Review of
My Undergraduate Experiment

Yuta Michimura
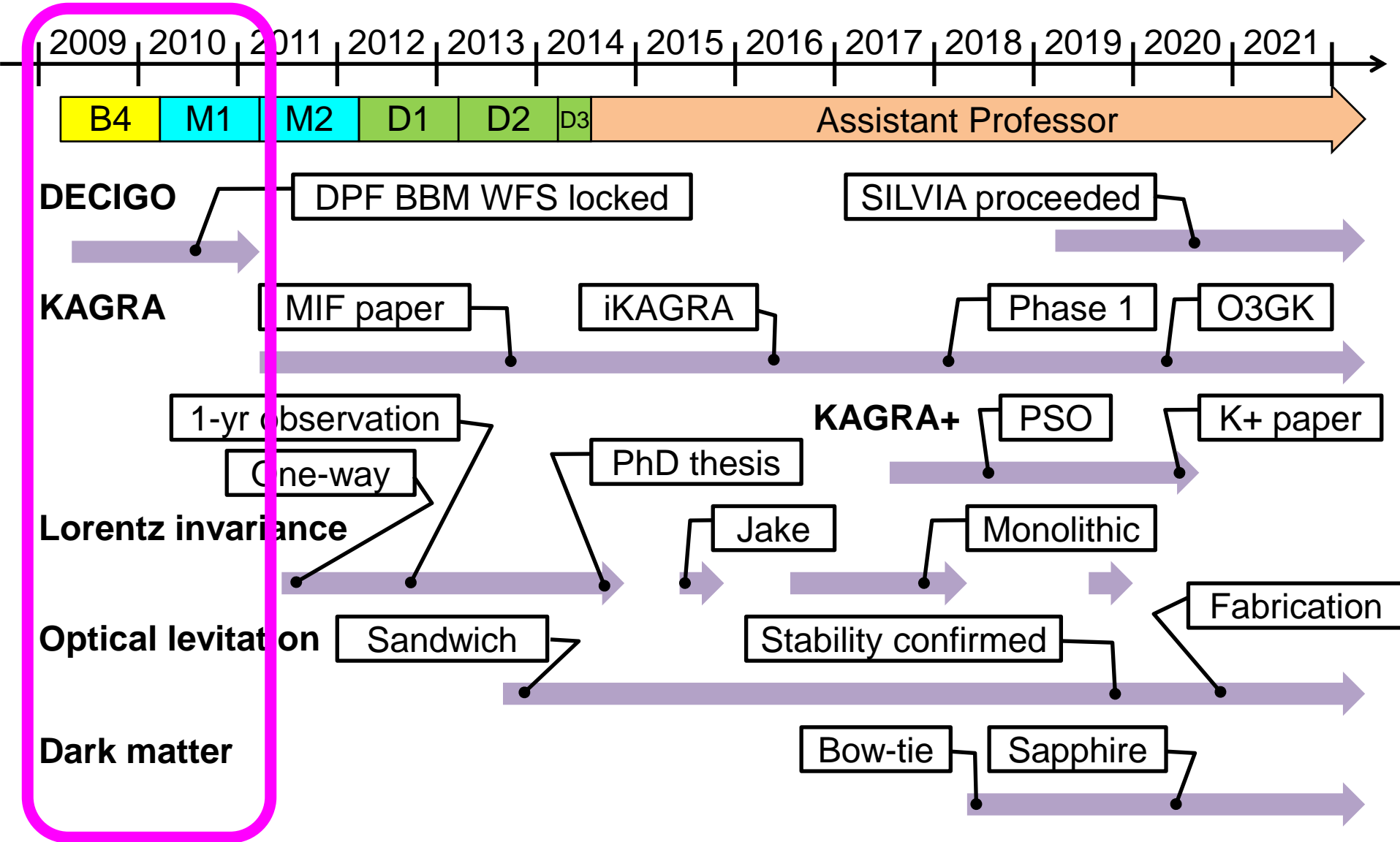
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Contents

- Review of my B4 experiment in 2009
- How it continued to my master's (and my PhD)
- Some thoughts on B4 experiments

Three things you shouldn't do when you are old: preaching, telling old stories and self-praise.
- *Junji Takada* (情熱大陸 2015年7月20日)

Research Timeline

2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021

B4 | M1 | M2 | D1 | D2 | D3 | Assistant Professor

DECIGO
DPF BBM WFS locked
SILVIA proceeded

KAGRA
MIF paper
iKAGRA
Phase 1
O3GK

KAGRA+
PSO
K+ paper

1-yr observation
One-way
PhD thesis

Lorentz invariance
Jake
Monolithic

Optical levitation
Sandwich
Stability confirmed
Fabrication

Dark matter
Bow-tie
Sapphire

Tsubono Group

- I picked Tsubono Group because I was interested in gravity
- I've never talked with Prof. Tsubono nor Shoda-san
- Ando-san went to Kyoto, so no Assistant Prof. until Aso-san came in June
- Kokuyama-san (D1) taught us how to make electric circuits and feedback servo in the first place since we were not sure what to do in the beginning

Magnetic Levitation

- Magnetic levitation of a torsion pendulum using previous B4 experiment started before we decide our topic, and was achieved on May 19

- Good start for learning feedback servo and gaining successful experience
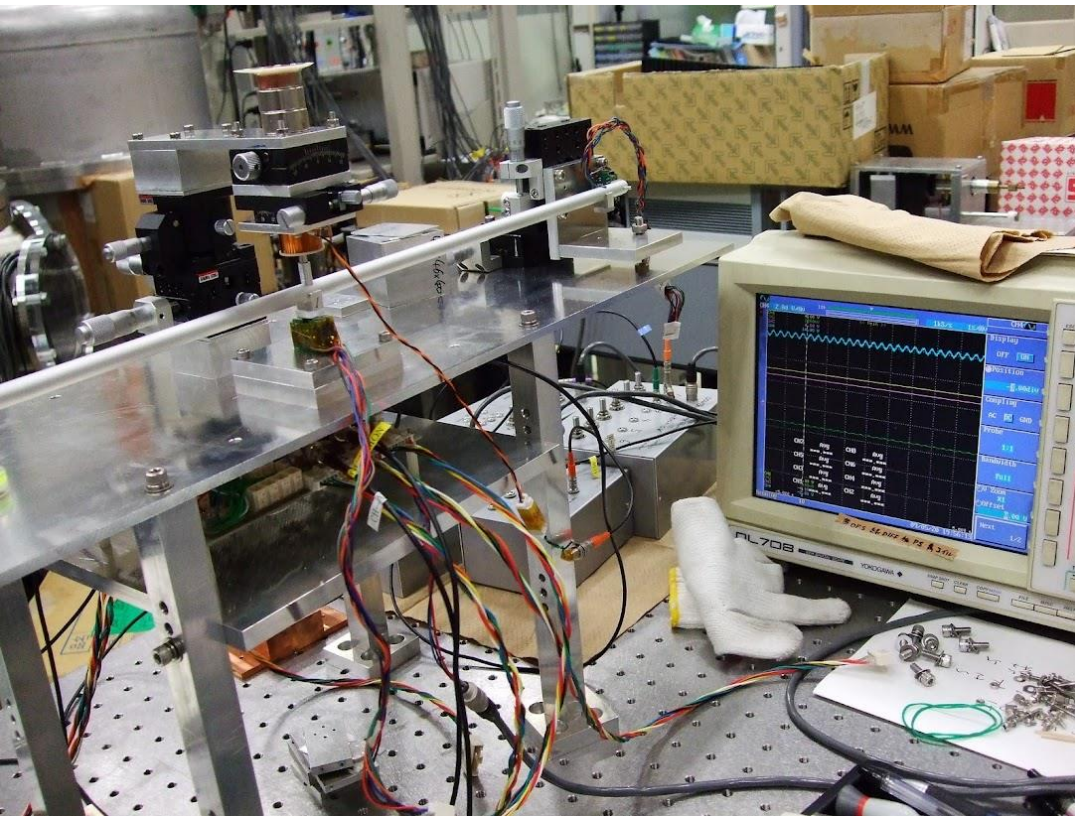
7th DECIGO Workshop

