

# Status of KAGRA



- ◆ **Underground** and **Cryogenic** interferometric 3 km gravitational-wave detector at Kamioka, Japan
- ◆ KAGRA signed MoA with LIGO/Virgo, October 2019.
- ◆ **KAGRA runs as PR-FPMI, under final noise-hunting for joining O3.**

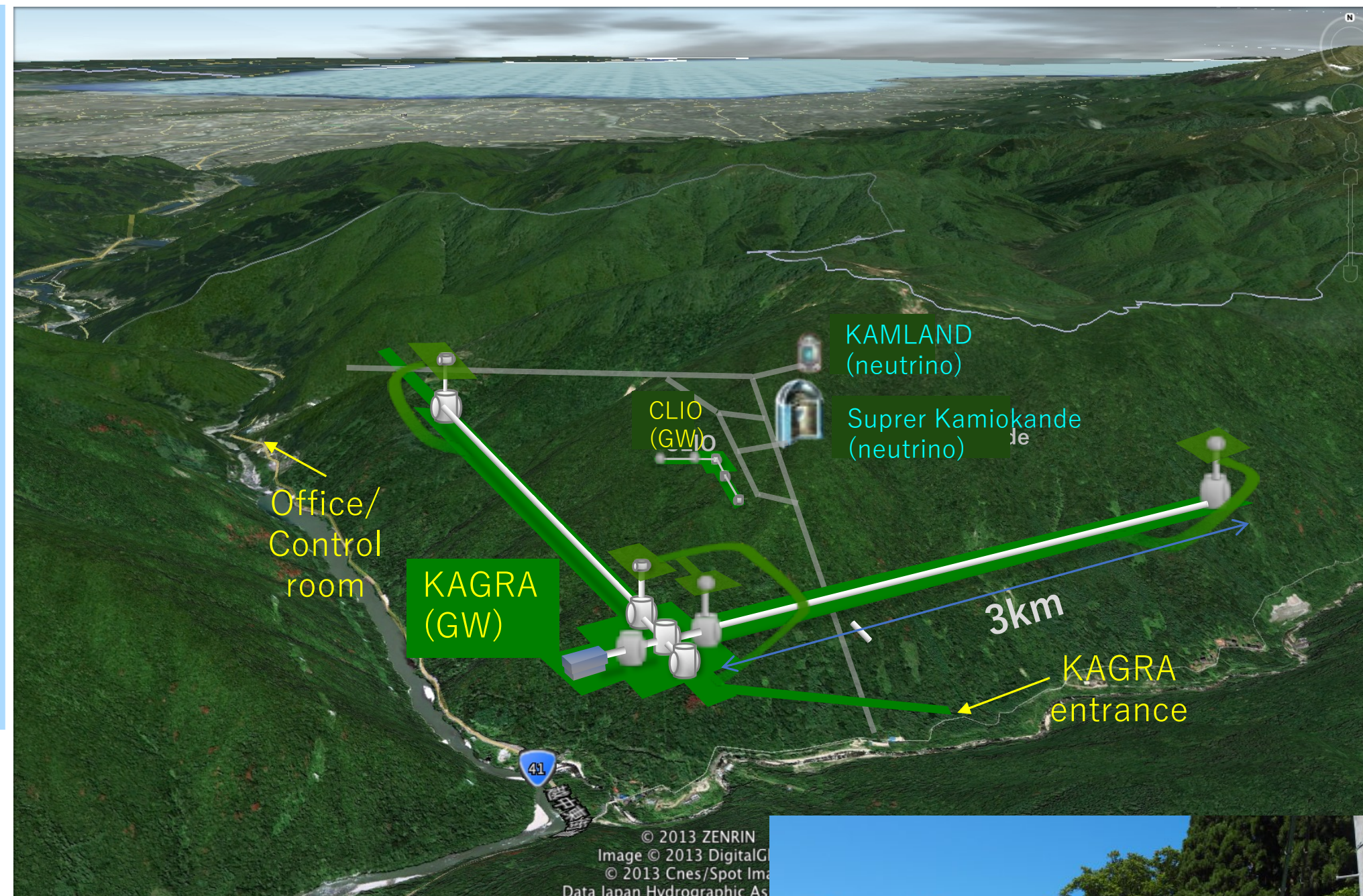


fig. by Osamu Miyakawa



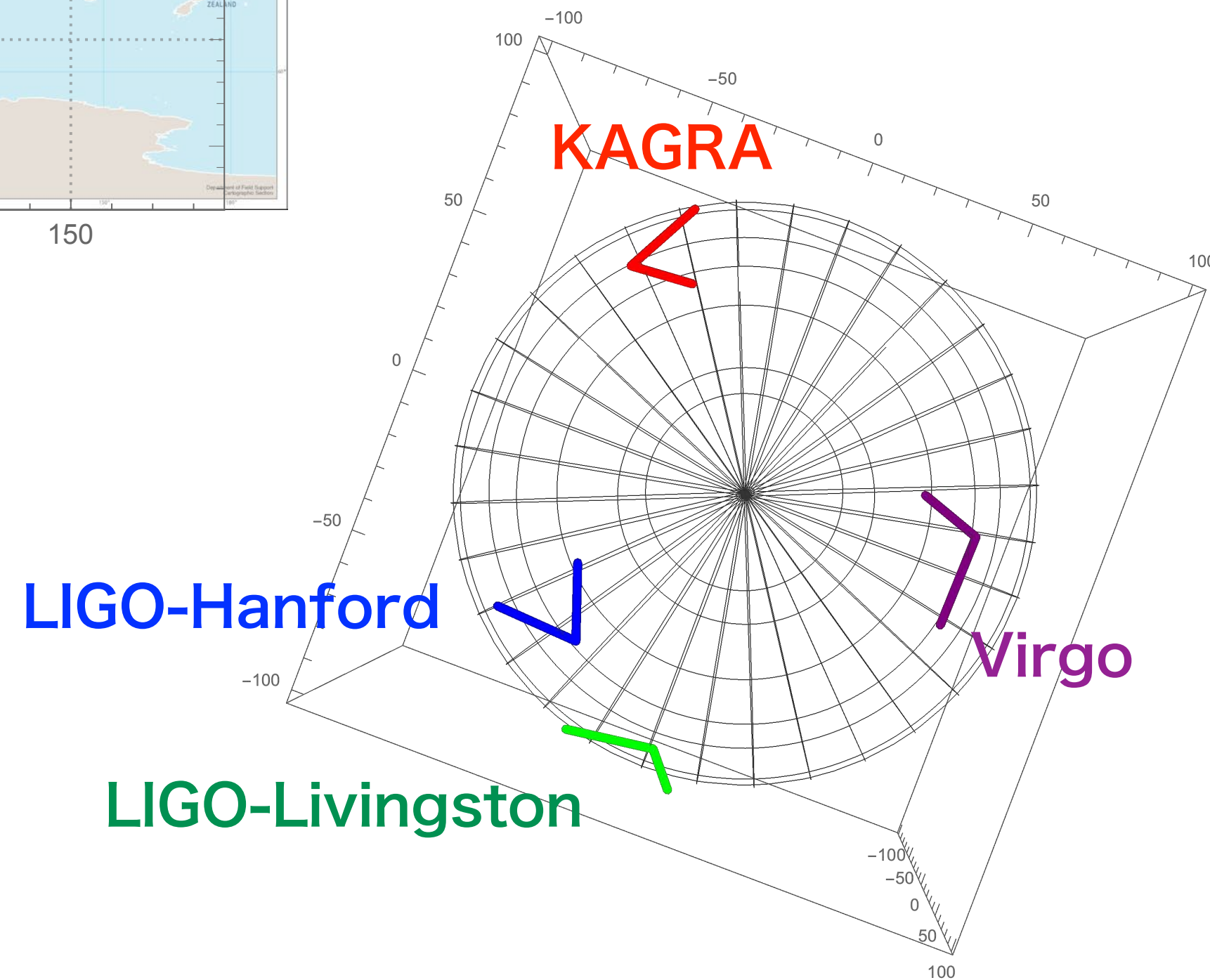
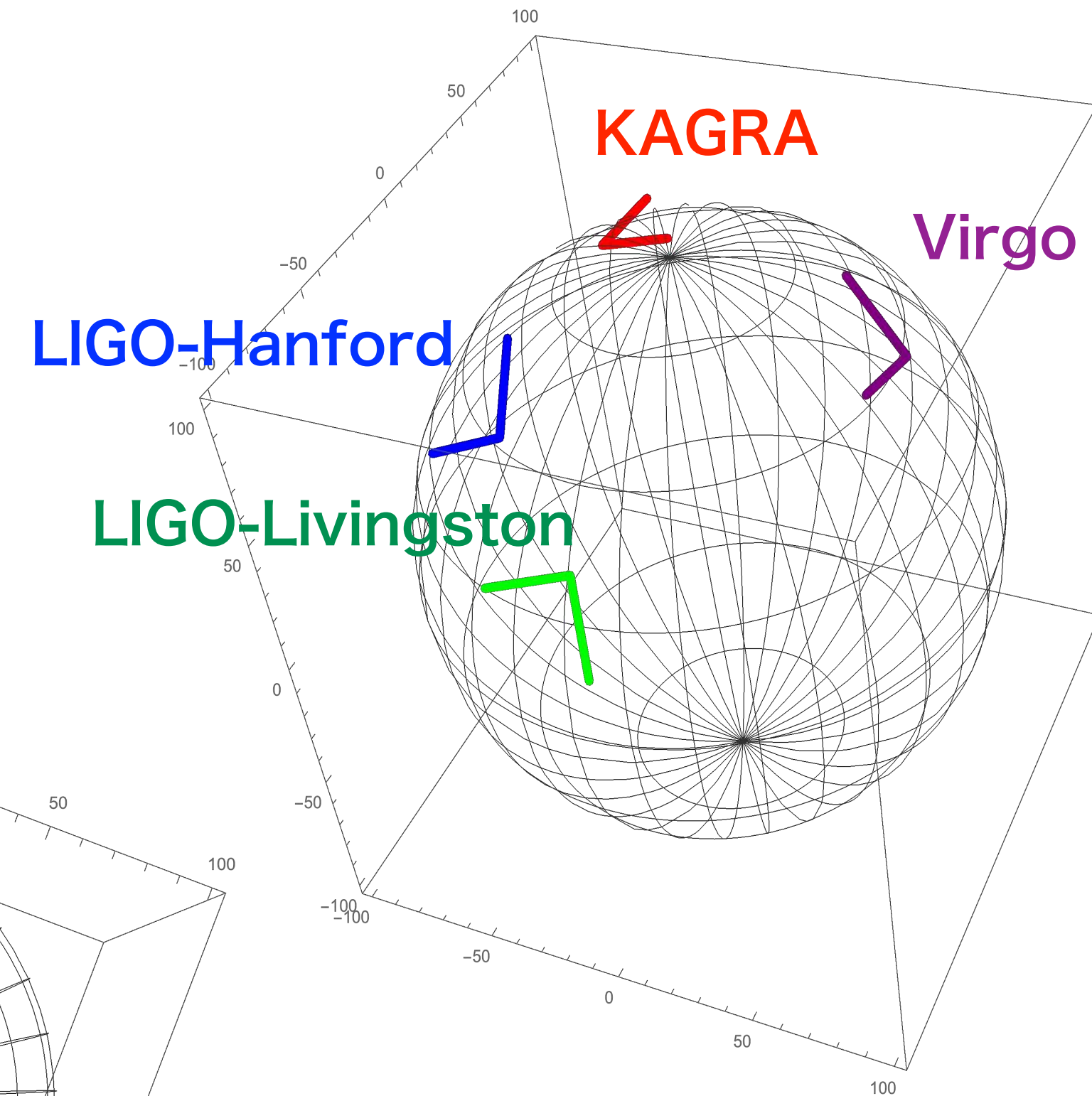
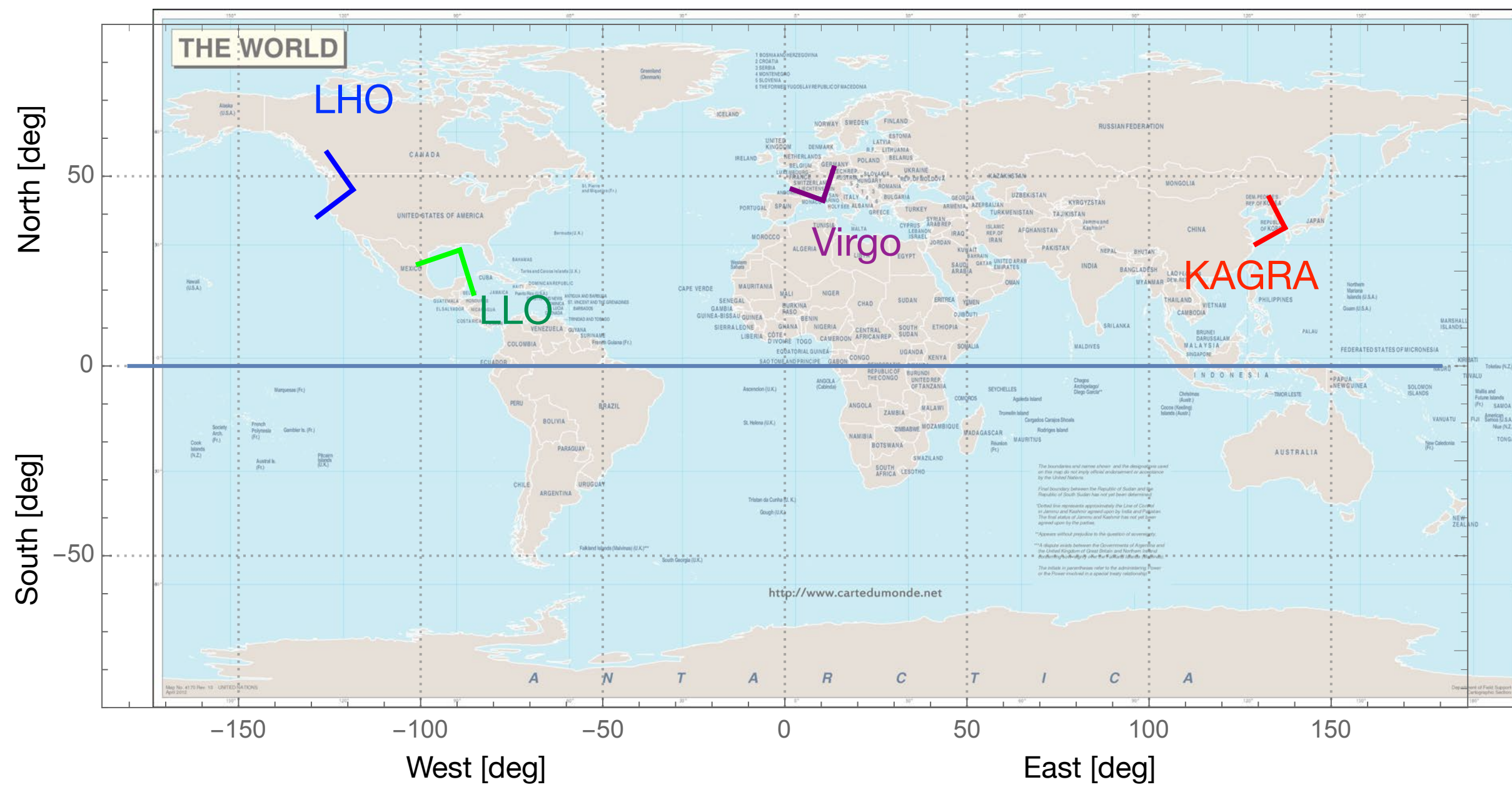
**Hisaaki Shinkai** (Osaka Inst. Tech.)  
KAGRA Scientific Congress, board chair



on behalf of KAGRA collaboration



# Fourth 2nd generation detector on the Earth



- more precise GW source localization
- more certain GW source parameters
- more chances to hunt GW events
- more ideas for GW researches
- more man power
- ~~more burden~~



