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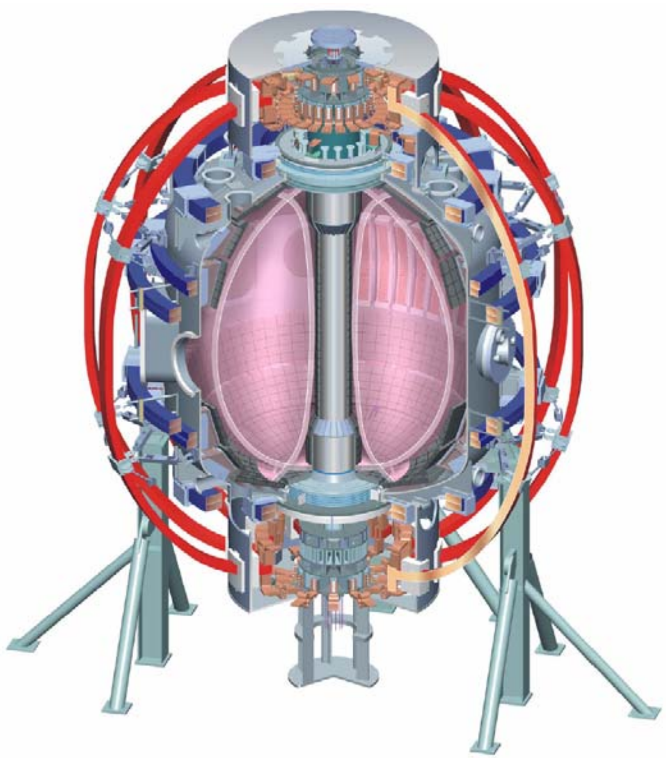
Draft NSTX Program Letter 2005 – 2007



Martin Peng
Oak Ridge National Laboratory
@ Princeton Plasma Physics Laboratory

On behalf of the NSTX National Team

NSTX PAC-16th Meeting

September 9 – 10, 2004
PPPL

Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
NYU
ORNL
PPPL
PSI
SNL
UC Davis
UCLA
UCSD
U Maryland
U New Mexico
U Rochester
U Washington
U Wisconsin
Culham Sci Ctr
Hiroshima U
HIST
Kyushu Tokai U
Niigata U
Tsukuba U
U Tokyo
JAERI
Ioffe Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
U Quebec

NSTX Program Letter Provides Inputs to Support DOE Review of NSTX Collaboration Research Proposals

- **8/04 Notice for NSTX research collaboration proposals: http://www.science.doe.gov/grants/FAPN04-24 indicates availability of NSTX Program Letter**
- **Letter of Intent to DOE by 10/1/04; Proposal by 10/14/04**
- **Accounting for recent progress, and facility & research plans, Program Letter describes 2005-2007 NSTX**
  - **Program objectives**
  - **Major scientific areas of research**
  - **Relative priorities among elements of each scientific area**
  - **Collaboration opportunities for these elements**
- **Seek PAC review and advice on priorities and balance**
- **Submit Program Letter to DOE and publicize on 9/15/04**

NSTX research contributes to campaigns guided by FESAC Priorities Panel's Overarching Themes

NSTX

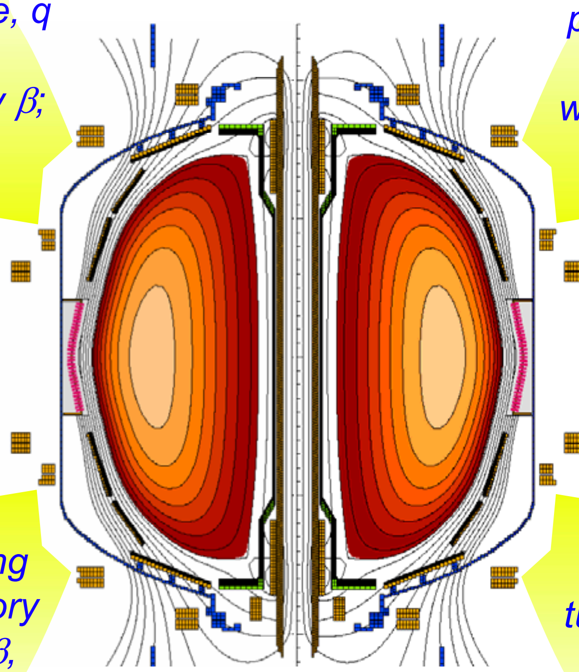
Campaign: *Understand the role of magnetic structure on confinement, & plasma pressure limits*

