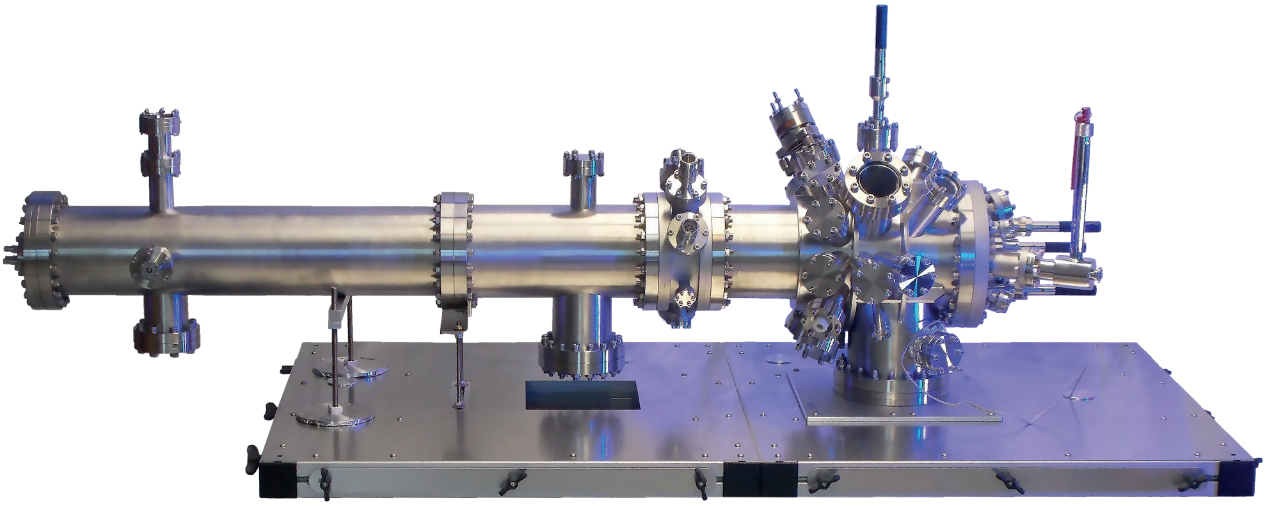
Time-Of-Flight Momentum Microscope with Spin Imaging Option



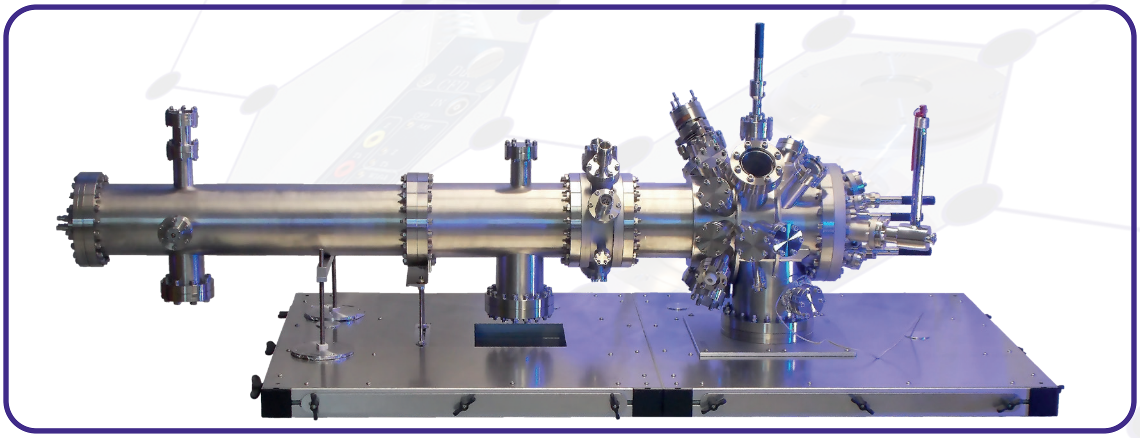
SURFACE CONCEPT

Time-Of-Flight Momentum Microscope with Spin Imaging Option

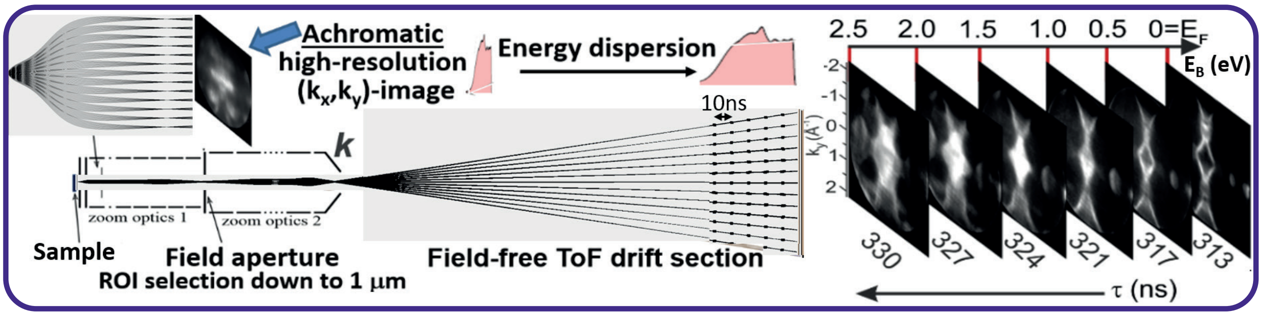
Momentum microscopy and spectroscopy system: Time-of-Flight and parallel imaging spin analysers based on the spin dependent reflection on Ir or Au/Ir, patented spin filter principle

