1-D Delayline Detector for High Resolution XPS

Technical Notes

The 1-D delayline detector was particularly developed for the needs of channel and time detection of electrons for high resolution XPS. The physical form of the 1-D DLD detector series was specifically designed for the use with the PHOIBOS analyzer. The standard Channeltron Detector, the CCD Imaging Detector, the 3D-Delayline Detector and the 1-D Delayline Detector can be used with the same analyzer without any physical modification to the analyzer (can be retrofit on site).

The large number of detection channels (70 channels for the PHOIBOS 100 analyzer and 100 channels for the PHOIBOS 150 analyzer) enables higher resolution at shorter dwell times as well as a great snapshot performance at high pass energies. The 1D-DLD returns investment by remarkably lower costs of the electron multiplier replacements.

1D Delayline Detector

- Increases in analyzer performance
- Enables higher resolving power
- Facilitates time resolved experiments
- Snapshot capability for fast spectrum acquisition
- Lower costs for multiplier replacements

Resolution	MCD-9	1D Delayline
0.85 eV	1,200,000	1,600,000
0.60 eV	600,000	1000,000
0.50 eV	150,000	250,000

The PHOIBOS 150 analyzer exceed with the FOCUS 500 monochromator the values specified in the table (values are given in cps for the Ag 3d5/2 signal above the background). Values are specified for optimal geometric conditions (Emission angle ϕ = 30° and X-Ray angle of incidence ψ = 70°).

