NEUTRINOFLUX UPGRADE

Release V01-00-01

Docs: http://www.icecube.wisc.edu/~tmontaruli/neutrinoflux

Main change

- Neutrino flux (ConventionalNeutrinoFlux) interpolates atmospheric neutrino tables from 10 GeV to 10 TeV but most of the tables (expecially Bartol) show poor statistics between 1-10 TeV
- A 5 degree polynomial in costheta and E fits reasonably well the tables

$$\frac{dN_\nu}{dE} = \sum_{i=1}^{5} p_{ix} x^i + p_0 + \sum_{i=1}^{5} p_{iy} y^i + \sum_{i=1}^{4} p_{ixy} x^i y^{5-i}$$

- A 2 physics driven formulas (from Tom) have been fitted to tables between 500 GeV-10 TeV. For numu this works fine and parameters allow an understanding of relative pion/K contributions. For nue functions are complicated so many combinations of parameters are possible. The connection to the low energy function is hard and shows up in a few bins.
- The change for numu is active since summer 2008 but only in the trunk

Model strings

ConventionalNeutrinoFlux::ConventionalNeutrinoFlux(string model): model_(model_nutype)
PromptNeutrinoFlux::PromptNeutrinoFlux(string modelPrompt): model_(modelPrompt_nutype)

Flux model	modelConv (string type)	modelPrompt (string type)
Bartol 2004	**bartol_numu, bartol_nue**	
HKKM2006	**honda2006_numu,honda2006_nue**	
HKKM2004	**honda_numu,honda_nue (only polynomium fit, obsolete)**	
Naumov/RQPM		**naumov_rqpm_numu, naumov_rqpm_nue**
Naumov/QGSM		**naumov_qgsm_numu, naumov_qgsm_nue**
Martin/KMS		**martin_kms_numu, martin_kms_nue**
Martin/MRS		**martin_mrs_numu, martin_mrs_nue**
Martin/GBW		**martin_gbw_numu, martin_gbw_nue, martin_gbw_nutau**
Enberg et al, 2008		**sarcevic_std_numu, sarcevic_std_nue, sarcevic_min_numu, sarcevic_min_nue, sarcevic_max_numu,sarcevic_max_nue, sarvevic_nutau**
Costa 2001		**pQCD_opt_numu, pQCD_opt_nue, pQCD_pes_numu, pQCD_opt_nue RQPM_opt_numu, RQPM_opt_nue, RQPM_pes_numu, RQPM_pes_nue QGSM_opt_numu, QGSM_opt_nue, QGSM_pes_numu, QGSM_pes_nue**

http://icecube.wisc.edu/%7Etmontaruli/neutrinoflux/NeutrinoFlux_Teresa.html

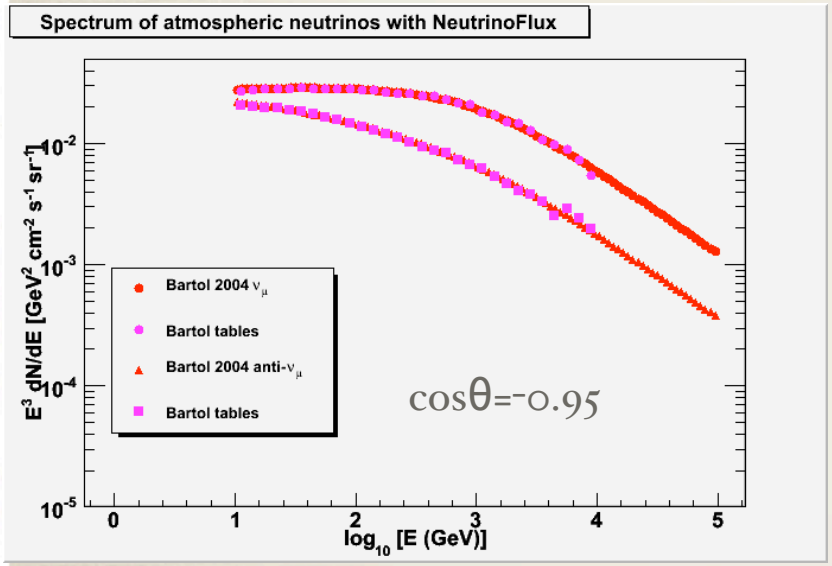
Numu Conventional

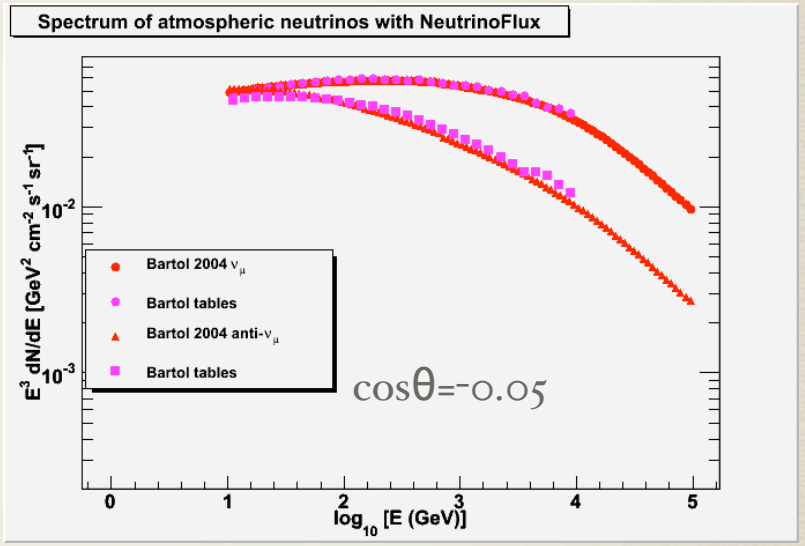
$$\frac{dN_{\nu_\mu}}{dlnE} = A_{tot} E^{\gamma} \left[\frac{A_\nu}{1 + B_p E \cos\theta^* / \epsilon_\pi} + \frac{B_\nu}{1 + B_k E \cos\theta^* / \epsilon_k} \right]$$

