



Italian National Agency for New Technologies,
Energy and Sustainable Economic Development



EUROfusion



SuperComputing Applications and Innovation



EU Fusion Initiative

Roadmap of the High Performance Computing in Italy and the settlement of a Scientific Advisory Board in CINECA. Bologna 23 March 2018

ENEA: F.Iannone, G.Bracco, S.Migliori, A.Quintiliani, A.Pizzuto

CINECA SCAI: S.Bassini, C.Cavazzoni, E.Rossi

francesco.iannone@enea.it



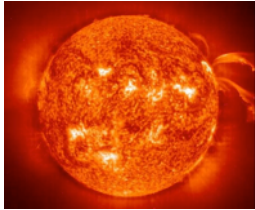
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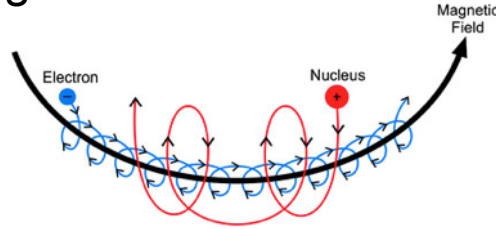
NUCLEAR FUSION RESEARCH

Plasma confinement

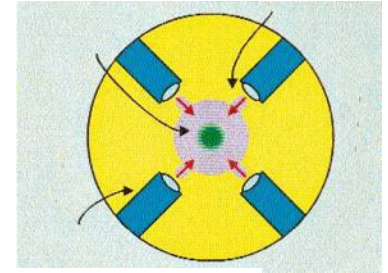
Gravity - SUN



Magnetic - Tokamak/stellarator

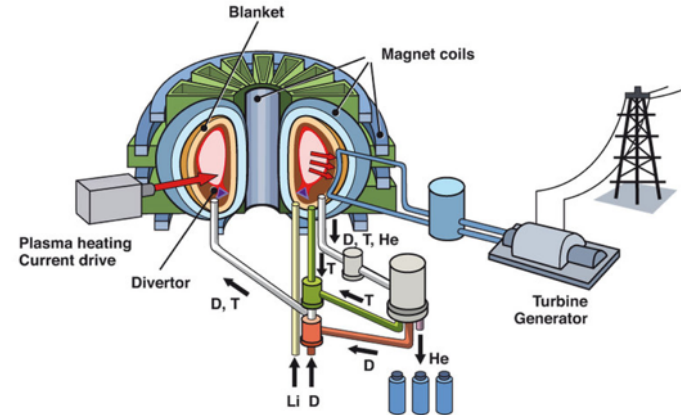


Inertial - Laser/beam



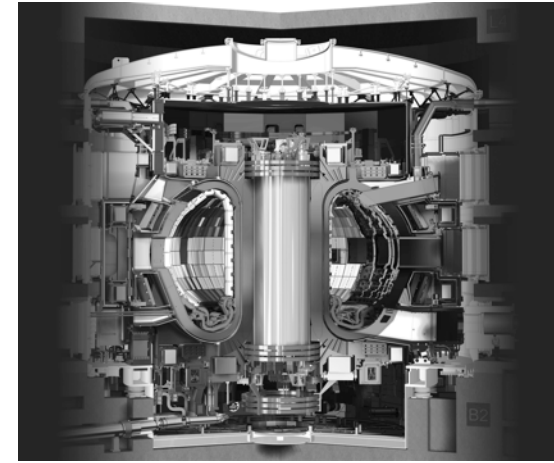
Electricity by magnetic confinement

TOKAMAK



WORLDWIDE NUCLEAR FUSION

ITER



Main construction milestones:

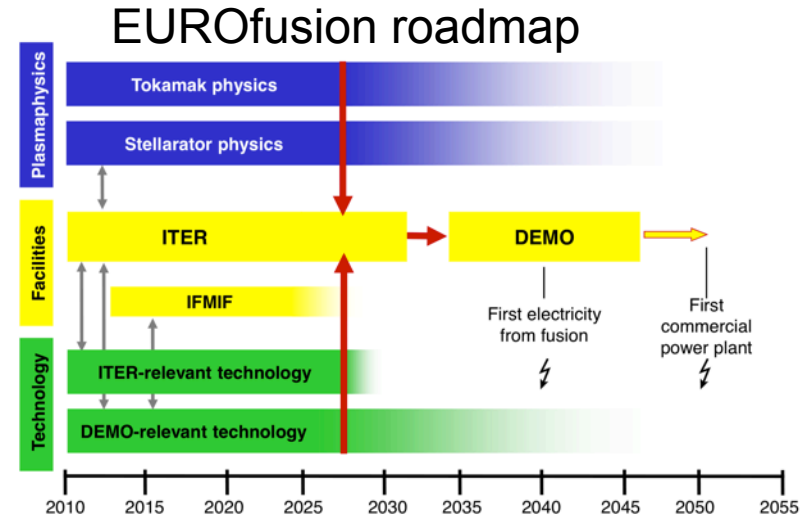
- 2006 Signature of the ITER Agreement
- 2007-2009 Land clearing and levelling
- 2010-2014 Ground support structure and seismic foundations for the Tokamak
- 2014-2021 Construction of the Tokamak Building (access for first assembly activities in 2018)
- 2010-2021 Construction of the ITER plant and auxiliary buildings for First Plasma
- 2018-2025 Assembly phase 1
- Dec 2025 Operations: First Plasma**

