Status of KAGRA and its science goals

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Outline

- *Introduction*
- *Overview of KAGRA*
- *Status of KAGRA*
- *Plan of KAGRA*
- *Science Goals*
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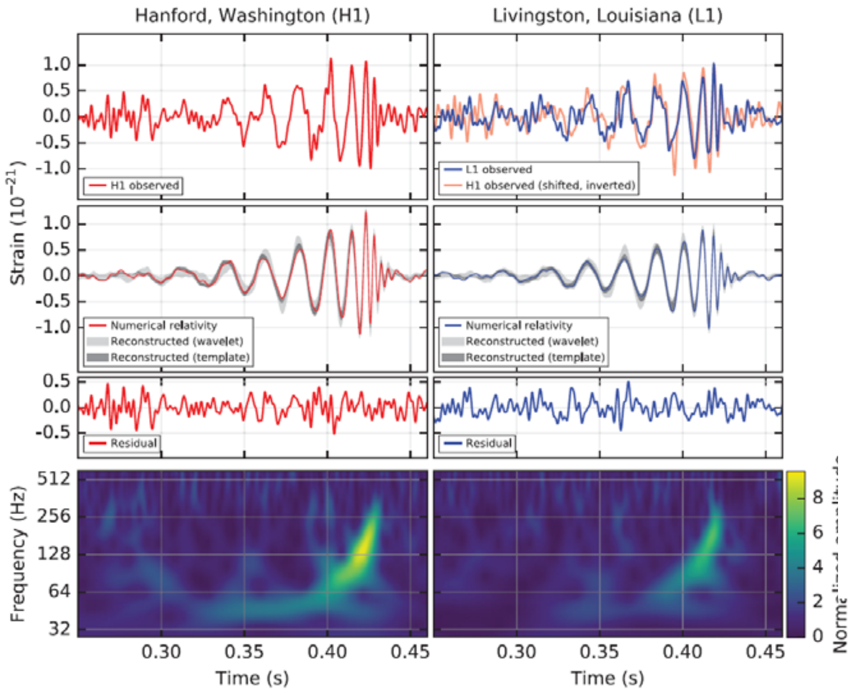
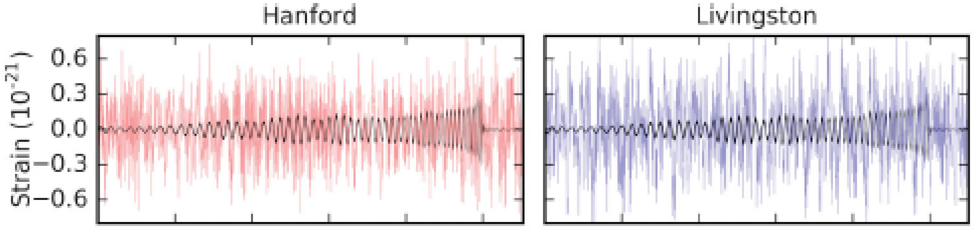
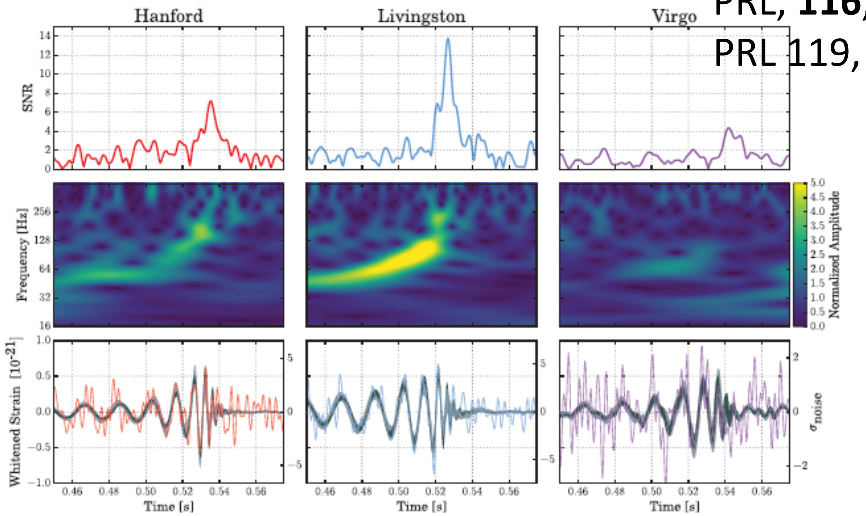
Introduction

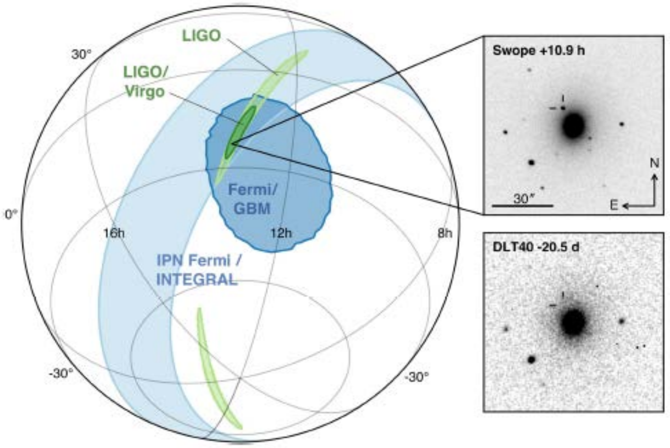
Introduction

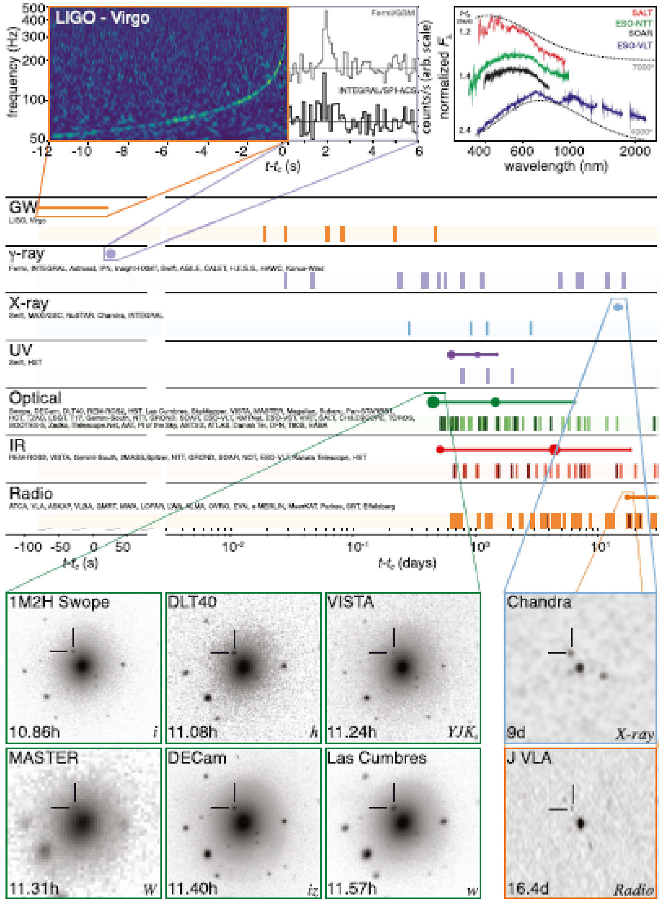






LIGO Scientific Collaboration and Virgo Collaboration, PRL, **116**, 061102 (2016), PRL, 116, 241103 (2016), PRL 119, 141101 (2017) ApJL, 848 L12 (2017), ….



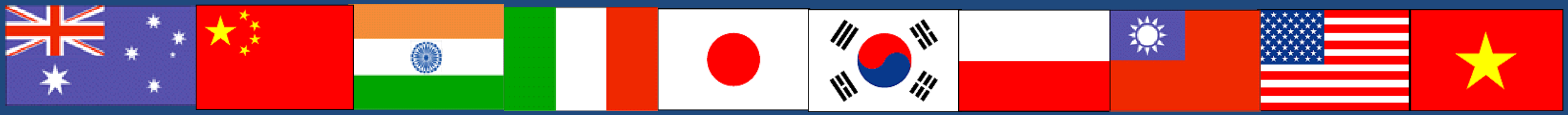


Congratulations to LIGO and Virgo!

Now it is clear that we can do many important science with GW, if we do it right.

