PHOIBOS 225 HV: High Energy and High Resolution Electron Analyzer

Thorsten U. Kampen, Sven Mähl, and Oliver Schaff

PHOIBOS Series

PHOIBOS 100

PHOIBOS 150

- Superior performance in XPS, UPS, AES and ISS
- Excellent sensitivity
- Ultra high energy resolution
- High count rate applications
- Small spot XPS analysis
- Angular mapping

HSA 3500

Multi Channel

2D CCD

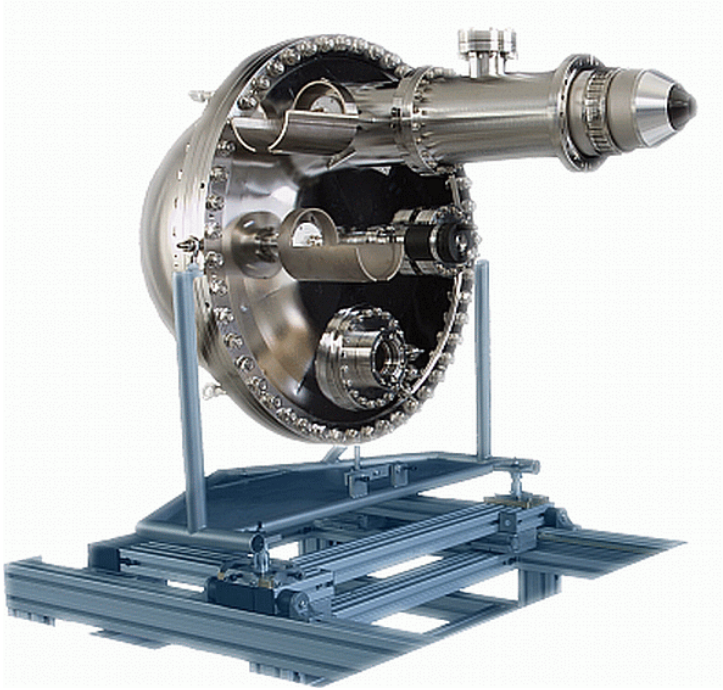
3D Delay Line

Spin

PHOIBOS 225 HV

Features:

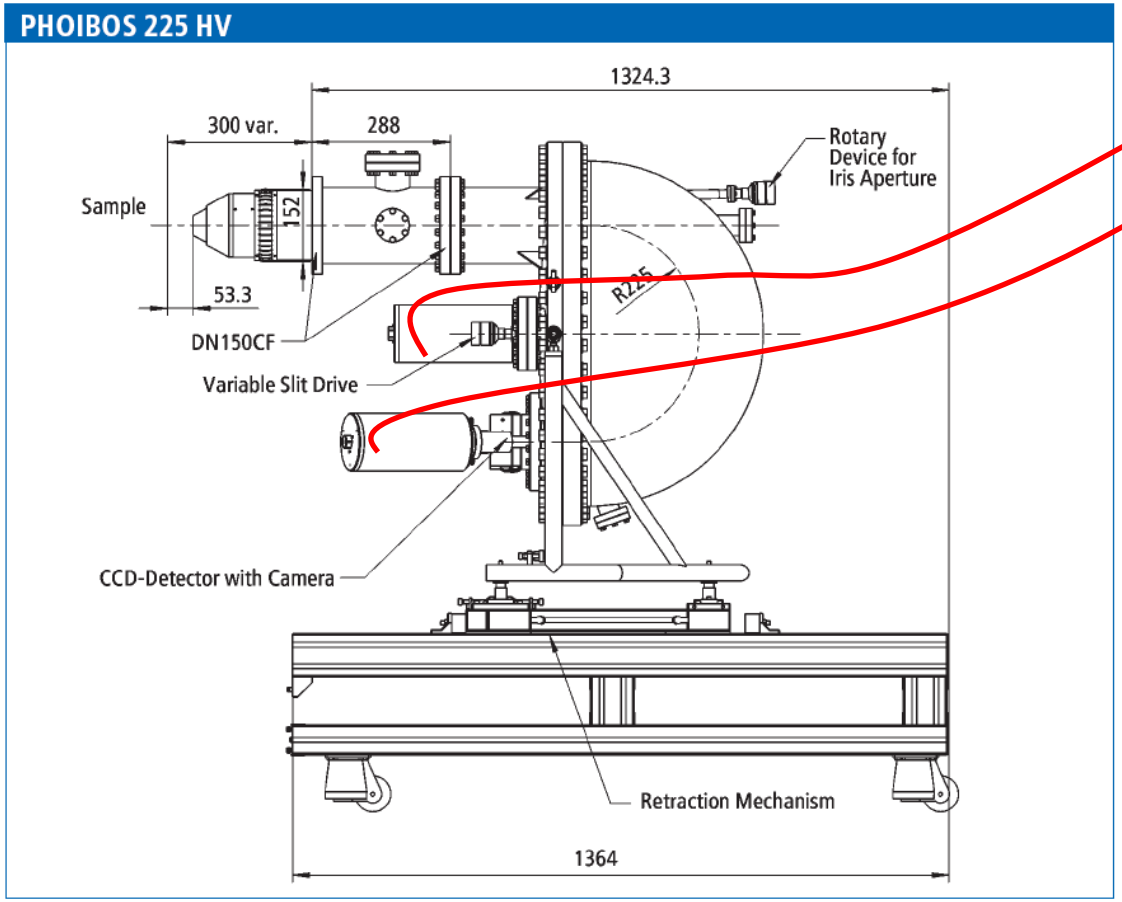
- Handles electron energies of up to 15 keV
- Ultra high energy resolution in UPS (< 1meV), XPS (< 7 meV) and HAXPES (<15 meV)
- Angular Mapping (ΔΘ < 0.1°)
- CCD, DLD and DLD/SPIN detection available
- Low dark-count detector units
- High stability power supplies
- High retarding ratios; E_k/E_p can be changed continuosly
- Different modes of operation (UPS, XPS and HXPS)
- 8 entrance slits (< 100 µm) and 3 exit slits

