

Wide Bandwidth Dual Acoustic GW Detectors

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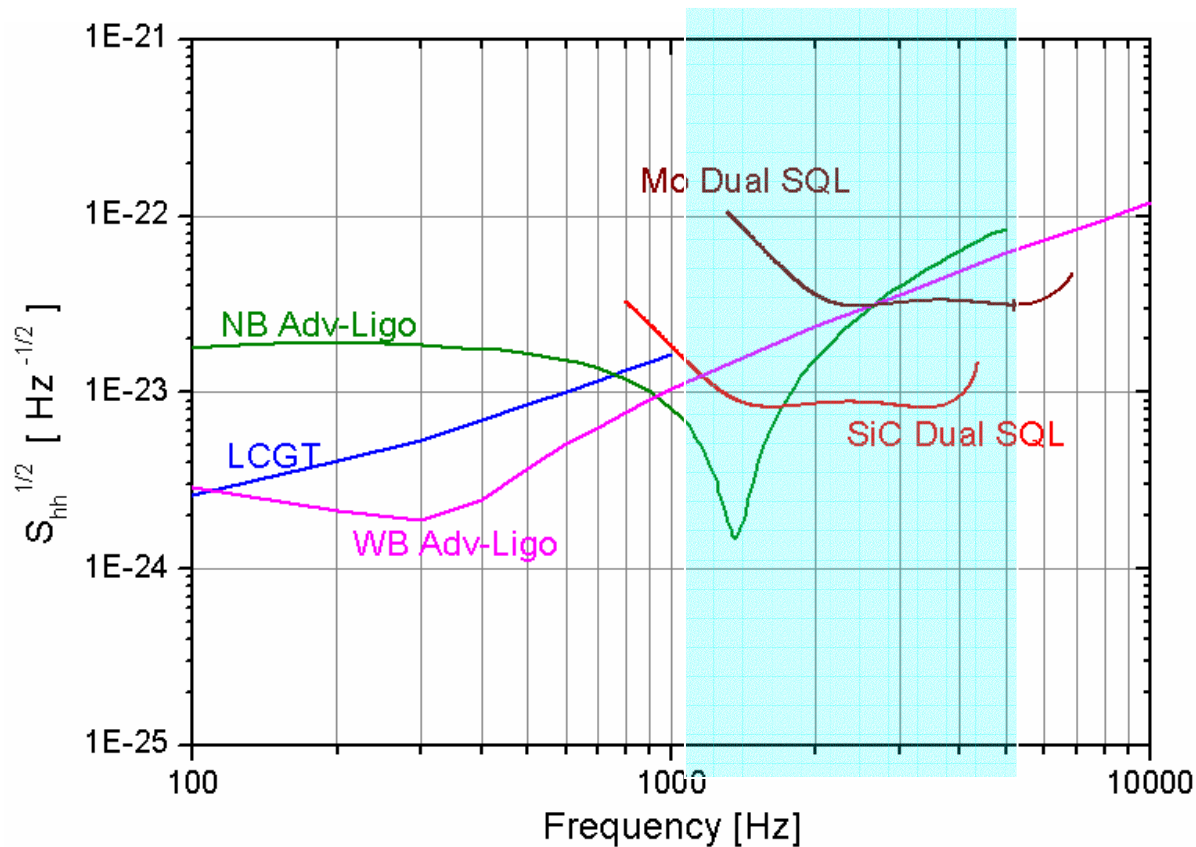
on behalf of the **AURIGA** collaboration
www.auriga.infn.it



5th Edoardo Amaldi Conference on Gravitational Waves



DUAL detectors estimated sensitivity at SQL:



Science with HF GW

- BH and NS mergers and ringdown
- NS vibrations and instabilities
- EoS of superdense matter
- Exp. Physics of BH

- Only very few noise resonances in bandwidth.
- Sensitive to high frequency GW in a wide bandwidth.

