Lo sviluppo delle tecnologie e il contributo scientifico a livello italiano e regionale

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Campus di Padriciano , Trieste , 4 giugno 2025

L'ENERGIA NUCLEARE PER LO SVILUPPO SOSTENIBILE. SCENARI POSSIBILI - Sistema Scientifico e dell'Innovazione del FVG

Consorzio RFX

Consiglio Nazionale delle Ricerche

ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

INFN Istituto Nazionale di Fisica Nucleare

Università degli Studi di Padova

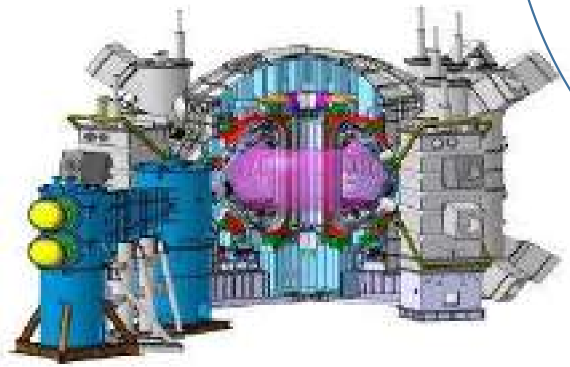
Acciaierie Venete

CNR - Research Area, Padova

CRFX main programs

RFX-mod2 / RFP and Tokamak physics

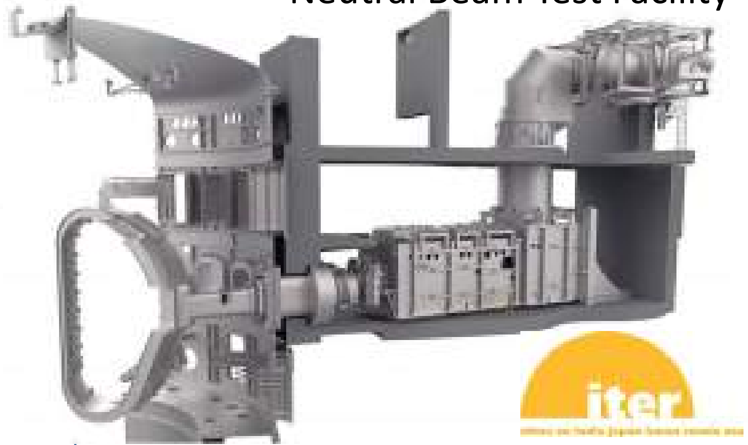
Broader Approach
JT60-SA

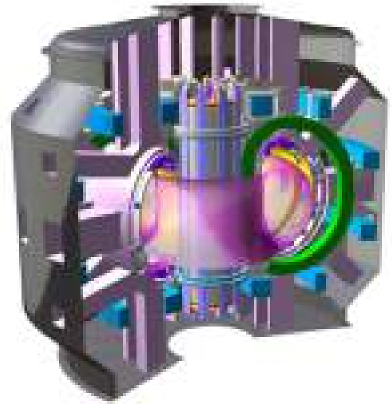


Higher Education:

- Master Students
- PhD Programme in Fusion Science and Engineering

Neutral Beam Test Facility

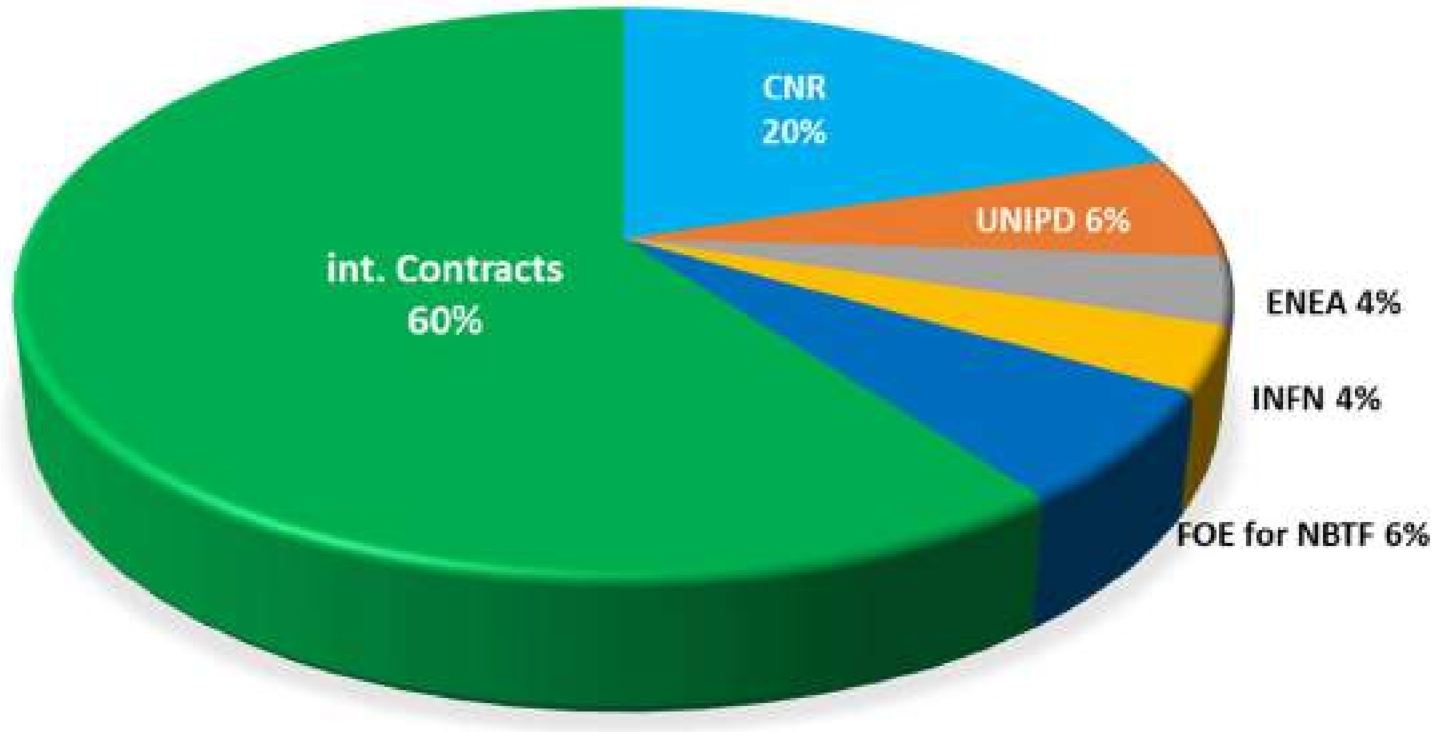




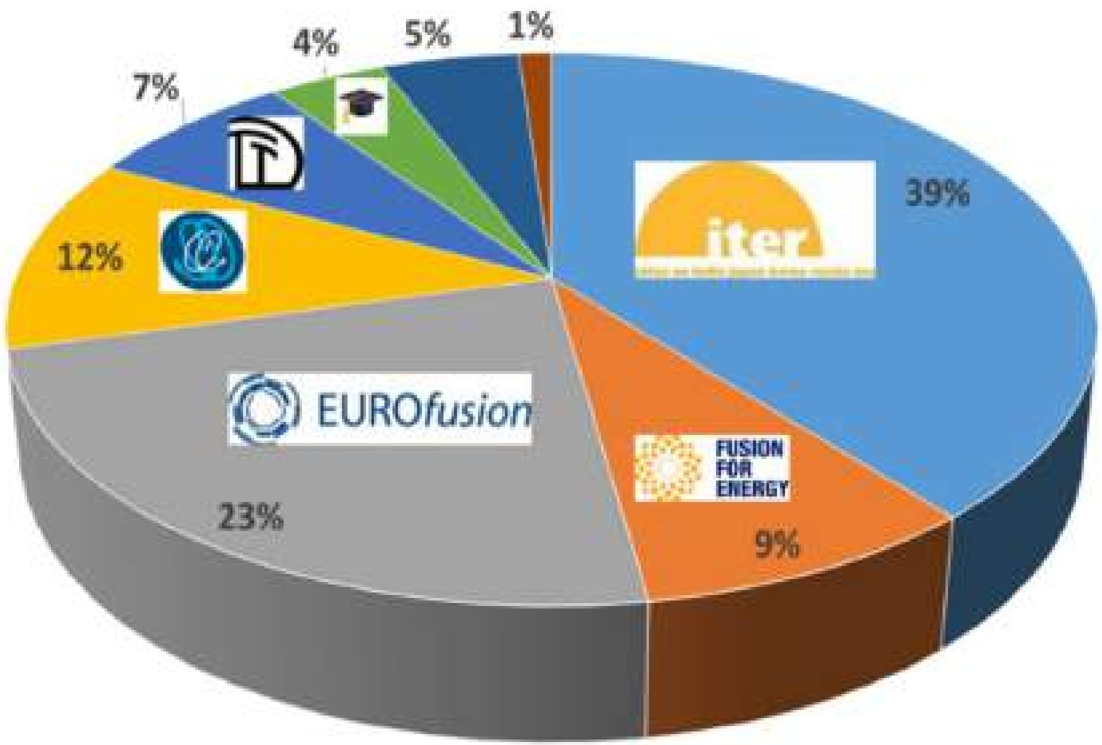
Partner di DTT
Other EUROfusion facilities
and DEMO

Ripartizione finanziamenti internazionali e nazionali

(inclusiva del costo del personale assegnato dai soci)

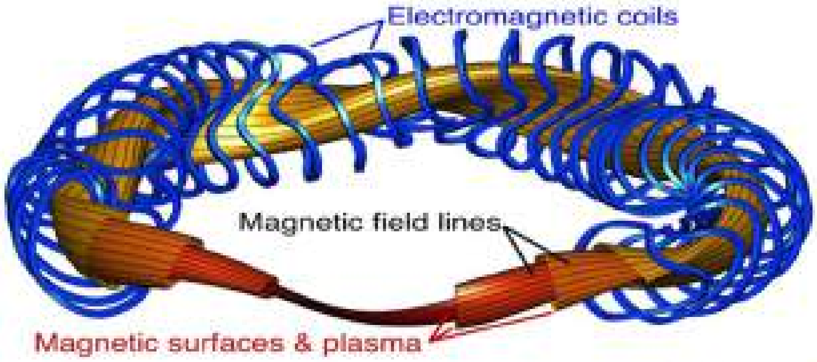


Ripartizione sponsors delle attività

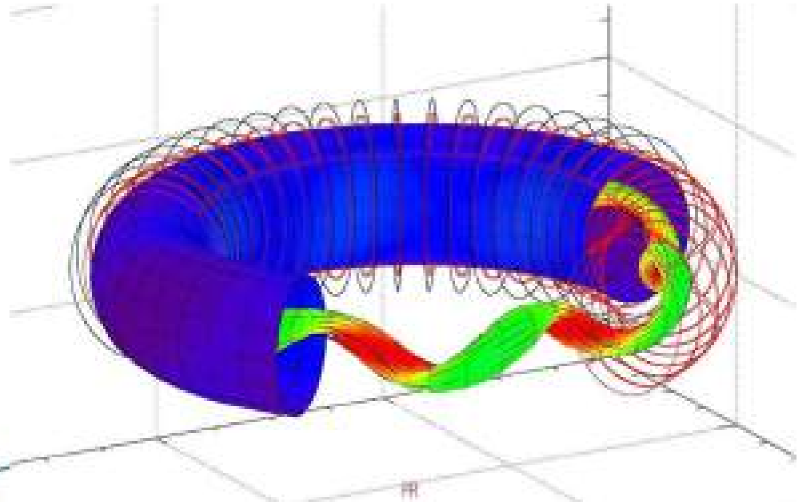


CRFX è comparabile come attività ai maggiori laboratori europei

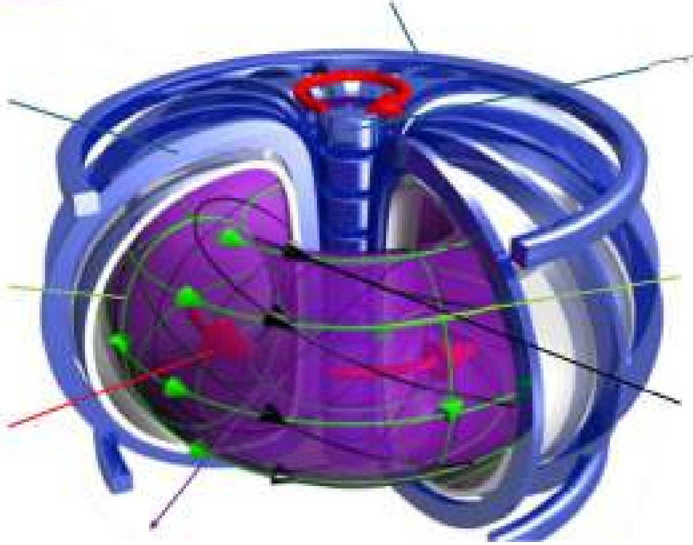
Various solutions for magnetic confinement



