

# ID: 1116 Study of ITB formation and sustainment with optimized current profiles in the high-performance steady state plasma on EAST



H.Q.Liu<sup>1\*</sup>, Y.Q.Chu<sup>1</sup>, W. Z. Mao<sup>2</sup>, H.Lian<sup>1</sup>, S.X.Wang<sup>1</sup>, S.B.Zhang<sup>1</sup>, J.P. Qian<sup>1</sup>, Y. Yang<sup>1</sup>, L. Zeng<sup>1</sup>, J. L. Xie<sup>2</sup>, Y.X.Jie<sup>1</sup>, X. Gao<sup>1</sup>, X. Z. Gong<sup>1</sup>, W.X. Ding<sup>2</sup>, K. Hanada<sup>3</sup>, Y. F. Liang<sup>1</sup>, N. Xiang<sup>1</sup>, X.D. Zhang<sup>1</sup>, B.N. Wan<sup>1</sup> and EAST Team

<sup>1</sup>Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, China

<sup>2</sup>University of Science and Technology of China, Hefei, China

<sup>3</sup>Research Institute for Applied Mechanics, Kyushu University, Kasuga, Fukuoka, Japan

Email: hqliu@ipp.ac.cn

## ABSTRACT

- Improve high-performance steady state (SS) plasma operation has been achieved on EAST with high  $\beta$  and optimized of current profile. Better confinement with e-ITB was obtained with flat central safety factor  $q$  profile.
- The internal transport barrier (ITB) and edge transport barrier (ETB) are both observed with an optimized reverse shear  $q$  profile with MHDs like Alfvén cascades and reverse-sheared Alfvén eigenmode (RSAE).
- In the high-performance SS plasma, optimized current profiles and current induced fluctuations may play a role for ITB formation and sustainment. The ITBs with different current profiles and core fluctuations are presented..

## BACKGROUND

- Recently, improved high-performance plasma operation has been found the related high beta steady-state regime with optimization of current profile ( $\beta_p \sim 2.5$  &  $\beta_N \sim 1.9$  with ITB +ETB of using RF & NB and  $\beta_p \sim 1.9$  &  $\beta_N \sim 1.5$  with e-ITB + ETB of using pure RF) on EAST.
- The ITB formation and sustainment company with optimization of the current profiles, which seem to be due to different MHD-modes, similar with other devices.
- With reduced anomalous transport in core region, a high confinement performance could be achieved. In the past works, relations have been verified between ITB and factors like  $q$  profiles, MHD behaviors,  $E_r$  profiles, etc. ITB can be formed by changing  $q$  profiles with unaltered  $E \times B$  shearing rate, reducing turbulence growth rate plays a big role in better confinement. MHD behaviors are always mentioned with rational magnetic surface where The effect of ITB foot locally enhanced shear should be emphasized.

## EXPERIMENTAL SETUP

- Core magnetic fluctuation and reconstructed current profile dynamics are provided with the 11 chords polarimeter-interferometer. Corresponding diagnostics system configurations are shown in figure 1.
- Plasma parameters for the three high  $\beta_N$  discharges with ITB are shown in figure 2. Plasma current of #71326 and #80496 is 450kA, while for #71320 it is 400kA.. Maximum  $\beta_N$  for three shots are close around 1.9 while the lasting period is determined by different conditions.

