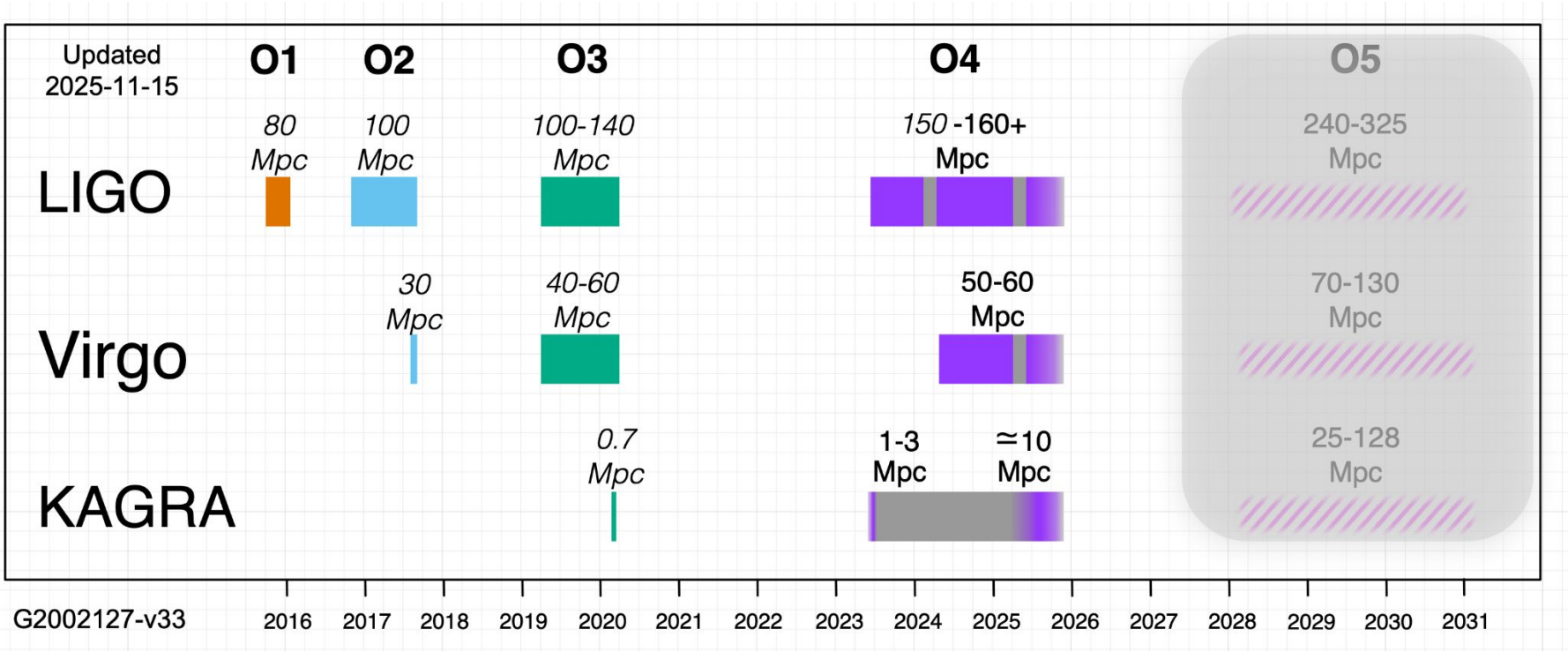
Zjazd CAMK 2026

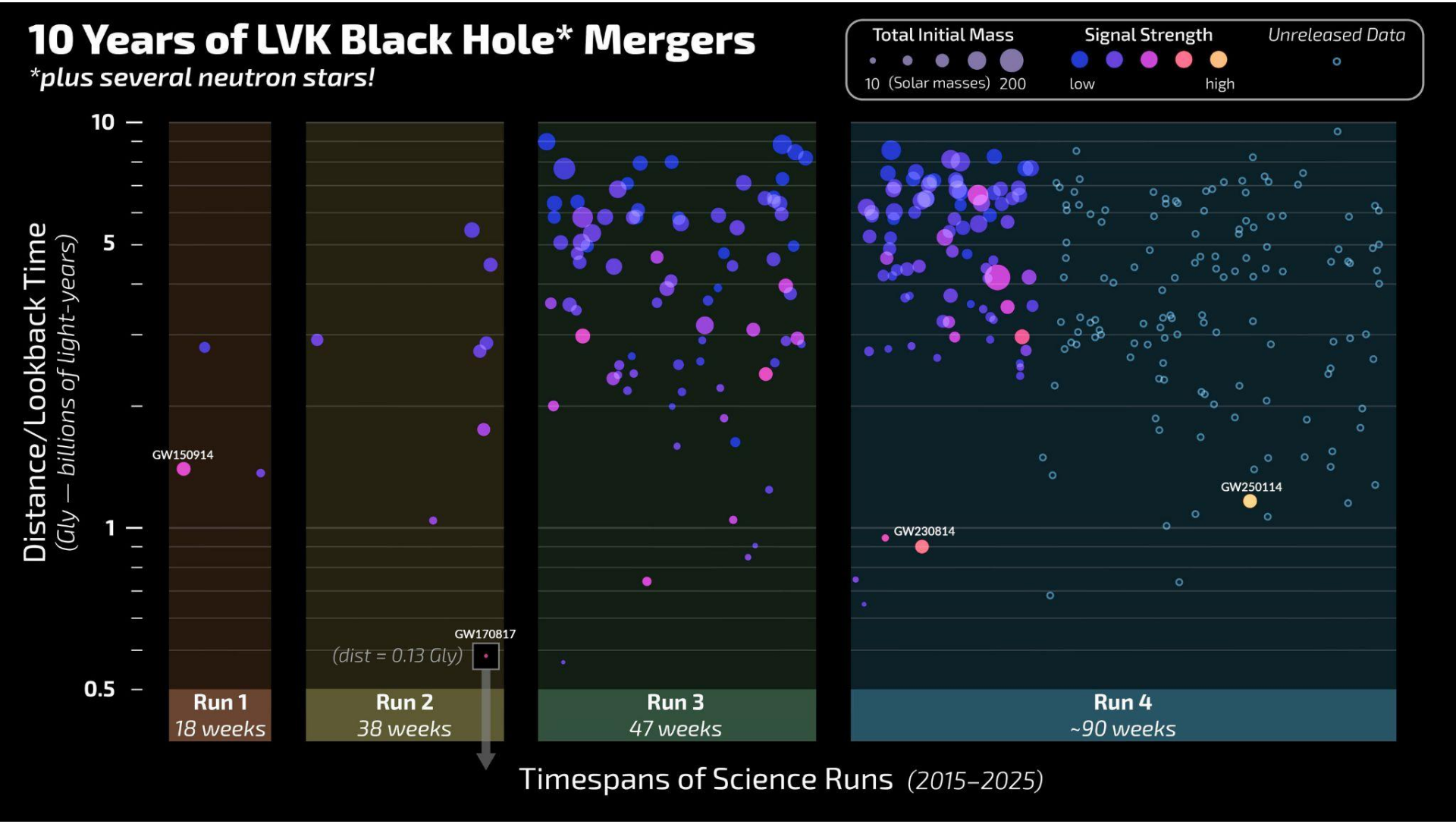
Michal Bejger (for the CAMK Virgo group)

Observing runs
https://observing.docs.ligo.org/plan



- O4 observing run concluded on 18 November 2025
  - O4a data (24 May 2023 to 16 January 2024) released on 24 August 2025: https://gwosc.org/news/o4a-open-data-release
  - O4b release May 2026, O4c December 2026
- Six-month observing run to begin in the late summer/early fall of 2026
  - To observe with EM partners, e.g. Rubin
  - ''Under new management'', IGWN https://igwn.docs.ligo.org/web/website/

