

The SuperNova Early Warning System (SNEWS) is a neutrino burst coincidence detector that has operated autonomously since 2005. A new version of the network, called SNEWS 2.0, is now operational, with participation from the latest generation of neutrino and dark matter detectors. Built on the SCiMMA Hopskotch service designed for multi-messenger astronomy, SNEWS 2.0 replicates the coincidence capabilities of the old network while adding new functionality, including real-time estimates of the false alarm rate and multilateration (pointing) to compute the location of the supernova progenitor. By enabling the prompt follow-up of a galactic supernova neutrino burst with detailed new information, SNEWS 2.0 will maximize the science gained from this once-in-a-lifetime event.

Modeling CCSN ν Detection

During a core-collapse supernova (CCSN), the star will be opaque to photons but transparent to neutrinos and gravitational waves. **Pre-SN neutrinos** from O and Si shell burning may be detectable days before collapse, and an intense ~ 10 s **all-flavor ν burst** after collapse will lead the optical breakout burst by minutes to hours, depending on the stellar shock-crossing time (Fig. 1).

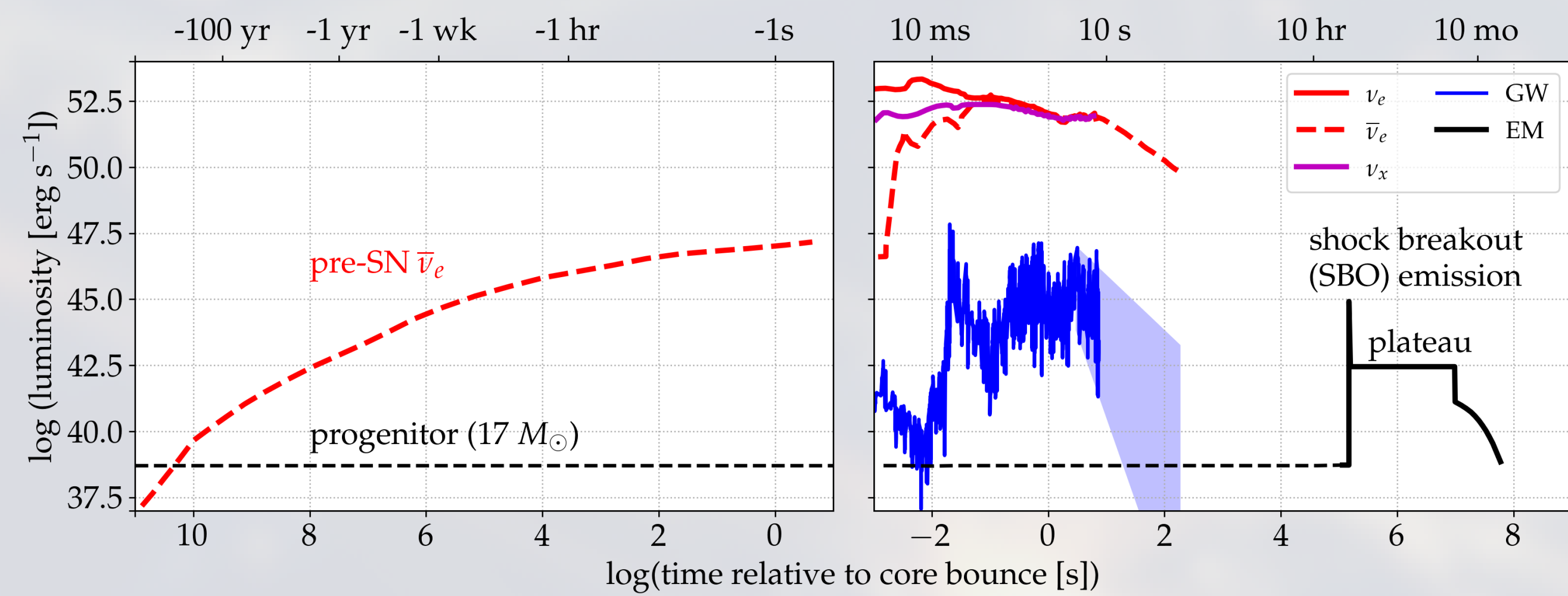


Figure 1: Production of neutrinos (red and purple), gravitational waves (blue), and optical radiation (black) in a core-collapse supernova. (Adapted from Nakamura+, MNRAS 2016.)

snewpy

Neutrinos, if observed, thus provide a **real-time alarm** of a CCSN in progress. To model CCSN ν detection, we have developed **SNEWPY** (Baxter+, ApJ 2022), an open-source Python package which gives:

- Access to > 1000 pre-SN + CCSN models (e.g., Fig. 2) with a single interface.
- Calculation of ν flavor transformations in vacuum and via the MSW effect in stars and in the Earth with the **BEMEWS** oscillations module.
- Quick estimates of event rates in various detectors using **SNOwGLoBES**.
- Integration with event generators such as **MARLEY** and **sntools**.

