

Charges and Membership of the Specialists Working Groups on Diagnostics

1. Charges of the Specialist Working Groups

1.1 Neutron Diagnostics Working Group

A wide range of diagnostics for neutron, gamma and escaping charged fusion products are being considered for burning plasma experiments (BPXs). Radial and vertical cameras are likely to be desirable, for which a range of different types of neutron and gamma detectors are proposed. The shield/collimator structures could incorporate neutron fluence, flux and spectral measurement systems. In addition to measurements of the evolution of fusion power and ion temperature profiles, high-energy neutrons and gammas could provide information about the confined alpha-particle distribution and the n_D/n_T ratio. The high neutron source strengths of the plasmas in BPXs will give neutron measurements the potential for being an extremely important tool that will be explored for burn control of the reactor plasma. The aim of the Working Group on Neutron Diagnostics is to advise and guide the design teams of BPXs on optimizing neutron, gamma and escaping charged fusion products diagnostics. The group will work as a subcommittee to the ITPA Topical Group on Diagnostics, under the voluntary physics arrangements.

Specifically the Working Group on Neutron Diagnostics will:

- a) assist in the evaluation of the physics requirements and bases for the measurements of neutrons, gammas and escaping charged fusion products for BPXs;
- b) identify and advise on necessary physics and design studies and review such studies under the voluntary arrangements;
- c) advise on the feasibility and suitability of the system choices and designs being developed for BPXs.
- d) assist in establishing priorities among proposals for different measurement techniques, if required;
- e) assist in the development of a comprehensive plan for system calibrations, including identification of any special equipment or calculations needed to implement the plan;
- f) review proposals for alternate techniques, such as those for using calorimetry of water in the blankets for fusion power measurement and water activation in a compact flux detector, as required by the design teams;
- g) recommend specific R&D tasks if needed;
- h) assist in the definition of space required for development, test and maintenance of equipment;
- i) encourage participation by other physicists in resolving issues in neutron diagnostics for next step devices within the ITPA Parties.

1.2. Reflectometry Working Group

Several different approaches for implementing the reflectometry technique and analysing the data are being developed which have different measurement capabilities and require different measurement instrumentation. It is envisaged that BPX's will be equipped with extensive reflectometer systems which will provide important measurements for machine protection and plasma control and it is important that the diagnostic potential is fully established and the best choice of instrumentation is made. Presently reflectometers are envisaged for the main plasma, for plasma position and for

divertor plasmas. The aim of this group is to advise and guide the design teams of BPXs on the available choices and options. The group will work as a subcommittee to the ITPA Topical Group on Diagnostics, under the voluntary physics arrangements.

Specifically the Working Group on Reflectometry will:

- a) assist in the evaluation of the physics requirements and basis for the reflectometry measurements for BPXs;
- b) consult on necessary physics and design studies and assist in the co-ordination of R&D studies under the voluntary arrangements;
- c) advise on the feasibility and suitability of the system designs being developed;
- d) encourage participation by other physicists in resolving reflectometry issues for BPXs within the Parties;
- e) assist in the definition of space required for development, test and maintenance of equipment.

1.3. Thomson Scattering Working Group

Various Thomson scattering systems are envisaged for the measurement of electron temperature and density in the core, edge, x-point and divertor plasma in BPXs. The aim of this group is to advise and guide the design teams of BPXs on the available choices and options. The group will work as a subcommittee to the ITPA Topical Group on Diagnostics, under the voluntary physics arrangements. There are immediate needs for considering the design feasibility of the edge, x-point and divertor systems for ITER, but it is foreseen that the group will also devote its attention to diagnostics for BPXs in general.

Specifically the Working Group on Thomson Scattering will:

- a) review the use of Thomson scattering to meet the measurement requirements for all locations specified for plasmas in BPXs and especially ITER;
- b) assist designers in the Parties and in the design teams of BPXs in revising the design concepts for the edge, divertor and x-point Thomson scattering systems;
- c) advise on the feasibility and suitability of the system choices and designs, including comparison with alternative methods suggested for some of the measurements;
- d) assist in the development of plans for calibration, including identification of any special equipment or calculations needed to implement the plans;
- e) coordinate work ongoing in the Parties in the field of damage of diagnostics components due to electromagnetic radiation ;
- f) recommend specific R&D tasks, and assist in consulting on these tasks as they progress;
- g) assist in the definition of space required for development, test and maintenance of equipment.

