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Office of Fusion Energy Sciences — Excellent Science, Attractive Energy

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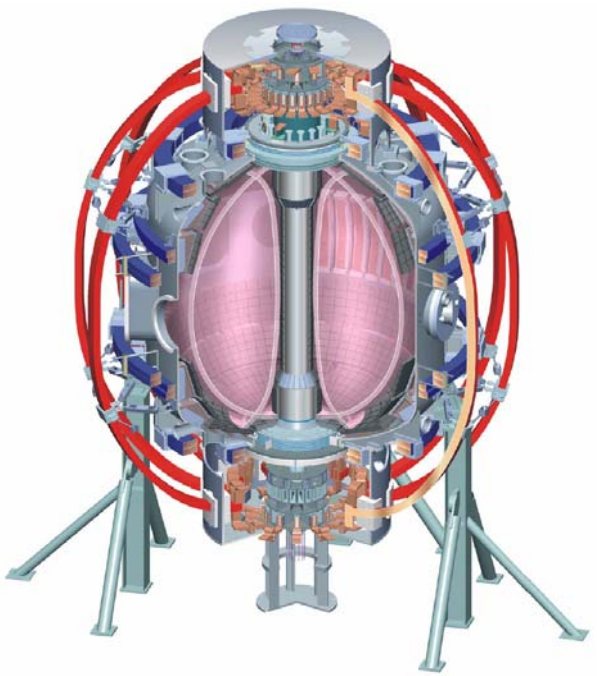
NSTX Status and Plans



Martin Peng
Oak Ridge National Laboratory, UT-Battelle
@ Princeton Plasma Physics Laboratory

For the NSTX Team

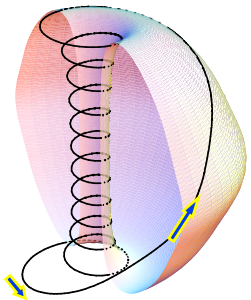
IEA Cooperation Among
Large Tokamak Facilities
20th Executive Committee Meeting

9 – 10 May 2005
PPPL

NSTX Team Contributes to Fusion Energy on a Broad Front Through Scientific Investigations

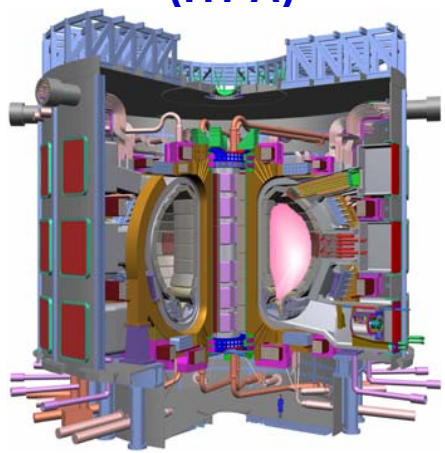
NSTX

Configuration Optimization: Unique & Complementary

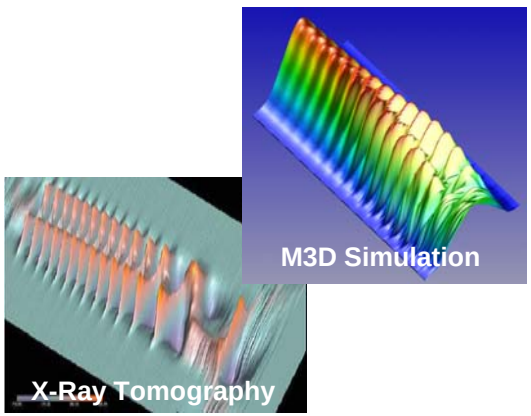


NSTX Team

Burning Plasma (ITPA)



