Satellite Meeting to the IAEA FEC 2004 on
Collaborative Activity between the Integrated Fusion Modelling Initiatives
Vilamoura, Portugal, 2004/11/05

Status of the BPSI activity in Japan

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- BPSI: Burning Plasma Simulation Initiative
- TOPICS: Integrated Transport Code in JAERI
- TASK: Core Code for Integrated Modeling
- Summary

Burning Plasma Simulation

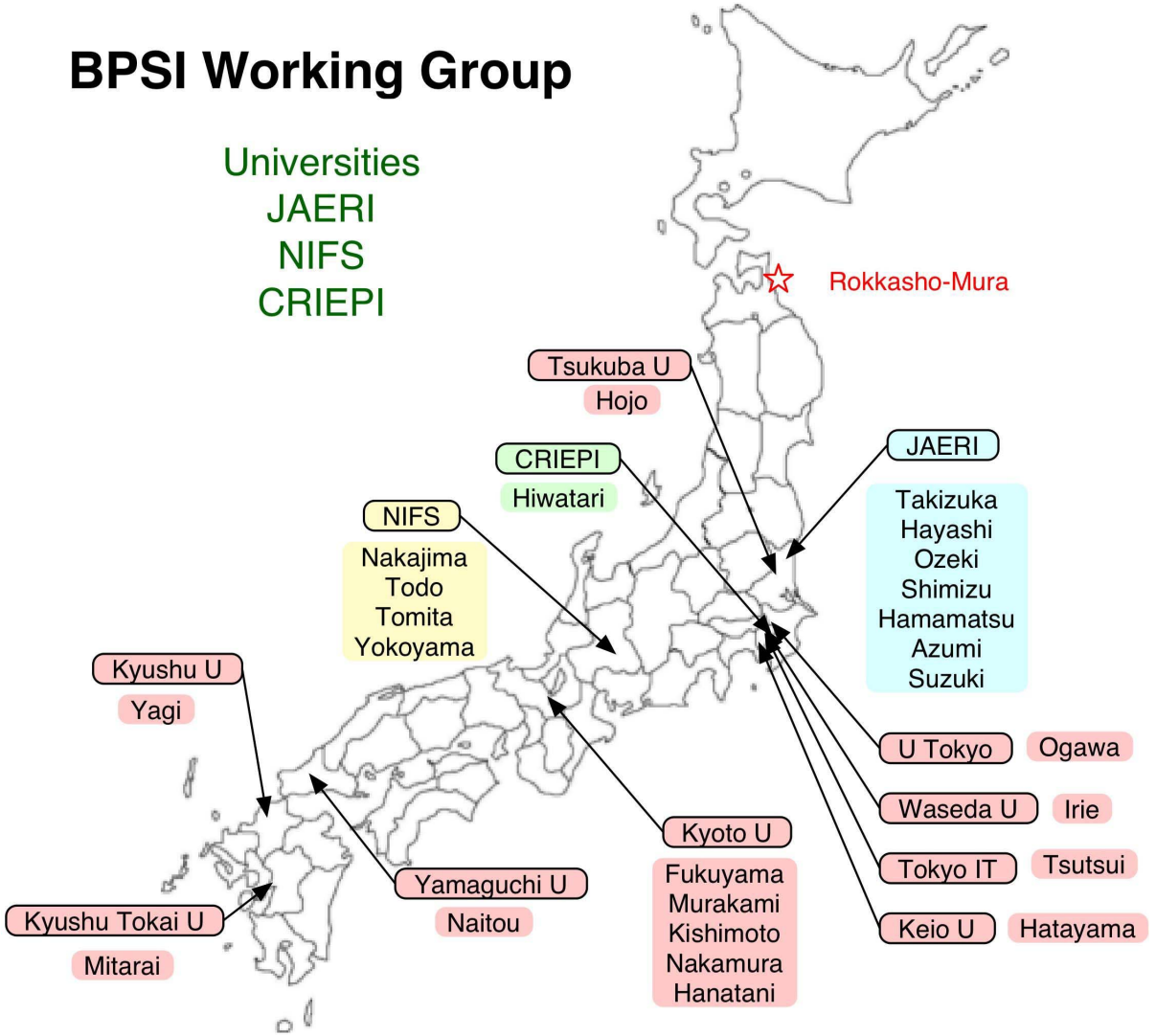
- **Why needed?**
  - **To predict the behavior of burning plasmas**
  - **To develop reliable and efficient schemes to control them**

