F4E NEWS

Fusion for Energy Magazine

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ITER worksite - July 2018 © ITER Organization/EJF Riche

Crown of concrete and doors of steel at the ITER Tokamak complex

The Tokamak complex, the Assembly Hall, the Cryoplant and Magnet Power Conversion buildings on the right. ITER Construction site, Cadarache, July 2018 © ITER IO

Tokamak Building Level 5 construction on-going, ITER construction site, Cadarache, June 2018

(L-R) Poloidal Field coils facility, ITER Cryoplant, Magnets Power Conversion buildings, galleries civil engineering works on-going, ITER construction site, July 2018 © ITER IO

During summer the activity in the south of France gradually slows down. On the ITER site, however, the pace remains intense. The noise from drilling, building, and lifting, as the cranes gracefully lift massive loads, does not abate. The F4E team, responsible for the construction of the 39 buildings, ITER Organization (IO), and the 2 000 contractors' staff on the ground, remain focused on their tasks. People work round the clock, new equipment is arriving, shifts change, but there is one thing that doesn't change - the race against time.

The civil engineering works at the Tokamak complex, which consists of the Tritium, Tokamak, and Diagnostics buildings, are advancing. The construction works of the walls of the last floor (Level 5) of the Tokamak building have started, raising the total of people involved in the construction of the complex to 750. And just as the building is rising by one level, more concrete is poured to form the so-called crown, where the ITER machine will rest upon. Out of the four plots in total, two have been poured signaling a 50% completion of the works. Next, it will be the turn of the cryostat support bearings to be installed.

On the first floor of the Tokamak building (Level B1) the first six out of the 46 port cell doors have arrived. Romaric Darbour, F4E Deputy Programme Manager for Buildings, Infrastructure and Power Supplies, explains that "after three years of design, development and qualification, and almost one year of manufacturing, the first ITER Port Cell doors have been delivered at the Tokamak building. Each door of around 5.5 x 4 m is made of 30 t of steel. The doors have been transported from the area of Munchen (Germany) in a special lorry. The company manufacturing the Port Cell doors is Sommer, a sub-contractor of the Vinci Ferrovial Razel (VFR) consortium, which has the overall responsibility of the construction of the ITER Tokamak complex. Once the doors are delivered to the Tokamak building, they are filled with heavy concrete increasing the weight up to 58 t and lifted to their final position with the help of a mounting tool, especially manufactured for this purpose."

Nearby the Tokamak complex is the Assembly Hall, where piping, cabling, and electricity distribution are on-going. The works are expected to be completed by the end of the year so that the building is handed over to IO. Similarly, the Magnets Power Conversion buildings are expected to be handed over to IO by November 2018. The galleries, consisting of an underground network cross-cutting the entire ITER platform where pipping will be installed, has advanced reaching a 74% completion rate.

As tooling keeps arriving from different parts of the world, the workforces in the Assembly Hall are busy putting together the sub-sector assembly tooling manufactured by ITER Korea. The growing number of components is gradually transforming the site from a construction platform to a technical hub. There is progress at the Cryostat workshop, managed by ITER India, where the massive shell is progressing bit by bit. A few metres away, the European tanks of the Cryoplant and cold boxes are fully installed, while other pieces of equipment are mounted inside the cryogenic facility. Europe's Poloidal Field coils are also manufactured on-site at a facility exclusively set up for their production. There is a wind of change as the pieces of the biggest fusion puzzle start falling into place. The end of this year promises to be a turning point with the completion of some key civil engineering works and the arrival of more components. Stay tuned!

Building the crown that will support the ITER machine, Tokamak building, ITER construction site, Cadarache, June 2018

SPIDER is switched on and produces its first plasma!

Consorzio RFX, F4E, ITER India and ITER Organization inaugurate the first experiment of the Neutral Beam Test Facility.

Representatives of Consorzio RFX, F4E, ITER Organization, ITER India, European and Italian authorities getting ready to launch the first SPIDER plasma.

"Pulse on!" said the chief operator from the SPIDER Control Room and instantly the 350 guests in the vast hall of the ITER Neutral Beam Test Facility (NBTF) started the countdown. Only few seconds were left for the Director General of the ITER Organization to press the button so as to trigger off the first plasma of SPIDER—the world's most powerful negative ion beam source. A decade of research and manufacturing carried out by Consorzio RFX, F4E, European companies, laboratories, ITER India and ITER Organization were reaching a crescendo. All eyes were on stage. The tension started to build up as representatives from the SPIDER Parties together with political authorities were getting ready to make history. The cameras placed in the vacuum vessel of the beam source were now transmitting live from the core of the machine. The audience started to count 5-4-3-2-1…plasma! A spark illuminated the big screen on stage. The first SPIDER plasma was now paving the way for the one that will follow in MITICA, the real-scale ITER neutral beam injector prototype, assembled a few metres away, which will be operational in a couple of years . And MITICA, in turn, would pass the torch to ITER.

The room was charged with emotion and excitement. A big round of applause, almost like a wave of energy, spread in the hall. The feeling was contagious, euphoric and uplifting. The spark they had witnessed represented years of collaboration which turned into a celebration. A dancer dressed in white moved gracefully through the audience, holding a ball on which beams of light were thrown upon and were deflected in the entire hall. A quartet playing Vivaldi's "Gloria" filled the hall with music as the beams of light caressed the big concrete door, known as the bioshield, protecting the beam source. Slowly the door opened and revealed SPIDER almost like a hidden treasure coming to light. It was epic. Art and science, two of Europe's finest hallmarks, fused in perfect harmony to set the tone of the inauguration ceremony.

