Measurements of Magnetic Fluctuations in HSX

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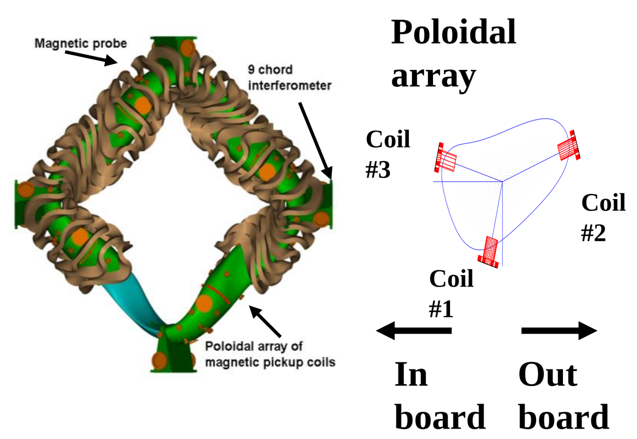
Results

In QHS mode operation, there exist 3 types of magnetic fluctuations

- Fluctuation level is about up to 2 ~ 3 gauss.
- Broadband fluctuations extend up to 200 kHz.
- "Coherent" magnetic fluctuations.
  - These are well correlated with line averaged plasma electron density fluctuations, but have no impact on plasma.
  - Coherent magnetic fluctuations have poloidal mode number, m = 0.
  - May be related to GAE mode.
- "Bursty" fluctuations.
  - These occur at low plasma density (less than 5.0 x 10^{11} cm^{-3}) and have strong impact on the plasma
  - Bursty fluctuations have poloidal mode number, m = 1.
- Coherent & Bursty fluctuations are present depending on plasma density & resonance location.
- Plasma biasing changes the poloidal mode structure of coherent fluctuations.

1.Design



Probe & pickup coil Design

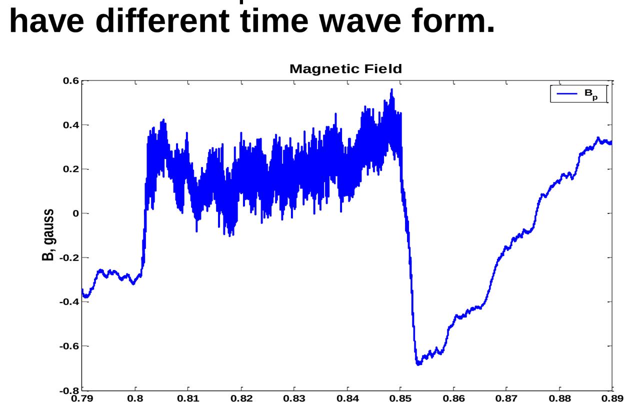
- Movable magnetic probe
  - Effective area
    - 8.4 cm² for parallel
    - 6.6 cm² for poloidal
    - 11.5 cm² for radial
  - Can be rotated & inserted radially
- 3 pickup coils
  - Effective area
    - 165.5 cm for poloidal
    - 9.8 cm for toroidal
  - Fixed at wall
- Both probe and coils have Boron Nitride particle shield
- High gain dB/dt amplifier with 250 kHz bandwidth

2.Fluctuation Level

Magnetic fluctuations have been detected at wall.

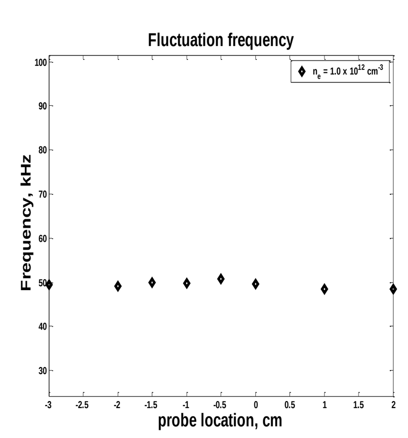
n_e = 1.0 x 10^{12} cm^{-3} probe at wall

B_r has ~ 1.5, B_p has ~ 0.8 gauss and B_r & B_p have different time wave form.

