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Inertial fusion energy technology

While the U.S. magnetic fusion energy science program leverages off the over $1 billion per year international fusion program, the inertial fusion energy program leverages off the U.S. defense program in stockpile stewardship that is based on inertial confinement fusion. The National Ignition Facility is the premier defense facility, and its goals are to demonstrate ignition and thermonuclear burn. These goals are consistent with the technological challenges of fusion energy.

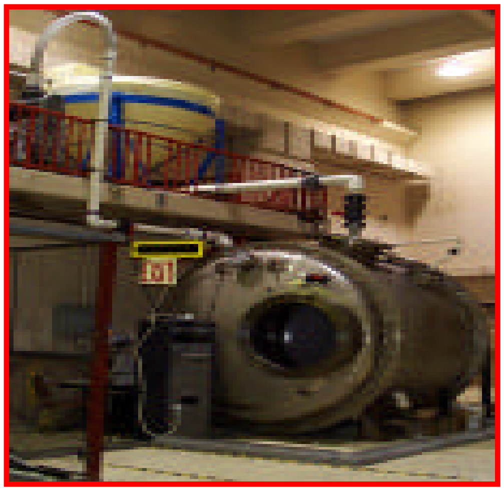
Inertial fusion energy has several inherently attractive features, including ease of access and maintenance because the laser, or particle accelerator, target chamber and target factory are separate components of the system.

Within the VLT infrastructure, the inertial fusion energy technology areas of emphasis include:

- **All R&D associated with candidate inertial fusion chambers,**
- **Methods to protect final optics,**
- **Methods for low-cost target manufacturing,**
- **Target injection and tracking,**
- **Blanket and fuel cycle technology, as well as chamber materials,**
- **Safety and environment R&D, and**
- **Power plant studies.**

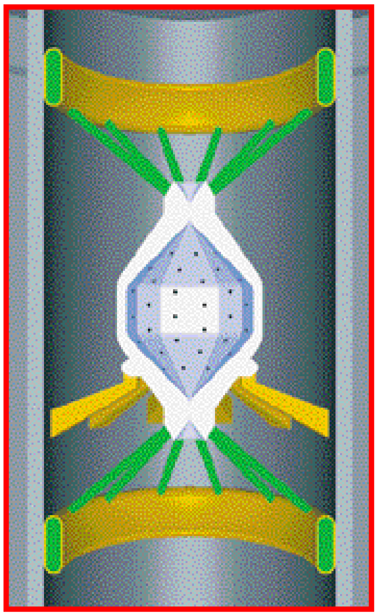
Energy chamber technology

A high priority for VLT engineering scientists is the area of plasma and inertial fusion energy chamber technology. Researchers are interested in liquid wall chamber concepts using either a thin liquid layer to protect chamber structures from short-ranged target emissions (x-rays and debris), or a thick liquid layer to also protect structures from neutron damage and reduce activation.



Experiments are underway at the UC-Berkeley to study oscillating liquid jets in support of thick liquid wall chamber concepts such as HYLIFE-II.

Other chamber technology concepts under investigation are dry wall chamber concepts, e.g., the Sombrero chamber, that rely on low-density, high-Z gas to prevent X-ray and debris damage. Research efforts underway are to demonstrate dry-wall chamber lifetimes of one year between replacements. Both theoretical and experimental methods are being employed to advance the understanding of gas-protected chamber dynamics.



Sombrero chamber

VLT Virtual Laboratory for Technology For Fusion Energy Science

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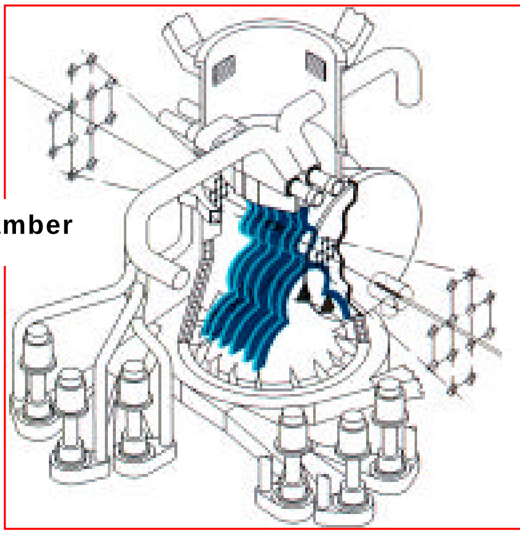
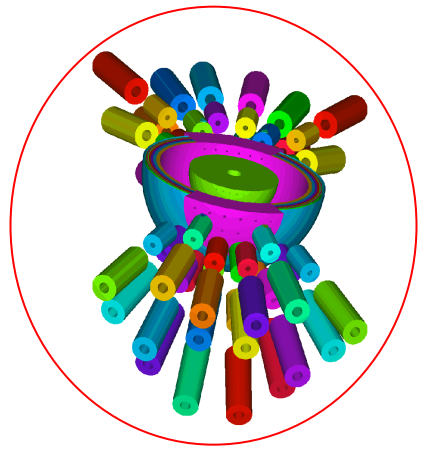
The interface of the driver beam with the fusion chamber is an important area of R&D for the inertial fusion energy element of the VLT. For heavy ion drivers, near term efforts are aimed at producing a self-consistent design for final-focus/chamber interface consistent with heavy-ion target requirements, as well as protecting the focus magnets from radiation damage and excess nuclear heating.

HYLIFE-II



Driver/chamber interface



Recent driver designs require 40 or more beams from each of two sides for indirect drive targets, so the physical packing of these magnets presents a design challenge. For lasers, the key issues are the design and survivability of the final optics.

Target technology

The advancement of cost-effective target technology is a key element in the development of inertial fusion energy power systems. The explosion of an inertial fusion target occurs when the target is compressed and heated to fusion conditions by the driver beams. For direct drive the target is a spherical capsule containing deuterium-tritium fuel. For indirect drive the capsule is contained within a metal container, or hohlraum, which converts the driver energy into X-rays to drive the capsule.

In the future, the target factory at an inertial fusion power plant must produce hundreds of millions of targets each year with extreme manufacturing precision, filling them with deuterium-tritium fuel, and layering the fuel into a frozen symmetric and smooth shell inside the capsule. These fragile targets must be precisely injected into the center of the high temperature target chamber at a rate of 5-10 hertz, or 5-10 target injections per second, without any damage to the target. The near term objectives for both heavy ion and laser drivers include identifying methods to lower manufacturing costs and increasing the injection rate of both direct- and indirect-drive targets.