Subject: Determination of the Mo source which dominates the core Mo levels

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

   To try and isolate the relative contribution Mo sources from the inner wall, outer limiter/antennas, and divertor to the core Mo levels. In addition we hope to be able to determine the screening of the Mo source from these different locations. If the data is amenable to modeling with DIVIMP this could lead to further understanding of the important physics governing impurity transport in the SOL and divertor. The identification of the Mo source locations and their relative strength may provide some insight into why the Mo is generated and how to reduce it. This has implications both for the current increase of input powers and the planned long-pulse operation with LHCD.

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

   The Mo levels in the plasma core are an important concern and potential limit for operation of C-Mod. We do know that as we lower the plasma density and or raise the input power, that the Mo levels in the core rise. This obviously leads to cooling of the core and ultimately to poor core confinement[1]. If we could isolate where the dominant Mo source is, and the transport physics that governs its travel to the core, we might be able to minimize the core Mo levels.

   At the moment our knowledge of the source from a variety of locations, inner limiter, outer limiter, antennas, or divertor, is minimal. The Mo source rate from the inner limiter appears below our spectrometer sensitivity. There may be a strong Mo source at the top of the D and E antennas, outside our field of view during the last run period. The antenna Mo source, at least from body of the antenna, was sporadic and did not correlate with core levels. The outer limiter effect on the core was measured in the 1994 run campaign and shown in Figures 1 and 2. The divertor source, although measured and successfully
modeled[2,3] does not strongly correlate with the core levels. This likely means that either
the Mo source which dominates the core Mo levels is below our measurement capability (a
large, diffuse source), or, that the Mo source is localized, and not in one of our spectrometer
views.

Figure 1. Dependence of Mo core brightness on the outer gap.

Figure 2. Dependence of the core radiated power $P_{\text{rad}}$
and $P_{\text{rad}}/P_{\text{in}}$ on the outer gap. The closed symbols
are for shot where there was no argon puff.

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

This effort will take place on two levels. On the gross, or overall level, we will try and
isolate the region (inner wall, outer limiter, divertor) of dominant source by varying the
gap to the inner and outer limiters (at powers $\leq 2$MW). On a more basic level, we hope to
monitor the Mo source rate at ‘typical’ spots on these surfaces. Since the Mo source rates
at the inner wall are very low during normal operation, we assume that the Mo source can
measured for smaller gaps (We are sure for a gap of 0). The variation of source with gap
distance will allow us to extrapolate the inner wall Mo source to the ‘normal’ gap distance.
We now have new spectrometer views of the upper edge of the D and E antennas as well as part of the J antenna. We plan to try and track the Mo source rate from these locations as well. The core level of such ‘intrinsic’ impurities as Ar, Cl, F and S will be monitored to see if the gap changes affect those impurities.

The experience with the RF was that it can be coupled as the gap distance is varied. If so, we will try and vary the gap distance during the shot. It would be useful to have an ohmic as well as RF-heated part of the shot. We could then compare these conditions. The flapper will be used to determine if the effect it has on impurity transport is a function of gaps. The McPherson spectrometer will be used to track core flourine levels. HIREX will be used to follow Mo, Ar, Cl and S levels in the core. The Chromex spectrometer will be used to measure Mo source rates at the first wall surfaces. The Omegatron, if operational, will be used to measure the impurity levels in the SOL.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

**Toroidal Field:** 5.3 T

**Plasma Current:** 1.0 MA

**Working gas species:** $D_2$

**Density:** $\bar{n}_e \approx 1.5 - 2.5 \times 10^{20} m^{-3}$

**Equilibrium configuration** (if possible, refer to database equilibria): 980106 equilibra used for gap variation

**Pulse length, typical current & density waveforms, etc.** Refer to database or sketch desired waveforms: $\geq 1.1$ s at end of flattop if possible. We would like to vary the inner and outer gaps independently during a shot.

4.2 Auxiliary Systems

**RF Power, pulse length, phasing:** $\approx 2$ MW (we rally want the maximum allowed by the gap distance sweep). for RF parts of mp.

**Pellet Injection (species):** None

**Impurity blow-off injection:** None

**flapper:** some shots

**Special gas puffing:** Trace, calibrated amounts of Ar injection. The Ar will be puffed through “B side lower”.

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

Interferometer; divertor probe array; ECE; Main and divertor Bolometer arrays; Fast scanning and divertor probes; Omegatron (if possible); Visible bremsstrahlung; Chromex spectrometer viewing inner wall and divertor surfaces looking at source rates for Mo & recycling of the injected gas; Edge Thomson (if possible); McPherson spectrometer viewing the main plasma; Hirex viewing the core; All reticon arrays with $H_\alpha$ filter; Ratiomatic pressure gages; Divertor pressure gages; Divertor Prisma RGA

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.)

Standard H-mode 2.0 - 2.5 MW plasma

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.

Approximately 1 run.

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.

low target density, $\bar{n}_e \approx 1.5 \times 10^{20} m^{-3}$

(1) Inner gap scanned from 0 to 1.5 cm during the shot. 5 shots required for determining the proper tuning for the RF to keep power up during scan. This should be enough shots for the spectrometers and FSP to get data. 2 additional shots to see if the flapper has an effect.

(2) Outer gap scanned from 0 to 1.5 cm during the shot as during 980106. 5 shots required for determining the proper tuning for the RF to keep power up during scan. Two additional shots for flapper.

higher target density, $\bar{n}_e \approx 2.5 \times 10^{20} m^{-3}$

(3) Inner gap scanned from 0 to 1.5 cm during the shot 5 shots required for determining the proper tuning for the RF to keep power up during scan. This should be enough shots for the spectrometers and FSP to get data. 2 additional shots to see if the flapper has an effect.

(4) Outer gap scanned from 0 to 1.5 cm during the shot as during 980106. 5 shots required for determining the proper tuning for the RF to keep power up during scan. Two additional shots for flapper.
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.

1. Locate dominant Mo source and its dependence on gap. See if there is a similar dependence for other intrinsic impurities.

2. Determine the Mo source rate at different locations as a function of the gap distance. This will allow us to extrapolate to normal gaps. We will also be able to determine the screening as a function of gap distance.

3. This data will greatly enhance the thesis of D. Pappas.

4. This data has the potential to provide the knowledge of how to reduce core Mo levels.

7. **References**

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

