Status and future of KAGRA

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GWPAW
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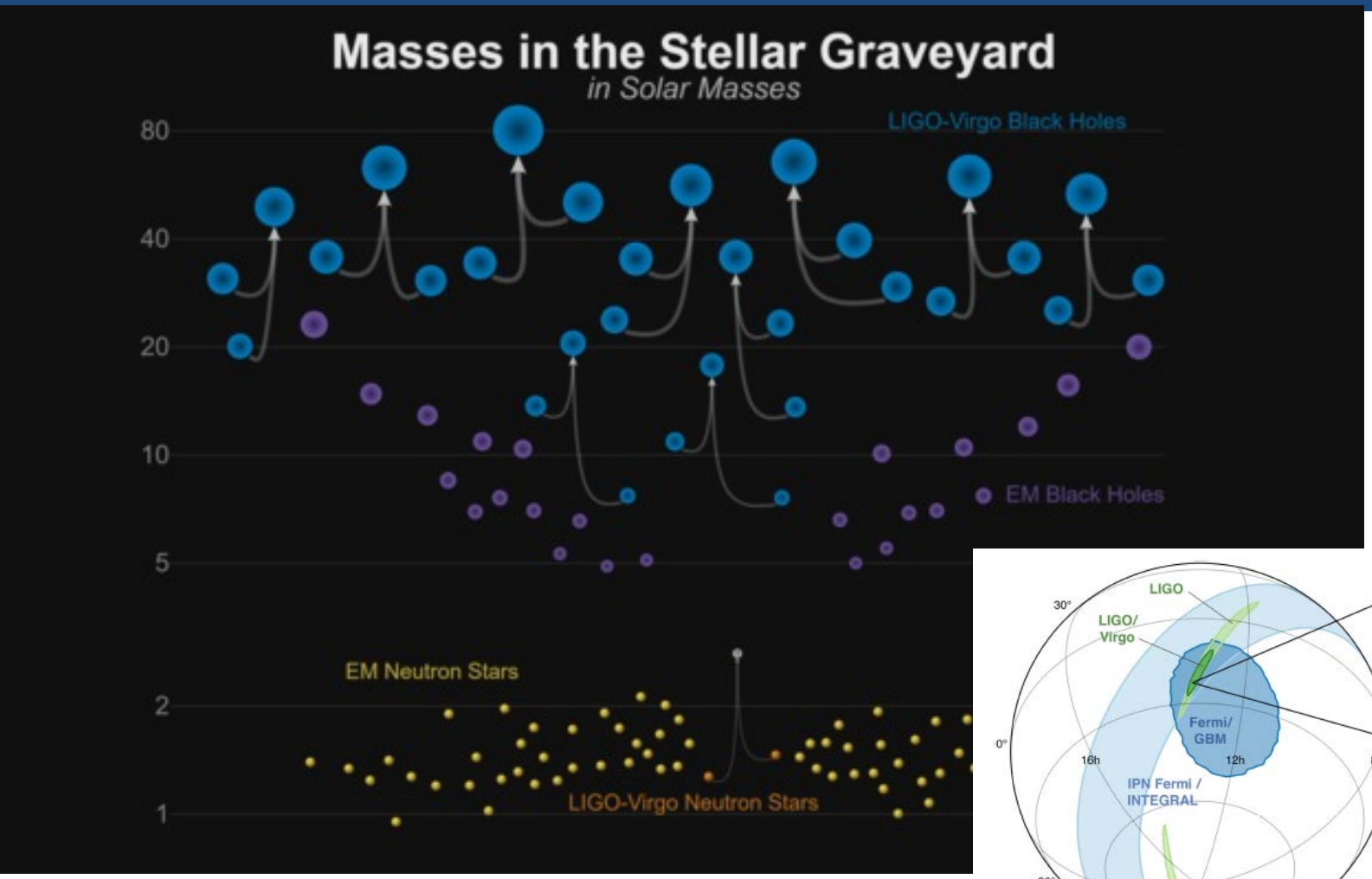
Outline

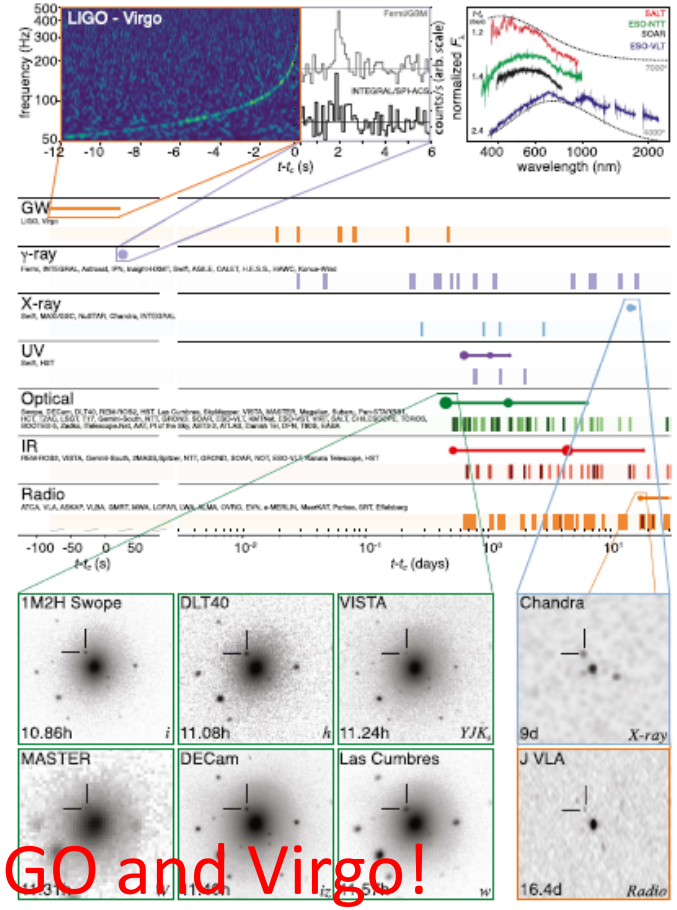
- *Introduction*
- *Status of KAGRA*
- *KAGRA's contribution to the GW science*
- *Future plan of KAGRA*
- *Summary*

Introduction

Introduction



LIGO Scientific Collaboration and Virgo Collaboration, PRL 119, 141101 (2017), ApJL, 848 L12 (2017), ….
arXiv: 1811.1290, https://www.ligo.caltech.edu/gallery

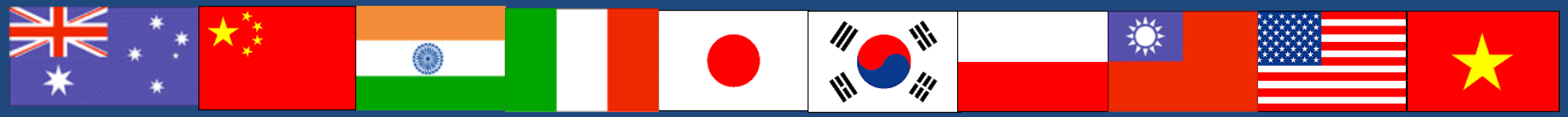


Many exciting news! Much more in O3! Congratulations to LIGO and Virgo!