The patented [patents DE102013005173C5 and DE102014018555B3] Time-Of-Flight Momentum Microscope images the full emission hemisphere ($2\pi k^2$) k-space out of a selectable real space sample area down to a diameter of <1µm, a novel type of ARPES.

- Momentum resolution <0,01Å^{-1}
- Spatial resolution <50nm
- Energy resolution <20meV
- L-He cooled sample stage available
- Parallel spin imaging available

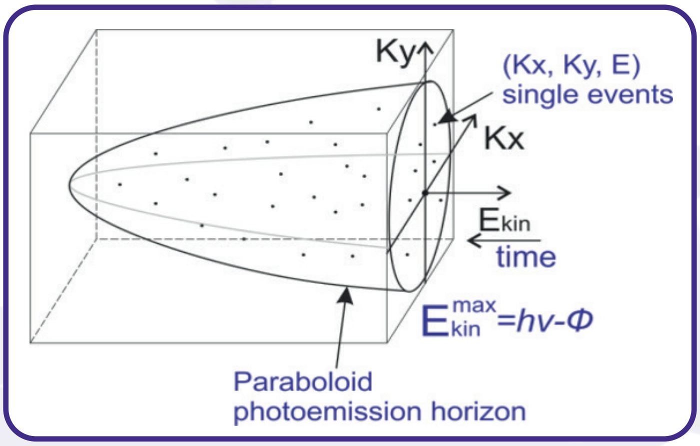


The ToF Momentum Microscope works this way: The zoom optics 1 select a real-space sample area, the switching between real-space and k-space-image is done by the zoom optics 2.



[Medjanik et al., Nature Materials, 16(6):615-621(2017)]

The user can access the full space of the photoemission paraboloid from work function cut-off to Fermi edge during one measurement (verified for excitation energies up to 21.7eV). The optics directly image the angular distribution in k_x and k_y (isogonic), no further transformation is necessary.

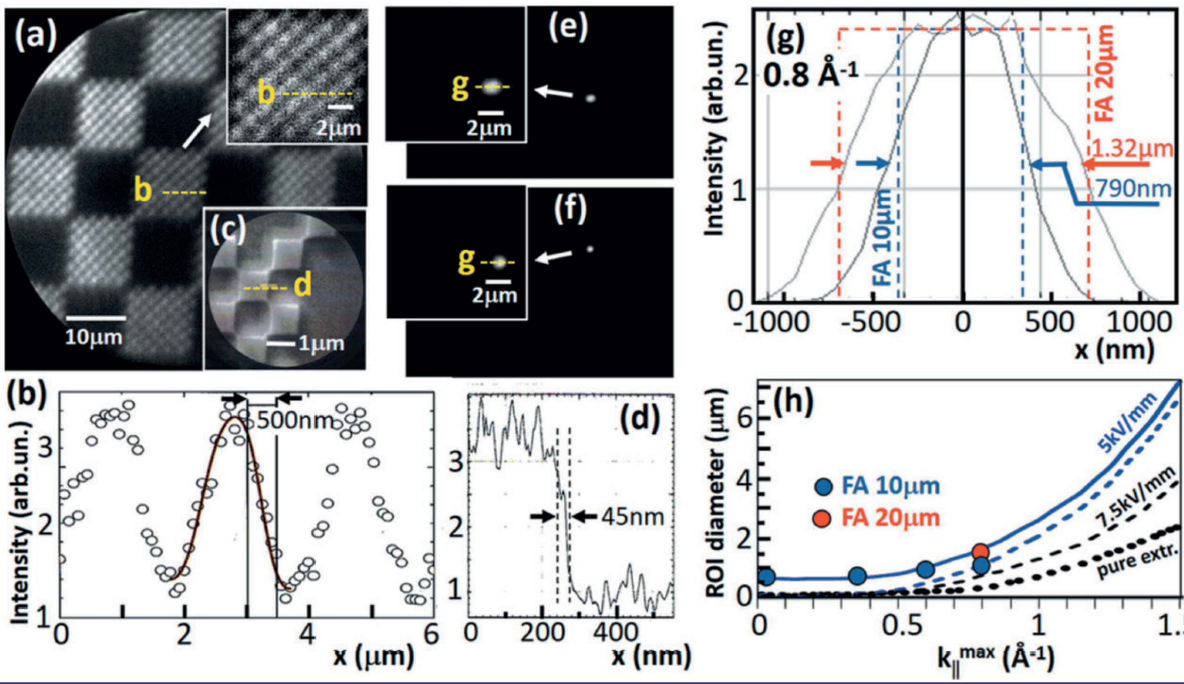


Microscope Specification Parameters

Technical specifications for a complete Momentum Microscope system including the hexapod sample stage

