17th International Conference on General Relativity and Gravitation
Dublin, July 18-23, 2004

Present status of EXPLORER and NAUTILUS

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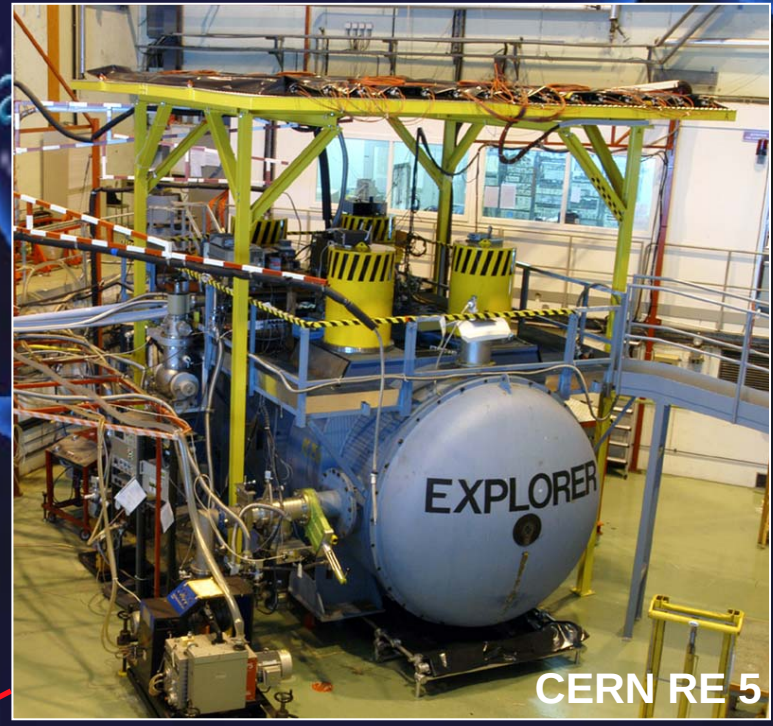
ROG Collaboration

