Recent results from LIGO-Virgo-KAGRA and Future Prospects

Stephen Fairhurst
Spokesperson, LIGO Scientific Collaboration



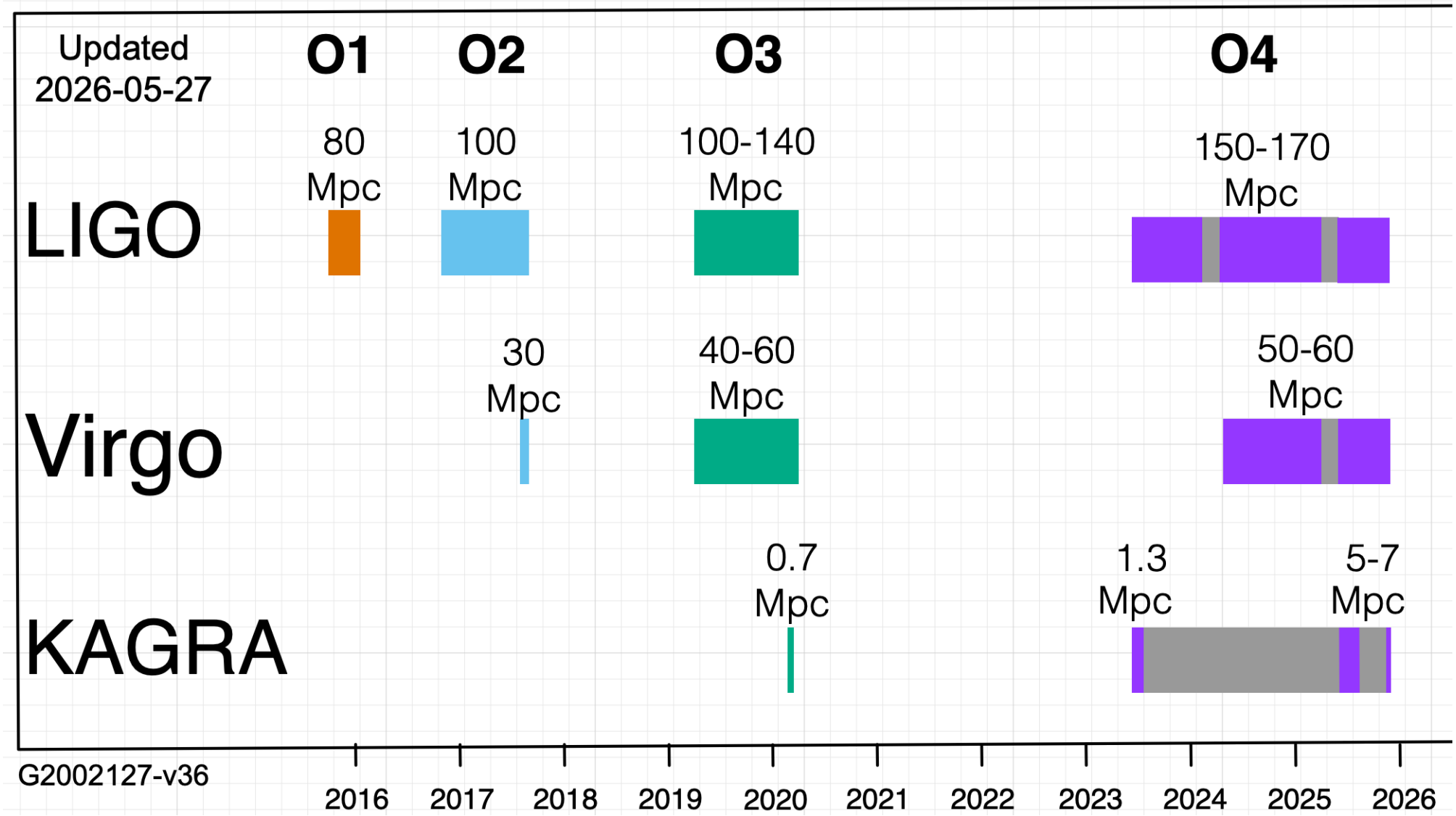


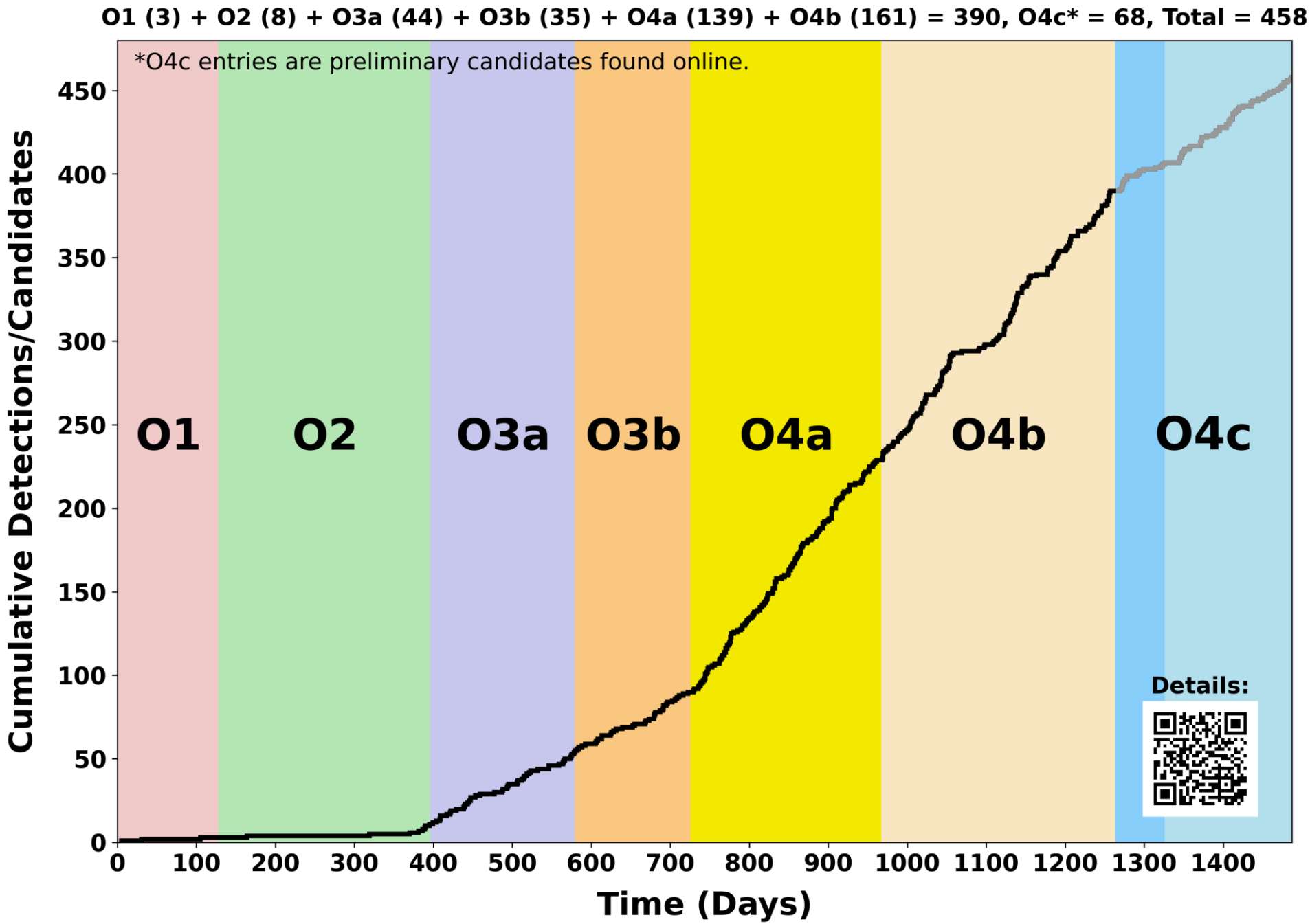
Images from https://www.ligo.caltech.edu, Credit Caltech/MIT/LIGO Lab





LIGO, Virgo and KAGRA Observing Runs





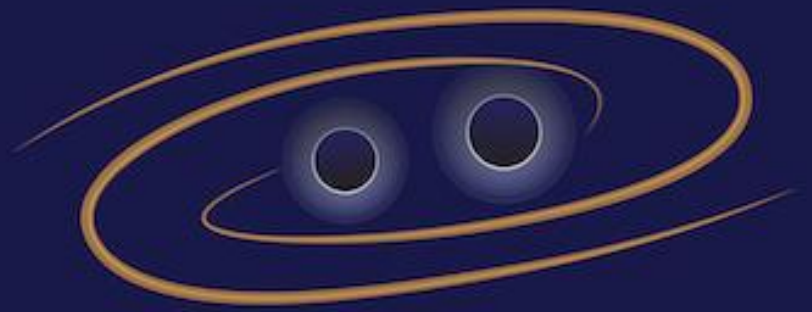
LIGO-G2302098 (f244d4f6), updated on 25 May, 2026

