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First Workshop on MFE Development Strategy in China

Ministry of Science and Technology (MOST)
MFR integration design group
Beijing, 5-6 January 2012

Strategic orientation of the Euratom Fusion Programme

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INNOVATION UNION

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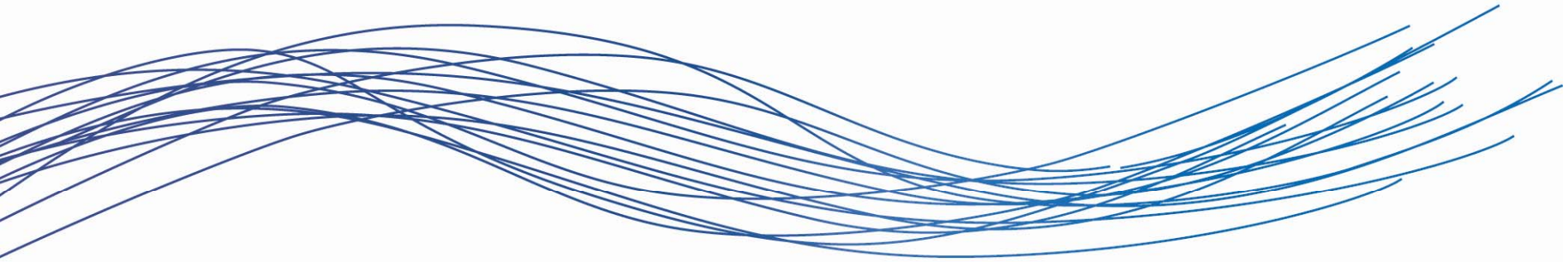
Outline

- **Main features of the Euratom Fusion Programme (2012-2013)**

- **Strategic orientation for 2014-2020**



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Euratom Framework Programme (2012-2013)

Council decision on 19 December 2011

DG-RTD

indirect actions

Fusion Energy

€ 2209 million

DG-RTD

indirect actions

Nuclear Fission & Radiation Protection

€ 118 million

JRC

direct actions

Nuclear Safety and Security

€ 233 M

Total budget: € 2560 million

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Areas of activity in the Fusion Programme of the Euratom FP7+2 (2012-2013)

- **The realization of ITER**
  Governance of the European Joint Undertaking for ITER (F4E); construction of equipment and installations; support to the project
- **R&D in preparation of ITER operation**
  Focused physics and technology programme to exploit JET and other ITER-relevant devices; assessment of key ITER technologies; consolidation of ITER project choices and preparation of ITER operation
- **Limited technology activities in preparation of DEMO**
  Fusion materials and key technologies; preparation of IFMIF construction; DEMO conceptual and design studies
- **R&D activities for the longer term**
  Preparation of operation of W7-X Stellarator; plasma theory and modelling
- **Human resources, education and training**
- **Infrastructures**
- **Technology transfer, industry involvement & innovation**

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Main players in the Euratom Fusion Programme

- **The European Commission**
  - In charge of programme management, including funding
- **The Joint Undertaking for ITER and the Development of Fusion Energy, or so-called "Fusion for Energy" (F4E)**
  - Domestic agency for ITER, and Implementing agency for 'Broader Approach' projects with Japan, including preparations for IFMIF construction
- **Euratom Fusion Associations**
  - A total of 26 'Contracts of Association' between Euratom and national programmes and laboratories of EU Member States (plus Switzerland), in which R&D activities are performed
- **EFDA (European Fusion Development Agreement)**
  - A multi-lateral framework partnership agreement among all Associates and Euratom aimed at co-ordinating the research activities of those Fusion Associations, and at exploiting collectively JET (Joint European Torus)

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The European Commission (EC)

- Representation of the European Atomic Energy Community (Euratom)
- In charge of the overall programme management (including funding)
- Management of the Associations' programmes through joint Steering Committees with the national partners
- Co-funding of the Fusion Associations, EFDA and F4E activities
- Management of the "Mobility Agreement" which promotes collaboration between Associations by funding travel and subsistence costs
- Implementation of a Fusion Training Scheme for young engineers
- Funding of co-ordination and support actions in fusion education, fusion materials research, atomic data and modelling
- Representation of the programme internationally (multilaterally, bilateral Cooperation Agreements, etc.)

