FEL 2004

Photon Radiometry

Ioffe Physico-Technical Institute

DESY

Gas-Monitor Detectors for FEL Online Photon Beam Diagnostics

M. Richter

S.V. Bobashev, J. Feldhaus
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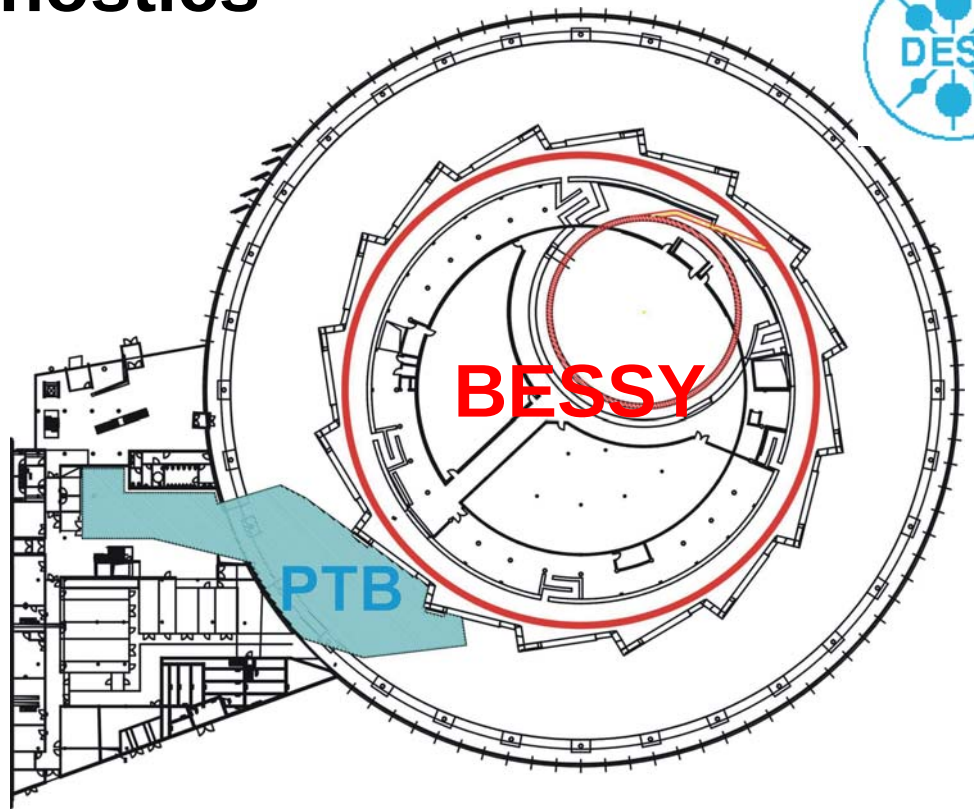
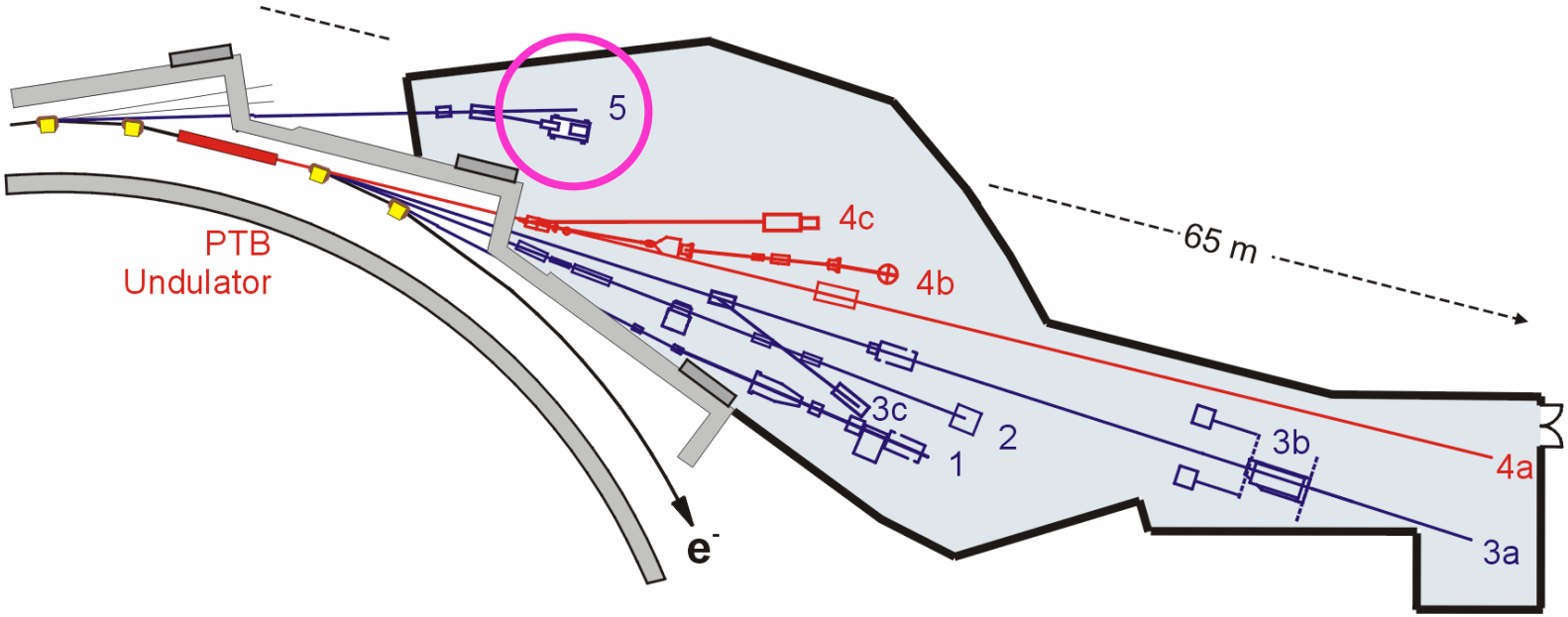
A.A. Sorokin, K. Tiedtke