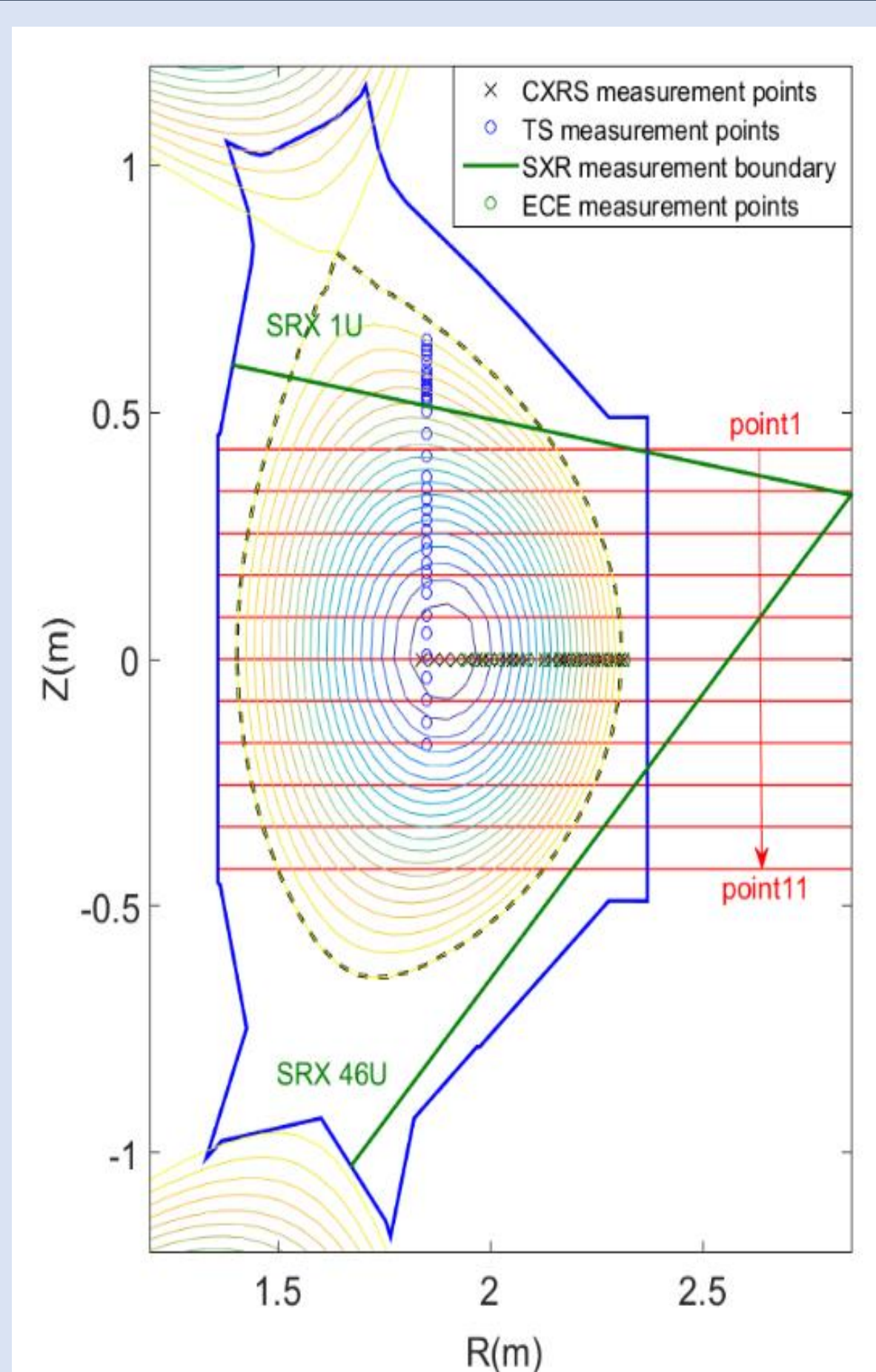


Figure 1 Poloidal view of main diagnostics for data analysis

