NEW MODEL FOR GRB PROMPT EMISSION AND THE IMPACT OF MIRAX IN GRBs SCIENCE

José Rodrigo Sacahui Reyes

Instituto Nacional de Pesquisas Espaciais- INPE

J. Braga - M. Castro- F. D'Amico- A. Penacchioni

VIII Workshop da Pós-Grduaçao em Astrofísica

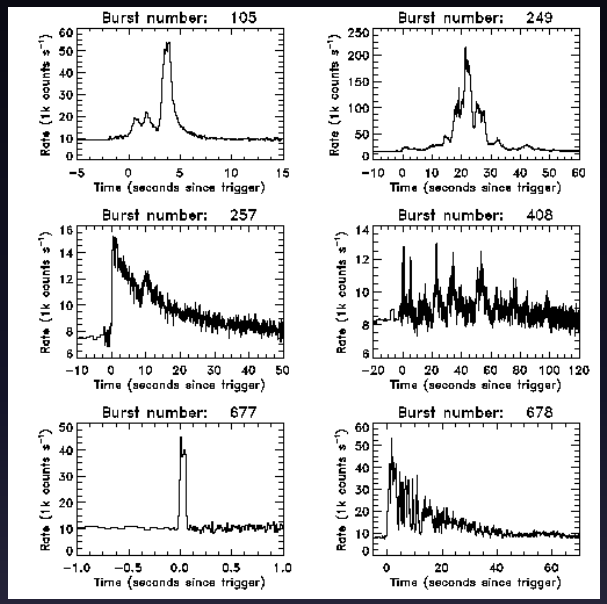
April 2015

Gamma Ray Bursts (GRBs):

They are short bright gamma or X-ray emissions (prompt phase), followed by a long lasting emission observed in several wavelengths, called Afterglow. They are classified depending on their duration.

The **Prompt emission** of the GRBs is characterized by:

- Energy = 100keV-10MeV.
- Duration (T_{90}) = ms - thousands of s.
- Variability: activity episodes with less duration than the bursts itself.

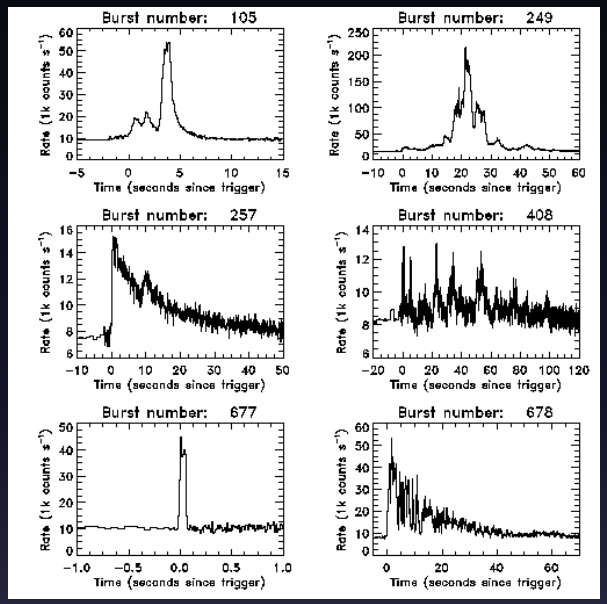


Gamma Ray Bursts (GRBs):

They are short bright gamma or X-ray emissions (prompt phase), followed by a long lasting emission observed in several wavelengths, called Afterglow. They are classified depending on their duration.

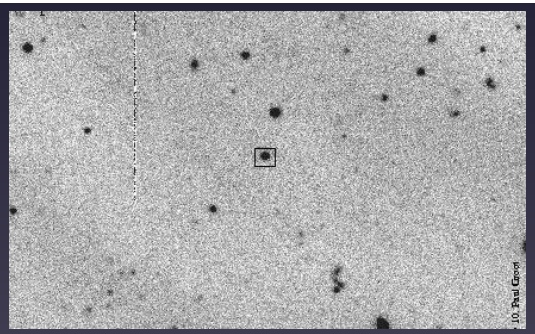
The **Prompt emission** of the GRBs is characterized by:

- Energy = 100keV-10MeV.
- Duration (T_{90}) = ms - thousands of s.
- Variability: activity episodes with less duration than the bursts itself.



