FOCUS HV-CSA
HAXPES UP TO 15 keV

- HAXPES, XPS, Auger & UPS with one instrument
- Continuous energy range from 1eV to 15keV
- Unique 2D event counting
- Large working distance (lens to sample: 50mm)
- TCP/IP remote control
FOCUS HV-CSA: Motivation

XPS at high kinetic energies is attracting increasing scientific attention worldwide. This demand is mainly driven by the availability of brilliant medium energy x-ray beam lines at a number of synchrotrons. A new field of applications for these light sources has been opened up, commonly described by the keywords “Hard x-ray photoemission spectroscopy” or “HAXPES”.

With the FOCUS HV-CSA, we have extended the energy range of electron spectroscopy up to 15keV. We have enabled the operator to probe the sample chemistry from deeper within the sample than with any other electron energy analyzer.

Design philosophy

The concept of the analyser is based on the well-proven Cylindrical Sector Analyser (CSA) as developed and produced by FOCUS already many years ago. Compared to a conventional hemispherical analyser, the CSA allows collection of a larger solid angle of electrons at the same energy resolution, which is of great importance to ensure excellent count rates and sensitivity at high kinetic energies (see e.g. (1)).

The FOCUS HV-CSA is a Cylindrical Sector Analyser (CSA) with a slit to slit distance of 300mm.

It is designed to achieve optimum performance in a wide kinetic energy range between 1eV and 15keV.

Due to its 2nd order focussing, the CSA geometry achieves a higher angular acceptance compared to spherical (1st order focussing) analyser types. For this reason, it is especially suitable for high kinetic energies together with low pass energy operation using large retardation ratios.

The analyser is equipped with a selectable entrance slit (3 different fixed sizes) and a selectable exit slit in case of the single channeltron detection.

The analyser is completely mounted within a mu-metal UHV chamber which also covers the low energy section (retardation stage) of the transfer lens.
The entrance lens is a dedicated transfer zoom lens that meets the needs of both low and high energy spectroscopy. A wide range of lateral magnifications from 1 up to 50 is available by lens curve settings.

The best operation in the HAXPES regime is obtained with retardation ratios up to 1500 and large lateral magnifications.

The lens angular acceptance is up to ±8°, depending upon lateral magnification and applied retardation ratio. The different lens curves are easily selectable by software operation.

The zoom lens consists of four independently adjustable active lens elements and two quadruple deflector elements.

A large lens to sample distance of 50mm allows enough free space to combine the analyser with other excitation and/or preparation sources.
2D event counting detector

In its basic version the analyser has a single channeltron detector for single channel pulse counting.

Alternatively, a 2D event counting detector can be employed to reduce long measuring times. Compared to the single channel version, we gain at least a factor of 20 that way. Depending on the requested resolution and the experimental conditions, the detector is able to deliver up to 300 energy channels.

The 2D detector is based on a multi channel plate detection screen on the UHV site with a fast high-end camera outside the vacuum used for fast frame capturing and processing. Special event recognition software achieves Poisson statistics comparable to true pulse counting detectors. More details about the 2D detector can be found in ref (5).

Electronics architecture

The analyser low drift and low noise digital power supply is based on a multi module / multi processor architecture.

In its basic configuration it consists of one master unit (19”/3HU rack case) delivering all potentials needed to operate the CSA itself, two slave units (19”/6HU) housing five lens supply modules and one double deflector supply module. With the 2D detector an additional detector supply (19”/3HU ) is required.

For manual adjustment prior to the data acquisition, a hand-held remote control unit with a graphical display offers the possibility for user-friendly and safe operation of all analyser parameters in local mode. More details can be found in ref. (2) to (4).
Application Examples

Top: HAXPES spectra on Gold acquired at beam line P09 of PETRA III in Hamburg (DESY).

Left: HAXPES on Silicone taken at the SpLine beamline of the ESRF, Grenoble.

All spectra are taken with the FOCUS HV-CSA equipped with the 2D event counting detector.

Spectra can be acquired from low kinetic energy up to the highest energy within one run without any change of the electronics set-up.

For further applications/experimental results please refer to ref. (6).
Outline dimensions of HV CSA (2D detector version)
ProCSA™: Expert mode GUI (top) for adjustment of all detector settings of the event counting detector and measurement GUI (bottom) for both experiment batch setup, data acquisition and real time visualization.

Note: Imaging HAXPES (HAXPEEM)

Recently FOCUS has launched an energy filtered PEEM to be operated at up to 10 keV, called HAXPEEM (see ref. (9)).

Software ProCSA™

Remote control of the analyser for data acquisition is achieved by Windows-based PC software called ProCSA™ via a RS232 connection to the master unit.

With ProCSA™, tasks like parameter setting, lens curve choice, spectra acquisition and workflow (batches) organisation are possible.

Operated with the 2D detector ProCSA™ allows both for single shot spectra and scanned wide span spectra.

Popular software packages like CasaXPS (7) or unifit (8) are able to import the date sets for further analysis.

Remote control of ProCSA™ can be done using a TCP/IP interface that is fully documented.

References

(7) http://www.casaxps.com
(8) http://www.unifit-software.de
Technical Data

**Cylindrical sector analyser:**
Second order focusing for high transmission (essential for high kinetic energies e.g. high retardation ratios)

**Analyser angular acceptance:**
±5° (up to ±8° depending upon the lateral magnification and retard ratio).

**Analyser slits:**
Single channeltron detector:
1, 3, 9mm; entrance and exit slits independently selectable,
2D-detector: 0.5, 1.5 and 4.5mm entrance slit.

**Slit to slit distance:** 300mm

**Analyser pass energies:**
1 to 500eV continuously adjustable.

**Energy resolution:**
Down to 100meV for the entire energy range (up to 15 keV kinetic energy)

**Kinetic energy range:**
1eV to 15keV (with one power supply).

**Min. kinetic energy step width:**
1 meV (over the entire energy range).

**Lens lateral magnification:**
1 to 60 (selectable).

**Max. retardation ratio:**
1500 (at the lateral magnification of 50).

**Flange to sample distance:**
203mm (8”), 254 mm (10”) or 480mm, other length on request.

**Lens to sample distance:** 50mm

**Single channel detection (optional):**
Channeltron detector and counting electronics.

**2D-Detector (standard):**
Camera based event counting detector;
40mm width in dispersive direction; channel width free selectable; more than 200 channels possible; improvement of count rate (standard XPS at Ag3d, compared to single channel detection) by a factor of about 25 at 1eV FWHM (0.6eV energy resol.) and a factor of about 7 at 2eV FWHM (1.8eV energy resol.).

**Total Weight (with 2D-Detector):**
about 46 kg.

**Mounting flange:** DN 100 CF.