# KAGRA collaboration



110 groups, 14 countries

390+ active members

Default-author list 2018 has 200 members.

+100 collaborators in the past 12 months.

+40 collaborators in the past 6 months.

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

F2F December 2019 @ RESCEU, Japan

~~F2F April 2020 @ ICRF, Japan~~

F2F Aug. 2020 @ Toyama, Japan

Organize International Workshop  
twice / year

KIW5 Feb. 2019 @ Perugia, Italy

KIW6 June 2019 @ Wuhan, China

KIW7 ~~May~~ 2020 @ NCU, Taiwan

July?

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



# Organization of KAGRA, KSC (KAGRA Scientific Congress)



Takaaki Kajita  
(PI)



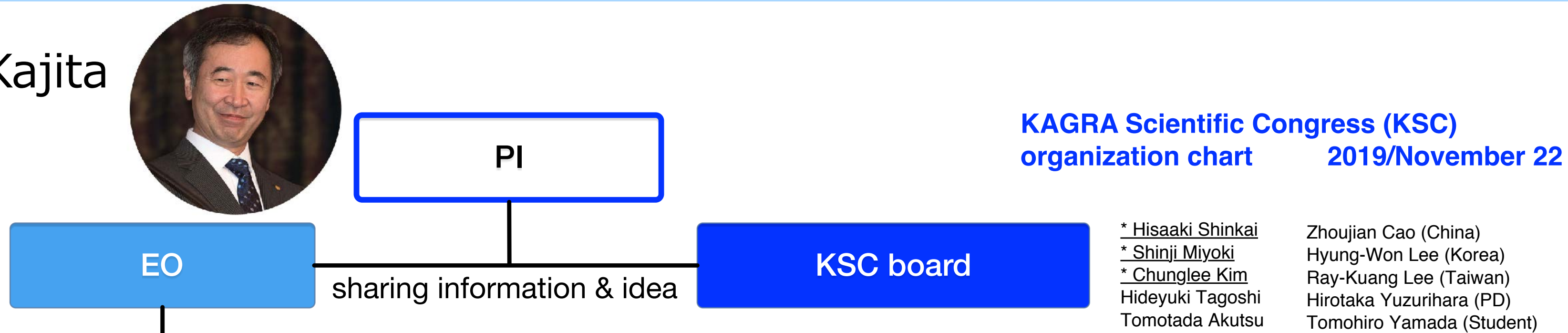
Masatake Ohashi  
(vice PI)



Yoshio Saito  
(SEO proj. manager — retires March)

