# Wide Bandwidth Dual Acoustic GW Detectors

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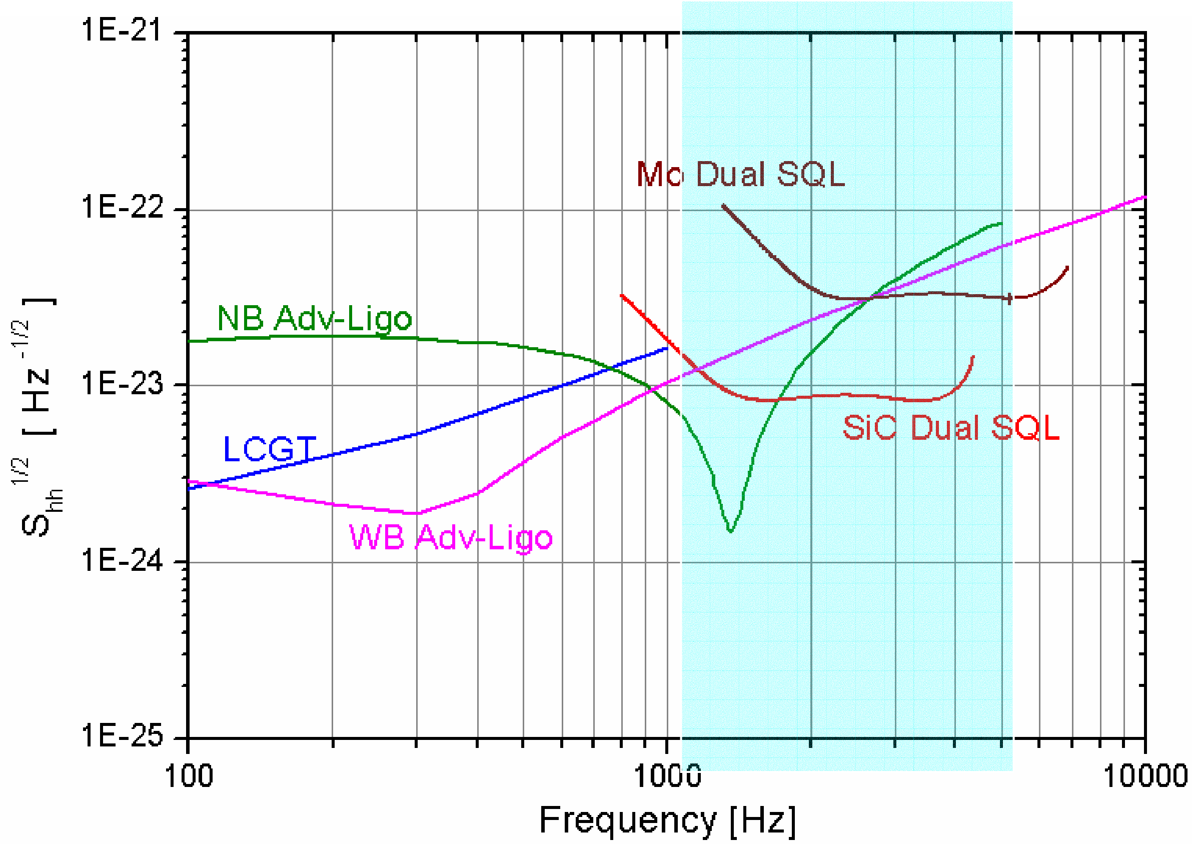
# DUAL detectors estimated sensitivity at SQL:



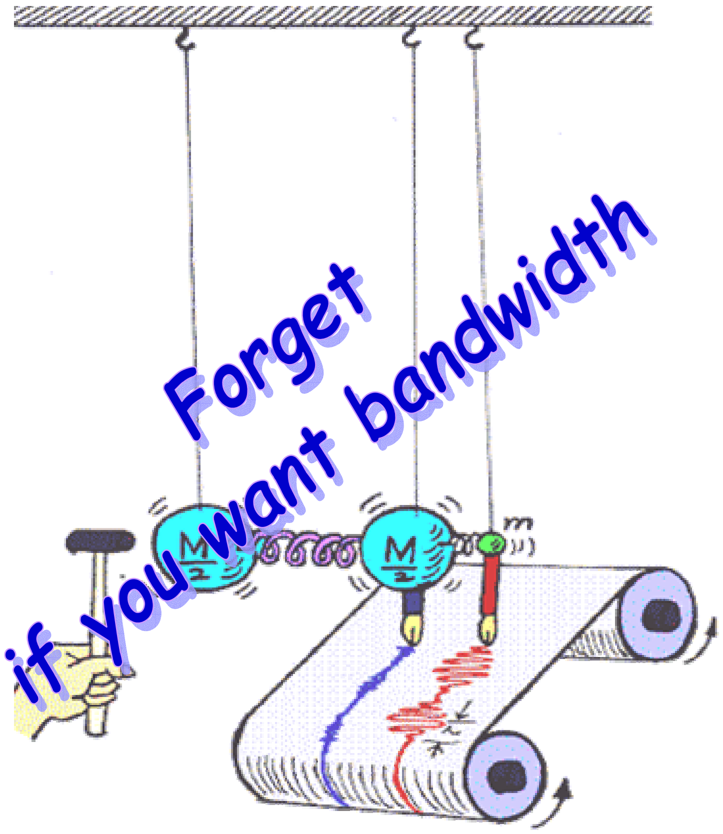

**Science with HF GW**

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

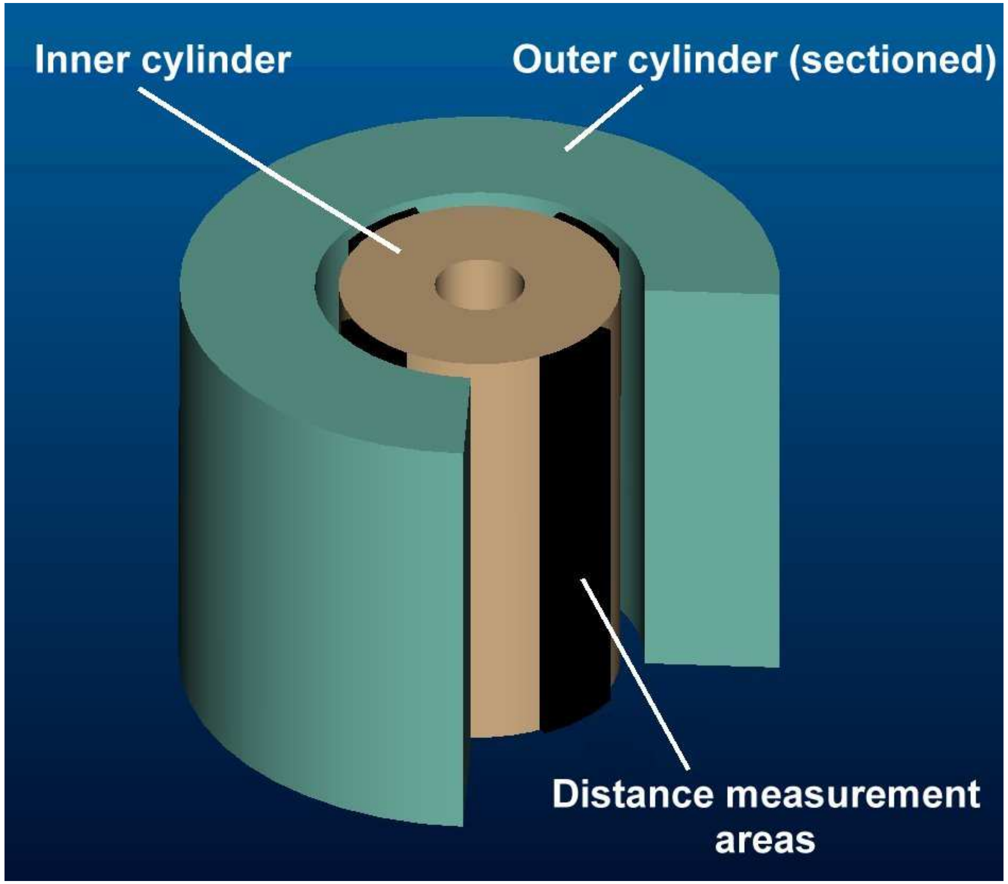
- Only very few noise resonances in bandwidth.
- Sensitive to high frequency GW in a wide bandwidth.

