EFDA WORKPROGRAMME 2011

Call for Participation

(Part of the EFDA WP, Diagnostic TG)

Diagnostics Topical Group

Deadline for Responses: **January 14th 2011**

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This Call for Participation aims to implement the EFDA Work Programme for 2011 on Diagnostics under Task Agreements as foreseen in the new EFDA Art. 5

Introduction

At its meeting in Dublin on the 23rd June 2010, the EFDA Steering Committee approved elements of the EFDA 2011 Work Programme, including the tasks identified below. This Call for Participation covers the activities of the 2011 WP under the Diagnostics Topical Group, and will be implemented on the basis of the provisions given in Article-5 of the EFDA Agreement.

No JET related activities are meant to be implemented as a result of this call. JET related activities are implemented under EFDA Article-6. However some JET activities are mentioned for information when they closely relate to the activity implemented under Article-5. JET data collected and analysed under the JET part of the EFDA WP can be brought together with other data under EFDA Article 5 Task Agreements when relevant for the progress of the work or used in multi-machine modelling activities.

The activities to be implemented following this call for participation will be organised in a Task Agreement (WP11-DIA-01), whose tasks are grouped together in different sections (from WP11-DIA-01-01 to WP11-DIA-01-04), depending on their subject, as in the following:

Task Agreement WP11-DIA-01: Diagnostics for burning plasma

- Experiments on confined fast particles
- Experiments with fast ion loss detectors
- Experiments of IBW modulations for fuel ion ratio measurement

Task Agreement WP11-DIA-02: Diagnostics for protection of plasma facing components

- Thermography on metallic surfaces
- Speckle interferometry

Task Agreement WP11-DIA-03: New diagnostic concepts

- Experiments with GEM gas detector for neutrons and for Soft X-ray. Experiments with SXR polycapillary lenses
- Experiments with a C-MOS Imager for SXR imaging and with a Transmission Grating VUV spectrometer

- Experiments on innovative edge sensors
- Realisation of prototypes of TPR and CVD neutron spectrometers

Task Agreement WP11-DIA-04: Data analysis validation, calibration and real time techniques

- Development of new techniques for data acquisition and analysis
- Feasibility studies for algorithms and diagnostics for real time feedback control

Task Agreements (WP11 DIA): DIAGNOSTICS

Introduction

The 2011 Work Programme is intended mostly as the continuation of the work during 2010. It covers three areas: burning plasma diagnostics, innovative developments and activities concerning data analysis and feedback control. Diagnostics for burning plasmas represent a critical area and EFDA supports collaborative efforts to test different techniques installed in the same Tokamak, therefore, analysing in detail the fast ion production and dynamics. Regarding new diagnostic developments, the priority is given to diagnostics for neutrons and soft X-rays, such as gas-filled and advanced energy resolving pixel detectors, due to radiation hardness, speed, energy and spatial resolution, making them particularly relevant for ITER and other future devices; and innovative magnetic sensors, requiring wide collaborations, including contributions from outside the fusion community. Regarding data analysis and feedback control techniques, the goal is to provide valuable synergies between the methods developed in the different associations; making the application of the various techniques more efficient, with the benefit of bringing expertise and competencies from other domains. Finally, it is proposed to complete some tasks launched in WP2010 in the area of diagnostics for protection of plasma facing components and for the plasma edge.

List of tasks to be performed under this call

Eleven tasks have been identified to be launched in the present call for participation.

- WP11-DIA-01-01 Experiments on confined fast particles
- WP11-DIA-01-02 Experiments with fast ion loss detectors
- WP11-DIA-01-03 Experiments of IBW modulations for fuel ion ratio measurement
- WP11-DIA-02-01 Thermography on metallic surfaces
- WP11-DIA-02-02 Speckle interferometry
- WP11-DIA-03-01 Experiments with GEM detectors for neutrons and SXR. Experiments with SXR polycapillary lenses
- WP11-DIA-03-02 Experiments with a C-MOS Imager for SXR imaging and with a Transmission Grating VUV spectrometer
- WP11-DIA-03-03 Experiments on innovative edge sensors

- WP11-DIA-03-04 Realisation of prototypes of TPR and CVD neutron spectrometers
- WP11-DIA-04-01 Development of new techniques for data acquisition and analysis
- WP11-DIA-04-02 Feasibility studies for algorithms and diagnostics for real time feedback control