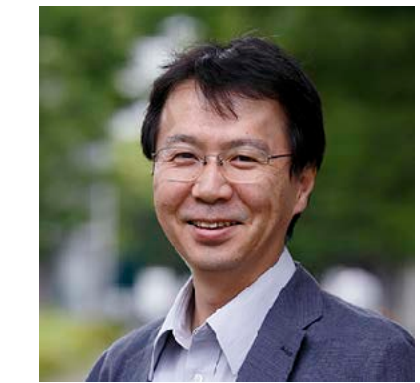
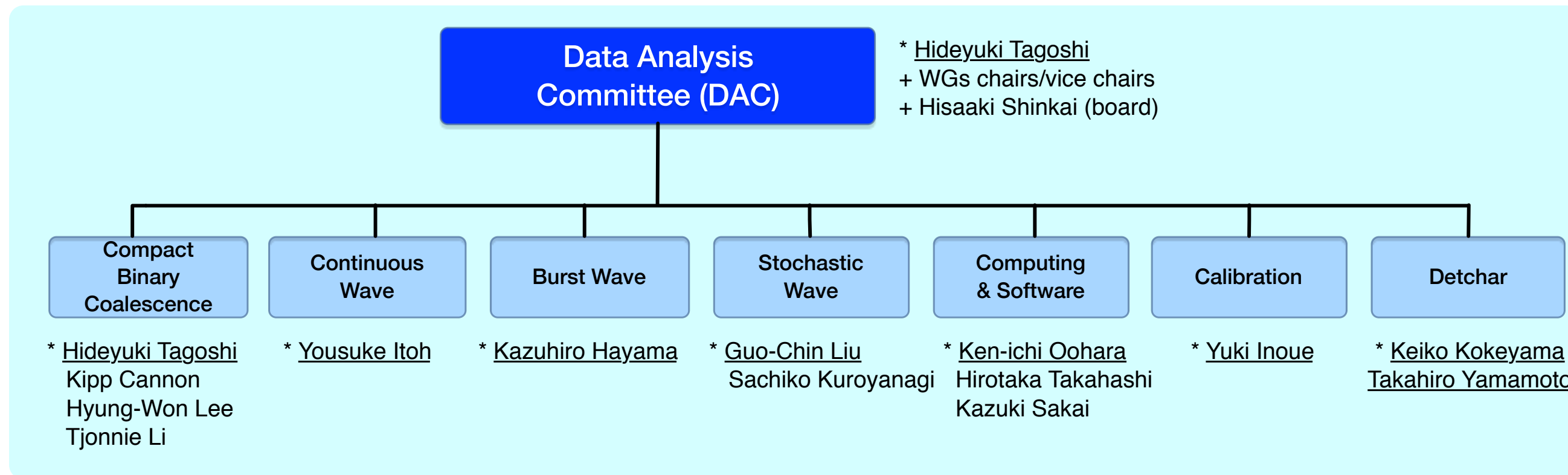


Shinji Miyoki  
(new SEO proj. manager — from April)

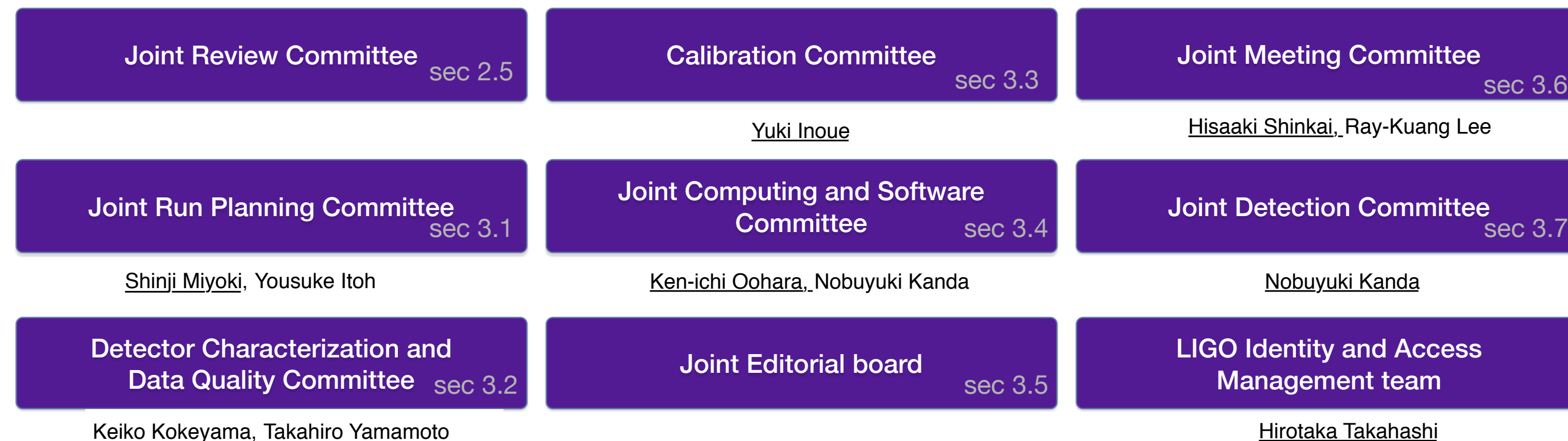


HS  
(KSC chair)

◀ Board  
(2019/8-2021/8)



Hideyuki Tagoshi  
(DAC chair)







# KAGRA collaboration papers

IOP Publishing Classical and Quantum Gravity  
 Class. Quantum Grav. 37 (2020) 035004 (19pp) <https://doi.org/10.1088/1361-6382/ab5c95>

## An arm length stabilization system for KAGRA and future gravitational-wave detectors

T Akutsu<sup>1,2</sup>, M Ando<sup>1,3,4</sup>, K Arai<sup>5</sup>, K Arai<sup>6</sup>, Y Arai<sup>6</sup>, S Araki<sup>7</sup>, A Araya<sup>8</sup>, N Aritomi<sup>3</sup>, Y Aso<sup>9,10</sup>, S Bae<sup>11</sup>, Y Bae<sup>12</sup>, L Baiotti<sup>13</sup>, R Bajpai<sup>14</sup>, M A Barton<sup>1</sup>, K Cannon<sup>4</sup>, E Capocasa<sup>1</sup>, M Chan<sup>15</sup>, C S Chen<sup>16</sup>, K Chen<sup>18</sup>, Y Chen<sup>17</sup>, H Chu<sup>18</sup>, Y-K Chu<sup>19</sup>, K Doi<sup>20</sup>, S Eguchi<sup>15</sup>, Y Enomoto<sup>3,7,33</sup>, R Flaminio<sup>1,21</sup>, Y Fujii<sup>22</sup>, M Fukunaga<sup>6</sup>, M Fukushima<sup>1</sup>, G-G Ge<sup>23</sup>, A Hagiwara<sup>6,24</sup>, S Haino<sup>19</sup>, K Hasegawa<sup>6</sup>, H Hayakawa<sup>25</sup>, K Hayama<sup>15</sup>, Y Himemoto<sup>26</sup>, Y Hiranuma<sup>27</sup>, N Hirata<sup>1</sup>, E Hirose<sup>6</sup>, Z Hong<sup>28</sup>, B H Hsieh<sup>29</sup>, G-Z Huang<sup>28</sup>, P-W Huang<sup>23</sup>, Y Huang<sup>19</sup>, B Ikenoue<sup>1</sup>, S Imam<sup>28</sup>, K Inayoshi<sup>30</sup>, Y Inoue<sup>18</sup>, K Ioka<sup>31</sup>, Y Itoh<sup>32,33</sup>, K Izumi<sup>34</sup>, K Jung<sup>35</sup>, P Jung<sup>25</sup>, T Kajita<sup>36</sup>, M Kamiizumi<sup>25</sup>, S Kanbara<sup>20</sup>, N Kanda<sup>32,33</sup>, G Kang<sup>11</sup>, K Kawaguchi<sup>6</sup>, N Kawai<sup>37</sup>, T Kawasaki<sup>3</sup>, C Kim<sup>38</sup>, J C Kim<sup>39</sup>, W S Kim<sup>12</sup>, Y-M Kim<sup>35</sup>, N Kimura<sup>24</sup>, N Kita<sup>3</sup>, H Kitazawa<sup>20</sup>

### arm length stabilization

Class. Quantum Grav. 37 (2020) 035004  
 [arXiv:1910.00955]

Living Rev Relativ in prep  
 DOI:XXXXXXXXXXXXXXXXXXXXXXXXXXXX

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1 Prospects for Observing and Localizing Gravitational-Wave  
 2 Transients with Advanced LIGO, Advanced Virgo and  
 3 KAGRA

4 Abbott, B. P. et al. (KAGRA Collaboration, LIGO  
 5 Scientific Collaboration and Virgo Collaboration)

Observing Scenario Paper revision  
 [Living Rev. Rel. (2018) 21]  
 [arXiv:1304.0670] (updated Jan, 2020)

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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<sup>1</sup>

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

[What is an Accepted Manuscript?](#)

### Vibration isolation

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

arXiv.org > astro-ph > arXiv:1908.03013

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. Furuhashi, 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]

iKAGRA data analysis

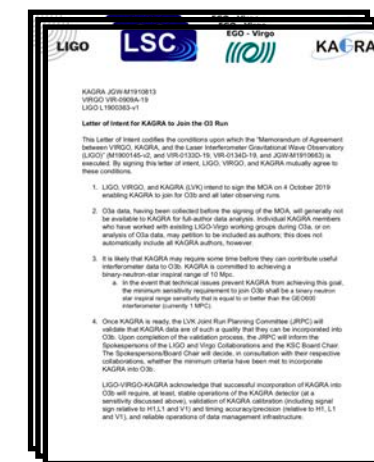
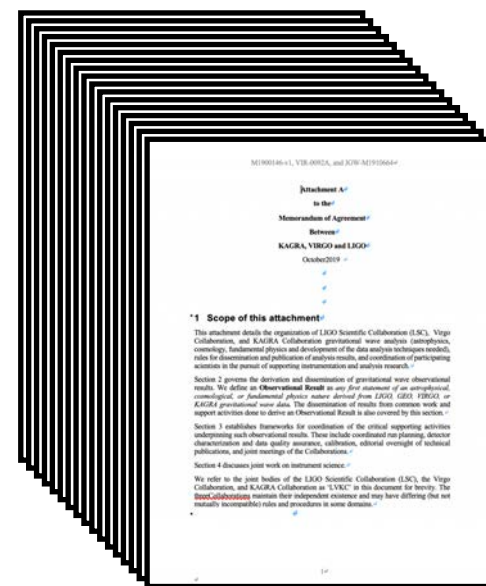
+ Several review articles in PTEP, July-August 2020



# Joint Research MoA signed LIGO-Virgo-KAGRA



October 4, 2019 @ Ceremony of MoA signing



**main part (10 pages)**  
Concept, Definitions,  
Purposes

**Appendix A (17 pages)**  
Organizations, Procedures

**Letter of Intent (3 pages)**  
KAGRA's Join to O3

Apr 1, 2019



O3a

Sep. 30, 2019

October 2019

Nov 1, 2019



O3b

April 30, 2020

Fall, 2021



O4

Individual KAGRA members who have worked with existing LIGO-Virgo working groups during O3a, or on analysis of O3a data, may petition to be included as authors.