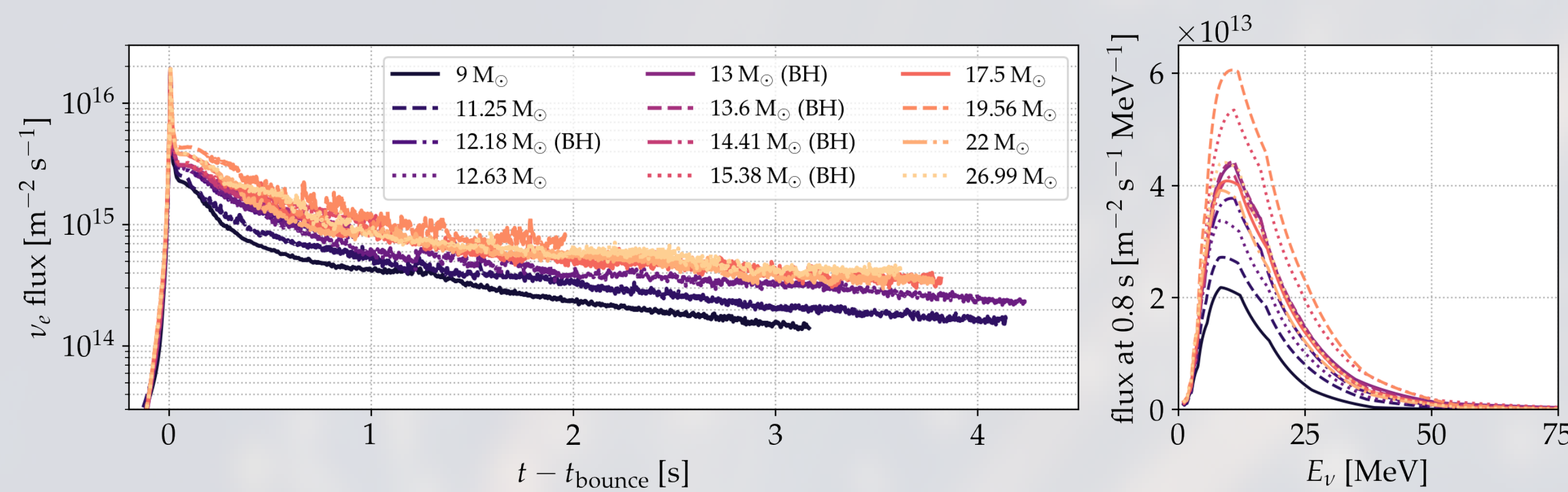


Figure 2: ν_e fluxes from selected CCSN models (Tsang+, ApJL 2022 and Wang+, MNRAS 2022) computed with **SNEWPY**, assuming a progenitor 10 kpc from Earth.

In July 2026, **SNEWPY 2.0** (Almonte+, in prep.) will become available for beta testing. The new version will increase the number of available SN ν models by $> 30\%$, provide new support for 3-flavor and 4-flavor transformations, and greatly simplify access to model fluxes.

Network & Infrastructure

Both ν and dark matter detectors are sensitive to CCSN neutrinos through a variety of detection channels (Fig. 3). Combining the burst alerts from these detectors allows us to:

- Reduce spurious alerts and boost sensitivity to marginal signals;
- Identify the probable CCSN t_0 and progenitor location on the sky.
- Coordinate optical and GW follow-up of the alert.

