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Radio Follow-up of GW Events: Opportunities and Challenges

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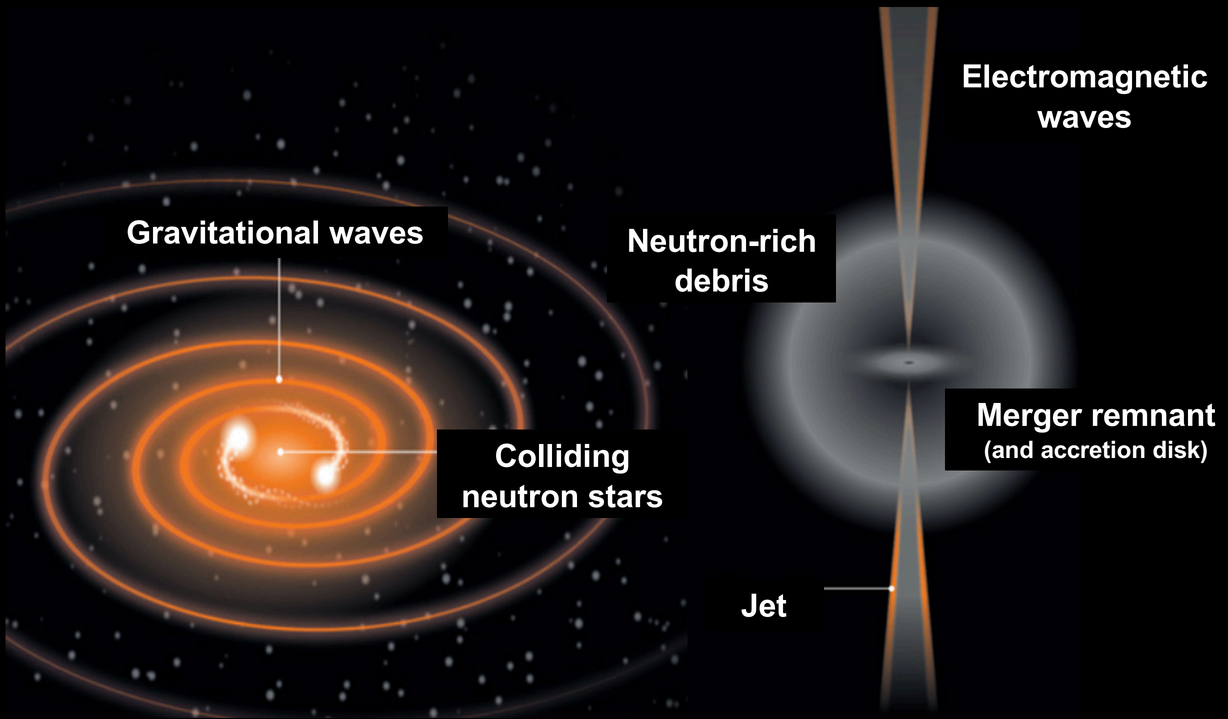
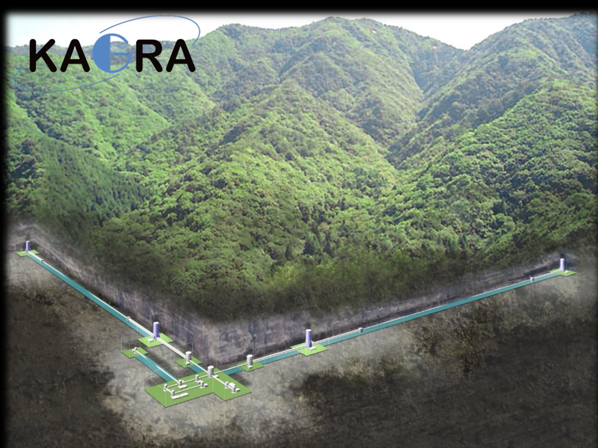
Throughput Computing 2026 (HTC26) June 9 - 12

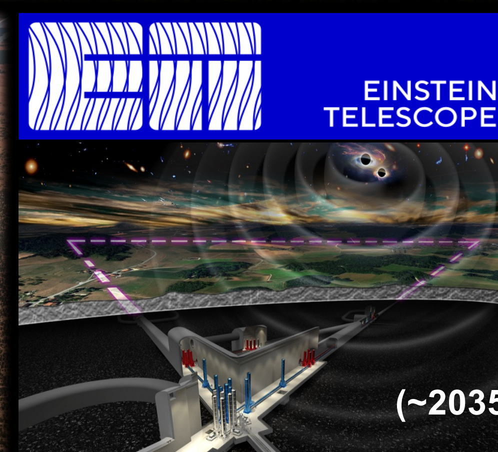
Why radio follow up of GWs?



