MITICA Beam Source
Megavolt ITER Injector & Concept Advancement

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- **MITICA RFX HYSTORY**
- **ITER**
- **PROGETTO MITICA**
- **INFN**

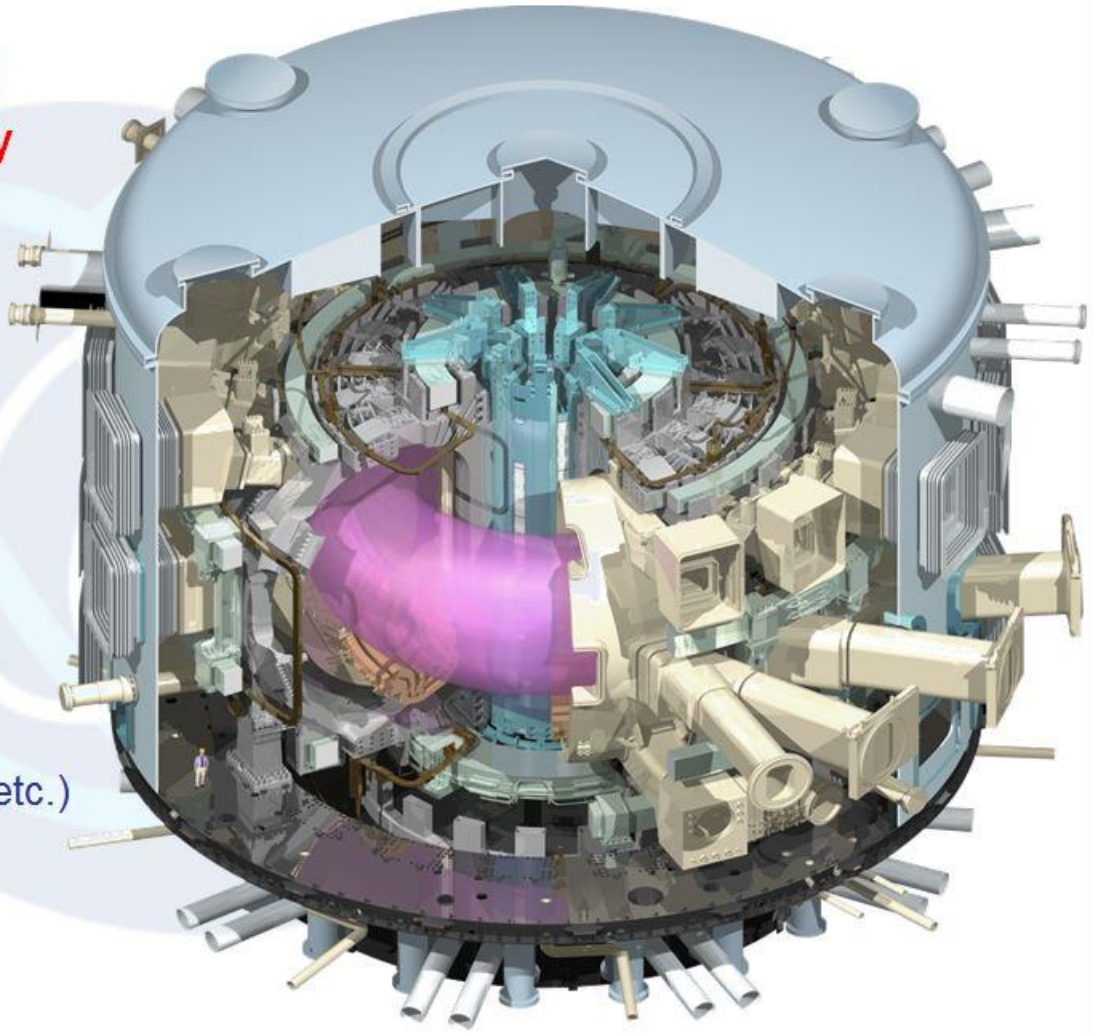
MITICA RFX HYSTORY

- L'ingresso al consorzio RFX è stato voluto dalla Moratti mettendo insieme i tre enti ENEA,CNR e INFN, per realizzare l'iniettore di neutri di ITER.
- L'INFN e' stato ritenuto indispensabile per il progetto in esame per le sue competenze sulla fisica e la tecnologia degli acceleratori.
- **Consorzio RFX**
- **Partners** CNR, ENEA, INFN, Univerista' di Padova e Acciaerie Venete
- **Goals**
  Scientific and technological research activity in the field of controlled thermonuclear fusion, as a possible energy source Development of the RFX Project. Design and realization of the Neutral Beam Injector (NBI) prototype for ITER. Design, development and realization of new technologies, equipment and devices devoted to research activities and industrial developments.
  Training activity of young physicists and engineers in close collaboration with Padova University.
- **Il ministero ha contribuito fino ad ora con 20 Meuro.**
- **Attualmente questo progetto costituisce il maggior contributo Italiano a ITER.**

ITER aims to demonstrate that it is possible to produce energy from fusion

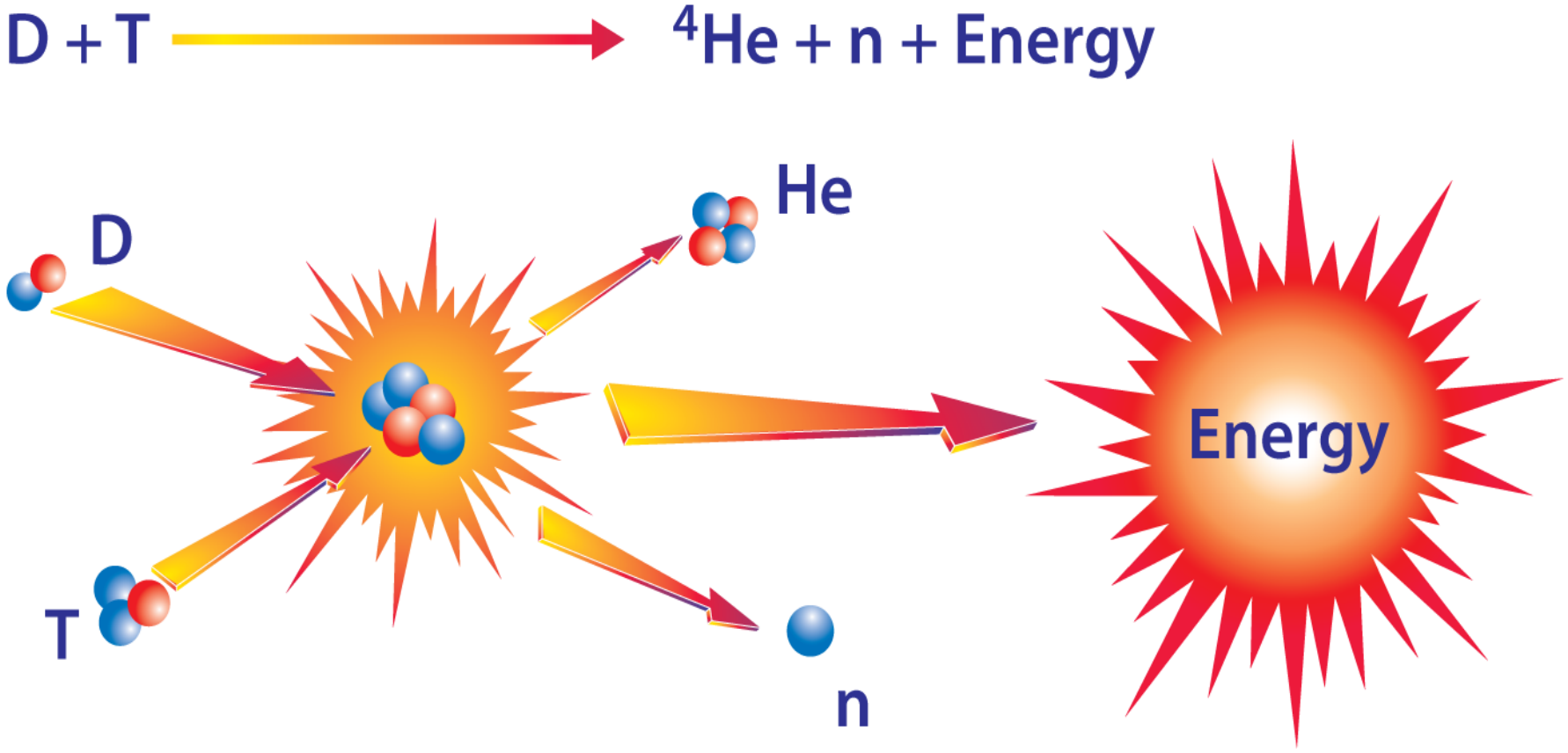
Key objectives

- 500 MW fusion power for some 5 to 8 minutes
- Q>10
- Q>5 in steady state
- Demonstrate key reactor technologies (superconducting magnets, robotics etc.)
- Test key reactor components (divertor, tritium handling system etc.)
- Test “breeding blanket” modules



