



June 23, 2005, Okinawa (Japan)



ricerca onde gravitazionali
gravitational wave research

The 2003 science run of EXPLORER and NAUTILUS

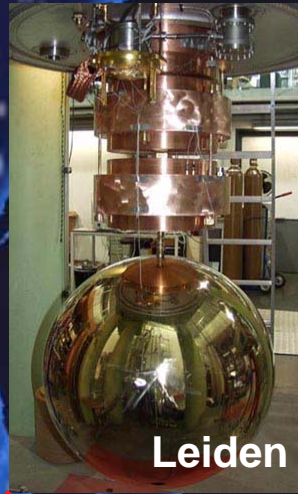
Eugenio Coccia
for the ROG Collaboration

Gravitational Wave Detectors

INFN

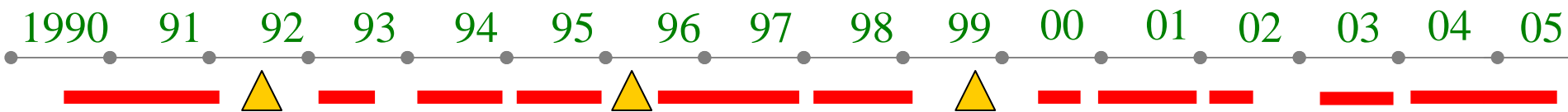
- Frascati Labs
- Genova
- Gran Sasso Labs
- L'Aquila
- Roma 1
- Roma 2

