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Simulations and experiments of intense ion beam current density compression in space and time[1]

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The Heavy Ion Fusion Science Virtual National Laboratory has achieved 60-fold longitudinal pulse compression of ion beams on the Neutralized Drift Compression eXperiment (NDCX) at LBNL. To focus a space-charge-dominated charge bunch to sufficiently high intensities for ion beam-heated warm dense matter and inertial fusion energy studies, simultaneous transverse and longitudinal compression to a coincident focal plane is required. Optimizing the compression under the appropriate constraints can deliver higher intensity per unit length of accelerator to the target, thereby facilitating the creation of more compact and cost-effective ion beam drivers. Experiments utilize a drift region filled with high-density plasma in order to neutralize the space-charge and current of a 300 keV K^+ beam, and separately achieve transverse and longitudinal focusing to a radius < 2 mm and pulse width < 5 ns, respectively. Simulations predict, and experiments are underway, to demonstrate that a strong solenoid ($B_z < 10$ T) placed near the end of the drift region can transversely focus the beam to the longitudinal focal plane. Measurements and simulations of plasma penetration into strong solenoids for ion beam neutralization, as well as progress on simultaneous charge bunch focusing, are presented. The total achievable current density compression is expected to be strongly dependent upon the level of neutralization provided by the plasma, especially near the focal plane. The upcoming improved accelerator NDCX-II will capitalize on the insight gained from NDCX simulations and measurements in order to provide a higher-energy (>2 MeV) ion beam user-facility for warm dense matter and inertial fusion energy-relevant target physics experiments.

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