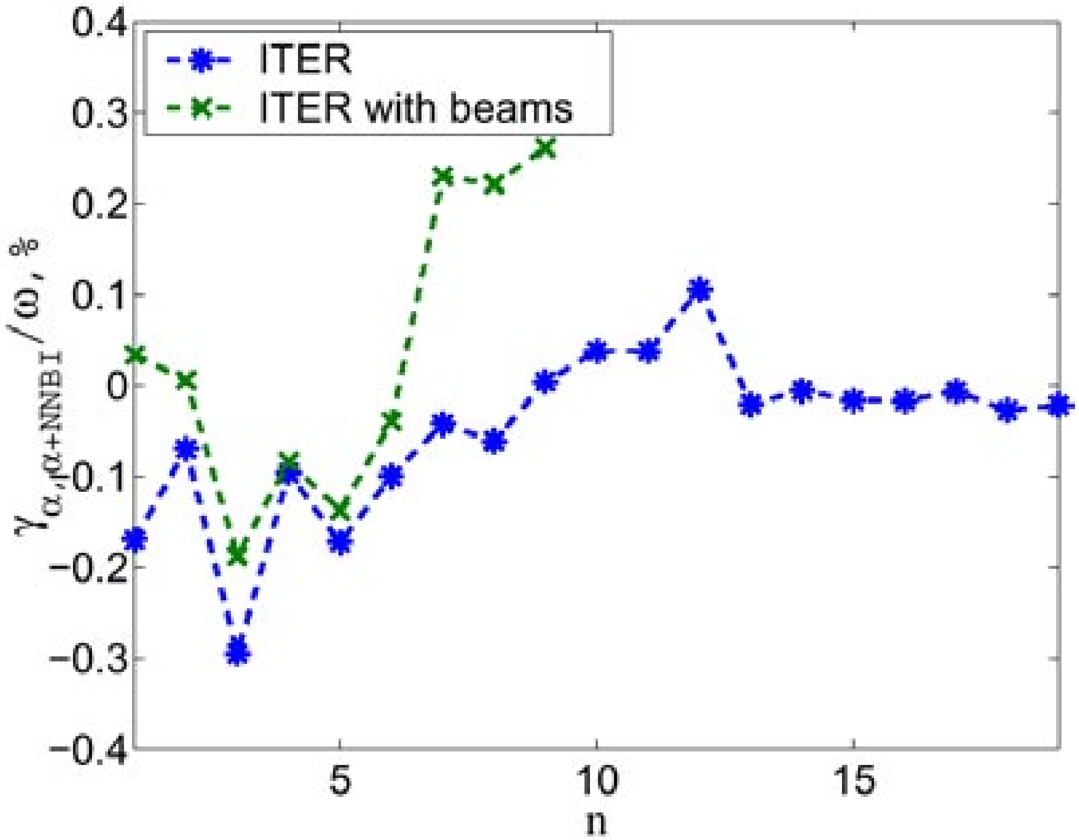
ST Has Lots to Benefit from BPX and Lots to Contribute

- ST concept is based on Tokamak D-D data and understanding
- BPX will strengthen this basis at tokamak reactor parameters
- Examples of BPX α physics $\Rightarrow$ ST fast particle physics
  - "Sea of α-driven TAE's" $\Rightarrow$ Bursty TAE's in ST
  - Theory of ICE $\Rightarrow$ "Sea of CAE's" in ST
- Examples of ST research $\Rightarrow$ BPX (standard tokamak) physics issues
  - Large shaping, ρ_θ, edge q′ $\Rightarrow$ test pedestal models $\Rightarrow$ reduce uncertainties in BPX confinement
  - Larger ρ_e and modest B $\Rightarrow$ test ETG-related large-k transport $\Rightarrow$ reduce uncertainties in BPX electron loss channel
  - Low A effects $\Rightarrow$ test physics of L-H transition $\Rightarrow$ reduce uncertainties in BPX threshold power
  - Contributions on ELM's, RWM, edge physics, etc.
- ST Projections indicate large expansion in toroidal parameter space, $\Rightarrow$ **extended tests to improve physics understanding**