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The European Joint Undertaking for ITER and the Development of Fusion Energy (F4E)

[http://fusionforenergy.europa.eu]

- Established as a Joint Undertaking in Barcelona (Spain) under the Euratom Treaty and largely financed by through the Euratom Framework Programme

- Domestic agency with the main responsibility of providing and manage the contribution of Euratom to ITER-IO within scope, schedule and cost. F4E is responsible for the placement and execution of contracts for manufacturing ITER components

- Implementing agency coordinating the contribution of Euratom Voluntary Contributors (FR, IT, ES, DE, BE and CH) to projects of the 'Broader Approach Agreement' between Japan and Euratom

- F4E also implements a programme of long term R&D activities in preparation for a future demonstration fusion reactor (DEMO)

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"Broader Approach" Agreement between Euratom and Japan

- **"Broader Approach" (BA) projects:**
  - Design of a materials test facility (IFMIF-EVEDA) to allow testing and qualification of advanced materials → IFMIF available for DEMO
  - Satellite Tokamak Programme: upgrade the Japanese JT-60 tokamak in Naka (JP) as advanced superconducting satellite tokamak → exploitation of ITER
  - International Fusion Energy Research Centre (IFERC) in Rokkasho (JP) aimed at coordinating **DEMO design and R&D**, and launching the Computational Simulation Centre (CSC) and the ITER Remote Experimentation Centre
- **Wider internationalisation of BA projects is possible**
  - New guidelines on participation of ITER Parties to BA already in force
  - European voluntary contributions: France, Italy, Spain, Germany, Belgium and Switzerland
- **The BA projects complement the construction of ITER towards fusion power deployment**

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DEMO activities within BA-IFERC

- **DEMO design coordination**
  - phase 1 (2007-2010) analysis of common elements for DEMO
  - phase 2a (2011-2012) definition of common basis for DEMO design and of priorities for R&D tasks
  - phase 2b (2013-2014) detailed studies – engineering choices
  - phase 2c (2015-2017) development of pre-conceptual design options
- **DEMO R&D coordination**
  - Five areas of generic nature identified: SiC_f/SiC composites; Tritium technologies; Development of TBMs (materials engineering; neutron multiplier of blanket; tritium breeders of blanket)
  - This R&D work carried out outside the BA framework, but findings and recommendations to integrated with DEMO design activity
- **Integrated Project Team**
  - DEMO design activity (DDA) unit of the IFERC project team
  - EU home team + JP home team

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Euratom Fusion Associations

- The Euratom Programme supports R&D in the Member States and Switzerland (associated to Euratom FP) through bilateral Contracts of Association (CoA) with programmes and national laboratories of the EU Member States
  - About 4000 people over 27 EU Member States plus Switzerland
  - Operating 12 plasma devices and ~ 40 technology facilities
  - Overall expenditure ~ € 300 million a year (incl. Euratom and Member States funds)
  - Each CoA includes a specific 'Work Plan' to be yearly revised by the corresponding Steering Committee resulting in an 'Annual Work Programme' (fixed WP structure to facilitate cross-cutting and coordination) and an 'Annual Mobility Plan'
- The Associates:
  - Carry out a focused physics and technology programme for consolidation of ITER project choices and in preparation for a rapid start-up of ITER operation
  - Carry out longer term fusion R&D, developing competences and enlarging the knowledge base in strategically relevant fields
  - Participate in procurements for ITER under contracts from F4E

