Improvement of SAXS Lab Equipment by Using Scatterless Apertures

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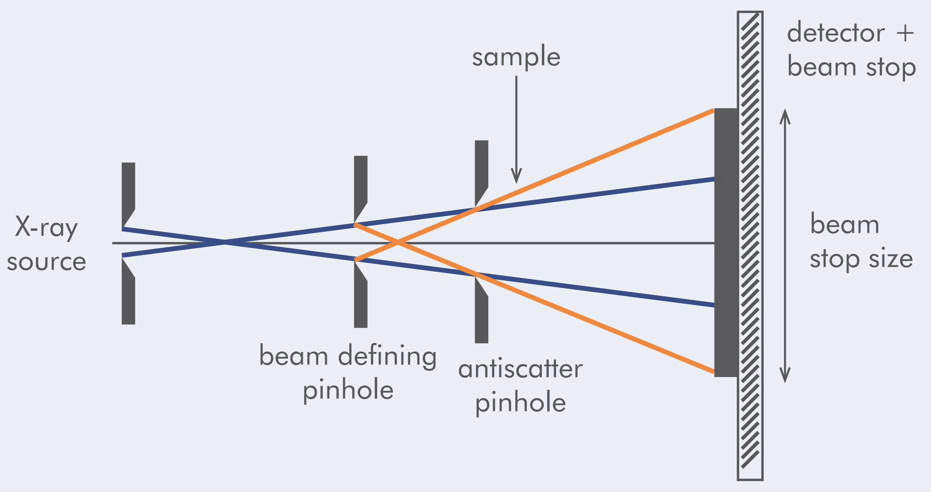
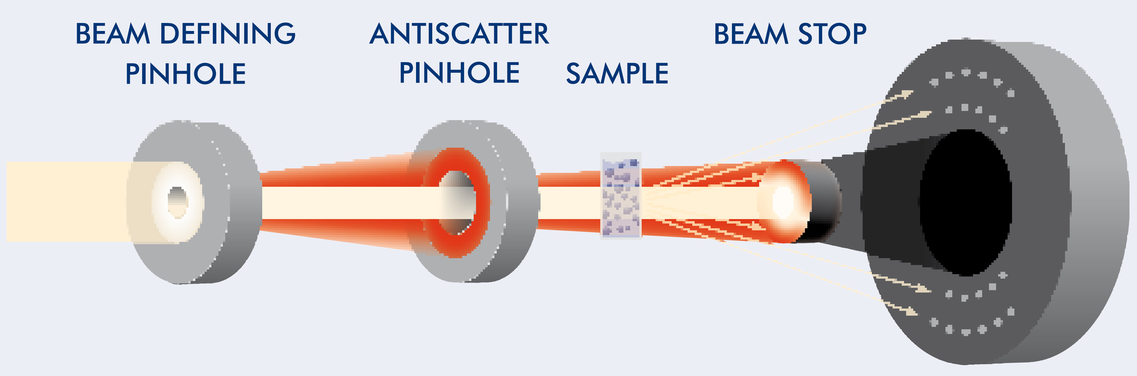
SCATEX - The New Scatterless Pinholes

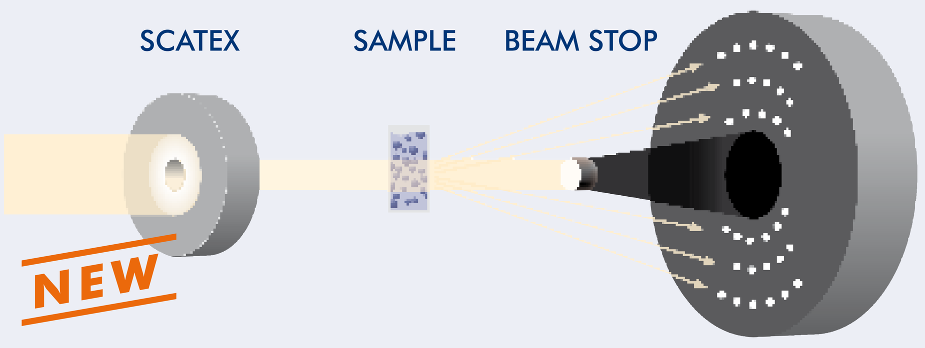
Parasitic scattering caused by apertures is a well-known problem in X-ray analytics, which forces users and manufacturers to adapt their experimental setups to this unwanted phenomenon. Increased measurement times due to lower photon fluxes, a lower resolution caused by an enlarged beam stop, a larger beam defining pinhole-to-sample distance due to the integration of an antiscatter guard and generally a lower signal-to-noise ratio leads to a loss in data quality.
The new SCATEX pinholes produce almost no parasitic scattering and overcome the aforementioned problems: hence, antiscatter pinholes become dispensable, system sizes shrink, resolution and photon flux increase, data quality improves.