Afterglow:

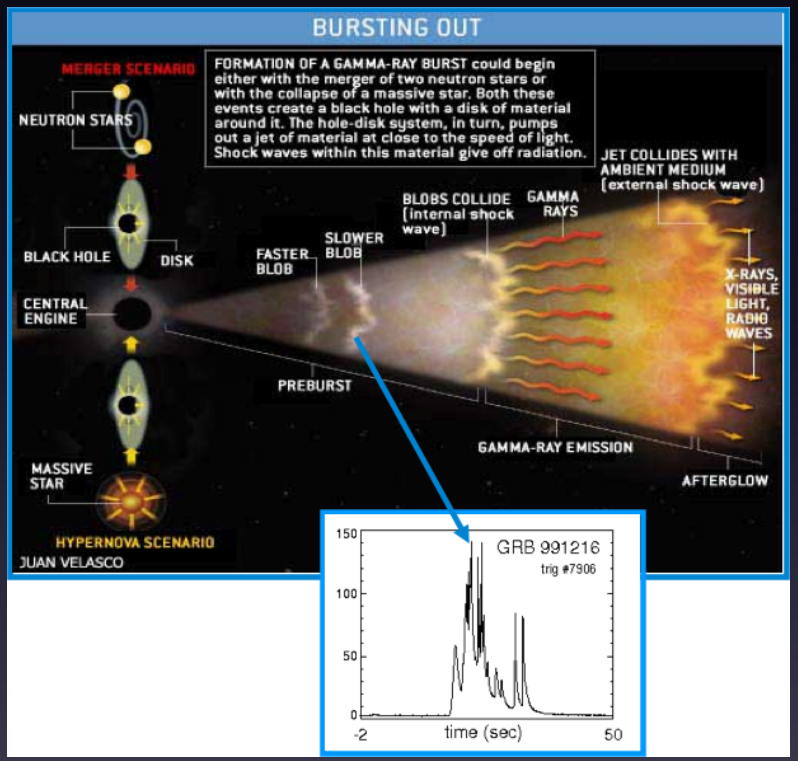
- X-Rays (hours) $\rightarrow$ Optical-IR (days) $\rightarrow$ Radio (months)
- Allow to calculate distances of the bursts. (Cosmological origin)



http://apod.nasa.gov/apod/ap970513.html

Fireball model:

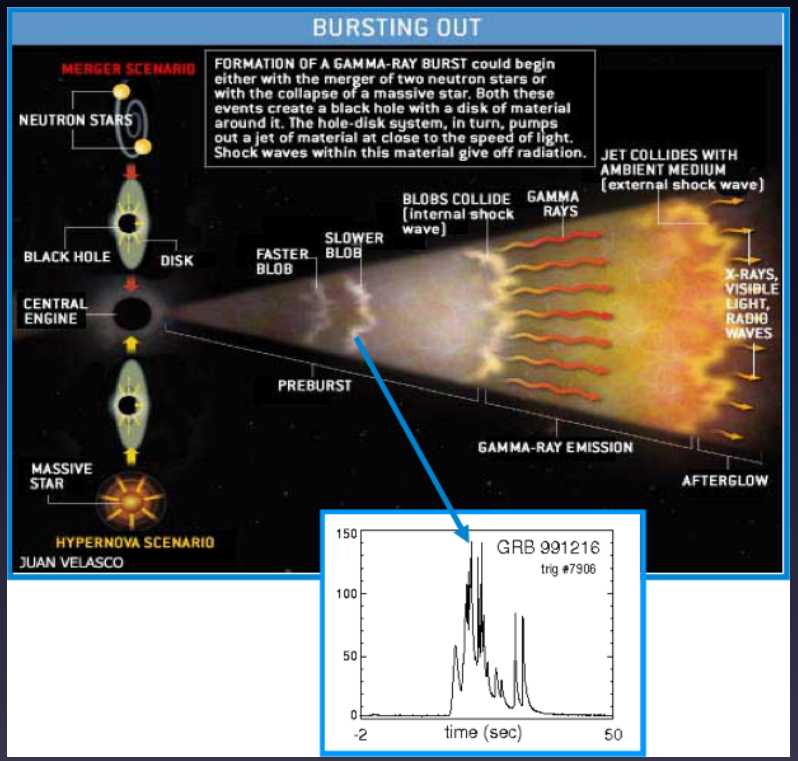
Huge energy concentration in small volume, the energy is eventually liberated in two jets of radiation and particles.



One compact object (progenitor) throws material shells at relativistic velocities. This model is independent of the progenitor.

Fireball model:

Huge energy concentration in small volume, the energy is eventually liberated in two jets of radiation and particles.