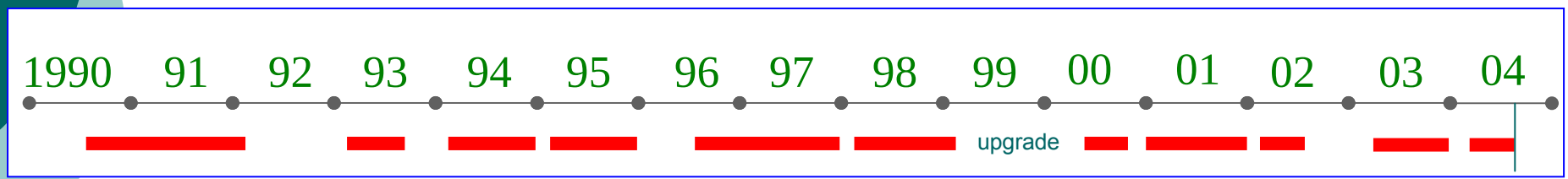

Interferometer
Resonant-Mass
MiniGrail
GEO
EXPLORER
AURIGA
VIRGO
NAUTILUS


EXPLORER
CERN RE 5


INFN Frascati

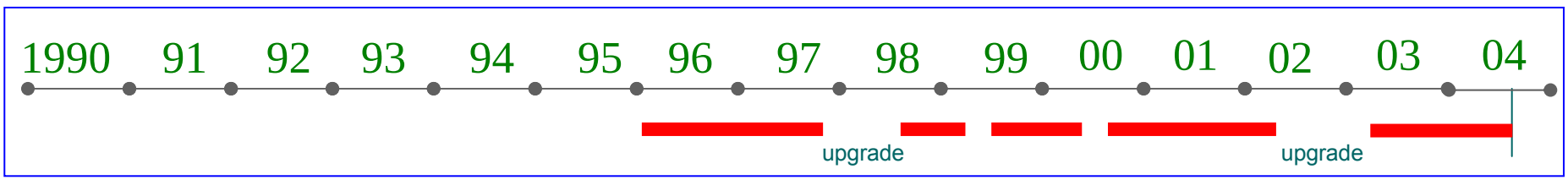
Data taking during the last 10 years

EXPLORER



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

NAUTILUS

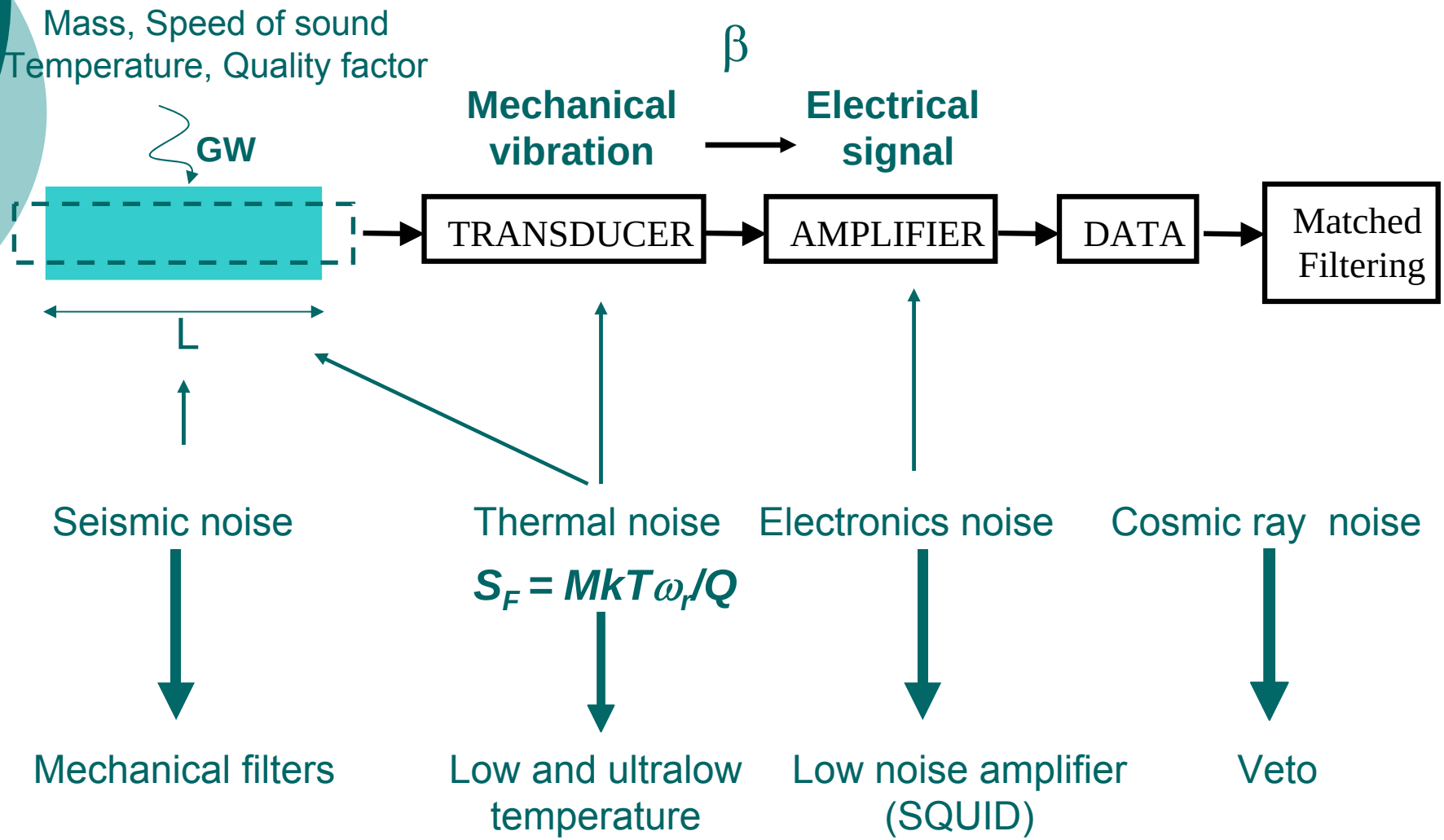


h from 10^{-18} to $2 \cdot 10^{-19}$

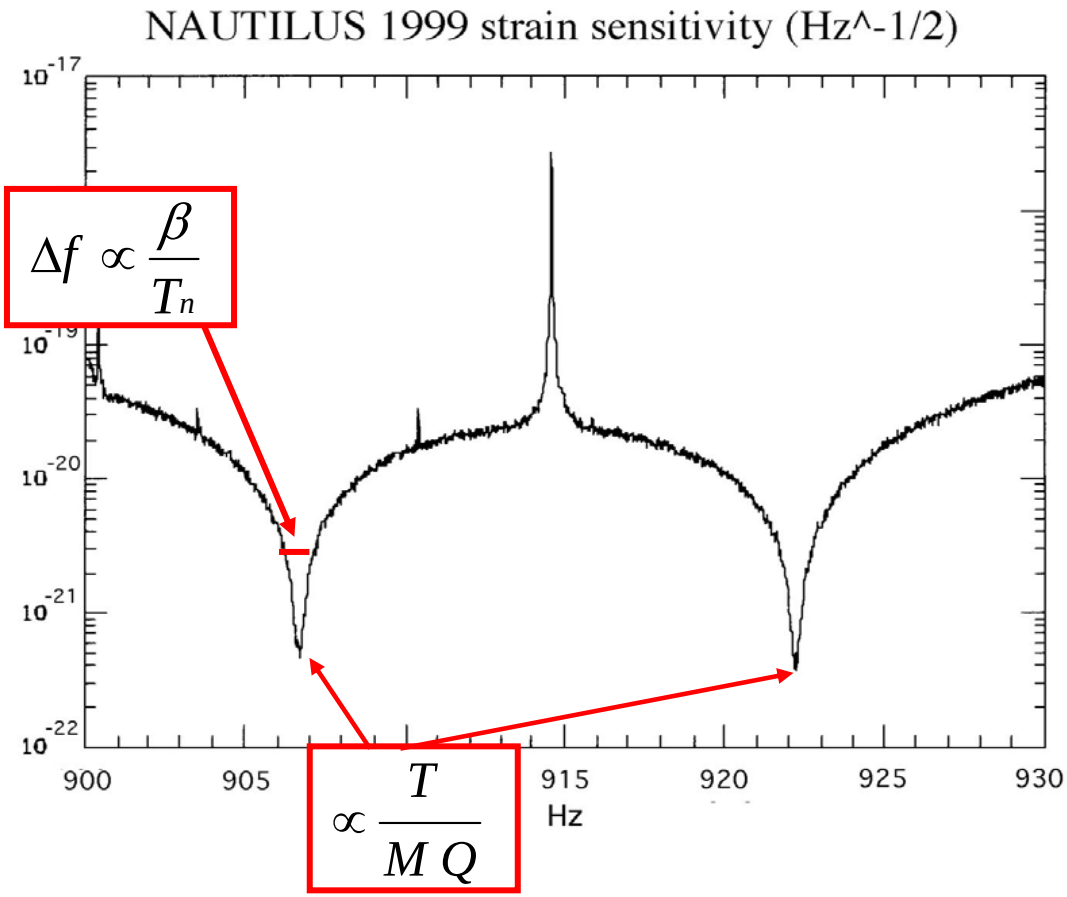
GRAVITATIONAL WAVE DETECTORS

The GW excites the longitudinal mode of vibration of a massive (~2 ton) cylinder

$$h = \frac{\Delta L}{L}$$



Sensitivity of bar detectors



The sensitivity of a detector is usually given in terms of the noise spectral density referred to the input of the antenna $\tilde{h}(f)$

$$\tilde{h}(f_0) \propto \sqrt{\frac{T}{MQ}}$$

$$\Delta f \propto \sqrt{\frac{\beta}{T_n}}$$

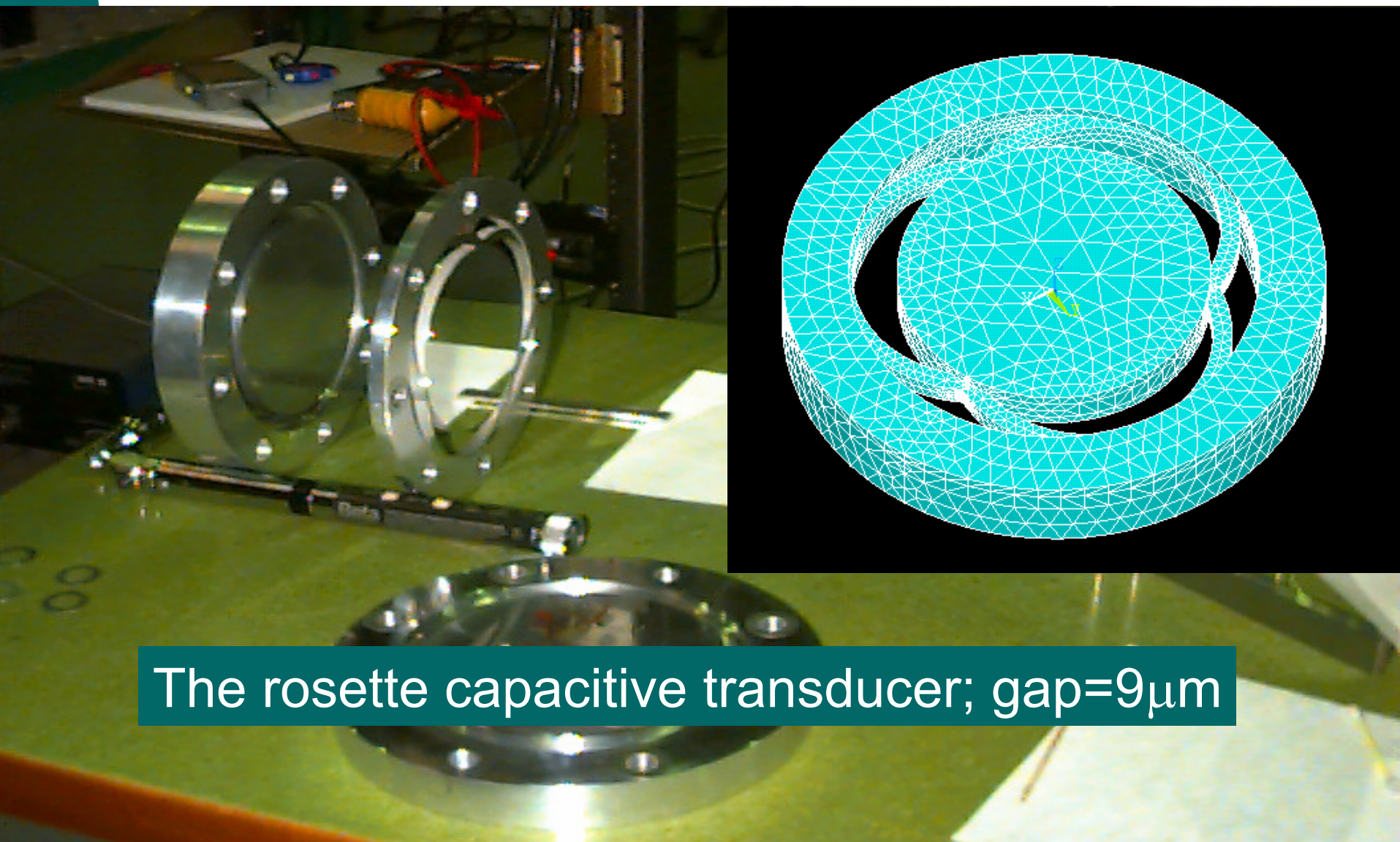
$$\Delta E_{\min} = k_B T_{eff} \approx \frac{k_B T}{\beta Q} + 2k_B T_n$$