1 MeV NNBI is destabilizing to TAEs in ITER: May be used to simulate alphas in Hydrogen Phase



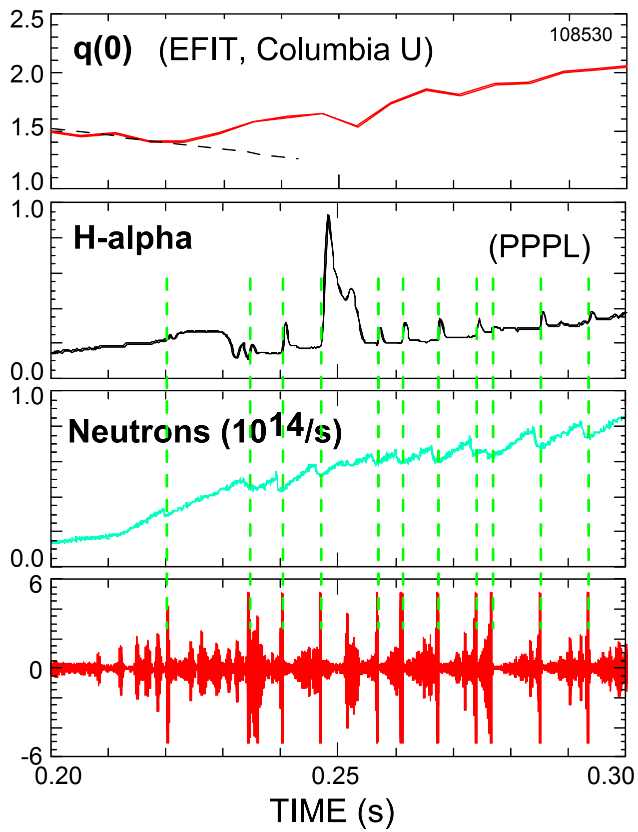
- Beam ion loss may be an issue!

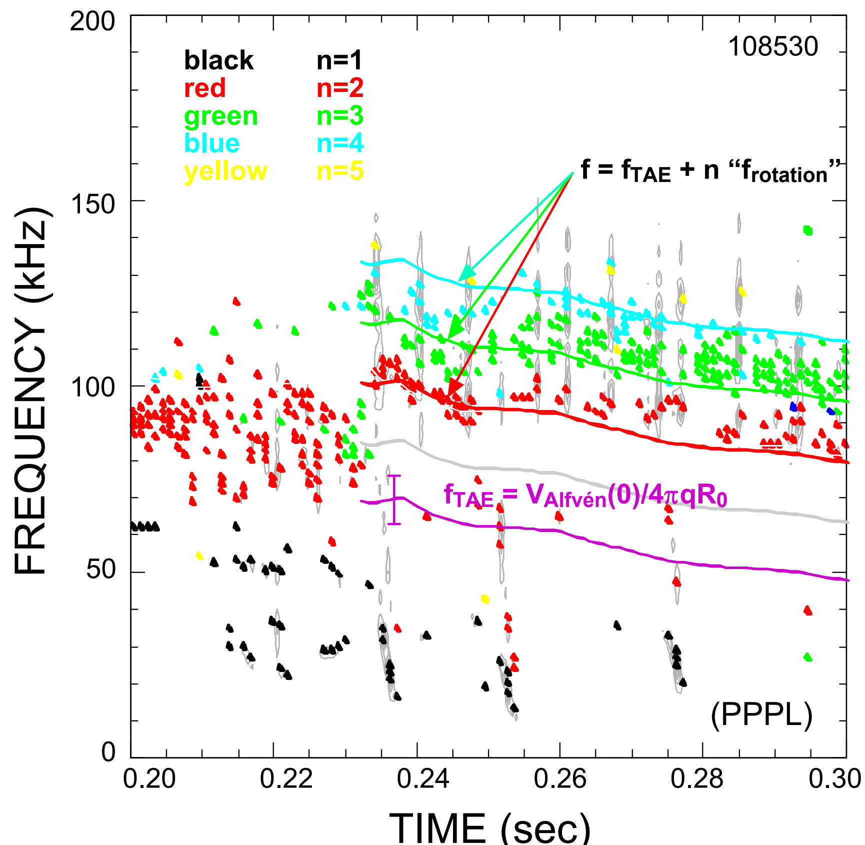
- Lower energy edge localized beams may be an effective control tool to stabilize TAEs in ITER (R. Nazikian)

Could Bursty TAE's Expel Fast α's in Future Fusion ST Devices?

