GRBSim: Gamma-Ray Burst Physical model

GRB Code Review

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Nicola Omodei

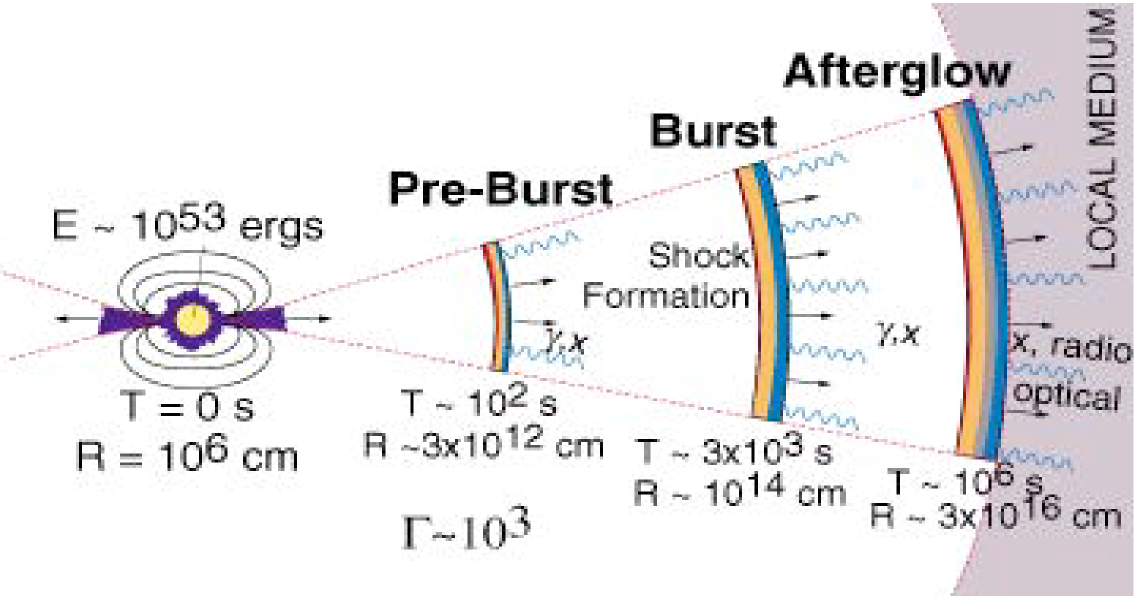
Overview

- This presentation wants to introduce the classes developed for the GRB physical model (located in src/GRB/ directory)
- Presentation of (block scheme) how the model is initialized and how the model compute the flux and returns an event to the Glast simulator.
- *For any detail about the classes design see the "doxygen" documentation !!*

The Fireball Model

The GRB physical model starts from an astrophysical plausible model of GRB: ***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.



GRBengine

- It builds a sequence of N shocks.

  Different hypothesis can be done:

  - Starting from the physical parameters of the shocked material (GRBShell) such as its geometry, dimensions, and energy available…
  - The initial condition can also be observables quantities (rise and decay time and peak energy of each shock). The physical parameters are then calculated to satisfy the observed quantities.

Input: the parameters file (GRBParam.txt)