Energy Resolution:	< 20meV (17meV shown with Drift Voltage 10V)
Simultaneously focused energy range:	Up to 10eV
Momentum Resolution:	< 0.01A^{-1}
Momentum Resolved Range:	+/- 3A^{-1}
Lateral Resolution:	< 50nm
Real Space Field of View:	11...1000µm
Piezo driven Contrast Aperture:	3 aperture sizes and a 200 mesh (x/y adjustable)
Piezo driven Field Aperture:	9 aperture sizes (down to 10µm possible) and a 200 mesh (x/y adjustable)
Motorized Manipulator:	6 axis (Hexapod) which makes in situ sample tilt adjustment possible (e.g. for cleaved samples)
Temperature Range:	< 15K...400K (< 9K lowest value shown)

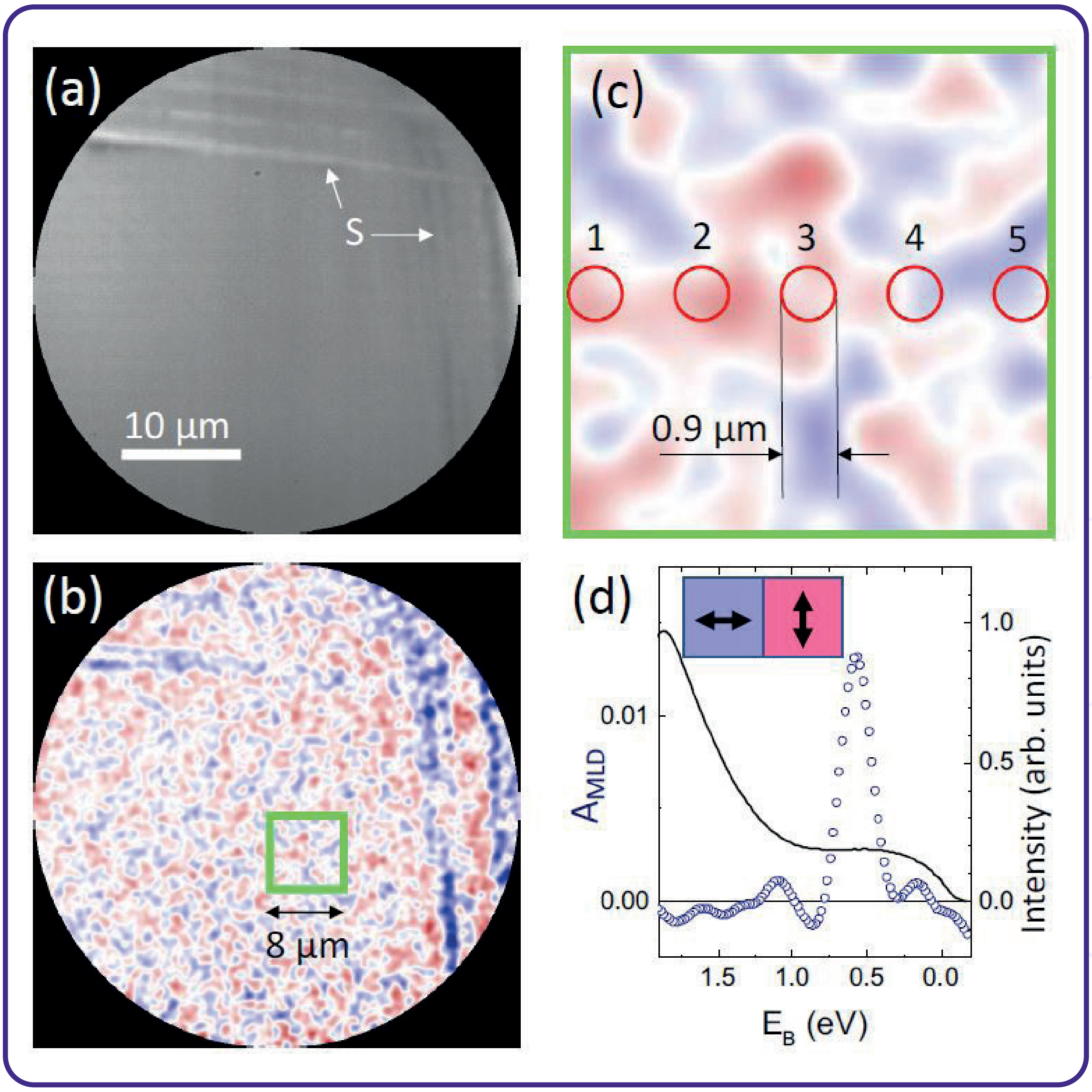
Sub-Micron Areas in Real Space are now accessible for ARPES