218 significant detections in O1 – O4a



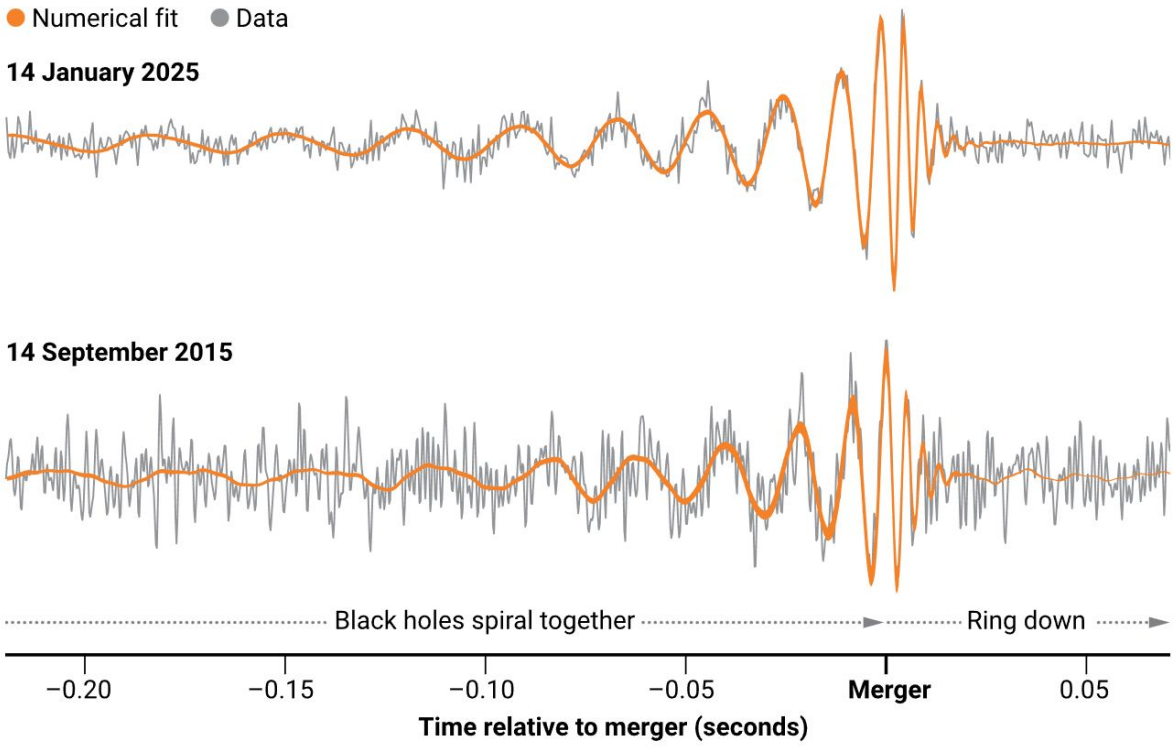
2025 collaboration papers

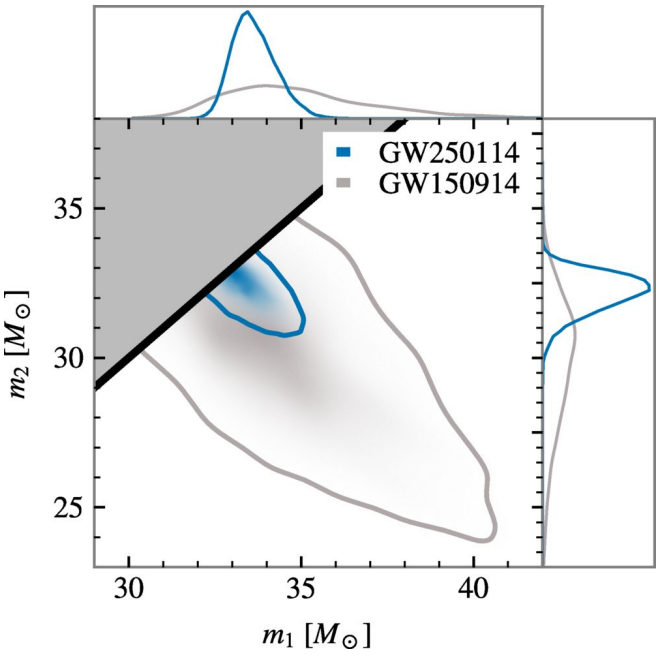
1. The LIGO Scientific Collaboration, et al., "Constraints on gravitational waves from the 2024 Vela pulsar glitch", arXiv e-prints arXiv:2512.17990 (2025)
2. Abac, A. G., et al., "GWTC-4.0: An Introduction to Version 4.0 of the Gravitational-Wave Transient Catalog", The Astrophysical Journal 995 L18 (2025)
3. The LIGO Scientific Collaboration, et al., "Search for planetary-mass ultra-compact binaries using data from the first part of the LIGO--Virgo--KAGRA fourth observing run", arXiv e-prints arXiv:2511.19911 (2025)
4. The LIGO Scientific Collaboration, et al., "All-sky search for continuous gravitational-wave signals from unknown neutron stars in binary systems in the first part of the fourth LIGO-Virgo-KAGRA observing run", arXiv e-prints arXiv:2511.16863 (2025)
5. Abac, A. G., et al., "All-sky search for short gravitational-wave bursts in the first part of the fourth LIGO-Virgo-KAGRA observing run", Physical Review D 112 102005 (2025)
6. Abac, A. G., et al., "GW231123: A Binary Black Hole Merger with Total Mass 190—265 $M_\odot$", The Astrophysical Journal 993 L25 (2025)
7. Abac, A. G., et al., "GW241011 and GW241110: Exploring Binary Formation and Fundamental Physics with Asymmetric, High-spin Black Hole Coalescences", The Astrophysical Journal 993 L21 (2025)
8. The LIGO Scientific Collaboration, et al., "Direct multi-model dark-matter search with gravitational-wave interferometers using data from the first part of the fourth LIGO-Virgo-KAGRA observing run", arXiv e-prints arXiv:2510.27022 (2025)
9. The LIGO Scientific Collaboration, et al., "Cosmological and High Energy Physics implications from gravitational-wave background searches in LIGO-Virgo-KAGRA's O1-O4a runs", arXiv e-prints arXiv:2510.26848 (2025)
10. The LIGO Scientific Collaboration, et al., "Directional Search for Persistent Gravitational Waves: Results from the First Part of LIGO-Virgo-KAGRA's Fourth Observing Run", arXiv e-prints arXiv:2510.17487 (2025)
11. Abbott, R., et al., "Tests of general relativity with GWTC-3", Physical Review D 112 084080 (2025)
12. The LIGO Scientific Collaboration, et al., "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", arXiv e-prints arXiv:2509.07352 (2025)

