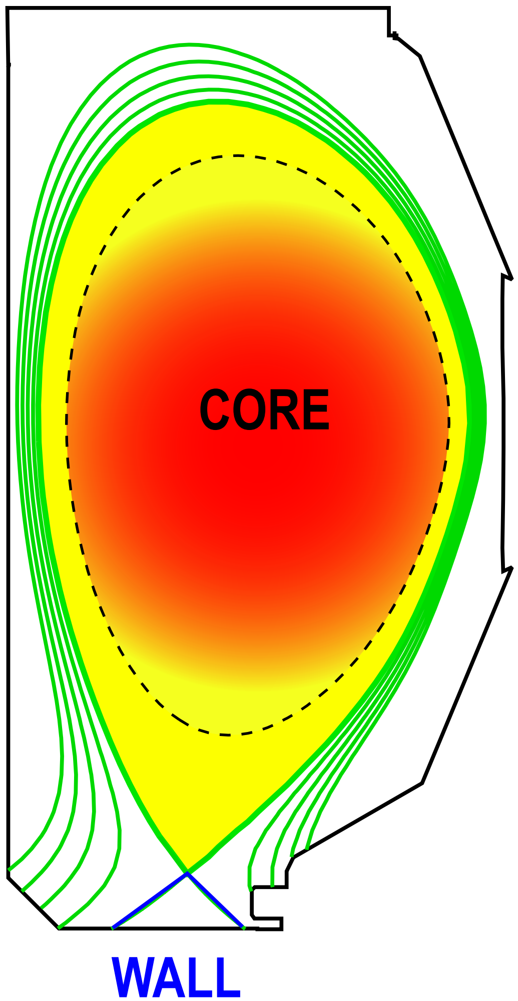


Boundary Plasma Interfaces

Working Group Summary, Section 6:

Interim Report of the Panel

on Program Priorities

for the

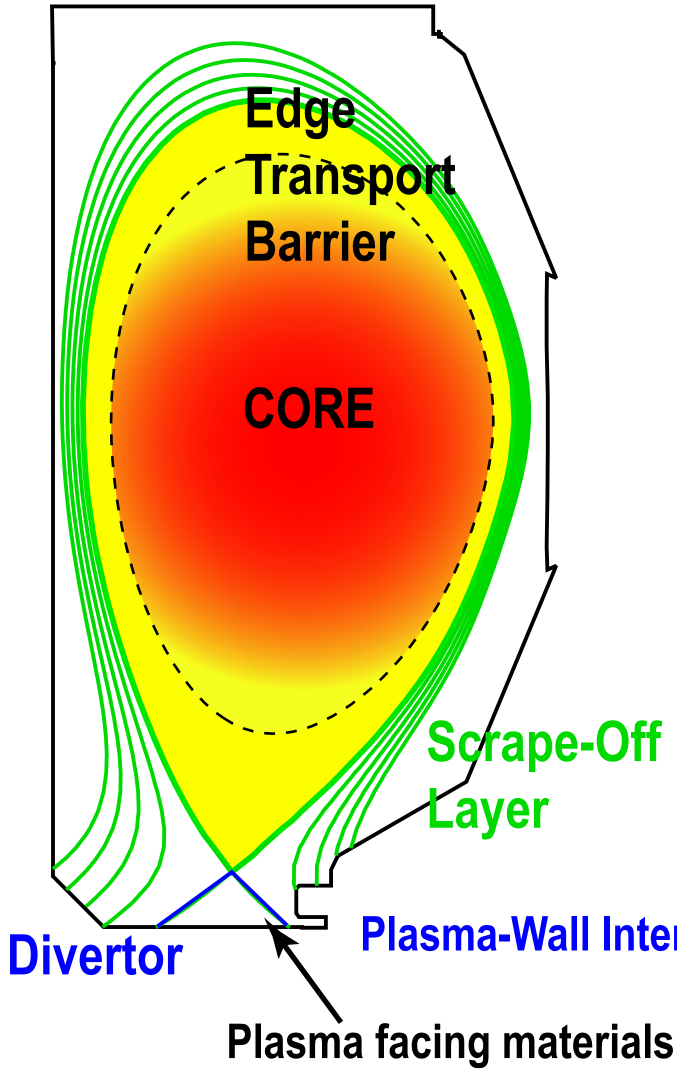
Fusion Energy Sciences Advisory Committee

