The Neutral Beam Test Facility NBTF is a joint international effort to develop the neutral beam injector prototypes for ITER.

It is funded by Fusion for Energy, ITER International Organization and Italy.

The ITER Domestic Agencies of India and Japan are also contributors and partners.
The **ITER Neutral Beam Test Facility (NBTF)** is a joint international effort to develop the neutral beam injector prototypes for **ITER**. It is funded by **Fusion for Energy**, **ITER International Organization** and **Italy**. The ITER Domestic Agencies of **India** and **Japan** are also contributors and partners.

**Consorzio RFX (ENEA, CNR, INFN, University of Padova and the Acciaierie Venete spa)** has invested huge resources in NBTF construction, called **PRIMA (Padova Research on ITER Megavolt Accelerator)**, that is hosted in Padova, Italy. It includes two experiments: **MITICA (Megavolt ITER Injector & Concept Advancement)** the full-scale prototype of the ITER Neutral Beam injector and **SPIDER (Source for Production of Ion of Deuterium Extracted from RF plasma)** the full-size Radio Frequency (RF) negative-ions source.

The realization of NBTF and the start of its experimental phase are important tasks of the fusion roadmap, since the target requires injecting in the plasma a beam of deuterium atoms with a **power up to 16.5 MW, at 1MeV of energy and with a pulse length up to 3600s. These parameters have never been reached together before.**
NBTF MANAGEMENT
(Padova)

From top left: Vanni Toigo - Project Manager, Samuele Dal Bello - Site Manager, Pierluigi Zaccaria - Liaison Officer, Loris Zanotto - Liaison Officer, Roberto Pasqualotto - Liaison Officer, Adriano Lucchetta - Liaison Officer, Diego Marcuzzi - Deputy Liaison Officer, Marco Bigi - Liaison Officer, Nicola Pomaro - Liaison Officer.
PRIMA - 2 COMPLEMENTARY EXPERIMENTS/PROTOTYPES

**SPIDER**

- To test
- To optimize

**ION SOURCE**

100 kV ion source

**MITICA**

- To test
- To optimize

**ITER INJECTOR (1MV)**

- Beam source
- Accelerator
- Beam-line components

to reach full performance in time for ITER NBIs construction
1 MV necessary in ITER to penetrate the large plasma volume at such high energies, positively-charged ions are difficult to neutralize (strong R&D)
negatively-charged ions are easier to neutralize
conversely negative ions are more difficult to handle (strong R&D)

D Neutralization efficiency = 55% at 1MV
D Losses in the source ~ 30%

PARAMETERS

50 MV  40 MV  16.5 MV  
4 m^2 0.5 m^2

obtained in JT60
500 kV ion energy
2A current
10s pulse length

requested
1MeV ion energy
40A current
3600s pulse length
SPIDER shall test the ITER HNB negative ion source up to full ITER specifications:
- full extracted current
- full pulse length
- source uniformity ± 10%
  both in H and D operation

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen</th>
<th>Deuterium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam energy (KeV)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Maximum Beam Source pressure (Pa)</td>
<td>&lt;0,3&gt;</td>
<td>&lt;0,3&gt;</td>
</tr>
<tr>
<td>Uniformity (%)</td>
<td>± 10%</td>
<td>± 10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen</th>
<th>Deuterium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracted current density (A/m²)</td>
<td>&gt;355</td>
<td>&gt;285</td>
</tr>
<tr>
<td>Beam on time (s)</td>
<td>3600</td>
<td>3600</td>
</tr>
<tr>
<td>Co-extracted electro fraction (e/H) and (e/D)</td>
<td>&lt;0,5&gt;</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>
SPIDER
the components

VACUUM VESSEL
Zanon (I)

B E A M  S O U R C E
Thales (F)
Cecorn (I)
Galvano-T (D)
Zanon (I)

STRIKE
CfT 2016

B E A M  D U M P
PVA Tepla (D)
**SPIDER POWER SUPPLIES**

ISPES - A set of Power Supplies (RF generators, HV PS, etc.), including a 5MVA 100kV insulating transformer

HVD - 100kV dc Faraday cage (13m x 11m)

TL - Multi-conductor 100kV dc air insulated

AGPS - 9MVA, -96kVdc, 75A
MITICA
1:1 scale prototype of the ITER HNB injector

View of MITICA bio-shield and injector.

The transmission line (Japan Domestic Agency procurement) is connected to the vacuum vessel via the High Voltage Bushing (in green), also procured by JADA.

- Extracted and accelerated current: 40 A
- Beam energy: 1 MV
- Pulse length: 1 h
- Beam optics: same of ITER
- Hydrogen and Deuterium operation

<table>
<thead>
<tr>
<th>Hydrogen</th>
<th>Deuterium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam energy (KeV)</td>
<td>870</td>
</tr>
<tr>
<td>Acceleration current (A)</td>
<td>49</td>
</tr>
<tr>
<td>Max BS pressure (Pa)</td>
<td>0.3</td>
</tr>
<tr>
<td>Beamlet divergence (mrad)</td>
<td>&lt;7</td>
</tr>
<tr>
<td>Beam on time (s)</td>
<td>3600</td>
</tr>
<tr>
<td>Co-extracted electro Fraction (e/H) and (e/D)</td>
<td>&lt;0.5</td>
</tr>
</tbody>
</table>
MITICA
THE COMPONENTS

CRYOGENIC PUMPS

CALORIMETER

RESIDUAL ION DUMP

NEUTRALIZER

BEAM SOURCER

neutral beam injection for
AGPS rated for 60 MW, 1 MVdc cw, is composed of a conversion system AGPS-CS feeding the step up transformers and the diode rectifiers (AGPS-DCG)

1 MV Transmission Line (TL) connecting the power supplies to the injector

High Voltage Deck (HVD1) a Faraday cage, 1 MV insulated, hosting ISEPS, connected to the TL through an air-gas High Voltage Bushing

Residual Ion Dump Power Supply (RID-PS) which applies an electric field between the grids of the Residual Ion Dump

MITICA
POWER SUPPLIES
Experiments duty cycle of 1:4 (one hour on, 4 hours stand-by) allows power optimization: energy is stored in two underground basins (850m³) and then cooled down by air coolers and cooling towers with a continuous cooling power of 24 MW.

- Heat removal (up to 70 MW) of SPIDER and MITICA experiments, Power Supplies and auxiliaries (like MITICA HV line).
- Temperature control of several components: Plasma Grid and Bias plate of both experiments, calorimetric diagnostics, voltage holding
- Chemical control of cooling water (dissolved O₂, pH, conductivity