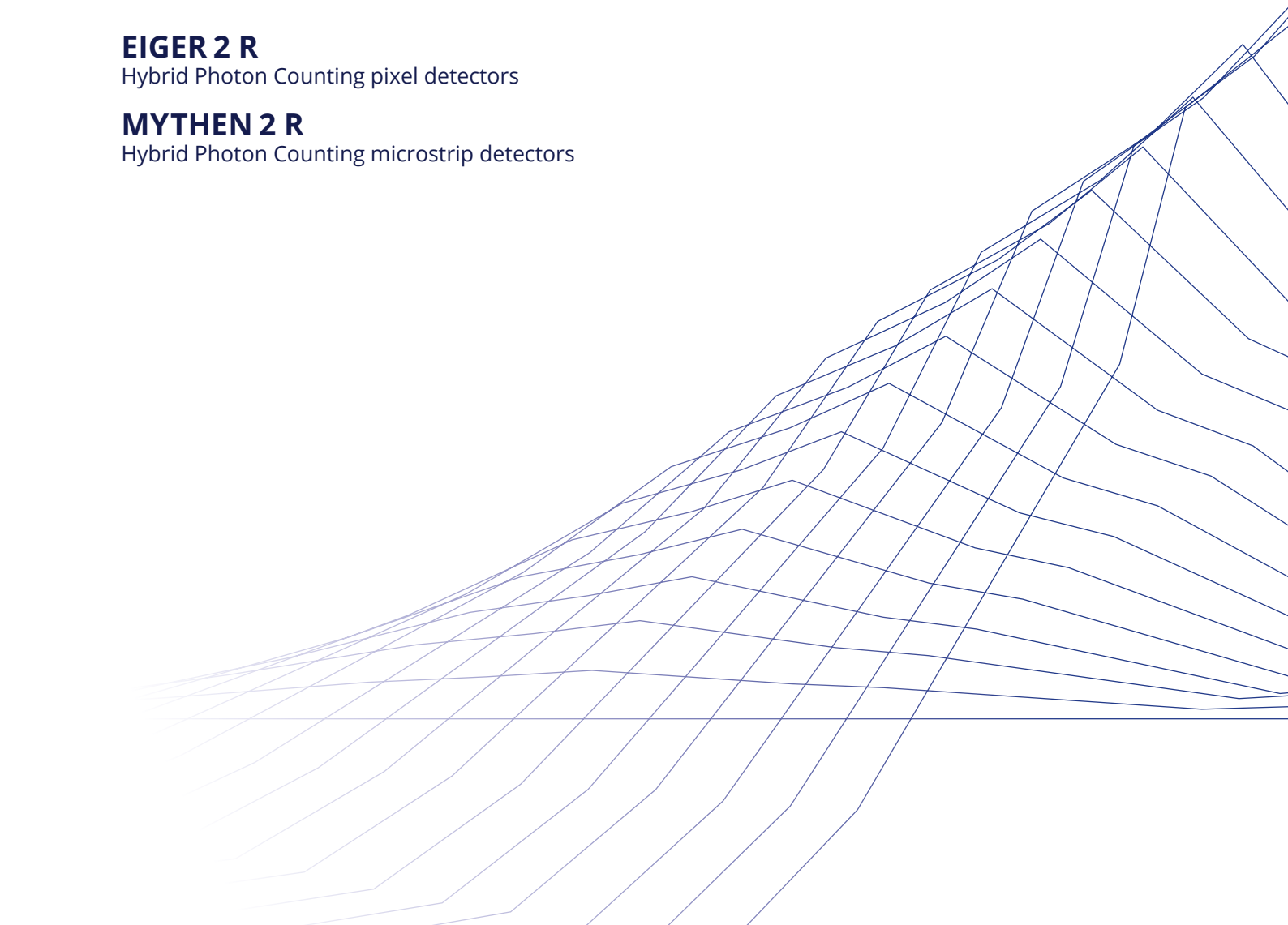
DECTRIS

Laboratory **Detectors**

EIGER 2 R
Hybrid Photon Counting pixel detectors

MYTHEN 2 R
Hybrid Photon Counting microstrip detectors



EIGER 2 R and **EIGER 2 R CdTe**

HPC Pixel Detectors

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. Read more about EIGER2 R on pp. 3 and 4.

