

The Status of KAGRA Underground Cryogenic Gravitational Wave Telescope

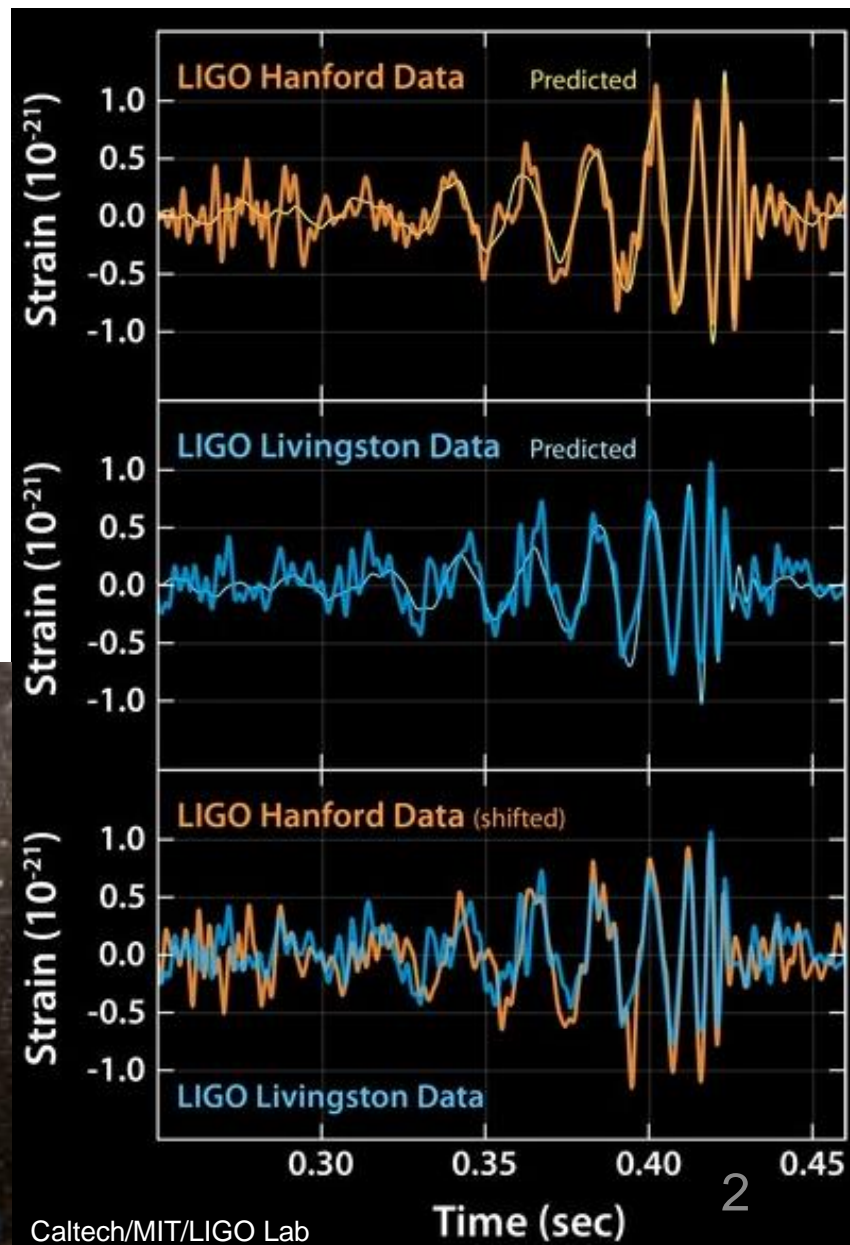
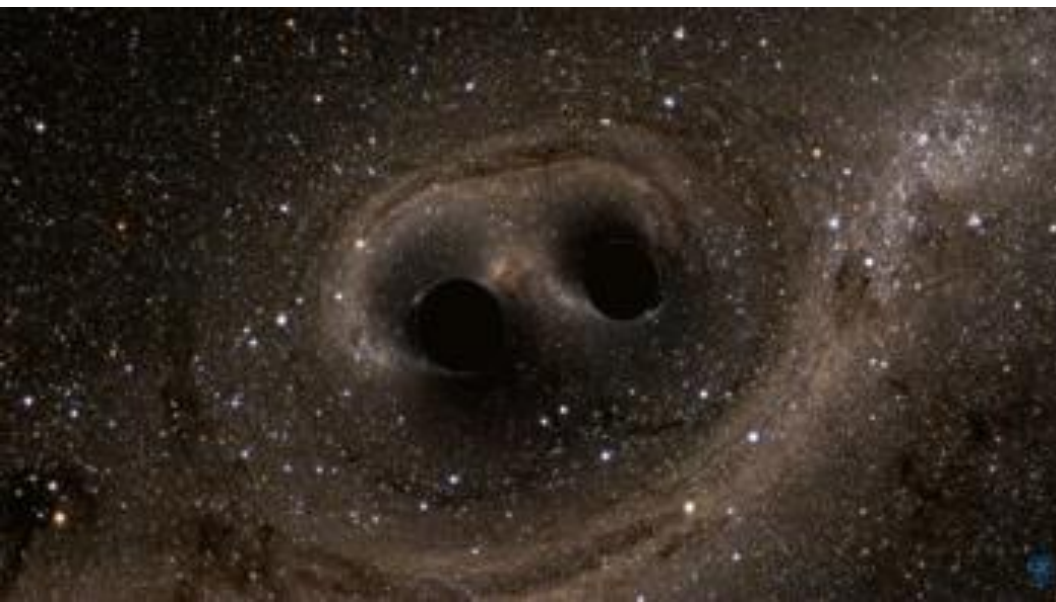
Yuta Michimura

Department of Physics, University of Tokyo

on behalf of the KAGRA Collaboration

First Detection of GW

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



Global Network of GW Detectors

- for better sky localization, parameter estimation



**Advanced LIGO
(observing run O2)**



**KAGRA
(construction)**

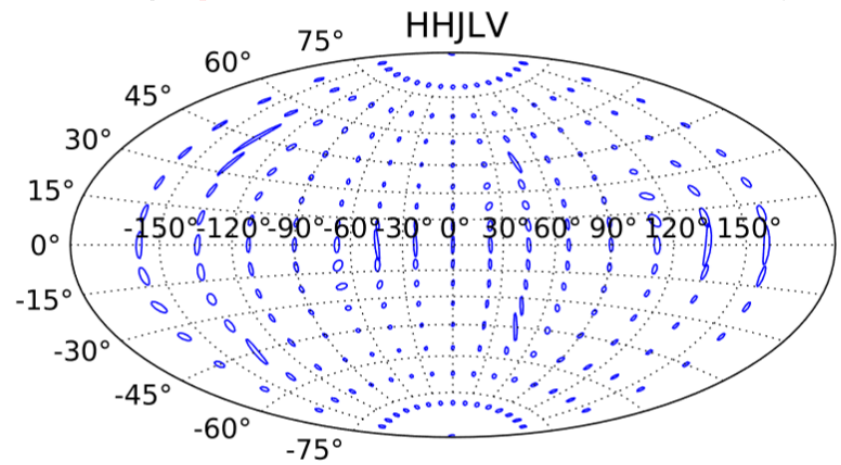
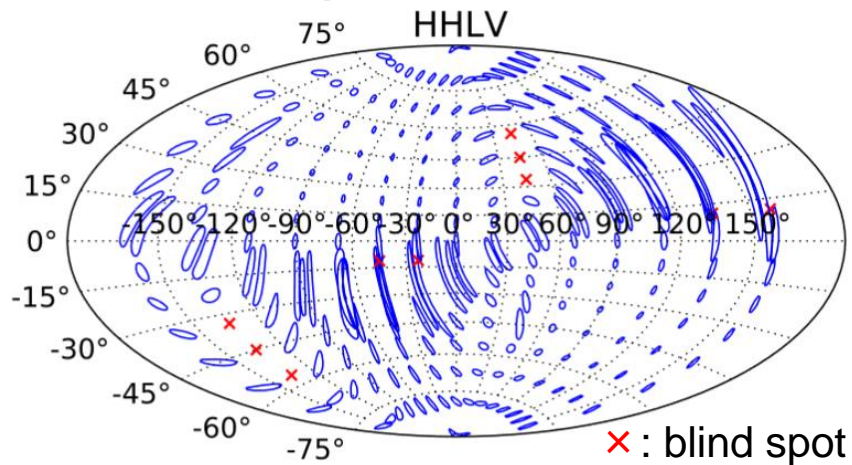


LIGO-India (approved)



GW Astronomy (~5years)