Stability pressure limits & magnetic reconnection vs. A, shape, profile, q & flows, for internal & external modes, with $V_{flow}/V_A \leq 0.4$ & unity β; helicity transport.

Campaign: *Learn to use energetic particles & e-m waves to sustain and control high temperature plasmas*

E-M waves in over-dense plasmas; phase space manipulation with high electron trapping; energetic ions with large orbits; Alfvén eigenmodes and turbulence with $V_{fast}/V_A >>1$.

NSTX



Overarching Themes:

O1: Understand dynamics of matter and fields

O2: Create and understand controlled burning plasma

O3: Make fusion power practical

Microscopic ion, electron & tearing turbulence measurements & theory comparison, over wide range in β, flows & magnetic shear, with good average curvature and high trapping.

Campaign: *Understand & control the processes that govern confinement of heat, momentum, and particles*

Physics of ELMs, pedestal, SOL turbulence & high divertor heat flux, with large in/out asymmetry; Li coatings & liquid surface interactions with plasma.

Campaign: *Learn to control the interface between a 100 million degree plasma and its room temperature surroundings*

NSTX contributions also support the DOE SC Strategic Goals for Fusion Energy Sciences Program

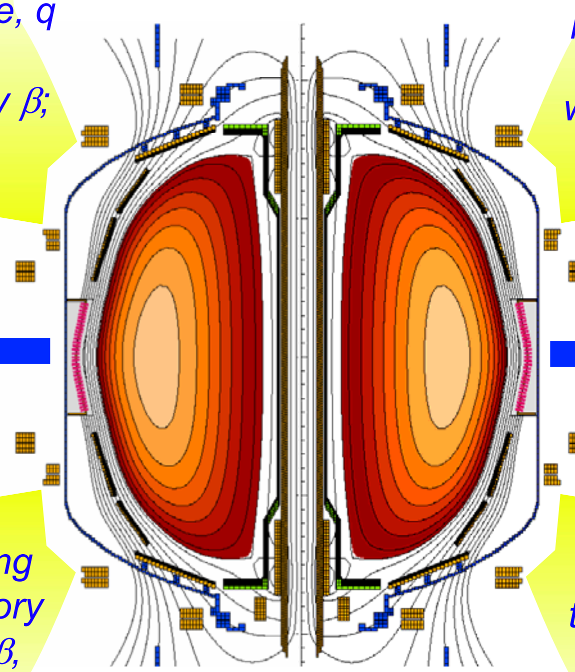
Campaign: *Understand the role of magnetic structure on confinement, & plasma pressure limits*

Stability pressure limits & magnetic reconnection vs. A, shape, profile, q & flows, for internal & external modes, with $V_{flow}/V_A \leq 0.4$ & unity β; helicity transport.

Campaign: *Learn to use energetic particles & e-m waves to sustain and control high temperature plasmas*

E-M waves in over-dense plasmas; phase space manipulation with high electron trapping; energetic ions with large orbits; Alfvén eigenmodes and turbulence with V_{fast}/V_A >>1.