Snowmass 2002

- TAE bursts identified in H-mode plasmas
- Correlate with fast ion loss and D-α spikes
- Due to larger gaps in frequency?





Is “Sea of CAE’s” Expected in Future Fusion ST Devices?

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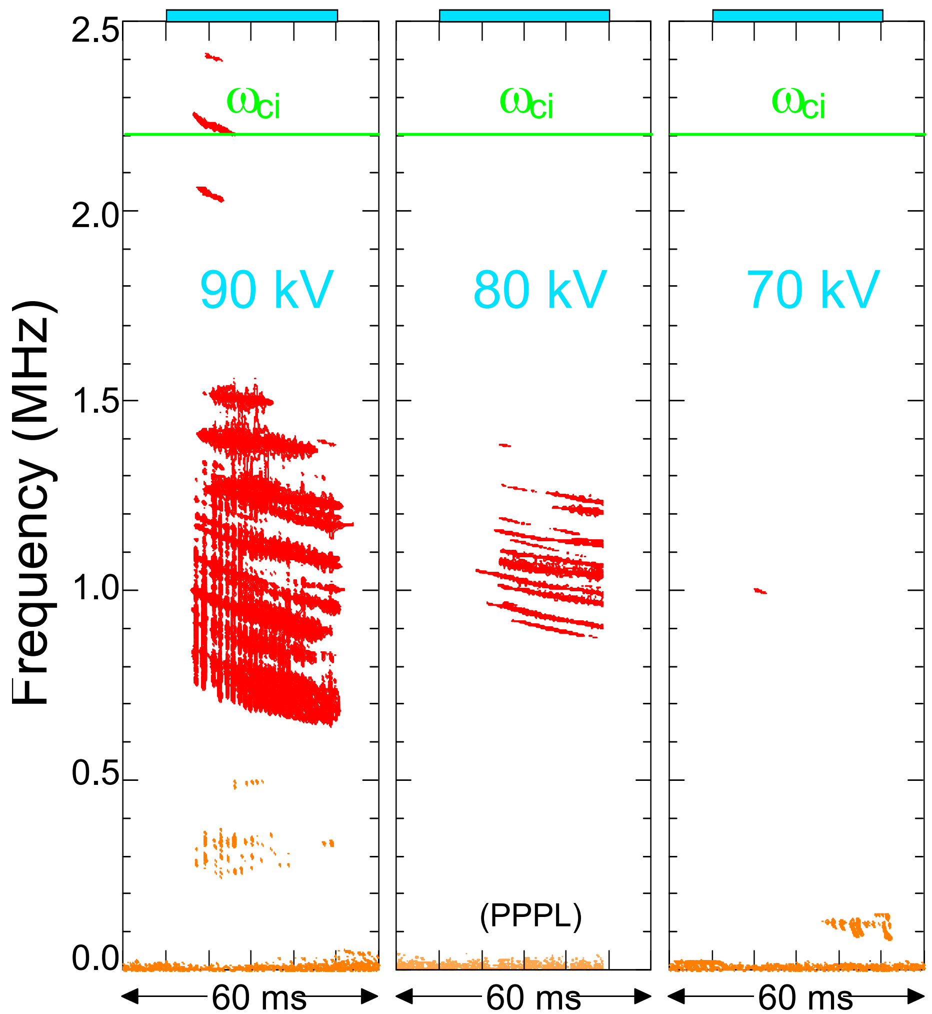
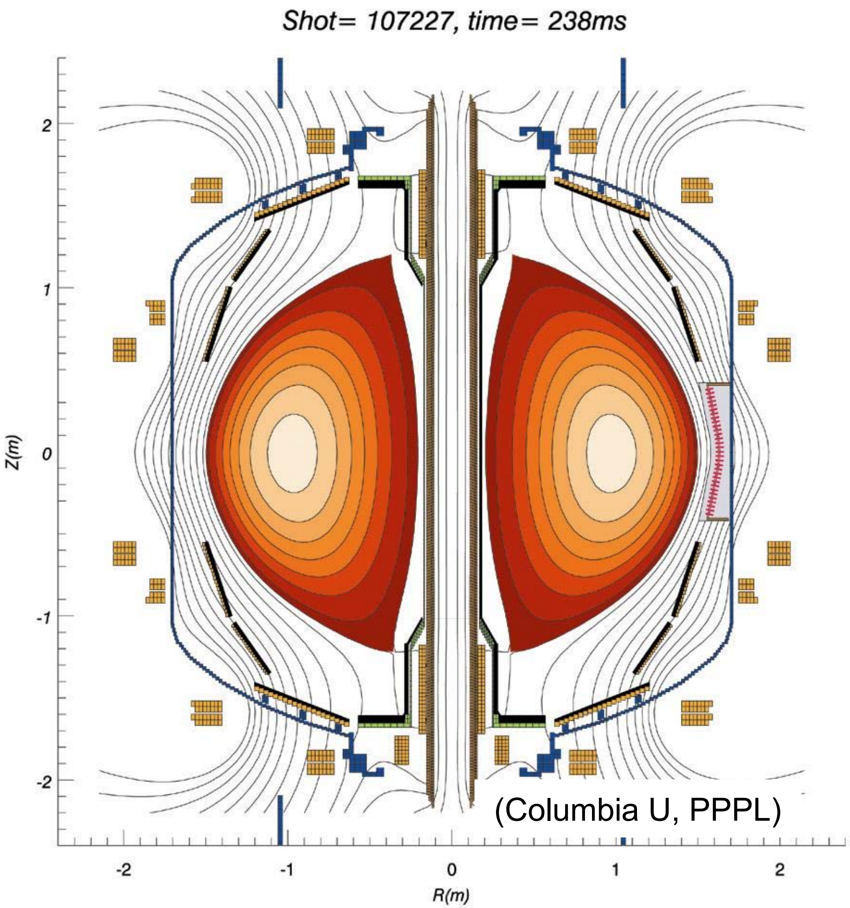


