Upgrade of the FLASH beamlines

New diagnostic and beam transport tools

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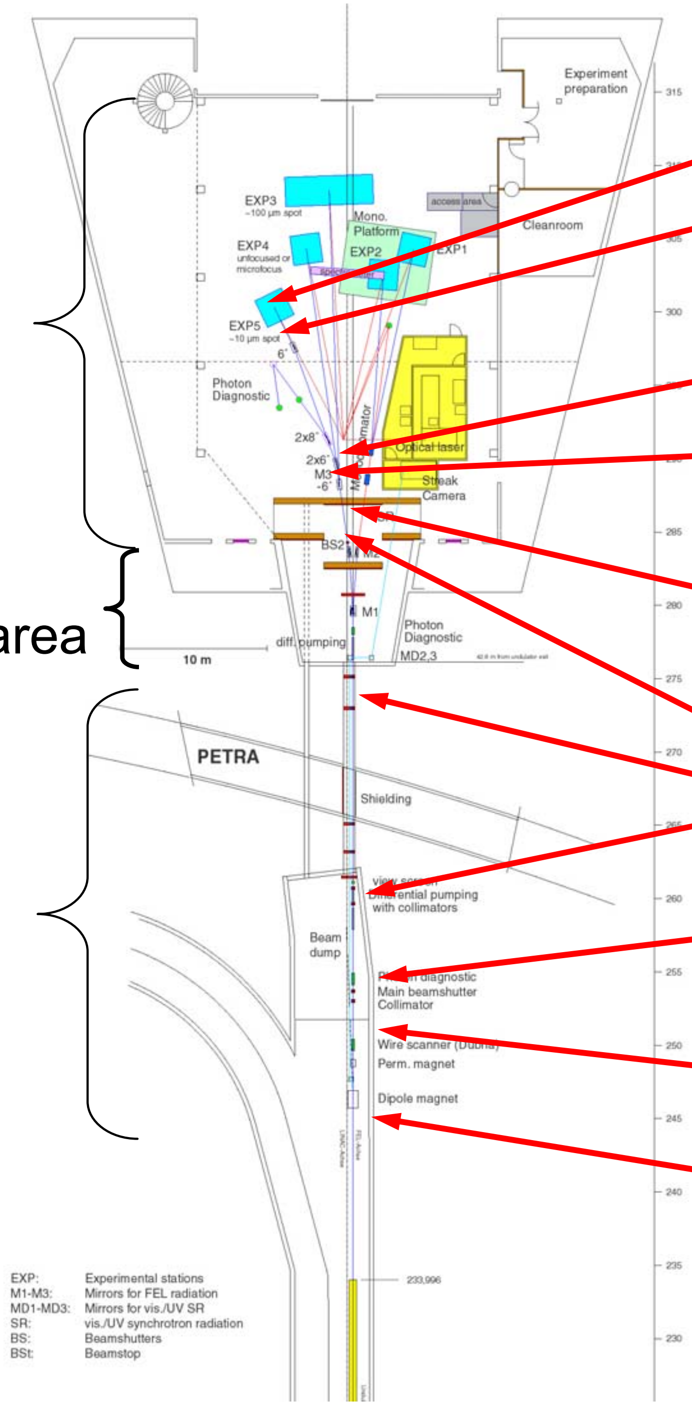
FLASH Seminar
16.3.2010

HELMHOLTZ
ASSOCIATION

DESY

Installation in the tunnel and experimental hall



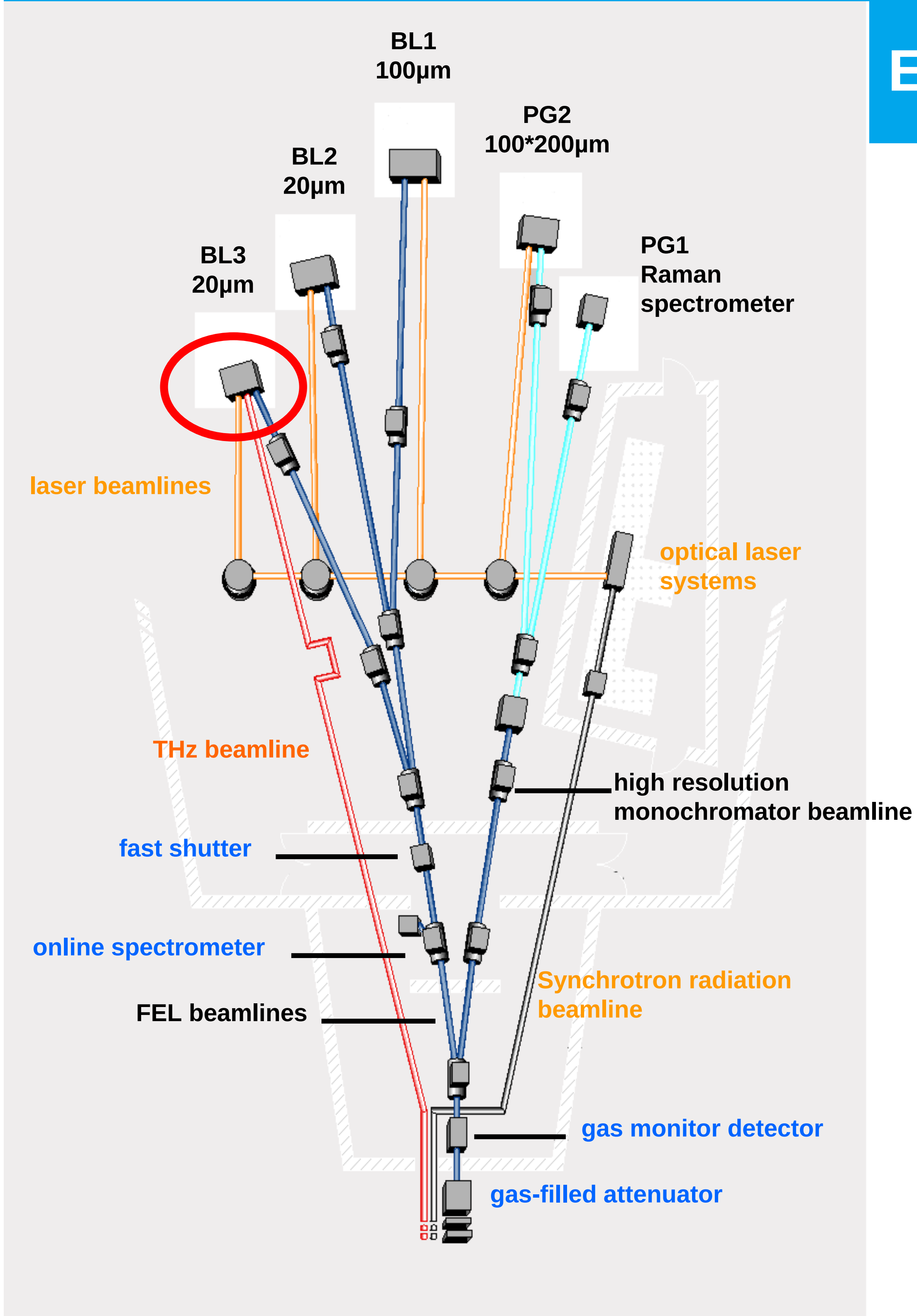
Experimental hall

Beam distribution area

Tunnel section

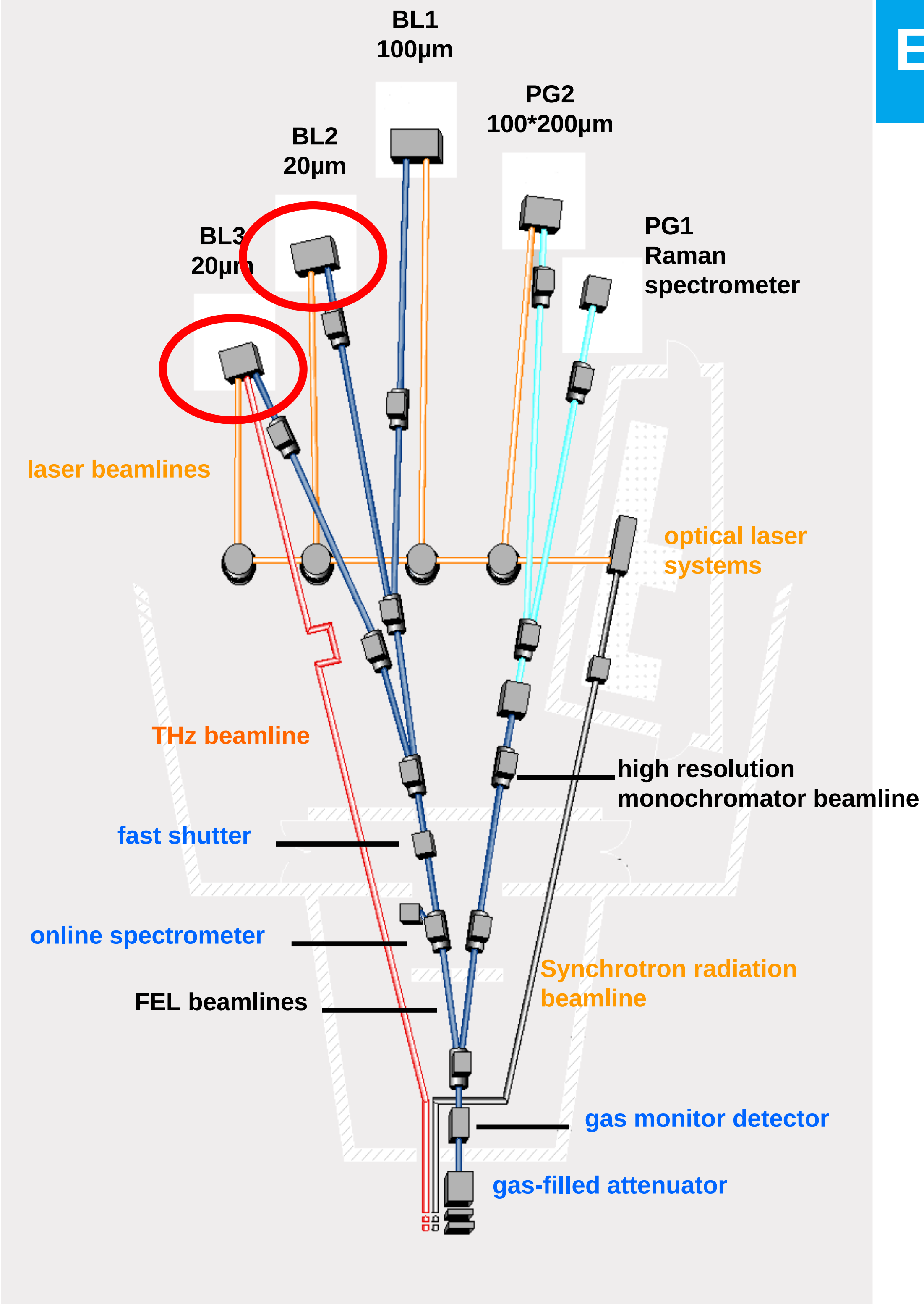
- Install a focusing mirror at BL3
- Modify differential pumping units of the BL2 and BL3 end stations
- Install a fast switching mirror unit
- Permanently install the autocorrelator on BL2.
- Install new filter units and new fast shutters
- Repair VLS spectrometer
- Modify differential pumping units
- Install additional BPMs with MCP/fluorescence screen monitor
- Install new online spectrometer based on atomic photoionization (like GMD)
- Install a MCP/fluorescence screen monitor in the MCP tool

Experimental hall

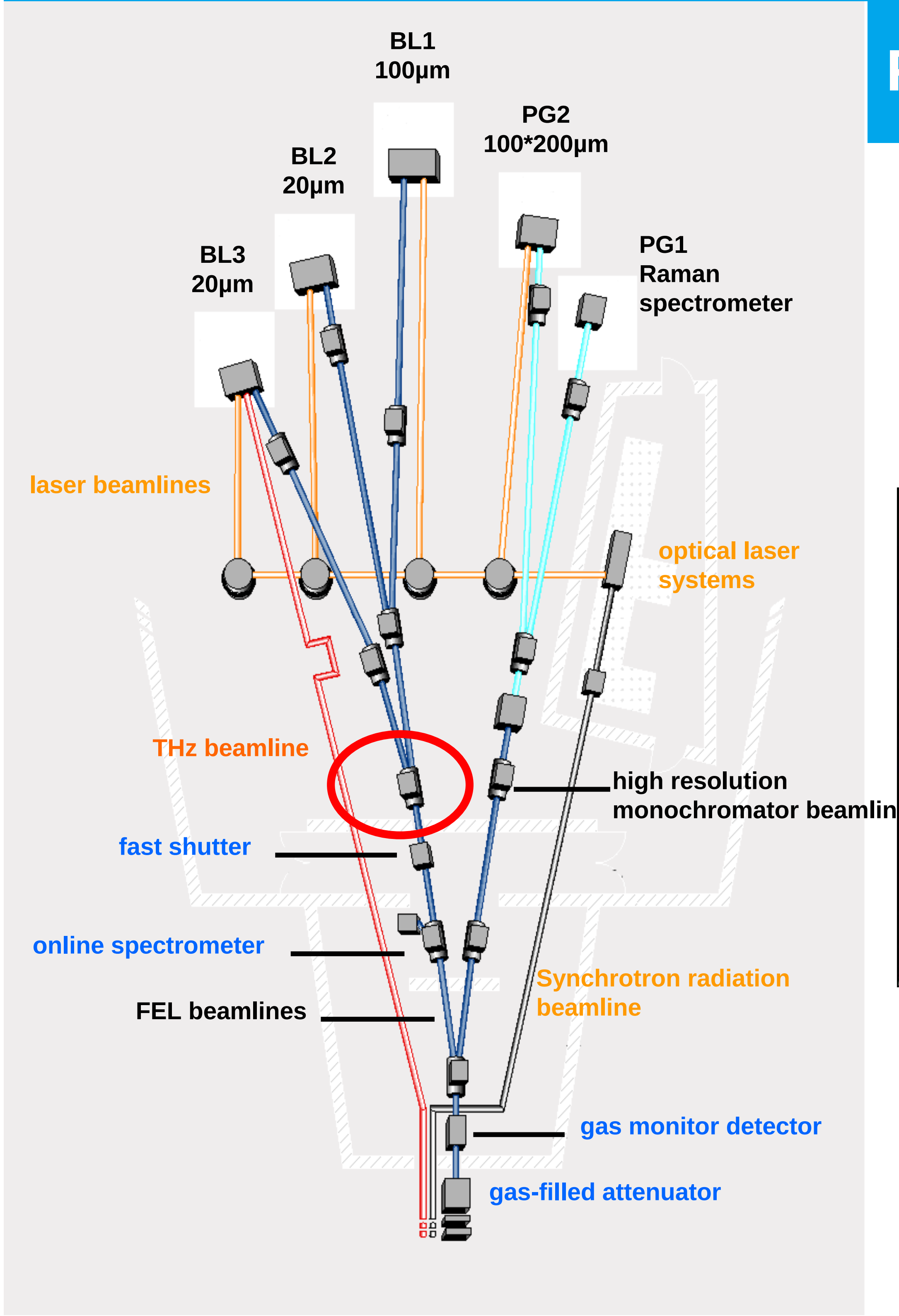


- ➢ Installation of a focusing mirror at BL3

Experimental hall

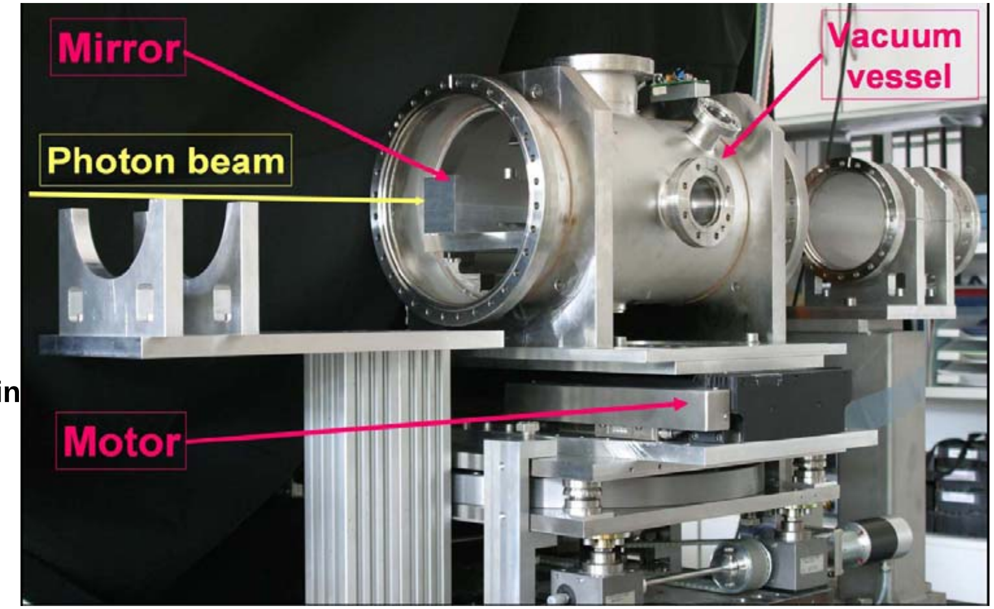


- Installation of a focusing mirror at BL3
- Modify differential pumping units of the BL2 and BL3 end stations to allow users to choose either the focused or the unfocused beam

