Status report on Light Simulator

Claudia Cecchi
Francesca Marcucci
Monica Pepe

GLAST *Collaboration Meeting*

GSFC Washington-DC October 22-25 2002

Why the light simulator…

Very fast simulation of the skymap seen by the GLAST experiment:

✓from ~10m for the simplest case (region of 60°, with Poissonian bg, and orbit simulation)

✓to ~36h for the complicated one (all the sky, with the bg convoluted with the PSF and exposure time fixed)

Generation of a photon list, with photons distributed randomly, according to PSF, AS and ED distributions (determination of the true and measured energy, the incidence angle, the true and the measured position of the photons)

The code (C++) is running under Windows and under Linux

Input: map of the galactic background (Egret or Galprop)
Third Egret Catalogue with sources
photon energy range (0.1 – 100 GeV)
region of the sky (-90° - 90°, -180° - 180°)
orbit or fix time

Simulation: extragalactic background
galactic background
sources
exposure
convolution

Output: FITS-images of sky-map view and sources

255 sources from the Third Egret Catalogue

Source name	AR	DEC	Long.	Lat.	Spectral index	Standard energy	Flux @st.energy
3EG J0010+7309	2.56	73.17	119.92	10.54	1.8464610E+00	4.8522080E+02	1.6500180E-10
3EG J0038-0949	9.74	-9.82	112.69	-72.44	2.7042760E+00	1.5626760E+02	5.3436390E-10
3EG J0118+0248	19.6	2.81	136.23	-59.36	2.6336160E+00	1.7153680E+02	2.3813020E-10
3EG J0130-1758	22.7	-17.97	169.71	-77.11	2.5050740E+00	1.9170150E+02	3.2784570E-10
3EG J0159-3603	29.84	-36.06	248.89	-73.04	2.8922490E+00	1.2666270E+02	8.0606110E-10
3EG J0204+1458	31.11	14.97	147.95	-44.32	2.2321450E+00	2.6488440E+02	1.3811020E-10
3EG J0210-5055	32.58	-50.93	276.1	-61.89	1.9899620E+00	2.8397580E+02	8.8435840E-10
3EG J0215+1123	34	11.38	153.75	-46.37	2.0280930E+00	6.0997420E+02	8.8540930E-12
3EG J0222+4253	35.7	42.9	140.22	-16.89	2.0100220E+00	4.1280090E+02	9.5417540E-11
3EG J0229+6151	37.32	61.86	134.2	1.15	2.2863630E+00	2.3071570E+02	5.4674250E-10

The orbit

Elliptic orbit defined by the following parameters:

- *a* semi-major axis of the ellipse (distance of the orbit from the Earth ≅ 550 Km)
- *e* eccentricity (is set to zero, because we assume a circular orbit)
- *P* epoch (time of transit to the perigee)
- *T* period (5739 s)
- *ν* anomaly (the angle between the perigee and the point from where we start to calculate the orbit)
- *i* inclination of the orbit with respect to the terrestrial equator (28.5°)
- *Ω(t)* the orientation of the semi-major axis of the ellipse
- *R* rocking (35°).

Simulated with a geometrical approach by steps of 30″ (≈ 2°), assuming

Diffuse extra galactic background

Differential flux of photons from diffuse extra galactic background described (Skreekumer, 1997) as:

$$\frac{dN}{dE} = 7.3 \cdot 10^{-6} \cdot 0.451^{2.1} \cdot E^{-2.1} \qquad [1]$$

$$(photons \cdot cm^{-2} \cdot s^{-1} \cdot GeV^{-1} \cdot sr^{-2})$$

Total contribution of the extra galactic background obtained by the integration of (1) between E_{min} and E_{max} taken into account only if $|b| > 15°$.

The gamma ray galactic background

Galprop simulates the gamma ray background taking into account:

- neutral pion decay;
- bremsstrahlung;
- inverse Compton scattering.

Galprop produces FITS file containing 24 images in the energy range from *0.001* to 10^4 *GeV*

EGRET map measured between *0.1* and *30 GeV*

Sources

First approximation: sources point-like
located at an infinite distance

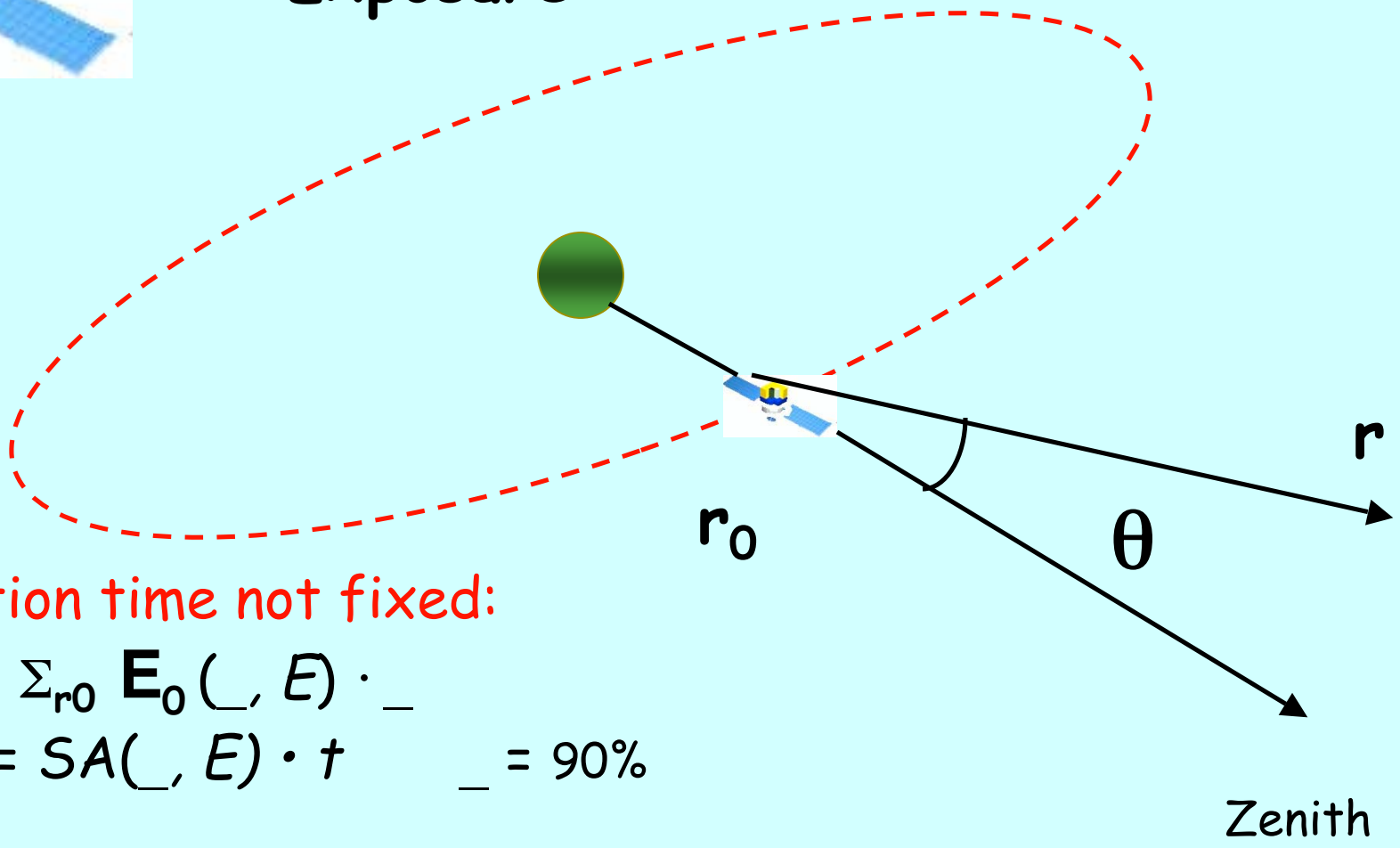
Intensity of photons:

$$I(E) = I_0 \cdot E^{-\alpha}$$

$$(photons \cdot cm^{-2} \cdot s^{-1} \cdot GeV^{-1})$$

Sources information: localization, α and I_0 from Third Egret Catalogue.

