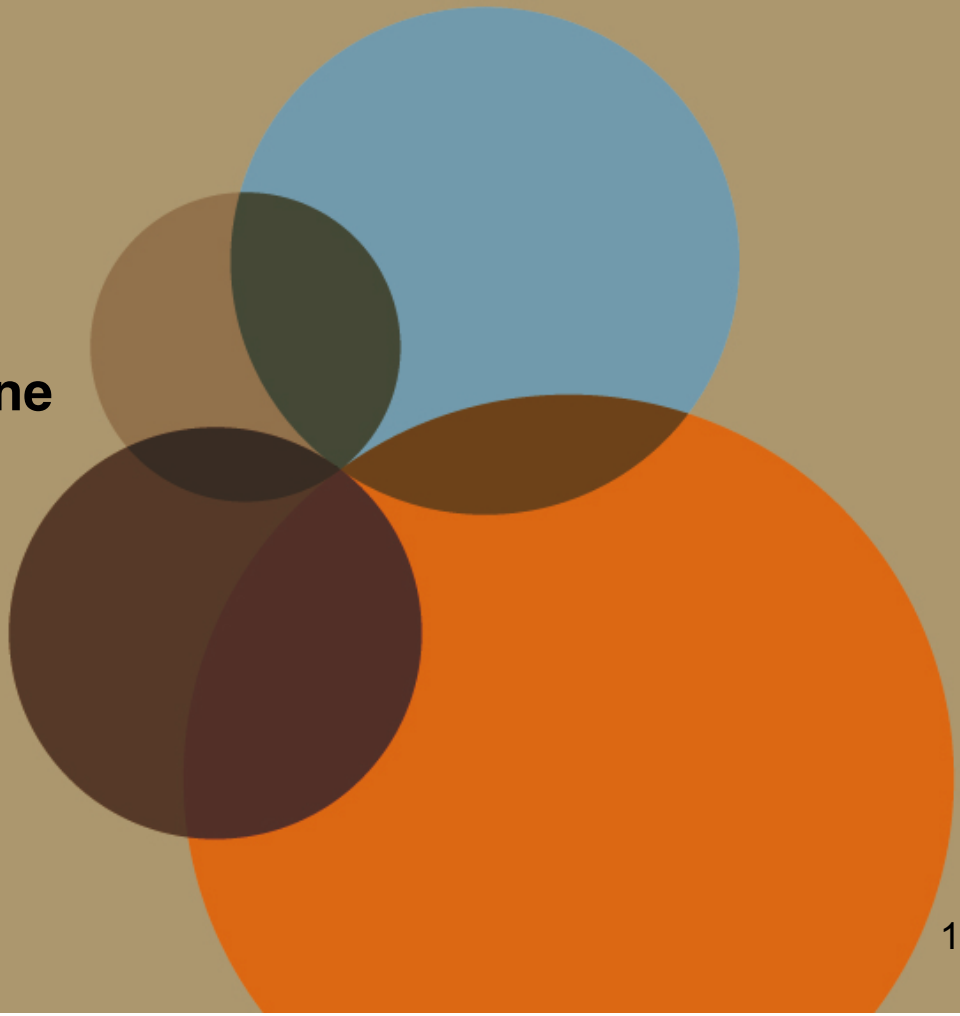
UNIVERSITÀ DEGLI STUDI DI UDINE

HERMES SP

# Study of Gamma-Ray Bursts Microvariability

**Giovanni Della Casa**

**PhD Università degli studi di Udine**



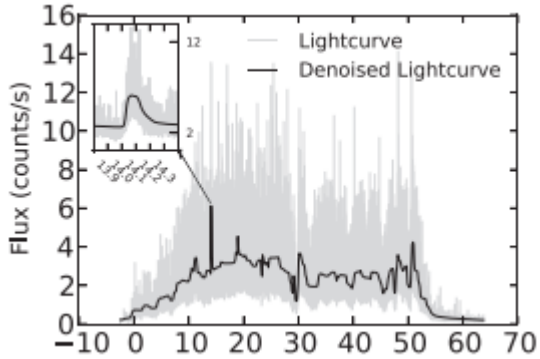
**15/09/2022**

# 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 litterature about it.


GAMMA-RAY BURSTS HAVE MILLISECOND VARIABILITY

Minimum variability time-scales of long and short GRBs

UNCOVERING THE INTRINSIC VARIABILITY OF GAMMA-RAY BURSTS

THE ENERGY-DEPENDENCE OF GRB MINIMUM VARIABILITY TIMESCALES

