# Time Stretching of GeV Emission from GRBs: Fermi LAT vs Geometrical Model

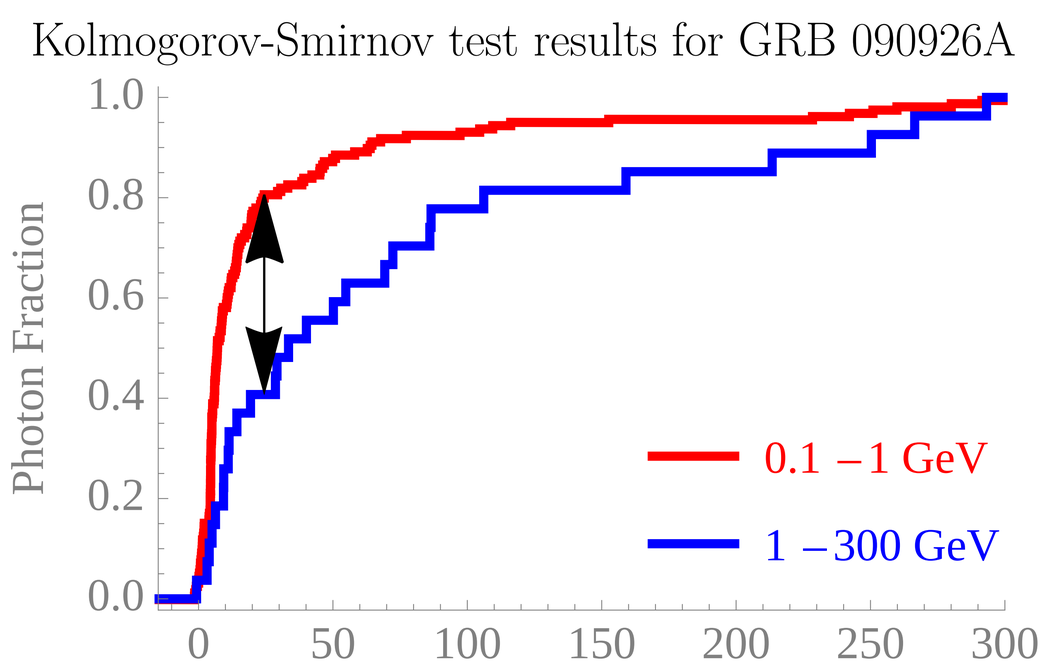
Maxim Piskunov and Grigory Rubtsov
maxit@ms2.inr.ac.ru
Institute for Nuclear Research RAS

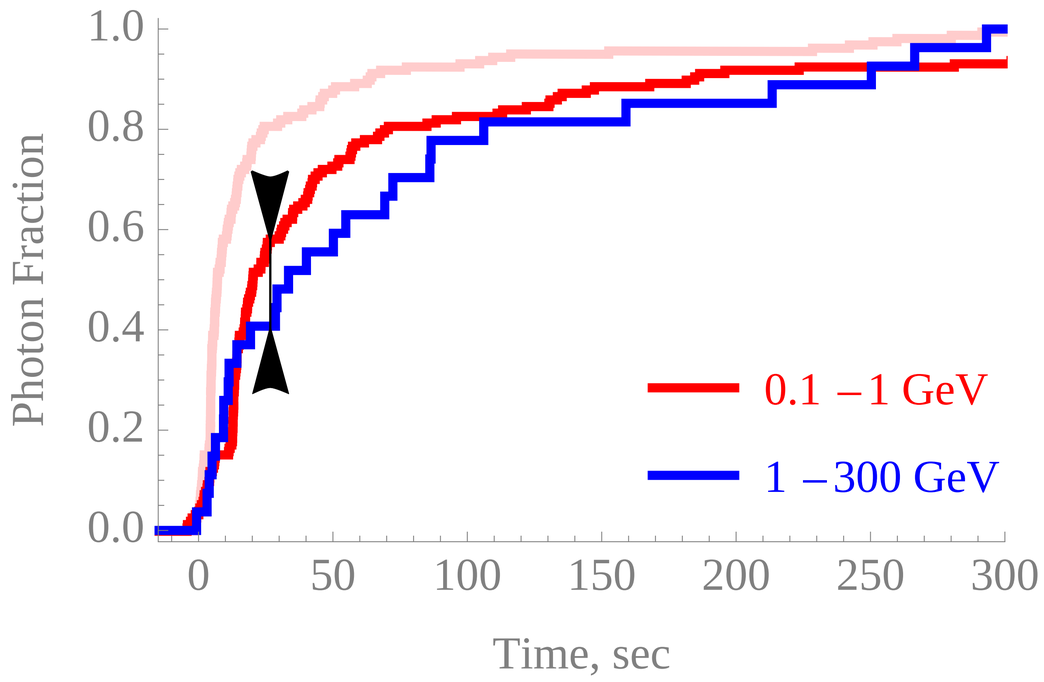
https://github.com/maxitg/GammaRays

## Introduction

Observations confirm that the high energy ($> 100\,\text{MeV}$) emission of gamma ray bursts is delayed with respect to the low energy emission. However, the difference of light curves in various high energy bands has not been studied properly. We study GRBs in two energy bands: 100 MeV to 1 GeV, and 1 GeV to 300 GeV.

