

# TOBA: TOrsion Bar Antenna

## The Current Status and Future Plans

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### Abstract

TOBA (TOrsion-Bar Antenna) is a gravitational wave detector using a torsion pendulum. The resonant frequency of torsional motion is  $\sim 1$  mHz, therefore it can be a ground-based GW detector which is sensitive to low frequency GWs (0.1-10 Hz). Our target sensitivity is  $\sim 10^{-19} / \sqrt{\text{Hz}}$  @ 0.1 Hz, which will enable us to detect IMBH (intermediate mass black hole) binary mergers and GGN (gravity gradient noise), etc. Here we show the current status of TOBA. We also explain future update plans, Phase-III TOBA.

## 1. Introduction | What is TOBA?

TOBA = "TOrsion Bar Antenna" [1]

- GW detector using a torsion pendulum
- Low resonant frequency ( $\sim$  mHz)
  - target range: 0.1 Hz  $\sim$  10 Hz
- Ground-based
  - inexpensive, easy to maintenance

Our goal:  $10^{-19} / \sqrt{\text{Hz}}$  @ 0.1 Hz

### Targets of TOBA

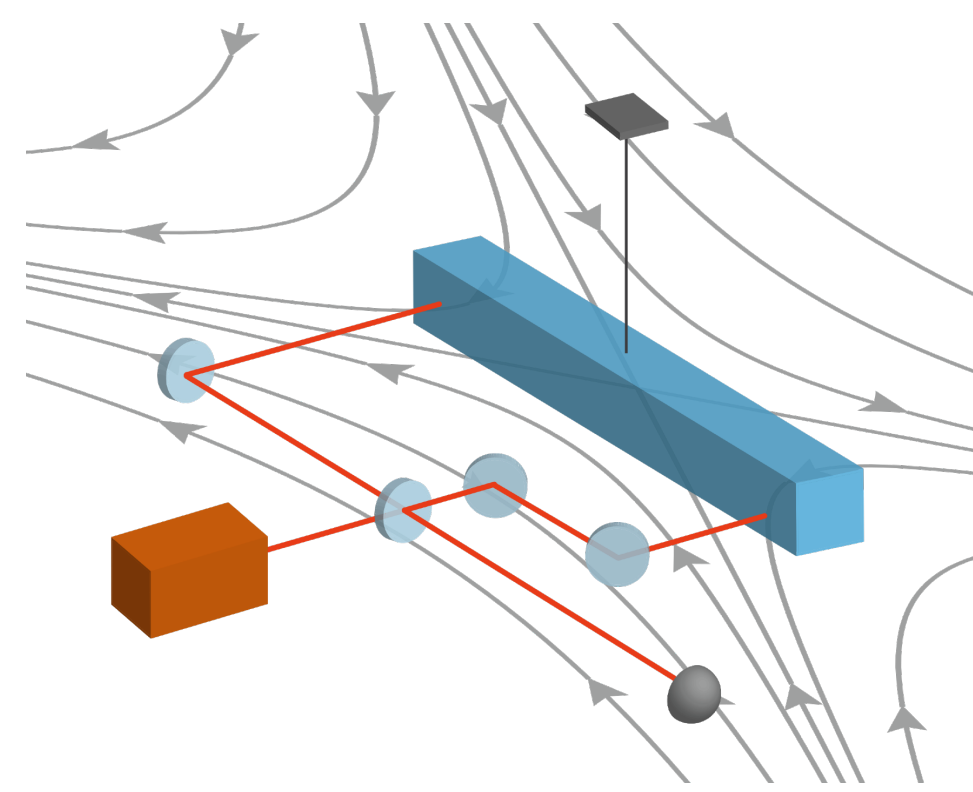
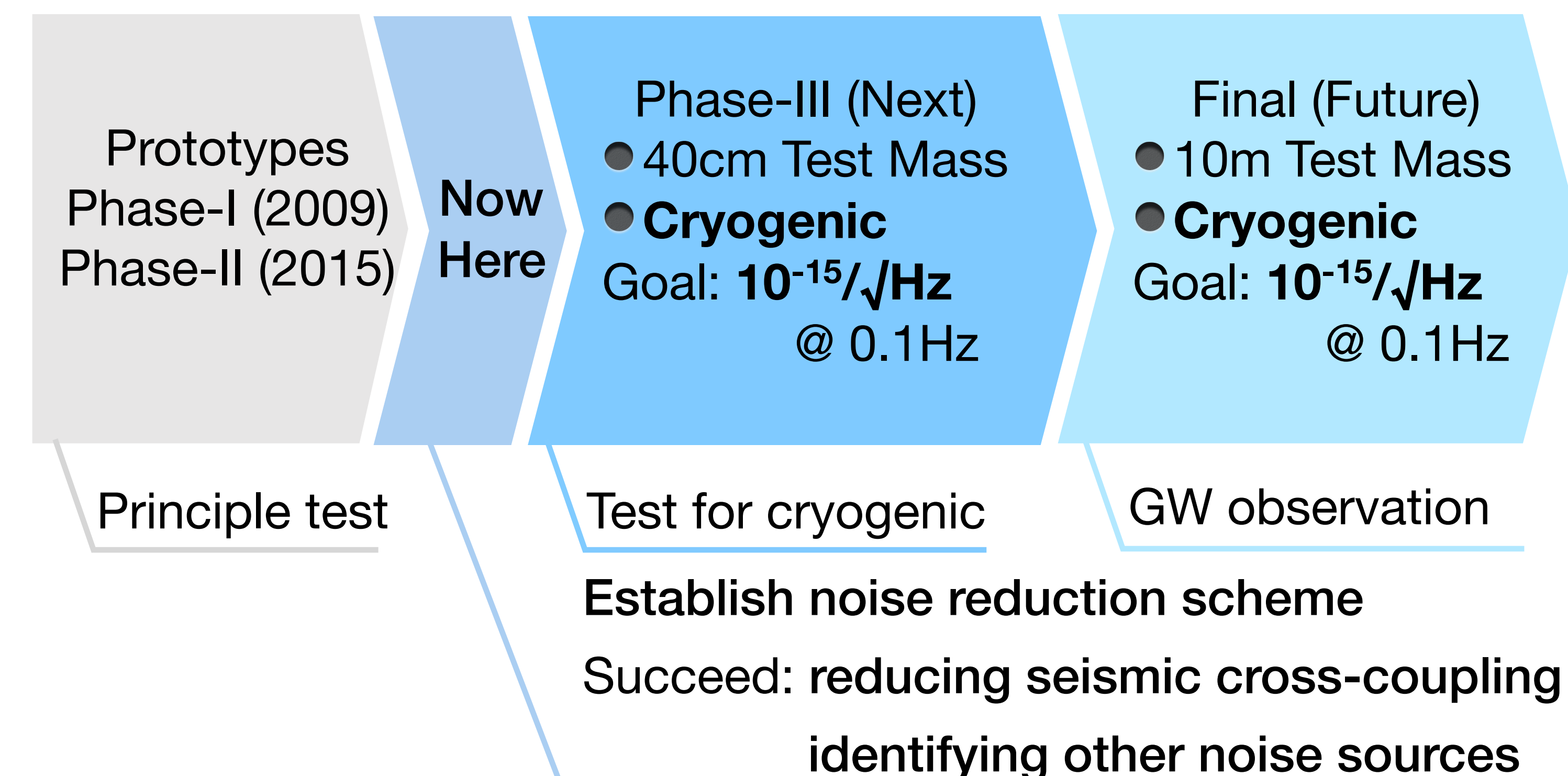
Newtonian Noise

