Comparison of Critical Values of R/L_{Te} for ETG Modes Based on an Analytic Expression with GKS Simulations for DIII-D Discharges

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Motivation

- Understanding electron thermal transport remains a key area of study in the overall understanding of transport in tokamak plasmas.
- Electron Temperature Gradient (ETG) modes can lead to enhanced electron heat flux when coupling of these modes leads to the formation of so called streamers.
- Full gyrokinetic stability (GKS) code calculations can be used to find the critical electron temperature gradient scale length for ETG modes but the code requires significant computing time.
- An analytic expression for $(R/L_{Te})_{crit}$ can be useful if accurate enough

$\therefore$ Compare an analytic expression for $(R/L_{Te})_{crit}$ with GKS code results

Expression for $(R/L_{Te})_{crit}$ for ETG Modes From Jenko*

$$(R/L_{T_e})_{crit} = \max\{(1+\tau)(1.33+1.91s/q) \\ x(1-1.5\varepsilon)[1+0.3\varepsilon(d\kappa/d\varepsilon)],\ 0.8R/L_n\}$$

For magnetic shear s ≥ 0.2

and normalized pressure gradient α ≤ 0.1

Where s = (r/q)(dq/dr) ; α = -q^2R(dβ/dr) ; τ = Z_{eff}(T_e/T_i) ;

ε = r/R_0 ; κ = elongation and R/L_n = (R/n)(dn/dr)

*F. Jenko, W. Dorland and G.W. Hammett, Phys. Plasmas **8** (2001) 4096

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Experimental Profiles From DIII-D Discharges Used For Comparison

- **Three pairs of discharges studied**
  - **L-mode vs H-mode: compares varying T_e/T_i with both T_e and T_i varied**
  - **L-mode pair 107564 and 107567: vary T_e/T_i with fixed T_i**
  - **L-mode pair 106740 and 106748: vary s/q by varying q**

- **General discharge characteristics**

	L-Mode	H-Mode
B_T (T)	2.0	1.9
I_p(MA)	0.8-1.5	1.3
$n_e(10^{19}m^{-3})$	1.9-2.6	3.6
κ	1.4-1.6	1.8