The detectors in 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 a 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 what is possible when using 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. Find further details about EIGER2 R CdTe on pp. 5 and 6.

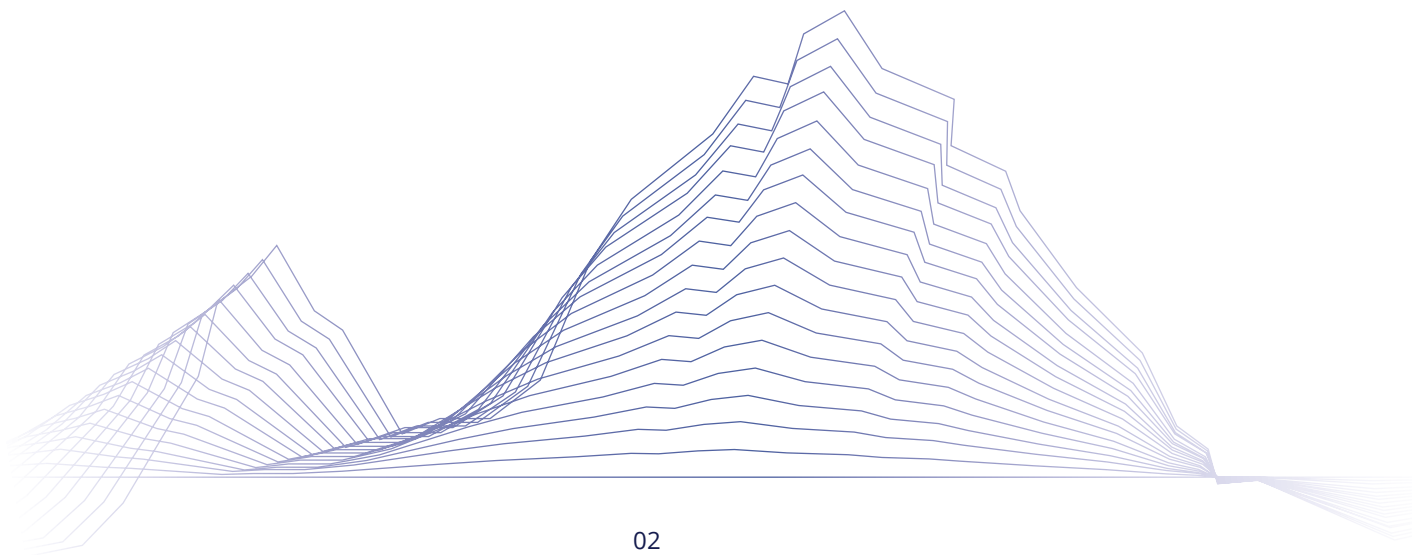
MYTHEN 2 R

HPC Microstrip Detectors

Getting the perfect 1D detector for X-ray diffraction, scattering, or spectroscopy experiments does not require a compromise. The widest portfolio of **MYTHEN2** microstrip detectors lets you optimize both data coverage and the signal-to-noise ratio for a range of X-ray energies. Two module sizes and four sensor geometries ensure that your data are collected with the best possible detector for your application.

All MYTHEN2 detectors feature no-noise performance, high dynamic range and superior count rates. They advance any experiment carried out with weak or bright sources, and long or short exposure times. MYTHEN2 allows you to reach the maximal resolution of your data: its strip is the narrowest available on the market.

The systems are easy to use, thanks to the versatile software interface, 3-year warranty, and maintenance-free operation. Jump to pp. 7 and 8 to learn more about MYTHEN2 R.



EIGER 2 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 the signal-to-noise ratio, in particular for weak signals and long exposure times. Eliminate absorption and scattering from air and windows, thanks to optional vacuum compatibility. Choose from three different models to match your needs.

Key Advantages

DECTRIS Instant Retrigger for a virtually linear response and superior count rates.

Direct detection and a small pixel size for the best spot separation, minimal background overlap and better signal-to-noise ratio.

The highest possible dynamic range thanks to zero detector background, superior count rates, and simultaneous read/write.

