

# Nuclear fusion related research programs in France

Commissariat à l'Énergie Atomique  
(CEA, French Atomic Energy Commission)

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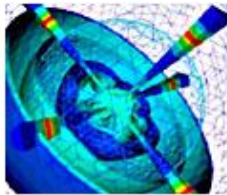
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on behalf of G. Marbach

Director of the Magnetic Fusion Research Institute  
(CEA IRFM)

CEA is a French government-funded technological research organization

It is a major European Research Center involved in many projects all over the world with an active policy of patents, licensing and start-up



#### Defense & security

- The simulation program
- Nuclear warheads and nuclear propulsion



#### Energy

- Research on nuclear wastes
- Nuclear systems for the future
- New energy technologies



#### Health & information technologies

- Micro and nanotechnologies
- Software technologies
- Health technologies



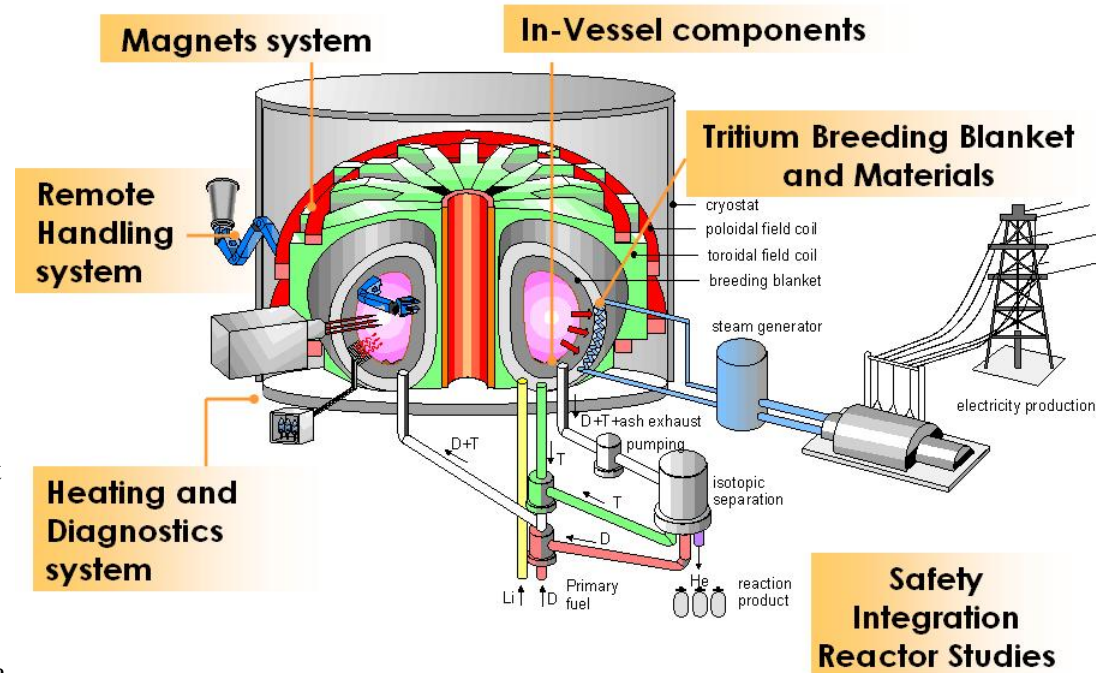
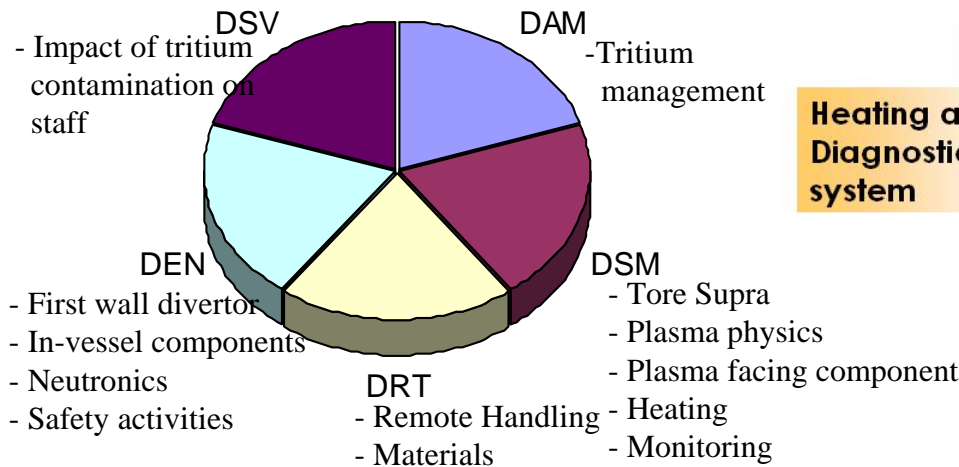
#### Fundamental research

