



# Report of GWADW & KIW

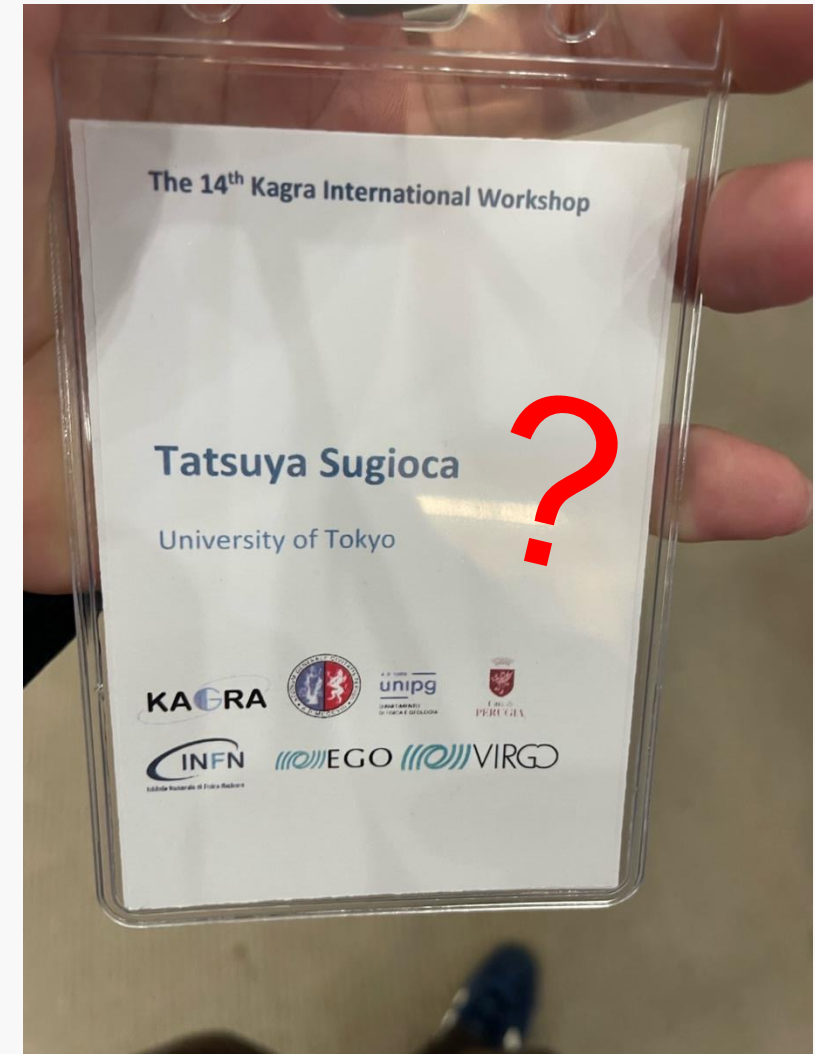
Tatsuya Sugioka



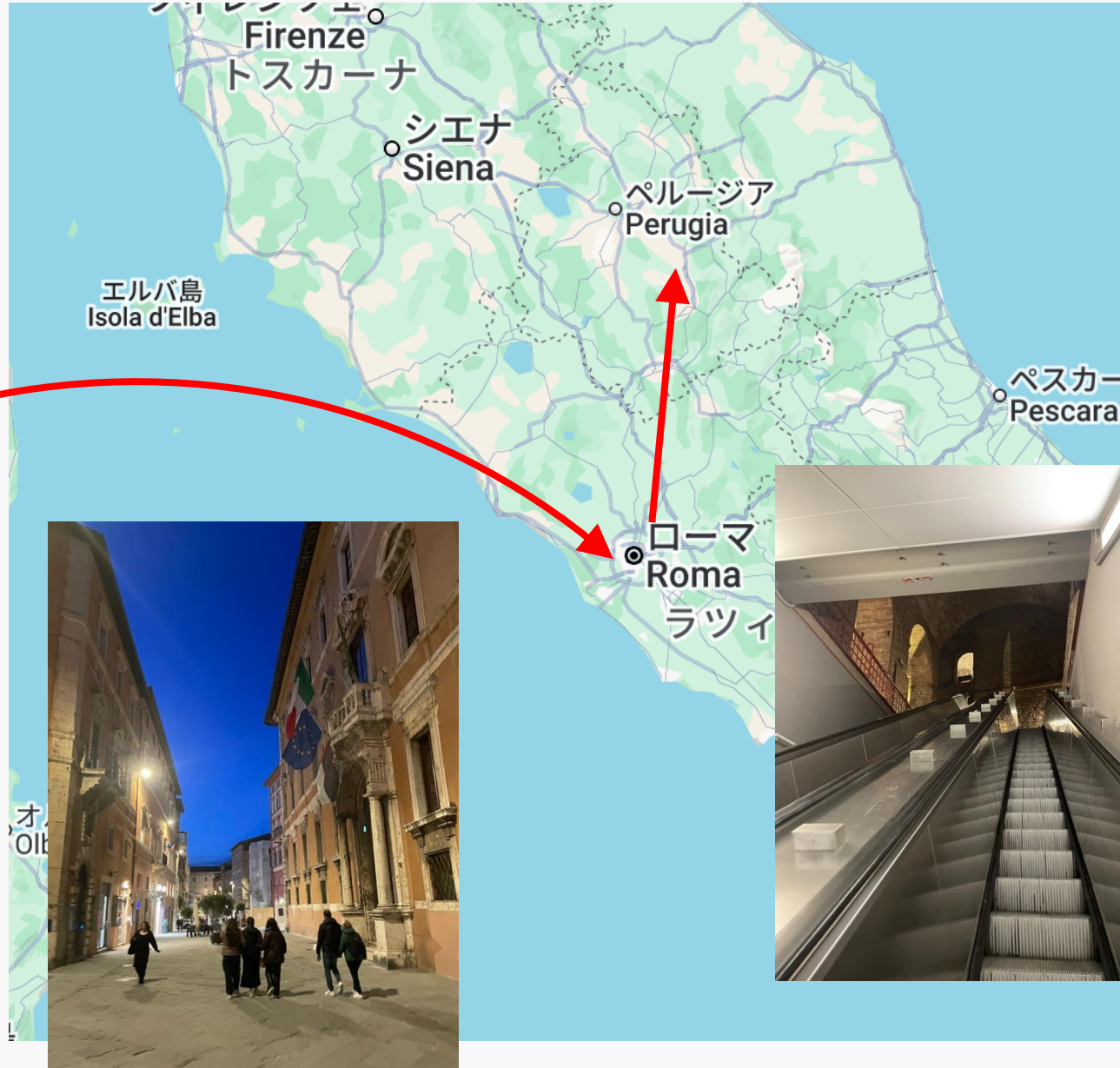
# The 14th KAGRA International Workshop

@Perugia

- The 14th KAGRA International Workshop
- May 15~16, 2026
- Sina Brufani Hotel, Perugia, Italy
