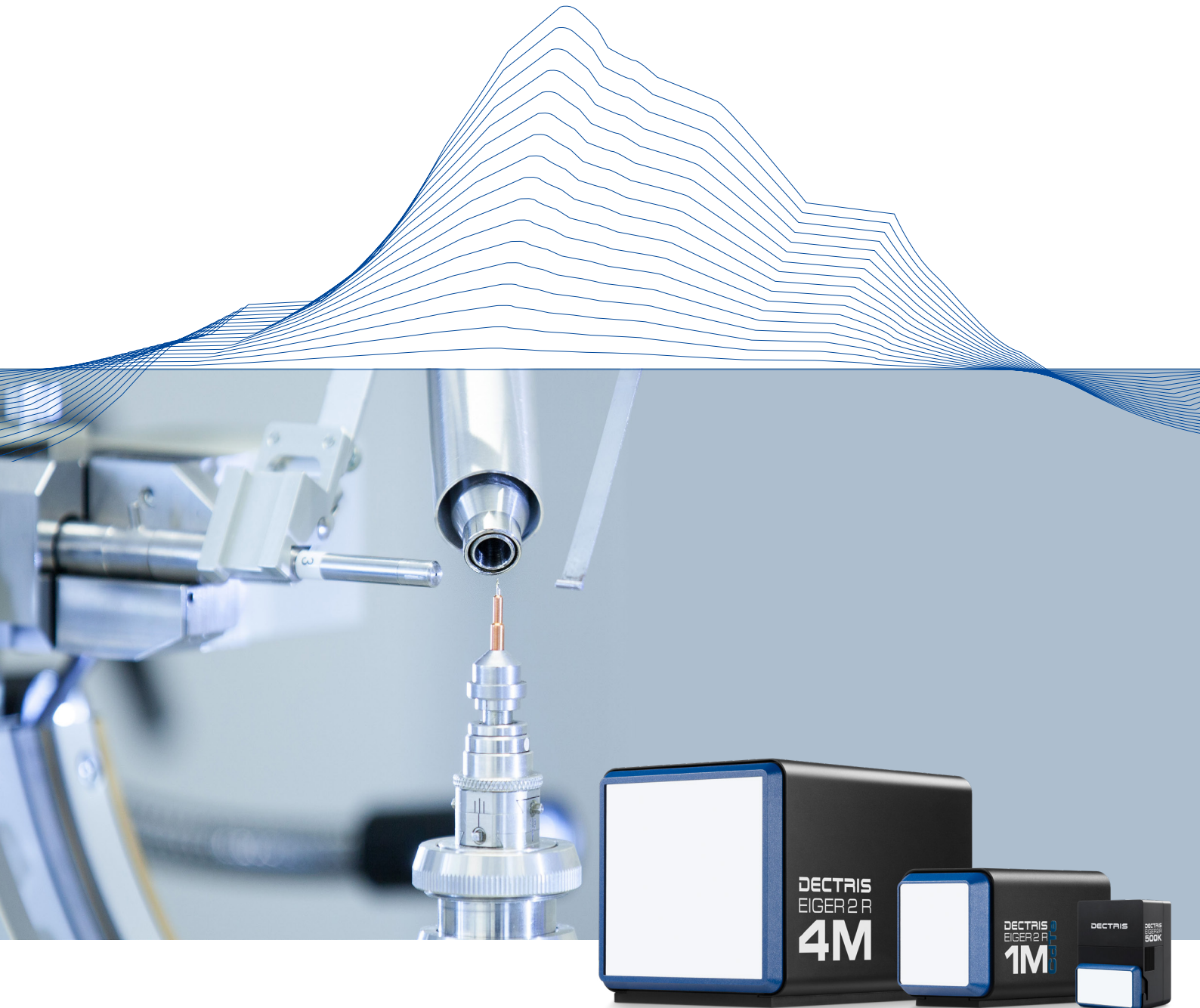
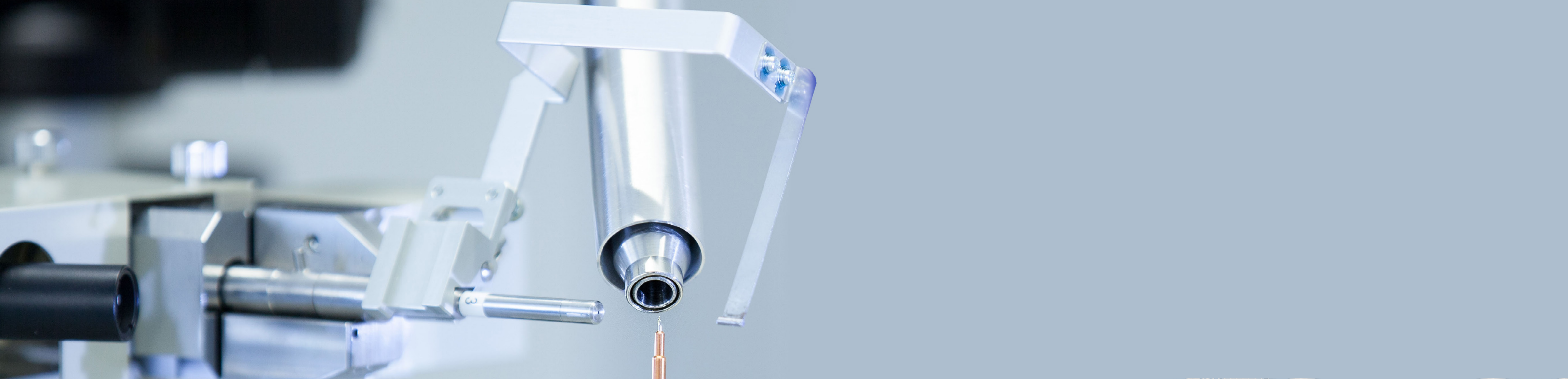


