

# Summary of Activities for TC-1: $\beta$ Scaling

by  
C. C. Petty

Presented at  
Transport and Confinement ITPA Meeting  
PPPL, Princeton University  
October 5 – 7, 2009

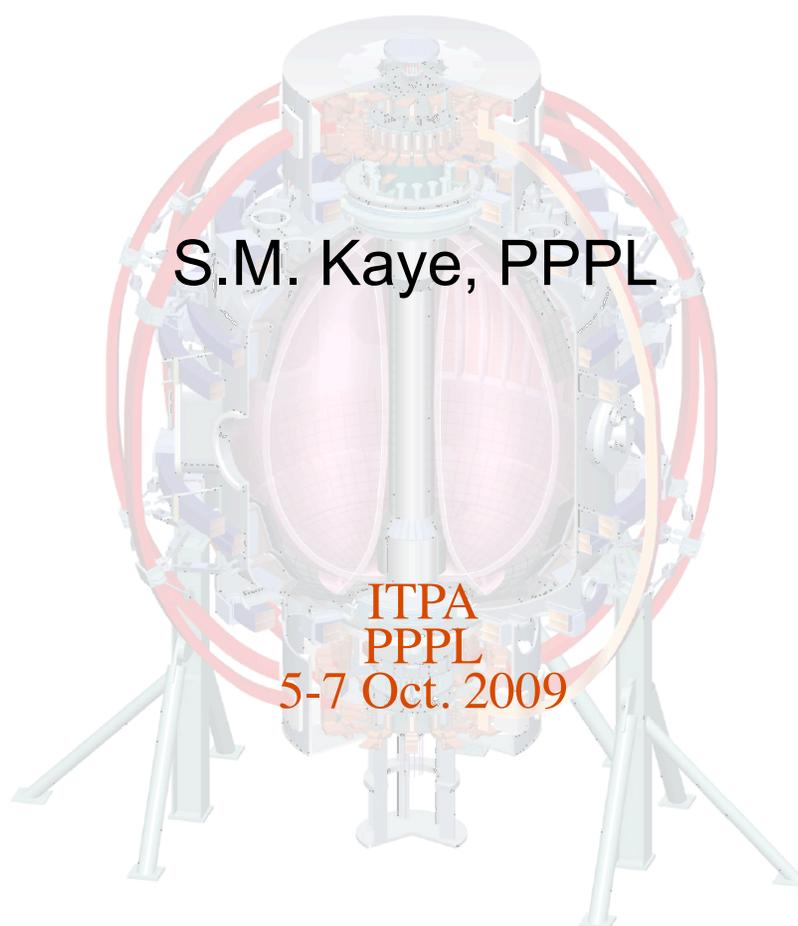
# TC-1 “ $\beta$ Scaling” – analysis ongoing for completed experiments, new experiments from NSTX

## Plans for next 12 months:

- **AUG:** No new experiments in 2009 due to technical restrictions of machine. Next opportunity at end of 2010
- **DIII-D:** Continue to analyze turbulence and transport results from joint  $\beta$  scaling experiment with AUG in 2007
  - Have good BES and FIR turbulence results
- **JET:** Recent experiments in hybrid scenario reported at last meeting, analysis continues
- **MAST:** Two experimental sessions planned for December 9-10, 2009, utilizing upgrade to NBI heating power
- **NSTX:** New experiments in 2009 in ELM-stabilized H-mode plasmas using Lithium injection (shown next)

## Beta Scaling of Confinement in NSTX

College W&M  
Colorado Sch Mines  
Columbia U  
Comp-X  
General Atomics  
INEL  
Johns Hopkins U  
LANL  
LLNL  
Lodestar  
MIT  
Nova Photonics  
New York U  
Old Dominion U  
ORNL  
PPPL  
PSI  
Princeton U  
SNL  
Think Tank, Inc.  
UC Davis  
UC Irvine  
UCLA  
UCSD  
U Colorado  
U Maryland  
U Rochester  
U Washington  
U Wisconsin



