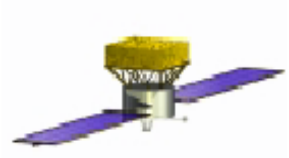
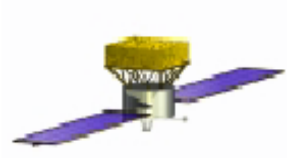


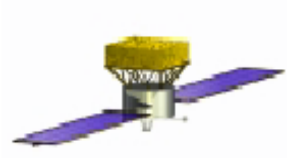
GRB Spectrum
Simulating a transient source

Nicola Omodei



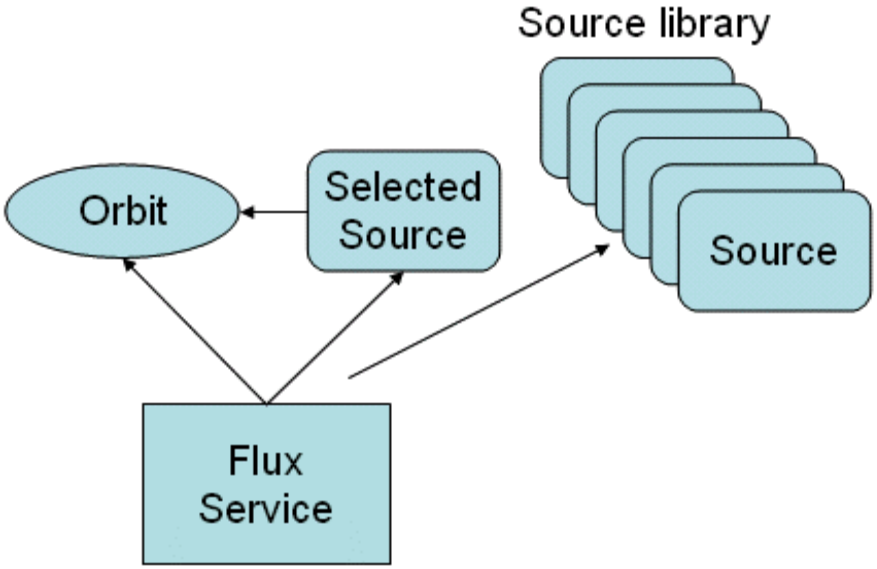
The activities...

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

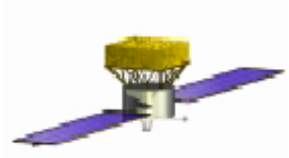


Flux Svc

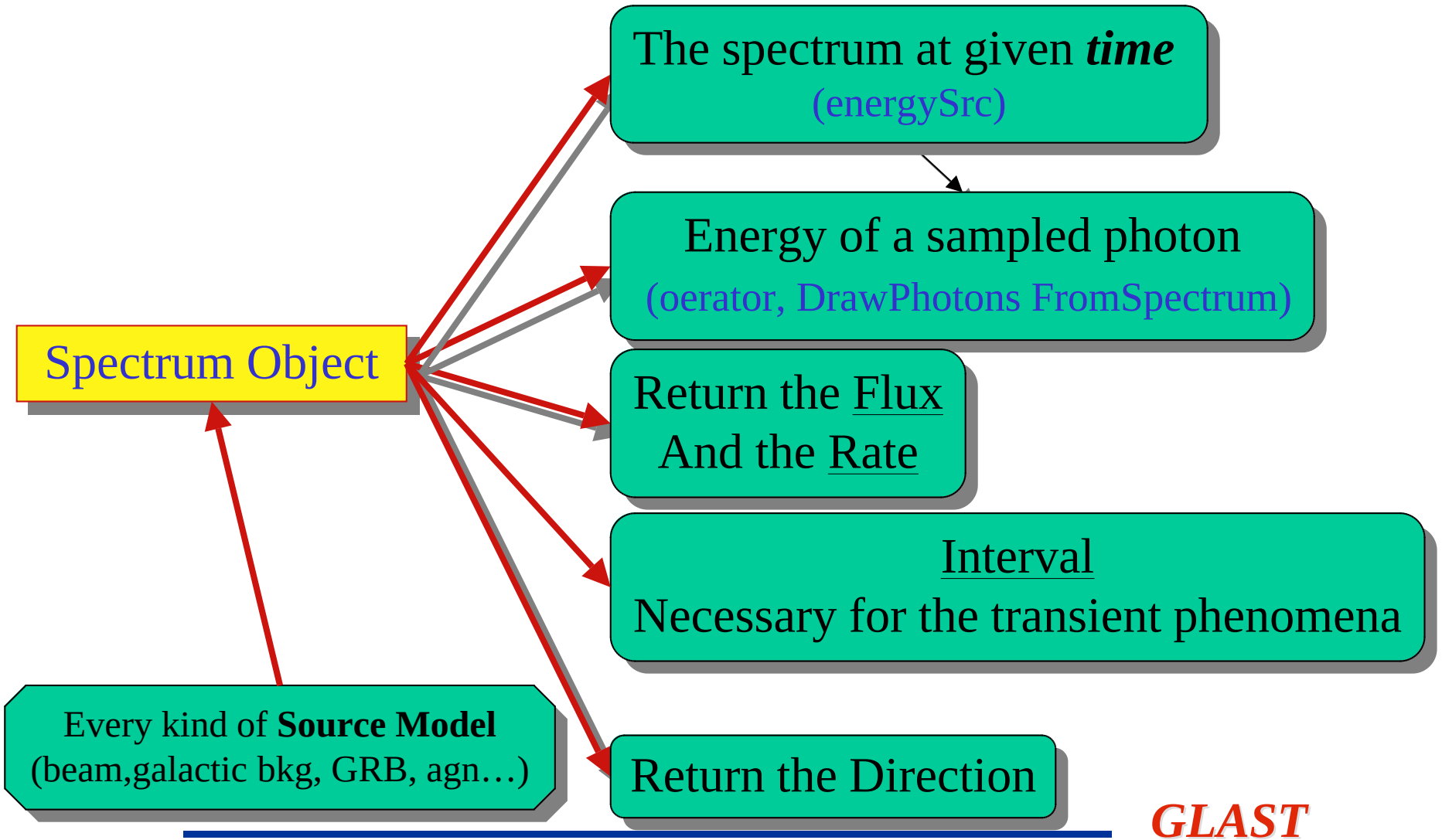
- Selection of different particle for the simulation
- Different Sources
  - Primary and secondary Galactic Cosmic Rays: protons and electrons
  - Albedo gammas
  - Gammas for testing resolution
  - Galactic gamma point sources
  - Galactic diffuse sources
  - Transient sources-> GRB Spectrum
- The satellite 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.