PTB's Radiometry Laboratory at BESSY II

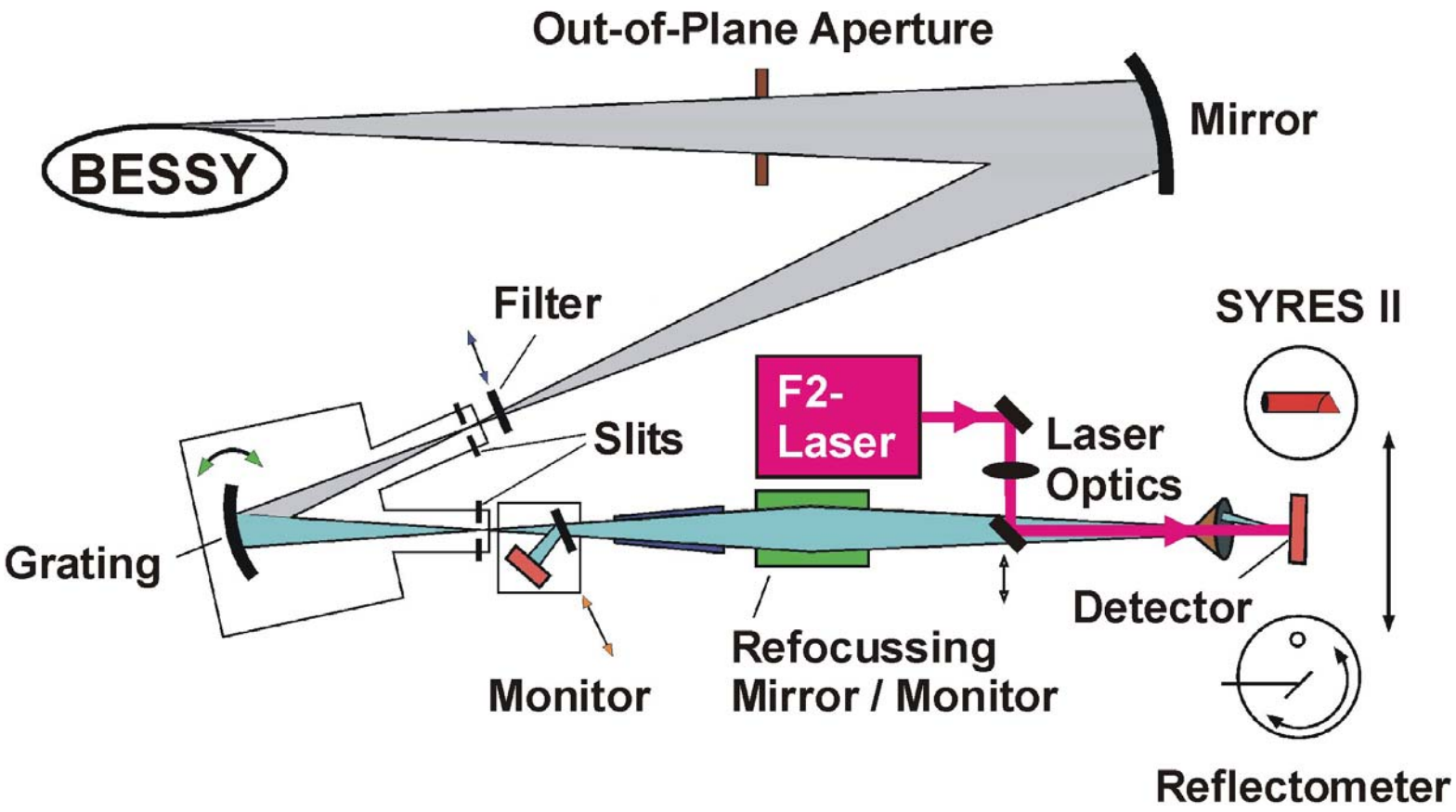
Photon Radiometry



1	plane grating monochromator 30 eV to 1800 eV	**4a**	undispersed undulator radiation
2	four crystal monochromator 1.75 keV to 10 keV	**4b**	plane grating monochromator at undulator 20 eV to 1900 eV
3a	undispersed bending magnet radiation	**4c**	deflected undispersed undulator radiation metrology test station
3b	normal incidence monochromator 3 eV to 35 eV	**5**	normal incidence monochromator 3 eV to 35 eV
3c	deflected undispersed bending magnet radiation, irradiation test station		

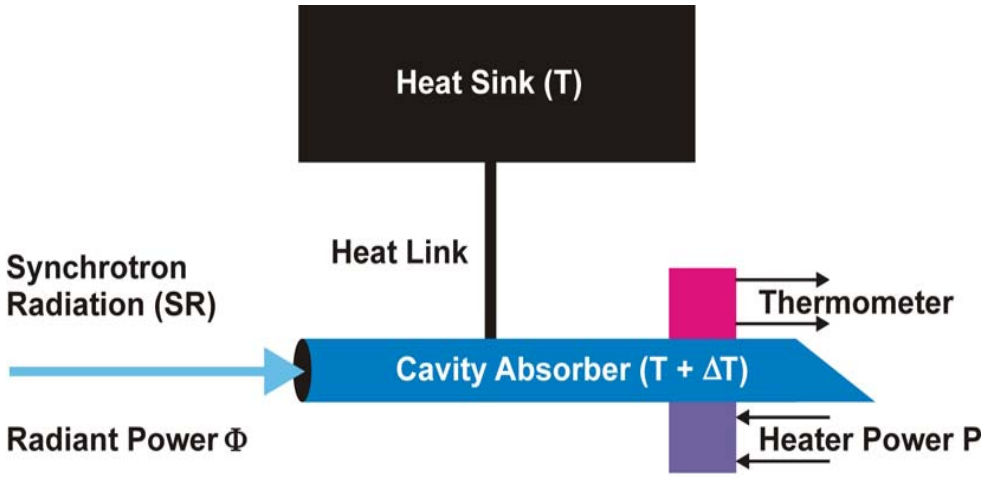
Normal-Incidence-Monochromator (NIM) Beamline for Detector Calibration and Reflectometry in the (V)UV

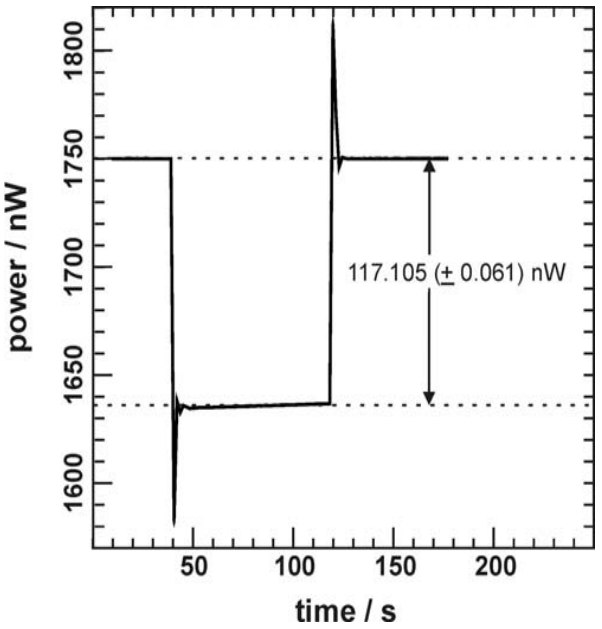
Photon Radiometry



Cryogenic Electrical Substitution Radiometer as Primary Detector Standard (SYRES II)