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



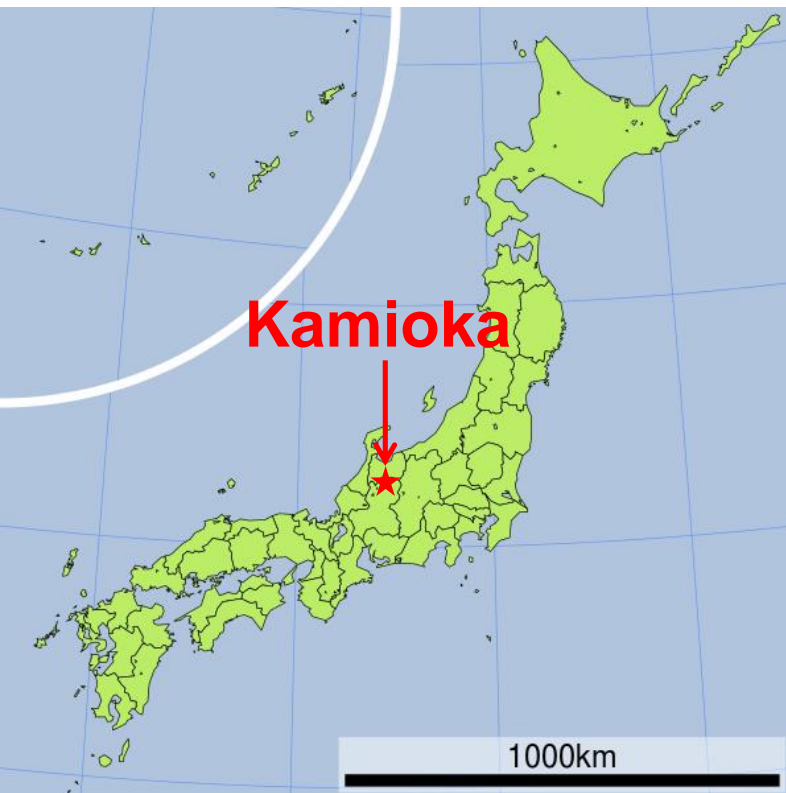
S. Fairhurst, [CQG 28, 105021 \(2011\)](#)

- more **BH-BH** mergers
origin of $\sim 30 \text{ Msun}$ 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)⁴