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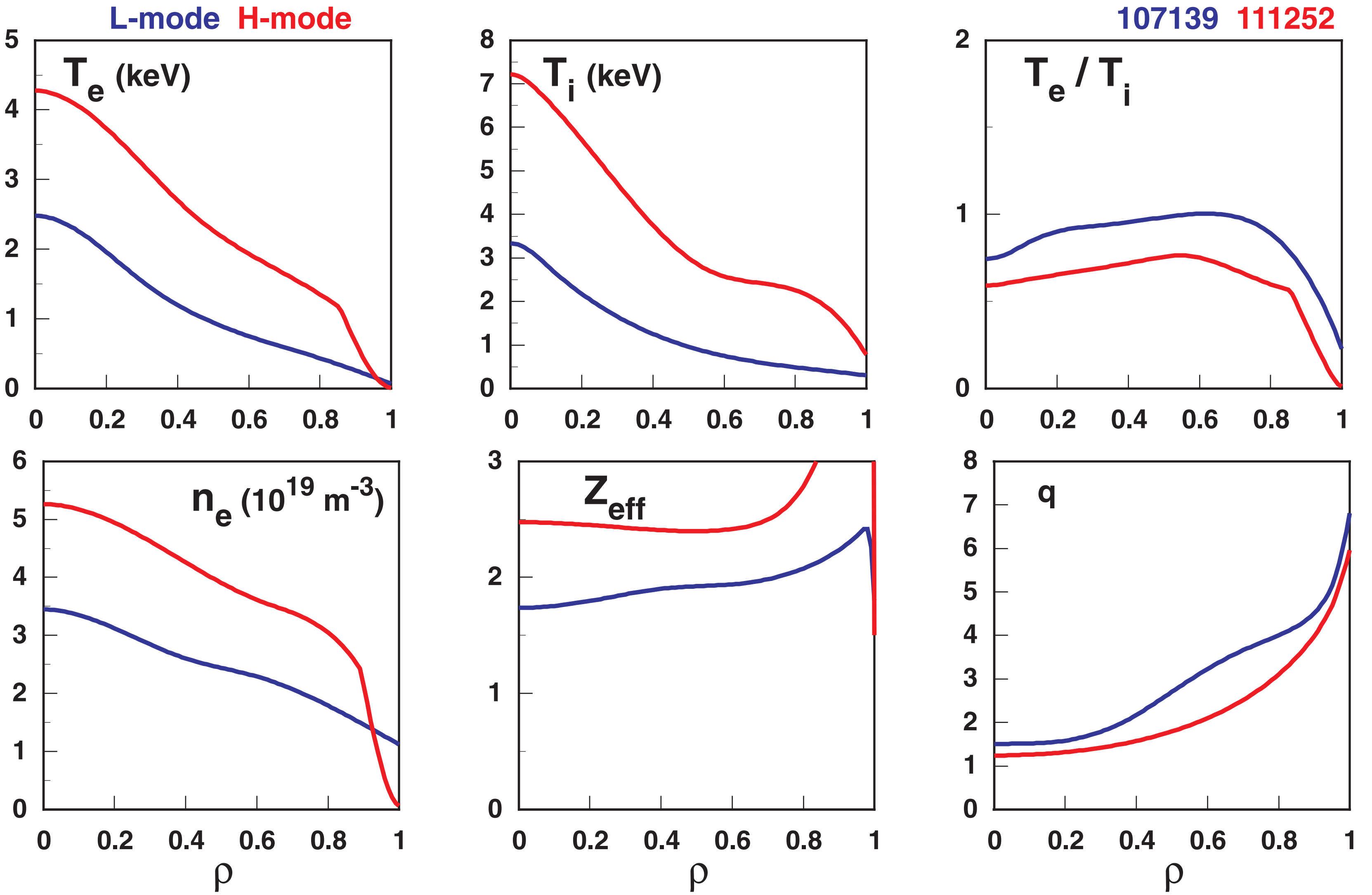
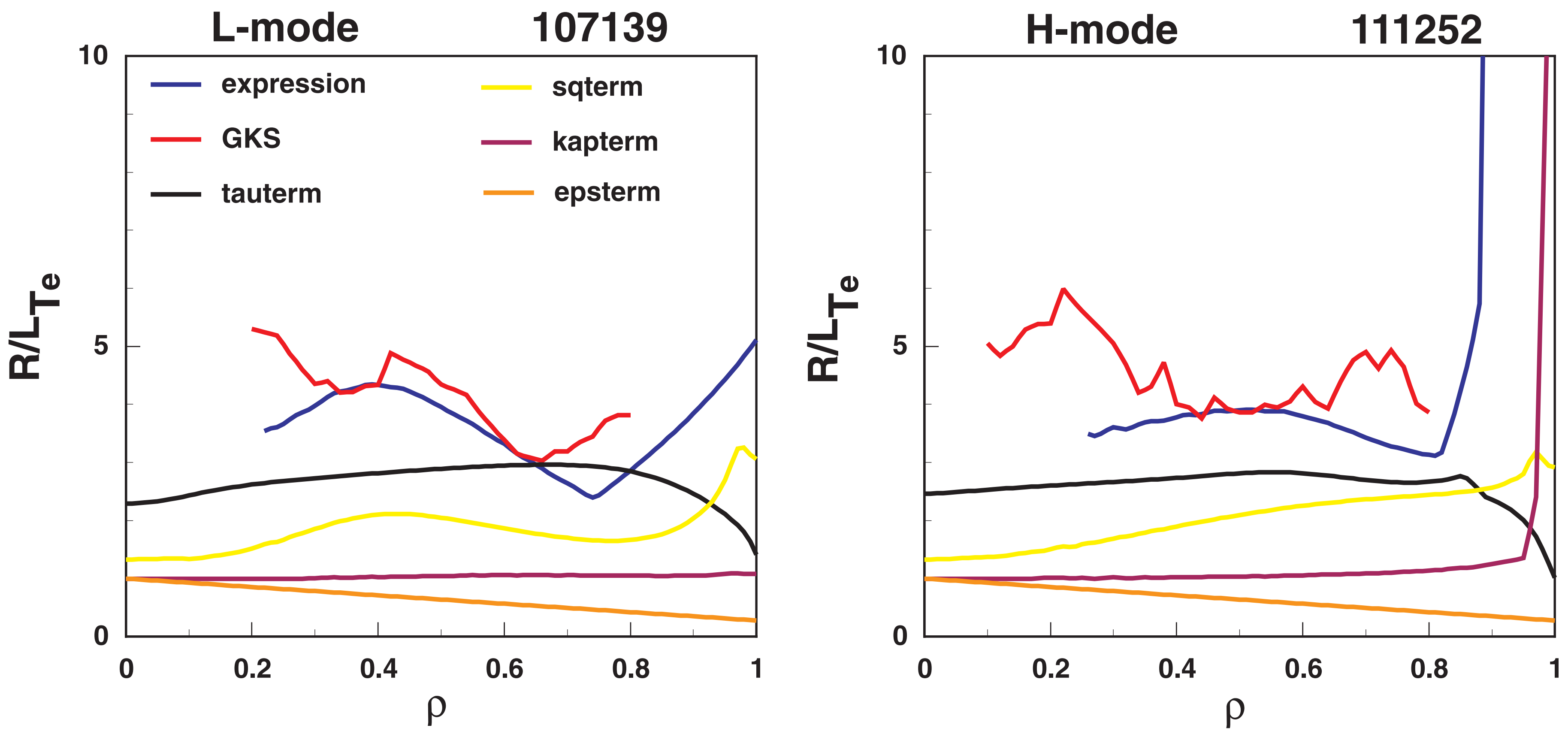
Comparison of L-Mode and H-mode Profiles



