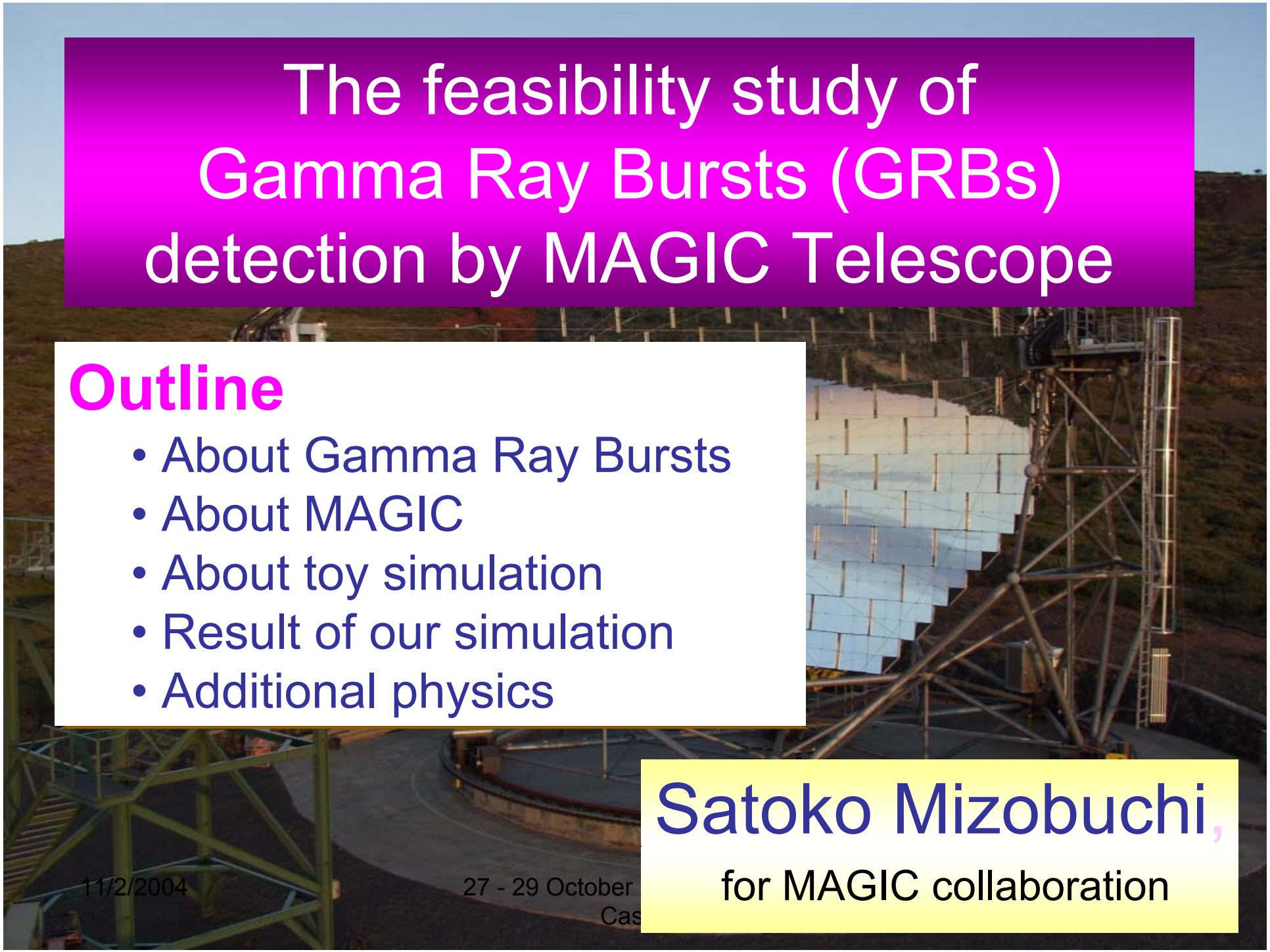


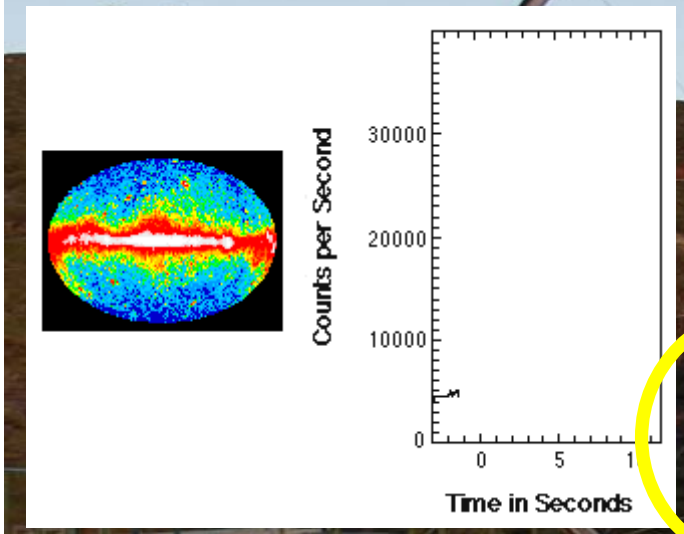
The feasibility study of Gamma Ray Bursts (GRBs) detection by MAGIC Telescope

Outline

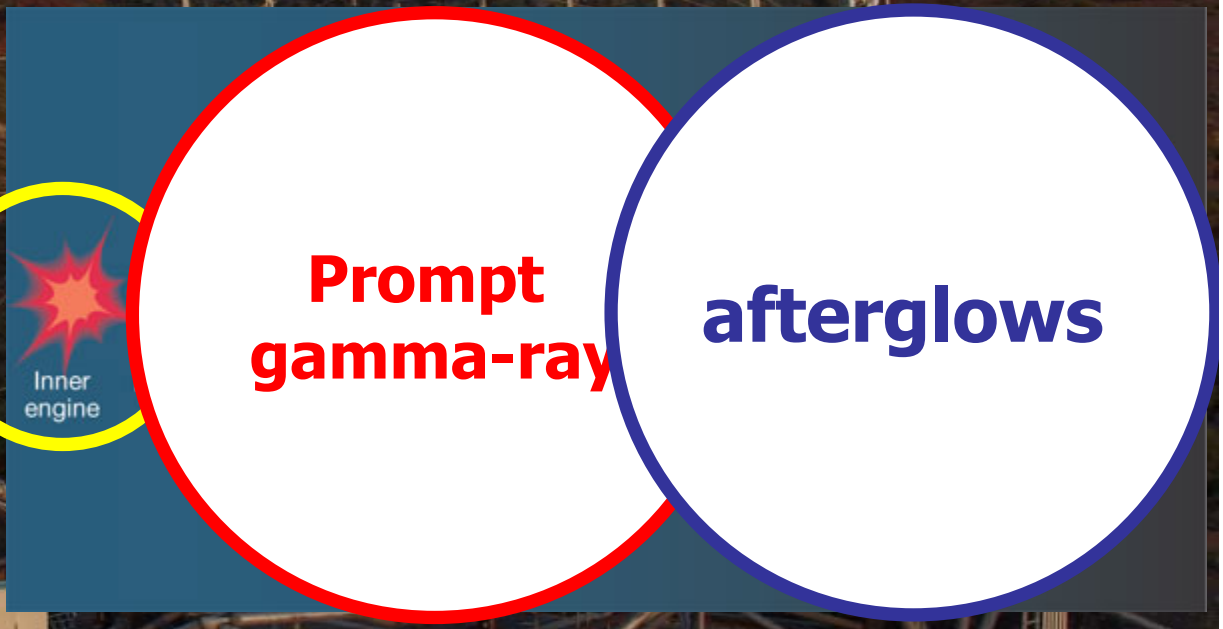
- About Gamma Ray Bursts
- About MAGIC
- About toy simulation
- Result of our simulation
- Additional physics

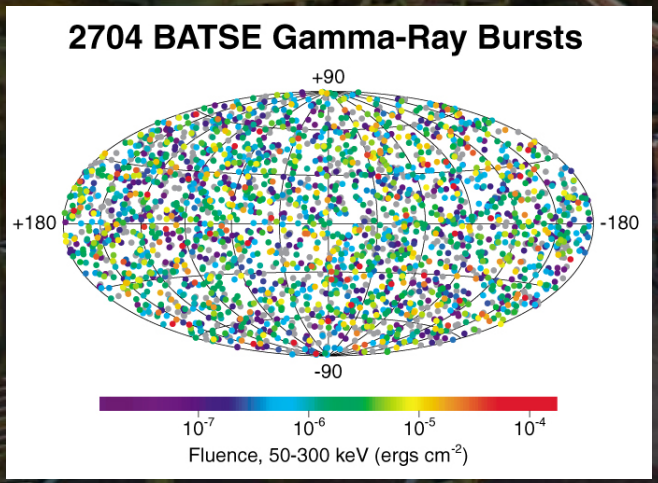
Satoko Mizobuchi,
for MAGIC collaboration