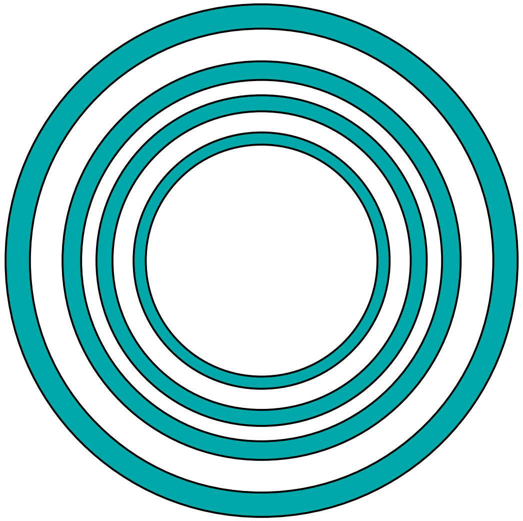
Output: a std::vector<GRBShock>

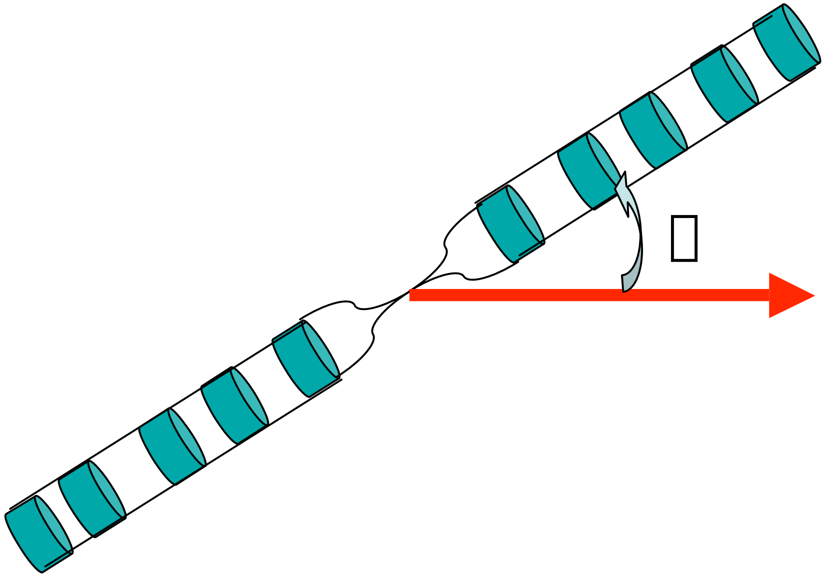
GRBShock

- The shock mechanism is responsible to the acceleration of the charged particles.
- Depends on the geometry of the shocked region, and on the dynamics of mechanism of acceleration.
- We are interested both on the particle energy distribution, and on the temporal behavior of the acceleration process.
- Our knowledge of the shocks physics is still poor, assumption of how particles are accelerated are needed (pulse shape related to this !!)

GRBShell

- It is the “geometrical” object. Represents both the object emitted into the ISM, and both the geometry of the shocked material.
- Different geometry (spherical and beamed) can be considered…