Credit: LIGO-Virgo-KAGRA Collaboration

Short duration

Long duration

Modelled



compact binary coalescence





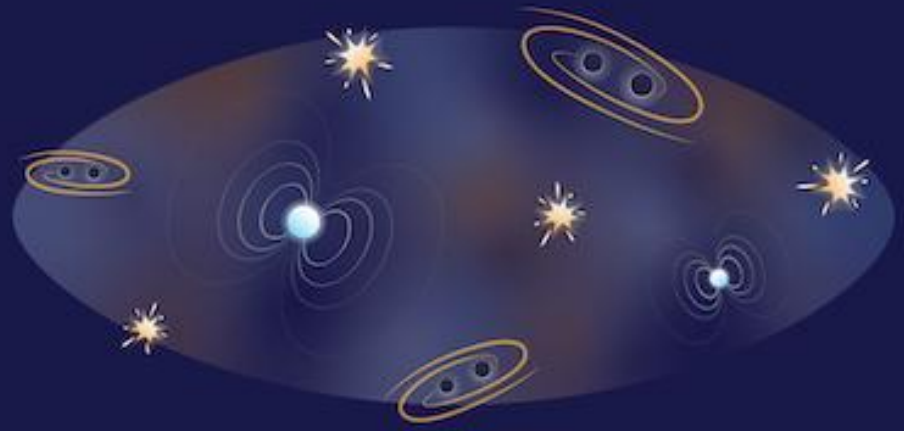
continuous

Unmodelled



burst





stochastic



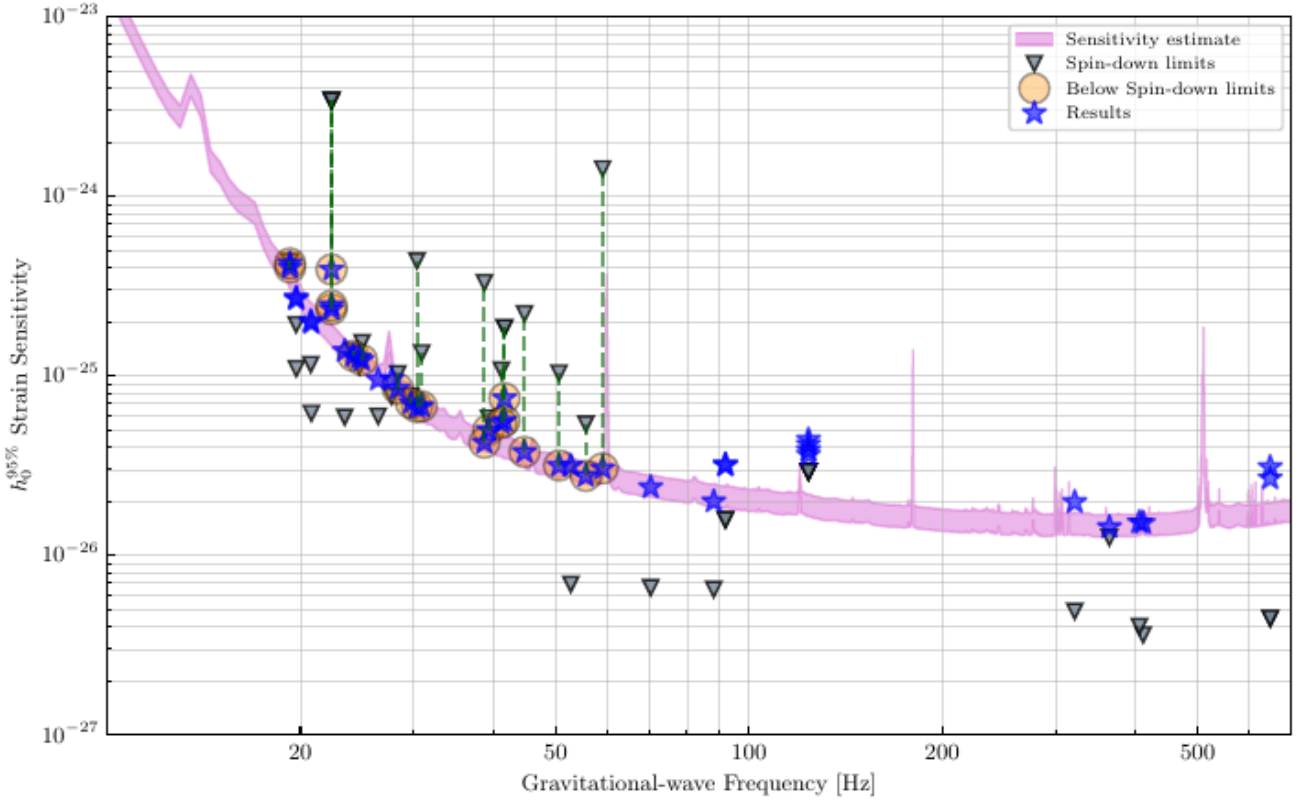
@astronerdika

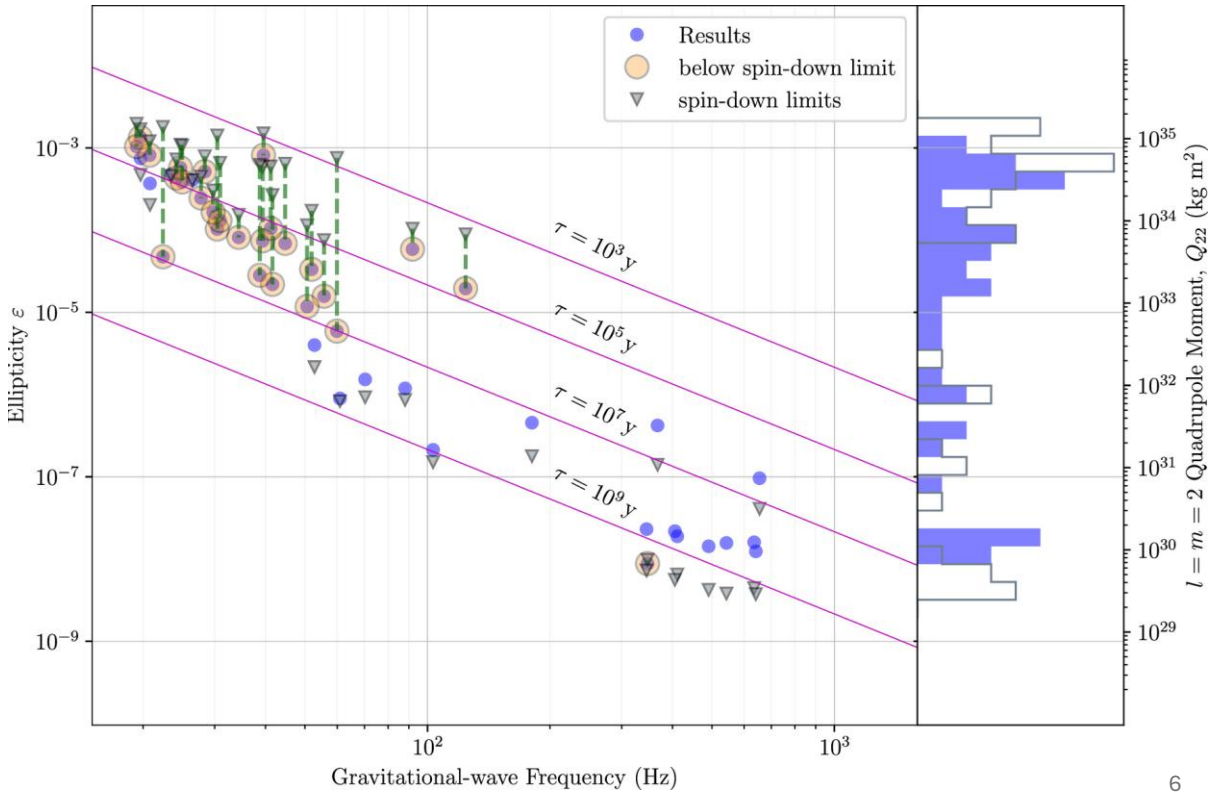
Continuous Gravitational Waves

Search for GWs from known pulsars

Figures from Abac et al, arXiv:2603.25938

Also search for signals from unknown neutron stars, both isolated (Abac et al, arXiv:2603.14168) and in binary systems (Abac et al, arXiv:2511.16863)



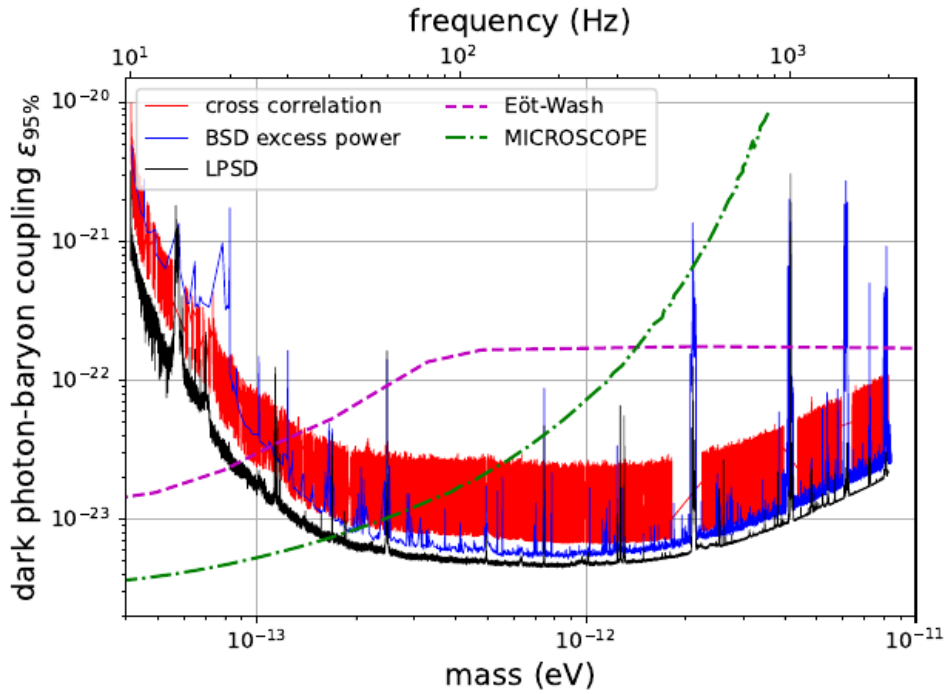


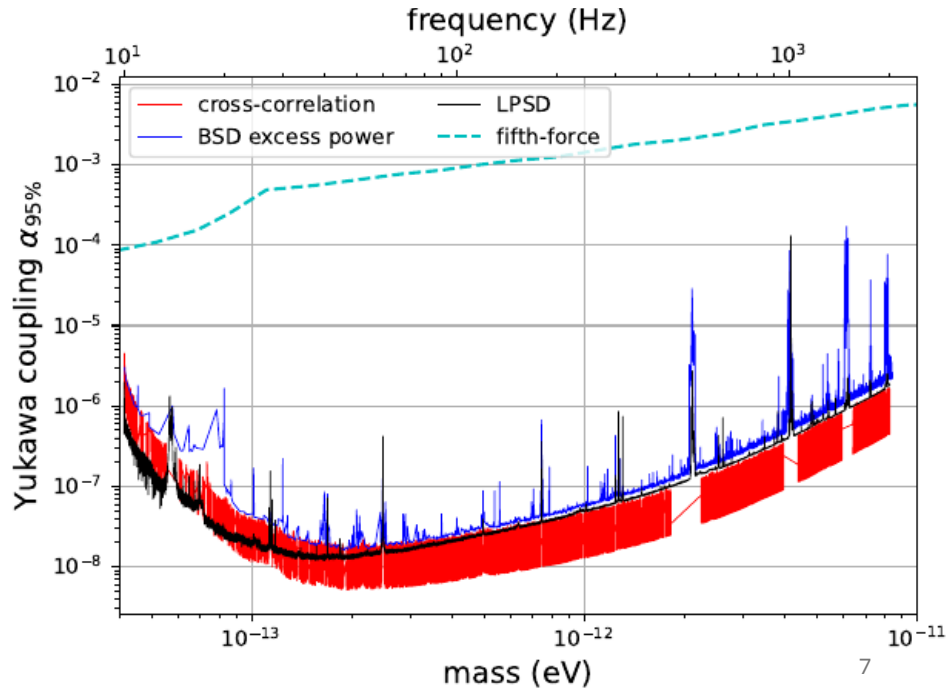
Searching for Dark Matter

GW Interferometers are sensitive to different kinds of Ultra Light Dark Matter that directly interact with the detector:

- Scalar dark matter (spin 0): Expand/Contract mirrors
- Dark photon dark matter (spin 1): Accelerate mirrors
- Tensor dark matter (spin 2): Modify gravity

Figures from Abac et al, arXiv:2510.27022,





Stochastic GW background

- A cosmological background of gravitational waves could be generated in the early universe
- An astrophysical background would arise from a population of gravitational-wave sources which are too weak to observe individually
- No observable signal to date. Constrain $\Omega_{GW}(f)$, the strength of the signal as a fraction of the total energy density of the universe

