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HILITE - Ion Trap for Studies with Intense Laser Pulses

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Synopsis We present our Penning Trap setup which is designed for capture, confinement and preparation of well-defined ion clouds for use in experiments with high-intensity lasers. We explain the experimental setup and the techniques used to capture, confine, manipulate and detect the ions inside the Penning trap. We give an overview of the status of the project and the planned procedures to measure the laser-focus shape in situ.

We are currently devising an experimental setup which allows the preparation of well-defined ion targets for the interaction with high-intensity and high photon-energy lasers. The ion-target preparation is supported by an open-endcap cylindrical Penning trap, which can store atomic ions of an arbitrary charge state up to bare uranium U^{92+} [1].

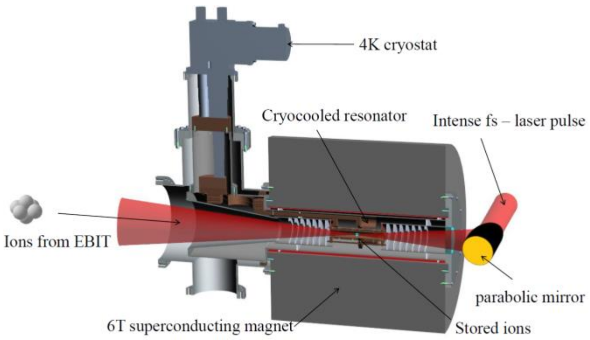

Figure 1. Experimental setup consisting of a superconductive magnet with a warm bore and an open-endcap Penning trap with three trap electrodes and two conical capture electrodes. The laser focus is in the trap center.

We have established a superconducting magnet with a horizontal warm bore and a magnetic field strength of up to 6 T. The Penning trap is a mechanically compensated trap consisting of three trap electrodes and two conical electrodes for dynamic capture of externally produced ions. The trap is optimized to allow the non-destructive detection also of small particle numbers over a large range of species using the FT-ICR (Fourier Transform Ion cyclotron resonance) technique. We will apply the SWIFT (Storage Waveform Inverse Fourier Transform) technique to select one or more defined ion species of an arbitrary mass and charge state by resonant ejection of the non-wanted ions. Application of the rotating wall technique will allow to define the ion number density up to values of about 10^9 cm^{-3}. It also allows good control over the ion-cloud shape by appropriate adjustment of the trapping parameters. The ions can be resistively cooled to kinetic energies of around 0.1 meV [2], which allows a well-defined nearly step-like frontier of the ion cloud. The ion-cloud position with respect to the laser focus may be controlled by an induced asymmetry of the trap voltages providing an accuracy of positioning in the micrometer scale.

With such a well-defined ion target, we intend to probe the laser-focus geometry in situ, yielding the intensity distribution inside the laser focus without the need for laser attenuation or outcoupling. With this configuration we also intend to investigate the ionization behaviour of ions under the influence of extreme laser fields up to an intensity of 10^{20} W/cm². To this end, we optimize the focusing parameters as well as our target ion cloud to maximize the number of particles which are exposed to an intensity above the ionization threshold. Since the whole setup is designed to be moved readily we are able to perform studies with a variety of high-intensity lasers, e.g. PHELIX at GSI, JETI and POLARIS in Jena or FLASH at DESY.

We present the experimental outline, the devised setup with its current state and the intended experiments with their possible benefit.

References

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