Gamma Ray Bursts



Internal – external shock model

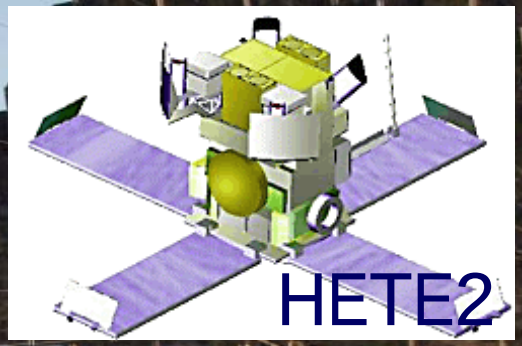


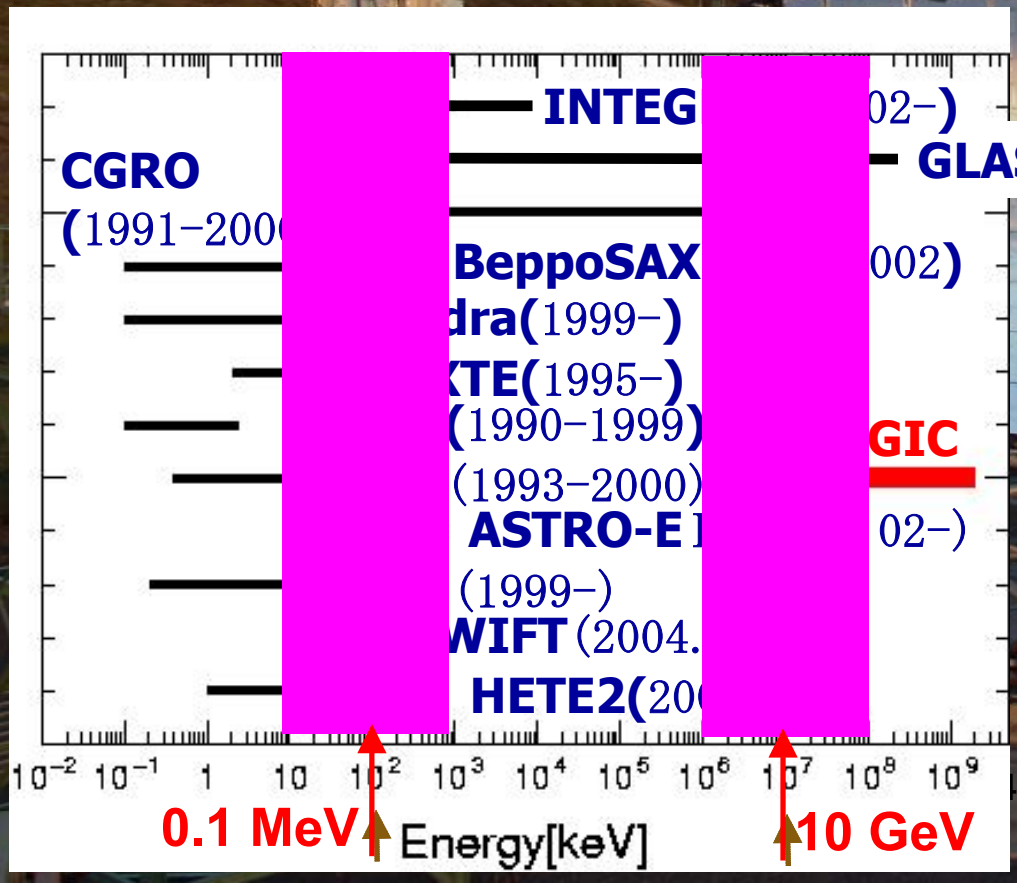


Prompt gamma-ray emission

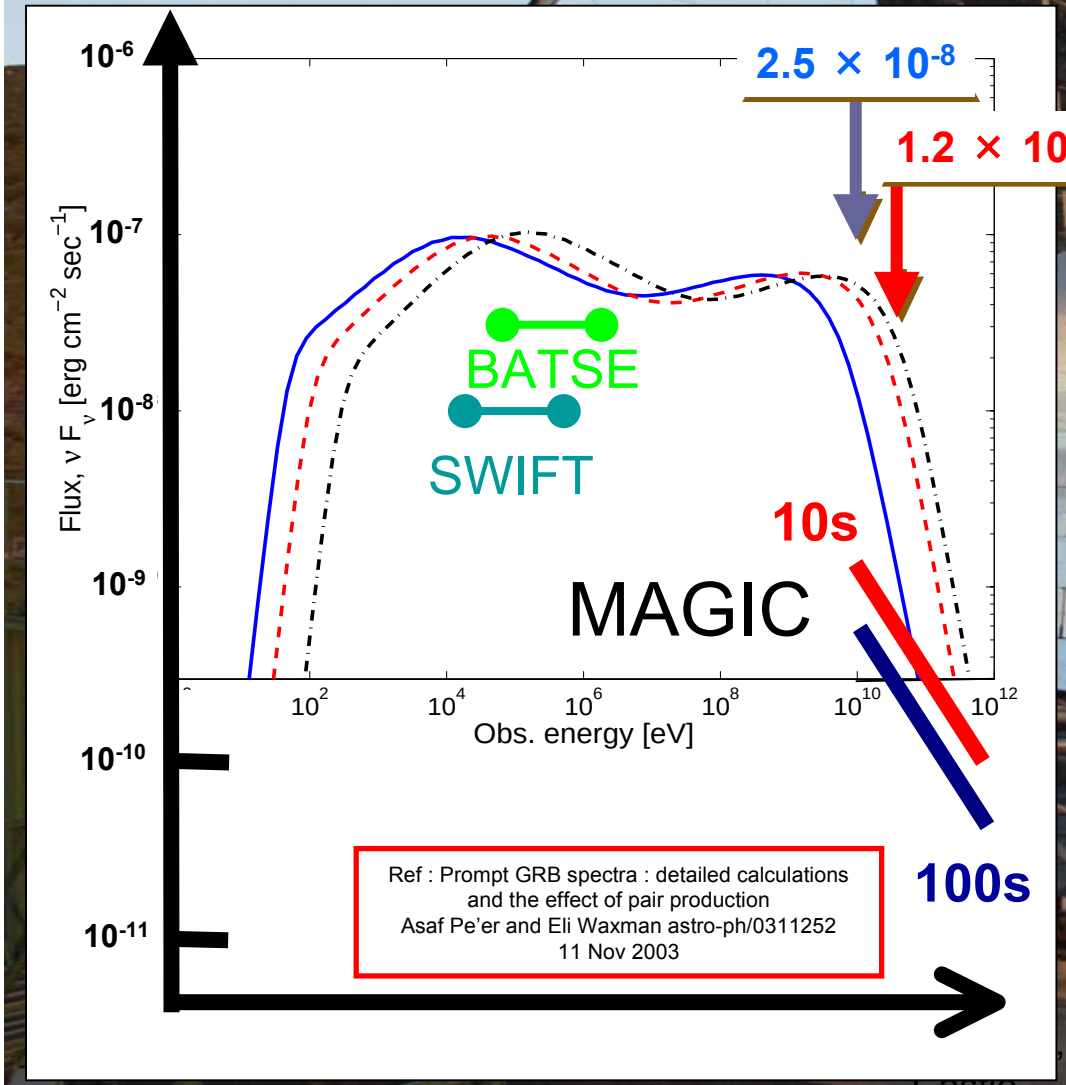
Synchrotron and inverse-Compton emission of electron accelerated by internal shocks

The energy range





The MAGIC sensitivity and expected prompt GRB spectra



Source of GRBs

- L : the total luminosity
- Γ : the Lorentz factor of shocked plasma
- Δt : developing time

Microphysics

- ε_B : ratio of magnetic energy to total thermal energy
- ε_e : ratio of electron energy
- P : power law index

