Wide Bandwidth Dual Acoustic GW Detectors

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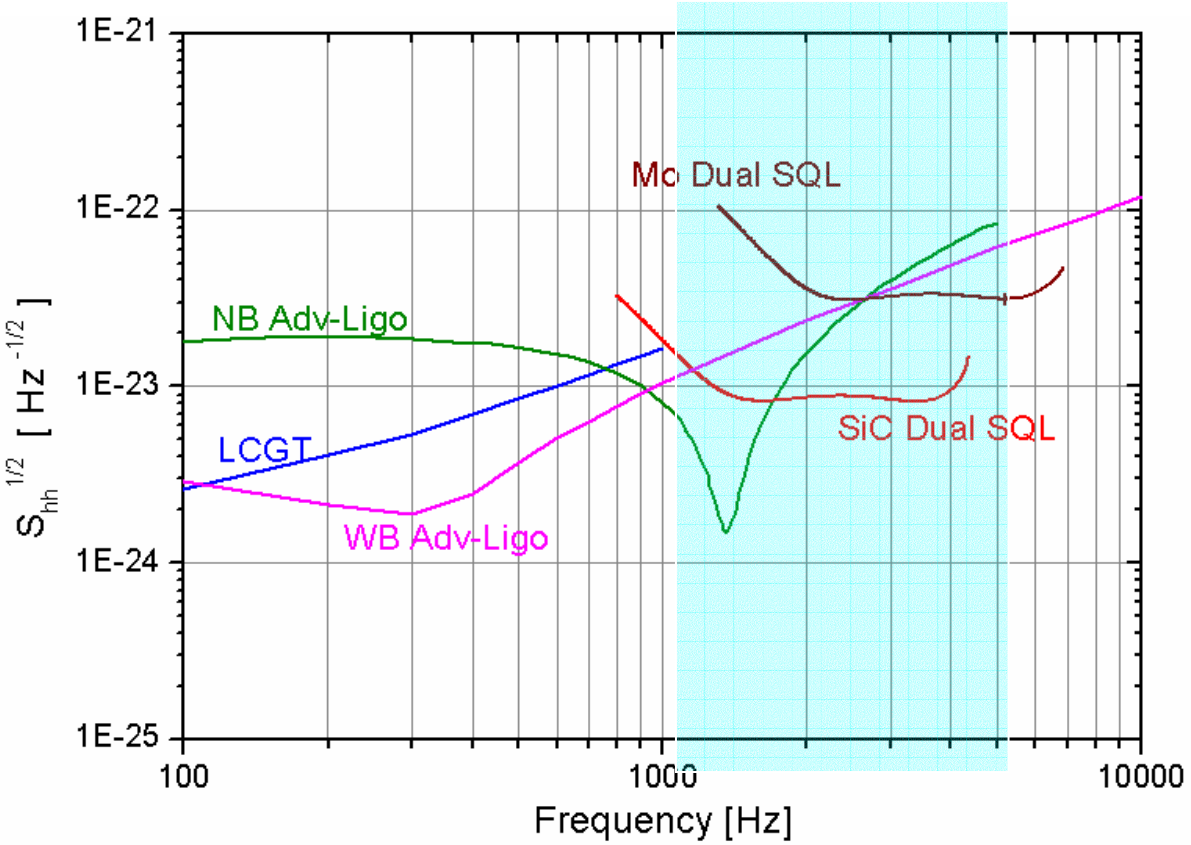
DUAL detectors estimated sensitivity at SQL:



