Retuning of the GLF23 Transport Model for Reversed Magnetic Shear and Moderate MHD Alpha

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Presented at the
Integrated Modeling Meeting

March 13, 2003

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GENERAL ATOMICS

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GLF23 Transport Model

- The GLF23 model is a gyro-Landau-fluid based model
  - 10 low-k (ITG/TEM) and 10 high-k (ETG) eigenmodes solved from linear dispersion equations to yield quasi-linear turbulent fluxes
  - Linear growth rates fit to GKS gyro-kinetic simulations
  - Fluxes originally normed to gyro-fluid simulations and renormed model (v1.50) was normed to non-linear gyro-kinetic simulations from GYRO
- Turbulent fluxes follow from linear growth rates and a quasi-linear mixing length rule

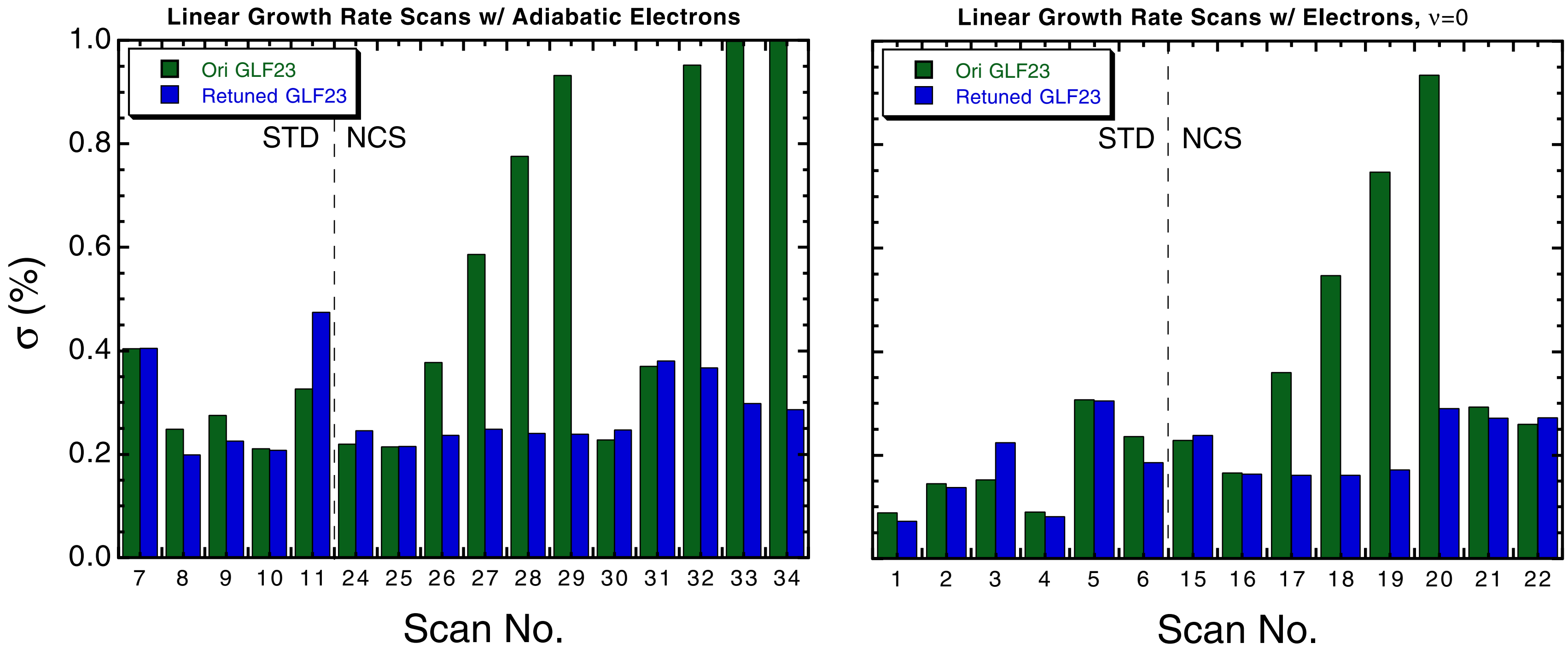
$$\chi \propto \gamma_{net} / k^2 (\gamma_d \gamma) / (\omega^2 + \gamma^2) \quad \text{with}$$

$$\gamma_E = (r/q) d(q\, v_E/r)/dr \quad \text{and} \quad \gamma_d \propto \omega_{Di} \quad \text{(n=0 radial mode damping rate)}$$