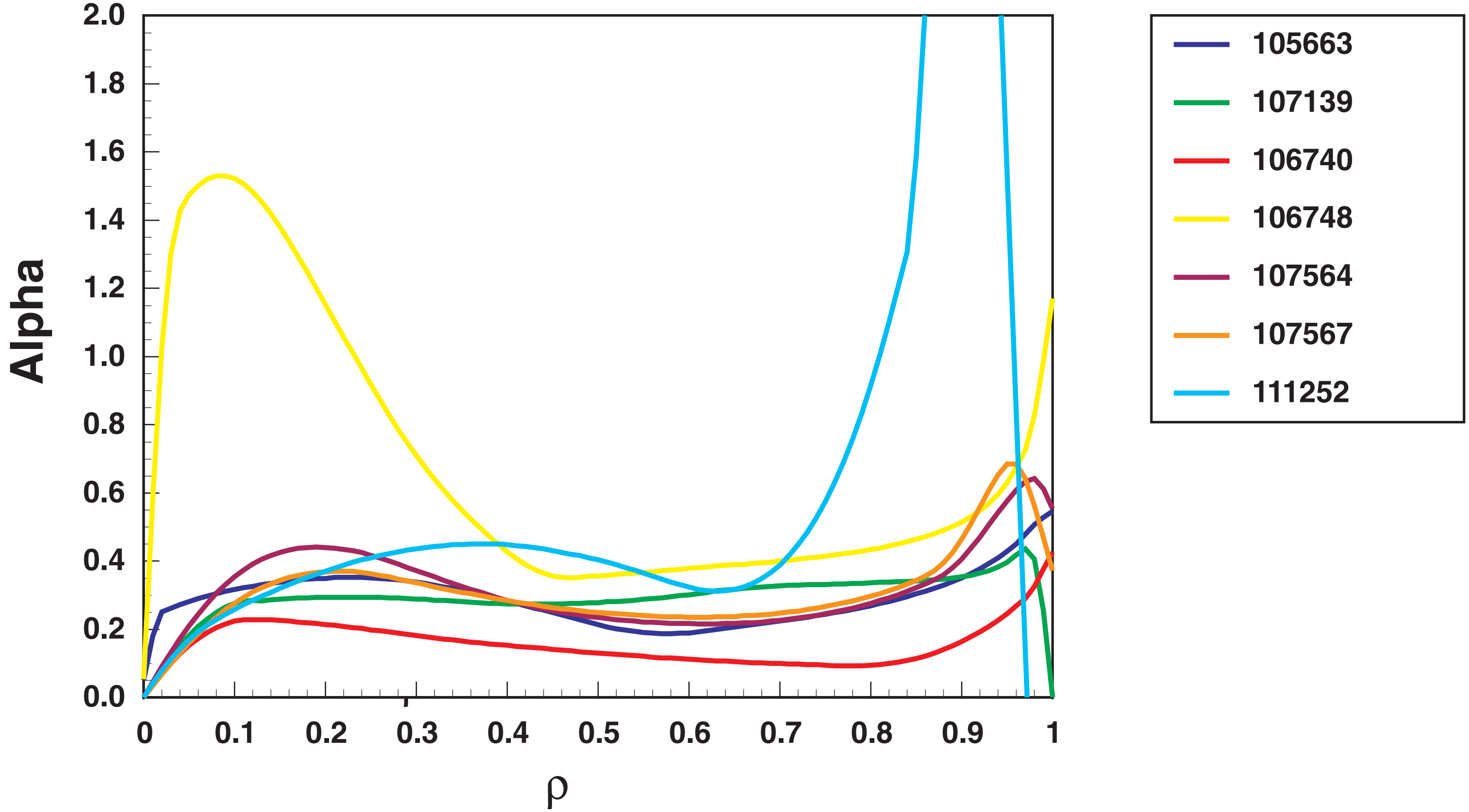
Analytic Expression Agrees Reasonably Well With GKS Code And Shows Similar Trend Across Plasma

- Analytic expression not evaluated where s < 0.2
- The two most dominant terms in the analytic expression are the terms containing $\tau = Z_{eff} T_e / T_i$ and s/q



