CONSORTIUM WORK PLAN 2021-2025

CALL for the work package SA – JT-60SA Exploitation:

Design of Neutron Diagnostics

1. INTRODUCTION

JT-60SA is a large fully superconducting tokamak device with high plasma current, high auxiliary power and long pulse operation capability. The JT-60SA tokamak was fully assembled in March 2020 and it is expected to produce the first plasma in 2023 as part of the Operation-1(OP1).

The main characteristics and scientific goals of JT-60SA can be found in the JT-60SA research plan, https://www.jt60sa.org/pdfs/JT-60SA_Res_Plan.pdf, which was developed in the period 2010-2020.

Scientists from Europe jointly with Japanese scientists will participate in all the phases of the experiments as members of the unique JT-60SA Experiment Team, with the scientific coordination of the Experiment Team Leader and organized in the Topical Groups.

The EUROfusion work package SA [wiki page] provides support and resources to the European scientists to contribute to the scientific programme of JT-60SA in the next years, including participation in plasma and systems operations (SA Operation Area), development of sub-systems and diagnostics (SA Enhancements Area), preparation and application of analysis tools (SA Code Management Area).

2. DESCRIPTION OF THE CALL

The present call concerns the design and procurement (in future calls) of Neutron Diagnostics for the JT-60SA tokamak.

The recently created JT-60SA Experiment Team has prioritized the machine enhancements (including diagnostics) for the upcoming years. For this prioritization, the scientific objectives, along with the budget and timeline constraints have been considered. The installation of **Neutron Diagnostics with Neutron Spectroscopy capabilities** has been considered high priority by the Experimental Team.

Neutron diagnostics, in particular those measuring the neutron spectrum and radial distribution, are an essential tool to properly evaluate the neutron generation characteristics. It will be useful to distinguish neutrons generated by thermal deuterium and those coming from beam-target reactions and this is something essential in order to extrapolate the performance of JT-60SA plasmas to ITER. Such measurements can be used to evaluate the deuterium fast ions characteristics, a measurement that it is essential to evaluate the potential impact of fast ions on transport/turbulence both from the experimental and modelling point of view.

Different Neutron Diagnostics are already planned for JT-60SA, to be installed during the upcoming years. Specifically:

- **Neutron monitor system**, for monitoring the fusion performance and measuring neutron yields to meet the requirements from nuclear license will be prepared. The time-resolved volume-integrated neutron-emission rate (neutron yield) will be estimated from a neutron count rate by a detector using a U235 fission chamber (FC). Based on the nuclear license, three identical sets of

neutron monitor are installed for redundancy, while two sets should be always active during deuterium plasma operation.
- **Neutron profile monitor system**, for the measurement of a line-integrated neutron emission profile will be prepared. An NE213 liquid organic scintillator or a stilbene crystal scintillator will be used as a detector because of its better sensitivity and fast response.

The diagnostics proposed in this call, are intended to complement and support the already planned ones to enhance the Neutron diagnose capabilities of JT-60SA and its impact on the fast-ions physics studies. Such topic is one of the most important research topics in view of the impact of alpha particles on transport/turbulence in ITER. Specifically, according to the ET prioritization:

- The installation of an **extra neutron emission profile monitor** in an upper port, can complement the expected one in a horizontal port. Covering a wide region of the plasmas can give a proper view of the neutron emission and its profile, which can be used for detailed fast ion studies and its interaction with turbulence.
- The installation of a **neutron energy spectrometer** would significantly benefit the characterization of fast ions in JT-60SA. Similarly to JET, it is expected that fast ions can be very well confined in JT-60SA avoiding strong fast ion loses from the different plasma perturbations. Therefore, in the case of FILD (diagnostic already planned), which measures the energy distribution of fast ion loses, would not be a good indicator of the confined fast ions energy spectrum. In the case of FIDA (also planned for the upcoming years), obtaining confined fast ions spectrum are in principle possible, however FIDA has never been used in the expected JT-60SA plasma conditions, i.e. high density and highly energetic fast ions.

Finally, it is worth noting that during the last years, within the WPSA workpackage, significant effort has been made to study the feasibility of different Neutron Diagnostics. Reports can be found in the corresponding IDM folder (https://idm.euro-fusion.org/default.aspx?uid=2PQLFL). The main studies performed are:

- The performance of a **high-resolution DD neutron spectrometer** (of similar kind as the TOFOR spectrometer currently installed at JET) has been evaluated. It was found that a TOFOR-like spectrometer can be expected to provide good separation of the beam-target and thermonuclear components of the neutron spectrum, and hence provide valuable information about beam slowing down, fast-ion physics etc.
- A preliminary analysis of the expected performance of compact diamond detectors for **neutron flux measurements** and of ionization chambers for **shut-down dose-rate measurements** have been performed.
- Finally, a preliminary study for a neutron activations system providing an absolutely calibrated time-integrated measurement of the **total neutron yield** is also available.

The activity will be conducted within the Enhancements Area of the WPSA workpackage and in collaboration withF4E. The work is expected to be developed in the timeframe (2024-2027). This call is focussed on the works for 2024.

Required competencies (for the Responsible Officer and the Team):

- In depth knowledge of plasma diagnostics, particularly Neutron and Fast-ions Diagnostics.
- Multidisciplinary team formed by physicists and engineers. Engineering works should be provided by the applicant team.
- Coordination and management skills.

Activity goals can include (depending on the timeframe considered):

For this call (work to be developed during 2024, possibly in the first 6 months):

- Review and evaluation of the Neutron Diagnostics capabilities (planned and expected).
- Development of Implementation Plan (to meet the requirements for Procurement Arrangement signature).
- Conceptual design (including selection of detector type, preliminary analysis, space reservation and main components definition).

In future calls:

- Preliminary design (engineering analysis, in-depth analysis and detailed design).
- Final design (design for manufacturing).
- Manufacturing and Procurement (manufacturing monitoring, in-lab testing, reporting and procurement).
- Commissioning (collaboration in installation, on-site training, operation).

The selected Responsible Officer will report to the SA Enhancements Area Coordinator and to the SA Project Leader

3. FINANTIAL ASPECTS AND BUDGET

Manpower available: 1 ppy.

Timeframe: 2024 (first 6 months).

Conditions of appointment: The salary will be reimbursed by EUROfusion to the sending Beneficiary according to the Internal funding rates within the new Consortium Agreement for the period 2021-2025 (Personnel costs 50% plus beneficiary overhead 25%).

Hardware expenses: No hardware expenses are expected in the first phase (present call). In the following implementation phase the hardware expenses will presumably be supported 100% by the European Implementation Agency of the JT-60SA F4E.

4. ELEGIBILITY AND PARTICIPATION

Candidates should be staff of one of the EUROfusion Consortium members or its Affiliated Entities. The application should be submitted through the EUROfusion IMS system by the relevant Beneficiary sending:

- the Responsible Officer candidate's detailed CV.
- the Team description with short CV.
- a motivation letter including expressions of interest in future calls.

by 10th November 2023. Shortlisted candidates will be interviewed in the final phase of the selection.

5. REFERENCES

Other useful information can be found at the following links:

- EUROfusion WPSA wiki page:

https://wiki.euro-fusion.org/wiki/WPSA_wikipages:_JT-60SA_Work_Package

- JT-60SA public web page
  https://www.jt60sa.org/wp/

- Visitors' handbook for EUROfusion staff on mission at the Naka site:
  https://users.euro-fusion.org/iterphysicswiki/index.php/WPSA_Visitors_Handbook

6. FURTHER INFORMATION

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