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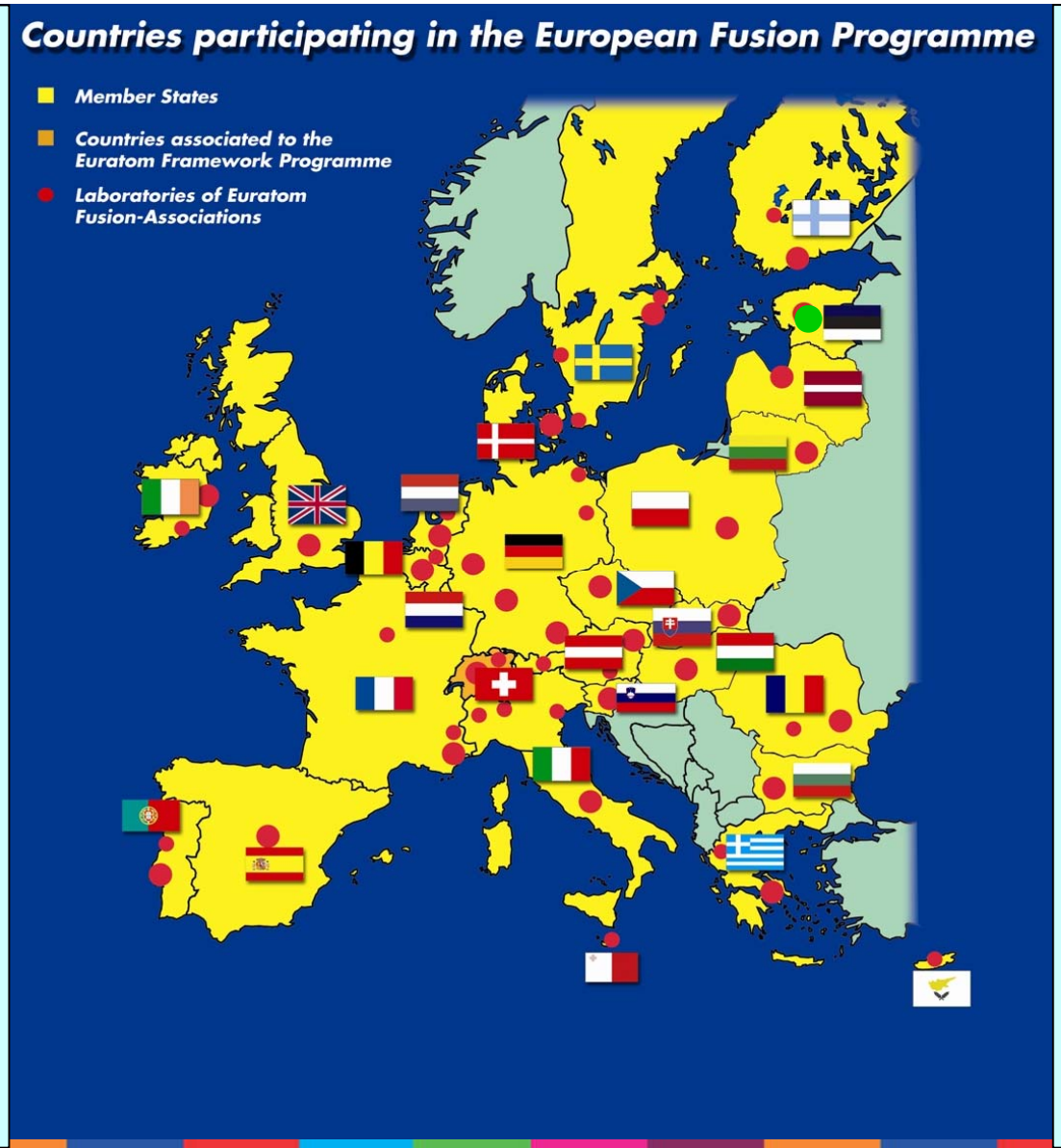
R&D in an Integrated Programme of 26 Associations

- **Euratom - CEA** (1958) France
- **Euratom – ENEA** (1960) Italy (incl. Malta)
- **Euratom - IPP** (1961) Germany
- **Euratom - FOM** (1962) The Netherlands
- **Euratom - FZJ** (1962) Germany
- **Euratom - Belgian State** Belgium (1969) (incl. Luxembourg)
- **Euratom - RISØ** (1973) Denmark
- **Euratom - CCFE** (1973) United Kingdom
- **Euratom - VR** (1976) Sweden
- **Euratom - Conf. Suisse** Switzerland (1979)
- **Euratom - KIT** (1982) Germany
- **Euratom –CIEMAT** (1986) Spain
- **Euratom – IST** (1990) Portugal



