Status of KAGRA

- **Underground** and **Cryogenic** interferometric gravitational-wave detector at Kamioka, Japan
- KAGRA plans to finish all the installations by the end of March, 2019.
- **KAGRA plans to join LV Observation Run 3 from fall 2019.**

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

March 20, 2019 @ LIGO-Virgo Collaboration Meeting
KAGRA (Kamioka GW Observatory)

**Underground and Cryogenic** interferometric gravitational-wave detector at Kamioka, Japan
KAGRA: 2.5 generation interferometric gravitational wave detector

KAGRA collaboration

The recent detection of gravitational waves (GW) 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 unraveling the unknown nature of the universe in coordinated observations with astronomical telescopes and detectors. Here we introduce KAGRA, a new GW detector with three baseline arms arranged in an L-shaped configuration. KAGRA’s design is similar to the second-generation of Advanced LIGO and Advanced Virgo, but it will be operating in cryogenic temperature with sapphire windows. This low-temperature feature is advantageous for improving the sensitivity around 50Hz 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 2.5 generation GW detector based on laser interferometry. KAGRA’s first observation run is scheduled in 2019.

Japan to begin pioneering hunt for gravitational waves

The underground KAGRA detector will deploy ambitious technology to improve sensitivity.

In a clean-room-sized scaffolding wrapped in thick plastic sheets, Takayuki Tomaru is in full clean-room attire. The physicist, who works at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan, is performing one of the most delicate and crucial tasks in the construction of a gravitational wave observatory: installing one of the machine’s four mirrors, each a 23-kilogram cylinder of solid sapphire known as a test mass.

When operations begin later this year, their job will be to bounce infrared laser beams back and forth along two 3-kilometre, high-vacuum pipes, ready to sense the passage of gravitational waves (see ‘Japan’s wave hunter’).

With the addition of KAGRA, the growing global network of detectors will enable astrophysicists to more precisely locate the position of these cosmic signals in the sky. They will be able to dissect the waves’ properties, such as how they are polarized and their phase, and use these measurements to differentiate between different theoretical models of the universe.

Science News 195 (2019 Feb) 8
https://www.sciencenews.org/
KAGRA collaboration

98 groups, 15 countries
250+ active members

Latest paper has 197 authors.
227 members applied for authorlist 2018

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

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

Organize International Workshop
2 times / year

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

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

Hisaaki Shinkai (Osaka Institute of Technology)  March 20, 2019  @ LIGO-Virgo Collaboration Meeting

Organization of KSC (KAGRA Scientific Congress)

Takaaki Kajita

EO

SEO

KSC board

PI

sharing information & idea

KAGRA Scientific Congress (KSC) organization chart 2019/March 10

* Hisaaki Shinkai
* Chunghee Kim
Sadakazu Haino
Yuta Michimura
Nobuyuki Kanda (EO)

Takahiro Yamamoto (PD)
Koji Nagano (Student)
Zong-Hong Zhu (region)
Hyung-Won Lee (region)
Ray-Kuang Lee (region)

Hisaaki Shinkai

Data Analysis Committee (DAC)

Compact Binary Coalescence
Continuous Wave
Burst Wave
Stochastic Wave
Computing & Software
Calibration
Detchar

Compact Binary Coalescence
Continuous Wave
Burst Wave
Stochastic Wave

* Hideyuki Tagoshi
Kipp Cannon
Hyung-Won Lee
Tjonnie Li

* Yousuke Itoh
* Kazuhiro Hayama
* Guo-Chin Liu
Sachiko Kuroyanagi

* Ken-ichi Ohara
Kazuki Sakai

* Yuki Inoue

* TBD

Joint Run Planning Committee

Joint Editorial board

LVC-KAGRA taskforce

Joint Meeting Committee

Joint Detection Committee

Yoshio Saito

* TBD

* TBD

* TBD

Yoshio Saito (leader, project manager)
Hideyuki Tagoshi (Data analysis)
Takahiro Yamamoto (Calibration)
Osamu Miyakawa (commissioning)
Hisaaki Shinkai (MoU)
## Status of KAGRA

### Brief History of KAGRA

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- **iKAGRA** = initial KAGRA
- **bKAGRA** = baseline KAGRA

![Diagram](arXiv:1712.00148)

![Diagram](arXiv:1901.03569)
Status of KAGRA

bKAGRA phase-1 operation (April & May 2018)

[arXiv:1901.03569]
Status of KAGRA

"Scenario Paper"
Living Rev Relativ (2018) 21:3
https://doi.org/10.1007/s41114-018-0012-9

Hisaaki Shinkai (Osaka Institute of Technology)  March 20, 2019  @ LIGO-Virgo Collaboration Meeting
Status of KAGRA

