JT-60SA Newsletter

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Headline

Temporary 360° VV torus appears

Figure 1: VV inside view

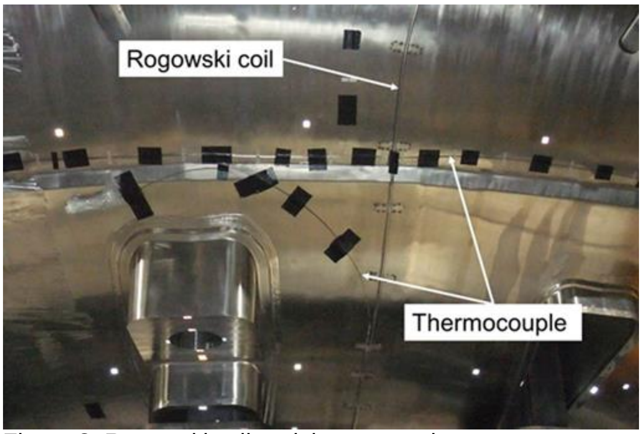

Figure 2: Rogowski coil and thermocouples

Figure 3: Inserting the final 20° sector temporarily

Figure 4: 360° VV torus appears

After the 340° vacuum vessel (VV) torus was completed, all of the constraint jigs inside the VV, except the ones at both ends, were disassembled and removed (Figure 1). 4 Rogowski coils for plasma current measurement and 22 thermocouples were mounted on the VV outer surface (Figure 2).

In December 2015, the final 20° VV sector was inserted into the opening of the 340° torus to measure the gaps between the 340° and 20° sectors for the later welding with splice plates (Figure 3), and the unique tokamak donut shaped 360° VV appeared for a while (Figure 4).

The 20° sector has already been removed. The VV thermal shields and 18 toroidal field (TF) coils will be inserted from the 20° gap and mounted in their designated positions one by one.

News

First TF coil completed and delivered to Saclay

ñWe did it!ò That was what P. Decool, JT-60SA TF coil project leader at CEA, said with a big smile and a great feeling of satisfaction, when the truck, loaded with the first TF coil, left the Alstom/GE[*1] factory in Belfort on the sunny morning of 15 December 2015 (Figure 1). And undoubtedly thinking likewise were the members of the Alstom/GE team led by M. Nusbaum and G. Billotte, the members of the CEA team led by P. Decool, and the members of the F4E and ENEA teams, who had worked hard throughout the last few years to reach this important milestone. Before the departure, the coil was packed and mounted on a special coil transportation frame (Figure 2) for the ground transportation from Belfort to Saclay, where the coil would be inspected with the TF coil cold test facility. A message saying, ñWe, GE, strongly wish your successful installation and commissioning.ò in Japanese to the members of JAEA, the final destination of the coil, was stuck on the transportation frame (Figure 3).

Figure 1: First TF coil departure from Alstom/GE Belfort

Figure 2: Packing the first TF coil

Figure 3: Friendly message for JAEA colleagues

The TF coils are one of the key components for the scientific success of any tokamak. To appreciate the challenges that have been overcome thus far, it is enough to know that these superconducting coils for JT-60SA are among the world's largest in size, shape and magnetic characteristics. For fusion devices, they will only be overshadowed by the ITER TF coils.

The design and manufacturing[*2] of the JT-60SA TF coils are the outstanding results of an intense, fruitful and efficient international collaboration. The design activities during the years from 2007 to 2011 were widely shared between European and Japanese institutions: F4E, ENEA, CEA, and JAEA. The manufacturing of the TF coils, defined as a part of the European contributions to the JT-60SA project in the framework of the Broader Approach agreement, is the result of the assembly of various components procured by different stakeholders. Each component requires a high level of skill and quality as well. For this purpose, F4E procured superconducting strands from Furukawa Electric Co., Ltd. in Japan, and entrusted ICAS, the Italian consortium with their subsequent cabling and jacketing to produce cable-in-conduit conductor. ENEA procured the TF coil casings, manufactured by Walter Tosto S.p.A. With these components, CEA and ENEA, who each have the duty to produce 9 TF coils plus 1 spare with a high level of accuracy and reliability, made industrial contracts with renowned superconducting coil manufacturers: Alstom/GE and ASG superconductors S.p.A., respectively. The industrial contracts included: the winding of the conductors into 6 double pancakes per coil, the mounting of the electrical joints and terminals for power supply, the resin impregnation of the winding pack (WP) to provide the necessary electrical insulation and mechanical integrity, the insertion of the WP into the casing, the closure welding of the casing, the embedding impregnation of the WP in the casing, the final machining of the integrated coil, and the fitting of the final cooling pipes and measuring sensors (Figure 4). At each step, the manufacturer had to complete a dedicated testing and quality control programme. Before the start of the manufacturing, each manufacturer had to develop and qualify the manufacturing process and manufacturing tools.

