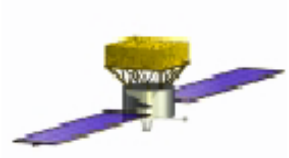
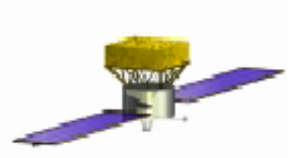


GRB Spectrum
Simulating a transient source

Nicola Omodei

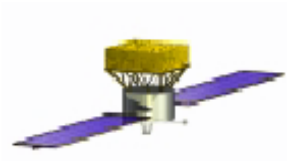
INFN Pisa

University of Siena



The activities...

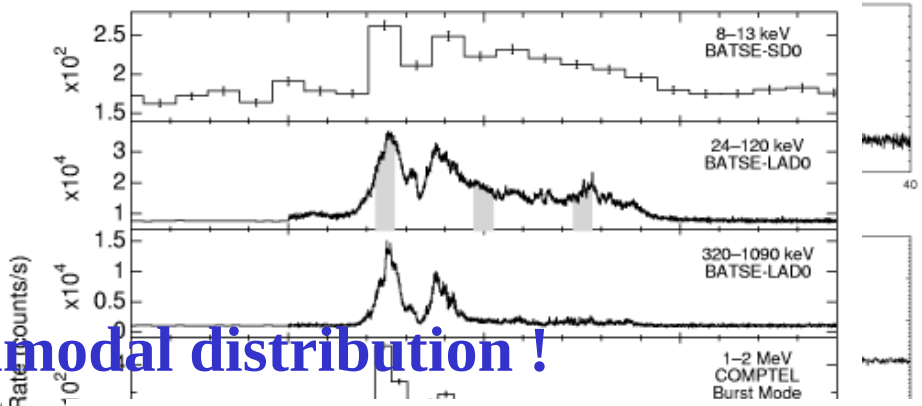
- Overview & General Design
  - General Design
  - The Fireball model
  - How the model works
    - Initialization
    - Computation of the flux
  - Scheme of the classes
  - Some results (presented as picture gallery)
- To do list and conclusions

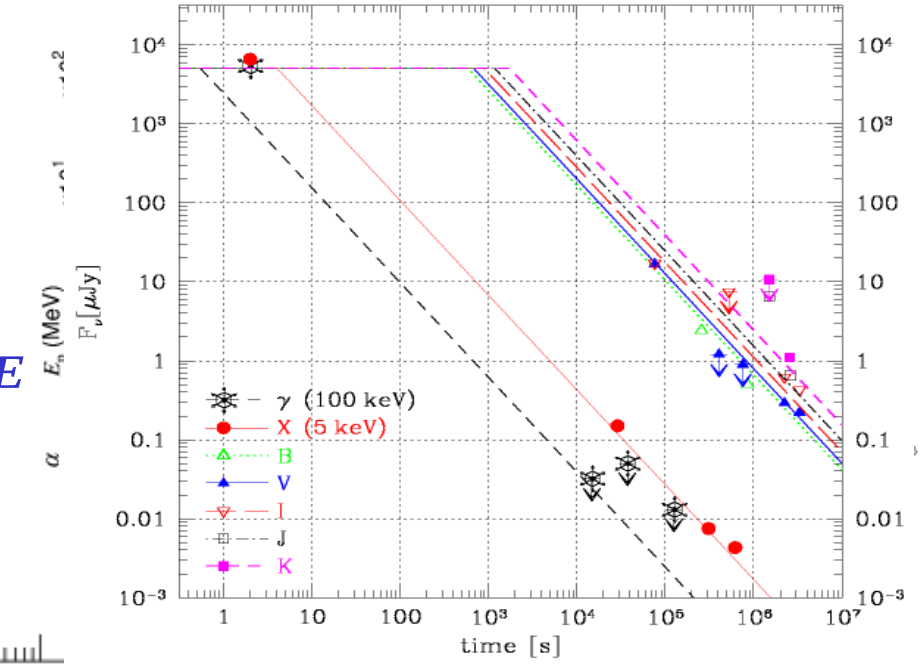


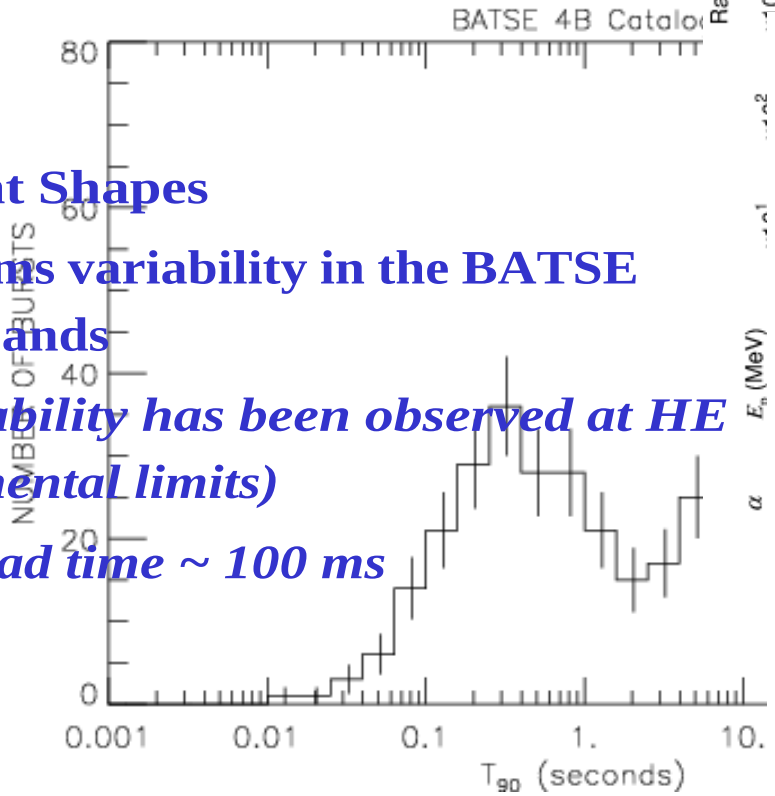
Temporal Behavior & Time Scales

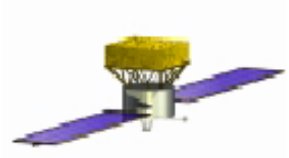
- Prompt Emission
  - –Burst Duration -> 1s ÷ 100 s **Bimodal distribution !**
  - –Va
- **Different Shapes**
- **Typical ms variability in the BATSE energy bands**
- ***No variability has been observed at HE (Instrumental limits)***