- Plenary sessions, Discussions and Small poster session mainly about detector
- Social event; Planetarium and music event
- Workshop lunch and social dinner



LHR

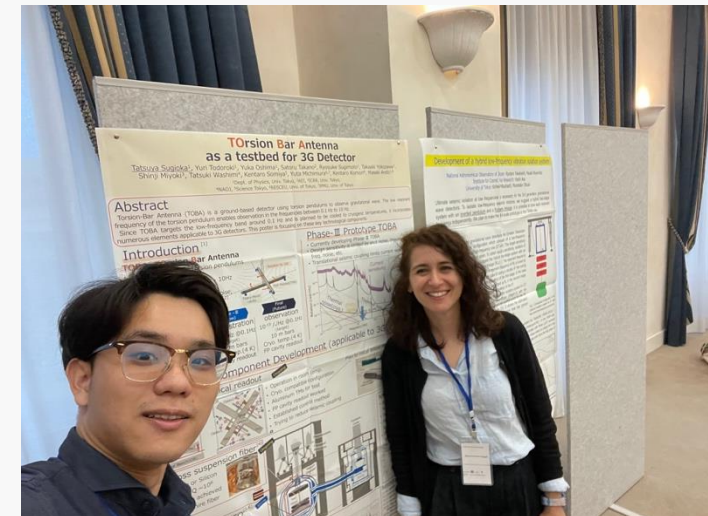


- Small, hilly city
- Escalator in center of city

Life in Perugia is slow  
: Zhizhong, Ph.D. student in Perugia Univ.



