Operation in the quiescent regime with a high runaway electron current fraction on the EAST tokamak

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Introduction

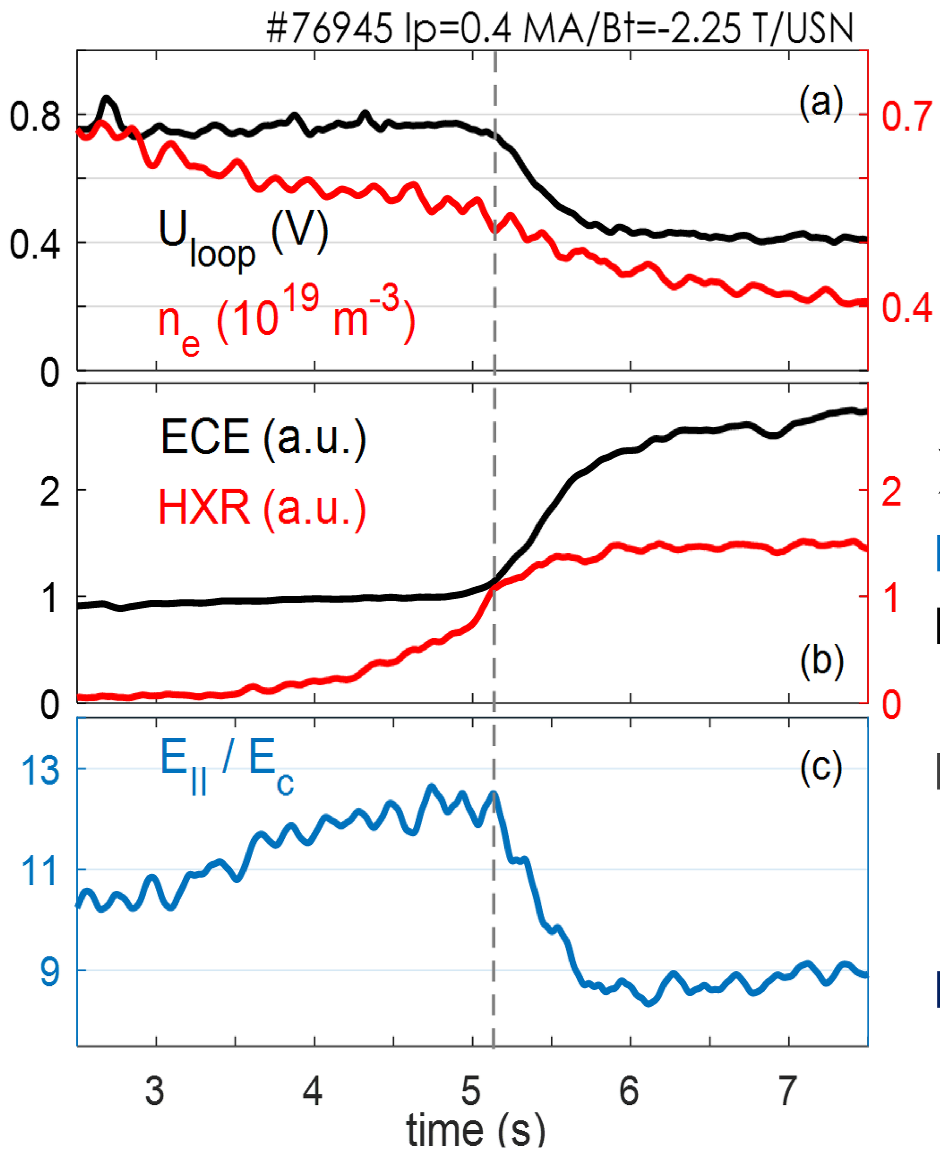
I. Quiescent regime with a high runaway electron (RE) current fraction have been achieved recently during the flattop of EAST ohmic plasma:
- Identify two different threshold field characterizing electric field for significant seed RE generation and RE avalanche onset;
- A suitable platform for RE excitation and dissipation.

II. Various instabilities and their contributions to RE loss are essential elements:
- Whistler wave-runaway interaction has been confirmed as a new mechanism influencing RE generation rate and so on;
- Advance understanding of RE loss and support further research in RE mitigation .

