

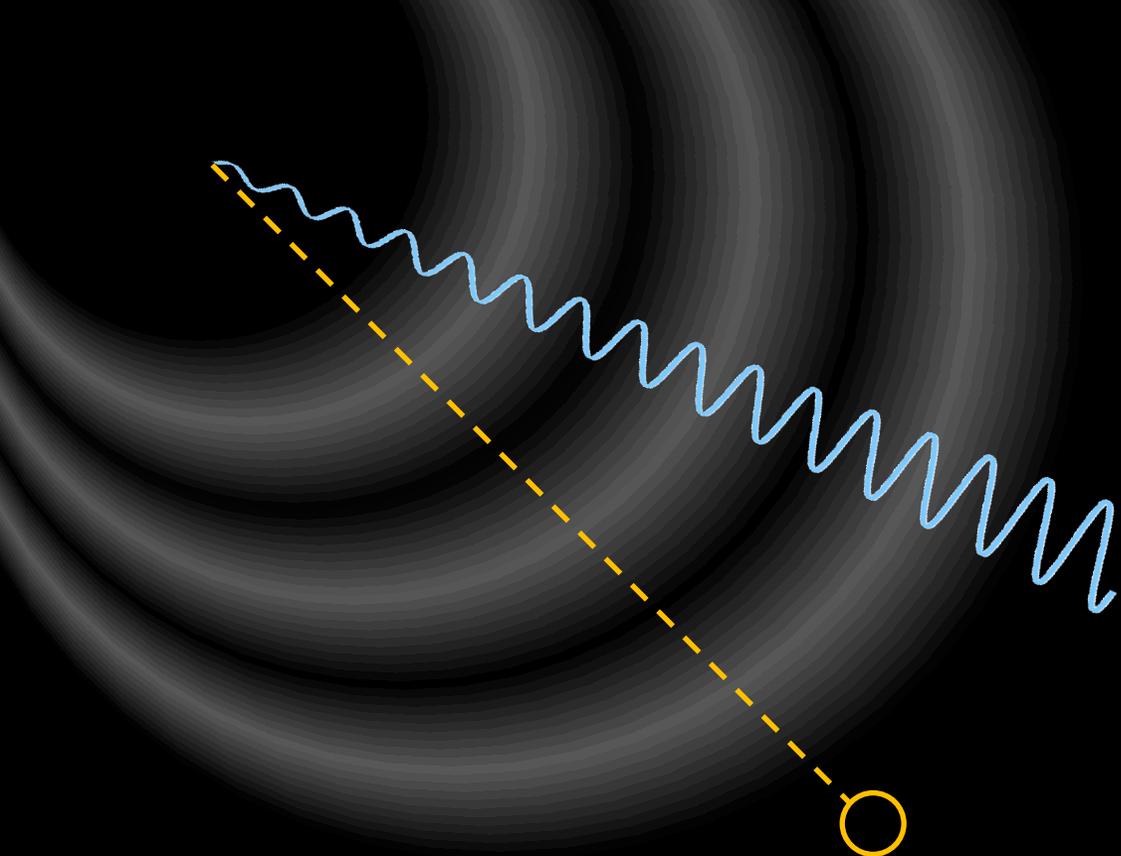
# Current Status and Future Run Prospects of LIGO, Virgo and KAGRA