Small-area momentum microscopy using small field apertures. Results taken for an Au checkerboard structure ('Chessy', Plano GmbH) with fully open field aperture (a) and apertures of 20 μm (e) and 10 μm (f). (c) Resolution limit in PEEM mode. (b, d, g) Line scans along the dashed lines in (a, c, e and f). Dashed square profiles in (g) denote the widths expected for an ideal, aberration-free lens. (a, b, e – g) Measured at the Fermi edge of the Au structure at E_{kin} = 2.5 eV, corresponding to k^{max} = 0.8 Å^{-1}. (h) ROI diameter as a function of k^{max} as measured for field apertures of 20 μm (red dot) and 10 μm (blue dots) and as calculated for the full lens optics at field E = 5 kV mm^{-1} in the small-aperture limit (dashed blue curve) and for a 10 μm aperture (full blue curve). For comparison, the small$^{||}$aperture limits for E = 7.5 kV mm^{-1} and for the pure extractor field of 5 kV mm^{-1} are also shown [all curves from C. Tusche et al., Ultramicroscopy 159, 520-529 (2015)].

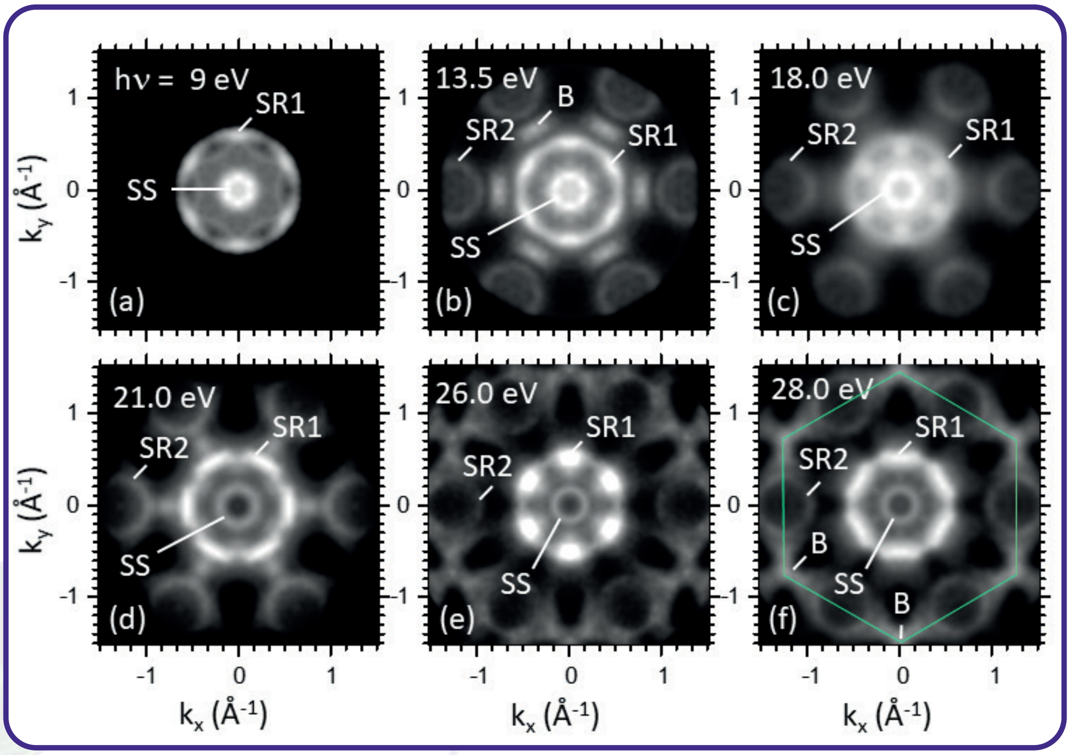
[G. Schönhense et al., J. Synchr. Radiation 28, 1891 (2021)]

Resolving Micro-Sized Antiferromagnetic Domains in Mn_2Au Antiferromagnetic Parity Violation (APV)



(a) PEEM image of the $Mn_2Au(100)$ sample surface obtained with 6.4 eV photon energy. Scratches (S) on the otherwise homogeneous surface serve for position determination. (b) Magnetic linear dichroism (MLD) image for the area as in (a) with colour (red/blue) coded asymmetry AMLD = $(I_p - I_s)/(I_p + I_s)$ (E_B = 0.6 eV, p- and s-polarized light). (c) Magnified image from the green square indicated in (b). The five numbered circles define the regions of interest selected by the field aperture that are used for momentum microscopy. (d) Intensity (black line) and MLD asymmetry, AMLD, (circles) vs. E_B

