Virtual National Laboratory for Heavy Ion Fusion

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HIFNews

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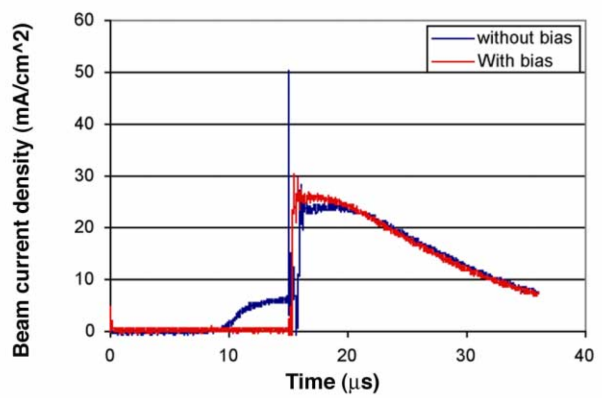
100 ns risetime achieved with plasma ion source

In many HIF experiments, including the proposed IBX, a beam pulse less than 0.5 μs is required because (1) a given size induction core (fixed volt-seconds) provides more acceleration with a shorter beam and (2) a given length of accelerator can drift-compress a shorter beam by a larger factor in length. For the ion source to produce such a short pulse, the rise time must be very short. There is a simple solution for a rigid ion-emitting surface like that of a contact ionization source, for which it is possible to produce a rise time as short as 50 ns from an extraction diode by matching the propagation of the beam front with a special voltage waveform applied to the diode.



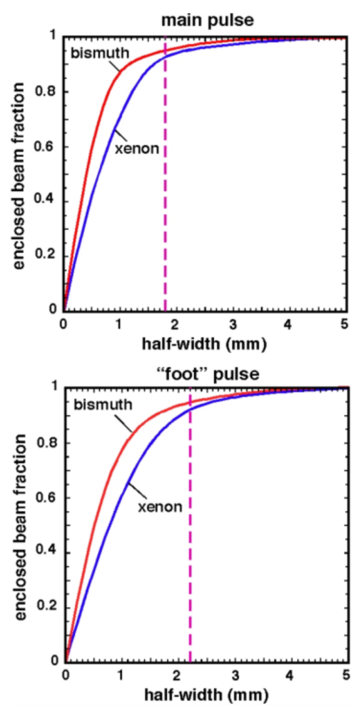
However, the problem is more complicated for ion sources that produce ions from a plasma. First, the plasma formation time is typically in the order of a few μs so it cannot be used as the mechanism to control the rise time. On the other hand, if the beam formation is controlled by the extraction voltage waveform, the plasma can leak out of the aperture before the extraction voltage is turned on. It is not possible to stop a plasma flow with large apertures, but if the aperture is covered by a grid (or mesh), with mesh size on the order of Debye length, then the plasma flow can be stopped by electrically biasing the grid with respect to the plasma chamber.

An experiment, to test the possibility of controlling the plasma flow from a laser ion source, was done at Tokyo Institute of Technology as part of the Japan/US exchange program on HIF. As shown in the red data of the above figure, the grid with a 90V bias voltage was able to withhold the plasma from 10 μs until the extraction voltage was turned on at 15 μs, thus resulting in a fast rise time of about 100 ns. Detailed results of this experiment were published in a paper by J. Hasegawa, and others at the IFSA conference last September.

– Joe Kwan

Chamber-Transport Advantages

Recent LSP chamber-transport simulations suggest that parameters for the Robust Point Design (RPD, see S. S. Yu, *et al*., published in Fusion Science and Technology, Sept. 2003) are unnecessarily conservative, increasing the cost of HIF power plants. The published design specified Bi^{+1} ions with up to 4-GeV energy, a 10-mm-mrad emittance, and a 10-mrad convergence angle. When we use the same chamber geometry, background-gas density, and power-deposition profile as the RPD, we find larger but still usable focal-spot radii for 2.3-GeV Xe^{+1} beams, despite the 37% higher current. As seen in the figure, the simulations show that 93% of the xenon main pulse would fall within a 1.8-mm half-width annulus on the end of a RPD target, compared with about 95% for the comparable bismuth beam. A similar difference is seen in the figure for the lower-energy "foot" pulses that do the initial hohlraum heating. Good focal spots are also seen for convergence angles as low as 5 mrad and for emittances up to twice the nominal value.



In another series of runs, we find that beam of negatively charged halogen ions, photo-neutralized just after focusing, have even smaller spot sizes than comparable plasma-neutralized positive-ion beams. This improved focusing, which results from the lower net charge during transport, may allow us either to relax the limits on transverse emittance or to use lower-mass ions, with a proportional reduction in particle energy and increase in current. These results suggest that optimized HIF power-plant designs would cost significantly less than predicted for the RPD design.

– Bill Sharp

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To get on the mailing list of the HIF News, send a request to WWTabler@lbl.gov

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