Core turbulence and comparison with gyro kinetic simulation in high Ti discharge of LHD

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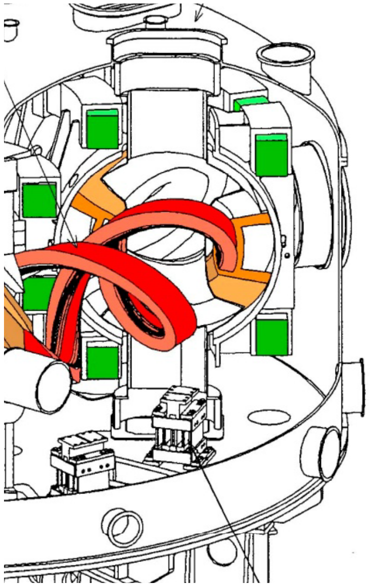
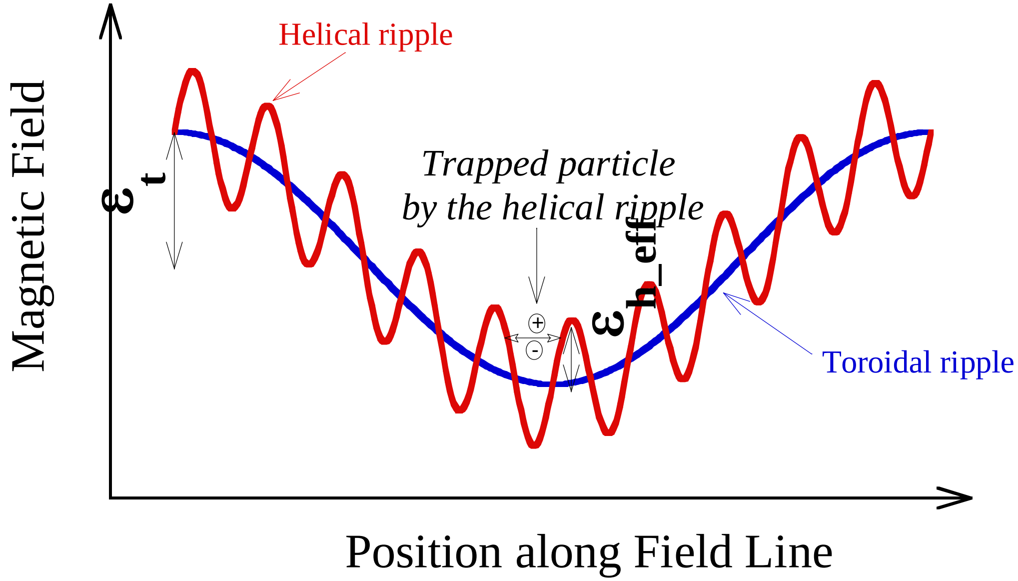
Outline

1. Characteristics of ITB like high Ti discharge in LHD
2. Turbulence of high Ti discharge measured by two dimensional phase contrast imaging
3. Comparison with gyro kinetic simulation
4. Summary

Magnetic configuration and profile character of LHD differs neoclassical and anomalous transport from tokamak.



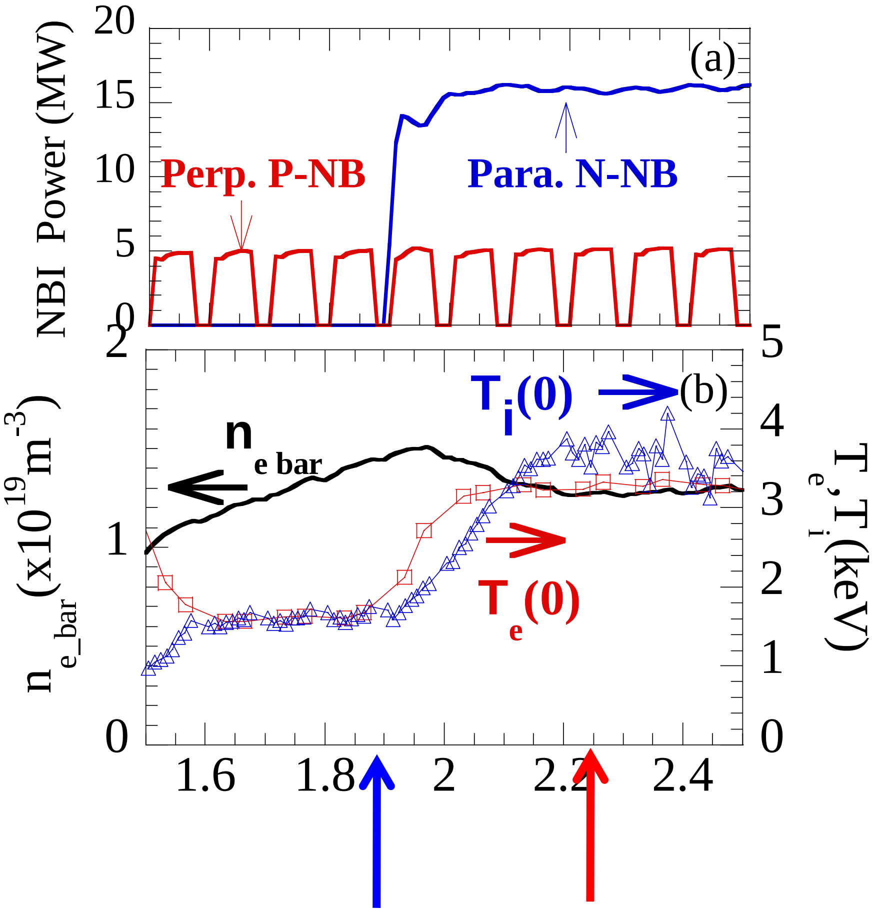


Large magnetic ripple 2% at ρ=0.5 ,5 % at ρ=1.0 (Rax=3.6m)
Enhancement of neoclassical transport
Reduction of γITG
Dumping of Zonal flow

