

Reports on GRASS 2022 and a Visit to the University of Trento

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Contents

- GRASS 2022
 - Access to Padova, venue, timetable
 - Social events (coffee break, banquet, museum)
 - Chats with Tanioka-san and Matteo
 - Interesting talks
- A visit to the Univ. of Trento
 - Schedule, access to Trento
 - Members of LISA Trento team
 - Experimental room tour

I had a very good time in Italy!

I post a lot of photos in bonus slides

Why did I visit Padova and Trento?

Apr. 7 Announcement of GRASS to KAGRA ML by Matteo Leonardi
→ I missed this email, but Takano-san suggested me to attend GRASS because WFS was included in topics

Apr. 8 Email to Ando-sensei expressing my interest in GRASS

Apr. 13 Meeting with Ando-sensei

→ I said I wanted to visit a university

→ Ando-sensei proposed LISA group at Univ. of Trento



Can you travel two hours by train from Padova to Trento?

I can. Because I have been to Italy and taken trains with my family in 2018

(If I had never been to Italy, I would not have attended GRASS)



Apr. 18 Application for my oral presentation to GRASS

Apr. 21 Email from Ando-sensei to Stefano

→ Prompt welcome reply, but Stefano retired and became a full prof. so I needed to contact Bill

Apr. 23 My first email to Bill

GRASS

GRASS:

GRAvitational-waves Science&technology Symposium

1st GRASS: Mar. 1-2, 2018

at Palazzo Moroni, Padova

2nd GRASS: Oct. 24-25, 2019

at Palazzo Moroni, Padova

3rd GRASS: Jun. 6-7, 2022

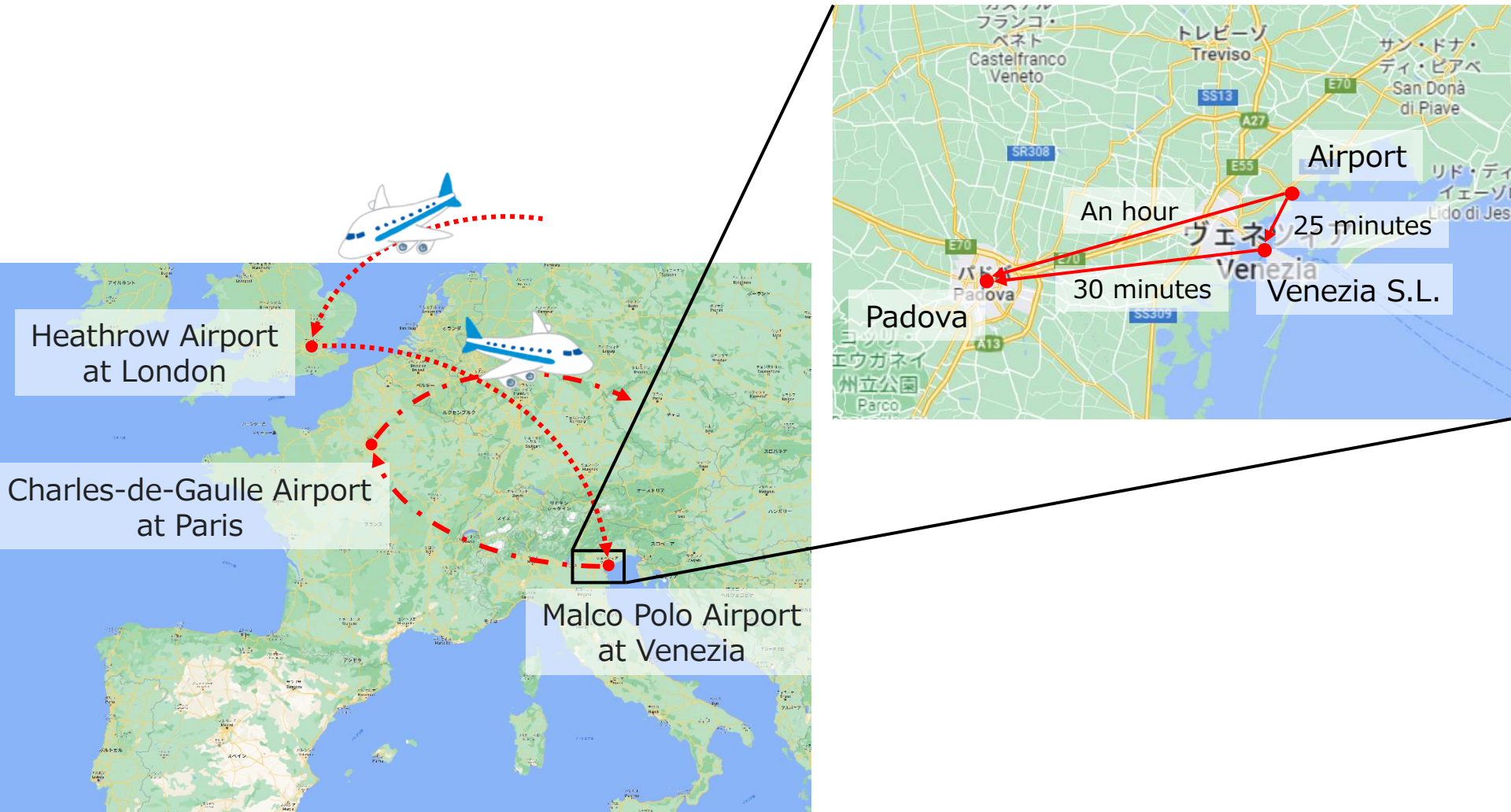
at Palazzo Moroni, Padova



How to get to Padova

Padova is 30 minutes by train from Venezia

There are no direct flights from Japan to Venezia



Venue of GRASS

Palazzo Moroni, which hosts Padova City Hall and is located next to Univ. of Padova



Reception



Souvenirs



Timetable of GRASS 2022

June 6

8:30

08:30	Registration	08:30 - 09:00
08:30	Welcome	08:30 - 09:00
08:30	Optical coatings	08:30 - 09:00
08:30	Coffee break	08:30 - 09:00
08:30	Data analysis	08:30 - 09:00
08:30	5 invited talks	08:30 - 09:00
08:30	27 contributed talks	08:30 - 09:00
08:30	Coffee break	08:30 - 09:00
08:30	Other challenges for future GW	08:30 - 09:00
08:30	Banquet	08:30 - 09:00

Registration
Welcome

Optical coatings

Coffee break

Data analysis

5 invited talks
27 contributed talks

Coffee break

Other challenges
for future GW

18:20

20:30

22:30

June 7

9:00

09:00	Stray light	09:00 - 09:30
09:00	Poster session	09:00 - 09:30
09:00	7 posters	09:00 - 09:30
09:00	Tour to museum	09:00 - 09:30
09:00	Wavefront sensing and control	09:00 - 09:30
09:00	Coffee break	09:00 - 09:30
09:00	My talk	09:00 - 09:30
09:00	63 participants	09:00 - 09:30
09:00	(half from Italy, half from Europe, 5 from USA, 2 from Japan)	09:00 - 09:30

Stray light

Poster session

7 posters

Tour to museum

Wavefront sensing
and control

Coffee break

My talk

63 participants
(half from Italy, half from Europe,
5 from USA, 2 from Japan)

18:05

Coffee break



Banquet

Antico Brolo Restaurant



Undergraduate student
from Boise, USA

Alvise Pizzella ([His slides](#))
Ph.D. student from Hannover

Andrea Grimaldi ([His slides](#))
Ph.D. student from Padova

Ph.D. student
from Cagliari

D3 student
from Trento



Mauro Oi (p.20)
Ph.D. student from Cagliari

Sophie Bini (p.18)
D1 student from Trento

Full Italian course (fish menu)



+ red and white wine

Guided tour to museum of physics

Museum of the history of Physics, Univ. of Padova



Device to study the motion along cycloid

- Two balls that dropped from different heights arrived at the end of the cycloid at the same time
- Considered to be important for isochronous pendulums
- Confirmed the relationship between the velocity at the end and the drop height

It appears to climb upward and to break the laws of physics, but the center of gravity goes down

Chat with Tanioka-san



[Members of Syracuse Univ.](#)

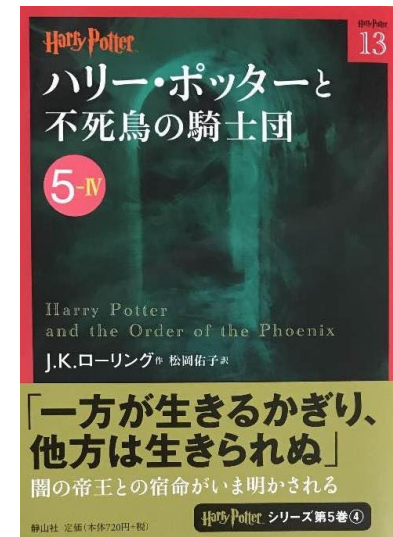
Tanioka-san kindly spoke to me
during a coffee break on the first day
He is the only Japanese participant
except for myself

He got his Ph.D. in Mar. 2021 at 総研大 NAOJ
and now a postdoc at Syracuse University

He works on Cosmic Explorer at Stefan Ballmer's group

He said Stefan stopped coming to GRASS and came to Japan
(Stefan and Kokeyama-san are committees, but didn't come to Padova)

He said,
"CE will be operated at room temp.
with fused silica mirror" and
"Only LIGO Voyager or CE will be built
due to budget limits"



Chat with Matteo

I spoke to Matteo after the tour of the museum

I walked and talked with him for 15 minutes
on the way back to the conference venue

He is an assistant prof. at NAOJ
and the only participant from Japan except for myself



[His profile](#)

He asked me about the current members of Ando Lab

- He didn't know Komori-san became assistant prof. from June
- He said Komori-san considered MIT and NAOJ as a postdoc

He graduated from the Univ. of Trento

He plans to stay home in Italy with his family after GRASS

He kindly said, "welcome to TAMA at NAOJ anytime!"