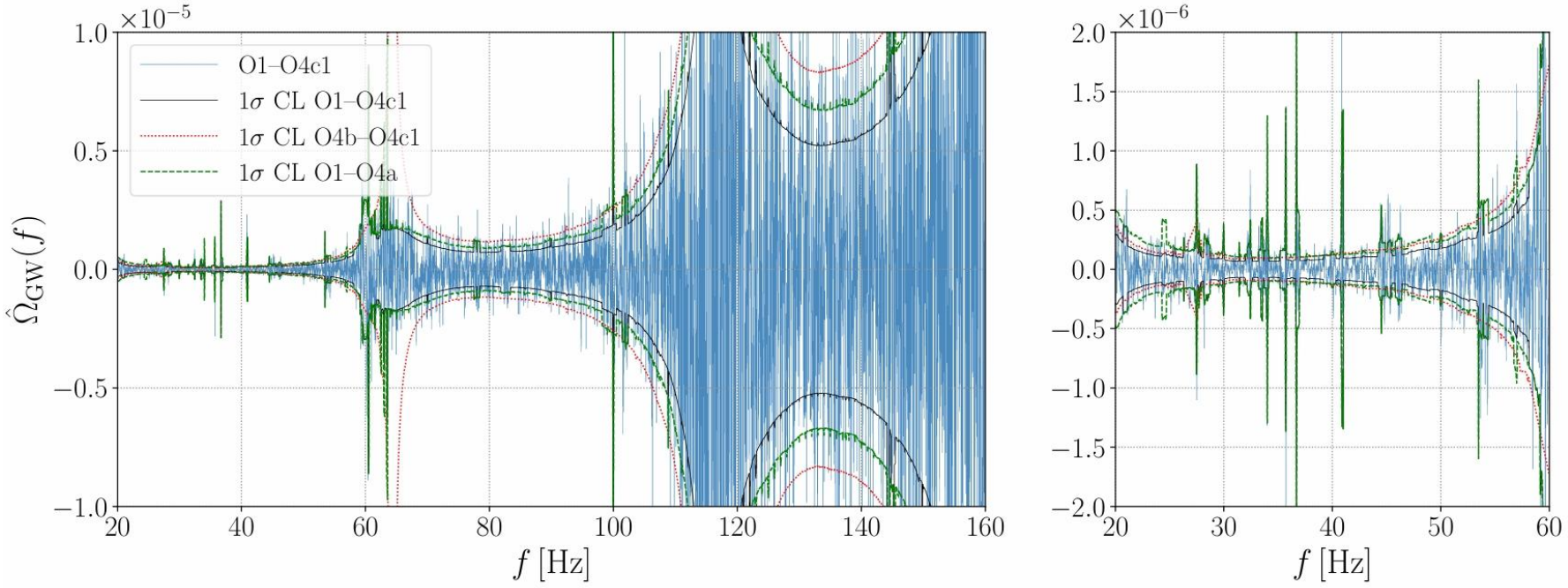
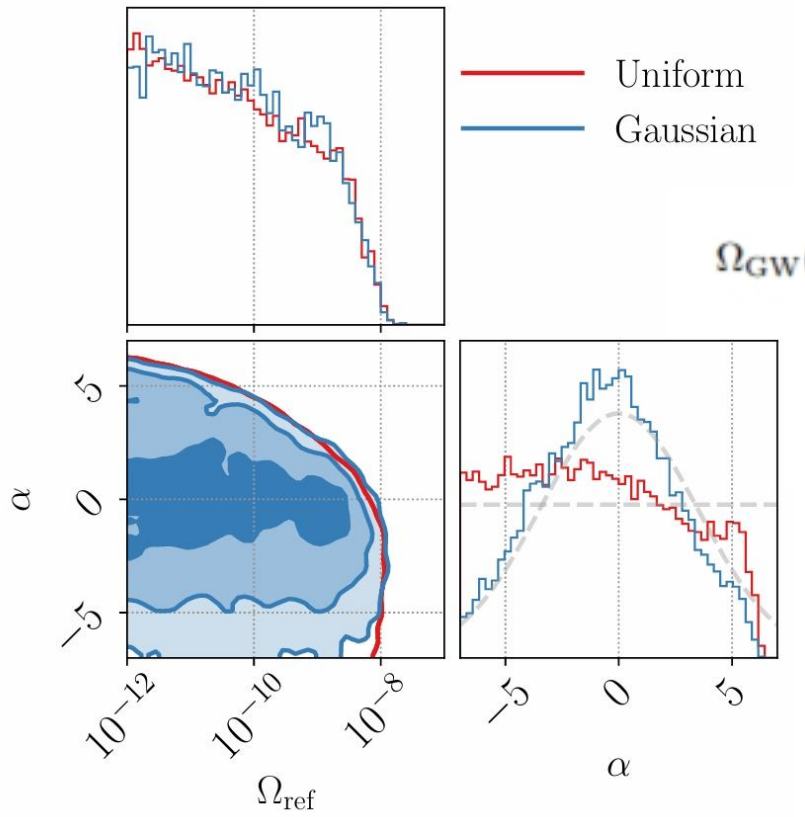


Figure from Abac et al, arXiv: 2608.23477

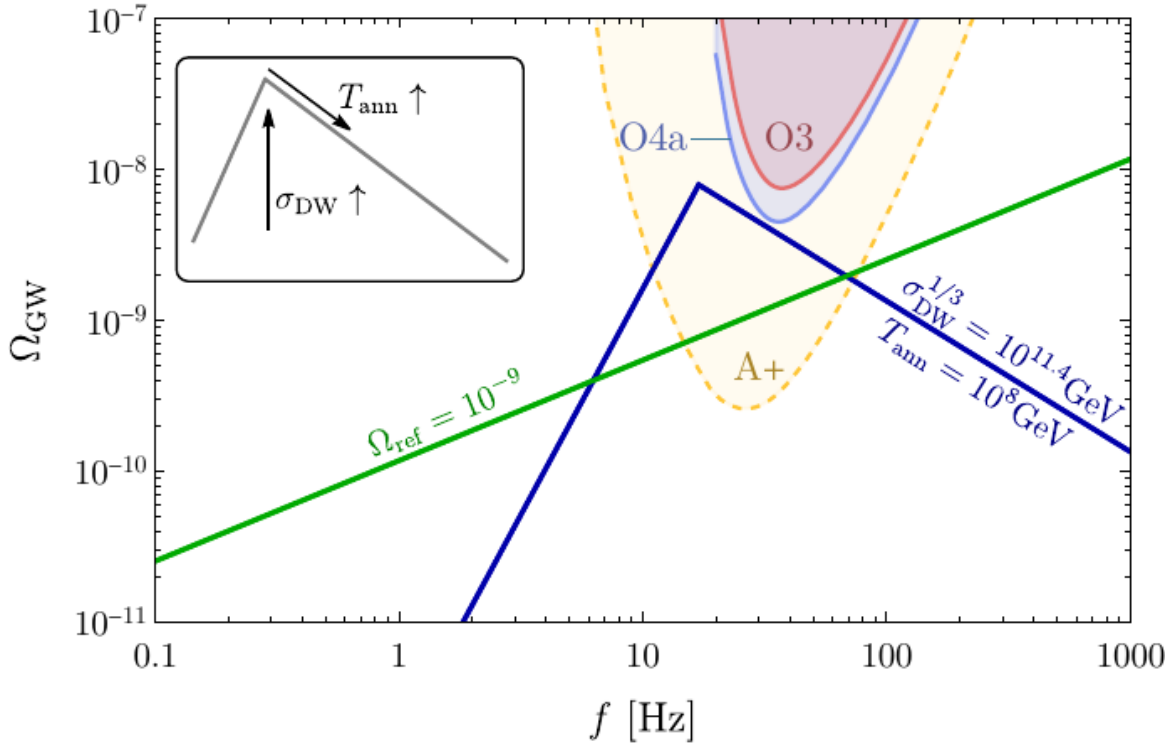
Stochastic GW background

Place constraints on

- Ω_{GW} and power law index α
  from Abac et al, 2608.23477

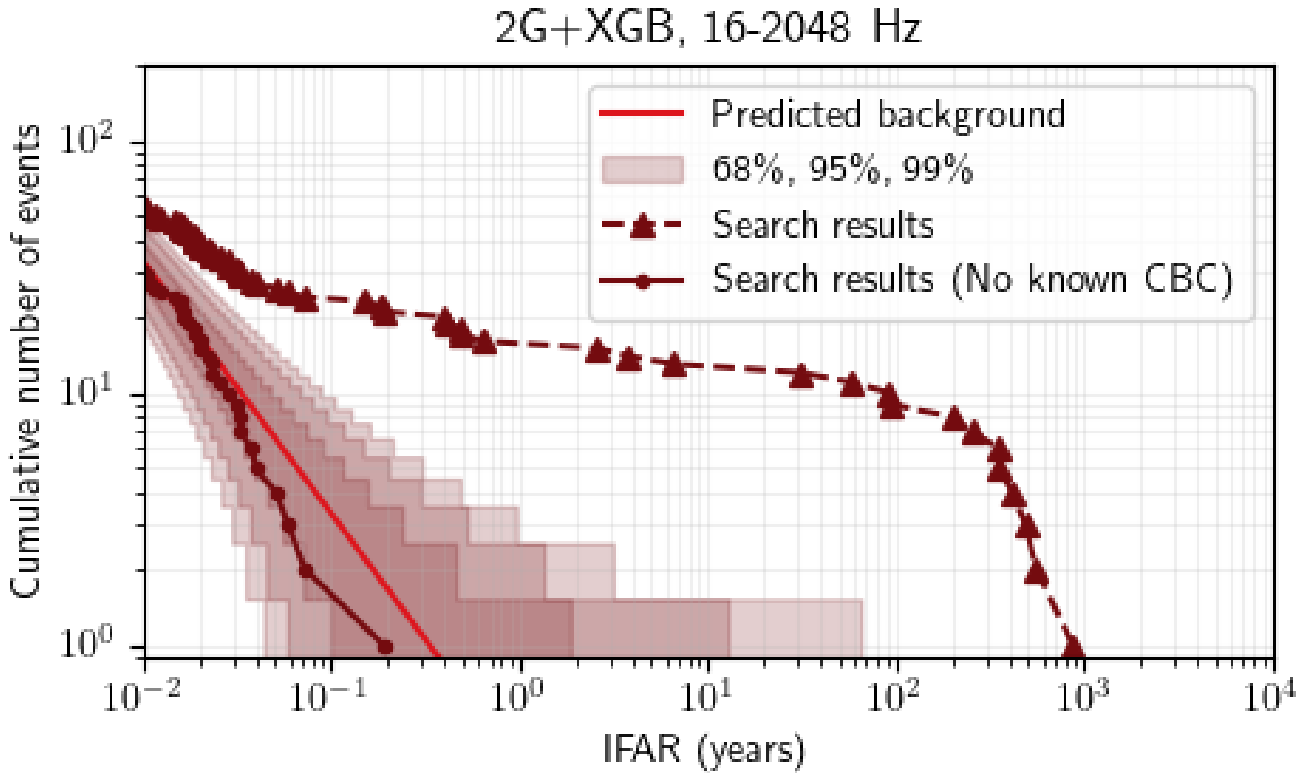


- Various cosmological models which predict GW backgrounds,
  from Abac et al, arXiv:2510.26848
- e.g. domain walls



Unmodelled transients

- Searches for short- and long-duration transients (bursts)
- Analyses to date identify a subset of the observed BBH mergers, but no other significant transients
- Short bursts:
  Abac et al, arXiv:2507.12374
- Long duration transients:
  Abac et al, arXiv:2507.12282

