraining the ME flux

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July 30/2012



# Study on Neutrino Electron Elastic Scattering

## Theoretical Prediction:

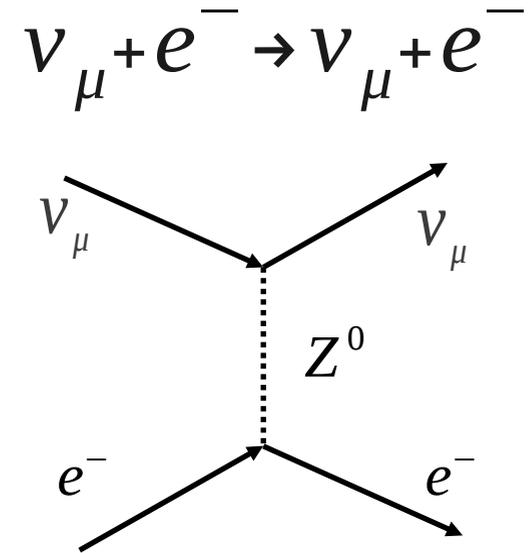
$$\frac{dN(T)}{dT} = \int dE_\nu \frac{d\Phi(E_\nu)}{dE_\nu} \frac{d\sigma(T, E_\nu)}{dT}$$

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

T: Scattered Electron Kinetic Energy

For neutral current, the total cross section is:

$$\sigma_{NC}(\nu_\mu e) = \frac{2G_F^2 m_e E_\nu}{\pi} \left[ \left( -\frac{1}{2} + \sin^2 \theta_w \right)^2 + \frac{1}{3} \sin^4 \theta_w \right] = 0.15 \times 10^{-43} \left( \frac{E_\nu}{10 \text{ Mev}} \right) \text{cm}^2$$



# Calculating The Absolute Event Rate

$$R = \Phi \cdot \sigma$$

Event Rate      Flux      Cross-section

Unit of Event Rate: # of events/POT

Unit of ME Flux we have: # of neutrinos/GeV/cm<sup>2</sup>/12E20POT  
( Document : MINERvA-doc-2004-v3)

Unit of Cross-section: cm<sup>2</sup>

*Total Electrons in Fiducial:* 1.97 E30

~5% difference compare with Jaewon's independent calculation

1.98E30

## Absolute Events

$$= Flux \left( \frac{Neutrinos}{m^2 \times 12 \times 10^{20} POT} \right) \times 0.15 \times 10^{-43} \left( \frac{E_\nu}{10 Mev} \right) cm^2 \times 1.97 \times 10^{30}$$

$$= \sum_1^{500} \left( \frac{Neutrinos(E_\nu)}{m^2} \right) \times 0.15 \times 10^{-43} \left( \frac{E_\nu}{10 Mev} \right) cm^2 \times \Delta E_\nu \times 1.97 \times 10^{30} \text{ (per } 12 \times 10^{20} POT \text{)}$$