Condition

$L = 10^{52}$erg

$\varepsilon_e = \varepsilon_B = 10^{-0.5}$, p=3

$\Delta t = 10^{-2}$s, $\Gamma = 300$

$\Delta t = 10^{-3}$s, $\Gamma = 600$

$\Delta t = 10^{-4}$s, $\Gamma = 1000$

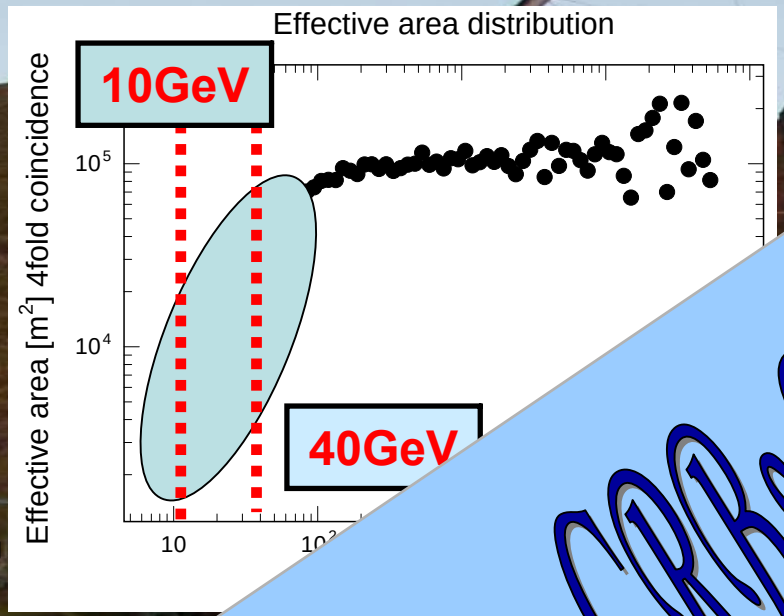
Assumption

Luminosity distance

$d_L = (1+Z)\, r = 2\times10^{28}$

$z = 1$

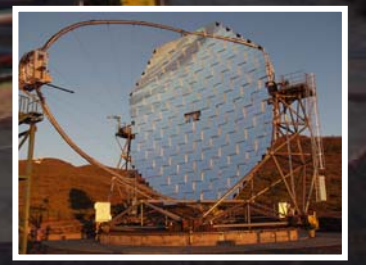
GRBs detection by MA



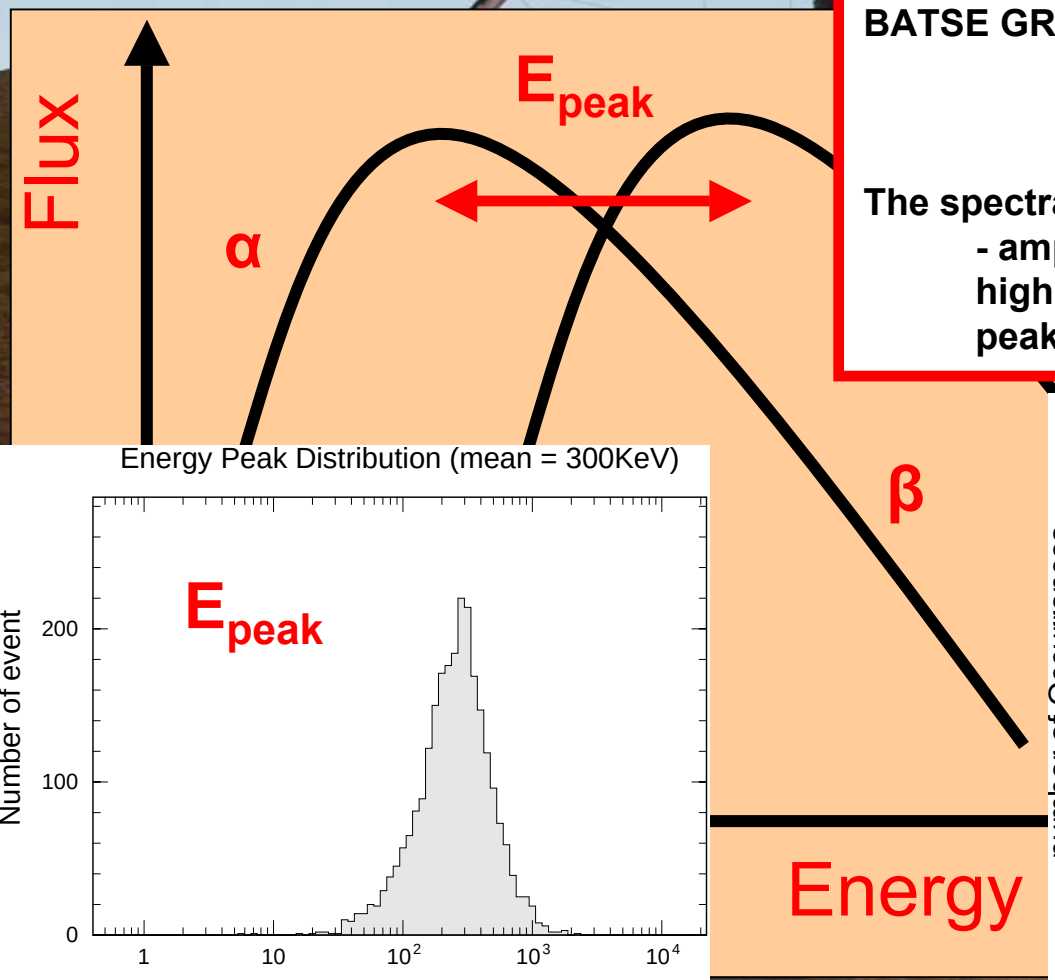
How many GRBs MAGIC can detect?!

- scope
- econds - several minutes
- accuracy within **10 seconds**

MAGIC positioning time < 25s

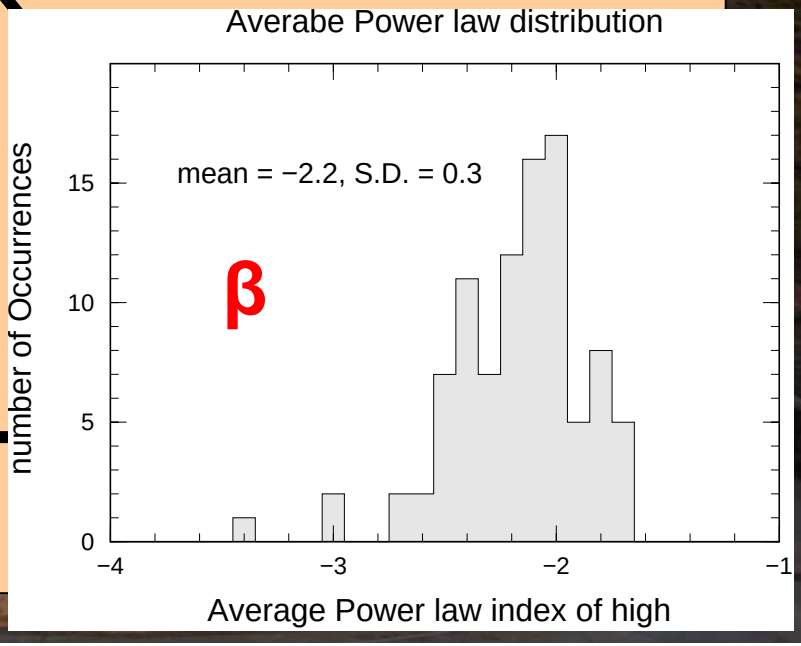


Information of GRBs detected by BATSE



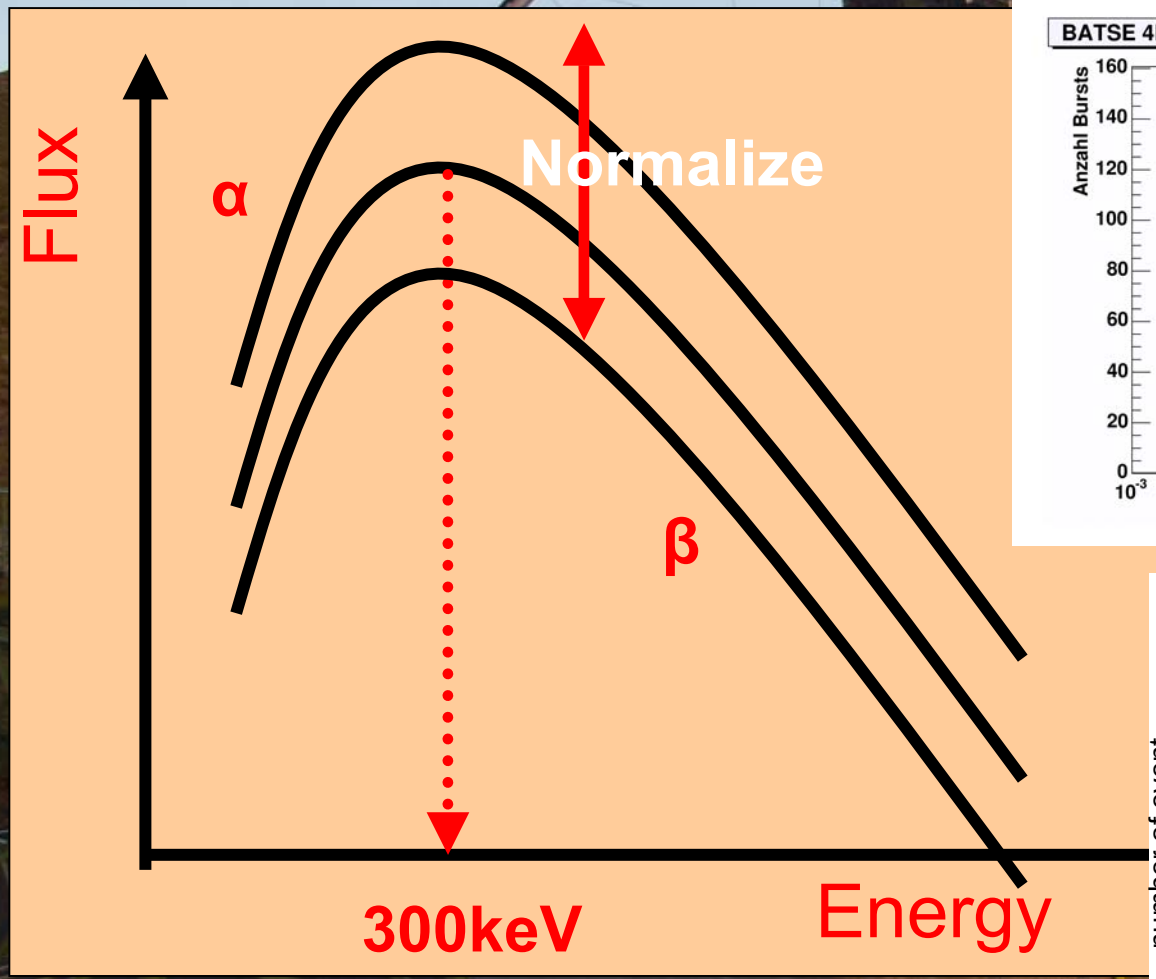
BATSE GRB Current Catalog (2702 GRBs)
- fluence
- duration
- light curve (64ms resolution)