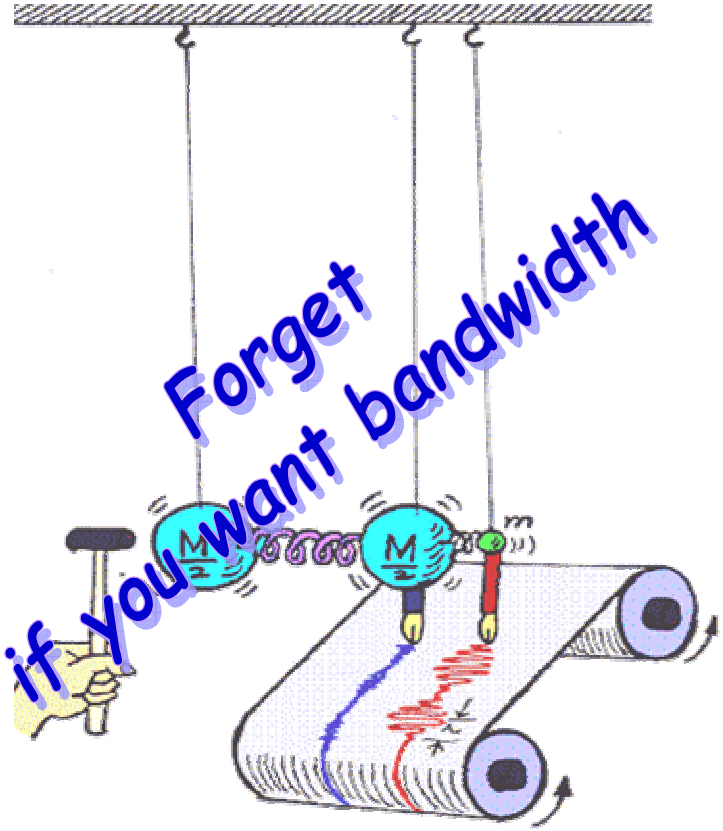
Science with HF GW

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

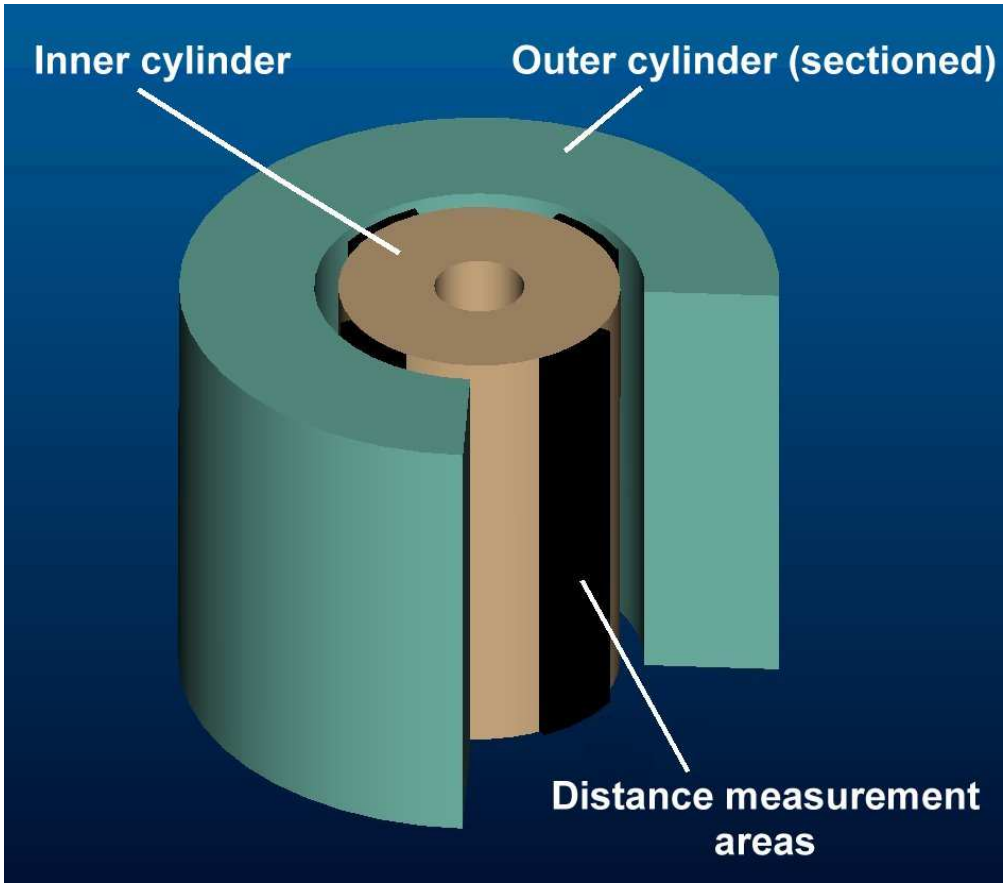
- Only very few noise resonances in bandwidth.
- Sensitive to high frequency GW in a wide bandwidth.

New concepts - new technologies:

- No resonant transducers:



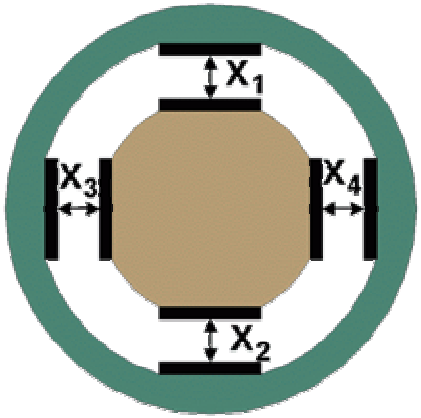
New concepts - new technologies:



- No resonant transducers:

  measure differential motion of massive cylindrical resonators

- Mode selective readout:

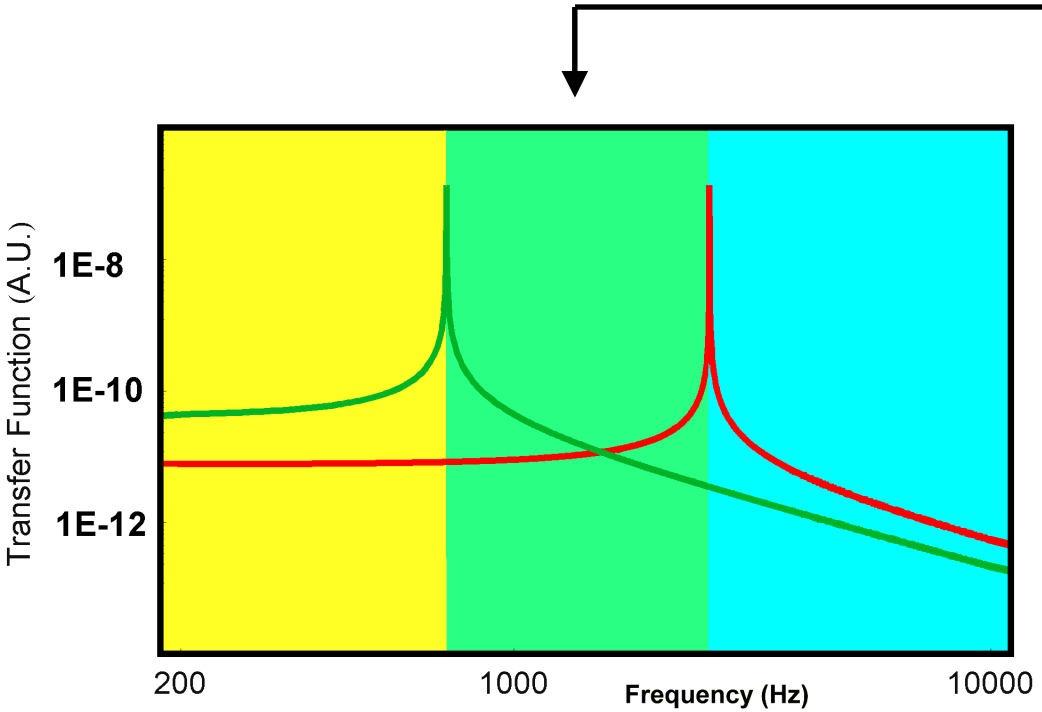


$$X1 + X2 - X3 - X4$$

- High cross section materials

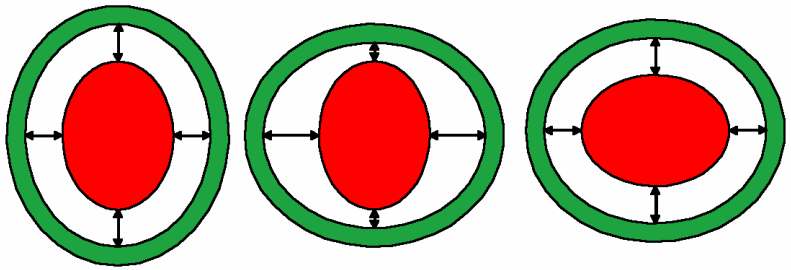
  (up to 100 times larger than Al5056 used in bars)

