EXPLORER and NAUTILUS

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Data taking during the last 10 years

**EXPLORER**

1990 91 92 93 94 95 96 97 98 99 00 01 02 03 04

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

**NAUTILUS**

1990 91 92 93 94 95 96 97 98 99 00 01 02 03 04

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

Class. Quant. Grav. 18, 43 (2001)

Continuous signals


Stochastic Background


Search for correlation with GRB’s

Gravitational near field

Effect of cosmic rays

more
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*

Time resolution vs bandwidth

Larger $\Delta f \Rightarrow$ smaller $\Delta t$

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)

Zoom
Peak=-0.05 msec
Sigma=3.8 msec
NAUTILUS spectral density at 3.5 K  
June 2003

Expected spectral density at 0.15 K
For ~ 80% of time the sensitivity to short gw bursts is better than $h = 2.1 \times 10^{-19}$
Sensitivity to short bursts:

\[ h_c \sim \frac{\tilde{h}_{\text{peak}}}{\sqrt{\Delta f}} \]

Detectors having the same burst sensitivity \( h_c \)

<table>
<thead>
<tr>
<th>detector</th>
<th>strain sens.</th>
<th>( \Delta f )</th>
<th>( h_c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPLORER</td>
<td>( 2 \times 10^{-21} \text{ Hz}^{-1/2} )</td>
<td>40 Hz</td>
<td>( 4 \times 10^{-19} )</td>
</tr>
<tr>
<td>Equivalent</td>
<td>( 6.4 \times 10^{-21} \text{ Hz}^{-1/2} )</td>
<td>400 Hz</td>
<td>( 4 \times 10^{-19} )</td>
</tr>
</tbody>
</table>
The EXPLORER/NAUTILUS SEARCH FOR SHORT GW BURSTS


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

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

2003 3677 hours; analysis in progress

2004 data taking
• 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
ROG Coll.:CQG 20, 395 (2003); Proc. of GWDAW 2002, gr-qc/0304004
E. Coccia, F. Dubath, M.Maggiore gr-qc 0405047

Corr. Coeff.=0.96 (-0.19 on the 24 hours)
G. Paturel, Yu.V. Barishev

The expected rate of events on EXPLORER for sources on the galactic disc and on the GC
The 2003 Run: 153 days

<table>
<thead>
<tr>
<th>detector</th>
<th>latitude</th>
<th>longitude</th>
<th>azimuth</th>
<th>mass (kg)</th>
<th>freq. (Hz)</th>
<th>temp. (K)</th>
<th>band (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPLORER</td>
<td>46.45 N</td>
<td>6.20 E</td>
<td>39° E</td>
<td>2270</td>
<td>904.7</td>
<td>4</td>
<td>8.7</td>
</tr>
<tr>
<td>NAUTILUS</td>
<td>41.82 N</td>
<td>12.67 E</td>
<td>44° E</td>
<td>2220</td>
<td>921.3</td>
<td>4</td>
<td>9.6</td>
</tr>
</tbody>
</table>
Large hollow sphere *PRD 57, 2051 (1998)*

possibly underground - R&D in progress by ROG

Detection of collapses and chirps @ 200Mpc; Stochastic Background : $\Omega_{gw} \sim 10^{-8}$

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)*

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

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**Hollow Sphere 1st and 2nd modes**
R&D SFERA

30 anni di operazione di barre criogeniche

LSU: studio della deconvoluzione del segnale e simmetria dei trasduttori

Leida/ROG: fattibilità criogenica, sospensioni

2005: COMPLETAMENTO R&D SFERA

Materiale (CuAl, Mo)

Tecnica di fabbricazione (electron beam)

LOI per Sfera al Gran Sasso

ROG, LEIDA, Others (Fi-Urb., Barcellona, INR Mosca,....)
EXPLORER 2004
Duty cycle > 90%

Improved bandwidth 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
$\langle T_{\text{noise}} \rangle = 628 \, \mu K$
If the observed pulsar spindown is due to GW emission, we expect $h=4.7 \times 10^{-26}$ on Earth.

**NAUTILUS** can reach this sensitivity (SNR=1) with 1 month integration time if its spectral sensitivity at 935 Hz is $h=6 \times 10^{-23}$ Hz$^{-1/2}$.
preliminary