Dual-energy discrimination for suppression of low- and high-energy background.

Zero readout noise or dark current thanks to digital counting and readout, enabling the best signal-to-noise ratio.

Applications

- Single-crystal X-ray diffraction
- Powder X-ray diffraction
- SAXS/WAXS
- EXAFS, XANES

Technical Specifications

EIGER 2 R	4M	1M	500K	250K
Active area (W x H) [mm²]	155.1 x 162.2	77.1 x 79.7	77.1 x 38.4	38.4 x 38.4
Pixel array (W x H)	2,068 x 2,162	1,028 x 1,062	1,028 x 512	512 x 512
Pixel size (W x H) [µm²]	75 x 75			
Energy range [keV]	5.4 - 22.2			
Number of energy thresholds	2			
Threshold range [keV]	3.5 - 30			
Count rate (max.) [ph/s/pixel]	3.8×10^6			
Frame rate (max.) [Hz]	20	100	50	50
Sensor material	Silicon (Si)			
Sensor thickness [µm]	450			
Point-spread function (FWHM) [pixels]	1			
Vacuum compatibility	Optional			
Acquisition mode	Simultaneous read/write with zero dead time			
Cooling	Water	Water	Air	Air
Dimensions (W x H x D) [mm³]	235 x 237 x 372	114 x 133 x 240	100 x 140 x 93	100 x 140 x 93
Weight [kg]	15	4.7	1.8	1.8

All specifications are subject to change without notice.

EIGER 2 R CdTe

All the Advantages of HPC Technology for High-Energy Applications

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 you are using high-energy sources or a dual-wavelength setup. Their unprecedentedly high count-rate capability, enabled through 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

Integrated **DECTRIS Instant Retrigger** technology for superior count rates.

Direct detection and a small pixel size for the best spot separation, minimal background overlap and better signal-to-noise ratio.

The highest possible dynamic range thanks to zero detector background, superior count rates, and simultaneous read/write.

Zero readout noise or dark current thanks to digital counting and readout, enabling the best signal-to-noise ratio.

Dual-energy discrimination for suppression of low- and high-energy background.

Applications

- Single-crystal X-ray diffraction
- Powder X-ray diffraction
- SAXS/WAXS
- µCT

Technical Specifications

EIGER 2 R	CdTe 4M	CdTe 1M	CdTe 500K
Active area (W x H) [mm²]	155.1 x 162.2	77.1 x 79.7	77.1 x 38.4
Pixel array (W x H)	2,068 x 2,162	1,028 x 1,062	1,028 x 512
Pixel size (W x H) [µm²]	75 x 75		
Energy range [keV]	8 - 25 (8 - 100)[1]		
Number of energy thresholds	2		
Threshold range [keV]	4 - 30 (4 - 80)[1]		
Count rate (max.) [ph/s/pixel]	5.5×10^6		
Frame rate (max.) [Hz]	20	100	100
Sensor material	Cadmium telluride (CdTe)		
Sensor thickness [µm]	750		
Point-spread function (FWHM) [pixels]	1		
Vacuum compatibility	Optional		
Acquisition mode	Simultaneous read/write with zero dead time		
Cooling	Water		
Dimensions (W x H x D) [mm³]	235 x 237 x 372	114 x 133 x 242	114 x 92 x 242
Weight [kg]	15	4.7	3.7

All specifications are subject to change without notice.

[1] With optional extended energy range calibration

MYTHEN 2 R

Scan-Free Data Collection

MYTHEN2 modules come with 1,280 (1K) or 640 (1D) strips. Depending on the geometry of the instrument, a 1K module can collect either 25° 2θ of diffraction data or a 1.24 eV wide-energy spectrum [3]. For even wider coverage, up to four modules can be operated simultaneously, using a single Detector Control System (DCS4).

Premium Resolution With a 50-µm Strip

MYTHEN2 provides unprecedented resolution, thanks to the narrowest strip currently available on the X-ray market. Diffractometers equipped with a MYTHEN2 detector achieve a resolution of 0.03° 2θ (FWHM) [1], while the resolution of WD-XRF-spectrometers can reach 2 eV [2].