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Audience during the final act of the SPIDER Inauguration

Keynote speakers praised the role of science and Italy's role as a Host of the ITER NBTF. Francesco Gnesotto, President of Consorzio RFX, paid tribute to the members of staff, all contributors and the founding father of the facility—Giorgio Rostagni. The mayor of Padua, Sergio Giordani, welcomed the establishment of this "centre of scientific excellence" in the city where Galileo held a chair at the University of Padua. Salvatore La Rosa, representing Italy's Ministry of Universities and Education, stressed the importance of R&D and the commitment of the new government to maintain this as a priority. Carles Dedeu, representing the European Commission, and Flavio Zanonato, Member of European Parliament, used this opportunity to remind audiences of the EU's commitment to ITER and its potential in changing the energy mix. Bernard Bigot described this day as "an important achievement" for ITER and the fusion community. Johannes Schwemmer, Director of F4E, argued that SPIDER built a bridge between business and science. And last, but not least, Chandramouli Rotti, representing ITER India, highlighted the need of sharing technical knowhow which is essential for progress.

During a round table discussion, companies highlighted the industrial benefits stemming from fusion and explained how SPIDER helped them grow, learn, expand their supply chain and become familiar with the fusion community. Charles-Antoine Goffin (Thales) described the importance to be involved in research projects in order to remain competitive. Giuseppe Taddia (OCEM) listed reputation, staff motivation and market expansion as some of the direct benefits. Fabien Siroti (ATT) mentioned how SPIDER enabled smaller companies to work with bigger ones and create partnerships. Christian Eckardt (PVA Tepla) talked about the way SPIDER offered a new level playing field in line with Big Science business opportunities. Michele Tamagnone (Delta Ti Impianti) described how SPIDER has proven to be a good school to sharpen project management skills and apply new standards.

You may wonder why the ITER Neutral Beam Test Facility is a key step in the fusion roadmap. When ITER starts producing energy through the fusion of hydrogen atoms, it will rely on very powerful heating devices to achieve the necessary 150 million °C for the fusion reactions to occur. The power-horses of the ITER heating systems are two neutral beam injectors, with a third as an option during operation. Although neutral beam injection is routinely used for plasma heating in fusion devices, the size of ITER poses a set of challenges: particle beams have to be much thicker and individual particles have to be much faster to travel far into the core of the plasma. SPIDER (Source for the Production of Ions of Deuterium Extracted from a Radiofrequency plasma) will help developing this new technology.

The experiment is built on the premises of Consorzio RFX, located in Padua, Italy. SPIDER also represents a unique international collaboration. Italy and Consorzio RFX have provided the facility and a large contribution towards the personnel. The team of Consorzio RFX will also be responsible for the operation of SPIDER. F4E has procured, financed and supervised the fabrication of most of the components, building on the expertise of European industry and research organisations. ITER India, managing India's contribution to ITER, has also provided important equipment. ITER Organization, has led the design and oversight, and when it operates the ITER machine it will use the knowledge generated in the NTBF.

F4E staff present at the SPIDER inauguration ceremony (L-R) S. Galvan, B. Devi, M. Simon, F. Paolucci, J. Schwemmer, T. Bonicelli, A. Garbuglia, V. Pilard, F. Cauvard, C. Labate, A. Masiello, A. Apollonatos

Cryoplant equipment arrives at ITER Neutral Beam Test Facility

The trucks transporting the equipment of the cryoplant that will cool down MITICA, the second experiment of the prestigious ITER Neutral Beam Test Facility, have reached Padua. It's a humid hot summer afternoon, in stark contrast to the cold temperatures that will be produced by the "refrigerator" of this experiment.

Unpacking the auxiliary cold box at the ITER Neutral Beam Test Facility, MITICA, Padua, Italy

Installation of the Gas Helium tank at ITER Neutral Beam Test Facility, MITICA, Padua, Italy

Consorzio RFX, in collaboration with F4E, ITER Japan, and ITER International Organization are the Parties contributing to MITICA (Megavolt ITER Injector and Concept Advancement). The tests carried out there will help scientists test the potential of a Neutral Beam Injector (NBI) prototype that will feed directly towards the design and manufacturing of the NBI used in ITER.

MITICA requires a cryogenic system to cool down the cryogenic pump in order to maintain the necessary vacuum during operation. F4E in collaboration with Air Liquide, have been working together since autumn 2016 to manufacture the components of the MITICA cryoplant. In July 2018, more than 90% of its equipment has been completed. The overall budget of the contract is in the range of 6 million EUR and the cryoplant is expected to be ready by April 2019. Grigory Kouzmenko, F4E Technical Officer, explains that "…the teams on the ground have started installing the components and they are expected to conclude this stage by October 2018. From November until spring next year, the phases of commissioning and testing should be concluded."

Unpacking the auxiliary cold box at the ITER Neutral Beam Test Facility, MITICA, Padua, Italy

Connecting the main cold box, on the left, with the auxiliary cold box, on the far right, with the help of cryolines, ITER Neutral Beam Test Facility, MITICA, Padua, Italy

The cryoplant will supply helium at -196 °C to cool down the thermal shields and at -269 °C it will cool down the cryopanels, which will absorb the gas used to neutralise the high-energy beams. Periodically, warmer gas at room temperature or at 127 °C will flow through the cryopanels to extract any gas stored. In spite of the fact that the cryoplant is based on conventional equipment, it is enhanced with sophisticated auxiliary systems to cope automatically with a wide range of operational conditions.

Benoît Hilbert, Managing Director of Air Liquide advanced Technologies, explains that "…in addition to the ITER Cryogenic system that Air Liquide is responsible for delivering; it is also contributing to cryoplant system of the ITER Neutral Beam Test Facility in Padua, Italy. In close collaboration with F4E, the manufacturing and delivery of equipment was completed in June. Next, we will procced with the installation of the piping interconnections which involve more than 20 vacuum lines."

Arrival of the Gas Helium tank at the ITER Neutral Beam Test Facility, MITICA, Padua, Italy

Water tanks to quench the thirst of ITER

Four more water detritiation tanks have been delivered to ITER as part of its fuel cycle system. The components resulted from a contract signed between F4E and Equipos Nucleares, SA (Ensa) in order to design, manufacture and deliver them to the site of the project in Cadarche.