- comes from fluctuation of terrestrial gravity field [2]
- testing models for R&D of 3G GW detectors

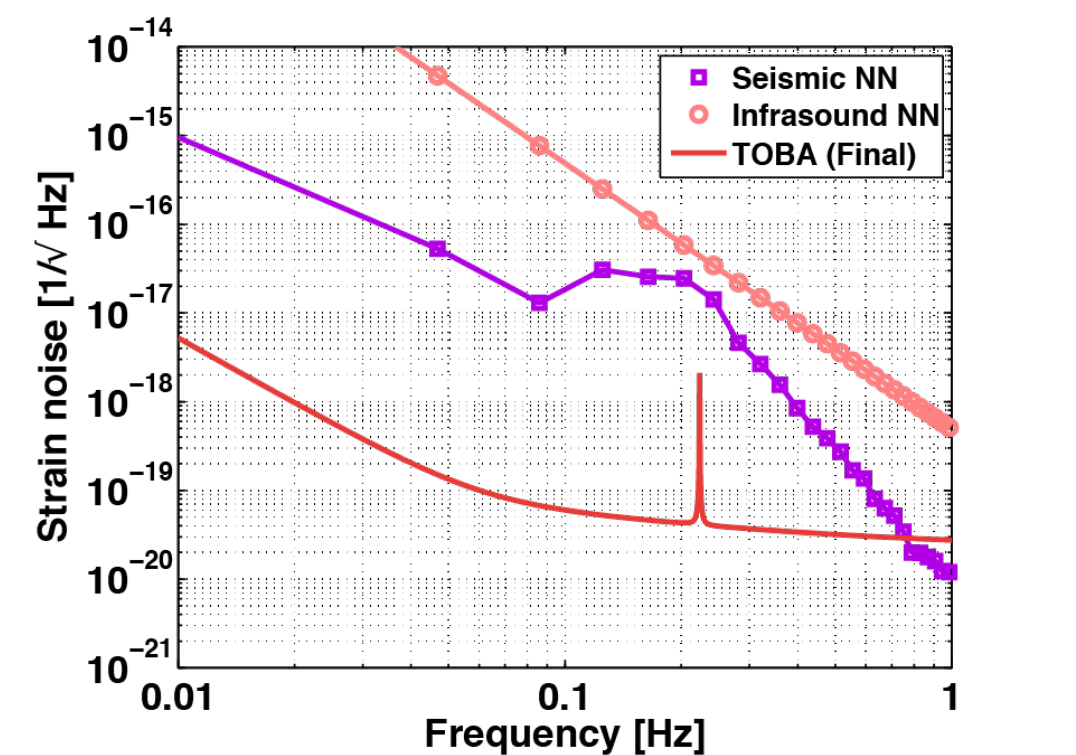
IMBH Binary Merger

- 10 Gpc for  $10^5 M_{\odot}$  BH

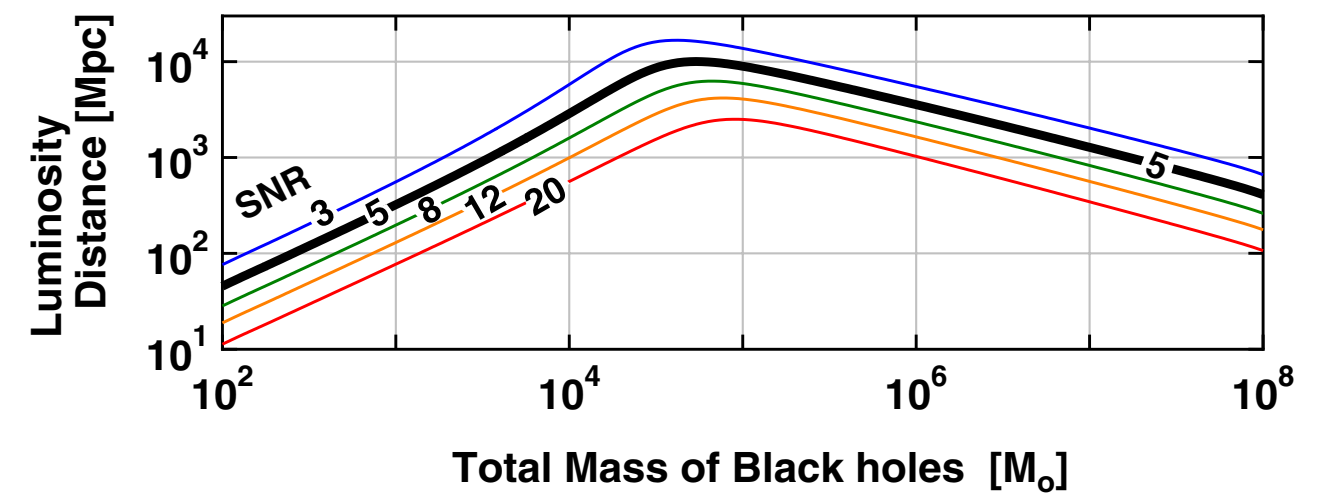
### R&D Plan



an estimation of Newtonian noise [2]



an estimation of SNR for IMBH merger [1]