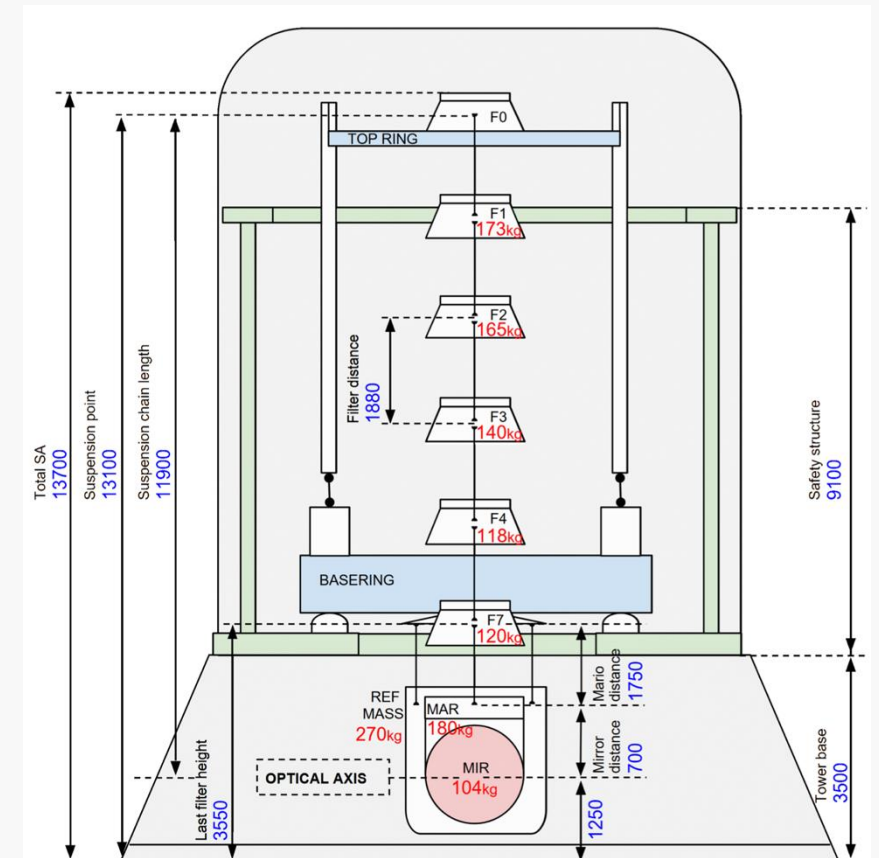
- Workshop for collaboration towards Einstein Telescope
- Many students from Perugia University
  - Most of them are working on simulation? Reinforcement learning?
- Talks about Superattenuator, low-loss fiber, Environmental noise, etc.
- CAOSのお披露目
- TOBA workshopに来ていた Irena, Mariaと再開

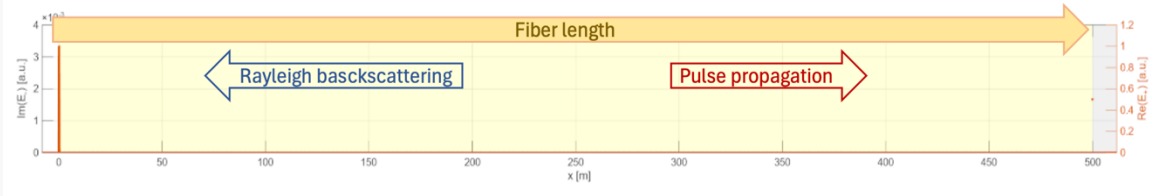


- Full-Scale Testing of ET Superattenuators
- 6.5m FP cavity between 15m Tower

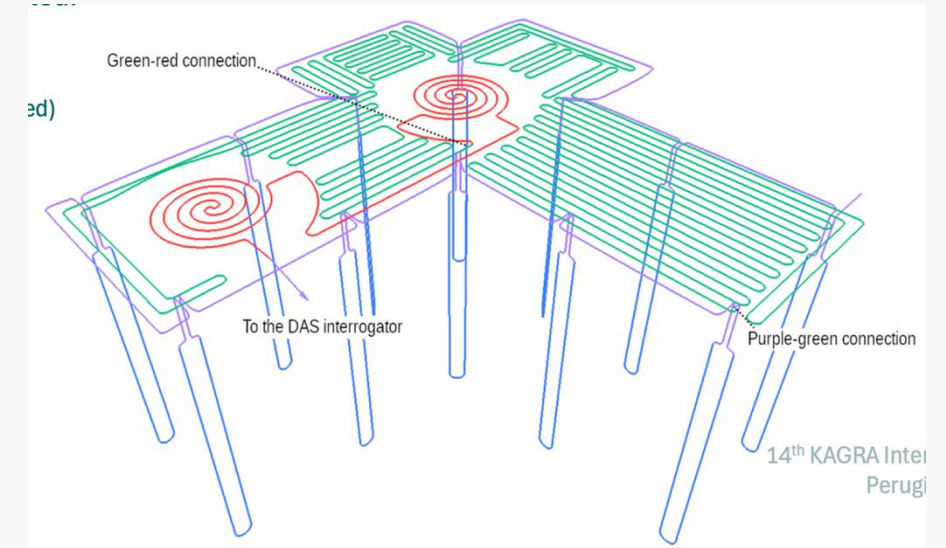


[F. Bianchi+](#)

