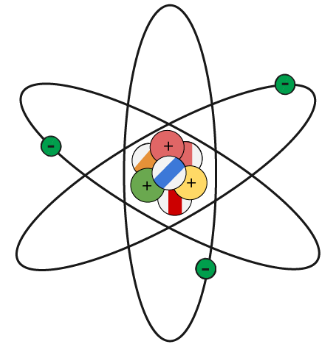
Playing atomic billiards

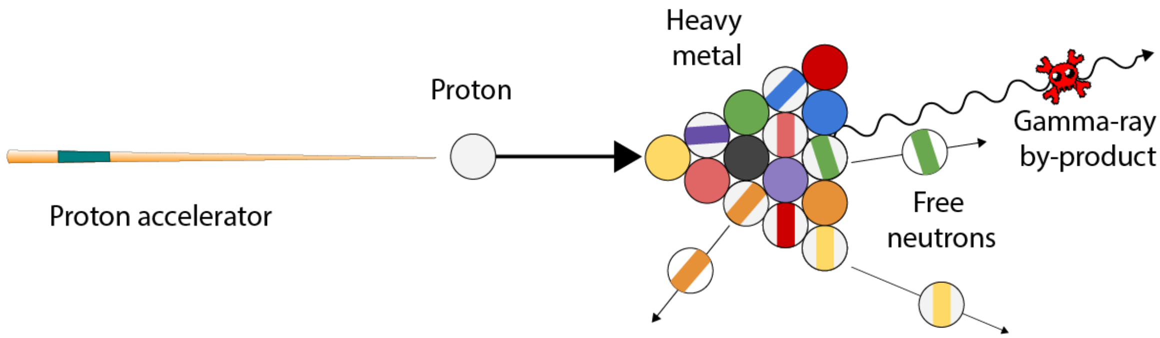


An atom with neutrons and protons at the nucleus and orbiting electrons.

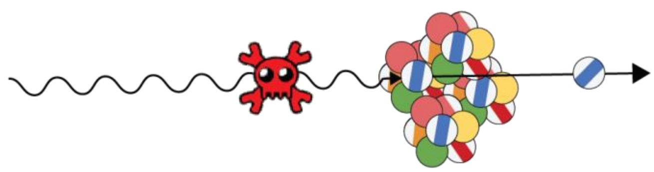
Neutrons are very small particles with no charge that you normally find in the nucleuses of atoms. Thanks to their lack of charge neutrons have very attractive properties when used to examine other materials. In this thesis a problem facing modern neutron sources, called spallation sources, is investigated.

When neutrons are separated from the protons and electrons in an atom, they are called free neutrons. Thanks to the neutrality of neutrons the free neutrons are good at penetrating materials. The free neutrons can be aimed at samples like proteins, solar cells, powders, liquids and other materials and give information about the samples all from the atomic scale through the nano-region up to centimeter sizes.

Free neutrons are not ``created'' but are freed from nucleuses using different methods, such as nuclear reactors, radioactive sources or through a process called ``spallation''. This project has focused on one of the problems that occurs in the spallation process called fast photoneutrons. Spallation is similar to billiards, where a white ball knocks colored balls out of triangle of colored balls. In spallation, instead of a white ball a proton is hitting atoms (usually a heavy metal), knocking out neutrons, rather than colored balls.



This analogy skipped one phenomenon which is bothering spallation sources in operation today. There are not only free neutrons coming out after the collision of the incoming protons, high-energy photons called gamma-rays are also created. These gamma-rays are unwanted, as when they hit other materials around the spallation source the gamma-rays can knock out more neutrons from other atoms that interfere with the experiments.



The gamma-rays can interact with materials around the spallation souce, leading to the production of fast photoneutrons.

At the MAX-laboratory, experiments were performed where photons were created to imitate the unwanted gamma-rays coming from a spallation source. The imitation gamma-rays were shoot at samples of materials typically used around a spallation source. Neutron detectors were used to collect data about what came out.

Using radioactive sources with known energy spectra, the neutron detectors have been calibrated, a necessary step in the analysing of the data from the experiments. Together with computer simulations of the neutron detectors response, this thesis adds to the understanding of the data that was collected. This thesis provides valuable guidelines to the work that continues, to minimize the effects of the unwanted gamma-rays at the spallation source.