Transport ET: Overview

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T&T Task Force Leader

NSTX Results Review
19-20 September 2001

Transport Goals: FY00-01

- Move quickly from global to local physics studies -

- Global Characterization
  - Confinement
  - L-H threshold
- Fast Ion Confinement
  - Comparison to expected classical losses
- Local Power Balance Studies
  - Characterize diffusivities
  - Assess neoclassical vs uturbulence induced transport
  - Study ITB's
- Edge Fluctuations
  - Dedicated gas puffer and fast camera

XPs

XP #	Title	Author	# Days
18	H-mode search	R. Maingi	4
19	Global Confinement Scaling	S. Kaye	0 (piggyback)
26	Fast Ion Transport	W. Heidbrink	1
29	Perturbative Particle Transport	D. Stutman	1
34	Edge Turbulence	R. Maqueda	1
35	Kinetic Documentation	R. Bell	2

Theory and Modeling

Power Balance Studies	S. Kaye/B. LeBlanc/E. Fredrickson…
μinstability Analysis	C. Bourdelle
Neoclassical Theory – NCLASS	W. Houlberg

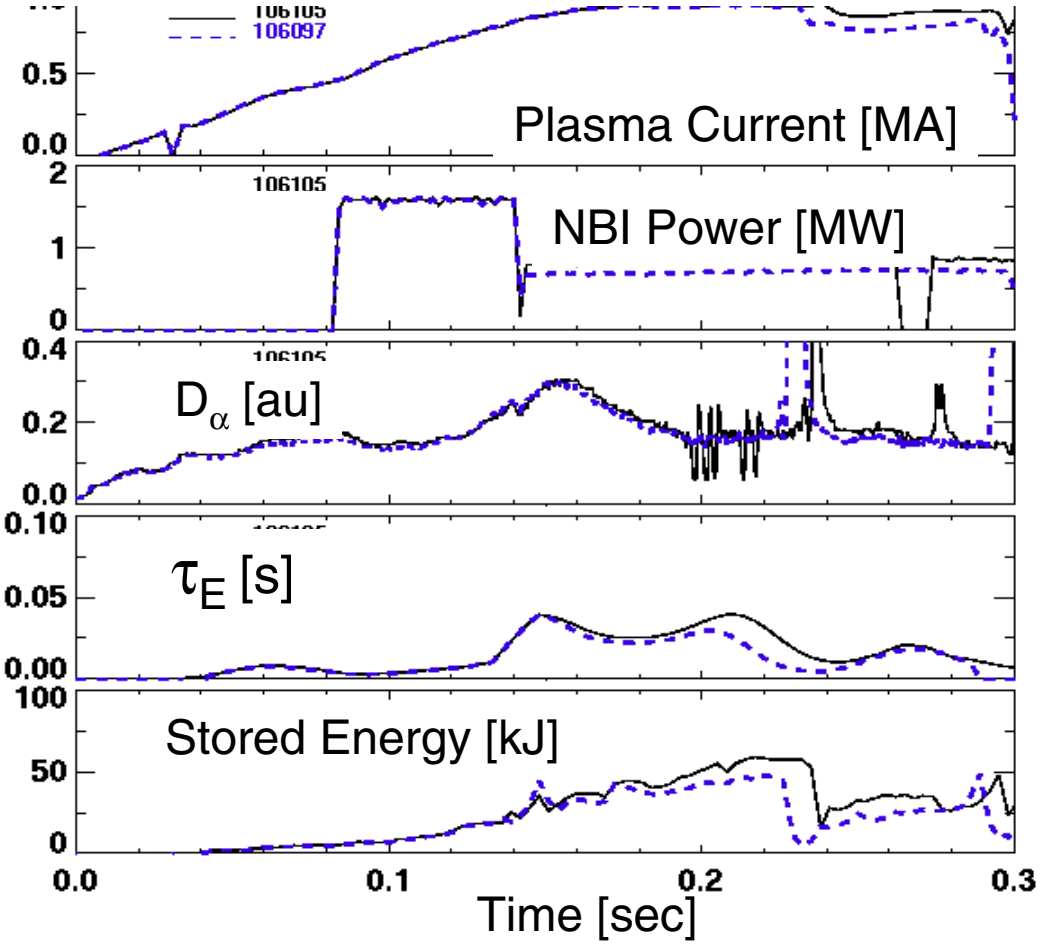
Diagnostic Development

Interferomtry/Polarimetry	M. Johnson/H. Park
X-Ray Crystal Spectroscopy	M. Bitter
Fast Ion Losses	D. Darrow