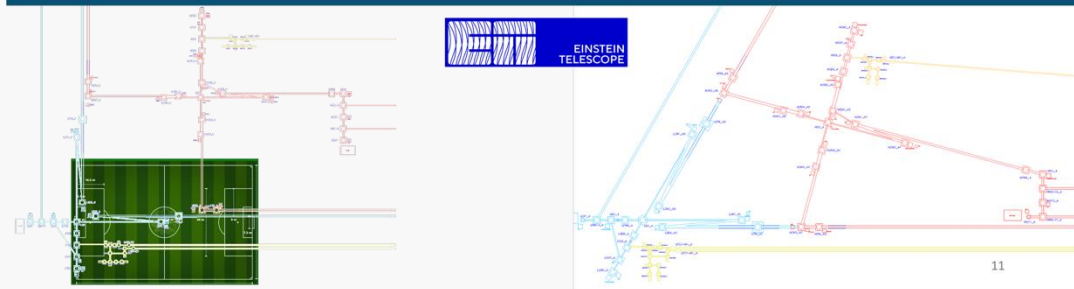
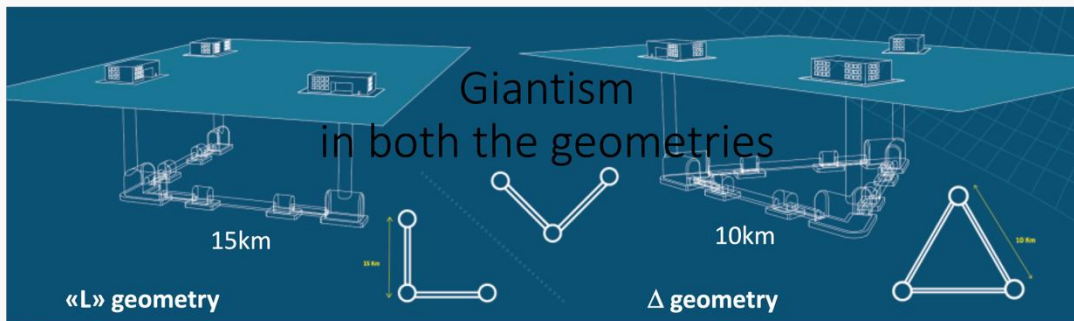




## ● Acoustic sensing with distributed fiber



[P. Chessa+](#)



[M. Punturo+](#)

- ET configuration
- $L \times 2$  VS triangle
- L: 60 km tunnel,  $\Delta$ : 30 km tunnel
- $\Delta$ は共振器が6本、太くすると高い
- 単純に短い $\Delta$ が安いとは言えない

## Torsion Bar Antenna as a testbed for 3G Detector

Tatsuya Sugioka<sup>1</sup>, Yuri Todoroki<sup>1</sup>, Yuka Oshima<sup>1</sup>, Satoru Takano<sup>2</sup>, Ryosuke Sugimoto<sup>1</sup>, Takaaki Yokozawa<sup>3</sup>, Shinji Miyoki<sup>3</sup>, Tatsuki Washimi<sup>4</sup>, Kentaro Somiya<sup>5</sup>, Yuta Michimura<sup>6,7</sup>, Kentaro Komori<sup>4</sup>, Masaki Ando<sup>1,6</sup>

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### Abstract

Torsion-Bar Antenna (TOBA) is a ground-based detector using torsion pendulums to observe gravitational wave. The low resonant frequency of the torsion pendulum enables observation in the frequencies between 0.1 Hz to 10 Hz. Since TOBA targets the low-frequency band around 0.1 Hz and is planned to be cooled to cryogenic temperatures, it incorporates numerous elements applicable to 3G detectors. This poster is focusing on these key technological components.

