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NSTX Science & Program Goals

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NSTX Scientific Goals Have Been Clearly Defined and Well Directed to Program Goals

	Great Science	for Energy Program
Nearer Term	Make preliminary determination of the attractiveness of the Spherical Torus, by assessing high-beta stability, confinement, self-consistent high-bootstrap operation, and acceptable divertor heat flux, for pulse lengths >> energy confinement times.	
Longer Term	Assess the attractiveness of extrapolable, long-pulse operation of the Spherical Torus for pulse lengths >> current penetration times.	Assess potential of Spherical Torus as a basis for burning plasma studies and/or fusion-nuclear component testing.

The NSTX Scientific Goals Have Exciting New Questions to Address as Suggested by Theory

NSTX

- **New Startup Technique:**
  - Very Small magnetic flux & helicity content ⇒ CHI & CHE (Ejection)?
  - Coaxial Helicity Injection (CHI) ⇒ help understand reconnection?
  - Large dielectric constant ⇒ EBW, HHFW noninductive startup and CD?
- **Order-Unity Central Beta:**
  - $v_{sound} \sim v_{Alfvén}$ ⇒ electromagnetic turbulence important?
  - $v_{flow} \rightarrow v_{Alfvén}$ ⇒ large plasma flow modifies equilibrium, stability?
  - Strong magnetic well ⇒ stable, hollow current matches bootstrap?
- **Turbulence Suppression:**
  - Improved curvature & large ion gyroradius ⇒ reduce micro-instability?
  - ∇p-driven flow shearing rates >> micro-instability growth rates ⇒ different ITB and QH-mode behavior?
- **Supra-Alfvénic Fast Ions:**
  - v_{fast} (NBI ions) ~ $3v_{Alfvén}$ ⇒ new eigenmode gaps and continuum?
  - Large gyroradius, small size ⇒ reduced Alfven turbulence spectrum?
  - Large magnetic well ⇒ suppression of energetic particle modes?

This Scientific Goal Points to Progression of ST Physics Investigations and Potential Discoveries

NSTX

Present Collaborations | **Collaborations to be Reviewed/Renewed**

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Now … **nearer term** … **longer term**

Device: **pulse >> τ_E** **(New centerstack, PFC, Li module)** **pulse >> τ_{skin}**

Noninductive Startup: CHI, combined CHI, full startup, rf-only startup, bootstrap startup

Heating, Current Drive, Fueling: full HHFW, initial EBW, fueling, startup-sustainment, long pulse

Macroscopic Stability: no-wall limit, active control, disruption avoided, high I_{BS}, profile control

Turbulence & Transport: τ_E, χ_e, χ_I, D, sup. turbulence, edge barrier control, ITB control, double-barrier