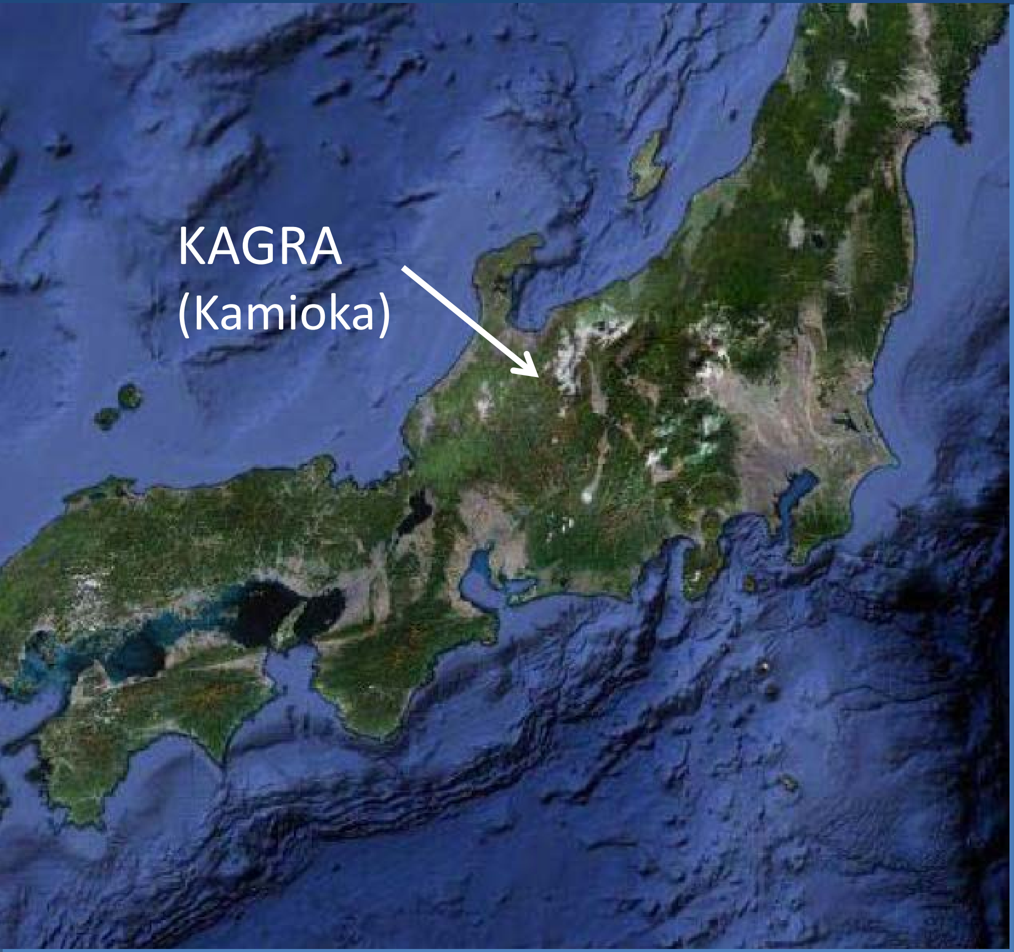
Overview of KAGRA

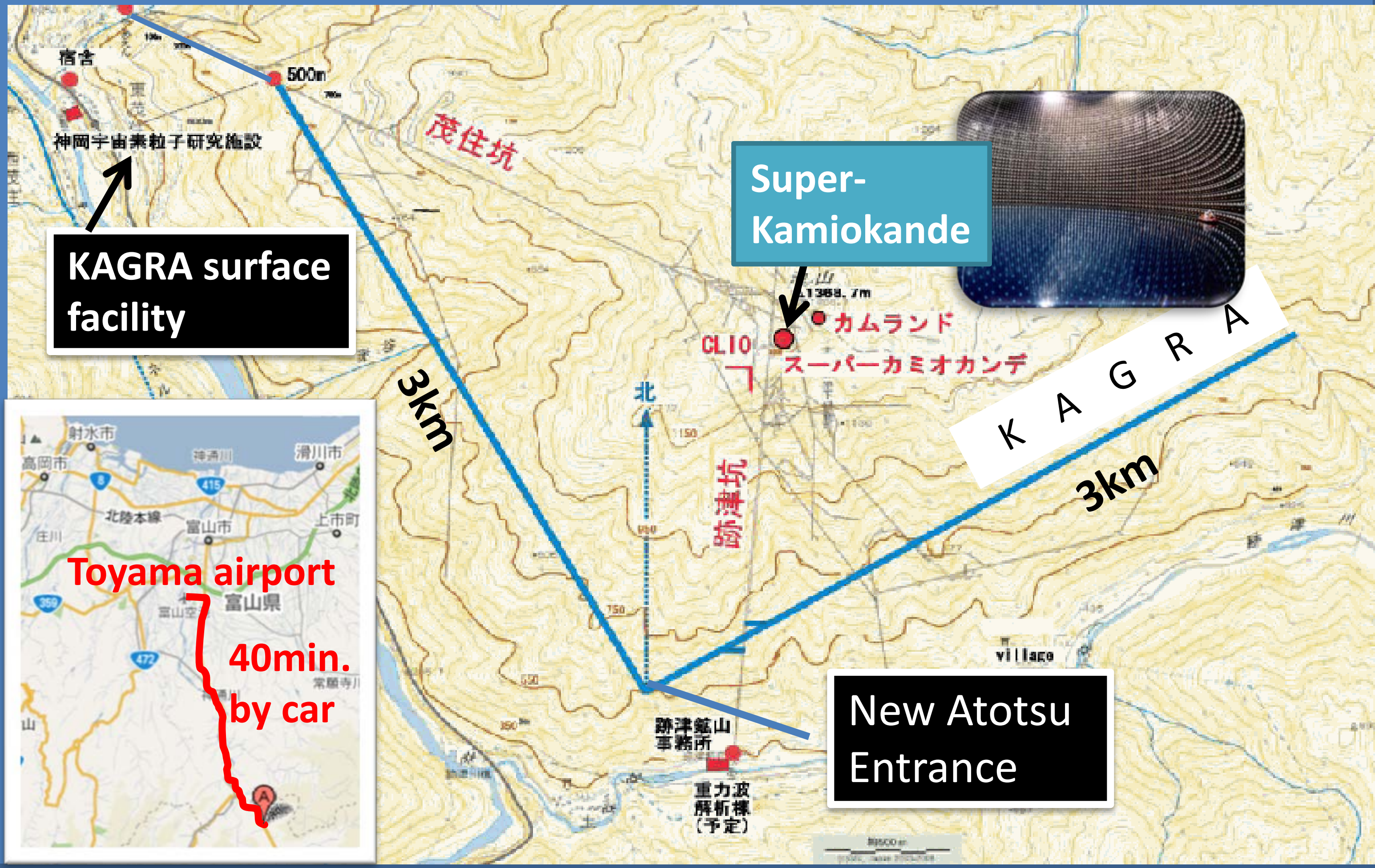
KAGRA collaboration



10 countries, >200 members

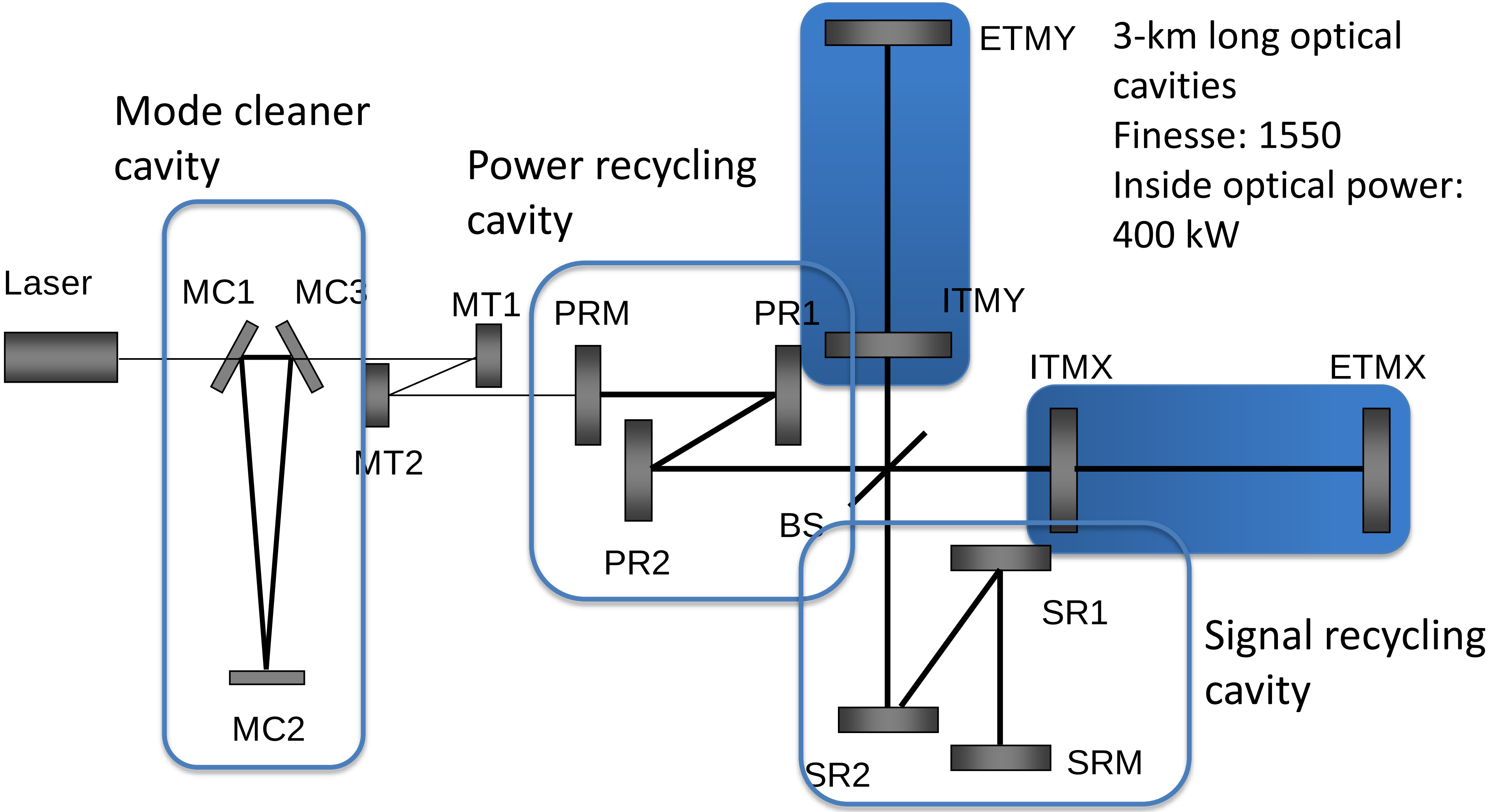
Location


KAGRA
(Kamioka)


KAGRA surface facility
神岡宇宙素粒子研究施設
500m
茂住坑
3km
Super-Kamiokande
カムランド
スーパーカミオカンデ
CLIO
北
跡津坑
K A G R A
3km
New Atotsu Entrance
village
Toyama airport
富山県
40min.
by car

Schematic view of KAGRA optical system

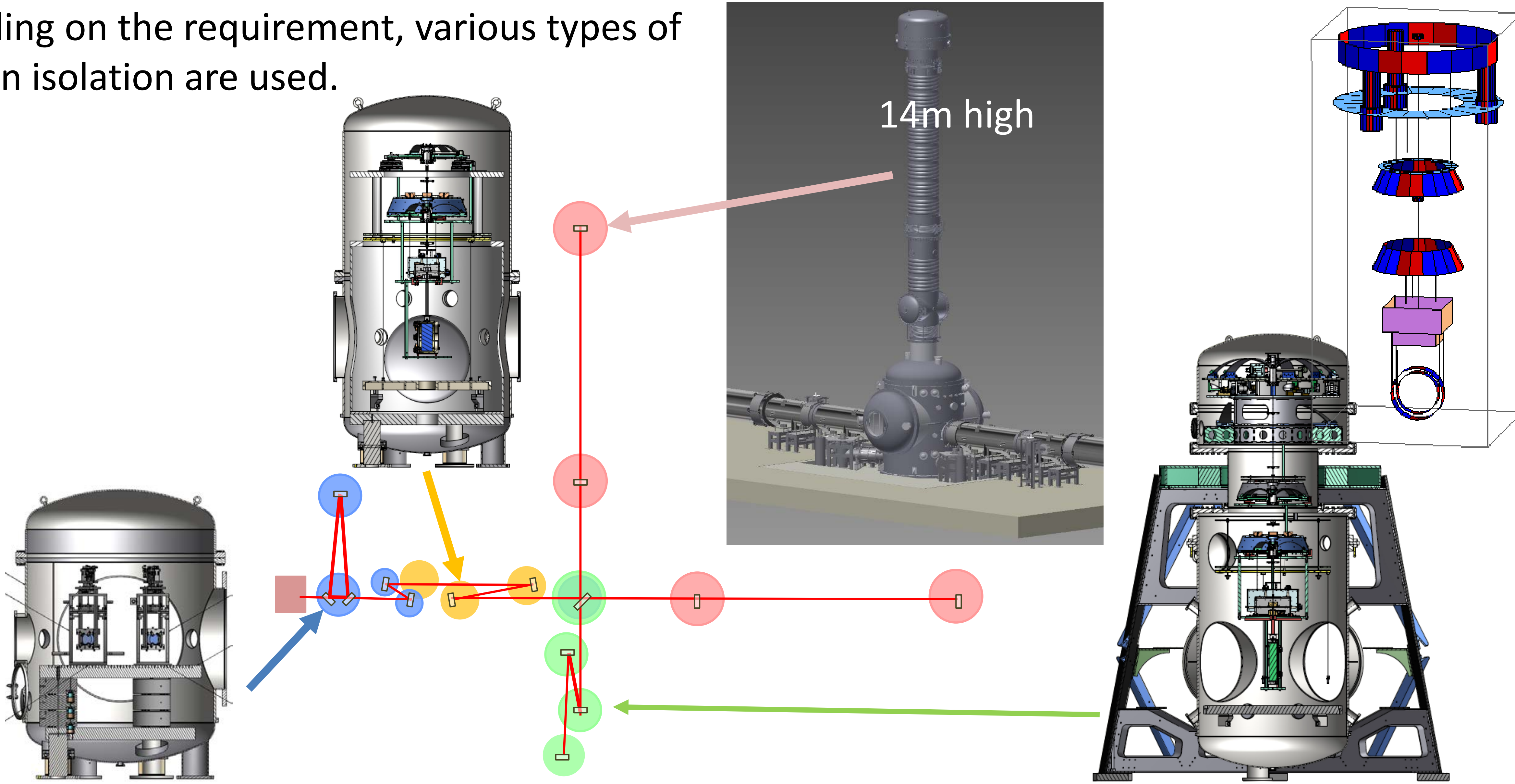
- *KAGRA is a huge Michelson interferometer that has optical cavities in the arms and recycling systems. (Very similar to LIGO and Virgo.)*



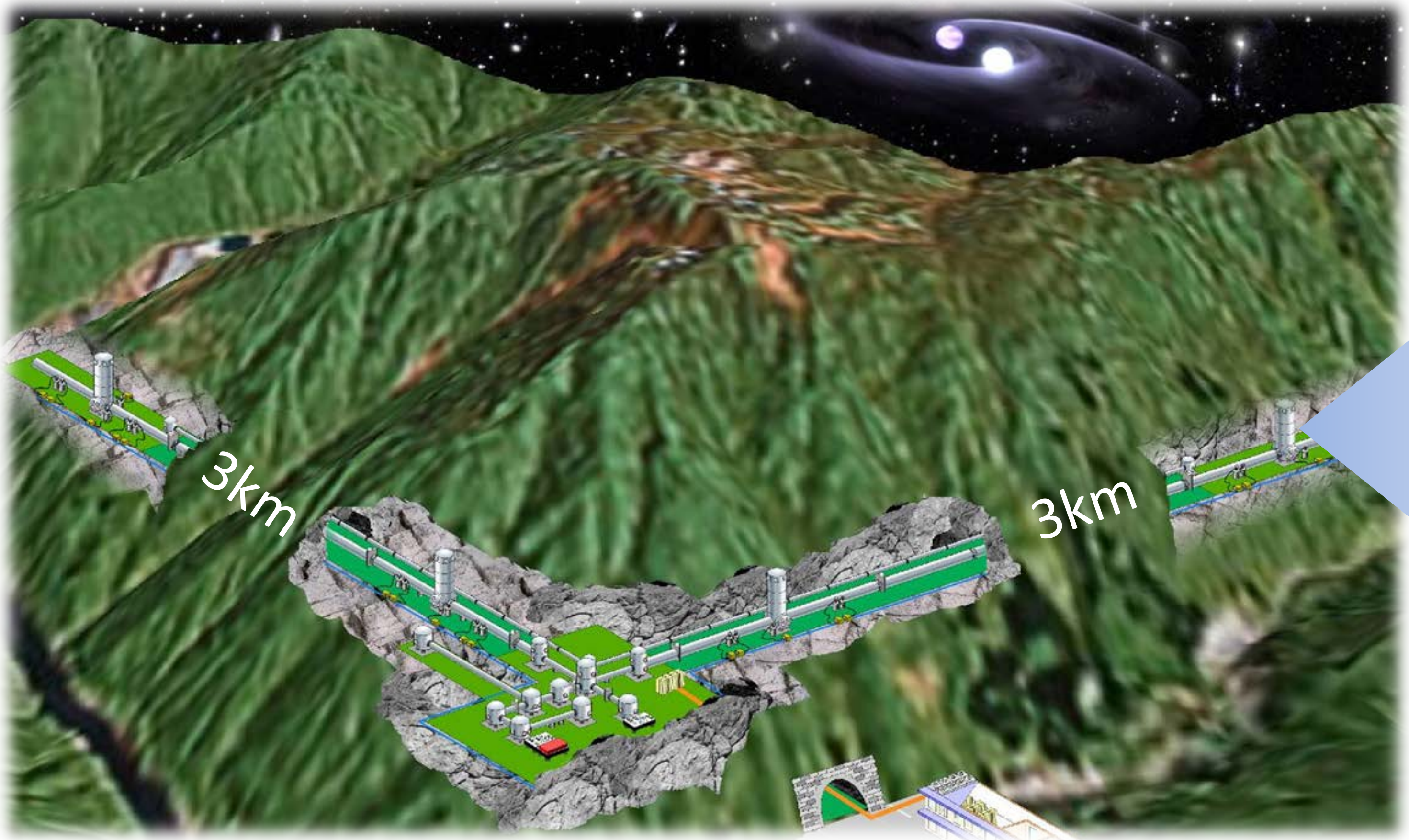
3-km long optical cavities
Finesse: 1550
Inside optical power: 400 kW