Operation in quiescent regime with a high RE current fraction

Setup of Quiescent regime

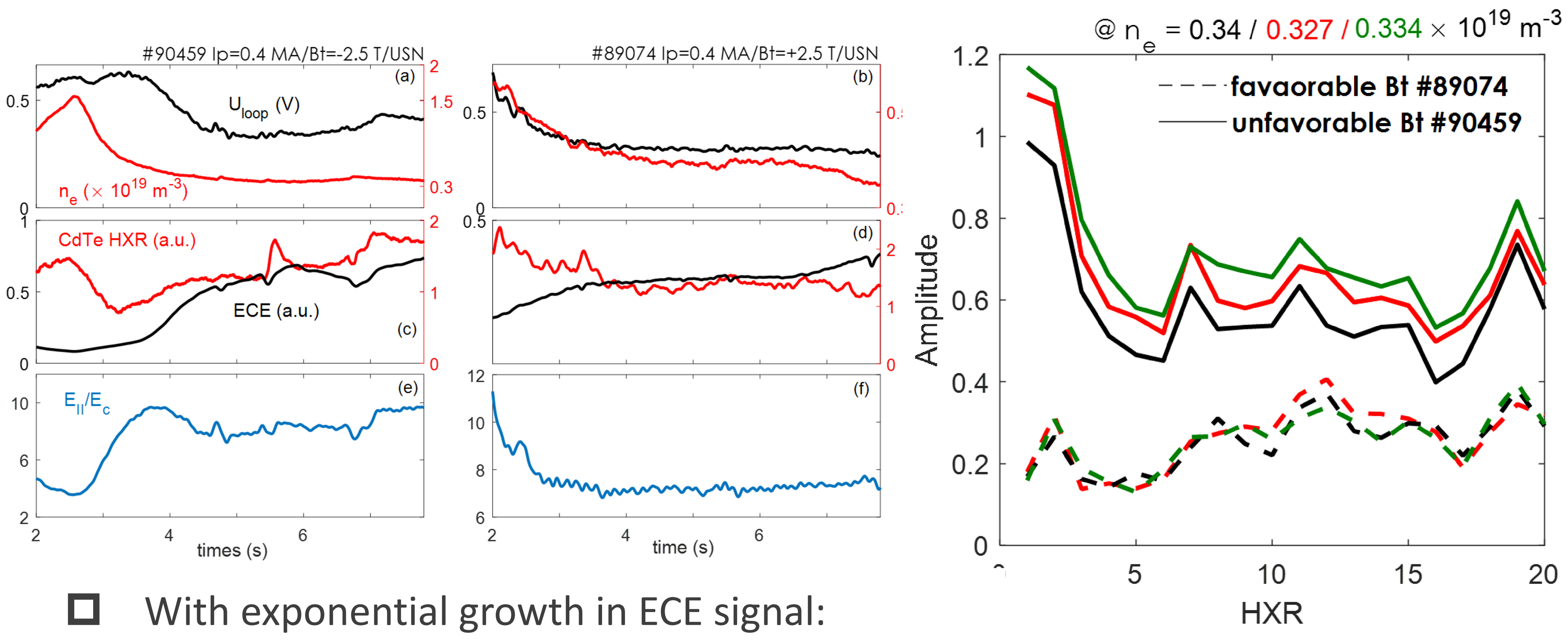
- Slowly letting the electron density ramp down to a very low density ($< 0.5 \times 10^{19}$ m^{-3})



Advantages:
- Accurate measurement of all key parameters important to RE excitation;
- Measure the evolution of RE populations.

Characteristics:
- **High RE current fraction;**
- Threshold fields for onset of the RE detection and avalanche;
- A saturated electric field is achieved:
  - Hypothesized as threshold field E_{th} for fully RE avalanche suppression;
- **Stable RE current fraction and energy distribution** in this regime.