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

Status of KAGRA

KAGRA collaboration



10 countries, >300 members

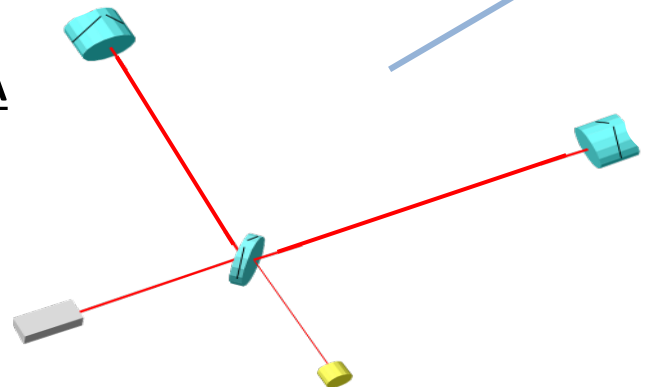
Timeline (Construction and Operation)

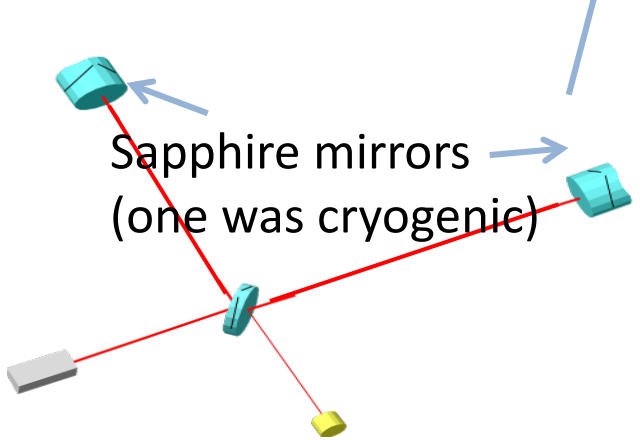
Calendar year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Project start											
Tunnel excavation											
iKAGRA											
operation											
bKAGRA											
Commissioning and Operation											