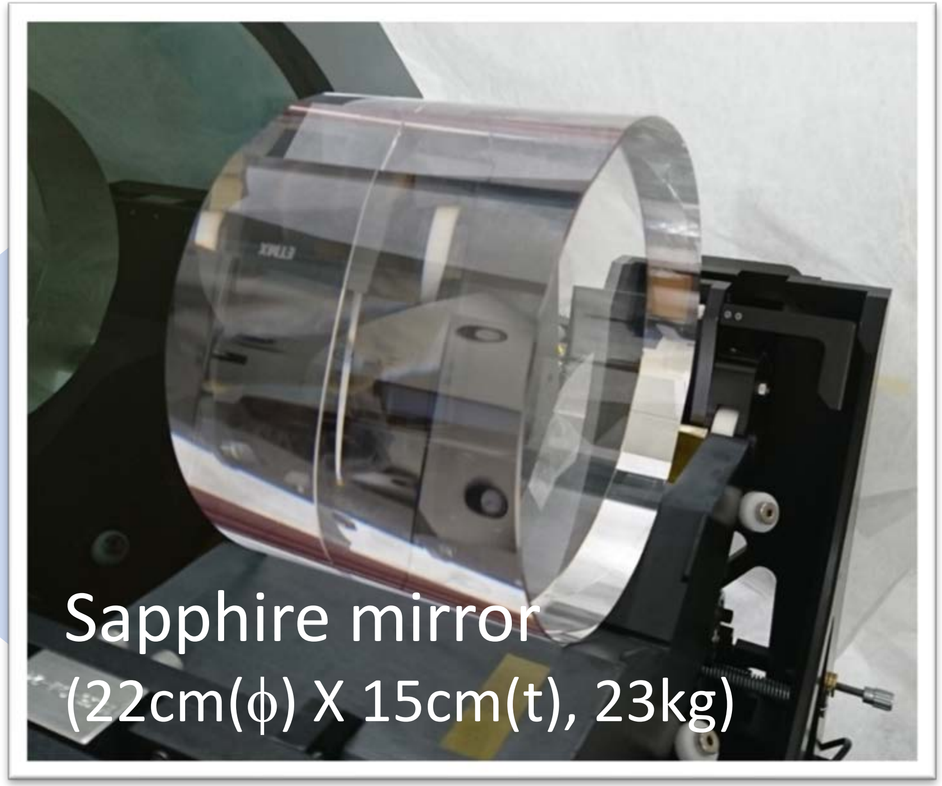
Vibration isolation system

Depending on the requirement, various types of vibration isolation are used.



Key features of KAGRA





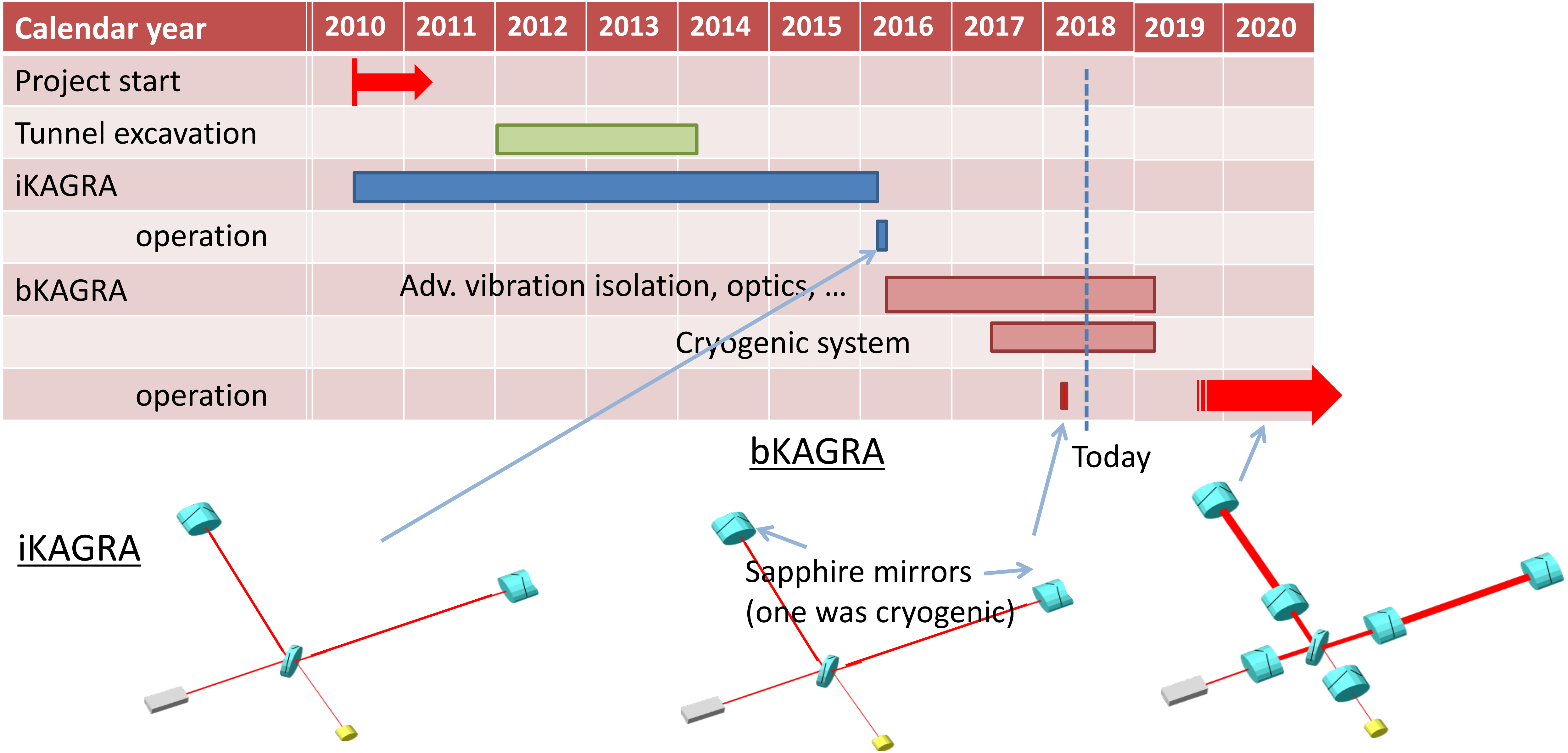
The detector is constructed underground Kamioka.
➔ Reduction of seismic noise (to approximately 1/100).

Cryogenic mirrors to reduce the thermal noise.

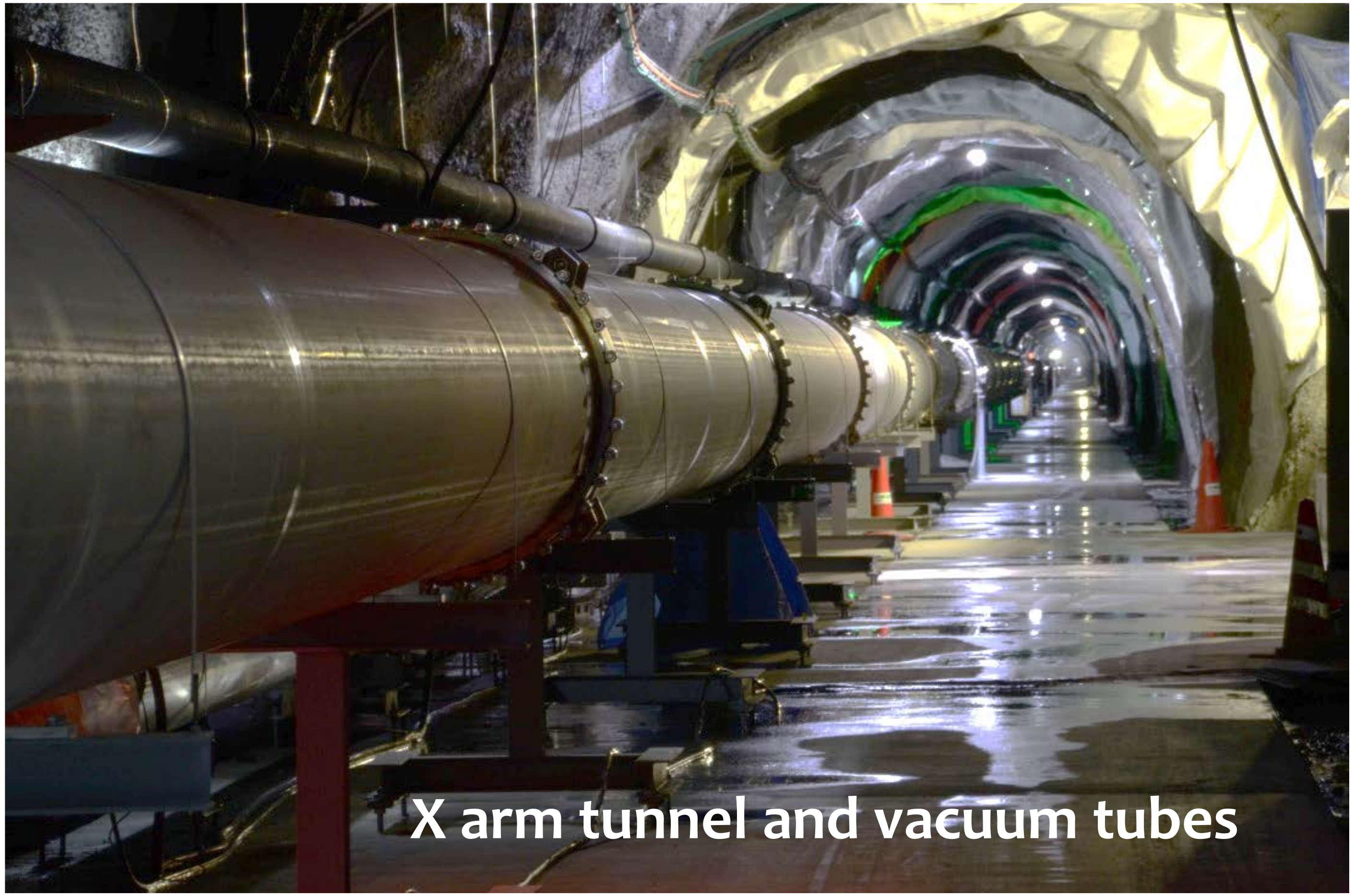
➔ Very high sensitivity.

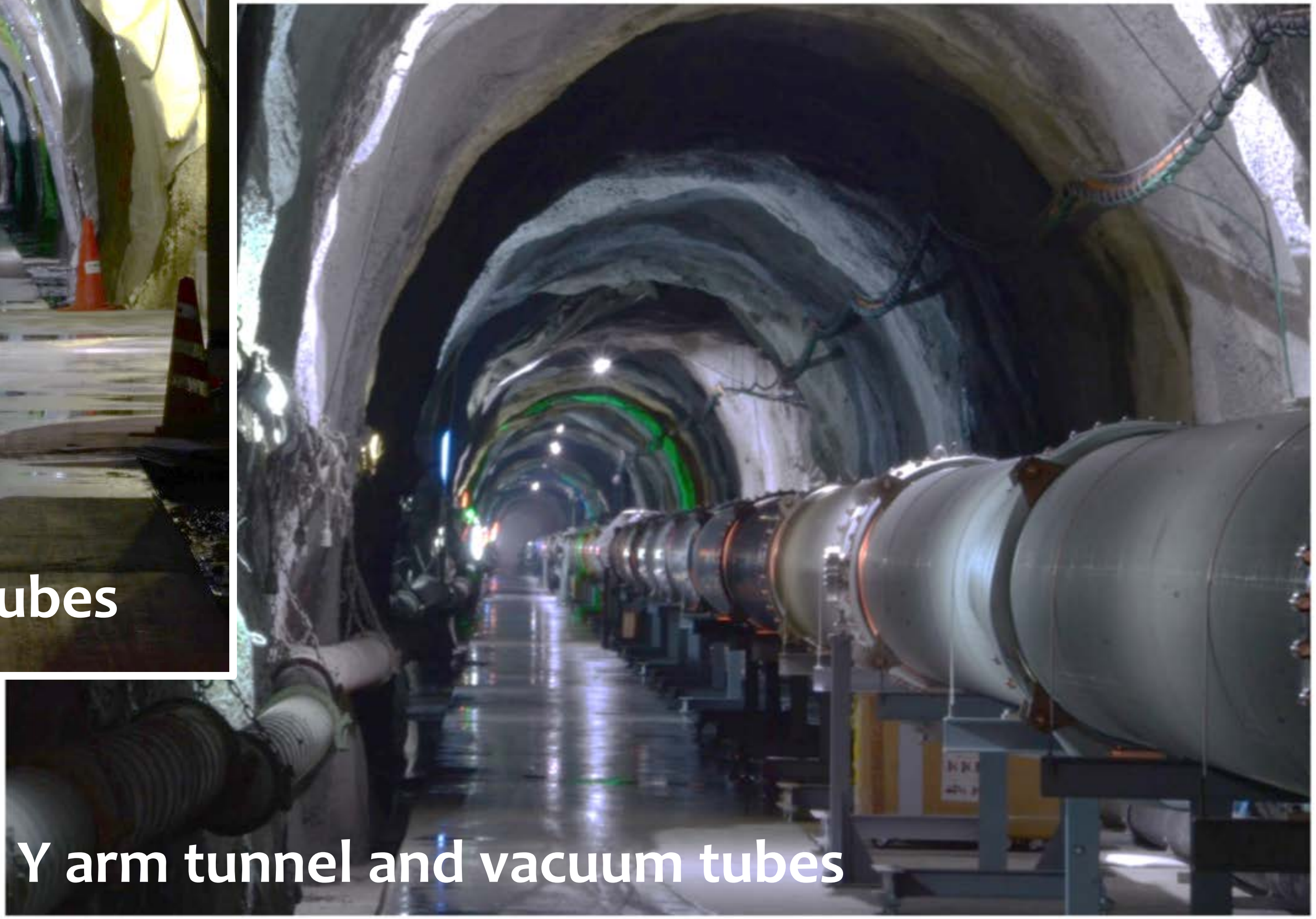
Status of KAGRA

Time line (Construction and Operation)