2025 collaboration papers

13. The LIGO Scientific Collaboration, et al., "GWTC-4.0: Constraints on the Cosmic Expansion Rate and Modified Gravitational-wave Propagation", arXiv e-prints arXiv:2509.04348 (2025)
14. Abac, A. G., et al., "GW250114: Testing Hawking's Area Law and the Kerr Nature of Black Holes", Physical Review Letters 135 111403 (2025)
15. The LIGO Scientific Collaboration, et al., "Upper Limits on the Isotropic Gravitational-Wave Background from the first part of LIGO, Virgo, and KAGRA's fourth Observing Run", arXiv e-prints arXiv:2508.20721 (2025)
16. The LIGO Scientific Collaboration, et al., "GWTC-4.0: Population Properties of Merging Compact Binaries", arXiv e-prints arXiv:2508.18083 (2025)
17. The LIGO Scientific Collaboration, et al., "GWTC-4.0: Updating the Gravitational-Wave Transient Catalog with Observations from the First Part of the Fourth LIGO-Virgo-KAGRA Observing Run", arXiv e-prints arXiv:2508.18082 (2025)
18. The LIGO Scientific Collaboration, et al., "GWTC-4.0: Methods for Identifying and Characterizing Gravitational-wave Transients", arXiv e-prints arXiv:2508.18081 (2025)
19. The LIGO Scientific Collaboration, et al., "Open Data from LIGO, Virgo, and KAGRA through the First Part of the Fourth Observing Run", arXiv e-prints arXiv:2508.18079 (2025)
20. The LIGO Scientific Collaboration, et al., "All-sky search for long-duration gravitational-wave transients in the first part of the fourth LIGO-Virgo-KAGRA Observing run", arXiv e-prints arXiv:2507.12282 (2025)
21. Abac, A. G., et al., "Search for Gravitational Waves Emitted from SN 2023ixf", The Astrophysical Journal 985 183 (2025)
22. Abac, A. G., et al., "Search for Continuous Gravitational Waves from Known Pulsars in the First Part of the Fourth LIGO-Virgo-KAGRA Observing Run", The Astrophysical Journal 983 99 (2025)
23. Abac, A., et al., "The Science of the Einstein Telescope", arXiv e-prints arXiv:2503.12263 (2025)
24. Raman, G., et al., "Swift-BAT GUANO Follow-up of Gravitational-wave Triggers in the Third LIGO–Virgo–KAGRA Observing Run", The Astrophysical Journal 980 207 (2025)

