ITPA Diagnostic Topical Group

Report on Activities in 2002

Tony Donné and Alan Costley

ITPA Coordinating Committee Meeting

Garching, Germany

October 24, 2002

MEMBERS OF THE TOPICAL GROUP ON DIAGNOSTICS

Japan:

Y. Kusama (JAERI), M. Sasao (NIFS)

(JA PT is considering to nominate two additional members)

Russia:

A. Kislyakov (IOFFE), A. Krasilnikov (TRINITI), V. Strelkov (Kurchatov), K. Vukolov (Kurchatov), V. Zaveriaev (Kurchatov)

USA:

R. Boivin (GA), D. Johnson (Princeton), G. McKee (GA), W. Peebles (UCLA), G. Wurden (LANL)

Europe:

A. Donné (FOM - Chairman), F. Orsitto (ENEA/CSU), R. Pitts (CRPP), F. Serra (IST)

ITER IT: A. Costley (Co-chairman), T. Sugie

TOPICS FOR CC REPORT

Meetings in 2002

Progress with High Priority Tasks

- High Priority Tasks 2001
- High Priority Tasks 2002/2003

Additional Specific Topics

- Review of target measurement requirements and their justification
- International Diagnostic Database

Progress with Intermediate and Long Term Tasks

Specialist Working Groups

Progress with ITPA CC Action items

Concluding Remarks and Forthcoming Meetings

MEETINGS OF THE TOPICAL GROUP ON DIAGNOSTICS

2nd ITPA Topical Group Meeting:

4 – 8 March 2002, General Atomics, San Diego, USA

Combined with a Progress Meeting on BPX Relevant Diagnostic Work ongoing in the US

Two joint sessions with Divertor & SOL TG and with Transport & ITB TG on measurement requirements

3rd ITPA Topical Group Meeting:

17 – 21 September 2002, Nat. Inst. Fusion Sci., Toki, Japan

Combined with a Progress Meeting on ITER/BPX Relevant Diagnostic Work ongoing in Japan

Joint session with representatives from all other TGs on measurement requirements and their justification

HIGH PRIORITY TASKS – 1/1

1. **Determination of requirements for measurement of q(r) and assessment of possible methods that can be applied to a BPX**

Requirements and justification have been reviewed and developed with other TG's

An improvement of spatial resolution to a/30 (instead of a/20) is recommended

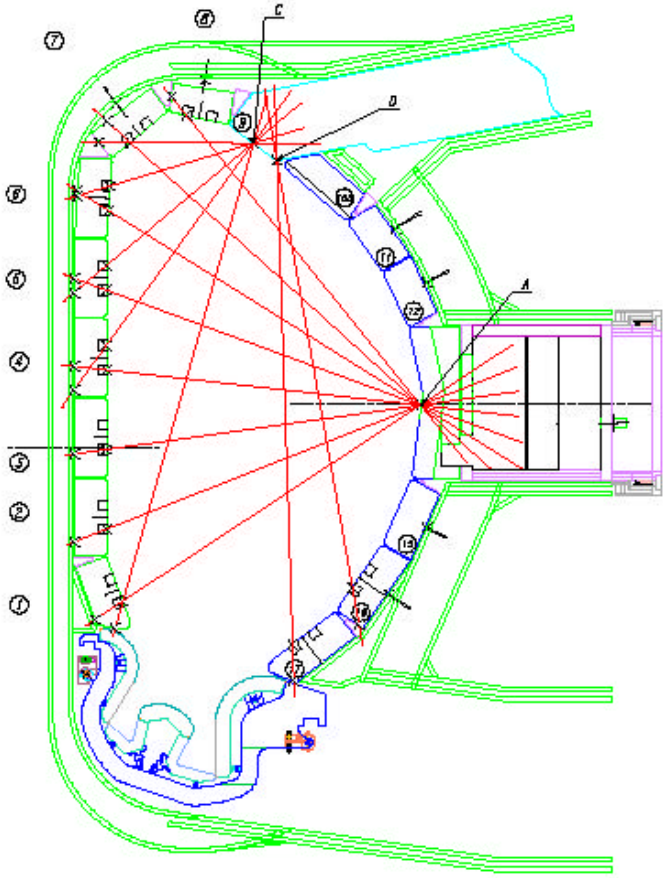
- **In the vicinity of ITB's and in the edge an even better spatial resolution is proposed (a/50)**

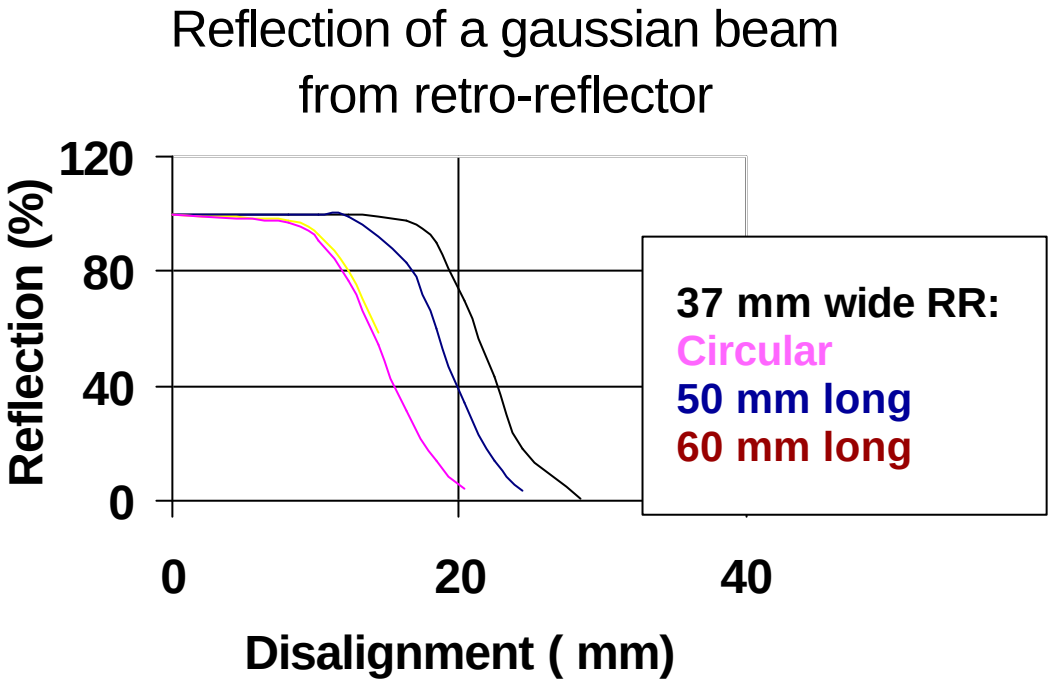
Justifications for proposed enhancements not yet fully developed

- **This is a subject of on going discussions with other TG's**

It is believed that feasible solutions have been found to most of the difficult implementation issues for polarimetry and MSE.