Photon Radiometry





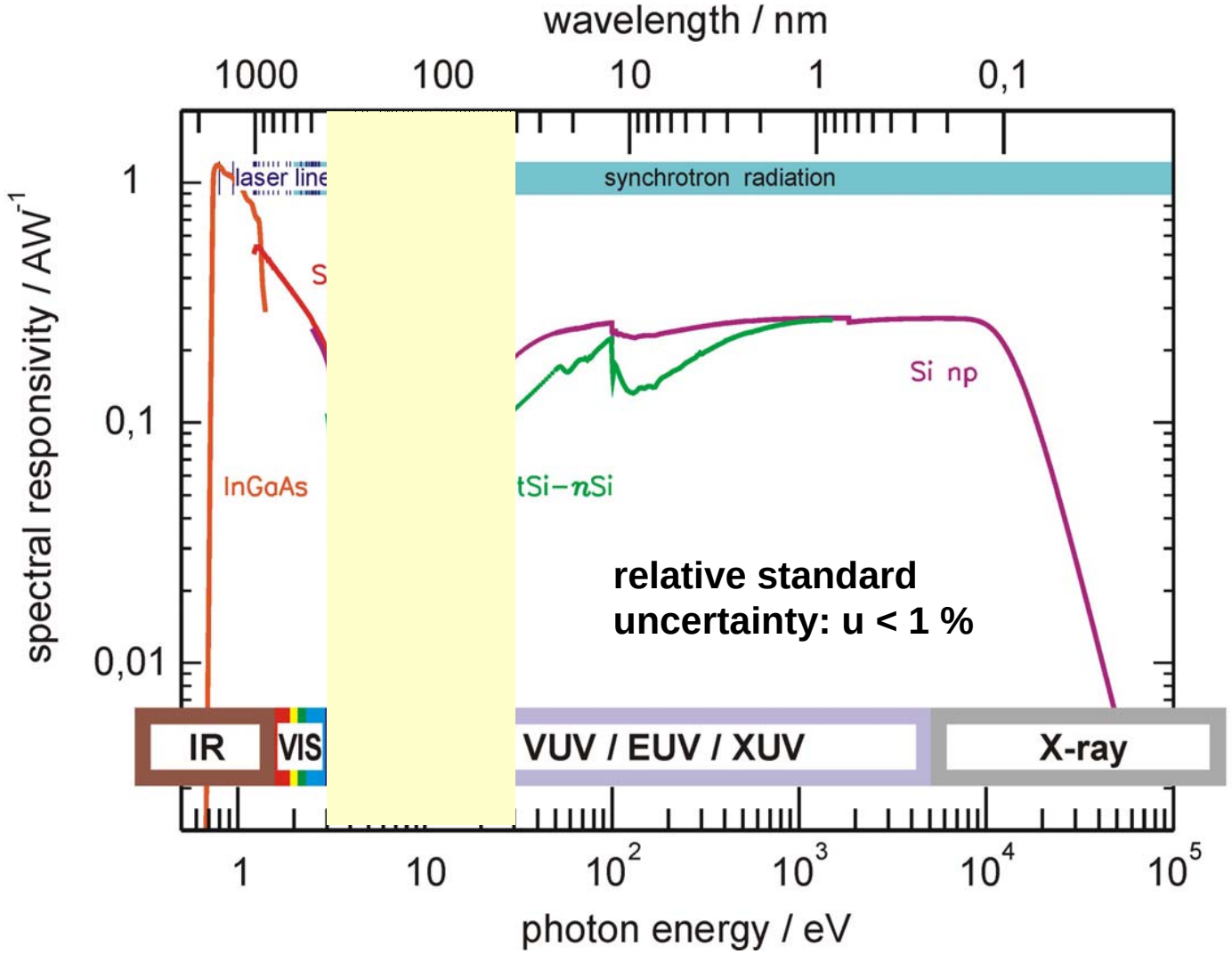
For constant absorber temperature T + ΔT:

$\Phi = P_{SR\ off} - P_{SR\ on}$ (Electrical Substitution)