H-mode Studies Focus on Transition Physics with End Goal to Obtain Higher β in NSTX

- More than 100 transitions obtained in NSTX

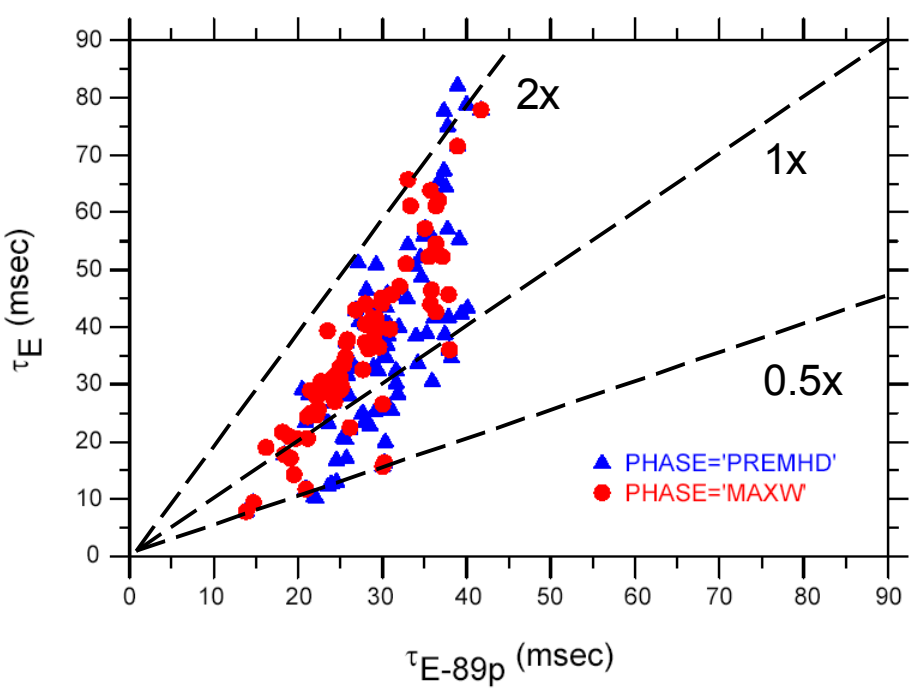
- NBI power near P_{L-H}
- Dithers show up in D_α
- τ_E improves
- Stored energy increases

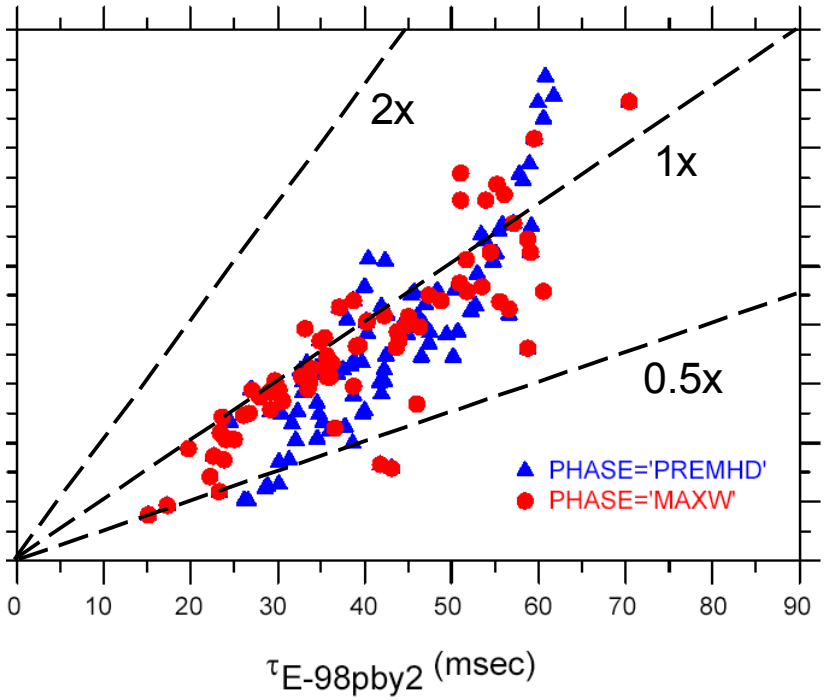


XP19 – Global Confinement Scaling

- Generally similar parametric scalings as higher R/a
  - Stronger I_p scaling (thermal + fast ion effect?)
  - Enhanced confinement observed

