We thank the reviewer for their suggestions, and as a result have made the following improvements to our discussion:

On point 1:

The units of Y are eV^2, and this has now been fixed on all figures.

On points 2-3:

We have augmented our previous discussion substantially, and added the requested plot:

Constraints on ``secret'' neutrino interactions (compiled in~\cite{PhysRevD.90.065035}) may further bound the range of values for $n$ that are consistent with our fitted parameters. These constraints fall into two broad classes: direct limits on $g\_i$ from particle decay widths \cite{Bilenky:1999dn,Lessa:2007up}, and limits from absorption or down-scattering of neutrinos travelling over astronomical baselines proportionally to $\eta=g^4\_in$ \cite{Kolb:1987qy,PhysRevD.90.065035}. Since the refractive mechanism described here depends on $g^2\_in=\eta/g^2$ both are naturally evaded with a suitably large local over-density and small $g\_i$.

Constraints on secret neutrino interactions from meson decays are derived experimentally in terms of coupling constants to neutrino flavor eigenstates, whereas here we consider mass-diagonal couplings. Using the appropriate mixing parameters and masses it is possible to re-express the limits from \cite{Lessa:2007up} in this space. Fig~\ref{fig:Constraints} shows the 90\% CL upper limit on $g$, the coupling to the heaviest mass state under each ordering assumption, given a massless lightest neutrino.

The absorption strength of propagating neutrinos on the relic neutrino background can be related to the imaginary part of the forward scattering amplitude via the optical theorem. The heaviest mass states experience the largest couplings and are more strongly absorbed, and conversely, a lightest neutrino with an arbitrarily small mass would not absorb at all. For this reason, objects where the source neutrino luminosity is not known to better than a factor $\sim$3, such as supernova 1987A \cite{Kolb:1987qy} or high energy astrophysical accelerators \cite{PhysRevD.90.065035}, cannot be used to derive meaningful limits on this mechanism.

For solar neutrinos, on the other hand, the initial flux is well predicted by the Standard Solar Model (SSM) \cite{Bahcall:2004pz, Bahcall:2004mq}. The $^{8}$B flux in particular has been measured to 3\% precision ($\Phi\_B=5.05^{+0.19}\_{-0.20}$) \cite{Aharmim:2009gd}, and is found to be consistent with predictions of the SSM within uncertainty ($\Phi\_B=5.69\pm0.9$) \cite{Patrignani:2016xqp}. This implies a constraint on the surviving fraction of 0.89$\pm$0.16. $^{8}$B neutrinos exit the sun in mass eigenstate $m\_2$ due to adiabatic MSW conversion, and hence an upper limit can be placed on $g\_2$ that can be re-expressed in terms of $g$ given an assumption about the absolute neutrino mass scale. The 90\% CL limit given a massless lightest neutrino is shown in Fig~\ref{fig:Constraints}.

On point (4):

We do not understand the reviewers request on this point. We note that the scalar is not long-lived, so cannot escape the star to cool it. We have drawn various loop diagrams to try to explore the eeS coupling, but these always appear sub-dominant to similar Standard Model diagrams involving final-state neutrinos that would have a stronger cooling effect. In particular the electron self-energy diagram appears to us to give a contribution smaller by a factor g than the ordinary 1-loop weak self-energy correction that one gets without our Higgs. This is because, by construction, the electron does not couple directly to the new Higgs, only to neutrinos.