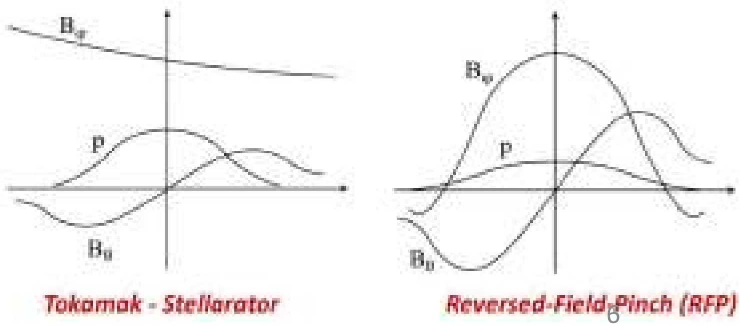
Stellarator



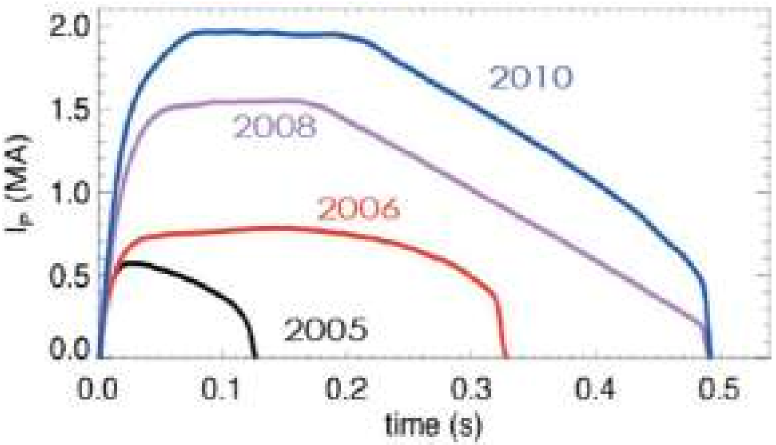
Reversed Field Pinch

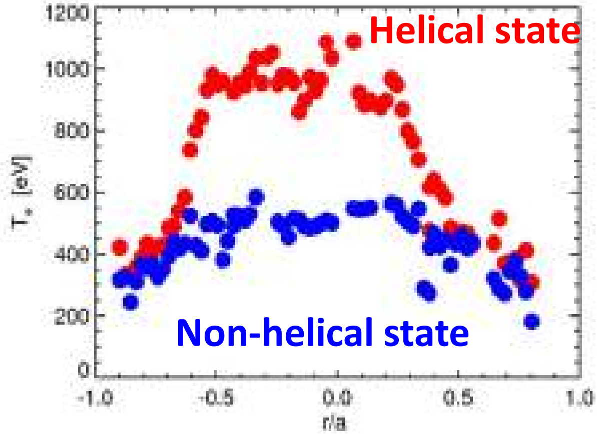


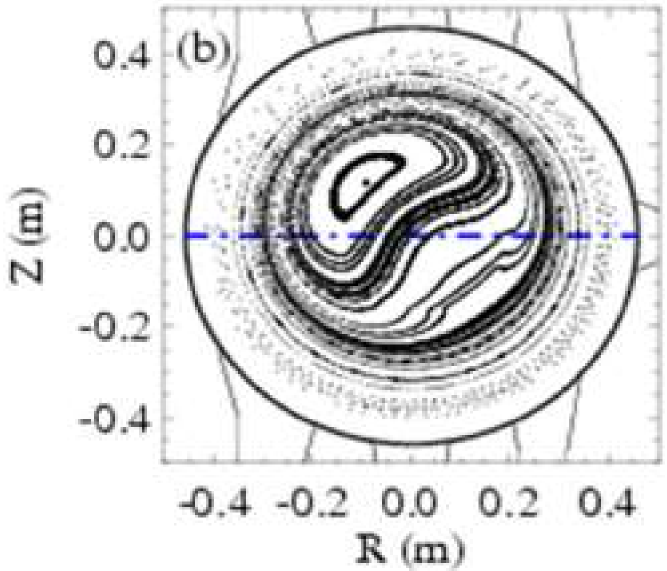
Tokamak

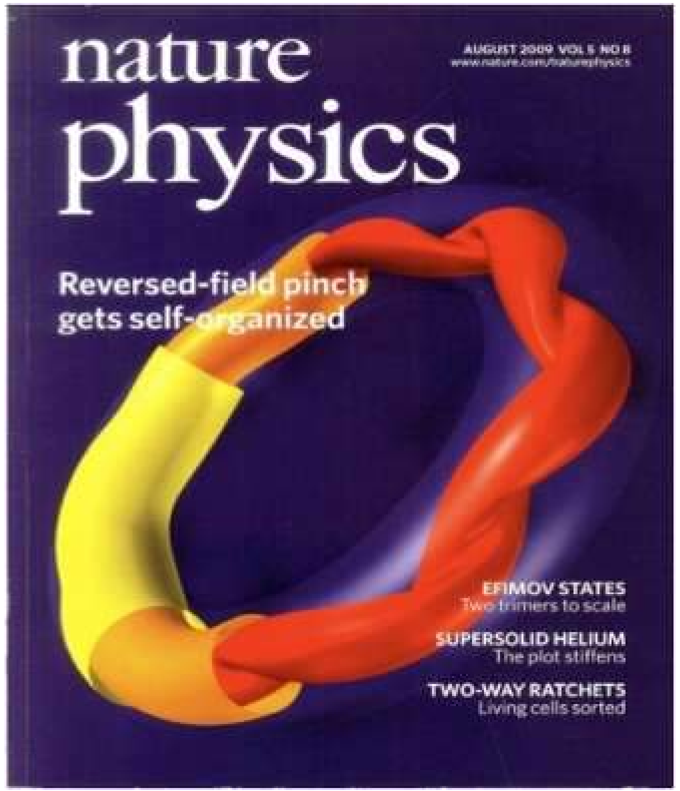


L'esperimento RFX : un nuovo paradigma per l'RFP







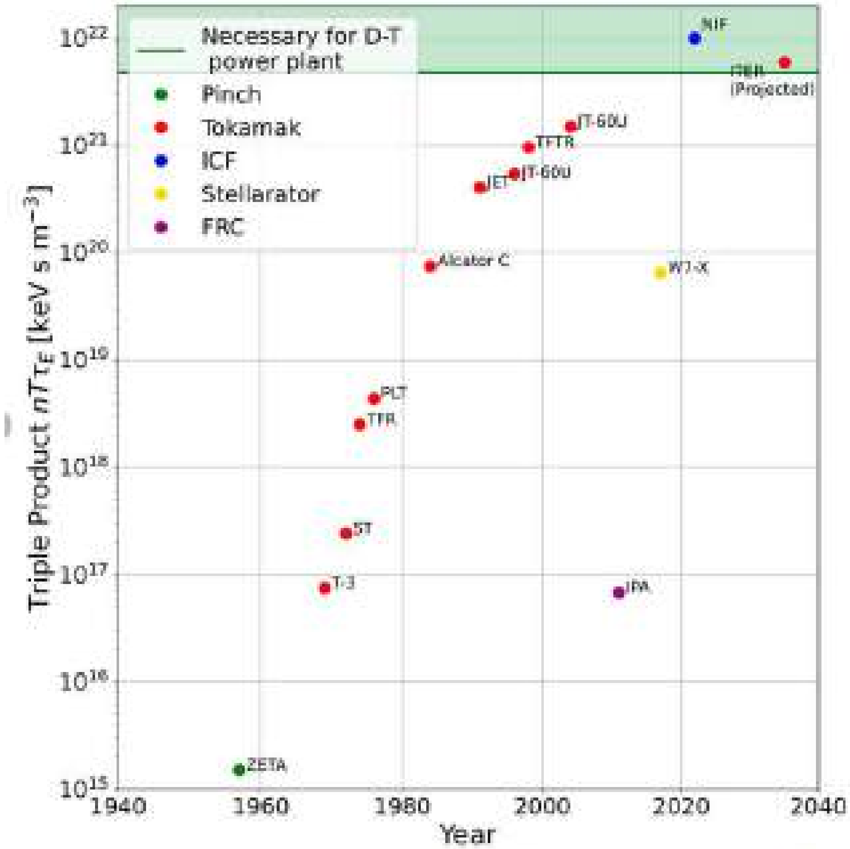


The triumph of control.

Feedback control required for

- Plasma Current
- Plasma Density
- Plasma position and shape
- MHD instabilities
- Correct drifts towards dangerous or inefficient regions of the parameter space

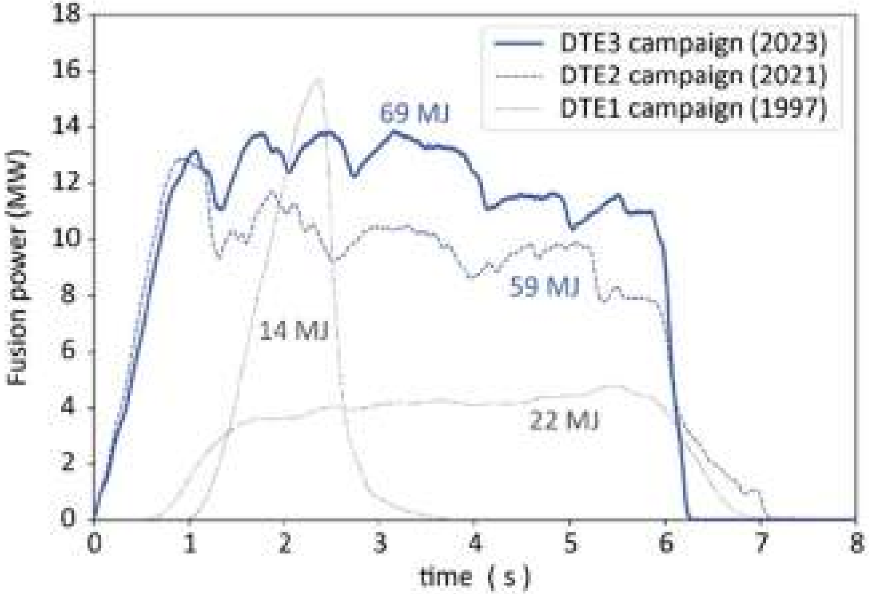
Progress of $n\, T\, \tau_E$ over the years



Triple product achieved by different fusion devices along the years. The green region depicts the triple product required to achieve ignition. Data from: NIF (approximated) (Bishop, 2022), ITER (Mukhovatov et al., 2003), JT-60U (Fujita et al., 1998; Kishimoto et al., 2005), W7-X (Wolf R. et al., 2019), IPA (Slough et al., 2011), TFTR (Hawryluk et al., 1998), JET (JET Team, 1992), Alcator-C (Greenwald et al., 1984), PLT (Grove et al., 1977), TFR (TFR Group, 1985), ST (Stodiek, 1985), T-3 (Peacock et al., 1969), ZETA (Thonemann et al., 1958).

