Report from the Edge & Pedestal TG

1) Scope and Task definition for the Topical Groups;
opportunities for increased effectiveness
2) High priority, medium term, and long term physics research areas

3) Specific recommendations for international collaboration
within IEA Large Tokamak framework

4) Reports on TG meetings

5) Annual reports
brief highlights of technical results and expectations in the coming year,
plans for publications including IAEA Conference, and plans for meetings

6) Proposal for areas of major progress
to be covered by « Tokamak Physics Basis » document

1) Scope and Task Definition

1-1. Group Activity

In order to develop the physics basis for burning tokamak plasmas, the Edge Pedestal Physics Topical Group shall coordinate tokamak physics research in the subjects listed below,

foster collaborative research activities among international fusion research establishments (experiment & modeling), construct and analyze the international database treating wide ranges of plasma parameters and magnetic configurations, and carry out modeling.

Based on these activities, the Topical Group shall recommend the physics guidelines and methodologies for physics design for burning plasma experiments.

1-2. Goal of the activity

Understanding:

2-1) the H-mode edge pedestal origin & structure, and its response to external controls,

2-2) the origin and dynamics of the edge localized modes (Type I, II, III and quiescent), accessibility to the small ELM regimes,

2-3) parameter linkages among the pedestal and the core parameters, and effects of the edge localized modes on core transport and SOL/divertor heat&particle flows.

Development:

2-4) tools to predict BPX pedestal performance & accessibility to types of ELM regimes.

Recommendation:

2-5) the operational solutions of the edge pedestal compatible with both burning core and radiative SOL and divertor.

Since the research area treated by the pedestal TG is the boundary between the core and the SOL/divertor areas, the pedestal TG shall maximize the collaborative activities with the other TGs in charge of the core confinement and divertor physics.

2) High priority, medium term & long term physics research areas

2-1. High Priority Research Topics

Edge & Pedestal TG

A) Predictive Capability of Pedestal Structure through Profile Modeling

The Pedestal TG has started to construct the profile database of carefully treated ne(r), Te(r), Ti(r), Vt(r), Vp(r), Zeff(r), Pheat(r), Prad(r), q(r) etc. with equilibrium. The database includes profiles prior to ELM crashes and/or profiles averaged over a few ELMs, and also profile evolution in a ELM cycle. (AUG, ALCATOR-C Mod, DIII-D, JET, JT-60U, MAST , (NSTX))

The data analyses are focusing on dependence of the pedestal structure on

*** magnetic structure (shape and q(r)) ,**
*** electron density,**
*** neutral penetration.**

In parallel, the TG is conducting systematic summary of the results of 'dimensionally similar inter-machine comparison' among the world tokamaks listed above.

Based on the profile DB, the pedestal TG will develop & validate the predictive models including both plasma physics (transport & stability) and atomic physics.

T. Osborne will prepare the guidelines to provide the data into the inter-TG profile DB based on MDS Plus.

2-1. High Priority Research Topics (2)

B) Physics-based Empirical Scaling of Pedestal Parameters

The pedestal width scaling is the urgent issue.
We will also focus on dependence of the pedestal parameters on magnetic structure in particular triangularity (shape).

The Pedestal TG will expand and improve the scalar DB by adding data of
- **MAST (& NSTX) (in particular for aspect ratio dependence)**
- **pedestal width of JET**
- **density pedestal width + information of neutrals**
- **electron temperature width (JT-60U) and ion temperature width (others)**
  as much as the diagnostics allows.
- **both flux averaged and outer-midplane (JT-60U) values of pedestal width & Bp**
- **squareness, HH-factors, etc.**
- **typical error bars and uncertainties**
- **review sheets for each discharge**

In the 19th IAEA Fusion Energy Conference, the Pedestal TG and the Confinement & Modeling TG has reported the joint paper treating the two-term, core and pedestal, confinement scaling. Both TGs will continue this collaborative activity.

The scalar databases v1, v2 and v3.1 have been already opened to the public. The database v3.2 is under confirmation of data quality, and will be opened soon.
L. Horton will continue to be the manager of the database activity of the Pedestal TG.

2-1. High Priority Research Topics (3)

C) Predictive Capability of ELM size and frequency, and Accessibility to small ELM regimes

The Pedestal Gr. will study on dynamics and structure (for example, radial depth, poloidal asymmetry etc.) of ELMs observed in the world tokamaks for different types of ELMs, different density (collisionality), and different shape, etc.

Dependence of the energy release by ELMs ($\Delta W_{ELM}/W_{ped}$) should be studied in terms of both the eigen function distribution and the transport in the SOL layer.

