Panel II: Supernova Neutrino Early Alert Strategies

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1) How should we set parameters for the alert? (inputs, coincidence rates, significances, etc.)
2) How can we reduce latency?
3) How can we incorporate pointing?
4) Can we add presupernova information?

HALO / SNO+ point of view

- How should we set parameters for the early alert?
  - SNEWS 1.0 was very conservative
  - Consultation with astronomical community on false alarm rates required
  - Different rate tolerance for publicly announced alarms than those sent to GCN etc.?
  - SNEWS 2.0 coordinated effort perfect vehicle to decide how individual experiment coincidence rates, significances, etc. feed into how such input would be defined and used
- How can we reduce latency?
  - Two step approach
    - Keep it simple
    - Value-added information (significances, pointing, ...) CPU-intensive → add resources
- How can we incorporate pointing and presupernova information to the early alert?
  - Follow-up alerts with the value-added information (not really part of SNEWS 1.0)
  - Pre-supernova – different list of subscribers?

➢ How should we set parameters for the early alert?

- Most of the current SNEWS parameters are fine with us except for the "At least two experiments at different laboratories". SK and KamLAND are in the same "laboratory". It is quite unlikely both SK and KamLAND make fake SNEWS signals at the same time and never happened so far.
- After some improvements, the current fake rate of SK alert is much smaller than the criteria of SNEWS.

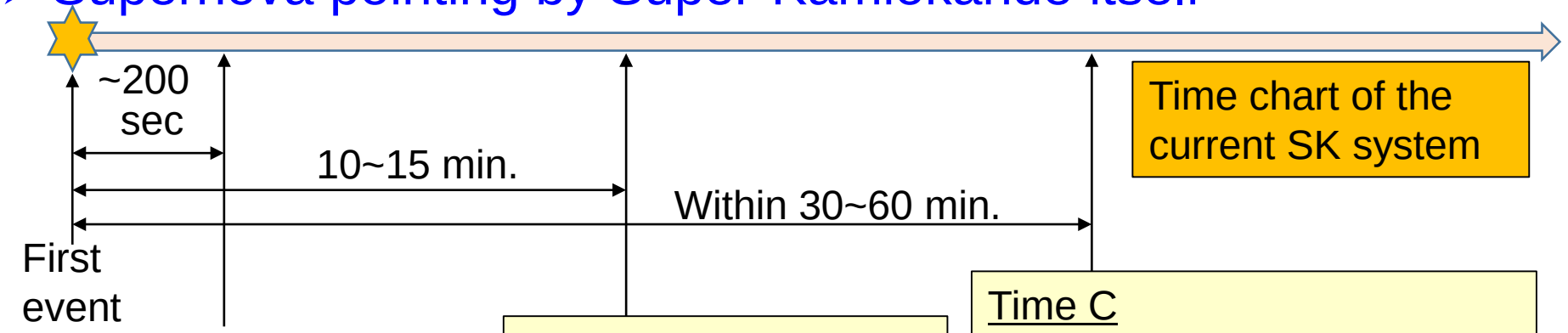
➢ How can we reduce latency?

- Latency of current SK SNWATCH is about 200 sec which includes 60sec for sub-run unit and processing with 5 CPUs. By increasing CPUs it might be shortened.
- After SK-Gd phase starts, we can detect $\overline{\nu_e}$ free from spallation background. If we install an intelligent algorithm in the real time trigger system called WIT, we could reduce the latency drastically down to a few seconds.

➢ How can we incorporate pointing and presupernova ….?

- SK report the time of the first event with an accuracy of 500 nsec (GPS clock). So, the GPS time itself must be precise enough for triangulation.
- However, the ramp-up of the initially very low signal rate during the first few milliseconds of the burst would determine the pointing accuracy.

➢ Supernova pointing by Super-Kamiokande itself



Time A
Send signal to SNEWS.
Send e-mail to experts to open a meeting.

Time B
All supernova events are processed and the direction of supernova is obtained.

Time C
In the meeting, discuss whether we can announce supernova direction.
Send alert to ATEL, GCN, IAU/CBAT.

