

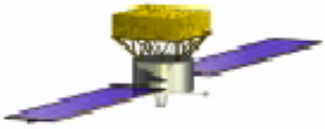


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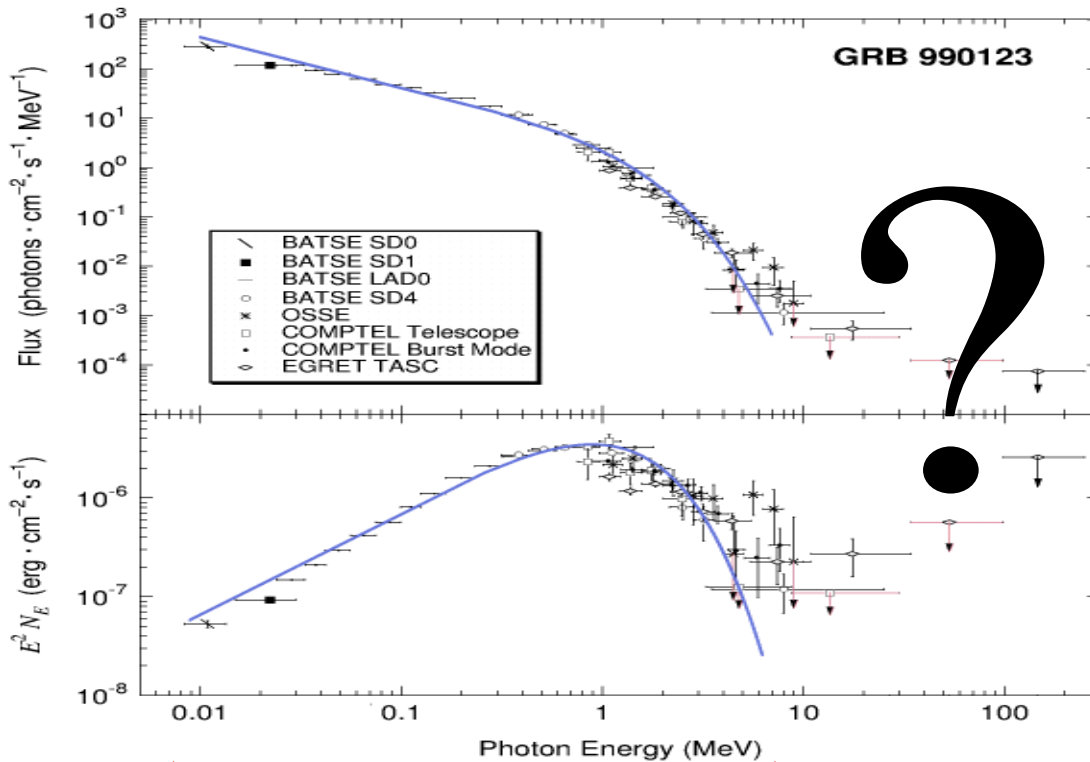
# Emission Model And GRB Simulations



Nicola Omodei (University of Siena, INFN Pisa)



# Spectral Properties



**Data collected Range ( $\gamma$ )**  
**10 KeV ÷ 10 GeV**

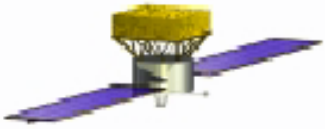
In the BATSE energy range:  
 (25 KeV ÷ 10 MeV)

**Double Power Low**  
 (D.L. Band et al. 1993)

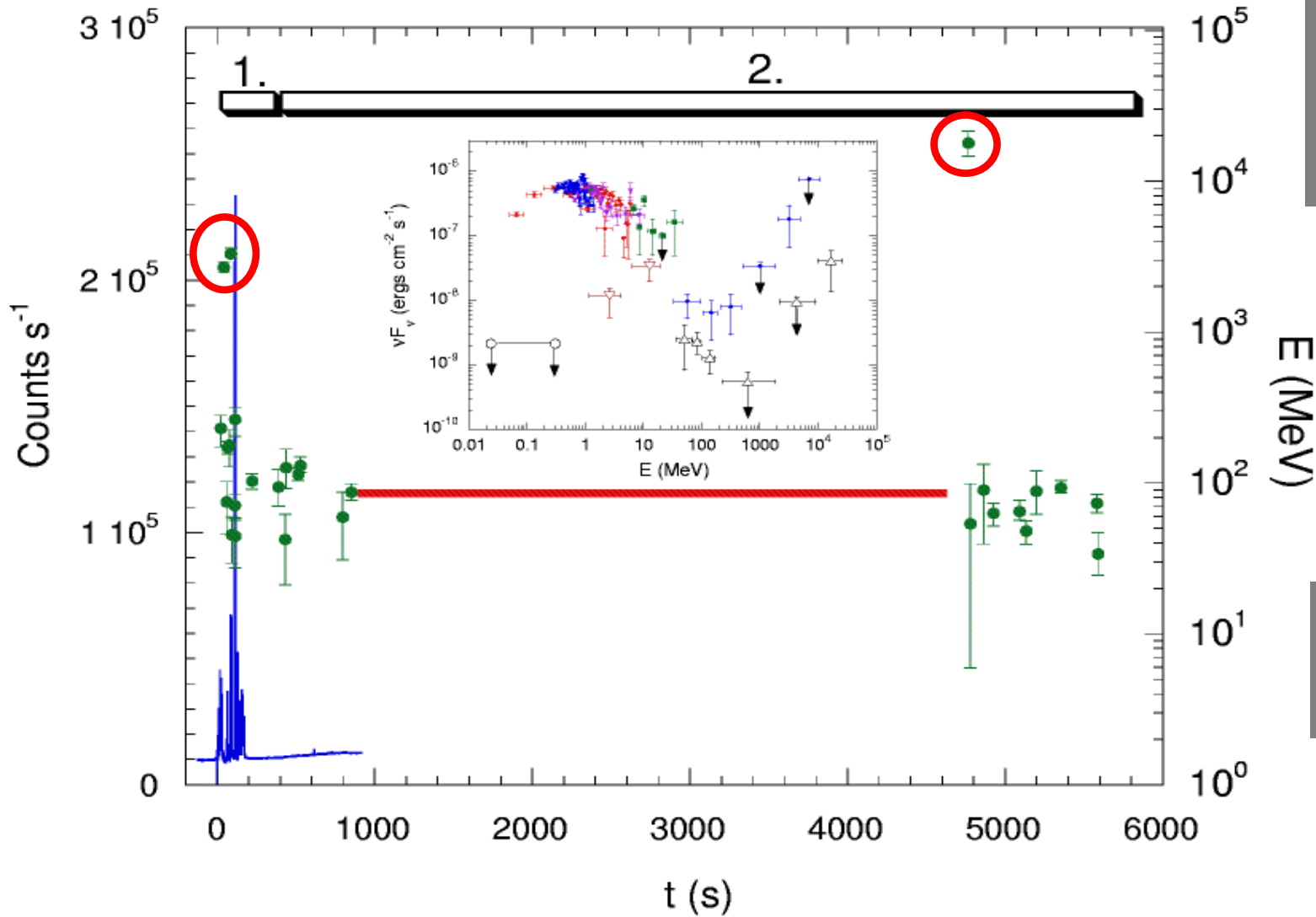
$$N(\nu) = N_0 \begin{cases} (h\nu)^\alpha \exp\left(\frac{h\nu}{E_0}\right) & h\nu < (\alpha - \beta)E_0 \\ ((\alpha - \beta)E_0)^{(\alpha - \beta)} & h\nu > (\alpha - \beta)E_0 \end{cases}$$

$$E_0 = E_p / (\alpha + 2) \quad \alpha = -0.86 \pm 0.15 \quad \beta = -2.5 \pm 0.07 \quad E_p = 457 \pm 30 \text{ KeV}$$