- Ion and electron thermal, hydrogenic particle, momentum transport
- Includes the effects of ExB shear and Shafranov-shift (α) stabilization
  - ExB shear rate γ_E is computed with all 3 terms in E_r (v_ϕ , v_θ , ∇P) using predicted temperatures and v_ϕ along with v_θ from neoclassical
  - Transport is computed from net growth rate, $\gamma_{net} = \gamma - \gamma_E$

GLF23 Has Been Retuned to Fit Linear Growth Rates for Reversed Magnetic Shear Parameters

- **Added MHD alpha dependence to extended ballooning mode angle which determines mode width**
- **Tuned mode width to match linear growth rates from GKS code**
- **Agreement for STD parameters nearly the same but much better for NCS parameters (model restricted to α < 4)**



STD: R/a=3,r/a=0.5,a/Lte,i=3, a/Ln=1,q=2,s=1,α=0,β=0,Ti/Te=1

NCS: STD + a/LTi=10, a/LTe=4, s=-0.5

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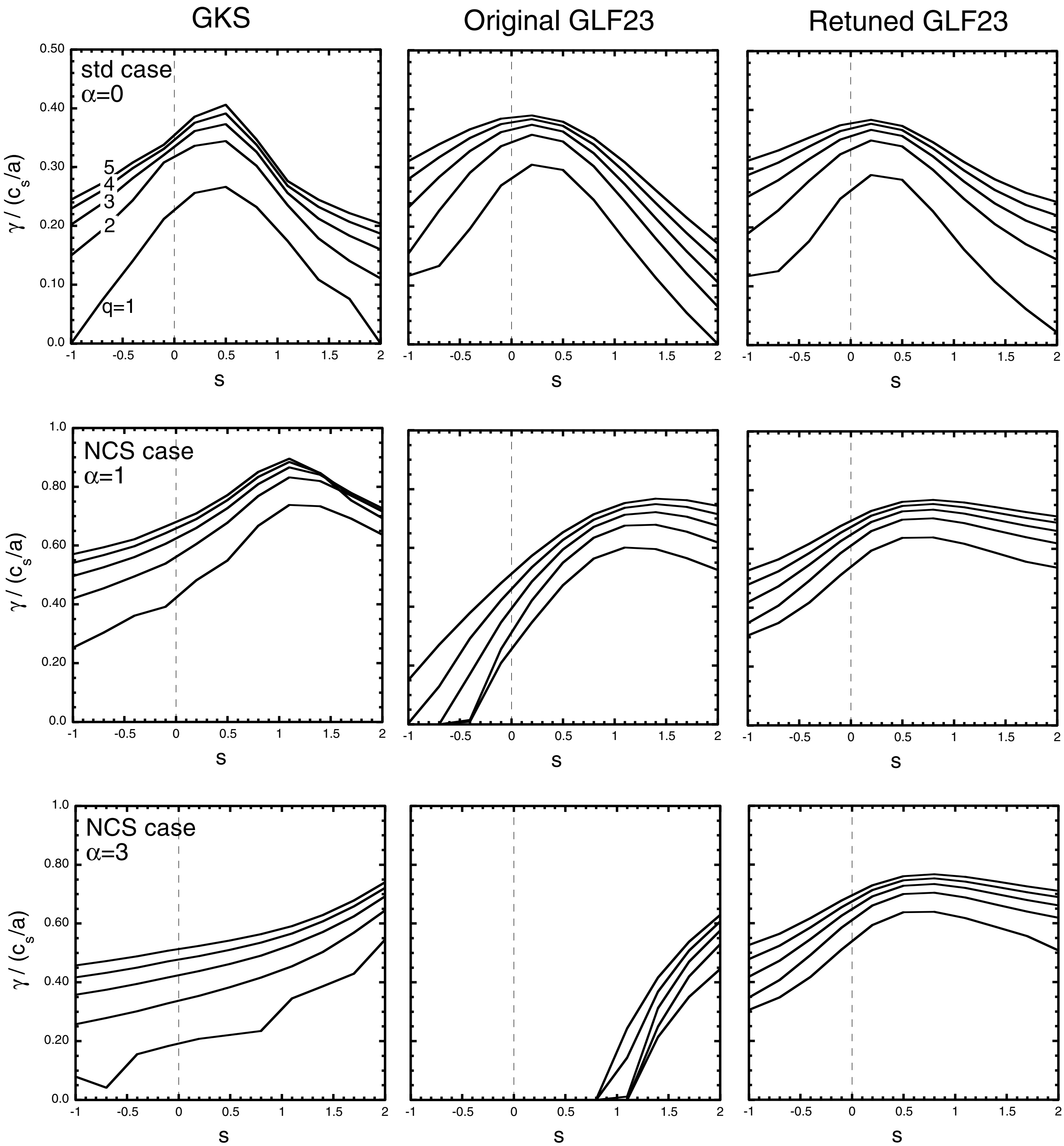
GLF23 vs GKS Linear Growth Rate Comparison

