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Antiproton physics in the ELENA era

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Introduction

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The programme of physics with low energy antiprotons at CERN, the European Particle Physics Laboratory, has a long history, beginning with the inauguration of the Low Energy Antiproton Ring (LEAR) in 1982 [1]. That machine produced antiprotons decelerated to kinetic energies of a few MeV, an achievement made possible due to advances in techniques that enabled cooling of charged particles held in storage rings [2,3]. Pioneering experiments to trap and cool antiprotons to meV energies were carried out at LEAR [4,5] and a landmark achievement was reached in 1995, when the first nine atoms of antihydrogen were observed by the PS210 experiment [6].

A short lapse in the availability of low energy antiprotons followed this success, as LEAR was closed for antiparticle use in 1996. However, in 2000, out of the ashes of the complex of high-energy machines used to feed antiprotons to LEAR, arose the antiproton decelerator (AD) [7]. The AD again made antiprotons available at MeV energies, but now in short bursts containing around 30 million antiparticles, about once every 120 s.

So far, the AD has been host to eight different experiments (ACE [8], AEgIS [9], ALPHA [10,11], ASACUSA [12,13], ATHENA, ATRAP [14] BASE [15] & GBAR, and all but ACE and ATHENA are ongoing), that delve into the myriad of questions one can hope to answer using low energy antiprotons. Thanks to a string of successes from the experiments (see the following articles in this volume for further details), CERN has decided, with help from the user community, to expand the facility in a remarkable way with development of the extra low energy antiproton (ELENA) facility [16].

ELENA will decelerate the MeV antiprotons from the AD and from 2021, after the CERN accelerator shutdown in 2019 and 2020, will provide antiprotons with a kinetic energy of 100 keV to the experiments. The reduction in energy will facilitate, in particular,

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two spectacular improvements in the low energy proton physics programme. First, at 100 keV the antiprotons will be delivered using electrostatic transfer lines (rather than the typical magnet technology), which will allow for rapid switching whereby separate bunches can be directed to different experiments. This will make possible more-or-less 24/7 exploitation for all experiments on a single-shot-request basis, as opposed to the present day beam-time sharing in 8-h blocks. Secondly, at 100 keV, the straggling when degrading the energy of the beam through a foil (most experiments can only capture antiprotons that exit the foil with kinetic energies in the few keV range) is small enough that the dynamic capture efficiency of antiprotons in a typical Penning-trap will increase from about 1% today to around 80% with ELENA.

These dramatic enhancements in both the number and availability of antiprotons made possible by ELENA is what spurred the Theo Murphy International Meeting on which this issue is based. Articles from most of the main experiments now working at the AD inform about their current status, and provide a glimpse of their visions for how they plan to exploit the ELENA upgrade to increase their physics output and explore new areas. The meeting was kicked off with theoretical inputs to inform the meeting on what, from a theoretical viewpoint, we might learn from the experimental efforts [17–19].

Q1 Data accessibility. This article has no additional data.
Q2 Competing interests. We declare we have no competing interests.
Q3 Funding. We received no funding for this study.

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