DECTRIS
detecting the future



EIGER2 R

*The leading Hybrid Photon Counting
X-ray detectors*



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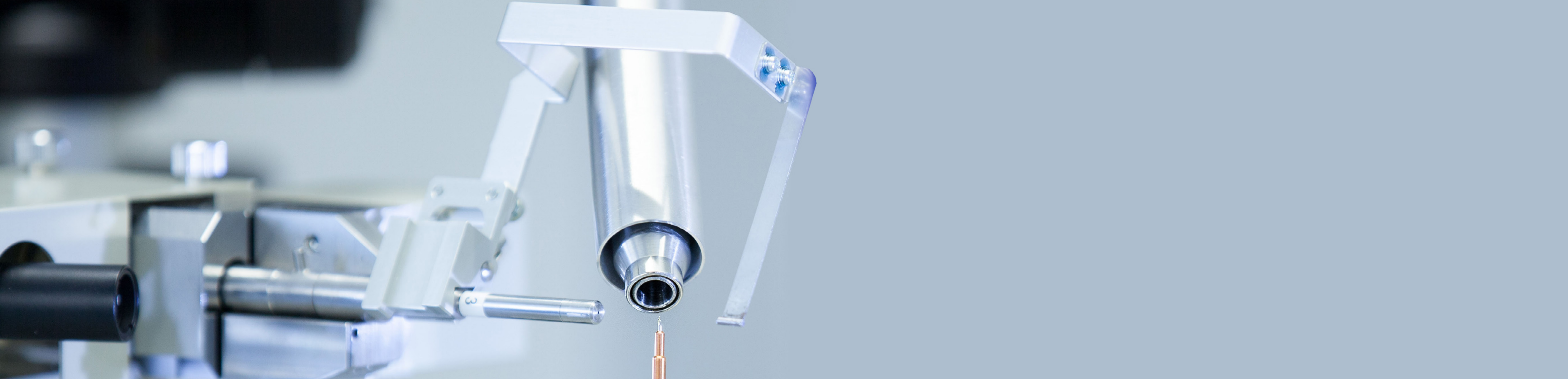
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EIGER2 R and EIGER2 R CdTe

EIGER2 is DECTRIS' most advanced family of Hybrid Photon Counting (HPC) X-ray detectors. One of the key features of HPC technology is direct conversion from X-ray to charge in a solid state sensor enabling high sensitivity and well resolved signals.

The recently introduced **EIGER2 R** detector series features a silicon sensor and is the ideal companion for Ga, Cu, or longer wavelength X-ray sources in the laboratory.

The detectors of the novel **EIGER2 R CdTe** series are equipped with a CdTe sensor. The EIGER2 R CdTe detectors maintain similar performance for Cu and Ga radiation compared to the EIGER2 R series with Si sensor. Thanks to the high-Z sensor material, quantum efficiency, sensitivity and measurement speed are greatly improved when using high energy radiation compared to EIGER2 R or other HPC detectors equipped with Si sensors. Choose EIGER2 R CdTe as the perfect match for any dual-wavelength setup or high-energy laboratory source.