- INAF - IFSI
- CNR- IFN
- CERN
- Geneva



Data taking during the last 14 years
largest data base of GW data worldwide

EXPLORER



h from 10^{-18} to $3 \cdot 10^{-19}$

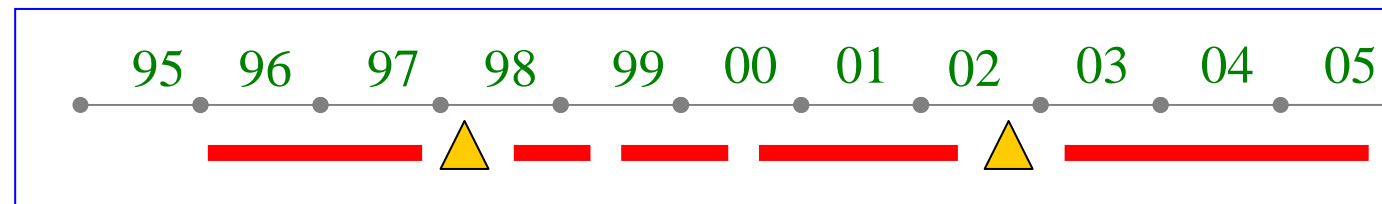
IGEC search

S01

S03

S04/05

NAUTILUS

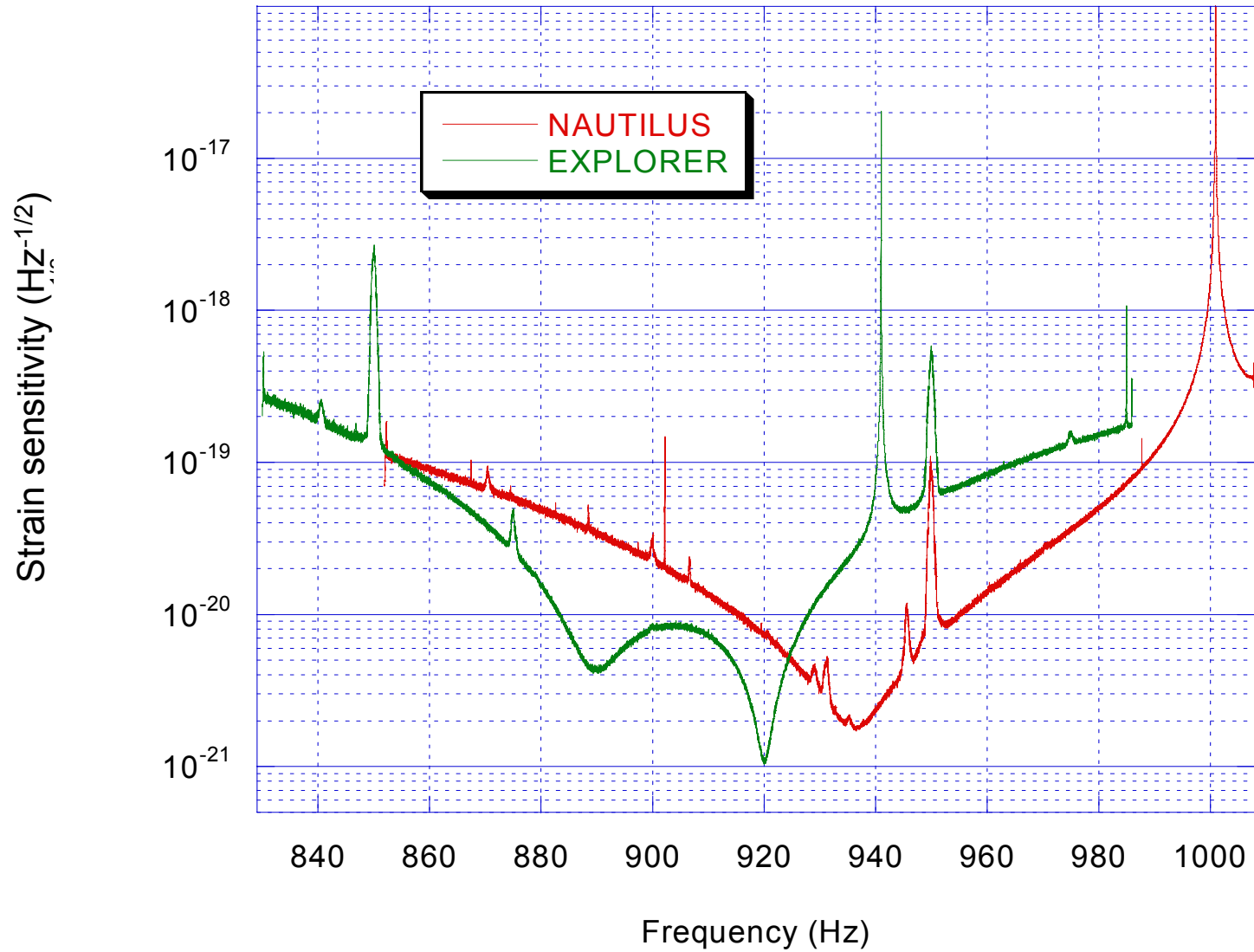


h from 10^{-18} to $2 \cdot 10^{-19}$

▲ = upgrade

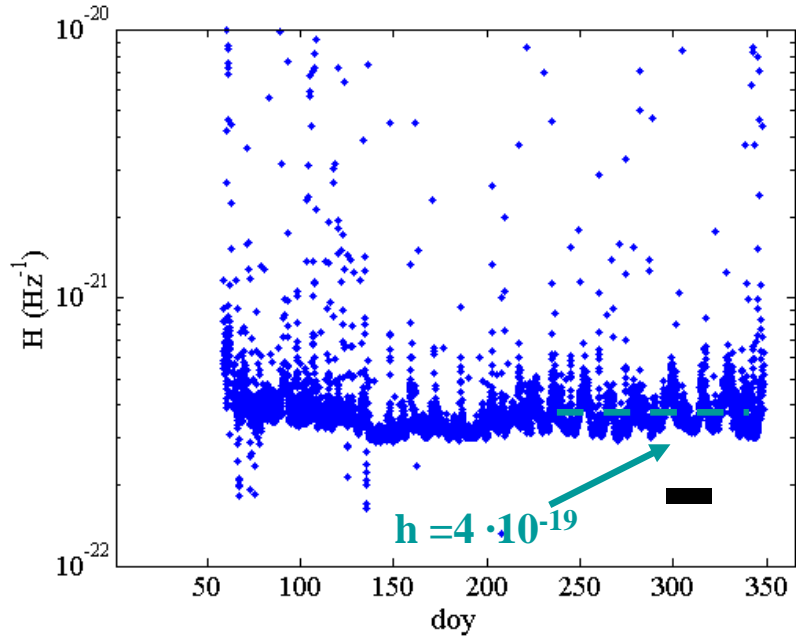


2005

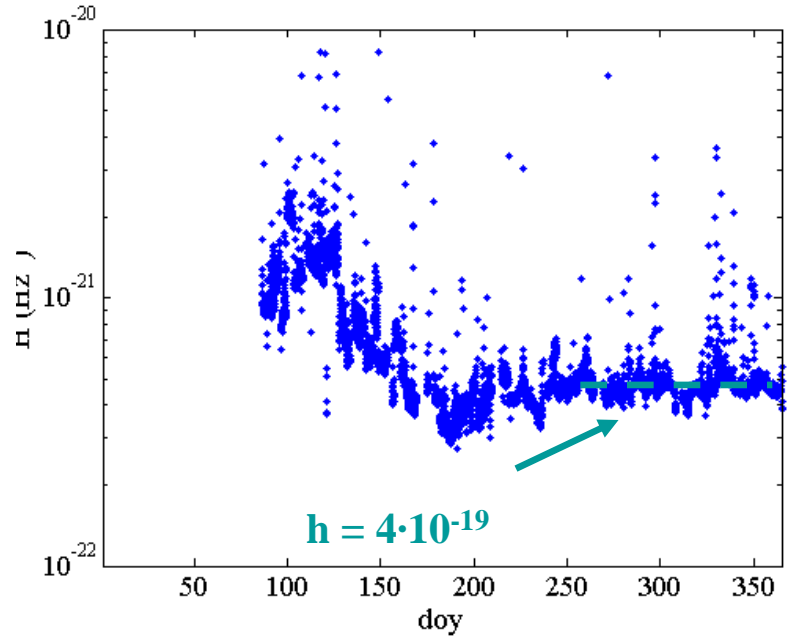


DATA TAKING DURING 2003

EXPLORER



NAUTILUS



Science Run 03

Coincidence measurement time

148.7 days

Data selection

Accepted periods: Hourly averaged Noise Temp. < 12 mK

Accepted events: Noise Temp. before the event < 8 mK

$\text{SNR}_E = \text{Event energy} / \text{Noise Temp.} > 19.5$

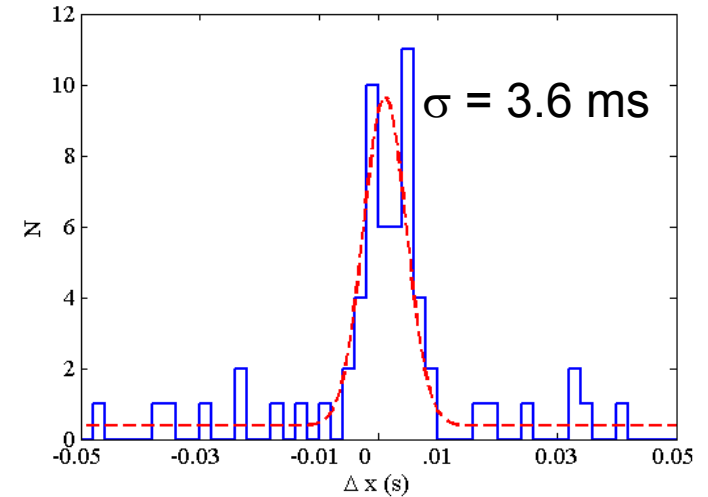
Coincidence time window

30 ms

The study of the events induced in the detectors by cosmic ray showers is very fruitful

It is a delta excitation!

- Efficiency test for the algorithms
- Determination of the detectors time resolution
→ Coincidence window
- Independent detector calibration
→ Coincidence energy filter



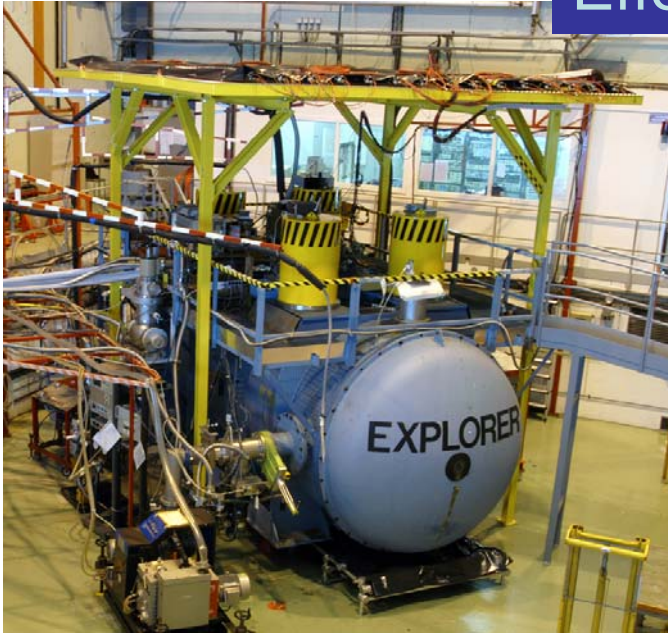
www.inf.infn.it/esperimenti/rap

RAP (acoustic detection of particles at the DAFNE BTF)
Recent results (look at the poster!)