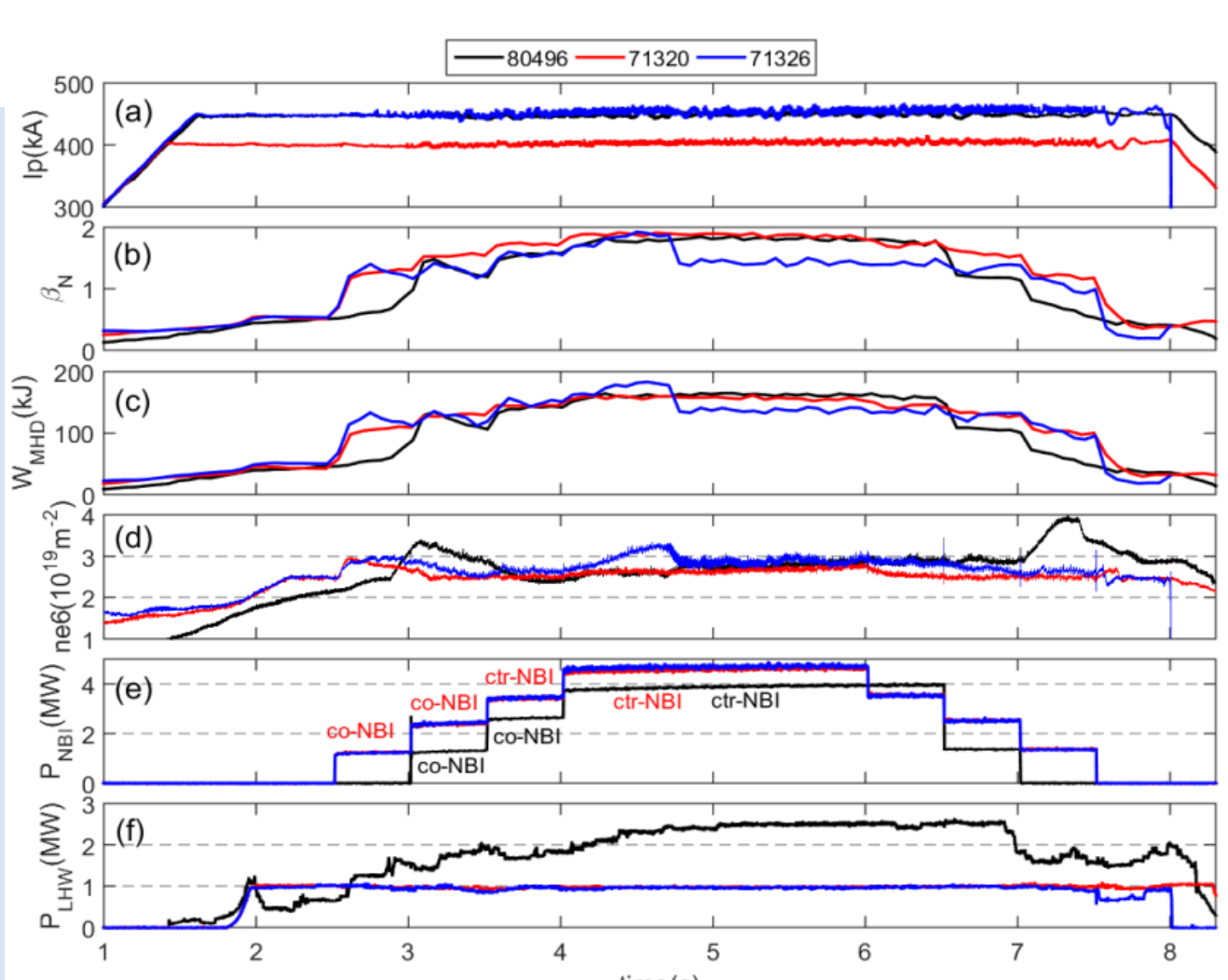


Figure 2 Three typical discharges, #80496(black line), #71320(red line), #71326(blue line).

