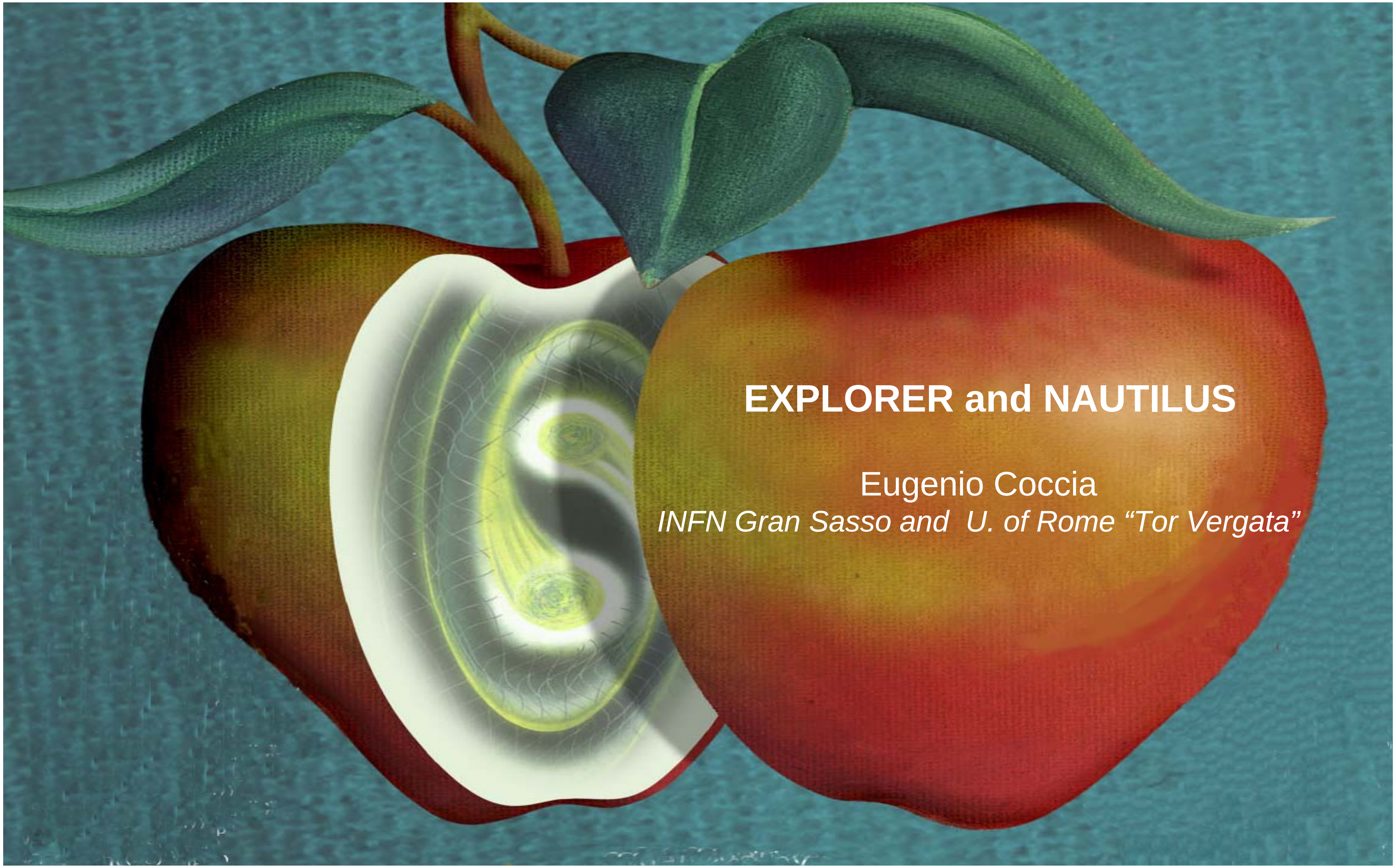
5th International LISA Symposium

ESA Noordwijk (The Netherlands)

July 13, 2004



EXPLORER and NAUTILUS

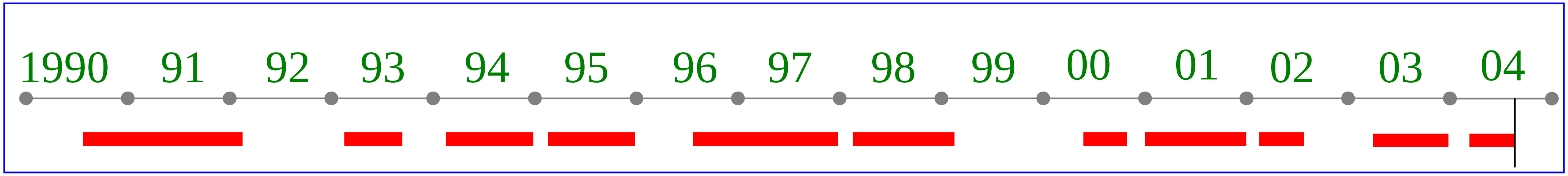
Eugenio Coccia

INFN Gran Sasso and U. of Rome “Tor Vergata”


Gravitational Wave Detectors
Interferometer
Resonant-Mass
GEO
MiniGrail
EXPLORER
AURIGA
VIRGO
NAUTILUS
CERN RE 5
EXPLORER
INFN Frascati
gravitational wave

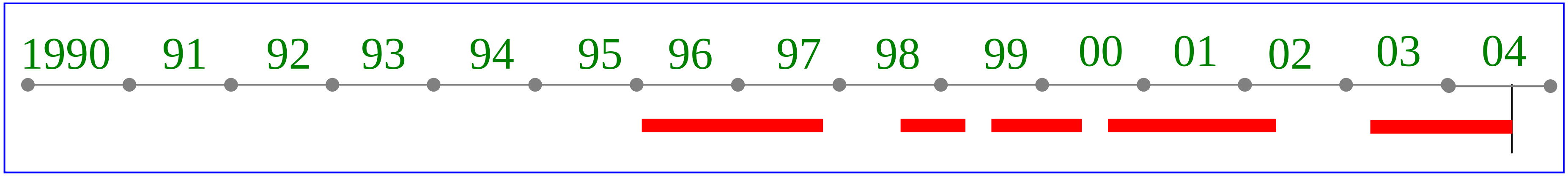
Data taking during the last 10 years

EXPLORER



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

NAUTILUS



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

Bursts

*IGEC, Phys. Rev. Lett. **85,** 5046 (2000)*
*Class. Quant. Grav. **18**, 43 (2001)*
Class. Quant. Grav. 19, 5449 (2002)

Continuous signals

*Phys. Rev. D **65,** 022001(2002)*
*Phys. Rev. D, **65**,042003 (2002)*
Class.Quant.Grav. 20 (2003) S665-S676