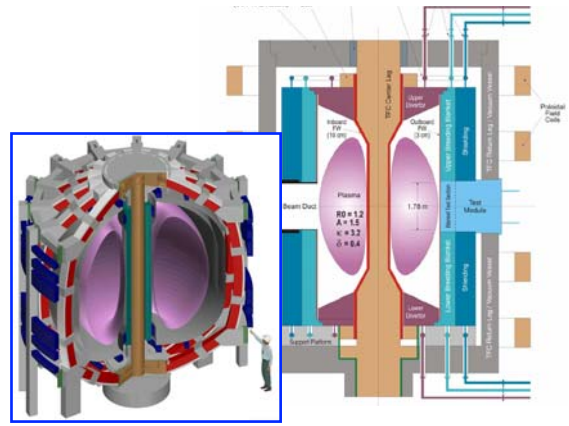
Fundamental Understanding



Scientific Topics

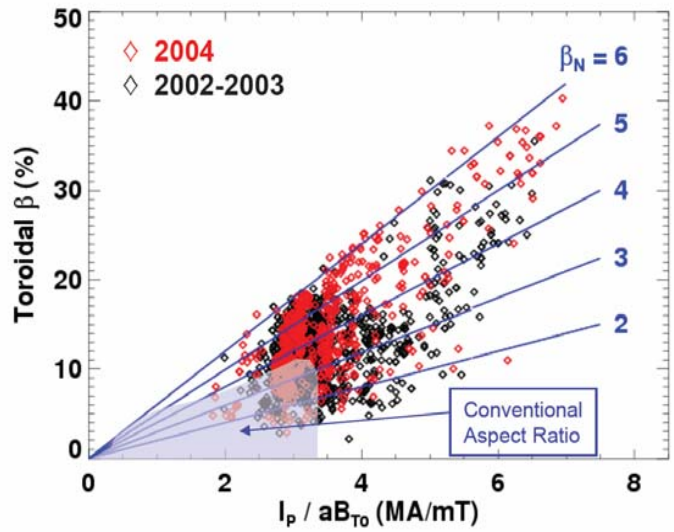
- Turbulence
- Stability
- Waves & Energetic Particles
- Magnetic Flux Generation
- Boundary Physics
- Integration

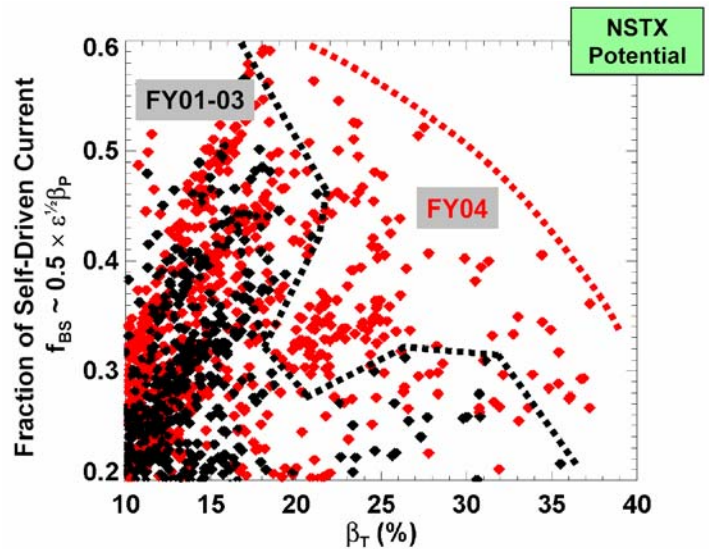
Materials, Components, Technologies (NSST & CTF)



NSTX Had a Successful Year; Achieved 21 Run-Weeks; Made Key Progress on a Broad Scientific Front

- **Expanded parameter space via improved control, shaping & operation – broadening plasma science.**
- **Extended high beta-tau discharges with high B/S fraction to > tau-skin, with wall-stabilization of strongly rotating plasma.**
- **Measured RWM at substantially above no-wall limit, indicating $\omega_{crit}/\omega_A \sim 1/q^2$, consistent with neoclassical visc.**
- **Measured large radial correlation length of fluctuations in core that decreases with increasing B_T and radius.**
- **Observed increased electron energy confinement via reversed q-shear; verified ion Internal Transport Barrier.**
- **Reconstructed equilibria for strong plasma rotation, constrained by isothermal electrons and MSE field pitch.**
- **Determined via MSE & EFIT changes in core current density resulting from variations in operating scenario.**
- **Observed and modeled *AE's driven by supra-Alfvénic ions, which are anticipated in ITER burning plasma.**
- **Measured via NPA fast ion depletion due to MHD modes.**
- **Identified bursts of edge plasma filaments ("blobs") as primary characteristics of ELMs of varied severity.**
- **Measured EBW emission from core, consistent with theory.**
- **Obtained first evidence of parametric ion heating by HHFW.**





