Effect of Reverse Shear Alfvén Eigenmodes on Delivered Neutral Beam Torque

by
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In collaboration with
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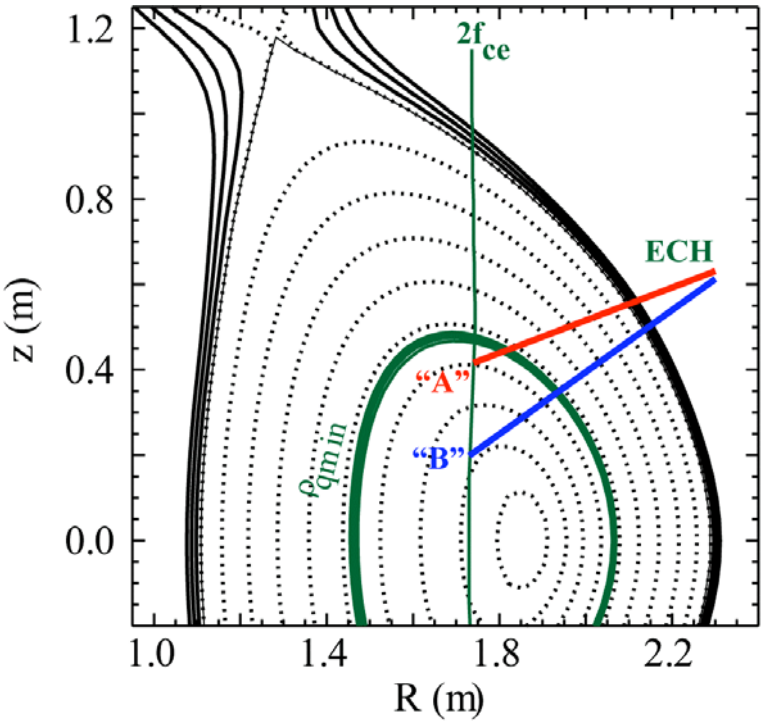
PPPL PRINCETON PLASMA PHYSICS LABORATORY