- I said I would come on June 22 for PEM injection for TAMA with Yokozawa-san and Washimi-san
- Email from Washimi-san on June 8 saying that the meeting postponed

Tips for in-person talks (I think)

1. Speak loudly
2. Speak slowly
3. Slides with large text, especially **labels of the figures**

I think these tips are more important than the contents of the slides because no matter how good the contents are, it is meaningless if the audience does not listen

Even if students' presentations, you'll get a lot of questions when you give nice presentations

Even if invited talks, the audience will be bored when these tips are not achieved



Selected talks

I introduce the following 9 talks with one slide for each

Optical coatings

- Steven Penn
- Satoshi Tanioka

Stray light

- Eleonora Polini

Data analysis

- Andrea Virtuoso
- Sophie Bini

Wavefront sensing and control

- Antonio Perreca (invited)
- Gabriella Chiariniv

Other challenges for future GW

- Matteo Leonardi (invited)
- Mauro Oi

Total 6 talks,
3 about mode matching control

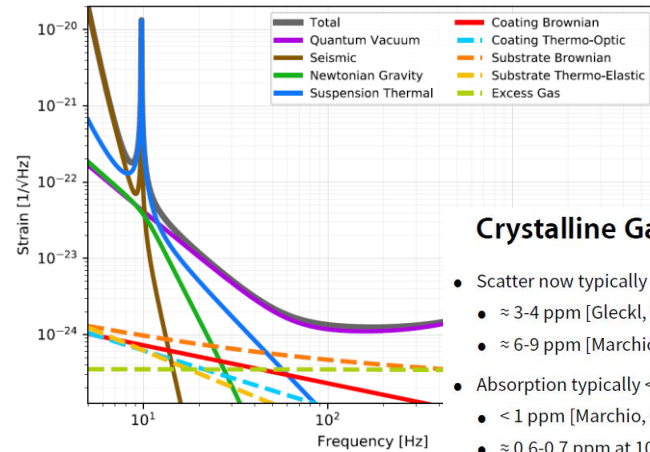
Overview of GaAs/AlGaAs coatings

by Steven Penn from Syracuse Univ.

Crystalline GaAs/AlGaAs coatings will meet optical specs

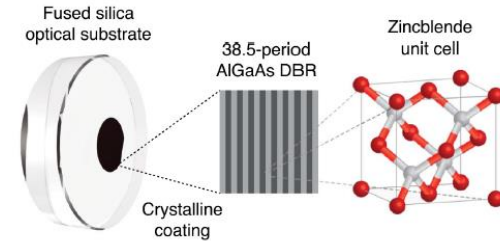
Coating thermal noise (CTN) will not limit sensitivity
for current or planned detectors

A+ Design Sensitivity + Crystal Coating (Mean Value)



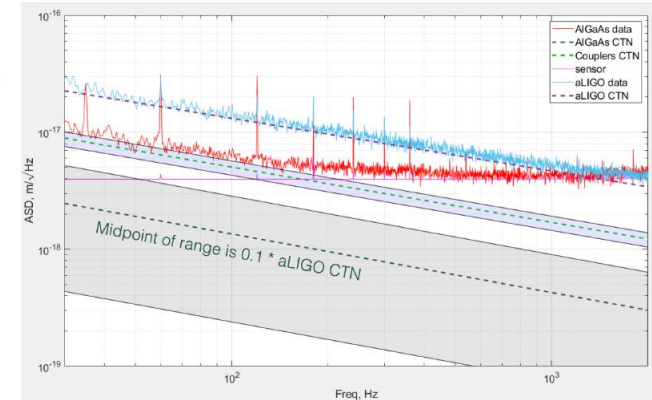
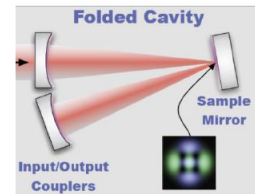
Crystalline GaAs/AlGaAs Coatings • Optical Properties

- Scatter now typically < 5 ppm
 - ≈ 3-4 ppm [Gleckl, Fullerton]
 - ≈ 6-9 ppm [Marchio]
- Absorption typically < 1 ppm
 - < 1 ppm [Marchio, et al.]
 - ≈ 0.6-0.7 ppm at 1064 nm [Cole, 2016]
- Uniformity
 - < 2 nm/5 cm [Koch 2019]
- Laser Damage Threshold
 - > 64 MW/cm² [Koch 2019]
- Finesse: ≈ 500,000 at 1397 nm
 - ≈ 500,000 at 1397 nm [Thorlabs]
 - > 600,000 at 1550 nm



CTN Measurements

- Measured by Nick Demos, Slawek Gras, & Matt Evans (LIGO-G2001592)
- Noise dominated by cavity end mirrors (couplers)
- Upper limit CTN is 5x lower than Adv. LIGO
- Mean CTN is 10x lower than Adv. LIGO



Birefringence: 4-5 MHz between polarizations

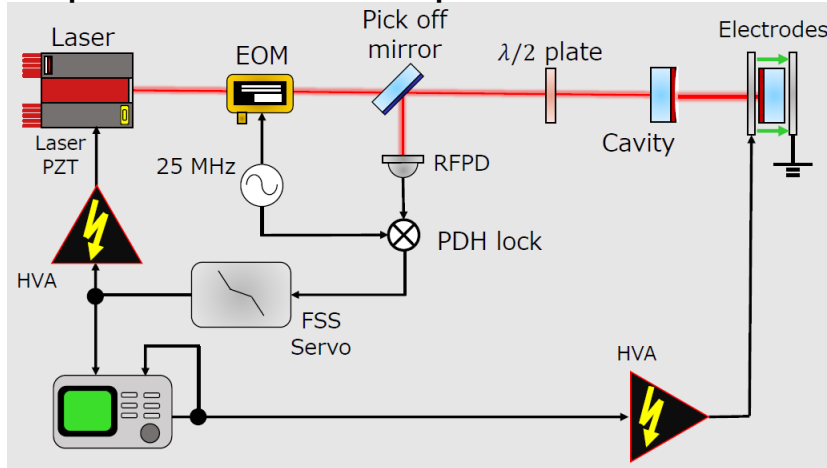
Electro-optic noise: next Tanioka-san's talk

Electro-optic noise in AlGaAs coating

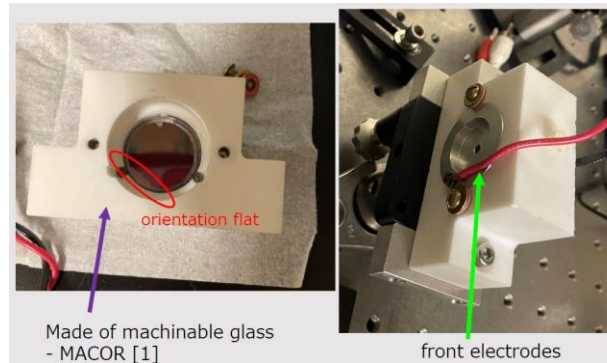
by Satoshi Tanioka from Syracuse Univ.

Evaluated electro-optic noise in crystalline AlGaAs coating mirror

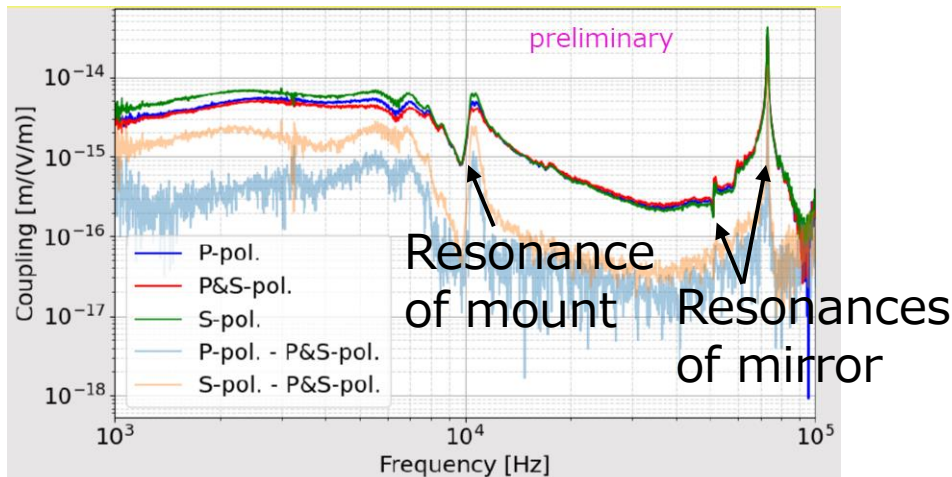
Experimental setup



Measured coupling (transfer function) from electric field to cavity length



Result



Coupling $\sim 5 \times 10^{-17}$ m/(V/m)

→ Converted to strain:

$$\sim 7.5 \times 10^{-26} / \sqrt{\text{Hz}}$$

aLIGO+ sensitivity: $10^{-24} / \sqrt{\text{Hz}}$

Electro-optic noise in AlGaAs coating will not limit sensitivity

Overlapping signal detection with cWB

by Andrea Virtuoso from Univ. of Trento

Data analysis pipelines for GW
coherent WaveBurst

[Japanese article by Shinkai-san](#)



Burst analysis
First alert



PyCBC

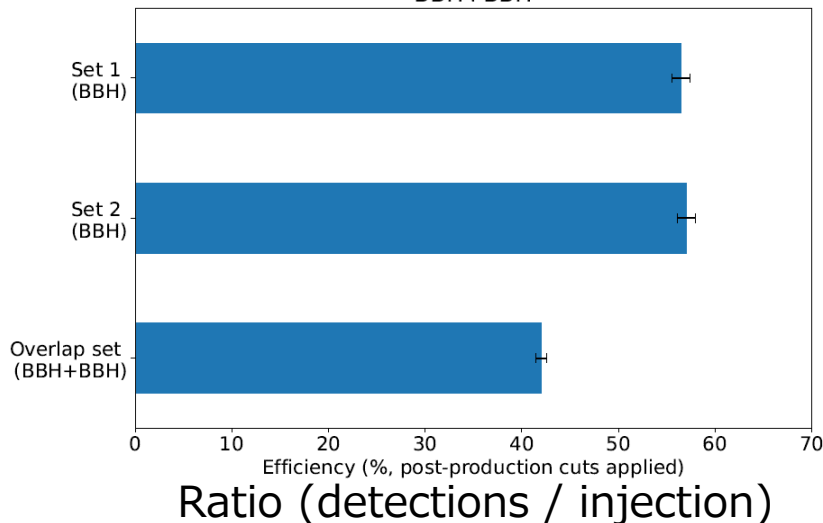
Matched filter analysis
Need template waveform