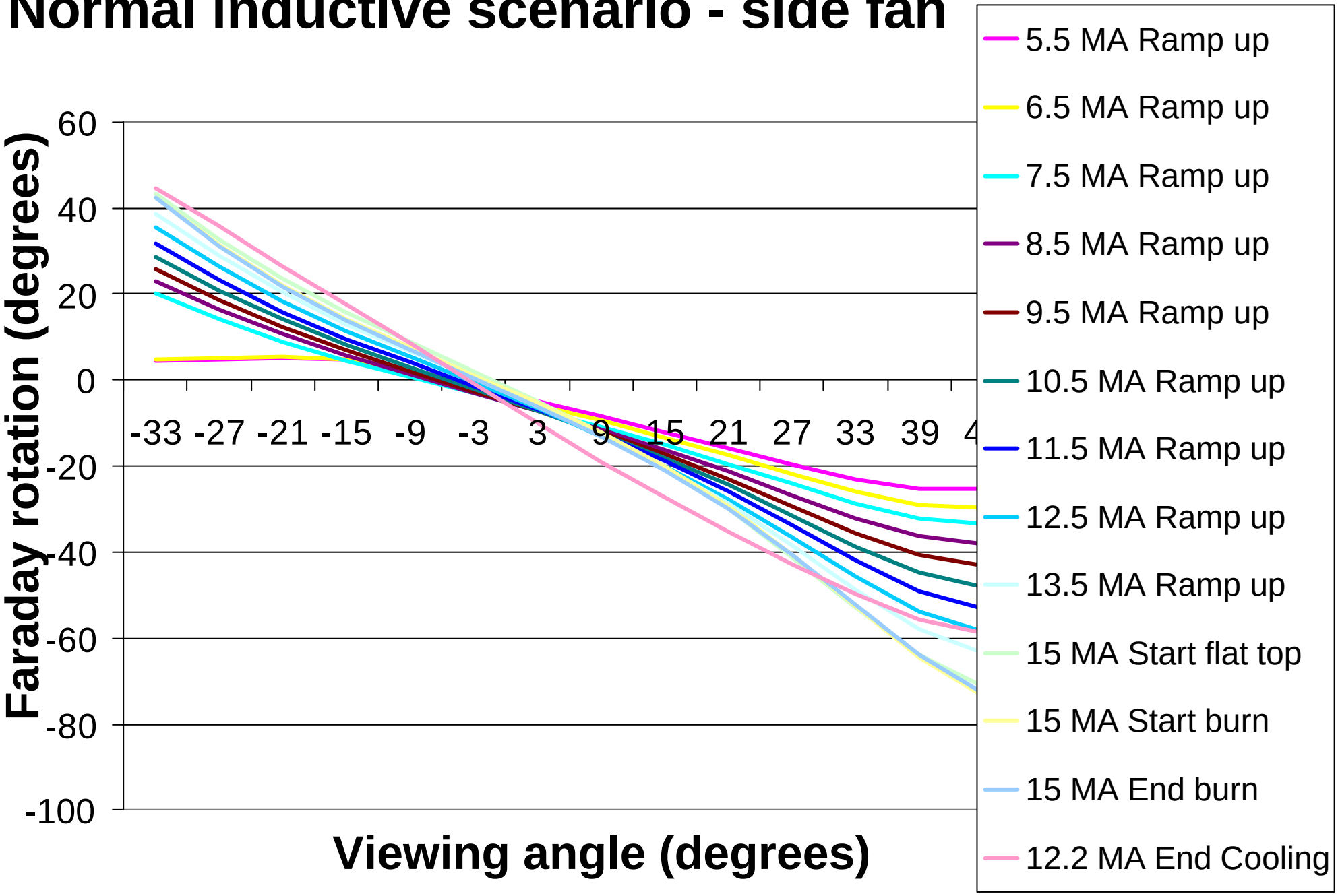
Because of the progress in this area it is proposed to shift priority from HIGH to INTERMEDIATE

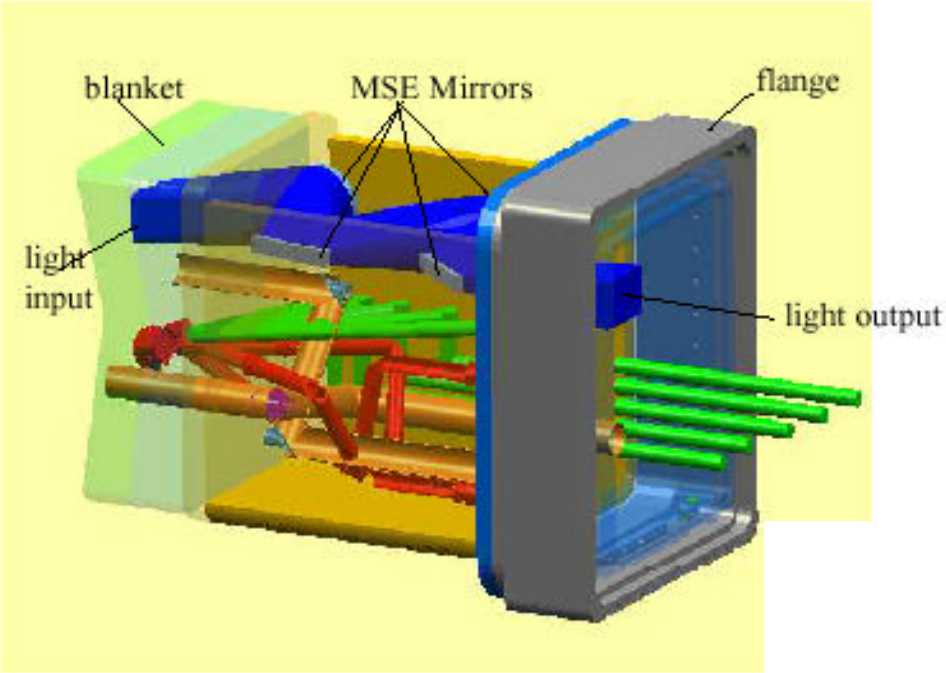




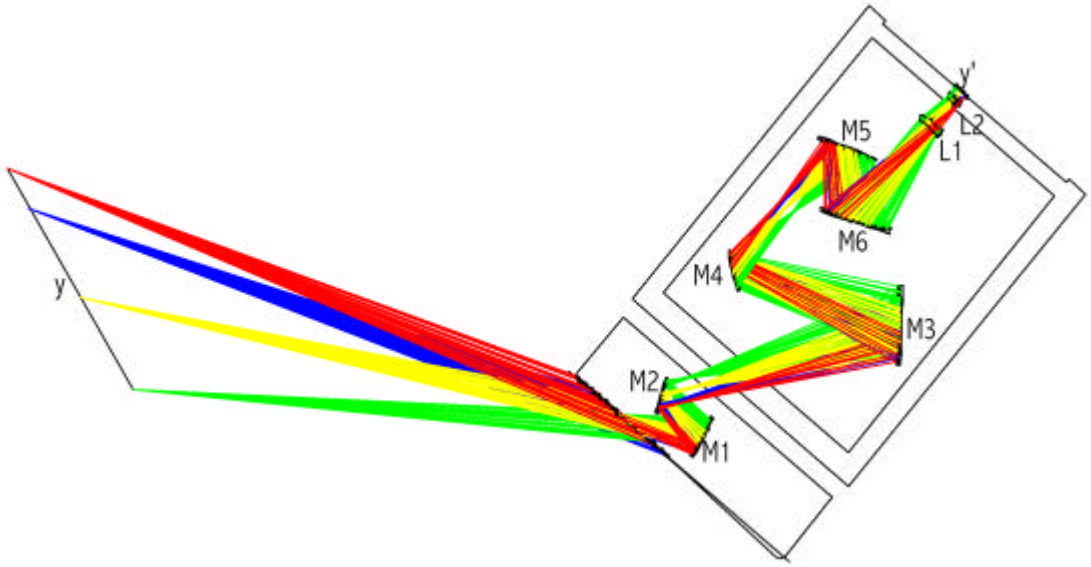
Planned lines of sight for the Poloidal Field Polarimeter in a mid-plane port, and effect of misalignment of beam on the reflectivity of the retroreflector. Additional lines of sight through a top port are under consideration.