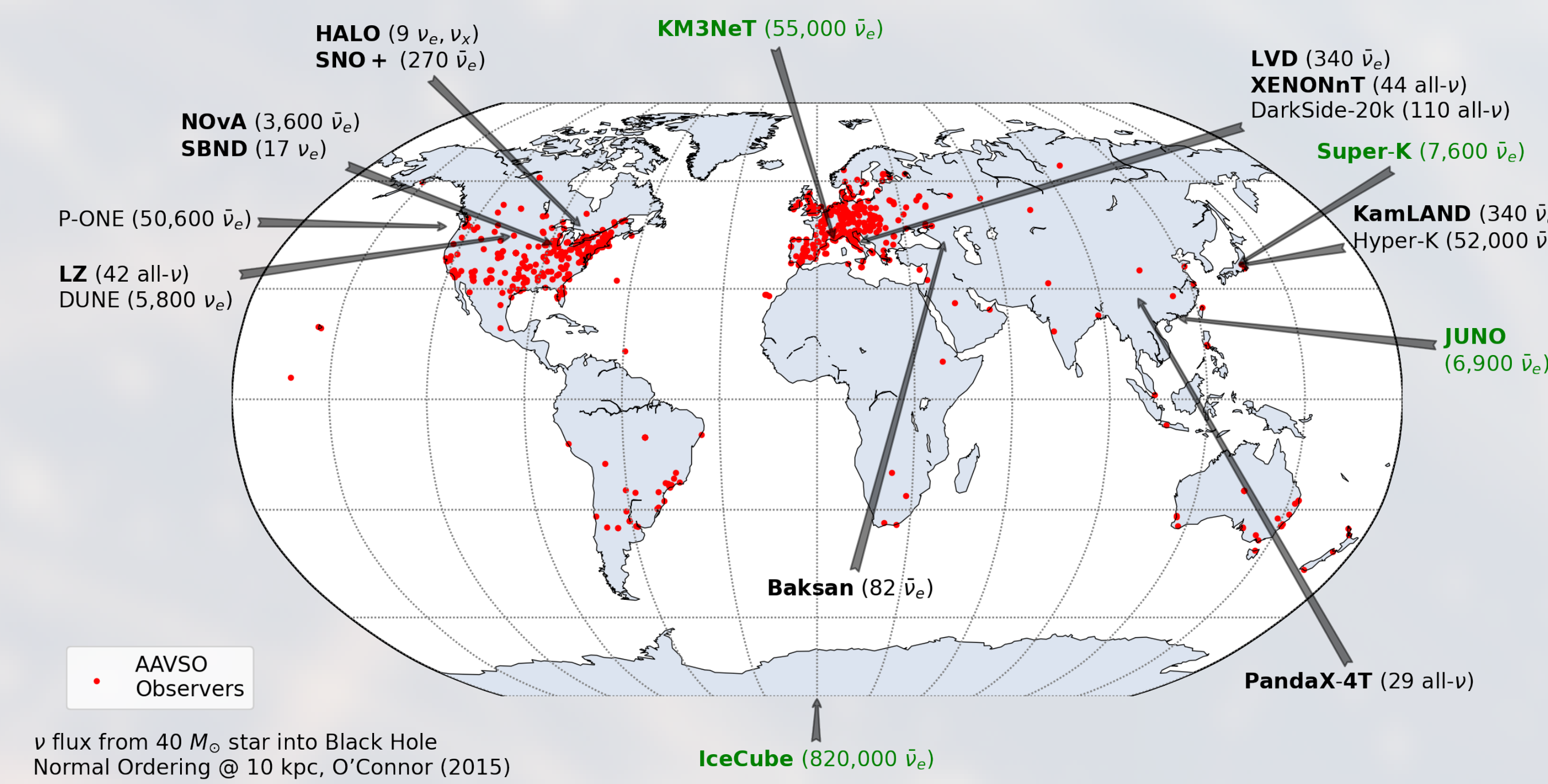


Figure 3: Current and planned ν and DM detectors with sensitivity to a nearby CCSN.

Publishing, Combining, and Receiving Alerts

SNEWS 2.0 (Al Kharusi+, NJP 2021) implements multi-detector coincidence alerts using the Kafka-based **SCiMMA Hopskotch** network transport layer.

SNEWS 2.0 members can publish alerts using the pip-installable Python project **snews_pt**, which provides three message “tiers”:

Tier	Description
Coincidence Tier	Detectors provide an alert t_0 and optional p -value to SNEWS 2.0 (equivalent to a “classic” SNEWS alert).
Significance Tier	Detectors provide a binned time series with p -values per bin, appropriate for detectors like KM3NeT or IceCube.
Timing Tier	Detectors provide an alert t_0 and a time series of neutrino hits, appropriate for low-background detectors.

The open-source **snews_cs** project (Kara+, JINST 2024) caches messages from member detectors, forms alerts when ≥ 2 detectors have alerts in time coincidence, and sends low-latency coincidence alerts to all SNEWS 2.0 subscribers. The **snews_pt** package is now available for any experiment that wishes to join SNEWS 2.0 and send alerts to the network.

Automated observatories can subscribe to SNEWS 2.0, including via GCN, Slack, and email lists. Individuals may also subscribe using an iOS alert app.

Enabling Science with SNEWS 2.0

Members of SNEWS 2.0 are actively monitoring likely CCSN progenitors to produce baseline measurements for future transient detection.

SNEWS 2.0 is collaborating with the American Association of Variable Star Observers (**AAVSO**) to monitor nearby progenitors and carry out “**fire drills**” to test coordinated follow-up strategies.

SNEWS members also recently produced a new catalog of > 600 red supergiant (RSG) candidates for continuous monitoring (Healy+, MNRAS 2024).