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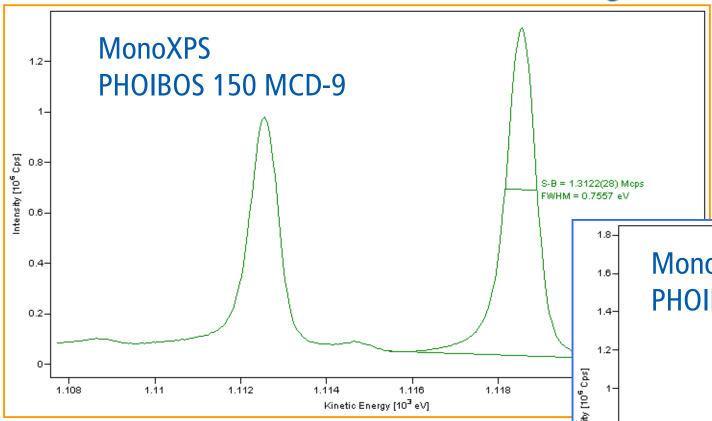
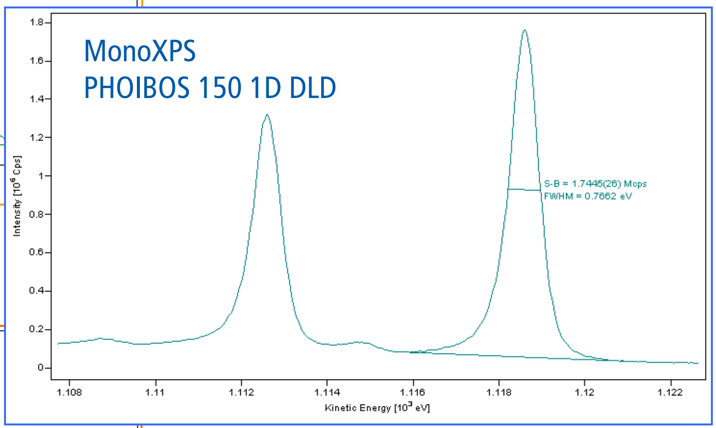
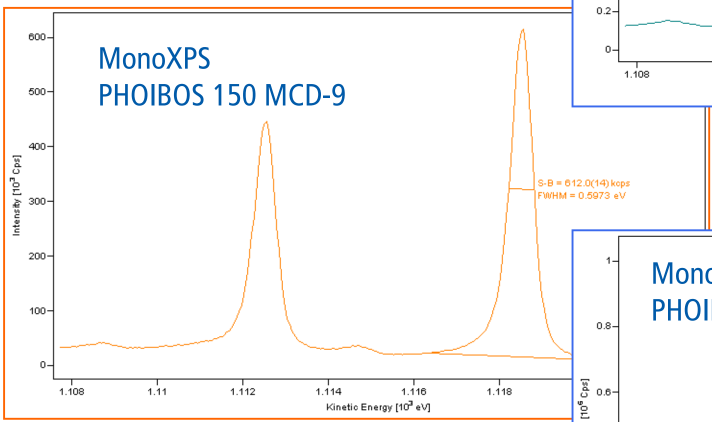
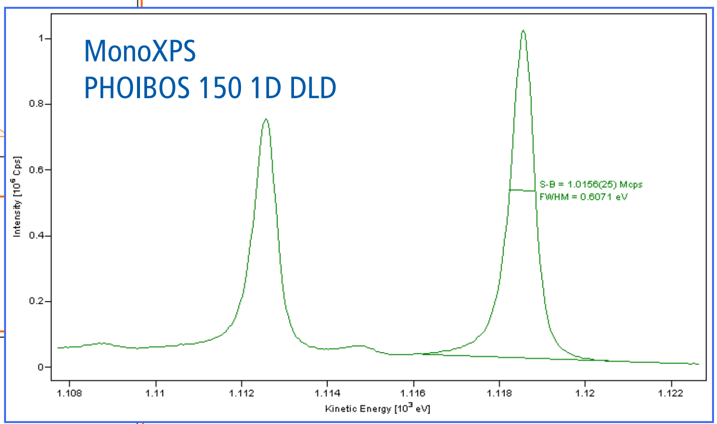
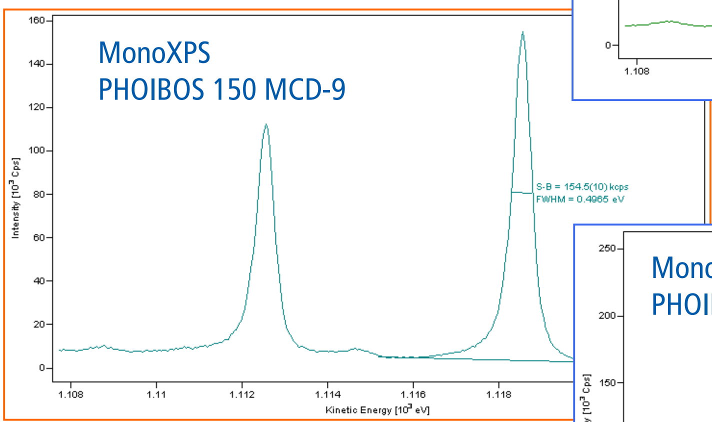
Ag $3d_{5/2}$ peak intensities obtained with the PHOIBOS 150 analyzer and the FOCUS 500 monochromated x-ray source with a MCD-9 channeltron detector and 1D-Delayline Detector under same conditions. The 1D Delayline detector gains intensity up to 65% depending on the resolution.