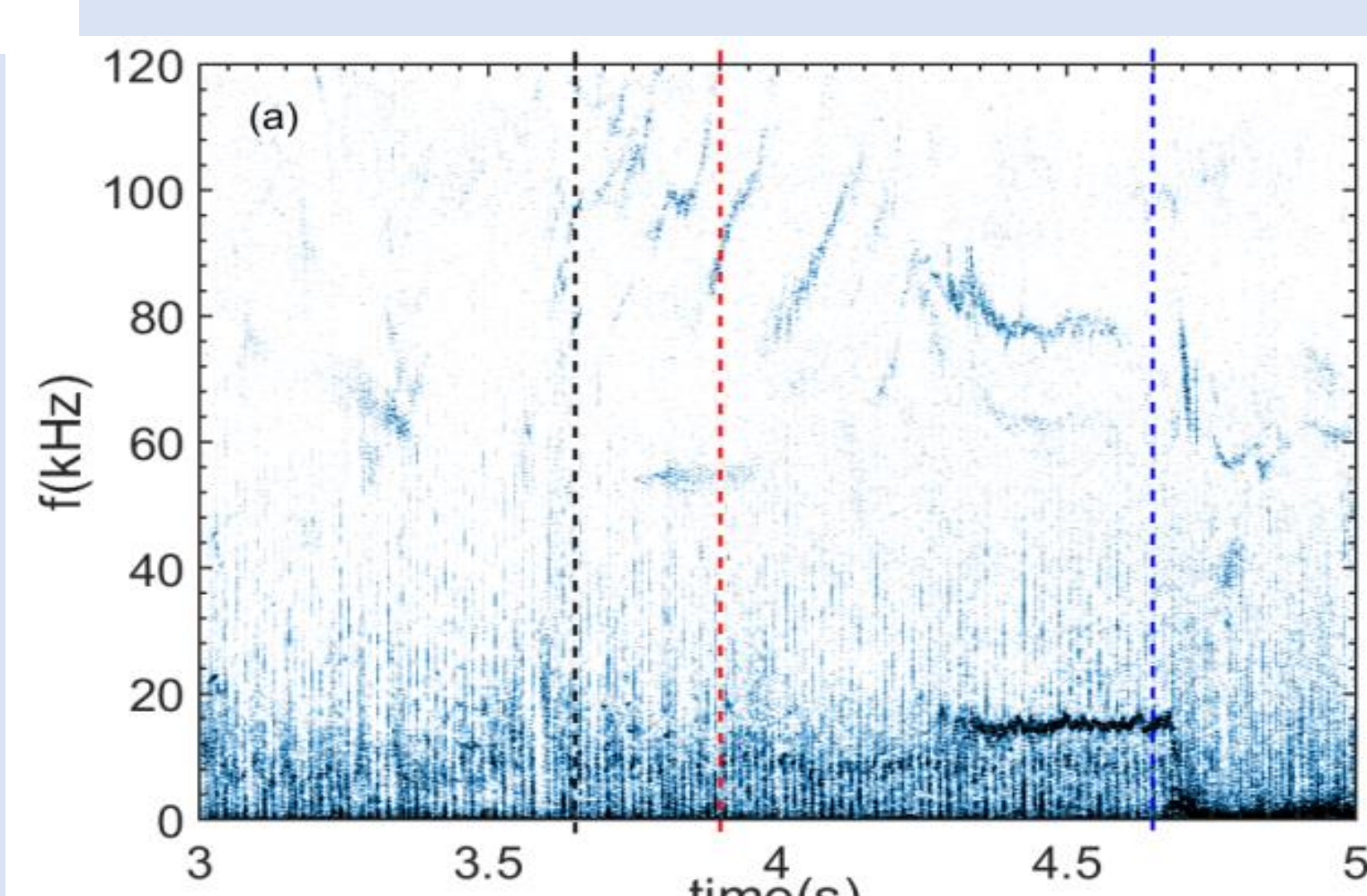


Figure 3 MHD observation in #71326

## EXPERIMENTAL RESULTS