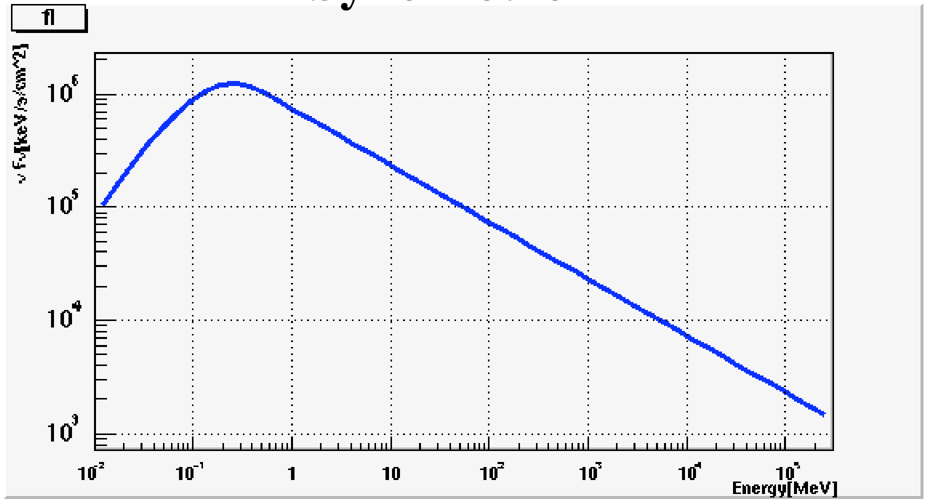




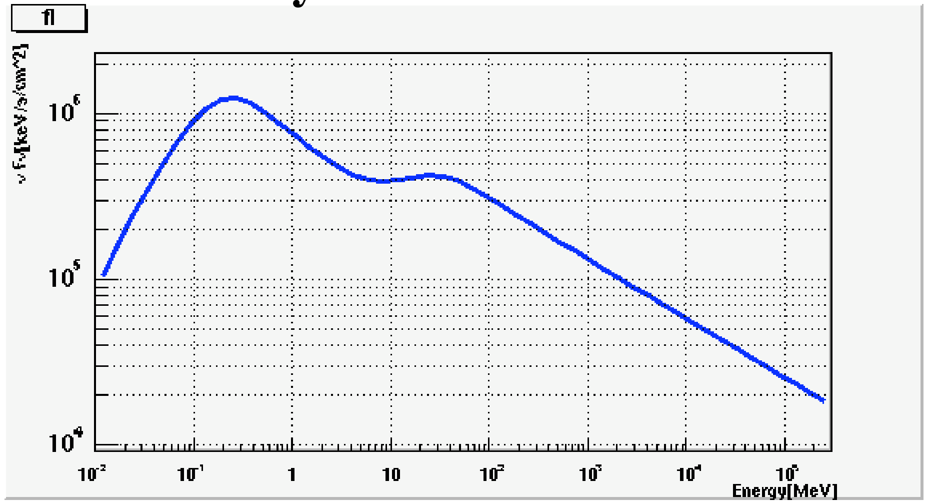
Emission Processes:

- To compute an emission process usually we need to know the region of the space where it occurs, the distribution of electron accelerated, the environmental conditions (presence of magnetic fields…) -> Generic interface class: RadiationProcess
- GRBSynchrotron (the synchrotron spectrum) inherits from RadiationProcess
  - *Electron distribution + Magnetic field*
- GRBICompton (Inverse Compton) inherits from RadiationProcess.
  - *Synchrotron spectrum (seed photons) + Electron distribution*