Representatives of F4E, Ensa, ITER IO welcoming on the ITER site the additional four water detritiation tanks that will be part of the fuel cycle system © ITER IO

Works for their fabrication lasted approximately two years reaching a value of approximately 1 M EUR. Two tanks measuring 7 m³, known as "holding tanks", will be used to store water. The two additional tanks, measuring 12 m³, known as "feeding tanks", will be used to feed the fuel cycle system with tritiated water. All four tanks will be installed next to the six water detritiation tanks, also manufactured by Ensa, which have been on-site since March 2015, claiming the title of Europe's first-ever components delivered to ITER. The biggest fusion device will count ten of these tanks in total in order to cater for the needs of its fuel cycle.

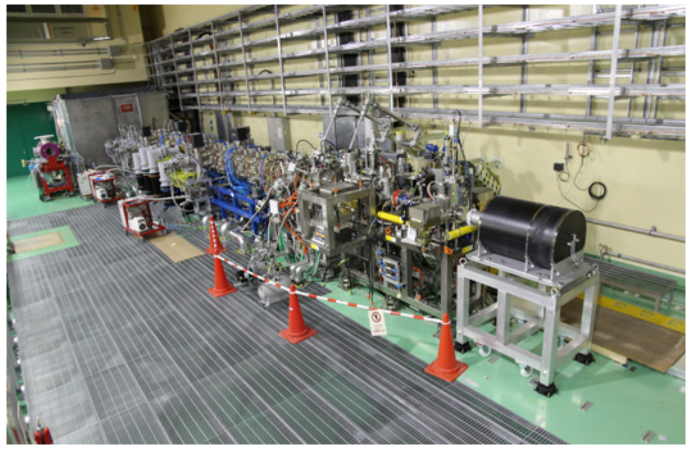
Why do we need a water detritiation system in the ITER Tritium plant? The answer is simple: because we need to recover the fuel to use it again so as to trigger off a new fusion reaction. Here is how it works in few simple steps: first, the two hydrogen isotopes (deuterium and tritium) are supplied to the machine through the Tritium plant; second, when the two isotopes reach the core of the machine they are heated at extremely high temperatures in order to fuse and to release energy; then, the fuel left from the fusion reaction, together with other gases, return through pumps to the ITER Tritium plant in order to recover the tritium and use it in a future reaction.

The company located in Cantabria, has been awarded this contract following a procurement procedure launched by F4E. "The manufacturing of these additional tanks and their delivery to the ITER site conclude Europe's contribution vis-à-vis the fuel cycle tanks. Our good collaboration with Ensa and the co-ordination with ITER IO have been fundamentally important for the successful completion of this task" explained Josep Benet, F4E Technical Officer. Sofía Corino, Ensa Special Projects Manager, Business Development Area said, "Ensa, in cooperation with its subsidiary, ENWESA, has been responsible for the design and manufacturing of the four additional water detritiation tanks which will be part of ITER's fuel cycle system. Ensa's expertise and commitment to innovation have been decisive in consolidating it as one of the leading European manufacturers of components for the biggest fusion energy project."

Europe and Japan operate accelerator to deliver first beam

The Broader Approach Agreement, signed between Europe and Japan, offers a framework for three R&D projects in the field of fusion energy to push forward the state of play. The International Fusion Materials Irradiation Facility (IFMIF)/Engineering Validation and Engineering Design Activities (EVEDA) is one of them. With the help of LIPAc, a prototype accelerator, scientists will validate the design of a neutron source which will be used to irradiate materials and key equipment of DEMO, the fusion machine that will succeed ITER.

Representatives from Europe and Japan witnessing the first beam of the accelerator at the LIPAc facility, Rokkasho, Japan



The Radio Frequency Quadrupole (RFQ) accelerator, measuring 9.8 m, using eight radio frequency lines, LIPAc facility, Rokkasho, Japan

QST (Japan) in collaboration with F4E, coordinating the European contributions of INFN (Italy), CIEMAT (Spain), CEA Saclay (France) and SCK-CEN (Belgium), have resulted in this experimental facility with the world's longest Radio Frequency Quadrupole (RFQ) accelerator, measuring 9.8 m, using eight radio frequency lines.