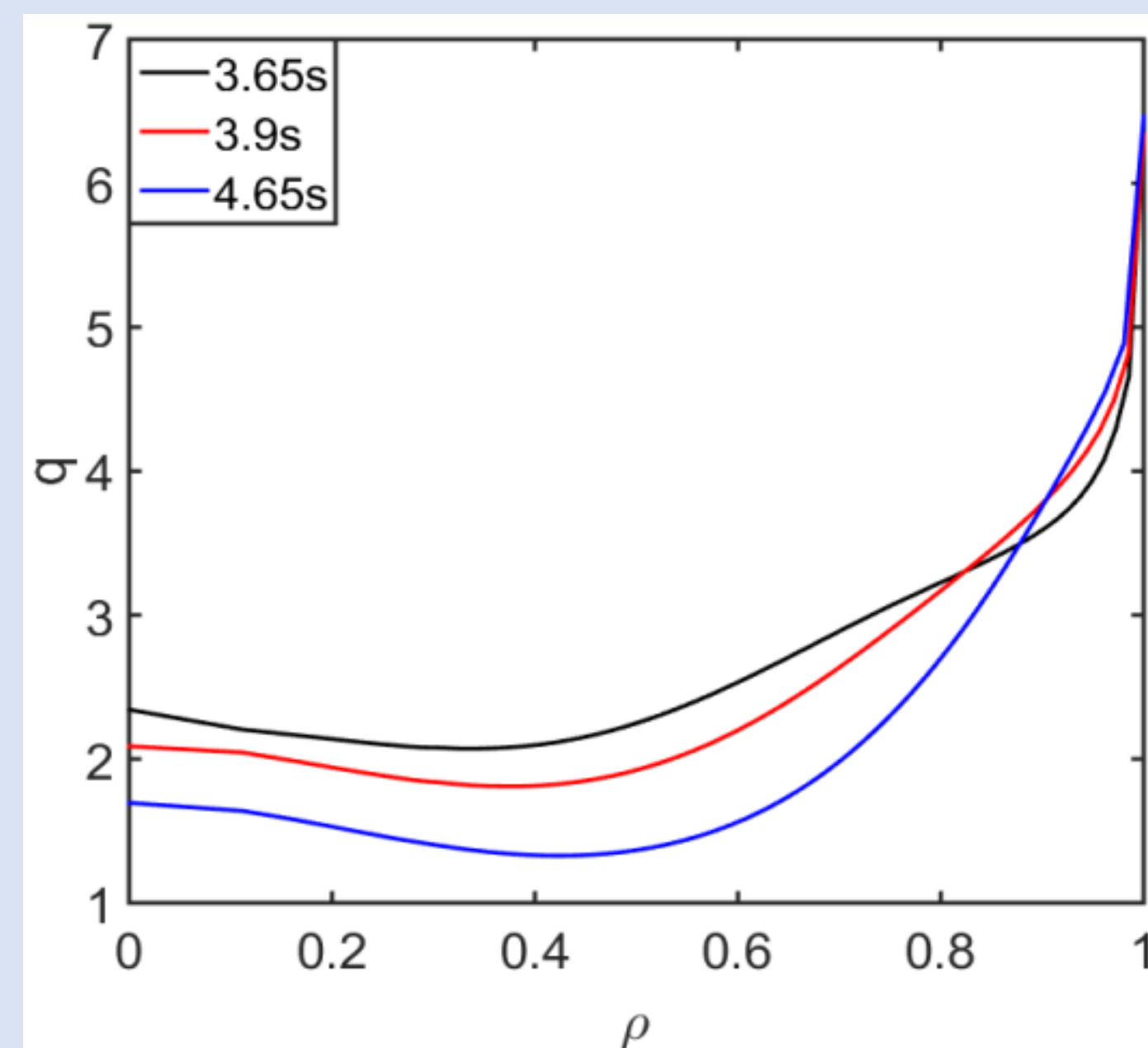


Figure 4  $q$  profiles of #71326 at 3.65s (black line), 3.9s (red line) and 4.65s (blue line).

