Status of KAGRA

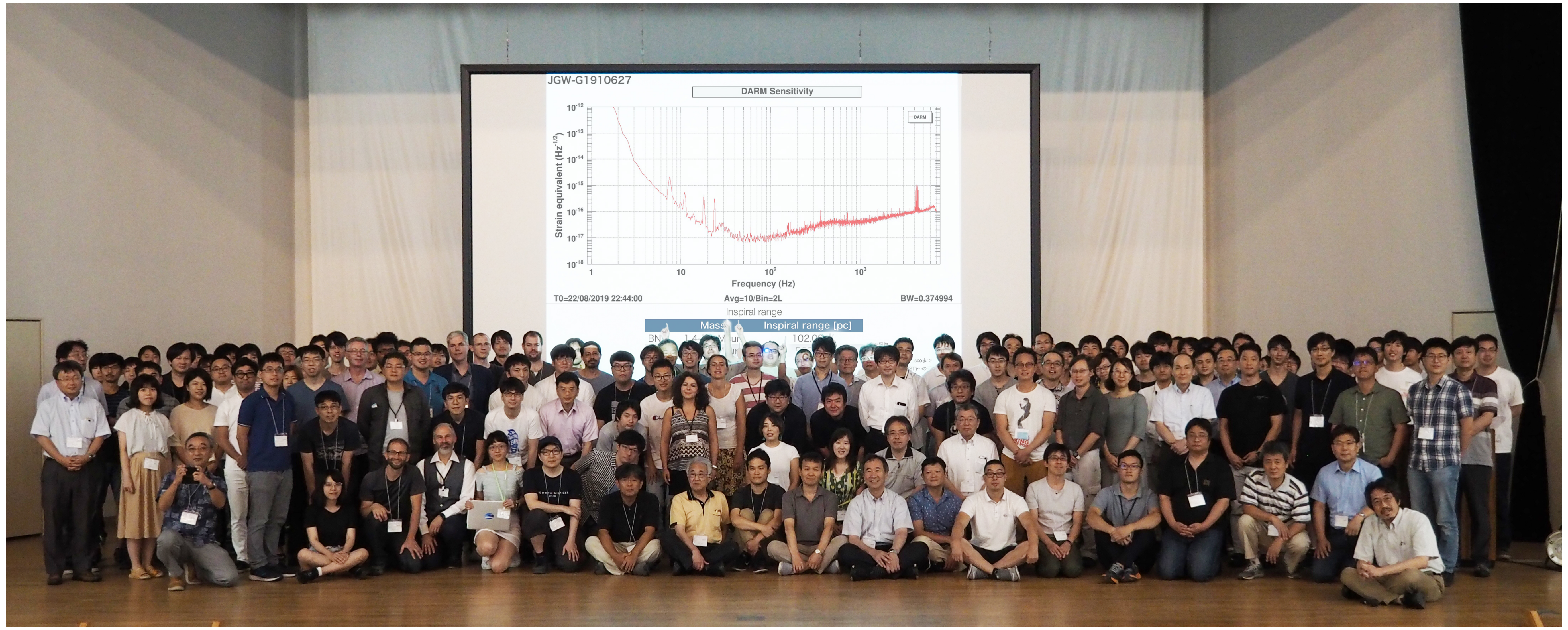
◆ **Underground** and **Cryogenic** interferometric 3 km gravitational-wave detector at Kamioka, Japan

◆ KAGRA finished all the installations May 2019, and the first full lock of FPMI for 5+ hours Aug 23.

◆ Now trials with DRFPMI. Final configuration will be decided soon.

◆ **KAGRA plans to join LV Observation Run 3 from the end of 2019.**

◆ Towards MoA with LIGO/Virgo, the round table discussion is ongoing in this LVC meeting.



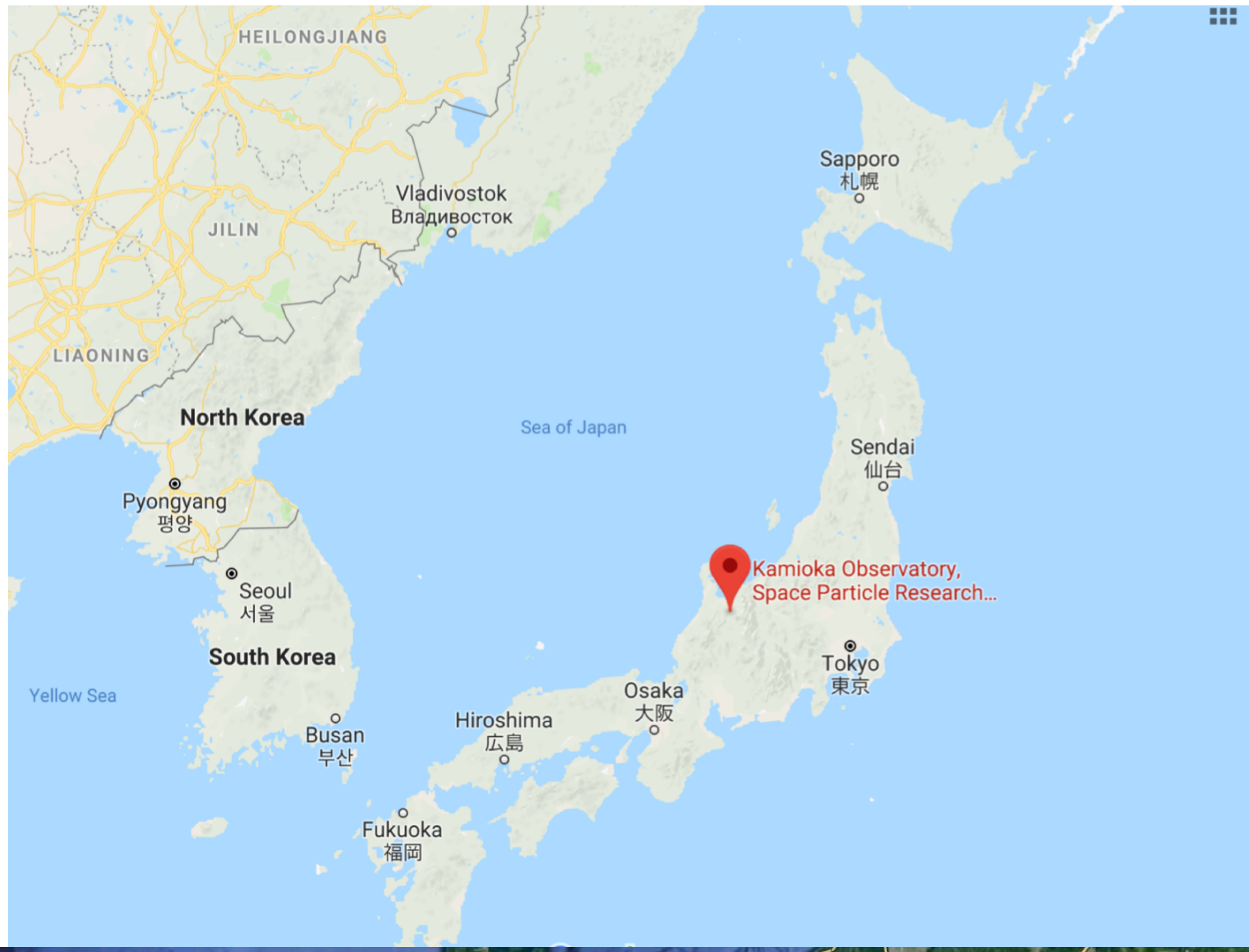
Aug.23 @ KAGRA F2F meeting at Toyama

Hisaaki Shinkai (Osaka Inst. Tech.)
KAGRA Scientific Congress, board chair

on behalf of the KAGRA collaboration

KAGRA (Kamioka GW Observatory)

◆ **Underground** and **Cryogenic** interferometric 3 km gravitational-wave detector at Kamioka, Japan



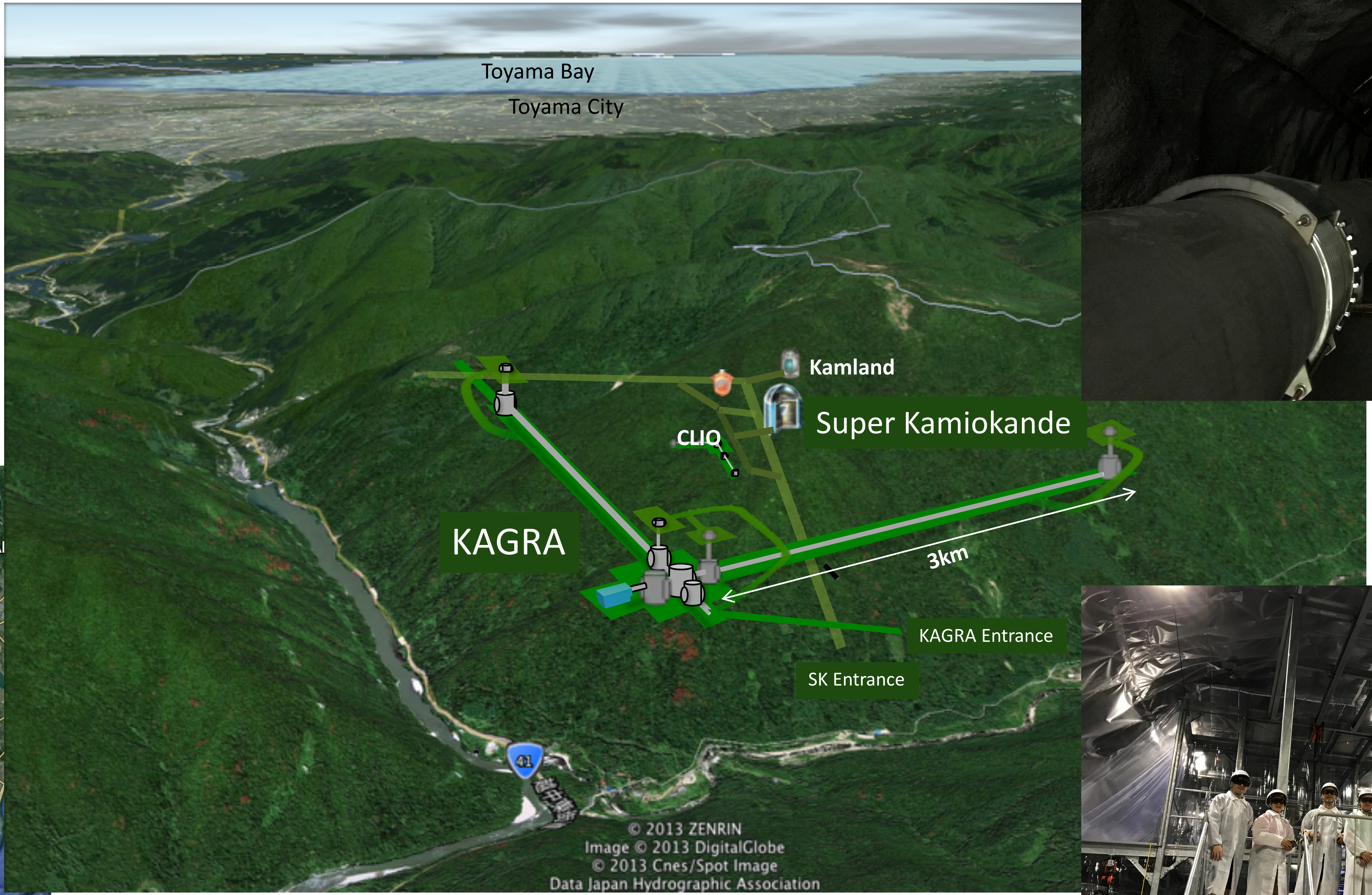


fig. by Keiko Kokeyama

KAGRA collaboration

KAGRA

110 groups, 14 countries
350+ active members

Default-author list 2018 has 200 members.
Obs. shift candidate list has 260 names.
+60 collaborators in the past 6 months.