Synchrotron

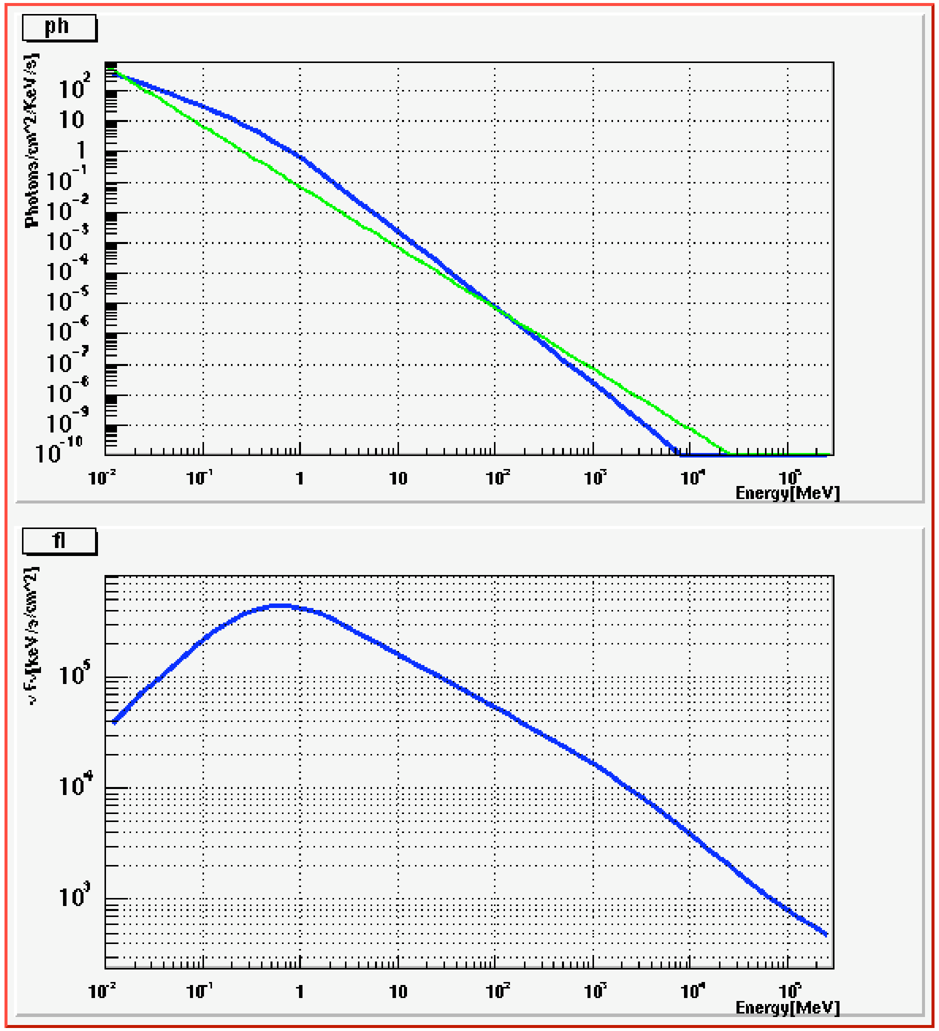


Synchrotron + IC



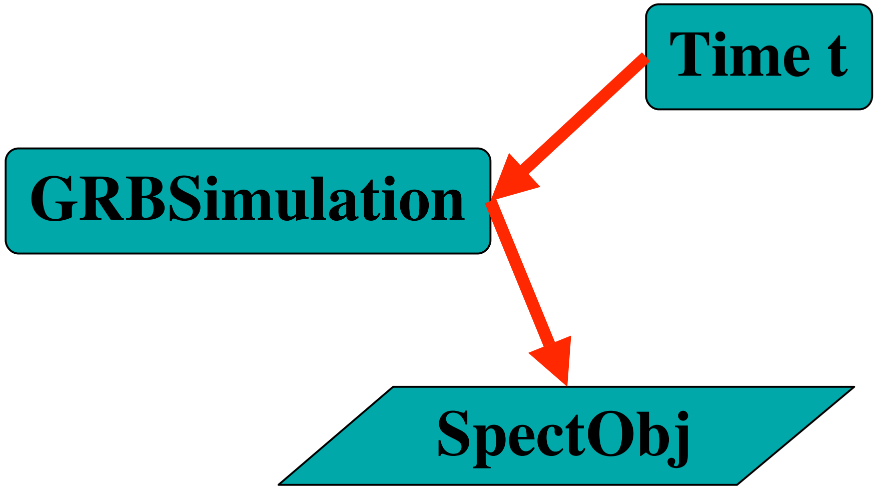
The SpectObj

Spectrum Object



The Spectrum Object is an **interface** that carries all the information and **methods** that permit the manipulation of a "spectrum"

"Algebra" of fluxes (+ - * /), **units conversions**, **Draw photon from spectrum…**



