ULTRA
for X-RAYs

20,000 Frames Per Second
1D Silicon Strip Detector
5-17 KeV Sensitivity

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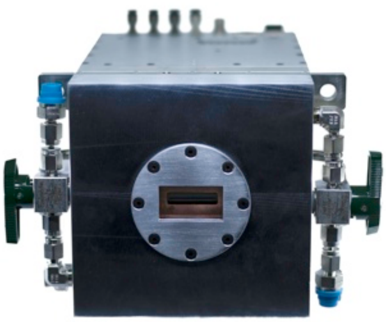
1. Intro

The ULTRA Detector System from Quantum Detectors enables capture of one dimensional spectra at extremely high rates. Where CCDs were used to capture a line of data at a time, the ULTRA Detector System offers many orders of magnitude faster time framing.

The system is used for X-RAY applications at prestigious laboratories such as the Advance Photon Source, Chicago, USA; European Synchrotron Radiation Facility, Grenoble, France and Synchrotron SOLEIL, Paris, France.

ULTRA is a compact turnkey system. The data acquisition system is attached in a compact form factor unit with gigabit Ethernet out and multiple I/O options onboard.



2. Features

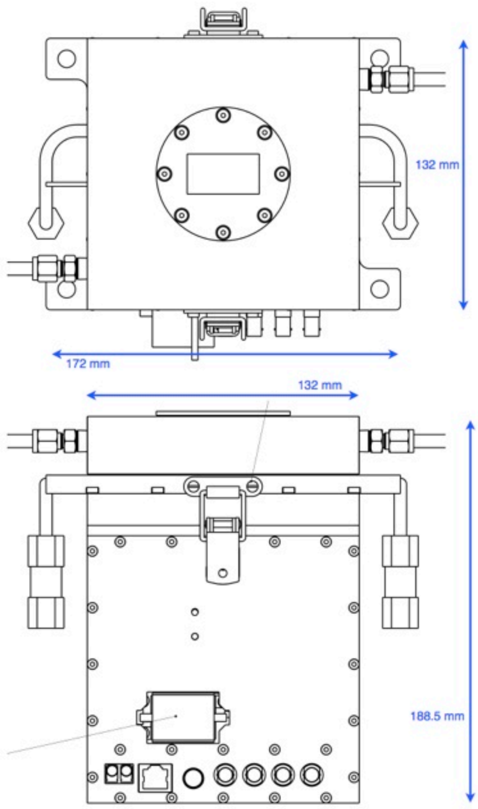
Sustained Spectral Rate	20 KHz (spectra per second) Maximum
Frame Period	<500 ns Minimum
Software	Controllable via SPEC, TANGO and custom interface / using TCP and Windows®
Spectral Sensitivity	**5 – 17KeV** 300μm thickness. 500μm also available.
Output	Gigabit Ethernet
Pixel configuration	Si 512 linear strips @ 50μm pitch
ADC Dynamic Range	16 Bit
Synchronisation Inputs	TTL or Fibre Optic

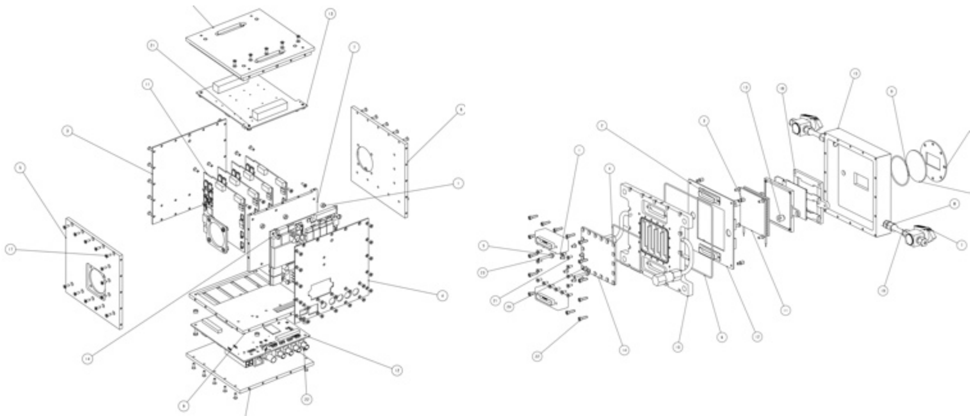
3. Spectral Sensitivity

The sensor material in the ULTRA for X-Rays is a 300 (or optionally 500) micron thick silicon sensor. The bulk of this material is fully depleted using a bias voltage to ensure that electron hole pairs created by photons absorbed throughout the thickness are fully collected. It is understood that approximately all incident photons that are absorbed in the sensor create charge and are therefore read out by the detector. The detector has a very good quantum efficiency just above the window transparency of approx. 5KeV until 10KeV. Above this value, the sensor becomes progressively transparent until the usage limit at 17KeV.