Organize Face-to-Face meeting
3 times (April/August/Dec) / year

F2F Aug. 2019 @ U. Toyama, Japan
F2F December 2019 @ U. Tokyo, Japan

Organize International Workshop
2 times / year

KIW5 Feb. 2019 @ Perugia, Italy
KIW6 June 2019 @ Wuhan, China
KIW7 May 2020 @ NCU, Taiwan

http://gwwiki.icrr.u-tokyo.ac.jp/JGWwiki/KAGRA

Organization of KSC (KAGRA Scientific Congress)

Takaaki Kajita
(PI)

Masatake Ohashi
(vice PI)

Yoshio Saito
(SEO proj. manager)

PI

EO — sharing information & idea — KSC board

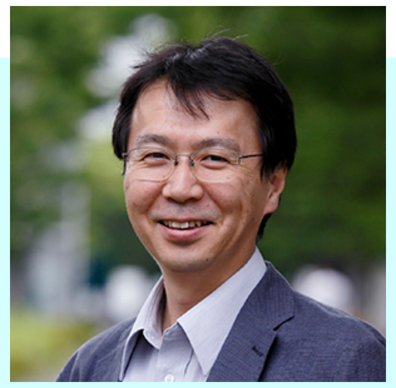
SEO

KAGRA Scientific Congress (KSC)
organization chart 2019/August 24

KSC board:
* Hisaaki Shinkai
* Shinji Miyoki
* Chunglee Kim
Hideyuki Tagoshi
Tomotada Akutsu
Zhoujian Cao
Hyung-Won Lee
Ray-Kuang Lee
Hirotaka Yuzurihara
Tomohiro Yamada

◀New Board
(2019/8-2021/8)

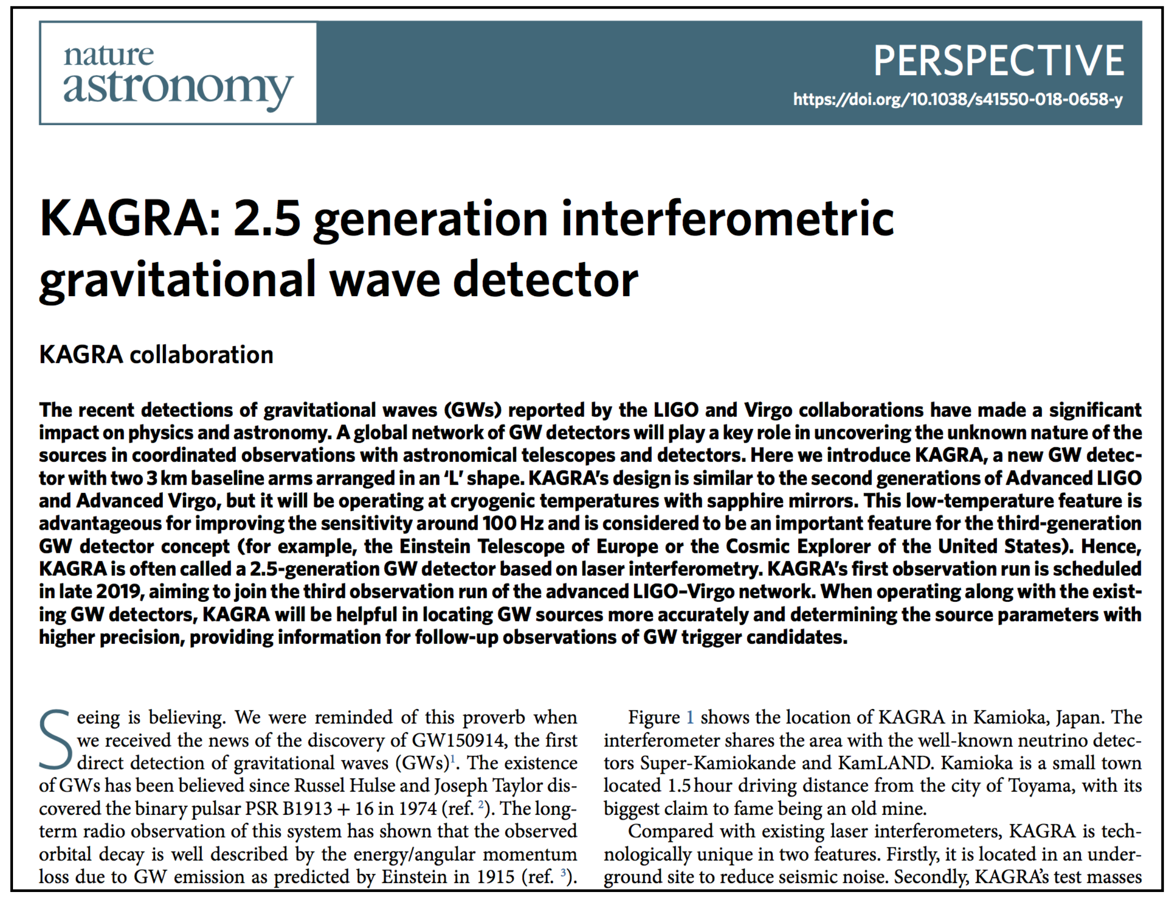
Data Analysis Committee (DAC)
* Hideyuki Tagoshi
+ WGs chairs/vice chairs
+ Hisaaki Shinkai (board)



- Compact Binary Coalescence: * Hideyuki Tagoshi, Kipp Cannon, Hyung-Won Lee, Tjonnie Li
- Continuous Wave: * Yousuke Itoh
- Burst Wave: * Kazuhiro Hayama
- Stochastic Wave: * Guo-Chin Liu, Sachiko Kuroyanagi
- Computing & Software: * Ken-ichi Oohara, Hirotaka Takahashi, Kazuki Sakai
- Calibration: * Yuki Inoue
- Detchar: * Keiko Kokeyama

- Joint Editorial board: * TBD
- Joint Run Planning Committee: Yousuke Itoh, Shinji Miyoki
- LVC-KAGRA taskforce: Yoshio Saito (leader, project manager), Hideyuki Tagoshi (Data analysis), Takahiro Yamamoto (Calibration), Osamu Miyakawa (commissioning), Hisaaki Shinkai (MoU)
- Joint Meeting Committee: * TBD
- Joint Detection Committee: * TBD

KAGRA collaboration papers



nature astronomy | PERSPECTIVE
https://doi.org/10.1038/s41550-018-0658-y

KAGRA: 2.5 generation interferometric gravitational wave detector

KAGRA collaboration

The recent detections of gravitational waves (GWs) reported by the LIGO and Virgo collaborations have made a significant impact on physics and astronomy. A global network of GW detectors will play a key role in uncovering the unknown nature of the sources in coordinated observations with astronomical telescopes and detectors. Here we introduce KAGRA, a new GW detector with two 3 km baseline arms arranged in an 'L' shape. KAGRA's design is similar to the second generations of Advanced LIGO and Advanced Virgo, but it will be operating at cryogenic temperatures with sapphire mirrors. This low-temperature feature is advantageous for improving the sensitivity around 100 Hz and is considered to be an important feature for the third-generation GW detector concept (for example, the Einstein Telescope of Europe or the Cosmic Explorer of the United States). Hence, KAGRA is often called a 2.5-generation GW detector based on laser interferometry. KAGRA's first observation run is scheduled in late 2019, aiming to join the third observation run of the advanced LIGO–Virgo network. When operating along with the existing GW detectors, KAGRA will be helpful in locating GW sources more accurately and determining the source parameters with higher precision, providing information for follow-up observations of GW trigger candidates.

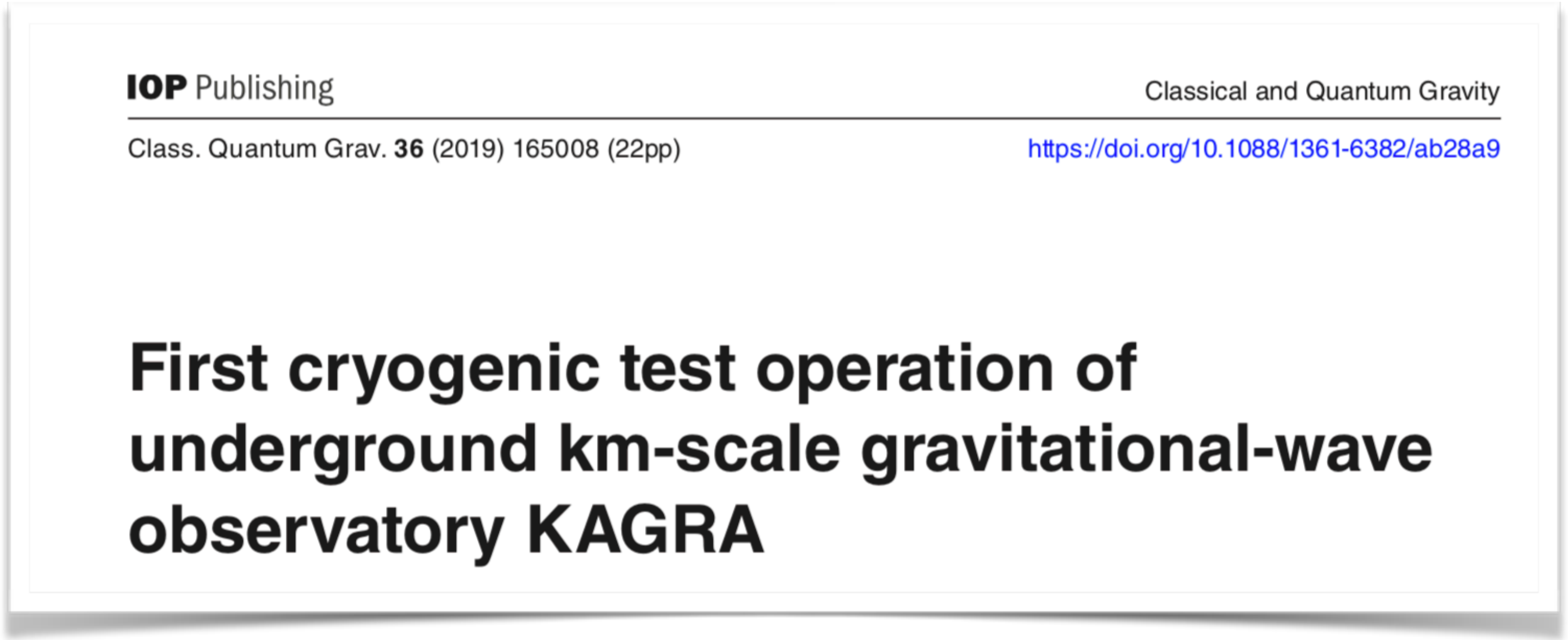
Seeing is believing. We were reminded of this proverb when we received the news of the discovery of GW150914, the first direct detection of gravitational waves (GWs)[1]. The existence of GWs has been believed since Russel Hulse and Joseph Taylor discovered the binary pulsar PSR B1913 + 16 in 1974 (ref. [2]). The long-term radio observation of this system has shown that the observed orbital decay is well described by the energy/angular momentum loss due to GW emission as predicted by Einstein in 1915 (ref. [3]).

Figure 1 shows the location of KAGRA in Kamioka, Japan. The interferometer shares the area with the well-known neutrino detectors Super-Kamiokande and KamLAND. Kamioka is a small town located 1.5 hour driving distance from the city of Toyama, with its biggest claim to fame being an old mine.

Compared with existing laser interferometers, KAGRA is technologically unique in two features. Firstly, it is located in an underground site to reduce seismic noise. Secondly, KAGRA's test masses

Nature Astronomy, 3 (2019) 35.
[arXiv:1811.08079]

introduction & history



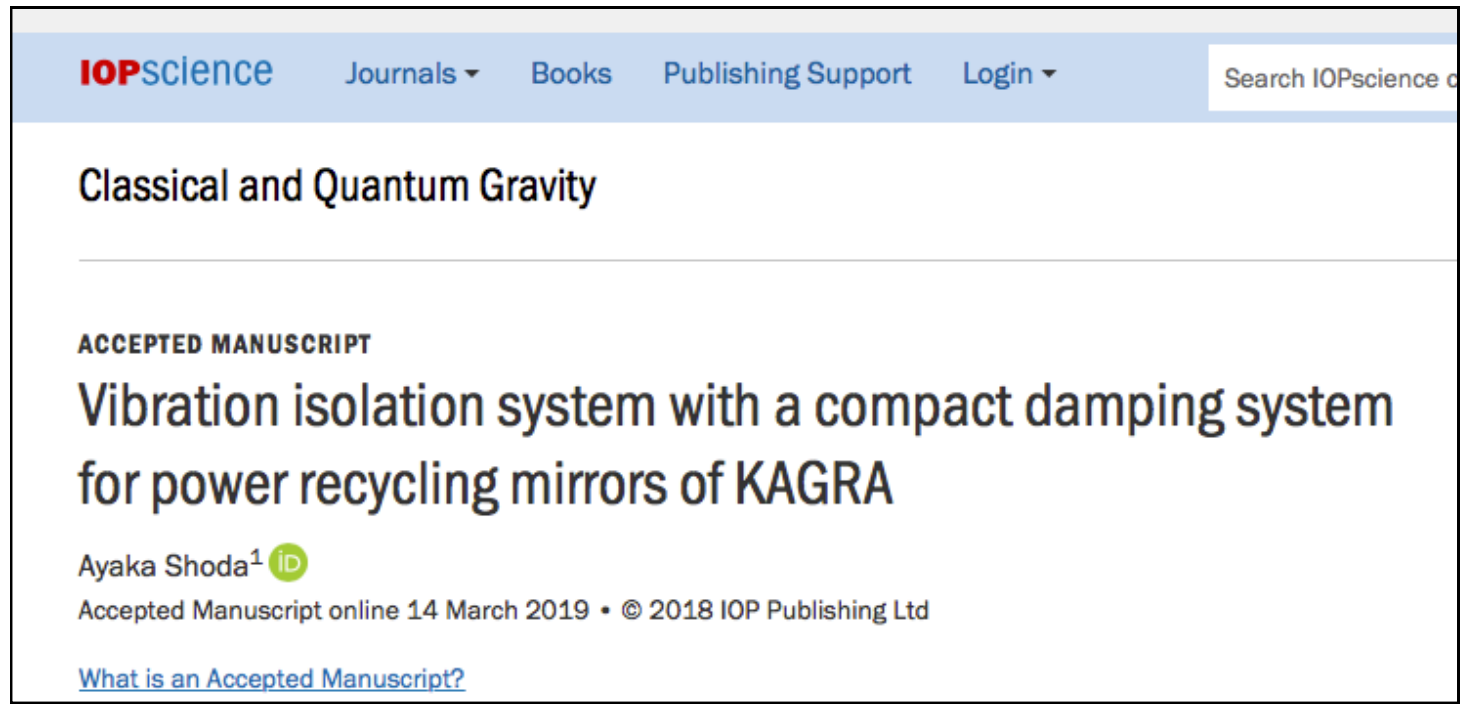
IOP Publishing | Classical and Quantum Gravity