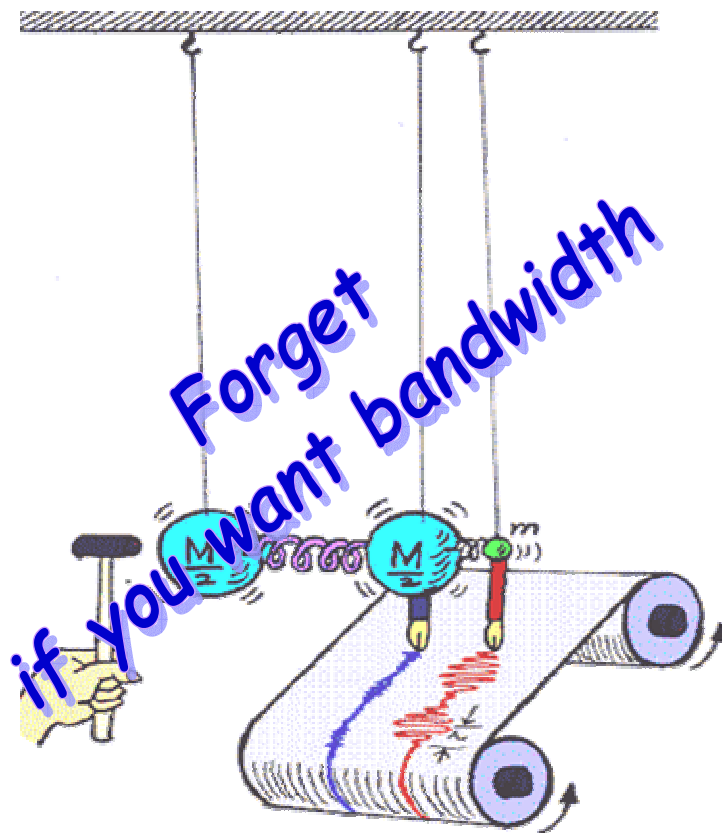


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New concepts - new technologies:

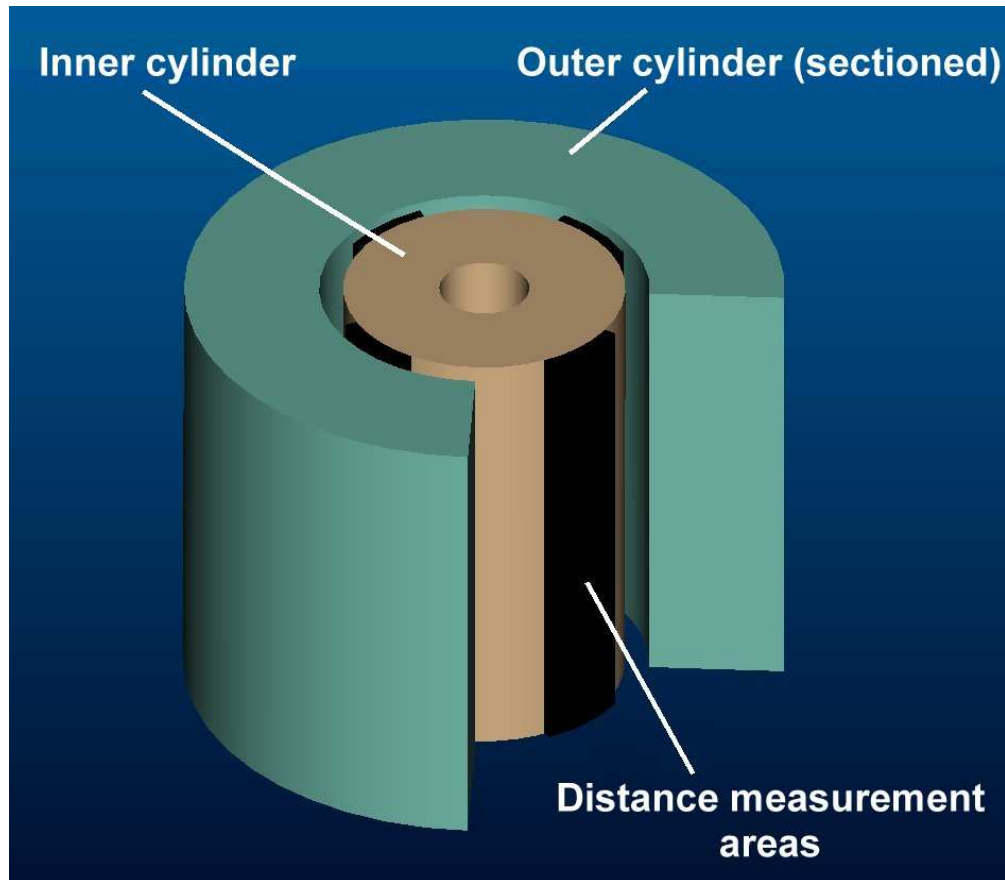
- No resonant transducers:



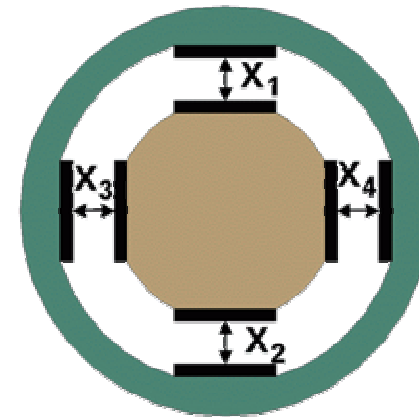
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New concepts - new technologies:



- No resonant transducers:
measure differential motion of massive cylindrical resonators
- Mode selective readout:



$$X_1 + X_2 - X_3 - X_4$$

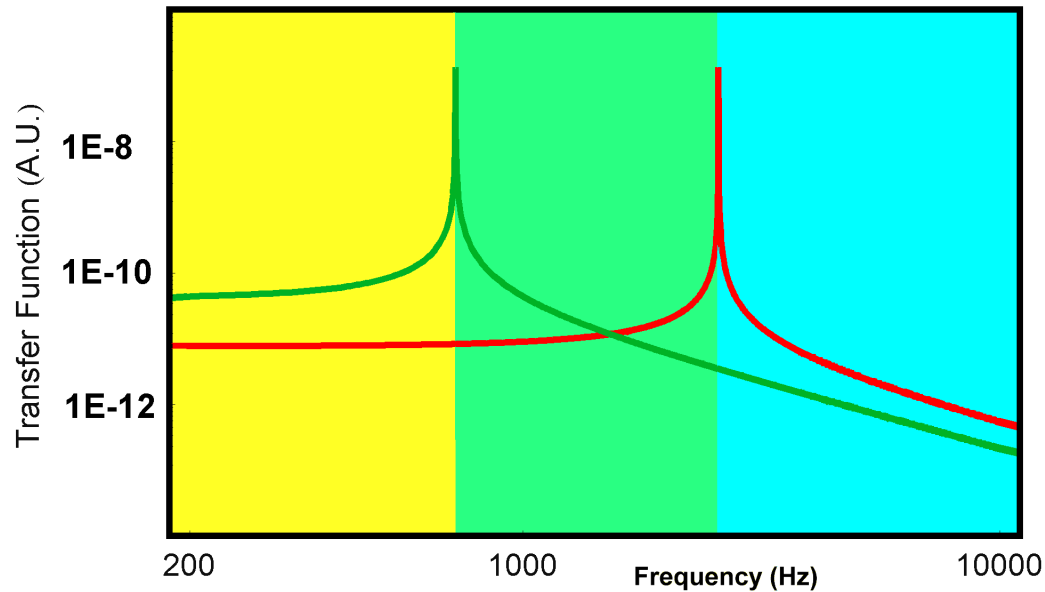
- High cross section materials
(up to 100 times larger than Al5056 used in bars)



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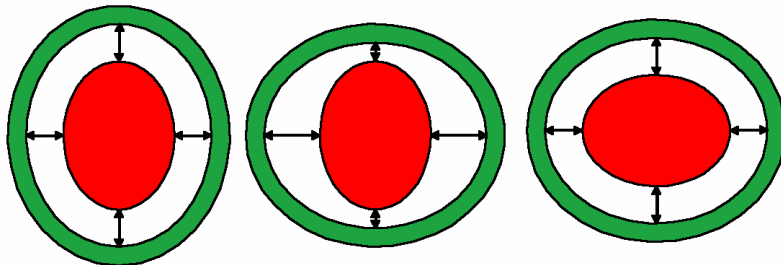
Dual detector: the concept