**GLAST**  
 Italia

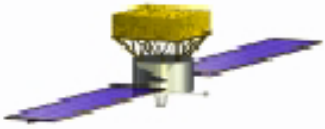


# High Energy Emission

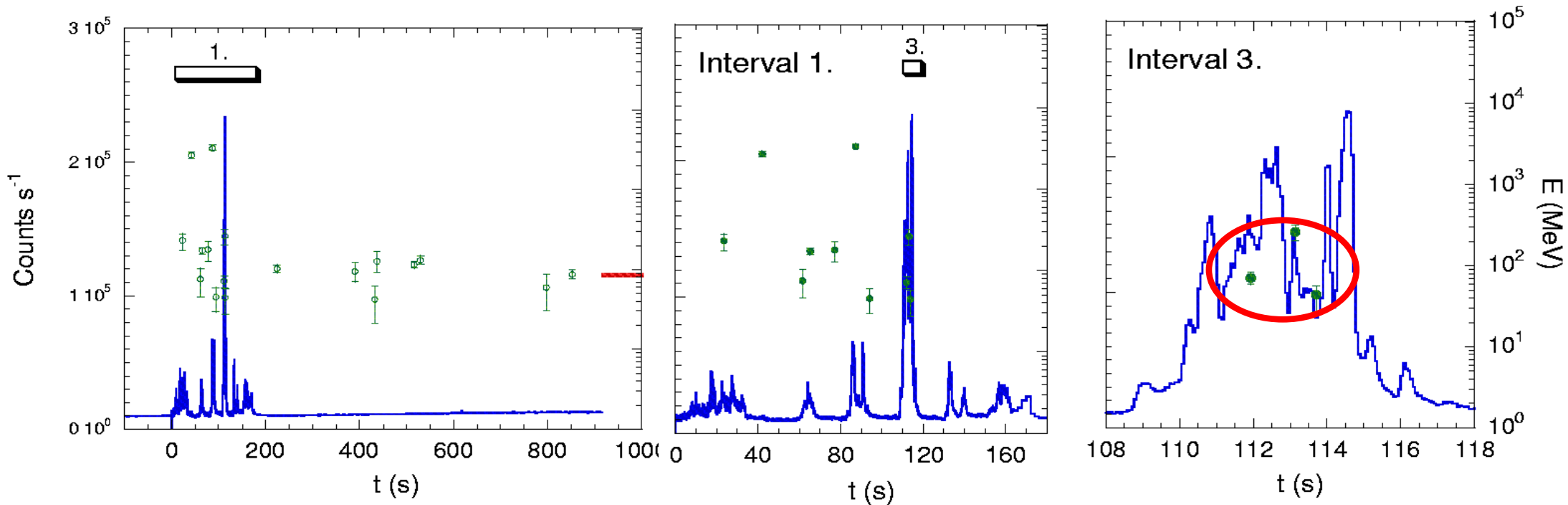


2 photons @ 3 GeV  
During the  
BATSE burst

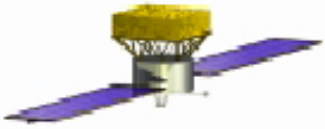
1 photon @ 18 GeV  
95 minutes later



# High Energy Emission

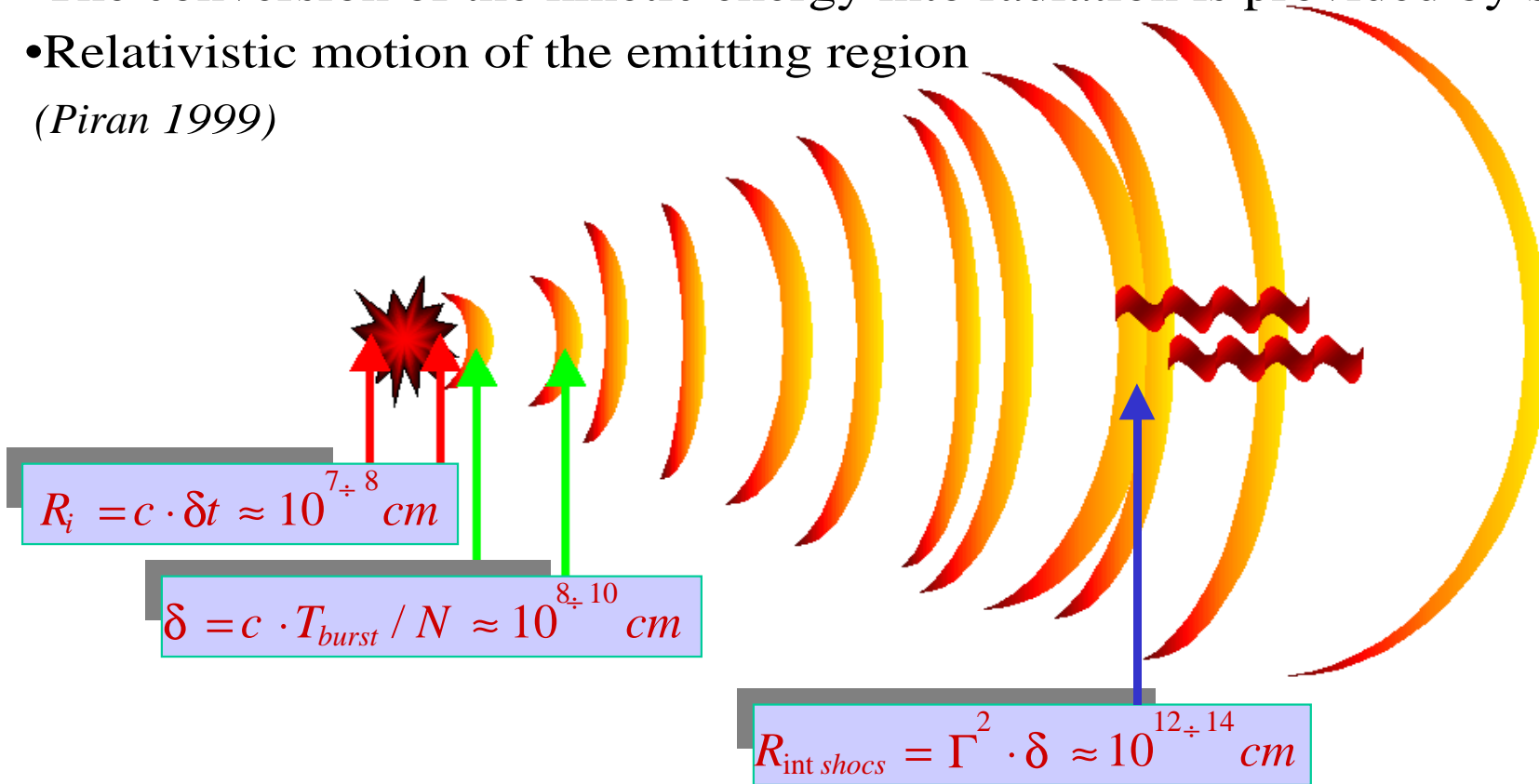


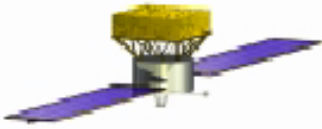
There are photons @ 10<sup>2</sup> MeV  
During the BATSE burst



