



SNEWS 2.0: Supernova Neutrinos in the Multi-Messenger Era

Alec Habig
(Univ. of Minnesota Duluth)
for the SNEWS project



SNEWS as it exists today

The SuperNova Early Warning System
A star is opaque to photons (*the definition of a photosphere!*) but transparent to ν : thus, the ν signal will lead the photon signal by ~hours (*shock breakout time-scale*): Early Warning of galactic fireworks

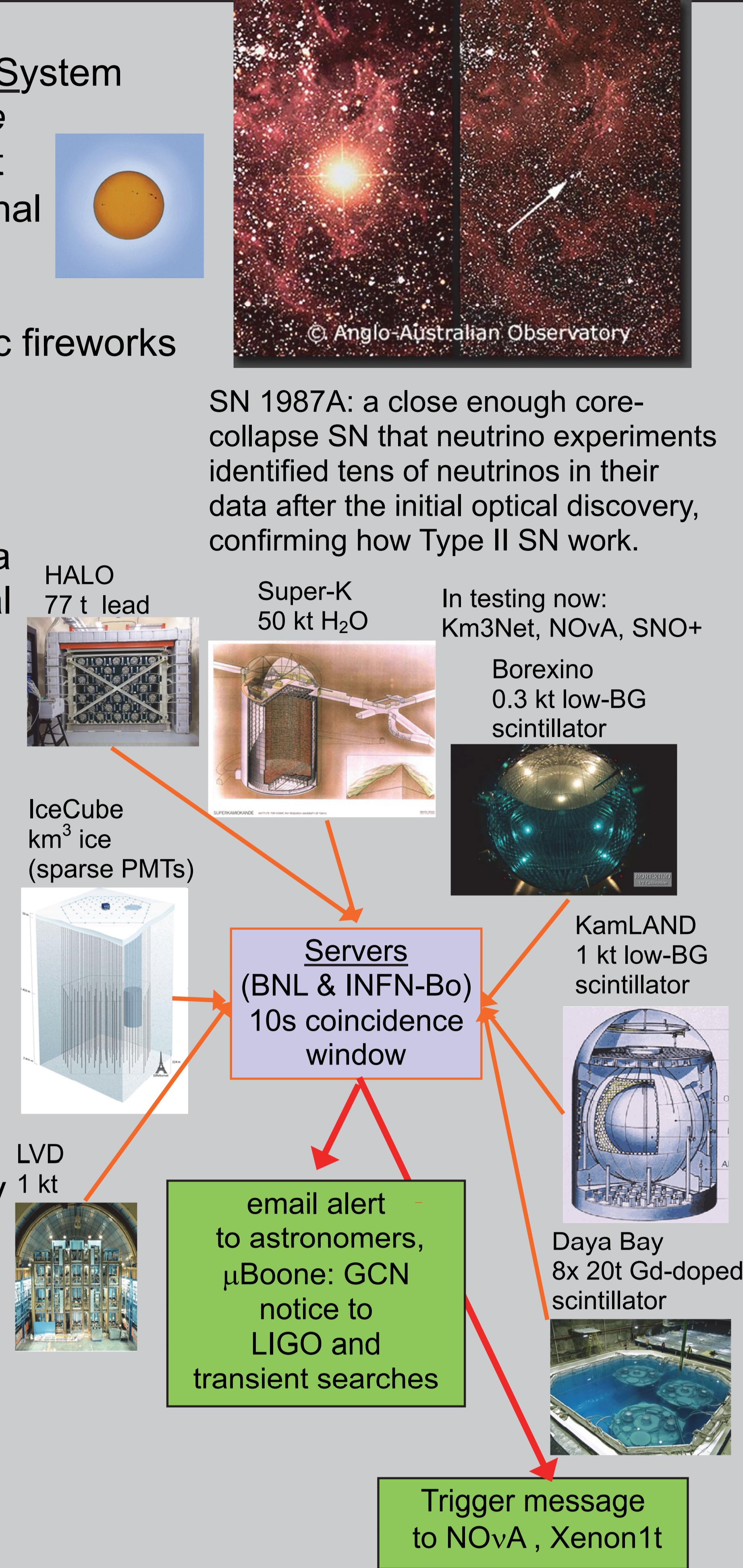
To allow for a quick (*human-free*) alarm, seven neutrino experiments automatically send any Supernova (SN) triggers via custom SSL sockets to a central coincidence server. A real SN neutrino front will show up in more than one detector, noise will not: an automated alarm is issued in the form of PGP-signed “Supernova alarm” emails.