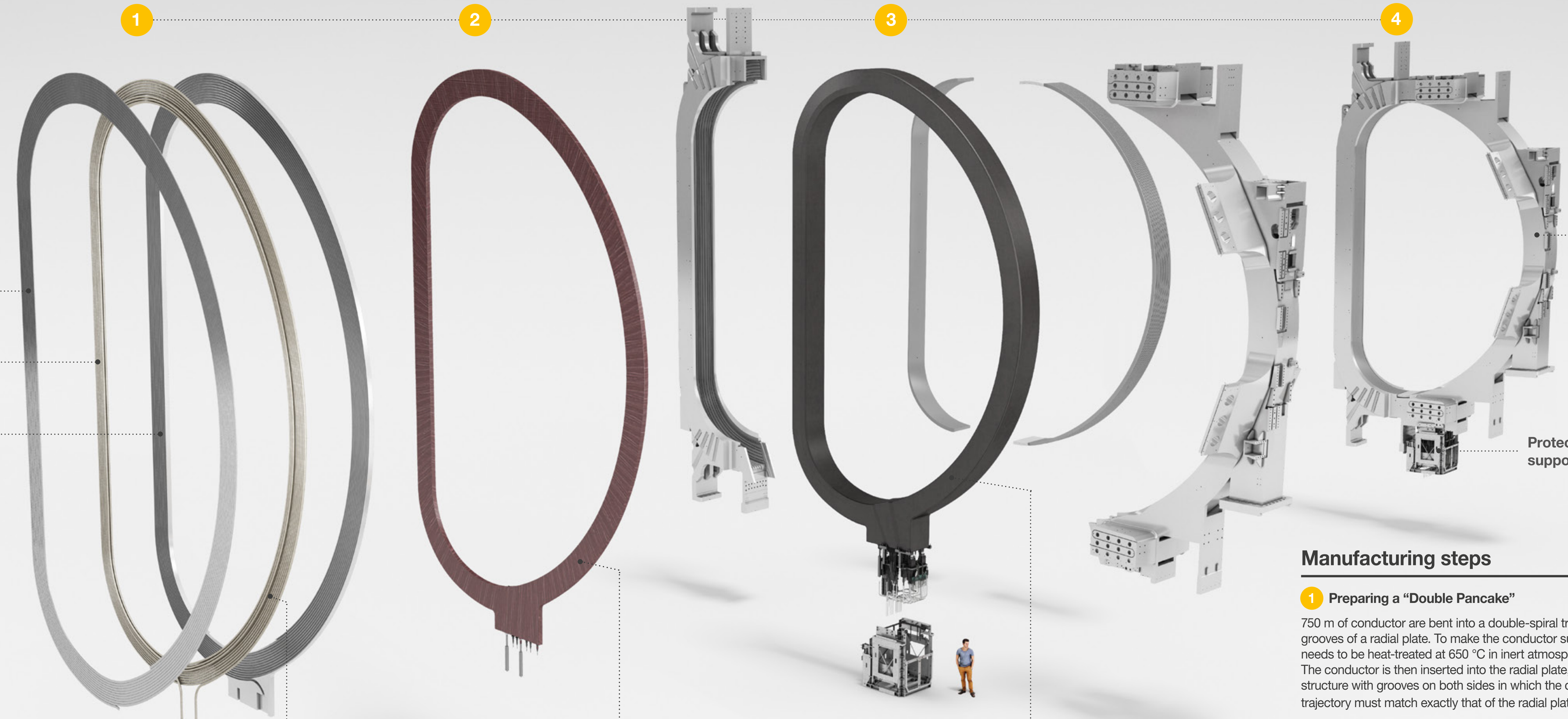
The components of LIPAc (Rokkasho, Japan) have been installed, commissioned, and in operation, as part of the accelerator, for nearly two years. On 13 June, the RFQ delivered the first beam of particles (so far: protons) reaching the energy of 2.5 MeV. The progress is impressive, especially if one bears in mind that the injector provides protons with energy of 50 keV. The transmission values obtained in June are significant. They represent more than 80% of the beam's full potential transmitted by the RFQ. This is an essential step towards the acceleration of deuterons, atoms consisting of a proton and neutron, demonstrating the capability of the RFQ design to reach the high currents needed for the neutron source.

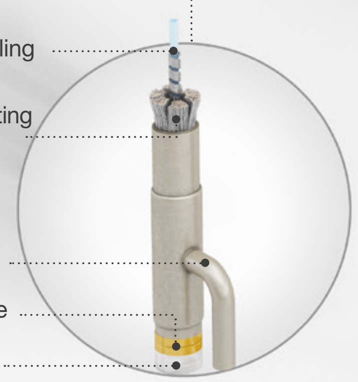
The total in-kind contribution to the LIPAc facility by all European parties and Japan is in the range of 100 M EUR taking into consideration infrastructure costs. This result represents ten years of close co-ordination between all Parties. Nearly 90% of the European hardware has been delivered and commissioning is halfway through. Roland Heidinger, F4E European Project Manager for IFMIF/EVEDA, explains, "This first beam is the dawn of the accelerator operations. We have taken a step forward paving the way for more qualifications during 2019." Philippe Cara, IFMIF/EVEDA Project Leader, elaborates on the systematic efforts that have been made since 2015 to adapt the schedule to the project plan: "During the last three years we have been working closely with all Parties to develop a realistic schedule and we managed to respect it. We have established a method of international collaboration which works well between Europe and Japan. And on top of that, we have successfully manufactured an entire system in Europe, and installed it in Japan, ensuring full compliance with the standards."

ITER Toroidal Field Coils

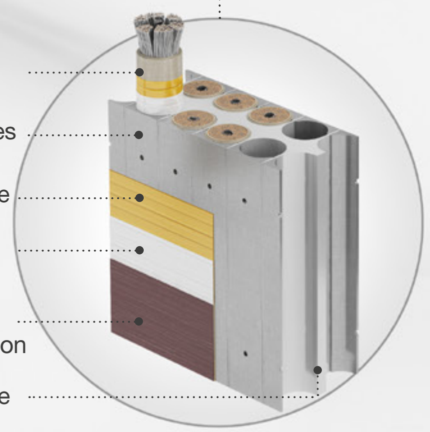
18 powerful superconducting magnets will confine the ITER plasma reaching 150 million °C.
Powered with 68 000.A, they will generate a strong magnetic field of 11.8 Tesla (approximately 1 million times stronger the magnetic fields of the Earth).
Europe will manufacture 10 of the TF coils and Japan 8 plus one spare. They will be the biggest Niobium-tin (Nb_3Sn) magnets ever produced.
More than **600 people from 26 companies** have collaborated to produce the European TF coils.

Each coil is approximately:
14 m high
9 m wide
300 t with its case - the weight of a Boeing 747

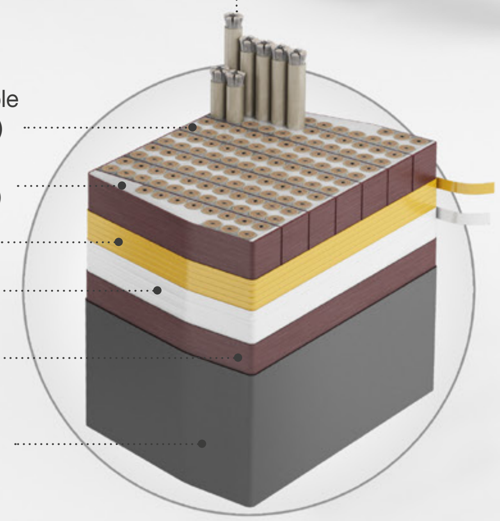




Conductor



Double Pancake



Winding Pack

Manufacturing steps

1 Preparing a "Double Pancake"

750 m of conductor are bent into a double-spiral trajectory to fit into the grooves of a radial plate. To make the conductor superconductive it first needs to be heat-treated at 650 °C in inert atmosphere.
The conductor is then inserted into the radial plate, a stainless steel structure with grooves on both sides in which the conductor nestles. Its trajectory must match exactly that of the radial plate.