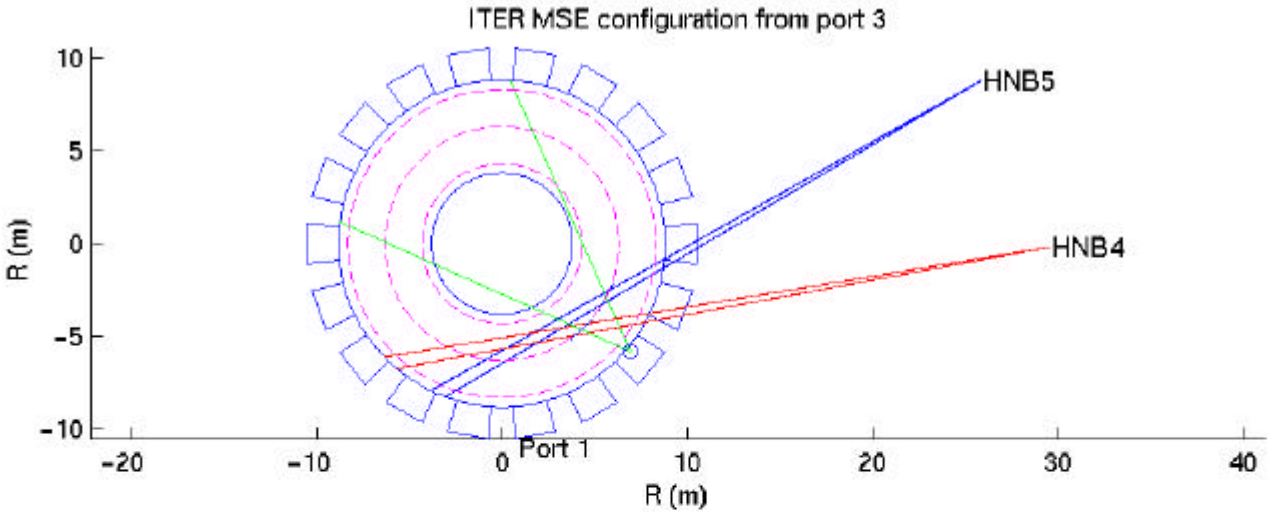
Normal inductive scenario - side fan

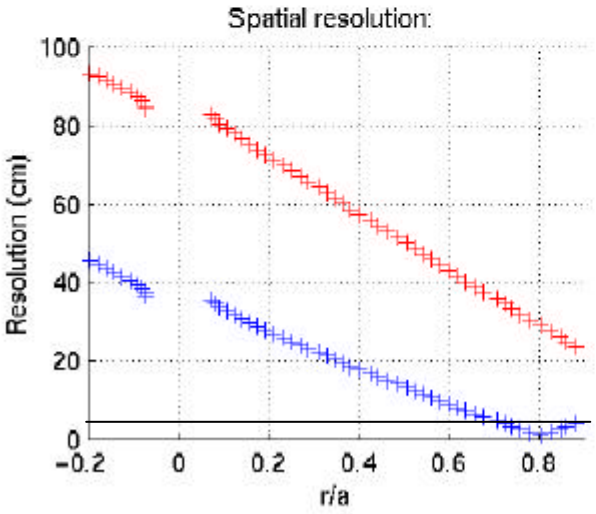




Optical system of MSE in equatorial port. Viewing angle o first two mirrors is optimised to have minimum depolarisation effect due to deposition of layer onto mirrors.







ITER Target Resolution

Geometry for MSE on HNB's – spatial resolution

HIGH PRIORITY TASKS - 2

2. Determination of measurement requirements in divertor region and recommendation of diagnostic techniques

Discussion with Divertor & SOL TG on requirements for ITER divertor parameters has continued

- **Many of the issues have been closed**
- **Some requirements have been changed and justifications developed**
- **System designs have been also advanced**

There is now a closer match between requirements and anticipated diagnostic capability, although there are still some significant discrepancies:

- **Measurement of T_e in divertor very difficult (even in outer leg)**
- **No measurements of T_e and n_e in the inner leg**

Current design work is aimed at improving diagnostic capability in inner leg.

Because of progress on this topic we recommend changing priority changed to INTERMEDIATE.

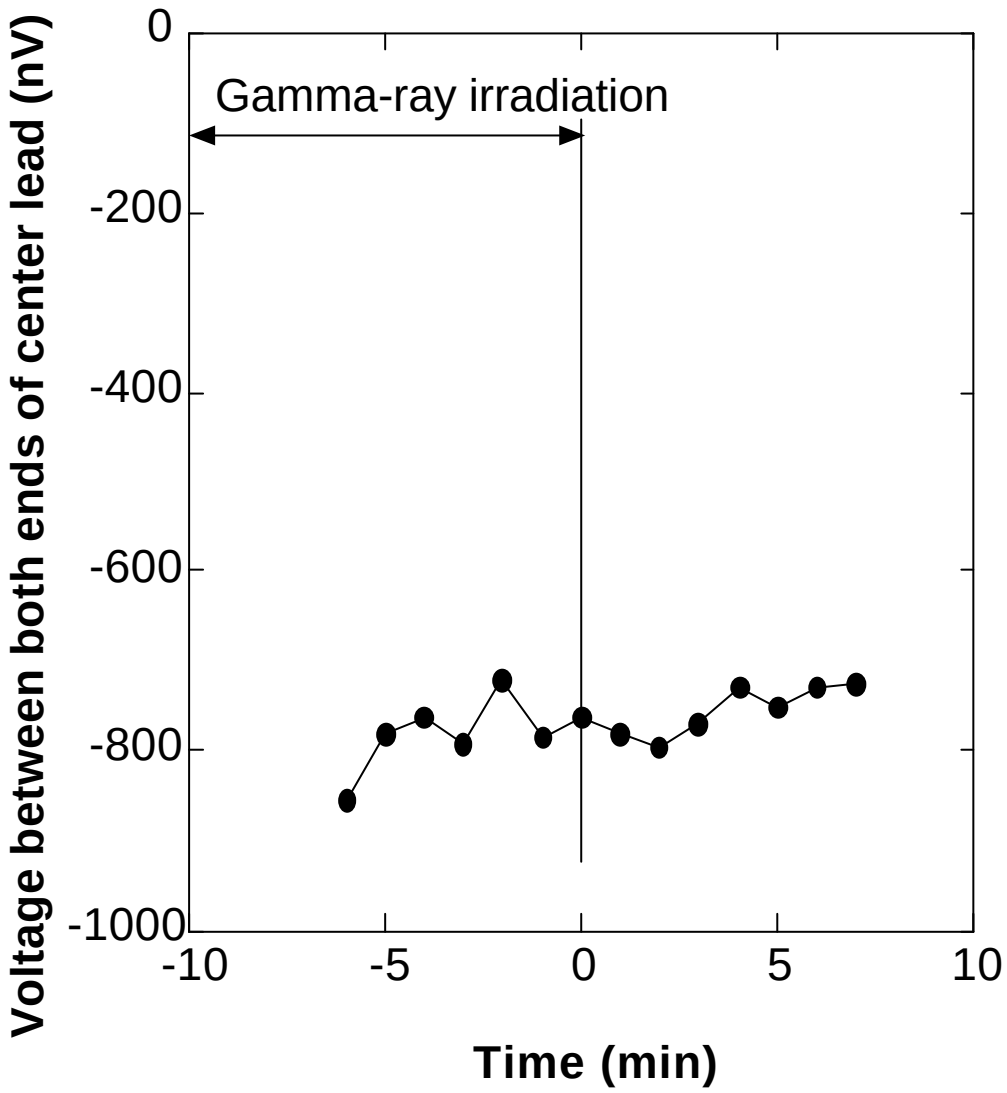
HIGH PRIORITY TASKS – 3/1

3. Assess the impact of RIEMF (Radiation-Induced Electro-Motive Force) on magnetic measurements and perform improved measurements on prototype coils

Progress has been made:

- **Differential measurement on prototype coil in Japan under g-irradiation at the Fusion Neutron Source**
  - **Small steady current (5 pA) but large transient peak (< 100 pA) at turn-on/off of the radiation.**
  - **Extrapolation of the steady current to ITER ® RIEMF not a serious problem**
  - **Transient level is probably also not a problem for ITER, but it might be for FIRE**
- **Single-ended measurements on irradiated cables and coils have been made in Belgium. Measurements are in good agreement with model calculations by the same group.**
- **Mitigation measures have been established.**

- **Careful choice of conductor material, insulator thickness, mantle thickness, etc.**



Time evolution of the voltage across a coil measured in a test rig (^{60}Co, 4 Gy/s). The upper limit of 50 nV of differential voltage change at the transition translates to > 800 s of pulse length under ITER conditions for this (smaller than planned) test coil.

