HPAD for Time-resolved and Imaging Applications with 56,000 fps Sustainable Frame Rate

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SPECIFICATIONS (SINGLE MODULE)	
Active Area:	77.8 mm x 38.9 mm
Sensor Material:	Compatible with Si, CdTe, CdZnTe, GaAs etc…
Number of Pixels:	1024 x 512 pixels
Size of Pixels:	76 µm x 76 µm
Counter Depth:	14-bit x 2 (long counter mode: 28-bit x 1)
Max Count Rate:	> 2 x 10^6 cps / pixel
Energy Resolution:	< 20 % (at Cu Kα, FWHM)
Max Frame Rate:	56 kfps (ZeroDead 2-bit / pixel), 33 kfps (ZeroDead 4-bit / pixel) 17 kfps (ZeroDead 8-bit / pixel), 8.5 kfps (ZeroDead 14-bit / pixel) 970 kfps (2-bit BurstMode: Duty ratio 1.12%)
Min Single Exposure Time	32 + 4 x [number of modules] ns (capable to sum up every > 576 ns)

Inter-chip Less Monolithic Sensor

XSPA detectors maps the sensor's 76 µm sq pixel array on to the array of 16 UFXC32k ASICs with 75 µm sq pixels using our patented pixel re-mapping technology. The result is that every pixel across the 77.8 mm x 38.9 mm sensor has the same sensitivity and noise characteristics providing for more uniform imaging, Figure 1.

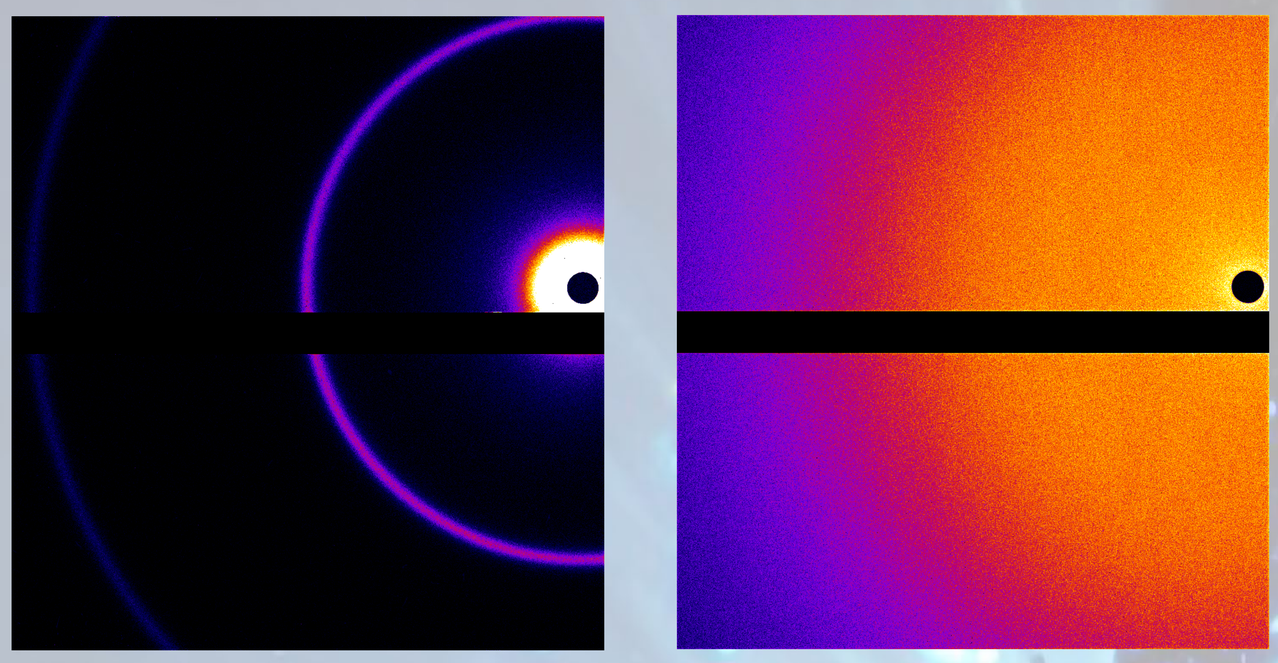

Figure 1. SAXS image of $C_{22}H_{43}AgO_2$ (left) showing low background, high resolution image. And SAX image of glassy carbon (right) showing uniform response of all pixels resulting from the elimination of the inter-chip pixels. 16 readout chips / module are tiled on the back of the monolithic sensor without any gap in the module. Inter-Module gap is tentative (currently about 5.3 mm.) Both images are taken with Cu Ka rotating anode tube with 10 ms exposure time (10,000 images piled up.)

