Final Report # DOE-UCLA-0010424

DOE Award DE-SC0010424: Development of Long-Pulse Heating and Current Drive Actuators and Operational Techniques Compatible with a High-Z Divertor and First Wall

11/2/2017

Research task: RF effects on pedestal structure and SOL properties – SOL Reflectometer

Institution: University of California Los Angeles (UCLA)

Principle Investigator: Edward Doyle, UCLA

Prepared by: Guiding Wang, UCLA

I. Background

Accurate measurement of the edge electron density profile is essential to optimizing antenna coupling and assessment of impurity contamination. Measurement of the edge density profile has been demonstrated on C-Mod, DIII-D, and TFTR amongst many devices, and has been used for RF loading and impurity modeling calculations for many years. The goal of the funded UCLA work was to develop a similar capability on EAST. USTC has recently installed a profile reflectometer system on EAST based on the UCLA-designed reflectometer system on DIII-D. UCLA has been working with USTC to optimize the existing microwave antenna, waveguide system, microwave electronics, and data analysis to produce reliable edge density profiles.

II. Summary of progress made during the budget period

Progress has been made in three major areas:

(1) Effort to achieve reliable system operations under various EAST operational conditions, e.g. critical system components such as mixers need to survive long pulse plasmas with harsh radiations

- Notch filters to protect system from possible radiation due to the operation of the 140 GHz Electron Cyclotron Heating system on EAST has been installed.
- A remotely controlled shutter to protect the system from plasma radiation coming into the corrugated waveguide during 'bad' discharges has been installed and functional.

(2) Effort to optimize system performance

- System signal-to-noise ratio has been greatly improved as a result of reduced phase noise of the VCO source by increasing the optical path length of the receive channel. Figure 1 compares the normalized IF spectra as a function of frequency and time with fixed metal plate reflections before (left) and after (right) the path length increase in the receive channel. It indicates great improvements in signal-to-noise ratio and recovery of the linearization of the IF frequency after the path length increase.

(3) Effort to provide quality density profiles into EAST's database routinely

- Continued working with the EAST team for data acquisition and storage
- Continued improving algorithm for phase processing and density profile inversion. Figure 2 displays improved profiles across an L-H transition. It shows density profile evolution in the SOL and edge pedestal region.

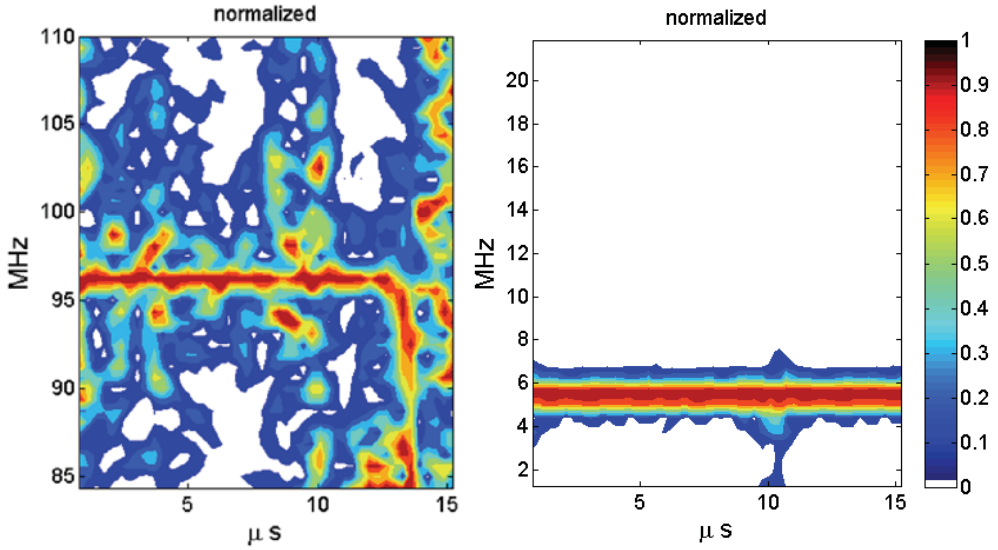

Figure 1. Normalized IF spectra from a fixed metal plate before (left) and after (right) the increase of the path length on the receive channel.