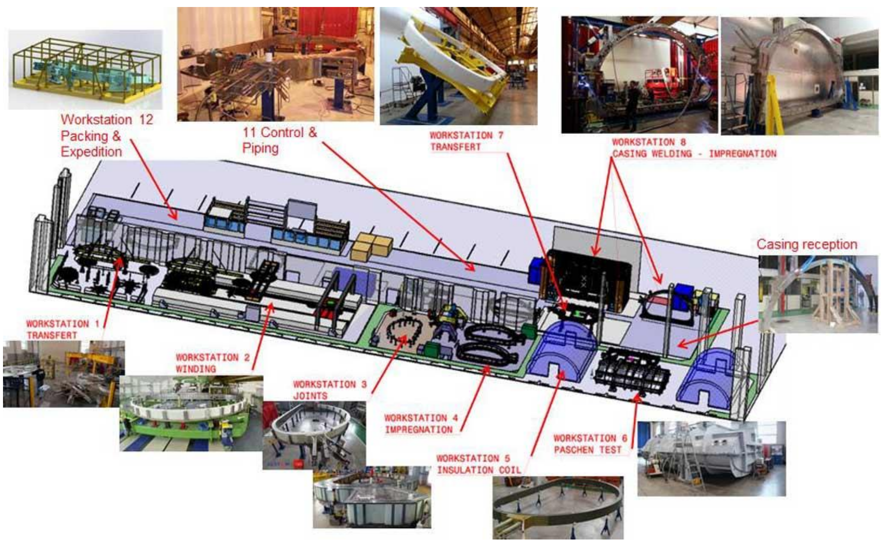

Figure 4: Alstom/GE factory organization

As for the CEA coils, the winding operations of the first coil started in January 2014, and the coil was finally completed on 11 December 2015 (Figure 5). Now at the Alstom/GE's premises in Belfort, 8 TF coils are in different manufacturing stages along the production line.

On 17 December, the first coil was delivered to the cold test facility at CEA Saclay (Figure 6), where it would be tested at its nominal operating conditions (25.7kA, 4.5K) and subjected to a temperature-induced quench. Then, it will be assembled with its outer intercoil structures (OIS), re-packed and transported to Japan. The 17 remaining coils and 2 spare coils will all experience similar full current testing in Saclay before shipment to the JAEA Naka site.

Figure 5: Group photo taken inside the first TF Coil completed at Alstom/GE Belfort

Figure 6: First TF coil arrived at CEA Saclay during unloading

*[1]) *Alstom Power and Grid, the manufacturer of the TF coils for the JT-60SA project to be provided as the French contribution by CEA, were acquired by General Electric (GE) in 2015.*

*[2]) *Watch a movie introducing the* <u>manufacturing process of TF coils in CEA/GE</u> *on the JT-60SA project website.*

<u>News</u>

Factory acceptance and delivery of first OIS

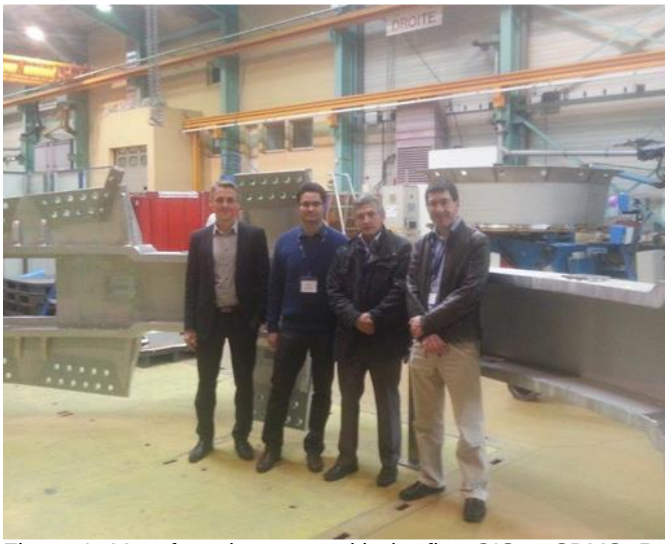

Figure 1: Manufacturing team with the first OIS at SDMS: P. Eymard-Vernein (project leader at SDMS), G. Disset (CEA), R. Gondé (CEA) and S. Davis (F4E) from left to right

