

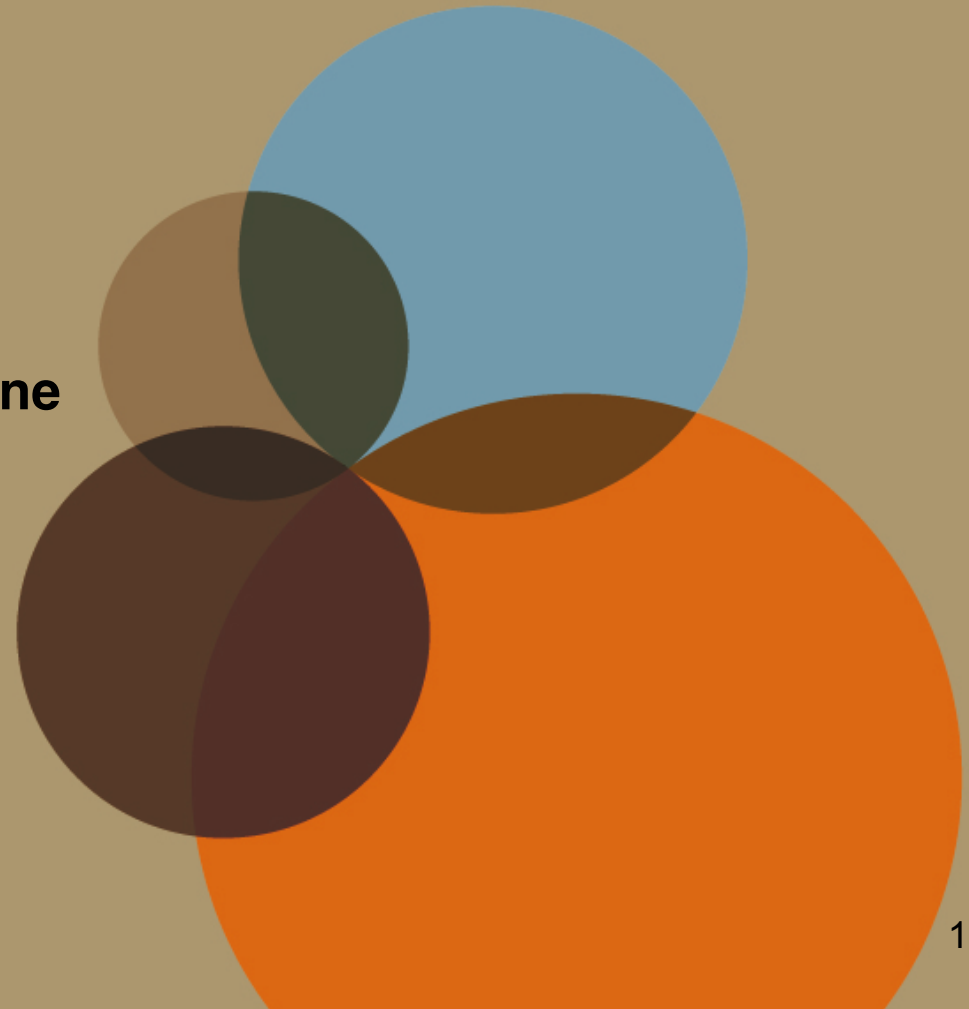


Study of Gamma-Ray Bursts Microvariability

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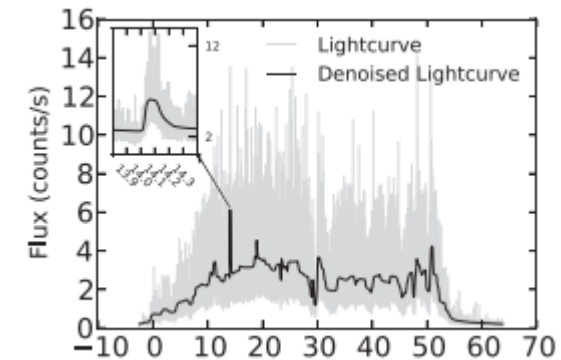


Index

- What is microvariability.
- Why study microvariability.
- How to calculate it.
- Examples and comparison.
- Conclusions.

What is Microvariability

- Minimum timescale of intensity variations in a GRB spectrum.
- Very little literature about it.



MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY
GAMMA-RAY BURSTS HAVE MILLISECOND VARIABILITY
KATHARINE C. WALKER¹ AND BRADLEY E. SCHAFFER²
Yale University, P.O. Box 208121, New Haven, CT 06520-8121
doi:10.1093/mnras/42.1.1

Minimum variability time-scales of long and short GRBs
G. A. MacLachlan,¹ A. Shenoy,¹ E. Sonbas,^{2,3} K. S. Dhuga,¹ B. E. Cobb,¹
D. C. Morley,^{1,3,4} T. N. Ukwatta,^{1,3,4} and W. C. Parke¹
MNRAS 432, 857-865 (2013)
Advance Access publication 2013 April 29

UNCOVERING THE INTRINSIC VARIABILITY OF GAMMA-RAY BURSTS
VAHID Z. GOLKHOUB¹ AND NATHANIEL R. BUTLER¹
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Received 2014 March 10; accepted 2014 April 4; published 2014 May 6
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THE ENERGY-DEPENDENCE OF GRB MINIMUM VARIABILITY TIMESCALES
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Accepted to ApJ

ABSTRACT
Train the minimum variability timescales for 938 GRBs observed by the Fermi/G to July 11, 2012. The tightest constraints on progenitor radii derived fr igned from light curves in the hardest energy channel. In the softer bands e GRBs in the hard X-rays from Swift – we show that variability Applying a survival analysis to account for detections and short-dur able in the rest frame for long-duration and short-duratio than 10% of GRBs show evidence for variability with Lorentz factors $\gtrsim 400$ and imply typical $\approx 3 \times 10^{13}$ cm for short-duration GRBs. We investigate whether GRB minimum variability timescales are consistent with the light curve minimum variability timescale. Gamma-rays:

Why Microvariability

- Set upper limit on size of the emitting region.
- Constraints on models (e.g. fireball model).
- Looking for relations between quantities (microvariability and T90, energy peak, ...).

Microvariability calculation

- Different techniques in each article.
- One thing in common, use of Haar wavelet to study temporal series.
- From Haar wavelet, we define the structure function:

$$SF(\tau) = \langle [X(t) - X(t + \tau)]^2 \rangle$$

Walker method

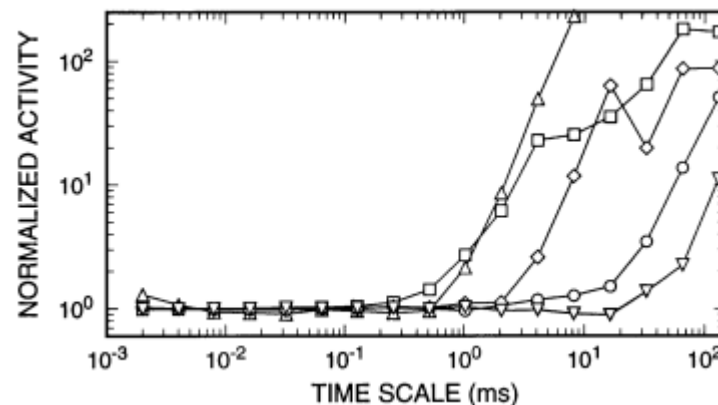
- Defines a normalized activity (or structure function in other articles):

$$A_{norm} = \frac{\langle (C_i - C_{i+1})^2 \rangle}{2 \langle C_i \rangle}$$

- The denominator represent the activity of the background, assumed poissonian.

Walker criteria

- The normalized activity is initially equal to 1 (background level).
- Microvariability \rightarrow first timescale for which normalized activity is 3σ above this level.



Golkhou and Butler method

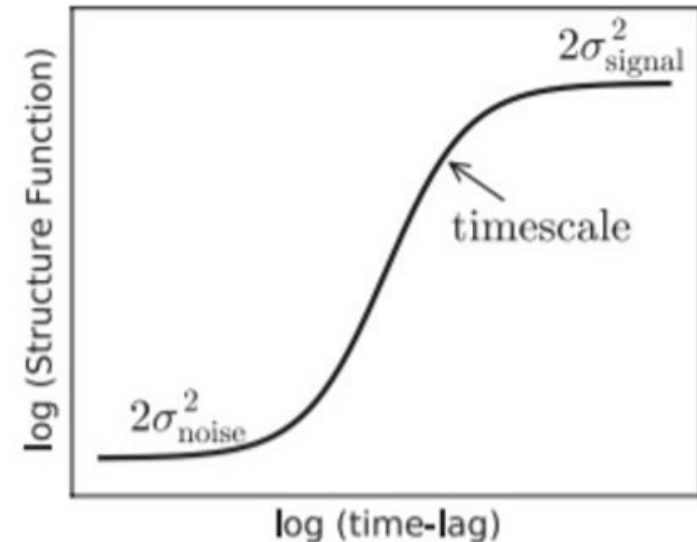
- Starts from the structure function equation.
- Expanding at first order :

$$v(SF(\tau)) \propto \tau$$

- Linear dependence.

