# Application example: XPCS and rheology in colloids

**Spectrum**

The LAMBDA pixel detector is designed for high-end X-ray experiments, particularly at synchrotron sources. It achieves an extremely high image quality by combining effectively noise-free photon-counting operation with a small pixel size of 55 μm. For fast and time-resolved experiments, LAMBDA can be read out at up to 2000 frames per second with no time gap between images. But speed and resolution are not the only thing LAMBDA excels at, you can find a more information at www.x-spectrum.de . Or contact us anytime at info@x-spectrum.de

Every version of the LAMBDA pixel detector is available with different sensor layers for different X-ray energy ranges. For hard X-ray detection, the GaAs and CdTe LAMBDA systems replace the standard silicon sensor layer in LAMBDA with a "high-Z" (high atomic number) sensor. This provides high quantum efficiency at high X-ray energies (75% at 40 keV for GaAs, and 75% at 80keV for CdTe), while retaining single-photon-counting performance and our high frame rate of up to 2 kHz. Upon request we also provide LAMBDA versions that can be operated in vacuum.

Ever since the first prototypes of the LAMBDA camera have been developed it has been used in different applications. The following example has been chosen to demonstrate the capabilities of the system. LAMBDA has already found its way into routine operation at a few light sources, so the following example highlight only a fraction of the many possible ways LAMBDA cameras can be used.

## Key features:

- **Effectively zero noise (photon counting)**
- **55 μm pixel size**
- **Up to 2000 frames per second**
- **Deadtime-free readout**
- **up to 1536 by 1536 pixels (85 x 85 mm$^2$)**
- **Energy binning capability**





*Comparison of different LAMBDA sizes; a 750K single module of 1528 x 512 pixels and a 2M system with three-module system and 1528 x 1536 pixels.*

# XPCS and rheology in colloids

X-ray Photon Correlation Spectroscopy is a technique for studying dynamics in soft matter. If a beam of coherent X-rays is fired at a sample with an irregular structure, such as colloidal particles in a liquid, the resulting diffraction pattern will contain speckles whose positions depend on the particular arrangement of particles. As the particles move, the speckles will fluctuate, and by measuring this fluctuation information about the particle dynamics can be obtained. This experimental technique requires a combination of high speed, high sensitivity and small pixel size to successfully measure these fluctuations, which means that a detector like LAMBDA is particularly well-suited to XPCS.

A rheometer is an experimental setup for measuring the viscoelastic properties of material. A fluid sample is placed between a pair of plates, and the plates can then rotate or oscillate to produce different shear forces on the fluid and measure the corresponding deformation. By combining rheology with X-ray diffraction techniques such as XPCS, it becomes possible to relate these macroscopic viscoelastic properties to the microscopic behaviour of the fluid. This has been demonstrated with LAMBDA [1]. For example, these experiments demonstrate that an effect called "shear thinning", where a colloidal sample becomes less viscous as the shear force on the colloid increases, occurs when the spacing of particles along the direction of flow becomes less regular. In these experiments, the X-ray beam passed vertically through the rheometer to reach the detector. This meant that the distance between source and detector was limited, and so the small pixel size of LAMBDA was a particularly important requirement.

[1] Westermeier, Fabian, et al. "Connecting structure, dynamics and viscosity in sheared soft colloidal liquids: a medley of anisotropic fluctuations." *Soft matter* 12.1 (2016): 171-180.