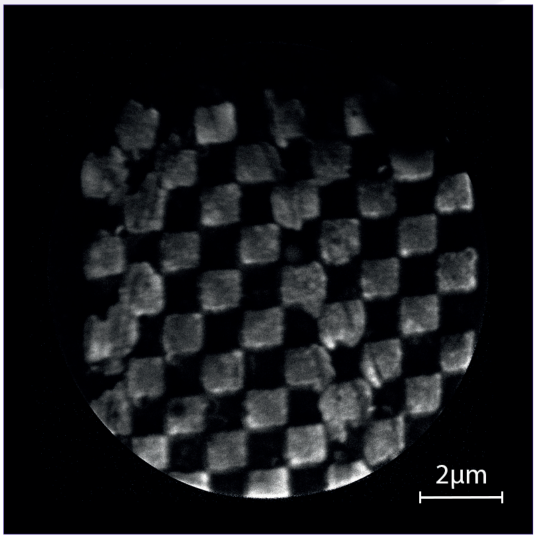
[H. J. Elmers et al., arXiv:2110.12186 (2021)]



Constant-energy maps measured at various photon energies of Re (0001)

[H.J. Elmers et al., Phys. Rev. Research 2, 013296 (2020)]

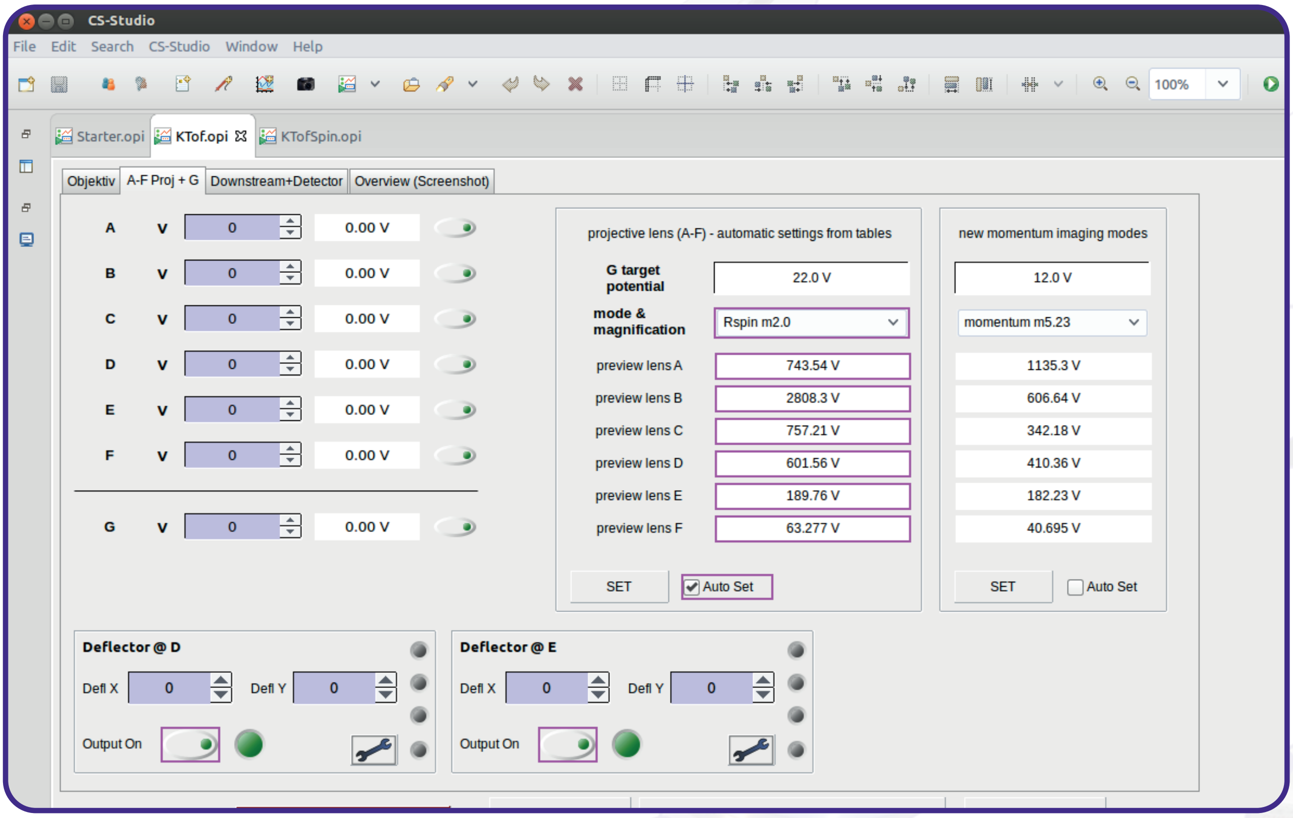
Real space image of 1µm^2 squares of Au on Si (Chessy). Even imperfections on the sample surface such as scratches and contaminations are visible.