### Introduction<sup>[1]</sup>

#### TOBA; Torsion Bar Antenna

- GW detector using torsion pendulums
- Ground-based
- Target freq. range: 0.1Hz - 10Hz
- Scientific targets:  
IMBH merger, Newtonian Noise,  
Earthquake Early Warning [2]

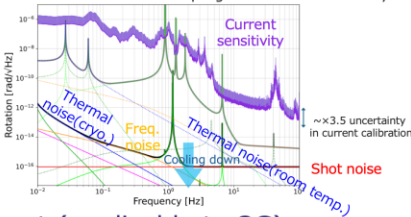
#### Development plan

| Phase - I<br>(2013)                   | Phase - II<br>(2015)              | Phase - III<br>(Now)              | Final<br>(Future) |
|---------------------------------------|-----------------------------------|-----------------------------------|-------------------|
| Principle test                        | demonstration                     | observation                       |                   |
| $10^{-8}$ /Hz @0.1Hz<br>(established) | $10^{-15}$ /Hz @0.1Hz<br>(target) | $10^{-19}$ /Hz @0.1Hz<br>(target) |                   |
| 20 cm bars                            | 30 cm bars                        | 10 m bars                         |                   |
| Room temp.                            | Cryo. temp.(4 K)                  | Cryo. temp.(4 K)                  |                   |
| MI readout                            | FP cavity readout                 | FP cavity readout                 |                   |



### Phase-III Prototype TOBA

- Currently developing Phase-III TOBA
- Design sensitivity is limited by shot noise, thermal noise, freq. noise, etc.
- Translational seismic coupling limits current sensitivity



## Prototype & Component Development (applicable to 3G)

### Suspension & optical readout

- Operation in room temp.
- Cryo. compatible configuration
- Aluminum TMs for test
- FP cavity readout worked
- Established control method
- Trying to reduce seismic coupling

Plan to install Silicon TMs for cooling down

Silicon TMs

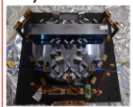
### Low loss suspension fiber<sup>[4]</sup>

- Sapphire or Silicon
- Required  $Q \sim 10^8$
- $\sim 3 \times 10^5$  is achieved with sapphire fiber



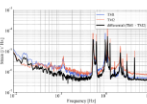
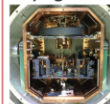
### Cryo. Monolithic IFO<sup>[5,6]</sup>

- For readout
- Cryogenic (12K)
- Silicon made
- Full monolithic
- $\sim 10^{-14}$  m/√Hz



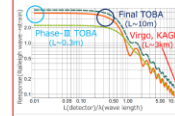
### Cryogenic torsion pendulum<sup>[5,7]</sup>

- Cooled down to ~6K in 10 days
- Copper TMs (surface oxidized)
- Optical levers readout
- Significant magnetic noise
- $\sim 10^{-6}$  /Hz @0.1Hz



### NN detection<sup>[8]</sup>

- Aiming at first direct NN observation
- Test current models
- More sensitive than larger detectors
- Possibly subtract NN from 3G detector



### References

- [1] M. Ando et al., PRL, 105, 161101 (2010).
- [2] J. Harms et al., GJI, 201, 1416 (2015).
- [3] Y. Oshima, Ph.D. thesis, U Tokyo (2024).
- [4] Y. Yamaguchi, M. thesis, U Tokyo (2025).
- [5] S. Takano et al., Galaxies, 12(6), 78 (2024).
- [6] S. Takano, Ph.D. thesis, U Tokyo (2024).
- [7] T. Shimoda, Ph.D. thesis, U Tokyo (2019).
- [8] J. Harms, Living Rev Relativ 22, 6 (2019).

Few people were interested in poster...

# Social event, Bonus

9/19

- ご飯美味しかった、昼からワイン
- プラネタリウムはETのアウトリーチのための施設、高校の中？
- Virgoでも思ったがアウトリーチ頑張ってる
- 梶田さんの対談とアインシュタインバイオリンのイベント、夜11時まで
- 市民に科学が浸透している