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

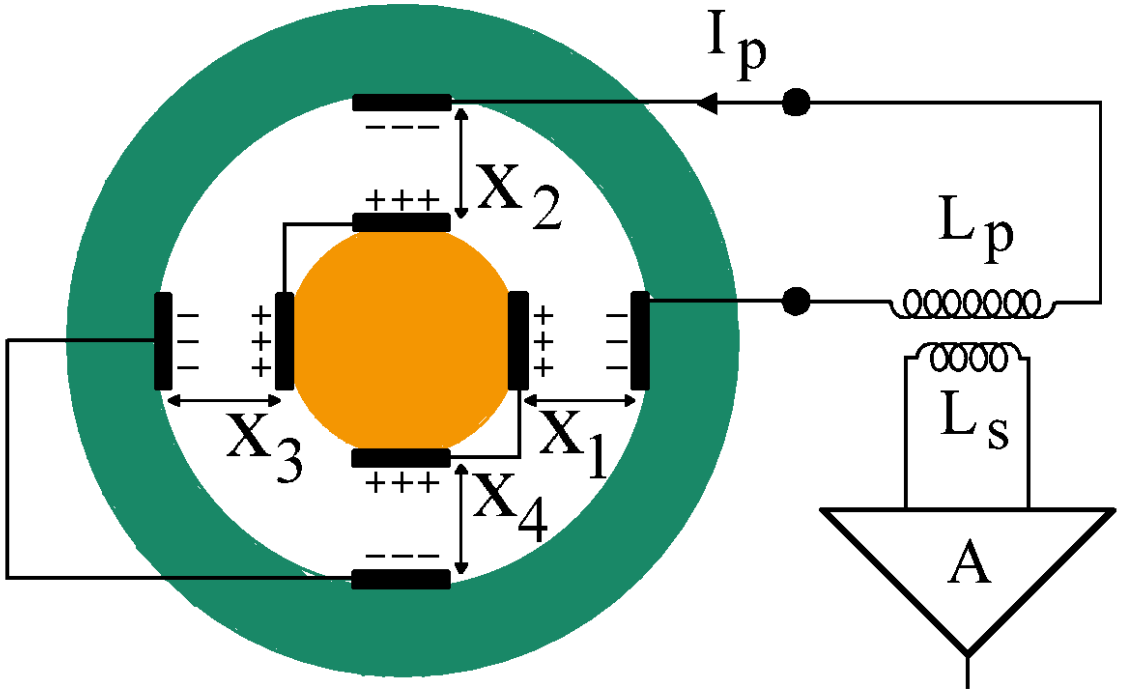
Differential measurement strategy

- 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:

$$X1 + X2 - X3 - X4$$

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

Molybdenum

- *$Q/T > 2x10^8\ K^{-1}$ - Mass = 16 tons*
- *R = 0.47 m - height = 2.3 m*

Silicon Carbide (SiC)

- *$Q/T > 2x10^8\ K^{-1}$ - Mass = 62 tons*
- *R = 1.44 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

R&D on readouts: status

- Requirement: ~ 5×10^{-23} m/√Hz
- Present AURIGA technology: ~ 5×10^{-20} m/√Hz

with:

optomechanical readout - based on Fabry-Perot cavities

capacitive readout - based on SQUID amplifiers

⇩

Foreseen limits of the readout sensitivity: ~ 5×10^{-22} m/√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.

R&D program funded by EGO

Collaboration:

INFN

Istituto di Fotonica e Nanotecnologie - Trento

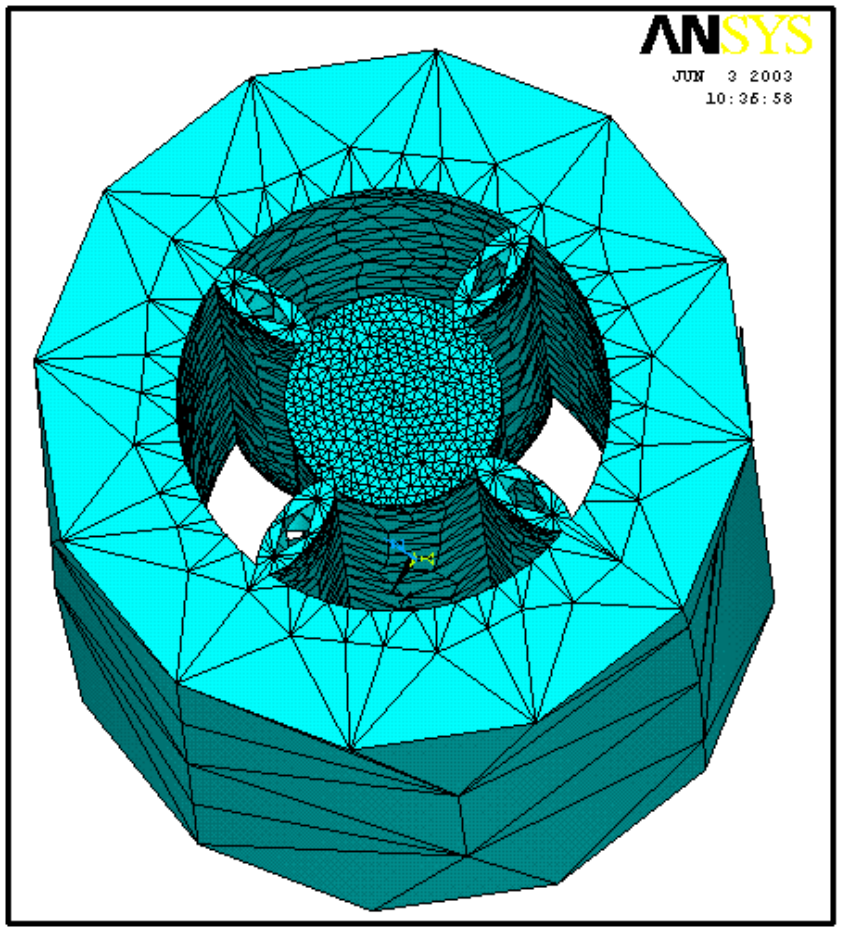
Laboratory Kastler – Brossel CNRS (Paris)

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 .

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.