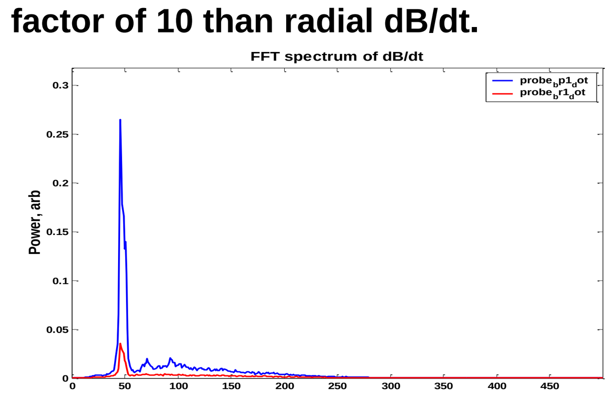


Frequency does not change up to 2 cm inside the plasma.

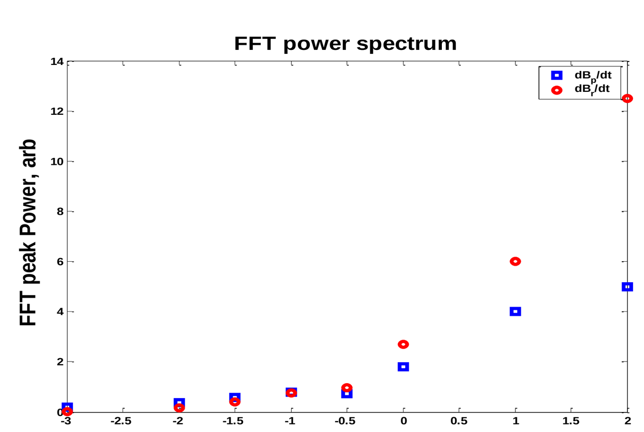
It is an indication of an existing mode inside the plasma.



Poloidal dB/dt peak power is greater by factor of 10 than radial dB/dt.

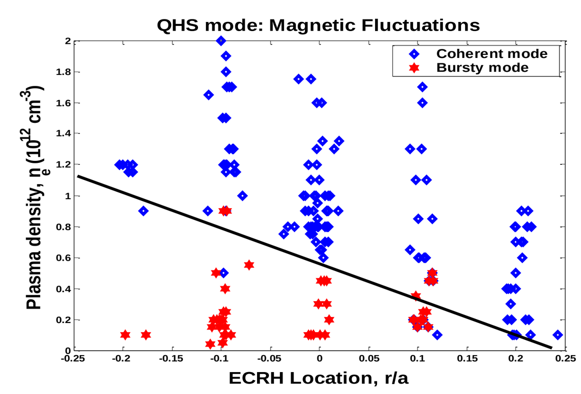


FFT peak power increase as the probe moves toward to the plasma.

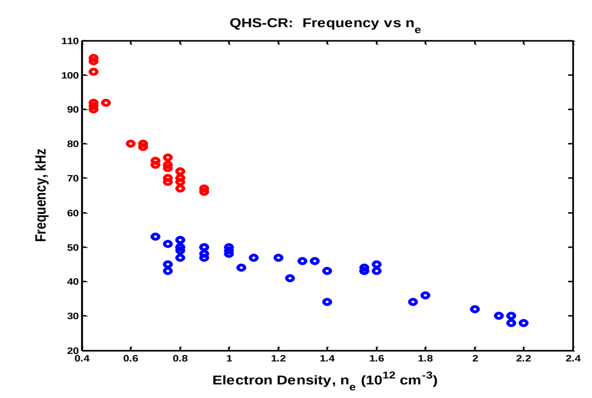


3.Magnetic Fluctuations in QHS

Coherent & Bursty fluctuations in QHS strongly depend on the electron plasma density and ECRH heating location.

