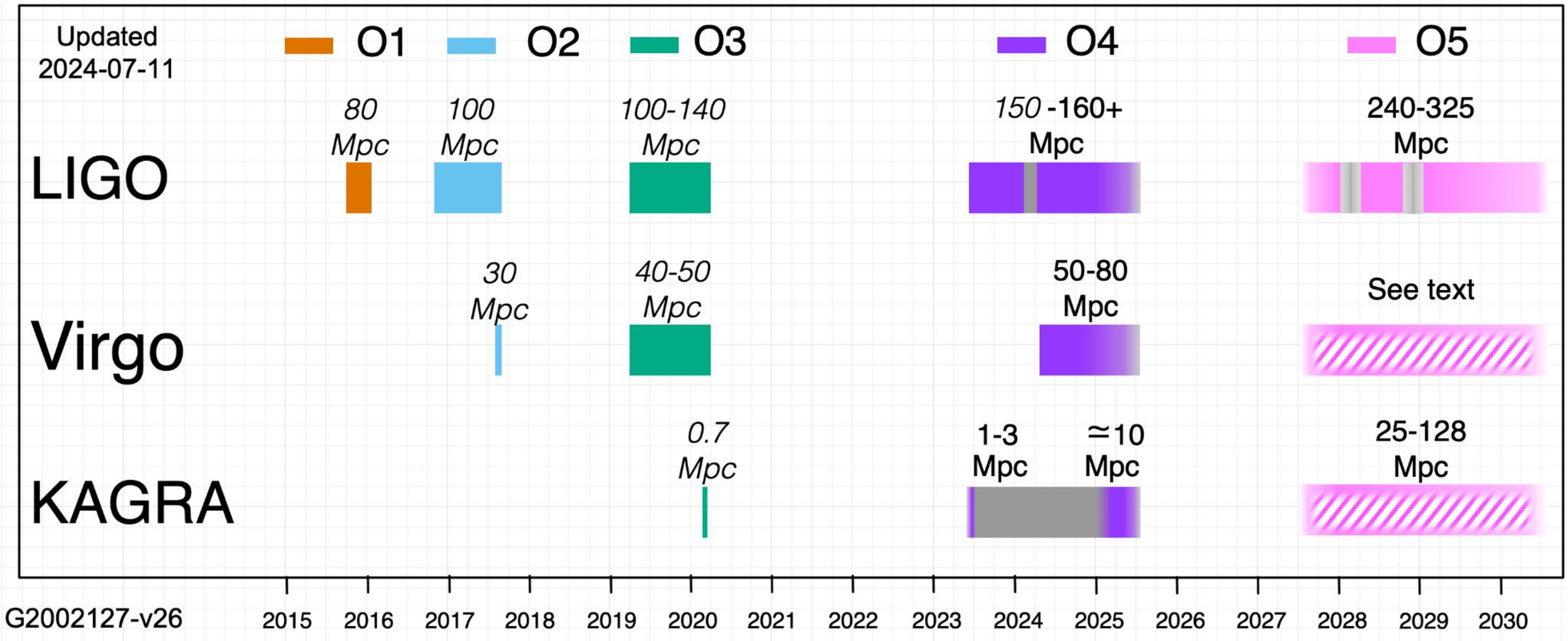
Zjazd CAMK 2025

Michal Bejger (for the CAMK Virgo group)

Observing runs

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



- O4a (LIGO detectors): 24 May 2023 - 16 Jan 2024
- O4b started 15:00 UTC on 10 April 2024
  - Virgo joined O4b
- Current plan: O4 ends 9 June 2025
  - Next update to the plan: 15 June 2025

LIGO/Virgo/KAGRA Public Alerts: https://gracedb.ligo.org/superevents/public/O4/

GraceDB Public Alerts Latest Search Documentation Login

Please log in to view full database contents.