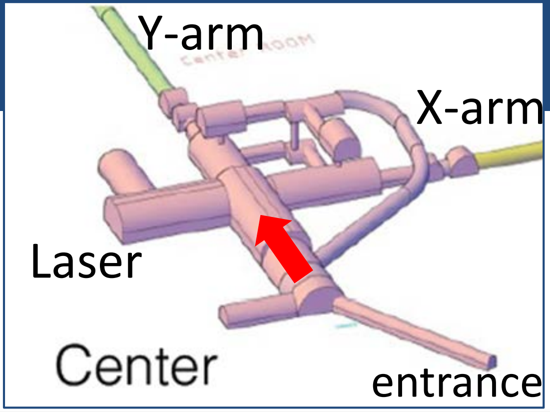
3km x 3km arms





- ✓ Connection and the leak tests of 3km X 3km beam tubes have been finished in March 2015.

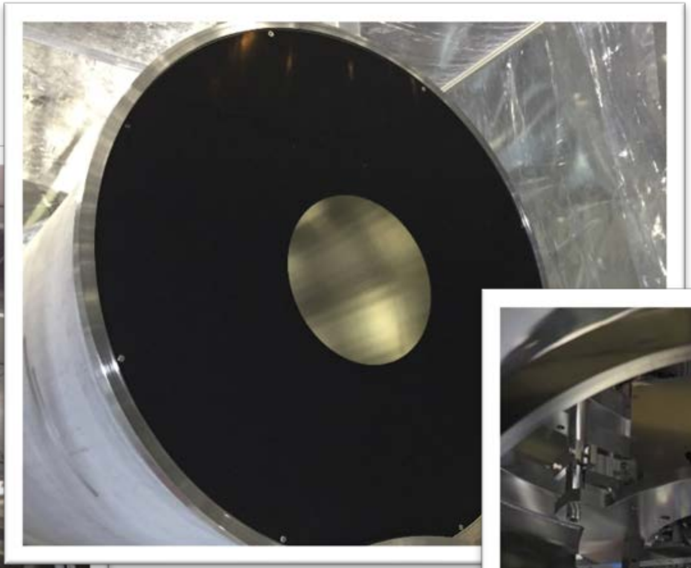
Center area



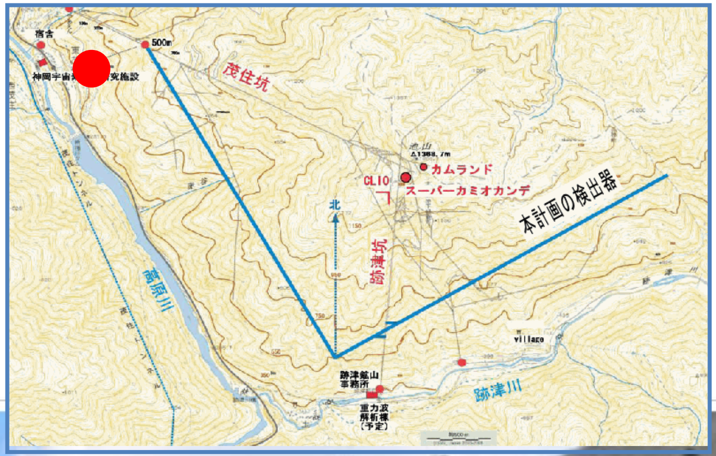
Fall 2015

Spring 2017 (essentially everything is covered by clean booths)

Construction work going on

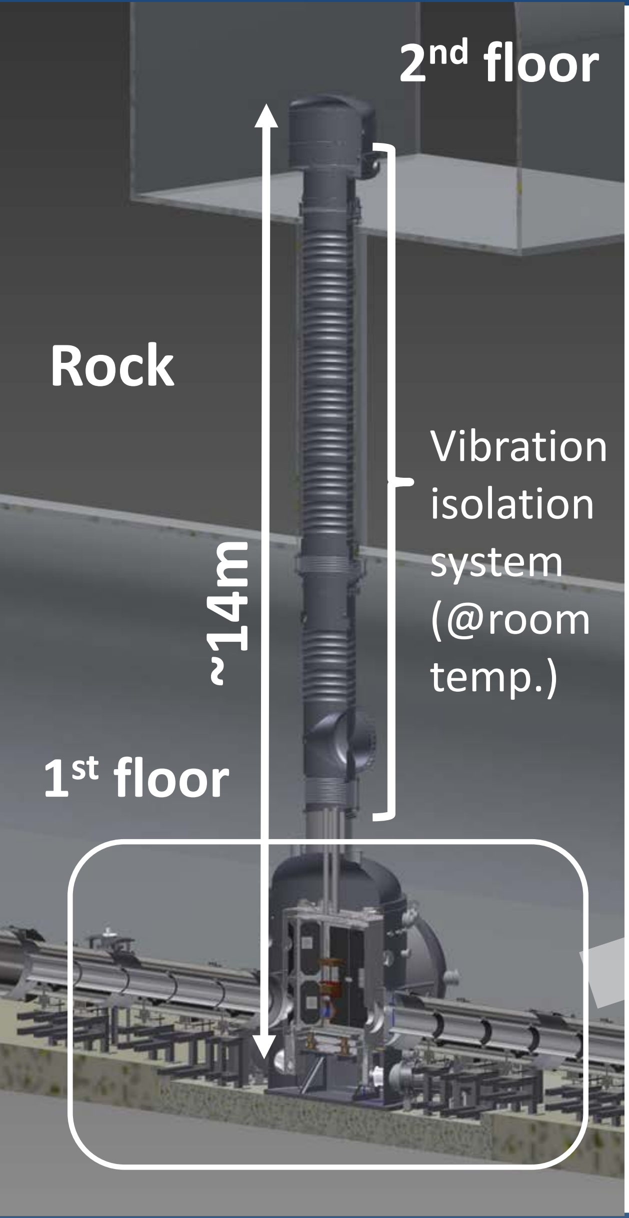


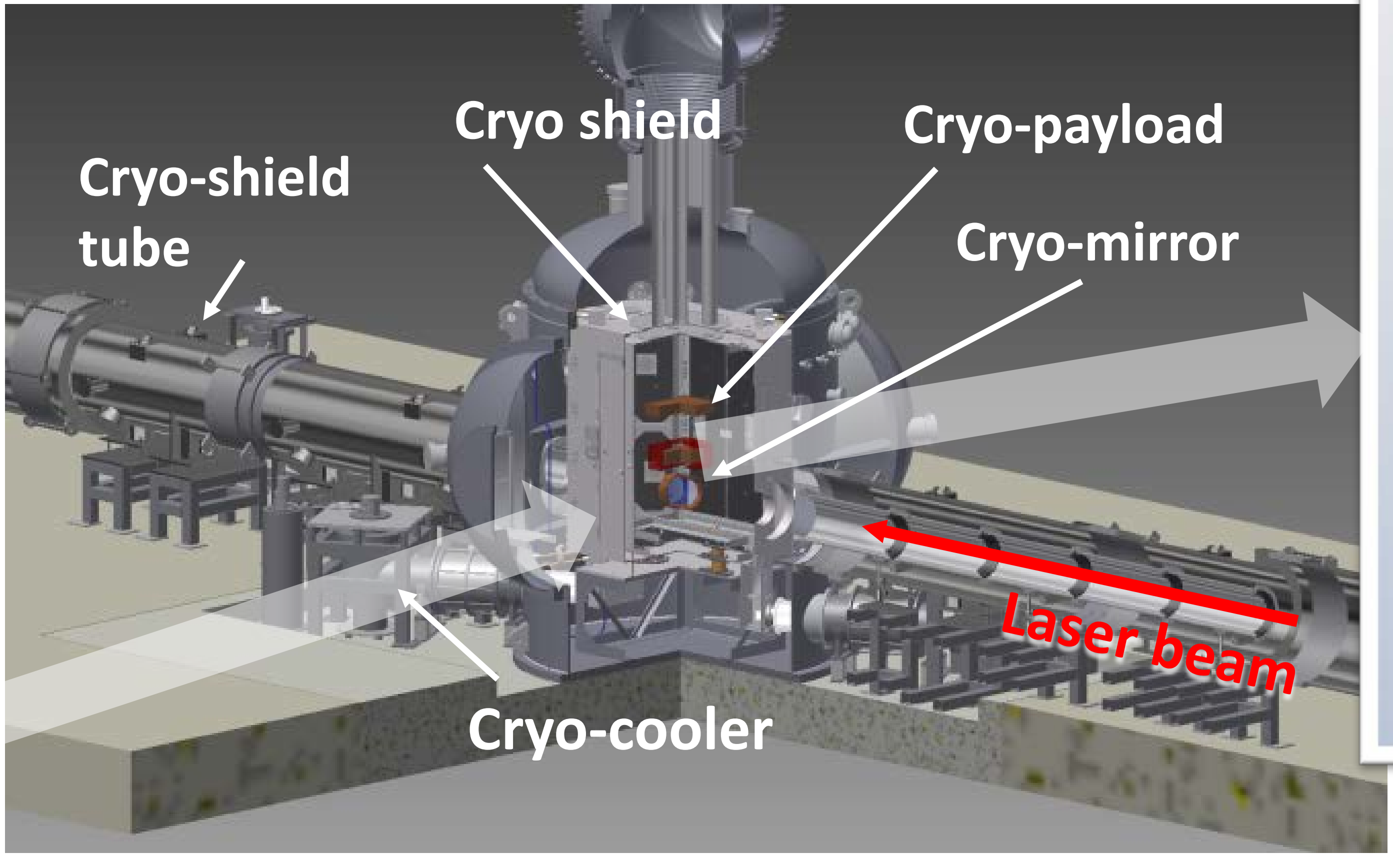
Office building



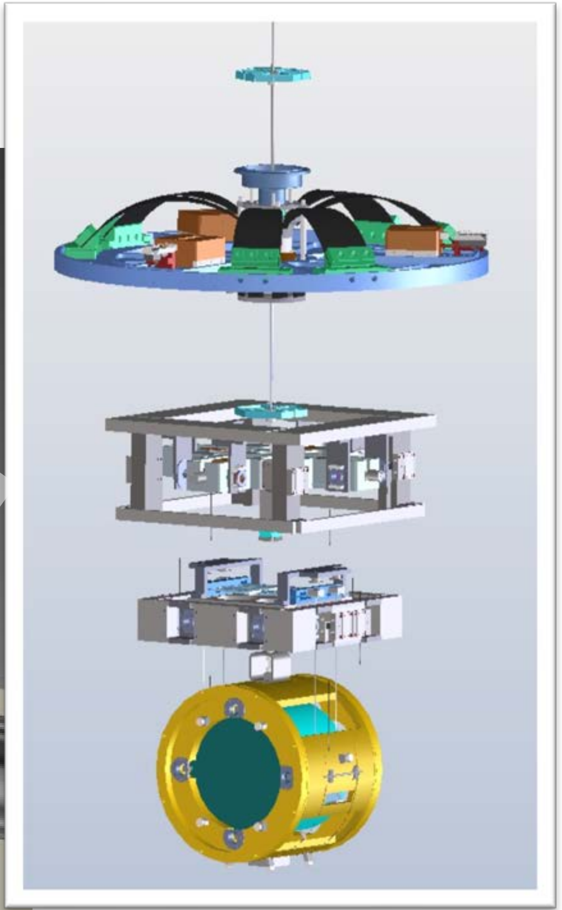
KAGRA control room
in the office building