- 15-20% discrepancy between external magnetics and kinetic stored energy
  - Kinetic EFITs being prepared

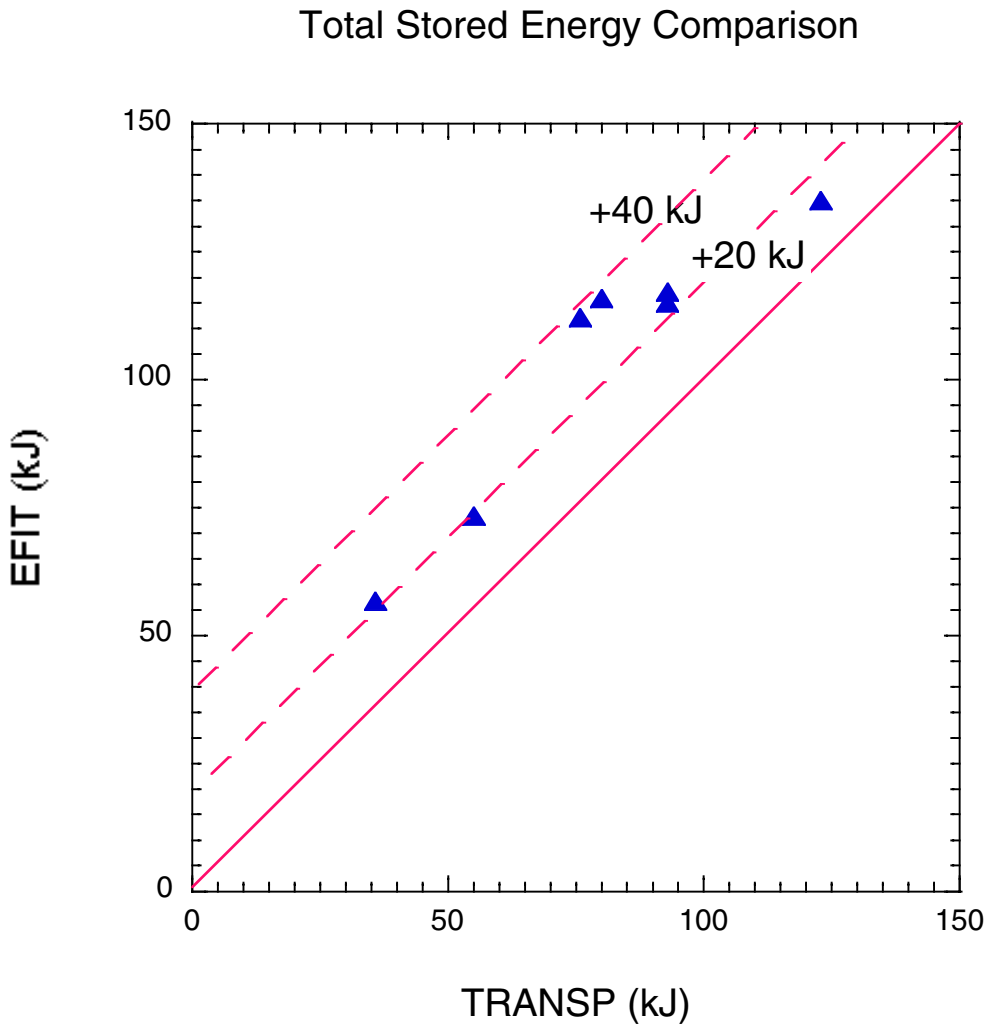




EFIT stored energies 20-40 kJ greater than those computed in TRANSP

- External magnetics in EFIT
- Measured profiles + M-C beam model in TRANSP

• Kinetic EFITS being prepared



Joint XP 29 - Perturbative Transport using Neon puffs

Goals

•Test weak Neon puff as 'tracer' of impurity transport and as 'staining agent' for MHD imaging with the USXR system

First results

- Enhanced signals for MHD imaging without significantly perturbing the background plasma
- Indications of particle transport barrier around r/a ≈ 0.6 in NBI heated discharges
- Estimated D ≈ 0.15-0.25 m^2/s inside barrier and ≈ 1.5-2.5 m^2/s outside
- Barrier seems associated with sheared (MHD) rotation around rational (3/2) surface

