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 (especially Bartol) show poor statistics between 1-10 TeV

* A 5 degree polynomial in costheta and E fits reasonably well the tables

\[
\frac{dN_\nu}{dE} = \sum_{i=1}^{5} p_{zx} x^i + p_0 + \sum_{i=1}^{5} p_{zy} y^i + \sum_{i=1}^{4} p_{zxy} x^i y^{5-i}
\]

* 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

### Conventional Neutrino Flux

```plaintext
ConventionalNeutrinoFlux::ConventionalNeutrinoFlux(string model): model_(model_nutype)
```

### Prompt Neutrino Flux

```plaintext
PromptNeutrinoFlux::PromptNeutrinoFlux(string modelPrompt): model_(modelPrompt_nutype)
```

<table>
<thead>
<tr>
<th>Flux model</th>
<th>modelConv (string type)</th>
<th>modelPrompt (string type)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bartol 2004</td>
<td>bartol_numu, bartol_nue</td>
<td></td>
</tr>
<tr>
<td>HKKM2006</td>
<td>honda2006_numu, honda2006_nue</td>
<td></td>
</tr>
<tr>
<td>HKKM2004</td>
<td>honda_numu, honda_nue (only polynomial fit, obsolete)</td>
<td></td>
</tr>
<tr>
<td>Naumov/RQPM</td>
<td>naumov_rqpm_numu, naumov_rqpm_nue</td>
<td></td>
</tr>
<tr>
<td>Naumov/QGSM</td>
<td>naumov_qgsm_numu, naumov_qgsm_nue</td>
<td></td>
</tr>
<tr>
<td>Martin/KMS</td>
<td>martin_kms_numu, martin_kms_nue</td>
<td></td>
</tr>
<tr>
<td>Martin/MRS</td>
<td>martin_mrs_numu, martin_mrs_nue</td>
<td></td>
</tr>
<tr>
<td>Martin/GBW</td>
<td>martin_gbw_numu, martin_gbw_nue, martin_gbw_nutau</td>
<td></td>
</tr>
<tr>
<td>Enberg et al, 2008</td>
<td>sarcevic_std_numu, sarcevic_std_nue, sarcevic_min_numu, sarcevic_min_nue, sarcevic_max_numu, sarcevic_max_nue, sarcevic_nutau</td>
<td></td>
</tr>
<tr>
<td>Costa 2001</td>
<td>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</td>
<td></td>
</tr>
</tbody>
</table>

[http://icecube.wisc.edu/%7Etmontaruli/neutrinoflux/NeutrinoFlux_Teresa.html](http://icecube.wisc.edu/%7Etmontaruli/neutrinoflux/NeutrinoFlux_Teresa.html)
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
< 20 GeV some bins may need better fits than 5 degree pol but the integrated difference respect to tables is < 5% (see next page)
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.
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
$\cos \theta = -0.95$

$\cos \theta = -0.45$
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 10 TeV 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

tot formula
muon decay term
no muon decay term
orig tables
Details of formula
Honda2006 best fit in costheta vs log(energy)
Prompt models


- 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