Stochastic Background

*Astron. Astrophys. **351**, 811 (1999)*

more

Search for correlation with GRB's
*Astron. Astrophys. **138**, 603 (1999)*
*Phys. Rev. D **66** 102002 (2002)*

Gravitational near field
*Eur. J. Phys. C **5**, 651 (1998)*

Effect of cosmic rays
*Phys. Rev. Lett. **84** , 14 (2000)*
*Phys. Lett. B **499**, 16 (2001)*
Phys. Lett. B (2002)

analysis of data

EXPLORER

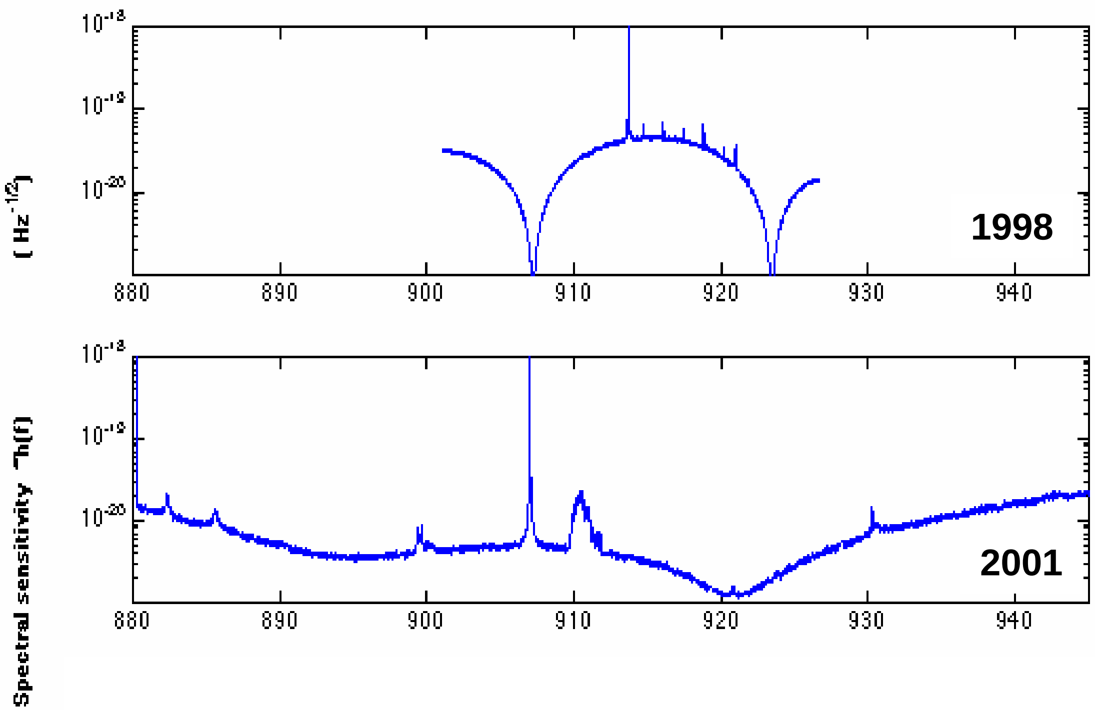
EXPLORER has been on the air since May 2000 with:

-new, 10 µm gap transducer

-new, high coupling SQUID

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

Bandwidth: the detector has reached a sensitivity better than 10^{-20} $Hz^{-1/2}$ on a band of about 50 Hz



Increasing the Bandwidth of Resonant Gravitational Antennas: The Case of Explorer

PRL 91, 11 (2003)