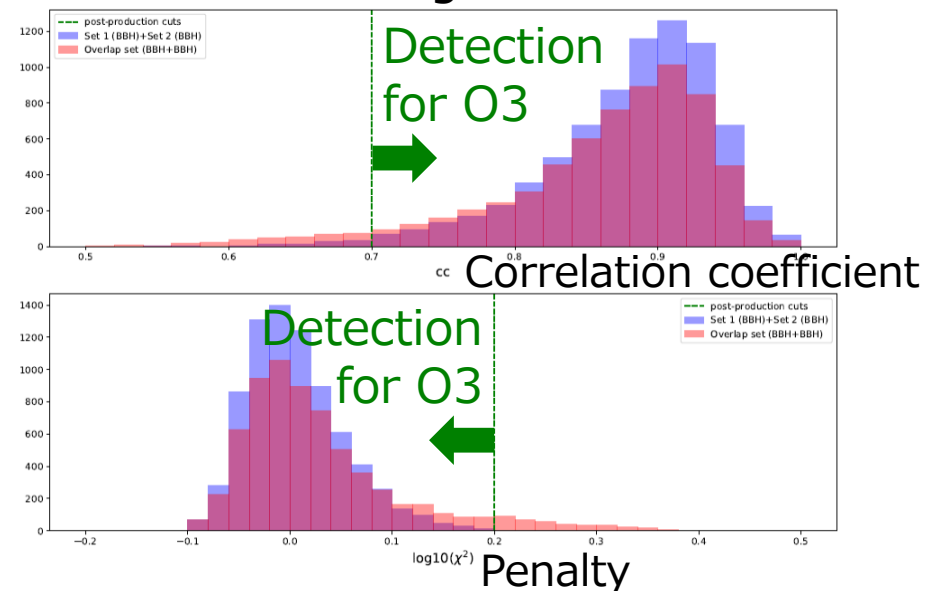
Detection of overlapping signals will be common with 3G detectors
 Analyzed overlapping signals with cWB for O5 sensitivity

One example of the results

BBH+BBH



Histograms



Automated signal-noise classification

by Sophie Bini from Univ. of Trento

XGBoost (eXtreme Gradient Boosting):
open-source library for **machine learning**

Developed machine-learning-based signal-noise classification
with XGBoost in cWB

Training dataset:

Noise

- We use 50% of the available background data (obtained through time-shifting) for training and the remaining 50% for testing

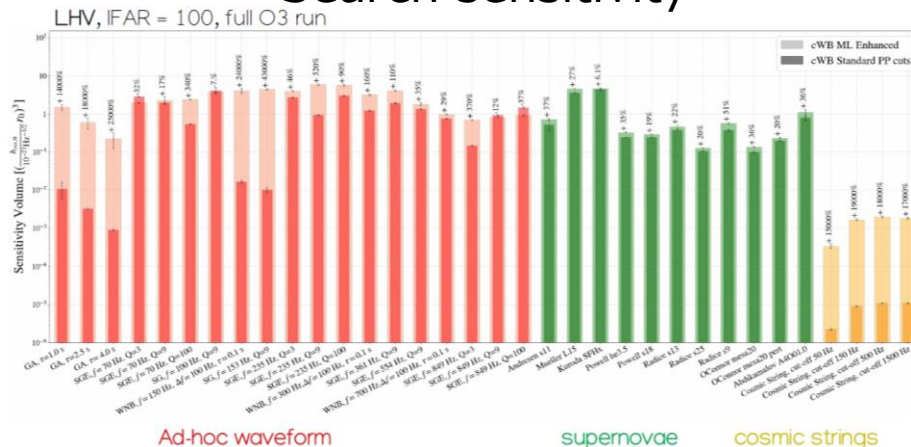


Signal

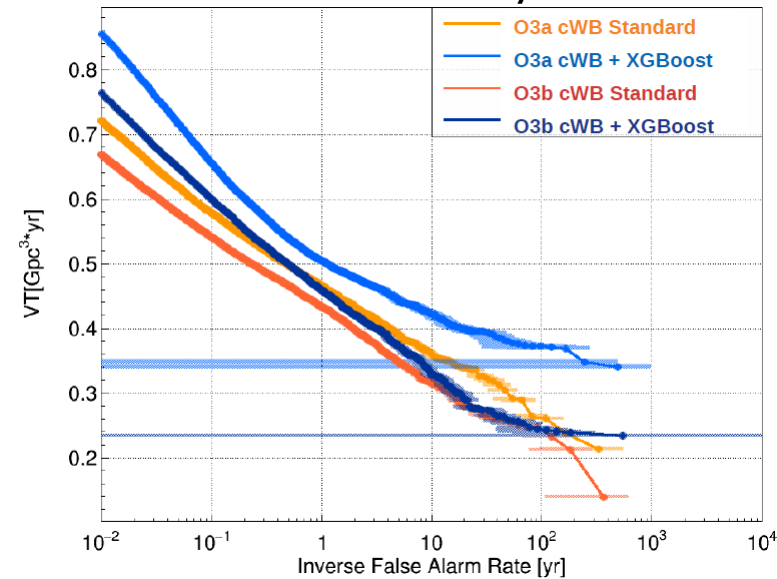
- We do not use targeted simulations that follow specific astrophysical population distributions
- Instead, we train the models on White-Noise-Bursts (WNB) with randomly chosen peak frequency, duration and bandwidth that populate different region of the time-frequency map



Search sensitivity



Search sensitivity for BBH



Sapphire mirrors for KAGRA

by Matteo Leonardi from NAOJ

First half: introduction and current status of KAGRA

Second half: issues of sapphire mirror birefringence

More than 5 questions!

The Japanese GW detector: KAGRA

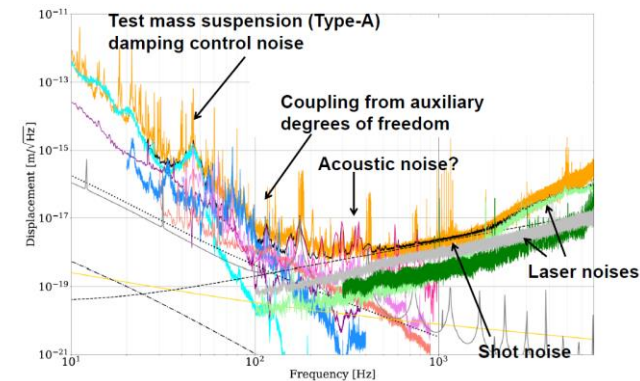
KAGRA is located near Kamioka in Gifu prefecture, one hour drive from Toyama.

Unique features:

1. Underground site
2. Cryogenic operation



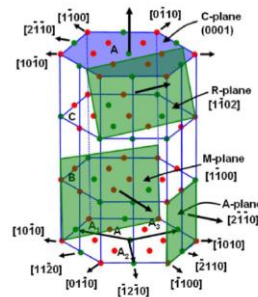
O3GK noise budget



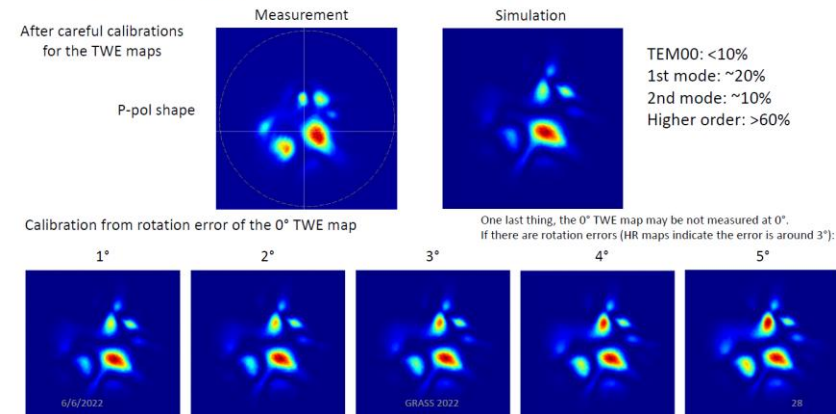
Recap on sapphire

Sapphire substrate:

- Absorption:
well known problem from design phases
- Birefringence:
partially unexpected problem