# 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

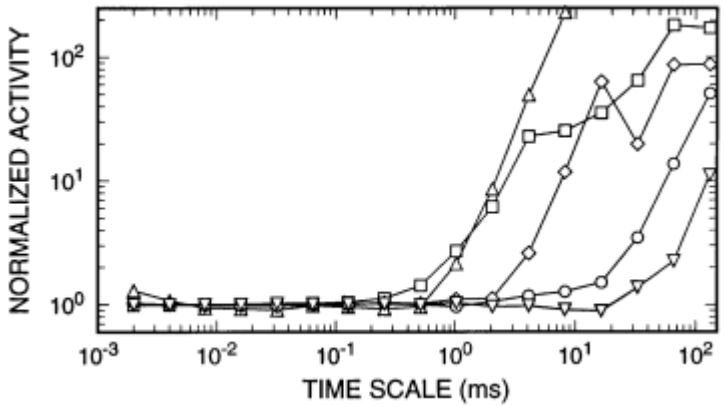
- Defines a normalized activity (or structure function in other articles):

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

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

# Walker criteria

- The normalized activity is initially equal to 1 (background level).
- Microvariability ➔ 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 :

$$\sqrt{(SF(\tau))} \propto \tau$$

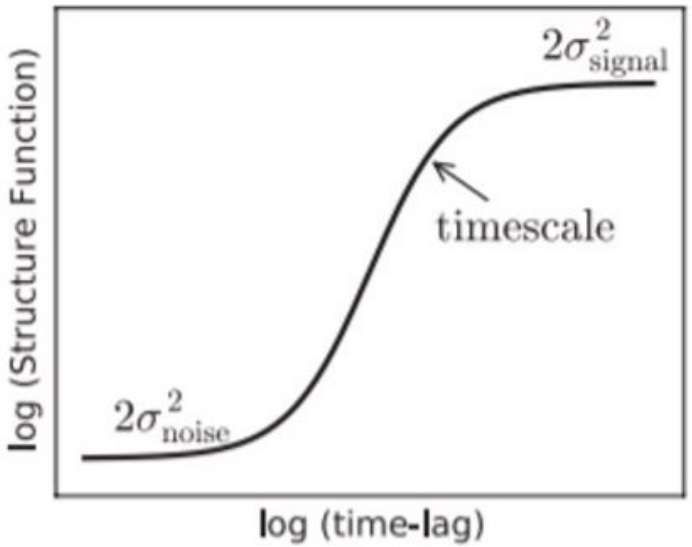
- Linear dependence.

