Virtual National Laboratory for Heavy Ion Fusion

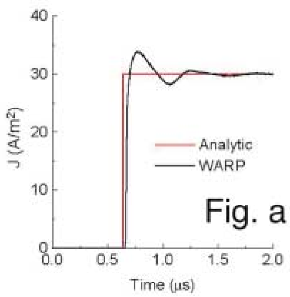
June 2003

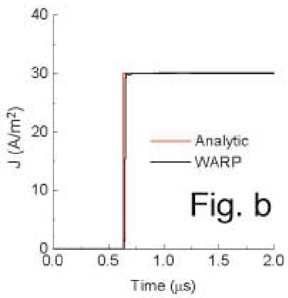
HIF News

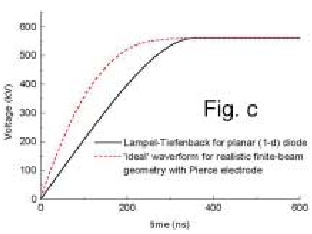
LBNL-PUB-844-03-06

Time-dependent modeling of fast rise-time diodes

Time-dependent simulation of beam injection has received renewed attention due to the requirement of a short risetime (~50ns) for a 200ns IBX beam pulse. Accurate calculation in realistic geometry has until now been prohibitively expensive. We have introduced new mesh refinement techniques in WARP that improve efficiency dramatically and make the problem tractable. The standard algorithm for injecting simulation particles uses a virtual surface located at a small distance in front of the emitting surface. The potential drop between the emitter and the virtual surface is used to compute the current, assuming Child-Langmuir emission between the two surfaces, yielding the number of macroparticles launched during each time step. A 1-D test using the Lampel-Tiefenback waveform, for which analytical solution predicts an instantaneous current rise, revealed that the standard algorithm produces a large nonphysical oscillation (Fig. a). A more accurate history profile (Fig. b) was obtained using the combination of a fixed refinement grid patch between the injection and virtual surfaces and a dynamic patch following the beam head. While the fixed patch removes the oscillations, the dynamic patch allows accurate representation of the beam head (a spike following the beam head is observed otherwise). Using similar techniques in 3-D, it is in addition possible to predict the required voltage waveform producing a given current history profile for realistic diode geometry (Fig. c). *–Jean-Luc Vay, A. Friedman, D.P. Grote and J.K. Kwan.*





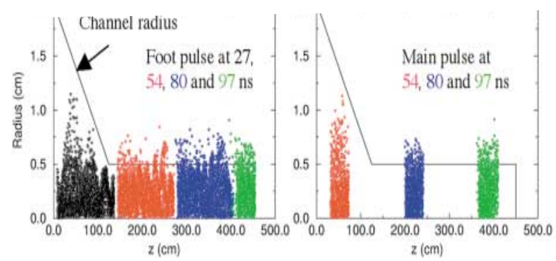


NIF exceeds design requirements with a single beam

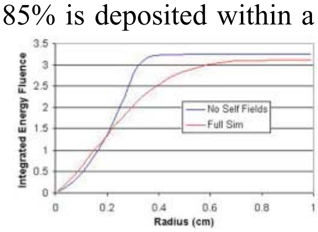
The National Ignition Facility (NIF) recently announced setting a world record for laser performance, producing 10.4 kJ of ultraviolet laser light in a single laser beamline. This corresponds to 2 MegaJoules (MJ), from all 192 beams, exceeding the design requirement of delivering 1.8 MJ to a target. The first four NIF beam lines have also set records for infrared (21 kJ) and green (11kJ) single-beam laser energies delivered to NIF 's Precision Diagnostic System. In addition NIF researchers have transported a quad of four beams to targets at the center of the 10 m diameter target chamber. NIF will be used to study high-energy density physics in millimeter size targets, including the achievement of inertial fusion ignition with energy gain. This will provide valuable data for future inertial fusion energy production from HIF. *– Craig Wuest*

Assisted-Pinched Transport of HIF Beam Coupled to Hybrid Targets

The efficient transport of heavy ion beams in a reactor chamber over several meters is required in all HIF scenarios. A promising transport scheme, assisted-pinched transport, or APT, makes use of a preformed discharge channel to confine and guide the beams. Many individual low-current beams are combined and focused outside of the chamber into two high current beams and propagated at small radius in discharge channels to the target. Two beam-carrying channels exit into two return-current discharge channels that also provide channel alignment at the target. Shown below, Pb^{+72} beams are initially captured at roughly 1-cm radius and compressed in a discharge channel tapered from 2 to 0.5-cm radius. A large beam divergence can be contained by the strong magnetic field resulting from a 50-kA discharge current. The APT approach also decouples the requirements on beam emittance from the chamber radius, enhancing design flexibility.



Hybrid particle-in-cell simulations with the IPROP code, including foot and main pulses, calculate efficient chamber transport of Pb^{+} and Xe^{+} ion beams in a discharge channel formed in 5-torr Xe gas. Of the injected 3.45 MJ of total beam energy (per side), 85% is deposited within a 5-mm spot at the target. Results from detailed 2-D simulations indicate that the Xe plasma becomes sufficiently conductive to limit self-field effects and achieve good transport efficiency. As shown in the figure, if self-fields are neglected, a 94% transport efficiency is expected. Deviation from the ideal case is primarily due to beam interaction with the axially varying azimuthal magnetic field-profile that evolves self-consistently in time. Three-dimensional IPROP calculations are in agreement with semi-analytic theory that predicts benign resistive hose growth over a wide range of plasma conductivities. These results have been recently published in Phys. Plasmas. These calculations suggest adequate beam coupling to a 0.5 cm radius allowed by the hybrid target design. *– Dale Welch, David Rose, Craig Olson and Simon Yu*



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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.