Resources foreseen for the Task Agreement WP11-DIA-01

The ceiling for resources is 25 ppy under Baseline Support; 500 kEuros for personnel and hardware under Priority Support

WP11-DIA-01: Diagnostics for burning plasma

Background

Information on many key plasma parameters in ITER will be derived from diagnosing the fusion products. This is the reason why feasibility studies were launched in WP2008-2009 on these diagnostics. Based on these evaluations, the Work Programme 2010 for confined and lost alphas and fuel ion ratio was conceived to provide experimental validation of these techniques. The WP2011 is meant to complete these experiments, only initiated in WP2010. Concerning neutron spectroscopy, in WP2011 all the different spectrometers will be fully simulated, using experimental calibrations, and compared with each other, with the emphasis on the applicability of these techniques for ITER.

Detailed Description of the tasks

WP11-DIA-01-01: Experiments on confined fast particles

Introduction

Feasibility studies have been done in WP2008-2009 for the further development of CTS, FIDA and neutron spectroscopy diagnostics for the measurement of confined fast ions. In 2010 four diagnostics, for detailed data comparison, have been installed at ASDEX-Upgrade: CTS, FIDA, high resolution neutron spectroscopy and NPA. In addition, gamma ray detectors have been mounted on ASDEX-Upgrade for dedicated experiments that will be carried out first to set up the instruments and the optimized plasma scenarios and then for the production of fast particles.

Objectives

- In 2011, it is proposed to perform experiments with CTS, CXRS, FIDA, gamma spectroscopy at ASDEX-Upgrade to produce fast deuterons and verify the real diagnostic capabilities of these systems, accompanied by detailed simulations of fast ion dynamics. In particular the plasma scenario to be produced is a discharge with Bt = 2.5 , Ip = 1.2 MA, where about 5 MW of ICRH power is used to create fast distributions of deuterons with their

2^{nd} harmonics at 36.5 MHz (or 3^{rd} harmonics at 54 MHz as further option). Small power of NBI (one injector, core deposition, radial) , energy at 90 keV) is used as seed of fast ions. Accurate simulations will be required for optimization of the plasma scenario and for interpretations of the results. Spectral distributions of deuterons should be measured by CTS at least up to 500 keV, with a spatial resolution of 5 cm and time resolution of a about 10 ms. These fast ions should be also measured by means FIDA emissions, using the CXRS diagnostics, in the range 25 -100 keV, with background subtraction and NBI modulation, and time resolution of 10 ms.

- One of the crucial problems for fusion diagnostic is the availability of cross-section data. To improve the gamma-ray spectrum analysis, the excitation functions of all levels for the diagnostic reactions are needed. Since the experimental values of these cross-sections are partially old or missing, or at least for part of their spectrum, new good data are requested. Here a list of the reactions whose cross sections should be measured, particularly for a few energy bands: $^{12}C(^{3}He,p\gamma)^{14}N$, $^{9}Be(^{3}He,p\gamma)^{11}B$, $^{9}Be(^{3}He,n\gamma)^{11}C$, $^{9}Be(^{3}He,d\gamma)^{10}B$, $^{12}C(d,p\gamma)^{13}C$, $^{9}Be(d,n\gamma)^{10}B$, $^{9}Be(d,p\gamma)^{10}Be$, $^{9}Be(d,\gamma)^{11}B$, $^{9}Be(t,n\gamma)^{11}B$, $^{9}Be(t,\gamma)^{12}B$

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on the review of the techniques under consideration at the present for the measurements of the confined alphas and comparison of the different features.
- Report on the simulation of the spatial and energy distribution of the confined alphas in the ITER scenarios.
- Summary on the performed experiments to demonstrate the capabilities of the proposed techniques

WP11-DIA-01-02: Experiments with fast ion loss detectors

Introduction

A FILD diagnostic has been installed in ASDEX-Upgrade based on a scintillator plate detector. It allowed preliminary measurements of deuterons between 0.1 and 1.5 MeV, with different pitch angles.

