The Status of KAGRA Underground Cryogenic Gravitational Wave Telescope

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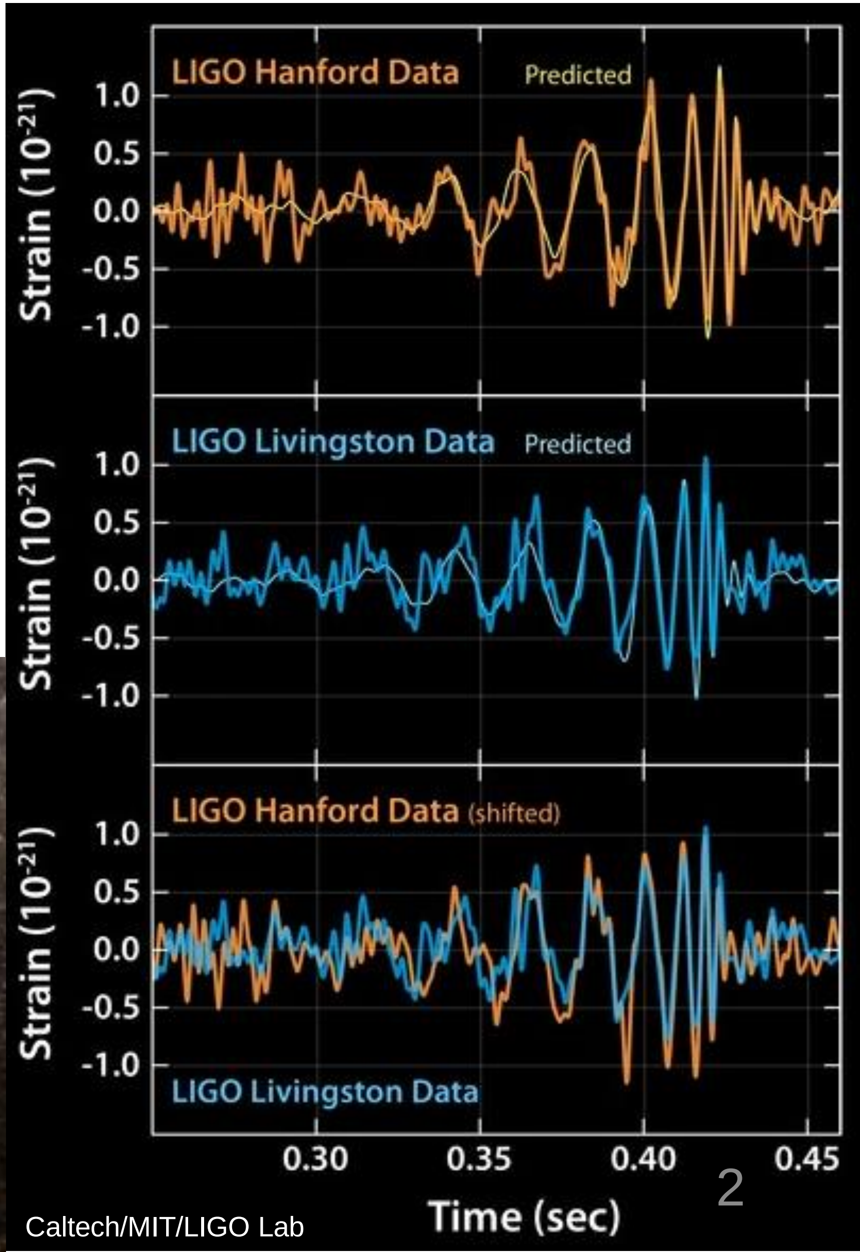
on behalf of the KAGRA Collaboration

First Detection of GW

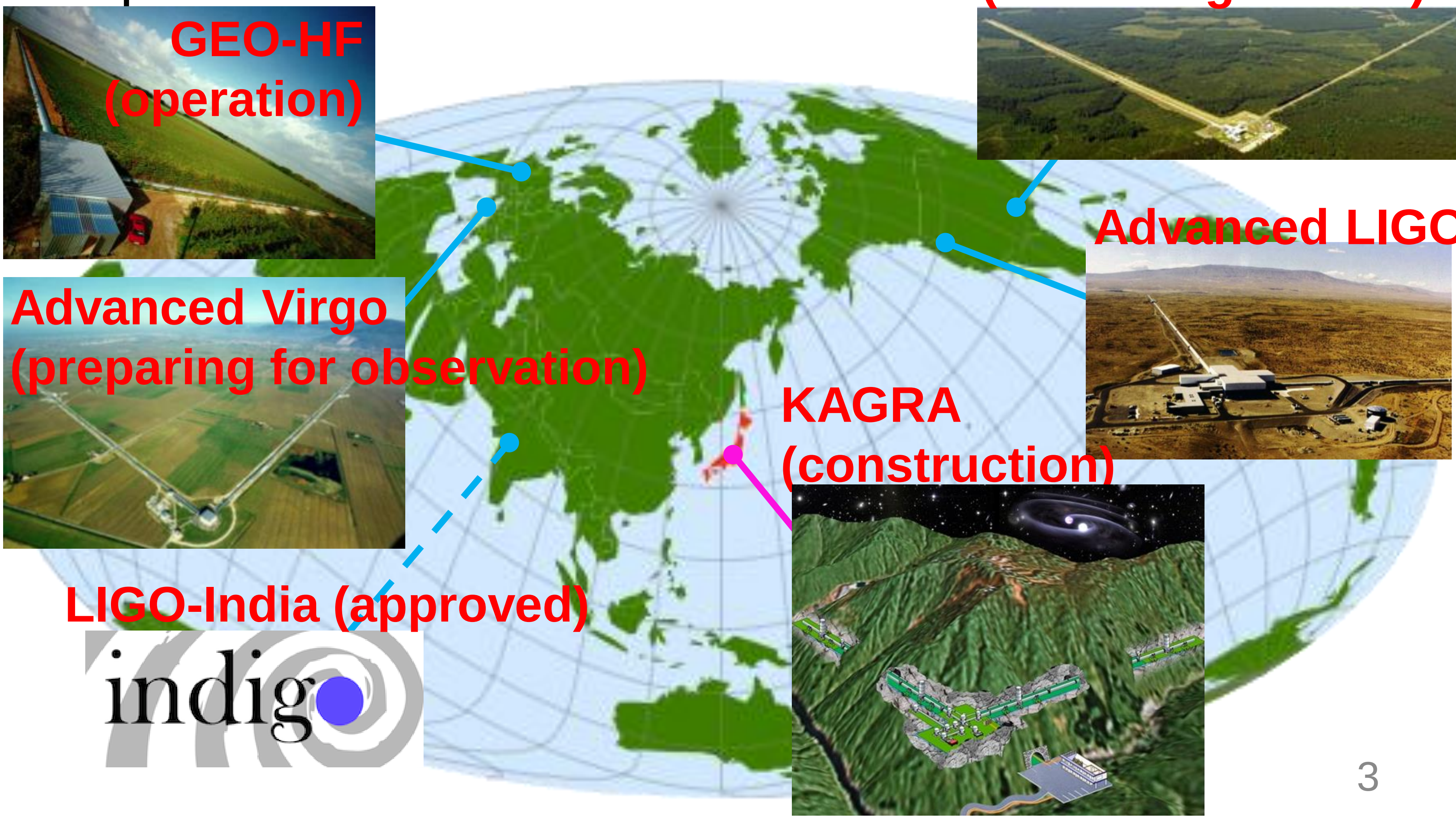
- Advanced LIGO detectors
- Binary black hole mergers
  GW150914
  GW151226
  GW170104
- “heavy” BHs



Caltech/MIT/LIGO Lab

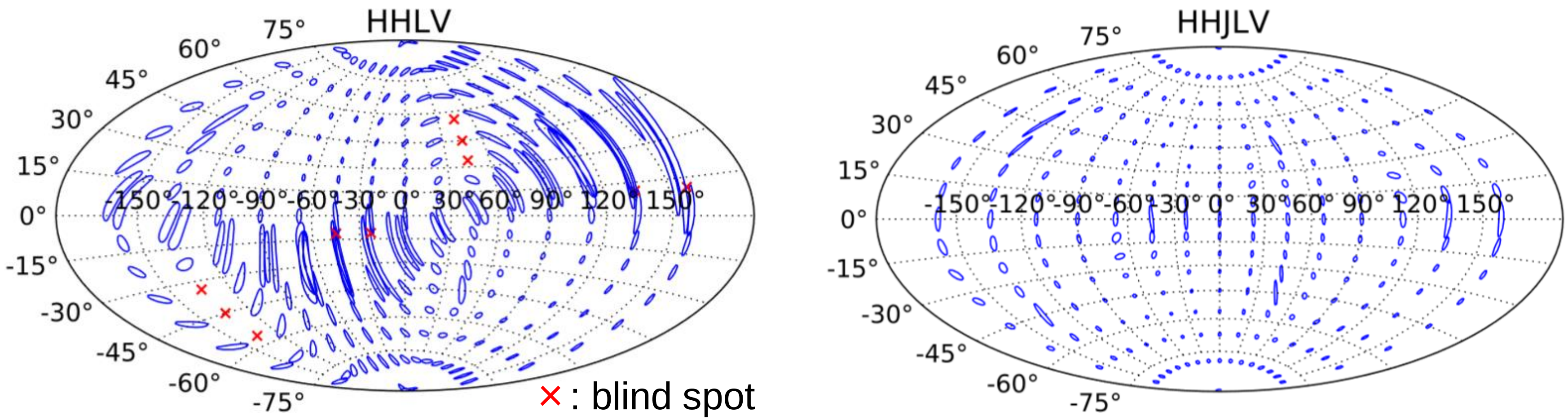
Global Network of GW Detectors

- for better sky localization, parameter estimation



GW Astronomy (~5years)

- better sky localization (<10 deg^2 with LHVK)
- better parameter estimation (spin, distance, etc.)