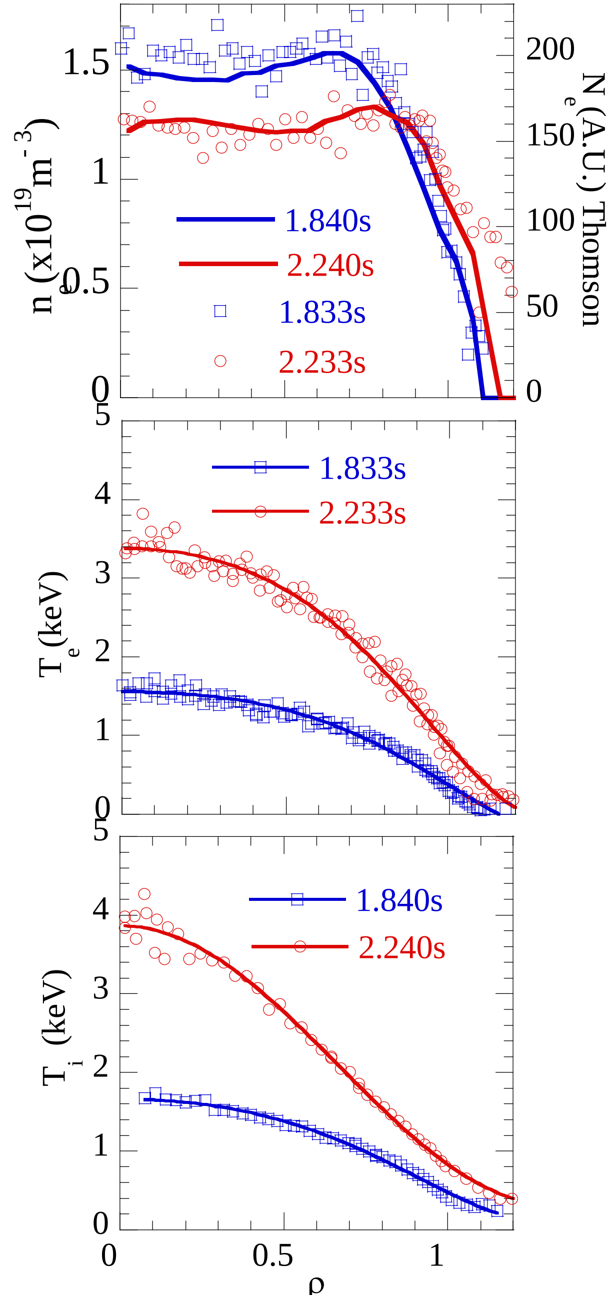
Density profile is flat or hollow.
R/Ln is insensitive ,R/Lti is sensitive to γITG

Small Er shear is likely in core (ρ<0.8) in the analyzed shot
ITG is not stabilized.

High Ti was achieved with combination of P-NB (perp. injected) and N-NB. (para. injected)