Class. Quantum Grav. **36** (2019) 165008 (22pp) https://doi.org/10.1088/1361-6382/ab28a9

First cryogenic test operation of underground km-scale gravitational-wave observatory KAGRA

CQG 36 (2019) 165008
[arXiv:1901.03569]

phase-1 operation (2018)



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Classical and Quantum Gravity

ACCEPTED MANUSCRIPT

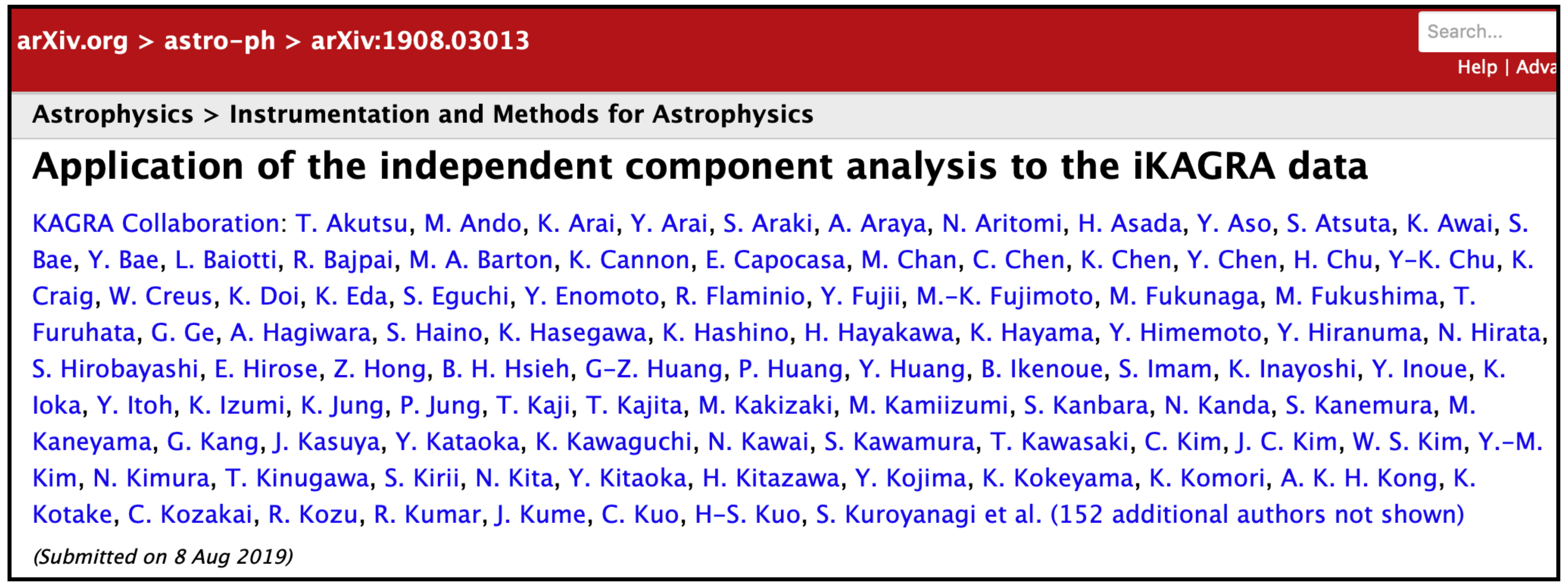
Vibration isolation system with a compact damping system for power recycling mirrors of KAGRA

Ayaka Shoda[1]

Accepted Manuscript online 14 March 2019 • © 2018 IOP Publishing Ltd

What is an Accepted Manuscript?

Class. Quant. Grav. 36 (2019) 095015
[arXiv:1901.03053] Vibration isolation



arXiv.org > astro-ph > arXiv:1908.03013

Search... | Help | Adva

Astrophysics > Instrumentation and Methods for Astrophysics

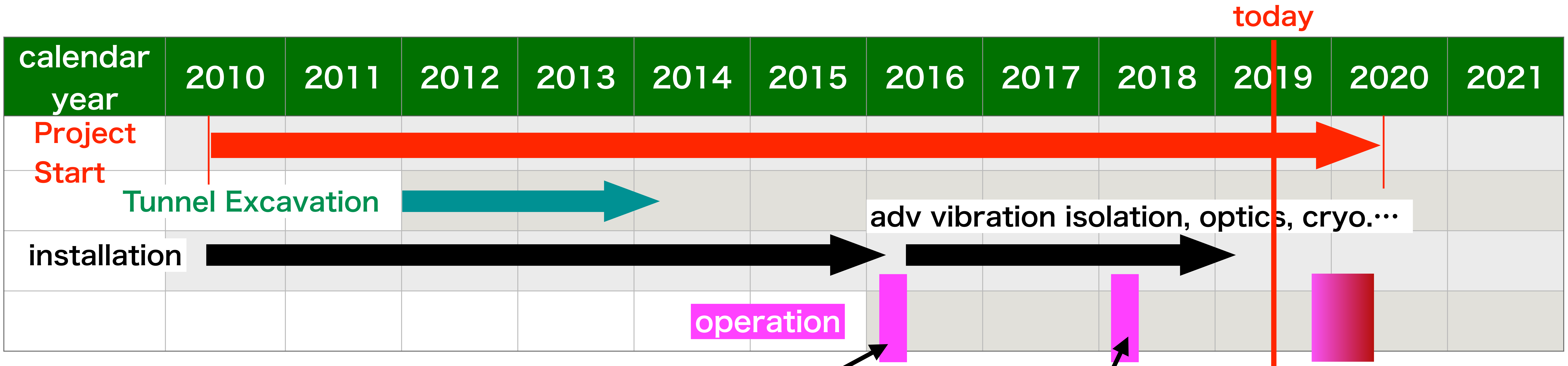
Application of the independent component analysis to the iKAGRA data

KAGRA Collaboration: T. Akutsu, M. Ando, K. Arai, Y. Arai, S. Araki, A. Araya, N. Aritomi, H. Asada, Y. Aso, S. Atsuta, K. Awai, S. Bae, Y. Bae, L. Baiotti, R. Bajpai, M. A. Barton, K. Cannon, E. Capocasa, M. Chan, C. Chen, K. Chen, Y. Chen, H. Chu, Y-K. Chu, K. Craig, W. Creus, K. Doi, K. Eda, S. Eguchi, Y. Enomoto, R. Flaminio, Y. Fujii, M.-K. Fujimoto, M. Fukunaga, M. Fukushima, T. Furuhata, G. Ge, A. Hagiwara, S. Haino, K. Hasegawa, K. Hashino, H. Hayakawa, K. Hayama, Y. Himemoto, Y. Hiranuma, N. Hirata, S. Hirobayashi, E. Hirose, Z. Hong, B. H. Hsieh, G-Z. Huang, P. Huang, Y. Huang, B. Ikenoue, S. Imam, K. Inayoshi, Y. Inoue, K. Ioka, Y. Itoh, K. Izumi, K. Jung, P. Jung, T. Kaji, T. Kajita, M. Kakizaki, M. Kamiizumi, S. Kanbara, N. Kanda, S. Kanemura, M. Kaneyama, G. Kang, J. Kasuya, Y. Kataoka, K. Kawaguchi, N. Kawai, S. Kawamura, T. Kawasaki, C. Kim, J. C. Kim, W. S. Kim, Y.-M. Kim, N. Kimura, T. Kinugawa, S. Kirii, N. Kita, Y. Kitaoka, H. Kitazawa, Y. Kojima, K. Kokeyama, K. Komori, A. K. H. Kong, K. Kotake, C. Kozakai, R. Kozu, R. Kumar, J. Kume, C. Kuo, H-S. Kuo, S. Kuroyanagi et al. (152 additional authors not shown)

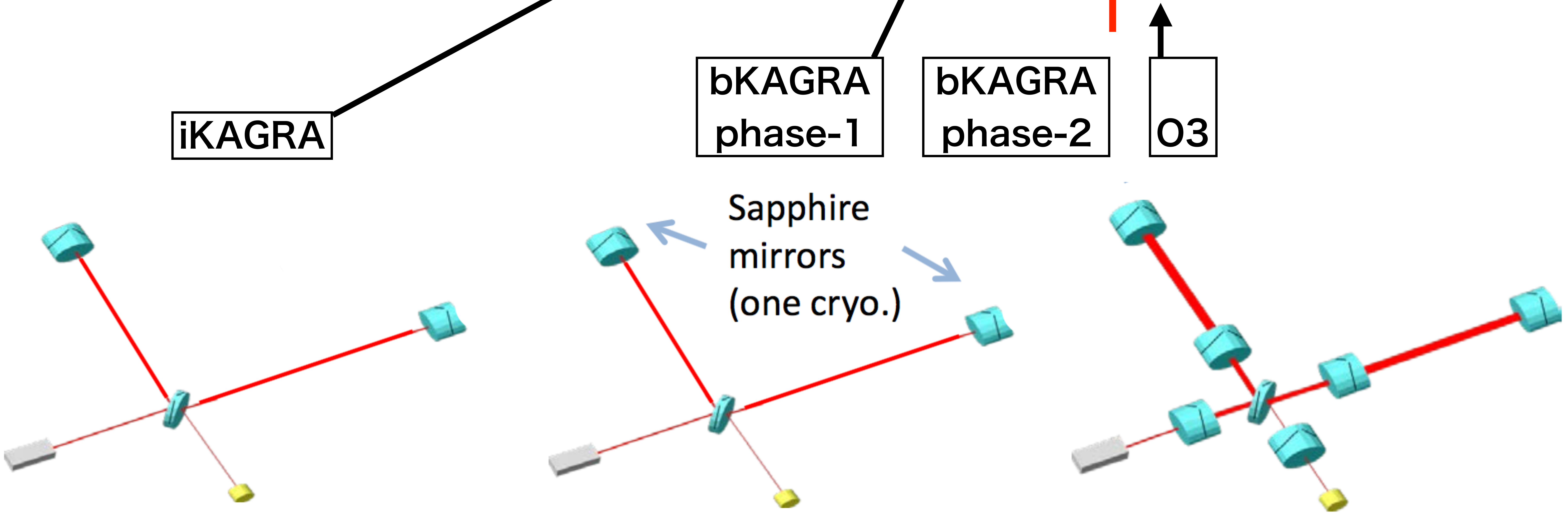
(Submitted on 8 Aug 2019)