EPICS based Measurement Software

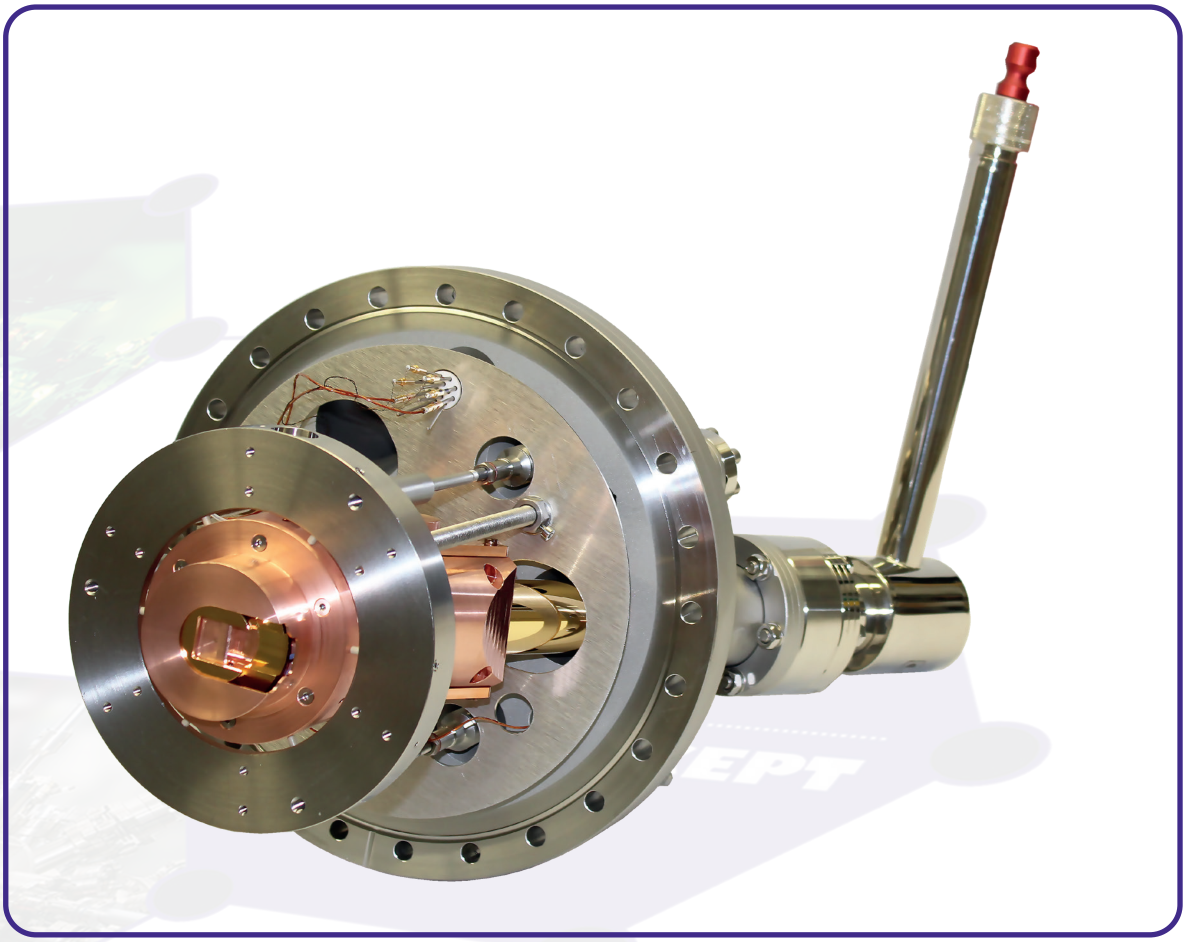
The EPICS (https://epics-controls.org) based software supports fully remote controlled measurements via network. The server-client architecture enables customized, automatic measurement routines via user scripts.

You can integrate additional customer specific devices by implementing further EPICS modules.