NSTX



FES Program Strategic Goals:

1) *Demonstrate feasibility with burning plasmas*
2) *Develop fundamental understanding and reliable predictive capability*
3) *Determine the most promising approaches and configurations*
4) *Develop necessary new materials, components, and technologies*

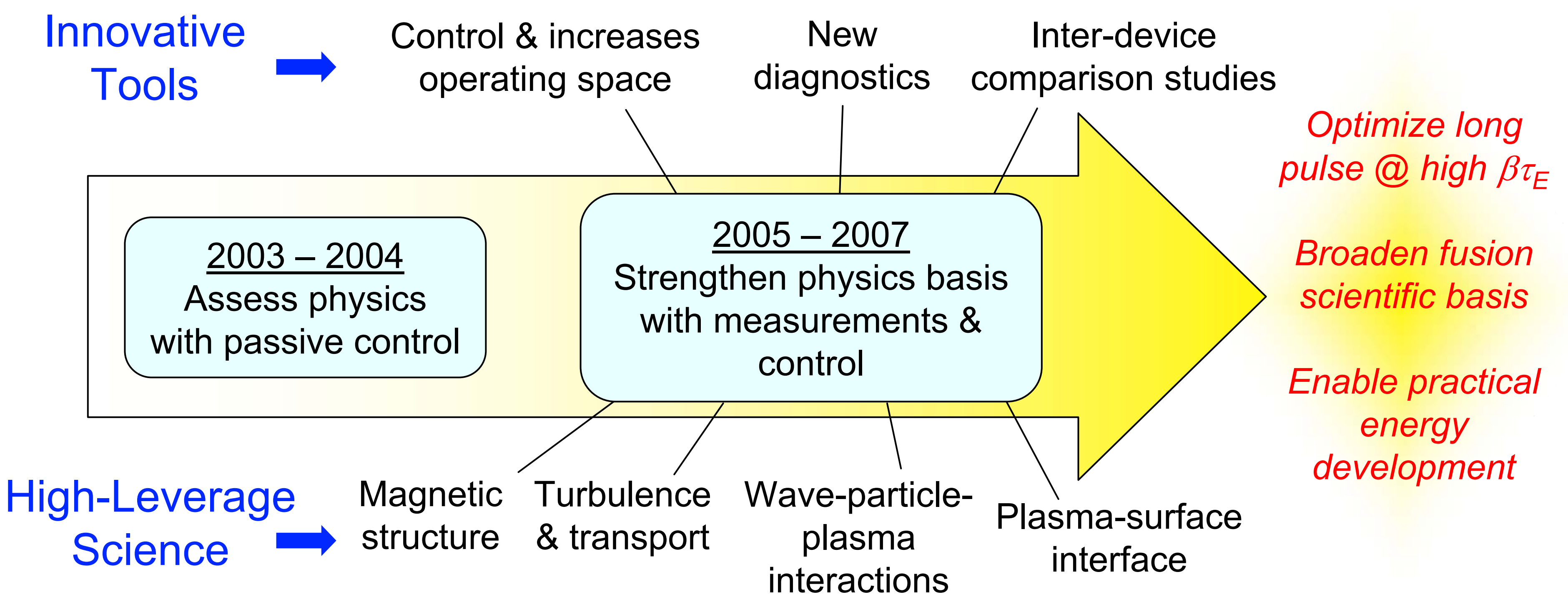
Microscopic ion, electron & tearing turbulence measurements & theory comparison, over wide range in β, flows & magnetic shear, with good average curvature and high trapping.

Campaign: *Understand & control the processes that govern confinement of heat, momentum, and particles*

Physics of ELMs, pedestal, SOL turbulence & high divertor heat flux, with large in/out asymmetry; Li coatings & liquid surface interactions with plasma.