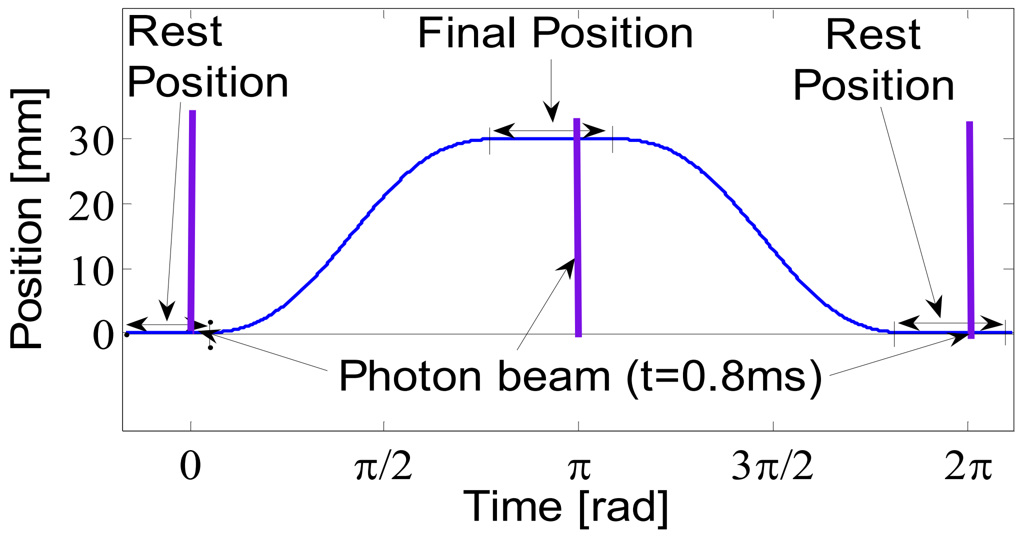


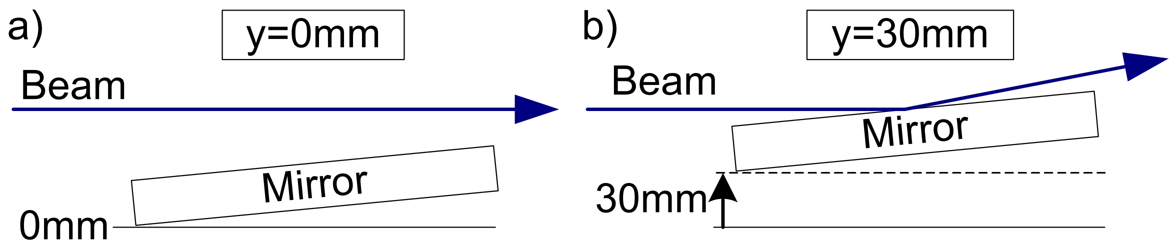
Fast Switching Mirror

- Installation of a fast switching mirror unit in collaboration with Zeuthen (M. Sachwitz and colleagues)