Golkhou criteria

- Microvariability is the lowest timescale with uncorrelated temporal variability → exiting linear situation.
- Above the noise level, fixed at 3σ above 0.
- If no linearity → upper limit.

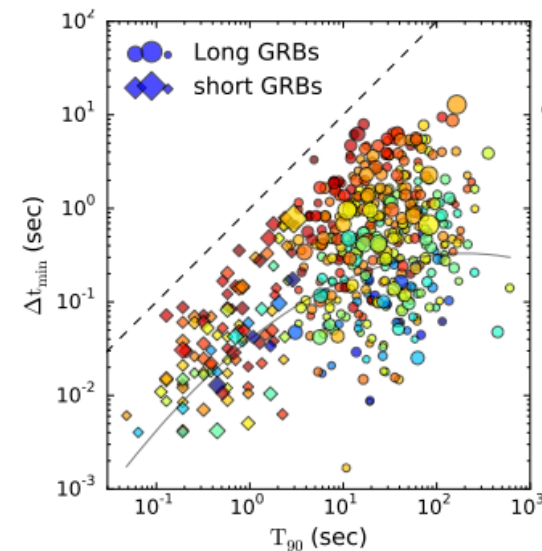
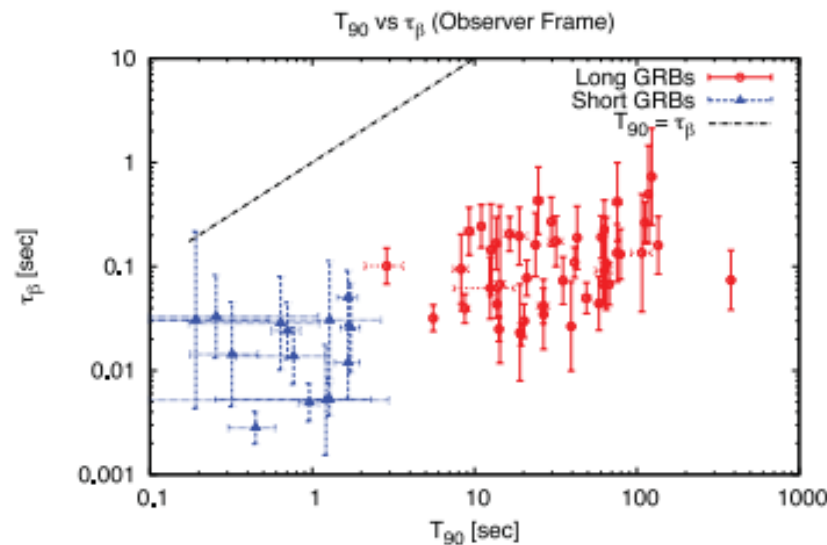