- CAE’s identified
- Fit theory: broad resonant spectra away from ion cyclotron frequencies
- Sharp dependence on NBI energy – V_{fast}/V_{Alfven} > 2-4
- Benign to fast ions so far
- Higher $V_{fast} \Rightarrow$ more bands?
- Effects on thermal ions?
- Important for future devices with $\mathbf{V_{\alpha}/V_{Alfven}}$ **> 2-4**

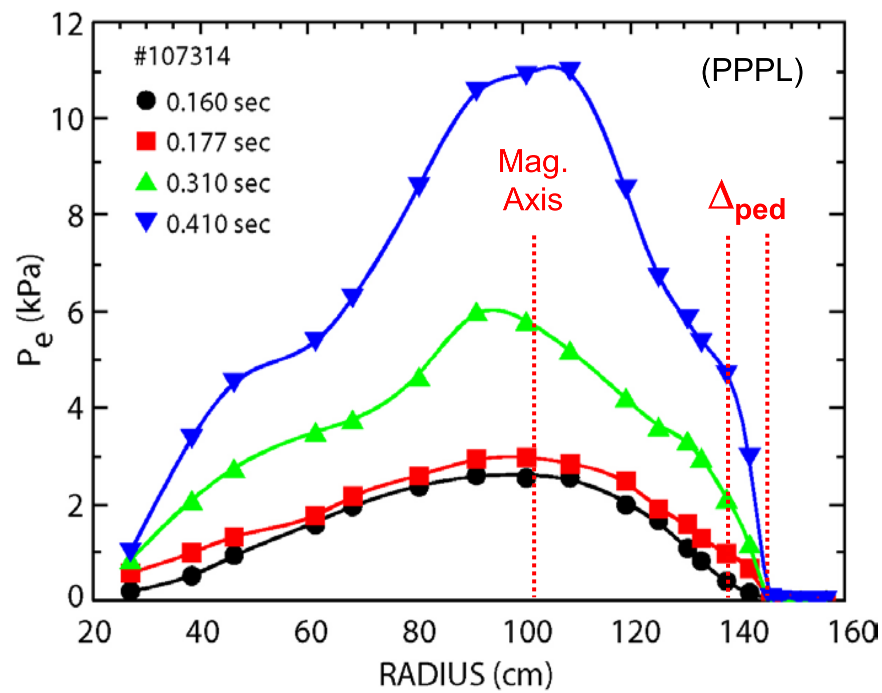
Strong Shaping, Large ρ_θ* and Edge q′ Change Pedestal Height and Width ⇒ Better Understanding