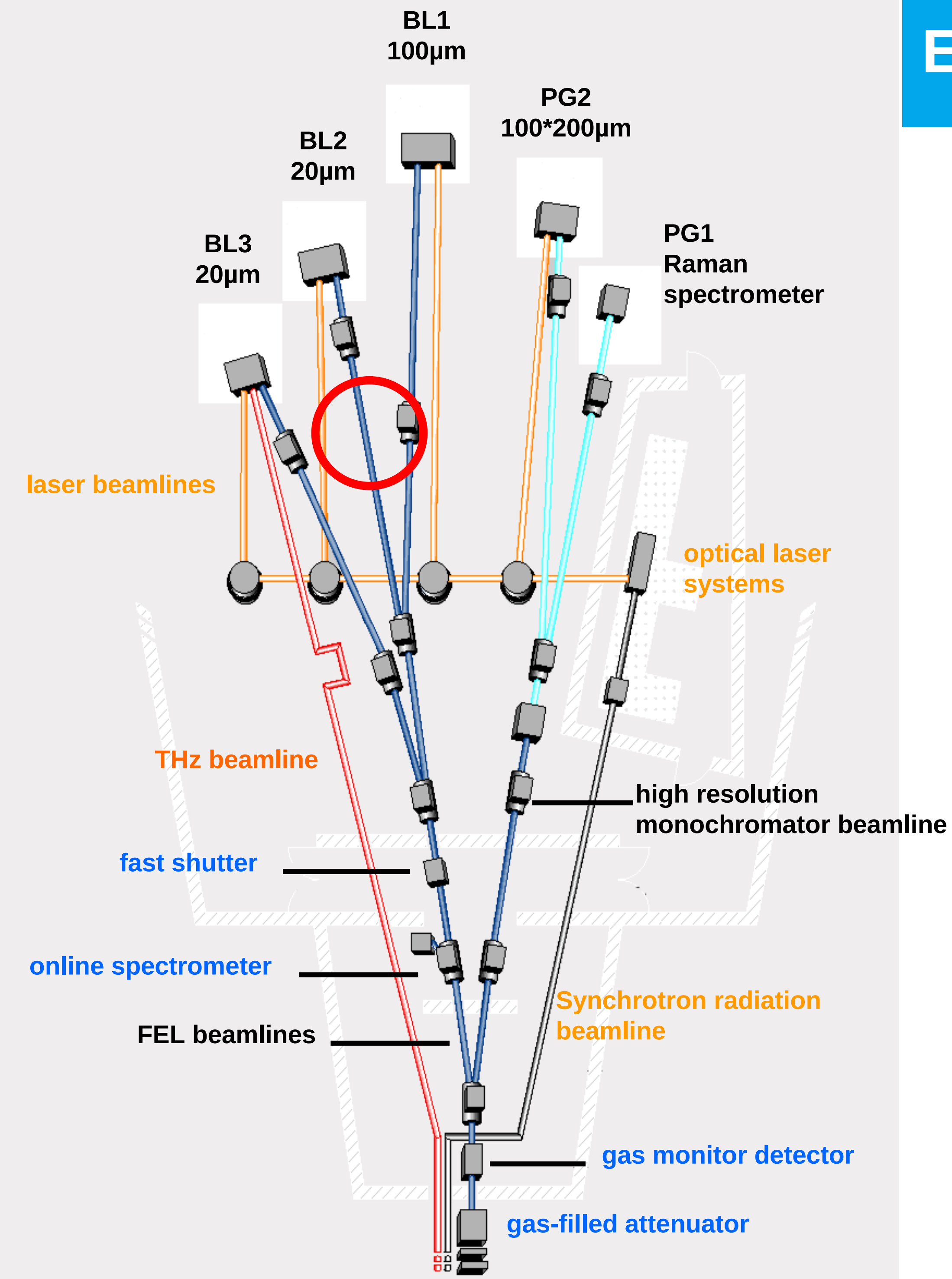
Motion of the Mirror





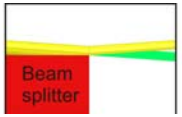
Up to 2.5 Hz Motion Frequency

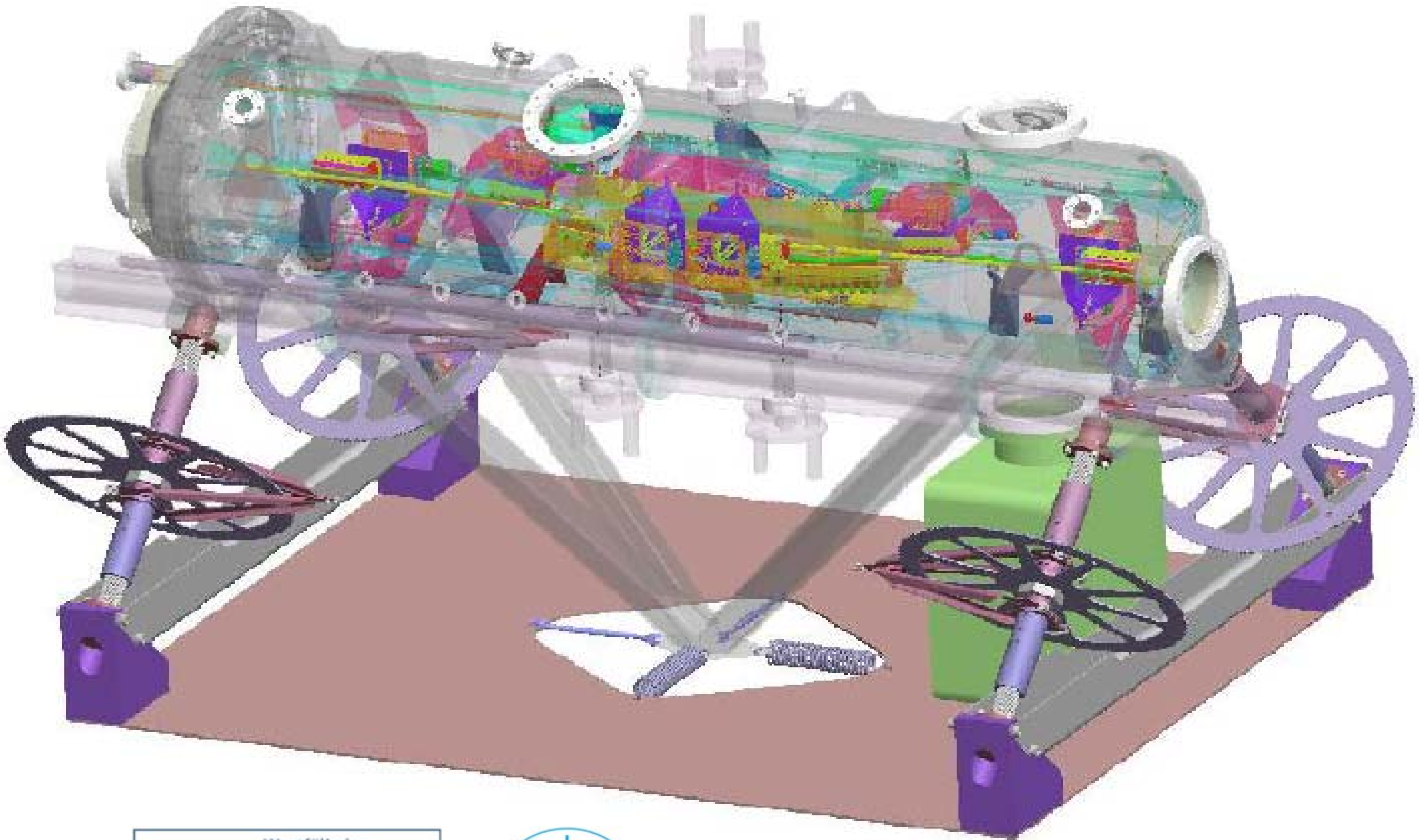
Experimental hall



- Include the autocorrelator as a permanent device in the direct beamlines

Autocorrelator / beam splitter

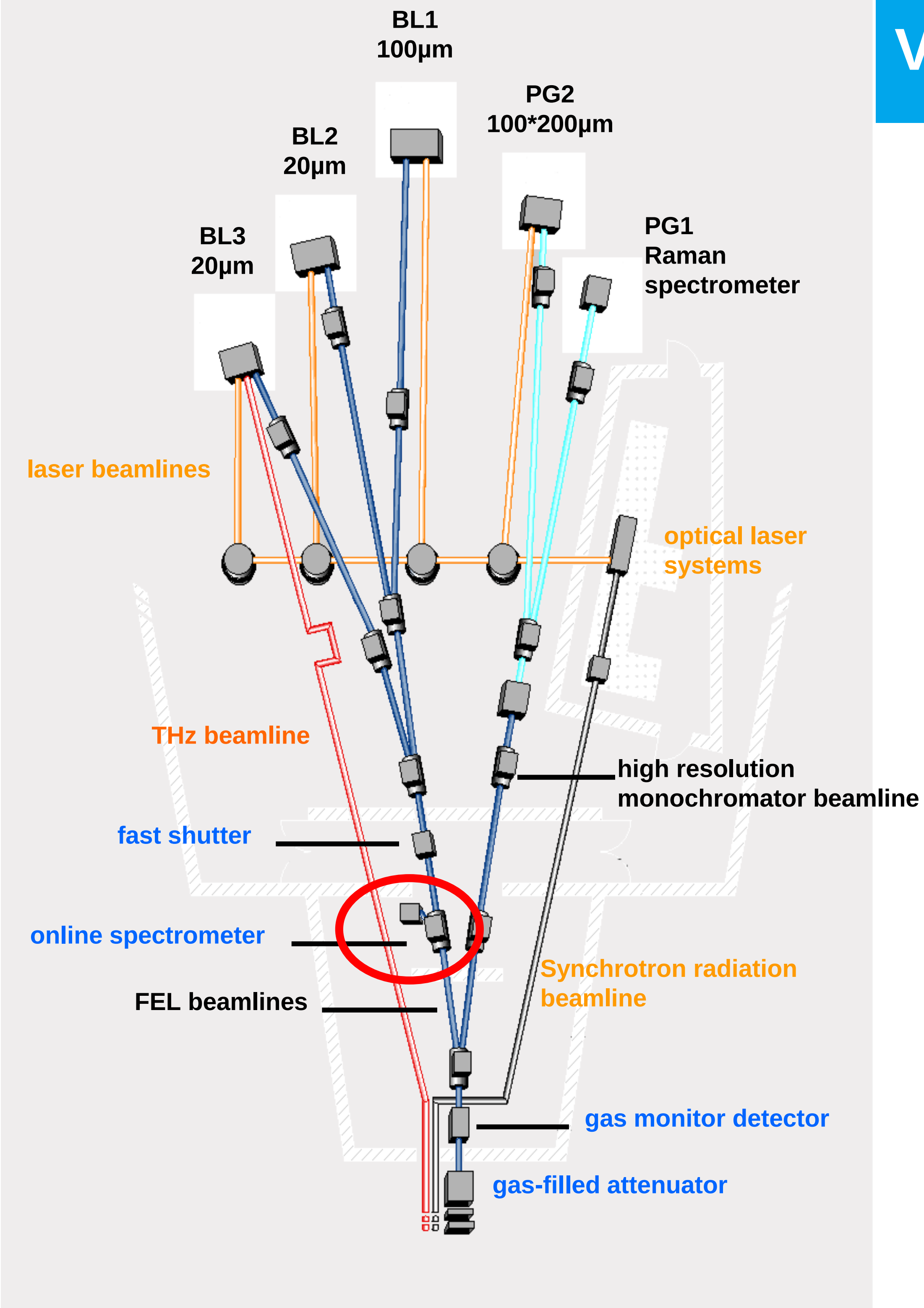




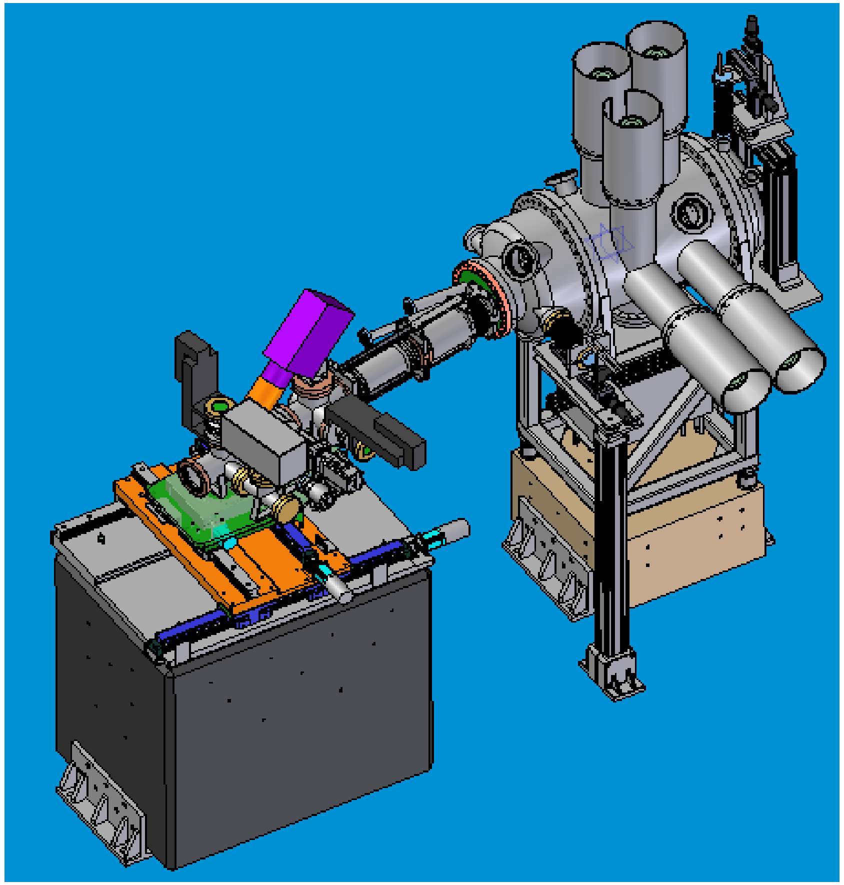
Courtesy of Tino Noll

R. Mitzner, H. Zacharias et al. 2008

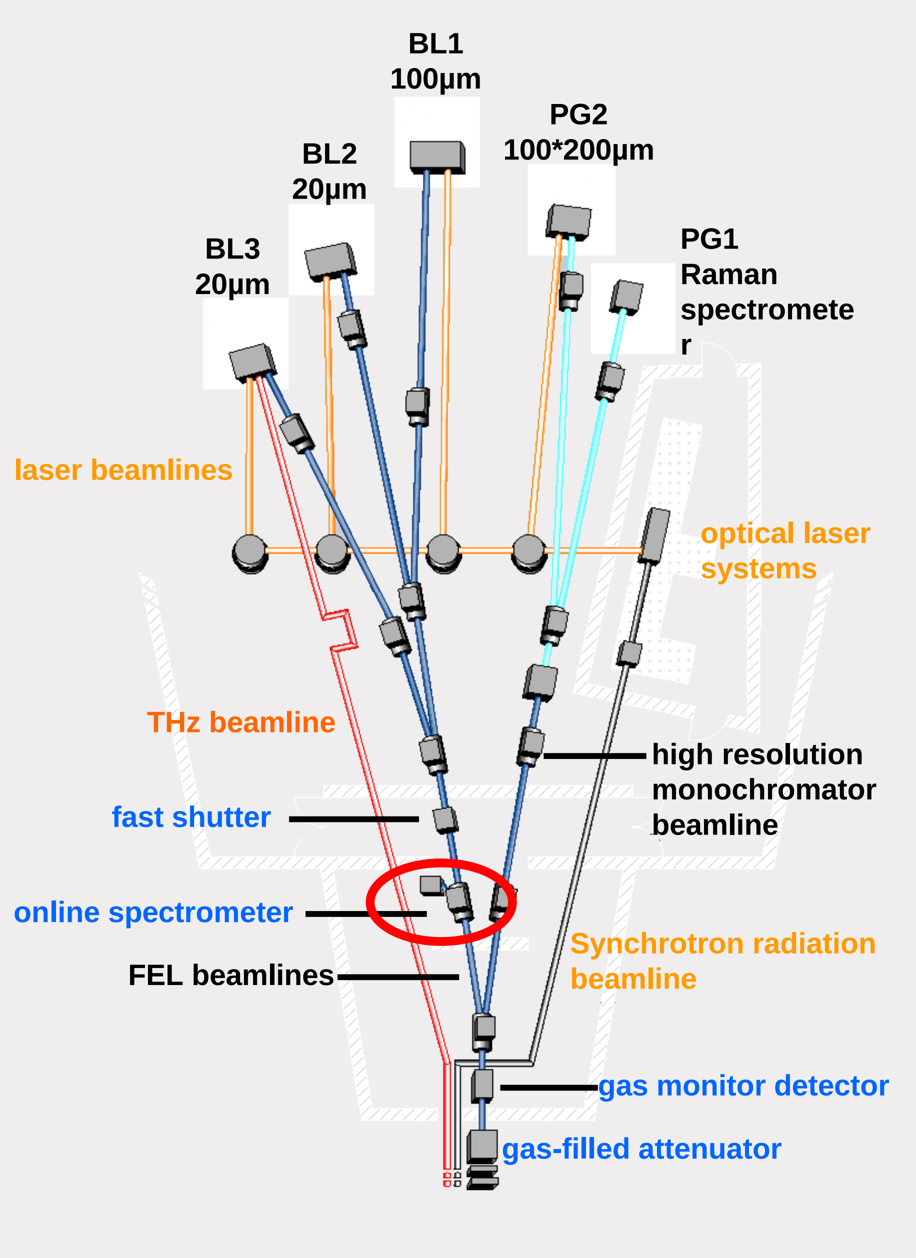
VLS Spectrometer

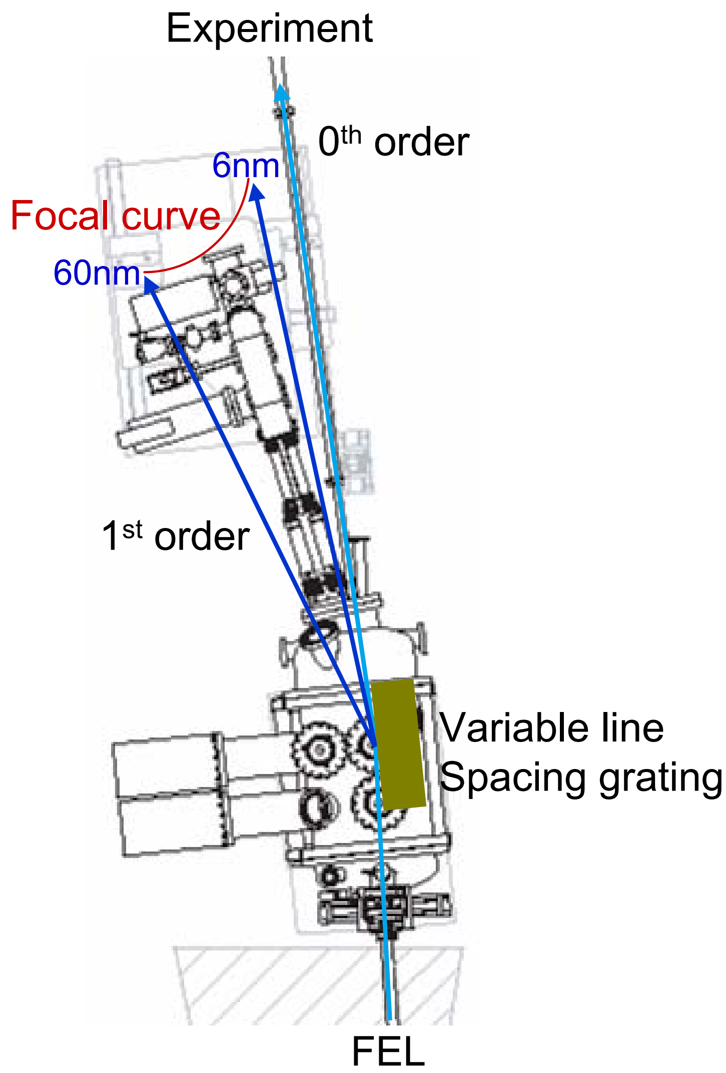


- Repair VLS spectrometer

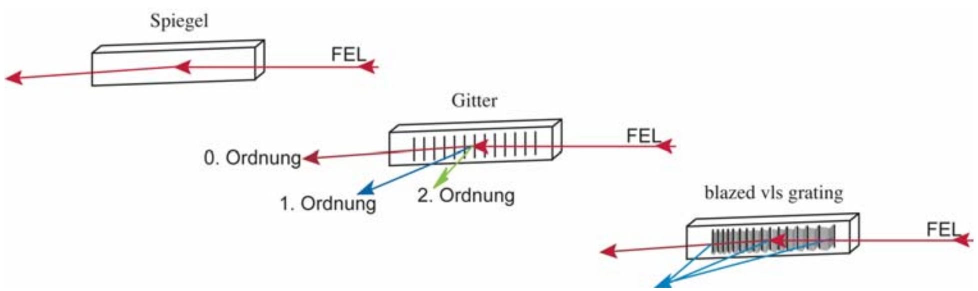


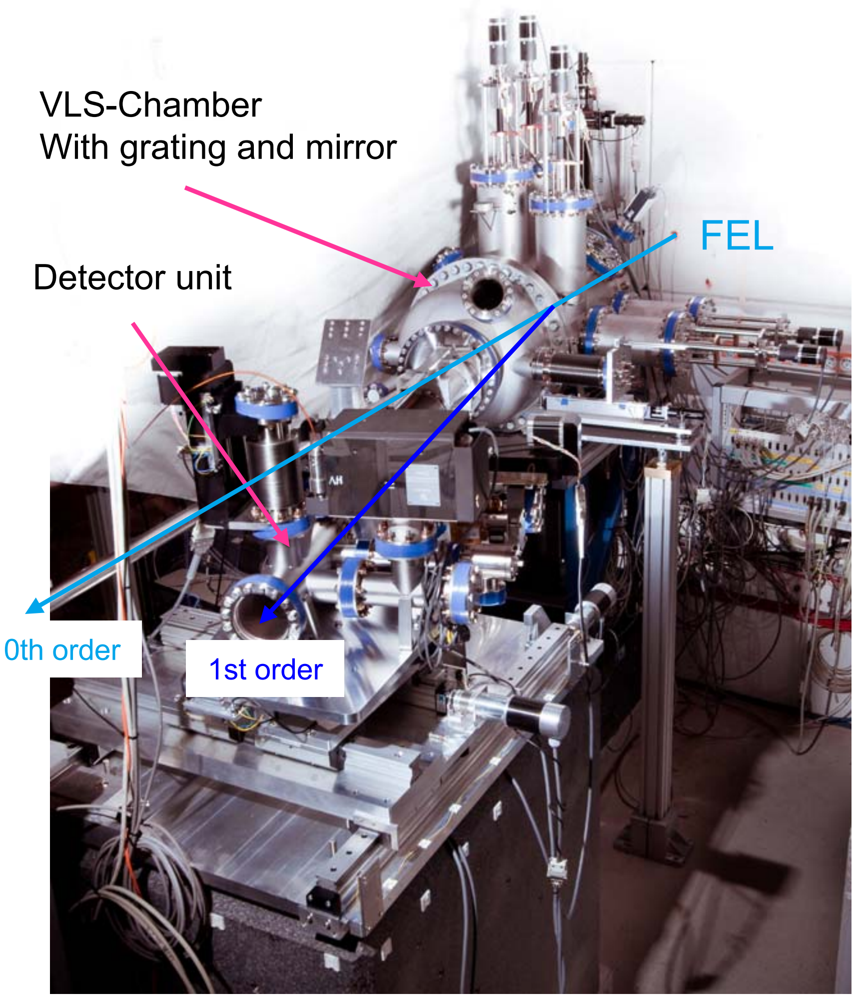
VLS-Spectrometer





Principle of the VLS at FLASH



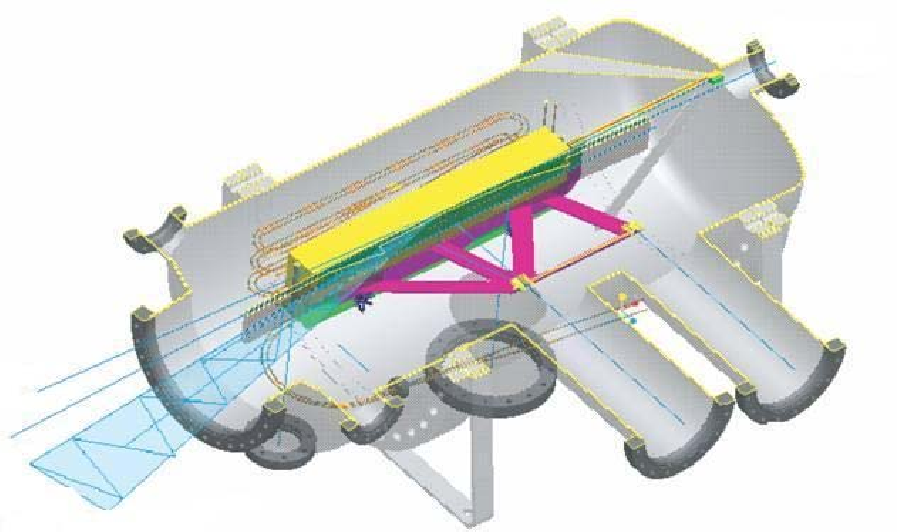


- Mirror replaced by grating -> at FLASH: combination of mirror plus VLS-grating on top