EGRET Dead time ~ 100 ms









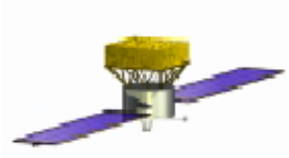
GRB simulation

- We've started from a plausible astrophysical source model (Fireball Model) that describes the temporal behavior of a typical Gamma Ray Burst
  - Rapid variable signal (ms)
  - Non thermal emission (Synchrotron & Inverse Compton Scattering)
- XML description not yet available
  - Dictionary of spectra implemented for look up
  - Many parameters -> might be clumsy
  - Chance to have a 'real' simulator (also for the sources)

Written Entirely in C++

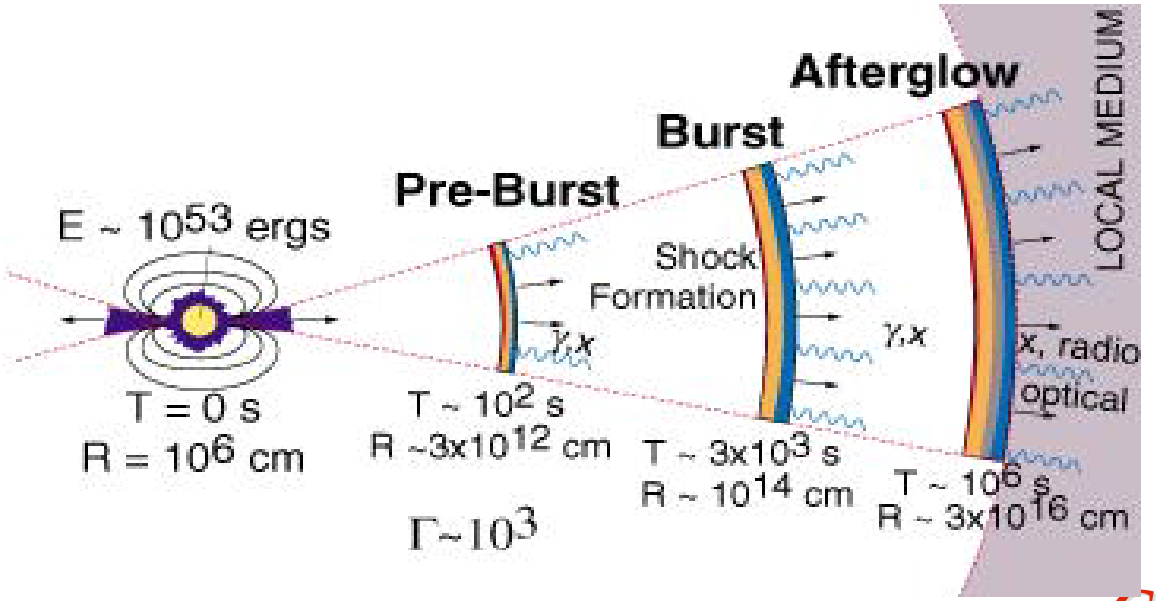
FluxSvc *HEAD Version (v5r2):* src/GRB/<all the source files>
src/test/GRBParam.txt (the configuration file)
Some changes in the requirements

FluxDisplay *HEAD Version (v0)* src/test/GRBTest.cxx (Test Program)
src/test.GRBParam.txt (the configuration file)
Some changes in the requirements

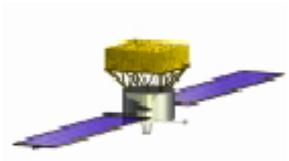


The Fireball Model

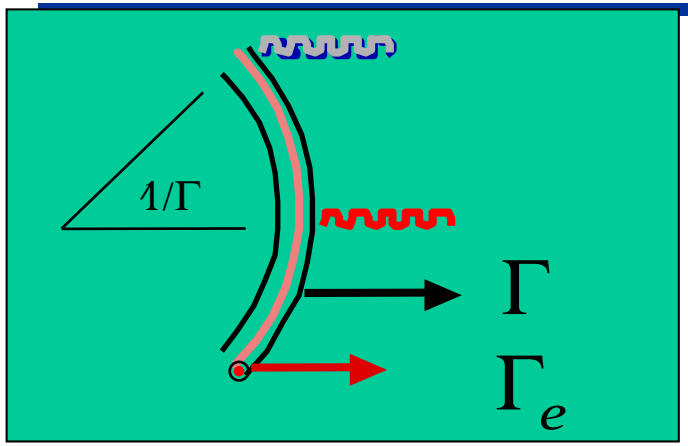
The central engine emits shells with different Lorentz Factor.
The shells collide -> formation of shocks wave inside the shell's material
The shock accelerate the electrons that emits by synchrotron (presence of MF).
The high energy emission is provide by the Compton Scattering.



