THE pnCCD COLOR X-RAY CAMERA

The Color X-ray Camera (CXC) is PNDetector's high resolution spectroscopic X-ray imaging system based on an energy dispersive pnCCD detector. It can be used in a wide variety of instruments in X-ray fluorescence, X-ray diffraction, small angle X-ray scattering and computed tomography.

The full system is now available at PNDetector and comes with

The pnCCD Camera

- pnCCD with an active area of 12.7 x 12.7 mm
- dimensions of the vacuum sealed housing: 120 mm x 212 mm x 80 mm (W x H x D)
- Sensor cooled to -20°C with thermo electronic cooling
- Be-window or vacuum solution possible

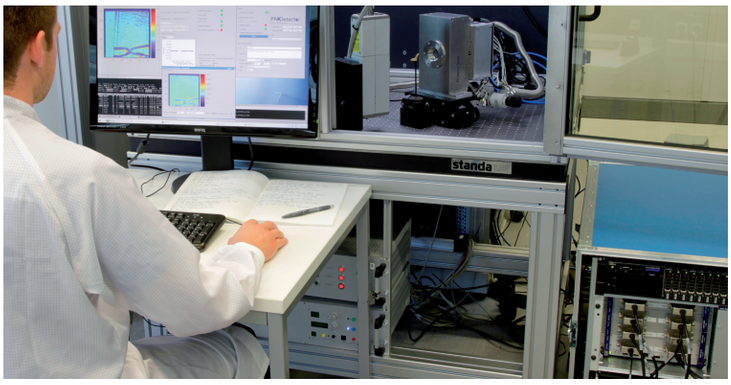
Electronics & Data Acquisition System

- Ultra-low noise power supplies, sequencer and data acquisition system located in a 19 inch rack mount
- High speed parallel data acquisition, selectable amplifier bandwidth and analog gain for high dynamic range

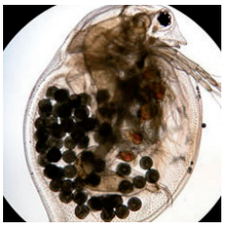
Software Package

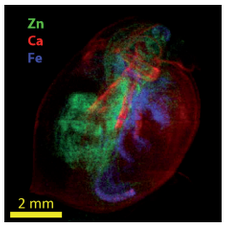
- Control of power supplies, the readout electronic system, monitoring of the housekeeping sensors, real-time online data display and storage of the data cube
- Software for offline data analysis

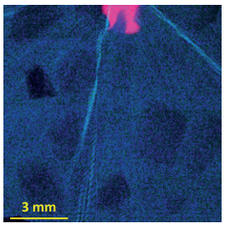
Example for a computer tomography setup using the Color X-ray Camera with an X-ray tube. The camera head is positioned inside a radiation shielded cabinet. The camera controller is located on the right side.

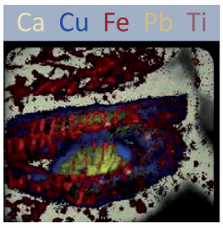


... and a wide variety of application possibilities









Applications of Imaging Spectrometry with the pnCCD

Full Field XRF

*The **pnCCD** creates X-ray images **without scanning the stage** by using a **polycapillary optic** to focus the fluoresced X-rays. The raw data can easily be converted into a binary X-ray spectrum image (such as the NIST-Lispix format) where a full spectrum is recorded at each pixel location. Features as small as 20 µm, can be resolved in the image, providing high quality X-ray imaging and analysis.*

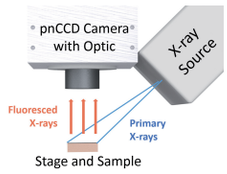


Fig. 1: Setup for an FF-XRF experiment

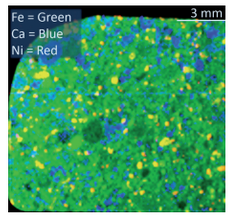


Fig. 2: An image of an Fe-Ni meteorite, which was created without moving the stage or focusing the X-ray beam.