- Back on April 18, we visited NAOJ Mitaka for DECIGO workshop

- Shoda-san wanted to do an experiment related to space GW detector (I was open to anything) and we tried to find a research topic

- Shuichi Sato-san provided us a topic to control the test mass for DECIGO Pathfinder (DPF) at the banquet (I didn't attend the banquet)

重力波の観測が
宇宙の起源を探る手がかり
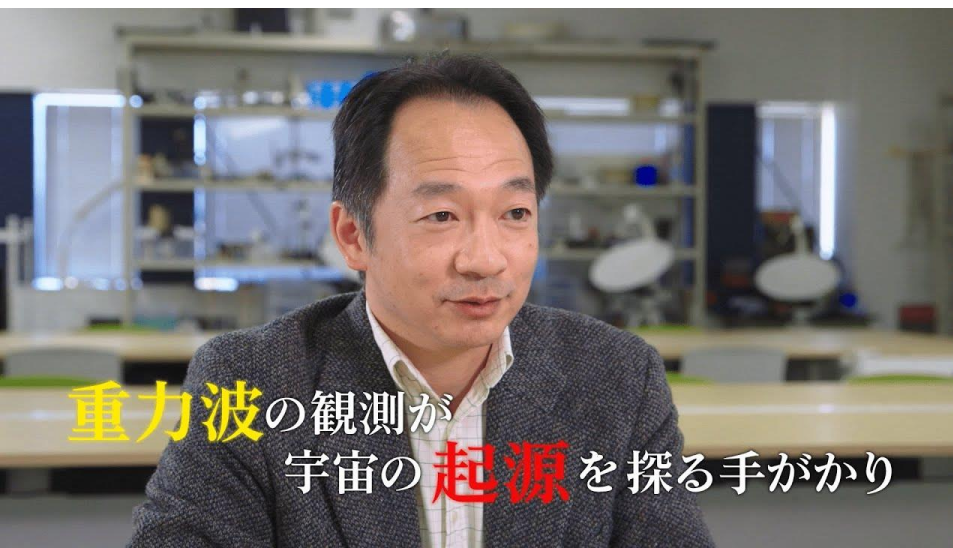
Araya-san's Setup

- On May 14, we visited Araya-san at ERI Utokyo to see laser sensor setup for DPF

- Araya-san kindly agreed to let us use this whole setup for our experiment
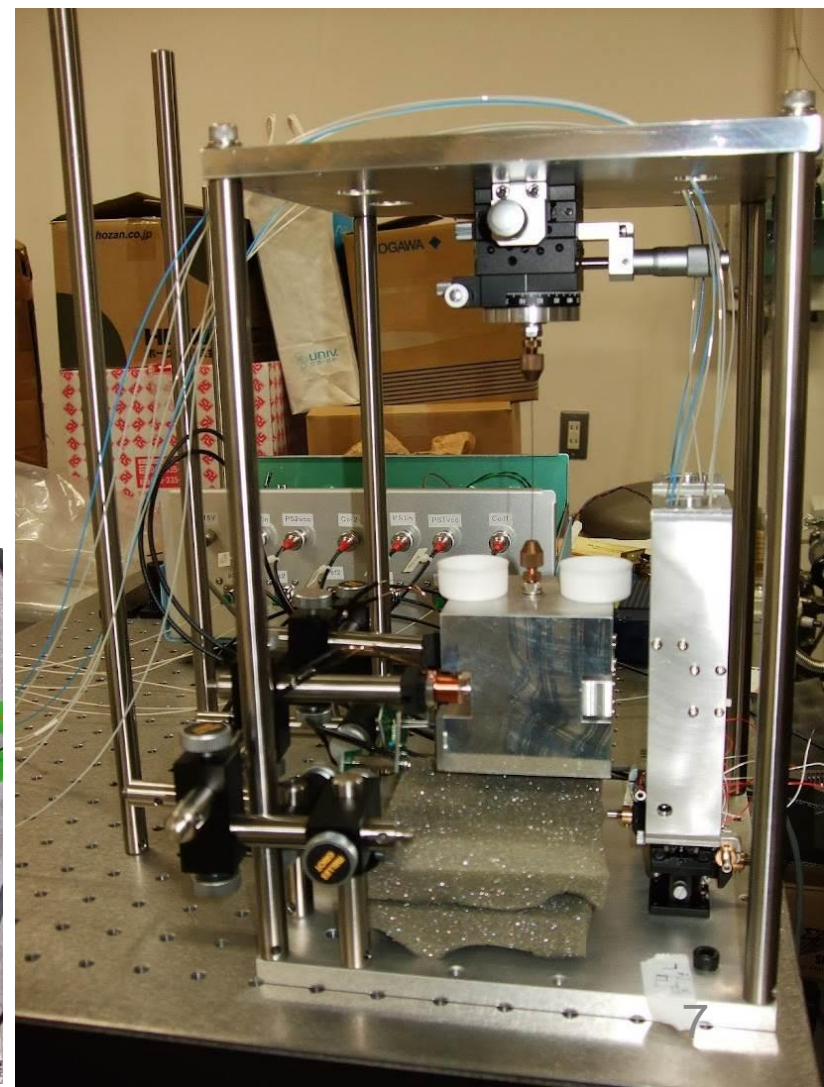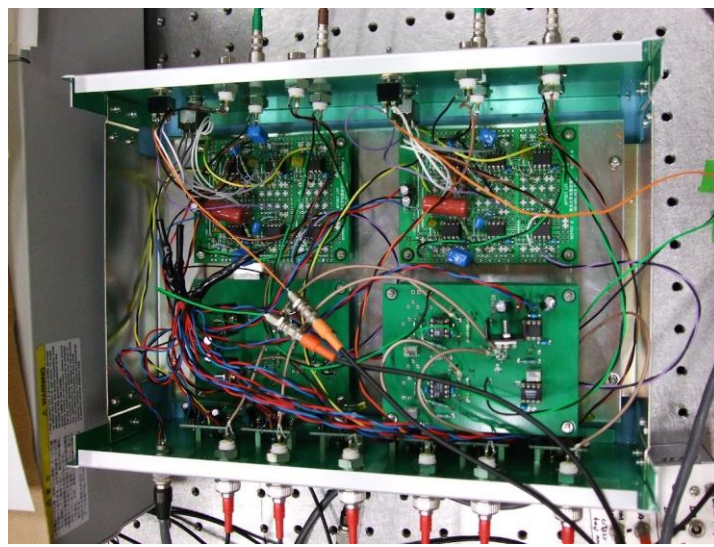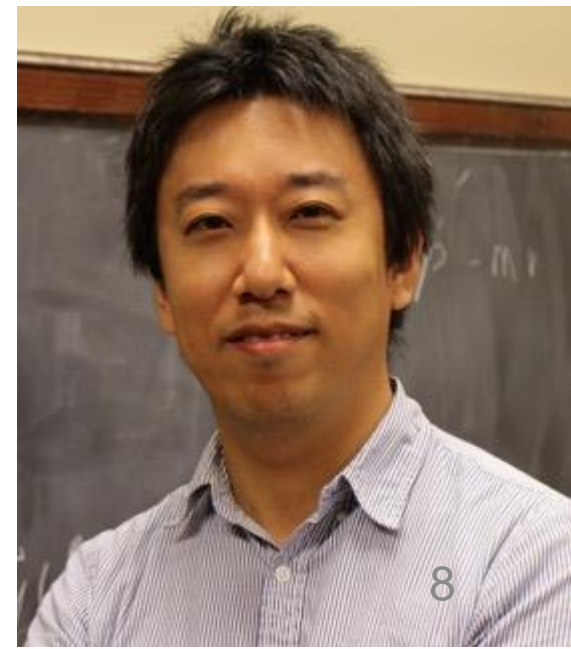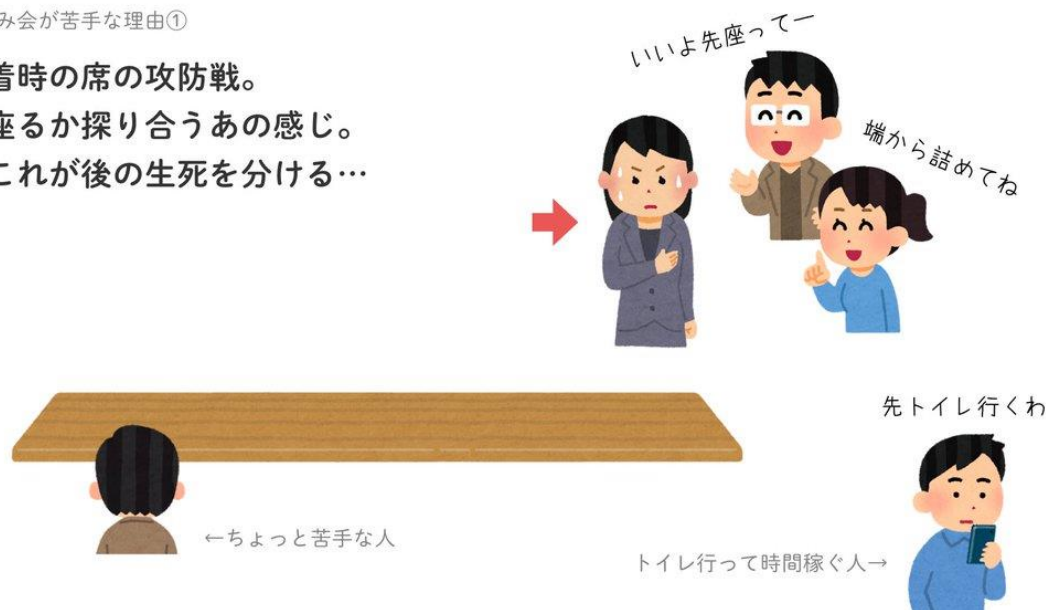
Student's Party