Relative standard uncertainty for detected radiant power: u < 0.1 %

PTB's Spectral Responsivity Scale of Semiconductor Photodiodes

Photon Radiometry



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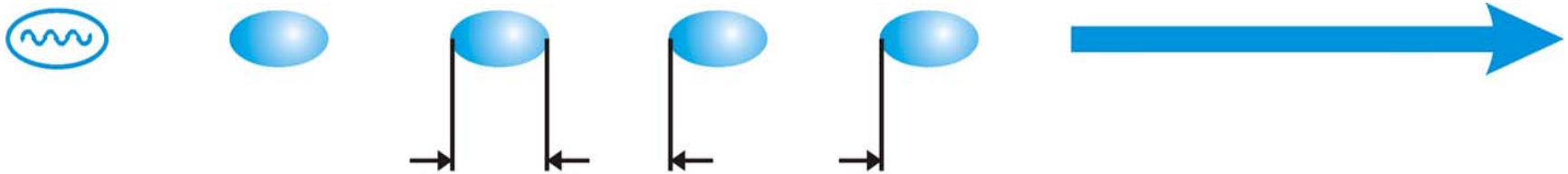
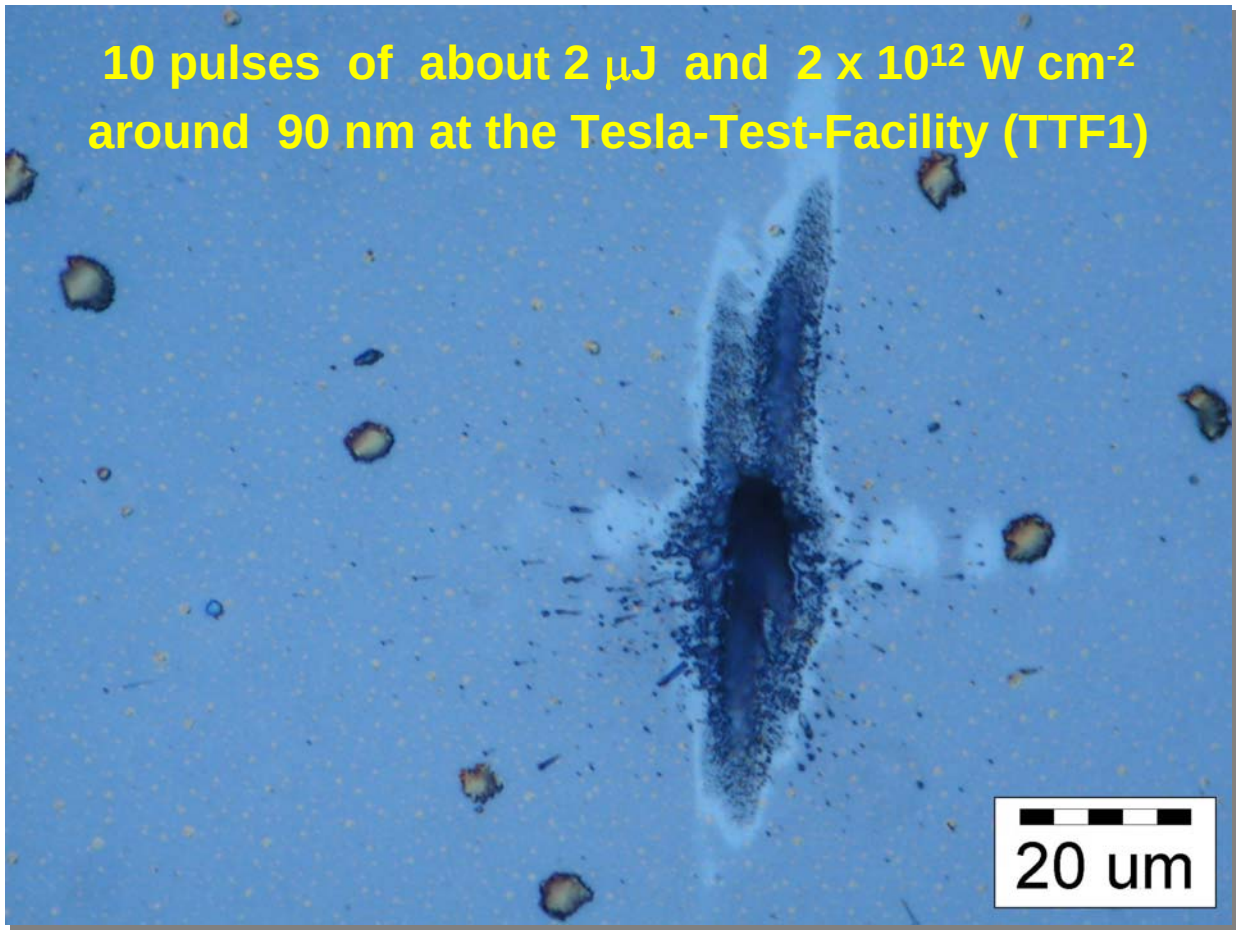
Time Structure of VUV Radiation Sources

Photon Radiometry



	Pulse duration	Pulse distance	Average power	Pulse energy	Peak power
Undulator (BESSY multi bunch)	30 ps	2 ns	0.5 W	1 nJ	30 W
Undulator (BESSY single bunch)	80 ps	0.8 µs	50 mW	50 nJ	600 W
F2 laser (lithography)	10 ns	0.5 ms	20 W	10 mJ	1 MW
EUVL source (pinch plasma)	20 ns	0.5 ms	40 W	20 mJ	1 MW
FEL (TTF)	0.1 ps	111 ns	20 W	0.1 mJ	1 GW

Interaction of VUV Free-Electron-Laser Radiation with Silicon at the Tesla Test Facility (TTF 1)



R. Sobierajski and J. Krzywinski, Institute of Physics, Polish Academy of Sciences, Warsaw, Poland, private communication

Outline

Photon Radiometry

Introduction

Rare-Gas Photoionization Detector for Monitoring VUV and EUV FEL Radiation

Four TTF 2 Gas-Monitor Detectors for Online Intensity and Beam Position Measurements

Rare-Gas Photoionization Detector for Ultra-Short X-Ray Pulses

Summary and Outlook

Rare-Gas Photoionization Detector for Monitoring VUV and EUV Free-Electron-Laser Radiation

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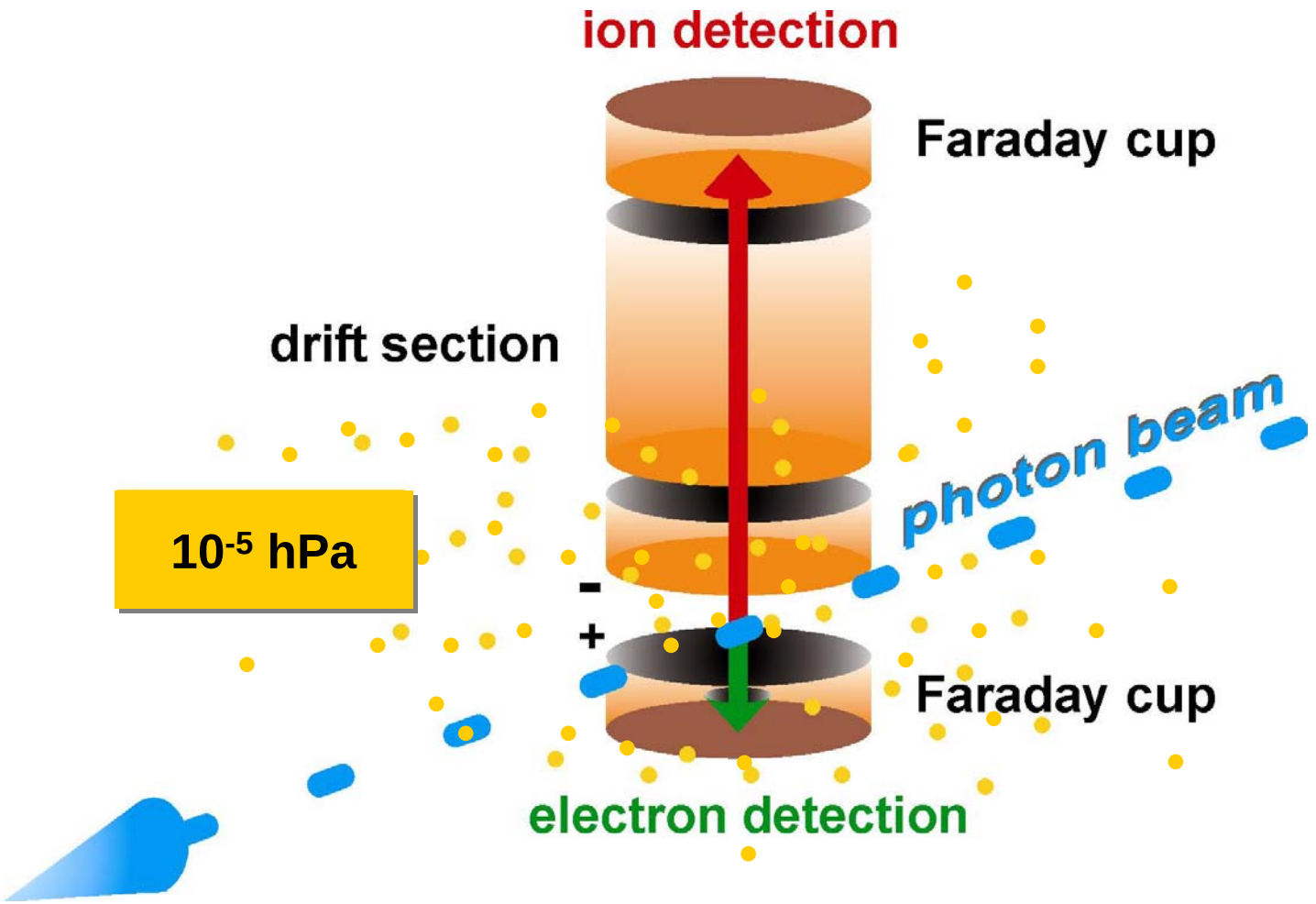