- thermoacoustic model OK with electrons on Al
- s/c effect understood with Nb

QuickTime™ e un
decompressore TIFF (LZW)
sono necessari per visualizzare quest'immagine.

Effect of cosmic rays



EXPLORER is equipped with 3 layers (2 above the cryostat - area 13m² - and 1 below -area 6 m²) of Plastic Scintillators.

The cosmic ray effect on the bar is measured by an offline correlation, driven by the arrival time of the cosmic rays, between the observed multiplicity in the CR detector (saturation for $M \geq 10^3$ particles/m²) and the data of the antenna, sampled each 4.54 ms and processed by a filter matched to δ signals



NAUTILUS is equipped with 7 layers (3 above the cryostat - area 36m²/each - and 4 below -area 16.5 m²/each) of Streamer tubes.

$$\Delta E = 1 \text{ mK} = 0.15 \mu\text{eV}$$

EXPLORER

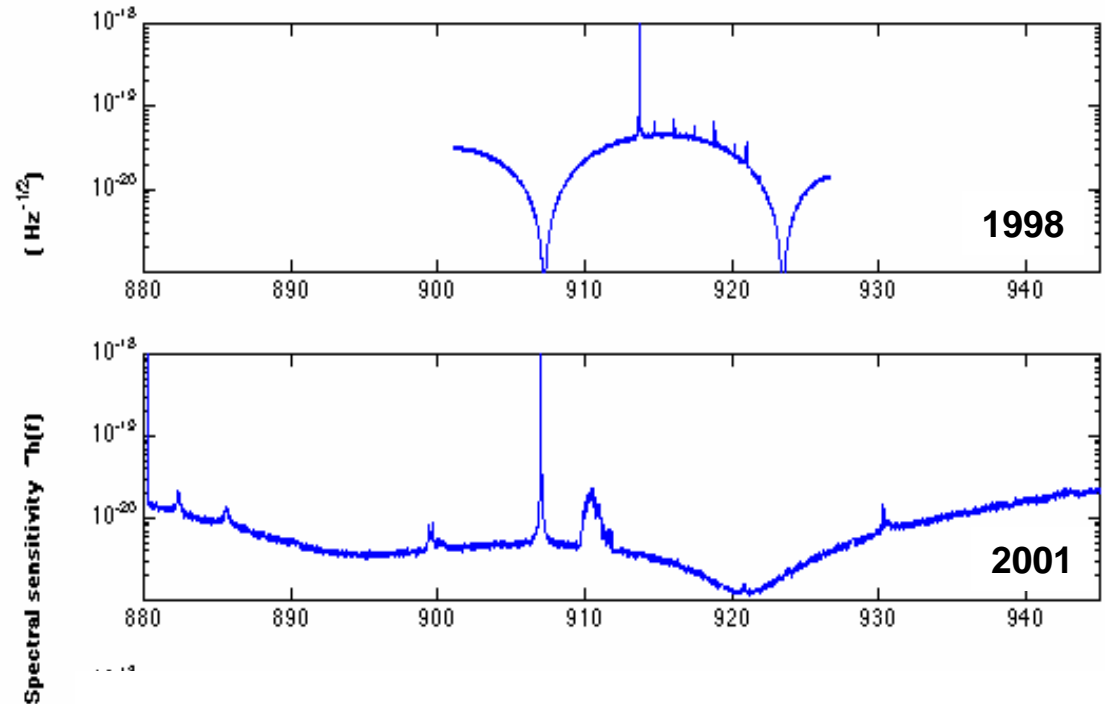
EXPLORER has been on the air since May 2000

with:

- new, 10 μm gap transducer
- new, high coupling SQUID

Bandwidth: the detector has a sensitivity better than $10^{-20} \text{ Hz}^{-1/2}$ on a band larger than 50 Hz

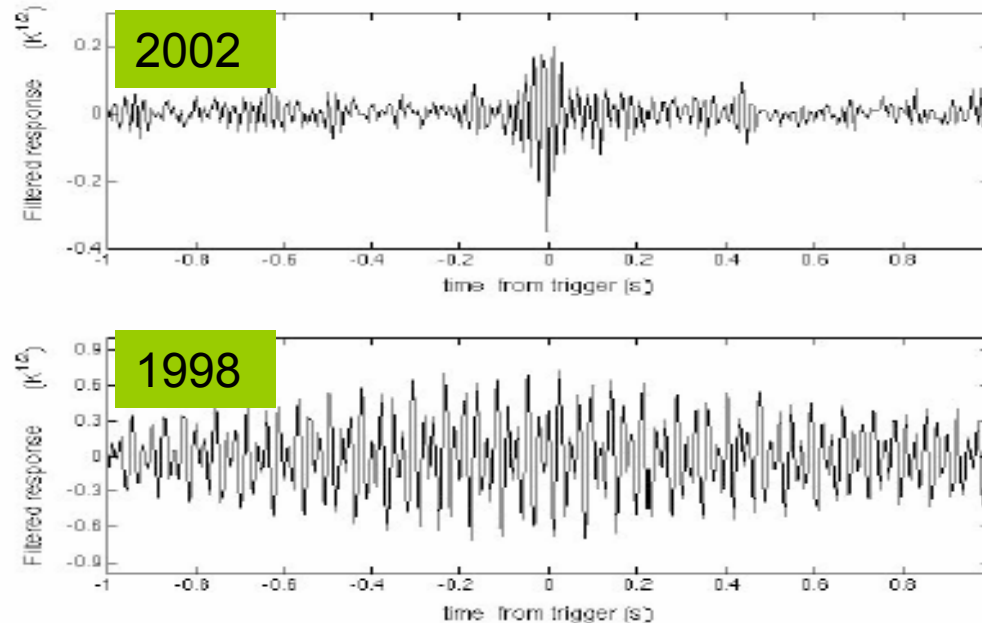
The noise temperature is $< 3 \text{ mK}$ ($h=4.4 \cdot 10^{-19}$) for 84% of the time.