Peter S. Shawhan  
University of Maryland

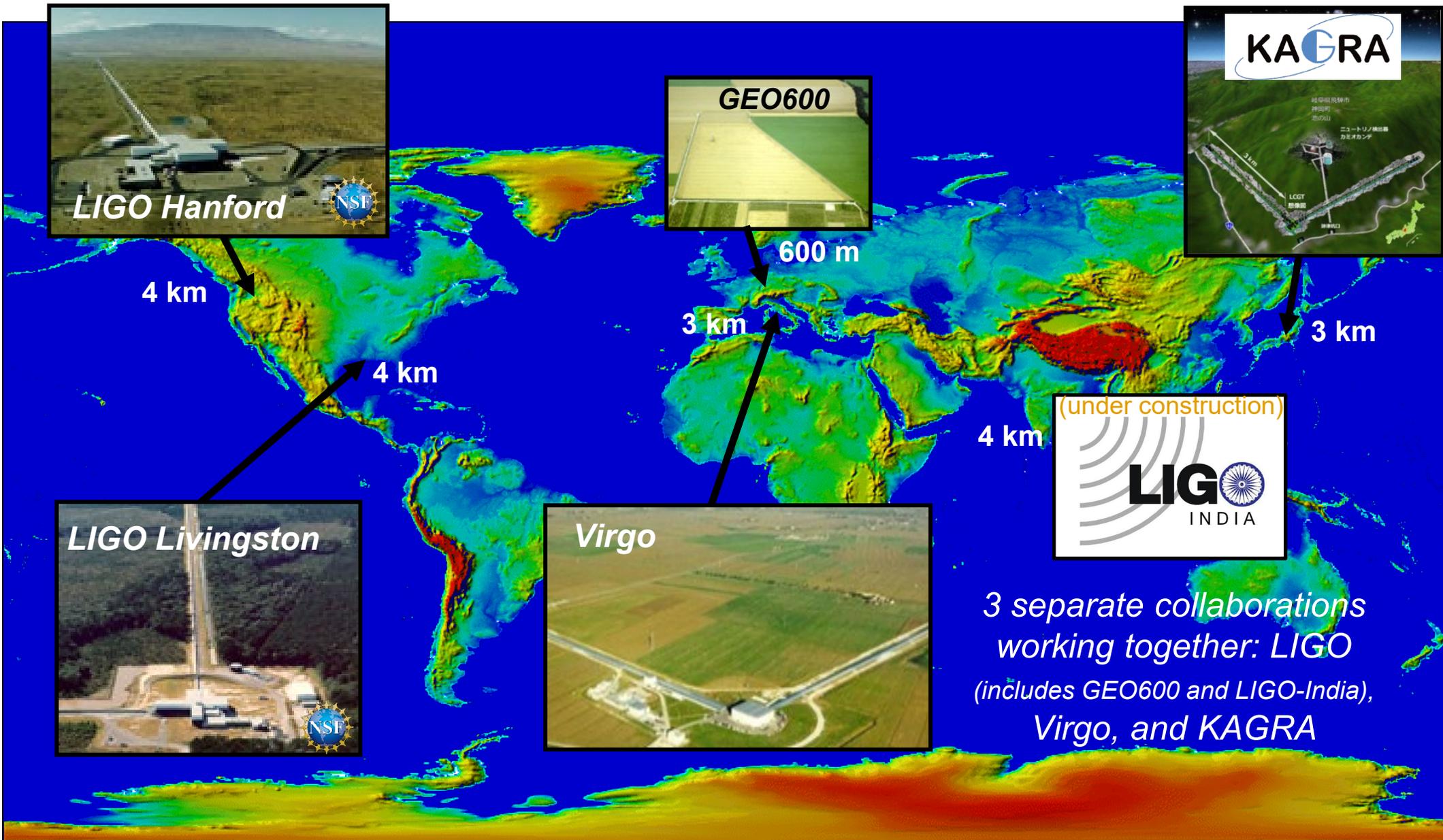
For the LIGO Scientific Collaboration,  
Virgo Collaboration and KAGRA Collaboration