∇B drift direction and RE energy distribution

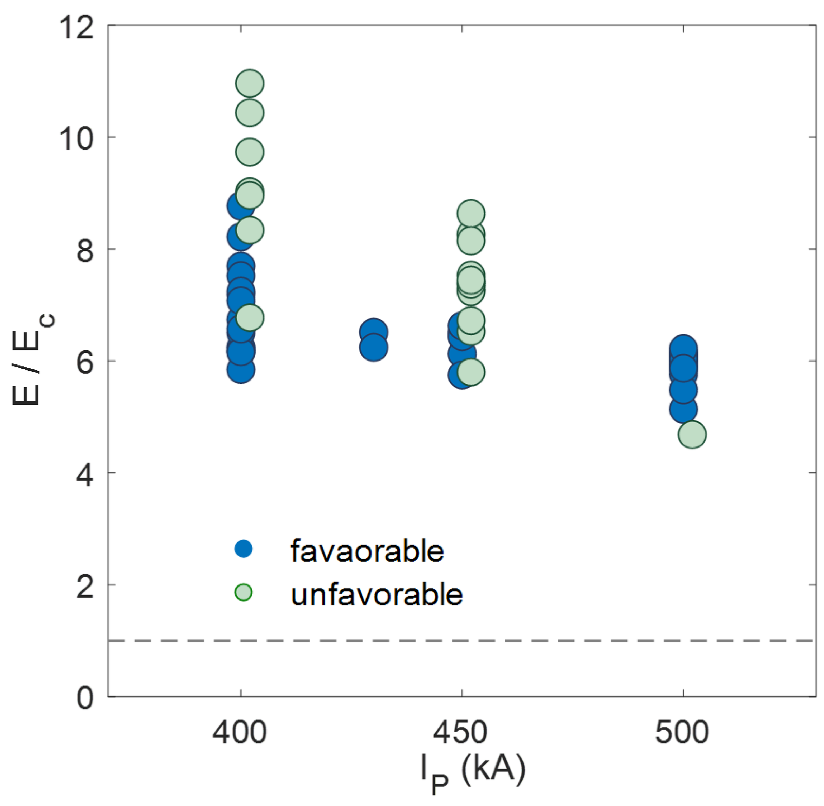


- With exponential growth in ECE signal:
  - significant **increasing HXRs with unfavorable B_t ;**
  - while **slight decreasing HXRs with favorable B_t** ➡ **Energy transfer process**
- Great gap in edge channels of HXRs, suggesting the **RE loss term** may resolve different evolutions of RE energy distribution.