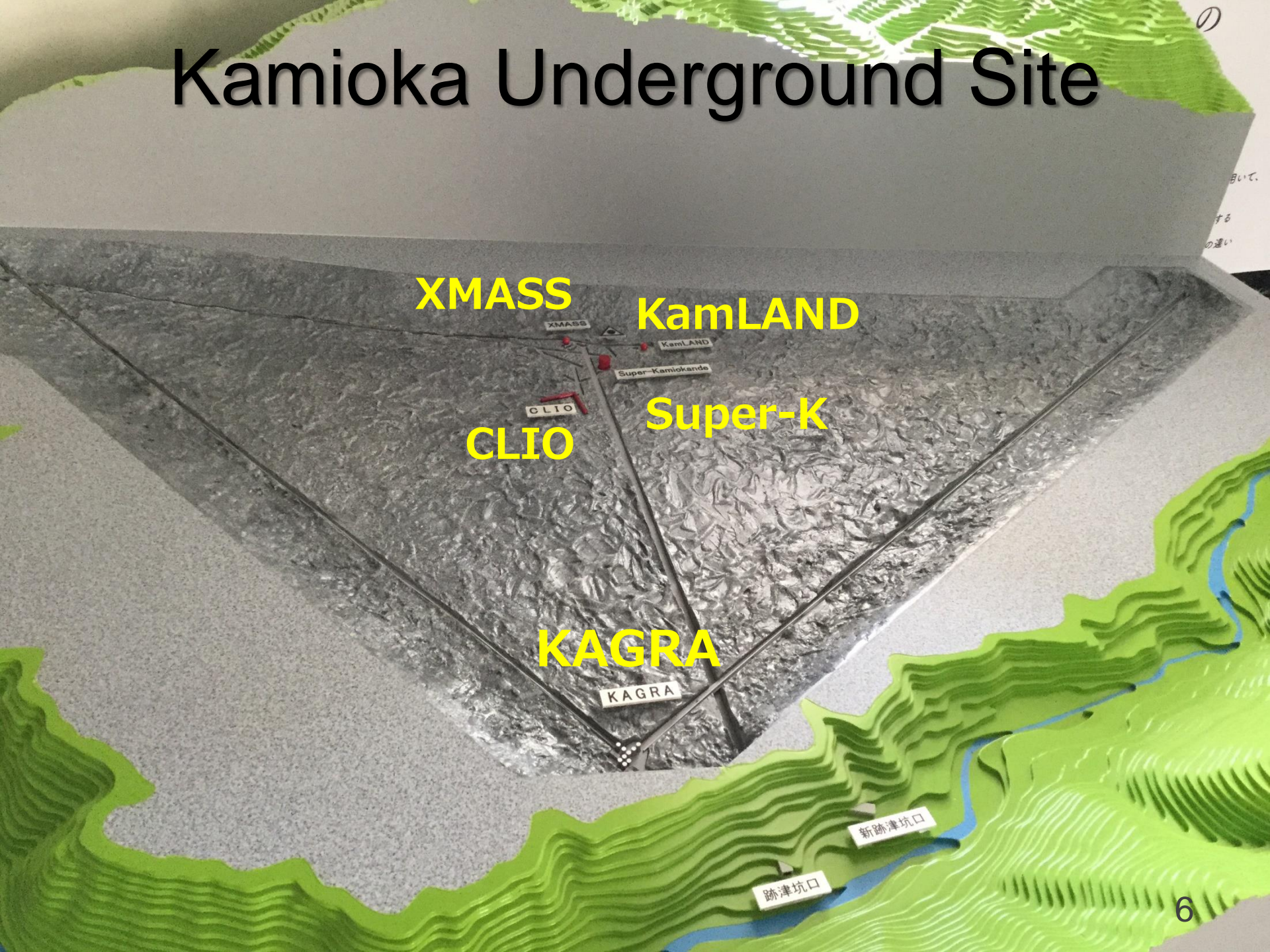
GW Telescope in Japan: KAGRA

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

KAGRA



Kamioka Underground Site



XMASS

KamLAND

CLIO

Super-K

KAGRA

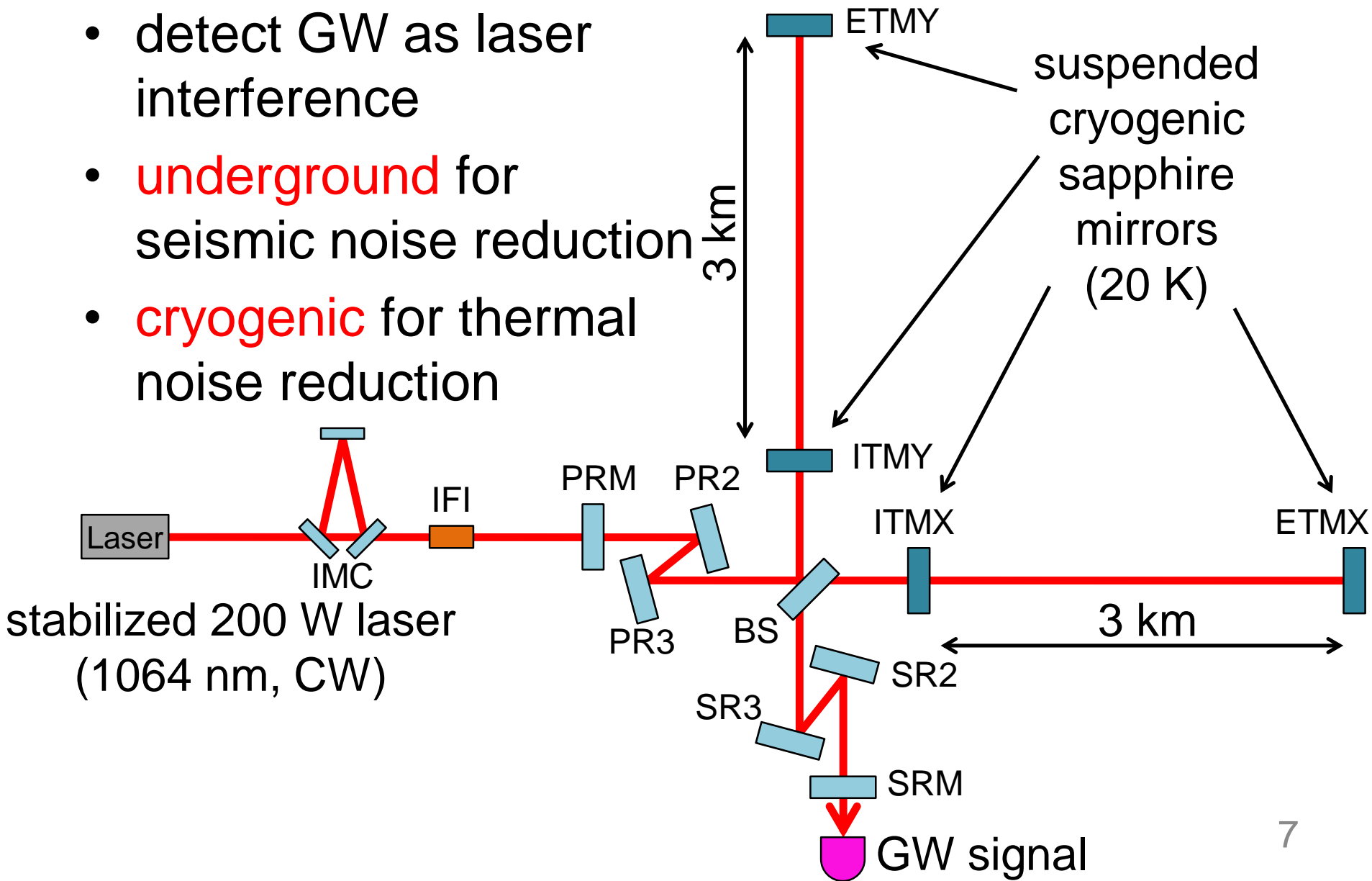
KAGRA

新跡津坑口

跡津坑口

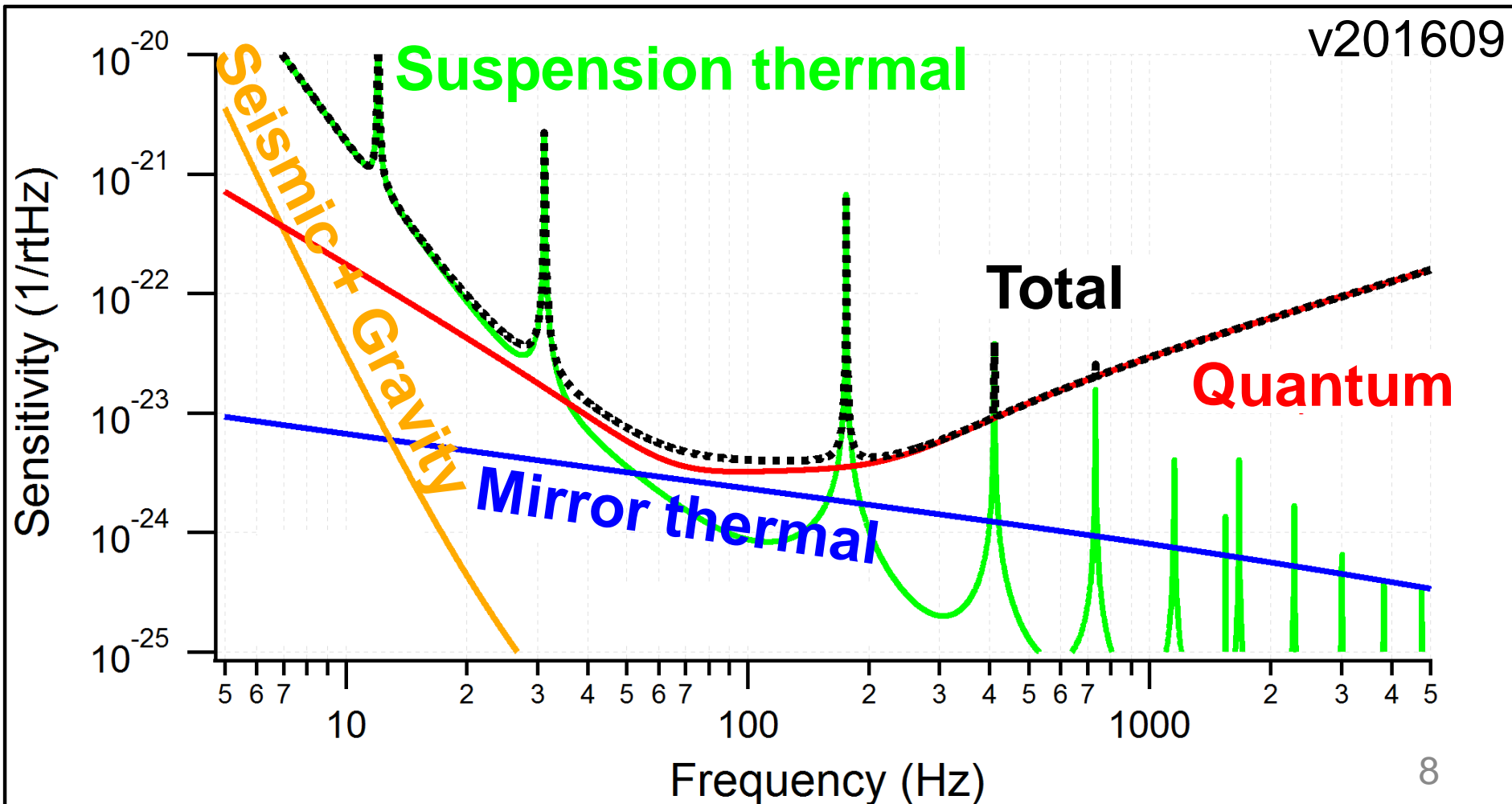
Interferometer Configuration