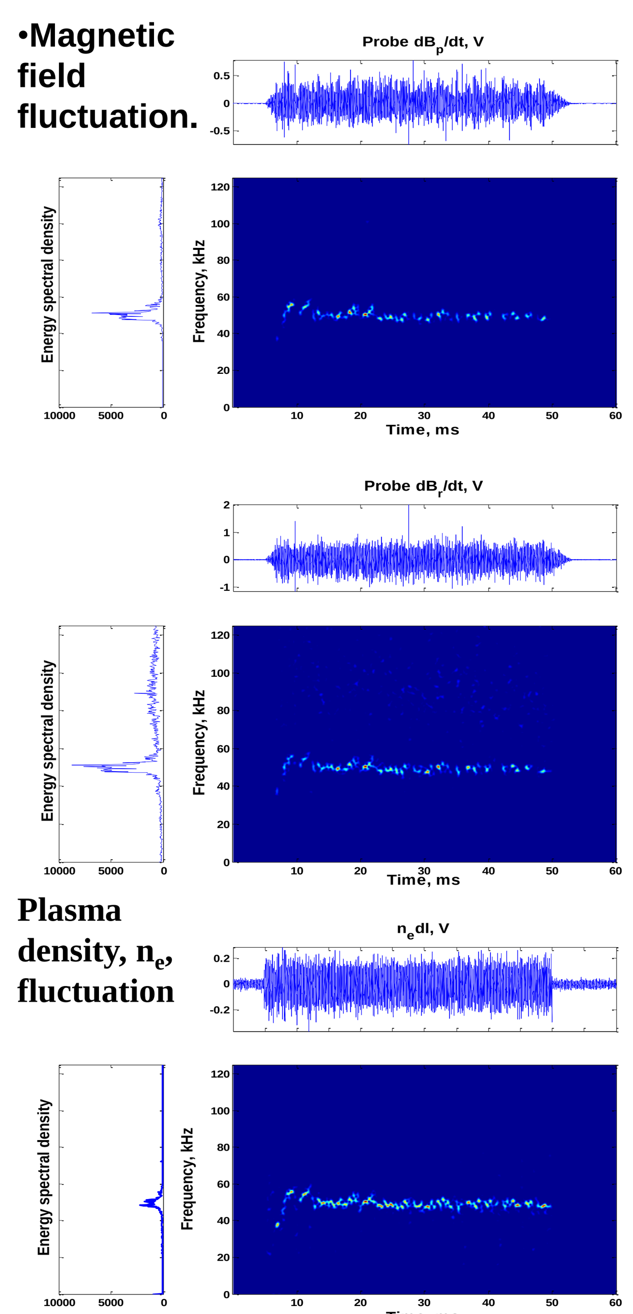


Coherent mode frequency changes when electron density n_e = 0.7 ~ 0.9 x 10^{12} cm^{-3}.

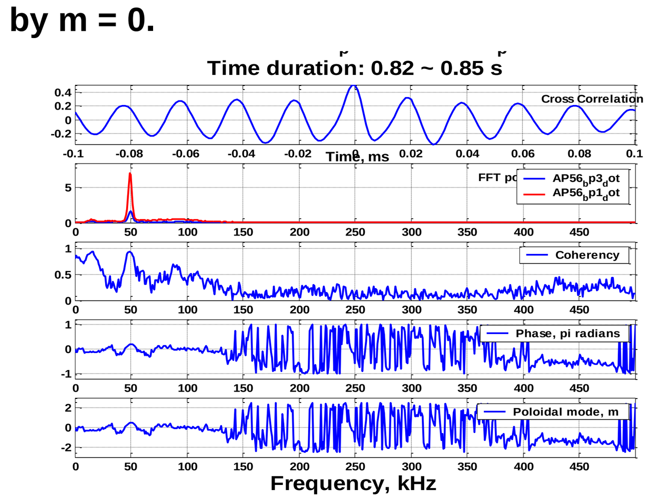


Coherence between dB/dt & n_e

- Cross coherency between dB/dt and n_e is very high (0.9 ~ 1.0) at frequency of 30 ~ 120 kHz.
- Frequency vs. time wavelet analysis demonstrates that dB/dt & n_e are strongly correlated.

