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Quantitative experiments with electrons in a positively-charged particle beam[1]

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Intense ion beams are an extreme example of non-neutral plasma. We use experiments and simulations to study the complex interactions between beam ions and (unwanted) electrons. (Such electron clouds limit the performance of many accelerators.) The detailed, self-consistent simulations use the 3-D Particle-In-Cell code WARP, with the addition of beam-transport fields, and electron and gas generation and transport, to compute unexpectedly rich behavior [1], much of which is confirmed experimentally. In magnetic-field-free regions, we observe a variety of beam-surface interaction phenomena: electron emission, gas desorption, ionization of gas, and virtual cathode fluctuations. In a quadrupole magnetic field, ion and dense electron plasmas interact to produce multi-kV oscillations in the electron plasma and distortions of the beam velocity space distribution, without becoming homogenous or locally neutral. We developed a variety of methods to measure and control electron and gas clouds in ion beams. Parameters we measure include: beam potential profiles and time dependence, total and local electron production and loss, electron line-charge density [2], gas pressure within the beam, electron accumulation, and electron trapping depth. Control methods include surface treatments to reduce electron and gas emission, and techniques to remove electrons from the beam.

1. R. H. Cohen, et al., Phys. Plasmas **12**, 056708 (2005).
2. M. Kireeff Covo, et al., Accepted by Phys. Rev. Lett. May 2006.

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