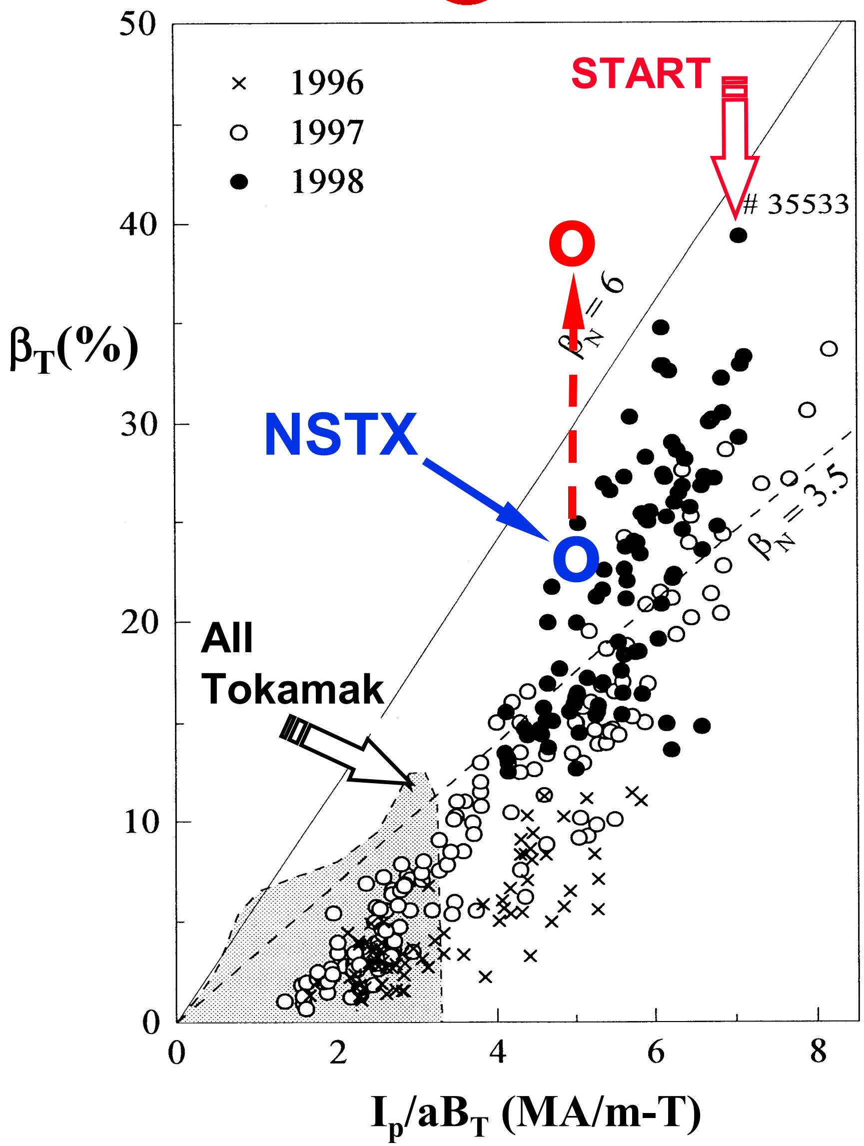
Energetic Particles: modes, Alfven turbulence, EP ejection control

Multi-state Interface: edge fluxes, edge control, Li control, recycle control

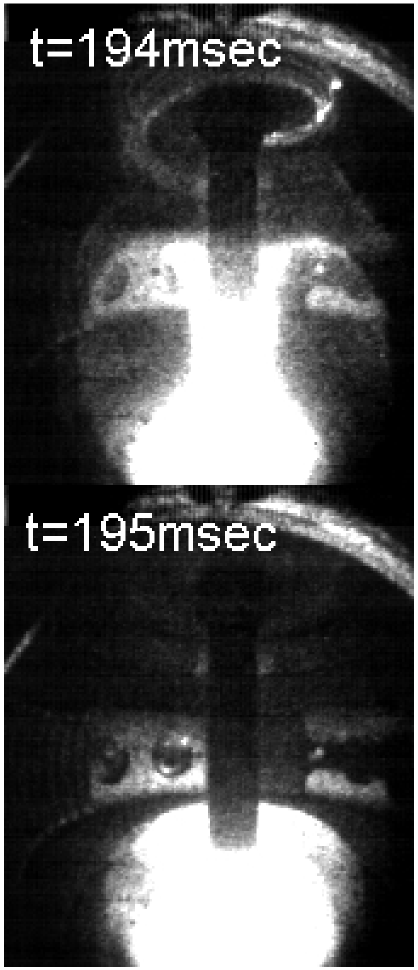
Integration: β_{NW}-τ_E, β_{NW}-τ_E-CD-edge, β_{MC}-τ_E, β_{MC}-τ_E- CD- I_{BS}-edge