GLAST
Italia



The Shape of a spike



Rise Time ~Geometry of the Shell

$Dt_{rise} \sim r / (2\,\Gamma^2) \sim 10^{-5 \div -3} s$

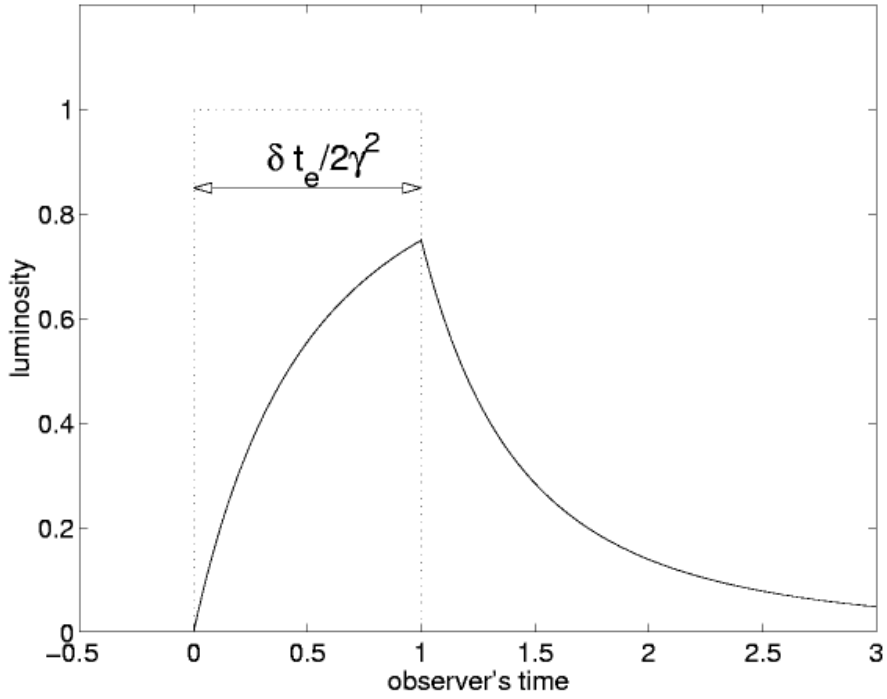
Decay Time ~ Cooling Time

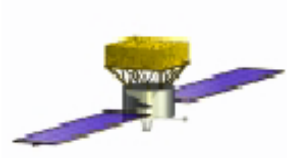
$dt_{decay} \sim 10^{-4} \div 10^{-3}\ s \sim 1/\sqrt{E}$

FRED = Fast Rise Exponential Decay

If the first shell slows down the conversion efficiency is higher !

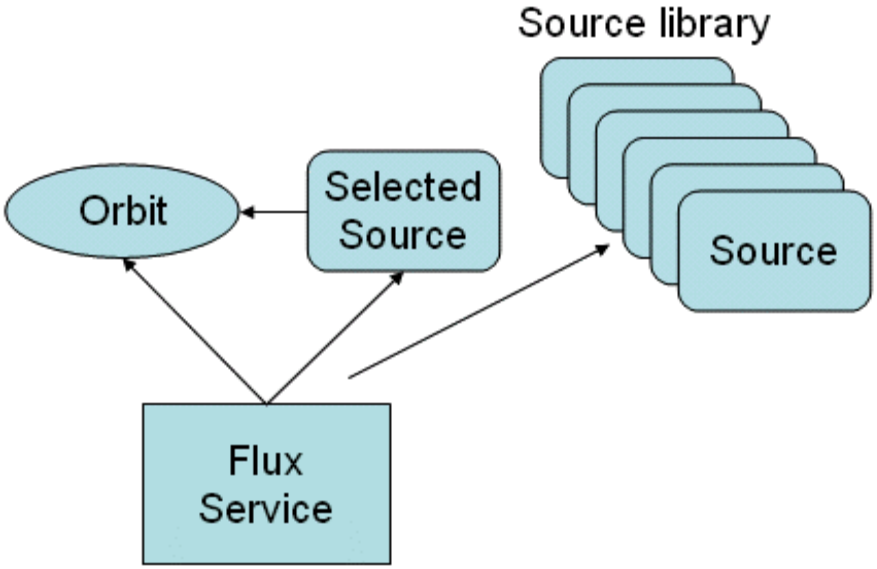
(Fenimore & Ramirez-Ruiz 1999)