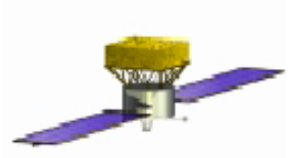


GLAST Italia



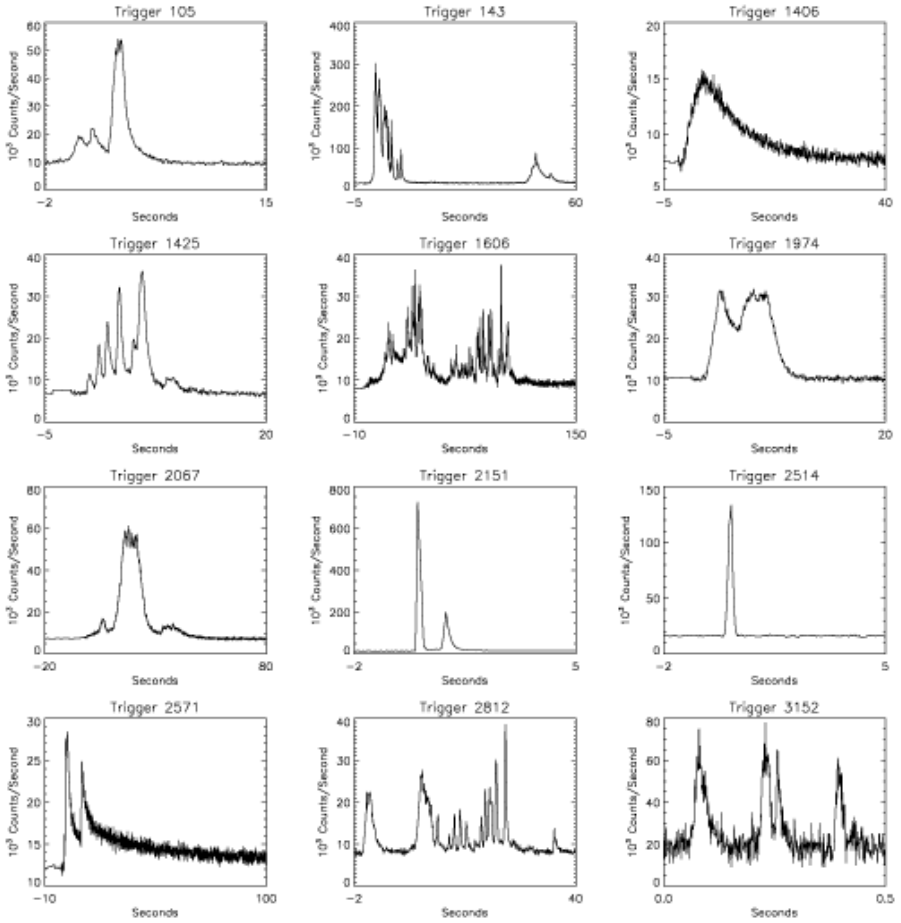
What is a “spectrum” object ?



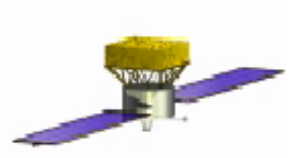


Temporal Behavior & Time Scales

- Prompt Emission:
  - Light Curves have been observed with a typical variability of ms in the BATSE energy range (nothing we can conclude about the variability in the high energy part of the GRB spectrum)
  - The light curves present different shapes, and seems to be connected to a variable (random) activity of the source.

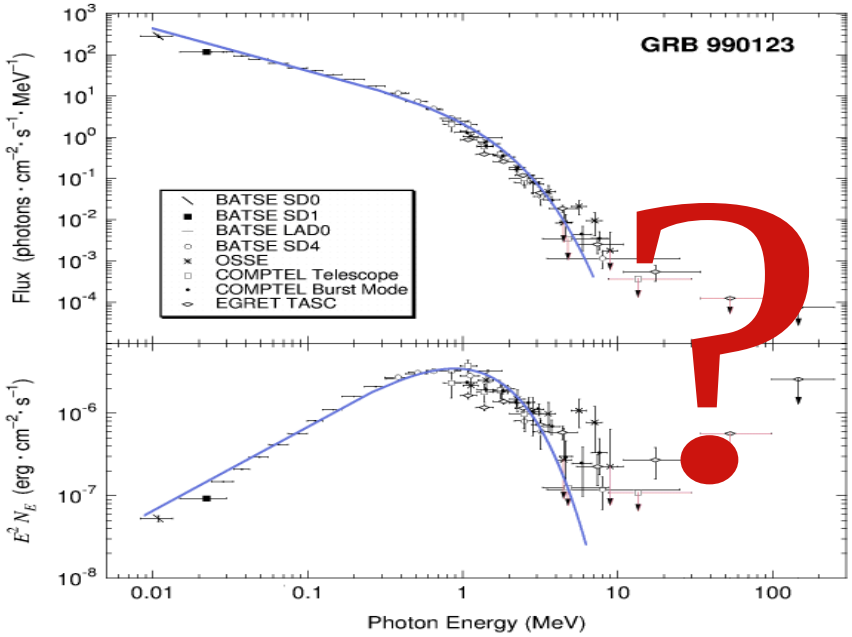


GLAST Italia

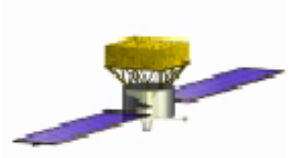


Non thermal emission

- The observed flux is typically non- thermal



- Uncertainty in the High energy region (GLAST)



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)

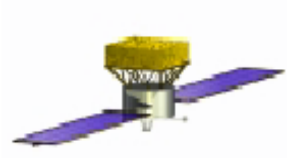
Written Entirely in C++

GRB is now a package!!