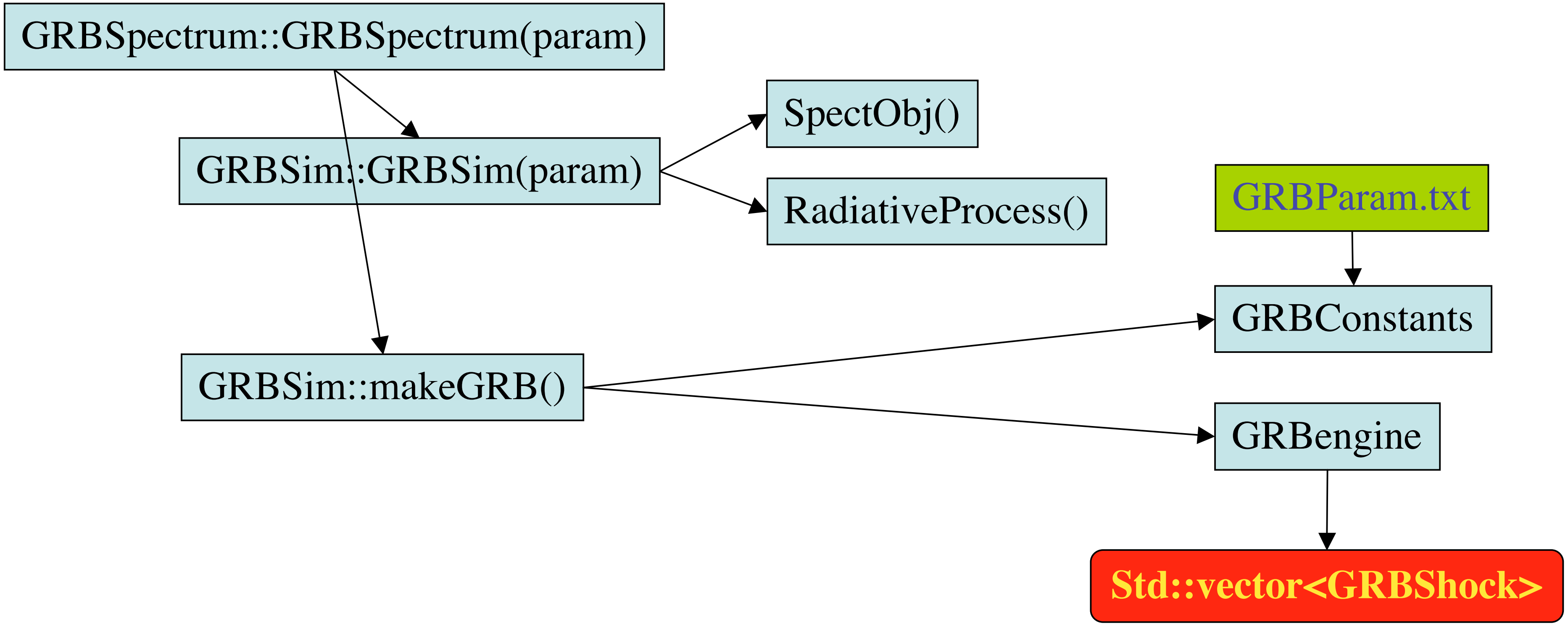
Time t

GRBSimulation

SpectObj

<u>Every Radiation Process has to return a SpecObj class</u>

Initialization



GRBSpectrum::GRBSpectrum(param)

GRBSim::GRBSim(param)

SpectObj()

RadiativeProcess()

