Inelastic charged current interaction of SN neutrinos in two-phase liquid xenon dark matter detectors

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P. Bhattacharjee, A. Bandopadhyay, S. Chakroborty, K. Kar and S. Saha.

P. Bhattacharjee, *et. al.*, arXiv:- 2012.13986

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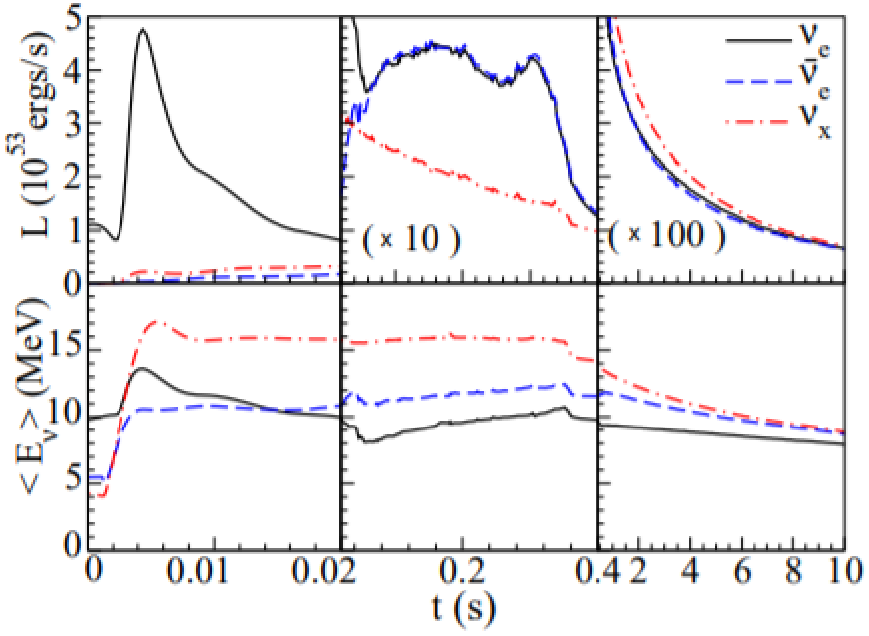
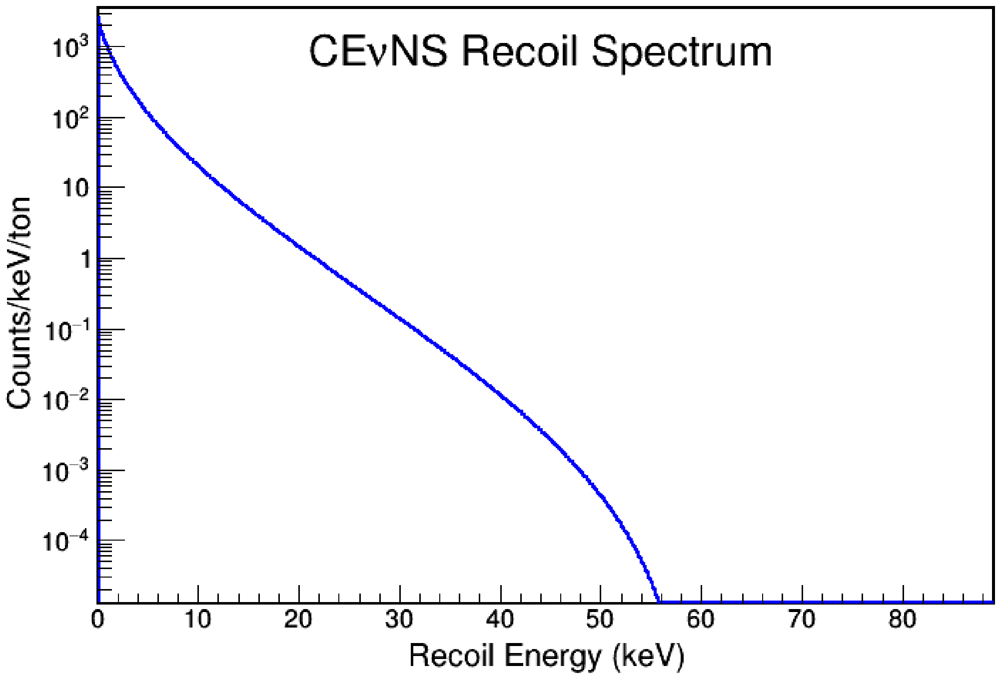
Supernova neutrinos and Xenon NR spectrum due to CEνNS spectrum