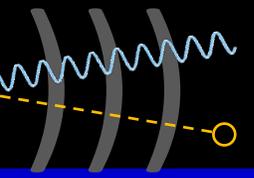


*4th TDAMM Workshop*  
October 27, 2025



# The current global gravitational-wave detector network





# BTW, an organizational transition is being planned

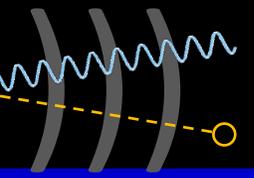


LVK → IGWN

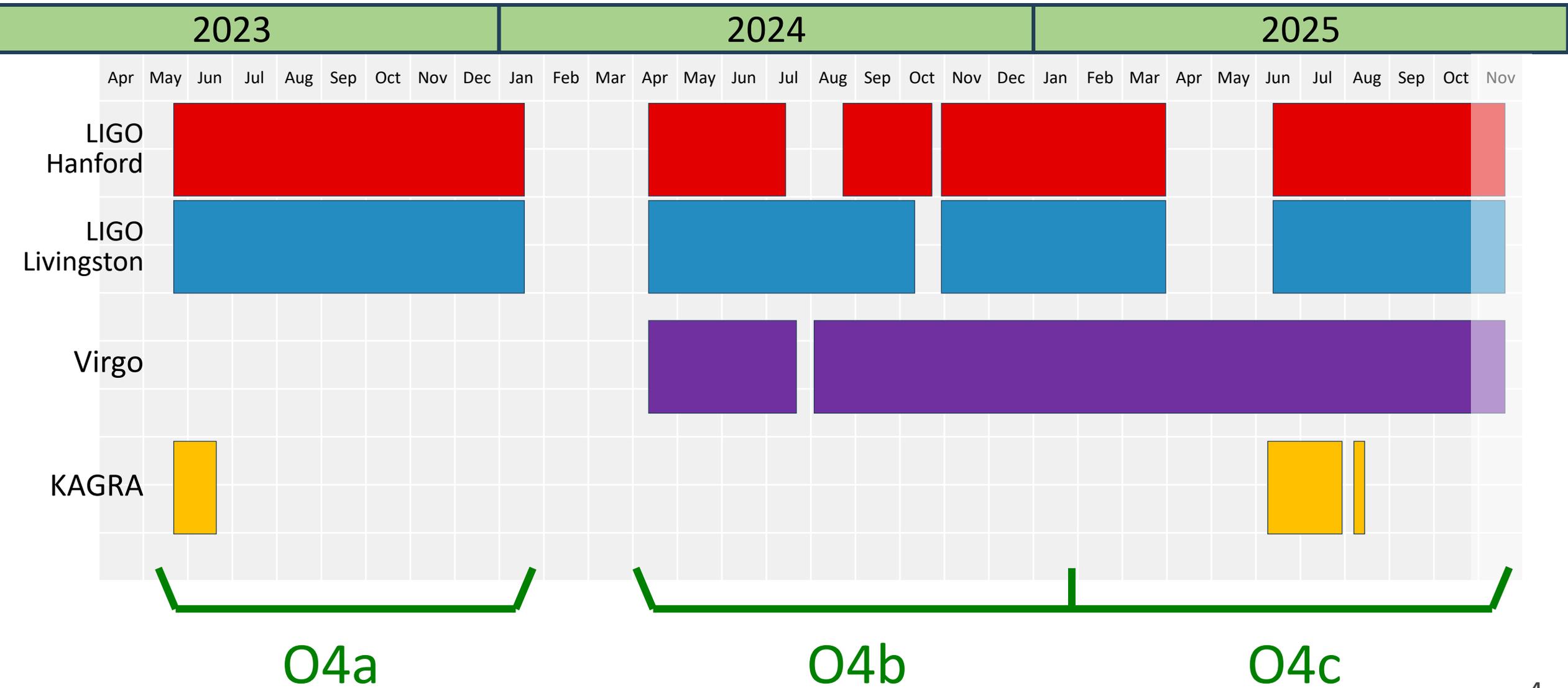
The **International Gravitational-Wave Observatory Network** is envisioned as a self-governing consortium using laser interferometer GW detectors to explore the fundamental physics of gravity and observe the universe.

IGWN will build upon the success of the LIGO Scientific Collaboration, Virgo Collaboration, and KAGRA Collaboration, evolving them into a single unified global consortium that executes its scientific program in a coordinated and efficient fashion.

- 2020-2023: Discussions of the concept, appointment of an IGWN Formation Committee
- 2024: LVK approvals to proceed, appointment of IGWN Design Committee, first draft of bylaws
- 2025: Further design, planning of scientific program and funding / resource coordination framework
- 2026: LVK groups (and others) will be able to formally join IGWN
- 2027: IGWN fully operational



# The O4 Observing Run



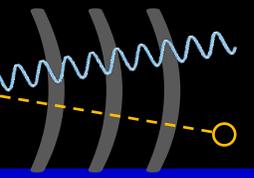


The LIGO Scientific Collaboration and Virgo collaboration have been co-authoring observational result papers since 2010. Beginning in 2021, the KAGRA Collaboration too is co-authoring observational results from the full O3 run. See [here](#) for additional information.

