

Number of the Subclasses of the Gamma-ray Bursts: Two or Three?

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The key members of the team

- **Zsolt Bagoly**, Eötvös Univ., Budapest, Hungary
- **Lajos Balázs**, Konkoly Observatory, Budapest, Hungary
- **Attila Mészáros**, Charles Univ., Prague, Czech Republic
- **Peter Mészáros**, Penn State Univ., State College, USA
- **Il H. Park**, Sungkyunkwan Univ., Seoul, Korea
- **Jakub Řípa**, Sungkyunkwan Univ., Seoul, Korea
- **Péter Veres**, Penn State Univ., State College, USA

THE MAGNIFICENT SEVEN

They fought like seven hundred



STEVE MCQUEEN

JAMES COBURN
"BRITT"

HORST BUCHHOLZ
"CHICO"

YUL BRYNNER
"CHRIS ADAMS"

BRAD DEXTER
"HARRY LUCK"

ROBERT VAUGHN
"LEE"

CHARLES BRONSON
"BERNARDO O'REILLY"

Figure: The magnificent seven!

Some other collaborators - occasionally captured

- **István Horváth**, Zrínyi Univ., Budapest, Hungary
- **David Huja**, Charles Univ., Prague, Czech Rep.
- **Sylvio Klose**, Tautenburg Observatory, Germany
- **Stefan Larsson**, Stockholm Univ., Sweden
- **Felix Ryde**, Stockholm Univ., Sweden
- **Dóra Szécsi**, Eötvös Univ., Budapest, Hungary
- **Jiří Štoček**, Charles Univ., Prague, Czech Rep.
- **Roland Vavrek**, Konkoly Observatory, Budapest, Hungary

A survey of the gamma-ray burst (GRB) topic

Discovery: 1967-1973 - Vela military satellites

Total number of all discovered GRBs: cca 8000

Typical energy range of photons: $20 \text{ keV} - 1 \text{ MeV}$

Durations: $0.1 \text{ s} - 1000 \text{ s}$

Peak fluxes: $0.2 - 50 \text{ photons}/(\text{cm}^2\text{s})$

Fluences: $10^{-8} - 10^{-4} \text{ erg}/\text{cm}^2$

Redshifts (z): $0.0085 - 8.2$

The cosmological of GRBs origin is doubtless

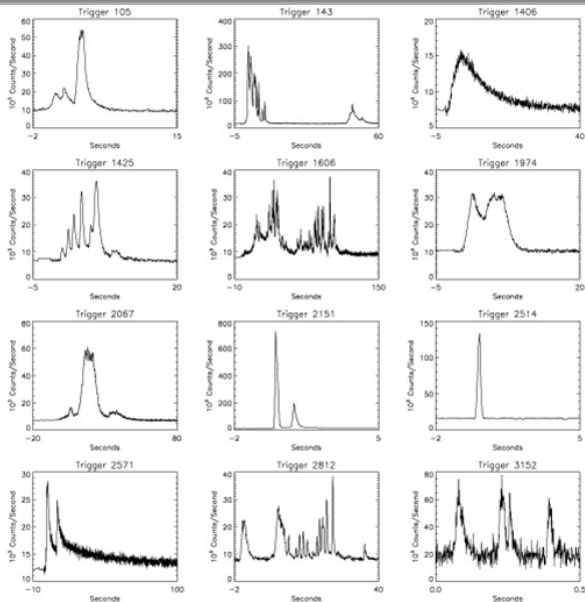


Figure: Typical light curves

The satellites and instruments used for our statistical studies

BATSE instruments on the Compton Gamma-Ray Observatory (1991 - 2000)

BATSE = Burst And Transient Source Experiment

RHESSI (2002 -)