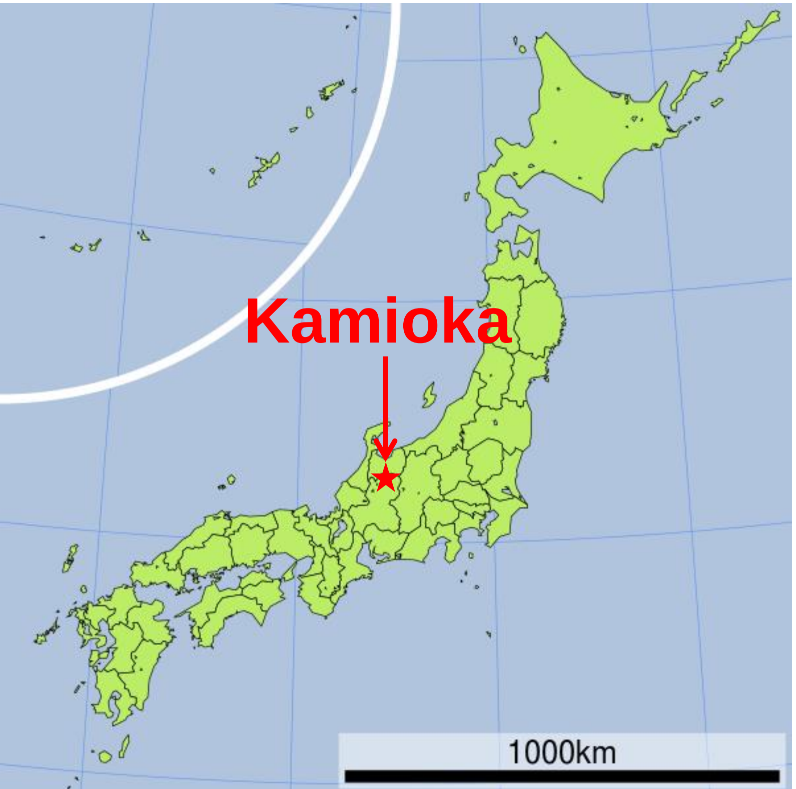


S. Fairhurst, CQG 28, 105021 (2011)

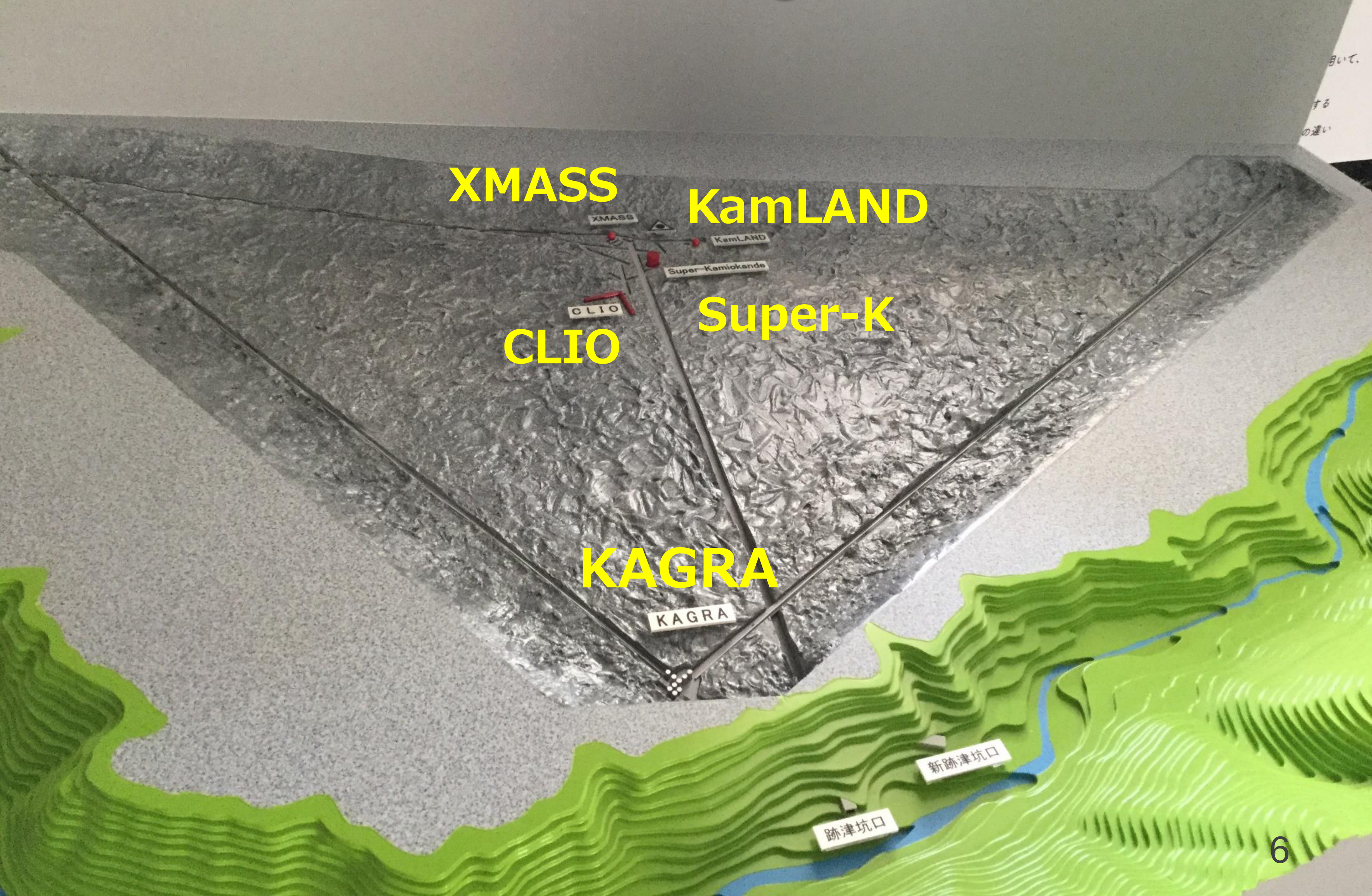
- more BH-BH mergers
  origin of ~30 Msun BH
- first detection of BH-NH merger, NS-NS merger
  NS equation of state
  origin of short gamma ray burst?
  multi-messenger astronomy (electromagnetic, neutrino)

GW Telescope in Japan: KAGRA

- under construction in Kamioka mine, Japan
- project approved in 2010
- 60+ institutes, 200+ collaborators
- 3-km interferometric GW telescope

