Analysis of EPH-mode transition mechanism based on the Gyro-Center Shift

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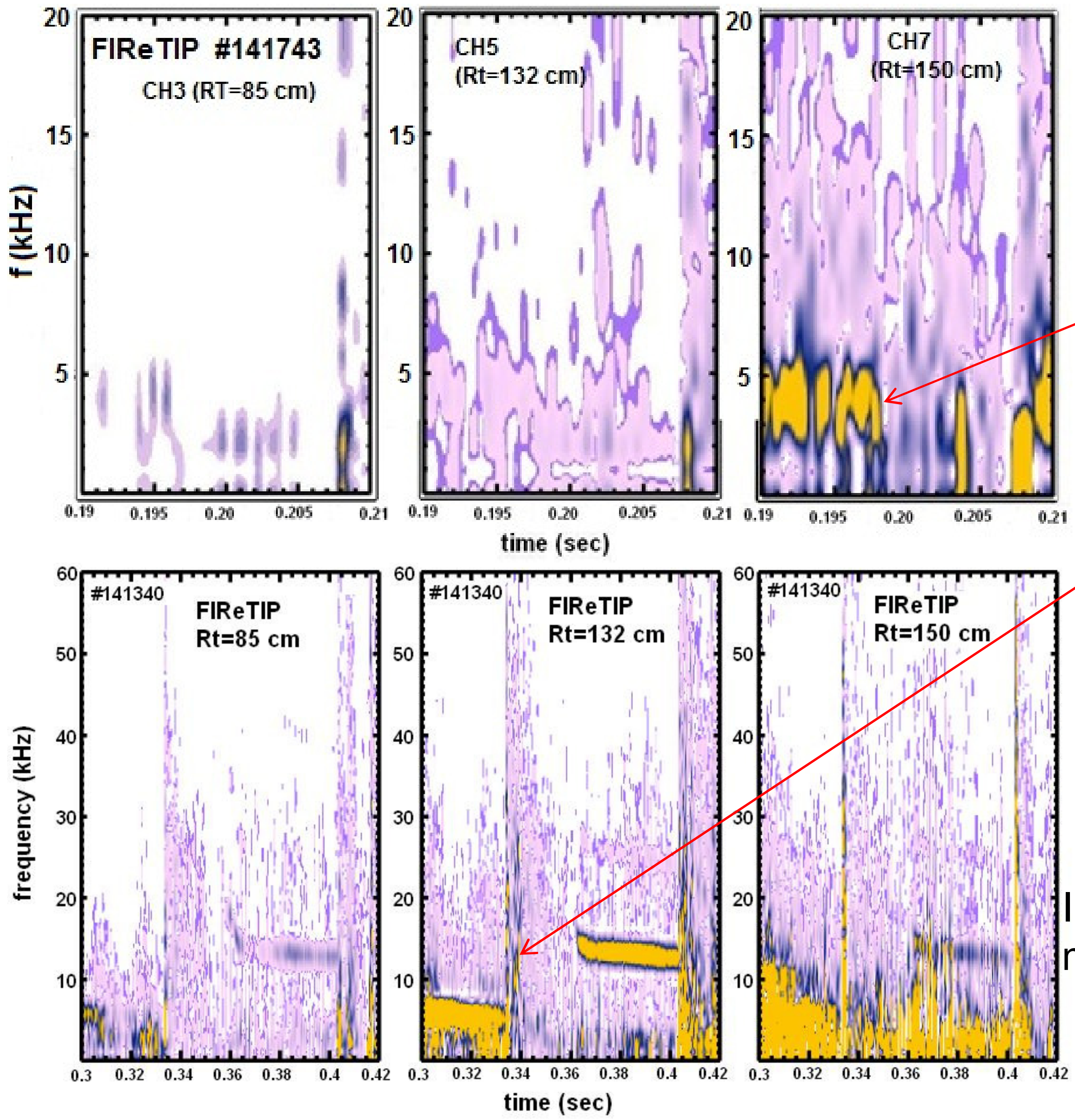
2010 NSTX result review

