P3: Towards ghost imaging by correlation measurements of electron-photon pairs

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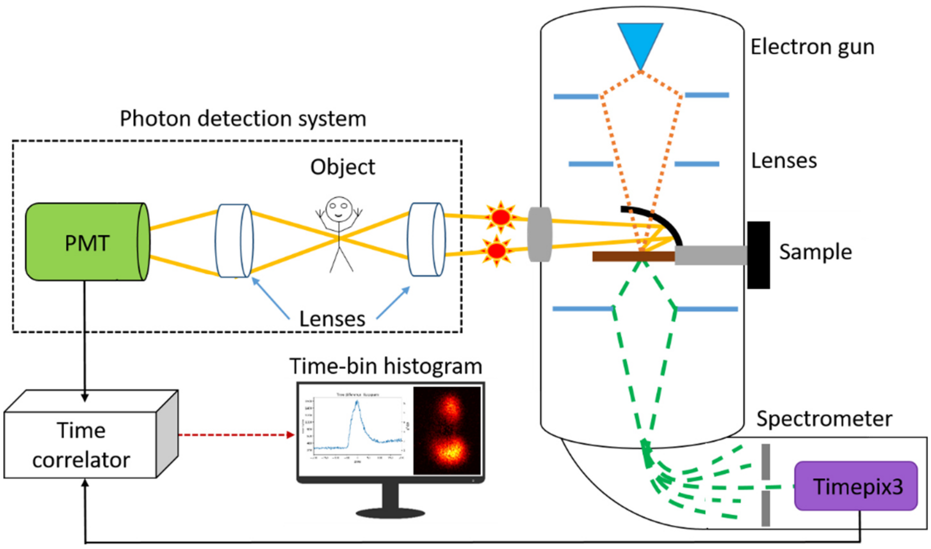
In recent years, fast electron microscopy has garnered increased interest within the scientific community. Particularly, temporal correlation measurements have proven to dramatically enhance the useful signal by suppressing background noise [1, 2]. Here, we introduce a new method of imaging at the intersection of quantum optics and electron microscopy. Ghost imaging, also known as coincidence imaging, of an object is a method classical and quantum physics that involves constructing an image by gathering information from past correlation measurements [3]. To produce correlated electron-photon pairs we use a transmission electron microscope (TEM) working at an acceleration voltage of 200 keV to illuminate a thin monocrystalline silicon membrane of 100 nm thickness. Primary electrons scatter inelastically inside the membrane and undergo a small momentum deflection, simultaneously emitting coherent photon emission through a process known as cathodoluminescence [4]. As a result, the emitted photons are correlated in momentum and energy with the transmitted electrons. A parabolic mirror collects emitted photons and directs them through a window to the object placed in the optical detection system. After the photon interacts with the object, it is collected by a bucket detector incapable of directly recording an image, see Figure 1. By energy-filtering the transmitted electrons we detect only those electrons which were involved in the emission of corresponding photons with the same energy. Coincident measurements are conducted using a time-resolved pixelated direct electron detector (Advascope, Timepix3) and a time correlator (Swabian Instruments, Time Tagger Ultra). Interestingly, despite electrons never directly interacting with the object, we are able to perform ghost imaging of the object through correlated electron-photon pairs. Future plans involve enhancing the spatial resolution of the optical setup, enabling the imaging of finer structures.



[1] Feist et al, Science 377, 6607 (2022). [2] Varkentina et al, Science Advances 8.40 (2022). [3] D'Angelo et al, Physical review letters 92.23 (2004). [4] Scheucher et al, Ultramicroscopy 241 (2022).