We need to broaden AND deepen the dips in this curve:

⇒ More peak sensitivity

⇒ AND more bandwidth

MICROMECHANICS



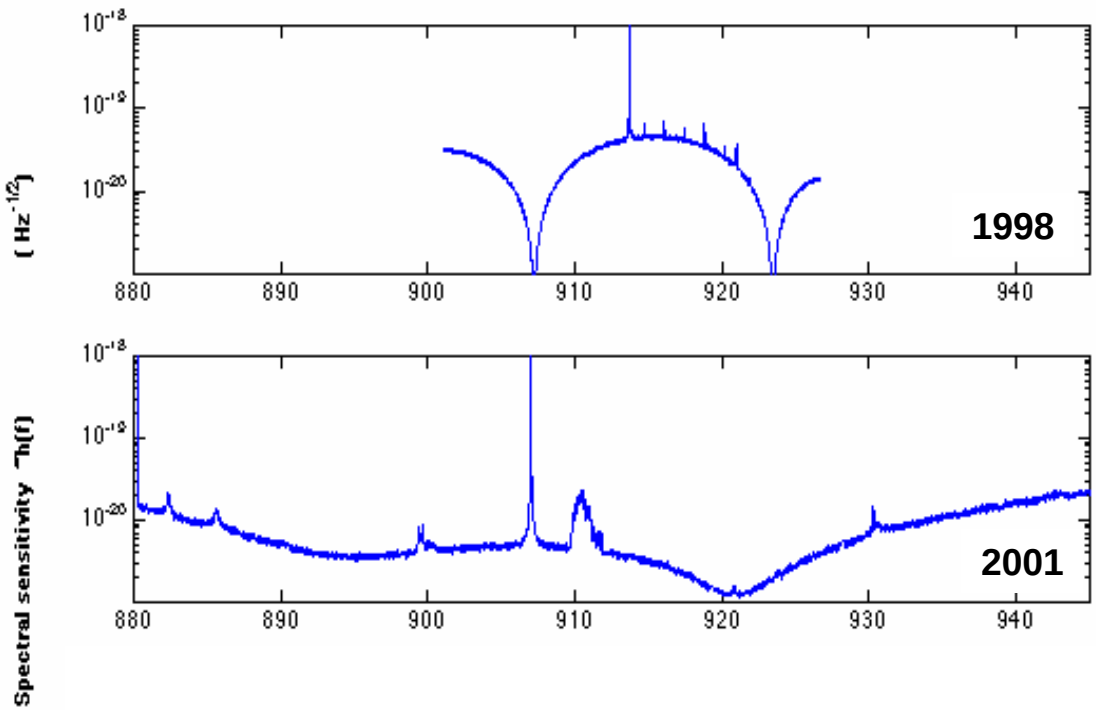
The rosette capacitive transducer; gap=9μm

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} $Hz^{-1/2}$ on a band larger than 50 Hz

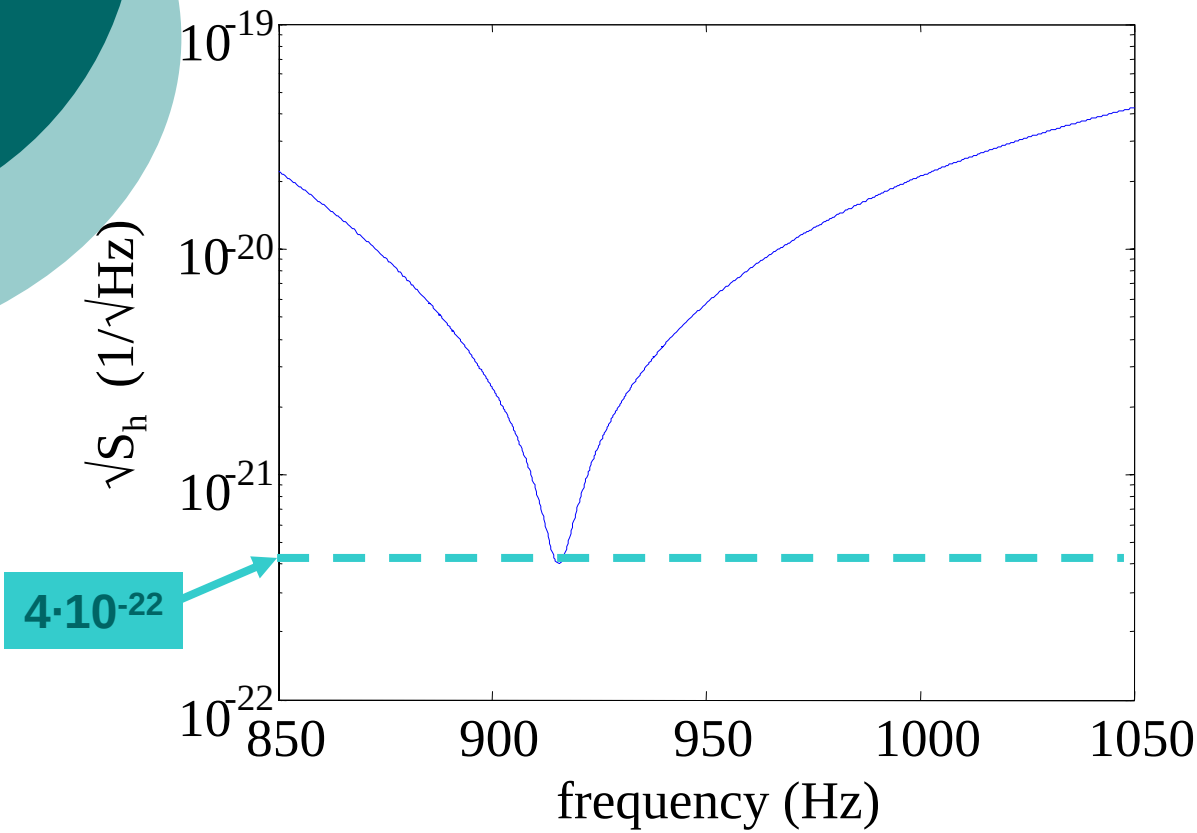
The noise temperature is < 3 mK (h=4.4 10^{-19}) for 84% of the time.



