

Model-independent reconstruction of full flavor supernova neutrino spectra in future large liquid-scintillator detectors

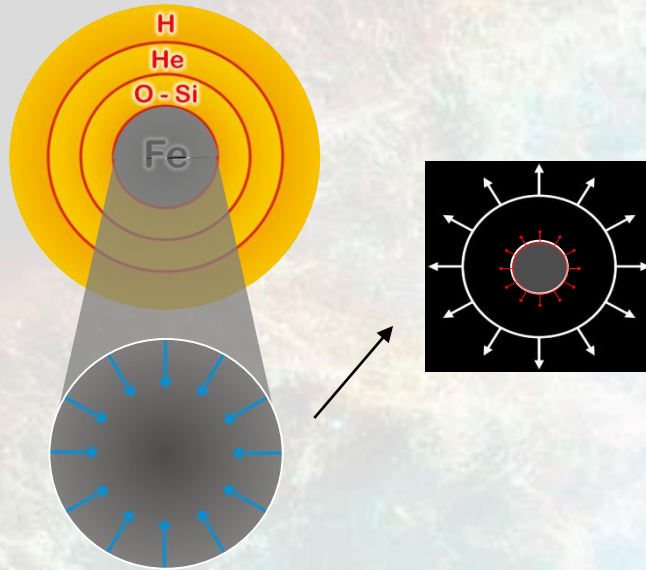
Huiling Li

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2018.11.02

SN neutrino events in LS

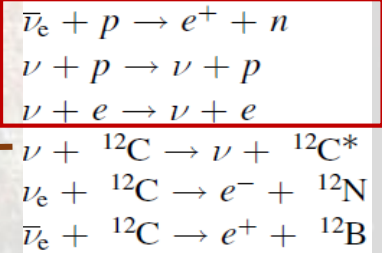


All flavor supernova burst
neutrinos emitted from a CCSN

In liquid scintillator detectors, all flavor
information is mixed in multiple channels

Channel

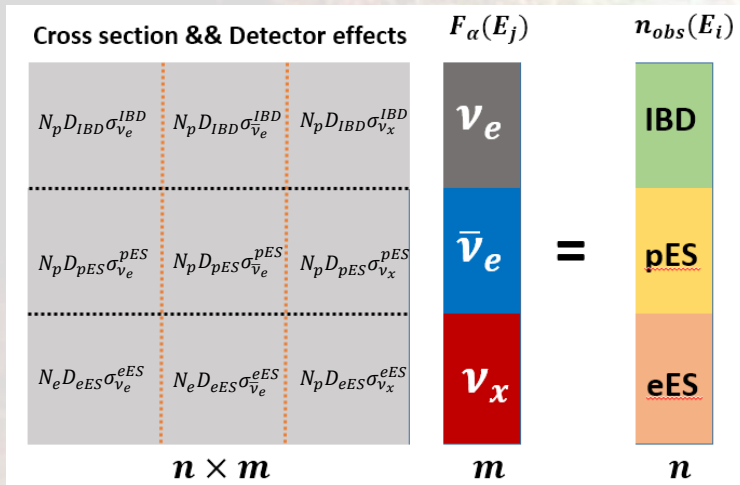
This work



Goal: reconstruct energy spectra for all flavor
SN neutrino emitted from the core of a SN

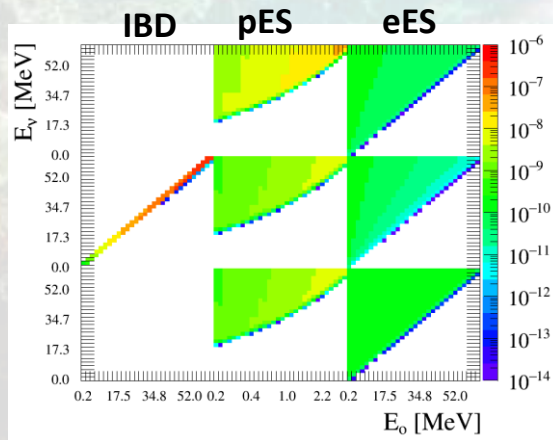
The combined method

Detected spectra \longrightarrow Energy spectra for different flavor SN neutrinos