EIGER2 R: The latest-generation HPC technology for your laboratory

EIGER2 R incorporates every state-of-the-art feature of HPC technology. Small pixels, in combination with direct detection, enable a high spatial and angular resolution and give you the benefit of fine sampling of reciprocal space. A superior count-rate performance ensures accurate measurements of even the highest intensities. Take full advantage of this detector series' vast dynamic range, even during long exposures, using simultaneous read/write with zero dead time. Dual-energy discrimination allows for extensive background suppression and improves signal-to-noise, in particular for weak signals and long exposure times. Eliminate absorption and scatter from air and windows, thanks to optional vacuum compatibility. Choose from three different models to match your needs.

Key Advantages

- The highest possible dynamic range thanks to zero detector background, superior count rates, and simultaneous read/write
- Direct detection and a small pixel size for the best spot separation and minimal background overlap
- Dual-energy discrimination for suppression of low- and high-energy background
- DECTRIS Instant Retrigger for a virtually linear response without limitations in the dynamic range

Applications

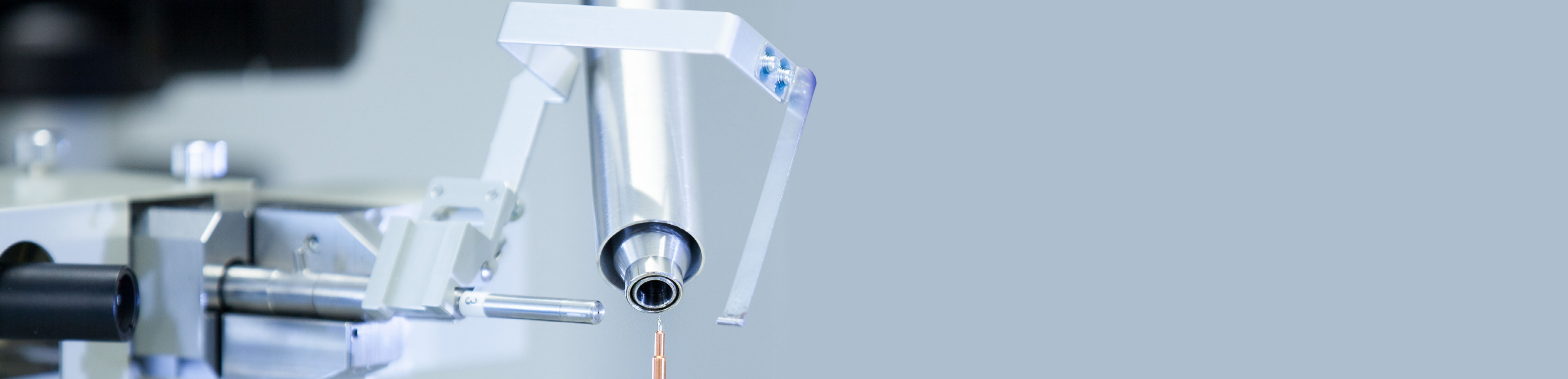
- Macromolecular crystallography
- Chemical crystallography
- SAXS/WAXS
- X-ray powder diffraction
- X-ray reflectometry
- Diffuse scattering

Technical specifications

EIGER2 R	500K	1M	4M
Number of detector modules	1	1 × 2	2 × 4
Active area, width × height [mm²]	77.3 × 38.6	77.1 × 79.7	155.1 × 162.2
Pixel size [µm²]	75 × 75		
Point-spread function	1 pixel (FWHM)		
Energy-discriminating thresholds	2		
Threshold range [keV]	4 - 11	3.5 - 30	3.5 - 30
Maximum count rate [cps/mm²]*	3.6 × 10 ⁸	6.9 × 10 ⁸	6.9 × 10 ⁸
Counter depth [bit/threshold]	2 × 16		
Acquisition mode	simultaneous read/write with zero dead time		
Image bit depth [bit]	32		
Optional vacuum compatibility?	yes		
Cooling	Air-cooled	Water-cooled	Water-cooled
Dimensions (WHD) [mm³]	100 × 140 × 93	114 × 133 × 240	235 × 237 × 372
Weight [kg]	1.8	3.9	15

* Values are for Cu radiation. Instant Retrigger and higher count rates for EIGER2 R 500K will be available in 2021.
All specifications are subject to change without notice.





