Ion Source and Injector Experiments at the HIF/VNL*

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Heavy ion fusion requires ion sources that can produce high current, but the beams must have low emittance in order to achieve high brightness. Furthermore the injector must be able to transport and match the severely space-charge dominated beam into an induction linac channel.

The traditional approach is to use large diameter surface ionization sources that produce ions with low thermal velocities. In this case, the maximum current density is determined by the space-charge limit of a large extraction diode. At low ion "temperature" the beam emittance can be dominated by spherical aberrations. An experiment is set up on a 500-kV test stand to study the beam optics and to find ways for improvement. The finite ion transit time in a large diode can be a problem for injectors that try to produce short pulses with fast rise time. Fortunately, our simulations have shown that a proper waveform can be constructed to produce a rise time as short as 50-ns beam. We have conducted an experiment to benchmark the simulation results.

Simulation has also shown that by merging a large number of high current density beamlets, a high current beam can be formed with an acceptable low emittance. In our experiment, we have tested an RF-driven argon plasma source to produce an array of 61 beamlets. We have reached our goal of producing 100 mA/cm^2 current density (= 4.9 mA per beamlet) with 90% of the ions in the single charged Ar^+ state. Other beamlet parameters will be reported in the symposium. At present, the schedule is to complete the Merging-Beamlets Experiment in FY05. Design of the apparatus is in progress and the experiment is expected to begin in the summer of 2004.

There are other innovative injector concepts being developed in the VNL, e.g., using an accel-decel scheme to reach high line charge density, or using negative ion beams to prevent the secondary electrons problem in beam transport. These proposed experiments along with data from the present experiments will be discussed.

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