Case-1 Plan (No Run in FY06, 12 Run-Weeks in FY07)
Research Milestones

	FY05	FY06	FY07	FY09
Exp. Run-Weeks:	17	0*	12*	

1) Transport & Turbulence: Physical processes that govern heat, particle and momentum confinement

Characterize q' & ∇T_e effects on electron transport		(1) Measure high-k turbulence

2) Macroscopic Stability: Role of magnetic structure on plasma pressure and bootstrap current

Study rotating plasmas close to "wall-stability" with EF correction	(1) Compare EF/RWM/LM data with theoretical models of stability conditions	(1) Characterize effectiveness of closed-loop EF/LM control

3) Wave-Particle Interaction: Role of electromagnetic waves & modes in sustaining and controlling hot plasmas

Assess effects of supra-Alfvénic ion driven instabilities on core J_{NB}	(1) Compare fast ion driven mode data with non-linear simulation	(1) Characterize & optimize HHFW coupling

4) Start-up, Ramp-up and Sustainment: Physical processes of magnetic flux generation and reconnection

		(1) Assess CHI creation of closed magnetic flux

5) Boundary Physics: Interface between fusion plasmas and normal temperature surroundings

Characterize pedestal and SOL of low-A, H-mode, high P/R plasmas		

6) Physics Integration: Synergistic effects of external control and self-organization

Characterize high-B/S & low-V_L plasmas for > τ_{skin}	(1) Benchmark time-dependent scenario simulation with high-B/S & low-V_L data	

**CASE-1*

Advanced Particle Control Decision Point

Case-2 Plan (12 Run-Weeks for FY06 & FY07) Research Milestones

	FY05	FY06	FY07	FY08
Exp. Run-Weeks:	17	+12*	12	

1) Transport & Turbulence: Physical processes that govern heat, particle and momentum confinement

- Characterize q' & ∇T_e effects on electron transport
- (2) Measure high-k turbulence
- (2) Assess high-k turbulence spectra and electron transport

2) Macroscopic Stability: Role of magnetic structure on plasma pressure and bootstrap current

- Study rotating plasmas close to "wall-stability" with EF correction
- (2) Characterize effectiveness of closed-loop EF/LM control
- (2) Characterize effectiveness of closed-loop RWM control

3) Wave-Particle Interaction: Role of electromagnetic waves & mdoes in sustaining and controlling hot plasmas

- Assess effects of supra-Alfvénic ion driven instabilities on core J_{NB}
- (2) Characterize & optimize HHFW coupling

4) Start-up, Ramp-up and Sustainment: Physical processes of magnetic flux generation and reconnection

- (2) Assess CHI creation of closed magnetic flux
- (2) Test solenoid-free ramp-up

5) Boundary Physics: Interface between fusion plasmas and normal temperature surroundings

- Characterize pedestal and SOL of low-A, H-mode, high P/R plasmas
- (2) Characterize Li pellet & evaporator coating effectiveness

6) Physics Integration: Synergistic effects of external control and self-organization

- Characterize high-B/S & low-V_L plasmas for > τ_{skin}

**CASE-2*

(2) Advanced Particle Control Decision Point

Wave-Particle Research Will Make Unique Contributions to Understanding Supra-Alfvénic Ion Driven Modes for ITER

Motivation & NSTX Opportunities

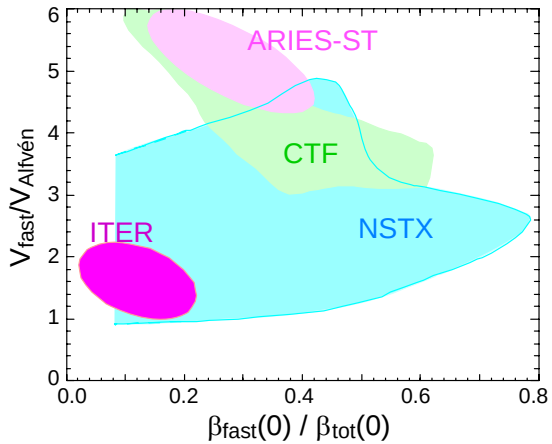
- ITER burning plasma will have supra-Alfvénic α's & beam ions
- NSTX covers the ITER regime in V_{fast}/V_A and β_{fast}/β_T; and has measured range of *AE's driven by such ions of confined orbits