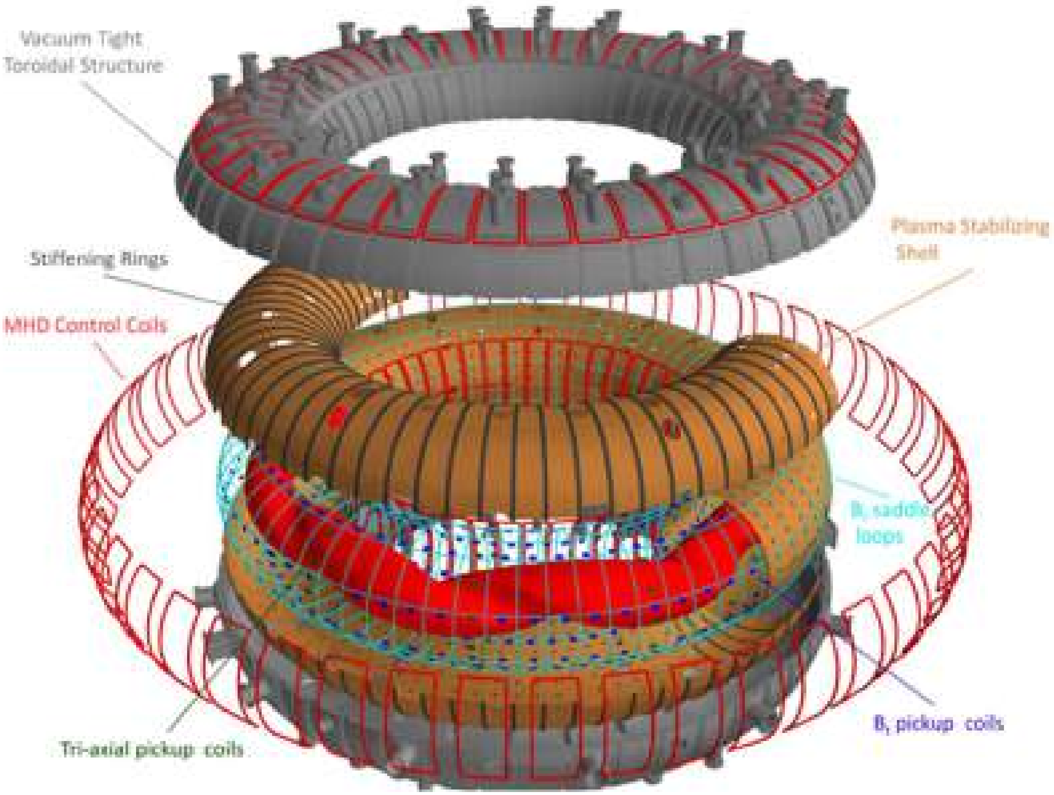
Best results achieved in fusion research

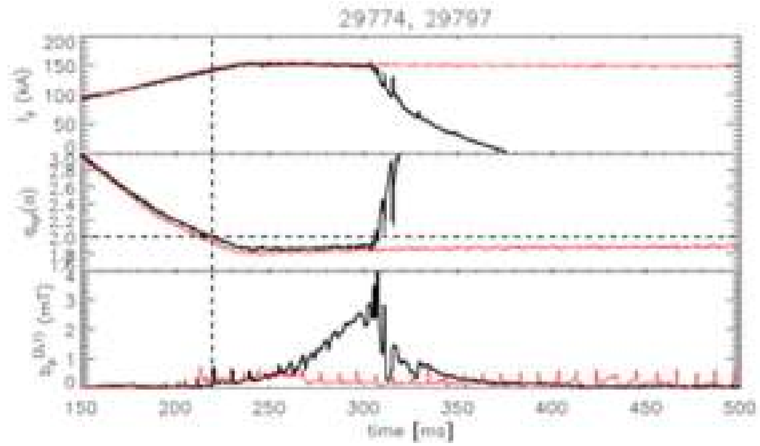
JET/ EUROfusion



1985

RFX-mod2: designed to master MHD feedback control





Example of MHD control in a Tokamak discharge in RFX-mod

Finanziamenti di RFX-mod2. 2016 - oggi

- **2016-2019 Progetto MIAIVO Fondi POR FESR – Regione Veneto**

In collaborazione con il Distretto della Meccanica dell’Alto Vicentino

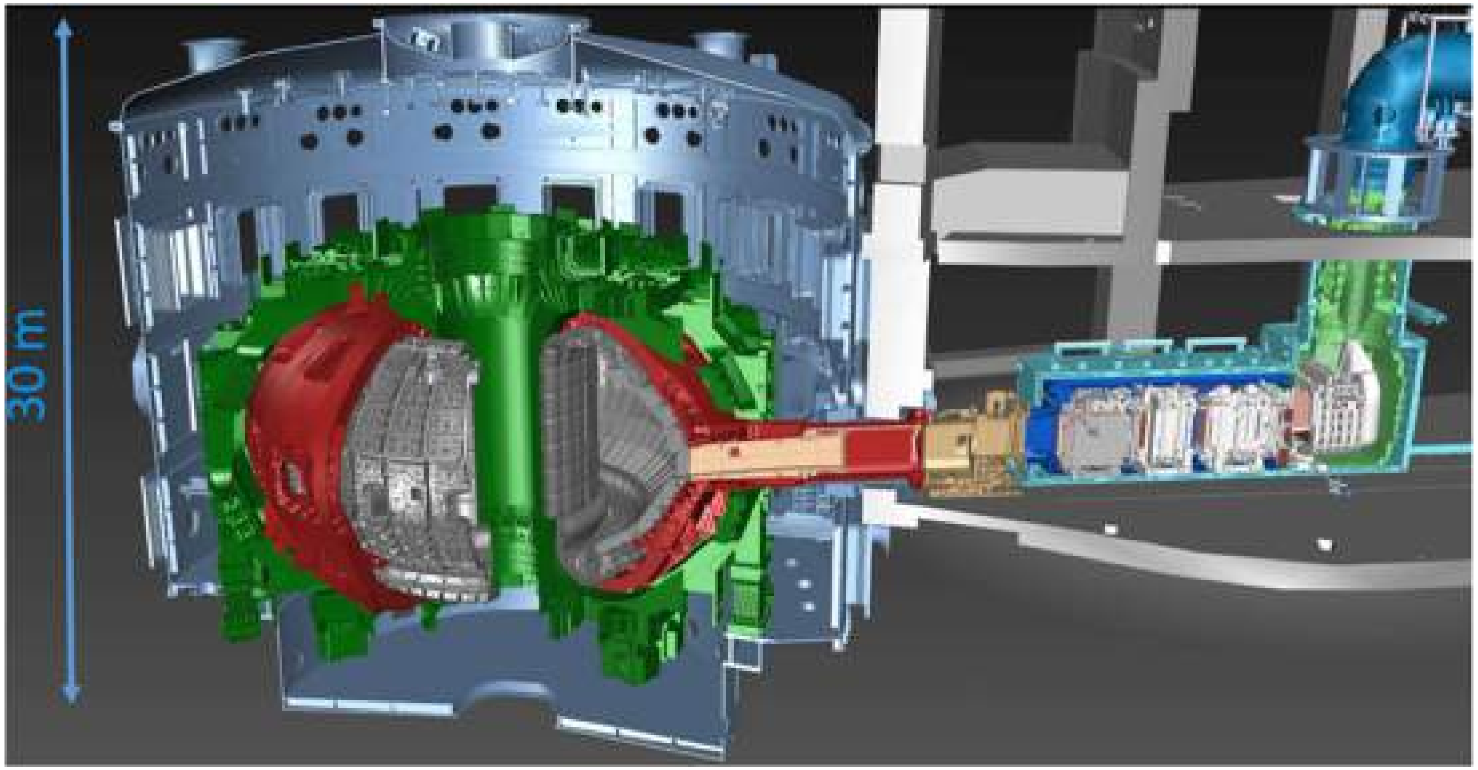
- **2023-2025 Progetto NEFERTARI /PNRR**