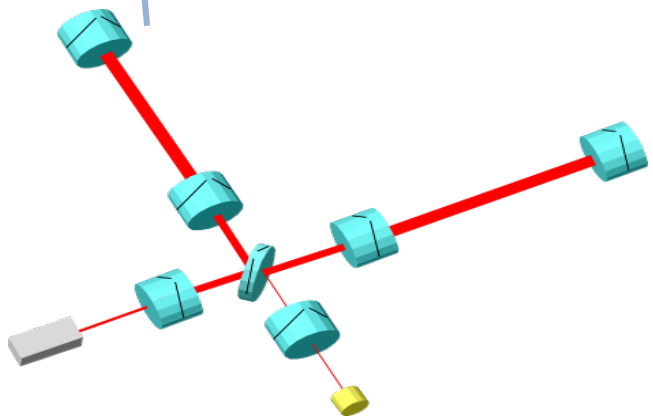
Adv. vibration isolation, optics, …

Cryogenic system

Today

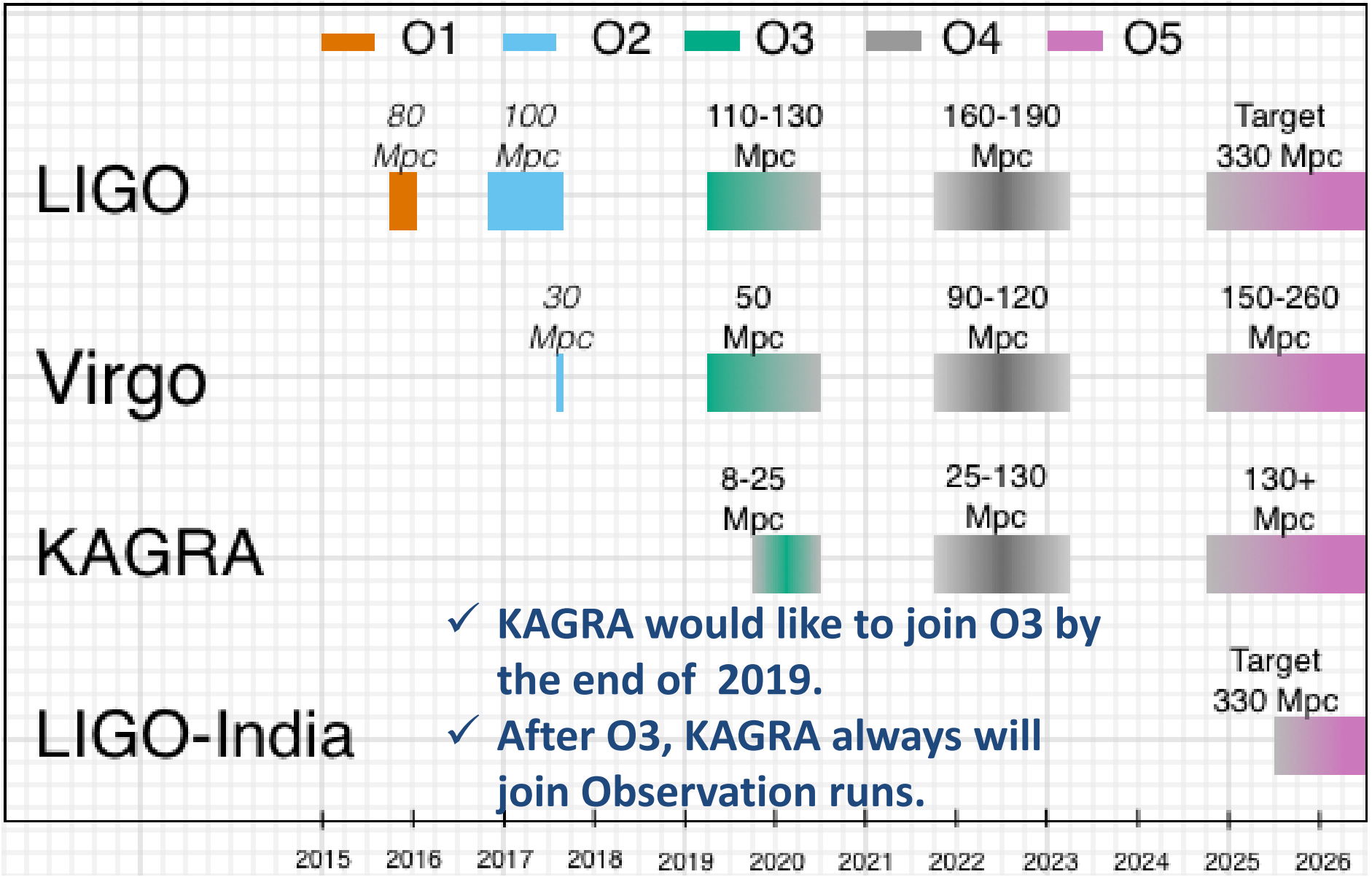






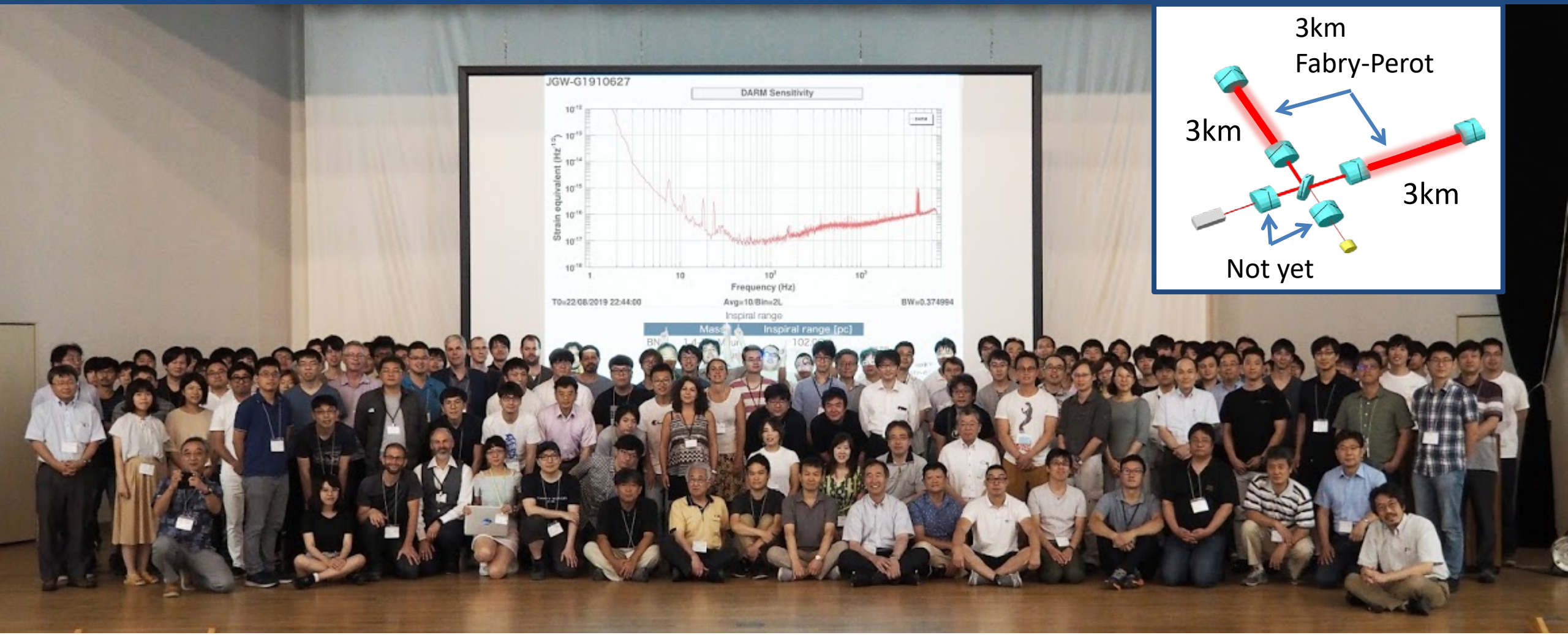
“Observation scenario paper”

LIGO, Virgo, KAGRA, arXiv: 1304.0670v9 (Sep.2019)



- ✓ **KAGRA would like to join O3 by the end of 2019.**
- ✓ **After O3, KAGRA always will join Observation runs.**

Status of KAGRA



On Aug. 23, 2019, KAGRA has successfully operated the interferometer with the 3km Fabry-Perot cavities. (Photo during the KAGRA Face-to-Face meeting on the same day.)

Signing Memorandum of Agreement with LIGO and Virgo

M1900145-v2, VIR-0091A, and JGW-M1910663

Memorandum of Agreement

between

VIRGO,

KAGRA,

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

October 2019

Purpose of agreement:

The purpose of this Memorandum of Agreement (MOA) is to establish and define a collaborative relationship between VIRGO, KAGRA and the Laser Interferometer Gravitational Wave Observatory (LIGO) to develop and exploit laser interferometry to measure and study gravitational waves.

We enter into this agreement in order to lay the groundwork for decades of world-wide collaboration. We intend to carry out the search for and analysis of gravitational waves in a spirit of teamwork, not competition. Furthermore, we remain open to participation of new partners, whenever additional data can add scientific value to the detection and study of gravitational waves. All partners in the world-wide collaboration should have a fair share in the scientific governance of the collaborative work.

Among the scientific benefits we hope to achieve from this collaboration are: better confidence in detection of signals, better duty cycle and sky coverage for searches, better estimation of the location and physical parameters of the sources, and gravitational wave studies based on the detected signals. Furthermore, we believe that the sharing of ideas will also offer additional benefits.