Energy Range from 4 to 40 keV

The wide MYTHEN2 portfolio comprises four sensor geometries, each optimized to deliver the optimal efficiency and signal-to-noise ratio for a chosen energy range. The combination of 320-µm sensor thickness and a 4-mm strip length allows detection of energies as low as 4 keV. The 1,000-µm sensor provides high efficiency, even for Mo or Ag radiation.

Key Advantages

DR

High dynamic range with up to 10^6 counts/s per strip.

Premium resolution, owing to 50-µm strip.

Fluorescence suppression.

Energy range from Ti to Ag.

Hz

Continuous scanning, thanks to a **high frame rate**.

Zero readout noise or dark current thanks to digital counting and readout, enabling the best signal-to-noise ratio.

Applications

- PXRD analysis
- PDF analysis
- SAXS, WAXS, GISAXS
- Residual stress analysis
- X-ray reflectometry
- WD-XRF, EXAFS, XANES

[3] Sato, K. et al. (2017) X-Ray Spectrom. 46, 330-335.

[1] www.stoe.com/wp-content/uploads/2014/03/STOE_STADI_P-1.pdf
[2] Németh, Z. et al. (2016) Rev. Sci. Instrum. 87, 103105.

Technical Specifications

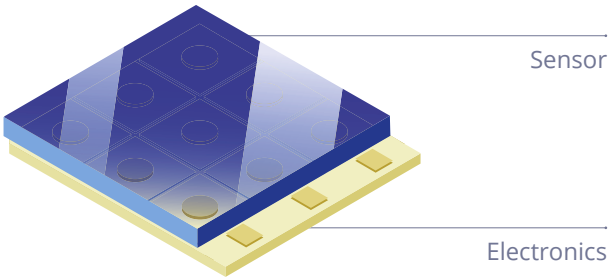
MYTHEN 2 R	1K	1D
Strip width [µm]	50	
Strip height [mm]	8	8 (450 µm only) 4 (320 µm only)
Active area (W x H) [mm²]	64 x 8	32 x 8 (450) 32 x 4 (320)
Energy range* (depending on the sensor thickness) [keV]	5 - 40 (320) 6.6 - 40 (450) 7.4 - 40 (1,000)	4 - 40 (320) 6.6 - 40 (450)
Threshold range (depending on the sensor thickness) [keV]	4.5 - 20 (320) 5.5 - 20 (450) 6.0 - 20 (1,000)	3.5 - 20 (320) 5 - 20 (450)
Frame rate (max.) [Hz]	100	
Count rate (max.) [ph/s/strip]	10^7	
Readout time [µs]	89	
Strips per module [strips]	1,280	640
Sensor material	Silicon (Si)	
Sensor thickness [µm]	320, 450, or 1,000	320 or 450
Point-spread function [strips]	1	
Vacuum compatibility	Optional	
Module dimensions (W x H x D) [mm³]	70 x 62 x 22	36 x 62 x 22
Cooling method	Air	

* X-ray energies down to 4 keV are available only with the 320 µm x 4 mm sensors.

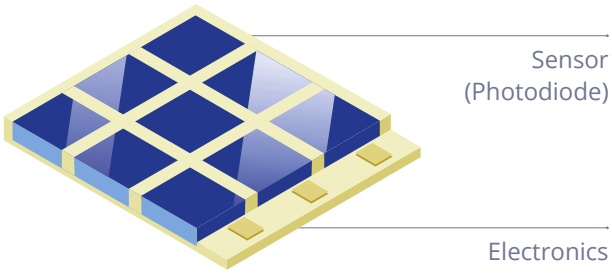
Hybrid Photon Counting

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 or compromising quantum efficiency.