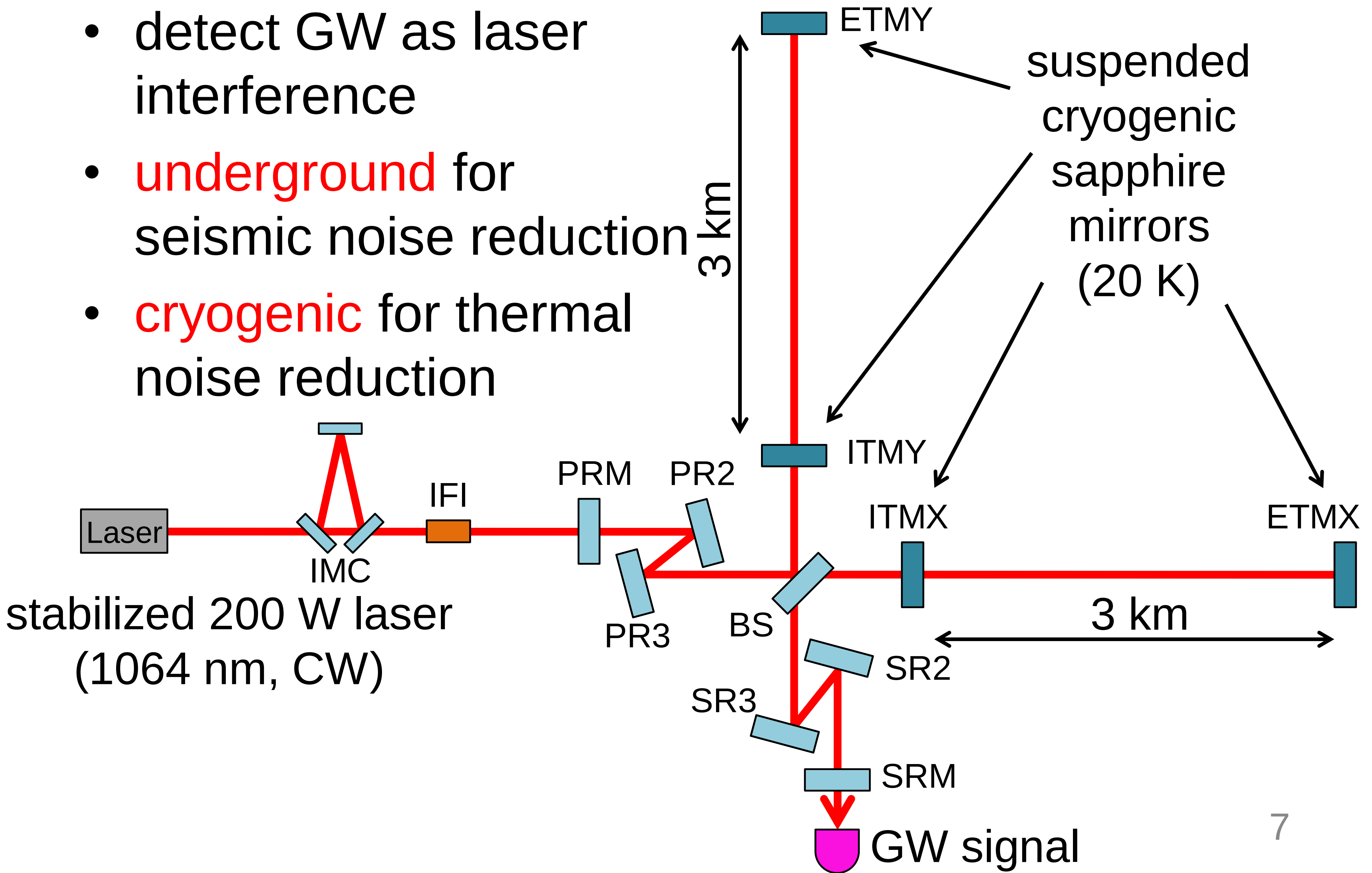


Kamioka Underground Site



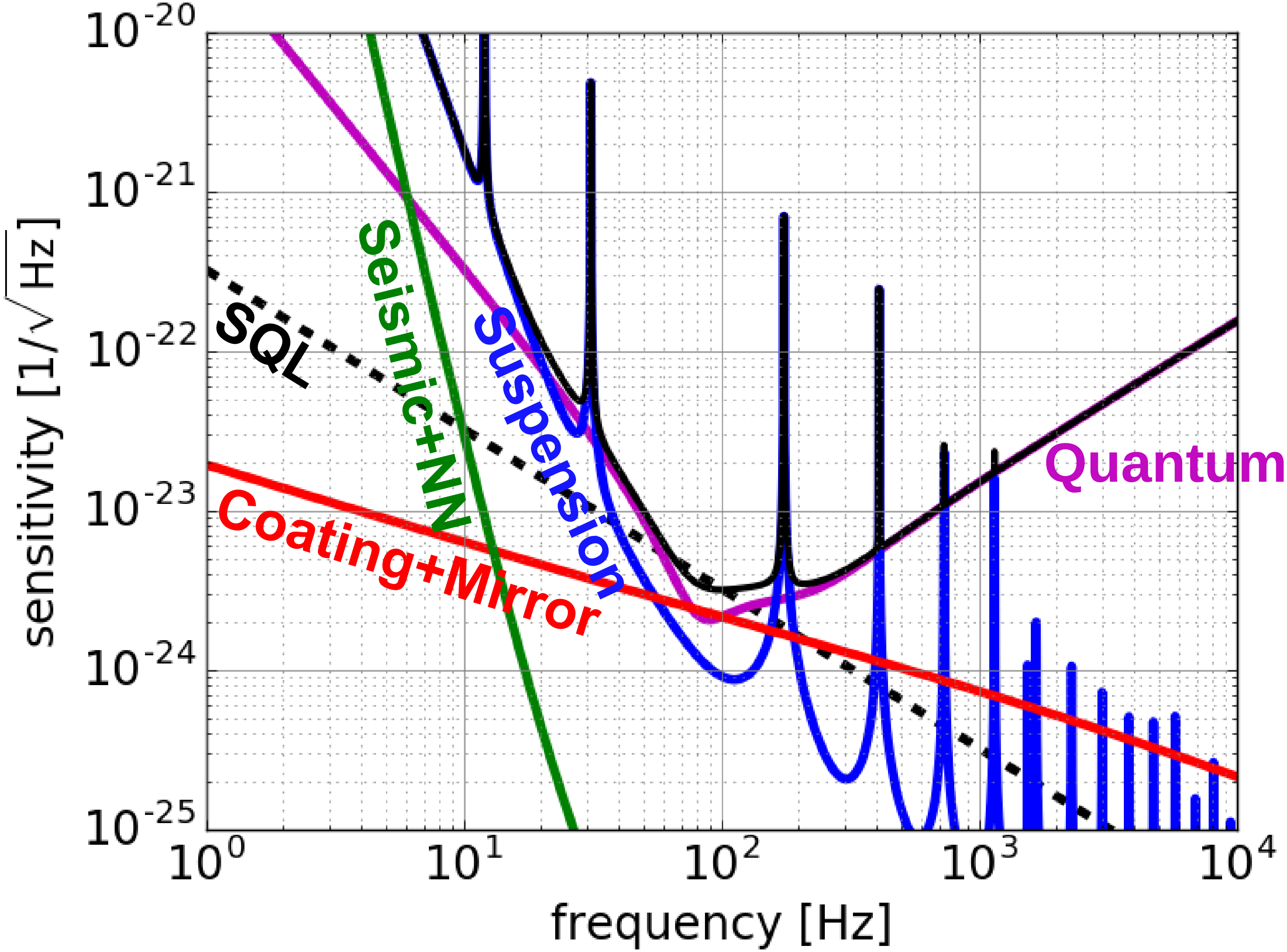
Interferometer Configuration

- detect GW as laser interference
- underground for seismic noise reduction
- cryogenic for thermal noise reduction



KAGRA Estimated Sensitivity

- NS-NS 158 Mpc, BH-BH 1.0 Gpc, SN ~10^2 kpc

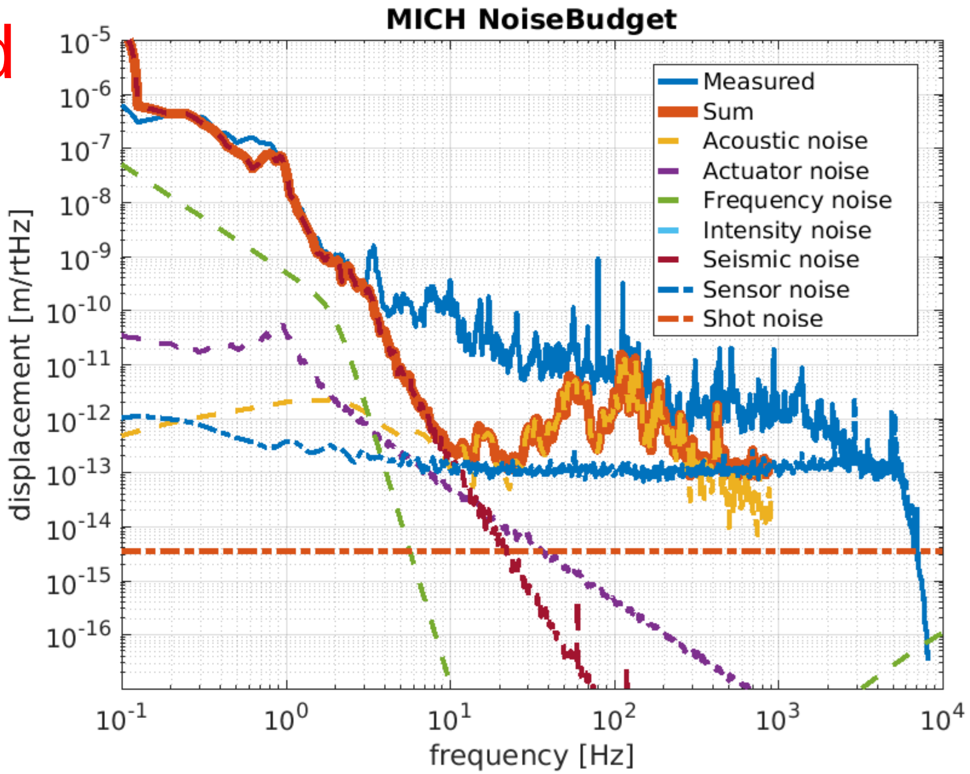


KAGRA Timeline

- 2014 — Tunnel excavation done
- 2015 — Inauguration of initial-phase facility
- 2016 — First test run at room temp. (iKAGRA)
- 2017
- 2018 — Cryogenic test run (Phase 1)
- 2019 — Test operation with full config. (Phase 2)
- 2020 — Observation runs (Phase 3)

Current Status of KAGRA

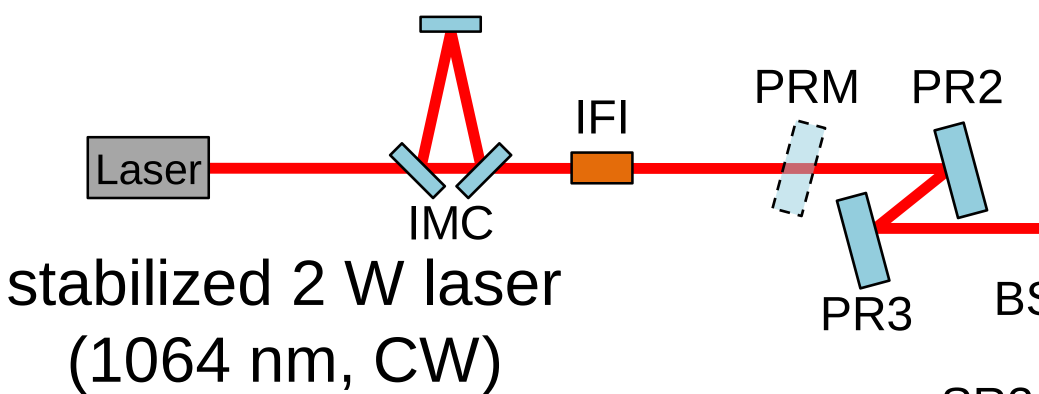
- successfully completed
  the first test run
  at room temperature