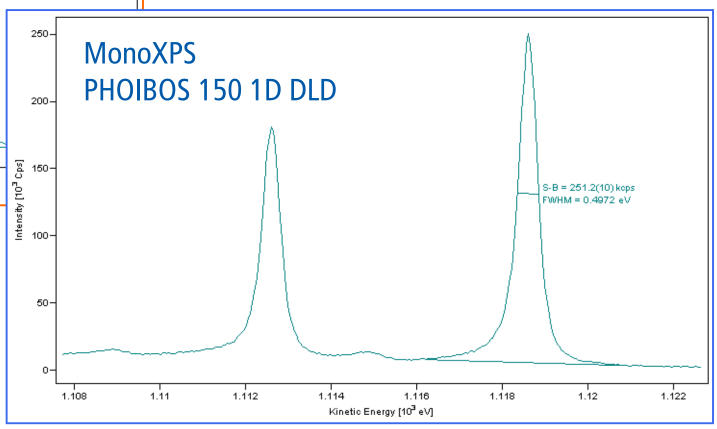












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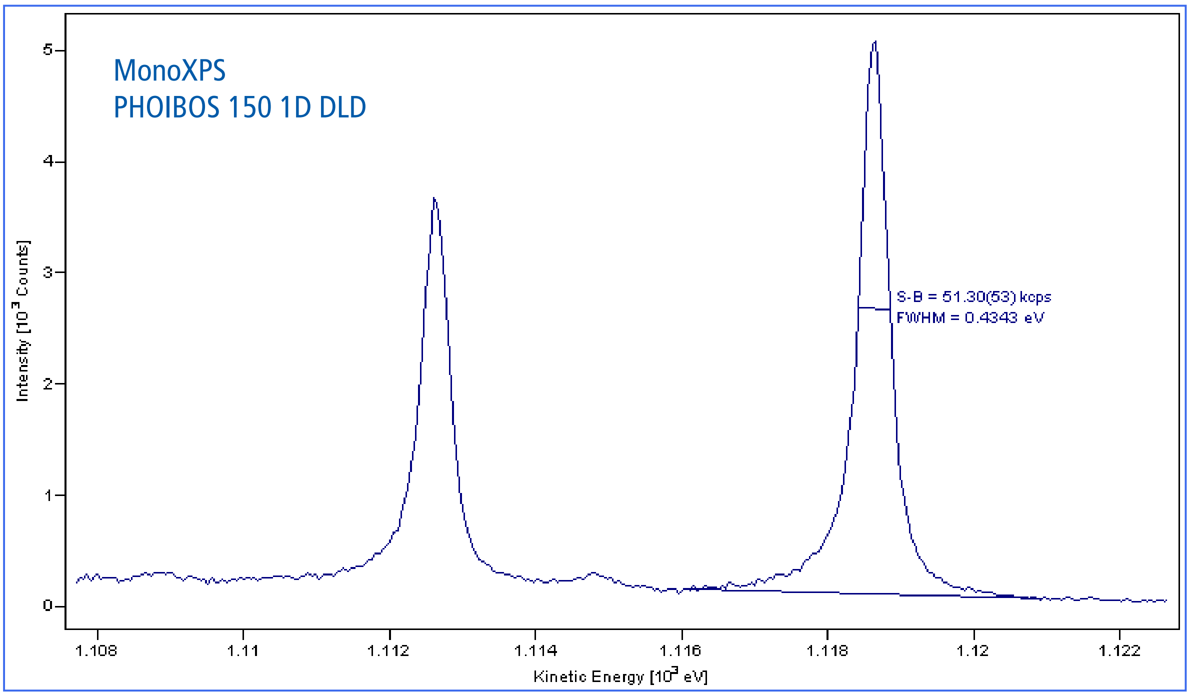
High Resolution Spectra

The diagram shows the Ag 3*d* peak. The measurement has been performed with a FOCUS 500 x-ray monochromator and a PHOIBOS 150 1D DLD hemispherical analyzer using the Medium Area mode. The analyzer was set to pass energy (6.2 eV) and analyzer slits (7 mm width at entrance and exit) to give an inherent electron energy resolution of about 220 meV. The Iris aperture was fully opened and the x-ray source was run in focus mode.

The result has proven that the instrument's high throughput is attainable even at highest resolution.