4. Mechanical Properties

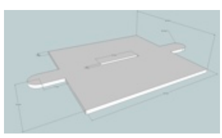
The ULTRA Detector System body is CNC machined out of aluminium. The surface is treated with a conductive coating to reduce EMC interference, ensuring the unit can produce excellent data in lab environments with many other electronic systems running.
There are comprehensive mechanical drawings and a 3D model of the system that are available to customers. This improves the integration possibilities at your lab.

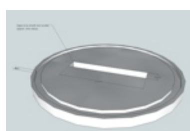




5. Custom Engineering

Scientists often find that with a small change, our instruments can be used for a wider range of applications in their area. We have a team of engineers able to make a huge range of changes to the detector to suit your requirements. Some of the customer requested modifications carried out by our engineers have been:





Evacuated detector head, including new window design;
Tungsten mask;
New TTL timing method through aux LEMO connector;
New power cable system;
Increased framing limit (from 1500 to 20,000);
Changes to Windows® interface to specify frames to capture, format of output, review history of frames and compare with live view.
.ddl and library for custom integration;
SPEC integration;

6. An Application at the Advanced Photon Source
X-Ray Diffraction Studies in Pulsed Magnetic Fields

The ULTRA Detector System is used on the undulator beamline 4-ID-D to perform X-ray diffraction experiments to determine magnetic properties of a crystal under strong magnetic fields. The frustrated pyrochlore $Tb_2Ti_2O_7$ has complex magnetic states that have evaded understanding for decades.

The experimental setup is shown below: The x-rays are incident on the crystal and diffract onto the silicon strip at the front of the ULTRA Detector System. The detector starts recording, the capacitor bank storing the charge for the solenoid is triggered and a magnetic field of up to 30T is applied to the crystal. Under this field, the crystal is deformed, which moves the Bragg peak along the detector. The distance that the Bragg peak moves enables measurement of the transverse magnetostriction and hence better understanding of the properties of the pyrochlore. See Figure 2.

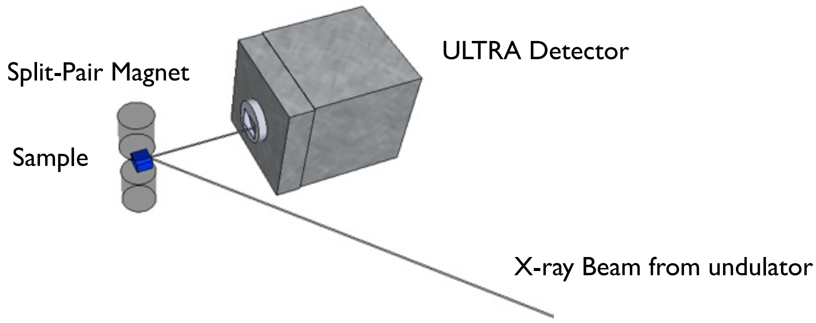


Figure 1. A schematic of the APS 4-ID-D X-Ray diffraction experiment

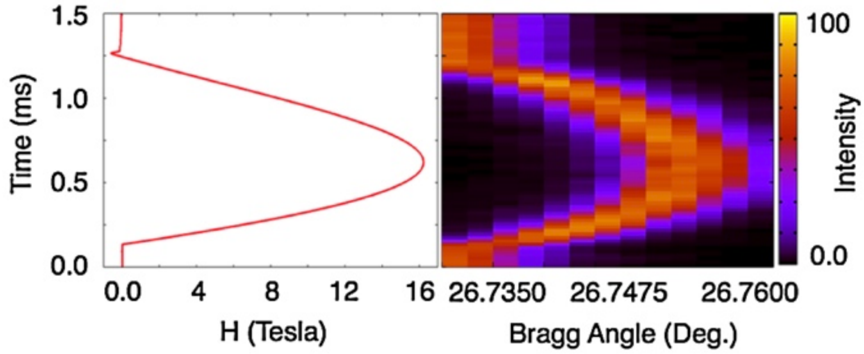


Figure 2. Showing magnetostriction. Left panel: Magnetic field generated at the sample as a function of time, for a charging voltage of 1.1 kV. Right panel: False-color intensity map of a θ - 2 θ scan of pulses through the (008) Bragg peak.[1]

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[1] "Magnetoelastics of a Spin Liquid: X-Ray Diffraction Studies of Tb2Ti2O7 in Pulsed Magnetic Fields" was published by J. Ruff, Z. Islam et al. at 4-ID-D using the ULTRA Detector System. Reproduced with kind permission. Copyright 2010 American Physical Society. DOI: 10.1103/PhysRevLett.105.077203

7. An Application at the European Synchrotron Radiation Facility

Energy Dispersive XMCD

The core element of the energy dispersive X-ray absorption spectroscopy beamline ID24 at the ESRF is a focusing polychromator. This polychromator, an elliptically bent Si crystal, focusses the incident pink beam to the sample position and introduces at the same time a correlation between the X-ray energy and the angle. This mapping of the energy to angle, allows one to simultaneously acquire the entire absorption spectrum on a linear detector array placed at some distance from the sample.