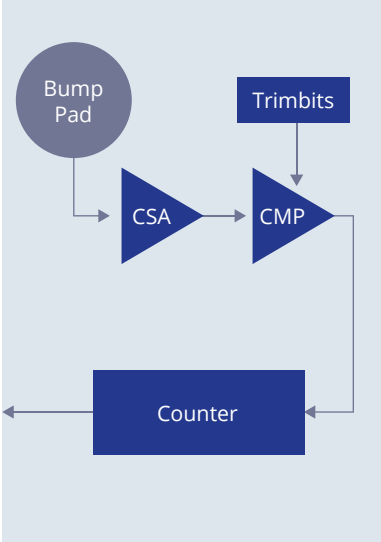
Hybrid-Pixel Detector



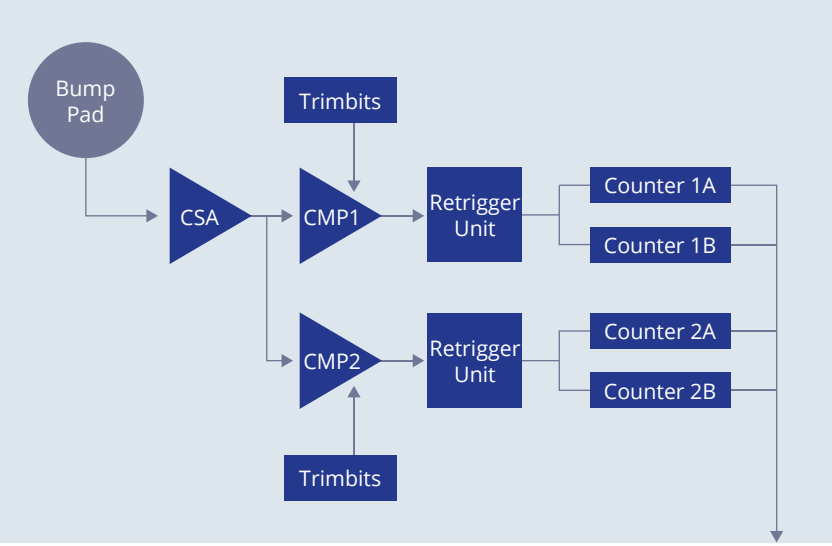
CMOS Active Pixel Sensor

Highly Advanced HPC Chip

EIGER2 features one of the most advanced Application-Specific Integrated Circuits (ASICs) 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 you to take advantage of both dual-energy discrimination and simultaneous read/write 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.**



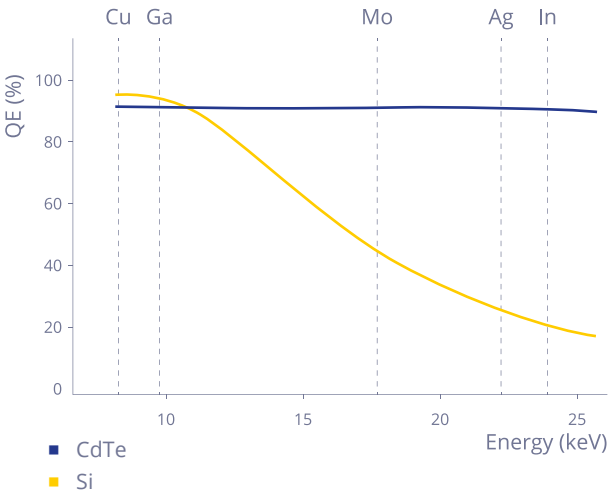
Schematics of a single pixel in an **EIGER2 ASIC.**

High Quantum Efficiency

Direct detection enables high quantum efficiency that is 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 Cu to In. 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 Cu and Ga 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.

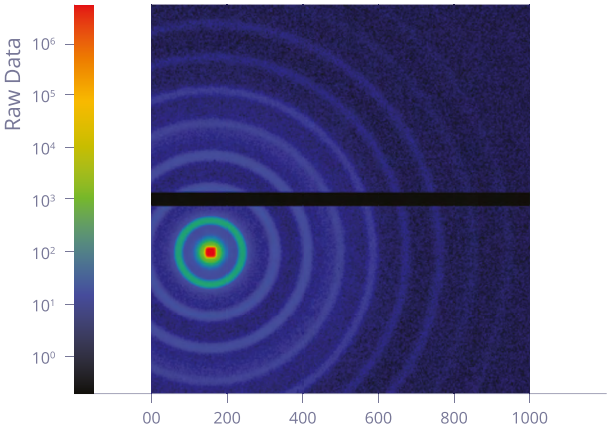
EIGER2 R detectors with silicon sensors achieve 94% quantum efficiency for Cu and Ga radiation. They are the perfect companion for any such laboratory source. The decreasing quantum efficiency for shorter wavelengths of this sensor material can be compensated for by increasing exposure times. Thanks to the absence of detector background, as well as the suppression of experimental background with EIGER2's dual-energy discrimination, this strategy also enables excellent data quality for high X-ray energies.



