The DSNB

Meeting 11/04

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DSNB 101

For a neutrino flavour ν_i:

$$\frac{\mathrm{d}\phi_i}{\mathrm{d}E_i}(E_i) = \int_0^{z_{max}} (1+z) \left| \frac{c\mathrm{d}t}{\mathrm{d}z} \right| \mathrm{d}z \, R_{\mathrm{SN}}(z) \, F_i(E_i(1+z)) \, . \quad (1)$$

$$\boxed{\frac{\mathrm{d}\phi_i}{\mathrm{d}E_i}(E_i) = c \int_0^{z_{max}} \mathrm{d}z \, \frac{R_{\mathrm{SN}}(z) \, F_i(E_i(1+z))}{H(z)} .} \quad (2)$$

Three main ingredients: supernova rate, supernova neutrino spectrum and the Hubble parameter.

Core-collapse supernova (CCSN) rate

$$R_{\rm SN}(z) = R_{\rm SF}(z) \frac{\int_{8M_\odot}^{125M_\odot} \psi(M)\,{\rm d}M}{\int_{0.5M_\odot}^{125M_\odot} \psi(M)\,M{\rm d}M}. \qquad (3)$$

- Star formation rate

$$R_{\rm SF}(z) = \rho_0 \left((1+z)^{\alpha\eta} + \left(\frac{1+z}{B}\right)^{\beta\eta} + \left(\frac{1+z}{C}\right)^{\gamma\eta} \right)^{1/\eta}. \qquad (4)$$

- Initial Mass Function (IMF)

$$\psi(M) \propto (M/M_\odot)^{-2.35}. \qquad (5)$$

Star formation rate: let's agree to disagree...

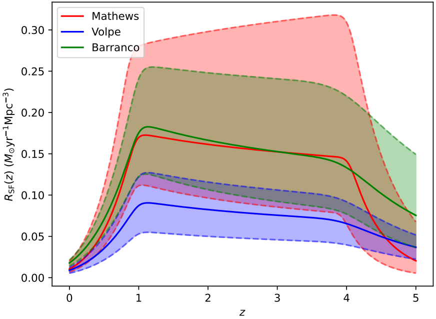


Figure 1: Star formation rate as a function of the redshift according to equation (4), with three sets of parameters coming from three different articles.

Maybe the DSNB can help us resolve this astrophysicists quarrel !

Supernovae neutrino spectrum: we are still in the dark...

- Fermi-Dirac spectrum:

$$F_i^{\mathrm{FD}} = \frac{120}{7\pi^4} \frac{E_i^2}{T^4} \frac{E_i^{\mathrm{tot}}}{\exp E_i/T + 1} \tag{6}$$

- Pinched spectrum

$$F_i(E) = \frac{(\alpha_i + 1)^{\alpha_i + 1}}{\Gamma(\alpha_i + 1)} \frac{E_i^{\mathrm{tot}}}{\overline{E_i}^2} \left(\frac{E}{\overline{E_i}}\right)^{\alpha_i} \exp\left(-\frac{(\alpha_i + 1) E}{\overline{E_i}}\right). \tag{7}$$

A whole zoology of parameters E_{tot}, $\overline{E}$, α... We can either go on a coffee break until the next galactic CCSN, or use the simulations Antoine has got his hands on !

A bit of cosmology

- Λ-CDM

$$H(z) = H_0 \left(\sum_i \Omega_i (1+z)^{3(w_i+1)} + \left(1 - \sum_i \Omega_i \right) \right)^{1/2} \quad (8)$$

- Logotropic

$$H(z) = H_0 \left(\Omega_m (1+z)^3 + (1-\Omega_m)(1 - B \ln(1+z)) \right)^{1/2} \quad (9)$$

- Volometric

$$H(z) = H_0 \left(\left(1 - \frac{\zeta_0}{3-\zeta_1} \right) (1+z)^{(3-\zeta_1)/2} + \frac{\zeta_0}{3-\zeta_1} \right) \quad (10)$$