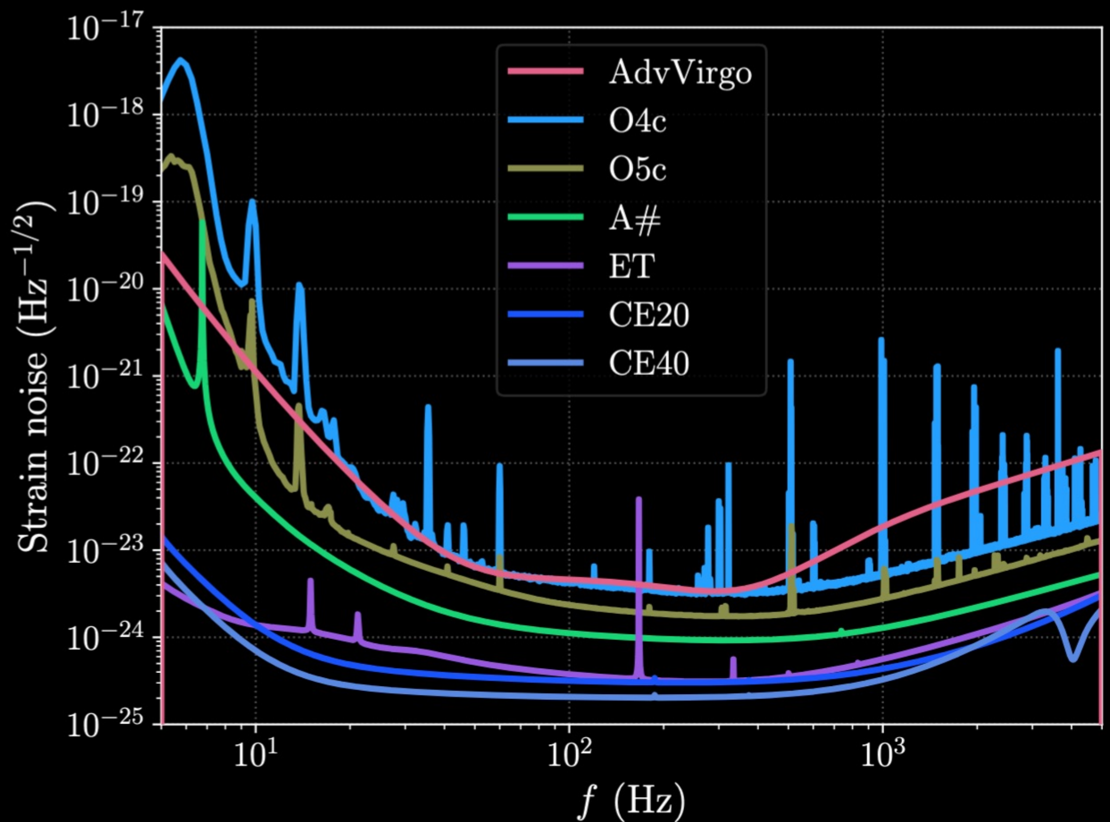
The **big picture** of the most cataclysmic cosmic events can only be made clear **when all messengers are gathered to probe progenitors, outflows, and remnants** in a holistic fashion.