This MOA supersedes the MOU LIGO-M060038-v5 between VIRGO and LIGO, established in March 2019. This MOA also supersedes the MOU JGW-M1201315-v3 between KAGRA, LSC

M1900145-v2, VIR-0091A, and JGW-M1910663

Approved:

4 OCT 2019
David Reitze Date
LIGO Executive Director and LIGO Principal Investigator

27-Sep-2019
Albert Lazzarini Date
LIGO Laboratory Deputy Director

27 September 2019
Patrick Brady Date
LSC Spokesperson

27 September 2019
James Hough Date
GEO Representative

30-Sep-2019
Stavros Katsanevas Date
Director of EGO

Oct. 4, 2019
Jo van den Brand Date
Virgo Collaboration Spokesperson

Oct. 4, 2019
Takaaki Kajita Date
KAGRA Principal Investigator

Oct 4, 2019
Hisaaki Shinkai Date
KSC Board Chair

Sign-up ceremony on Oct. 4, 2019

KAGRA's contribution to the GW science

Importance of multiple antennas

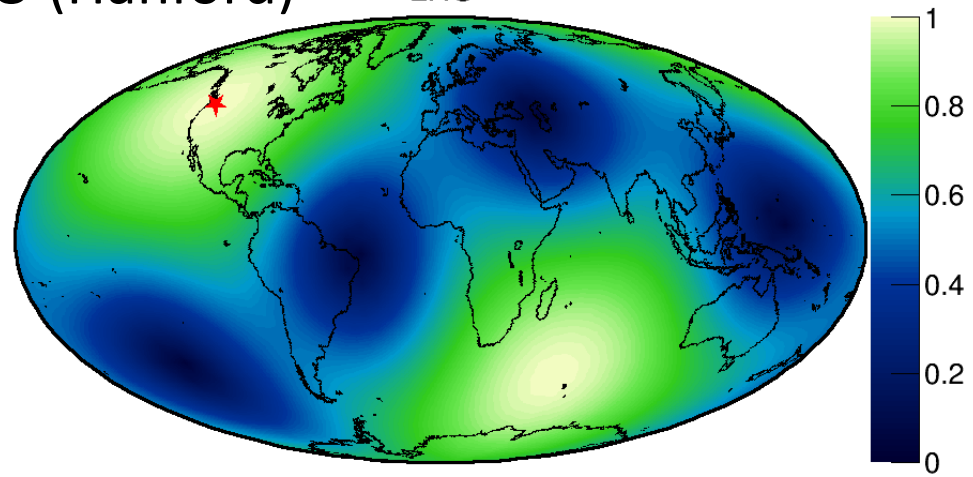
- Let us require at least 3 detector operation for the determination of the source direction.

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%

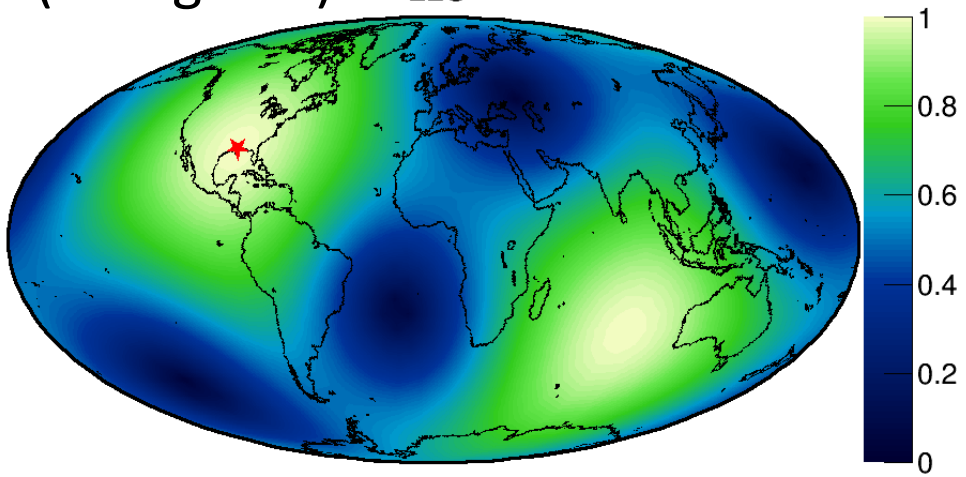
Adding KAGRA (and LIGO-India) has a significant impact on the 3 detector coincidence!

Importance of Global GW Network: Detector antenna patterns

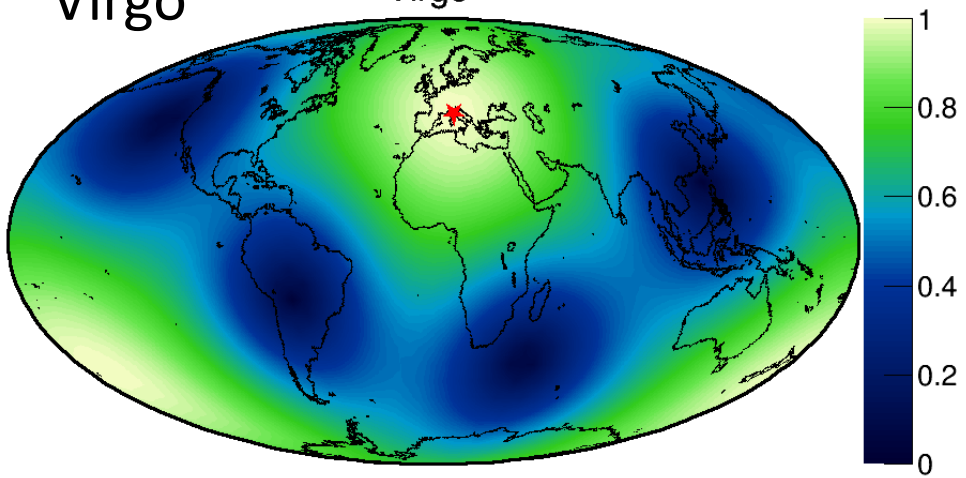
LIGO (Hanford)