- In this work, we consider the SN due to the collapse of a 18 $M_\odot$ progenitor star at 1 kpc distance from the Earth.
- 1 tonne liquid Xenon detector (consider ^{132}Xe for illustration).
- The temporal profiles of the average energy and luminosity of different neutrino species are taken from T. Fischer, S. C. Whitehouse, *et. al.*, Astron. Astrophys. 517, A80 (2010).

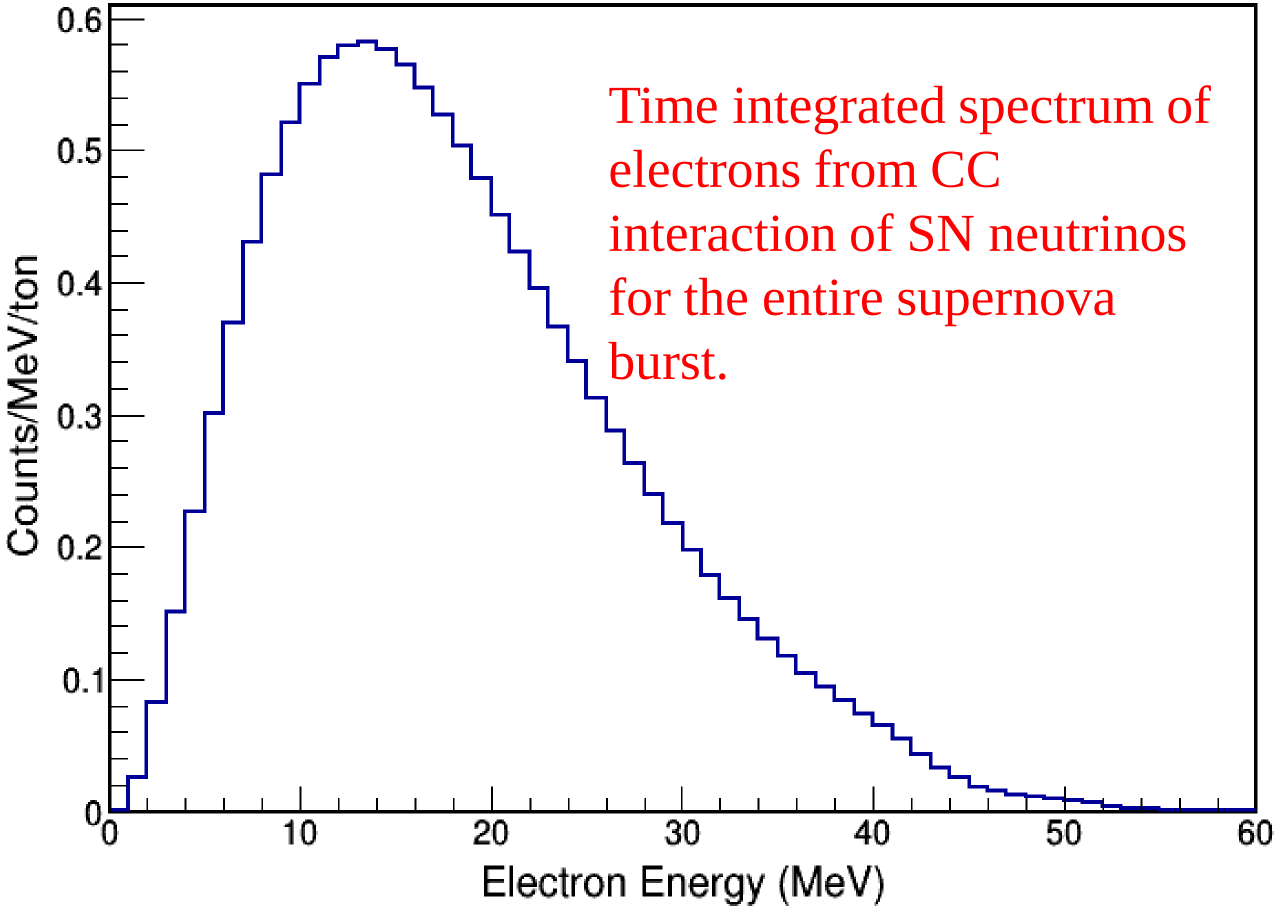
S. Chakroborty, P. Bhattacharjee and K. Kar Phys. Rev. D **89**, 013011 (2014)





