# A7.  GRB Physical Modeling

Date:   23 June 2002 (draft v2)
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## Function

This tool fits a GRB physical model to the combined GBM and LAT data when both are available; or for data from only one instrument, if desired, or if data from only one is available.  Essentially, a fitting engine provides feedback to the physical model algorithm which adjusts parameters to realize a "best fit" – given the model's complexity and capabilities – to the observed energy-dependent impulsive emission as a function of time.

Input parameter values from the GRB spectral-temporal analysis tool (A6) may be used to guide or constraint the fitting process.  The LAT data require the fitting engine to perform computations in the Poisson (low counts per bin, or unbinned) regime.  The fitting engine incorporates the LAT exposure and the GBM detectors' responses, in order to transform the physical units of the model to the observed data units.  The fitting engine procedure could be very similar to the A1 likelihood tool, but with energy and time as the independent variables.  Probable free physical parameters (which may be a function of time) include emission volume, and distance from source; observer viewing angle with respect to the jet axis, and profile of Lorentz factor.

Besides the GRB data and exposure information, the other required ingredient to be supplied to the fitting engine is a physical model evaluated with model parameter values.  A separate module expresses and evaluates the physical model, supplying the time and energy-dependent numerical realization to the fitting engine for comparison with the data.  Physical models may be computationally intensive, including integrals over the emission region for energy-loss mechanisms and contributions from a range of angles off jet axis.

## Inputs

- Gamma-ray data extracted by the LAT Data Extractor U1 and the corresponding exposure matrix calculated by the LAT Exposure calculator U3.  (These tools are the front ends to the Event summary database D1 and the Pointing/livetime history database D2 for all of the analysis tools.)  A GRB option in the U1 tool should afford the option of "relaxed" filters, since bursts are much brighter than other sources and are localized in time.
- Gamma-ray data extracted by a GBM tool (analogue of U1), and corresponding detector response matrix (DRM, the analogue of LAT exposure versus energy).
- Option for simultaneous input of GRB data from other missions (Swift, AGILE).
- A selectable physical model – a separate module.
- Constraining information from any long-wavelength observations (such as redshift).
- Pulse model descriptors and/or spectral fits, from the A6 tool, provided as constraints or guides to the physical model.

## Databases required

D6 – CALDB (or an intermediate tool, analogous to U3) for the GBM's DRMs.

## Outputs

The desired output includes parameter values which describe, e.g. the sequence of impulsive emissions and their temporal-spectral shape in flux units, and each emission region's shape, volume and distance from source; and more extensive parameter values which describe, e.g. the view angle w.r.t. the jet axis, and profile of Lorentz factor.

Sufficient information should be provided to link the A6 and A7 analysis outputs for a burst.  Provision for scripting should allow re-invoking a previously performed fit to make adjustments.

## Performance requirements

The performance limiting factor will be iterated generation of the numerical model.

## Other modules required

GRB numerical models.

## Host environment

Client computer

## Existing counterparts

A phenomenological pulse fitting algorithm exists (Norris et al.), based on a least squares approach.  Bayesian likelihood algorithms exist which work in the Poisson (low counts per bin, or unbinned) regime.

As proof of existence, at least one physical model (colliding, shocked shells) has been coded by GLAST members (Omodei et al.), providing the means and motivation to proceed with development of the A7 fitting engine tool.

## Open issues for definition or implementation

1.  The nature of the feedback mechanism and the information channeled from fitting engine to the physical model evaluator – required for iterative parameter adjustment – needs to be developed.

2.  Development of GRB physical models is open-ended, and we may envision (private) user-specified models that merely utilize the GRB data, A6 input and the fitting engine.

3.  GRB simulators will be used to make synthetic bursts to help develop the fitting engine.  The simulators need to continue across the GBM energy range to be fully useful.