D. Stutman, Johns Hopkins University

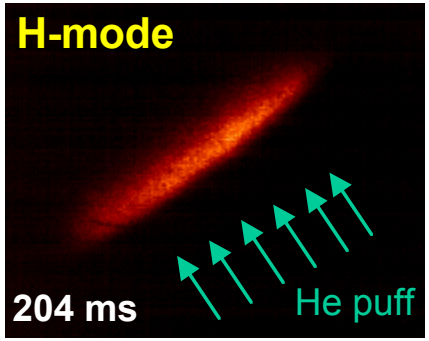
XP 34 – Edge Turbulence Studies

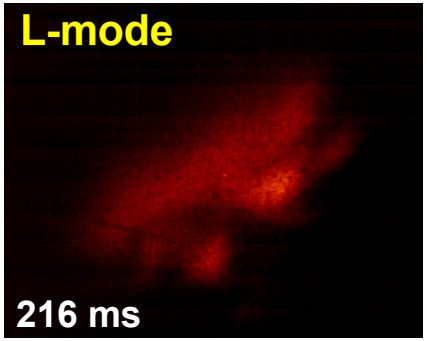
Goals

- Characterize cross-field and frequency spectrum of edge turbulence
- Comparison with BAL (Myra, Lodestar) & BOUT (XU, LLNL) simulations

First Results

- Data obtained in a variety of plasma conditions (configuration, I_p, B_T)
- I_p/B_T variations had strongest influence
- Strong suppression of turbulent eddies observed during H-phase



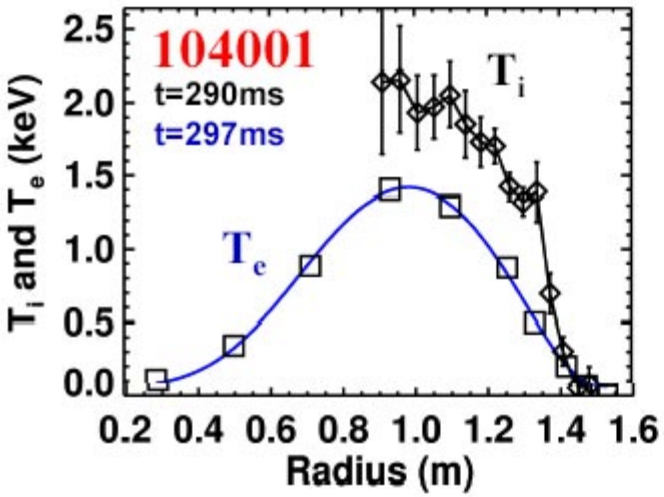


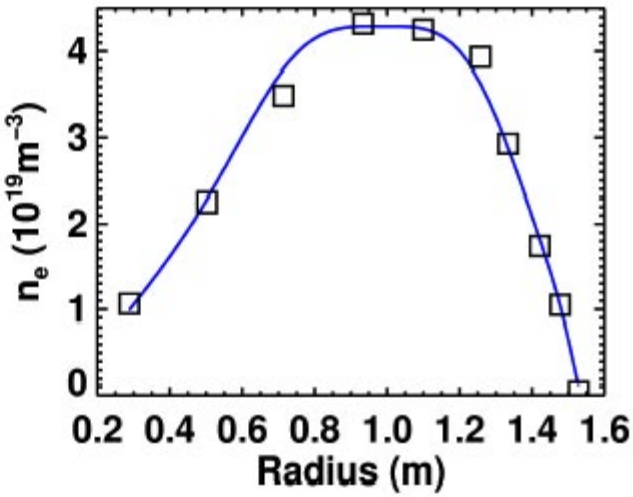
R. Maqueda (LANL), S. Zweben (PPPL)