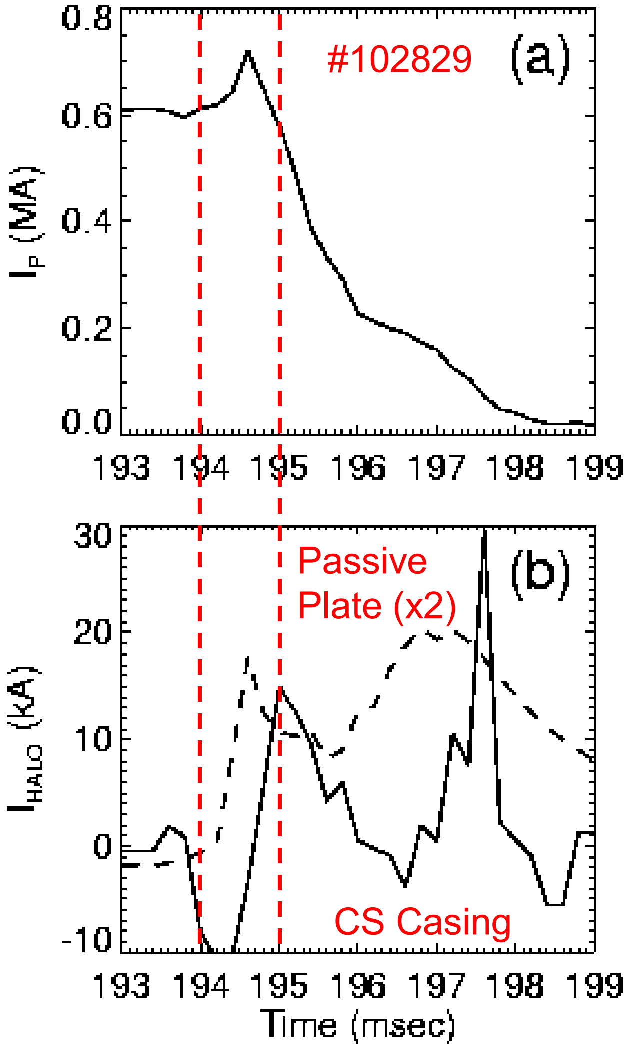
Macroscopic Stability of NSTX Plasma at High β_T Is a Major Scientific Endeavor in the Nearer Term

- Sawtooth
- Kink Mode
- Resistive Tearing Mode
- Reconnection Event
- Neoclassical Tearing Mode
- Ballooning Mode
- Pressure-Driven Mode
- Resistive Wall Mode
- Alfven Eigenmode
- Edge Localized Mode
- Peeling Mode
- Edge Harmonic Oscillation
- Mode Control



VDE From an Reconnection Event Only Induced 3–5% Halo Current in NSTX Center Stack Casing