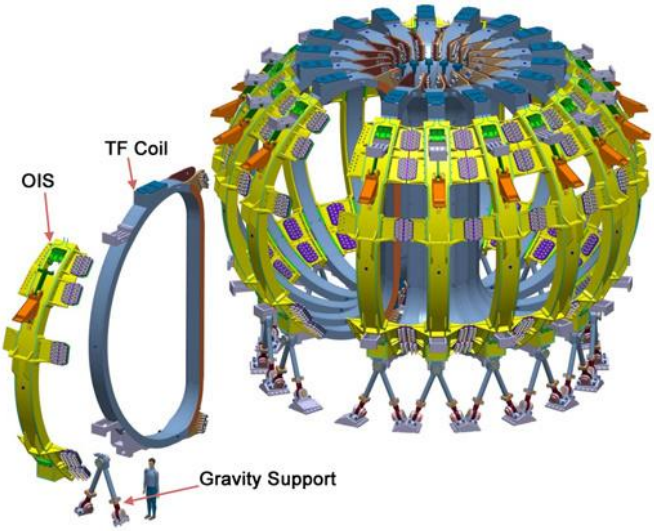

Figure 2: Final assembly of the TF coils (blue), OISs (yellow) and gravity supports (18 sets in total)

On 3 November 2015, CEA and F4E jointly accepted the first OIS manufactured by SDMS technologies (SDMS) in Saint-Romans, Isère, France (Figure 1). A full day was devoted to a careful review of the component and of the acceptance data package associated with it.

When assembled, the 18 OISs, in each of which a TF coil will be inserted, form the outer structure supporting the magnet system. It must withstand the out-of-plane electromagnetic loads exerted on the TF coils during JT-60SA operation. The 18 OISs are to be assembled and completed by means of 180 splice plates and 1980 bolts in total. Each OIS is hung from the corresponding coil by a rotating mechanical connection (Figure 2).

2 years of development were needed for SDMS to define and implement the manufacturing process of these heavily welded pieces with a length of 7 m, a weight of 6 t, and a total weld length of several km. In this process, the structural deformations

that accumulate at each manufacturing step had to be anticipated, in order to reach the prescribed tolerance of a few mm at the final machining step.

ñIt has been machined and then measured very carefully ï this is a nice piece of workò said S. Davis, representing F4E, after the presentation of the final results achieved on the first OIS made by P. Eymard-Vernein, project leader of the OIS project at SDMS.

Presently, the manufacturing of the 17 remaining OISs is progressing well, according to the schedule implemented by SDMS with the support of CEA to comply with the TF coil deliveries. The OISs will be delivered to CEA Saclay to be pre-assembled with the tested TF coils, before shipment to Japan.

The first OIS was delivered to Saclay on 3 December 2015. It was stored in the pre-assembly hall (Figure 3), where it will be ready for integration with the first TF coil by February 2016 after a complementary measurement survey. In addition, all of the pre-assembly tools have already been installed and commissioned (Figure 4).

Figure 3: First OIS in the pre-assembly hall of CEA Saclay

Figure 4: Pre-assembly tools for the TF coil and OIS

News

CS2/3 converter transformer tested


Figure 1: Group photo taken in front of the transformer during the short-circuit test

Regarding ENEAõs contribution of 8 power supplies (PSs) to the JT-60SA poloidal field (PF) coil PSs, the first design report (FDR) of the transformers was officially approved by ENEA, F4E and JAEA in April 2014, whereas the superconducting coils magnet PS convertersô FDR was approved in April 2015.

In order to assure the quality of the CS transformer design and to improve its reliability, Poseico-Jema proposed an alternative approach to evaluate the robustness of the central solenoid module 2 (CS2) and CS3 transformers under electro-dynamic and thermal stresses.

In order to avoid any possible doubt on the results of the electro-dynamic and thermal analyses, which was foreseen in the first design, Poseico-Jema suggested to perform:

- a short-circuit type test on one of the CS transformers;
- a thermal type test based on the temperature measurement in the primary and secondary windings of a CS transformer.