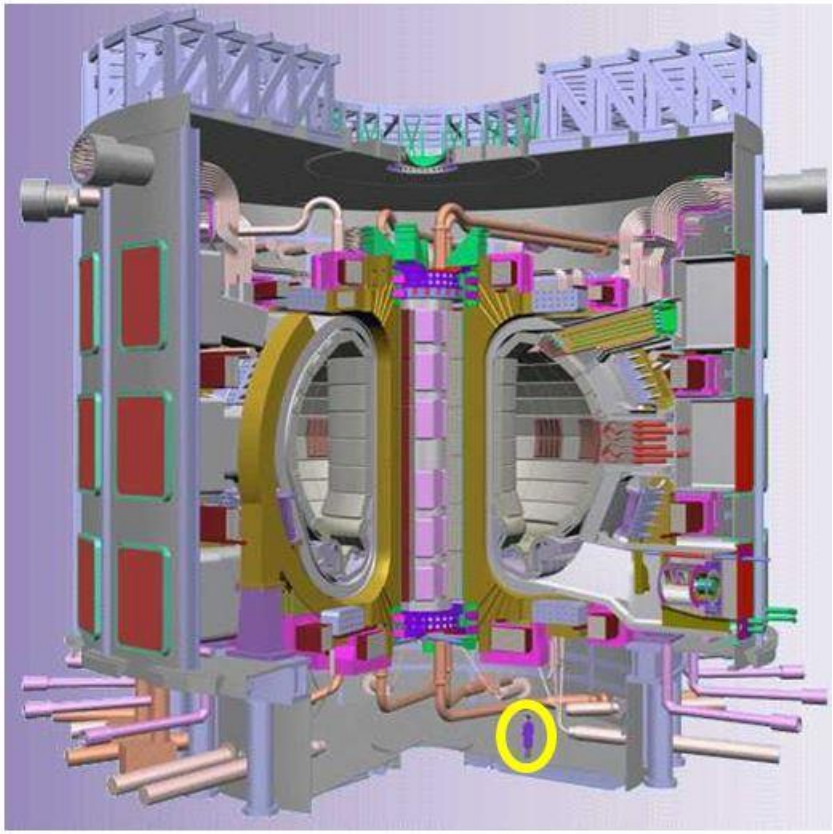
The Fusion Reaction on Earth
"... is not the same as in the Sun"

- **ITER Nuclear fusion**



ITER: International cooperation

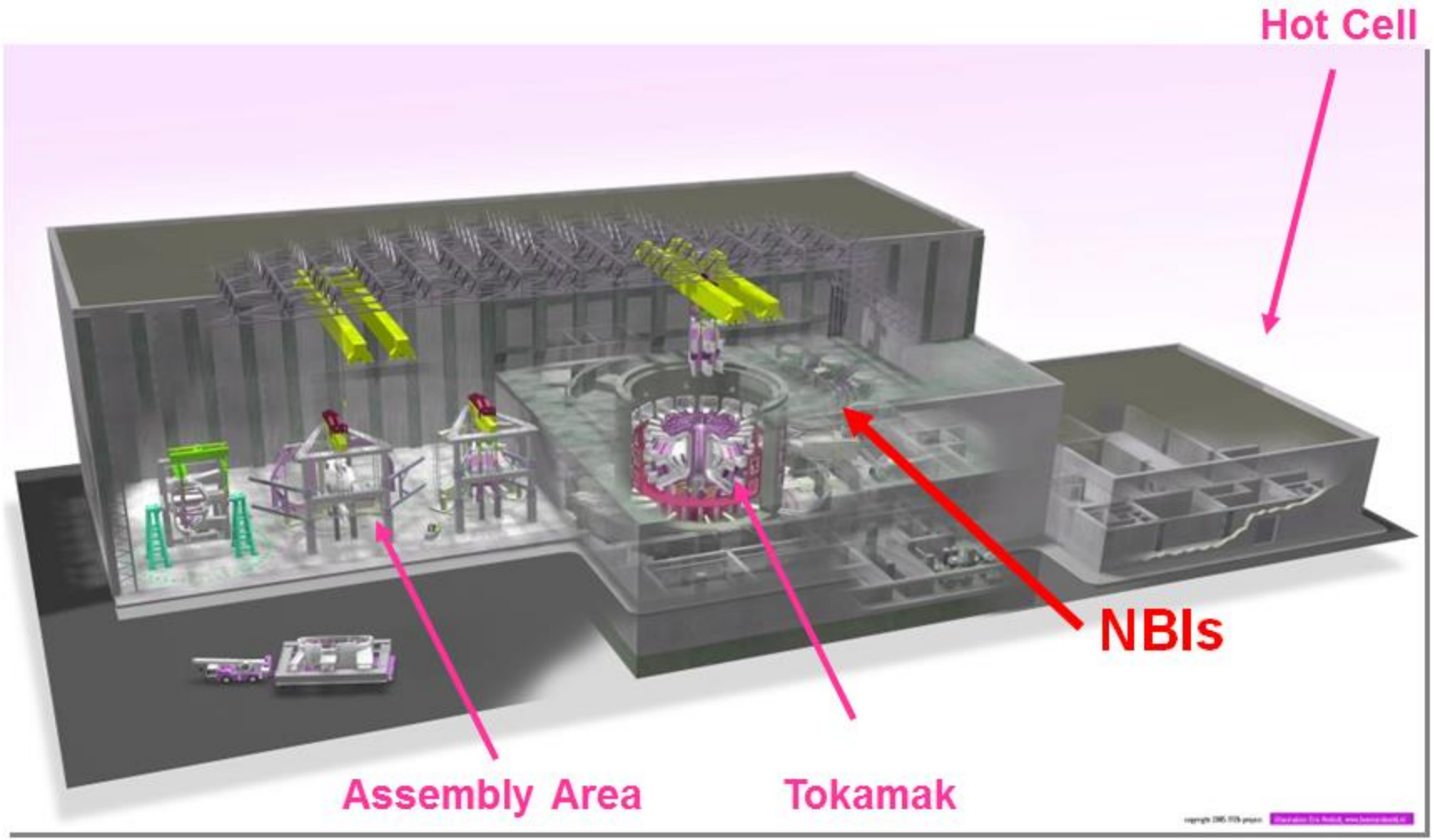
Total fusion power	500 MW
Q = Pot. Out/Pot. In	10
Pulse duration	300 s
Plasma major radius	6,2 m
Plasma minor radius	2 m
Plasma current	15 MA
Toroidal field B_T	5,3 T
Plasma volume	837 m^3
Plasma surface	678 m^2
Tipical plasma temperature	20 keV