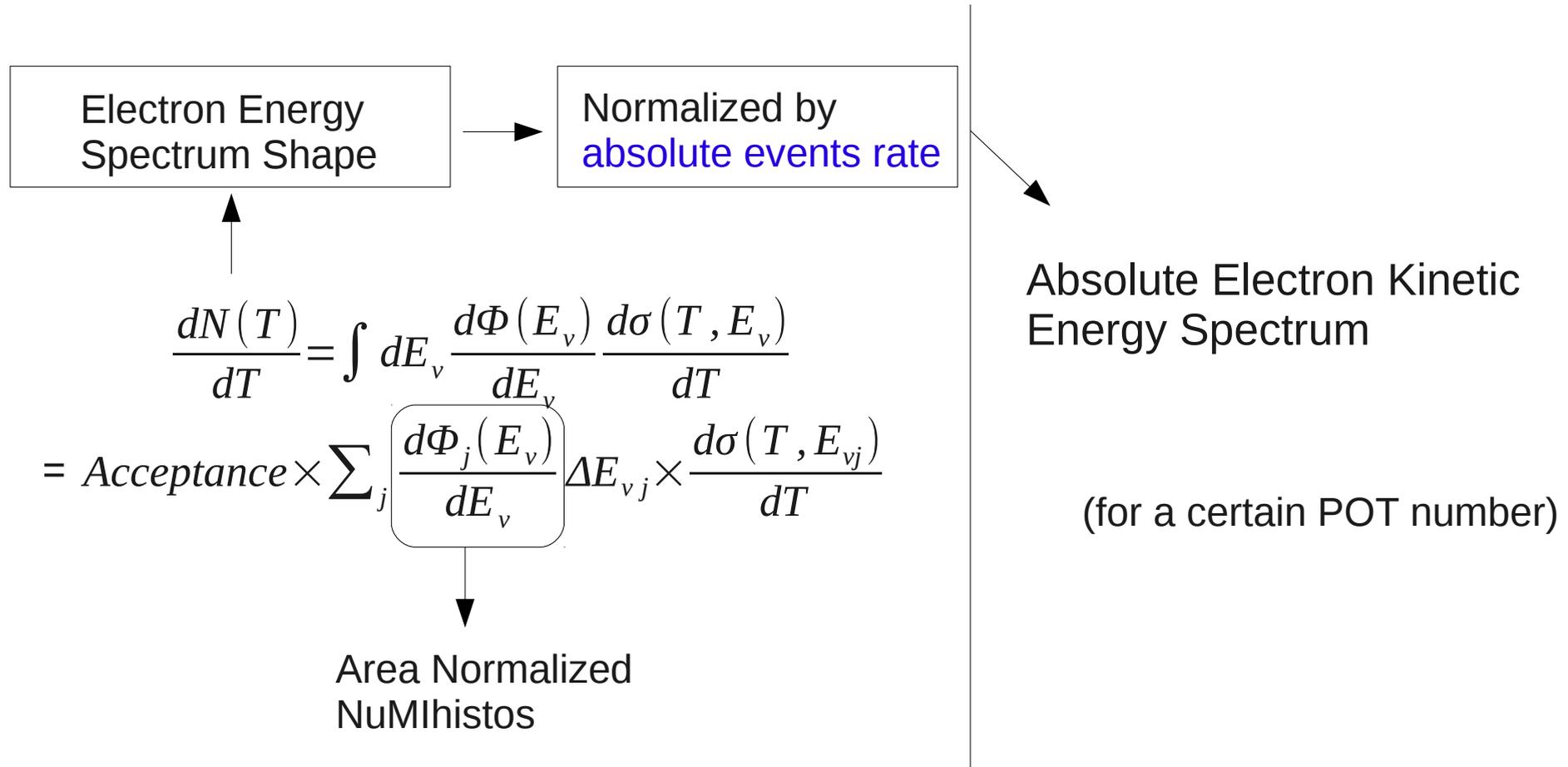
$$= 2484 \quad (\text{per } 18 \text{ E20 POT})$$

Compare with result from Genie(nu\_mu, fiducial(circular section)):