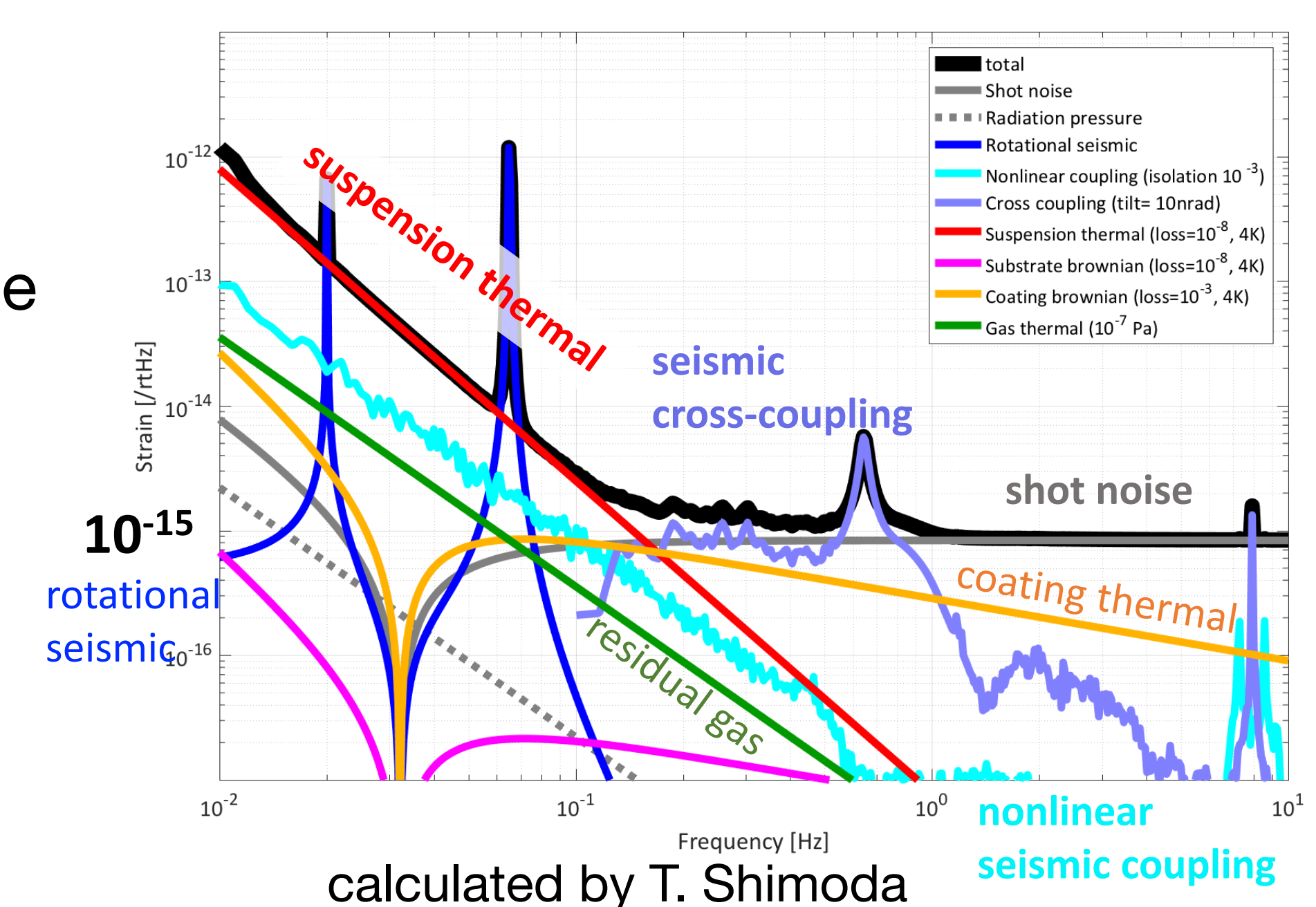


## 3. Future