- Weight: 23000 tonn
- Plasma Temperature: 150 million °C
- Fusion Output Power: **500 MW**
- Plasma volume: 840 m³
- Plasma Major radius= 6.2 m
- Toroidal magnetic field on axis: 5.3 T
- Heating Power: 50 MW
- Steady-State operations (1000s)
- Site: 42 hectares (3 Mm³ rocks moved)
- Cost: **€18 - 22 Billion**

EU NUCLEAR FUSION ROADMAP

EUROfusion (2014-2018): *the European Consortium for the Development of Nuclear Fusion Energy', manages and funds European nuclear fusion research activities on behalf of EURATOM*

- ✓ 30 EU Research Organizations and Universities from 26 EU countries + Swiss and Ukraine
- ✓ 150 Linked Third Parties in charge through Consortium members
- ✓ Research field: thermo-nuclear plasmas controlled by confinement magnetic
 - Experiments supported
 - Tokamaks: JET(?), JT-60 SA(BA), AUG,...
 - Stellarators: W7-AS, Wendelstein-7x
 - Nuclear Reactors: ITER (500 MW), DEMO
 - Test facilities: DTT, IFMIF(BA)



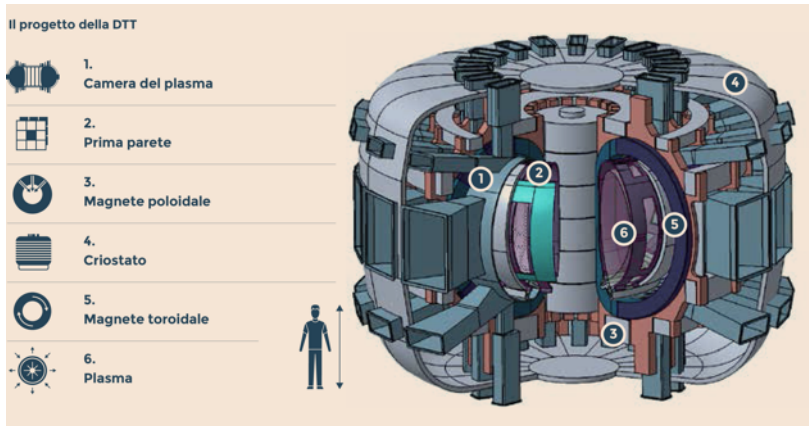
Divertor Tokamak Test Facility

The Italian Fusion Project

ENEA – CNR – INFN – CREATE



- 9 candidate sites (Apr.10th 2018)
- Construction: 7 years
- Operations: 25 years
- Start 2018



Finanziamenti	Milioni di euro
<i>Prestito erogato o nel piano Junker o tramite BEI/Innofin (25 anni)</i>	250
<i>Laboratori coinvolti</i>	30
<i>Contributo in natura da partner Cinesi</i>	30
<i>Contributi Nazionali</i>	130
<i>EUROfusion</i>	60
Totale	500

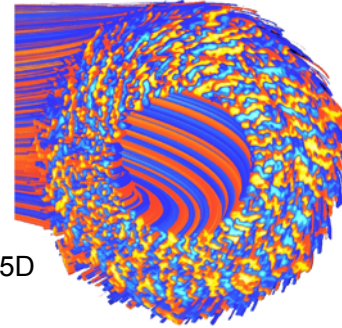
Nuclear Fusion Advanced Computing

Nuclear Fusion reactor with Magnetic Confinement Plasmas

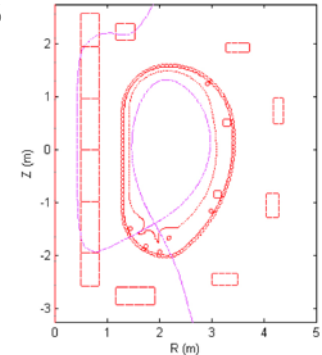
Plasma Physics:

- Turbulence (Gyro-kinetic codes), Edge
- MHD (Equilibrium, Transport, Instabilities)
- Heating, Fast particles

