

Modular soft X-ray spectrometers series

Hettrick-Underwood type parallel spectrometer

Specifications

The spectrometers are designed for absorption and/or fluorescence spectroscopy using laboratory soft x-ray sources such as laser-produced plasma (LPP), High Harmonics Generators (HHG), gas jet Isolated attosecond X-ray Pulse Generators (IPP), Relativistic Oscillating Mirror HHG (RHHG), Synchrotron radiation (SR) sources and free-electron lasers (FEL) with nano-femto-second pulse duration.

Minimum optical elements: extremely easy in alignment, extremely high throughput

Energy range:

Best performance in the energy range of 10 eV – 1300 eV

Energy resolving power:

$E/\Delta E > 1000$ in the entire energy range

Acceptance:

angular acceptance up to 3.6° in sagittal and 1.5° in meridional directions

Absolute transmission efficiency:

~ 20% in the energy range 40 eV – 600 eV,

~ 10% in the energy range 600 eV – 900 eV

~ 4% in the energy range 900 eV – 1300 eV

Detectors: back-illuminated CCD camera with a pixel size of 13.5 μm

UHV compatibility ($p < 10^{-8}$ mbar)

Modular design principle:

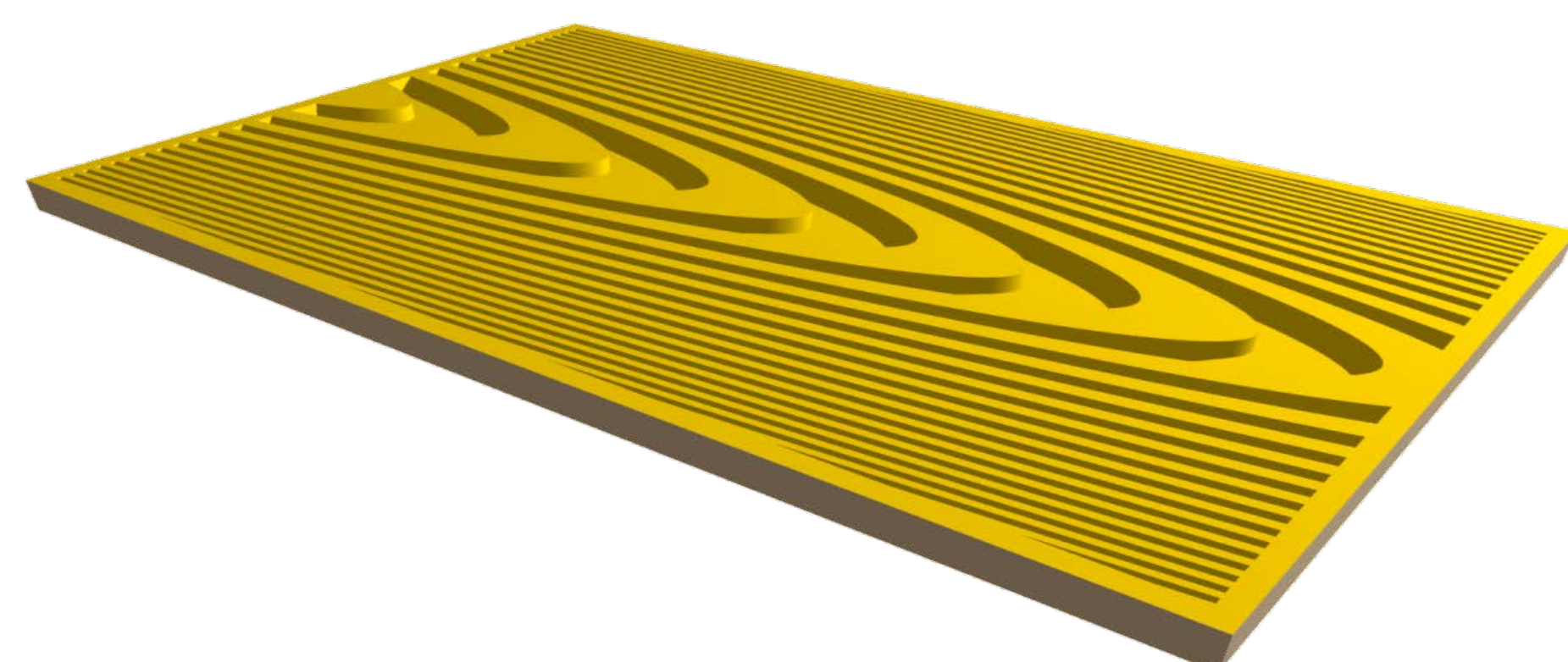
Optical elements are mounted in standardized vacuum chambers with mechanical alignment systems. Flexible combination possible.

Basic dispersion optical elements:

2-dimensional variable line spacing (2D-VLS) diffraction gratings and Reflection Zone Plates (RZP).

