Status report on Perugia group
software activities

K. Augustson - C. Cecchi - M. Fiorucci - F. Marcucci - M. Pepe

- Observation simulator
- Independent Component Analysis (ICA)
- Wavelets Analysis -

Roma, sept 16 2003
**Perugia Observation Simulator:**

**Light_Sim** package of Science Tools: standalone generation of sky maps, tables for photons and SC parameters (FITS files) using:

- Parameterization of instrument response functions (SA, PSF, ED) (from S. Ritz and S. Digel)

- Orbit model (**astro** package)

- Source emission modeled as a power law with parameters from **3EGC** or from user file.

- Diffuse emission (>100 MeV) from EGRET model
First attempt of data production to compare with other simulators and to test analysis tools

Simulation of 1 week GLAST sky survey

- Energy range (0.03 , 30 ) GeV
- 30 degrees radius around [b,l]=[0,75]
- sources list from S. Digel
  - 134 sources from:
    - 3EG, faint blazars, local galaxies, galactic halo, low latitude sources with flux (>100 MeV) > 10^{-8} cm^{-2} s^{-1}

**OUTPUT:**
Maps + FITS binary tables available on web
http://www.slac.stanford.edu/~lubrano/skymap_tot.fits
   /source_map_tot.fits
   /tables/xxx.fits

Details on the simulation can be found in:
http://www.slac.stanford.edu/~lubrano/light_simulator_new.doc