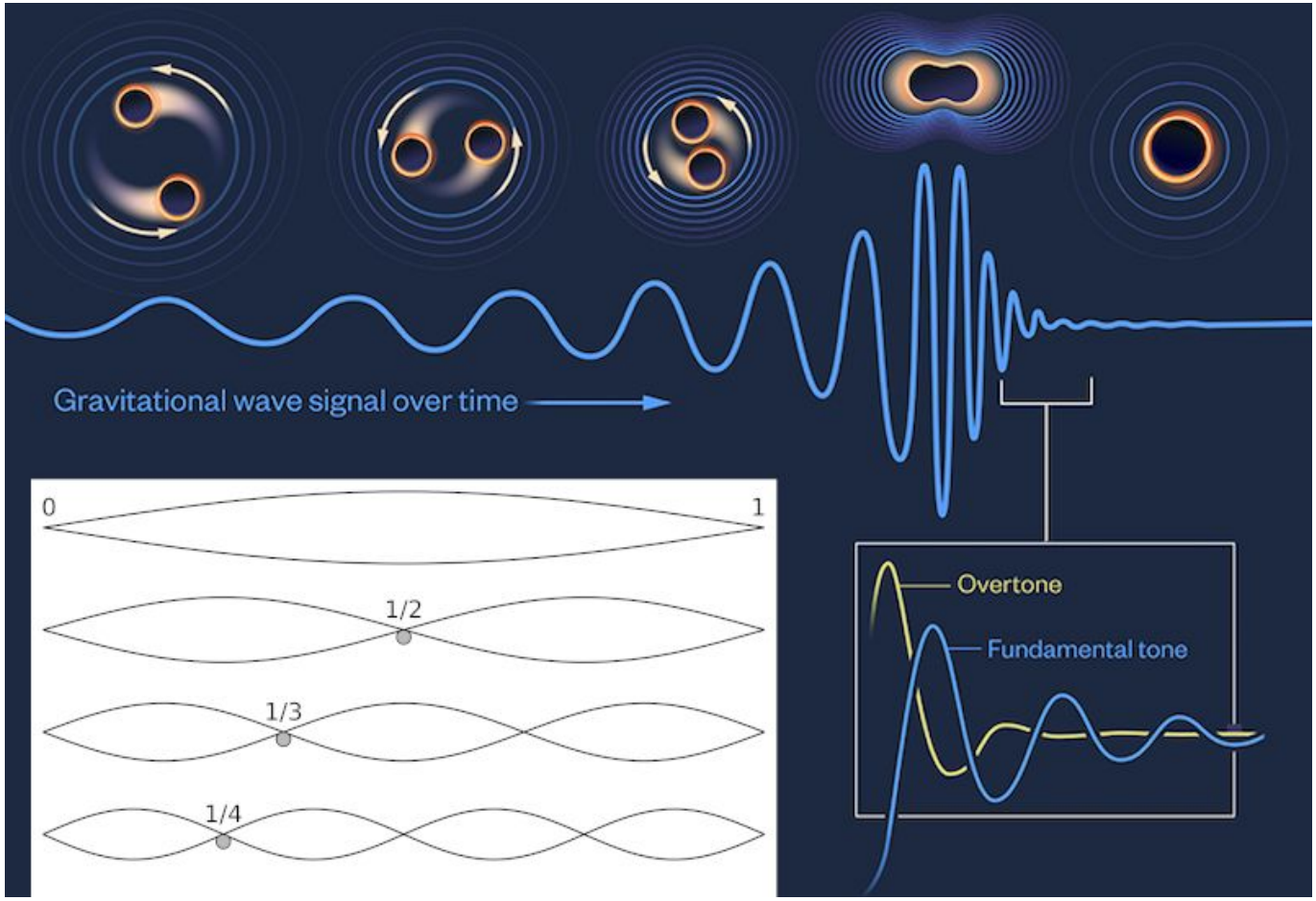
GW250114: younger sister of GW150914





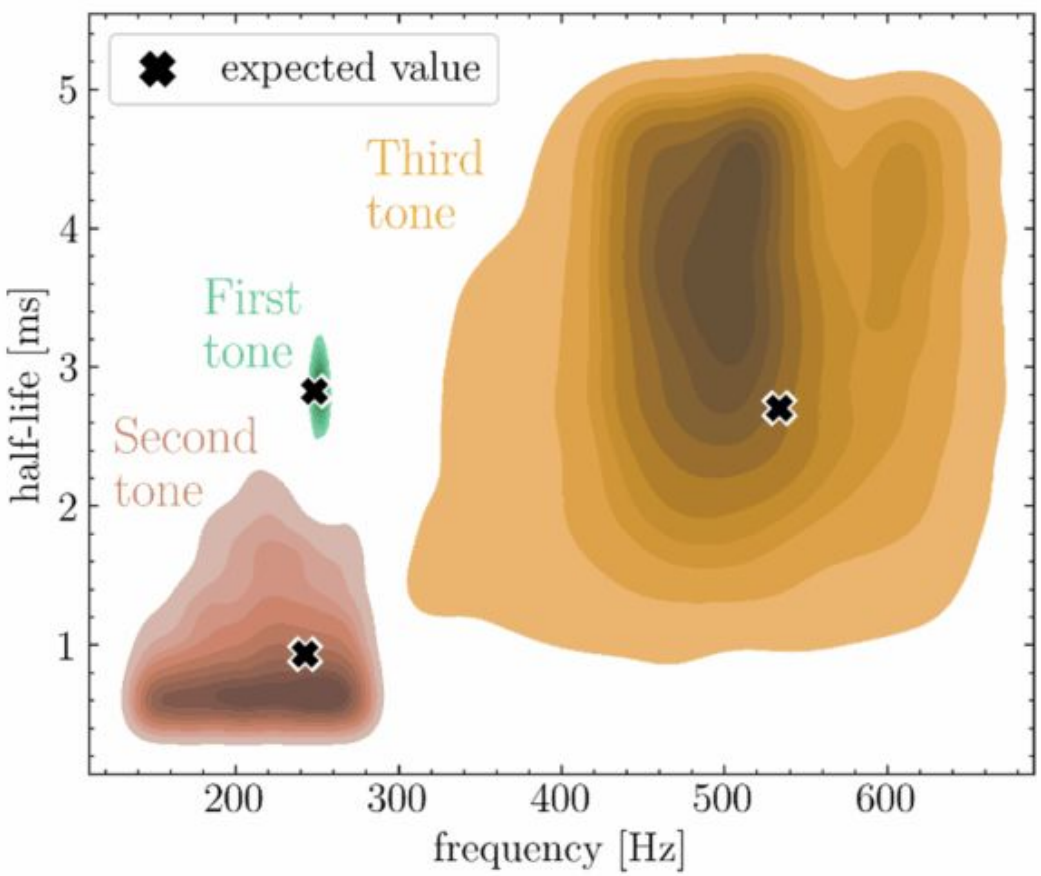
Binary black hole system of 33.6 $M_\odot$ and 32.2 $M_\odot$ with signal-to-noise SNR≈80
Masses and distance very similar to GW150914 with SNR≈24