submitted to PTEP [arXiv:1908.03013] [JGW-P1910218]
iKAGRA data analysis

Brief History of KAGRA



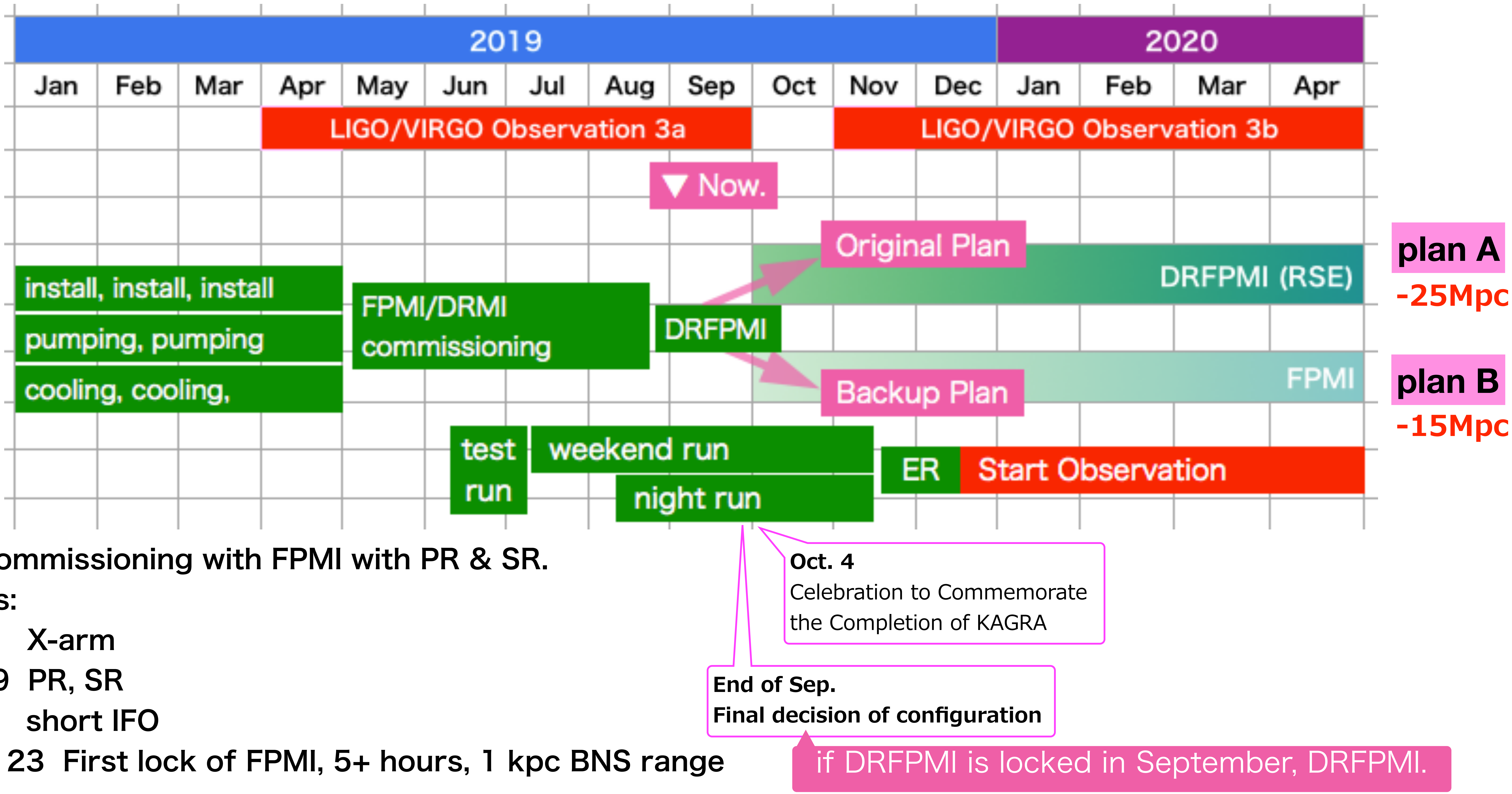
iKAGRA = initial KAGRA
bKAGRA = baseline KAGRA



[arXiv:1712.00148]

[arXiv:1901.03569]

On-going schedule

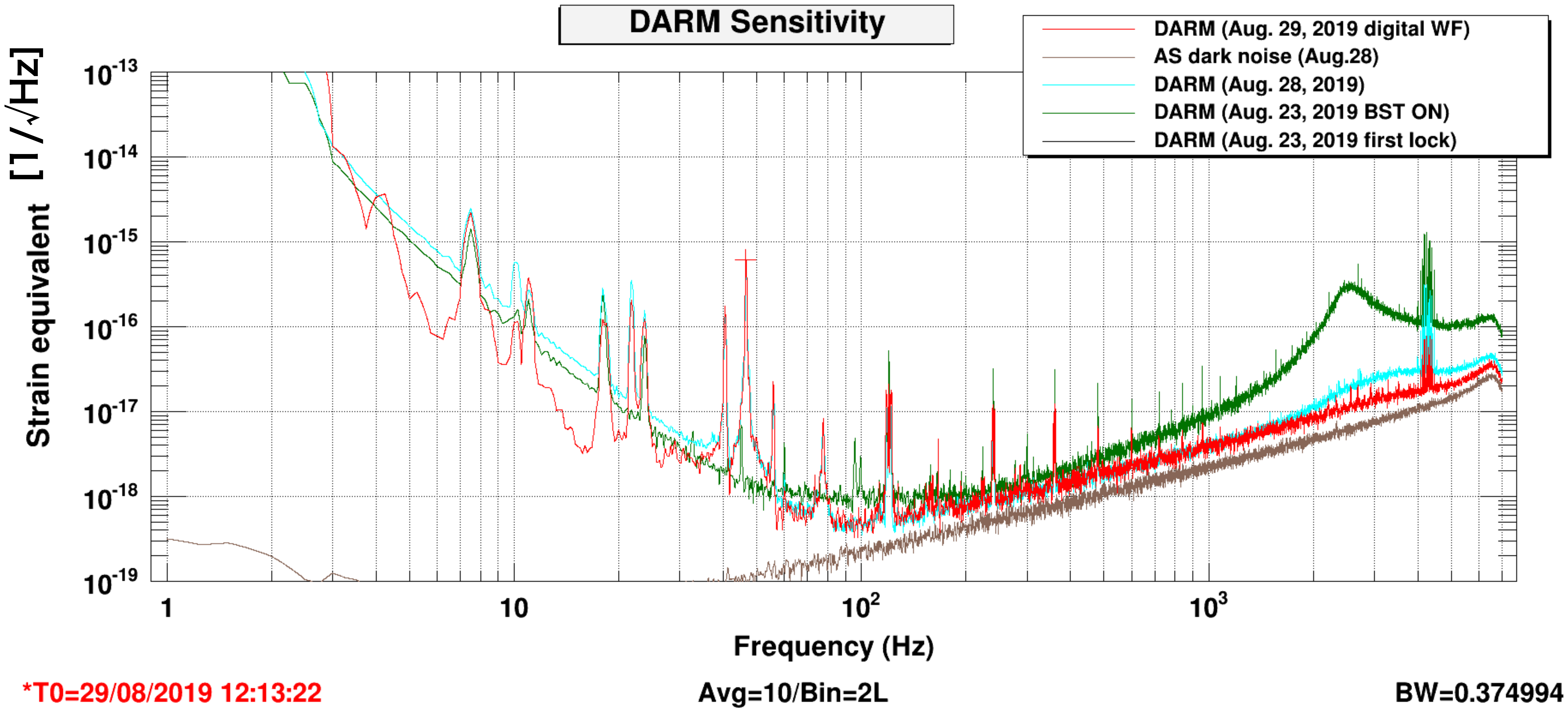


We are commissioning with FPMI with PR & SR.

Test Runs:

- June 6 X-arm
- June 19 PR, SR
- July 13 short IFO
- August 23 First lock of FPMI, 5+ hours, 1 kpc BNS range

August 23 First lock of FPMI automated, 5+ hours, 1 kpc BNS range



We appreciate contributions of **Stefan Ballmer, Valery Frolov, Keita Kawabe** (July & August), **Jenne Driggers, Stefan Ballmer, Rana Adhikari** (September) at KAGRA on-site.

Current Concerning Issues

* **Asymmetry of Finesse** (～10%) due to difference of transmissivity of ITMx & ITMy

→ OK for O3, to be fixed by O4

* **Polarization (sapphire birefringence)** due to inhomogeneity of ITMx & ITMy

→ low PR & SR gain, no replacements for O3. May be the same in O4.

* **Frosting of Mirrors** due to incompleteness of vacuum

→ re-heat, outgas, and re-cool

* **Refrigerator maintenance cycle** (Mean Time Between Failure) is shorter than expected

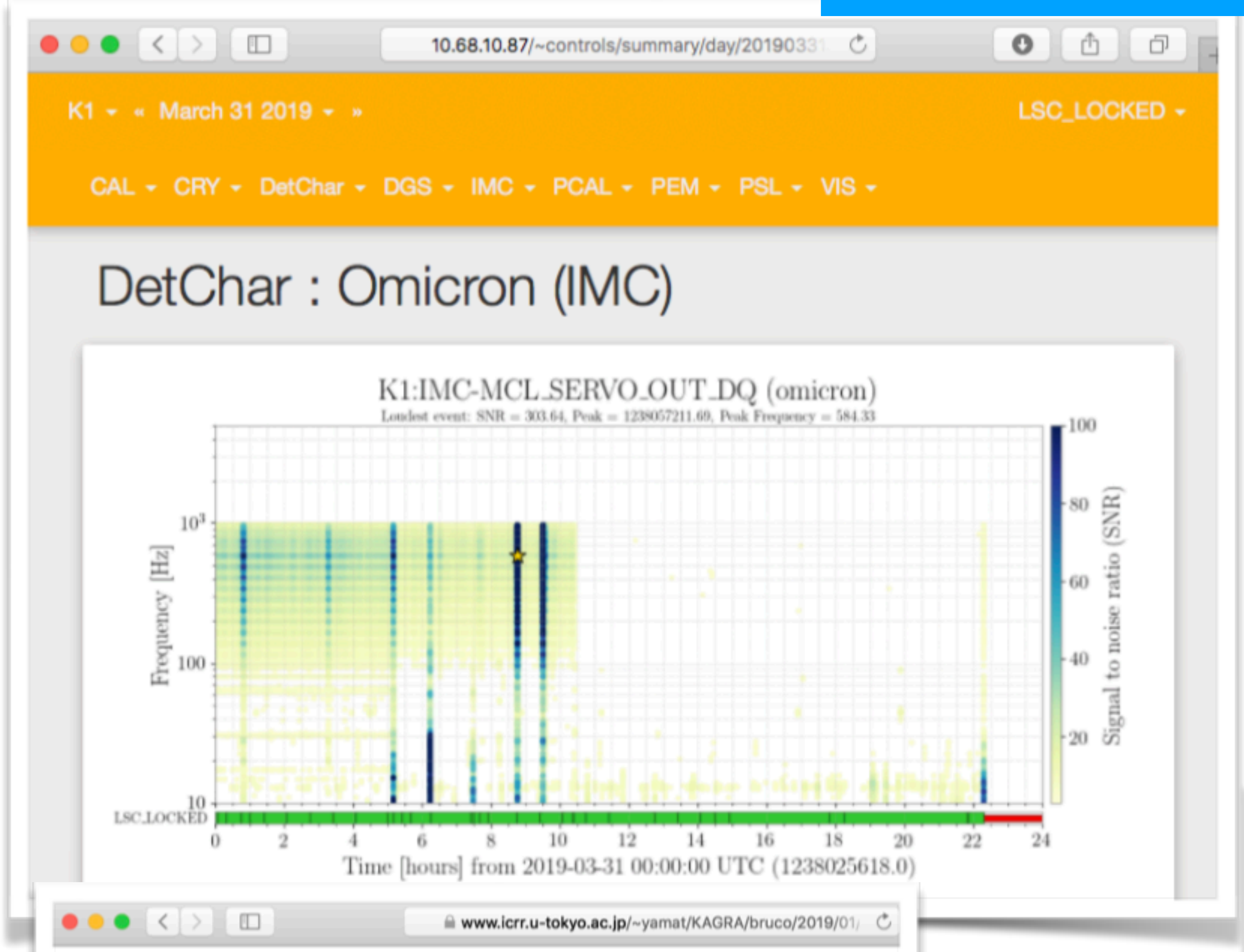
→ thermal shield valves, every two weeks, $ 5K