Current and future ground-based GW detectors





Ground-based GW detectors' sensitivities



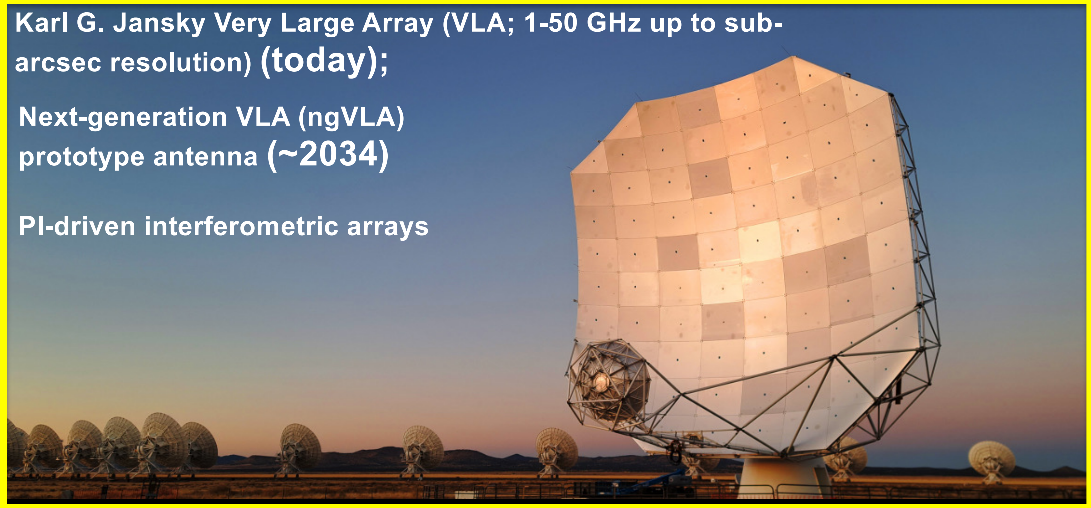
Credit: Divyajyoti

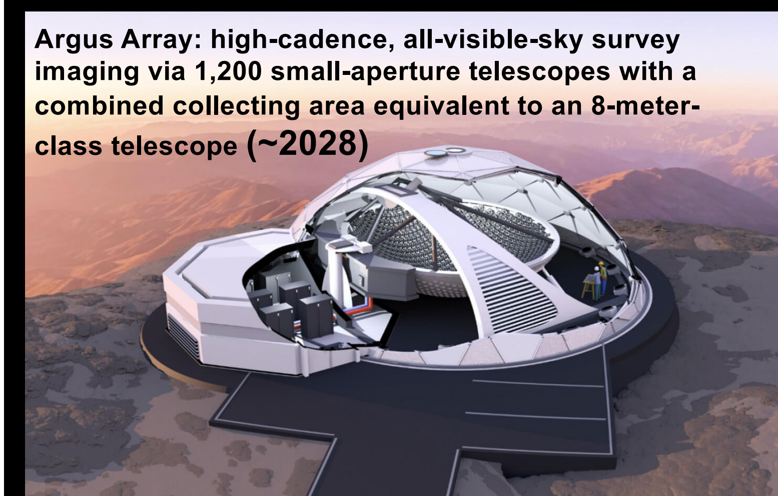
Abbott et al. 2018, LRR, 21, 3

Evans, Corsi, et al. arXiv:2306.13745

Abac et al. 2026, JCAP, 03, 81

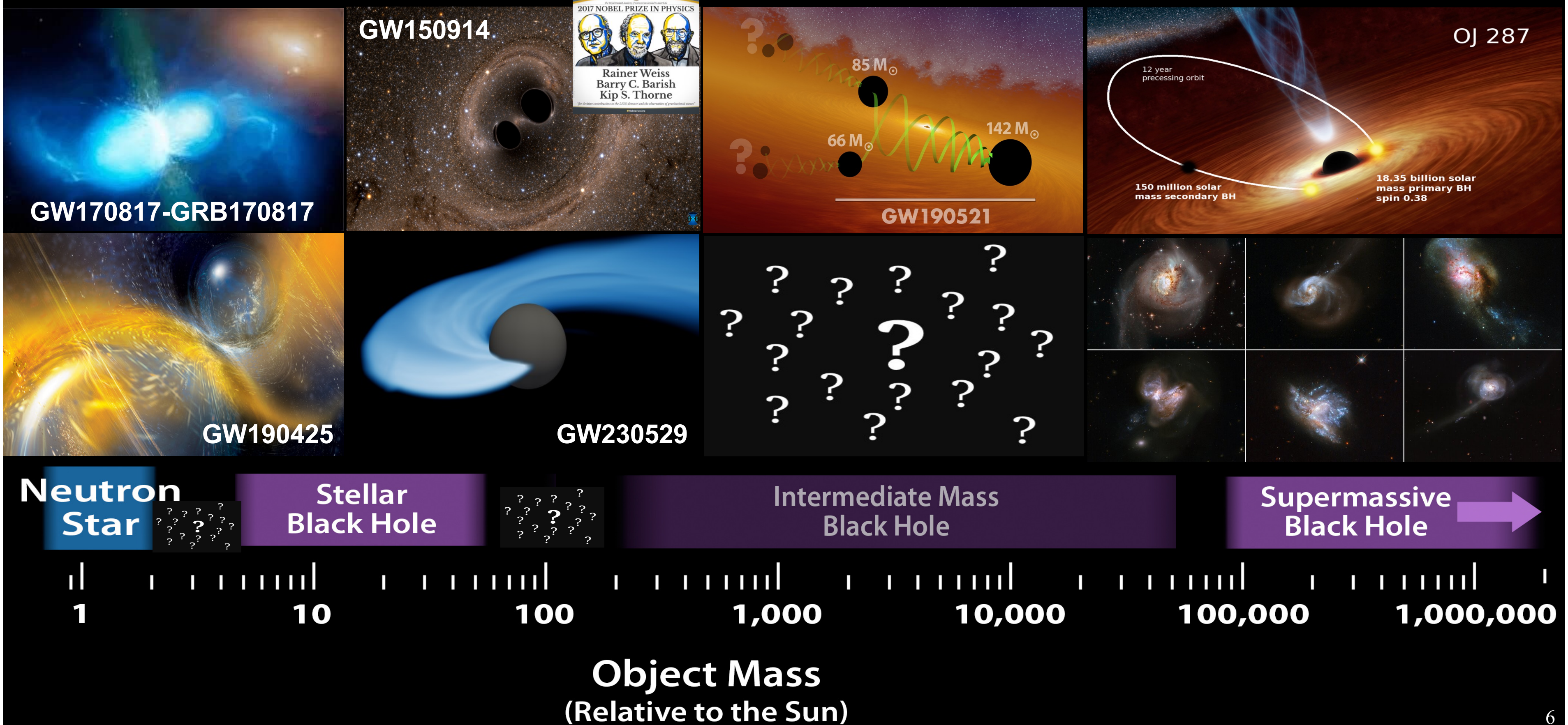

Rubin LSST: ~10 deg^2 FOV camera;
8.4 m-diameter primary mirror;
millions of alerts per night!
(~2026)


Karl G. Jansky Very Large Array (VLA; 1-50 GHz up to sub-arcsec resolution) (today);
Next-generation VLA (ngVLA) prototype antenna (~2034)
PI-driven interferometric arrays

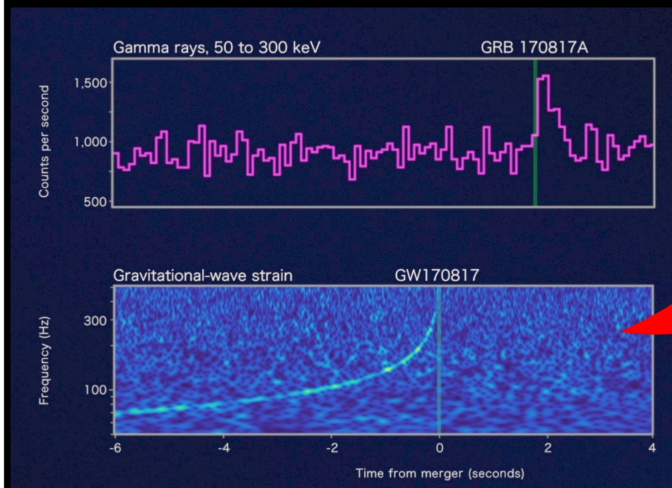

Argus Array: high-cadence, all-visible-sky survey imaging via 1,200 small-aperture telescopes with a combined collecting area equivalent to an 8-meter-class telescope (~2028)