- ammodernare gli impianti di RFX-mod2 e dotarlo di diagnostiche innovative
- creare/rafforzare una rete nazionale di laboratori CNR, Università di Napoli e Università di Padova
- contribuire allo sviluppo della scienza e tecnologia della fusione in Italia per contribuire a DTT, ITER e DEMO

- **2025_2027 * Fondi Mission Innovation** dedicati alle tecnologie di fusione per il lungo periodo. In questo ambito una quota delle risorse sarà utilizzata specificatamente per attività di formazione, con l’obiettivo di rafforzare le competenze professionali, tecniche e specialistiche in questo settore

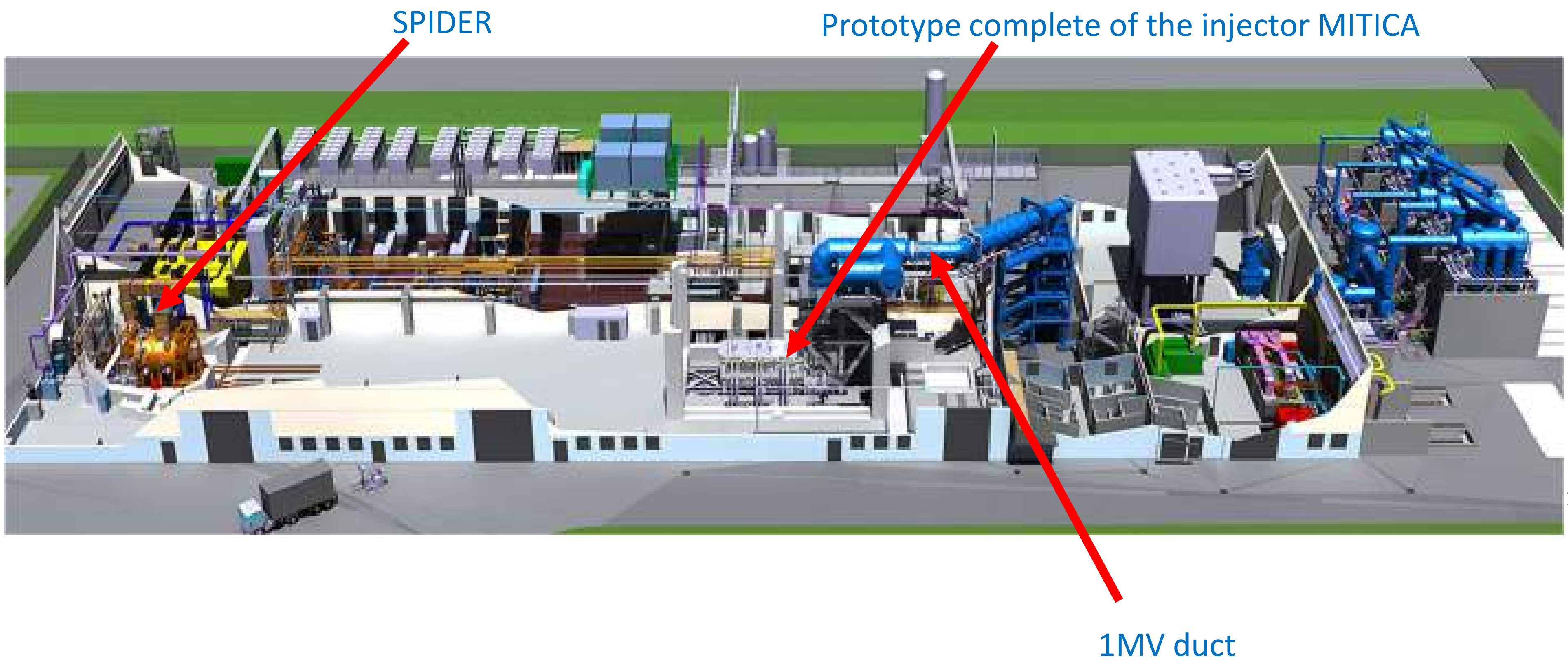
(*) ipotesi

Negative Ion Beam for ITER being built in the Neutral Beam Test Facility in Padova