Cryogenic mirrors and cryostat

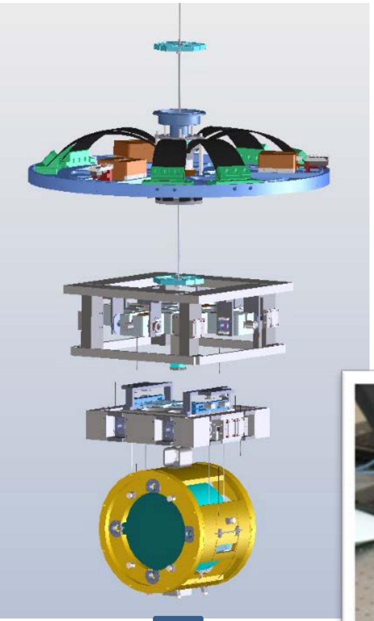


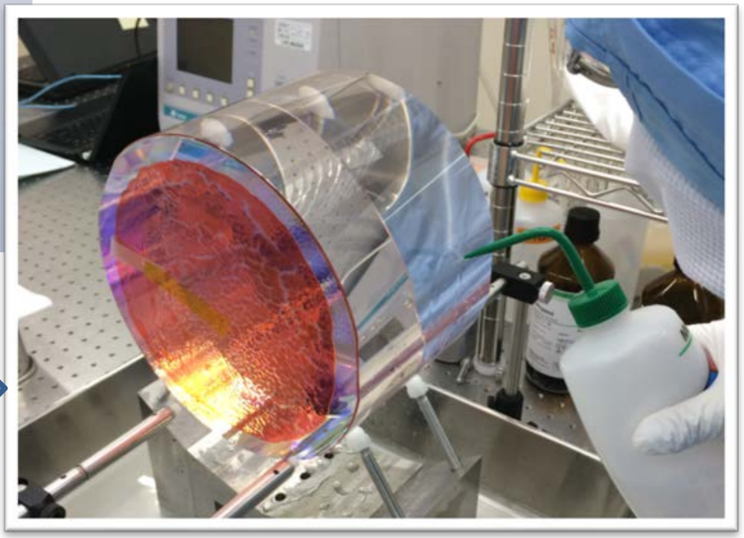


Cryo-payload and mirror

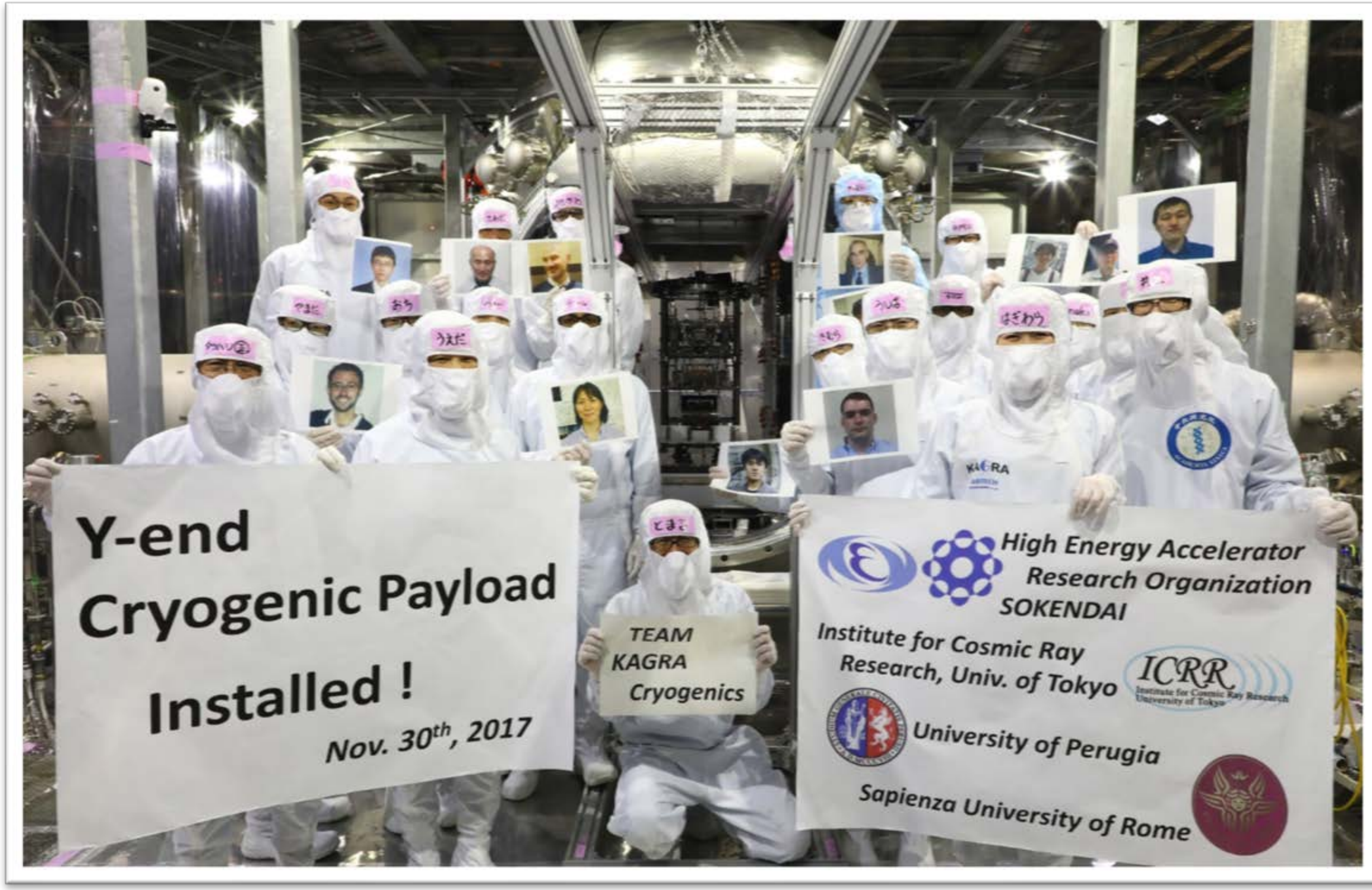


Cryo-payload and Sapphire mirror installation





Preparation of cryogenic mirror at the Toyama University.
（22cm (diameter), 15cm (thick), 23kg）
➔ To the KAGRA site

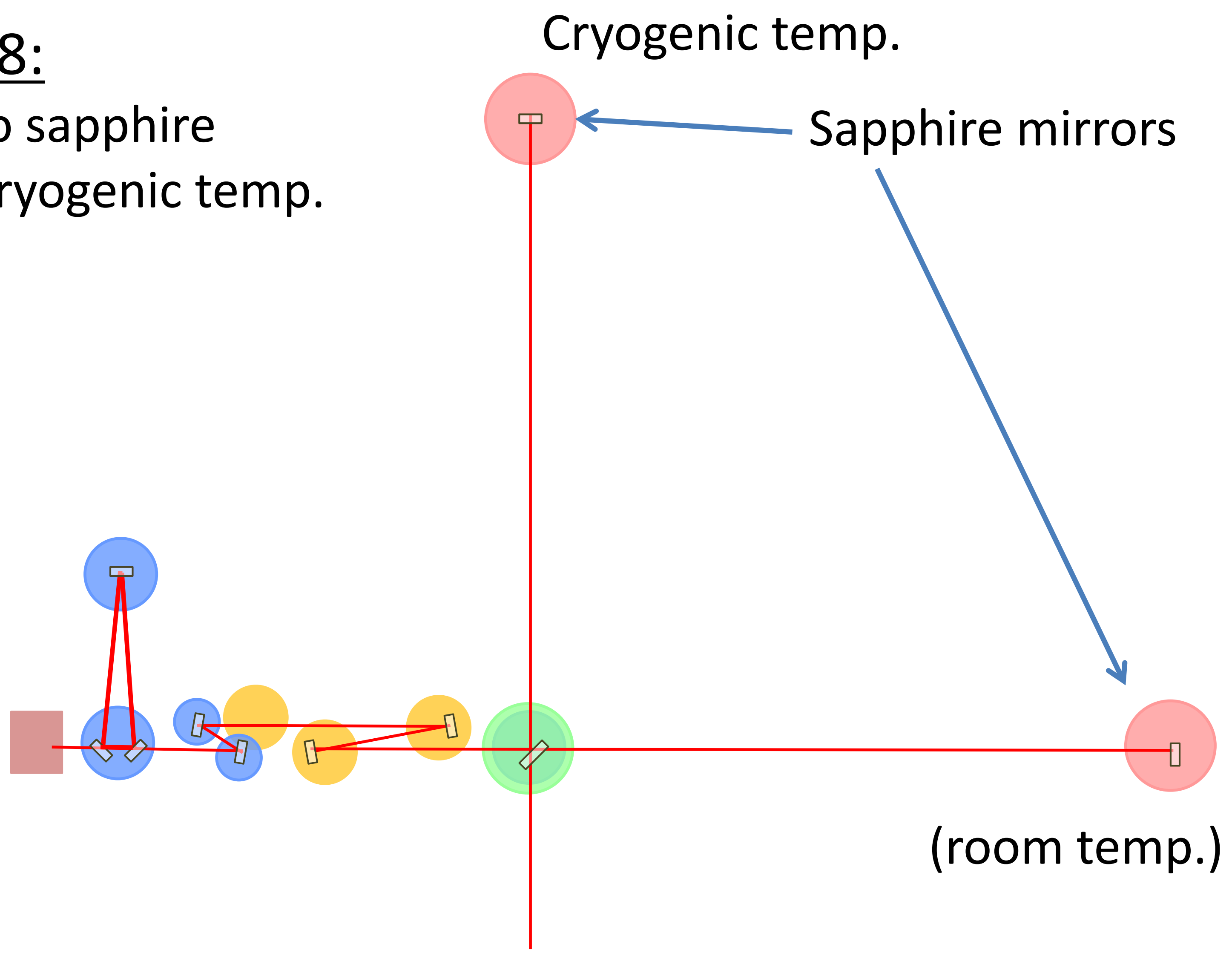


Installation of the first cryogenic mirror（Nov.30, 2017）

Operation of interferometer with a cryogenic mirror

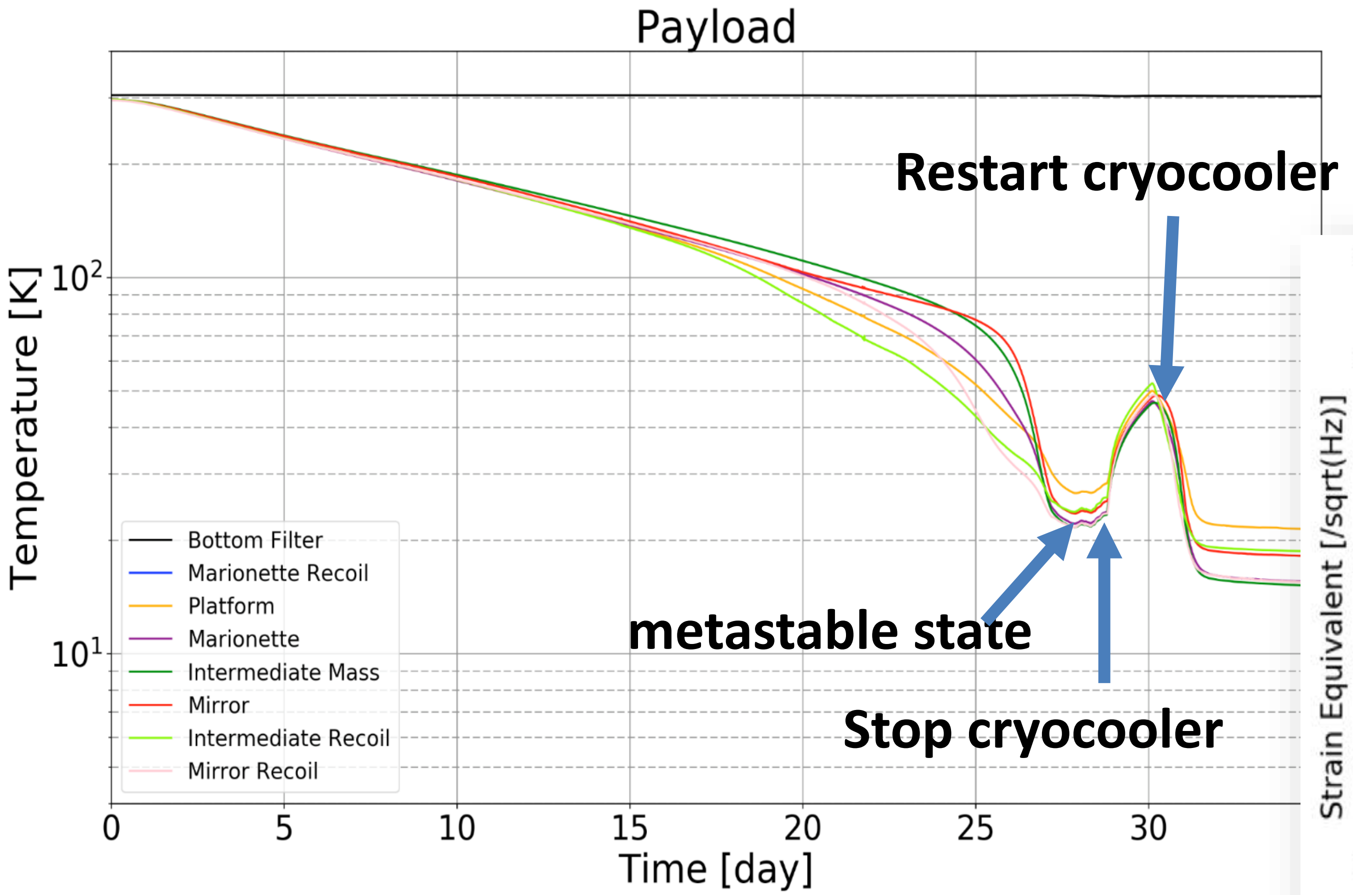
<u>End of April to early May, 2018:</u>

Michelson Interferometer with two sapphire mirrors with one cooled down to cryogenic temp.