EIGER2 R CdTe: All the advantages of HPC technology for high energy

EIGER2 R CdTe X-ray detectors combine the latest developments in HPC technology with the high quantum efficiency of cadmium telluride sensors. This makes them indispensable for your laboratory when using high-energy sources or a dual-wavelength setup. Their unprecedentedly high count-rate capability, enabled by DECTRIS' patented Instant Retrigger, allows for more accurate measurements of the highest intensities that can be achieved with laboratory sources. Equipped with two energy-discriminating thresholds, these detectors have lower dark counts from environmental background than their predecessors did. This significantly improves the signal-to-noise ratio for weak signals and long exposures, allowing for shorter measurement times and better data quality. Single-photon counting, in combination with continuous read/write, overcomes all saturation issues and the limited dynamic range of integrating detectors. In addition, direct detection and the small, 75-µm pixel size guarantee high spatial and angular resolution.

Key Advantages

- The highest possible quantum efficiency for shorter measurement times and better data
- Integrated DECTRIS Instant Retrigger technology for a higher count rate
- Two energy-discriminating thresholds for suppression of low and high background
- Lack of readout noise or dark current ensures the best signal-to-noise ratio
- A simultaneous read/write functionality for a high dynamic range and saturation-free images

Applications

- Macromolecular crystallography
- Chemical crystallography
- SAXS/WAXS
- µCT

Technical specifications

EIGER2 R CdTe	500K	1M	4M
Number of detector modules	1	1 × 2	2 × 4
Active area, width × height [mm²]	77.1 × 38.4	77.1 × 79.7	155.1 × 162.2
Pixel size [µm²]	75 × 75		
Point-spread function	1 pixel (FWHM)		
Energy-discriminating thresholds	2		
Photon energy [keV]	8 - 24.2	8 - 24.2	8 - 24.2
Threshold energy [keV]	4 - 30	4 - 30	4 - 30
Maximum count rate [cps/mm²]	9.8 × 10 ⁸	9.8 × 10 ⁸	9.8 × 10 ⁸
Counter depth [bit/threshold]	2 × 16		
Acquisition mode	simultaneous read/write with zero dead time		
Image bit depth [bit]	32		
Optional vacuum compatibility?	yes		
Cooling	Water-cooled	Water-cooled	Water-cooled
Dimensions (WHD) [mm³]	114× 92 × 242	114 × 133 × 242	235 × 237 × 372
Weight [kg]	3.7	3.9	15

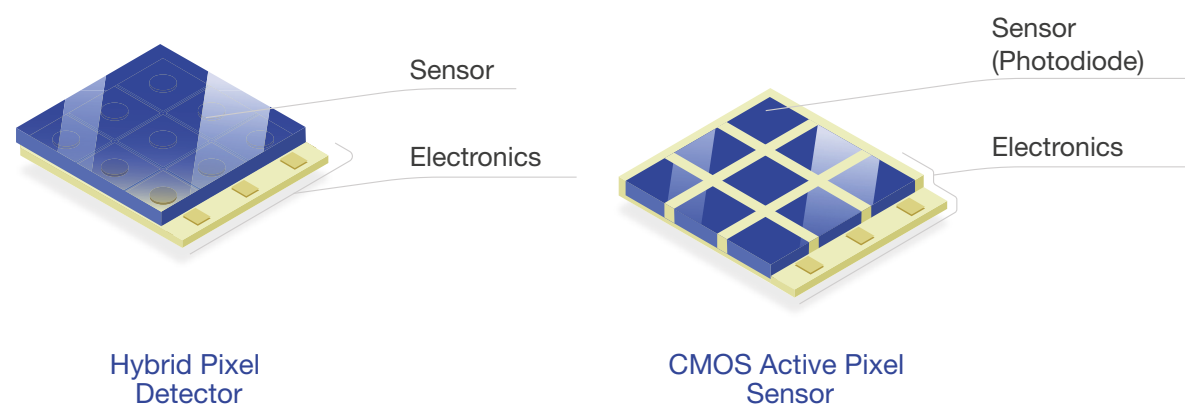
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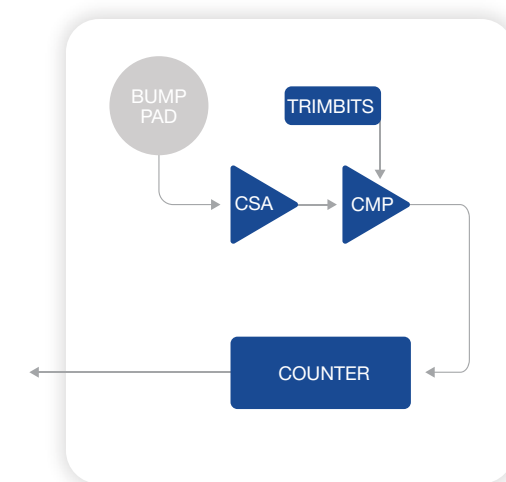
Direct conversion in hybrid pixel technology

