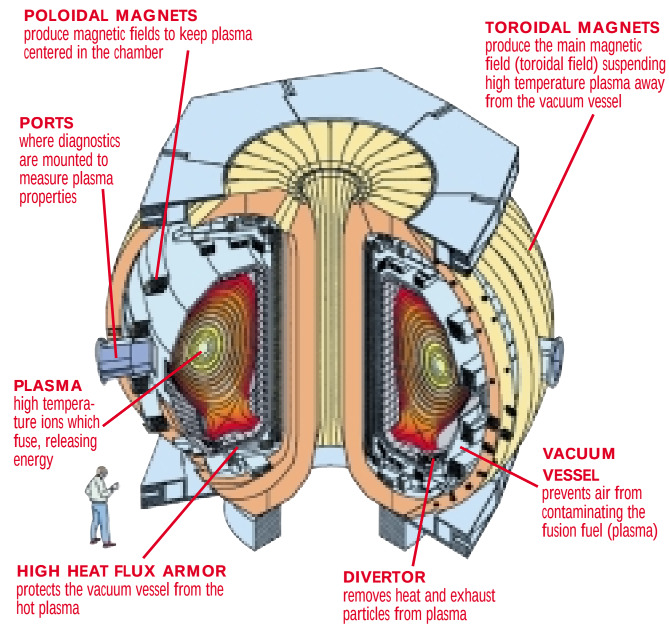
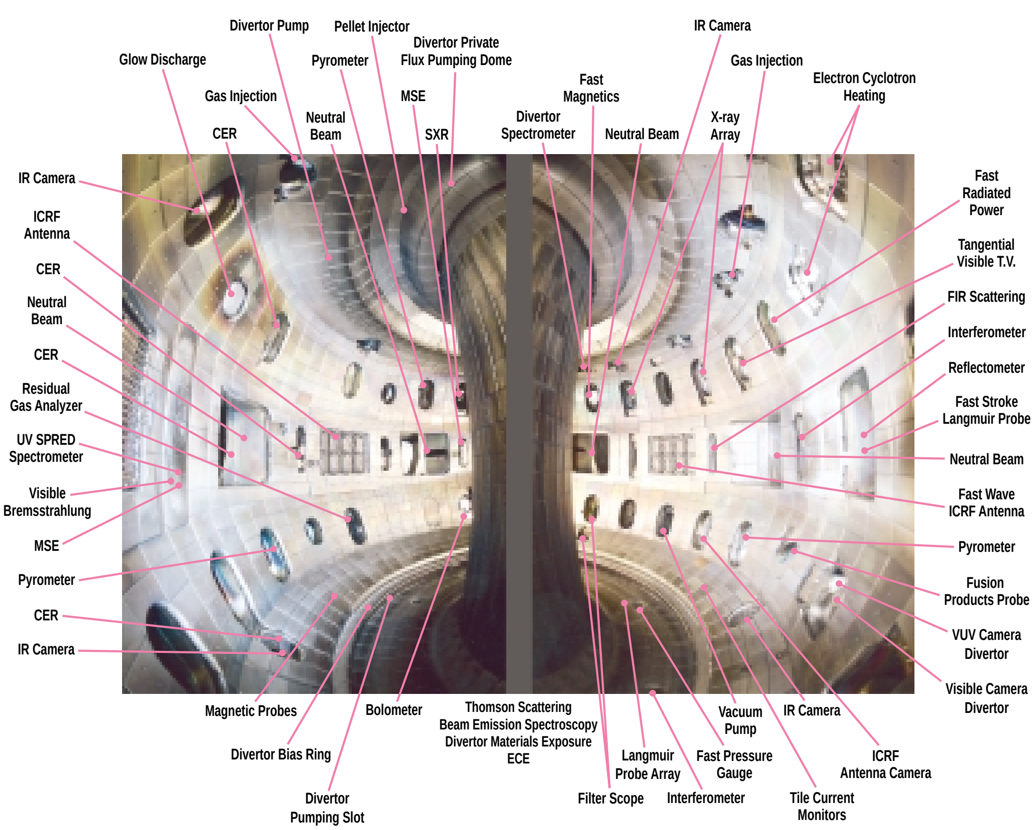
DIII-D NATIONAL FUSION FACILITY

The DIII-D National Fusion Facility is operated by General Atomics (GA) and collaborating institutions to perform basic plasma physics research under contract from the Office of Fusion Energy Sciences, U.S Department of Energy. The mission of the DIII-D Program is to establish the scientific basis for the optimization of the tokamak approach to fusion energy. The heart of the facility, the DIII-D tokamak, provides magnetically confined plasmas at close to fusion reactor temperatures (25 keV, 230,000,000 K) for study by researchers seeking to understand the stability, confinement, and other properties of the plasma. The DIII-D National Fusion Program is a multi-institutional research program with 60 institutional participants worldwide and about 355 scientific users.

The DIII–D National Program evolved from the original Doublet III facility which was dedicated in 1978. In the period 1978-1984, the Japan Atomic Energy Research Institute (JAERI) became the first major collaborator, investing substantially in the facility prime power and plasma heating and vacuum systems and using half



Major features of DIII-D Tokamak



View of interior of vacuum vessel. Over 60 plasma measurement systems view the plasma through ports.