Exposure



Observation time not fixed:

$\mathbf{E}(\_, E) = \Sigma_{r0}\, \mathbf{E}_0(\_, E) \cdot \_$

$\mathbf{E}_0(\_, E) = SA(\_, E) \cdot t \qquad \_ = 90\%$

Observation time fixed:

$\mathbf{E}(\_, E) = SA(\_, E) \cdot t \cdot \cos \_$

Convolution with PSF, SA and ED
Background and Sources

In each pixel P_0:

Bkg-differential flux $C(P_0)$ ($\gamma\ cm^{-2}\ t^{-1}\ \Omega^{-1}$) = Σ all contributions

map of the sky in small regions of 0.5° x 0.5° without detector effects

convolution of our result with the SA, PSF and ED.

$$D(E) = \int_{0\text{-}60^\circ} \mathbf{E}(\_, E) \cdot I_0 \cdot E^{-\alpha}\, d\_$$

For Bkg:

$\alpha = 2.1$

$I_0 = C(P_0) \cdot \Omega$

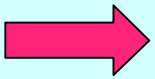
$\Omega = dl \cdot db \cdot \cos(b)$

Generation of a photon list

$N_\gamma = \int_{\Delta E} D(E)$

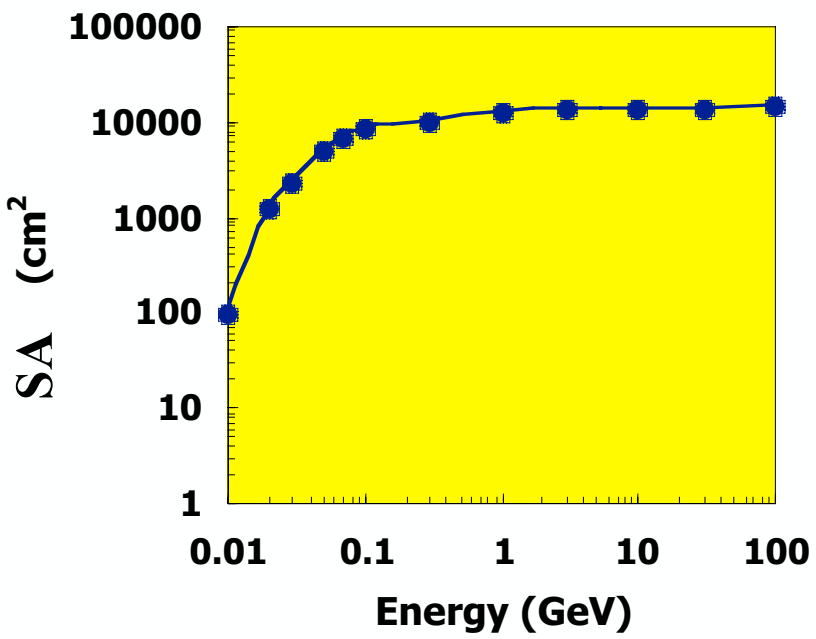
Each γ randomly distributed in the map with:

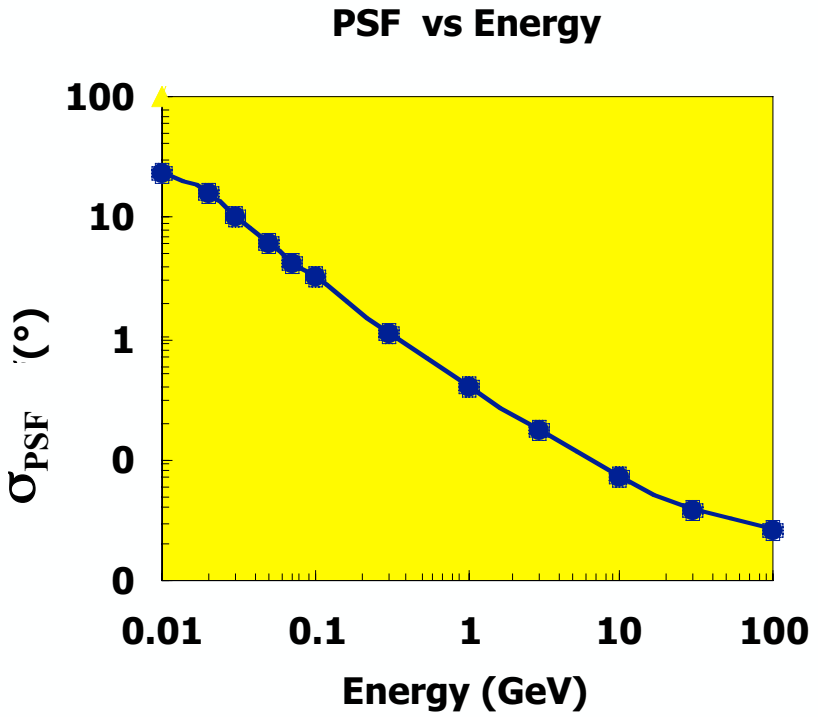
- random energy $E_{true} \in [E_{min}, E_{max}]$ according to $D(E)$
- inclination angle _ distributed according to $\mathbf{E}(\_, E_{true})$
- E_{meas} obtained using the function $ED(E_{true}, E_{meas})$
- angular distance, _, from origin point $P_0 \equiv (l_0, b_0)$ *consistent with* $PSF(\rho, E_{true})$



final position of each photon is $P_1 \equiv (l_1, b_1)$ obtained considering that the total angular distance from P_0 is ρ

