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

Since its installation on C-Mod, the beam-emission spectroscopy (BES) system has not detected broadband ($\delta \omega \sim \omega$), $k_\theta \rho_s \sim 0.1$ fluctuations interior to the separatrix. This proposal is to test, under the most favorable conditions, if recent upgrades to the system and DNB will be successful.

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

Alcator C-Mod is a challenging device for BES:

- $D_\alpha$ emission from the edge is of order 1000 times the emission from the DNB, requiring extremely sharp bandpass filters and careful alignment of the spectrometer optics to block the unshifted edge emission.
- Bremsstrahlung and impurity line emission (CI, CII, FIII) is of the same order as the beam emission. The former is emitted all along the view chord (although concentrated at the peak density), while the latter are emitted from the edge. The emission fluctuates and therefore contaminates the local beam emission.
- Perpendicular wavelengths of the turbulence are very short ($\lambda_\theta \sim \rho_s$), thus requiring very small viewing volumes and resulting poor etendue.
- Toroidal rotation is relatively small in C-Mod (compared to co-beam DIII-D discharges). Thus, core fluctuations are expected to be in the same low frequency range as the large edge fluctuations which are imprinted on the beam through modulation of the attenuation.
- Fluctuations in the emissivity are attenuated because of saturation of the $n=3$ state at the high densities of C-Mod. ($\delta \varepsilon / \varepsilon \sim 1/3 \ \delta n / n$)
The DNB is injected radially, which requires viewing across flux surfaces to obtain any Doppler shift of the beam emission to minimize collection of edge $D_\alpha$. This results in a net viewing volume that can be larger than the typical wavelengths of the turbulence, thus strongly attenuating it.\cite{1,2} Other BES systems, e.g. on DIII-D,\cite{3} view a toroidally injected beam tangent to the flux surfaces, thus minimizing this problem.

Because of the trade-off between radial resolution and Doppler shift, there is only a narrow region near the edge (the top of the H-mode pedestal) where turbulence measurements are at all possible.

### 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.

Recently, a number of improvement to the system have been made:

- The discrete four-fiber bundles plugged into discrete holes in the image dissector have been replaced with a single densely packed 6×6 fiber array. This allows smaller viewing volumes (albeit less light collection) and closer channel separation for cross-correlation.
- Four channels of a CPCI digitizer have been made available by the MSE group. The 2-s digitization time (compared to 0.131 s for the existing CAMAC) will provide better statistics.
- The DNB is capable of higher-current (< 7 A) and longer pulse (<1.5 s steady) with injection slightly off radial (~7º).

For this experiment the system will view the edge region ($R \sim 88$ cm) where the radial averaging is not prohibitive yet where there exists some Doppler shift of the beam emission. Data from four poloidally spaced channels will be taken during steady Ohmic discharges for a DNB pulse roughly half the shot length (~1 s). This is done for two plasma densities and three radial viewing locations. If the coherences and phases between the channels are different between beam-on and beam-off, the data will be more closely analyzed after the run to determine its validity. If no differences are observed, even with the beam running at full current (~7 A), the measurements will be declared futile. Analysis, e.g., virtual BES simulations including finite decay times would be performed to fully understand the results.

### 4. Resources

#### 4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: nominal
- Plasma Current: nominal
- Working Gas Species: any
Density: $1.2 \times 10^{20} \text{ m}^{-3}$
Equilibrium configuration (if possible, refer to database equilibria): as long a flat top as possible (< 2 s)

4.2 Auxiliary Systems

RF Power, pulse length, phasing: none
Pellet Injection (species): none
Impurity blow-off injection: none
Diagnostic Neutral Beam: $\sim 7 \text{ A}, \sim 1$-s pulses
Special gas puffing: none
Non-axisymmetric Coils (Connections, Current): none
Other:

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

BES (MSE fixed polarizer removed)
CXRS, reflectometry (desirable)

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.

A day or two of C-Mod shots with beam (not necessarily optimized, steady, nor full-length) will be required before the experiment to tune the bandpass filters to maximize the ratio of beam-to-background signal for three viewing radii. The MSE fixed polarizer must be removed and a cell access will be required to remove the outermost MSE channel for a few shots. The experiment itself needs twelve “good” shots (steady $\sim$2-s plasma; full-power, $\sim$1-s beam).

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.

Two good shots at each of two plasma densities $1$ and $2 \times 10^{14} \text{ m}^{-3}$ – with fiber array in “normal” position and using column of array viewing $R \sim 88.4$ cm. Repeat using the innermost column of the array viewing $R \sim 87.2$ cm. A cell access of $\sim$ half hour will then be requested to remove outermost MSE fiber and move BES fiber array to innermost position. Repeat using innermost column of array now viewing $R \sim 86.0$ cm.

If beam is running in a significantly degraded state ($I < 6$ A, large water component, etc.), the experiment should be postponed.
The results of this experiment will determine once and for all whether BES (in its current configuration) can measure broadband turbulence. The longer integration time allowed by the long-pulse beam and CPCI digitizers will certainly reduce dark and photon noise in the cross correlations, and the new densely packed fiber array will allow more fine-grained cross correlation analysis. However, these will not mitigate fluctuations of edge $D_\alpha$ that leaks into the filter passbands or bremsstrahlung and impurity line emission (from the edge) within the passbands. These fluctuations are real and correlated between channels; thus, they will not be eliminated by better statistics nor cross-correlation between channels. Success of this experiment hinges on the beam emission dominating these sources of contamination, or the local turbulence being Doppler shifted to higher frequencies than the edge fluctuations.

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