Momentum Transport Studies Using n=3 Non-Resonant Braking

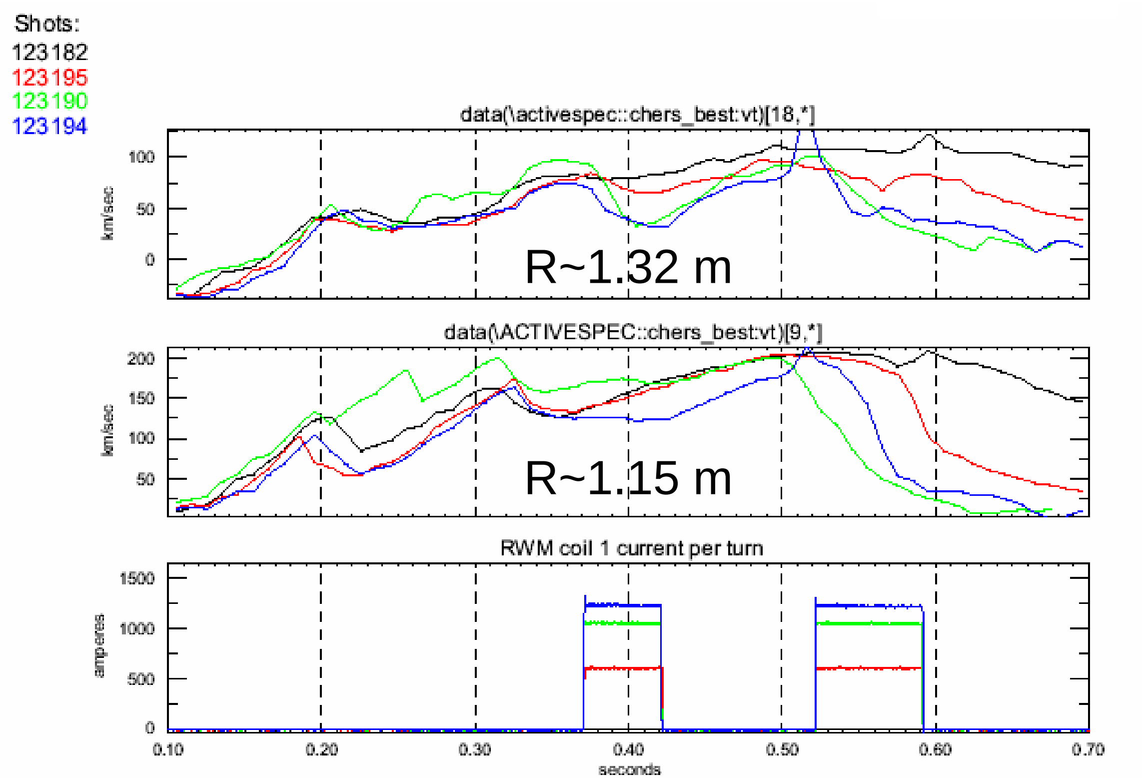
NSTX

- Aims:
  - Continue characterization of momentum transport on NSTX
  - Experimentally distinguish turbulent pinch theories
  - Look at B_ϕ and I_p variation in momentum transport (resolved into χ_ϕ and V_{pinch})
  - Investigate dependence of momentum transport on background rotation profile.

- Technique:
  - Use n=3 non-resonant magnetic perturbations to distort the rotation profile, allowing for separation of the roles of momentum diffusion vs convection (pinch).