S.M. Kaye, PPPL

ITPA  
PPPL  
5-7 Oct. 2009

Culham Sci Ctr  
U St. Andrews  
York U  
Chubu U  
Fukui U  
Hiroshima U  
Hyogo U  
Kyoto U  
Kyushu U  
Kyushu Tokai U  
NIFS  
Niigata U  
U Tokyo  
JAEA  
Hebrew U  
Ioffe Inst  
RRC Kurchatov Inst  
TRINITI  
KBSI  
KAIST  
POSTECH  
ASIPP  
ENEA, Frascati  
CEA, Cadarache  
IPP, Jülich  
IPP, Garching  
ASCR, Czech Rep  
U Quebec

# Approach

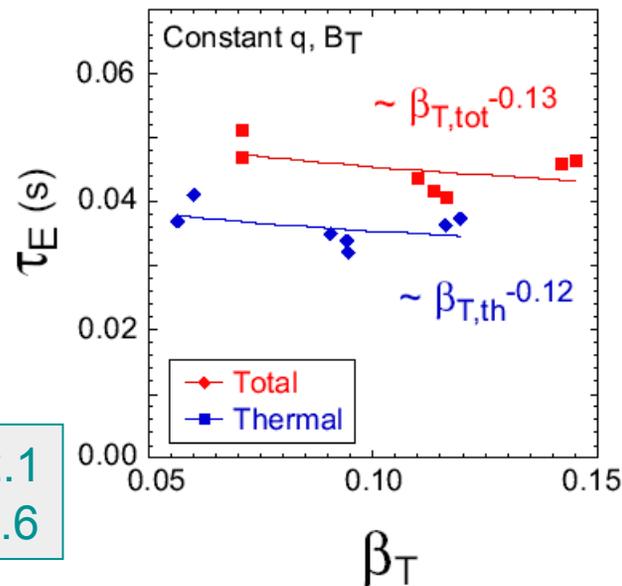
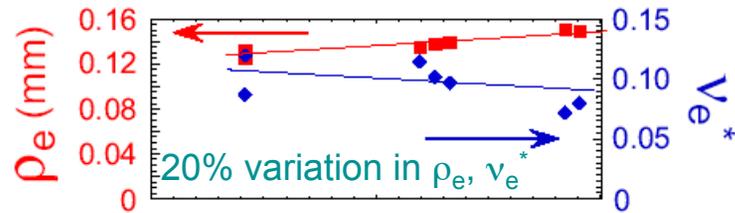
- Approach is to hold collisionality fixed and perform beta (power) scan to assess degradation of confinement with beta
- Initial experiments run in 2006 and 2007
  - Little or no degradation observed in strongly shaped plasmas ( $\kappa \sim 2.1$ ,  $\delta \sim 0.65$ ), consistent with DIII-D, JET results
    - This part was completed in plasmas having Type V ELMs
- Redid scan in 2007 in weakly shaped plasmas ( $\kappa \sim 1.8$ ,  $\delta \sim 0.45$ ) to test effect of shaping (strong degradation seen in JT60-U, AUG)
  - Found large variation in ELMs from low to high powers
  - Observed very strong degradation, but could have been due to different ELM behavior
- Scans redone in 2009 in plasmas with ELMs suppressed by Lithium
  - Issue was to establish plasma that would allow  $> 4$  MW power without hitting beta limit
  - Able to do this at higher  $B_T$  (0.5 T)

# Beta Scaling of Confinement

## 2006 Results

$\beta$ -scan at fixed  $q$ ,  $B_T$

- Factor of 2-2.5 variation in  $\beta_T$
- Degradation of  $\tau_E$  with  $\beta$  weak on NSTX