HIGH PRIORITY TASKS – 3/3

Future plans:

- **Further tests are required to determine precise limitation due to RIEMF**
- **In particular key repeat test of coils irradiated in a reactor (neutrons and gammas) is still outstanding (planned for Dec. 2002)**
- **Because of general progress there is growing confidence that RIEMF will not be a significant effect (at least for ITER) but until the outstanding repeat coil tests are made we propose to keep this item as HIGH priority**

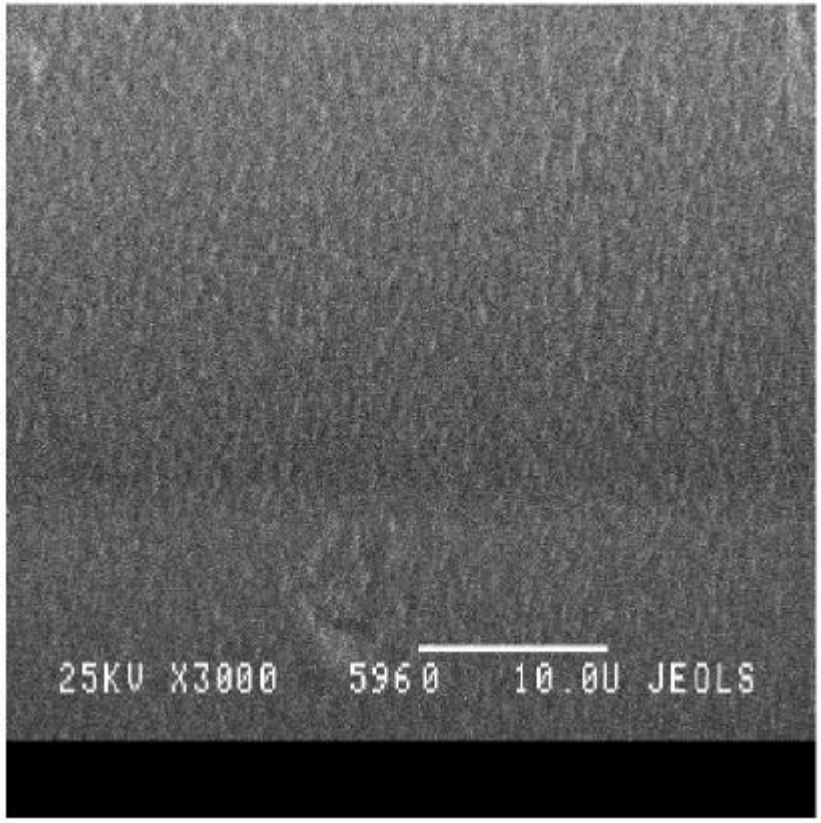
HIGH PRIORITY TASKS - 4/1

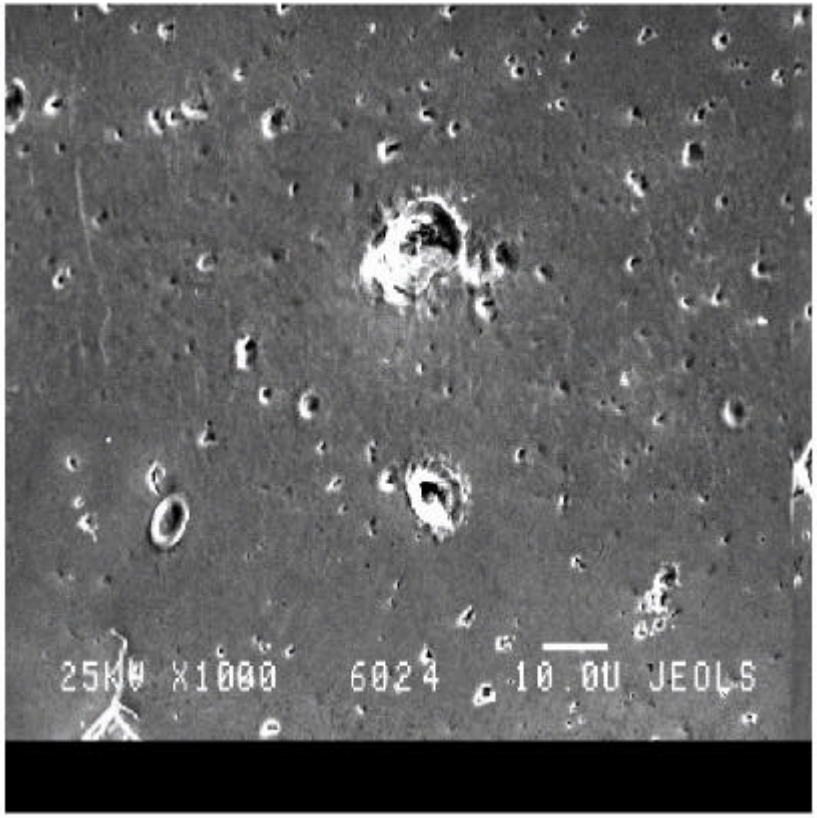
4. Determination of life-time of plasma facing mirrors used in optical systems