Boundary Plasma Interfaces Working Group:

Chair: S.L. Allen (LLNL)
Vice-Chair: M. Ulrickson (SNL)

July, 2004

Plasma Boundary Interfaces has one key topic: T9



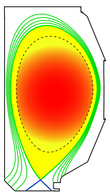
T9: How do we interface a

100 million degree burning plasma

to its room temperature surroundings?

(A "Layered" Approach)

The BPI working group depended strongly on community input

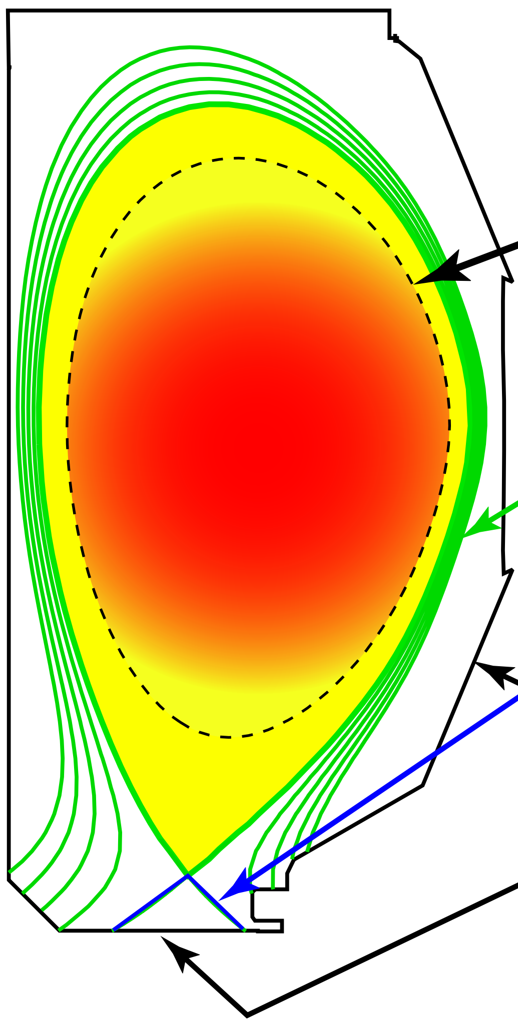


- M. Ulrickson presented a poster at the International Plasma Surface Interactions meeting in May (Portland, Maine)
  - — Stimulated many informal discussions
  - — (Held every 2 years, a good opportunity)
- A web-based discussion forum was used to gather input from the community:

  http://lists.psfc.mit.edu/mailman/listinfo/plasma_boundary
  - — Very active after the PSI meeting
  - — Thrusts picked and discussion leaders "volunteered"
- Several calls for input from Priority Panel members:
  - — D. Hill, LLNL; A. Hubbard, MIT; M. Ulrickson, SNL

Research approach: Four thrusts corresponding to plasma regions

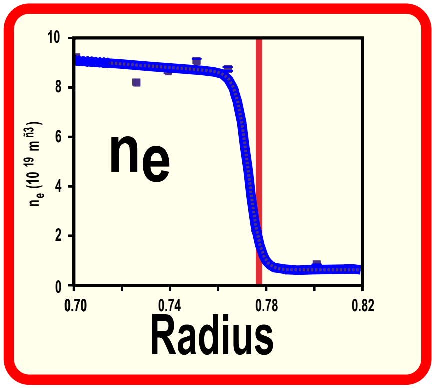
T9: How do we interface a 100 million degree burning plasma to its room temperature surroundings?