- Kokuyama-san kindly invited us to drinking party among students
- I was at the same table with Niwa-san and Nishizawa-san (lucky seat)

大人数の飲み会が苦手な理由①

会場到着時の席の攻防戦。
どこに座るか探り合うあの感じ。
そしてこれが後の生死を分ける…

いいよ先座ってー

端から詰めてね

←ちょっと苦手な人

先トイレ行くわ

トイレ行って時間稼ぐ人→

https://twitter.com/onigiritan/status/1303999724832260097

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Digital Control

- We could lock with original 2 photo-sensor setup, but we decided to change the setup to 4 photo-sensor setup with digital control based on Aso-san's suggestion (Digitalization from young Assistant Prof. from US)
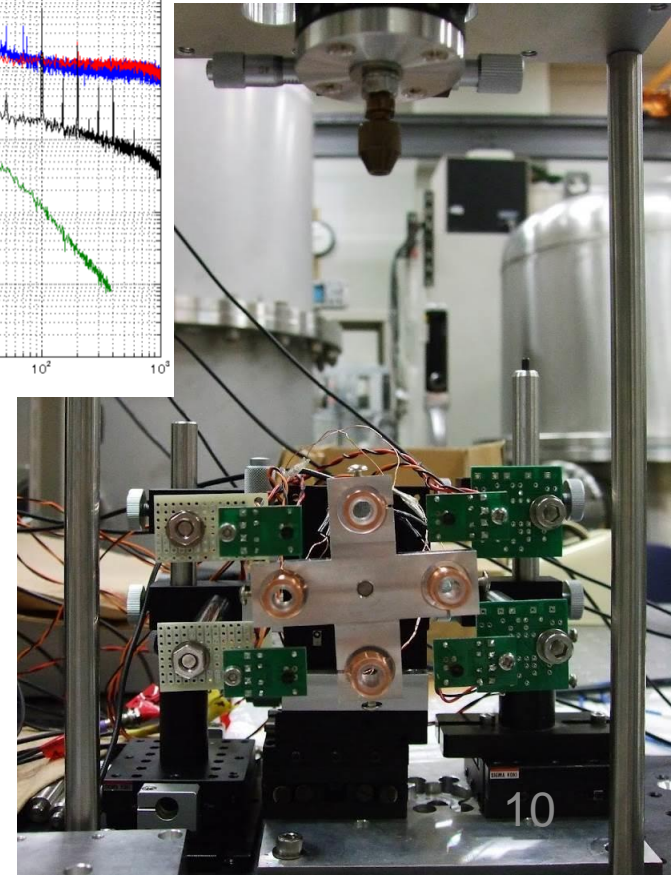
Water damper to damp pitch motion