- **What is needed?**
  - **Simulation describing a burning plasma:**
    - — **Whole plasma** (core & edge & diverter & wall-plasma)
    - — **Whole discharge**
      (startup & sustainment & transients events & termination)
    - — **Reasonable accuracy** (comparison with experiments)
    - — **Reasonable computer resources** (still limited)

- **How can we do?**
  - **Gradual increase of understanding and accuracy**
  - **Organized development of simulation system**

BPSI: Burning Plasma Simulation Initiative

Research Collaboration among Universities, NIFS and JAERI



Targets of BPSI

- **Framework** for collaboration of various plasma simulation codes
  - **Common interface** for data transfer
  - **Reference core code**, TASK
  - **Helical configuration** included
- **New Physics** in interactions of phenomena with different time and space scales (e.g.)
  - **Transport during and after a transient MHD events**
  - **Transport in the presence of magnetic islands**
  - **Core-SOL interface**
- **Advanced technique** of computer science
  - **Parallel computing**: PC cluster, Massively Parallel, Vector-Parallel
  - **Distributed computing**: GRID computing, Globus, ITBL
  - **Visualization**: Parallel visualization, VisiGRID

Status of BPSI

- **1st Stage**
  - **Development of standard dataset and module interface**
  - **Integrated simulation of multi-physics**
  - Validation of modules with **experimental results**
  - Transport simulation in **3D helical configuration**
- **2nd Stage**
  - **Integration of existing and newly-developed modules**
  - **Global integrated simulation** (Core+Edge, Transport+RF+MHD,. . .)
  - Validation of modules with **direct numerical simulation**
  - Integrated simulation in **3D helical configuration**
- **3rd Stage**
  - **Integrated simulation including startup and termination**
  - **Full integrated simulation of burning plasmas**