O4a ended January 2024, providing 81 new high-confidence gravitational wave candidates

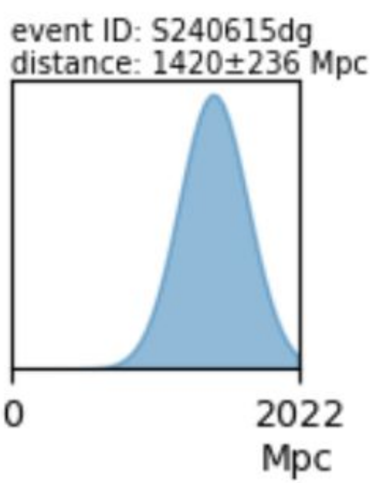
LIGO/Virgo/KAGRA Public Alerts

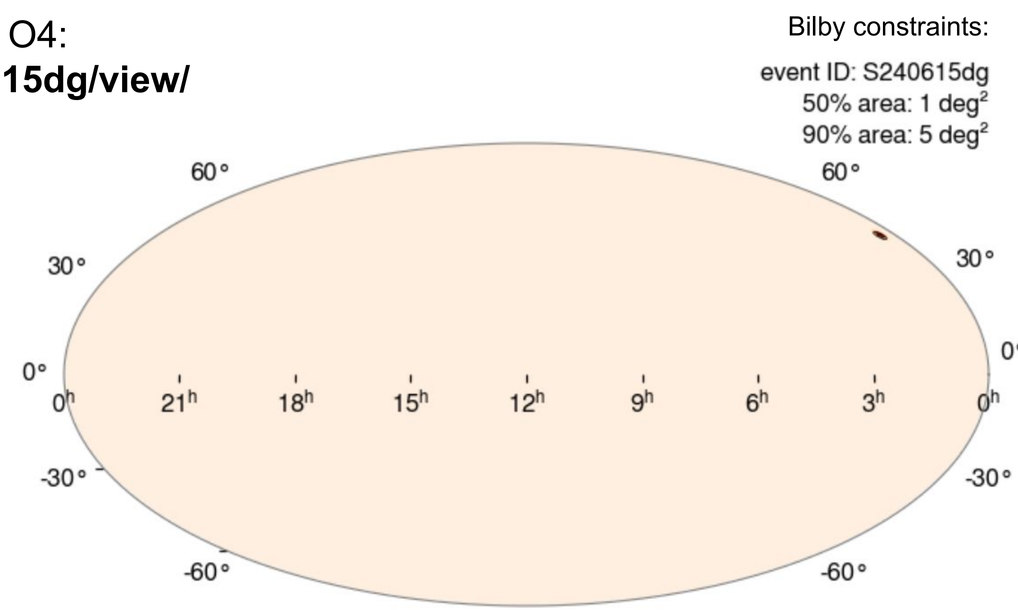
- More details about public alerts are provided in the LIGO/Virgo/KAGRA Alerts User Guide.
- Retractions are marked in red. Retraction means that the candidate was manually vetted and is no longer considered a candidate of interest.
- Less-significant events are marked in grey, and are not manually vetted. Consult the LVK Alerts User Guide for more information on significance in O4.
- Less-significant events are not shown by default. Press "**Show All Public Events**" to show significant and less-significant events.

O4 Significant Detection Candidates: **186** (206 Total - 20 Retracted)