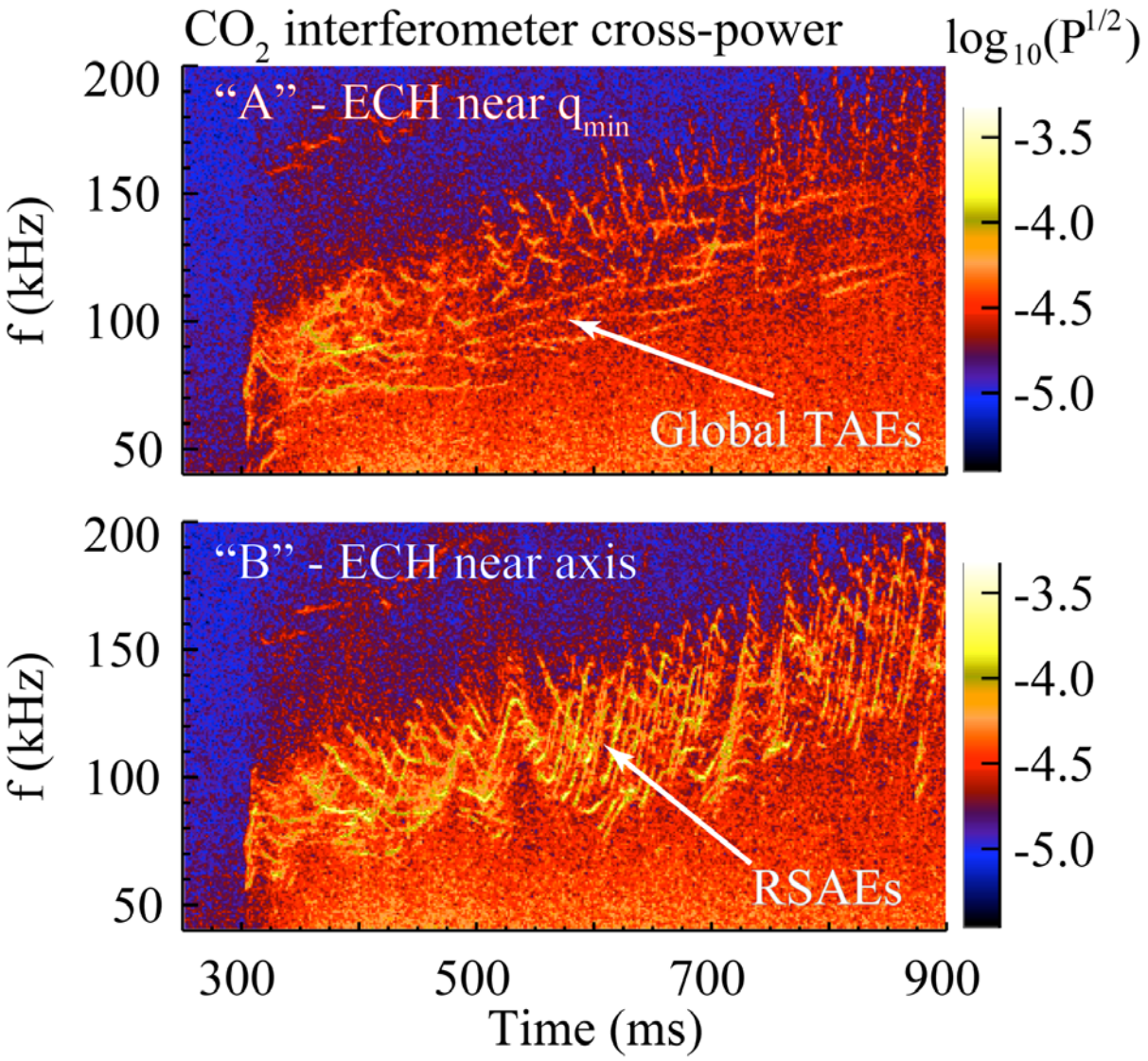
Motivation

- **Rotation affects broad range of issues in fusion plasmas**
- **Understanding momentum transport requires knowledge of sources**
- **Most high performance plasmas have some level of Alfvén Eigenmode (AE) instabilities, eg**
  - Reverse Shear Alfvén Eigenmodes (RSAE)
  - Toroidicity Induced Alfvén Eigenmodes (TAE)
- **Experiments show that these modes are capable of redistributing fast ions**
  - Fast ion transport is not classical
- **Such modes may complicate momentum transport studies**
  - Difficult to assess transport if cannot calculate the source

Recent Experiments Used ECH as a Means of Controlling RSAE Activity

- **ECH near $\rho(q_{min})$**
  - RSAEs suppressed
- **ECH near axis**
  - RSAEs present