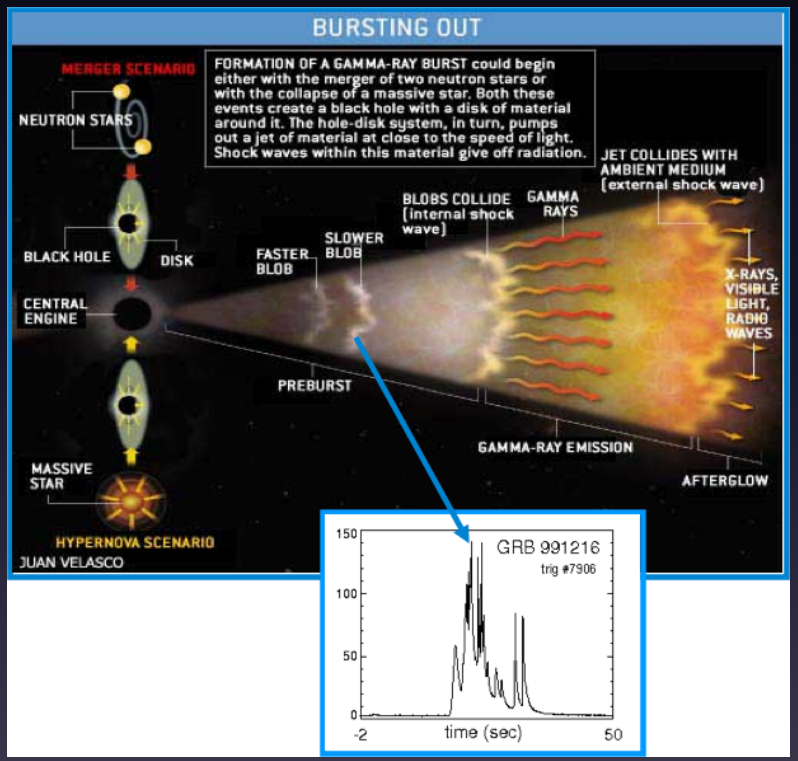


One compact object (progenitor) throws material shells at relativistic velocities. This model is independent of the progenitor.

- **Internal Shocks:** Generate the prompt emission.

Fireball model:

Huge energy concentration in small volume, the energy is eventually liberated in two jets of radiation and particles.

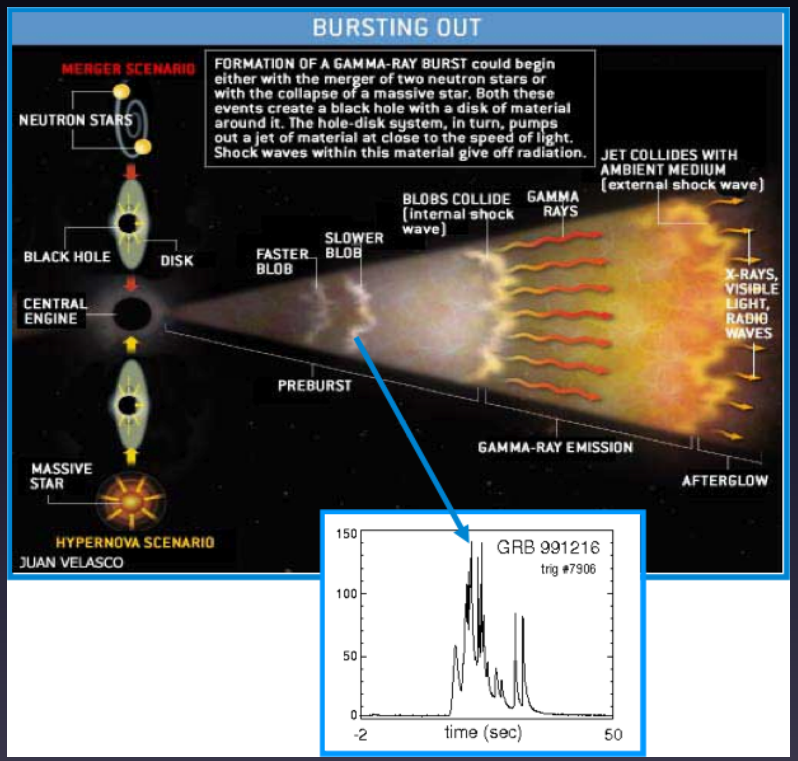


One compact object (progenitor) throws material shells at relativistic velocities. This model is independent of the progenitor.

- **Internal Shocks:** Generate the prompt emission.
- **External Shocks:** Shocks generated when the fireball interacts with the IM. These originate the Afterglow.

Fireball model:

Huge energy concentration in small volume, the energy is eventually liberated in two jets of radiation and particles.



One compact object (progenitor) throws material shells at relativistic velocities. This model is independent of the progenitor.

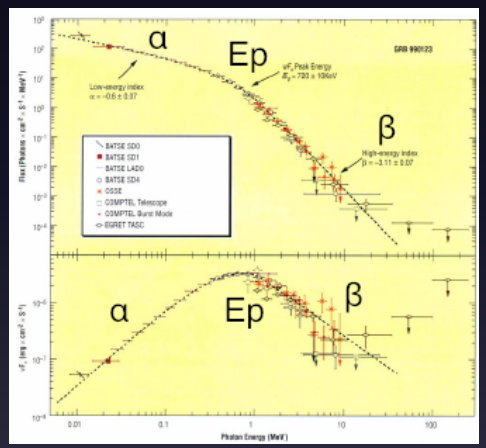
- **Internal Shocks:** Generate the prompt emission.
- **External Shocks:** Shocks generated when the fireball interacts with the IM. These originate the Afterglow.

