

# Neutrino Events from Presupernova Stars; Supernova Alarm

*Presuprenova neutrino events relating to the final evolution of massive stars,  
PRD **93**, 123012 (2016); arXiv:1606.04915*

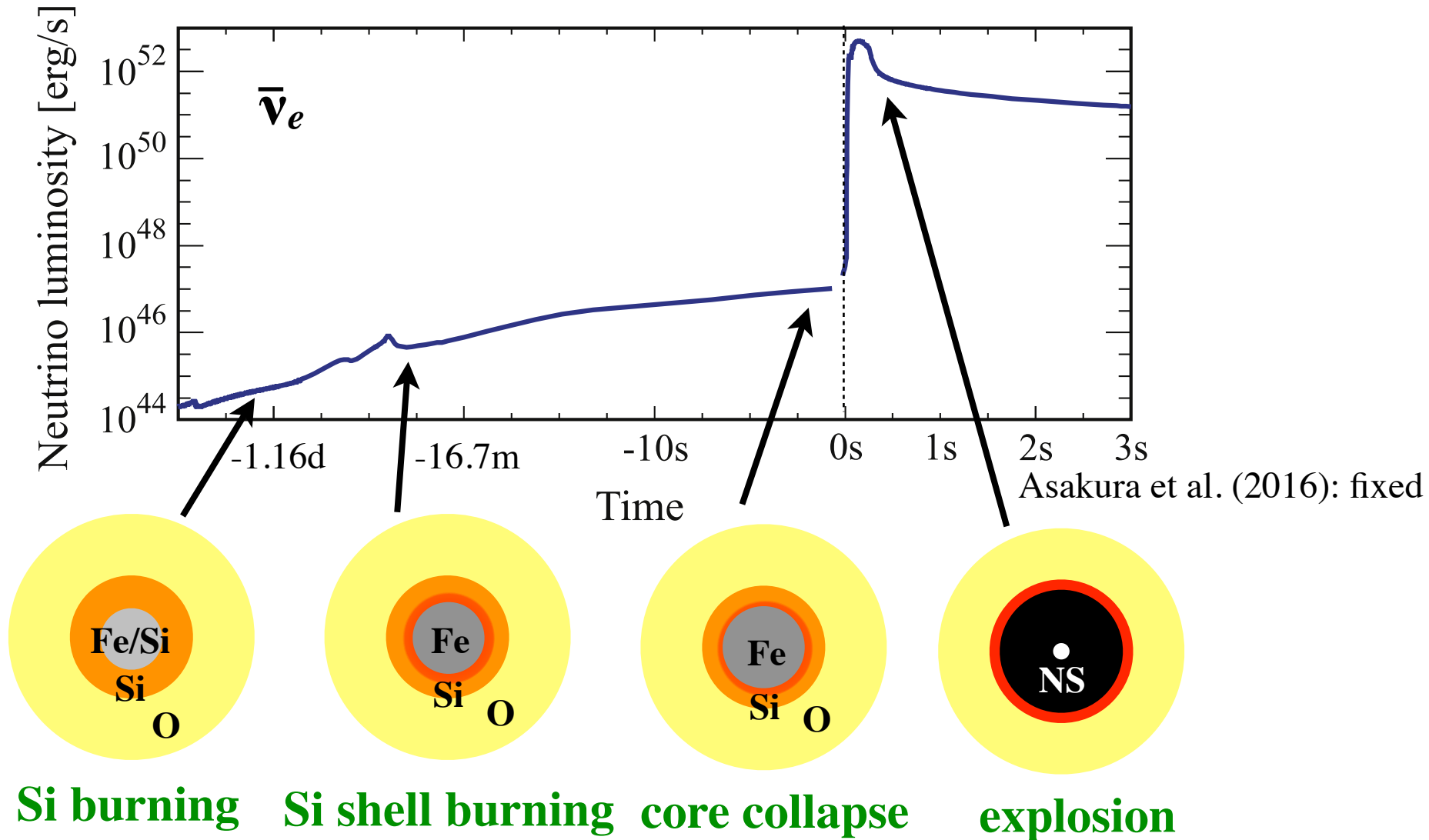
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# Neutrinos from a Presupernova (PreSN) Star