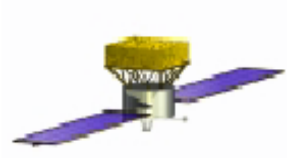




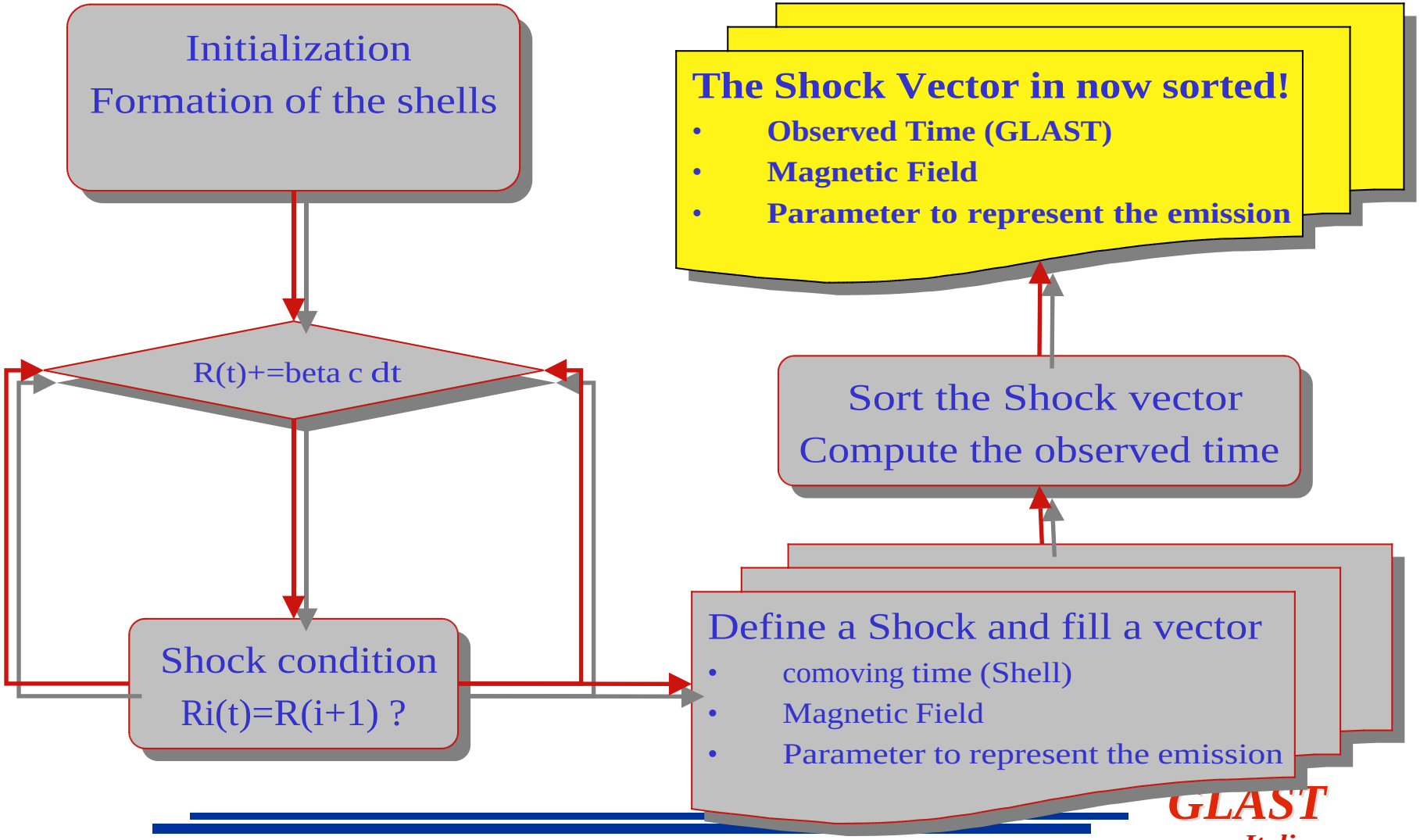
Flux Svc

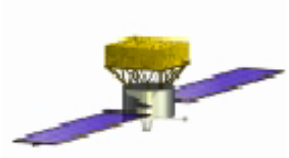
- Selection of different particle for the simulation
- Different Sources
  - Primary and secondary Galactic Cosmic Rays: protons and electrons
  - Albedo gammas
  - Gammas for testing resolution
  - Galactic gamma point sources
  - Galactic diffuse sources
  - Transient sources-> GRB Spectrum
- The satellite is illuminated in the correct way
  - Given the position of the source FluxSvc computes the incident photon's angle depending on the orbit of GLAST.





Initialization





Computation of the flux

The Shock Vector is now sorted!

- **Observed Time (GLAST)**
- **Magnetic Field**
- **Parameter to represent the emission**

TIME

Computation the Flux

Summation over all the shock emission

m_spectrum(time)

Draw Photon from Spectrum

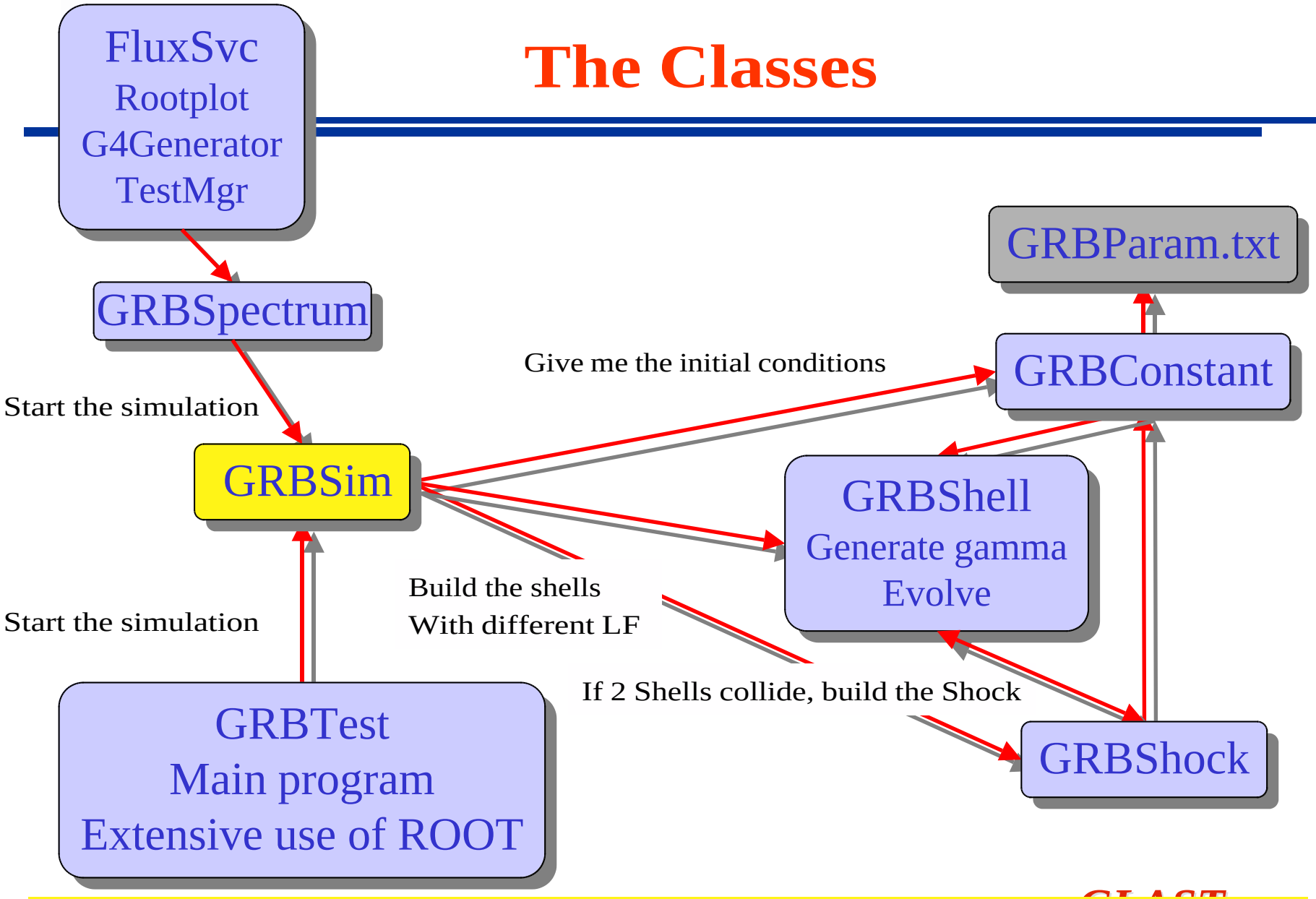
Energy of a photon, in agree with the flux

Energy of the photon

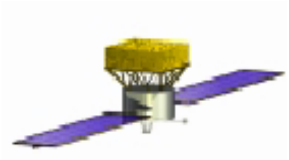
(to be processed by the simulation)

Flux, Rate, direction.