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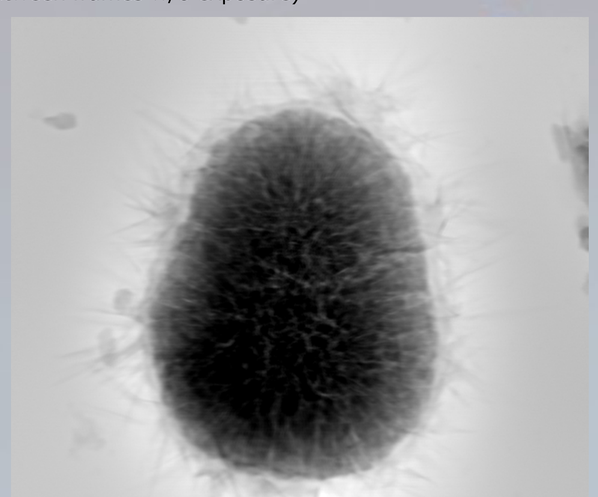
High speed Ptychography (measured up to 7 kfps, works upto 17 kfps with 8-bit/pixel)

High speed ptychography measurement was performed at 2-ID-D at APS. Results shown here are preliminary. Measured from 200 fps to 7 kfps (counter depth: 8-bit / pixel). Frame rate was limited by the position recording frequency, the detector itself can work up to 8.5 kfps with single counter mode and up to 17 kfps with ZeroDeadTime mode.

X-ray Energy: 10 keV, Sample to Detector: 2.285 m, Position recording frequency 20 kHz

Figure 2. Left: Schematic 3D drawing of the Velociprobe at 2-ID-D; Right: reconstructed Ptychography image of 30 nm central spokes with XSPA-1M running at 7 kHz with zone focused X-ray beam (see in-set image.) All images are acquired with 50% duty cycle. Due to the limitation of the position logging system (50% as exposure time and 50% as gap between frames w/o exposure)



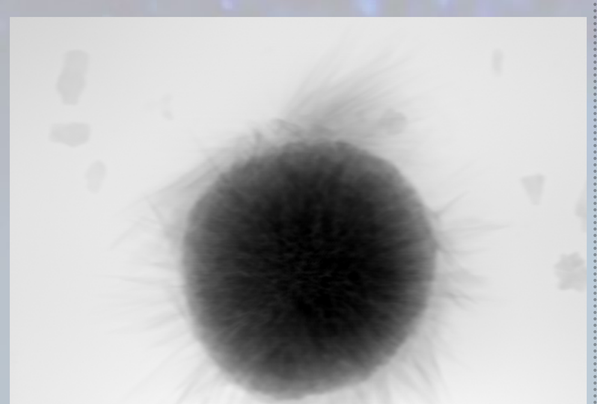


Figure 3. Ptychography reconstructed image of a cycled NCM battery particles. Acquired with 200 fps due to stage operation limitation.