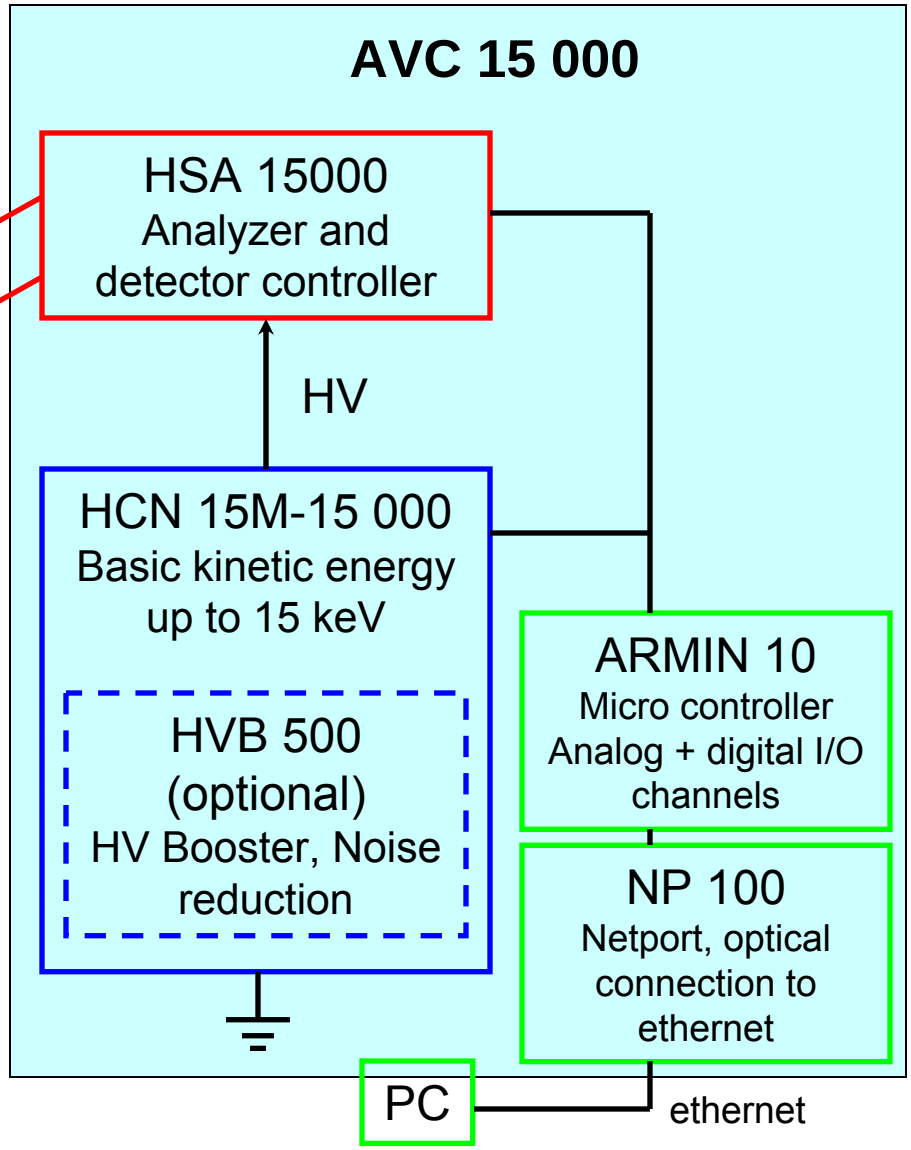


Applications:

- Investigation of the bulk properties of solids with HAXPES
- Gamma-Spectroscopy
- UPS with high angular resolution and high energy resolution

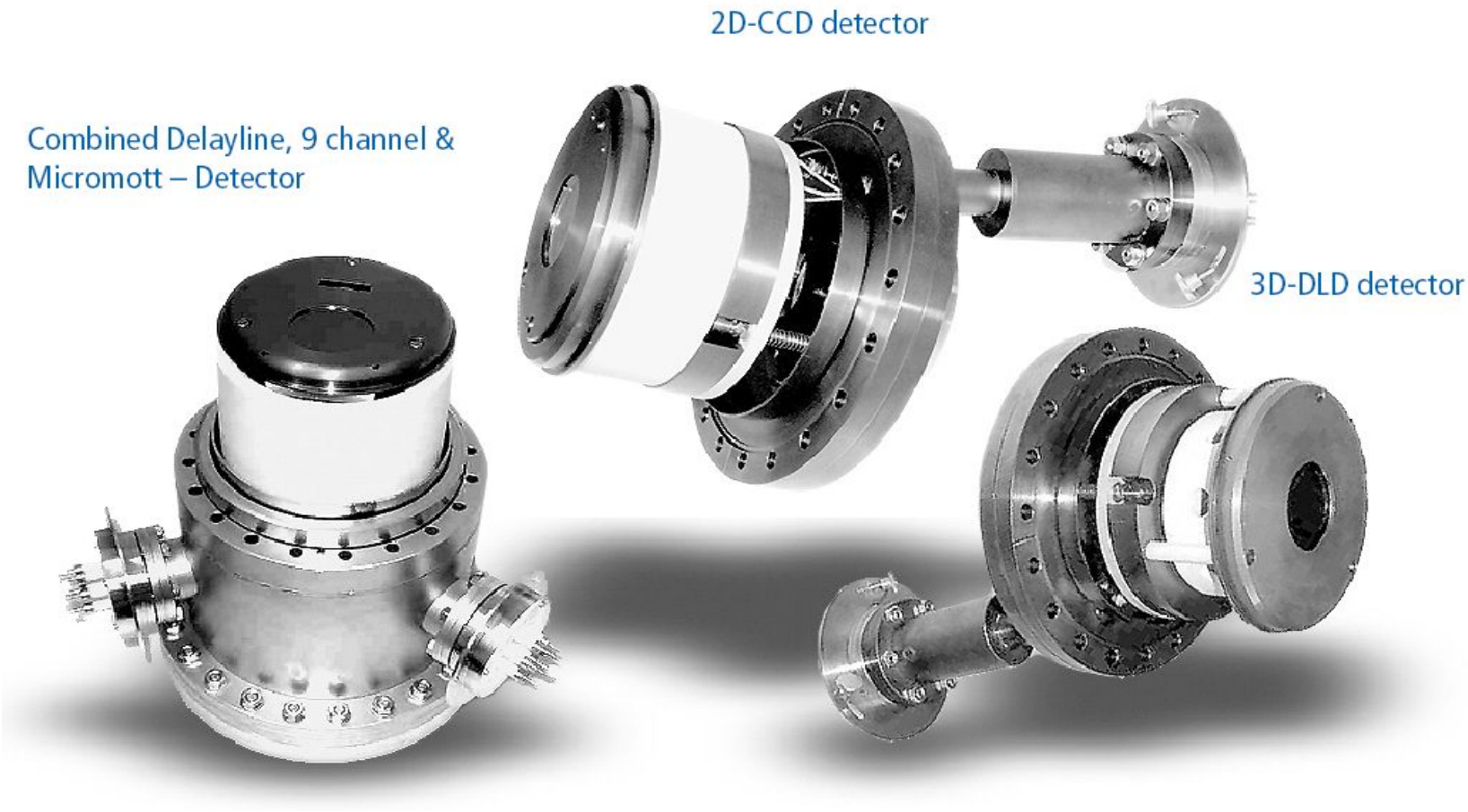
Power Supply





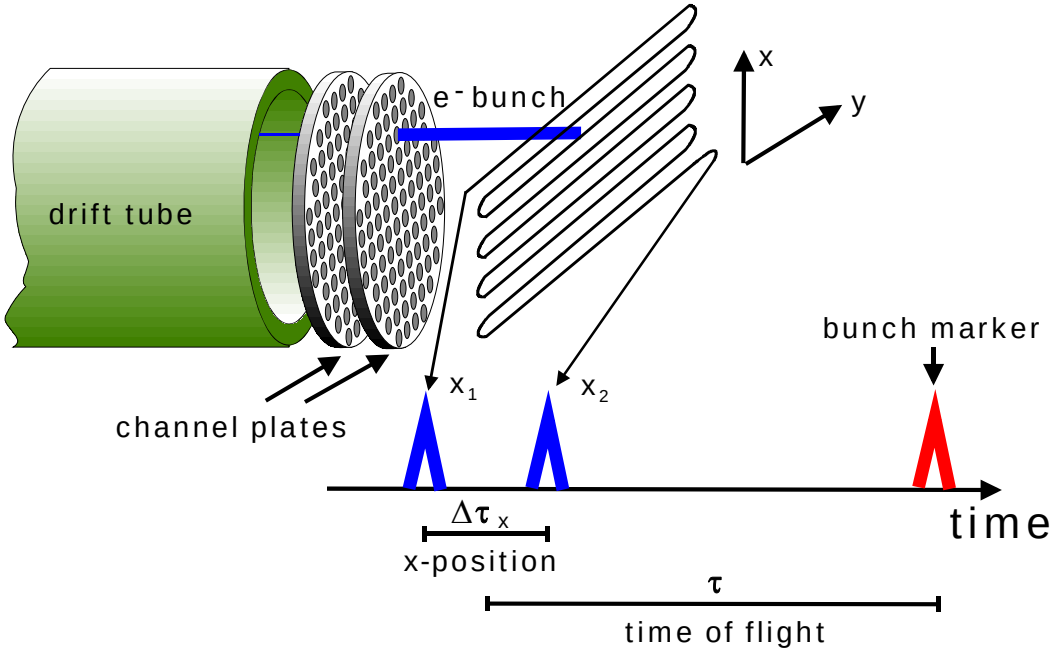
Voltage Setting Accuracy: 20 Bit
Voltage Ripple and Noise: < 15 mVpp at 15 kV
Temperatur Coefficient: < 1 ppm/K
Long time stability: < 1 ppm over 8 h