2 Double Pancake

The conductor is wrapped and electrically insulated using several layers of glass & Kapton tape. Cover plates are fitted and laser welded. At this stage it becomes a Double Pancake (DP). The DP is wrapped and electrically insulated with glass & Kapton tape before impregnation with epoxy resin. A vacuum-pressure process is used to eliminate gaps or voids. Once cured the resin gives mechanical strength to the insulation and consolidates its electrical properties.

3 Winding Pack

Seven Double Pancakes are stacked and electrically jointed. They are wrapped, and electrically insulated with glass & Kapton tape to form a Winding Pack (WP) – the core of the magnet!
Then, the WP is heat-dried in vacuum at 110 °C to eliminate any humidity trapped and finally, resin is injected to fill in any gap in the electrical insulation. After that, tests are done to reassure engineers that the component is in compliance.

4 Final Toroidal Filed coil

Finally, the WP is inserted into a massive stainless steel case, weighing almost 200 tonnes, strong enough to resist the huge forces generated during operation.

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Further subassemblies for Vacuum Vessel sectors completed

Further segment subassemblies for ITER's Vacuum Vessel for sectors 5, 4 and 3 have been completed. The companies within the AMW consortium: Ansaldo Nucleare, Mangiarotti and Walter Tosto, together with their sub-suppliers Ensa, Pro-beam, have successfully worked together to produce these segment subassemblies which marks a big step towards reaching the final assemblies of the segments.

The completed subassemblies, which weight ranges from 1400 to 11000 kg, form part of 3 of the 5 sectors which make up Europe's contribution to ITER. Each of these sectors will measure 6.5 m high, 3 m wide and 6.3 m deep and will weigh around 500 t.

The first part of the manufacturing process – cutting and rolling of the plates of the inner shell (the part of the vacuum vessel which will be closest to the plasma in ITER) – was carried out by Walter Tosto. The plates of the inner shell for the first and fourth segments were then transported to Mangiarotti and Ensa, while Walter Tosto kept those for the second and third segments. The next step carried out at these three workshops was the cutting and machining of the holes which will house the so-called flexible housings (cylindrical parts which act as bolts) and the intermodular keys (parts which are used to align interfacing components). Due to the size of the inner shell plates (up to 6 m long, 1.5 m wide, and 60 mm thick), large milling machines were used to make the holes for the flexible housings and the intermodular keys. These plates, made up of the special ITER grade stainless steel, are flat stainless steel slabs which have been rolled flat and which will be used to manufacture the inner shell which will make up the inner walls of vacuum vessel sectors.

The positioning operation and assembling of inner shell plates with the T-ribs (the part of the sector which will be curved) and the intermodular keys entails a number of challenging steps. This is due to the narrow gap allowed by electron beam welding between the two parts to be welded, known as the welding gap. In this case, this gap needs to be as narrow as 0.6 to 0.8 mm. An additional challenge is the flatness tolerance (the allowed limit or limits of variation in the overall flatness of each plate) and general dimensional tolerance, which are both extremely tight in order to keep gap and misalignment between parts within the maximum acceptable limit of electron beam welding.

A wide variety of inspection techniques were applied in order to

A sub-assembly of a sub-assembly segment for sector 4, manufactured by Walter Tosto and welded at Pro-beam.

check for potential defects and carry out measurements without causing any damage to the parts themselves (known as Non-destructive Examination – NDE). These inspection techniques demonstrated that despite the large size of the plates, the necessary dimensional tolerance had been achieved.

After positioning the plates and ribs on the customised support structures, the so-called jigs, the initial welding operation (the root pass) was manually performed at the respective Mangiarotti, Walter Tosto and Ensa workshops. Subsequently the assemblies were transported to Pro-beam, to perform electron-beam welding of the full thickness. The conclusion of the electron-beam welding, together with its related inspection, marked the completion of each of the subassemblies.

"The Vacuum Vessel Central Team has coordinated the interface management work needed to prepare the mentioned manufacturing activities and has worked very efficiently to make this a success", says Francesco Zacchia, F4E Project Manager for the Vacuum Vessel Team "Thanks to good team work there, we continue to deliver and solve any arising problems", he notes.

"As production of single parts of the segments of vacuum vessel sectors is well advanced, we are now moving full-steam ahead into the next technically challenging phase of assembling different parts into segment subassemblies, whilst staying within the required dimensional tolerances", says Gianfranco Savoldi, Vacuum Vessel Contract Project Director for the AMW consortium.

On a further positive note, an inspection of the French Nuclear Safety Authorities (ASN) in Walter Tosto, with the presence of ITER IO, F4E and AMW, reviewing in detail, among other things, the correct application of the manufacturing procedures and also the level of Nuclear Safety culture, was recently satisfactorily concluded. "We are obviously proud and happy to achieve this good success and we continue to engage in continuously improving and developing the nuclear safety culture in our work", said Francesco Zacchia.