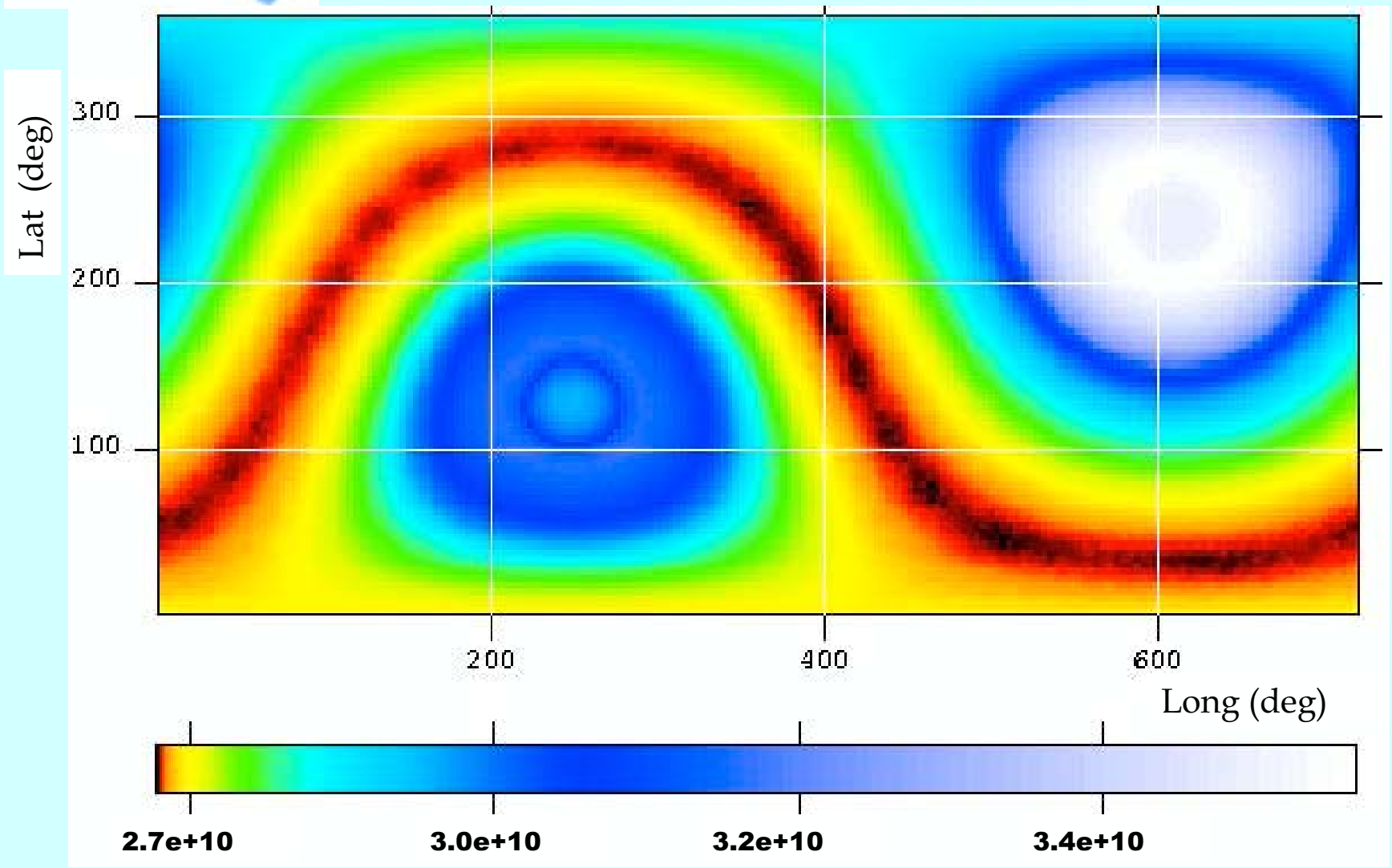
PSF and SA as function of the Energy





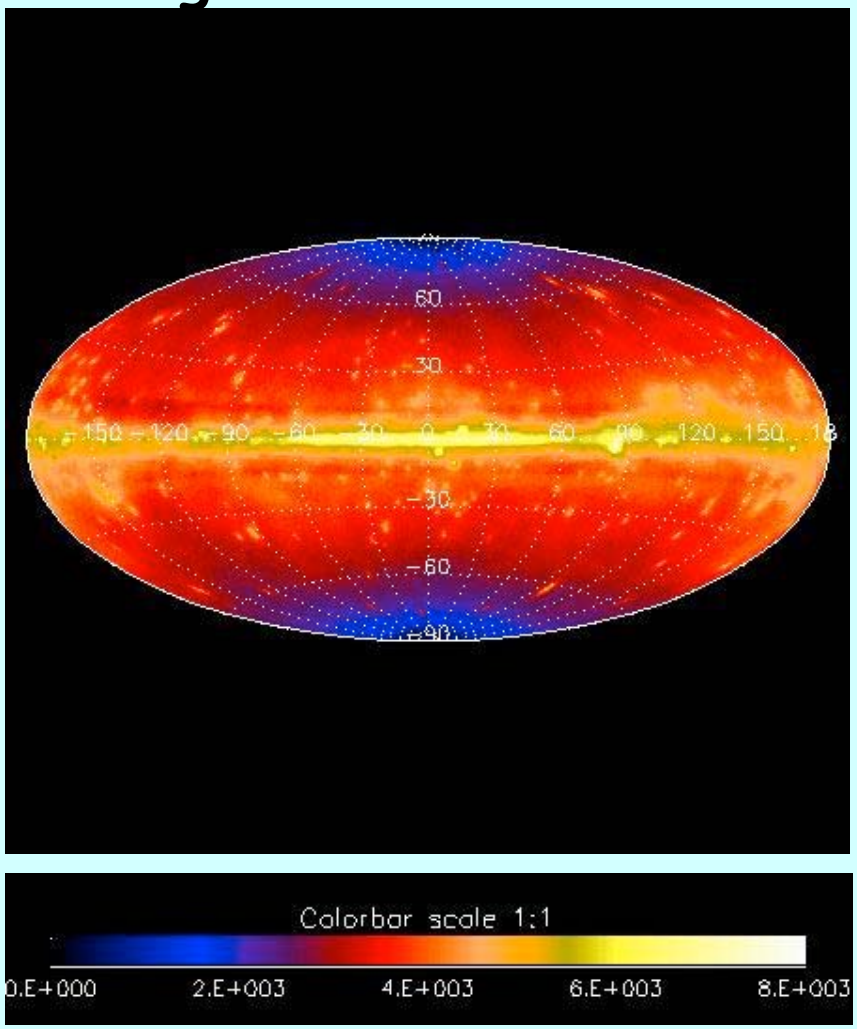
- The PSF is assumed to be a gaussian with RMS given by σ_{PSF}