src/GRB/<all the source files>

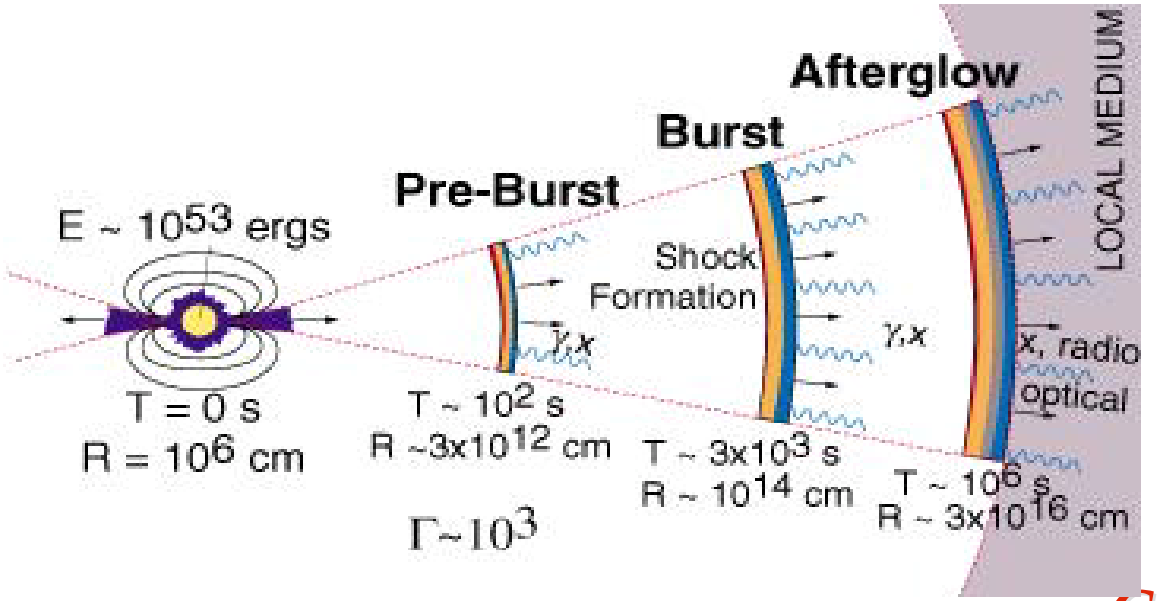
src/test/GRBParam.txt (the configuration file)

src/test/GRBTest.cxx (Test Program)

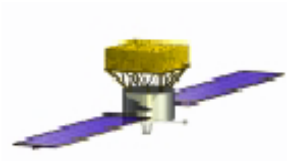


The Fireball Model

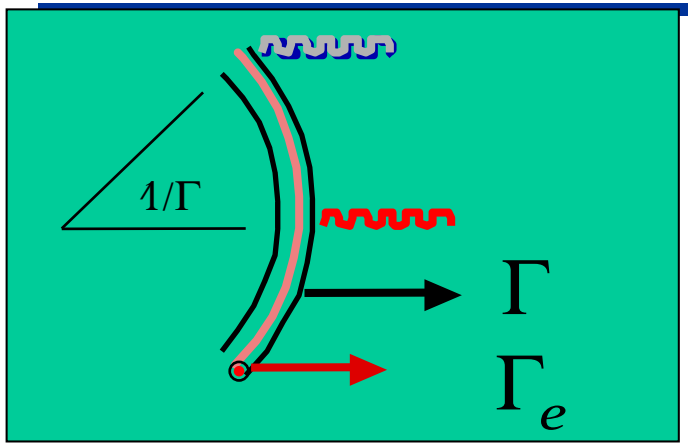
The central engine emits shells with different Lorentz Factor.
The shells collide -> formation of shocks wave inside the shell's material
The shock accelerate the electrons that emits by synchrotron (presence of MF).
The high energy emission is provide by the Compton Scattering.



GLAST Italia



The Shape of a spike



Rise Time ~Geometry of the Shell

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

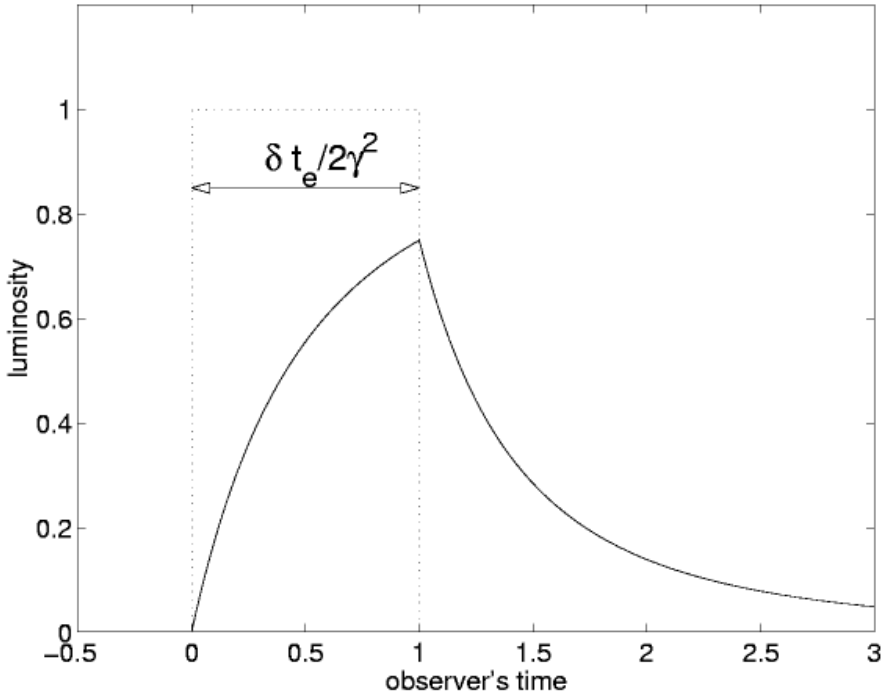
Decay Time ~ Cooling Time

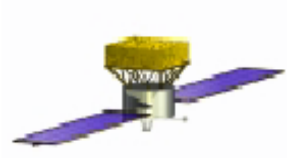
$dt_{decay} \sim 10^{-4} \div 10^{-3}\ s \sim 1/\sqrt{E}$

FRED = Fast Rise Exponential Decay

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

(Fenimore & Ramirez-Ruiz 1999)





GRB source model: Initialization

Initialization
Formation of the shells

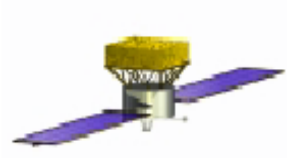
R(t)+=beta c dt

Shock condition
Ri(t)=R(i+1) ?