* **Type A Suspensions** (ITMs ETMs) requires stabilazation circuit

→ requires better damping servos

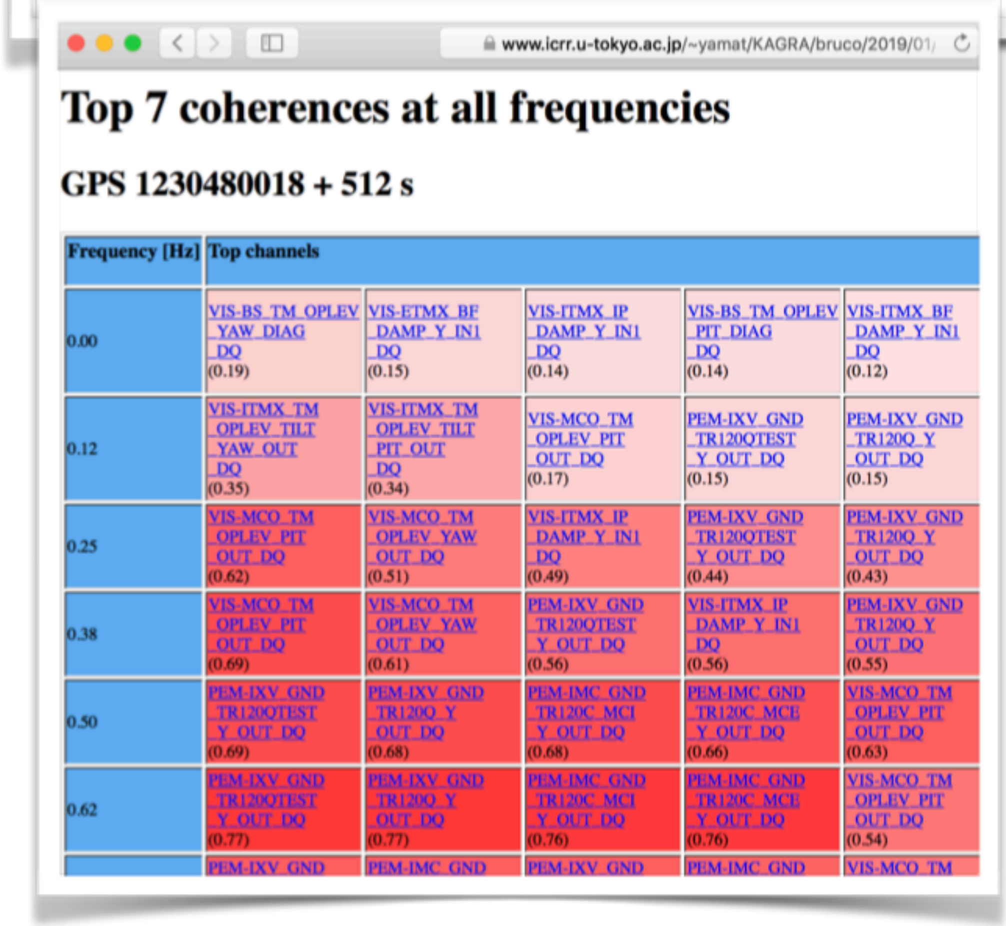
Commissioning tools

LV DetChar tools

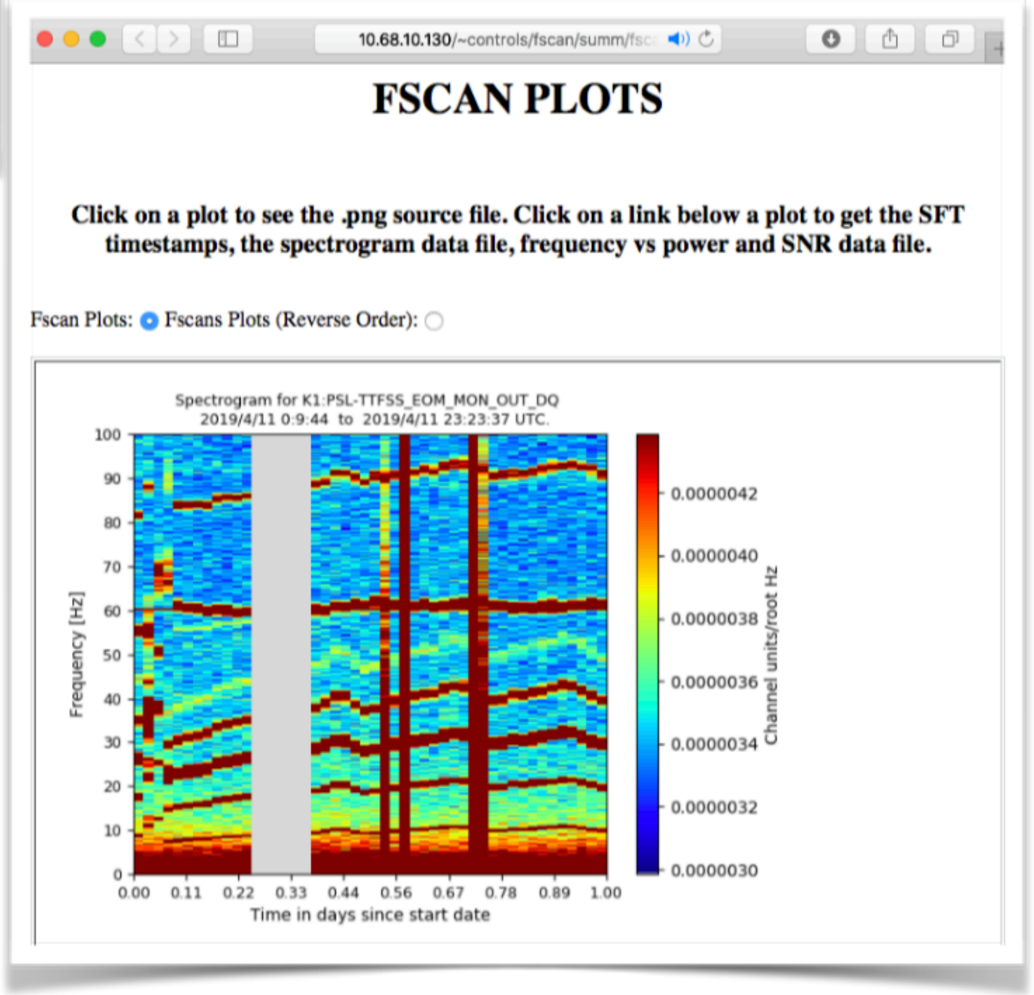


Glitch trigger generation (Omicron)

Diagnostics Test Tool (DiagGui)

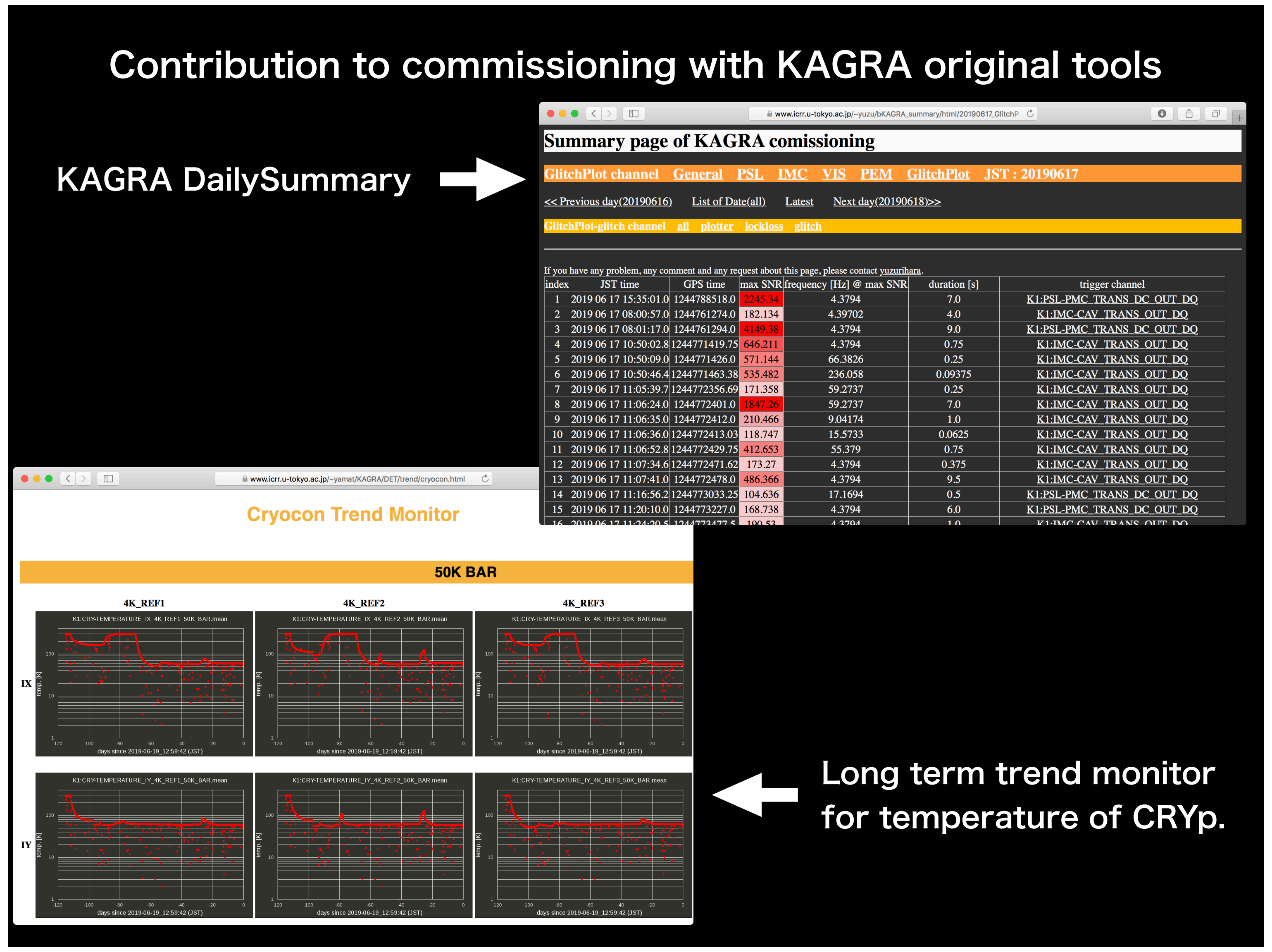


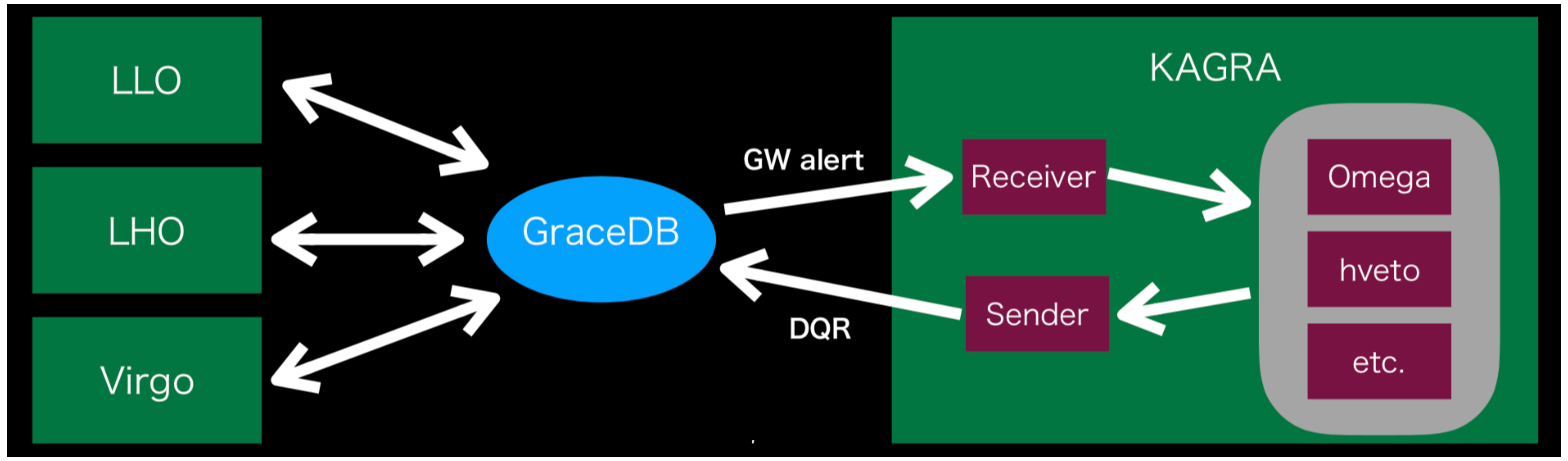
Coherence search (Bruco)



Spectral Line identification (Fscan)

KAGRA original tools





by T. Yamamoto

We appreciate contributions of **Joseph Areeda, Nicolas Arnaud, Andrew Lundgren, Duncan MacLeod, Florent Robinet, Siddharth Soni, Alex Urban** at KAGRA on-site.

Data-exchange tests with low latency

Low Latency h(t) transfer

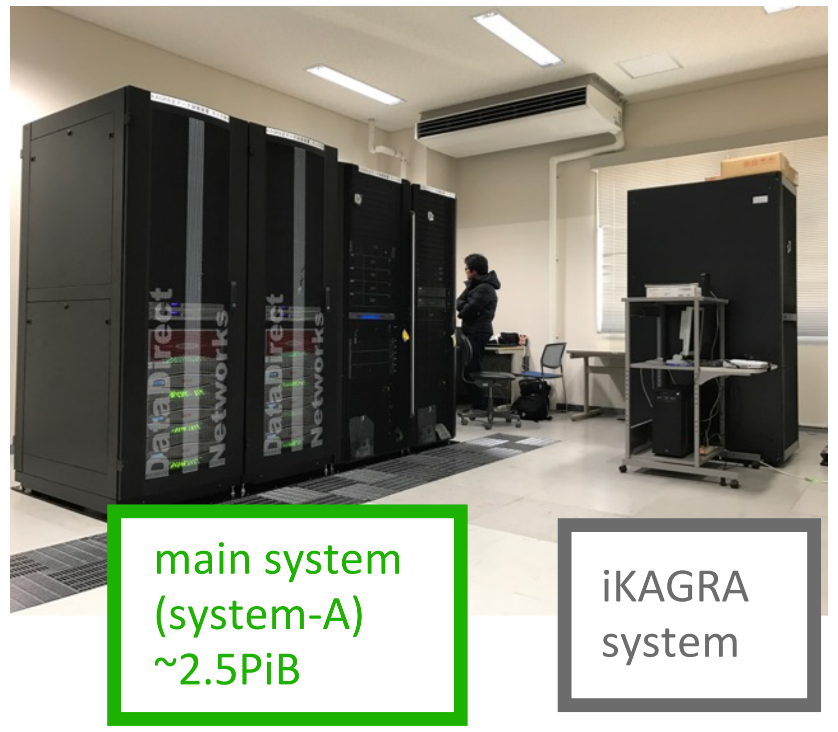
KAGRA tunnel —> the surface —> Kashiwa server : 3 sec