→ 10 years of sensitivity improvements

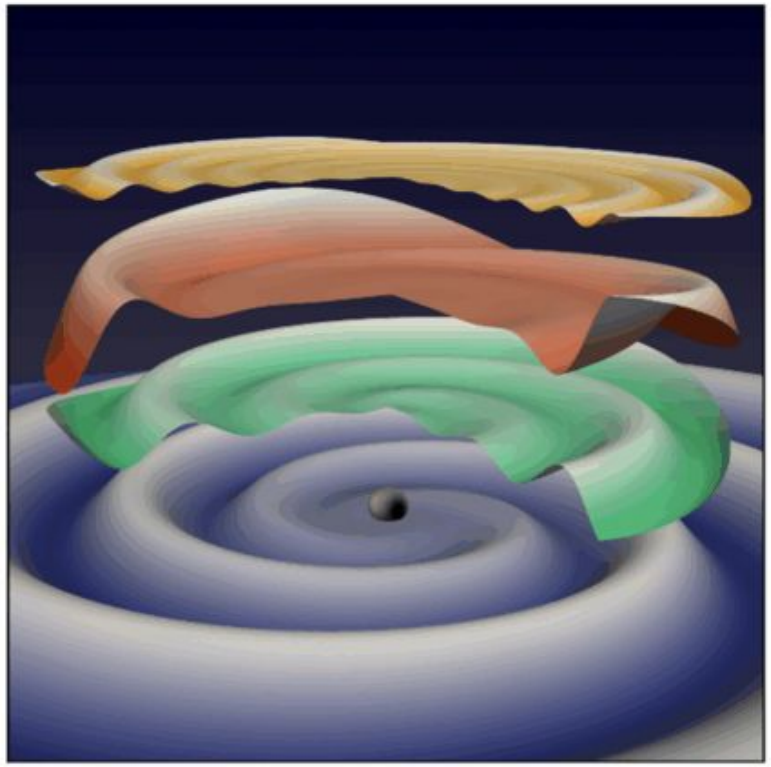
GW250114: "no hair theorem" test



Check if parameters of the remnant BH (mass and spin) are consistent with GR, as well as with the parameters of the inspiral, and ringdown modes (''podzwonne'')