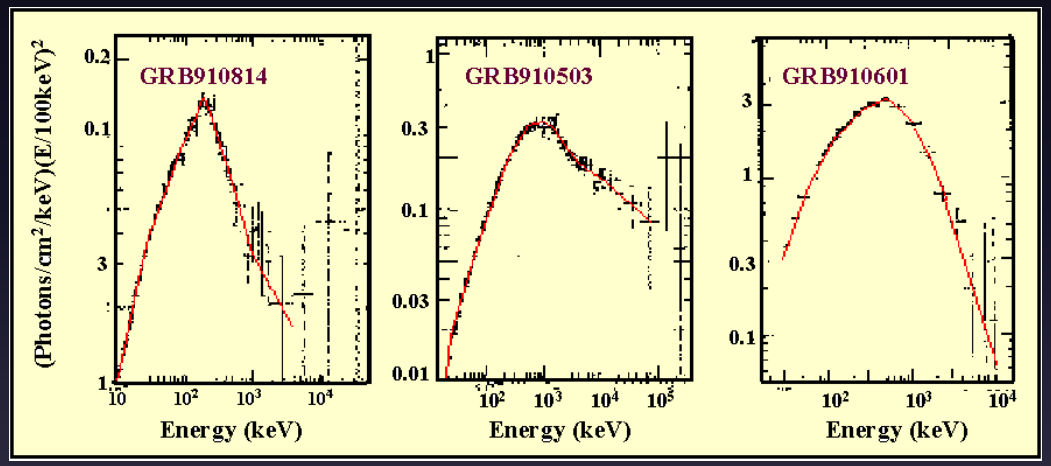
The model predicts thermal emission.

Prompt emission spectra:

The Prompt emission spectra are described by an EMPIRICAL function that consists of two power laws smoothly joint at a break energy (Band Function):

$$N(\nu) = \begin{cases} (h\nu)^{\alpha} exp(-\frac{h\nu}{E_p}), & para \quad h\nu < (\alpha-\beta)E_p; \\ [(\alpha-\beta)E_p]^{\alpha-\beta}\,(h\nu)^{\beta} exp(\beta-\alpha), & para \quad h\nu > (\alpha-\beta)E_p. \end{cases}$$

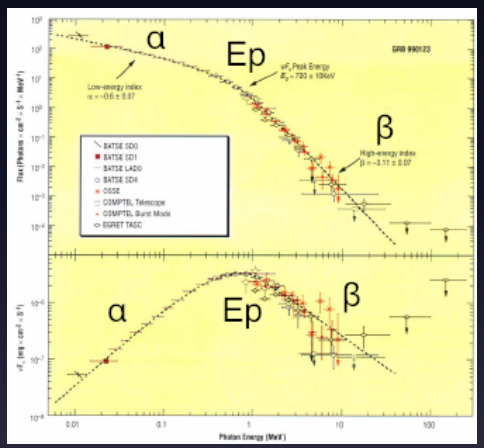


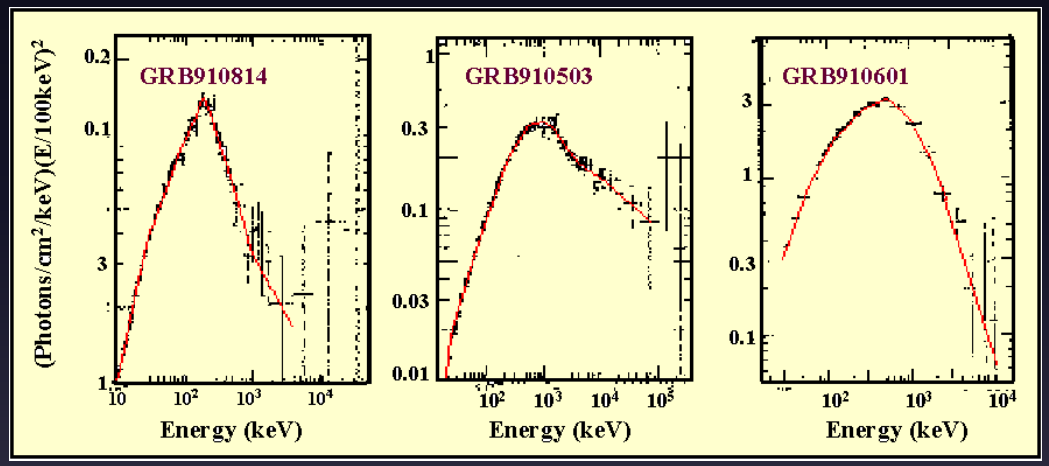


Prompt emission spectra:

The Prompt emission spectra are described by an EMPIRICAL function that consists of two power laws smoothly joint at a break energy (Band Function):

$$N(\nu) = \begin{cases} (h\nu)^{\alpha} exp(-\frac{h\nu}{E_p}), & para \quad h\nu < (\alpha - \beta)E_p; \\ [(\alpha - \beta)E_p]^{\alpha-\beta} (h\nu)^{\beta} exp(\beta - \alpha), & para \quad h\nu > (\alpha - \beta)E_p. \end{cases}$$





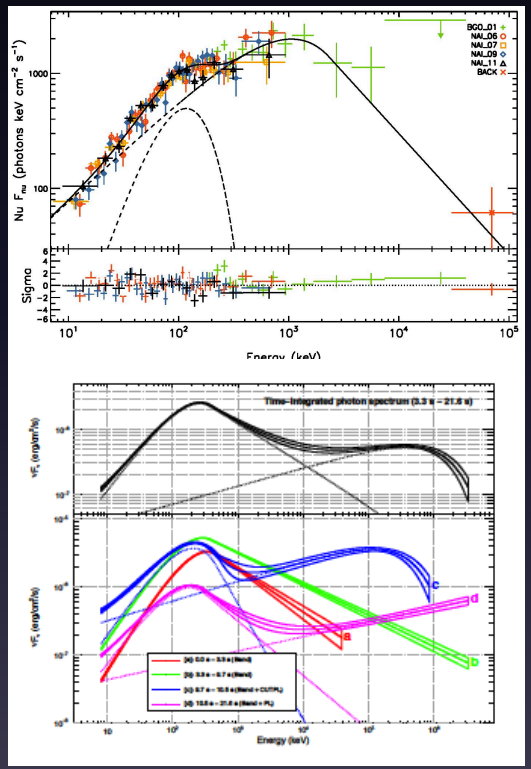
Problem:

No physical origin!

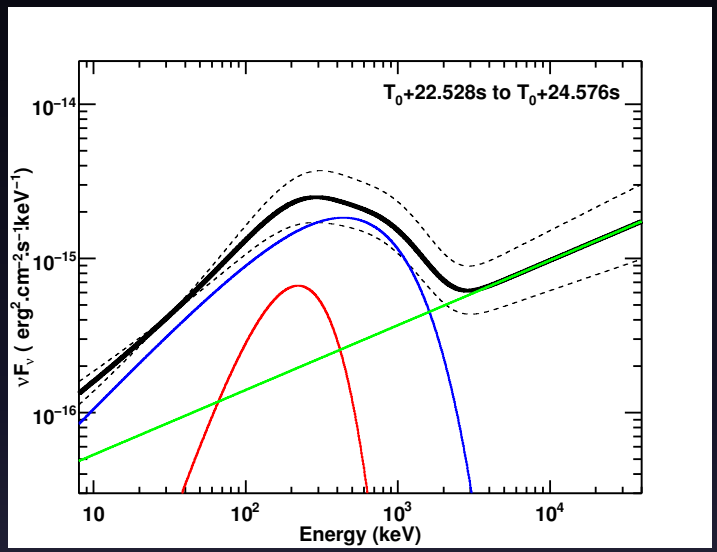
Multicomponent spectra:

We investigated the possibility that several components are present simultaneously in the Prompt emission spectra.

- BB emission was predicted by the model.
- Deviations from the Band function have been detected in some GRBs.
- PL and BB components have been detected separately in some GRBs.
- Band function switches to a Componized function.

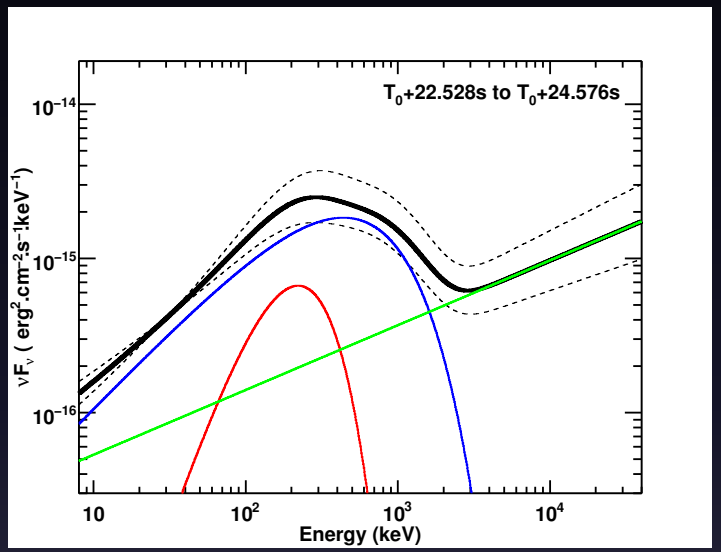


The best model (BB+C+PL) was tested in 2 Fermi Bursts: GRB080916C and GRB090926A:



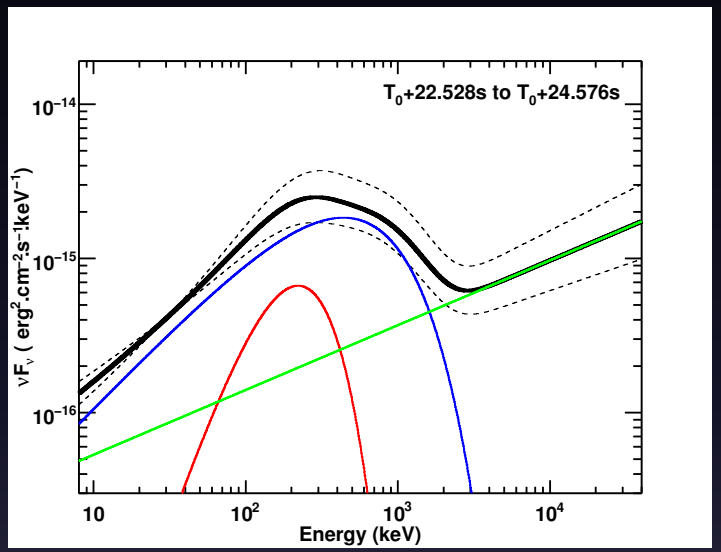
The best model (BB+C+PL) was tested in 2 Fermi Bursts: GRB080916C and GRB090926A:

- Both models become statistically comparables with some assumptions.
- With the Band function both bursts have different spectral properties.
- With the three model escenario they become alike.
- MC simulations were made to validate the analysis.
- Collateral discovery: PL component is present since the beginning.



The best model (BB+C+PL) was tested in 2 Fermi Bursts: GRB080916C and GRB090926A:

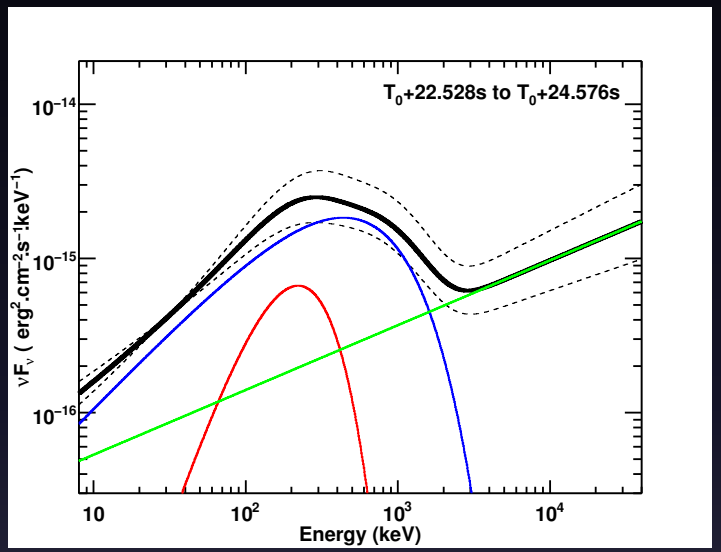
- Both models become statistically comparables with some assumptions.
- With the Band function both bursts have different spectral properties.
- With the three model escenario they become alike.
- MC simulations were made to validate the analysis.
- Collateral discovery: PL component is present since the beginning.



The spectrum become physical

The best model (BB+C+PL) was tested in 2 Fermi Bursts: GRB080916C and GRB090926A:

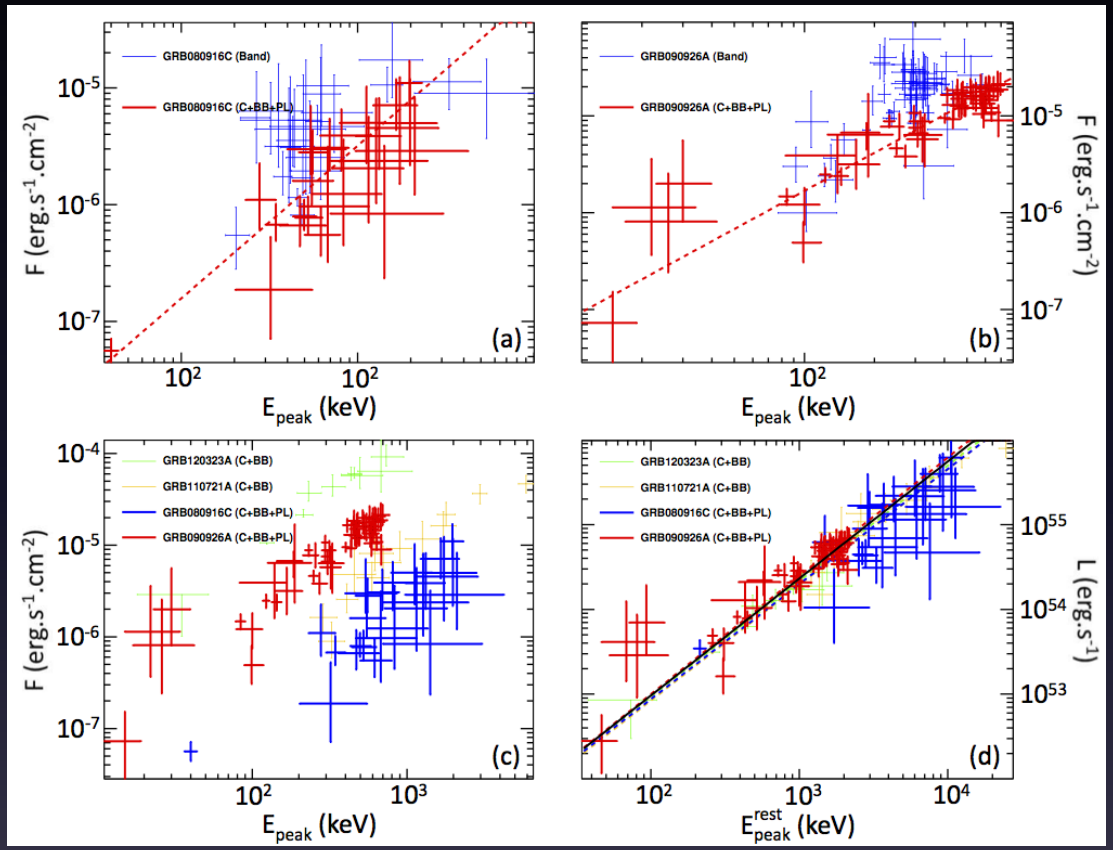
- Both models become statistically comparables with some assumptions.
- With the Band function both bursts have different spectral properties.
- With the three model escenario they become alike.
- MC simulations were made to validate the analysis.
- Collateral discovery: PL component is present since the beginning.



