Photon-ion merged beam setup at PETRA III


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The Photon-Ion Spectrometer at PETRA III, PIPE (shown in figure 1), is an experimental merged beam setup for studying interactions of photons with charged particles [1, 2]. Target species are provided in the form of ion beams with ion masses up to \( q \times 50000 \) u at energies of \( q \times 2.4 \) keV for \( q \)-fold charged ions. Possible target species are atomic and molecular ions or electrically charged clusters, fullerenes, biomolecules and nanoparticles. Photoionization and photofragmentation will be studied. Photo-ions, photo-fragments, photo-electrons and photon-induced fluorescence light will be observed at the Variable Polarization XUV beamline P04 at PETRA III.

![Figure 1: Schematic layout of the PIPE setup. Ions can be separated by their mass-to-charge ratio with an analyzing magnet. An electrostatic 50°-deflector transports the ions into the interaction region, where the overlap with the photon beam occurs. The primary ion beam is monitored with a Faraday cup inside the demerging magnet. Reaction products can be measured with a single particle detector after 90°-deflection towards a detector chamber.](image)
Commissioning beamtimes of the PIPE experiment were in September and in November 2012. A 10 GHz permanent-magnet ECR ion source was used for producing ions. First experiments were carried out with singly- and doubly charged xenon and nitrogen ions to study the performance of the setup. Three requirements have to be fulfilled for a viable cross section measurement:

- Preparation of the ion target: the requested ion species can be selected with the analyzing magnet by performing a mass-to-charge separation of the primary ion beam. This aspect was working according to expectations. Figure 2 shows a mass scan of singly charged xenon ions recorded during the beamtime in November.

![Mass spectrum of singly charged Xe-ions](image)

Figure 2: Mass spectrum of singly charged Xe-ions as a function of the analyzing magnet coil current. The measuring device is a Faraday cup positioned behind the $50^\circ$-deflector. The combination of the analyzing magnet and the $50^\circ$-deflector increases the resolution of the mass scan significantly, which allows one to separate the different xenon isotopes.

- Beam overlap: Photon and ion beam have to overlap during their way through the interaction region. This condition was achieved during the beamtimes. PIPE allows to measure the total overlap at three different positions in a plane perpendicular with respect to the collective beams’ axis.

- Primary and product ions have to be detected. The primary beam is measured inside the demerging magnet while the product ions are deflected inside a detector chamber, where a single-particle detector is installed. The detection of the primary ion beam inside the demerging magnet could be achieved. The problem on both beamtimes was the detection of the product ions. The main problem was the low photon flux coupled with a very low energy resolution due to the premature situation with photon optics in P04. A low ion product rate resulted and prevented cross section measurements.

Both beamtimes provided substantial progress towards a successful operation of the PIPE setup in 2013.

References