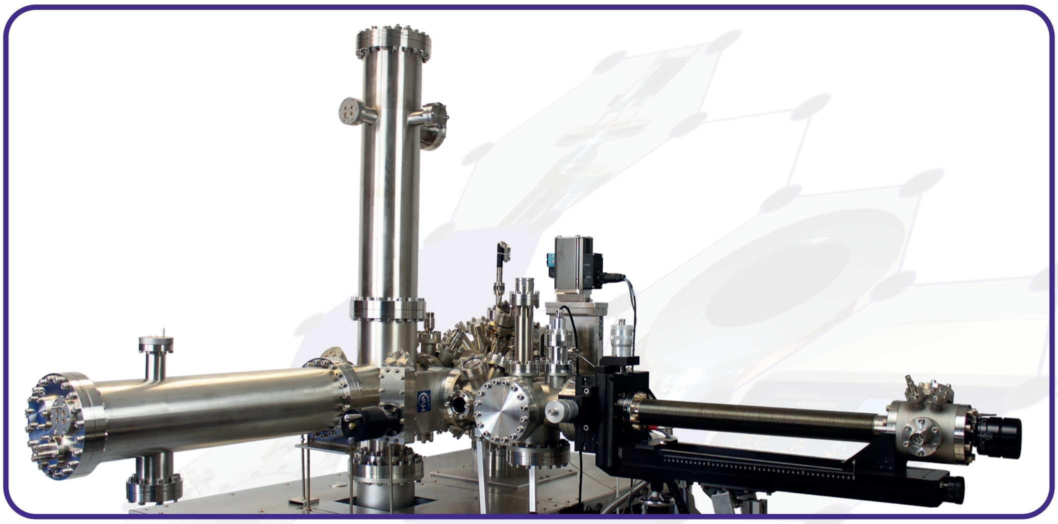
Hexapod for Time-Of-Flight Momentum Microscope

The Hexapod is a L-He cooled 6-axis sample stage, reaching temperatures < 15K (lowest value shown < 9k). It enables very precise sample positioning, including rotation and tilt up to ±5°. Each axis is equipped with a position readout. Therefore the user can store sample positions which can be recalled later on.