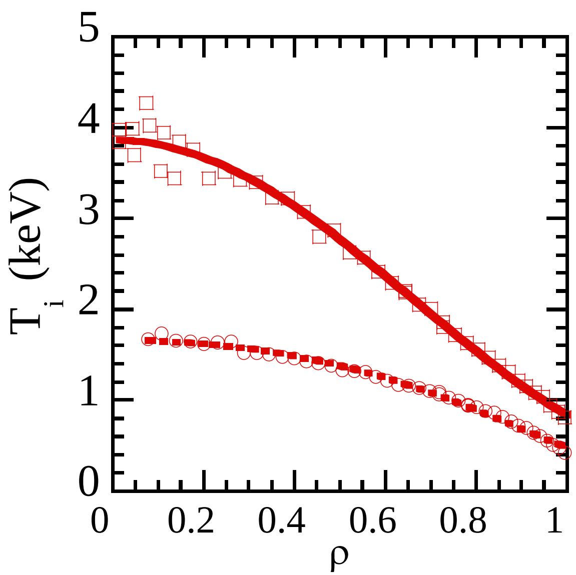
Low Ti phase **High Ti ITB phase**

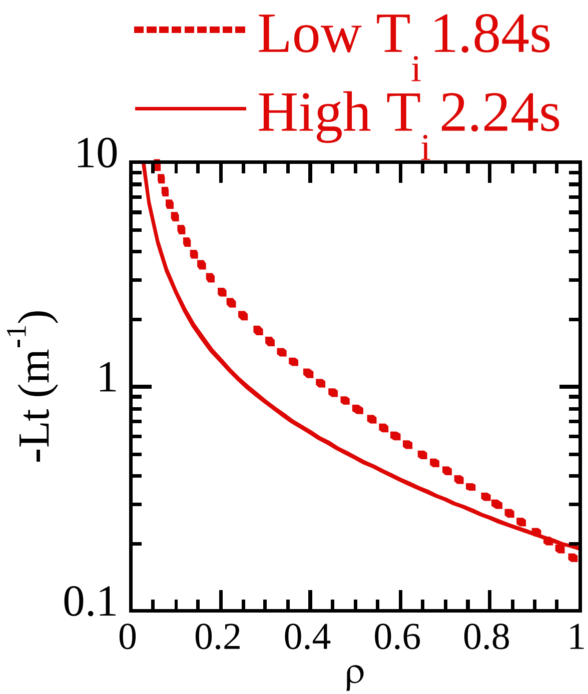


Hydrogen plasma

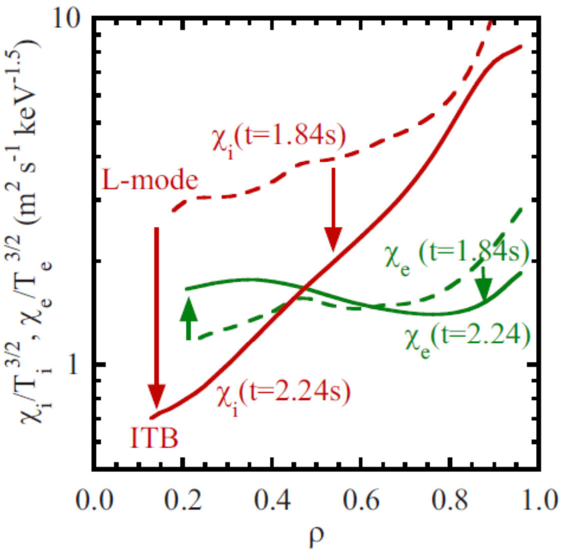
Ion transport improved at ITB phase compared with Gyro Bohm scaled χ_i, although, electron transport did not improve.

International stellarator scaling shows Gyro Bohm dependence $\chi \propto T^{1.5}/B^2$





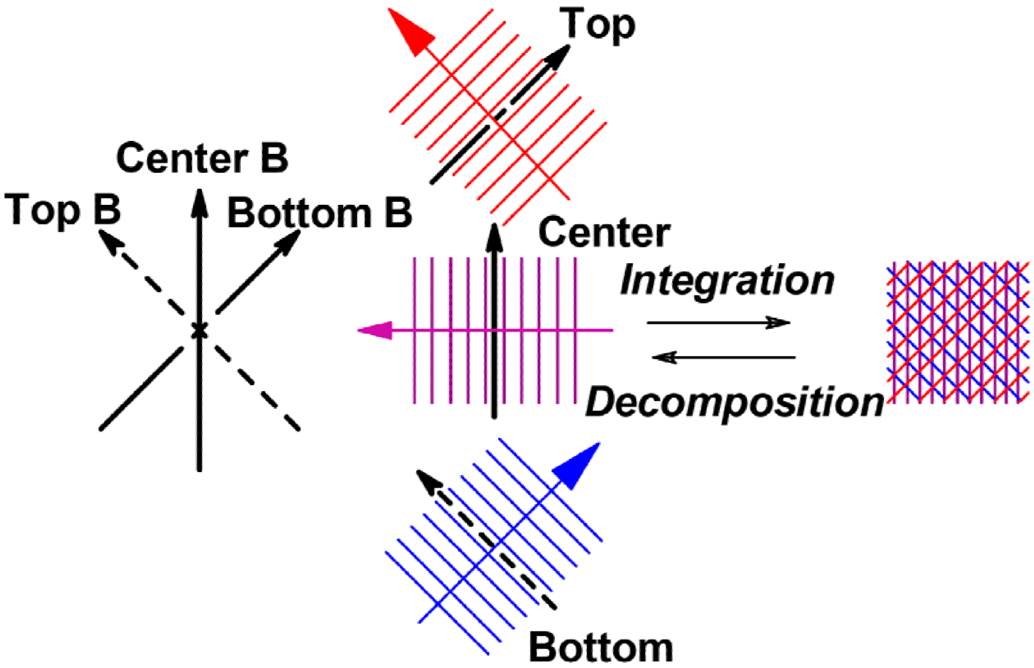
Ida et al., POP (2009)