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

TARGET SENSITIVITY OF EXPLORER

EXPLORER can reach a sensitivity of T_{eff}=150 μK and h=10^{-19} and Δf≈90 Hz at the level of $10^{-20}/Hz^{1/2}$

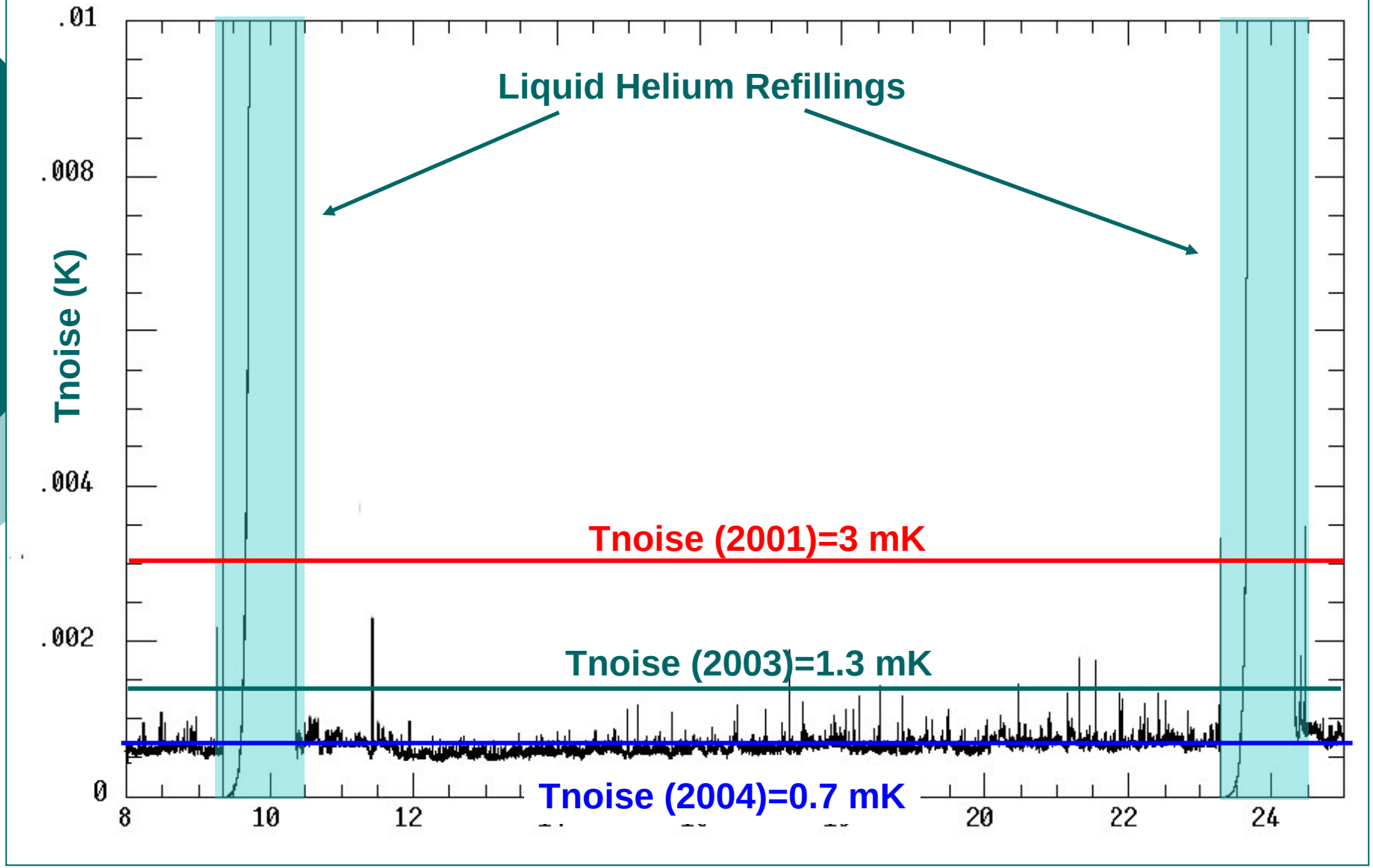


- New transducer double gap
- New transformer higher elect. Q
- New Double SQUID system

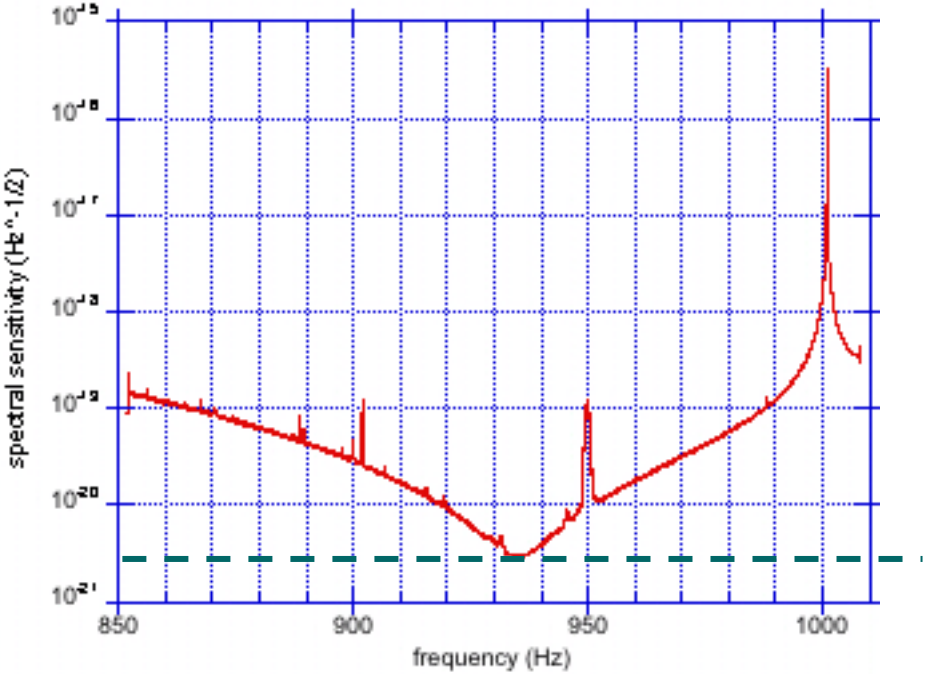
NAUTILUS 2003

- ν_a= 935 Hz
- new antenna suspension cable
- new capacitive transducer
- new high-Q SC transformer
- Quantum Design dc SQUID

The bar was cooled down to 3.5 K in april 2003. Data taking is under way.