SNEWS was born in 1998, became operational in test mode in 2001, and has been fully operational since 2005.

But, there have been no nearby supernovae in that time. (We expect several per century close enough to see in ν

Original goals:

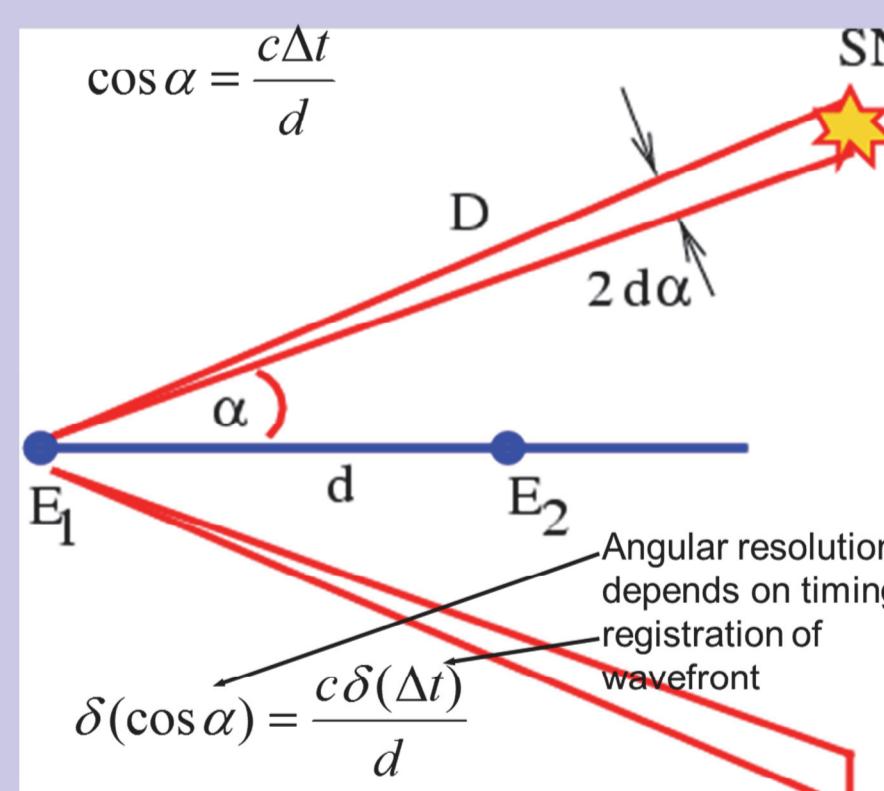
- Prompt (✓ << hr)
- Pointing (~ only SK's own)
- Positive (✓ no false alarms)