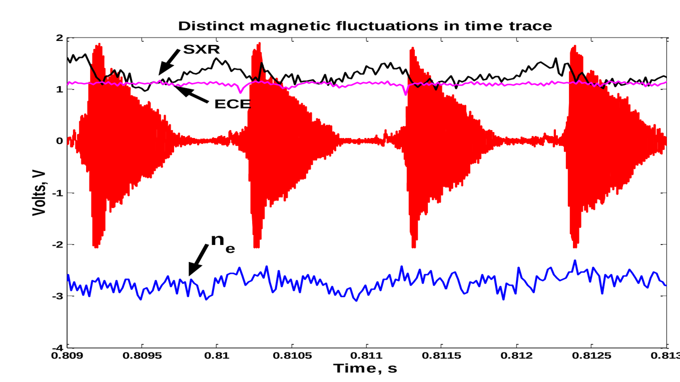


- Coherent fluctuations are predominated by m = 0.

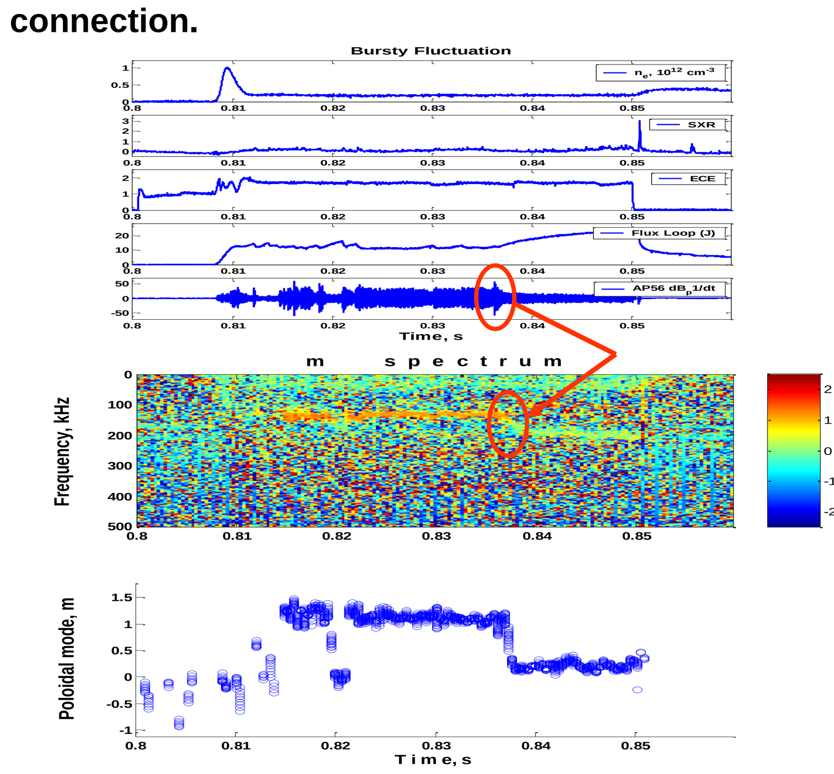


Low density Bursty Fluctuations

- Occurs at plasma density range is less than 0.5 x 10^{12} cm^{-3}.
- Has dominent frequency in the range of 90 ~ 180 kHz.
- Bursty fluctuations have large impact on the plasma parameters.
- We observe large sawteeth-like crashes in the stored energy and ECE.



- Hard X-ray(HXR) measurements indicate the presence of super-thermal tails.
- Bursty fluctuations have poloidal mode number m = 1 spectrum.
- Low n_e, high energy tail measured by HXR, and m = 1 structure indicates a possible Alfvenic connection.



