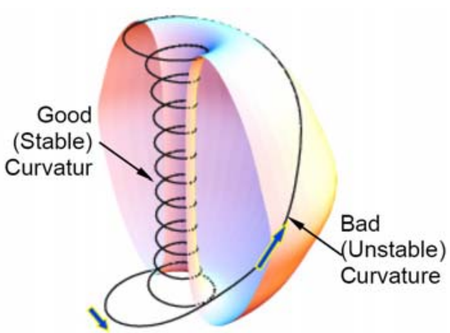
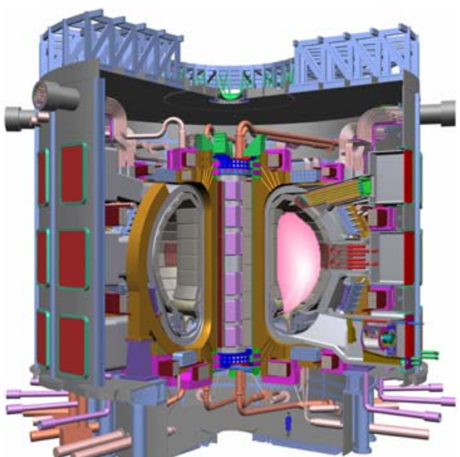
NSTX Program Addresses Broad Fusion Energy Sciences Missions Through Scientific Investigations

- Determine physics principles of ST (very high β_T and A ~ 1.5)
- Complement lower β_T and A ~ 3 experiments in addressing key scientific issues of fusion plasmas
- Support preparation for burning plasma research (ITPA, ITER) and benefit from it
- Complement ITER by establishing attractive configurations for Component Test Facility (CTF) and Demo

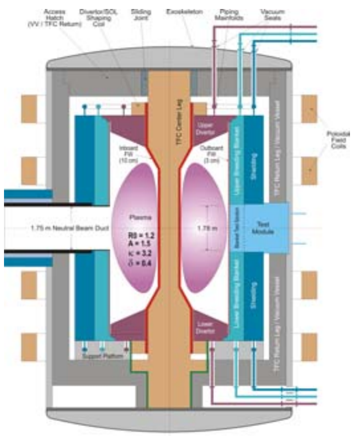
Spherical Torus
(A ~ 1.5, β_0 ~ 1)



ITER
(A = 3.1, R = 6.2 m)



CTF
(A ~ 1.5, R ~ 1.2 m)



NSTX Plans to Advance Research in Error Field, Locked Mode, RWM, and *AEs in FY06-07