- **Euratom - TEKES** (1995) Finland (incl. Estonia)
- **Euratom - DCU** (1996) Ireland
- **Euratom - ÖAW** (1996) Austria
- **Eur. - Hellenic Rep** (1999) Greece (incl. Cyprus)
- **Euratom - IPP.CR** (1999) Czech Rep.
- **Euratom - HAS** (1999) Hungary
- **Euratom – MEdC** (1999) Romania
- **Euratom – Univ. Latvia** Latvia (2002)
- **Euratom - IPPLM** (2005) Poland
- **Euratom - MHEST** (2005) Slovenia
- **Euratom – CU** (2007) Slovakia
- **Euratom – INRNE** (2007) Bulgaria
- **Euratom – LEI** (2007) Lithuania

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The European Fusion Development Agreement (EFDA)

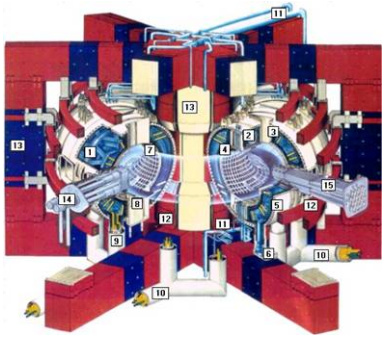
[www.efda.org]

- **Partnership agreement between all fusion Associates and Euratom**
  - Coordinated research of the Associations on physics in support to ITER and on longer-term technology – also through 2 Tasks Forces and 5 Topical Groups of EFDA
  - European collective scientific **exploitation of JET** by the Associations through the JET Implementing Agreement (JIA), and JET orders and notifications
  - Joint Operation Contract (JOC) between Euratom and UK
  - Implementing Agreement for High Performance Computer (HPC)
  - **Implementing Agreement for Power Plant Physics and Technology (PPP&T)**
  - Training and career development of researchers, promoting links to universities and carrying out support actions
  - Located in Garching (Germany) and Culham (United Kingdom)

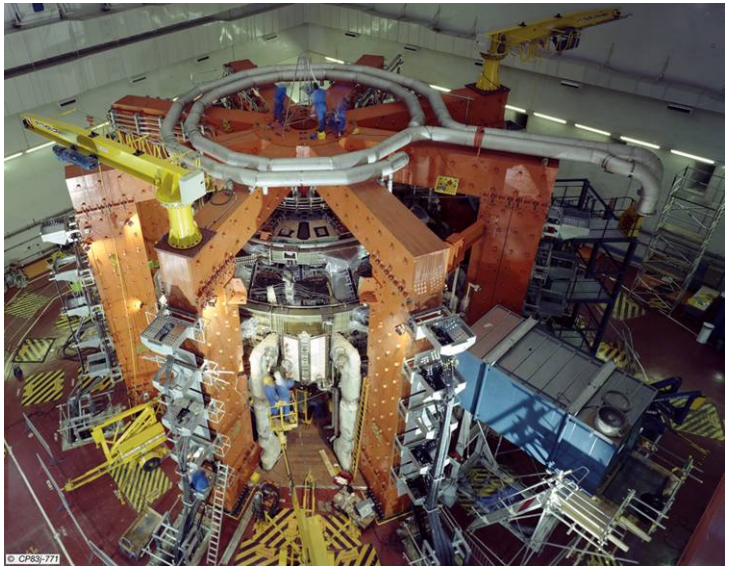
- **Accession to EFDA by Third States feasible**
  - Collaboration with the JET facility operation and exploitation