Exposure 827 orbits

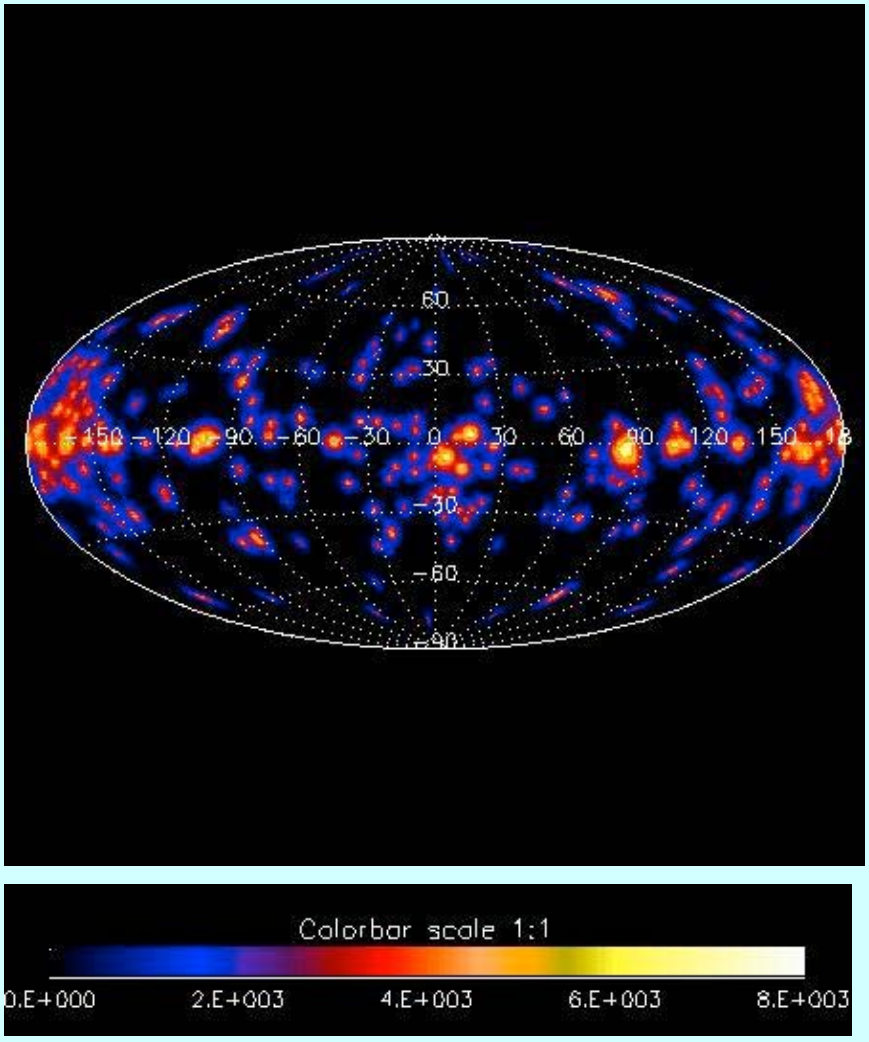


All sky + sources 0.1-30 GeV
827 orbits bg with PSF

Bkg + sources

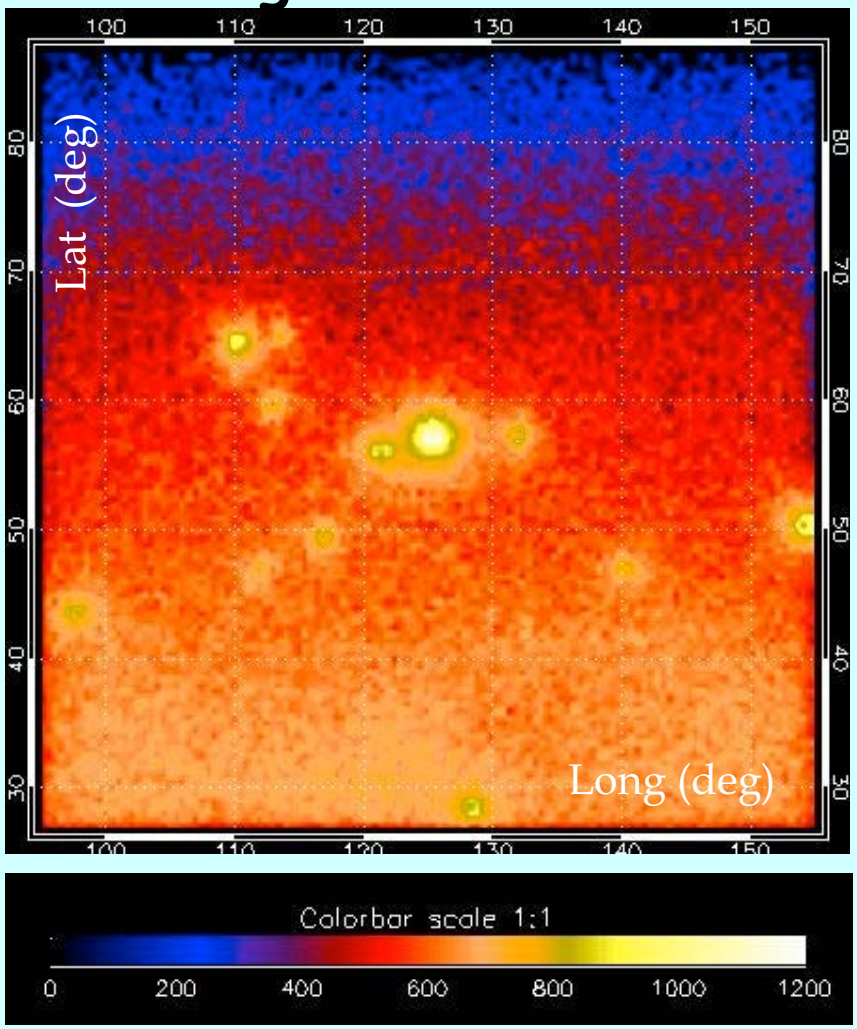


sources

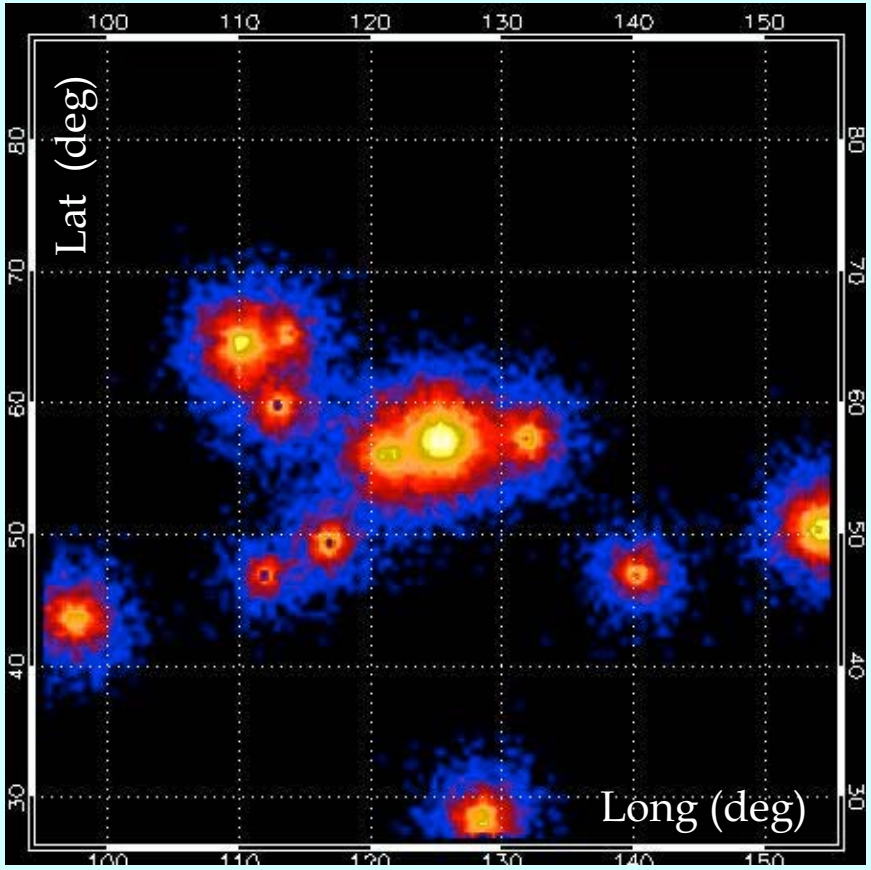


3C279-60 sky + sources 0.1-30GeV
Bg with PSF 827 orbits

Bkg + sources

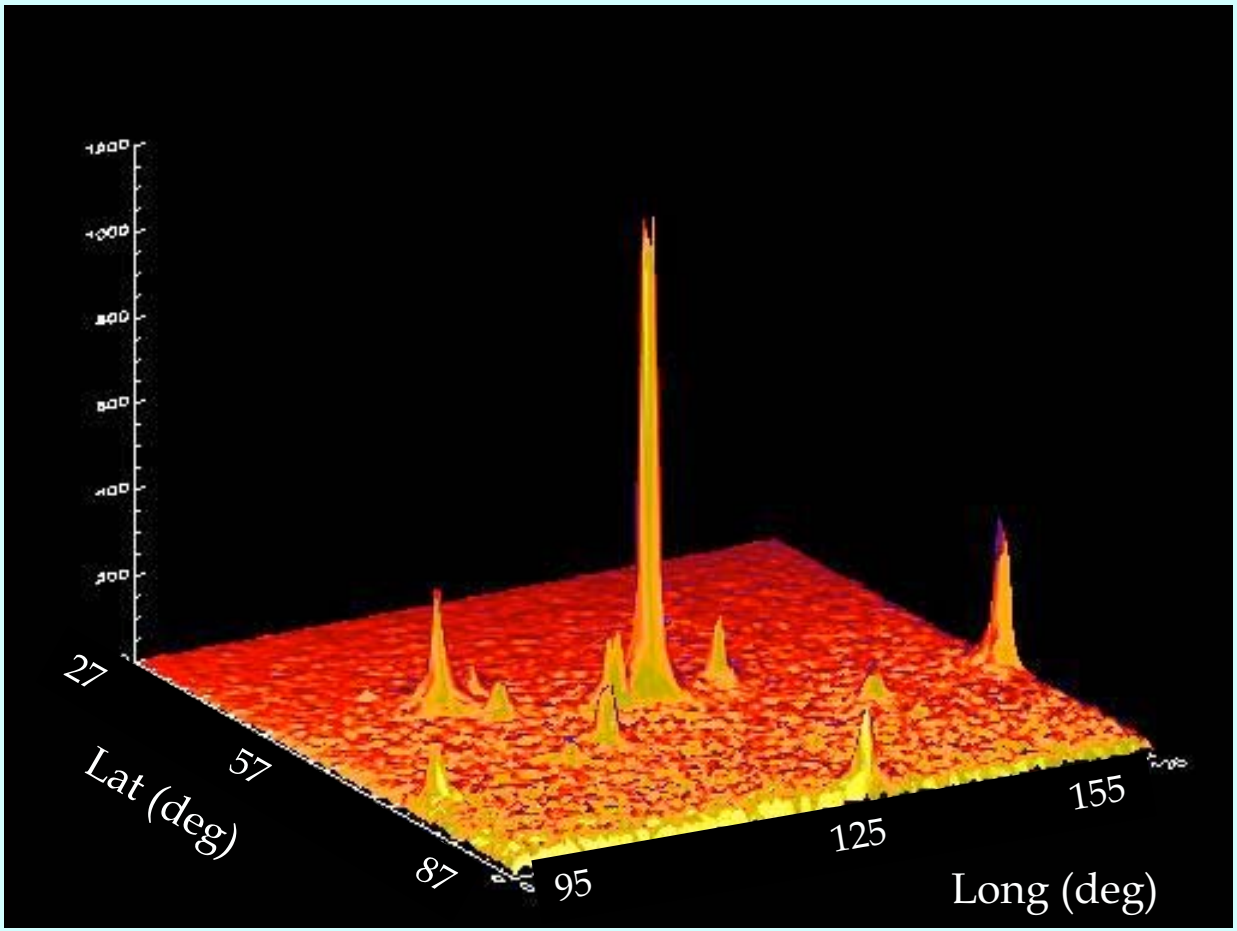


sources



3C279-60 sky + sources 0.1-30GeV
Bg with PSF 827 orbits

Surface plot



CONCLUSIONS

