CREATING A SMALL SUN ON EARTH

SPIDER

THE MOST POWERFUL NEGATIVE ION BEAM SOURCE IN THE WORLD

For further information
Consorzio RFX
www.igi.cnr.it
E-mail: relazioniesterne@igi.cnr.it

F4E
www.f4e.europa.eu
E-mail: info@f4e.europa.eu

ITER INDIA
www.iter-india.org

ITER Organization
www.iter.org
E-mail: itercommunications@iter.org
Energy is essential for our economic growth and social well-being. It helps us reduce inequalities and avoid conflict when we have enough supply. As we increase in numbers we need more of it but we must make sure it is clean. Lowering our dependency on fossil fuels to fight climate change is one of the biggest challenges facing mankind. For this reason, now more than ever, we need a sustainable energy mix where fusion can play a role in the future.

ITER is the biggest experiment to test the potential of fusion energy. China, Europe, India, Japan, Korea, Russia and the USA are working together to deliver the most advanced fusion reactor in history. Thousands of scientists, engineers, companies and laboratories around the world are involved in this one-of-a-kind project, which is under construction in Cadarache, south of France.

SPIDER (Source for the Production of Ions of Deuterium Extracted from a Radio frequency plasma) is the most powerful negative ion beam source in the world. It will operate in the ITER Neutral Beam Test Facility, hosted by Consorzio RFX in Padua.

The goal of SPIDER is to achieve the high performance levels of the ion source that will be used in ITER. Its contribution is essential towards the development of the powerful heating systems needed to reach approximately 150 million °C allowing the fusion reaction to occur.

The SPIDER facility is the result of a unique international collaboration between Italy and Consorzio RFX (ENEA, CNR, INFN, University of Padua, Acciaierie Venete SpA; Fusion for Energy (F4E) and ITER India managing respectively Europe’s and India’s contribution to ITER, and ITER Organization, leading the design and oversight, and ultimately operating the ITER device, where the innovation produced in Padua will see its fullest expression.

The expertise that we will acquire through SPIDER is essential for the realisation of fusion energy. SPIDER will help us create a small sun on Earth.
How SPIDER will pave the way to fusion energy

The materials that are used in the fusion reaction are deuterium, which can be extracted from seawater, guaranteeing a supply for thousands of years, and tritium which is not available readily but can be created from lithium, which is abundant in the crust of the earth. Deuterium and tritium are heated at extremely high temperatures in order to fuse and release virtually unlimited energy. The powerhouse of the ITER heating systems are two neutral beam injectors, with a third one as an optional upgrade during operation.

The SPIDER beam source will help scientists to develop the ion source, one of the critical elements needed for the operation of the ITER Neutral Beam Injectors.

A few metres away from SPIDER, another experiment known as MITICA (Megavolt ITER Injector and Concept Advancement) will develop and test a prototype of the Neutral Beam Injector.

Although neutral beam injection is routinely used for heating the gas in fusion devices, the size of ITER poses a set of challenges: particle beams have to be more powerful and individual particles have to travel faster to penetrate far into the core of the ITER plasma. For this reason, negative ion based injectors are developed. The negative ions, when created, will be accelerated at 1 MV, a speed that no other neutral beam system has achieved. Once accelerated, they will be neutralised before they are injected into the ITER machine to heat the plasma.

This is the first full-scale ITER ion source, capable of running pulses of up to 3 600 seconds at maximum power with hydrogen or deuterium. The 6 MW beam generated for one hour by 1280 powerful beamlets is equivalent to the energy required by roughly 1 000 medium apartments in one day.

The realisation and exploitation of the ITER Neutral Beam Test Facility is recognised as a necessary step to make the operation of the ITER heating neutral beam injectors efficient and reliable. The knowledge acquired will help us to deliver the plasma temperatures needed in ITER and potentially in DEMO, the demonstration fusion power plant that will follow.
ITER Neutral Beam Test Facility –
a tour of the site
“SPIDER is the result of collaboration between technical teams, companies and laboratories that worked for years to get here. It feels like putting together a mini ITER. In fact, this is the first fully integrated ITER system deploying successfully various technologies. Europe has made important technical and financial contributions to SPIDER because it will help us develop the powerful heating systems to achieve the superhot plasma of the big fusion device.”

Tullio Bonicelli
Neutral Beam & Electron Cyclotron Power Supplies and Sources Project Manager
Fusion for Energy

“I’m very proud that a first important milestone has been reached with the SPIDER operation. Since the beginning, we’ve been aware of the Neutral Beam Test Facility’s strategic role and felt the responsibility to ensure its success within the timeframe requested by ITER. The international team involved in this project, placing in Padua its competences and resources, is committed to the goal and is strongly committed in reaching it.”

Vanni Toigo
Neutral Beam Test Facility Project Manager
Consorzio RFX

“The exemplary framework provided through the ITER project, has ensured the successful integration of SPIDER. This facility will host the research for the development of the ITER Neutral Beam injector system. India conveys its best wishes for the inauguration of SPIDER, and compliments Consorzio RFX, the other ITER Parties and the Neutral Beam Programme Committee for their efforts in ensuring its successful integration and operation.”