Magnetic shear scans for various q values for simulations with trapped electrons

Retuned GLF23 model retains agreement with gyrokinetic theory for standard parameters while yielding better agreement for reversed magnetic shear parameters



std case: a/Lti=a/Lte=3, a/Ln=1,q=2,shat=1,β=0, ν=0
NCS case: a/Lti=10, a/Lte=4, a/Ln=1,q=2,shat=-0.5,β=0, ν=0

GKS Linear Growth Rate Scans

Adiabatic Electron

Scan	Set	Scan type
7	STD	ky scan @ various q (1-5), α=0
8	STD	shear scan @ various q, α=0
9	STD	shear scan @ various q, α=1
10	STD	ky scan @ various a/Lt (2-5), α=0
11	STD	ky scan @ various Ti/Te (0.5-2), α=0
24	NCS	ky scan @ various q, α=0
25	NCS	shear scan @ various q, α=0
26	NCS	shear scan @ various q, α=1
27	NCS	shear scan @ various q, α=2
28	NCS	shear scan @ various q, α=3
29	NCS	shear scan @ various q, α=4
30	NCS	ky scan @ various a/Lt (5-10), α=0
31	NCS	ky scan @ various Ti/Te, α=0
32	NCS	ky scan @ various Ti/Te, α=1
33	NCS	ky scan @ various Ti/Te, α=2
34	NCS	ky scan @ various Ti/Te, α=3

Electron, ν=0

Scan	Set	Scan type
1	STD	ky scan @ various q (1-5), α=0
2	STD	shear scan @ various q, α=0
3	STD	shear scan @ various q, α=1
4	STD	ky scan @ various a/Lt (2-5), α=0
5	STD	ky scan @ various Ti/Te (0.5-2), α=0
6	NCS	ky scan @ various q, α=0
15	NCS	shear scan @ various q, α=0
16	NCS	shear scan @ various q, α=1
17	NCS	shear scan @ various q, α=2
18	NCS	shear scan @ various q, α=3
19	NCS	shear scan @ various q, α=4
20	NCS	ky scan @ various a/Lt (5-10), α=0
21	NCS	ky scan @ various Ti/Te, α=0
22	NCS	ky scan @ various Ti/Te, α=1
23	NCS	ky scan @ various Ti/Te, α=2
24	NCS	ky scan @ various Ti/Te, α=3