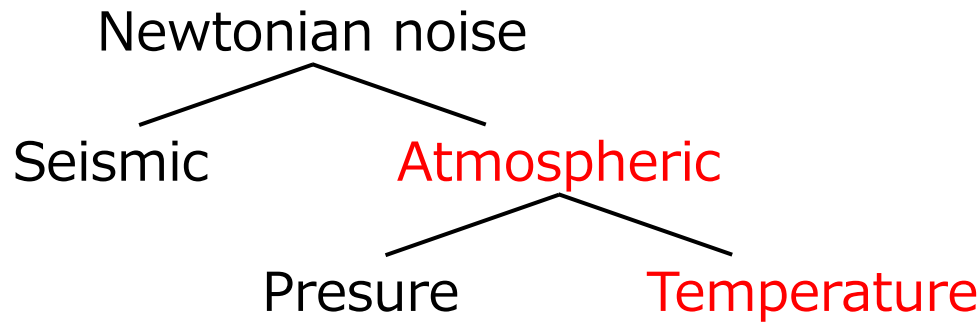


ITMX single bounce



Simulation for atmospheric Newtonian noise

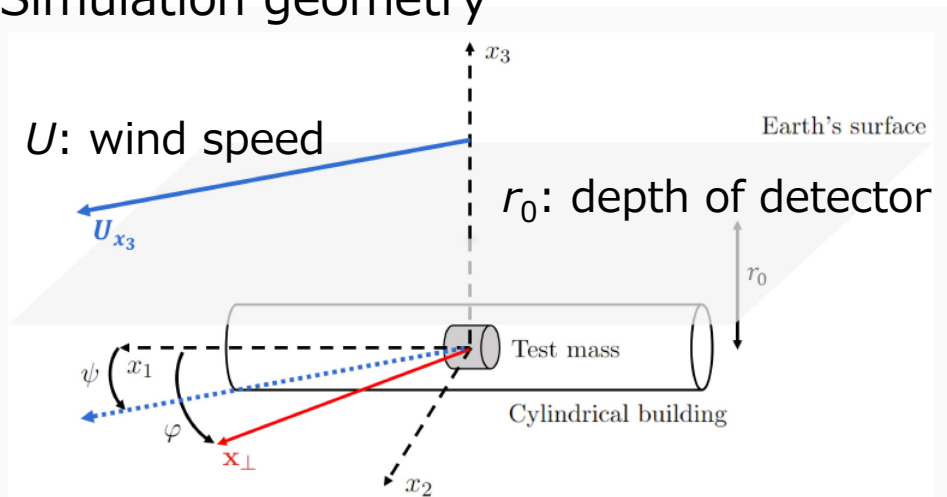
by Mauro Oi from Univ. of Cagliari



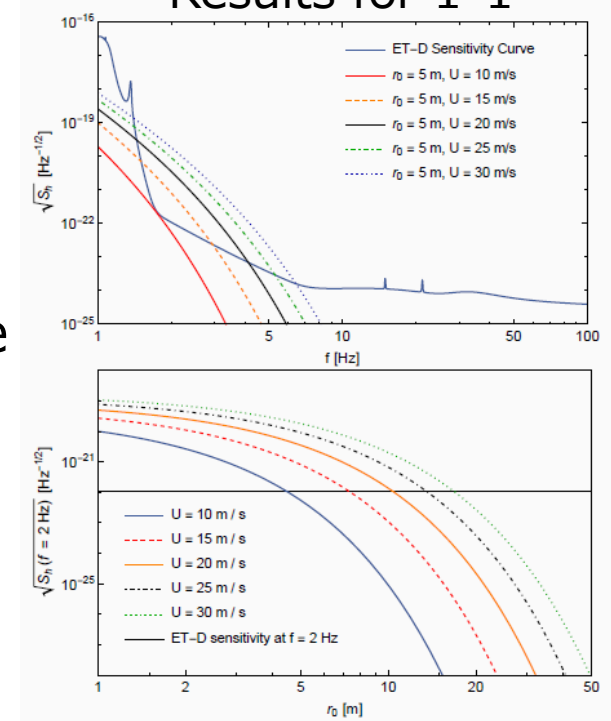
Assuming 3 cases

1. Homogeneous and isotropic turbulence
 - 1-1. Frozen approximation
 - 1-2. Finite correlation time
2. Inhomogeneous turbulence

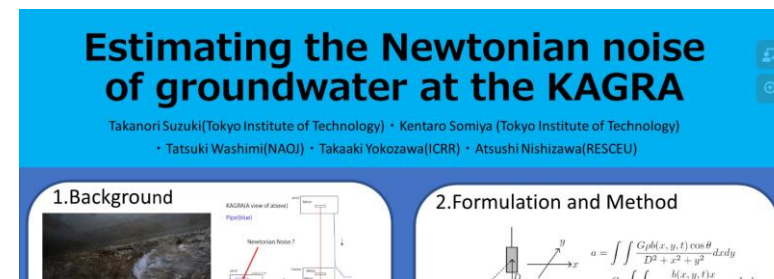
Simulation geometry



Results for 1-1



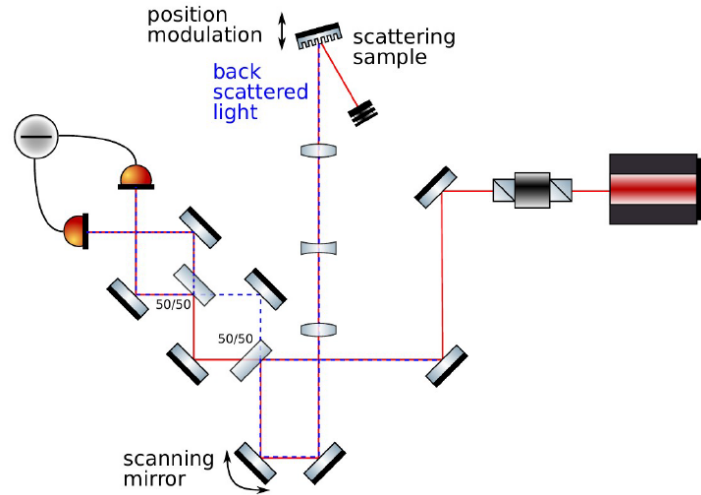
cf. Takanori Suzuki-kun's poster at GWADW 2022



Stray light control for AdVirgo+

by Eleonora Polini from LAPP

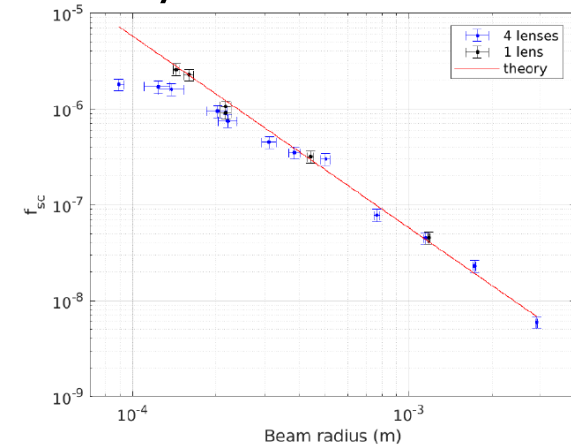
First half: measurement of back-scattered light
with balanced homodyne detector



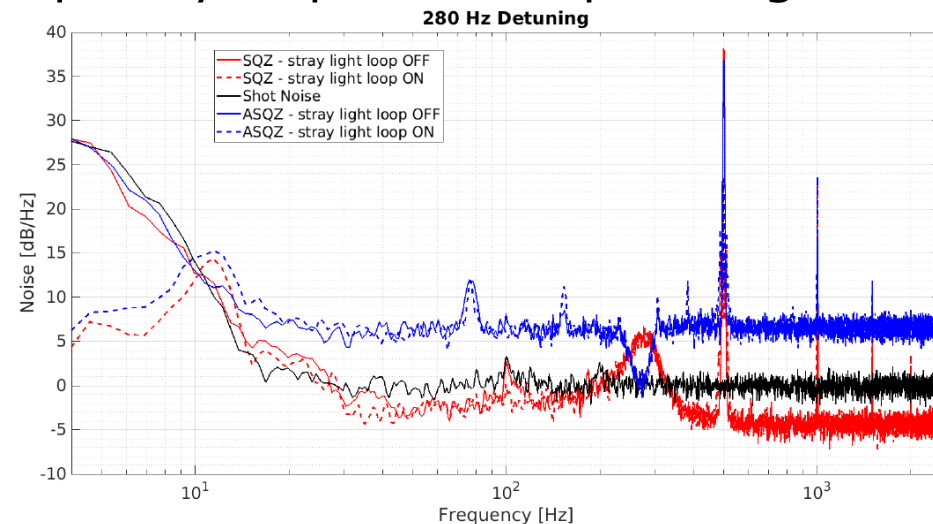
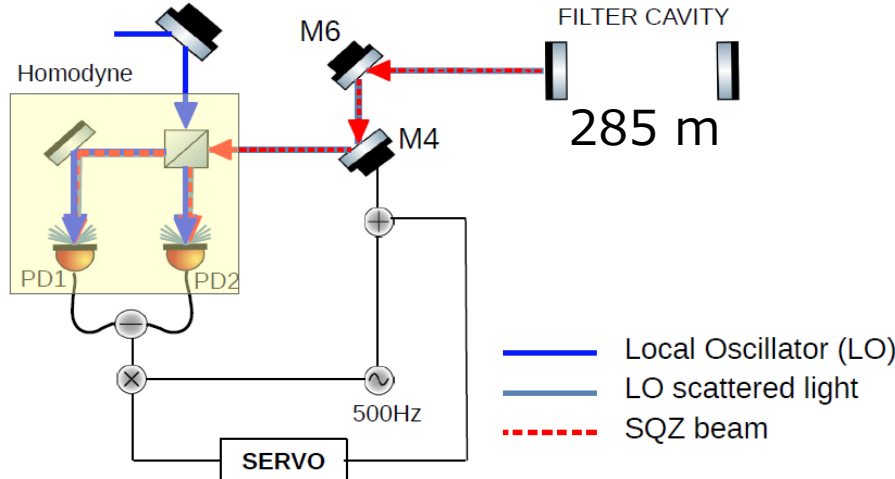
$$P_1(t) - P_2(t) = \frac{P_0}{\sqrt{2}} \sqrt{f_{sc}} \cos\left(2\pi \frac{\Delta L(t)}{\lambda}\right)$$

$$A(t) = \frac{P_1(t) - P_2(t)}{P_1(t) + P_2(t)} = \sqrt{2f_{sc}} \cos\left(2\pi \frac{\Delta L(t)}{\lambda}\right)$$

$$\text{Var}(A(t)) = f_{sc}$$



Second half: stray control for frequency-dependent squeezing



Overview of mode matching control

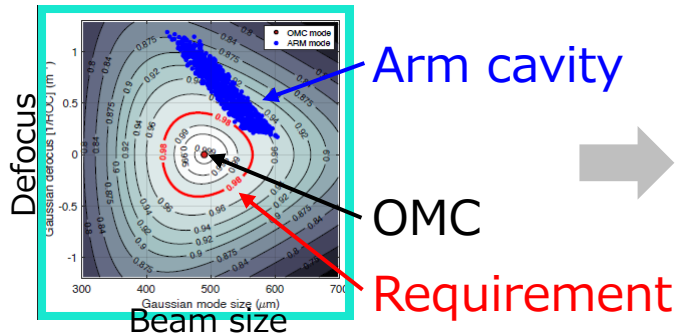
by Antonio Perreca from Univ. of Trento

First half: motivation of mode matching control

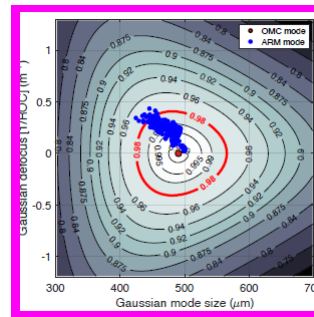
The level of frequency-dependent squeezing is **limited by losses**