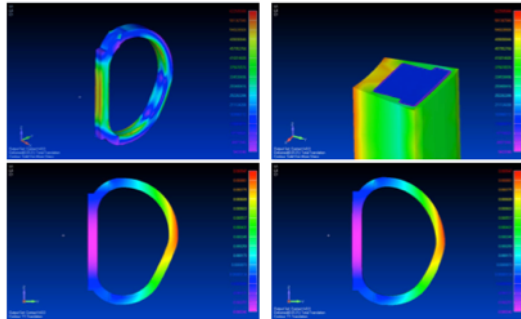
GYSELA 5D



SN scenario @ t=100s: $I_p=6$ MA, $\beta_{pol}=0.43$, $q=0.89$, $\Psi_b=-5.58$ Vs



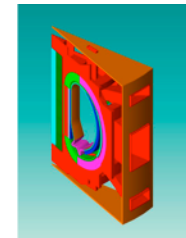
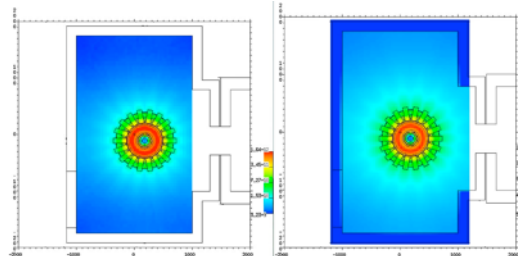
DTT equilibrium



DTT: 3D stress analysis

Reactor technologies:

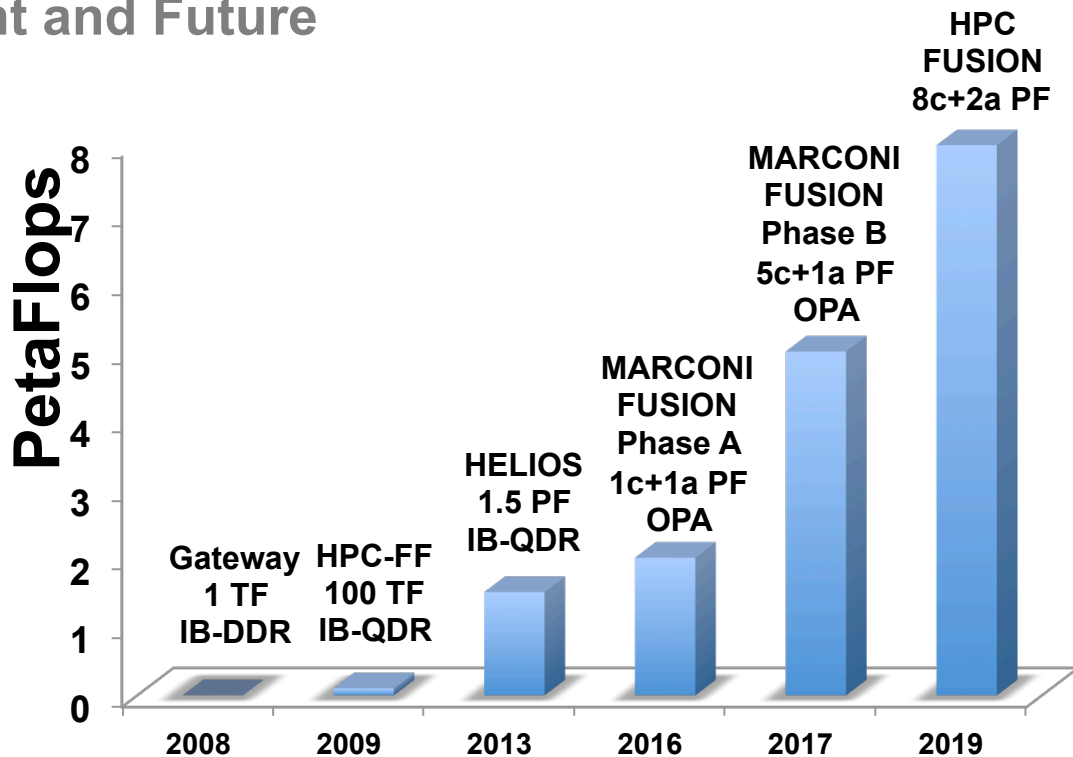
- Neutron Transport: MCNP: Montecarlo N-Particle Transport
- Materials: DFT: Density Functional Theory for Radiation Damage
- Structural Analysis : FEM (Ansys,Comsol Multiphysics)



DTT: 3D MCNP analysis

HPC FOR European Nuclear Fusion Research

Past, Present and Future



MARCONI FUSION – HPC dedicated to EUROfusion

The EUROfusion requests

- ✓ STEP 1: **4 Pflops** Jan.2017 to Dec.2018
- ✓ STEP 2: **8 Pflops** Jan.2018 to Dec.2019 (**Tender ongoing**)