**When after KAGRA > 1 Mpc & satisfy the validation by JRPC, "LVK" full-author publication starts.**

Otherwise, KAGRA collaboration members will become authors on LIGO-Virgo observational papers for O3b (and beyond) on October 1, 2020.



# under commissioning for joining O3

Target = 10 Mpc ; at least 1 Mpc for joining O3

May, 2019: Completed installations

Aug., 2019: First lock of FPMI (0.4 kpc)

Dec., 2019 : Engineering Run 7 days

Jan., 2020: First lock of PRFPMI \*

Feb. 4, 2020: OMC, DC readout ready (40 kpc)

Feb. 14, 2020: 394 kpc

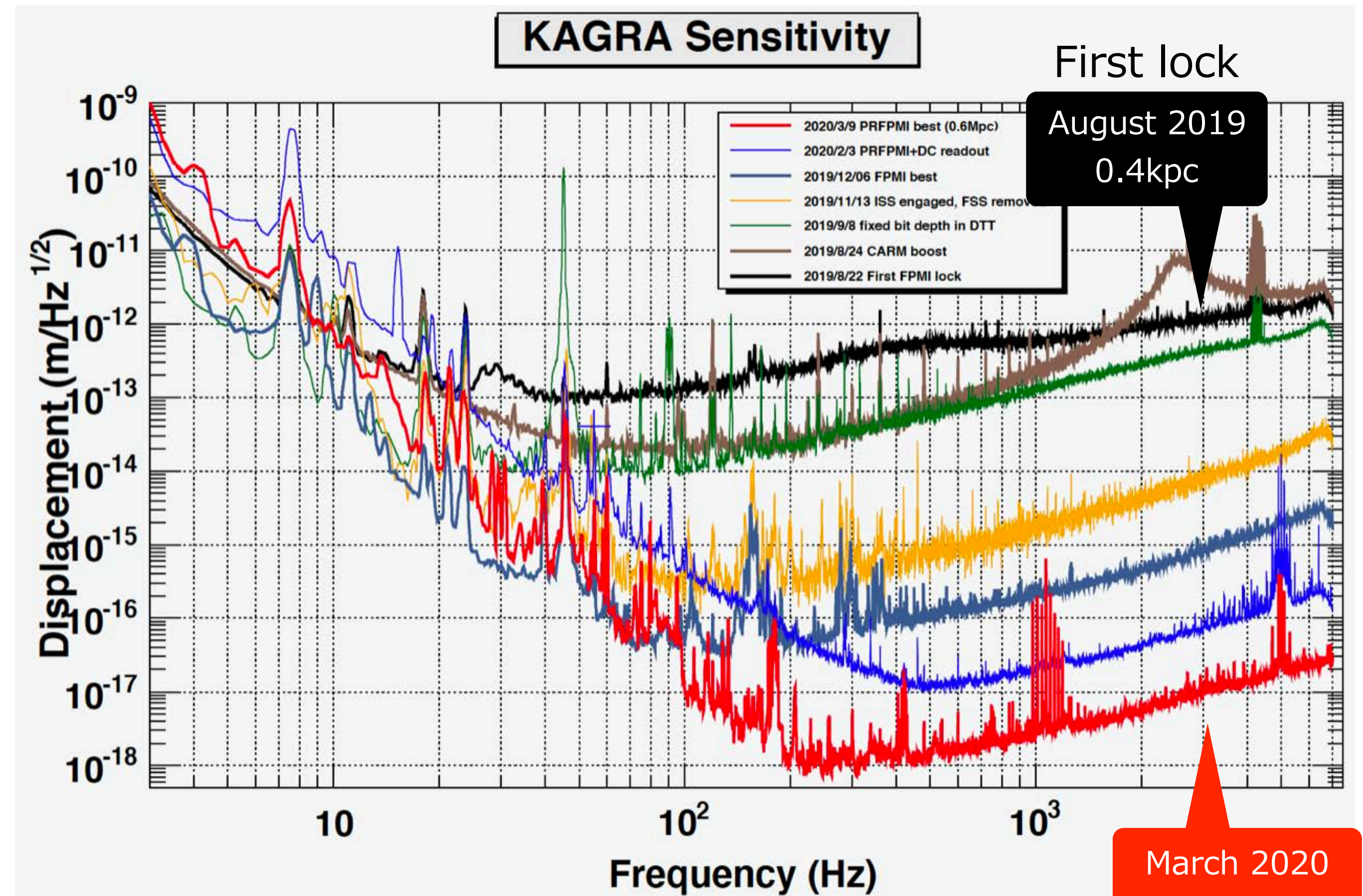
Feb. 18, 2020: 426 kpc

Feb. 25, 2020: Observation run (2 weeks)

Mar. 5, 2020: 504 kpc

Mar. 9, 2020: 594 kpc

... to be continued



March 2020  
594 kpc

current best

\* We appreciate many LV colleagues, especially **Stefan Ballmer, Valery V. Frolov, Keita Kawabe, Rana Adhikari, Jenne Driggers, Adam Mullavey, Sheila E. Dwyer, & Anamaria Effler** for their onsite help.