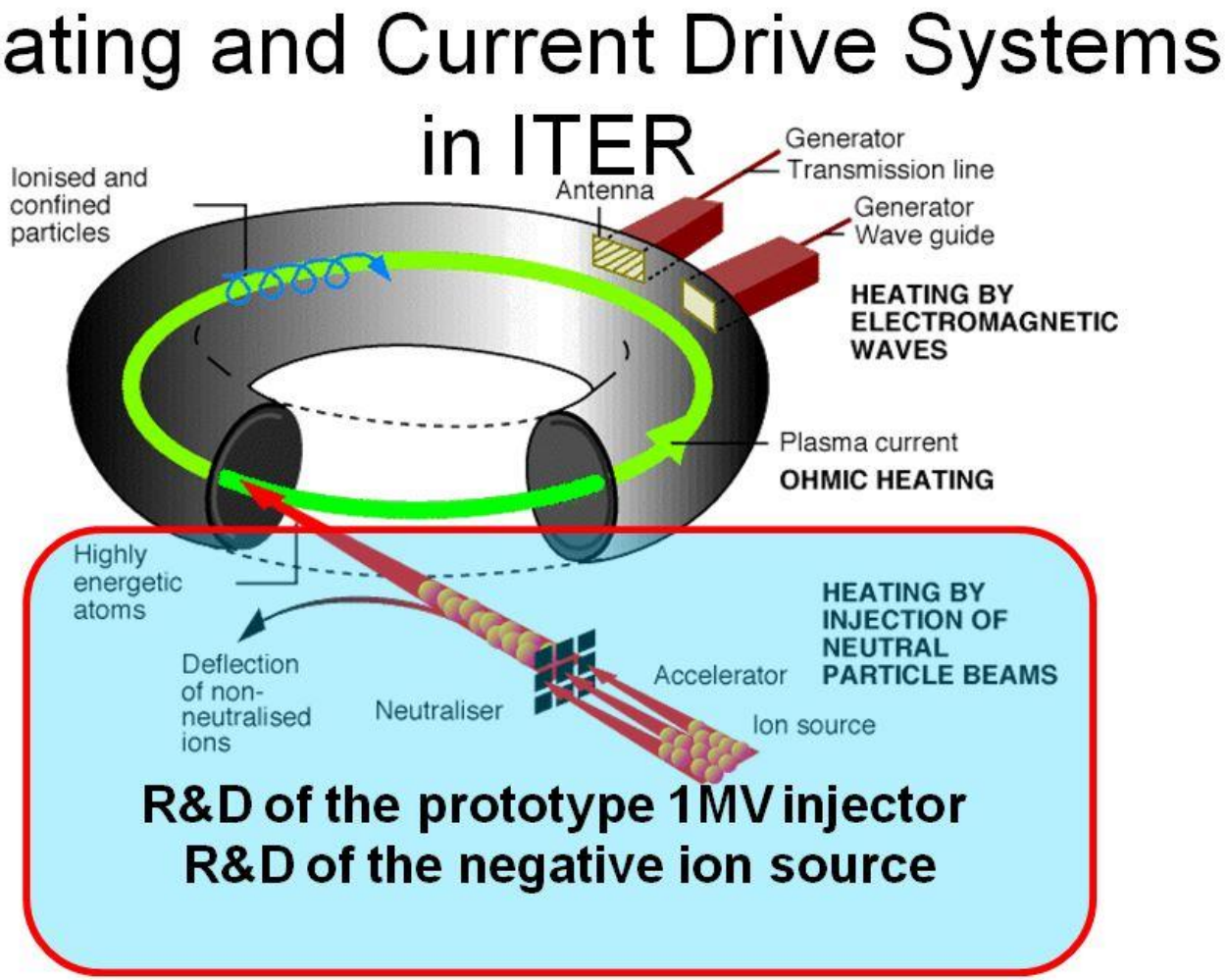
China
European Union
India
Japan
Korea
Russia
United States

hosted by France, ITER is a true world project (50% of world population, 80% of world PIL)

ITER: main buildings



- **PROGETTO MITICA**



ITER: additional heating – Neutral Beam Heating

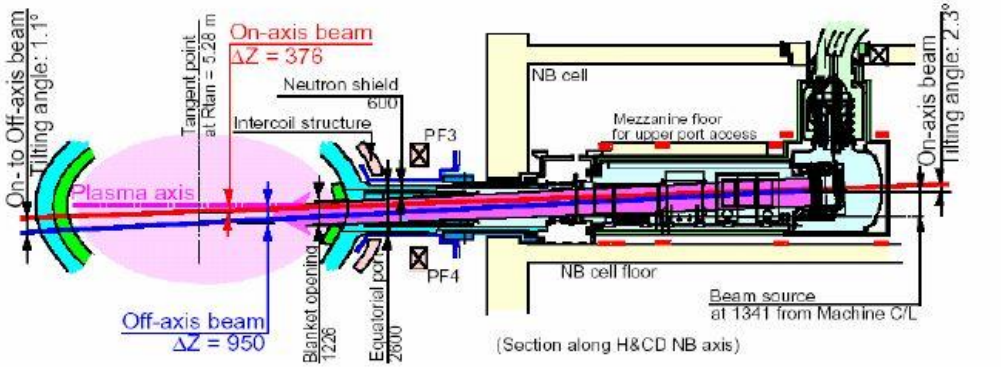
2 NBIs (+1)

P_{beam} = 16.5 MW

I = 40 A

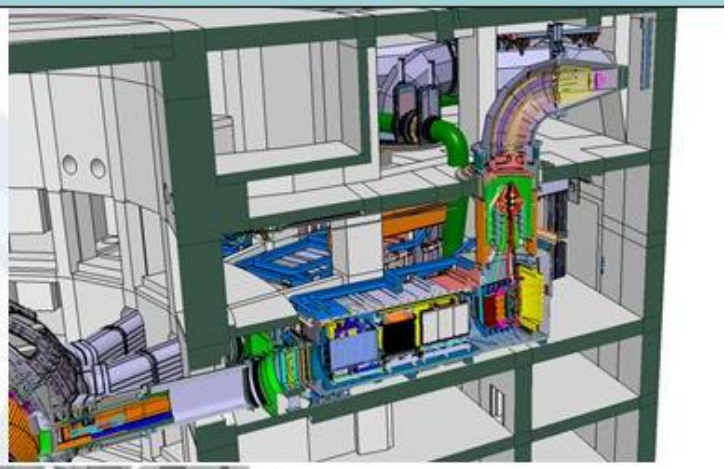
V = 1 MV

T_{pulse} = 3600 s

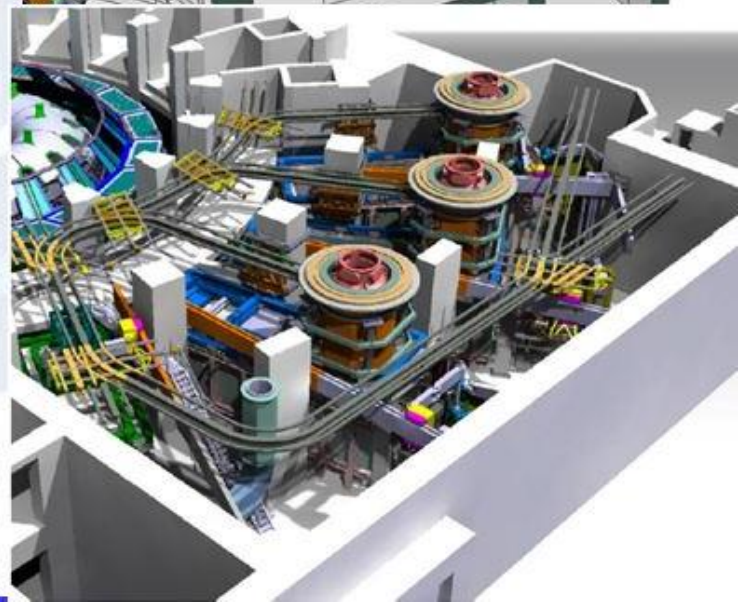


MITICA

- 2 (+1) HNB: Heating Neutral Beam Injectors
- 1 DNB: Diagnostic Neutral Beam Injector