RHESSI = Ramaty High Energy Solar Spectroscopic Imager

Swift (2004 -) - the name of a fast flying bird

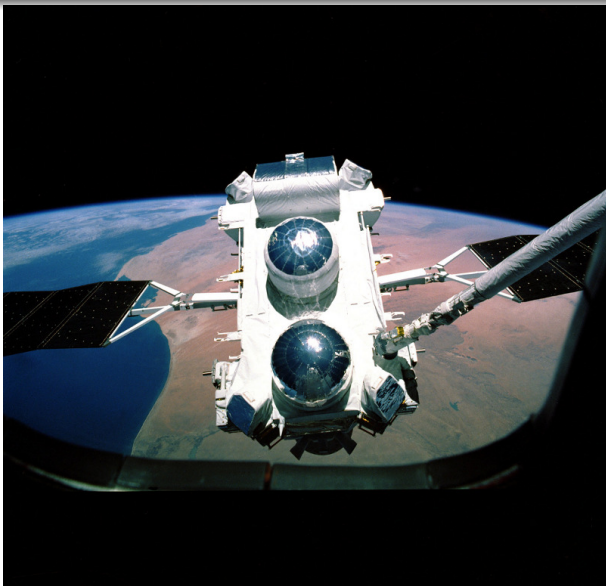


Figure: BATSE on Compton - data publicly available

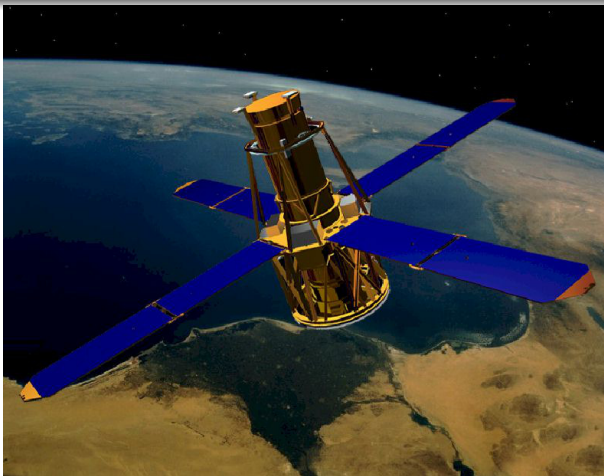


Figure: The RHESSI satellite - data analysis done mainly by J. Řípa

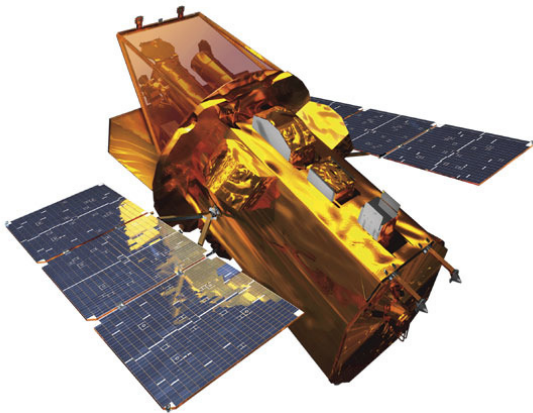


Figure: The Swift satellite - data publicly available

3 subgroups of GRBs - observational evidences

Since eighties = two different types of GRBs (short and long ones)

Since 1998 = also a third intermediate subgroup; Horváth 1998; Mukherjee et al. 1998 - simultaneous ApJ papers

Separation with respect to durations and "hardnesses"

Hardness: (fluence at a higher energy channel)/(fluence at a softer energy channel)

Separation at different satellite databases

Many statistical articles of the team in this topic since 1998 (ApJ, AA, MNRAS)

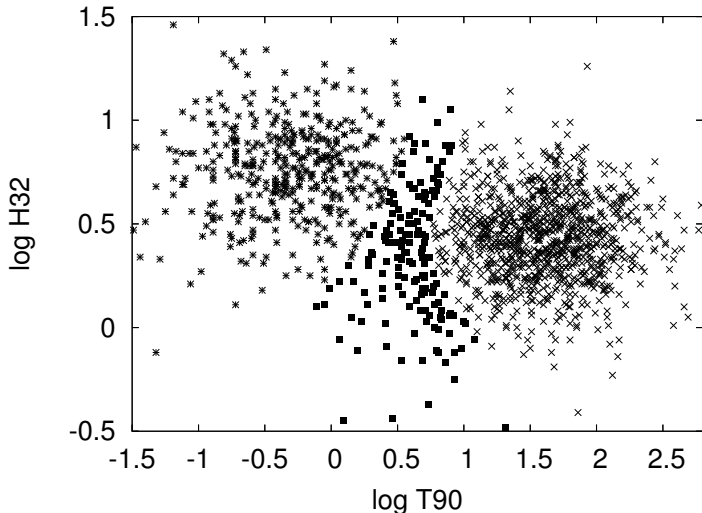


Figure: Three subgroups of the BATSE's GRBs separated with respect to the duration and hardness. T90 is in seconds.