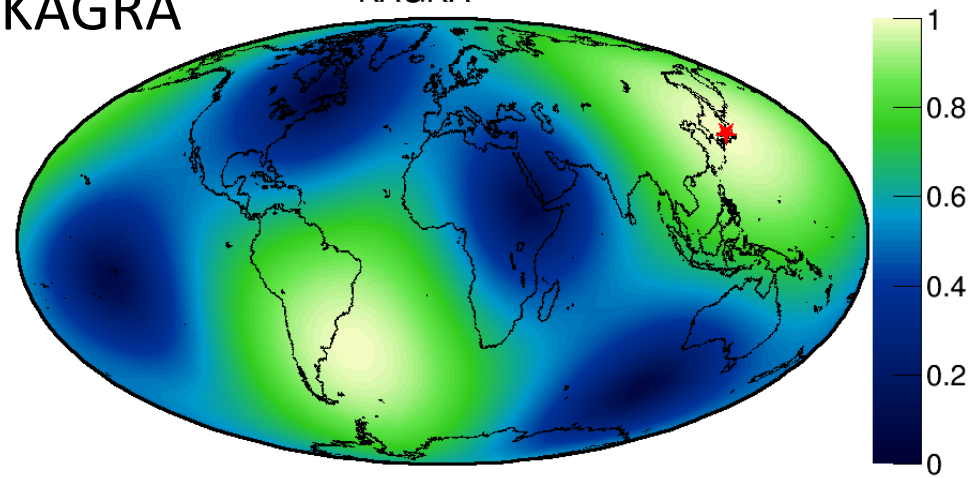
LIGO (Livingston)



Virgo



KAGRA



KAGRA is complementary in the sensitive direction to other detectors.

Importance of Global GW Network: Sky localization

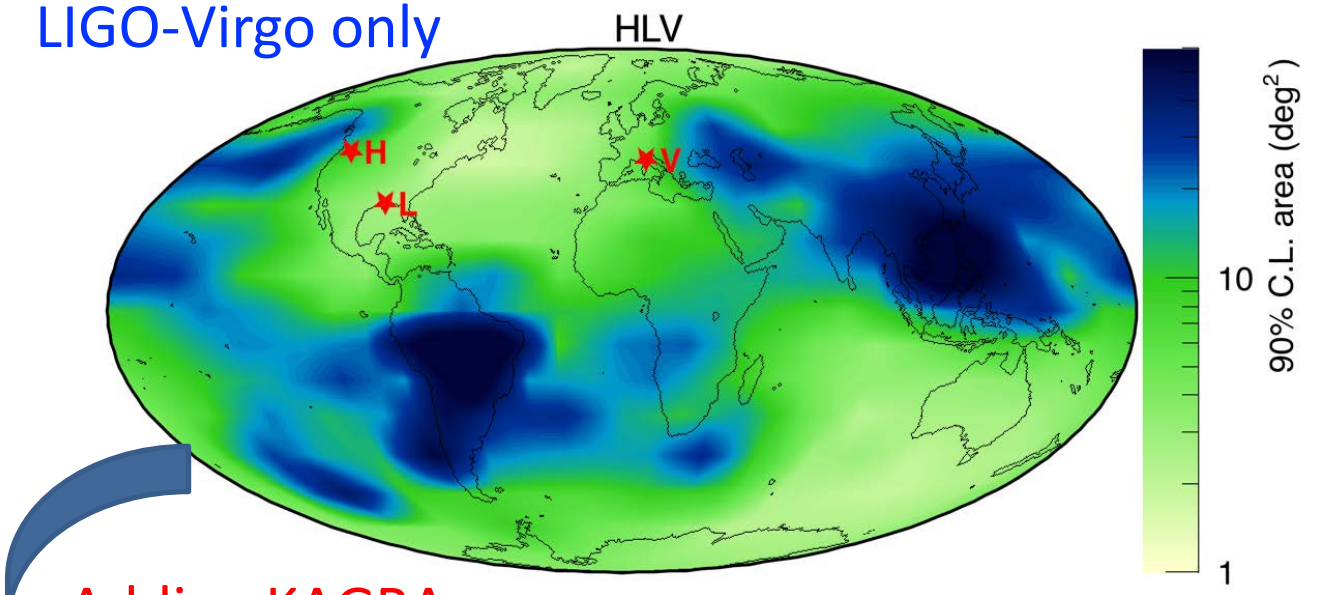
- Assuming the sensitivity of;