The simulation of the photon flux observed by GLAST works properly using sources from the Third Egret Catalogue and backgrounds either from Galprop results or Egret map.

Still to do:

- Add faint sources from Stecker and Salamon (1996)
- Include angular dependence in the PSF
- Include variability of the sources (see M. Fiorucci talk)

  End of November

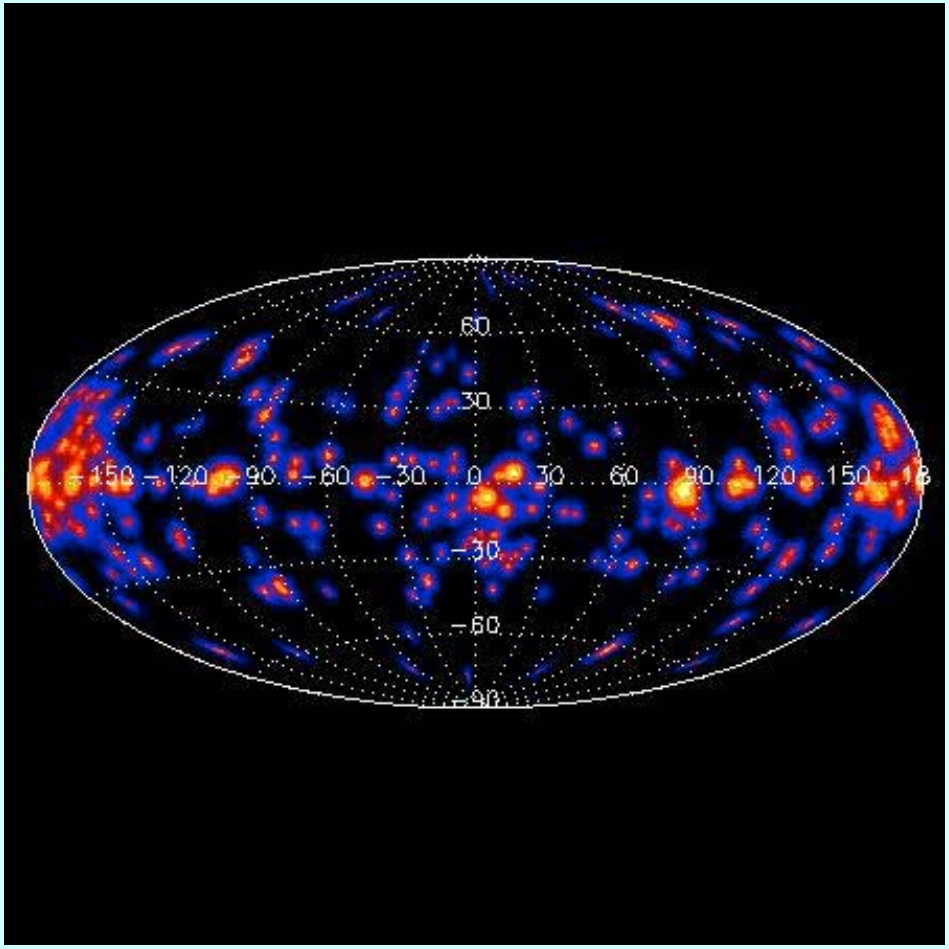
- Graphic interface (working prototype)