Snowmass 2002

Strong shaping of high β ST plasma



Relatively thick and tall pedestals build up over time scales >> energy confinement times

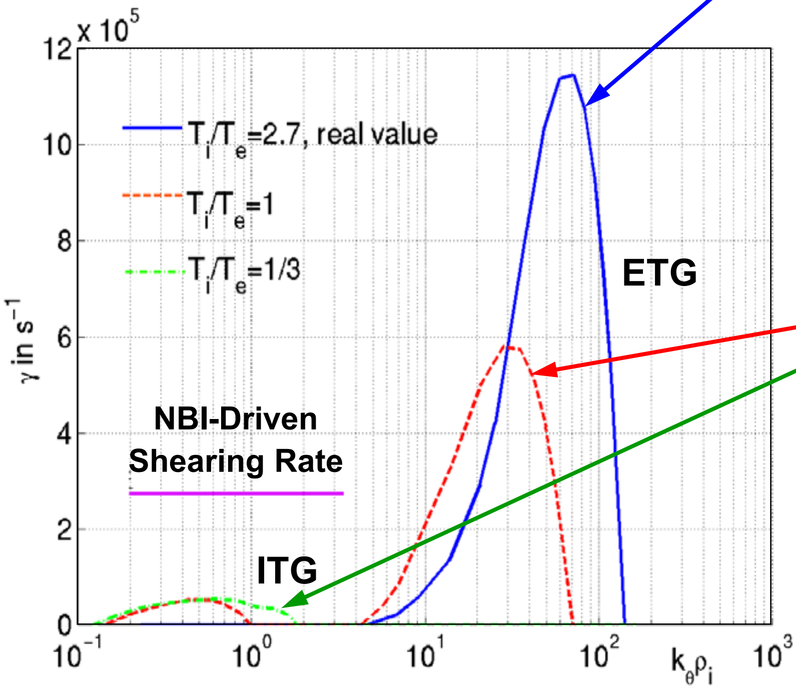


(I_p = 900 kA, P_{NBI} = 2→5 MW, ρ_θ*/a ~ 0.05)

High β & Larger ρ_e Introduce Special Opportunities to Help Understand ETG-Turbulence in BPX

Snowmass 2002

Gyrokinetic Fluctuation Growth Rates in NSTX



(PPPL, U Maryland)

- **Interpretation of NSTX data**
  - ITG stabilized
  - ETG strongly unstable
- **Questions**
  - High β' → diamagnetic flow?
  - High β → magneto-sonic effects?
  - Strong shearing + $T_i \leq T_e$ → stabilize both ITG & ETG?
- **High β large ρ_e ease measurement of large-k fluctuations**
  - High β → stronger electromagnetic fluctuations
  - Larger ρ_e → eases ETG measurement