Objectives

For 2011, it is proposed to carry out experiments with the fast ion loss detectors (FILD) in ASDEX-Upgrade, based on a fast scintillator **(**SrGa2S4 : Eu^{2+}**)** and a fast camera, with a framing rate up to 1 MHz. This diagnostic should detect deuterons in the energy range 60-600 keV and pitch angles between 30˚ and 87˚. The results of these experiments will be benchmarked with the simulations of lost fast ions with Fokker-Planck codes and Monte-Carlo codes.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on the performed experiments
- Report on the performed simulations

WP11-DIA-01-03: Experiments of IBW modulations for fuel ion ratio measurement

Introduction

As result of detailed simulations, an estimation of the accuracy of the fuel ion ratio measurements based on neutron spectroscopy has been provided, as function of the core ion temperature and the fuel ion. The ITER requirements are met using a MPR spectrometer, but the measurement fails at low temperature and at high tritium density. The use of CXRS has been assessed at TEXTOR. The acquired spectra agree with the simulations, but no absolute calibrated data are available yet. Beam modulation is required for fuel ion ratio measurements on ITER, with an accuracy better then 10% for $0.1 \leq D/(D+T) \leq 10$. Collective Thomson scattering (CTS) for measuring the fuel ion ratio using the scattering spectrum due to ion Bernstein waves (IBW) has been investigated, revealing preliminary evidence of sensitivity to the different ion compositions. In 2010, a second CTS receiver will be set up in ASDEX-Upgrade, together with the preparation of the other diagnostics for joint experiments.

Objectives

In 2011, it is proposed to have a quantitative evaluation at ASDEX-Upgrade of the technique based on the IBW modulations of the CTS signals with a temporal resolution of about 100 ms and spatial resolution of 5 cm, for different impurity content. The work will be complemented with a detailed comparison with other techniques, such as neutron spectroscopy and CXRS, in view of assessing the performance of the various techniques and their applicability to ITER

Work Description and Breakdown

- Experiments at ASDEX-Upgrade with the technique based on the IBW modulations of the CTS signals
- Comparison with other techniques such as neutron spectroscopy and CXRS, in view of assessing the performance of the various techniques and their applicability to ITER.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on performed experiments
- Report on comparison with other techniques

WP11-DIA-02: *Diagnostics for protection of plasma facing components*

Background

Infrared (IR) thermography has become a routine diagnostic in many devices to monitor the heat loads on the first wall for both physical studies and machine protection. The good results of the technique obtained so far motivate the use of IR cameras for control. Present day IR camera technologies are fully adequate for this purpose but versatile, efficient and reliable methods to automatically analyze the frames in real time for feedback purposes have to be developed. Moreover solutions to overcome the problems posed by thermography on metallic surfaces need to be consolidated. Particularly challenging are the problems induced by the reflected flux and the changing emissivity of Be with temperature. It should be noted that IR thermography is also a useful tool to observe the qualitative impact of lost alphas and fast ions on the first wall and is in this context important for machine protection for burning plasma devices as well.

Detailed Description of the tasks

WP11-DIA-02-01: Thermography on metallic surfaces

Introduction

Solutions to overcome the problems posed by thermography on metallic surfaces, due to the high amount of reflected radiation and the large variation of emissivity, need to be consolidated. In 2010, active pyrometry, with multicolour technique, will be studied in laboratory at CEA, with parasitic hot sources for simulating reflections on the metallic walls.

Objectives

It is proposed to complete the task on active pyrometry of metallic walls in 2011, assessing also bicolour pyroreflectometry to measure the ratio of the surfaces emissivities at the two different wavelengths λ_1 and λ_2 chosen after the optimization of the method. Bicolour piroreflectometry will be carry out with two lasers at the two wavelengths λ_1 and λ_2

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Feasibility studies of active pyrometry of metallic walls
- Feasibility studies of two-colour pyroreflectometry

WP11-DIA-02-02: Speckle interferometry

Introduction

Assessment of the real capabilities for time resolved measurement of the erosion rate, by means of Speckle interferometry is required in view of the prospects of using this technique in ITER. A speckle interferometer has been designed and its realization of on Magnum-PSI started during 2010, to study the feasibility of time resolved erosion measurements.

