Injection of cold antiprotons for the ASACUSA antihydrogen experiment

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Synopsis Injection of cold antiprotons with small energy spread of sub eV into positrons is achieved by optimization of extraction and transport of antiprotons in the ASACUSA antihydrogen experiment. It suppresses heating of positrons which avoids decrease of antihydrogen production rate.

The ASACUSA antihydrogen experiment has been making efforts for measurement of hyperfine splitting of ground-state antihydrogen atoms to test CPT symmetry. Antihydrogen atoms are produced in a cusp like magnetic field as a spin selector. After antihydrogen synthesis in the cusp magnetic field[1] and detection at 2.7 m downstream from the production region[2] have been succeeded, a more intense and colder beam is needed for a precision spectroscopy. Antihydrogen atoms are produced by injection of antiprotons directly into a positron plasma which is confined in advance in an electrostatic potential well called a nested trap. In this scheme, injection of cold antiprotons with small energy spread is important to suppress heating of positrons and to trap as many antiprotons as possible at the same time. Therefore we have been trying to extract a cold antiproton cloud and then to transport it adiabatically. To extract a cold antiproton cloud, potential manipulations are optimized to avoid heating by extraction procedure. To keep it cold, antiprotons are transported at low energy of 1.5 eV using pulse coils to avoid drastic divergence of magnetic field along the transport line. As a result, figure 1 shows that the energy spread at the injection into the antihydrogen production region of sub eV is achieved which is improved by a factor of 100 compared to the old scheme. Time structure of antihydrogen production suggests less heating of positrons by the improvement [3]. However, total antihydrogen yield did not increase so much due to a quick separation between antiprotons and positrons. By the improvement of antiproton injection, relatively quantitative analysis is also possible including space charge potential of positrons which might provide an insight into mixing in the nested well.

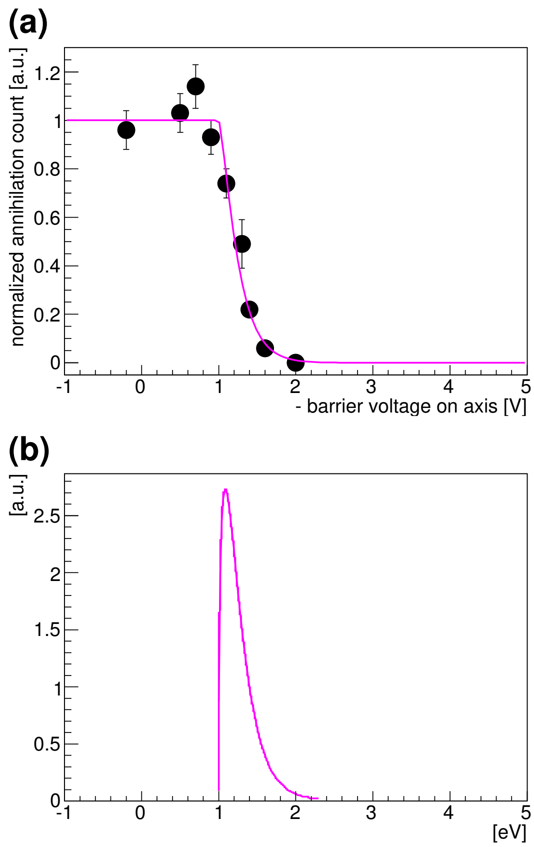

Figure 1. (a) Measurement and fitted curve of integrated energy distribution of injected antiprotons. (b) The energy distribution of the fitting result.

References

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