Steady progress is being made

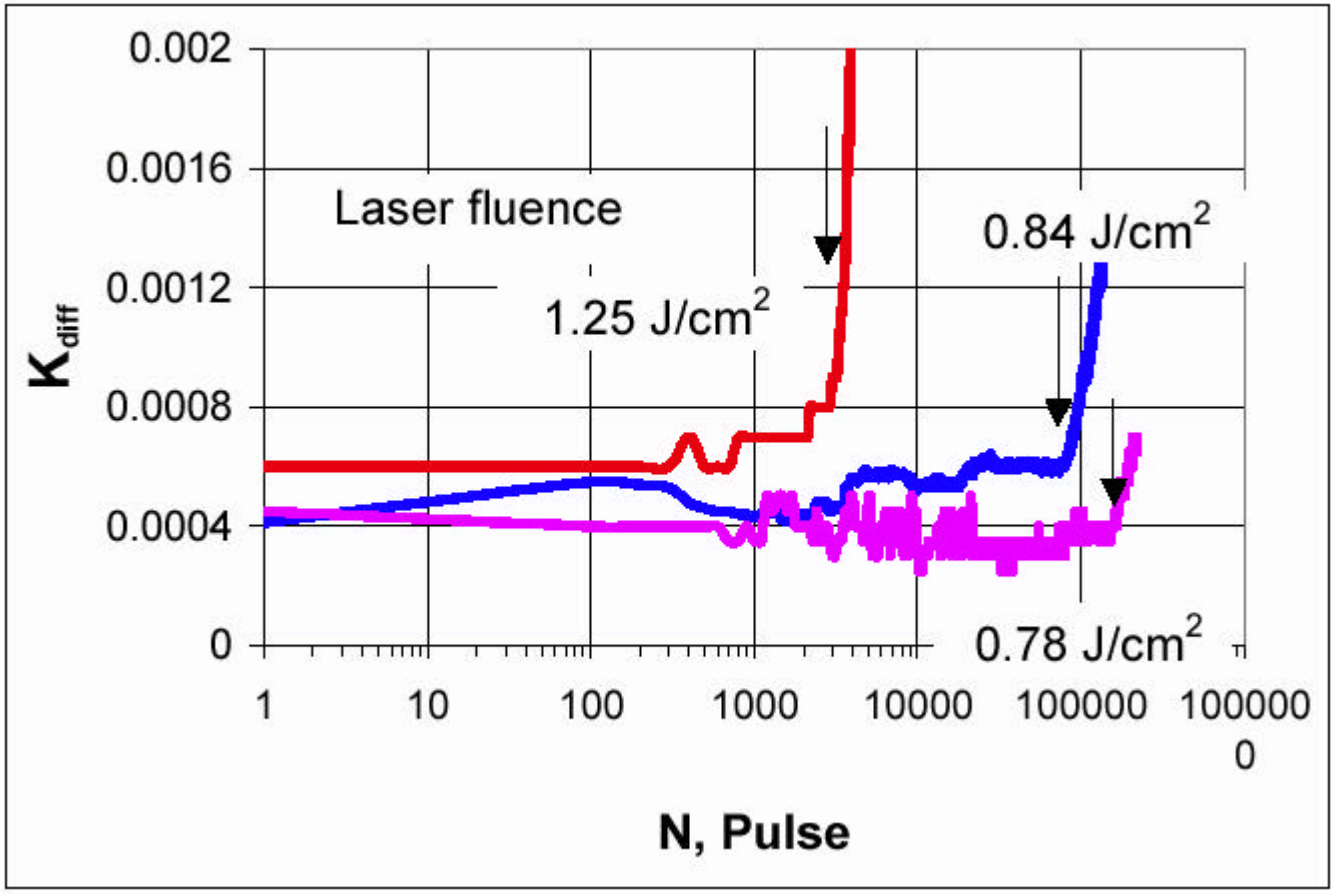
- **In regions where sputtering dominates suitable mirrors are available**
- **Fabrication process of mirrors is very important, since it determines sensitivity**
- **The role of deposition on mirrors and windows is less clear and needs testing on present day devices**
- **Work on mitigation measures (cleaning, shutters, etc.) is in progress.**
- **Specific experiments are planned in the JET divertor, at TEXTOR, Tore Supra and at the PSI-2 plasma simulator.**

Item should maintain HIGH priority.

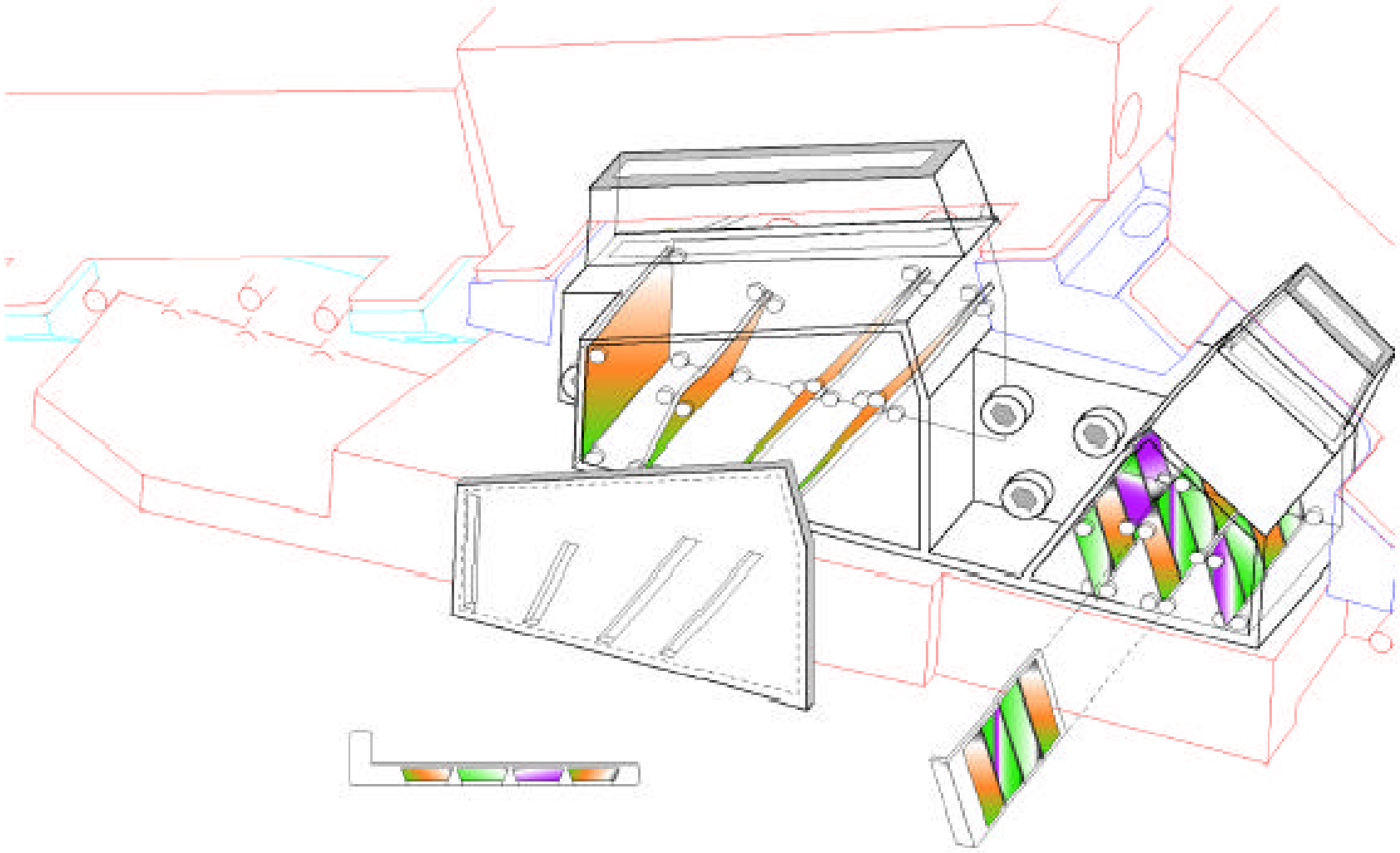




Scanning electron microscope photos of mirror surface, horizontal line gives the scale: left) - molybdenum single crystal, right) – molybdenum polycrystal



Diffusive scattering coefficients as function of number of laser shots for a single-crystal molybdenum mirror under different laser fluence - 0.78, 0.84, 1.25 J/cm^2 .



Schematic of First Mirror Test Box mounted on the Wide-Base Tile Carrier (the above design is still for the original JET MKII-HP Divertor, but is now modified for the new MKII-HD Divertor)

HIGH PRIORITY TASKS – 5/1

5. Determination of measurement requirements for confined and escaping a's and assessment of possible methods to measure their energy and density distribution in a BPX

At ITPA-2 it was pointed out that 1 MeV D-ions from HNB's will cause considerable background for any technique that does not distinguish a's by their mass (i.e. not by q/m). This because deuterons have the same q/m

Preliminary considerations suggest that this may not be important because the key wave-particle physics depends on q/m. On the other hand, the slowing down will be different (depends on m), but in any case this is thought to be classical.

CTS measurements may be able to distinguish a's from deuterons by differential measurements (e.g. observing both sides of the scattered spectrum, the effect of the a's will be symmetric, that of deuterons not).