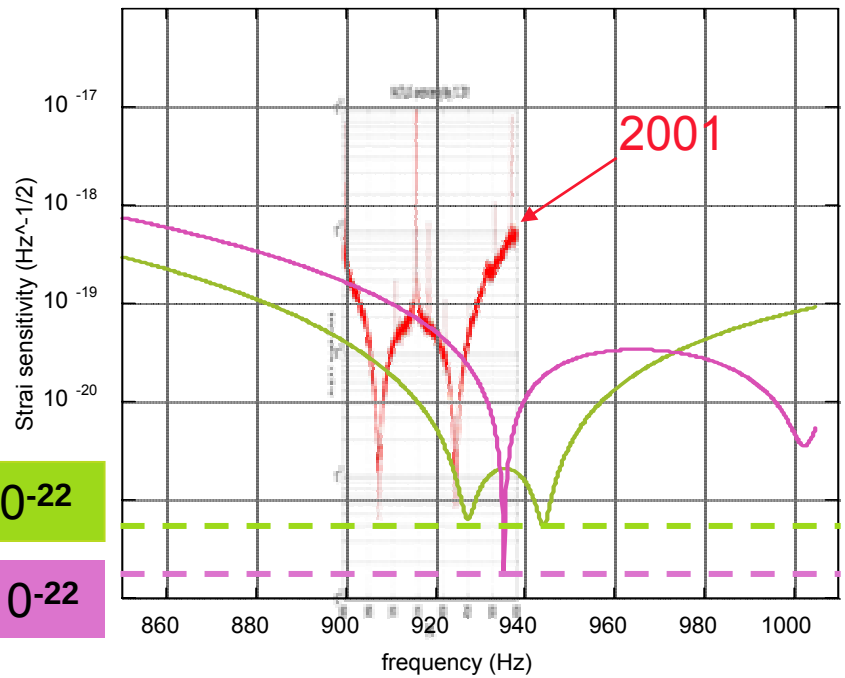
For ~ 80% of time the sensitivity to short gw bursts is better than $h=2.1\cdot10^{-19}$



NAUTILUS spectral density at 3.5 K
June 2004

$2 \cdot 10^{-21}$

Expected spectral density at 0.15 K



$6 \cdot 10^{-22}$

$1.6 \cdot 10^{-22}$

Bursts

Continuous signals

Stochastic Background

more

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

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

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

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

Gravitational near field effects
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

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

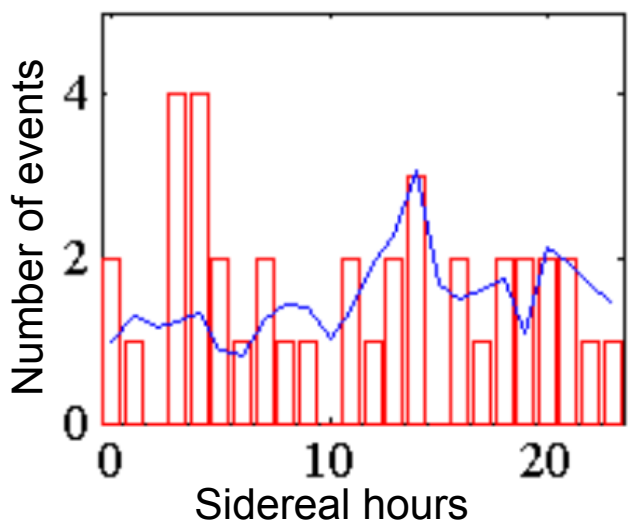
2004 data taking

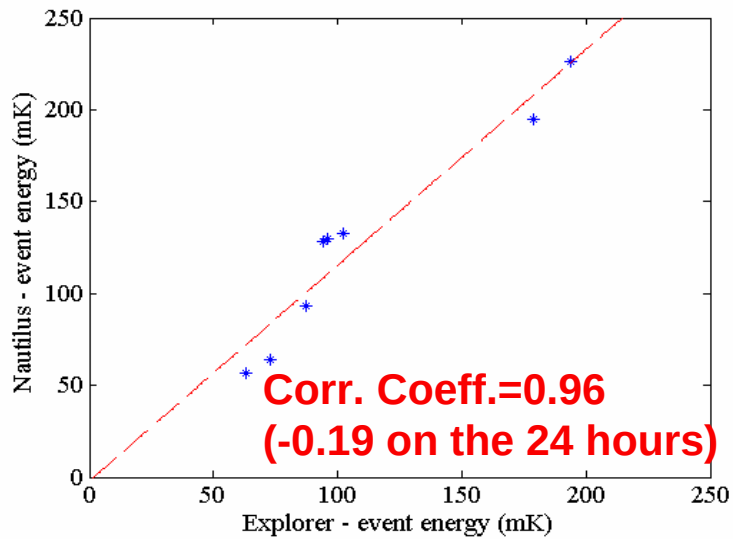
EXPLORER-NAUTILUS 2001 data analysis

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

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

A new algorithm based on energy compatibility of the event was applied to reduce the "background"





Comments, analysis and studies

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

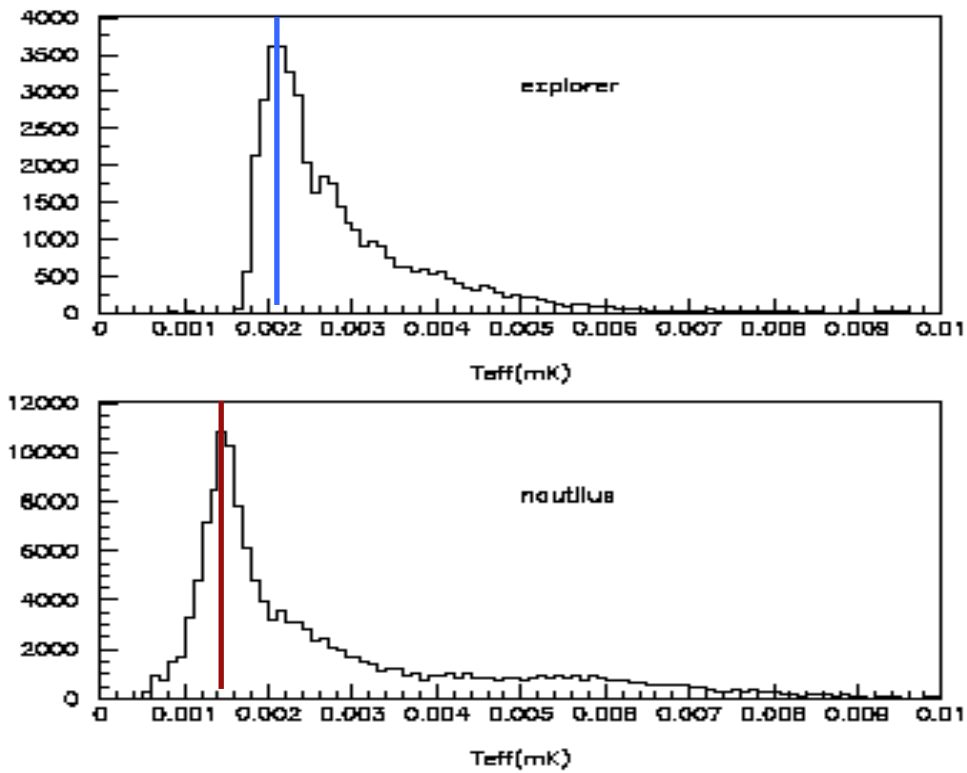
*P.Astone, G.D'Agostini, S.D'Antonio: CQG **20**, S769 (2003)*