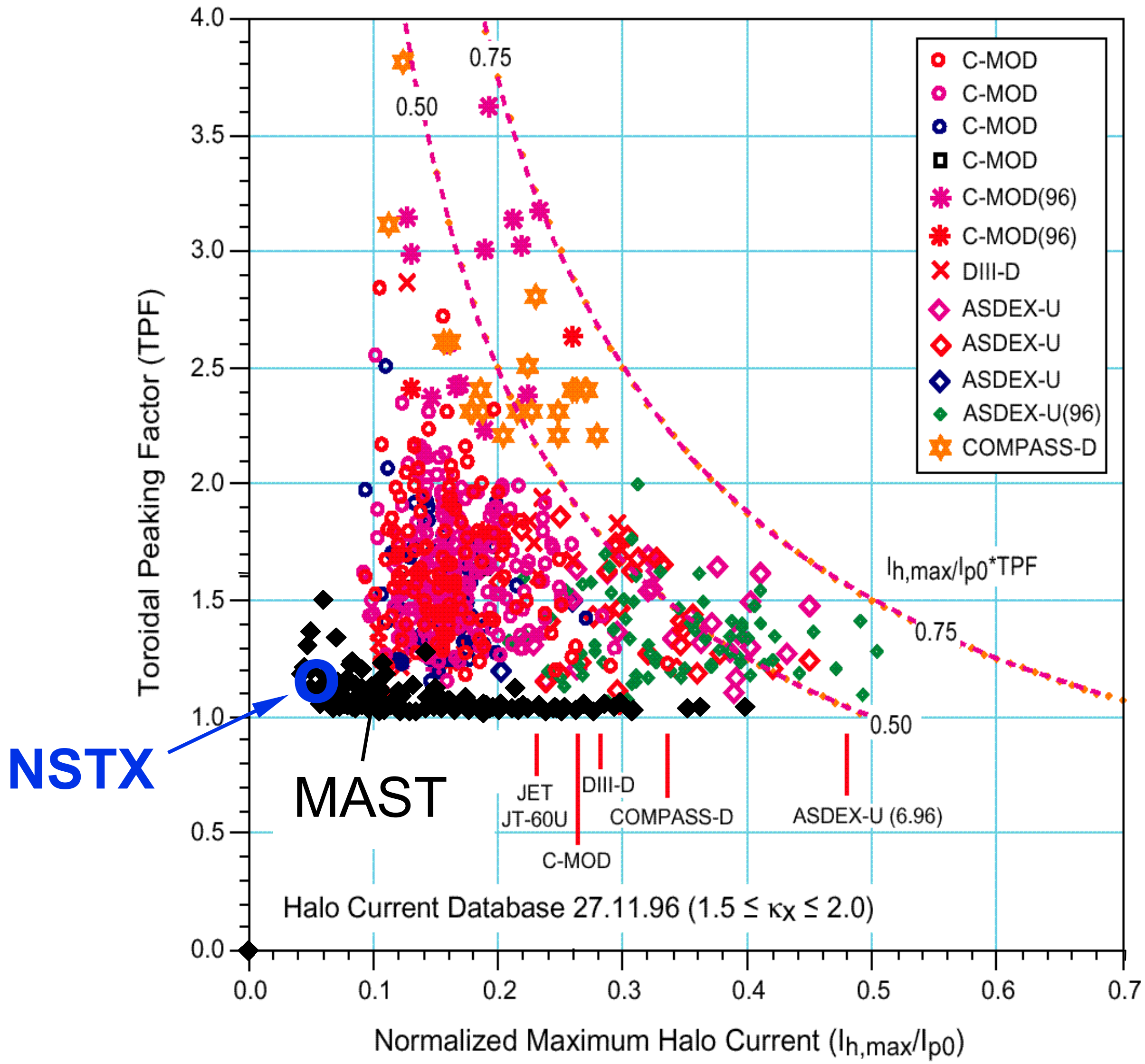




- **Loss of position control in lower single-null plasma**
- **Fastest current decay in 2-3 ms**
- **Maximum Halo current to CS ~ 30 kA**
- **Smaller passive plate current ~ 10 kA**
- **Inboard limited plasma decays in 20-50 ms after Reconnection Events**

Small Halo Currents Are Observed In MAST and NSTX

UKAEA Fusion Working with Europe



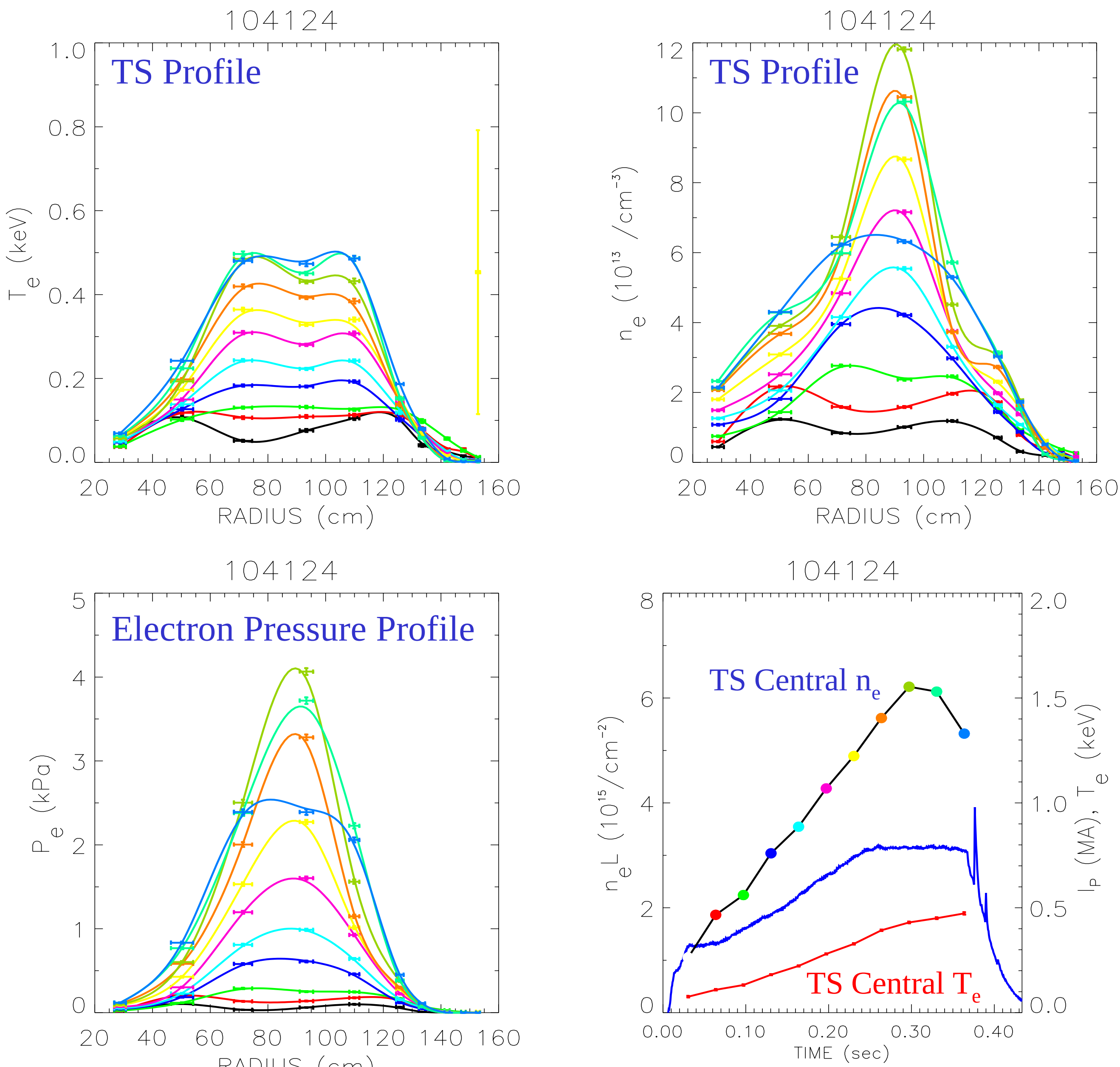
*(ITER Physics Basis, Nuclear Fusion **39** (1999) 2137)*