Alpha Values Are Close To But Typically Above The Model Criteria For Applicability

- The model is expected to be applicable to Tokamak discharges with $\alpha \leq 0.1$



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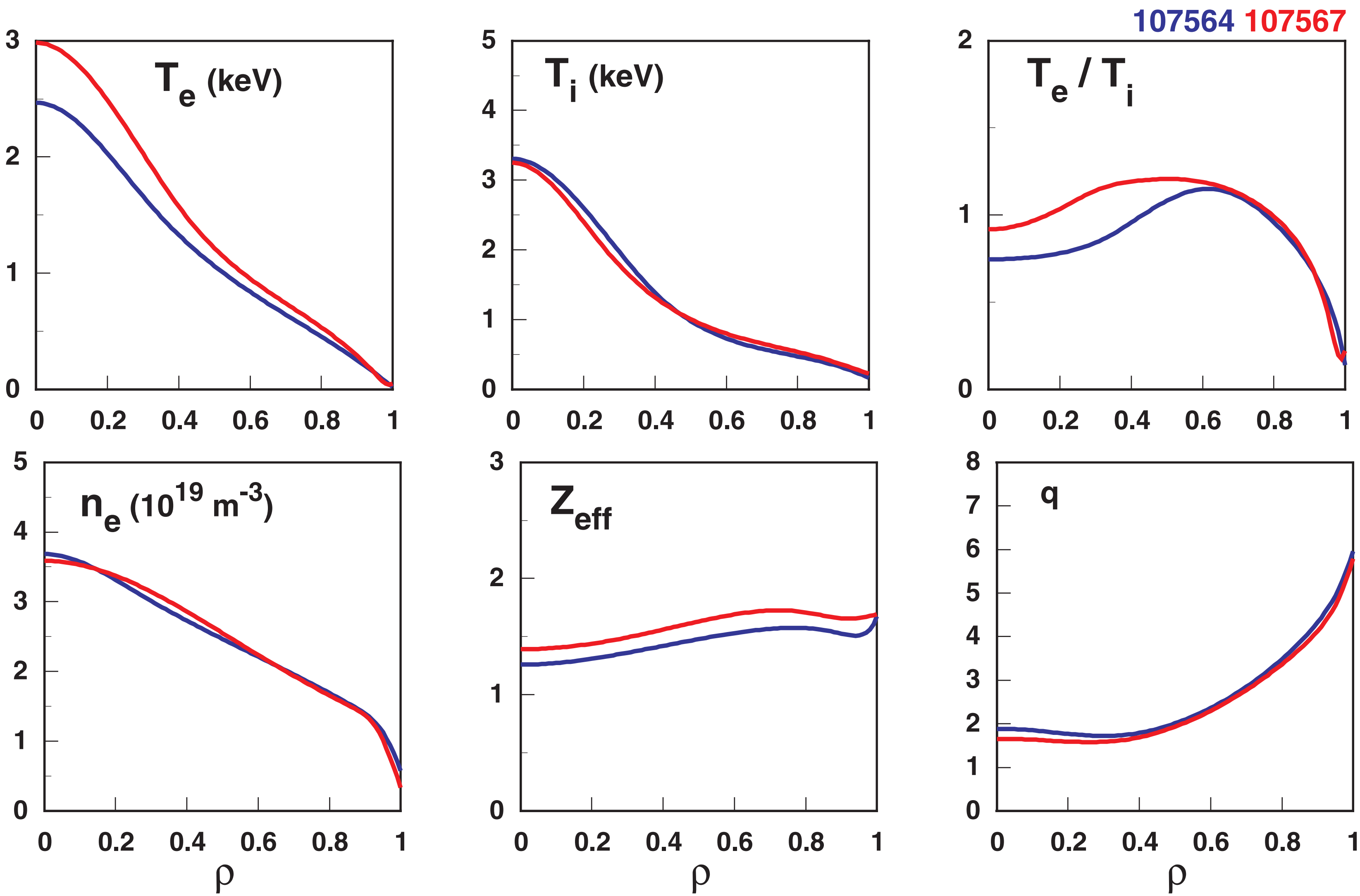
Plasma Profile Comparison For T_e Variation At Fixed T_i



