Beam Quality Measurements for Low Energy Antiproton Machines

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From 2016 the Extra Low Energy Antiproton (ELENA) ring will allow better quality, higher intensity antiproton beams to reach the experiments at the antimatter facility at CERN. Also currently in development is the Ultra-low energy Storage Ring (USR) at the Facility for Low-energy Antiproton and Ion Research (FLAIR). In order to ensure the experiments receive the best quality beams possible, unique diagnostics systems for these machines must be developed.

In this contribution, a system using a scraper for measuring the emittance of beams in next generation low energy antiproton machines is investigated. After developing a working theory, particle tracking using multiple codes is performed to establish a reliable simulation of the scraper in operation. The working scraper model is used to determine how accurately the emittance of the beam can be reconstructed from scraper position and beam intensity measurements. As there is no point of zero dispersion around the ELENA ring, several complications are considered. These include difficulties determining the closed orbit and the effects of a correlation between the emittance and momentum offset. An algorithm employing the best possible method of reconstruction is developed and offered for practical application. Additional effects such as a diffusion process and intrabeam scattering may further complicate the measurement and possible future studies are discussed. Challenges arising from the adaption of the device from ELENA to the USR are considered.

KEYWORDS: ELENA, antimatter, antiprotons, low energy, beam diagnostics, scraper device

1. Introduction

ELENA is a low energy storage ring currently under construction at CERN [1]. It will increase the number of antiprotons supplied to the experiments from the Antiproton Decelerator (AD) [2] by further decelerating them from an energy of 5.3 MeV to 100 keV. This will be achieved by utilizing an electron cooler to keep the beam under control during the deceleration process. The lower energy of the beam means fewer antiprotons will be lost passing through the thinner degrader foils before the experiments, resulting in a 10-100 fold increase in the number of particles reaching the experiments.

Emittance measurements using a scraper will be used to monitor the quality of the beam between the deceleration and cooling phases. The scraper will work as a destructive diagnostics device, consisting of a set of blades moving slowly (compared to the velocity of the beam) into the path of the beam and gradually removing all of the particles