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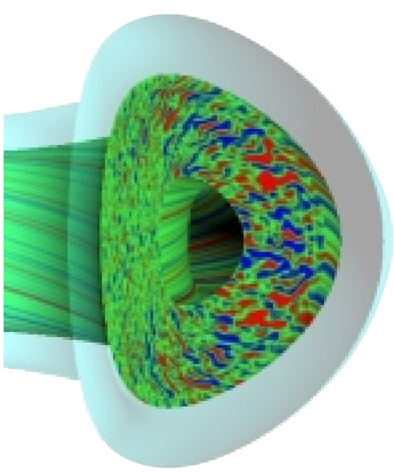
the experimental time. In a major upgrade in 1986, Doublet III was converted into the present DIII–D tokamak. Research collaborators have grown to about 75% of the users. Research participants range from undergraduates to recognized senior researchers: 8 winners of the American Physical Society Excellence in Plasma Physics Award and 50 APS Fellows.

Major collaborators now include:

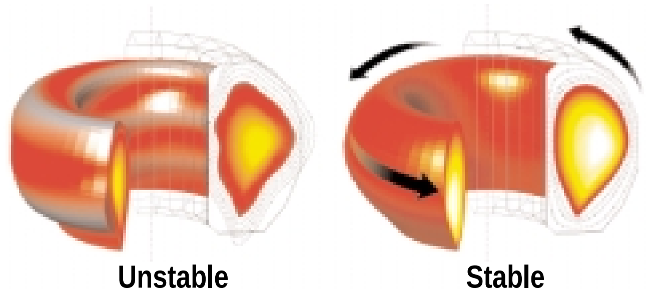
- Lawrence Livermore National Laboratory (LLNL),
- Oak Ridge National Laboratory (ORNL),
- Princeton Plasma Physics Laboratory (PPPL),
- Sandia National Laboratory (SNL),
- University of California at Los Angeles (UCLA),
- University of California at San Diego (UCSD).

DIII-D is the largest magnetic fusion research facility in the United States. On the world scene, this medium scale facility allows research in fusion reactor grade hydrogen and deuterium plasmas while retaining the accessibility of a university research program. The device's ability to make varied plasma shapes and its plasma measurement system are unsurpassed in the world. These capabilities have enabled DIII-D to flexibly match plasmas made in other devices for "wind tunnel" like comparisons of basic plasma properties. The device is equipped with powerful and precise plasma heating and current drive systems [20 MW neutral deuterium beams, 6 MW radio frequency system (30-120 MHz) for ion heating, and a developing 6 MW microwave power system (110 GHz)], particle control systems, and plasma stability control systems. Its digital plasma control system is pioneering precise control of plasma properties and its open data architecture facilitates international participation.

Generally researchers have requested about three times as much experimental time in a given year as has been available. About 200 research proposals are made annually by the staff. A multi-institutional Research Council manages an extensive planning process to select the experiments that will be run.



Massively parallel computer calculations of turbulent electrostatic potential fluctuations are exhibiting the basic processes of plasma transport.



Spinning plasma stabilizes the plasma surface allowing improved performance. Unstable kink mode distortion shown 10x exaggerated.

ACCOMPLISHMENTS

The DIII–D Program pioneered shaping of the plasma cross-section and control of its spatial distributions of temperature, density, and current as a means of improving plasma stability. DIII-D has achieved a value of 13% for the ratio of confined plasma pressure to confining magnetic field pressure, well exceeding the 5% value considered a minimum feasibility threshold for a tokamak fusion reactor. Four DIII-D researchers were awarded the APS Excellence Prize for showing that theoretical stability calculations could account for the observed stable pressure limits in the tokamak. A recent major advance has opened up exploration of new stable operating space above the pressure limit available with the plasma just suspended free in space by making the plasma spin rapidly inside a nearby conducting metal wall (*Physics Today*, Sept. 2001).

Plasmas must be heated to fusion temperature (10-20 keV) competing against the heat leakage across the confining magnetic field which arises from turbulence in the plasma. Four DIII-D researchers also won the APS Excellence Prize recently for their discovery that plasma turbulence can be quenched by sheared E×B flows resulting in regions in the plasma of greatly improved thermal insulation. In the best case, the turbulence in the ion fluid was nearly entirely quenched everywhere, reducing the thermal transport to the theoretically irreducible minimum set by Coulomb collisions in the tokamak magnetic geometry.

The DIII-D Program has pioneered both the physics and technology of plasma heating and current drive at the electron cyclotron (EC) resonance frequency (110 GHz). The basic theory of EC current drive was recently verified. Power sources of 1 MW at 110 GHz have been developed to support this research aimed at steady-state operation of fusion systems.

DIII-D pioneered divertor magnetic geometries which surround the closed magnetic surface plasma with an open field line region to divert plasma particle and heat exhaust to pumps and high heat removal surfaces. Such geometries are now common in the world's tokamaks.

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