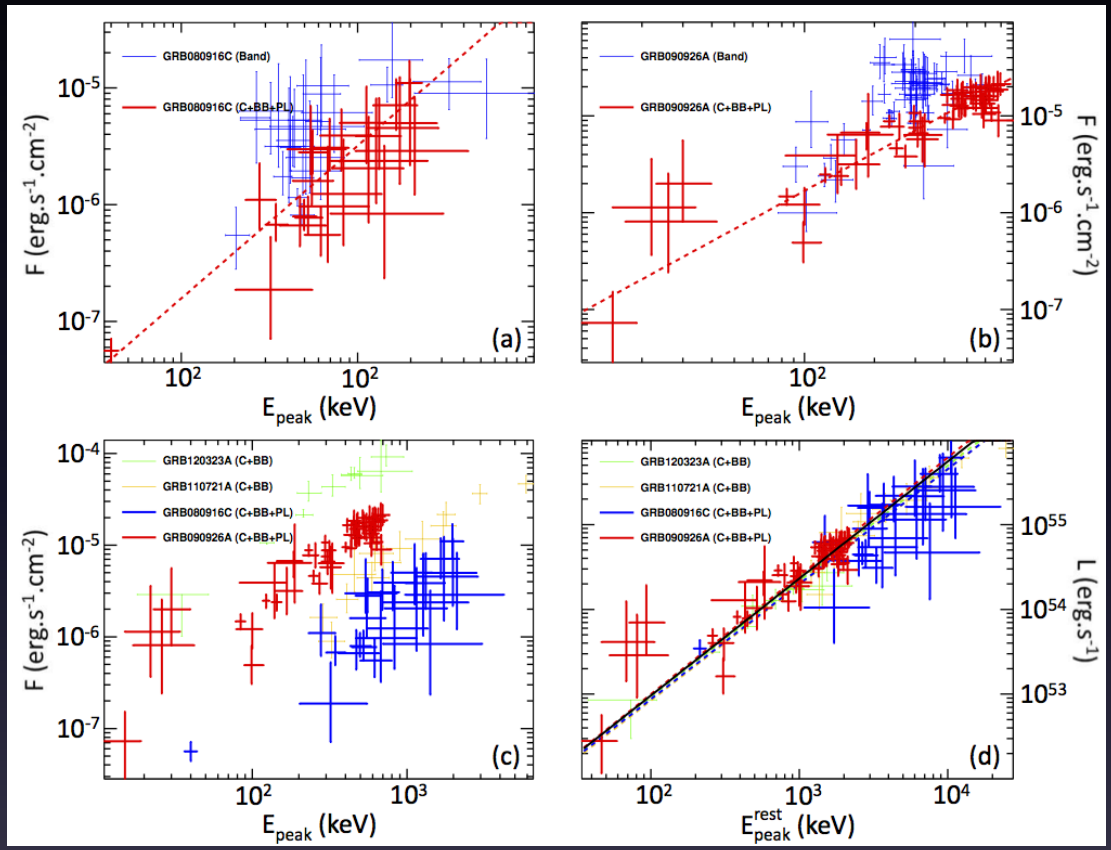
The spectrum become physical

The analysis was made also for three BATSE GRBs (GRB941017, GRB971021, GRB990123) obtaining the same result.

Flux-E_p and L-E_p relationships:



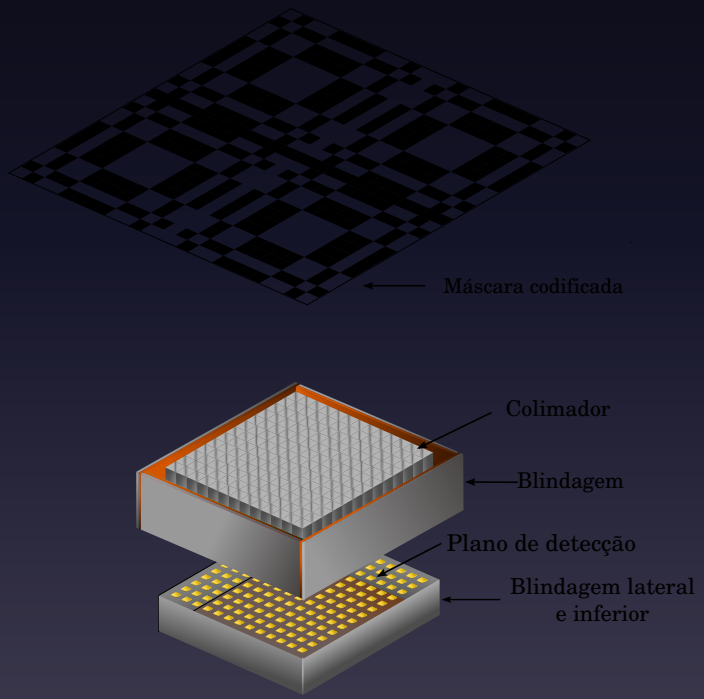
Flux-E_p and L-E_p relationships:



Distances to GRBs could be inferred from this rellationship

MIRAX (Monitor e Imageador de RAios-X):

Brazilian led X-ray astronomy mission designed to perform a wide band survey of the X-ray sky.



MIRAX

- Energy range: 30-200 keV
- Field of View $20^o \times 20^o$
- Ang Res 1.45^o
- Good energy and temporal resolution ($\sim$ 8% at 60 keV, 10 μs)
- Will contribute with observations of AGNs, Accreting Neutron Stars, Black Holes, GRBs (prompt and early After Glow)

MIRAX and GRBs

Cartoon of a GRB

- **Given MIRAX characteristics it is expected that it will detect several GRBs every year, both long and short type.**
- Become really important for joint observations with other observatories (LIGO, HAWC, CTA).
- Because of the energy band it covers, MIRAX will detect GRBs from large distances ($z \sim 8$).
- Will contribute with observations from the called early afterglow, important topic on the field.

Perspectives and conclusions

- A catalog with the three component scenario is planned.
- Simulations for GRBs detections with MIRAX.
- Study of possible relationship between HE components and low energy tails in GRBs.

Perspectives and conclusions

- A catalog with the three component scenario is planned.
- Simulations for GRBs detections with MIRAX.
- Study of possible relationship between HE components and low energy tails in GRBs.

Conclusions

- The prompt emission spectra take physical origin.
- Results independent from the mission.
- New correlation found could infere GRBs distance.
- MIRAX will contribute in several topics on GRBs field.

Perspectives and conclusions

- A catalog with the three component scenario is planned.
- Simulations for GRBs detections with MIRAX.
- Study of possible relationship between HE components and low energy tails in GRBs.

Conclusions

- The prompt emission spectra take physical origin.
- Results independent from the mission.
- New correlation found could infere GRBs distance.
- MIRAX will contribute in several topics on GRBs field.

Muito obrigado!

rodrigo.sacahui@inpe.br