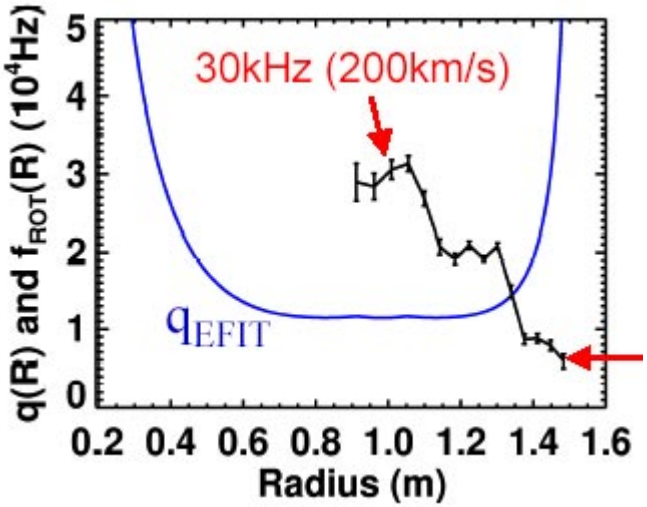
XP 35 – Kinetic Documentation

- Power balance studies performed in NBI and RF-heated plasmas
- Studies have revealed apparent very low ion thermal transport across plasma
  - Associated with high plasma rotation across plasma
  - Results suggest need to assess the importance of physics mechanisms not previously considered

$T_i > T_e$ Over Most of Plasma





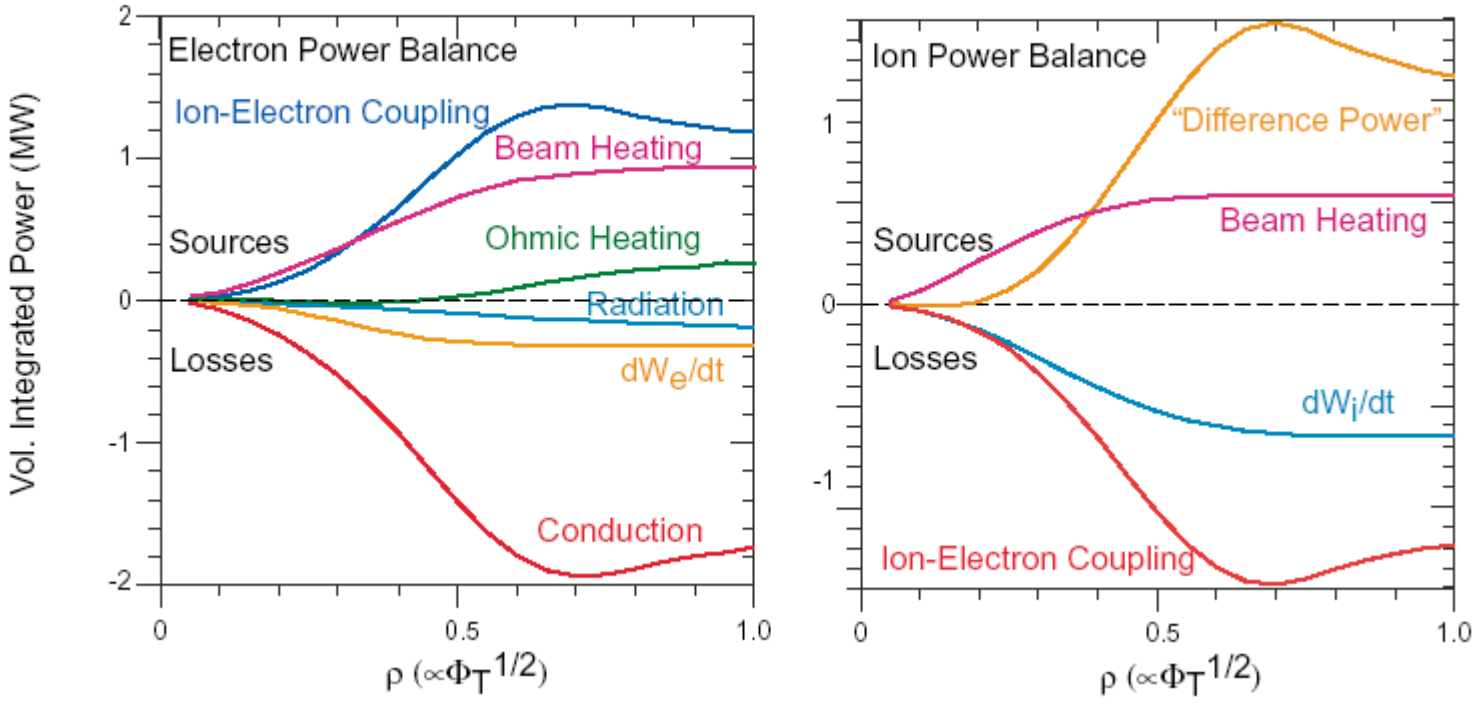


High toroidal rotation

5 kHz (50 km/sec)