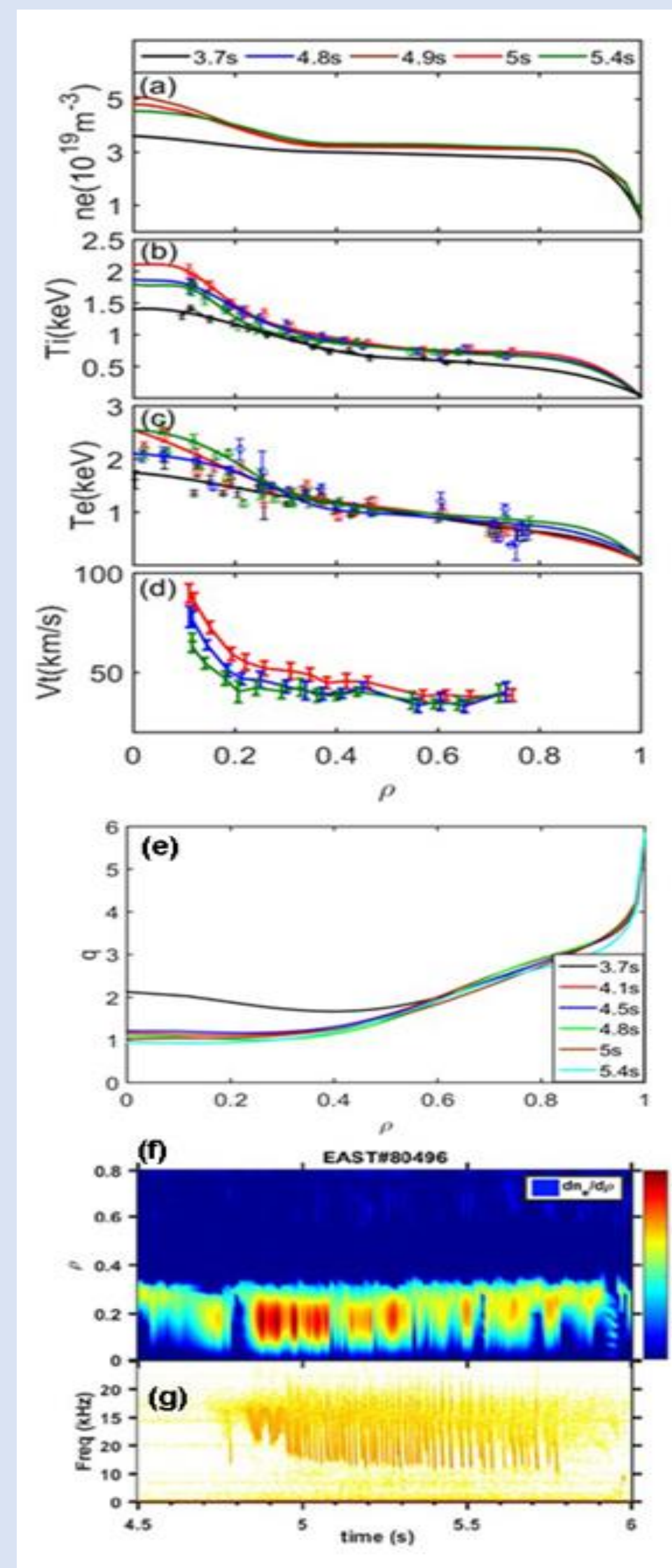


Figure 7 Kinetic profiles (a-d),  $q$  profiles (e) and the electron density gradient contour-plot (f) and the  $m/n = 1/1$  fishbone (g) analysis with ITB discharge #80496.

- ✓ RSAE is also observed with reverse shear  $q$  profile in 80496#

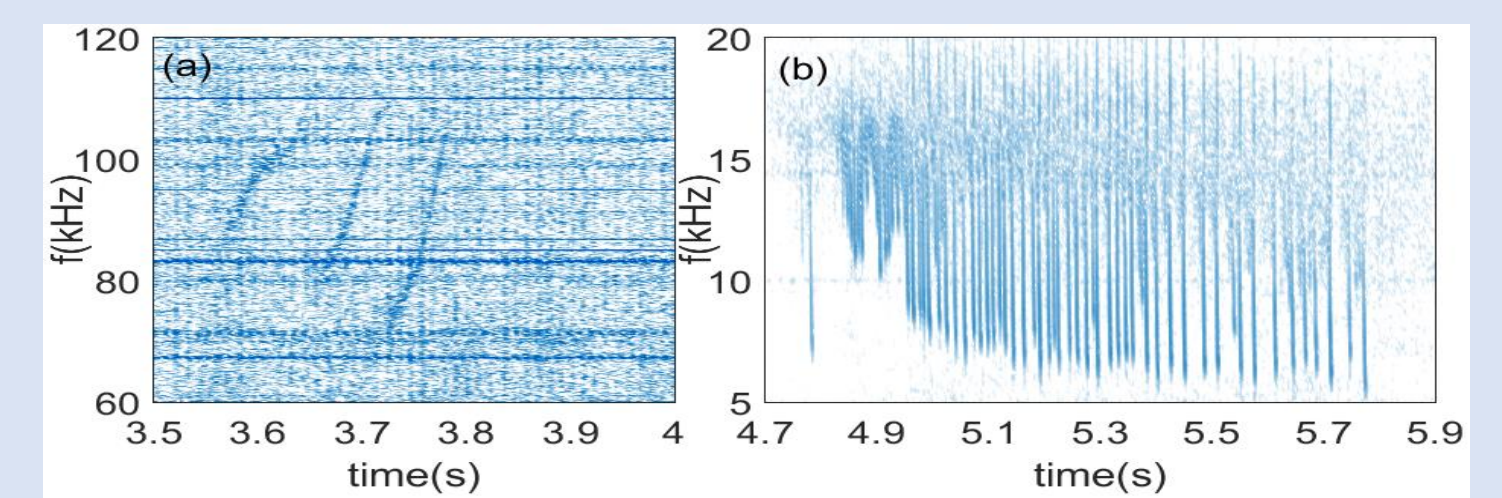


Figure 5 Spectrum of #80496, (a) RSAE, (b) fishbone instability.