- PreSN neutrinos from a neighboring SN (at **hundreds pc**) are detectable. (Recent studies: Kato et al. 2015; Asakura et al. 2016; Yoshida et al. 2016)
- PreSN neutrino events can be **SN alarms**. (Asakura et al. 2016; Yoshida et al. 2016)

# Supernova Alarm

- SNEWS: the **S**uper**N**ova **E**arly **W**arning **S**ystem (Antonioli et al. 2004)

➡ Providing the astronomical community with a prompt alert for a galactic supernova

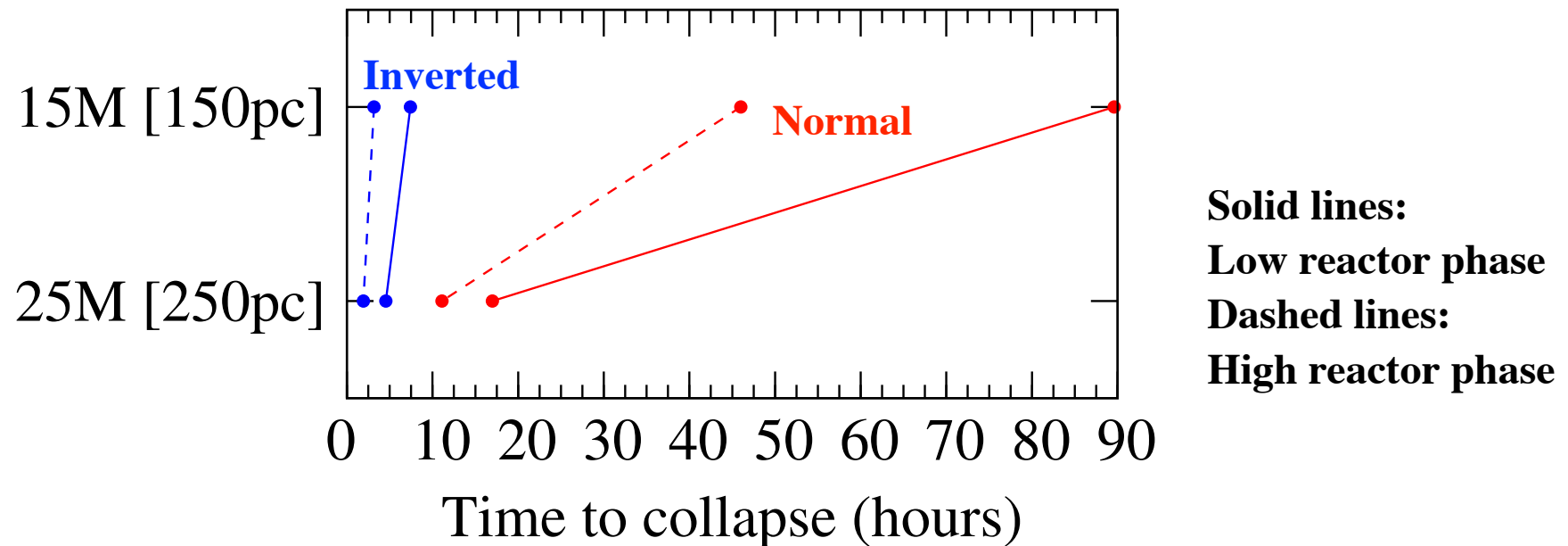
Involved neutrino experiments:

Super-K, LVD, IceCube, KamLAND, Borexino, Daya Bay, HALO

- SN alarm using preSN neutrino events by KamLAND (Asakura et al. 2016)