Charge Current Interaction

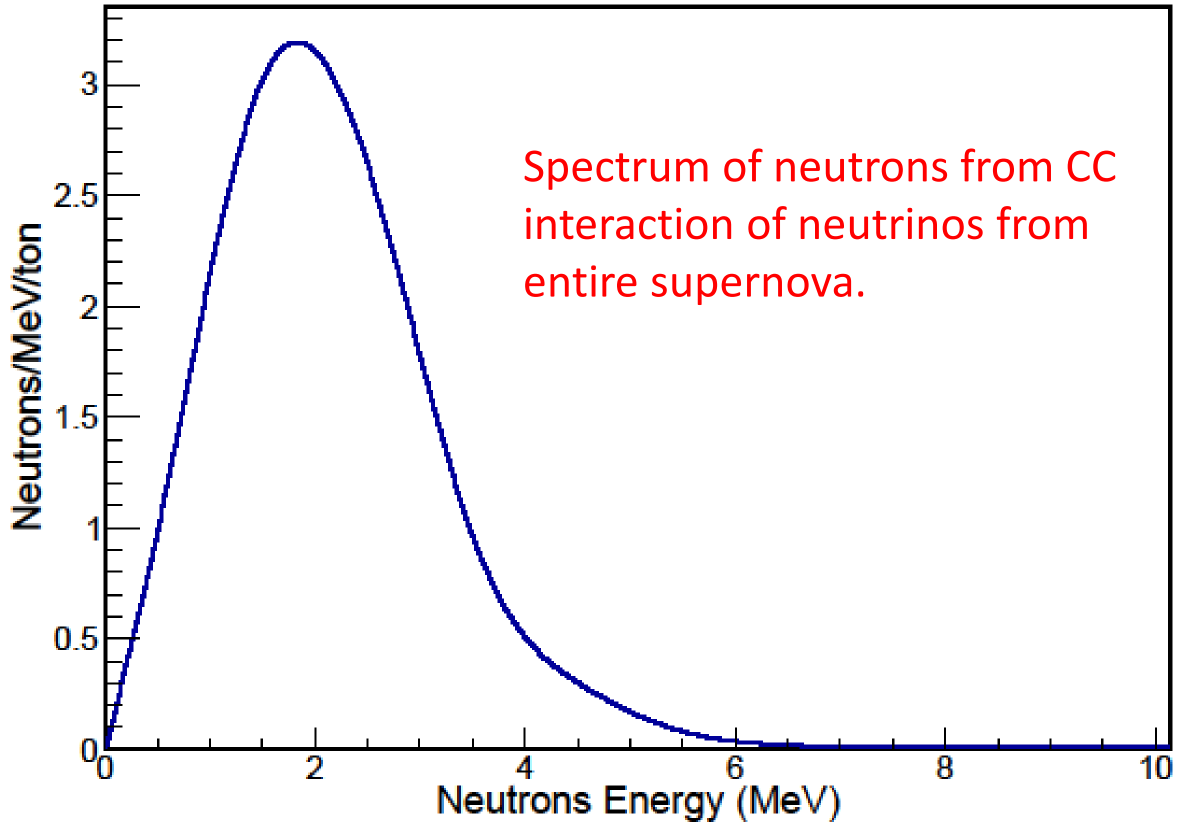
$$\nu_e + {}^{132}_{54}\mathrm{Xe} \rightarrow e^- + {}^{132}_{55}\mathrm{Cs}^* \quad {}^{132}\mathrm{Cs}^* \rightarrow {}^{132-X}\mathrm{Cs} + Xn$$ ⟶ Neutrino-induced neutrons (νIn)