A SAXS setup with a typical 3-pinhole collimation system. This illustration clearly shows that even with an antiscatter pinhole the beam stop needs a large diameter due to the parasitic scattering. With SCATEX pinholes the antiscatter pinhole becomes dispensable and the beam stop only needs to have the size of the primary beam. This enables a higher resolution and photon flux.

parasitic scattering
primary beam





- strongly reduced parasitic pinhole scattering
- resolution and photon flux enhancement
- easier and faster pinhole alignment
- no antiscatter pinhole needed
- diameters 30-2000 μm
- SCATEX-Ge for lower and SCATEX-Ta for higher energies

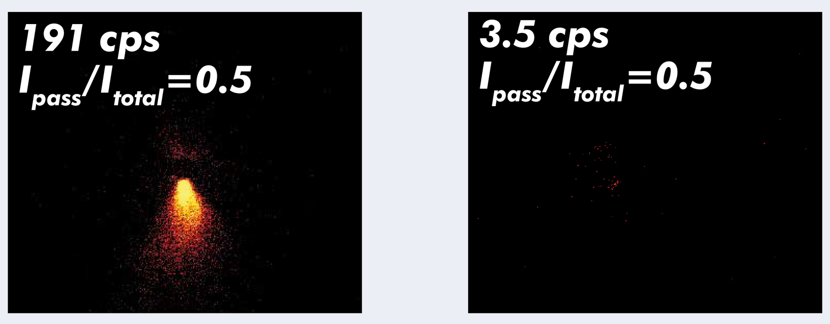
SCATEX Pinholes for SAXS Home-Lab Systems

Many SAXS home-lab instruments have a 3-pinhole collimation where the first two define beam size and divergence and the third antiscatter pinhole absorbs parts of the parasitic scattering. Here we show the potential of scatterless SCATEX pinholes for home-labs which improve the performance regarding photon flux and resolution while simultaneously shrinking the footprint of the instrumentation.

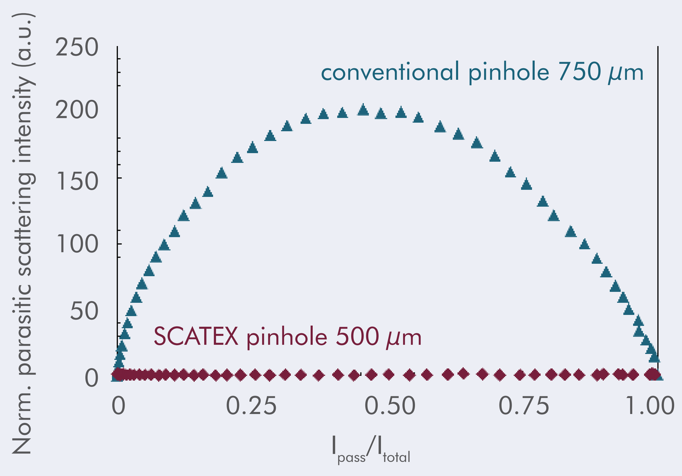
Measuring Parasitic Aperture Scattering

Pt/Ir Pinhole
- cause a two orders of magnitude higher parasitic scattering signal
- aperture scattering deep into the q-space

SCATEX-Ge Pinhole
- basically scatter-free
- parasitic scattering signal below the detection limit

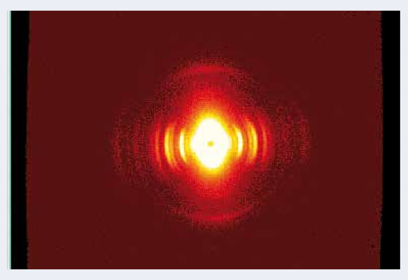


Detector images and corresponding count rates around the beam stop for 50% of the primary beam intensity passing the pinhole.