[BibTeX file for these papers](#) [Click to toggle doi information](#) [Link to this page with keyword filter O4 applied](#) Highlighting: [Event discoveries](#) [Multi-messenger](#)

Release Date	Title	Keywords (clear filter)	Science Summary	Journal citation	arXiv Preprint	Public Report
Oct 20, 2025 <i>*Recent*</i>	<b>Directional search for persistent gravitational waves: Results from the first part of LIGO, Virgo, and KAGRA's fourth Observing Run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 Stochastic LVK</a>	-	Submitted to PRD	<a href="#">2510.17487</a>	<a href="#">P2500380</a>
Sep 10, 2025 <i>*Recent*</i>	<b>GW250114: Testing Hawking's area law and the Kerr nature of black holes</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GW250114 LVK</a>	<a href="#">summary</a>	<a href="#">Phys. Rev. Lett. 135, 111405 (2025)</a>	<a href="#">2509.08054</a>	<a href="#">P2500421</a>
Sep 10, 2025 <i>*Recent*</i>	<b>Black Hole Spectroscopy and Tests of General Relativity with GW250114</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GW250114 TGR LVK</a>	<a href="#">summary</a>	Submitted to PRL	<a href="#">2509.08099</a>	<a href="#">P2500461</a>
Sep 9, 2025 <i>*Recent*</i>	<b>GW230814: investigation of a loud gravitational-wave signal observed with a single detector</b> (by A. G. Abac et al. (LSC, Virgo and KAGRA))	<a href="#">O4 GW230814 LVK</a>	<a href="#">summary</a>	Submitted to ApJL	<a href="#">2509.07348</a>	<a href="#">P230814</a>
Sep 9, 2025 <i>*Recent*</i>	<b>Directed searches for gravitational waves from ultralight vector boson clouds around merger remnant and galactic black holes during the first part of the fourth LIGO-Virgo-KAGRA observing run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CW LVK</a>	<a href="#">summary</a>	Submitted to PRD	<a href="#">2509.07352</a>	<a href="#">P2500256</a>
Sep 4, 2025 <i>*Recent*</i>	<b>GWTC-4.0: constraints on the cosmic expansion rate and modified gravitational-wave propagation</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC LVK</a>	<a href="#">summary</a>	Submitted to ApJL	<a href="#">2509.04348</a>	<a href="#">P2400152</a>
Aug 28, 2025 <i>*Recent*</i>	<b>Upper Limits on the Isotropic Gravitational-Wave Background from the first part of LIGO, Virgo and KAGRA's fourth Observing Run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 Stochastic LVK</a>	<a href="#">summary</a>	Submitted to PRD	<a href="#">2508.20721</a>	<a href="#">P2500349</a>
Aug 25, 2025	<b>Open Data from LIGO, Virgo, and KAGRA through the first part of the fourth observing run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 data LVK</a>	<a href="#">summary</a>	Submitted to ApJS	<a href="#">2508.18079</a>	<a href="#">P2500167</a>
Aug 25, 2025	<b>GWTC-4.0: An Introduction to Version 4.0 of the Gravitational-Wave Transient Catalog</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GWTC LVK</a>	<a href="#">summary</a>	Accepted by ApJL	<a href="#">2508.18080</a>	<a href="#">P2400293</a>
Aug 25, 2025	<b>GWTC-4.0: Methods for identifying and characterizing gravitational-wave transients</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GWTC LVK</a>	<a href="#">summary</a>	Submitted to ApJL	<a href="#">2508.18081</a>	<a href="#">P2400300</a>
Aug 25, 2025	<b>GWTC-4.0: Updating the Gravitational-Wave Transient Catalog with Observations from the First Part of the Fourth LIGO-Virgo-KAGRA Observing Run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GWTC LVK</a>	<a href="#">summary</a>	Submitted to ApJL	<a href="#">2508.18082</a>	<a href="#">P2400386</a>
Aug 25, 2025	<b>GWTC-4.0: Population Properties of Merging Compact Binaries</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC LVK</a>	<a href="#">summary</a>	Submitted to ApJL	<a href="#">2508.18083</a>	<a href="#">P2400004</a>
Jul 16, 2025	<b>All-sky search for long-duration gravitational-wave transients in the first part of the fourth LIGO-Virgo-KAGRA Observing run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 Burst LVK</a>	<a href="#">summary</a>	Submitted to PRD	<a href="#">2507.12282</a>	<a href="#">P2500090</a>
Jul 16, 2025	<b>All-sky search for short gravitational-wave bursts in the first part of the fourth LIGO-Virgo-KAGRA observing run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 Burst LVK</a>	<a href="#">summary</a>	Accepted by PRD	<a href="#">2507.12374</a>	<a href="#">P2400601</a>
Jul 14, 2025	<b>GW231123: a Binary Black Hole Merger with Total Mass 190-265 Msun</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CBC GW231123 LVK</a>	<a href="#">summary</a>	Accepted by ApJL	<a href="#">2507.08219</a>	<a href="#">P2500026</a>
Jan 2, 2025	<b>Search for continuous gravitational waves from known pulsars in the first part of the fourth LIGO-Virgo-KAGRA observing run</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 CW LVK</a>	<a href="#">summary</a>	<a href="#">Astrophys. J. 983, 99 (2025)</a>	<a href="#">2501.01495</a>	<a href="#">P2400315</a>
Oct 21, 2024	<b>Search for gravitational waves emitted from SN 2023ixf</b> (by LSC, Virgo and KAGRA)	<a href="#">O4 SN2023ixf LVK</a>	<a href="#">summary</a>	<a href="#">Astrophys. J. 985, 183 (2025)</a>	<a href="#">2410.16565</a>	<a href="#">P2400125</a>
Apr 5, 2024	<b>Observation of Gravitational Waves from the Coalescence of a 2.5-4.5 M_sun Compact Object and a Neutron Star</b> (by A. G. Abac et al. (LSC, Virgo and KAGRA))	<a href="#">O4 GW230529 LVK</a>	<a href="#">summary</a>	<a href="#">Astrophys. J. Lett. 970, L34 (2024)</a>	<a href="#">2404.04248</a>	<a href="#">P2300352</a>