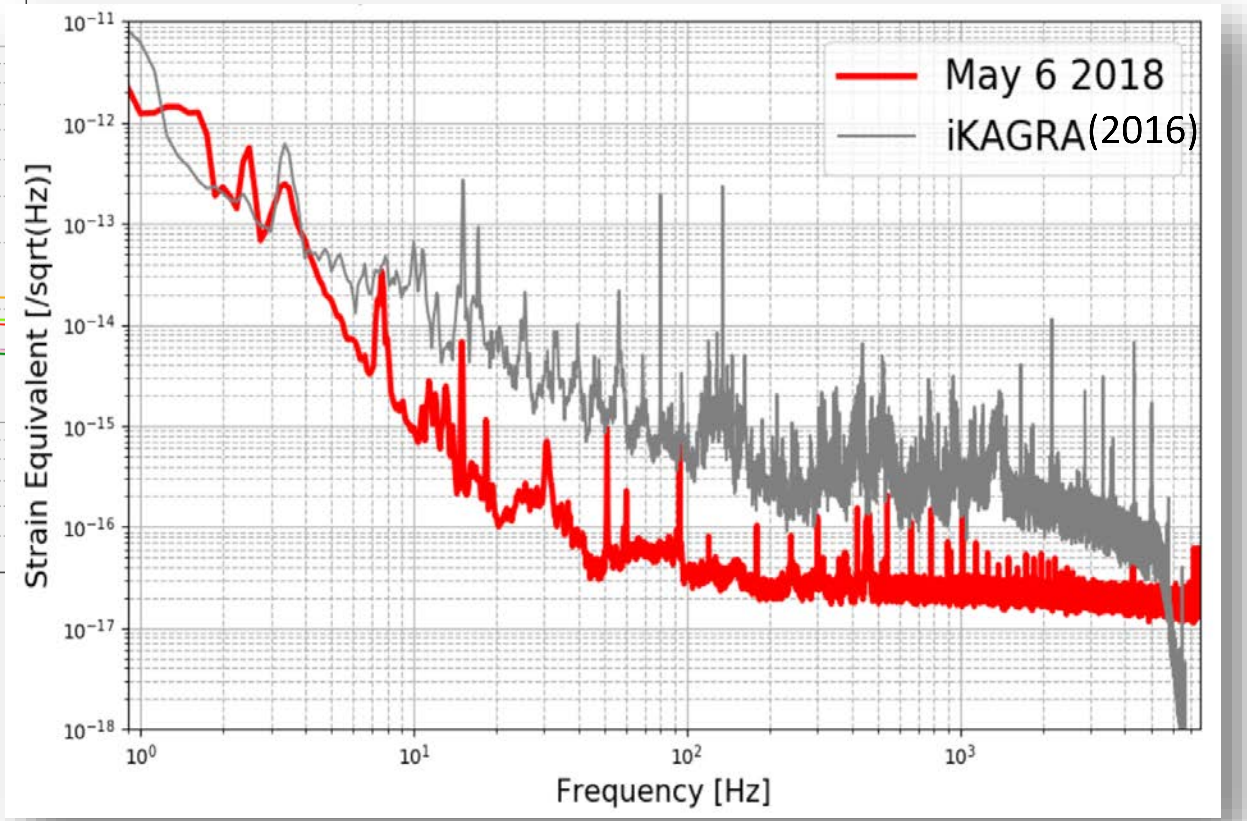


Operation of interferometer with a cryogenic mirror

Cooling down a mirror



Sensitivity….

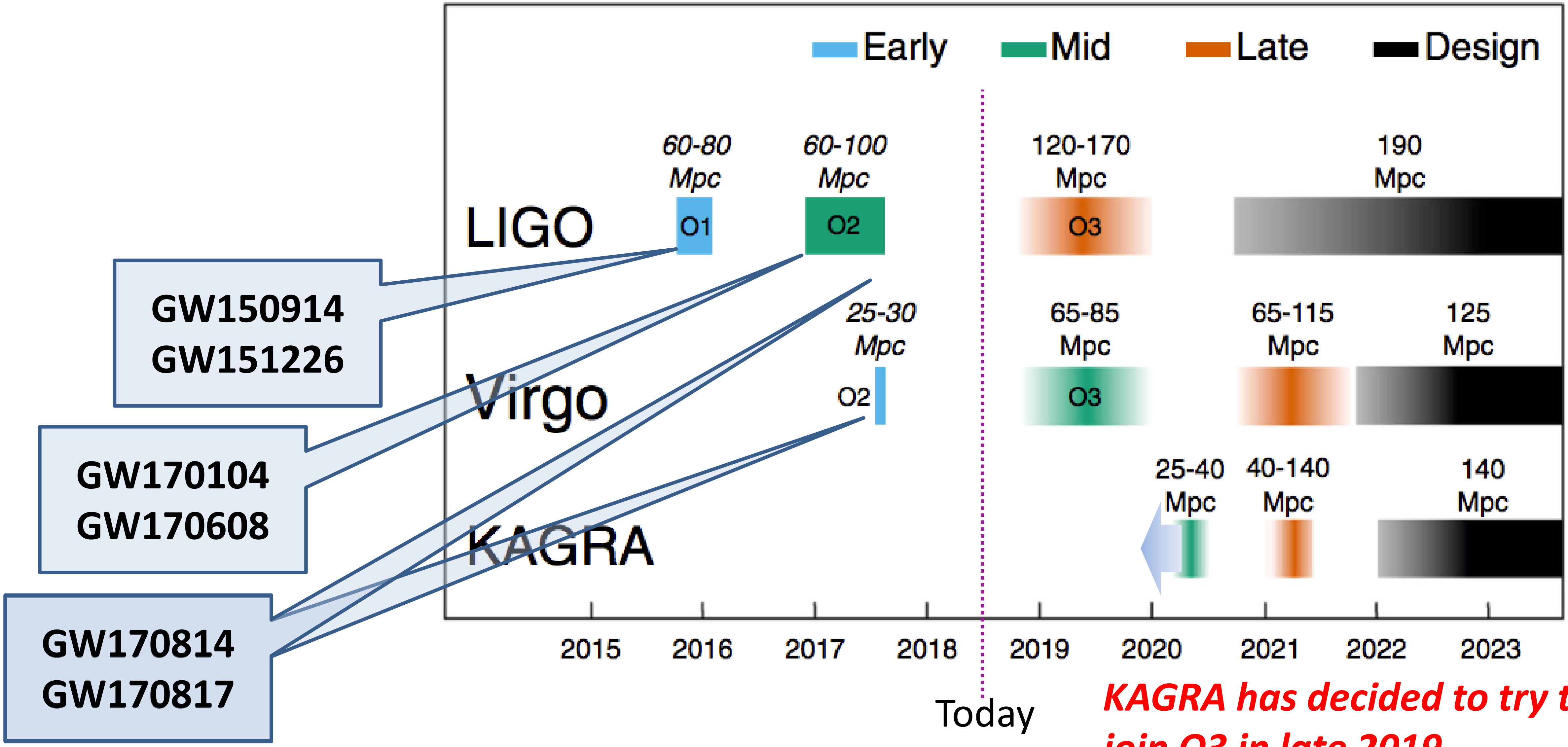


➔ About 27 days for cooling down

Plan of KAGRA

“Observation scenario paper”

LIGO, Virgo, KAGRA, Living Rev Relativ (2018) 21:3



KAGRA has decided to try to join O3 in late 2019.

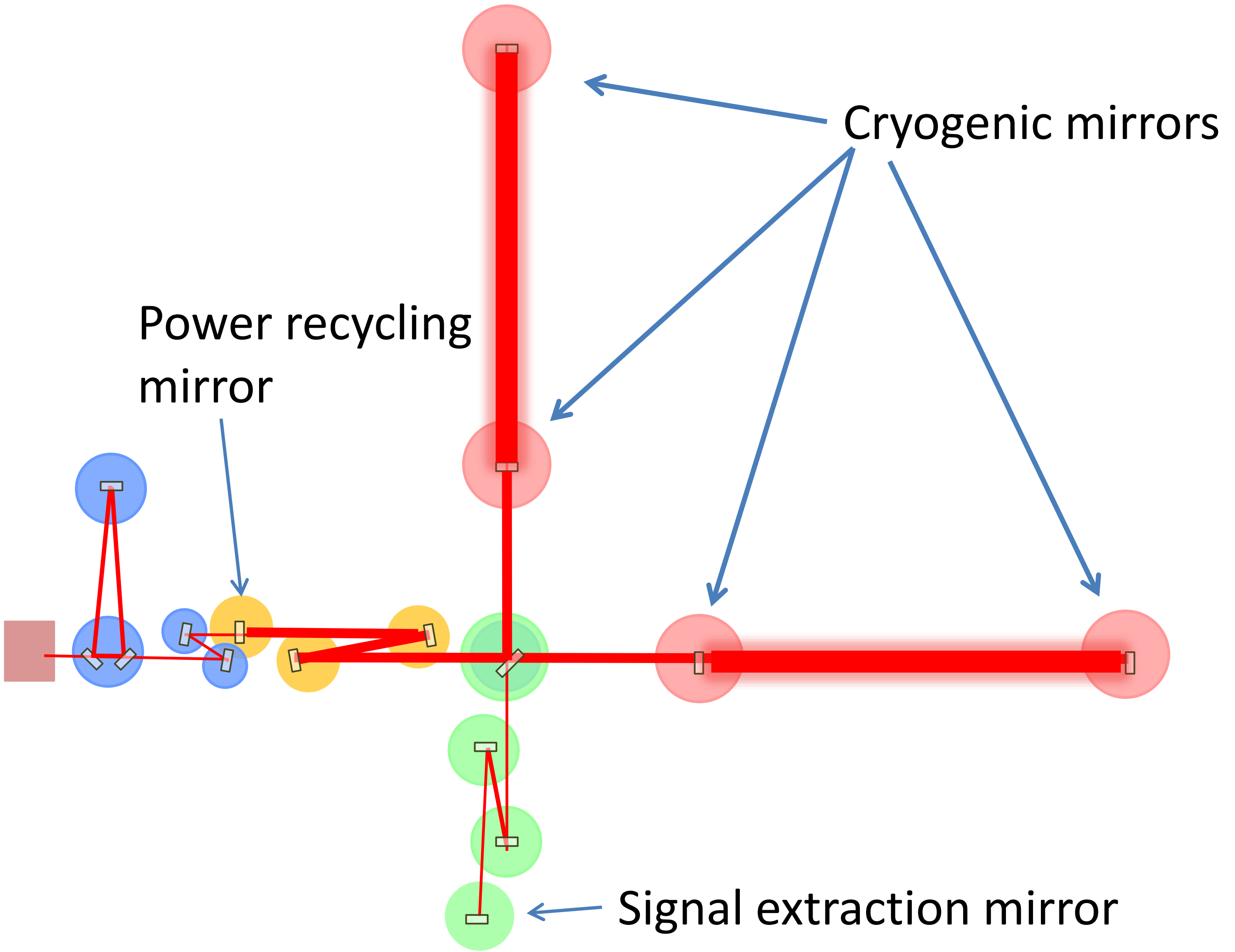
The next stage

Spring 2019:

- Installation complete
- (commissioning will be done in parallel to the installation)