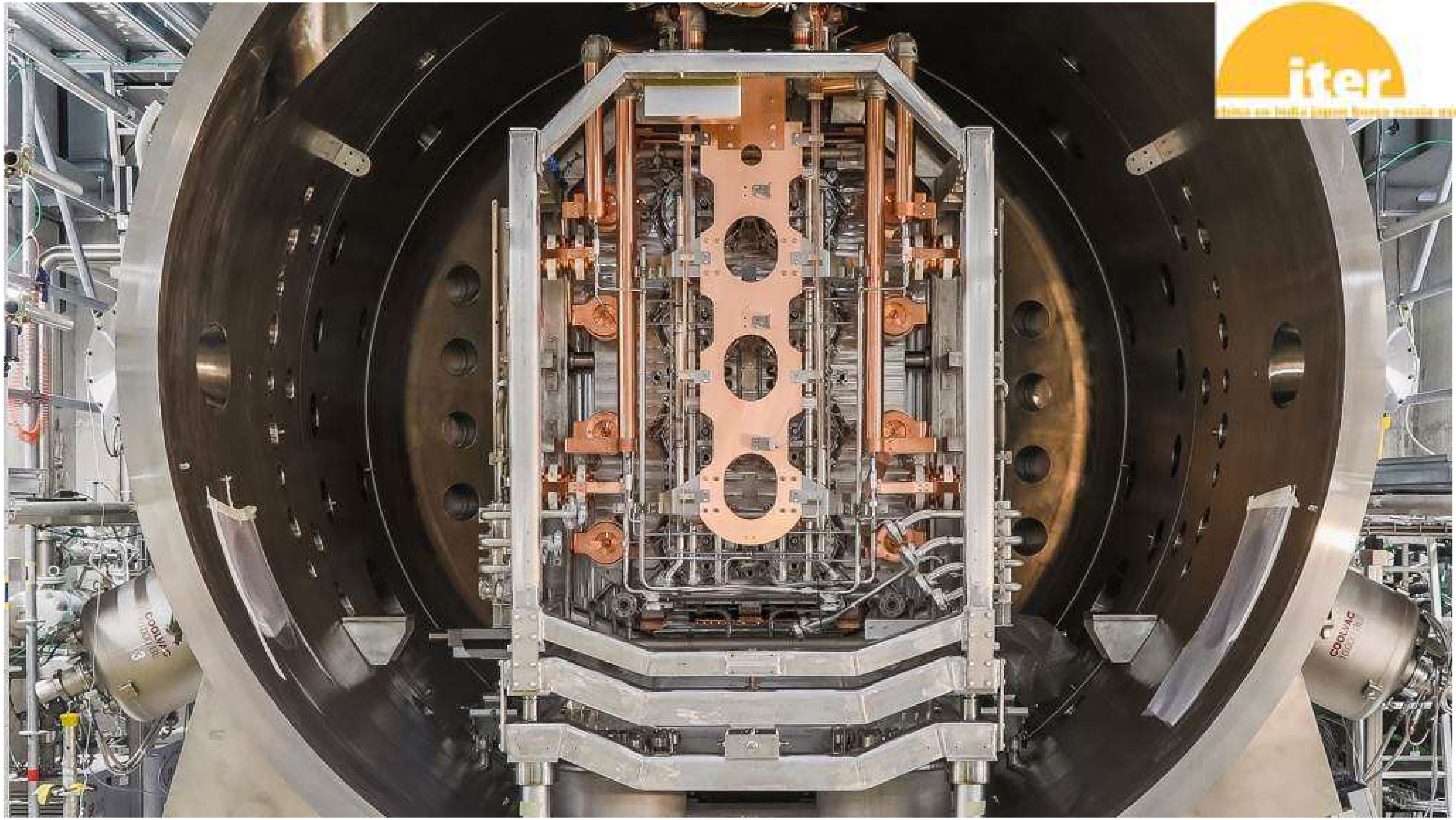


17 MW into the plasma , 1 MV - first of a kind

ITER Neutral Beam Test Facility

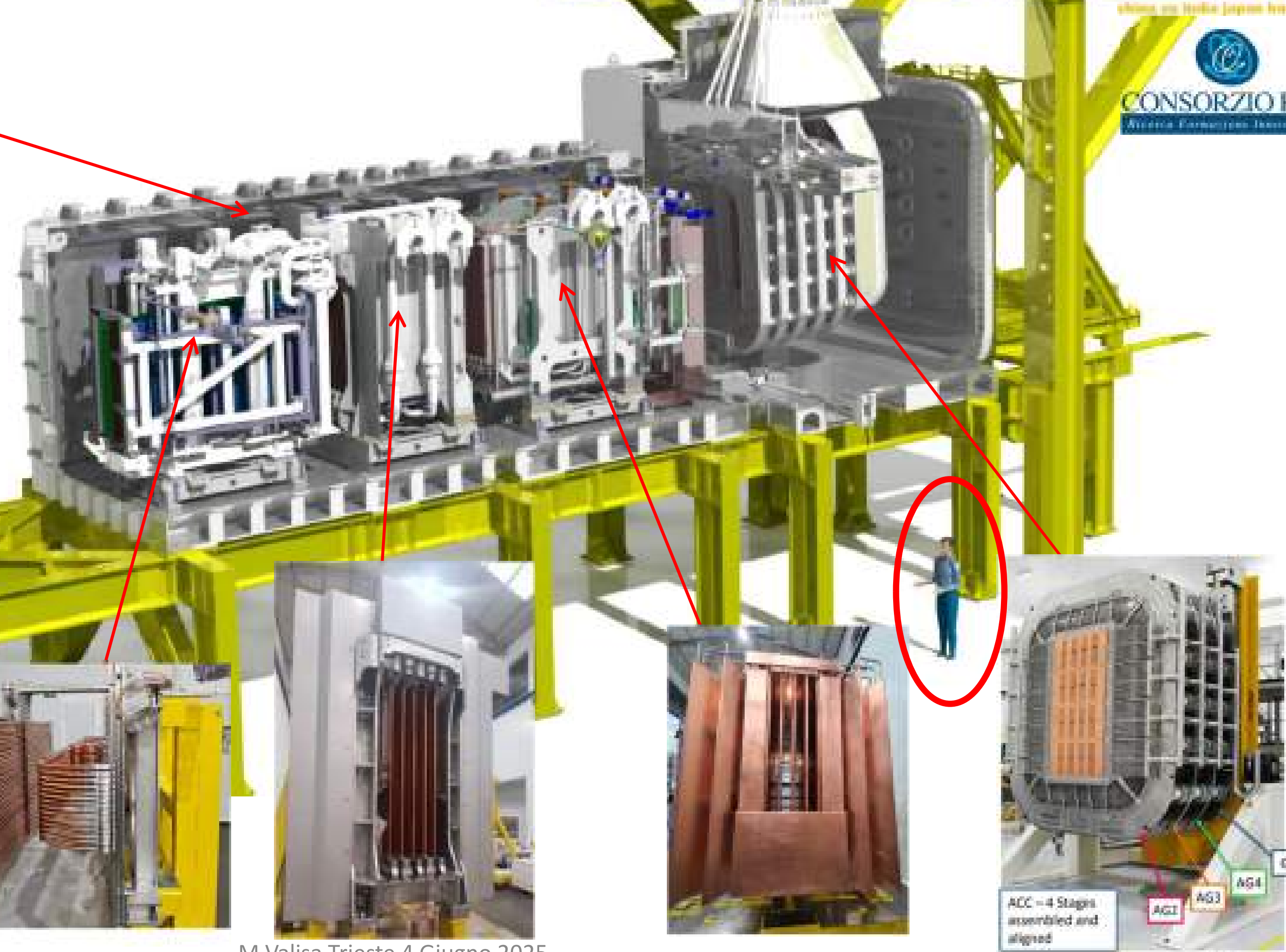


SPIDER . Prototype of the negative ion source for ITER



MITICA

CRYOPUMP

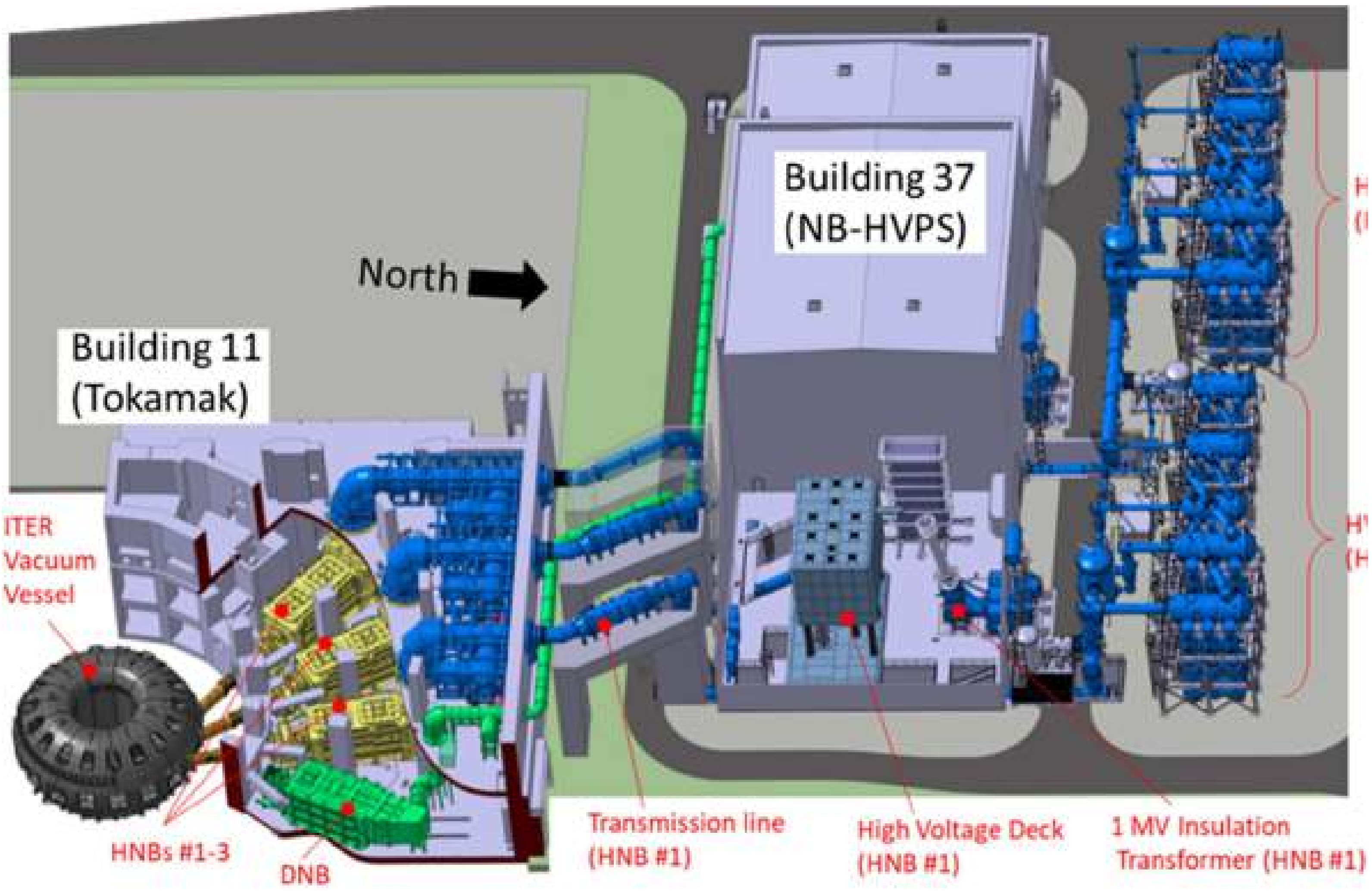


CALORIMETER

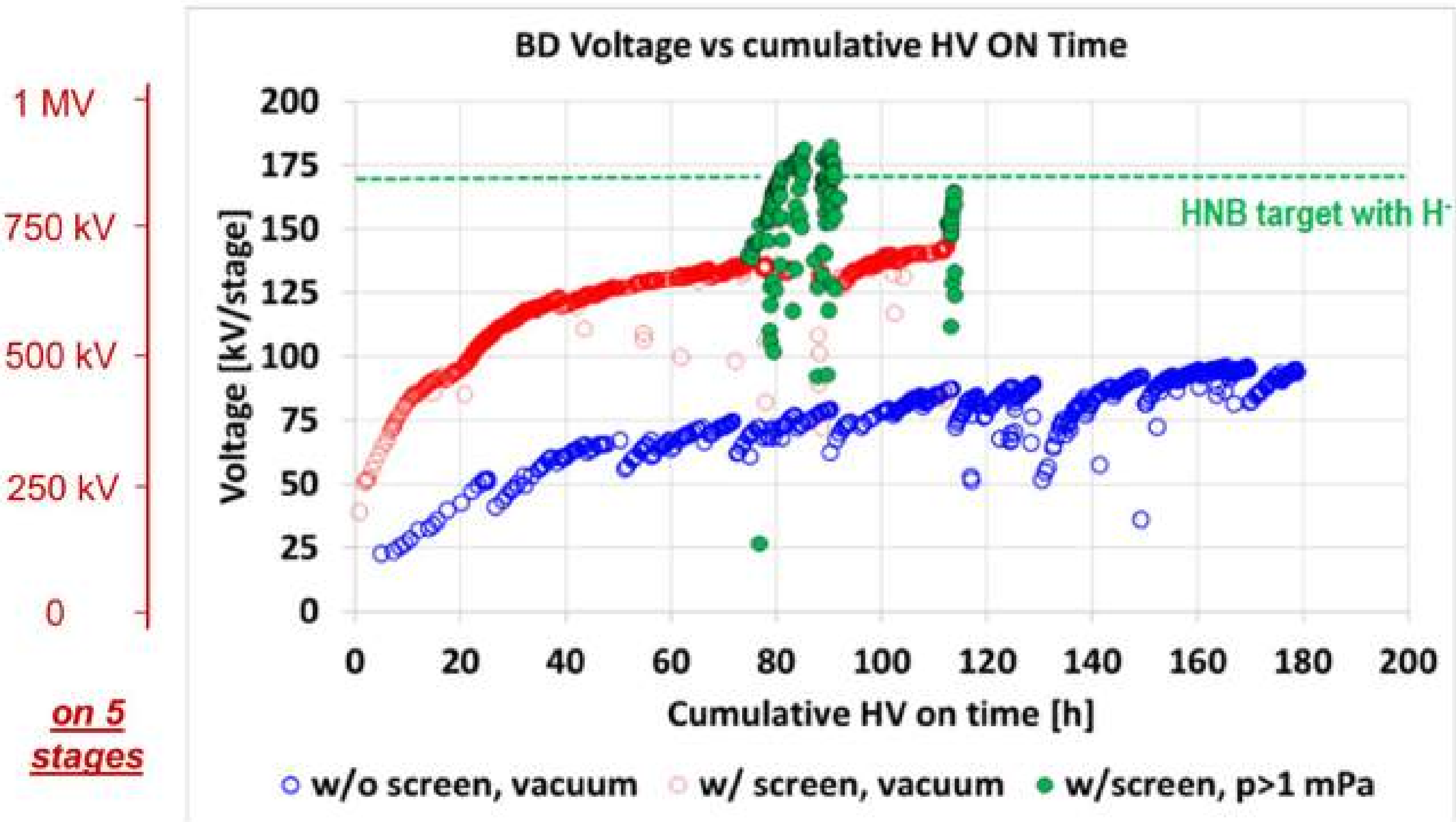
RESIDUAL ION DUMP

NEUTRALIZER

BEAM SOURCE


Building 37
(NB-HVPS)
North
Building 11
(Tokamak)
ITER
Vacuum
Vessel
HNBs #1-3
DNB
Transmission line
(HNB #1)
High Voltage Deck
(HNB #1)
1 MV Insulation
Transformer (HNB #1)


1 MV Faraday cage

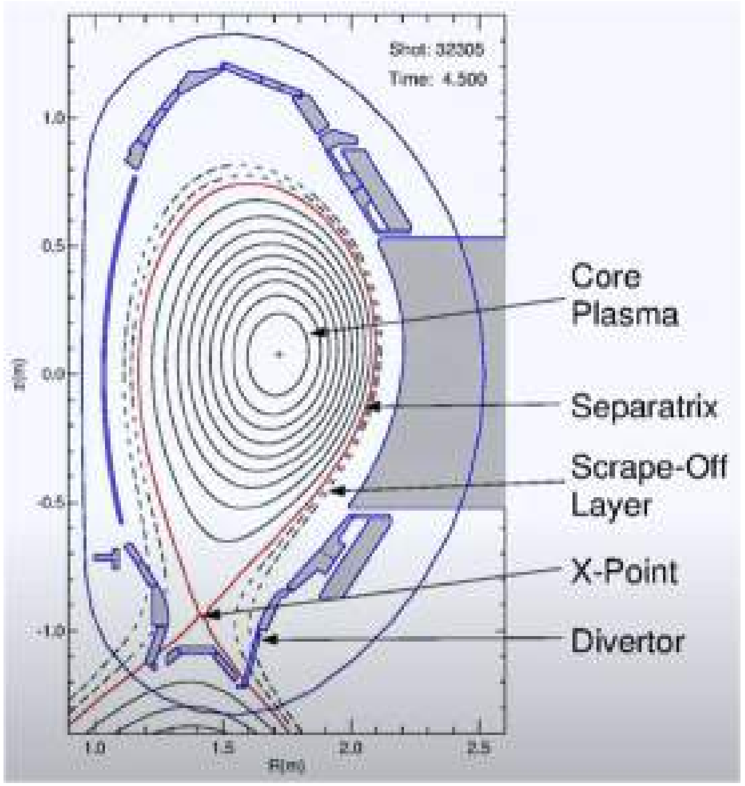


BD Voltage vs cumulative HV ON Time
1 MV
750 kV
500 kV
250 kV
0
on 5 stages
Voltage [kV/stage]
200
175
150
125
100
75
50
25
0
HNB target with H-
0
20
40
60
80
100
120
140
160
180
200
Cumulative HV on time [h]
w/o screen, vacuum
w/ screen, vacuum
w/screen, p>1 mPa

Plasma exhaust

- Reaction products (He4) must be pumped out
- Heat must be removed
- Materials have limited capability

  to withstand large heat loads , < $20 MW/m^2$



The heat flux sustained by the ITER divertor targets is estimated at 10-20 MW/m^2.
That's ten times the heat load of a spacecraft re-entering Earth's atmosphere.