Roadmap to join O3: Plan A & B

- either DRFPMI(RSE) (-25Mpc, Oct?) or FP MI (-10Mpc, June?)
- checking points: Sep/2018, Dec/2018 and Mar/2019
**bKAGRA configuration & installation 2018-2019**

**bKAGRA configuration**
- Cryogenic test masses
- 3 km arm cavities
- RSE with power recycling

**Type-C system**
- Mode cleaner
  - Silica, 0.5kg, 290K
- Stack + Payload

**Type-Bp payload**
- Test mass and Core optics (BS, FM,..)
  - Silica, 10kg, 290K
- Seismic isolator
  - Table + GASF + Type-B Payload

**Type-A system**
- Cryogenic test mass
  - Sapphire, 23kg, 20K
- Tall seismic isolator
  - IP + GASF + Payload

**Type-B system**
- Core optics (BS, SRM,..)
  - Silica, 10kg, 290K
- IP + GASF + Payload
- Stack for aux. optics

**[VIS]**
ALL the large suspensions have been installed! Tunings are ongoing along with the alignment.

**[Mirror]**
ALL Sapphire mirrors are installed.
**bKAGRA configuration & installation 2018-2019**

**bKAGRA configuration**
- Cryogenic test masses
- 3 km arm cavities
- RSE with power recycling

**Type-C system**
- Mode cleaner
  - Silica, 0.5kg, 290K
- Stack + Payload

**Type-Bp payload**
- Test mass and Core optics (BS, FM,...)
  - Silica, 10kg, 290K
- Seismic isolator
  - Table + GASF + Type-B Payload

**Type-A system**
- Cryogenic test mass
  - Sapphire, 23kg, 20K
- Tall seismic isolator
  - IP + GASF + Payload

**[VIS]**
ALL the large suspensions have been installed!
Tunings are ongoing along with the alignment.

In Feb., all SRs has been installed!

**[Mirror, CRYO]**
ALL Sapphire mirrors are installed.

Hisaaki Shinkai (Osaka Institute of Technology) March 20, 2019 @ LIGO-Virgo Collaboration Meeting
bKAGRA configuration & installation 2018-2019

【VIS】
ALL the large suspensions have been installed!
Tunings are ongoing along with the alignment.
In Feb., all SRs has been installed!

【Input Optics】
40W laser, PMC, Mach-Zehnder type modulation system, PM&AM monitor system are installed.

【Output Optics】
Mode cleaner, Faraday isolater, mode-matching telescopes are installed.

【Mirror, CRYO】
ALL Sapphire mirrors are installed.

- Output mode cleaner (OMC)
- Output Faraday Isolator (OFI)
- Output mode-matching telescopes (OMMTs) installed!
- Input mode cleaner was tested with 10W
- Intensity stabilization is being commissioned
- Frequency stabilization (mode cleaner & reference cavity) has been operating since phase1
- Cryogenic test mass: Sapphire, 23kg, 20K
- Dynamic isolator: IP + GASF + Payload
- Stack for aux. optics
- Core optics (BS, SRM,...): Silica, 10kg, 290K
- IP + GASF + Payload
- Seismic isolator: Table + GASF +
**bKAGRA configuration & installation 2018-2019**

**[VIS]**

- ALL the large suspensions have been installed!
- Tunings are ongoing along with the alignment.

- In Feb., all SRs has been installed!

**[Auxiliary Optics] All system finally installed.**

**[Mirror, CRYO]**

- ALL Sapphire mirrors are installed.

**[Input Optics]** 40W laser, PMC, Mach-Zehnder type modulation system, PM&AM monitor system are installed.

**[Output Optics]** Mode cleaner, Faraday isolater, mode-matching telescopes are installed.
Editors thank Takaaki Yokozawa for his suggestions of photos.

(Right) Photon Calibrator X-end installation completed. July 25. [G1809009]
In photo, Takaaki Yokozawa, Yuki Inoue, Takahiro Yamamoto, and Chihiro Kozakai.

(Left) Installed the BR6 part on the TMS-VIS in the EST chamber at the X-end! [klog 06342].
In photo, Fumihiro Uraguchi, Koji Nagano, Kunihiko Hasegawa, Kenta Tanaka, Naoki Kita, and Tomotada Akutsu.

(Above) OMC installation succeeded, October 18. [klog 06612].
In photo, Sotatsu Otabe, Kohei Kusayanagi, Hiraku Sasaki, and Kentaro Somiya.

(Right) Nov. 9, the last installation of cryogenic payload was completed. The photo at Y-front was distributed in [kagra 02500].
In photo, Masahiro Takahashi, Takayuki Tomaru, and Sakae Araki.