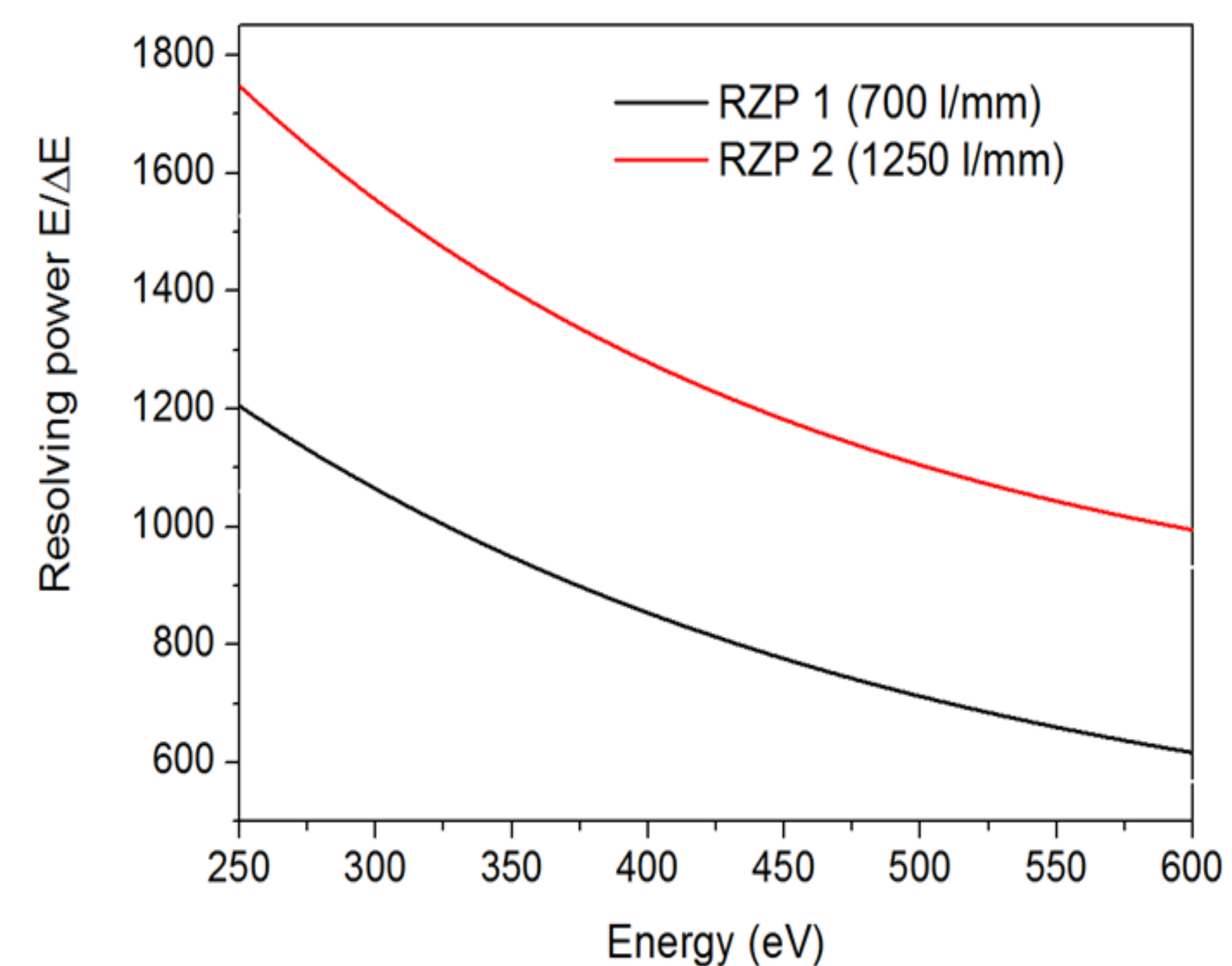
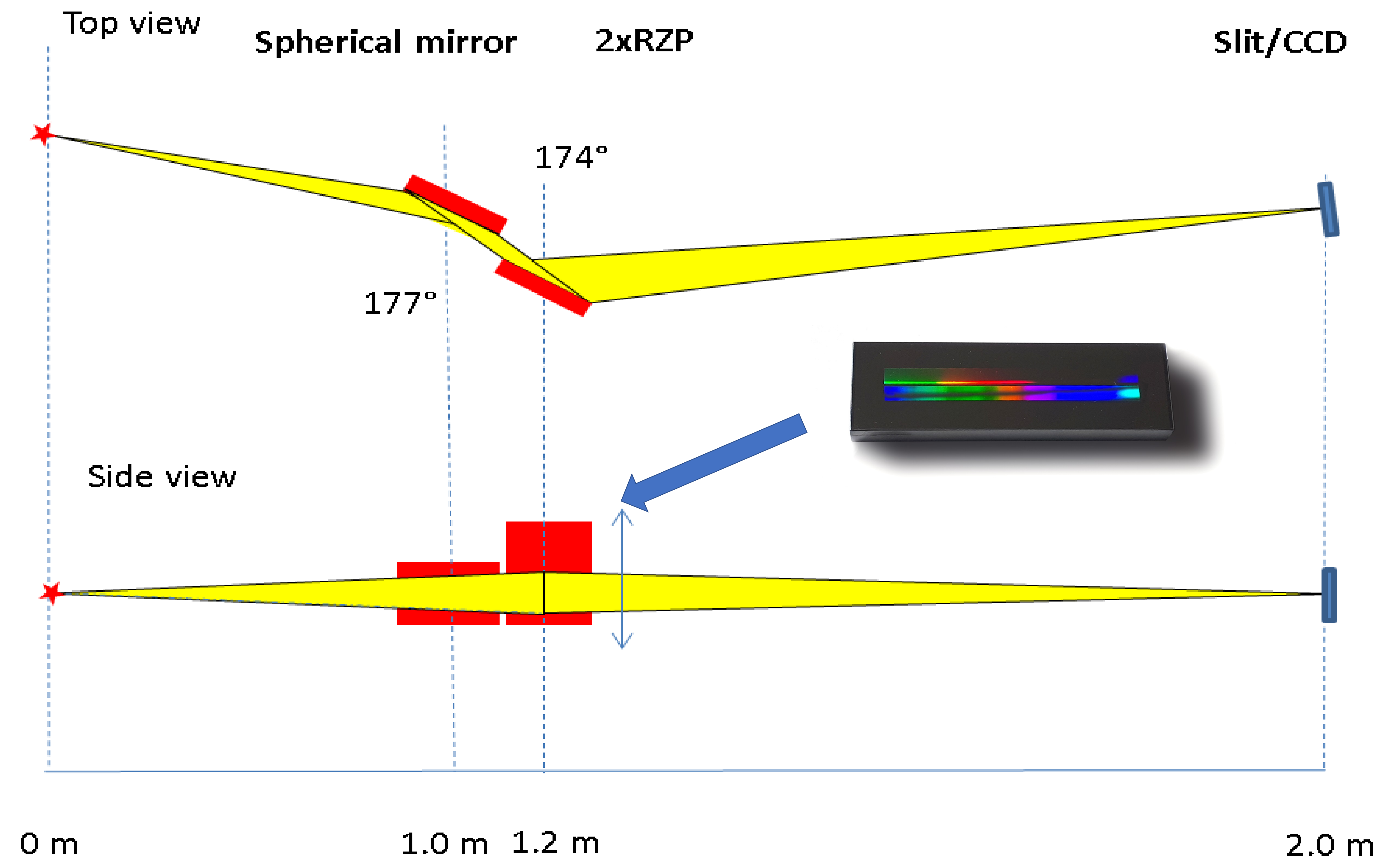
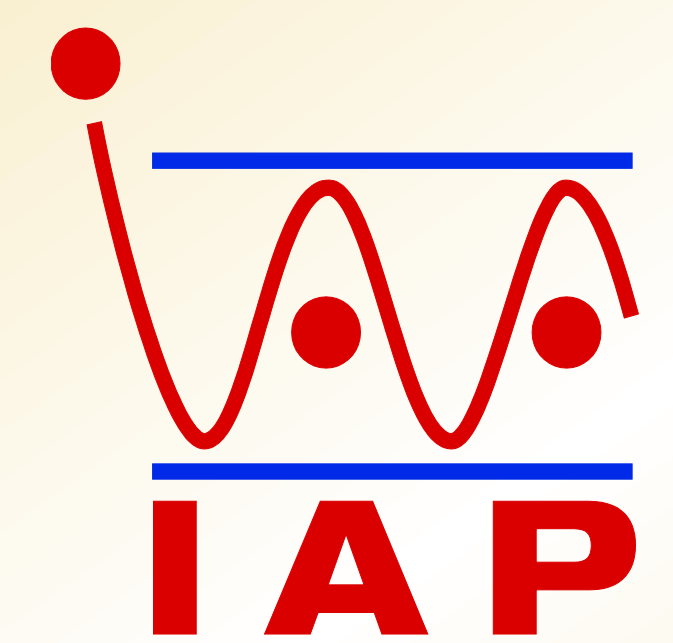
Producer: Nano Optics Berlin, NOB GmbH, Krumme Str. 64, 10627 Berlin.

Contact: info@nanooptics-berlin.com

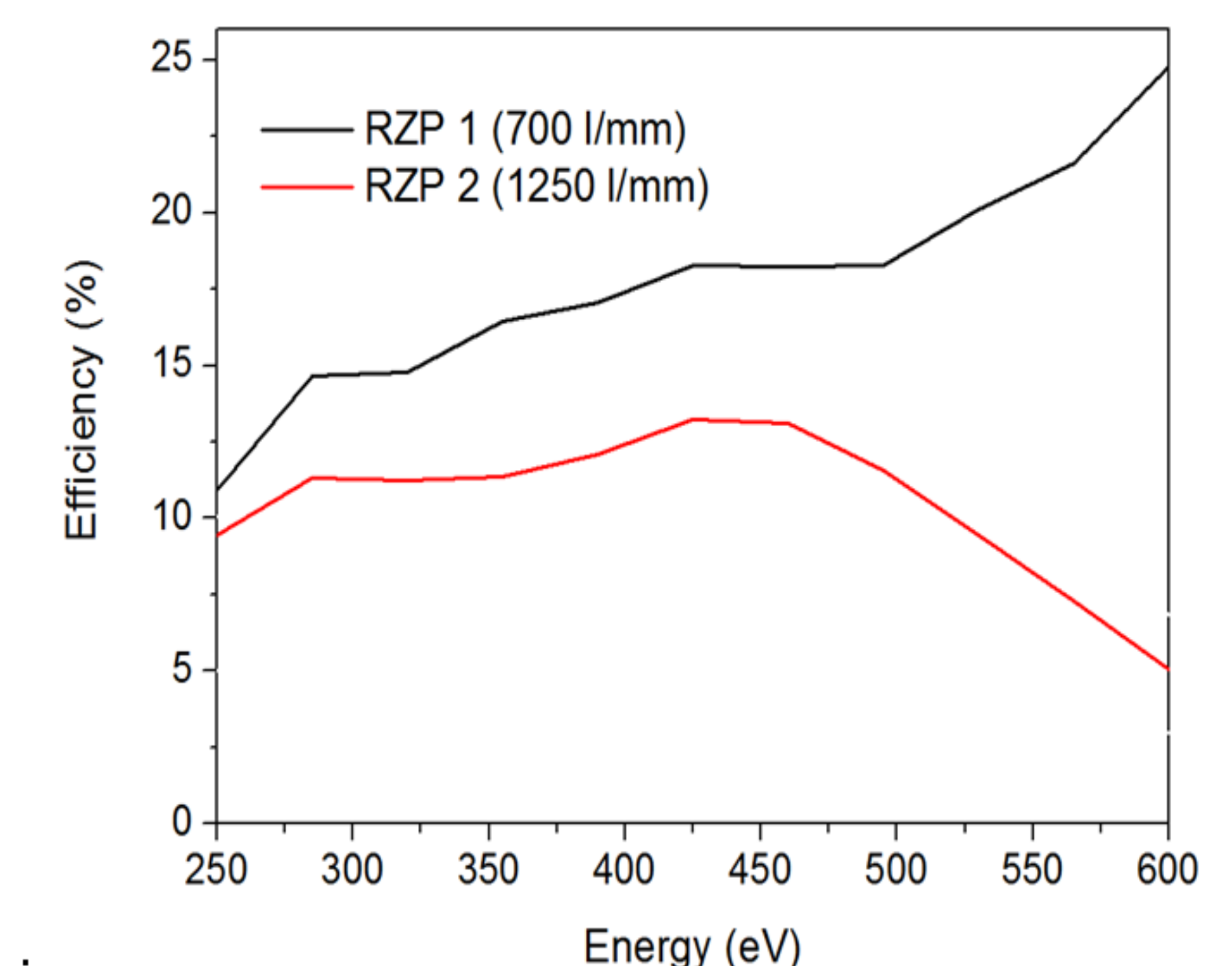


Customer specific design and construction

Ultra-high sensitive soft x-ray spectroscopy



Spectrometer resolving power.



Total efficiency, Ni coating

Characterization of real-world electro-catalysts under *operando* conditions by soft x-ray spectroscopy, R. Garcia-Diez et al., 13th International Conference on Synchrotron Radiation Instrumentation (SRI 2018), Abstracts, Poster, 119

Institut für angewandte Photonik, IAP e. V., Rudower Chaussee 29/31, 12489 Berlin, Germany,
 Phone: +49 (0) 30 6392-6503 (office)
 E-Mail: info@iap-adlershof.de
 Website: www.iap-adlershof.com



Time delay compensating monochromator

Specifications

The monochromator is designed for photoelectron spectroscopy using laboratory soft x-ray sources such as High Harmonics Generators (HHG), gas jet Isolated atto-second X-ray Pulse Generators (IPP), Relativistic Oscillating Mirror HHG (RHHG), Synchrotron radiation (SR) sources, free-electron lasers (FEL) with femto-second pulse duration.