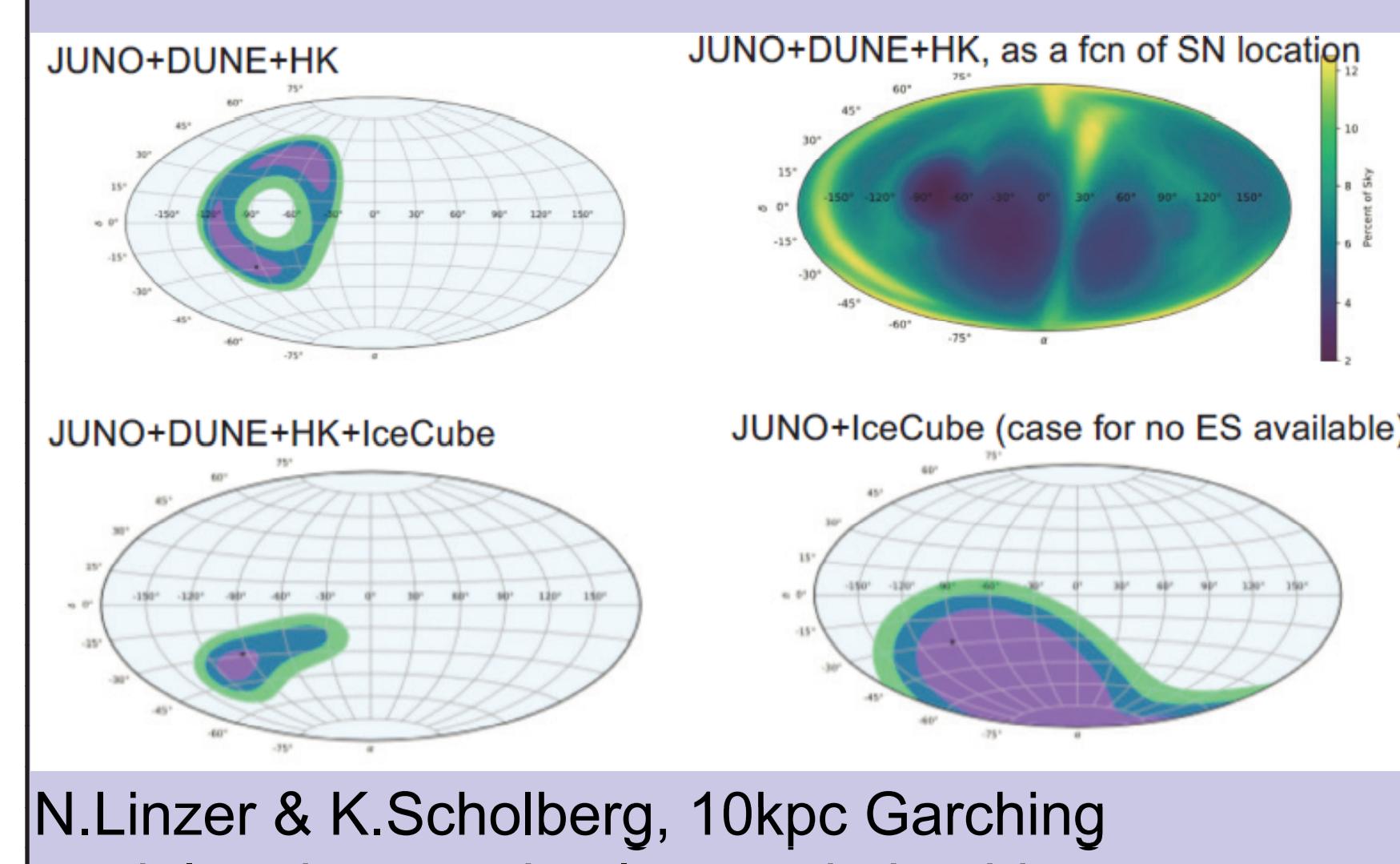
Pointing?

Individual water Cherenkov experiments can point to ~degrees with internal data analysis of $\nu \rightarrow e$ scattering. Can a network help get direction faster?

Triangulation:
Original experiments had too low a rate, but newer ones are larger.
Better statistics plus comparing whole “light curves” gives skymaps similar to LIGO’s.



Add in $\nu \rightarrow e$ scattering, IBD’s weak direction, DUNE tracking: error boxes keep getting better