Technique Differences

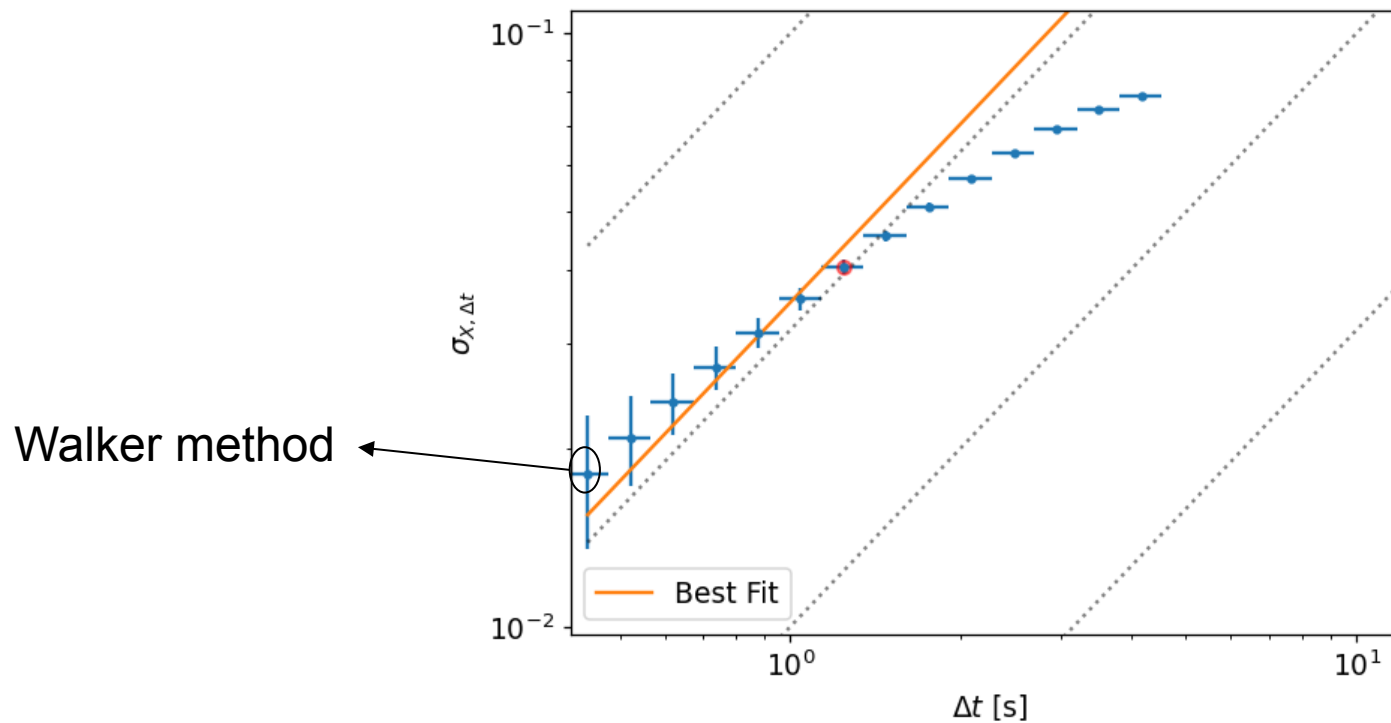
- Criteria: Walker/MacLachlan criteria doesn't consider the full extent of the prompt emission, while Golkhou looks for a variation in the behaviour of the function structure.
- Background dependence in Walker/MacLachlan method, while background is removed in Golkhou method.

Results differences

- Due to the criteria used, Walker/MacLachlan results show a very small microvariability (millisecond but even few microseconds for a few cases) compared to Golkhou.