coil-magnet
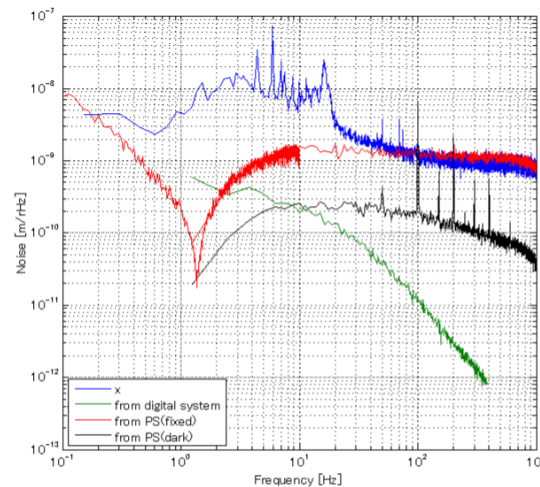
This is hopeless…

photo-sensor
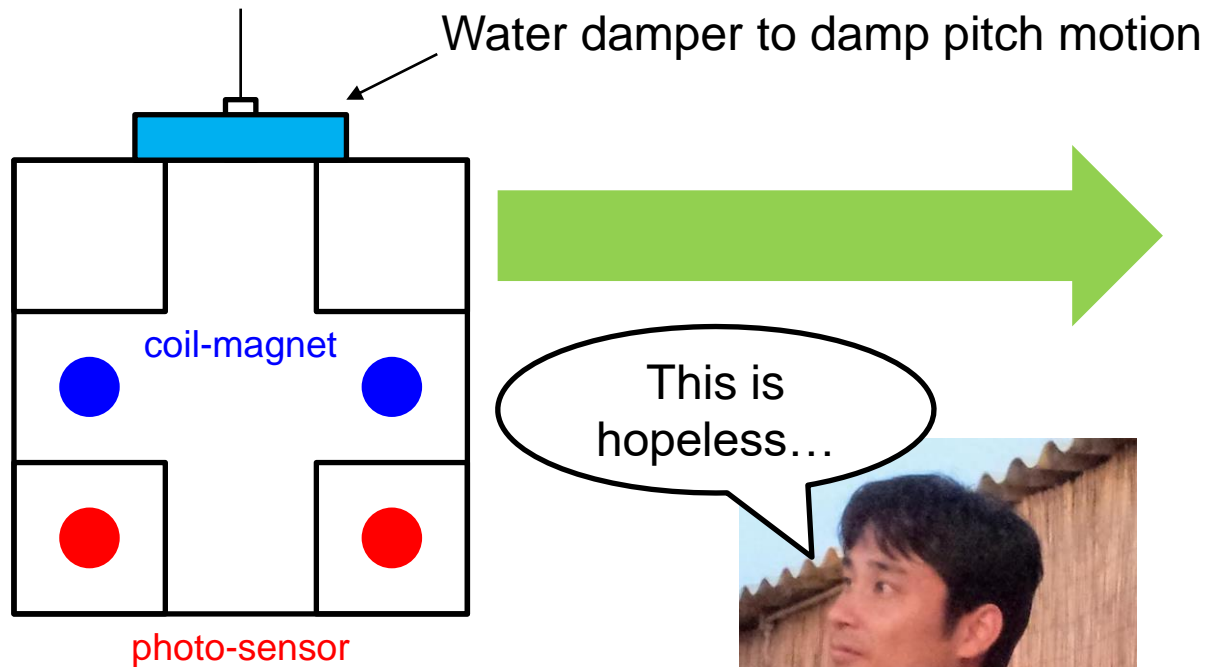
Control with analog circuits
Length only
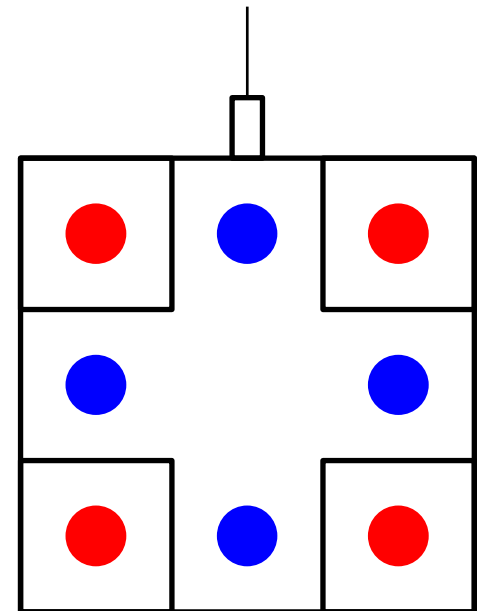
Control with digital system
Length, Pitch, Yaw

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Result

- After making a lot of circuits and having hard time with xPC Target and Simulink, we could control 3 DOFs in July
- Transfer function measurements and noise budgetting became routine work

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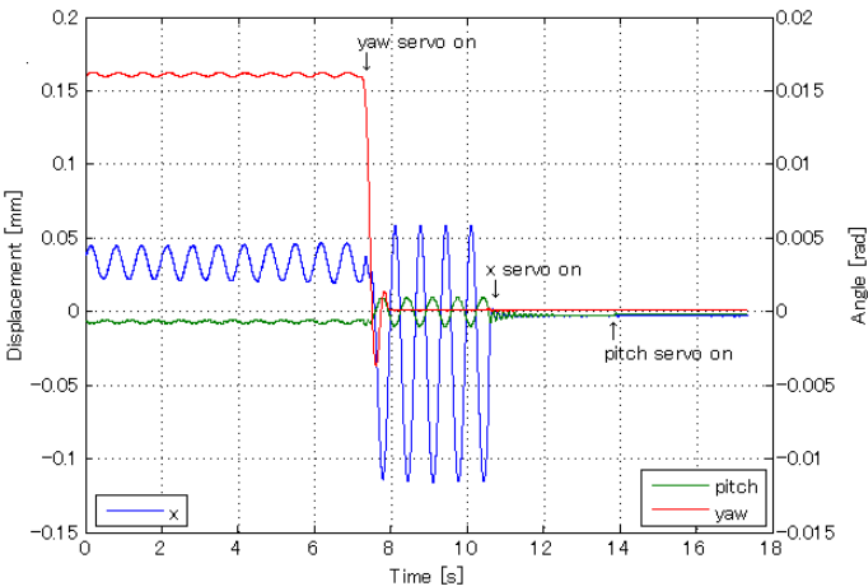
JPS Meeting 2009 Fall at Kobe

- Shoda-san presented the result at 日本物理学会2009年秋季大会 in September (I lost rock-paper-scissors)
- I encountered Kiwamu Izumi for the first time at the party

Hey, Yoichi, I'm going to the US. Any jazz recommendations for me?

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Fabry-Perot Experiment

- Shoda-san moved on to work on laser sensor

- While I moved on to work on Fabry-Perot experiment for DPF

Largest thing I've ever ordered to 試作室 (100 cm x 40 cm x 2.5 cm thick)