Updated catalog & population properties



# Observing Plans web page



IGWN | Observing Plans

<https://observing.docs.ligo.org/plan/>

## LIGO, VIRGO AND KAGRA OBSERVING RUN PLANS

(15 October 2025 update; next update 18 November 2025 or sooner)

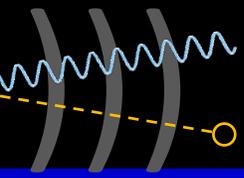
**Future planning: The current observing run, O4c, will conclude on 18 November 2025. After this date, all detectors will remain offline for upgrades at least until mid-2026.**

Plans beyond mid-2026 are under discussion and will depend on budgetary scenarios and other factors. We will provide updates here as the plans become firm.

The LIGO Hanford (LHO), LIGO Livingston (LLO), Virgo, and KAGRA detectors resumed the fourth observing run (O4c) at 15:00 UTC on Wednesday, 11 June 2025.

In mid-August, the main laser (fiber amplifier) of KAGRA failed, and KAGRA has not been in observational operation since then. The laser has already been replaced with a new unit, and work is underway to bring the interferometer back to its previous operational state with the new laser, followed by commissioning to recover sensitivity and resumption of observations as soon as the detector is ready.

Still a few weeks left to get a fabulous multi-messenger event before the O4 run ends and upgrade work begins!



# Low-latency analysis and public alerts



For details, see the **LVK Public Alerts User Guide**, <https://emfollow.docs.ligo.org/userguide/>

## Analysis Pipelines

## Information Provided

*Matched Filter*

*Excess Power*

*Machine Learning*

Sky Loc.

Classification

Properties

Signal Type

**CBC**

(Compact Binary Coalescence)

GstLAL  
MBTA  
PyCBC Live  
SPIIR

cWB  
(BBH tuned)

Aframe

✓  
BAYESTAR

%

BNS  
NSBH  
BBH  
Terr.

%

HasNS  
HasRemnant  
HasMassGap  
HasSSM

Binned chirp mass

**Burst**

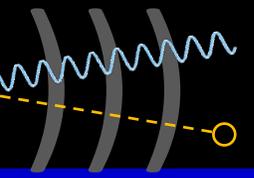
(Unmodeled Signal)

cWB  
(generic)

MLy

✓

*Plus:* RapidPE-RIFT and Bilby rapid CBC parameter estimation  
RAVEN search for coincident EM and GW events



Please log in to view full database contents.