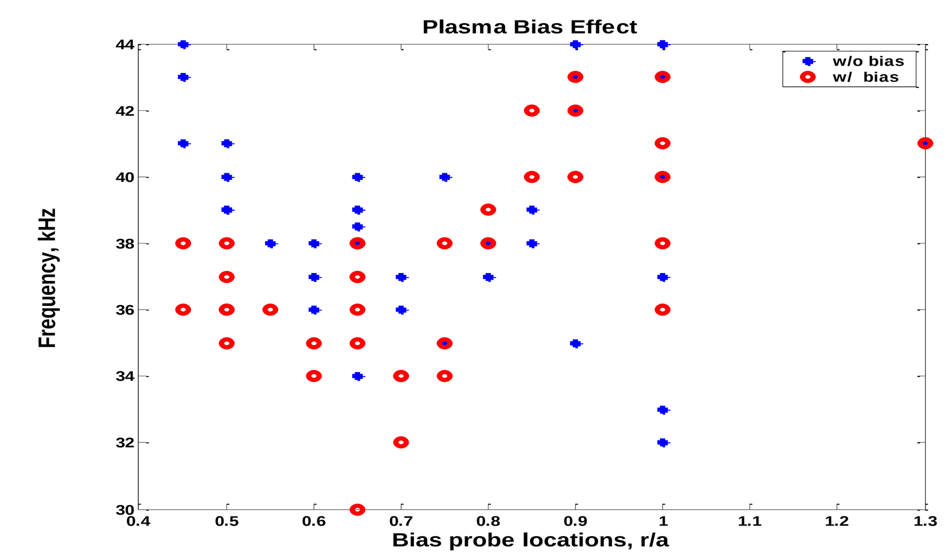
- At about 0.2 x 10^{12} cm^{-3} in QHS-Central Resonance, there exists a mode transition from m = 1 to m = 0.
- Stored energy at the transition increases.
- Frequency at the transition changes from 130 to 200 kHz.

4.Plasma Bias effect

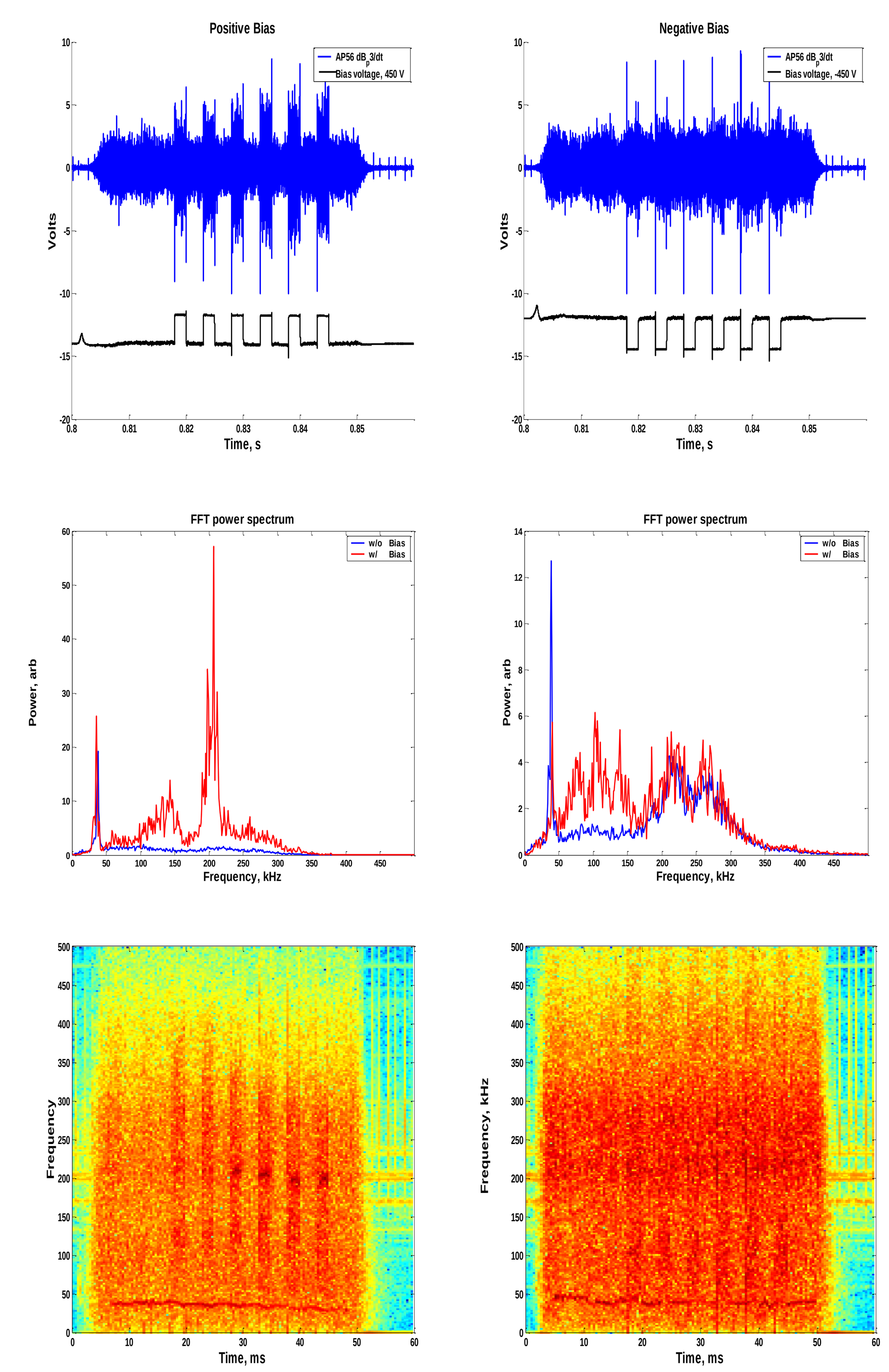
n_e =1.5 x 10^{12} cm^{-3}, 3 coil set fixed at wall

