3.1.1.4 . Overviews of MFE burning plasmas science, technology, and experimental approaches/objectives: Transport

The relation between transport science and burning plasma science can be viewed from two perspectives. First, what characteristics must a burning plasma experiment have to further the science of transport, turbulence, and control of the pressure profile? Second, what can existing transport science say about the likely performance characteristics of a burning plasma experiment? The first perspective asks if a proposed burning plasma experiment will be a sufficiently *flexible scientific instrument* that will serve transport science generally and will further the ability to predict and control the pressure profile dynamics of any toroidal confinement system in the future. The second perspective concerns the utility of our present state of knowledge in transport science: is our knowledge sufficiently deep to adequately *predict the performance of future devices*, including the ratio Q of fusion power produced to auxiliary power supplied, and the dynamics and controllability of a high Q operating point?

Generic transport issues accessible in a BPX – These include:

1. Nonlinear interactions between the pressure, bootstrap current, alpha heating, and turbulence.
2. Core and edge transport scaling and compatibility at reactor-relevant dimensionless parameters such as β,ρ^*,ν^*, and n/n_{GW}.
3. Profile stiffness.
4. Thermal transport, especially electron thermal transport, with strong alpha heating

Device flexibility and maximizing the value as a scientific instrument Flexibility is an important assessment criterion. If the device is sufficiently flexible, and if the diagnostic coverage sufficiently complete, then it can advance the science of unresolved transport questions as well as maximize the chances of success of the proposed burning plasma experiment (BPX). In addition to operational flexibility, other important criterion include access for diagnostic deployment and control tool development.

Examples of desired flexibility include shape control, edge pumping, flexible pellet launch, sufficiently long pulses to permit pressure profile dynamics to be characterized and manipulated, RF heating location variability, and high voltage neutral beams for rotation control. Maintenance of access for diagnostic and control tool development may have practical implications for the staging of a burning plasma experiment. An extended period of low neutron fluence operation may enable diagnostic and RF systems upgrades for control tool development that might not be possible in a later phase of operation of a BPX.

Performance projections - A key transport issue for MFE burning experimental facilities is the projected performance of the device: Q = P_fus/P_ext, the ratio of fusion power produced to external power supplied. Q is a very sensitive parameter and difficult to predict. Thus a varity of empirical and theoretical methods is best used. Q is important for energy economics. The fraction of alpha self-heating $F = Q/(5+Q)\ \alpha\ nT\tau$ the “fusion product” is less sensitive and more relavent to scientific goals. The BPX must have Q greater than 5 which amounts to more than 50% self-heating and preferably Q greater than 10 (66% self-heating) in the D-T phase. The controllability of self heated devices within MHD stability boundaries is a an experimentally open question that must be answered in a burning plasma device. The technology goals for material wall neutronics testing or power handling depend on some required P_fus per surface or circumference, and hence depend on achieving high Q at full design P_aux. Q=10 is the nominal goal of all current designs and the maximum design P_ext is generally set by the threshold power required to obtain good H-mode confinement in a non-burning (D-only) phase.