Activities of BPSI

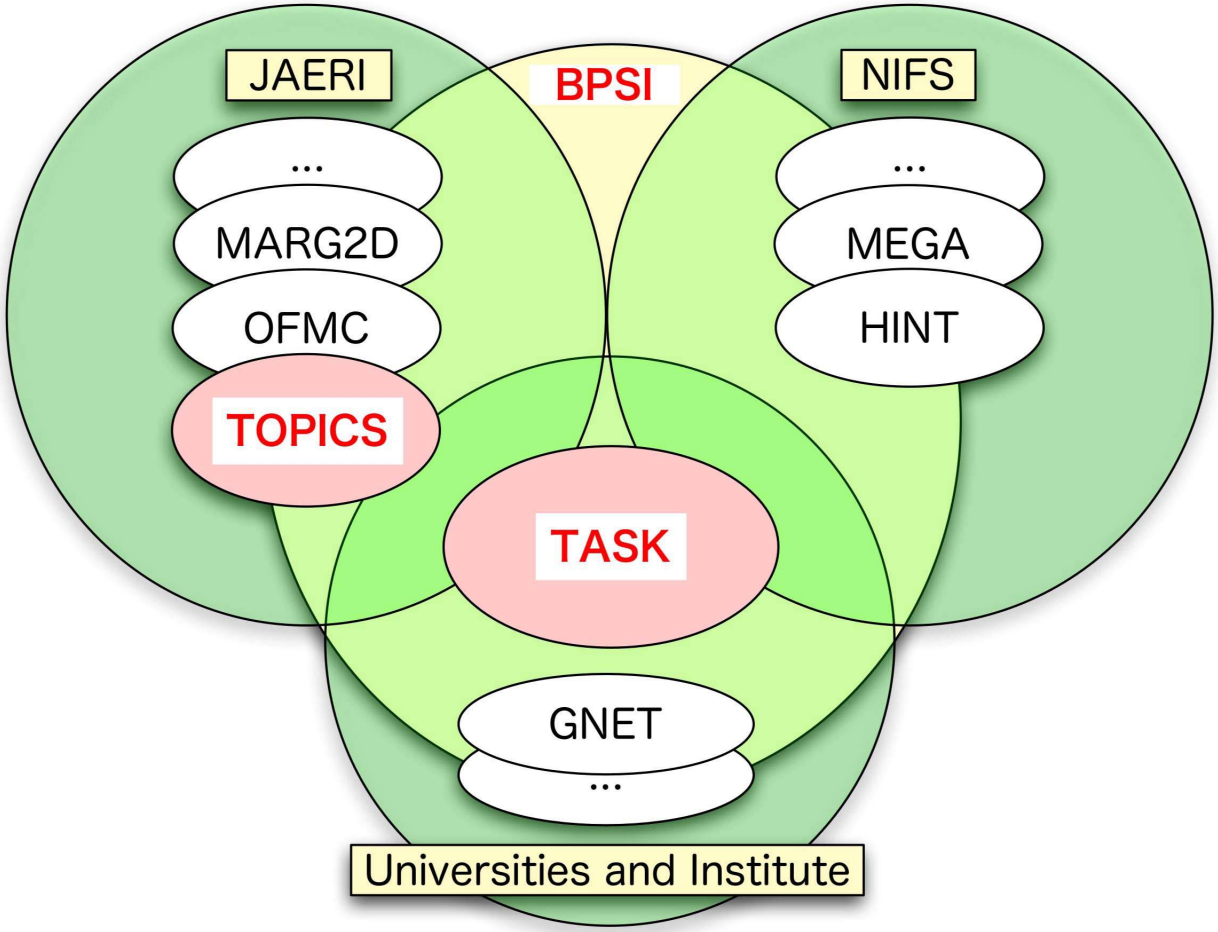
- **Meetings**

2002 Aug	Preparatory discussion	(NIFS)
2003 Aug	1st BPSI meeting	(Kyoto U)
2003 Dec	US-Japan workshop	(Kyoto U)
2004 Mar	2nd BPSI meeting	(Kyushu U)
2004 Aug	3rd BPSI meeting	(Kyushu U)
2004 Sep	US-Japan workshop	(PPPL)
2005 Apr	4th BPSI meeting during	(Kyoto U)

- **Support** from various resources
  - Grant-in-Aid from JSPS (M. Yagi, Kyushu U)
  - Part of Grant-in-Aid from MEXT (S.-I. Itoh, Kyushu U)
  - Research collaboration of RIAM, Kyushu U (M. Yagi, Kyushu U)
  - Research collaboration of NIFS (Y. Nakamura Kyoto U)
  - Research collaboration of JAERI (A. Fukuyama, Kyoto U)
  - US-Japan JIFT Workshop from JSPS (A. Fukuyama, Kyoto U)
  - **Only for meeting support at present**

Structure of BPSI

TASK: Core code of BPSI for ITER, JT-60, LHD, and small machines
TOPICS: Transport Analysis and Predictive Simulation for JT-60



TOPICS

- Tokamak Prediction and Interpretation Code System
- For estimations and analyses of burning plasmas in ITER, analysis and simulation codes for JT-60U experiments are being reconstructed and developed based on the transport code of TOPICS in JAERI.
- Plan of the reconstruction and development of the codes
  - Burning Plasma Simulation Code Cluster
  - Fusion research grid