Power Balance Shows Large Ion "Difference Power" >0

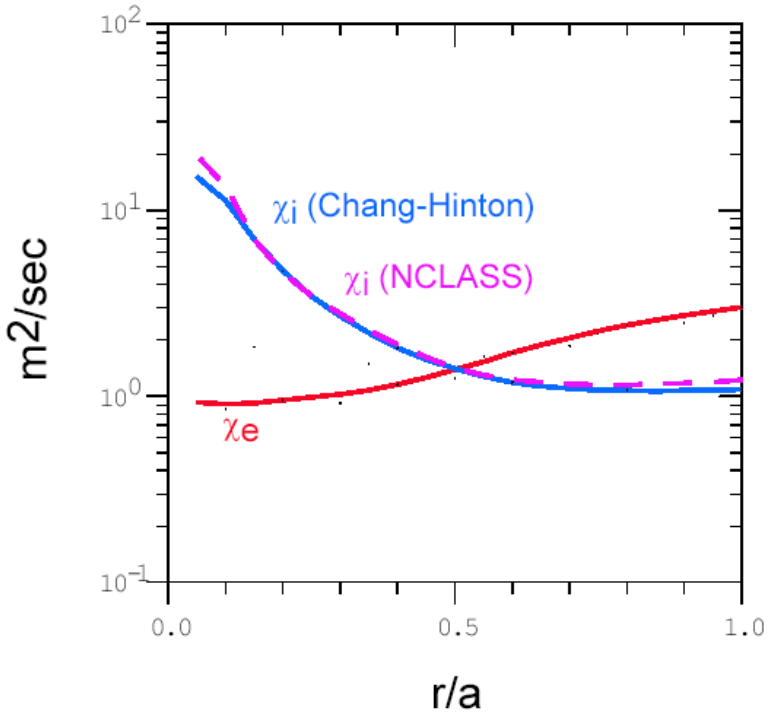
- Difference power usually a loss and attributed to thermal conduction
- Large classical Q_{ie}, dW_i/dt losses; additional ion heating power needed to balance terms

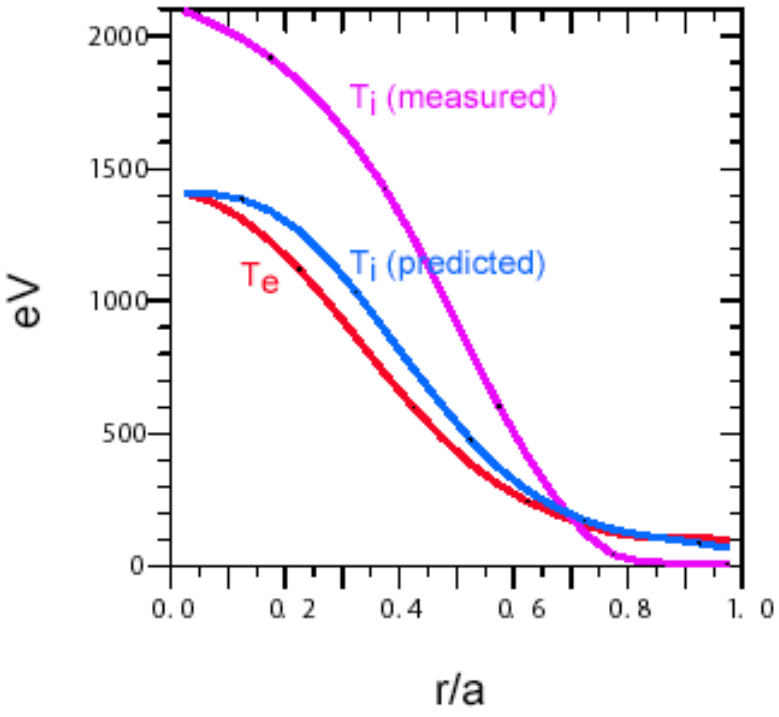


T_i Predicted To Be Only Slightly Above T_e Within Classical Heating/Loss Framework

Predictive transport calculation assumes

$\chi_i = \chi_{i,\ neoclassical\ (C\text{-}H)} \sim \chi_{i,\ neoclassical\ (NCLASS)}$