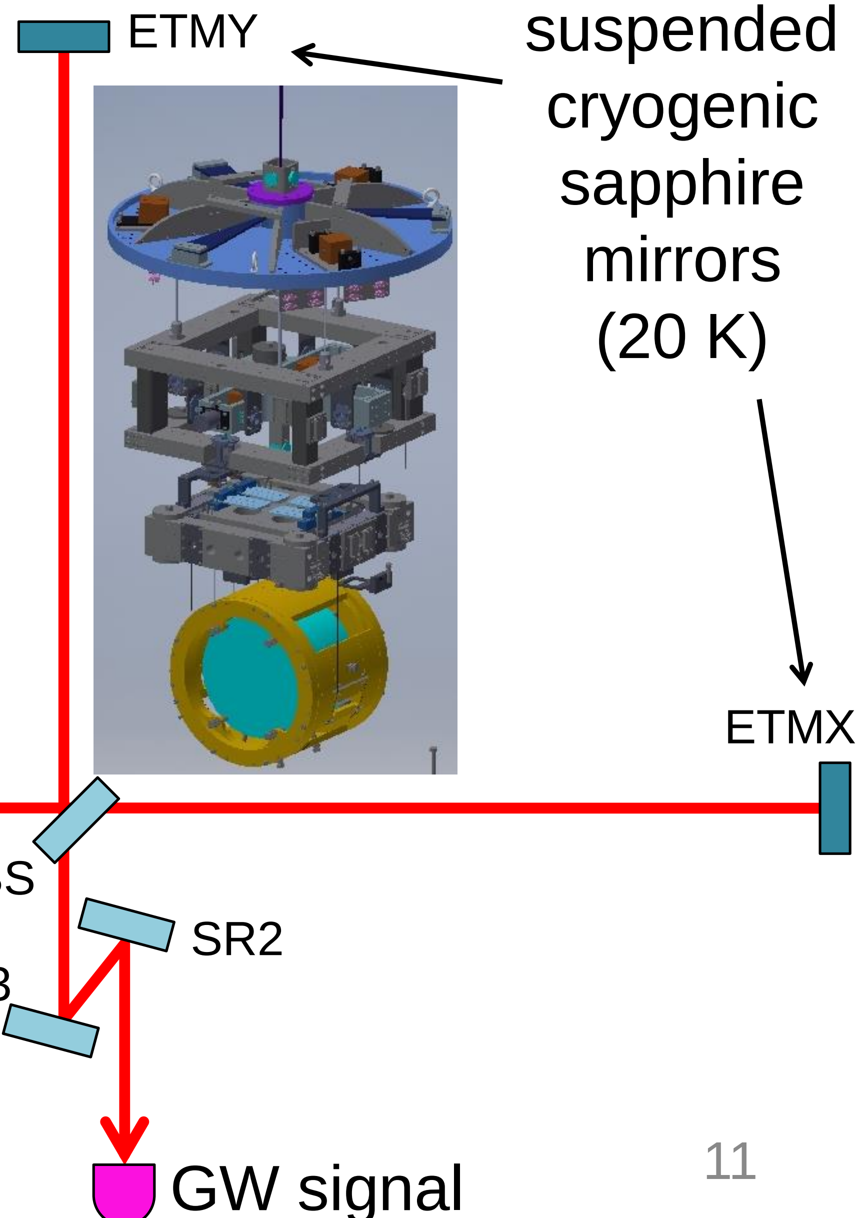


- working for the first cryogenic test run
  by March 2018 (Phase 1)
  - cryogenic sapphire mirror suspensions
  - room temperature mirror suspensions
  - pre-stabilized laser upgrade

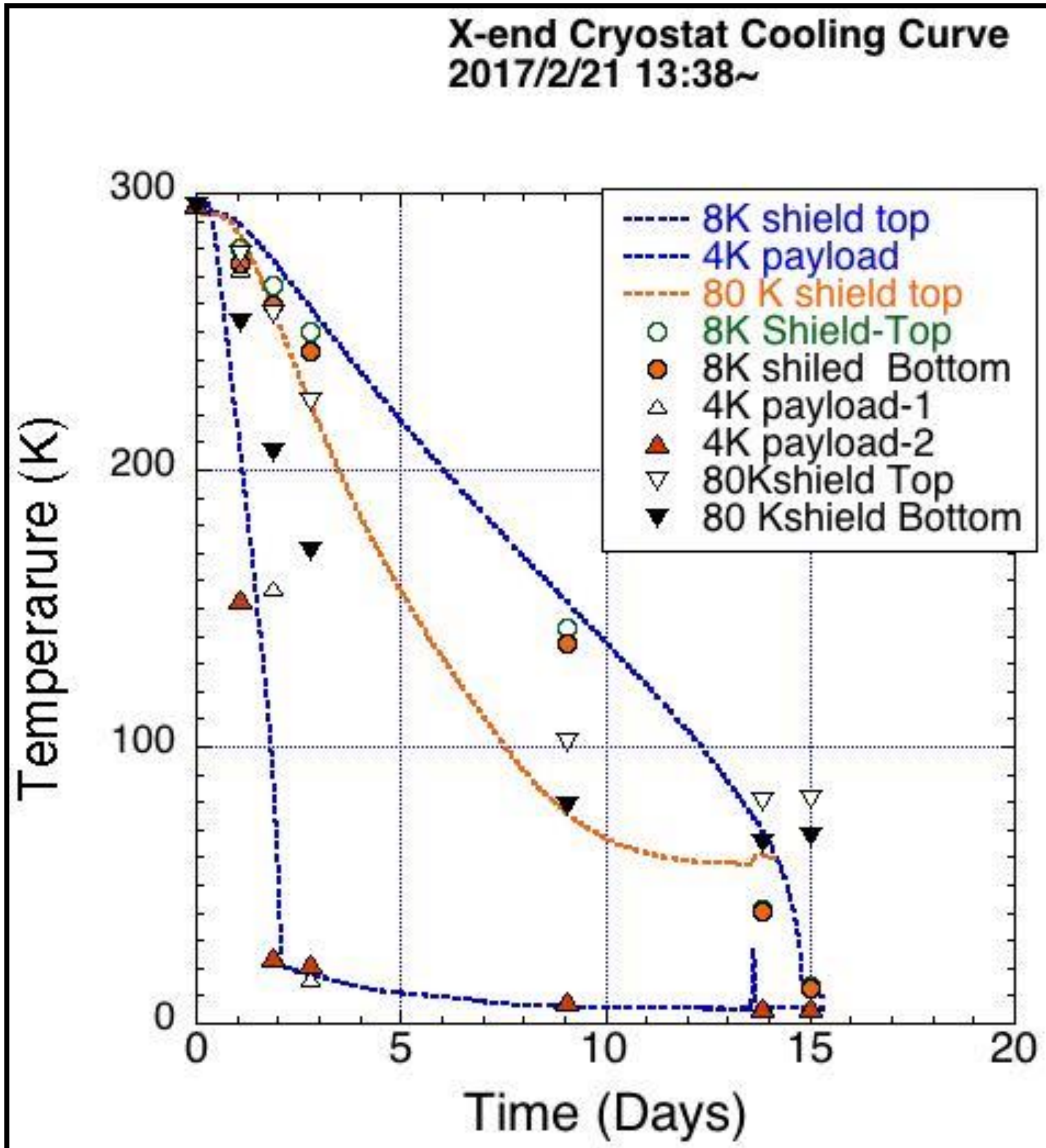
Phase 1 Configuration

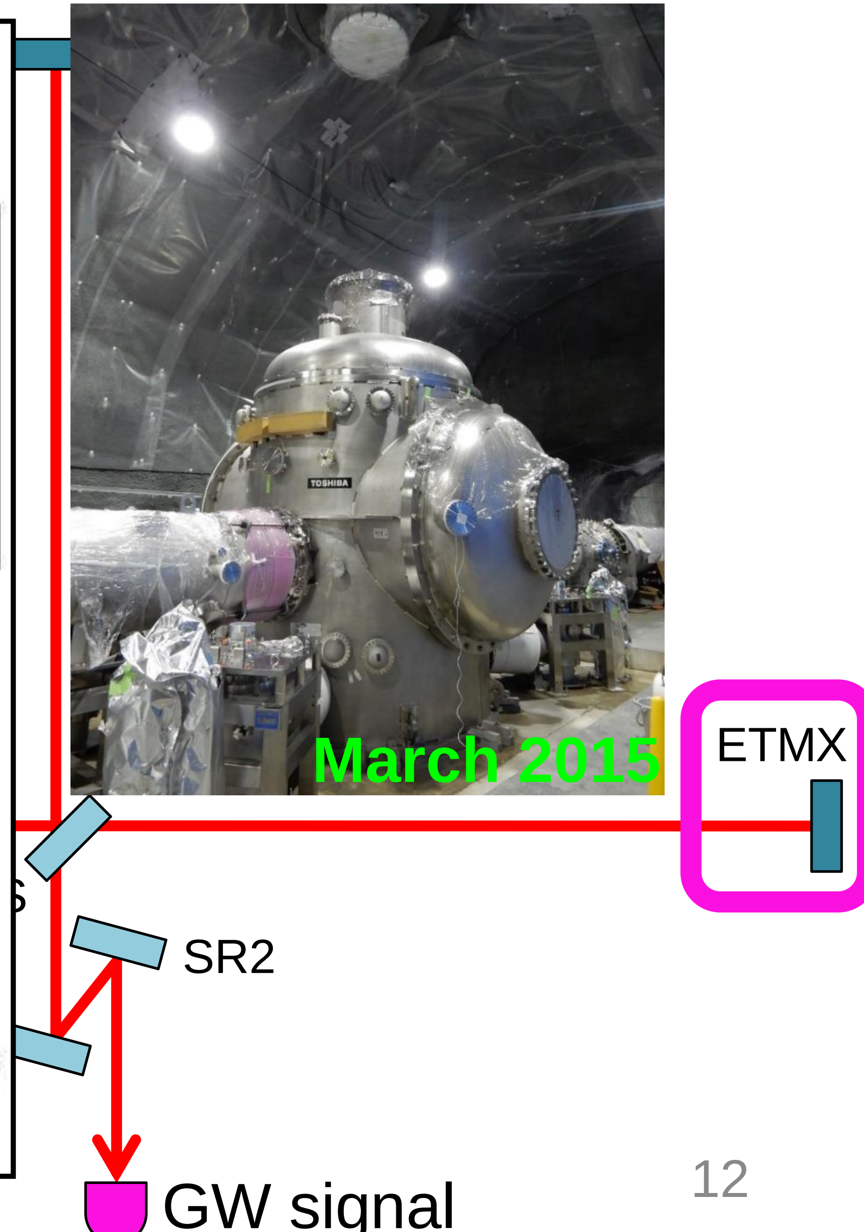
- Michelson interferometer
- cryogenic sapphire ETMs
- by March 2018