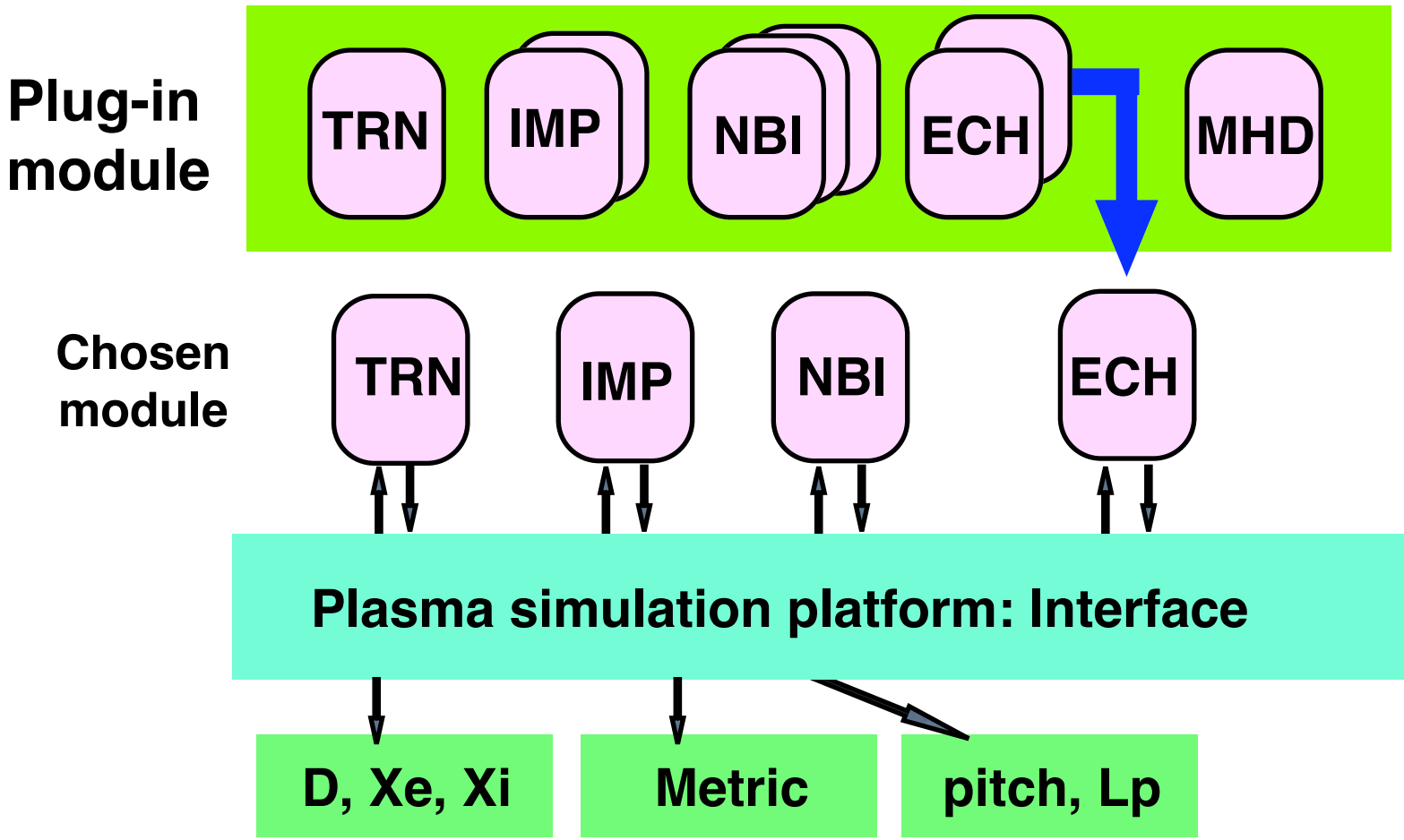
Burning Plasma Simulation Code Cluster in JAERI

Transport code TOPICS

Tokamak Prediction and Interpretation Code
Time dependent/Steary state analyses
1D transport and 2D equilibrium
Matrix Inversion Method for NeoClassical Trans.

