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Development of the HEXITEC 2 x 6 Detector System for NXCT

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Introduction

HEXITEC is a pixelated spectroscopic imaging system developed by the Science and Technology Facilities Council (STFC) for high energy X-ray and gamma-ray applications [1]. A single HEXITEC ASIC [2] comprises an array of 80×80 pixels on a 250 µm pixel pitch and is typically bonded up to CdZnTe, CdTe or other High-Z sensor material with data acquired using the HEXITEC GigE system. However, there is an increasing demand for large area high energy detectors. As a result we have employed the use of tiled arrays. We present the development of the HEXITEC 2×6, Figure 1a, for the National Research Facility in X-ray CT (NXCT) [3], for use in their Colour X-ray System based at the Henry Moseley X-ray Imaging Facility in Manchester..

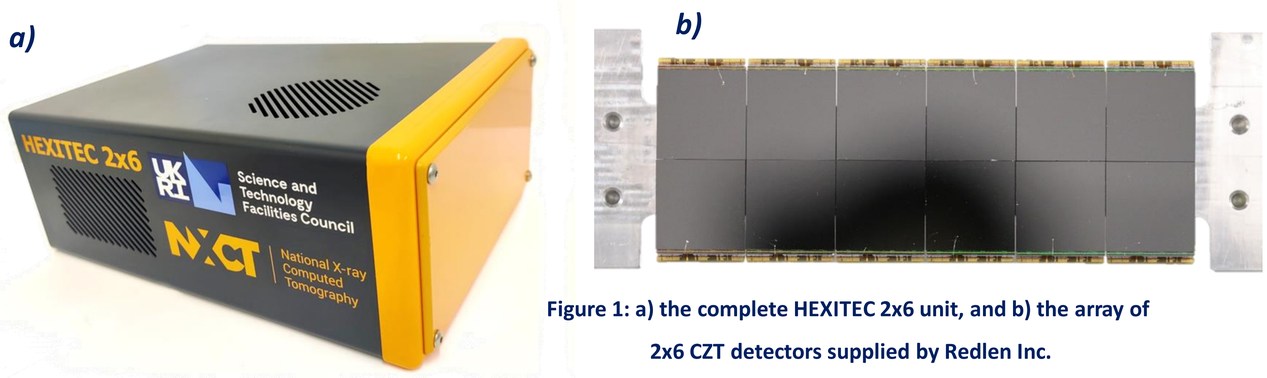

Figure 1: a) the complete HEXITEC 2x6 unit, and b) the array of 2x6 CZT detectors supplied by Redlen Inc.

HEXITEC 2x6 Detector System

The HEXITEC 2×6 is made of twelve 2 mm thick High Flux CdZnTe sensors supplied by Redlen Technologies Inc. mounted in a 2×6 array, see Figure 1b. The complete system is a compact unit, measuring 1750×2400×950 mm allowing it to be used flexibly for a large range of experimental setups in the dark or bright field. The HEXITEC 2×6 is operated from a web interfaced GUI designed using the OdinControl and OdinData acquisition framework [4]. A summary of the detector properties is included in Table 1.

Detector Thickness (mm)	2
Number Pixels	76.8k (160 x 480)
Active Area (cm²)	48
Pixel Pitch (µm)	250
Bias Voltage (V)	-750
Frame Rate (kHz)	9
FWHM @ 60 keV (keV)	<1
Inter-sensor Spacing (µm)	150

Table 1: Summary of HEXITEC 2x6 parameters and system settings

DAQ and Read-out

Each HEXITEC pixel contains a charge sensitive preamplifier followed by a shaping circuit and peak track-and-hold circuit recording the maximum incoming voltage signal following an irradiation event. The analogue voltage signal is stored by the peak track-and-hold until readout by a rolling shutter. Readout is performed row by row in four parallel blocks of 20 pixels and output to the front-end VSR (very small readout) board. Each VSR connects two detector ASICs, with a total 6 VSR boards used in the complete system. The board, designed and manufactured by aSpect Systems, digitises the ASIC output into 16-bit values. The VSRs are connected to an Interface Board receiving data via LVDS whilst additionally supplying each VSR with the necessary 12 V and HV bias. At the backend of the system an FPGA board converts incoming data streams into a single 160 × 480 pixel frame which is communicated with the PC via a 4 x 10G FMC module

Mechanics

The HEXITEC 2x6 measures 1750 mm x 2400 mm and has been assembled on a baseplate with optical mounts. The system is liquid cooled with each individual HEXITEC tile mounted on a large aluminium cooling block. Each detector operates at 1.5 W with the cooling block providing sufficient cooling to maintain all 12 tiles at an operating temperature of 28 °C. The system mechanics is shown in Figure 2.