We will unify the knowledge of accessibility to various small ELM / quiescent H-mode regimes observed in tokamaks. We will include results of stability analyses conducted in each device. We encouledge dimentionally similar inter-machine comparison.

The peeling-ballooning stability seems to explain the origin of typeI and type II ELMs in many tokamaks. This interpretation should be tested whether we can explain the duration of the ELM free period, ELM frequency, bifurcational change between type I and type II ELMs, etc.

We will develop tools for ELM mitigation and control (for example, pellet injection, radiation enhancement, dB/dt)

The Pedestal Gr. will share such information with the Divertor Gr. for understandings of ELM energy loss and divertor heat load.

2-2. Medium Term Topics

with new detailed pedestal diagnostics, inter-machine experiments, improved integrated predictive modeling tools :

Understandings of :

1) the H-mode edge pedestal structure and its response to external controls (for example j_{edge})

2) the origin and dynamics of the edge localized modes (Type I, II, III and quiescent), compatibility of the small ELM regimes with burning plasma conditions.

test ELM models with improved diagnostics and computational tools.

3) parameter linkages among the pedestal and the core parameters (incl. ITB core)

4) effects of the edge localized modes on core transport and SOL/divertor heat& particle flows.

2-2. Long Term Topics

Recommendation:

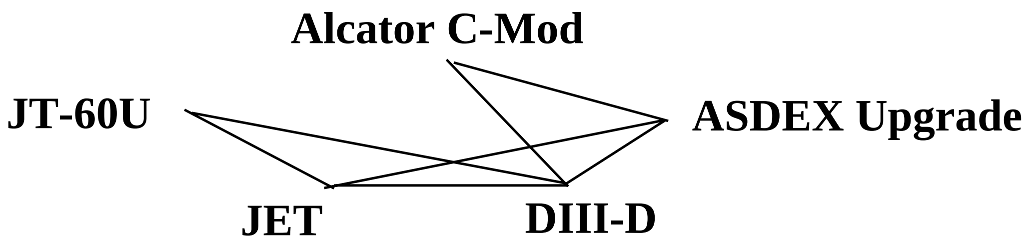
Realization of H-mode pedestal & ELM control in long pulse burning core with radiative divertor

Proposal for ITER Experiment.....

3) Specific recommendations for international collaboration within IEA Large Tokamak framework

The Pedestal TG recommends the following experiments / analyses and requests data for the international database:

1) Inter-machine comparison (ex. dimensionally similar approaches).



2) Contribution to the high priority research topics (A), (B) & (C), in particular shape and density dependence.

3) Carefully reconstructed profile data with magnetic shear profile.

4) Contribution of Modeling Gr. in each institute.

4) Reports on the 3rd.TG meeting

date: Oct. 21-23, 2002
location: IPP Garching
participants: 28 (EU:12, JA:3, RF:2, US:10, ITER:1) + joint sessions with MHD TG

Based on the ITPA Pedestal TG activity,
significant progress of the pedestal research in the world tokamaks
and variety of inter-machine collaborations.

TOPICS
1) Summary of Recent Pedestal Research & Issues

0) High Confinement at High Density:
Improving with triangularity.

A) Predictive Capability of Pedestal Structure through Profile Modeling
*** pressure gradient: Peeling-Ballooning model is consistent with experiments.**
Increases with beta-p at high triangularity.
*** width: Large uncertainties make it difficult to predict pedestal temperature based on a combination of transport barrier and stability physics. --> urgent issue.**
***density pedestal width: seems to be determined by neutral penetration.**
--> Importance of Atomic Physics.

B) Physics-based Empirical Scaling of Pedestal Parameters
*** New pedestal stored energy scalings were proposed. (Conf.TG. - Ped.TG. joint)**
(Aspect ratio dependence: MAST data)

C) Predictive Capability of ELM size and frequency, and Accessibility to small ELM regimes

* $\Delta W_{ELM}/W_{ped}$: (convective, convective+conductive)
  tends to decrease with increasing collisionality (exception: JT-60U)
  Both the eigen function distribution and the transport in the SOL layer seem to play roles.