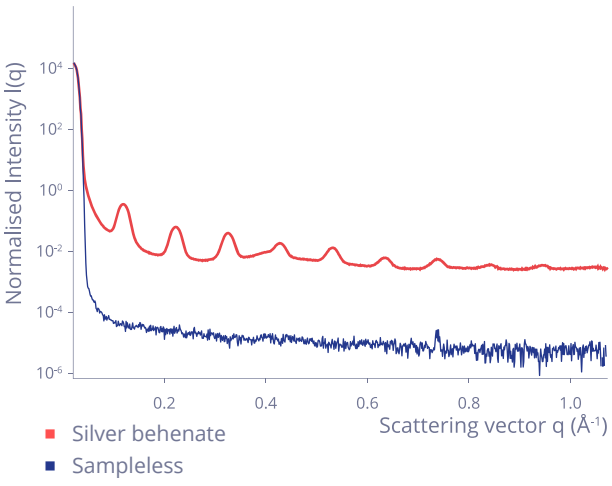
Quantum efficiency (QE) of EIGER2 R CdTe (blue) and EIGER2 R (yellow) with silicon sensors.

The 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.



The WAXS signal of Silver behenate (AgBH). The data were acquired with an EIGER2 R 1M in a Xeuss3.0 SAXS/WAXS instrument from Xenocs.

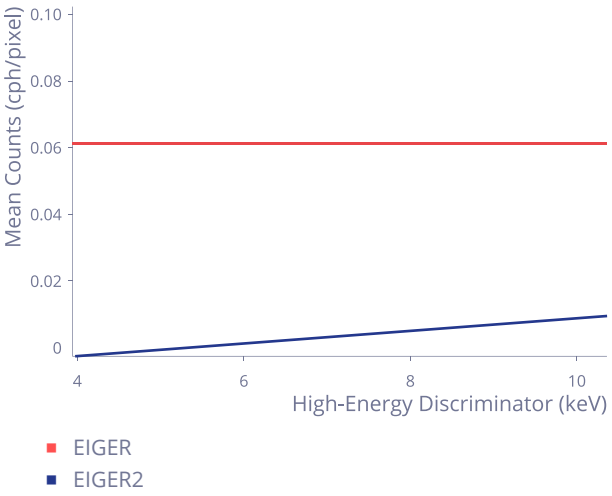


The WAXS signal of Silver behenate (AgBH). This dual plot of AgBH's signal and a negative control shows that the dynamic range of EIGER2 R detectors easily covers the more than ten orders of magnitude that are needed for weakly scattering samples.

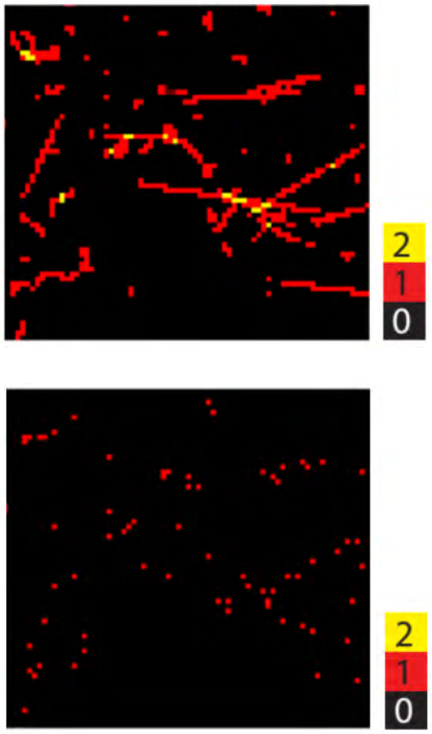
Background Suppression

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. Red line: Dark counts for EIGER with a single energy discriminator set at 4 keV. Blue line: Dark counts for EIGER2 R with a low-energy discriminator at 4 keV as a function of a high-energy discriminator setting.