GRBParam.txt

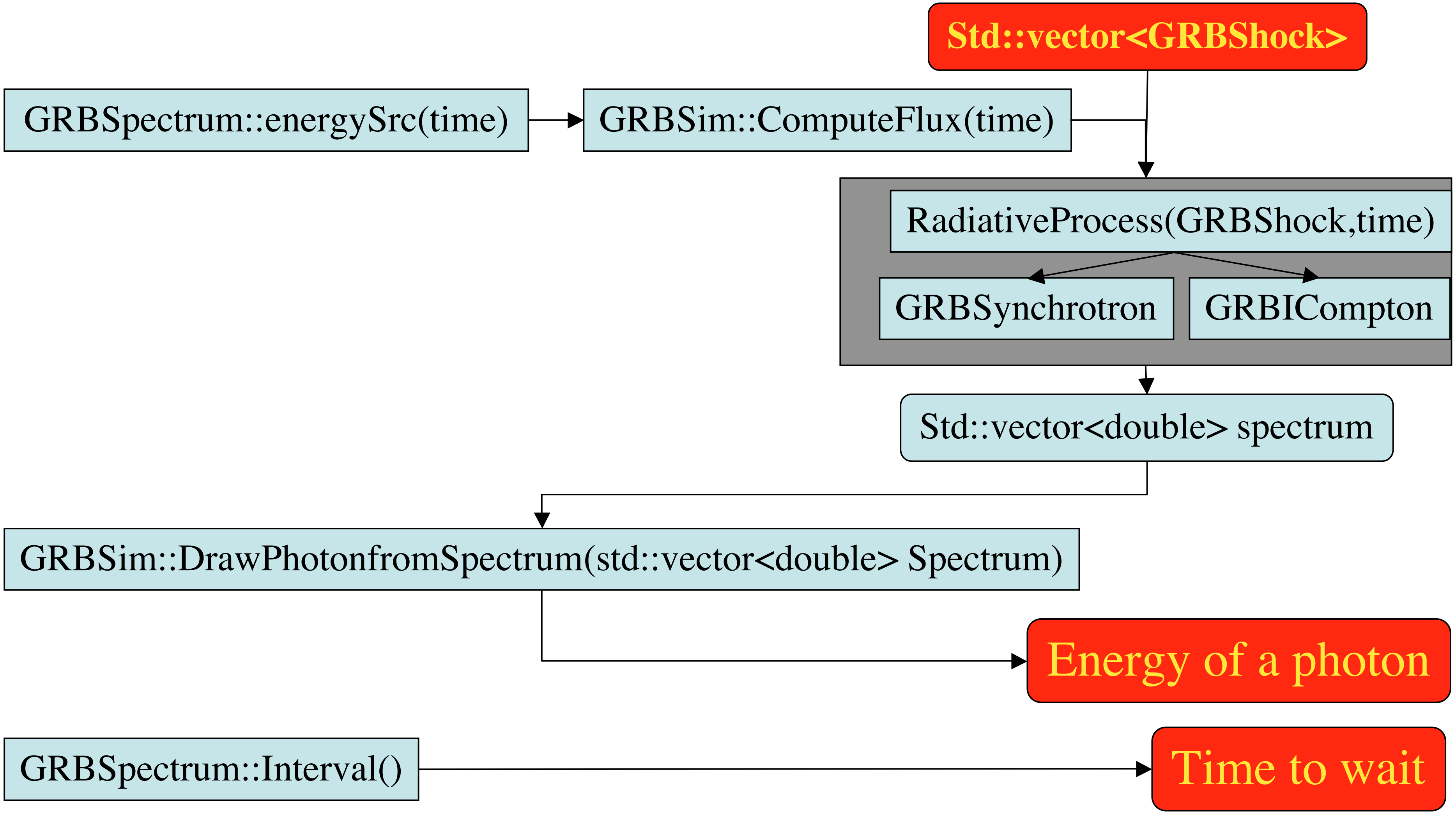
GRBConstants

GRBSim::makeGRB()

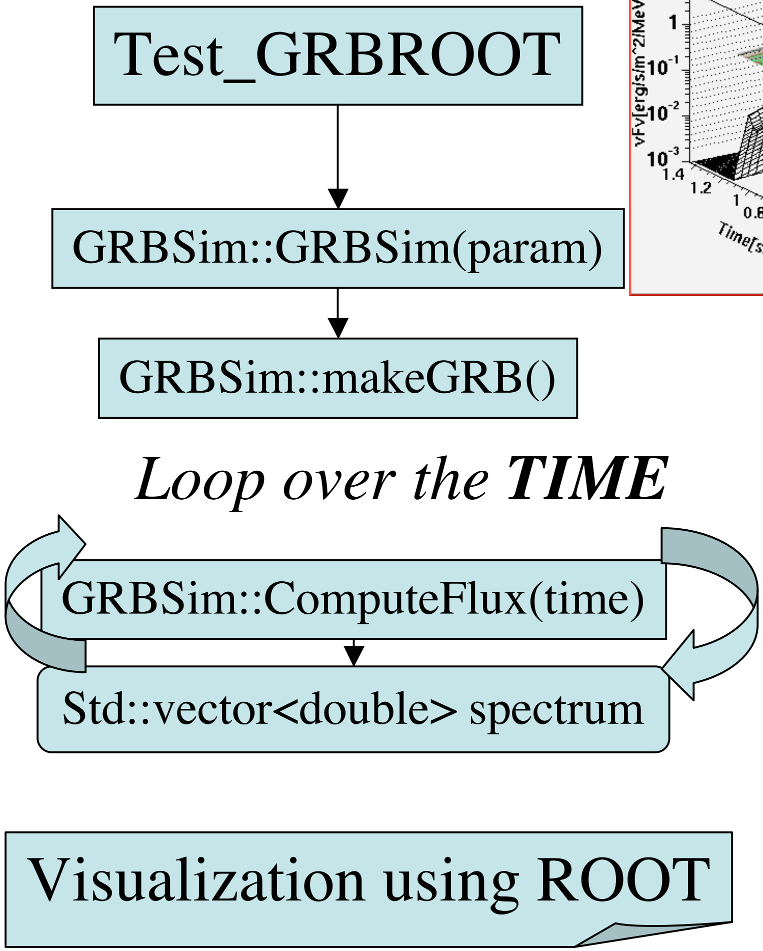
GRBengine

Std::vector<GRBShock>

Compute an event


Std::vector<GRBShock>
GRBSpectrum::energySrc(time)
GRBSim::ComputeFlux(time)
RadiativeProcess(GRBShock,time)
GRBSynchrotron
GRBICompton
Std::vector<double> spectrum
GRBSim::DrawPhotonfromSpectrum(std::vector<double> Spectrum)
Energy of a photon
GRBSpectrum::Interval()
Time to wait