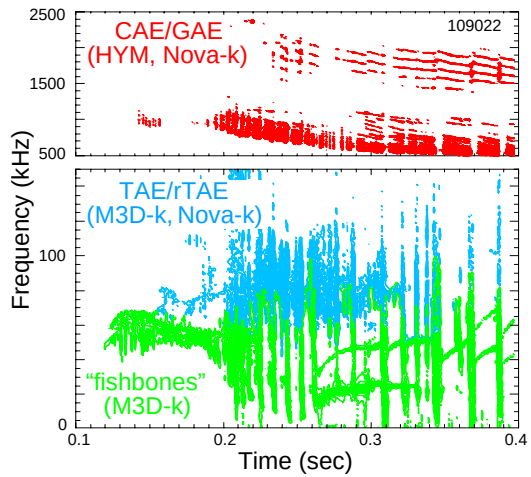
Milestones

- FY05: measure *AE's & correlate with fast ion, J_{NB} changes
- Extensive core measurements: USXR tomography for mode structure; fast tang. interferometer for amplitude; MSE for J profile
- Extensive analysis: linear & non-linear simulations
- Future: understand fast ion transport due to *AE cascades
- FY06: understand edge coupling (parametric and RF sheath effects) and optimize HHFW scenario

Additional Investigations

- EBW: B-X-O emission @ 20-40 GHz, to understand potential of Ohkawa current drive & electron phase space science
- Accumulate physics database for future high power EBW





3) Wave-Particle Interaction: Use of electromagnetic waves to sustain and control high-temperature plasmas

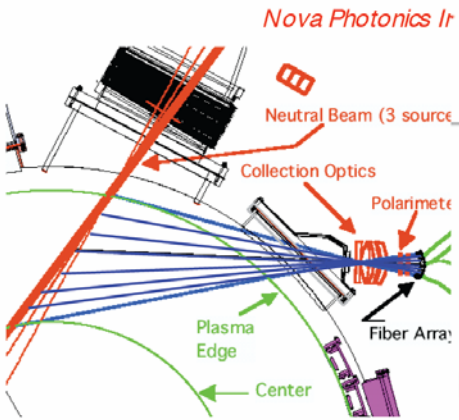
Assess effects of supra-Alfvénic ion driven instabilities on core J_{NB} — **Characterize & optimize HHFW coupling**

FY05 (17 wks)	FY06 (12 wks)	FY07 (12 wks)

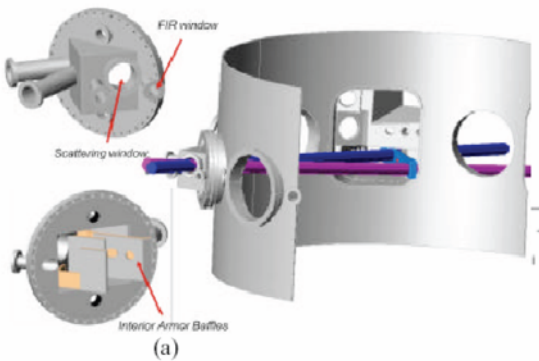
Major Improvements in Plasma Control and Diagnostics Are Readied or Being Readied

