1. Purpose of Experiments

Transport of particles within a tokamak remains an active area of research in plasma physics. With the discovery of new confinement modes (e.g. H-mode, PEP mode), it is of great interest to understand the underlying mechanisms for transport. The goal of this mini-proposal is to establish the diffusion coefficients for ohmic operation of Alcator C-Mod. A similar gas puffing experiment has been proposed for detached plasmas and the two results can be compared. It will be very useful to determine if the density rise seen during detachment is due to a simple increase in the edge source or a fundamental change in the transport. This will also constitute, in conjunction with the detached plasma mini-proposal, an essential part of the data required for Tom Luke’s thesis.

2. Background

The basic approach to measure the transport coefficients is through well known modulated gas techniques. Similar experiments have been down on all major machines including Alcator C.

3. Approach

The basic approach for this experiment is to create a plasma with a current flattop and a reasonable density level. Gas puffing will be turned on. Single puffs or a series of puff at up to 10 hz can be put in. The goal is to minimize the perturbation to the plasma but yet attain a measurable effect. After several shots at the same parameters, the current and background density will be varied to investigate the scaling of the coefficients. A perturbation in the form of a pellet can also be used but the perturbation will be large.
However, comparison of coefficients from gas puffing and from pellet density decay should be done. Analysis of the data can be done with several techniques: regression on the particle flux, a frequency domain analysis, 1-D simulation, a time-to-peak method and/or a coupled analysis with temperature profiles if ECE is working.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 5 Tesla

Plasma Current: 400 kA to 1 MA

Working gas species: D

Density: $5 \times 10^{19}$ to $2.0 \times 10^{20}$

Equilibrium configuration: (if possible, refer to database equilibria)

Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired waveforms:

4.2 Auxiliary Systems

RF Power, pulse length, phasing: None

Pellet Injection (species): Yes

Impurity blow-off injection: No

Special gas puffing: Yes, modulated gas puffs.

Other:

4.3 Diagnostics

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

ECE, $H_\alpha$, Tomography, TCI are absolutely essential. Thomson scattering would be appreciated but not expected.

4.4 Neutron Budget

Estimate the neutron dose rate at the site boundary. Give basis for estimate. (Once some experience has been gained a standard formula will be provided for estimating dose rates.)
5. Experimental Plan

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.

The time requirement is one full run day in the early part of June (first two weeks - constrained by thesis deadline) and one, possibly two piggy back days before the full day. The piggy back runs are required to measure exactly the acceptable level and frequency of the puffs and the full day is necessary to perform the actual set of measurements for the calculation of the diffusion coefficients.

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 system requirements, etc. Include contingency plans, if appropriate.

We expect that the first day will be as follows: We will start at a moderate density \(1.0 \times 10^{20}\) and 600 kA. Shots will be taken until 3 acceptable shots at each set of parameters is achieved. The parameters will then be moved to the next set. The parameters desired are \(I_p = .6, .8\) and 1.0 MA and background density of 0.5, 1.0 and 2.0 \(\times 10^{20}\). Thus, the total number of good shots will be 27. If there is any time left over, pellet shots will be taken and the coefficients during the density decay measured. This can also be done as a piggyback.

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.

We anticipate that diffusion coefficients will be deduced that will provide a benchmark for the particle transport in Alcator C-Mod. Furthermore, this will comprise a large part of the thesis work for Luke and should enable him to graduate by August 1994. I expect that in conjunction with the detached plasma MP, comparison of coefficients in the operational modes will lead to journal publications. Aside from that, a deeper understanding of particle transport will result.

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

Gas Puffing Experiments