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Ref: 7194-FR-LDH-L

11 March 2010

Heads of Research Units

Dear Colleagues

**CALL FOR INTEREST FOR PARTICIPATION IN ENHANCEMENT PROJECTS IN THE AREAS OF DIAGNOSTICS AND CONTROL**

STAC, at its meeting on 2 March 2010, has endorsed Revision 2 of the JET component of the EFDA 2010 Work Programme (EFDA(10) STAC 31/3.3.1), comprising Association participation in the new JOC wall protection project and the launch of four new small enhancements in support of the ITER-like wall programme.

Given the need for the proposed enhancements in the early phases of the ILW Programme, I am proceeding with a Call for Interest conditional on the approval of the work programme revision by the EFDA Steering Committee at its 44$^{th}$ meeting on 23 March.

A primary goal of the JET programme after the EP2 shutdown will be to provide ITER with the necessary information on operation with a tungsten divertor by 2012, i.e. in time for a decision on the armour material of the first ITER divertor. This programme requires enhancements of the real-time protection of ITER-like wall and of the diagnosis of the wall in order to allow timely exploitation while safeguarding the investment in the wall. The real-time protection of the wall is being upgraded in an Operator project (PIW) that involves a significant enhancement of the set of first wall temperature measurements and the implementation of scenario-based termination sequences. While the majority of the effort for this project will have to come from JOC staff (directly employed or seconded from the Associates) due to the implications of the new system on the safety of the machine, it is essential to the project to have expertise from the Associates in the following areas:

- Diagnostician and/or engineering expertise for the implementation of additional measurement systems. More than ten new IR camera systems will be installed in various locations on JET for which there is a need for additional effort outside the on-site team.
- Implementation of real-time image processing, in particular with regard to region-of-interest analysis. This system is related to the output from each of the new protection cameras. The same software will run in parallel on separate platforms for each camera and the results will be passed on to the real-time temperature map of in-vessel components.
- Definition and implementation of a real-time temperature map of in-vessel components. The system will provide an estimate of surface and bulk temperatures from a number of inputs

around the poloidal circumference of the machine at a limited number of toroidal locations and test diagnostic inputs against fault conditions. The system will be deployed in a staged manner. Initially, the system will check if temperature limits are expected to be exceeded in a given look-ahead time. In a later stage, the system will make comparisons with simple power exhaust models so as to identify the likely cause of the problem (plasma, NBI shine through, RF, LH, etc.) and send a labelled alarm to the control system.

- Upgrade of the JET Wall Load Limitation System (WALLS). An improved physics model is required to calculate the power flux to plasma facing components, while still maintaining the capability of running in real time.
- Modification of the Plasma Position and Current Control – Shape Controller software. The existing system executes stops following external events or triggered by internal conditions. It recalculates new waveforms at the event/condition. The project aims to provide six new PPCC stops with different event-triggered waveform generation software. The first priority is to produce more optimised versions of the present slow and fast stops. More complicated alternative stop sequences will be developed in a later, staged implementation.

It is the intention to implement the work of Associate staff as subprojects under the umbrella of the PIW Project and, while some work can be envisaged at the Associates' home labs, visits to JET will be required in order to integrate the results obtained into the overall project and to guarantee the successful commissioning of the various new systems.

The four small enhancements proposed are:

- An upgrade of the IR camera system with two new cameras on existing views;
- The replacement of the broken KX1 detector with a new detector based on Gas Electron Multiplier (GEM) technology;
- Implementation of a plasma design tool to allow session leaders and scientific coordinators to evaluate the expected power deposition on plasma-facing components for any proposed scenario; and
- An upgrade to the correlation reflectometer system, making it more relevant for turbulence studies.

A brief description of the goals of these projects is provided in the Annex to this letter. Should you need further technical details about these activities, please contact Claudius Morlock (Tel: 0044 1235 46 4428; Claudius.Morlock@jet.efda.org).

With regard to the tasks in support of the PIW Project, if you would like to participate please specify:

i) In which areas your Association proposes to participate;
ii) How you propose to contribute to the task; and
iii) The resources required for this work.

With regard to the small enhancements, if you would like to participate in these projects, please specify if you:

i) Propose to lead the projects and to nominate a candidate for the position of Project Leader; a CV of the candidate should be provided;
ii) Declare your interest in participating in specific activities of the project; or
iii) Declare your interest in providing a contact person to follow the project.