Minimum optical elements: extremely easy in alignment, extremely high throughput.

Energy range:

Best performance in the energy range of 10 eV – 1300 eV

Energy resolving power:

$E/\Delta E > 1000$ in the entire energy range

Acceptance:

angular acceptance up to 1.5 mrad in sagittal and meridional directions

Absolute transmission efficiency:

4% - 8.5% in the energy range of 100 eV – 600 eV

Ultra-fast spectroscopic applications:

Time delay compensation down to 1 fs. Pump-probe experiments.

Detectors: Photo-electron spectroscopy (PES), Time-of-Flight (TOF) PES, X-ray fluorescence spectroscopy (XFS). Provided by customer.

UHV compatibility ($p < 10^{-8}$ mbar)

Modular design principle:

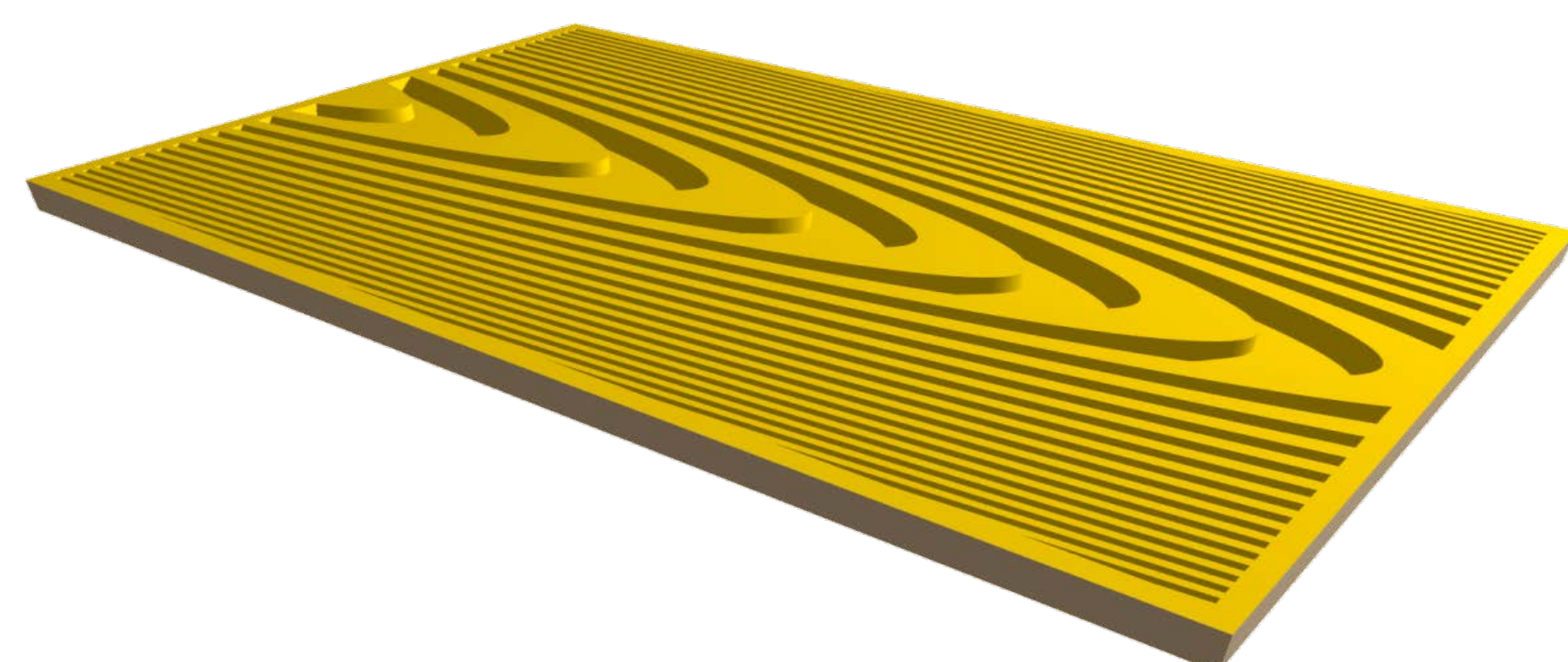
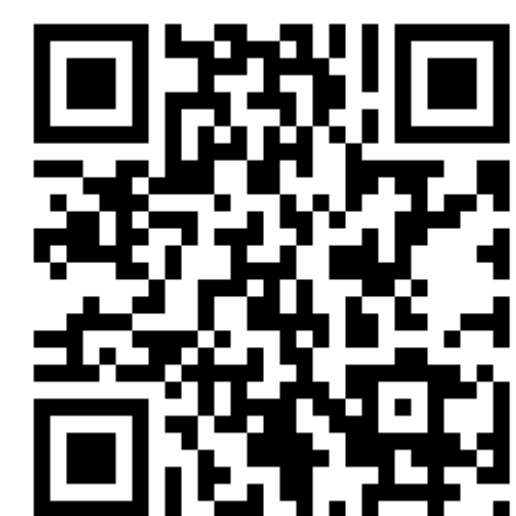
Optical elements are mounted in standardized vacuum chambers with mechanical alignment systems. Flexible combination possible.

Basic dispersion optical elements:

2-dimensional variable line spacing (2D-VLS) diffraction gratings and Reflection Zone Plates (RZP).

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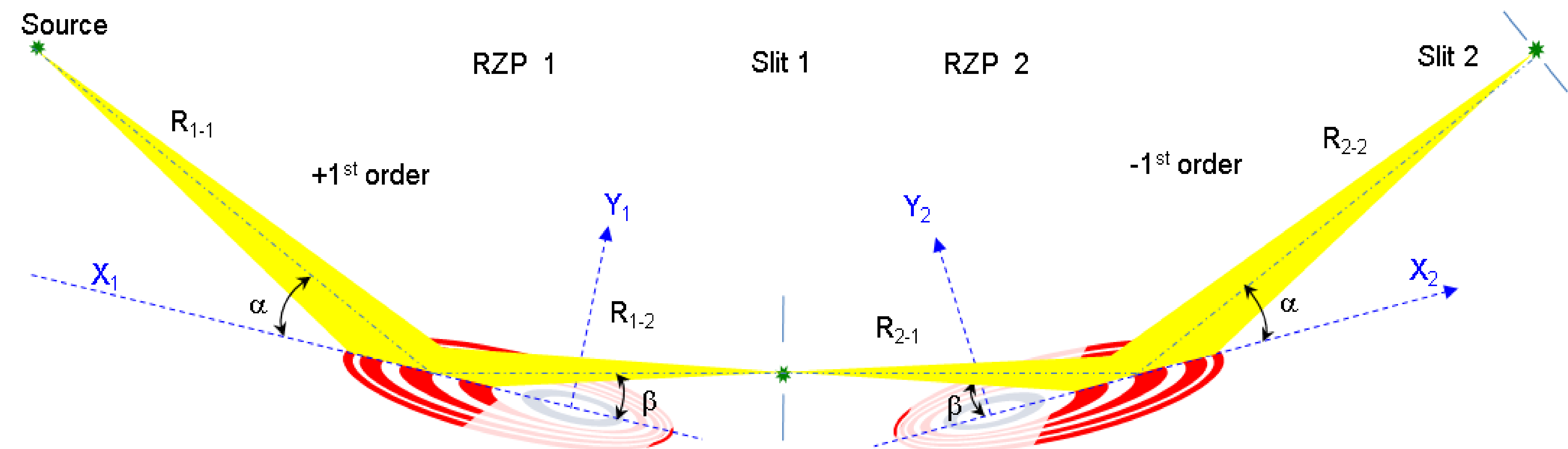


2-Dimensional VLS Gratings for X-ray Spectroscopy and Monochromators with Femtosecond Time Resolution Abstracts, International Conf. on X-ray Optics and Applications 2017, Yokohama, 18-21-April 2017