Campaign: *Learn to control the interface between a 100 million degree plasma and its room temperature surroundings*

NSTX 2005-2007 focus: strengthen physics basis with advanced measurements and control



- ***Strengthen NSTX National Research Team***
- ***Meet broad new scientific opportunities and challenges***

NSTX collaborators make crucial contributions and are reviewed by DOE every 3 years

Collaboration up for renewal	2005	2006	2007

Columbia U	• MHD stability & mode control • Stellar x-ray spectroscopy
Comp-X	• CQL-3D kinetic modeling of RF heating & current drive
GA	• CHI equilibrium, RF physics • Plasma control • Poloidal field coil start-up
LANL	• Ultra-fast turbulence imaging • CHI plasma stability modeling
LLNL	• Edge SOL physics • Edge plasma turbulence • Stellar x-ray spectroscopy
Lodestar	• Edge plasma stability and turbulence
MIT	• ECW-EBW modeling • HHFW modeling

Johns Hopkins U	USXR tomography & diagnostics
Nova Photonics	• MSE – CIF & LIF • Ultra-fast imaging (~10^6 /s) • Planar LIF
ORNL	• HHFW & EBW physics & technology • Boundary and pedestal physics • RF & transport modeling
UC Davis	• FIReTIP n, B & fluctuations
UCLA	• Reflectometry & fluctuations
UCSD	• Fast probe • HHFW modeling • Far SOL turbulent transport; Li limiter
U New Mexico	• Fast ion-plasma interactions
U Washington	• CHI research
U Wisconsin	• NSTX neoclassical modeling

Cooperation with OFES Theory, Technology, Diagnostic Innovations & SBIR programs.

INEL	• Tile surface & dust analysis
NYU	• Transport & RF modeling
PSI	• Ultra-fast imaging (~10^6 /s)

International Cooperation

SNL	• Plasma-facing material • Material surface analysis
U Maryland	• Transport & turbulence simulation

1) Understand the role of magnetic structure on plasma confinement and the limits to plasma pressure in sustained magnetic configurations – (I)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
M	Equilibrium reconstruction and tool development for between-pulse and post-pulse analysis, accounting for sonic flow, energetic ions, and very high beta	H*
H	Real-time plasma control, including capability for implementing current initiation, ramp-up, and sustainment strategies	H*
H	Characterize and understand effects on internal modes from sheared sonic flows – Compare with theory and modeling	M
H	Characterize and understand effects on external beta-limiting modes from – Nearby passive conductors – External and plasma induced non-axisymmetric fields – Plasma rotation and its damping – Active non-axisymmetric magnetic field modifications – Plasma shape modifications – Changes in aspect ratio – Compare with theory and modeling	H*

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

1) Understand the role of magnetic structure on plasma confinement and the limits to plasma pressure in sustained magnetic configurations – (II)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
H	Characterize and understand effects on tearing modes from – Plasma profiles – Externally driven, localized currents – Changes in aspect ratio – Compare with theory and modeling	H*
M	Characterize and understand effects on H mode pedestal and ELM properties from – Particle losses and recycling – Plasma edge configurations and conditions – Changes in aspect ratio (in/out asymmetry) – Compare with theory and modeling	H*
M	Characterize and understand effects on bootstrap and diamagnetic currents from – Low aspect ratio (large in/out asymmetry) – Order unity beta – Compare with theory and modeling	M
H	Characterize and understand magnetic reconnection and stability associated with – Co-axial helicity injection – Outer poloidal field only plasma initiation – Compare with theory and modeling	H*

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

2) Understand and control the physical processes that govern the confinement of heat, momentum, and particles in plasmas – (I)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
M	Characterize global confinement scaling	L
H	Characterize and understand core transport coefficients and fluxes (thermal, particle, momentum) as functions of local plasma parameters in core (e.g., internal transport barriers) and edge confinement (e.g., H-mode pedestal) regimes – Compare with theory and modeling	M
H	Characterize and understand spontaneous and driven plasma flows and assess their impact on core and edge transport properties – Compare with theory and modeling	M
M	Characterize and understand scaling of local transport properties as function of dimensionless parameters, including the aspect ratio – Compare with theory and modeling	M
H	Characterize and understand low and high k core plasma turbulence mechanisms in plasmas with both low and high core confinement, including – Divertor L-mode – Divertor H-mode – Inboard limited – Compare with theory and modeling	H*