- **Lower and more symmetric halo currents in ST than in tokamak**
- **Can major disruptions be avoided completely?**

- CALOUTSIS, A and GIMBLETT, C G, Nuclear Fusion **38** (1999) 1487.
- POMPHREY, N, BIALEK, J M & PARK, W, Nuclear Fusion **38** (1998) 449.

Interesting n_e profile behavior observed in D_2 and He Ohmic shots (Menard)

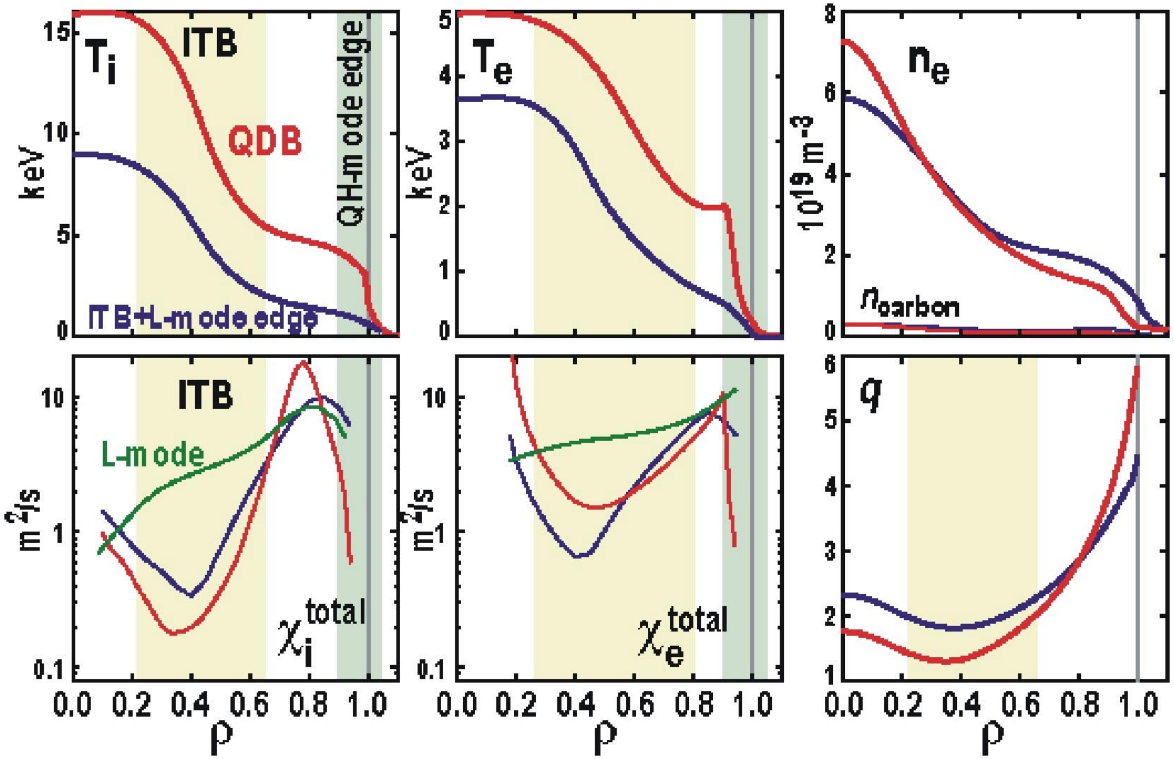
- Spontaneous n_e peaking in 3MA/s shots
- Fueling on for entire shot (150V to 135V)
- T_e profile flattened (or hollow) in core
- Cause not presently understood