Work in progress to compare results from observationSim from J. Chiang
<table>
<thead>
<tr>
<th>ENERGY_meas</th>
<th>ENERGY_UNC</th>
<th>SUBSYSTEM_FLAG</th>
<th>DIRECTION</th>
<th>RA_meas</th>
<th>DEC_meas</th>
<th>TIME</th>
<th>ZENIT_ANGLE</th>
<th>EARTH_AZIMUT_ANGLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GeV</td>
<td>GeV</td>
<td>1J</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
<td>s</td>
<td>deg</td>
<td>deg</td>
</tr>
<tr>
<td>4.97E-01</td>
<td>6.77E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.76E+02</td>
<td>3.42E+01</td>
<td>1.89E+03</td>
<td>1.16E+02</td>
<td>1.52E+02</td>
</tr>
<tr>
<td>1.00E-03</td>
<td>8.47E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.75E+02</td>
<td>2.90E+01</td>
<td>5.54E+02</td>
<td>1.03E+02</td>
<td>7.10E+01</td>
</tr>
<tr>
<td>3.90E-01</td>
<td>7.02E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.76E+02</td>
<td>2.89E+01</td>
<td>4.62E+02</td>
<td>9.97E+01</td>
<td>7.74E+01</td>
</tr>
<tr>
<td>1.08E-01</td>
<td>9.89E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.76E+02</td>
<td>2.92E+01</td>
<td>5.15E+02</td>
<td>1.02E+02</td>
<td>7.31E+01</td>
</tr>
<tr>
<td>1.04E-01</td>
<td>8.84E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.77E+02</td>
<td>2.89E+01</td>
<td>7.05E+02</td>
<td>1.07E+02</td>
<td>6.16E+01</td>
</tr>
<tr>
<td>8.78E-02</td>
<td>9.06E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.78E+02</td>
<td>5.92E+01</td>
<td>7.60E+02</td>
<td>8.83E+01</td>
<td>1.02E+02</td>
</tr>
<tr>
<td>1.12E+00</td>
<td>6.52E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.79E+02</td>
<td>5.94E+01</td>
<td>1.26E+03</td>
<td>9.10E+01</td>
<td>9.24E+01</td>
</tr>
<tr>
<td>1.20E-01</td>
<td>9.83E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.78E+02</td>
<td>5.91E+01</td>
<td>1.44E+03</td>
<td>9.19E+01</td>
<td>9.24E+01</td>
</tr>
<tr>
<td>1.11E-01</td>
<td>9.62E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.82E+02</td>
<td>5.94E+01</td>
<td>1.57E+03</td>
<td>9.27E+01</td>
<td>9.12E+01</td>
</tr>
<tr>
<td>2.48E-01</td>
<td>7.44E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.83E+02</td>
<td>5.98E+01</td>
<td>6.51E+02</td>
<td>8.64E+01</td>
<td>1.04E+02</td>
</tr>
<tr>
<td>4.72E-01</td>
<td>6.72E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.83E+02</td>
<td>5.92E+01</td>
<td>6.74E+01</td>
<td>8.37E+01</td>
<td>1.29E+02</td>
</tr>
<tr>
<td>2.42E-01</td>
<td>8.17E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.82E+01</td>
<td>9.88E+02</td>
<td>1.13E+02</td>
<td>3.11E+01</td>
</tr>
<tr>
<td>1.77E-01</td>
<td>7.41E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.90E+02</td>
<td>1.66E+01</td>
<td>7.81E+02</td>
<td>1.04E+02</td>
<td>4.73E+01</td>
</tr>
<tr>
<td>1.98E-01</td>
<td>7.87E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.84E+01</td>
<td>3.43E+02</td>
<td>8.36E+01</td>
<td>8.74E+01</td>
</tr>
<tr>
<td>1.49E-01</td>
<td>8.45E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.94E+02</td>
<td>1.78E+01</td>
<td>1.28E+03</td>
<td>1.25E+02</td>
<td>3.10E+01</td>
</tr>
<tr>
<td>3.01E+00</td>
<td>7.02E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.76E+01</td>
<td>1.62E+03</td>
<td>1.34E+02</td>
<td>8.61E+01</td>
</tr>
<tr>
<td>3.74E+00</td>
<td>7.15E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.76E+01</td>
<td>2.04E+03</td>
<td>1.36E+02</td>
<td>1.36E+02</td>
</tr>
<tr>
<td>6.74E-03</td>
<td>9.80E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.77E+01</td>
<td>1.95E+03</td>
<td>1.37E+02</td>
<td>1.37E+02</td>
</tr>
<tr>
<td>1.48E-01</td>
<td>8.89E-02</td>
<td>0</td>
<td>8.00E+01</td>
<td>2.92E+02</td>
<td>1.76E+01</td>
<td>7.35E+02</td>
<td>1.03E+02</td>
<td>4.98E+01</td>
</tr>
<tr>
<td>9.59E-01</td>
<td>6.52E-02</td>
<td>1</td>
<td>8.00E+01</td>
<td>2.95E+02</td>
<td>1.47E+01</td>
<td>1.03E+03</td>
<td>1.14E+02</td>
<td>2.93E+01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LatRaZ</th>
<th>LatDecZ</th>
<th>LatRaX</th>
<th>LatDecX</th>
<th>ins</th>
<th>SAA</th>
<th>SClon</th>
<th>SClat</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>deg</td>
<td>deg</td>
<td>deg</td>
<td>deg</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>5.16E+01</td>
<td>1.33E+01</td>
<td>1.14E+02</td>
<td>-9.32E+00</td>
<td>0.00E+00</td>
<td>1.39E+01</td>
<td>2.48E+01</td>
<td></td>
</tr>
<tr>
<td>2.55E+02</td>
<td>-4.44E+01</td>
<td>4.48E+01</td>
<td>-1.66E+01</td>
<td>0.00E+00</td>
<td>-7.19E+01</td>
<td>1.56E+01</td>
<td></td>
</tr>
<tr>
<td>2.41E+02</td>
<td>-4.46E+01</td>
<td>4.04E+01</td>
<td>-1.86E+01</td>
<td>0.00E+00</td>
<td>-7.68E+01</td>
<td>1.32E+01</td>
<td></td>
</tr>
<tr>
<td>2.50E+02</td>
<td>-4.46E+01</td>
<td>4.33E+01</td>
<td>-1.72E+01</td>
<td>0.00E+00</td>
<td>-7.36E+01</td>
<td>1.48E+01</td>
<td></td>
</tr>
<tr>
<td>2.77E+02</td>
<td>-4.19E+01</td>
<td>5.22E+01</td>
<td>-1.36E+01</td>
<td>0.00E+00</td>
<td>-6.34E+01</td>
<td>1.93E+01</td>
<td></td>
</tr>
<tr>
<td>2.86E+02</td>
<td>-4.02E+01</td>
<td>5.52E+01</td>
<td>-1.26E+01</td>
<td>0.00E+00</td>
<td>-5.99E+01</td>
<td>2.06E+01</td>
<td></td>
</tr>
<tr>
<td>3.46E+02</td>
<td>-1.54E+01</td>
<td>8.11E+01</td>
<td>-6.89E+00</td>
<td>0.00E+00</td>
<td>-2.78E+01</td>
<td>2.81E+01</td>
<td></td>
</tr>
</tbody>
</table>