- Major areas of CEA fundamental research

- 15.000 employees
- 350 active patents
- 100 startups in the high-technology sector
- > 1000 PhD students

## The all 5 CEA Research Divisions are involved in fusion projects

- DSM : Physical Sciences Division
- DEN : Nuclear Energy Division
- DRT : Technological Research Division
- DAM : Military Applications Division
- DSV : Life Sciences Division

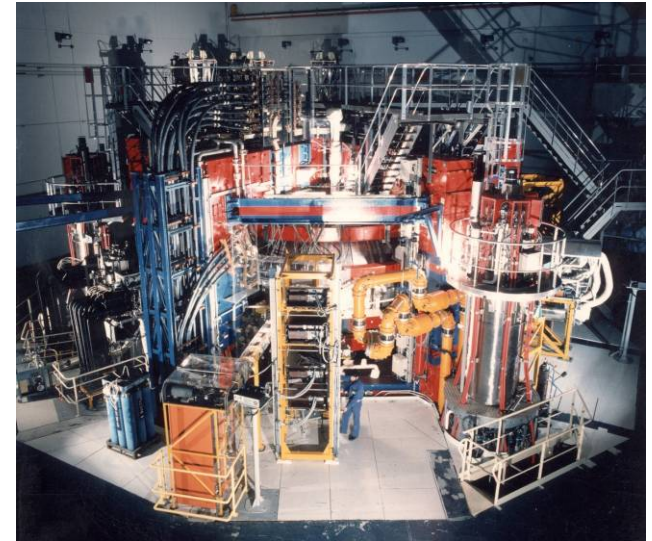


irfm

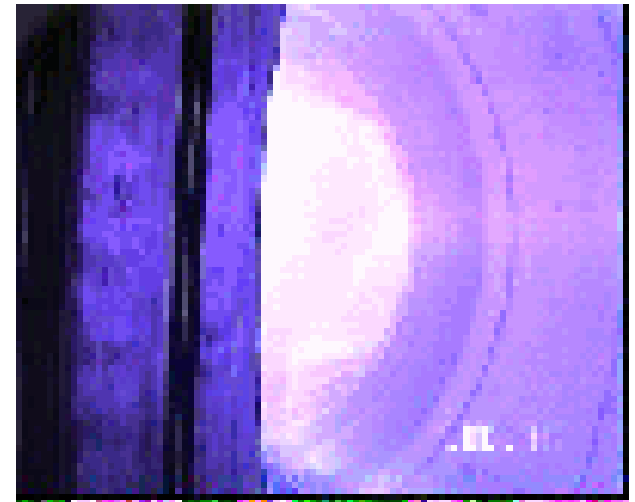


cadarache

- ✓ The leading Division on these activities is the Physical Sciences Division (DSM)
- ✓ IRFM is the only French research institute dedicated to magnetic fusion (300 people)
- ✓ It has been operating Tore Supra since 1988.
- ✓ Tore Supra holds the world record of long-plasma discharge at high energy (1 GJ) with a plasma duration of 6 mn 30 s
- ✓ With a deep know-how on :
  - Plasma facing components with active cooling
  - Supraconductor Magnets
  - Plasma heating
  - Plasma diagnostic and monitoring
  - Tokamak building and exploitation



*Tore Supra Tokamak at CEA Cadarache facilities*



*6 mn long-discharge inside Tore Supra (04/12/2003)*

i r f m



cadarache

In Europe, research laboratories on fusion are structured around "Contract of Association" with the European Commission.

