Bar data analysis for searching counterparts of gamma ray bursts.

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ROG and Beppo-Sax Collaborations

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What we know about GRBs:
(principal results from BATSE and Beppo-Sax)

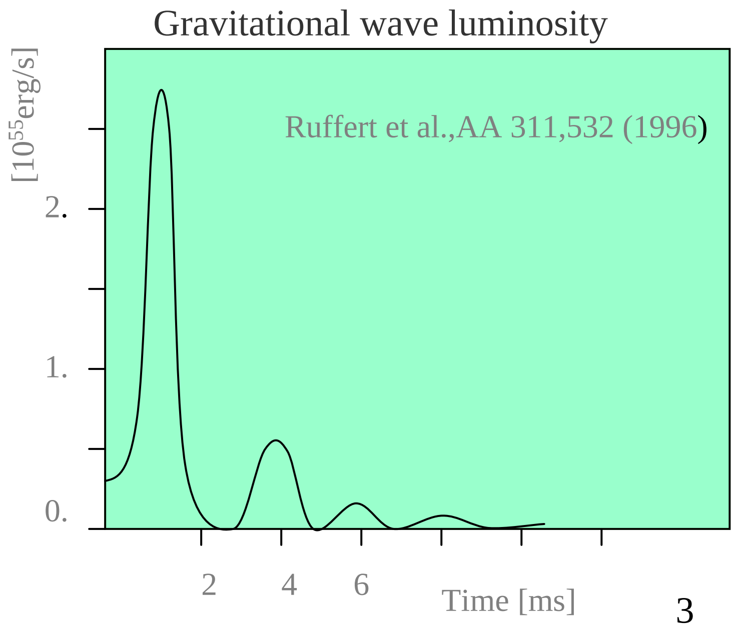
- Cosmological origin
- Isotropic distribution
- 10^{51} - 10^{53} erg (in a few seconds)
- Complex temporal behavior
- Bimodal statistic in the duration time
- EM counterparts in lower frequencies

(phenomenological process)

Typical theoretical prediction for GW associated to a single GRB event:

GW amplitude $h < 10^{-22} - 10^{-21}$ @ 1 kHz
@ R ~ 1 Gpc

$\Delta T = | T_{GW} - T_{GRB} | = \;?$



The detector sensitivity to short GW bursts

(in terms of GW amplitude) :

$$\Delta l / l = h \sim 10^{-18}$$

For NAUTILUS, EXPLORER:
bar length L = 3m
mass = 2300 Kg
material Al5056
resonance ~1 KHz
temperature = 0.1 K - 2 K

for a typical Galactic burst (10 kpc, 1ms, 10^{-3} $M_\odot$)
measurable with SNR=4

Previous studies and experimental results

- **Astron. Astrophys. Suppl. Ser. 138, 603 (1999).**
ROG Collaboration
- **Astron. Astrophys. Suppl. Ser. 138, 605 (1999).**
ROG Collaboration
- **Astron. Astrophys. 364, 419 (2000).**
G. Modestino, G. Pizzella
- **CNR-IFSI-2001-28 (2001).**
P. Bonifazi, G.V. Pallottino, A.V. Gusev, A.Kochetkova, Ak.Postnov, V. Rudenko, V.N.Vinogradov
- **Phys. Rev. D 63, 022005 (2001).**
AURIGA Group
- **Phys. Rev. D 65, 022005 (2002).**
G. Modestino, A. Moleti
- **Phys. Rev. D 66, 102202 (2002).**
ROG Collaboration

Cumulative techniques have been proposed to detect a statistically significant association between GW signals and GRBs.

Principal problems

- **Need to investigate a wide time window to include several possible delays.** As a matter of facts, taking into account the recent astrophysical hypothesis: $T_{GW}-T_{GRB}=\Delta T\sim 1000$ s

- **Non-stationary noise condition.** GW data are often dominated by the contribution of non-gaussian, non stationary noise.

In order to consider these fundamental items, studies of adaptive algorithms are required.

The two cumulative techniques

Combine the output data from each GRB and from different GW detectors, to simulate a single detector of better sensitivity.

Statistically significant: $S/N \sim (N_{det} \times N_{GRBs})^{1/2}$ BUT…

We need to assume:

$\Delta T = T_{GW}-T_{GRB} \sim cost$

Cross-correlate the output of **two** GW detectors.

