Snowmass 99 Fusion Summer Study
Technology Issues Working Group Report
Plasma Support Technologies — IFE Target Fabrication and Injection

This group addressed the key question: "Can the technologies needed for low cost, cryogenic targets and a high rep-rate injection system be developed?" We discussed the target fabrication, DT filling and layering, and target injection and tracking technologies that will be needed for practical Inertial Fusion Energy (IFE). Our conclusion is that although target fabrication and injection issues exist that must be resolved for IFE to be a practical energy alternative, potential solutions also exist that appear attractive. The basic approach we recommend is to take maximum advantage of the target development work being done by the Inertial Confinement Fusion (ICF) Program for the National Ignition Facility (NIF). In parallel, we must carry out modest scale laboratory development activities as part of Phase I of the IFE Program Roadmap to demonstrate that a credible pathway exists to practical IFE target fabrication and injection. This information will contribute to the decision of whether or not to proceed with an IFE Integrated Research Experiment (IRE) and if so, what technologies to use. These developments will then be applied to the IRE, demonstrating many of the technologies needed for IFE.

Target Fabrication. We need high quality, mass produced targets at low cost. Many of the materials and fabrication processes needed for IFE targets have been or are being developed by the ICF program. However, some are not. High Z foams for Heavy Ion Fusion distributed radiator hohlraums have no ICF analog and will require development. Plastic foam capsules needed for direct drive targets have been developed but IFE specifications have not yet been met; more development is needed. Even where ICF fabrication techniques meet IFE specs, the processes need to be adapted to mass production at low cost. This includes selection of the candidate processes such as microencapsulation and fluid bed coating of capsules and injection molding of hohlraum parts, demonstration on the lab bench that the processes can meet accuracy specs, and projection they can meet cost goals. Every IFE target could be inspected for gross defects, but detailed characterization to adjust fabrication processes must be done on a statistical sampling basis. Stable and repeatable fabrication processes are essential.

Filling and Layering. We must fill ~500,000 targets per day and precisely layer the DT ice. Most of the basic DT fill and layer issues will be investigated and resolved on the NIF. Permeation fill can have several kilograms of tritium in process. Current layering techniques are equipment-intensive, using an isothermal layering sphere or a hohlraum with precisely tailored temperature distribution to let beta layering make a smooth uniform DT layer. We must investigate alternate fill and layer techniques, such as fluidized bed technology.

Injection and Tracking. We must accurately inject cryogenic targets into the high temperature target chamber at about 5 Hz without thermal or mechanical damage and track them with high precision so they may be hit by the driver beams. Gas gun experiments at LBNL have demonstrated injection and tracking for indirect drive surrogate targets at room temperature. These must be extended to the higher precision needed for direct drive and cryogenic targets. Dry wall laser chambers are proposed to have ~1 Torr of Xe gas to absorb x-rays. It would also heat and slow the injected direct drive target. The thermal and mechanical properties of cryogenic targets must be measured and the target/chamber trade-offs must be studied.

IFE Roadmap Plans. IFE Target Fabrication and Injection are part of the IFE Roadmap. During Phase I, we will carry out tasks to support the decision as to whether or not to proceed with the IFE IRE, and if so, what target technologies to use. During Phase II of the IFE Roadmap, we will continue target fabrication development and will provide a target injection-tracking system to the IRE for integrated system experiments.