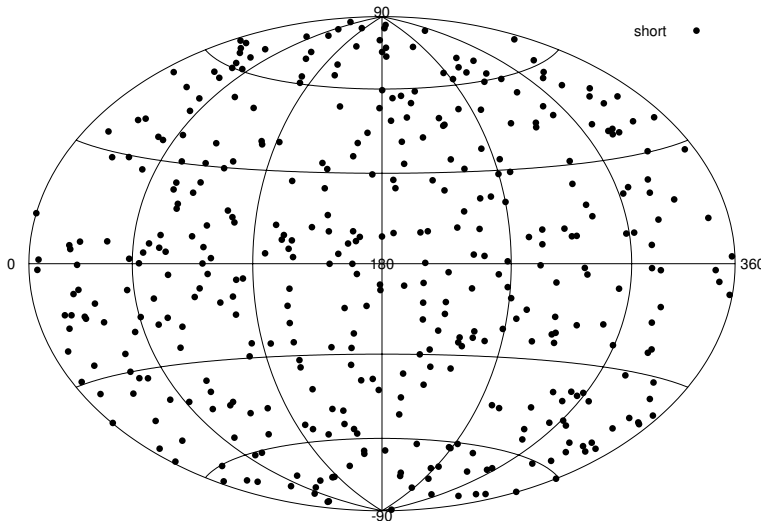


Figure: Celestial distribution of the short BATSE's GRBs. Short GRBs **are not distributed isotropically** (Vavrek et al. 2008).

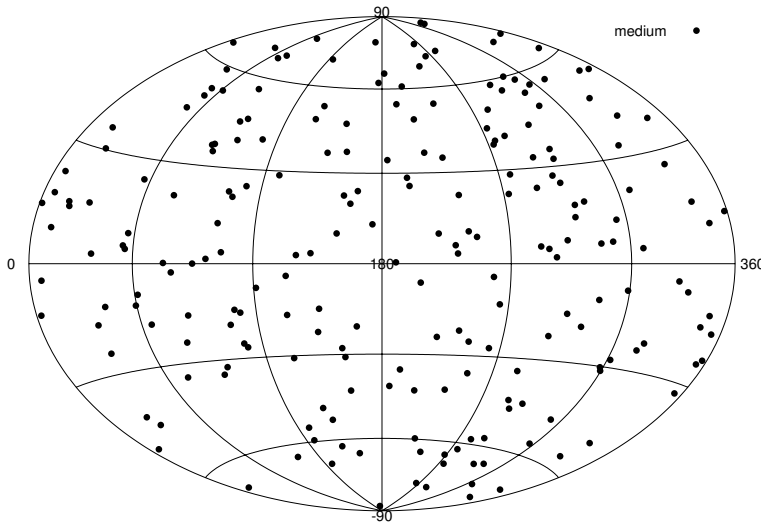


Figure: Celestial distribution of the intermediate BATSE's GRBs. **No isotropy!** (Mészáros A. et al. 2000).

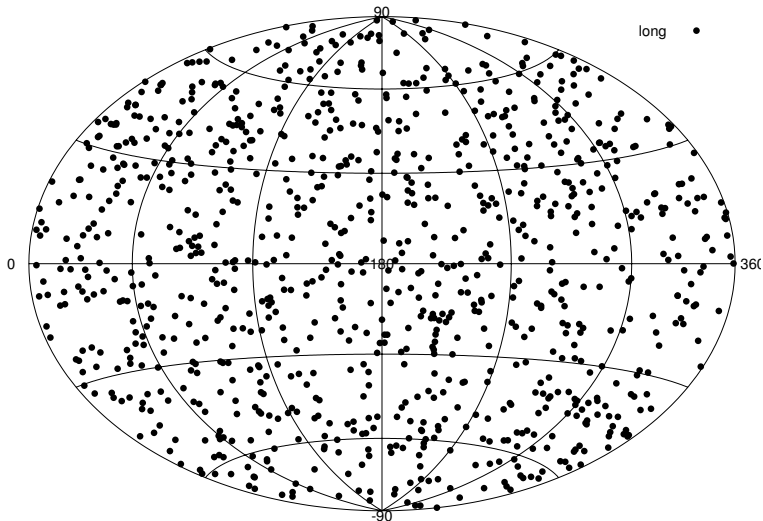


Figure: Celestial distribution of the long BATSE's GRBs. No clear result (Mészáros A. & Štoček 2003; Vavrek et al. 2008).