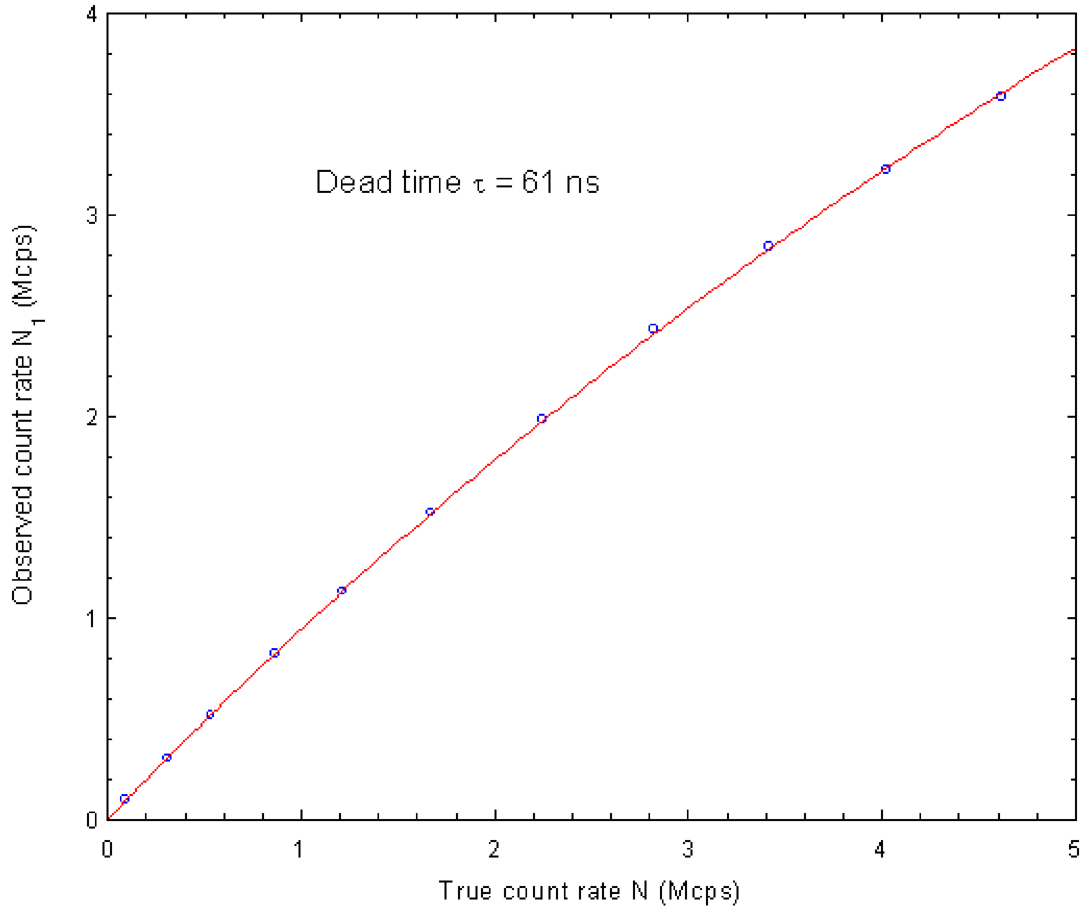


Maximum Count Rates

The relationship for an ideal counter with a non-extended dead time τ, observed count rate N_1 and true count rate N is given by

$$N_1 = N / (1 + N \tau).$$

We have measured the count rates as a function of the photoelectron current for a PHOIBOS 150 1D DLD analyzer. We have verified the linearity and the non-extended dead time behavior for the 1D delayline detector up to 4 Mcps. Up to these count rates no significant deviation from linearity could be observed with the detection system.



Time-resolved Methods using the 1D Delayline Detector

Many applications require time-dependent stroboscopic measurements, such as spectroscopy on pulsed cluster sources, MIES experiments with pulsed sources, the use of pulsed magnetic fields at magnetic samples, and any kind of experiment synchronization to pulsed photon sources like lasers, synchrotron facilities or free electron lasers. Such functionality can be used to improve the signal - background ratio or to separate repetitive changes in the spectroscopic signals at different coupled frequencies in the sample excitation setup. The most detector types may realize such functionality just by moving a small alternating active time aperture or step by step in time using a changeable delay. The disadvantage of such a method is the unavoidable duty cycle and so an intensity loss always occurs due to the random nature of the photo-ionization process. A delay-line detector overcomes that by measuring all incoming particles not only by position but also by time. Thus, the software can sort them into the appropriate time intervals and there will be no data loss at all.

All delay-line detector systems provide an intrinsic ability of clock-referenced measurements due to their data acquisition principle. The given dwell time for a point measurement can be sub-divided into various sub-time intervals, which can be defined as even in length or freely with different time lengths. The intervals may also overlap, or alternatively there could be any time gap between them. In order to use this functionality, the user must provide a periodic reference clock signal as a standard TTL signal which defines the zero time reference points of all defined intervals within the reference period time.