Newly designed TM to suspend it at close to the center of mass

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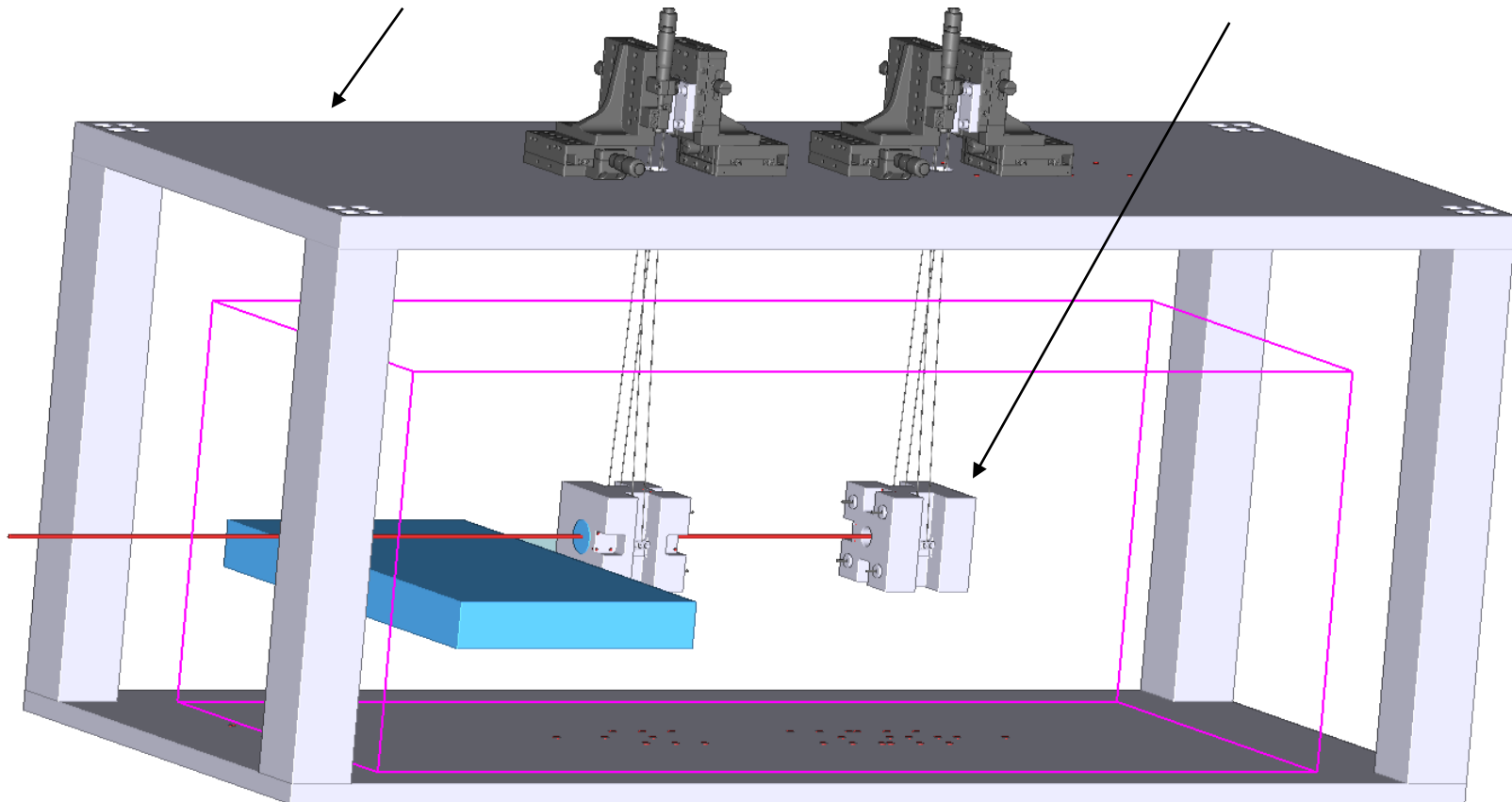
Basic Lectures

- Prof. Kawamura's Basic Lecture series was held from October 27th to February 2nd, and I could attend at NAOJ Mitaka

- Stefan Ballmer was also there, and he taught us about stochastic GWs

- Aso-san gave us hands-on lecture on Fabry-Perot control on November 26th

JPS 2010 Spring at Okayama

- My first conference talk was for 日本物理学会第65回年次大会 at Okayama University

- The first PDH lock was achieved on March 6 and presented it on March 21.

- Ishidoshiro-san was the first person arrived in the room and I was the second
(if I remember correctly)
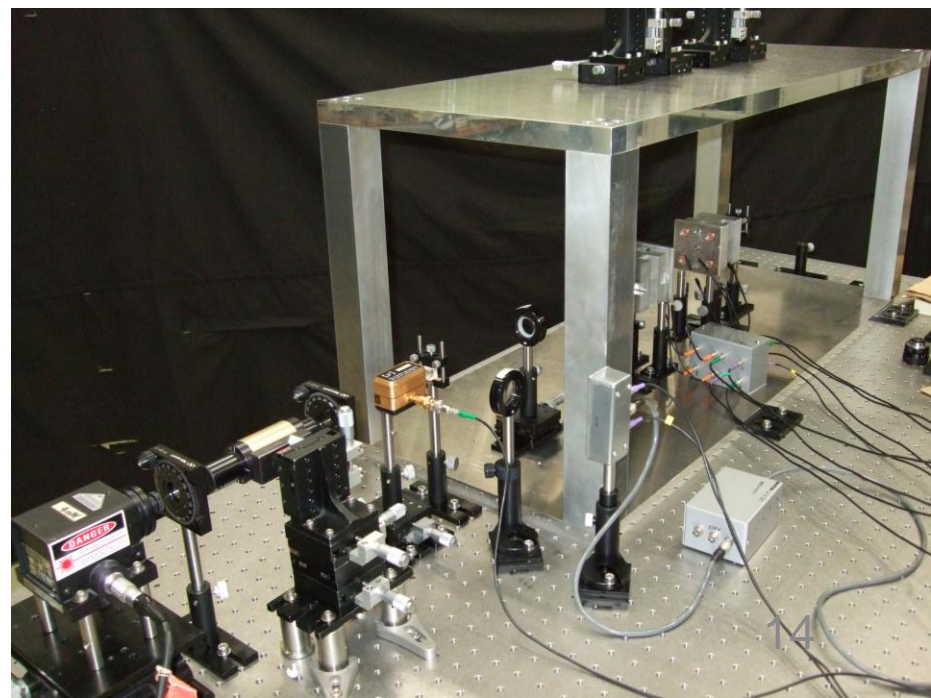
GWADW2010

- The first GWADW in Japan was held at Kyoto
- Prof. Tsubono said it is not so useful for M1 students, but Aso-san strongly argued and let us go
- First encounter with Rana Adhikari, and Aso-san arranged my Caltech visit in September

Do you know op amps?
Can you do soldering?

8th International LISA Symposium

- Presented the length control of DPF FP experiment
- My first presentation at international conferences
- Learned how to enjoy international conferences from Numata-san
- Many students around the world
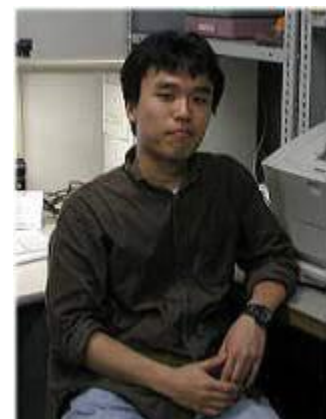
The Full Lock