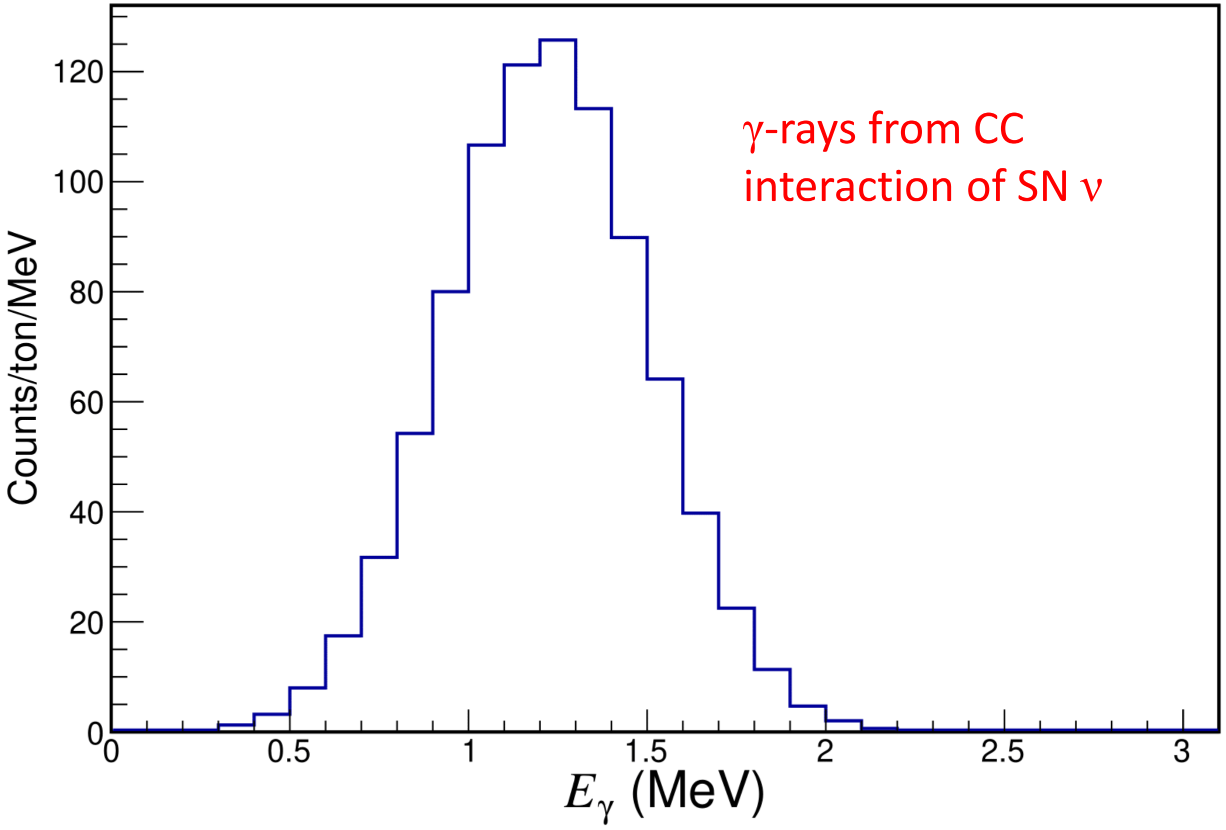


Time integrated spectrum of electrons from CC interaction of SN neutrinos for the entire supernova burst.

Contd.

Time integrated spectra of the neutrons and gamma-rays for the entire supernova burst.