Plan | Phase-III TOBA

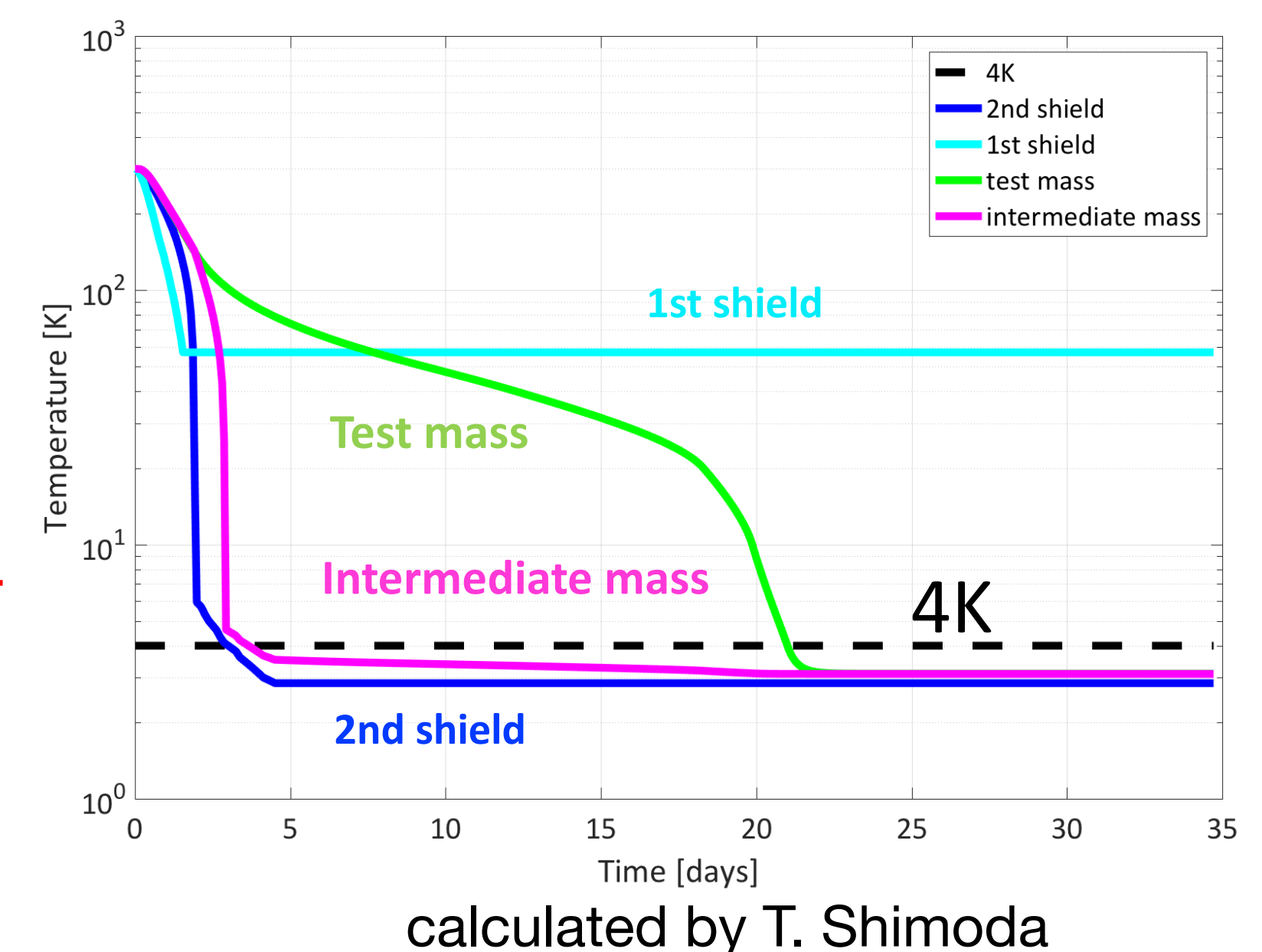