Define a Shock and fill a vector
- comoving time (Shell)
- Magnetic Field
- Parameter to represent the emission

Sort the Shock vector
Compute the observed time

The Shock Vector in now sorted!
- **Observed Time (GLAST)**
- **Magnetic Field**
- **Parameter to represent the emission**



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)

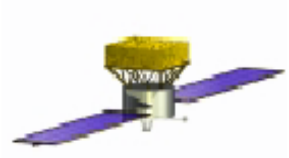
Draw Photon from Spectrum

Energy of a photon, in agree with the flux

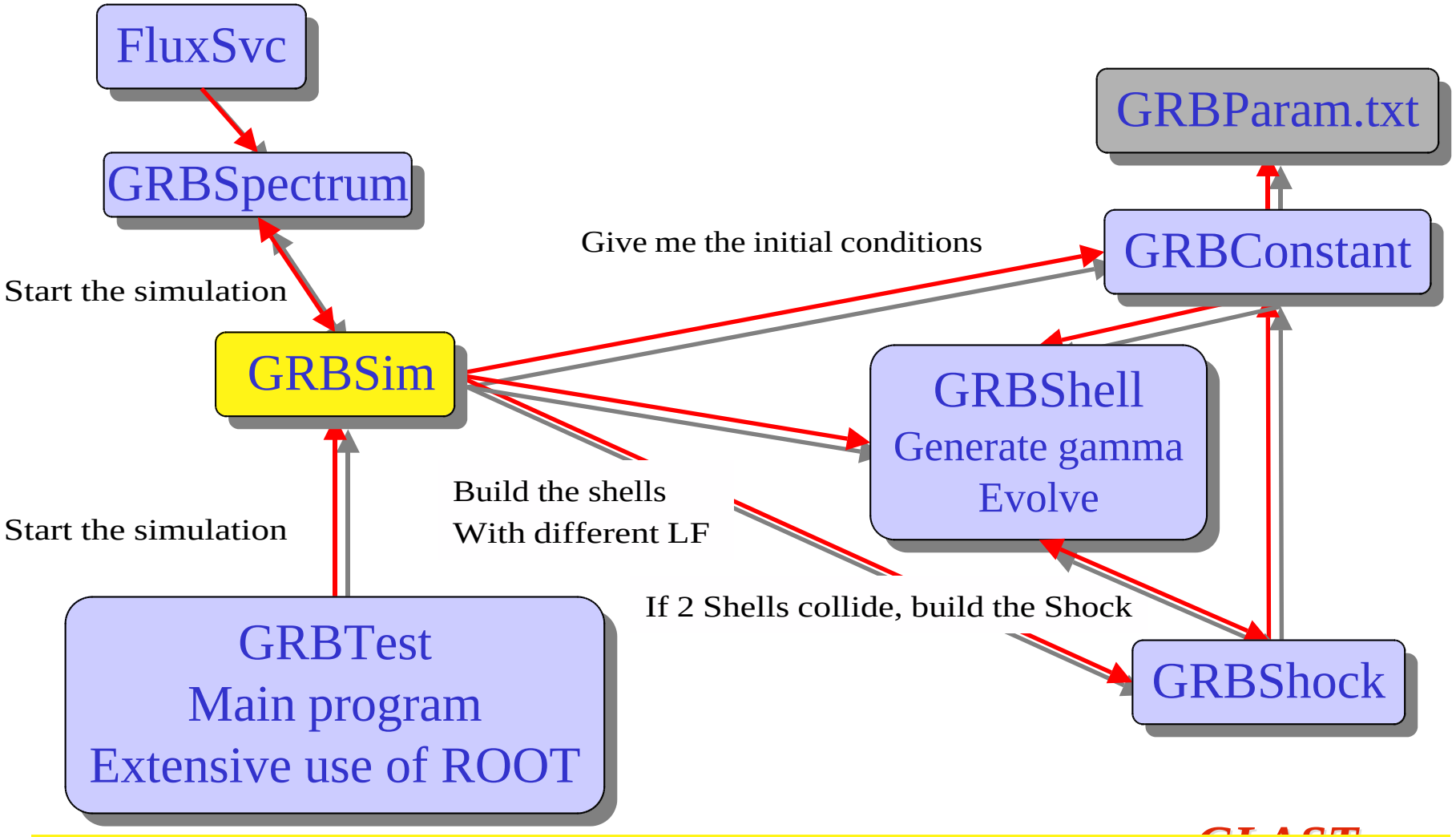
Energy of the photon

(to be processed by the Montecarlo)

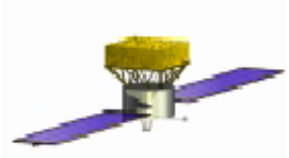
Flux, Rate, direction.



The Classes



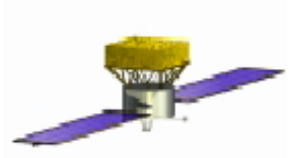
Doxygenation @ http://www.pi.infn.it/~omodei/GRBTest



Output

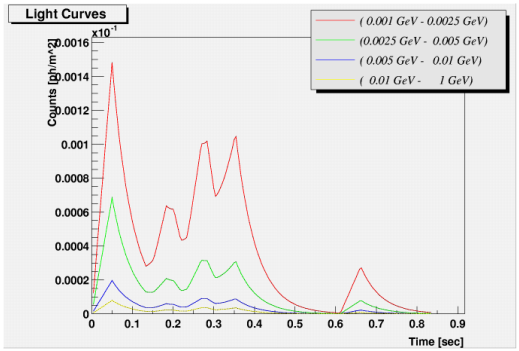
- GRBTest Calculates some quantities to test the physics of the model:
  - Light Curve, Spectrum...
- GRBTest can also “sample” the photon extracted from the spectrum.

