PRESUPERNOVA NEUTRINOS: OPEN QUESTIONS

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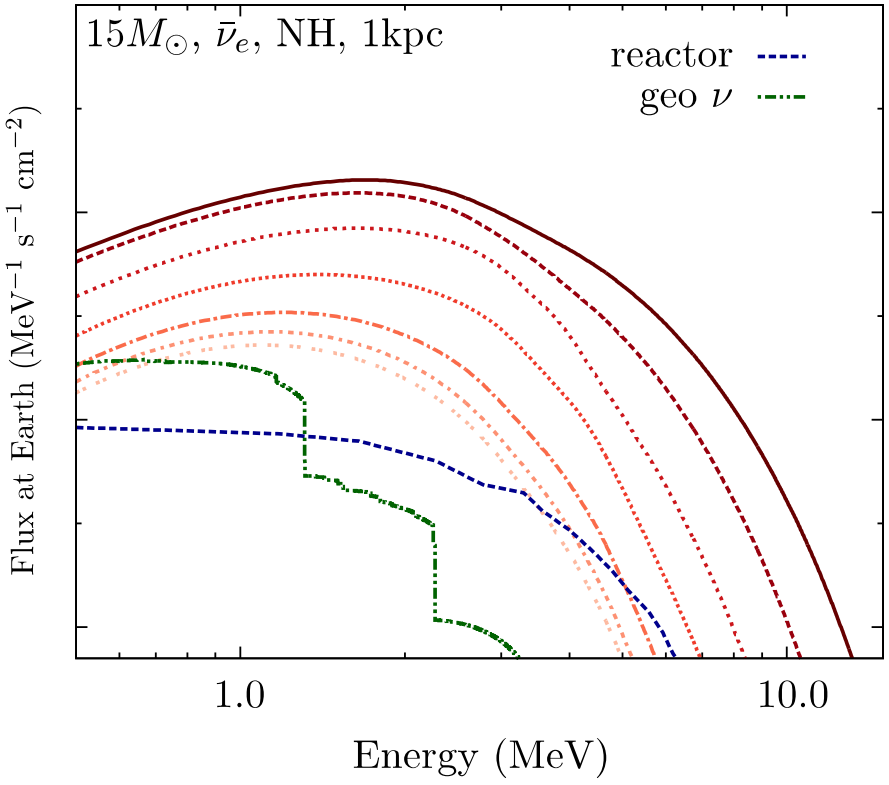
(disclaimer: references can be found in the SNEWS2.0 paper)

Presupernova → collapse → explosion

- Neutrinos from advanced stages of nuclear burning
  - Thermal (pair production)
  - Beta processes (capture, decay)
- 0.1-5 MeV energy
  - Need low threshold detector
- Detectable hours (days?) before the neutrino burst
  - For *near-earth stars* (D<1 kpc)



