2006 | 2016 X YEARS

DECTRIS®

detecting the future

PILATUS3 R CdTe

High energy hybrid photon counting detectors for your laboratory

laboratory and industry

The PILATUS3 R CdTe series combines the advantages of noise-free single-photon counting with the benefits of direct detection of hard X-rays in large cadmium telluride (CdTe) sensors.

Direct detection in a hybrid pixel results in sharper signals and better spatial resolution compared to scintillator based detectors. CdTe provides close to 100% absorption efficiency for Mo, Ag, and In radiation. Combined with noise-free single-photon counting, this brings X-ray detection in the laboratory to a new level of sensitivity and accuracy.

X-ray sources in the laboratory, particularly for hard X-rays, are much weaker than at the synchrotron, thus requiring longer exposure times and resulting in weaker signals. Thanks to the absence of dark current and readout noise, PILATUS3 R detectors outperform all other technologies in the laboratory. Single-photon counting is free of all other sources of noise and inaccuracy intrinsic to charge-integrating CMOS detectors, such as reset noise and nonlinear charge response. Instead, fastest counting electronics powered by DECTRIS Instant Retrigger Technology® in combination with accurate count rate correction provide a wide linear range, fully compatible with all laboratory applications and advanced X-ray sources.

Challenging laboratory applications such as charge density studies and pair distribution function analysis rely on hard radiation and on data with outstanding signal-to-noise ratios. The PILATUS3 R CdTe detectors series offers a unique combination of high-efficiency direct detection with noise-free single-photon counting and is the best match for these requirements in the laboratory.

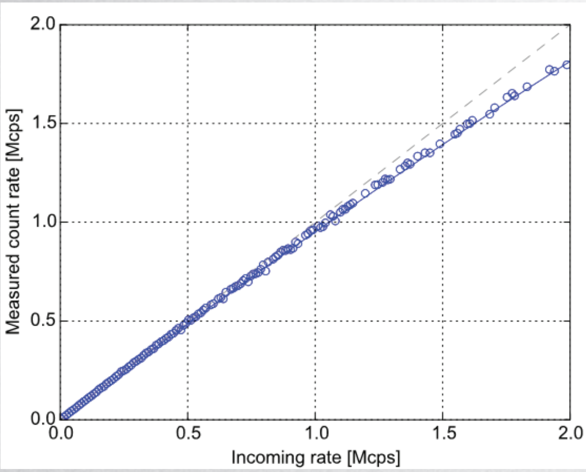

Figure 1: Count rate performance of PILATUS3 R CdTe detectors. The graph shows the measured (open circles) and theoretical (solid line) count rate performance of PILATUS3 R CdTe detectors across the X-ray intensity range relevant for laboratory experiments in millions of counts per second (Mcps) and pixel. PILATUS3 R CdTe closely matches the response of an ideal detector (dashed line) at high intensities of up to 1 Mcps per pixel. Thanks to a simple yet precise mathematical model, the small deviations at extreme intensities of 2 Mcps per pixel and above can be easily and accurately corrected for.

Key Advantages

- Quantum efficiency > 90% for Mo, Ag, and In
- Direct detection for sharpest spatial resolution
- No readout noise and no dark signal for highest accuracy
- High dynamic range
- Fluorescence background suppression
- Highest count rates
- Synchrotron-proven radiation hardness
- Maintenance-free operation
- High reliability: No failure-prone sealing or complex cooling below room temperature

Applications

- Charge density analysis
- Pair distribution function (PDF) analysis
- High-resolution chemical crystallography
- High-pressure/high-temperature XRD
- Critical Dimension SAXS
- Computed tomography (CT)
- Non-destructive testing (NDT)

PILATUS3 R CdTe for challenging charge density analysis

Charge density analysis is one of the most challenging crystallographic applications where highest data quality is absolutely paramount. PILATUS3 R CdTe detectors excel because of the absence of detector noise. In addition to that, direct detection in the CdTe sensor achieves quantum efficiency greater than 90% and makes best use of the weak Ag and Mo sources used in this application. Fluorescence background suppression is another advantage only HPC detectors can provide in laboratory applications. In HPC detectors, X-rays with an energy below a threshold set by the user are not measured. This way, fluorescence background can be substantially reduced or even eliminated from the acquired data. When working with integrating detectors such as CCDs or so called CPADs, fluorescence suppression is not possible and data quality suffers from increased background.