N.Linzer & K.Scholberg, 10kpc Garching model and some simple new timing ideas

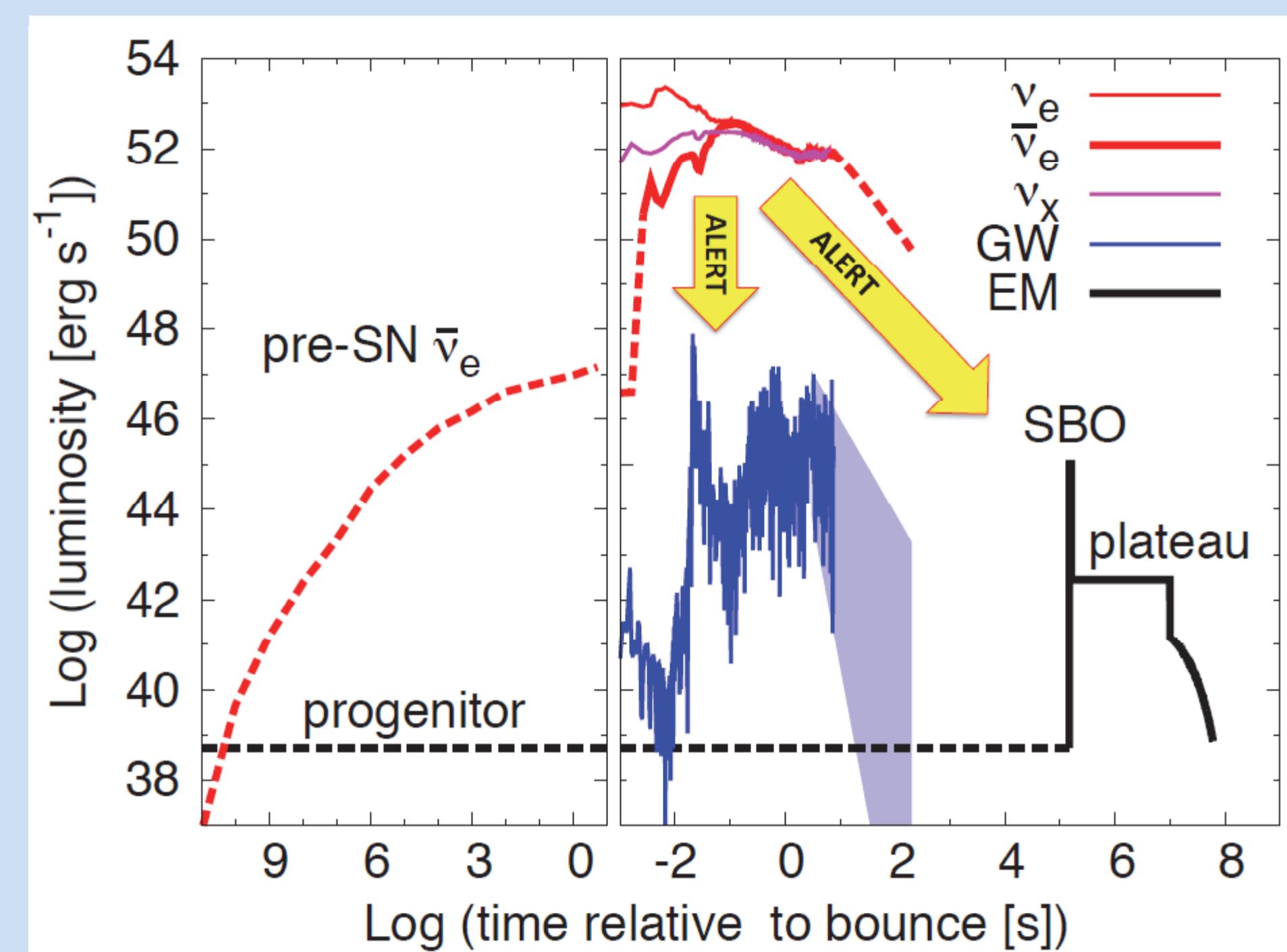
SNEWS 2.0: Supernova

Neutrinos in the Multi-Messenger Era

Other Multimessenger successes have changed astrophysics since SNEWS started:

- Bacodine/GCN followups ID “long/soft” GRBs as Hypernova (2003)
- IceCube UHE ν associated with Blazar flares (2017)
- LIGO/VIRGO GW coincidence IDs “short/hard” GRBs as colliding neutrino stars (2018)

What can SNEWS learn from this to make sure we learn as much as possible from the next galactic SN?