Example: aLIGO

More than 12% mismatch without control



The requirement will be fulfilled if we success control



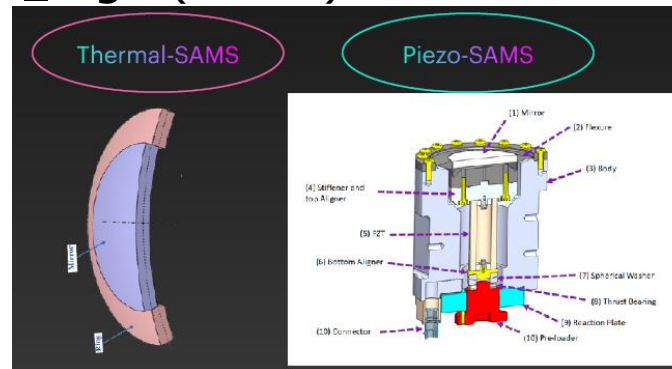
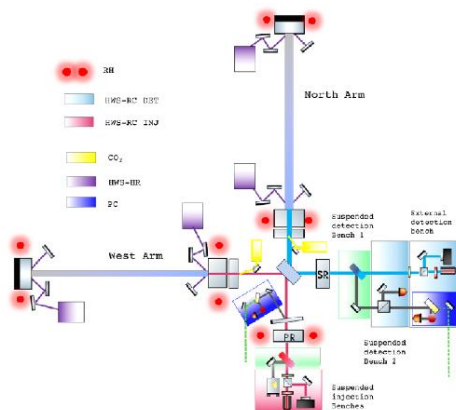
Requirement for losses

- Total $\sim 10\text{-}15\%$
- Due to mismodematch $\sim 2\%$

Second half: current and future techniques for mode matching

Thermal compensation system in AdVirgo

Ssuspended active matching stage (SAMS) in aLIGO O4



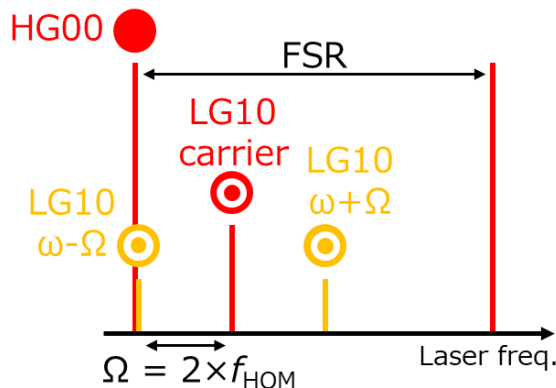
- Spatial light modulation based phase camera
- Time of flight camera
- Shearing interferometer
-
-

Detect the beating between the **LG10 sideband and LG10 carrier**
 Simplified setup  with the same RFPD for PDH method

Simplified setup

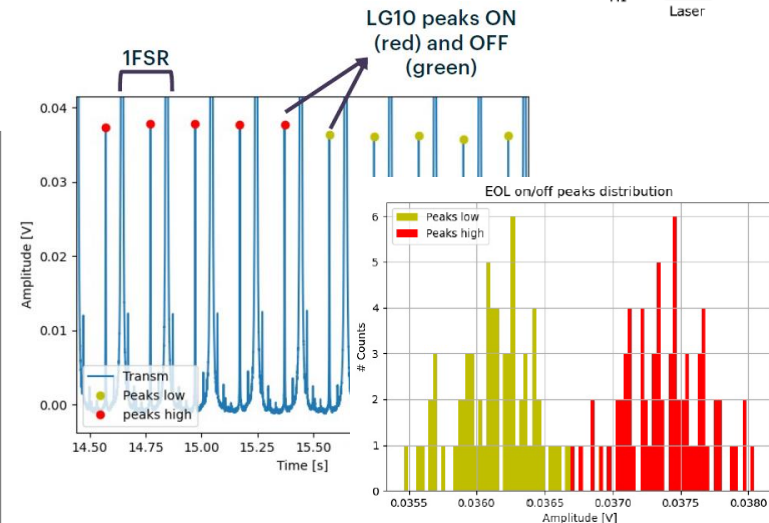
Diagram illustrating a simplified setup for a quantum memory experiment. The setup involves a laser source, a half-wave plate (HWP), a polarizing beam splitter (PBS), an Electro-Optic Lens (EOL), mirrors, a lens, and a detector. The laser beam is split into three paths: a red path labeled ω , a yellow path labeled $\omega + \Omega$, and a blue path labeled $\omega - \Omega$. These paths pass through the EOL and are reflected by two mirrors. The beams are then focused by a lens onto a detector. The detector outputs two signals, I and Q , which are labeled "Waist size and location error signals". The signals are then processed by a mixer (X) and a phase shifter (ϕ) to produce the final error signals. The phase shifter is labeled "cavity higher order mode spacing".

Break sideband symmetry
(= amplitude + phase modulation)


$$Q = I_0(\gamma m_G + \beta m_B)$$

$$I = I_0(\beta m_G - \gamma m_B)$$

m_B, m_G : modulation depth
 β : waist size mismatch
 γ : waist position mismatch



My talk at GRASS 2022

I was very nervous since this was my first face-to-face talk

My presentation turn was third from the end

→ Some people from other cities in Italy went back home

→ The number of the audience was small

I got 3 questions

- The reason I used an optical lever (by the chair, Matteo)
- Mode matching between main and auxiliary cavities
- **Timeline for the development of final TOBA**

I think I can qualify this question as a FAQ because I was asked three times

- By Ideguchi-sensei at my master defense (closed)
- GRASS 2022
- My seminar at the Univ. of Trento

Schedule at the Univ. of Trento

7:40 Padova station
10:20 Povo-Mesiano station
11:00 My seminar
12:00 Lunch at the pizzeria
13:30 Experimental room tour
16:15 Povo-Mesiano station
19:40 Padova station

Department of Physics,
the Univ. of Trento



Train travel from Padova to Trento

Padova station



Train from Verona P.N. to Trento



Povo-Mesiano station



LISA Trento team

Attended my seminar online

Attended my seminar in person



Stefano Vitale

Senior Professor of Physics



William Joseph
Weber

Associate Professor of Physics



Rita Dolesi

Associate Professor of Physics



Daniele Vetrugno

Researcher

Experimental room tour



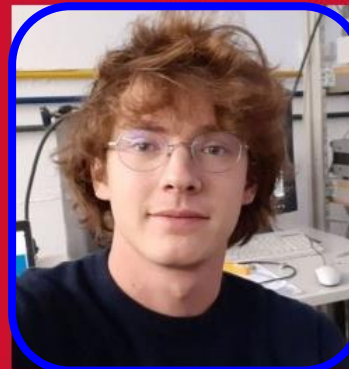
Davide Dal Bosco

PhD Student



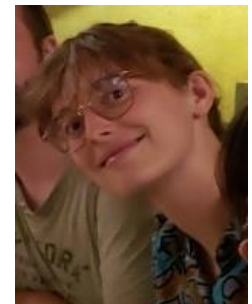
Lorenzo Sala

PhD Student



Vittorio Chiavegato

PhD Student



Sophie Bini
Data analysis team

+ ~3 more people

Seminar about my researches

My slides ~20 pages = my talk ~20 minutes

The total duration of my seminar ~60 minutes

→ Q&A ~40 minutes

The **toughest** presentation I have ever given!

Many critical questions and long, and English

cf.

- JPS or master defense practice at Ando Lab:
many critical questions and long, but Japanese
- International conference: English, but short

A few questions about DANCE and Coupled WFS,
and **many questions about TOBA** (because professional in pendulums?)

- Principle
- Design
- Noise budget
- Earthquake early warning

⋮

Torsion pendulums in chambers



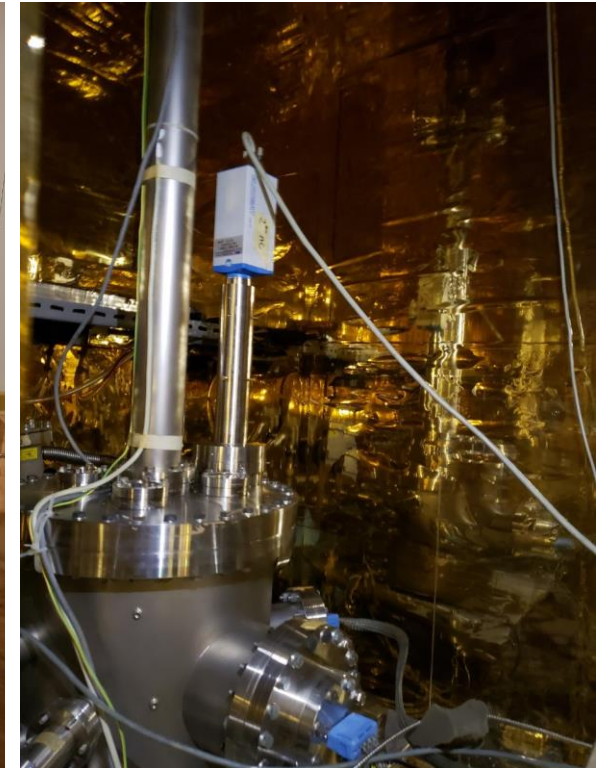
Davide's chamber

Vittorio's chamber

- $\sim 10^{-5}$ Pa
- Room temp.
- Temp. control

They said the pendulums drift when the room temperature changes by 1 °C

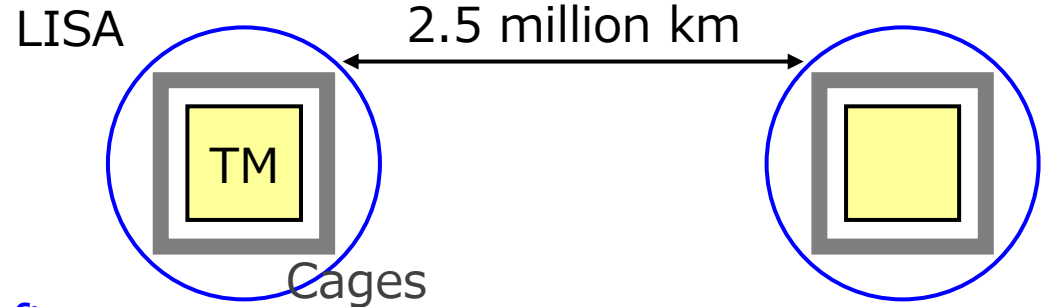
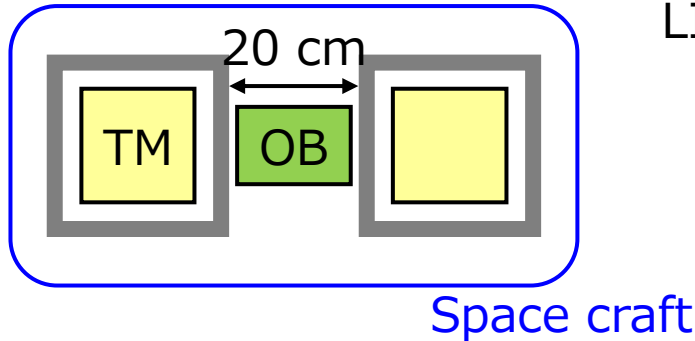
I saw op. lev. signal that the pendulum drifted as I approached