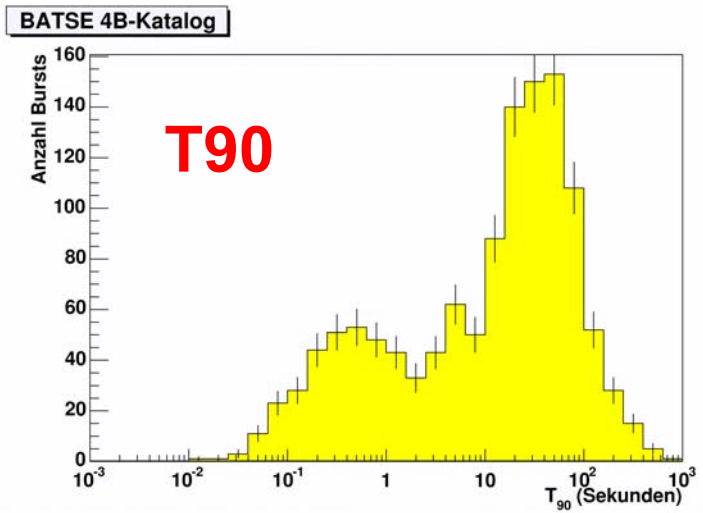
The spectral catalog (95 bursts)
- amplitude(A), low-energy spectral index (α), high-energy spectral index (β), peak energy (E_{peak})

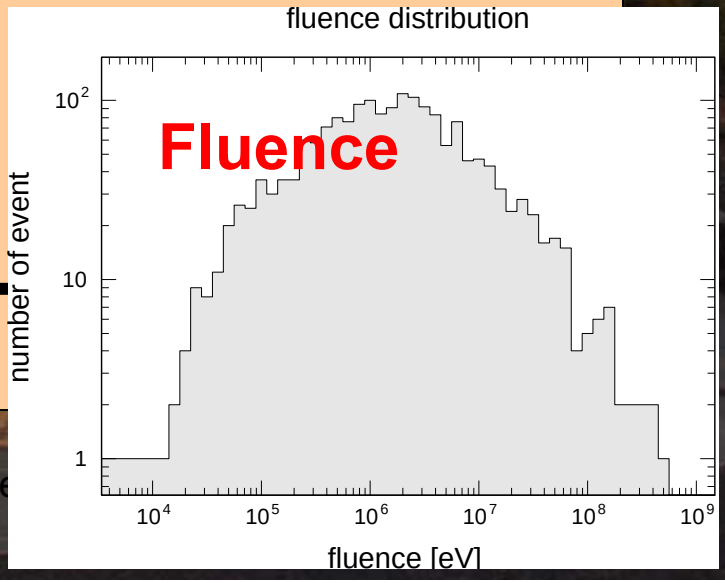


Ref : http://www.batse.msfc.nasa.gov/batse/grb/catalog/current/ , http://cossc.gsfc.nasa.gov/batse/batseburst/sixtyfour_ms/,
Preece R.D., ApJ 496: 849- 862, April 1998, Preece R.D., ApJ Supp., 126, 19-36, Jan 2000

Expected spectrum of GRBs

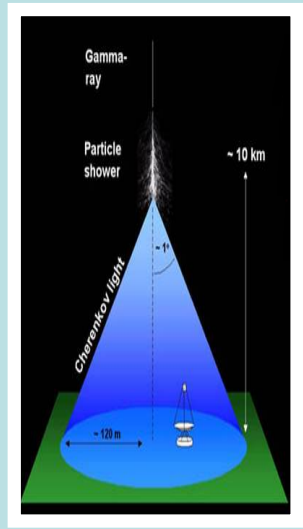






$$(flux@300keV) = C \times \frac{(Fluence)}{T90}$$

GRB Simulation method



Two energy region
- 10GeV-20GeV
- 20GeV-40GeV

Flux

GRB spectrum

Collection area of Magic

IR absorption

1GeV

10GeV

20GeV

40GeV

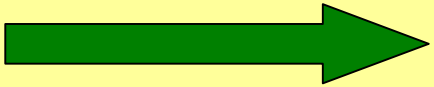
1TeV

Energy

Toy Simulation

Estimation of gamma-ray rate at MAGIC energy

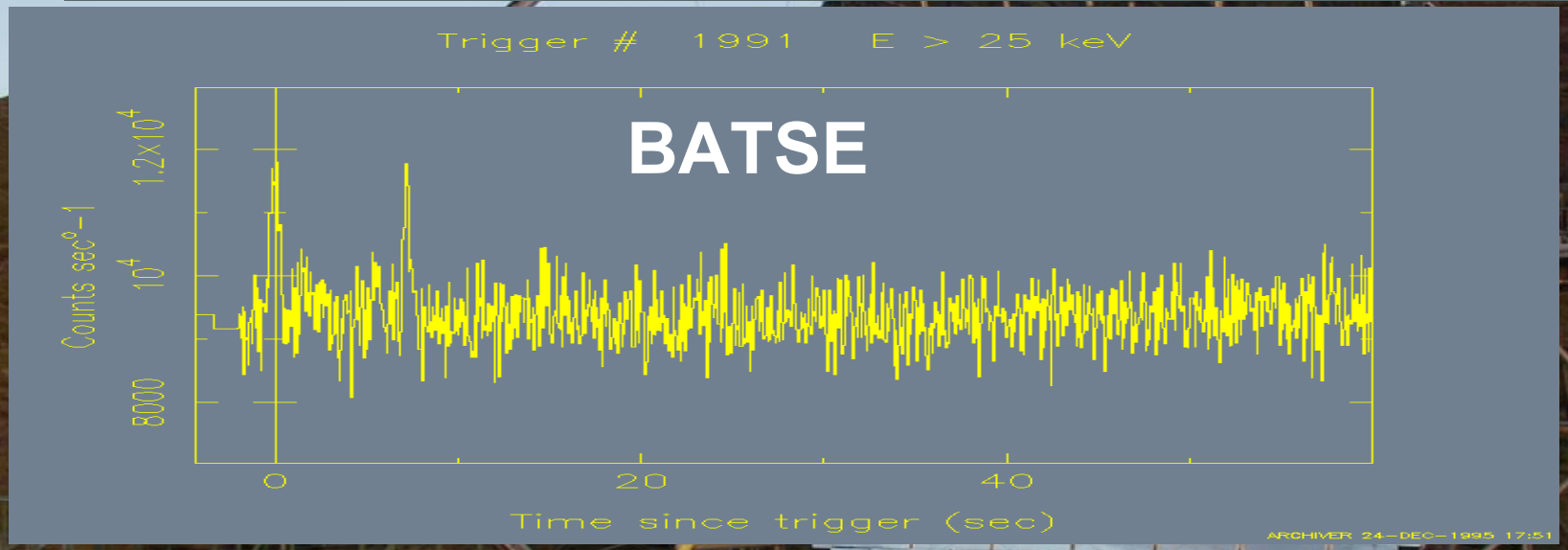
1. BATSE GRB Current Catalogue (2702 bursts)
   -Fluence
   -Duration time
   -Light curve (Time Profile)