Time resolution vs bandwidth

Larger Δf ⇒ smaller Δt

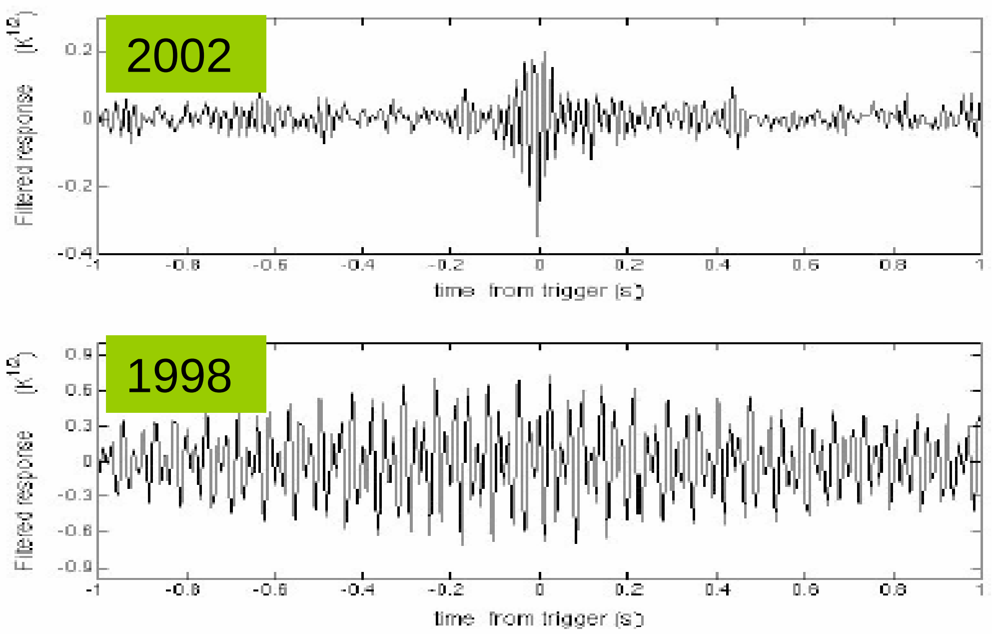
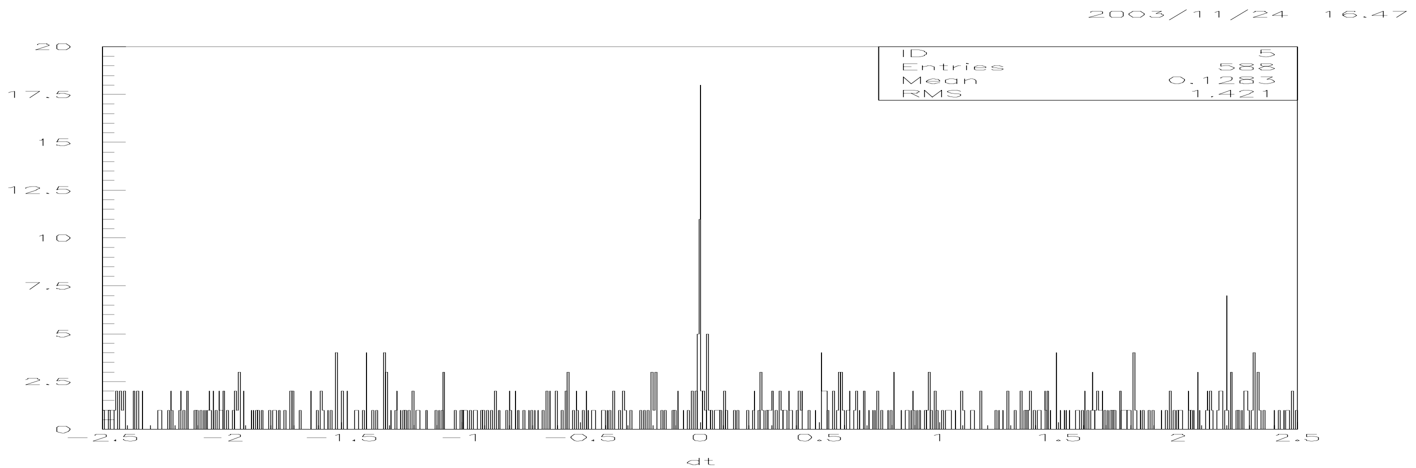
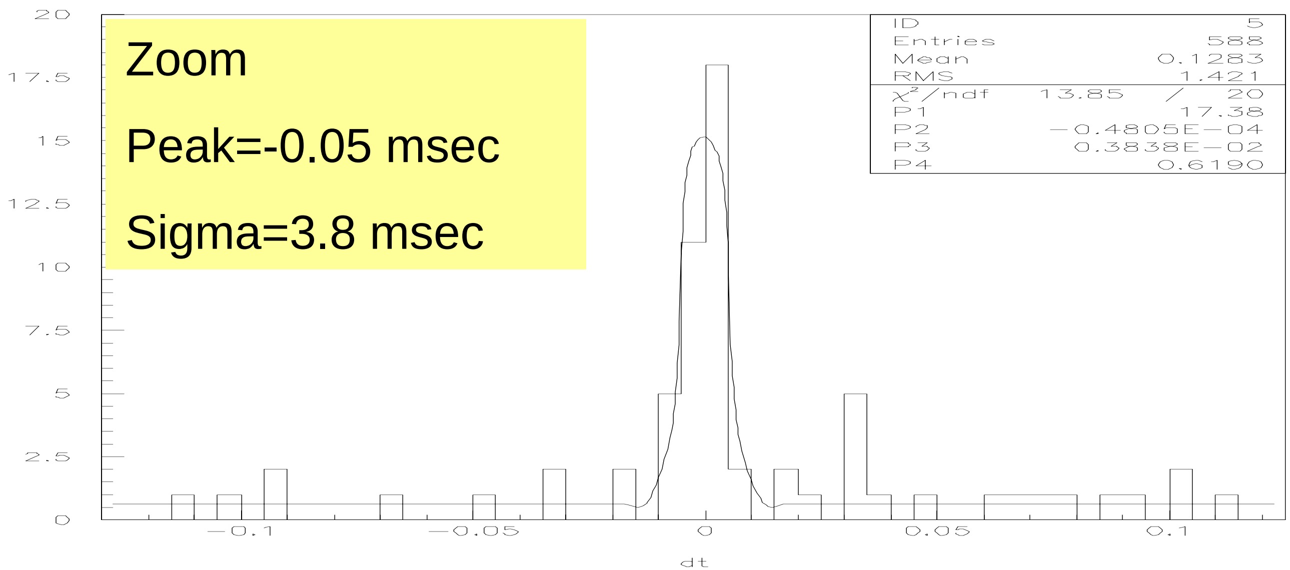


FIG. 4. An event triggered by a cosmic ray shower. For comparison, we show a similar event detected by the Nautilus antenna [18] where the slow beats between the two normal modes can be clearly seen: the improvement in arrival time resolution is evident

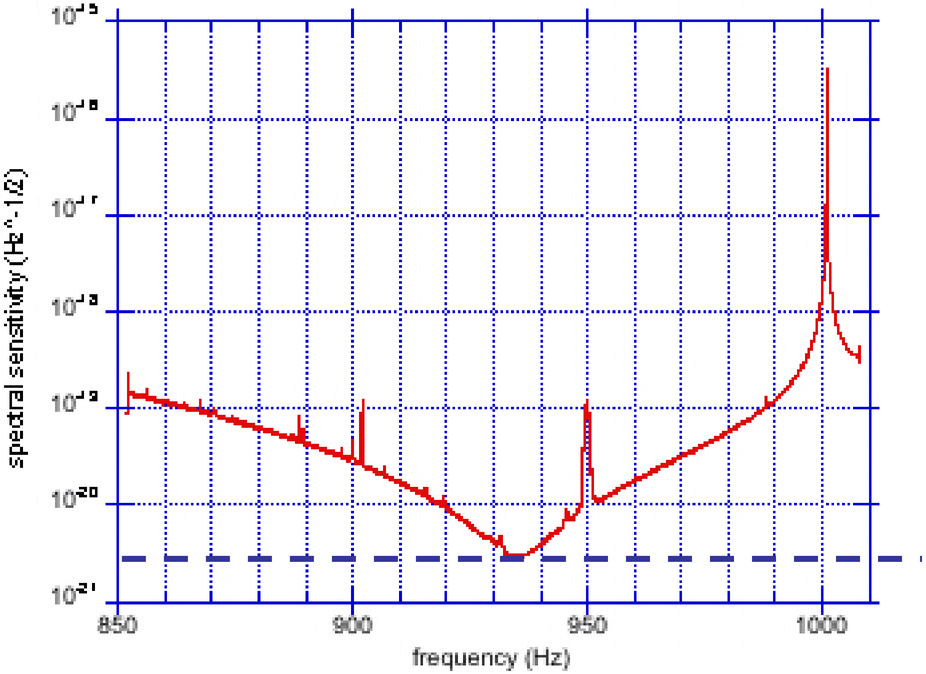
Distribution of differences between cosmic rays arrival time and antenna filtered signal (Explorer 2003)