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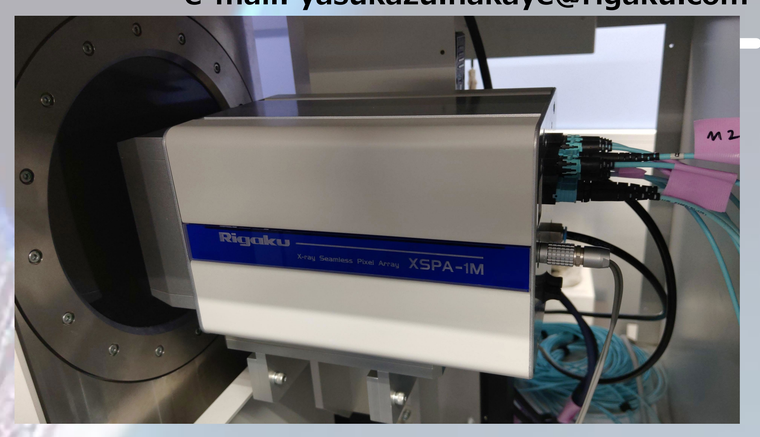
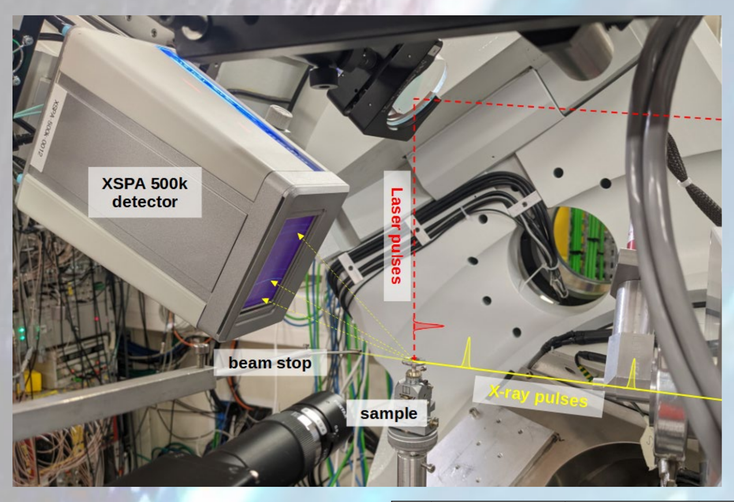


Figure 4. Photographs of the XSPA-1M detector (left: surface shown without window, right: installed in NANOPIX (SAX/WAX Instrument) at Rigaku Application Laboratory.)

Pump-Probe-Probe Experiment



Pump-Probe-Probe operation mode was tested at SOLEIL CRISTAL beamline.

- InSb sample with 7.074 keV beam
- 2500 triggers summed pumped and un-pumped images
- Laser frequency 2 kHz (1 ms between pumped and um-pumped signals)

Visible difference between pumped and un-pumped images indicates successful implementation and operation of the Pump-Probe-Probe acquisition mode.