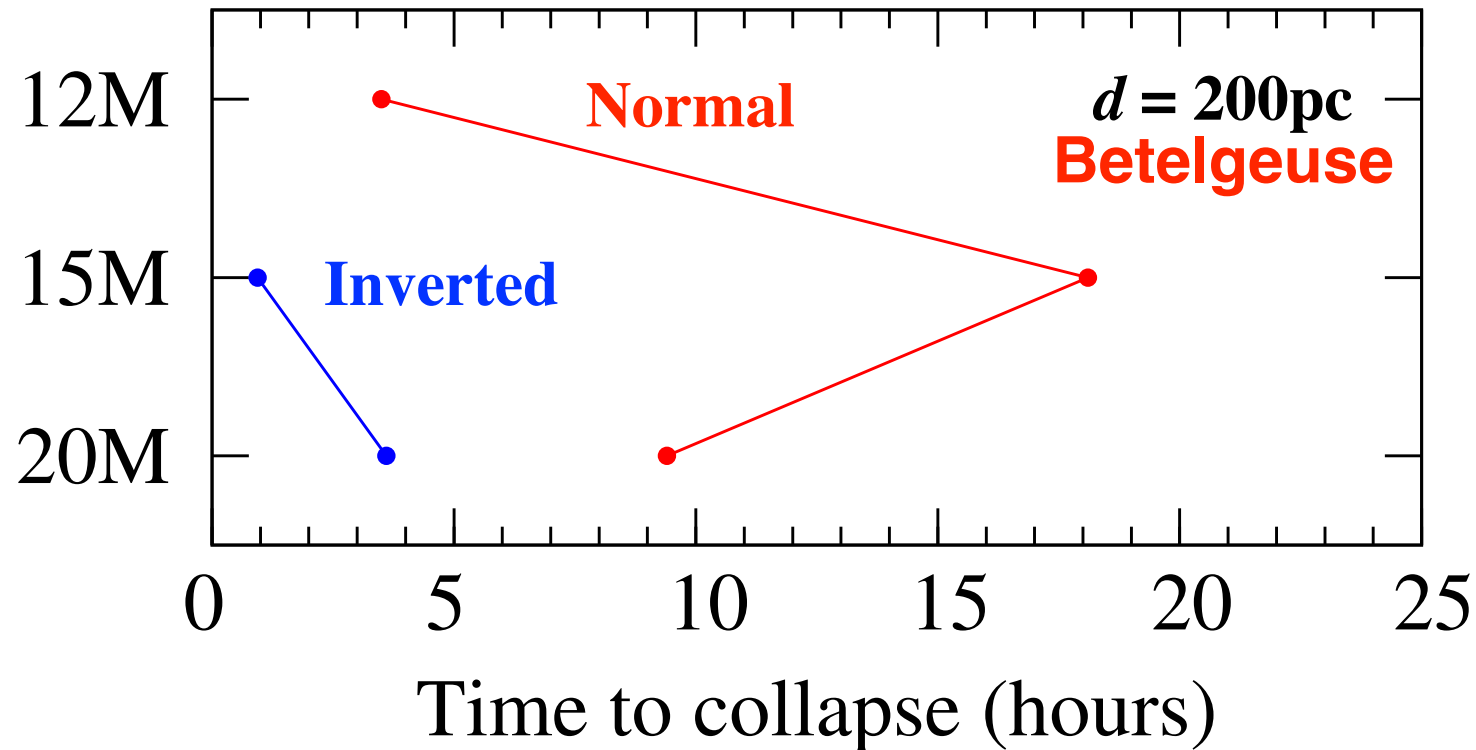
Neutrino events for 48 hours with  $3\sigma$  detection significance

$$0.9 < \varepsilon_p < 3.5 \text{ MeV} \quad (\varepsilon_p = \varepsilon_v - 0.78 \text{ MeV})$$



# Supernova Alarm

- **Three**  $\bar{\nu}_e$  events for 48 hours in KamLAND with  $0.9 < \varepsilon_p < 3.5$  MeV  
➡ **3.7 $\sigma$  (2.1 $\sigma$ ) detection significance in low (high) background**  
(using the analysis in Asakura et al. 2016)