FIReTIP n_e fluctuation Spectrum
H-mode vs. EPH-mode



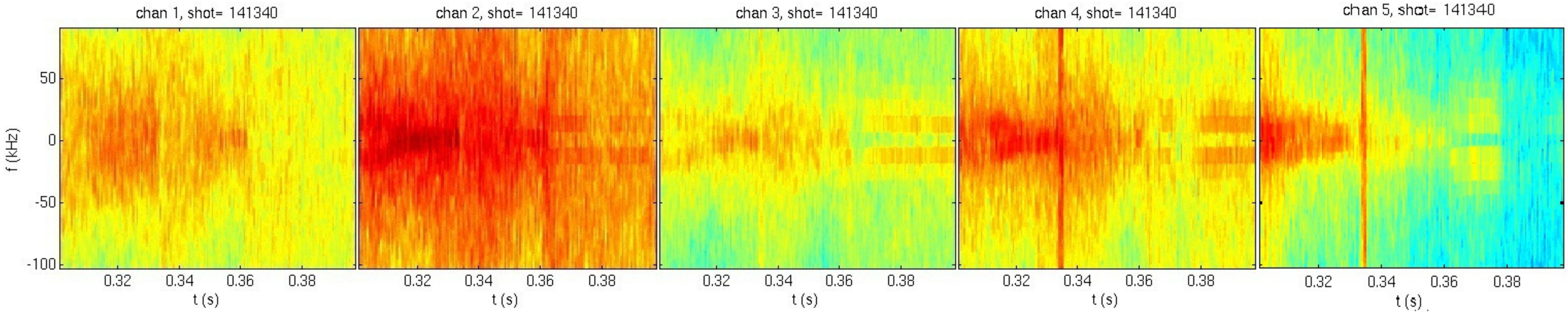
L\H Transition

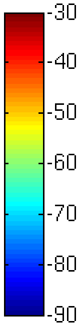
EPH- mode Transition

►Both reduced fluctuations but at different location

Intensity:
magenta < darkblue < yellow

High-k measurement also showed fluctuation reduction

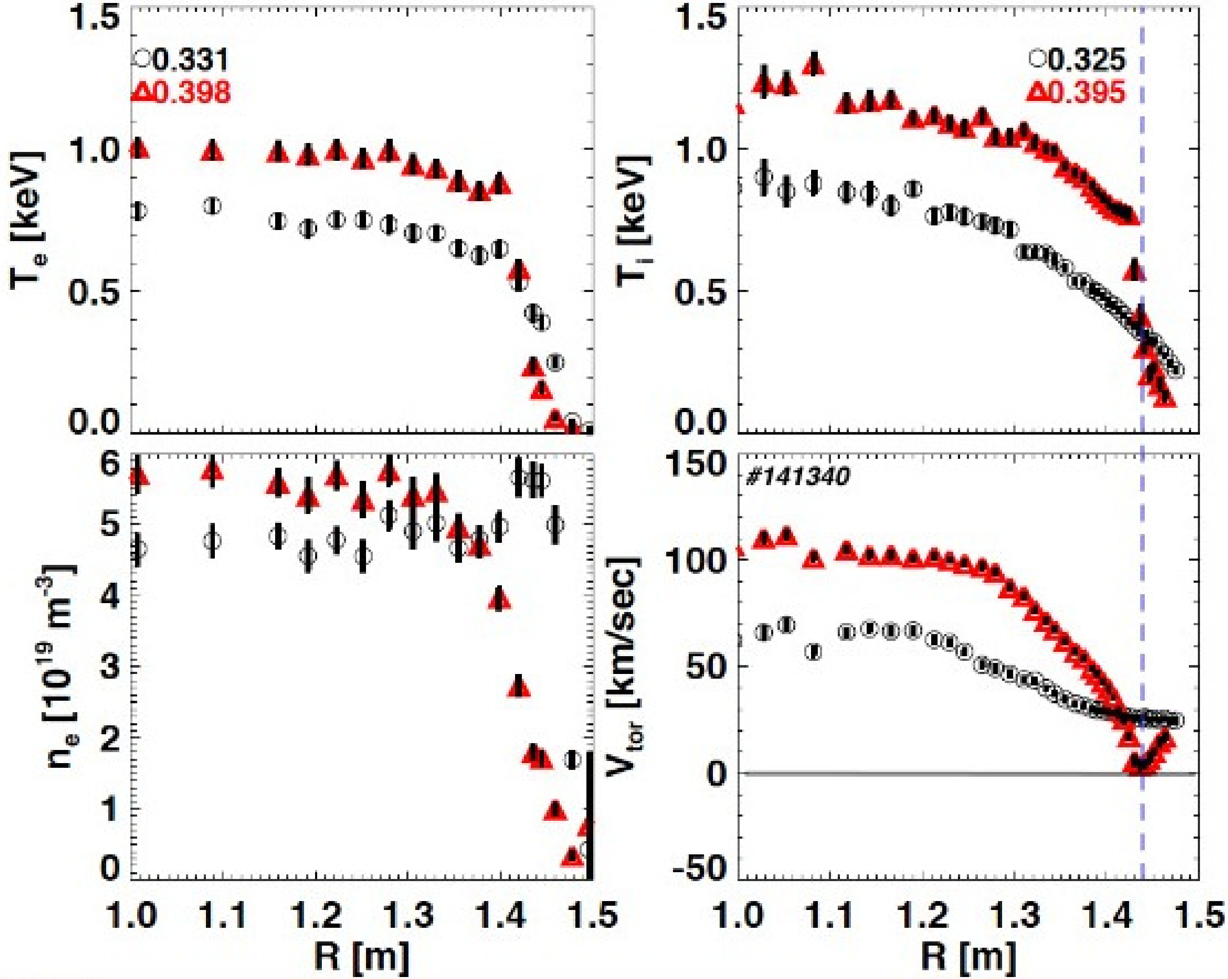




