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 this experiment is to characterize the change in the strength of parametric decay instabilities (PDI) of lower hybrid (LH) waves at the low field side (LFS) by varying plasma current. Previous two experiments (MP664 and MP729) in both the forward and reversed field at the fixed plasma current (Ip~550 kA) have identified the grad-B configuration dependency of the PDI onset, which is correlated to the change in poloidal scrap-off-layer plasma conditions.

In this MP, the idea is to change plasma current, instead of X-point configurations, to modify edge plasma conditions in order to study the onset of ion cyclotron PDI at the LFS, which is expected to be strongly dependent on the local density in front of the launcher. The goal would be to identify a correlation among SOL plasma conditions, PDI strength, and current drive efficiency that has been observed to increase with an increase in plasma current.

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

While the observed non-thermal hard X-ray count rate is observed to be lower than expected during lower hybrid current drive experiments on Alcator C-Mod due to enhanced edge parasitic absorption mechanisms at high densities [1], an increase in hard X-ray count rates by a factor of two has been observed when the plasma current is increased from 0.8 MA to 1.1 MA, as shown in Figure 1. A hypothesis for this observation is the enhanced Landau absorption due to a higher plasma temperature in the
higher current case, which might have helped reduce the level of edge parasitic wave-plasma interactions.

Figure 1. Non-thermal hard X-ray count rates as a function of the line averaged density in different plasma conditions [1].

In this regard, the purpose of this experiment is to examine changes in the PDI strength at the LFS as a function of plasma current in diverted tokamaks, and relate the observed PDI strength to edge SOL conditions. Figure 2 shows an example of different SOL density profiles at Ip = 0.55, 0.8 and 1.1MA in ohmic L-mode high density plasmas ($\tilde{n}_e \approx 1.36 \times 10^{20}$ m$^{-3}$), which shows a steeper density profile as plasma current increases, while the SOL temperature profile remains nearly the same. Because instability growth rates increase with plasma density, it is expected that stronger PDI would be observed in low current cases. This expectation is in line with previous PDI measurements on limited tokamaks; an increase in PDI threshold with plasma current has been observed on Alcator C [2] and FT [3]. So far, no systematic measurements of lower hybrid frequency spectra
have been performed as a function of plasma current on the diverted Alcator C-Mod tokamak.

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.

The focus will be given to the onset of ion cyclotron PDI at the LFS due to available SOL profile measurement diagnostics: scanning probes at the LFS and an X-mode reflectometer at the LH launcher. Because the main focus of this proposed experiment is to carefully document the onset of density-dependent PDI at the LFS, we will focus on the LFS edge.

We will use an upper-single-null configuration (in the forward B-field) for the following two reasons: first, in this configuration, ion cyclotron PDI at the LFS exhibits a slightly lower density threshold than in the lower-single-null configuration [4]. Second, ion cyclotron PDI at the HFS is not generally observed in this configuration, which will help focus on ion cyclotron PID at the LFS.

We will conduct density ramp \( n_e = 0.7 - 1.5 \times 10^{20} \text{ m}^{-3} \) during the LH injection for the following three different plasma currents: 0.55, 0.8, and 1.1 MA. Note that if LH coupling becomes an issue at \( I_p = 1.1 \text{ MA} \), we will reduce to \( I_p = 1.0 \text{ MA} \). While conducting current scan, we would like to keep the density and temperature at the launcher same as much as possible, in order to ensure the same launching condition. This will be monitored with launcher Langmuir probes.

Figure 3 shows a proposed LH and density pulses. LH waves will be injected for 800 msec and density ramp will be performed at a rate of \( 10^{20} \text{ m}^{-3}/\text{sec} \). In the previous run day (1120710xxx) for MP 664, \( I_p = 0.55 \text{ MA} \), and we will use this shot as a base case.

![Figure 3. Proposed LH and density pulses for SOL profile measurements using scanning probes at \( n_e = 0.9, 1.2, 1.4 \times 10^{20} \text{ m}^{-3} \) during the LH pulse for 800 msec](image-url)
Both LH spectral measurements and SOL profile measurements will be performed. LH spectral measurements can be done for every 25 msec. For each plasma current case, we will repeat the discharge to collect SOL profile data using scanning probes at the line-averaged density at \( n_e = 0.9, 1.2, 1.4 \times 10^{20} \text{m}^{-3} \) for profile characterization purposes. We would like to keep the density ramp same as much as possible, so that scanning probes can be plunged at similar \( n_e \) in each discharge. LH effects will be monitored using ECE, hard X-ray, Ly_alpha array, and divertor probe diagnostics to correlate SOL conditions to the instability onset and the observed loss of efficiency.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 5.4 T (forward field)
- Plasma Current: 0.55, 0.8, 1.1 MA
- Working Gas Species: D2
- Density: \( n_e = 0.7 - 1.5 \times 10^{20} \text{m}^{-3} \)

Boronization Requested (if yes, specify whether overnight or between-shot, how recently needed, and any special conditions.): No

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

4.2 Auxiliary Systems

- ICRF Power, pulse length, phasing: None
- LHCD Power, pulse length, phasing: 700 kW, or as high as possible (so that LH effects are not power-limited in high-density plasmas.) Pulse length: 0.8 sec, \( n|| = 1.9 \)
- Pellet Injection (species): No
- Impurity blow-off injection: No
- Diagnostic Neutral Beam: Yes, if MSE measurements are available
- Special gas puffing: None
- Cryopump: Yes, if density control is necessary
- Non-axisymmetric Coils (Connections, Current): Standard
- Other: None

4.3 Diagnostics

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

LH spectral measurement system, scanning probes, x-mode reflectometer at the LH launcher, hard X-ray, ECE, Lyman alpha array, divertor probes, Thomson, TCI.

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.

Half-day run (4 hours) would be sufficient as 6 good shots are requested. We would like to request for 3 different plasma conditions at Ip = 0.55, 0.8, and 1.1 MA, and repeat these discharges for scanning probe measurements.

However, please note that there is a chance that it would take more than 4 hours to complete this MP. These 6 good shots do not include discharges for LH conditioning or for optimizing probe measurements. It might take several shots to maximize the LH power in the beginning of the run to maximize the LH power (> 700 kW) to make sure that LH effects are not power-limited in high-density plasmas. In addition, it would take several shots to optimize coupling whenever plasma current is changed. Finally, it might take more than one shot to optimize scanning probe measurements, so that probes are plunged deep enough. We will work closely with Dr. G. Wallace to ensure the optimized LH coupling and Dr. B. LaBombard to ensure that profile measurements are good enough.

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.

1. LH conditioning (3–4 discharges) at Ip = 0.55 MA, density ramp (∼ = 0.7 ÷ 1.5 × 10^{20} m^{-3}),
2. Ip = 0.55 MA, density ramp (1-2 discharges)
3. Repeat #2 for scanning probe measurements (1-2 discharges)
4. Ip = 0.8 MA, density ramp (1-2 discharges)
5. Repeat #4 for scanning probe measurements (1-2 discharges)
6. Ip = 1.1 MA, density ramp (1-2 discharges) (If necessary, lower Ip to Ip = 1.0 MA)
7. Repeat #6 for scanning probe measurements (1-2 discharges)

If time permits, perform measurements at Ip = 0.7 and 0.9 MA.

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 experimental results are expected to provide a clear indication of the role of edge plasmas on the onset of ion cyclotron PDI at the LFS. It will further provide detailed edge conditions that may help correlate edge conditions to the observed loss of efficiency. Results of this experiment can lead to a publication by combining this experiment result with previous experimental results in MP 729. It will also contribute to Baek’s coming APS oral presentation.

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