Overview of models

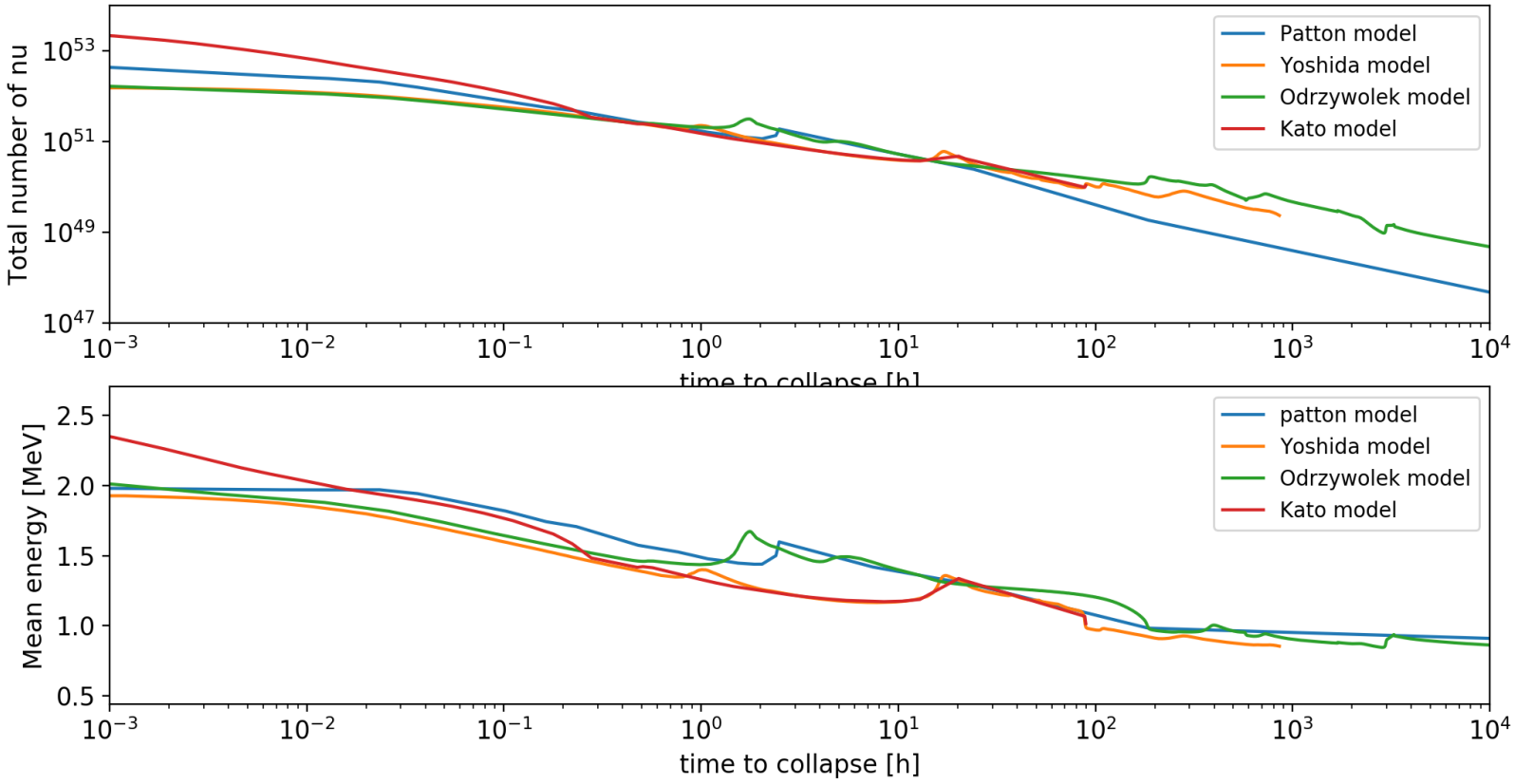


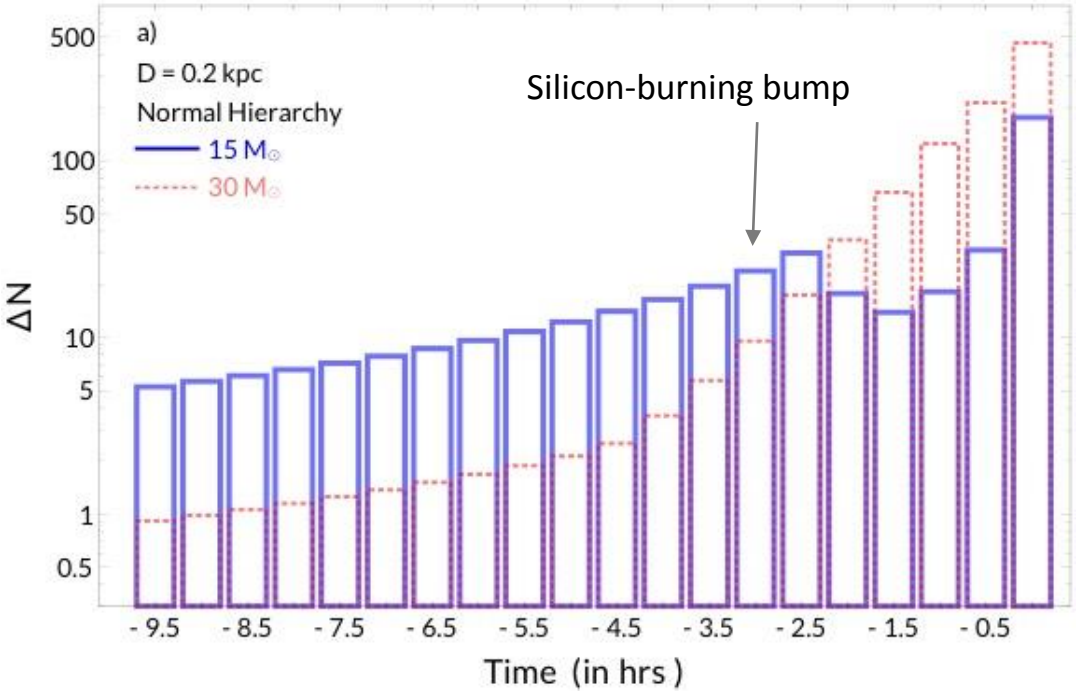
Fig. courtesy of Koji Ishidoshiro

Numbers of events

detector	composition	mass	interval	N_β^{CC}	N_β^{el}		N^{CC}	N^{el}		$N^{tot} = N^{CC} + N^{el}$
JUNO	C_nH_{2n}	17 kt	$E_e \geq 0.5$ MeV	3.19 [0.09]	2.34 [4.32]		10.1 [2.592]	7.19 [10.2]		17.3 [12.8]
SuperKamiokande	H_2O	22.5 kt	$E_e \geq 4.5$ MeV	0.04 [0.00]	0.02 [0.05]		0.43 [0.15]	0.03 [0.06]		0.45 [0.21]
DUNE	LAr	40 kt	$E \geq 5$ MeV	0.017 [0.27]	0.013 [0.032]		0.046 [0.33]	0.018 [0.039]		0.063 [0.37]

Table 3. Numbers of events expected in the two hours prior to collapse, for a presupernova with progenitor mass $M = 15\ M_\odot$, at distance $D = 1$ kpc and the normal mass hierarchy. The numbers in brackets refer to the inverted mass hierarchy. Different columns give the numbers for different detection channels: the superscripts CC and el refer respectively to the dominant charged current process (inverse beta decay or ν_e absorption on the Ar nucleus) and to neutrino-electron scattering. The subscript β indicates the contribution of the β processes