Übungsblatt 6

Exercise 1

We would like to estimate how many neutrino events a water Cherenkov detector would see in the case of a supernova (SN) explosion.

1. Consider a SN which liberates $E_{SN} = 3 \times 10^{53}$ erg of energy in form of neutrinos. If the average energy of a neutrino is $\langle E_\nu \rangle = 15$ MeV, what is the total number of neutrinos N_ν produced? Since our detector is sensitive only to electron antineutrinos, calculate $N_{\bar{\nu}_e} = N_\nu/6$ (6 is the total number of neutrinos and antineutrinos, 3+3).

2. Calculate the neutrino fluence

$$F = \frac{N_{\bar{\nu}_e}}{(4\pi d^2)} \quad ,$$

   where d is the distance of the SN to the earth. We consider d = 10 kpc (kpc=kilo-parsec).

3. Consider a 1000 tons water mass: how many protons N_p does it contain? Count only the "free" protons in hydrogen and remember that water = H_2O.

4. You can now calculate the total number of expected interactions which correspond to the number of detected positrons ($\bar{\nu}_e + p \rightarrow n + e^+$)

$$N_{e^+} = F \times \sigma \times N_p \times \epsilon \quad ,$$

   where $\sigma(15 \text{ MeV}) \approx 2 \cdot 10^{-41}$ cm^2 is the $\bar{\nu}_e p$ cross section and ϵ is the efficiency of the detector, which we neglect here for semplicity ($\epsilon = 1$).