LIGO	Virgo	KAGRA
205 Mpc	126 Mpc	152 Mpc

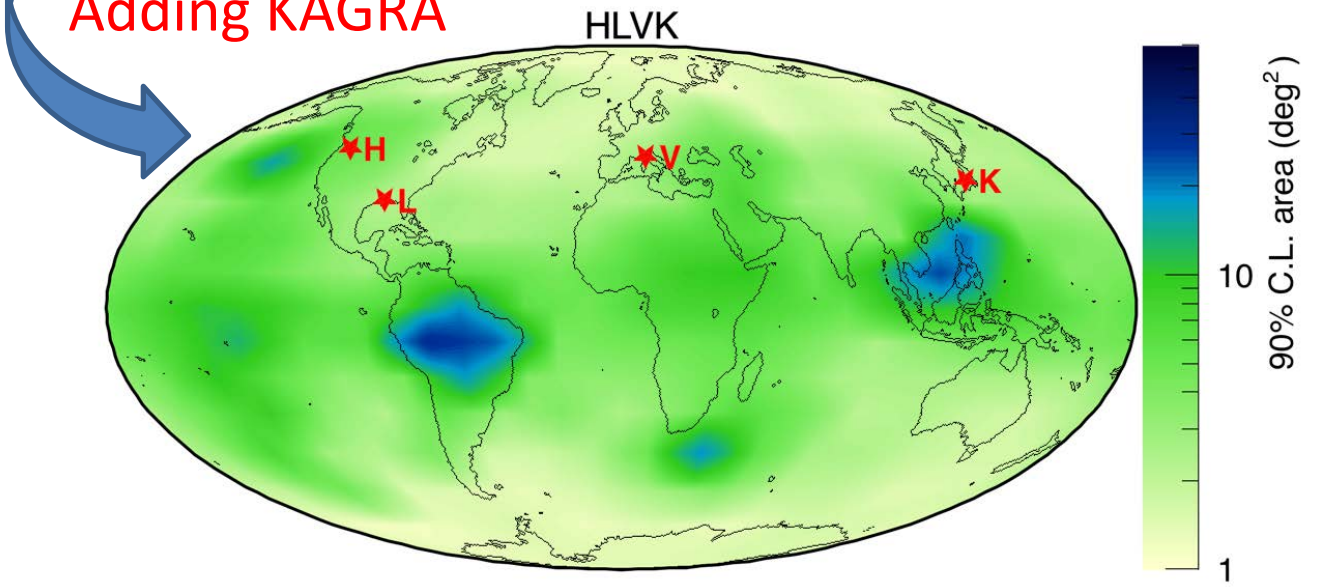
LV: *LIGO-P1200087,* K: *JGW-T1707038*

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

LIGO-Virgo only



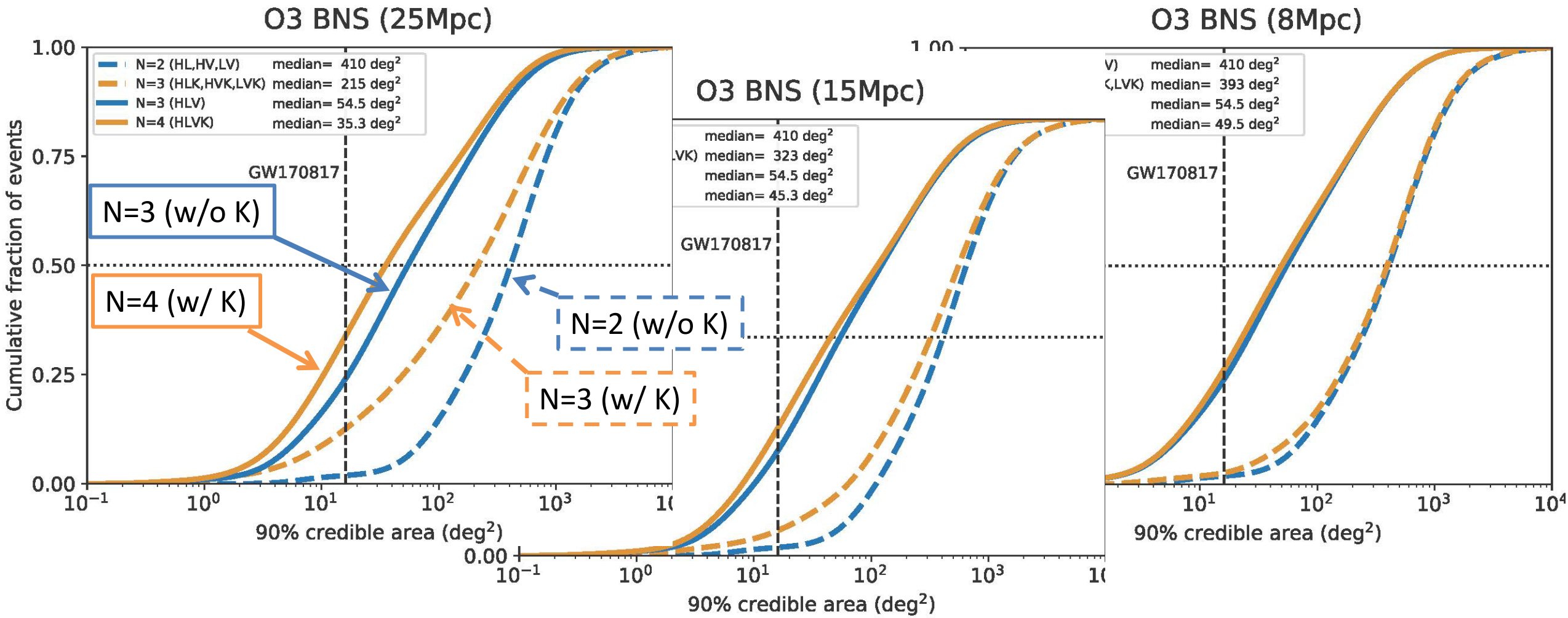
Adding KAGRA



However, the expected sensitivity of KAGRA (at least) during O3 is much lower than the design sensitivity…

Source localization during O3

- Assumed sensitivity (Binary NS range): LIGO 120Mpc, Virgo 60Mpc, KAGRA 8, 15 and 25Mpc



KAGRA should try to maximize the sensitivity as much as we can….

Importance of Global GW Network: Sky localization

- Assuming the sensitivity of;