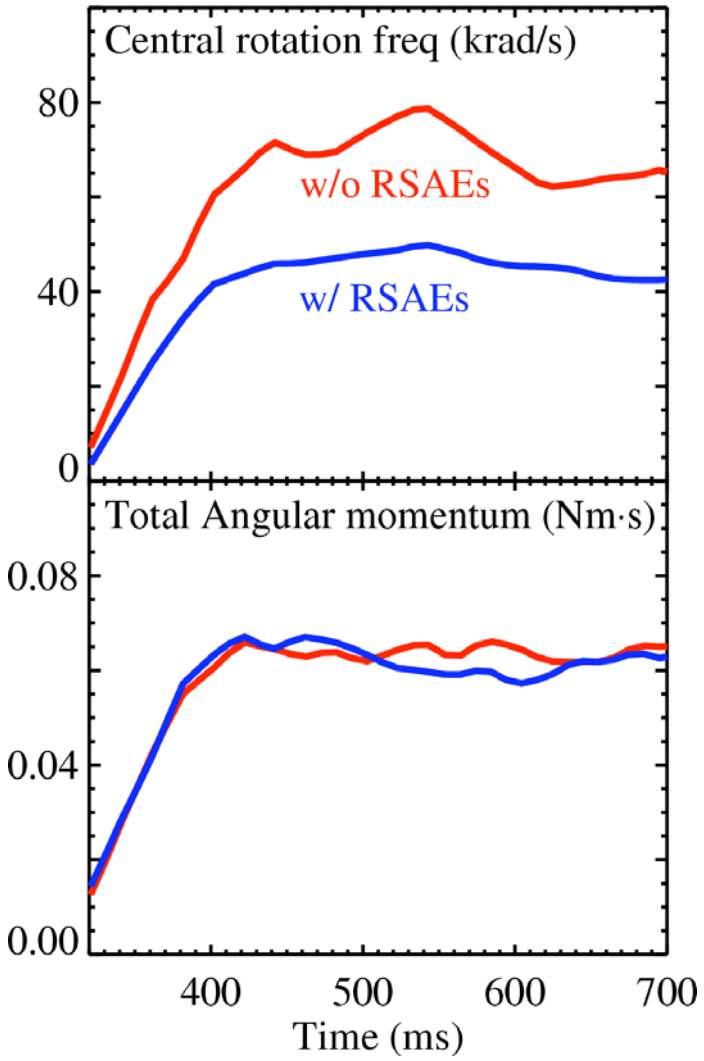




See Van Zeeland poster JP8.00087

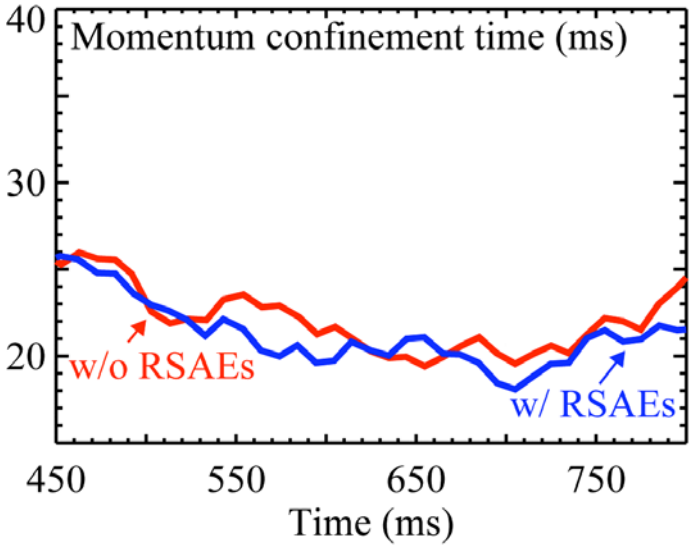
Rotation Profile Strongly Affected by RSAE Activity

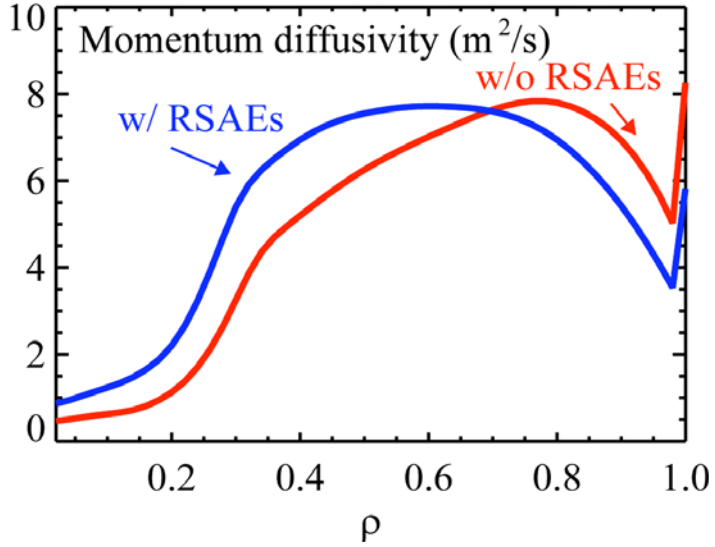
- **Central rotation almost 2x greater with RSAE activity suppressed**
  - Minor change in density does not explain difference
- **However, total angular momentum content comparable**
- **Hypothesis: Change in rotation due to changes in torque profile**
  - Redistribution of fast ions rather than complete loss?



Momentum Transport Quantities Dependent on Calculated Source Profile

- **Assuming classical fast ion (FI) transport**
  - Momentum confinement time τ_ϕ matches for two cases
  - But, local diffusivity χ_ϕ is notably larger for $\rho<0.7$ (wrong source profile)





- **Torque profiles calculated using NUBEAM monte carlo package in TRANSP**

Analysis of Momentum Transport Allows Anomalous Fast Ion Diffusion Driven by RSAEs to Be Estimated