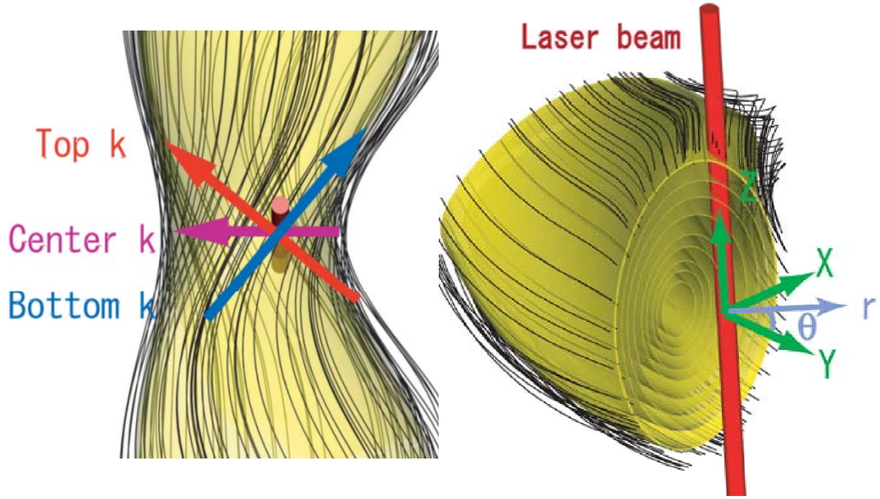


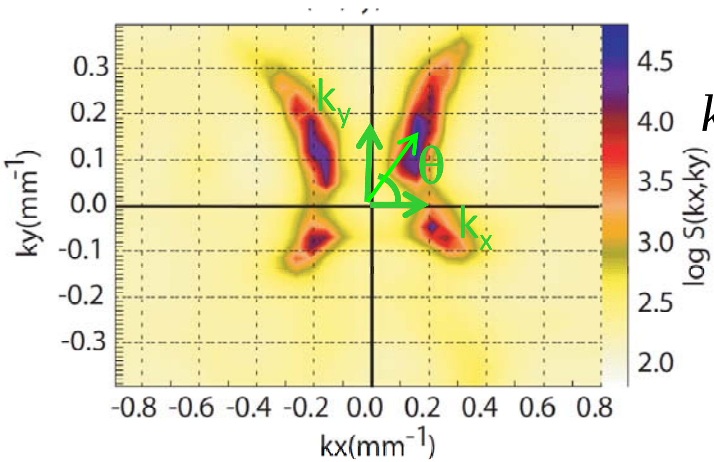
The improvement is clearer at more inner region.

Turbulence measurements with Two Dimensional Phase Contrast Imaging

K.Tanaka RSI (2008)