Objectives

- It is proposed to complete the set-up up of the speckle interferometer at Magnum PSI and perform experiments measuring erosion on a sample with a time resolution of a few seconds, sensitivity of erosion rate of a few tens of microns/s, space resolution of the order of one cm, in the conditions accessible at Magnum PSI of a beam with particle flux density in the range of 10^{23} hydrogen ions $m^{-2}s^{-1}$ and an enegy flux density in the range of a few MW/m^2 .
- Development of a FFT based model to interpret the measurements under vibrations by identifying the mechanical vibrations (of few tenth of mm amplitude and of hundreds of Hz to KHz range) from the erosion measurements.
- Assessment if surface patterns (with depth information ex: depth markers or patterns or wall distributed protrude erosion resistant materials, etc) engraved on the object to be measured would be helpful to keep a reference for the erosion measurements under vibrations and offsets.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- report on experiments with a time resolved speckle interferometer at Magnum PSI
- reports on the models developed to assess the effects of vibrations

WP11-DIA-03: New diagnostic concepts

Background

Since not all the ITER diagnostic requirements, for energy resolved measurements of neutrons and x-rays, can be fulfilled by a single approach with the present technology, further development of existing and new detectors is on going. These developments also aim at better measurements in present devices in support of physics experiments, in particular, in the area of X-rays measurements these could be used to monitor and study the properties of electron runway beams, together with better measurements of Synchrotron radiation as described in III.1.
In 2010, a new dual gas detector, able to detect selectively 2.5 and 14 MeV neutrons will be developed and mounted on FTU to be fully characterized.
A triple gem gas detector will be also realized and the performance assessed in terms of energy discriminating soft X-ray (SXR) tomography and for high resolution spectroscopy in Tore Supra. SXR polycapillary lenses will be also tested in laboratory and evaluated as a potential optic for advanced SXR diagnostics. Innovative magnetic sensors (optical, high temperature Hall sensors, MEMS etc.) will also be studied.

In 2011, the above mentioned prototypes will be completed and, in case of positive results, mounted on tokamaks as appropriate. Preliminary laboratory measurements with the C-MOS imager Medipix for SXR detection are proposed. Feasibility studies will be carried out for transmission grating VUV spectrometer as compact fast impurity monitor.

In WP2011 the realization of two prototypes of neutron spectrometers, the Thin foil Proton Recoil and Diamond detectors, will be launched.

Detailed Description of the tasks

WP11-DIA-03-01: Experiments with GEM gas detector for neutrons and for Soft X-ray. Experiments with SXR polycapillary lenses

Introduction

A dual neutron camera based on GEM detector has been carried out and tested in laboratory, able to detect contemporary neutrons at 2.5 and 14 MeV.

Studies have been done also for a neutron detector using the activation technique

A feasibility study has been done with a pixellated triple gem gas detector for energy resolved Soft X-ray detection (SXR)

Finally very preliminary and encouraging tests have been performed on SXR polycapillary lenses, to be used as optics for advanced SXR diagnostics

Objectives

- Completion of the experiments on tokamak with the dual neutron camera based on triple gem gas detector and its optimization in order to have a large area detector (around 50 cm^2), good time resolution (~50 ms) and efficiency of the order of 10^{-3} for neutrons at 2.5 MeV for the unit D-D, and 10^{-4} for neutrons at 2.5 MeV for the unit D-T. For the unit D-T and D-D, the efficiency is 10^{-3} for both.
- Realization of a prototype of GEM gas detector, filled with Neon, for detection of 14 MeV neutrons by means of neon activation in the drift region.
- Experiments on a tokamak (FTU and/or Tore Supra) of a pixellated gas detector of large area (10 cm X 10 cm), with triple gem, fully equipped with 128 independent channels to work in the SXR range 2-15 keV, with detection efficiency between 0.1 and 0.5, high time resolution (hundreds of kilohertz of framing rate) and energy discrimination in bands.
- Pilot experiments on a tokamak (FTU and/or Tore Supra) of the capabilities of polycapillary lenses to collect SXR radiation in the range 5-25 keV, with an etendue in the range 10^{-5} – 10^{-4} mm^2 sr . Verify also the capability of performing imaging with a full lens of a portion of the plasma, with a resolving power of 100.

Work Description and Breakdown

- Experiments on a tokamak with a dual neutron camera based on GEM gas detector
- Prototype of a neutron detector based on activation technique
- Experiments on tokamak with a SXR triple GEM camera
- Preliminary tests on tokamak with SXR polycapillary lenses

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on experiments with a dual neutron camera based on GEM gas detector
- Report on the prototype of a neutron detector based on activation technique
- Report on experiments on tokamak with a SXR GEM camera
- Report on preliminary tests on tokamak with SXR polycapillary lenses

WP11-DIA-03-02: Experiments with a C-MOS Imager for SXR imaging and with a Transmission Grating VUV spectrometer

Introduction

The very recent detectors, so called C-MOS imagers because they combine a highly pixellated semiconductor with a C-MOS underneath with all the electronics integrated corresponding to each pixel, have never been tested in tokamaks. They are in all senses complementary to the gas detectors. Even if at their first stage, they deserve to be explored. This kind of detector is considered now by ITER, but no tests have been done so far. In addition this detector could be useful coupled with the polycapillary lenses.