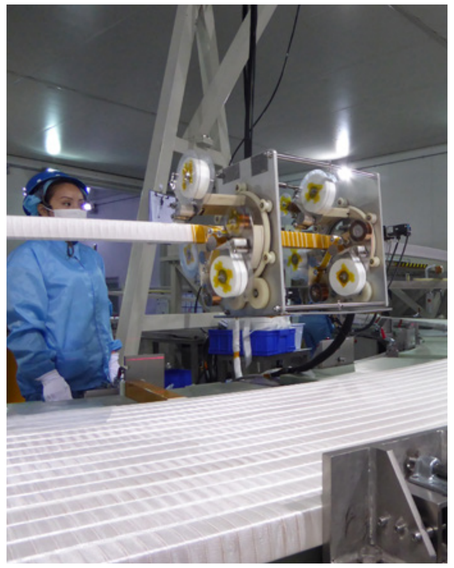
A sub-assembly manufactured by Mangiarotti for the Vacuum Vessel ready for electron-beam welding at Pro-beam.

Three sub-assemblies manufactured by Mangiarotti (for sectors 5 and 4) and Ensa for sector 3) are being electron-beam welded at Pro-beam.

Winding is over for ITER's sixth Poloidal Field coil

F4E and the institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) successfully complete an important fabrication milestone.

Group photo of ASIPP team celebrating the completion of the conductor winding for Poloidal Field coil six



Wrapping and insulating with Kapton and fiber and glass tapes the conductor of the sixth Poloidal Field coil

Six massive superconducting magnets, known as Poloidal Field (PF) coils, will embrace the ITER machine from top to bottom to shape and contribute to the stability of the superhot plasma. Europe is responsible for the production of five of these coils. One of Europe's coils, however, the heaviest and lowest of all PF coils, is manufactured in China. Following an agreement between F4E and ASIPP, and in line with the ITER project's spirit of collaboration, ASIPP and F4E have joined forces to manufacture the sixth PF coil, in Hefei (China).

At the end of June, ASIPP celebrated a major milestone by completing the winding of the conductor lengths needed for the coil. The sixth PF coil consists of nine pairs of windings, known as Double Pancakes (DPs). It has been a long journey since the fabrication of the first pre-dummy DP in February 2016, followed by a dummy Double Pancake, before going ahead with the production of the first DP in February 2017.

The winding of each DP took around one month. Basically, it involved winding two superconducting cable lengths which eventually take the form of a spiral. Each turn of superconductor had to be electrically insulated from the adjacent turn with a combination of Kapton and fibre glass tapes.

Furthermore two helium inlets had to be carefully fabricated to allow cold helium to flow inside the coil. The whole process was rigorously controlled to ensure the DP is fabricated in line with the technical requirements by a dedicated team of specialist technicians and engineers.

"ASIPP have been very collaborative with F4E and have reached this milestone due to the hard work, professionalism and attention to detail of their teams" explain Carlo Sborchia and Peter Readman, F4E Technical Officers following the production in China.

It is expected that by early October all nine DPs will be fully impregnated paving the way for stacking, an activity where they will be placed one of top of each other, connected electrically and hydraulically. Then the nine DPs will become one solid component, known as the "Winding Pack" (WP), it will be ground insulated and impregnated. The final assembly of the WP will take place before shipment to the ITER site in France, which is expected before mid-2019.

Discover the test facility of the ITER Pre-Compression Rings

A set of 18 Toroidal Field (TF) coils will create a massive magnetic cage to confine ITER's superhot plasma. While keeping the hot gas away from the walls of the vacuum vessel, they may experience some fatigue or deformation resulting from the powerful magnetic fields. Nine pre-compression rings hold the key to the survival of the TF coils.

Members of the teams from F4E, ITER IO, CNIM and Douce Hydro in front of the Pre-Compression Rings tooling, CNIM, La Seyne-sur-Mer, France.

They will need to be positioned at different levels—three on top and three below the inner "vault" formed by the wedged noses of the TF coils. An extra set of three will be manufactured as spare in case there is any future need to replace the lower set.

The pre-compression rings have an inner diameter of approximately 5 m, a cross-section of nearly 300 x 300 mm and will weigh roughly 3 t each. They are made of fiberglass composite, consisting of more than a billion minuscule glass fibers, which will be glued together using epoxy resin. Europe is responsible for their production. While their fabrication is still ongoing, ITER International Organization (IO) has taken the initiative to develop a facility where they will undergo a series of tests. The contract has been awarded to the consortium CNIM/Douce Hydro. F4E has developed the conceptual design of the test facility and is responsible for technical progress.

A brand new 140 m^2 test facility, located in La Seyne-sur-Mer, is getting ready to receive the first pre-compression rings. The construction works are completed and the central beam has been recently installed. This central column will host a tooling of 36 actuators exercising a force of 1000 t each. The goal will be to test the fabrication quality of each of the pre-compression rings by checking their resilience to the high loads they will experience in operation. When one of them is positioned on the tool, the 36 actuators will start to operate simultaneously, maintaining a position accuracy of 0.1 mm while releasing a total force of 36 000 t. This stress test will last a few hours and will be supplemented by other tests to confirm that the creep and fatigue performance is also adequate.

All teams, counting in total approximately 40 people, are working round the clock to meet the tight schedule making sure that the facility is fully operational by September. The first tests will be performed during the last quarter of the year when the first pre-compression rings prototypes will be delivered. Luigi Semeraro, F4E Metrology Group Leader, and Thierry Boutboul, F4E Magnets Technical Officer, explained that "F4E and ITER IO, in collaboration with the CNIM/Douce Hydro consortium, have made remarkable efforts to set up this test facility and deliver it on record time."

Philippe Lazare, Managing Director of CNIM Industrial Systems Division, elaborated on the background and on-going progress. "CNIM, expert in manufacturing large parts of technical composite, and Douce Hydro, specialist in high-pressure hydraulics, have partnered to provide ITER with the Pre-Compression Rings Test Facility. The tight schedule has been respected, the study and the production has been delivered on time. In a few weeks, the machine that will be installed at CNIM will measure the millimetric deformations of the first rings subjected to exceptional mechanical constraints" he stated.