DSA-2000 (0.7–2 GHz frequency; 3 arcsec resolution);
wide-field, multi-epoch survey science (~2029)

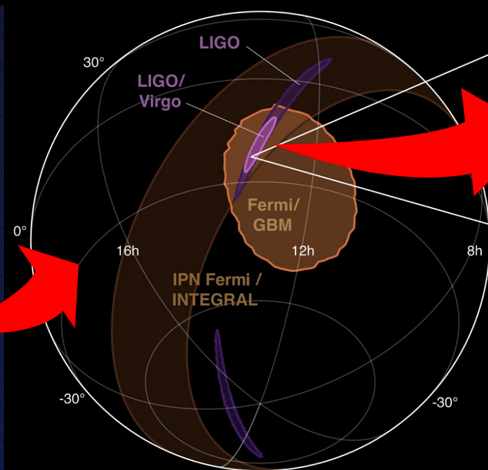
The mass spectrum of compact objects



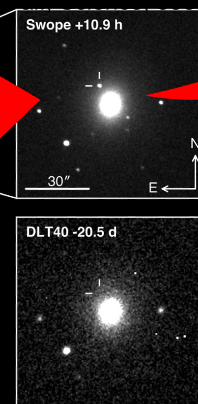
GW170817 and the start of GW-MMA



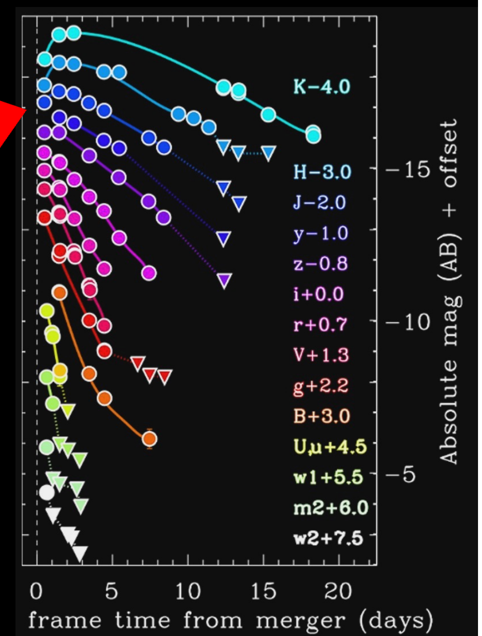
LIGO/Virgo; Fermi; NASA/DOE; NSF; EGO.