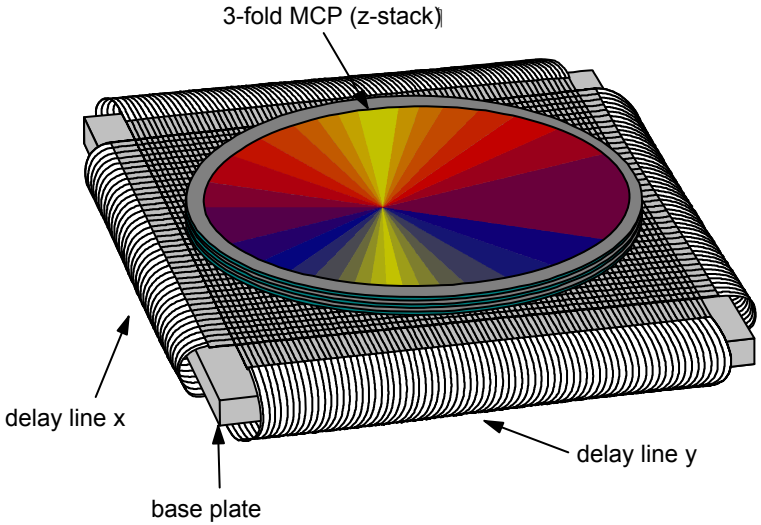
HV Detectors

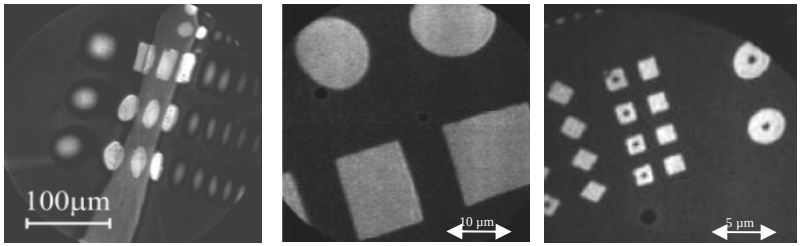


Delayline Detectors (DLD)

delay line detector – principle of operation

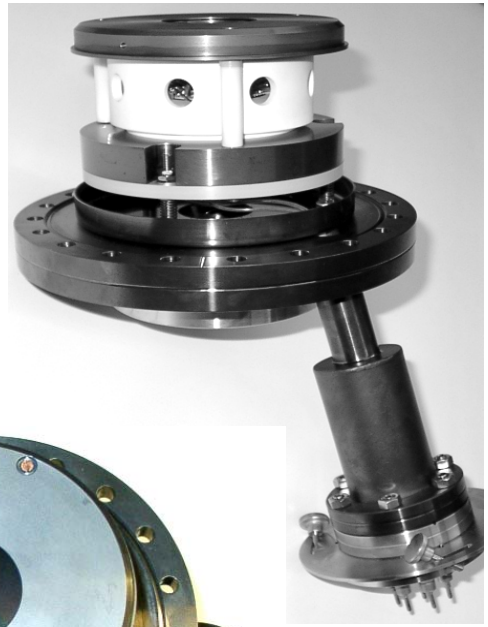






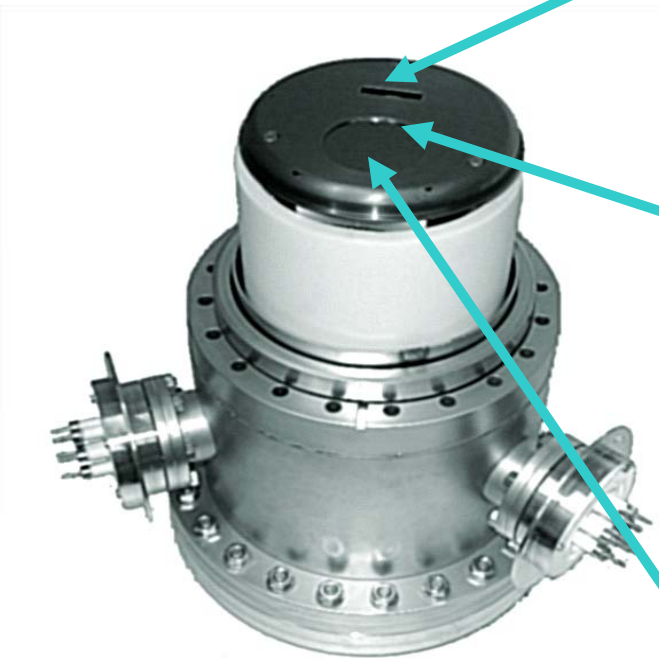
SURFACE CONCEPT

Segmented DLD 4040 – S9HV for HV PHOIBOS 225



- 2D/3D detector and 9 channel detector in one
- In-situ mode switching without breaking of vacuum
- Operation at base potentials ranging from zero up to -15 kV
- 40 x 40 mm² active area of DLD body and ∅ 46 mm active MCP area (active area of 40 x 20 mm² in PHOIBOS Analyzers)
- Up to 45 µm of pixel size
- Up to 27 ps digital time bin resolution
- < 250 ps over all time resolution
- Linear response due to single event counting
- Extremely low dark count rate: < 5 cps
- Up to 3 MHz count rate in 2D mode
- Up to 20 MHz count rate in 9 channel mode

Multimode DLD 4030 – S9MMHV :
Combined Delayline / 9 channel / Micromott – Detector:

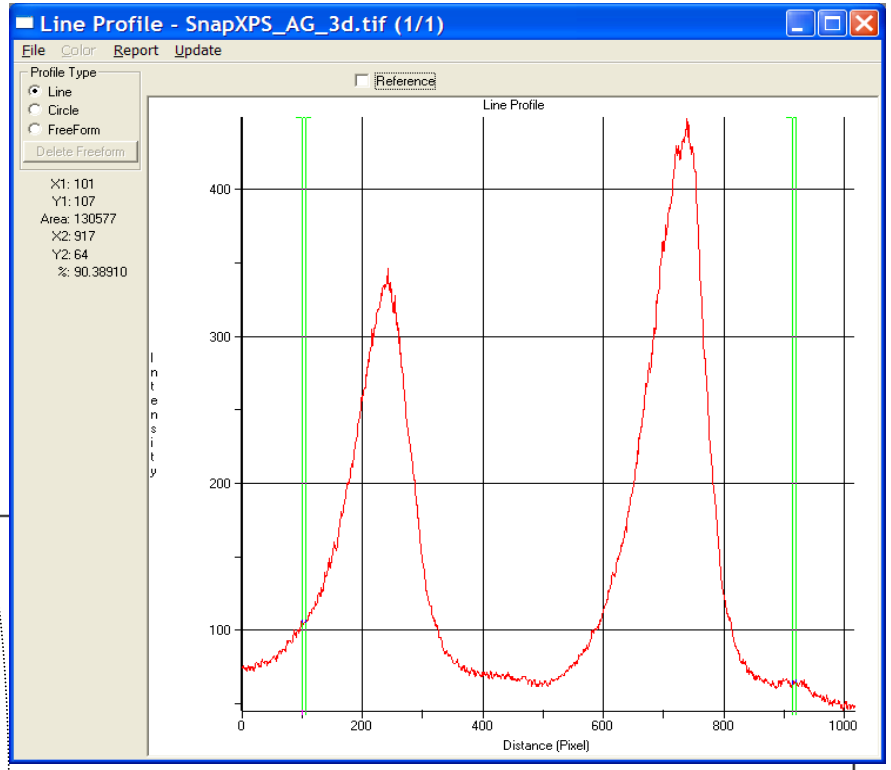


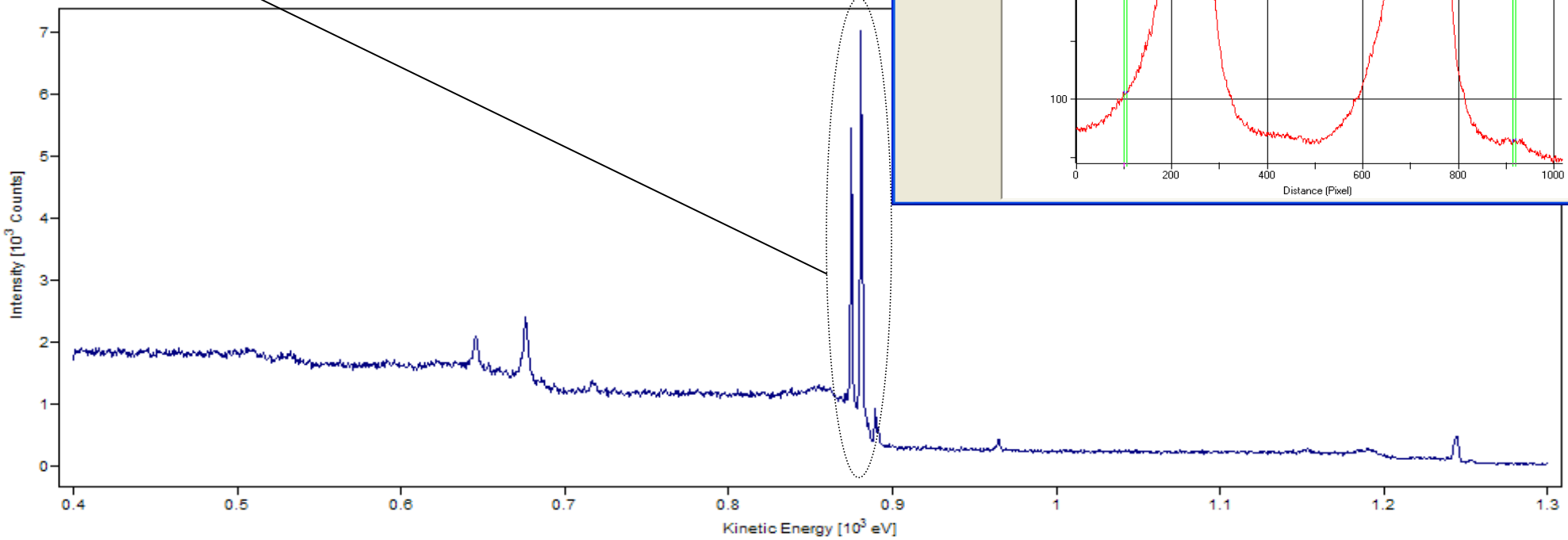
Micromott detector
technical parameters:
-extremely low dark count rate @ -15kV: < 4 CPS per channel
-4 channel backscattering Mott detector, Au or Th targets
-max. 25 keV scattering energy
-efficiency about 3 * 10^{-5} with a Sherman function of 0.1 (Au target)

Delayline detector
technical parameters:
-pixel resolution: 45 µm (spatial resolution typ. 150 µm, layout depending)
-max. count rate: 3 MCPS
-detection area: 40 mm x 30 mm
-time resolution: < 250 ps
-true counting, highly linear signal transfer
-extremely low dark count rate @ -15 kV: < 5 CPS at the entire detector

9 channel detector
technical parameters:
-max. count rate: typ. 20 MCPS
-dark count rate @ -15 kV: < 10 CPS per channel
-true counting, highly linear signal transfer