GW250114: "no hair theorem" test





Check if parameters of the remnant BH (mass and spin) are consistent with GR, as well as with the parameters of the inspiral, and ringdown modes (''podzwonne'')

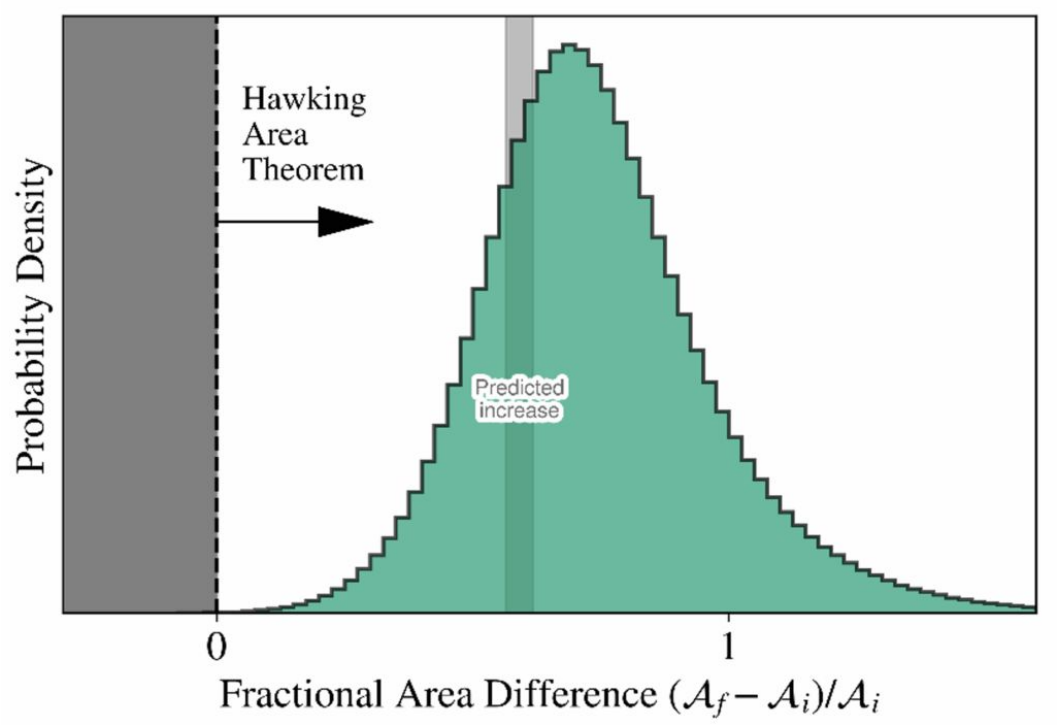
GW250114: Hawking area theorem test

Laws of BH thermodynamics:

0. Stationary BH has constant surface gravity on the event horizon (''constant temperature for systems in equilibrium''),

1. Change of BH mass (energy) is a function of horizon surface area, angular momentum and electric charge (''conservation of energy''),

2. Horizon area of an isolated BH never decreases (''entropy never decreases for isolated systems'').



BH size is proportional to its mass;
Schwarzschild radius: $R_s = 2GM/c^2$

A_f - horizon area of the final BH; $A_i = A_1 + A_2$ - sum of horizon areas of BHs before merger. Result: $A_f > A_i$

Grants & people

- **Science with Gravitational Waves in the Era of LIGO-Virgo-KAGRA Discoveries**
  OPUS NCN, PI Tomasz Bulik, start: Jan 2024 (4.4M PLN)
  - Anirudh Nemmani
  - Przemysław Figura