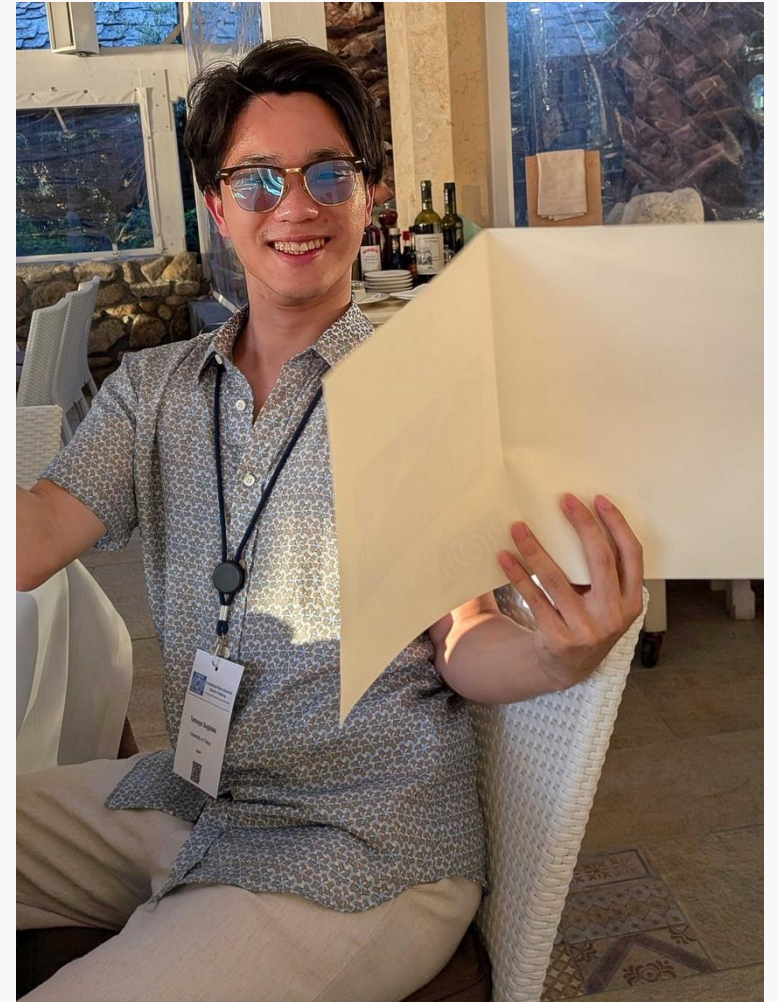


# GWADW 2026

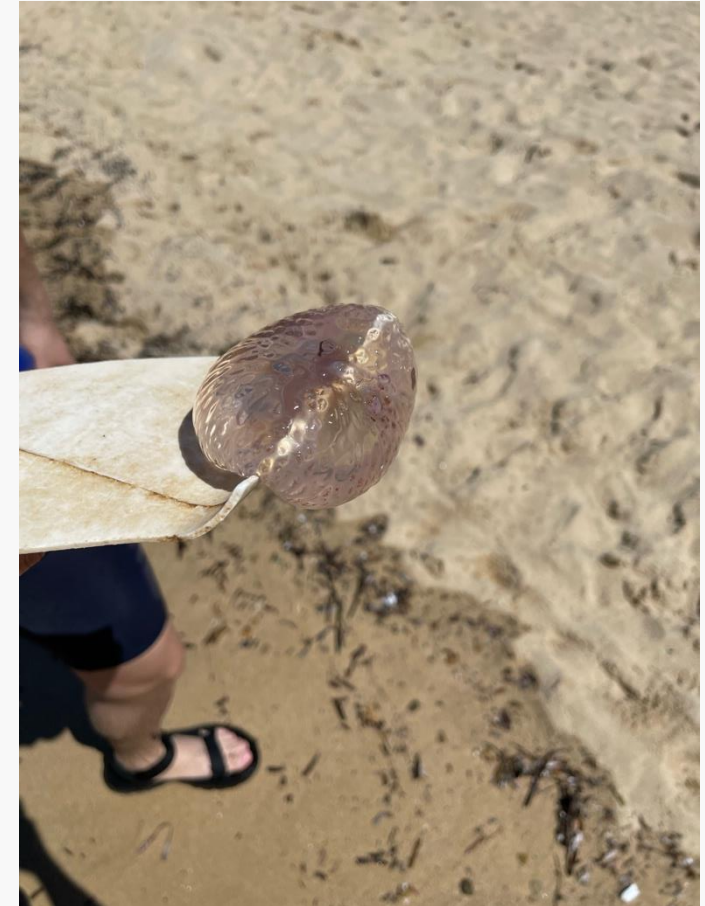
@Elba

- Gravitational-Wave Advanced Detector Workshop
- Hotel Hermitage, Elba Island, Italy
- Plenary sessions, Panel discussions, two poster sessions
- Long lunch time; ~3 hours
- Workshop lunch and dinner every day

Blank Menu



- Great discussions during lunch, dinner and breaks
- Many Japanese participants
- Many talks and discussions about squeezing
- AlGaAs coating ?
- 3G is getting realistic
- 葉くん、井殿くんと沢山話して刺激をもらった