### LIGO/Virgo/KAGRA Public Alerts

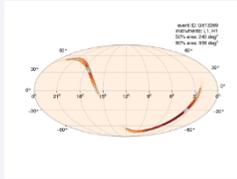
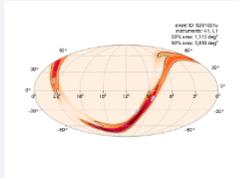
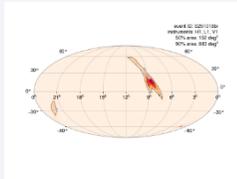
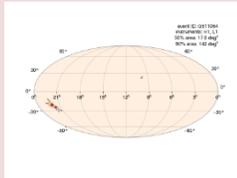
<https://gracedb.ligo.org/superevents/public>

O4 Significant Detection Candidates: **246** (275 Total - 29 Retracted)

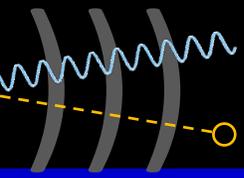
O4 Low Significance Detection Candidates: **4960** (Total)

**12 of these 29 retractions were Early-Warning triggers without full bandwidth confirmation**

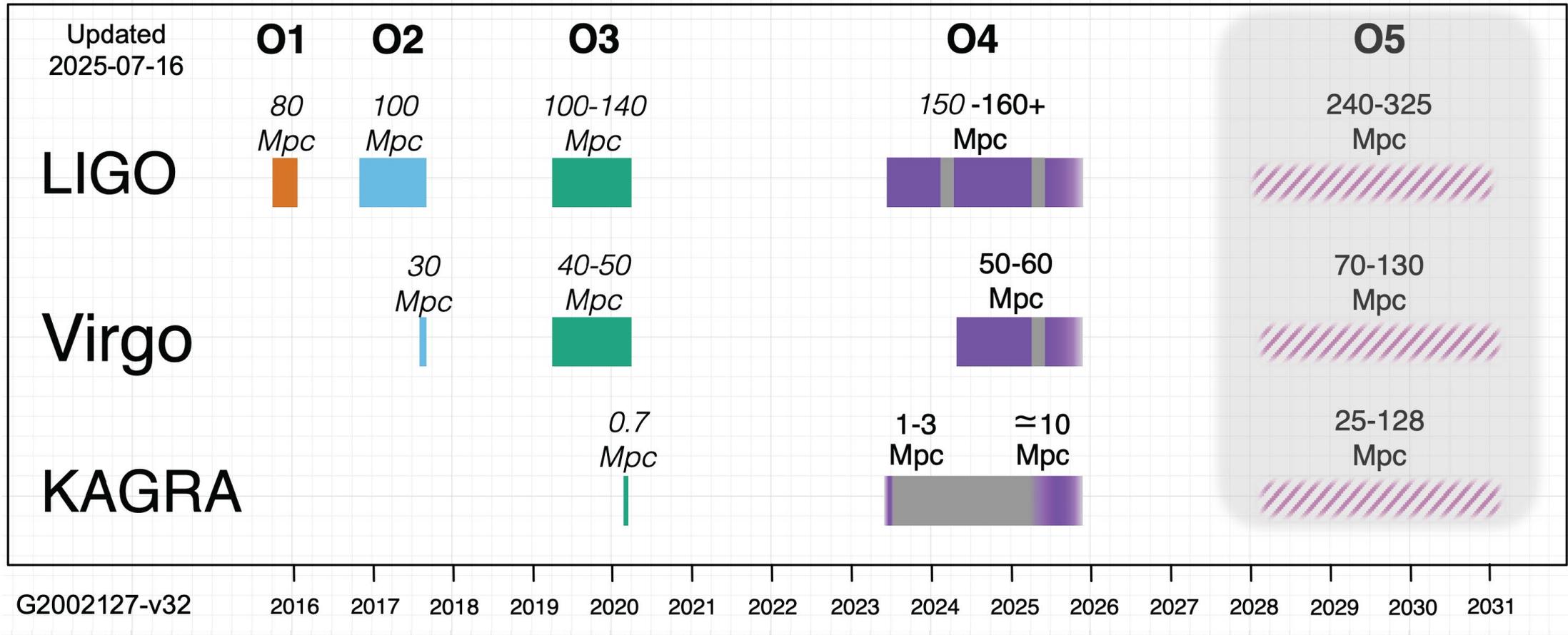
**Two significance thresholds**

Event ID	Possible Source (Probability)	Significant	UTC	GCN	Location	FAR
<a href="#">S251026bn</a>	BBH (>99%)	Yes	Oct. 26, 2025 21:16:05 UTC	<a href="#">GCN Circular</a> <a href="#">Query</a> <a href="#">Notices   VOE</a>		1 per 6560.2 years
<a href="#">S251021u</a>	BBH (>99%)	Yes	Oct. 21, 2025 03:22:15 UTC	<a href="#">GCN Circular</a> <a href="#">Query</a> <a href="#">Notices   VOE</a>		1 per 14.291 years
<a href="#">S251018bi</a>	BBH (>99%)	Yes	Oct. 18, 2025 15:25:47 UTC	<a href="#">GCN Circular</a> <a href="#">Query</a> <a href="#">Notices   VOE</a>		1 per 100.04 years
<a href="#">S251017di</a>	Terrestrial (98%), BNS (2%)	Yes	Oct. 17, 2025 21:08:10 UTC	<a href="#">GCN Circular</a> <a href="#">Query</a> <a href="#">Notices   VOE</a>		2.2222 per year

**Early-Warning trigger without full bandwidth confirmation**

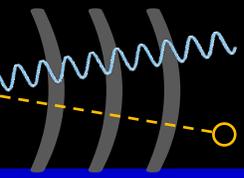


# Looking ahead ... with uncertainty



<https://observing.docs.ligo.org/plan/>

“Plans beyond mid-2026 are under discussion and will depend on budgetary scenarios and other factors.”



# LIGO's path to O5: complete the A+ upgrade



“Advanced LIGO Plus” (A+) is a comprehensive upgrade program to further boost the LIGO detector sensitivities by up to a factor of  $\sim 2$  in range

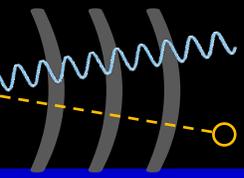
Major improvements to be completed:

- Improved vibration isolation
- Enlarged beamsplitter mirrors
- New interferometric readout scheme (balanced homodyne)
- Better control of stray light
- New mirror coatings to reduce thermal noise

Between O4 and O5, LIGO is planning to implement these in three phases

- Vent, install, pump down, commission and test

Funding cuts, if they become actual as outlined in the presidential budget request, would delay the later upgrade components



