Virtual National Laboratory for Heavy Ion Fusion

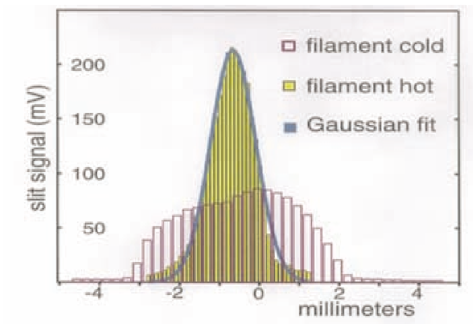
April 2001

HIF News

LBNL-PUB-844-01-04

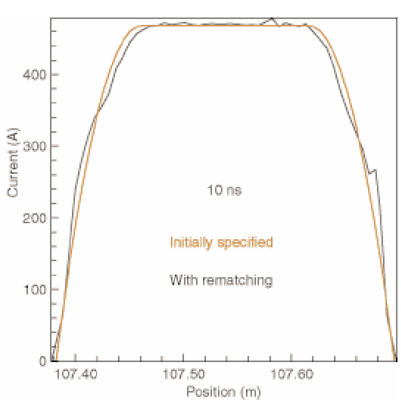
Experimental Neutralization of a Scaled Focus

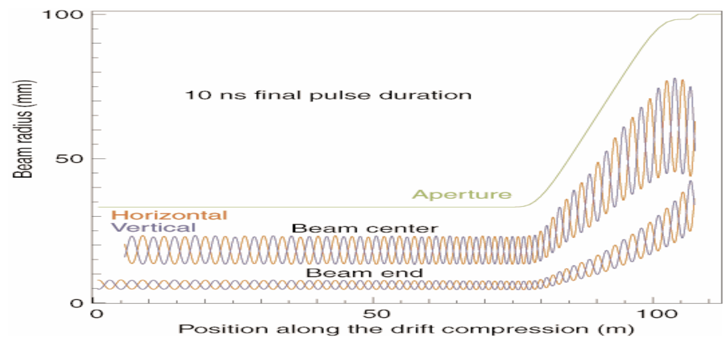
In addition to studying the properly scaled ballistic final focus of the HIBALL-II design in vacuum, the Scaled Final Focus experiment investigated a focus neutralized by the addition of electrons. Neutralization allows focusing of lower energy ions, which would reduce driver costs. An ion beam current of 400 μA (a factor of four larger than the value used for the scaling study) is just contained by the apertures and strengths of the focusing elements. This preserves the final convergence angle resulting in a space charge force that is five times the emittance force at the focal spot, and produces a nearly uniform radial density profile, as shown for 'filament cold.' If the space charge can be reduced significantly through the addition of electrons to the converging beam, the nature of the focus will shift from space charge- to emittance-dominated, and both the size and the shape of the spot profile should change significantly. In the experiment, a 75 μm diameter tungsten filament positioned in the beam path intercepts <1% of the beam current, and the heater circuit that raises its temperature to ~2100°C is switched off 1 ms prior to beam arrival to eliminate effects of the filament potential. The figure shows data from a 50 μm slit scanned vertically through the beam focus with the filament hot and cold. The addition of electrons both reduce the spot radius and produce the Gaussian signature of an emittance dominated spot. Data from scans in both transverse directions indicate an 80% neutralization fraction, which reduces space charge forces to the level studied with vacuum focus. – *Steve MacLaren*



Hermes code applied to drift compression

Drift compression reduces the pulse duration from a few hundred nanoseconds in the accelerator to about 10 ns at the target. We used the Hermes code to make preconceptual designs for an IRE drift compression section. This code was written to accurately calculate the longitudinal electric field in a beam traveling in a focusing lattice. A drift compression system is designed by starting with the desired beam duration and pulse shape at the end of drift compression, then running the beam backwards until its longitudinal expansion is sufficient to match the beam current at the end of the accelerator. As the beam expands, the quadrupole magnet transport fields and the half period lengths are iterated to keep the beam center properly matched. This procedure also yields the initial velocity tilt and current profile. Although the center of the beam will be matched, the ends of the beam are usually mismatched, due to a rapid variation of the current near the target. The mismatches can be avoided, however, by rematching the beam at the beginning of the drift compression section. Although this will cause a mismatch near the end of the compression section, its effect is not as severe because it occurs only in the last couple of half-lattice periods. We found that longitudinal expansion is only weakly dependent on the transverse beam dynamics, and therefore the final parameters are close (within several percent) to what was originally specified. *-Michiel de Hoon, John Barnard*

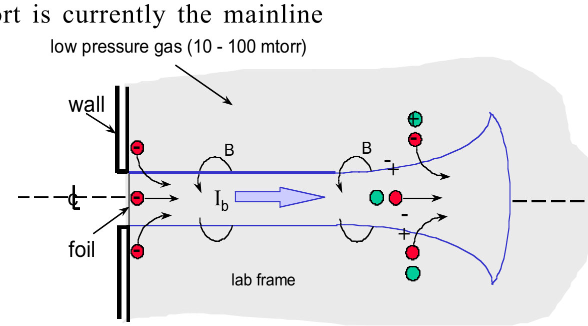




The current profile at the end of drift compression for a 10 ns final pulse duration, and the envelope at the beam center and the ends of the beam.

Pinch Workshop

A Workshop on Pinch Phenomena in Final Transport of Heavy Ion Beams was held at the San Damiano Retreat in Danville, California on February 13-15, 2001 with 35 participants representing LBNL, LLNL, SNL, NRL, MRC, GA, PPPL, UCB, SAIC, GSI, USC, and SLAC. Whereas neutralized ballistic transport is currently the mainline approach for the US HIF program, pinched transport is an alternate approach that offers many attractive features for power plant design. The Workshop examined (1) self-pinched transport [beam into gas (see Figure), beam into plasma, and pre-formed pinch]; (2) z-discharge channel transport ("assisted pinch"); (3) pinch-like lenses [z-discharge lenses, plasma lenses]; and (4) pinch effects in neutralized ballistic transport. Besides extensive presentations, discussions were directed toward answering (1) What are the critical issues that need to be addressed? (2) What is the "right " experiment? and (3) What theory issues could we begin to address in the near term? The Workshop is important to HIF since it ascertained the status and advantages of all pinch mode phenomena, explored generic requirements for a high-current low-emittance ion beam to study pinch-mode regimes, and produced several suggestions for near-term theory research. A notebook of the Workshop Proceedings is available. – *Craig Olson (Technical Chair) and Simon Yu*



For comments about the content of the HIF News, contact Art Molvik (925)422-9817, or molvik1@llnl.gov.
To get on the mailing list of the HIF News, send a request to PMBronte@lbl.gov

This work was performed under the auspices of the U.S. Department of Energy by the University of California Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48 and by Lawrence Berkeley National Laboratory under contract No. DE-AC03-76SF00098 (LBNL), and by Princeton Plasma Physics Laboratory performed under the auspices of the U.S. Department of Energy under contract No.DE-AC02-76CH-O3073.