Intermediate frequency range:

- the **outer resonator** is driven above resonance,
- the **inner resonator** is driven below resonance

→ phase difference of π



In the differential measurement:

- the signals sum up
- the readout back action noise subtracts

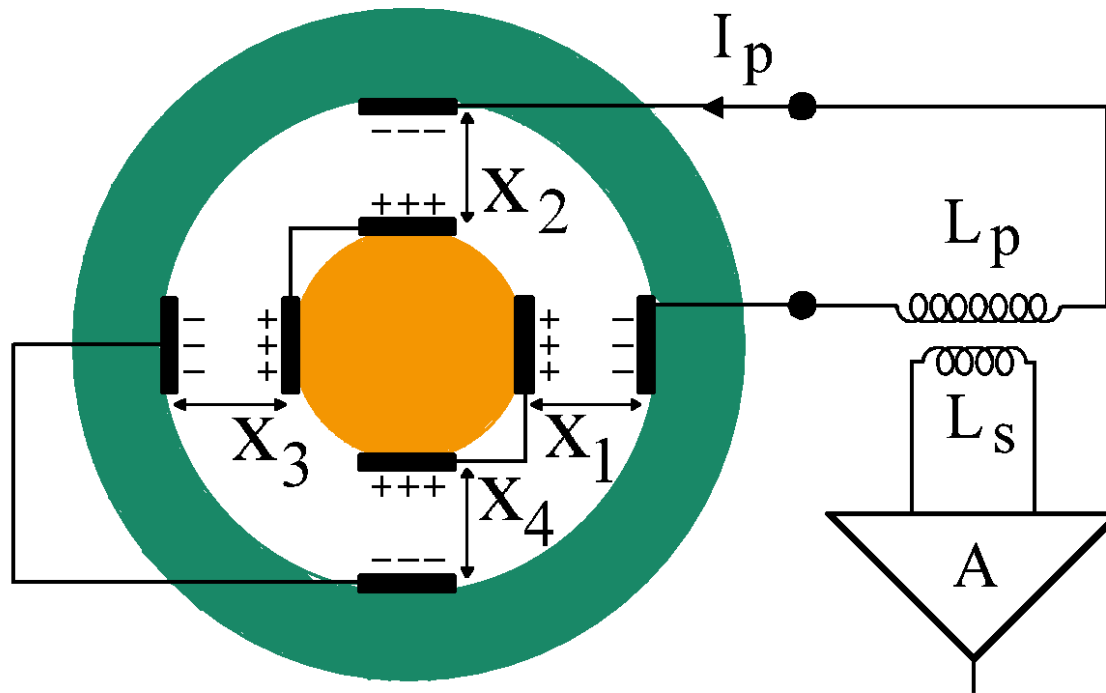


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Differential measurement strategy

- Average the deformation of the resonant masses over a **wide area**:
 - ➔ reject high frequency resonant modes which do not carry any gravitational signal but contribute to thermal noise
- Geometrically **selective readout** that rejects the **non-quadrupolar** modes
 - ➔ bandwidth free from acoustic modes not sensitive to gw.



Example:

- capacitive readout -

The current is proportional to:

$$X_1 + X_2 - X_3 - X_4$$

Dual Detector with $\sqrt{S_{hh}} \sim 10^{-23}/\sqrt{\text{Hz}}$ in 1-5 kHz range

Molybdenum

- $Q/T > 2 \times 10^8 \text{ K}^{-1}$ - Mass = 16 tons
- $R = 0.47 \text{ m}$ - height = 2.3 m

Silicon Carbide (SiC)

- $Q/T > 2 \times 10^8 \text{ K}^{-1}$ - Mass = 62 tons
- $R = 1.44 \text{ m}$ - height = 3 m

Feasibility issues

Detector:

- Massive resonators (> 10 tons)
 - Cooling
 - Suspensions
- High Q and cross-section materials