Characteristically, Hybrid Photon Counting (HPC) incorporates the method of single-photon counting as well as hybrid pixel technology. This technology enables direct conversion of X-rays to electric charge and is the state of the art in X-ray detection because it offers several advantages over indirect detection. In the sensor layer of a hybrid pixel, the charge generated by X-ray absorption is captured in an electric field, along which it moves rapidly, going towards the electronics layer for processing and counting. Both loss and spreading of the signal are minimized. Therefore, hybrid pixel detectors achieve a sharp point-spread function and quantum efficiencies that are close to the sensor's absorption efficiency. Hybrid pixel technology also makes it unnecessary to use a large fraction of the electronics layer's pixel area for a photodiode because the electric signal is generated in a separate layer that covers the full pixel area. This way, thousands of transistors for advanced detector features can be implemented in every pixel without reducing the area that is available for signal detection and compromising quantum efficiency.

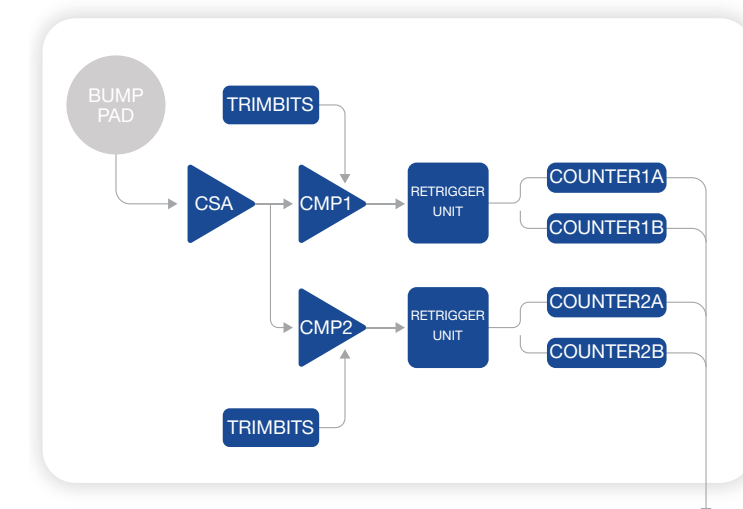


Highly advanced HPC chip

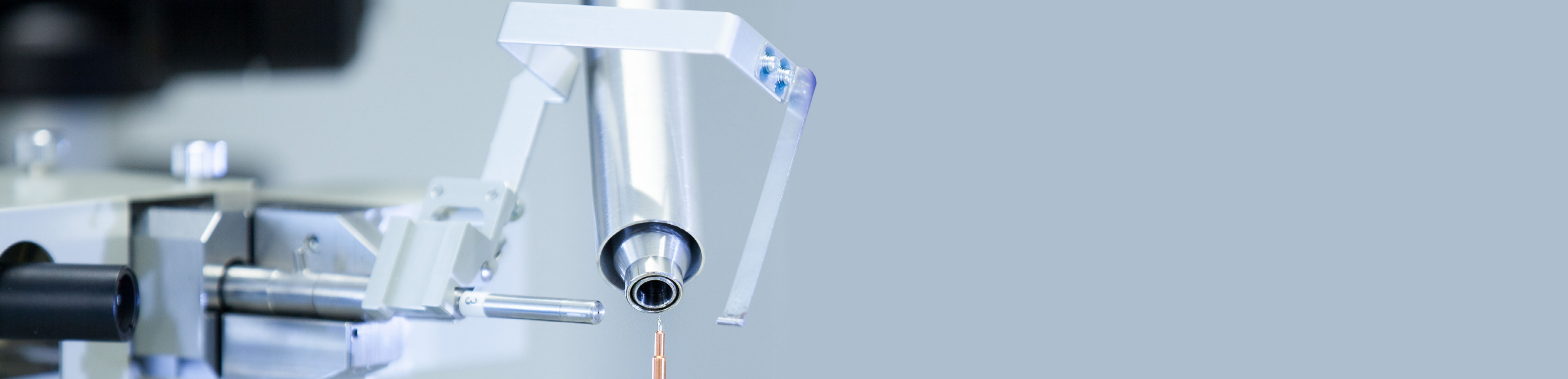
EIGER2 features one of the most advanced application-specific integrated circuits (ASIC) for HPC, with more than 150 million transistors per chip. As in a CPU or GPU, more transistors mean more features, and that means advantages over previous generations or competing products. Every pixel in an EIGER2 detector features not one, but two comparators per charge-sensitive amplifier (CSA). This enables high-energy discrimination, in addition