- ► **Scattering measured for R_T=143-144 cm**
- ► **most intensive Ch2 showed clear reduction at EPH transition**
- ► **Frequency range is similar to FIReTIP measurement**

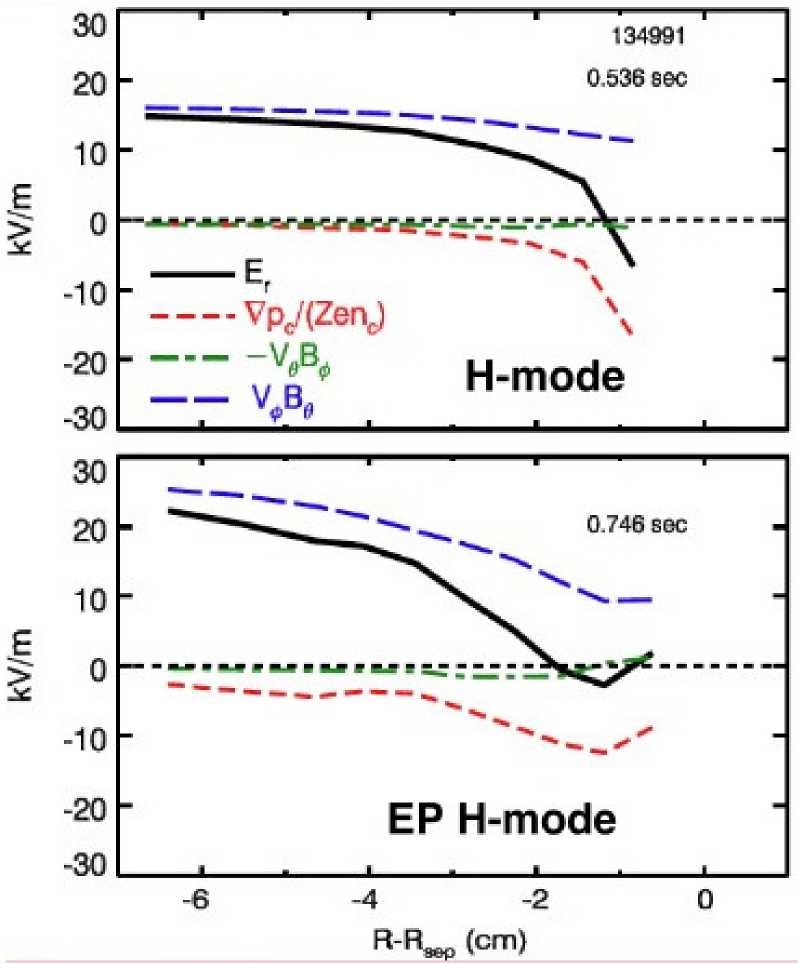
Both FIReTIP and High-k showed fluctuation reduction on EPH-mode transition at few cm inner location than normal H-mode transport barrier