Perturbative τ_ϕ, χ_ϕ Can be Obtained from Transient Application of nRMP

NSTX



- Braking should be
  - long enough to have measurable affect on rotation
  - Not so long as to affect underlying plasma (ie shorter than momentum confinement time)
- If apply second pulse, need to wait for plasma to “recover”

Local Momentum Transport Investigated During Spin Up After Perturbation

NSTX

- Toroidal rotation evolves according to momentum balance equation

$$mnR\frac{\partial V_\phi}{\partial t} = \eta + \nabla \cdot \Gamma_\phi$$

where

η = Torque density, m = mass, n = density, V_ϕ = toroidal rotation, Γ_ϕ = momentum flux

- TRANSP calculation of torque coupled with CHERS rotation measurement → Γ_ϕ well determined

- Model Γ_ϕ evolution to determine diffusive and convective contributions

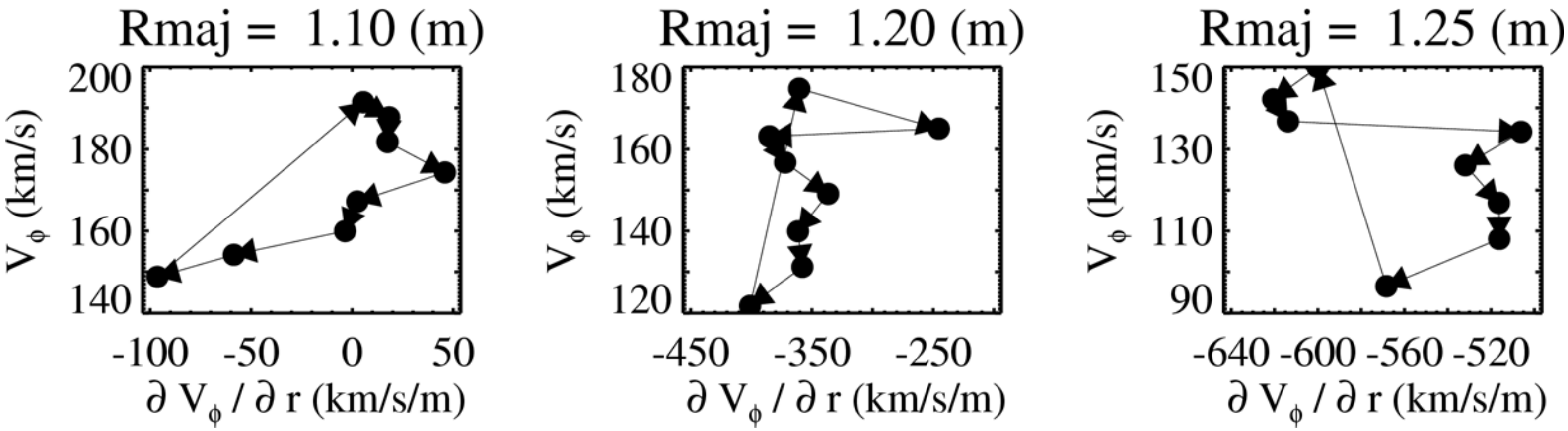
Successful Distortion to Rotation Profile Allows Separation of χ_ϕ and V_ϕ^{pinch}