Reference number at the German Patent Office: 102 44 303.3

Time Resolved Gas-Monitor Detector Signal from Free-Electron-Laser Radiation at 97 nm (TTF 1)

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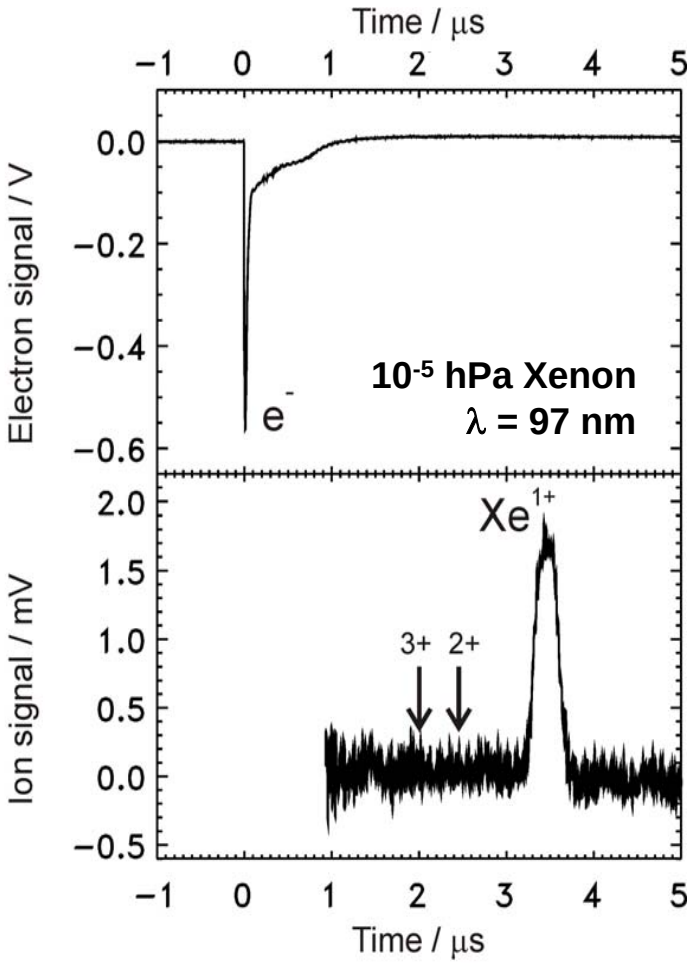
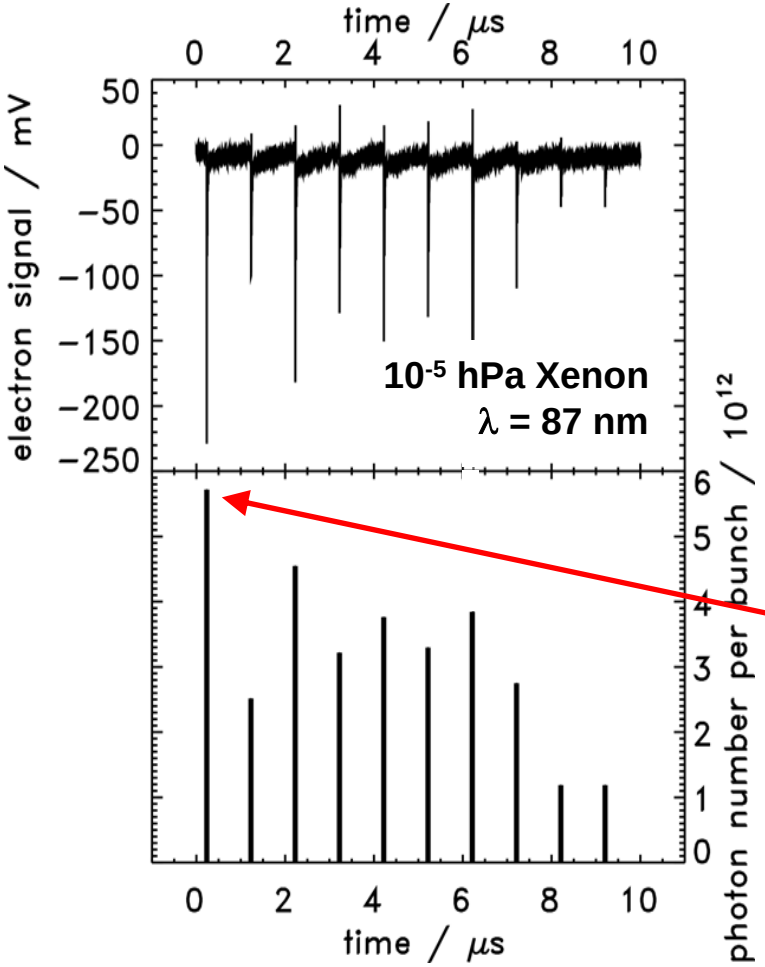