NSTX

8 Ch MSE-CIF for j(r)



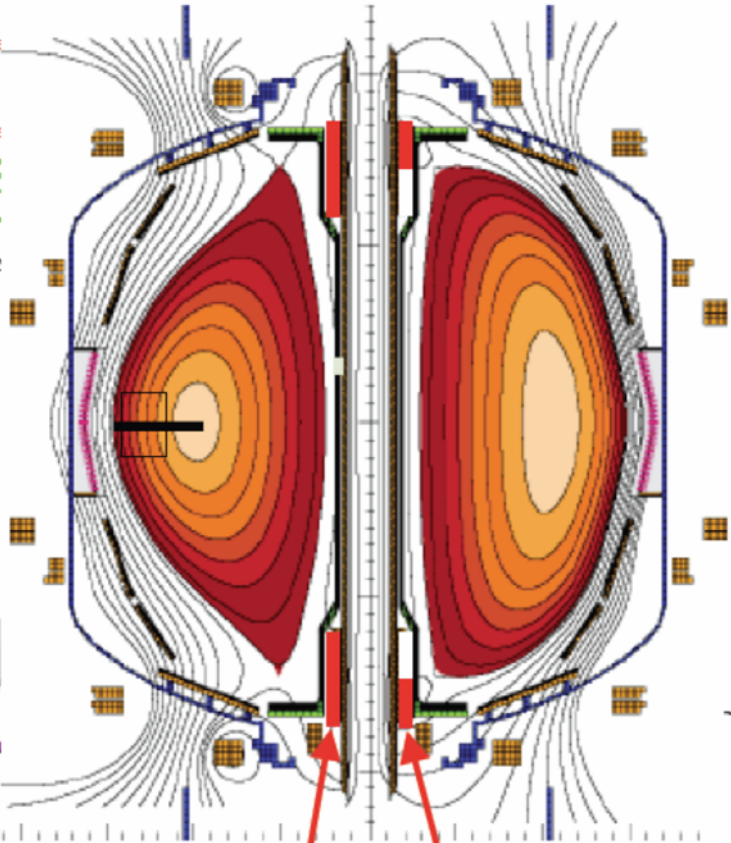
Tangential Microwave High-k Scattering



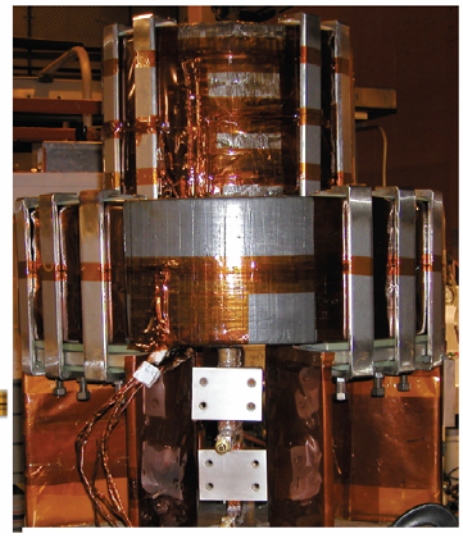
UCD

Achieved 2004 → Goal of 2005

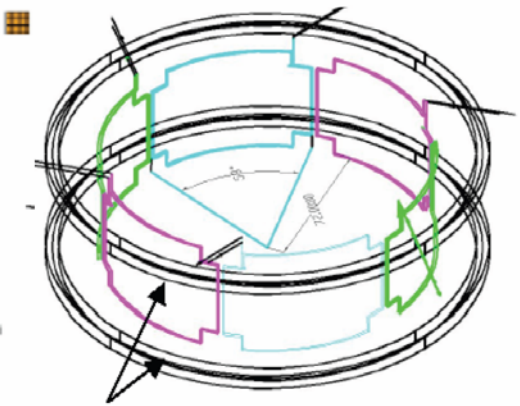
114465



New PF1A-L



EF/RWM Coils



PF5 coils (main vertical field)

Columbia

This FY, NSTX Plans to Complete 17 (40-Hour) Run-Weeks

Tues and Thur: 10-hour run days
⇒ 44 hours/calendar week

Week	Monday		Friday
1	28-Mar	ISTP ACTIVITIES	1-Apr
2	4-Apr	FIX TF COIL	8-Apr
3	11-Apr	ISTP + SHERWOOD and RF MEETINGS	15-Apr
4	18-Apr	BAKEOUT, NBI CONDITIONING, MAINTENANCE	22-Mar
5	25-Apr	RUN WEEK	29-Apr
6	2-May	RUN WEEK	6-May
7	9-May	RUN WEEK	13-May
8	16-May	RUN WEEK	20-May
9	23-May	TENTATIVE MAINTENANCE WEEK	27-May
10	Memorial Day	RUN WEEK	3-Jun
11	6-Jun	RUN WEEK	10-Jun
12	13-Jun	RUN WEEK	17-Jun
13	20-Jun	RUN WEEK	24-Jun
14	27-Jun	TENTATIVE MAINTENANCE WEEK (EPS MEETING)	1-Jul
15	Independence Day	RUN WEEK	8-Jul
16	11-Jul	RUN WEEK	15-Jul
17	18-Jul	RUN WEEK	22-Jul
18	25-Jul	RUN WEEK	29-Jul
19	1-Aug	MAINTENANCE (VACATION)	5-Aug
20	8-Aug	RUN WEEK	12-Aug
21	15-Aug	RUN WEEK	19-Aug
22	22-Aug	RUN WEEK	26-Aug
23	29-Aug	MAINTENANCE (VACATION)	2-Sep
24	Labor Day	RUN WEEK	9-Sep
25	12-Sep	CONTINGENCY	16-Sep
26	19-Sep	CONTINGENCY	23-Sep
27	26-Sep	CONTINGENCY	30-Sep

