THE GRAVITATIONAL WAVE EXPERIMENT OF THE ROME GROUP (ROG)

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P.Astone, M.Bassan, P.Bonifazi, P.Carelli, E.Coccia, C.Cosmelli, V.Fafone, S.Frasca, A.Marini, E.Mauceli, S.Merkowitz, Y.Minenkov, I.Modena, G.Modestino, A.Moleti, G.V.Pallottino, M.A.Papa, G.Pizzella, P.Rapagnani, F.Ricci, F.Ronga, M.Spinetti, R.Terenzi, M.Visco, L.Votano

1. **Explorer**
2. **Nautilus**
3. **SFERA**

LIGO-G980073-09-M

SELECTED PUBBLICATIONS OF THE ROME GROUP

1. "First gravity wave coincidence experiment between three resonant
E. Amaldi et al
Astronomy and Astrophysics,vol216,pag 325-332,june 1989.

2."Evaluation and preliminary measurement of the interaction of a dynamical gravitational near field with a cryogenic gravitational wave antenna"
P. Astone et al
Zeit. Script C - Particles and Fields, 50,21 (1991)

3. "First Cooling of the new Ultra Low Temperature Gravitational wave antenna Nautilus"
P. Astone et al
Europhysics Letters , 16(3),pp.231-235(1991)

4. "An Adaptive Filter for Gravitational-Wave Antenna"
P.Astone, P.Bonifazi, S.Frasca, G.V.Pallottino, G.Pizzella,
Il Nuovo Cimento, 15C, pag. 447, (1992).

5. "Long-term operation of the Rome Explorer cryogenic gravitational wave detector"
P.Astone et al
Physical Review D, 47, 2, January (1993).

6. "Upper limit for nuclearite flux from the Rome gravitational wave resonant detectors"
P.Astone et al
Physical Review D,47,10,4770-4773 (May 1993)

7. "Coalescing binaries and spherical gravitational wave detectors"
E. Coccia, V. Fafone,
Physics Letters A, 213, 16-22, 1996.

8. "Eigenfrequencies and quality factors of vibration of spherical resonators"
Coccia, et al.
Physics Letters A 219, 263-270, 1996.

9. "Testing Theories of Gravity with a Spherical Gravitational Wave Detector".
M. Bianchi, E. Coccia, C.N. Colacino, V. Fafone, F. Fucito,
Class. Quantum Grav. 13, 1 (1996).

10. "The fast matched filter for gravitational wave data analysis: characteristics and applications"
P.Astone, C.Buttiglione, S.Frasca, G.V.Pallottino, G.Pizzella
Il Nuovo Cimento 20,9,1997

11. "Resonant gravitational waves antennas for stochastic background measurements"
P.Astone, G.V.Pallottino, G.Pizzella
Classical and Quantum Gravity 14 (1997) 2019

12. "The gravitational wave detector NAUTILUS"
P. Astone et al
Astroparticle Physics 7 (1997) 231-243

13. "A search for gravitational radiation from SN 1993J"
Mauceli et al LSU
Astone et al ROG
Physical Review D, 56 (1997), pag.6081

14. "Gravitational-wave stochastic background detection with resonant-mass detectors"
S.Vitale, M.Cerdonio, E.Coccia, A.Ortolan
Phys. Rev. D 55, 1741 (1997)

15. "Search for correlation of gamma ray bursts with gravitational wave data"
P.Modestino et al.
Proc. Gravitational Wave Data Analysis Worshop 2
Orsay, November 1997

16. "On the efficiency of the coincidence search in gravitational wave experiments"
P.Astone, G.P.Pallottino, G.Pizzella
GRG Journal 30, (1998) 105-114

17. "On the detection of stochastic gravitational waves with resonant detectors"
P.Astone et al.
To be published, 1998