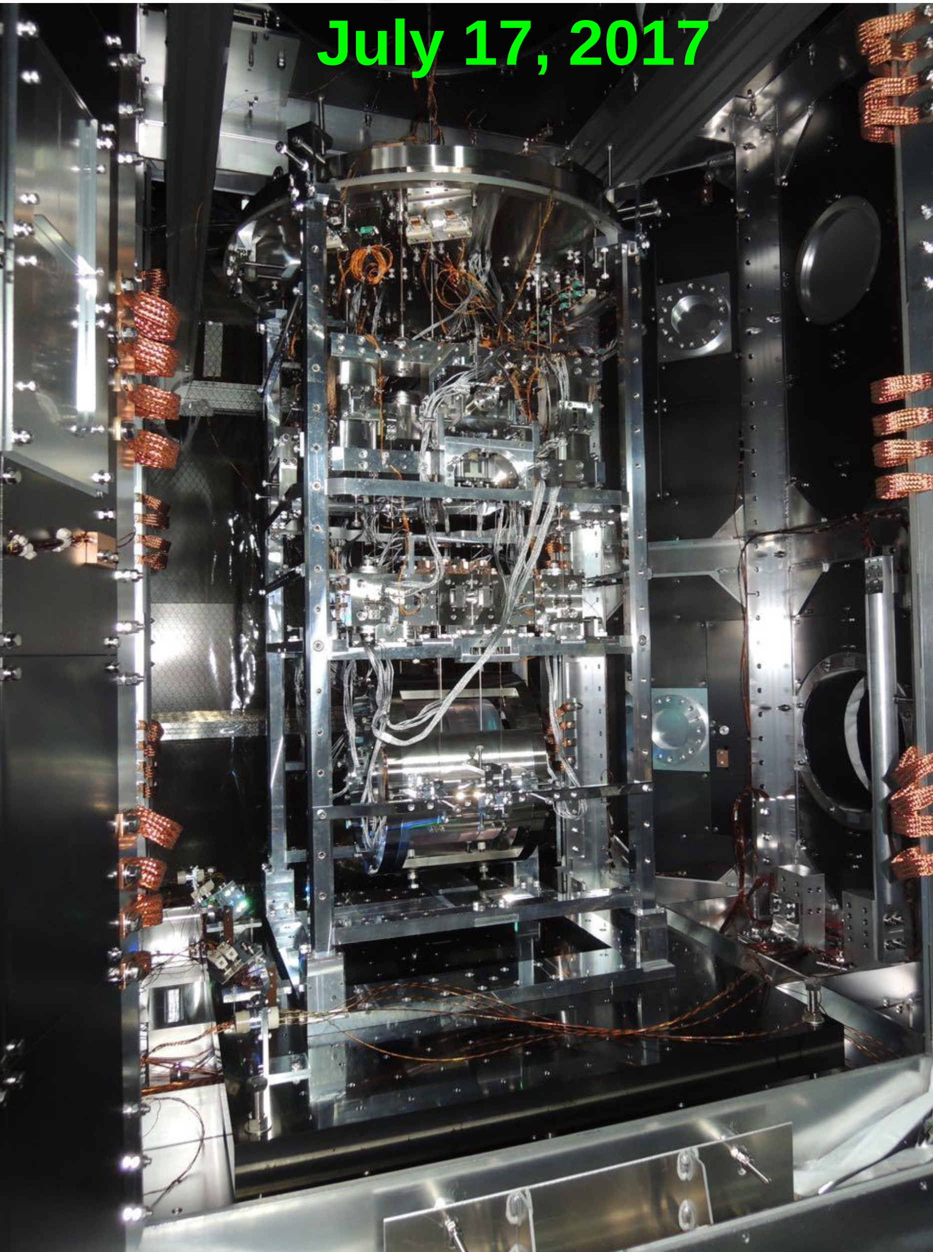


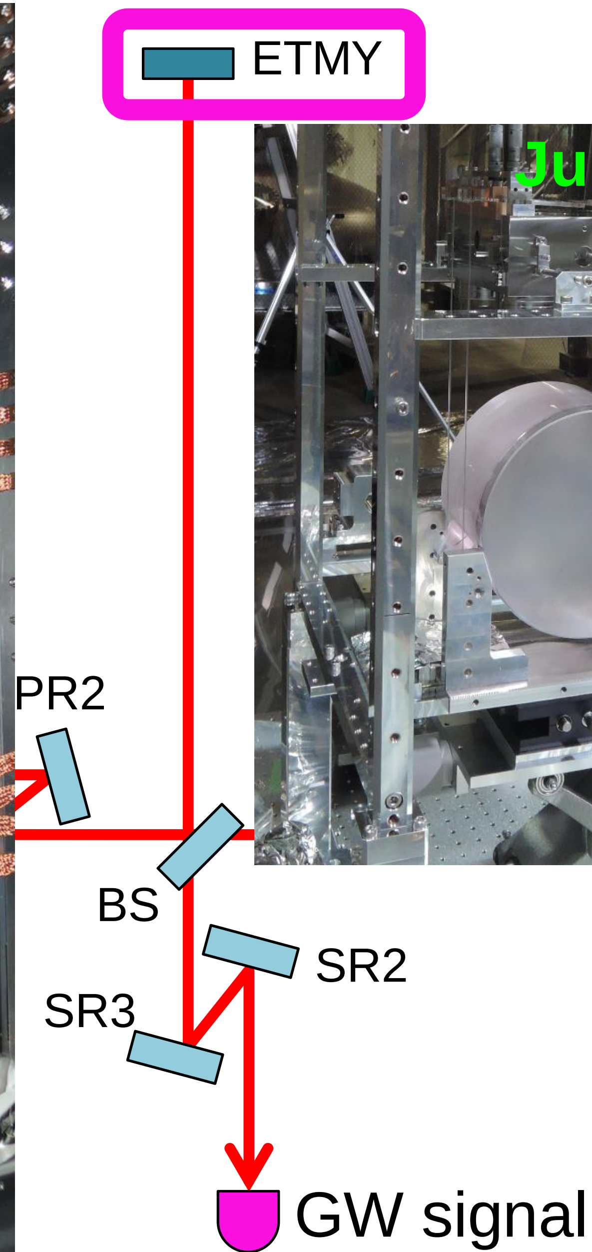
Cryostat Cooling Test



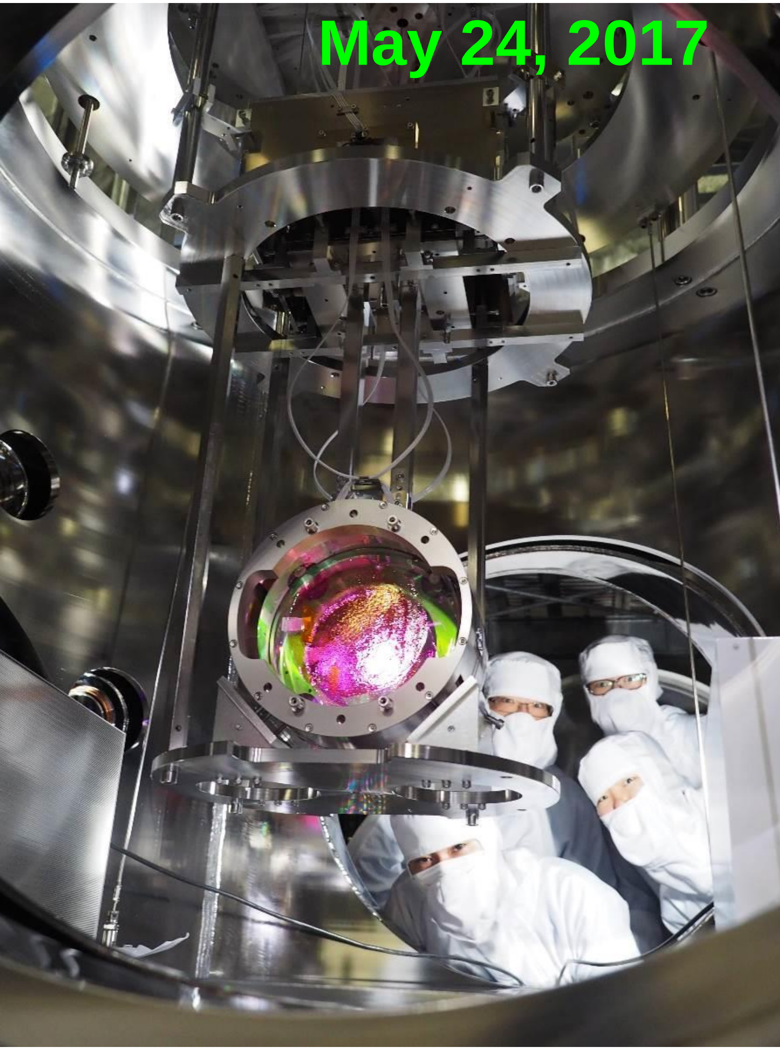


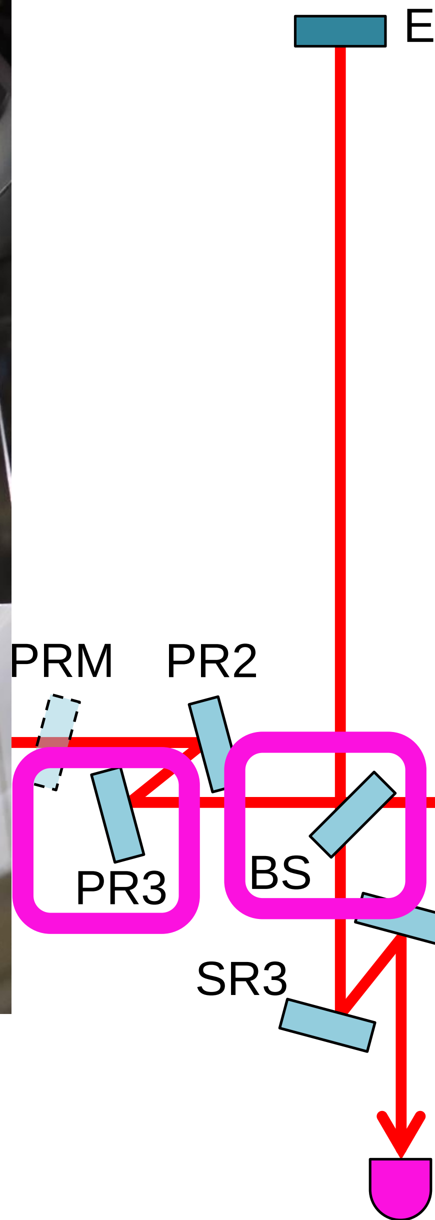
Cryogenic Mirror Test Installation