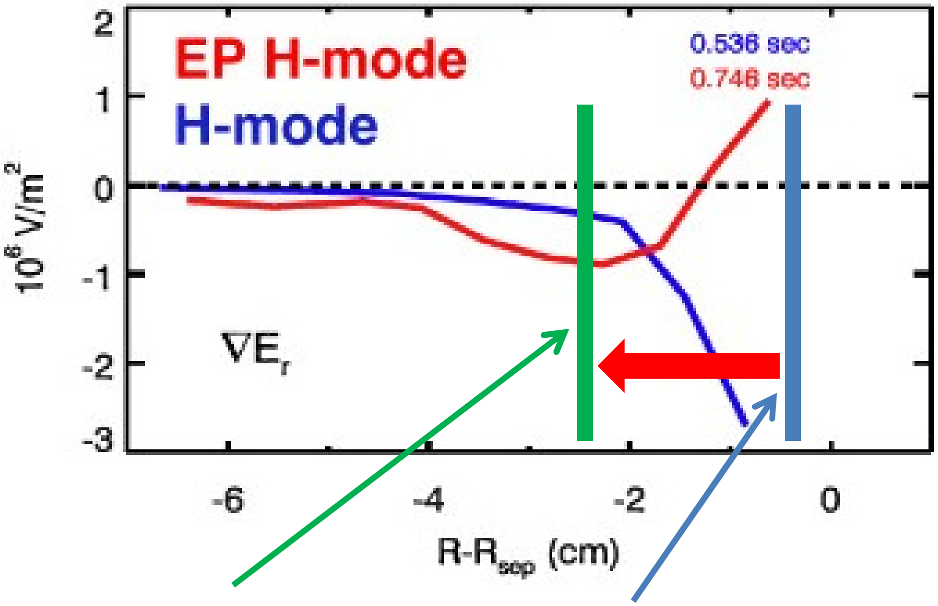
Profile changes before and after EPH-mode transition



[Maingi, APS DPP meeting 2010]

Er and grad Er changes before and after EPH-mode transition





EPH-mode transport barrier **H-mode transport barrier**

► **ExB shearing for EPH transport barrier is smaller than H-mode transport barrier.**

► **This suggest different analysis than ExB shearing for the turbulence suppression at the higher confinement transitions**