*ROG Coll.:CQG **20**, S785 (2003)*

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

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



Stochastic Background

Crosscorrelation of EXPLORER and NAUTILUS data

ROG Coll.: Astron. and Astrophys, 351, 811-814, (1999)

12 hours of data

$\Delta f = 0.1$ Hz

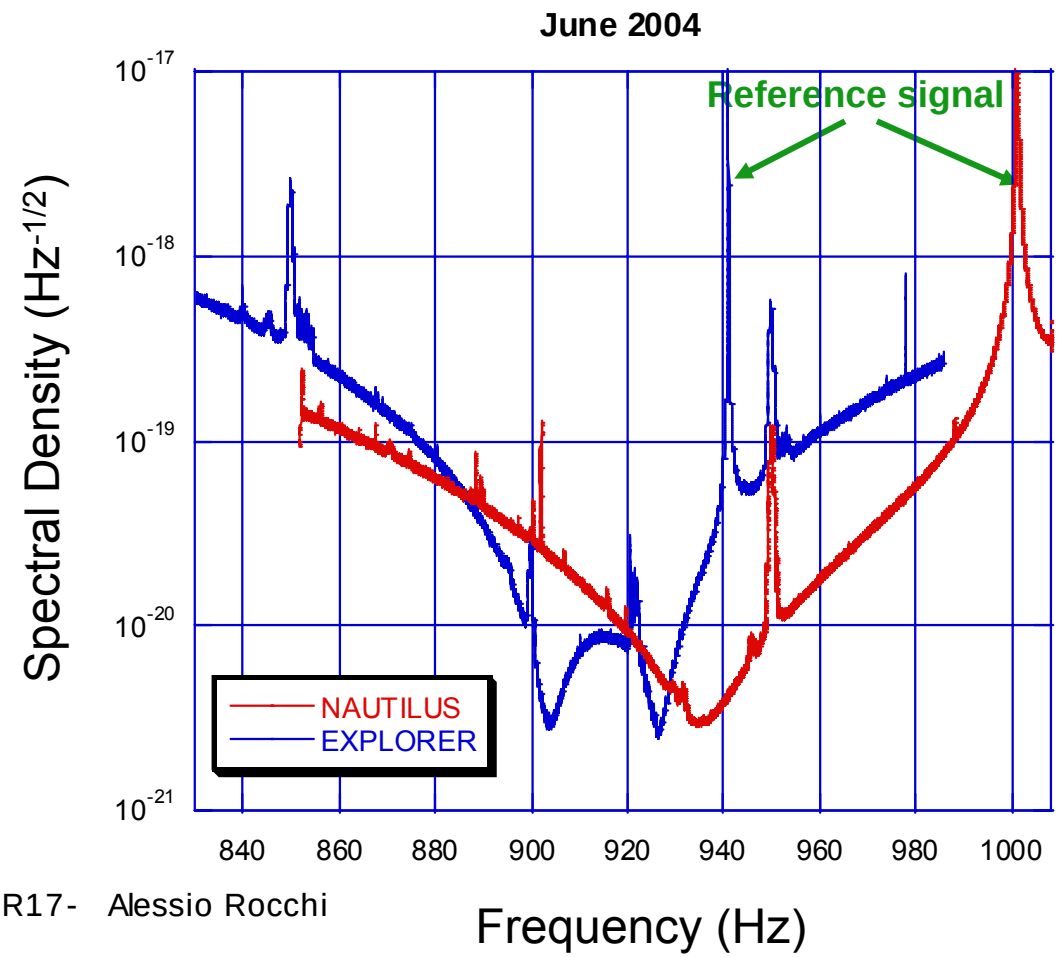
$S_{12} < 1 \times 10^{-44}$ Hz^{-1}

Ω_{GW} (920.2 Hz) < 60

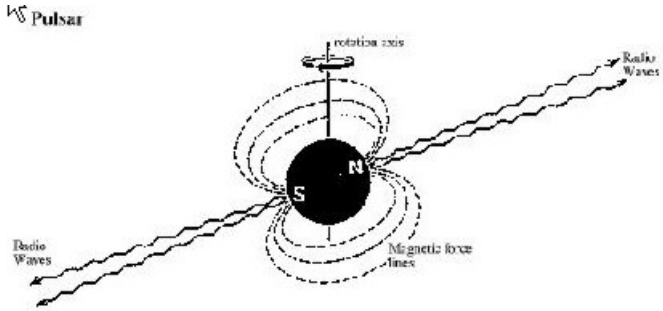
Will optimize overlapping bandwidth by acting on the bias E field.

Potential common band is ~ 30 Hz = 300 x that exploited in `99.

If T_{obs} = 4 months $\Rightarrow \Omega_{GW} < 0.4$



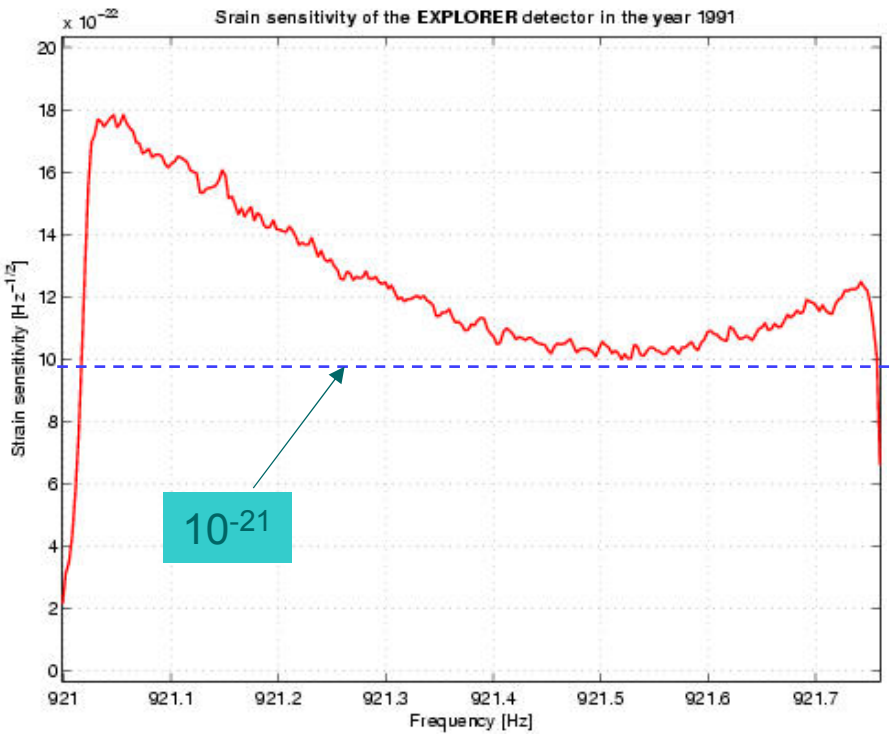
Continuous waves



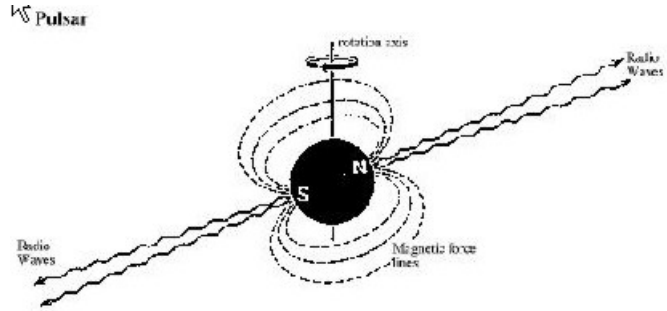
Limit for signals in the GC, using 95 days of EXPLORER data $h_c=3\cdot10^{-24}$, in the range 921.32 - 921.38 Hz (Astone et al. *PRD, 2002*)

Overall Sky Search

- Phase I: over 2 days of EXPLORER 1991 data in collaboration with A. Krolak and collaborators put an upper limit of $h_c=2\cdot10^{-23}$. (10^8 points, by choosing spin-down parameter and position randomly) (CQG, proc. GWDAW 2002)



Continuous waves



Phase II and III ended: collaboration with Krolak & C. and the Virgo Project Group in Rome.