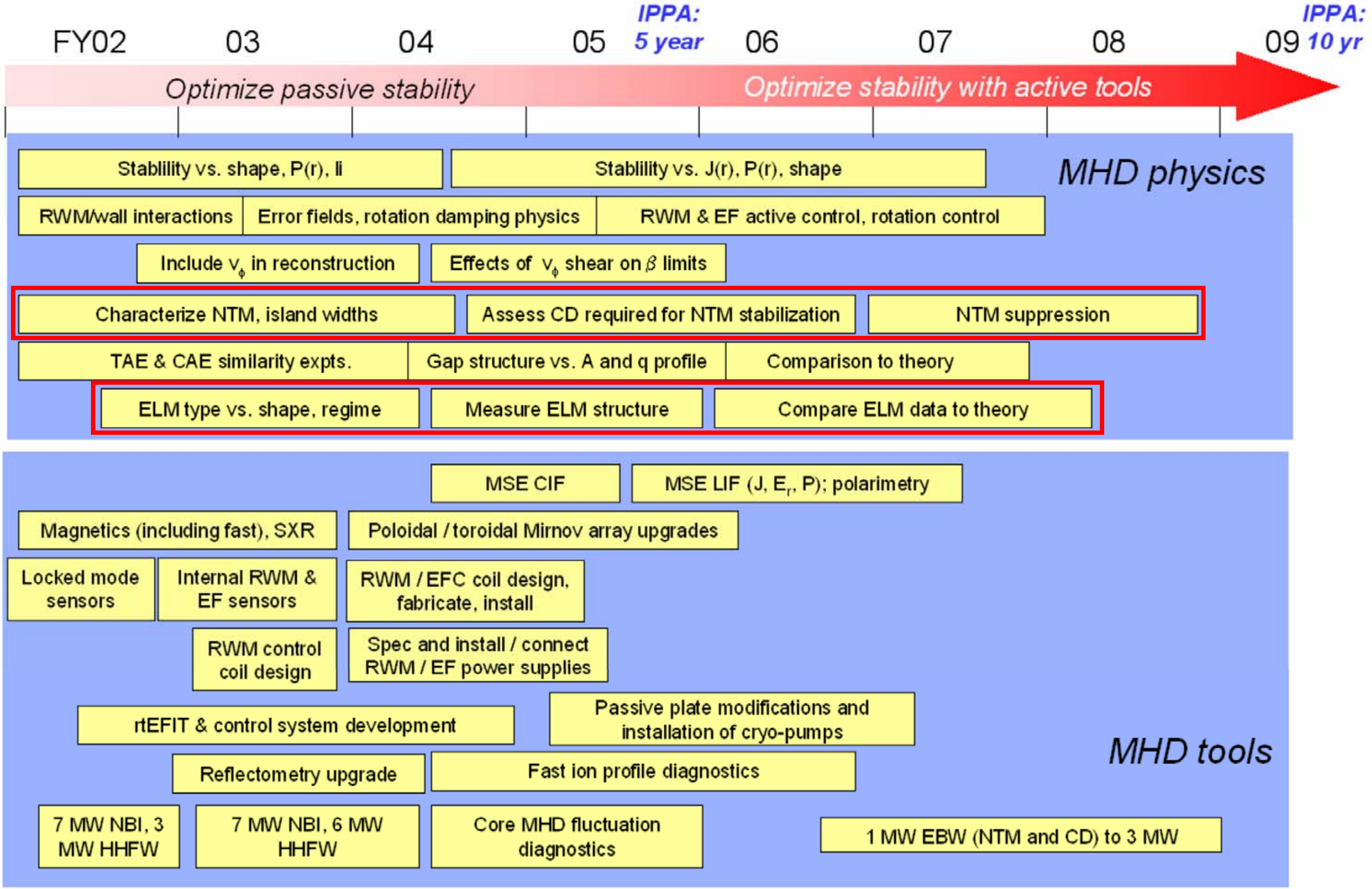
NSTX

	FY06	FY07	FY08
Exp. Run-Weeks:	12-14	12-14	12-14
1) Transport & Turbulence: Physical processes that govern heat, particle and momentum confinement			
	Assess high-k turbulence	Measure high-k turbulence spectra and electron transport	TBD
2) Macroscopic Stability: Role of magnetic structure on plasma pressure and bootstrap current			
	Characterize effectiveness of closed-loop EF/LM control	Characterize effectiveness of closed-loop RWM control	TBD
3) Wave-Particle Interaction: Role of electromagnetic waves & modes in sustaining and controlling hot plasmas			
	Characterize & optimize HHFW coupling	*Measure and identify modes driven by super-Alfvénic ions	TBD
4) Start-up, Ramp-up and Sustainment: Physical processes of magnetic flux generation and reconnection			
	Assess CHI creation of closed magnetic flux	Test solenoid-free ramp-up	TBD
5) Boundary Physics: Interface between fusion plasmas and normal temperature surroundings			
		Characterize Li pellet & evaporator coating effectiveness	TBD
6) Physics Integration: Synergistic effects of external control and self-organization			

**DOE-Level "JOULE" Milestone*

Advanced Particle Control Decision Point

NSTX Plans to Make Decision on FY08 MHD Milestone – NTM or Pedestal (ELM)?



ITER Design Issues that Need Urgent ITPA Input

Relevant TG	Issue	Comment
soldiv	Physics guidelines for disruptions thermal load (update)	
mhd	Examinations of current quench time for the fastest disruptions	
mhd	Disruption mitigation scenarios and guidelines for design of mitigation systems	
mhd/ pedestal	Design of coils to mitigate / control ELMs and resistive wall modes	Acceptable island size in the core plasma
pedestal	Pellet injection for ELM control	Inboard or outboard
soldiv/ pedestal	Heat load on first wall	Especially due to ELM
soldiv	Carbon erosion/deposition/control of tritium inventory and material choice	Especially tritium retention* and its removal
soldiv	Private region PFC and necessity of Dome	discussed at TGM in July
mhd	Second circuit for plasma vertical stabilization	Noise level
mhd	AC losses during RWM stabilization by side correction coils	Noise level

* Understanding of large difference of fuel gas retention in different machines or in the same machine with different configuration/operation

Summary Report of the Sixth Meeting of the ITPA Coordinating Committee (6-7 June 2005, Moscow, Russia)
Appendix G: ITER Design Issues that need ITPA input (revised 14 June 2005)

Major Physics Issues for ITER Operating Regimes

ALL REGIMES:

- Disruption avoidance/mitigation
- T retention control
- Type-I ELM avoidance/mitigation

INDUCTIVE HIGH-Q REGIME: Type-I ELMy H-mode (15MA, Q ≥10, β_N=1.8, HH=1)
HYBRID REGIME: Type-I ELMy H-mode (13MA, Q ≥5, β_N=2.0, HH=1)

