1. Purpose of Experiments

The experimental objective is to complete $\nu^*$ scans on JET and CMOD starting from a JET-CMOD identity discharge pair. On JET $\nu^*$ decreases from the identity discharge while on CMOD the $\nu^*$ would be increased from the identity discharge. The scans would be continued until the Greenwald fraction reached that of the identity discharge of the other device.

A further benefit of the $\nu^*$ scans would be that they would assist with resolving the discrepancy between the IPB98(y,2) ($B_{\tau_e} \propto \nu^*0$) scaling and the previous $\nu^*$ scans ($B_{\tau_e} \sim \nu^*^{-0.3}$).

2. Background

There has been considerable discussion in the literature about which is the most useful dimensionless parameter to describe confinement in a tokamak the dimensionless collisionality $\nu^*$ or the Greenwald fraction $F_{gr}$. This is important because the recent push to higher density in many devices puts them in high collisionality regimes where the lack of trapped particles changes the ELM and NTM behaviour such that they are not ITER relevant.

By comparing discharges on DIII-D and JET at the same Greenwald fraction Petty et al\(^{(1)}\) concluded that the collisionality was the more significant parameter, although the conclusion was only just outside the errors of the measurements. To firm up this conclusion a greater range in machine size is required comparing CMOD to JET. JET recently performed an identity experiment on 24 January 2004 where they successfully
scanned $v^*$ to compare with C-Mod (Table 1). To clarify the dependence of confinement on $v^*$ further experiments are needed on C-Mod to extend the range of $v^*$ at high $\beta$ (Figure 1).

<table>
<thead>
<tr>
<th></th>
<th>CMOD</th>
<th>JET $v^*$ match</th>
<th>JET Int</th>
<th>JET Greenwald matches</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1001018013</td>
<td>62662</td>
<td>62664</td>
<td>62665</td>
</tr>
<tr>
<td>$t$</td>
<td>1.3</td>
<td>64.15</td>
<td>67.0</td>
<td>69.5</td>
</tr>
<tr>
<td>$a$</td>
<td>0.22</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
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<tr>
<td>$\kappa$</td>
<td>1.67</td>
<td>1.71</td>
<td>1.71</td>
<td>1.71</td>
</tr>
<tr>
<td>$\delta u$</td>
<td>0.44</td>
<td>0.42</td>
<td>0.42</td>
<td>0.42</td>
</tr>
<tr>
<td>$\delta l$</td>
<td>0.52</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>$W_{th}$</td>
<td>0.20</td>
<td>0.42</td>
<td>0.97</td>
<td>1.35</td>
</tr>
<tr>
<td>$q_{95}$</td>
<td>4.44</td>
<td>4.34</td>
<td>4.34</td>
<td>4.34</td>
</tr>
<tr>
<td>$n(10^{19})$</td>
<td>36</td>
<td>2.6</td>
<td>2.6</td>
<td>2.8</td>
</tr>
<tr>
<td>$I$</td>
<td>0.99</td>
<td>0.68</td>
<td>1.03</td>
<td>1.17</td>
</tr>
<tr>
<td>$B$</td>
<td>5.5</td>
<td>0.96</td>
<td>1.38</td>
<td>1.6</td>
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<tr>
<td>$F_{gr} = n\pi a^2/l$</td>
<td>0.55</td>
<td>1.02</td>
<td>0.66</td>
<td>0.6</td>
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<tr>
<td>$W_{th}/a l^2$</td>
<td>0.93</td>
<td>1.04</td>
<td>1.01</td>
<td>1.03</td>
</tr>
<tr>
<td>$(W_{th}/n a^2)^{1/2} \Gamma$</td>
<td>0.72</td>
<td>0.68</td>
<td>0.69</td>
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<tr>
<td>$n_{a}/W_{th}^{2}$</td>
<td>29</td>
<td>46</td>
<td>9.0</td>
<td>5.5</td>
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<tr>
<td>$\tau_e$</td>
<td>0.048*</td>
<td>0.23</td>
<td>0.28</td>
<td>0.25</td>
</tr>
<tr>
<td>$B\tau_e$</td>
<td>0.26</td>
<td>0.22</td>
<td>0.39</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*Adjusted for ICRH coupling efficiency

Table 1.
\[ B \tau_\varepsilon \propto \nu^*^{-0.3} \]

**Figure 1.**

**3. Approach**

Describe the methodology to be employed; explain the rationale for the choice of parameters, etc. Describe the analysis techniques to be employed in interpreting the data, if applicable. If the approach is standard or otherwise self-evident, this section may be absorbed into the Experimental Plan.

