Optical Beam Diagnostics

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The plasma-lens used at the HHT cave has been demonstrated to be a unique tool for shaping high energy ion beams into hollow beam spots [1] and achieving focal diameters, that are not accessible with regular magnets. However, electric currents on the order of 400kA within 9μs are necessary to achieve 10cm focal length. These currents, and the preionization pulses necessary for stable plasma formation, induce strong floating of the nearby ground-potentials, thus hindering low level electric measurements. In particular time resolved measurements of ion beam pulse intensities are strongly influenced by the plasma lens firing, as shown in Fig. 1.

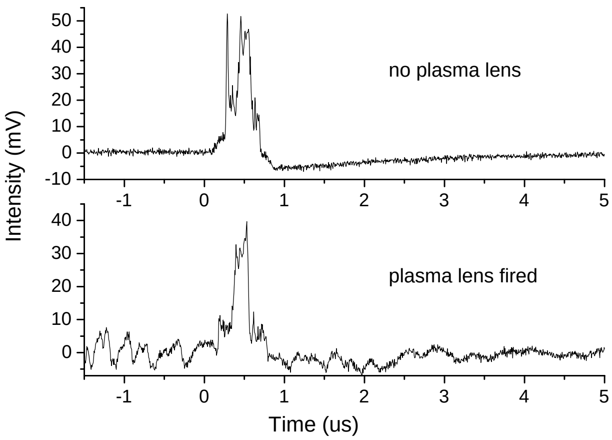

Figure 1: Fast current transformer signals of two different SIS pulses, without (upper) and with plasma lens fired (lower curve).

A first setup to circumvent this electric noise problem was installed, measuring the light emission from ion beam excited neon gas with a Si-PIN diode. Due to the optical measurement of the beam current, the system is rather insensitive to potential fluctuations and electric noise. A CF-100 double-cross was filled with 1bar neon, and the optical detector was placed in a distance of 0.5m. A D=2.5 neutral density filter had to be used for not overexposing the detector with an ion beam current of 2×10^9 Au particles per pulse. The signal to noise ratio increased by about one order of magnitude, without any additional means of shielding the signal lines (Fig.2).

Without plasma lens firing, the fast current transformer reflects well the temporal beam structure, except a negative overshoot after fast intensity drops. In order to simulate the optical signal, direct beam excitation of the light emitting species (neon 3p levels) is assumed, which then are supposed to decay within their natural lifetime of about 10ns. However, a 100ns decay time has to be used in order to coincide simulated and measured pulses, as shown in Fig. 3. This means that the 3p levels in neon, although no resonance transitions, are optically not thin and a linear response is not inherently given with the experimental conditions, used.

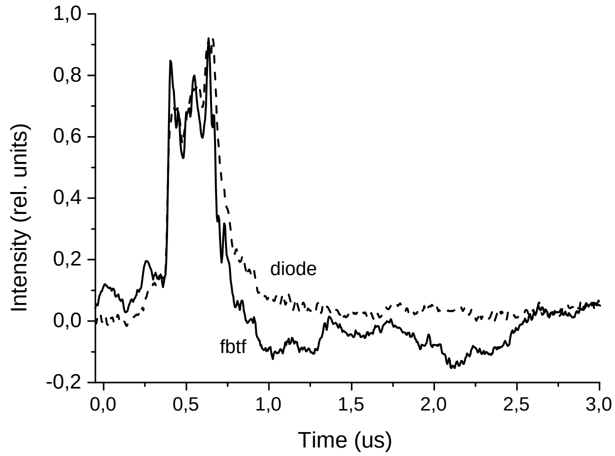

Figure 2: Comparison of the fast current transformer signal (fbtf, solid) and the optical signal (diode, dashed), with plasma lens fired. The entire pulse duration is 1μs.

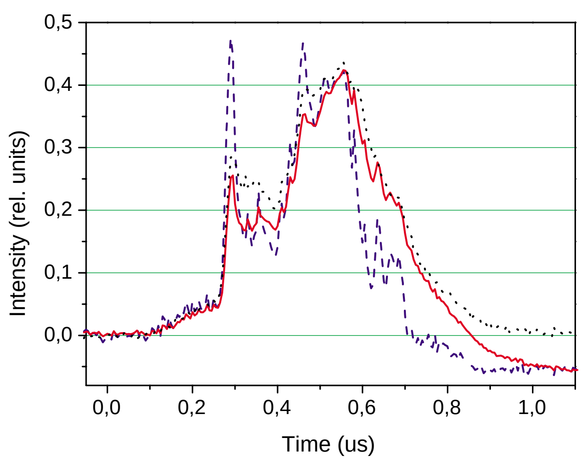

Figure 3: Without plasma lens fired, the signals of the fast beam transformer (dashed), the simulated optical signal (solid) and the measured diode signal (dotted) are given.

In a next set up, xenon will be used as a target gas, with a detector only sensitive to the molecular ion continuum radiation, not observing the 6p-6s transitions. In this way, a linear response over several orders of magnitude in ion beam intensities will be possible to be detected, with a linear response on a 5ns time scale, up to excitation densities of $10^{17}\mathrm{cm}^{-3}$.

work funded by BMBF

References

[1] U.Neuner et al., Phys. Rev. Lett. 85, 4518, (2000)