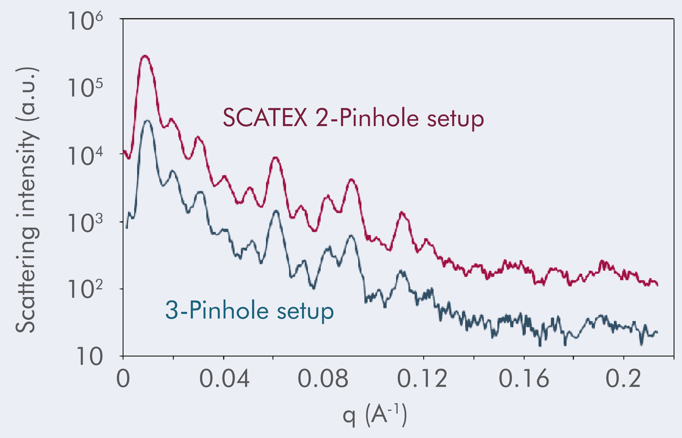


Measurement results of a SCATEX Ge and a conventional Pt/Ir pinhole. The apertures are driven stepwise into the X-ray beam while simultaneously measuring the parasitic aperture scattering around the beam stop. The parasitic scattering intensity is corrected for the dark current of the detector and for air scattering. The signal is normalized to a standard glassy carbon intensity in order to allow a comparison.

Comparison of a 2-Pinhole and a 3-Pinhole Setup



Detector image of a SAXS experiment: sample rat tail tendon



Advantages of a SCATEX 2-Pinhole Setup
- higher flux and smaller q_{min} possible due to a larger beam defining pinhole and a smaller beamstop
- faster data acquisition possible
- smaller footprint due to less pinholes

Scattering intensity vs. q-plot measured with a 3-pinhole high resolution NANOSTAR and a modified 2-pinhole NANOSTAR equipped with SCATEX pinholes. With a similar resolution the SCATEX setup gives a considerably higher scattering intensity.

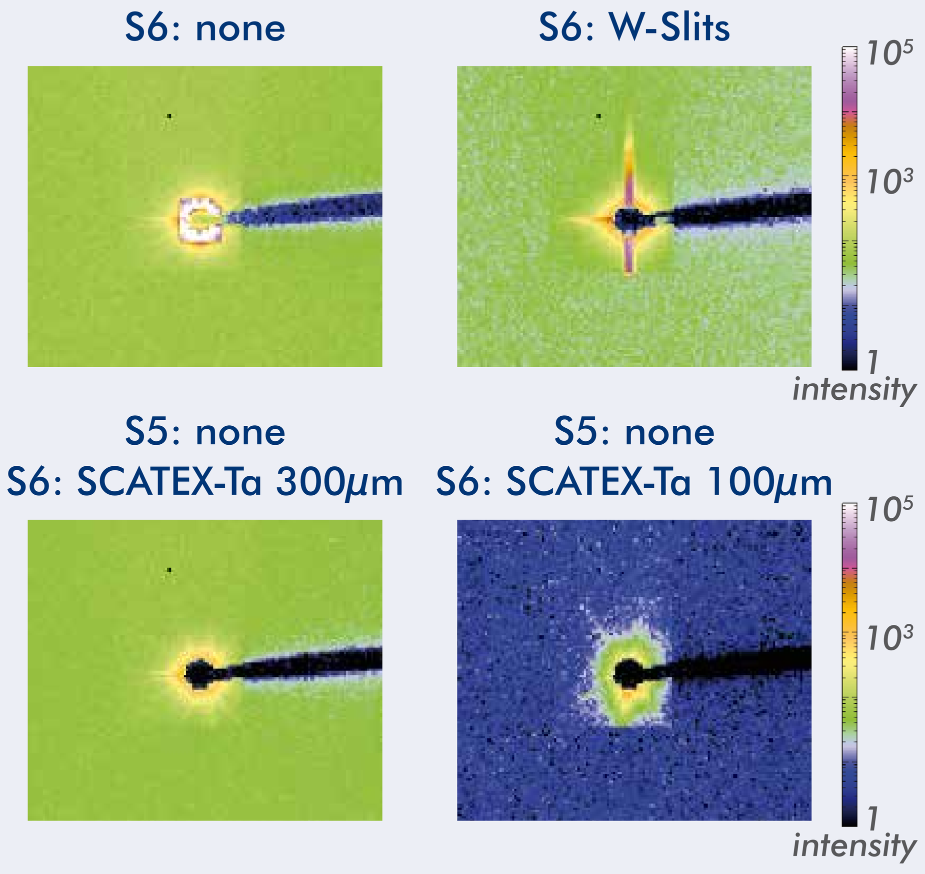
--- NEW --- quick&easy NANOSTAR upgrade available, no service needed --- NEW ---
SCATEX at 1st & 3rd position yields up to 19 times higher flux on sample @ constant bkg and q_{min}