1.4. Working Group on Spectroscopy

A wide range of spectroscopic diagnostics are envisaged for BPXs. These instruments should be able to achieve the requirements set for a very large number of measurements of plasma parameters in the core, edge and divertor regions of the plasma. These requirements include ion temperature and rotation velocity in the core, He-ash and low-Z impurities in the core, n_D/n_T at the edge, edge impurity levels, divertor impurity. Many of these measurements are required for operational feedback control. Active control of the divertor operation may require the use of injected high-Z gases and disruption control may make use of large impurity pellets. The environment of BPXs provides many challenges for diagnostics. Access and vacuum boundary constraints may limit

capability in the vacuum UV and x-ray spectral ranges. Laser induced fluorescence (LIF) may enhance capability in the divertor region. Absorption and fluorescence are caused in windows, lenses and fiber optics by nuclear radiation. Because of the impact of radiation on lenses and the need to provide labyrinthine paths for the emitted light, it is proposed to use mirrors close to the first wall, with resultant concerns about their survivability in the local environment of nuclear radiation and neutral particles from the plasma edge. Detectors dependent on photon measurement are likely to be sensitive to the background neutron and gamma environment and radiation-shielding will be required to protect them. New calibration techniques must be considered.

Specifically the Working Group on Spectroscopy will:

- a) consider diagnostic techniques making use of the spectral range from the near IR to the soft x-ray region, including quantitative spectroscopy of the fuel gas constituents and impurities, for measuring the ion temperature and rotation, flows in the divertor.
- b) assist in the development of the physics requirements and bases for the spectroscopic measurements for BPXs;
- c) identify and advise on necessary physics, and design studies and review such studies under the voluntary arrangements;
- d) advise on the feasibility and suitability of the system choices and designs being developed for BPXs, including comparison with alternative methods suggested for some of the measurements;
- e) assist in the development of a plan for calibration, including identification of any special equipment or calculations needed to implement the plan;
- f) advise on the enhanced performance due to LIF with a realistic implementation;
- g) recommend specific R&D tasks, including needs in atomic physics, if needed;
- h) assist in the definition of space required for development, test and maintenance of equipment.

1.5. Working Group on Beam-Aided Spectroscopy and NPA

A wide range of beam-aided spectroscopic and neutral particle analysis (NPA) diagnostics are envisaged for BPXs. These instruments should be able to achieve the requirements set for a large number of measurements of plasma parameters in especially the core region of the plasma. These requirements include ion temperature and rotation velocity in the core, $q(r)$, He-ash and low-Z impurities in the core, n_D/n_T inside the plasma, and the properties of neutral particles. Many of these measurements are required for operational feedback control.

Beam-aided spectroscopy in the core is strongly affected by the penetration of neutral particles to the center: a concept for a pulsed diagnostic beam is under development. Absorption and fluorescence are caused in windows, lenses and fiber optics by nuclear radiation. Because of the impact of radiation on lenses and the need to provide labyrinthine paths for the emitted light, it is proposed to use mirrors close to the first wall, with resultant concerns about their survivability in the local environment of nuclear radiation and neutral particles from the plasma edge. Detectors dependent on photon measurement are likely to be sensitive to the background neutron and gamma environment and radiation-shielding will be required to protect them. New calibration techniques must be considered.

Specifically the Working Group on Beam-Aided Spectroscopy will:

- a) consider all beam-aided spectroscopic techniques for measuring the plasma parameters in especially the core, e.g. ion temperature and rotation by CXRS, $q(r)$ and $E(r)$ by MSE, fluctuations by BES as well as diagnostic techniques for neutral particle-based n_D/n_T measurements;

- b) assist in the development of the physics requirements and bases for the active spectroscopic measurements for BPXs;
- c) identify and advise on necessary physics, and design studies and review such studies under the voluntary arrangements;
- d) advise on the feasibility and suitability of the system choices and designs being developed for BPXs, including comparison with alternative methods suggested for some of the measurements;
- e) assist in the development of a plan for calibration, including identification of any special equipment or calculations needed to implement the plan;
- f) assist in evaluating the need for, and capability of, a special diagnostic neutral beam;
- g) recommend specific R&D tasks, including needs in atomic physics, if needed;
- h) assist in the definition of space required for development, test and maintenance of equipment.