Proposals to lead a project should be accompanied by a detailed proposal for the implementation of the project, including a description of the physics issues to be addressed with the proposed system. All proposals should be accompanied by an estimate of the required resources.

You are kindly invited to answer to this call by 9 April 2010 to Claudius.Morlock@jet.efda.org.

Best regards

Francesco Romanelli
EFDA Associate Leader for JET

Annex:

1. Description of Proposed Small Enhancements

cc: Y Capouet, G Hasinger, F Gnesotto, D Maisonnier, L Horton, C Morlock, C Soltane

## ANNEX 1: Description of Proposed Small Enhancements

### IR thermography

IR thermography is an extremely important diagnostic technique to both protect the new ITER-like wall and to maximise its scientific exploitation. The two new cameras proposed would allow a better view of the strike point position on tile #1 (replacement of the old KL3b system) and a duplication of the KL9 view in a different toroidal position (old KL2 system). Improved thermography on tile #1 is very important for the investigation of high triangularity discharges. Experience from KL9A measurements has revealed that the inner strike line shows large modification due to ELMs and a large variation of the actual peak heat flux region on the inner strike line with varying current/field due to the extremely large local flux expansion there. In the past, complete power balance and ELM studies have therefore made use of shot-to-shot repeats with varying inner strike line position. By installing the proposed new camera the spatial resolution can be improved by a factor of between ~1.4 (when optics limited) and 2 (when pixel limited) with simultaneous similar data framing rates as for KL9A. The duplication of the KL9 view, in addition to providing redundancy on a system considered fundamental for the operation of JET with the ITER like wall, would allow the simultaneous measurement of fast power transients and wide angle divertor monitoring as well as the assessment of the toroidal symmetry of the power deposition in JET divertor.

### KX1 detector

The high-resolution X-ray crystal spectrometer (KX1) is expected to measure the impurity concentrations, ion temperature, and the toroidal rotation velocity from Doppler width and shift of $Ni^{+26}$ at 1.586 Å. In order to measure the tungsten impurity concentration in the new ITER-like JET configuration, the upgraded spectrometer will operate with an additional (10$\underline{1}$1) quartz crystal (2d=6.68 Å) mounted in June 2009 and taking up the second half of the same 266 mm diameter beam line. The quartz crystal will be used for the reflection of low energy x-ray photons emitted by $W^{46+}$ at 2.4 keV. The higher energy range of the $W^{46+}$ spectra can be measured by means of the Si crystal, which has been provided. An x-ray detector with adequate resolution and quantum efficiency is necessary to measure the W content in the core of JET plasmas. A new detector based on the GEM technology is proposed.

### Plasma Design Tool

Operation of JET with the new ITER-like wall will require a well-planned and staged approach in order to allow a timely exploitation of the ILW while safeguarding the investment in the wall. The wall itself was designed based on calculations of the expected heat flux on first wall components for a range of plasma equilibria, including shadowing effects. It is proposed to develop a similar tool for use by session leaders developing the actual scenarios to be used in the experimental programme. To be useful, the tool must be closely linked to the JET database, must have a user-friendly interface allowing use by all session leaders and must be capable of running on an inter-shot basis.

### Correlation Reflectometry

Long experience of operation and scientific exploitation of the present correlation reflectometer has revealed some significant limitations of the diagnostic and a comprehensive assessment of the system performance has shown the following main problems:

- Low quality of the detected signals;
- Degradation of performance of some equipment due to aging (in some cases more than 10 years of operation) and equipment failure.
- Insufficient stability of the Oscillators.

A state of the art correlation reflectometry system would therefore significantly improve JET's diagnostic capability in the field of turbulence measurements, which remains a weakness of the experiment. Such a new system would be in the position to fully exploit the recently installed sweeping reflectometer, which has been proven to measure the density profile with spatial and temporal resolution adequate to support correlation measurements. The sweeping reflectometer also

covers the entire plasma minor radius and therefore offers the possibility to perform correlation reflectometry both in the core and in the edge. Correlation reflectometry at the very edge to study the region of the H mode barrier would be particularly relevant to JET's scientific programme of investigating the behaviour of the plasma with the new wall.
The final detailed specification for this project will be determined by the input received from the Associations and further discussions amongst experts from STAC, JET-CSU and TFs.