NSTX

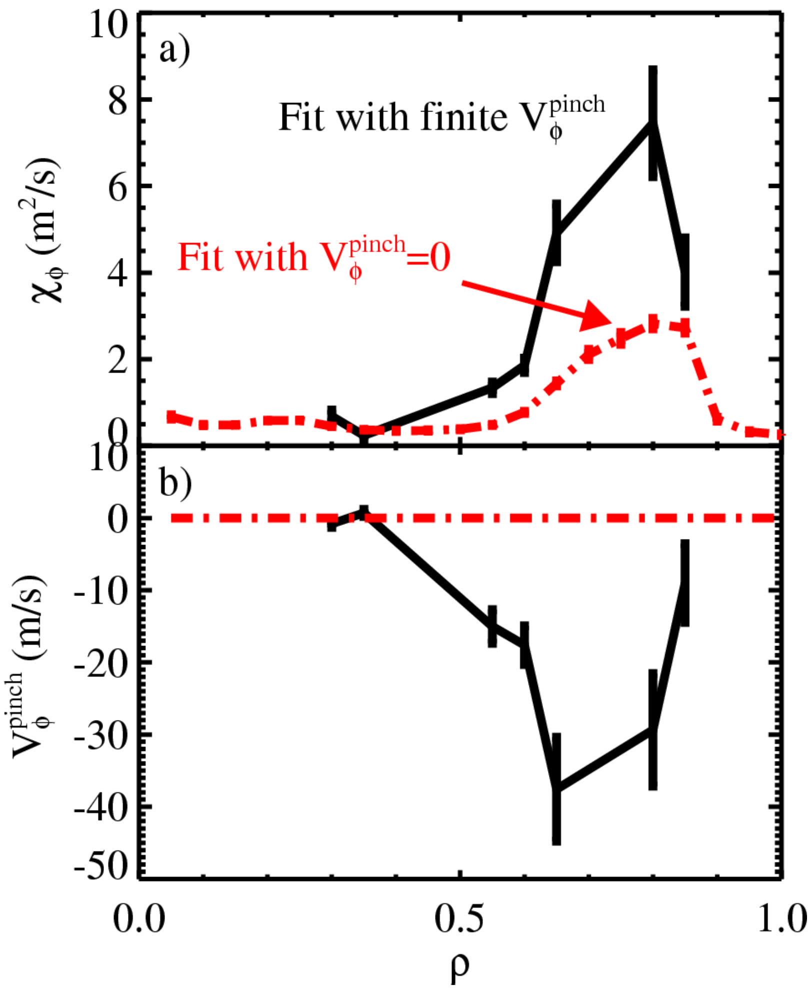
- Use simple model for momentum flux

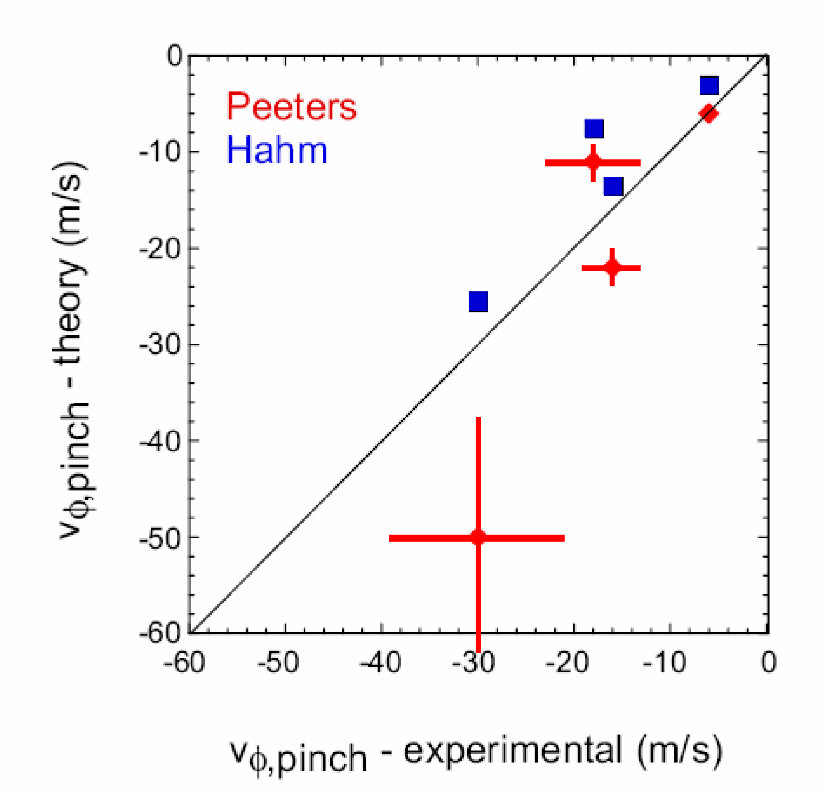
$$\Gamma_\phi = mnR\left(\underbrace{\chi_\phi \frac{\partial V_\phi}{\partial r}}_{diffusion} - \underbrace{V_\phi V_\phi^{pinch}}_{convection}\right)$$

- Must change V_ϕ independently of dV_ϕ/dr
  - can unravel relative contribution of χ_ϕ and V_ϕ^{pinch}