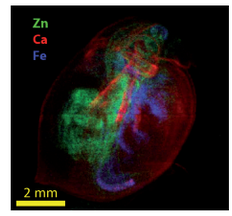


Fig. 3: An X-ray image of a Water Flea showing the distribution of elements in this biological sample.

Energy Dispersive Small Angle X-ray Scattering

*With its **high frame rate** and excellent spectroscopic performance, the pnCCD can perform **energy dispersive** Small Angle X-ray Scattering (SAXS) with unparalleled speed and efficiency. By passing polychromatic X-rays through the sample and detecting the small angle diffraction caused by the crystal structure of the material, the CXC can perform ED-SAXS without monochromating the primary beam.*

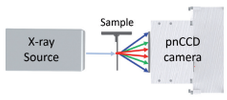


Fig. 4: Transmission X-ray microscopy setup

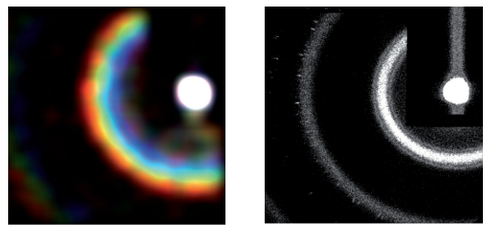


Fig. 5: A side-by-side comparison of energy dispersive SAXS (left) vs. monochromatic SAXS (right). The colors on the energy dispersive image represent the different wavelengths used to create the image. As the wavelength increases, the diameter of the diffraction ring decreases.

Simultaneous X-ray Fluorescence and X-ray Diffraction

*Because the pnCCD records both the position and energy of each incoming X-ray photon, high speed, high resolution X-ray diffraction experiments are possible in both transmission and traditional forward scattering modes. At every single point in the image, a **full diffraction pattern and fluorescence spectrum** can be derived. This is done **simultaneously, without monochromation, stage scanning or beam focusing**, and the measurements take **less than one minute to acquire**.*

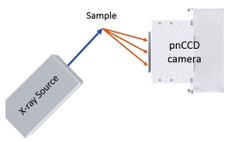


Fig. 6: X-ray diffraction setup

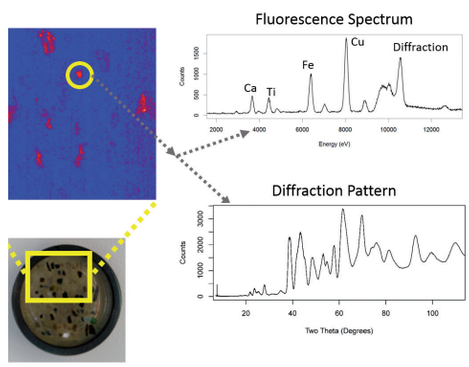


Fig. 7: The sample had several diffraction minerals, shown in red on the image above. The diffraction pattern and fluorescence spectrum come from the specimen in the yellow circle.

Materials Application: Pigment Analysis

*Pigments are complex materials that often require both X-ray diffraction and X-ray fluorescence to analyze. With **simultaneous, energy dispersive XRD-XRF**, pigment identication can be done with one measurement, in a single instrument with no moving parts.*

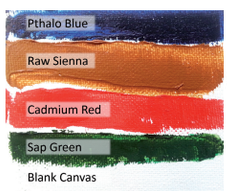


Fig. 8: Four pigments chosen for analysis and applied to $CaCO_3$ prepared canvas

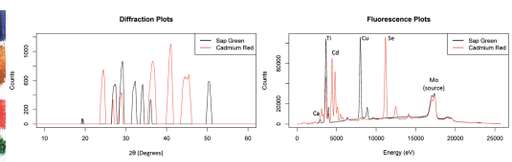


Fig. 9: The fluorescence spectrum and diffraction pattern from the Sap Green (brominated copper pthalocyanine) and Cadmium Red (cadmium sulfoselenide) pigments.

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