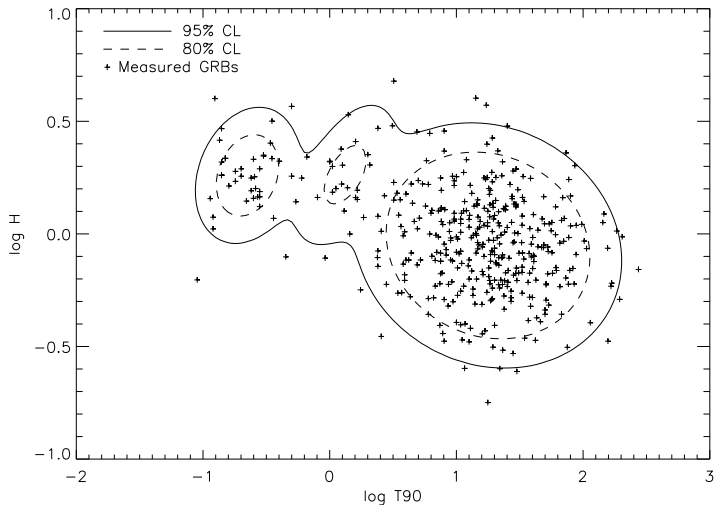


Figure: The three subgroups of the RHESSI's GRBs. T_{90} is in seconds.

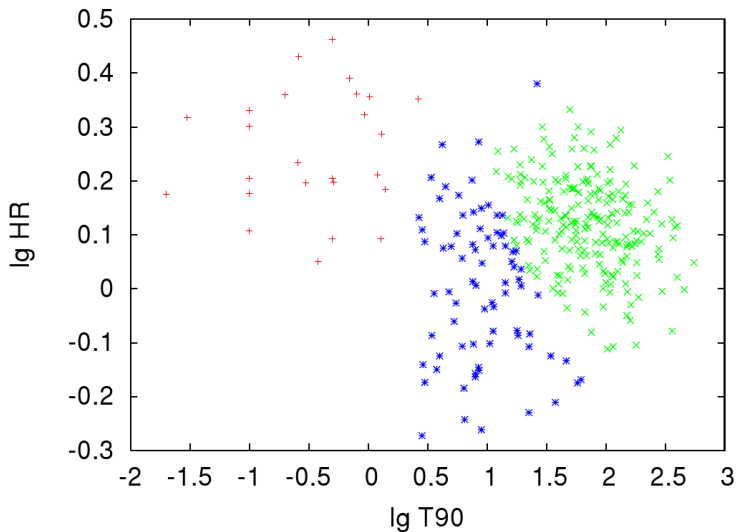


Figure: The similar three subgroups of the Swift's GRBs. T90 is in seconds.

Intermediate subgroup: **It exists, but...!**

From the observational point of view:

Statistical tests **confirm** its existence!

But, carefully: This can still be a consequence of some selection effects, biases, etc...

The intermediate subgroup **need not be** an astrophysically different GRB class

Simply: **Carefully with the physical meaning!**

Astrophysics of the third subgroup - year 2010

Intermediate GRBs: Physical meaning - a key step

Veres P., Bagoly Z., Horváth I., Mészáros A., Balázs L.G. ApJ, 725, 1955 (2010)

Intermediate subgroup in the **Swift** database = X-Ray Flashes (XRFs)

→ X-Ray Flashes (XRFs) = in essence long bursts
Conclusion for Swift: Intermediate bursts **are not** astrophysically different phenomena → they are in essence long GRBs.

Intermediate GRBs - year 2011-13

Intermediate GRBs - Physical meaning for RHESSI data:

Is it the same as for Swift? No, it is not!

Řípa J., Mészáros A., Veres P., Park I.H., ApJ, 2012, 756, 44

Mészáros A., Řípa J., A&A, 2013, submitted

Intermediate subgroup in the RHESSI database \neq X-Ray Flashes (XRFs)!

Intermediate subgroup in the RHESSI database is similar to short bursts!

No relation to the long bursts!!!

Intermediate GRBs - year 2011-13

Intermediate GRBs - Physical meaning for BATSE:
Is it the same as for Swift? Or as for RHESSI?

Mészáros A., Řípa J. A&A, 2013, submitted

**Intermediate subgroup in the BATSE
database = X-Ray Flashes (XRFs) cannot
hold for the whole intermediate subgroup.
The identity can be fulfilled only partly.**

Summary

- There are at least two different GRB subgroups
- The short/hard and long/soft GRBs are different objects
- Intermediate GRBs: the team claims permanently that their existence is real - at least statistically
- Intermediate and short BATSE's GRBs are distributed anisotropically on the sky - this can be a strong impact on the cosmology (not discussed here in detail)
- The celestial distribution of the long BATSE's GRBs - probably also anisotropic (not proven yet obviously)
- Swift's intermediate GRBs = long bursts (\rightarrow they are not astrophysically different objects)
- **RHESSI's intermediate GRBs = no relation to the long bursts!!!**; they remember the short ones
- BATSE's intermediate GRBs = no clear result yet

Summing up:

The question of the third group is a fully open problem!

The author encourages also others to study this question!

Thanks for attention!

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