Status of the GLAST BG model

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CA-SO Workshop

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Plan of this talk

• Marco and Fancesco gave nice updates of background fluxes of LEO (not L&EO but Low Earth Orbit) from PAMELA and Agile. These updates should be compared with the GLAST background flux model.

• I will summarize the current status of the GLAST background model. New information from PAMELA and Agile will be included in it before the launch. Any comments and questions are very welcome.
Why BG flux model?

• Operation:
  ➢ Flux of background is many orders of magnitude higher than that of gamma-rays from astrophysical objects. We need to throttle the trigger to reduce the rate so as to download the gamma-ray events and events for calibration/monitoring.

• Science
  ➢ Contamination with residual background will be severe for weak objects and diffuse emission. High BG rejection power is necessary to maximize the science output.

• BG flux model has been used to optimize the filter and event selection algorithm.
• The flux model will be updated frequently in early operation. We need to know what is implemented and what’s not, but no single document can tell about this.
• Therefore, we prepared a confluence page
  • http://confluence.slac.stanford.edu/display/SCIGRPS/Background+Flux+Model+in+Gleam
• The page is not so friendly (no images…). This talk is intended to give an overview of the current model.
Particles Implemented

- Protons - primaries and secondaries
- Electrons - primaries and secondaries
- Positrons - primaries and secondaries
- Alphas - primaries
- Neutrons – secondaries
- Heavy Ions
- Trapped particles
- Earth(albedo) gammas

Long efforts by Pat, Toby, Eric, Tune, Masanobu, Benoit, Jonathan, Markus, T.M. and others!
Primary Protons - Spectrum

Primary(\(E\)) = \frac{(E)^2 - (Mc^2)^2}{(E + Ze\Phi)^2 - (Mc^2)^2} \times \frac{1}{1 + \left( \frac{R}{R_{cutoff}} \right)^{-12.0}}

force-field approx. (Gleeson&Axford 1968)  
geomag cutoff to reproduce AMS data

Energy Spectrum

\(\Phi\) varies from 540 MV to 1100 MV in sinusoidal curve  
(11 years period, solar maximum on 2001-11-1)

• circles: AMS data (Alcaraz et al. 2000)  
• solid lines: model w/ cutoff  
• dotted lines: model w/o cutoff
Primary Protons (Ang. Distr.)

- No zenith angle dependence above the Earth rim ($\cos\theta > -0.4$).
- EW effect was approximately implemented
  - generate particles uniformly above the Earth rim
  - calculate $R_c$ and the flux for $(\theta, \phi)$
  - reject the event by the ratio of the flux to that form west

\[
R_c = \left( \frac{M}{2r_E^2} \right) \left[ \frac{\cos^4 \lambda_B}{1 + (1 - \cos^2 \lambda_B \sin \theta \sin \phi)^{0.5}} \right]
\]

Particle Flux vs. Azimuth

NB We use the convention of rootplot (FluxSvc) in this talk. Direction of $\theta$ and $\phi$ is opposite in CRflux.
Secondary Protons

• We refer to AMS data above 100 MeV
• Low energy data by NINA-2:
  ➢ spectrum is saturated or even decreased below 100 MeV.

• Calculated ang. distr. from L=1.01 to 2.09 (bottom to top). We approximate this by 1+a*sin^2θ. EW effect not implemented (yet).

(cf. Alcaraz et al. 2000 and Bidoli et al. 2002. AMS is zenith pointing and NINA-2 is zenith or Sun pointing)

Zuccon et al. 2003
Leptons in Equatorial Region

• We refer to AMS data (Alcaraz et al. 2000) and MARIA-2 data (Voronov et al. 1991; Mikhailov et al. 2002)
  ➢ Model formula for primary leptons is similar to that for primary protons. Angular distribution is the same.
  ➢ Large positron fraction of secondary due to EW effect.
  ➢ e-/e+ ratio below 100 MeV is close to 1 (since gyroradius is small and particles do not drift in geomag. field)

$\frac{e^+}{e^+ + e^-} = 0.078$  
(Golden et al. 1994)

• No zenith-angle dependence is assumed. (AMS is zenith pointing and MARIA-2 doesn’t report strong zenith angle dependence)
• No EW effect for secondary leptons implemented (yet).
Leptons in High Latitude Region

- $e^+/e^-$ ratio is close to 1, since the EW effect for primary protons is small.
- Steep spectrum gives high flux below 100 MeV.
Alphas

• The same formula as that of proton primaries, but Z=2. The same angular distribution as that of proton primaries
• Secondary not modeled. (We assume they are negligible)

• Difference btw. the data and model for 0.4<θ_m<0.8 is probably because the latitude region is too.
• Anyway, the integrated flux is only ~1/10 of that of proton primaries.
Neutron Spectrum

- We refer to a recent calculation by Selesnik et al. (2007).

@Rc=5GV (see next)

E=10 MeV-70 MeV

\[ \phi = \frac{24}{(2\pi)} \times \left( \frac{E}{70\text{MeV}} \right)^{-1.05} \]  
[\text{c/s/m}^2/\text{sr/MeV}]

E=70 MeV-500 MeV

\[ \phi = \frac{24}{(2\pi)} \times \left( \frac{E}{70\text{MeV}} \right)^{-2.25} \]

E=500 MeV-1 TeV

\[ \phi = \frac{0.286}{(2\pi)} \times \left( \frac{E}{500\text{MeV}} \right)^{-3.15} \]

- Uniform angular distribution above the rim is assumed.

NB Vertical flux here is defined as \( J_{2\pi} = \int_0^{2\pi} dy \int_0^{\pi/2} \phi \cos \theta \sin \theta d\theta \), where \( \phi \) is the angular flux.
Rigidity/Angular Dependence

- Rigidity dependence of $e^{-0.152R_c}$, as measured by COMPTE (Morris et al. 1995). Implemented.

- HE neutrons are predicted to come from Earth rim (Selesnik et al. 2007). No yet implemented.
Heavy Ions/Trapped Particles

• Sorry, I don’t know much about the detail of the model.

• Markus developed the trapped particle model. I saw Benoit’s name in the code of Heavy Ions.

• They are very important for calibration and operations. Can Benoit and CAL team (Heavy Ions) and Markus (Trapped Particles) update of the code (if necessary)?
Earth Gamma

- Developed by D. Petry using EGRET data
- Modeled in 10 MeV-10 GeV w/ EW effect.

They contribute to the residual BG and GLAST is supposed to provide data with higher statistics and resolution. Somebody has to update the code. TM?
Summar y

• An overview of Background Model is given.
  ➢ Particle type, model function and dependences
  ➢ What has been implemented and what is not.
  ➢ Who is supposed to maintain the code.
• Model is about right, but not perfect.
• New data of Pamela and Agile are very useful. GLAST will also provide new information.
  ➢ Model will be updated before the launch and during early operations.