Euratom-CEA, the French Association is coordinated by IRFM



European fusion research activities are coordinated by EFDA (excluding ITER)

<http://www.efda.org>

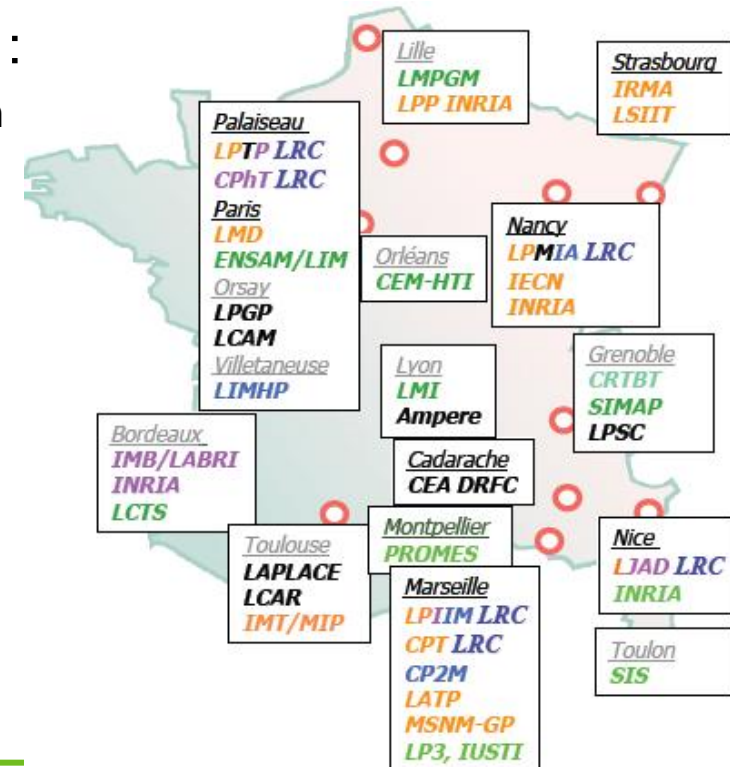
- French research in magnetic fusion is coordinated through the French National Research Federation for Fusion by magnetic confinement directed by Pascale Hennequin (Ecole Polytechnique – CNRS Lab.)

- French research organisms have signed a cooperation agreement (CEA, INRIA, CNRS, Universities),

- The federation has several objectives :
  - Bring program coherency and coordination
  - Ensure the sharing of competences
  - Strengthen the French fusion community

- The scientific thematics are aligned on EFDA topical groups :

- Plasma stability and control (MHD)
- Turbulence & Transport
- Diagnostics
- Heating & current drive
- Materials



10 French universities/graduate schools federated since 2006 propose a common Master on physics and technology of fusion

Information available on national web site :

[www.sciences-fusion.fr](http://www.sciences-fusion.fr)



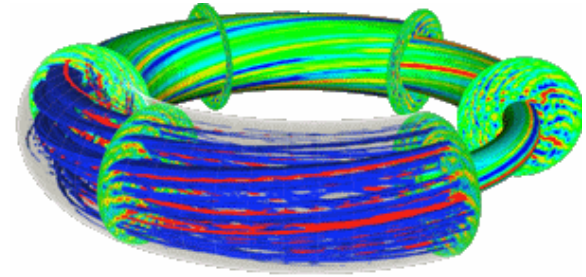
The screenshot shows the homepage of the SF Sciences de la Fusion website. The header features the SF logo, the text "Sciences de la Fusion", and the website URL "www.sciences-fusion.fr". A navigation menu on the left includes links for "Welcome", "Federation", "Master's degree" (with a sub-link for "2nd academic year"), "Post-graduate", "Textbooks", "Download the booklet", and "Admission form". The main content area is divided into several sections: "NEWS & EVENTS" with a news item from 2008 about five engineering schools becoming associated partners; "CONTACT INFORMATION" with a map of France and links for Île de France, Bordeaux, Nancy, and Marseille; "FUSION AT A GLIMPSE" with a diagram showing the fusion of Deuterium and Tritium into Helium and a Neutron; and a "Welcome" section with introductory text about the federation's mission and structure. The text describes the federation's role in providing interdisciplinary knowledge and skills for scientists and engineers, supported by a joint effort of graduate universities within a federation "Education for fusion sciences". It also details the curriculum structure, including a core group of basic modules on plasmas and major scientific and technological issues of fusion, and three pathways: Magnetic confinement fusion (MCF), Inertial confinement fusion (ICF), and Physics and Technologies of fusion (PTF).