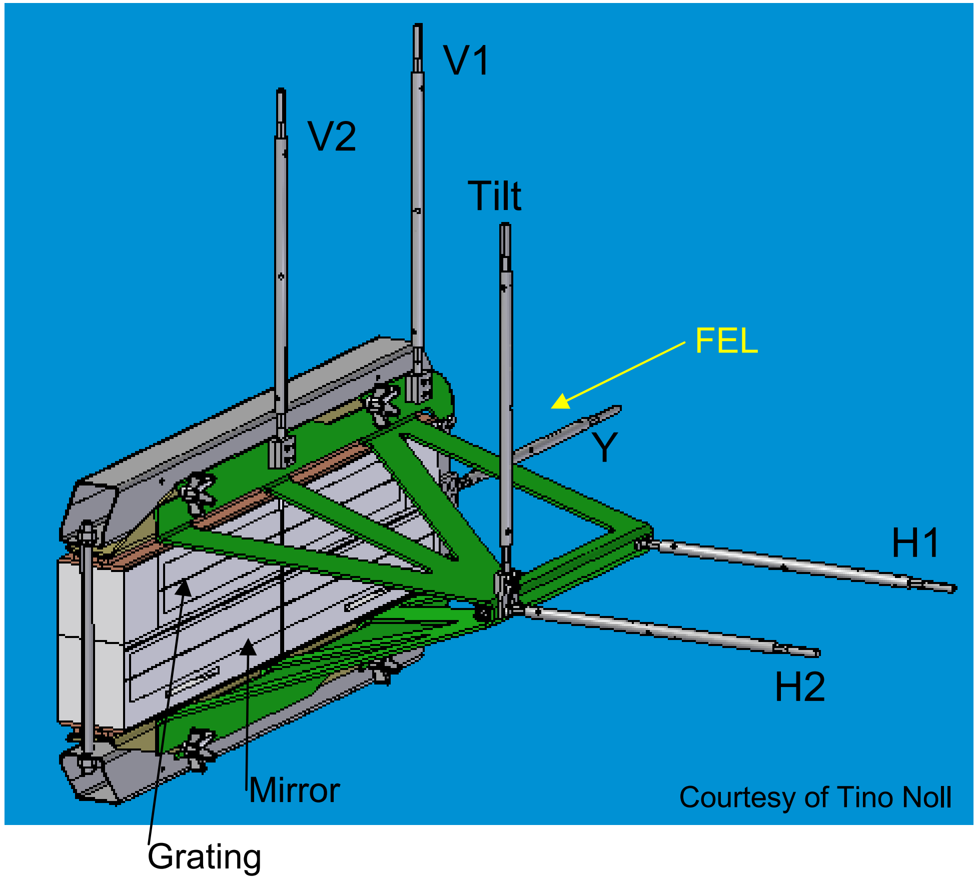
- In contrast to a standard grating, the blazed angle for the 0th order is transported to the experiments

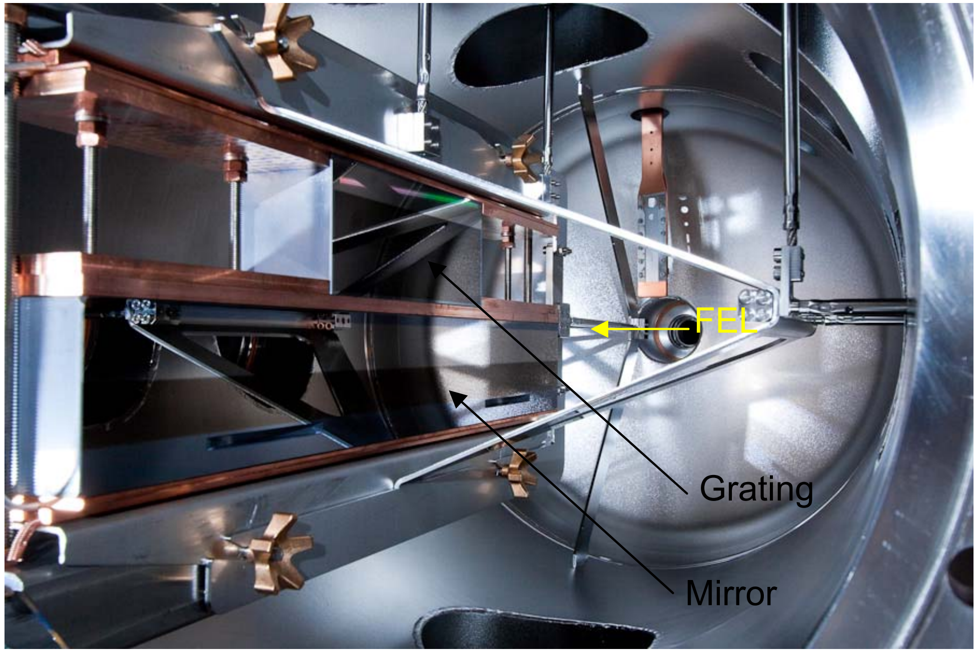
- Depending on the wavelength: 1-10% of the beam for the spectrometer

- Detector can follow the focal plane of the gratings



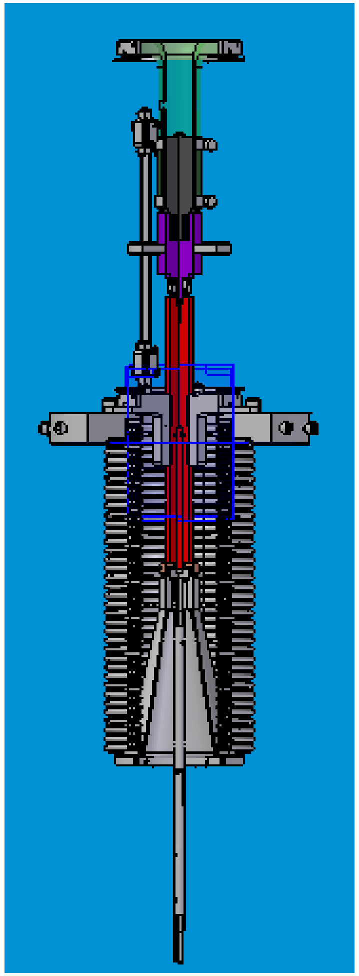
Functional principle of the construction



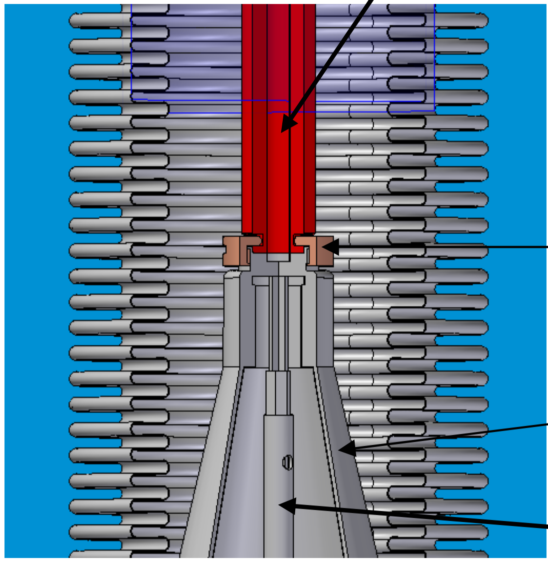


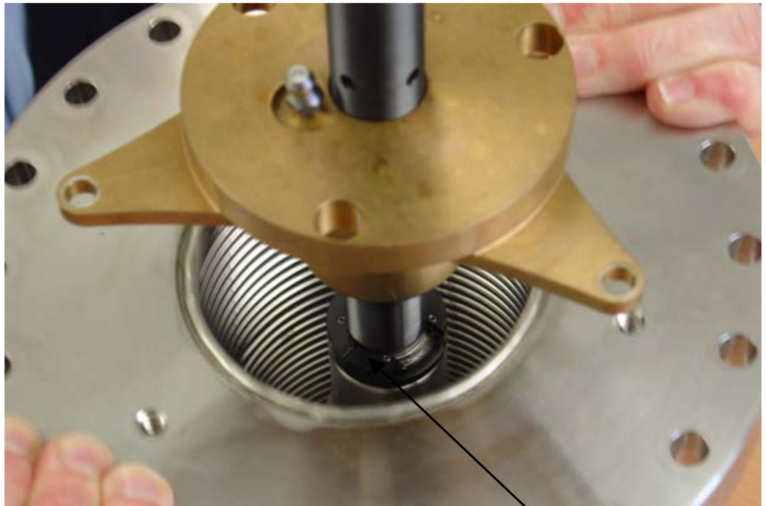
- Sophisticated principle evolved by Bessy/HZB
- 6 rod bearing system allows 6 degrees of freedom
- In case of VLS: only 5 degrees of freedom are motor-operated

Old drive <-> New drive: a comparison



Courtesy of Tino Noll



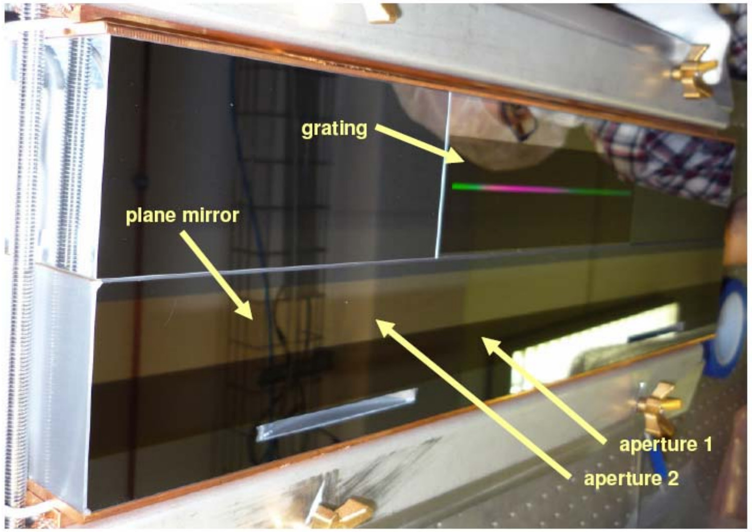


- Challenging design-values for drives:
  - translation 10nm
  - rotation 40nrad
- Fine thread spindle: pitch= 0.5 mm/rotation
- Bearing plate connects the spindle to the funnel

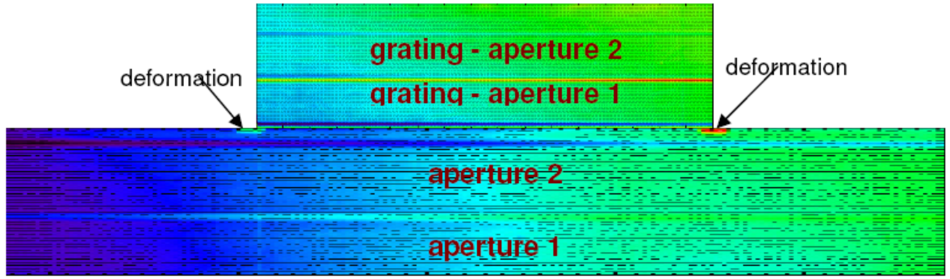
Bearing plate:

- Connects the outer rotational movement of the spindle to the inner translatory motion of the rods
- Gives the opportunity to vary the play of the drive

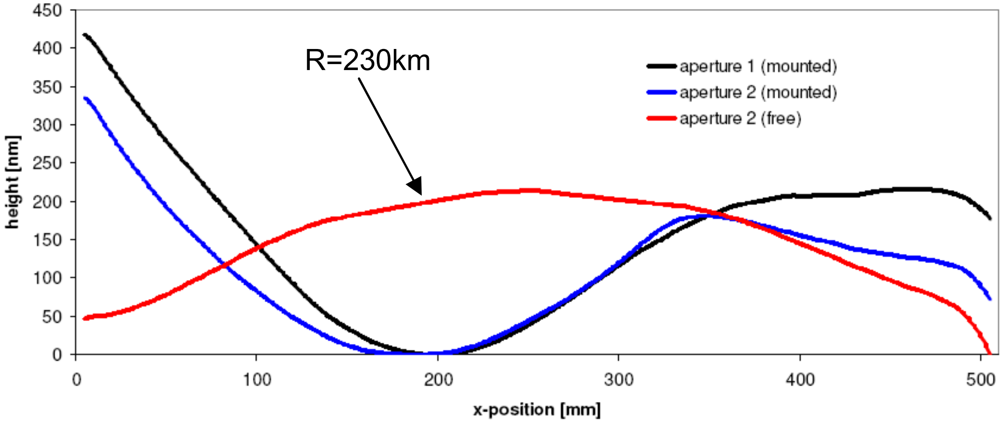
Measurement results of the old optics-holders



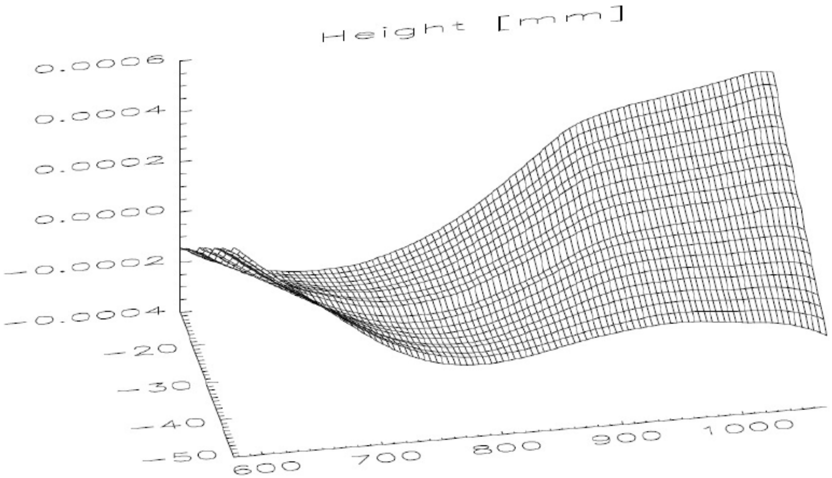
Slope Errors



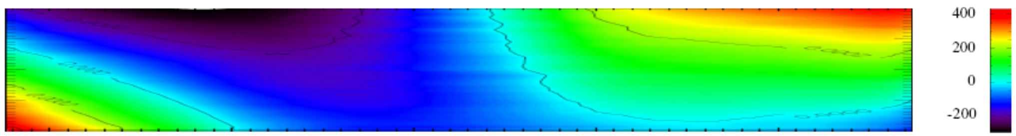
Height profile of the mirror



Mapping of the mirror surface



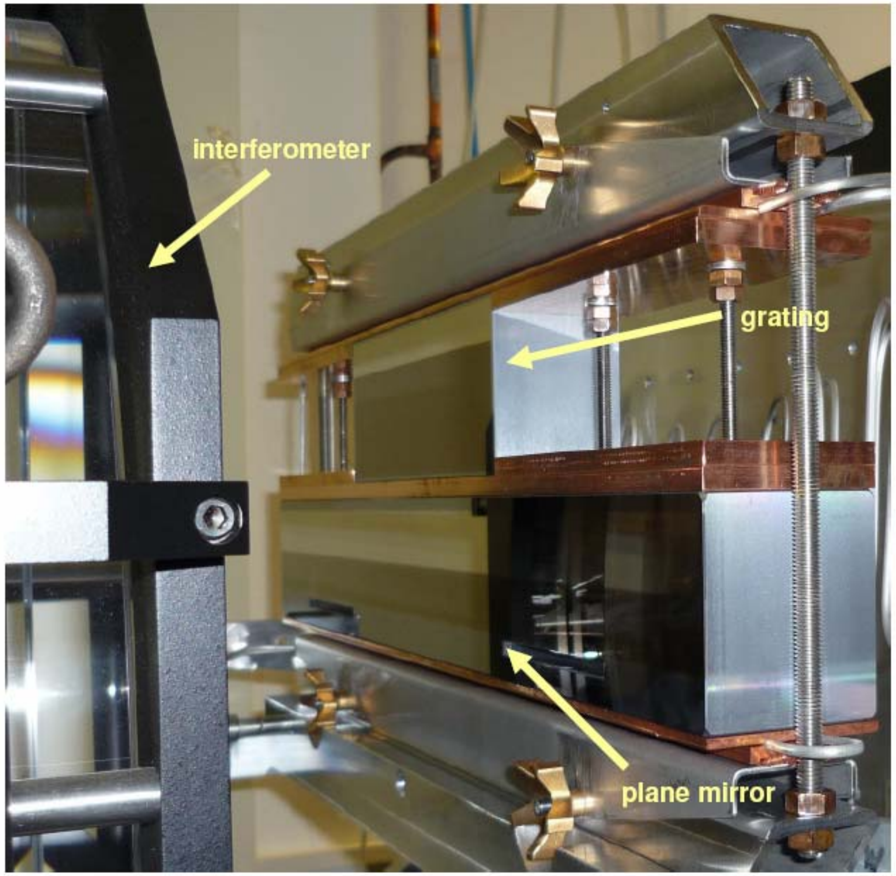
Courtesy of Frank Siewert



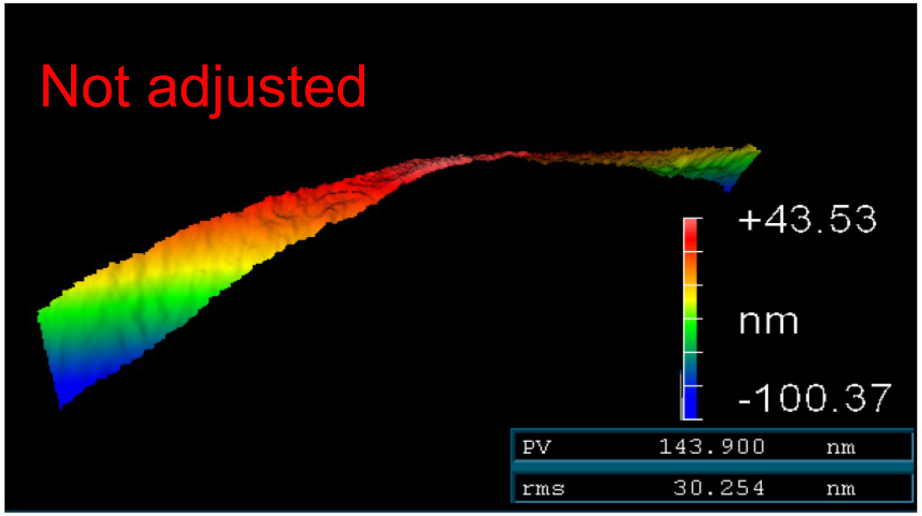
Height map (nm) measured with NOM (Nanometer Optical Machine at HZB)