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

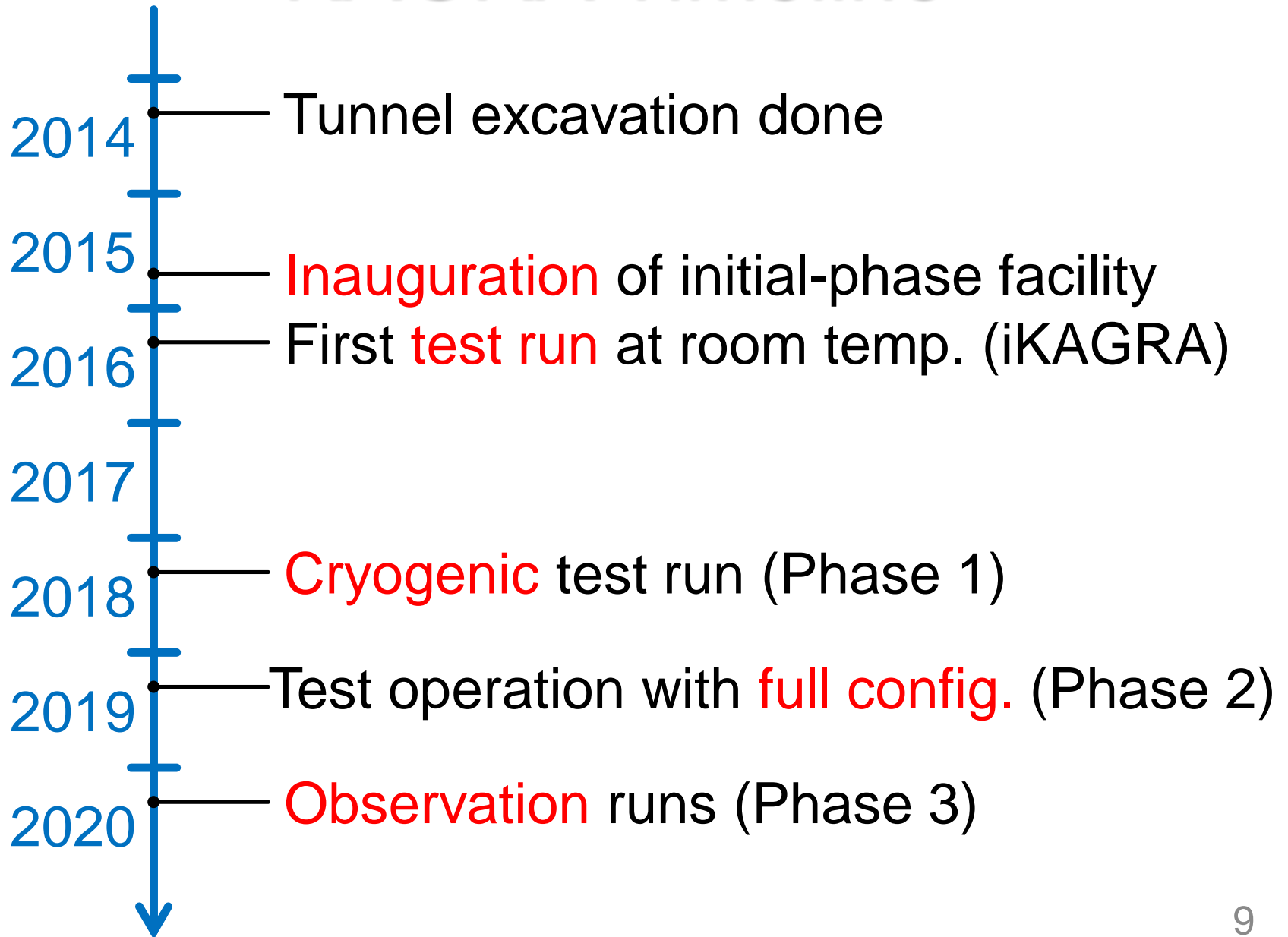


KAGRA Estimated Sensitivity

- NS-NS 152 Mpc, BH-BH 1.2 Gpc, SN $\sim 10^2$ kpc

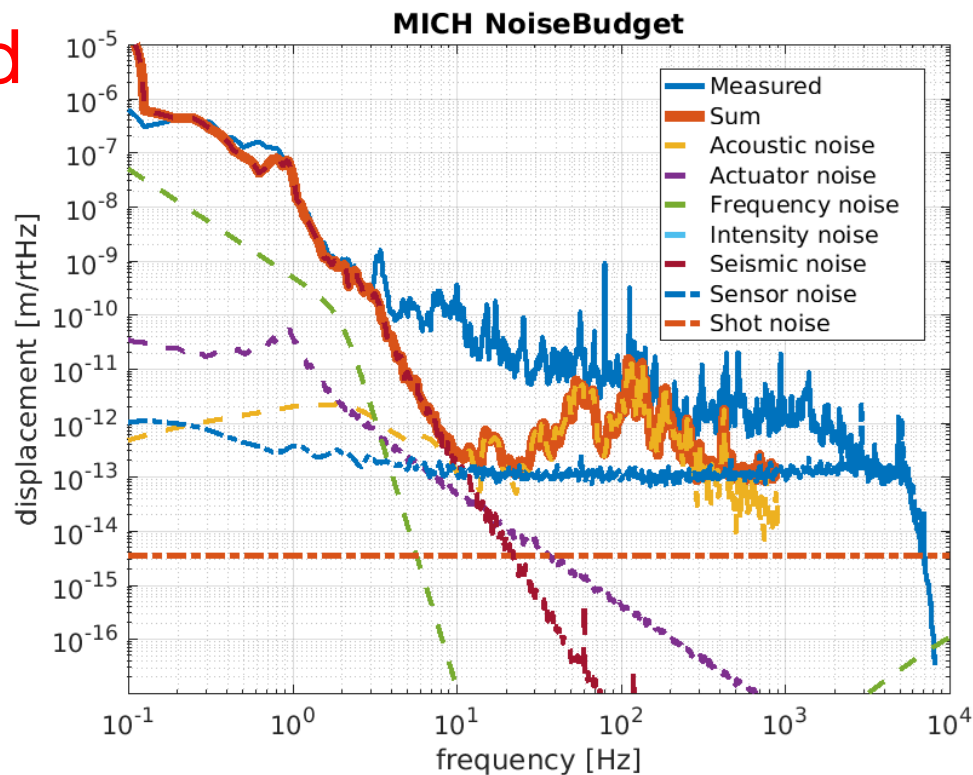


KAGRA Timeline



Current Status of KAGRA

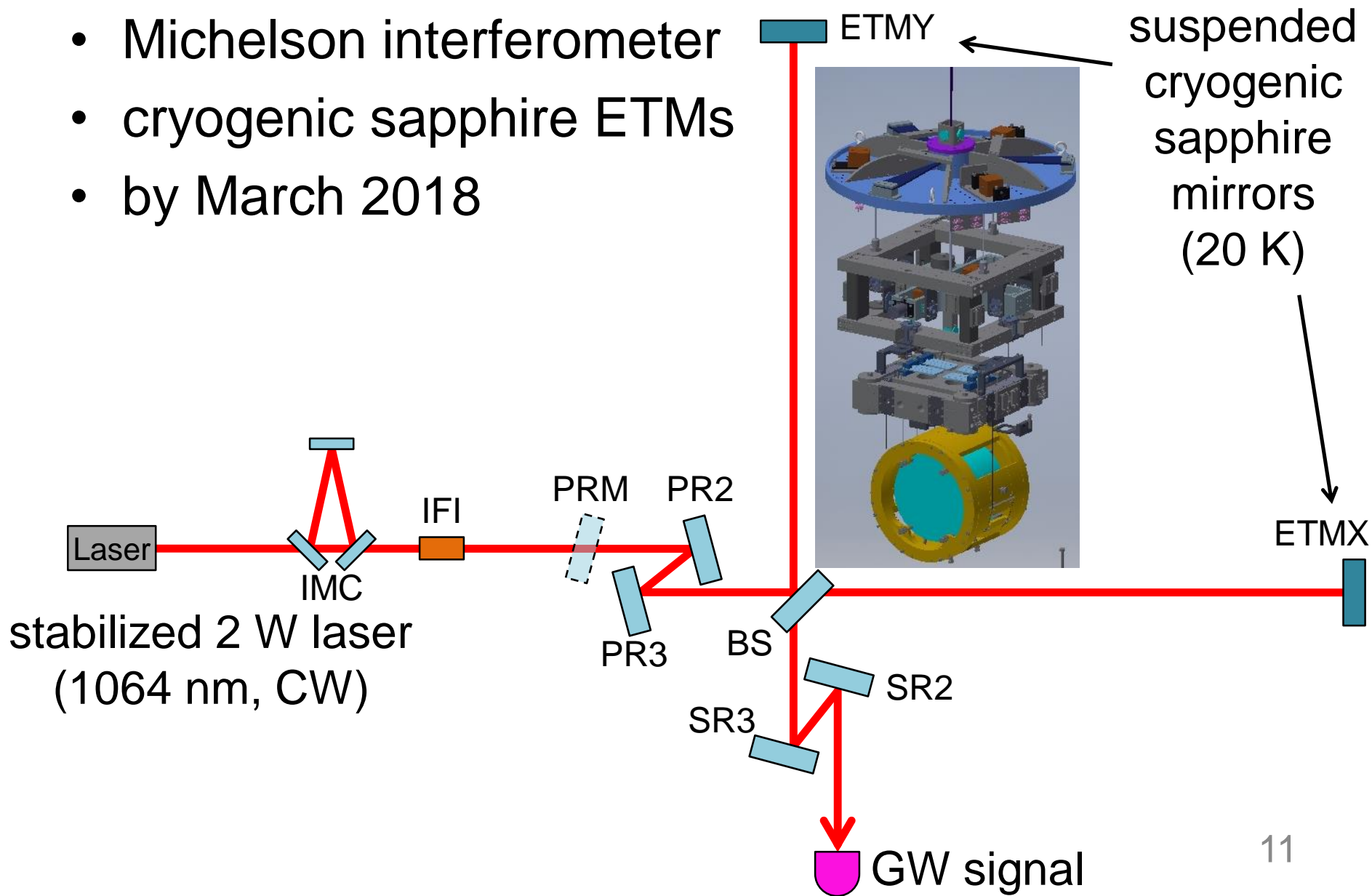
- **successfully completed** the first test run at room temperature