Increasing the Bandwidth of Resonant Gravitational Antennas: The Case of Explorer
P. Astone *et al.* (ROG Collaboration)
Phys. Rev. Lett. 91, 11 (2003)

Time resolution vs bandwidth

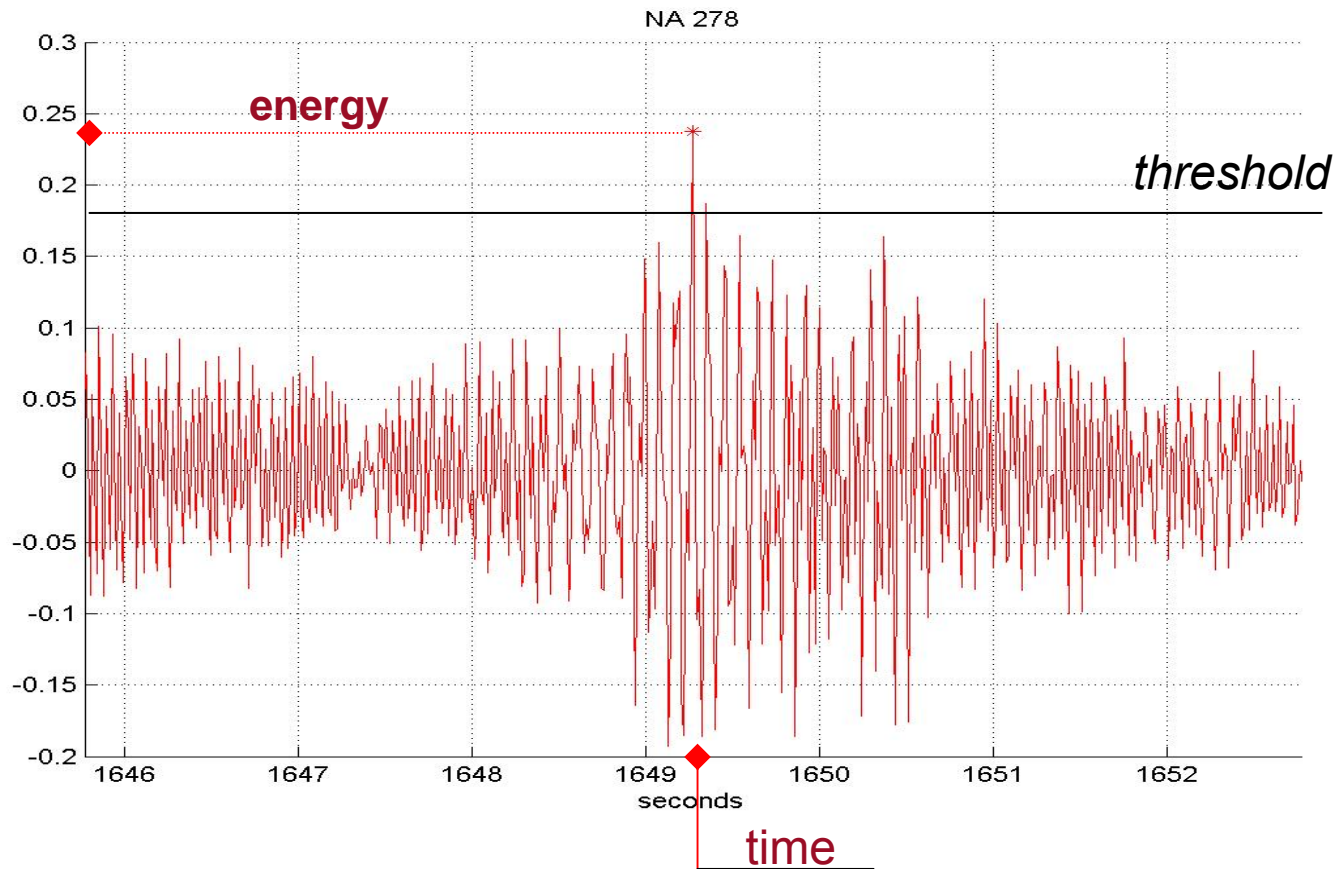
Larger
bandwidth Δf
 \Rightarrow Better time
resolution Δt

