NSTX-U

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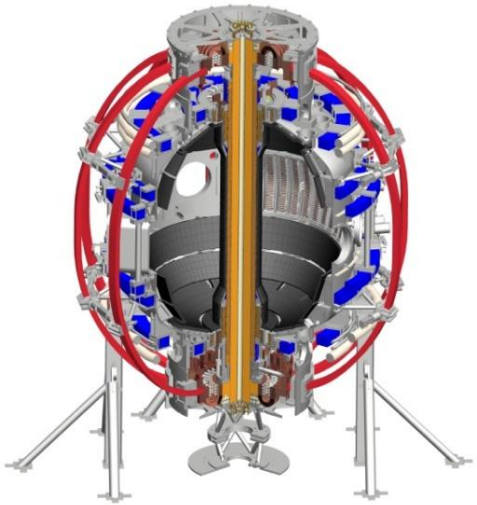
NSTX-U Program Update

J. Menard

NSTX-U Team Meeting
B318
January 3, 2013



Coll of Wm & Mary
Columbia U
CompX
General Atomics
FIU
INL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Lehigh U
Nova Photonics
Old Dominion
ORNL
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York U
Chubu U
Fukui U
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Seoul Natl U
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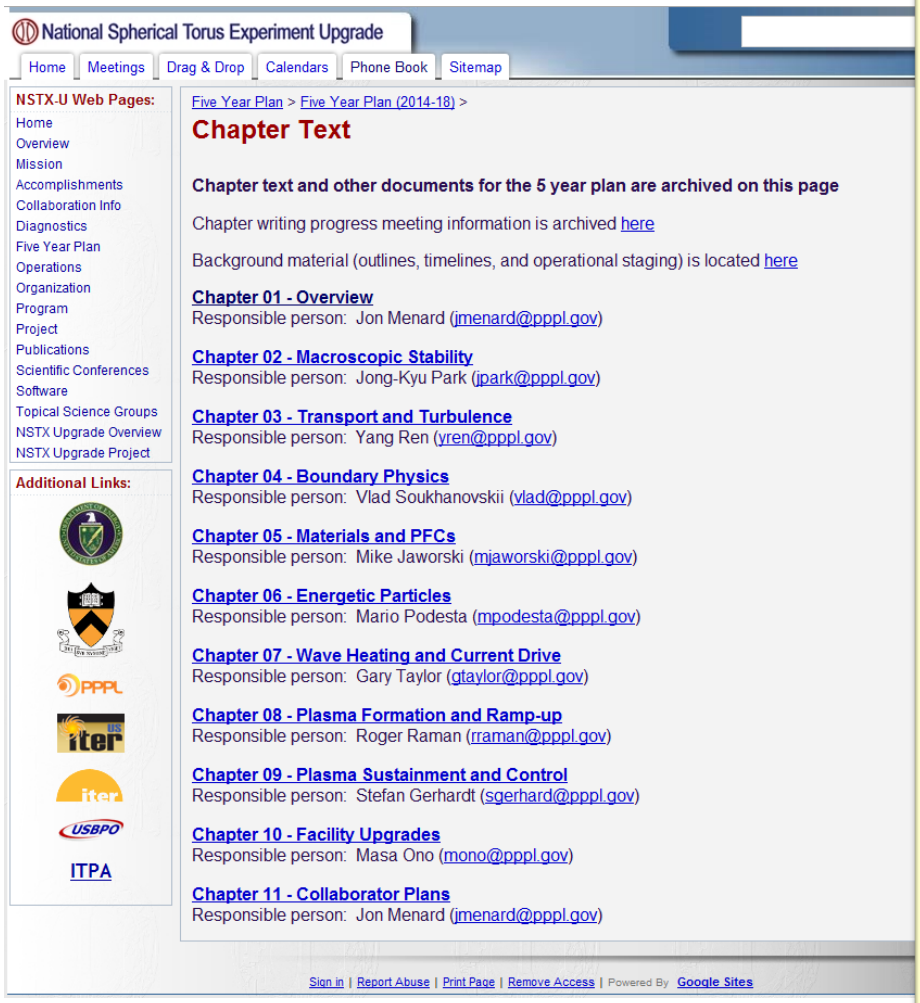
CIEMAT
FOM Inst DIFFER
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep

Team actively engaged in writing 5 year plan for 2014-2018



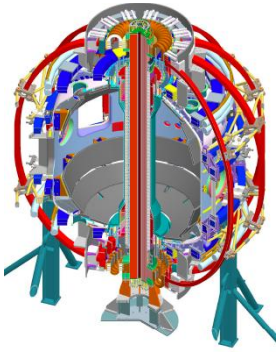
- Plan text to be due to FES approx. April 1, and review in May 2013
- Drafts of each chapter in-hand
  - Many are largely complete
- Complete drafts due mid-January
- Plan and text will be assessed at NSTX-U PAC-33
- Emphasizing support of FNSF, ITER, predictive capability
  - Role of reduced collisionality
  - Non-inductive start-up, sustainment
  - 3D field effects

Your comments on the plan are welcome!

FY2014-18 5 year base plan aims to access new ST regimes with Upgrade + additional staged high priority upgrades

2014	2015	2016	2017	2018
Upgrade Outage	1.5 → 2 MA, 1s → 5s			

New center-stack



2nd NBI

Start-up and Ramp-up	● Upgraded CHI for ~0.5MA	ECH/EBW ● 1MW		
Boundary Physics			● Divertor cryo-pump	
Materials and PFCs				● U or L Mo/W divertor
Liquid metals / lithium	● Li granule injector	● Upward LiTER		
MHD	● MGI disruption mitigation		● Enhanced MHD/RWM sensors	
Transport & Turbulence	High k_θ ●	● δB polarimetry	● DBS	
Waves and Energetic Particles			● HHFW limiter UG or EHO/AE straps	
Scenarios and Control	Establish control of: ● Rotation	● Snowflake	● Divertor P_{rad}	● q_{min}

NSTX Upgrade research goals in support of PMI, FNS, ITER

- Low collisionality plasma regimes
- 100% non-inductive operation
- Long-pulse, high power divertor
- Advanced high-β scenarios

Draft PAC-33 agenda and speakers

PAC dates: February 19-21, 2013

PAC meeting will effectively be dry-run for 5 year plan review

• Program overview	Jon Menard
• Upgrade progress, facility and diagnostic prep, budget	Masa Ono
• Initial Operations Plan, Scenarios and Control	Stefan Gerhardt
• Macroscopic Stability	Jack Berkery
• Non-axisymmetric control coil (NCC) applications	Jong-Kyu Park
• Transport and Turbulence	Yang Ren
• Energetic Particles	Mario Podesta
• HHFW and ECH / EBW	Gary Taylor
• Solenoid Free Start-up and Ramp-up	Roger Raman
• Long-term issues and strategy for boundary and PMI	Rajesh Maingi
• Pedestal, SOL, Divertor	Vlad Soukhanovskii
• Cryo-pumping and particle control	John Canik
• Materials and Flowing liquid Li module development	Mike Jaworski

NSTX-U researchers will be playing active role in MAST 2013 run campaign

- Thanks to MAST team for strong outreach/accomodation to NSTX team
- And to Gary Taylor for helping coordinate NSTX collaboration on MAST

Number	Title	Person in charge
FPP-001	Time-resolved measurements of DD fusion products using proton detector & neutron camera/fission chamber during short timescale MHD activity & NBI blips	D. Darrow M. Cecconello
FPP-006	Identification & study of TAE avalanches	E. Fredrickson
MHD-011	Effect of I_P and β_P on pedestal	A. Diallo
TC-014	Measure perturbative particle transport in MAST	Y. Ren
TC-011	Momentum transport	W. Guttenfelder