XPS Snapshot Mode

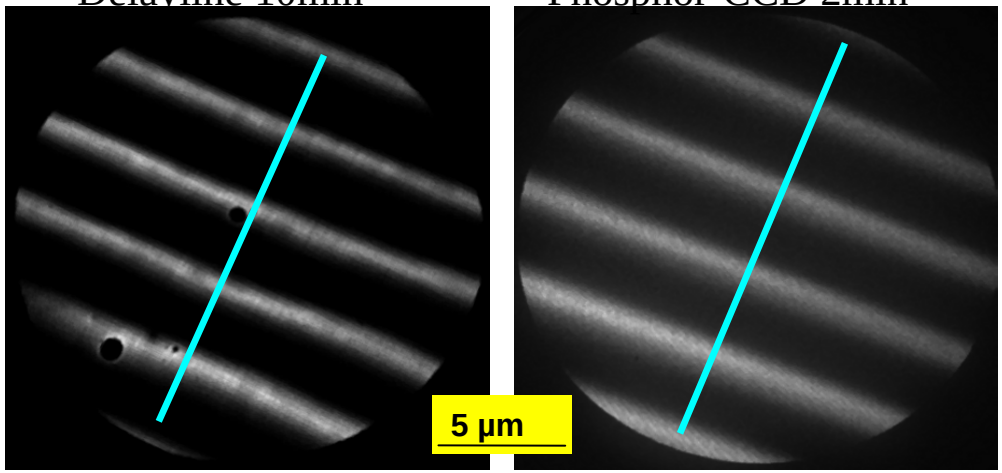


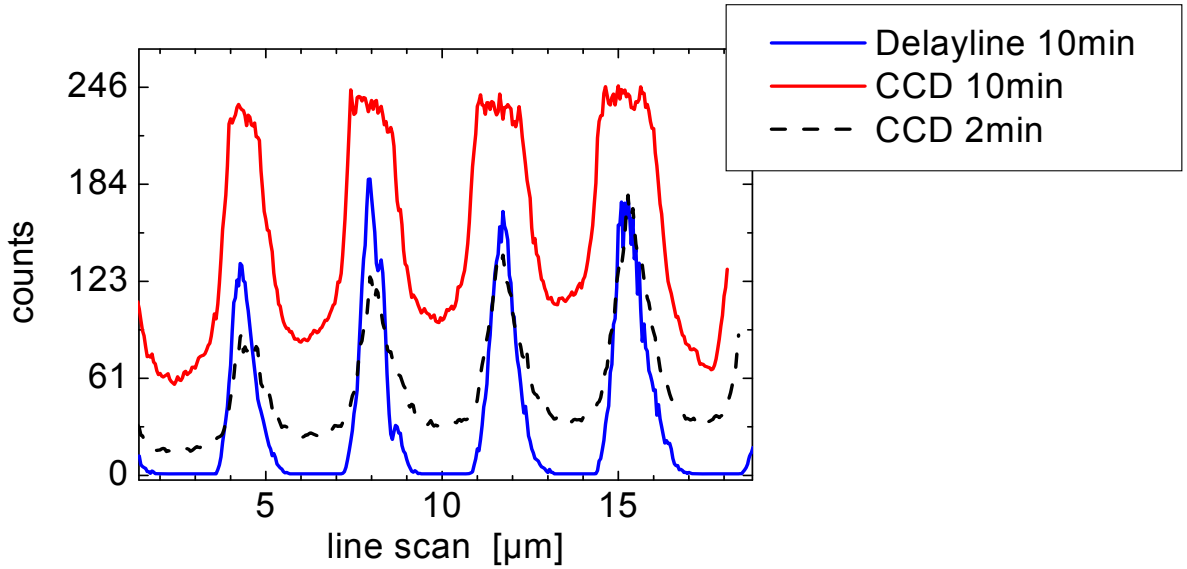


Delayline vs. Phosphor-CCD

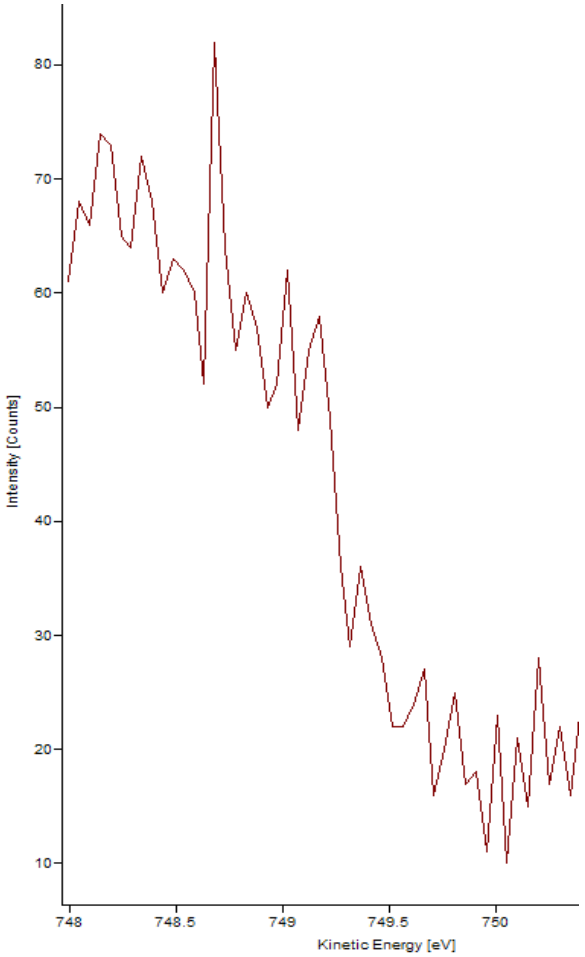
Delayline 10min

Phosphor-CCD 2min





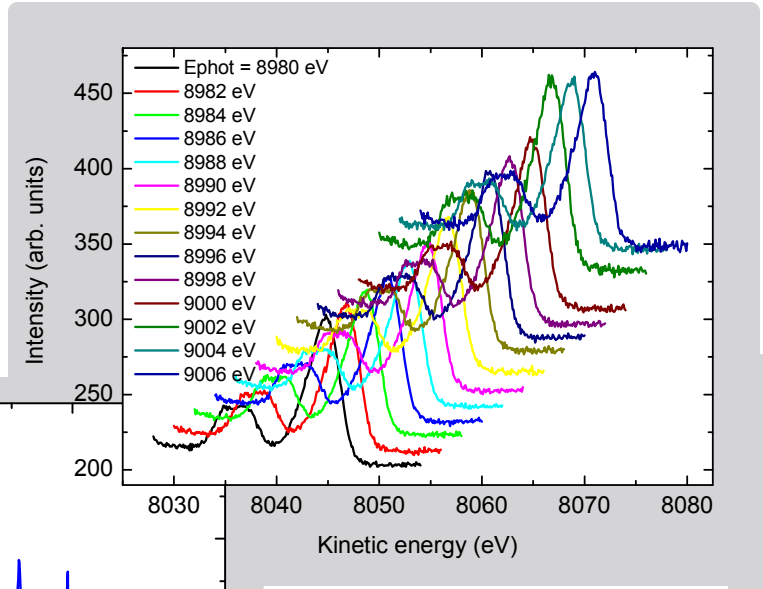
delay line detector – high energy XPS at 3 CPS:



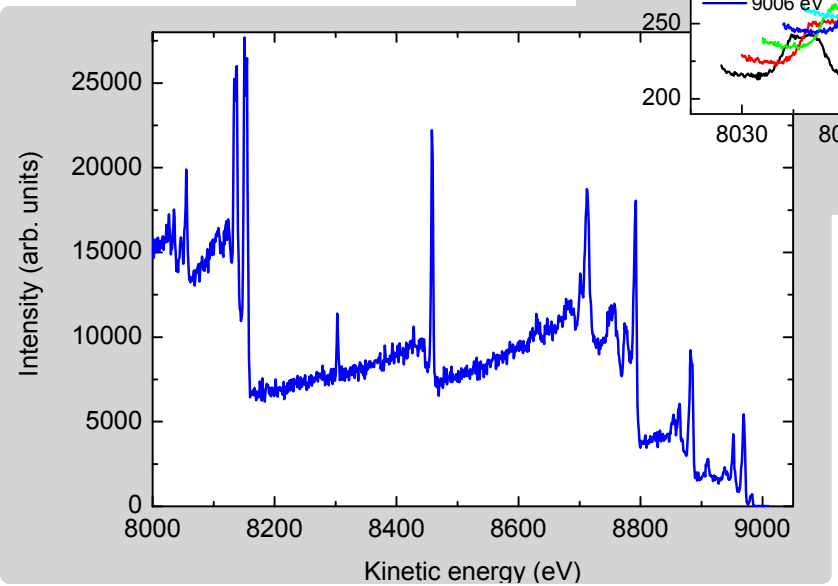
Results at the ID32 beamline

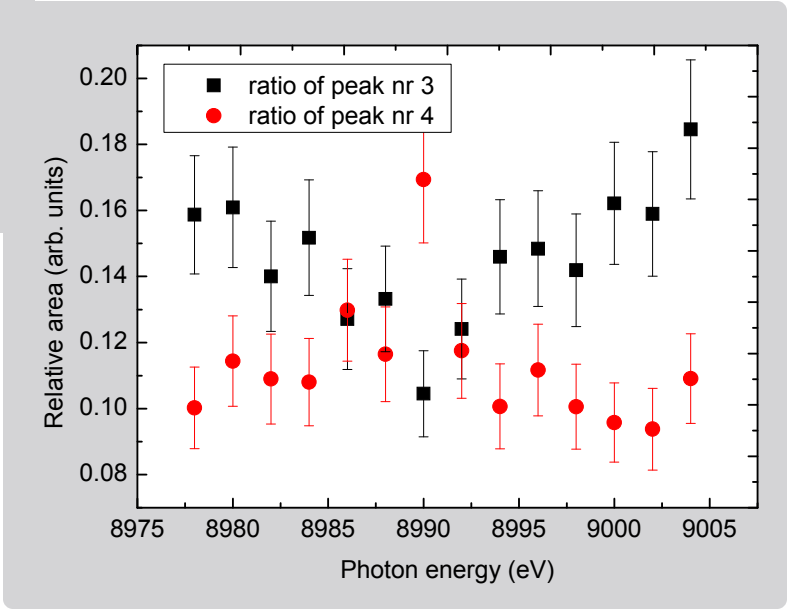
Blanka Detlefs[1], Tien-Lin Lee[1, 2], J. Roy[1], Y. Mi[1], B. Hesse[1,4], Helena Isern[1], Sebastian Thiess[1, 3], Lucien Petit[1],Michel Renier[1] and Jörg Zegenhagen[1]