for 18E20 POT the events rate = 2427

~2.29% difference

# Absolute Electron Energy Spectrum



# Energy Spectrum: Compare prediction with Genie

\*For process  $\nu_\mu e \rightarrow \nu_\mu e$

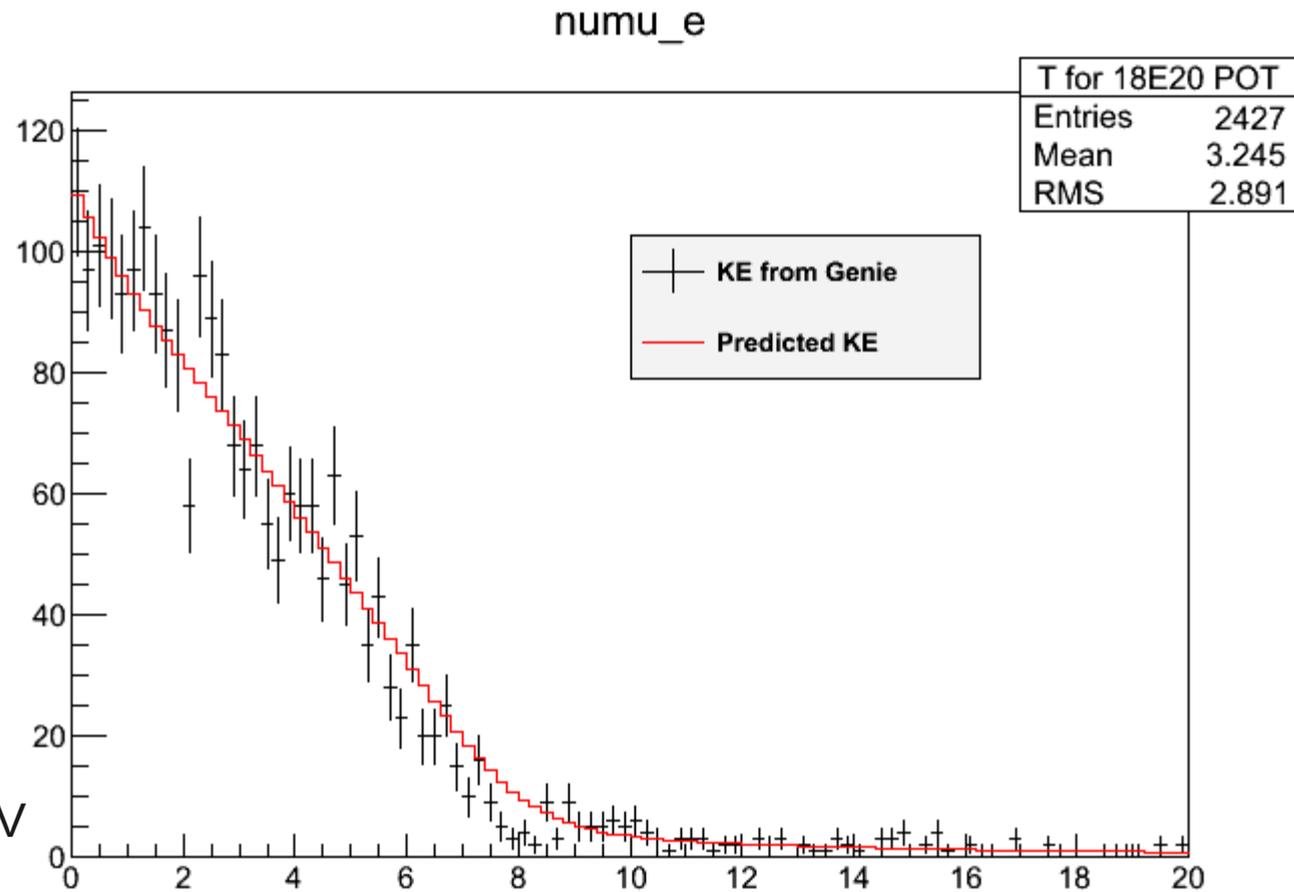
\*"Temporary" Fiducial region

\*18E20 POT

\*Bin-Size: 0.2 GeV

$$\chi^2 = 2.42$$

Calculation have to stop at 8 GeV  
to avoid 0 content bins



# Adjust the Bin-Size of Ke Plot

Ke Range(Gev)	Bin Size (Gev)	#Bin s
0 -20	0.4	50
20-50	1	30
50-100	25	2

\*Minimize 0 content bins

\*Smaller fluctuation and more precise histogram

\*Focus on the important part of the flux (like 0 - 20 GeV) that need to be known well