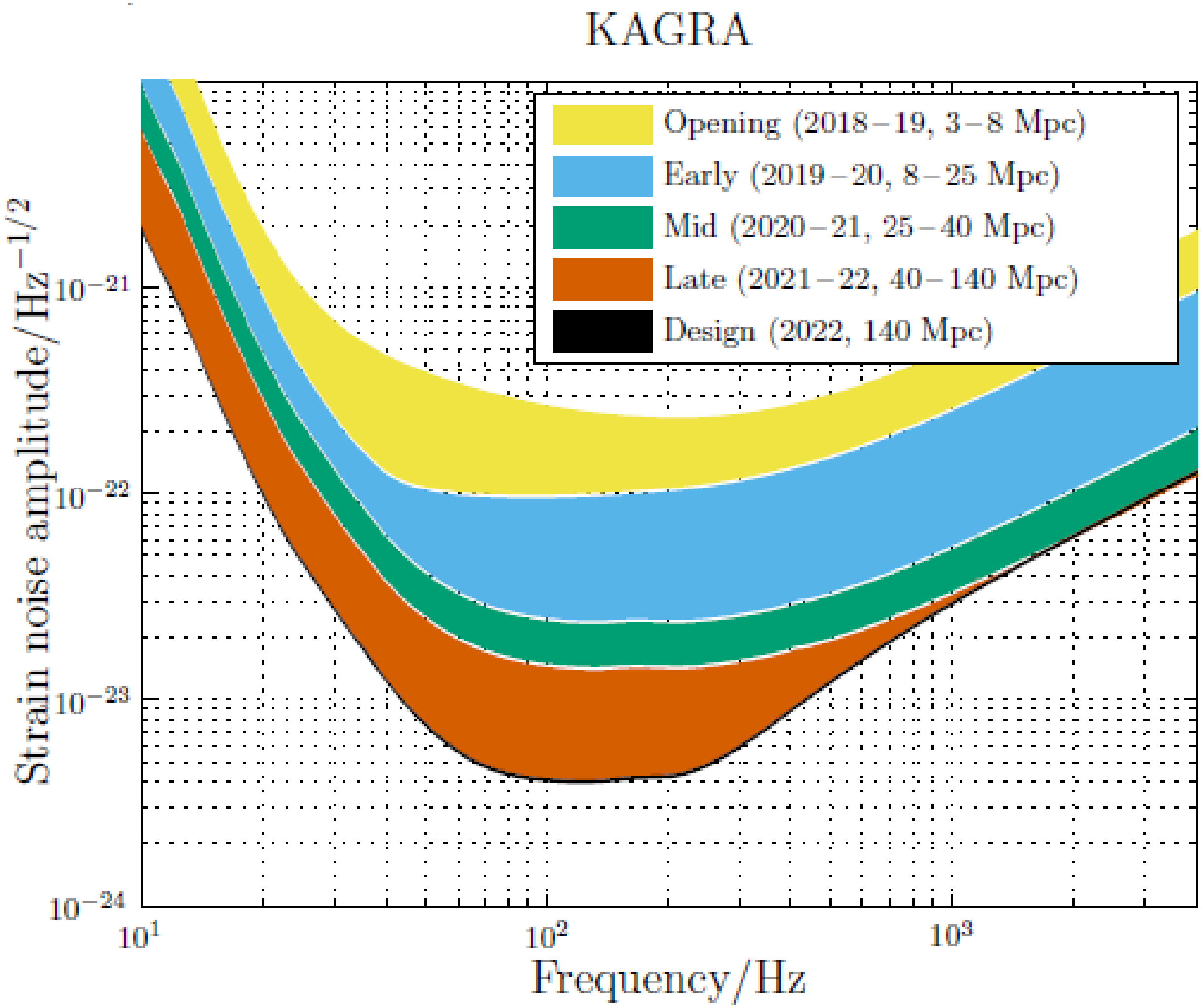
Late 2019:

- Operation of Cryogenic Dual-recycling Fabry-Perot interferometer
- (If some troubles/problems, cryogenic Fabry-Perot interferometer)

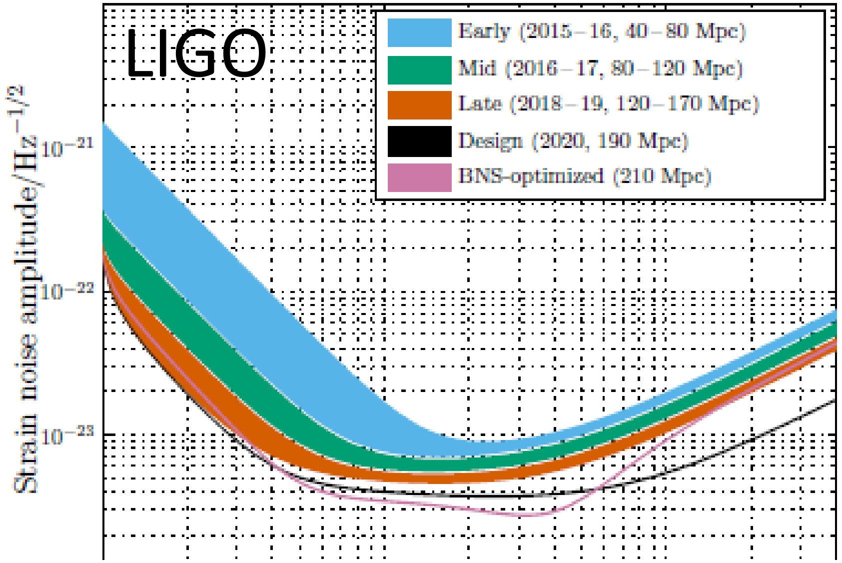


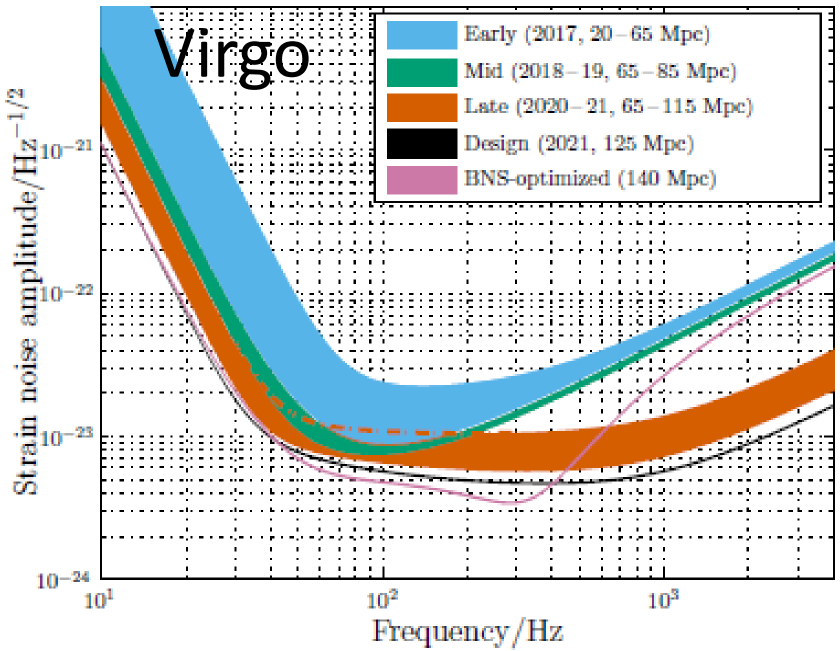
Target sensitivity

LIGO, Virgo, KAGRA, Living Rev Relativ (2018) 21:3



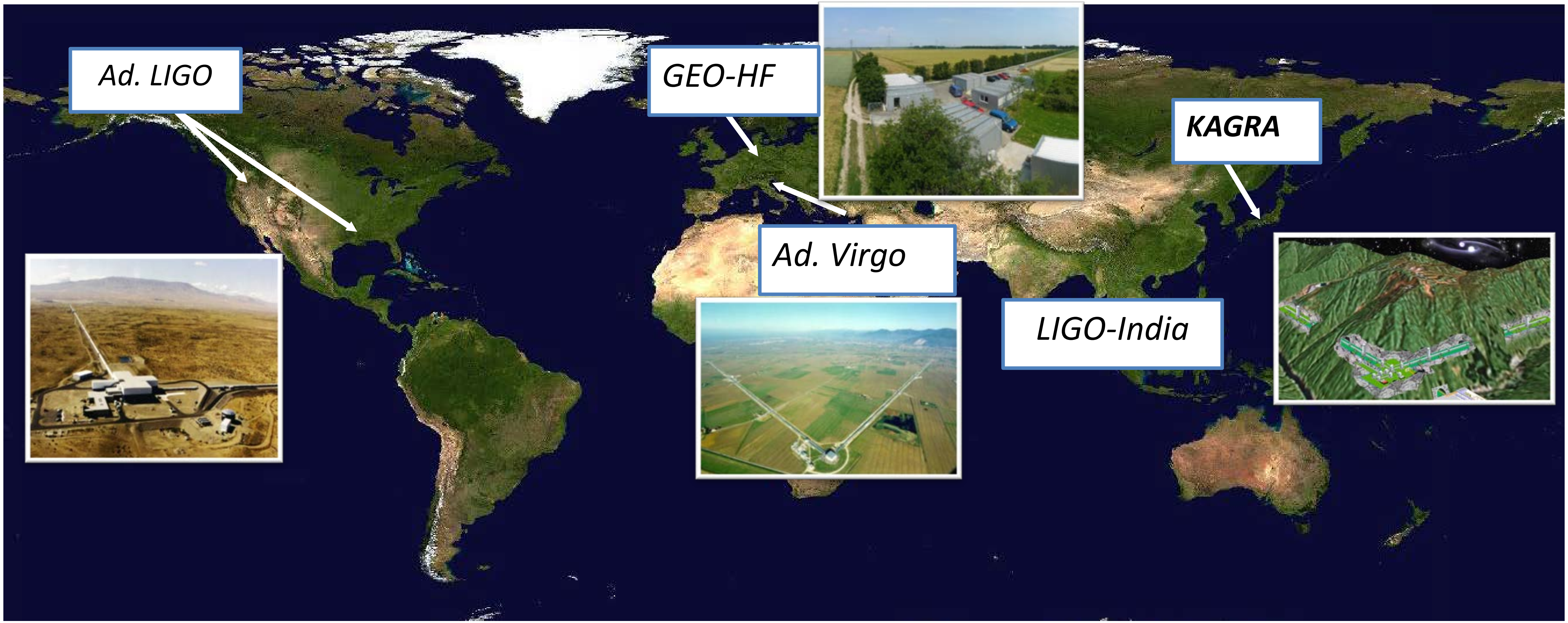
🡸 KAGRA tries to reach (lower part of) the blue band in late 2019.





Science goals

Joining the global GW network



- The scientific output will be maximized by the global network.
- KAGRA plans to join the worldwide network of gravitational wave detection / astronomy in late 2019 (near the end of O3 observation run of LIGO and Virgo).

Importance of multiple antennas

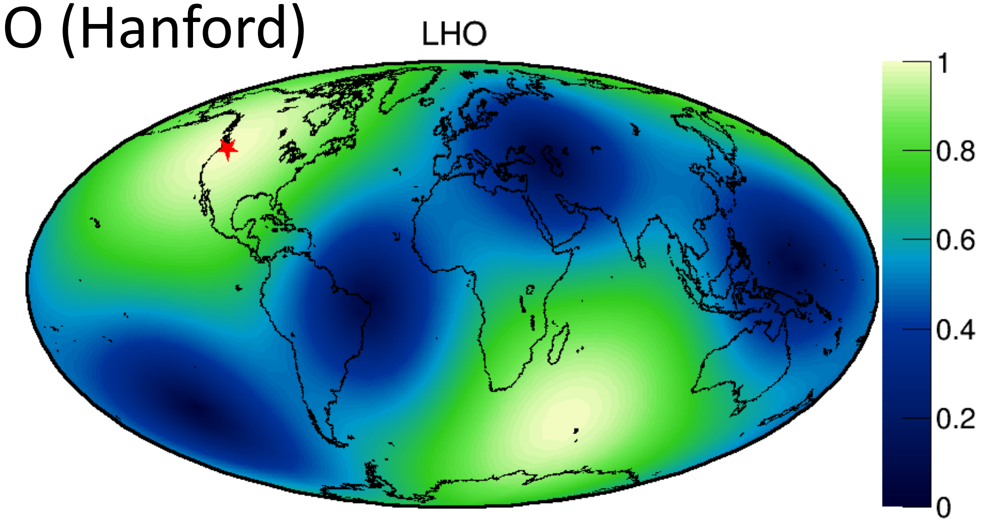
- Let us require at least 3 detector operation for the determination of the source direction.

Duty cycle of a single detector	70%	80%
3 detectors (LHO, LLO, Virgo)	34%	51%
4 detectors (LHO, LLO, Virgo, KAGRA)	65%	81%
5 detectors (LHO, LLO, Virgo, KAGRA, LIGO-India)	83%	94%

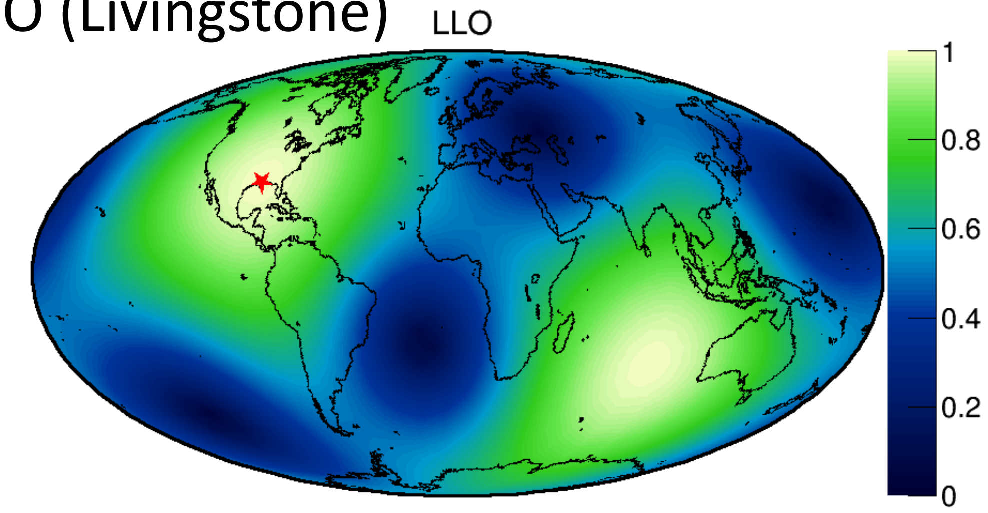
Adding KAGRA (and LIGO-India) has a significant impact on the 3 detector coincidence!