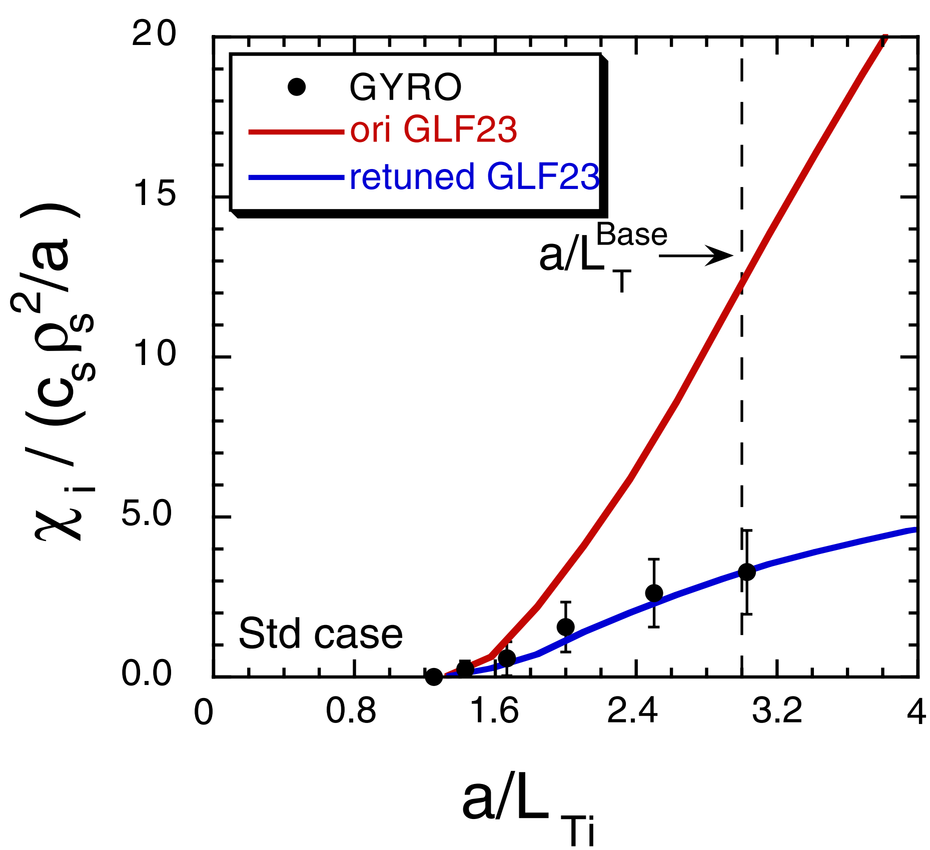
STD: R/a=3,r/a=0.5,a/LT=3, a/Ln=1,q=2,s=1,α=0,β=0,Ti/Te=1

NCS: STD + a/LTi=10, a/Lte=4, s=-0.5

Saturation Level in Retuned GLF23 Model Normalized Using GYRO Nonlinear Gyrokinetic ITG Simulations

- **Ion heat diffusivity via ITG mode computed using GYRO gyro-kinetic code w/ adiabatic electrons for standard test case** *
- **Original model, normalized to gyro-fluid simulations, overpredicts diffusivity by more than a factor of 3 at baseline a/L_{Ti}**
- **Retuned (v1.6) GLF23 model shows excellent agreement over a range of a/L_{Ti} for std parameters**

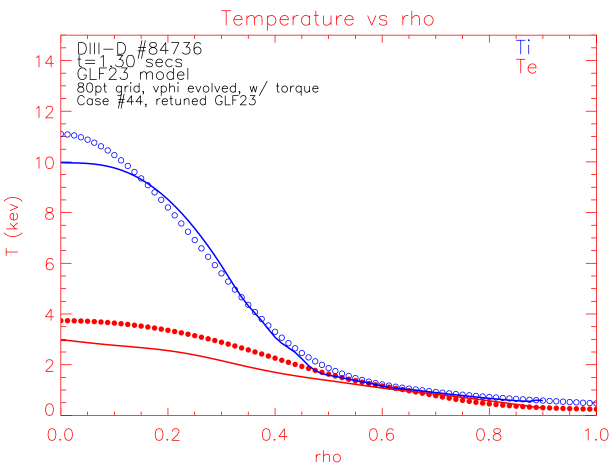
***R/a=3, r/a=0.5, a/L_T=3.0, a/L_n=1.0, q=2, s=1, T_i/T_e=1, β=0, α=0, k_y=0.3**

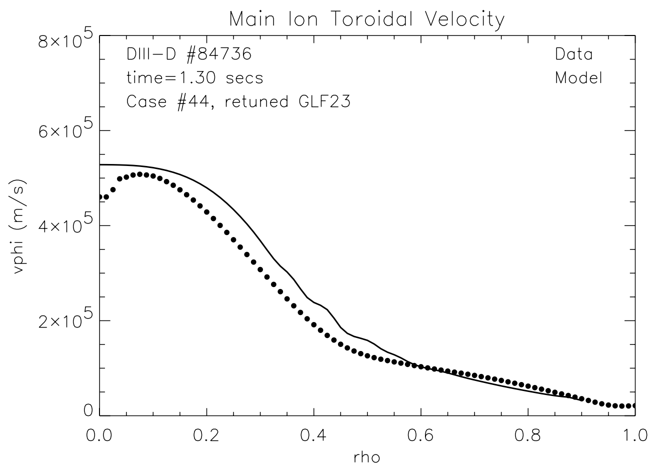


Waltz, et al., Phys. Plasmas 4, 2482 (1997)