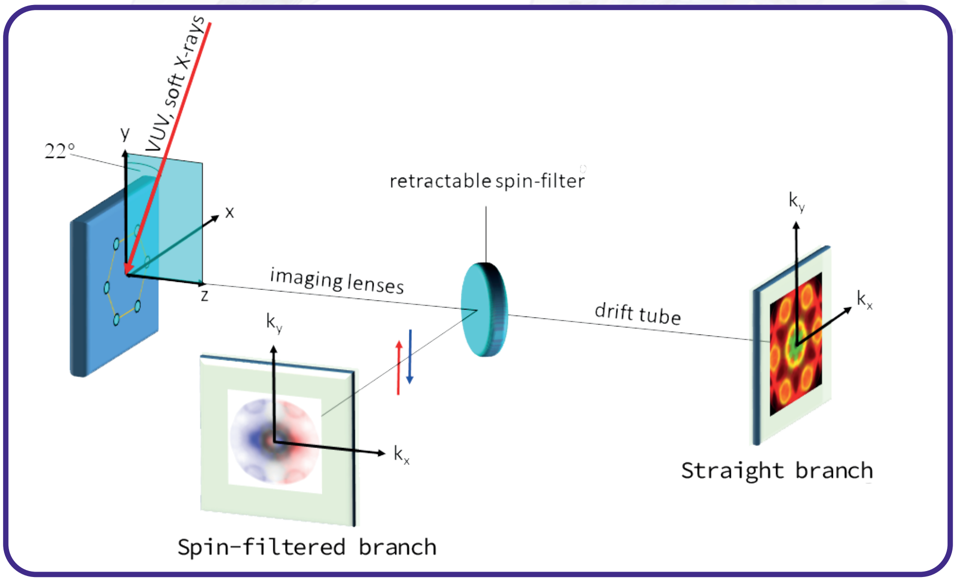


Time-Of-Flight Momentum Microscope with Spin Imaging Option

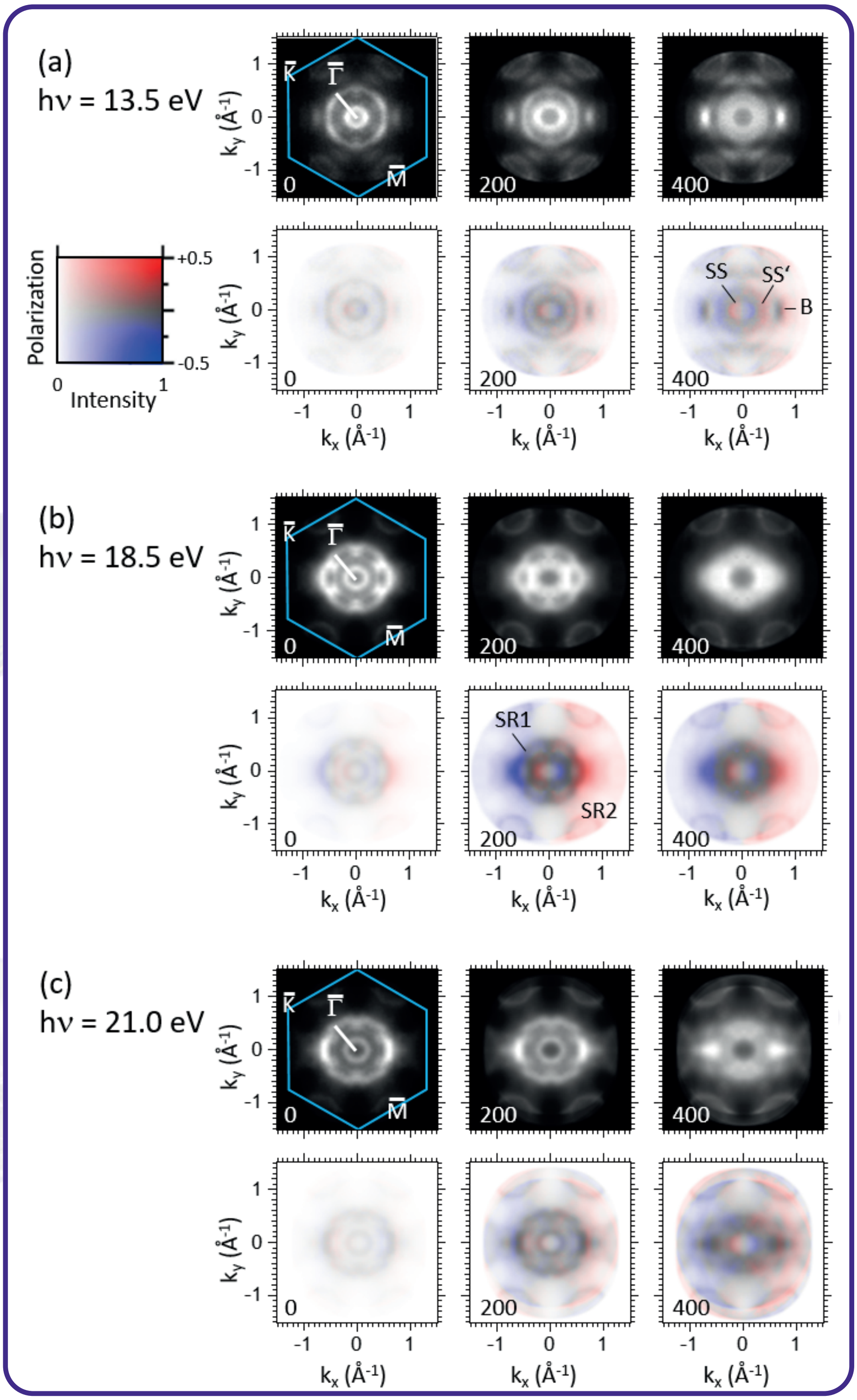
The Imaging Spin Filter is an upgrade for an existing ToF Momentum Microscope. The spin imaging is based on the spin dependent reflection on Au/Ir patented spin filter principle [patents DE102013005173C5 and DE102005045622B4].



Working principle of the parallel spin analyser. The instrument works either as a conventional ToF Momentum Microscope in the straight branch or the spin filter crystal deflects the image for spin analysis in the perpendicular branch (spin-filtered branch).



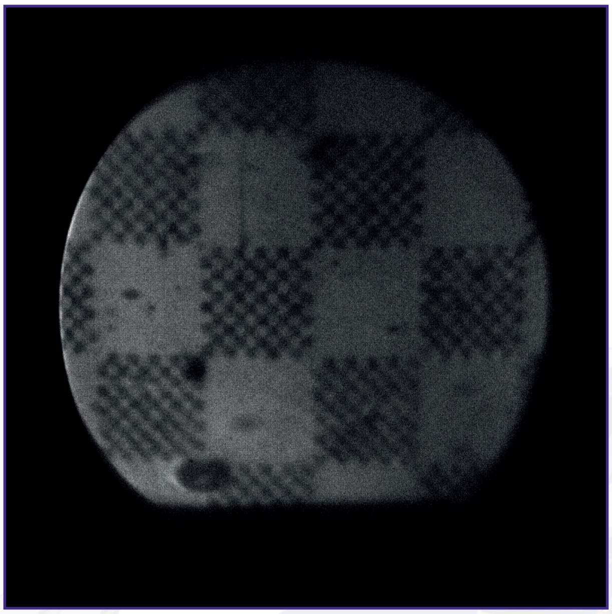
[H.J. Elmers et al., Phys. Rev. Research 2, 013296 (2020)]



Constant-energy maps of Re (0001) measured with photon energies of 13.5eV, 18.5eV and 21eV. Left to right binding energies 0meV, 200meV and 400meV. The lower row displays the spin filtered measurements.

[H.J. Elmers et al., Phys. Rev. Research 2, 013296 (2020)]

An image with a FoV 450µm of a Chessy sample with >9.000 resolved channels in the complete image. This demonstrates the image quality of the spin-filtered branch.



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Overview
Time-Of-Flight Momentum Microscope
with Spin Imaging Option
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