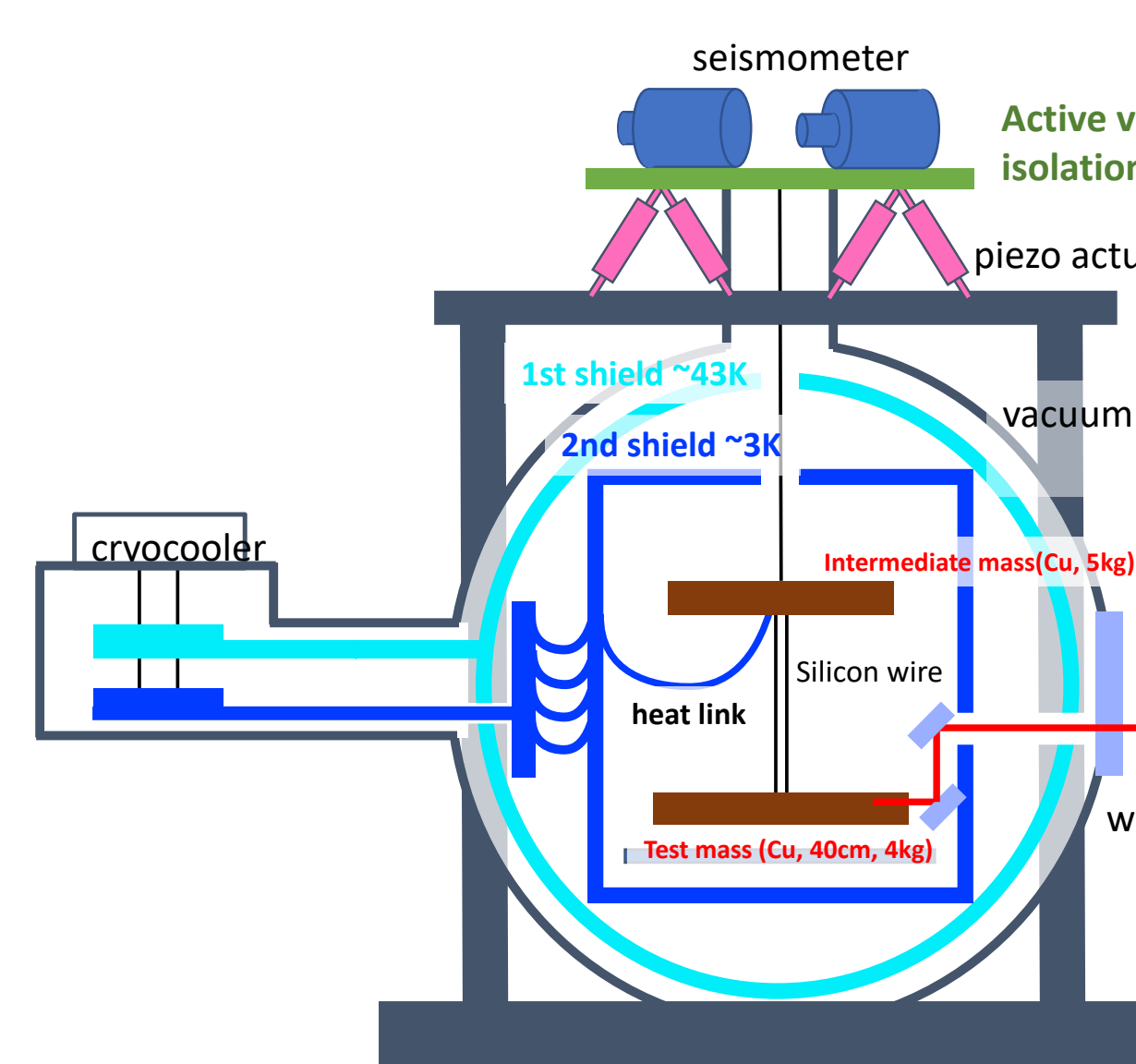
### Feature