ITER Council delegates visit Europe's Toroidal Field coils factory

International collaboration and exchange of know-how are essential to ITER's success. For this reason, Johannes Schwemmer, F4E Director, took the initiative to invite the ITER Council delegates to one of Europe's factories where the Toroidal Field (TF) coils are manufactured. It is the first time that such delegation visits a European industrial facility, bringing together 25 members in total from Japan, Korea, India and Europe.

F4E and ASG Superconductors unveil the manufacturing steps of the most complex superconducting magnets.

On the premises of what used to be a factory of washing machines, a magnets centre of excellence is now operating. Workforces have been carefully retrained and additional staff has been recruited to join ASG Superconductors. Their mission is to produce ten of the 18 TF coil winding packs (the core of the most sophisticated magnets), together with Iberdrola Ingeniería y Construcción, CNIM, SIMIC, Elytt and the ICAS consortium.

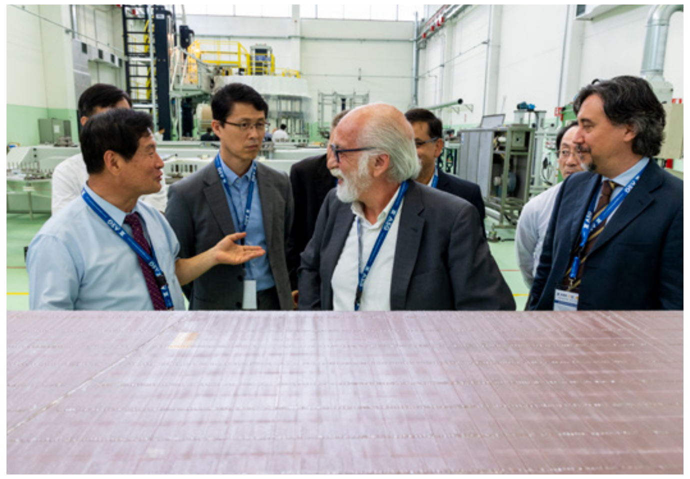
From any angle you may choose to see it, this is a success story of economic regeneration for La Spezia (Italy), where ASG Superconductors is based; technical expertise in the field of magnets, and the potential to use this know-how to penetrate markets outside Europe. The EU contribution to ITER has been conducive to helping companies become more competitive and experiment with new manufacturing processes. With almost 82% of Europe's TF coils production completed, the third winding pack has left to SIMIC to go through cold tests and be inserted in its case made in Japan.

Responding positively to F4E's idea to welcome the ITER Council delegates at ASG Superconductors, the company opened the doors of the vast facility to the guests in order to view the different manufacturing steps performed on-site. Davide Malacalza, President and Shareholder of ASG Superconductors, opened the event stressing the importance of ITER and the Broader Approach to the company together with the new business opportunities that stemmed from the two projects. Andrea Benveduti, Regional Counselor for Economic Development, highlighted the merits of business and innovation working hand in hand, their capacity to equip people with new skills, and the direct financial benefits for regions. Sergio Frattini, CEO of ASG Superconductors, outlined the various important projects carried out by the company in the field of high energy physics, fusion and medical research both in Europe and Asia. The different applications of Magnesium diboride, concluded his presentation highlighting the use of this superconductor. Johannes Schwemmer, F4E Director, praised the good collaboration of the ITER Parties involved in the TF coils (Russia, Europe and Japan), congratulated the F4E industrial partners for the excellent cooperation, and the F4E staff working in this field for their commitment and rigorous project execution. Alessandro Bonito-Oliva, F4E Magnets Project Team Manager, presented the procurement strategy, the main manufacturing milestones, a series of key performance indicators, and concluded his presentation by expressing some thoughts on the technological and societal impact of ITER.

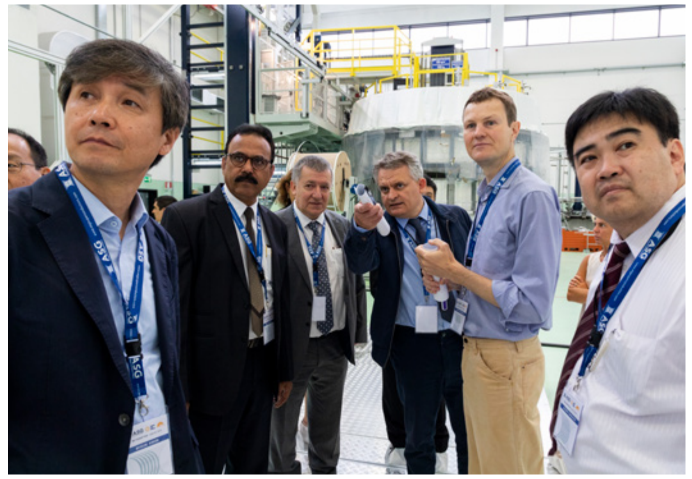
Then, the delegates of the ITER Council received a guided tour in the factory to view closely the different machines and tooling used for production of the European TF coil winding packs. The ITER Council delegates thanked ASG Superconductors and F4E for the kind invitation and underlined the importance of such field trips. The event helped the various delegates to become more familiar with Europe's contribution to magnets, meet the people behind the task and network with representatives from industry. F4E and ASG Superconductors were congratulated for this initiative and the delegates recommended that more events like this should be planned in future because they strengthen the international partnership and help ITER Parties see the real progress of the biggest fusion device components.

Technicians carrying out ground insulation on a Winding Pack, ASG Superconductors, La Spezia (Italy) © Andrea Botto

Technician lifting a Double Pancake to position it on another station, ASG Superconductors, La Spezia (Italy) © Andrea Botto



(L-R first row) Ki Jung Jung, Director-General of ITER Korea, NFRI, Alessandro Bonito-Oliva, F4E Magnets Project Team Manager, Stefano Pittaluga, ASG Superconductors Project Manager, discussing the impregnation process of TF coils winding packs © Andrea Botto



ITER Council delegates discussing the various manufacturing steps in the room, ASG Superconductors, La Spezia (Italy) © Andrea Botto

ITER at the core of the World Nuclear Exhibition

The World Nuclear Exhibition (WNE), the leading event for the global civil nuclear energy community, took place in Paris on 26–28 June 2018. ITER IO and F4E joined forces to showcase the continuous progress of the ITER project – the next important milestone in the way to fusion energy.