RESONANT DETECTORS

Spectral density

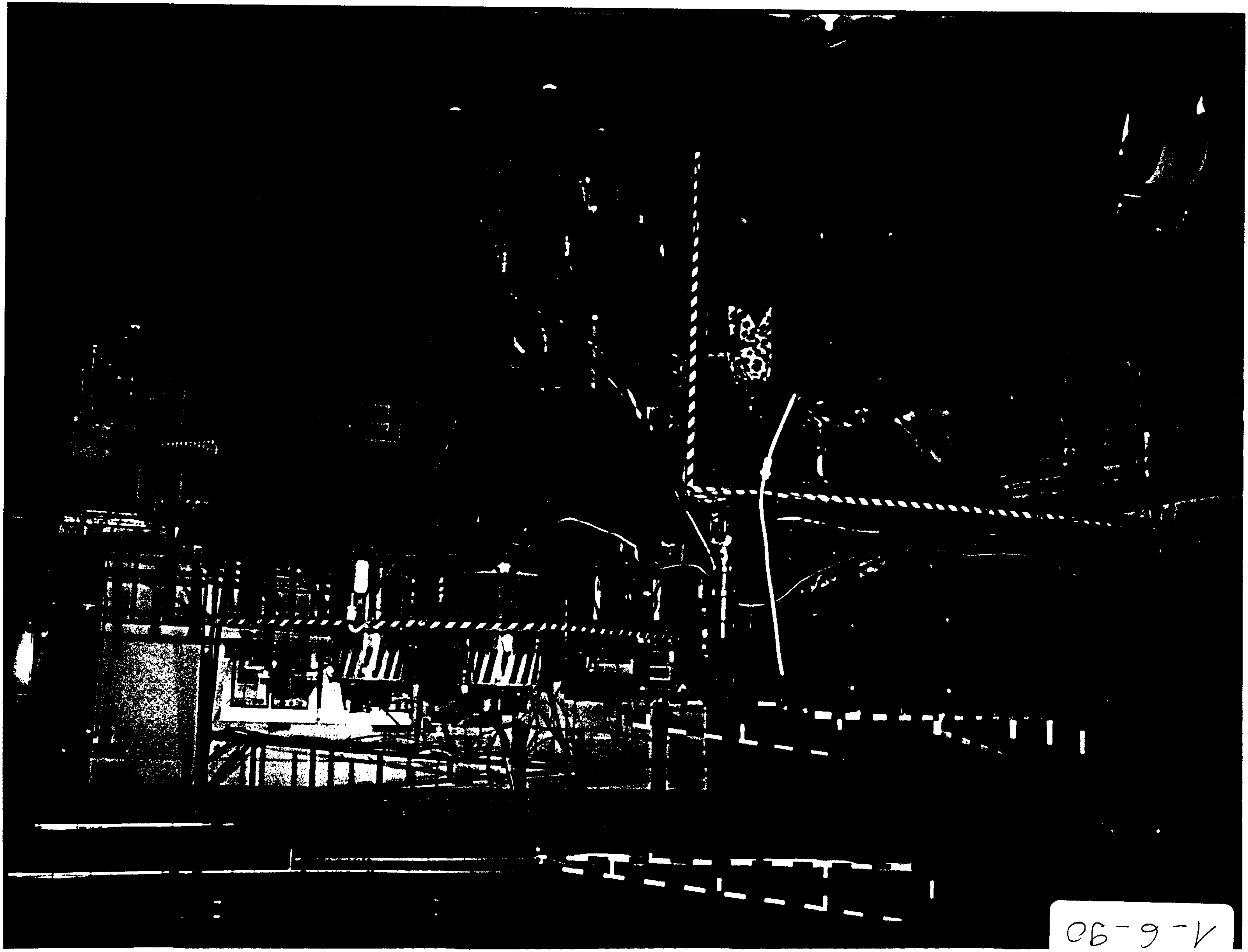
$$\tilde{h}^2 = S_h(f_o) = \frac{\pi}{2}\frac{kT_e}{MQv^2}\frac{1}{f_o} \qquad [\frac{1}{Hz}]$$