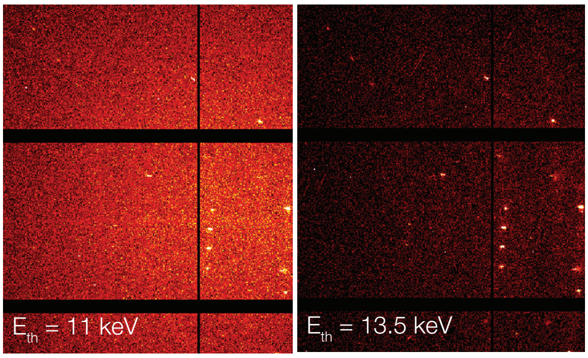

Figure 2: Fluorescence suppression decreases background. At a threshold energy (E_{th}) of 11 keV (left panel), Se fluorescence causes strong background. A diffraction image acquired with a charge integrating detector will suffer from the same fluorescence background in addition to its detector background. At E_{th} = 13.5 keV fluorescence is effectively suppressed (right panel), which dramatically improves the signal-to-noise ratio of the Bragg spots.

Data for charge density analysis were collected with an Ag microfocus source on an integrating CCD and a single-photon counting PILATUS3 R CdTe 300K detector. Two samples were studied, dibenzyl diselenide and paracyclophane. Dibenzyl diselenide is a particularly challenging sample because it exhibits strong Se-fluorescence when exposed to Ag radiation. For each of the samples, data reach the same high resolution and have a completeness of 100%.

Fig. 2 illustrates the benefit of fluorescence suppression on the dibenzyl diselenide data. A diffraction image acquired at a threshold energy of 11 keV shows the background from the Se-fluorescence between 11.2 and 12.5 keV. Setting the threshold to 13.5 keV effectively suppresses fluorescence and substantially reduces background. The better data quality thus achieved leads to cleaner and flatter residual density maps of dibenzyl diselenide (Fig. 3). Fluorescence suppression is not possible with any charge-integrating detector available for the laboratory.

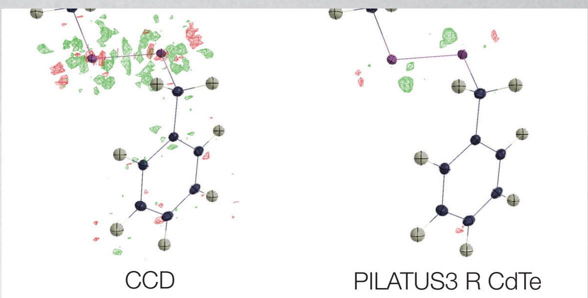

Figure 3: Residual density maps of dibenzyl diselenide calculated from data acquired with a CCD (left panel) and a PILATUS3 R CdTe (right panel). Thanks to fluorescence suppression, the map obtained from PILATUS3 R CdTe data is much flatter and largely featureless.

Even when fluorescence suppression is not necessary, data acquired with the PILATUS3 R is of superior quality. Fig. 4 shows residual density maps for paracyclophane calculated from data acquired with the PILATUS3 R detector and a CCD. Thanks to the much cleaner map, the disordered positions of the CH_2 hydrogen atoms can be identified significantly more reliably from the PILATUS3 R CdTe 300K data.

DECTRIS is grateful to Regine Herbst-Irmer and Dietmar Stalke (University Göttingen) for performing the experiments and sharing their results.

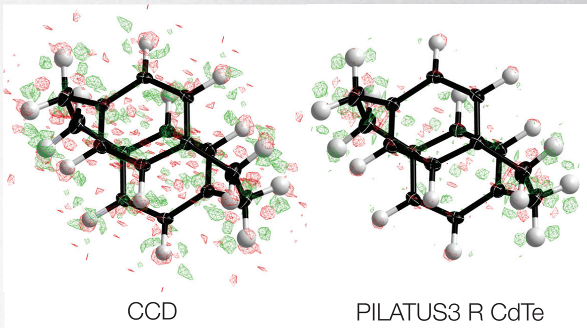

Figure 4: Residual density maps of paracyclophane calculated from data acquired with a CCD (left panel) or a PILATUS3 R CdTe (right panel). Noise-free detection with the PILATUS3 R CdTe HPC detector results in a much cleaner map.

PILATUS3 R CdTe

NEW - introduced at ACA 2016

PILATUS3 R CdTe detector series technical specifications

PILATUS3 R CdTe	300K	300K-W
Number of detector modules	1 × 3	3 × 1
Sensitive area: width × height [mm²]	83.8 × 106.5	253.7 × 33.5
Pixel size [μm²]	172 × 172	
Total number of pixels (horiz. × vert.)	487 × 619	1475 × 195
Gap between modules (horiz. / vert.) [pixel], *plus 1 pixel horizontal gap on each module	–* / 17	7* / –
Inactive area [%]	5.7	1.1
Defective pixels	< 0.1%	
Maximum frame rate [Hz]	20	
Readout time [ms]	7	
Point-spread function	1 pixel (FWHM)	
Counter depth	20 bits (1,048,576 counts)	
Power consumption [W]	30	
Dimensions (WHD) [mm³]	158 × 193 × 262	280 × 62 × 296
Weight [kg]	7.5	7.0
Module cooling	Water cooled	
External trigger/gating	5V TTL	

Specifications are subject to change without notice

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