irfm

From theory up to engineering and technology



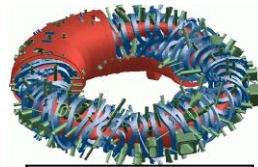
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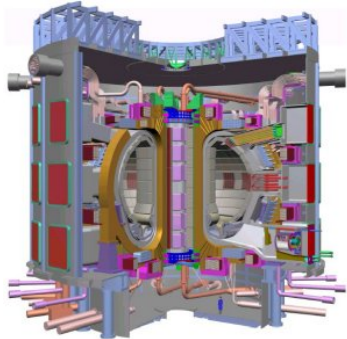
Gyrokinetic code simulation on a supercomputer



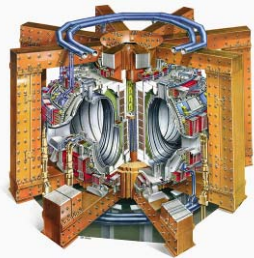
Tore Supra



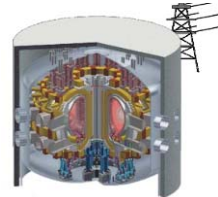
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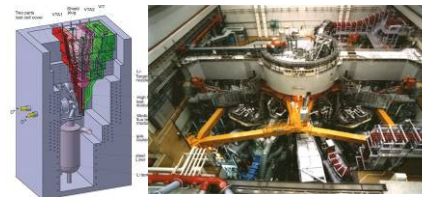
Support to ITER



JET program



Fusion Emerging technology program for DEMO & future power plants



Broader Approach

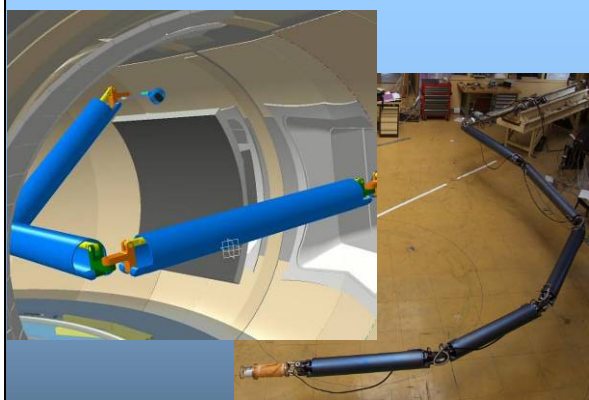
**2009 key features :**

- *IRFM -> 300 permanent researchers*
- *More than 40 PPY in other CEA labs*
- *40 national laboratories involved for a total of 100 PPY*

JT-60 SA  
IFMIF  
IFERC

## Articulated Inspection Arm : a long reach robot for visual inspection (8 meters)

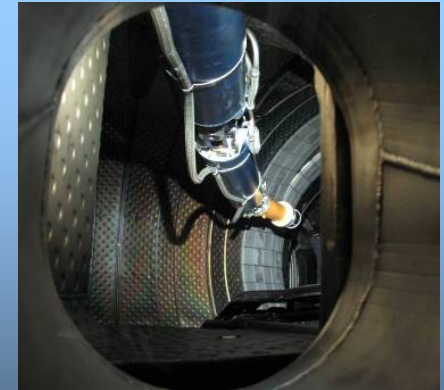
- Viewing,
- Leak detection on water loops (Helium sniffer),
- Layer laser ablation,
- Chemical characterisation,
- ...