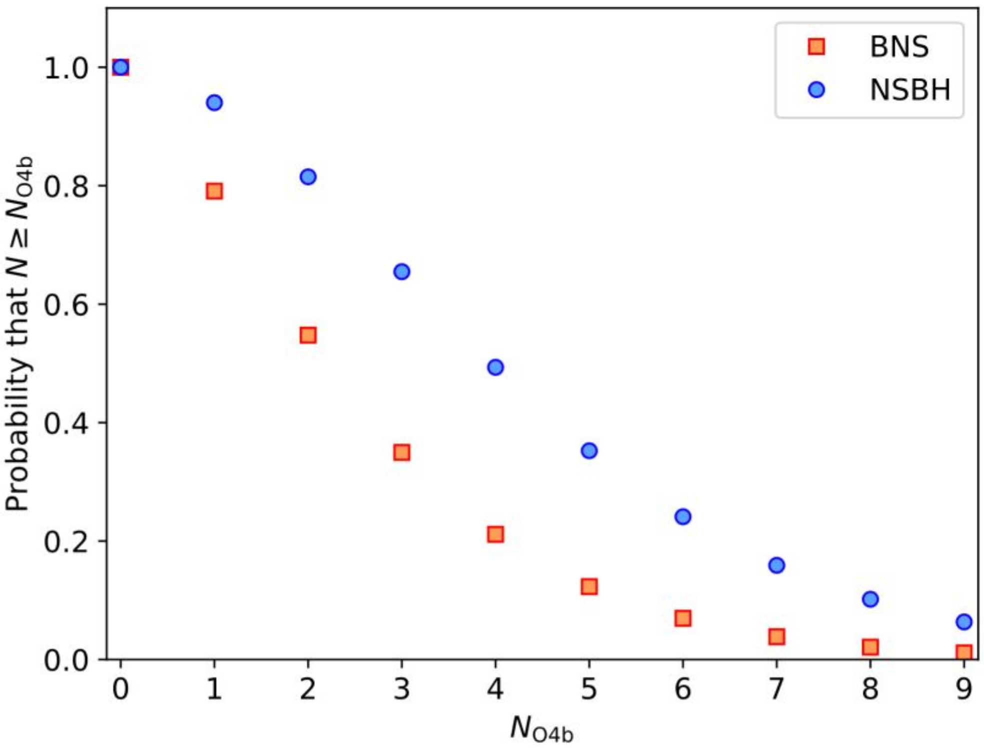
O4 Low Significance Detection Candidates: **3253** (Total)

Example of a well localized candidate event in O4:
https://gracedb.ligo.org/superevents/S240615dg/view/





Estimating the probability of BNS and NSBH in O4



- The probability of having at least one **BNS** detection is around 80%. BNS rate: 5 - 920 Gpc^{-3} yr^{-1}
- The probability of having at least one **NSBH** detection is 94%

An estimate of the probability of a number N of detections is obtained based on the number N' of previous detections (assuming they were of astrophysical origin), and on the ratio of the sensitive time-volume surveyed in the new run to that of previous runs, C=VT/V'T'

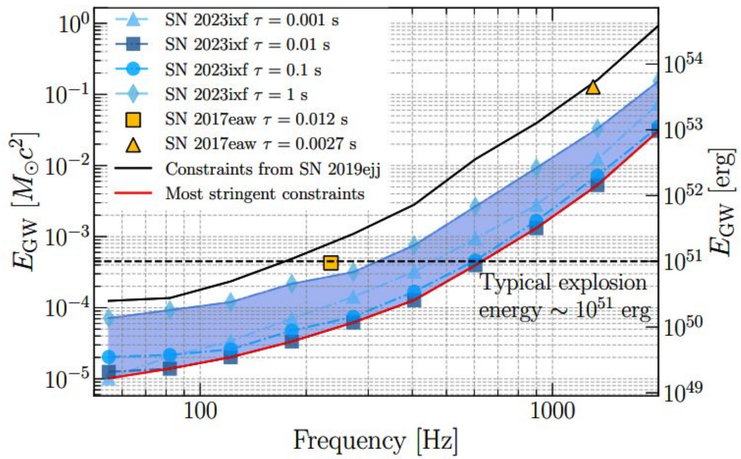
https://emfollow.docs.ligo.org/userguide/capabilities.html