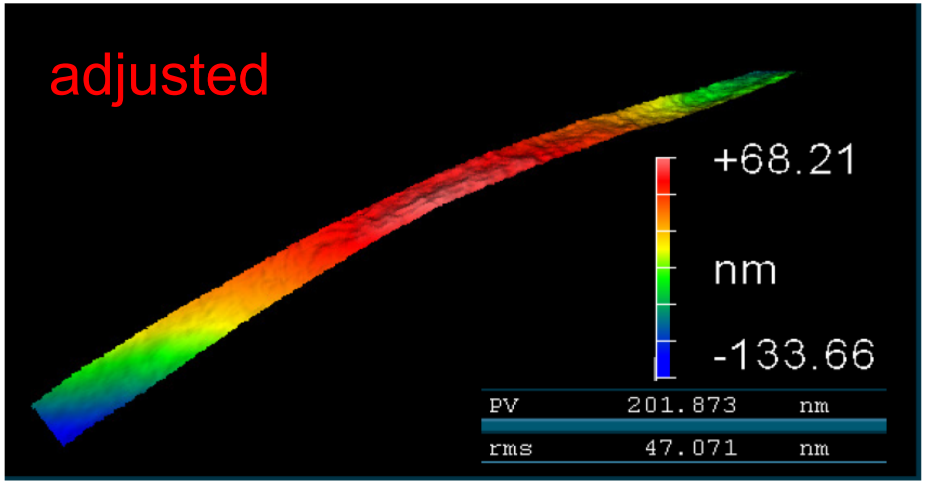
Measurement results of the new optics-holders

Height profile
measured at the 18"Zygo-Interferometer

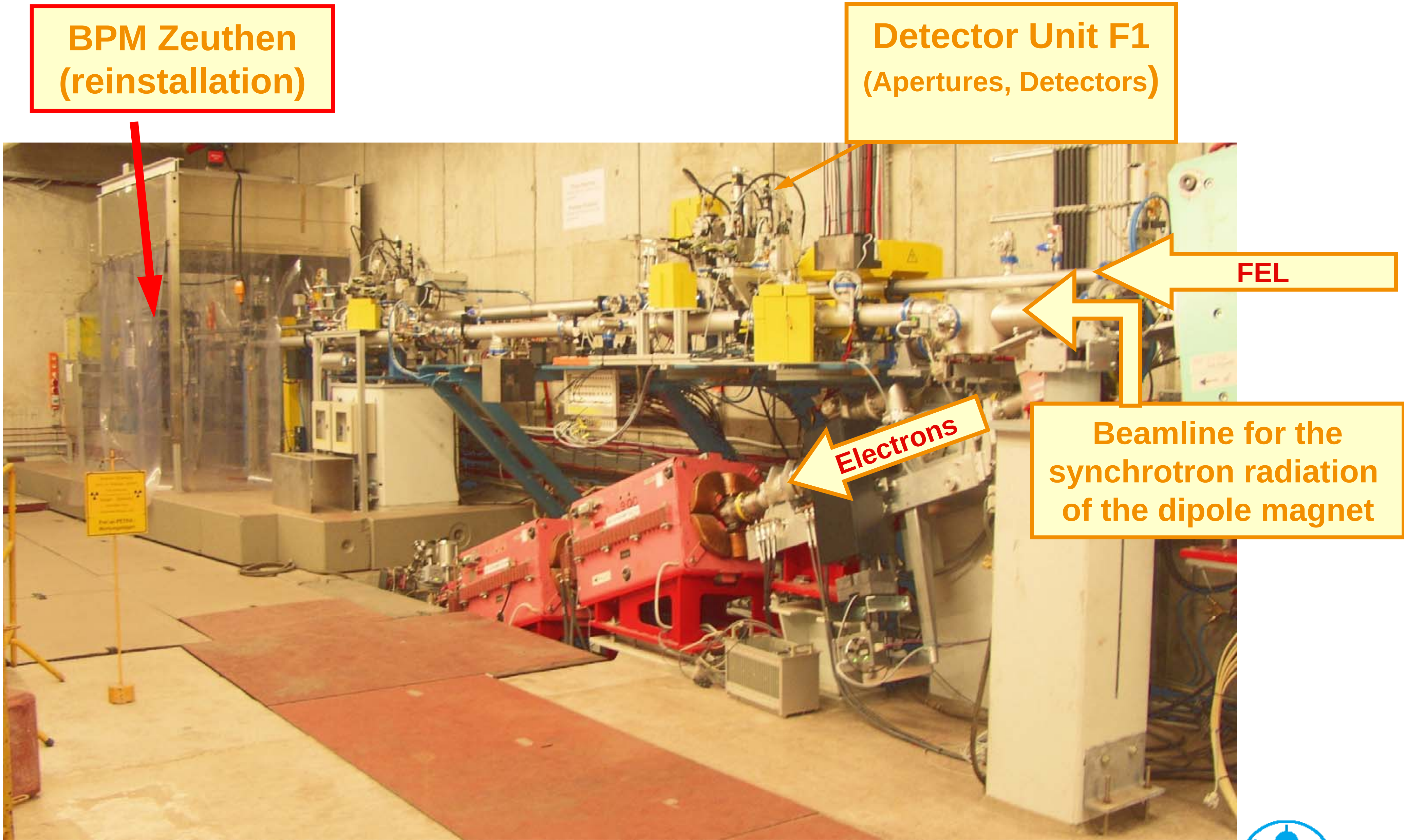


Courtesy of Frank Siewert





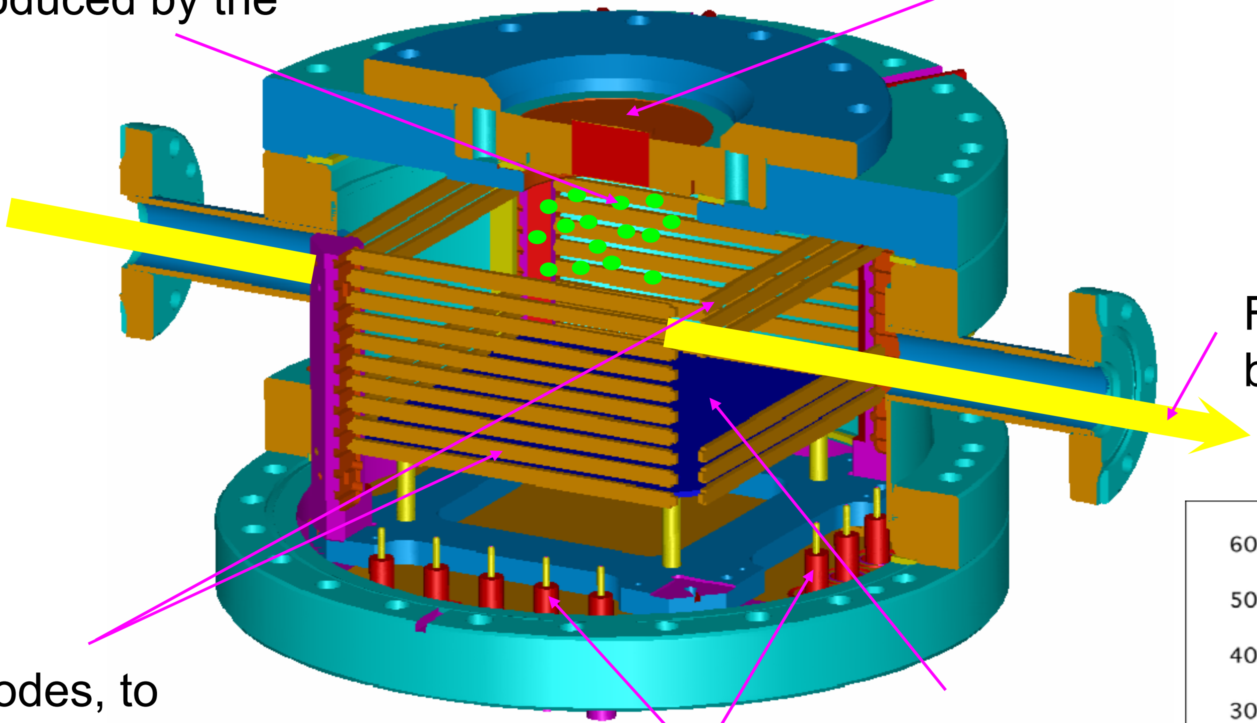
Visual Beam Position Monitor



Visual BPM

Ions produced by the FEL

Micro Channel Plate (MCP)