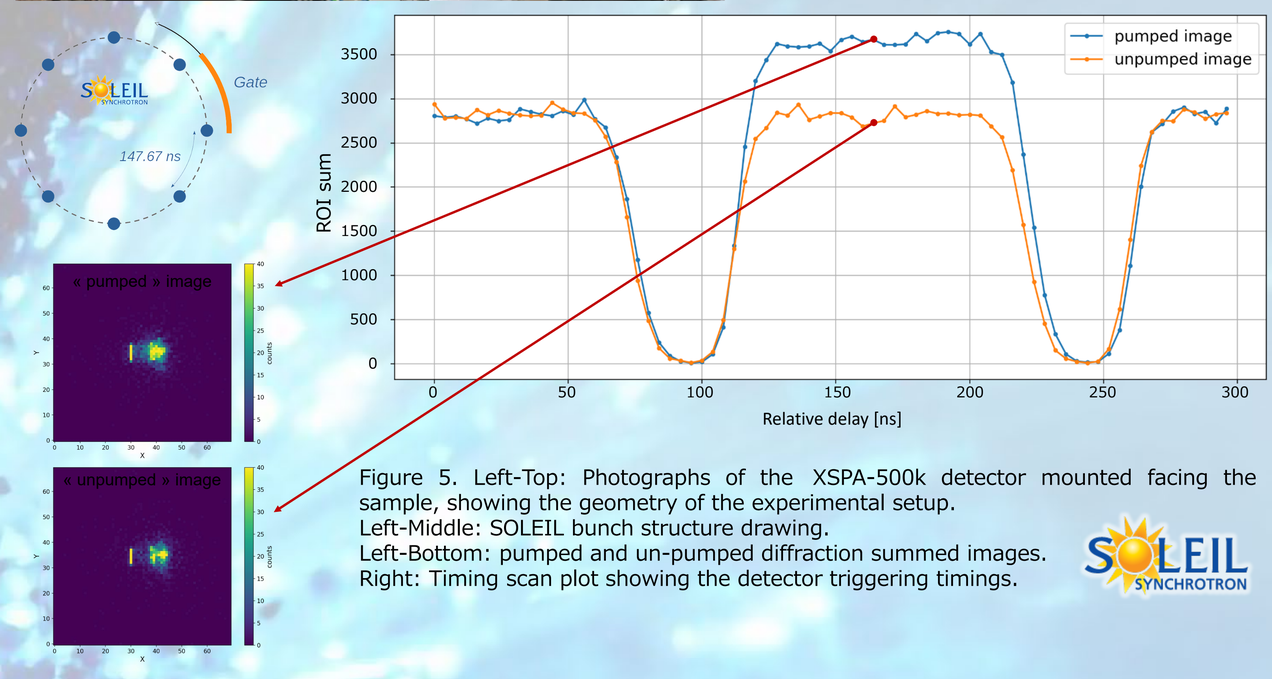


Figure 5. Left-Top: Photographs of the XSPA-500k detector mounted facing the sample, showing the geometry of the experimental setup.
Left-Middle: SOLEIL bunch structure drawing.
Left-Bottom: pumped and un-pumped diffraction summed images.
Right: Timing scan plot showing the detector triggering timings.

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Soft and Tender X-ray Detection (Preliminary results)

There is not very good 2D detector for the Tender X-ray region despite of the rapidly raising interests in the field of research. As we have our detector in vacuum originally for electron detection, we naturally went toward this lower energy region of X-ray detection.

Thanks to our very low noise readout ICs. We were able to successfully observe 1.75 keV X-ray clearly separated from electric noise peak and expecting that the detector can work with X-ray energy down to approximately 500 eV. The beamline we have used had a lower limit at 1.75 and we are expecting further experiment with lower energy X-ray at the different beamline in the near future.

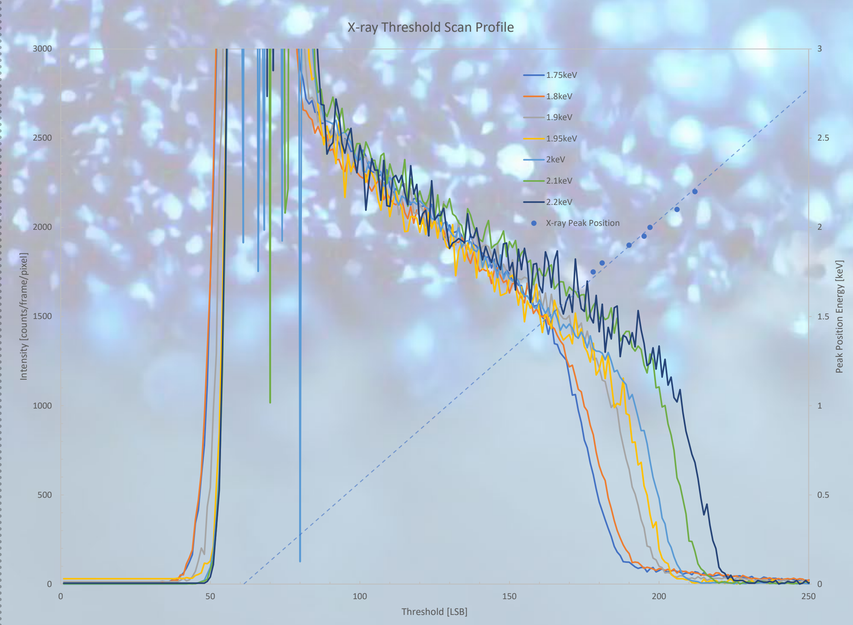

Figure 6. Left: Tender X-ray Threshold Scan result with energy peak position linearity plot.
Right: The detector mounted on the in-house X-ray diffractometer.

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Summary

The XSPA detector series is the fastest, commercially available HPC detector series. In zero-dead time mode the detector can acquire data at up to 56 kfps at 2-bit per pixel. And In burst mode the detector can collect 11 (2-bit) or 25 (1-bit) images at up to 970 kfps. High-end series of XSPA detector family is designed to keep this high frame rate operation capability with multi-module detectors (1M, 1.5M, 3M, 4M and 16M will work at 56 kfps in zero-dead time mode and at 970 kfps in burst mode) and with a full-speed readout option, you can read the images out in real-time.

XSPA detector series are also capable of gating mode, pump-probe-probe mode, post-processing charge share compensation mode and more.

Tender and possible Soft X-ray capability are also proved by the latest experiment at AichiSR BL6N1.

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