Readout:

- Selective measurement strategy
 - Quantum limited
 - Wide area sensor
- Displacement sensitivity



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R&D on readouts: status

- Requirement: $\sim 5 \times 10^{-23}$ m/ $\sqrt{\text{Hz}}$
- Present AURIGA technology: $\sim 5 \times 10^{-20}$ m/ $\sqrt{\text{Hz}}$

with:

optomechanical readout - based on Fabry-Perot cavities

capacitive readout - based on SQUID amplifiers



Foreseen limits of the readout sensitivity: $\sim 5 \times 10^{-22}$ m/ $\sqrt{\text{Hz}}$.

Critical issues:

optomechanical – push cavity finesse to current technological limit together with Watts input laser power

capacitive – push bias electric field to the current technological limit



Develop non-resonant devices to amplify the differential deformation of the massive bodies.



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R&D program funded by EGO

Collaboration:



INFN



Istituto di Fotonica e Nanotecnologie - Trento



Laboratory Kastler – Brossel CNRS (Paris)

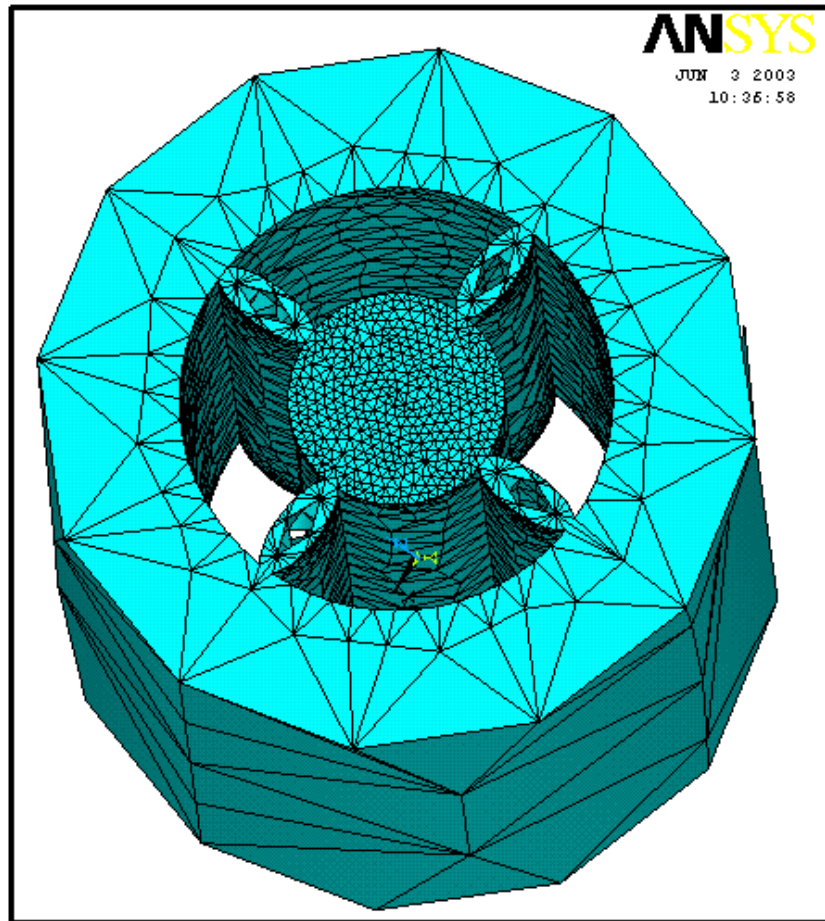


University of Barcelona

Requested funding from other sources:

- EU through ApPEC
- INFN
- Italian Ministry of Research

Preliminary study for the DUAL detector



Schematic model integrating
mechanical amplifiers and
suspension system .



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Idea to relax requirements on readout sensitivity: mechanical amplifiers

- based on the elastic deformation of monolithic devices
- well known for their applications in mechanical engineering.

GOAL:

Amplify the differential deformations of the massive bodies
over a wide frequency range.

Requirements:

- Gain of at least a factor 10.
- Negligible thermal noise with respect to that of the detector.



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