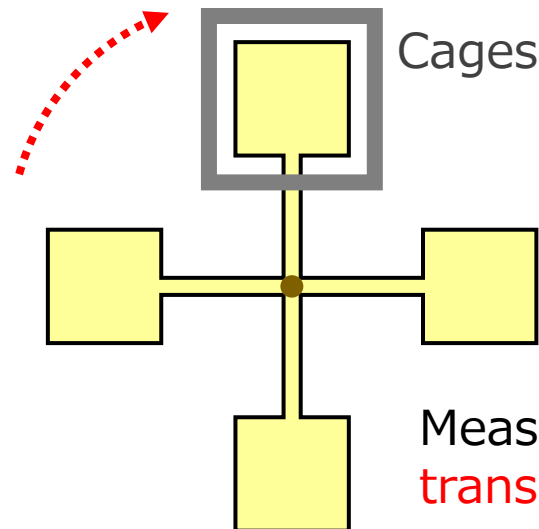
LISA and LISA pathfinder

The principle is to readout the acceleration of test masses
Need to control test masses inside cages for all DoF

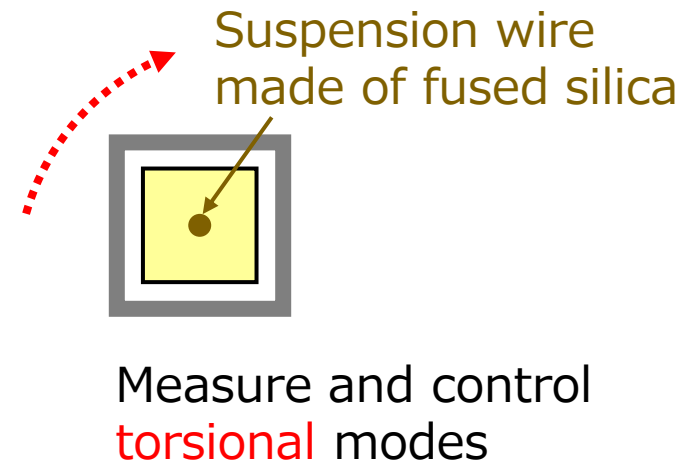
LPF



Davide's experiment



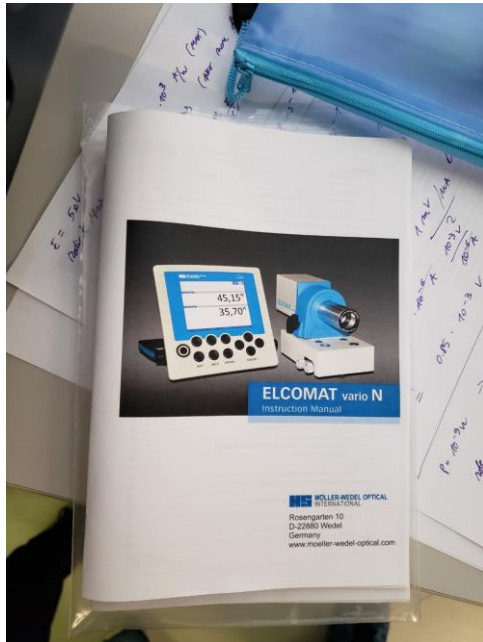
Vittorio's experiment



Top view

LISA test masses & readout devices

Commercial readout device
for torsion pendulums



The principle is the same as op. lev.
with CCD and visible red laser light
(black box)



Test masses and cages (housing)
made of Au and Pt

Devices and small components



Exactly the same function generator as in Ando Lab

I found soldering sets and RS Components boxes

Lock-in amp.



We had a nice chat because the bags of cookies I brought from Japan were similar to the RS Components bags



This analog circuit was made by Stefano many years ago

We have analog circuits made by Prof. Ando many years ago, too



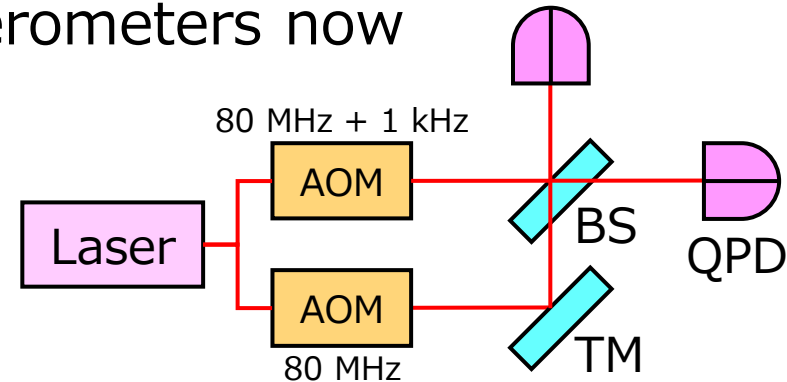
Heterodyne Mach–Zehnder interferometer

Experiment many years ago

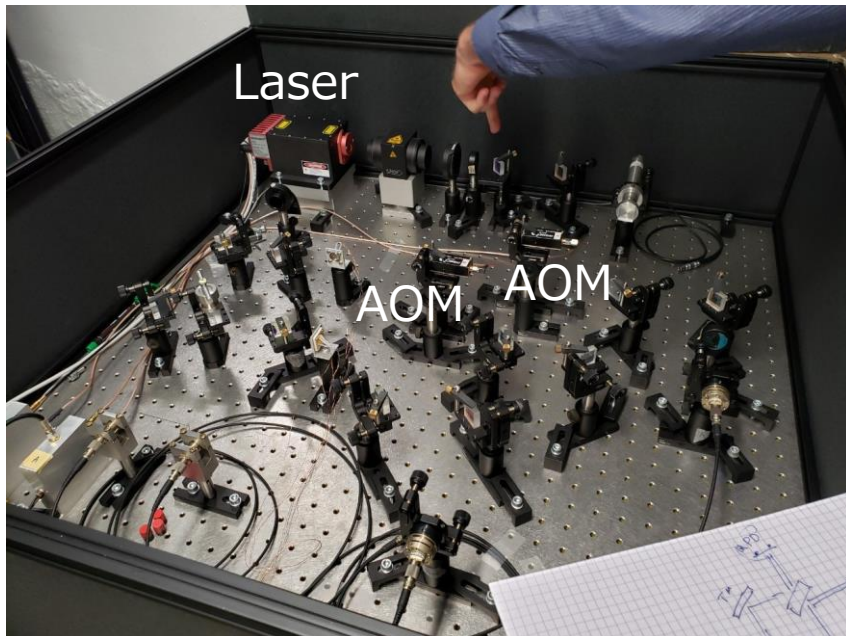
No students studying with interferometers now

→ Davide and Vittorio also didn't know about this setup

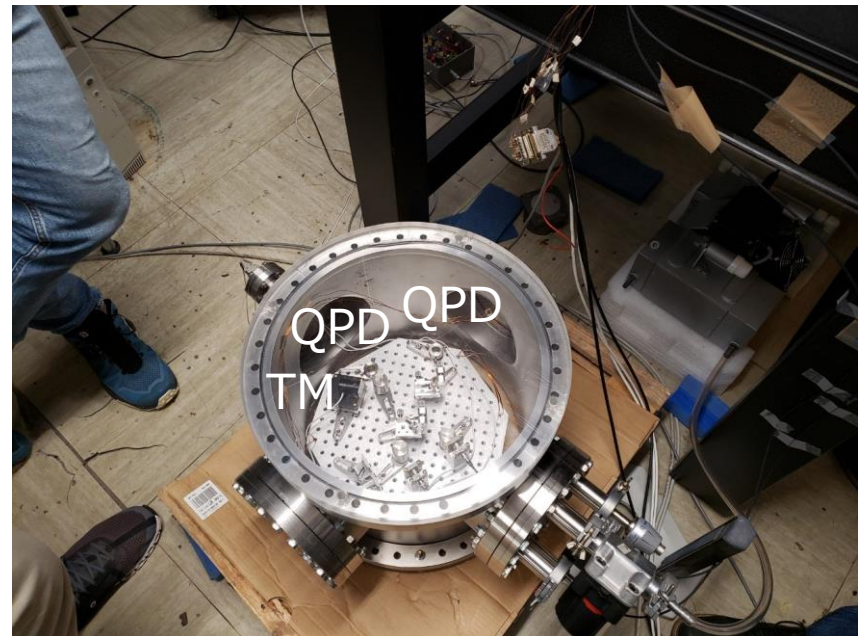
→ Bill gave a lecture to us



Input optics



Interferometer in the chamber



Summary

- GRASS 2022
 - In-person conference >>>>> online conference
 - I was all alone if I didn't speak to someone
I got to know people at banquet and chats
- A visit to the Univ. of Trento
 - Atmosphere (people, exp. room) is similar to Ando Lab
 - Seminar with people in close research fields is quite tough, but I learned a lot
 - Experimental room tour in another lab is very interesting

Preparation is harder due to COVID-19,
but it was well worth going abroad!