# Talk about ET pathfinder

13/19

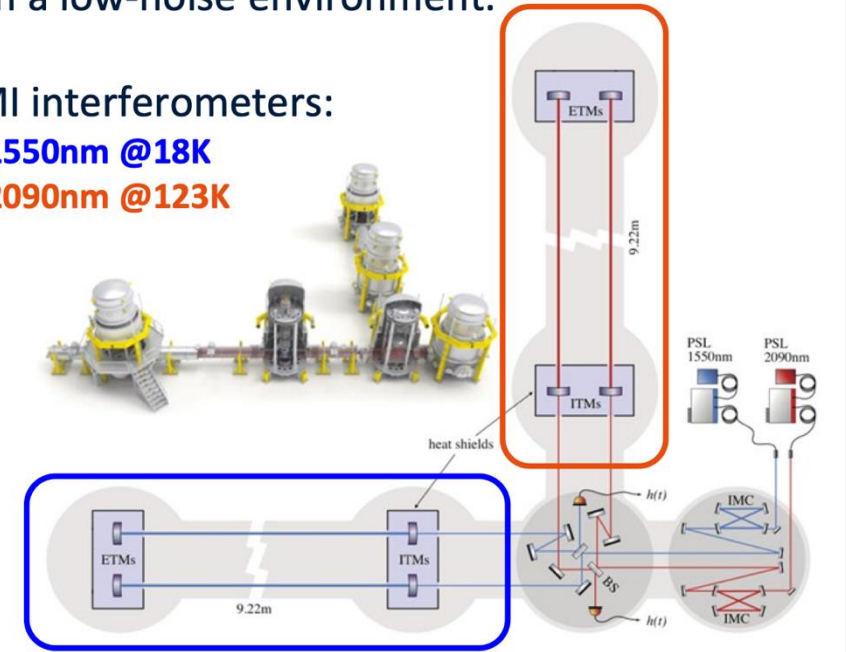
- Etpathfinder is ongoing at Maastricht
- 2 FPMI with different laser color, temp.
- 2 suspension benches installed out of 6
- Saffire & Silicon option for suspension fiber
- Operation at zero cross point of silicon's thermal expansion coefficient
- Developing two-colored laser( $1.5\mu$  &  $2\mu$ ) for ALS
- 行ってみたい

them in a low-noise environment.

2 FPMI interferometers:

1) 1550nm @18K

2) 2090nm @123K

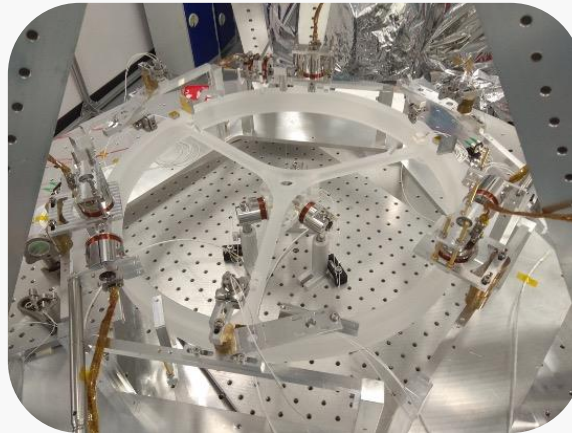


[L. Kranzhoff+](#)

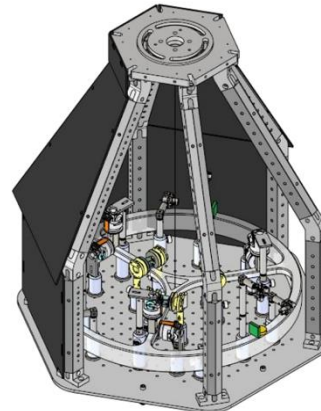


[M. Vardaro+](#)

- Same results as the talk in LVK
- Balancing coil ??
- They moved the setup to MIT test facility
- C6D suspension was once disassembled and transported with care