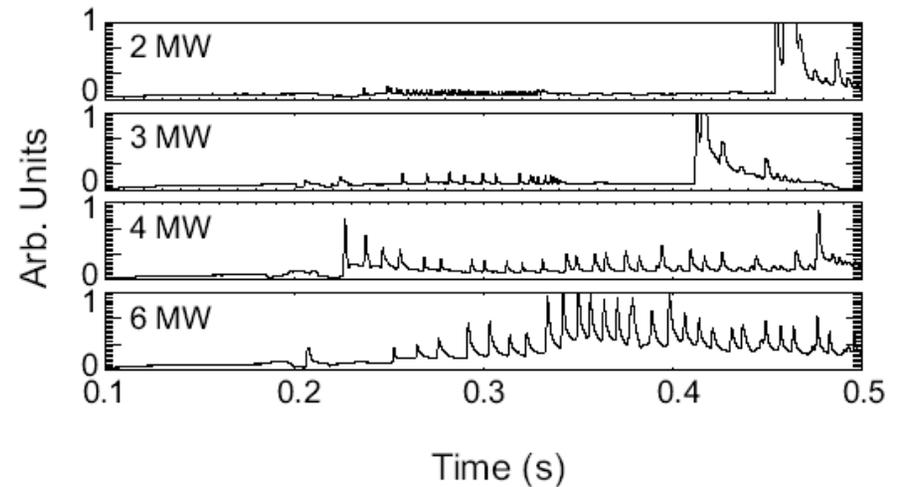
$\kappa=2.1$   
 $\delta=0.6$

2007: Test shape dependence with similar power scan

- $\kappa=1.8-1.9$ ,  $\delta\sim 0.4$
- $v_e^*$ ,  $\rho_e$  vary  $\leq 20\%$  across scan

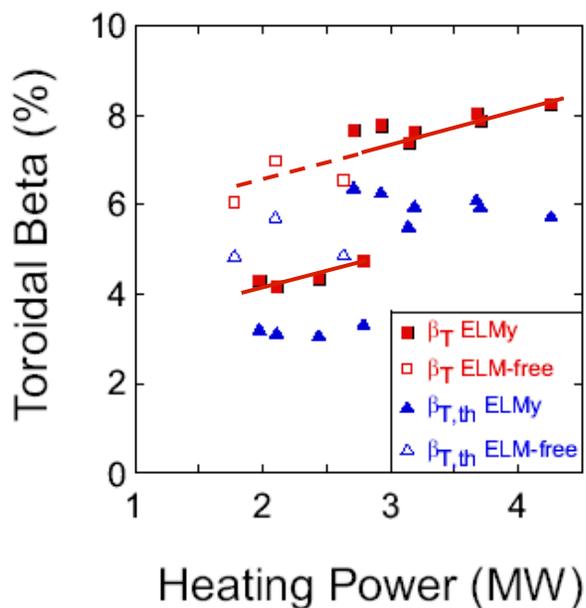
- ELM severity increased with increasing power

- Only few % loss per ELM
- High frequency ELMs at low power (Type III?)



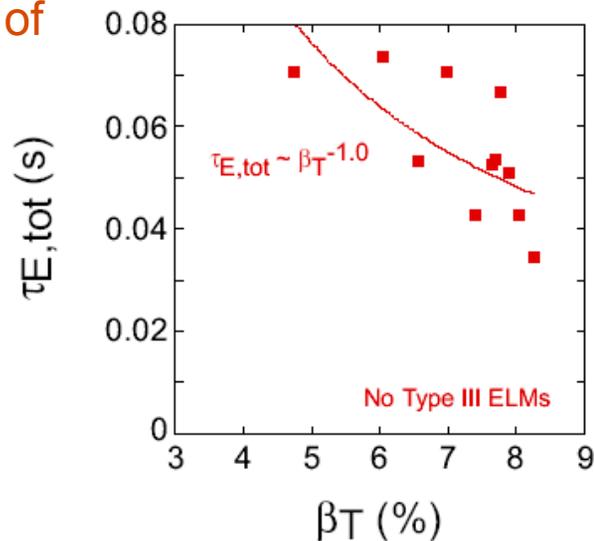
# 2007 Results Inconclusive

Type III ELMs severely degrade confinement



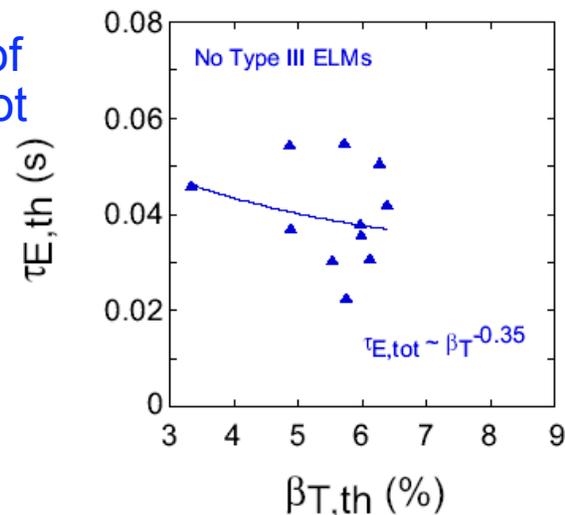
Beta scaling depends on plasma shape through difference in ELM behavior  
Consistent with results from AUG