- **Cryogenic**
  - cooled to 4K
  - reducing thermal noise
- **New readout sensor**
  - a kind of WFS
  - advantage in some points

Design sensitivity of Phase-III TOBA

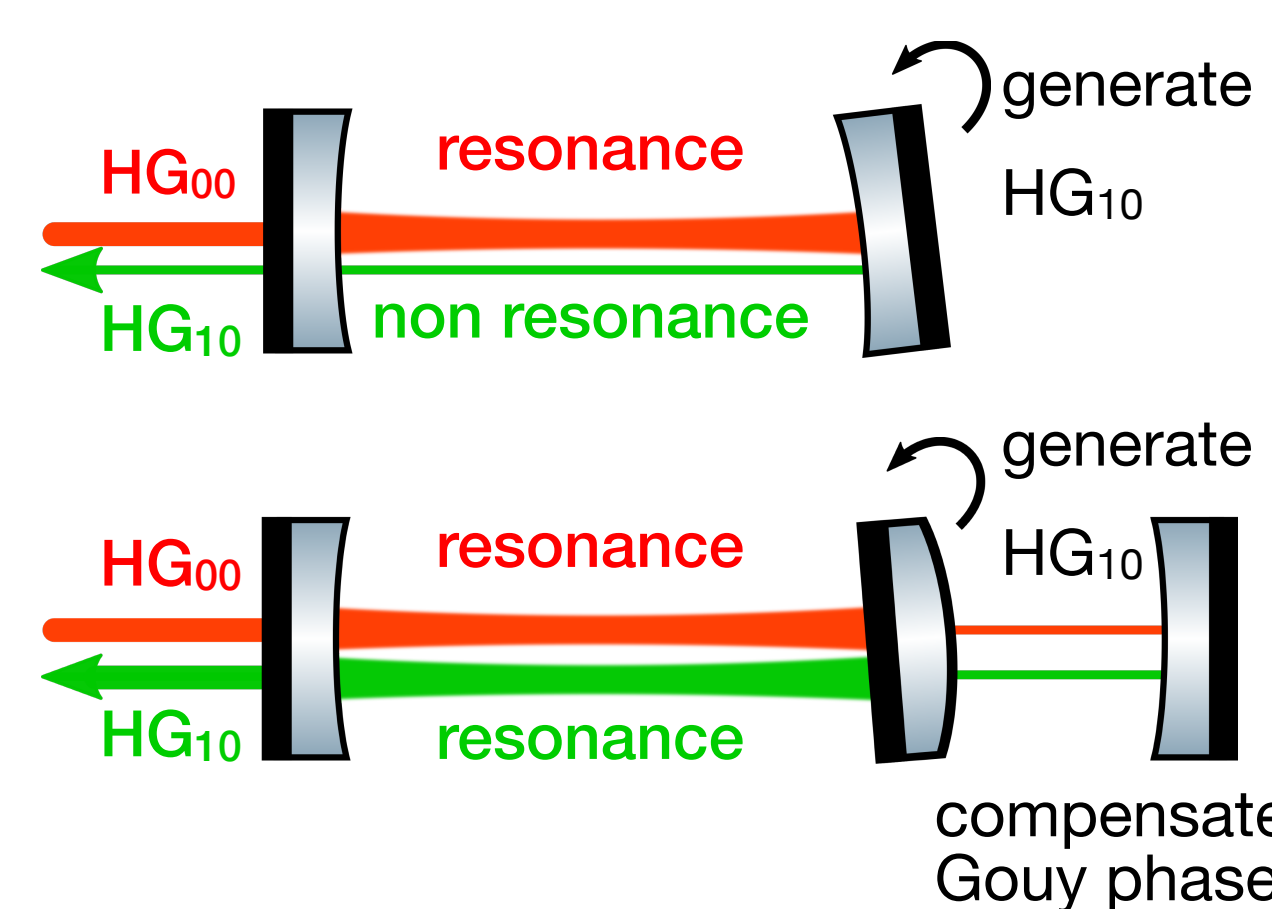


### Cryogenic | cooled to 4K



- two cryogenic shields
  - radiation cooling + heat
- reach 3.1K in 21 days

### New readout sensor | improved WFS



ordinary wave front sensor  
HG<sub>00</sub> resonates, but HG<sub>10</sub> doesn't

improved WFS  
**Both HG<sub>00</sub> and HG<sub>10</sub> resonates**

What is good?

- **No frequency noise**
- **Lower cross-coupling than Michelson interferometer (MI)**
- **The same optical gain and shot noise level as MI**