There are different reference period time ranges T_r available which operate with different time resolutions and digital dynamics:

Range	Specification
High precision range	T_r = 1 ns - 40 µs 2 - 16 time intervals freely definable Resolution 27 ps Using 21 bits dynamics in time measurement results
Extended high precision range	T_r = 1 ns - 950 s 2 - 16 time intervals freely definable Resolution: 27 ps – 232 ms Time results will be binned together in multiples of two by a user parameter in order to reach longer ranges of T_r using 12 bits dynamics in the time measurement results
Low precision range	T_r = 1 µs - 100 s 2 - 16 intervals freely definable Resolution: 25 ns Using 32 bits dynamics in time measurement results

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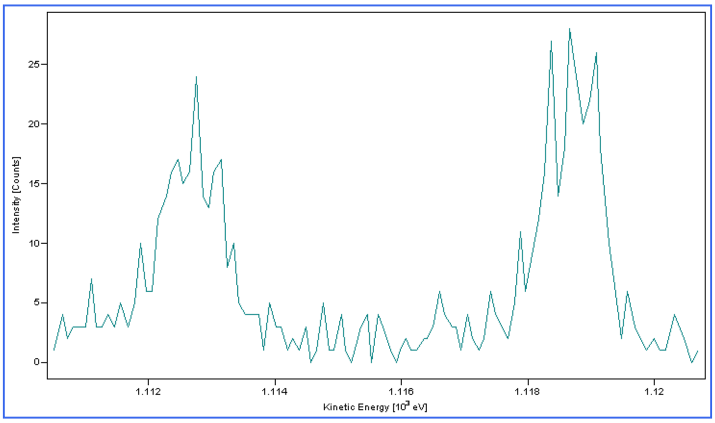
Snapshot Capability

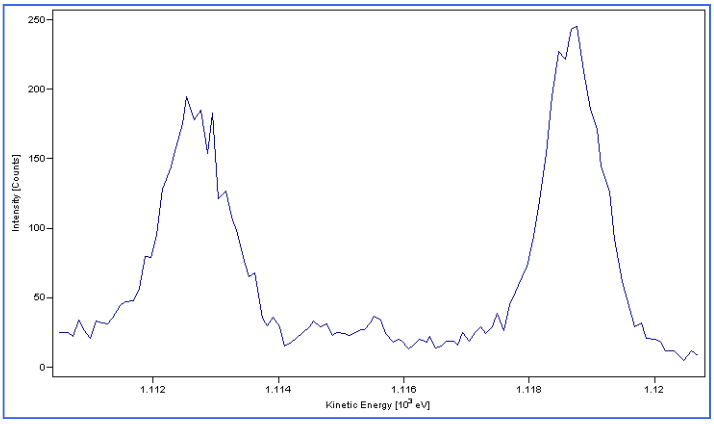
Using a PHOIBOS analyzer with a 1D Delayline detector, photoelectron spectra spanning a hundred channels of resolution can be obtained in as little as 1 ms using a snapshot mode without scanning the analyzer.

Fast spectra acquisition can be used to study chemical reactions on solid surfaces.

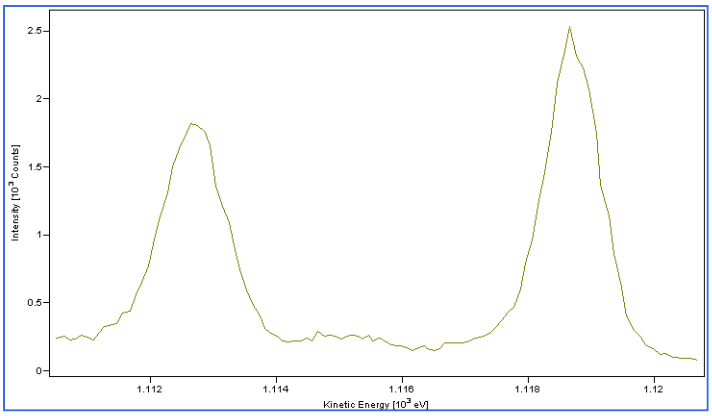
Acquisition Time 1 ms
Slit width 7 mm
Pass Energy 50 eV



Acquisition Time 10 ms
Slit width 7 mm
Pass Energy 50 eV



Acquisition Time 100 ms
Slit width 7 mm
Pass Energy 50 eV



SPECS GmbH
Surface Analysis and Computer Technology
Voltastrasse 5
13355 Berlin · GERMANY

Phone: +49 30 467824-0
Fax: +49 30 4642083
E-mail: support@specs.de
http://www.specs.de