Abbott et al. 2017, ApJL, 848 L12

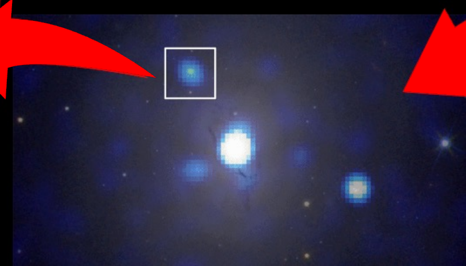


Valenti et al., ApJL, 848, L24,



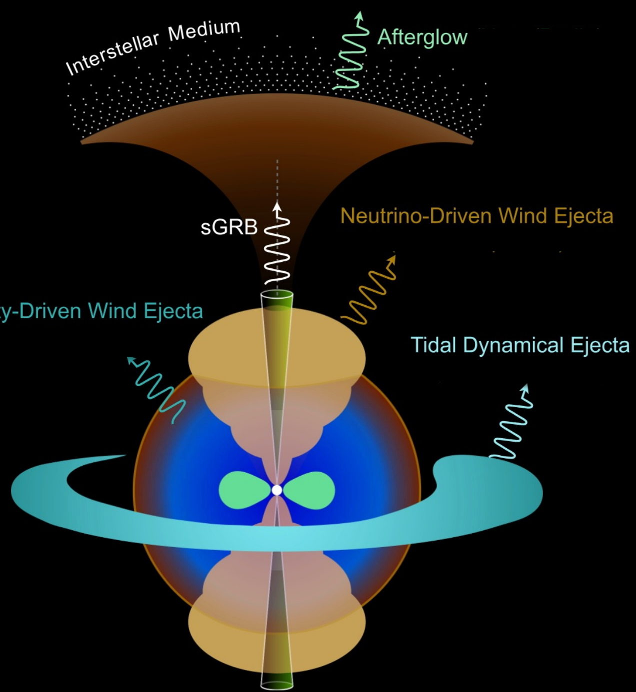
Drout et al. 2017, Science, 358, 1570

Hallinan, Corsi et al. 2017, Science, 358, 1579



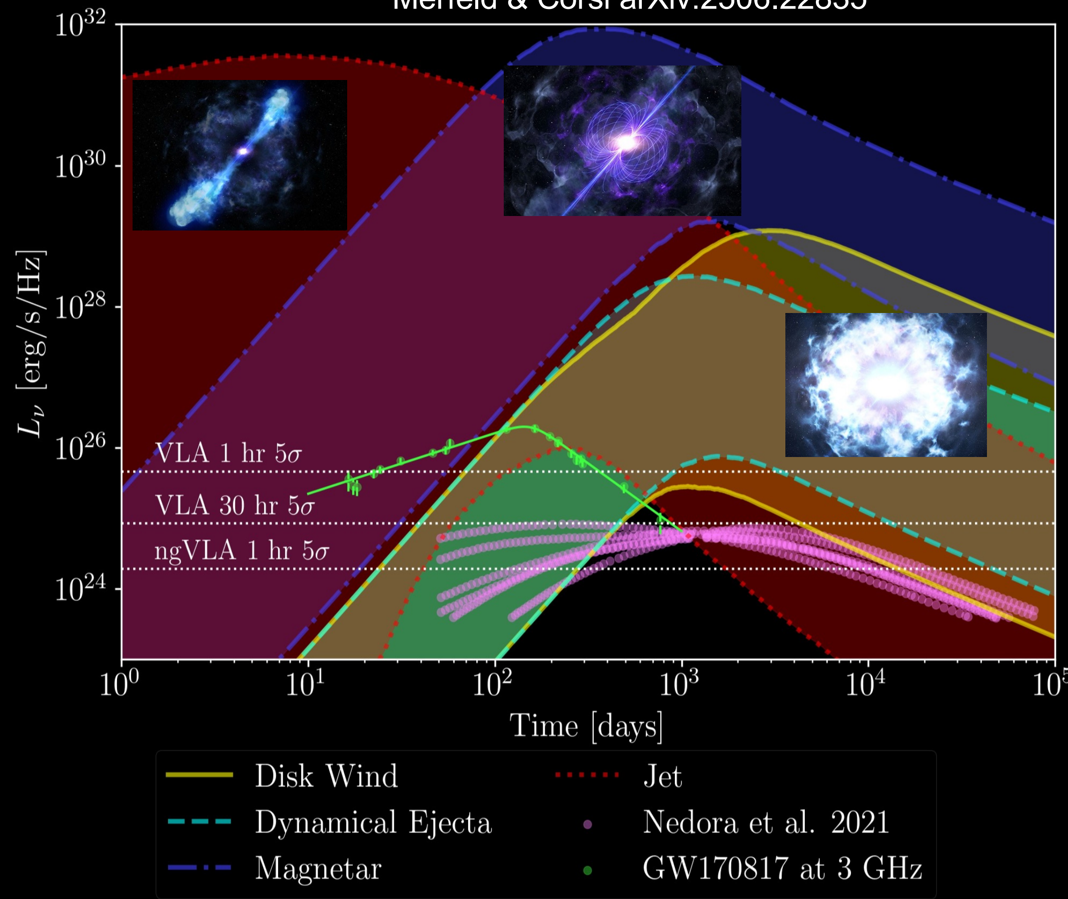
Troja et al. 2017, Nature, 551, 71

#1: Diversity of BNS radio counterparts

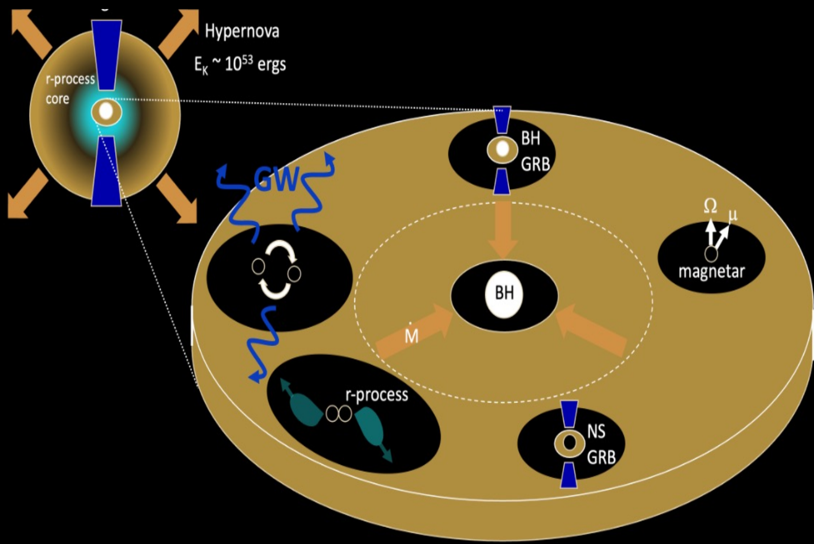