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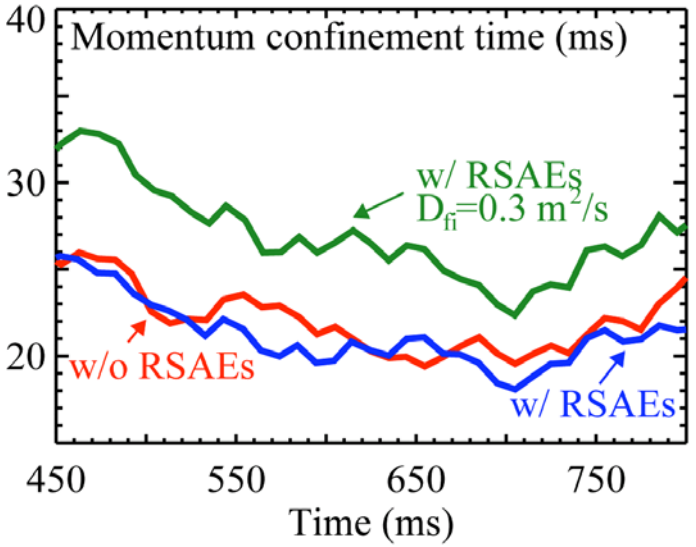
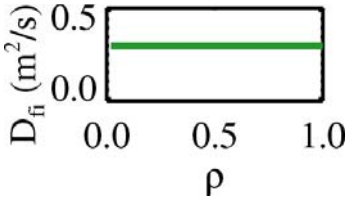
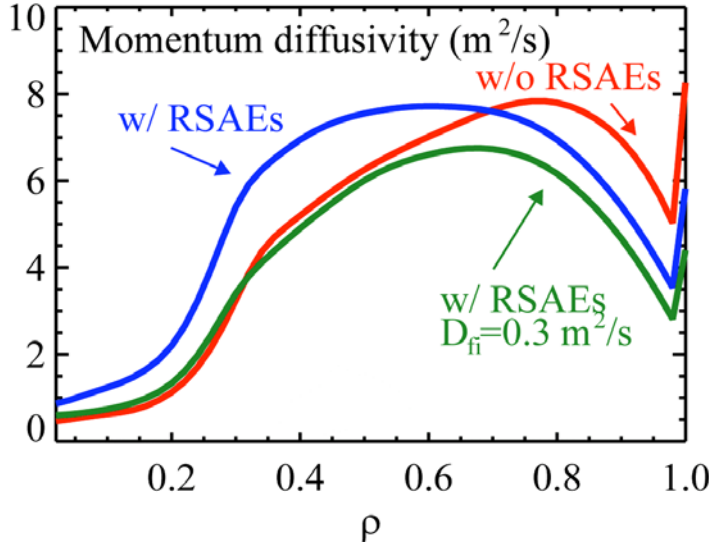
- **If invoke anomalous fast ion diffusion $D_{fi}=0.3\ m^2/s$**
  - Better match χ_ϕ for $\rho<0.6$
  - But global τ_ϕ increases (lost torque from the plasma)







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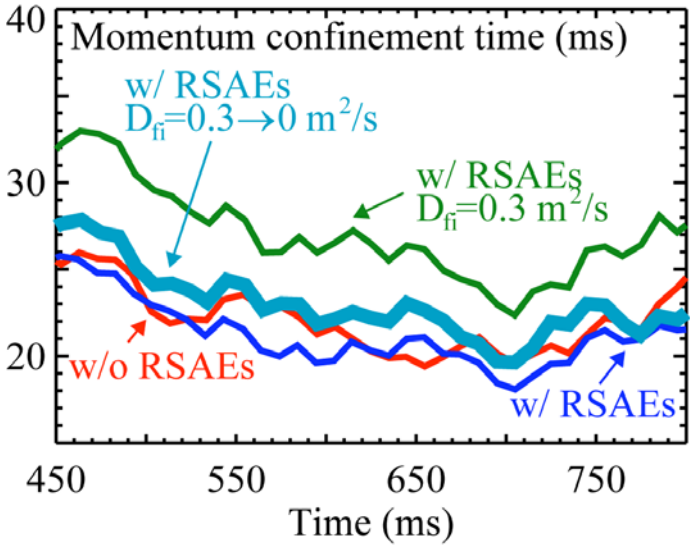
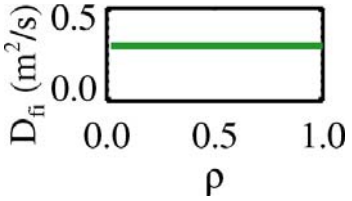
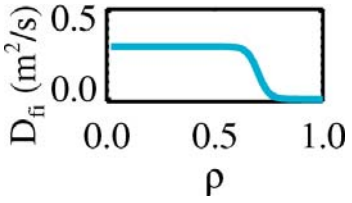
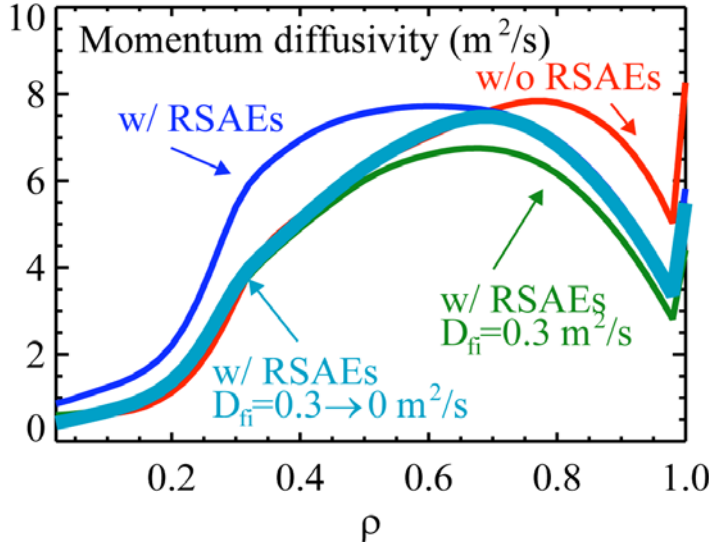
- **If use $D_{fi}=0.3\rightarrow0$ m²/s profile**
  - Match both τ_ϕ and χ_ϕ for $\rho<0.7$