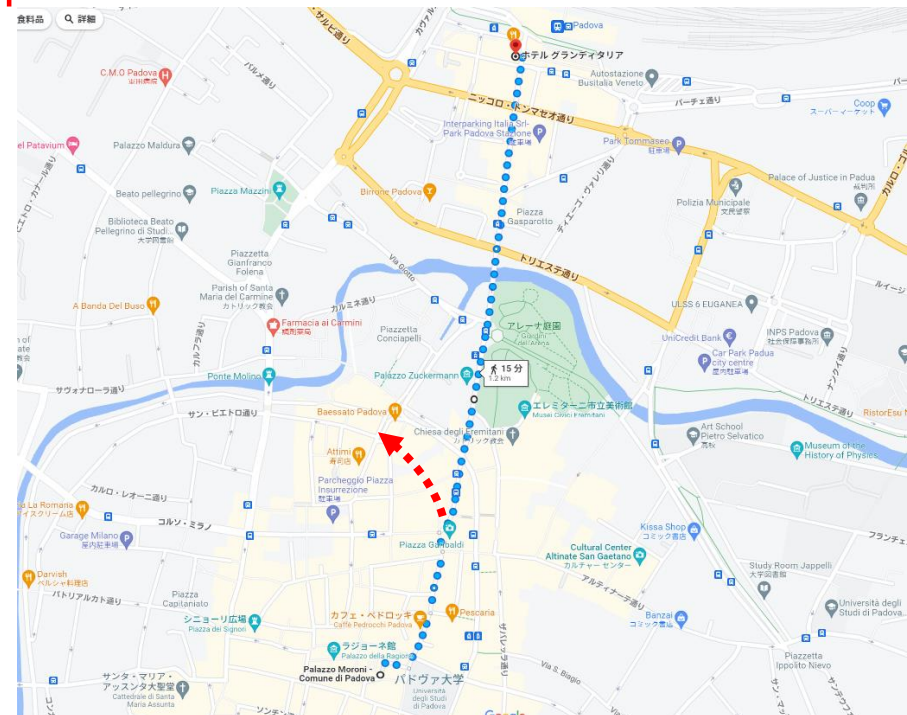
Bonus slides

Trouble 1: lost my way in Padova

15-minute walk straight
from the hotel to the conference venue

On the way back to the hotel
I made a wrong turn at the Y-shaped intersection
and lost my way a little

Lesson 1: be careful at the Y-shaped intersection



Trouble 2: breaker down at hotel

I wanted to make instant miso soup at the hotel

I asked the hotel to borrow an electric kettle by email in advance

→ No reply

→ I brought an electric kettle from Japan



When I plugged in the electric kettle at the hotel, the breaker in the room got down

Luckily, the electrical system was independent for each room and the breaker switch was in my room



After turning up the breaker, I asked the front desk for a kettle
They lent it to me, and it didn't make the breaker down

Lesson 2: borrow an electric kettle from the hotel

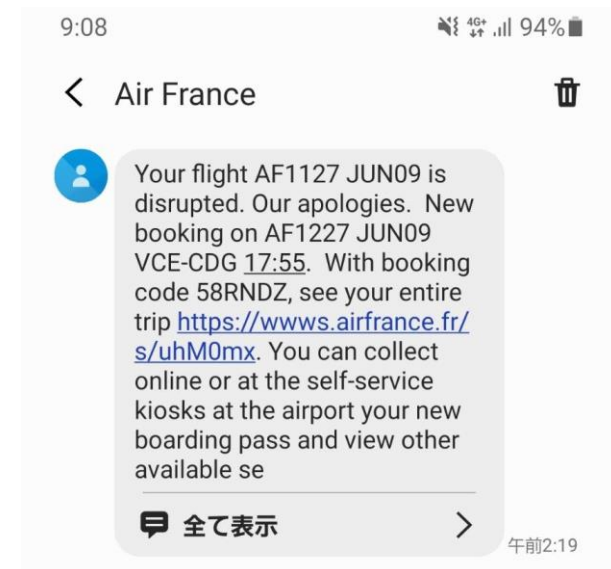
Trouble 3: flight to Paris canceled

My flight from Venezia to Paris was canceled

I booked the flight in the morning,
but the alternative flight was at night
→ I stayed at the airport **for 8 hours**

Actually, an SMS from Air France was sent
the day before

I checked only email, not SMS
(If I had noticed the SMS the day before,
I could have had a long sleep at the hotel...)



Some people said they would miss the transit plane from Paris,
but my transit had no problem because I was scheduled to
stay two days near Charles-de-Gaulle Airport for a PCR test

Lesson 3: check both email and SMS

Cappella degli Scrovegni (スクロヴェーニ礼拝堂)

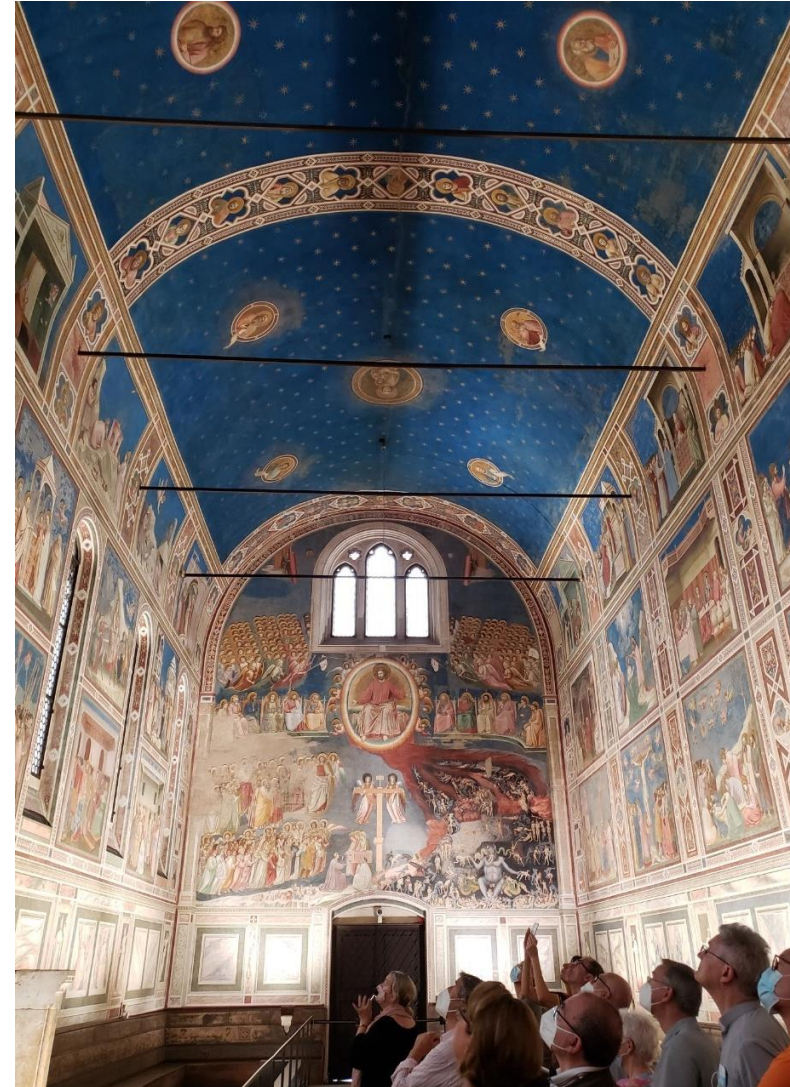
World Cultural Heritage



Plain on the outside,
but beautiful on the inside

More beautiful frescoes than
those I saw in Firenze and Pisa

Frescoes: paintings directly on
the plaster (漆喰) walls



University of Padova (Palazzo Bo)



The 800th-anniversary flags
all over Padova

Univ. of Padova established in 1222
(the second oldest in Italy)

Univ. of Tokyo established in 1877
(the oldest in Japan)

Currently used for
medical school Ph.D. defense
How stressful!



Botanical garden of Univ. of Padova

Much more wonderful than
小石川植物園 of Univ. of Tokyo
and 神代植物公園 at Mitaka

World Cultural Heritage



Greenhouse



Abbey of Santa Giustina
(サンタ・ジューティーナ修道院)



My ranking for Italy

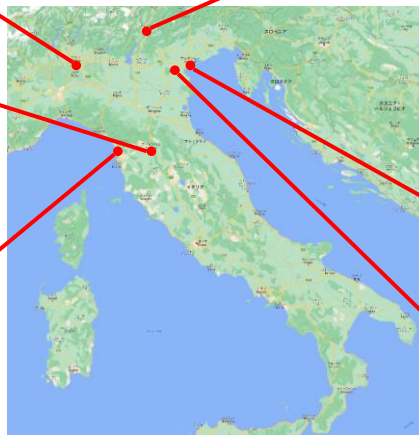
6. Milano



5. Trento



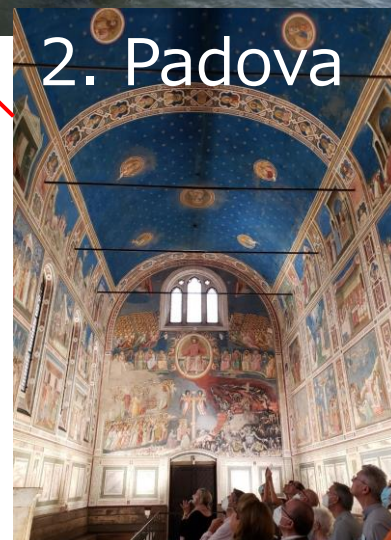
3. Firenze



1. Venezia



2. Padova



4. Pisa



Now I am a kind of professional
in middle and north Italy!
When you go to Italy,
please ask me how to take trains, etc.