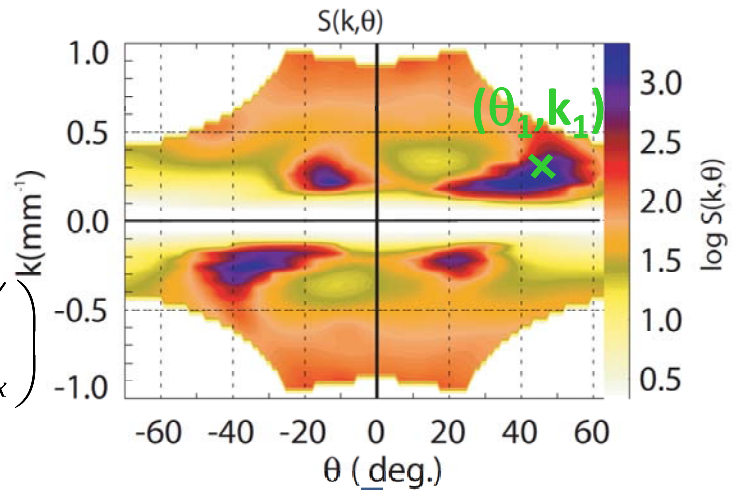






$$k = \sqrt{k_x{}^2 + k_y{}^2}$$

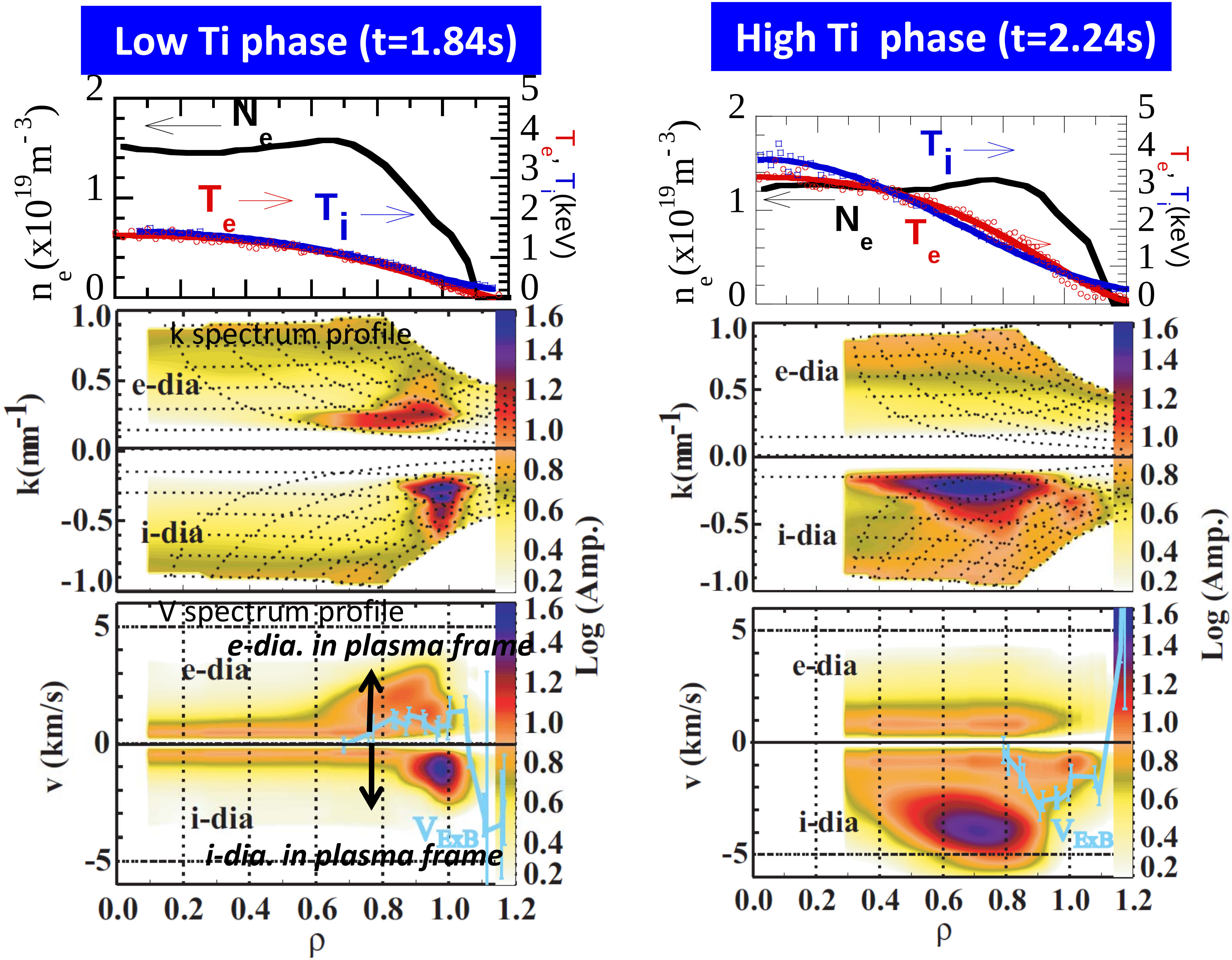
$$\theta = \tan^{-1}\left(k_y / k_x \right)$$



Vertical Position Z

S(k_x,k_y) in Cartesian Corrd.

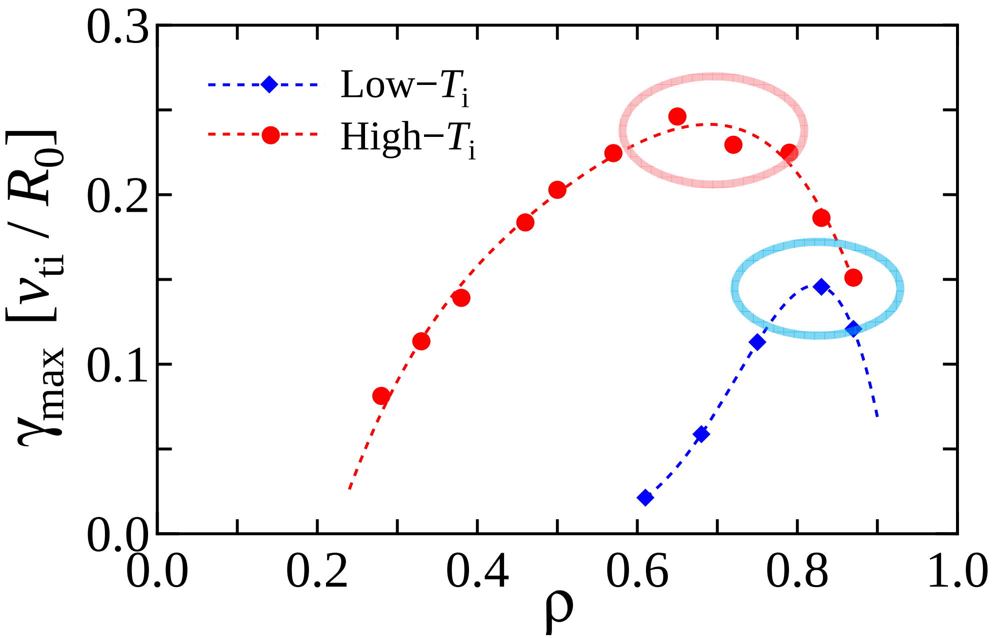
S(k,θ) in Polar Corrd.



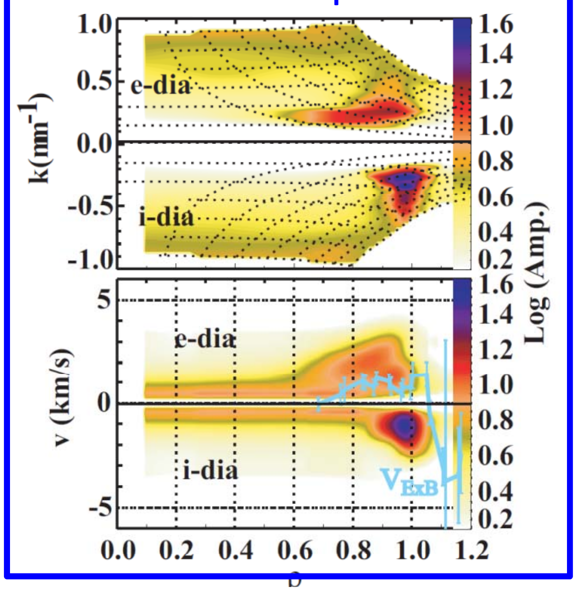
Low Ti phase (t=1.84s)
High Ti phase (t=2.24s)
N
e
T
e
T
i
n_e ($\times10^{19}$m^{-3})
T_e, T_i(keV)
k spectrum profile
e-dia
i-dia
k(mm^{-1})
Log (Amp.)
V spectrum profile
e-dia. in plasma frame
i-dia. in plasma frame
v (km/s)
V_{ExB}
ρ

