HIGH RESOLUTION, HIGH ENERGY AND HIGH SPEED

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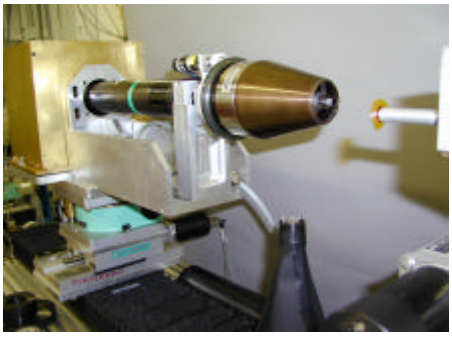
Third-generation synchrotron sources offer possibilities for x-ray imaging with a micrometer resolution due to the coherence and brilliance of the source. The spatial resolution of a micrometer with high-energy x-rays was achieved at the ESRF by combining a microscope objective and an eyepiece in order to magnify the x-ray image onto a FReLoN ("Fast Readout Low Noise") CCD camera. A radiation resistance of the scintillator, optics and CCD camera is necessary.

The development of a specific objective by the Special Detector Group[1] and a kinetic pipeline-mode readout CCD chip has been implemented for the new fast tomography detector.
The optic design uses the Cassegrain mirror system. It is a combination of two mirrors. Incoming x-rays enter through a thin scintillator, some of the x-rays are stopped in the scintillator which then emits light and the rest by a beam stop placed between mirrors and the scintillator. The light strikes the simple "concave" primary mirror and is reflected back up the tube. The light is then intercepted by a small "convex" secondary mirror which reflects the light out of an opening in the rear of the instrument, where the image is formed at the eyepiece. This design gives higher durability and resistance damage compared to a refracting objective at high energy.
The FReLoN camera has been developed by the Analog Transient Electronics[2] group. The camera uses an ATMEL chip, cooled to -20?C to reduce the dark current, with 2kx2k pixel numbers and 14?m pixel size running in full frame transfer mode. This chip gives exceptional advantages as regards readout speed using different modes made possible by their four outputs. In kinetic mode, a region of interest beside the readout register is defined by hardware. This localization, plus the high readout speed at four parallel outputs provides a high frame rate. Despite the high readout speed at 20 Mpixels / s, the Dynamic Range is a true 14 bit and the Integral Non Uniformity is less than 0.2%.
Further developments:
Thin-film scintillators have found applications in X-ray imaging with the micrometer resolution. For the coming year, more efforts will be concentrated on the absorption efficiency, light yield and decay time of scintillators to reduce the exposure time.
For the FreLoNs under development, a new readout technique using a memory area on the chip and simultaneous readout-exposure (frame transfer mode) added to a faster readout speed (40 Mpixels / s) and digital signal processing will provide 16 images (1k x 2k pixels) and 16 bit resolution.



Characteristics
Magnification: 10
Input field of view: 3 x 3 mm^2
Point spread function: 4?m at 65keV
Real dynamic range: 14bits
Readout noise: 1 ADU
Number of images / dataset: 751
Full data set acquisition time: 65s (12fps with 40ms exposure and 128x2048 pixels)

Figure: The 2D detector for fast high-energy x-ray microtomography and its characteristics.