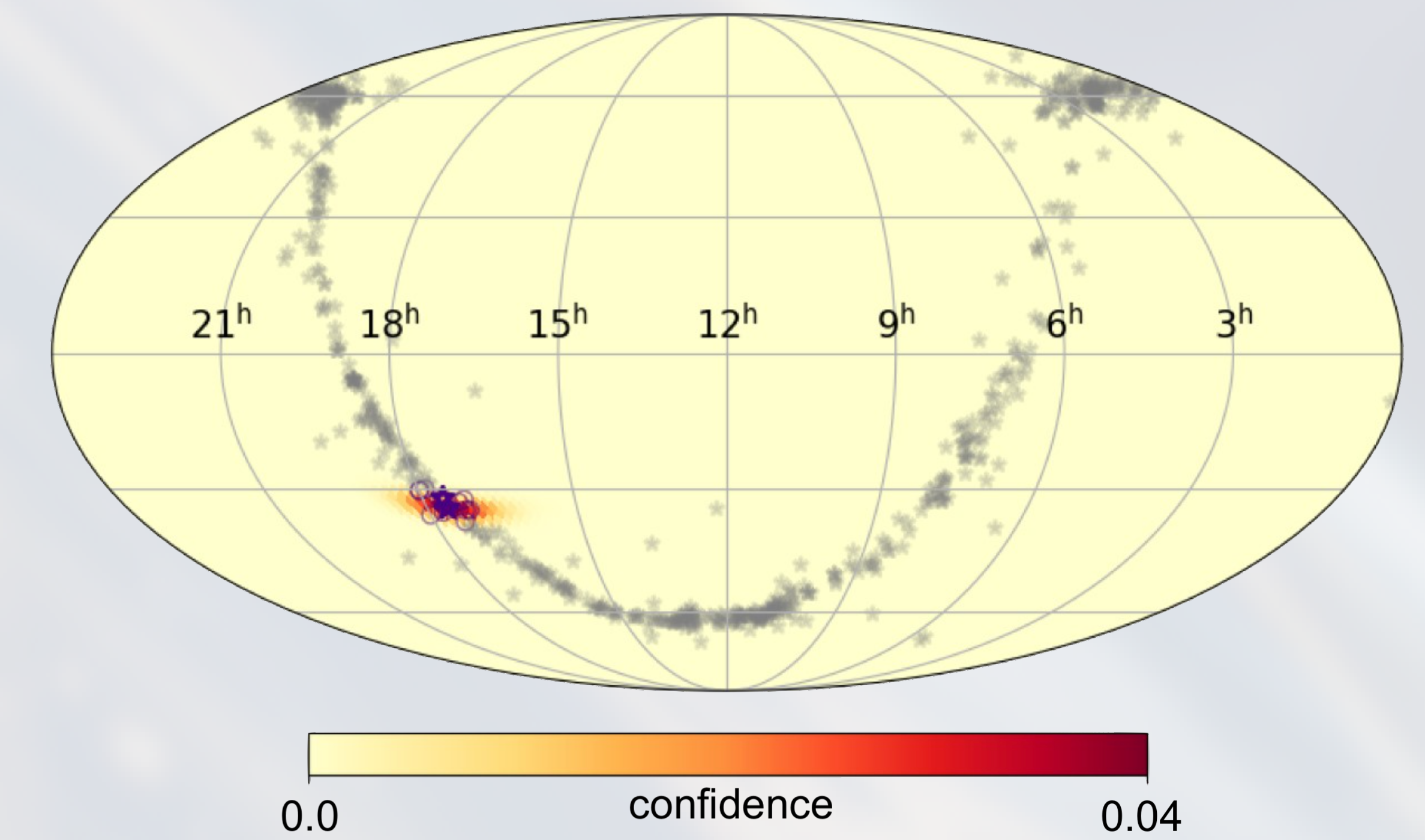


Figure 4: RSG candidates from Healy+ 2024 (dots) showing a simulated CCSN at $(263^\circ, -34^\circ)$ and $d = 4.1$ kpc. The colored contour indicates localization of the CCSN.

Multilateration using the neutrino arrival times can help localize the progenitor to within 100 deg^2 on the sky, depending on the progenitor location, its distance, and the number of coincident detector alerts (Azfar+, PRD 2026).

SNEWS 2.0 can thus rapidly identify tens to hundreds of possible progenitors after detection of the CCSN ν burst. These progenitors can be followed up in a coordinated campaign that includes amateur astronomers, organizations such as AAVSO, and wide-field surveys such as Rubin/LSST that will operate during the next decade (Banovetz+, OJA 2026).

Summary

By exchanging detailed alert information, SNEWS 2.0 allows for:

- Better and faster pointing to identify possible CCSN progenitors;
- Extended sensitivity to the pre-SN ν production;
- Coordinated “**fire drills**” on lower-significance signals;
- Long-term progenitor monitoring by neutrino experiments.



Learn more about SNEWS 2.0 at snews2.org.



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All SNEWS 2.0 code, including **SNEWPY**, is available at github.com/snews2/.