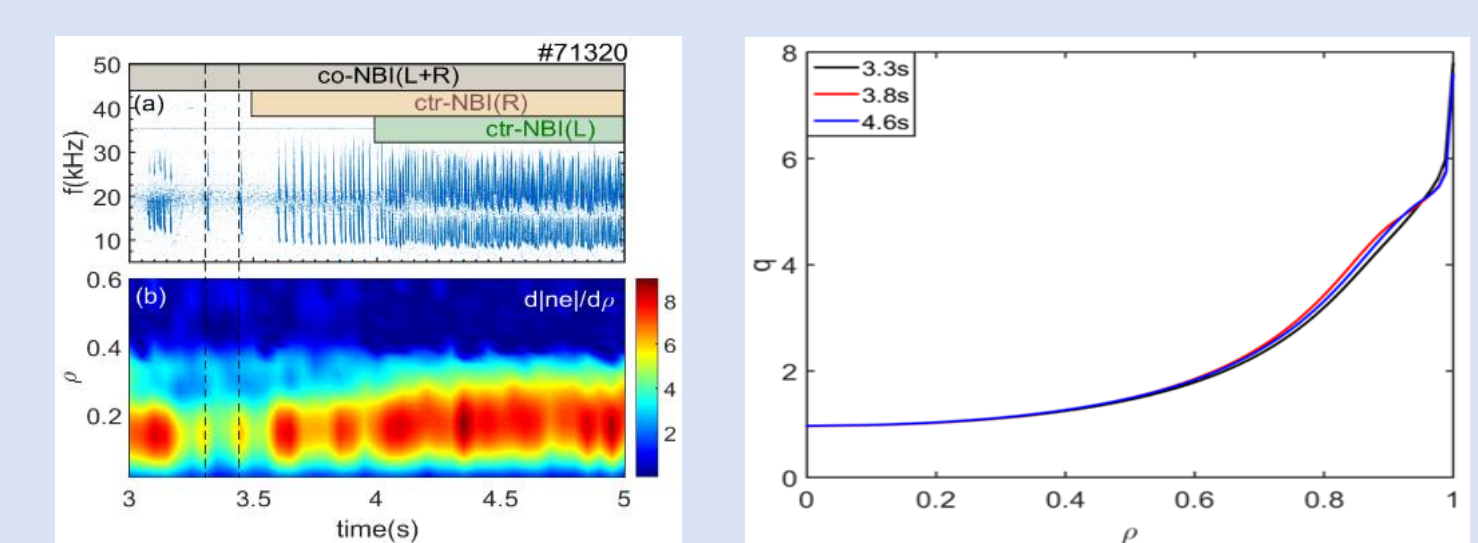


Figure 6 Fishbone was observed with flatten  $q$  profiles and  $q_0$  near to unit in #71320.

- ✓ The ITB and ETB are both observed with an optimized flat central  $q$  profile in the long-pulse high  $\beta_N$  operation, as shown in Figure 7..
- ✓ Further analysis shows that the  $m/n = 1/1$  fishbone signals located at the region of  $\rho=0.3$  which is consistent with central flat  $q$  profile and ITB region of electron density.