to low-energy discrimination of a single comparator (CMP). A retrigger unit for each of the comparators complements the fast CSA, further boosting the count rate performance. This makes EIGER2 compatible with the requirements of latest-generation synchrotrons and provides a virtually linear response for count rates that can be achieved in typical laboratory experiments. At the same time, two digital counters for each comparator allow to take advantage of dual-energy discrimination and simultaneous read/write with zero dead time at the same time. Thanks to the combination of zero detector background, superior count rates, and simultaneous read/write, EIGER2 detectors achieve a dynamic range of more than 10 orders of magnitude.



Schematics of a single pixel in a basic HPC ASIC.

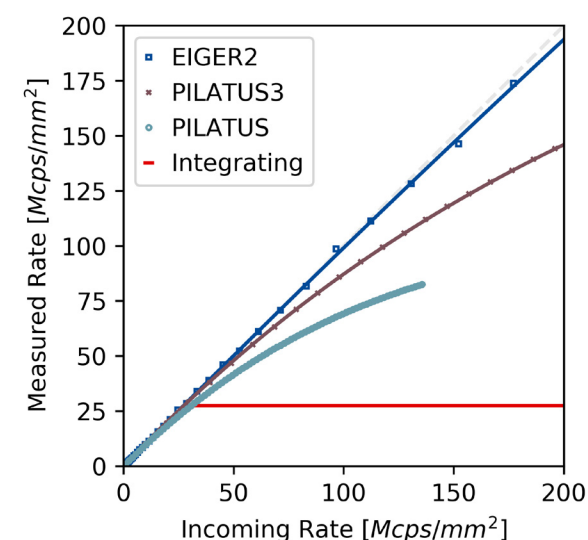


Schematics of a single pixel in an EIGER2 ASIC.



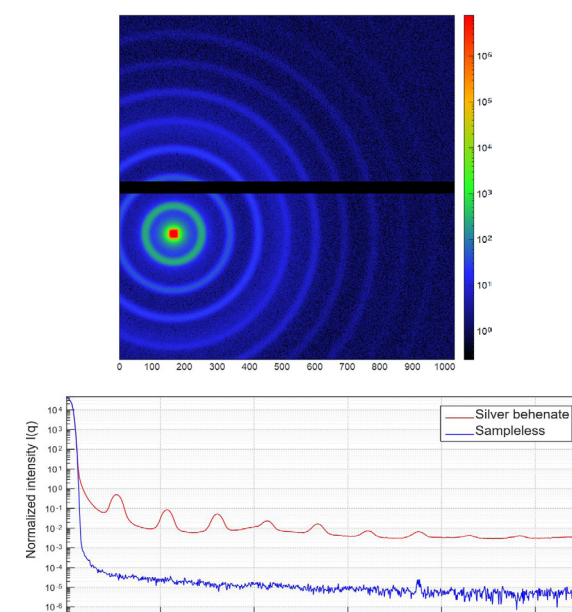
Superior count-rate performance

DECTRIS HPC detectors are designed to match the high count-rate requirements of synchrotron sources, but on the other hand, even the most advanced laboratory sources offer lower flux and brightness than a typical synchrotron beamline does. Therefore, EIGER2 R detectors far exceed the count-rate requirements of any laboratory set-up and experiment. At the same time, EIGER2 R overcomes the saturation issues and limited dynamic range that are typical of integrating detectors, even modern ones. Thanks to its superior count-rate performance, EIGER2 R is the best match for state-of-the-art laboratory sources. It provides high accuracy for strong intensities, without saturation issues, and even allows for measurement of a direct beam.