At ID24, the ULTRA system is used for time resolved experiments as for example in pulsed magnetic fields where its high frame rate has opened up the possibility of following the entire magnetic field dependence of the absorption spectra in field pulses of only 1ms duration.

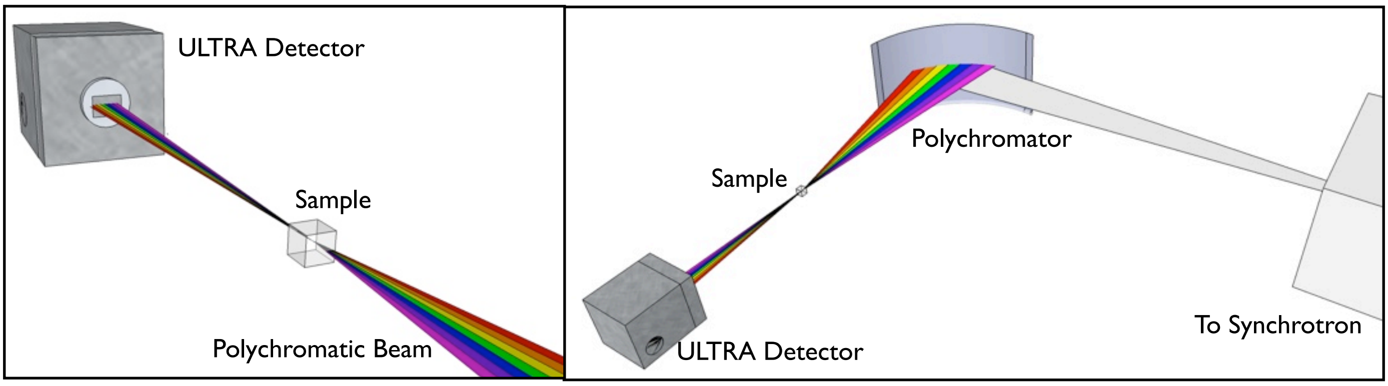

Figure 3 showing a schematic of the beamline layout at ID24 at the ESRF

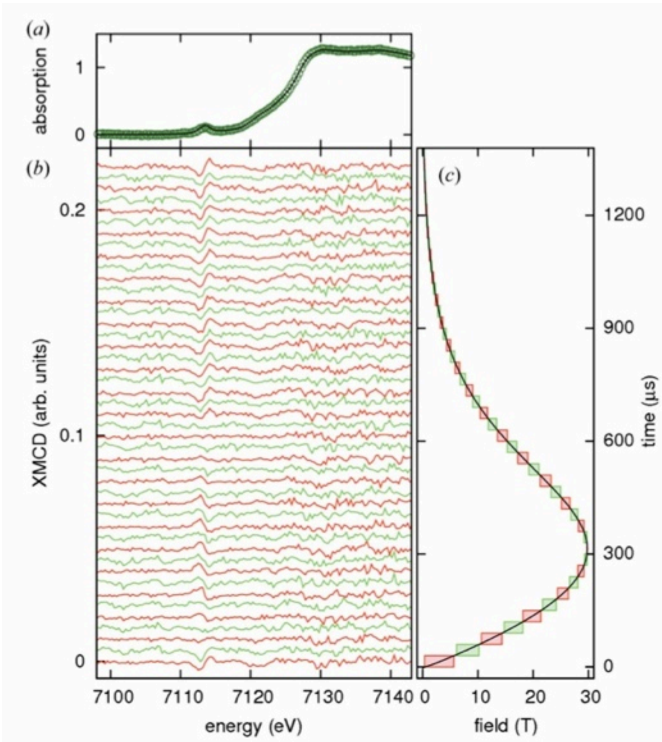

Figure 4. XMCD at the Fe K-edge in Er3Fe5O12 at 65K. (a) Normalized absorption. Points: data taken at ID24; line: reference spectrum for energy calibration recorded at BM29. (b) XMCD spectra. The spectra are offset by 0.005 for clarity. (c) Field pulse and acquisition windows corresponding to the spectra in (b). Red boxes and lines: delay 0 μs; green boxes and lines: delay 30 μs.[2]

[2] Reproduced with kind permission of IUCr. For further details, including a comprehensive explanation of the experimental setup, see the paper: "Multi-frame acquisition scheme for efficient energy-dispersive X-ray magnetic circular dichroism in pulsed high magnetic fields at the Fe K-edge. C Strohm et al. Journal of Synchrotron Radiation, Jan 2011. DOI: 10.1107/S090904951100080X