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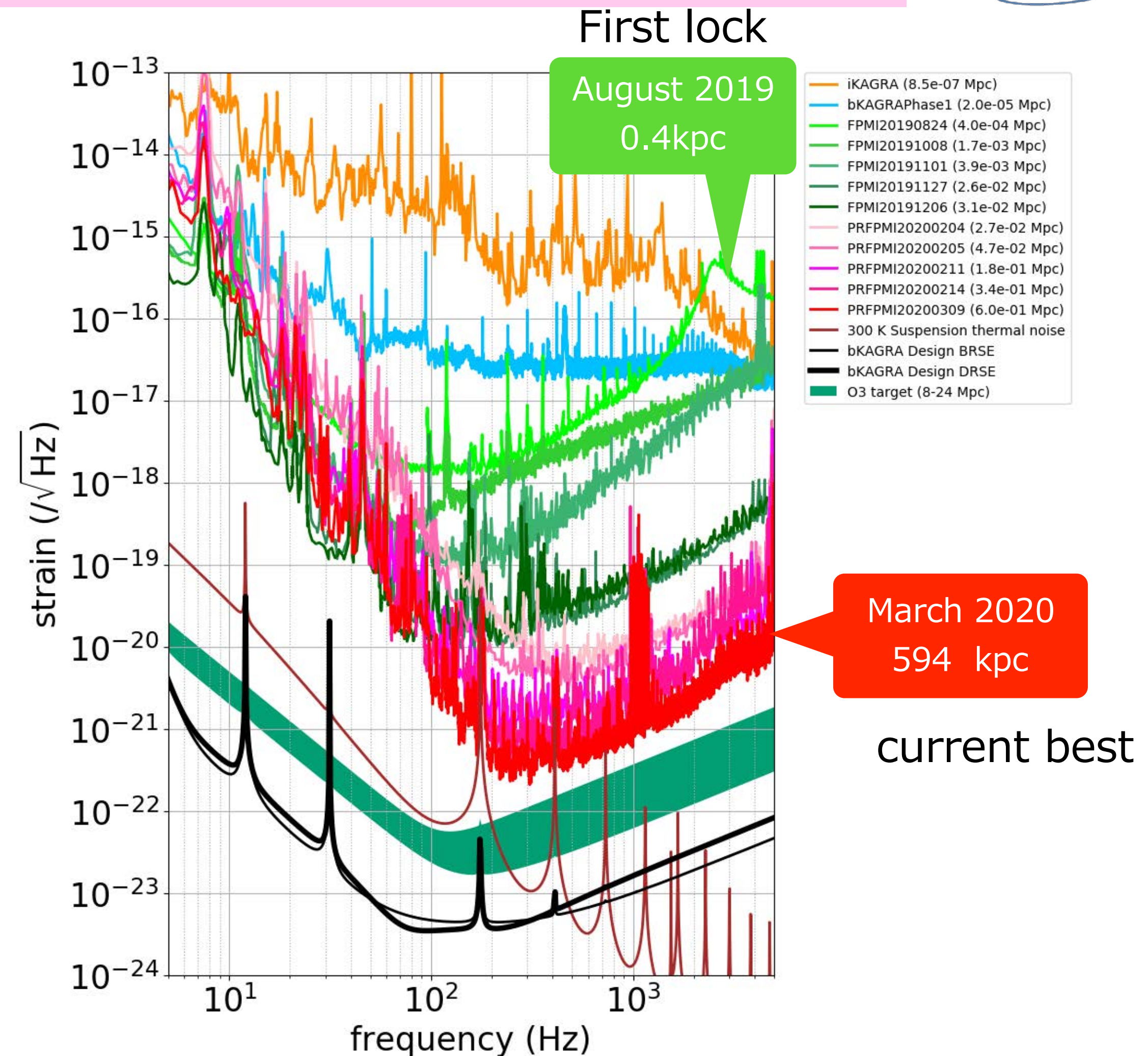
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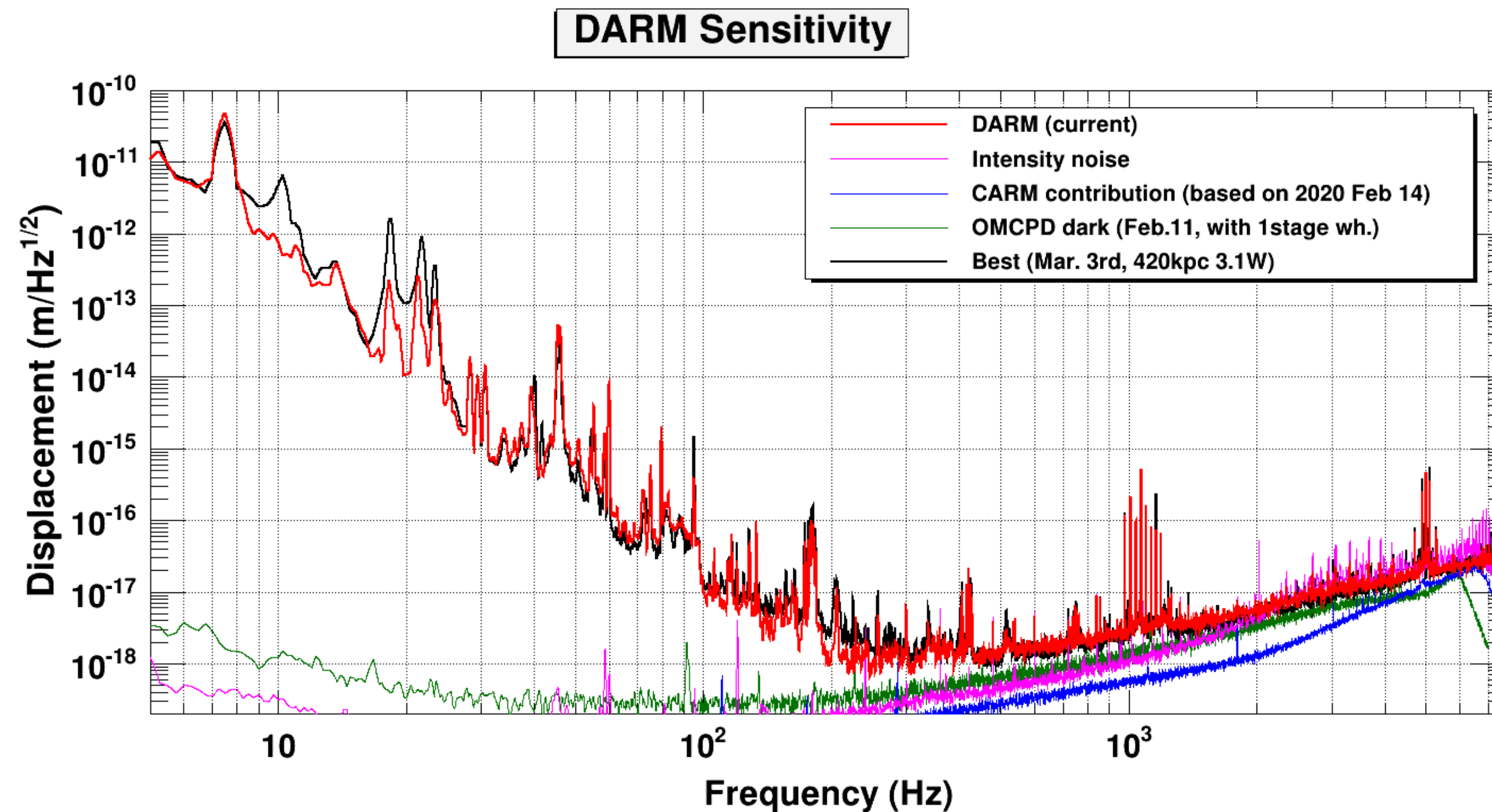
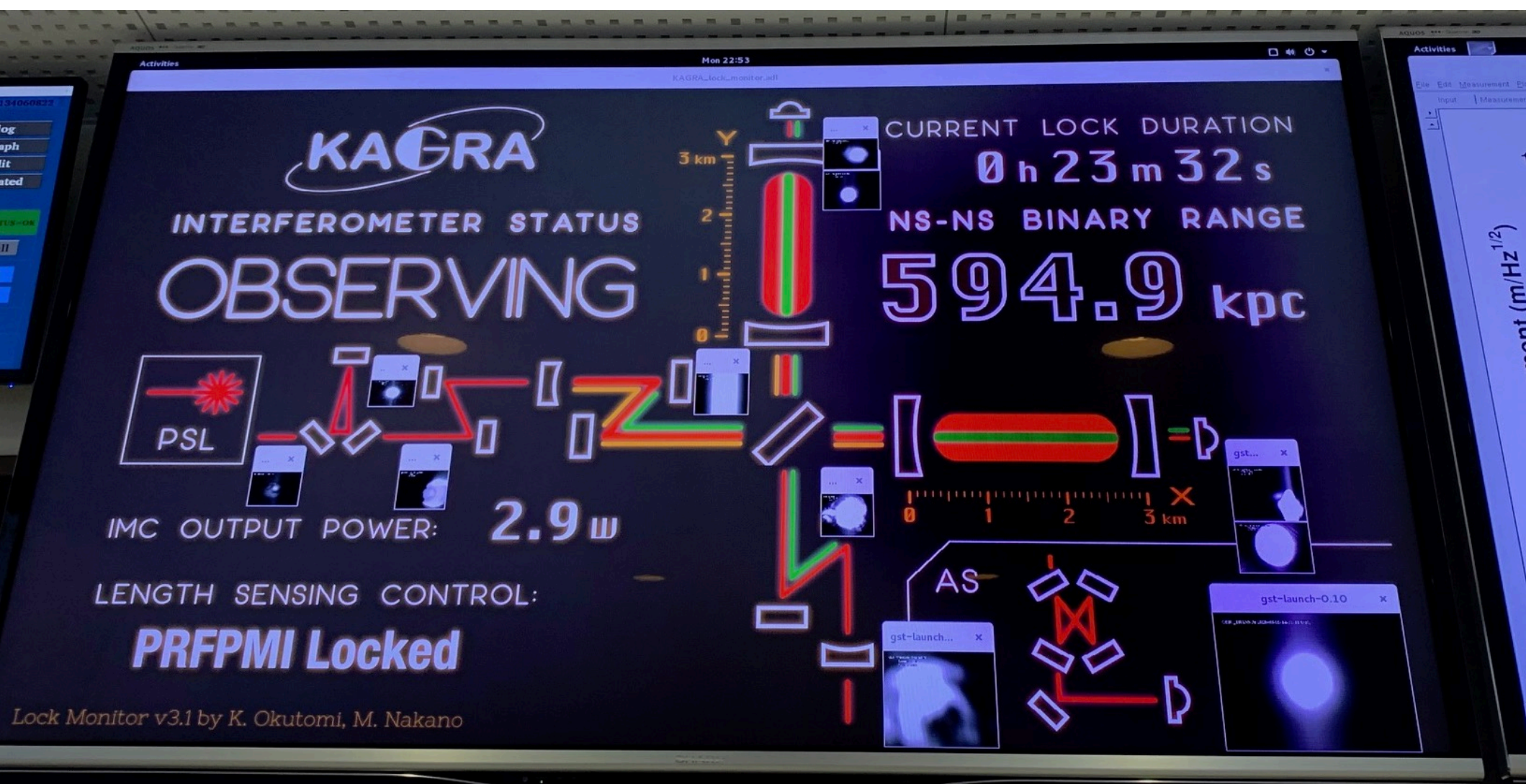


\* We appreciate many LV colleagues, especially **Stefan Ballmer, Valery V. Frolov, Keita Kawabe, Rana Adhikari, Jenne Driggers, Adam Mullavey, Sheila E. Dwyer, & Anamaria Effler** for their onsite help.



# observation run in February 2020

**Feb. 25 – Mar. 10 (2 weeks)** [Maintenance: Tue 0:00-8:00 UTC]



\*T0=09/03/2020 14:01:00

\*Avg=50/Bin=2L

BW=0.374994

longest lock: 10 h 28 m (2-5 hours typically)  
 max. sensitivity: 594 kpc (March 9)  
 duty cycle: 74.7% (locked, ave 13 days)  
 51.4% (obs, ave 13 days)