- **Current Drive** — ECCD/ECH (Ray tracing, Relativistic F-P), NBCD(1 or 2D F-P)
- **Impurity Transport** — 1D transport for each impurities, Radiation: IMPACT
- **Edge Pedestal** — Perp. and para. transport in SOL and Divertor, Neutral particles, Impurity transport on SOL/Div. : SOLDOR, NEUT2D, IMPMC
- **Divertor**
- **MHD** — Tearing/NTM, High-n ballooning, Low-n: ERATO-J, Low and Mid.-n MARG2D
- **High Energy Behaviour** — OFMC

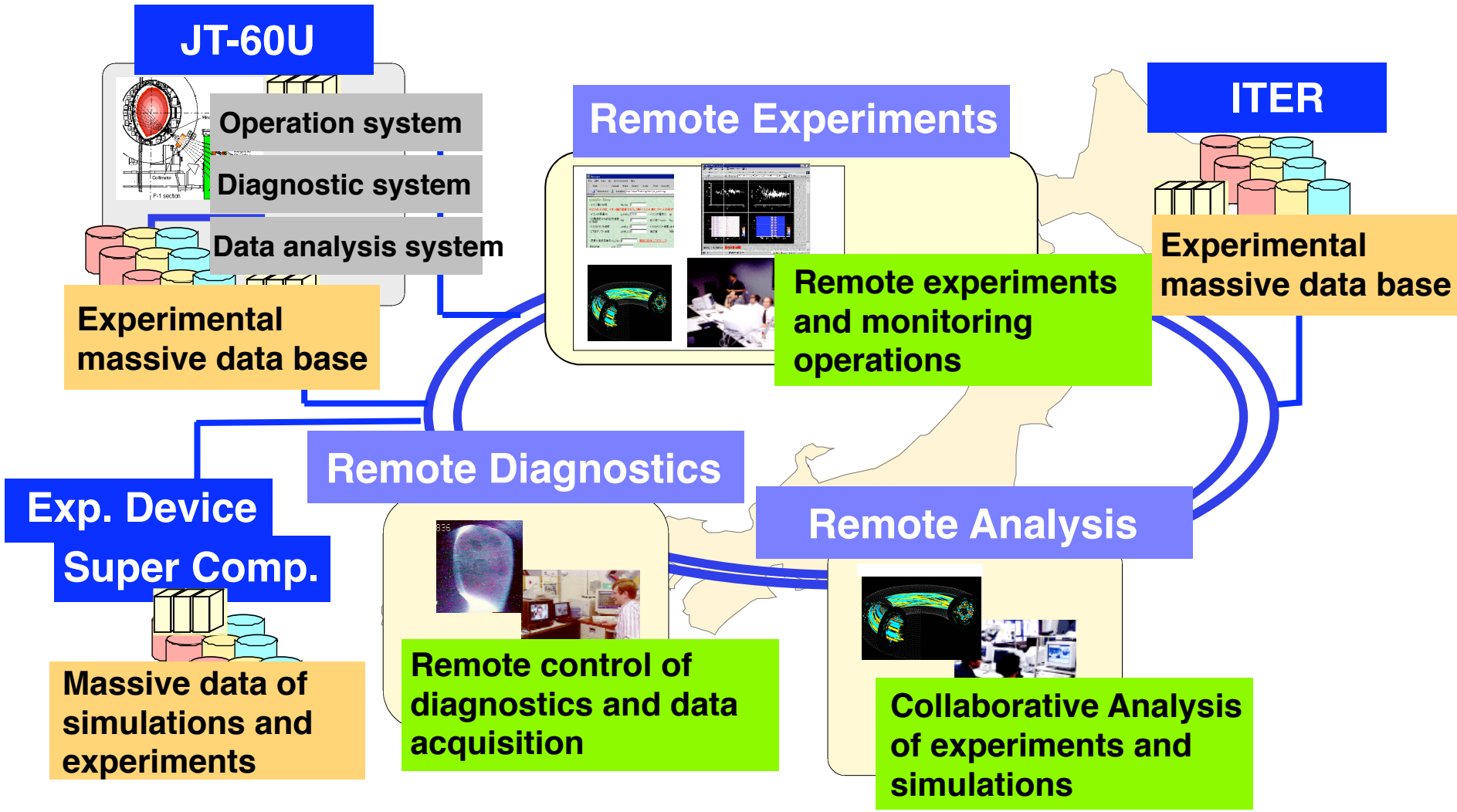
- **For the collaboration to BPSI, plug-in modules of the element of the code is proposed and investigated.**