European tokamaks in operation

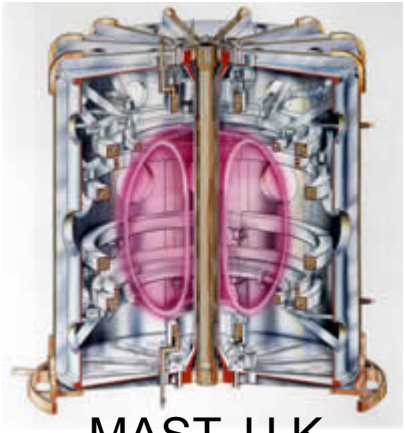
FTU, Italy



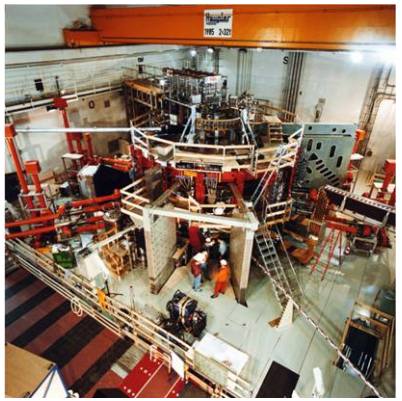
Tore Supra, France



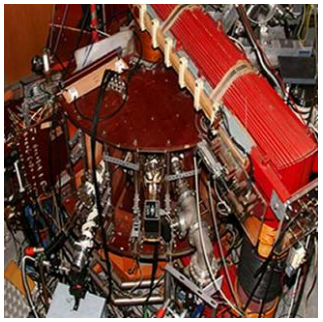
JET, Euratom



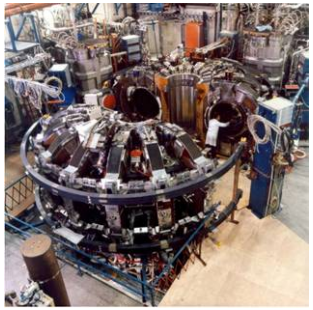
MAST, U.K.



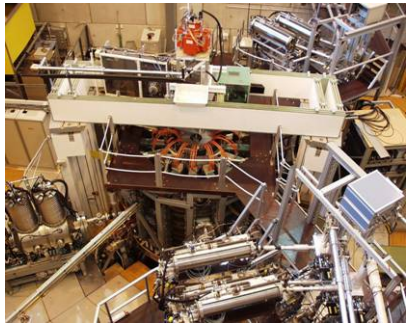
ASDEX-U, Germany



ISTTOK, Portugal



TEXTOR, Germany



TCV, Switzerland

COMPASS-D, Czech Rep.

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Fusion devices in the Euratom Fusion Programme

JET	Tokamak	Euratom EFDA Culham, UK	1983
TORE SUPRA	Tokamak	CEA Cadarache, France	1988
FTU	Tokamak	ENEA Frascati, Italy	1990
ASDEX Upgrade	Tokamak	IPP Garching, Germany	1991
TCV	Tokamak	CRPP Lausanne, Switzerland	1992
ISTTOK	Tokamak	IST Lisbon, Portugal	1992
TEXTOR-94	Tokamak	KFJ Jülich, Germany	1981 (1994)
TJ-II	Heliotron	CIEMAT Madrid, Spain	1997
MAST	Sph. Tokamak	UKAEA Culham, UK	1998
RFX	Rev. Field Pinch	ENEA Padova, Italy	1991 (2000)
EXTRAP–T2R	Rev. Field Pinch	VR Stockholm, Sweden	1994 (2000)
COMPASS	Tokamak	IPP.CR Prague, Czech Republic	2009
Wendelstein 7-X	Stellarator	IPP Greifswald, Germany	(2015)
[Wendelstein 7-AS	*Stellarator*	*IPP Garching, Germany*	*closed 2002]*

EFDA- Joint European Torus (JET) [1/3]

[www.jet.efda.org]

Relevant role of EFDA-JET infrastructures in the consolidation of ITER design choices and in the preparation for the ITER operation & exploitation in terms of:

- operating scenarios, ITER-like First Wall, Deuterium-Tritium (DT) operation, high frequency pellet injector, data acquisition and control systems, start-up requirements, etc.
- DT experiments should provide crucial information on access to the high confinement regimes required for ITER burning plasmas
- The present reference scenario until 2015 includes ITER-like First Wall experiments and DT operation

EFDA- Joint European Torus (JET) [2/3]

[www.jet.efda.org]

EFDA-JET programmes 2011-2012 developed as a coherent block of experiments for initial exploitation of the ITER-like Wall (ILW)

1 - Characterisation of ITER-like Wall (ILW)