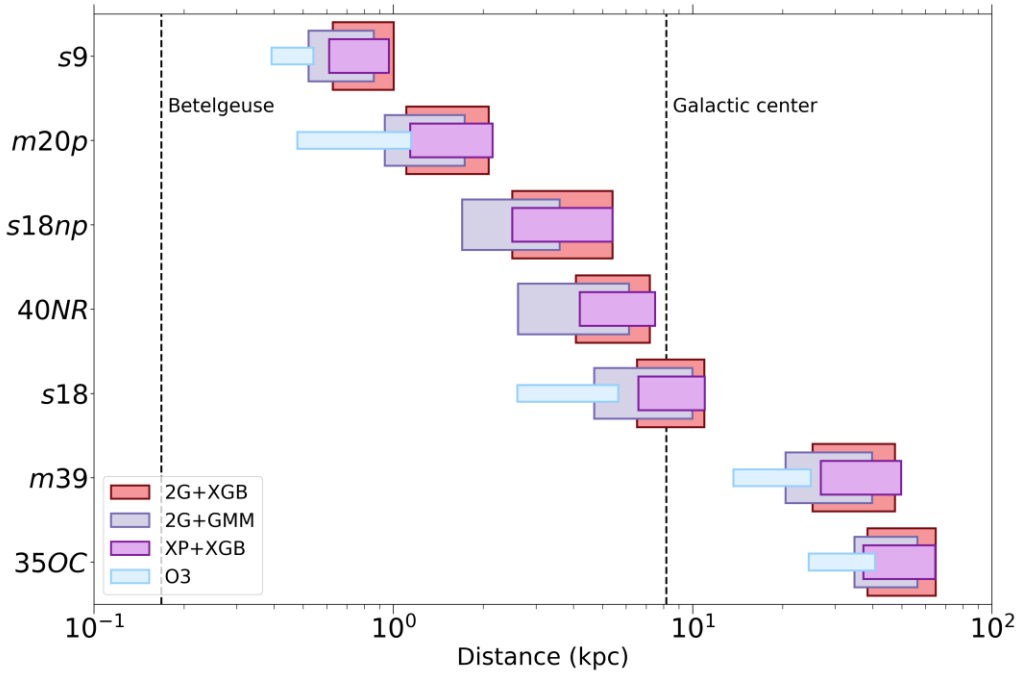


Short transients

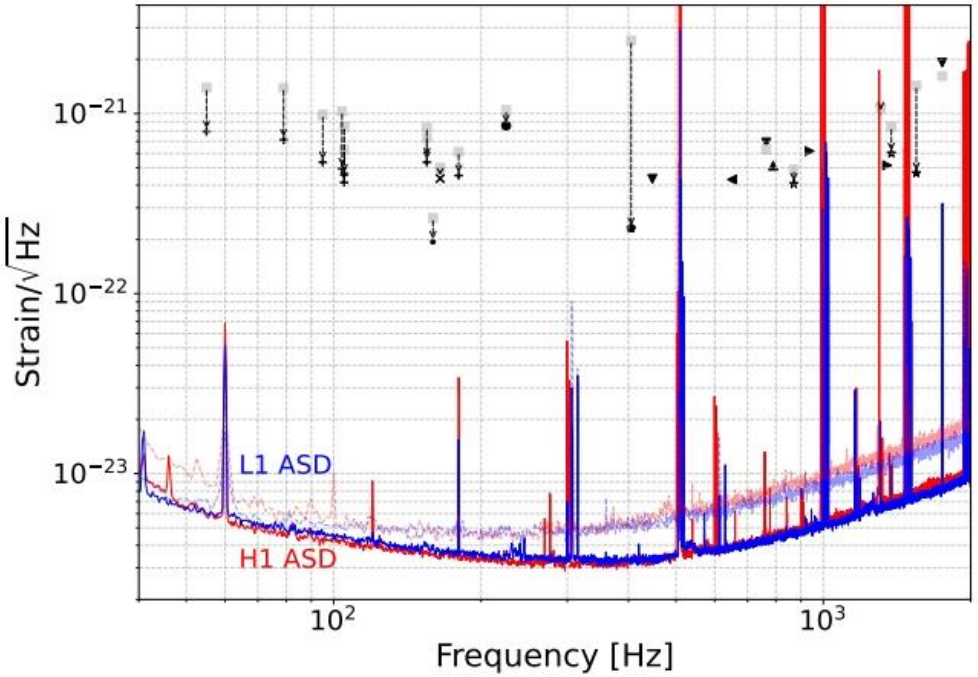
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Supernova sensitivity



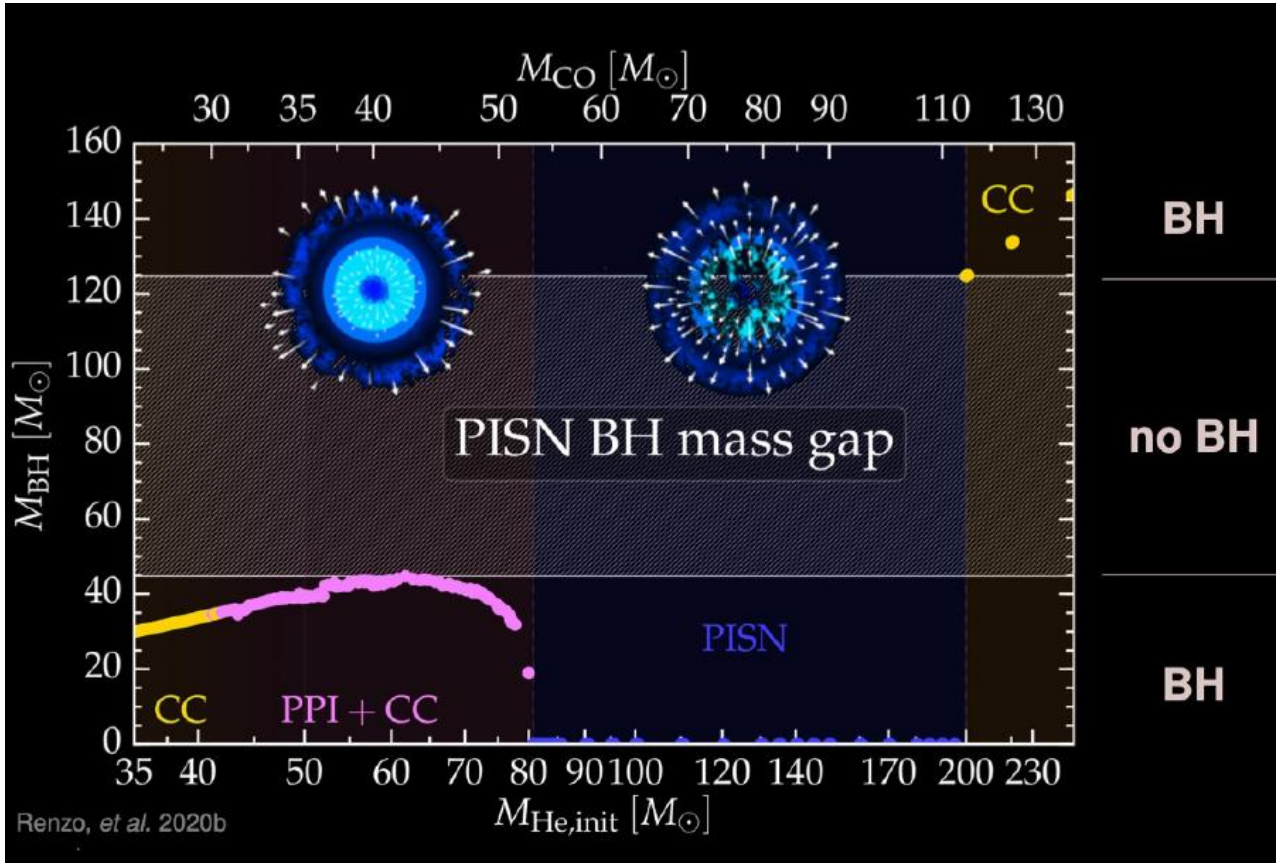
Long Transient sensitivity



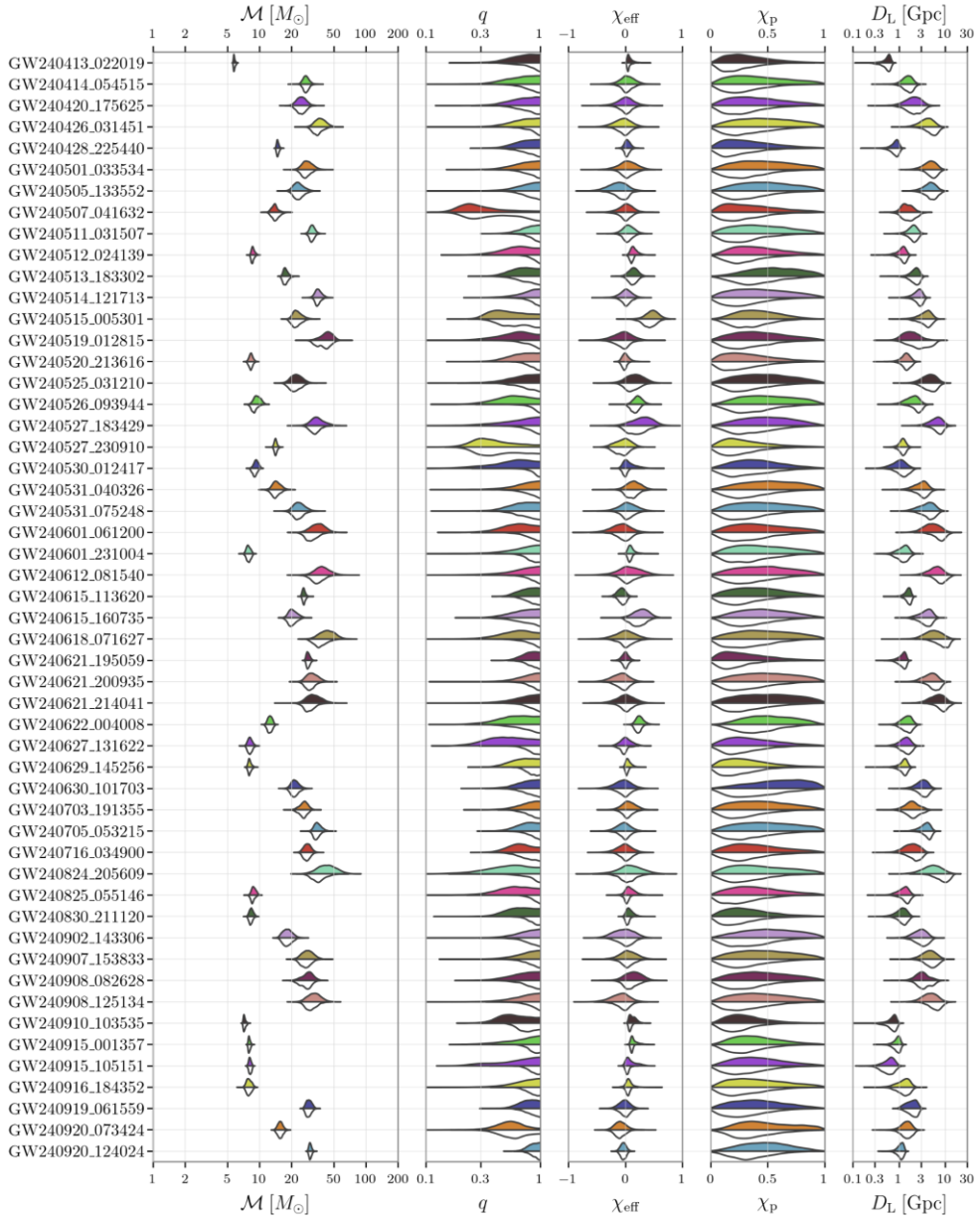
Compact Binary Coalescence

What was expected?