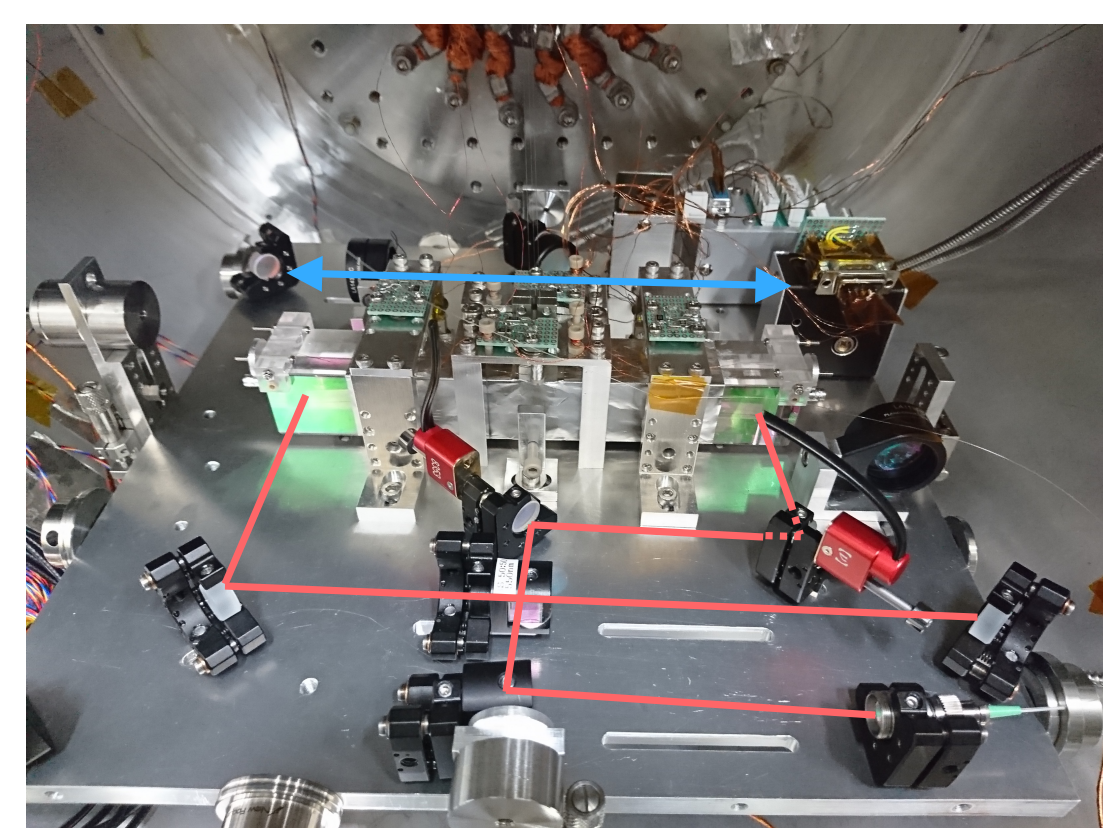
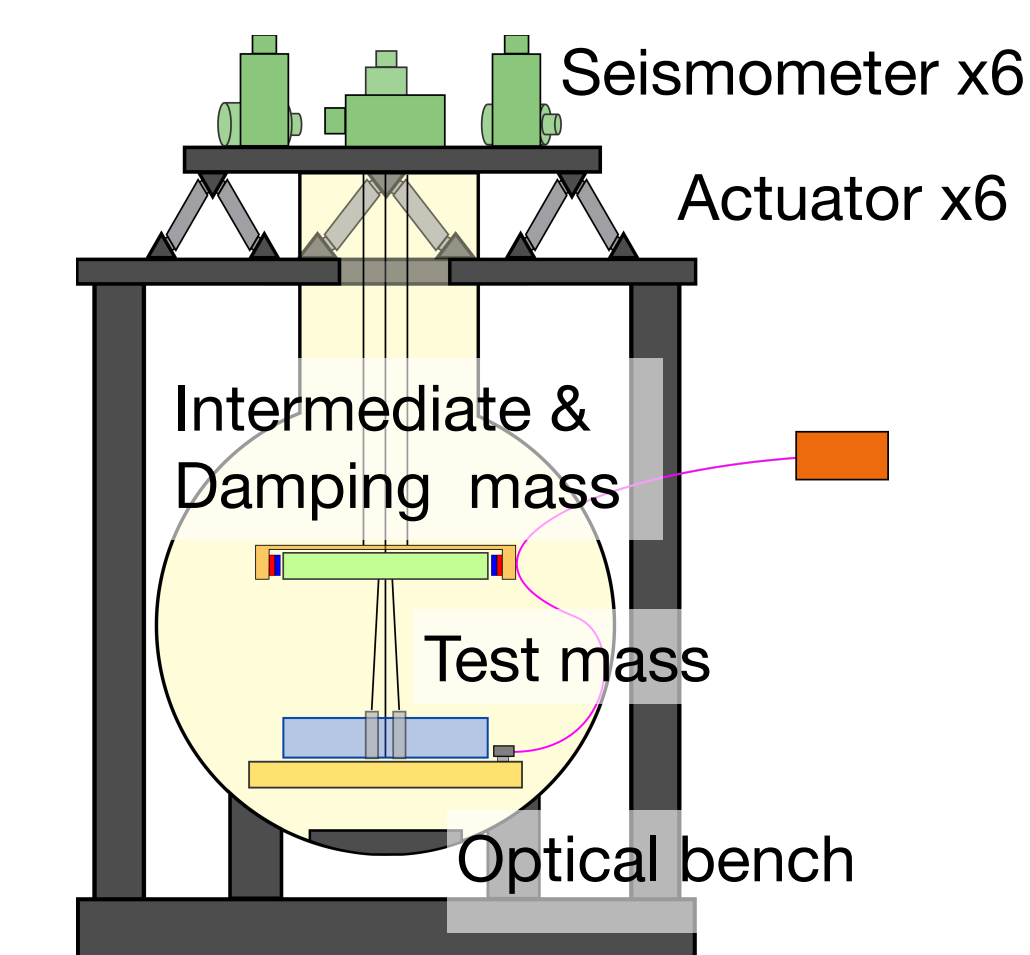
## 4. Summary

We showed basic concept of TOBA. Our goal is to observe Newtonian noise and IMBH binary mergers. So far we have identified many noise sources and demonstrated reducing schemes. We started Phase-III TOBA, in which we cool tests mass to 4K and employ new angular sensor, improved WFS.

### Reference

- [1] M. Ando et al., Phys. Rev. Lett. **105**, 161101 (2010)  
[2] J. Harms et al., Phys. Rev. D **88**, 122003 (2013)

## 2. Current Result | Noise investigation



- 20cm test mass
- Michelson interferometer