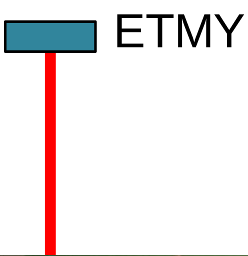


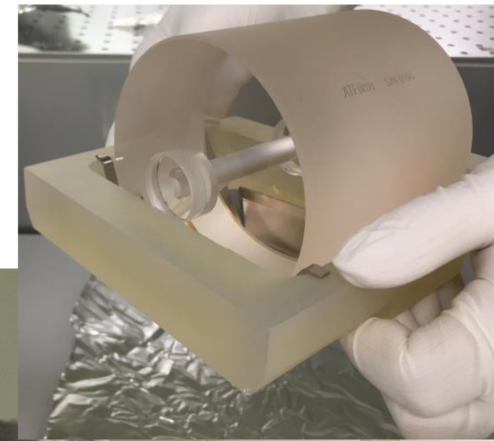
Room Temp. Mirror Installation

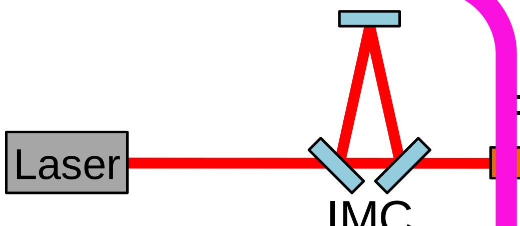




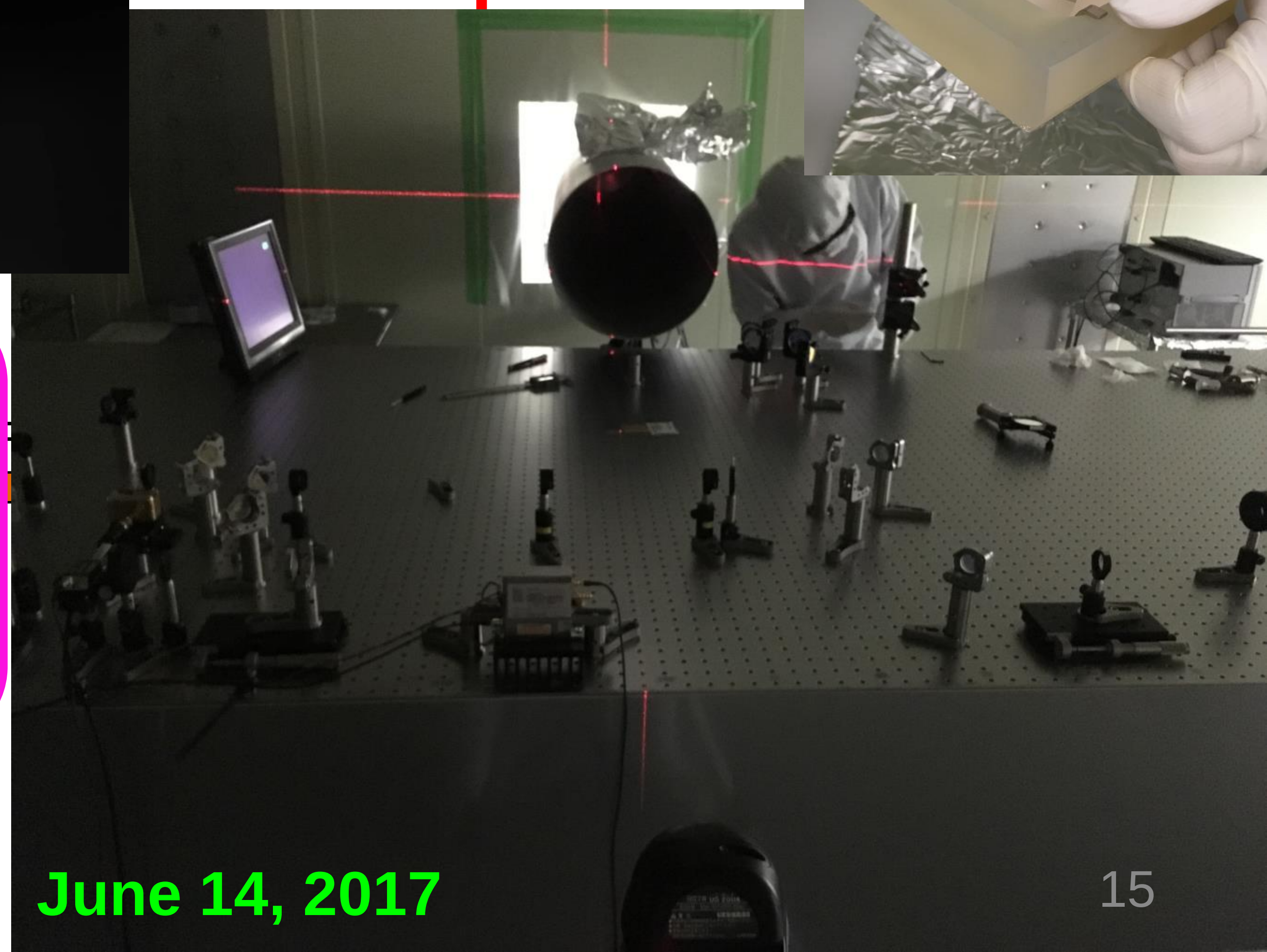
Pre-stabilized Laser Upgrade







stabilized 2 W laser
(1064 nm, CW)

