**Time Correlation between Electrons and X-rays in TEM with Nanoseconds Resolution**

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Electron energy loss spectroscopy (EELS) is a method which measures the energy distribution of the inelastically scattered electrons. The energy distribution is measured via the use of magnetic prism with a pixelated detector at the end where the position indicates the energy loss of the electron. This energy loss enables information on the local energy levels available in the specimen. One important application of the technique is measuring the elemental abundances present in the specimen which is accessed via the core-loss edges that have a very distinct onset energy. Another method in TEM is energy dispersive spectroscopy (EDX) which measures the energy distribution of the emitted fluorescent x-rays where the x-ray energies are unique for the different elements. This fluorescent x-ray is a secondary process which occurs when an atom is in an excited state due to the energy transfer of the incoming electron with the atom. Hence, for every emitted x-ray there is one electron which has interacted with the atom leaving behind a core-hole.

Since both methods rely on the same type of interaction, these two particles (electrons and photons) should also have a correlation in time. To measure this correlation, a setup was developed where a Timepix3 detector was used to detect the incoming electrons with a time resolution of 1.5 ns. The time of arrival of the x-rays was extracted via the use of a digital pulse processor [1]. Here we show the implementation and the current time resolution of the setup which is currently ± 300 ns. This is sufficient to detect the correlation between the electrons and x-rays (see Fig. 1) [2].

In this work we show how the time correlation between the two particles enables new types of information. For instance, by only selecting electrons which are correlated in time with the x-rays, it is possible to remove the background signal from the core-loss edge without any prior knowledge on its shape. Moreover, it will be shown that the coincidence method can in principle be used to detect trace elements in materials and the effect of incoming count rate will be investigated with respect to signal-to-noise.
Figure 1. Histogram showing the number of coincidence events with a certain time difference. A peak is observed indicating a time correlation between the electrons and x-rays.


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