$La_{2-x}Sr_xCuO_4$

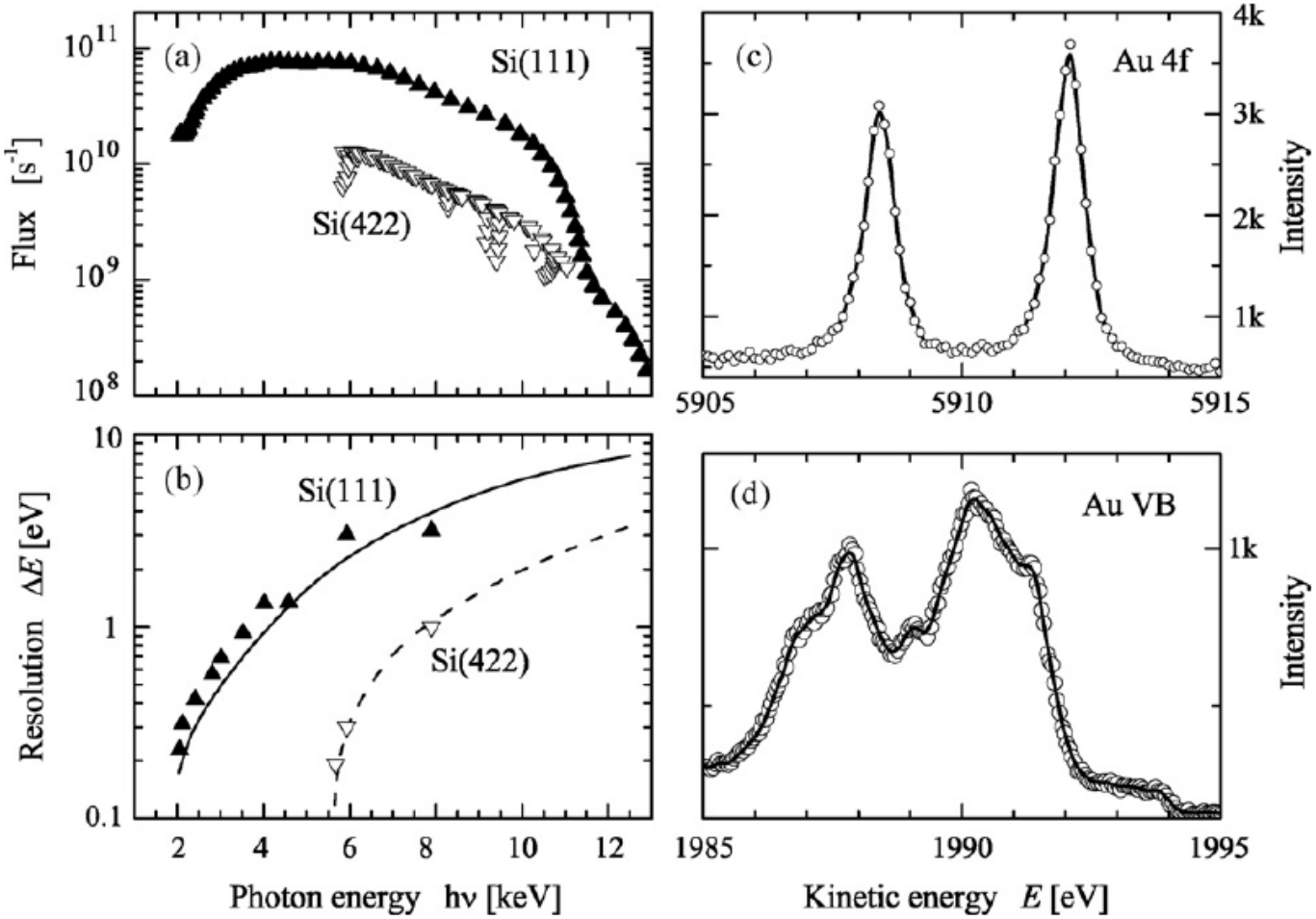


- 3 undulators (1 to ~35 keV)
- beam-size at sample 30 x 300 μm^2
- photon energies 2.3 to 30 keV
- energy resolution $\Delta E/E = 1.3 \cdot 10^{-4}$
- flux > 10^{+13} mm^{-2}





CoTiSb



Characteristics of the KMC-1 monochromator.

(a) flux normalised to a current of 100mA in the storage ring

(b) the calculated (lines) and measured (symbols) resolution

(c) Au 4f core level excited by 6 keV (Si(422))

(d) valence band excited by 2 keV (Si(111))

Fecher et al.,
Journal of Electron Spectroscopy and Related Phenomena
156–158 (2007) 97–101

2D-CCD Detector

pixelfly qe

- quantum efficiency up to 65%
- ultra compact design
- 12bit dynamic range
- high resolution (1392 x 1024pixel)
- temperature compensated
- exposure times from 5µs - 65s

Fast data collection
(400 spectra in 0.1 sec)

pco.
imaging

sensicam qe

- quantum efficiency up to 65%
- extremely low noise, down to 4e$^-$ rms
- 12bit dynamic range
- thermo-electrical cooling (Peltier) down to -12°C
- high resolution (1376 x 1040pixel)
- shutter / exposure times from 500ns - 1000s

LASER excited ARUPS

QWS – Ag/Cu(111)

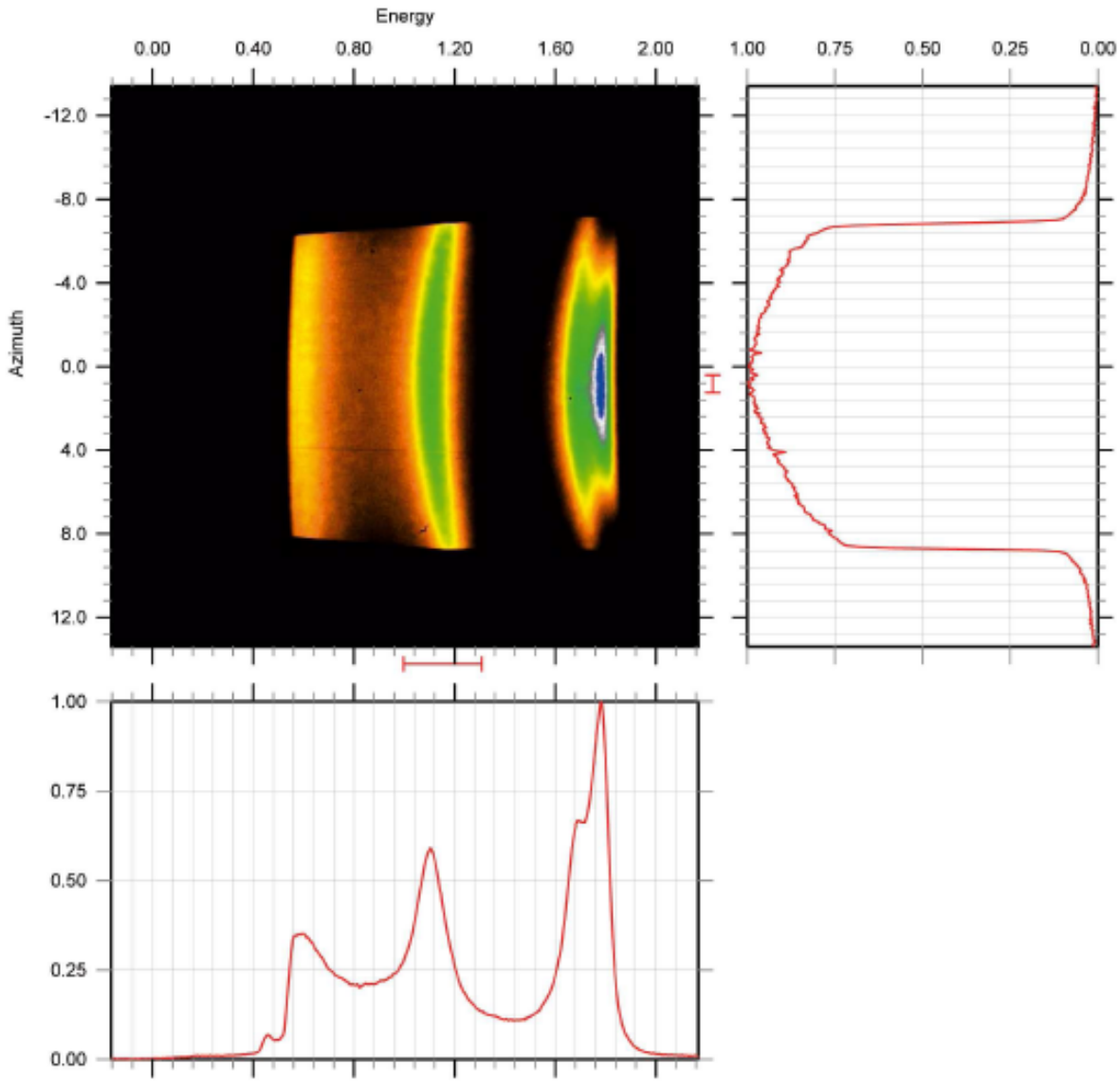
The 4th harmonic of a laser system (hv = 5.8 eV) is used to excite the electrons.