DSNB results

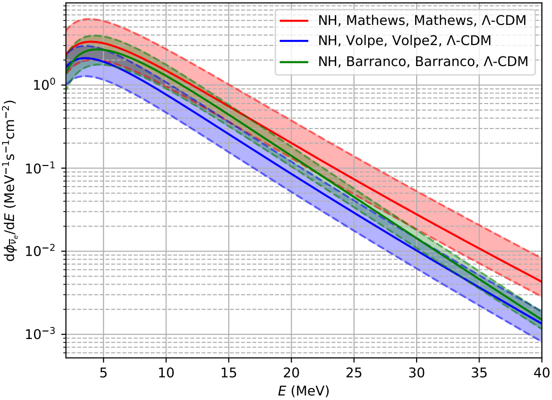
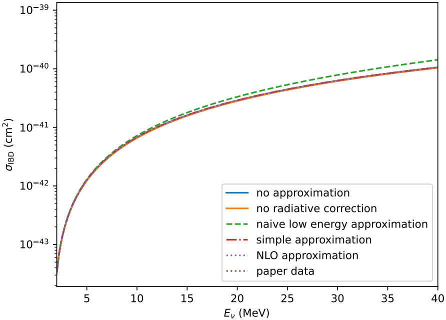


Figure 2: $\overline{\nu}_e$ for the three articles. We use the second mass intervals scenario for Volpe. They all use different parameters for their cosmological model, star formation rate and neutrino spectra.

Detecting the DSNB

Quasi-elastic scattering IBD cross-section from Vissani:

$$N_{\overline{\nu}_e} = \epsilon_{\mathrm{det}} \Delta t_{\mathrm{exp}} N_{\mathrm{target}} \int_{\mathrm{DSNBwindow}} \mathrm{d}E_\nu \frac{\mathrm{d}\phi_{\overline{\nu}_e}(E_\nu)}{\mathrm{d}E_\nu} \sigma_{\mathrm{IBD}}(E_\nu) \,. \tag{11}$$



Detecting the DSNB: the three articles

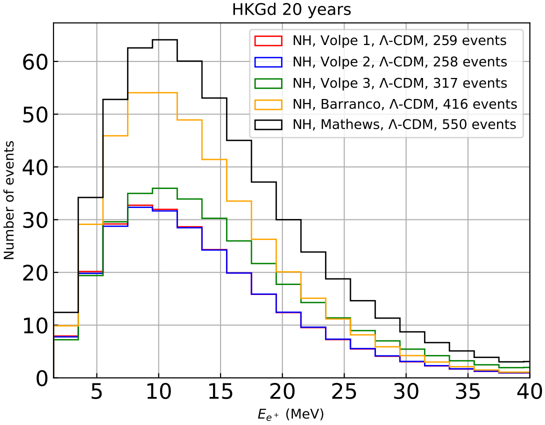
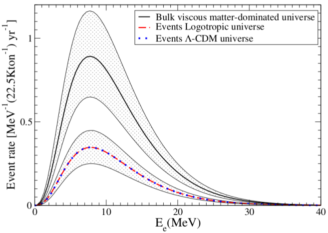


Figure 3: event rate in HKGd (20 years run) for the five different parameters set. We do not display the star formation parameter envelop for better readability.

Detecting the DSNB: non-standard cosmologies



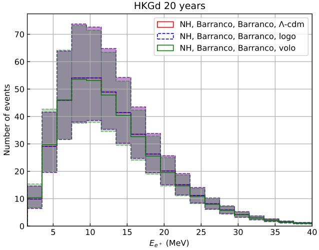


Figure 4: The $\overline{\nu}_e$ DSNB flux and event rate for the different cosmological models used in Barranco.

I don't wanna say we're right and they're wrong but...

Are we even sensitive to the cosmological tension ?

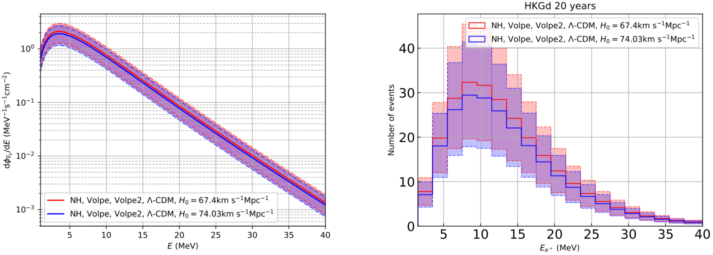


Figure 5: The cosmological tension influence on the DSNB.