The Classes

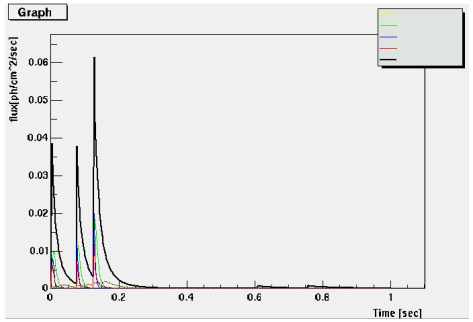


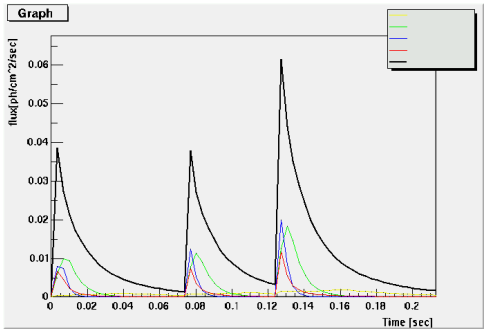
Doxygenation @ http://www.pi.infn.it/~omodei/GRBTest

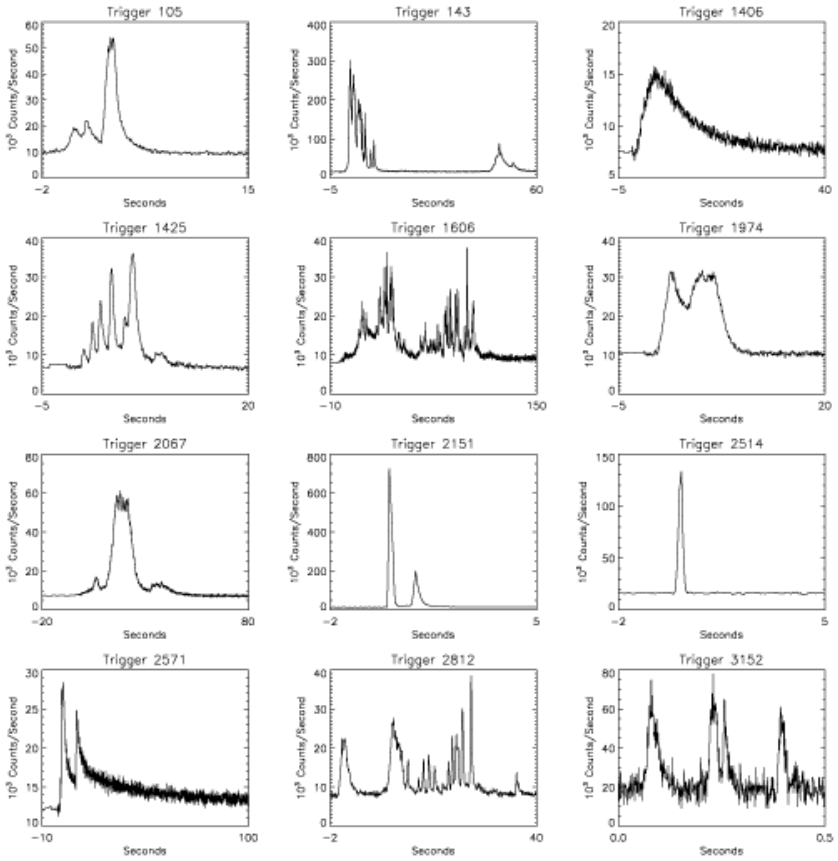


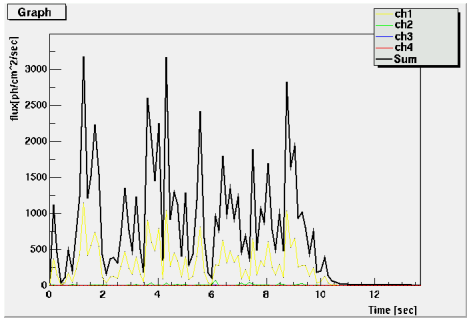
Light Curves

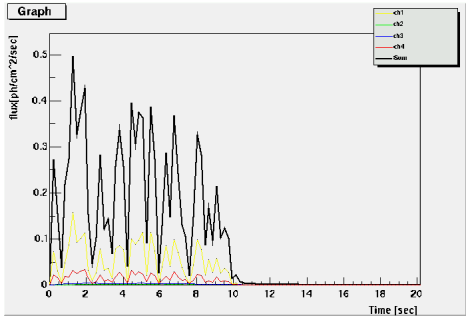
Short Bursts & Long Bursts





