Fast high-energy radiography at 1 kHz for crash testing

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In medical applications, monitoring surgical procedures in real-time radiography is a well-established standard. In industrial X-ray inspection, real time radiography is used for manual inspection task in order to adjust the X-ray geometry for the best inspection position or to add a kind of depth information for the operator by moving or rotating the object. Both applications have in common their optimization for the human eye at a framerate of 25 to 30 Hz. At the Fraunhofer Institute for high speed dynamics, X-ray flash radiography is employed for imaging analysis of transient processes on the scale of km/s with image windows well below 1 µsec. The limitation of this technology is the low number of X-ray images for every experiment, usually given by the number of single X-ray flash sources. Driven by our research project in car safety called "X-Ray Car Crash", we invested into the next step in technology: A linear accelerator providing a constant stream of X-ray pulses. With a typical length of the X-ray puls of 4 µsec, exposure time is short enough to allow radiography up to phenomena in the range of several 10 m/sec. Via synchronizing the high-speed camera in the X-ray detector to single pulses of the linear accelerator, a framerate of 1 kHz can be reached. Therefore, the X-ray system matches the acquisition frequency of optical camera systems used in automotive crash testing. In this presentation, we will show an example of a mechanical deformation typical for crash test application. Another application example is a fast rotating turbocharger. By measuring the frequencies and phase shift of both turbocharger and linac, the X-ray images will sorted in respect to the rotation angle and add up to a slow motion movie of the turbocharger. For both applications, an especially prepared detector is synchronized to the application in order to optimize image quality. We will monitor the image quality with IQI and discuss the results for the test cases. In the outlook, we will discuss the use of the fast high-energy radiography for very fast computed tomography. While High-Speed Tomography has already been successfully demonstrated with frequencies of up to 200 3D-Reconstructions per second, this approach was limited to small samples on the scale of mm and only possible with a synchrotron as X-ray source.