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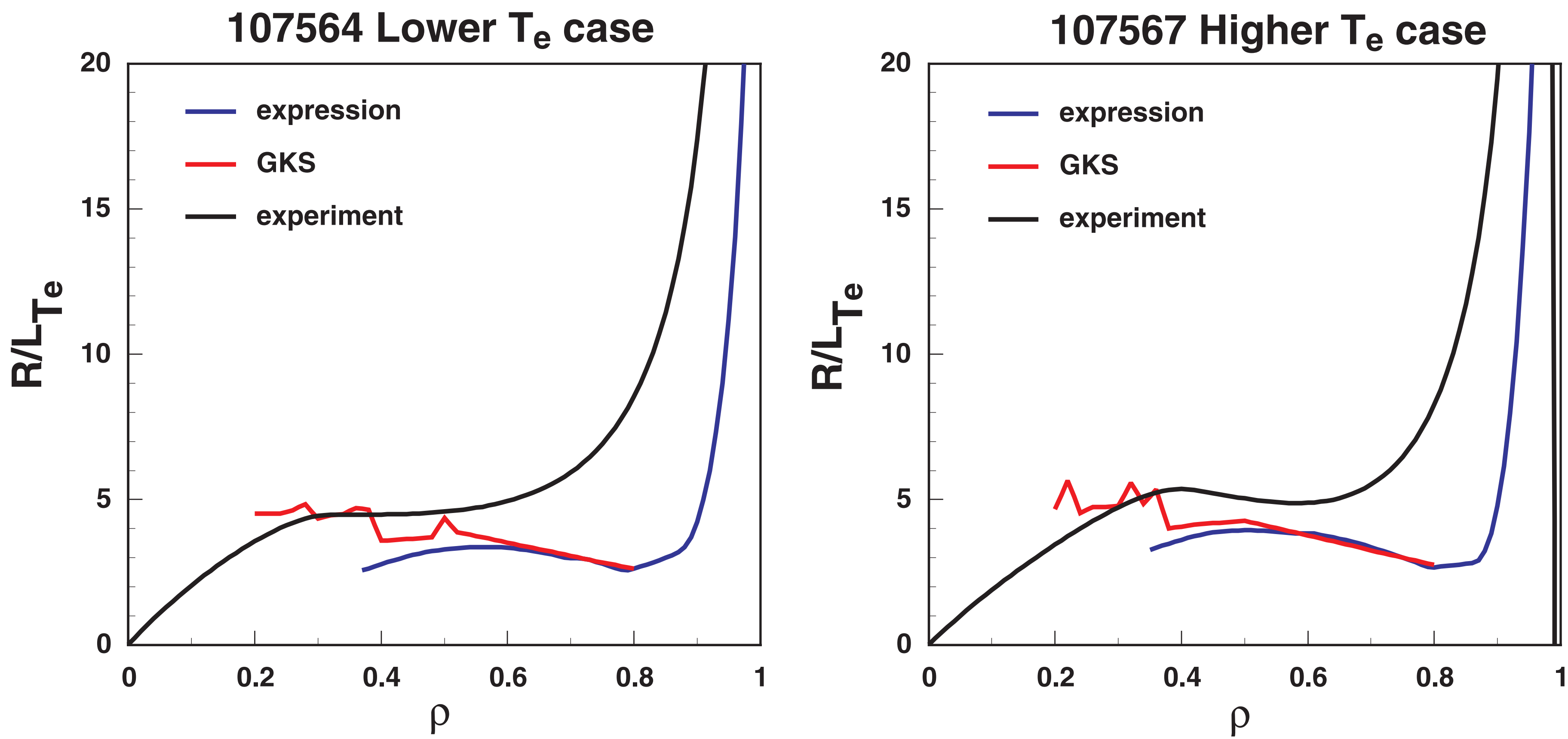
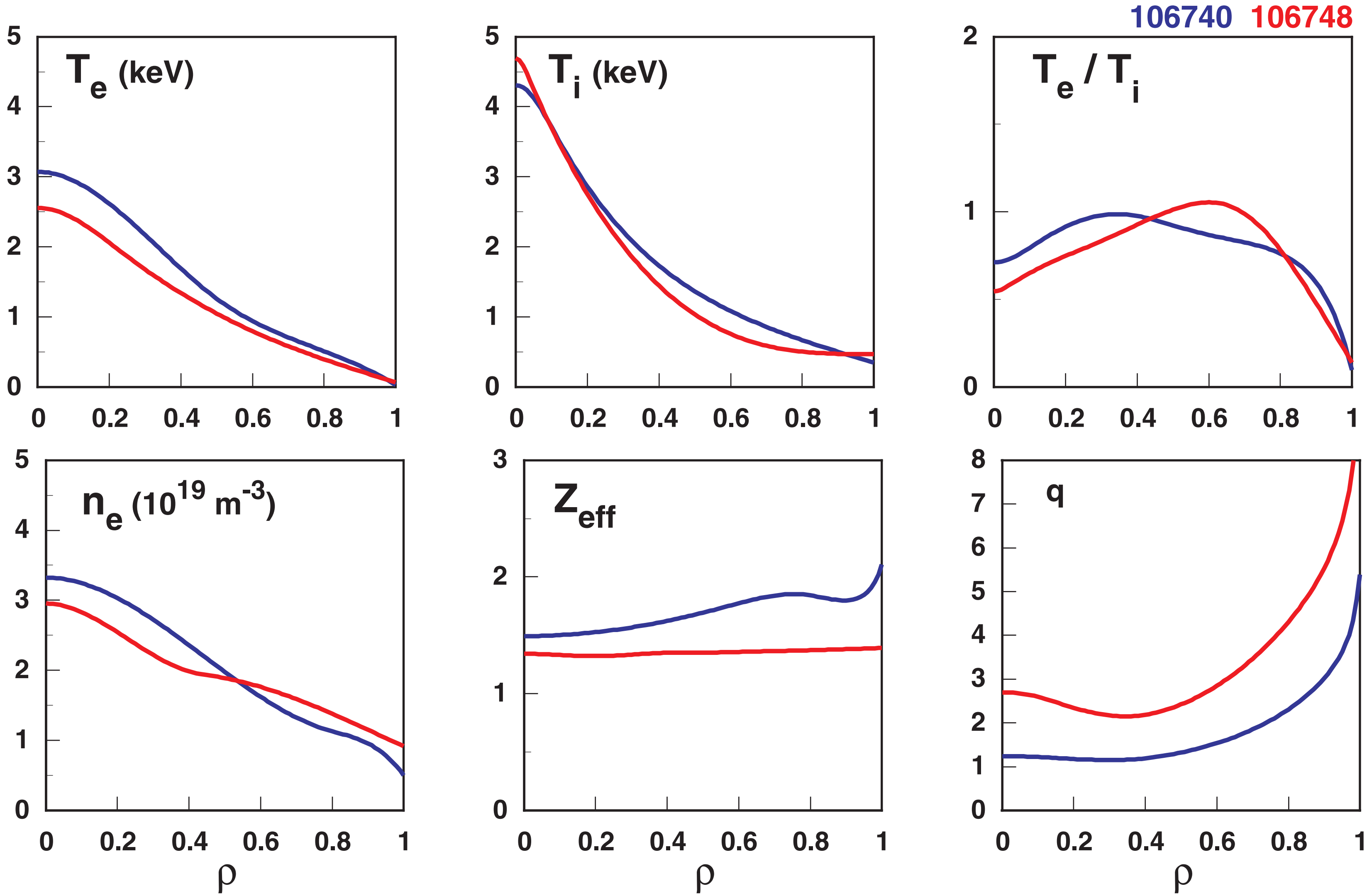
Agreement Between GKS Code Results and Analytic Expression Remains Good with T_e/T_i Variation