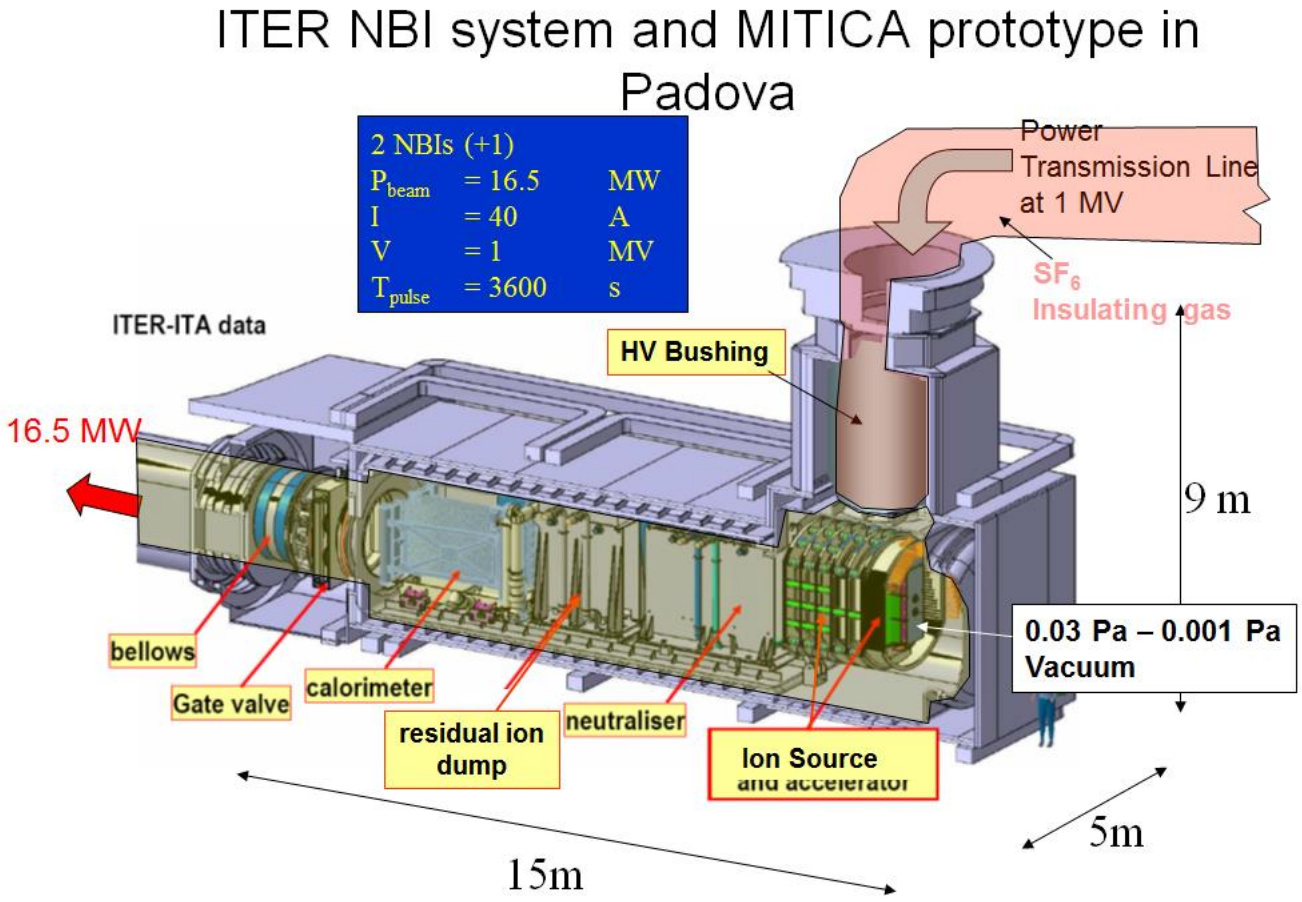


Un progetto per fornire al plasma di ITER 50 MW di potenza per dimostrare la fattibilità della fusione nucleare come sorgente energetica.

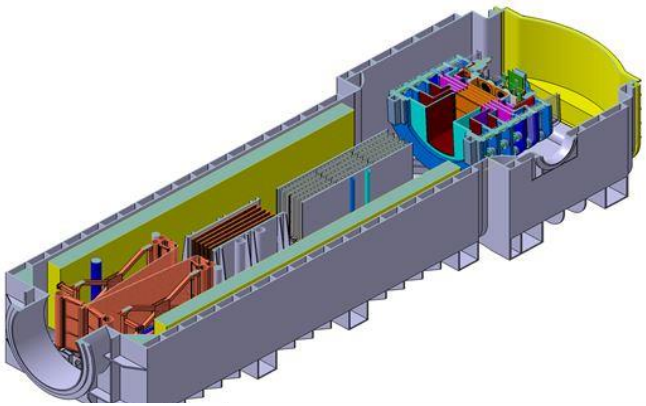


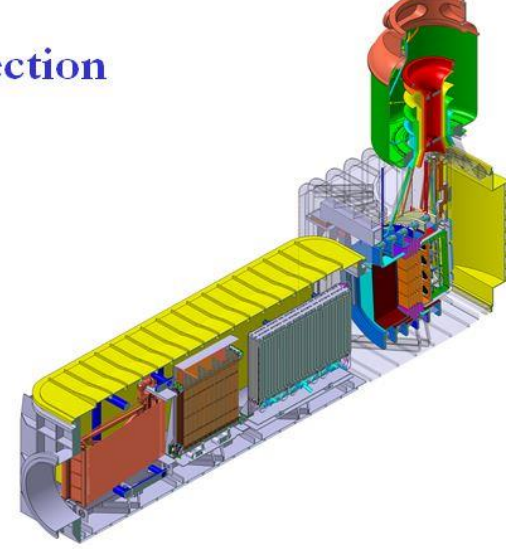
NBI sono gli iniettori dei fasci di atomi di deuterio che forniscono energia addizionale al plasma. A Padova è in costruzione il prototipo MITICA per ottimizzarne la costruzione. Inizialmente è prevista la costruzione di due iniettori, c'è spazio anche per un terzo.

- # PROGETTO MITICA



MITICA ➔ The Injector section





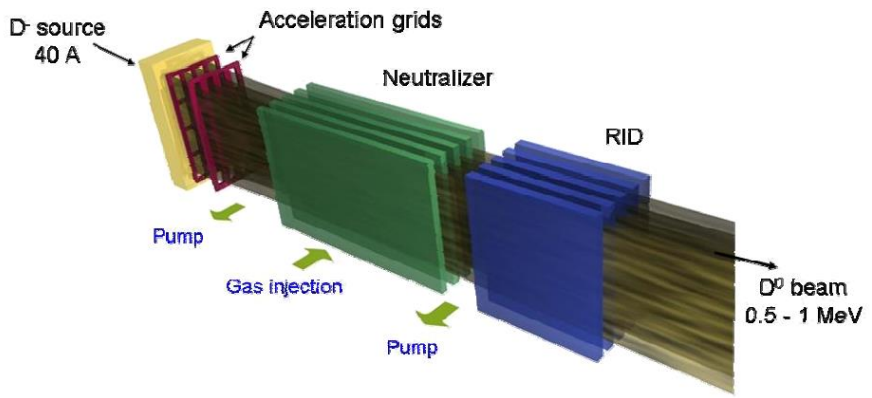
	Present state-of-art	ITER specification	DEMO specification
Acceleration voltage (kV)	500	1000	1000
Beam power (MW)	≈ 6	17	≈ 30 ?
Beam duration (s)	10	3600	continuous
Efficiency (%)	≈ 25	30	≈ 60

big step ahead!