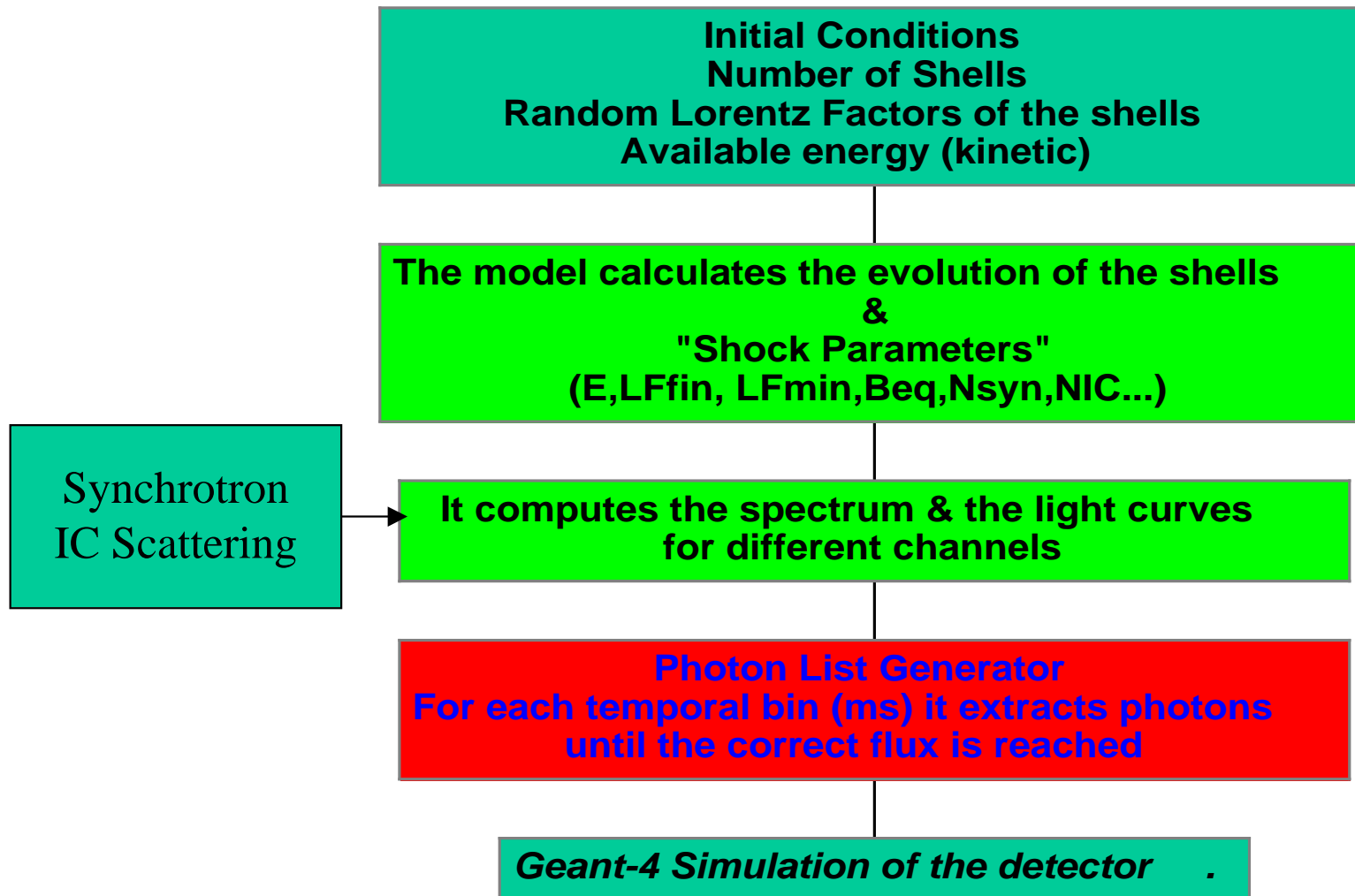
## The Fireball Model (an artistic view)

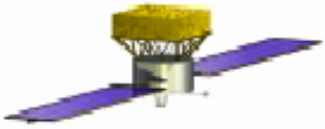
- The source has to be a compact object (from the observed time variability)
- The central engine is hidden but, the observed variability seems to be directly connected with the variability of the central engine.
- The conversion of the kinetic energy into radiation is provided by shocks
- Relativistic motion of the emitting region  
(Piran 1999)



