Subject: Commissioning of the Laser Blow-Off System

From: N. Howard, M. Greenwald, J. Terry, J. Rice, M. Reinke

Group: Transport

Date: August 27, 2009

1. Purpose of Experiments
Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones.

The purpose of these experiments is to commission the newly installed laser blow-off system and gain experience with its operation. This includes the demonstration of the design goals of this new laser blow-off system. These goals are the following: demonstration of non-perturbative operation of the impurity injection for a variety of different materials, fully remote operation to achieve non-perturbative injections, and the ability to introduce multiple impurity injections during a single plasma shot. After these goals are demonstrated it is hoped that frequent piggybacking during current flat top periods will be allowed. Following successful commissioning, and opportunistic collection of data in piggy-back, requests for dedicated time are anticipated via a future MP.

2. Background
Discuss Physics Basis of the proposed research. Prior results at Alcator or elsewhere, and any related work being carried out separately.

Laser blow-off systems have been used on numerous machines worldwide (including previously on Alcator C-Mod) as a tool for studying impurity transport [1]. They are ideally suited for this task because unlike other methods of impurity injection, such as gas puffing, they allow for the introduction of trace amounts of an impurity at what is effectively a delta function in time and therefore simplify the transport equations during analysis. Trace impurity injections can be non-perturbative which by definition do not alter the underlying processes that dominate the transport. Therefore insight into not only the impurity transport but also the bulk particle transport maybe be obtained by use of the laser blow off technique. The exact definition of non-pertubative in the sense of
measured plasma parameters is often defined as less than a ~10% change in \( T_e, n_e \) and \( Z_{\text{EFF}} \). To insure the notion of a trace injection from a turbulent transport point of view, it is verified that there is no noticeable effect on the density fluctuation measurements at the time of injection [2]. When these criteria are fulfilled, the laser blow-off technique has been shown to allow detailed impurity transport studies which include confinement time analysis, determination of transport coefficients, and dependence of these measured quantities on a variety of machine parameters.

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.

Given that the nature of this mini proposal is simply to commission the new laser blow-off system and therefore no particular plasma parameters are required at this time but there are two easily identifiable goals for this mini proposal. They are 1) demonstration of the non-perturbative injection ability of the laser blow-off system and 2) determine based on the results of operation the optical configurations which provide the best injections for impurity transport studies. In order to achieve these goals the following approach will be taken.

Based on previous laser blow-off studies, such as those previously performed on Alcator, a standard thickness, a highly detectable material, and a standard spot size will be used for the first impurity injections. A number of spectroscopic diagnostics will then be employed to verify the success or failure of the injections. Additionally, the electron density, electron temperature, \( Z_{\text{EFF}} \), \( P_{\text{RAD}} \) and density fluctuations will be monitored to assure that the injection meets the criteria for non-perturbative operation. This process will be iterated until a method of operation which yields non-perturbative, detectable, and reproducible injections is found. The same process will also be repeated for a wide range of materials to aid future operation and impurity transport studies.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: None Specified
Plasma Current: None Specified
Working Gas Species: None Specified
Density: None Specified
Boronization Requested (if yes, specify whether overnight or between-shot, how recently needed, and any special conditions.): Not Required
Equilibrium configuration (if possible, refer to database equilibria): None Specified

4.2 Auxiliary Systems
ICRF Power, pulse length, phasing: Not Required
LHCD Power, pulse length, phasing: Not Required
Pellet Injection (species): Not Required
Impurity blow-off injection: Yes
Diagnostic Neutral Beam: Not Required
Special gas puffing: Not Required
Cryopump: Not Required
Non-axisymmetric Coils (Connections, Current): Not Required
Other:

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

Thomson Scattering (for electron density and temperature)
ECE
Reflectometry, PCI (density fluctuations) (When available)
A wide variety of spectroscopic diagnostics are desirable for verification of impurity injection these include but are not limited to: McPherson (VUV), Charge Exchange, Bolometry, and Soft X-Ray (SXR) Diagnostics

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.

1 week of piggybacking is requested.

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.

There is no planned shot sequence but initially tests will be performed during current ramp down. After an acceptable operation regime is found, these tests will be performed at the end of flat top portions of the discharge.

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, an ITER request, or an external database.

The anticipated results of this mini proposal will be to simply verify the operational abilities of the impurity injector that were set as the design goals. It will also serve as a template for the future operation of the laser blow-off system that and therefore more predictable injections during shots used for impurity transport studies. Some of this
work may then be compared to other laser blow-off based impurity transport studies and therefore inter-machine comparison as well as lead to a publication about this new system in a journal such as Review of Scientific Instruments.

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