GEANT4 simulation

- We take a 1 ton liquid Xenon tank with the diameter and height being ~75.4 cm. Density ~ 2.953 g/cm^3

- Simulation of interaction of neutrons, electrons and gamma rays following their energy spectra.

  - Neutrons can undergo multiple elastic scatterings and in-elastic scattering.

  - Electrons and gamma rays would deposit all of their energies through various processes within a very small area around their production vertices.

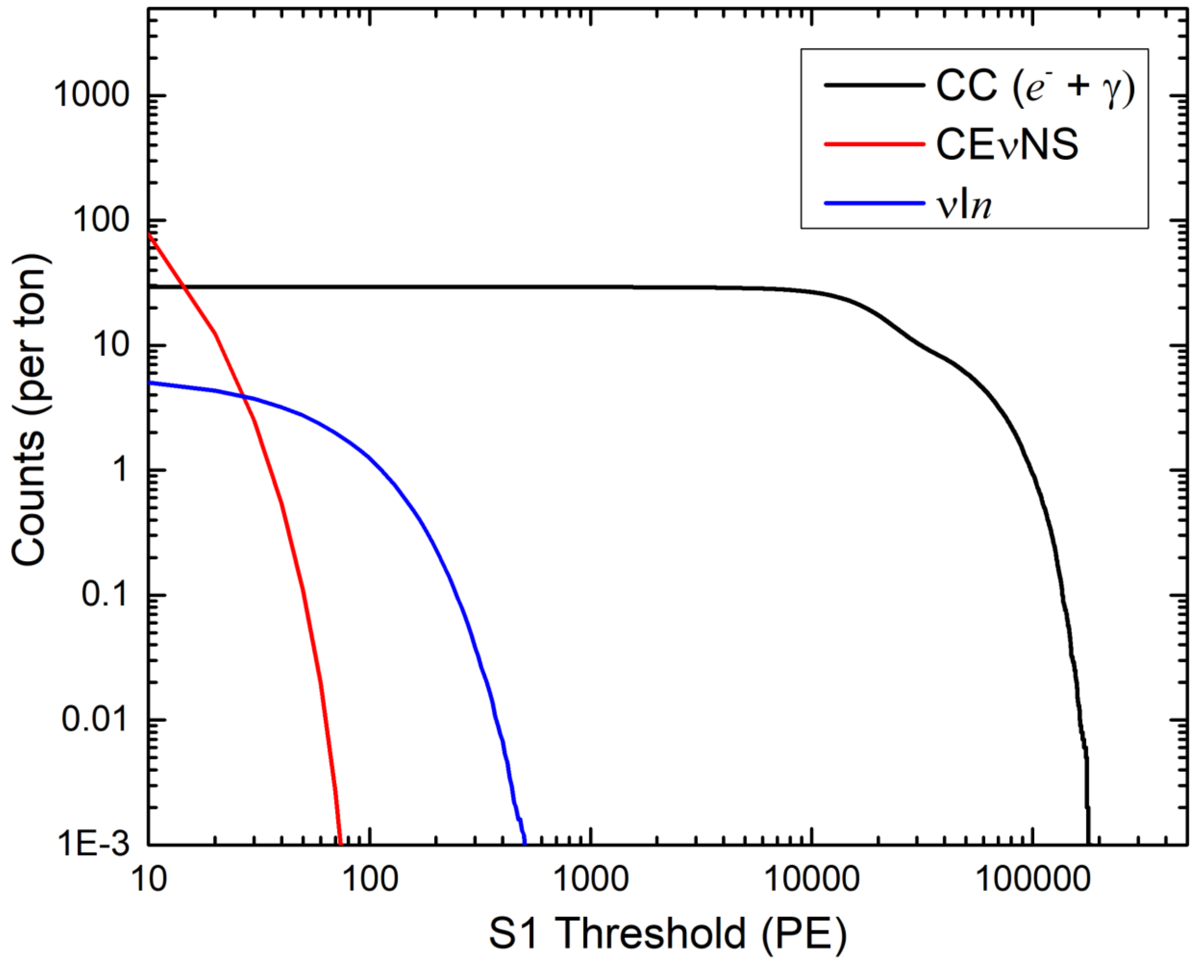
S1and S2 signal generation

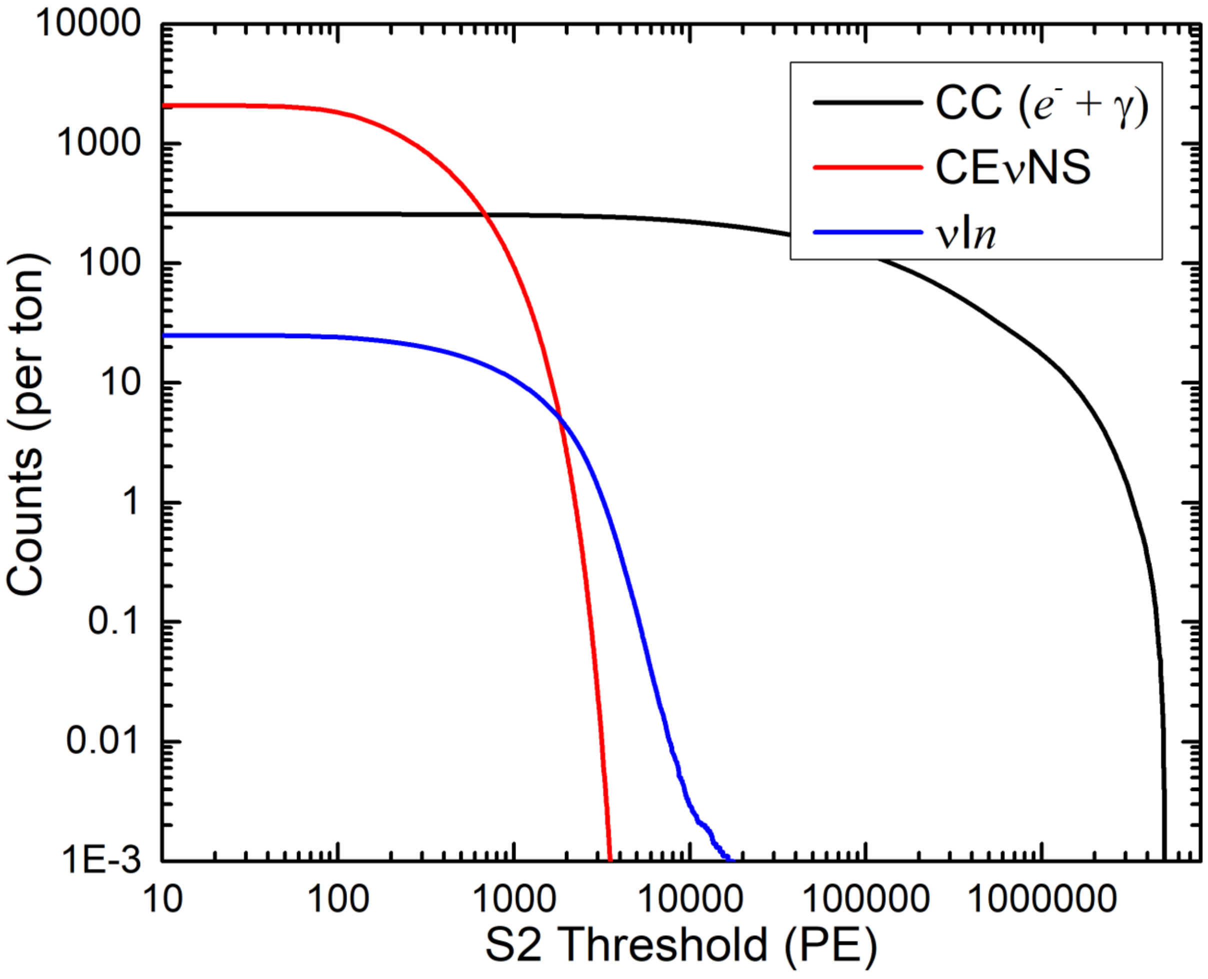
- S1 and S2 signals in this work have been computed using MC simulations based on the model described in E. Aprile, *et. al.*, (XENON), J. Cosmol. Astropart. Phys. 04 (2016) 027 and R. F. Lang, C. McCabe, *et. al.*, Phys. Rev. D 94, 103009 (2016).