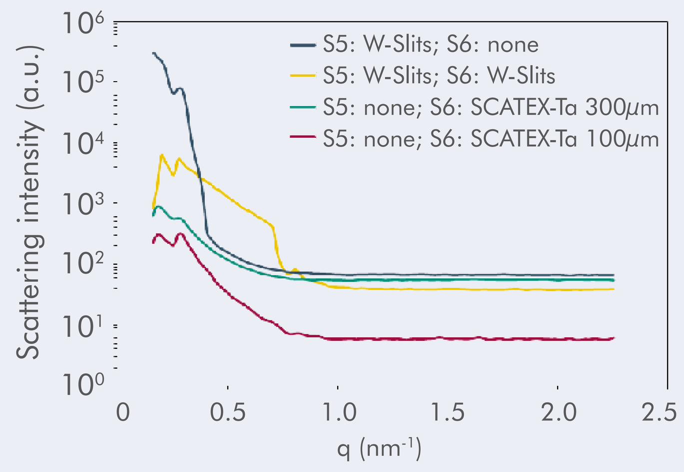
SCATEX Pinholes for Synchrotrons

Synchrotrons provide higher photon fluxes, higher resolution and often higher energies compared to home-lab instrumentations. Thus, in order to guarantee the best performance, apertures need to be of higher quality and should be made of a material suited for the dedicated energies. To fulfill these requirements we recommend SCATEX-Ge for energies below 11.1 keV and SCATEX-Ta for energies larger than 11.1 keV.

Comparison of Tungsten Slits and SCATEX-Ta Pinholes

The measurements were performed at 13 keV at the Nanofocus Endstation P03 beamline at PETRA III with typical photon fluxes of 10^{11}-10^{12} ph/s.





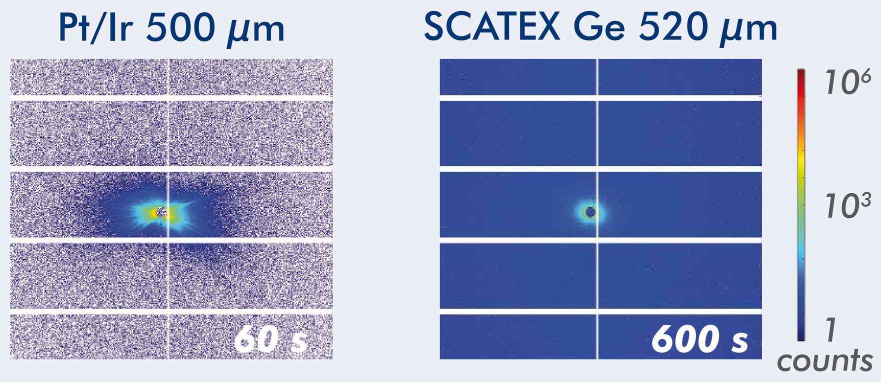
Scattering intensity vs. q-plot deduced from an integration along a full circle and normalized to the number of summed up pixel. Various apertures were tested at position S5 (beam definition) and S6 (scatter guard) (top).

Detector images of the parasitic aperture scattering at 13 keV. In the standard beamline setup S5 denotes the position of the beam defining aperture and S6 the position of the antiscatter aperture (pictures left).