  End of December

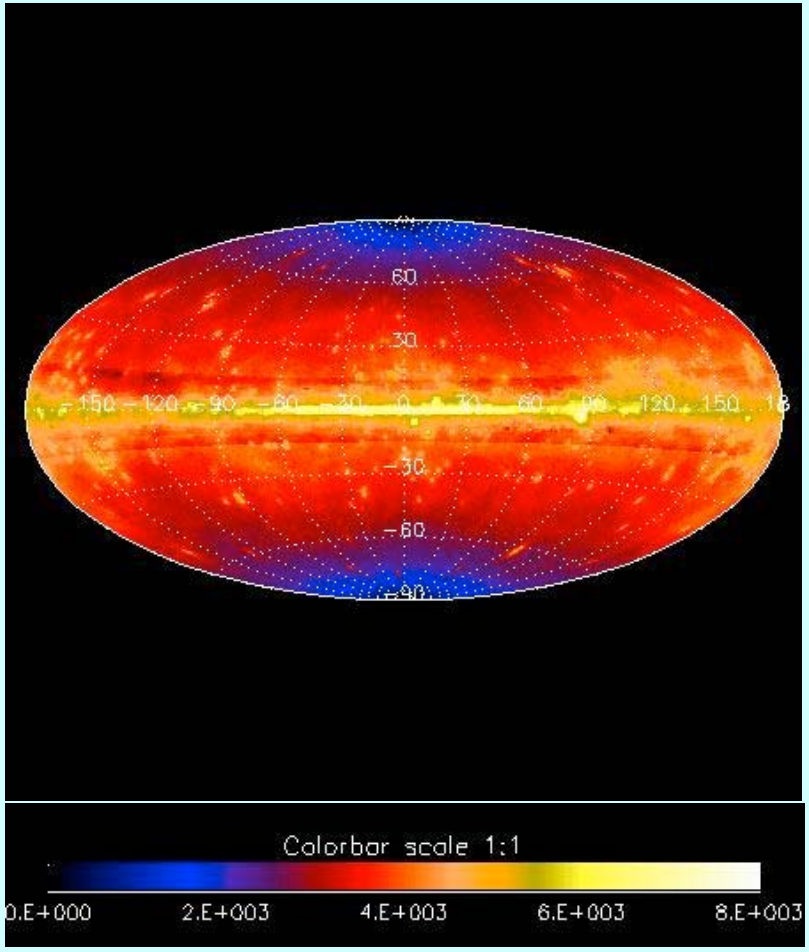
All sky + sources 0.1-30 GeV

827 orbits constant bg

sources

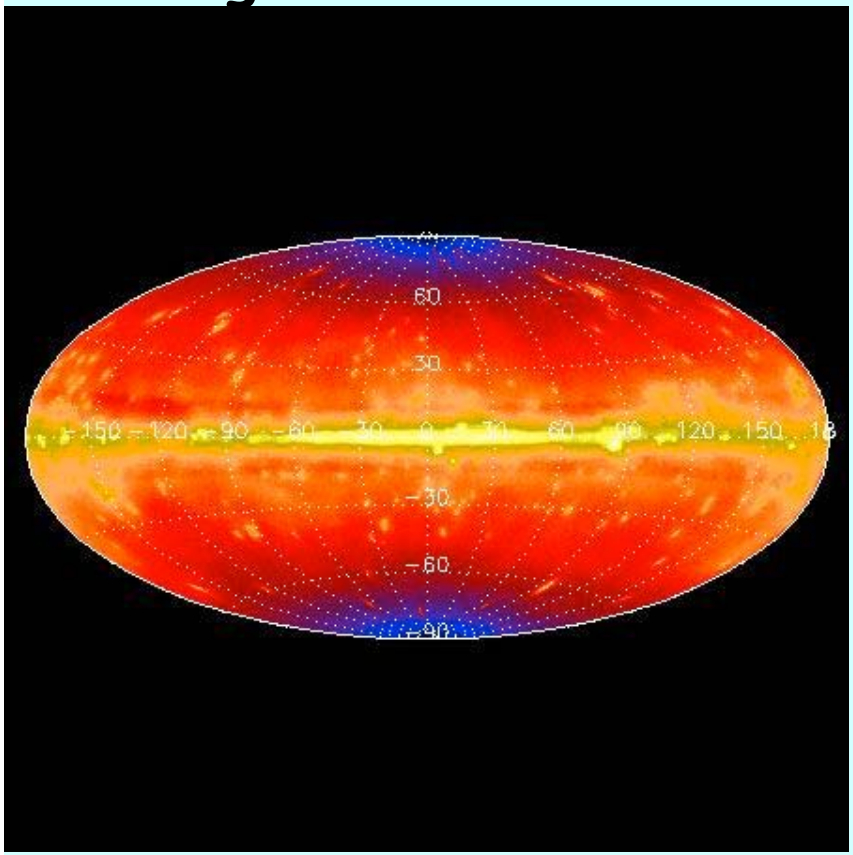


Bkg + sources

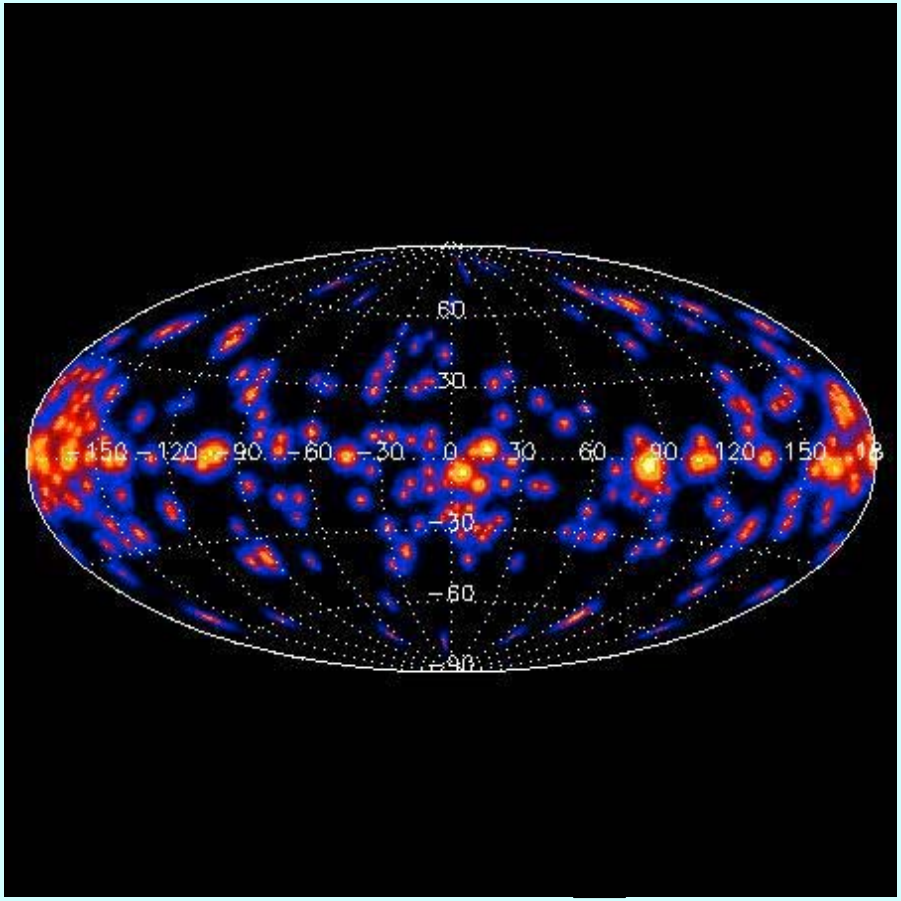


All sky + sources 0.1-30 GeV
no orbit t=4E06 bg with PSF

Bkg + sources