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

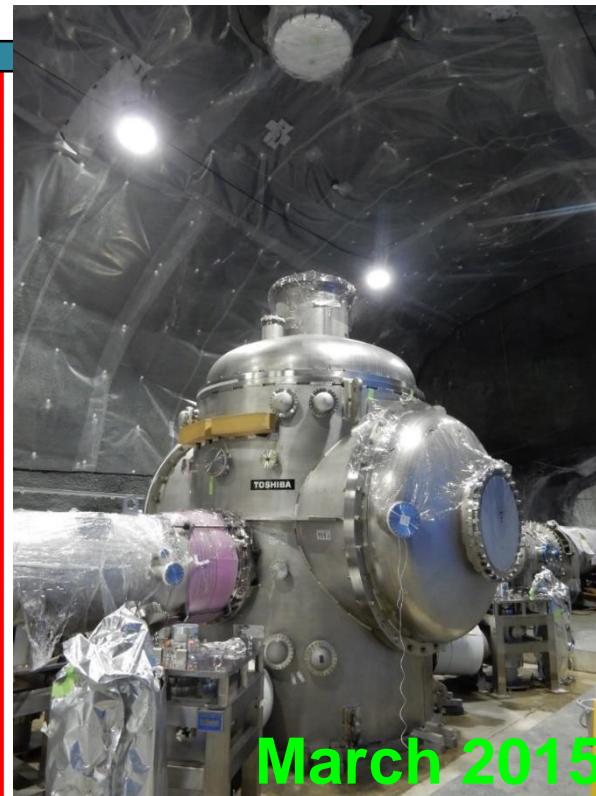
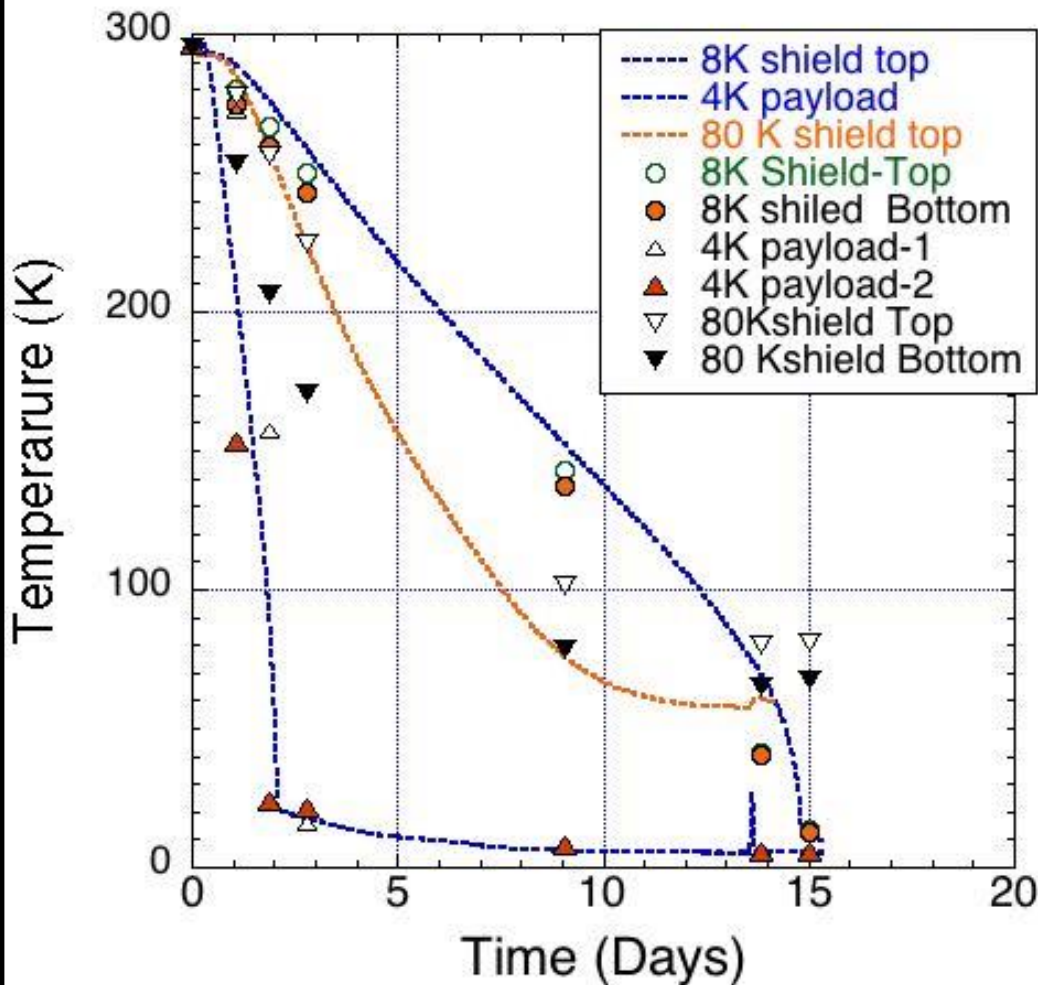
Phase 1 Configuration

- Michelson interferometer
- cryogenic sapphire ETMs
- by March 2018

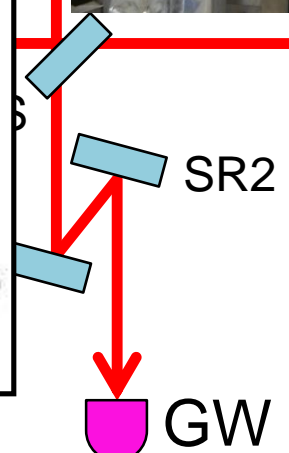
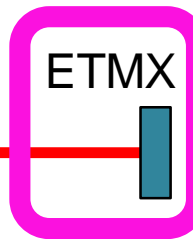


Cryostat Cooling Test

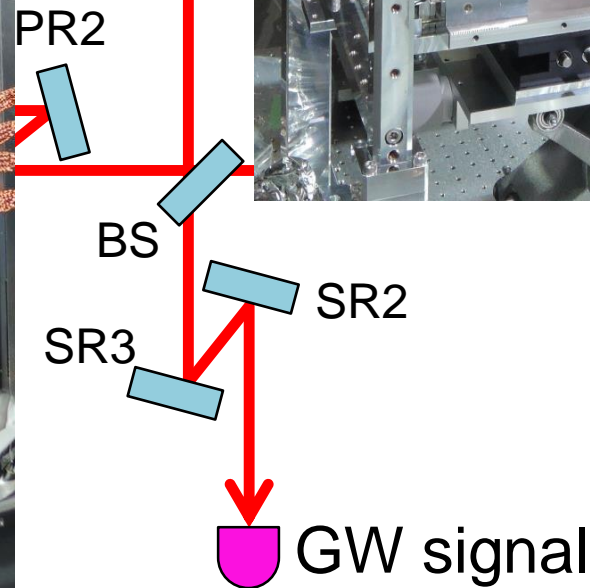
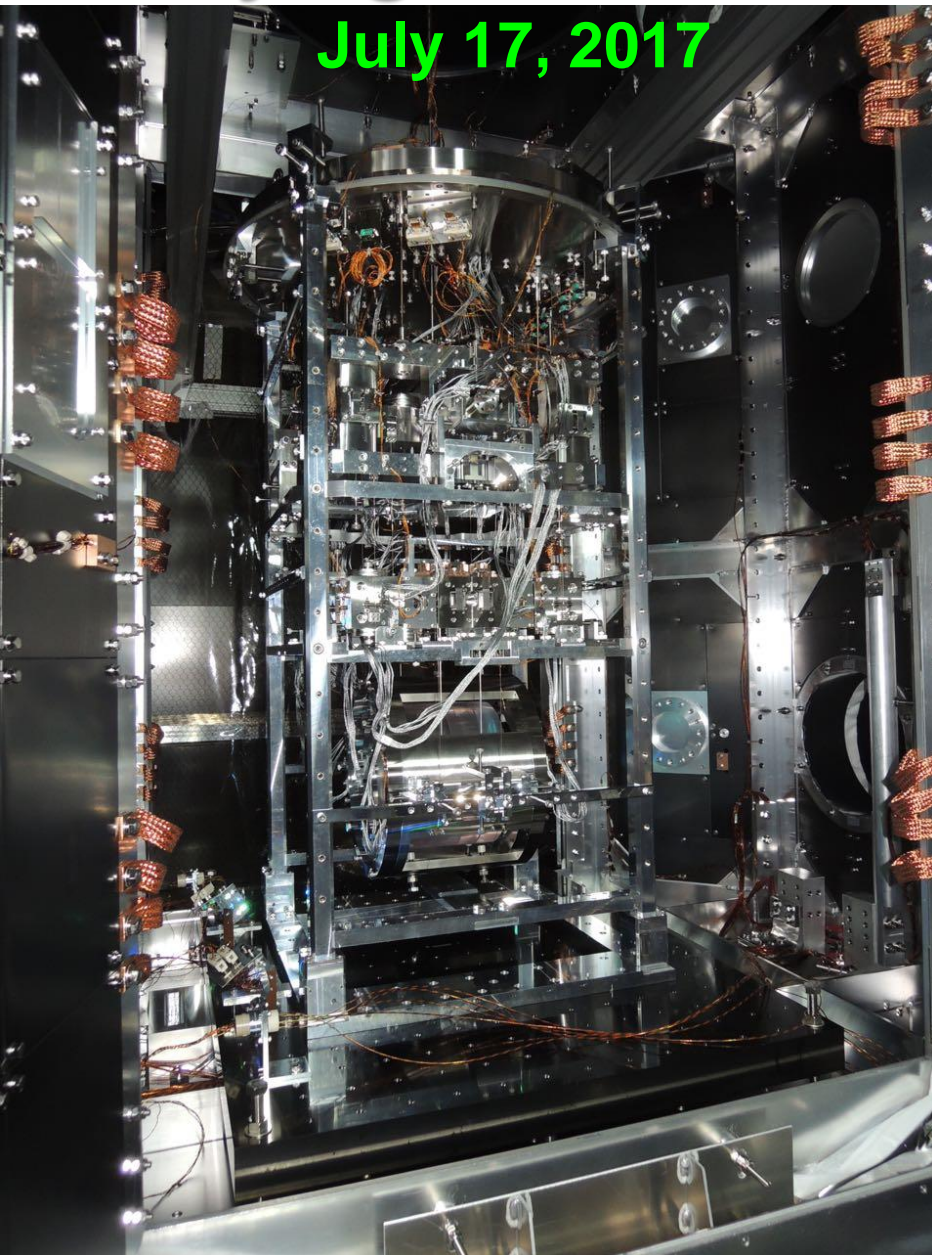
X-end Cryostat Cooling Curve
2017/2/21 13:38~