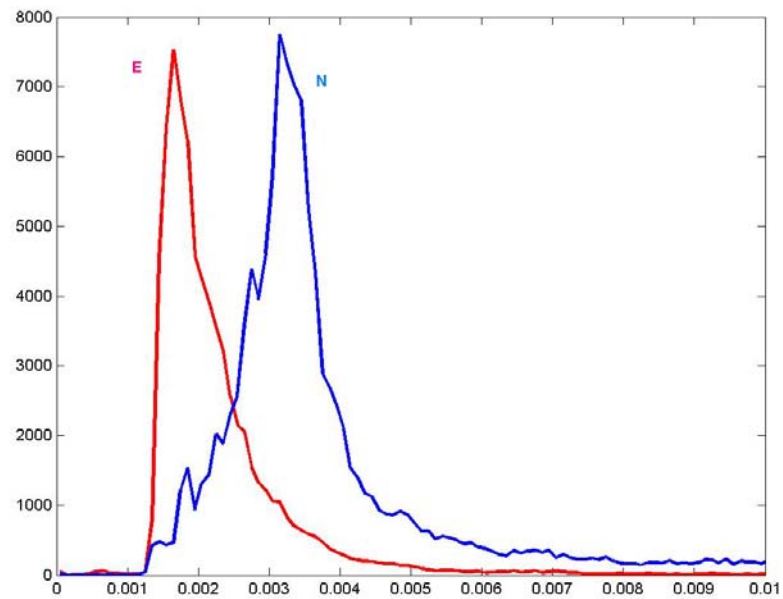


Event triggered by cosmic ray shower

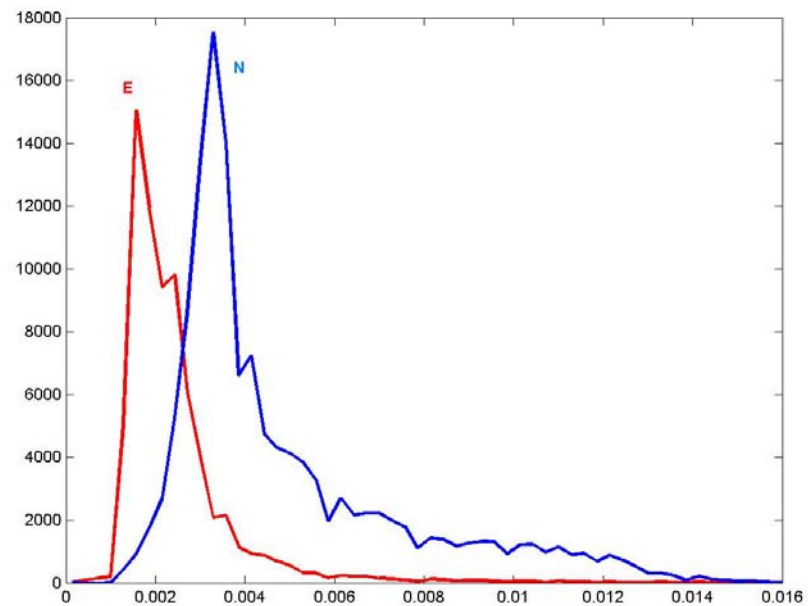
Events are characterized by

- **time**: time of the maximum of the filtered output
- **energy**: energy of the maximum

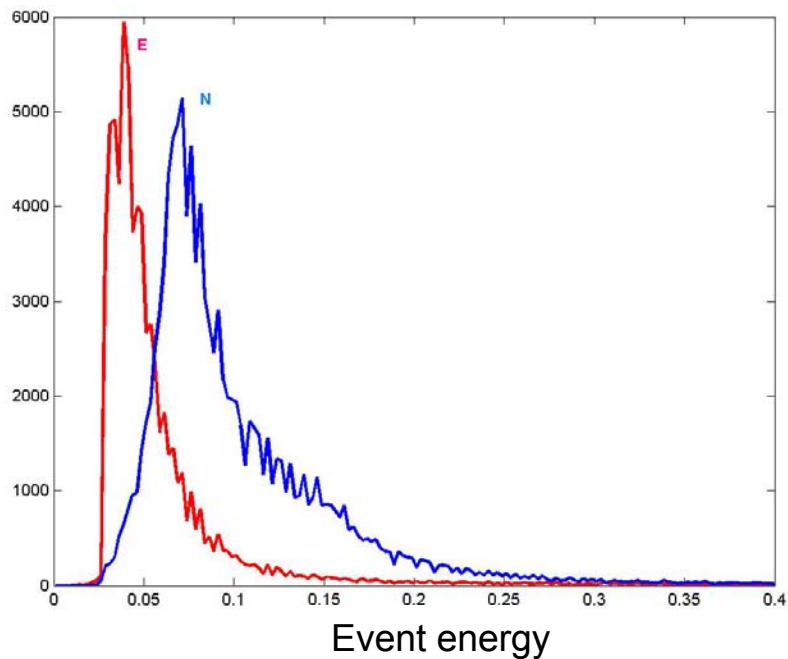




Hourly averaged Noise Temperature



Noise Temp. before the event



Event energy

ROG S 03

N events

Explorer 72086; Nautilus 114911

Accidentals

Shifting 1000 times, $dt = 1s$

Result

$N_c = 24$

Background = 18.8

$P(\text{Poisson}) = 14\%$

GWDAW Kyoto 2002

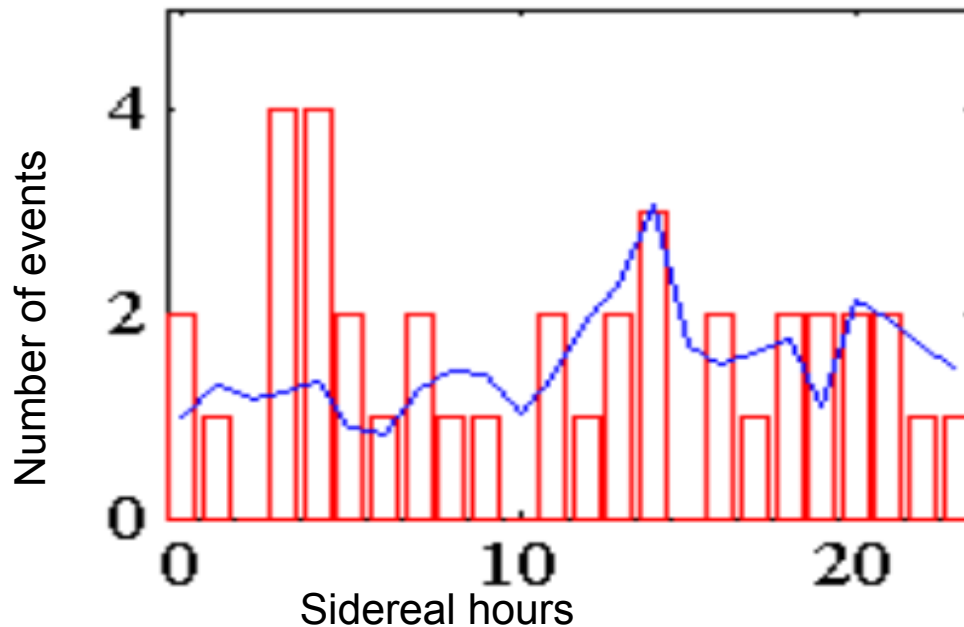
- Classical and Quantum Gravity 19, 5449 (2002)

3 points:

- **Unprecedented sensitivity**
- **Two powerful tools in the same analysis:**
 - **amplitude (energy) consistency**
 - **sidereal time analysis**
- **Defined analysis procedure for the next run**

EXPLORER-NAUTILUS 2001 data analysis

ROG Coll.: CQG 19, 5449 (2002)