Can NSTX Produce Combined ITB and QH Conditions Recently Seen in DIII-D?

DIII-D Plasma

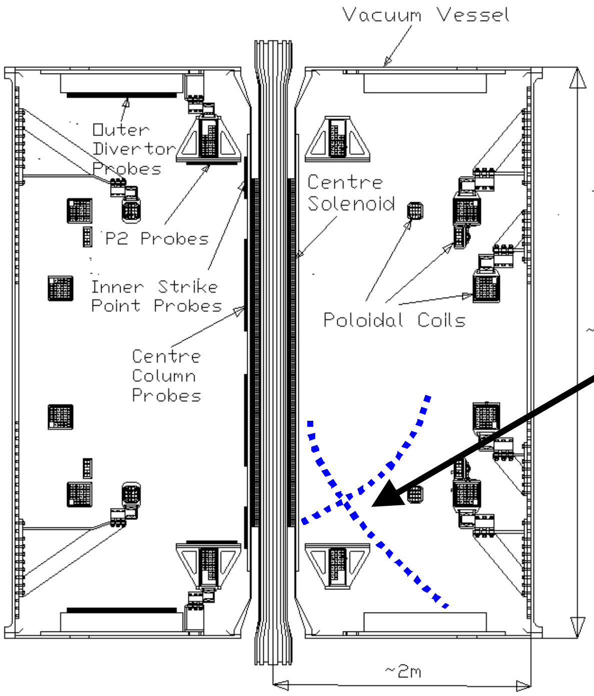
- Combine ITB & QH
- $\beta_N \sim 2.8$, $\beta_T \sim 3.3\%$
- $f_{BS} \sim 0.45$
- H89 ~ 2.5, $\tau_E \sim 150$ ms
- Edge harmonic oscillations
- Sustained ~ $5\tau_E$
- Peak, modest n_{GW} via reduced recycling

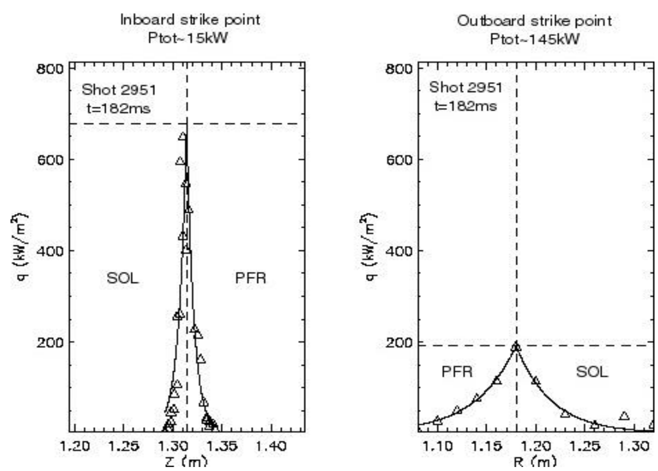


Some Key Physics Recipe for NSTX?

- ITB via large $\omega_{E\times B}{}^{\nabla p}$?
- QH edge via large beam ion current?
- Strong reduction of edge recycling? How?

9-to-1 Split of Outboard-to-Inboard Divertor Power Observed on MAST[1]





But higher inboard peak.

What are the physics mechanisms?

How to moderate divertor fluxes?

The total input power to the plasma is ~1.49MW (approx 0.72MW Ohmic, 0.77MW NBI).

