Anti-hydrogen production conditions in ATHENA.

What we (don't) know.

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Antihydrogen was produced in large quantities in the ATHENA experiment at CERN over a three-year period. The usefulness of the anti-atoms so produced and the feasibility of future experiments with antihydrogen depend on the quantum state and momentum distribution of the anti-atoms. For beam-like experiments ground state anti-atoms should emerge from the interaction region in a preferential direction with both low divergence and velocity spread. Experiments aimed at trapping antihydrogen require low velocity anti-atoms and states with low quantum number. I will report on experiments which attempted to elucidate these matters.

A summary of the antihydrogen production efficiency over the three-year period will be given[1]. I will present the results of experiments which attempted to measure the production rate as a function of positron temperature[2,3] as well as the onset time of antihydrogen production[4]. Recent analysis of the spatial distribution of antihydrogen[5,6] indicates that antihydrogen is produced before the antiprotons and positrons have reached thermal equilibrium, meaning that the antihydrogen is moving too fast to be trapped. Time permitting; various mixing techniques will be presented which might overcome this difficulty in the future. A preliminary report on an attempted stimulated recombination experiment will be given.

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[1] M. Amoretti *et al*. Phys. Lett. B 578, 23-32 (2004)
[2] M. Amoretti *et al*. Phys. Rev. Lett. 91, 055001 (2003)
[3] M. Amoretti *et al*. Phys. Lett. B 583, 59-67 (2004)
[4] M. Amoretti *et al*. Phys. Lett. B 590, 133-142 (2004)
[5] M. C. Fujiwara *et al*. Phys. Rev. Lett. 92, 065005 (2004)
[6] N. Madsen *et al*. Phys. Rev. Lett. 94, 033403 (2005)