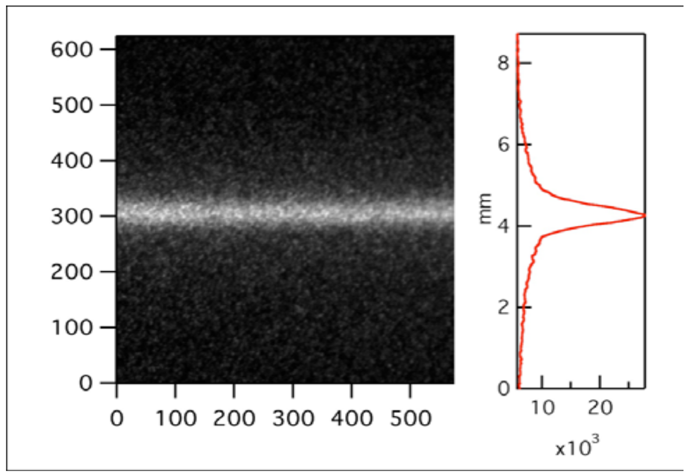


FEL beam

Electrodes, to provide a homogeneous field

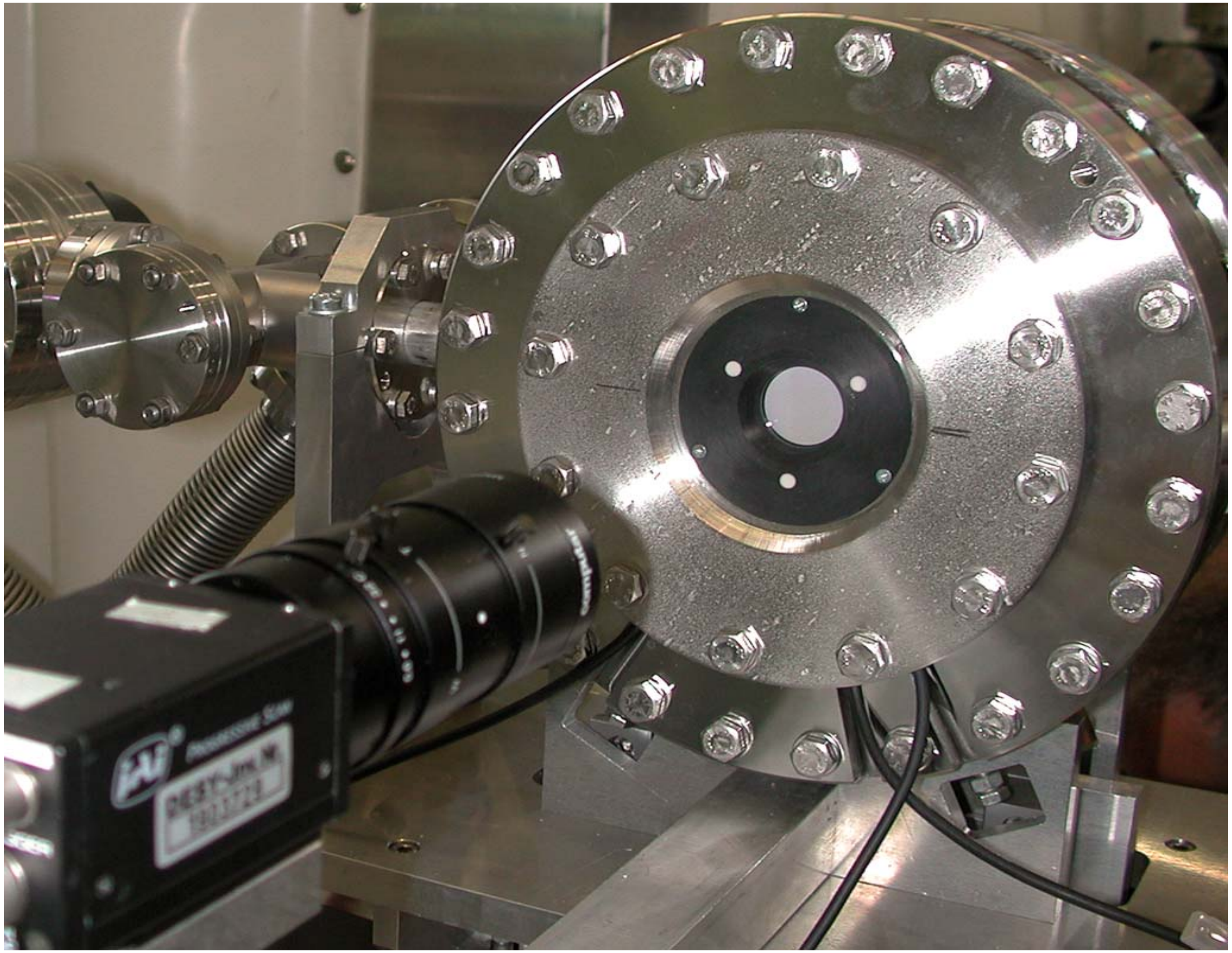
Electrical feedthroughs

Repeller plate



In collaboration with DESY Zeuthen

Visual BPM

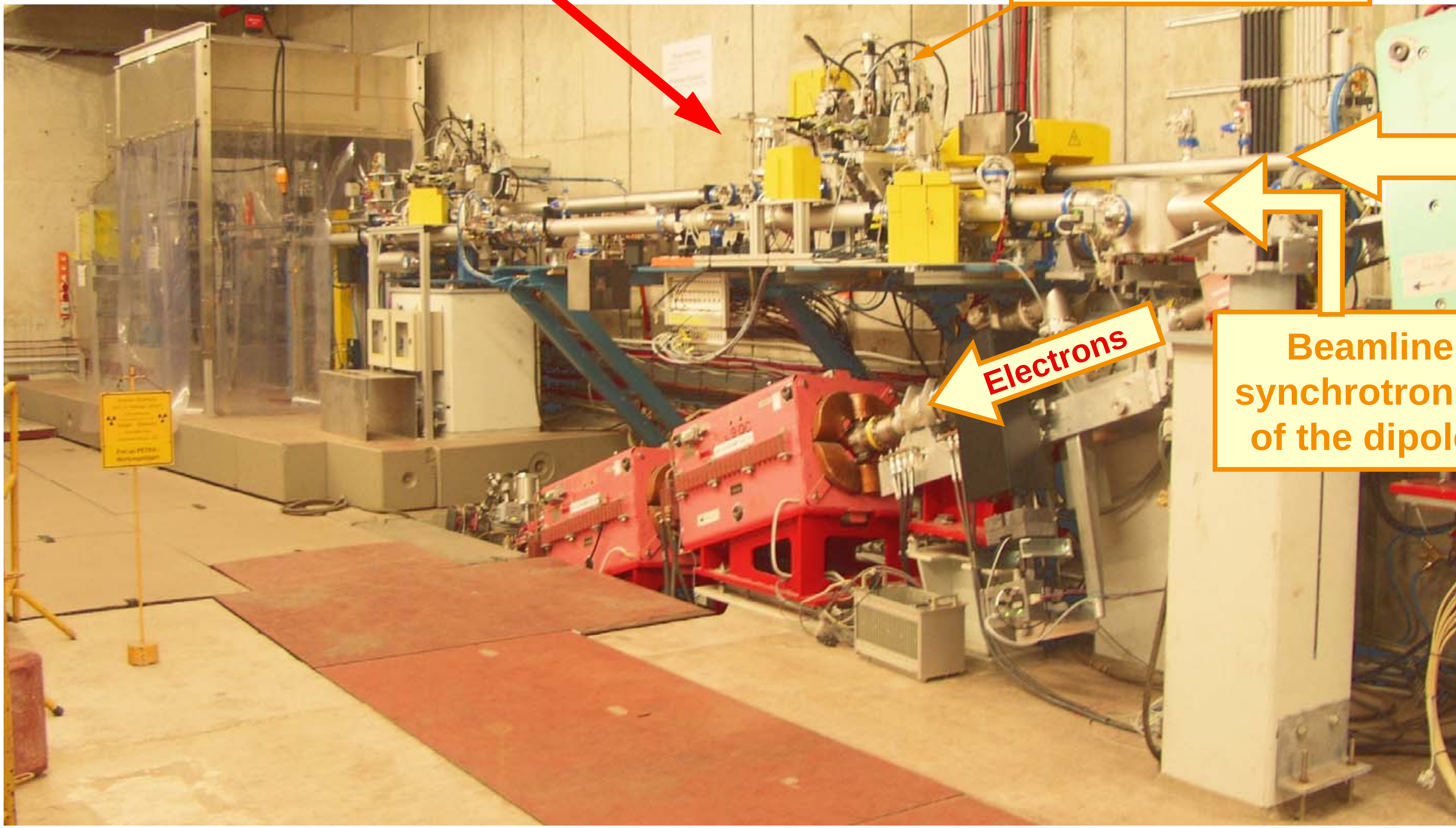


In collaboration with DESY Zeuthen

Upgrade of MCP-based photon detector

MCP based intensity monitor

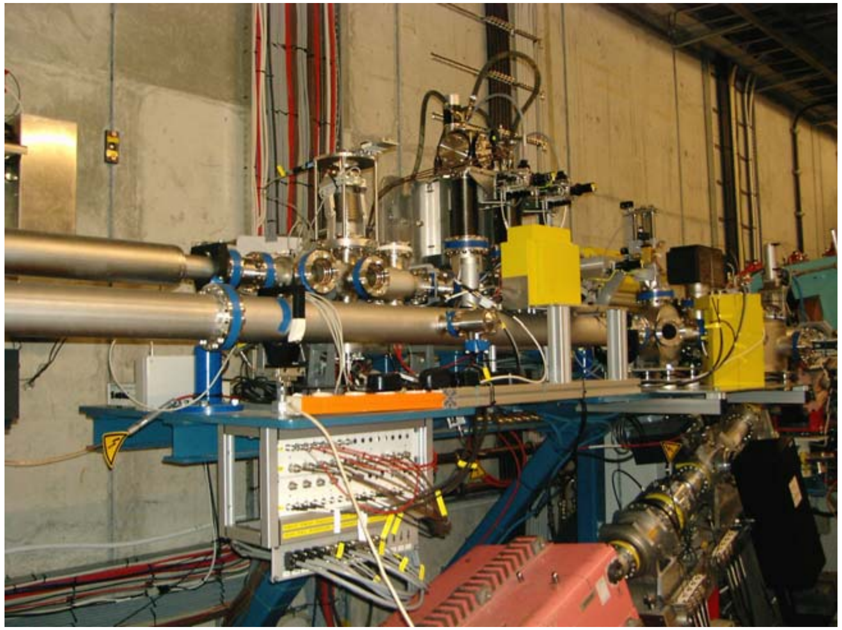
Detector Unit F1
(Apertures, Detectors)



Beamline for the synchrotron radiation of the dipole magnet

Upgrade of MCP-based photon detector

MCP detector: 2004

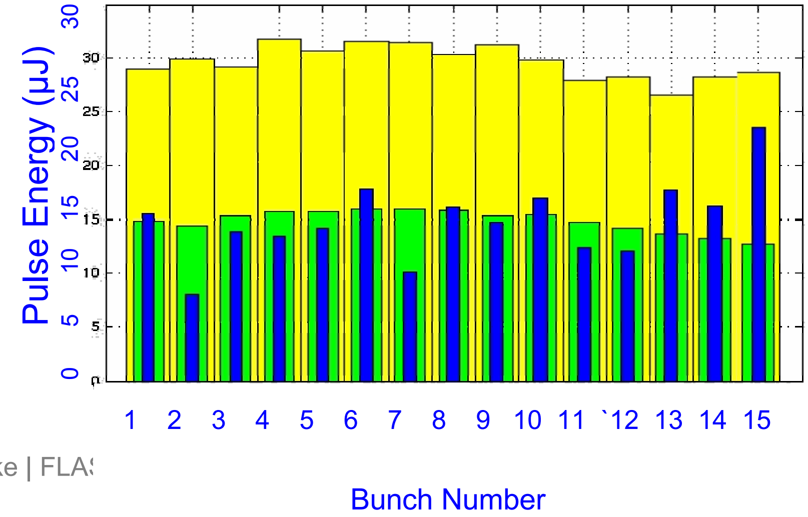


MCP detector: 2007

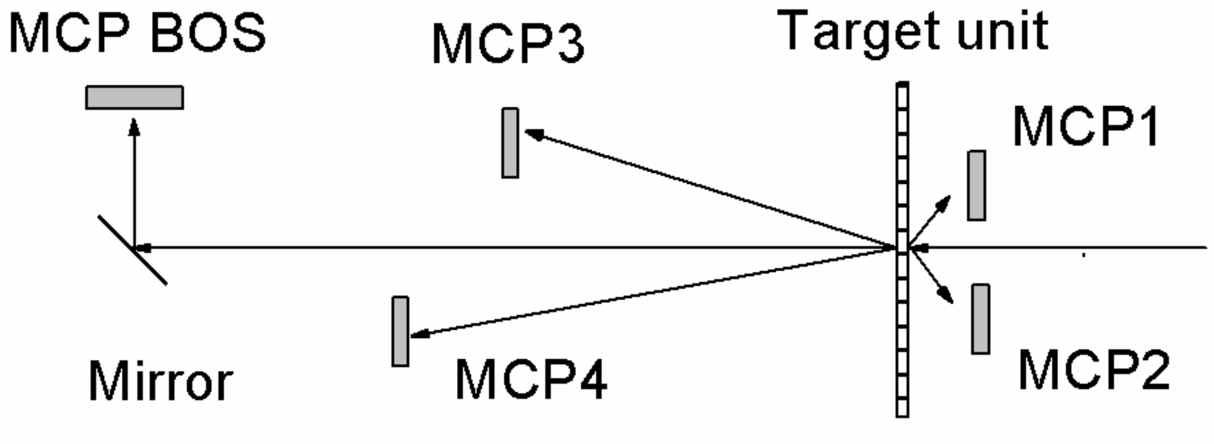
- MCP detectors were developed in collaboration with JINR, Dubna.

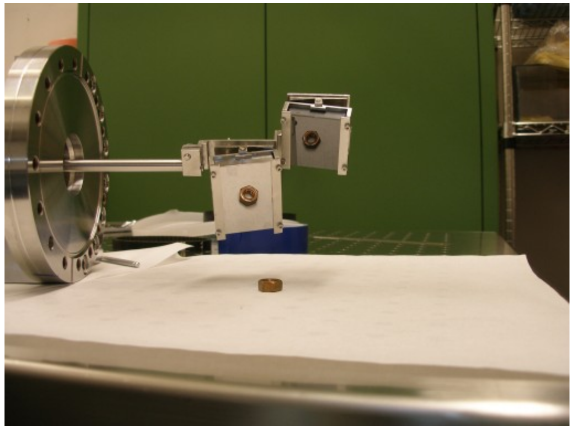
- Four generations of MCP detectors has been developed an installed at the TESLA Test Facility/FLASH in 1999, 2001, 2004, and 2007.

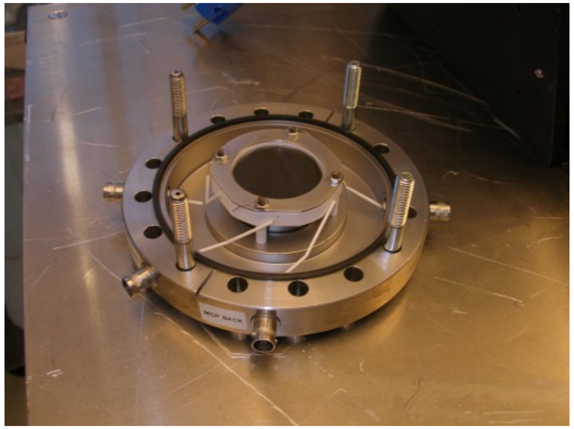
- MCP-detector is the main tool for search, tuning and primary characterization of SASE.

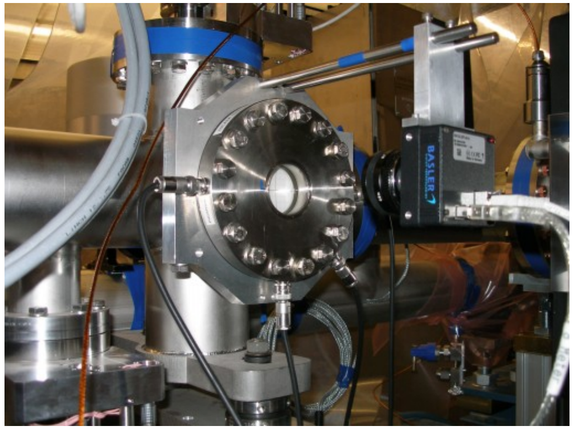


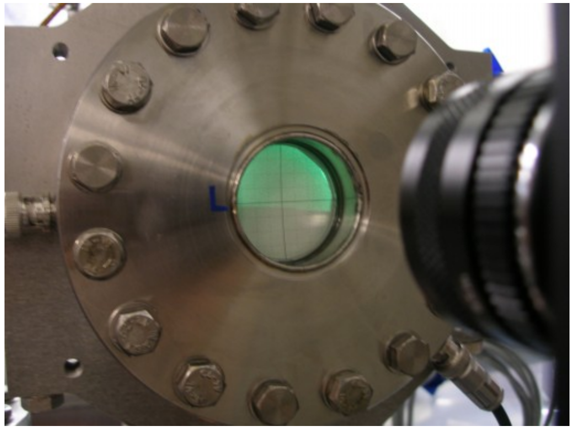
Upgrade of MCP-based photon detector in 2009/10