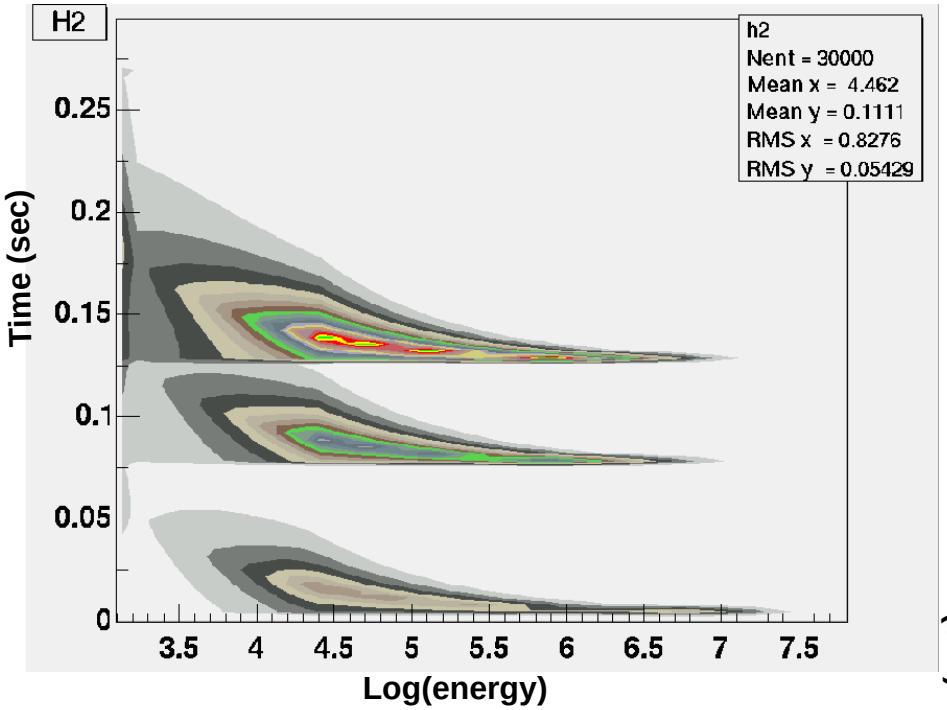






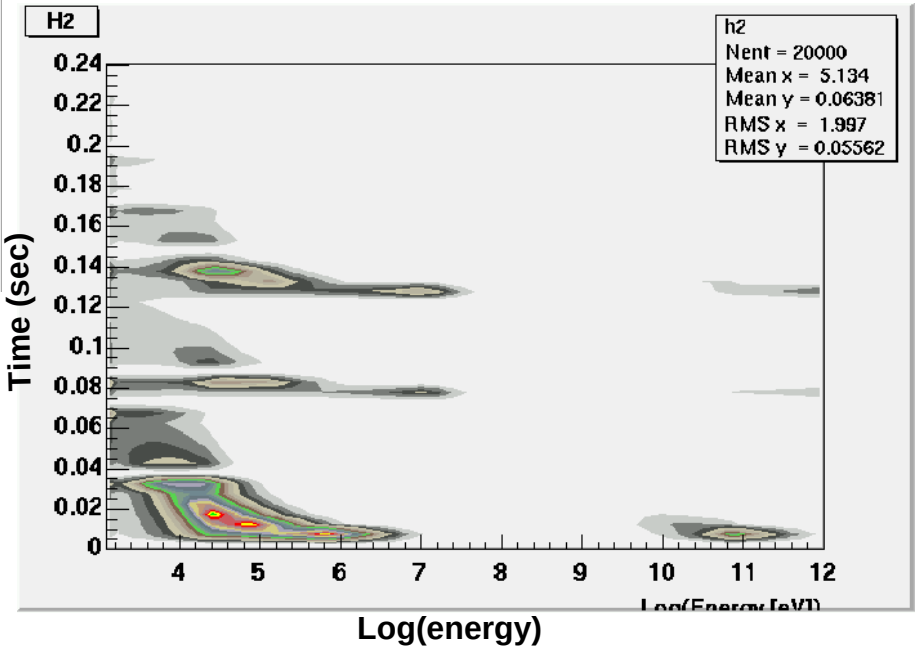
GLAST Italia

Contour Plot

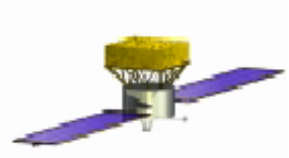


<- Synchrotron

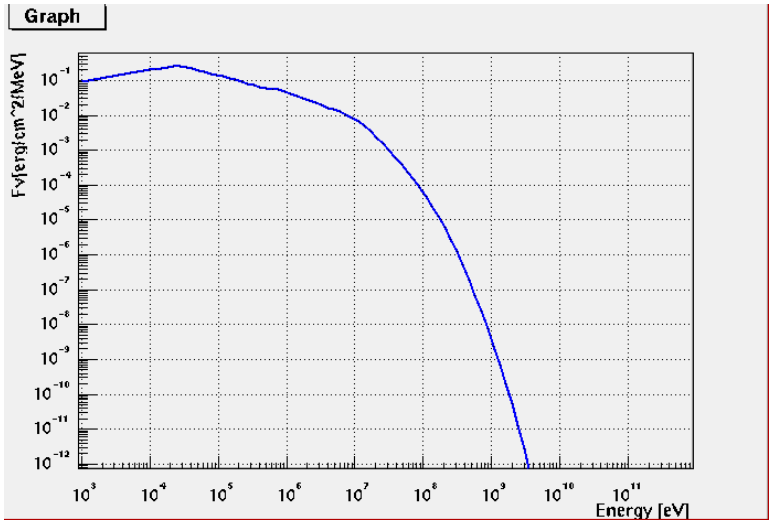
Synchrotron & IC ->

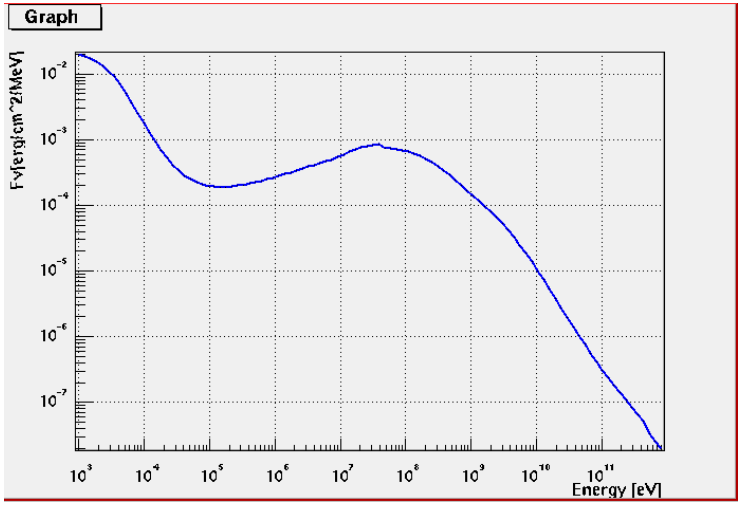


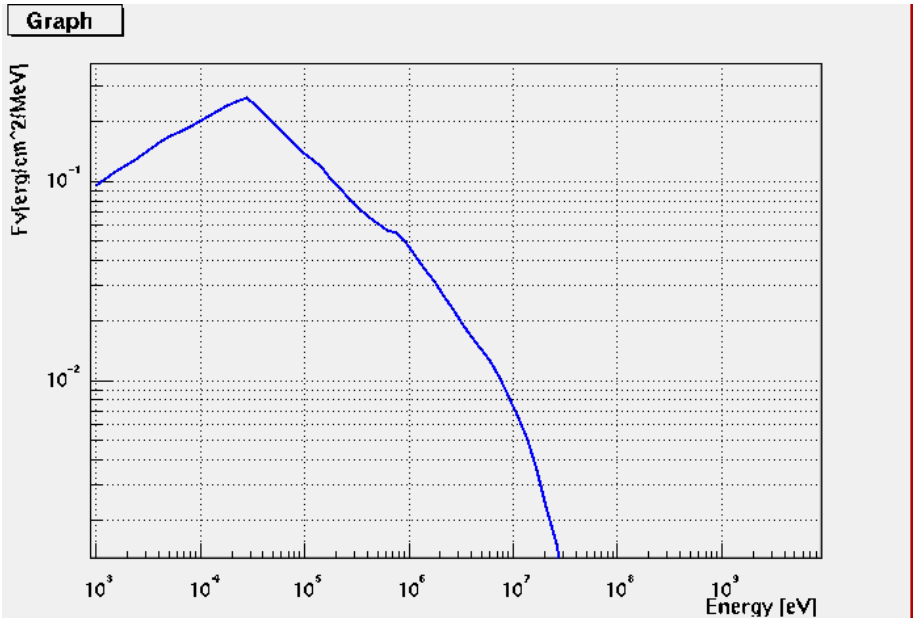
Harder Peak are shorter!