- All the loops (PDH for length and WFS for pitch/yaw of two TMs) closed in September 7th, using FPGA developed for SWIMμν (Ishidoshiro-san mostly did the FPGA part; 日本物理学会2010年秋季大会 was on September 14th and my visit to Caltech was from 23rd)
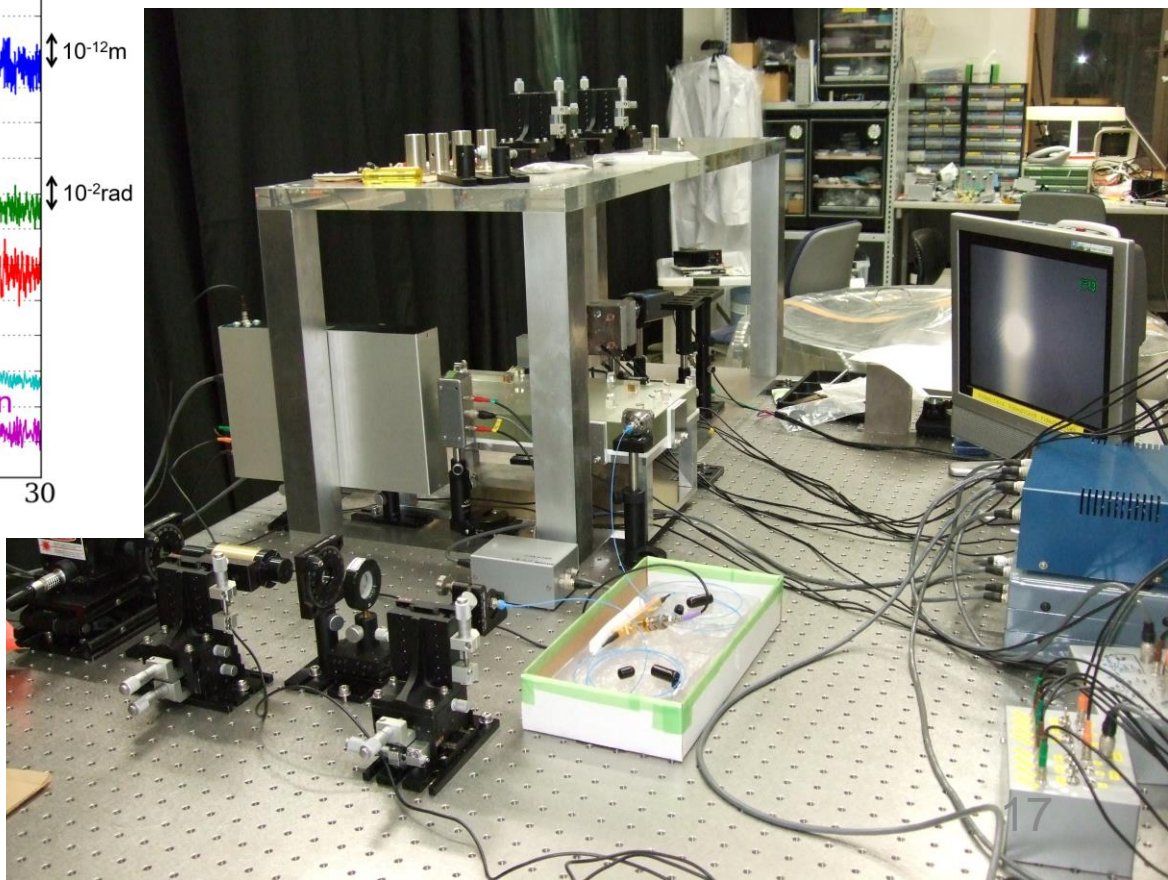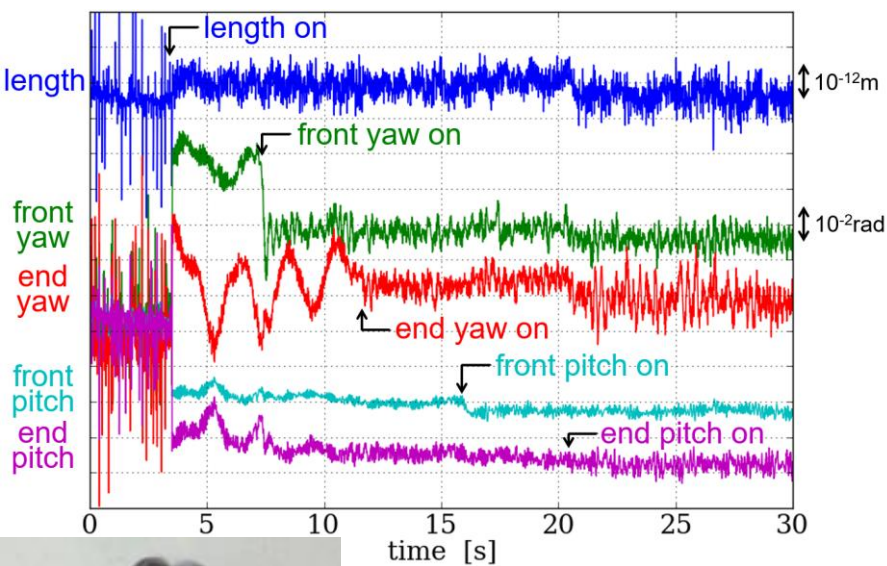
Caltech Visit and LGCT ASC

- Caltech Visit in 2010.9.23-11.22
  - 40m was being upgraded to aLIGO-like setup
  - 40m is really a good size
  - Experience with suspended FP in DPF was very useful
  - Probably there was Aso-san's intention to make me work on LCGT

- LCGT ASC
  - Aso-san suggested me to work on this in December 2010
  - I was not very motivated: pickle was also hard to read.
  - Visited Hanford in 2011.4.20-5.6 to meet Lisa Barsotti and Matt Evans
  - I took a driver's license in February-March 2011 for this visit (2011 Tohoku Earthquake shook right after 卒業検定)

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Kyoto Visit

- Ando-san suggested some of students in Tsubono Group to visit his lab since there was some confusion in Tokyo area after the earthquake (aftershock, power outages …)

- I worked on the characterization of the monolithic Michelson interferometer

- This was the starting point of my Lorentz violation search (and to chase after two hares: KAGRA and table-top experiment)

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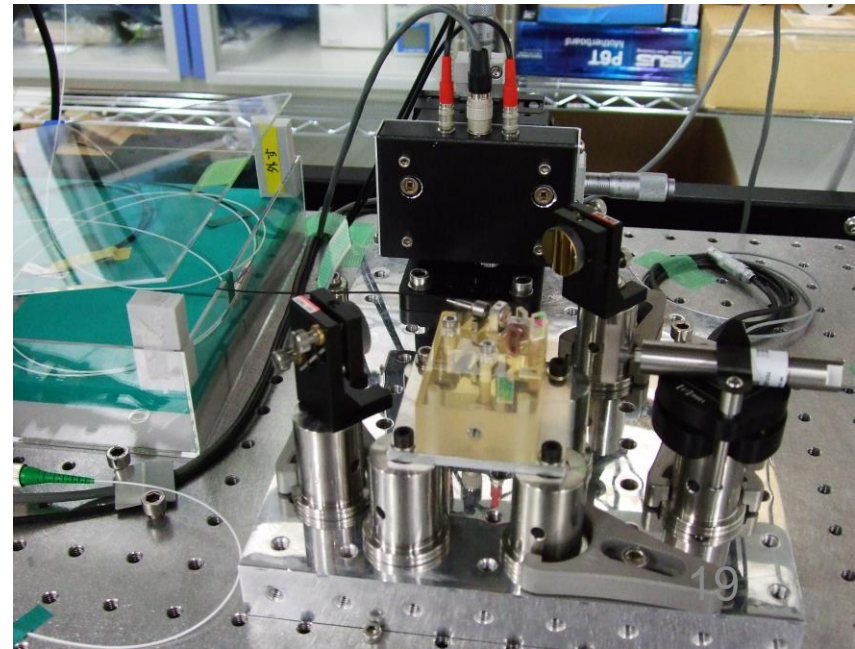
I was extremely lucky that…

- Shoda-san was highly motivated, and I didn't have to worry too much about the research topic

- I could attend the workshop in April

- I could meet many people, and everyone was supportive

- I could learn different perspectives from different people

- I could learn the basics using existing setups

- My interferometer gradually got bigger, and the transition was smooth
  (DPF TM -> DPF FP
    -> Caltech 40m -> KAGRA)