**2001-2006**  
Development



**2007** Trials under atmospheric conditions



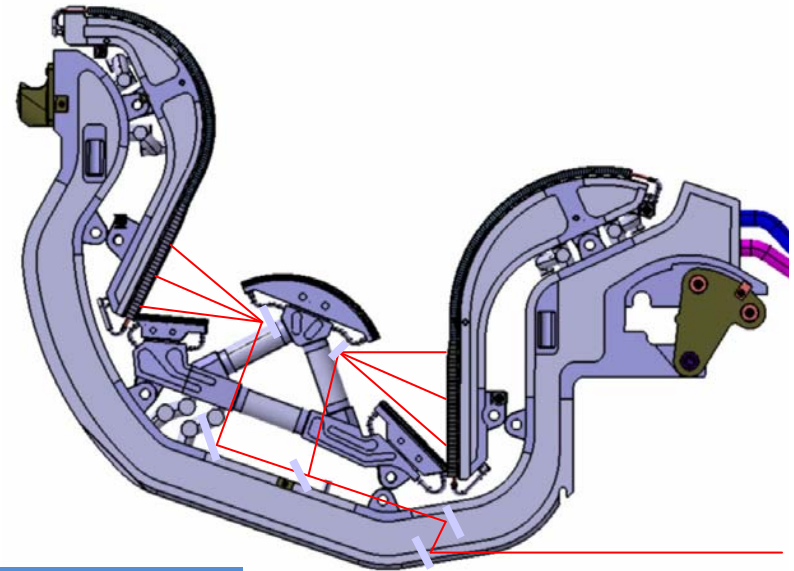
**2008** Tests under vacuum (10<sup>-5</sup> Pa) and temperature (120°C) conditions

## Speckle interferometry system for ITER

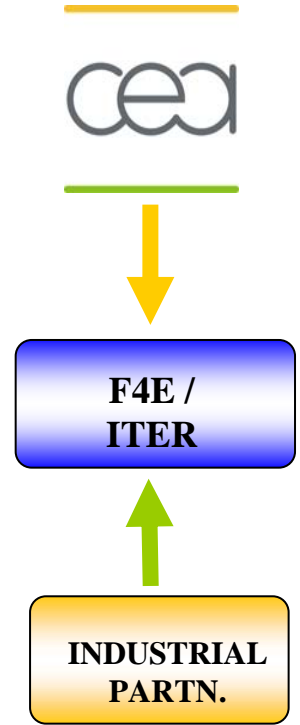
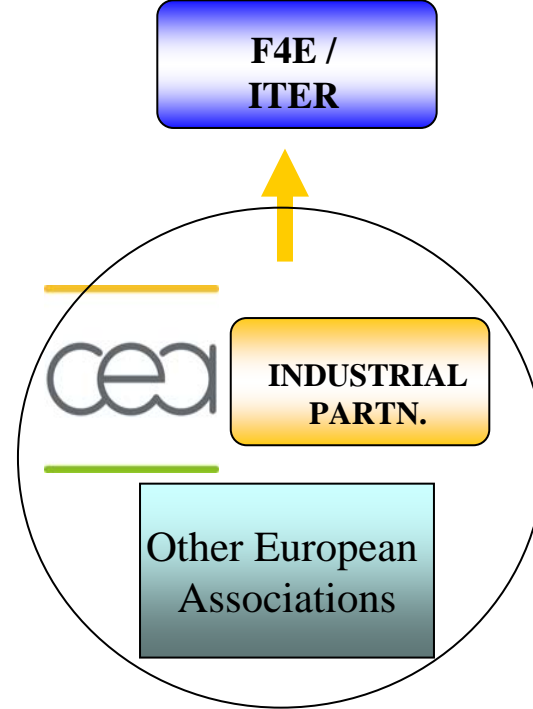
Coordinated experiments on plasma wall interaction in collaboration with FOM.

Realization of a prototype for real time erosion monitoring based on Speckle interferometry

- LASER-based depth probing techniques (Speckle interferometry at 2-wavelength).
- Lasers located at ~40 m
- Measure both **erosion and deposition**
- Very complex optical path



Testing planned in MAGNUM-PSI facilities



- CEA AS SUBCONTRACTOR  
For expertise or R&D activities as supportive action

1

- CEA AS CONTRACTOR  
when expertise or R&D activities are central actions

2

- CEA AS CO-CONTRACTOR  
in a classic consortium

3

- CEA AS CONTRACTOR for assistance on project definition and management

4

**Thank you for your attention**