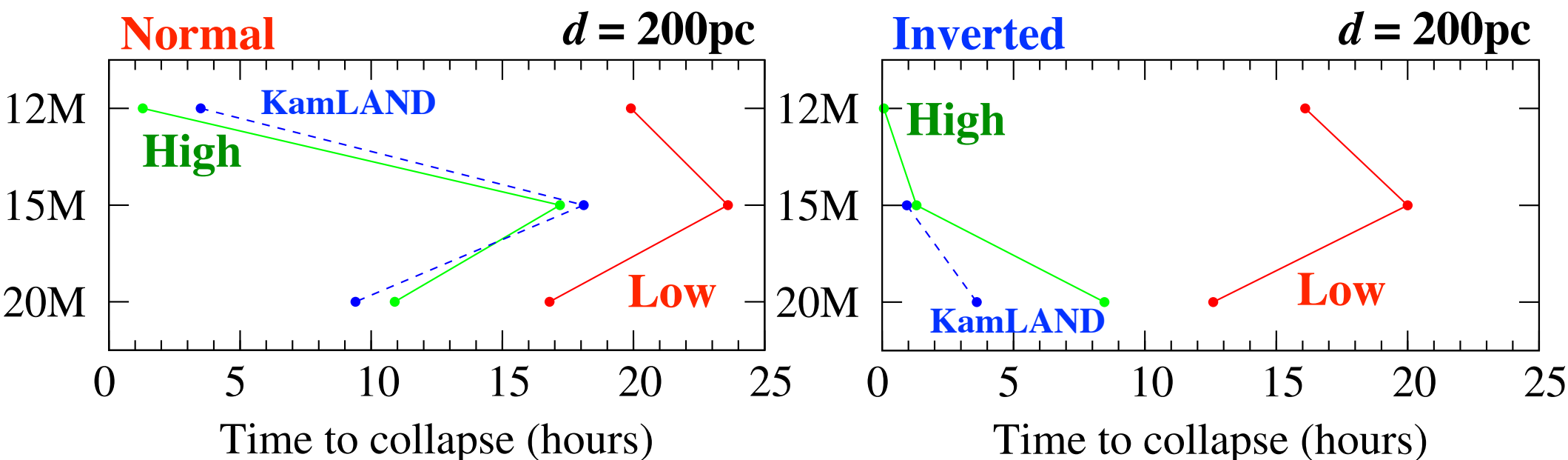
- SN alarm using preSN neutrino events could be possible a few to ten hours before the explosion.
- SN alarm using preSN neutrinos will also be possible by SNO+.

# Supernova Alarm

● PreSN neutrino events can be a SN alarm by JUNO.

>  $3\sigma$  detection significance against background

➡ Three (nine)  $\bar{\nu}_e$  events for one hour with  $0.9 < \varepsilon_p < 3.5$  MeV  
in low- (high-) reactor phase. (using reactor neutrino estimation in An et al. 2016)



Low reactor phase ➡ SN alarm > 10 hours before the explosion

High reactor phase ➡ SN alarm similar to KamLAND

➡ SN alarms by multiple neutrino detectors will be important.

# Possibility for Observing PreSN Neutrinos

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- **Neighboring red supergiants and Wolf-Rayet stars**
  - ➡ **Antares (150pc), Betelgeuse (200pc), Epsilon Pegasi (210pc), Pi Puppis (250pc), Sigma Canis Majoris (340pc), Gamma Velorum (340pc), NS Puppis (520pc), CE Tauri(550pc), 3 Ceti (640pc)** (Asakura et al. 2016)
- **Lifetime of the He burning**
  - ➡  **$10^{5-6}$  years**
- **The possibility of neighboring SNe**
  - ➡ **One event per  $10^{4-5}$  years**
- **The possibility of SNe within 3 kpc**
  - ➡ **One event per a few hundreds to one thousand years**

**Details: Poster P4.090**

**Yoshida, T. et al. (2016), PRD 93, 123012 (arXiv: 1606.04915)**

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