March 2015



Cryogenic Mirror Test Installation



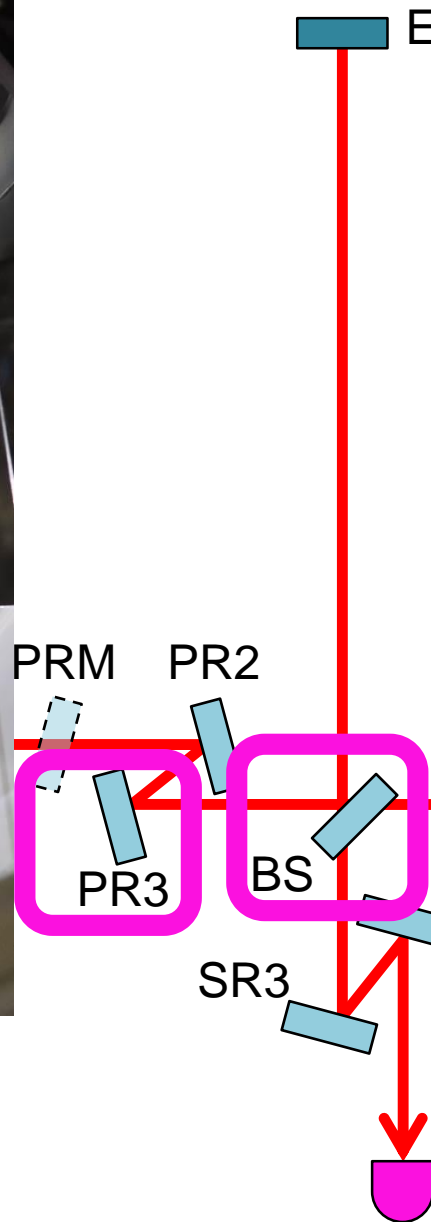
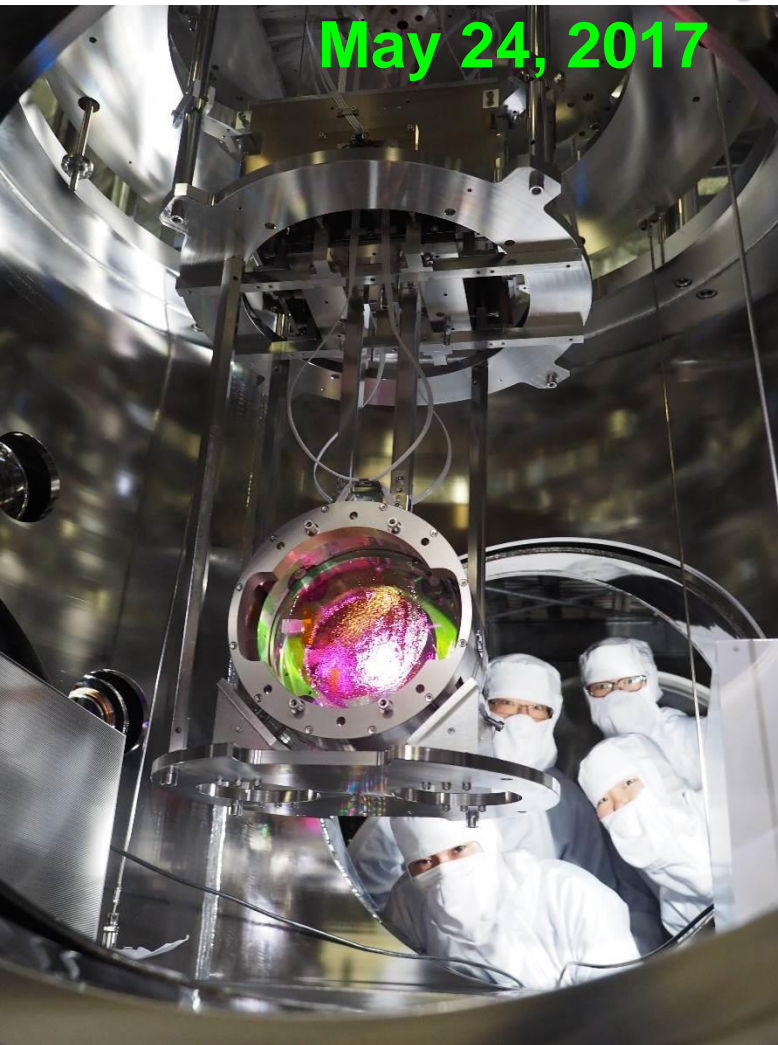
Cryogenic Mirror Vibration Isolation

ETMY

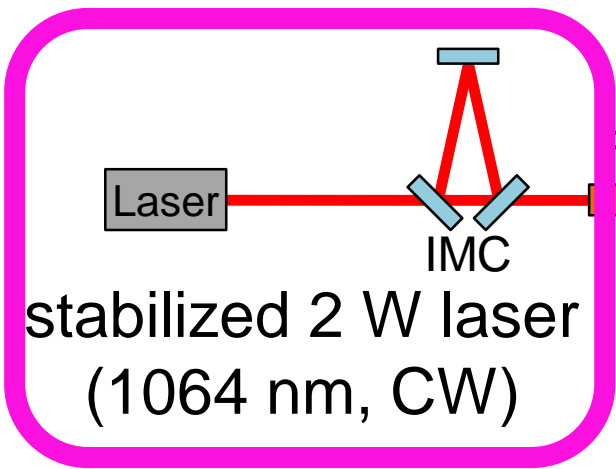
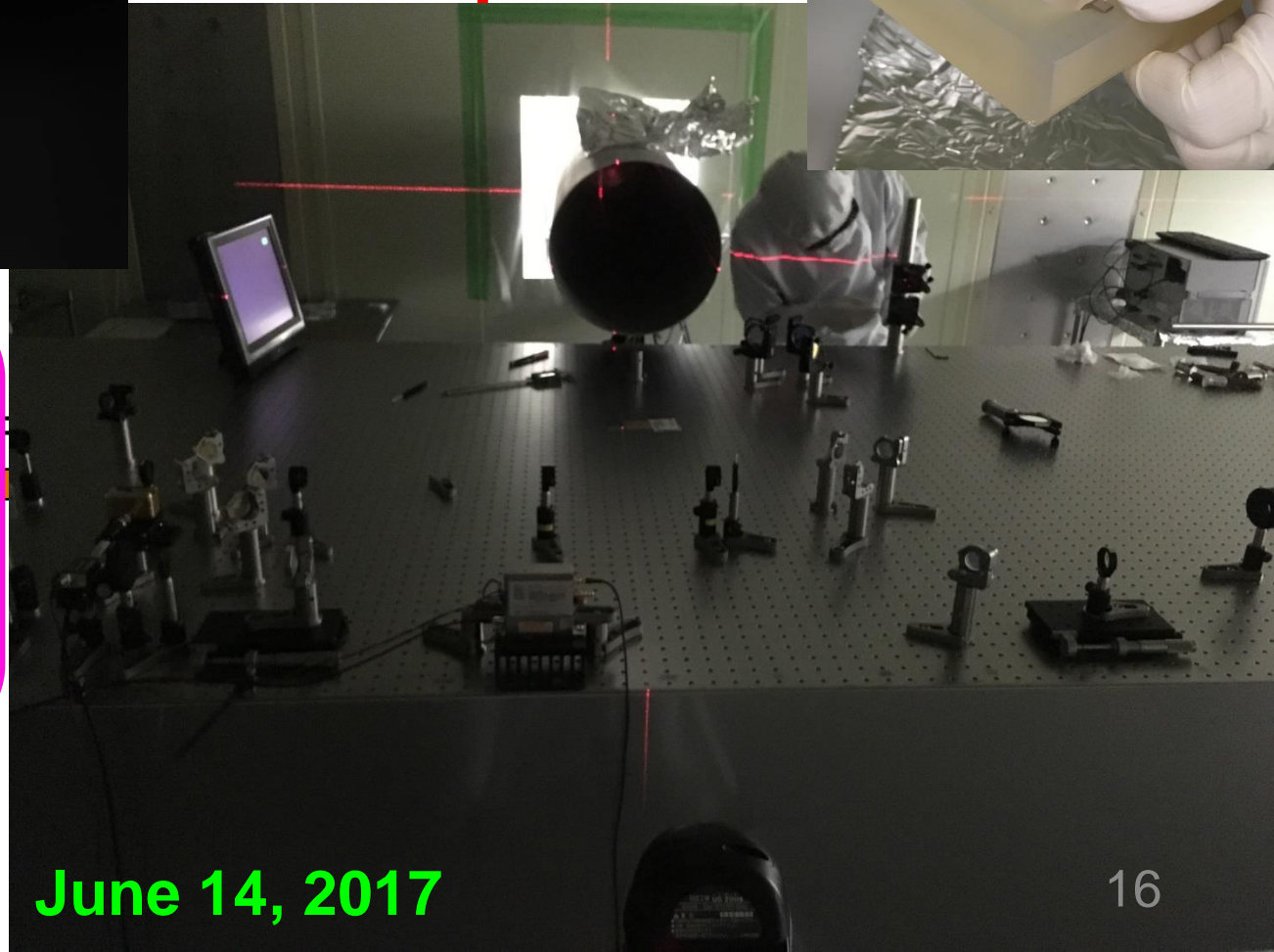
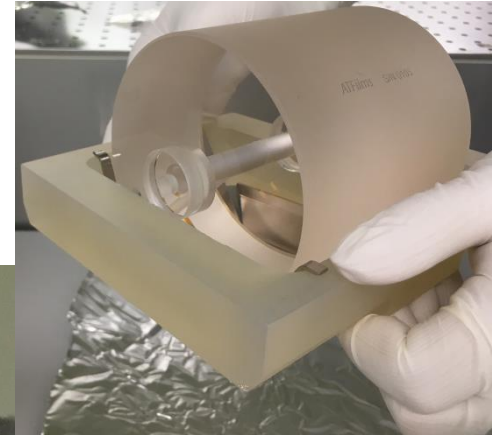
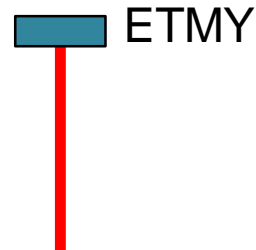
June 9, 2017