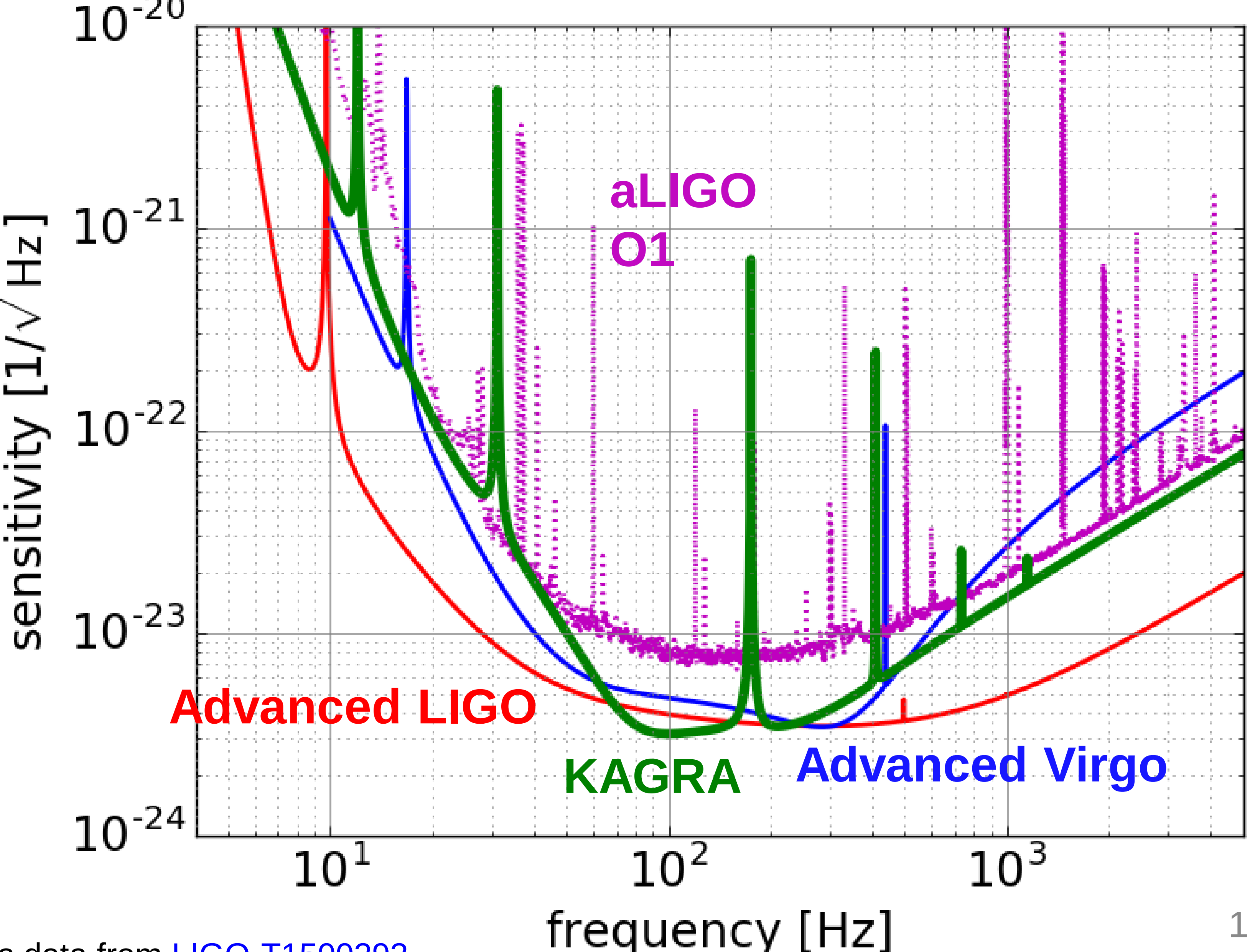


Summary

- The era of gravitational wave astronomy has begun
- Fruitful science with global network
  - better sky localization, parameter estimation
  - origin of heavy stellar-mass black holes
  - NS-NS, NS-BH binaries
  - multi-messenger astronomy
- GW telescope in Japan: KAGRA
  - unique features: underground and cryogenic
  - completed initial-phase test run
  - first cryogenic test run in March 2018
  - observing runs by ~2020

Supplementary Slides

KAGRA vs Other 2G



Spectra data from LIGO-T1500293

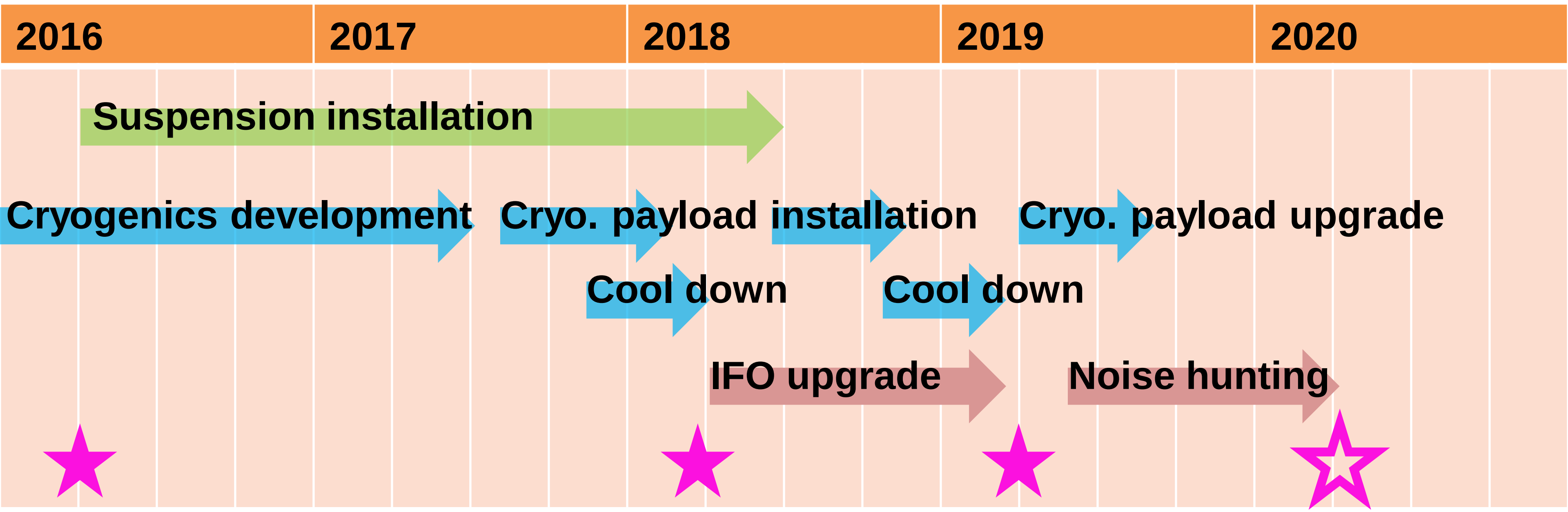
2G/2G+ Parameter Comparison

	KAGRA	AdVirgo	aLIGO	A+	Voyager
Arm length [km]	3	3	4	4	4
Mirror mass [kg]	23	42	40	80	200
Mirror material	Sapphire	Silica	Silica	Silica	Silicon
Mirror temp [K]	21	295	295	295	123
Sus fiber	35cm Sap.	70cm SiO_2	60cm SiO_2	60cm SiO_2	60cm Si
Fiber type	Fiber	Fiber	Fiber	Fiber	Ribbon
Input power [W]	78	125	125	125	140
Arm power [kW]	400	700	710	1150	3000
Wavelength [nm]	1064	1064	1064	1064	2000
Beam size [cm]	3.5 / 3.5	4.9 / 5.8	5.5 / 6.2	5.5 / 6.2	5.8 / 6.2
SQZ factor	0	0	0	6	8
F. C. length [m]	none	none	none	16	300

LIGO parameters from LIGO-T1600119, AdVirgo parameters from JPCS 610, 01201 (2015)

Roadmap of KAGRA

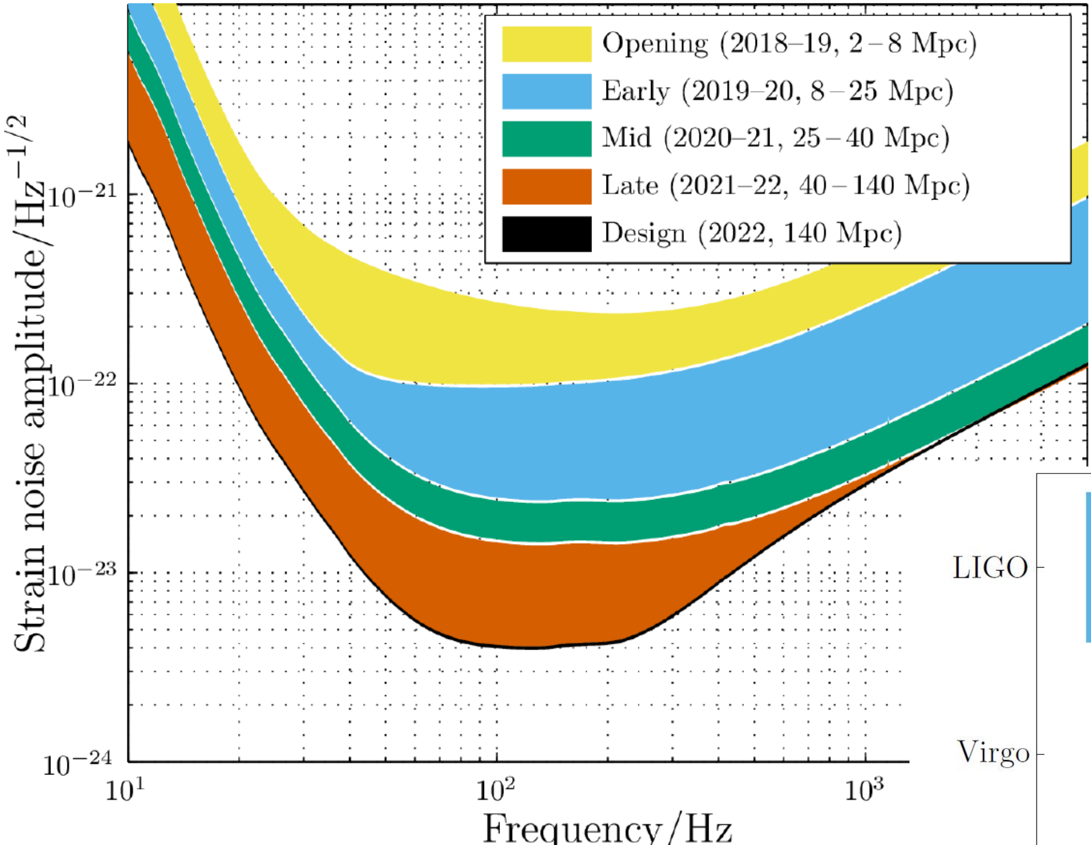
- Completed first test run at room temperature. Working for cryogenic test run.
- Baseline KAGRA (bKAGRA) in 3 phases.