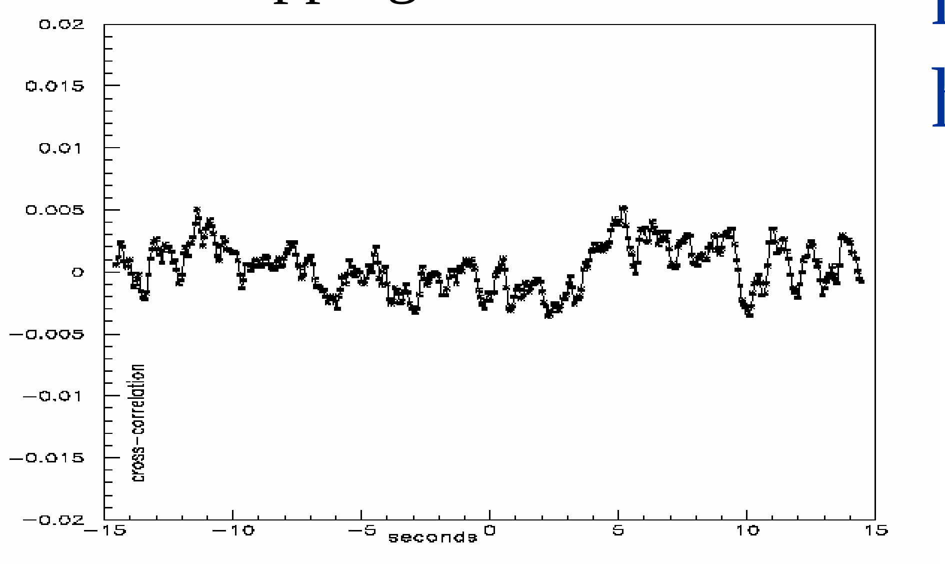
$h^2 \sim [\Delta T/(N_{GRBs}\ BW)]^{1/2}$

Effective also in the case of poor statistic.

No hypothesis is required about ΔT (model independent).

EXPLORER - NAUTILUS
Cross-correlation result

Overlapping 47 c-c stretches



h $\leq 1.2\ 10^{-18}$ ($\Delta T = \pm 400s$)

h$\leq 6.5\ 10^{-19}$ ($\Delta T = \pm 5s$)

Astone et al. (ROG Coll), Phys. Rev. D 66 102002 (2002).

Searching for GW counterparts at GRB arrival time.

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- GRB list = BATSE + Beppo-Sax

- GRB arrival time = Peak Time

- GW detectors = EXPLORER + NAUTILUS

- $DT = |T_{GRB} - T_{GW}| = 0$ (Peak Time ± 5 s)

- GW data background = 30 minutes
  with temperature noise $t_n < 15 \quad 10^{-3}$ kelvin
  (Peak Time ± 15 min)

- Cumulative median algorithm

Adopting the median algorithm (instead of average)

ROG Coll
in progress

Better sensitivity : the output filtered data have an exponential distribution. So:

$$m = \ln 2\ \mu$$

(m and μ the are the median and the mean value of the distribution)

Better stationary : the background is much less affected by spurious peaks.

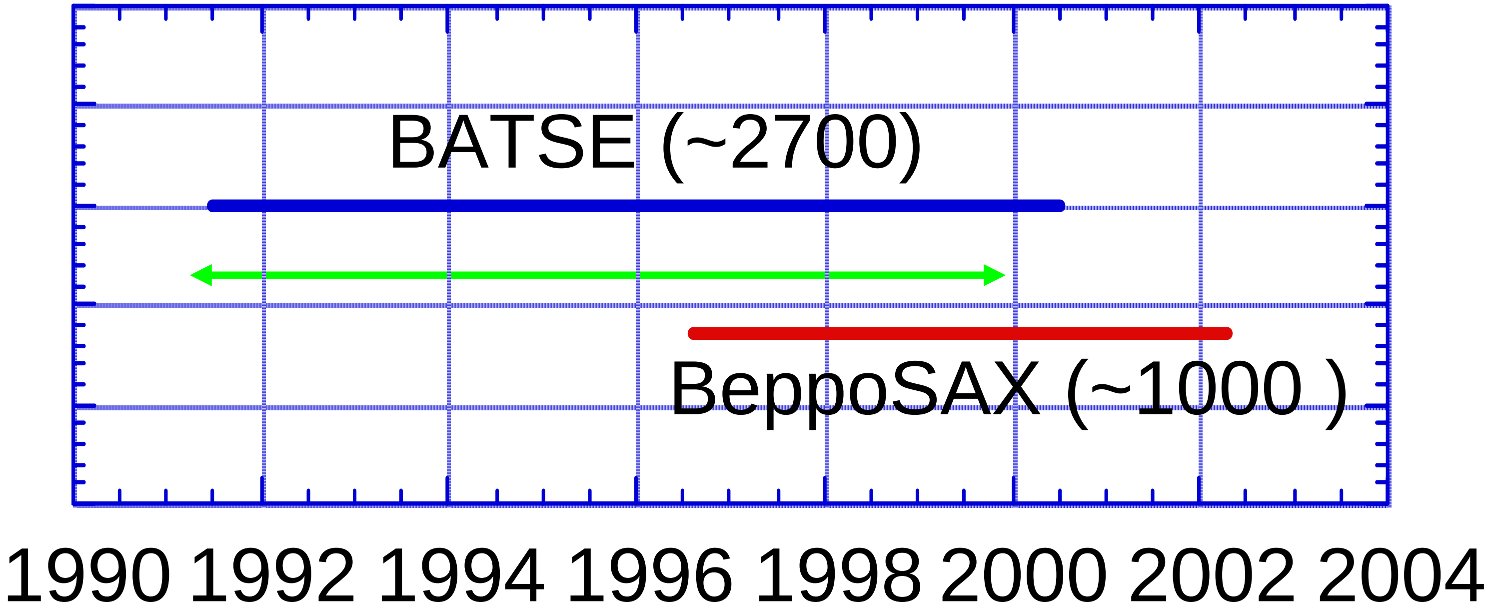
It is ideal for searching small systematic signals