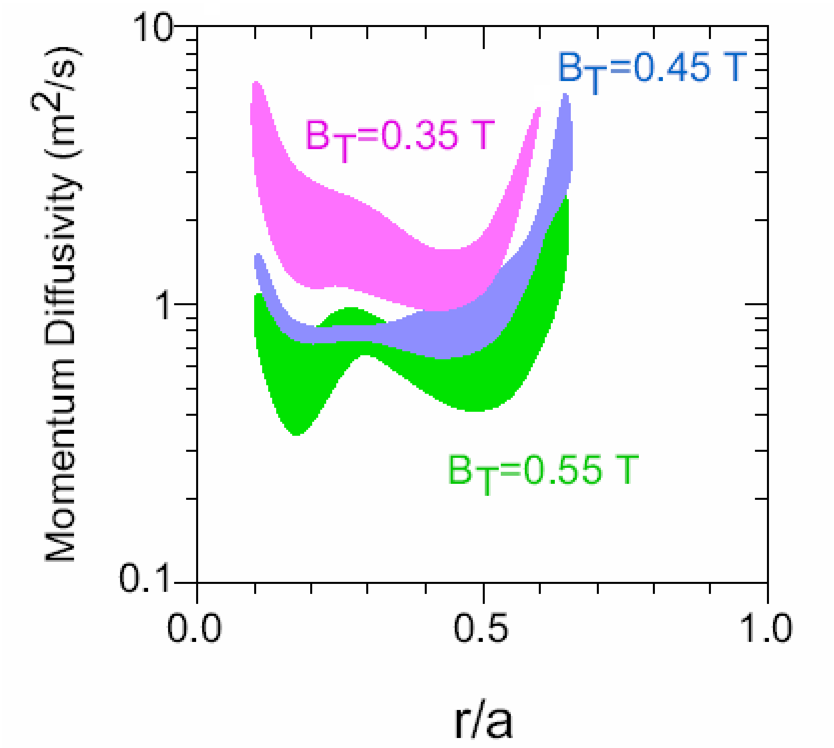
Reasonably Good Agreement Between Theory and Experiment in Limited Comparison

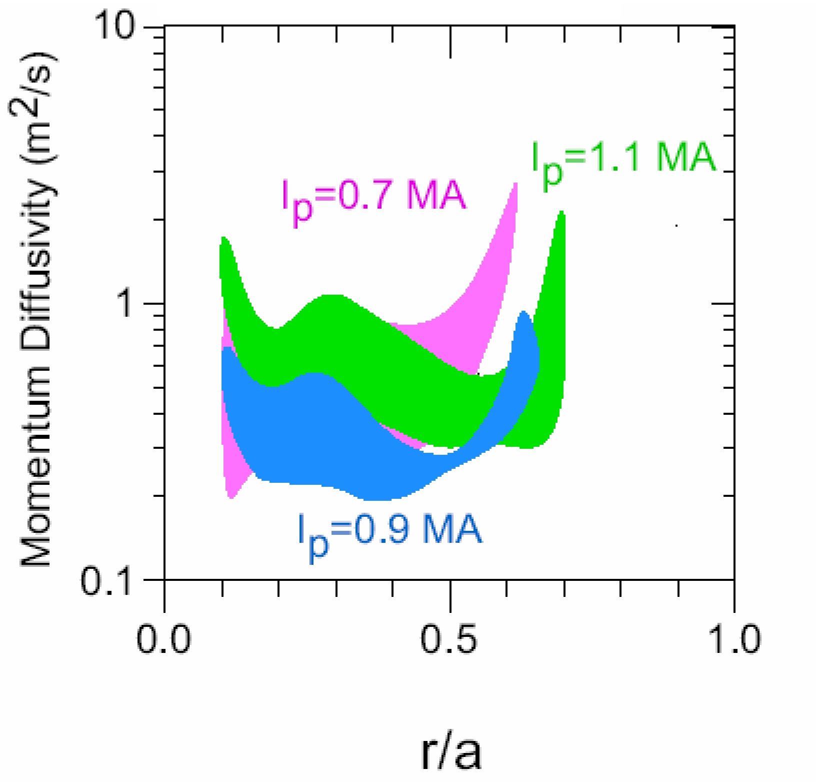




Can comparisons with large variations in L_n be used to discriminate between theories?