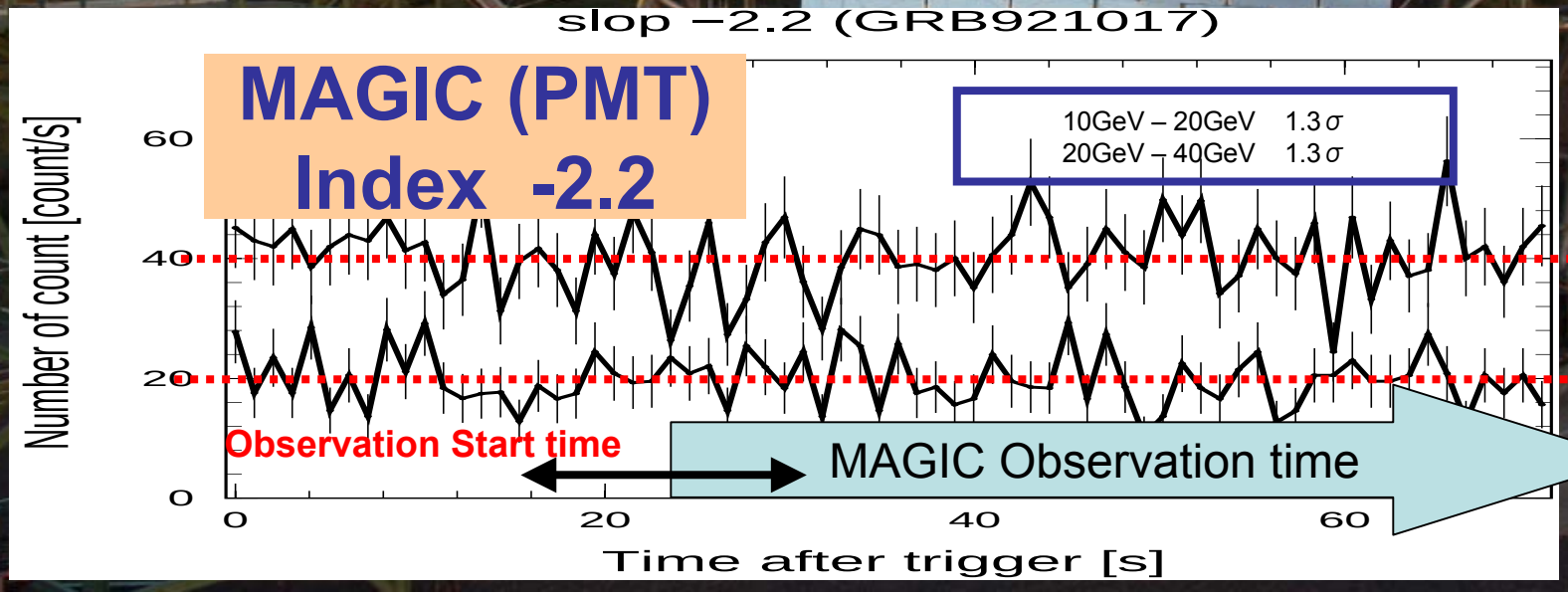


Gamma Ray flux at 300keV

2. Assume Power law index -1.9,-2.2 and -2.5 between 300keV and 40GeV energy, estimate Gamma Ray flux at 10-20 GeV, 20-40 GeV energy bins.
3. Convolute MAGIC acceptance with Gamma Ray flux at 10-20GeV, and 20-40GeV
4. Add Expected Hadron shower rates 20Hz, and 40Hz in 10-20GeV and 20-40GeV energy bin.

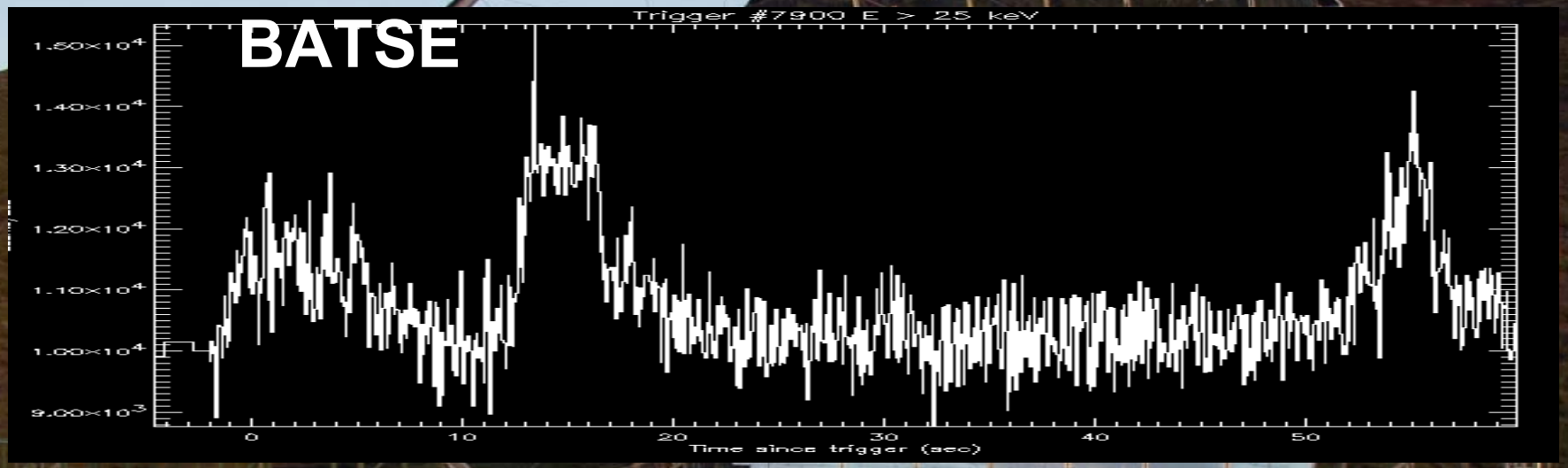
Light curve of GRB921017
(Fluence = $1.9 \times 10^5 eV/cm^2$)