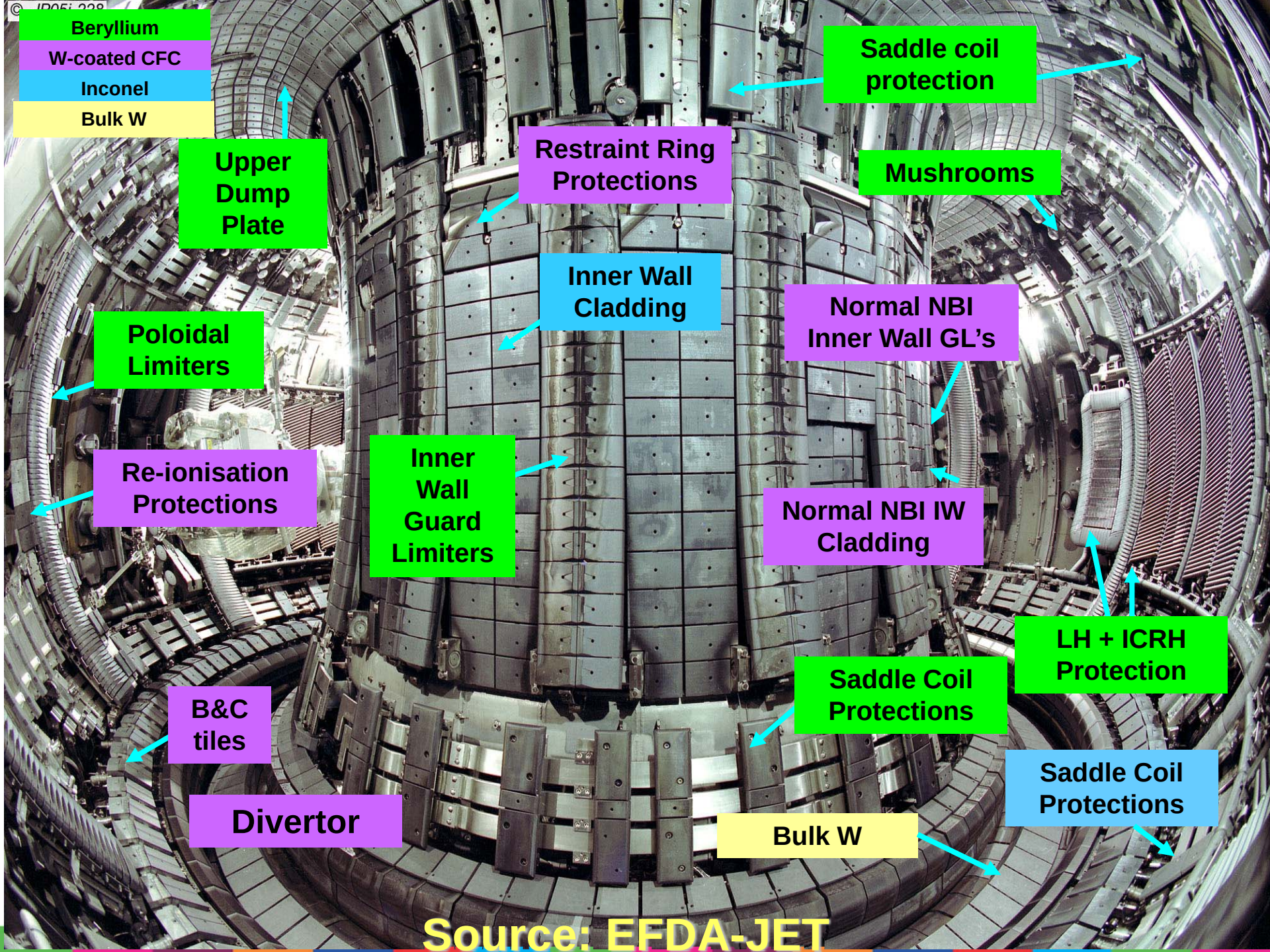
- Fuel retention and material migration; Material limits and long term samples; Transient and steady state power loads

2 - Exploration of ITER operating scenarios with ILW

- Develop plasma scenarios; Assess plasma scenarios with regard to power loads, their mitigation and control; Explore scenarios in domains closest to ITER dimensionless parameters

3 - Physics issues essential to the efficient exploitation of ILW and ITER

- Divertor and scrappe-off layer physics; Confinement, pedestal and ELM physics; Disruptions, MHD and fast particle physics; High priority diagnostic issues for ITER