Ion Time-Of-Flight (TOF) Spectroscopy

M. Richter, A. Gottwald, U. Kroth, A.A. Sorokin, S.V. Bobashev, L.A. Shmaenok, J. Feldhaus, Ch. Gerth, B. Steeg, K. Tiedtke, R.Treusch, Appl. Phys. Lett. 83, 2970 (2003)

Time Resolved Gas-Monitor Detector Signal from Free-Electron-Laser Radiation at 87 nm (TTF 1)

Photon Radiometry



6 x 10^{12} VUV photons at 87 nm ($\hbar\omega$ = 14.3 eV) within a photon pulse of 100 fs:

$\Rightarrow$

pulse energy: 13.7 μJ

peak power : 137 MW

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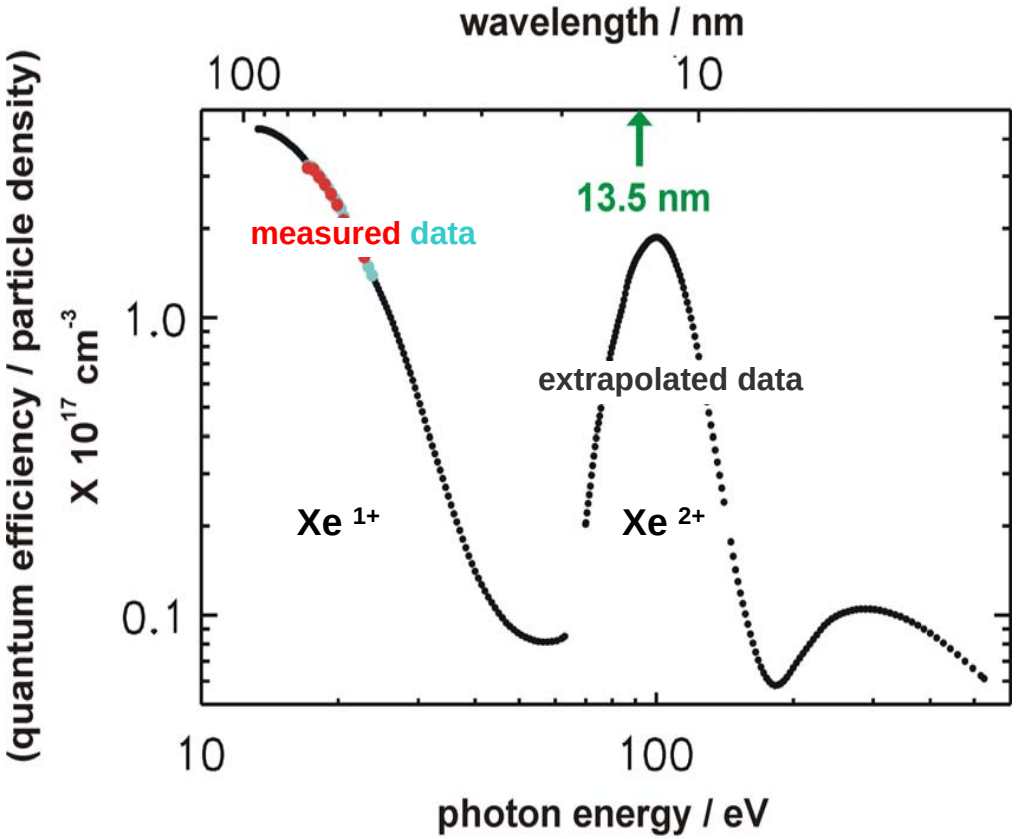
Quantum Efficiency of the TTF 1 Gas-Monitor Detector: Ion-Current Signal of Xenon

Photon Radiometry



Relative standard uncertainty: 4 %

M. Richter, A. Gottwald, U. Kroth, A.A. Sorokin, S.V. Bobashev, L.A. Shmaenok, J. Feldhaus, Ch. Gerth, B. Steeg, K. Tiedtke, R. Treusch, Appl. Phys. Lett. 83, 2970 (2003)

M. Richter, G. Ulm, Chr. Gerth, K. Tiedtke, J. Feldhaus, A.A. Sorokin, L.A. Shmaenok, S.V. Bobashev, AIP Conference Proceedings 652, 165 (2003)

Four TTF 2 Gas-Monitor Detectors for Online Intensity and Beam Position Measurements

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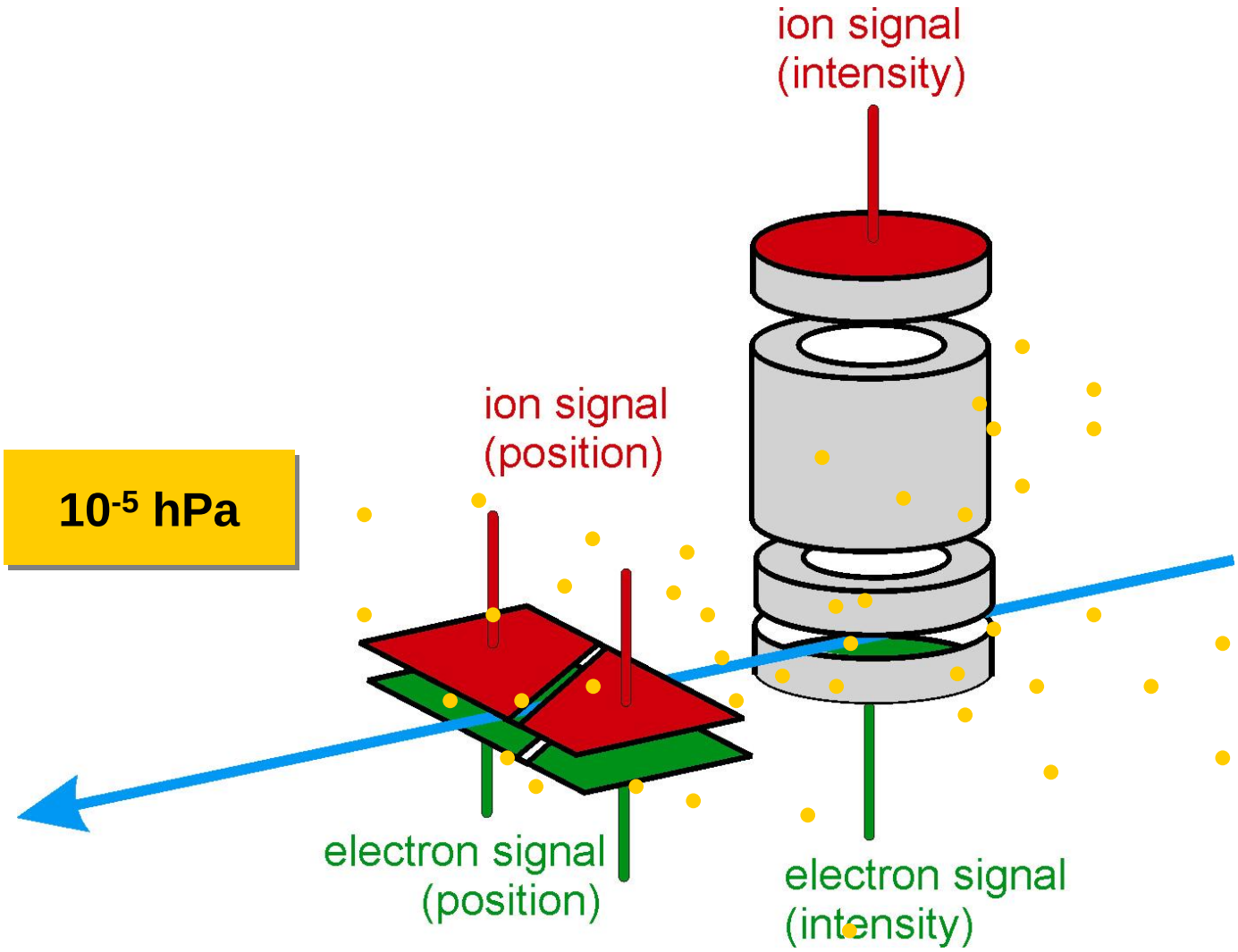