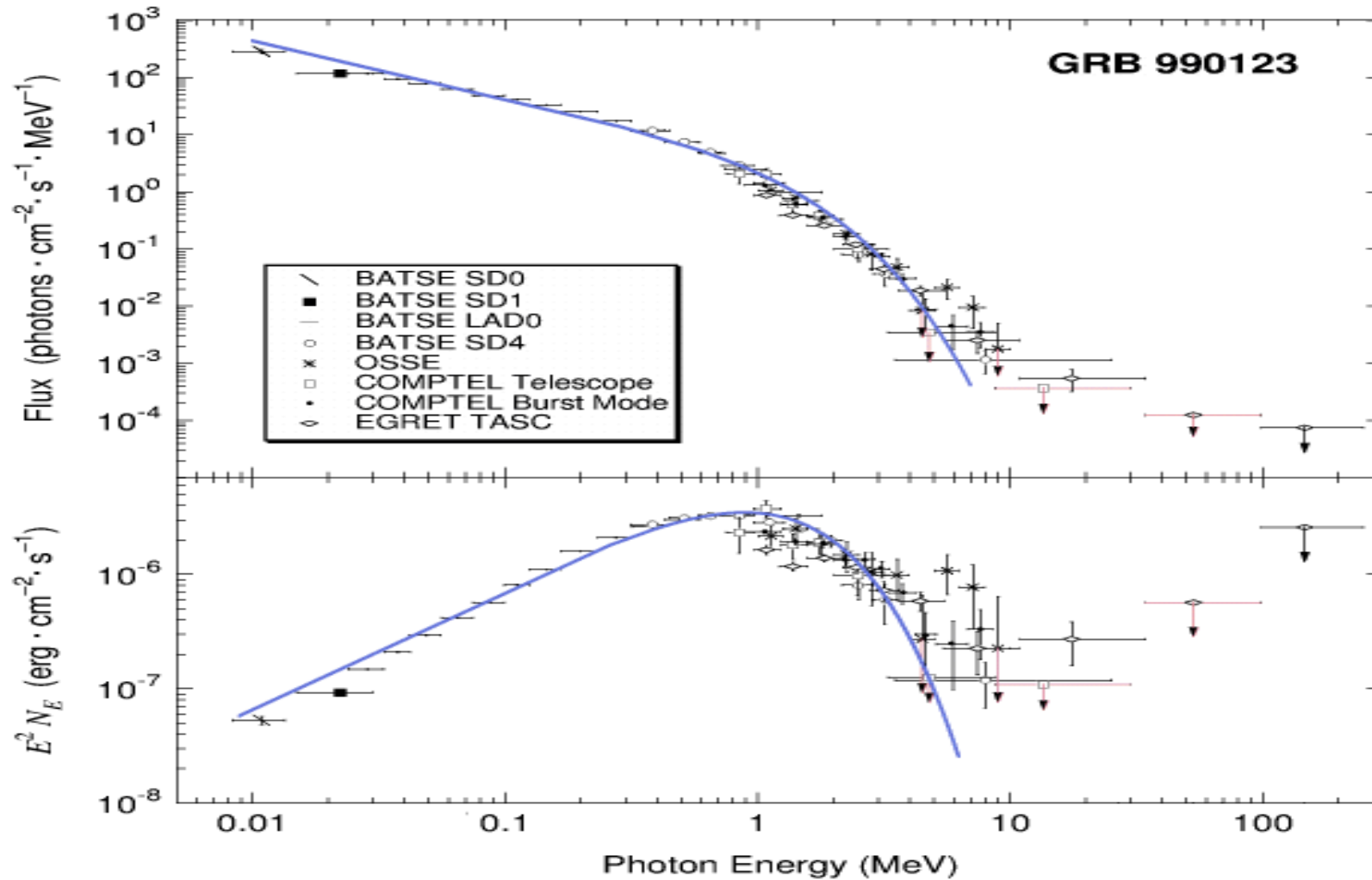


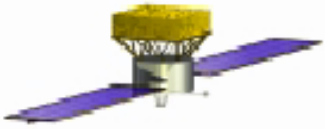
# Chart





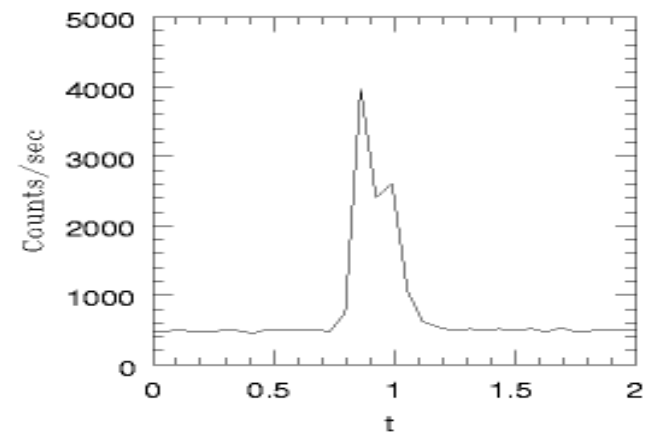
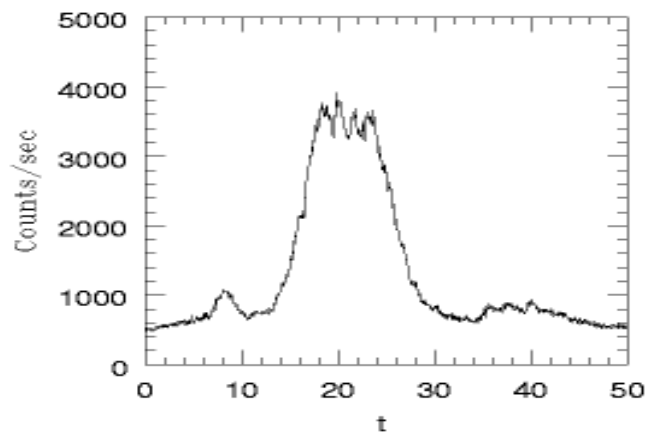
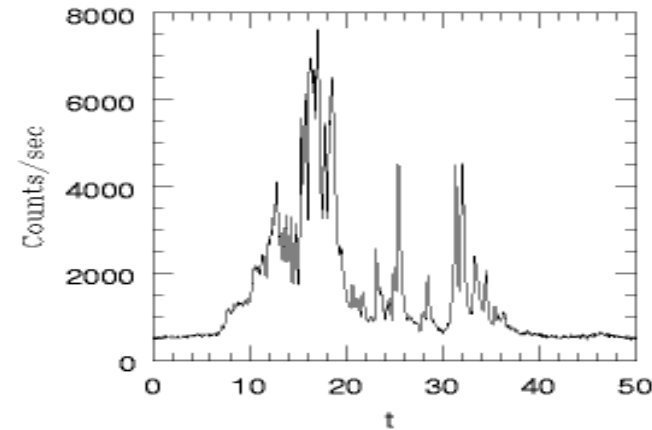
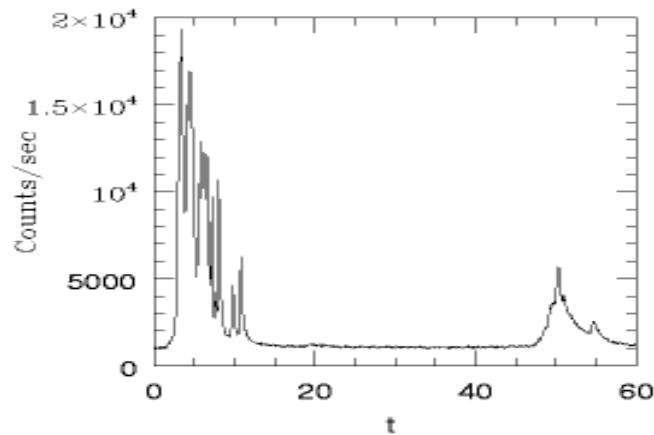
# Observed Spectrum



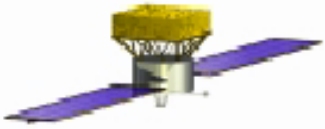


# Observed Light Curve

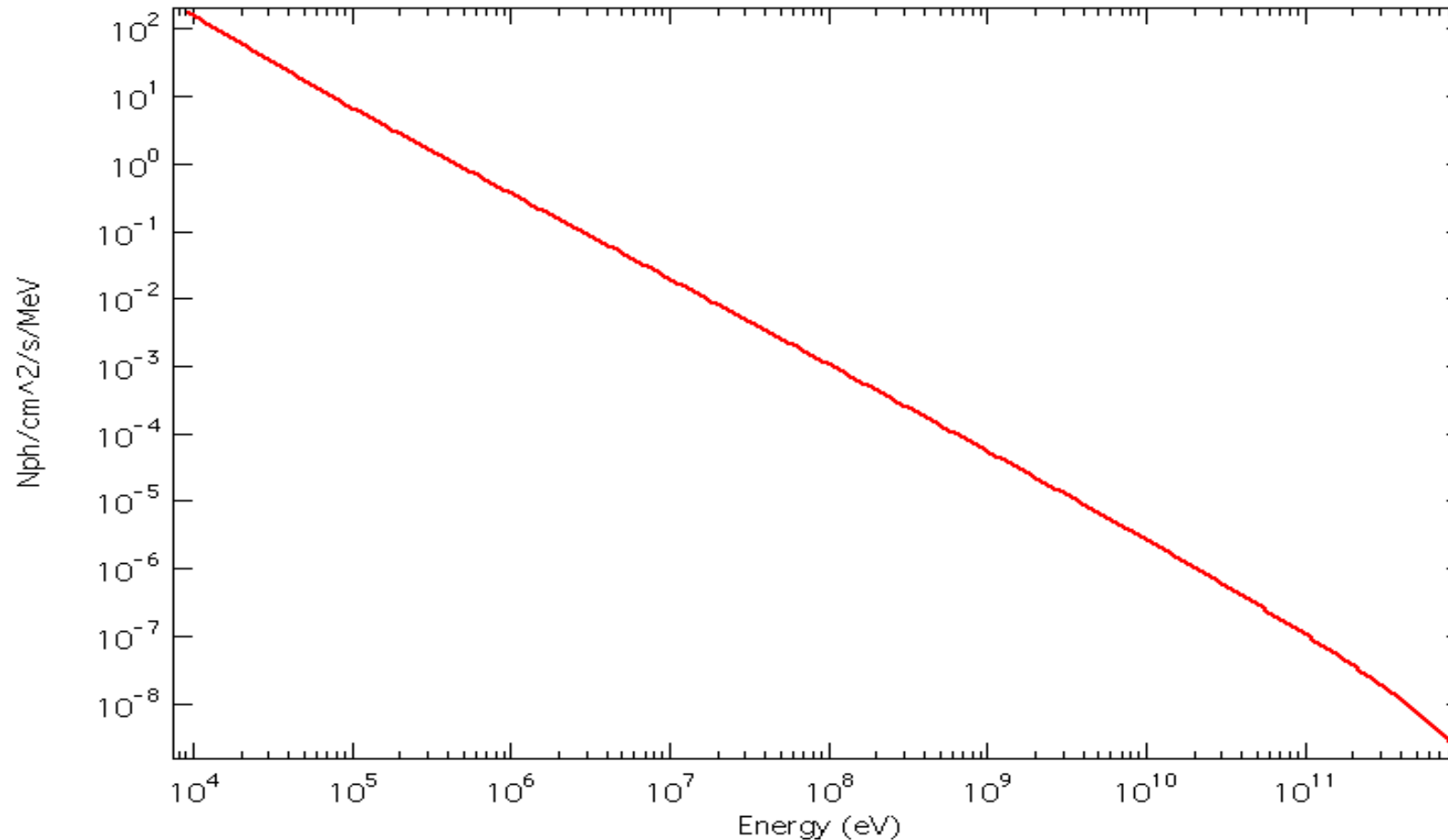
The observed light curves present different shapes and different time durations!