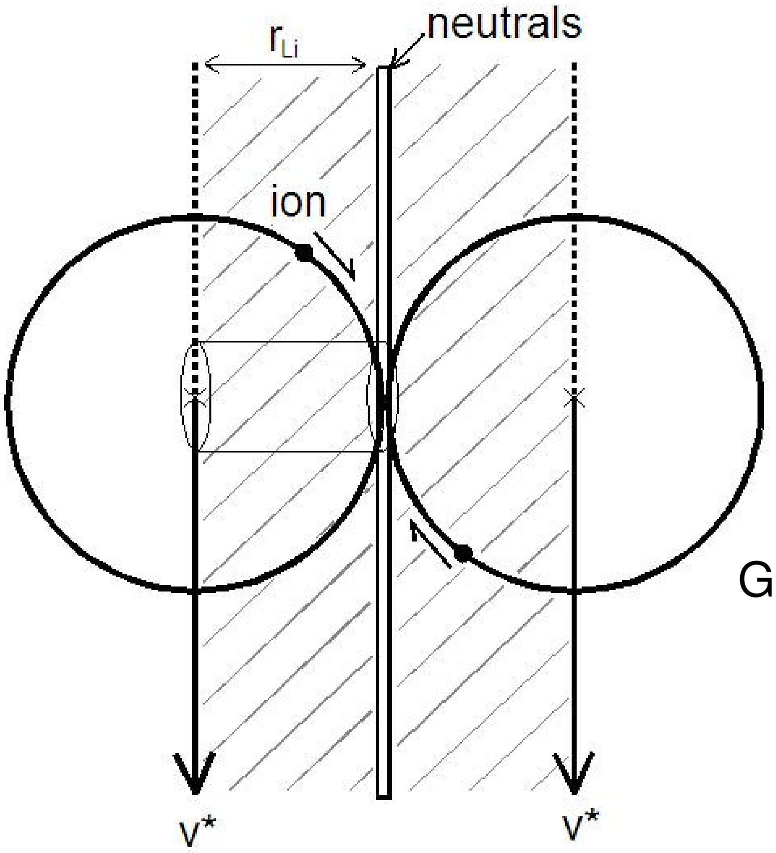
Analysis by Gyro-Center Shift theory

[Lee, PPCF 2009]

Turbulence

- ▶ ions and electrons move toward boundary => ***diffusion***
- ▶ charge (ρ) moves toward core => ***dilution current =>*** **saturation condition**

$$\boxed{J_r^{GCS} = e n_i \frac{r_{Li}}{\lambda_{i-n}} \underbrace{\left(\frac{E}{B} - \frac{1}{eB}\frac{\nabla P_i}{n_i} + \frac{kT_i}{eB}\frac{\nabla n_n}{n_n}\right)}_{v^*}}$$



Inertia force

$$\mathrm{Re} \equiv \frac{n_i m_i \upsilon^{*2} / r_{Li}}{n_i m_i \nu_{i-n} \upsilon^*} = \frac{eB}{kT_i}\lambda_{i-n}\upsilon^*$$

viscosity force

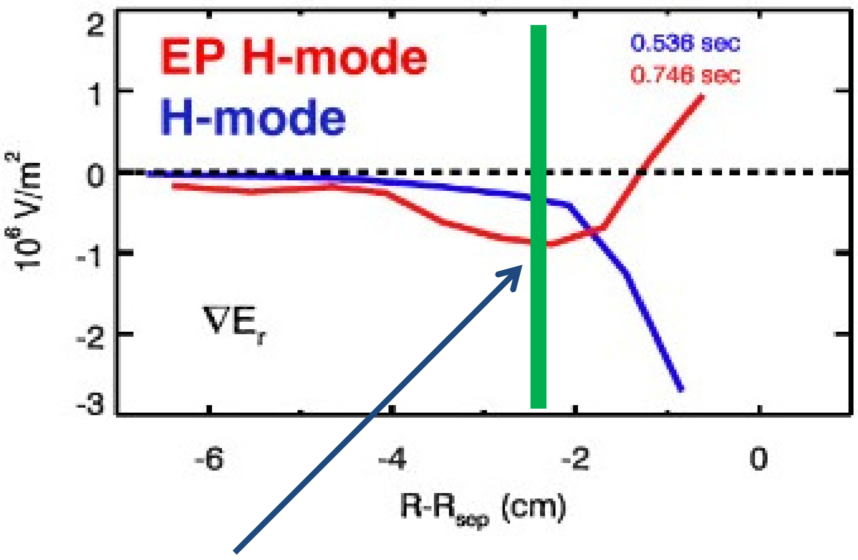
(saturation condition : $J_r^{GCS} = D\nabla\rho$)

$$\mathrm{Re} = \frac{2}{\pi}\eta^2 \frac{B}{m_i n_i (\sigma_{i-n} n_n)^2 \upsilon_\perp}\nabla\rho$$