- Energy confinement at high density
- Density limit: Borrass, Greenwald, B2Eirene modelling [(0.45/1.0/1.4) × n_G]
- Particle transport: core plasma fuelling, density peaking
- NTM suppression

IMPROVED HYBRID REGIME: (10-12MA, Q~10, β_N ≥2.5, HH≥1.2)

- Accessibility of Improved H-mode: q(0)>1; P_{loss}/P_{thr} >2
- Sustainment of Improved H-mode: prevention of sawteeth
- NTM suppression
- Prevention of He and impurity accumulation

STEADY STATE REGIME: (9MA, β_N=3.0, Q ≥5, HH=1.4-1.6)

- ITB formation at large radius
- SS scenarios esp. CD, beta, confinement & divertor
- ITB sustainment at high β_N, $T_e \approx T_i$, low v_{tor}: control of q and pressure profiles
- Compatibility of core and edge transport barriers
- RWM suppression: plasma rotation; feedback stabilization
- Prevention of He and impurity accumulation

MHD Suggestions of NSTX Participation from ITPACC-IEA-LT Joint Meeting, November 1-2, 2005

ID No	Topical Group	2006 Proposal Title	Keypersons [1]	Devices [2]	2005 Ext	Ctg	Comments/ Recommendations/ Results	NSTX Forum	DIII-D Forum
MDC-2	MHD, Disruptions & Control	Joint experiments on resistive wall mode physics	H Reimerdes, M Okabayashi (DIII-D), M Gryaznevich(JET), S D Pinches (JET), R Koslowski (TEXTOR), M Takechi (JT60-U), S Sabbagh (NSTX), H Zohm (AUG)	DIII-D, JET (experiments scheduled Feb 06), NSTX, JT-60U, AUG and TEXTOR	YES	E	Report,		Sabbagh
MDC-4	MHD, Disruptions & Control	Neoclassical tearing mode physics - aspect ratio comparison	M Maraschek (AUG), D Howell (MAST), E. Frederickson(NSTX), R. LaHaye(DIII-D)	AUG, MAST, NSTX, DIII-D	YES	E	Report. Must have either AUG or DIII-D to vary A.		Fredrickson
MDC-5	MHD, Disruptions & Control	Comparison of sawtooth control methods for neoclassical tearing mode suppression	O Sauter, R Pinsker, R La Haye (DIII-D), A Mueck, H. Zohm (AUG), S. Coda(JET), R Buttery (JET), ,J Menard (NSTX), T Goodman (TCV), Yi Liu (HL2A), Wukitch(C-mod),F. Gandini(FTU)	AUG , DIII-D, JET, NSTX, TCV and HL2A, C-mod, FTU	YES	E	Report		Menard
MDC-6	MHD, Disruptions & Control	Low beta error field experiments	S Wolfe, I Hutchinson (C-Mod), T Hender(JET), T Scoville (DIII-D), R Koslowski (TEXTOR), D Howell (MAST), Menard (NSTX)	C-mod, TEXTOR, MAST, DIII-D, NSTX, JET(done)	YES	E	Report		Menard
MDC-9	MHD, Disruptions & Control	Fast ion redistribution by beam driven Alfvén modes and excitation threshold for Alfvén cascades	A.Fasoli, D.Borba(JET/AUG), S.Pinches and D.Testa (JET), K. Shinohara (JT60-U), W.Heidbrink (DIII-D),R. Nazikian(DIII-D) E. Frederickson(NSTX), M. Gryaznevich/S. Sharapov(MAST), P. Martin (AUG)	JT-60U, JET, DIII-D, NSTX, MAST, AUG	YES	E	Report		Fredrickson
SSO-2.2	Steady-State Operation	MHD effects on q-profile and confinement for hybrid scenarios	S. Guenter, R. Buttery, M. Wade, Isayama. C. Kessel	AUG, JET, DIII-D, JT-60U, NSTX, C-mod	YES	E	Report		Kessel

Extensive Facility and Diagnostic Capabilities on NSTX

Device Parameters

R = 85 cm

a = 65 cm

κ = 1.7 - 2.7

δ = 0.3 - 0.8

B_T = 5.5 kG

τ_{TF} ~ 3 sec ~ 6 τ_{skin} (3.5kG)

I_p = 1.5 MA

V_p = 14 m^3

E_p ~ 430 kJ

P_{NBI} = 7.4 MW (110 kV)

P_{HHFW} = 6 MW (30 MHz)

