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You can't measure what you can't see – detectors for microscopies

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For centuries, the human eye has been the imaging detector of choice thanks to its high sensitivity, wide dynamic range, and direct connection to a built-in data recording and analysis system. The eye, however, is limited to visible light, which excludes microscopies with electrons and X-rays, and the built-in recording system stores archival information at very low rates. The former limitation has been overcome by "indirect" detectors, which convert probe particles to visible light, and the latter by a variety of recording techniques, from photographic film to semiconductor-based imagers. Semiconductor imagers have been used for decades as "direct" detectors in particle physics, and almost as long for hard X-rays. For soft X-ray microscopy, the challenge has been the small signal levels – plus getting the X-rays into the detector itself, given how quickly they are absorbed in inert layers. For electron microscopy, the challenge has been reconciling detector spatial resolution and pixel count with the large multiple scattering of electrons with energies used for microscopy. Further, a high recording rate ("movies" rather than "snapshots") enables time-resolved studies, time-dependent corrections, shot-by-shot experiments and scanning techniques – at the expense of creating large data volumes. This talk will discuss solutions to these challenges, as well as an outlook towards future developments.