Examples GRB061202

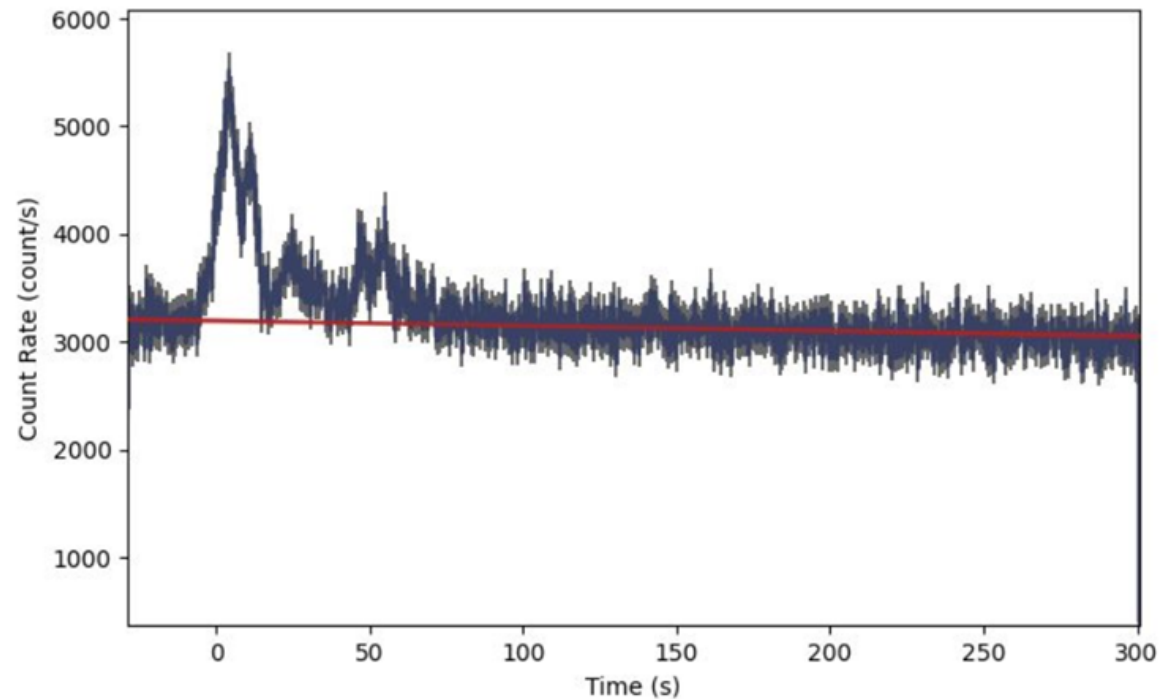


Microvariability = 1.24 s

Fermi GBM

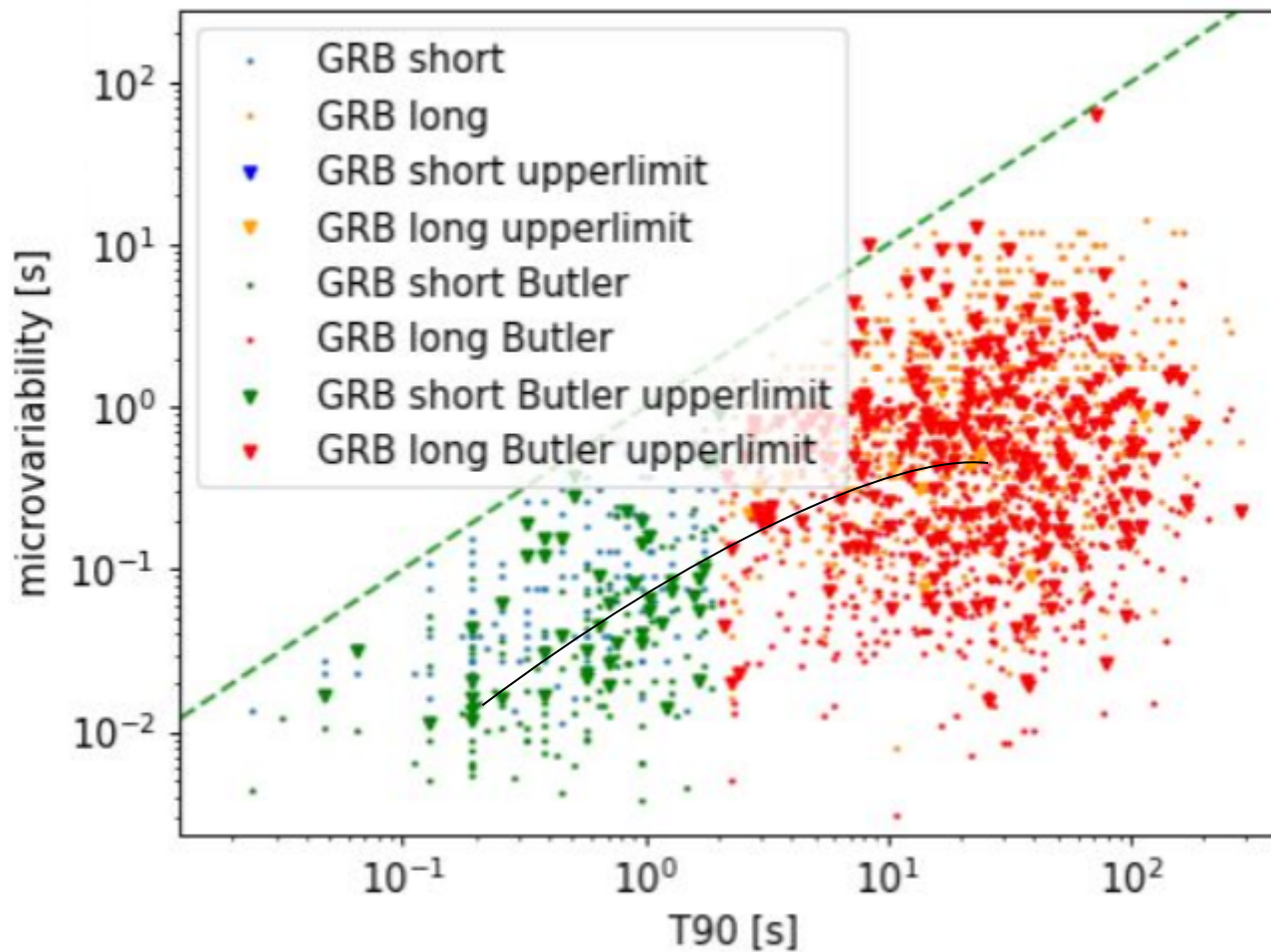
- Sample of 949 GRBs, used in the Golkhou article, for a comparison.
- Requires background subtraction from the GRB spectrum.
- First order polynomial function.