# 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.



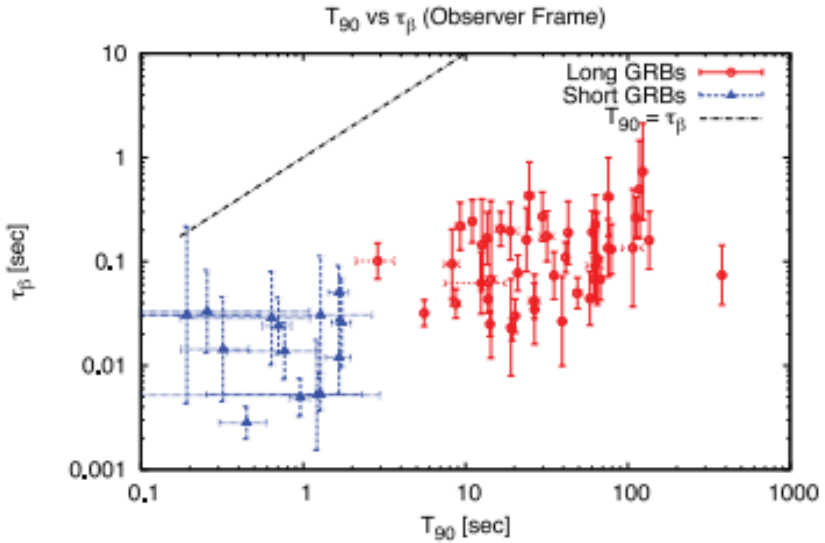
# Technique Differences

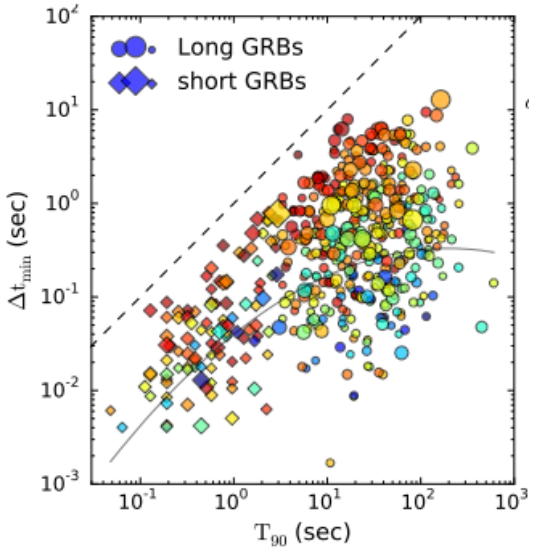
- Criteria: Walker/MacLachlan criteria doesn't consider the full extent of the prompt emission, while Golkhou looks for a variation in the behaviour of the function structure.

- Background dependence in Walker/ MacLachlan method, while background is removed in Golkhou method.