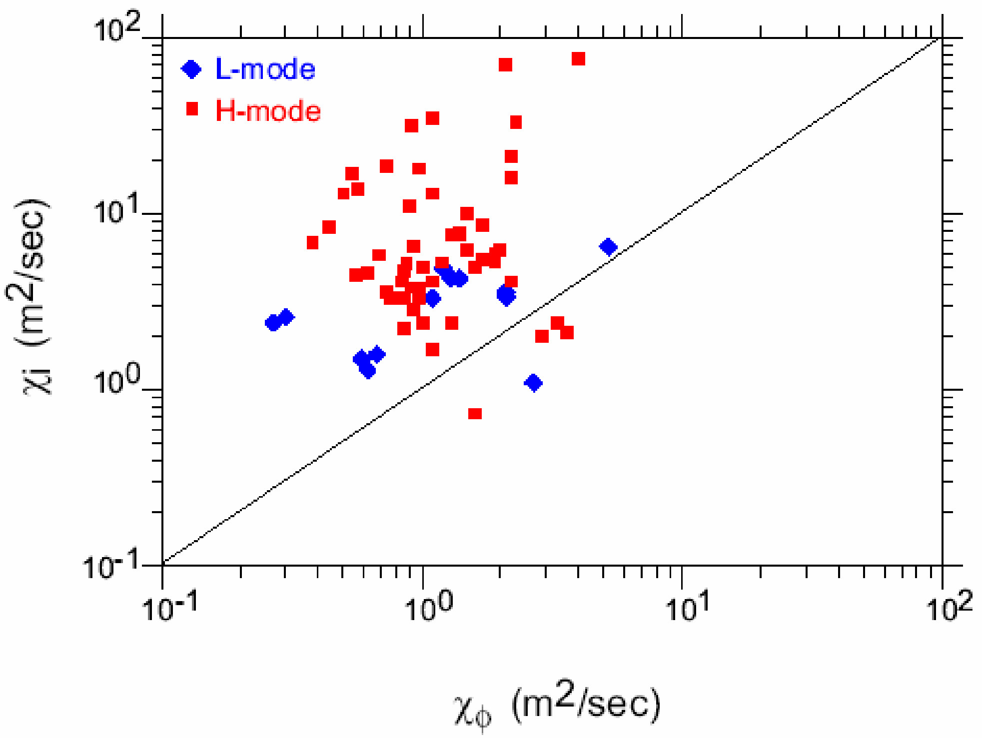
Unlike Ion Heat Diffusivity, Momentum Diffusivity Scales More Strongly with B_t than I_p





Is momentum diffusivity tied more to electron diffusivity when ions are neoclassical?

Steady-State χ_ϕ Does Not Scale With χ_i As At Conventional Aspect Ratio



- From momentum balance (TRANSP)
- Is there any rotation dependence?
- How does including momentum pinch affect conclusions?

Experimental plan

NSTX

Establish MHD quiescent H-mode (max 8 shots)
Bt ~ 0.55 T, Ip ~ 0.9 MA

Fail → Defer

Success → Pseudo density scan
Apply nRMP early vs
late in discharge (4 shots)

↓

Three point Bt scan (4 shots)
Bt = {0.45, 0.35} T

Fail → If lowering Bt produces MHD, then skip → Three point Ip scan (4 shots)

Success → Three point Ip scan (4 shots)
Ip = {1.1, 0.7} MA

→ Rotation scans (5 shots)
NB sources A+B vs A+C
nRMP to change baseline rotation
followed by additional step

↑ If didn't need development time

Compare L and H mode
single source (7 shots)

1. After L-H transition, drop from 2 → 1 source
2. Develop MHD quiescent high density L-mode

↑

17 shots + (8 up-front development
<u>*or*</u> 4 development + 3 physics at end)