GRBs Database

ROG Coll.
In progress

Used Data

Trigger GRBs



Cumulative Median

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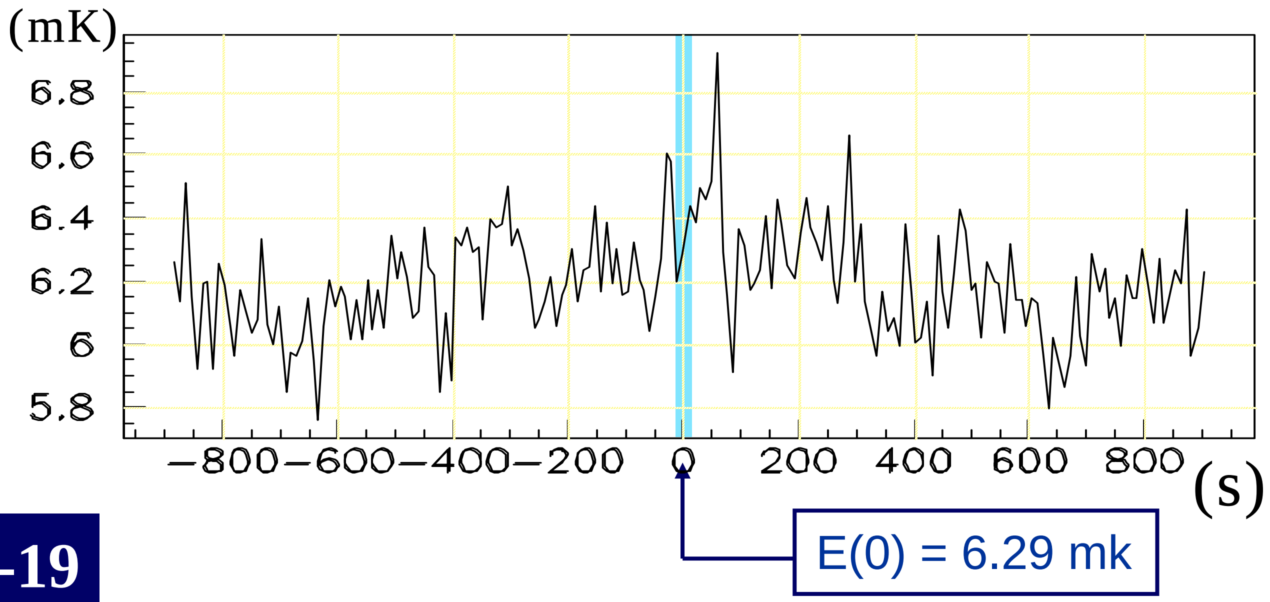
- Integration Time: ±5s
- Overlapping 304 30 min GW data stretches

GW detector energy as a function of the GW-GRB delay



<E> = 6.19 mK

σ = 0.17 mK

$h \leq 1.4 \; 10^{-19}$

Conclusions:

The last decade contains a very rich data archive for searching association between GW and GRB emissions.

Correlating the data of the GW bar detectors with existent GRB lists, significant measurements are performed.

Interesting ranges have been investigated : h~10^{-19}.

The results represent relevant indications for future measurements