curvature of the Earth atm

$$\cos\theta^* = \sqrt{\frac{\cos^2\theta + p_0^2 + p_1 \cdot \cos^{p_2}\theta + p_3 \cdot \cos^{p_4}\theta}{1 + p_0^2 + p_1 + p_3}}$$

Bartol

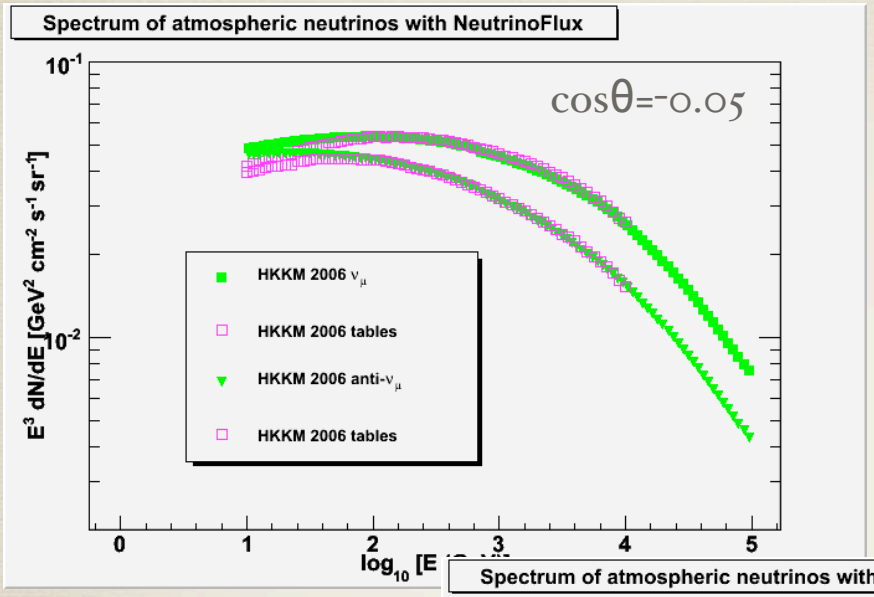


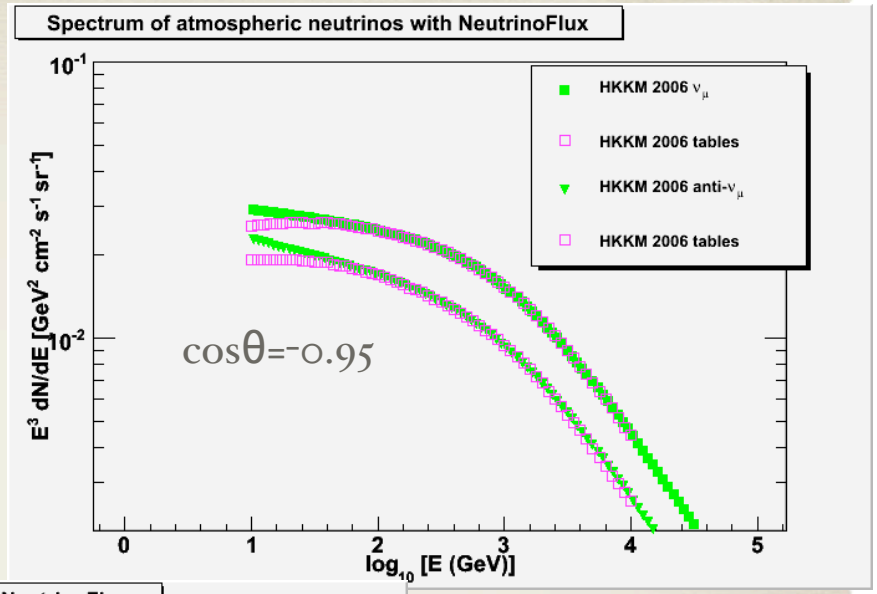


Examples of low-high energy functions compared to tables
In some bins the connection with the low energy and high energies needs some normalization tweak and changing the connection energy around 500-1 TeV