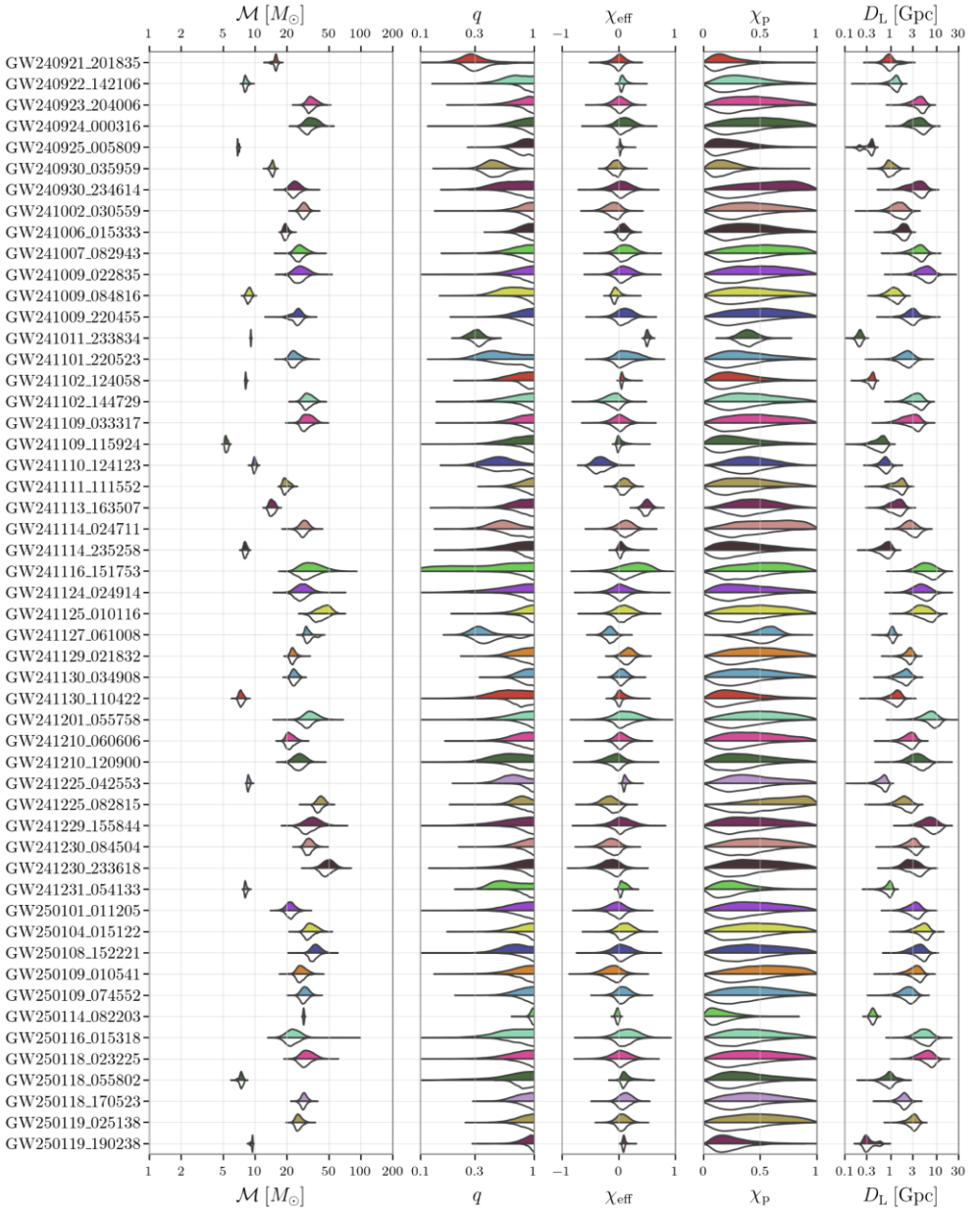
- High rate of neutron star mergers, as high as 40 observations per year
- Wildly uncertain black hole merger rates, from zero to hundreds per year
- Most massive black holes around $40M_{\odot}$, due to pair instability supernovae
- No black holes below 5 $M_{\odot}$, a “mass gap” between neutron stars and lightest black holes
- Highly spinning black holes



GWTC-5.0



- Six papers released on 26 May describing O4b data and new observations
- “This brings the total number of transients in the cumulative GWTC having $p_{astro} > 0.5$ to 390”
- From Abac et al, arXiv:2605.27225
- Final O4 data and updated catalog will be released on 16 December 2026

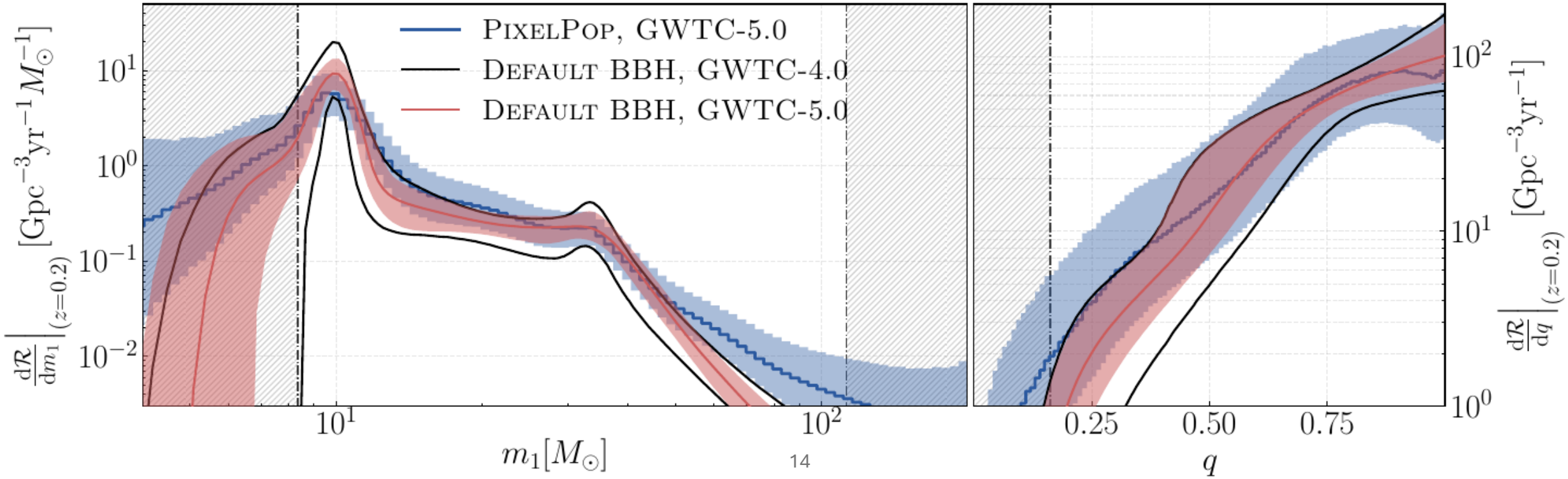


GWTC-5.0: The astrophysical population

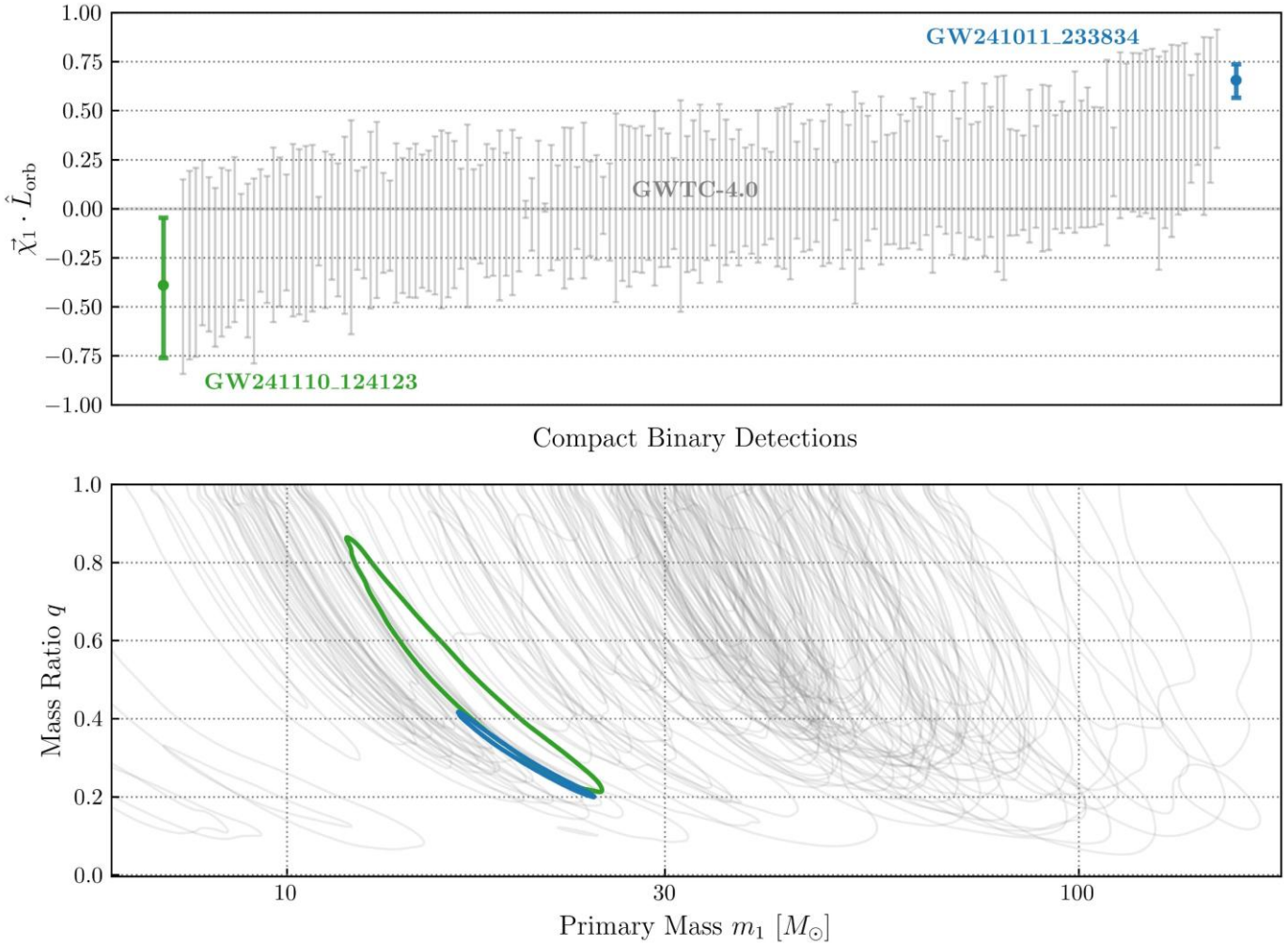
- Infer the population of black hole/ neutron star mergers from GW observations.
- Starting to identify sub-populations with interesting properties