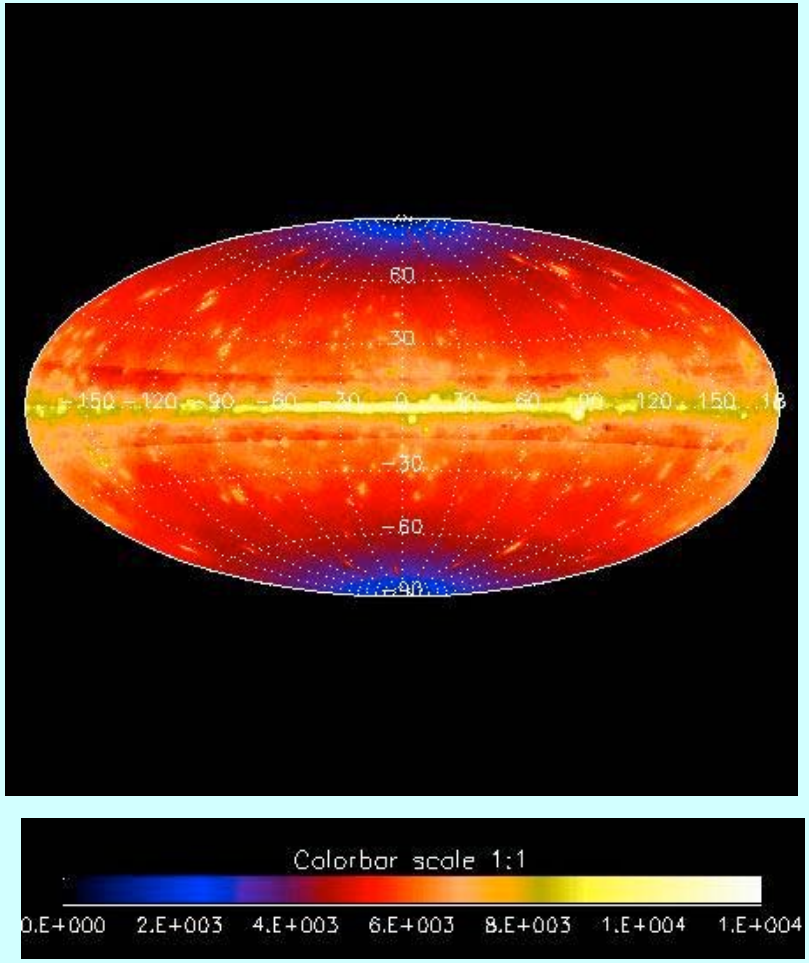


sources

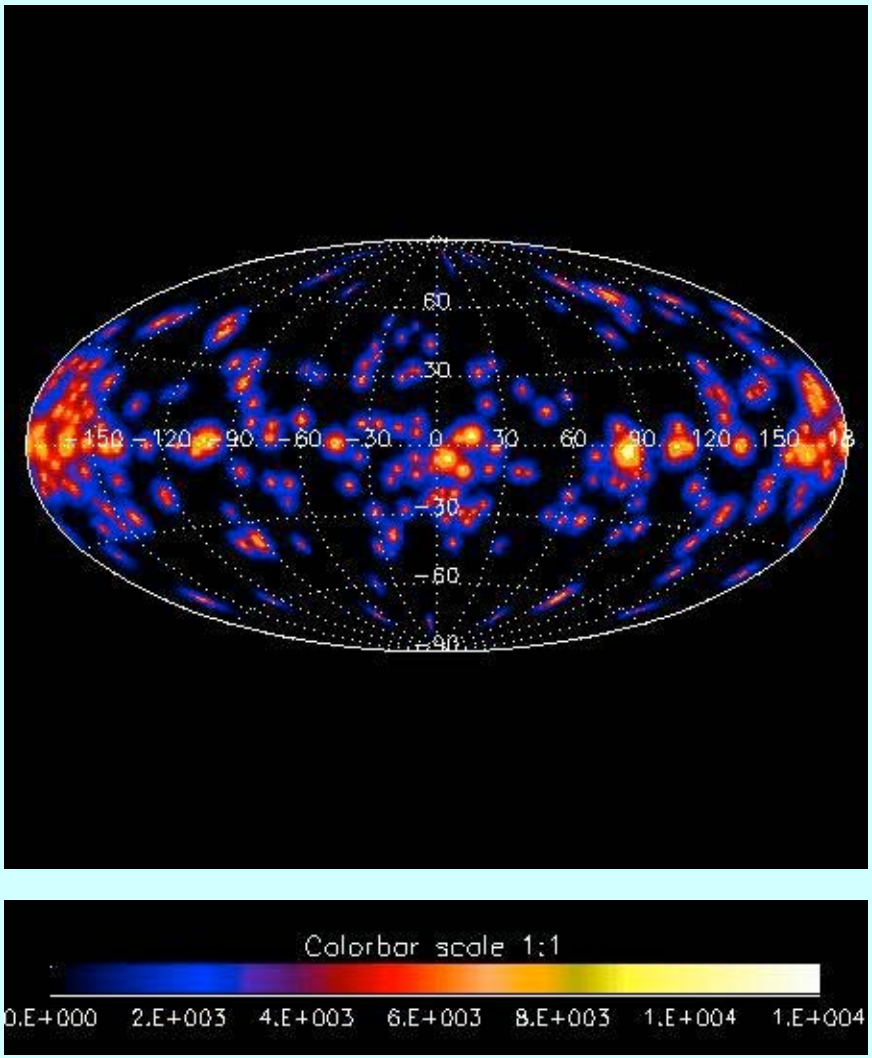


All sky + sources map 0.1-30 GeV
no orbit constant bg t=4E06 s

Bkg + sources



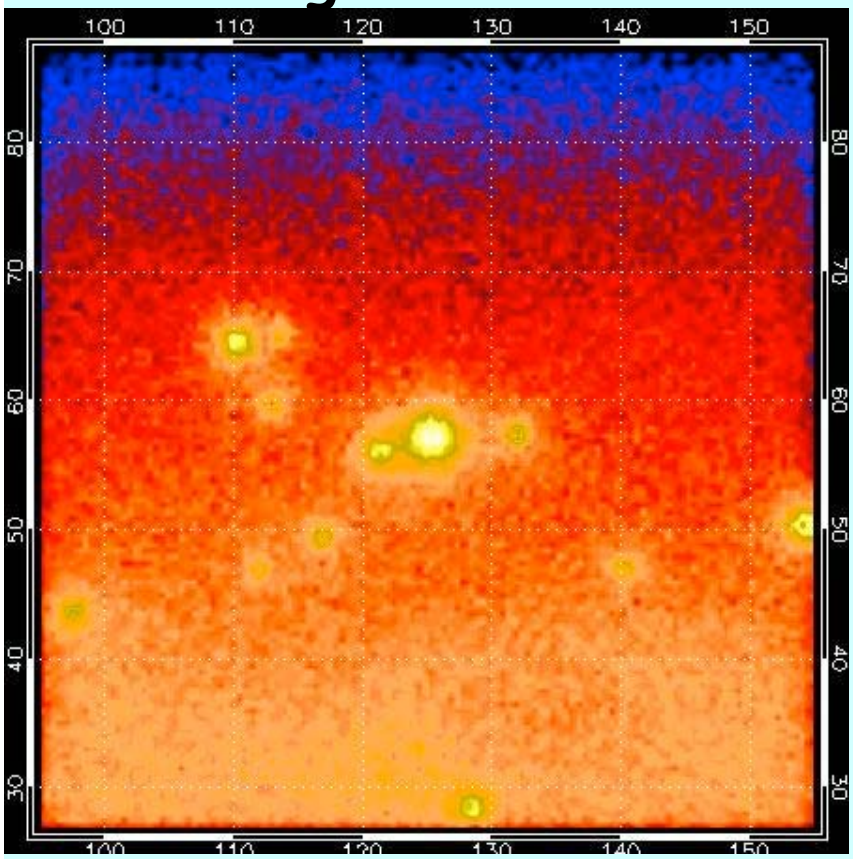
Sources



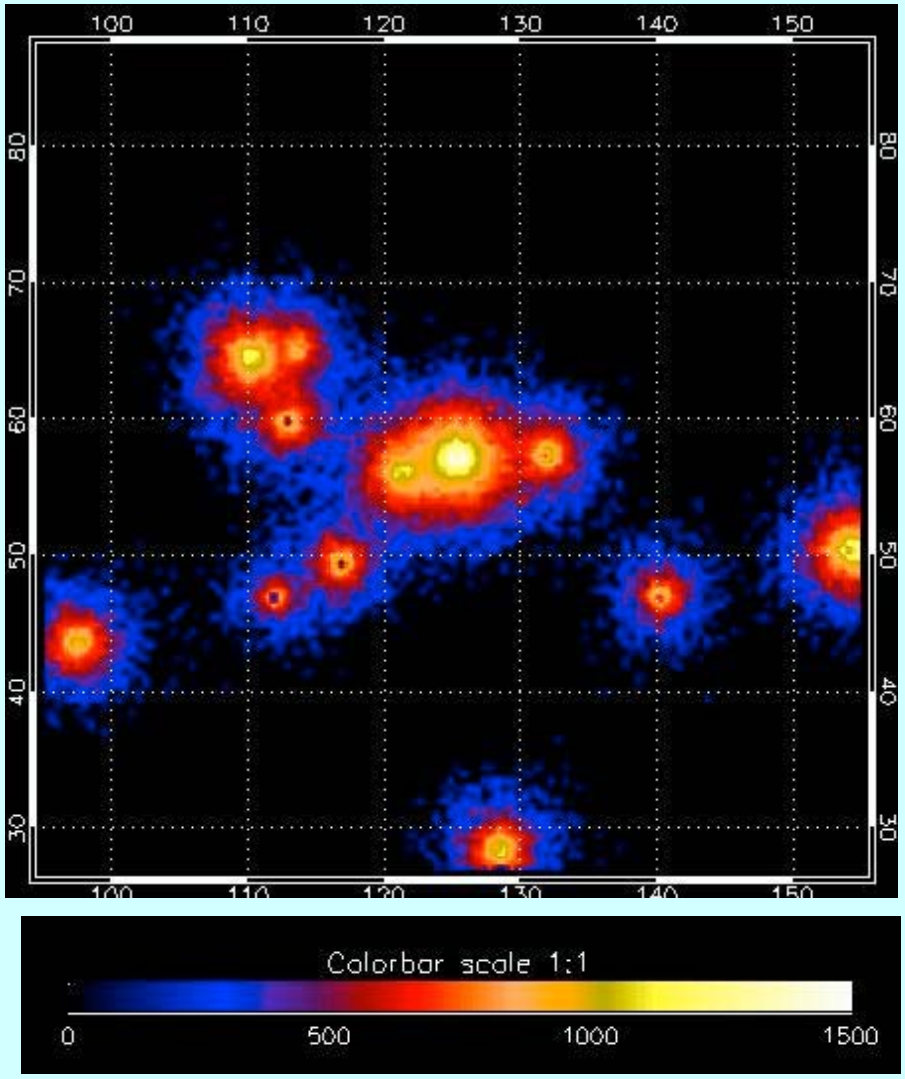
3C279-60 sky + sources 0.1-30GeV

Bg convoluted with PSF (t = 4E06 s)