Zhu et al. 2020, ApJ, 897, 20

Merfeld & Corsi arXiv:2506.22835

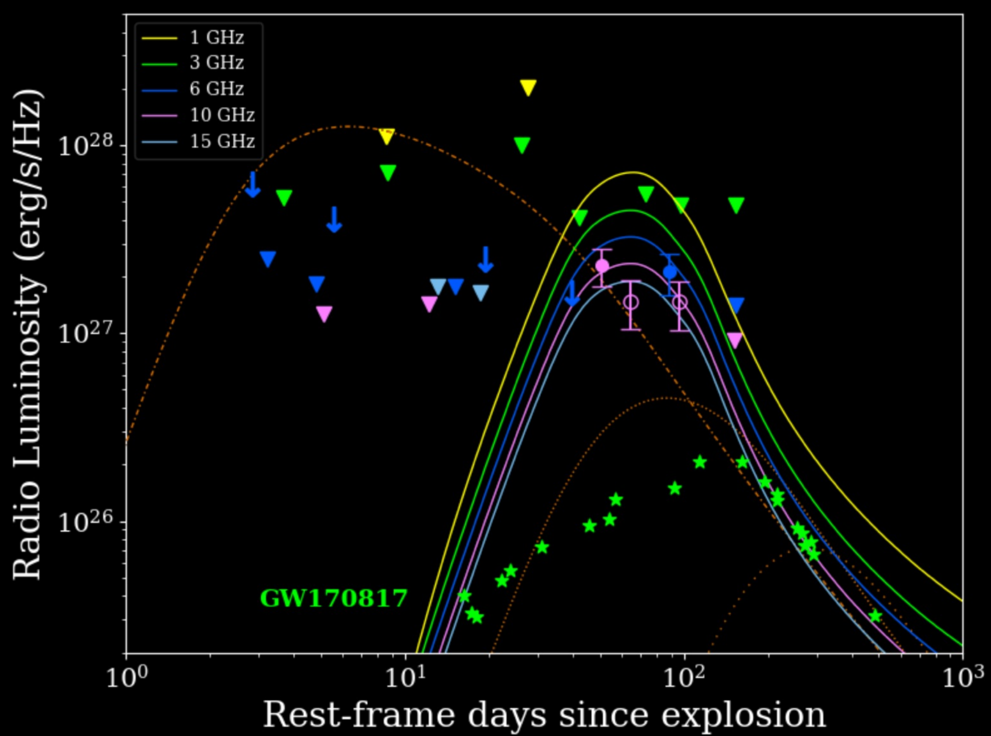


#2: Sub-solar NS-NS mergers and "superkilonovae"?

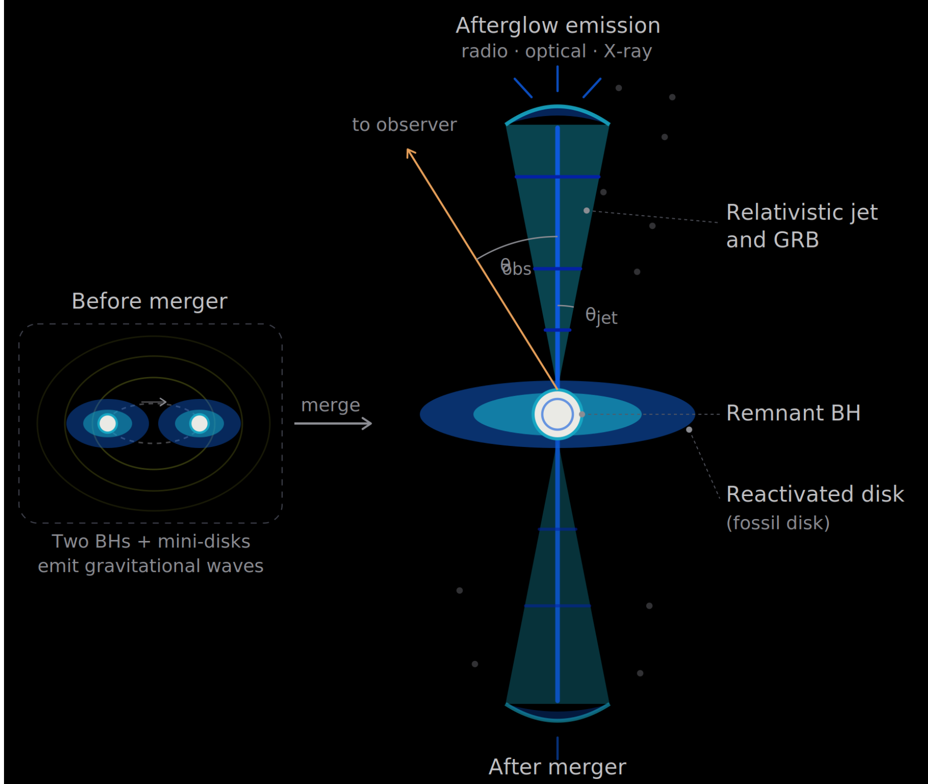


Metzger et al. 2024, ApJL, 971, L34
See also Kasliwal et al. 2025, ApJL, 995, L59

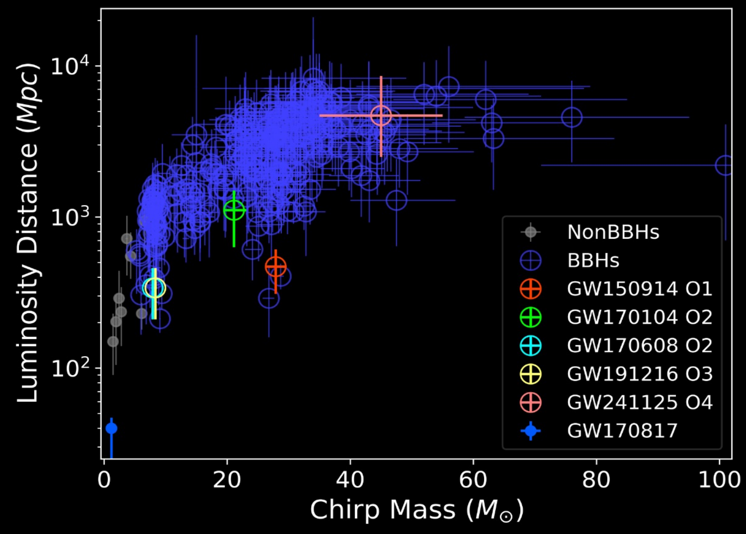
S250818k/SN2025ulz radio follow up:
O'Dwyer, Corsi et al. 2026, ApJL, submitted