The thermal type test was performed by placing probes at the upper hottest point of the windings. In addition, the temperature distribution in the outer casing and oil-air radiators was monitored with a thermo-graphic camera (this proposal had been accepted by all project partners (ENEA, F4E and JAEA) beforehand). Prior to the short-circuit tests, the CS transformer was subjected to routine acceptance tests as specified in IEC 60076-1.

The short-circuit type test was carried out at SIEMENS SVEPPI Laboratories Scorzè (VE, Italy) on 25 September 2015, according to IEC 60076-5. A suitable value of short-circuit current was injected in the CS transformer and current and voltage waveforms were acquired. 9 short-circuit shots were carried out in total (3 shots for each phase of the transformer), and the short-circuit reactance was measured after each shot. The short-circuit type test gave successful results.

The final acceptance tests, with the attendance by P. Zito, A. Lampasi (ENEA), F. Fasce (Poseico-Jema) and L. Novello (F4E), were performed on 14 to 16 October 2015 according to IEC 60076-1,2,3,5.

All tests gave positive results, the only exception being that the oil temperature, the winding average temperature and the absolute hot spot temperature, after 20 cycles, exceeded the limits foreseen for this test. To correct this, the transformer manufacturer added a fan cooler to the bottom of each oil-air radiator of the transformer to improve the efficiency of thermal exchange. The introduction of fan coolers does not change the overall transformer dimensions, and the weight increase is negligible, but it guarantees a long life operation.

The temperature rise type test was performed again on 24 October 2015 with a positive result. The air fan cooling system was very effective both at minimising the oil temperature rise and at limiting the hot-spot temperature. Furthermore, the thermo-graphic camera did not highlight any critical hot spot.

Figure 2: Group photo taken in front of the transformer during the temperature rise test