Variables as defined in: [http://www-glast.stanford.edu/protected/mail/scisoft/0155.html](http://www-glast.stanford.edu/protected/mail/scisoft/0155.html)
INDEPENDENT COMPONENT ANALYSIS (ICA)

ICA is a statistical method to determine the independent sub-parts of a complex dataset. It is useful to solve a typical Blind Source Separation (BSS) problem.

The assumed model is a linear convolution of the “source” signal $s$ by a mixing matrix $A$ producing observed data $x$

$$x = A s$$

If the mixing matrix $A$ is unknown, using the central limit theorem the method is able to find the latent variables $s$, without any assumption on the components except for their statistic independence.

Algorithm (FastICA) tested on simulated (light_sim package) and real (EGRET) data in an energy range between 100 MeV and 30 GeV.
Simulated images: 21x21 pixels around 3C279, 827 orbits
Number of photons from sources is reduced of a factor 150
Real and Simulated images: CRAB region, 300 orbits

ENERGY RANGE 40 MeV-150 MeV

Best INPUT

S/N = 3

Best OUTPUT

S/N = 4

S/N = 5

S/N = 10
TEST: HOW THE ALGORITHM DEPENDS ON MODEL LINEARITY

INPUT Mixing: PSF convolution

OUTPUT

INPUT Mixing: random matrix (perfectly linear model)
A model independent method of source detection is critical for the discovery of un-modeled and unknown objects.

One project is addressing the viability of the wavelet transform for source detection. EGRET data are being reanalyzed with the above procedure and compared with the acclaimed 3EG catalog.

Currently there are 269 sources detected at 5σ by the detection algorithm. These are results of a yet unfinished algorithm, of which 203 sources match other catalogs.

This study of the wavelet transform provides a glimpse at the possibilities yielded in gamma-ray astronomical use of the wavelet transform.
WT analyzed EGRET all-sky map

269 point sources detected (preliminary results), background map subtracted

Analyzed by Kyle Augustson
WT Analysis of light_sim GLAST Simulated Data

WT analysis           Raw simulated data
300 orbit exposure of Crab region

Analyzed by Kyle Augustson
EGRET Crab Region WT Per Energy

1) 30-50 MeV
2) 50-70 MeV
3) 70-100 MeV
4) 100-150 MeV
5) 150-300 MeV
6) 300-500 MeV
7) 500-1000 MeV
8) 1000-2000 MeV
9) 2000-4000 MeV

Energy bins 1-9 energy range 30 - 4000 MeV

Analyzed by Kyle Augustson
FUTURE PLANS

**Simulator:**
- Understand differences between two simulator packages
- Implement time variability

**ICA:**
- Study non linear method and verify its feasibility on data

**Wavelets:**
- Complete EGRET data analysis producing source catalogue (point and extended)
- Improve the algorithm for the GLAST data analysis, using simulated images
- Include time series analysis
2 gauss $\sigma \neq \sigma(E)$ without Poidev

2 gauss $\sigma = \sigma(E)$

2 gauss $\sigma \neq \sigma(E)$ with Poidev