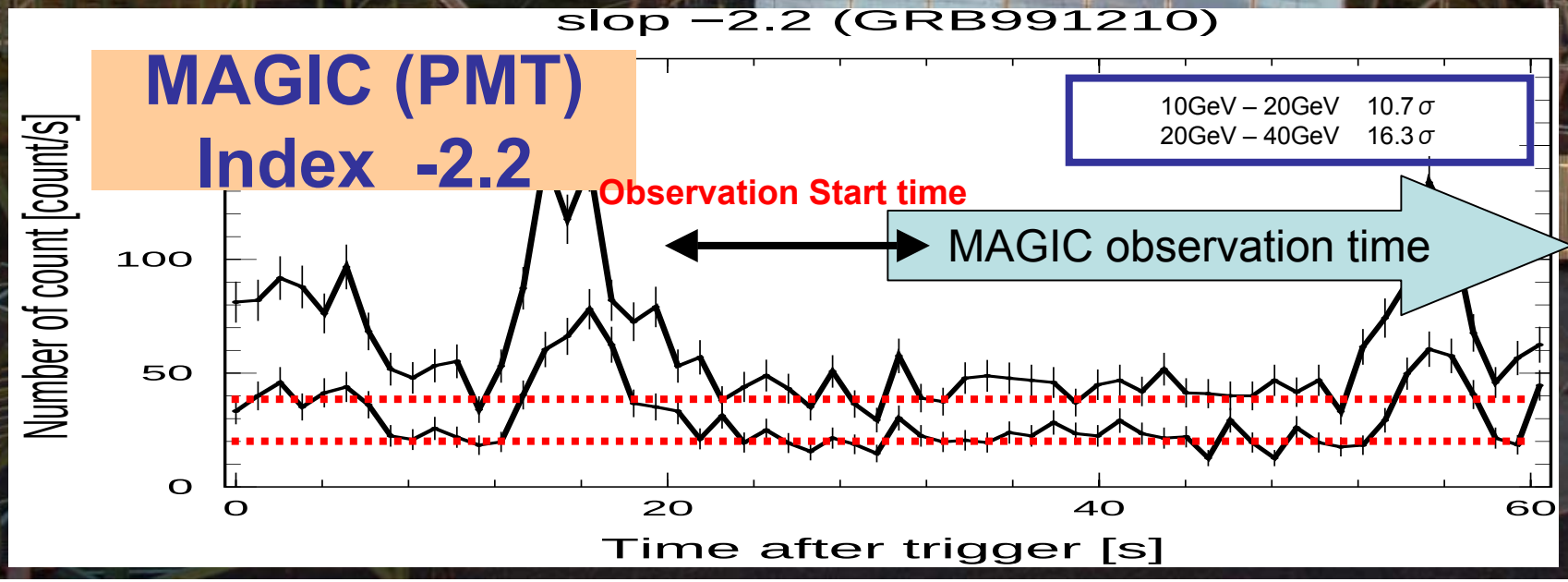




Light curve of GRB991210

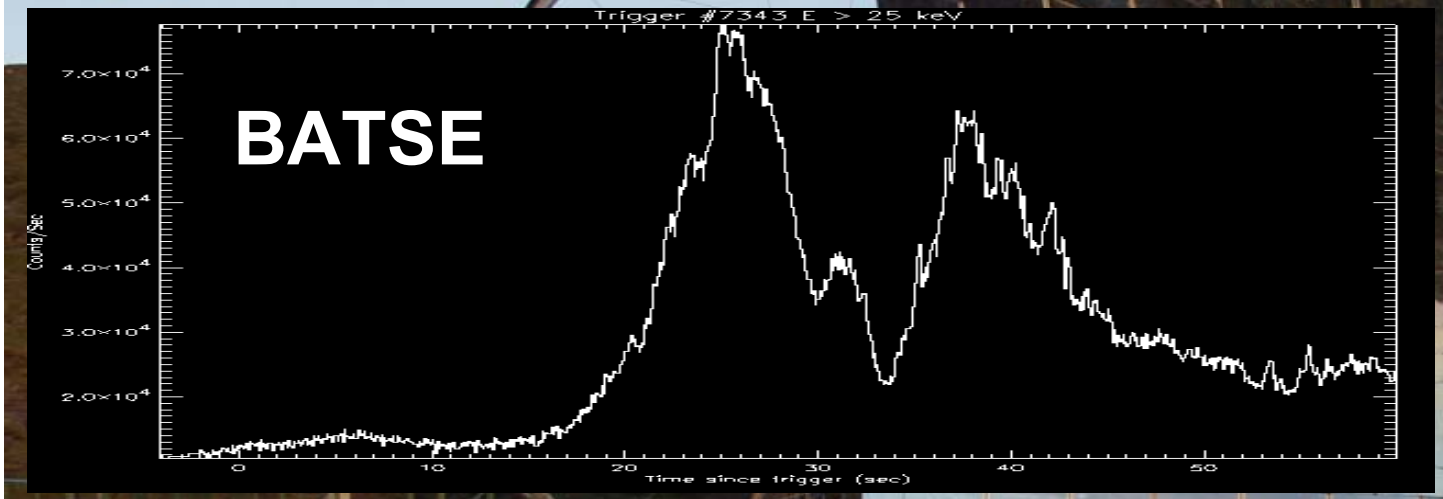
(Fluence = 5.0×10^6eV/cm2)

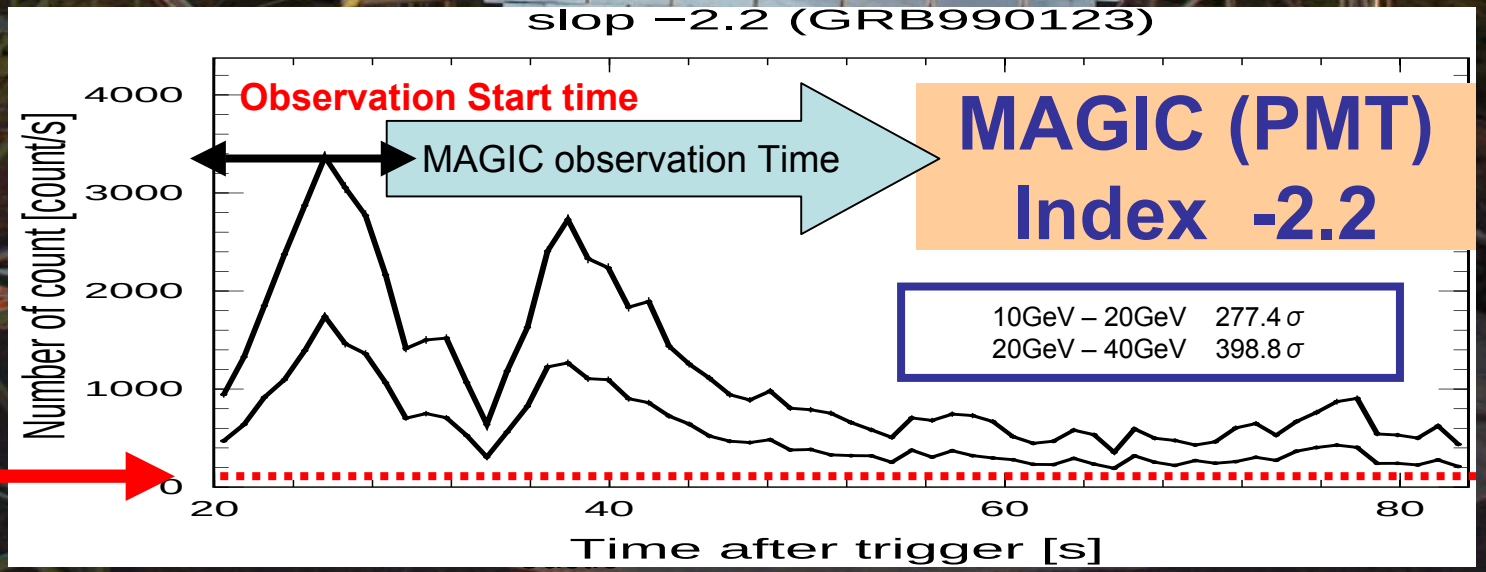




Light curve of GRB990123

(Fluence = 3.0×10^8eV/cm^2)