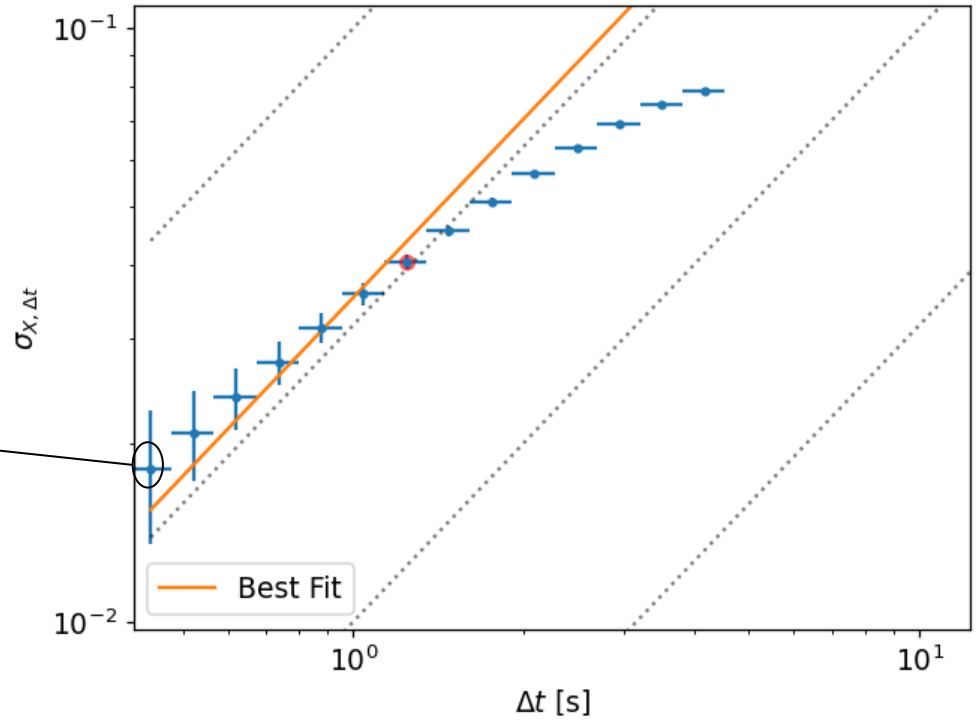
# Results differences

- 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

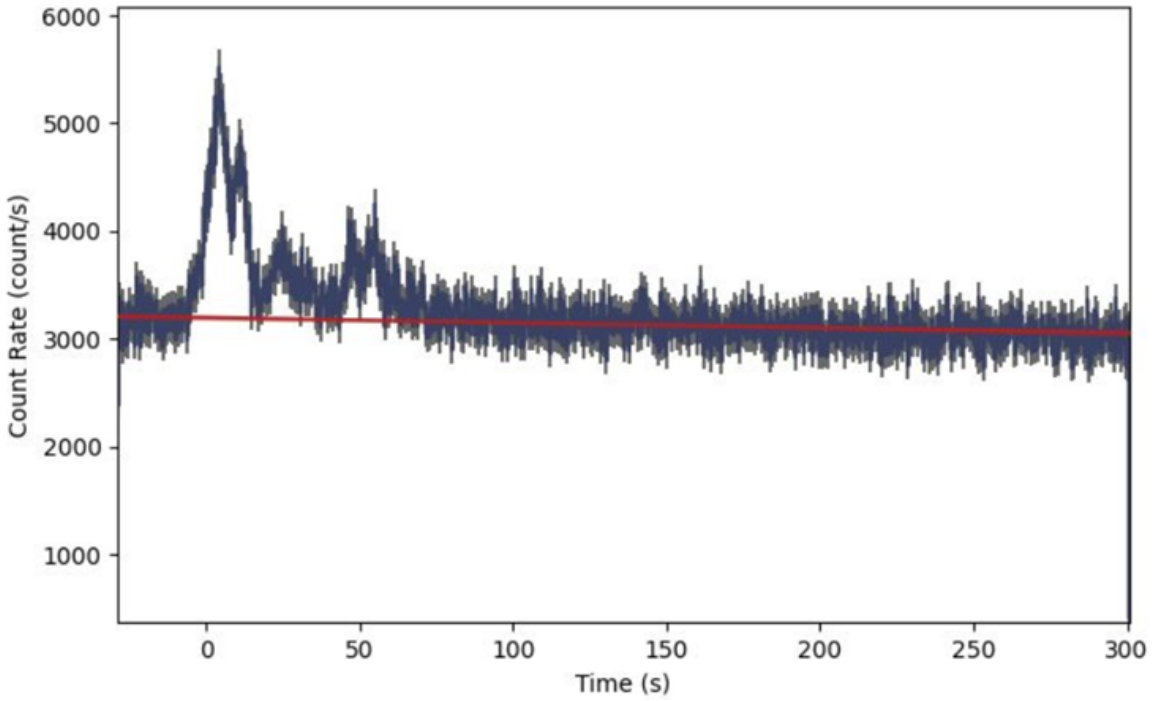



Microvariability = 1.24 s