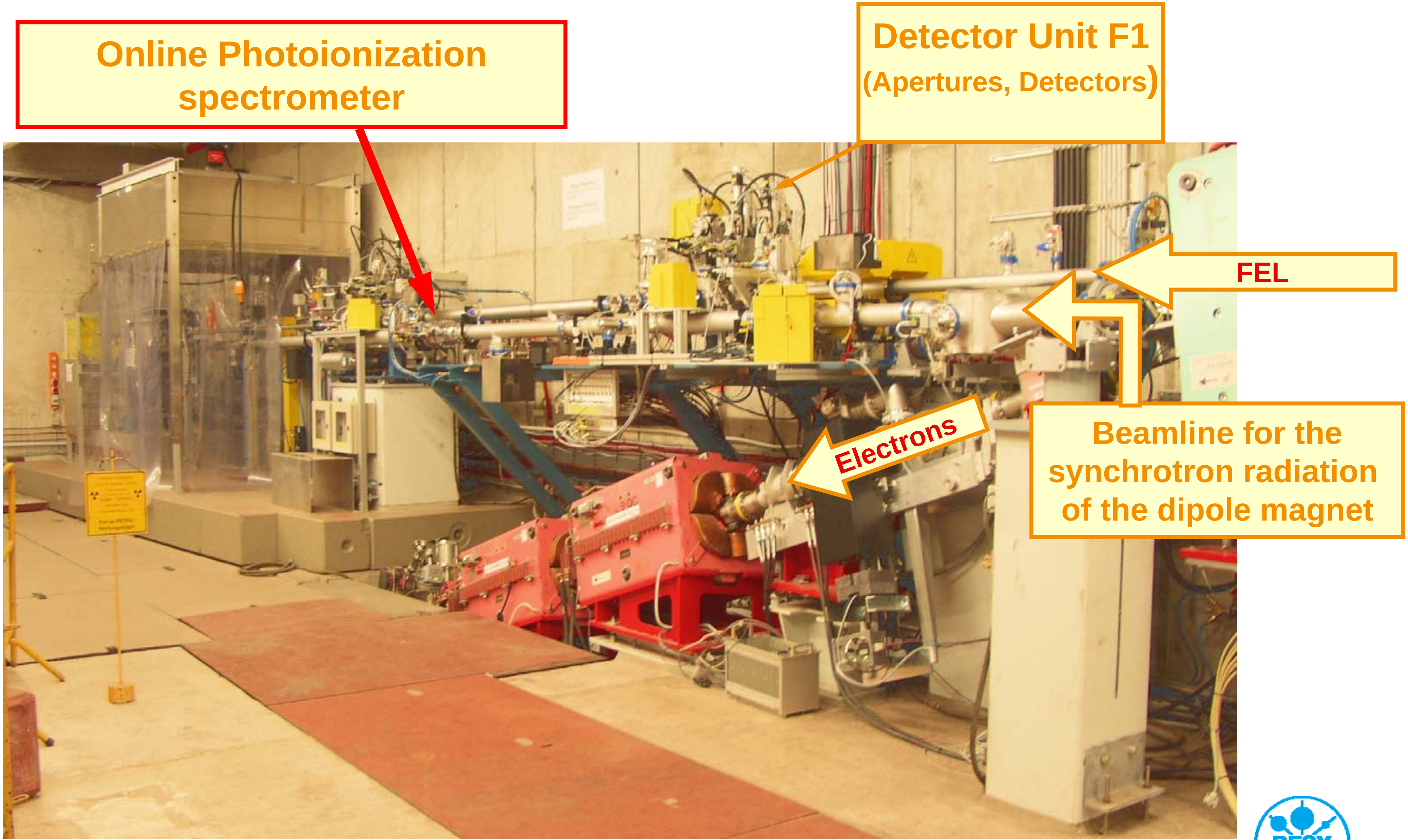






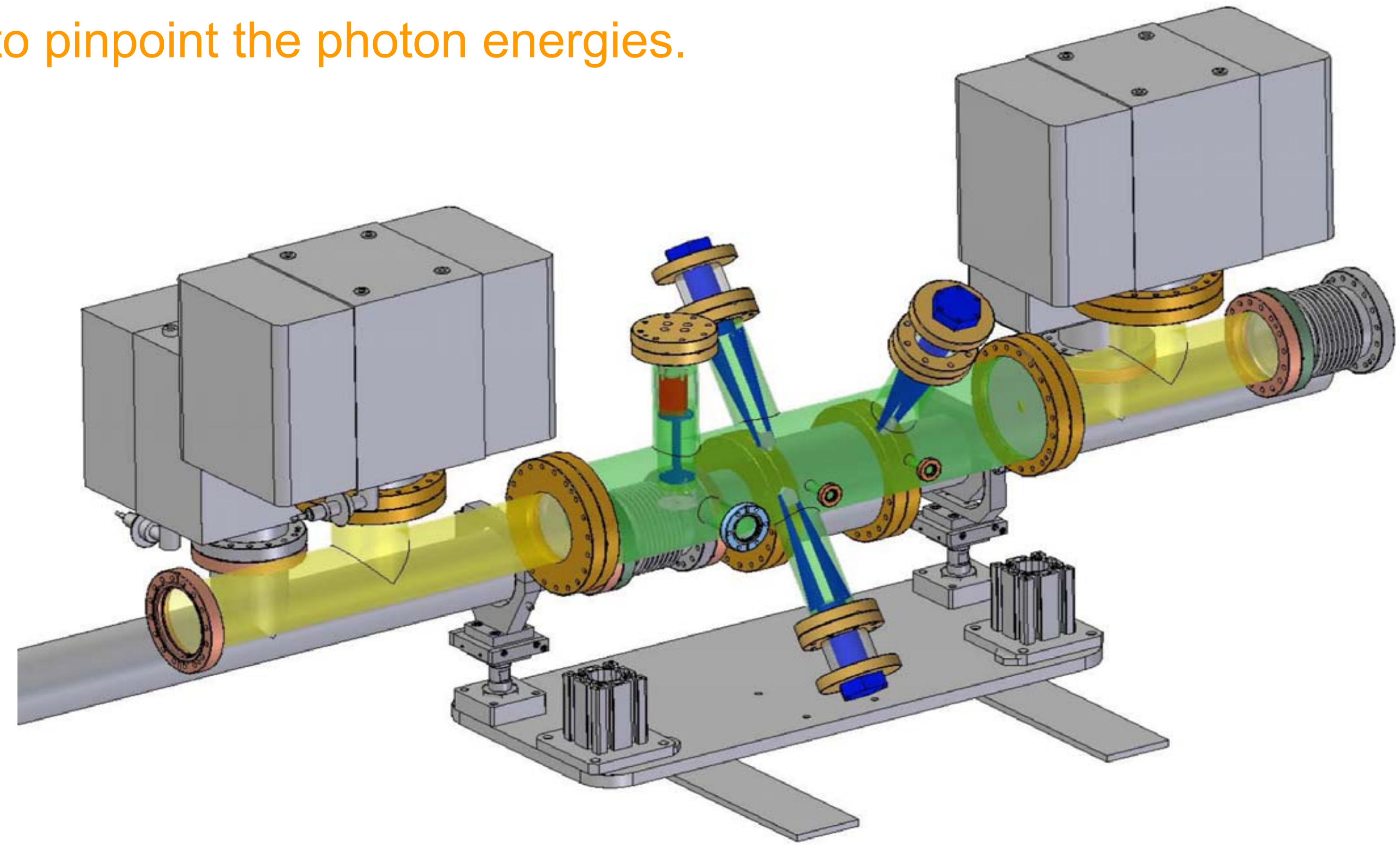
- During 2009/10 upgrade MCP-based beam observation system (BOS) has been installed.
- This upgrade has been done in collaboration with JINR (Dubna) and EXFEL.
- An idea is to use it for photon beam profile characterization and (possibly) for visual SASE search.

Online Photionization Spectrometer



Online Photoionization Spectrometer

One can use the Ion and Electron TOF data to pinpoint the photon energies.



M. Wellhöfer, J. T. Hoeft, M. Martins, W. Wurth, M. Braune, J. Viefhaus, K. Tiedtke, M. Richter, *Photoelectron spectroscopy as a non-invasive method to monitor SASE-FEL spectra*. JINST 3, P02003 (2008)

P. N. Juranić, M. Martins, J. Viefhaus, S. Bonfigt, L. Jahn, M. Ilchen, S. Klumpp, K. Tiedtke, *Using I-TOF spectrometry to measure photon energies at FELs*, JINST 4, P09011 (2009)

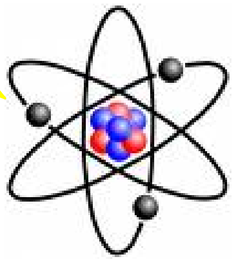
Online determination of the spectral distribution

using i- and e- TOF spectrometer

$E_{kin} = E_{photon}$ – Binding Energy

Light Beam

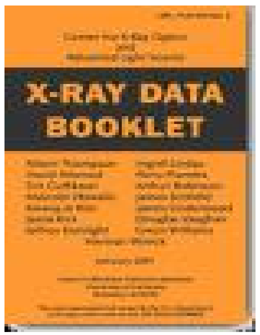
Electron



Atom

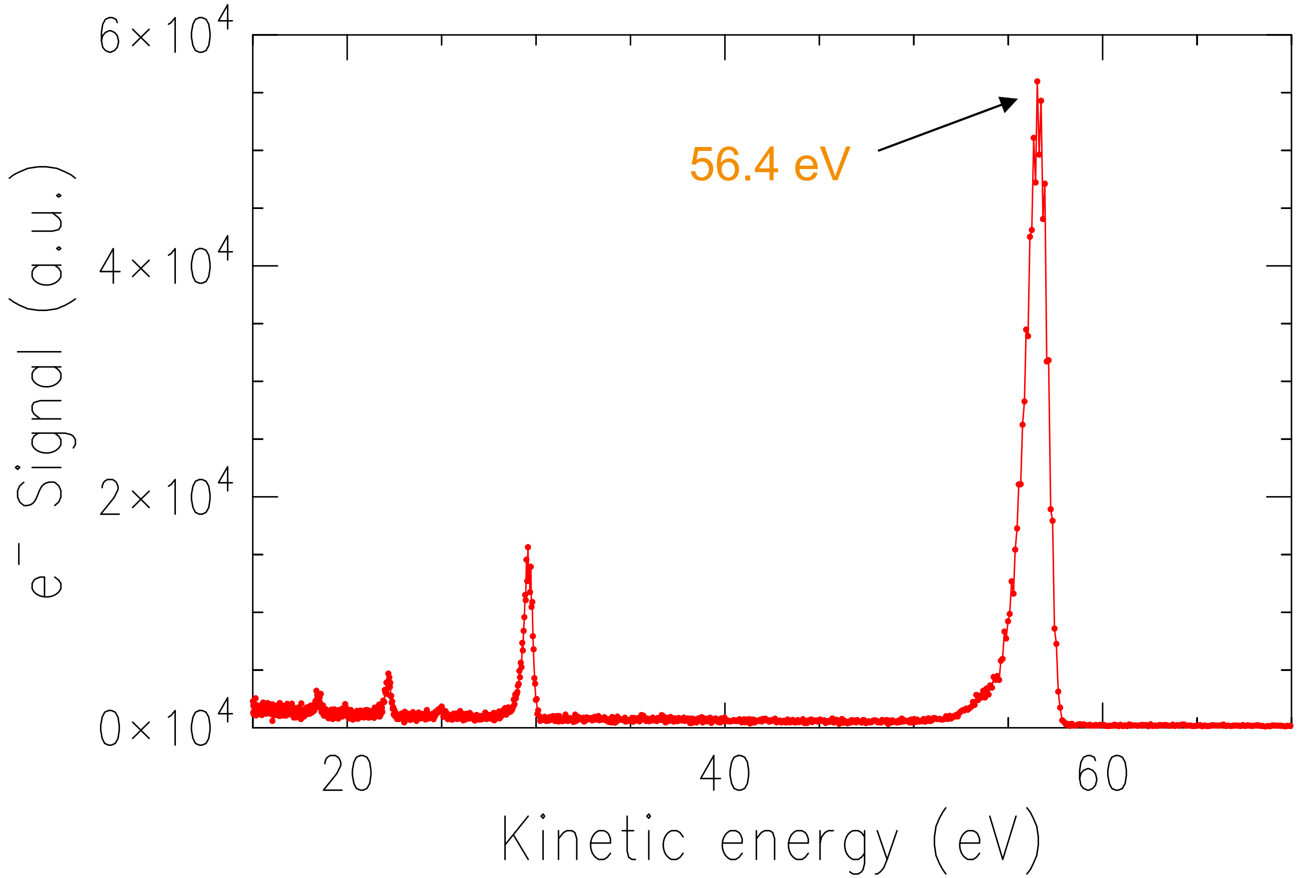
→ If you know the binding energy, and you can measure the electron kinetic energy, you can evaluate the energy of the photon!

The binding energies are easy . . .



The Spectra

eTOF spectrum of Ne

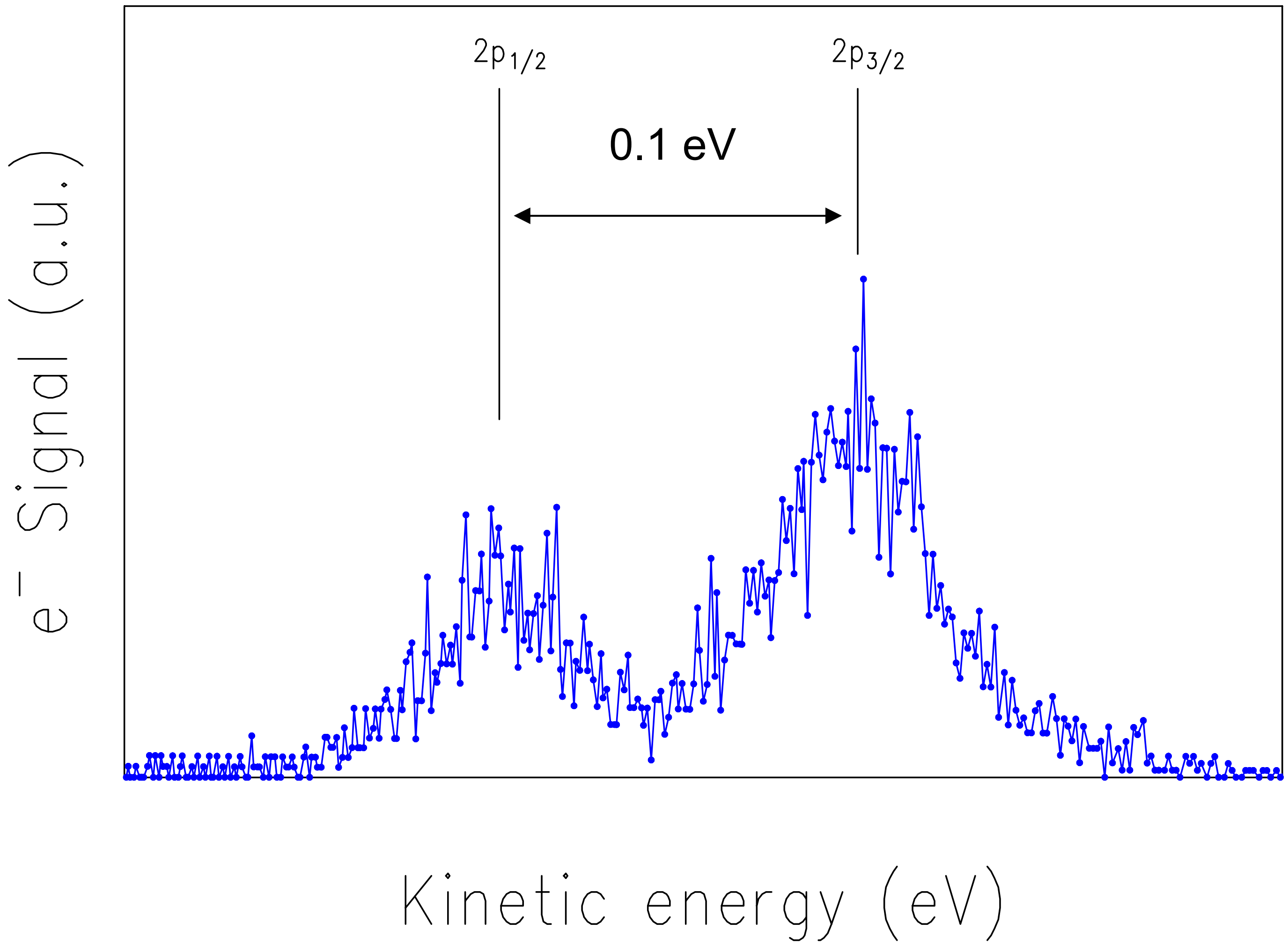


The $2p_{3/2}$ level for Ne has a binding energy of 21.7 eV. The $2p_{1/2}$ binding energy is 21.6 eV.

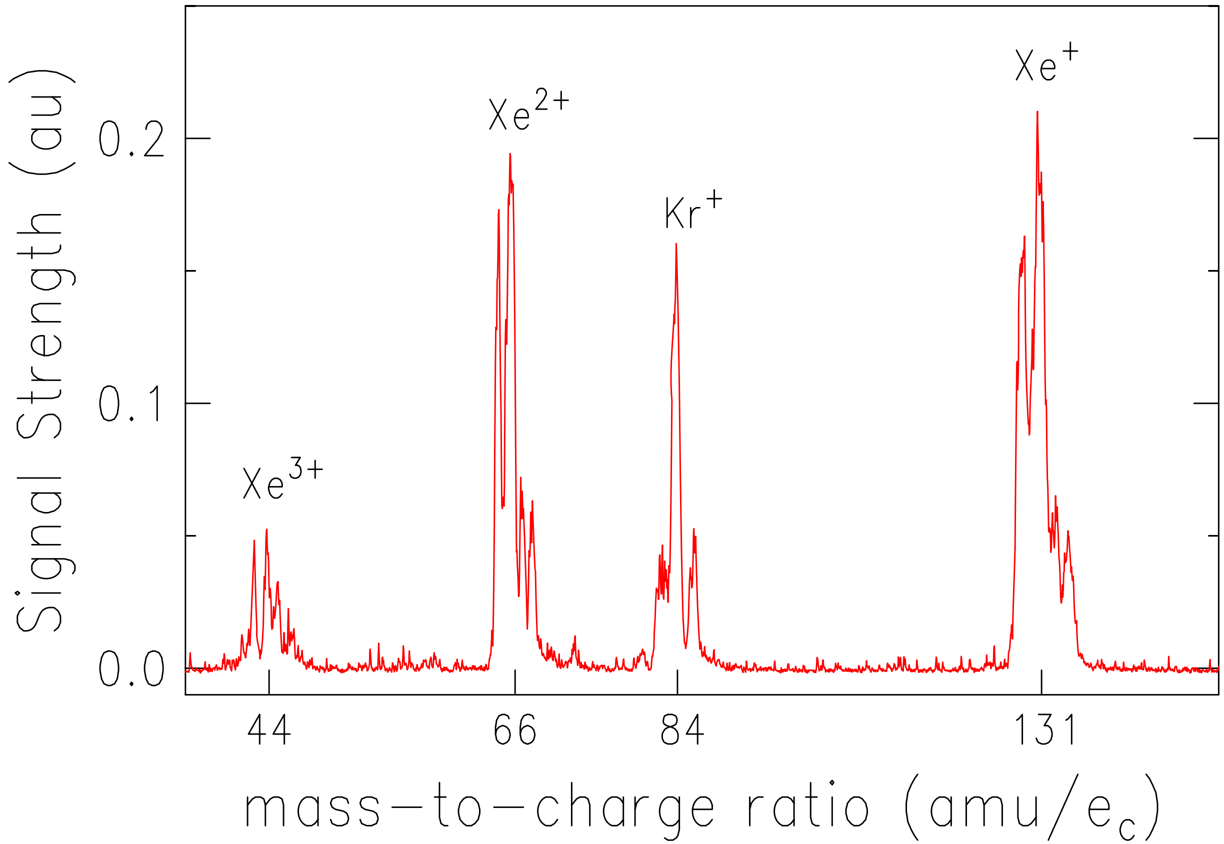
That would make the photon energy 78 or 78.1 eV. The set photon energy was 78 eV.

