Imaging Antimatter: The Challenges and Applications

Makoto C. Fujiwara*
TRIUMF, 4004 Wesbrook Mall, Vancouver, V6T 2A3 Canada

Position sensitive detection of antiprotons and positrons was a key feature of the ATHENA experiment in establishing the production of old antihydrogen atoms, and in subsequent physics measurements [1]. After a brief review of the ATHENA detection system, I will discuss a recent example of its applications in trap physics [2]. By reconstructing annihilation vertices, images of antiproton annihilations in a Penning trap are obtained. The capability of antiparticle imaging allows, for the fist time, the observation of the spatial distribution of the particle loss in a Penning trap, a previously unexplored regime in trap physics. The radial loss of antiprotons on the trap wall is localized to small "hot spots," strongly breaking the azimuthal symmetry expected for an ideal trap. Important implications for antihydrogen detection will be discussed.

In a proposed experiment ALPHA [3], we will face new challenges in antihydrogen detection. In particular, the thickness of the materials between the annihilation points and the detector can be up to one radiation length, a condition imposed by the requirements for trapping neutral antihydrogen atoms. This will absorb most of the 511 gamma rays, and increase multiple scattering for charged pions. I will present a preliminary design of the new antihydrogen detector for the Project ALPHA, and discuss how we plan to overcome these challenges.

[1] M. Amoretti et al., Nature (London) **419**, 456 (2002); see talk by P.B. Bowe.
[2] M.C. Fujiwara et al., Phys. Rev. Lett. **92**, 065005 (2004).
[3] ALPHA Collaboration, proposal to CERN (2005); see talk by J.S. Hangst.

* E-mail: Makoto.Fujiwara@triumf.ca