Changing bias probe location

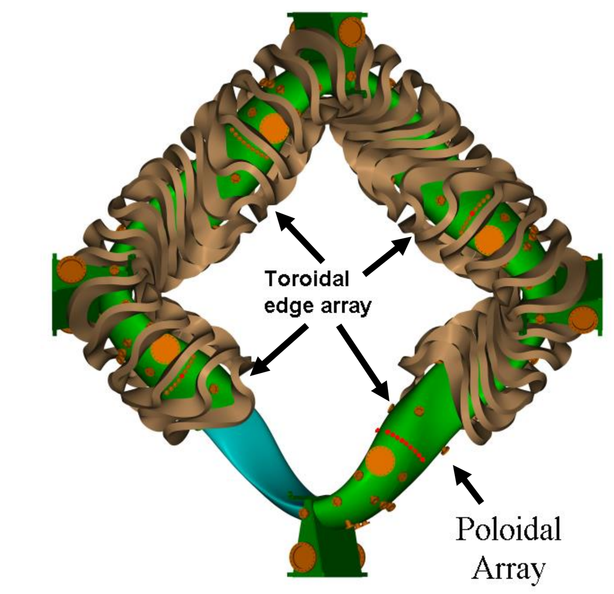
- As a positively biased probe inserted into plasma, coherent mode frequency changes and has minimum at r/a = 0.7.



- Positive plasma biasing initiates a narrow high(200 kHz) frequency fluctuation, and increases the amplitude of higher frequency broadband spectrum.
- Negative plasma biasing increases the amplitude of higher frequency broadband fluctuations.



5.Plans to measure n spectrum



- Toroidal edge array at same field period locations will be used to detect the toroidal mode number, n, at high and low field side of the plasma.
- Poloidal mini flange array and toroidal edge array will be used to specify the higher m and n mode spectrum.

Conclusions & Future work

Summary

- Magnetic fluctuations consist of broadband, coherent, and bursty fluctuations.
- Coherent fluctuations of B_r and B_p are strongly correlated with the plasma density, have poloidal mode number m=0, and have no impact on the plasma parameters.
- Bursty fluctuations have poloidal mode number m=1, and have significant impact on plasma parameters; such as stored energy, ECE, and SXR.
- Positive biasing increases higher frequency fluctuation amplitude while negative biasing does not affect the fluctuation amplitude.
- Future work
  - Understand the nature of the dB/dt fluctuations.
  - Measure toroidal and poloidal mode spectrum.
  - Measure the magnitude of Pfirsh-Schluter currentusing insertable current probe.