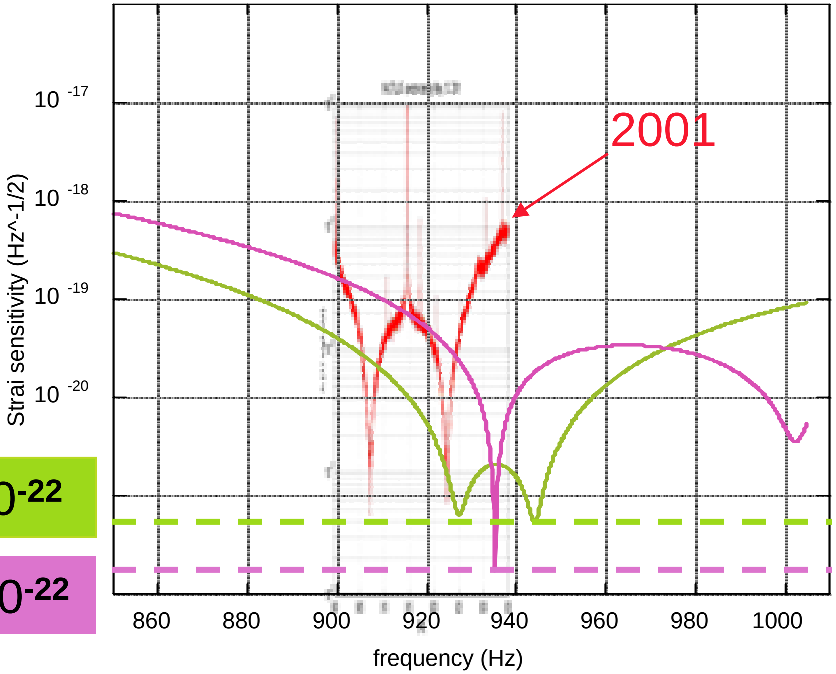
NAUTILUS spectral density at 3.5 K

June 2003



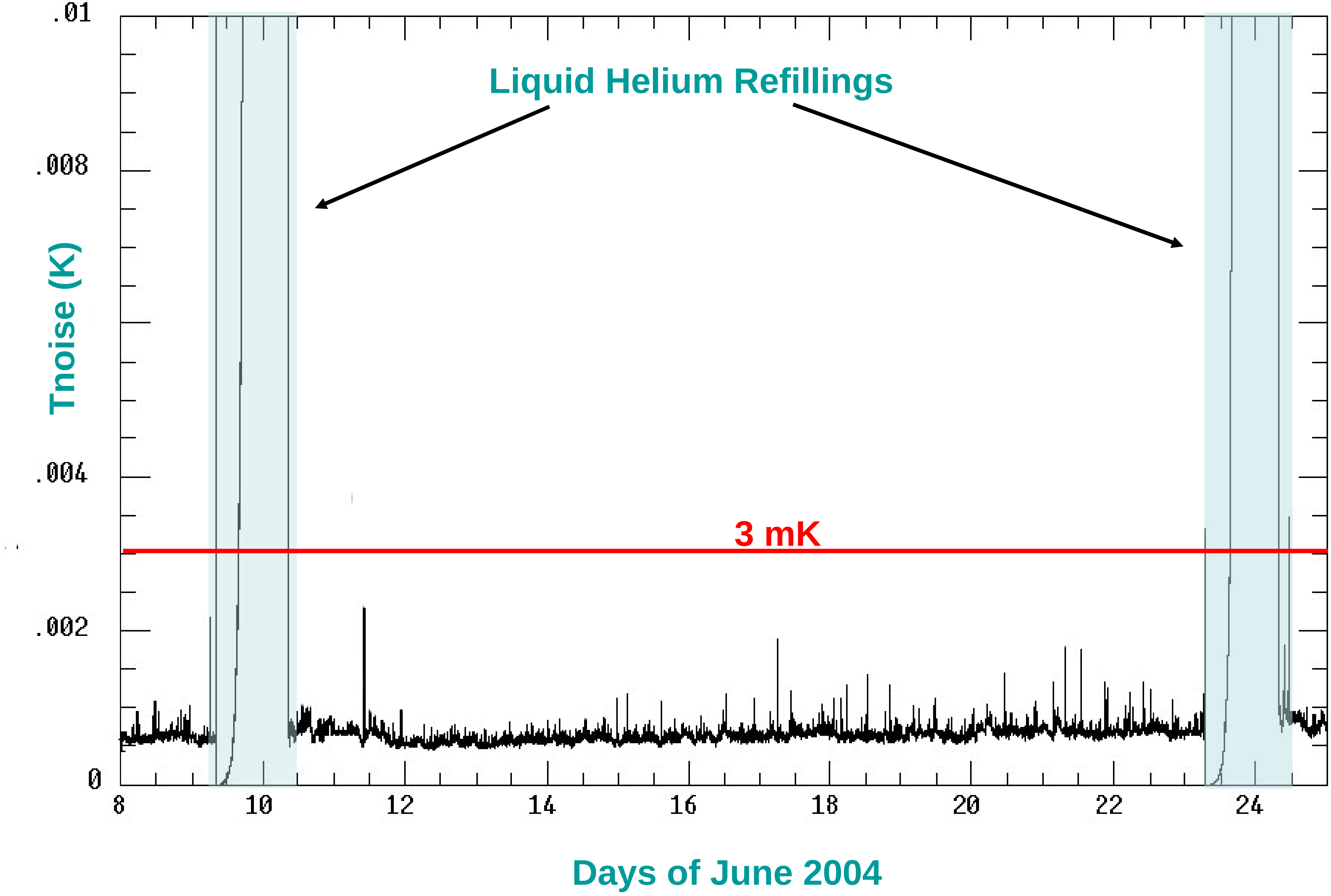
$2{*}10^{-21}$

Expected spectral density at 0.15 K



$6{*}10^{-22}$

$1.6{*}10^{-22}$



For ~ 80% of time the sensitivity to short gw bursts is better than $h=2.1*10^{-19}$

Sensitivity to short bursts:

$$h_c \sim \frac{\tilde{h}_{peak}}{\sqrt{\Delta f}}$$

Detectors having the same burst sensitivity h_c

detector	*strain sens.*	Δf	h_c
EXPLORER	$2\ 10^{-21}\ Hz^{-1/2}$	40 Hz	$4\ 10^{-19}$
Equivalent	$6.4\ 10^{-21}\ Hz^{-1/2}$	400 Hz	$4\ 10^{-19}$

The EXPLORER/NAUTILUS SEARCH FOR SHORT GW BURSTS

1997- 2000 IGEC search ***PRL 85, 5046 (2000)***

1998 931 hours; ***CQG 18, 43 (2001)***

2001 2156 hours; ***CQG 19, 5449 (2002)***

2003 3677 hours; analysis in progress

2004 data taking

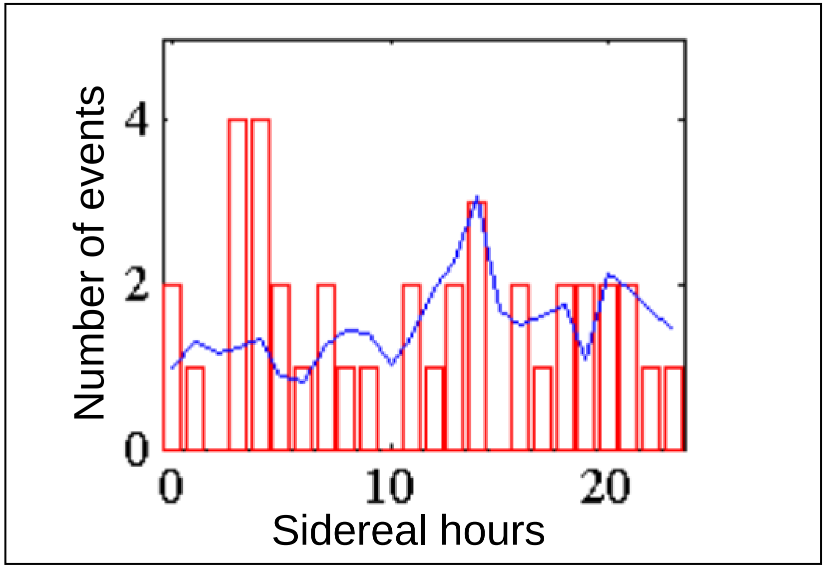
- 2001 Run - Classical and Quantum Gravity 19, 5449 (2002)