Effects of ∇B drift direction and plasma current on E_{th}

① Higher I_p contributes to lower E_{th}

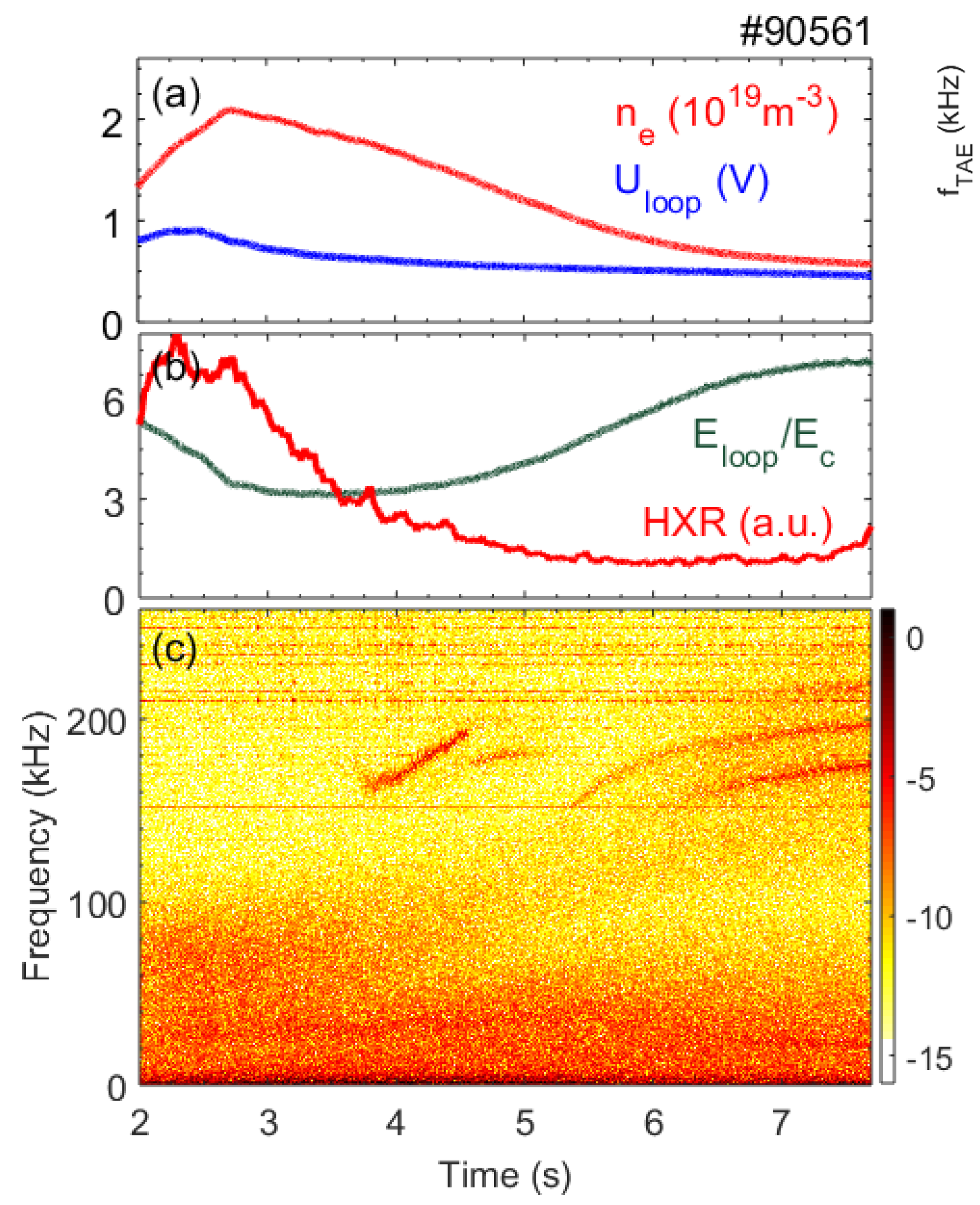
② Lower E_{th} with favorable B_t with ∇B drift towards primary X-point;