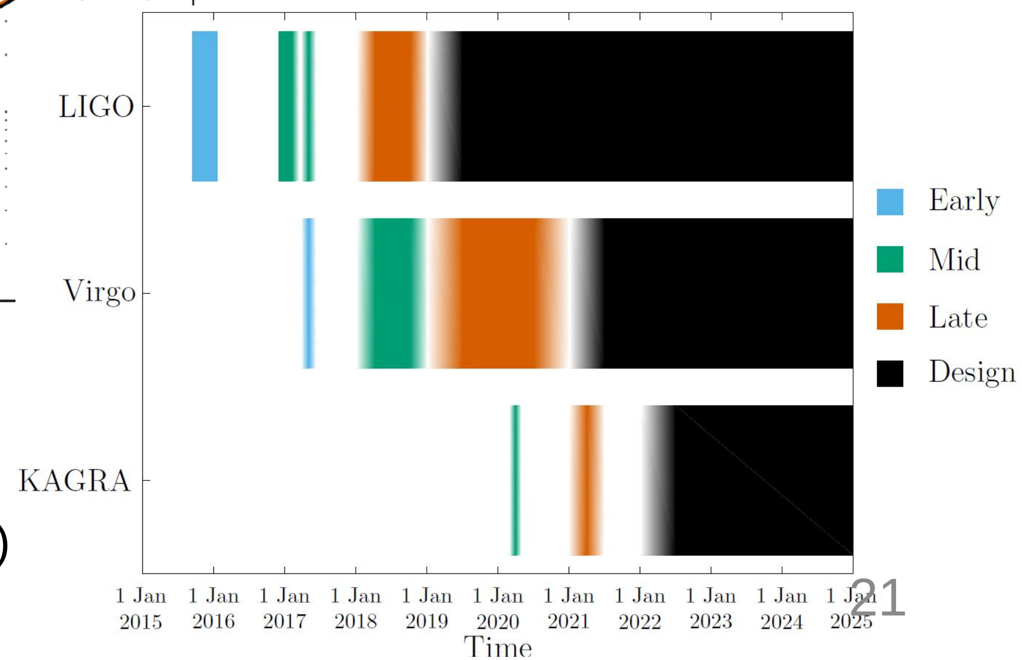


Initial KAGRA	Phase 1	Phase 2	Phase 3
Michelson at room temp. Test run	Michelson at cryogenic temp. Test run	RSE at cryogenic temp. Test run	RSE at cryogenic temp. Observation run

Observation Scenario

- With 25-40 Mpc in 2020, 40-140 Mpc in 2021

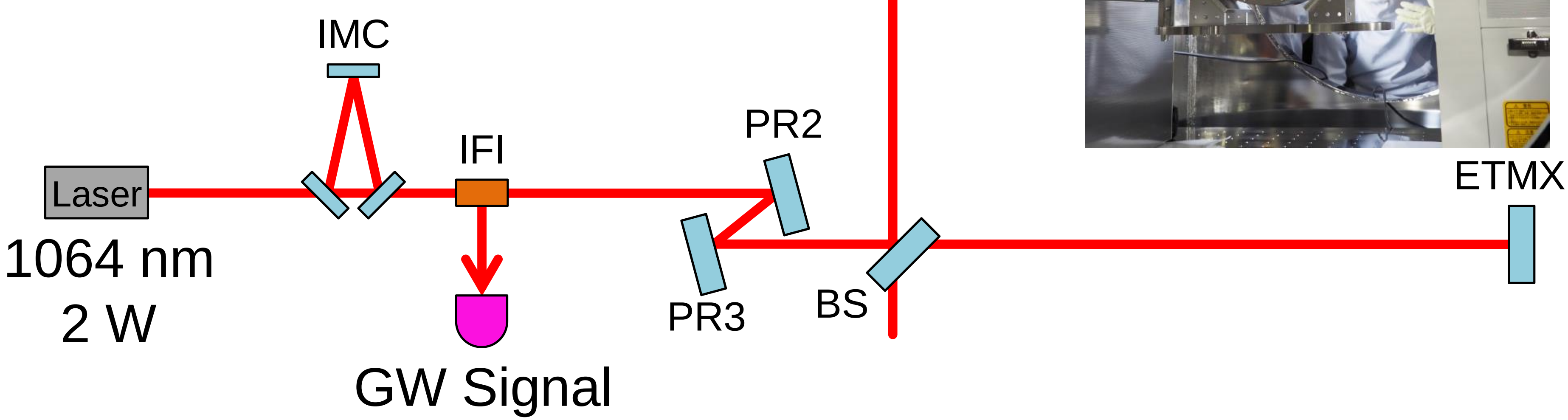




Living Reviews in Relativity 19, 1 (2016)
to be updated

Initial KAGRA Configuration

- 3 km Michelson
  at room temperature
- Low power
- Simplified suspension
- At air pressure



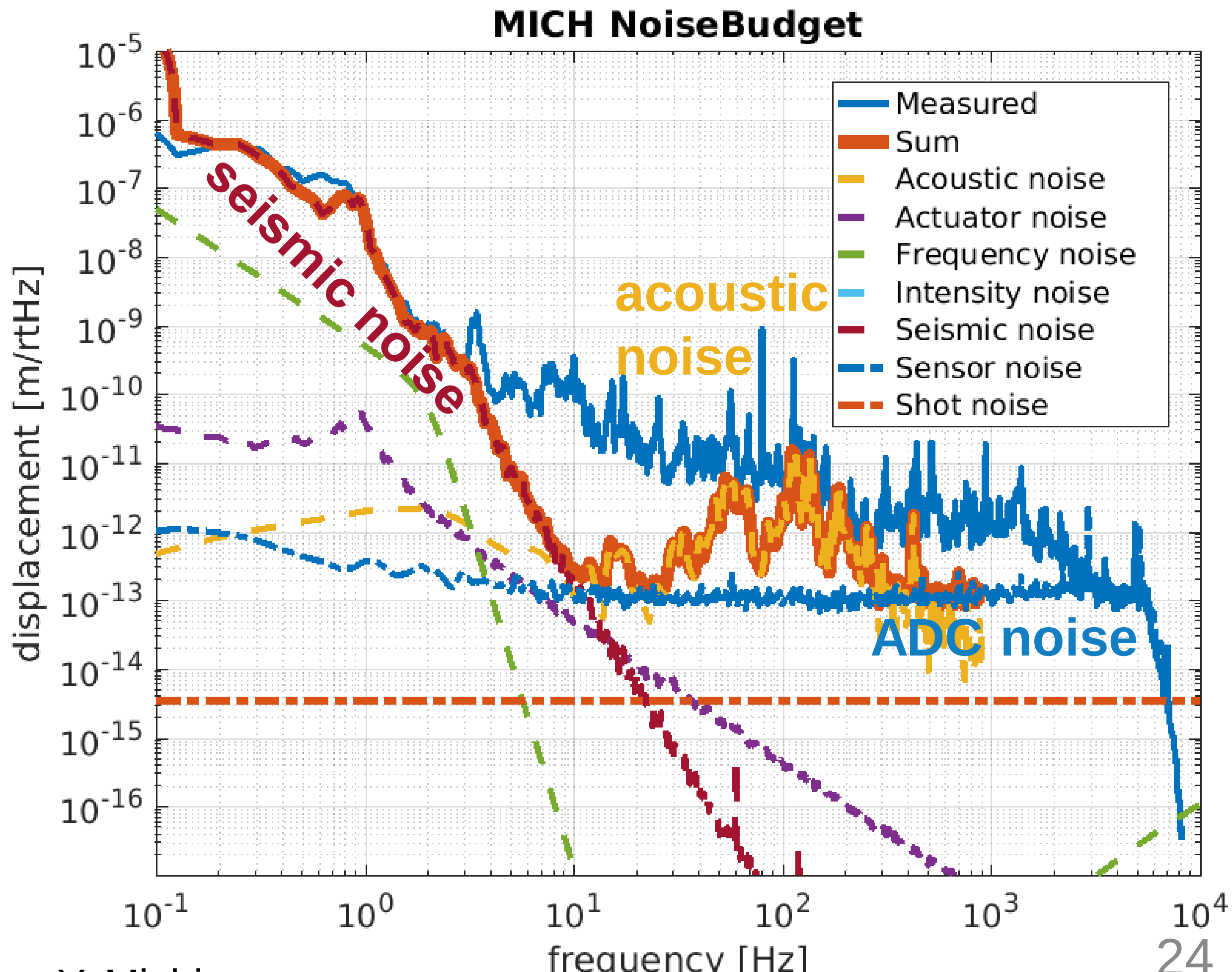
iKAGRA Test Run in 2016

- Period
  - March 25 to 31
  - April 11 to 25
- Purpose
  - confirm layout of the 3 km vacuum ducts
  - test controls, data transfer, observation shift, etc.
  - get environmental data
  - obtain experiences of the management and operation of the km-class interferometer

http://kyodonews.net/news/2016/03/25/54510

iKAGRA Sensitivity

- ~3e-15 /rtHz @ 100 Hz
- Limited by seismic noise, acoustic noise and ADC noise



- Reduction possible in bKAGRA

plot by T. Shimoda, M. Nakano, Y. Michimura