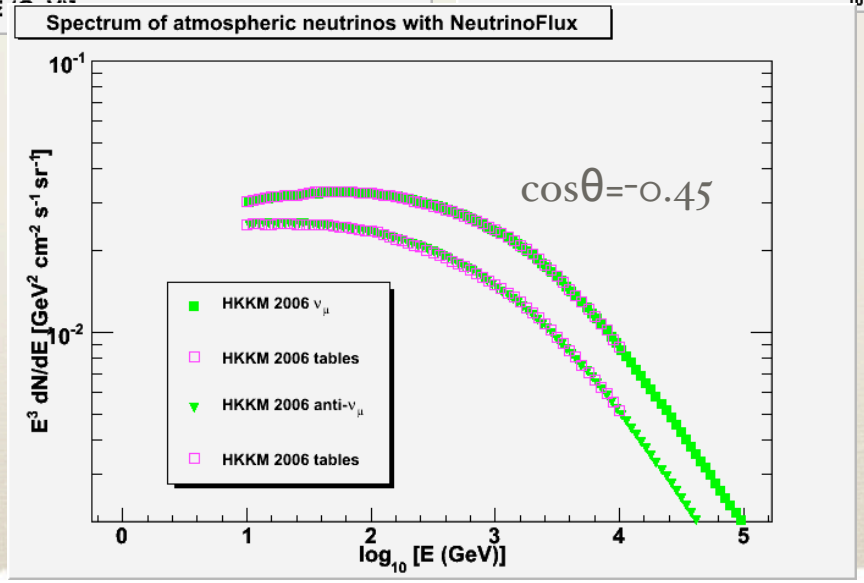
Numu

- Honda 2006

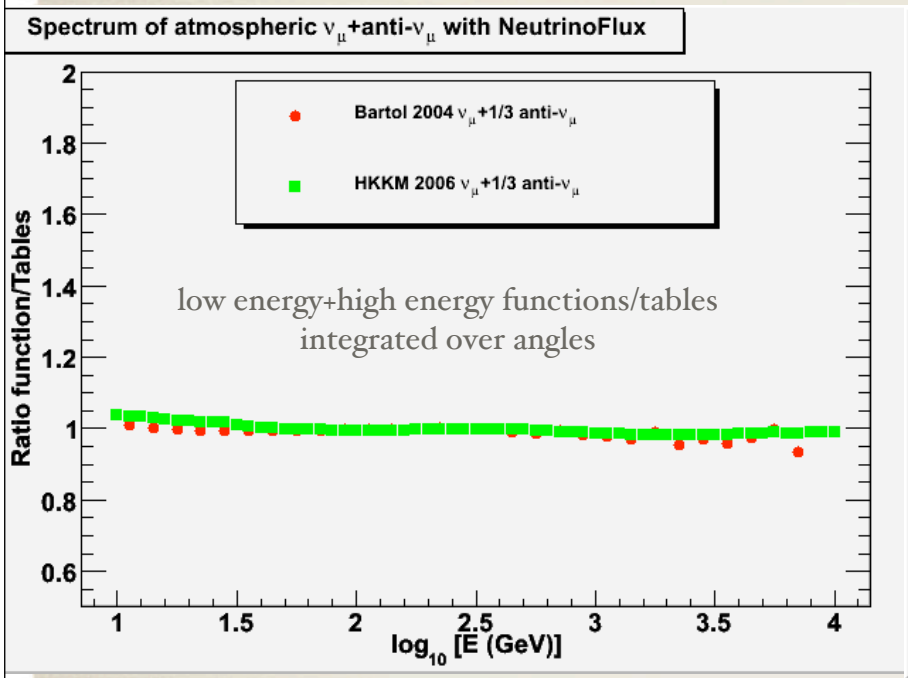


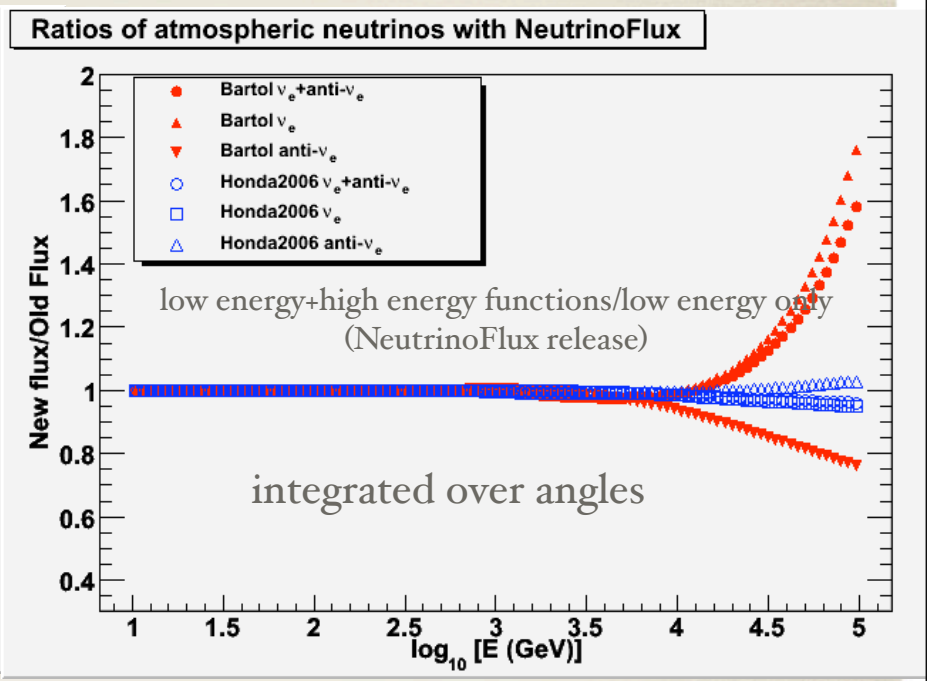


< 20 GeV some bins may need better fits than 5 degree pol but the integrated difference respect to tables is < 5% (see next page)