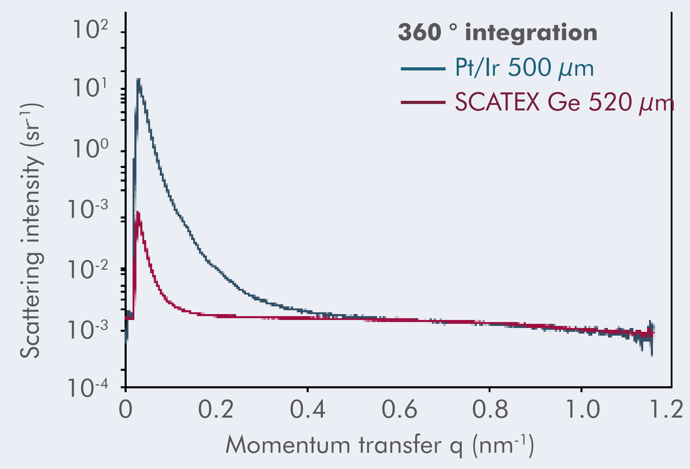
- a single SCATEX-Ta pinhole replaces both beam defining slit S5 and antiscatter slit S6
- the beam-defining SCATEX-Ta aperture can be positioned closer to the sample
- one order of magnitude less parasitic aperture scattering with SCATEX pinholes made of Tantalum compared to the standard setup with Tungsten slits

Comparison of SCATEX-Ge with other Pinholes and Scatterless Ge Slits

The corresponding measurements were performed at the PTB four-crystal monochromator beamline at BESSY II at 8 keV with a typical photon flux in the range of $4*10^9$-$4*10^{10}$ ph/s. The tested apertures were aligned centric into the primary beam.

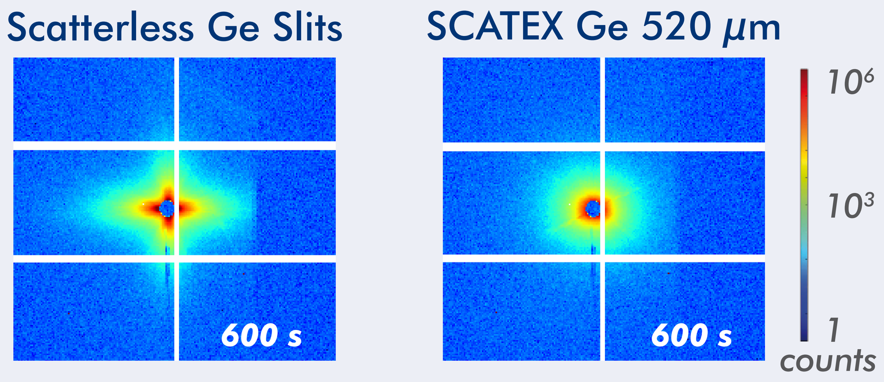


Detector images of the parasitic aperture scattering at 8 keV.

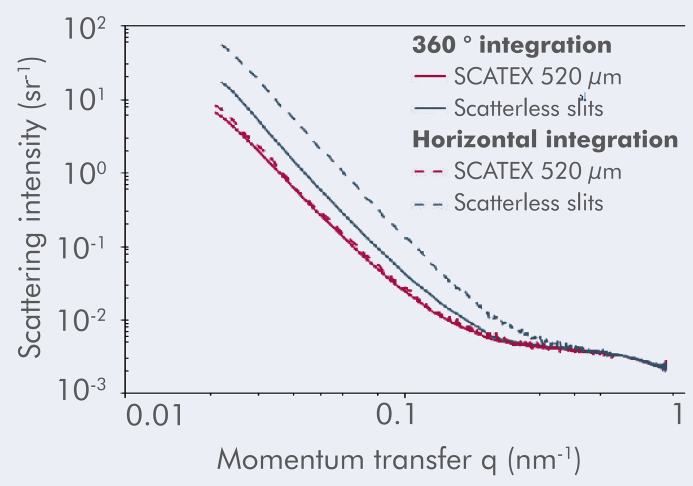


Scattering intensity deduced from the detector images and corrected for the different measurement times and normalized to the photon flux upstream of the tested aperture.

SCATEX-Ge Pinholes
- allow 10 times longer exposure time
- 2 orders of magnitude less parasitic scattering
- much less scattering into the q-space
- scattering pattern is circular, thus showing the high overall structural quality of the pinhole



Detector images of the parasitic aperture scattering at 8 keV of scatterless Ge slits and of a SCATEX pinhole made of Ge.



Scattering intensity vs. q-plot deduced from the integration in horizontal direction with an opening angle of 5° and from an integration along a full circle. The data is normalized to the photon flux downstream of the test aperture and to the solid angle.

SCATEX-Ge Pinholes
- up to 8 times less parasitic aperture scattering
- guarantee higher data quality and faster data acquisition

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