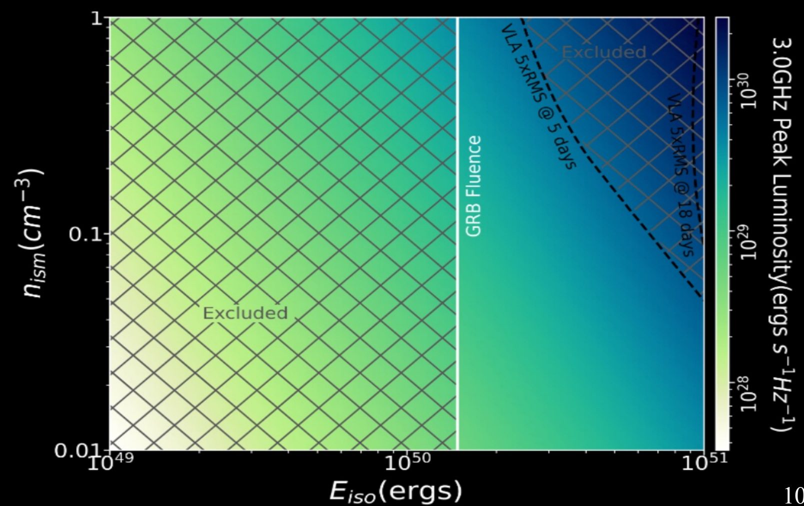


#3: Radio afterglows of BBHs?



Gottschlich, Corsi et al. 2026 in prep.





See also: Perna, Lazzati, Giacomazzo 2016, ApJL, 821, L18

•**Minor cycle:** Peak-find and subtract the PSF in the image domain to build the sky model — fast but approximate.

CLEAN Imaging in CASA: gridding, FFT, and cycles

From visibilities to image

Adapted from:
James Robnett

- Interferometers don't image directly, they sample the sky's Fourier transform (visibilities) at scattered (u,v) points (or tracks with Earth's rotation) set by each antenna pair.
- The FFT to the image needs a regular rectangular grid, but (u,v) sampling is not uniform.
- Gridding (which can be spread over multiple cores) convolves each visibility onto nearby grid cells; the gridded data are then FFT'd to produce the dirty (residual) image.
- Minor cycle: Peak-find and subtract the PSF in the image domain to build the sky model: fast but approximate
- Major cycle: Degrid the model, subtract from observed visibilities, re-grid to a fresh, accurate residual image.

Challenges for CASA imaging apply to MMA

M. Lacy's talk and https://casa.nrao.edu/casa_hardware-requirements.shtml

File I/O

I/O-bound during gridding (major cycle) when data sits on a single disk is the major limitation of parallel CASA.

1× 6 TB Hard Disk Drive
~200 MB/s

«

16-core node needs
400–800 MB/s

Rule of thumb **25–50 MB/s per core**

Tip — for data sets under 100 GB, SSDs are a cost-effective fix.

Memory

Two demands compete for RAM:

Implicit **Filesystem cache**
RAM ≥ data → cached & fast. RAM < data → disk. For 100 GB+, faster I/O beats more RAM.

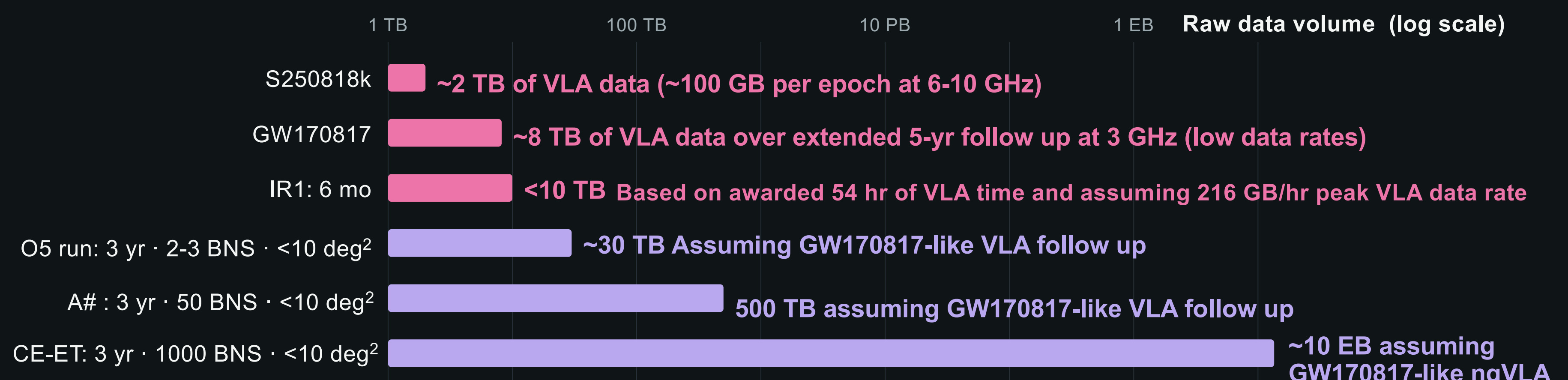
Explicit **Images**
Must hold all intermediate minor-cycle images. Wide-band, wide-field, and newer algorithms need more.