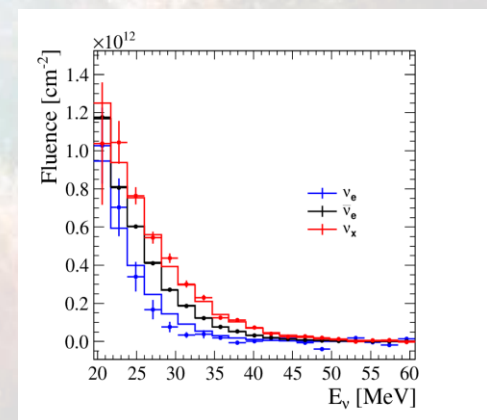
This method:

- ❑ All flavor neutrino spectra reconstructed
- ❑ SN neutrino model independent
- ❑ Potential to deal with SN neutrinos with flavor conversion



Response matrix

SVD Unfolding
 \longrightarrow
 JUNO-like LS detector



1kpc

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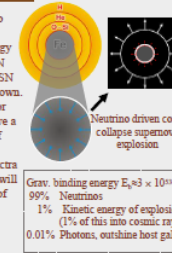
- ❑ Observed energy threshold effect
- ❑ Spectra Reconstruction for SN neutrinos with flavor conversion
- ❑ ...

Model-independent reconstruction of supernova neutrino spectra in future large liquid scintillator

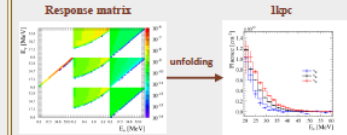
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1. SN neutrino burst

- The sparse SNI987A neutrino data provide us precious information on the total energy and average energy of the SN neutrinos. But details of the SN neutrino spectra are still unknown.
- Future large liquid scintillator detectors (e.g. JUNO) can give a high-statistics observation of supernova neutrino burst.
- The extraction of energy spectra of different flavor neutrinos will be helpful in understanding of SN neutrino production and flavor conversion as well as exploring the true explosion mechanism.

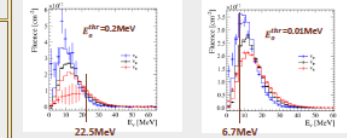


4. Reconstruction of energy spectra

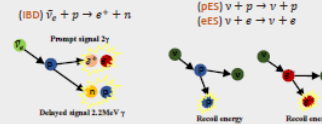


JUNO-like LS detector:
20kt LS, 3% energy resolution, 0.2MeV observed energy threshold

The low observed energy threshold is one of the advantages of LS to detect SN neutrinos. The lower threshold value is, the more complete the neutrino spectra can be reconstructed.

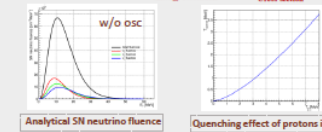


2. Detection in LS

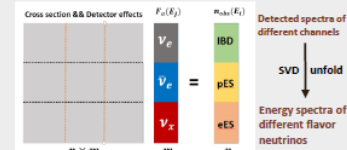


In a more realistic scenario (e.g. pES):

$$\frac{dN_{\nu\mu}}{dE_\mu} = N_0 \int_{E_\mu}^{\infty} dT_e \cdot G(E_\mu, T_e, \phi_E) \int_{E_\mu}^{\infty} dE_p \frac{dF_p}{dE_p} \frac{d\sigma_{pES}}{dE_p} dE_e$$

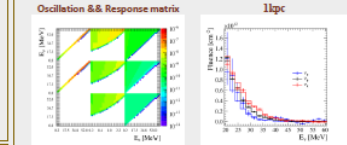


3. The combined method



5. Reconstruction with flavor conversion

If the MSW resonance effect of SN neutrinos at the envelope of a SN is taken into account, the relation between the original neutrino spectra and the detected ones covers both flavor conversion and detector response effects.



Normal mass hierarchy assumed here

6. Conclusion

- The combined method is model-independent and can extract SN neutrino spectra for different flavors directly from the observed spectra of IBD, pES and eES in LS.
- This method has the potential to be a general method for SN neutrino spectra reconstruction, even for a complicated scenario with SN neutrino flavor conversions.