AGN Simulation for DC2

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Outline

- Luminosity function (LF) and evolution
- Spectral Transient source
  - Light curves
  - Spectral variability
- EBL attenuation
- Light curve generation
Luminosity Function and Evolution

- Use LF and evolution derived by Chiang & Mukherjee (1998; others could be used as well, e.g., Stecker & Salomon 1996; Mücke & Pohl 2000; Giommi et al. 2005):

\[
\frac{dN}{dL_0 dV} = N_0 (L_0/L_B)^{-\gamma_1} \quad L_0 \leq L_B
\]

\[
= N_0 (L_0/L_B)^{-\gamma_2} \quad L_0 > L_B,
\]

where \( \gamma_1 > 1 \), \( \gamma_2 = 2.2 \), and \( L_B(z=0) = 1.1 \times 10^{46} \text{ ergs}^{-1} \).

- Luminosity evolution is modeled as

\[
f_{\text{evo}} = (1 + z)^{\beta_p} \quad \text{if power-law form,}
\]

\[
= \exp(\beta_p H_0 \tau(z)) \quad \text{exponential form,}
\]

so that

\[
L_B(z) = f_{\text{evo}}(z) L_B(0)
\]

- Sampling of this LF is implemented in Python and is available on SLAC CVS:

http://glast.stanford.edu/cgi-bin/cvsweb/users/jchiang/lfunc/python/
Simulation Results

Upper left: The two dashed lines correspond (roughly) to the EGRET 4 sigma flux limit at Galactic latitudes $|b| > 10^\circ$ of $1.1 \times 10^{-10}$ erg cm$^{-2}$s$^{-1}$ and the flux limit that yields 1212 sources (the number of light curves in lc.fits.gz) of $1 \times 10^{-11}$. Lower left: Redshift distributions for these two flux limits. Upper right: The full cumulative flux distribution with the limit corresponding to 1212 sources. Lower right: The distribution of photon fluxes, unattenuated by EBL.
• A week-long simulation of 1212 blazars using this LF model:
- Use ascii or FITS binary table to specify flux and spectrum as a function of time in a series of discrete intervals.

- Example input file

```plaintext
# @file testTemplate.dat
# @brief Used by SpectralTransient class
# The columns are
# tstart tstop flux gamma1 gamma2 ebreak/MeV
  0.  0.3  50.  1.7  2.5  300.
  0.5  0.8 100.  1.5  2.2 1000.
  0.8  1.0  10.  2.1  2.1 1000.
```

- Intervals need not be the same length or even contiguous, but they must be time-ordered.

- The light curve will be scaled to fit into the total interval length specified in the XML definition.

- Mean flux will also be scaled to match that given in XML def.
• Example XML entry for use by flux, observationSim, Gleam:

    <source name="spectral_transient">
        <spectrum escale="MeV">
            <!--
            mean flux = 0.1 (1e-4/m^2/s)
            start time = 0 (MET s)
            stop time = 1e4 (MET s)
            template file name = $(GENERICSOURCESROOT)/data/testTemplate.dat
            emin = 20 (MeV, this is the default)
            emax = 2e5 (MeV, default)
            lc # (in FITS file) = 0 (default)
            z (redshift) = 0 (default)
            -->
            <SpectrumClass name="SpectralTransient"
                params="1e-1, 0., 1e4, $(GENERICSOURCESROOT)/data/testTemplate.dat,
                20,2e5,0,0"/>
            <celestial_dir ra="193.4" dec="-5.82"/>
        </spectrum>
    </source>
EBL Attenuation

- Thanks to Julie, Liz Hays, and Luis, we have a variety of extragalactic background light attenuation models from which to choose:
  1. Stecker and de Jager (ApJ 2002), "baseline"; valid for $z < 0.3$
  3. Primack’s model (1999)

- Redshift is specified in SpectralTransient XML entry.
- Interface to select the desired model is not yet implemented — Primack 1999 is used for now.
- EBL attenuation also needs made available as a model for fitting by Likelihood.
Light Curves

- Large libraries of light curves can be stored as FITS binary tables.
- Julie has provided a sample of 1212 thirty-day light curves based on an empirical power density spectrum for blazars. These have been converted to FITS (ftp://ftp.slac.stanford.edu/users/jchiang/lc.fits.gz).
- Example light curve:
Conclusions

- To do list:
  - Implement for specific sources, 3EG guys and other known blazars.
  - More realistic light curves showing appropriate flaring behavior.
  - Better (more physical) descriptions of spectral variation taking into account particle acceleration and energy loss models.
  - What else?

- This is just a start...other model(er)s are welcome!

- DC2 Confluence page:
  http://confluence.slac.stanford.edu/display/DC2/AGN+modeling