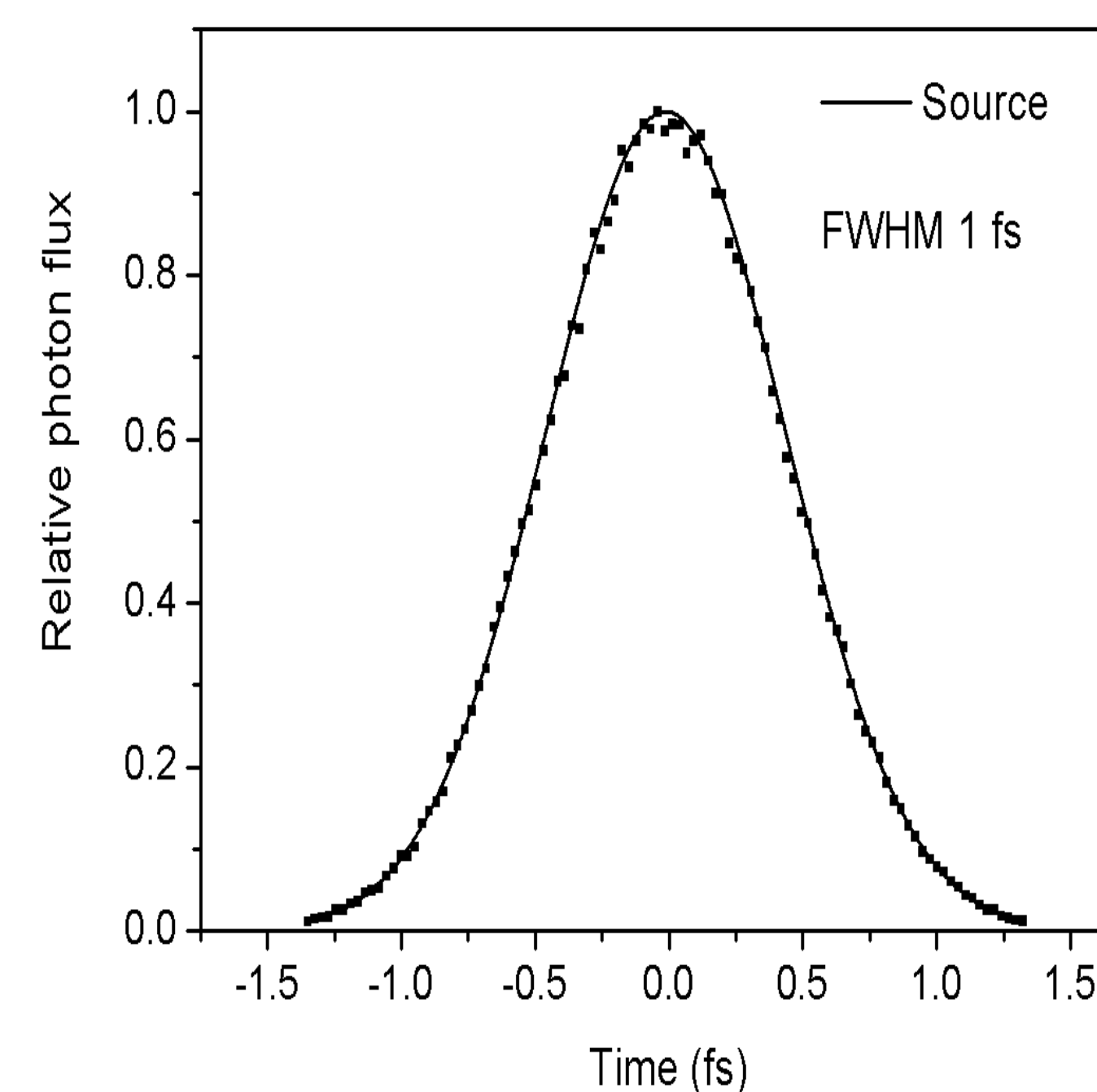
Femto-second absorption/photoelectron spectroscopy

Design parameters for the RZPs

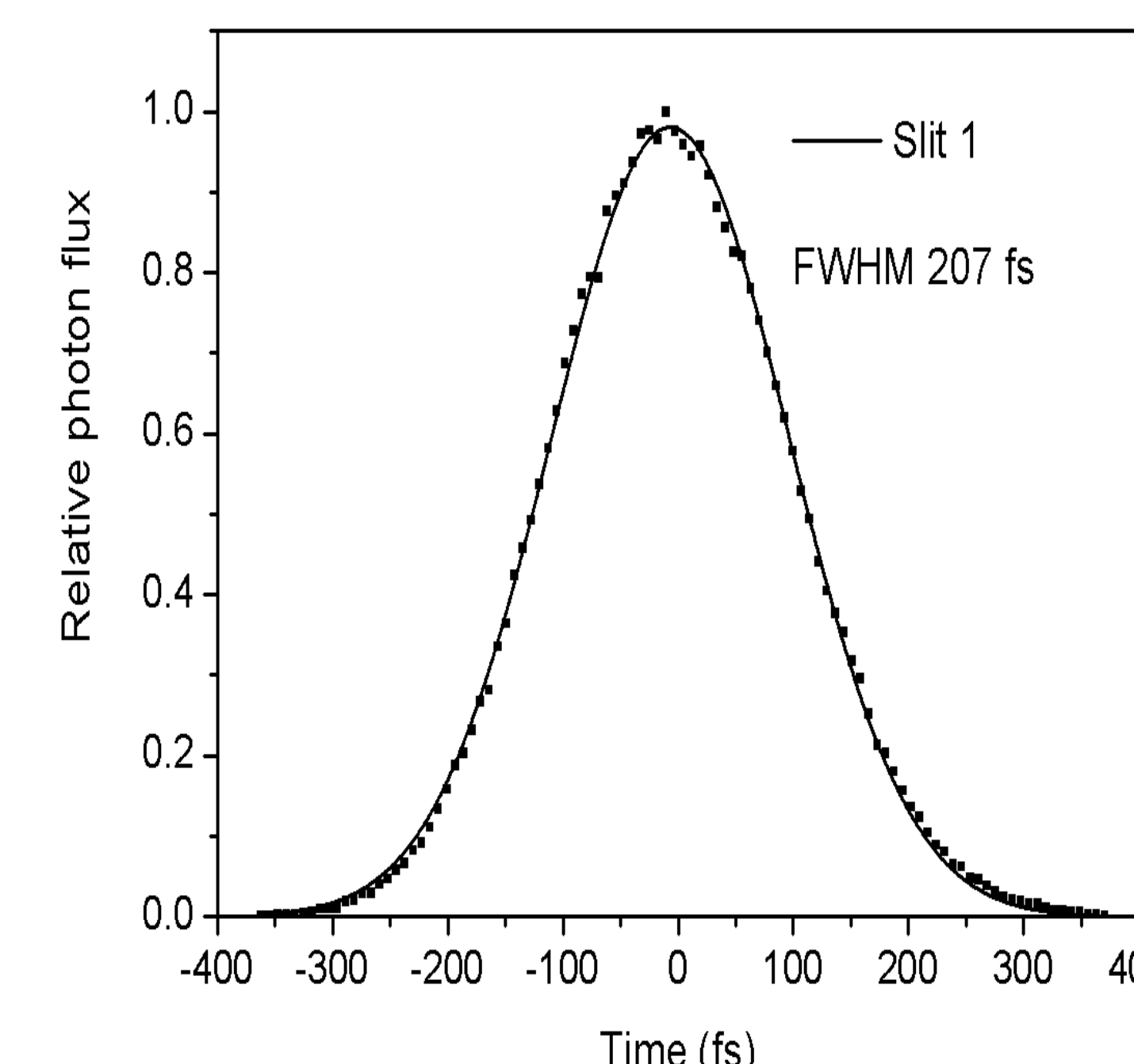
$\lambda/\Delta\lambda$	α (°)	β_n (°)	R_1 (mm)	R_2 (mm)	Δt_{pulse} (fs)
1000	2	4	1500	1500	5



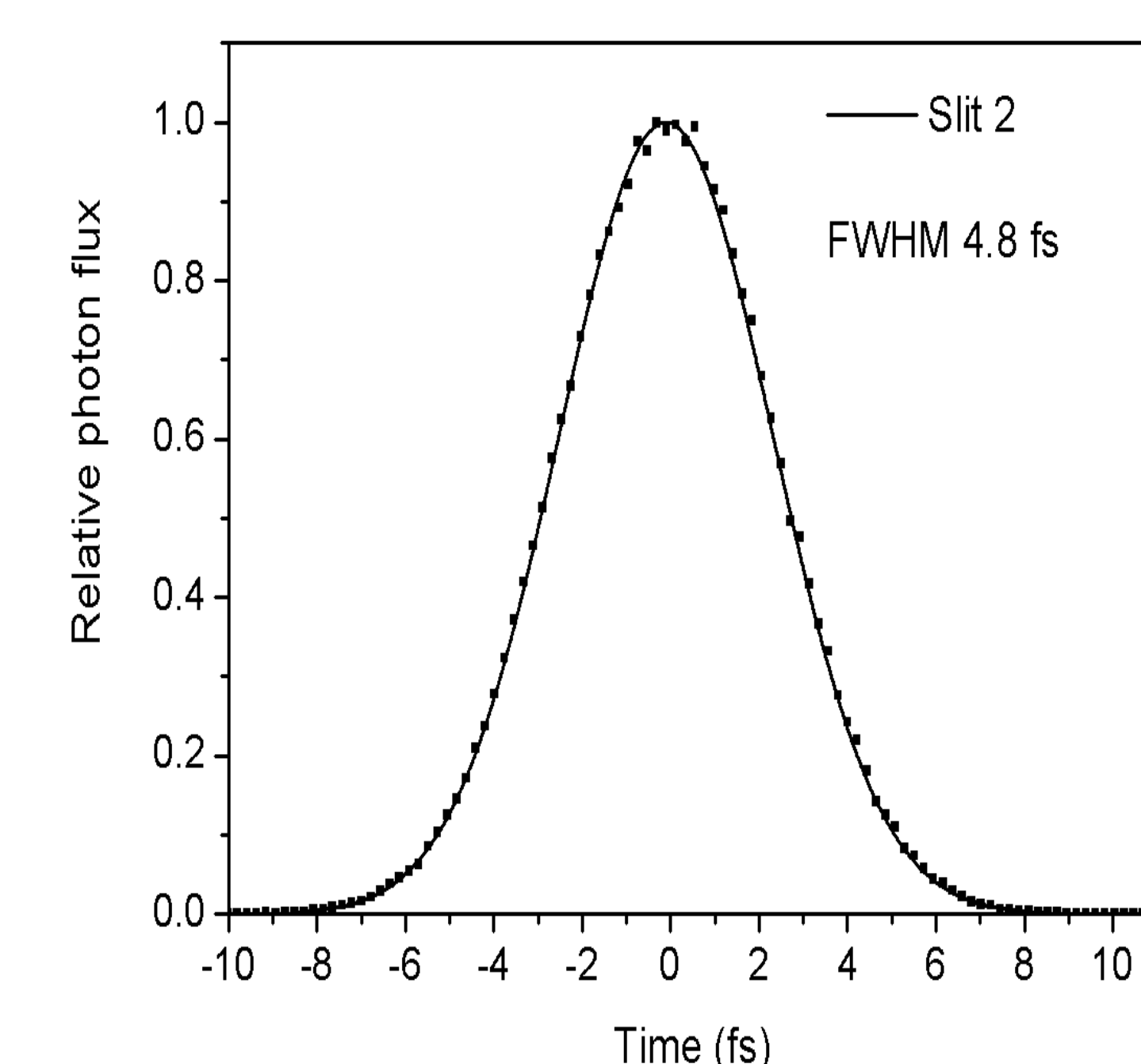
RZP	E (eV)	Depth (nm)	Line/mm	Coating	Eff 1 RZP %	Eff 2 RZP %	Efficiency %
1	100	48	152	C	25	37	8.5
2	200	30	303	C	31	30	9
3	300	18	455	Ni	22	23	4.4
4	450	12	682	Ni	24	22	5.4
5	600	10	910	Ni	22	20	4.5