Ratios





At high energy the largest difference since a physical motivated function (scaling laws apply to CRs) is better than tables that run out of statistics. The change is minimal since we have few events above 10 TeV

Nue Conventional

$$\frac{dN_{\nu_e}}{dlnE} = A_{tot}E^{\gamma}\left\{\left[\frac{A_e}{1+B_kE\cos\theta^*/\epsilon_k}+\frac{B_e}{1+B_kE\cos\theta^*/\epsilon_{k_L}}\right]+\Phi_{\mu}\left[1-e^{-\lambda_{\mu}/E\cos\theta^*}\right]\right\}$$

curvature of the Earth atm

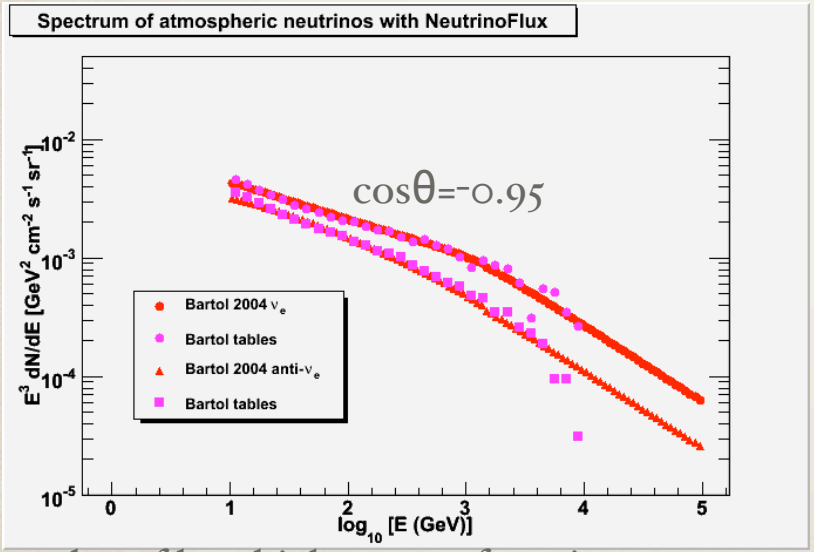
muon decay

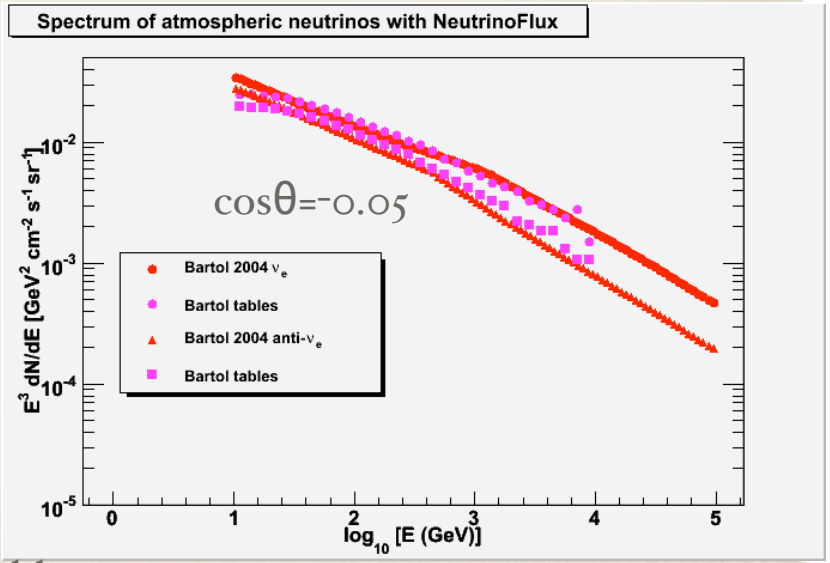
$$\cos\theta^* = \sqrt{\frac{\cos^2\theta + p_0^2 + p_1\cdot\cos^{p_2}\theta + p_3\cdot\cos^{p_4}\theta}{1+p_0^2+p_1+p_3}}$$

$$\Phi_{\mu^+} = B_{tot}\left[\frac{A_{\pi^+}}{1+B_{\pi}E\cos\theta^*/\epsilon_{\pi}}+\frac{A_{K^+}}{1+B_{k_{\mu}}E\cos\theta^*/\epsilon_k}+\frac{A_{K_L}}{1+B_{K_L}E\cos\theta^*/\epsilon_{K_L}}\right]$$

$$\Phi_{\mu^-} = B_{tot}\left[\frac{A_{\pi^-}}{1+B_{\pi}E\cos\theta^*/\epsilon_{\pi}}+\frac{A_{K^-}}{1+B_{k_{\mu}}E\cos\theta^*/\epsilon_k}+\frac{A_{K_L}}{1+B_{K_L}E\cos\theta^*/\epsilon_{K_L}}\right]$$