Too little → swapping → severe slowdown.

Bottom line: Match I/O throughput and memory to your data-set size
size I/O to core count · buy I/O speed before RAM for big data · keep RAM for all intermediate images.

Evolution of the radio data volume for GW follow up (guesstimate)

Raw interferometric radio data per 3-year GW run: terabytes today (VLA), exabytes with the ngVLA



Log scale · pink = collected/awarded, lavender = projected

ngVLA avg data rate

27 TB/hr

peak 1.1 PB/hr · ~1000× VLA

Golden (<10 deg^2) BNS / 3-yr run

50 → 1000

A# → CE-ET· <10 deg^2, radio-followable

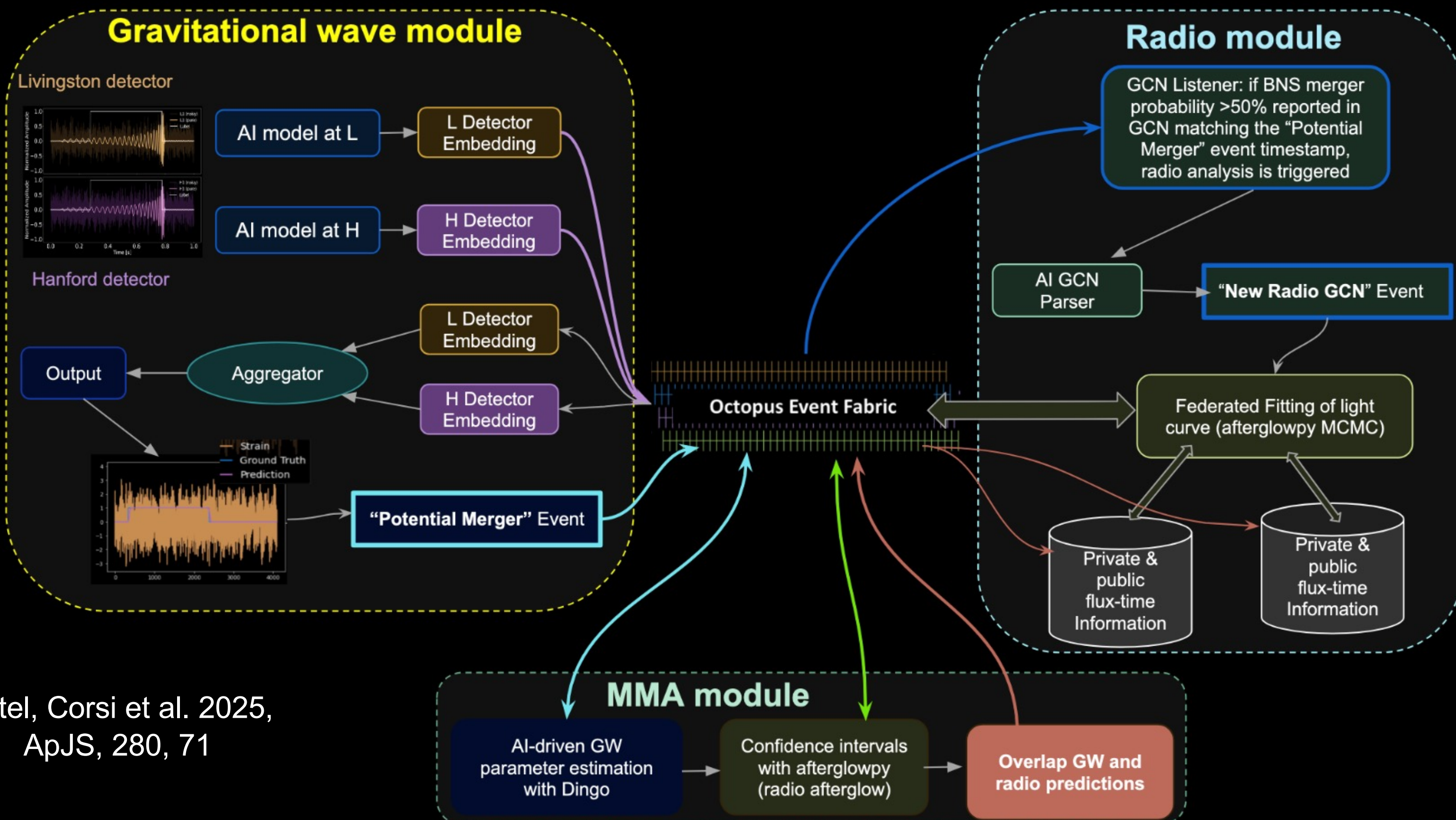
Science-ready data

~1000× lighter

than raw visibility data

RADAR-Radio Afterglow Detection and AI-driven Response:

A Federated Framework for Gravitational Wave Event Follow-Up



Patel, Corsi et al. 2025, ApJS, 280, 71

The End

Thank you!