Source pulse
1 fs



Pulse elongation after RZP1:
206 fs



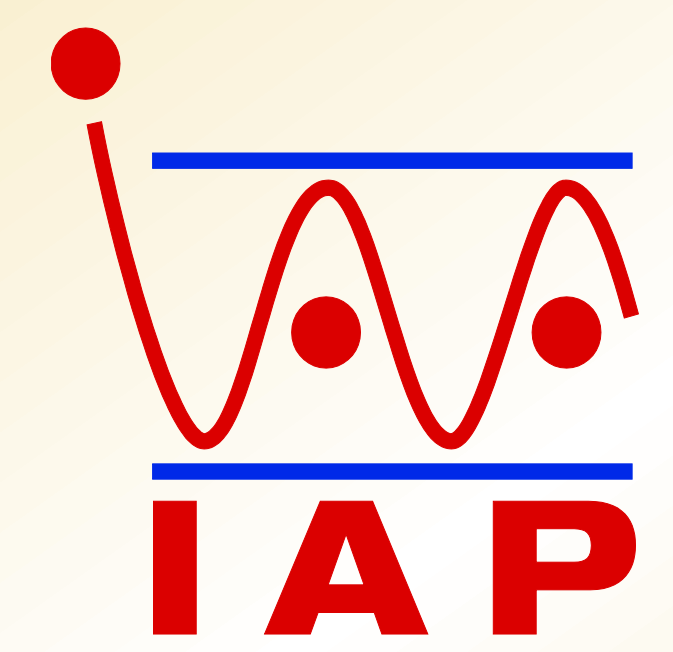
Pulse compression after RZP2:
4.8 fs

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Modular soft X-ray spectrometers series

Customer specific design and construction



Single reflection zone plate monochromator

Specifications

The monochromator is designed for photoelectron spectroscopy using laboratory soft x-ray sources such as High Harmonics Generators (HHG), gas jet Isolated atto-second X-ray Pulse Generators (IPP), Relativistic Oscillating Mirror HHG (RHHG), Synchrotron radiation (SR) sources, free-electron lasers (FEL) with femto-second pulse duration.

Energy range:

Best performance in the energy range of 10 eV – 1300 eV

Energy resolving power:

$E/\Delta E \sim 40$ to 1000 in the entire energy range

Acceptance:

angular acceptance up to 1.5 mrad in sagittal and meridional directions

Absolute transmission efficiency:

> 20% in the energy range 10 eV – 600 eV,

> 10% in the energy range 600 eV – 900 eV

> 4% in the energy range 900 eV – 1300 eV

Ultra-fast spectroscopic applications:

Optimized time delay down to 25 fs. Pump-probe experiments.

Detectors: Photo-electron spectroscopy (PES), Time-of-Flight (TOF) PES, X-ray fluorescence spectroscopy (XFS). Instrumentation provided by customer.

UHV compatibility ($p < 10^{-8}$ mbar)

Modular design principle:

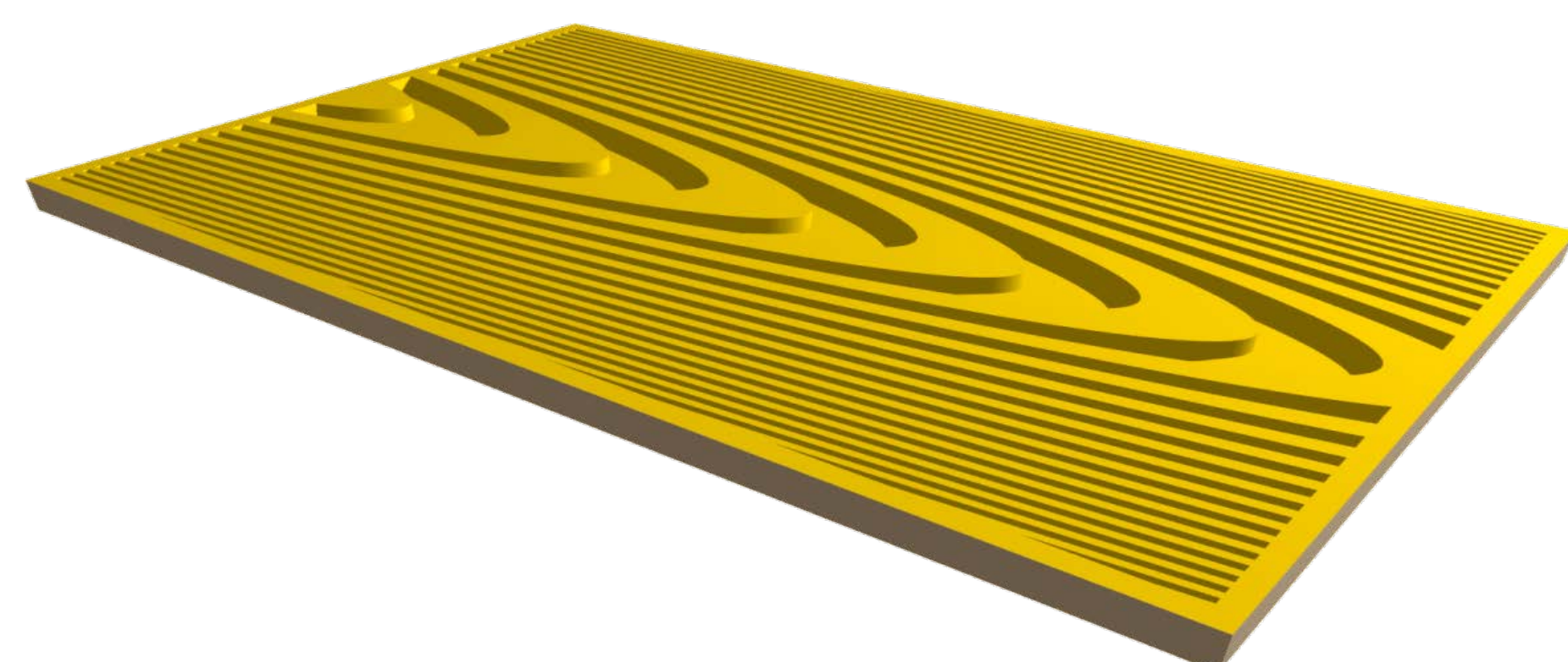
Optical elements are mounted in standardized vacuum chambers with mechanical alignment systems. Flexible combination possible.

Basic dispersion optical elements:

2-dimensional variable line spacing (2D-VLS) diffraction gratings and Reflection Zone Plates (RZP).

