Overview of Analyzing GLAST Data

David Band
(GLAST SSC—GSFC/UMBC)
The Goal of Today’s Presentation

- Last meeting we presented details on the definition and development of the Standard Analysis Environment (SAE).
  - Definition by a joint LAT-GSSC working group
  - Development managed by the LAT team with major GSSC participation
  - Supplements and is compatible with FTOOLS
  - Will also analyze GBM burst data with the addition of two GBM-specific tools

- Today we focus on the methods underlying the SAE. We also present the relationship between the SAE and the standard FTOOLS.

- In the future we will address the user interface and the documentation, and arrange for the Users’ Committee to beta test the tools.
Data Analysis Issues

- The PSF is large at low energy, small at high energy.
- With the LAT’s large effective area, many sources will be detected; their PSFs will merge at low energy.
  - Analysis is inherently 3D—2 spatial and 1 spectral (& users are interested in temporal!)
- For a typical analysis the source model must include
  - All point sources within a few PSF lengths of the region of interest
  - Diffuse sources (e.g., supernova remnants)
  - Diffuse Galactic emission (modeled)
  - Diffuse extragalactic emission
- Sources are defined by position, spectra, and perhaps time history. Initial values may be extracted from the point source catalog that will be compiled by the LAT team.
- The source model will have many parameters. In an analysis some will be fitted, some will be fixed.
• The instrument response (PSF, effective area, energy resolution) will most likely be a function of energy, angle to the LAT normal, conversion layer (the front or back of the LAT), and the electron-positron vertex angle. The IRF may also depend on the charged particle background resulting from the geomagnetic latitude, Solar cycle phase, etc.

• The LAT will usually survey the sky. Therefore a source will be observed at different instrument orientations.

• Pointed observations will keep the source of interest within 30° of normal.
• The observables for a photon are:
  – Apparent energy
  – Apparent origin in sky coordinates (2 observables)
  – Apparent origin in instrument coordinates (2 observables)
  – Time
  – Front vs. back of LAT
  – Other detailed information from the LAT (e.g., the vertex angle between the electron-positron pair)

Note that with aspect information—where the instrument was pointed as a function of time—there is a redundancy among the time and the apparent origins in sky and instrument coordinates.

• Therefore, a very large data space results. Even with $10^5$ counts, this data space will be sparsely populated.
Planned Basic Analysis Strategy

• We plan to detect sources, determine source intensities, fit spectral parameters, set upper limits, etc., using the likelihood $\Lambda$ of the observed counts given a source model.

• Burst, pulsar analysis will take advantage of the source’s temporal variations.

• Today methodology is the focus, but a schematic of the SAE architecture is helpful for context.
Schematic of SAE

Note that some details have changed.
Data Extraction

- Level 0.5
- Level 1 (D1)
- Pointing/livetime history (D2)
- Observation simulator (O2)
- Pt.ing/livetime simulator (O1)
- Data sub-selection (U2)
- Pt.ing/livetime extractor (U3)
- Event display (U1)
- Data extract (U1)
- Pt.ing/livetime extractor (U3)
- IRFs (D3)
- GRB LAT DRM gen. (U14)
- IRF visualization (U8)
- Source model def. tool (U7)
- Catalog Access (U9)
- Storm ID (A2)
- Map gen (U6)
- Interstellar em. model (U5)
- Likelihood (A1)
- GRB spectral-temporal modeling (A10)
- GRB unbinned spectral analysis (A9)
- Arrival time correction (U10)
- GRB visual-ization (U13)
- Arriva...
GRB Tools

- Level 0.5
  - Event display (U1)

- Level 1 (D1)
  - Data extract (U1)
  - Pt.ing/livetime extractor (U3)

- Pointing/livetime history (D2)
  - Observation simulator (O2)
  - Pt.ing/livetime extractor (U3)

- Alternative source for testing high-level analysis
  - Alternative for making additional cuts on already-retrieved event data

- Data in
  - Data sub-selection (U7)
  - Pt.ing/livetime extractor (U3)

- GRB LAT DRM gen. (U14)
  - GRB event binning (A5)
  - GRB rebinning (A6)

- GRB spectral analysis (A8)
  - GRB visualization (U13)

- GRB spectral-temporal modeling (A10)
  - GRB visual-ization (U13)

- Source model def. tool (U7)
  - Catalog Access (U9)
  - Lat Point source catalog (D5)

- Interstellar em. model (U5)
  - Map gen (U6)

-Likelihood (A1)
  - IRF visualization (U8)

- IRFs (D3)
  - GRB unbinned spectral analysis (A9)

- GRB LAT DRM gen. (U14)
  - GRB spectral analysis (A8)

- GRB temporal analysis (A7)
  - GRB rebinning (A6)
  - GRB event binning (A5)

- Data in
  - Data sub-selection (U7)
  - Pt.ing/livetime extractor (U3)

- GRB LAT DRM gen. (U14)
  - GRB event binning (A5)

- GRB spectral analysis (A8)
  - GRB rebinning (A6)
  - GRB event binning (A5)
Catalog Tools

- Pulsar ephem. (D4)
- Pulsar period search (A4)
- Ephemeris extract (U11)
- Pulsar phase assign (U12)
- Pulsar profiles (A3)

Level 1 (D1)
- Event display (U1)
- Data extract (U1)
- Pt.ing/livetime extractor (U3)

Level 0.5
- Data sub-selection (U2)
- Pt.ing/livetime extractor (U3)

Alternative source for testing high-level analysis
- Observation simulator (O2)
- Pt.ing/livetime simulator (O1)

Alternative for making additional cuts on already-retrieved event data
- Exposure calc. (U4)
- IRFs (D3)
- IRF visualization (U8)
- GRB LAT DRM gen. (U14)
- GRB event binning (A5)
- GRB rebinning (A6)
- GRB spectral analysis (A8)
- GRB rebinning (A6)
- GRB spectral-temporal modeling (A10)
- GRB event binning (A5)

LAT Point source catalog (D5)
- Catalog Access (U9)
- Source model ref. tool (U7)
- Likelihood (A1)
- Interstellar em. model (U5)
- Map gen (U6)
- GRB unbinned spectral analysis (A9)
- GRB visual-ization (U13)
- GRB temporal analysis (A7)
- GRB visual-ization (U13)
- GRB spectral-temporal modeling (A10)