15 ML Ag on Cu(111).

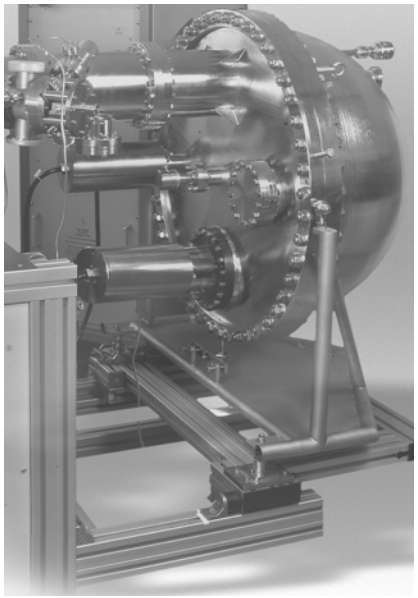
Surface state, 1st & 2nd QWS are shown.

PHOIBOS 150 with 2D-CCD Detector, E_{kin} = 1 eV, E_{pass} = 20 eV.

S. Mathias, M. Bauer and M. Aeschlimann (University Kaiserslautern, Germany).



Resolution Test of the PHOIBOS 225

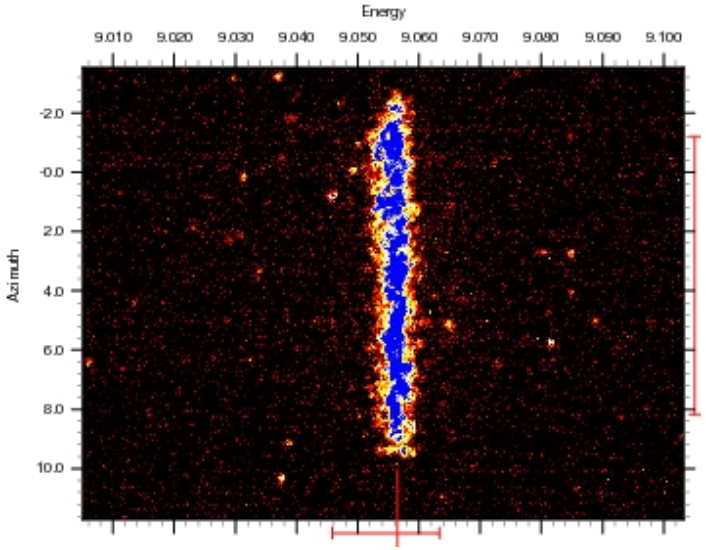


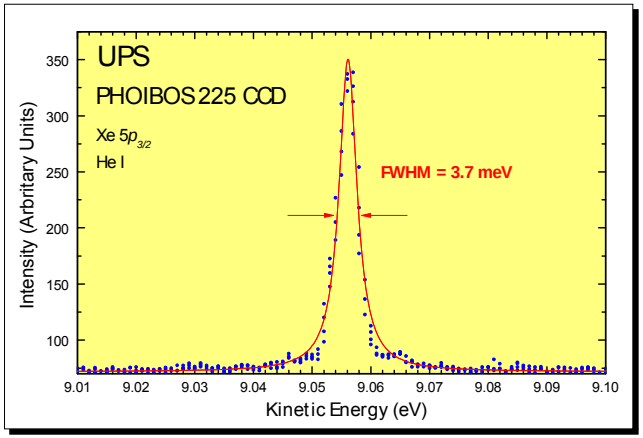
Lline width Γ of the Xe $5p_{3/2}$ gas line using the SPECS gas cell UGC 10 and the SPECS UV-light source UVS 300.

The Doppler broadening Γ_D of the target gas:

$$\Gamma_D = 0.7215\sqrt{\frac{E_{kin} \cdot T}{M}}$$

Atomic, Molecular, & Optical Physics Handbook, Chaps. 19 and 57, ed. G.W.F. Drake (AIP, Woodbury, NY, 1996).





CCD camera image of Xe $5p_{3/2}$ (excited with He) measured with FAT 1.8 eV. The measurement was performed using a PHOIBOS 225 HiRes CCD analyzer.