Antoni Courtial xxxx

Leonardo Biagioni, F4E Head of Contracts & Procurement, during the F4E Workshop on "ITER: the way to fusion energy"

Stavros Chatzipanagiotou, F4E Head of Communication, during the F4E Workshop on "ITER: the way to fusion energy"

The new ITER IO exhibit offered a panoramic view of the ITER site and the insides of the Tokamak complex, while F4E presented business opportunities and provided specific information to the many companies interested in the project.

This record-breaking third edition covered an area of approximately 25,000 m², with almost 1 000 exhibitors, 20 national pavilions, and 20 000 visitors from all over the world.

The specific F4E workshop on "ITER: the way to fusion energy" counted with a high participation from industry and government representatives. Stavros Chatzipanagiotou, F4E Head of Communication, explained the basics of fusion energy, its potential contribution to the future sustainable energy mix and highlighted the important progress of the ITER project, now steadily on the path to commence first operations in December 2025. Leonardo Biagioni, F4E Head of Contracts & Procurement, presented the business opportunities in the short and medium-term and underlined the importance to exploit fusion technologies for other markets. In the longer-run, F4E aims at creating a European fusion supply chain to ensure that Europe is in a position to be the leader in the future fusion market.

The WNE is a business show par excellence and over the years has confirmed its standing as the "business-to-business" event for the international nuclear energy community. The steady progress of ITER and the great potential of fusion energy are now attracting high interest from companies looking for new business opportunities and for capitalising on the new fusion technologies.

F4E participates at the 1st Barcelona Energy Days

Megan Richards, Director at the Directorate-General for Energy, European Commission

(from left to right) Eloi Badia (Adviser at Water and Energy, Barcelona Municipality), Joan Callau (Mayor of Sant Adrià de Besòs), Fransesc Torres (Rector UPC BarcelonaTech University), Francesc Subirada (Director-General for Research, Generalitat de Catalunya), Stavros Chatzipanagiotou (F4E Head of Communication).

Dr. Shakeib Arshad (F4E Technical co-ordinator for Diagnostics) presenting "Fusion in the Future Energy Mix"

Energy is a key factor for our societies and for our well-being. Our needs for energy are high and keep increasing every day. It is expected that the world demand will rise by 30% in the next 20 years. This is the equivalent of adding another China and India to the world economy. Similar growth rates are expected for the second half of the century. Today, we get most of our energy from fossil fuels: they still represent around 80% of our energy mix. However coal, oil and gas cause environmental pollution and are responsible for climate change. The world needs to find a way to reconcile the potential for growth without putting at risk the well-being and future of the planet.

The European Union is leading the efforts for clean energy aiming to reduce its gas emissions by 80-95% by the year 2050. This will bring important changes to the long-term structure of energy systems, the "energy transition" as its widely known. The 1st Barcelona Energy Days, organised by UPC BarcelonaTech University, the Government of Catalonia, the City Halls of Barcelona and Sant Adrià de Besòs, and Fusion for Energy, highlighted different ways to achieving this important target. A sustainable energy mix is the answer for the future, and Europe is at the forefront of developing one of the most promising long-term options— fusion power.

The Conference took place at the Campus Diagonal Besòs of UPC on 19 June 2018. It brought together more than 200 professionals and experts from public administration and industry, as well as representatives from the European Commission, the Government of Catalonia and F4E. This was the first edition of the Barcelona Energy days, organised in the framework of the EU Sustainable Energy Days, an initiative of the European Commission.

Antimatter seeks inspiration in fusion

FAIR looks to benefit from F4E procurement experience

Dr. Sonia Utermann and Felix Arndt from FAIR (Facility for Antiproton and Ion Research) visited Fusion for Energy on 17-18 July to meet staffand exchange best practices in the procurement of high technology components for big science facilities. Discussions focused in particular on F4E practices in pre-procurement analysis, indexation, open software, export control, and in-kind procurement. The FAIR colleagues were hosted by Leonardo Biagioni, F4E Head of Contracts & Procurement, and Victor Saez, Head of Market Intelligence. Dr. Utermann thanked them sincerely for welcoming them to Barcelona and underlined that "F4E experience in procurement is extremely useful for us and would be of great help for improving our practices."

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The Facility for Antiproton and Ion Research FAIR is an international accelerator facility under construction. The facility will use antiprotons and ions to solve some of the most perplexing mysteries of matter and will carry out experiments in the area of high density plasma physics. The facility is being built in Darmstadt, Germany, by partners from Finland, France, Germany, India, Poland, Romania, Russia, Slovenia and Sweden that signed an international treaty, the FAIR Convention, in March 2014. It should be ready in few years' time and is expected to host more than 3000 scientists from about 50 countries.

Fusion for Energy
The European Joint Undertaking for ITER and the Development of Fusion Energy

C/ Josep Pla, 2
Torres Diagonal Litoral, Edificio B3
08019 Barcelona - Spain

Tel: +34 93 320 18 00
E-mail: info@f4e.europa.eu

www.fusionforenergy.europa.eu
www.youtube.com/fusionforenergy
www. twitter.com/fusionforenergy
www.flickr.com/photos/fusionforenergy

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Design: M. Boulguy
Contributors: J. Benet Ciurana, T. Boutboul, P. Cara, S. Chatzipanagiotou, M. Cornelis, R. Darbour, R. Harrison , R. Heidinger , L. Jamous, G. Kouzmenko , N. Mitchell, M. Ortiz De Zúñiga, P. Readman, G. Savoldi, C. Sborchia, L. Semeraro, F. Zacchia

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