Table 1 gives the parameters of the JET/C-Mod identity experiments comparing JET shot 62662 with C-Mod shot 1001018013. This proposal is to scan the toroidal field as far as possible and change the amount of ICRF heating power to maintain constant high $\beta = 1.3$ to effectively scan the collisionality parameter $\nu^*$. The plasma shape, aspect ratio and $q_{95}$ should be maintained equal between C-Mod and JET. In the $\nu^*$ scan, the density should be held constant and the temperature should scale as $T \sim B^2$. This follows from maintaining constant $\beta \sim nT/B^2$ and constant $\rho^* \sim T^{-0.5}/(BR)$. Then, since $\nu^* \sim nR/T^2$.
R/B^4, even a small range of toroidal field scan will scan ν* over a fairly large range. To better match existing JET/C-Mod similarity data, we will first try to increase the density of 1001018013 to $n_e \sim 4.5 \times 10^{20}$ m$^{-3}$ and increase $I_p$ to 1.04 MA and $B_T$ to 5.7 T and hopefully achieve stored energies of 0.24 MJ. If that is not possible, we will return to the parameters of 1001018013 and vary $B_T$ to scan $ν*$ and JET will have to redo the experiment in 2005 at lower density to properly match C-Mod. Then, the resulting confinement will be compared on the $B\tau_E$ vs $ν*$ with the JET identity data to see if the trend in C-Mod matches or not the trend in JET of $B\tau_E \propto ν*^{-0.3}$.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.0 – 6.0 T
- Plasma Current: 0.9 – 1.1 MA
- Working Gas Species: $D_2$
- Density: $1.0 – 1.25 \times 10^{20}$ m$^{-2}$
- Equilibrium configuration (if possible, refer to database equilibria): 1001018013

4.2 Auxiliary Systems

- RF Power, pulse length, phasing: 3.5 - 6 MW central heating for 0.5 s
- Pellet Injection (species): none
- Impurity blow-off injection: none
- Diagnostic Neutral Beam: not essential
- Special gas puffing: none
- Non-axisymmetric Coils (Connections, Current); avoid locked modes
- Other:

4.3 Diagnostics

List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

Need all kinetic diagnostics for confinement studies.

5. Experimental Plan

Both sections must be filled in.

5.1 Run sequence Plan

Specify total number of runs required, and any special requirements, such as consecutive days, no Monday runs, extended run period – 10 hours maximum – etc.

One run is required to scan $ν*$ at high $β$ across as high a range as possible and still maintain high $β$. We will need a well boronized machine and high RF power with all four antennas running well with core heating to obtain good confinement.
5.2 Shot sequence plan
For each run day, give detailed specification for proposed shot sequence: number of shots at each condition, specific parameters and auxiliary systems requirements, etc. Include contingency plans, if appropriate.

Begin by repeating shot 1001018013 to ensure that good confinement, high $\beta$ conditions with $\beta_N \sim 1.6$ can be reproduced. Then, attempt to produce a better match with existing JET/C-Mod similarity data by increasing $B_T$ to 5.7 T and $I_p$ to 1.04 MA and raising $n_{04}$ to $1.25 \times 10^{20}$ m\(^{-3}\) and see if high $\beta$ plasmas can be obtained. If not, we will return to the conditions of 1001018013. Then, take similar shots at varying flattop toroidal fields from about 5 T to 6 T or as far as good core heating can be obtained to maintain constant high $\beta$ plasmas (10 shots) while varying the plasma current in proportion to maintain constant $q_{95}$. Vary the ICRF power to obtain the required $\beta$ and ensure that the geometry matches the JET shape and aspect ratio. While the number of good shots required is not that high, a number of setup shots will be necessary to ensure the correct matching geometry and to achieve the required $\beta$.

6. Anticipated Results
Discuss possible experimental outcomes and implications. Indicate if the program may be expected to lead to publications, milestone completions, improved operating techniques, etc. Indicate if the experiments are intended to contribute to a joint research effort, or an external database.

Together with the previous results of the JET/DIII-D identity experiments, these experiments should help to determine how the confinement scales with collisionality, which is important for predicting confinement in ITER. Conference and refereed publications together with the full ITPA H-mode confinement database will result.

7. References
Include references both to external and internal literature or communications which bear on this proposal. See Section 2.