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Beam-transport simulations for antihydrogen production with the GBAR experiment at CERN

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The GBAR (Gravitational Behavior of Antihydrogen at Rest) experiment, located at CERN's AD/ELENA "Antimatter factory,"aims at measuring the free-fall of antihydrogen atoms to test the Equivalence Principle of General Relativity. Unlike other experiments producing antihydrogen, GBAR uses an in-flight charge-exchange reaction of antiprotons with a cloud of positronium [https://doi.org/10.1140/epjc/s10052-023-12137-y].
Since the reaction cross section is proportional to the positronium density, the production cavity must be made very small. This makes injection of the antiproton beams very challenging since the beam emittance is larger than the geometrical acceptance of the cavity.
Therefore a Penning-Malmberg trap is used to collect and cool antiprotons to reduce the beam emittance. [https://doi.org/10.1088/1748-0221/17/10/T10003].
GBAR uses a fast-switching electrostatic decelerator system that provides antiproton bunches at energies of a few keV, which can be injected into the Penning trap [https://doi.org/10.1016/j.nima.2021.165245]. Using the ion-optics program SIMION, the injection optics are simulated, as well as the transport of the antiprotons to the reaction chamber. Results of these simulations will be presented.
Producing antihydrogen ions opens the possibility of cooling them to micro-Kelvin temperatures by Coulomb coupling with a cloud of trapped ions that are laser cooled.

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