Bartol





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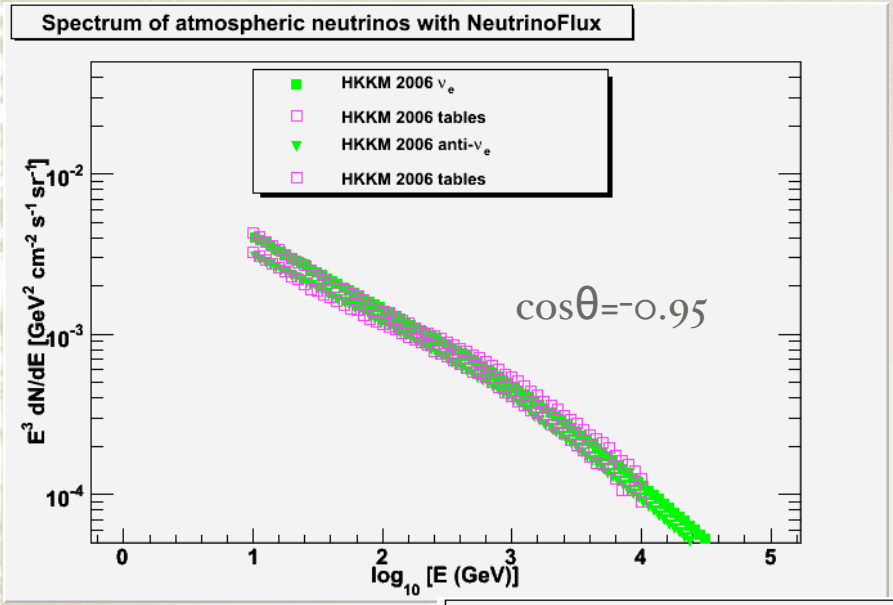
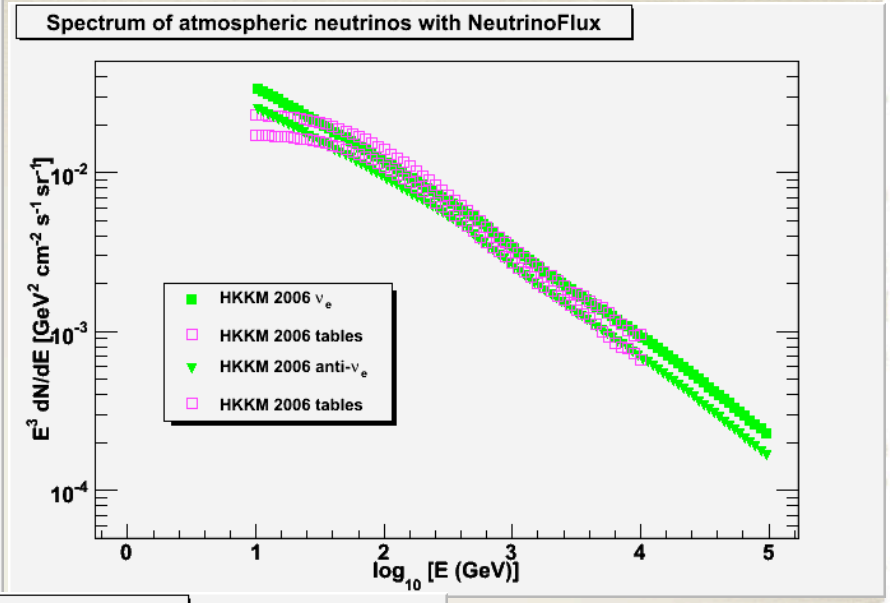
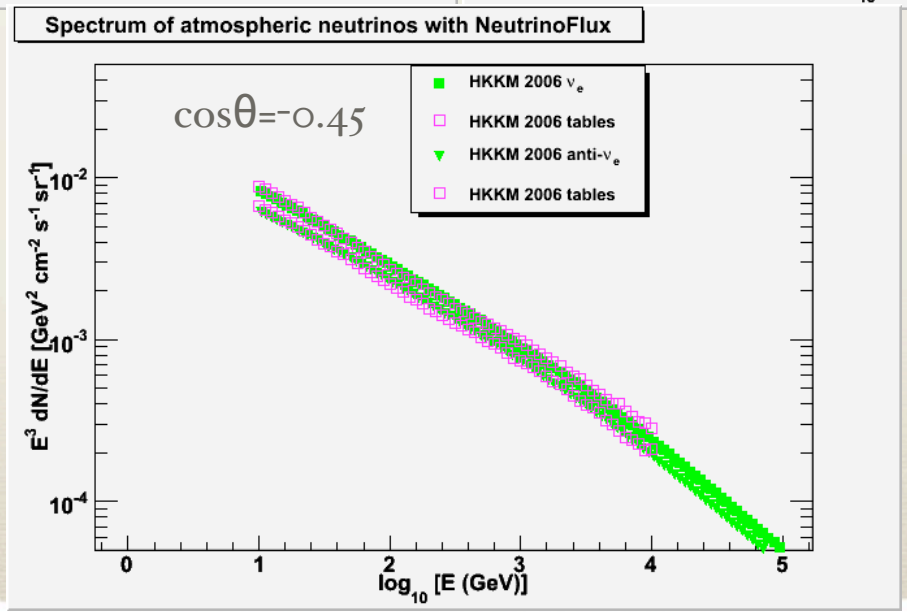
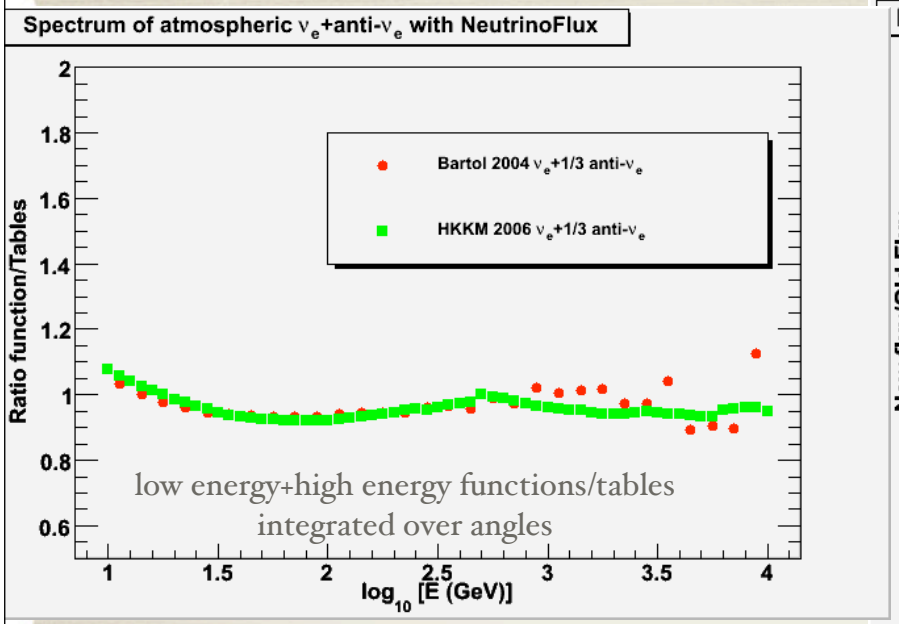
Nue Honda 2006