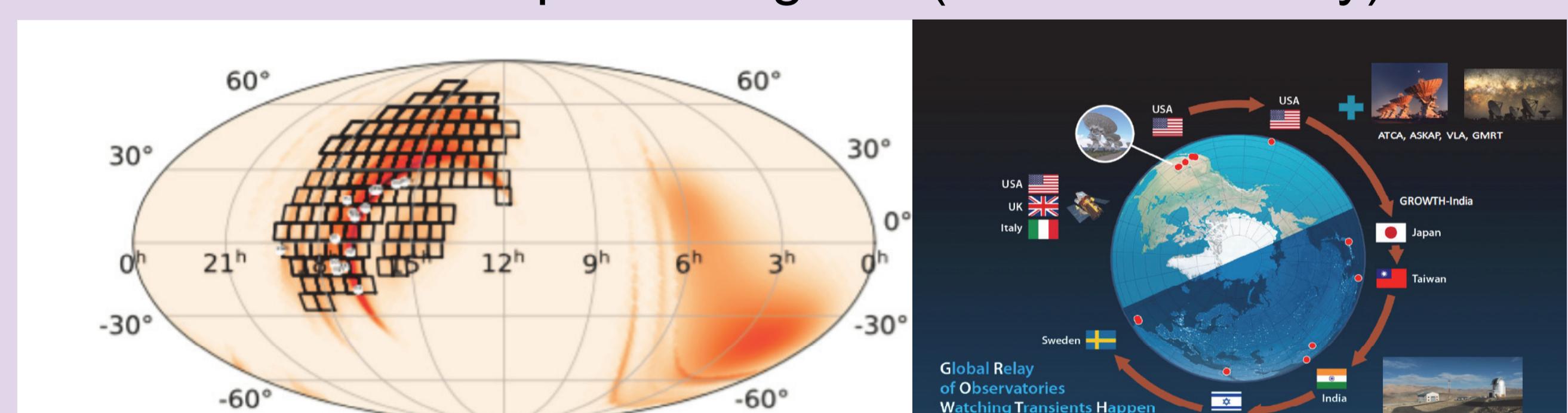


Time of multi-messenger signals pre- and post- core collapse of a $17 M_{\odot}$ progenitor star in neutrinos, gravitational waves, and electromagnetic radiation. Neutrinos prior to collapse come from the last stages of stellar evolution. The EM light curve shown has shock breakout (SBO), plateau, and decay components. The focus of SNEWS 2.0 is to establish the neutrino burst as an alert for gravitational waves and electromagnetic followup, as shown by arrows. Figure adapted from Nakamura et al, MNRAS 161, 3296 (2016)

Changed landscape: Transient Hunting is now A Thing
LIGO/VIRGO, Auger, and IceCube send out regular alerts for their interesting events, joining many electromagnetic transient alerts.

→ People now expect lots of transients to chase, and aren’t upset if they all aren’t real.

Transient-chasing telescope networks can cover very wide error boxes: good pointing less vital than in 1998.
For example, ZTF covers thousands of square degrees quickly in the IR (ideal for seeing past dust), and the GROWTH network spans the globe (and thus the sky).



Left: followups to S190425z (the 2nd potential NS-NS merger) by the Zwicky Transient Facility. The initial localization was 10,000 square degrees (refined later to 6,000). In the 30 hours before the GW signal was shown to be noise, ZTF covered half of that, finding several high-confidence transient candidates that were further narrowed down to those consistent with kilonovae using an internal pipeline employing machine learning algorithms (Coughlin et al. 2019, GCN 24283). ZTF is part of the GROWTH network (right), handing off observations as the earth rotates. Figures courtesy of Mansi Kasliwal.

Summary:

By exchanging more information, neutrino experiments could enable:

- Better, faster pointing
- Extended pre-SNe ν range
- “Fire Drills” on lower significance signals to test response

SNEWS 2.0 is working towards this:

Whitepaper with details is coming soon!

Sign up for an alert yourself here:



SNEWS 2.0 Workshop, June 2019 slides at: <http://snews2.0.snlab.ca/>