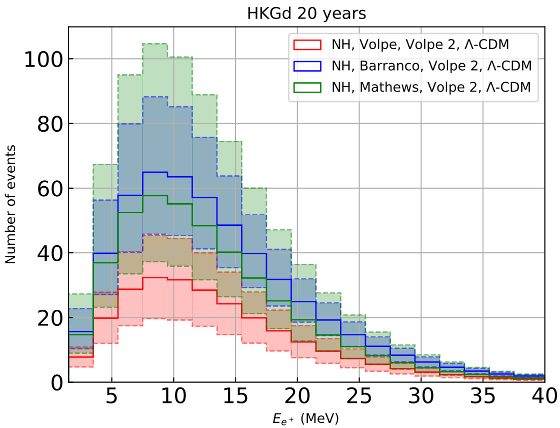


Figure 6: The event rate in HKGd (20 years run), varying the star formation rate parameters, all other parameters fixed to Volpe scenario II.

Detecting the DSNB: emission spectrum

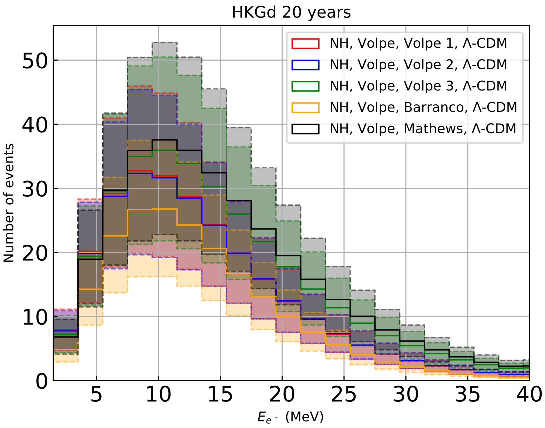


Figure 7: The event rate in HKGd (20 years run), varying the spectral parameters (and associated mass intervals), all other parameters fixed to Volpe.

What's next ?

- Insert non-standard neutrino interactions (non radiative decay...) in the DSNB
- Constrain star formation rate parameters using available SK data
- Is it worth it to investigate non-standard cosmologies further ?

NH vs IH

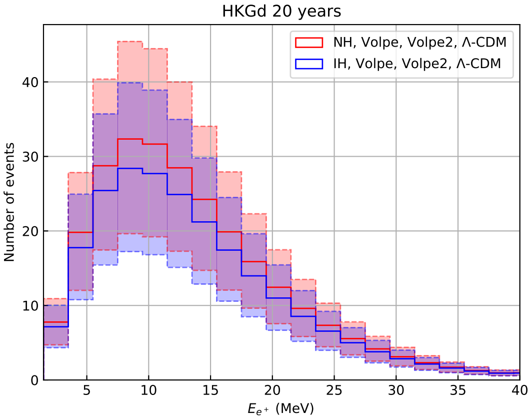


Figure 8: Normal mass hierarchy vs Inverted mass hierarchy for Volpe.

Redshift contribution

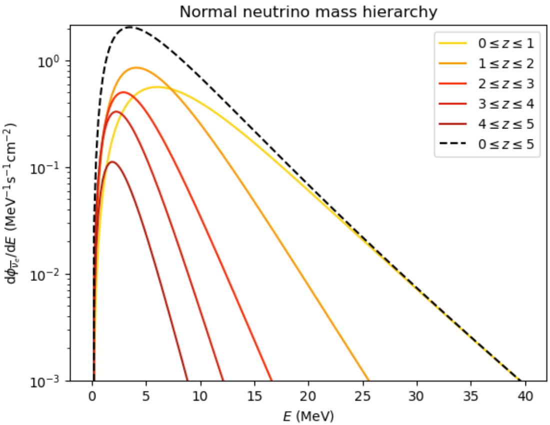


Figure 9: Redshift intervals contributions to the DSNB for Volpe.

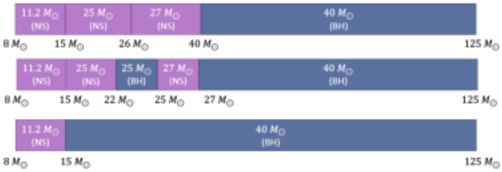


FIG. 2. Scenario I to III (top to bottom) for the BH fraction as well as the progenitor dependence of a supernova that left either a neutron star or a black hole. The parameters (neutrino luminosity, average energies and pinching) of the corresponding fluences are given in Table VI (Appendix A).