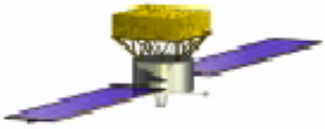


# Obtained Spectrum



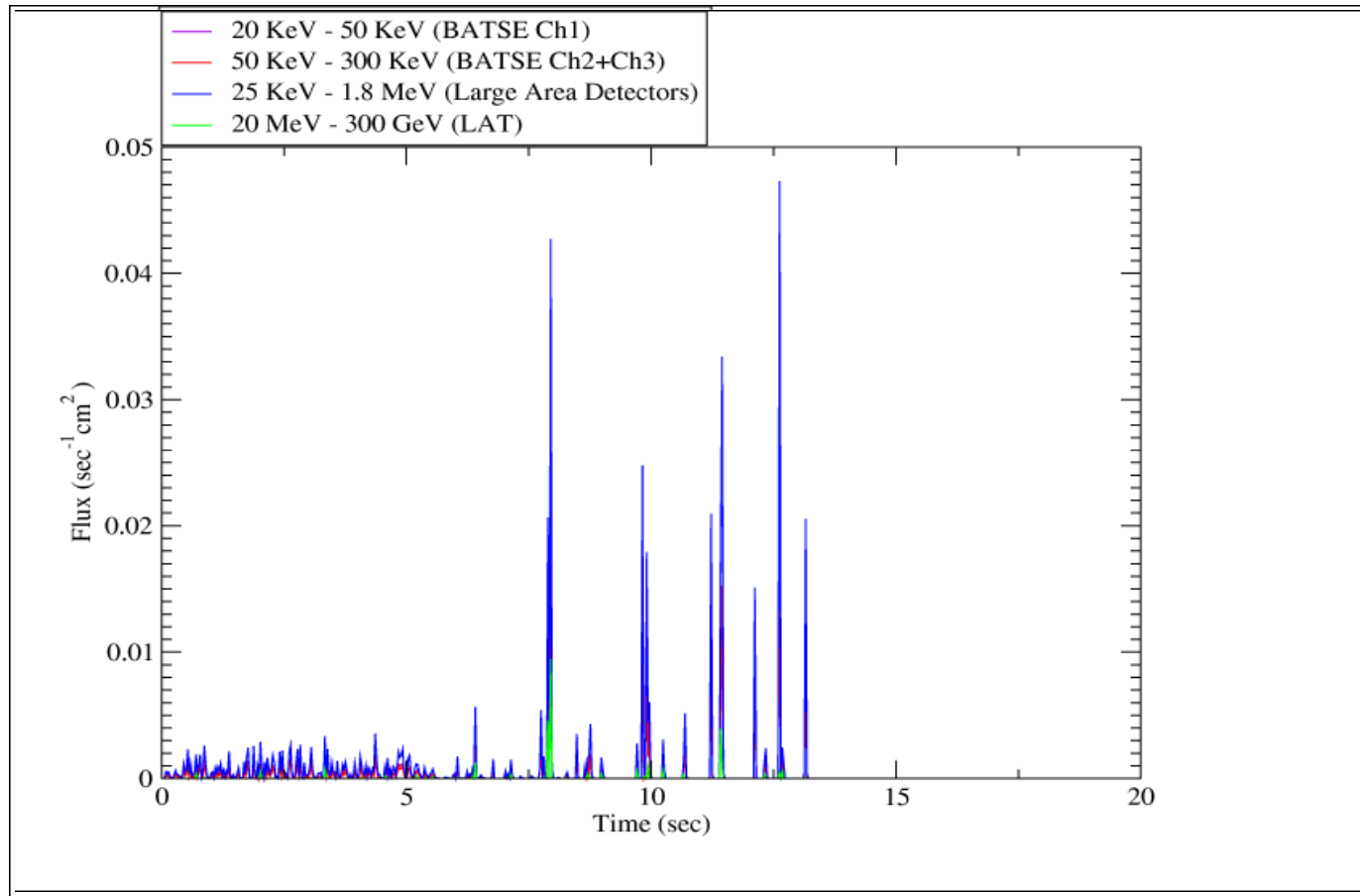
During the internal shocks phase the FBs are IC optically thick !!

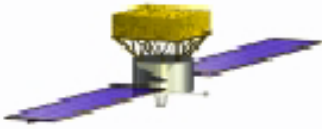
**GLAST**  
Italia



# First Results

- Tuning the initial conditions one can reproduce a large family of GRB events





# How can we use this model?

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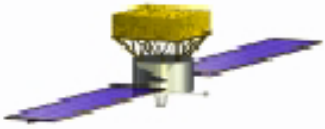
## Testing the capabilities of the GLAST detector:

- Trigger
- 'Hits' reconstruction
- Data acquisition

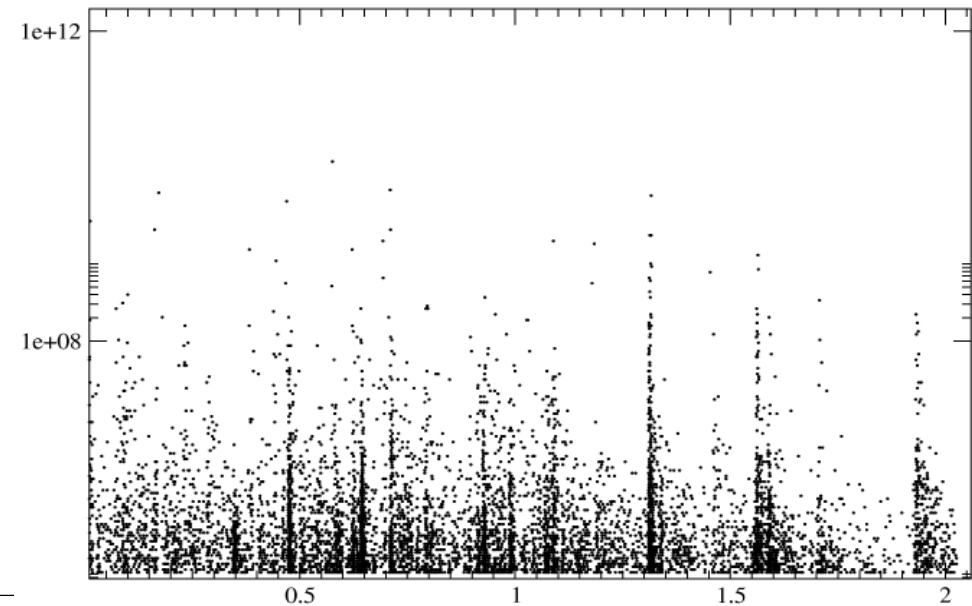
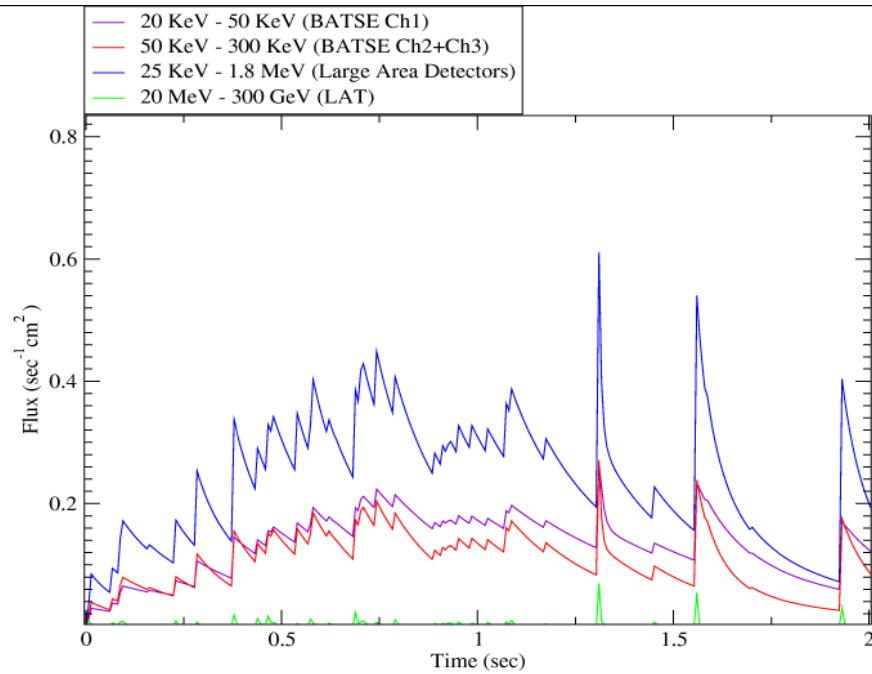
## Analysis software for GLAST