- Excellent agreement toward outside of plasma
- Agreement becomes worse in region where T_e/T_i begins to differ in the two discharges

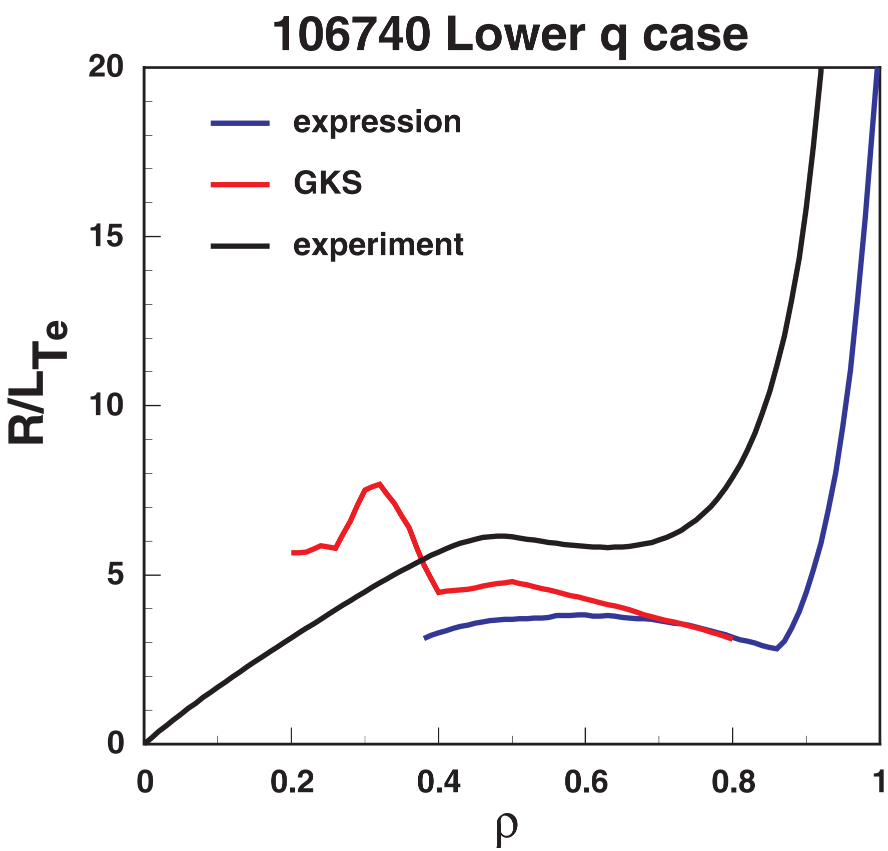


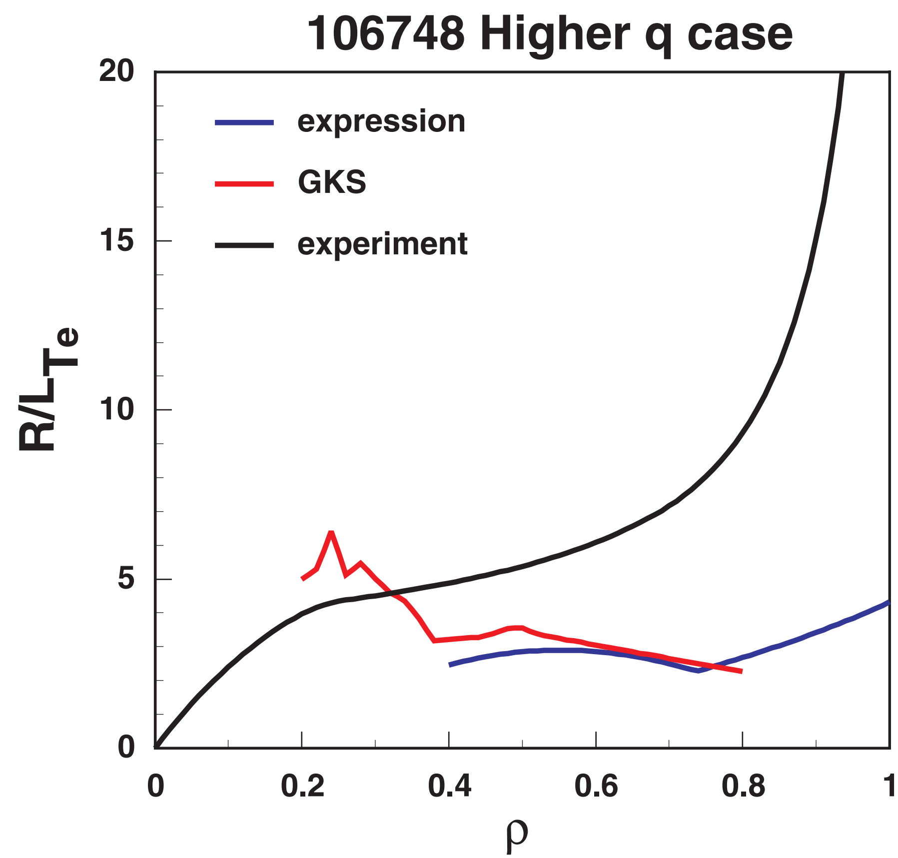
Plasma Profile Comparison At Two q Values



Agreement Between GKS Code Results and Analytic Expression Remains Good At Low and High q Values

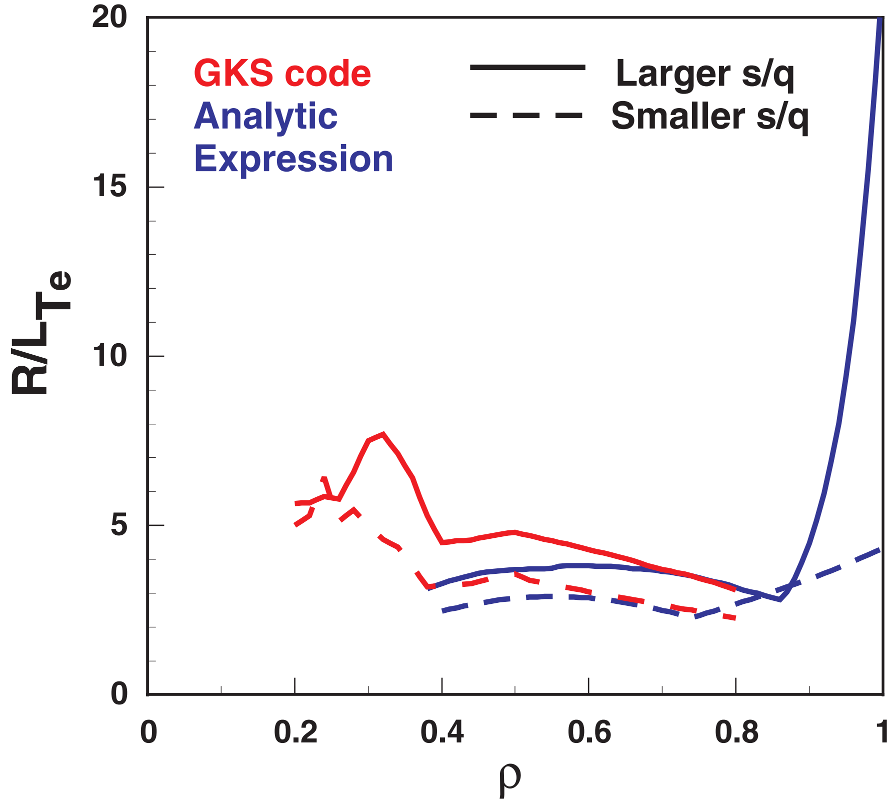
- Agreement improves toward outside of plasma where s/q is larger