Test and Calibration Measurements at BESSY with the TTF 2 Gas-Monitor Detectors : Beam Position

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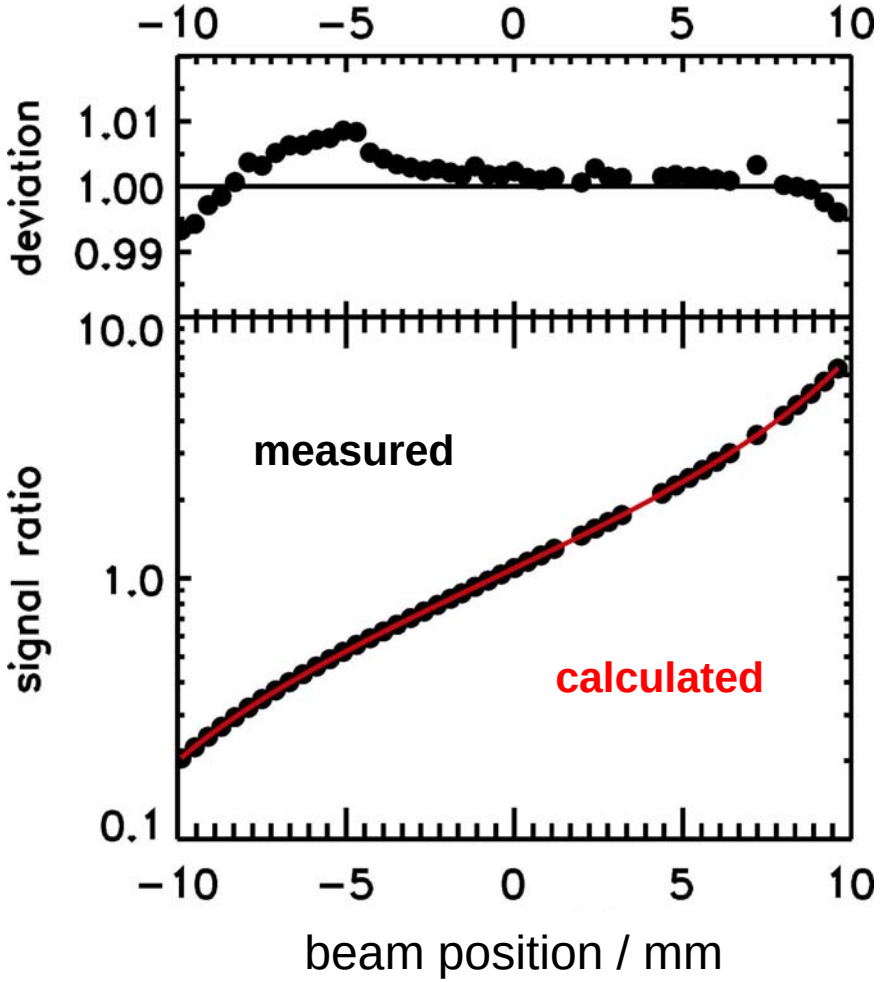

Accuracy for online measurements of relative beam positions: ~ 20 μm

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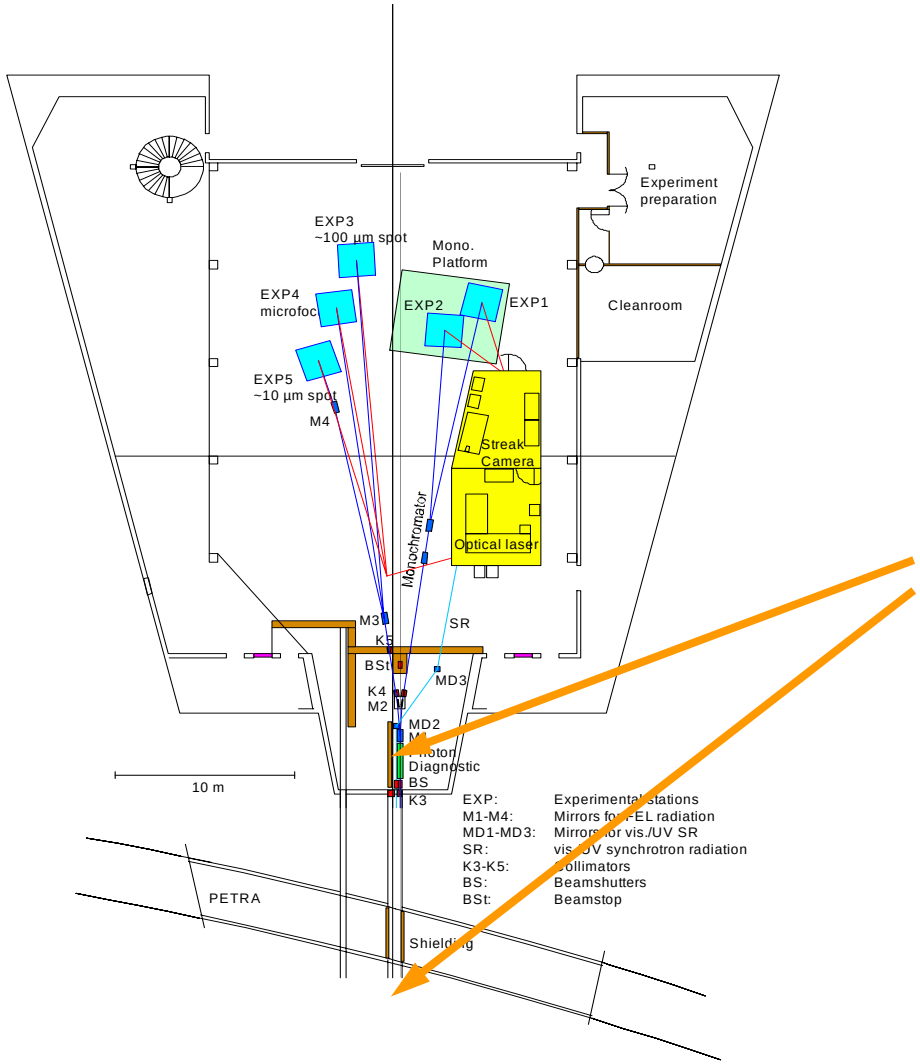
TTF 2 Experimental Area