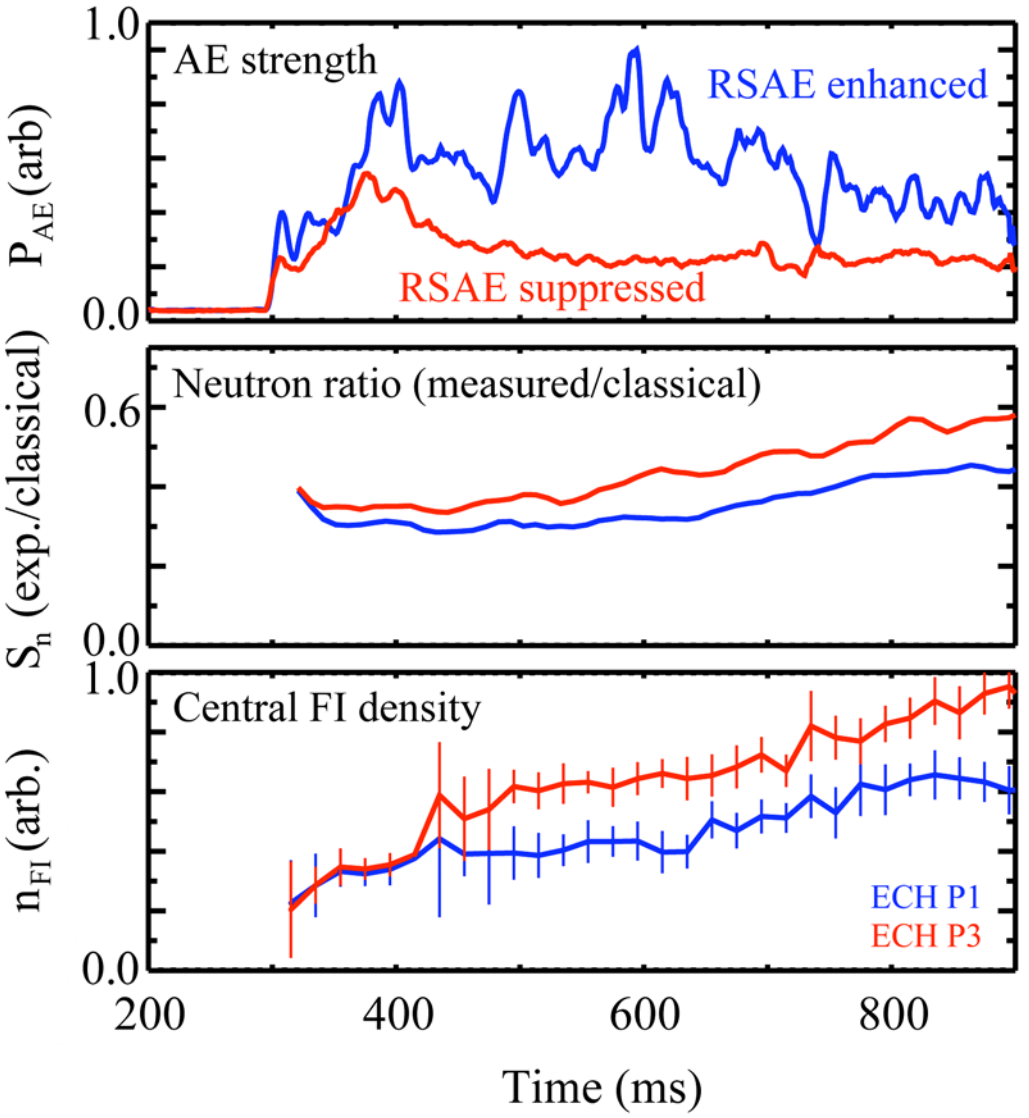






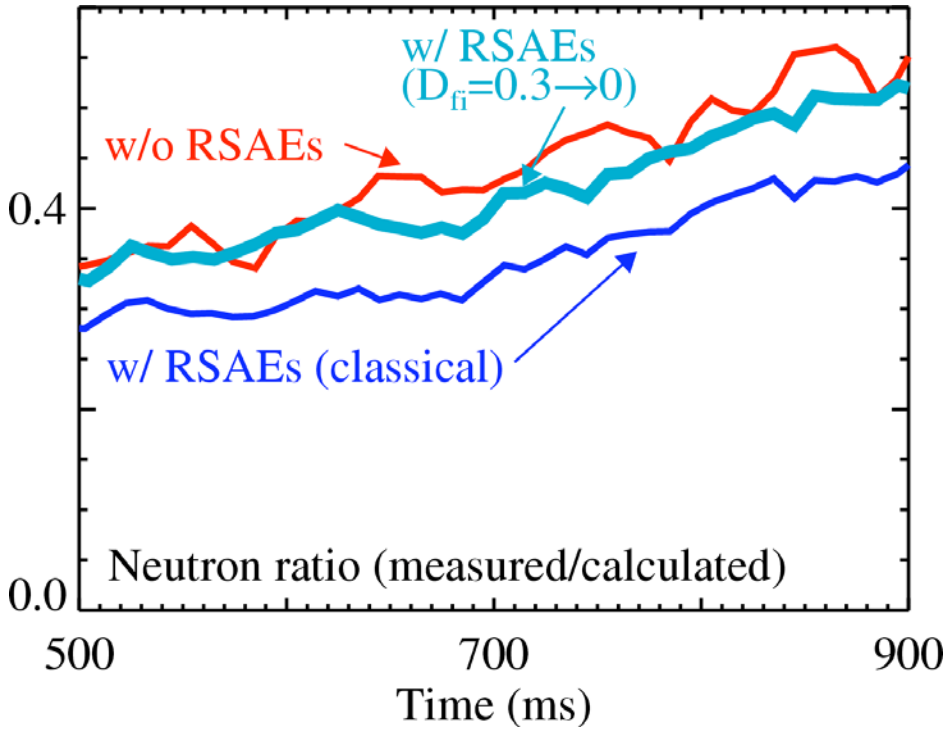
Enhancement of Fast Ion Transport by RSAEs Also Supported by Neutron Rates and FI Density

- **AE strength estimated from band-passed CO_2 interferometer measurement**
- **Large deficit in neutron rate compared with classical computation for both cases**
  - Largest when RSAEs present
- **Central fast ion density is larger when RSAEs are suppressed**



Anomalous FI Diffusion Deduced from Momentum Transport Accounts for RSAE Neutron Deficit

- **Neutron rate recalculated based on deduced anomalous fast ion diffusion profile**
- **Neutron deficit between plasma with/without RSAEs now more comparable**
- **However, still huge difference between calculated and measured neutron rate for both cases**
  - RSAEs only account for relatively small part of neutron deficit
  - Other AEs (eg TAEs) affecting neutron rate much more



Summary

- **RSAE activity has been shown to modify the rotation profile, while leaving the total angular momentum content unchanged**
  - Suggests redistribution of fast ion profile delivering torque to plasma
- **Study of momentum transport quantities (momentum diffusivity and momentum confinement time) allows estimate of fast ion redistribution caused by RSAEs**
- **Deduced fast ion redistribution consistent with additional deficit in neutron rate**
- **Large discrepancy still remains between measured and calculated neutron rates even when RSAE's suppressed**
  - Potentially serious issue for study of rotation and momentum transport