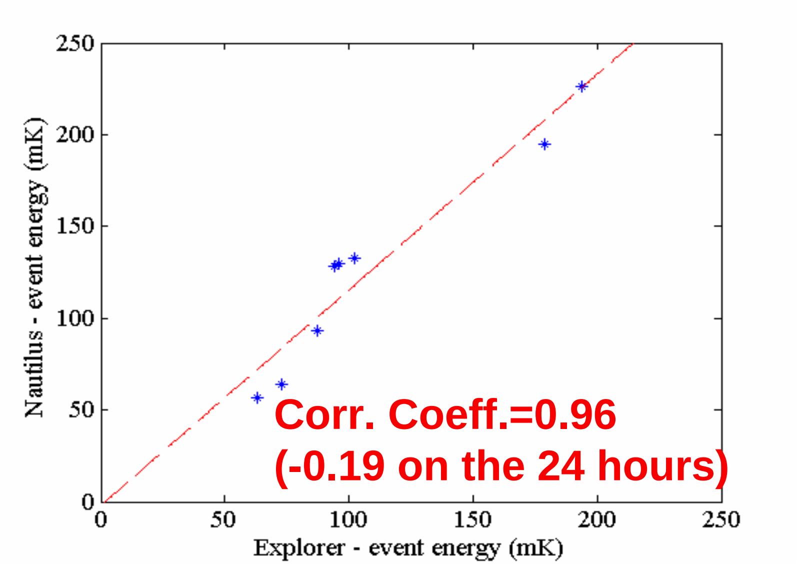
- **Unprecedented sensitivity**
- **Two powerful tools in the same analysis:**
  - **- amplitude (energy) consistency**
  - **- sidereal time analysis**
- **Define analysis procedure for the next run**

EXPLORER-NAUTILUS 2001 data analysis

*ROG Coll.: CQG **19**, 5449 (2002)*

During 2001 EXPLORER and NAUTILUS were the only two operating resonant detectors, with the best ever reached sensitivity.





Comments, analysis and studies

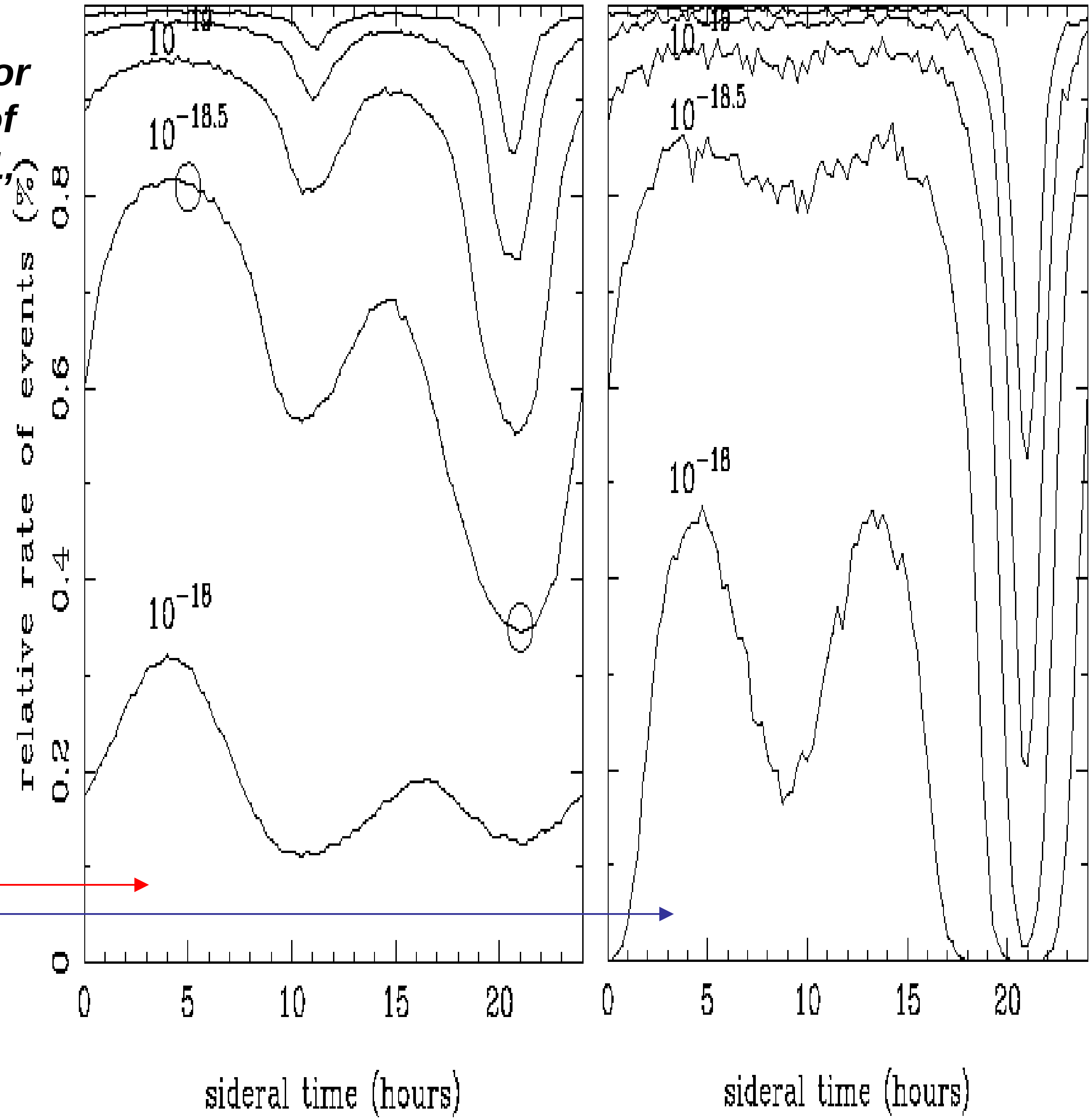
*L.S.Finn: CQG **20**, L37 (2003)*

P.Astone, G.D'Agostini, S.D'Antonio: CQG 20, 365 (2003) Proc. of GWDAW 2002, gr-qc/0304096

