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Upgrade of GSI's laser-driven ion beamline at Z6*

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The LIGHT beamline

The German national collaboration "LIGHT" (Laser Ion Generation, Handling and Transport, [1]) has implemented a worldwide unique laser-driven proton beamline at GSI. Compact acceleration up to nearly 30 MeV proton energies is possible from the novel plasma source via the TNSA mechanism, which is driven by the PHELIX 100 TW laser beam. Therefore, at the Z6 experimental area laser intensities of up to 5×10^{19} W/cm^2 are accessible. A pulsed high-field solenoid then provides for the necessary beam collimation and energy selection [2] and typically protons with an energy between 8 and 10 MeV are chosen.

Furthermore, a radiofrequency (rf) cavity is implemented at 2 m distance to the source for phase rotation of the created single bunch, which shows a typical energy spread of around 20% (FWHM around central energy) and high particle numbers of up to 10^9. Energy compression of the bunch below 3% was demonstrated in an experimental run in 2013 [3].

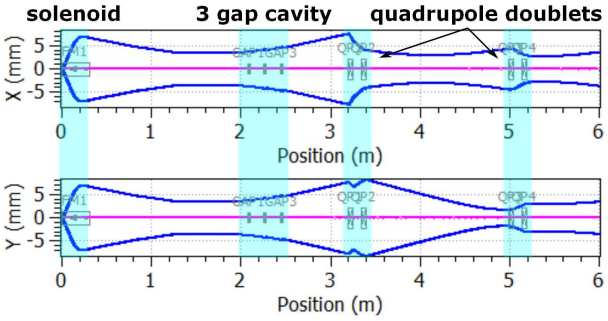

Figure 1: Simulation (code: *TraceWin*) of the 7.8 MeV proton beam size (rms) through the current beamline, from the source up to a new diagnostic chamber at 6 m.

For the 2014 campaign, the beamline has been extended by a diagnostic chamber at 6 m distance to the source, two permanent magnetic quadrupole doublets (50 mm, 25 T/m) for beam transport, see figure 1, and an optional third doublet (80 mm, 85 T/m and 45 mm, 105 T/m) for final focusing of the bunch. The additional space behind the cavity, which is again used at -90 deg synchronous phase but this time at higher rf power to 'over-focus' the bunch in longitudinal phase space, compare figure 2, is necessary as drift space for phase focusing experiments.

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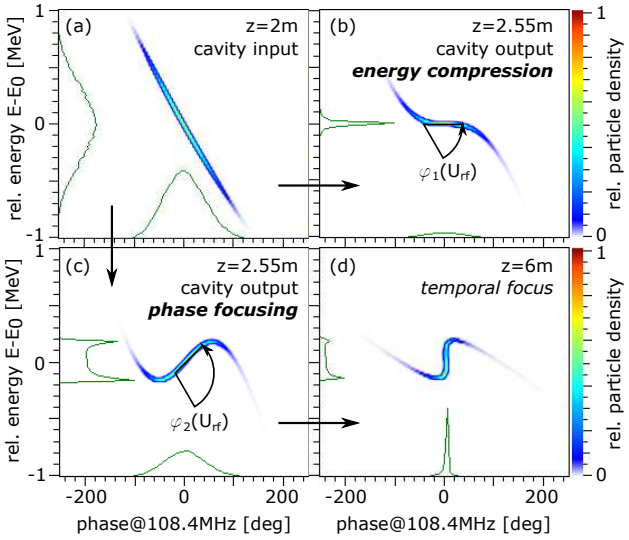

Figure 2: Simulated longitudinal phase space diagrams for the two current operation modes when injecting the laser accelerated proton bunch into the rf cavity at -90 deg synchronous phase: energy compression or temporal compression of the bunch along a drift via phase focusing.

Recent results and outlook

In the 2014 campaign, proton bunches with a central energy of 7.8 MeV were selected from the source and propagated through the beamline, containing typically particle numbers in the range of 2×10^8 to 5×10^8 within FWHM. Their length could be compressed in time to a FWHM bunch length of τ=(462±40) ps.

The transverse beam profile, however, could be reduced in the experiment only to a line focus of 3×18 mm^2 (FWHM). Therefore, the implementation of a second pulsed solenoid at the end of the beamline is planned as a new steep final focusing system to access highest peak intensities. Also the acceleration of not only protons but also carbon, oxygen and flourine will be explored in 2015.

References

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