GRB ROOT Test Program



Test_GRBROOT

GRBSim::GRBSim(param)

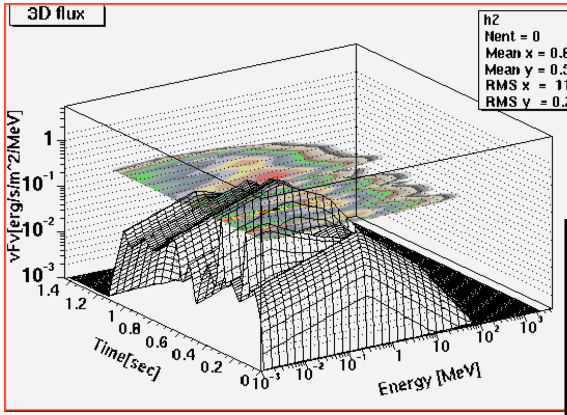
GRBSim::makeGRB()

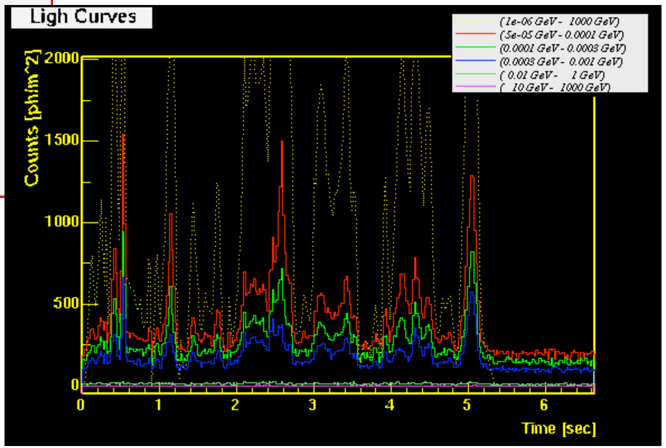
Loop over the ***TIME***

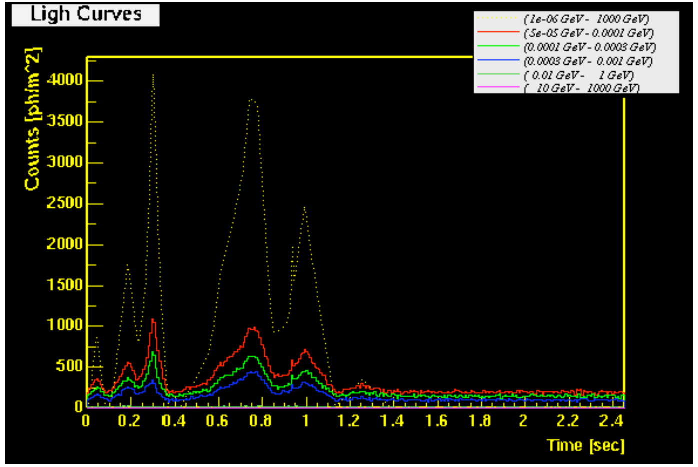
GRBSim::ComputeFlux(time)

Std::vector<double> spectrum

Visualization using ROOT


3D flux
h2
Nent = 0
Mean x = 0.6524
Mean y = 0.5211
RMS x = 11.95
RMS y = 0.2804
vFv[erg/s/m^2/MeV]
10^-1
10^-2
10^-3
Time[sec]
Energy [MeV]
10^-3
10^-2
10^-1
10^2
10^3


Ligh Curves
(1e-06 GeV - 1000 GeV)
(5e-05 GeV - 0.0001 GeV)
(0.0001 GeV - 0.0003 GeV)
(0.0003 GeV - 0.001 GeV)
(0.01 GeV - 1 GeV)
(10 GeV - 1000 GeV)
Counts [ph/m^2]
Time [sec]


Ligh Curves
(1e-06 GeV - 1000 GeV)
(5e-05 GeV - 0.0001 GeV)
(0.0001 GeV - 0.0003 GeV)
(0.0003 GeV - 0.001 GeV)
(0.01 GeV - 1 GeV)
(10 GeV - 1000 GeV)
Counts [ph/m^2]
Time [sec]