News

All SNU tests successfully completed

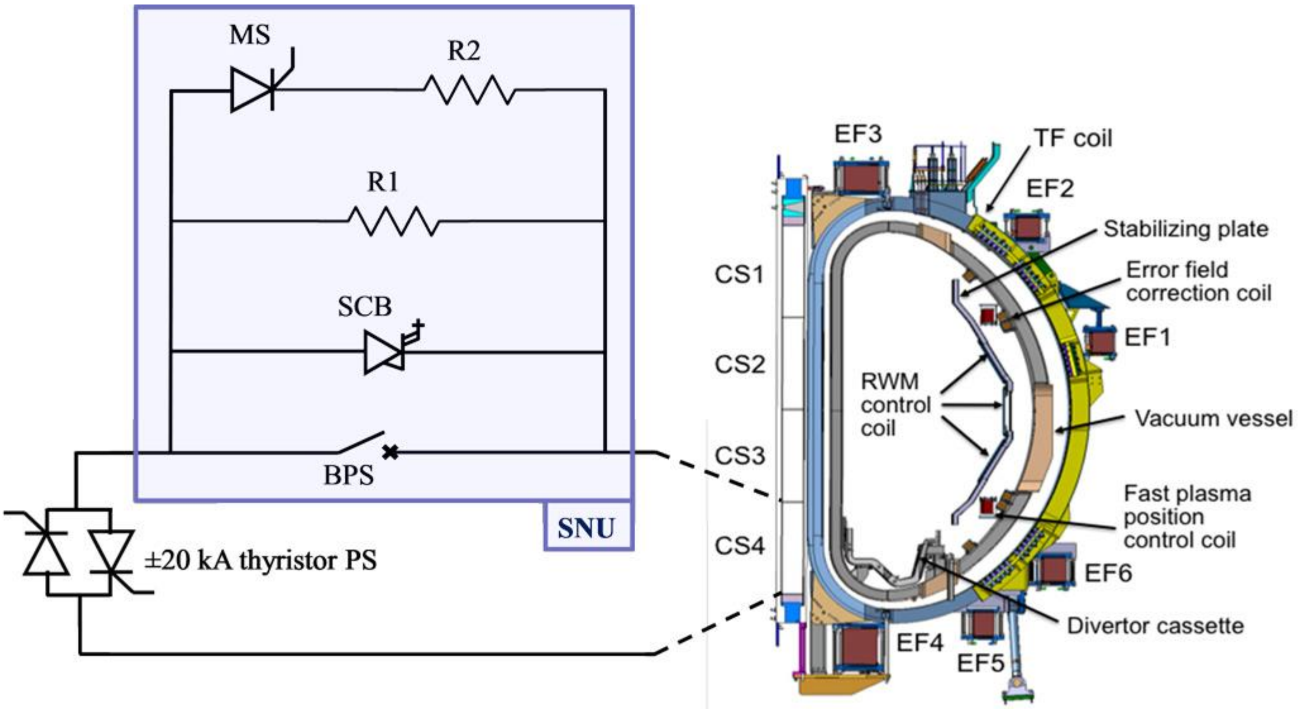

Figure 1: Simplified scheme of the SNU inserted in the CS module PS circuit

Figure 2: 4 SNUs and LCC installed in the OCEM premises reproducing the final installation at the JAEA Naka site.

The JT-60SA CS (central solenoid) is divided into 4 superconducting modules. As sketched in Figure 1, each module is connected to an independent switching network unit (SNU) for plasma initiation. The 4 CS SNUs are procured by ENEA through a contract, signed in October 2012, with the Italian industrial supplier, OCEM Energy Technology S.r.L. (OCEM). The detailed design of the SNUs was approved by the JT-60SA Project Leader (PL) in July 2013.

Due to the criticality of these components, it was agreed firstly to perform thorough tests, even at full current (20 kA) and full voltage (5 kV), on the first SNU (full-scale prototype) to confirm its performance, and then to proceed to complete the remaining 3 SNUs. The first SNU was successfully tested at ENEA Frascati facilities in September 2014.

Afterwards, the remaining 3 SNUs were completed and tested during 2015. Finally, the 4 SNUs together with their local control cubicle (LCC) were assembled in a configuration similar to the final installation in the JT-60 rectifier building at the JAEA Naka site. This was accomplished in the new OCEM premises located in Crespellano, Bologna, Italy (Figure 2).

The most critical elements and the whole assembly of these SNUs were tested. For example, Figure 3 summarizes the accuracy of all SNU breakdown resistances (being kept well within the required range, ±2%). As shown in Figure 4, the complete SNU operations were tested on a dummy current load, which was lower than that used during the ENEA (routine) tests. The operations were set up, controlled and monitored by an updated version of the SNU test stand, emulating the JT-60SA supervising computer provided by JAEA (Figure 4 and 5). The final routine tests of the complete SNU system were attended by ENEA, F4E and OCEM representatives (Figure 6).

Since all of the tests on the CS SNUs were successfully completed, the SNUs are ready for shipment to Japan. The delivery date to the JAEA Naka site will be agreed among the JT-60SA partners in 2016.

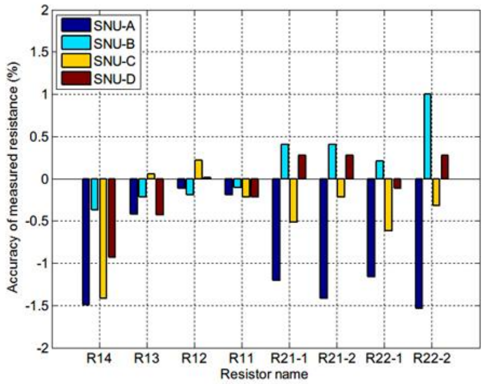

Figure 3: Range of the SNU breakdown resistances

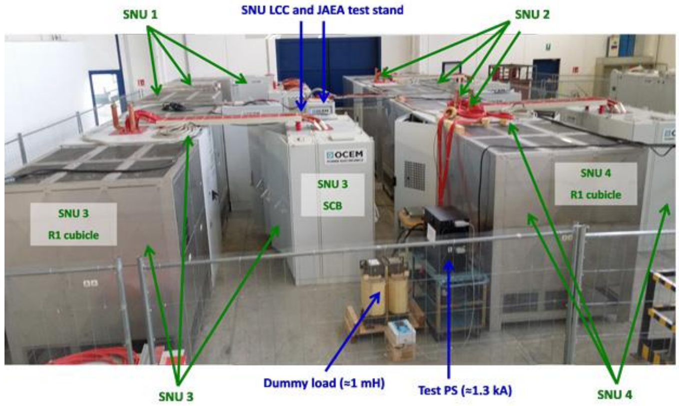

Figure 4: Complete SNU system set up for the routine tests

Figure 5: Observing the final routine tests on the SNU LCC remote monitor and the JT-60SA test stand