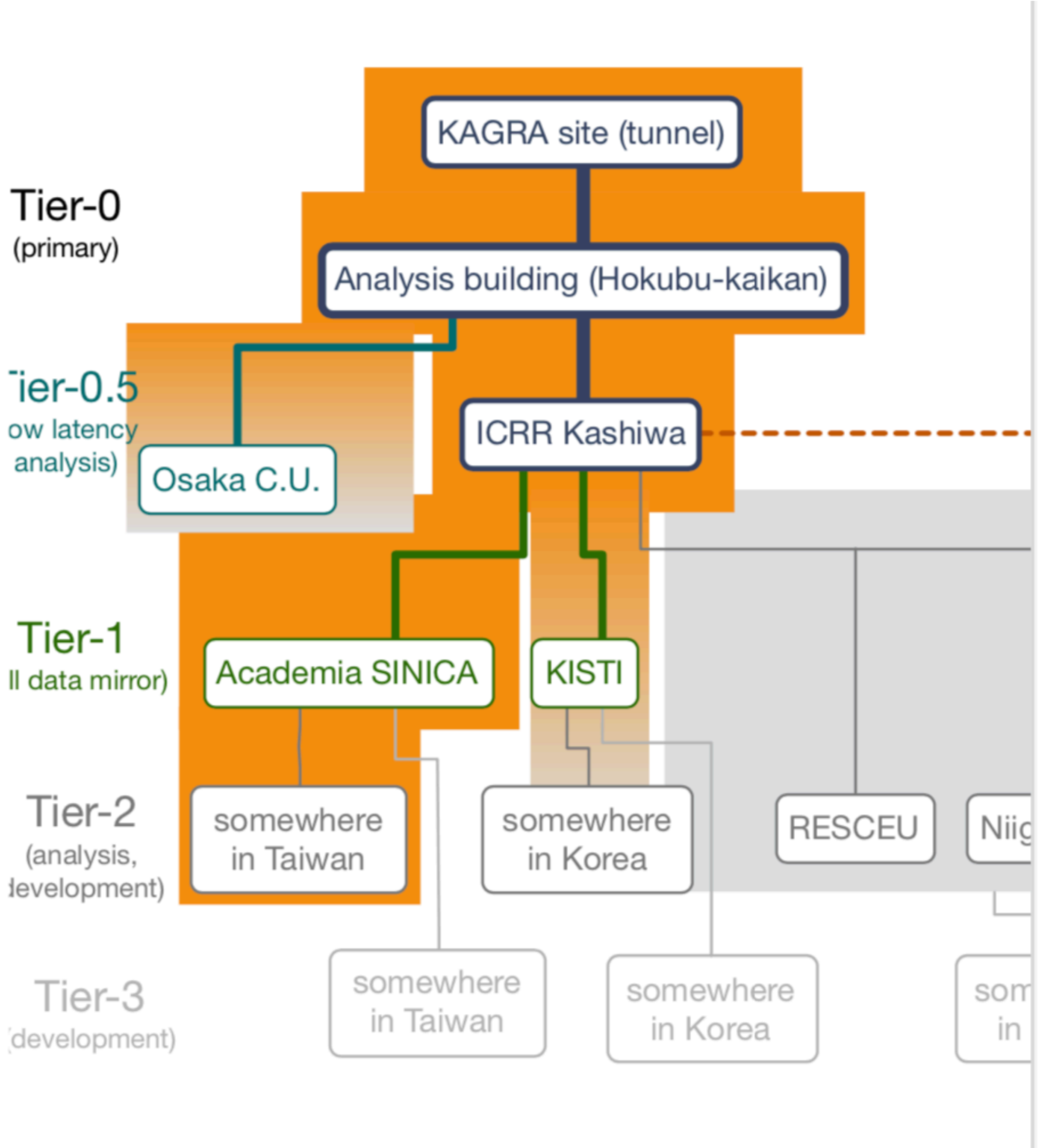
Low Latency connection with LV

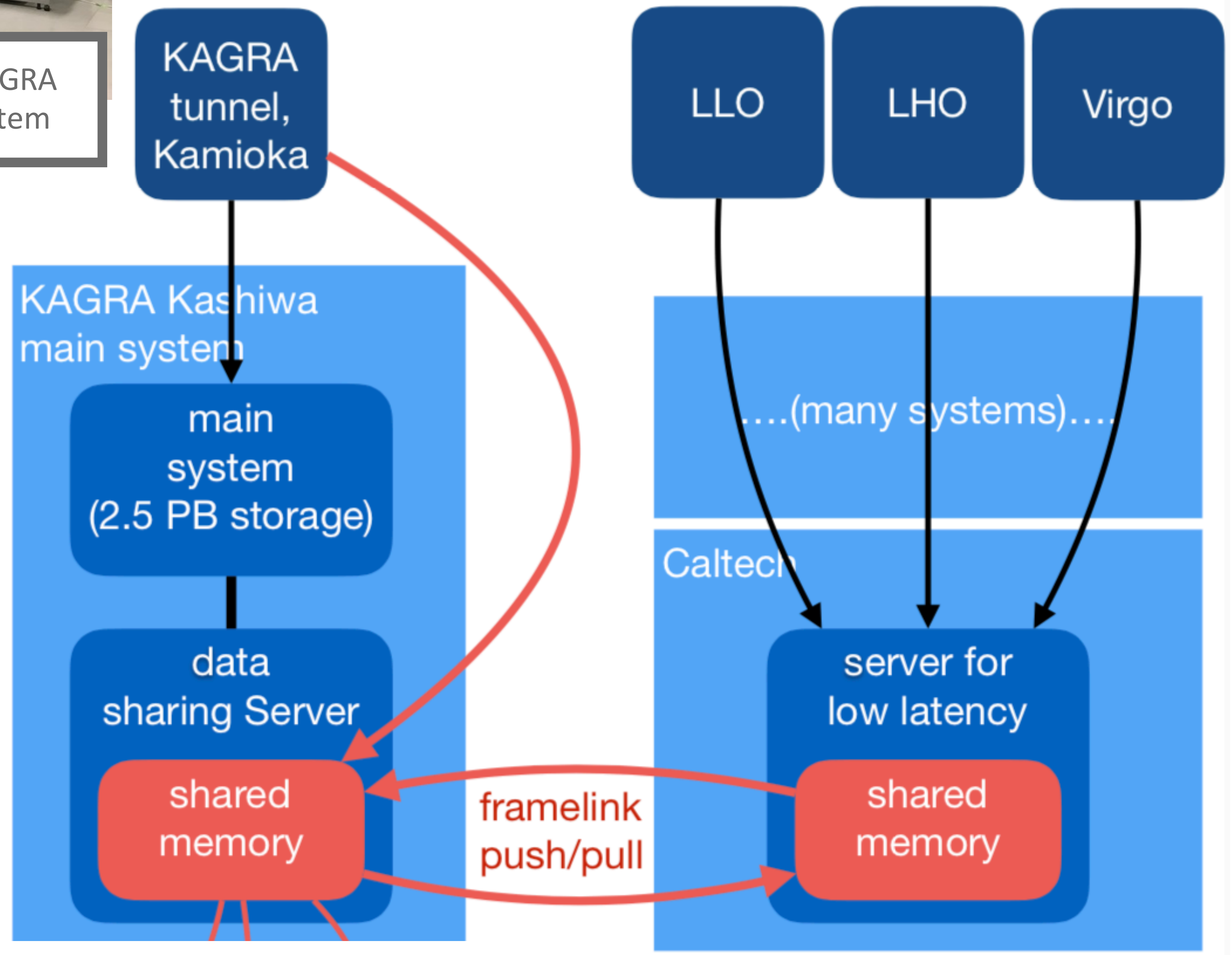
LHO/LLO —> Caltech —> Kashiwa : 6-14 sec

Virgo —> Caltech —> Kashiwa : 10-16 sec

(time includes reconstruction)







by N. Kanda

LV data distribution to Tier-x level will be monitored by Tier-site managers.

JPRC (Joint Run Planning Commitee)　KAGRA's contribution in O3 (report draft)

KAGRA

KAGRA focused week: June 6 & August 1

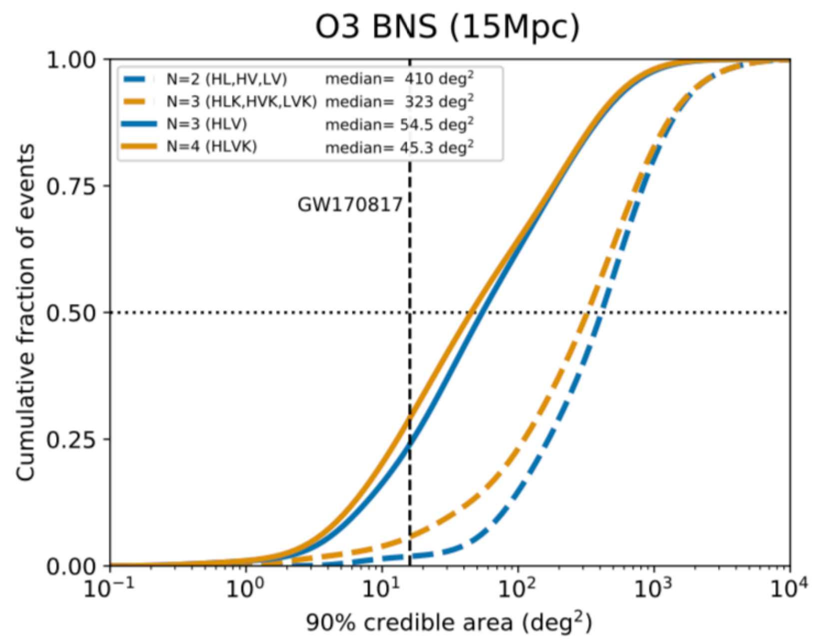
https://wiki.ligo.org/LSC/JRPComm/Agenda2019Jun06
https://wiki.ligo.org/LSC/JRPComm/Agenda2019Aug01

LVC-KAGRA taskforce term report (draft)　**JGW-T1910330**

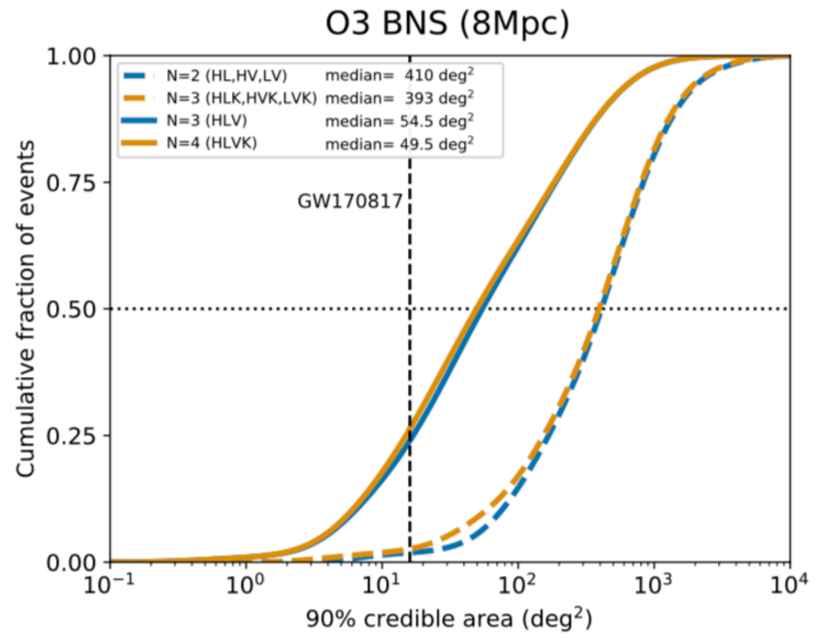
LVC-KAGRA taskforce

Yoshio Saito (KAGRA - leader, project manager)
Hideyuki Tagoshi (KAGRA - Data analysis)
Takahiro Yamamoto (KAGRA - Calibration)
Osamu Miyakawa (KAGRA - commissioning)
Hisaaki Shinkai (KAGRA - MoU)
Sadakazu Haino (KAGRA data analysis)

Steve Fairhurst (LSC)
Patricia Schmidt (LSC)
Leo Singer (LSC)
Marie Anne Bizouard (Virgo)
Helios Vocca (Virgo)



(b) BNS (KAGRA's Range: 15 Mpc)



(c) BNS (KAGRA's Range: 8 Mpc)

◀ **How much source localization is improved.**

▼

(a) KAGRA's BNS range: 25 Mpc

Source	(HL, HV, LV)	(HLK, HVK, LVK)	HLV	HLVK
BBH	607	336	79.2	57
NSBH	682	384	90.2	67.9
BNS	410	215	54.5	35.3

(b) KAGRA's BNS range: 15 Mpc

Source	(HL, HV, LV)	(HLK, HVK, LVK)	HLV	HLVK
BBH	545	447	68.1	53.8
NSBH	614	482	75.2	60.5
BNS	410	323	54.5	45.3

(c) KAGRA's BNS range: 8 Mpc

Source	(HL, HV, LV)	(HLK, HVK, LVK)	HLV	HLVK
BBH	545	525	68.1	65.4
NSBH	614	567	75.2	68.3
BNS	410	393	54.5	49.5

Table 1: The median of the distribution of 90%-credible region of the source localization. All values are in the unit of deg^2.