HIGH PRIORITY TASKS – 5/2

In addition new ideas have been proposed to measure α-particle population:

One based on knock-on trition ion tail measurements, one based on active CXRS using high energy diagnostic He-beam.

Both methods may have substantial implementation difficulties , although the details have not yet been studied.

HIGH PRIORITY TASKS – 6/1

Two new HIGH priority tasks have been identified and proposed

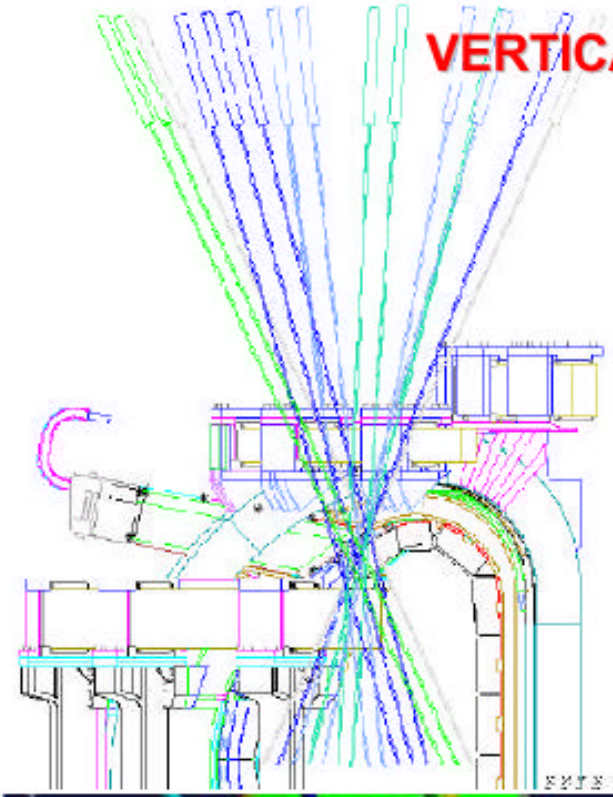
Implementation of vertical neutron camera (VNC) on appears difficult/impossible

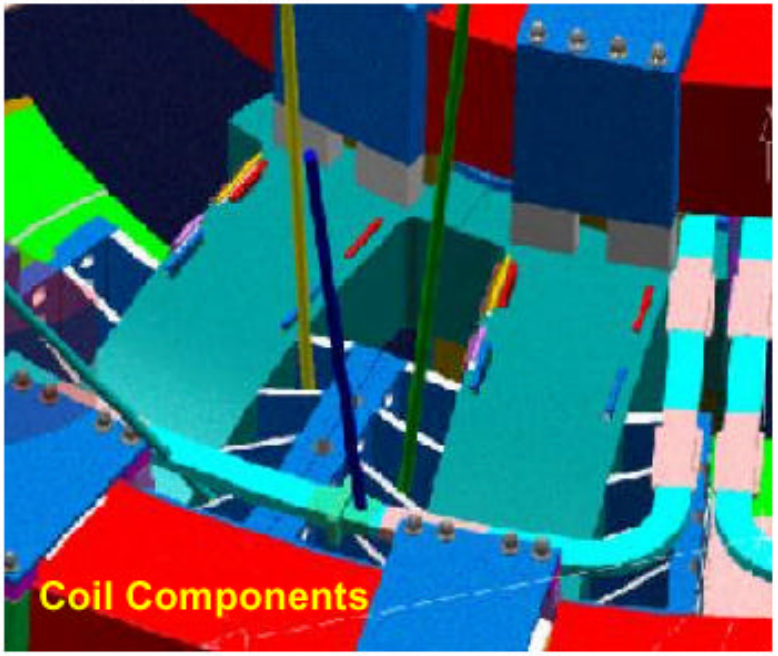
- **Consequence: neutron/a source profile will not be measured directly**

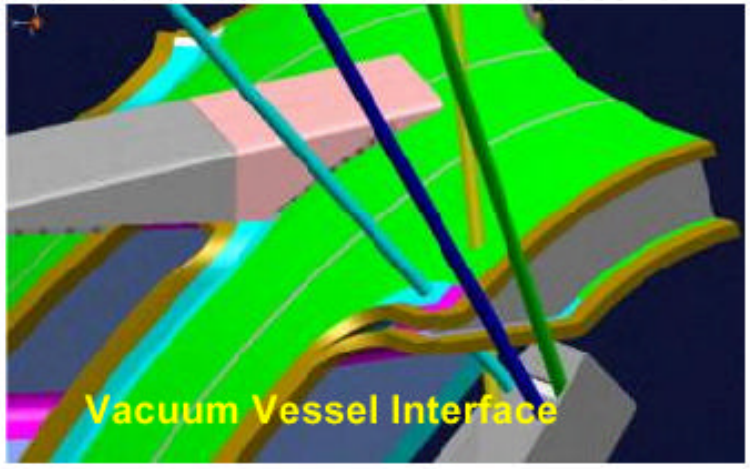
Hence:

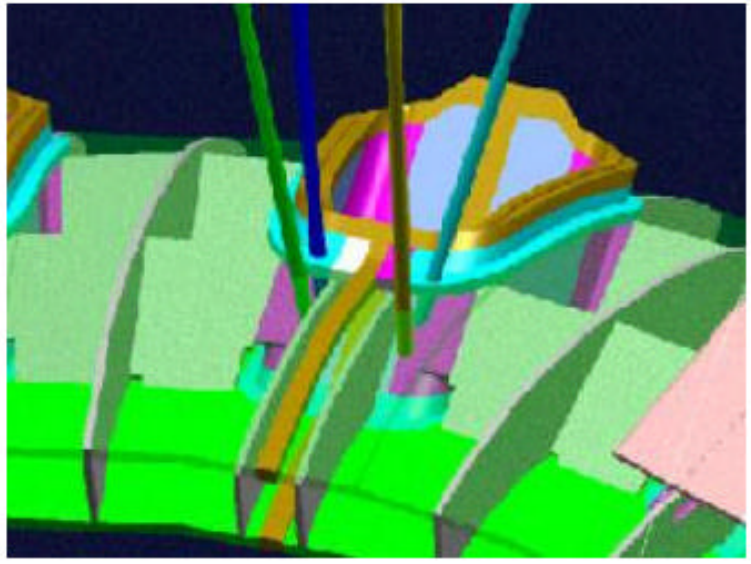
Review requirements for measurements of neutron/a particle source profile and assessment of possible methods of measurement

VERTICAL NEUTRON CAMERA









HIGH PRIORITY TASKS – 6/2

Other TG's are recommending to have a higher resolution in the measurement of several key parameters (T_e, n_e, T_i, v_{rot}, q, etc.) to support the advanced tokamak type of operation

These measurements are very difficult under BPX conditions and it therefore important to have a HIGH priority topic:

Determination of MINIMUM requirements necessary to support advanced tokamak operation and assessment of the possible measurement techniques.