need of a Neutral Beam Test Facility

- # PROGETTO MITICA schematic

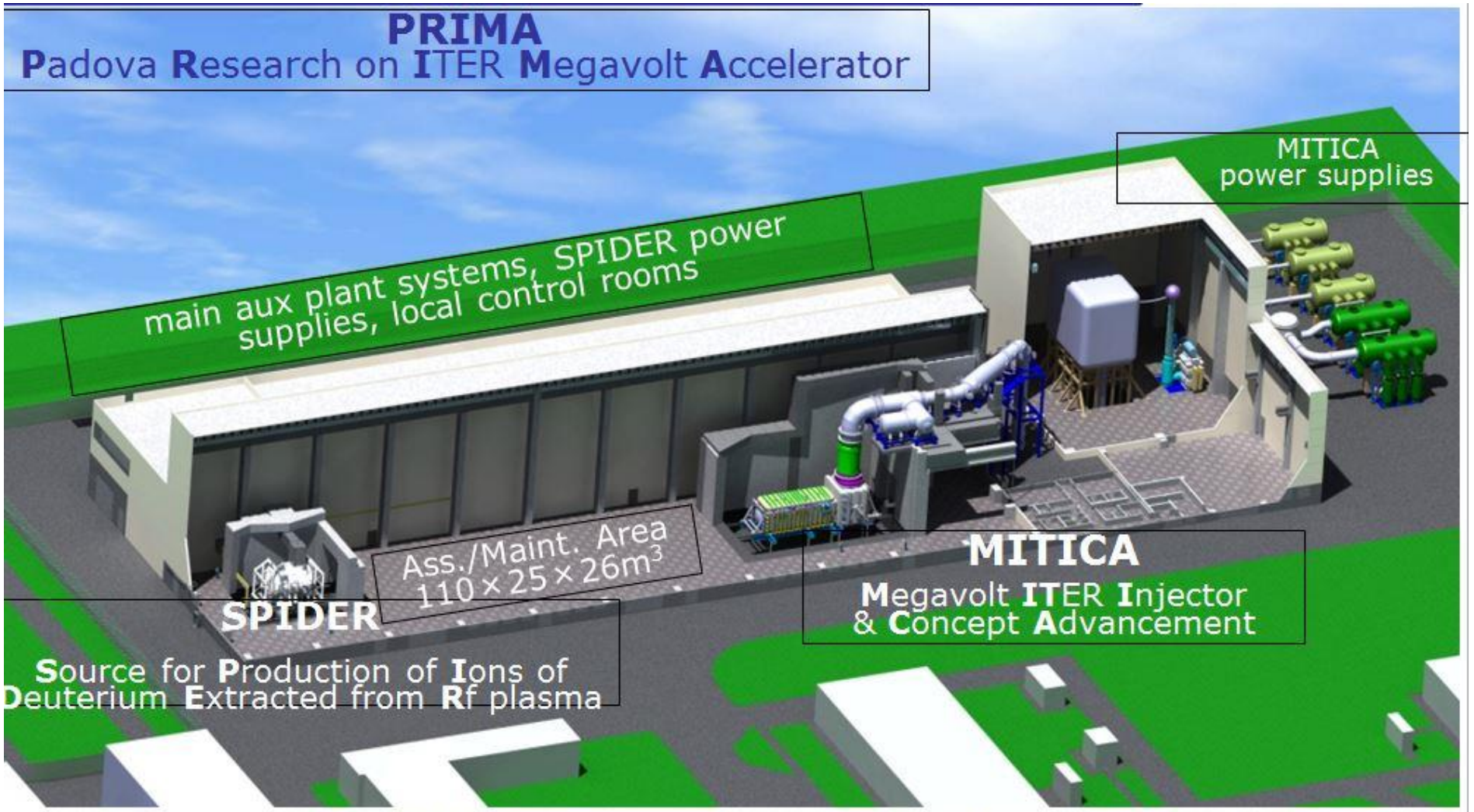
The **ITER heating Neutral Beam** system is based on the acceleration to high energy (1MeV) of negative ions, which to enter the plasma region need to be converted into neutral atoms below reports a principle scheme of a neutral beam.
Negative ions are generated in the ion source and are extracted and then accelerated through an electrostatic accelerator. The ions are neutralized in the neutralizer (the first of the beam line components), which also adsorb the heat load coming from the co-accelerated electrons on the panels of the electron dump. Emerging from the neutralizer will be a neutral beam (60% of the original negative ion beam) and negative and positive ion beams, each with approximately 20% of the initial power/current. The charged beams are removed from the path of the neutral beam in a controlled manner by the residual ion dump (RID). This is obtained by electrostatic deflection of the charged beams onto a water-cooled collector system designed to accept the high power-density. The beam of neutral atoms is either injected into the ITER plasma or intercepted inside the injector by a calorimeter with movable panels which can accept the full neutral beam power.



Completato

Main milestones:

2006	Proposal to host the NBTF in Padova
2010	Call for tender Buildings
2011	Agreement between F4E and Consorzio RFX on the NBTF project
2012	Signature of the contract and start of works (excavation, basement)
2013	Start building erection



- Total area 17.500 m^2
- Covered surface 7.050 m^2
- Trampling surface 9.170 m^2
- Max building height 26.40 m

MITICA – the HNB prototype

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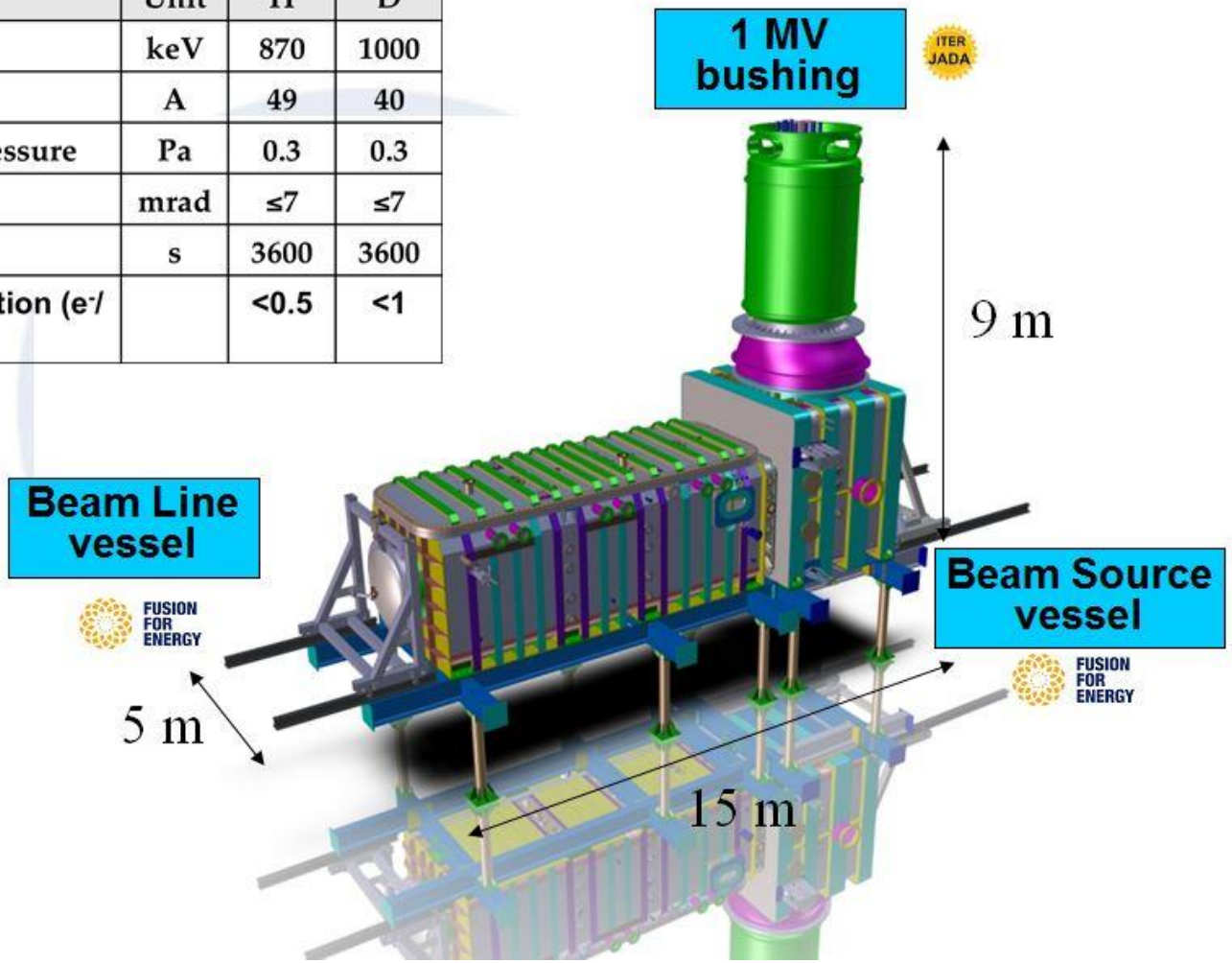
	Unit	H	D
Beam energy	keV	870	1000
Acceleration current	A	49	40
Maximum Beam Source pressure	Pa	0.3	0.3
Beamlet divergence	mrad	≤7	≤7
Beam on time	s	3600	3600
Co-extracted electron fraction (e^-/H^- or e^-/D^-)		<0.5	<1