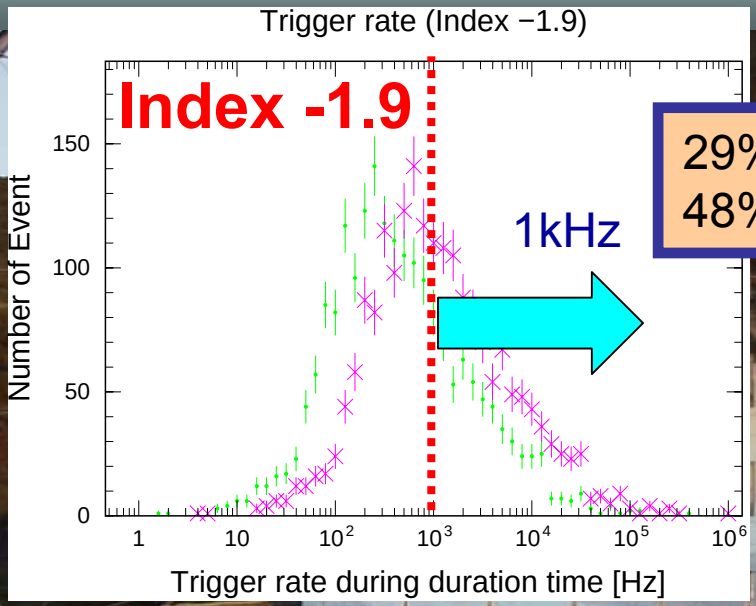


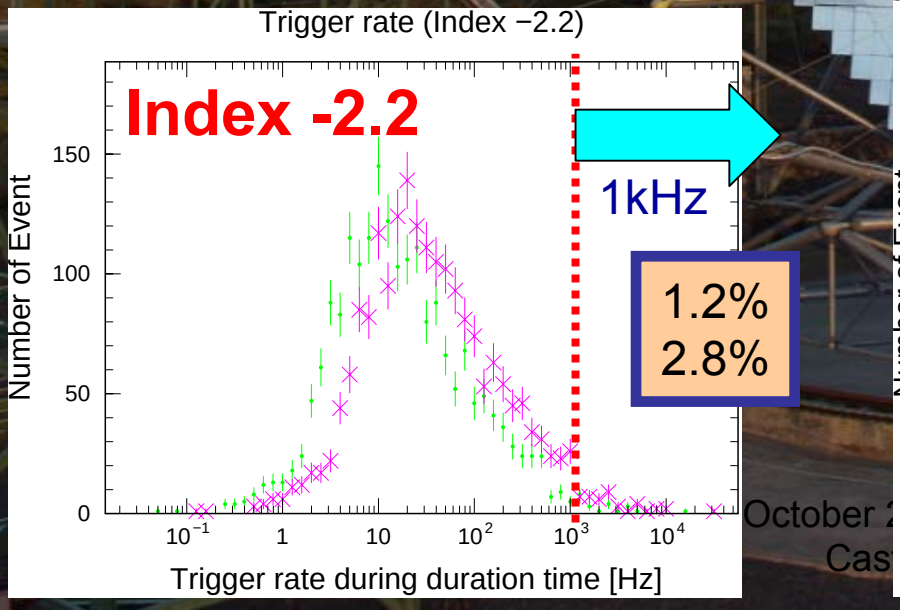


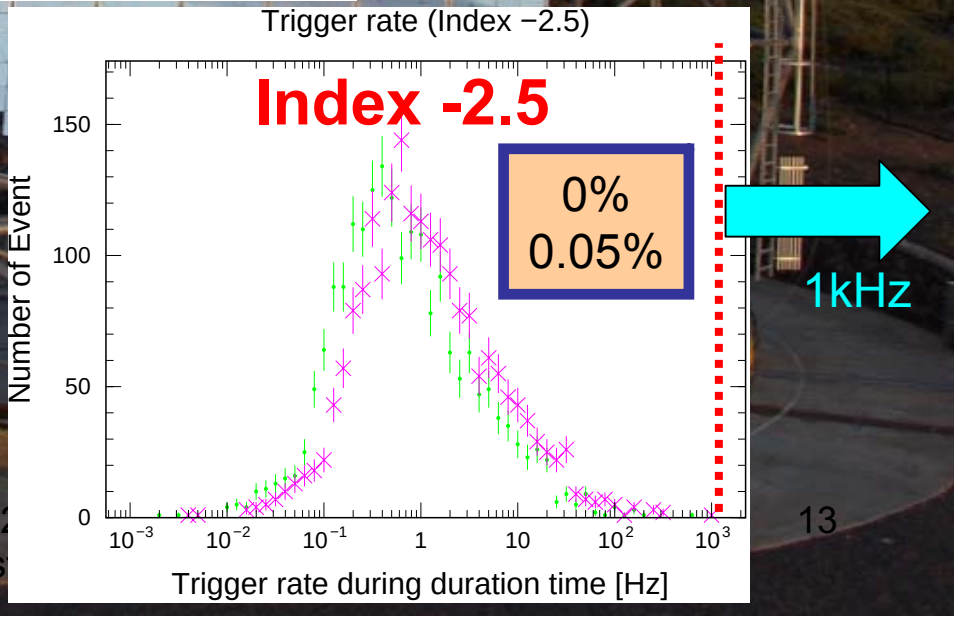
BG 20Hz

BG 40Hz

GRB event rate with MAGIC

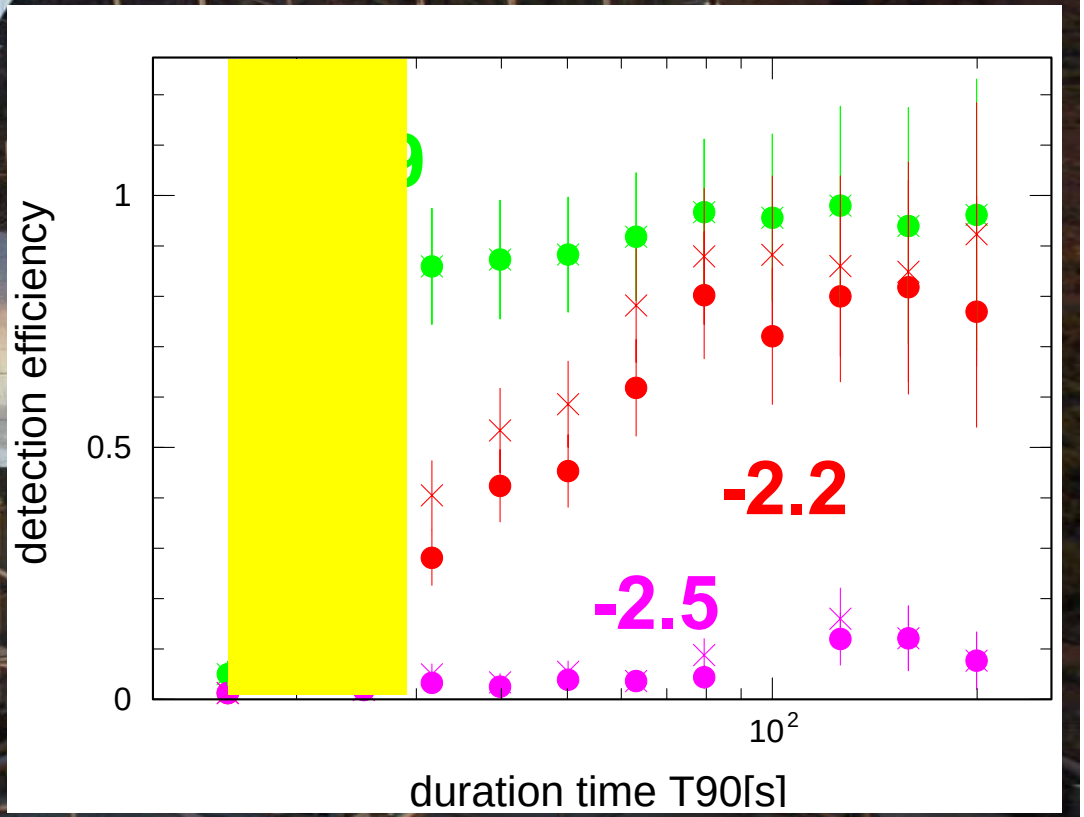






Detection capability with MAGIC Telescope

	10GeV−20GeV (・)	20GeV−40GeV (×)
−2.5	2.0%	3.0%
−2.2	24%	29%
−1.9	41%	42%



Significance > 5 σ
Observation start time 15sec – 30sec

Number of observable GRBs with MAGIC

- **Predicted number of GRBs by SWIFT Satellite : ～200 bursts/year**
- **Duty Cycle of observation time by MAGIC 14%**
- **Observable sky by MAGIC (zenith angle <45°) 15%**
- **GRB detection efficiency by MAGIC: >24%**

≥1.0 bursts/year

Preliminary

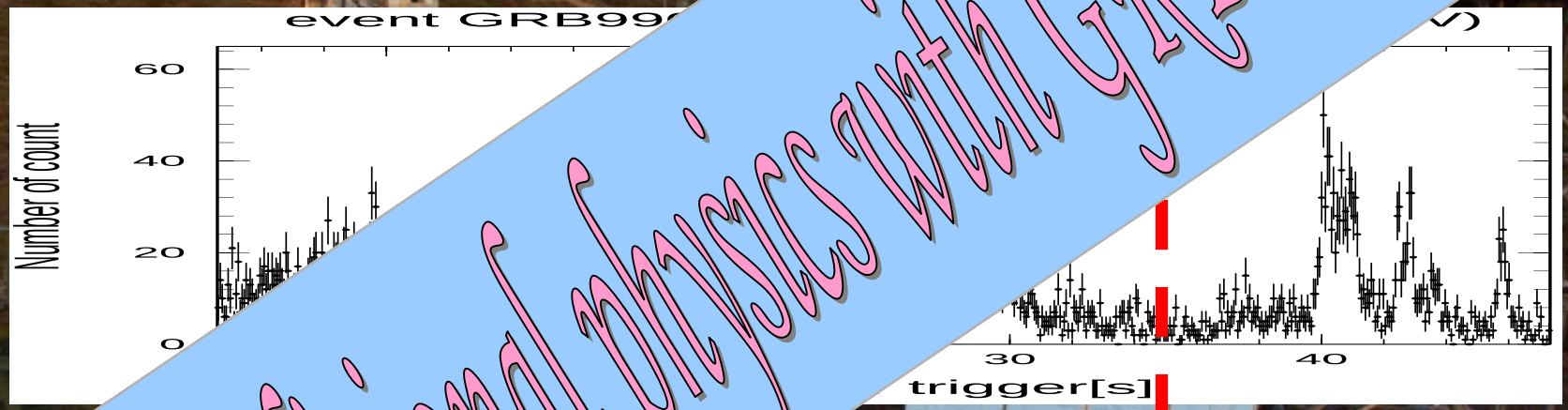
- With Hybrid Photo Detector (HPD) Camera
  - Larger observable sky x1.7
  - Higher Detection efficiency x1.3