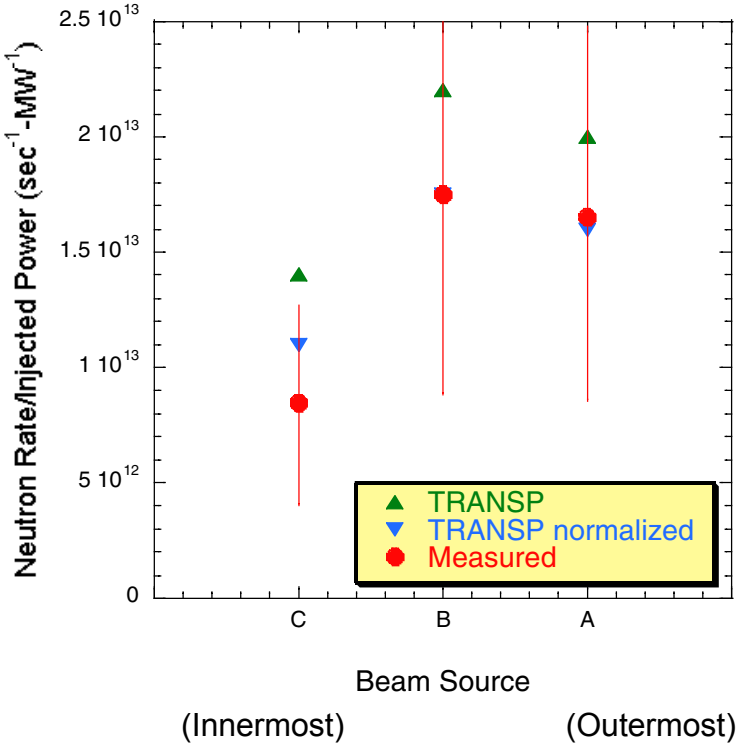




Non-classical mechanisms may be important

Fast Ion Confinement Appears to be Near Classical

- *Calculated neutron rates in agreement with measurements (L. Roquemore)*

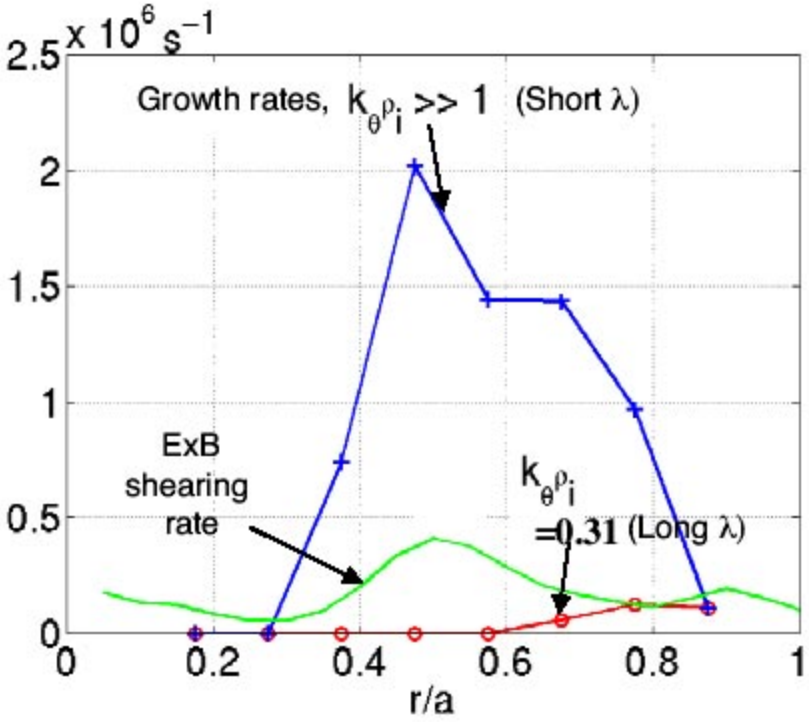


- *Beam blip XP26 shows classical slowing down (W. Heidbrink)*
- *Fast ion loss probes show much lower loss than expected (D. Darrow)*

μ–turbulence Calculations Indicate Short λ Modes May Dominate Transport

- Long-λ growth rates lower than ExB shearing rate
  - Associated with ion transport

- Short-λ growth rates large
  - Associated with electron transport



C. Bourdelle (PPPL), W. Dorland (UMd)

Summary

- Transport studies are well underway and have moved from global to local studies
- Work is underway with experiments, modeling and theory
- Transport results have identified the need to “think outside the box”
  - Additional ion heating mechanisms possibly needed
    - Stochastic heating by CAEs
    - Centrifugal heating associated with high plasma rotation
    - Modifications to neoclassical theory in the presence of strong rotational shear, $\rho^i > L_n$ (Wang)