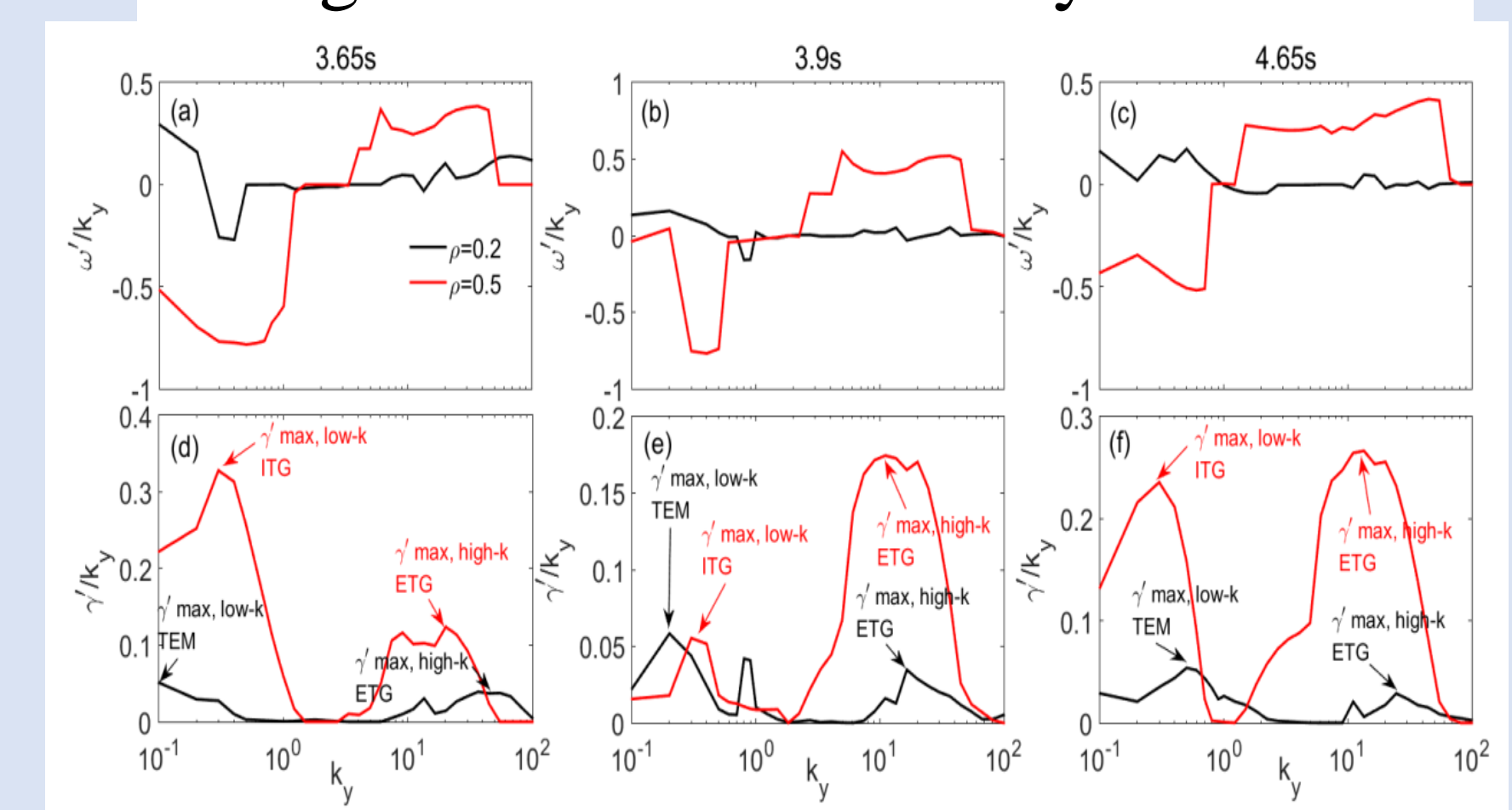


Figure. 8. Comparison of growth rate(d,e,f) and frequency spectrum(a,b,c) at different position( $r=0.2$  is black line,  $r=0.5$  is red line) in #71326.

- ✓ Suppression of ITG is strongly relevant with formation of Ti ITB.
- ✓ TEM is dominating in the core region and ITG is dominating in the outer region.

## CONCLUSION

- The 1/1 mode almost exists during the entire discharge period for improved H mode on EAST, and is a common phenomenon for many similar shots..
- The 1/1 mode might play important role in shaping current density profile and sustaining the ITB in the high-performance plasma on EAST.
- It is speculated that 1/1 modes may have interactions with background turbulence and play a role in current relaxation to sustain flat  $q$  profile and high-performance plasma with ITB..

## ACKNOWLEDGEMENTS

Work supported by National Key R&D Program of China under Grant No. 2017YFE0301205, 2019YFE03040000 and No.2017YFE0301705, This work is also supported in part by Key Program of Research and Development of Hefei Science Center, CAS with contract No. 2019HSC-KPRD001.