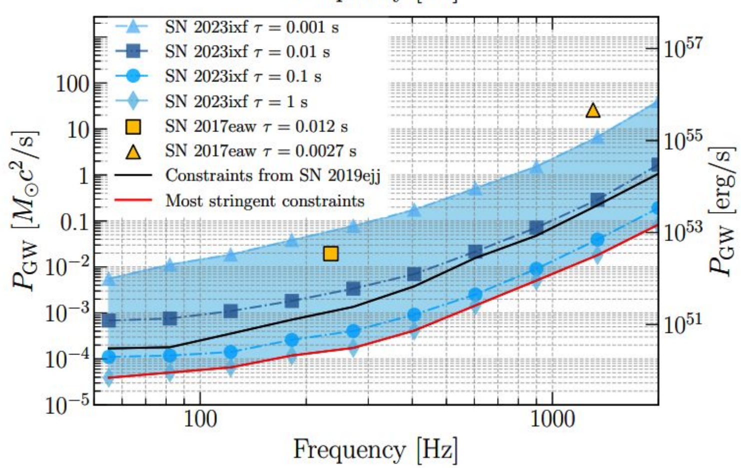
2024 LVK papers

1. Abac, A. G., et al., ‘’A Search Using GEO600 for Gravitational Waves Coincident with Fast Radio Bursts from SGR 1935+2154", The Astrophysical Journal 977 255 (2024)
2. The LIGO Scientific Collaboration, et al., ‘’Search for gravitational waves emitted from SN 2023ixf", arXiv e-prints arXiv:2410.16565 (2024)
3. Abac, A. G., et al., ‘’Search for Eccentric Black Hole Coalescences during the Third Observing Run of LIGO and Virgo", The Astrophysical Journal 973 132 (2024)
4. Abac, A. G., et al., ‘’Ultralight vector dark matter search using data from the KAGRA O3GK run", Physical Review D 110 042001 (2024)
5. Abac, A. G., et al., ‘’Observation of Gravitational Waves from the Coalescence of a 2.5–4.5 $M_\odot$ Compact Object and a Neutron Star", The Astrophysical Journal 970 L34 (2024)
6. Abbott, R., et al., ‘’Search for Gravitational-lensing Signatures in the Full Third Observing Run of the LIGO–Virgo Network", The Astrophysical Journal 970 191 (2024)
7. Raman, G., et al., ‘’Swift-BAT GUANO follow-up of gravitational-wave triggers in the third LIGO-Virgo-KAGRA observing run", arXiv e-prints arXiv:2407.12867 (2024)
8. Abbott, R., et al., ‘’Search for Gravitational-wave Transients Associated with Magnetar Bursts in Advanced LIGO and Advanced Virgo Data from the Third Observing Run", The Astrophysical Journal 966 137 (2024)
9. Fletcher, C., et al., ‘’A Joint Fermi-GBM and Swift-BAT Analysis of Gravitational-wave Candidates from the Third Gravitational-wave Observing Run", The Astrophysical Journal 964 149 (2024)
10. Abbott, R., et al., ‘’GWTC-2.1: Deep extended catalog of compact binary coalescences observed by LIGO and Virgo during the first half of the third observing run", Physical Review D 109 022001 (2024)

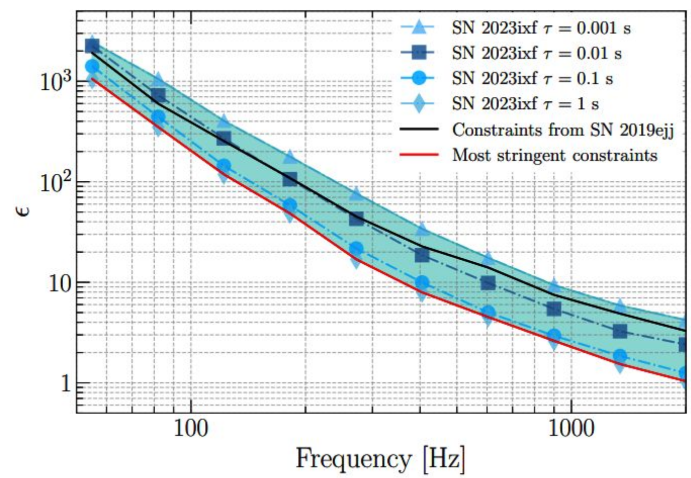
SN 2023ixf (Abac et al., arXiv:2410.16565)

Core collapse SN observed in Messier 101 (distance: 6.7 Mpc) in EM on 2023 May 19th, during the LVK 15th Engineering Run