- Light curve reconstruction
- Spectral Analysis

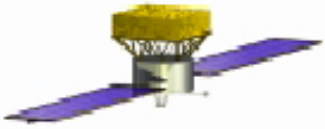
Photon list (time-energy-position)  
to use as input of the  
G4 simulator  
“Event Generator”



# “Photon List”

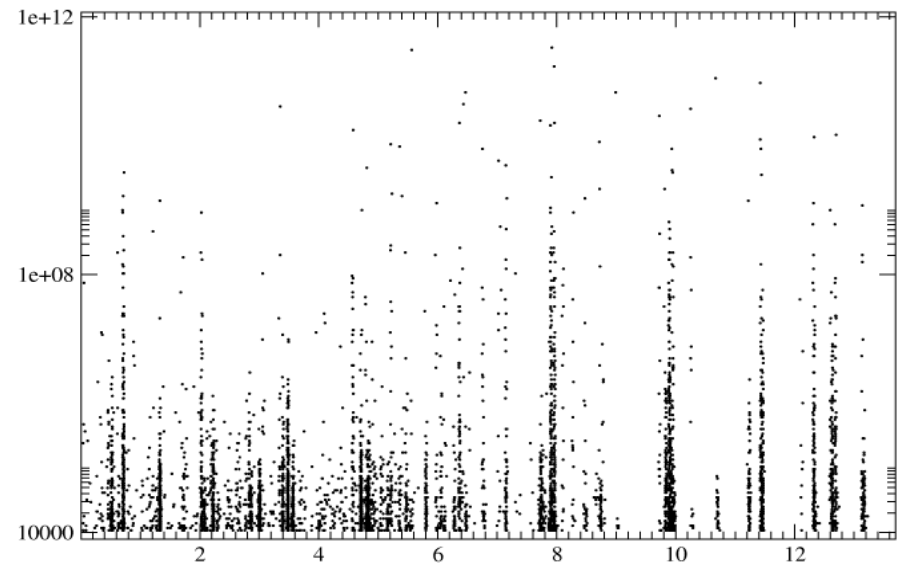
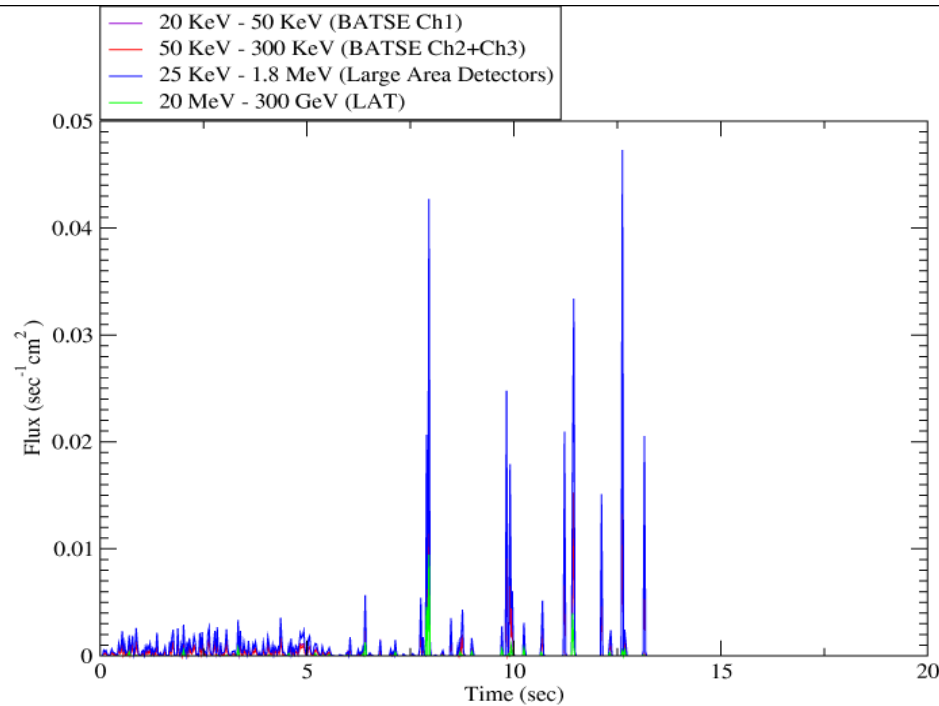


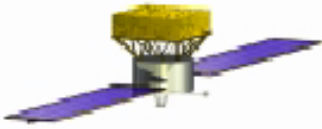
Short Burst, Bright, with spikes overlapped



# “Photon List”

Long Burst, faint with separate spikes





# Future Improvements

*External shock model:* modeling the HE spectra generated during the interaction between the shells and the ISM  
(relativistic reverse shock)

## Delayed HE Emission

Interaction Between the high energy particles produced in the first stage with the external e.m. field (Background Radiation)

## *Scientific Validation of the GRB model*

(how the model reproduces the observed data)

