Highly Efficient TOF-Measurements of Photoelectrons and -ions at the PETRA III-XUV Beamline

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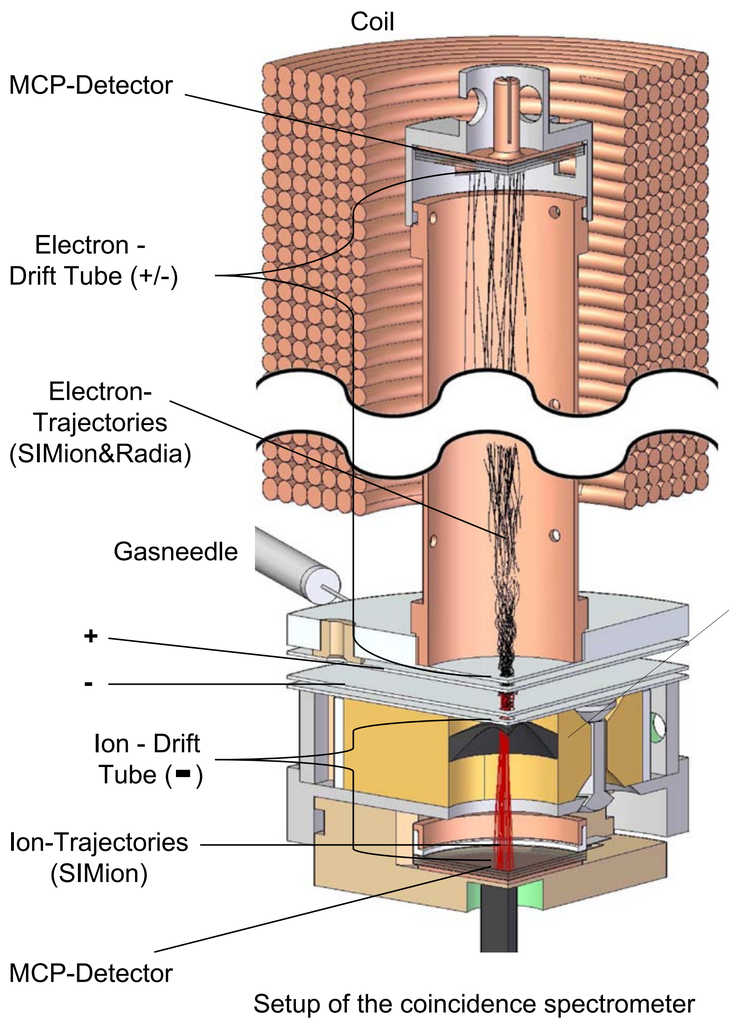
Introduction

A highly efficient Time-of-Flight spectrometer for coincident photoelectron and -ion measurements has been used for various photoionization experiments at the P04 Variable Polarization XUV Beamline (PETRA III). The spectrometer consists of a short Time-of-Flight spectrometer for ion detection, using electrostatic fields according to the principle of Wiley and McLaren [1], and a so called *magnetic bottle* spectrometer for efficient electron measurement [2]. The design is based on the work of Eland and Feifel [3] but it is optimized for the specifications of the P04-Beamline.

Ion-ToF-Spectroscopy

Various ion-ToF-spectra of atoms (Ne, Ar, Xe...) and molecules (H_2, SF_6, CO_2...) have been measured, e.g. see poster 39 (Gregor Hartmann et al.).

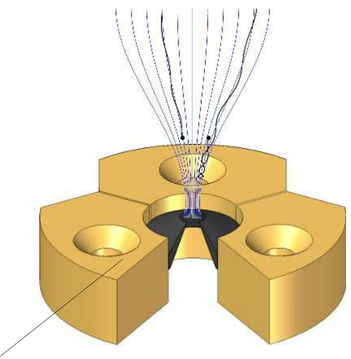
Setup



Setup of the coincidence spectrometer

Characteristics

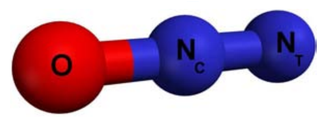
- Energy Resolution 1-2 eV
- Mass Resolution ~250
- Efficiency (Electrons) up to 30 %
- Efficiency (Ions) up to 55 %