NSTX Facility Is Ready; Experiments Have Started (Jon Menard – Run Coordinator)

4	2-May	3-May	4-May	5-May	6-May
	RWM coil ISTP Neumeyer, C	**PCS->SPA + XMP 24/32** rtEFIT commissioning Mueller / Gates	**XP 506** Ohmic H-mode Bush, C	**XMP 37 - RWM coils/sensors** Sontag, A	**XP 523** SOL Meas - Boedo
				XMP 3 - Mag cal - Menard	**SPA #2 testing - Neumeyer**
	Start XP 515 Lithium Pellet Inj - Kugel	**XP 507** Early Div and H-mode Menard, J		**XP 523** SOL Meas - Boedo	**XP 508 - DND long-pulse** Gates, D
					Menard gone
Hours	8	10	8	10	8

5	9-May	10-May	11-May	12-May	13-May
	XP 508 - DND long-pulse Gates, D	**24kA PF1A ISTP**	**XP501 - MHD Spectroscopy** Sabbagh, S	**XP 522** Transport w/ Rev Shear Levinton, F	**XP 512 - RWM similarity** Sontag / Reimerdes ✈
		XP 507 - LSN long pulse Menard, J	*or*		*or*
			XP502 - High beta w/ PF1A Gates, D		**XP 515 - Lithium Pellet Inj** Kugel, H
	PFC meeting	J. Boedo departs, PFC mtg	PFC meeting		Reimerdes departs
Hours	8	10	10	8	8

6	16-May	17-May	18-May	19-May	20-May
	MHD XP	**MHD XP**	**XP 513 MAST-NSTX ITB** Peng / Field	**XP 505 - LH threshold w/ NBI** Meyer ✈ / Maingi (requires rtEFIT)	**XP/XMP - Transient CHI** Raman, R
			or		
			XP 504 - Fast-ion loss NPA Medley, S		
Hours	8	10	8	10	8

7	23-May	24-May	25-May	26-May	27-May
	TENTATIVE Maintenance week for high-k scattering preparation activities in NTC				
	Mueller gone	*Mueller gone* *Randy gone*	*Mueller gone* *Randy gone*	*Mueller gone*	*Mueller gone*
Hours	0	0	0	0	0

NSTX Participates Strongly in ITPA Topical Groups and is Committed to Important 2005 Joint Experiments

Topical Groups	ID#	Burning Plasma Issues	Participating Programs
Confinement Database & Modeling	CDB-2	β degradation in confinement scaling of ELMy H-modes	AUG, DIII-D, JET, JT-60U, MAST, NSTX, Tore-Supra
	CDB-6	Improving condition of global ELMy H-mode and pedestal database: low A	DIII-D, MAST, NSTX
Transport Physics	TP-8.1	ITB similarity experiments	MAST, NSTX
	TP-9	H-mode aspect ratio comparison	DIII-D, MAST, NSTX
Pedestal & Edge Physics	PEP-9	Pedestal similarity experiments	DIII-D, MAST, NSTX
	PEP-16	Small ELM regime comparison	C-Mod, MAST, NSTX
Divertor, SOL	DSOL-9	Carbon migration and deposition	AUG, DIII-D, JET, JT-60U, NSTX, TEXTOR
	DSOL-15	Comparison of edge “blob” characteristics	C-Mod, JT-60U, NSTX, TJ-II, Tore-Supra
MHD, Disruption Control	MDC-2	Resistive Wall Mode physics	AUG, DIII-D, JET, JT-60U, NSTX, TEXTOR
	MDC-4	Neoclassical Tearing Mode – A comparison	AUG, DIII-D, MAST, NSTX
	MDC-6	Error field physics comparison	C-Mod, DIII-D, JET, MAST NSTX, TEXTOR
	MDC-9	Fast-ion redistribution by *AE & cascade	AUG, DIII-D, JET, JT-60U, NSTX
Steady-State Op	SSO-2.1	Complete mapping of hybrid scenario	AUG, DIII-D, JET, JT-60U, NSTX