Comments, analysis and studies

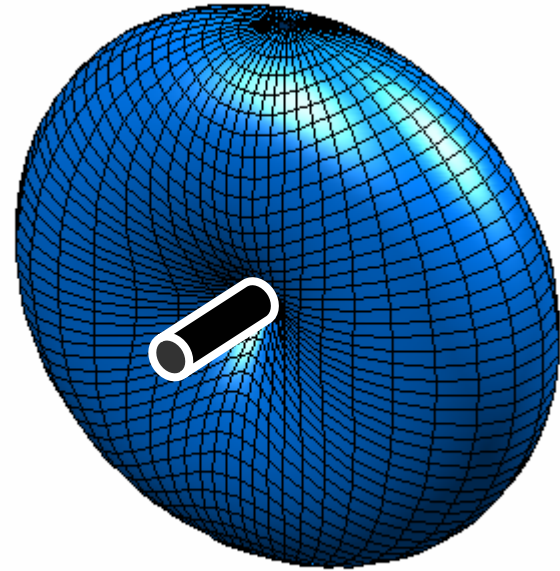
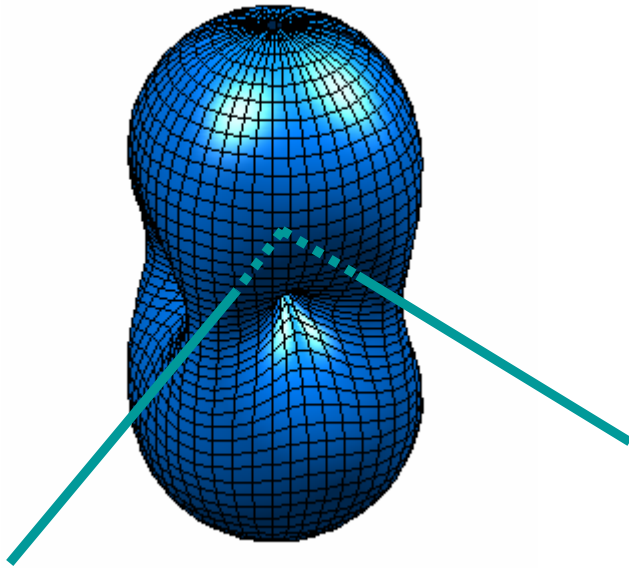
L.S.Finn: CQG 20, L37 (2003)

P.Astone, G.D'Agostini, S.D'Antonio: CQG 20, S769 (2003)

ROG Coll.:CQG 20, S785 (2003)

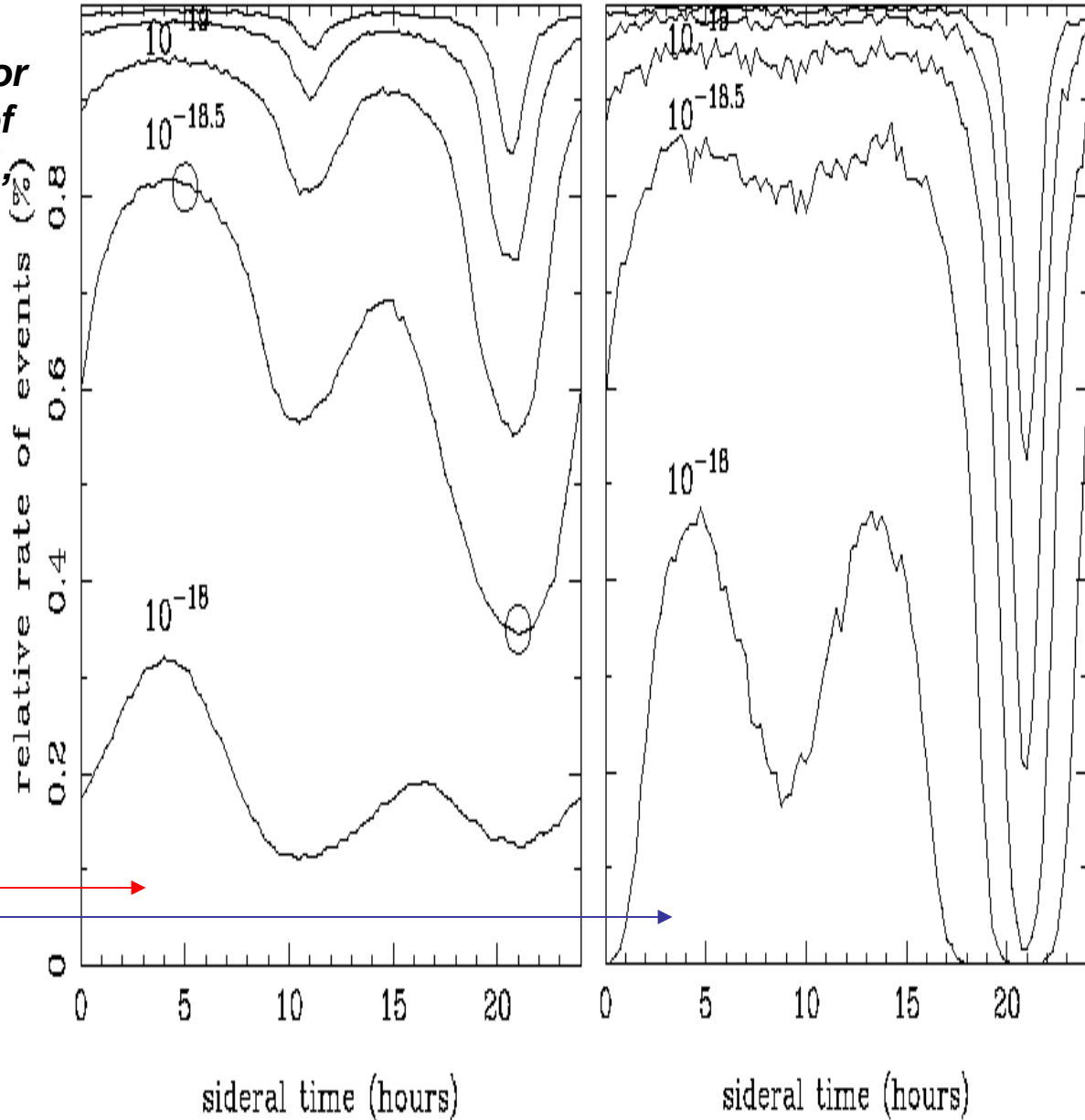
E.Coccia, F. Dubath, M. Maggiore: PRD 70, 084010 (2004)