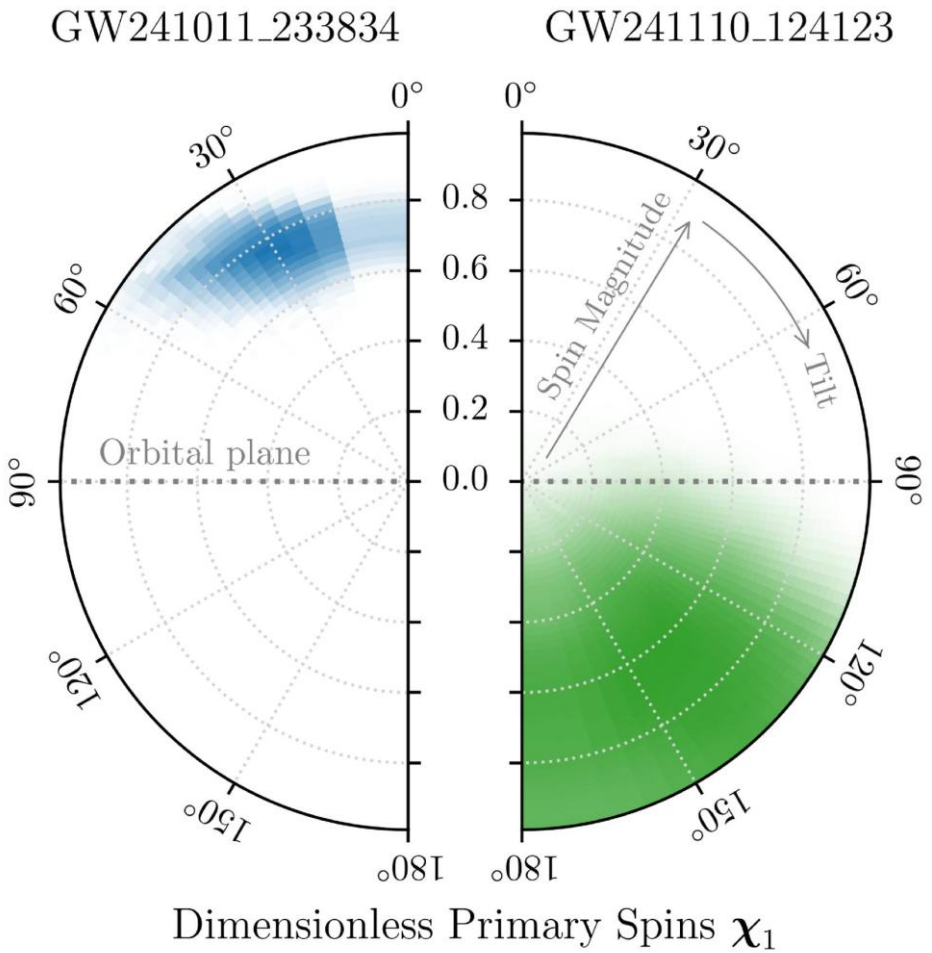
- Fit both strongly parametrized and weakly parametrized [PixelPop] models.

From Abac et al, arXiv:2605.27226



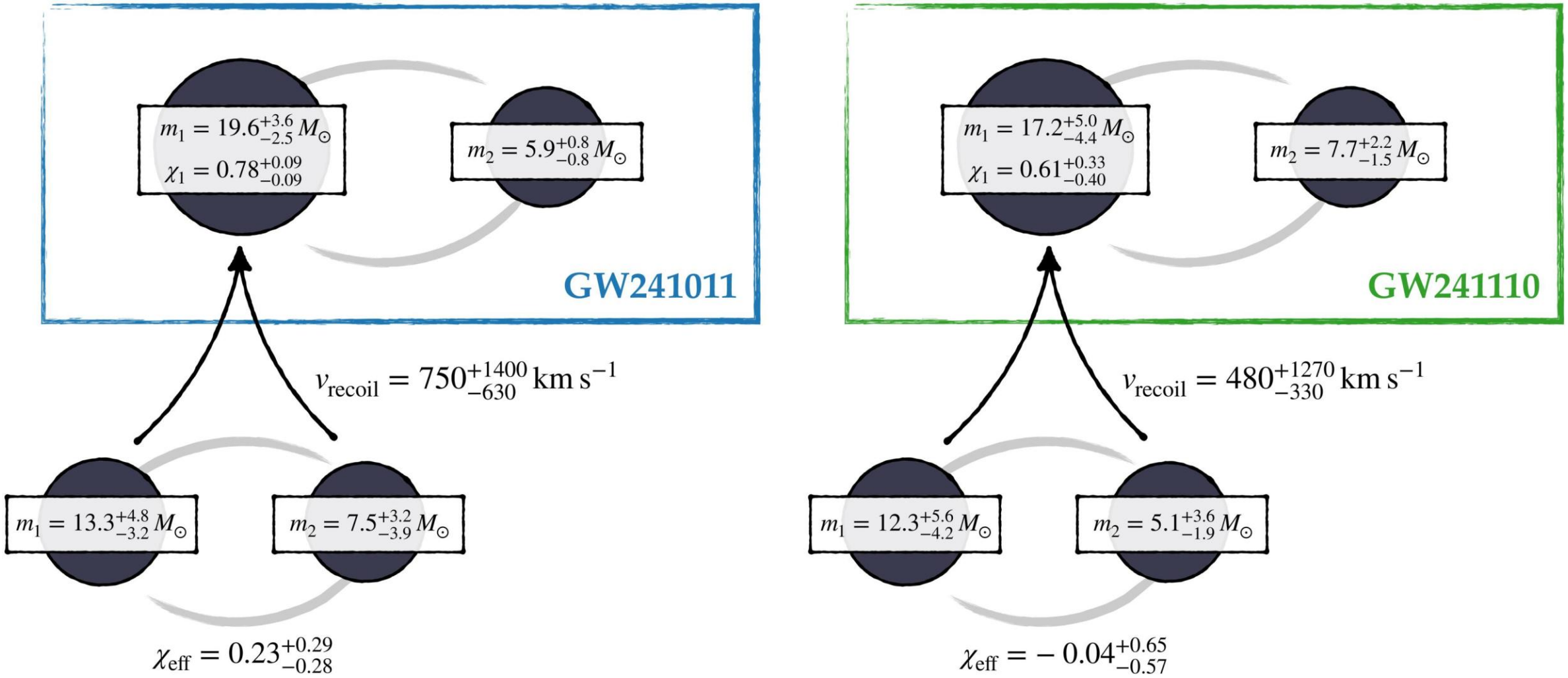
GW241011 and GW241110





From Abac et al, arXiv:2510.26931, "GW241011 and GW241110: Exploring Binary Formation and Fundamental Physics with Asymmetric, High-Spin Black Hole Coalescence"

GW241011 and GW241110 as hierarchical mergers



From Abac et al, arXiv:2510.26931, "GW241011 and GW241110: Exploring Binary Formation and Fundamental Physics with Asymmetric, High-Spin Black Hole Coalescence"

LIGO, Virgo and KAGRA Observing Plans

(from https://observing.docs.ligo.org/plan/)



IGWN

International Gravitational-Wave Observatory Network

- A global consortium with a unified governance structure and set of policies
- Consolidates experience from LSC, Virgo & KAGRA while removing redundancies and inconsistencies between current collaborations
- Overseen by the International Joint Oversight Group of funders

3,000+	4 + 1	5
SCIENTISTS	DETECTORS	CONTINENTS

- LHO — Hanford
- LLO — Livingston
- Virgo — Cascina
- KAGRA — Kamioka
- LIGO-India — Aundha (under construction)

SCIENCE GAINS

- ✓ Greater coordination of upgrades and observing runs
- ✓ Improved localization when LIGO-India joins
- ✓ Coordination of all aspects of science program

OPERATIONAL EFFICIENCY

- ✓ Shared computing & digital infrastructure
- ✓ Improved ability to direct person-power to under-resourced tasks

COLLABORATION MODEL

- ✓ Streamlined decision-making authority
- ✓ Closer coordination with global funding agencies
- ✓ Common cost model for all observatories and groups

IGWN TRANSITION TIMETABLE (V4, FEB 2026) — TARGET: Q2 2028

✓ COMPLETE

Foundation

Jan 2025 — IGWN Inaugural Board formed
Oct 2025 — Program v1 released

IN PROGRESS — NOW

Framework

Q3 2026 — IGWN MOA finalized
Dec 2026 — LVK MoA ceases

UPCOMING

Consortium Launch

Q1 2027 — Charter & Bylaws released
Q2 2027 — Groups apply with pledges

2027

Governance Established

Q3 2027 — Board & leadership elected
Q4 2027 — Council adopts Bylaws

TARGET

Fully Operational

Q2 2028 — IR1 data released
Q2 2028 — Consortium fully operational

Source: IGWN Transition Timetable V4 (Feb 2026). Milestones represent current planning.

Transition via an IGWN MOA

The IGWN MOA begins to harmonize LVK structures in a controlled, incremental manner

LSC, Virgo, KAGRA

Three individual collaborations with differing

- Membership requirements
- Authorship requirements
- Governance
- Collaboration structure
  - Some common divisions/groups
- Membership fees

IGWN MOA

Evolution towards common structures

- Joint divisions and working groups
- Common membership and authorship criteria
- Global resource requirements and pledges
- Joint interaction with global funding agencies

IGWN Consortium

Single global consortium with common

- Leadership and governance structures
- Scientific Program
- Requirements on groups
- Authorship requirements
- Cost model

The IGWN MOA

- The IGWN MOA has been approved by the governing bodies of the three collaborations
- It was signed by the spokespeople and lab directors at the September LVK meeting

LIGO-M2600148-v6, VIR-0442D-26, and JGW-M2617281-v4

Memorandum of Agreement

between

KAGRA,

VIRGO,

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

under the umbrella of the

International Gravitational-Wave Observatory Network (IGWN)