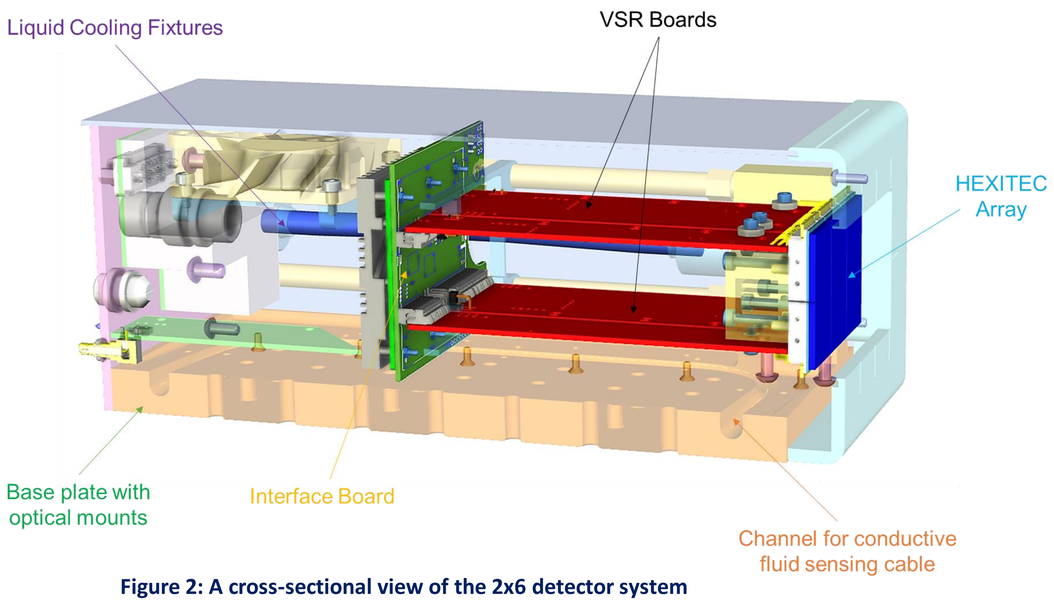

Figure 2: A cross-sectional view of the 2x6 detector system

Tests and Results

Earlier this year, the HEXITEC 2x6 was taken to the I12 JEEP Beamline at the Diamond Light Source to conduct an energy dispersive diffraction imaging experiment on a stressed SiCaTa sample. The results are displayed in Figure 3. A white beam X-ray was used on the sample, as illustrated in Figure 3a, and the characteristic scattered X-rays were captured by the HEXITEC 2x6. Leveraging the 2x6's spectroscopic imaging capabilities, images were produced for different energy bins which can be combined with angular information to determine changes in the sample's d-spacing. An example of a single energy image is shown in Figure 3b. The color axis represents photon counts in the 3300-3350 ADU, which corresponds to an energy range of approximately 2 keV centered around 99 keV. The spectrum obtained for a single pixel under increasing stress levels is illustrated in Figure 3c

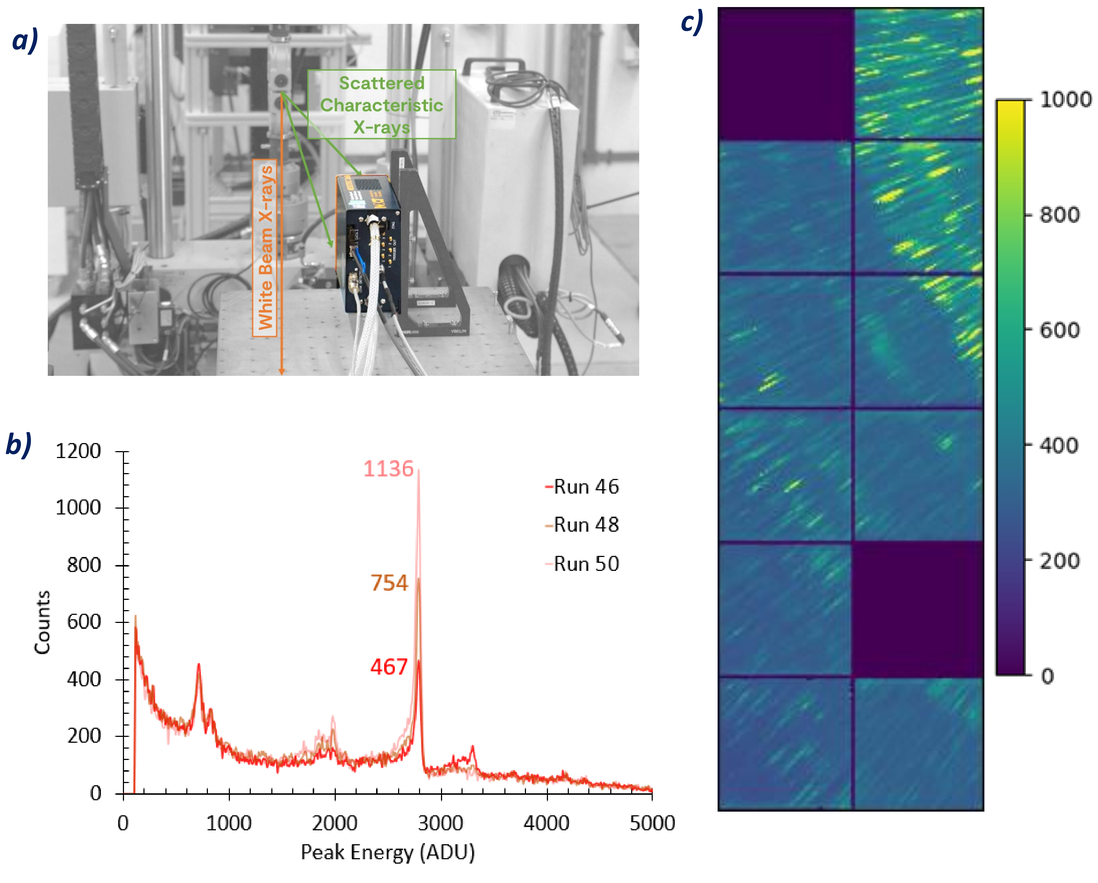

Figure 3: a) photograph of the experimental setup at DLS, b) changes in photopeak counts with increasing sample tension and c), X-ray Diffraction Ring Image taken from DLS.

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[4] G. Yendell, A. Greer, T. Nicholls, U. Pedersen and N. Tartoni, **"Odin—a control and data acquisition framework for Excalibur 1 m and 3 m detectors**," Proc. 16 th Int. Conf. on Accelerator and Large Experimental Control Systems ICALEPCS2017, 2018.

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