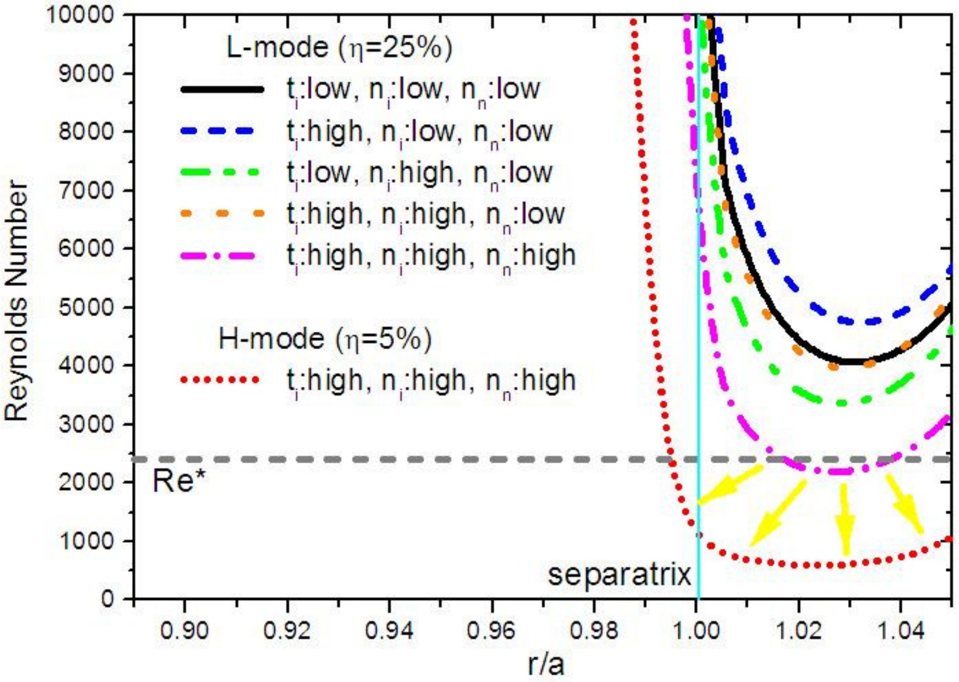
Gauss's law in slab geometry $\nabla E = \frac{\rho}{2\varepsilon_0}$

$$\boxed{\mathrm{Re} = \frac{4\varepsilon_0}{\pi}\eta^2 \frac{B}{m_i n_i (\sigma_{i-n} n_n)^2 \upsilon_\perp}\nabla^2 E}$$

Re for H-mode and EPH-mode transitions



$\nabla^2 E \to 0$ (Inflection point)



$$\boxed{\mathrm{Re} = \frac{4\varepsilon_0}{\pi}\eta^2 \frac{B}{m_i n_i (\sigma_{i-n} n_n)^2 \upsilon_\perp} \nabla^2 E}$$

- ► **for normal H-mode,** $\left|\nabla^2 E\right| > 0$ **and n_n determines Re profile**
- ► **for EPH-mode,** $\nabla^2 E \to 0$ **and Re < Re***

Summary

1. FIReTIP & High-k density fluctuation measurement showed reduction at EPH-mode transition similar to L\H transition

2. Location of EPH-mode transport barrier is few cm inside of normal H-mode edge transport barrier

3. Mechanism of turbulence suppression by ExB shearing is hard to apply for EPH-mode transition.

4. Reynolds number by Gyro-Center shift become smaller than critical value at EPH-mode transition by $\nabla^2 E \to 0$

5. Coincidence of q=3 rational surface with EPH-mode triggering is possibly explained as polodal localized plasma feature can stay longer in rational surface so that it makes easy for transition.

6. Artificial triggering of EPH-mode using n=3 applied field needs to be investigated in conjunction with q=3 coincidence.