1.6. First Mirror Working Group

Most of the optical/IR/millimetre-wave systems and spectroscopic systems of diagnostics for next step BPX devices employ mirrors as the first optical component. These mirrors will be exposed to the plasma and subject to high flux of particle bombardment, radiation and nuclear heating. Erosion of the plasma facing mirror by neutral particle bombardment, or deposition on the mirror surface of eroded divertor plate could give rise to a serious degradation of the performance of the diagnostics involved. The maintenance of the optical performance and the lifetime of these mirrors are therefore key design issues. Various protection schemes including a passive baffle and a shutter in front of the first mirror are under consideration, but further development and testing are necessary.

Specifically the Working Group on First Mirrors will:

- a) review the proposals for first mirrors developed in the system designs;
- b) advise on the choice of materials, mirror design etc;
- c) assist in the estimation of the lifetime and performance of the mirrors;
- d) assist in the coordination of the three party R&D programme on first mirrors;
- e) develop a data base and design guidelines which can be used by system designers;
- f) advise on methods of protecting the mirrors using baffles, shutters etc.
- g) the specific subject of radiation induced effects in first mirrors will be addressed in cooperation with the Specialists Working Group on Radiation Effects.

1.7. Radiation Effects Working Group

Many components used in diagnostics for Burning Plasma Experiments (BPX) will experience high levels of radiation and this will affect their physical properties. For example, Radiation Induced Conductivity (RIC), Radiation Induced Electrical Degradation (RIED) and Radiation Induced Electro-Motive Force (RIEMF) will change the electrical properties of ceramic insulators. Similarly, Radiation Induced Absorption (RIA) and photoluminescence can have a detrimental effect on optical components such as lenses, windows and fibers, while volume effects (nuclear heating, swelling, etc.) could have an adverse effect on the operation of a range of diagnostic components. Apart from radiation induced damage to diagnostic components also the effect of radiation on the operation of detectors (e.g. soft X-ray detectors, compact diamond spectrometers, bolometers) needs to be addressed. Finally, also the characteristic features of mirrors (e.g. reflectivity, polarization, specular reflection) are changed when exposed to radiation.

Detailed research in the field of radiation effects is necessary and is being performed in the various parties that constitute the International Tokamak Physics Activity. It is important that the individual activities of the parties are coordinated and reviewed as much as possible.

Specifically, the Working Group on Radiation Effects will:

- a) assist in the coordination of the four party R&D programme on radiation effects;
- b) review the work on prompt and long-term radiation effects in the various parties;
- c) advise on the choice of materials, detectors, location of components, etc;
- d) advise on methods of protecting diagnostic components and on mitigating the effects of radiation;
- e) assist in the estimation of the lifetime and performance of diagnostic components;
- f) advise on the radiation experiments to be performed;
- h) develop data bases and design guidelines which can be used by system designers;
- i) the specific subject of radiation induced effects in first mirrors will be addressed in cooperation with the Specialists Working Group on First Mirrors.

2. Membership of the Specialists Working Groups

There shall be 3 - 5 members from each Party in each of the Specialists Working Groups (SWG). The chair and co-chair of each SWG will be appointed by the chair and co-chair of the ITPA Topical Group on Diagnostics, using recommendations and consultations with the members of the Topical Group. The SWG members of each Party will be nominated by the Topical Group members of that Party. The chair of each SWG may invite other experts on to the subcommittee if the need for a particular expertise is required.

3. Functioning of the Specialists Working Group

The chair and co-chair of each SWG will appoint any supporting officers that they feel they need from the membership. Communication will be normally by e-mail, telephone or regular mail, but opportunities should be taken for occasional meetings attached to relevant physics or diagnostics conferences or other meetings if and when they occur. The SWG will not require specific travel for its own purposes.

Attendance at the relevant ITPA Topical Group meetings by at least one member of the Group is desirable if it can be arranged without substantial extra travel costs.

The chair should provide a short report to the Topical Group meetings, held approximately every six months, in person, or by delegation to a colleague or in writing. This report should clearly show the progress and any potential problems or need for R&D funds.

In case tasks of the SWG overlap with those of another SWG, close contact between the two groups (e.g. via the chairs) is stimulated. The ITPA Topical Group can be asked to actively steer the work in the grey areas between the groups.