2 stretches of data lasting 2 days each disjoint from the two-day stretch analysed in the previous search.

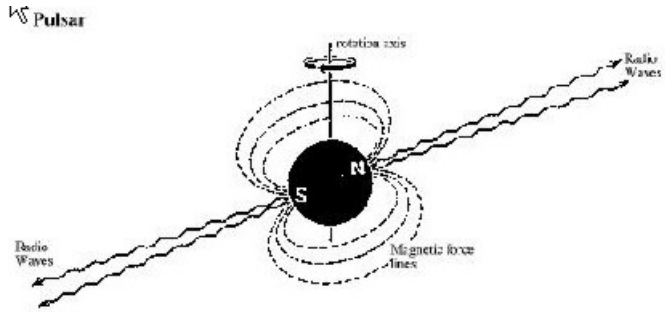
Search done using the computers provided by the Virgo Project (March-May 2003). Number of candidates found: 29909.

Comparison of candidates found in the three searches is now in progress.

The results of the search will be compared with those of an analysis done using the hierarchical search procedure, developed by the Virgo group of Rome, in collaboration with the ROG group (this work is now in progress). The aim is to analyze at least 1 year of data of EXPLORER and NAUTILUS.

www.astro.uni.torun.pl/~kb/all-sky and www.roma1.infn.it/rog

Continuous waves



Agreement between ROG and Max Planck in Golm for the coherent All-Sky analysis (search for pulsars) of data selected from 1 year of data of Nautilus 2001.

The data base of FFTs (17193 FFTs, 28 minutes each, in the format used by GEO/LIGO in their analysis) has been produced and is now in the cluster in Golm.

The procedures to veto the data have been set.

Effect of cosmic rays on a resonant detector

Grüneisen coefficient

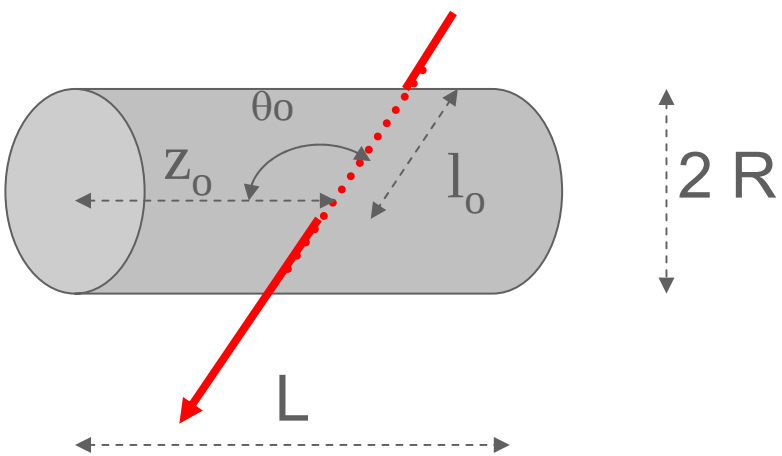
Energy lost

$$E = \frac{4}{9\pi}\frac{\gamma^2}{\rho L v^2}\left(\frac{dW}{dx}\right)^2\left(\sin\left(\frac{\pi z_o}{L}\right)\frac{\sin(\pi l_o \cos(\theta_o)/2L)}{\pi R\cos(\theta_o)/L}\right)^2 = 7.64\cdot 10^{-9} W^2 f \left[\frac{K}{GeV^2}\right]$$

density

sound velocity

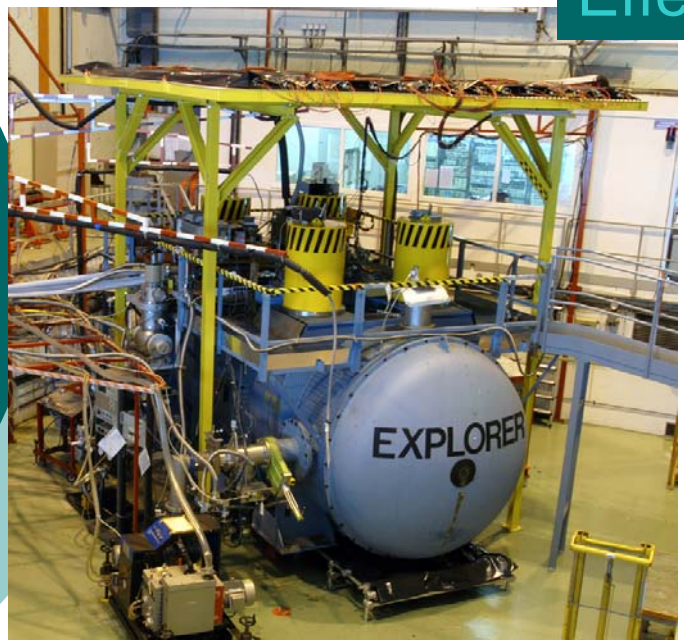
Calculation for Nautilus



$$\delta T = \frac{\delta E}{\rho C V_0} \qquad \delta p = \gamma \frac{\delta E}{V_0} \qquad \gamma = \frac{\alpha Y}{\rho C}$$

The longitudinal mode of vibration of the antenna is excited by the thermal expansion due to the energy lost by the particles