Fusion Research Grid

Establish the remote research environment using the IT technology

- Remote Experiments, Remote diagnostics, and Remote collaborative analysis
- Communication, information shearing and much presence with high security



TASK Code

- **Transport Analysing System for TokamaK**
- **Features**
  - **A Core of Integrated Modelling Code in BPSI**
    - — Modular Structure
    - — Reference Data Interface
  - **Various Heating and Current Drive Scheme**
    - — EC, LH, IC, AW, (NB)
  - **High Portability**
    - — Most of Library Routines Included (except LAPACK and MPI)
    - — Own Graphic Libraries (gsaf, gsgl)
  - **Development using CVS** (Concurrent Version System)
    - — Open Source (by the end of 2004)
  - **Parallel Processing using MPI Library**
  - **Extension to Toroidal Helical Plasmas**

Modules of TASK

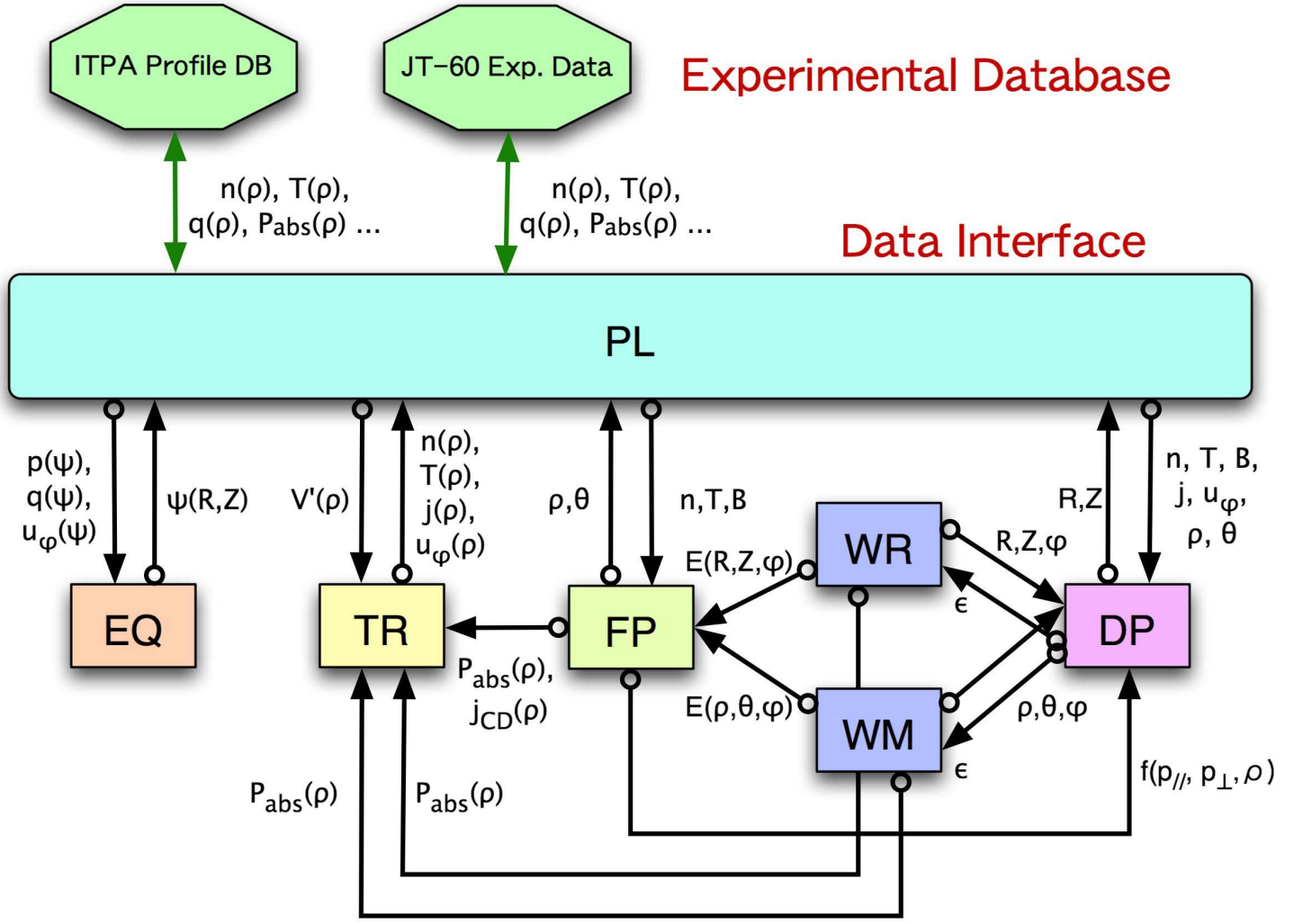
EQ	**2D Equilibrium**	Fixed boundary, Toroidal rotation
TR	**1D Transport**	Diffusive Transport, Transport models
WR	**3D Geometr. Optics**	EC, LH: Ray tracing, Beam tracing
WM	**3D Full Wave**	IC, AW: Antenna excitation, Eigen mode
FP	**3D Fokker-Planck**	Relativistic, Bounce-averaged
DP	**Wave Dispersion**	Local dielectric tensor, Arbitrary $f(\boldsymbol{v})$
PL	**Data Interface**	Data conversion, Profile database
LIB	**Libraries**	