How much multi-detector duty-cycle is improved.

probability calculation

Table 4: Observing duty cycles as of July 31, 2019. [5]

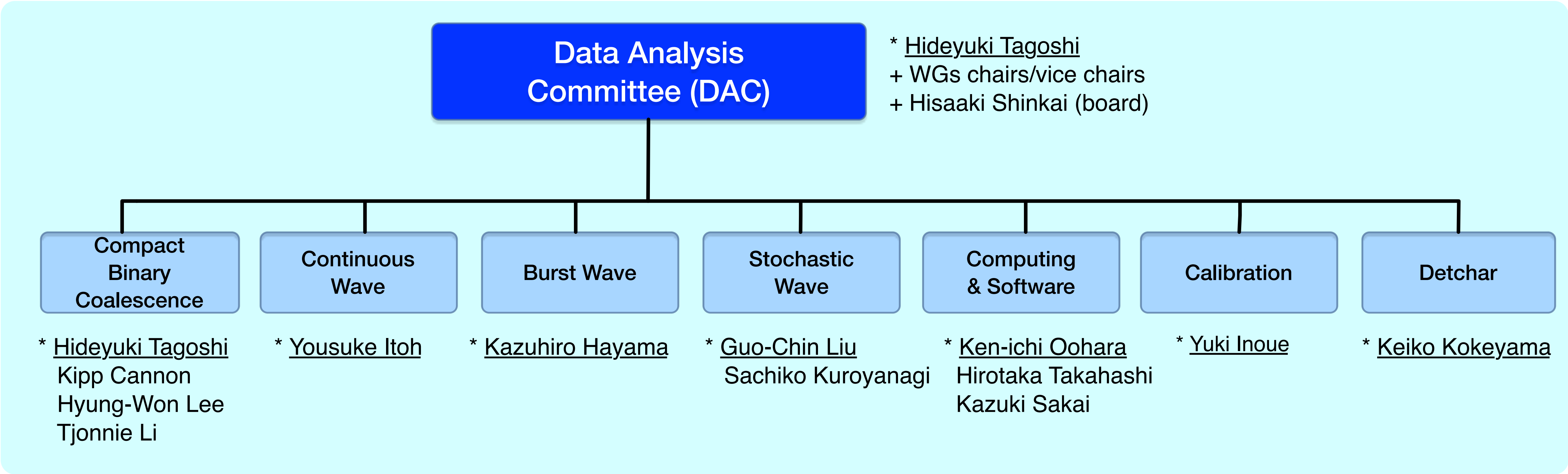
	H1	L1	V1
Observing	69.7 %	72.9 %	76.4 %
Ready	0.8 %	0.4 %	
Locked	3.3 %	3.7 %	5.7 %
Not locked	26.2 %	23.0 %	17.9 %

	actual	estimated
Triple	42.7 %	38.8 %
Double	37.2 %	45.7 %
Single	16.2 %	15.9 %
No interferometer	3.9 %	1.9 %

Table 5: Estimation of the observing duty cycles for several cases of that of KAGRA (P_K), using $P_H^{O3} = 0.697, P_L^{O3} = 0.729$, and $P_V^{O3} = 0.764$ (the numbers of H1/L1/V1 of July 31, 2019).

P_K	0.4	0.5	0.6	0.7	0.8	0.9
Quadra	15.5 %	19.4 %	23.2 %	27.2 %	31.1 %	34.9 %
Triple	40.6 %	41.1 %	41.5 %	42.0 %	42.4 %	42.9 %
with K	17.3	21.6	26.0	30.3	34.7	39.0
w/o K	23.3	19.4	15.5	11.6	7.8	3.9
Double	32.4 %	29.6 %	26.9 %	24.1 %	21.4 %	18.7 %
with K	6.4	8.0	9.6	11.2	12.8	14.3
w/o K	26.0	21.7	17.3	13.0	8.7	4.3
Single	10.3 %	8.9 %	7.5 %	6.1 %	4.7 %	3.3 %
No interferometer	1.2 %	1.0 %	0.8 %	0.6 %	0.4 %	0.2 %

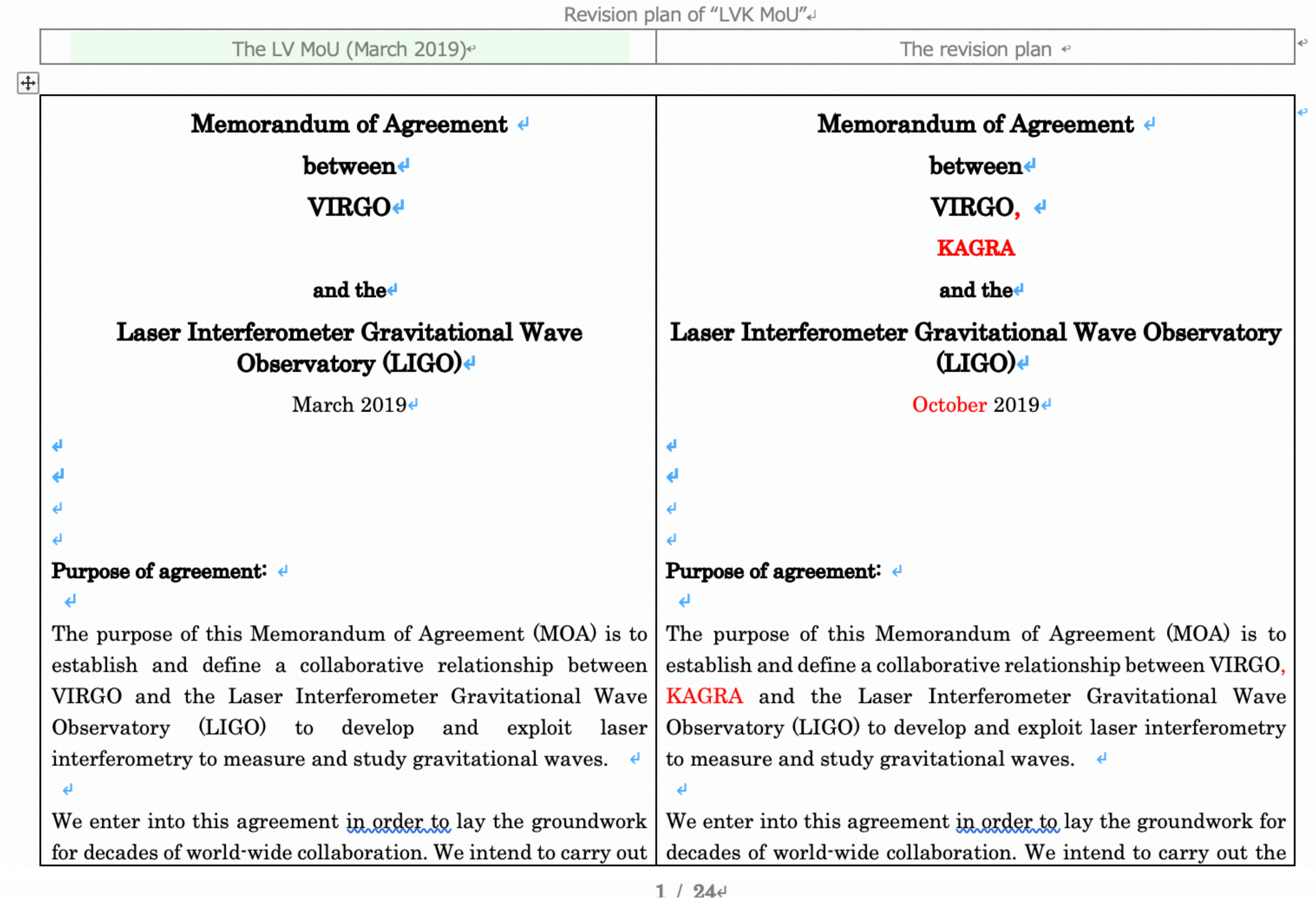
publication plan O3b , white paper 2019 MoA round table



LV-DAC white paper 2019 ◀ **at least 3 new proposals from KAGRA-CBC**

LV-DAC publication plan O3b

Ringdown search
BH echo search
test of massive gravity

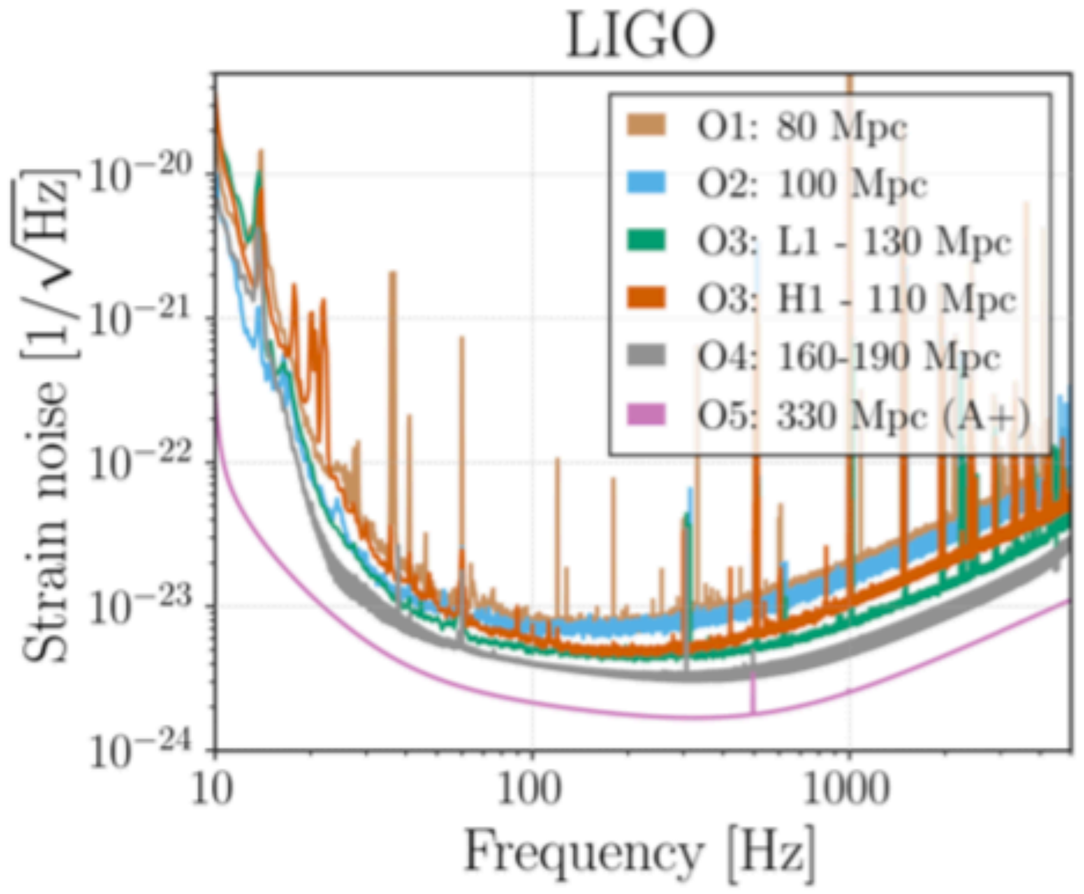


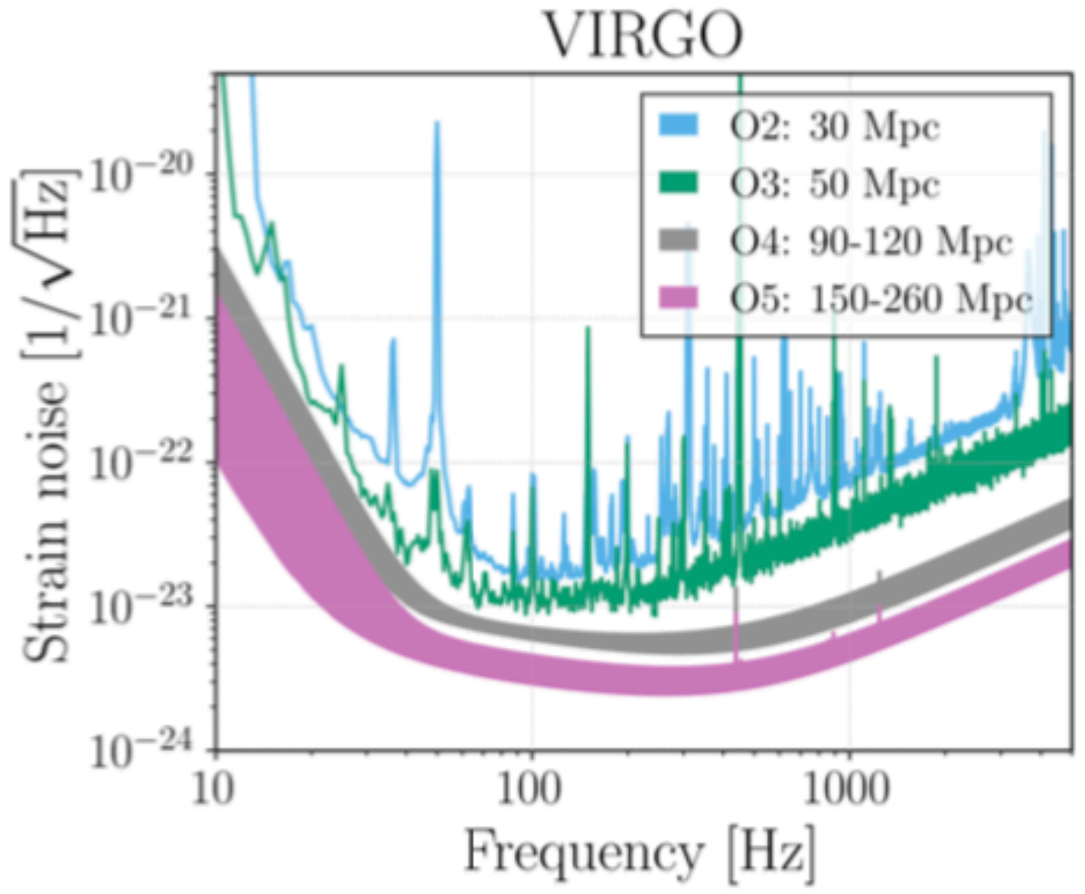
Revision plan of "LVK MoU"