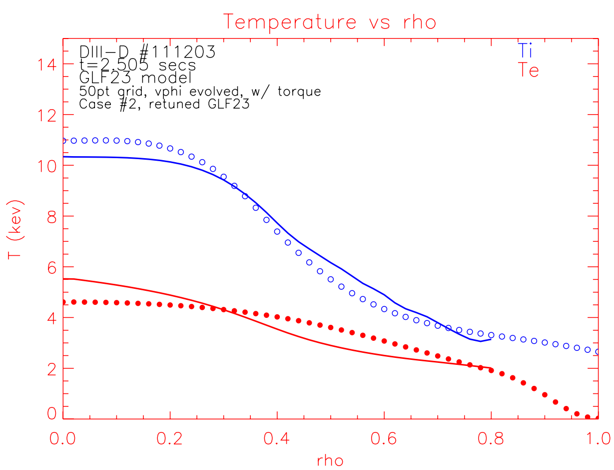
Retuned GLF23 Shows Agreement With DIII-D Discharges for L-mode, AT H-mode, ITB Test Cases

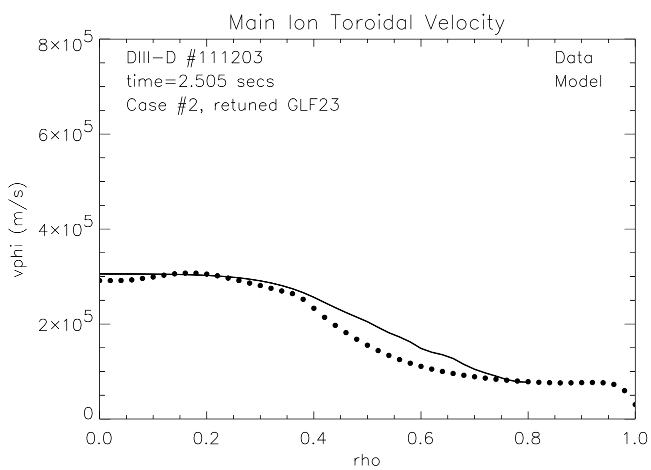
ITB:



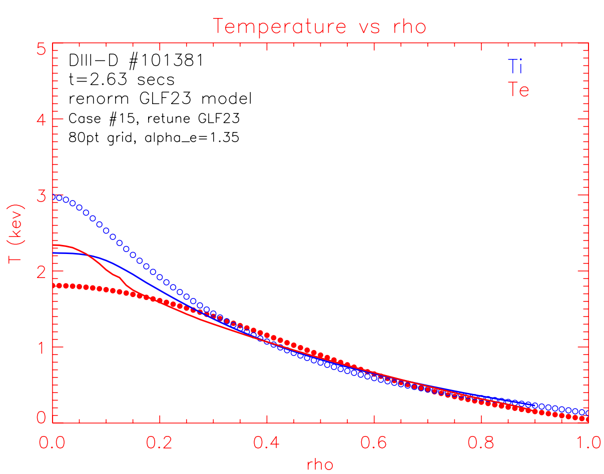


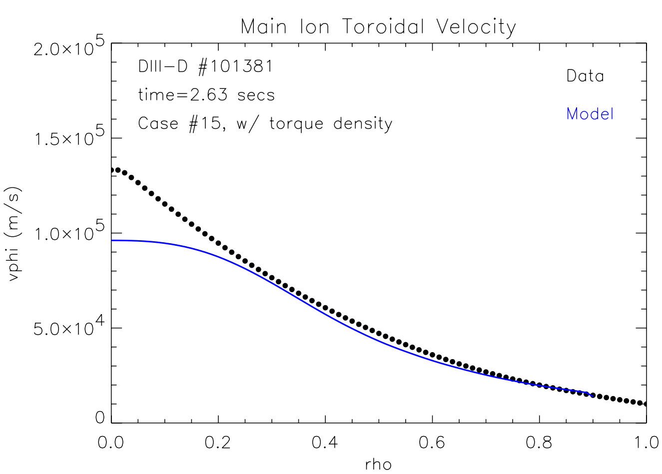
H-mode,AT:





L-mode:





Preliminary Transport Simulations Using Retuned Model For Strong NCS Discharges Are Promising

- **Model tested on strong NCS L-mode discharges from 2002 Shafranov shift experiment**
- **ExB shear multiplier = 1.35 (was 0.60 in v1.5 renormed model)**