Associated Libraries

GSAF	2D Graphic library for X Window and EPS
GSGL	3D Graphic library using OpenGL

All developed in Kyoto U

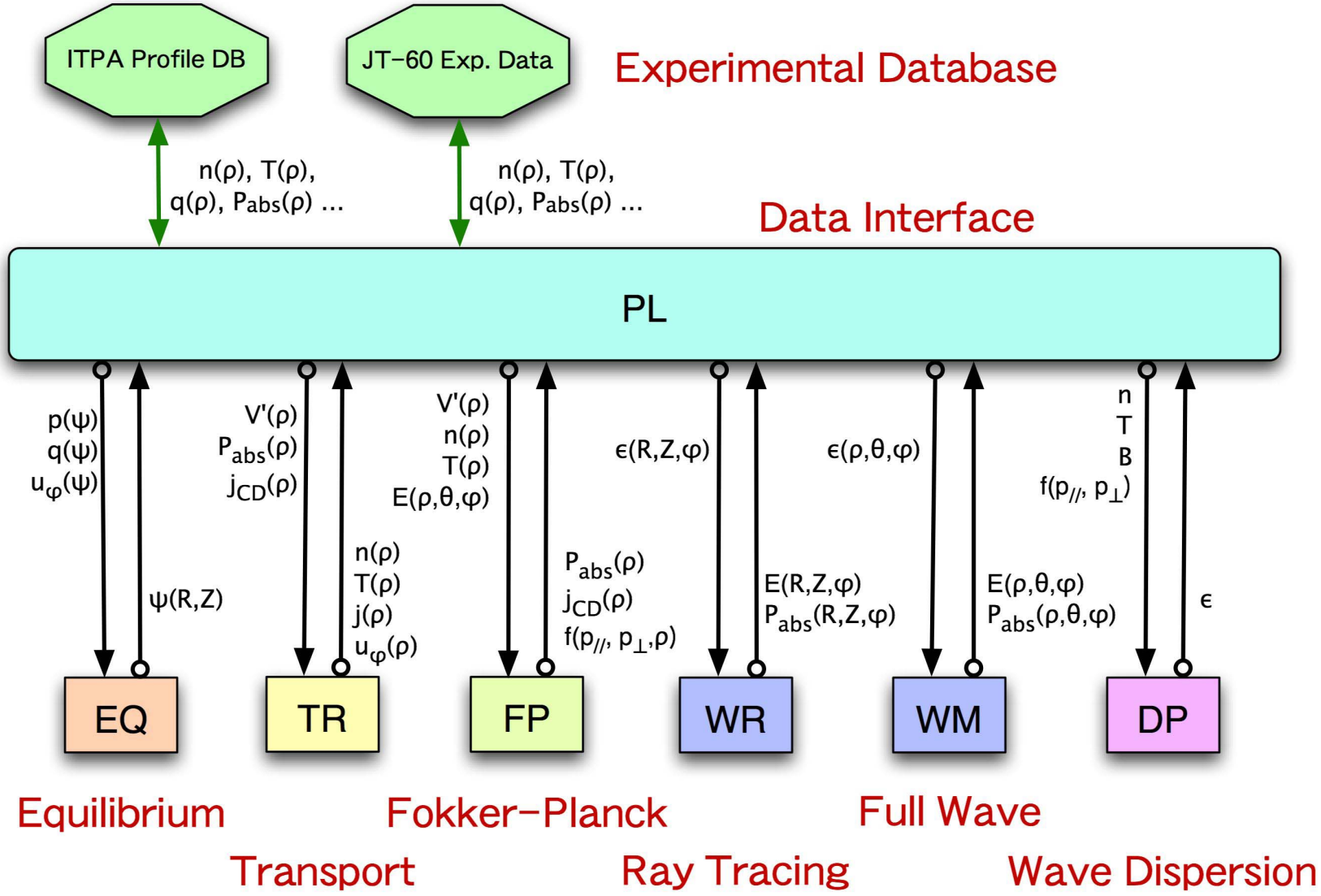
Present Structure of TASK



Under Development

- **New Modules**
  - **EX**: 2D equilibrium with free boundary
  - **TX**: Transport analysis based on flux-averaged fluid equation
  - **WA**: Global linear stability analysis
  - **WI**: Integro-differential wave analysis (FLR, $\boldsymbol{k} \cdot \nabla B \neq 0$)
- **Extension to 3D Helical System**
  - **3D Data Structure**
  - **3D Equilibrium**: VMEC, HINT
  - **Wave Analysis**: Already 3D
  - **Transport Analysis**: New transport model
- **New Modular Structure**

New Modular Structure of TASK



An Example of Standard Dataset

- **Machine ID, Shot ID, Model ID**
- **Equilibrium Data**: e.g. EFIT
- **Plasma Status Data**
  - **Plasma Fluid Data**: Fluid quantities, n_s,$\boldsymbol{u}_s$,T_s,$\boldsymbol{q}_s$
  - **Plasma Kinetic Data**: Momentum distribution, $f_s(\boldsymbol{r}, \boldsymbol{p}, t)$
  - **Electromagnetic Data**: Quasi-static $\boldsymbol{B}$, $\boldsymbol{j}$, $\boldsymbol{E}$
- **Wave Data**
  - **Wave Characteristics**: ω, $\boldsymbol{k}$, Power
  - **Electromagnetic Wave Data**: $\boldsymbol{E}$, $\boldsymbol{B}$, Ray characteristics
- **Transport Data**
  - **Particle Source and Sink**: S
  - **Momentum Source and Sink**: j_{CD}, M_ϕ
  - **Power Source and Sink**: P_{OH}, P_{abs}, P_{rad}
  - **Transport Coefficients**: D, χ

Summary

- We have started Burning Plasma Simulation Initiative in Japan as a research collaboration among universities, NIFS and JAERI.
- Our present targets are
  - Development of standard dataset and module interface
  - Development of the core code TASK with New modular structure
  - Module validation with experimental results
  - Code collaboration between TOPICS and TASK
  - Extension to the 3D helical configuration
  - Promotion of BPSI activities to experimentalists
- We welcome international collaborations on code exchange and benchmark test, though human resource is limited.