Figure 6: ENEA, F4E and OCEM representatives with the CS SNUs after the successful completion of the final routine tests

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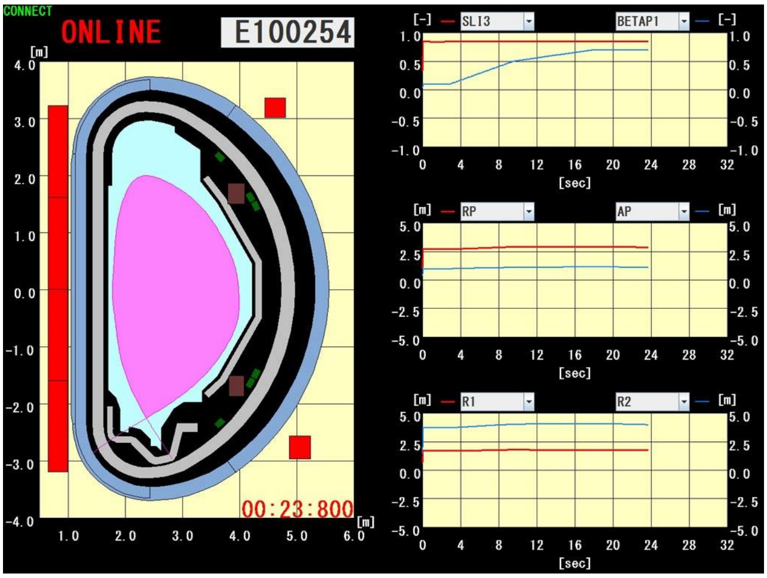
News

Progress of remote experiment system development



JT-60SA plasma shape image displayed in real-time

The JT-60SA remote experiment system is now under development in cooperation with the ITER Remote Experimentation Centre of the IFERC project in Rokkasho, Japan. The prototype of the JT-60SA real-time plasma shape display, which is essential for the remote experiments, was tested to confirm its performance.

In the performance test, it was confirmed that the plasma shape was being displayed on the plasma shape viewing tool (see figure) in Rokkasho, in close synchronization with a simulated JT-60SA discharge sequence being operated at the JAEA Naka site, through a data transmission link via the Science Information Network (SINET). As a result, it was confirmed that the data communication software worked well.

Meeting

17th BASC Meeting

Figure 1: Discussions at the BASC-17 meeting

Figure 2: Group photo of the BASC participants

On 11 December 2015, the 17th Broader Approach Steering Committee (BASC) meeting was held at Consorzio RFX in Padua, Italy with attendance of representatives and experts from Europe and Japan. The 2016 Work Programmes for the 3 projects (IFMIF/EVEDA, IFERC and the Satellite Tokamak Programme (STP)) were discussed and approved. It was also decided to extend the IFMIF/EVEDA and IFERC projects until the end of 2019, the same as for the STP project.

For the STP Project, the PL, H. Shirai, reported that the project had been progressing well with achievements in both European and Japanese procurements as well as the assembly, including fabrication of the TF, equilibrium field and CS superconducting coils, manufacturing of the high temperature superconductor current leads, production of the cryostat vessel body cylindrical section, delivery and installation of the cryogenic system, installation and commissioning of the quench protection circuit components, and completion of the 9 VV sectors welding on the cryostat base forming the 340° torus. The SC expressed satisfaction with the progress of the STP project.

The next BASC meeting will be held in Rokkasho, Japan on 22 April 2016.

Calendar

24 - 25 February 2016
24th Technical Coordination Meeting (TCM-24)
Naka, Japan

16 March 2016
18th Meeting of the STP Project Committee (PC-18)
Naka, Japan

22 April 2016
18th Meeting of the BA Steering Committee (SC-18)
Rokkasho, Japan

30 May ï 3 June 2016
22nd International Conference on Plasma Surface Interactions in Controlled Fusion Devices (PSI 2016)
Rome, Italy

4 ï 8 July 2016
43rd European Physics Society Conference on Plasma Physics (EPS 2016)
Leuven, Belgium

Contact Us

The JT-60 Newsletter is released monthly by the JT-60SA Project Team.
Suggestions and comments are welcome and can be sent to newsletter@jt60sa.org.

For more information, please visit the website: http://www.jt60sa.org/.