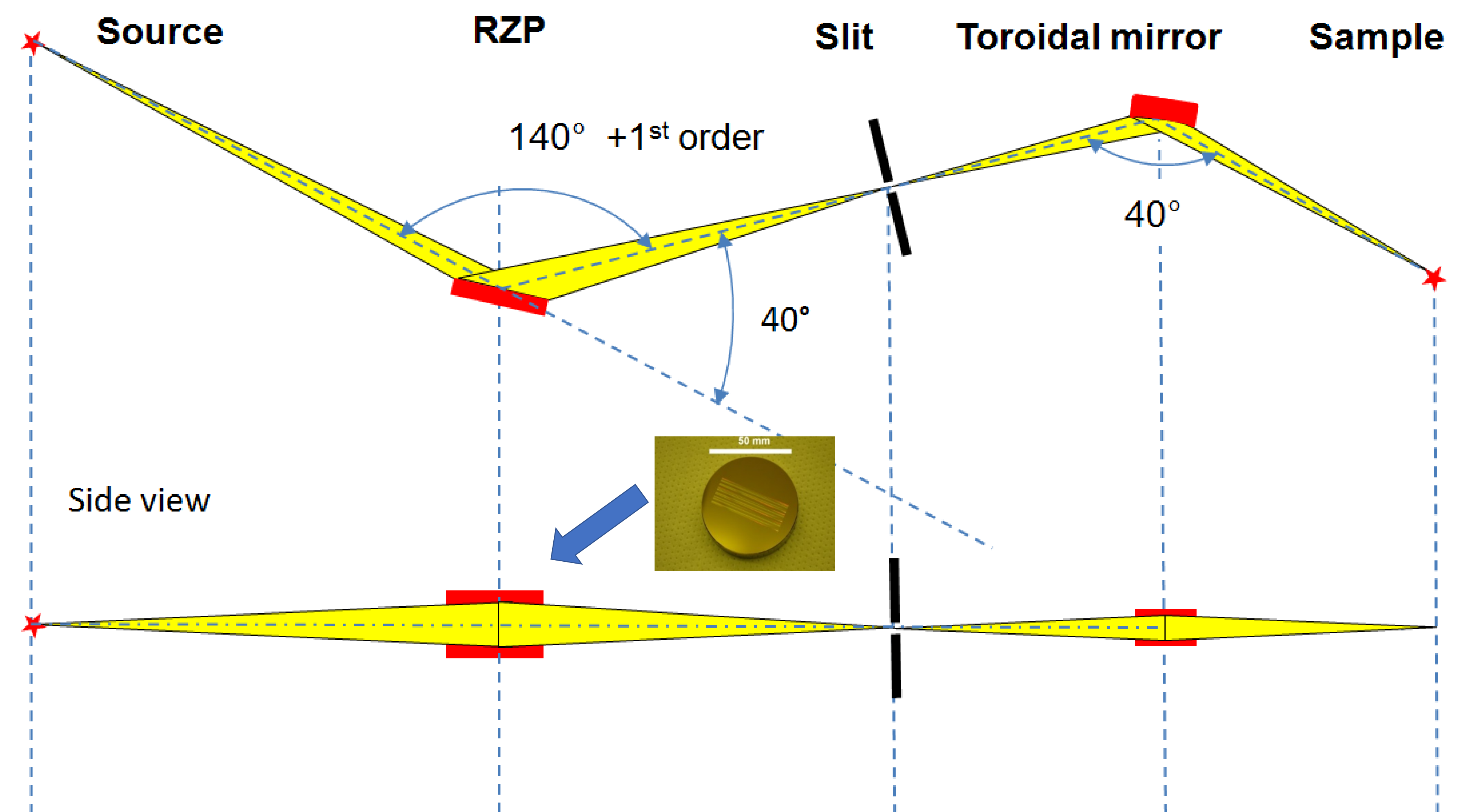
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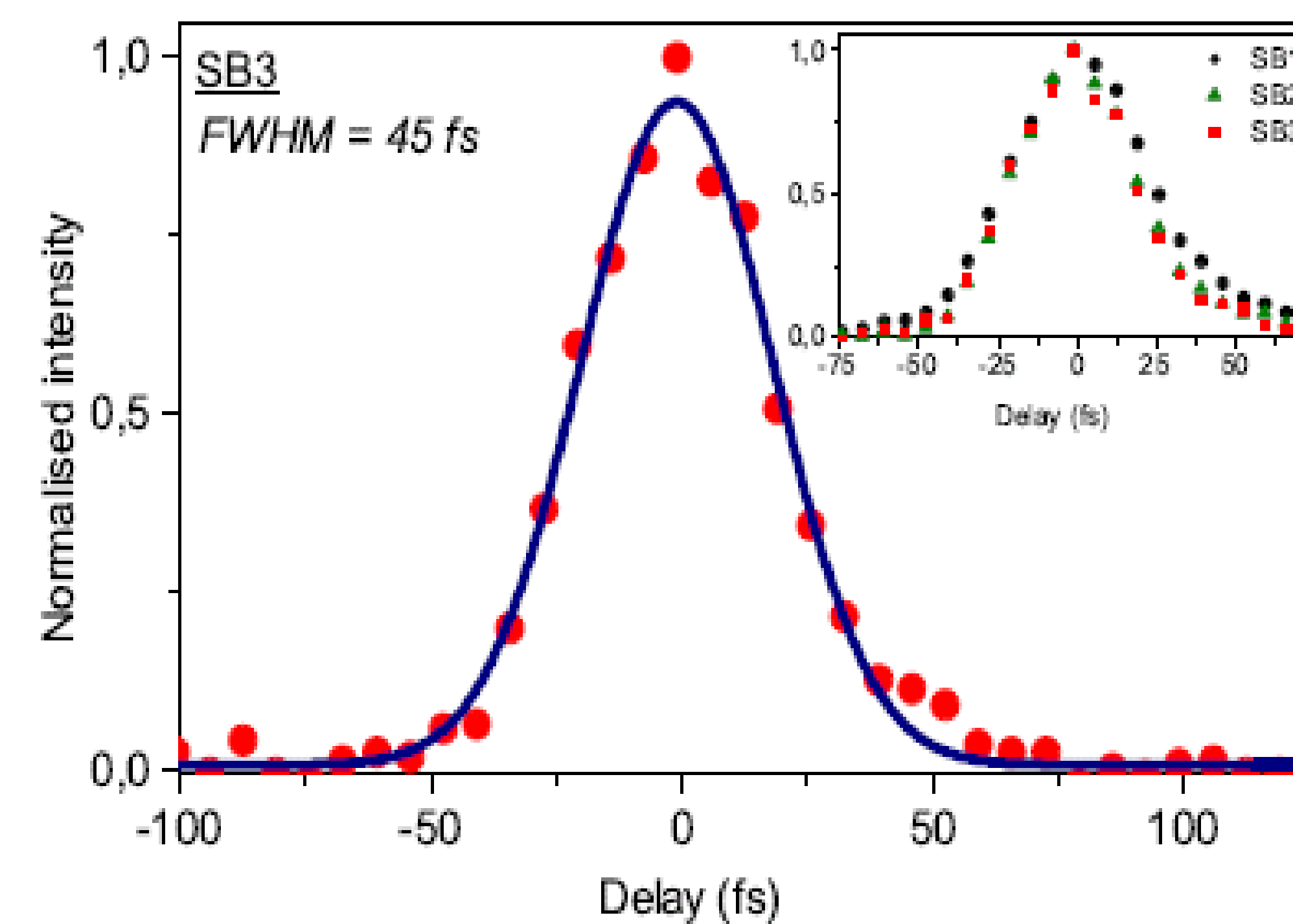


