More on the BH fraction

$$\Phi_{\nu_\beta}(E) = \frac{c}{H_0}\int_0^{z_{\max}} dz\ \frac{R_{SN}(z, M)}{\sqrt{\Omega_M(1+z)^3 + \Omega_\Lambda}} \times [f_{\mathrm{CC-SN}} F_{\nu_\beta,\mathrm{CC-SN}}(E', M) + f_{\mathrm{BH-SN}} F_{\nu_\beta,\mathrm{BH-SN}}(E', M)]$$

More general expression (I think): $\Phi_{\nu_\beta}(E) = \frac{c}{H_0}\int_0^{z_{\max}} dz\ \frac{R_{SN}(z, M) F_{\nu_\beta}(E', M)}{\sqrt{\Omega_M(1+z)^3 + \Omega_\Lambda}}$

So this implies that we can identify
$f_{\mathrm{CC-SN}} F_{\nu_\beta,\mathrm{CC-SN}}(E', M) + f_{\mathrm{BH-SN}} F_{\nu_\beta,\mathrm{BH-SN}}(E', M)$ with $F_{\nu_\beta}(E', M)$

I don't see how this is…

A couple ways to interpret $F_{\nu_\beta}(E', M)$ under our assumptions that some stars collapse into BHs:

- Method 1: could assume that at each mass M, a star has some likelihood $f_{\rm BH}(M)$ to collapse into a black hole and a likelihood $f_{\rm NS}(M) = 1 - f_{\rm BH}(M)$ of becoming an SN
  - We thus have a mass-dependent black hole fraction
  - We can thus write $F_{\nu_\beta}(E', M) = f_{\rm NS}(M) F^{\rm NS}_{\nu_\beta}(E', M) + f_{\rm BH}(M) F^{\rm BH}_{\nu_\beta}(E', M)$

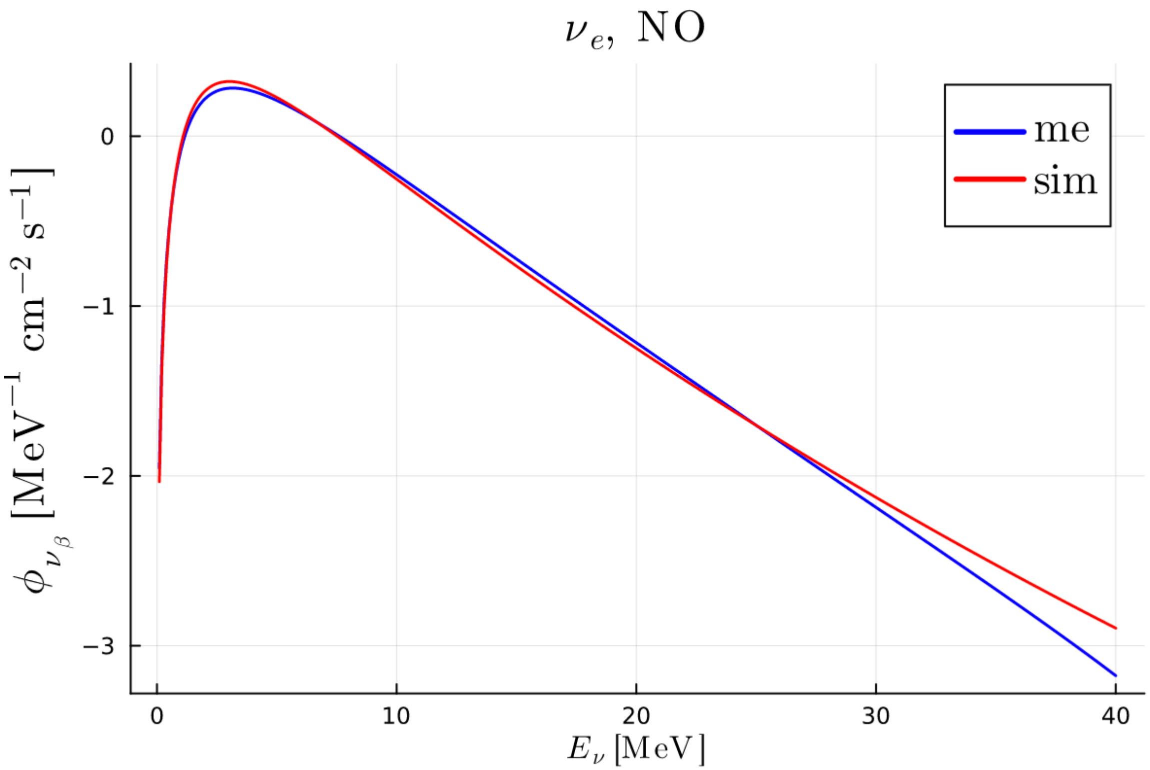
- Method 2: could assume that for certain ranges in our mass space $\Lambda \subseteq [8M_\odot, 125M_\odot]$, **all** stars collapse into black holes
  - This gives us a **total** black hole fraction $f_{\rm BH} = \dfrac{\int_\Lambda \eta(M)\ dM}{\int_{8M_\odot}^{125M_\odot} \eta(M)\ dM}$ and $f_{\rm NS} = 1 - f_{\rm BH}$
  - We'd write $F_{\nu_\beta}(E', M) = F^{\rm NS}_{\nu_\beta}(E', M) + F^{\rm BH}_{\nu_\beta}(E', M)$, with these functions being defined piecewise, i.e. $F^{\rm NS}_{\nu_\beta}|_{M\in\Lambda} = 0,\ F^{\rm BH}_{\nu_\beta}|_{M\notin\Lambda} = 0$, because by assumption no masses in the respective regions collapse into the respective (we could equivalently write this like the first case, with explicit fractions, but these fractions being defined piecewise as either 1 or 0 depending on the mass)

It seems like the expression $f_{\mathrm{CC-SN}} F_{\nu_\beta,\mathrm{CC-SN}}(E', M) + f_{\mathrm{BH-SN}} F_{\nu_\beta,\mathrm{BH-SN}}(E', M)$ is doing neither of these: it's explicitly including the BH and NS fractions, but from the paper it seems like we're defining the fluxes in a piecewise fashion as well: e.g. for the fiducial model,

$$F(E', M) = \begin{cases} F^{11.2M_\odot}(E') & M \in [8,15] \\ F^{27M_\odot}(E') & M \in [15,22] \cup [25,27] \\ F^{\mathrm{BH},40M_\odot}(E') & M \in [22,25] \cup [27,125] \end{cases}$$

This doesn't make sense to me; it feels like we're almost double-counting the BH and NS fractions in a sense, as they're already baked into the piecewise nature of the flux definitions

What gives? Where am I mistaken here?



The blue line is calculated using my method 2 (with the fiducial model), i.e. defining the fluxes piecewise and not explicitly specifying the BH fraction

Doesn't seem to adequately account for the BH contributions at large energies