Delicious Italian food

Breakfast

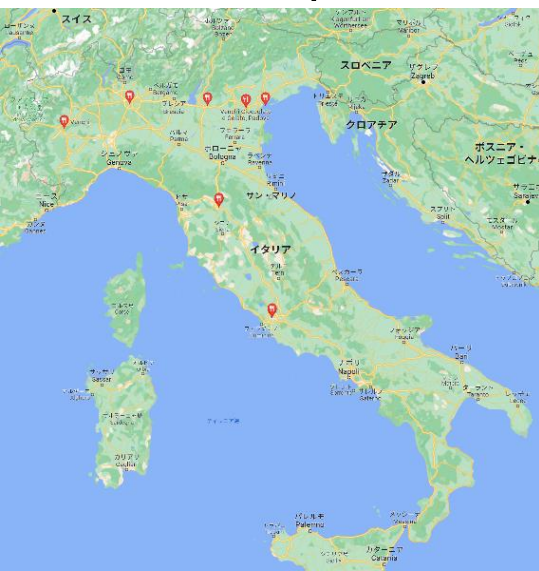


Venchi (ベンキ)

Famous chocolate and gelato (Italian ice cream) shop in Italy
I love gelato of Venchi!



A lot of shops in Italy



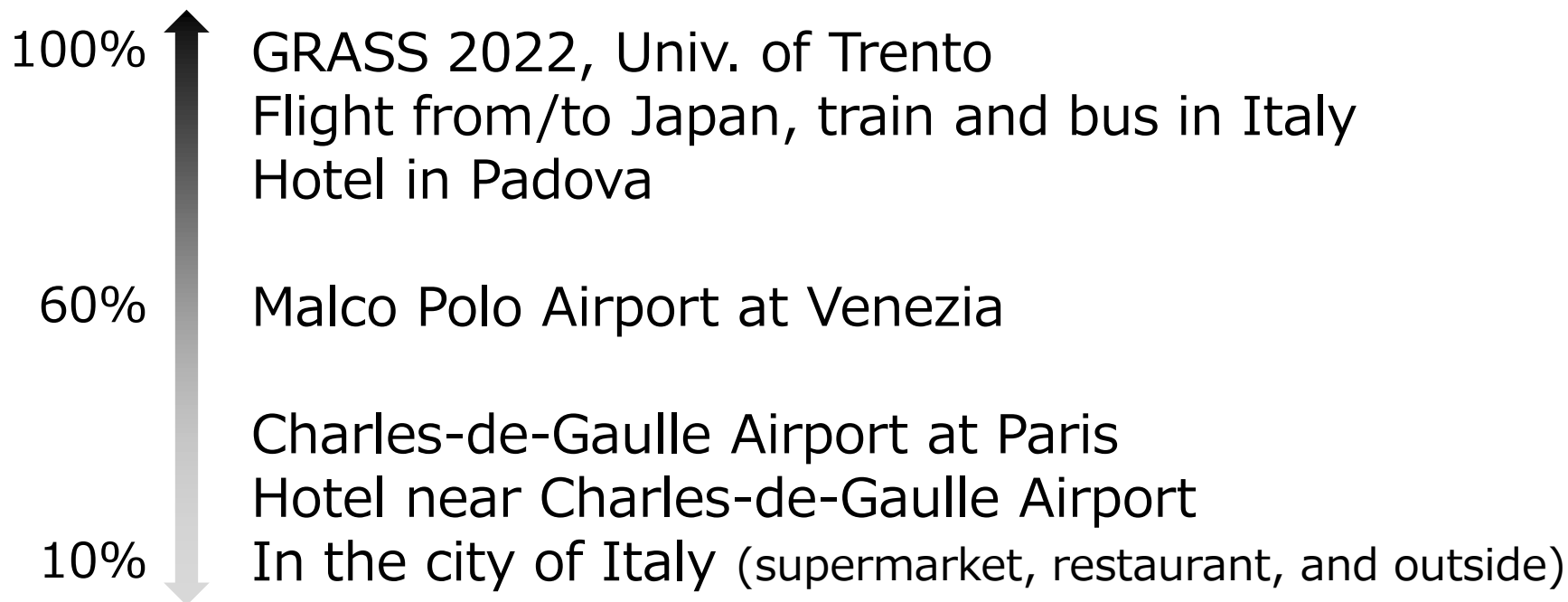
I found many shops so far

- At Firenze S.M.N. station
- At Venezia S.L. station
- At Milano Centrale station

You can also find in Japan
銀座, 大手町, ...

[Venchi shops in Japan](#)

Ratio of people wearing masks



In Japan >> Italy > France

Italian people put the strings through their arms
when they take off their masks



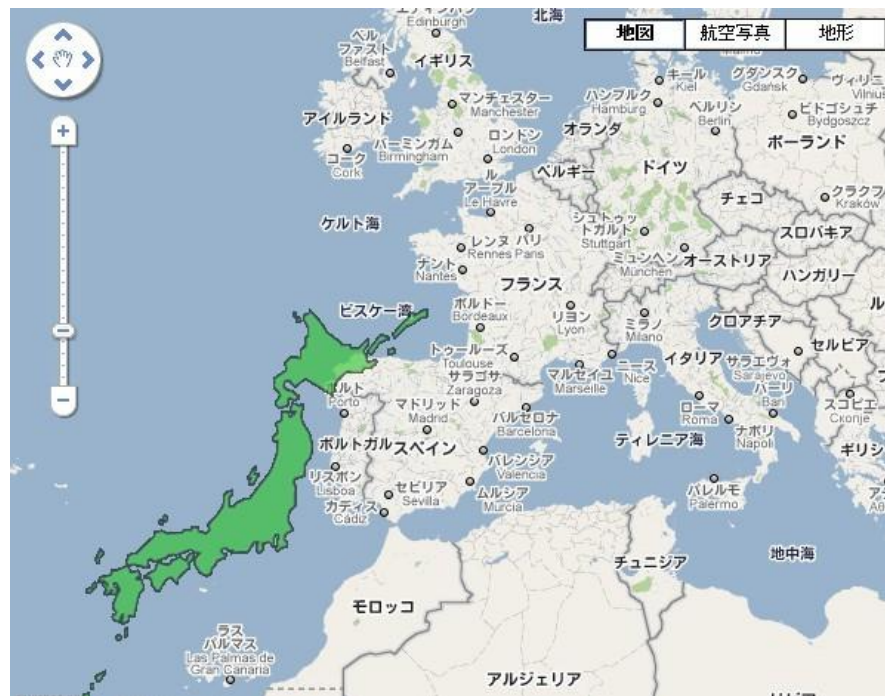
Later sunset than in Japan

View from the hotel
in Padova at 21:05



I felt safer because I didn't
have to walk in the dark

Note that supermarkets
close at 20:00

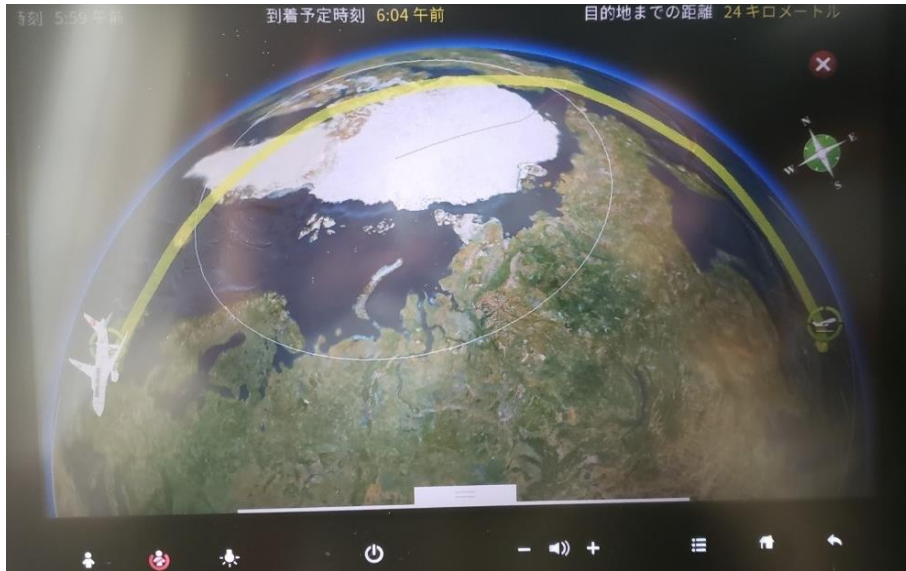


Middle of June

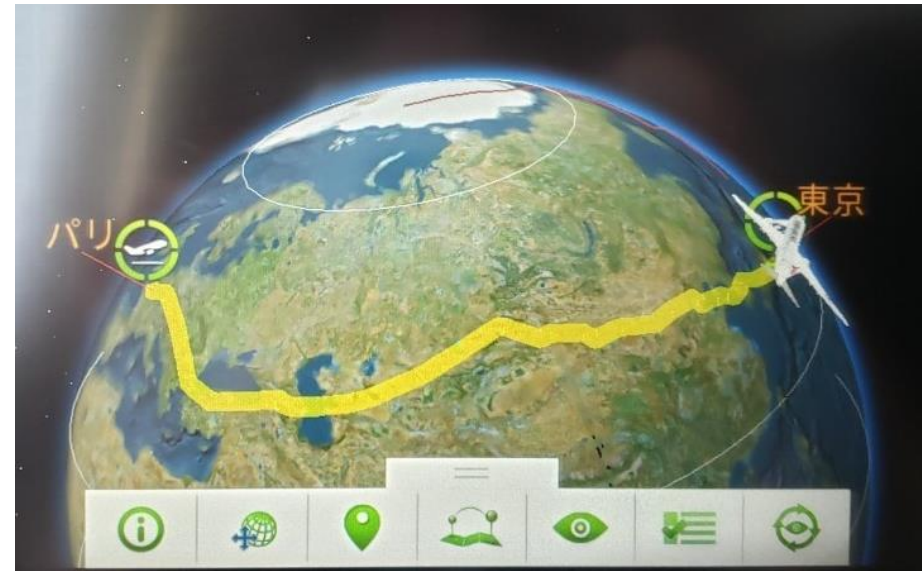
	Sunrise	Sunset
Tokyo	4:30	19:00
Venezia	5:30	21:00
Paris	5:45	22:00

No passing over Russia

From Tokyo to London
Passing over the North Pole



From Paris to Tokyo
Passing over China



Harry Potter shop at LHR

Harry potter shop is located
only in Terminal 5, London Heathrow Airport



So excited to see many goods
not sold in Japan!

I bought gloves with my credit card since I had only euros,
not knowing how much one pound was