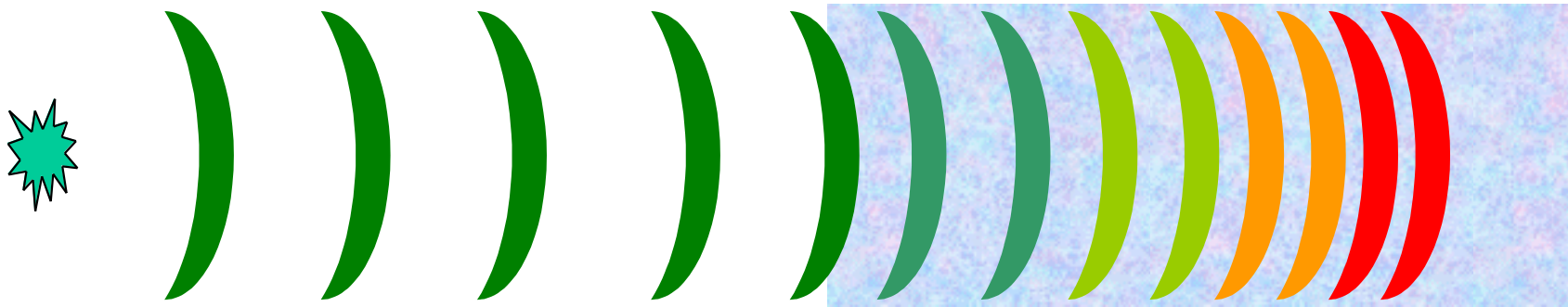
## Spectral Shape

Correlations between Variability-Luminosity-Spectral Lags



## External Shock Model (An Artistic View)

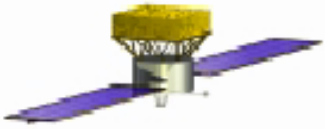
- The Blast wave interacts with the surrounding medium (SN Remnant?)
- The initial Lorentz factor of the shell is closely related to the baryon loading
- As the blast wave sweeps up and captures material from the surrounding environment, it decelerates, becomes energized and emits radiation



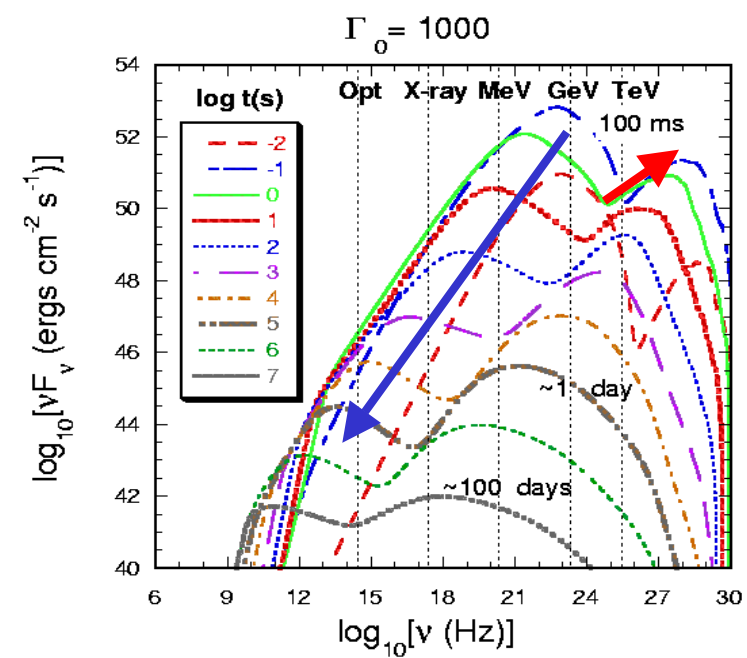
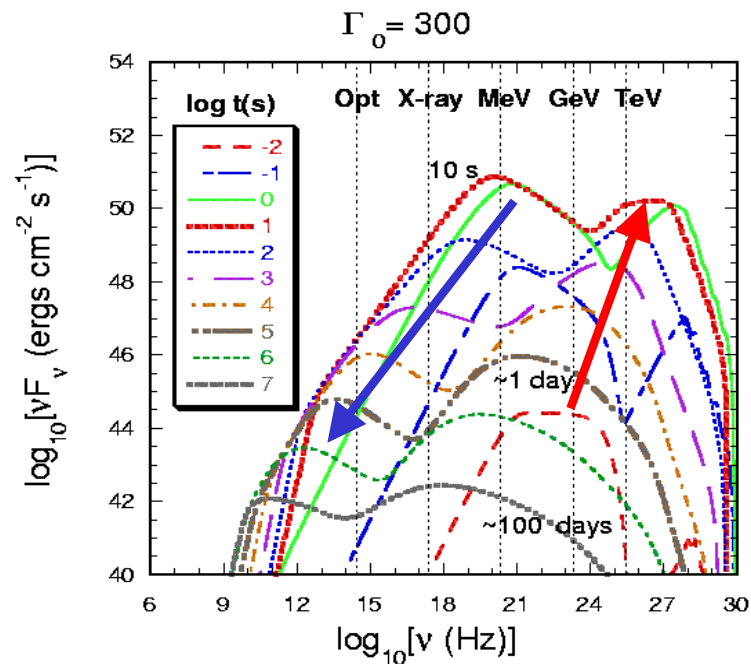
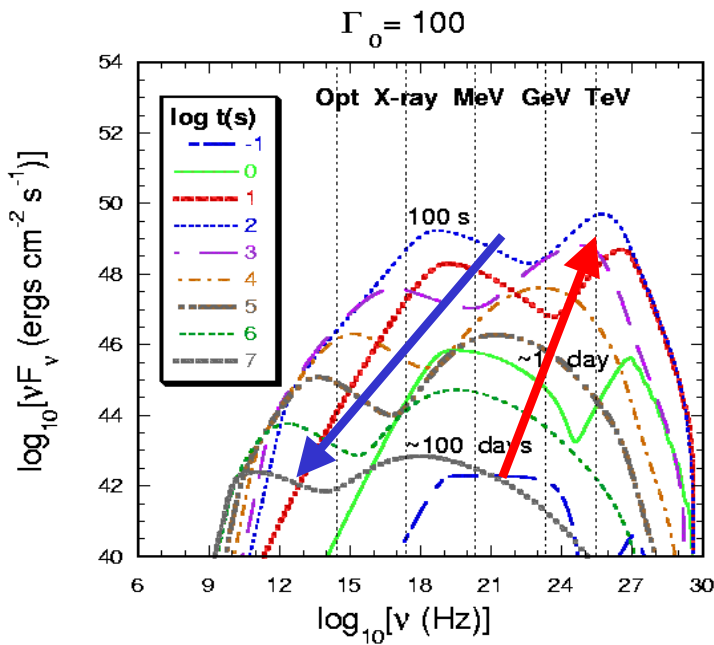
Synchrotron - Synchrotron Self Compton - Synchrotron Self Absorption

$$\gamma\gamma \rightarrow e^+e^-$$

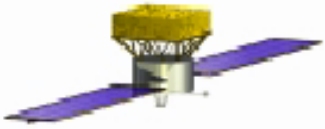
(C.D. Dermer, J.Chang,E.Mitman, M. Böttcher, 1999)