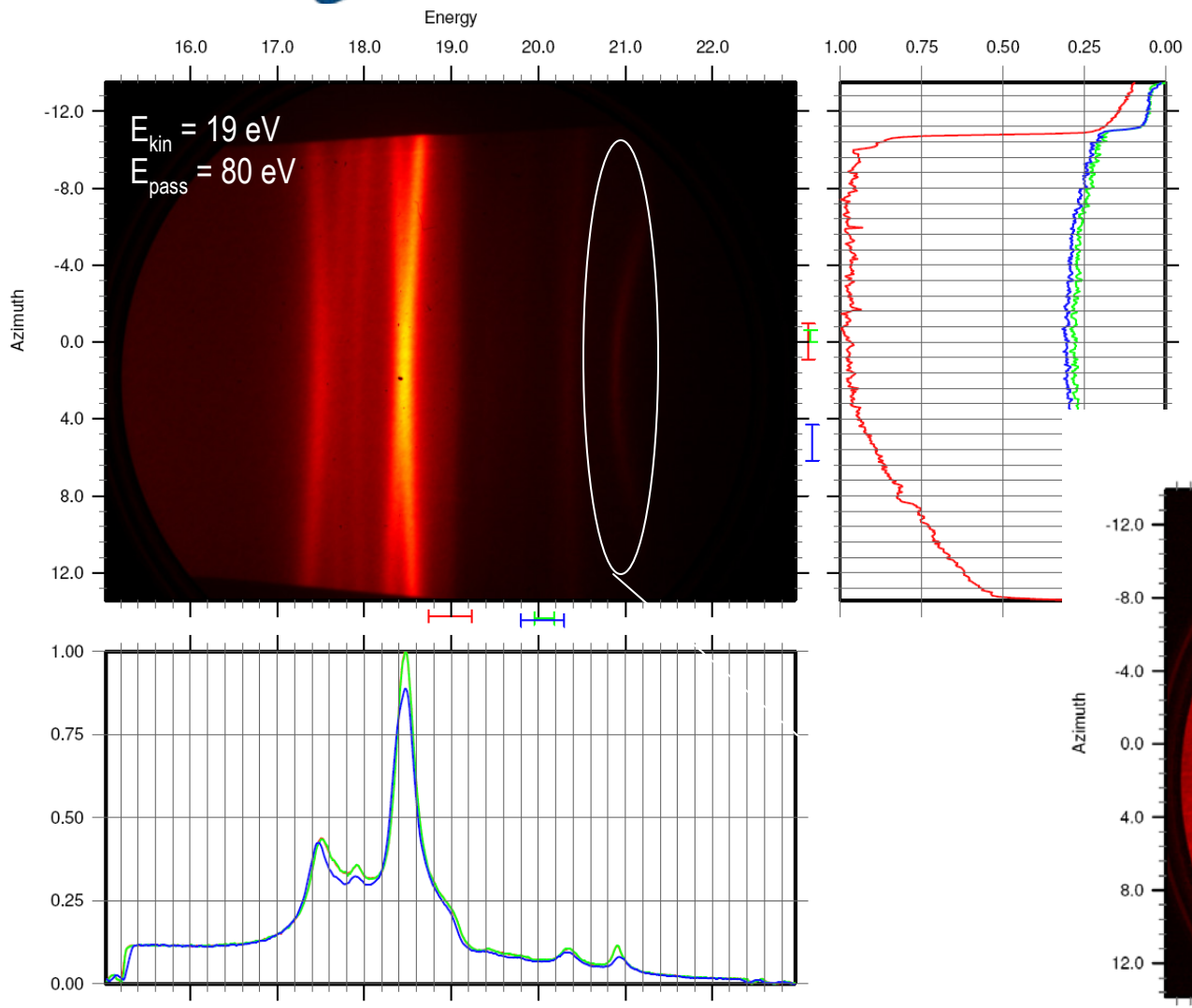
Measured line width: Γ_M
UV-source line width: Γ_S = 1 meV
Doppler broadening: Γ_D = 3.3 meV

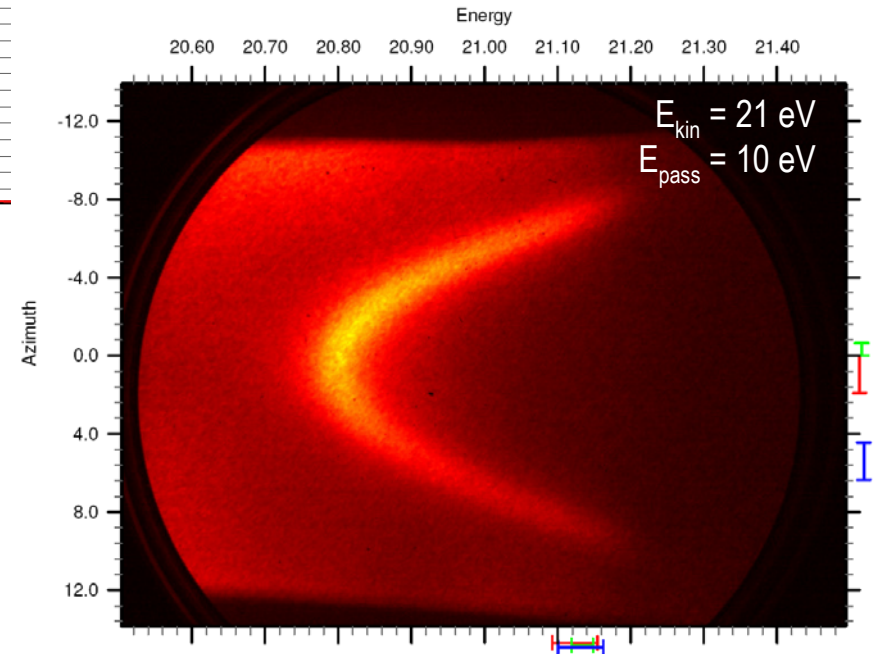
Analyzer resolution: Γ_A

$$\Gamma_A = \sqrt{\Gamma_M^2 - \Gamma_S^2 - \Gamma_D^2}$$

$$\Gamma_A = 1.3\,\text{meV}$$

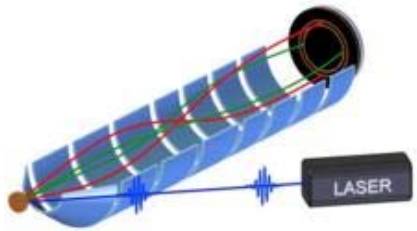
Cu(111)

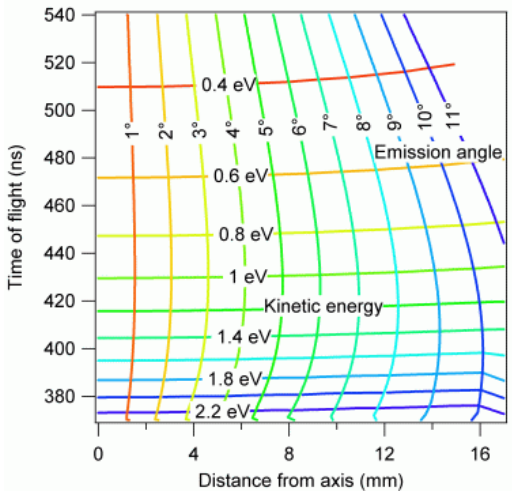

Energy
16.0
17.0
18.0
19.0
20.0
21.0
22.0
1.00
0.75
0.50
0.25
0.00
Azimuth
-12.0
-8.0
-4.0
0.0
4.0
8.0
12.0
E_{kin} = 19 eV
E_{pass} = 80 eV


Energy
20.60
20.70
20.80
20.90
21.00
21.10
21.20
21.30
21.40
Azimuth
-12.0
-8.0
-4.0
0.0
4.0
8.0
12.0
E_{kin} = 21 eV
E_{pass} = 10 eV

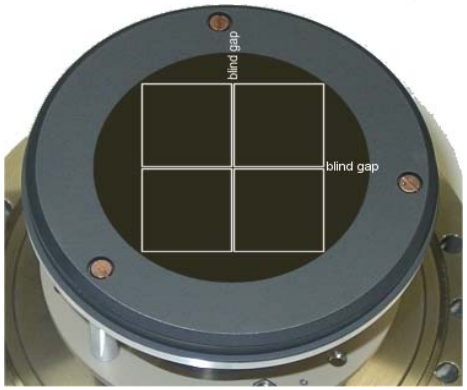
THEMIS 600 / 1000

- parallel angle and energy detection up to +/-13° and 70 eV windows
- kinetic energy ranges 0 - 40 eV, 0 - 400 eV, 0 - 3500 eV
- high energy option up to 15 kV
- angular modes with +/- 13°, +/- 7°, +/- 3.5° and +/- 2° acceptance angle
- spatial resolving modes with 10x, 5x and 2x magnification
- accelerating and retarding operation with retard ratios from 0.05 – 1000
- energy resolution down to < 200 µeV
- 3D-DLD detector with 3 MHz maximum count rate





4 Quadrant multi-hit delayline detector for PHOIBOS 150/225



- Multi-hit 2D/3D 4-fold delayline detector
- Up to 4 multi hits with zero dead time
- Up to 400 multi hits per 1 µs
- 60 x 60 mm² active area of DLD body

One dimensional delayline detector for PHOIBOS 150/225

- line detector with temporal resolution, 1D mode (x) - 2D mode (x, t)
- 100 to 1600 virtual channels

Thank you for your attention!

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