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IFSA Abstract
Progress in the U.S. Heavy-Ion Beam Science Program¹

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The US program in heavy-ion fusion is coordinated in a three-laboratory consortium of LBNL, LLNL, and PPPL, with other HIF related research at the University of Maryland, NRL, MIT, SNL, and the University of Missouri. The long-range HIF program goal is to provide the comprehensive scientific knowledge for inertial fusion energy (IFE) driven by high-brightness heavy-ion beams. The four top-level scientific issues that guide the U.S. HIF research are:

1. What physics determines beam brightness in heavy-ion sources and low energy transport?
2. What dynamical phenomena affect the quality of space-charge-dominated beams undergoing transport and acceleration?
3. What role do non-linear processes and beam-plasma interaction play in beam chamber propagation and focusing onto a target?
4. How can we best apply and improve computational tools to provide the needed support (integrated modeling) for experiments, exploration of issues, and planning for the future?

The HIF VNL is organized with four task areas that address these four top scientific issues, initially with separate experiments that concentrate on specific beam dynamics issues affecting beam brightness (emittance). Particle in cell simulations are in good agreement with past low current (mA level) beam experiments in transport, merging, acceleration and final focus, in which the dimensionless beam perveances (space-charge potential/ion kinetic energy) were similar to those in a driver. The program is now pursuing higher current experiments (100 mA to 1 A) in high brightness merging beamlet sources, transport at 1-2 MeV, and ballistic focusing with plasma neutralization. The first high current transport experiment is slated to begin this year. Improved simulation models enable modeling these experiments with realistic (not just idealized) beam distributions. The higher beam space-charge potentials attendant to these higher current experiments will allow us to study the effects of ionization of the residual gas by the beam, the neutralization of the beam by stray electrons, and the dynamical effects on the beam of these two processes.

After these separate experiments are completed, the next step will be to study transverse and longitudinal emittance growth through injection, acceleration, longitudinal beam compression, and final focus in an integrated beam experiment. The integrated beam experiment will be much more challenging because prediction of the final focus spot size with integrated models depends on the accumulated beam phase space changes through each region along the accelerator. The separate experiments in the next few years will test the key model pieces to be used in integrated modeling of the follow-on integrated experiment. New code development efforts are underway aimed at terascale computing required for integrated 3-D beam simulations of a driver from source to target.

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