Highest dynamic range

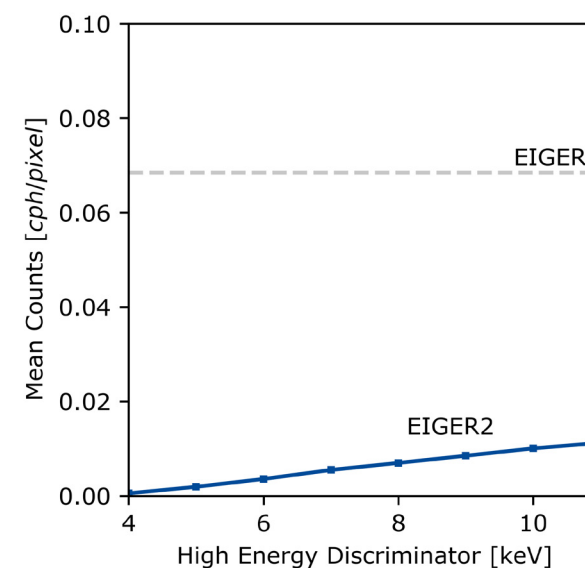
EIGER2 R's zero detector background, superior count rates, and simultaneous read/write provide the highest dynamic range. Determine the highest and lowest intensities accurately and in a single image, whether you are measuring strong and weak reflections or diffuse scattering, or facing a challenging SAXS/WAXS measurement



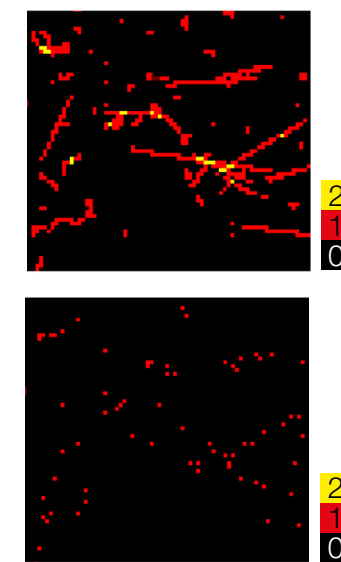
WAXS signal of Silver behenate (AgBH). Top: Raw data acquired with an EIGER2 R 1M in a Xeuss3.0 SAXS/WAXS instrument from Xenocs. Bottom: This dual plot of AgBH's signal and a negative control shows that the dynamic range of EIGER2 R detectors easily covers the more than ten orders of magnitude that are needed for weakly scattering samples.

Background suppression

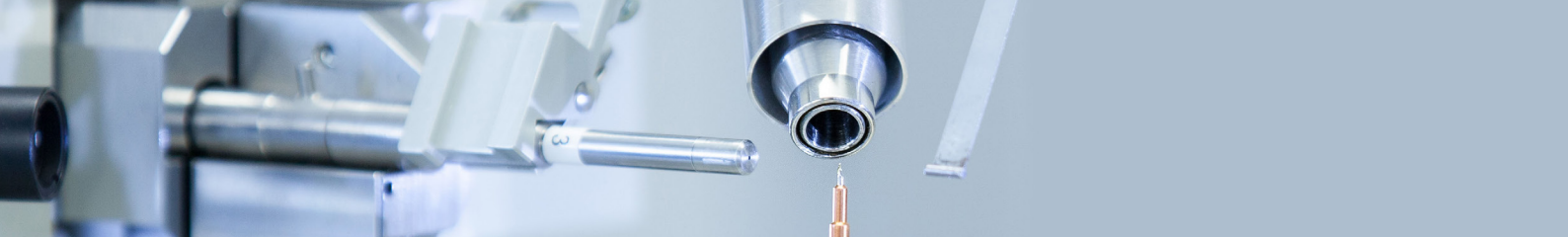
The dual-energy discrimination of EIGER2 R enables suppression of both low- and high-energy background. A single energy-discriminating threshold, as implemented in any HPC detector, allows for the suppression of low-energy background. This is a tremendous advantage when dealing with X-ray fluorescence from the sample or low-energy contamination in the spectrum of the X-ray beam. However, with a second energy-discriminating threshold, as implemented in EIGER2, it is possible to suppress high-energy background as well. Cosmic radiation is a source of high-energy background that compromises data quality when measuring very weak signals with long exposure times. EIGER2 R achieves a fivefold reduction of high-energy background from cosmic radiation, which ensures better data quality. If there is high-energy contamination of the X-ray beam, such as higher-order harmonics, dual-energy discrimination becomes even more critical. Thanks to their lack of detector background and their extensive capabilities for suppression of experimental background with dual-energy discrimination, EIGER2 R detectors are your best choice for measuring weak intensities with high accuracy.