Strong degradation of  $\tau_{E,tot}$  ( $\tau_E \sim \beta_T^{-1.0}$ )



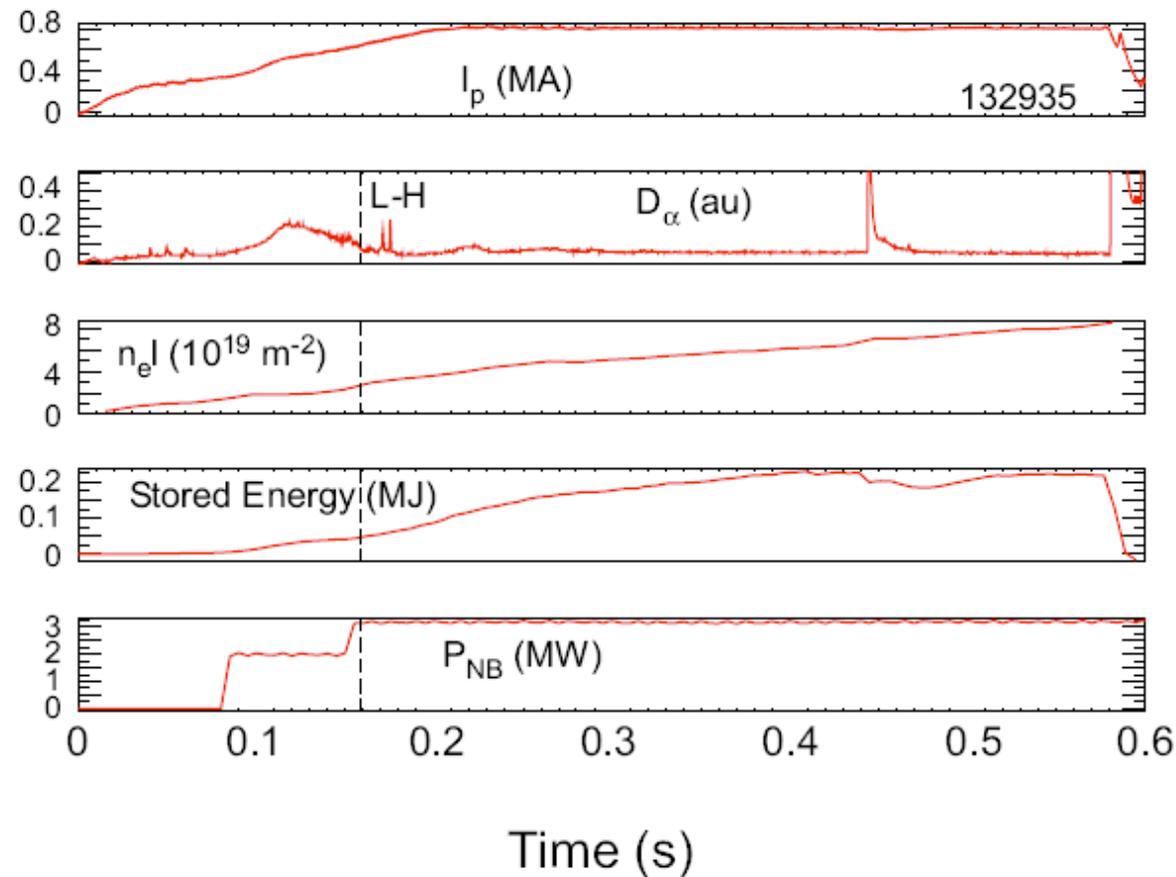
Weaker degradation observed in  $\tau_{E,th}$

Stronger degradation of  $\tau_{E,th}$  than  $\beta_{T,th}^{-0.35}$  cannot be ruled out



# Lithium Evaporation Produced Plasmas with Long ELM-free Durations in 2008 and 2009

- 200 mg of Lithium evaporated between shots
- $P_{NB}$  from 2 to 6 MW (H-mode accessible with  $P_{NB} < 2$  MW with Lithium)



## Confinement Remains Weakly Dependent On $\beta$

- $\kappa \sim 1.9$ ,  $\delta \sim 0.5$ 
  - Not as low as desired
  - MHD impact for weaker shapes
- Range in  $\beta$  more limited than in previous scans
- $\tau_E \sim \beta^{-(0.20-0.25)}$

