7.3 Assume the neutrino has mass m_ν and that is the whole reason it arrives 2 hr late (It is not. There are also steller astrophysical processes involved.).

For the neutrino: $\gamma = \frac{E}{m_\nu c^2}$

$$\Rightarrow v = \sqrt{1 - \frac{m_\nu^2 c^4}{E^2}}\, c \simeq //\text{Taylor}// \left(1 - \frac{m_\nu^2 c^4}{2E^2}\right) c$$

The time difference between the arrival of the ν and the photon is:

$$\Delta t = \frac{L}{v} - \frac{L}{c} \simeq //\text{Taylor}//$$

$$= \frac{L}{c}\left(1 + \frac{m_\nu^2 c^4}{2E^2}\right) - \frac{L}{c} = \frac{L m_\nu^2 c^3}{2E^2}$$

$$\Rightarrow m_\nu = \sqrt{\frac{2E^2 \Delta t}{L c^3}} = \frac{E}{c^2}\sqrt{\frac{2\Delta t c}{L}}$$

$$= 20\,\text{MeV}/c^2 \cdot \sqrt{\frac{2 \times 2 \cdot \cancel{60} \cdot \cancel{60}\,\text{s} \cdot \cancel{c}}{1.68 \times 10^5 \cdot 365 \times 24 \times \cancel{60} \cdot \cancel{60}\,\text{s} \times \cancel{c}}}$$

$$= 20\ \mathrm{MeV}/c^2 \times 5.2\times10^{-5} = 1.04\ \mathrm{keV}/c^2 .$$

Note that this is NOT the strongest bound on the ν masses we have!