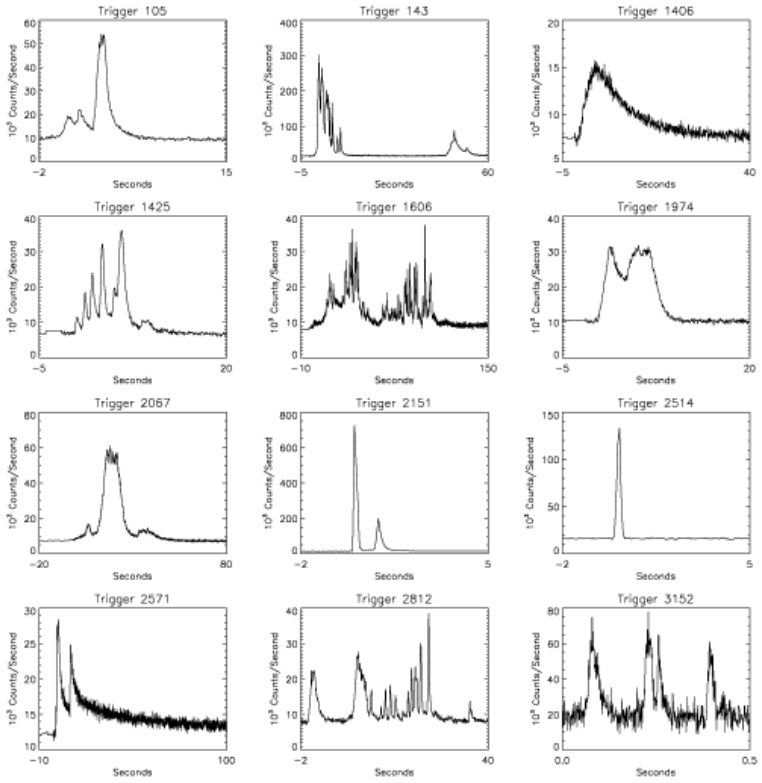
They are the same photons that reach the detector in the Montecarlo simulation !!