A unique flexible facility, to address one of the gaps towards the realization of a commercial fusion reactor:

- **Power and Particle Exhaust**

Materials

In DEMO, like in future fusion power plants, the deuterium-tritium nuclear fusion reactions will generate neutron fluxes in the order of $10^{18} m^{-2}s^{-1}$ with an energy of 14.1 MeV that will collide with the first wall of the reactor vessel.

A commercial fusion reactor will require materials capable of withstanding 150 dpa (i.e.neutron-induced materials degradation), now an unexplored region.

In IFMIF (International Fusion Materials Irradiation Facility)neutrons will be generated by bombarding liquid lithium with accelerated deuterium ions

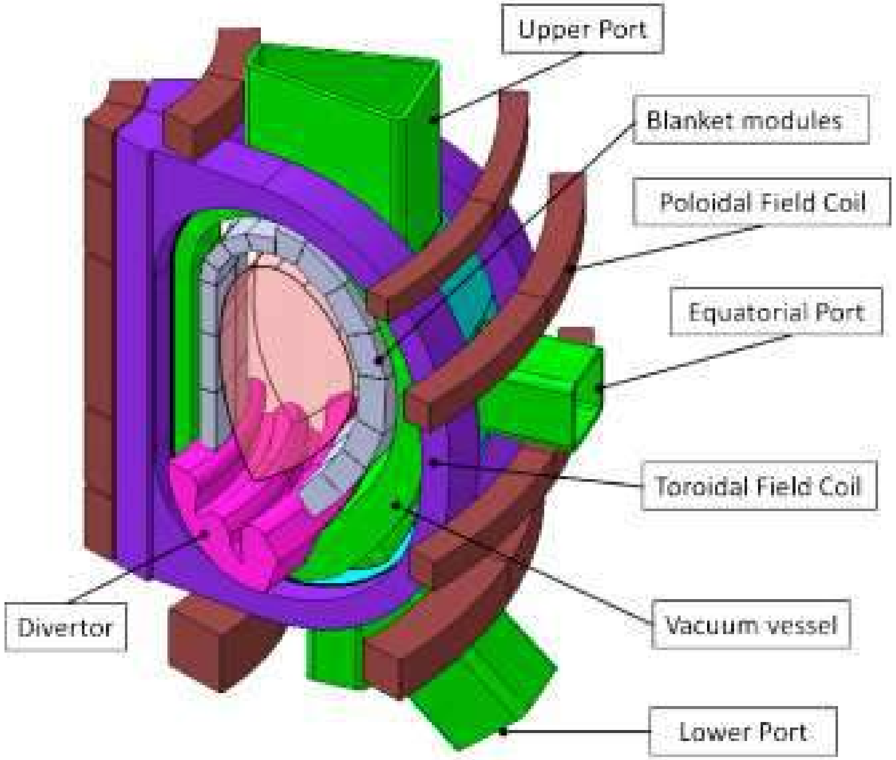
DONES (Demo Oriented Neutron Source) in Spain
A-FNS, in Rokkasho

Breeding Blanket for Tritium production

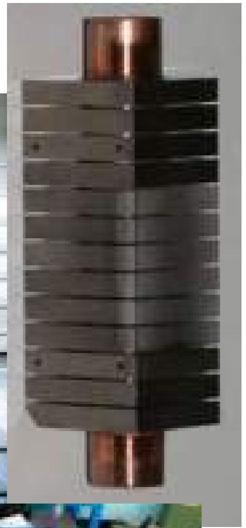
Methods to produce Tritium in a selfsustained way have still to be demonstrated

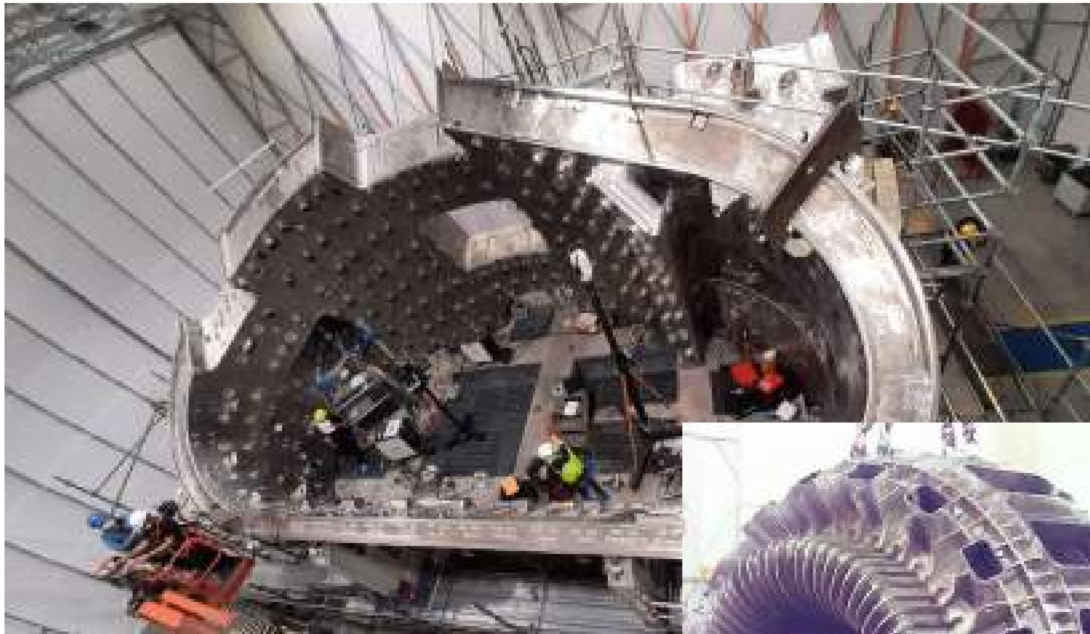
$$^{6}_{3}\mathrm{Li} + ^{1}_{0}\mathrm{n} \longrightarrow ^{3}_{1}\mathrm{H} + ^{4}_{2}\mathrm{He} + 4.8\ \mathrm{MeV}$$

$$^{7}_{3}\mathrm{Li} + ^{1}_{0}\mathrm{n} \longrightarrow ^{3}_{1}\mathrm{H} + ^{4}_{2}\mathrm{He} + ^{1}_{0}\mathrm{n'} - 2.5\ \mathrm{MeV}$$



iter





ANSALDO

walter tosto

mangiarotti

ASG SUPERCONDUCTORS

Criotec

TRATOS

- *” Pour ce qui est de l’avenir, il ne s’agit pas de le prévoir, mais de le rendre possible. “*
- **– Antoine de Saint Exupéry**, *Citadelle,* 1948