# Fermi GBM

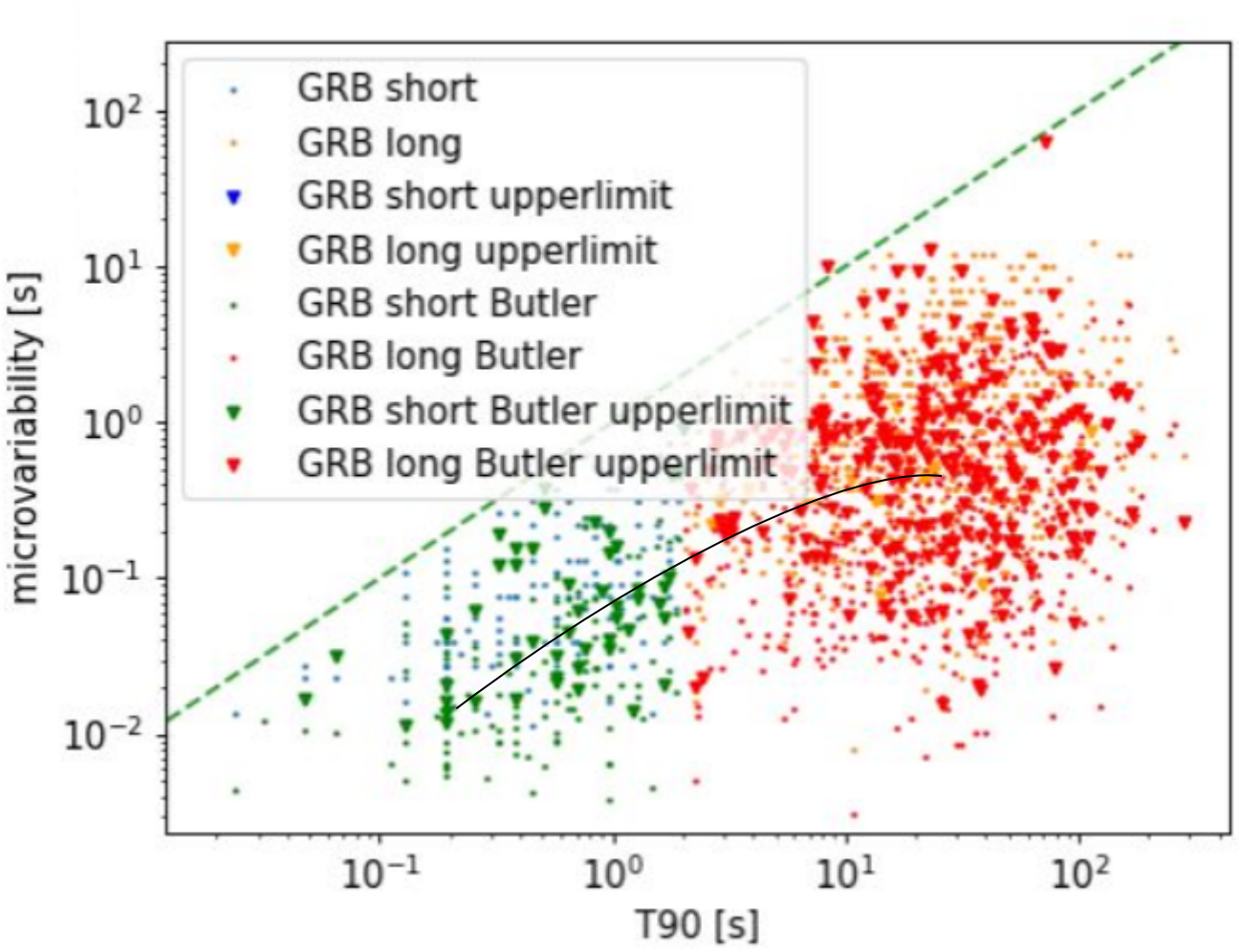
- Sample of 949 GRBs, used in the Golkhou article, for a comparison.
- Requires background subtraction from the GRB spectrum.
- First order polinomial function.