- I myself could pick my own research topic from various (but not too many) candidates
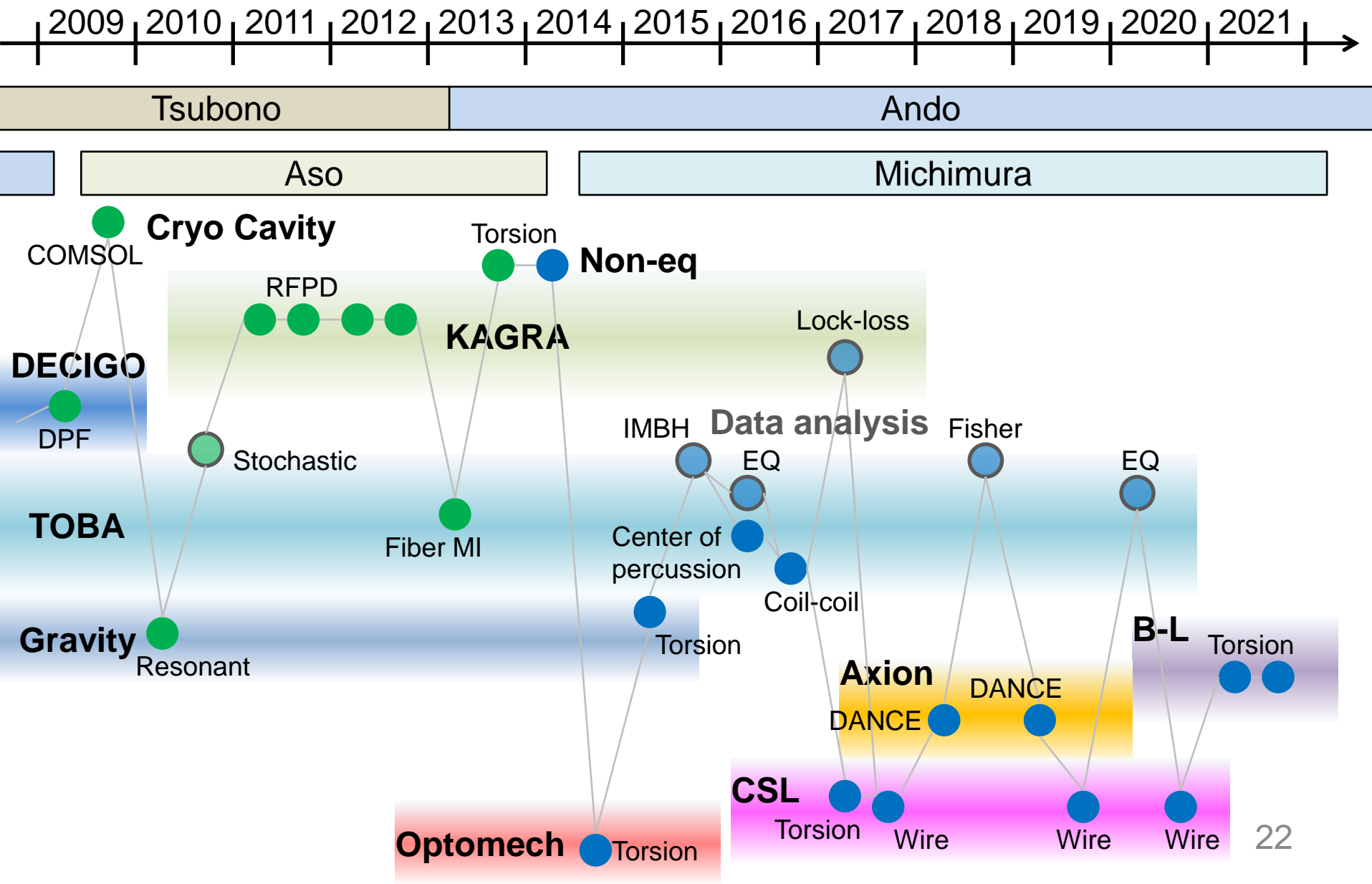 (I also had an option to work on cryo-cavity)

B4 Experiments Since 2009

年度	期	名前	題名
2021	夏	安立史弥	B-L数に結合するゲージ場による力の測定のためのねじれ振り子の設計
2021	夏	林康太	B-Lダークマター探索のためのねじれ振り子と光学系の作成
2020	冬	三島大和	シャドーセンシングを用いたCSL模型の検証
2020	冬	水村彰吾	ワイヤーの振動測定によるCSL模型の検証
2020	夏	飯島健五	TOBAによる地震波検出における解析手法の提案
2020	夏	梅田滉也	時間領域での解析を用いたTOBA による地震検知手法の検討
2019	冬	岩谷昌樹	タングステンワイヤーの振動測定によるCSL模型の検証
2019	冬	桑原聡一朗	シャドーセンシングによるCSL模型の検証
2019	夏	大島由佳	アクシオン暗黒物質探索のための光リング共振器作成とレーザー周波数制御
2019	夏	渡邊泰平	光リング共振器を用いたアクシオン探索のための光学系設置と周波数制御
2018	冬	上田柊介	TOBAによる重力波検出とパラメータ推定
2018	冬	佐藤陽太郎	フィッシャー解析によるTOBAの測定精度計算
2018	夏	千代田大樹	アクシオン探査のための光リング共振器の設計
2018	夏	平野航亮	四枚鏡共振器の作成と性能の評価
2017	冬	及川瑞稀	タングステンワイヤーを用いたCSL模型の検証の準備
2017	冬	渡辺彬生	タングステンワイヤを用いたCSL 模型の検証
2017	夏	米田靖史	ねじれ振り子を用いたCSL模型の検証
2017	夏	宮崎祐樹	iKAGRAのロックロス診断
2016	冬	新井友也	3コイル浮上型コイルコイルアクチュエーターの特性評価
2016	冬	川﨑拓也	3コイル浮上型コイルコイルアクチュエーターの特性評価
2016	夏	上野智久	TOBAによる地震アラートの実現可能性
2016	夏	高野哲	Center of percussion を用いた感度向上の技術検証
2015	冬	佐藤遼太郎	TOBA重力波データ解析システムの構築
2015	冬	両角達彦	TOBAのデータを用いた重力波解析
2015	*	Jake Guscott	Anisotropy of Light
2015	夏	川名好史朗	重力逆二乗則の検証
2015	夏	和田祥太郎	ねじれ振り子による重力の逆二乗則検証
2014	冬	榎本雄太郎	光学浮上へ向けたFabry-Perot共振器によるねじれ振り子の制御
2014	冬	有冨尚紀	光ばねによるねじれ振り子の制御へ向けた基礎実験
2014	夏	長野晃士	非平衡状態下での熱運動の測定
2014	夏	森崎宗一郎	非平衡熱雑音の測定に向けた平衡状況下での熱雑音測定