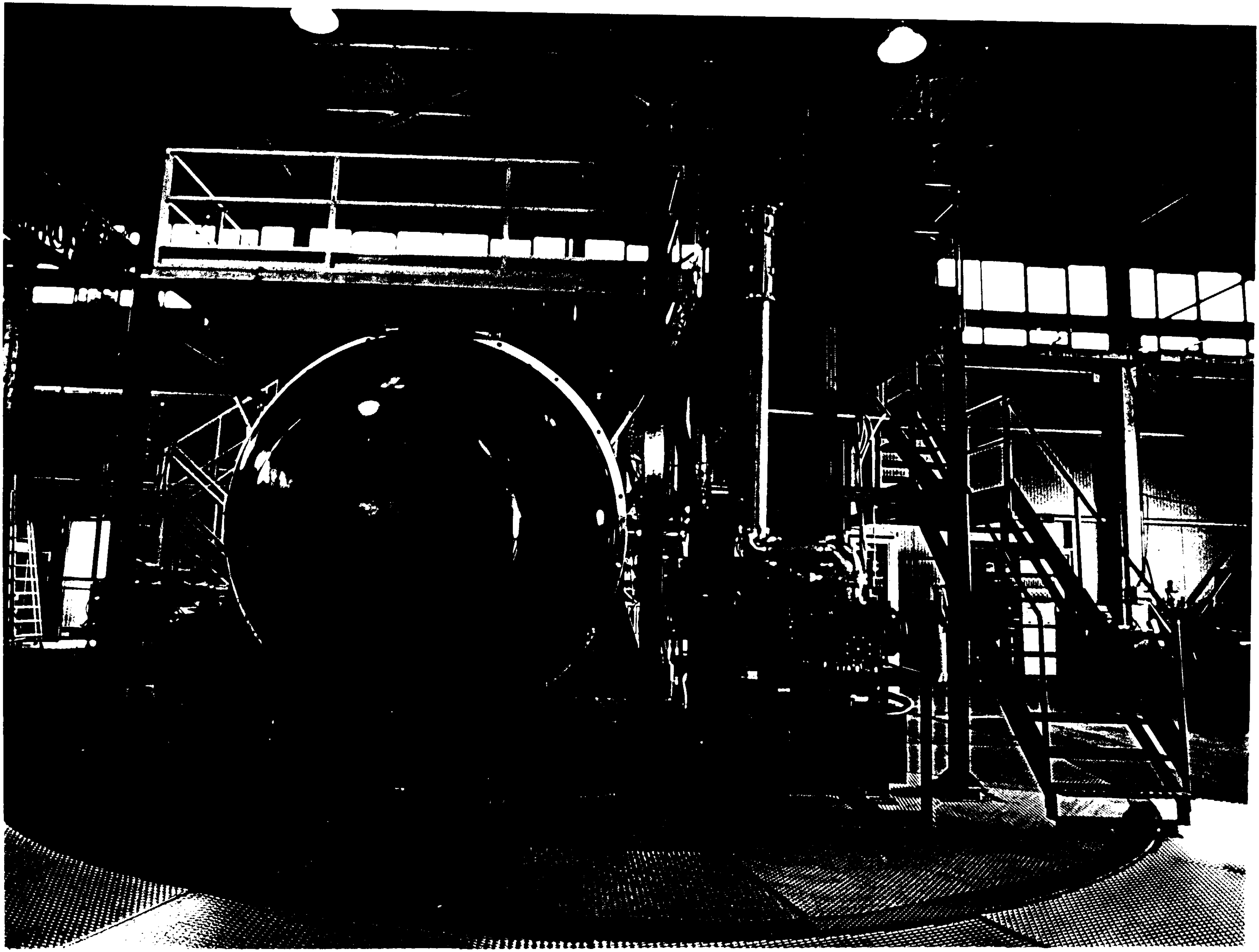
Pulse sensitivity

$$h = \frac{1}{\tau_g}\sqrt{\frac{S(f_o)}{2\pi\Delta f}}$$

Bandwidth

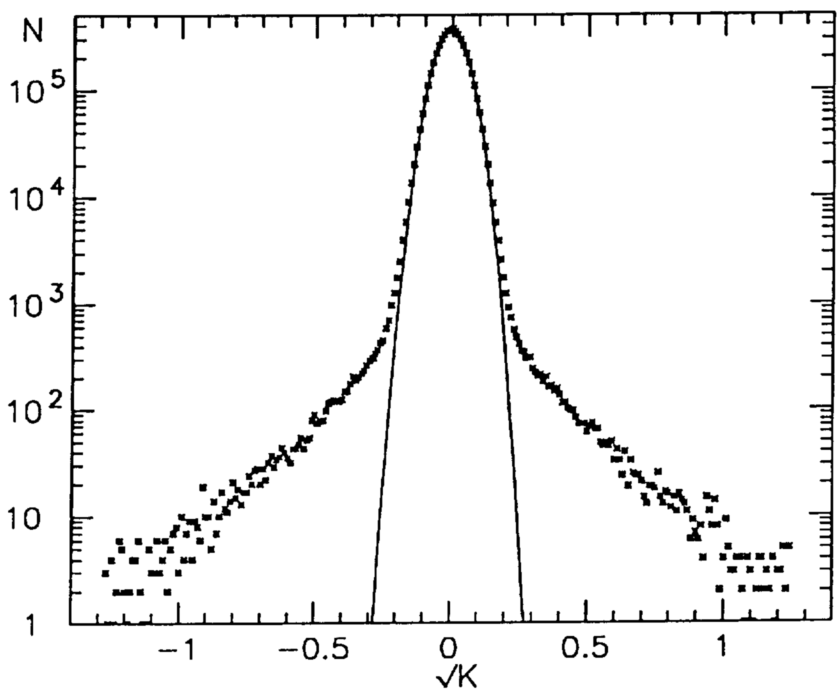
$$\Delta f = \frac{f_o}{Q}\frac{4\,T_e}{T_{eff}}$$