$$\mathrm{S1} = \mathrm{Gauss}(N_{\mathrm{PE}}, 0.4\sqrt{N_{\mathrm{PE}}}) \qquad \mathrm{S2} = \mathrm{Gauss}(20\ \tilde{N}_{\mathrm{el}}, 7\sqrt{\tilde{N}_{\mathrm{el}}})$$

- N_{PE} and $\tilde{N}_{\mathrm{el}}$ are the number of detected photoelectrons and ionization electrons reaching the liquid-gas interface respectively.

Contd.

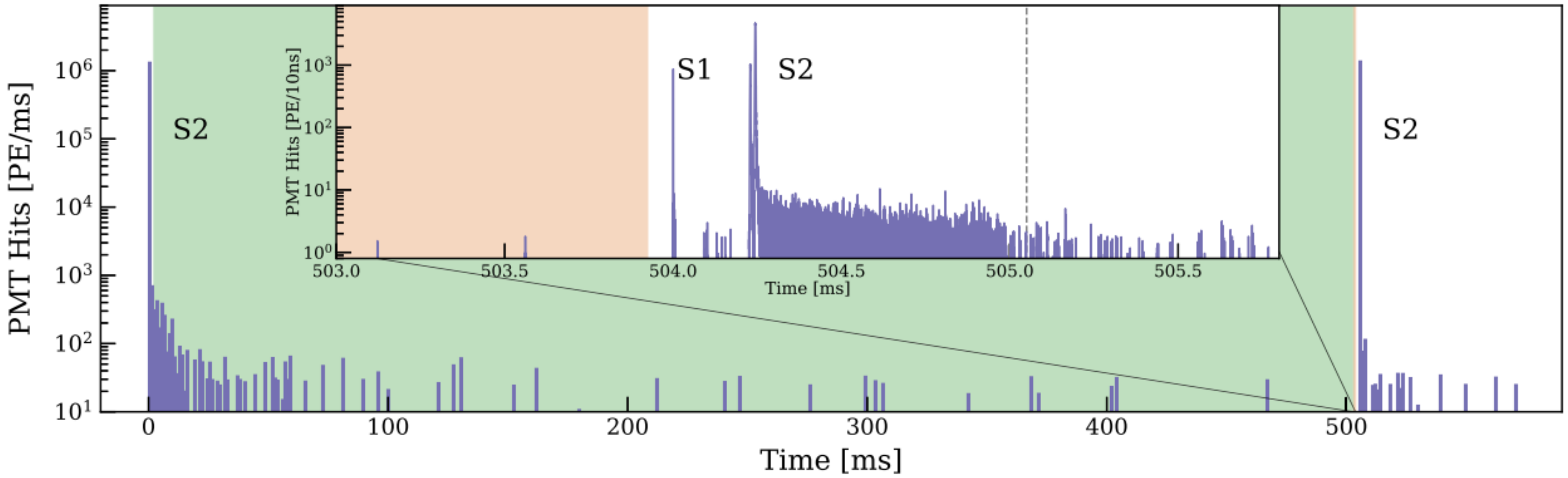




- Integrated S1s and S2s as a function of detector threshold including the contribution from the electrons and gamma-rays.

Summary

- Very big S1s and S2s from electrons and gamma-rays produced in CC interactions.
  - S2s > 10^6PE have non-linearity and saturation problems in the PMTs. (arXiv:2003.03852)
- Large S2s may cause long delayed electron trains which may cause loss in exposure.
  - CEvNS events following the CC interaction events not seen due to dead time?



(arXiv:2112:12116)

More on backgrounds in Amanda's talk

- Lower bound on the supernova distance due to the blinding effect of CC interactions for noble liquid detectors?
- Implications on design of future generation detectors (XLZD for example).

Thank You