Life on the Earth is sustained by energy coming from the Sun, where Hydrogen nuclei fuse into Helium.

The aim of Controlled Nuclear Fusion Research is to develop on Earth a way to replicate the same process and obtain a virtually inexhaustible source of energy, which will be safe and environment friendly.

This is a huge scientific and technological challenge for the large research community that is working on it worldwide.

Deuterium + Tritium = Helium + 1 neutron + ENERGY

Deuterium and Tritium (two heavier hydrogen isotopes) are used in the experiments, since their fusion is the most easily achieved reaction to get fusion in the lab.
Consorzio RFX is one of the leader labs in the World Fusion Community.

It was founded in 1996 in continuity with the Fusion Research activity started in Padova since 1958, and it is a partnership of CNR, ENEA INFN and Padova University.

In the Consorzio physicists and engineers synergistically share their competencies to achieve Fusion in magnetically confined plasmas in the framework of the EUROFusion program, and of the International Thermonuclear Experimental Reactor (ITER) project.
RFX-mod is an experiment operating at the Consorzio RFX since 2004. The plasma is magnetically confined in a Reversed Field Pinch device, a toroidal (doughnut) configuration alternative to the Tokamak, where a much weaker magnetic field is employed, with the advantage of potentially achieving Fusion via the intrinsic ohmic heating entailed by the plasma current only, i.e. without applying additional heating systems.

A highly sophisticated feedback control system suppresses MagnetoHydroDynamic (MHD) plasma instabilities, allowing to safely achieve currents as high as 2 Mega Ampere.

In RFX-mod a new operational mode was first achieved: the Quasi Single Elicity state. It is a self-organized plasma that had previously been predicted by RFX theoretical physicists, where confinement properties are improved and much higher core temperatures (15M deg) are seen.
RFX-mod has been shut down in 2016 to perform several modifications that will be completed in 2020 and which will allow to significantly improve the plasma performance.

The most important change will be the removal of the inner vacuum vessel, functionally replaced by the mechanical structure (properly modified to be vacuum proof). Such action will lead to a larger plasma and a more closely fitting stabilizing shell that, thanks also to a further improvement of the magnetic feedback control system, is expected to lead to an optimal control the MHD instabilities.

The entailed reduction in plasma-wall interaction is expected to improve confinement and allow the achievement steady state QSH.
The program focusses on 3 projects:

- **JT-60SA** - A superconducting coils tokamak under construction in Naka (Japan). Its mission will be to realize nearly steady state plasma and to study key engineering and physics issues for ITER and DEMO.

- **IFMIF / EVEDA** - An international facility to study materials for plasma facing components exposed to extreme particles and power fluxes.

- **IFERC** - The International Fusion Energy Research Centre (IFERC) will promote 3 sub-projects: ITER Remote Experimentation Centre (REC), DEMO Design and R&D Coordination Centre, Computational Simulation Centre (CSC)
The “Broader Approach agreement” between Europe and Japan performs research & Development activities in support of ITER and DEMO, the future prototype Fusion Reactor.

**Consorzio RFX**

Consorzio RFX participates in all of the 3 BA projects:

- **JT-60SA** - the procurement of the “Quench Protection Circuits” of the superconducting coil superconducting coils was successfully completed in 2015; the procurement of the Power Supply system of the in-vessel sector coils devoted to Resistive Wall Modes (RWM) control is under way and to be completed in 2018. Finally Consorzio RFX contributes to definition of the future research and experimentation program for the exploitation of the machine.

- **IFMIF / EVEDA** - RFX takes part to the procurement of the Radio Frequency Quadrupole (a key component of the device) and to design activities of the whole project.

- **IFERC** - The contribution to IFERC entails an important role in the studies to define the REC to be realized in Japan.
ITER is a worldwide international project with the aim to demonstrate scientific and technological feasibility of Fusion as an Energy Source in a single integrated device. ITER is being built in France and it is a major step forward relative to existing devices and therefore prototypes had to be realized to develop and optimize some of its key components.

Source for Production of Ion of Deuterium Extracted from Rf plasma (SPIDER) has started operating in 2018 as the first ITER component prototype.