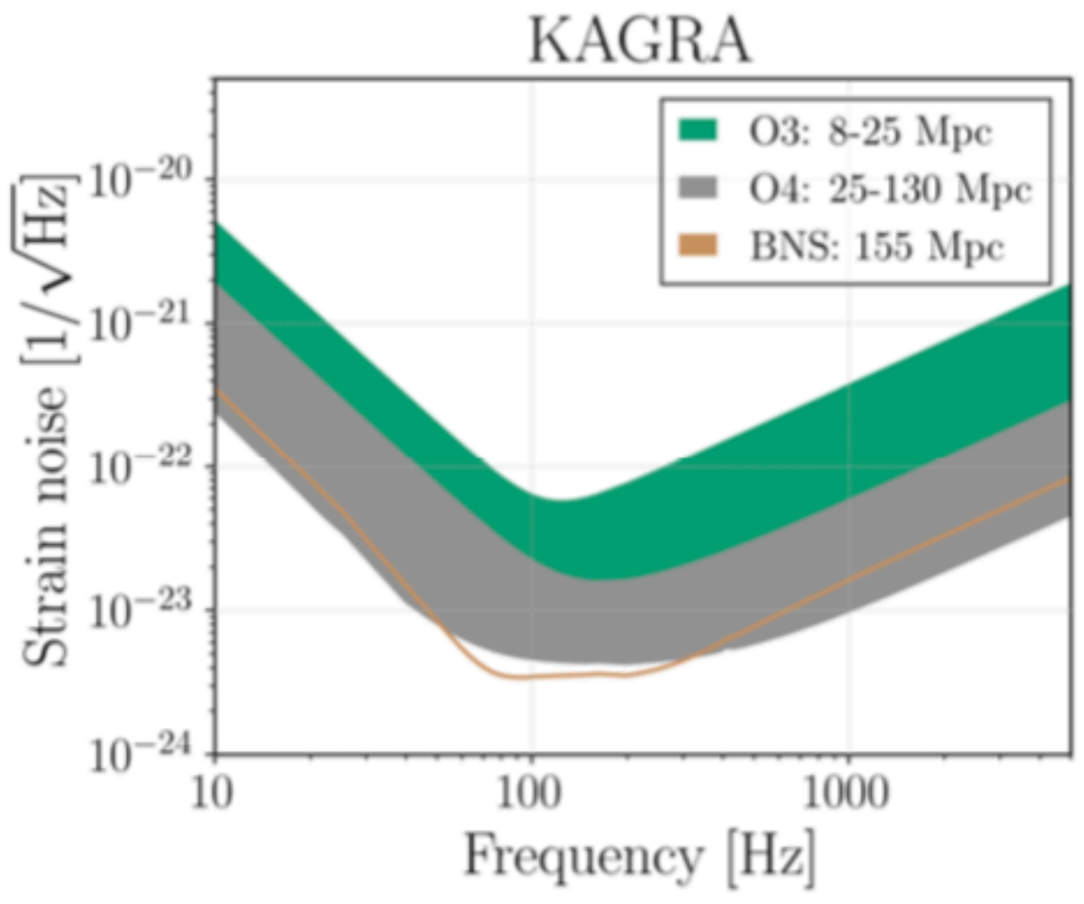
The LV MoU (March 2019)	The revision plan
Memorandum of Agreement **between** **VIRGO** **and the** **Laser Interferometer Gravitational Wave Observatory (LIGO)** March 2019 **Purpose of agreement:** The purpose of this Memorandum of Agreement (MOA) is to establish and define a collaborative relationship between VIRGO 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	**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

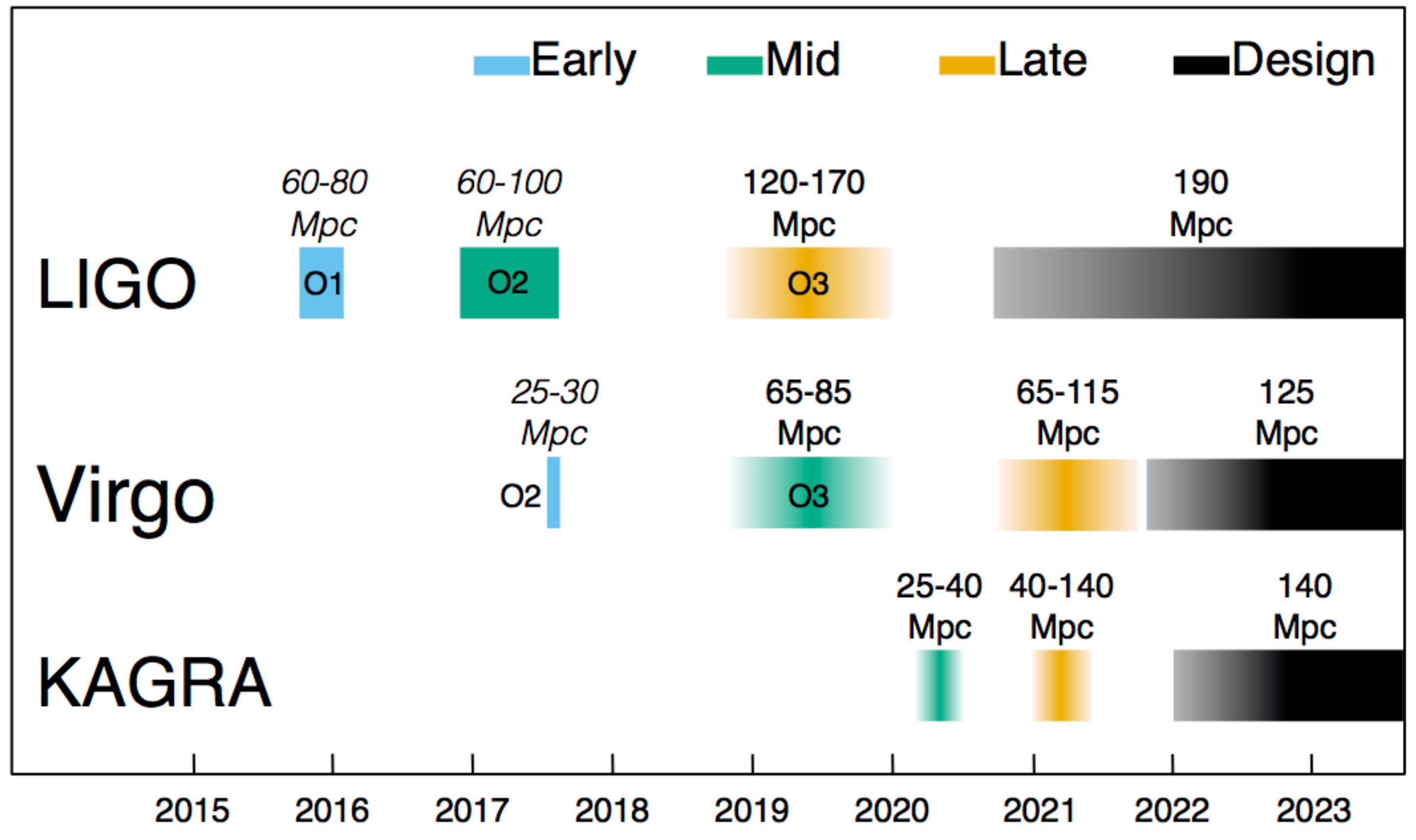
1 / 24

Target Sensitivity & Schedule



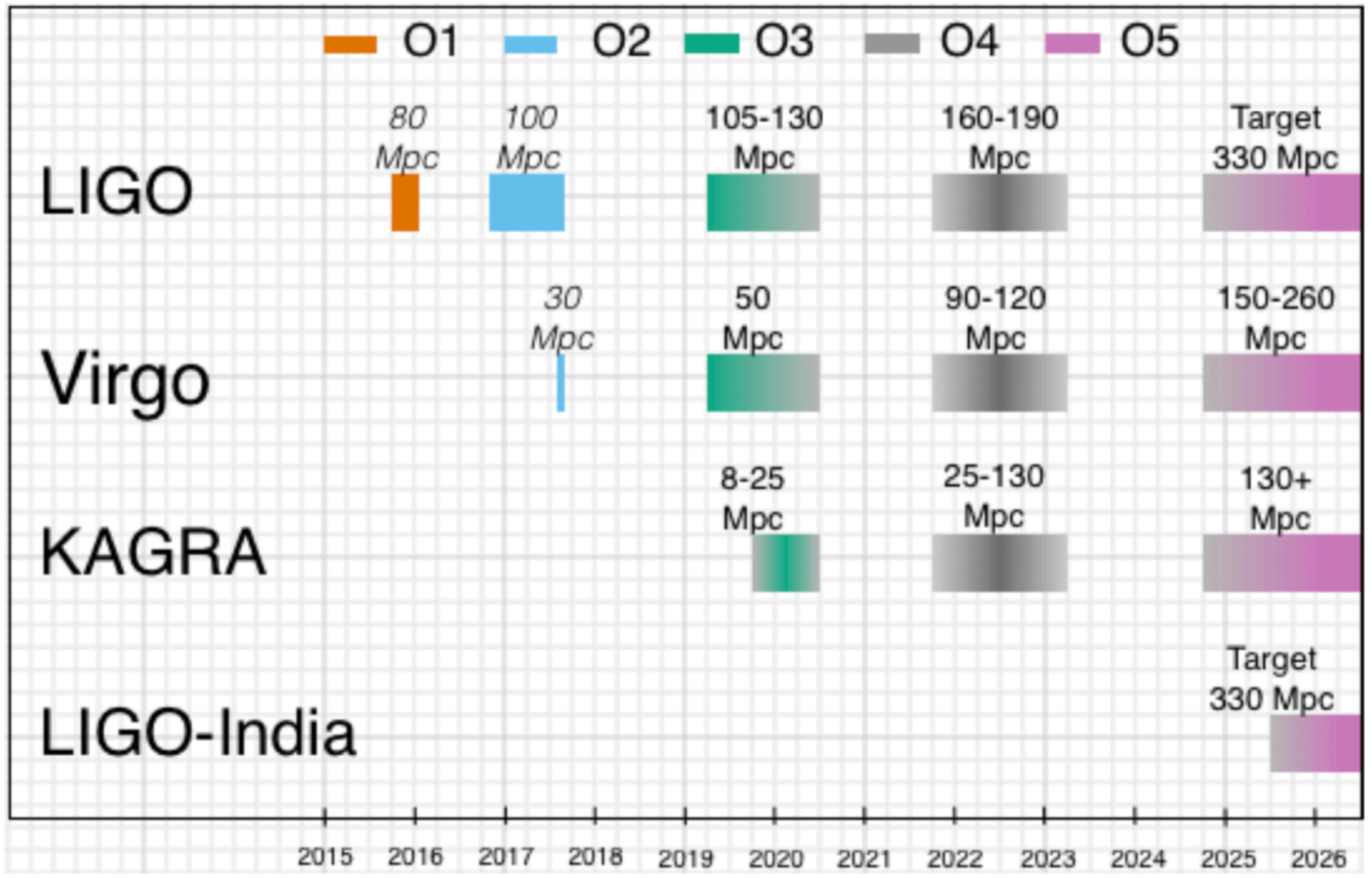






[1304.0670v4]

https://dcc.ligo.org/LIGO-P1900218/public



"Scenario Paper"

Living Rev Relativ (2018) 21:3

https://doi.org/10.1007/s41114-018-0012-9

[1304.0670v4]

Status of KAGRA: Summary

KAGRA

- ◆ Now trials with DRFPMI. Final configuration will be decided soon.
- ◆ **KAGRA plans to join LV Observation Run 3 from the end of 2019.**
- ◆ Towards MoA with LIGO/Virgo, the round table discussion is ongoing in this LVC meeting.

- ◆ KAGRA-LV data exchange started.
- ◆ KAGRA-LV data analysis groups meetings has started.
- ◆ KAGRA plans to join O4 from the beginning.

KAGRA appreciates the community's warm welcomes.

back up slides