Target heating in high-energy-density matter experiments at the proposed GSI FAIR facility: Non-linear bunch rotation in SIS100 and optimization of spot size and pulse length

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Abstract

The Gesellschaft für Schwerionenforschung (GSI) Darmstadt has been approved to build a new powerful facility named FAIR (Facility for Antiprotons and Ion Research) which involves the construction of a new synchrotron ring SIS100. In this paper, we will report on the results of a parameter study that has been carried out to estimate the minimum pulse lengths and the maximum peak powers achievable, using bunch rotation RF gymnastic-including nonlinearities of the RF gap voltage in SIS100, using a longitudinal dynamics particle in cell (PIC) code, ESME. These calculations have shown that a pulse length of the order of 20 ns may be possible when no prebunching is performed while the pulse length gradually increases with the prebunching voltage. Three different cases, including 0.4 GeV/*u*, 1 GeV/*u*, and 2.7 GeV/*u* are considered for the particle energy. The worst case is for the kinetic energy of 0.4 GeV/*u* which leads to a pulse length of about 100 ns for a prebunching voltage of 100 kV (RF amplitude). The peak power was found to have a maximum, however, at 0.5–1.5 kV prebunching voltage, depending on the mean kinetic energy of the ions. It is expected that the SIS100 will deliver a beam with an intensity of 1–2 x 10^{12} ions. Availability of such a powerful beam will make it possible to study the properties of high-energy-density (HED) matter in a parameter range that is very difficult to access by other means. These studies involve irradiation of high density targets by the ion beam for which optimization of the target heating is the key problem. The temperature to which a target can be heated depends on the power that is deposited in the material by the projectile ions. The optimization of the power, however, depends on the interplay of various parameters including beam intensity, beam spot area, and duration of the ion bunch. The purpose of this paper is to determine a set of the above parameters that would lead to an optimized target heating by the future SIS100 beam.

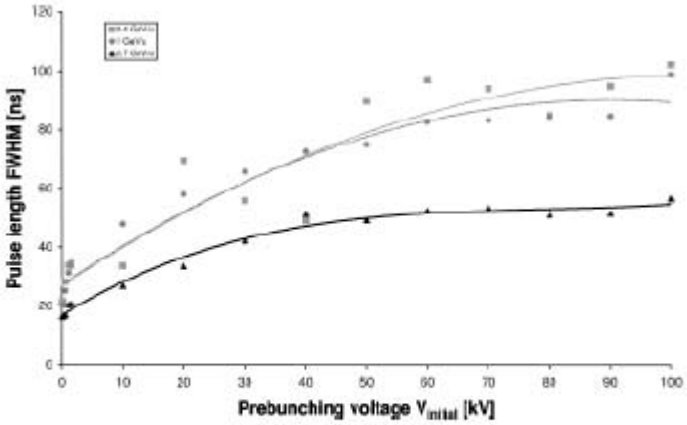

Fig. 1. Minimum pulse length at maximum compression versus $V_{initial}$ for $^{238}U^{28+}$ at an intensity of 2×10^{12} ions. The energies quoted in the legend are those of the mean kinetic energy per nucleon of the ions. The smooth curves are only for visual guidance.