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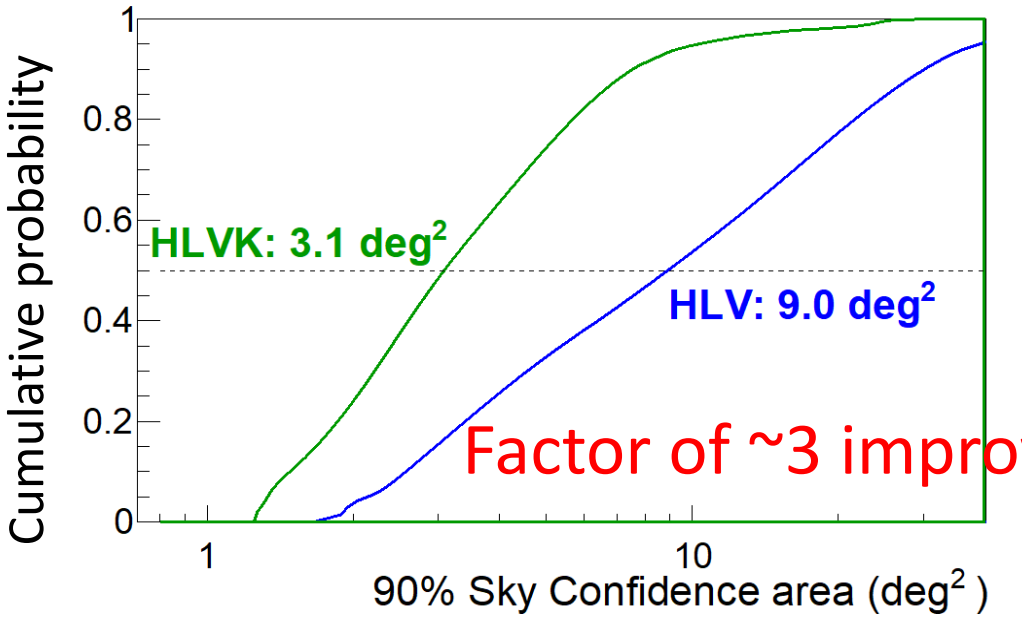
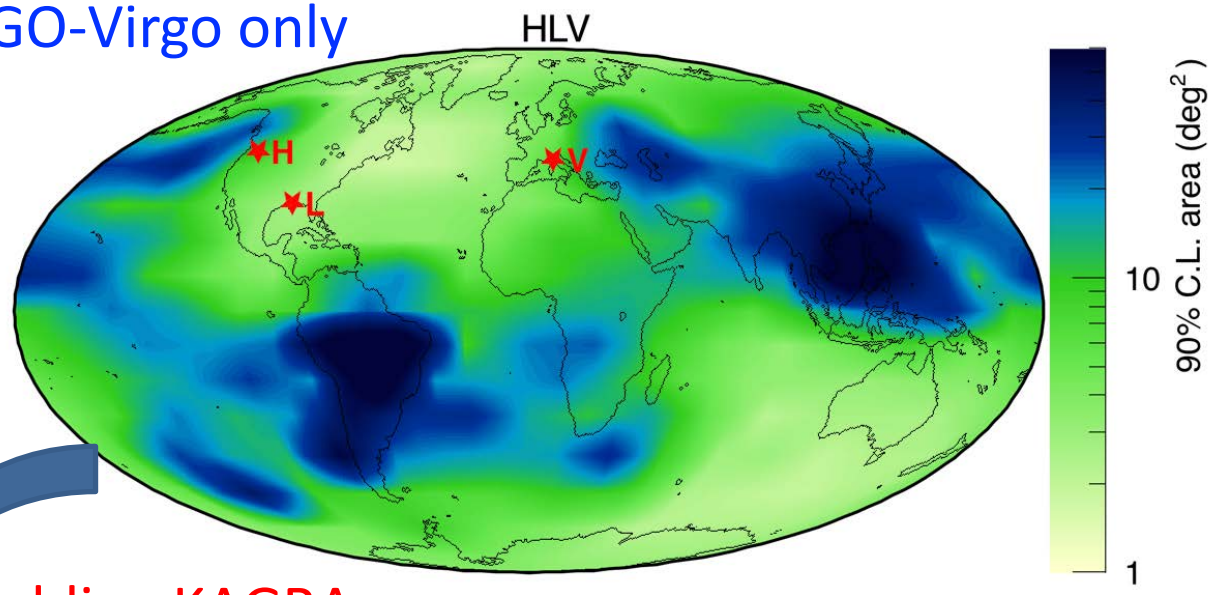
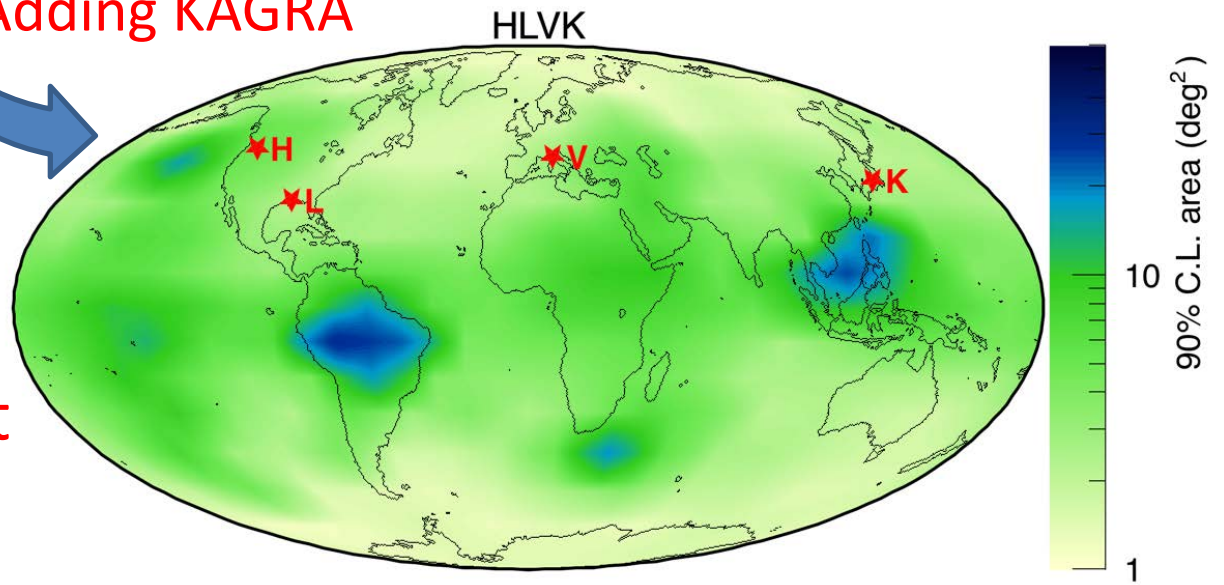


LIGO-Virgo only



Adding KAGRA



Factor of ~3 improvement

Future plan of KAGRA

After O3

- After finishing the O3 run at the end of April 2020, KAGRA will soon begin the works to achieve a higher sensitivity by improving the present instruments (and software).
- The target sensitivity of KAGRA for O4 (fall 2021 to spring 2023) is between 25 and 130 Mpc for BNS mergers.