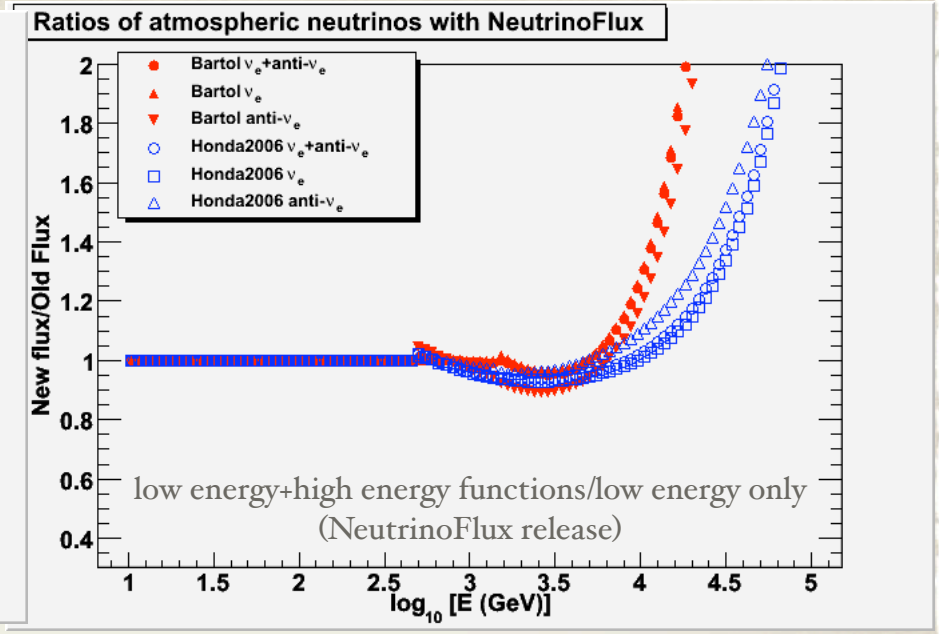






Ratios





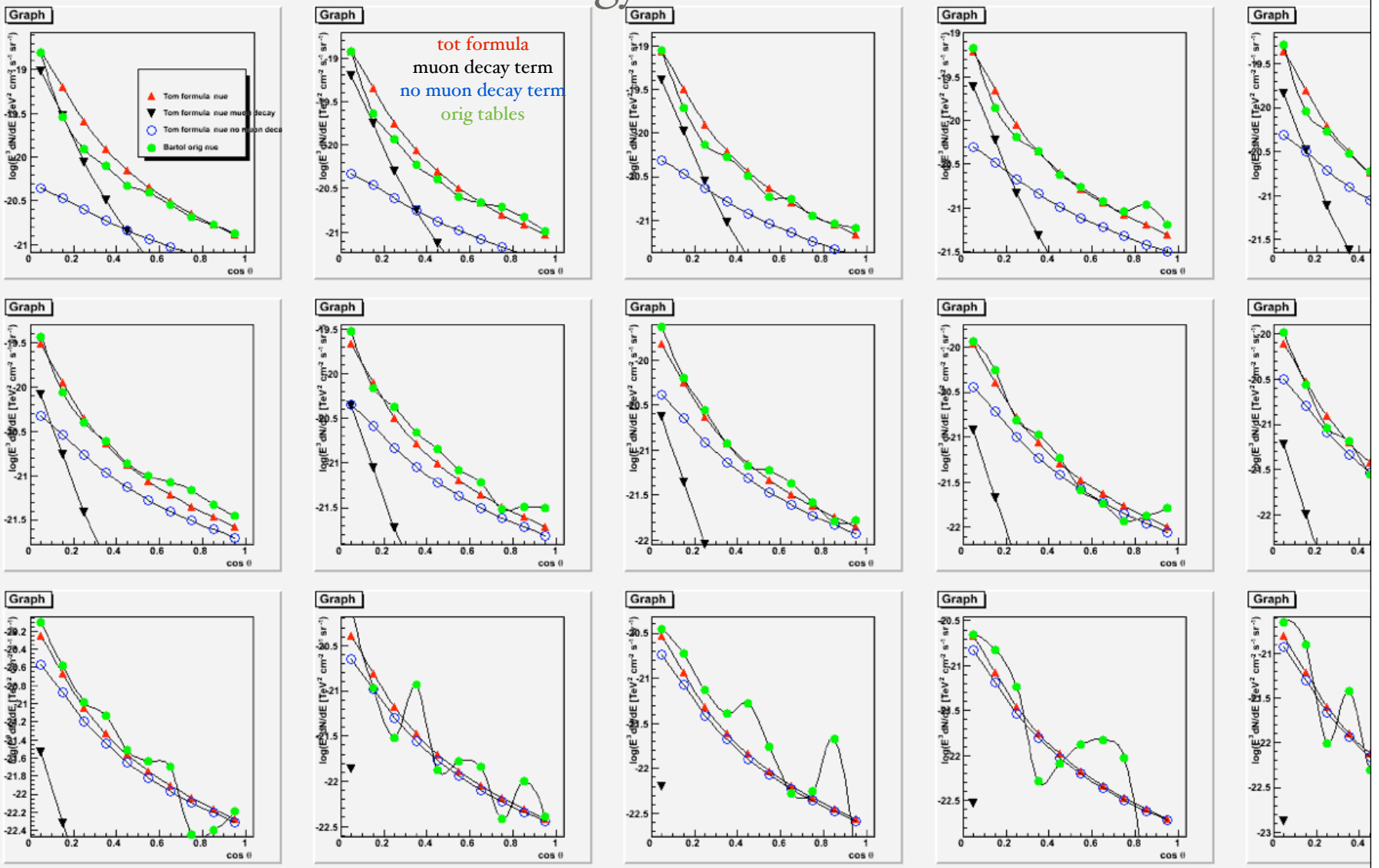
Fluxes have a more complex shape than for numu and tables run out of statistics earlier in energy

High energy function keeps a physics motivated trend above 1 0TeV while low energy function becomes unreliable