Hisaaki Shinkai (Osaka Institute of Technology)  March 20, 2019  @ LIGO-Virgo Collaboration Meeting

KSC newsletter (2018 Dec.)

Status of KAGRA

bKAGRA configuration & installation 2018-2019

【CAL】
Photon calibrator modules installed at the both ends Calibration pipelines are being constructed

【Mirror】
Many mirrors were cleaned before starting the DRMI commissioning.

We did it! in 2018

Interferometer Initial Alignment Ongoing

We did it! in 2018

Interferometer Initial Alignment Ongoing

X-arm Locking Test

• X-arm test has completed
  • X-arm locked with the axillary (green) laser, then successfully handed off to the IR laser
  • Noise budgeting
Data-exchange tests with low latency

- **KAGRA-LV data exchange will start in April.**

  (MOU between K-LV 2012, attachment B)

For KAGRA members, LV data access account will be issued only whom filed his/her signed “O3 commitment form” and applied for.

(declare ethical statement on confidential issues).
### Status of KAGRA

**Roadmap to join O3: Plan A & B**

<table>
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<th>2018</th>
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</table>

- **Jan 6:** X-arm commissioning was finished.
- **Feb 11:** Y-arm alignment was finished.
- **Feb 12-15:** all the chambers in the central area were pump-downed.
- **Feb 18:** DRMI commissioning (ITMs) was started
- **Feb 26:** cool-down of ITMs was started
  - troubles at BS, suspension, cryo
- **Mar 25:** FPMI commissioning will be started.

**Jan 6:** X-arm commissioning was finished.
**Feb 11:** Y-arm alignment was finished.
**Feb 12-15:** all the chambers in the central area were pump-downed.
**Feb 18:** DRMI commissioning (ITMs) was started
**Feb 26:** cool-down of ITMs was started
  - troubles at BS, suspension, cryo
**Mar 25:** FPMI commissioning will be started.

#### Roadmap to join O3: Plan A & B

- **Plan A:**
  - DRFPMI (RSE)
  - Post commissioning
  - DRFPMI (RSE)

- **Plan B:**
  - FPMI

**Data Sharing with KAGRA-LIGO-Virgo**

- **ER? ER? ER?**

- either DRFPMI (RSE) (-25Mpc, Oct?) or FPMI (-10Mpc, June?)
- checking points: Sep/2018, Dec/2018 and Mar/2019
Status of KAGRA

Hisaaki Shinkai (Osaka Institute of Technology)  March 20, 2019  @ LIGO-Virgo Collaboration Meeting

Links to Physics and Astronomy people (in Japan)

KAGRA collaboration

Grant-in-Aid for Scientific Research on Innovative Areas

Japanese Collaboration for GW Electro-Magnetic Follow-up

GW physics and astronomy: Genesis

A01 Testing GR
A02 Gravity theories
A03 Study on binary BH formation
B01 GWs from NS-NS/BH-NS, Pulsars and Magnetars
B02 Sources probed with High Energy Observations
B03 Nucleosynthesis with follow-up observations
C01 Physics of Core-Collapse SN
C02 SN explosions via their neutrino emissions

J-GEM collaboration

1. Katana Telescope  1.5m optical-infrared telescope of Hiroshima Univ. Japan
2. Mini-TAO Telescope  1m optical-infrared telescope of Univ. of Tokyo. & Atacama, Chile
3. Kiso Schmidt Telescope  1.05m Schmidt telescope of Univ. of Tokyo. & Kiso, Japan
4. OAO-WFC  0.9m infrared telescope of NAOJ. & Okayama, Japan
5. MITSuME Telescopes  0.5m optical telescopes of NAOJ and TITech. & Okayama & Akeno, Japan
6. IRSF  1.4m infrared telescope of Nagoya Univ. & South Africa
7. Yamaguchi  32m Radio Telescope, Yamaguchi Univ. & Yamaguchi, Japan
8. Kyoto  3.8m Telescope,  3.8m optical-infrared telescope of Kyoto Univ. & Okayama, Japan
9. Hinotori Telescope  0.5m optical telescope of Hiroshima Univ. & Tibet, China.
10. MOA-II  1.8m optical telescope of MOA collaboration. & New Zealand
11. Subaru Telescope  8.2m optical infrared telescope of NAOJ & Hawaii, USA.
KAGRA will finish all the installations by middle of April, 2019. (at least 2-week delay from the plan a year ago).

Our test run begins in early June.

KAGRA plans to join Observation Run 3 from fall 2019.

KAGRA-LV data exchange will start in April.

KAGRA-LV MOU discussion will be started soon.

KAGRA CBC members are waiting to have access to LV wiki.

KAGRA plans to join O4 from the beginning.

Regarding future plans, please check out Haino’s talk yesterday.