1-6-90



NAUTILUS

6 hours of data



$T_{eff} = 3$ mK

$h = 4 \times 10^{-19}$

Data Analysis

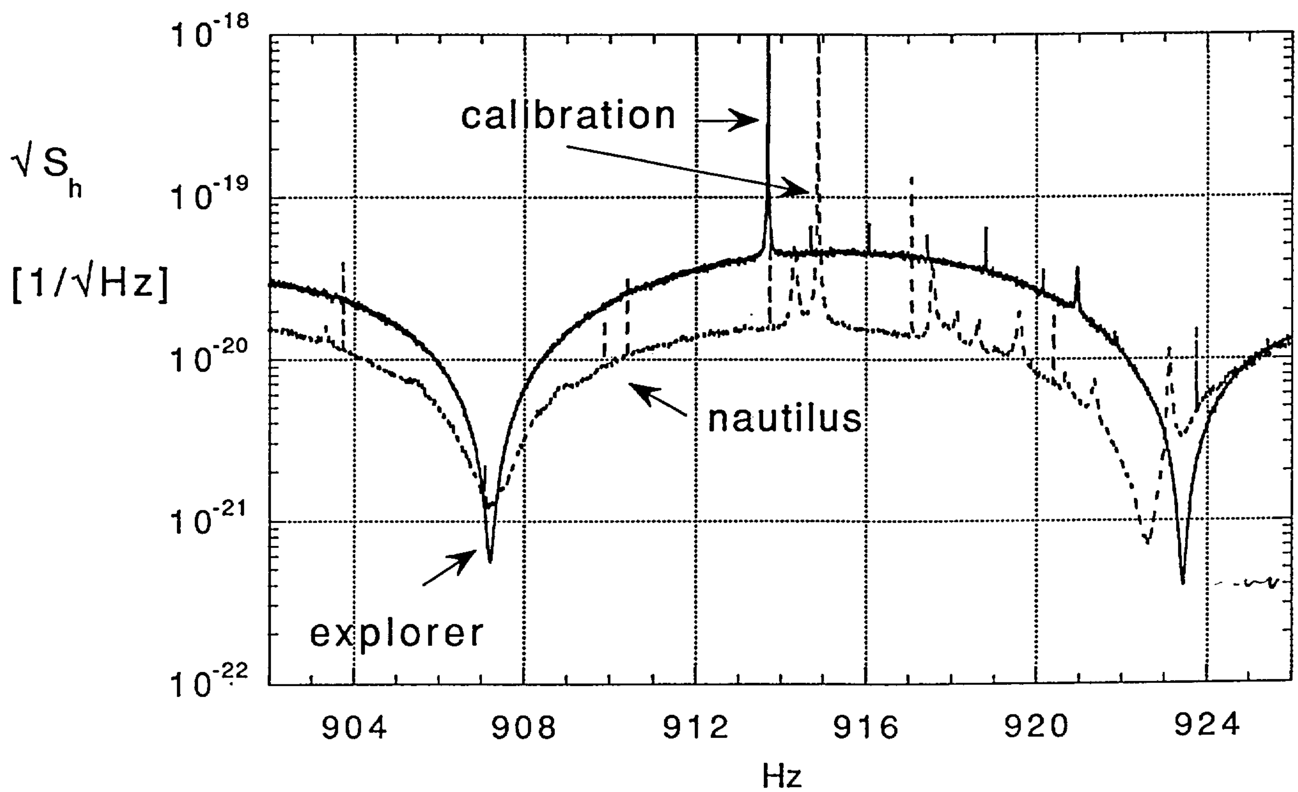
1. Coincidence search among ALLEGRO, AURIGA, EXPLORER, NAUTILUS, NIOBE