See the result on next page

# Vary Bin-Size for different range in Ke histogram

## Whole range view

No 0 content bins  
before 18.4 GeV

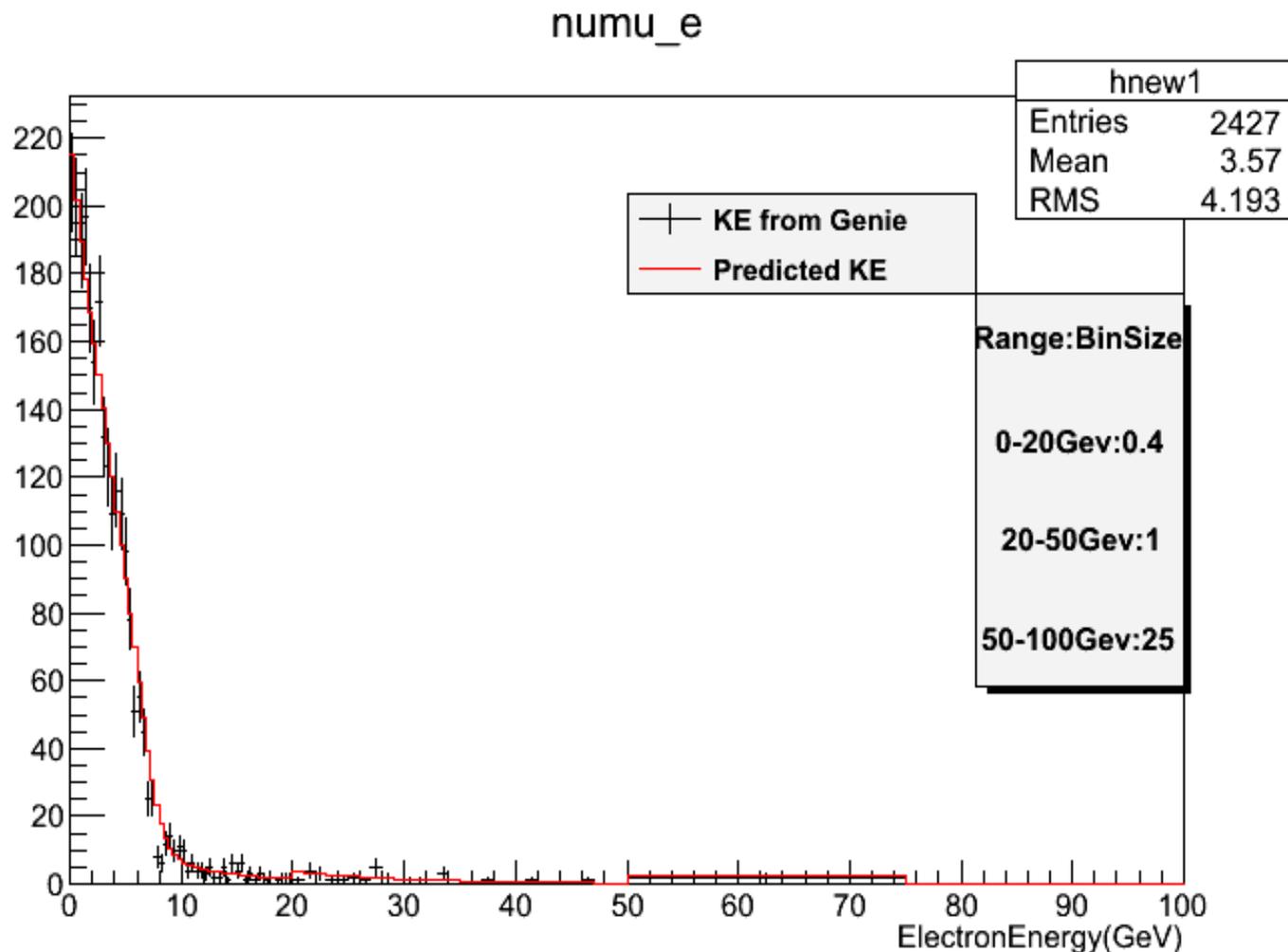
Make a cut on 18.4 GeV  
to get

$$\chi^2 = 1.22$$

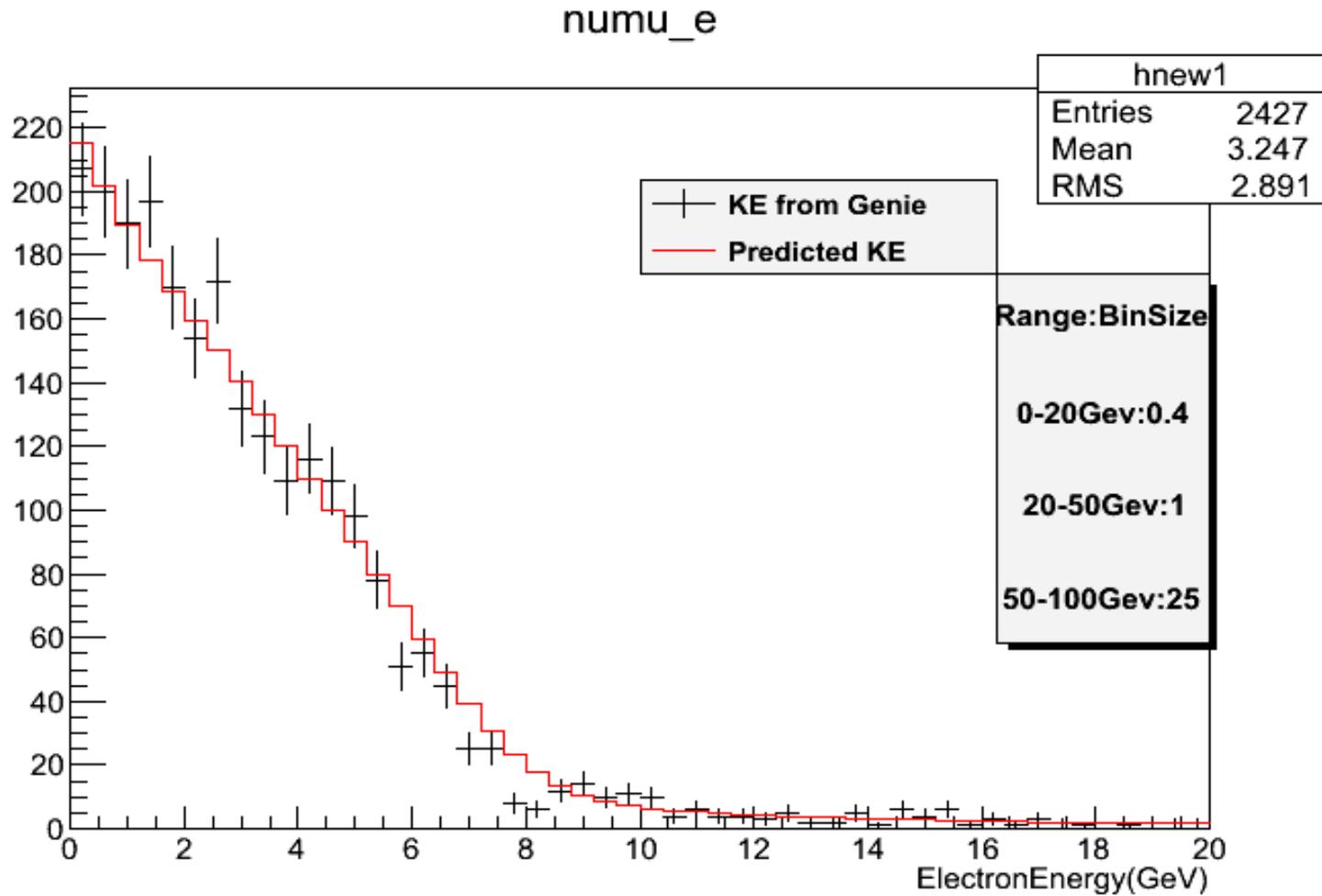
Remained data after cut

Genie: 96.21%

Prediction: 98.02%



# Crucial Part of the Varied Bin-Size Ke Histogram



# Threshold Energy Cut

Electrons with the energy  $K_e < 0.8$  GeV can not be detected in the reconstruction

Genie	83.23% events remained
Prediction	82.69% events remained

# Next Steps

Fitting the NuMI flux histos  $\longrightarrow$  Get the flux function (parameters)

$\chi^2$ : Predicted Ke and Genie Ke (observed)

Fitting Tool of the flux: Given Ke spectrum  $\longrightarrow$  Flux (with error bars)