Bkg removal: example

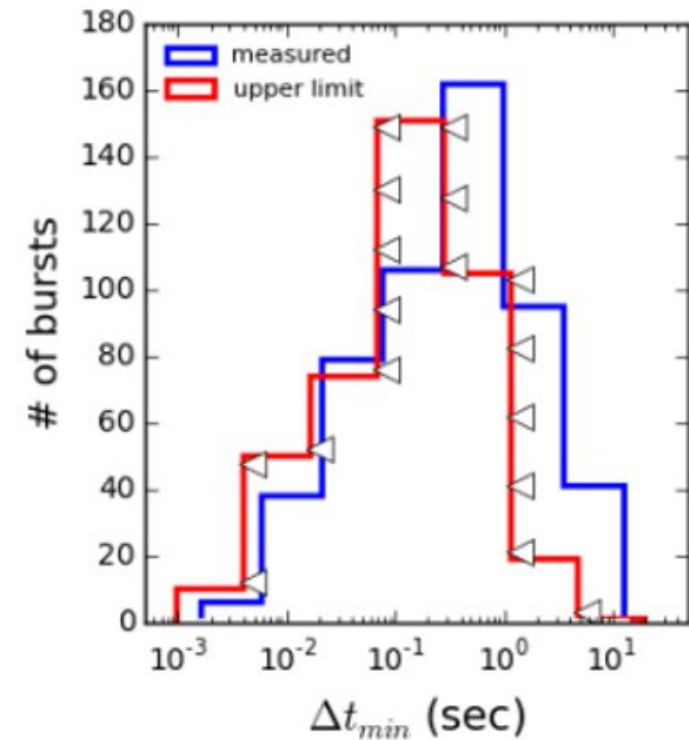
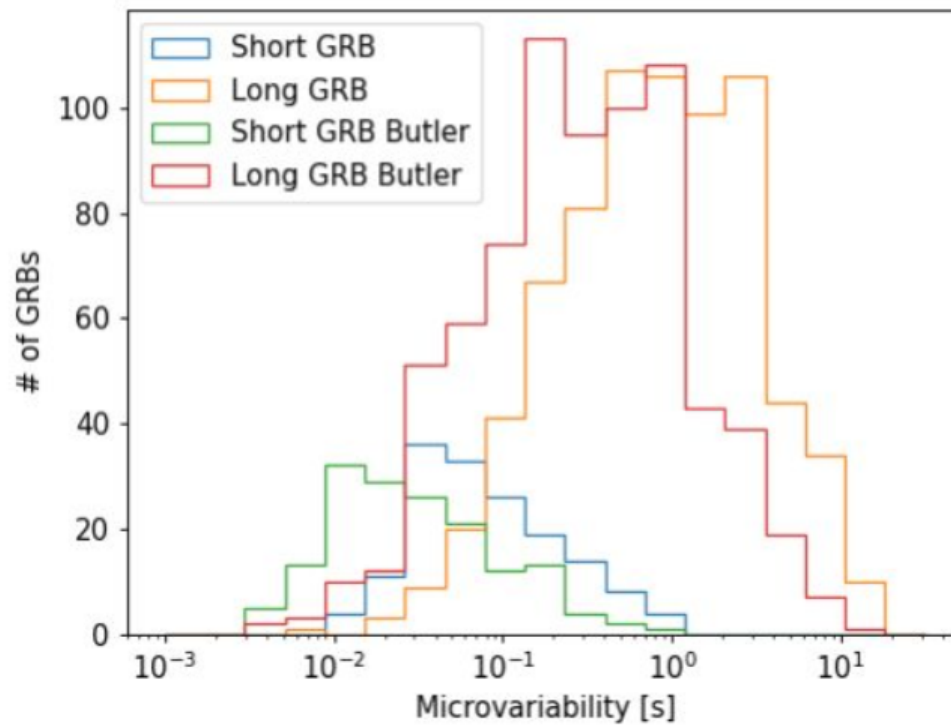


- Taking 15 sec before and 75 sec after (where possible).

Comparison



Comparison



- Upper limit cases lower microvariability mean.

Results

- Their techniques brings many more upper limits.
- Mean value short GRBs : 0,06s vs 0,14s
- Mean value long GRBs : 0.73s vs 1.72s
- In general, I obtain higher values of microvariability.

Conclusions

- Starting from literature we developed a solid technique to calculate microvariability.
- We found some good preliminary results, but as pointed out initially, there is a lot more to work on.