ELENA: An Upgrade to the Anti-proton Decelerator at CERN

Walter Oelert[(a)]
representing the community of people constructing and later using the AD- ELENA complex

[(a)] IKP, Research Center Jülich, Germany

CERN has a long exciting tradition of pursuing fundamental physics on a variety of energy scales. For anti-protons, CERN famously produced the high-energy SPS beam, but also the world's only and unique sources of low-energy anti-protons – first the Low Energy Anti-proton Ring (LEAR) and now the Anti-proton Decelerator (AD). LEAR and the AD led to widely recognized scientific successes that include:

- The trapping, cooling and accumulation of extremely cold anti-protons, more than 10^{10} times lower in energy than the LEAR and AD anti-protons.
- The most precise comparison of the charge-to-mass ratios for the anti-proton and proton, resulting in the most stringent test of CPT invariance with baryons.
- Some of the most precise studies of CP violation.
- The observation and laser spectroscopy of meta-stable anti-protonic Helium atoms.
- The first observations of fast and slow anti-hydrogen atoms.

The scientific demand for low-energy anti-protons at the AD continues to grow. By now there are four experiments running at the AD, a fifth one is approved, and further proposals are under consideration. Thus, CERN's unique Anti-proton Decelerator can no longer provide the number of anti-protons needed. As anti-hydrogen studies evolve into anti-hydrogen spectroscopy and gravitational measurements, the shortage will become even more acute.

It is now possible to consider more rapid progress and much higher measurement precision by upgrading the AD to increase and optimize the number of cold anti-protons that can be trapped and accumulated. To achieve this the construction of the Extra Low ENergy Anti-protons (ELENA) upgrade to the AD is proposed. This upgrade involves the addition of i) a small post-decelerator and cooling ring and ii) electrostatic beam lines. The design parameters have been carefully studied and agreed upon over several years. In fact ELENA will further slow down the AD anti-protons from 5.4 Mev to 100 kev and use electron cooling to keep the phase space density extremely high. Presently in most experiments the anti-protons from an AD pulse are captured and cooled with an efficiency of only $\approx 2\times10^{-4}$ essentially due to the energy straggling in the degrader foil used. With the much thinner foil possible when decelerating the anti-proton beam further with ELENA the overall efficiency will increase drastically.

The ELENA upgrade will not only enable higher quality low-energy anti-hydrogen physics at CERN over the next decade, it will also be an accelerator test platform of use in developing the methods needed for future generations of low-energy facilities. In a decade,

a new generation of low-energy anti proton sources may start with FLAIR, a facility that is being planned in response to the ever-increasing interest in low-energy anti proton physics. ELENA will provide vital experience and methods for the design and operation of such future facilities. During the next decade there is no alternative low-energy anti-proton source for physics to be done now.

E-mail: w.oelert@fz-juelich.de