2013	冬	出野雄也	非平衡熱振動の定量的評価
2013	冬	徳田順生	熱勾配存在下における熱雑音の測定
2013	夏	小森健太郎	ファイバー干渉計の感度測定
2013	夏	桑原祐也	ファイバー干渉計の感度測定
2012	冬	石垣真史	RFフォトディテクターの周波数特性の測定
2012	冬	小林雅俊	RFフォトディテクターの周波数特性の測定
2012	夏	大屋瑶子	フォトダイオード非一様性自動測定の高速化
2012	夏	佐々木健斗	フォトダイオード非一様性の自動検出の高速化
2011	冬	中野雅之	フォトダイオード非一様性検出の自動化について
2011	冬	鄭昇明	フォトダイオード非一様性検出の自動化について
2011	夏	枝和成	PD受光感度の非一様性の測定
2011	夏	渡辺篤史	フォトダイオードの感度一様性の測定
2010	冬	中間智弘	重力波データに対する疑似雑音時系列の生成
2010	冬	三上諒	重力波データに対する疑似雑音時系列の生成
2010	夏	牛場崇文	共振型ねじれ振動子を用いた重力の逆二乗則の検証
2010	夏	柴田和憲	共振型振動子を用いた重力逆二乗則の検証
2009	冬	橘保貴	COMSOLMultiphysics を用いた 光共振器の振動に対する応答の評価
2009	冬	久保肇	COMSOLによる光共振器の変形解析
2009	夏	道村唯太	DPFにおける試験マスモジュールの3自由度デジタル制御
2009	夏	正田亜八香	DECIGO pathfinderにおける試験マスモジュールの制御実験

Topics Fluctuation

Winding Road

- Research topics fluctuated too much
  <- topics selected by students
  (it also requires some responsibility for us when we decide the topic)

- Most experiments/data analysis started from scratch
  <- hard to keep previous setups for a long time (not enough space, no one maintains the setup)
        -> hard to learn from existing setups

- Achievements were not as high as students had anticipated

- Past experiences were not accumulated well

- We tried to motivate students with (ultimate) research goals (e.g., low frequency GWs), but not achieving their original target (e.g., control torsion pendulum) might demotivated students

Customer Satisfaction

Too fancy research goals might
make students' anticipation too high.

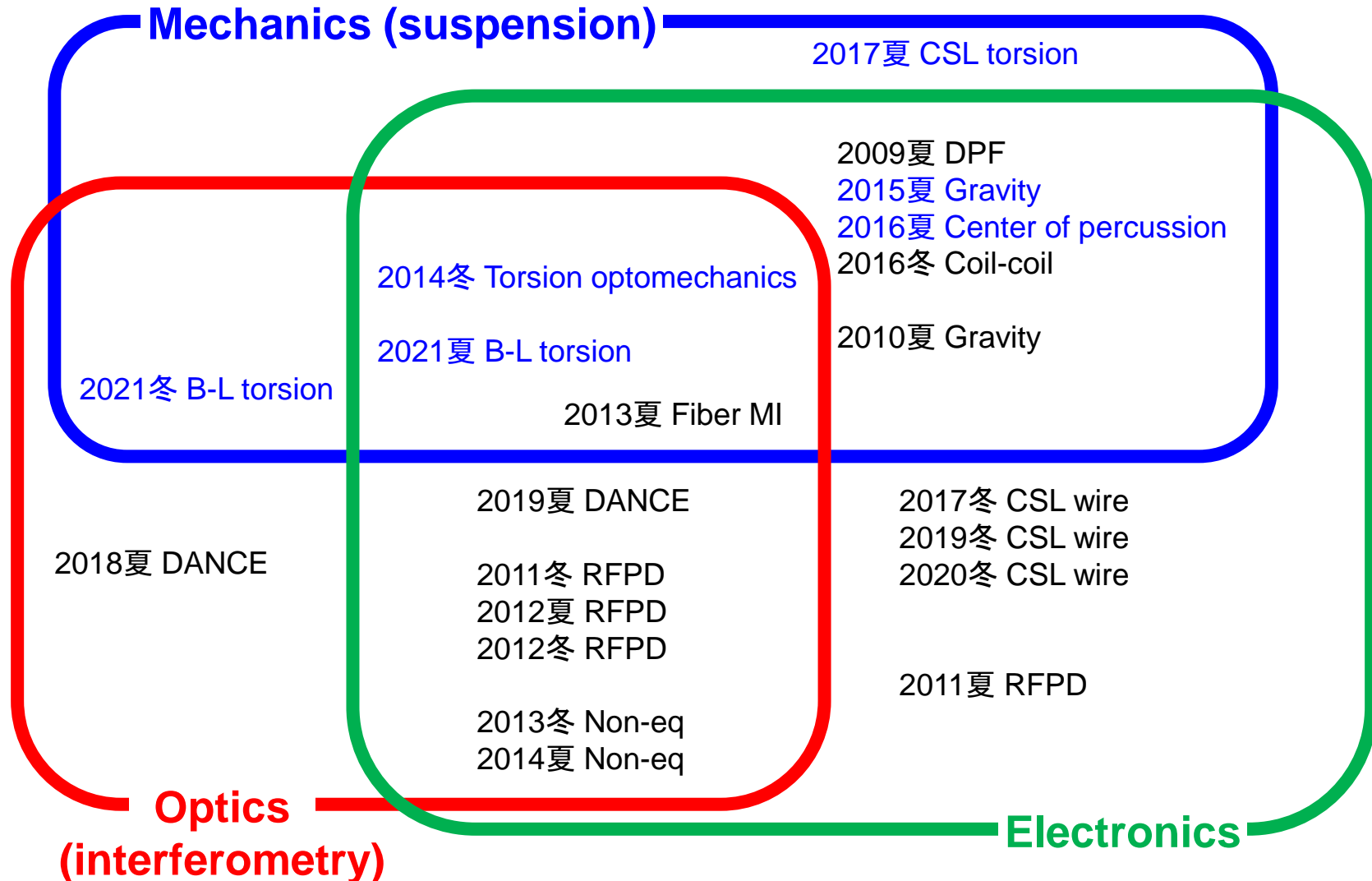Students'
anticipation

Our
expectation

Achievement

We need to help students set their
target close to ours.
We also shouldn't expect too much.
(Some students set their target too
low (because they don't want to fail?))

Everyone is
not happy

We are happy
but students
are not

Students are
happy but we
are not

Everyone is
happy

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Suspended Test Masses are Tough?

Especially if you combine it with some optical setup.
Suspension for vibration isolation is OK.

Mechanics (suspension)

2017夏 CSL torsion

2009夏 DPF
2015夏 Gravity
2016夏 Center of percussion
2016冬 Coil-coil

2010夏 Gravity

2014冬 Torsion optomechanics

2021夏 B-L torsion

2021冬 B-L torsion

2013夏 Fiber MI

2019夏 DANCE

2017冬 CSL wire
2019冬 CSL wire
2020冬 CSL wire

2018夏 DANCE

2011冬 RFPD
2012夏 RFPD
2012冬 RFPD

2011夏 RFPD

2013冬 Non-eq
2014夏 Non-eq

**Optics
(interferometry)**

Electronics

My Two Cents

- Maybe we should have given some certain topics (not one, but not too many so that students think they had picked the topic) to students unless they have something particular in their mind or something they really don't want to do
- Maybe we should keep some suspended system to learn the basics of feedback control etc. to start with
- Maybe we should have let them talk with people outside of our group
- Maybe we should let them know what would be the realistic target in the first place
- I should have followed their experiments more carefully so that I can reproduce their experiments after they left (also using Google Drive etc. to keep their files); I was too lazy

- I received more than I give now……

- I hope they had fun anyway……