MITICA: Beam Source & Beam Line Components

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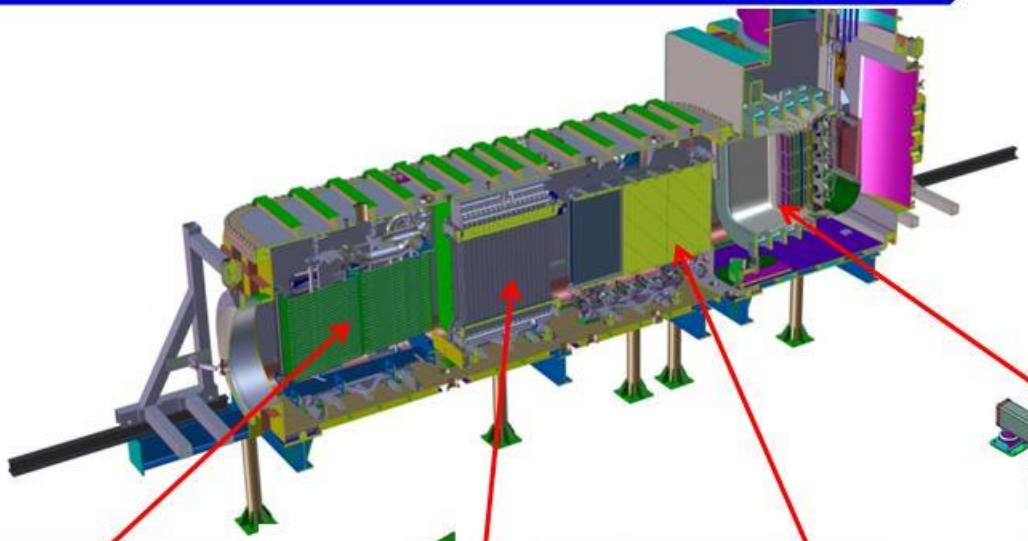
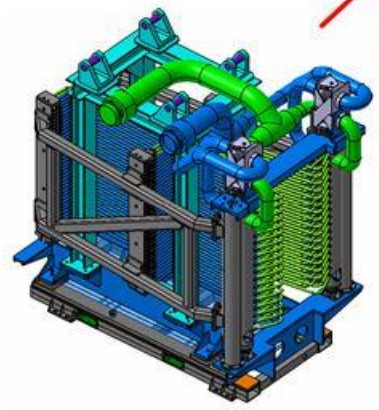
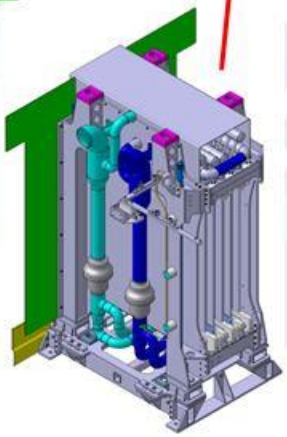
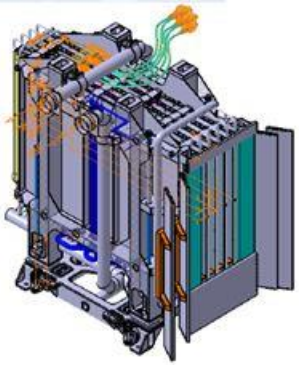




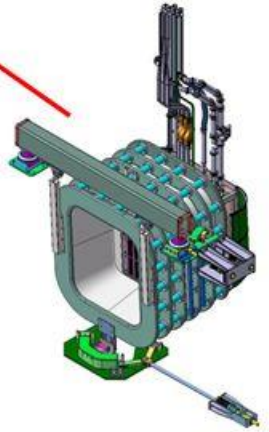
Calorimeter



E-RID



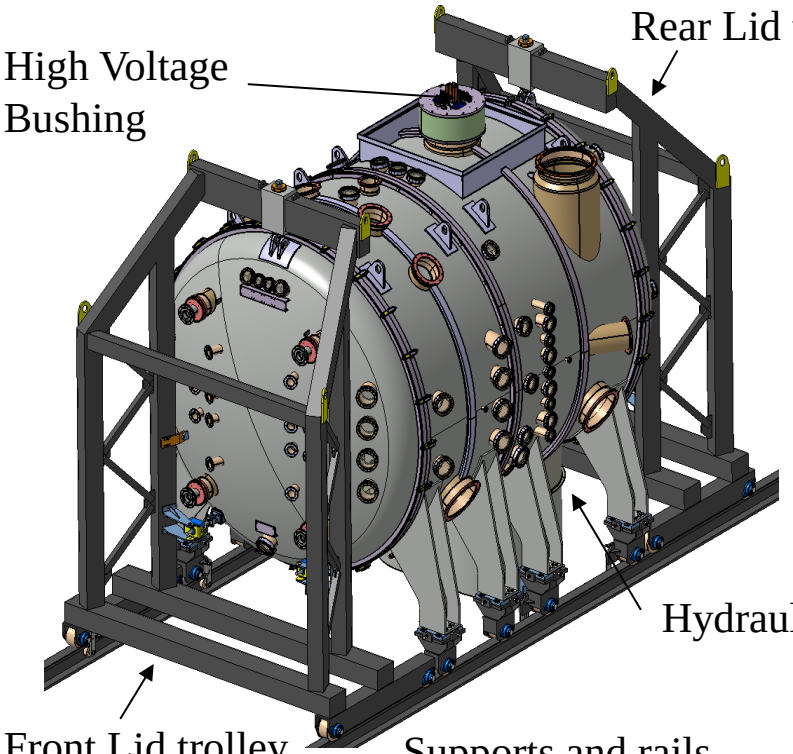
Neutralizer

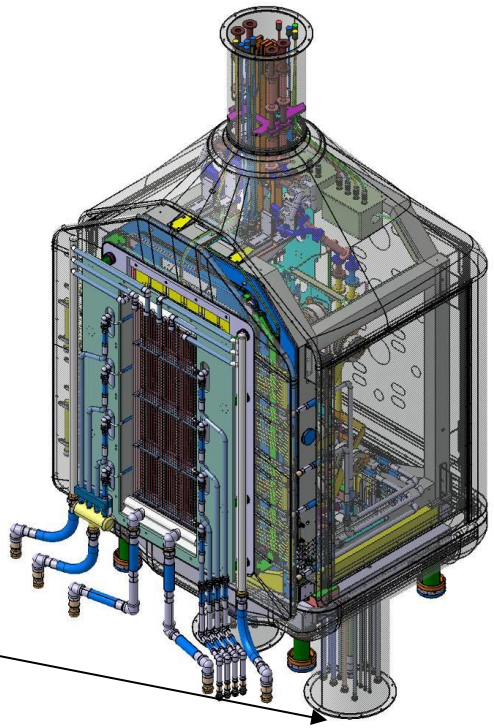


Beam Source

SPIDER - Vacuum Vessel & full size Beam Source

Parameter	Unit	H	D
Beam energy	keV	100	100
Extracted current density (**1.52x0.56 m^2**)	A/m^2	>350	>290
Uniformity	%	±10	±10
Beam on time	s	3600	3600





SPIDER: Beam Dump

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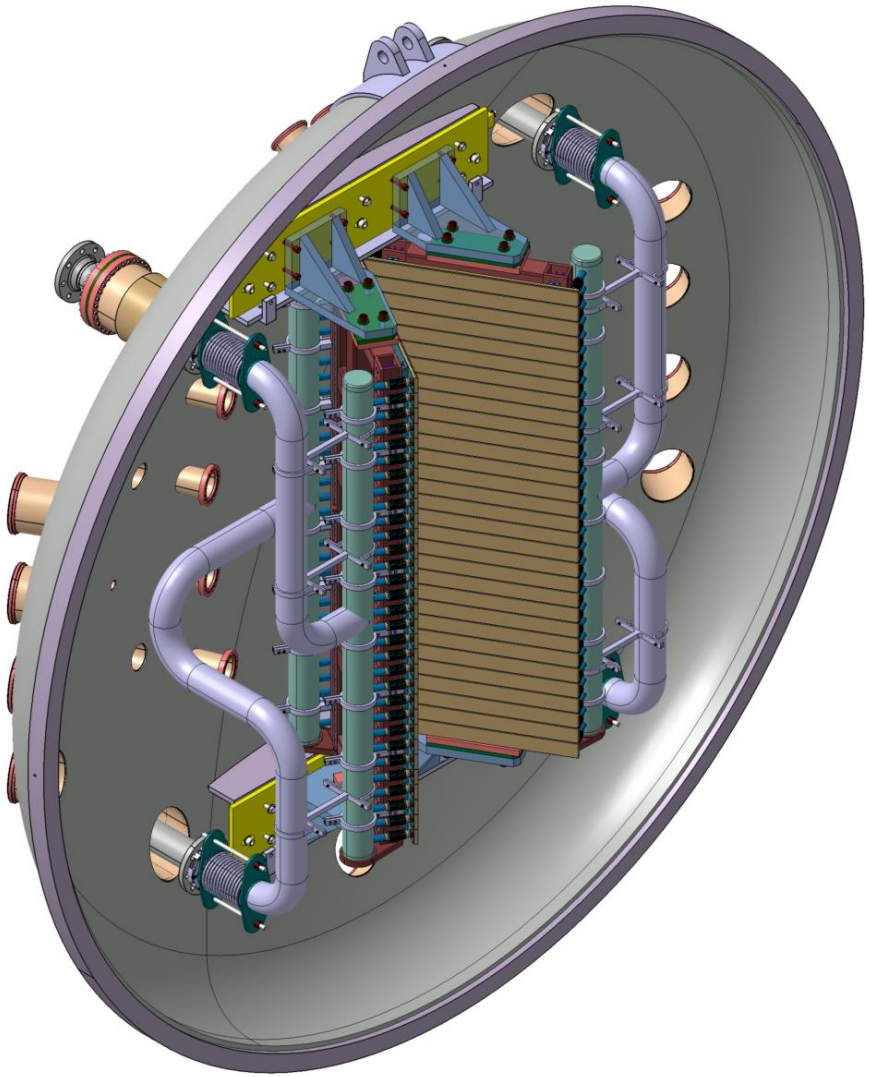