PROGRESS WITH INTERMEDIATE AND LONG TERM TASKS

- **There are 13 Intermediate and Long Term Tasks. Progress on many of them has been made and is summarised in the table in the written report.**

- **A substantial part of the progress is due to timely and relevant research in the Home Team laboratories. It is not clear how much of it is due to the ITPA TG, but we are grateful for it nevertheless.**

Measurement Requirement	Motivation and Required Investigation/Development	Progress since March 2002
Devise new concepts for measuring j(r) that can be applied to a BPX with sufficient spatial resolution.	Techniques are required for measuring j(r) that can be realistically implemented on a BPX and will meet the measurement requirement. It is anticipated that measurement of j(r) will be required for real-time plasma control for advanced tokamak modes. Techniques that have been used include MSE and Heavy-Ion Beam probe. MSE requires the use of a current-drive beam with many optical sightlines for good spatial resolution (and, potentially, radial electric field correction) and many components, such as windows, are sensitive to the local magnetic field. The heavy ion-beam probe requires very high energy and a special, maybe impossible, access. Hence both are very difficult to implement on ITER. 1) Propose and develop alternative techniques for measurement of q(r). 2) Analyze performance of an MSE system in a D-T device. 3) Using MSE data in real time, determine minimum requirements on the measurement of q(r) needed for plasma current-density control.	It has been demonstrated that reflectometry can detect the location of NTMs and MHD islands but it is not certain how their location exactly relates to the position of the resonant q surfaces. Recently it was observed at ASDEX-UG that the position of low m-number rational q-surfaces can be clearly identified in the level of density fluctuations measured by reflectometry. A new proposal by the Kurchatov Institute involves CXRS and the measurement of escaping neutral particles by NPA to obtain q(r). Detailed investigation is needed. Another method that has demonstrated to be very useful for the measurement of the central part of the q-profile is MHD-spectroscopy. First very promising experiments have been conducted at JET.

SPECIFIC TOPICS THAT HAVE BEEN ADDRESSED - 1

1. Review of Measurement requirements and their justification

A considerable effort took place to document the reasons behind the choice of parameter resolutions, accuracies, etc. for ITER and FIRE and to connect these justifications with the measurement requirements.

While doing this some inconsistencies where discovered and removed.

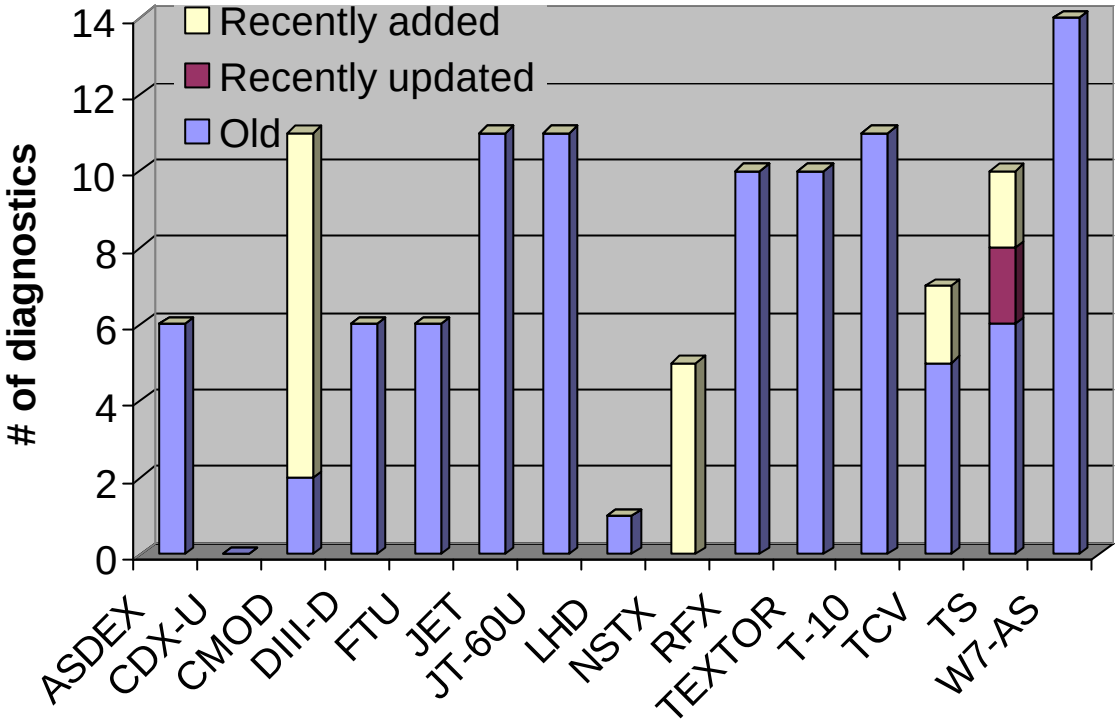
All other ITPA TG's are now involved in the discussion of the measurement requirements and the development of their justifications. The discussion on the divertor parameters are well advanced. Those with the other TG have recently started and will be continued.

- **Joint Session with the Transport & ITB TG in March and with all TGs in September**
- **Also as part of the new high priority item.**

SPECIFIC TOPICS THAT HAVE BEEN ADDRESSED - 2

2. International Diagnostic Database

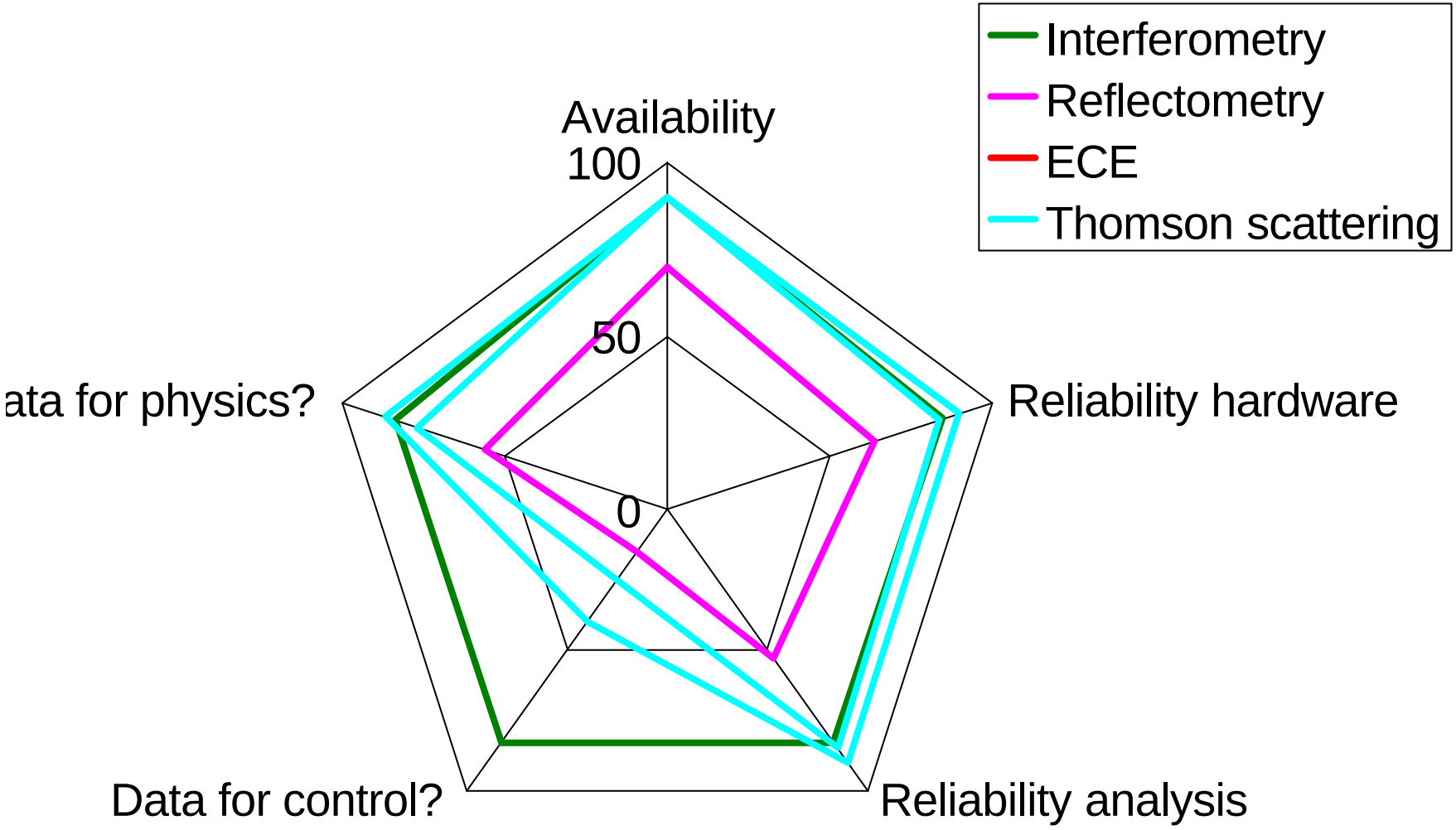
- **The International Diagnostic Database (IDD) is accessible via a password protected internet site (www.rijnh.nl/IDD)**
- **Guidelines for the database (similar to those of other databases) have been developed**
- **Responsible officers have been appointed in the various laboratories contributing to the database**
- **IDD now contains information about 119 diagnostics from 15 different machines**



Machines contributing to IDD (Recently and old refer to 1 March 2002)

Responsible officers are motivated/stimulated to contribute many new diagnostics (bottle of wine for the most active contributor!)