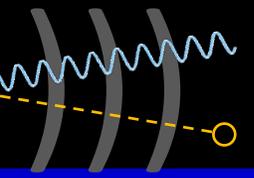
# Possibility of LVK observing in 2026 / 2027 ?



The Observing Plans web page notes the possibility: **“The current observing run, O4c, will conclude on 18 November 2025. After this date, all detectors will remain offline for upgrades at least until mid-2026.”**

Different scenarios are being discussed; there are no firm plans yet

- Balance the value of collecting data against the push to complete the upgrades for O5
- The NSF funding outcome could require cuts or delays that impact plans
- For LIGO, a natural opportunity would be after the first A+ installation phase
- Virgo and KAGRA have their own upgrade and commissioning plans to consider



# What would GW observing in 2026 / 2027 be like?



Any interim observing run would likely be short; perhaps ~6 months

It's not clear what such a run should be named

Would have both LIGO detectors observing together as much as possible

Probably with sensitivity similar to O4 or *slightly* better.

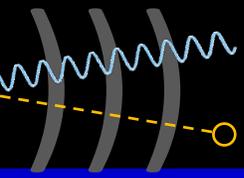
(Larger gains in sensitivity will come from the later phases of A+ component installation.)

It's unclear whether, or how much, Virgo and/or KAGRA would observe at the same time as LIGO

Low-latency data analysis and alerts will be a priority to continue

Possibly with a smaller set of pipelines than currently in use

I would not expect any *major* changes to GW alerts or data products before the actual O5 run, though some pipeline and infrastructure updates could be tested



# GW data analysis and alerts in the O5 era



Multi-messenger science, including low-latency alerts, will continue to be a central part of the LIGO-Virgo-KAGRA ( $\Rightarrow$ IGWN) science program

Expect to make some technical improvements during lead-up to O5

- Updates to low-latency search pipelines for speed, robustness

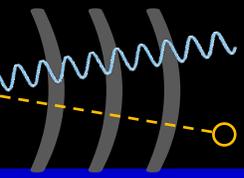
- Rapid response procedures

- Better classification probability estimates using multiple pipeline triggers

Expect (relatively) good localizations of GW events to become more common when 3+ updated, commissioned detectors are operating

- LIGO-India is under construction and will join the network too

- (And looking farther ahead, next-generation GW detectors: Einstein Telescope, Cosmic Explorer)



