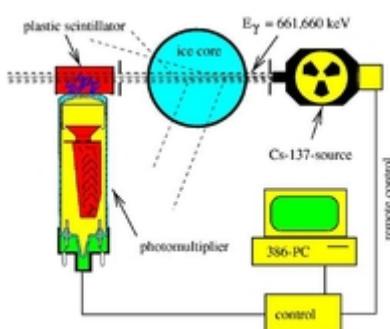
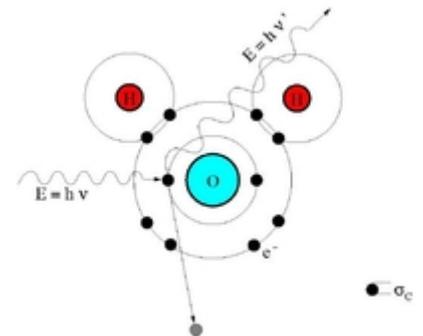


The Gamma Densimeter

Density is by its definition mass per volume. The traditional method is to weigh a known volume and directly calculate the density. This is done with the ice cores directly after drilling to get a rough estimate of the density immediately after drilling. However this over several dm averaged density does not yield the high frequent density variations due to the different density of the snow deposited on the ice sheet and the different further transformation it undergoes [Wilhelms, 1996; Gerland et. al., 1999]. Knowing the volume of an ice core one may determine the mass not only by weighing, but as well be measuring a material property being proportional to the mass. Such a property is e.g. the number of electrons per volume as each water molecule contains 10 electrons and has a known weight of approx. 18 g/mol. Photons with an energy of about 662 keV purely interact with the electrons and thus by knowing the scatter properties of each electron one can determine the number of watermolecules and further the density of a material by measuring the attenuation of a gamma beam.

The interaction of a photon with a water molecule. In the given energy range the photon only scatters with electrons and thus a beam with intensity I_0 in air is attenuated to a intensity I_d after scattering through ice of a thickness d . The attenuation of the beam is according to Beer's Law: $I_d = I_0 \cdot \exp(-a \cdot r \cdot d)$. Where the mass absorption coefficient a is a constant collecting the properties of the material and r is the density. The natural logarithm yields the formula for the density according to the measured parameters: $r = -1/(a \cdot d) \cdot \ln(I_d / I_0)$.



The principle of the gamma densimeter. The ¹³⁷Cs-source emits monochromatic gamma radiation with an energy of about 662 keV. The emitted beam is collimated to a diameter of about 2 mm and radiates through the ice core. The electrons in the volume scatter the photons in the used energy range. The weakened beam is collimated again and its intensity is measured with the scintillation detector consisting of the plastic scintillator, which generates light flashes proportional to the gamma beam intensity and energy, and a photomultiplier tube converting the light intensity into a measurable voltage signal [Leo, 1994] being recorded with a PC.

The gamma densimeter on the GRIP-ice core analyses bench. The core rests in a trough on a rail system mounted on the bench. The trough is moved with a tooth belt and thus positioned in about 1 to 10 mm increments into the scanners. The metal container with the handle and the radioactive sign to the right is a 3 Cu (111 GBq) ¹³⁷Cs-Source. The metal block to the right hosts the plastic scintillator and the photomultiplier tube. The arc above the core in the middle is a lead radiation protection shielding complemented by a lead sheet under the rail. The scintillation detector is thus not operated in counting, but in current mode [Fortescue et. al., 1994].