Background counts per pixel in 1 hour dark images. Grey dotted line: Dark counts for EIGER with a single energy discriminator set at 4 keV. Blue solid line: Dark counts for EIGER2 R with a low-energy discriminator at 4 keV as a function of a high-energy discriminator setting.

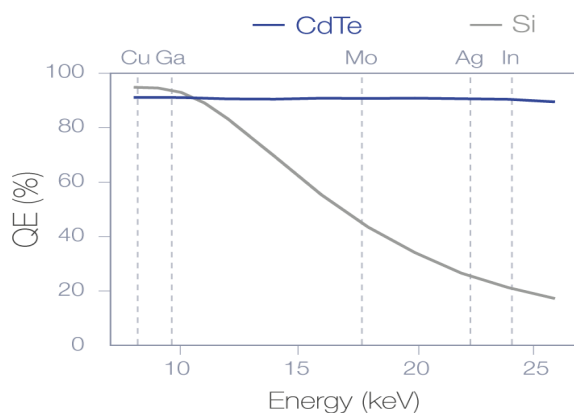


Identical regions obtained through a 1 hour dark exposure of an EIGER2 R detector. Top: Counts obtained with a low-energy discriminator at 4 keV. Bottom: The difference between the counts with a high-energy discriminator at 10 keV and the counts with a low-energy discriminator at 4 keV.



High quantum efficiency

Direct detection enables high quantum efficiency close to the absorption efficiency of the sensor material. High quantum efficiency gives you better data in less time. EIGER2 R CdTe offers high quantum efficiency of more than 90% for any wavelength from copper to indium. Measurement times with short wavelengths can be reduced by a factor of 2 to 4, thanks to the efficiency advantage of cadmium telluride over silicon. The performance of EIGER2 R CdTe detectors with copper and gallium radiation is similar to that of their silicon counterparts. Choose EIGER2 R CdTe for the shortest measurement times with high-energy sources or dual-wavelength setups. EIGER2 R detectors with silicon sensors achieve 94% quantum efficiency for copper and gallium radiation. They are the perfect companion for any such laboratory source. The decreasing quantum efficiency for shorter wavelengths of this sensor material can be effectively compensated by increasing exposure times. Thanks to the absence of detector background as well as the background suppression features of HPC technology, this strategy allows for excellent data quality also for high X-ray energies.

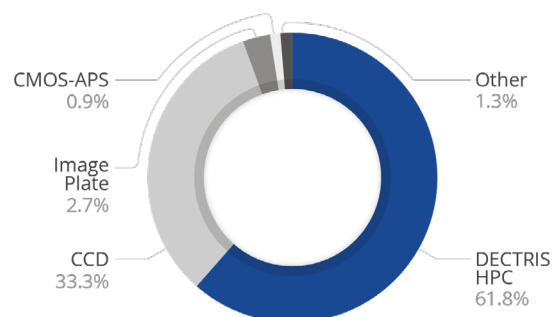


Quantum efficiency (QE) of EIGER2 R CdTe (blue) and EIGER2 R (grey) with silicon sensors.

DECTRIS HPC: The world's most successful detector technology

At synchrotrons and in laboratories, more and more indirectly detecting X-ray detectors, such as CCDs and image plates, are being replaced by hybrid pixel technology. The use of indirectly detecting CMOS active pixel sensor detectors in protein crystallography was first reported in 2009 [1], but the technology nowadays does not provide substantial contributions to the field of protein structure determination. Sixty percent of the structures released in the Protein Data Bank from January to November 2019 are based on data that were acquired with DECTRIS HPC detectors. The advantages of direct detection and single-photon counting are key to the success of DECTRIS HPC technology. With EIGER2 R, the most successful detector technology in protein crystallography is getting even better.

[1] K. Hasegawa et al., "Development of a shutterless continuous rotation method using an X-ray CMOS detector for protein crystallography," *Journal of Applied Crystallography*, vol. 42, no. 6, pp. 1165–1175, Dec.



X-ray detector technologies used in PDB releases 2019