L-H Threshold Powers in ST's Have Deviated From Standard Scaling

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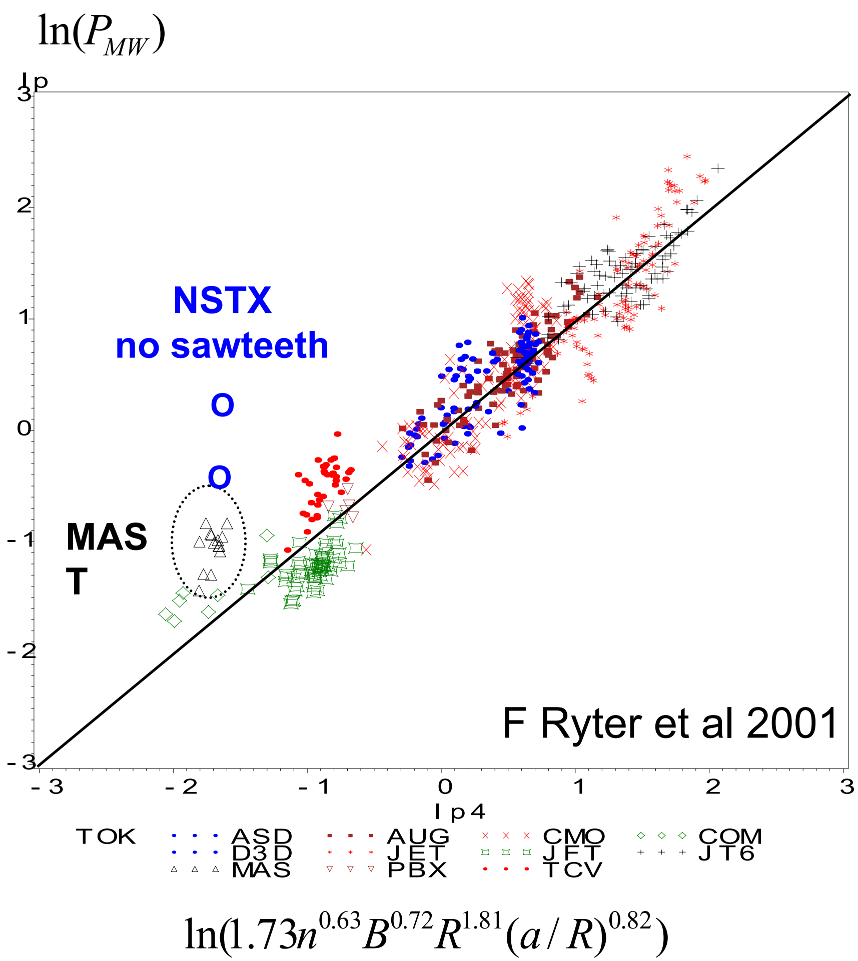
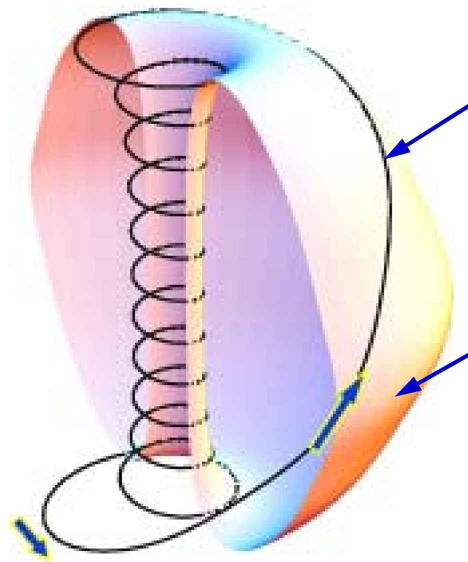


- MAST/NSTX data double the range of a/R
- Compare with ITER scaling: $P_{MW} = 1.73n^{0.63}B^{0.72}R^{1.81}(a/R)^{0.82}$
  - Higher P_{th} by factor 5-10
  - $P_{th}\sim aR$ rather than $P_{th}\sim R^2$
- What mechanisms related to low A may cause the deviations?

Courtesy of: UKAEA Fusion

ST Plasmas Expands Toroidal Parameter Space & Provide Extended Tests to Improve Physics Understanding

Snowmass 2002



Spherical Torus

Expanded plasma parameter space:

- Strong plasma shaping & large edge q′ ($A \geq 1.27$, $\kappa \leq 2.5$, $B_p/B_t \sim 1$, $q_{edge} \sim 10$)
- Stability with hollow current (low l_i) with $q' \geq 0$; $\beta_T \leq 40\%$ & central $\beta_0 \sim 100\%$
- Large |B| well (~30%)
- Large ρ_i/a (~ 0.03 – 0.01), ρ_θ/a
- Large plasma flow ($V_{rotation}/V_A \sim 0.25$)
- Large flow shearing rate ($\gamma_{ExB} > 10^5$/s)
- Supra-Alfvénic fast ions ($V_{fast}/V_A \sim 2$–4)
- High dielectric constant ($\varepsilon \sim 30$–100)
- Large mag. curvature & mirror in edge