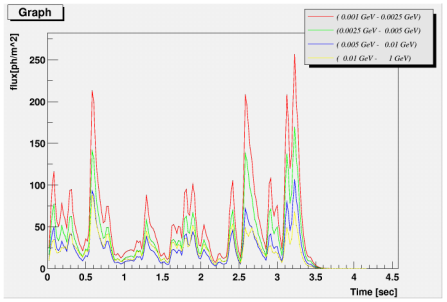


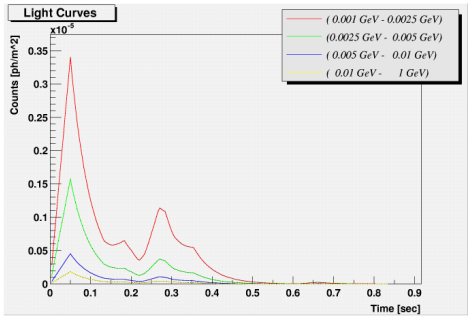
Light Curves

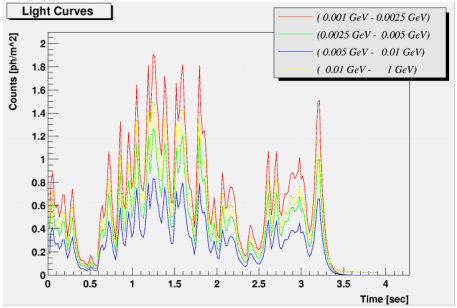
Short Bursts & Long Bursts



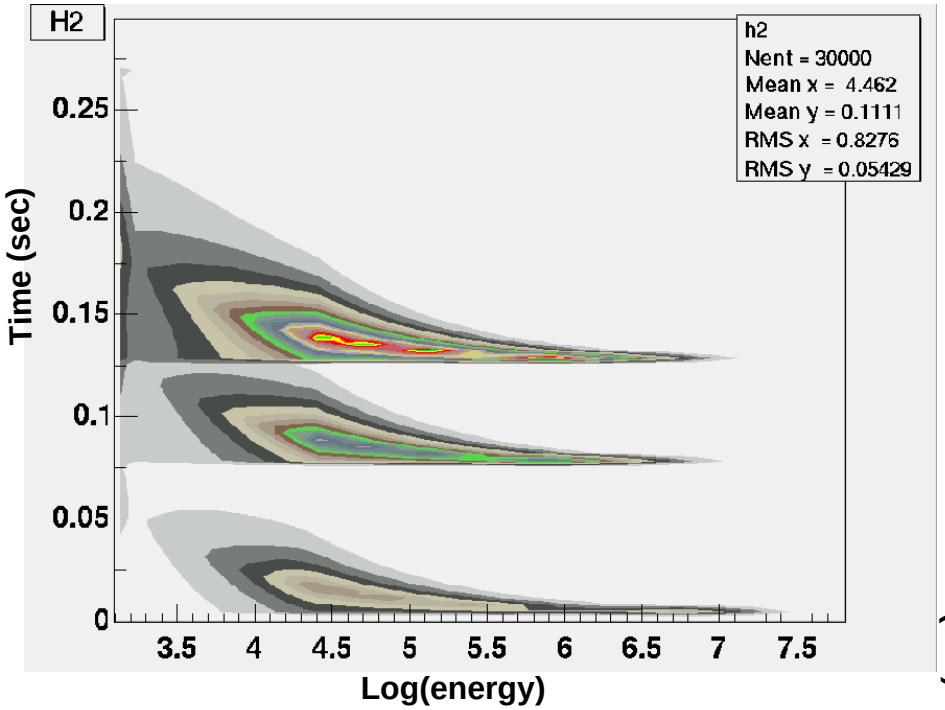






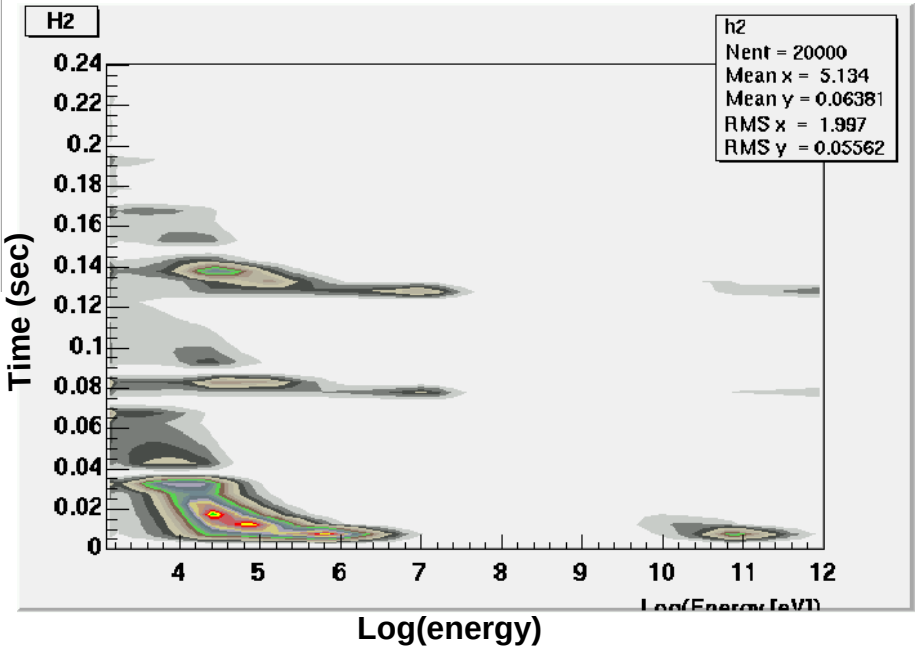


Contour Plot

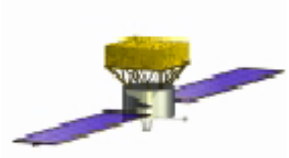


<- Synchrotron

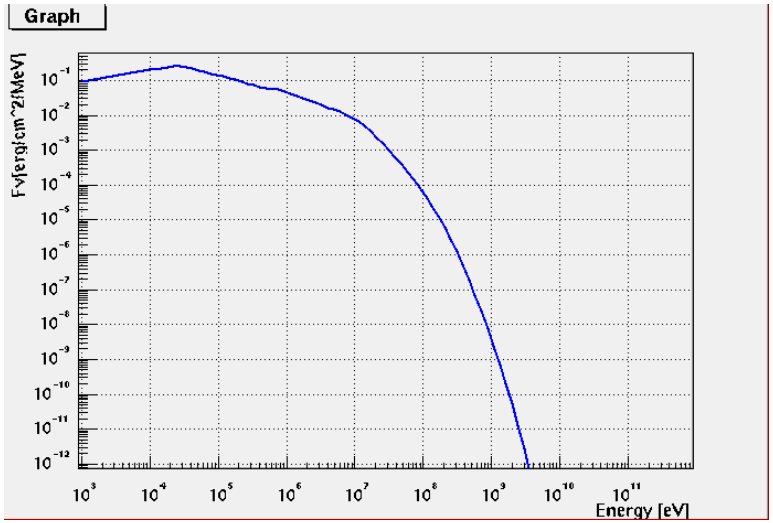
Synchrotron & IC ->

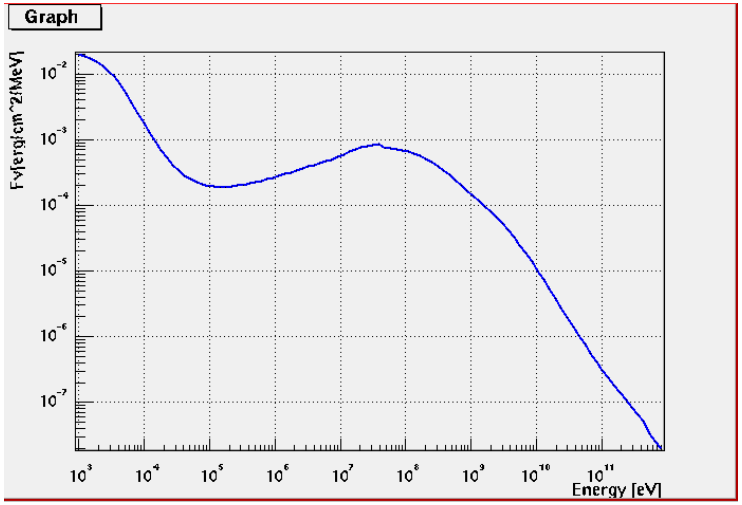


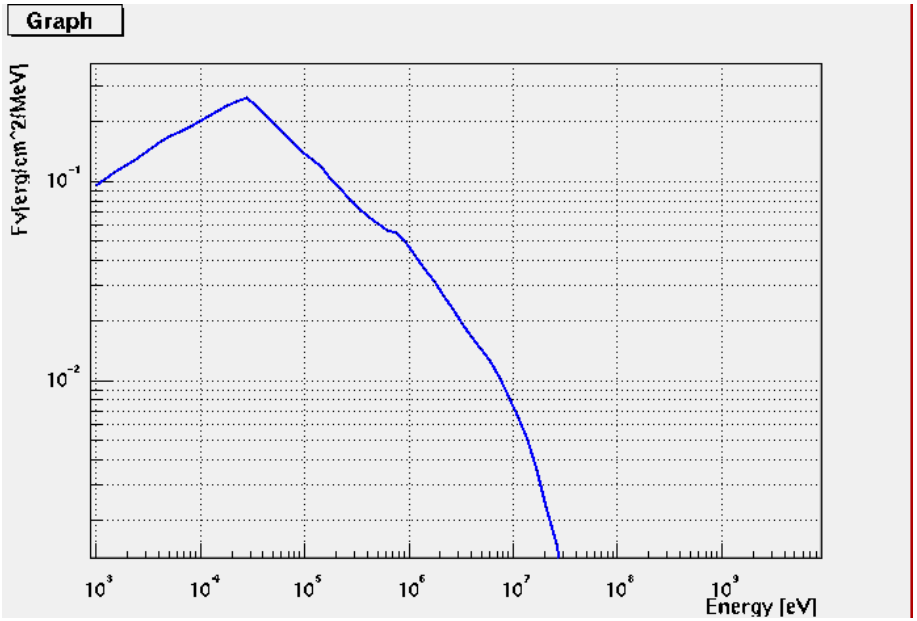
Harder Peak are shorter!