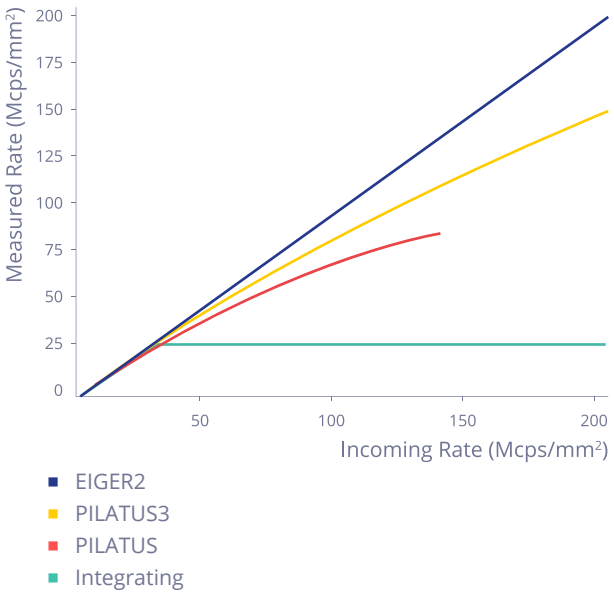


Identical regions obtained through a 1-hour dark exposure of an EIGER2 R detector. Top: Counts obtained with a low-energy discriminator at 4 keV. Bottom: The difference between the counts with a high-energy discriminator at 10 keV and the counts with a low-energy discriminator at 4 keV.

Superior Count-rate Performance

DECTRIS HPC detectors are designed to match the high count-rate requirements of synchrotron sources, but 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.

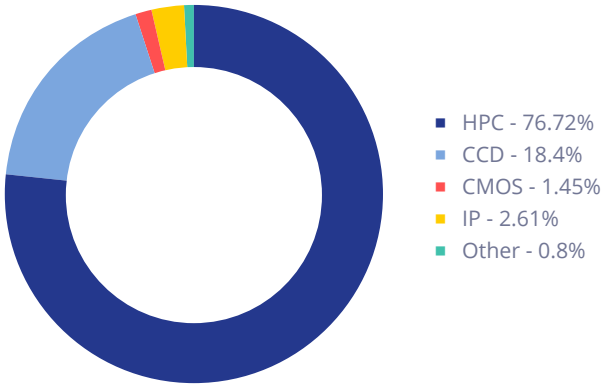
Thanks to its superior count-rate performance, EIGER2 R is the best match for state-of-the-art laboratory sources. It provides high accuracy for strong intensities, without saturation issues, and even allows for measurement of a direct beam.



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 nowadays, the technology is not providing the field of protein structure determination. About 77% of the X-ray-identified structures released in the Protein Data Bank from January to November 2022 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.



X-ray detector technologies used in PDB releases – 2022.

[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.

OEM Partners

DECTRIS EIGER2 and **MYTHEN2** detectors are integrated in diffractometers and residual stress analyzers made by the following producers:

- Anton Paar
- Bruker AXS (EIGER2)
- Forvis Technologies
- GNR (MYTHEN2)
- HP Spectroscopy (EIGER2)
- Huber Diffraktionstechnik
- marXperts (EIGER2)
- PHOTRON-X
- Proto
- Rigaku (EIGER2)
- Sirius X-ray Solutions
- STOE & Cie
- Xenocs (EIGER2)
- XRD Eigenmann

Table of Contents

DECTRIS AG

Taefernweg 1
5405 Baden-Daettwil
Switzerland
+41 56 500 21 00

sales@dectris.com
support@dectris.com

www.dectris.com

DECTRIS USA Inc.

1500 Walnut Street, Suite 1630
Philadelphia, PA 19102
USA
+1 215 384 3479

DECTRIS Japan K.K.

Nakagawa building 801
3-37 Higashi-Nobusue
Himeji-shi
Hyogo 670-0965
Japan
+81 (0)79 280 9585

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"DECTRIS EIGER": AUS, CH, CN, EU, JP, KR, UK, USA
"DECTRIS MYTHEN": AUS, CH, CN, EU, JP, KR, UK, USA

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