The analysis of the Cherenkov detector of the antiproton-nucleus annihilation experiment by ASACUSA collaboration

Y. Murakami\textsuperscript{a}, H. Aghai-Khozani\textsuperscript{b,c}, D. Barna\textsuperscript{a,d}, M. Corradini\textsuperscript{e,f}, R.S. Hayano\textsuperscript{a}, M. Hori\textsuperscript{a,b}, T. Kobayashi\textsuperscript{a}, M. Leali\textsuperscript{e,f}, E. Lodi-Rizzini\textsuperscript{e,f}, V. Mascagna\textsuperscript{e,f}, M. Prest\textsuperscript{g,h}, A. Soter\textsuperscript{b}, K. Todoroki\textsuperscript{a}, E. Vallazza\textsuperscript{i}, L. Venturelli\textsuperscript{e,f}, and N. Zurlo\textsuperscript{e,f}

\textsuperscript{a}Department of Physics, University of Tokyo, Tokyo 113-0033, Japan
\textsuperscript{b}Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany
\textsuperscript{c}Physics Department, CERN, 1211 Geneva 23, Switzerland
\textsuperscript{d}Wigner Institute for Particle and Nuclear Physics, H-1525 Budapest, Hungary
\textsuperscript{e}Dipartimento di Ingegneria dell’Informazione, Università’ di Brescia, 25133 Brescia, Italy
\textsuperscript{f} INFN, Gruppo Collegato di Brescia, 25133 Brescia, Italy
\textsuperscript{g} Dipartimento di Scienze Fisiche e Matematiche, Università’ di Como, I-22100 Como, Italy
\textsuperscript{h} INFN, Sezione di Milano Bicocca, I-20126 Milano, Italy
\textsuperscript{i} INFN, Sezione di Trieste, I-34127 Trieste, Italy

Contact adress: murakami@nucl.phys.s.u-tokyo.ac.jp

The ASACUSA (Atomic Spectroscopy And Collisions Using Slow Antiprotons) collaboration at CERN is currently attempting to measure the antiproton-nucleus annihilation cross sections at 130 keV for the first time.\cite{1}\cite{2} For this it is essential to reliably monitor the intensity of the antiproton beam used during the measurement.

In the experiment, a 100-ns-long pulsed beam containing $3 \times 10^6$ antiprotons was allowed to pass through C, Pt, and Pd target foils of respective thicknesses 55, 20, and 7 nm. Most of the antiprotons traversed the target foils, and arrived at the end of a chamber where they annihilated. A Cherenkov counter detected the charged pions emerging from the antiproton annihilations. It consisted of a UV-transparent acrylic plate measuring 170 mm $\times$ 70 mm $\times$ 20 mm with a refractive index of $n=1.49$. The Cherenkov photons were detected with a fine-mesh photomultiplier, and the analog waveform of the anode signal recorded with a digital oscilloscope (Fig. 1). The pulse widths and relative intensities of each antiproton pulse could thus be monitored.\cite{3}

Some of the antiprotons underwent Rutherford scattering in the target foils, and annihilated on the lateral walls of the chamber. The resulting deformations in the Cherenkov signal could cause us to overestimate the intensity of the antiproton beam. To estimate the size of this systematic error and correct for the contributions from Rutherford scattering, we carried out a Monte-Carlo simulation based on the GEANT4 simulation package. The results implied that some 2 \%, 28 \%, and 18 \% of the total intensity of the Cherenkov signals in the C, Pd, and Pt targets were due to Rutherford scattering.

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{figure1.png}
\caption{Typical time spectrum of the Cherenkov detector for a 100-ns-long antiproton pulse}
\end{figure}

\begin{thebibliography}{9}
\bibitem{1} A. Bianconi et al., Physics Letters B 704 (2011) 461-466.
\end{thebibliography}