Recently a Transmission Grating VUV spectrometer has been set up and tested at NSTX, for monitoring in a broad spectral range, at high efficiency, robust to background radiation, extremely compact and with an absolute calibration constant in time. It is a good candidate to monitor the emissions of W ions, at low ionisations stages, coming form the divertor and the plasma edge.

Objectives

- Laboratory tests (detection efficiency vs energy in the range 5-30 keV, spatial resolution, energy band discrimination) and preliminary experiments on a tokamak (FTU) with a C-MOS imager (like Medipix) with Silicon as semiconductor, with an active area of about 1.5 cm X 1.5cm, high pixel density (256 X 256) and pixel size 55 μm X 55 μm to study the feasibility of Soft X-ray imaging at high spatial resolution. Time resolution is not an issue in this phase, being acceptable acquisition in time intervals even of a few hundred milliseconds.
- Experiments on tokamak of a Transmission Grating VUV spectrometer, operating in a survey mode in the wavelength range 30 Å – 700 Å , with a resolving power $\lambda/\Delta\lambda \sim 30$ with 1-D imaging, as compact and fast impurity monitor, in presence of light, metallic and high Z impurities (W in particular) in plasmas with bright VUV emissions

Work Description and Breakdown

- Laboratory tests and experiments on a tokamak with an SXR C-MOS imager
- Experiment on a tokamak with a Transmission Grating VUV spectrometer

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on tests and experiments with an SXR C-MOS imager
- Report on experiment with a Transmission Grating VUV spectrometer

WP11-DIA-03-03: Experiments on innovative edge sensors

Introduction

In 2010 activities on innovative magnetic sensors have been launched, in particular for

- High temperature resistant highly doped InSb Hall sensors
- High-Temperature Magnetoresistors
- MEMS magnetometers
- Optical sensors for Polarization Reflectometry for Magnetic field

Objectives

Completion of the activities launched in 2010 on these innovative magnetic sensors. In particular the realisation of prototypes with the following final characteristics:

- Hall sensors able to work at temperature range 100 - 300 ˚C, with a sensitivity of about 100 mV/T , resistant to neutron background
- High-Temperature Magnetoresistors with a very low temperature dependence of resistance and good magnetic sensitivity above 0.5 T
- MEMS magnetometers with resolution 0.6 mT/rtHz @1T, with electronics adapted for long cables and working at moderate/high temperature
- Optical sensors for Polarization Reflectometry for Magnetic field with high spatial resolution (< 1 cm for distances < 100 m) and time resolution of a few millisecondes

The above mentioned prototypes will be completed and, in case of positive results, mounted on tokamaks as appropriate.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables and Milestones

- Report on tests and experiments on these innovative edge sensors

WP11-DIA-03-04: Realisation of prototypes of TPR and CVD neutron spectrometers

Introduction

Feasibilities studies for different neutron spectrometers have been done in WP2008-2009 . Response functions have been incorporated into the simulations for the following devices: magnetic proton recoil (MPR), thin foil proton recoil (TPR), scintillator (NE213), diamond, time of flight (TOF). The MPR and TPR show the best performances in almost all the ITER plasma scenario. The reduced interfacing issues for the TPR system make this technique very attractive. Therefore simulations and assessments for the design of a Thin foil Proton Recoil spectrometer have been carried out in 2010, (geometry, foil thickness and area, distance to detector, detector segmentation etc..) in order to find the best trade-off between efficiency and resolution.

Diamond detectors (CVD) also are very attractive because they are very compact, highly resistant to radiation, with low γ sensitivity, high energy resolution and able to measure higher neutron fluxes. Laboratory measurements of the Response Function of CVD for 14 MeV neutrons has been done, but at low counting rate.

Objectives

- It is proposed the construction and test of a flexible TPR system, with energy resolution in the range 5 – 7 % and efficiency 2 10^{-4} – 10^{-3} cm^2, with a detector able to measure proton energies in the range 2-20 MeV, with high counting rate, adequate shielding to minimize the backgroung noise of neutrons and gammas and a dedicated electronics.
- Completion of the laboratory characterization of a CVD spectrometer with neutrons in the energy range 6-20 MeV, at high counting rate and with remote front end electronics located up to 100 m far from the detector itself. This prototype should be then installed in an experimental device.