* Highly poloidal asymmetry (type I) observed in JT-60U.
*ELM mitigation by Pellet inj. (AUG)

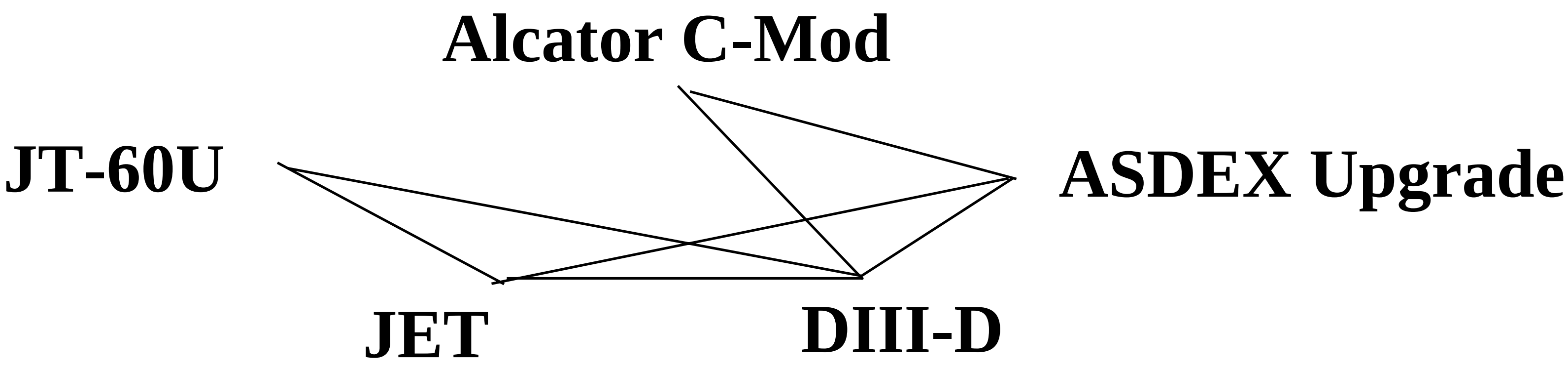
* type II grassy:
  Extended to low-q_{95} regime (AUG:3.5 near DN, JT-60U:3.8 with δ~0.6).
  Edge shear plays a role (AUG: near double null config.)
  Narrow radial eigen function of peeling/ballooning mode can explain.

* Quiescent H-mode:
  Wide regimes of triangularity, q & ne but only with Counter-NB. (DIIID)
  AUG (DIIID-similar) reproduced QH.
  EHO: Possibility of fast particle drive.

* EDA: ideal MHD stable.

*small ELM with 'divertor top' config. + Ar inj. (JT-60U)

3) Inter machine collaborations



3) Data Base

* Profile DB : into the inter-TG profile DB based on MDS Plus. (see HP(A))

* Scalar DB : v3.2 is under improvement (see HP(B))

4) ITER Diagnostics Needs proposed for Diag. TG

* Pedestal area = r>0.8a
* Basic radial resolution = 5 mm (q/400) (ne, Te, Ti, rotation, Zeff..., q(r) ~2cm?)
  poloidal distribution
* time resolution (~ 100micro sec for Te & ne, ~10ms? for Ti & rotation, Wdia~0.5ms)
etc.

5) Annual reports

5-1) brief highlights of technical results (see Sec.4)
5-2) expectations in the coming year

A) Predictive Capability of Pedestal Structure through Profile Modeling

Pedestal Width data / analyses incl. atomic physics : urgent

j_{edge} diagnostics and improved stability calculations.

creating a profile database for stability and transport analyses.

B) Physics-based Empirical Scaling of Pedestal Parameters

expansion of scalor DB

creating a database of discharges in common between the pedestal, confinement and divertor Grs.

C) Predictive Capability for ELM Control and Accessibility to small ELM regimes

Dependence of $\Delta W_{ELM}/W_{ped}$: eigen function distribution
ELM dynamics and radial/poloidal distribution
ELM mitigation with pellet etc.
Unification of the ssmall / no ELM operations.

5-3) plans for publications including IAEA Conference

19th IAEA paper --> Nucl. Fusion

H-mode WS 2003
a few group papers --> Tokamak Phys. Basis

5-4) plans for meetings

2003:March (middle) at JAERI
Joint analyses / discussion
Tokamak Phys. Basis

2003: Sep. after H-mode WS in US
Tokamak Phys. Basis

Integrated Basis for Pedestal Physics

Plan: a few H-mode WS papers (2003, Sep.) -> combine (2003. Oct. - Nov.)

1. Introduction

2. Pedestal parameter regimes and spatial structure

2-2. Pedestal Energy: scaling

2-2. Height (gradient) and Width

2-3. Role of neutrals

2-4. Modeling and Theory (incl. L-H transition)

3. ELM Regimes

3-1. Type I ELM regimes (incl. freq., dynamics & stability)

3-2. Type II and Small ELM regimes (incl. freq., dynamics & stability)

3-3. Type III regimes (incl. freq., dynamics & stability)

3-4. Energy release by ELMs

4. Impact of Pedestal Characteristics on Burning Plasma Performance

4-1. Impact on the core confinement and stability

4-2. Impact on the divertor performance (incl. energy release of ELMs)

4-3. Possible Control Scenario including diagnostic needs

5. Summary of Issues (and recommendation for BPX ?)