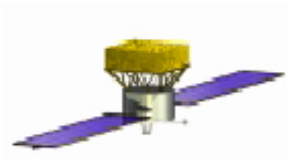
Spectrum



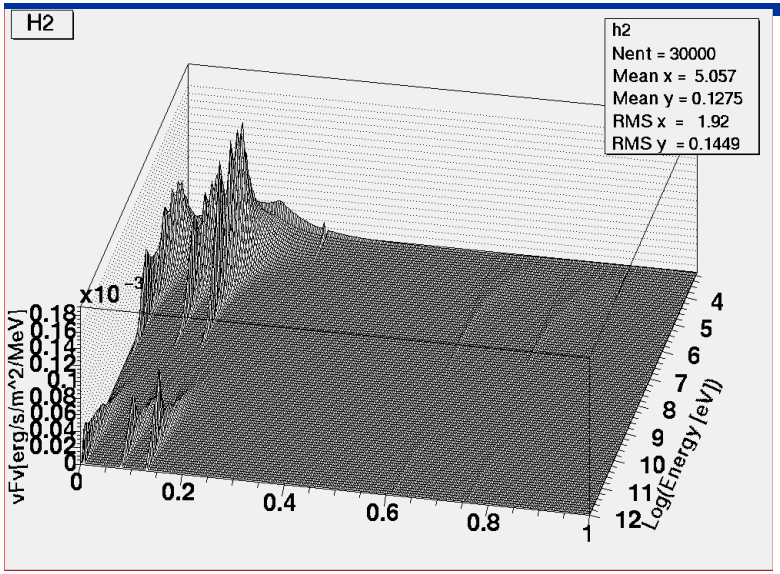


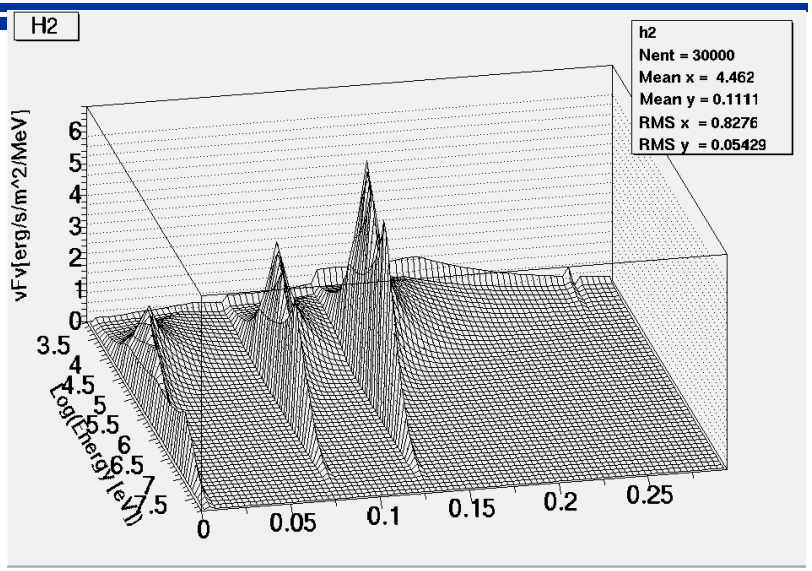


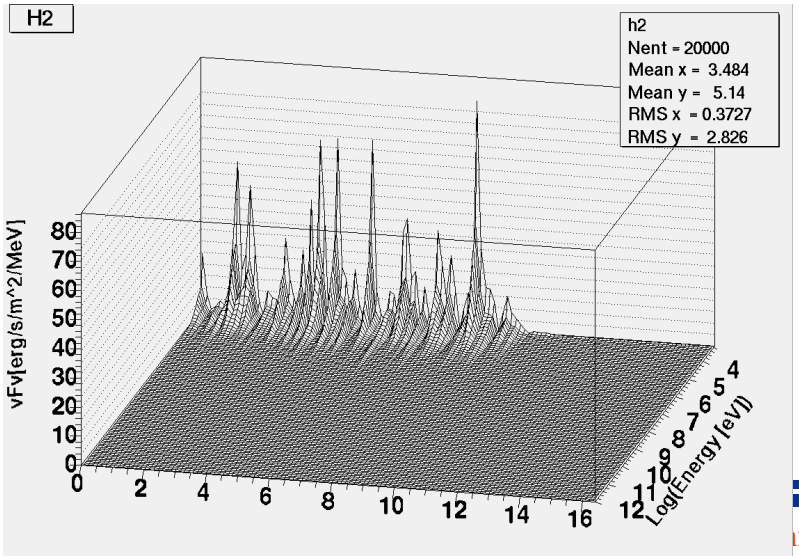
Different Emission processes are included. *The Shape of the spectrum will be a key study to understand the nature of this phenomenon.*

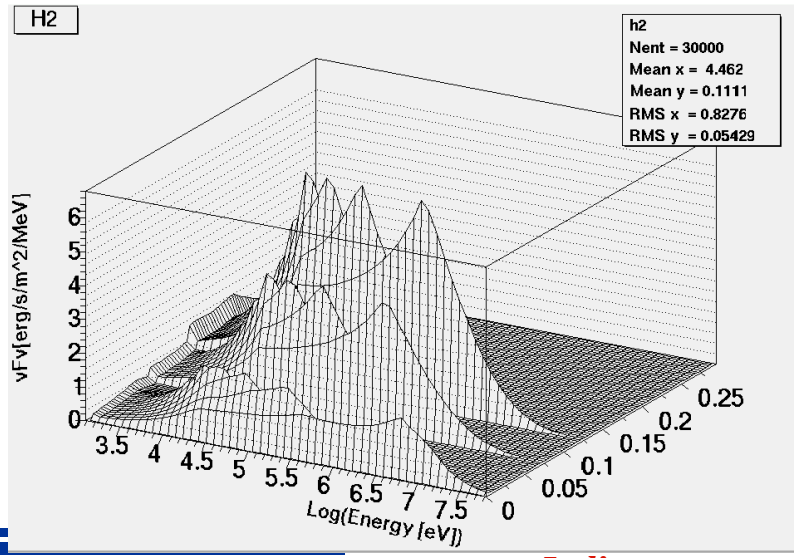


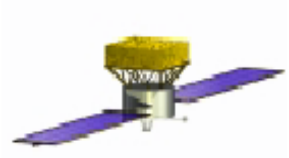
Waves, Mountains ? No GRBs !!