Work Description and Breakdown

- Realisation of a prototypes of a TPR neutron spectrometer
- Realisation of a prototypes of a CVD neutron spectrometer

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables and Milestones

- Report on the Realisation of a prototype of a TPR neutron spectrometer
- Report on the Realisation of a prototype of a CVD neutron spectrometer

WP11-DIA-04: Data analysis validation, calibration and real time techniques

Background

Two expert working groups have been created in 2008/09 under the auspices of the EFDA Topical Group Diagnostics: one concerning data analysis techniques and calibration and the other one on feedback control for real-time applications. These aspects are crucial for burning plasma diagnostics, fast MHD activity and in general event recognition, plasma operations, long pulses and disruption prediction.

Data Analysis

In 2010, tasks to promote the use of data mining techniques for automatic search of information (off-line event recognition), for the determination of optimal quantities (data-driven description of physical behaviour) and conformal predictors (for classification and machine-learning methods) were launched. In addition, the developments of pilot virtual diagnostics were started for experimental design, together with the evaluation of the graphics processing unit (GPU) for real time applications; integrated data analysis (Bayesian approach) and error evaluation tools. In 2011, the continuation of these activities will lead to further development of new techniques for improved data analysis including: classification methods with estimations of confidence and credibility in the predictions, calibration, integrated Data Analysis (IDA) and synthetic diagnostics. This activity will be complemented by those carried out within the JET Fusion Technology programme and consisting in building a general relational database to analyse a subset (about 1 terabyte) of JET data with the objective of providing a generic tool to extract information in a user friendly and standardised way on any general issue of interest.

Feedback control

In 2010, the development of feedback control strategies based on new and more complex diagnostics such as SXR measurements have been launched and for 2011 it is proposed to extend this analysis to other diagnostics such as Infra Red measurements. The development of these advanced feedback control strategies will be applied to the detection and potential mitigation of disruptions. In addition, model based profile control will be developed for long pulse scenarios,

together with the investigation of the use of quantized methodology; the management of exception and failures in a discharge with adaptive strategies such as exception handling.

WP11-DIA-04-01: Developments of new techniques for improved data acquisition and analysis

Objectives

Proposals for improved data analysis in the following areas:

- Machine learning methods with estimations about how accurate and reliable the predictions are. In particular, conformal predictors can be used to provide confidence and credibility. The most important property of conformal predictors is their automatic validity under the randomness assumption. It means that the samples and their labels are assumed to be generated independently from the same (but unknown) probability distribution. No other assumptions (such as specific distributions for samples and/or errors) are necessary at all. Possible applications (but not restricted to) of accurate and reliable predictions can be L-H transitions and disruptions.
- Analysis of disruptions: Development of automatic techniques to improve the early recognition of disruptions. The methods can include the determination of optimal physical quantities as precursor identifiers as well as the generation of reliable software systems to detect incoming disruptions.
- Integrated Data Analysis (IDA): Identification of most urgent diagnostics for next generation fusion devices where forward modelling has to be developed and expected to be most beneficial. Further forward functions will be developed and implemented to explore possible designs of 'meta-diagnostics', i.e. sets of diagnostic units. Particular focus will be led on robustness in case of partial failures and synergies from complementary measuring capabilities of the individual diagnostics.
- Application of GPU-based algorithms for accelerated molecular dynamics simulations for plasma-material interactions. The focus will be on the assessment of appropriate parallelisation strategies which exploit the vectorisation capabilities of modern GPUs.
- Implementation of the set of synthetic diagnostics
- Calibration techniques (both in situ and in vivo) for low accessibility diagnostics is one of the issues to tackle for long pulse operation and high yield discharges. The need to provide not only detailed calibration constants but also high level quantities should be emphasised.

In particular, robust validation methods and cross calibration techniques (which are suited to integrated data analysis) are considered of high priority.

