Novel crystallography beamline takes delivery of in vacuum X-ray detector

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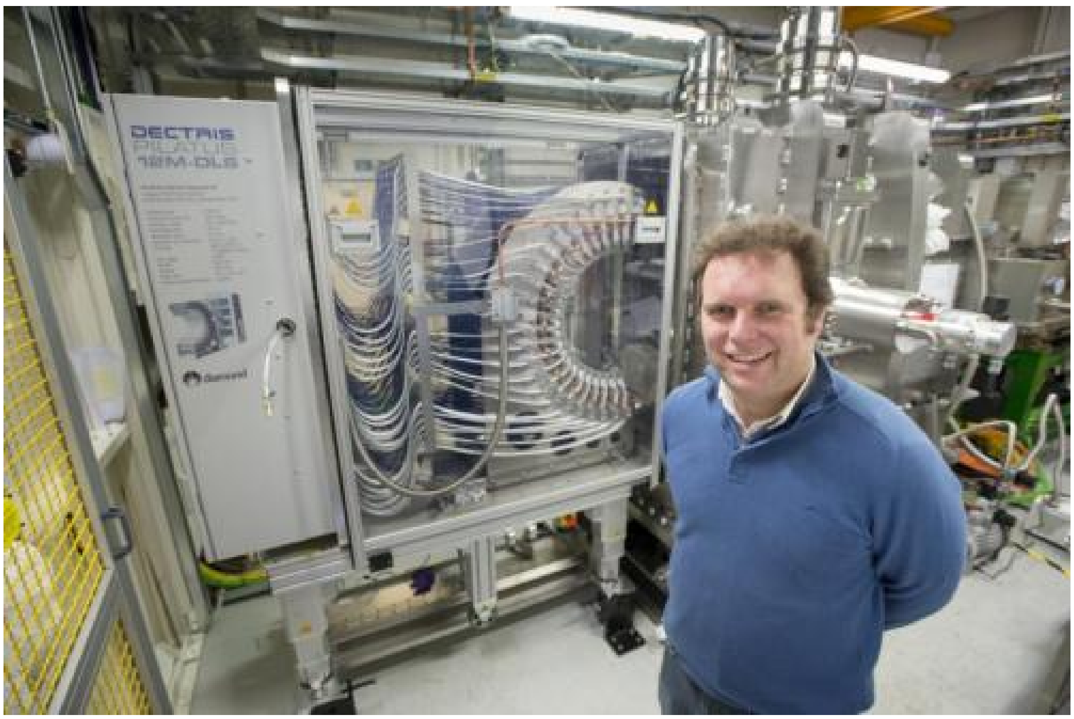

Credit: Diamond Light Source

Diamond Light Source, the UK's national synchrotron science facility, is celebrating an important milestone this month as a 2 year project to design and build a highly specialised in vacuum X-ray detector for its new long wavelength life science beamline enters the commissioning phase. The beamline, one of the most ambitious macromolecular crystallography (MX) beamlines to be built anywhere in the world, will facilitate challenging research on DNA, RNA, native proteins and other building blocks of life.

Beamline I23, which is currently under construction as part of Diamond's Phase III development, is the Long Wavelength Macromolecular Crystallography beamline, optimised for operation in the wavelength range 1.5 to 4 Å, and its' detector requirements have taken the I23 team and specialist detector company DECTRIS Ltd. into uncharted territory.

Armin Wagner, Principal Beamline Scientist for I23, explains:

"This beamline, which will come online for first users this summer, will be an important additional tool for crystallography at Diamond. It will utilise long wavelength X-rays and, in doing so, offer a unique facility for carrying out challenging research on DNA, RNA, native proteins and other building blocks of life. To facilitate this, we need an in vacuum detector that is calibrated for low-energy X-rays. When we began this project, no such detector was commercially available so we worked with our in-house detector group on initial design concepts and tests."

Two years ago, when Diamond was satisfied that such as detector was feasible using the latest technology, the company tendered and DECTRIS was brought on board to help turn an ambitious in vacuum low-energy detector development project into a reality.

From a global perspective, I23 is one of the most ambitious MX beamlines ever built. The scientific goal, to use long wavelengths to tackle the crystallographic phase problem, has long been hampered by strong air absorption and large scattering angles. However, this approach is vital for projects where protein labelling to introduce anomalous scattering is not feasible. The beamline's wavelength range will also provide access to the M-edges of elements, with huge anomalous signals offering new opportunities for phasing large molecular complexes.

Together, DECTRIS and the I23 team have built a solution that effectively overcomes the issues of strong air absorption and large scattering angles. By placing the sample and the detector in vacuum air absorption and scattering effects can be eliminated.

The semi-cylindrical shape of the PILATUS 12M-DLS detector covers a 2θ range of ±100°, enables researchers to simultaneously collect low- and high-resolution data over a large range of diffraction angles. A multi-axis goniometer will be available for crystal alignment and orientation. In addition, an X-ray tomography setup will be integrated into the beamline end station to obtain the crystal shape and volume as a basis of an analytical absorption correction.

While DECTRIS drew on its expertise in constructing vacuum-compatible detectors with custom geometries, the I23 team was able to focus on other engineering challenges such as transferring and cryo-cooling protein crystals in vacuum.

The 12M-DLS detector consists of 120 PILATUS detector modules mounted on a high precision frame to form a semi-cylindrical shape. With an active area of 0.34 m2, this is the largest PILATUS detector ever built. The detector can detect X-rays with low energies like 1.8 keV and it is vacuum compatible down to a pressure of 10-6 mbar. The modules are water-cooled and the system is built without a single direct water-to-vacuum connection, which greatly reduces the risk of vacuum contamination. For performance and maintenance reasons the read-out electronics are placed in an electrical cabinet outside the vacuum chamber. The electrical connections between the modules and the read-out electronics involve over 400 m of vacuum cabling and over 6700 vacuum-to-air feedthrough pins. Finally, the electrical and software interface is identical to a standard PILATUS3 detector. Therefore the integration is very simple and it is also possible to use existing tools.

Benjamin Lüthi , the DECTRIS project manager PILATUS 12M-DLS, adds:

"On previous specific solution projects we (DECTRIS Ltd.) have gained extensive experience with in-vacuum detectors, custom geometries and special energy calibrations. But the combination of the three on such a high level posed some real challenges. The results from the initial tests of the PILATUS 12M detector at the beamline exceed our expectation and we feel rewarded after all the hard work and many careful thoughts that went into this elaborate design."

Armin Wagner, Principal Beamline Scientist for I23, concludes:

"While MX is a well established technique at synchrotrons with contributions to 28 Nobel prizes, this unique, cutting edge project enters new scientific ground by pushing technological boundaries. I23 will allow scientists to get direct access to three dimensional images of their samples, without having to go through the additional step of modifying their samples, giving them a closer eye on the biological elements that make up the natural world. We are very much looking forward to welcoming our first researchers to the beamline this summer, and to many years of exciting biology in the years to come."

More information: For more information on Diamond's Long Wavelength Macromolecular Crystallography beamline (I23), please visit www.diamond.ac.uk/Beamlines/Mx/I23.html

Provided by Diamond Light Source