- Pointing accuracy is 3~4 deg.(1σ) for 10kpc SN. It will be improved to 2~2.5 deg. in SK-Gd.
- In the current scheme, it takes about 30~60 minutes until the directional information is sent to ATEL, GCN, IAU/CBAT and etc.
- Time B could be shortened by increasing computer power.
- If we can make a direct connection between SK and automatic telescopes (also eliminate human intervention), the latency could be reduced to a few minutes which would enable us to detect the initial optical signal even for Type Ib and Ic SN.

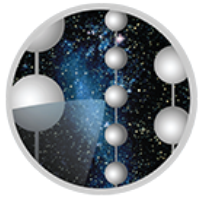
Jiangmen Underground Neutrino Observatory

Detection in JUNO (under construction)

- ~5000 IBD events for SN at 10kpc (*F. An et al, Neutrino Physics with JUNO, 2016*)
- Important ν_x information from ν-p ES channel due to low energy threshold (*Li et.al, arXiv:1903.04781*)
- Significant detection of pre-SN neutrinos for nearby SNe, e.g. 0.2 kpc Betelgeuse (see Huiling's talk)
- Low energy events (even <0.2 MeV) kept for multi-messenger physics (see Donglian's poster)

Potential for SNEWS2.0:

- Online SN burst neutrino alert
- SN location: IBD pointing, Triangulation with global contributions
- Significant pre-SN neutrino alert for nearby SNe via IBD
- Alert latency: algorithm under progress



IceCube
South Pole Neutrino Observatory

University of Rochester

- *High-signal, high-background* CCSN ν detection with IceCube:
  - ~10^6 DOM hits in 10 s from $\overline{\nu}_e$ during Galactic CCSN.
  - ~250 Hz background per DOM.
  - Hardware+software upgrades in works [see talk by S. Griswold].
- Potential for **SNEWS 2.0**:
  - High-rate "test" channel of low-significance alerts. Easy!
  - Light curve in 2 ms bins, for triangulation [Brdar *et al.*, JCAP 1804 (2018) 025]. Technically easy! Politically: need data-sharing MoU.
  - Alert latency: currently ~7 min., easily reducible to ~2 min.
  - Observing pre-supernova neutrinos via, e.g., neutron tagging: geometry for doing this in IceCube Gen-2 is far from ideal.

Rethinking how we classify alerts

• With SNEWS 2.0 capabilities, the GOLD/SILVER paradigm may need to be expanded
• One can imagine a variety of alerts a subscriber may be interested in:
  - "Coincidence between detectors; combined significance > X"
  - "Pre-supernova significance > Y"
  - "There is a multi-messenger coincidence"
  - *More advanced?:* "There is pointing information with uncertainty < Z"

Distributing alerts

• v1.0: Triggered by singular event; email alert to public/astronomers, server sends packets to experiment clients
• v2.0: More metadata to consider; could imagine several avenues to triggering an alert.
• Email alerts should stay, but support for modern media could be added:
  - HTTP API (for developers who want to write polling scripts)
  - Social media (LIGO does this now*)
  - Web page on official site that displays latest alert information (for the generally curious)
  - Desktop/mobile apps for push notifications

Public data sharing

• Ideally would like to make historical SNEWS 2.0 data accessible to public (e.g. amateur astronomers)
• LVC does this via GraceDB*, which I think serves as a great example of this sort of thing
• Perhaps this complicates MOUs? Would need signatories to agree to let us publish this information
• Could classify certain data as internal vs. public

Getting the word out

Let's say we have pointing and pre-supernova and multi-messenger info in our alert. ***Now what?***

* The **LIGO Twitter account** posts information about new GW detections as they come in. This is great for public outreach, and for scientists that are active on social media. https://twitter.com/LIGO/status/1130697713367097344

* **GraceDB** is the Gravitational Wave Candidate Event Database. It's a DB with a webpage frontend where you can get a bunch of info/data about a particular GW event, including EM follow-ups. We could do something similar if MOUs allow. https://gracedb.ligo.org/superevents/S190408an/view/