Room Temp. Mirror Installation



Pre-stabilized Laser Upgrade



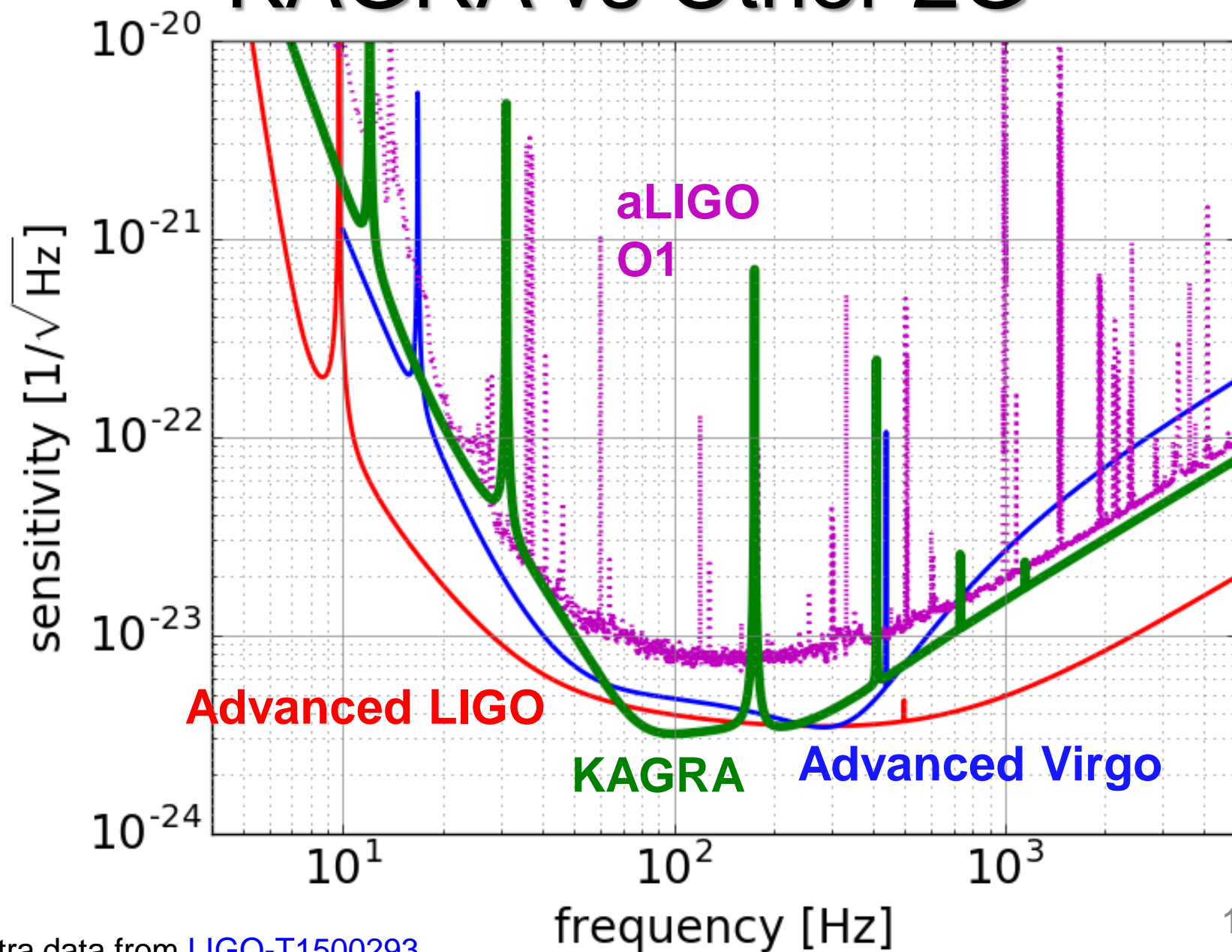
June 14, 2017

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



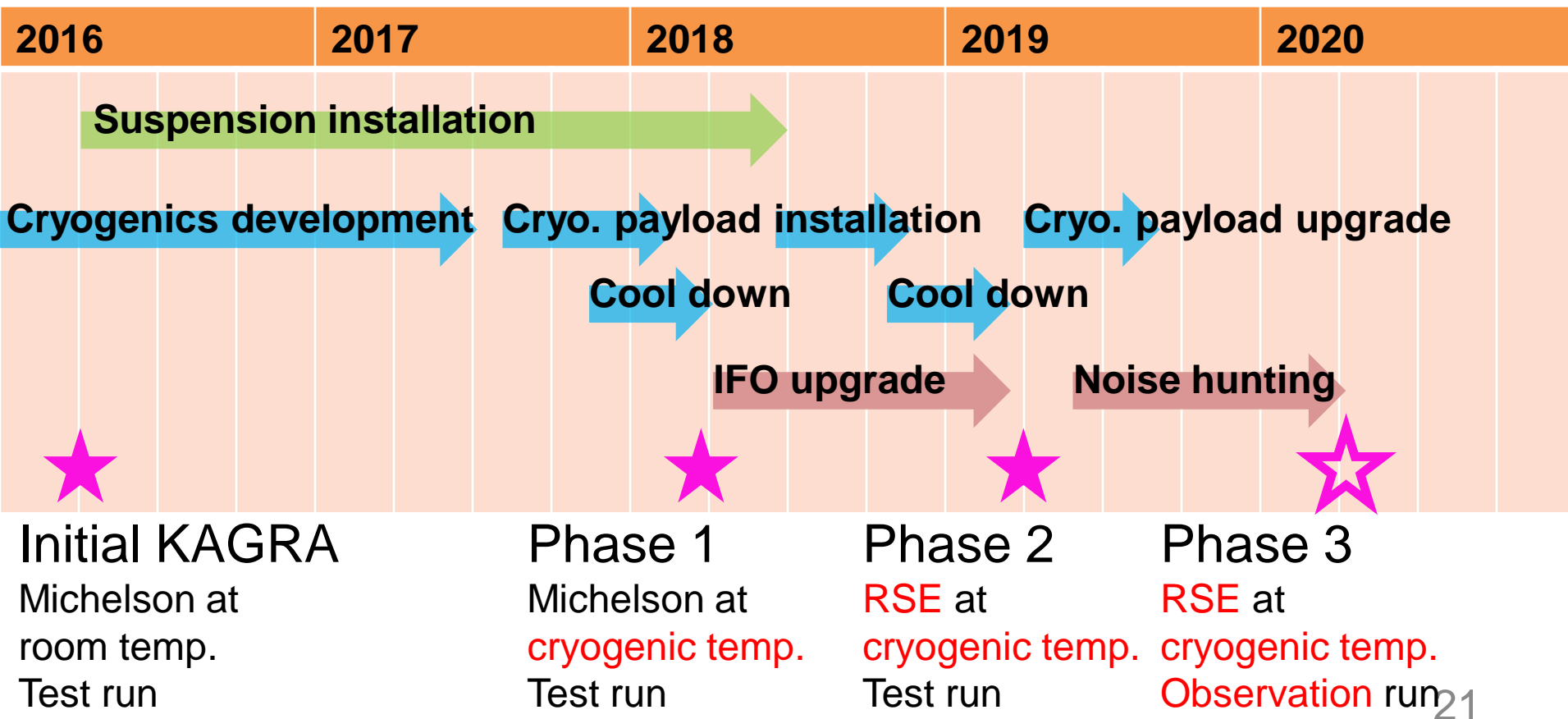
2G/2G+ Parameter Comparison

	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]	23	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]	280	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 \(2015\)](#)
 KAGEA parameters are v201609