*Fig. 12. C-6D  
undergoing  
testing on  
Birmingham ISI*



*Fig. 13. 3D  
rendering of C-6D*

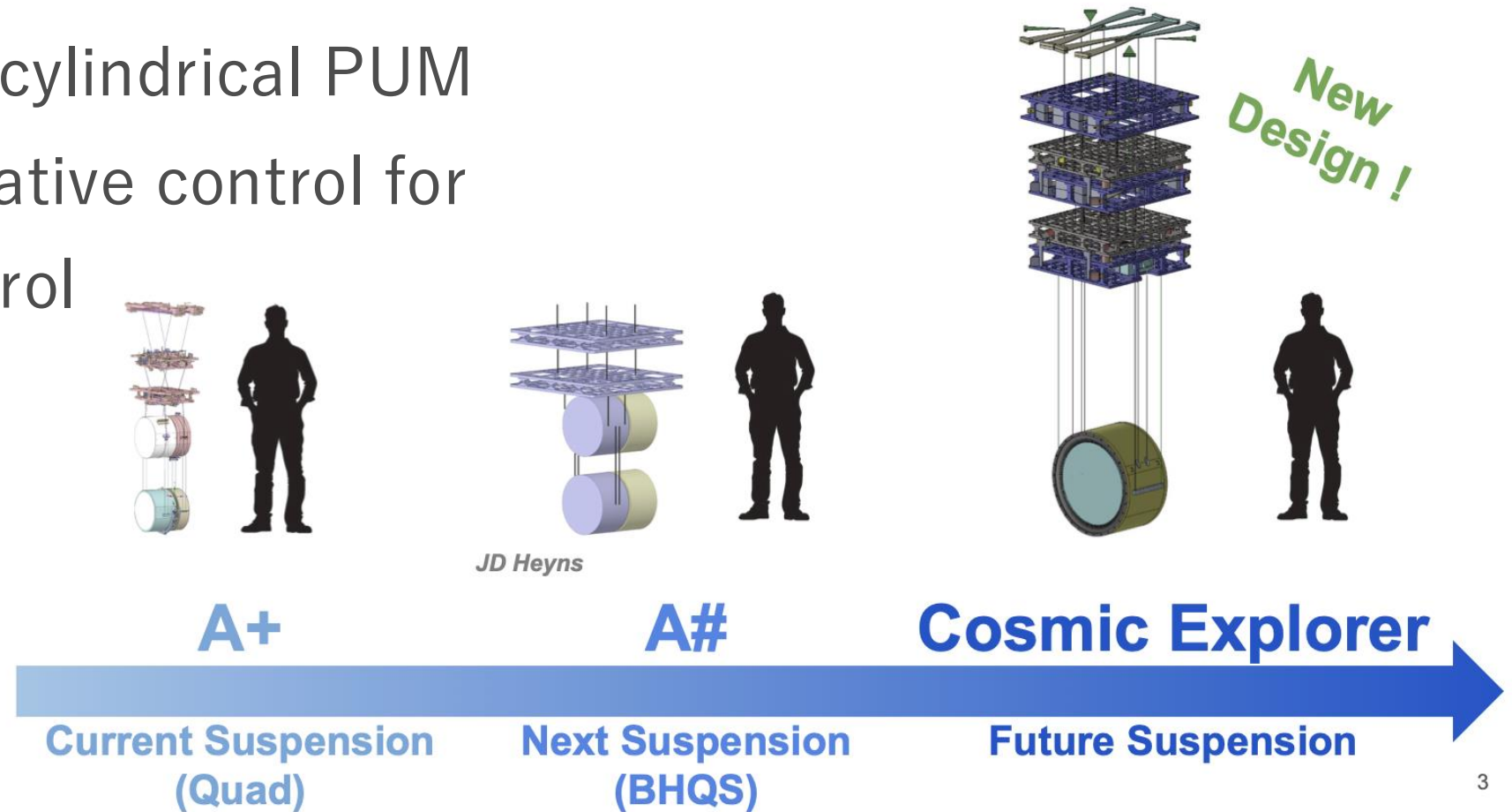


*Fig. 14. C-6D  
undergoing  
installation at MIT  
LASTI facility*

# Talk about CE suspension

15/19

- CE suspension design
- Virgo or KAGRA like reaction mass
- Pizza box  $\times 3$ , not cylindrical PUM
- Plan to vertical relative control for bounce mode control



- Status talk of TOBA in “New Directions” session
- Introduced developed components mainly focusing on my master’s work
- 3 questions
  - What is the coupling route of seismic motion?
  - In AVIT, any penalties due to actuator?
  - Does NN limit Sensitivity for GW?
- 3Gへの応用を押し出したが反応は薄かった
  - TOBAのプレゼンスを上げたい
  - まず感度を出すしかない



- Discussed about AVIT
- Microseismic attenuation is not feasible only with L4C
- Actuator coupling to rotation is critical
  - Non-linear and drifts
- Easiest way is sensor correction with ground seismometer, and compensate rotation with relative sensor
  - Maybe 2 months
- Kindly introduced some documents about VIS
- “Torsion bar is ○○”

- Whether and how to move TOBA to Kamioka-site
- In October?
- Mainly considering installation in Xend toward collaboration with Ncal
- 1550 laser source?, Oplevはその辺のやつ適当に使う
- 横澤さん(と誰か?)が本郷に来てロックできるようになってもらう
- あまり工数を割きすぎないように



- Squeezingがアツいらしい
- LIGOの人はかっこいい
- LVK, 3Gにつながる話ばかり
- みんなやさしい