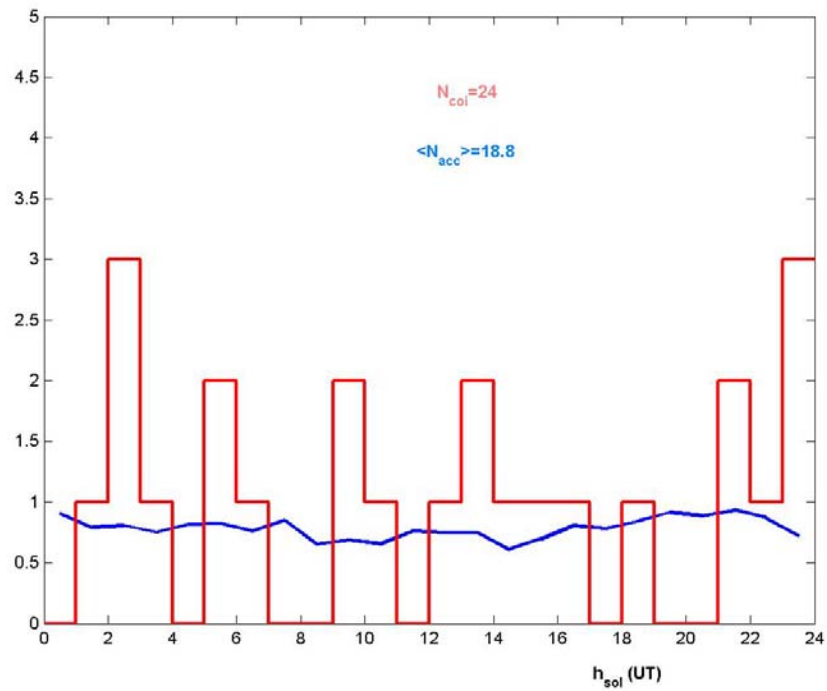
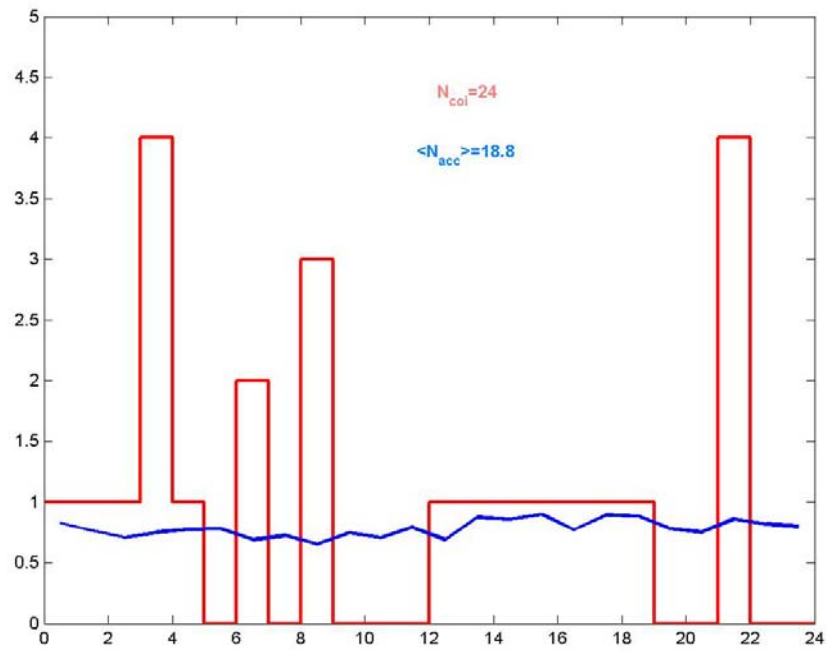
DIRECTIONALITY



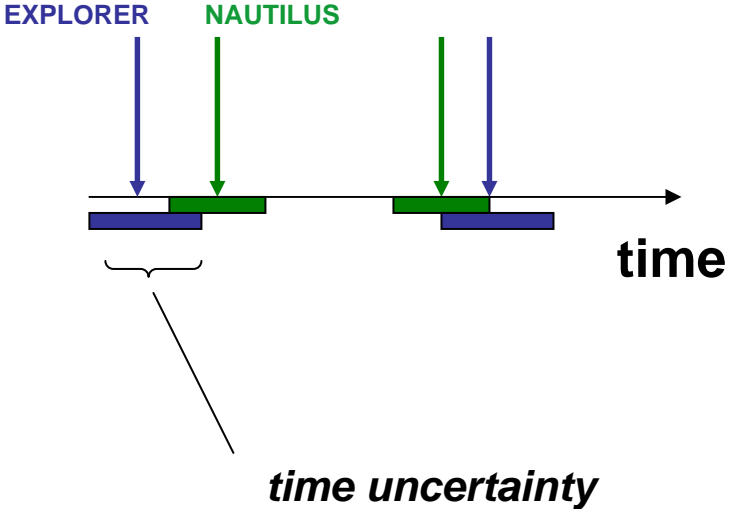
G. Paturel, Yu.V. Barishev
*Sidereal time analysis as a tool for
study of the space distribution of
gw sources. Astro-ph/0211604v1,
A&A 398, 377 (2003)*

*The expected rate of events on
EXPLORER for sources on the
galactic disc and on the GC*

