To continue investigations of H-Mode confinement with boronized walls and strong ICRF heating. In particular we will look at the scaling of confinement over the widest range in parameters that are accessible—particularly Ip, Bt, k, ne, P. This data will be an important contribution to the ITER database in support of urgent need 3.2 or something like that. We will inject trace amounts of scandium, niobium, and/or zirconium into these discharges in order to characterize impurity confinement in H-mode. At the same time, we will attempt to get SOL data in support of edge transport studies.

During the last run period we achieved very high quality H-modes following boronization. These discharges all had confinement higher than that predicted by the ITER scaling laws. The parameter range of our own data was quite limited (see fig 1) and it was not possible to perform a reliable independent fit on our own data. Our data has been incorporated into the ITER data base and a new regression performed. This fit has stronger dependence on Bt, ne, and weaker dependence on R. Since our data differs from other machines, mainly in the parameter nR/B, the dependencies of these three parameters can't be reliably identified at this point. The edge transport data base is also in need of H-mode data points over a wider parameter.

3. Approach

A series of single parameter scans designed for maximum range rather than detailed coverage. Sufficient profile measurements for global analysis will be taken. It will probably not be possible to obtain complete ion temperature profiles, but we will attempt to get enough information for local analysis as well. In addition to the gross parameter scans, we want a slight ramp on the TF in order to "fill-in" the GPC profiles. Impurity particle confinement will be measured on each shot by injecting trace impurities and observing x-ray and VUV line emission from the injected impurity. It is likely that temperatures as high as 5 keV will be reached in the some of the H-mode regimes. Thus the high-Z elements Zr and/or Nb, whose He-like states should be central, will be injected if this can be done without seriously perturbing the discharge. HIREX will observe He-like lines, while the grazing incidence spectrograph will observe the Li-like and Be-like resonance lines. We know that by observing multiple ionization states, we better constrain the transport coefficients. There is evidence that the confinement properties of the H-mode can change. Typically there is a non-steady state phase (ELM free) with the Wp and ne increasing, followed by a nominally steady state phase. The impurity confinement will be measured in this steady state phase, so that the timing of the injection will be tailored to meet this condition. For any repeated shots the spectrometers will be scanned spatially, in order to obtain more information about the spatial variation of the transport coefficients. Obtaining scanning probe data will require notching the ICRF power during the probe plunge. Because this has led to modification of the H-mode confinement in the past, we will time this to occur later in the H-mode discharge. For ELM-free plasmas which are not
in steady state, we will try to time the probe scan long enough after the \( \frac{dW}{dt} = 0 \) point to get good confinement data, but before impurity buildup causes too serious discharge degradation.

4. Resources

4.1 Machine and Plasma Parameters

- **Toroidal Field:** 4.5 - 6.2
- **Plasma Current:** 0.4 - 1.4 MA
- **Working gas species:** D2
- **Density:** \( n_{\text{bar}} \) (target) = 1-2 \( \times 10^{20} \), final density = 2 - 5 \( \times 10^{20} \)
- **Equilibrium configuration:** \( k = \text{(minimum for ICR coupling)} = 1.75 \)
- **Pulse length, typical current and density waveforms, etc.:**

4.2 Auxiliary Systems

- **RF Power, pulse length, phasing:** \( \sim 1 - 3.5 \) MW (L-H threshold to max. available). RF pulse length sufficient to provide at least 0.1 sec "steady-state" before notch. Turn off synchronized with scanning probe scan.
- **Pellet Injection (species):** Impurity blow-off injection: Sc, Zr, Nb
- **Special gas puffing:** Other: Freshly boronized walls

4.3 Diagnostics

All available core diagnostics, + scanning probe + spectroscopy for impurity injection

4.4 Neutron Budget 1 - 3 \( \times 10^{13} \) per shot

5. Experimental Plan

5.1 Run sequence plan

2 Runs

5.2 Shot sequence plan

We need to scan 5 parameters; \( I_p, B_t, n_e, k, P \). For each parameter, at least a high, medium, and low value are required. Even with no shots wasted for set-up, fizzes, etc., filling up the full matrix would require more running time than we have available. The proposal is to perform a much more limited set of scans, namely:

- **Scan** \( I_p \) (0.4, 0.6, 0.8, 1.0, 1.2, 1.4) at \( n_{\text{bar}} = 1.2, B_t = 5.3, k = 1.7, P_{\text{rf}} = \text{max} \)
- **Scan** \( I_p \) (0.4, 0.6, 0.8, 1.0, 1.2, 1.4) at \( n_{\text{bar}} = 2.0, B_t = 5.3, k = 1.7, P_{\text{rf}} = \text{max} \)
- **Scan** \( B_t \) (4.5, 4.9, 5.3, 5.7, 6.2) at \( n_{\text{bar}} = 1.2, I_p = 1.0 \) (if possible at 4.5), \( k = 1.7, P_{\text{rf}} = \text{max} \)
- **Scan** \( B_t \) (4.5, 4.9, 5.3, 5.7, 6.2) at \( n_{\text{bar}} = 2.0, I_p = 1.0 \) (if possible at 4.5), \( k = 1.7, P_{\text{rf}} = \text{max} \)
- **Scan** \( B_t \) (4.5, 4.9, 5.3, 5.7, 6.2) at \( n_{\text{bar}} = 1.2, q_{95}(I_p) = 4.0, k = 1.7, P_{\text{rf}} = \text{max} \)
- **Scan** \( k \) (1.4, 1.6, 1.75) at \( n_{\text{bar}} = 1.2, B_t = 5.3, I_p = 1.0, P_{\text{rf}} = \text{max} \)
- **Scan** \( k \) (1.4, 1.6, 1.75) at \( n_{\text{bar}} = 2.0, B_t = 5.3, I_p = 1.0, P_{\text{rf}} = \text{max} \)
- **Scan Power** (1, 2, 3+) at \( n_{\text{bar}} = 1.2, B_t = 5.3, I_p = 1.0, k = 1.7 \)
- **Scan Power** (1, 2, 3+) at \( n_{\text{bar}} = 2.0, B_t = 5.3, I_p = 1.0, k = 1.7 \)

What is crucial here is maximum range for each parameters, not the precise values for each or for the parameters held constant during each scan. The total here is 45 good shots which may very well be more than can be achieved in two runs. Note: the specified densities are TARGET densities, the final density in H-mode will be much higher but cannot be programmed at this point.
6. Anticipated Results

Data which characterizes core energy and impurity confinement, and SOL transport. Contributions to ITER database and urgent R and D needs.

7. References