350°C vessel bake

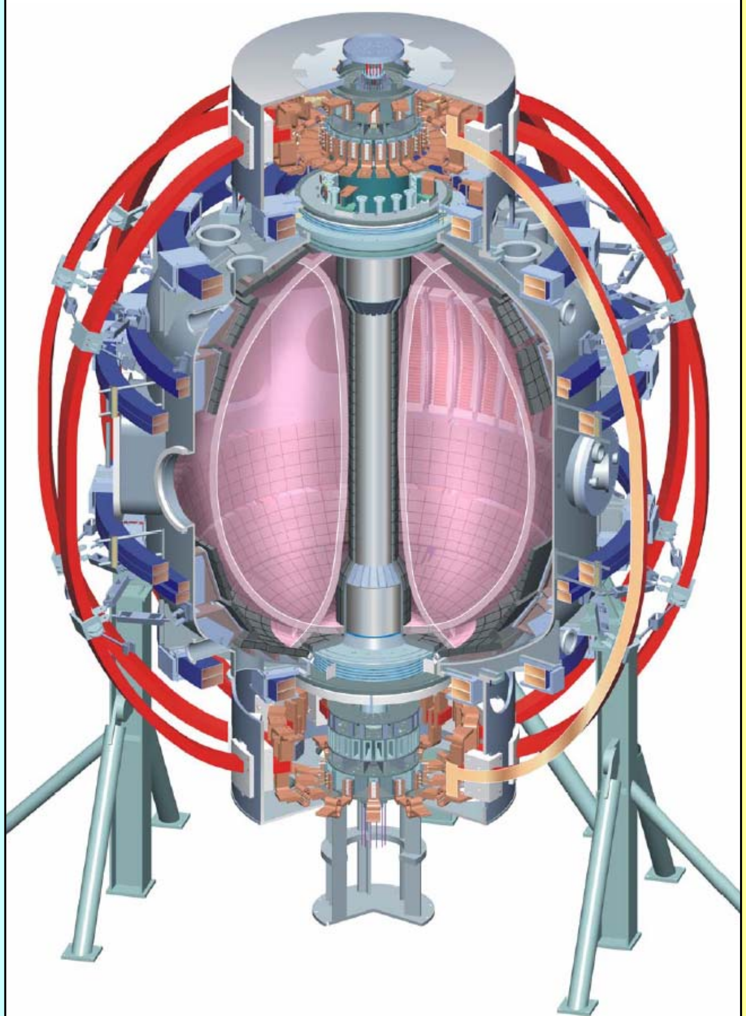
Nearby passive plates

RWM / EF control coils

I_{CHI} ~ 400 kA

60 cm dia. ports

Wide tang. access



Major Diagnostic Systems - Collab

Confinement Studies - Tang Access

- Magnetics for equilibrium reconstruction (CU)
- Diamagnetic flux measurement
- Multi-pulse Thomson scattering (30 ch)
- T-CHERS: $T_i(R)$ and $V_\phi(r)$ (51 ch); P-CHERS ('07)
- Neutal particle analyzer (NPA, 2D scanning)
- Solid state NPA (UCIrvine)
- FIReTIP interferometer (119mm, 6 ch) (UCD)
- Density Interferometer (1 mm, 1ch) (UCLA)
- Visible bremsstrahlung radiometer (1 ch)
- Midplane tangential bolometer array
- X-ray crystal spectrometer: $T_i(0)$, $T_e(0)$
- MSE-CIF (8ch) (Nova); 14-19ch ('06-'07)

MHD/Fluctuation/Waves

- High-n and high-frequency Mirnov arrays
- Ultra-soft x-ray arrays – tomography (4) (JHU)
- Fast X-ray tangential camera (2μs) (PSI)
- μwave reflectometers (UCLA)
- FIReTIP polarimeter (6 ch, 600 kHz) (UCD)
- Tangential μwave high-k scattering (UCD)
- Electron Bernstein wave radiometer
- Fast lost-ion probe (energy/pitch resolving)
- Fast neutron measurement
- Locked-mode detectors
- RWM sensors (n = 1, 2, and 3)

Edge/divertor studies

- Reciprocating Langmuir probe (UCSD)
- Gas-puff Imaging (2μsec)
- Fixed Langmuir probes (24) (ORNL)
- Edge Rotation Diagnostics (T_i, V_ϕ, V_{pol})
- 1-D CCD H_α cameras (divertor, midplane) (LLNL)
- 2-D divertor fast visible camera (HiroU, Nova)
- Divertor bolometer (4 ch)
- IR cameras (30Hz) (3) (ORNL)
- Tile temperature thermocouple array
- Scrape-off layer reflectometer (ORNL)
- Edge neutral pressure gauges (UWash)

Plasma Monitoring

- Fast visible cameras (Nova, HiroU, ORNL)
- Visible survey spectrometer
- VUV survey spectrometer
- "Optical" X-Ray array spectrometer (JHU)
- Fission chamber neutron measurement
- Visible filterscopes (LLNL)
- Wall coupon analysis
- X-ray crystal spectrometer (astrophysics) (KBSI)