Featured Report

The Wendelstein 7-X stellarator achieved its First Plasma milestone on 10 December 2015. The accuracy of the magnet system was verified by electron-beam field mapping (left) and expected island structures were observed. The first plasma (right) consisted of Helium and reached about 1 million degrees Celsius. (Photos: IPP)

The Wendelstein 7-X (W7-X) stellarator experiment officially opened on 10 December 2015 with the achievement of its First Plasma milestone. The facility, located at the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany, uses a ring of 70 specially shaped superconducting coils (50 planar and 20 non-planar), to confine the hot plasma. It will provide a large-scale test of an innovative physics-optimized 3D plasma configuration design (Figure 1). It will test the compatibility of a high-performance core plasma with a unique 3D divertor, and be capable of extending plasma-material interaction research to pulse lengths up to 30 minutes. The W7-X is a key element in Europe's fusion energy roadmap, with a mission to validate its optimized design and to qualify its so-called island divertor. Collaboration in W7-X research enables U.S. fusion scientists to deepen understanding of 3D plasma physics and to advance long-pulse PMI science using the world's most advanced stellarator. A formal collaboration agreement between the Department of Energy and IPP, signed in 2014, provides opportunities for U.S. scientists to participate in W7-X as full team members, with access to all data and the ability to lead experiments and publish results.

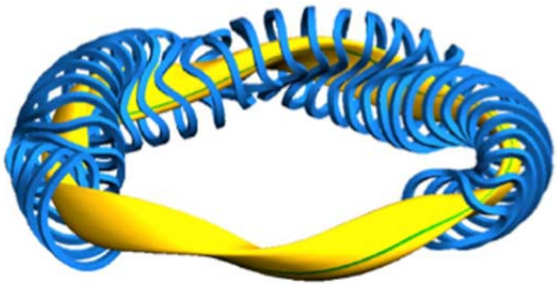

Figure 1. Wendelstein 7-X plasma and non-planar coils.

The U.S. collaboration on W7-X began with an invitation from IPP in 2008 for the U.S. to join the project, then in construction, as a partner. A number of urgent engineering tasks, well matched to U.S. capabilities, were identified. After a proposal from Princeton Plasma Physics Laboratory, Oak Ridge National Laboratory, and Los Alamos National Laboratory was approved by DOE in 2010, work started on several projects, including the design and construction of a full system of low-order field perturbation "trim" coils, which W7-X will use for balancing heat loads among its ten divertor chambers. U.S. Laboratory researchers participated in the commissioning of the trim coil system and in vacuum field mapping experiments to check that their effect on the magnetic configuration was as predicted.

In 2015, with W7-X research preparations intensifying, DOE approved proposals from four university and industry teams, bringing the Massachusetts Institute of Technology, the University of Wisconsin, Auburn University, and Xantho Technologies, LLC into the

collaboration. By the time W7-X achieved first plasma, the U.S. had several tasks either completed or in progress. U.S. equipment items were installed and operating, and several U.S. scientists were on site, operating U.S. diagnostics, and contributing to the experiment from the first day of plasma operation. A list of U.S. institutions and their current roles in the W7-X collaboration is given in Table 1.

Table 1. U.S. Institutions Currently Involved in the W7-X Collaboration

Institution	W7-X Activities
Massachusetts Institute of Technology	Phase contrast imaging Gas puff imaging MDS-plus
University of Wisconsin	Penning gauge neutral gas analyzer Edge spectroscopy Edge transport / PMI simulation
Auburn University	Equilibrium reconstruction X-ray imaging crystal spectrometer (w/PPPL).
Xantho Technologies, LLC	Heavy ion beam probe feasibility study
Oak Ridge National Laboratory	Divertor scraper design Edge filterscope array Pellet injection
Los Alamos National Laboratory	Infrared and visible imaging
Princeton Plasma Physics Laboratory	Field mapping experiments Trim coils / magnetic configuration control High-resolution temperature/velocity profiles (x-ray imaging crystal spectrometer) Divertor scraper design (w/ORNL) and fabrication National coordination

The goals of the brief first plasma campaign (known as OP1.1) are to establish reliable electron-cyclotron heated plasma operation in a limiter configuration, commission diagnostics, and begin to characterize plasma conditions. After a year-long outage to complete the installation of in-vessel components including an inertially-cooled test divertor system, the second campaign (OP1.2) will begin in mid-2017. The U.S. will be well prepared to make key physics contributions during that campaign, which will feature the first operation with divertors and neutral beam heating, will explore the operating space of the device, and will address a diverse range of physics topics. Results from the OP1.2 campaign will help to determine the optimum in-vessel systems configuration and the most promising plasma scenarios for steady-state operation in the OP2 campaign to follow.

For further details on W7-X visit http://www.ipp.mpg.de/16900/w7x. For information on US participation, contact Hutch Neilson (hneilson@pppl.gov), U.S. Technical Coordinator for the W7-X collaboration, and visit http://advprojects.pppl.gov/home/w7-x