The spatial peak of γ_{max} calculated by GKV-X (Nunami et al. PFR 2010) corresponds to the around the spatial peak of i-dia. fluctuation amplitude

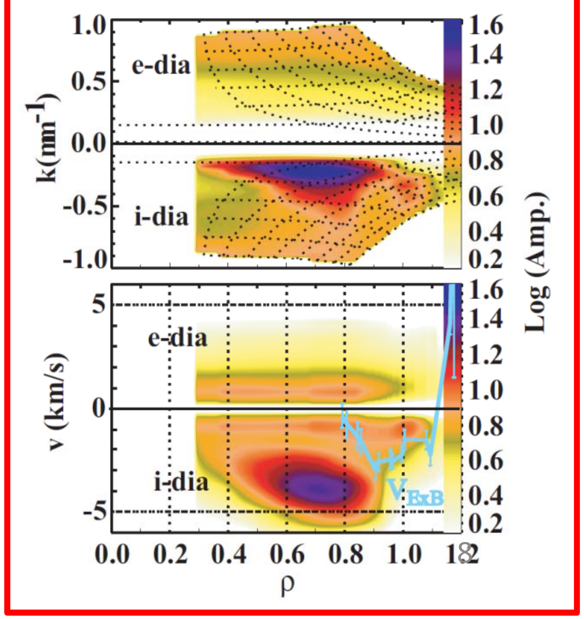
3D effects of the geometry is all included in calculation.