The new release produce a difference pf more than 50% above 10^4 GeV

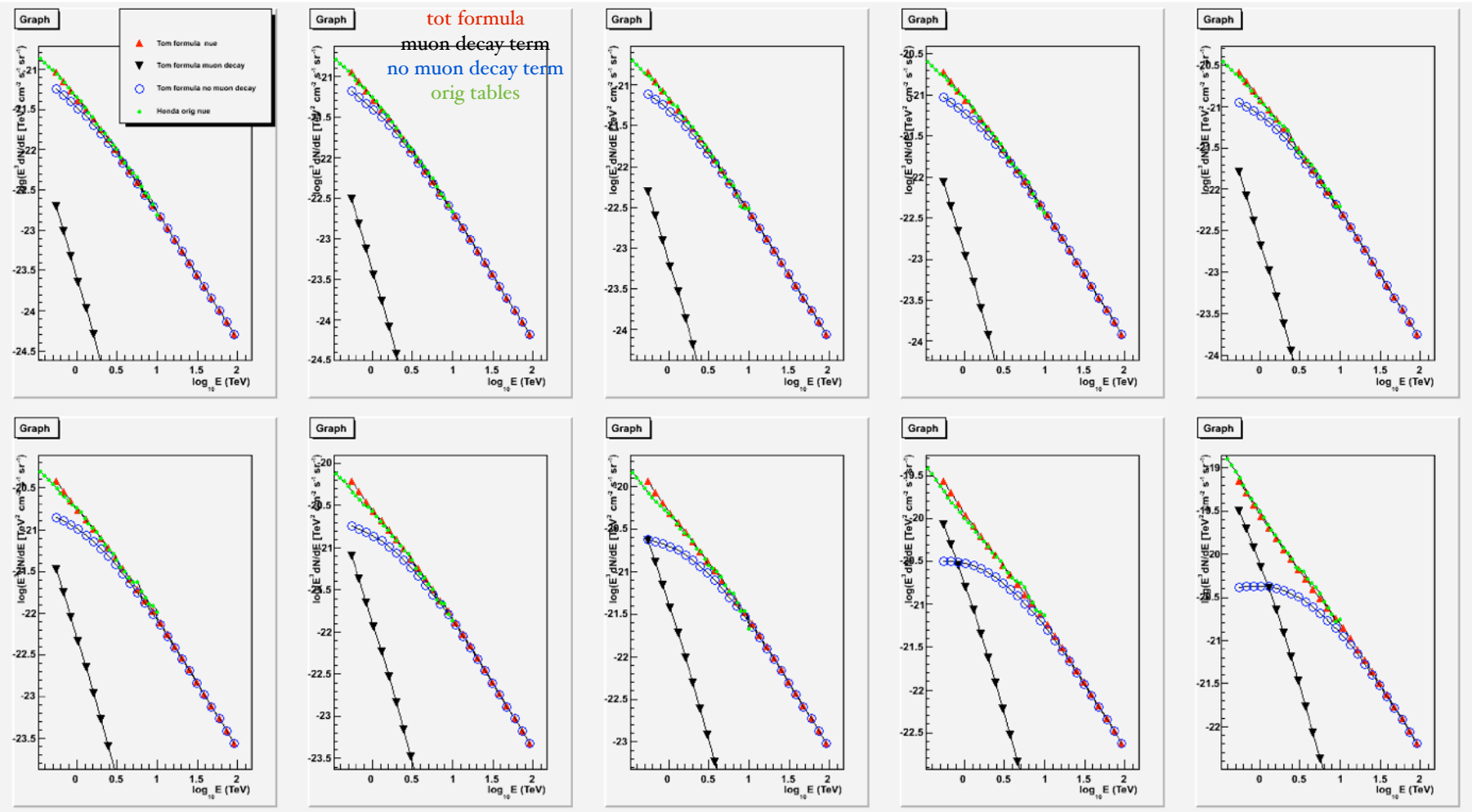
Details of functions

Bartol best fit in energy bins vs costheta



Details of formula

Honda2006 best fit in costheta vs log(energy)



Prompt models

- Added Enberg et al, 2008 http://arXiv.org/pdf/0806.0418 (pQCD) with systematic error study (max and min fluxes authors get changing parameters for numu and nue). One model for nutau also.
- Nutau for martin et al and Enberg et al

Oscillations (important for Deep core) with JohnK's help!

- Vacuum oscillations* (all flavors, theta_13 = 0) available for conventional flux (via new object)

- Constructor uses base model name:
  ConventionalOsciNeutrinoFlux("bartol")
  ConventionalOsciNeutrinoFlux("honda2006")

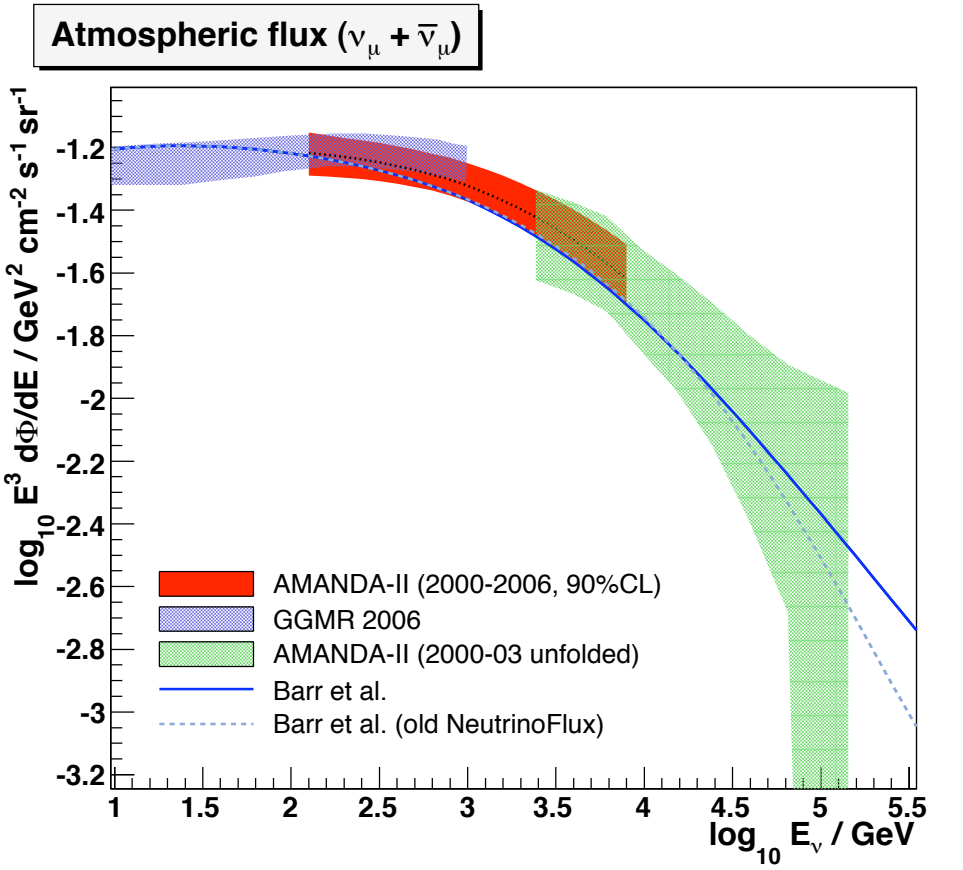
- getFlux() and getFluxIntegral() can return flux of any flavor

- Future: matter effects and nonzero theta_13

*Global parameter fits from A. Strumia and F. Vissani, hep-ph/0606054

Unfolding (from John)

- New fluxes (low_high energy) seem to follow better AMANDA unfolding compared to the low energy function only (notice John developed the analysis already using low energy+high energy for numu since it was in the trunk since a long time)



NeutrinoFlux

- Paper in preparation
- Code will be made available under request also outside IceCube