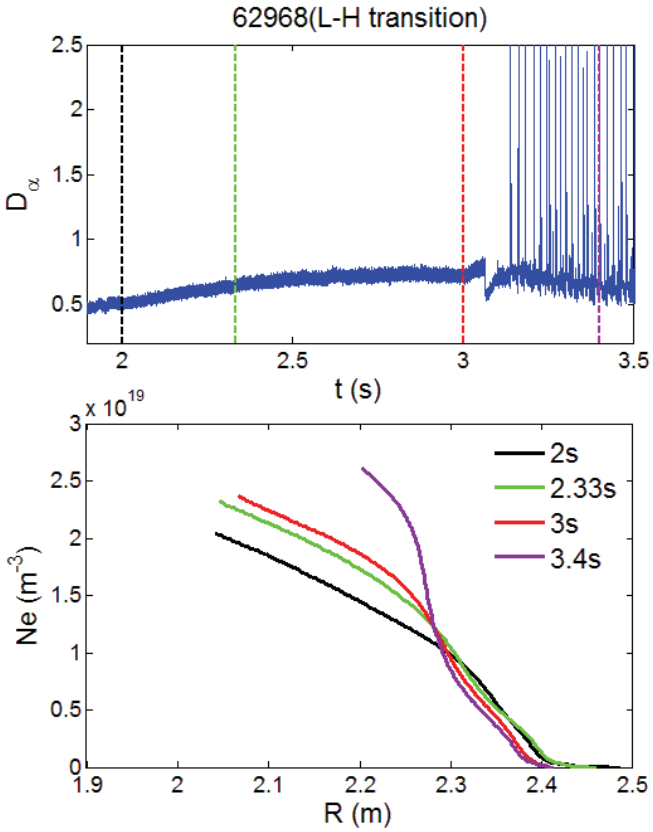

Figure 2. Example of USTC/EAST reflectometer measured density profile evolution from L- to H-mode plasmas. The L-H transition occurs at ~3.1 s.

III. EAST/USTC site visits during the budget period

EAST/USTC site visits by UCLA personnel are coordinated with Prof. Ahdi Liu at USTC according to systems conditions and EAST tokamak operation schedule.

1. Oct. 6-14, 2016 Guiding Wang, UCLA

2. Oct. 9-15, 2016 Edward Doyle, UCLA

IV. Publications and conference presentations during the budget period

1. Y. Sun, Y. Liang, Y.Q. Liu, S. Gu, X. Yang, W. Guo, T. Shi, M. Jia, L. Wang, B. Lyu, C. Zhou, A. Liu, Q. Zang, H. Liu, N. Chu, H. H. Wang, T. Zhang, J. Qian, L. Xu, K. He, D. Chen, B. Shen, X. Gong, X. Ji, S. Wang, M. Qi, Y. Song, Q. Yuan, Z. Sheng, G. Gao, P. Fu, and B. Wan, *Nonlinear Transition from Mitigation to Suppression of the Edge Localized Mode with Resonant Magnetic Perturbations in the EAST Tokamak*, **Phys. Rev. Lett.** 117, 115001 (2016).

2. Jianqiang Hu, Ahdi Liu, Chu Zhou, Xiaohui Zhang, Mingyuan Wang, Jin Zhang, Xi Feng, Hong Li, Jinlin Xie, Wandong Liu and Changxuan Yu, *An accurate automated technique for quasi-optics measurement of the microwave diagnostics for fusion plasma,* Plasma Sci. Technol. **19**, 084002 (2017).

3. C. Zhou, A.D. Liu, M.Y. Wang, J.Q. Hu, J. Zhang, H. Li, T. Lan, J.L. Xie, W.D. Liu and C.X. Yu, E.J. Doyle, G. Wang, *Doppler Back-Scattering Systems on EAST,* presented at the 32nd ITPA Diagnostics TG meeting, Chengdu, China, May 9-12, 2017.

4. J. Q. Hu, C. Zhou, A. D. Liu, M. Y. Wang, E. J. Doyle, W. A. Peebles, G. Wang, X. H. Zhang, J. Zhang, X. Feng, J. X. Ji, H. Li, T. Lan, J. L. Xie, W. X. Ding, W. D. Liu, and C. X. Yu, *An eight-channel Doppler backscattering system in the experimental advanced superconducting tokamak*, Rev. Sci. Instrum. **88**, 073504 (2017).