ROG Coll.:CQG 20, 395 (2003); Proc. of GWDAW 2002, gr-qc/0304004

E. Coccia, F. Dubath, M.Maggiore gr-qc 0405047

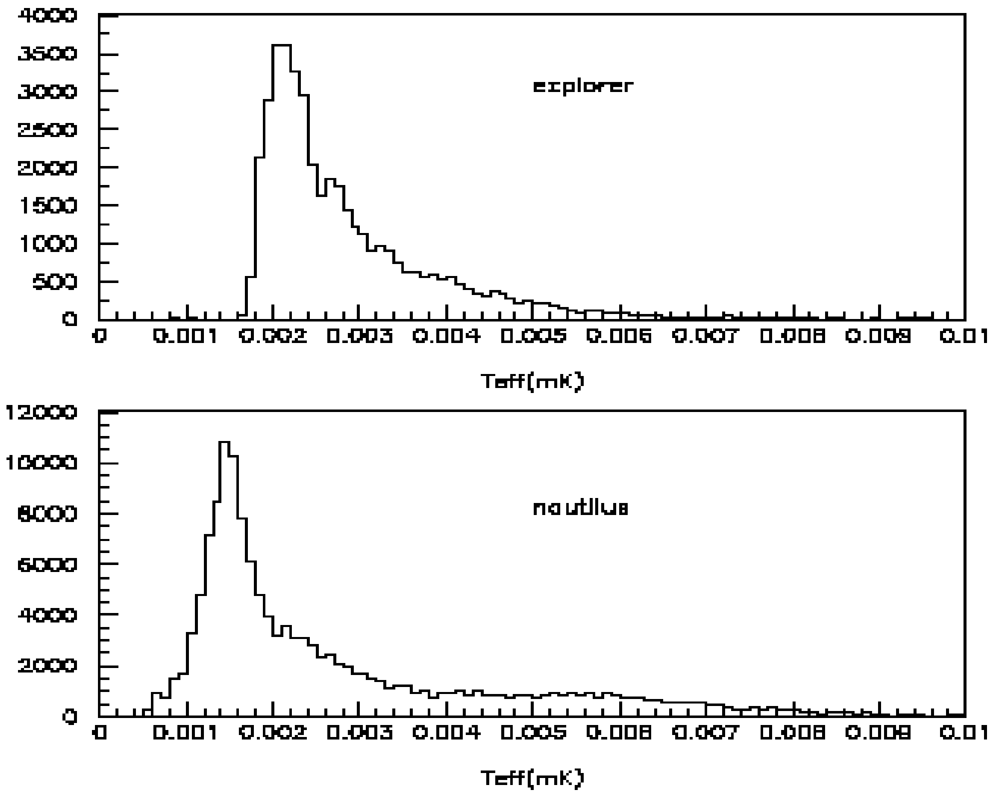
G. Paturel, Yu.V. Barishev
Sidereal time analysis as a tool for study of the space distribution of gw sources. Astro-ph/0211604v1, A&A 398, 377 (2003)



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

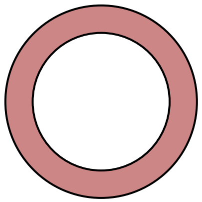
The 2003 Run: **153 days**

detector	latitude	longitude	azimuth	mass kg	freq. Hz	temp. K	band Hz
EXPLORER	46.45 N	6.20 E	39° E	2270	904.7 921.3	4	8.7
NAUTILUS	41.82 N	12.67 E	44° E	2220	926.3 941.5	4	9.6



Large hollow sphere *PRD 57, 2051 (1998)*

possibly underground - R&D in progress by ROG

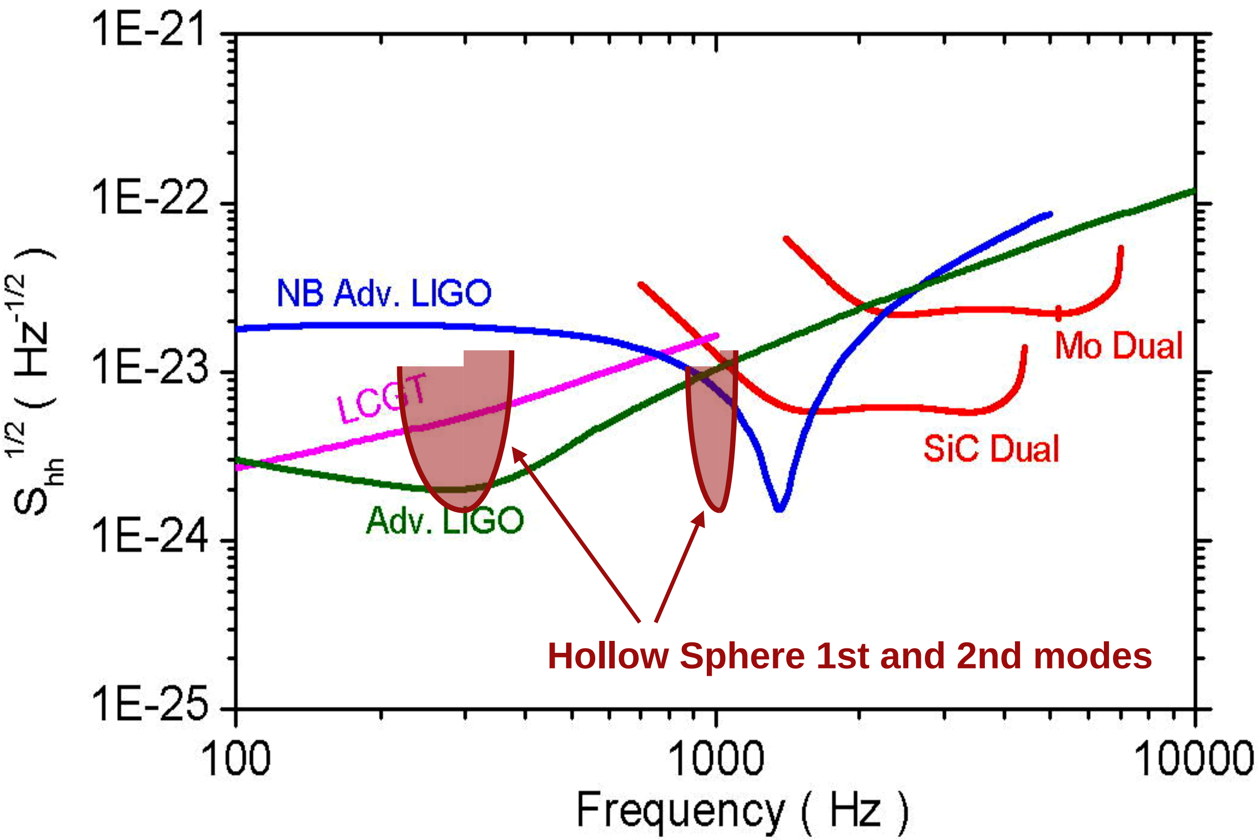


D = 4.8 m;
f_1=300 Hz;
f_2=1000 Hz;
SQL readout

Detection of collapses and chirps @ 200Mpc;
Stochastic Background : Ω_{gw}~ 10^{-8}

