4 Wendelstein 7-X and ITER

Polish contribution to Wendelstein 7-X programme is considered to play a very important role in the integration of all Polish parties that form our Association. Polish involvement in the W7-X programme is quite extended, ranging from cooperation on device assembly and development of NBI system through the development of several diagnostics (X-ray PHA, C/O monitor).

Participation of the Polish institutions to the ITER project is done through the direct ITER IO contracts and F4E grants. Wroclaw University of Technology (WrUT) has been continuing the contract on the Risk Analysis of ITER Cryogenic System and the following tasks were performed in 2012: scaling of safety devices (impact of Fukushima case), main cryostat risk analysis and risk analysis of He tank damage – TNT versus thermodynamic approach. AGH University of Science and Technology has finished works in the frame of F4E grant related to Nuclear Data studies/experiments in support of TBM activities.

4.1 Contribution to the W7-X project

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Introduction

The Polish contribution to the Wendelstein 7-X programme concerns the realization of the following tasks:

1. Contribution to W7-X assembly process: assembly of the bus bar system powering superconducting coils of the stellarator modules – continuation of bus bar interconnections between neighbouring modules (IFJ PAN)
2. Development of the soft X-ray spectrometry systems for the stellarator W7-X (Opole Univ)
3. Adapting the activation technique to apply on W7-X for determination of neutron yield from deuterium plasmas (IFJ PAN)
4. Development of the soft X-ray spectrometry systems for the stellarator W7-X (IPPLM)

Results

Ad. 1. In 2012, the assembly of the joints at Module Separation Planes (MSP) has been continued i.e. the bus bars of neighbouring modules have been connected. The joints at MSP 4-5 (between module 4 and module 5) started in 2011 were finished and at the remaining MSP 1-2, MSP 2-3, MSP 3-4 were completed [1]. The presented scope of work in 2012 was realized by about 20 technicians conducted and supervised by 2 Line Officers (LO) from IFJ PAN. The Bus Bar Assembly Team consisted on the average (at given time) of 12 technicians and 2 Line Officers (LO) working at the same time on W7-X construction.

Ad. 2. A soft X-ray spectrometer, called C/O monitor for Wendestein 7-X, is designed for monitoring intensities of Lyman-α lines emitted by hydrogen-like ions of carbon, oxygen, nitrogen and boron. The spectrometer will be fixed at suitable wavelengths and position (at AEK 30 port) and should work with

high throughput and high time resolution. The detectors of the spectrometer will consist of proportional counters (MSGC – multistrip gaseous chamber) of special construction with multichannel readout electronics. The detection system is under development by INP Kraków. The dispersion elements provided for three channels will be multilayer mirrors. As the first as well as second set of mirrors, delivered to the IPP, due to imperfectness of the mirror surface, could not be accepted, and were returned to the manufacturer. Due to different difficulties, the completion of the project will be somewhat delayed.

Ad. 3. Detection of the delayed neutrons from activation of fissionable materials in the neutron field created by fusion-plasma devices is a supplementary method to the classic neutron activation method. After irradiation of a sample of fissionable isotope (U or Th, for instance), prompt neutrons (~99 %) and delayed neutrons (~1 %) are emitted. A decay of the delayed neutrons in time is measured. Deconvolution of the time-decay curves enables to derive the primary neutron spectrum. Elaboration of a method of interpretation of the decaying delayed neutron flux from activated fissionable materials was continued. For this purpose, Monte Carlo simulations were performed to model irradiation of the fissionable samples with neutrons of various energies which can be present at fusion-plasma devices. Then the time decay of the delayed neutrons emitted from the samples was registered. Finally, transport of delayed neutrons from measuring position to detectors in the DET-12 device was simulated and the time distribution of counts was obtained [2].

Ad. 4. Two spectroscopic systems: pulse height analysis (PHA) and multi-foil system are currently under design for the Wendelstein 7-X stellarator for long pulse operation. The proposed PHA diagnostic is intended to provide the spectral energy distribution with energy resolution not worse than 180 eV along a central line of sight. The system consisting of 3 single Silicon Drift Detectors (SDDs) operated with different filters will be installed on the horizontal port AEK50 on W7-X. Each detector will record an X-ray spectrum in three different energy ranges from 400 eV to 20 keV. In MFS system the recorded spectrum is determined by the measurement of the total X-ray emission (as the effect from interaction of many quanta) in different ranges of energy, which are determined by the type and thickness of the filters and the thickness of the detectors (usually the ranges overlap). The MFS method is characterized by lower, in comparison with the PHA system, spectral resolution [3, 4].

Conclusions

Ad. 1. Milestone 1 (Completion of the bus bar interconnections: MSP 4-5, MSP 1-2, MSP 2-3 and MSP 3-4) has been completed. Milestone 2 (Start of current leads making): There was also some side activity with a preparation of procedures for mounting so called current leads: special joints connecting coil circuits to the external power supplies. We prepared several samples of complete joints for testing and additional samples for proving some technological details, what took quite a lot of time and manpower. Our experience in bus bar preparation and joint assembly and isolation was very useful for that. Due to technical problems and resulting delays, it was agreed the IFJ PAN team would not be involved in that task.

Ad. 2. Due to the lack of manpower in the designers group of IPP-Greifswald, the priority list of all diagnostic tasks was elaborated by IPP authorities. Because of low advancement of the project and existing, almost finished another spectroscopic system (HEXOS), the ‘C/O monitor for W7-X’ was given low priority number and consequently the realization of the project will be delayed.

Ad 3. The response of the DET-12 device for the delayed neutrons emitted from samples of fissionable materials irradiated with primary neutrons from a fusion-plasma device was obtained with the Mote Carlo method. For each sample, the ratio of the count rate distribution in DET-12 to the emitted delayed neutron flux is constant in time. This allows relying on registered count rate time distributions to proceed with elaboration of the interpretation method. Other aspects, like adjustment of width of time channels (maybe variable along the time axis) has to be analysed while continuing the work.

Ad. 4. At the beginning of 2012, a new Agreement on Cooperation between IPPLM and IPP Greifswald has been signed for 3 next years. In 2012, manufacture drawings with all details of proposed PHA and

MFS systems have been performed and present IPP Greifswald. The DN160CF detectors flange with multipin connectors for PHA system has been delivered. The detector cooling system for PHA diagnostics has been manufactured at IPPLM workshop. In 2012, detector arrays have been bought and tested for MFS diagnostics. Also, thicknesses of beryllium filters have been chosen. For both diagnostics a mechanism with wobble stick, which will be used for changing filters or/and cut the radiation from plasma, has been made and tested in the laboratory.

Collaboration

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Association EURATOM – CCFE, Culham, United Kingdom

References

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