Beryllium
W-coated CFC
Inconel
Bulk W
Upper Dump Plate
Restraint Ring Protections
Saddle coil protection
Mushrooms
Inner Wall Cladding
Normal NBI Inner Wall GL's
Poloidal Limiters
Inner Wall Guard Limiters
Re-ionisation Protections
Normal NBI IW Cladding
LH + ICRH Protection
Saddle Coil Protections
B&C tiles
Saddle Coil Protections
Divertor
Bulk W
Source: EFDA-JET

EFDA- Joint European Torus (JET) [3/3]

[www.jet.efda.org]

- Pump down achieved on 18 May 2011
- First plasma on 25 August 2011, starting campaign C28
- Start of campaign C29 on 3 January 2012
- Start of campaign C30 planned for 25 April 2012

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Power Plant Physics & Technology (PPP&T) - Implementing Agreement under EFDA

- Aimed at developing the physics and the technologies for, and the conceptual design of, future tokamak-based fusion power plants
  - Integration of physics, technologies and system engineering
- Programmatic objectives:
  - Consolidation of physics basis and integrated scenarios
  - Consolidation of Engineering Design basis
  - Efficiency, pulse length and reliability of heating and current drive systems
  - Plasma diagnostics and control strategies
  - Fuel cycle, including tritium breeding and handling; and plasma fuelling
  - Materials
  - Divertor concepts; in-vessels components; remote handling
  - Advanced superconductors (e.g. high temperature)
- Composed of Euratom Fusion Associations
  - Ongoing launching and entering into force foreseen early 2012

Strategic orientation (under preparation) for 2014-2020 [1/3]

- **The ultimate objective of the Euratom fusion programme is to develop the knowledge base required to build the first commercial fusion power plant, through two major steps:**
  - ITER as demonstration of the S&T feasibility of fusion power
  - DEMO as demonstration of the economic viability of fusion power

- **Draft main objectives (2014-2020)**

a) To construct ITER within scope, schedule and cost
b) To secure the success of future ITER operation
c) To prepare the ITER generation of scientists, engineers and operators
d) To lay the foundations for fusion power plants
e) To promote innovation and EU industry competitiveness

Strategic orientation (under preparation) for 2014-2020 [2/3]

- **A) To construct ITER within scope, schedule and cost**
  - R&D activities concerning the systems for which procurements are to be made and for which detailed designs and technologies should be developed and validated
  - Procurements for the ITER Organisation as per the ITER Baseline
- **B) To secure the success of future ITER operation**
  - Demonstrate ITER relevant scenarios and active plasma control to reach ITER performance
  - Demonstrate mitigation/avoidance of plasma disruptions, control of tritium and dust to ensure safe ITER operation
  - Develop tools for accurate predictive modelling of ITER operation
  - International networking of programmes and specific facilities

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Strategic orientation (under preparation) for 2014-2020 [3/3]

- **C) To prepare the ITER generation of scientists, engineers and operators**
  - Review the staffing situation in the fusion research centres and ITER, provide coordinated training for operators of ITER, plasma physicists and engineers, and review needs of other fusion stakeholders (industry, regulators, etc) for targeted training actions
  - Int. networking of programmes / specific facilities also aimed at training ITER operators
- **D) To lay the foundations for fusion power plants**
  - Develop scenarios for a reliable input to DEMO design
  - Develop & qualify materials for DEMO including irradiation in a suitable neutron source
  - Develop and validate the associated material modelling and exploit irradiation data
  - Develop and demonstrate advanced technologies for DEMO
  - Deliver DEMO conceptual design
- **E) To promote innovation and EU industry competitiveness**

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The Euratom fusion programme and the challenges of the ITER era

- **ITER remains the axis and main priority of the integrated Euratom fusion research programme, which is therefore fully aligned on ITER needs**
  - The construction of ITER mobilises between 450-700 ppy/y with a large impact on individual fusion associations' programmes
  - Therefore, Euratom R&D is focused to ITER component developments, as well as to risk mitigation and cost containment measures for ITER
- **ITER Preparation**
  - Credibility of fusion developments depends on ITER success - adequate preparation through accompanying programmes is essential
- **Power Plant**
  - The foundation for a fusion power plant must be laid down to make full use of the expertise arising from ITER construction and allow a fast realisation of fusion as a future energy source

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Many thanks for your attention.

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