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

2) Understand and control the physical processes that govern the confinement of heat, momentum, and particles in plasmas – (II)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
H	Characterize and understand plasma turbulence, transport, and stability properties in edge plasmas, including flows and field structure in – Divertor L-mode – Divertor H-mode and pedestal – Inboard limited – Compare with theory and modeling	H*
M	Update & apply neoclassical transport model accounting for effects of sonic flows, flow shears and very high beta – Compare with theory and modeling	M*
M	Innovative time & space-resolved plasma T_e & B fluctuations measurements	H
H	Update and apply linear and nonlinear gyrofluid and gyrokinetic simulation codes on microturbulence to plasma measurements with sonic flows and order unity β	H*

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

3) Learn to use energetic particles and electromagnetic waves to sustain and control high temperature plasmas – (I)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
H	Characterize and understand solenoid-free EBW initiation, ramp-up, and sustainment (emission, launching, mode conversion, propagation, absorption by passing and trapped electrons, current generation, etc.) – Compare with theory and modeling	H*
H	Participate in analysis, design, and construction of EBW sources, transmission systems, and launchers, including possible in-kind contributions of equipment	H*
H	Characterize and understand HHFW heating and current drive (launching, launcher-sheath-edge interactions, propagation, absorption by electrons, current generation, absorption including effects of fast ions, linear mode conversion, nonlinear mode coupling, etc.) – Compare with theory and modeling	H*
M	Characterize and understand early HHFW injection to assist current initiation and ramp-up – Compare with theory and modeling	M

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

3) Learn to use energetic particles and electromagnetic waves to sustain and control high temperature plasmas – (II)

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
M	Characterize and understand interactions between fast-ion driven modes and the fast ions, accounting for effects of – Fast ion energies, density, and profiles – Plasma profiles – Changes in aspect ratio – Compare with theory and modeling	M*
H	Characterize and understand NBI current drive, accounting for effects of fast ion driven instabilities; – Compare with theory and modeling	M
M	Characterize and understand effects of energetic ions, finite gyro-orbits, and large guiding center orbits on bootstrap and diamagnetic currents at low aspect ratio; – Compare with theory and modeling	M
H	Innovative time and space-resolved HHFW wave launch, conversion, coupling, propagation, and absorption measurements	M

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

4) Learn to control the interface between a 100-million-degree plasma and its normal temperature surroundings.

Relative Research Priority	Research Elements	Relative Collaboration Opportunity
H	Characterize and understand plasma edge fluxes, including – Plasma particle and heat fluxes, and impurity fluxes – Erosion and redeposition of divertor and first wall materials – Plasma power distribution – Effects of changing aspect ratio (in/out asymmetry) – Compare with theory and modeling	H*
H	Characterize and understand effects on plasma edge and SOL properties from – Edge & SOL turbulence – Intermittent ejection of filaments and “blobs” – ELMs and edge transport barriers (H-mode pedestals) – Changes in aspect ratio (in/out asymmetry) – Compare with theory and modeling	H*
M	Characterize and understand effects of wall conditioning and surface coating (such as boron, lithium, etc.) on – Particle and impurity recycling – Plasma density – Dust formation and distribution – Compare with theory and modeling	M
M	Innovative time and space resolved edge-SOL-divertor plasma measurements	H

*Research elements affected by the 2004 NSTX collaboration renewal proposal review.

PAC Advice on Program Letter Will Steer NSTX Research Collaboration

- **Contribute to Campaigns and guided by Overarching Themes under consideration by FESAC Priorities Panel**
- **Support DOE SC Strategic Goals for Fusion Energy Sciences, including ITER burning plasma**
- **Provide input to inform DOE's selection of winners**
- **Influence the final writing of proposals**
- **Build stronger and well focused NSTX National Team**