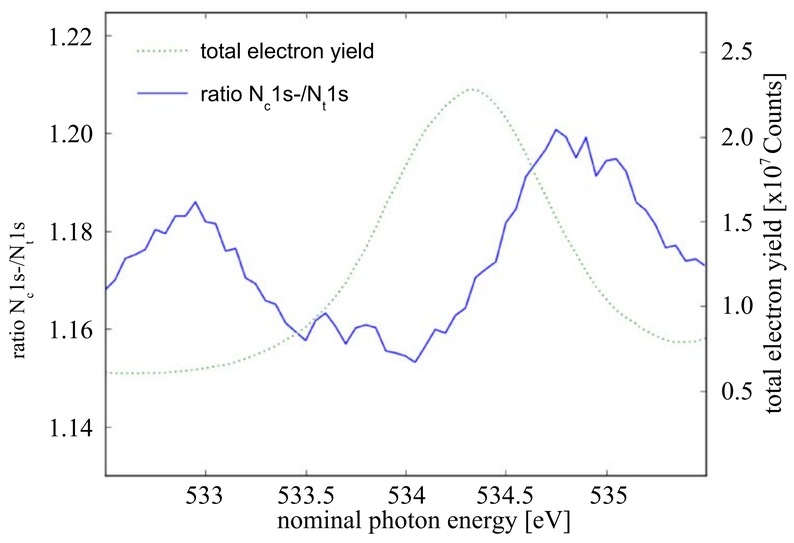
Assembly of three magnets and pole cap generating the magnetic field. The bottle neck shape turns electron trajectories upwards to the detector while the kinetic energy is conserved.

Electron-ToF-Spectroscopy on N_2O

NACHT – Effect[4]

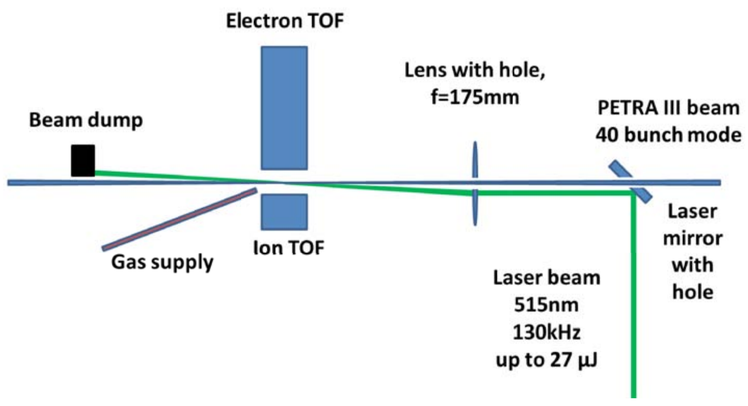


The chemical shift in N_2O allows to distinguish 1s-photoelectrons from the central (E_B (N_c1s) = 412.5 eV) and the terminal nitrogen atom (E_B (N_t1s) = 408.5 eV). It has been shown that the O1s →3π* excitation leads to a change in the non-dipole parameter for the N1s-photoelectron emission [4]. The new revision of the magnetic bottle allows clear seperation of the N_c1s- and N_t1s-photoelectrons in the range of the O1s→3π* resonance.