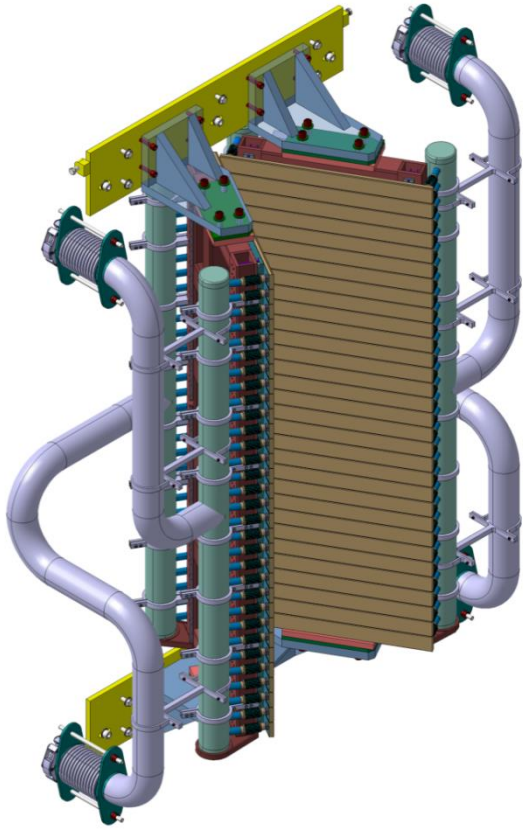

ITER-India

SPIDER : diagnostic calorimeter

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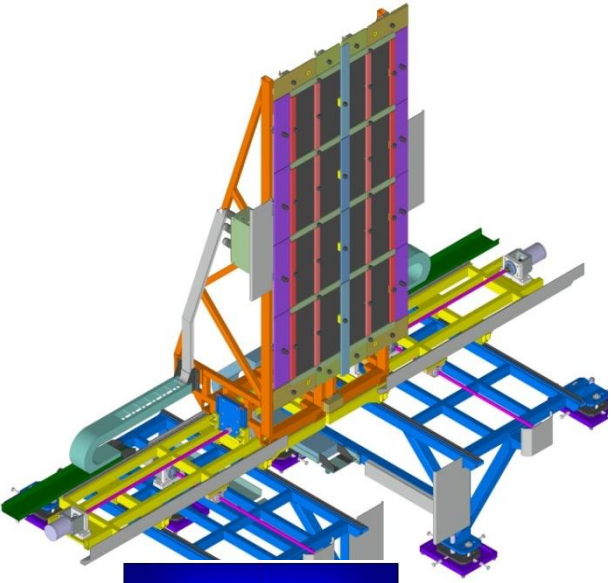
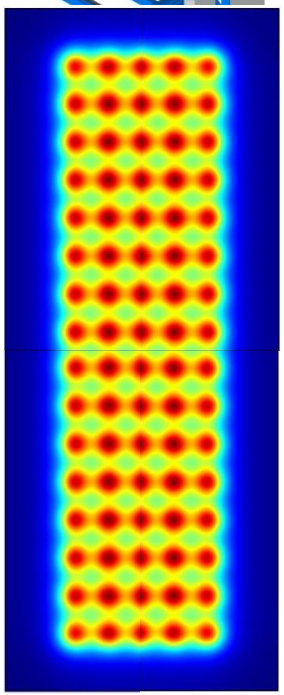
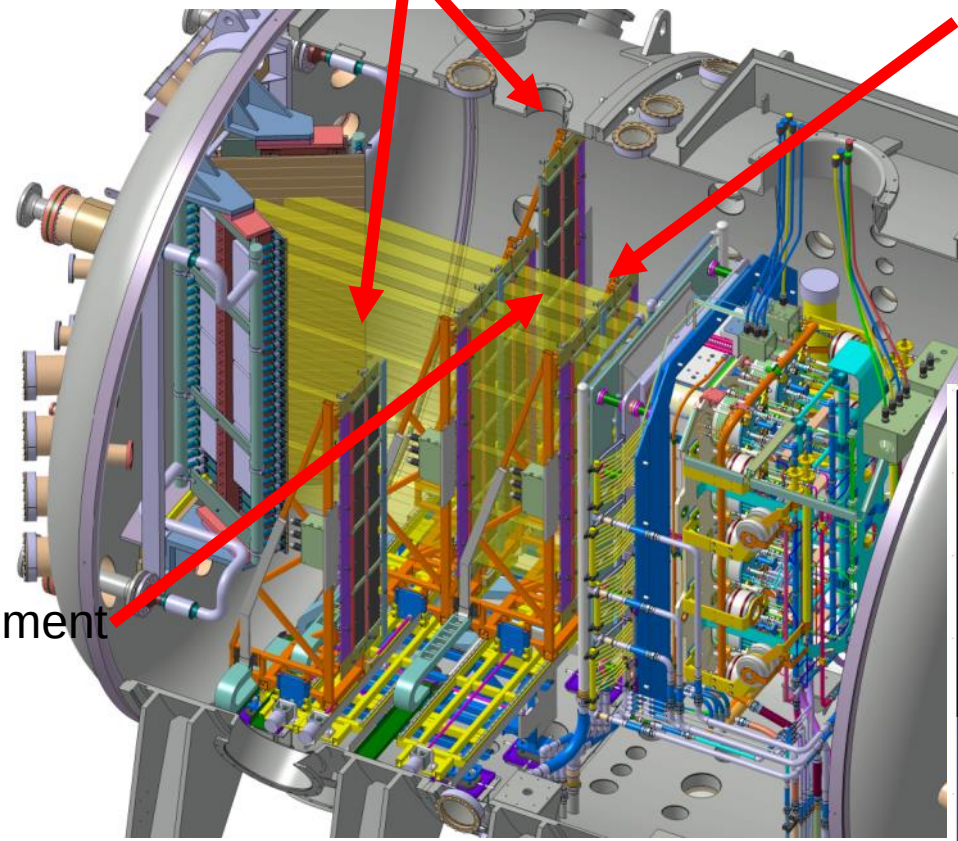


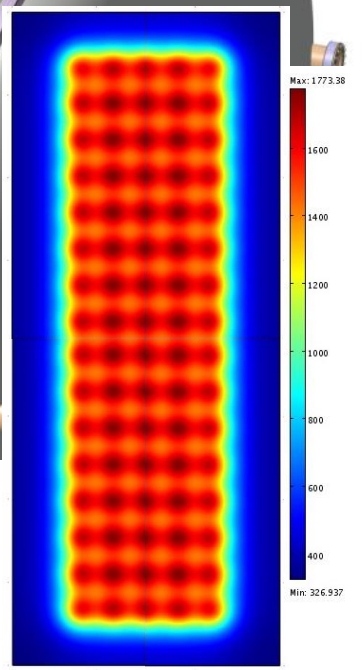


Long beam pulse position

Backward measurement position

forward measurement position





Beam Source sub-systems

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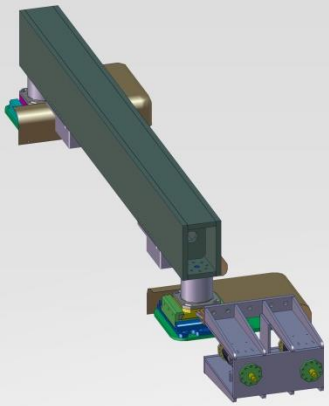
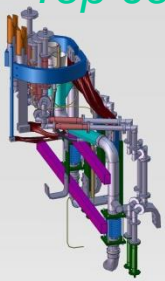
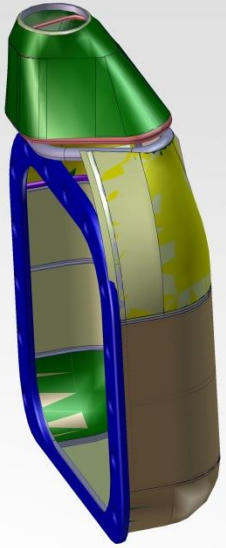