Determination of the chirp mass by double passage technique
(a chirp signal excites the two modes at different times)

***Phys. Lett. A* 213, 16 (1996)**



<u>R&D SFERA</u>

30 anni di operazione di barre criogeniche

LSU: studio della deconvoluzione del segnale e simmetria dei trasduttori

Leida/ROG: fattibilità criogenica, sospensioni

<u>2005: COMPLETAMENTO R&D SFERA</u>

Materiale (CuAl, Mo)

Tecnica di fabbricazione (electron beam)

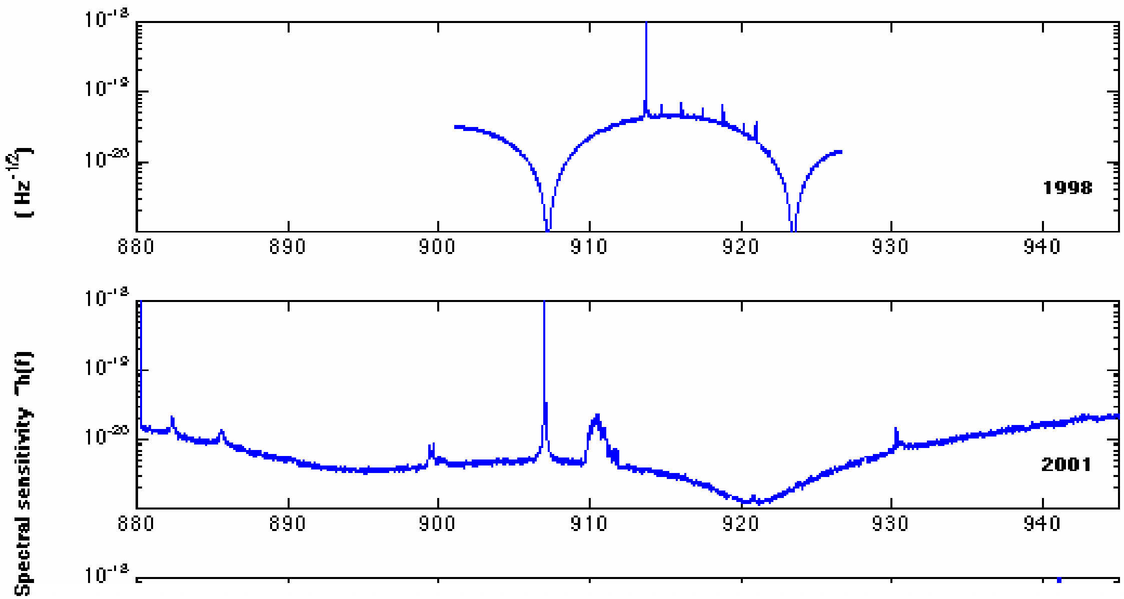
<u>LOI per Sfera al Gran Sasso</u>

ROG, LEIDA, Others (Fi-Urb., Barcellona, INR Mosca,….)