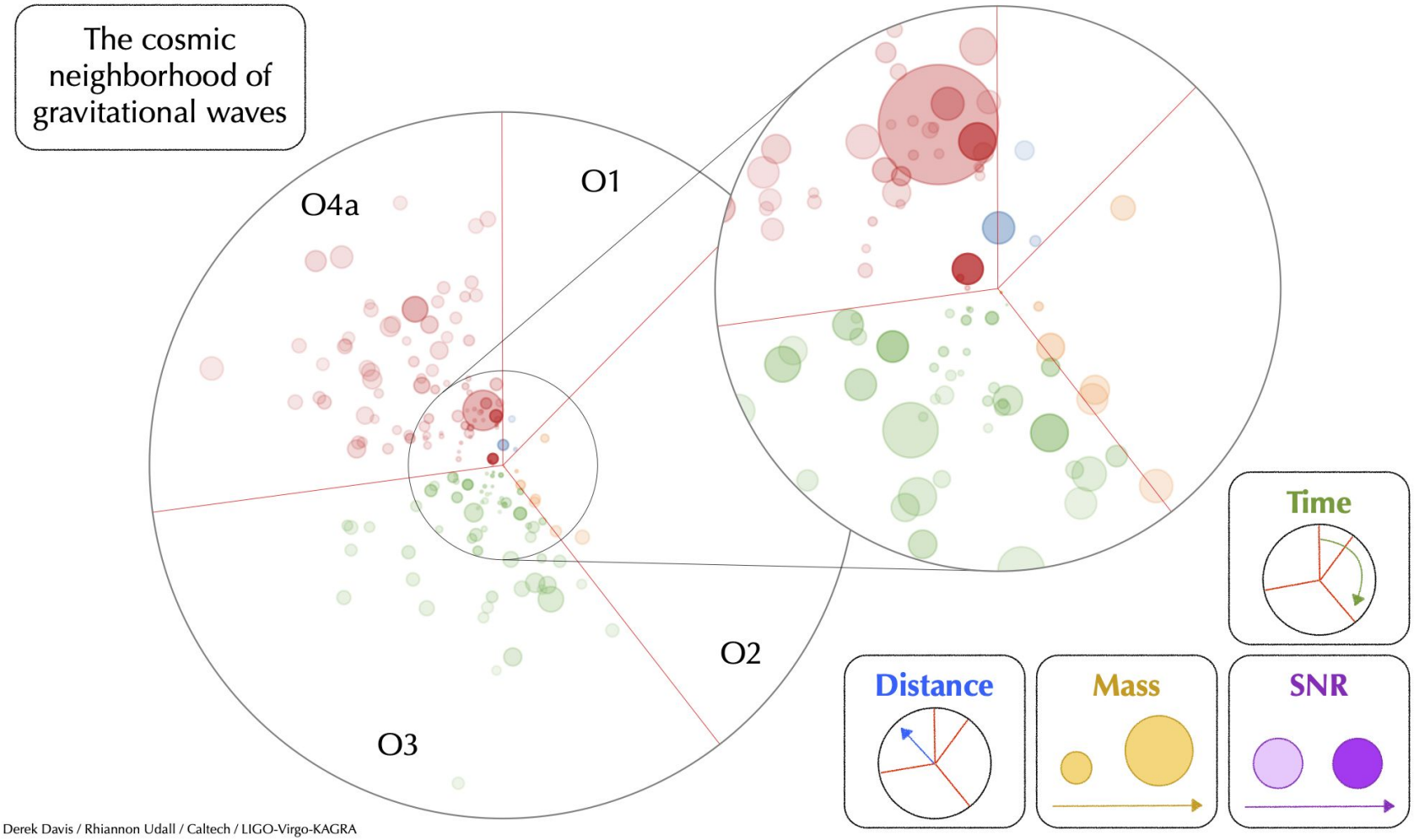
- **Through the lens: Discovering continuous gravitational waves amplified by microlensing**
  PRELUDIUM NCN, PI Sudhagar Suyamprakasam, start: Jan 2025 (140k PLN)

- **Gravitational Wave Lensing Exploration of Non-visible Structures**
  SONATINA NCN, PI Sreekanth Harikumar, start: Dec 2025 (735k PLN)

- **Virgo-PL: Polish participation in the Virgo gravitational wave observatory**

  Support for the participation of Polish research teams in international research infrastructure projects, PI Andrzej Królak, start: 2024 (12.3M PLN, CAMK: 870k PLN)

  - Support for technical expertise: Paweł Ciecieląg & Mariusz Suchenek
  - Computational resources in ACK Cyfronet AGH: at least 5000 CPU cores; GPU servers (at least 8 NVIDIA H100 class cards) + petabyte mass storage (hardware cost: 5M PLN)
  - Computing support personnel (1 FTE)


The cosmic neighborhood of gravitational waves
O4a
O1
O2
O3
Time
Distance
Mass
SNR
Derek Davis / Rhiannon Udall / Caltech / LIGO-Virgo-KAGRA