Virtual National Laboratory for Heavy Ion Fusion

**March 2003**

# HIF News

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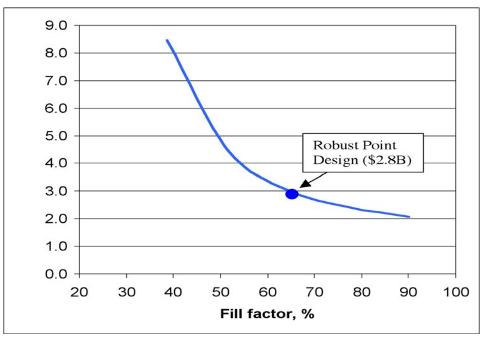
## Driver Cost is Strongly Dependent on Beam Fill Factor

The design and cost of a multi-beam driver for heavy ion fusion varies strongly with the size of the beam compared to the size of the beam bore. We quantify this in terms of the beam fill factor, the ratio of the maximum beam radius to the bore radius. As the beam is transported from quad to quad, its cross-section changes from an ellipse to a circle and back to an ellipse rotated by 90 degrees. The maximum beam radius (i.e., semi-major axis of ellipse) is nearly 1.3 times the average for typical driver parameters. Some clearance is needed between the beam and the bore to allow for beam halo and possible misalignment. A series of IBEAM driver systems code calculations were completed in order to determine the driver cost as a function of fill factor. The results, shown here, indicate a strong dependence on fill factor. The reference point is the robust point design, where we set the bore radius = 1.25xmax beam radius + 0.5 cm. This gives a bore radius of 2.91 cm for the maximum beam radius of 1.93 cm and a fill factor of 66%. Increasing the clearance by 0.5 cm decreases the fill factor to 56% and increases the driver cost by ~30%, while decreasing the clearance by 0.5 cm (fill factor = 80%) decreases the driver cost by ~20%. [Experiments on the HCX at LBNL have shown that a beam can be transported through 10 quadrupoles at fill factors of 60% and 80% without degradation, see HIF News Jan./Feb., 2003]




*– Wayne Meier*

## Beam profile simulations and experiments in the quadrupole-focusing subsystem for NTX

The Neutralized Transport Experiment, NTX, Final Focus System transforms the high brightness potassium ion beam from the NTX Source to a converging beam at the entrance to the neutralized drift section, where it will be focused to a small spot. The final focus lattice consists of four pulsed quadrupole magnets. We have started to characterize the quadrupole lattice by comparing experimental results with particle simulations using the particle-in-cell code WARP. Figures 1 and 2 show the beam profiles for several quadrupole strength configurations as calculated by WARP and as measured, respectively. (The good agreement was achieved by using a beam energy 3% higher than measured, which is within the measurement accuracy, for each of the calculated profiles.)

For each quadrupole, the corresponding row shows the profiles for a change of -5%, 0% and +5% from the nominal quadrupole strength. This comparison shows the good agreement that we have obtained so far, between measurements and calculations.

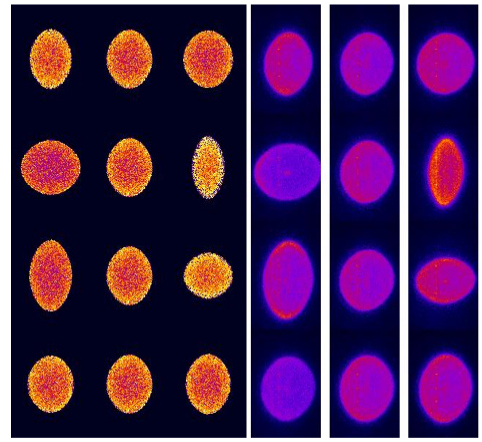


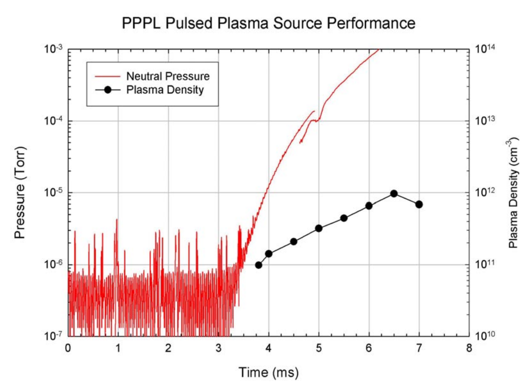
Fig 1 Fig 2

*~Enrique Henestroza*

## Low pressure RF argon plasma source for NTX

A pulsed plasma source, developed at PPPL, uses 3.5 kW of RF power at 17.6 MHz to generate argon plasmas. It was delivered to LBNL in December 2002 and was integrated into NTX in March 2003. This source produces a local plasma density of $10^{11}$ $cm^{-3}$ while having an instantaneous neutral argon pressure in the $10^{-6}$ Torr range. The plasma source is placed at the downstream end of NTX in order to simulate the volumetric plasma that will be present in the target chamber of a reactor after the detonation of a previous target.

The source consists of a 6-way cross that is inserted into the NTX beamline. The gas inlet and the window through which a planar spiral RF antenna looks are mounted to the top face. A turbopump is mounted below, and diagnostics such as Langmuir probes and pressure gauges may be mounted to the two unused transverse faces.




The plasma source achieves both high plasma density and low neutral pressure by taking advantage of the difference in the times-of-flight between the eV-energy plasma and the room temperature argon. Within 1 ms after breakdown, the plasma density remains in the $10^{11}$ $cm^{-3}$ range while the neutral argon pressure rises to almost 0.1 mTorr. By varying the time at which the ~10 μs NTX beam passes through the plasma, the beam particles can experience greatly different neutral gas pressures while experiencing essentially the same plasma density.

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