High-resolution high throughput monochromator

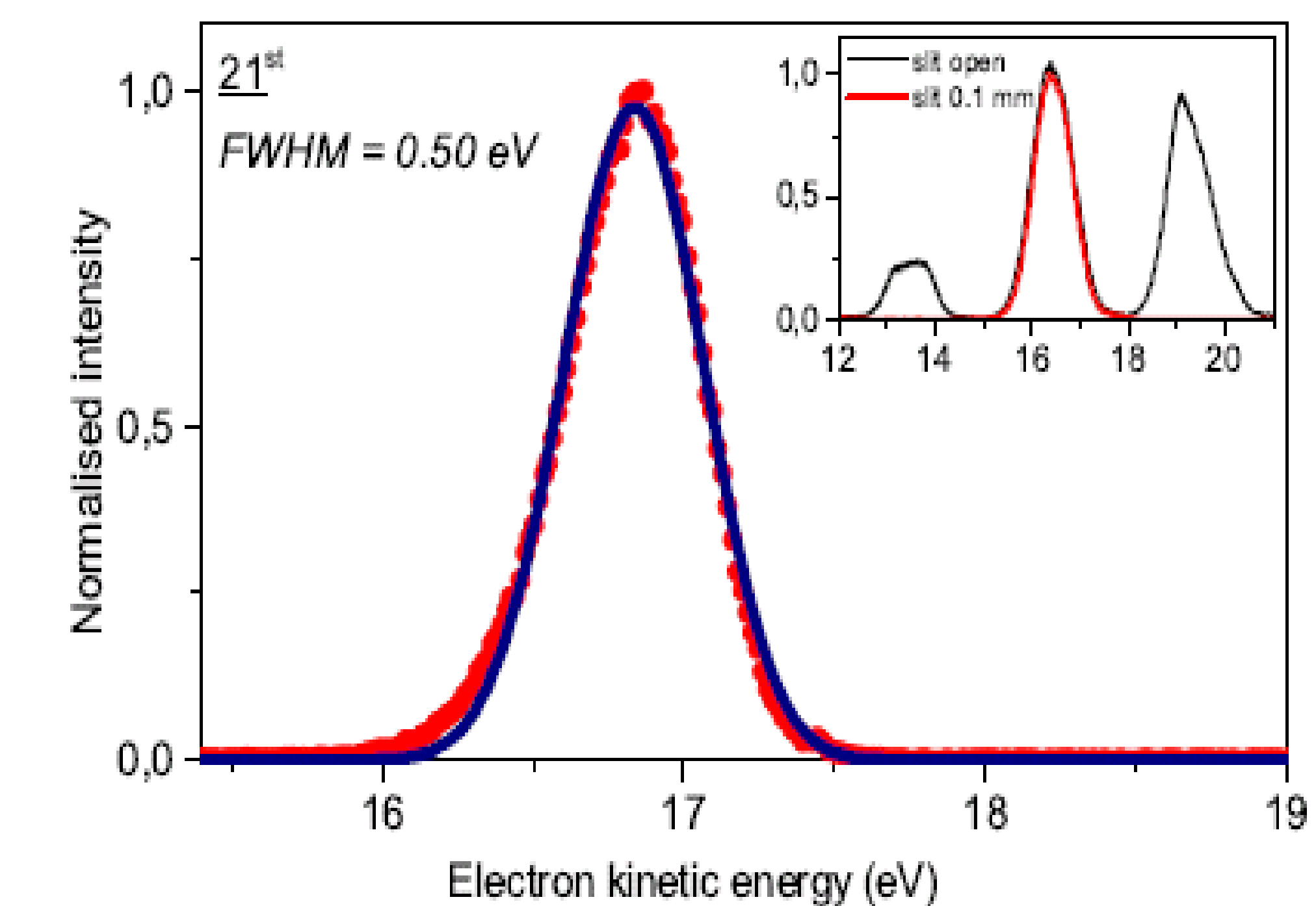
Top view



0 m 1.5 m 2.0 m 2.75 m 3.5 m



Kinetic energy spectrum of photoelectrons of Ar created by 21st harmonic. $E/\Delta E \sim 40$



Cross correlation signal from integrated SB3 intensities

Monochromatization of femtosecond XUV light pulses with the use of reflection zone plates J. Metje et al., Optics Express (2014), 22 (9), 10747-10760

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Single reflection zone plate spectrometers

Specifications

The spectrometers are designed for absorption spectroscopy using laboratory soft x-ray sources such as laser-produced plasma (LPP), High Harmonics Generators (HHG), gas jet Isolated atto-second X-ray Pulse Generators (IPP), Relativistic Oscillating Mirror HHG (RHHG), Synchrotron radiation (SR) sources, Free-electron lasers (FEL) with nano-femto-second pulse duration.

Single optical element: extremely easy in alignment, extremely high throughput.

Energy range:

Best performance in the energy range of 10 eV – 1300 eV

Energy resolving power:

$E/\Delta E > 2000$ in the entire energy range

Acceptance:

angular acceptance up to 10° in sagittal direction, 1.5° in meridional direction

Absolute transmission efficiency:

$> 20\%$ in the energy range 40 eV – 600 eV,

$> 10\%$ in the energy range 600 eV – 900 eV

$> 4\%$ in the energy range 900 eV – 1300 eV

Detectors: back-illuminated CCD camera with a pixel size of $13.5 \mu\text{m}$

UHV compatibility ($p < 10^{-8}$ mbar)

Modular design principle:

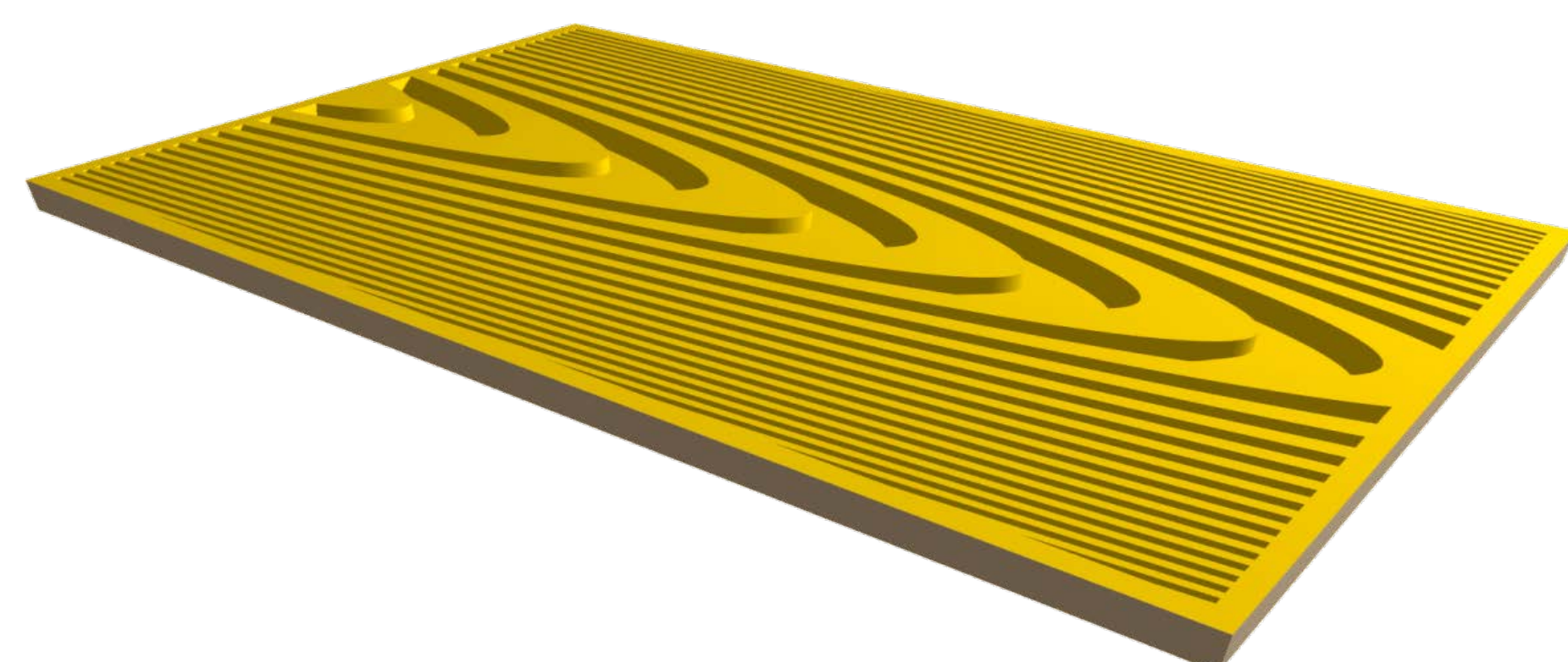
Optical elements are mounted in standardized vacuum chambers with mechanical alignment systems. Flexible combination possible.

Basic dispersion optical elements:

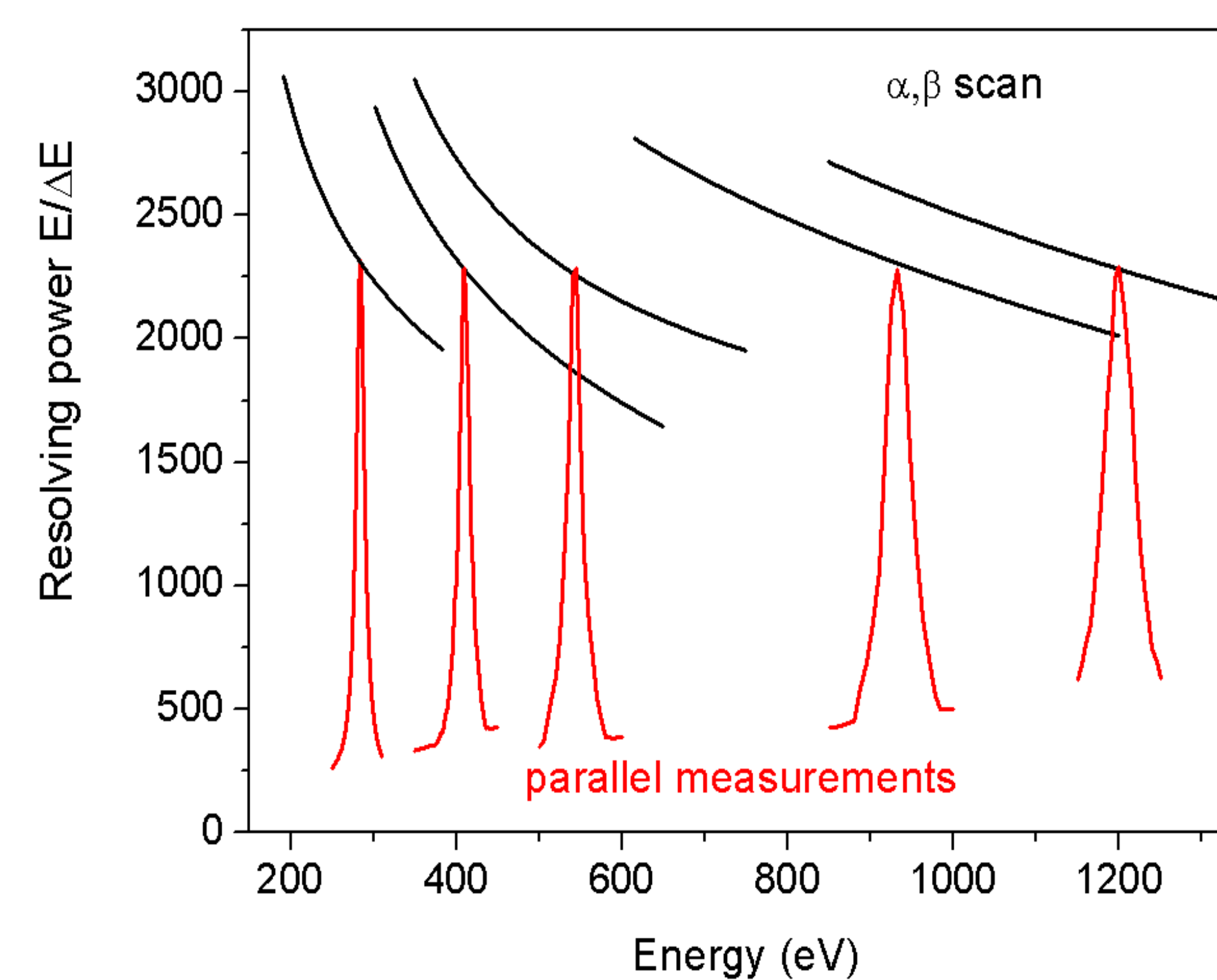
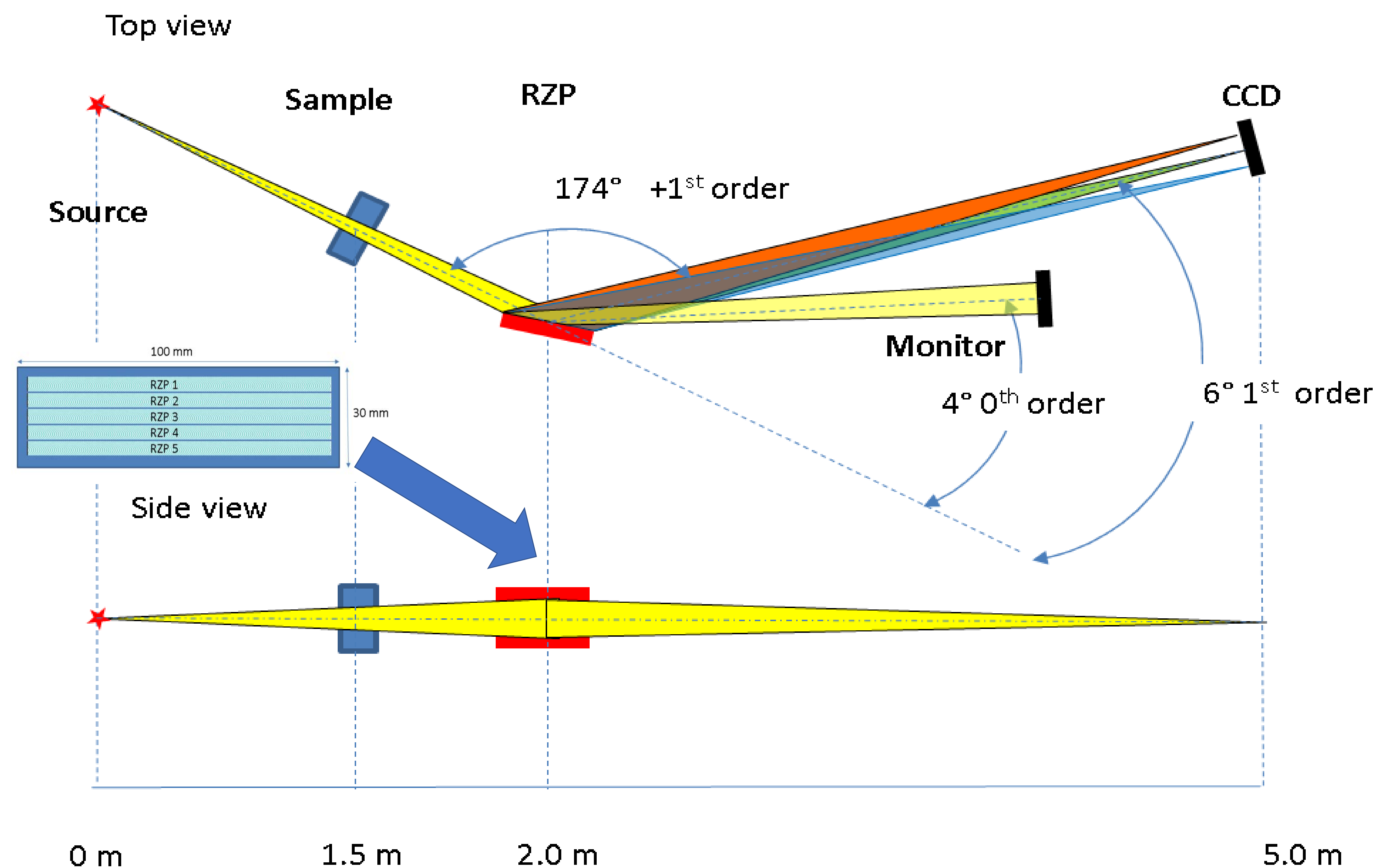
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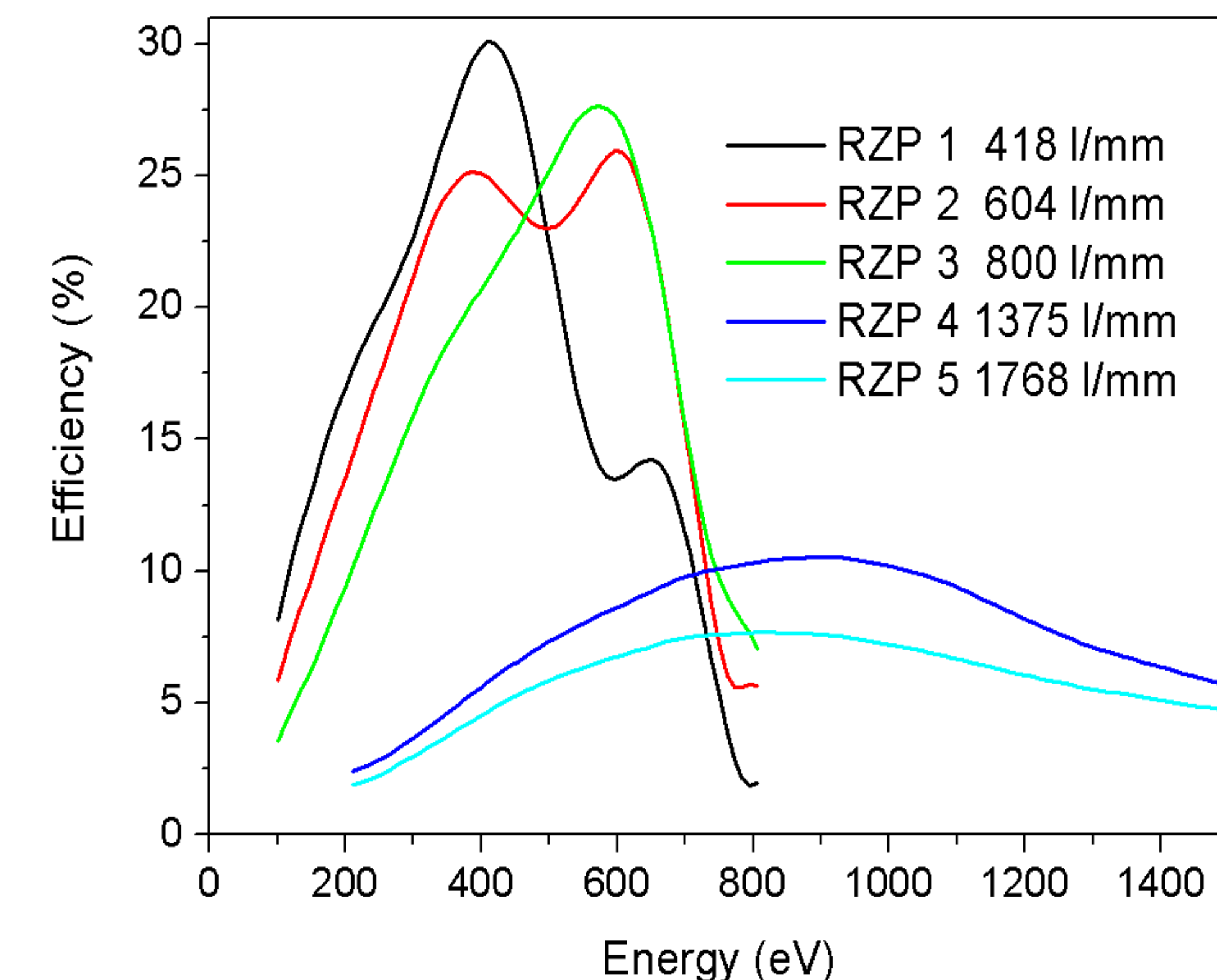
Contact: info@nanooptics-berlin.com



High-resolution high throughput absorption spectroscopy



Parallel measured energy range and $\alpha - \beta$ scan



Efficiency of the RZPs. Ni coating for RZP 1-3, Au coating for RZP 4-5.

FemtoSpeX: a versatile optical pump-soft X-ray probe facility with 100 fs X-ray pulses of variable polarization, K. Holldack et al., *J. Synchrotron Rad.* (2014). **21**, 1090-1104

Single shot near edge x-ray absorption fine structure spectroscopy in the laboratory, I. Mantouvalou et al., *Appl. Phys. Lett.* **108**, (2016) 201106

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