Photon Radiometry



TTF 2 gas-monitor detectors

as permanent parts of the online photon diagnostics

for the measurement of absolute pulse intensities, beam positions, (and photon energies)

within the framework of a DESY-PTB cooperation

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Rare-Gas Photoionization Detector for Ultra-short X-ray Pulses (e.g., at the SPPS)

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Test Measurements in the VUV at BESSY with the X-Ray Gas-Monitor Detector

Photon Radiometry

TTF 2 Photoionization Experiment

Photon Radiometry

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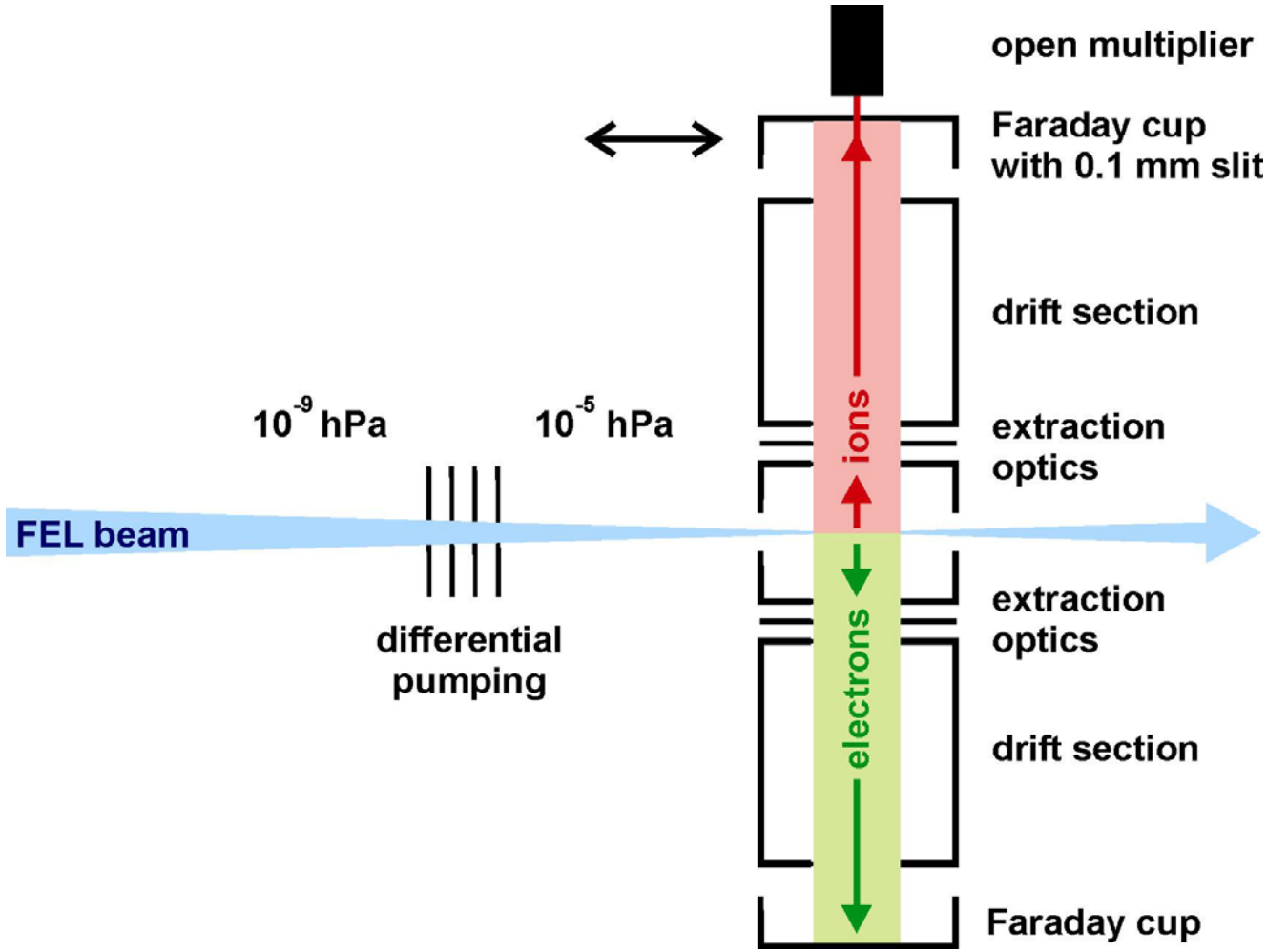

Summary and Outlook

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In order to overcome the difficulties of solid state detectors in the quantitative detection of highly intense VUV radiation as emitted by FELs like TTF, an almost transparent monitor detector has been developed based on photoionization of rare gases.

The device has been succesfully used at TTF 1 for the quantitative measurement of radiation pulses with peak powers up to 140 MW.

Based on this prototype, four gas-monitor detectors have been developed and successfully tested in the Radiometry Laboratory of PTB at BESSY which will be used at TTF 2 as permanent parts of the photon-beam diagnostics for online measurements of pulse intensities and beam positions.

The principle of the gas-monitor detector has been extended for the quantitative detection of ultra-short X-ray pulses as emitted, e.g., at the SPPS.

The developed detection systems serve as a background for photoionization experiments on free atoms and molecules at TTF 2.