<http://klog.icrr.u-tokyo.ac.jp/osl/?r=13432>

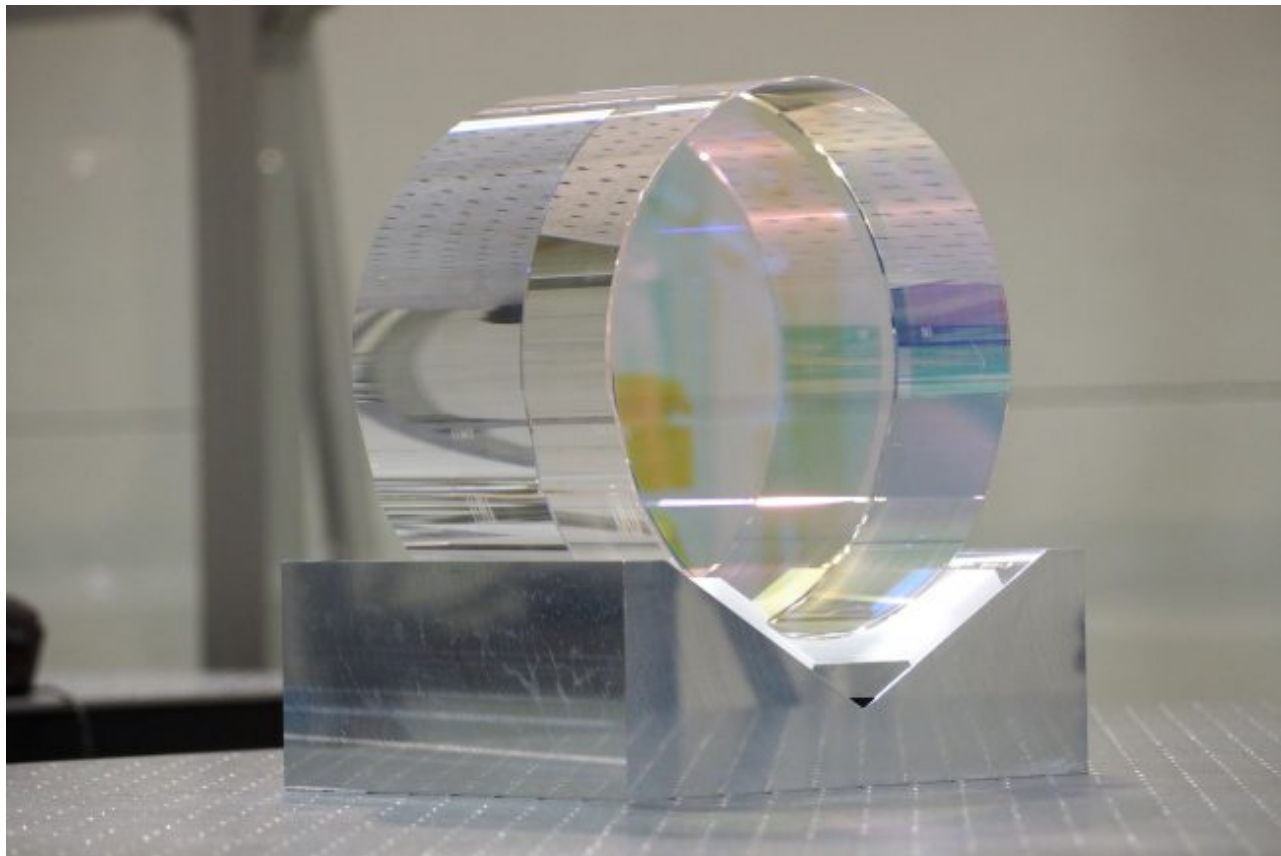
<https://monitor.ligo.org/gwstatus>

LIGO Hanford SCIENCE Duration: 0d 18:37:00 (prev: nohoft) Last updated at 2:19	LIGO Livingston SCIENCE Duration: 1d 16:58:59 (prev: nohoft) Last updated at 2:19	Virgo SCIENCE Duration: 1d 01:30:25 (prev: hoftok) Last updated at 2:19	<b>Kagra SCIENCE</b> Duration: 0d 01:40:59 (prev: nohoft) Last updated at 2:19	Sun Mar 01 2020 <b>2:19:59</b> 1267032017
DMT 15 OK Last updated at 2:19	Low-latency Data 46 OK Last updated at 2:19	LIGO Data Replicator 14 OK Last updated at 2:19	DetChar Summary 23 OK Last updated at 2:19	DetChar Jobs 16 OK Last updated at 2:19
GraceDB	LVAalert	GraceDB	DQSegDB	NDS

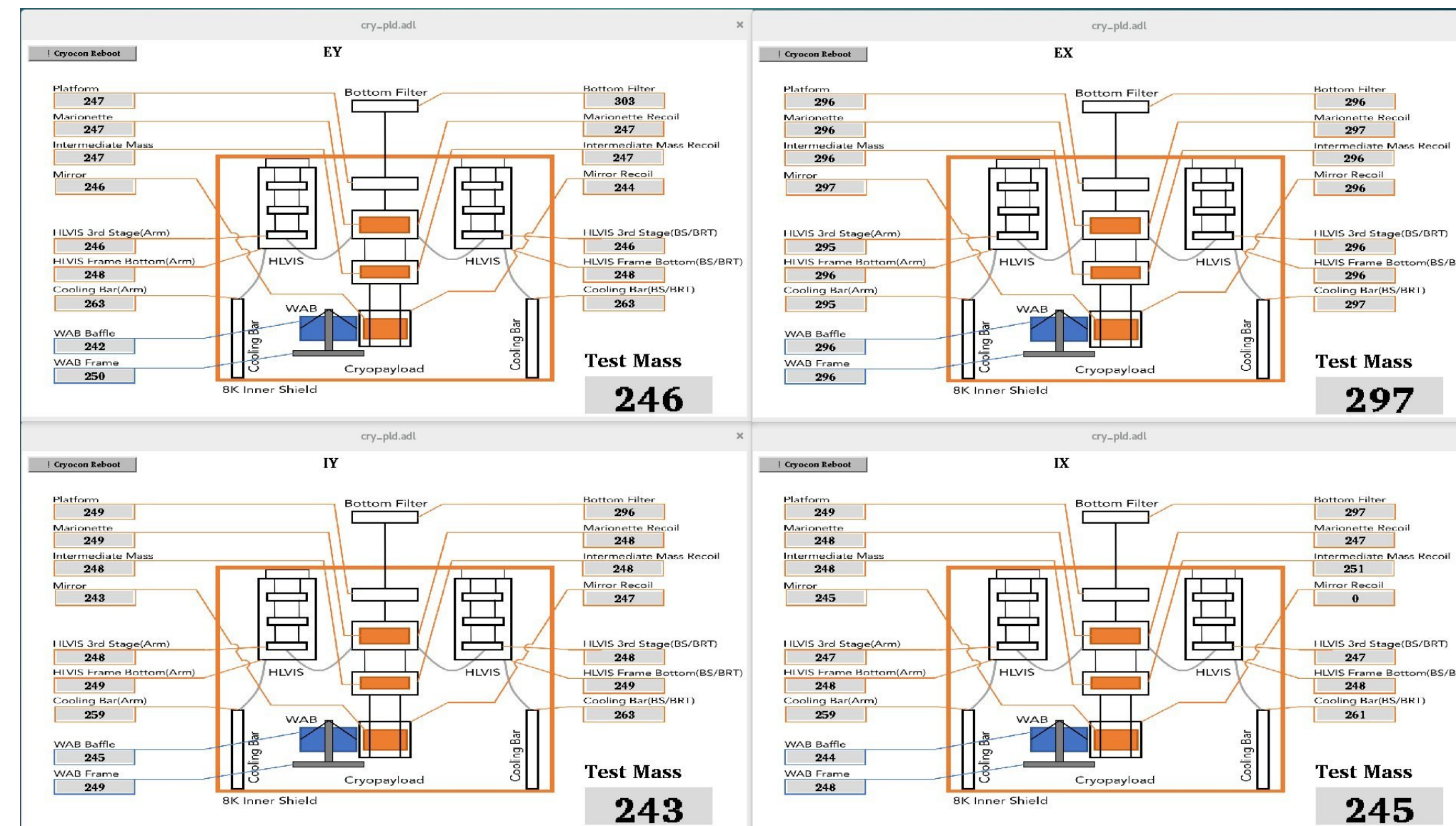


# Current Concerning Issues

- \* **Asymmetry of Finesse** ( $\sim 10\%$ ) due to difference of transmissivity of ITM<sub>x</sub> & ITM<sub>y</sub>
  - ➔ OK for O3, hope to be fixed by O4 **recoat?**
- \* **Polarization (sapphire birefringence)** due to inhomogeneity of ITM<sub>x</sub> & ITM<sub>y</sub>
  - ➔ no replacements for O3. May be the same in O4. ➔ PR gain = 10 as designed **repolish & recoat?**
- \* **Frosting of Mirrors** due to incompleteness of vacuum
  - ➔ re-heat, outgas, and re-cool ➔ not go to 20K, but 250K



A sapphire mirror. 22cm diameter, 15cm thick and 23kg weight





# KAGRA readiness check by JRPC / Schedule

<https://wiki.ligo.org/LSC/JRPCComm/Agenda2020Feb20>

## \* READY

- LDG access, GraceDB access
- State vector defined and documented
- DQSEGDB: capability to upload/readback segments to the DB
- Web page to see the status of the interferometer
- Procedure for RRT including KAGRA
- Low-Latency Transfer of KAGRA data to CIT/Virgo

## \* ON-GOING

- KAGRA IdP (Gakunin), An authentication issue to use REST API in GraceDB AP
- h(t) calibration and reconstruction reviewed; uncertainty budget
- DetChar/DQ: event validation
- High-Latency strain data transfer between KAGRA and LIGO-Virgo

## Schedule

**Feb. 25 — Mar. 10 (2 weeks)** [Maintenance: Tue 0:00-8:00 UTC]

**Mar. 10 — Mar. 24 (2 weeks) commission/noise-hunt**

**Mar. 24 — Apr. 30 Observation (hopefully as O3)**



# KAGRA Data Analysis

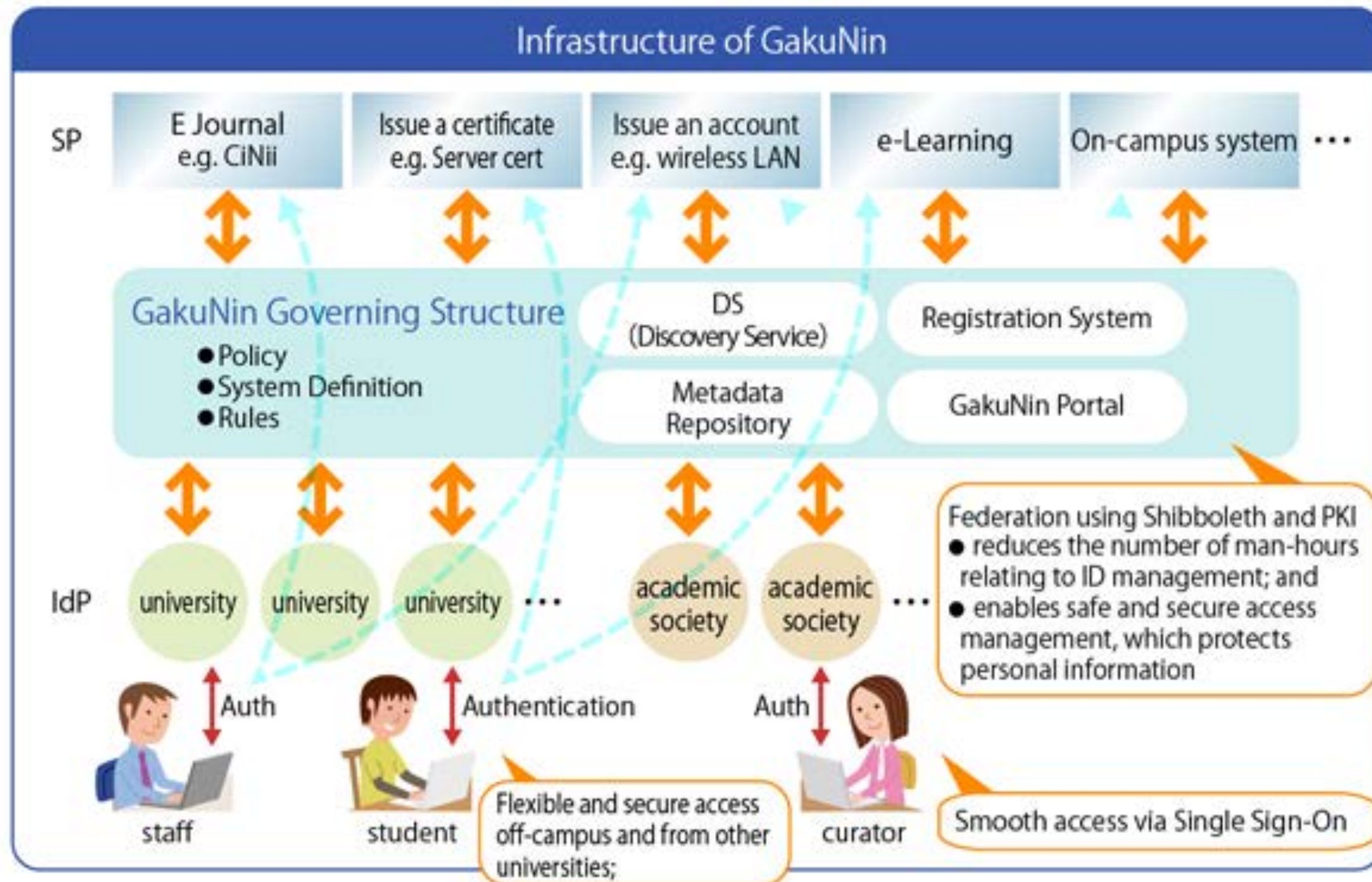
	Joint Works		Original Works
CBC	<ul style="list-style-type: none"> <li>* Participation to PE rota (if KAGRA data are available, use them)</li> <li>* Contribution to gstlal and other pipelines</li> </ul>	CBC	<ul style="list-style-type: none"> <li>* Off-line analysis of KAGRA data</li> </ul>
		CBC	<ul style="list-style-type: none"> <li>* KAGALI MCMC pipeline</li> <li>* GPU accerelated Nested sampling</li> </ul>
	<p><b><i>Future Joint Works</i></b> ←</p>	Burst	<ul style="list-style-type: none"> <li>* Off-line follow-up analysis</li> <li>* Original pipeline</li> </ul>
		others	<ul style="list-style-type: none"> <li>* Kyoto NSNS waveform (tidal deformability)</li> <li>* machine-learning approach</li> <li>* Testing GR</li> <li>* QNM, echo, polarization, ...</li> </ul>