Experiments to start Feb/Mar - will benefit MAST/MAST-U and NSTX-U

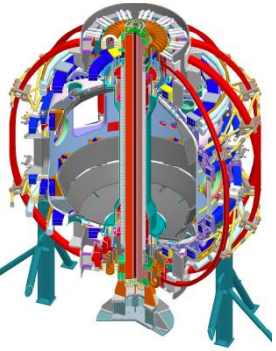
Backup

10 year plan goals with ~10-15% incremental funding

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023

Upgrade Outage | **Establish ST physics, scenarios** | **Integrate long-pulse + PMI solutions**

New center-stack



2nd NBI

Start-up and Ramp-up
- Increase CHI closed-flux current
- Understand plasma gun start-up at increased device size / major radius
- Develop/understand ECH/EBW H&CD for ST
- Increase/extend ramp-up heating and off-axis current-drive for advanced scenarios

Boundary Physics
- Establish main-ion density and ν^* control
- Understand snowflake divertor performance
- Investigate high-Z first-wall erosion, migration, particle sources & sinks

Materials and PFCs
- Assess high-Z divertor PFC impact and performance
- Assess high-Z first-wall
- Assess impact of high-temperature first-wall

Liquid metals / lithium
- Establish low impurities / Z_{eff} , assess increased Li coverage, replenishment
- Test flowing liquid metal for heat-flux mitigation, surface replenishment
- Assess flowing LM PFC with full toroidal coverage

MHD
- Extend disruption and RWM detection, develop disruption mitigation techniques
- Enhance non-axisymmetric field spectrum and capabilities for control of: RWM, EF, RMP, rotation, NTM, EP

Transport & Turbulence
- Understand ES and EM turbulence at high β, low ν^*, emphasizing e-transport
- Extend wave-number coverage of turbulence measurements

Waves and Energetic Particles
- Support plasma start-up, assess effectiveness of fast-wave in NBI H-modes
- Prototype driving edge-harmonic oscillations (EHOs) and/or *AE
- Drive and control EHO and/or *AE modes

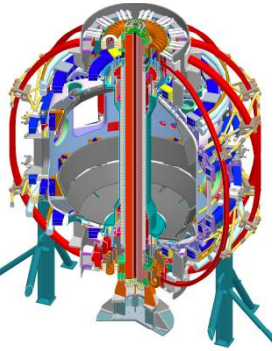
Scenarios and Control
- Demonstrate full non-inductive, high I_P & P_{AUX} operation
  Control: boundary, β, divertor heat flux, Ω & q profiles
- Assess integrated control of long-pulse / high-performance

U.S. FNSF conceptual design including aspect ratio and divertor optimization

10 year plan tools with ~10-15% incremental funding

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Upgrade Outage	1.5 → 2 MA, 1s → 5s				Metallic PFCs, 5s → 10-20s				

New center-stack



2nd NBI

Start-up and Ramp-up
- 0.3-0.5 MA CHI
- 0.5-1 MA CHI
- 0.2-0.4 MA plasma gun
- up to 1 MA plasma gun
- ECH/EBW
- 1MW → 2 MW
- Extend NBI duration or implement 2-4 MW off-axis EBW H&CD

Boundary Physics
- Divertor cryo-pump
- Divertor Thomson
- Diagnostics for high-Z wall studies

Materials and PFCs
- U or L Mo/W divertor
- U + L Mo/W divertor
- All High-Z PFCs
- Hot high-Z FW PFCs using bake-out system

Liquid metals / lithium
- Li granule injector
- Upward LiTER
- Flowing Li divertor or limiter module
- Full toroidal flowing Li divertor

MHD
- MGI disruption mitigation
- Enhanced MHD/RWM sensors
- NCC coils
- NCC SPA upgrade

Transport & Turbulence
- High k_θ
- δB polarimetry
- DBS
- PCI or other intermediate-k

Waves and Energetic Particles
- HHFW limiter upgrade
- HHFW straps for EHO, *AE
- Dedicated EHO or *AE antenna

Scenarios and Control

Establish control of:
- Rotation
- Snowflake
- Divertor P_{rad}
- q_{min}
- Control integration, optimization

U.S. FNSF conceptual design including aspect ratio and divertor optimization