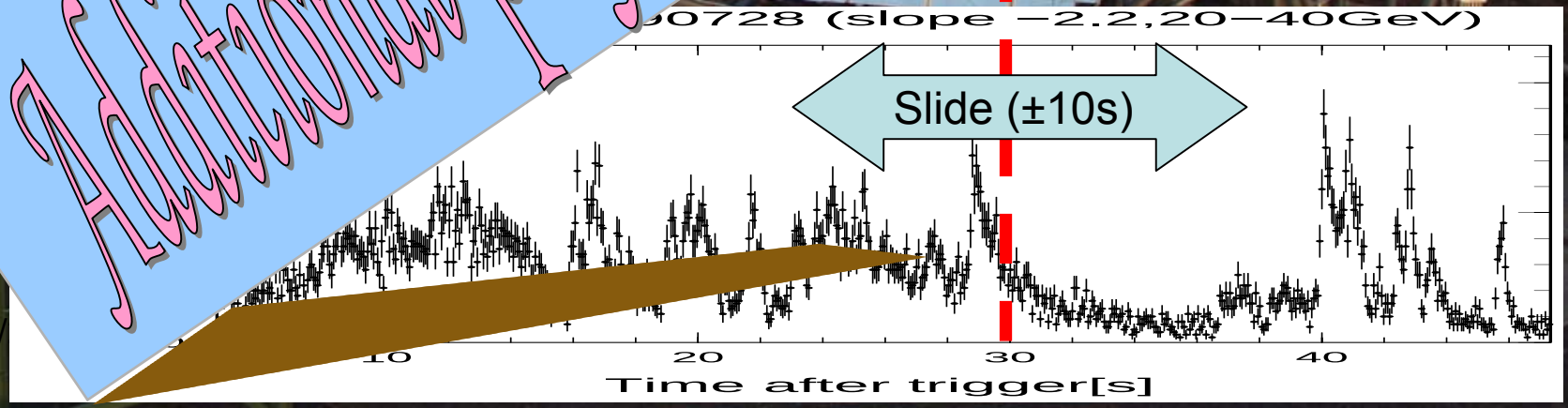
Quantum Gravity -Invariance of speed

$$\Delta t \sim \frac{E}{E_{QG}} \frac{L}{c}$$

~1-10 seconds

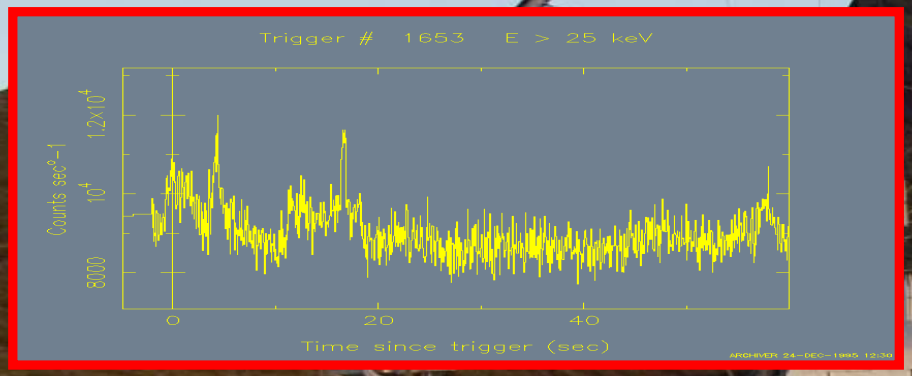
Exampl

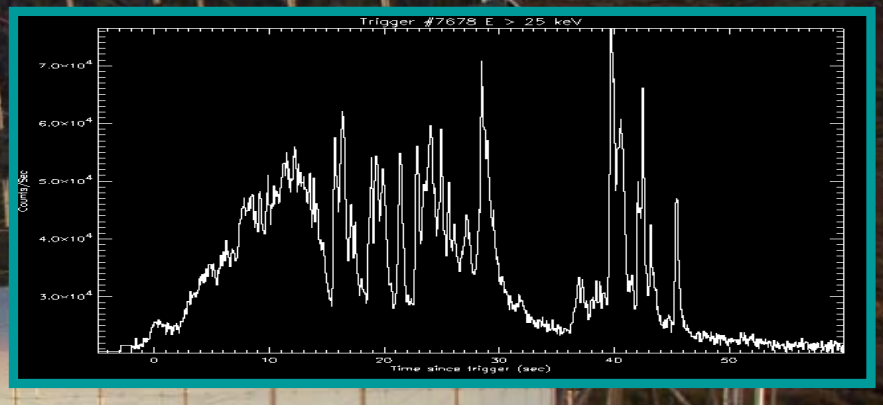


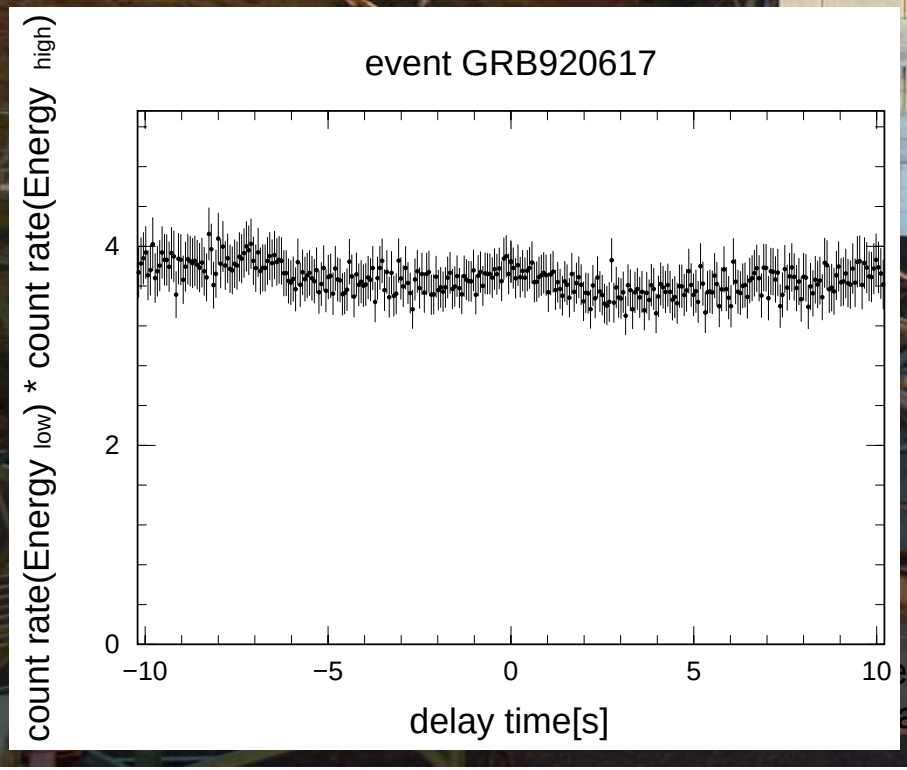


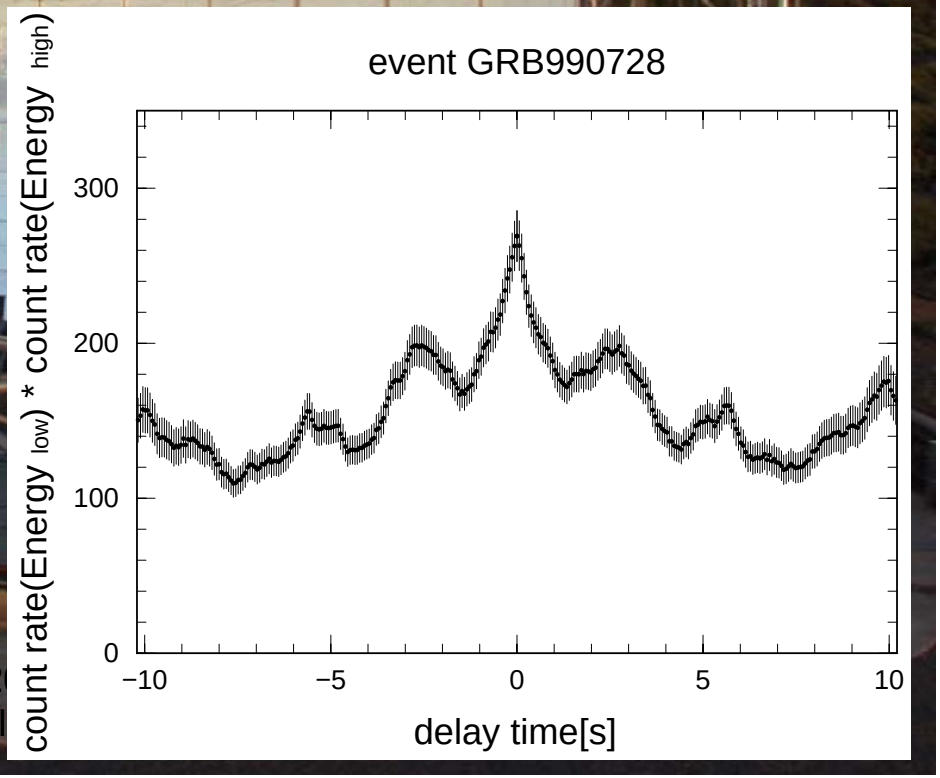
Additional physics with GRB studies!!

Quantum Gravity
- Example -









Conclusions

- **Detection capability**
  > 24% (10GeV-40GeV & index = -2.2)
- **≥ 1.0 bursts/year**

The next step:

- Improvement of simulation taking into account the IR absorption
- New analysis method for GRBs (> 10GeV)
  - imaging analysis for hadron rejection
  - time correlation study between satellite data and MAGIC data
- We wait for SWIFT satellite (November, 2004)
- With HPD, we improve our sensitivity by two times


End