# New concepts - new technologies:

• No resonant transducers:



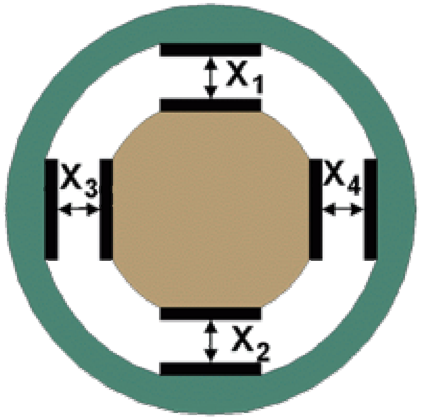
# New concepts - new technologies:




- No resonant transducers:

  measure differential motion of massive cylindrical resonators

- Mode selective readout:

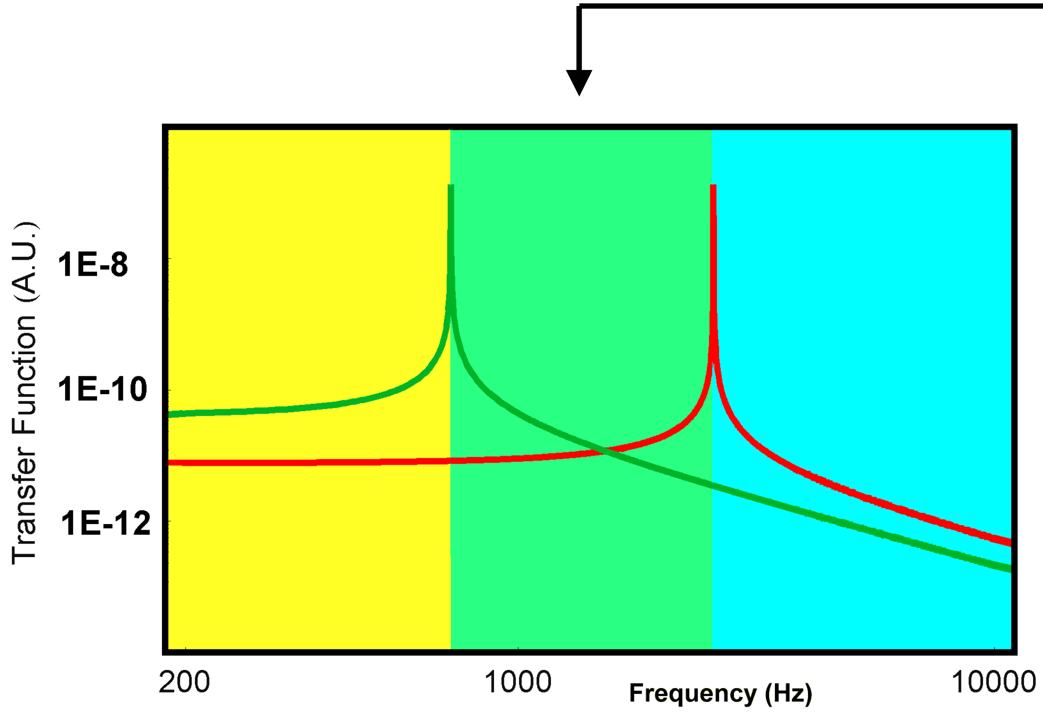



$$X1 + X2 - X3 - X4$$

- High cross section materials

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

# Dual detector: the concept

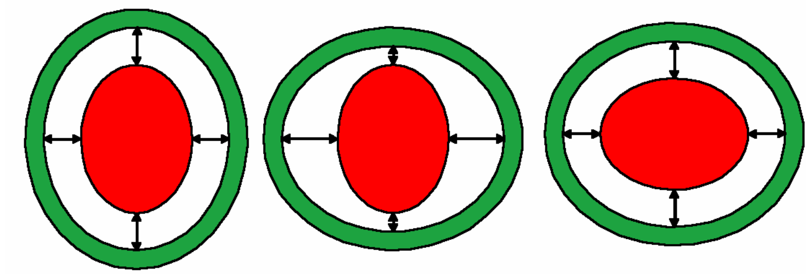



Intermediate frequency range:

• 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

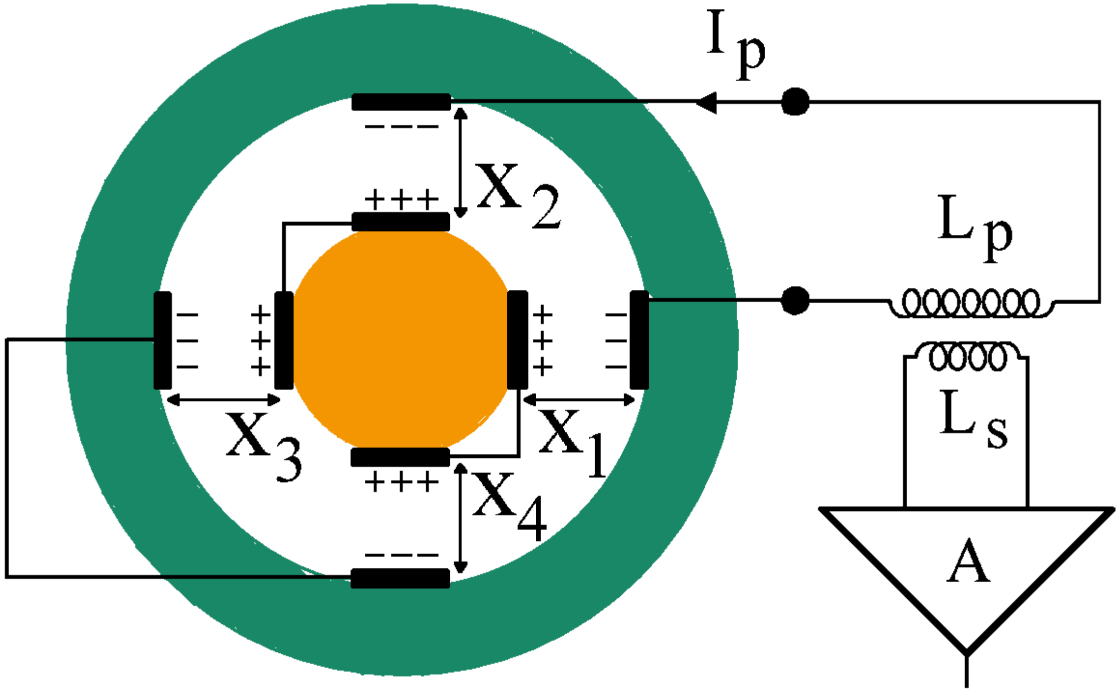
# Differential measurement strategy

• 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: ~ $5\text{x}10^{-23}$ m/√Hz

• Present AURIGA technology: ~ $5\text{x}10^{-20}$ m/√Hz

with:

optomechanical readout - based on Fabry-Perot cavities

capacitive readout - based on SQUID amplifiers

⇓

Foreseen limits of the readout sensitivity: ~ $5\text{x}10^{-22}$ 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

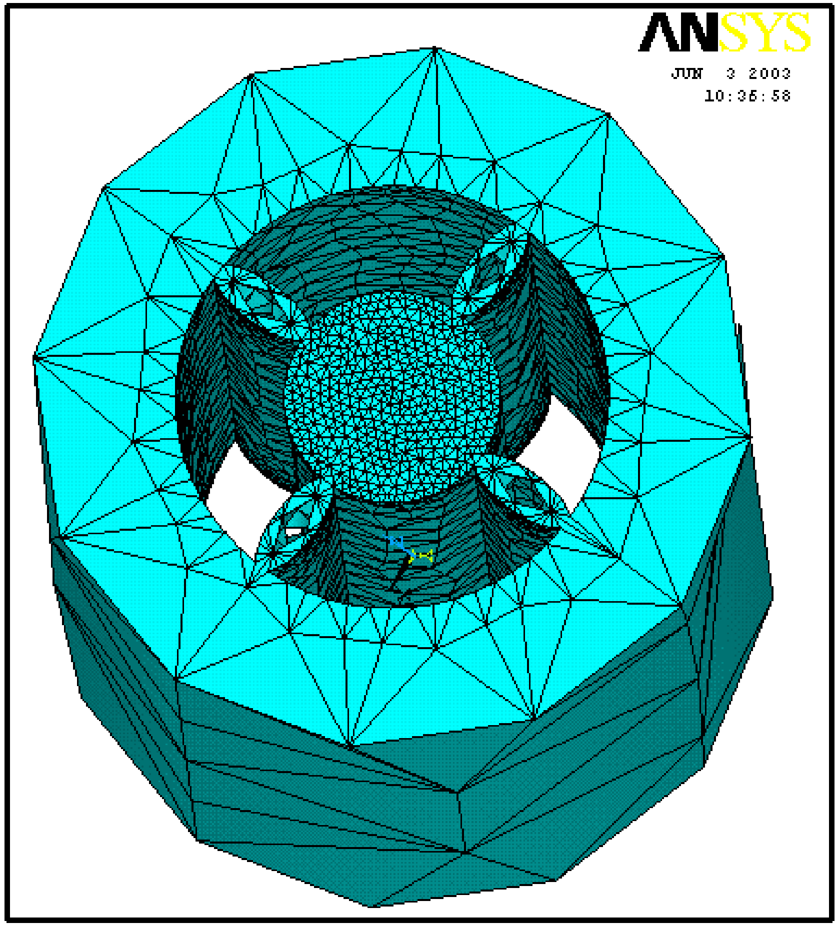
Laboratory Kastler – Brossel CNRS (Paris)

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.