## Worksheet 1:

**Introduction:**

In the video "Neutrinos (2016)", created as a mini lecture as part of the annual Lindau Nobel Laureate Meetings, **beta decay** in atomic nuclei plays an important role. What follows will focus on this type of radioactive decay and the physical correlations will be investigated in more detail.

**a)** To begin, watch the first three-and-a-half minutes of the video. You will get a quick overview of the topic dealt with in this lesson.

**The beta decay of tritium:**

Tritium $^{3}_{1}\mathrm{H}$ is the heaviest isotope of hydrogen. It is radioactive and turns into a stable helium isotope $^{3}_{2}\mathrm{He}$ due to $\beta^{-}$ decay. Tritium has a half-life of 12.3 years.

The energy of the emitted beta particles, meaning the electrons, is particularly important regarding the topic of neutrinos.

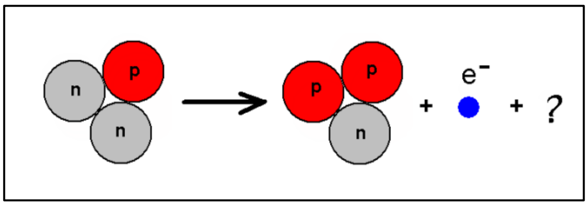


Photo credit: Matthias Borchardt

**What kinds of energy should electrons theoretically have?**

We know from quantum physics that particles that are only provided with limited space can only assume certain energy values. Therefore, the electrons in the shell of an atom hold discrete energies, since they are bound in the Coulomb field of the nucleus, meaning they are in a potential well. The atomic nucleus can also be described with the potential well model because the strong interaction limits the occupied area of the nucleons to an extremely small space. Therefore, if the nucleus changes from a higher energy level to a lower one, the emitted energy (in the case of beta decay, this is the kinetic energy of the electrons) should have a certain fixed value. We can calculate this energy by comparing the mass of the original nucleus with the masses of the final nucleus and the emitted electron.

**b)** Calculate that the electrons emitted during beta decay should have an energy of 18.6 keV. To do this, prepare a mass balance and use the following nuclear masses:

Tritium $^{3}_{1}\mathrm{H}$: $m_H$ = 3.015 500 69 u

Helium $^{3}_{2}\mathrm{He}$ : $m_{He}$ = 3.014 932 14 u

Electron $e^{-}$: $m_e$ = 0.000 548 579 909 u

Atomic mass unit: $1.660\ 539\ 040 \cdot 10^{-27}$

 