- T9-A. Physics of the formation, structure and stability of the edge transport barrier
- T9-B. Plasma and impurity transport in the scrape-off layer (open field lines)
- T9-C. Tritium retention and plasma material interactions
- T9-D. Plasma facing materials and components

Thrust A discussion leader(referee): A. Hubbard, MIT (M. Fenstermacher, LLNL)

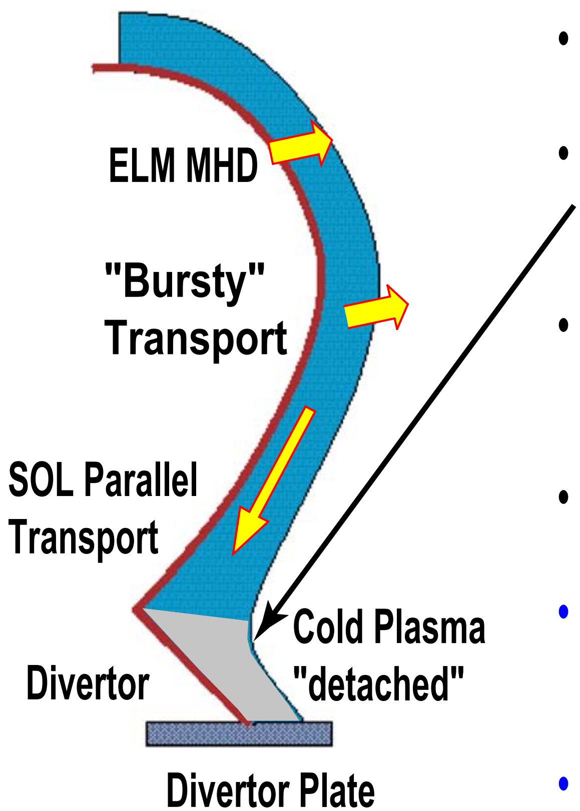
T9-A: Physics of the formation, structure, and stability of the edge transport barrier *(robust core coexist with SOL)*



- The boundary condition for the core plasma requires high temperature, could mean large ELMs
- The edge transport barrier has strong gradients in temperature and density
- Physics of this region uncertain, represents largest uncertainty in predicting performance of burning plasmas (progress in sheared flow suppression of turbulent transport
- Periodic bursts of heat and particles due to pressure-driven MHD: Edge Localized Modes (ELMs)
- Requires development of integrated models and 2-D measurements
  - — High spatial resolution because of strong gradients
  - — High temporal resolution required for ELMs

Thrust B discussion leader(referee): B. Labombard, MIT (T. Leonard, GA)

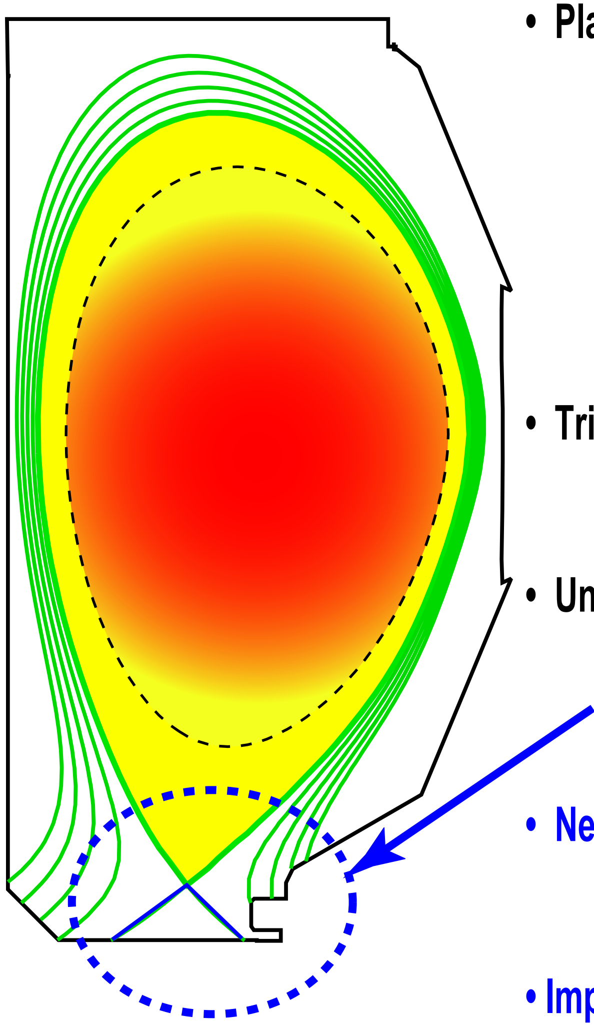
T9-B: Plasma and impurity transport in the scrape-off-layer