Low-T_i



High-T_i



Peaks of γ_{max}

Low-T_i phase

$\rho \sim 0.83$

$k_y\rho_i \sim 0.20$

High-T_i phase

$\rho \sim 0.65$

$k_y\rho_i \sim 0.35$

Peaks of i-dia. amp

Low-T_i phase

$\rho \sim 0.8\text{-}1.0$

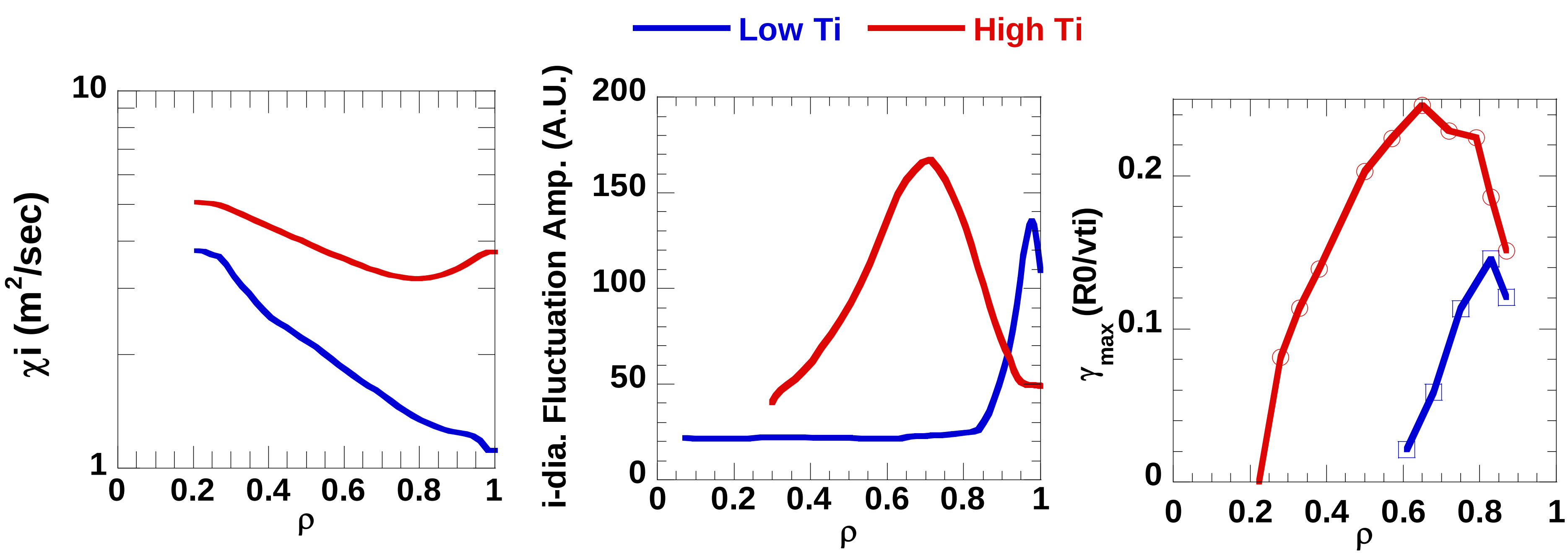
$k\,\rho_i \sim 0.26$

High-T_i phase

$\rho \sim 0.6\text{-}0.8$

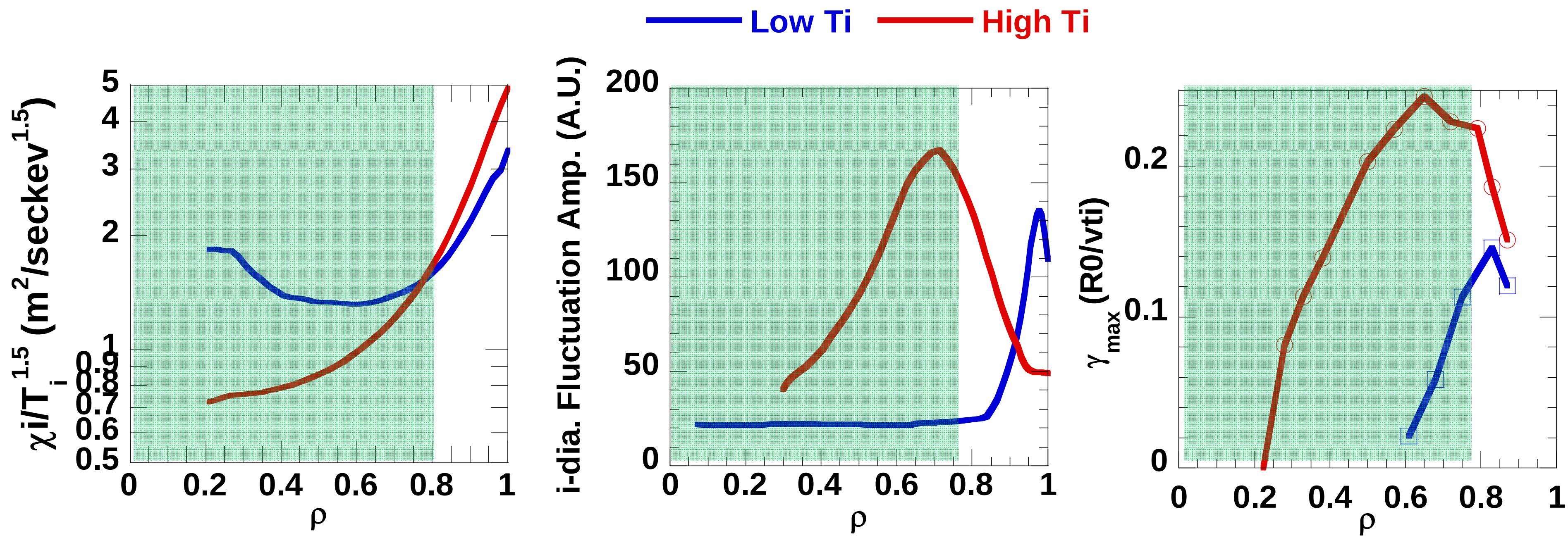
$k\,\rho_i \sim 0.45$

Comparison with confinements improvements



Absolute χ_i increases with increase of Ti.

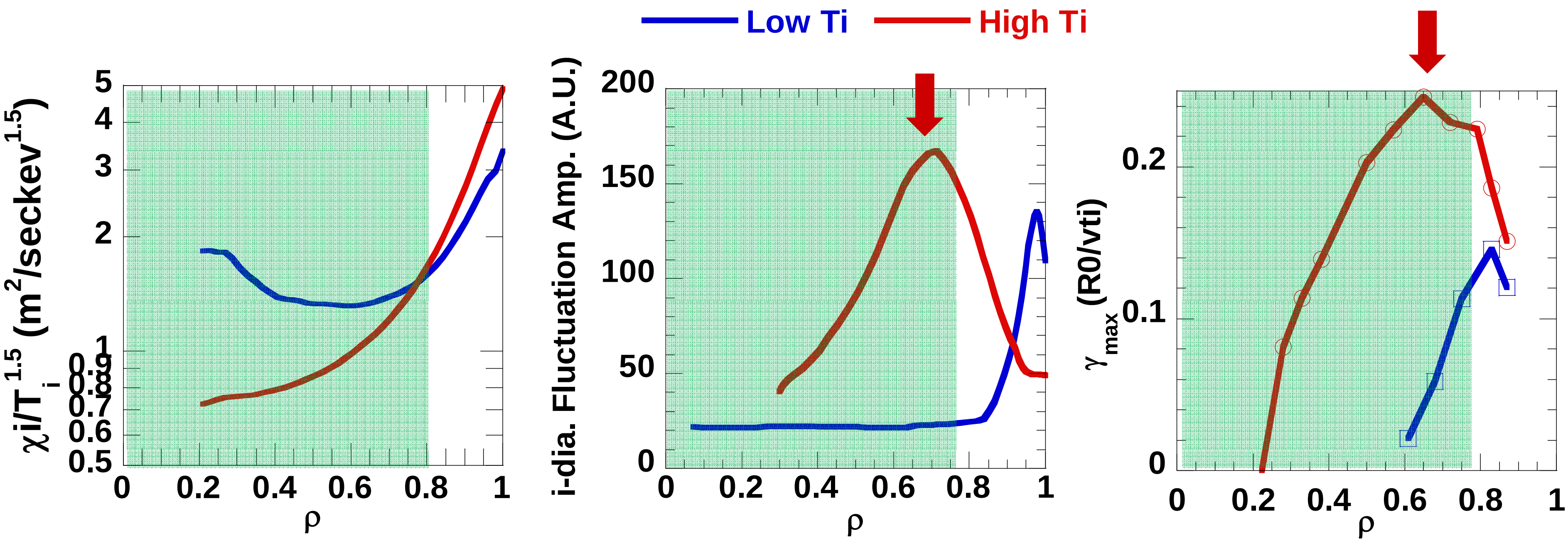
Comparison with confinements improvements



Absolute χ_i increases with increase of Ti.