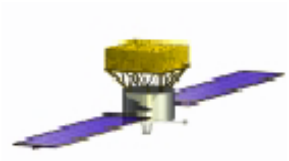
Spectrum



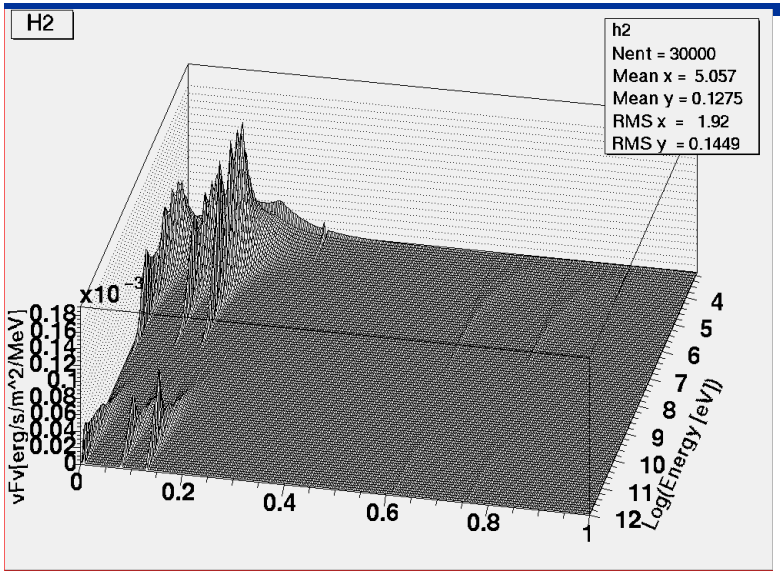


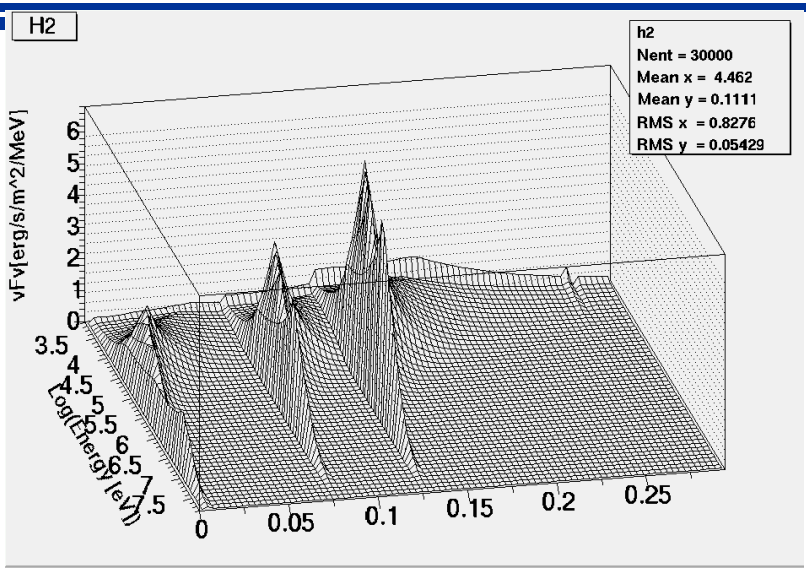


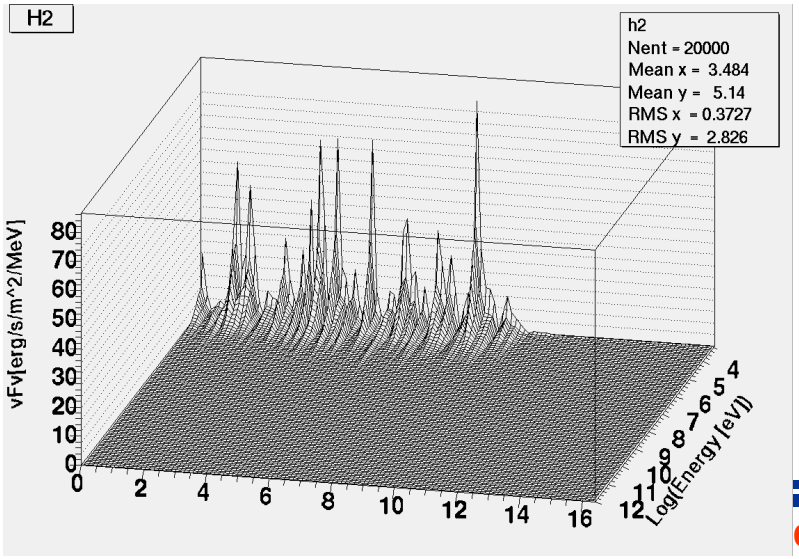
Different Emission processes are included. *The Shape of the spectrum will be a key study to understand the nature of this phenomenon.*