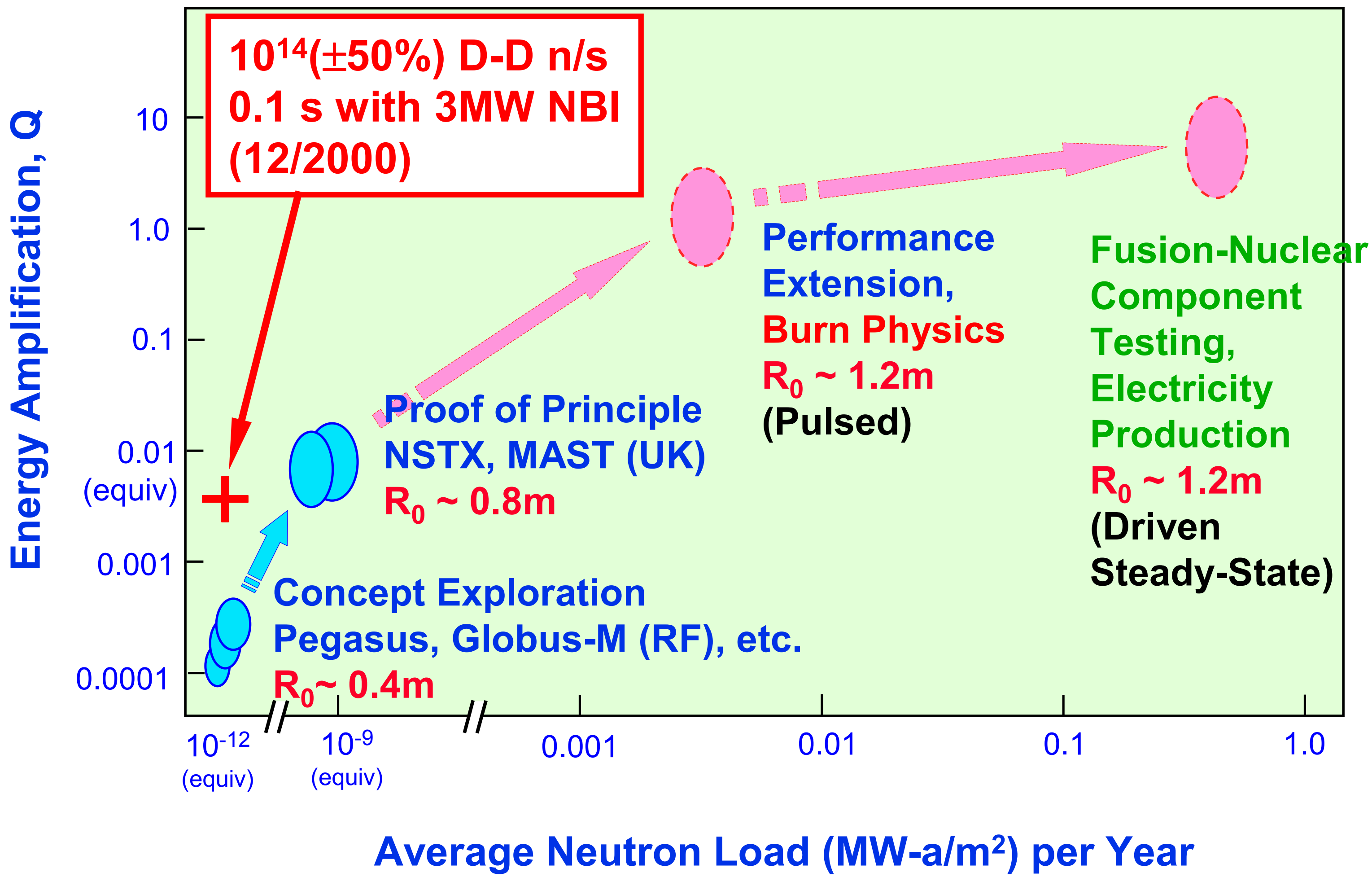
The peak divertor load is ~0.7MW/m^2 on the inboard

[1] G.F. Counsell, J-W. Ahn, S.J.Fielding and G.P.Maddison, 27th EPS, Budapest, 2000 P4.088

UKAEA Fusion Working with Europe

NSTX Science Goals Are Crucial to Making Fusion Energy Development More Affordable

Potential High Performance with Modest Major Radius



NSTX Scientific Goals Form Basis for the Program Goals

- NSTX scientific goals are well defined and directed toward program goals
- Scientific goals have exciting new questions to address
- Point to progression of ST physics investigations and discoveries
- A broad range of topics are available for team research
- Achieving these scientific goals are crucial to making energy development more affordable

Forum focus: research ideas to address these scientific goals