Effect of cosmic rays



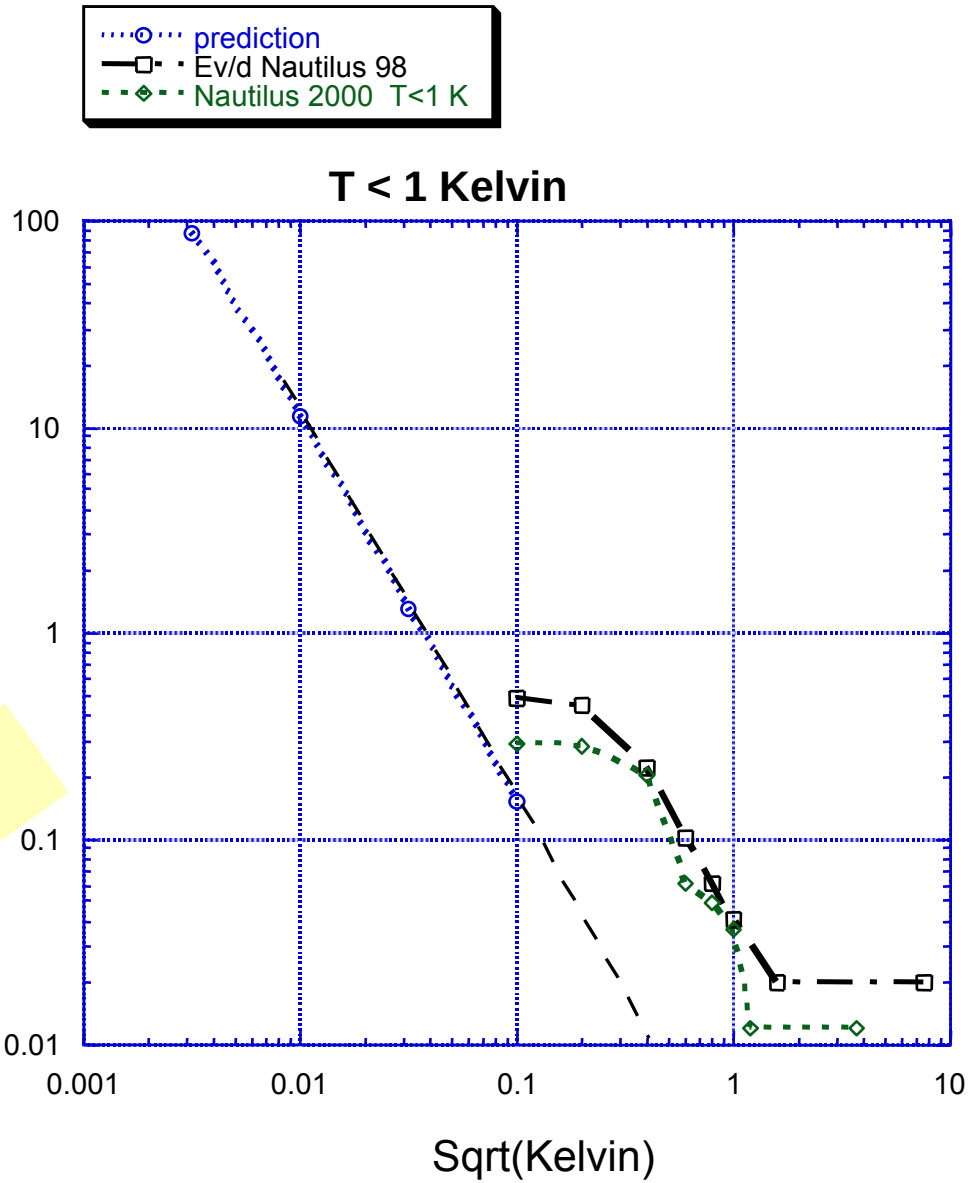
EXPLORER is equipped with 3 layers (2 above the cryostat - area 13m^2 - and 1 below -area 6 m^2) **of Plastic Scintillators.**

NAUTILUS is equipped with 7 layers (3 above the cryostat - area 36m^2/each - and 4 below -area 16.5 m^2/each) **of Streamer tubes.**

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 ST detector (saturation for M≥10^3 particles/m^2) and the data of the antenna, sampled each 4.54 ms and processed by a filter matched to δ signals

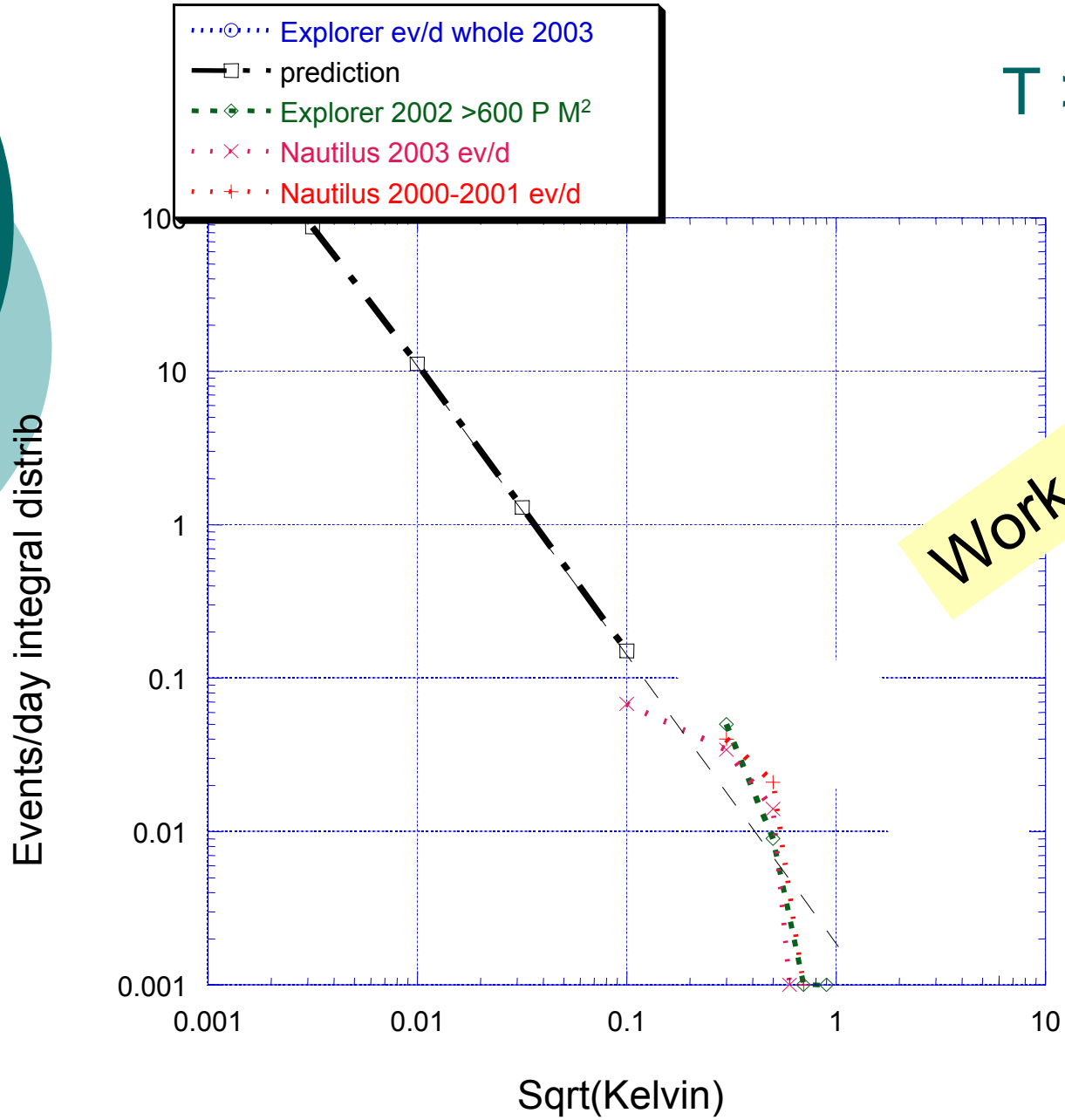
ΔE = 1 mK = 0.15 μeV

T < 1 Kelvin



Work in progress!!

T > 1 Kelvin



Work in progress!!

Effect of cosmic rays

RAP

Rivelazione Acustica di Particelle