- Open field line region outside the plasma core, connected to the material walls
- In a tokamak, open field lines end on a specially-armored area called the "divertor"
- Major accomplishment of experiments and modeling is "detached divertor"
  — Plasma energy is radiated in a low temperature recombining divertor plasma
- Periodic bursts of heat & particles due to Edge Localized Modes (ELMs) are transported to divertor, "Bursty" transport or "Blobs" discovered, models started
- Impurity transport in SOL (and shielding) important - part of "radiative divertor"
- Comparison of new measurements with computational models allows understanding the self-consistent relationship between turbulence and transport
- New diagnostics needed to measure ion temperature, plasma flows, and neutral densities - flow patterns need to be compared with codes

Thrust C discussion leader(referee): P. Stangeby, U. Toronto (D. Whyte, U. Wis.)

T9-C: Tritium retention and plasma material interactions



- Plasma materials interactions include:
  - — Collisions of ions with the wall (sputtering) causing erosion
  - — Chemical processes (chemical sputtering) causing erosion
  - — Deposition of impurities and particles in the wall
  - — Erosion takes place at divertor and main chamber wall, impurities enters SOL and can influence core plasma performance
- Tritium can be retained in the walls, particularly with carbon
  - — Important for in-vessel inventory, a safety and operations issue
- Understand & control large plasma heat and particle loads -- divertor and main walls
  - — Steady-state loads
  - — Pulsed loads from ELMs - difficult to predict in burning plasma experiment
- New diagnostics needed for flows, heat, and particle flux profiles, and impurity generation - also need experiments and modeling of tritium (carbon) transport
- Improved theory and modeling to integrate PMI and SOL modeling

Thrust D discussion leader(referee): M. Ulrickson, SNL (D. Stotler, PPPL)

T9-C: Plasma facing materials and components

- Low-Z solid wall materials (C, Be)
  - Low radiation if leak into core
  - Large database developed on tokamaks and other devices - high particle and heat loads have been handled
  - Database developed of fundamental properties
  - Reliable engineering solutions have been found for steady-state high heat flux (absence of neutrons)
  - Tritium retention (in re-deposited material) problem must be addressed
- Medium and High-Z solid wall materials (Molybdenum, Tungsten)
  - Used successfully on several machines
  - Database developed of fundamental properties
  - Some concern on off-normal events (ELMs and disruptions)
  - Reliable engineering solutions have been found for steady-state high heat flux (absence of neutrons)
- Liquid walls
  - Developing database, earlier stage of development
- Both laboratory studies and machine studies required.

Plasma Boundary Interfaces are important for overarching themes

- O2: Burning plasma research

  Plasma experiments, modeling and theory have shown:

  - — Plasma near edge sets boundary conditions which strongly influence transport in the hot core
  - — *Greatest uncertainy in predicting performance of a burning plasma experiment*
  - — Edge Localized Modes (ELMs) important part of power and particle control

- O3: Making fusion power practical
  - — Plasma boundary important in overall performance: *greatest uncertainty in predictions (now)*
  - — Combination of SOL plasma and materials must handle heat and particle loads, including pulsed and off-normal events
  - — Material choices can have safety, operations, and performance consequences

- O1: Scientific Understanding
  - — Complex interaction of turbulence, MHD limits, plasma-surface effects
  - — Detailed data required to develop adequate physics models of this region