to those two channels. The total number of events is given in the last column. The results for Betelgeuse ($D = 0.2$ kpc) can be obtained by rescaling by a factor of 25.

Signal at liquid scintillator detector

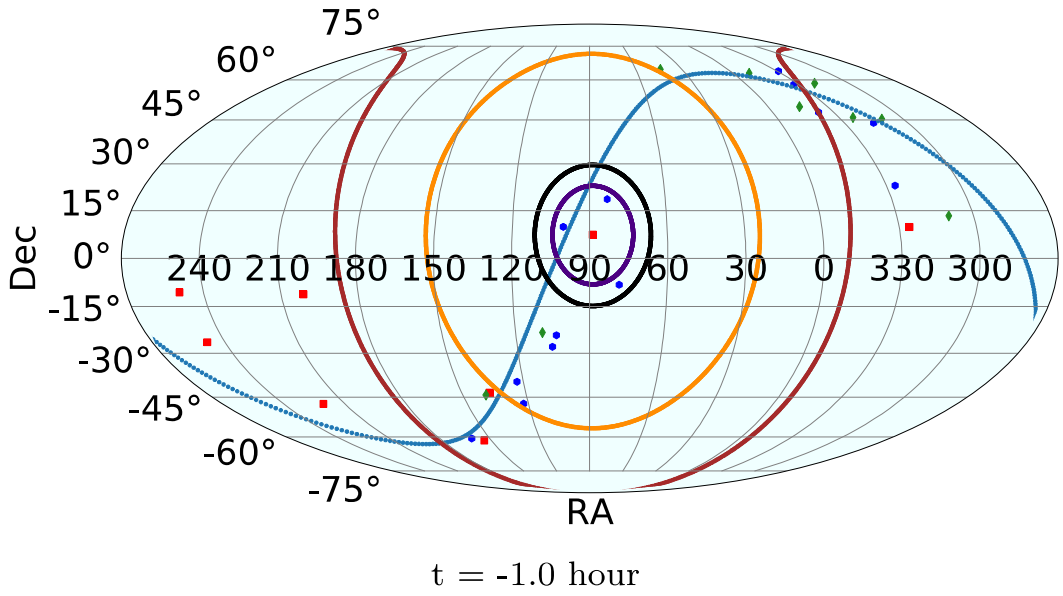


- JUNO-like detector (17 kt), inverse beta decay (IBD): $\bar{\nu}_e + p \rightarrow n + e^+$
  - E > 1.8 MeV threshold
  - Background: 2.6 events/hour in reactor-on phase

Pointing at 10-kt scale LS detectors

- Sensitivity up to 1 kpc; angular error ~70° from IBD
  - Can provide shortlist of 4-10 candidates, about 1 hour prior to collapse

- Possible long term improvements:
  - ~30° with THEIA (100 kt)
  - ~10° with LS-Li



Presupernova neutrinos @SNEWS2.0

- Dedicated “slow burn” alarm?
  - How to discover a *slow*, *directional* rise above background in real time?
- O(day) early alert: dedicated alert system?
  - Different technical possibilities
  - Different/broader list of alert recipients
- Greater public involvement: the event of the millennium
  - Role of mainstream media and social media?
  - Danger of disinformation → opportunity/duty of information?