September 28, 2026

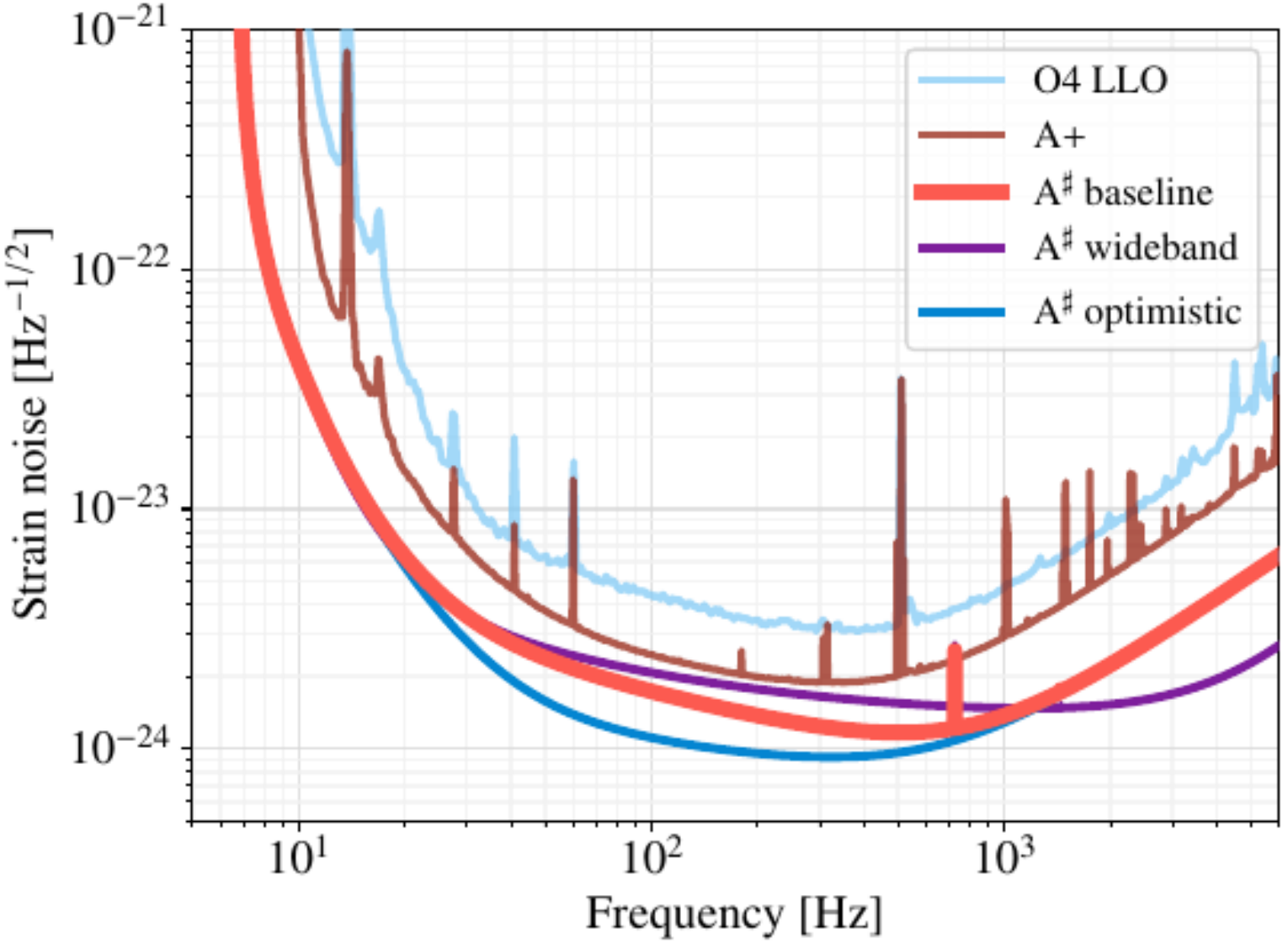


Planned Sensitivity Evolution

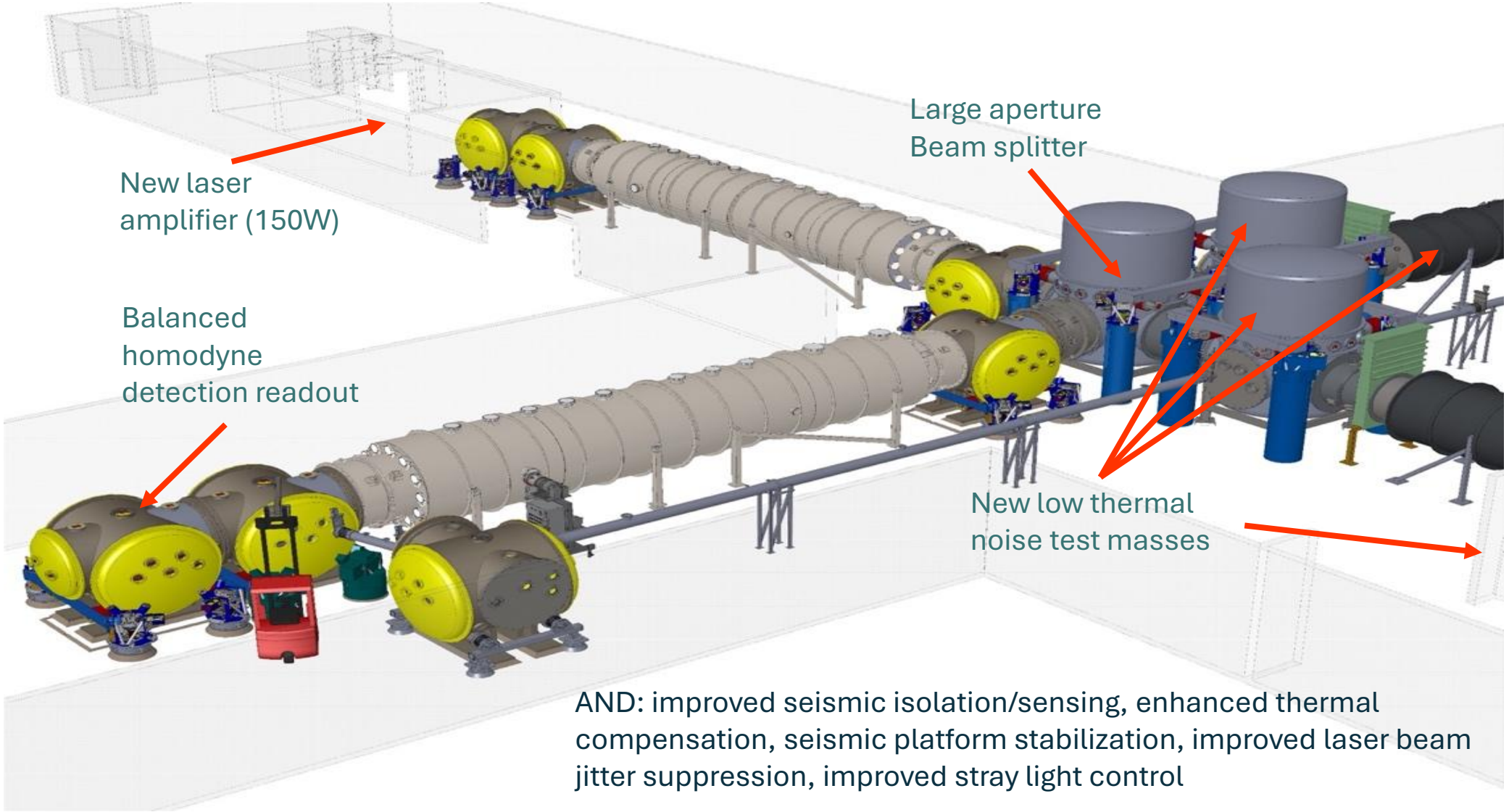
Low Frequency Sensitivity
- Longer signals (early warning)
- Sensitive to higher masses

“Bucket” Sensitivity
- Greater reach
- Higher SNR

High Frequency Sensitivity
- Sensitivity to merger and post-merger signals
- Sensitivity to Supernovae



Completing the LIGO A+ upgrade



AND: improved seismic isolation/sensing, enhanced thermal compensation, seismic platform stabilization, improved laser beam jitter suppression, improved stray light control

LIGO India

The LIGO India project obtained approval in February 2016.

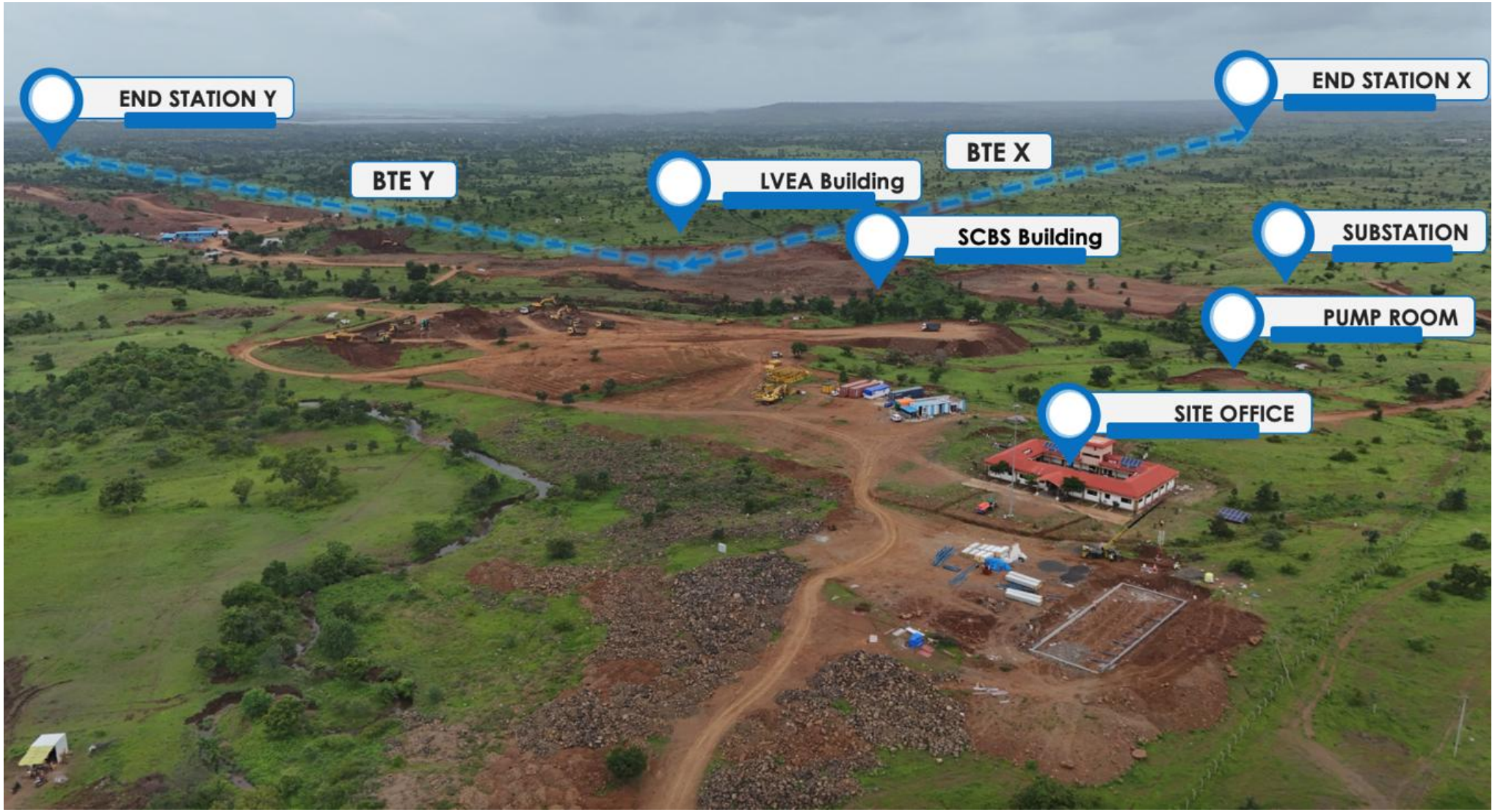
- The LIGO Laboratory is providing the hardware for a complete LIGO interferometer, including technical data on its design, installation and commissioning
- India is providing the site, the vacuum system, and other infrastructure required to house and operate the interferometer.