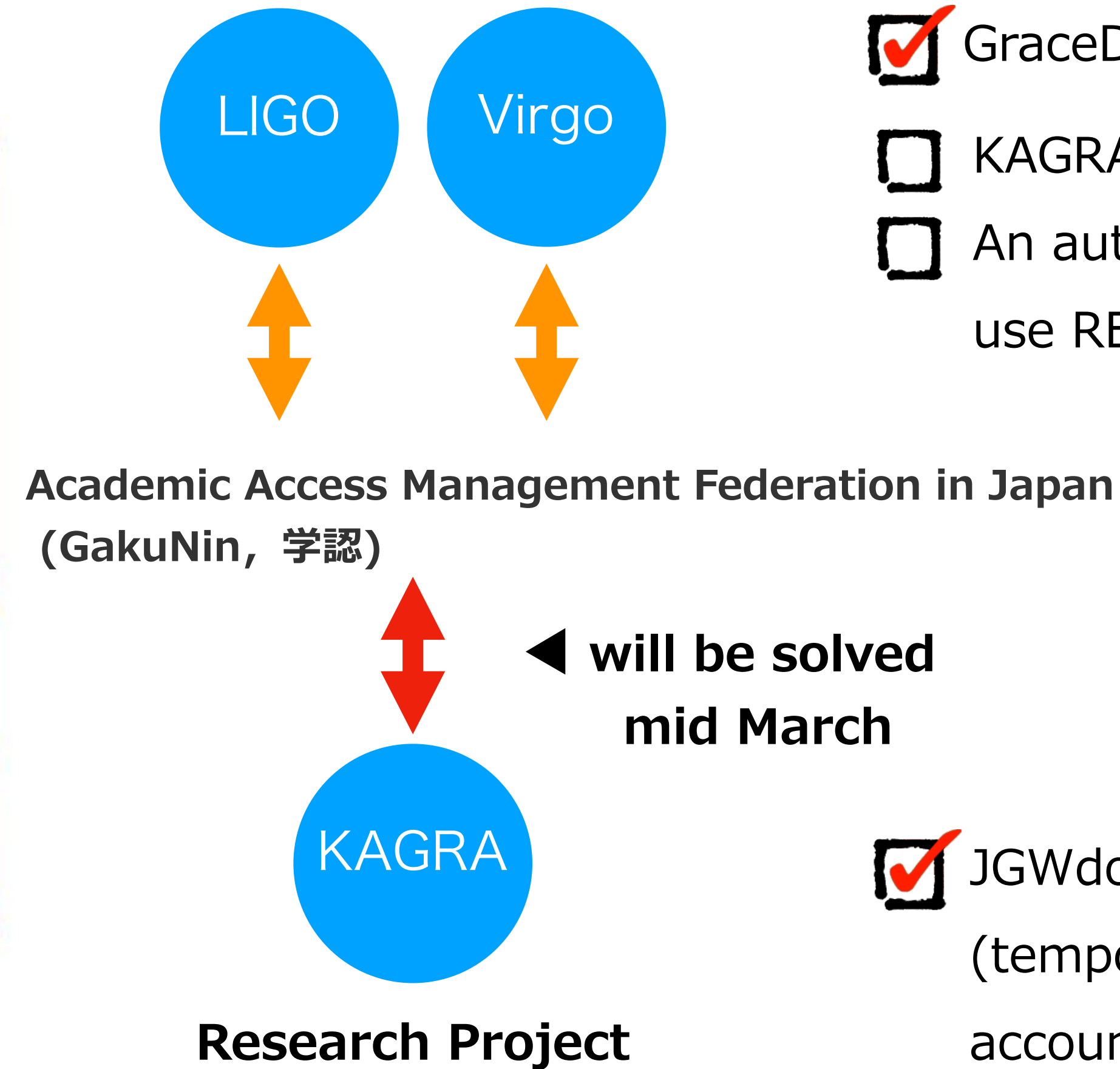
# Current Concerning Issues

\* **shibboleth problem** between KAGRA and LV systems

- LDG access
- GraceDB access
- KAGRA IdP (Gakunin)
- An authentication issue to use REST API in GraceDB AP