2. Correlation between EXPLORER and NAUTILUS for measuring the stochastic gravitational wave background

3. Search for monochromatic gravitational waves.

4. Search for correlation with cosmic gamma bursts

4×10^{-22} $/\sqrt{Hz}$



$\sqrt{S_{cros}} = 0.1 \times 10^{-22} / \sqrt{Hz}$

$S \leq 6 \cdot 10$

Search for monochromatic gravitational waves with the present sensitivity of Explorer

Integrating over one year

$$h = 2\ 10^{-25}$$

In one week

$$h = 1.5\ 10^{-24}$$

Combining 52 weeks

$$h = 5\ 10^{-25}$$

Search for correlation with cosmic gamma bursts

Using the Explorer and Nautilus data in the years 1991 and 1995-1997 and 226 gamma bursts no correlation has been found at a level of

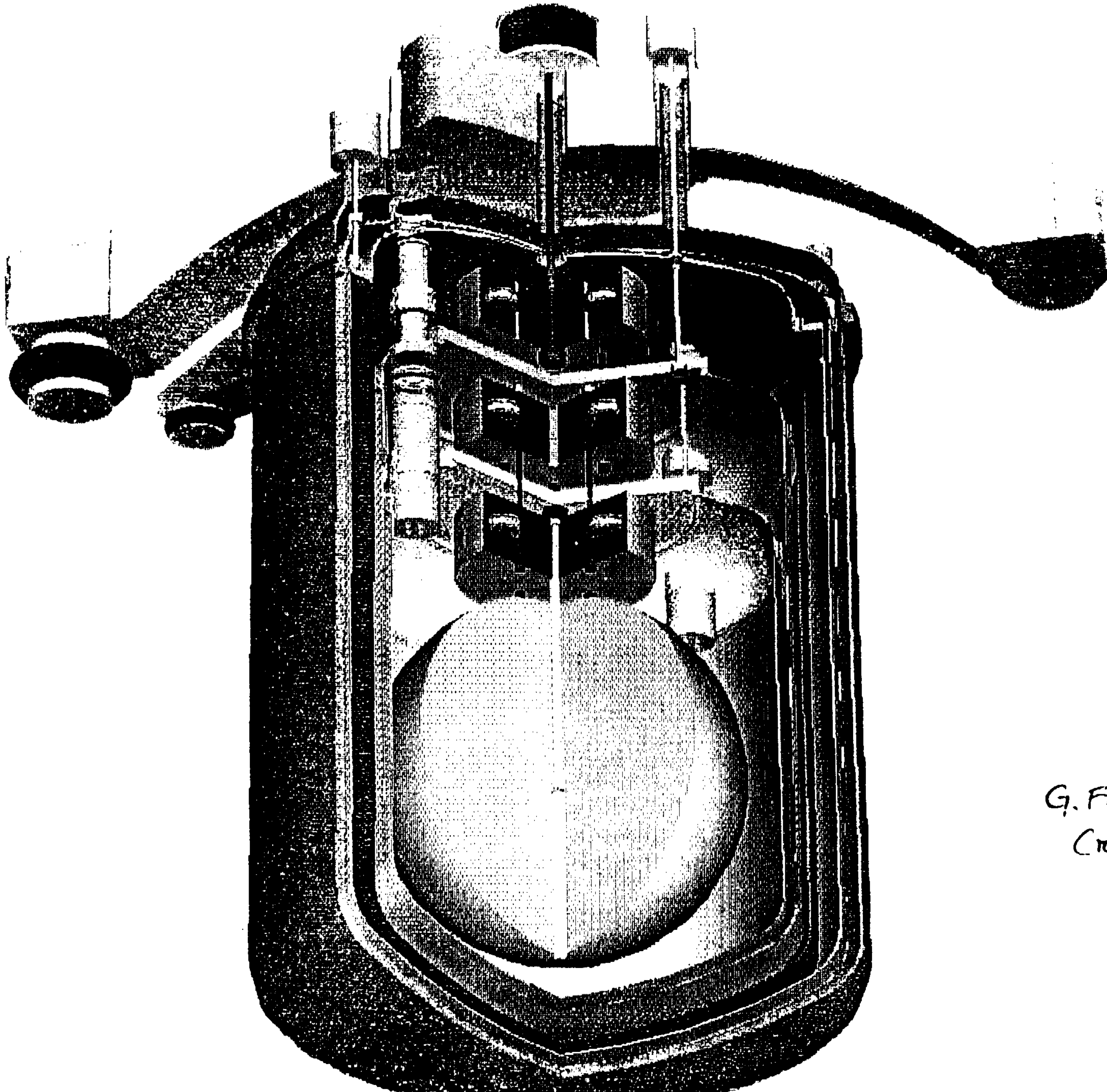
$$h = 2\ 10^{-19}$$

within ± 20 minutes around the gamma trigger time

TRANSDUCER

PARAMETERS	Explorer	Nautilus	Near future	Optimistic
Ctrasd (F)	$3.9\ 10^{-9}$	$4.2\ 10^{-9}$	$1.2\ 10^{-8}$	$2.0\ 10^{-8}$
d(μm)	**52**	**49**	**10**	**6**
L_o (H)	2.5	2.9	2.0	2.0
L (H)	$1.6\ 10^{-6}$	$8.0\ 10^{-7}$	$1.0\ 10^{-6}$	$1.0\ 10^{-6}$
L_{in}(H)	$1.0\ 10^{-6}$	$1.0\ 10^{-6}$	$1.0\ 10^{-6}$	$1.0\ 10^{-6}$