SPIDER is devoted to test and develop the most critical component of the heating beam: the negative ion source of deuterium (D-) and hydrogen (H-). To this aim SPIDER will be equipped with state-of-the-art diagnostics system that will allow a detailed study of the generated beam and its thorough optimization.
In particular Consorzio RFX has been assigned the task of developing the neutral beam heating system of ITER. The demanding specification of 1MeV energy and 50 MW from three modules called for a project divided in 2 steps: the development of 100KeV source called SPIDER to be used as a test and development bed and of the full beam prototype called MITICA.

**MITICA**

MITICA (Megavolt ITER Injector & Concept Advancement), MITICA will be the full scale prototype of the 1MV 18 MW neutral particle accelerator. Its final and optimized version will be replicated into the actual accelerator units of ITER.

**ITER Injector Components :**

1. 1 MV negative ion source
2. Neutralizer
3. Residual ions dump
4. Calorimeter
Every year RFX scientists publish their results as papers on International Journals and as communications to International Conferences.

Our Education and Outreach activities involve also visits and stages of secondary school students.
Consorzio RFX provides the tutorial activity for development of bachelor and master theses of about 30 engineering and physics undergraduate/graduate students per year. Starting from year 2007 in Padova has been active the European Doctorate in Fusion Science and Engineering, the first PhD school devoted to Controlled Nuclear Fusion, that presently has already graduated 84 PhDs.

PhDs
2010-2017
84

Stud. Tutoring
2010-2017
111
CONSORZIO RFX vs INDUSTRY

FUSION RESEARCH

European and National contracts to ITALIAN COMPANIES for innovative components

ITER

1000 M€  70 M€
Fusion Research has a well established relationship with private industry to develop high tech components. Consorzio RFX strongly developed such a relationship including the design stages developing a powerful synergy and a very effective knowledge transfer practice.
Firms that contributed to production of Consorzio RFX experimental devices:

RFX - RFX-mod and RFX-mod 2

- ABB Asea Brown Boveri (Svizzera)
- Alca Technology
- Alstom Italia - ex CEME – Noventa di Piave (Ve)
- Alstom (Francia)
- Ansaldo Ricerche (Genova)
- Ansaldo Sistemi industriali Spa - ora Nidec Asi – (Milano e Vicenza)
- Cinel Srl (Padova)
- De Pretto (Schio) - VI
- EEI Spa (Vicenza)
- FIAT CIEI (Torino)
- Gemmo Srl (Thiene - VI)
- Jeumont Schneider (Francia)
- Le Carbone-Lorraine (Francia)
- Leybold (Germania)
- OCEM Energy Tecnology Srl (Bologna)
- Plansee (Austria)
- Passoni & Villa Spa (Milano)
- Siemens GmbH (Germania)
  - SISMA Group
- Tecnomare Spa – (Venezia)
- Termics (Cuneo)
- Tesla (UK)
- Vaqtec Srl (Parma)
- Zanon SpA (Schio VI)
Firms that contributed to procurement of components for Consorzio RFX experimental devices

- ACS Data System SpA (Bolzano)
- AIR Liquide (Francia - Italia)
- Angelantonii Industrie ATT (Perugia)
- CECOM (Roma)
- Coelme Costruzioni Elettromeccaniche SpA (Venezia)
- COPIMEC Srl (Venezia)
- Delta-ti impianti S.p.A. (Torino)
- De Pretto Industrie (Vicenza)
- DILO GmbH (Germania)
- ELAD Srl (Pordenone)
- ETEL 4 Srl (Padova)
- Fratelli Franchini (Rimini)
- Galvano – T (Germania)
- Gemmo Srl (Thiene - VI)
- Hitachi (Giappone)
- Imequadri Duestelle SpA
  - IRS Srl (Padova)
- ITER Coop (Ravenna)
- LANTECH Solutions Srl (Padova)
  - Magro (Padova)
  - Marbet S.a.s. (Padova)
  - Nidec ASI S.p.A. (Milano)
- OCEM Energy Tecnology Srl (Bologna)
  - PVA TePla (Germania)
  - RIVORA Gas Srl (Torino)
  - SAES RIAL Vacuum S.r.l.
  - SAIIV SpA (Vicenza)
- Siemens GmbH (Germania)
  - Synecom (Bergamo)
- Tesистем Srl (Treviso)
  - Thales (Francia)
- TOYO TANSO Ltd (Giappone)
- Treesse Progetti Srl (Treviso)
  - Vipp SpA (Verona)
  - Zaffaroni (Varese)
  - Zanon SpA (Schio VI)