On 23 May 2026, There was a ground-breaking ceremony at the LIGO-India site, https://www.ligo.caltech.edu/news/ligo20260423





LIGO India


END STATION Y
BTE Y
LVEA Building
BTE X
END STATION X
SCBS Building
SUBSTATION
PUMP ROOM
SITE OFFICE

LIGO A# Upgrade

Improved low frequency sensitivity requires:

- Larger test masses, improvements to test mass suspensions
- Improved seismic isolation and subtraction of Newtonian noise

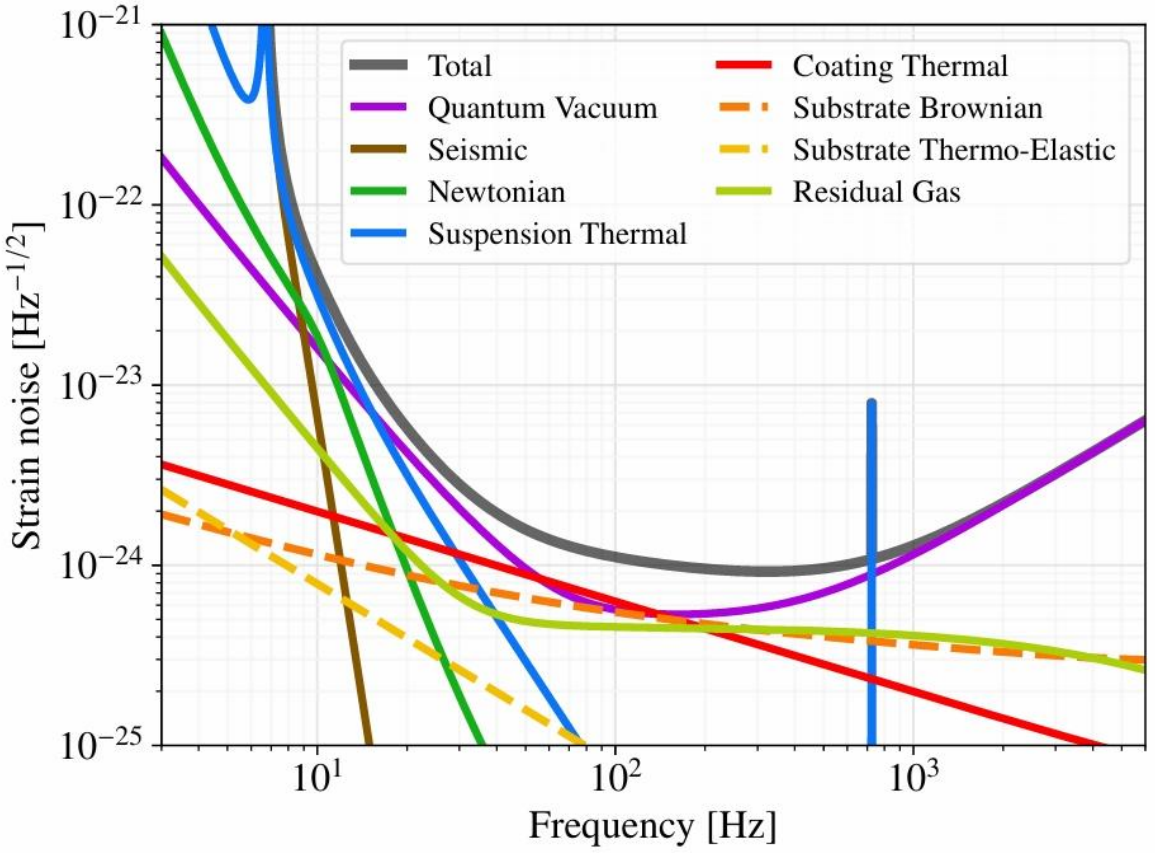
Improved mid-frequency sensitivity requires:

- Lower thermal noise coatings for the test masses.

Improved high frequency sensitivity requires:

- Laser power increase to 1.5 MW arm power
- Squeezing increase to 10 dB broadband

This is the best sensitivity we think we can achieve in the 4km LIGO detectors

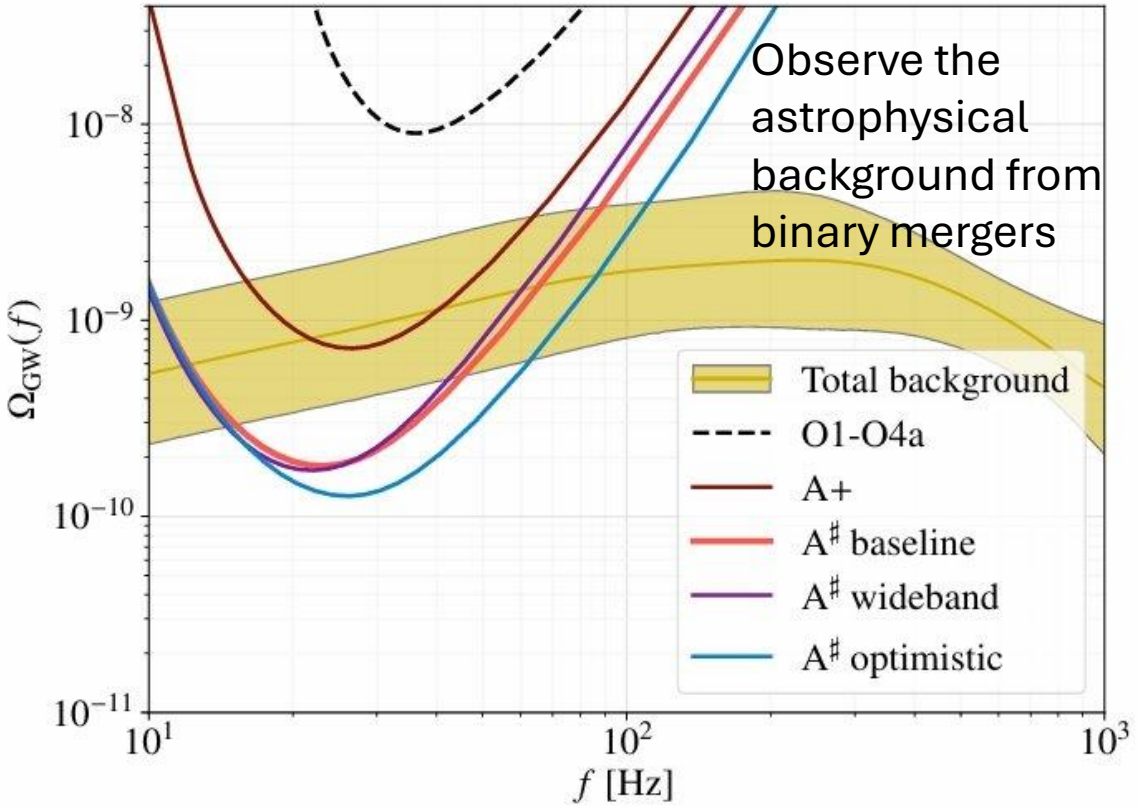


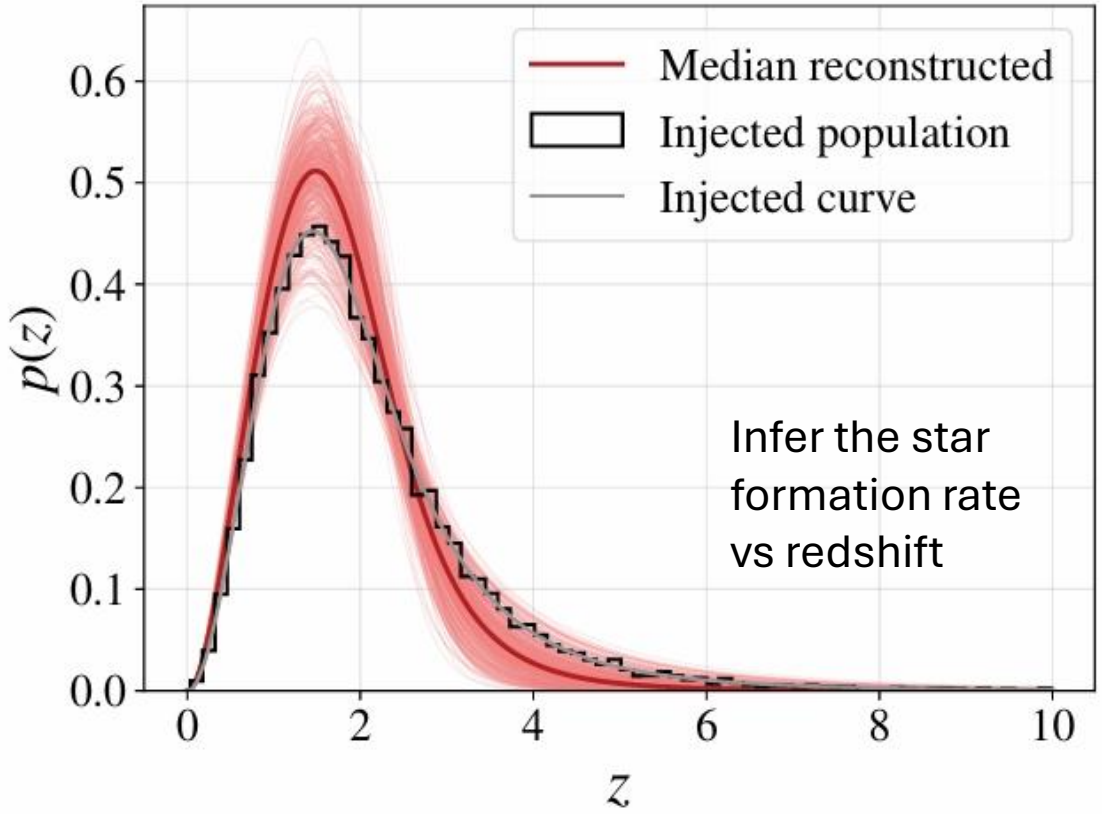
arXiv: 2608.11673: LIGO A#: Detector Design and Science Prospects Beyond A+

A# Science

arXiv: 2608.11673: LIGO A#: Detector Design and Science Prospects Beyond A+

Configuration	Annual Detections BNS	NSBH	BBH
A+	17^{+44}_{-14}	26^{+31}_{-16}	800^{+290}_{-220}
A♯ baseline	69^{+160}_{-51}	120^{+130}_{-62}	2800^{+1000}_{-740}
A♯ wideband	54^{+130}_{-40}	91^{+100}_{-50}	2200^{+820}_{-600}
A♯ optimistic	210^{+490}_{-150}	310^{+330}_{-160}	6600^{+2400}_{-1800}





Summary

- It is just over eleven years since the first gravitational wave observation
- We have observed several hundred signals from merging black holes and neutron stars
  - Beginning to unveil the properties of the population, and identify sub-populations
- Upgrades to existing facilities will enhance the gravitational wave view of the universe