k_{tr}	0.77	0.77	0.8	0.9
L_{sq}	$5.6\ 10^{-11}$	$5.6\ 10^{-11}$	$5.0\ 10^{-11}$	$5.0\ 10^{-11}$
k_{sq}	0.5	0.5	0.6	0.7
M_{tr}	$1.54\ 10^{-3}$	$1.16\ 10^{-3}$	$1.13\ 10^{-3}$	$1.27\ 10^{-3}$
N_e	590	647	566	636
MSQ (H)	$3.7\ 10^{-9}$	$3.7\ 10^{-9}$	$4.2\ 10^{-9}$	$4.9\ 10^{-9}$
f_{el} (Hz)	1865	1584	1231	1027
T (K)	**2.7**	**0.1**	**0.1**	**0.1**
tau (s)	350	500	1000	2000
Φ_n ($\Phi_o/\sqrt{Hz}$)	**$3.0\ 10^{-6}$**	**$2.0\ 10^{-6}$**	**$1.0\ 10^{-6}$**	**$2.0\ 10^{-7}$**
T_n (estimate)	$1.7\ 10^{-5}$	$1.2\ 10^{-5}$	$5.1\ 10^{-6}$	$8.7\ 10^{-7}$
E (V/m)	$6.2\ 10^{6}$	$8.0\ 10^{6}$	$1.0\ 10^{7}$	$1.0\ 10^{7}$
m_t (kg)	0.40	0.30	0.12	2.20
$T_{back\ action}$ (estimate)	$1.1\ 10^{-5}$	$8.6\ 10^{-5}$	$6.6\ 10^{-3}$	$5.9\ 10^{-3}$

T_{eff} (μK)	5200	280	12	2
h_c (1 ms)	**$6\ 10^{-19}$**	**$1.5\ 10^{-19}$**	**$6\ 10^{-20}$**	**$2\ 10^{-20}$**
bw (Hz)	**1.9**	**0.92**	**11**	**39**
mode spacing (Hz)	17	15	9.1	40



G. FROSSATI, E. COCCIA
Cryogenics 34, 9 (1994

SFERA

R&D activity for a large spherical detector (100 ton, 20 mK)

Funded by INFN (July 1997)

3 years program 1998-2000 (1M$) :

build a prototype spherical detector (10 ton, 4 K)