Importance of Global GW Network: Detector antenna patterns

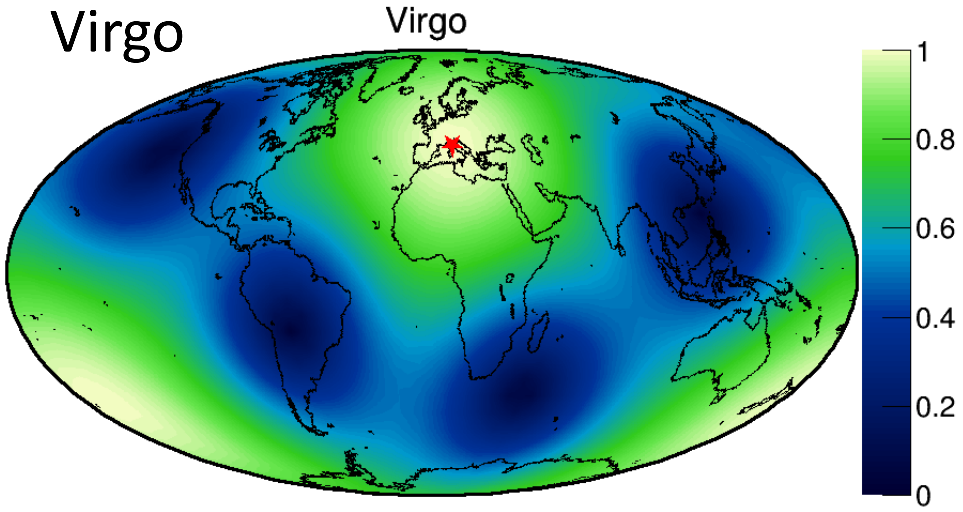
LIGO (Hanford)



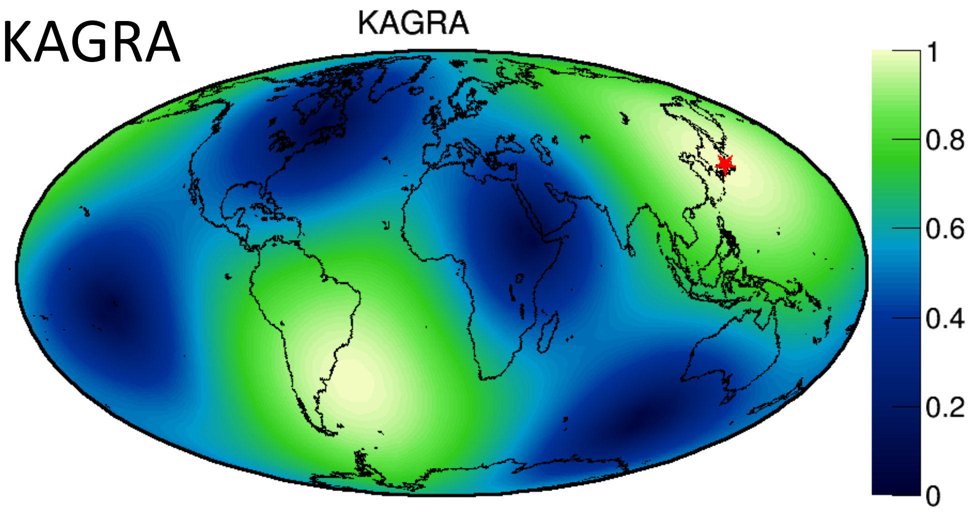
LIGO (Livingstone)



Virgo



KAGRA



KAGRA is complementary in the sensitive direction to other detectors.

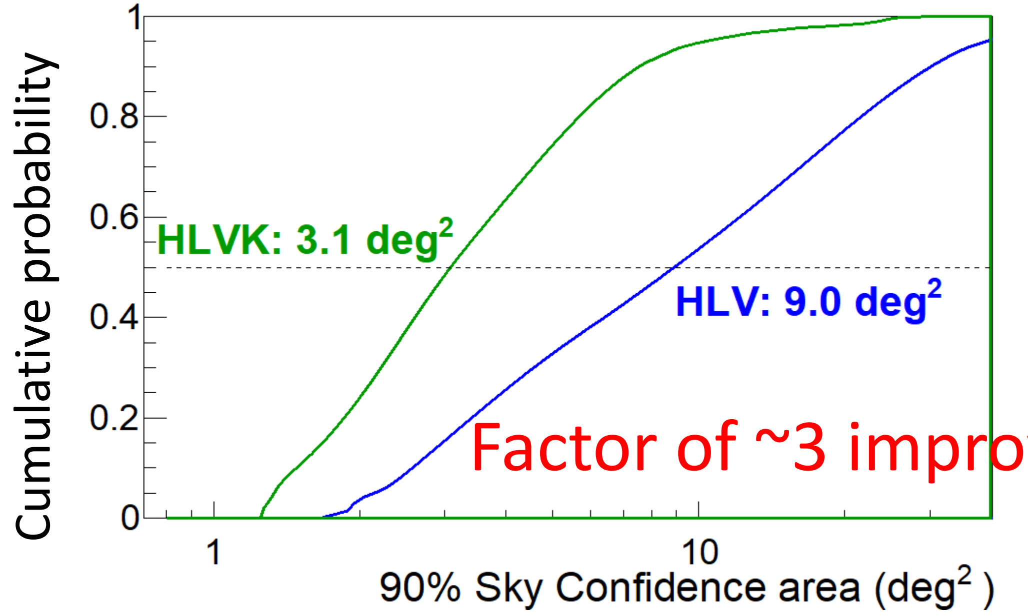
Importance of Global GW Network: Sky localization

- Assuming the sensitivity of;

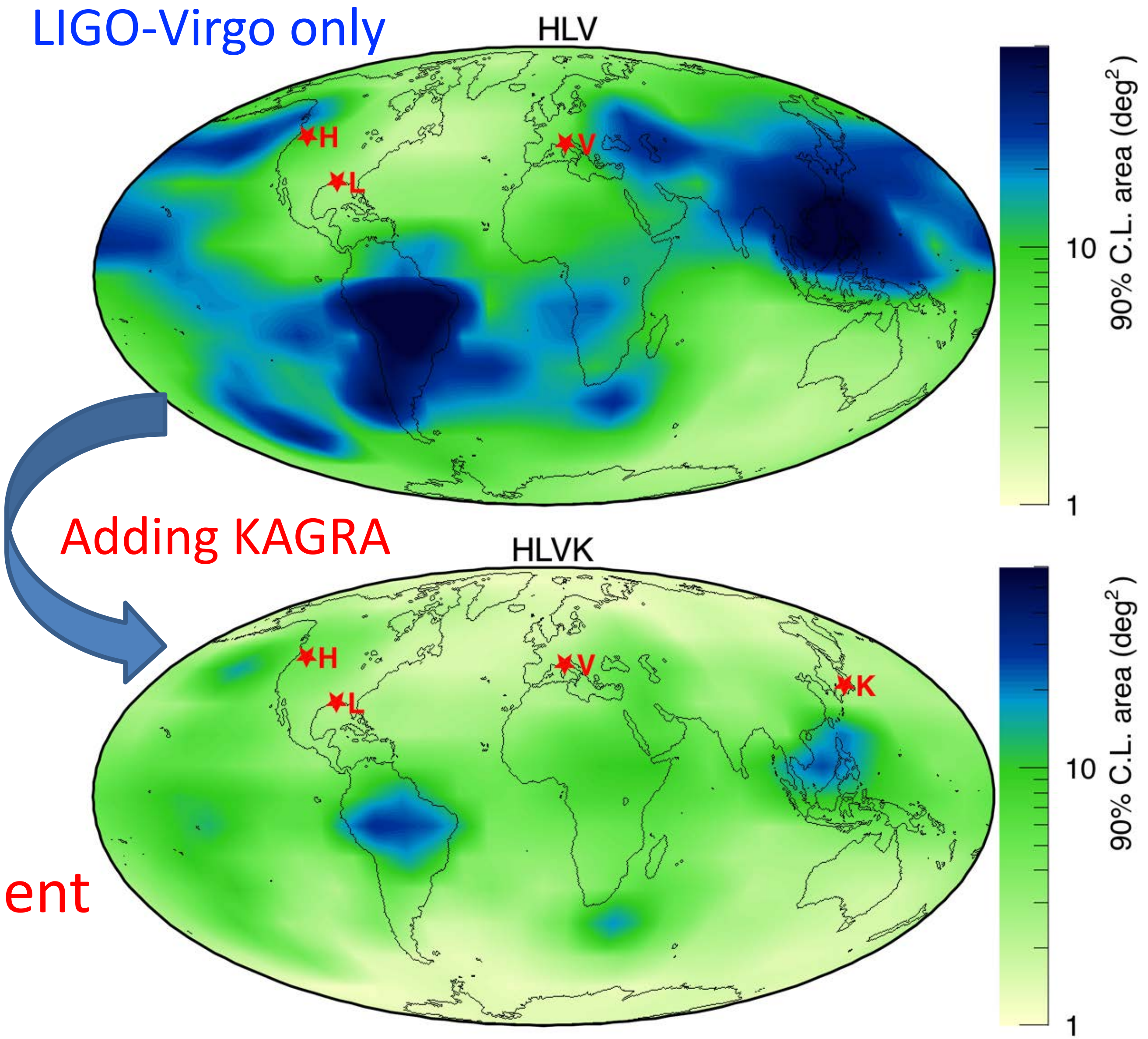
LIGO	Virgo	KAGRA
205 Mpc	126 Mpc	152 Mpc

LV: *LIGO-P1200087*, K: *JGW-T1707038*

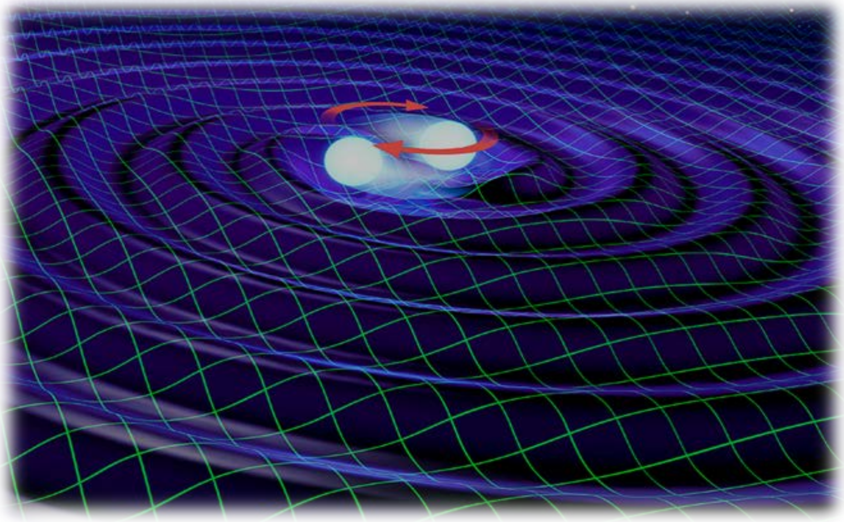
- Also, assuming NS-NS merger ($1.4\ M_{Sun}$ -$1.4\ M_{Sun}$) at 150 Mpc

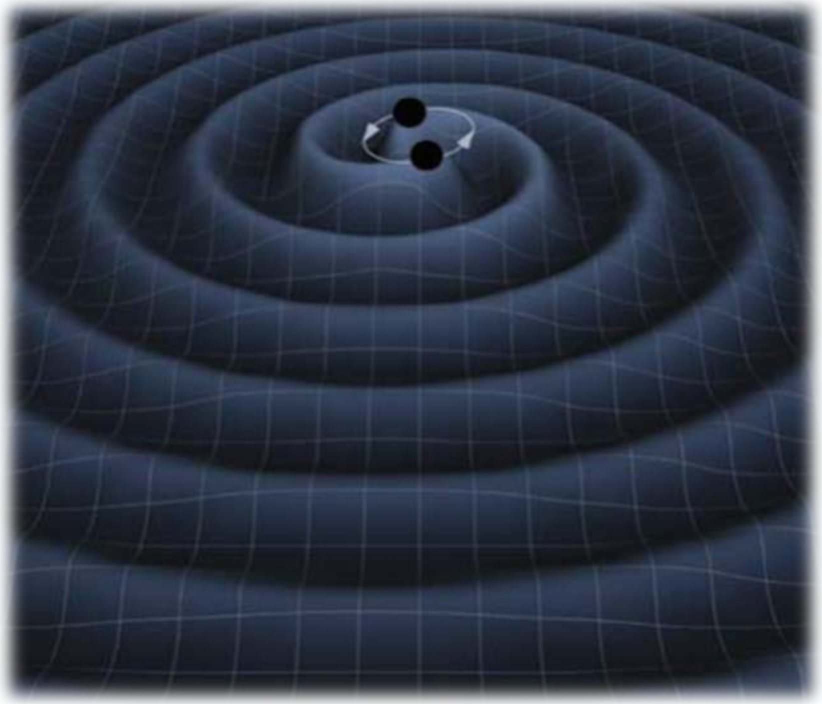


Factor of ~3 improvement



Science goals of KAGRA (common goals of ground based GW detectors)





Merger of binary neutron stars

- ➔ We want to understand the origin of the heavy metals in the Universe more accurately.?
- ➔ …

Merger of binary blackholes

- ➔ How the blackholes were created?
- ➔ …

Supernova explosion

- ➔ How the heavy stars finish their life?
- ➔ ….

Summary

- KAGRA is a unique GW interferometer with the underground site and the cryogenic technology.
- KAGRA had the initial cryogenic interferometer operation in April-May 2018.
- KAGRA plans to complete the installation in the spring of 2019 and join O3 in late 2019.
- KAGRA would like to contribute to the global network of gravitational wave detectors, and contribute to the science of gravitational wave astronomy.