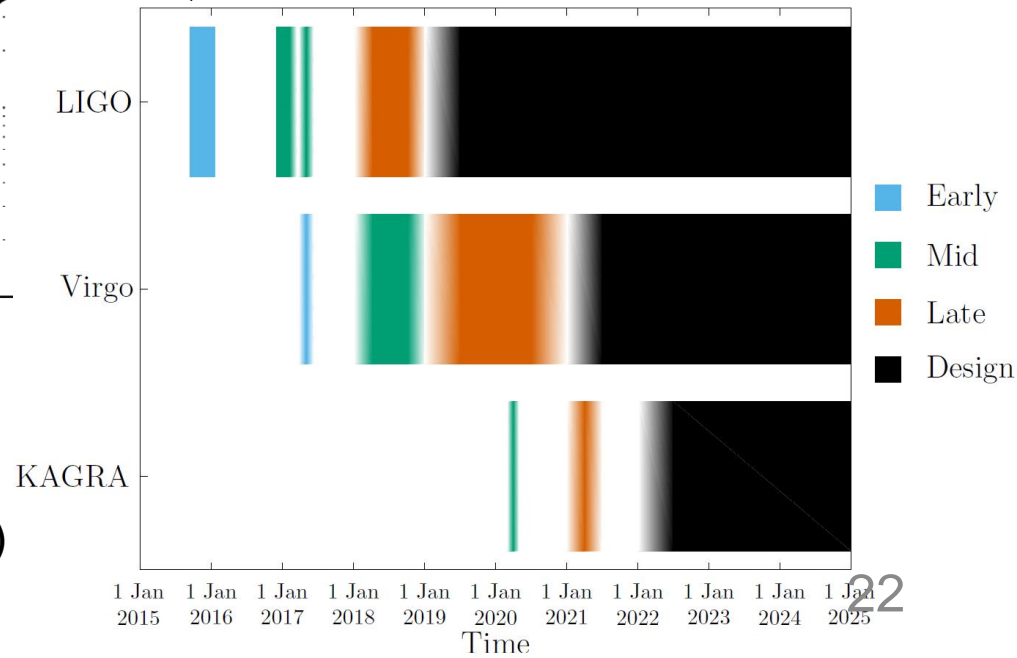
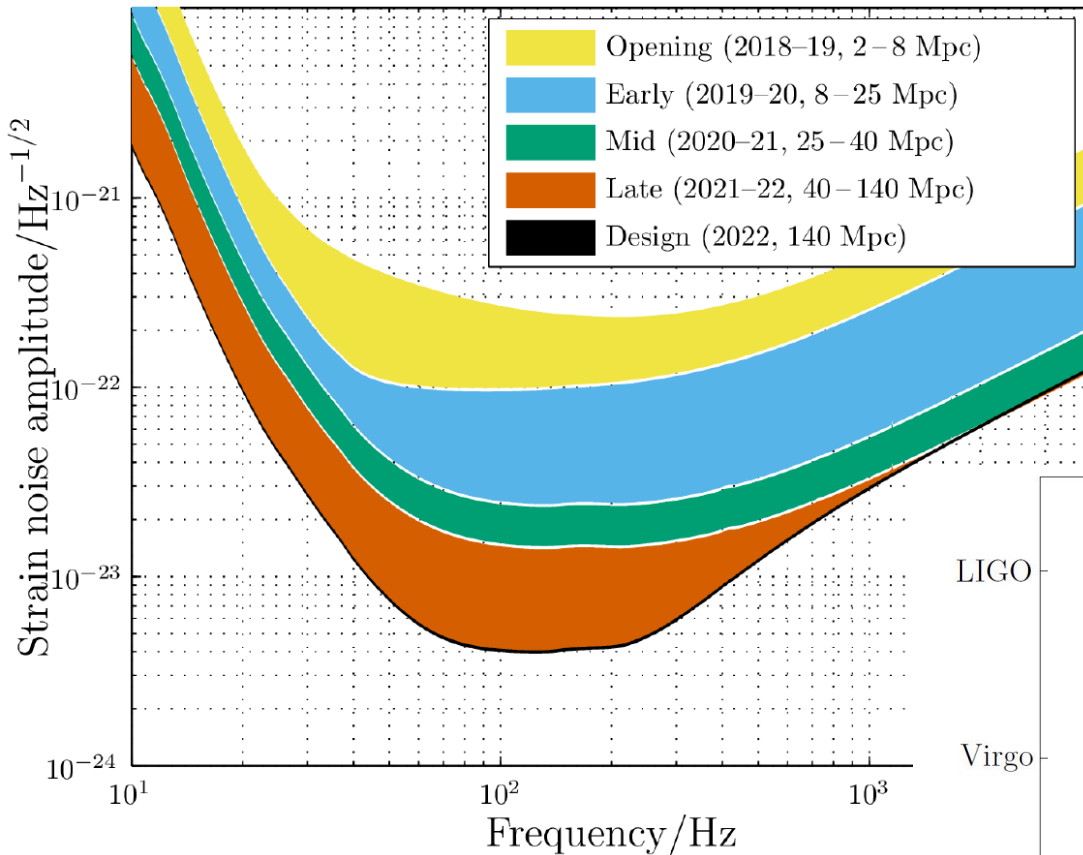
Roadmap of KAGRA

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



Observation Scenario

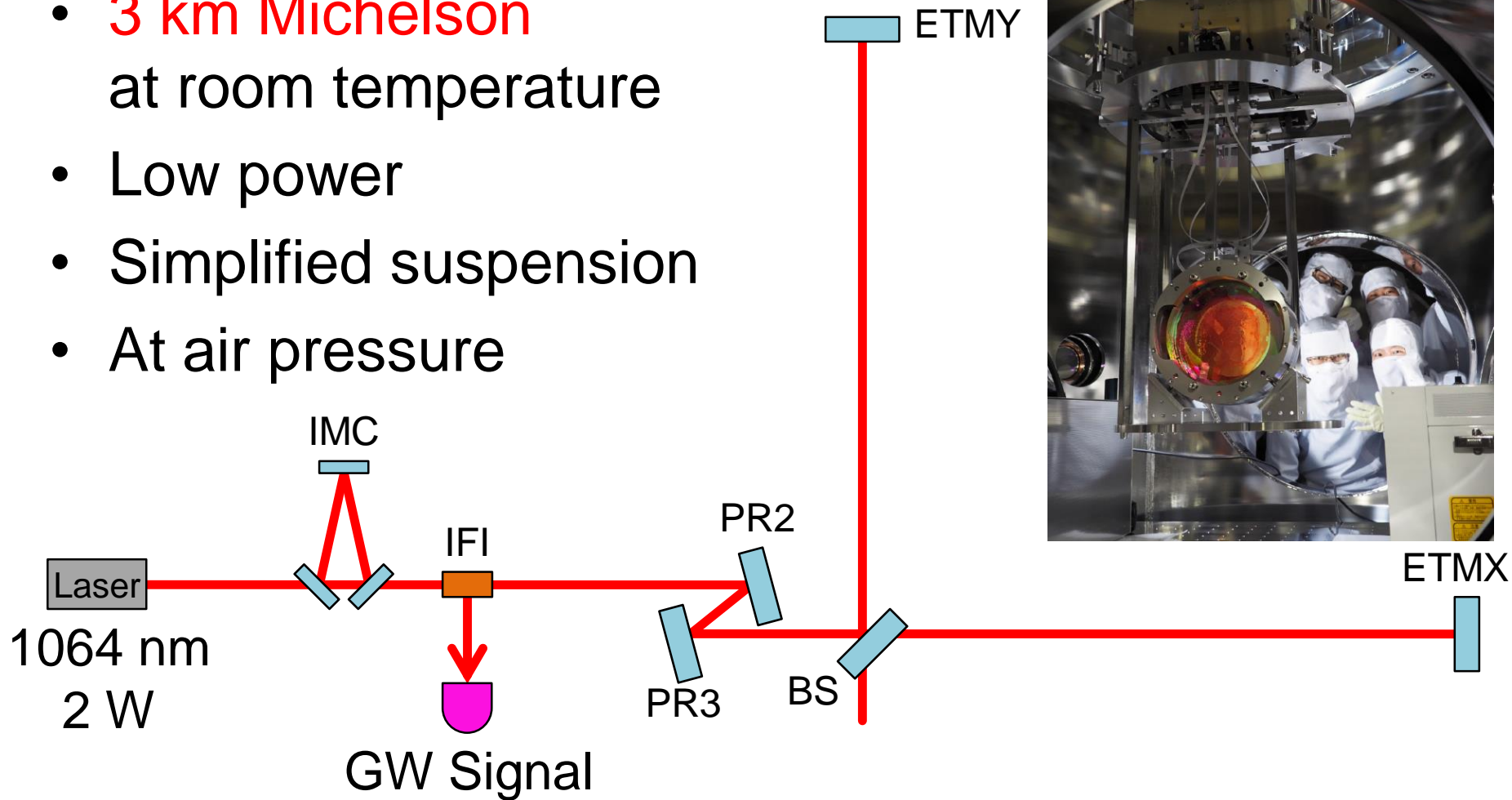
- With 25-40 Mpc in 2020, 40-140 Mpc in 2021



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



iKAGRA Sensitivity

- $\sim 3e-15$ /rtHz @ 100 Hz
- Limited by **seismic noise**, **acoustic noise** and **ADC noise**
- Reduction possible in bKAGRA

