Development Areas
for Likelihood Package

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LAT ISOC

Summary

- Errors on Integral Fluxes

- Upper Limits

- Plotting

- Model maps for different energy bands (request from Jürgen)

- Handling systematic uncertainties

Flux Error Propagation

The following is based on a suggestion by J. Ballet. See also
`http://polywww.in2p3.fr/~dsanchez/butterfly.pdf`.

We are interested in estimating the error for

$$F_a = \int_{E_1}^{E_2} E^a \frac{dN}{dEdAdt} dE, \tag{1}$$

where $a = 0$ for photon flux and $a = 1$ for energy flux. The differential photon flux is a function of some set of fit parameters, $\{p_k\}$,

$$\frac{dN}{dEdAdt} = n(\{p_k\}). \tag{2}$$

If cov_{km} is the covariance matrix, for which $\text{cov}_{kk} = \text{var}(p_k) = \sigma_k^2$, then the variance of F_a can be estimated using

$$\text{var}(F_a) = \sum_k \left(\frac{\partial F_a}{\partial p_k} \right)^2 \sigma_k^2 + 2 \sum_k \left[\left(\frac{\partial F_a}{\partial p_k} \right) \sum_{m<k} \left(\frac{\partial F_a}{\partial p_m} \right) \text{cov}_{km} \right] \tag{3}$$

The quantities $\partial F_a / \partial p_k$ can be computed numerically using finite differences, but since the derivatives with respect to the fit parameters for a given spectral function $n(\{p_k\})$ are required by Likelihood, the flux derivatives can be obtained more directly by integrating

$$\frac{\partial F_a}{\partial p_k} = \int_{E_1}^{E_2} E^a \frac{\partial n}{\partial p_k} dE. \tag{4}$$

Flux Errors and Upper Limits

- Jean pointed out that the so-called profile likelihood method that I have proposed for making upper limits does not properly account for correlations between model parameters unless the integral flux itself is the parameter that is being scanned, as it is for `PowerLaw2` and `BrokenPowerLaw2`. This means that this method is *inapplicable* for upper limit calculations for all other spectral models.

- Example: Flux upper limits at Vela location during off-pulse phases.
  `http://confluence.slac.stanford.edu/download/attachments/20022215/`
  `VelaX_offpulse_update2.pdf`

- The procedure, implemented in the script
  `http://www-glast.stanford.edu/cgi-bin/viewcvs/pyLikelihood/python/`
  `UpperLimits.py?view=markup`,
  still needs to be tested and verified more extensively with simulations.

Plotting

- νF_ν

    - Butterfly plots show model confidence regions (D. Sanchez)

        `http://confluence.slac.stanford.edu/x/BQFZ`

    - Unfolded "data" points? (D. Sanchez)

        `http://confluence.slac.stanford.edu/x/uIGHAQ`
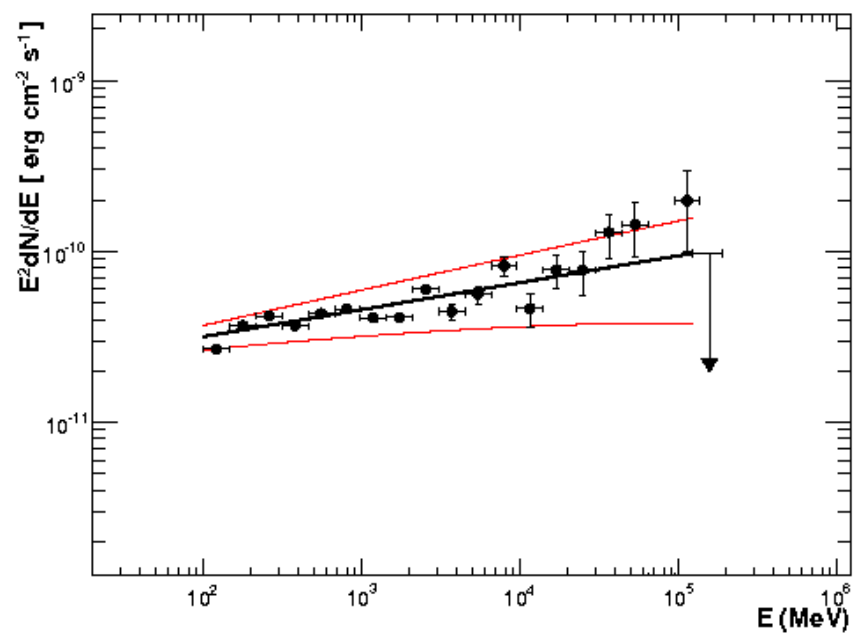
- Color coding of model components

  – Standard ordering of colors applied to the components as they appear in the XML model file (i.e., use same convention as `gtlike plot=yes`)

  – Provide interface to set colors by hand:

    ```
    >>> like['Geminga'].setColor('red')
    ```
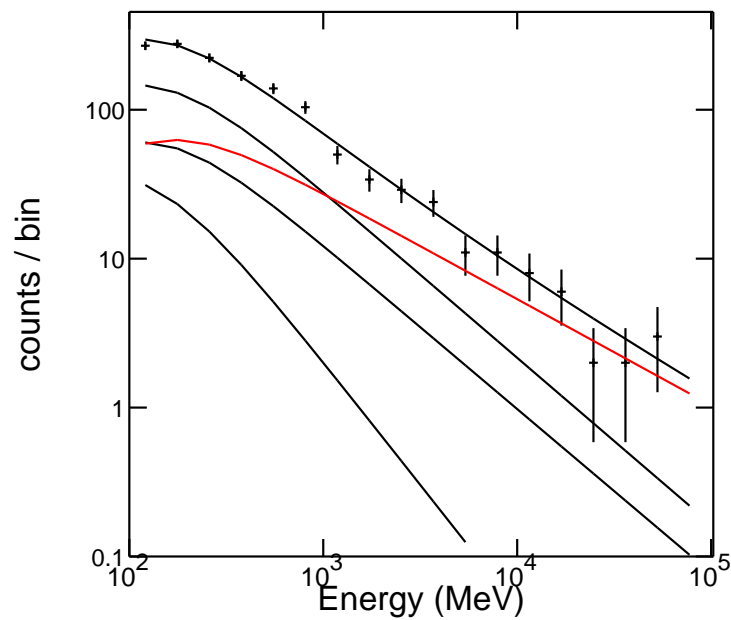

- Add pylab/matplotlib backend?

Systematic Uncertainties

- Use flight data studies to understand and apply corrections to IRFs

  - Philippe and Damien's Vela ON-OFF effective area studies:
    `http://confluence.slac.stanford.edu/x/wgCNAQ`
    `http://confluence.slac.stanford.edu/x/6QlbAQ`

  - Benoit's script to apply Philippe's corrections:
    `http://confluence.slac.stanford.edu/x/4ASNAQ`

  - Off-axis corrections (also using Vela):
    `http://confluence.slac.stanford.edu/x/lAaNAQ`

- Reanalyze data using alternative IRFs. Would be a lengthy process for unbinned Likelihood. Up to five different versions of IRFs?

- Monte Carlo studies with gtobssim (Marie-Helene):
  `http://confluence.slac.stanford.edu/x/qgWNAQ`