Ion confinement improvement (relative to Gyro Bohm scaling) appears at ρ<0.8

Comparison with confinements improvements



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Ion confinement improvement (relative to Gyro Bohm scaling) appears at ρ<0.8

Fluctuation and growth rate peaks appears ρ~0.7 within improvements region.

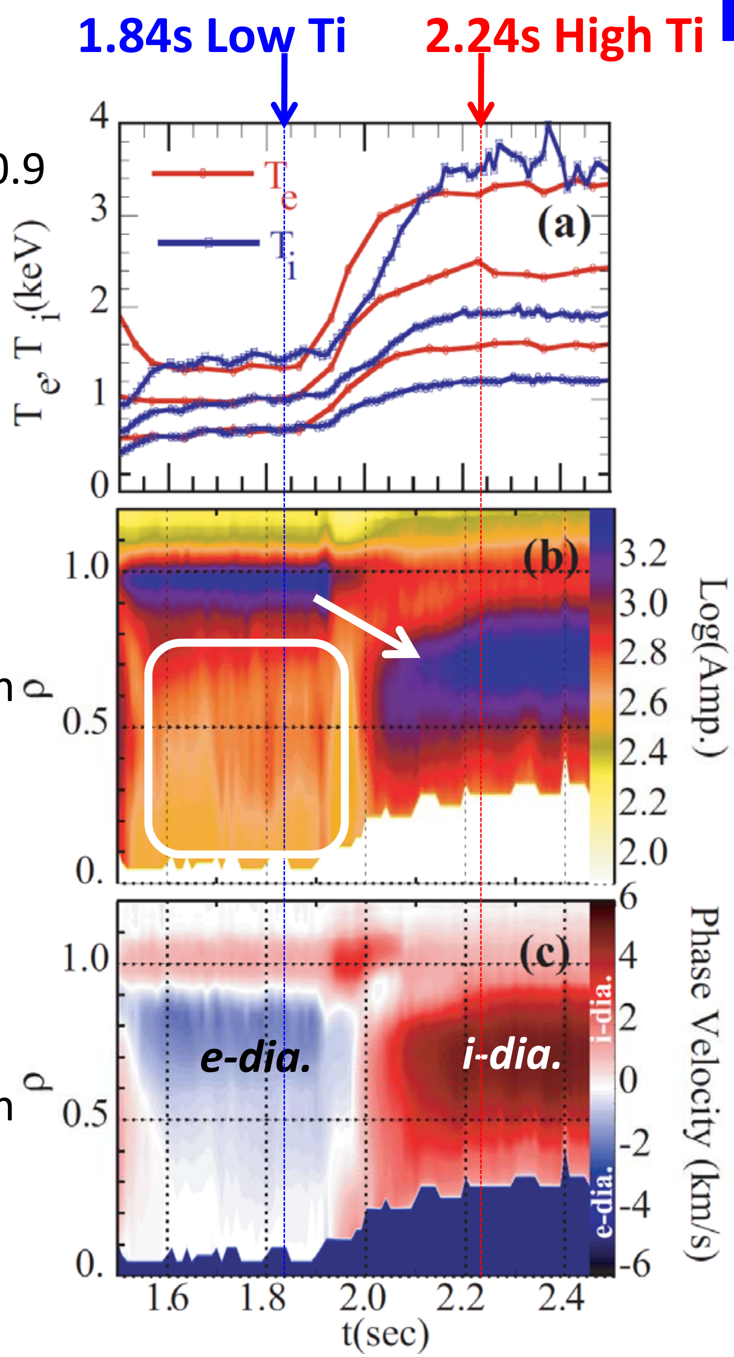
Fluctuation and growth rate does not move to further in , where confinement improvements are significant.

Questions from Temporal dynamics

ρ=0.3,0.7,0.9

Time history of fluctuation amplitude

Time history of fluctuation Velocity



Shifting or Switching?

What cause core Transport, where ITG is stable.

Summary

1. In high Ti discharge of LHD, turbulence was measured by 2D-PCI and compared with gyro kinetic simulation
2. The turbulence peaks localized in the edge in low Ti phase it moves to inward in the high Ti phase.
3. The propagation direction of the peak is likely to be ion diamag direction in plasma frame.
4. These observations are qualitatively agree with gyro kinetic linear simulation
5. Linkage with ion transport was not clear yet. →Fluctuation increase in improved region, but peak does not move to significant improvement region.
6. χi from non linear simulation agree with experimental anomalous χi within statistical error at ρ=0.46, 0.65
7. Temporal dynamics raises some questions of interpretations.