Arun K. Chakraborty
Diagnostics Neutral Beam Project Manager
ITER India

“The start of SPIDER is a significant step along the path in demonstrating one of the most powerful heating systems needed for ITER, where heating capabilities will exceed the sun core temperatures. With SPIDER, we will develop the ion source that will power ITER. Thanks to the perseverance and creativity of the scientific and industrial teams of RFX, Europe, India and the ITER Organization, together, we are moving one step closer to generating an artificial sun on Earth in the benefit of all future generations. It is a proud occasion for all those who have played a role in this important milestone.”

Deirdre Boilson
Head of Heating & Current Drive Division
ITER Organization

Fusion for Energy, (F4E), has procured, financed and overviewed most of the components by drawing on the expertise of European industry and research organisations.

ITER India has contributed in terms of equipment.

ITER Organization, as the chief client for SPIDER, has led its design and oversight, aiming to apply the knowhow that will be generated to the ITER machine.

**SPIDER Components and Construction (2012-2018)**

- **F4E components**: 34 M EUR
- **Consorzio RFX infrastructure**: 25 M EUR
- **ITER INDIA components**: 3 M EUR
- **Consorzio RFX**: 25 M EUR
- **ITER INDIA**: 14 M EUR
- **Third Parties**: 3 M EUR
SPIDER
connecting research, business and technology

To push forward our knowledge boundaries in order to acquire further technical expertise in the field of fusion energy, SPIDER promoted the collaboration between the R&D and business sectors. The former was responsible for designing the equipment that it will have to operate; the latter was entrusted with the manufacturing of its components. By working together this experiment has come to life and has earned Consorzio RFX the prestigious status of an ITER facility.

SPIDER has generated a wave of economic activity by involving directly at least 20 companies, the majority being small-medium enterprises, from the areas of power supplies, electronics, vacuum technology, cryogenics, mechanical engineering and construction. The value of contracts signed in the fields of manufacturing and construction is in the range of €2 M EUR, without taking into account the direct and indirect investment in R&D. Through their participation, companies gained insights into ITER and were given the incentive to grow and employ, re-train and retain workforces. Their association to this technically-advanced test bed is part of their legacy.

Charles-Antoine Goffin
Thales DefSI and Transformation Director

As part of the ITER project, our company was able to improve its technical and management know-how. We have been given fresh business opportunities and the possibility to develop new partnerships.

Mauro Margherita
Angelantoni Test Technologies General Manager

“SPIDER has been a success and such “state of the art” project, the difficulties we may face are unknown. SPIDER has generated a wave of economic activity by involving directly at least 20 companies, the majority being small-medium enterprises, from the areas of power supplies, electronics, vacuum technology, cryogenics, mechanical engineering and construction. The value of contracts signed in the fields of manufacturing and construction is in the range of €2 M EUR, without taking into account the direct and indirect investment in R&D. Through their participation, companies gained insights into ITER and were given the incentive to grow and employ, re-train and retain workforces. Their association to this technically-advanced test bed is part of their legacy.”

Charles-Antoine Goffin
Thales DefSI and Transformation Director

“Thanks to the involvement of Advanced Test Technologies in the ITER project, our company was able to improve its technical and management know-how. We have been given fresh business opportunities and the possibility to develop new partnerships.”

Mauro Margherita
Angelantoni Test Technologies General Manager

“This project has been a very interesting as well as a great opportunity for technical growth. The cooperation with F4E for the realisation of the SPIDER project has been a great opportunity for our technical growth. This experiment confirmed our propensity to research and the development of new solutions.”

Lugi Barbera
Treviso General Manager

“Because of our collaboration with F4E, we had the opportunity to deliver a large-scale plant and address technical challenges with a team of experienced people, in order to harness fusion – a new accessible energy.”

Giuseppe Biguglia
Delta-Tim spa CEO

“I am proud to have collaborated with ITER India and happy that the SPIDER, whose Acceleration Grid Power Supply was delivered by ECIL, is being incorporated for operation at Neutron Beam Test Facility (NBTF).”

Debabhrata Das
Chairman and Managing Director, Electra Corporation of India Limited

“This project has been a great experience with emphasis on learning and delivering the supply of Armatt converters for the Accelerated Grid Power Supply. Our equipment was successfully integrated achieving the desirable performance.”

Prashant Patel
Managing Director, Armatt Electronics (India) Ltd

“It has been a challenging experience to deliver novel multi-secondary transformers for SP-AGPS at the SPIDER facility, we stretched our limits to satisfy the demand.”

Jitendra Mamtors
Chairman and Director, Transformers and Rectifiers (India) Limited

“Contributing to the SPIDER facility as part of the ITER project, has been an exciting challenge. It motivated us to offer all our technical and project management skills. It has been a very demanding job making everyone in our company proud to be part of it.”

Giuseppe Taddea
OZEM FE General Manager

“We are really proud to have contributed to such an innovative and strategic project for the development of safe, clean and almost unlimited energy. Collaborating with F4E has been very interesting as well as a great opportunity for technical growth.”

Giovanni Faoro
COELME Project Manager for SPIDER High Voltage DC & Demonstration Line