Bkg + sources



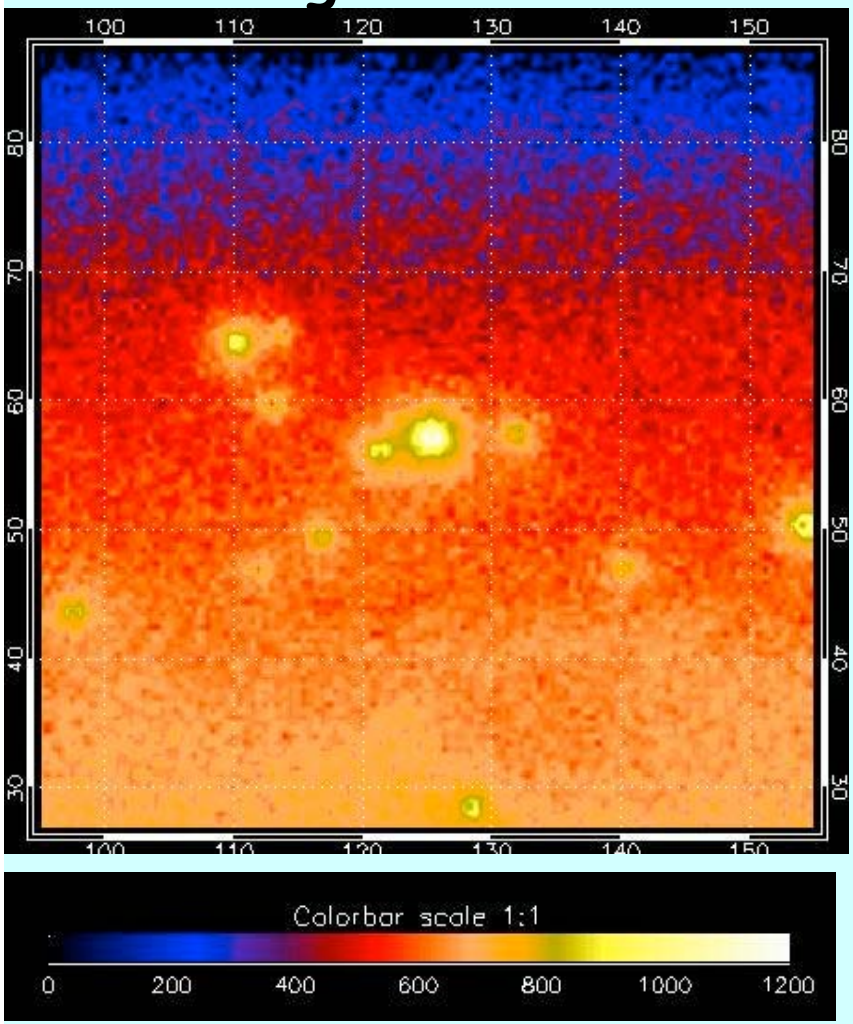
sources



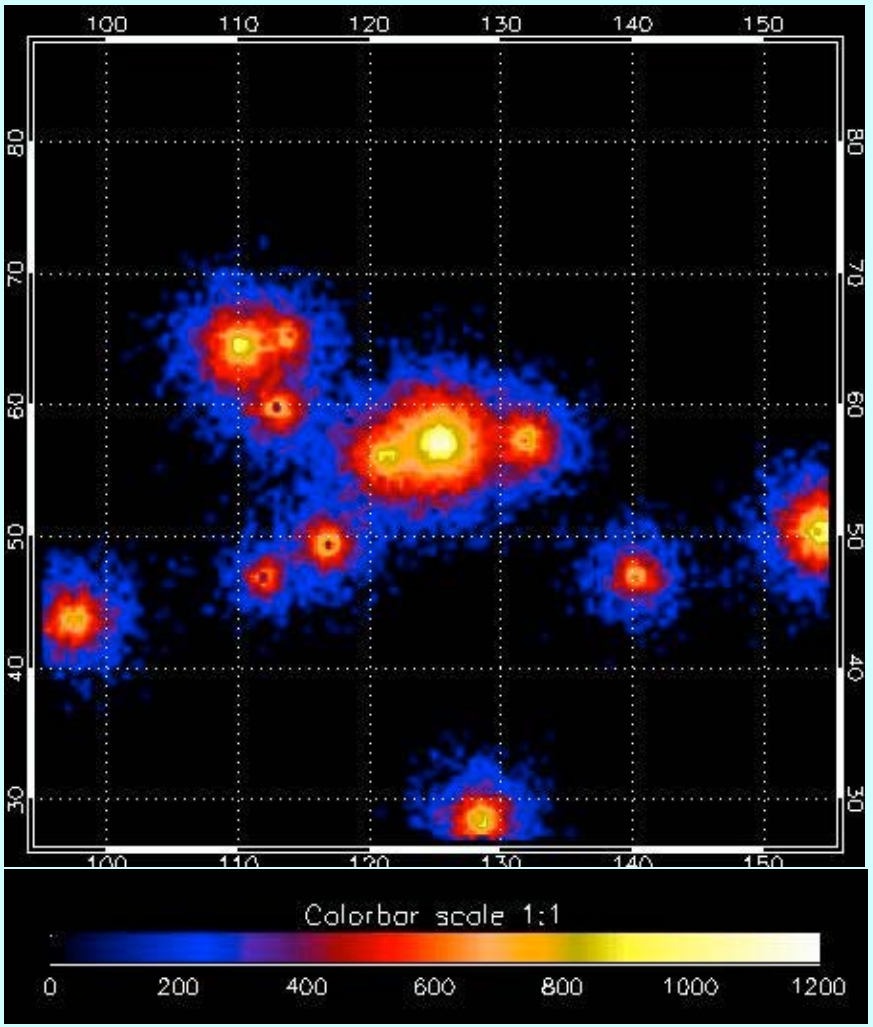
3C279-60 sky + sources 0.1-30GeV

Bg const 827 orbits

Bkg + sources

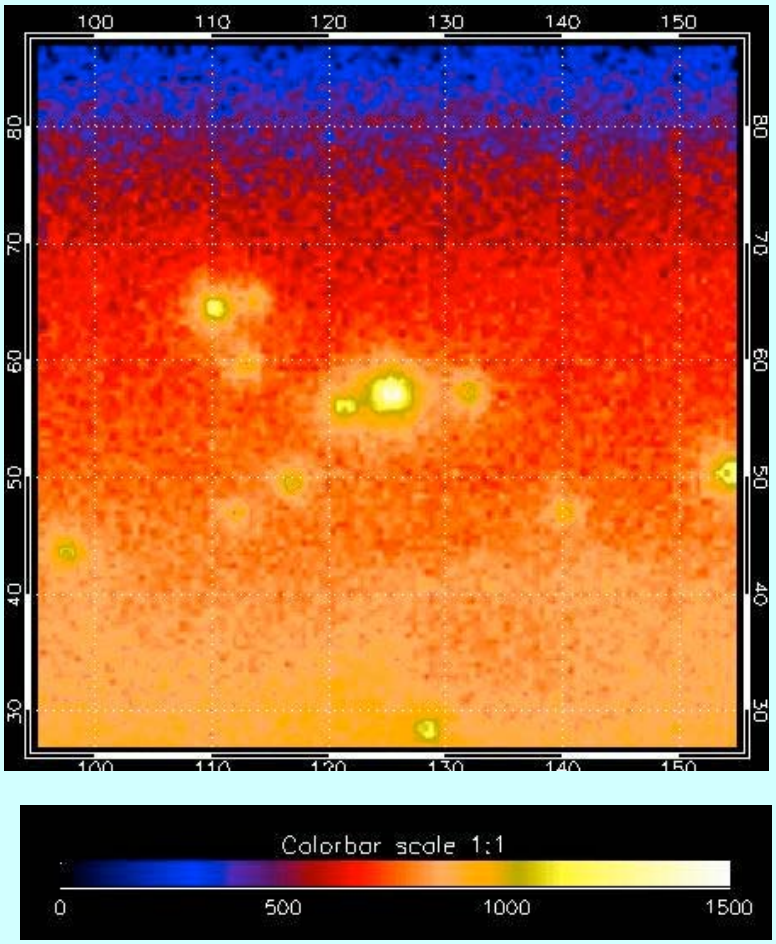


sources



3C279-60 sky + sources 0.1-30GeV
constant bg (t = 4E06 s)

Bkg + sources



sources