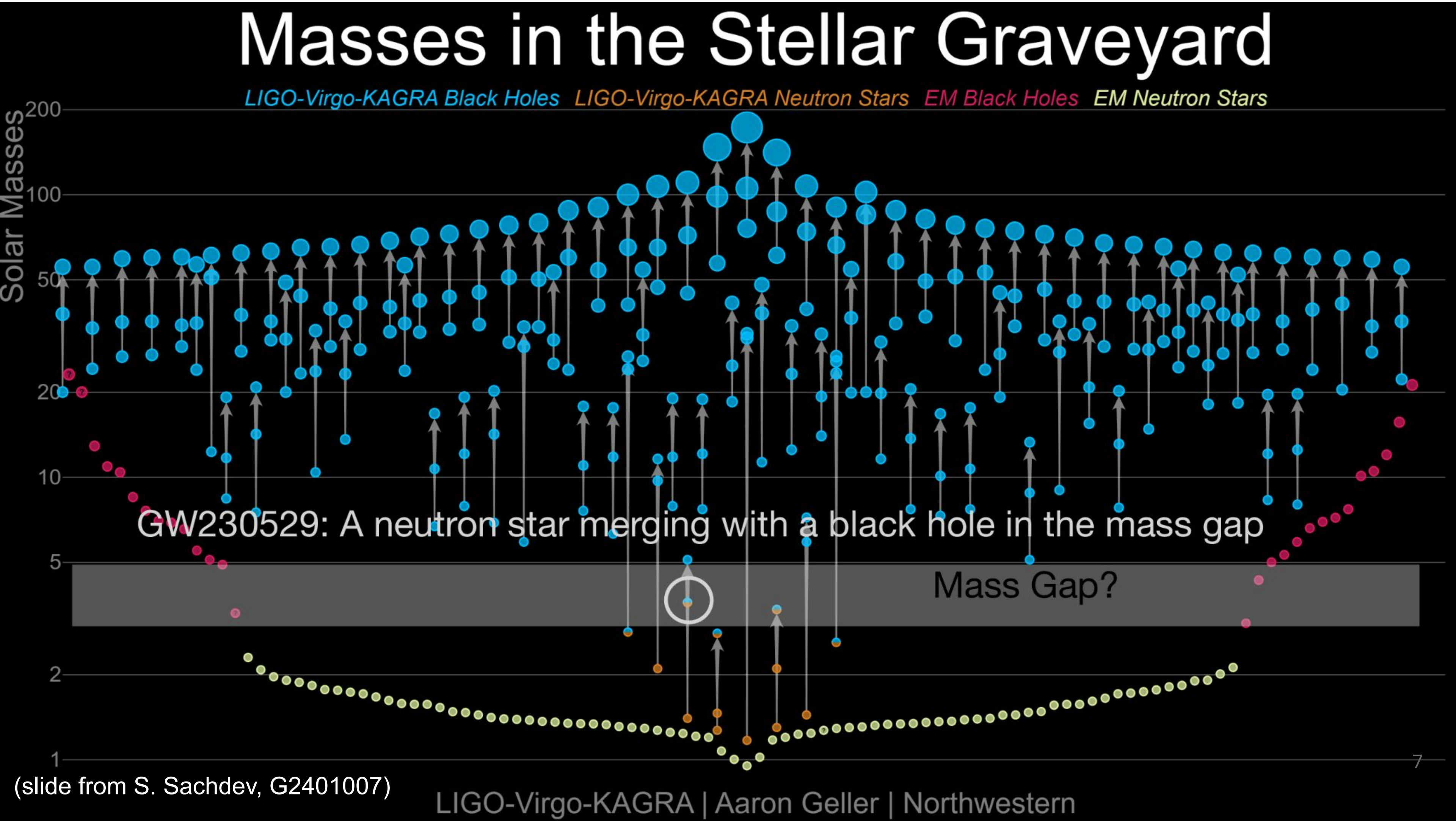
$$h_0 = \frac{2}{D}\frac{G}{c^4}\frac{I_{zz}\epsilon}{2}(2\pi f_0)^2$$ (amplitude of a rotating NS "bar", with ellipticity ϵ)



$$I_{zz}\epsilon = \frac{Dc^4}{G(2\pi f_0)^2}\left(\frac{2}{\pi\tau^2}\right)^{1/4} h_{\rm rss}.$$

$$E_{\rm GW} = \frac{2}{5}\frac{\pi^2 c^3}{G} D^2 f_0^2 h_{\rm rss}^2$$ where $h_{\rm rss}$ is the source root-sum-squared GW strain for an optimally oriented source.