<https://www.gakunin.jp/en>



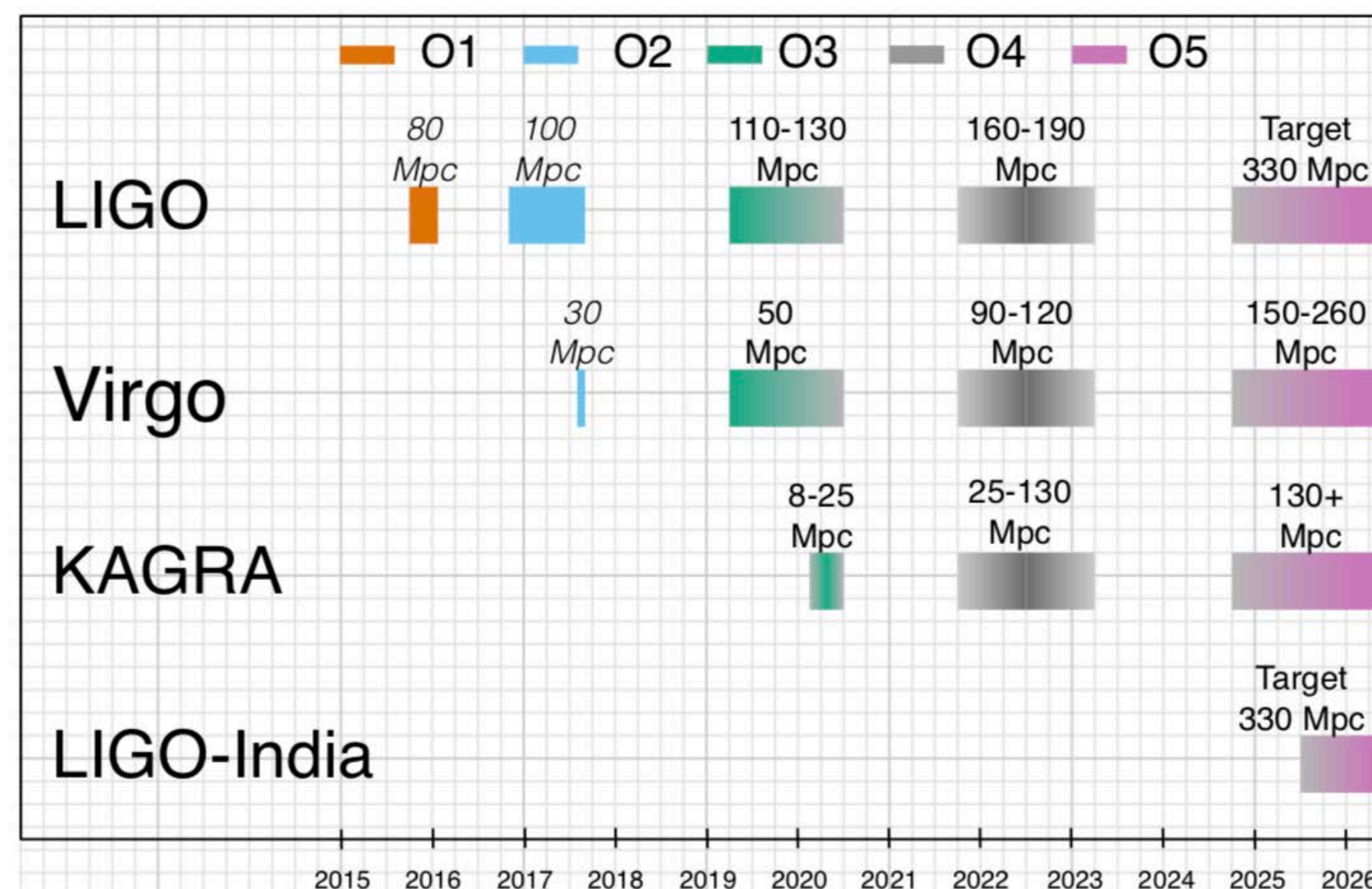
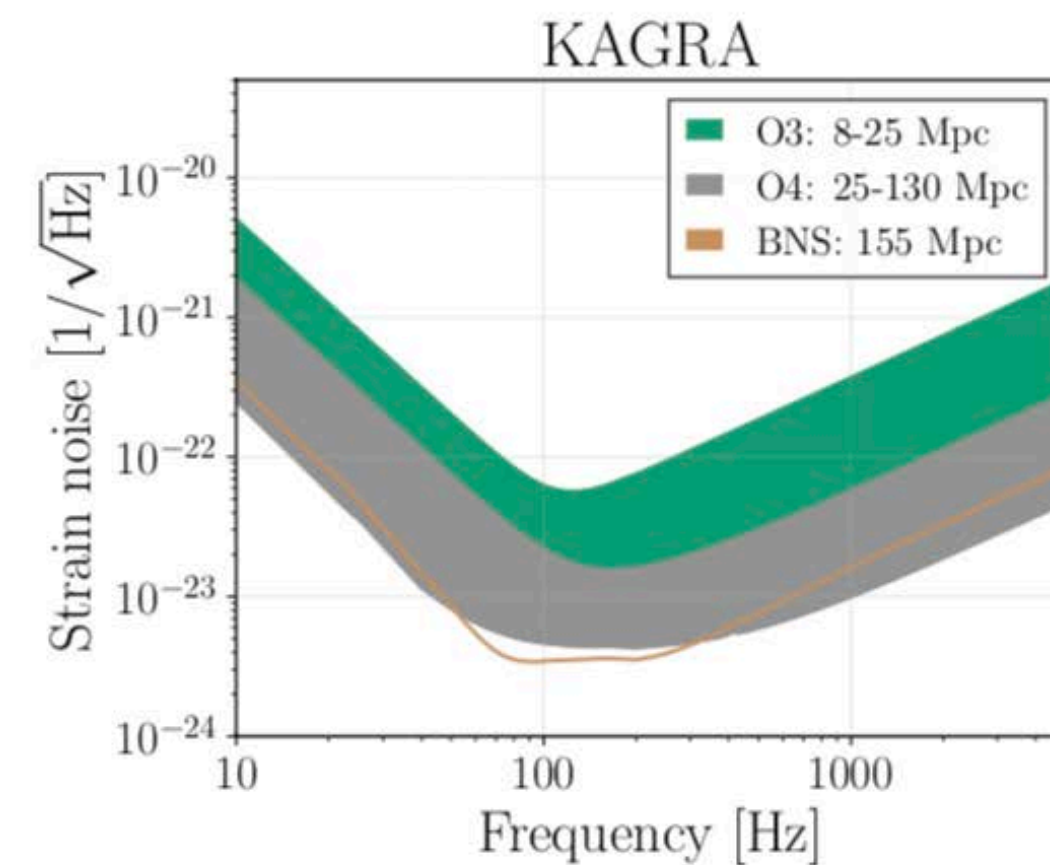
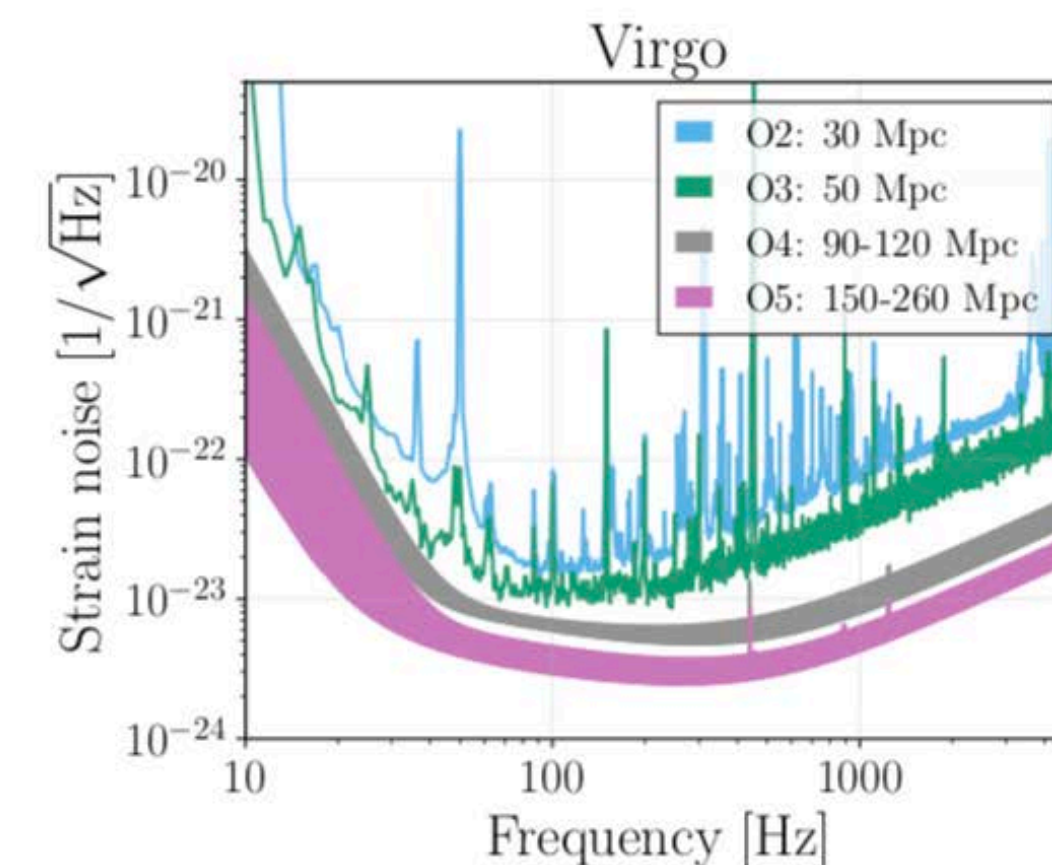
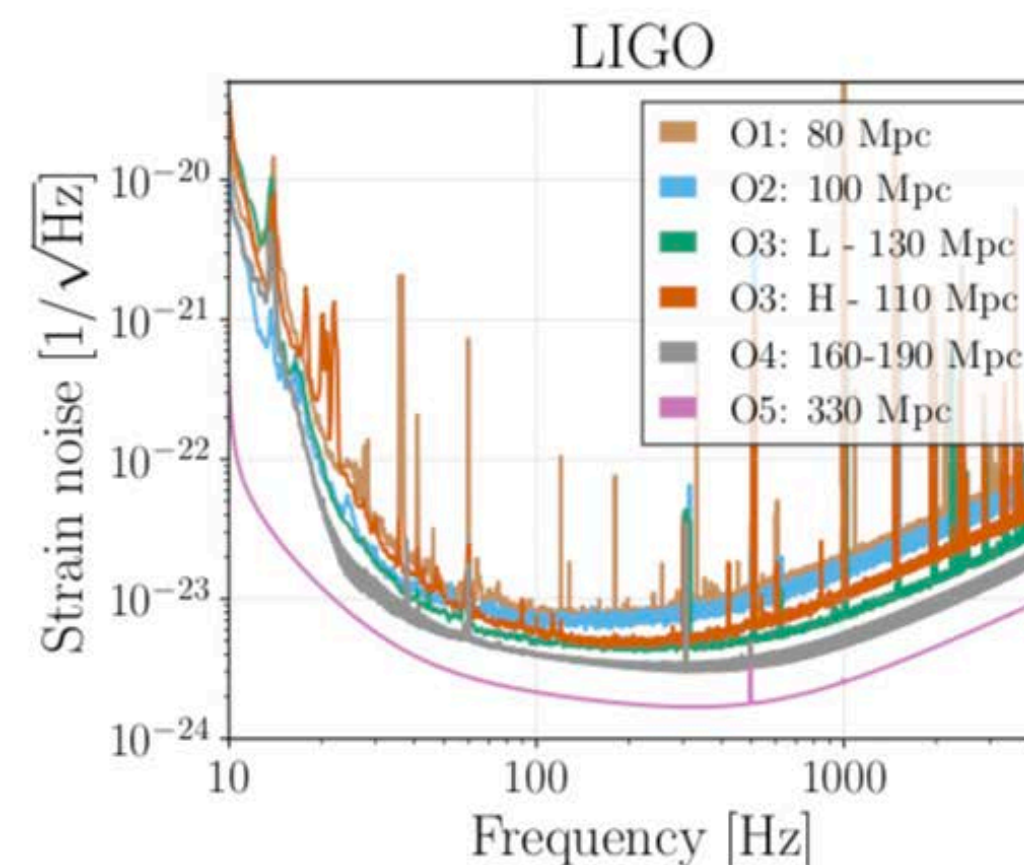
- JGWdoc access (temporarily, using a common account)



# Target Sensitivity & Schedule

## ◆ O3 → O4

- ❑ Cryo-Payload repairing (~ Sep)
- ❑ ETMY tower repairing (~ Sep)
- ❑ Signal Recycling
- ❑ mirror coating (?)
- ❑ install laser beam baffles
- ❑ KAGALI pipeline
- ❑ etc



“Scenario Paper” [1304.0670ver2020Jan]  
 Living Rev Relativ (2018) 21:3  
<https://doi.org/10.1007/s41114-018-0012-9>



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

◆ KAGRA signed MoA with LIGO/Virgo, October 2019.

Thanks for your warm welcomes.

◆ **KAGRA runs as PR-FPMI**

Thanks for your helps.

◆ **Feb 25 - Mar 10: Obs Run**

(max 594 kpc, duty cycle 74+% lock, 51+% obs, longest lock 10.5 hrs)

**Now: under final noise-hunting for joining O3.**

**Mar 24 - Apr 30: join O3, hopefully (> 1 Mpc and more)**

Thanks for your patience.