Resolving Power

Neon at 22 eV

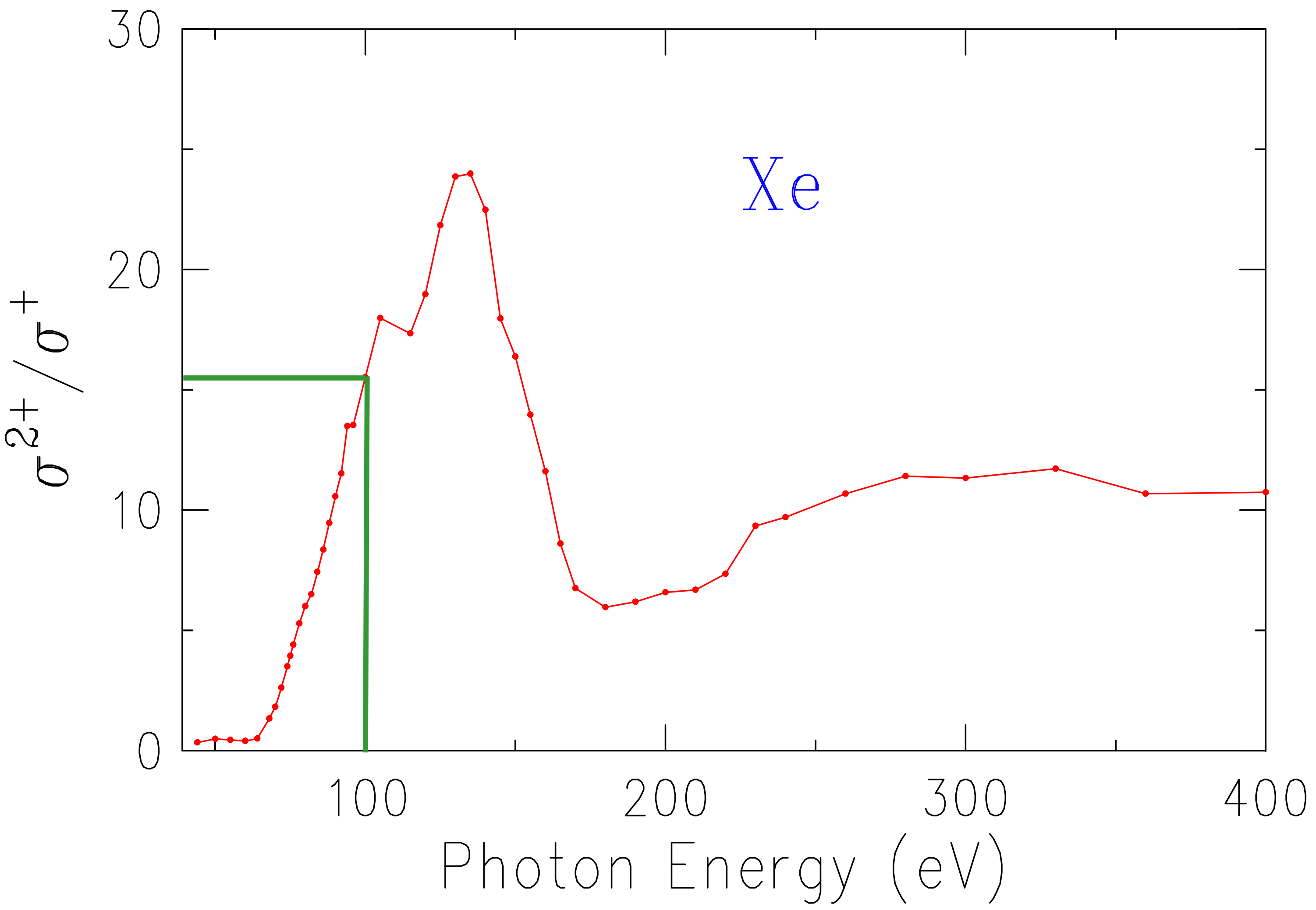


Well-Resolved I-TOF Spectra



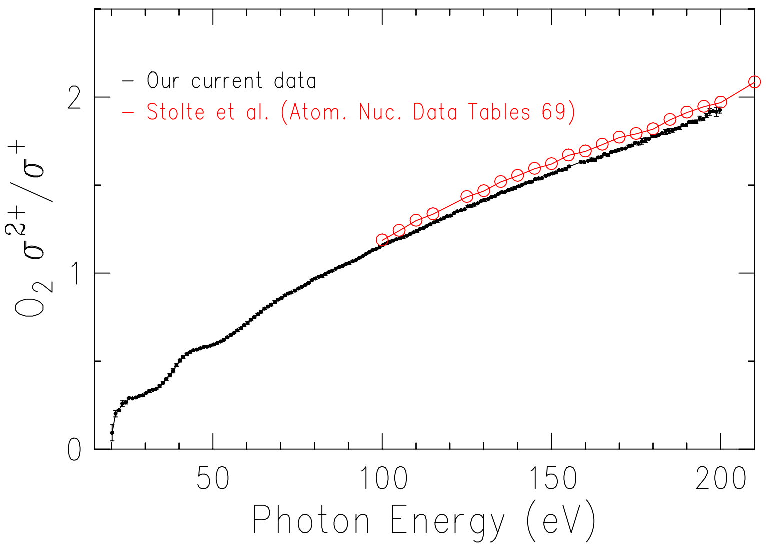
Isotope	Atomic mass (m_a/u)	Natural abundance (atom %)
^{124}Xe	123.9058942 (22)	0.09 (1)
^{126}Xe	125.904281 (8)	0.09 (1)
^{128}Xe	127.9035312 (17)	1.92 (3)
^{129}Xe	128.9047801 (21)	26.44 (24)
^{130}Xe	129.9035094 (17)	4.08 (2)
^{131}Xe	130.905072 (5)	21.18 (3)
^{132}Xe	131.904144 (5)	26.89 (6)
^{134}Xe	133.905395 (8)	10.44 (10)
^{136}Xe	135.907214 (8)	8.87 (16)

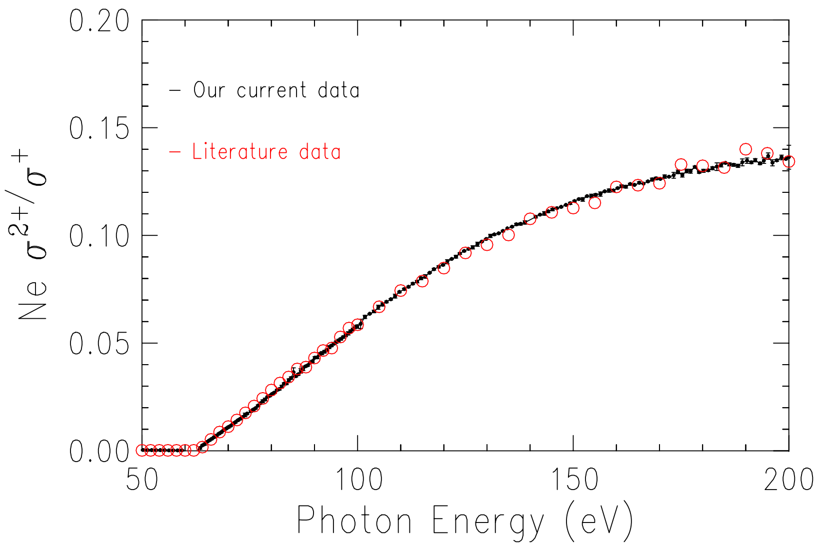
From the Spectra, Ratios

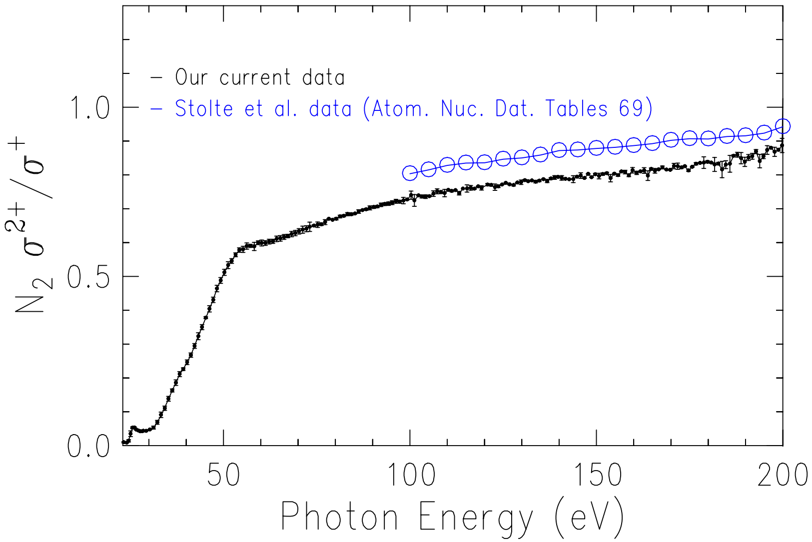


We must be at 100 eV photon energy! But it could also be 170 eV. . .

Other Gases

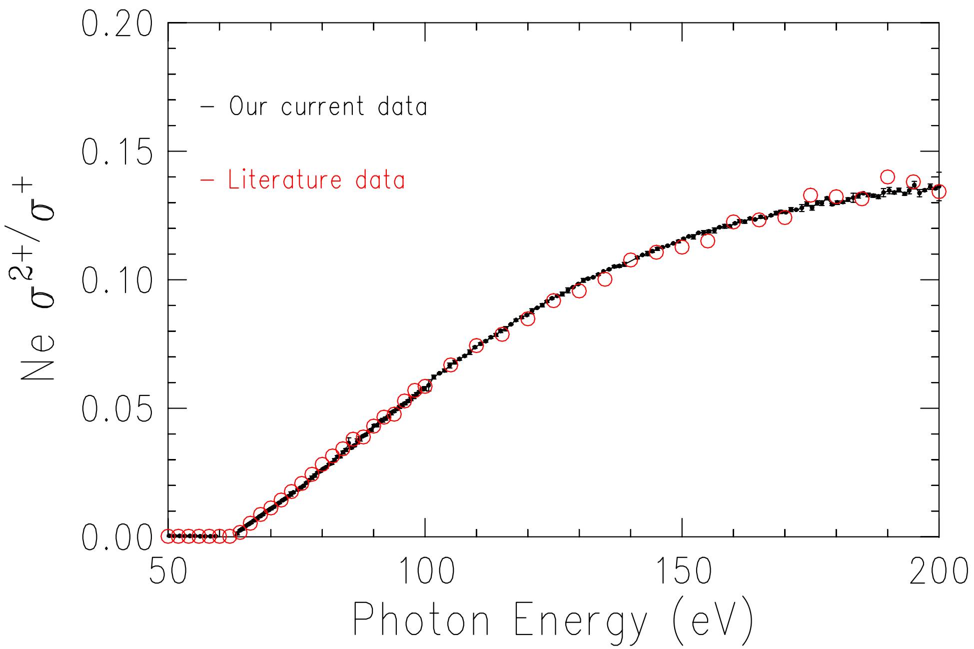


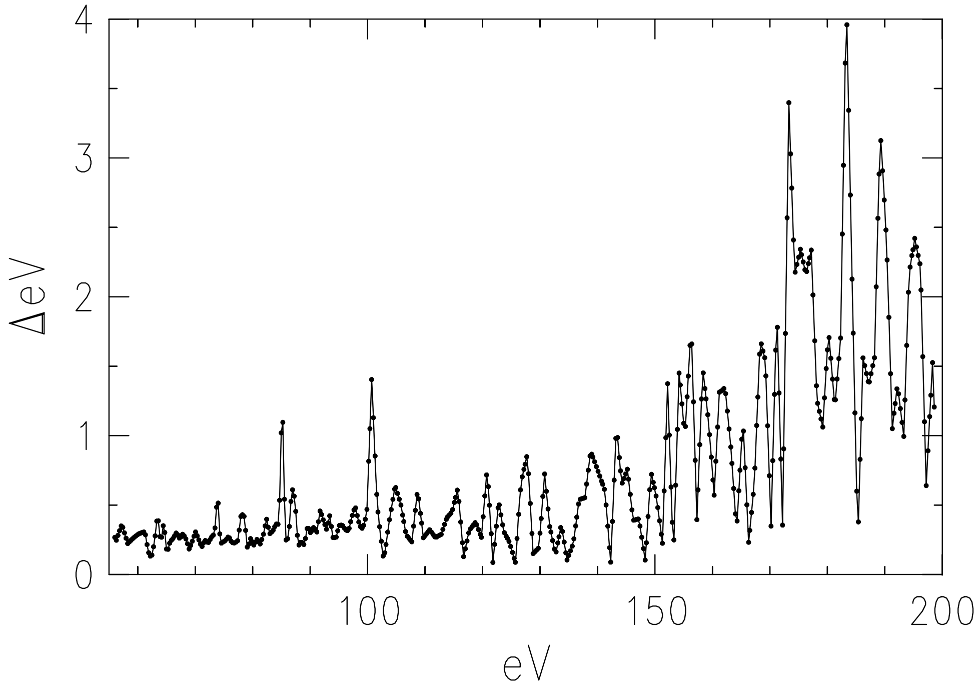




- Small Error Bars
- Lots of Literature Data
- Lots of Signal!

Uncertainty





Steep slopes are good! Oxygen looks particularly nice . . .

A Final Comparison (for FLASH)

	E-TOF	I-TOF
Speed of measurement	Nanoseconds	Hundreds of nanoseconds to microseconds
Uncertainty of “center” photon energy measurement	0.1 to 0.05 eV	0.7 eV to 0.3 eV
Expected “bonus” information	Can see the whole spectral distribution of the pulse and higher harmonics of a pulse	Can see the average photon energy
Robustness	Sensitive to electric and magnetic fields, beam stability	Like a rock

The End

> Everything proceeding very smoothly!

Many thanks to:
FS-BT group,
Colleagues from Dubna,
Martin Sachwitz and colleagues (DESY Zeuthen),
H. Zacharias and colleagues (Uni Münster),
Rolf Mitzner, Tino Noll, and Frank Siewert (HZB)
and in particular to:
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