# Bkg removal: example

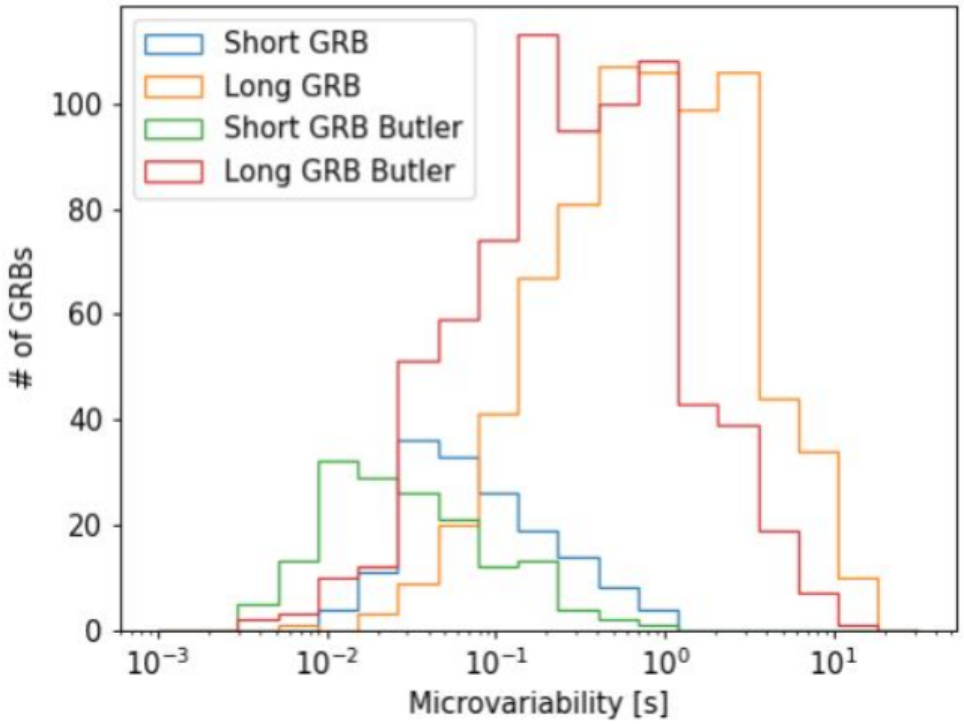


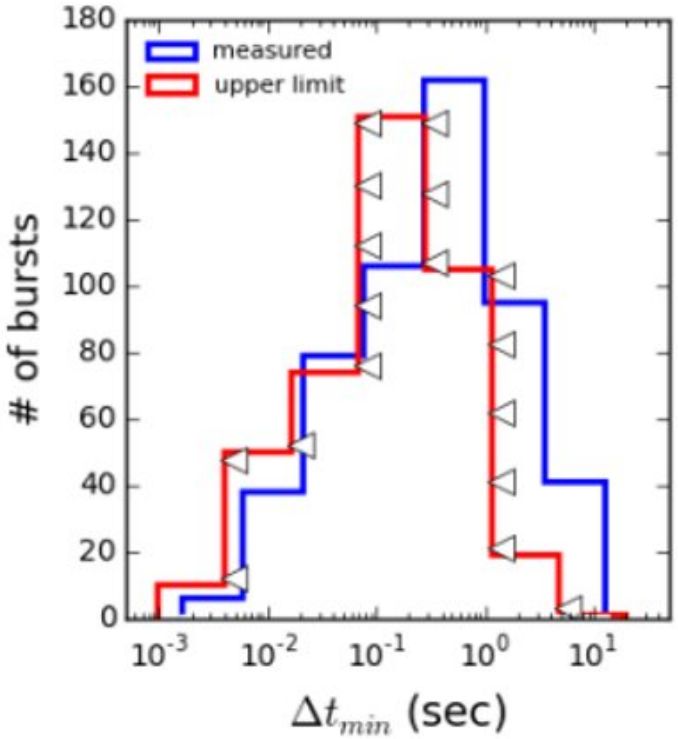

- Taking 15 sec before and 75 sec after (where possible).

# Comparison


GRB short
GRB long
GRB short upperlimit
GRB long upperlimit
GRB short Butler
GRB long Butler
GRB short Butler upperlimit
GRB long Butler upperlimit
microvariability [s]
T90 [s]
$10^{2}$
$10^{1}$
$10^{0}$
$10^{-1}$
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$
$10^{2}$

# 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 litterature 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.