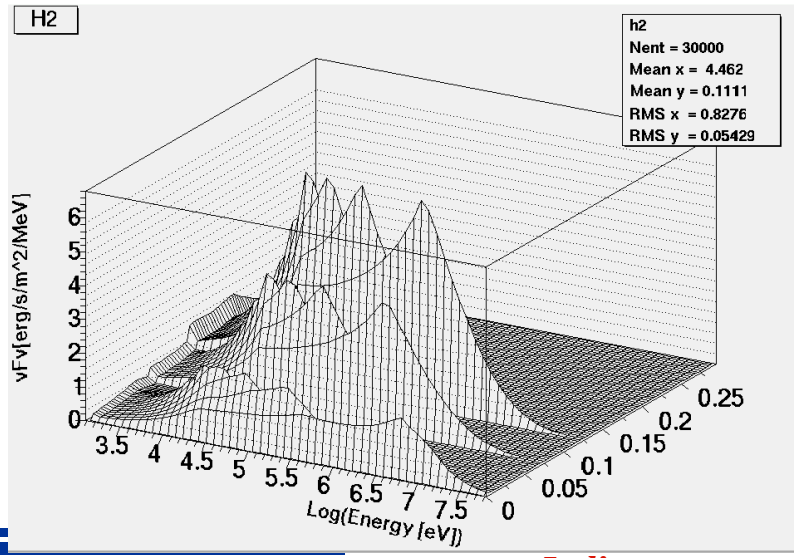


Waves, Mountains ? No GRBs !!

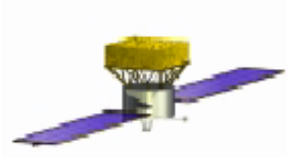




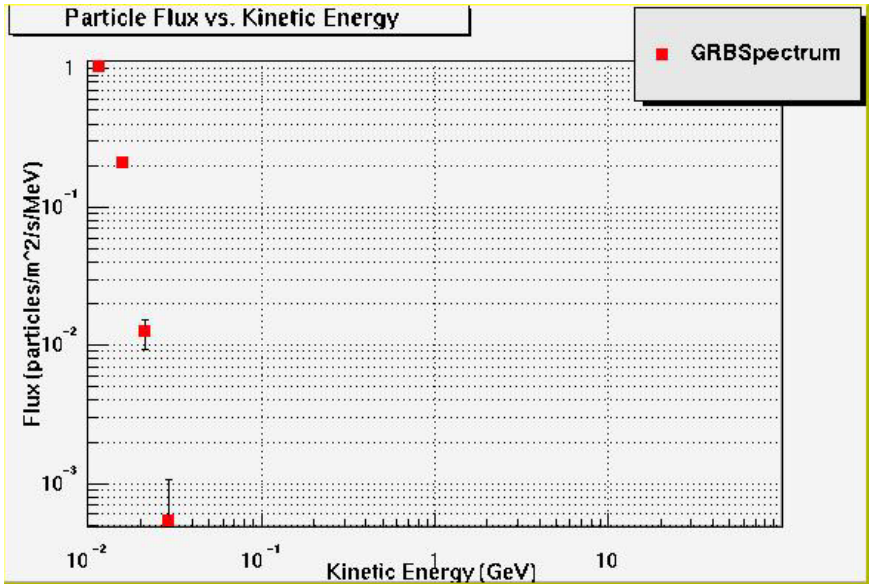




Italia

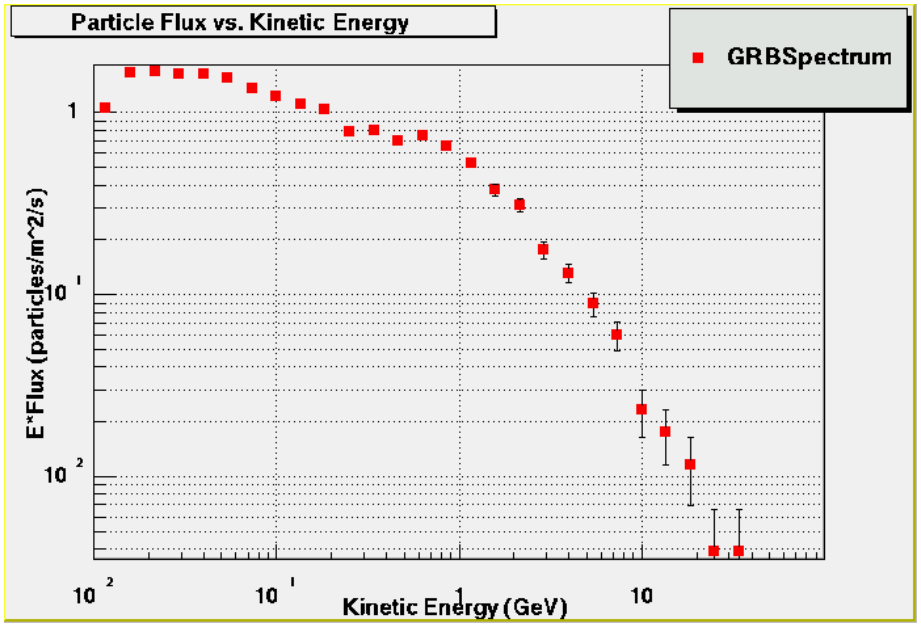


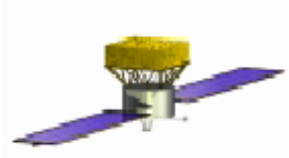
“Root Plot”



It plots a certain number of events Extracted from a Flux of the source library.

An already existing test executable is compatible with GRB





"To do list" about the SW

- **Clean Up the code (as always)…**
  - Include different HE emission processes (π^0 annihilation)
  - Study the surrounding Media (External Shock Scenario)
  - Official FluxSvc & FluxDisplay tagged versions ?
  - Include the GRBSpectrum in the new G4Generator relese (v2…) ?
- **Validation Procedure (with ROOT)**
  - Evolution of the flux peak (Hardness distribution in function of the time).
  - The spike duration depends on the energy band of the light curve
  - Variation of the spectral indexes in the time
- **Collect data of the MC response:**
  - Database of several GRBs (simulated catalog)?
  - Comparison between the knew *input flux* and the reconstructed *Detector response*.
  - Starting the Analysis Tool development
- **Conclusion**:
  - The GRB Simulator is a good example for describing a transient source and use it in the Gaudi framework. The basic structure could be extended to other astrophysical sources: AGN simulator, high energy emission from microquasars.