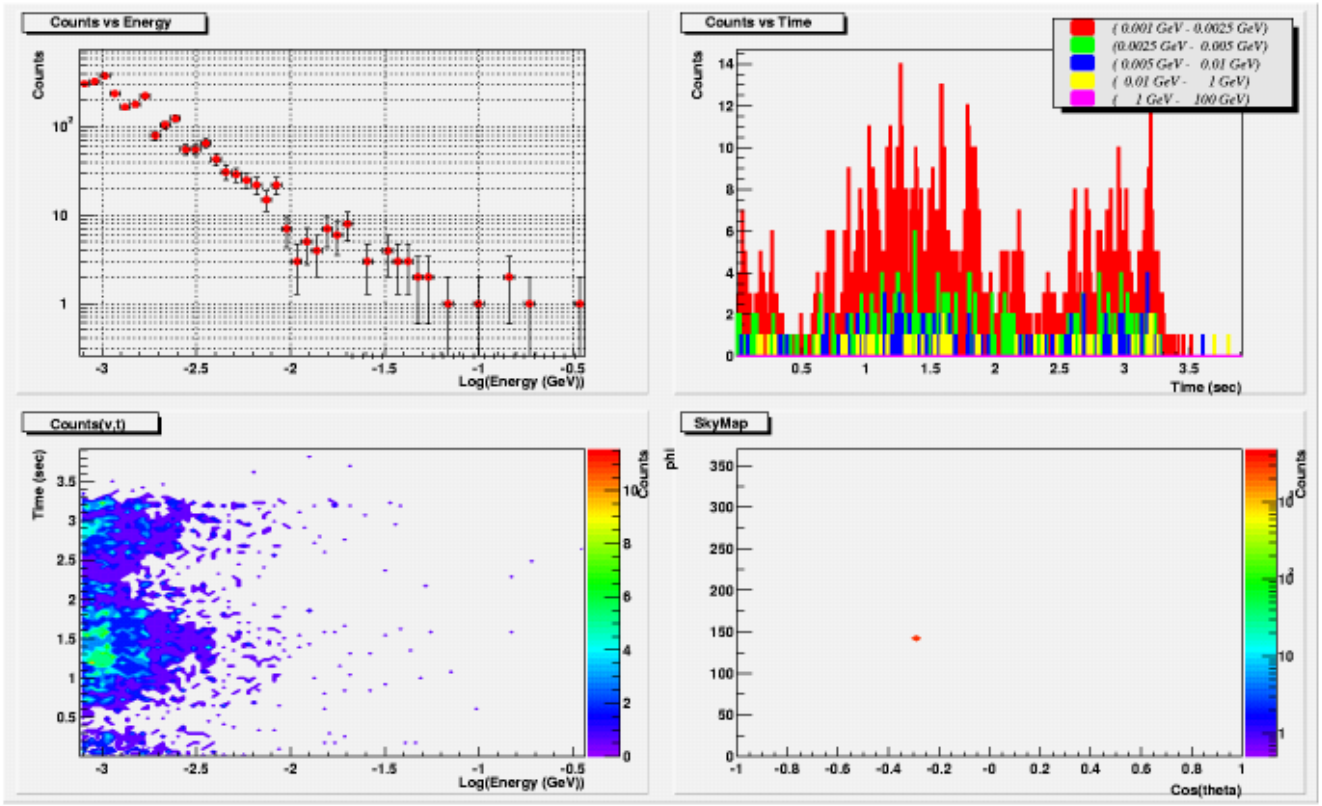




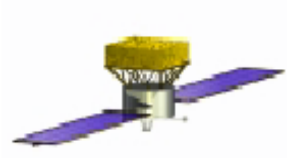


The Photons that reach GLAST...

Sampled Photons !!

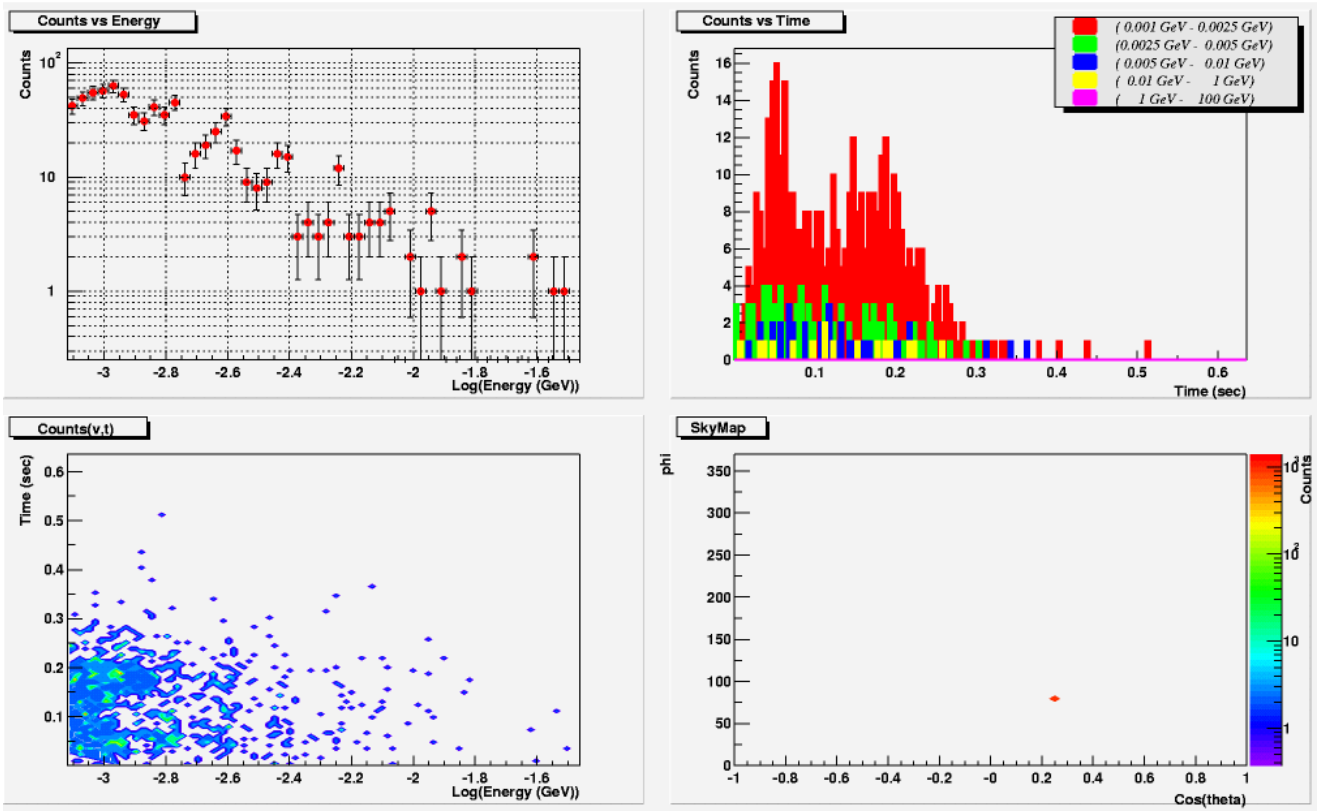


Long Burst with IC components

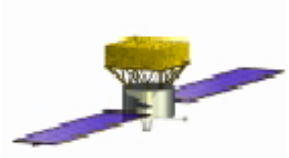


GRB & GLAST

Sampled Photons



Short Burst with IC components



"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)
  - Improve the documentations and make it more user friendly !
  - Generalization of some classes to be used for several astrophysical objects.
- **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*.
- **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.