1. Purpose of Experiments

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

To bring Omegatron diagnostic online, to calibrate grid transmission coefficients and operating parameters, and to use the Omegatron to characterize the scrape off layer ion impurity spectrum.

2. Background

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

Matthews et al. [1] have performed experiments on DITE using ion mass spectrometry; Wan [2] performed experiments on Alcator C using gridded energy analysis. The Omegatron diagnostic combines a gridded energy analyzer with an ion mass spectrometer. This combination has been tried on no other tokamak.

LaBombard and Thomas [3] designed and constructed the Omegatron probe and tested it on the Hollow Cathode Discharge (HCD) plasma source in the Nuclear Engineering plasma lab. Based on their results, LaBombard and Wenzel redesigned the grids closer together, to avoid space charge limitations on Alcator C-Mod. The resolution of the ion mass spectrometer increases with the local magnetic field; on C-Mod the Omegatron should provide Z/M resolution of the order $\Delta(Z/M) \approx 10^{-3}$ (compare with singly charged molybdenum, $Z/M \approx 10^{-2}$). In principle, the Omegatron could give the parallel distribution function for individual ion impurity species.

The Omegatron probe vacuum hardware was initially installed on C-Mod in September 1995 at F-TOP. During the first few days of the fall 1996 campaign, it was discovered that the Omegatron grids were shorted out and the probe head was frozen in position, fully withdrawn. Subsequent disassembly after the campaign revealed broken leads and metal filings, as well as galling between the support tube and bracket.

Before the spring 1997 campaign, the Omegatron probe head was completely rebuilt. New assembly technique was used to make the probe components more robust. The probe
head was tested extensively on the bench and in-situ. The bracket was redesigned to
prevent snagging on the support tube, and reinstallation of the Omegatron in April 1997
went smoothly. Full linear motion was demonstrated.

The Omegatron probe resides at J-TOP. In the offline position, we withdraw the
head of the Omegatron between the gusset protection tiles in the upper divertor. During
operation, we insert the probe head into the upper scrape off layer, with the probe axis
aligned along the magnetic field; except for vertical motion, the probe orientation is fixed,
so this field alignment is approximate. The Omegatron moves between shots only. In
addition to the gridded energy analyzer and ion mass spectrometer (each of which can
operate independently), the probe head has three Langmuir probes and two thermocouples.

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

We should be able to complete the entire mini-proposal in piggy-back mode. We’ll
use the first few days of plasma (including ECDC and glow discharge cleaning) to shake
down the electronics and computer interface tools for the Omegatron, as well as to test
the Langmuir probes and thermocouples.

Once we have the system comfortably operational, we’ll determine the transmission
coefficients for the front end slit, as well as each of the three grids. We’ll explore the
operational parameters of the probe by finding the potentials on the ion mass spectrometer
needed to get a spectrum of sufficient signal.

Finally, and for the rest of the campaign, we’ll actually use the Omegatron to char-
acterize the upper divertor scrape-off layer, monitor ion impurity species during ICRF
operation, L- and H-modes, enhanced D-α mode. Ultimately, we hope to use the Omega-
tron to describe impurity transport from the core by monitoring the concentration of highly
ionized high-Z impurities in the SOL.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

Toroidal Field: 2.6 - 8 T
Plasma Current: 0.5 - 1.5 MA
Working gas species: D, H, $^3$He, Ar, etc.
Density: $\bar{n}_e = 0.9 - 2.2 \times 10^{20}$ m$^{-3}$

Equilibrium configuration (if possible, refer to database equilibria): All, preferably with
as few upward-going disruptions as possible.

Pulse length, typical current & density waveforms, etc. Refer to database or sketch desired
waveforms: Pulse length of $\geq 1.5$ s, flattop $\geq 0.5$ s.
4.2 Auxiliary Systems

RF Power, pulse length, phasing: Any or none
Pellet Injection (species): Any or none
Impurity blow-off injection: Any or none
Special gas puffing: None special, but any
Other:

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

All available diagnostics, but particularly spectroscopy (Chromex, McPherson, OMA, \(Z_{\text{eff}}\)), and edge (fast scanning probe, flush mount probes).

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.)

\[ \leq 10^{18} \text{s}^{-1} \]

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.

One full campaign.

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.

We should be able to run the Omegatron during any shot, any equilibrium, with negligible effects on other diagnostics. At first we’ll be looking for sequential identical shots: we’ll use the first shot to map out the equilibrium scrape-off layer with the fast scanning probe, while the Omegatron head is withdrawn; for the next shot we’ll insert the Omegatron to the desired equilibrium flux surface. We expect to keep the Omegatron at least 1 cm outside the separatrix.

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.

In the best case scenario, this miniproposal should result in a new, important edge diagnostic for Alcator. If the Omegatron works as designed, this miniproposal should result in several important publications and at least one doctoral thesis.
7. References
Include references both to external and internal literature or communications which bear on this proposal. See Section 2.