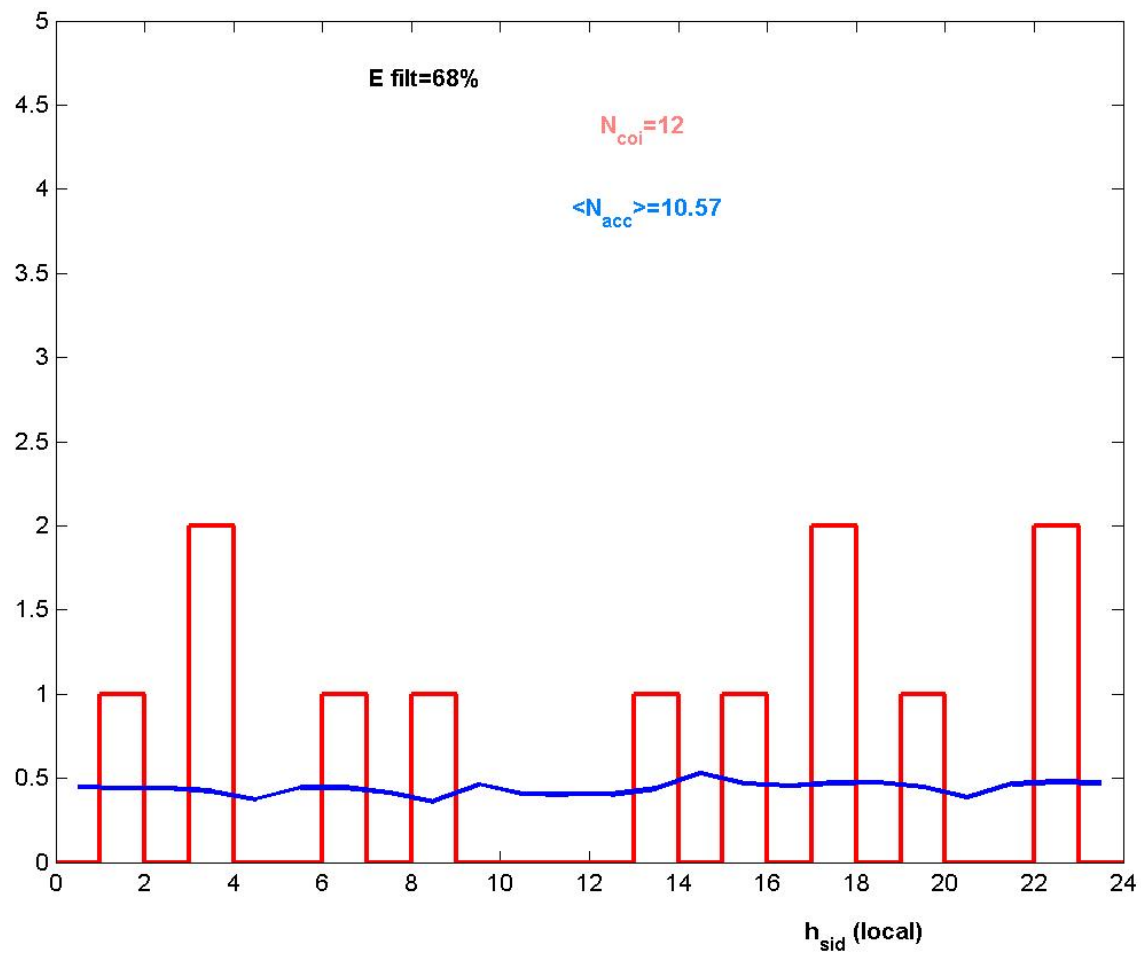


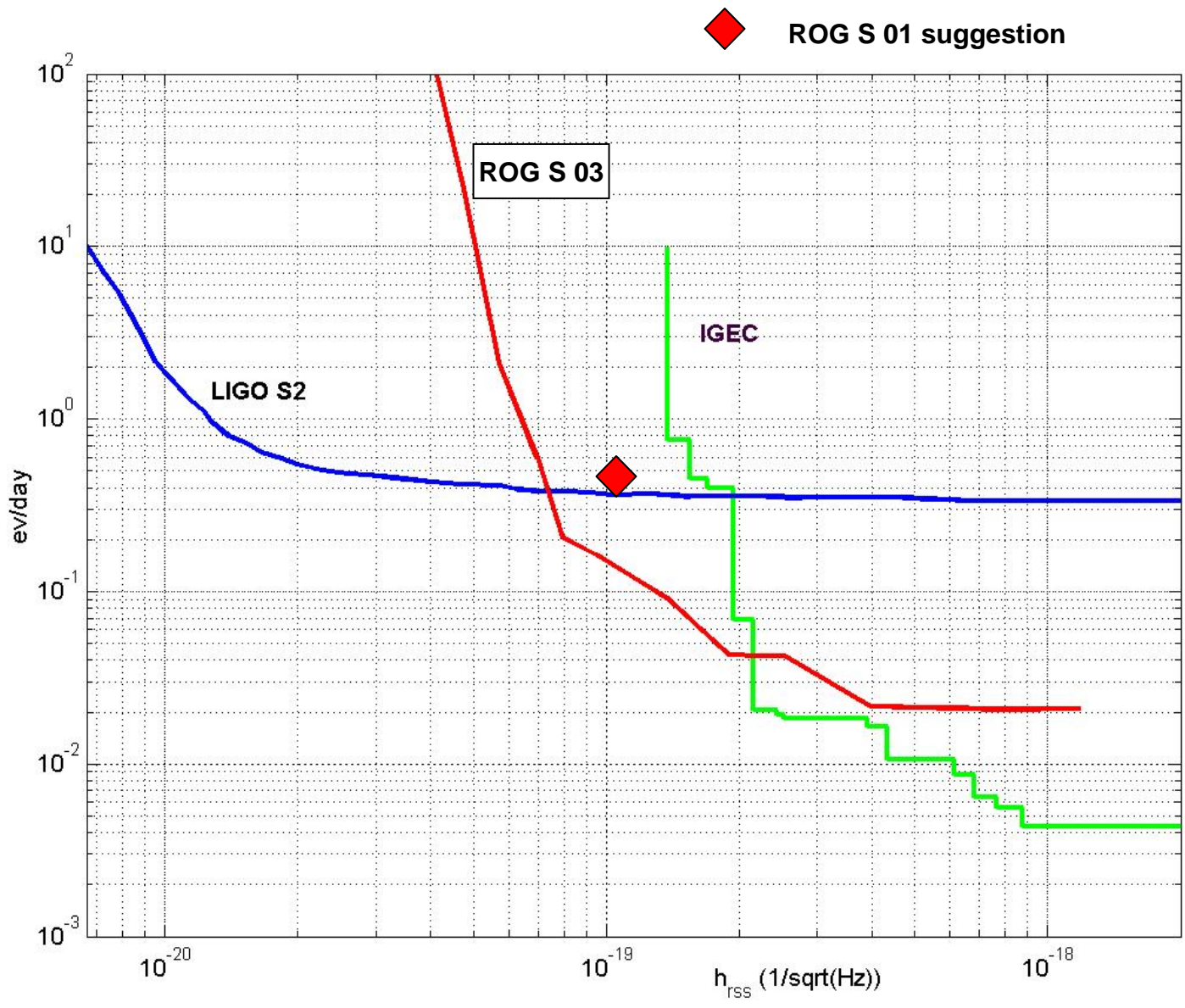


Time coincidence



68%





Conclusion

- EXPLORER NAUTILUS Science run 03:
 - crewless operation
 - data *validated* by cosmic ray effect
 - **new upper limit with bars, no significant coincidence excess nor sidereal effect.**

To be done

- Use cosmic ray data to reduce calibration uncertainty
- ROG data available for correlation studies with IGEC and all the other detectors.

$$H = h_o \tau$$

$$h_{rss} = h_o \sqrt{\tau} = H / \sqrt{\tau}$$

$$\tau = 1 \text{ ms}$$