EXPLORER 2004

Duty cycle > 90%

Improved bandwith
since SR 2 (2001);
PRL 91 (2003) 111101

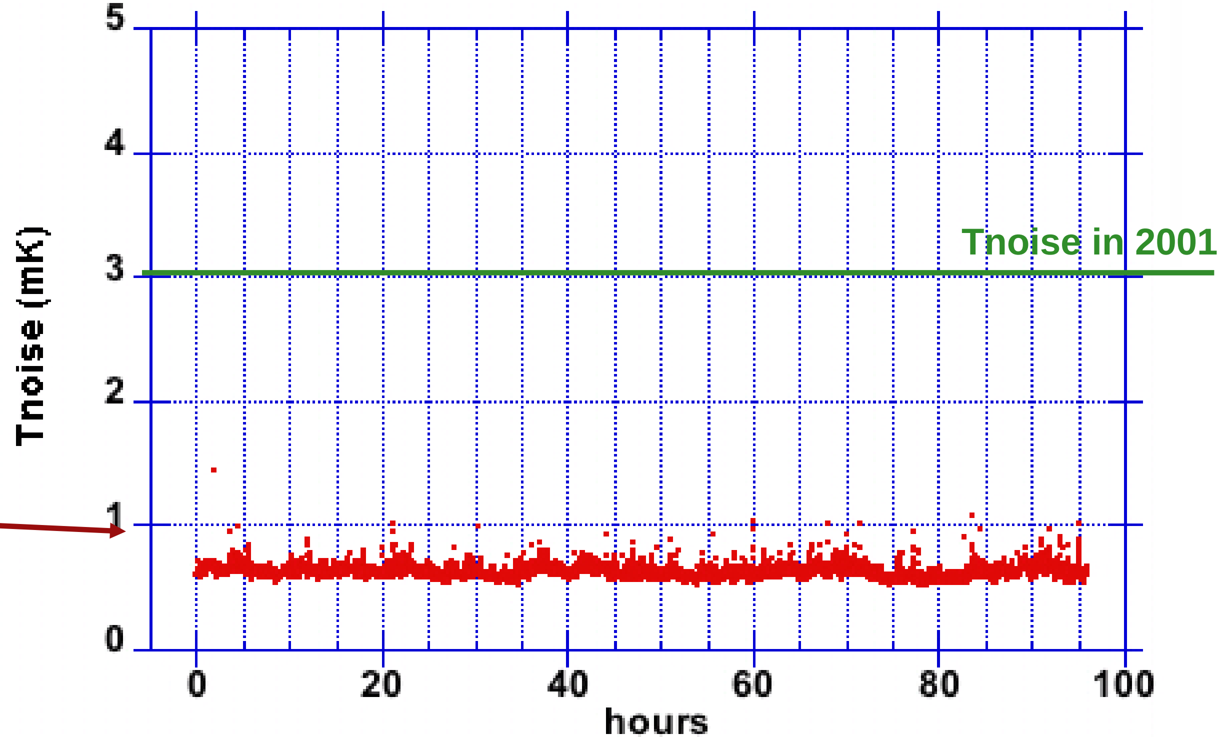


NAUTILUS 2004

Duty cycle > 90%

**Example: 100 hours in
june 2004 - 1 minute averages**

**All samples are below 1.4 mK
<Tnoise> = 628 μK**

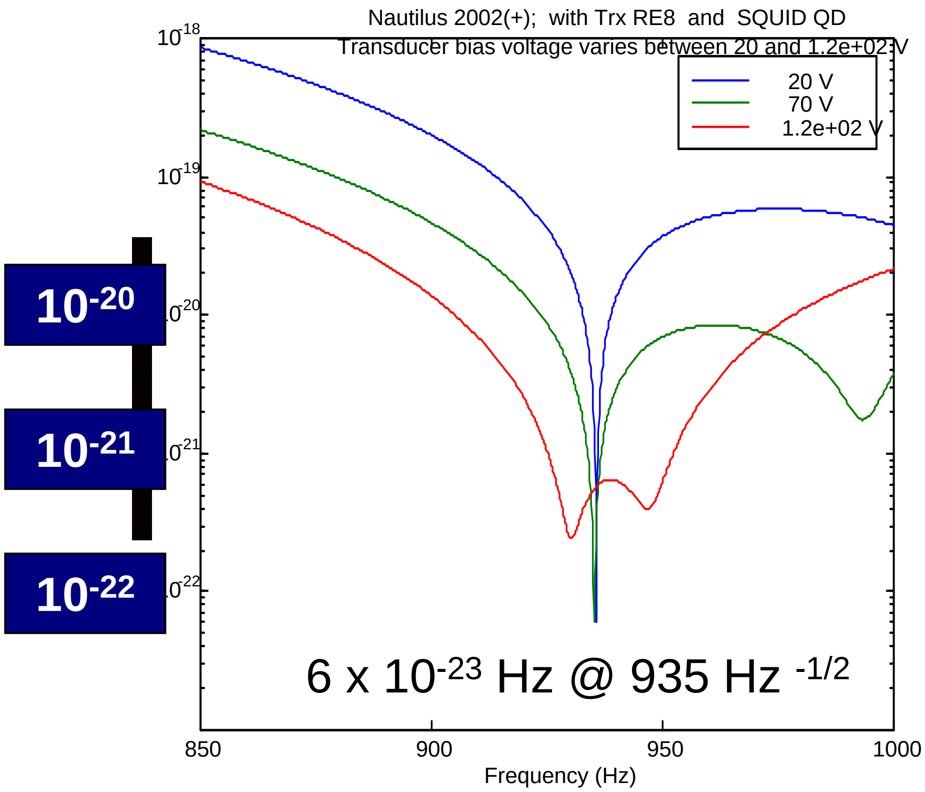


NAUTILUS
INFN Frascati Nat. Labs

2002: Tuning of the Nautilus antenna at 935 Hz for a possible detection of GW from the pulsar associated with SN1987A

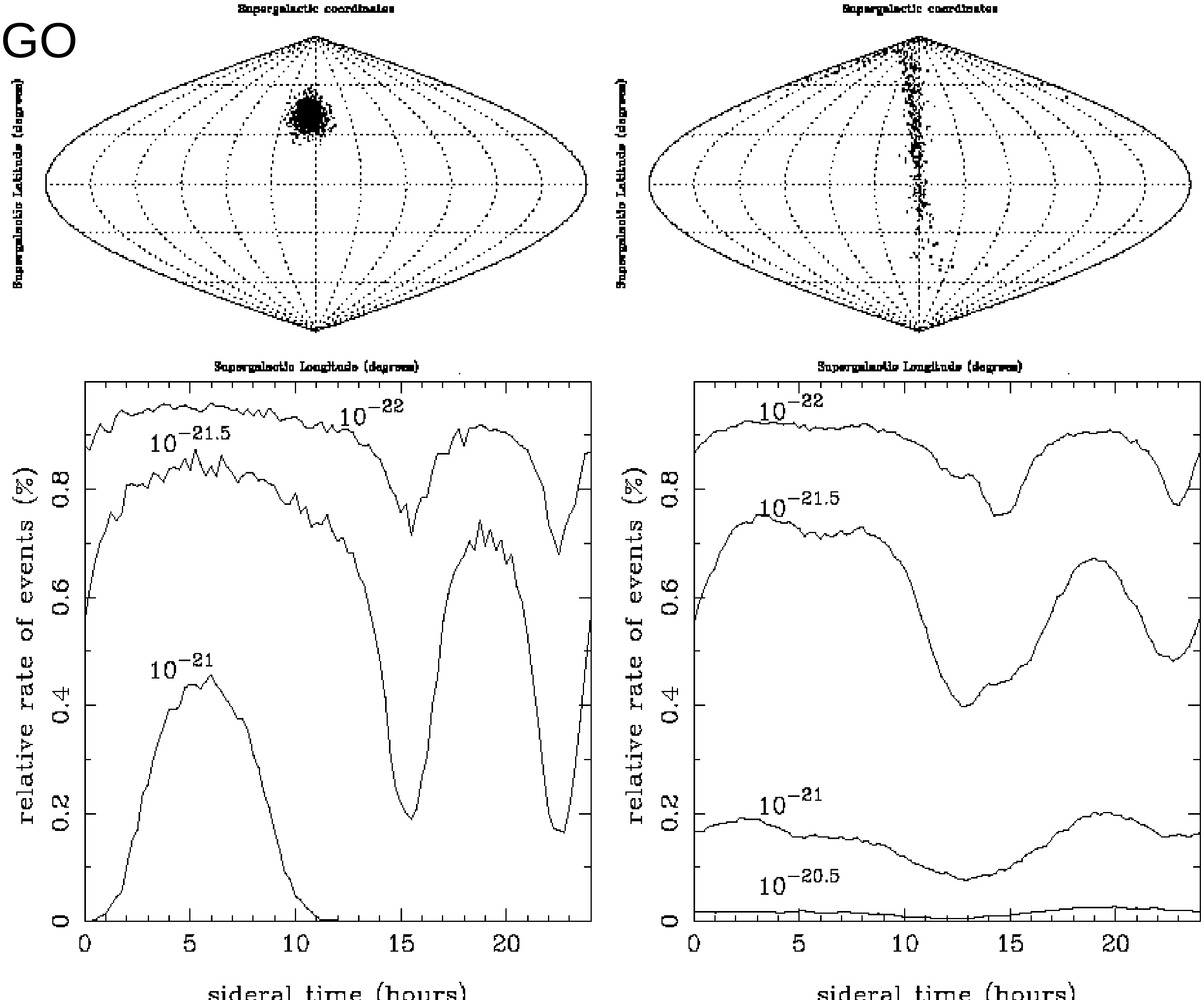
If the observed pulsar spindown is due to GW emission, we expect $h=4.7\times10^{-26}$ on Earth.

NAUTILUS can reach this sensitivity (SNR=1) with 1 month integration time if its spectral sensitivity at 935 Hz is $h=6\times10^{-23}\ Hz^{-1/2}$



G. Paturel, Yu.V. Barishev ***Astro-ph/0211604, A&A 398, 377 (2003)***

VIRGO



preliminary