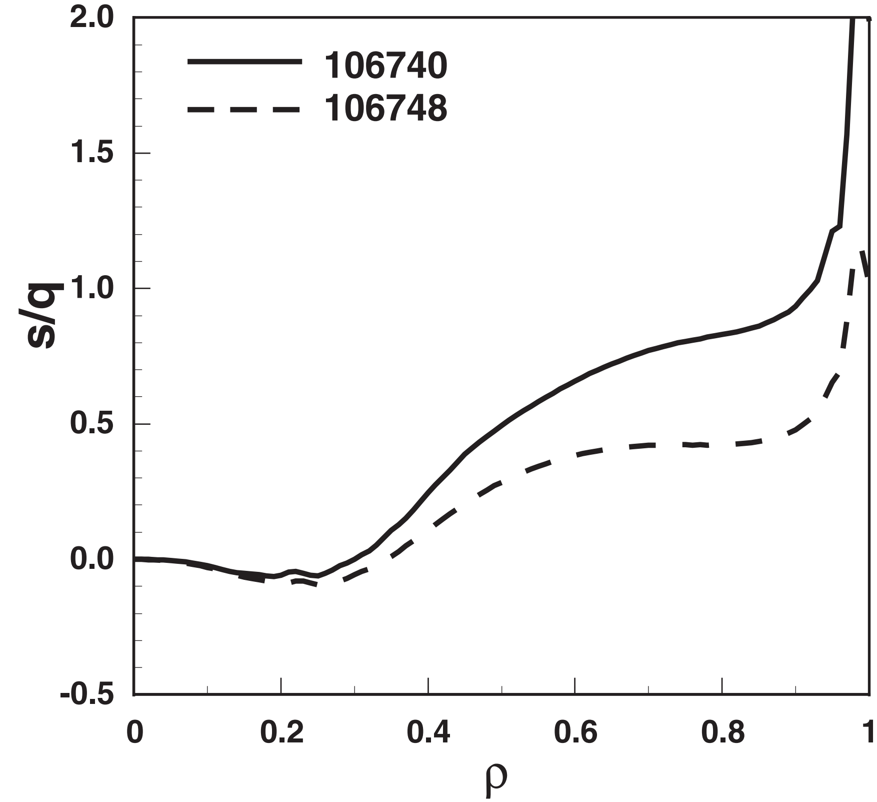




Larger s/q Is Stabilizing For ETG Modes

- The critical R/L_{T_e} is larger at larger s/q





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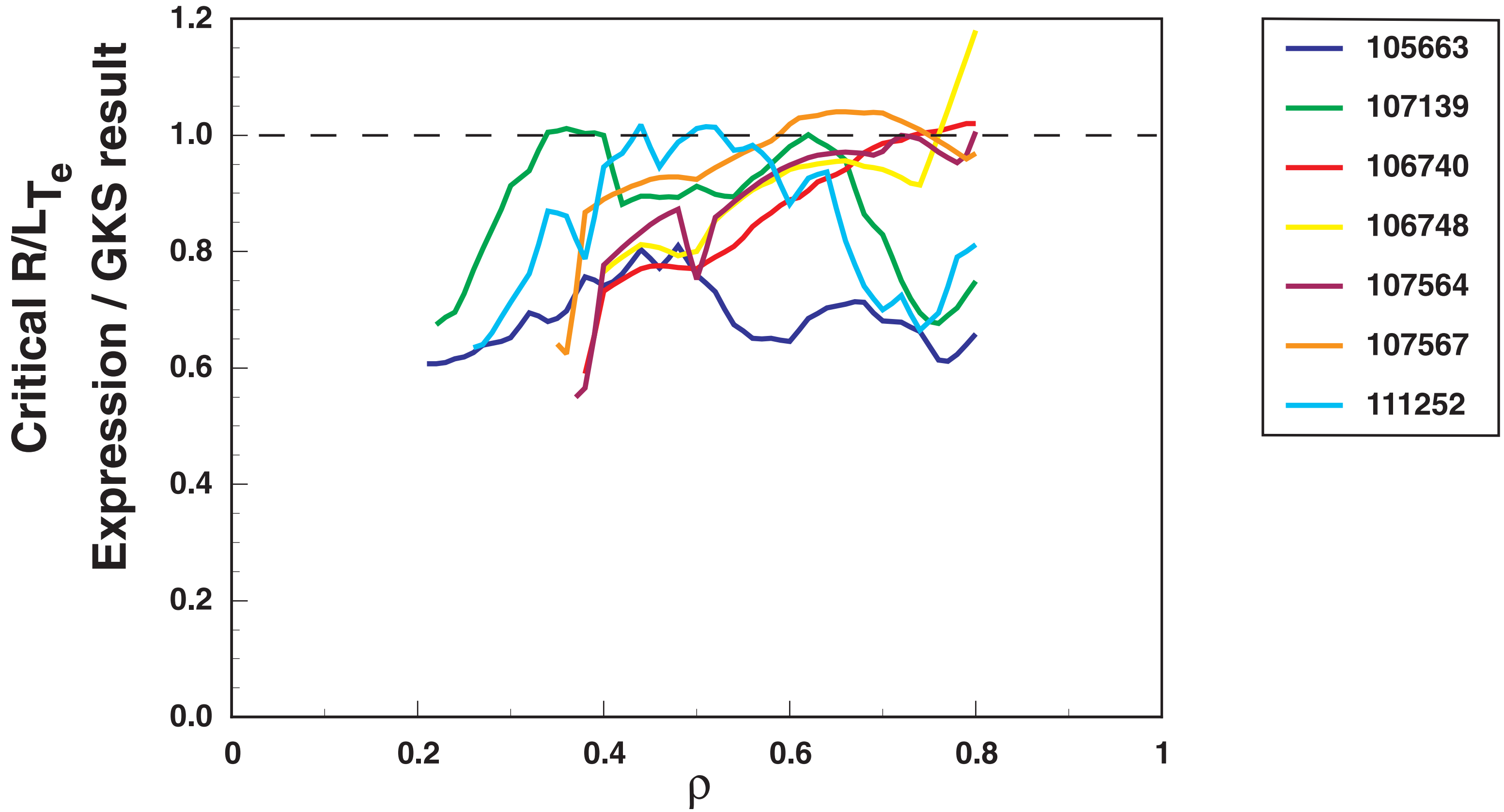
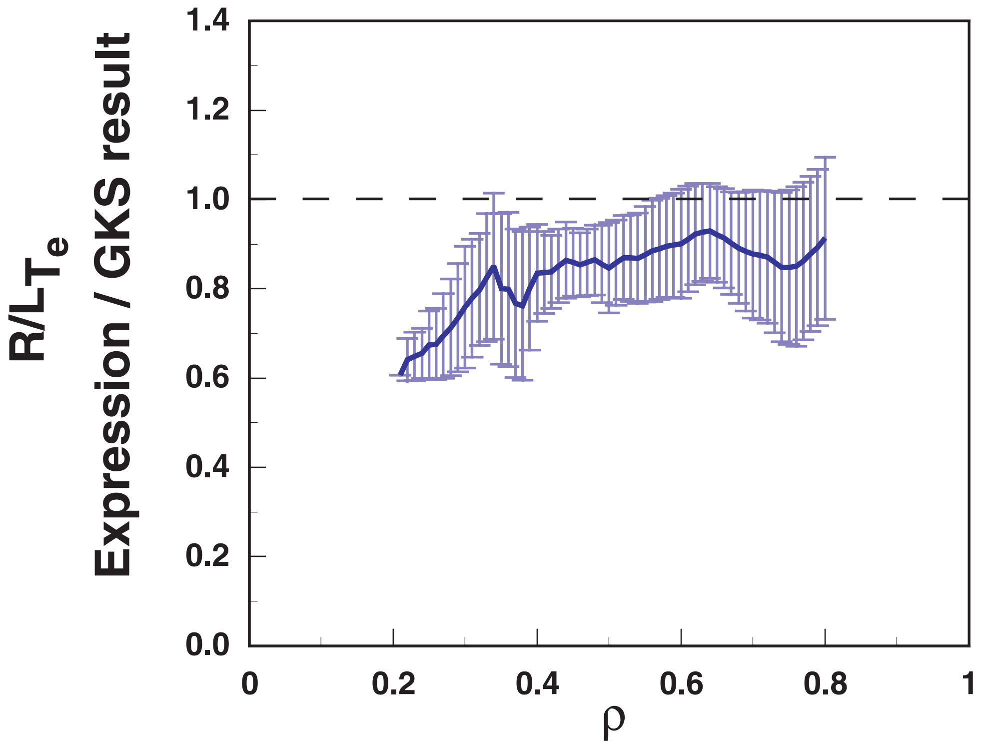
R/L_{T_e} Values From The Expression Are Systematically Below Values From The GKS Code, But Are Generally Within 30 %



When Averaged Over All Cases Studied A Slight Trend Toward Better Agreement Is Observed Toward The Plasma Edge

- Values from the expression are averaged by radial location over all cases studied
- Error bars represent ± 1 σ in the distribution



SUMMARY

- Critical R/L_{Te} values for ETG modes from the GKS code were compared to values from an analytic expression developed in F. Jenko, et al., Phys. Plasmas 8 (2001) 4096.
- Although the region of applicability of the expression is marginally violated for the normalized pressure gradient α ($\alpha \leq 0.1$) for the experimental discharges studied, the expression agrees reasonably well with GKS code calculations.
- R/L_{Te} values from the expression are systematically below values from the GKS code but are generally within 30% of GKS results with a slight trend toward better agreement toward the plasma edge.