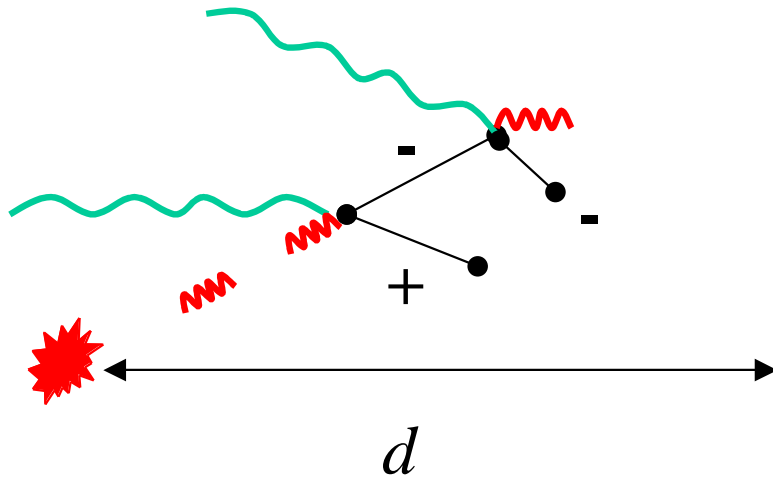
# Time evolution of the Spectrum in ESM







# Delayed MeV-GeV photons



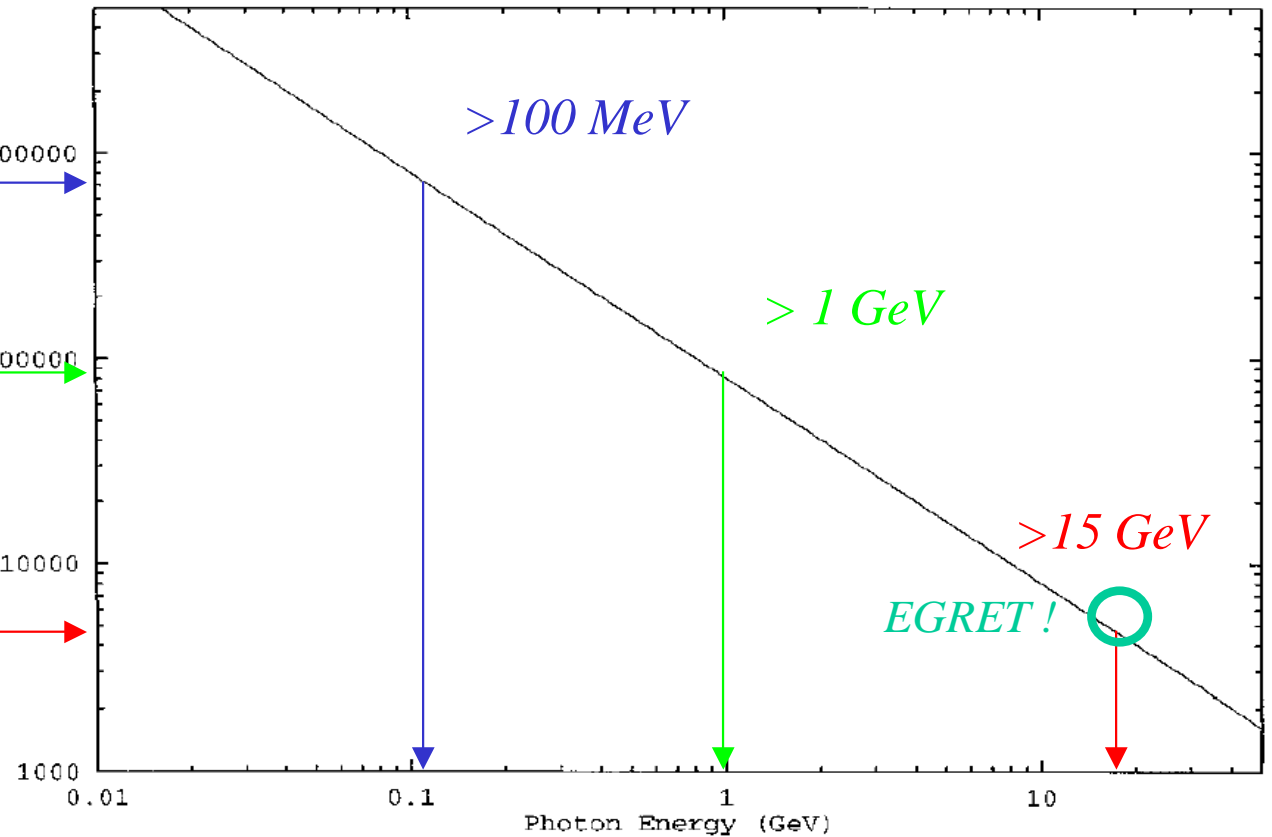
Cheng & Cheng 1996

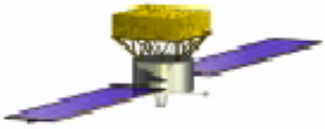
$$\delta t_{\max} = \frac{\theta^2 d}{8c} \quad \begin{cases} \theta^2 \sim \Gamma^{-2} \\ \varepsilon \sim \Gamma^2 \end{cases}$$

Without the presence of IMF !!

1 w  
24 h  
1 h

Maximum Time Delay (sec)

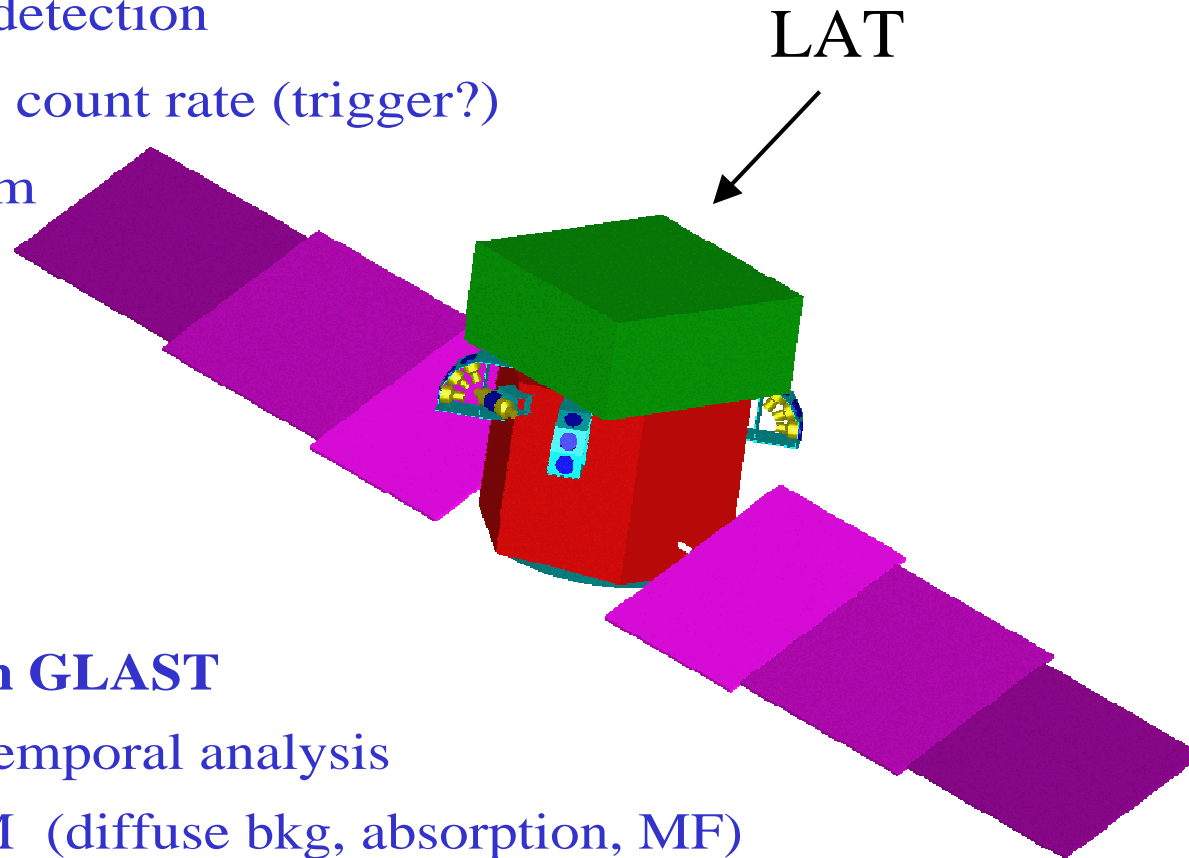




# Focusing the goal...

- **LAT detection of GRB**

- ↳ HE photon detection
- ↳ Low energy count rate (trigger?)
- ↳ Alert System



- **GRB studies with GLAST**

- ↳ Spectral & temporal analysis
- ↳ ISM & IGM (diffuse bkg, absorption, MF)
- ↳ QG studies