STEP 1: MARCONI FUSION From: **Jul.2016 to Dec. 2018**

The Stackholders

ENEA is member of EUROfusion Consortium and national coordinator of Nuclear Fusion research

CINECA is the national TIER 0 for HPC, PRACE member, Linked Third Party of EUROfusion

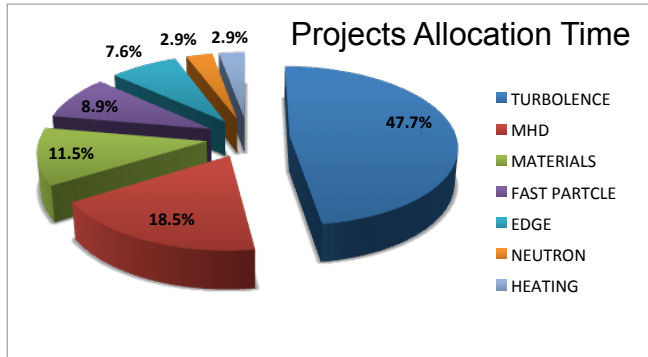
2015: ENEA – CINECA agreement: ENEA CRESCO 6 (0.7 Pflops SKL)



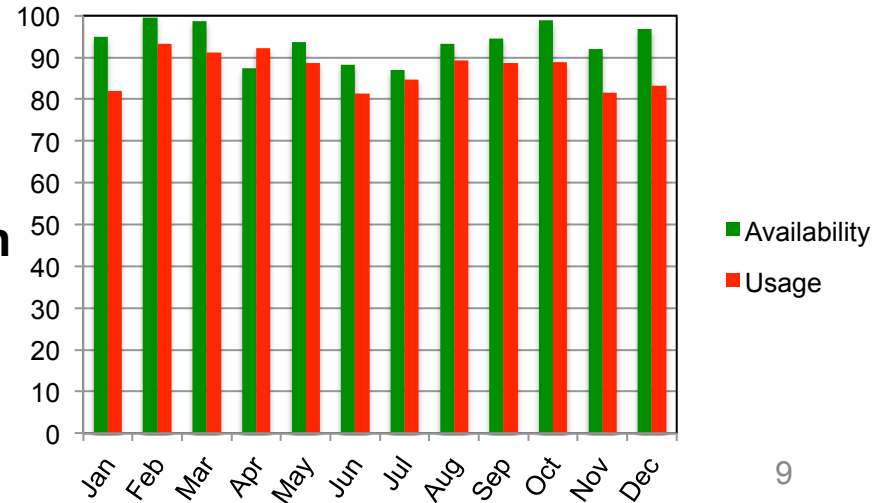
MARCONI FUSION Operations

Project Implementing Agreement – Service Levels

- KPIs:
 - HPC system: Availability (>97 %), Usage (>85 %)
 - ICT infrastructure: Network (WAN:10Gbps) – Long Term Storage
 - Users Support
- Operation Committee monthly meeting – Quarterly report
- Allocation Committee: call for HPC projects (annual issue)
- Project Committee (Decisions)



2017 Production



Conclusions

MARCONI cited in fusion papers

P.Donnel et al. *A multi-species collisional operator for full-F global gyrokinetics codes : Numerical aspects and validation with the GYSELA code.*

A.Biancalani et al. *Cross-code gyrokinetic verification and benchmark on the linear collisionless dynamics of the geodesic acoustic mode.*

M. Raghunathan et al. *Heavy Impurity Confinement in Hybrid Operation Scenario Plasmas with a Rotating 1/1 Continuous Mode.*

G. De Masi et al. 2018 Nucl. Fusion 58 046007: *Density and magnetic fluctuations in type III-ELM pedestal evolution in JET: experimental and numerical characterization.*

M. Oberparleiter et al. *Impact of fast particles and nonlocal effects on turbulent transport in plasmas with hollow density profiles.*

M. R. Hardman et al. *Modelling Coupled Ion and Electron Scale Turbulence in Magnetic Confinement Fusion Plasmas.*

N.Tronko et al. *Verification of Gyrokinetic codes: Theoretical background & Numerical implementations.*

T. Hayward-Schneider, Ph. Lauber *Nonlinear energetic particle transport by Alfvén eigenmodes and sensitivity study of hybrid-gyrokinetic physics models.*

G. J. Wilkie et al. *First principles of modelling the stabilization of microturbulence by fast ions.*

A. Biancalani et al. *Saturation of energetic-particle-driven geodesic acoustic modes due to wave-particle non-linearity.*

S.Pamela et al. *Recent Progress in the Quantitative Validation of JOREK Simulations of ELMs in JET.*

I. Voitsekhovitch et al. *Fusion Science and Technology Recent EUROfusion Achievements in Support of Computationally Demanding Multiscale Fusion Physics Simulations and Integrated Modeling.*