Support & Adjustment System

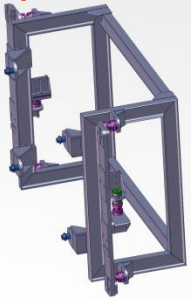
Top connections

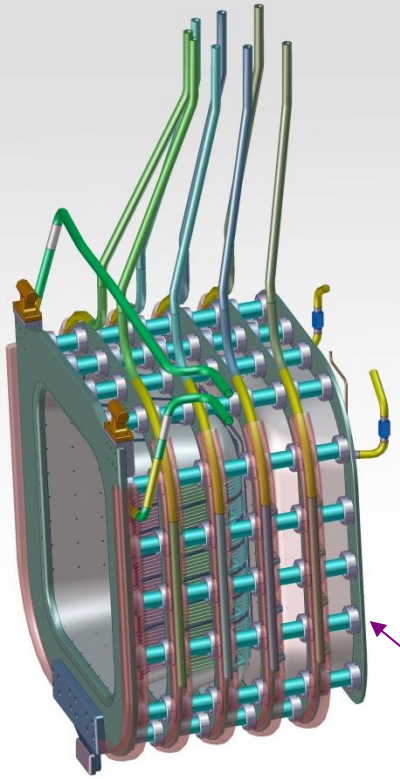


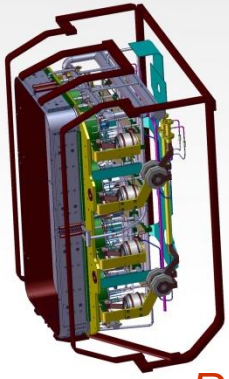
(Rear) Electrostatic shield



ion source supp.struct

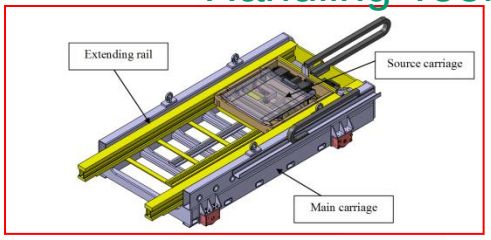






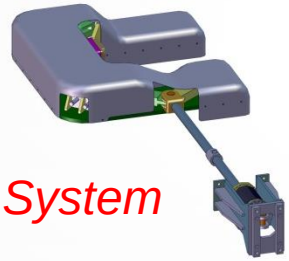
RF ion source

Handling Tool



Extractor

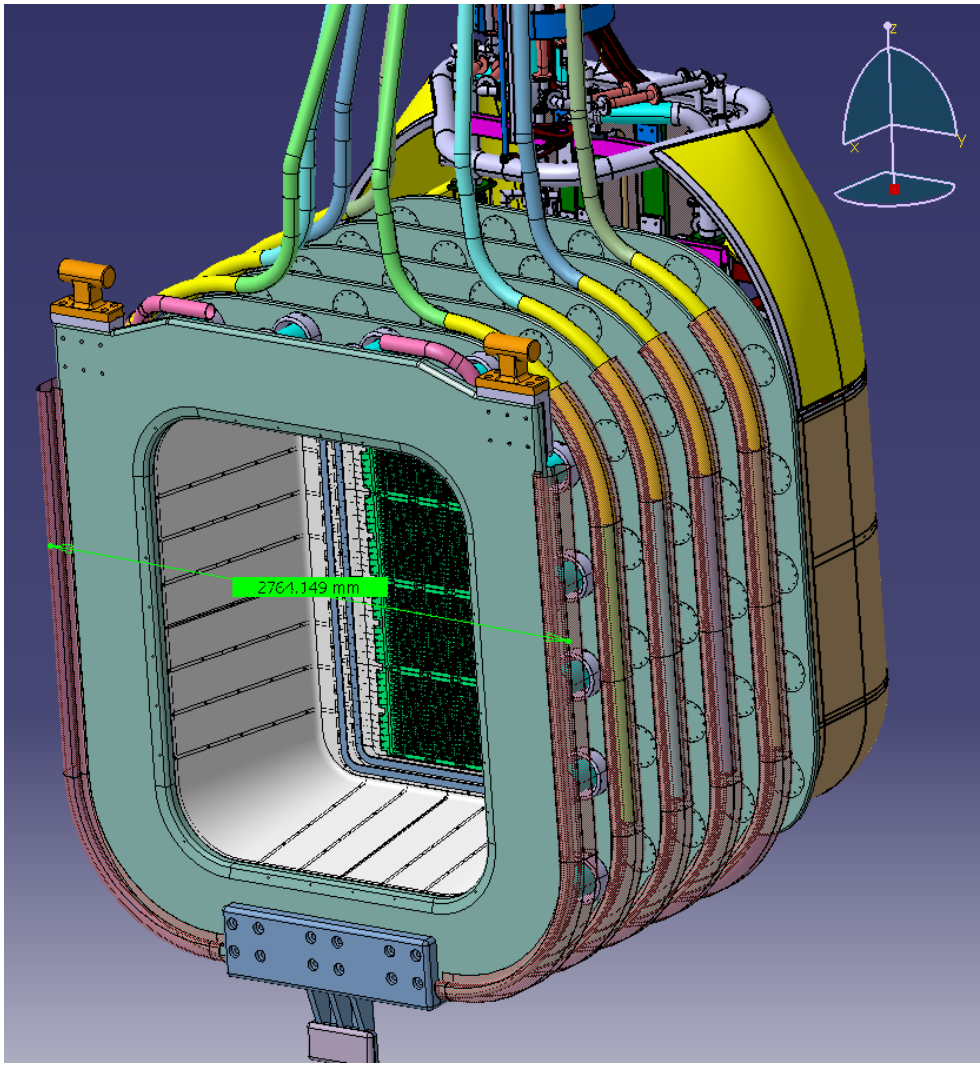
Accelerator



Tilting System

BS main geometrical parameters

Parameter	**Value**
Mass	15 + 5 tons For RH
Overall dimensions (**removable part**)	2.8x2.8x3.5 [m] X Y Z



- La costruzione del prototipo del NBI è stato affidato all’Italia, dopo La costruzione del prototipo del NBI è stato affidato all’Italia, dopo ampia discussione che ha visto un contributo importante dell’INFN, entrato nel consorzio RFX per contribuire all’impresa. La presenza dell’INFN è stata ritenuta fondamentale per l’esperienza nella costruzione di acceleratori d’avanguardia.

- Mitica hauna sorgente analoga, si può pensare a una realizzazione diretta,ma il vero cuore dell'impresa sta nella successiva parte accelerante,formata da una serie di griglie 5, che dovrebbero accelerare i fascettiuscenti dalla sorgente a un MeV. L'aiuto a INFN è richiesto per questaimportante fase, che non è mai stata realizzata, ma che è cruciale perfornire al plasma di ITER quei 50 MWatt di potenza in modo da consentire la fusione per un tempo sufficientemente lungo e dimostrare un guadagno energetico effettivo.

Possibile composizione del gruppo di lavoro INFN che potrebbe assumere la responsabilità della realizzazione delle varie componenti dell'Esperimento MITICA (Megavolt ITER Injector & Concept Advancement).

- Le Sezioni INFN coinvolte risultano:
- INFN Sezione di Padova;
- INFN Sezione di Pisa;
- INFN Sezione di Bari;
- INFN LNL.

Ciascuna delle Sezioni INFN coinvolte dovrebbe avere un carico di Responsabilità specifico nella realizzazione di una porzione della linea di accelerazione di MITICA, assegnando alla Sezione di Padova il ruolo di coordinamento.

Proposta di lavoro su Mitica INFN.

- Il Trasferimento di fondi da ITER all'INFN per Mitica e' considerato indispensabile.
- Questo deve permette l'utilizzo di personale tecnico esterno dedicato alla progettazione e la verifica dei componenti assegnati alla responsabilita' della sezione di Pisa.
- L'impiego di personale tecnico interno sarà cosi' limitato.
- Il coordinamento del personale esterno ricadra' sulla sezione.

Financial resources

(Agreement F4E – Consorzio RFX 2012-2019)

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investments

origin	objects	Value (M€)	Notes
ITER	Scientific apparatus, supplied by Europe, Japan, India	≈ 200	This value is an estimate, most components supplied in kind. Approx. 50% from the EU: so far, 40.5 M€ committed, 36.5 M€ to Italian companies
ITALY	Buildings and Infrastructures	22	Funded by MIUR through CNR and INFN
	TOTAL	**≈ 222**	

running budget

(including personnel, consumables and operating costs)

on average, 10 M€/year, 50% F4E 50% Italy