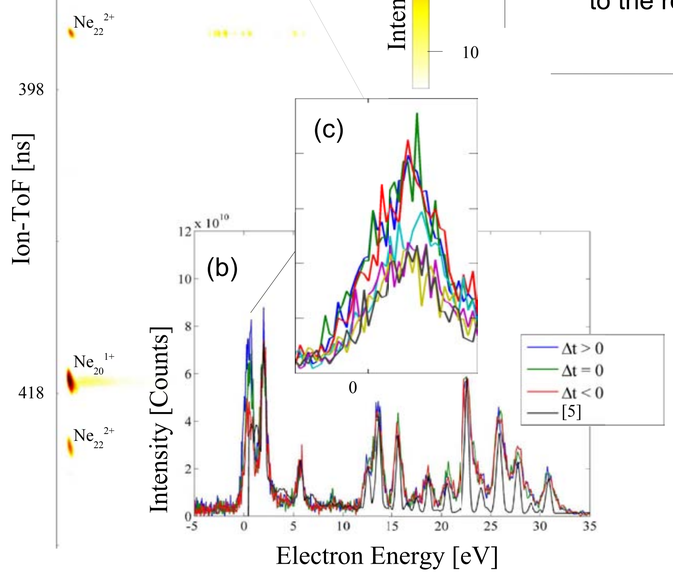


Total electron yield and ratio of N_c1s- and N_t1s – electrons in the range of the O1s→3π* resonance. The ratio changes with a shift to the resonance due to an increased N_c1s – electron yield.

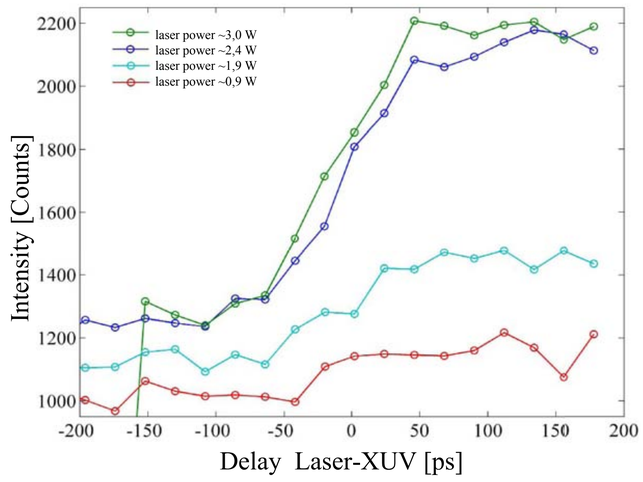
Time Resolved Studies



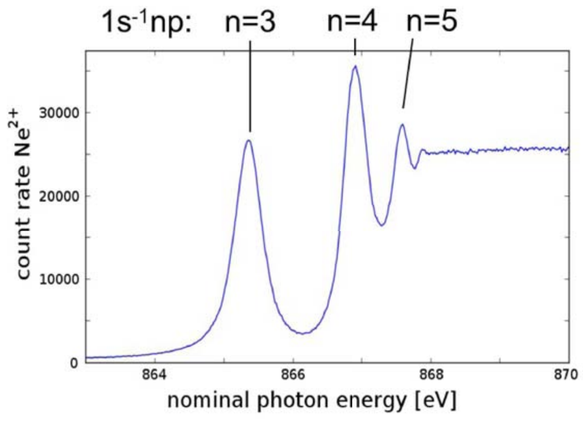
Schematic of the XUV-pump – laser probe experiment. The laser system is synchronized to the storage ring with a residual jitter of ~15ps. Every 40th bunch can be pumped at ~130kHz repetition rate.



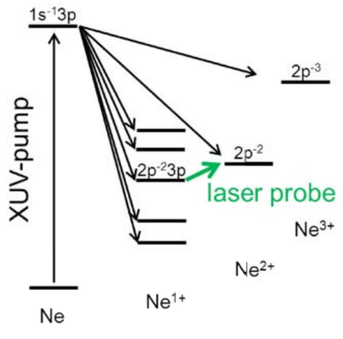
Electron-ion coincidence map of Neon with a laser delay of Δt ~ 200 ps (a) and spectra of electrons in coincidence with Ne^{2+} with different delays (b) compared with [5].
In (c) the slow electron signal is enlarged for different delays.
All spectra were taken on the Ne 1s →3p resonance.



Ion yield of Ne^{2+} in coincidence with slow electrons vs. laser delay and laser power. The rise time of the signal corresponds to the pulse duration of the X-ray pulses of ~100 ps.



Ne^{2+} ion yield at the Ne1s ionization threshold showing the first resonant rydberg states of the 1s-np-excitation.



Simplified energy level scheme of Ne. The laser-probed state is indicated by the green arrow.

References

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[5] J. Viefhaus, PhD Thesis

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