Material:	CuAl
Diameter:	1.3 m
Frequencies:	1700 Hz, 3200 Hz

Suspension system decoupled from the cryogenic system

Fast cooldown

T=4.2 K, implementable with a dil. refr. T=50 mK

At the end of the R&D, year 2000, SFERA may become a detector in data taking or be used as a test facility for the large (M=100 t) spherical detector

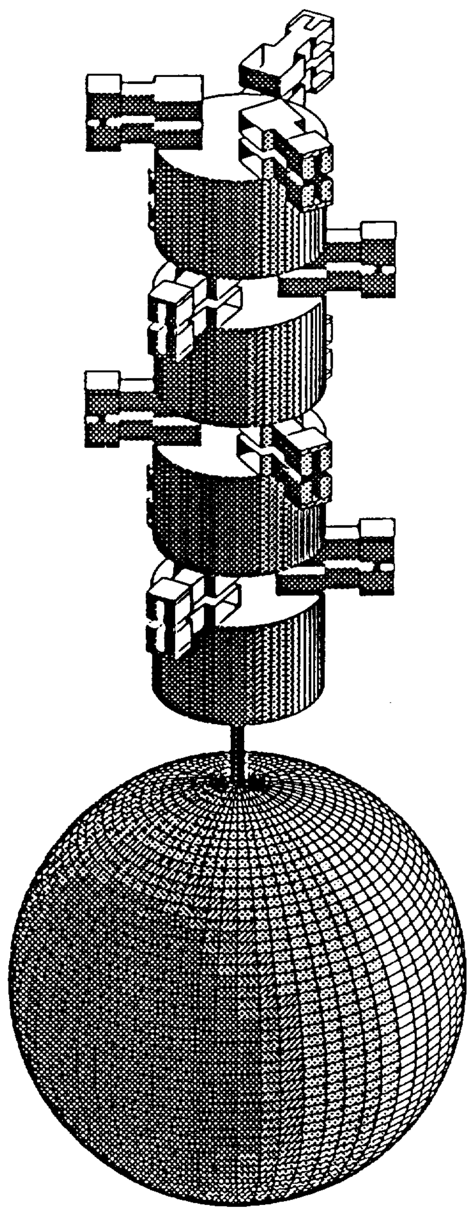
Collaboration with GRAIL in progress:

Investigate other materials and fabrication techniques

Study cosmic rays effect

Suspension system for prototype sphere

February 20, 1998



Red D

- **measure the vibration isolation of the suspension system at room temperature**

- **cryogenic test and test of the fast cool down**

- **measurements of the 5 quadrupole modes at 4 K with non-resonant transducers (PZTs)**
  first complete test for the
  cryogenic-suspension system
  test of signal processing and data acquisition

- **measure the Brownian noise of one quadrupole mode with a resonant transducer and dc SQUID amplifier**
  ultimate test of cryogenics and suspensions and evaluation of the duty cycle at the highest possible sensitivity

Target sensitivity for the 100 tonne sphere

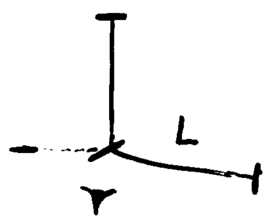
$$\tilde{h} = 5 \times 10^{-24} \frac{1}{\sqrt{Hz}}$$

$$\Delta f = 50 \text{ Hz}$$

$$h = 3 \times 10^{-22}$$

Interferometers and sphere

can be operated simultaneusly to make hybrid GW observatories of unprecedented <u>sensitivity</u> and <u>signal characterization power</u>



L= 0.3-4 km

- wide band
- h(t)

M=40-100 ton

- absolute $h(f_o)$
- source direction
- wave polarization

SUPERNOVAE: source location, absolute waveform

CHIRPS: independent determination of chirp mass

STOCHASTIC BACKGROUND:

$$\Omega_{GW} = 4 \cdot 10^{-6} \left(\frac{f_o}{700 Hz} \right)^3 \left(\frac{\tilde{h}}{10^{-23} Hz^{-1/2}} \right)^2 \left(\frac{20 Hz}{\Delta f} \right)^{1/2} \left(\frac{10^7 s}{t_m} \right)^{1/2}$$

Note 1, Linda Turner, 04/30/98 10:52:18 AM
LIGO-G980073-09-M