Work Description and Breakdown

The work description and breakdown have to be clearly described in the proposals

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

Report on the performed work

WP11-DIA-04-02: Feasibility study for improved algorithms and new diagnostics for real time feedback control

Objectives

Based on the already good results obtained from the last call, efforts will be pursued in the domain of model based control, management of disruptions, SXR simulation tools and event handling. These subjects are expecting to provide very good inputs for the preparation of ITER and DEMO. Concerning real time control, machines in the EU have their own control systems with different levels of generality and it is thus complicated to really compare the algorithms developed for specific machines and promote inter comparison of the obtained results. The objective could be to identify solutions and recommend some standards so that new developments can be shared at the EU level. A clear advantage is to exchange real time control algorithms developed for one application in one device and test it in another one and quantify the performance of the solution. If on the various existing machines the real time platform would be implemented with the same technology this would ease such tests. The main advantage is to develop control strategies which are not machine dependant and possibly develop control tool strategies applicable to ITER.

Work Description and Breakdown

Proposals are required for the following works:

- Model based control: Apply the model identification technique of the plasma profiles like current, temperature and rotation (developed during the last call from real data measurements) to ITER simulations using transport simulation codes to perform the required modulation of the actuators and provide inputs for the model identification. Investigate the potentiality of the technique for burn control in ITER.
- Management of disruptions: Develop some Real time precursor identifier and associated control strategy. The analysis will identify the several type of disruptive phenomena that can occur in tokamak plasmas, and will study
    - the most useful precursors (MARFe, VDE, …)
    - the possible control actions to be deployed to avoid and/or mitigate the disruption effects.
    - If appropriate implement the identified control strategy in existing machines

- SXR simulation tools to deduce the impurity content: develop a RT version of the SXR simulation tool (developed from the last call) to assess in real time the impurity content and

their spatial distribution using 1D reconstructed SXR emissivity. Starting from the atomic physics the code will reconstruct in real time the plasma emissivity based on a given simplified assumptions on the impurity content and profiles. Iterations will be performed on the impurity profiles to identify the best ones that fit the SXR measurements.

- Event handling: Management of exceptions (for example imminent disruption, MHD event or sudden rise of the temperature wall…) and failures (for example deficiency of a diagnostics, lost of requested power or part of power…) in a discharge has been already developed in 2010. The following step will be the integration of adaptative strategies for a better exploitation of long pulses discharges and make a clear demonstration of integrated control using the available tools in a given tokamak. A particular effort of integration is required for this activity.
- It is clear that for implementing controllers we need a very good infrastructure, sufficiently flexible, fast and simple to use and to modify. MARTe is a potential candidate: this real time infrastructure is very promising for the implementation of powerful controllers but needs to be used and developed by more users. In this respects some work is needed: the first one is to organise a managed repository of codes under a recognised leading authority [to be defined]. The codes and the documentation will be stored in an EFDA computing Facility. This will authorize all MARTe users to start their developments based on the same initial version of the code and make available to others any upgrade they have implemented [if this is not done there will be lots of ppys (from work already done to develop MARTe) lost]. We will then need to prepare the integration of MARTe and Plasma Control System (PCS) for the design of a future reactor grade controller; as a preliminary exercise investigate the use of Generic Application Modules (GAMs), which are the flexible structures based on MARTe, as inputs to organize diagnostic data acquisition for equilibrium reconstructions.

JET related activities

No JET experiments are foreseen to be implemented under this Task. However, should JET carry experiments in this area, a close coordination with the JET Task Forces will be sought.

Deliverables

- Report on improvements on feedback techniques and algorithms for plasma real time control
- Feasibility studies for new diagnostics to be included in the feedback control systems.

Scientific and Technical reports

Progress reports

At the end of each calendar year, and at intermediate times where appropriate, the Task Coordinator shall submit a report on activities under the Task Agreements resulting from this call to the EFDA Leader for his approval. These reports shall integrate the progress made by each Association on each task, and they shall indicate the level of achievement of the objectives, the situation of the activities, the allocation of resources and recommendations for the next year when applicable. The EURATOM financial contribution will be made through the usual procedures for baseline support through the Contract of Association.

Report of achievements under Priority Support (final report and, when appropriate, intermediate reports)

Achievement of Priority Support deliverables will be reported separately to the EFDA Leader. A final report (and intermediate reports marking substantial progress in the achievement of deliverables, if the EFDA Leader so requests) shall be prepared by the Task Coordinator and submitted to the EFDA Leader, after the assessment of the TG chairs. These reports shall include specific sub-sections for each of the Associations involved. They shall document the degree to which the deliverables have been achieved, and shall include a breakdown of expenditure for each Association. The EURATOM financial contribution will be made after approval by the EFDA Leader of these reports.

Association Proposal

The Associations are requested to complete the Association Response via the ECoM system.