04: GW230529 and mass gap objects



(slide from S. Sachdev, G2401007)

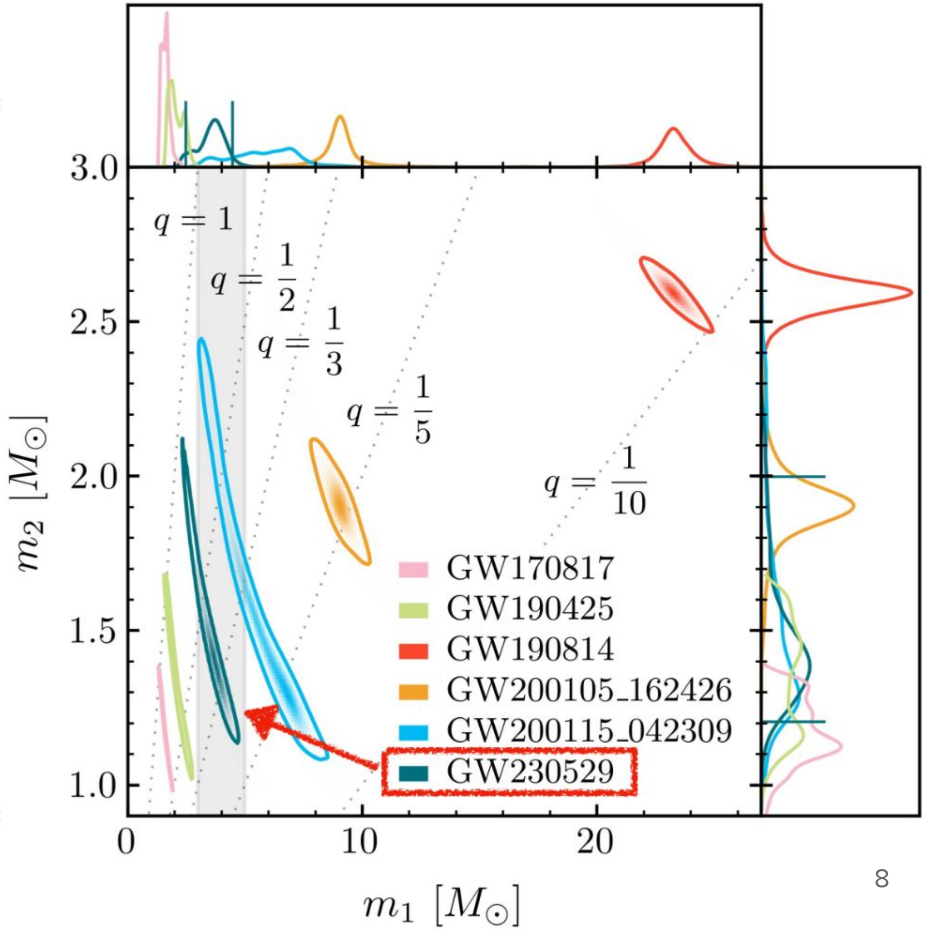
GW230529 properties

Online L1-only detection with GstLAL, MBTA, PyCBC (IFAR > 60 yr)

No confirmed EM counterpart, no clear tidal constraints

SNR ~11.5

Primary mass $m_1/M_\odot$	$3.6^{+0.8}_{-1.2}$
Secondary mass $m_2/M_\odot$	$1.4^{+0.6}_{-0.2}$
Mass ratio $q = m_2/m_1$	$0.39^{+0.41}_{-0.12}$
Total mass $M/M_\odot$	$5.1^{+0.6}_{-0.6}$
Chirp mass $\mathcal{M}/M_\odot$	$1.94^{+0.04}_{-0.04}$
Detector-frame chirp mass $(1+z)\mathcal{M}/M_\odot$	$2.026^{+0.002}_{-0.002}$
Primary spin magnitude χ_1	$0.44^{+0.40}_{-0.37}$
Effective inspiral-spin parameter $\chi_{\rm eff}$	$-0.10^{+0.12}_{-0.17}$
Effective precessing-spin parameter $\chi_{\rm p}$	$0.40^{+0.39}_{-0.30}$
Luminosity distance $D_{\rm L}/{\rm Mpc}$	201^{+102}_{-96}
Source redshift z	$0.04^{+0.02}_{-0.02}$



Abac et al., Astrophys. J. Lett. 970, L34 (2024)

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