# Acknowledgements



This material is based upon work supported by NSF's LIGO Laboratory, which is a major facility fully funded by the National Science Foundation. The authors also gratefully acknowledge the support of the Science and Technology Facilities Council (STFC) of the United Kingdom, the Max-Planck-Society (MPS), and the State of Niedersachsen/Germany for support of the construction of Advanced LIGO and construction and operation of the GEO 600 detector. Additional support for Advanced LIGO was provided by the Australian Research Council. The authors gratefully acknowledge the Italian Istituto Nazionale di Fisica Nucleare (INFN), the French Centre National de la Recherche Scientifique (CNRS) and the Netherlands Organization for Scientific Research (NWO) for the construction and operation of the Virgo detector and the creation and support of the EGO consortium.

The authors also gratefully acknowledge research support from these agencies as well as by the Council of Scientific and Industrial Research of India, the Department of Science and Technology, India, the Science & Engineering Research Board (SERB), India, the Ministry of Human Resource Development, India, the Spanish Agencia Estatal de Investigación (AEI), the Spanish Ministerio de Ciencia, Innovación y Universidades, the European Union NextGenerationEU/PRTR (PRTR-C17.11), the ICSC - Centro Nazionale di Ricerca in High Performance Computing, Big Data and Quantum Computing, funded by the European Union NextGenerationEU, the Comunitat Autònoma de les Illes Balears through the Conselleria d'Educació i Universitats, the Conselleria d'Innovació, Universitats, Ciència i Societat Digital de la Generalitat Valenciana and the CERCA Programme Generalitat de Catalunya, Spain, the Polish National Agency for Academic Exchange, the National Science Centre of Poland and the European Union - European Regional Development Fund; the Foundation for Polish Science (FNP), the Polish Ministry of Science and Higher Education, the Swiss National Science Foundation (SNSF), the Russian Science Foundation, the European Commission, the European Social Funds (ESF), the European Regional Development Funds (ERDF), the Royal Society, the Scottish Funding Council, the Scottish Universities Physics Alliance, the Hungarian Scientific Research Fund (OTKA), the French Lyon Institute of Origins (LIO), the Belgian Fonds de la Recherche Scientifique (FRS-FNRS), Actions de Recherche Concertées (ARC) and Fonds Wetenschappelijk Onderzoek - Vlaanderen (FWO), Belgium, the Paris Île-de-France Region, the National Research, Development and Innovation Office of Hungary (NKFIH), the National Research Foundation of Korea, the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canadian Foundation for Innovation (CFI), the Brazilian Ministry of Science, Technology, and Innovations, the International Center for Theoretical Physics South American Institute for Fundamental Research (ICTP-SAIFR), the Research Grants Council of Hong Kong, the National Natural Science Foundation of China (NSFC), the Israel Science Foundation (ISF), the US-Israel Binational Science Fund (BSF), the Leverhulme Trust, the Research Corporation, the National Science and Technology Council (NSTC), Taiwan, the United States Department of Energy, and the Kavli Foundation. The authors gratefully acknowledge the support of the NSF, STFC, INFN and CNRS for provision of computational resources.

This work was supported by MEXT, the JSPS Leading-edge Research Infrastructure Program, JSPS Grant-in-Aid for Specially Promoted Research 26000005, JSPS Grant-in-Aid for Scientific Research on Innovative Areas 2402: 24103006, 24103005, and 2905: JP17H06358, JP17H06361 and JP17H06364, JSPS Core-to-Core Program A. Advanced Research Networks, JSPS Grants-in-Aid for Scientific Research (S) 17H06133 and 20H05639, JSPS Grant-in-Aid for Transformative Research Areas (A) 20A203: JP20H05854, the joint research program of the Institute for Cosmic Ray Research, University of Tokyo, the National Research Foundation (NRF), the Computing Infrastructure Project of the Global Science experimental Data hub Center (GSDC) at KISTI, the Korea Astronomy and Space Science Institute (KASI), the Ministry of Science and ICT (MSIT) in Korea, Academia Sinica (AS), the AS Grid Center (ASGC) and the National Science and Technology Council (NSTC) in Taiwan under grants including the Science Vanguard Research Program, the Advanced Technology Center (ATC) of NAOJ, and the Mechanical Engineering Center of KEK.