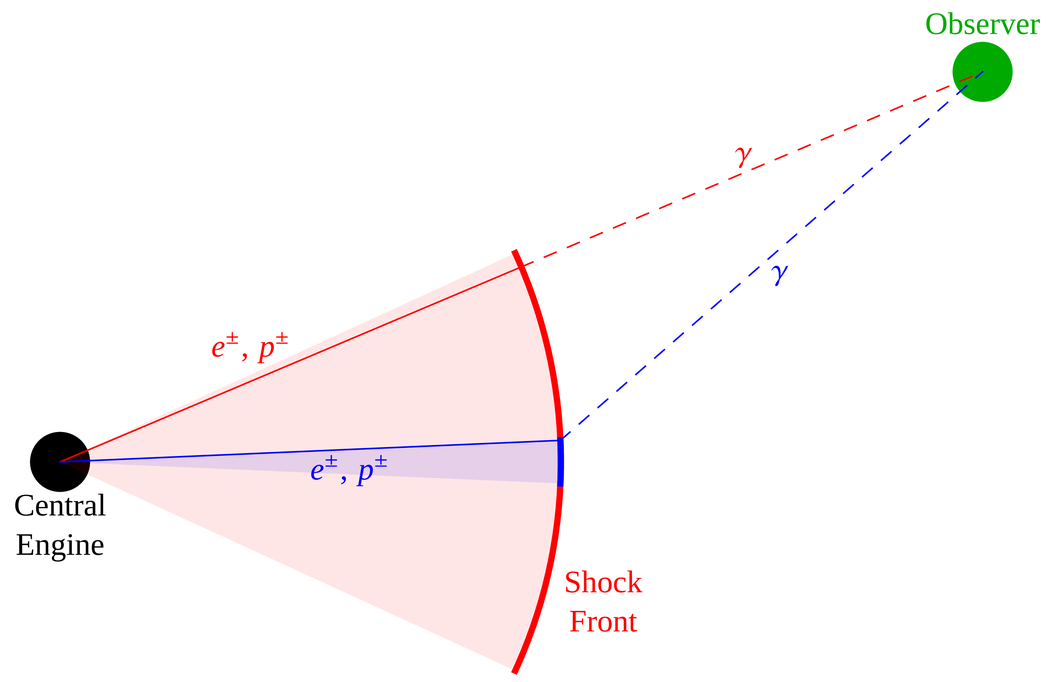
## Observations




- 4 GRBs were studied: 080916C, 090510, 090902B and 090926A.
- 080916C and 090902B have stretching factors compatible with 1 within $2\sigma$.
- High energy light curve of 090926A is stretched with respect to low energy one (with $3.3\sigma$ significance)
- Low energy light curve of 090902B is stretched with respect to high energy one (with $2.2\sigma$ significance)

## Model



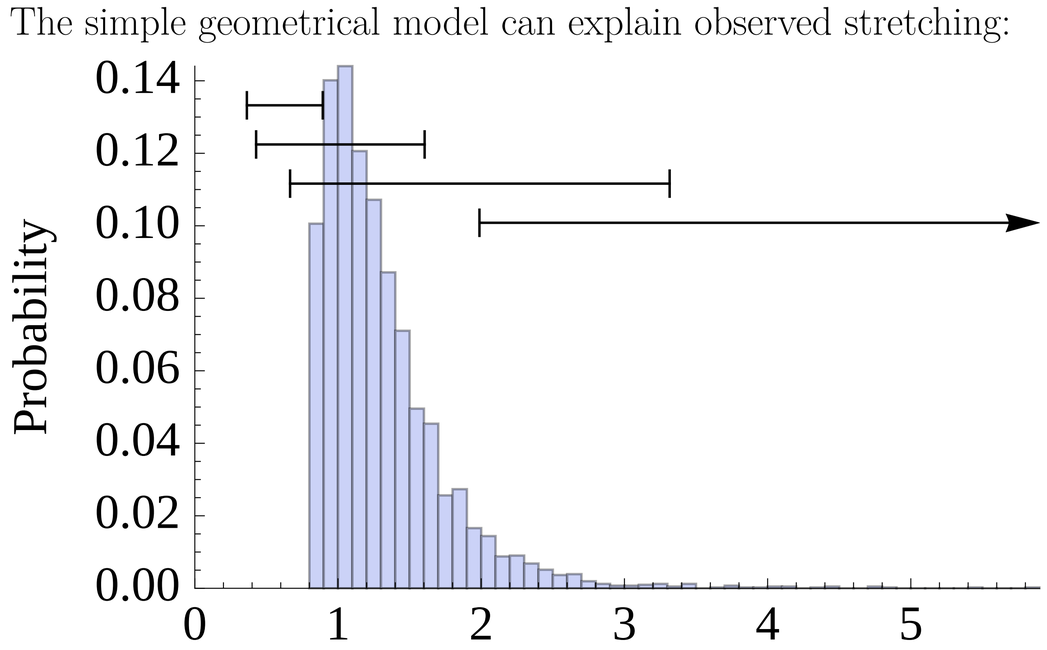

We suggest a simple geometrical model to explain this result. The main hypothesis is the jet opening angle dependence on radiation energy – the most energetic photons are emitted near the axis of the jet.

1. Time $t = 0$, the central engine emits a spherical shell of plasma.
2. The shell propagates with relativistic velocity.
3. Each jet point is an isotropic radiator in its inertial reference frame.
4. Intensity depends on coordinates in space and frequencies:

$$\eta(r, \theta, \omega) = \frac{\eta_0}{1 + (r/r_0)^n} e^{-(\theta/\theta_0)^2 (\omega/\omega_0)^{-2k}} (\omega/\omega_0)^{\alpha}$$

## Results

The simple geometrical model can explain observed stretching:




We also computed (for some parameter values):

- Total energy of the burst above 1 GeV. The result is reasonable.
- Fraction of bursts observable above 100 MeV, which are also observed above 1 GeV is $f_m = 0.072$. Observed value is $f_o = 0.086$.