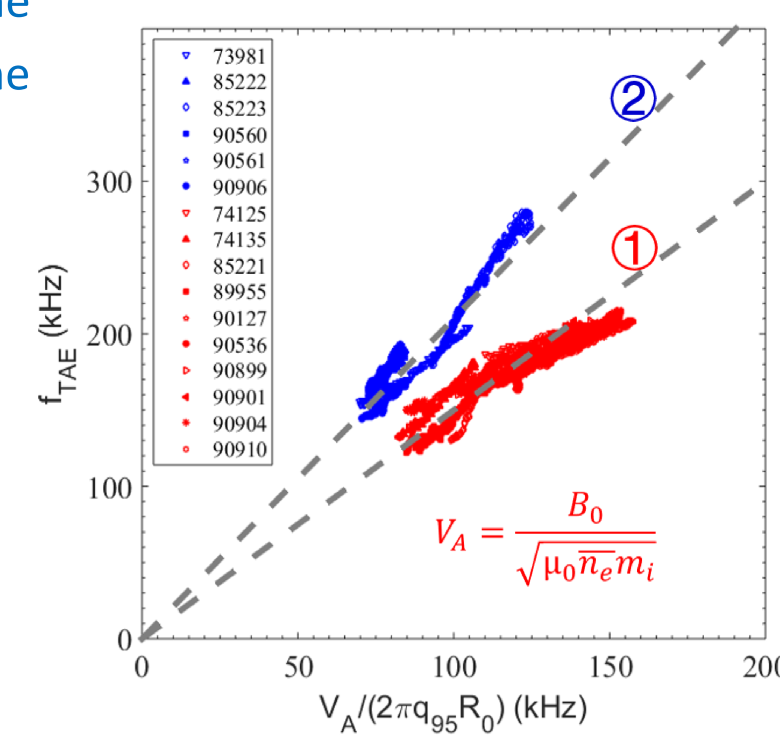


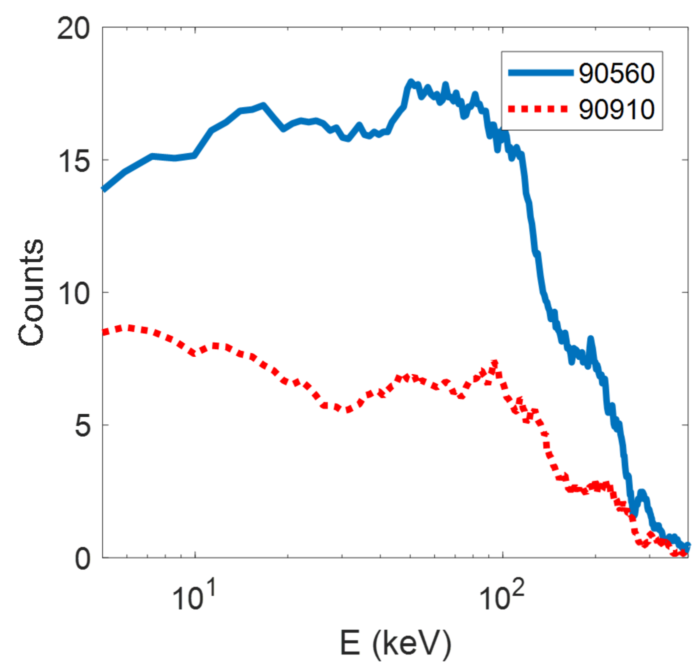
Toroidal Alfvén Eigenmodes driven by energetic electrons

High-frequency instabilities

- **Toroidal Alfvén eigenmode** are confirmed
  - ~160 kHz and n=1;
  - Driven by resonant interaction of the energetic electrons with the processional drift frequency.





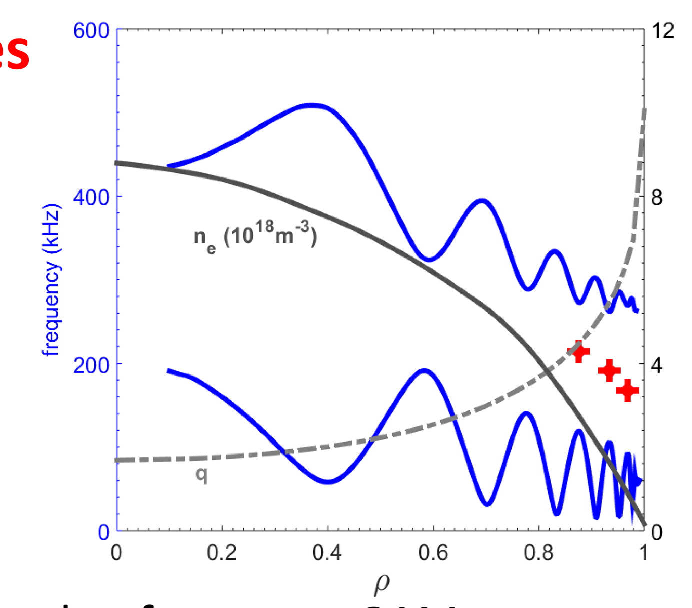


Two different linear relationships of TAEs frequency

- Abnormal result in series experiments:
  ① Small slope: lower frequency and lower density
  ② Large slope: higher frequency and higher density
- More energetic electrons in the same energy range with higher electron density

GAM and three high-frequency modes

- GAM
  - ~25 kHz and m/n=1/0.
- Toroidal Alfvén eigenmode
  - Simultaneously with GAMs;
  - n=1 and different poloidal mode;
  - **e-TAEs are confirmed;**
  - Uniform increment of these frequencies equal to frequency GAM:
    - **Resonant three-wave interactions** resolve the observation.



Conclusion

✓ Quiescent regime with a high RE current fraction are achieved by accessing very low density during ohmic flattop:
1. A threshold electric field, required for RE avalanche suppression have been experimentally observed;
2. ∇B drift direction has significant effects on RE energy distribution and E_{th}.

✓ Low toroidal mode number Alfvén eigenmodes(AE) excited by low-energy REs are clearly identified:
1. Different energy of energetic electrons resolves the different frequency characteristics of their exciting TAEs;
2. Three-wave interaction between e-TAEs and GAM have been identified.

Acknowledgements

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