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The purpose of our work is to show that electrostatic space charge fields can be used to accelerate, focus and bunch ions, from a background plasma, onto a target. Experiments at low energies (1 → 5 kilovolts) have shown the feasibility of the scheme. Present work is at the 100 → 300 kilovolt range using a Nereus accelerator on loan from Sandia Laboratories. A representation of the geometry used is depicted in Fig. 1. A π steradian section of the sphere is used as the anode. The compromise to spherical symmetry is due to the necessity of diagnostics on the ion beam. A background plasma is formed in front of the Nereus anode (more about the plasma later). To date, we have been able to successfully accelerate ions from the background plasma to near the full anode potential (90% → 100% $V_A$) with efficiencies greater than 20% electron beam to ion beam energy conversion. Geometrical focusing, due to the partial spherical geometry has also been observed. The question of bunching is still clouded due to the possibility of a two ion component plasma (He⁺ and He++). This report describes the efforts directed at the question of bunching and the associated requirement and problems this entails with the background plasma.

As stated in our last progress report, $\nu$-wave measurements of the background target plasma gave a density of $\sim 5 \times 10^{11}$ e-ion/cc. This was a factor of two less than we had assumed. This means that the accelerated ion currents were better than those first reported. Although this was most encouraging, the lower plasma density brought about an associated problem.
At the pressures used to form the helium background plasma (~ 30 mTorr), the energetic ions (~ 100 kV) accelerated by the beginning of the Nereus pulse can ionize the background gas and possibly form doubly-ionized helium to be accelerated by the remainder of the pulse. The possibility of a two component ion beam makes the demonstration of bunching difficult.

Working at lower pressures will resolve this problem since the ion-ionization is greatly reduced. During the last few months we have been attempting to obtain a stable, reproducible background plasma at lower pressures while maintaining the He⁺ density at ~ 5 x 10¹¹.

Several methods have been tried, none of which have been completely satisfactory. Several different configurations of anode and cathode to produce a hollow cathode discharge have been used. To prevent a discharge from forming in the diode region of the Nereus, a cylindrical can, concentric with the main chamber, was pulsed negative with the rest of the system at ground potential. This alleviated the problem of the discharge forming in the throat of the Nereus, but the discharge could not be reproduced consistently at low enough pressures.

Recently we have placed hot filaments in proximity to the hollow cathode's can to provide a source of electrons to aid in the breakdown of the gas into a discharge. This has been quite successful. We can produce a 5 mA helium hollow cathode DC discharge at ~ 32 volts (A-K voltages) at pressures of ~ 6 mTorr He. This current can then be pulsed to a 150 Amp peak, linearly decaying to 0 in 200 us.

The other obstacle to resolving the question of bunching is an increase in the 'noise' being picked up on the ion current probe. This 'noise' at times swamps the desired signal. The cause of this noise and why it has not been a problem before are as yet unanswered.
A solenoid is being built that will produce 1 - 3 kilogauss fields along the Nereus diode axis. This will reduce the dispersive beam losses to the container walls increasing the ion probe signal and improving the signal to noise ratio in case we find that the noise cannot be completely eliminated.
Fig. 1. Experimental setup indicating hemisphere anode, ring cathode K, and Faraday cup probe in vacuum vessel.