Electron diagnostics



SPECIALISTS WORKING GROUPS

A new SWG on Radiation Effects was established. This group had a 1/2 –day meeting at the SOFT-Conference in Helsinki, because the majority of members was present.

SWG's reported progress in their specific fields:

- **Thomson scattering**
- **Neutron diagnostics**
- **Reflectometry**
- **Spectroscopy and NPA**
- **First Mirrors**
- **Radiation Effects**
- **(IDD)**

	Japan	Russia	Europe	USA	ITER IT
Neutron WG	T. Iguchi Takeo Nishitani Mamiko Sasao	Yuri Kaschuk Anatoli Krasilnikov Sergey Popovichev Victor Zaveriaev	Paula Batistoni Neil Jarvis Jan Källne	Catherine Fiore Lane Roquemore William Heidbrink	
Thomson WG	Takai Hatae Kazimuchi Nari-hara	Gennady Razdobarin Vladimir Sannikov	Per Nielsen Francesco Orsitto Michael Walsh	Tom Carlstrom David Johnson	George Vayakis
Reflectometry WG	Kazuo Kawahata Atsushi Mase K. Shinohara	Victor Bulanin Alexey Petrov Vladimir Vershkov	Gerrard Conway Mathias Hirsch Maria Manso Joaquin Sanchez	Gerrit Kramer Tony Peebles Terry Rhodes	George Vayakis
Spectros-copy & NPA WG	Takashi Fujimoto Katsumi Ida Hirotaka Kubo Shigeru Morita	Yuri Gott Alexander Medvedev Dzholinard Shcheglov Mikhail Petrov Sergey Tugarinov	Robin Barnsley Kurt Behringer Ruggero Giannella Albrecht Pospi-eszczyk	Ken Hill Fred Levinton John Rice Dan Thomas Glen Wurden	Tatsuo Sugie
First Mirror WG	Yoshihiko Hi-rooka Hidekhi Zushi	Nikolay Klassen Dorian Orlinski Vladimir Voitsenya Konstantin Vukolov	Eric Hodgson Paulo Tartoni	John Hogan Charles Skinner	Alan Costley
Radiation Ef-fects WG	Toshiyuki Iida Takeo Nishitani Tatsuo Shikama	Sergey Bender Anatoli Krasilnikov Vladimir Stepanov Alexander	Benoit Brichard Marc Décreton Eric Hodgson Peter Jung	John Hunn Lance Snead Ken Young Steve Zinkle	Chris Walker

		Tomashuck Konstantin Vukolov			

ITPA DIAGNOSTICS WEBSITE

Website for the ITPA TG on Diagnostics (www.rijnh.nl/ITPA) further upgraded:

- **Top part of website is publicly accessible**
- **Presentations at and minutes of recent meetings are password protected.**

ACTION ITEMS OF ITPA CC MEETING

ITPA Topical Group on Diagnostics

Action	deadline	status
Are encouraged to use the ITPA website http://www.aug.ipp.mpg.de/itpa/ to provide information on their activities:		**Distributed to TG**
Distribution of responsibilities for "internal transport barriers", "improved scenarios", etc needs to be clarified	**2002.07.31**	**n.a. to TG on Diagnostics**
Each TG should define a "Working Group" in relation to each international database under its responsibility: this WG will be formally associated with the TG - the WG will maintain the relevant database, prepare initial publications of new results and recommend when new versions should become public	**2002.07.31**	**Done**
Establish a list of databases under their responsibility: with statement of functionality, manager and location - on website	**2002.07.31**	**Done**
Propose TG Meeting after IAEA/location, date, and local host to M Shimada	**2002.07.15**	**n.a.**
TG Chairs/Co-chairs to identify the areas where interfaces exist with other TGs and nominate "responsible officer(s)" to ensure coordination in such areas	2002.07.31 (SSEP:after new member nomin.)	**Done; liaisons being nominated**
TGs should revise statements of scope and tasks according to a common format (H Zohm to provide) for posting on ITPA website	2002.09.30	Waiting for trigger
Encourage a response from your TGs to the recent request for input to the development of specifications for burning plasma diagnostics circulated by Tony Donne and Alan Costley. • circulate the material distributed by Tony and Alan to all members of your TG with a request that they provide feedback	2002.07.31	**n.a. to Diagnostics TG since we initiated this action**
submit a list of significant progress for consideration for "Tokamak Physics Basis"	**2002.07.31**	

ATTENDANCE AT ITPA TG MEETINGS

Attendance of the TG members to the ITPA meeting is essential for effective operation of the TG

The attendance at our recent meeting in NIFS from EU and US side was too low (only one TG member from each of these PT's).

Decision in EU was made very late (a few days before the meeting). This led to the cancellation of 4 key presentations with a consequential reduction in the effectiveness of the discussion on the points involved.

Success of ITPA TG meetings and progress on the tasks is directly related to having a good participation of TG members from all parties.

Hence, we feel that it is essential that AT LEAST the TG members should attend.

CONCLUDING REMARKS

Overall a successful year with progress made on many of our key topics.

- **Sufficient progress to reduce two from HIGH to INTERMEDIATE priority.**
- **Hopeful that progress in a third (RIEMF) in near future will be sufficient to reduce to 'INTERMEDIATE/LONG TERM'.**

Developments in design and measurement requirements have led to proposal for two new 'HIGH' priority topics.

Discussion with all ITPA TGs established to develop measurement requirements and justifications.

SWGs operate successfully.

IDD established, developed and in use.

CONCLUDING REMARKS

There are still many issues where developments are needed. However, the Parties' fusion labs are still reluctant to develop BPX diagnostics as part of current programmes. In the meantime the time to a BPX is reducing (hopefully!) and so opportunities and time for development are diminishing. Since it is an established fact that the knowledge gained with and the performance of fusion machines is directly linked to the diagnostic capability, it is a necessity that diagnostic developments are encouraged and enhanced.

PROPOSAL FOR FORTHCOMING MEETINGS

17 – 21 February 2003:

Fourth Meeting of the ITPA Topical Group on Diagnostics, Padua, Italy including

- **a one-day session on candidate methods for a-particle measurements (to make progress with the high priority topics related to this)**
- **review of measurement requirements and justifications (i.e. feedback from other TGs)**

Combined with a Progress meeting on ITER/BPX relevant diagnostic developments in Europe

14 – 18 July 2003:

Fifth Meeting of the ITPA Topical Group on Diagnostics, Moscow, RF

- **connected to the EPS-2003 Conf. in St. Petersburg**

Sixth meeting would then line up with HTPD Conf. in spring 2004 in US.