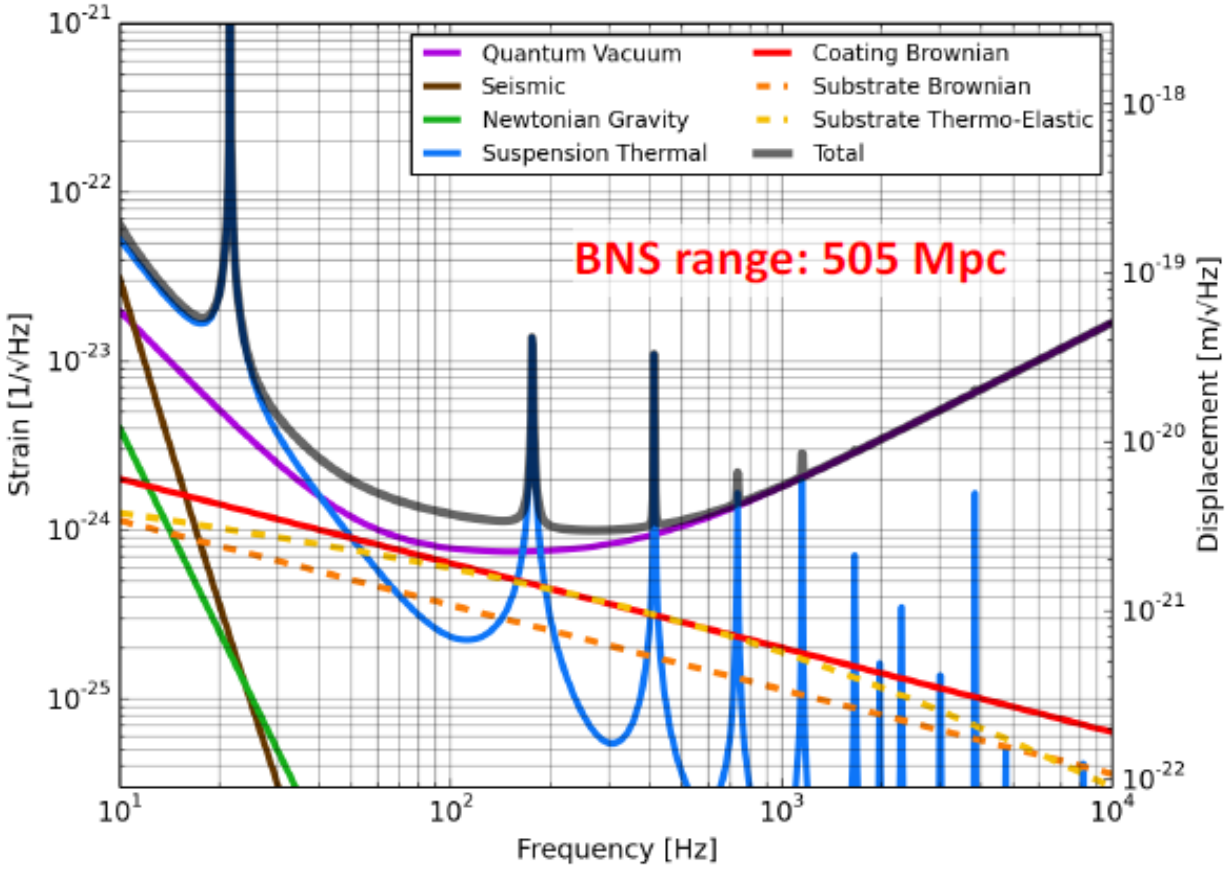
- In O5 (from fall 2024?), KAGRA would like to achieve > 130 Mpc for BNS mergers. Between O4 and O5, KAGRA may install something new, such as much better Sapphire Input Test Masses (ITMs) and squeezed light in order to get a high sensitivity.

- After O5, KAGRA would like to improve the sensitivity further (and substantially). Various options are discussed in the KAGRA Future Planning Committee. (Target sensitivity around 500 Mpc for BNS mergers?)

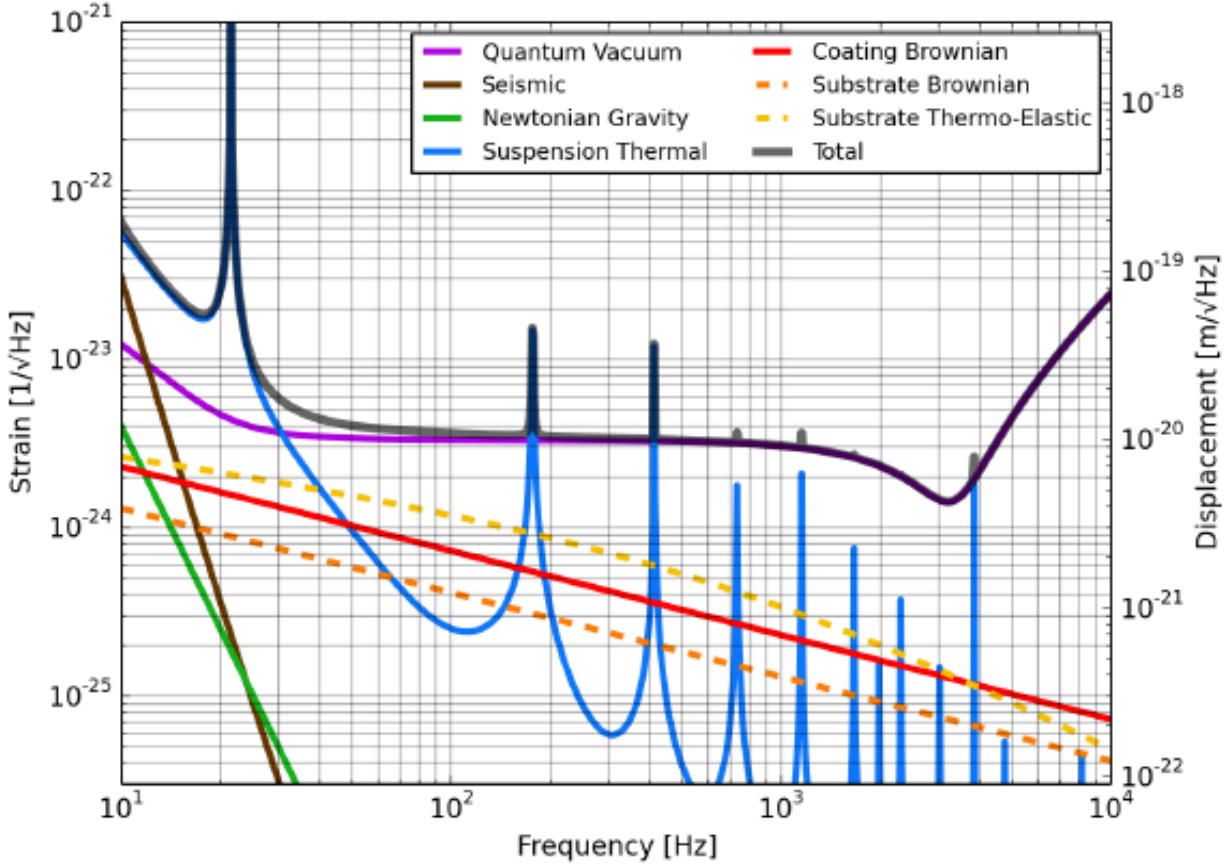
Possible future sensitivities of KAGRA

S. Haino (FPC) Aug. 2019 KAGRA F2F meeting

- Assuming: 200kg, 10ppm/cm sapphire, 500W laser, and 10dB FD squeezing



- High frequency option with 500m SRC



Summary

- KAGRA plans to join O3 in late 2019. We have signed a MoA with LIGO and Virgo.
- KAGRA has began the discussions to improve the sensitivity in the future.
- KAGRA would like to contribute to the global network of gravitational wave detectors and to the science of gravitational wave astronomy.