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NSTX Facilities and Diagnostics

Masayuki Ono

Princeton Plasma Physics Laboratory

For the National NSTX Team

NSTX Results / Theory Review and Research Forum
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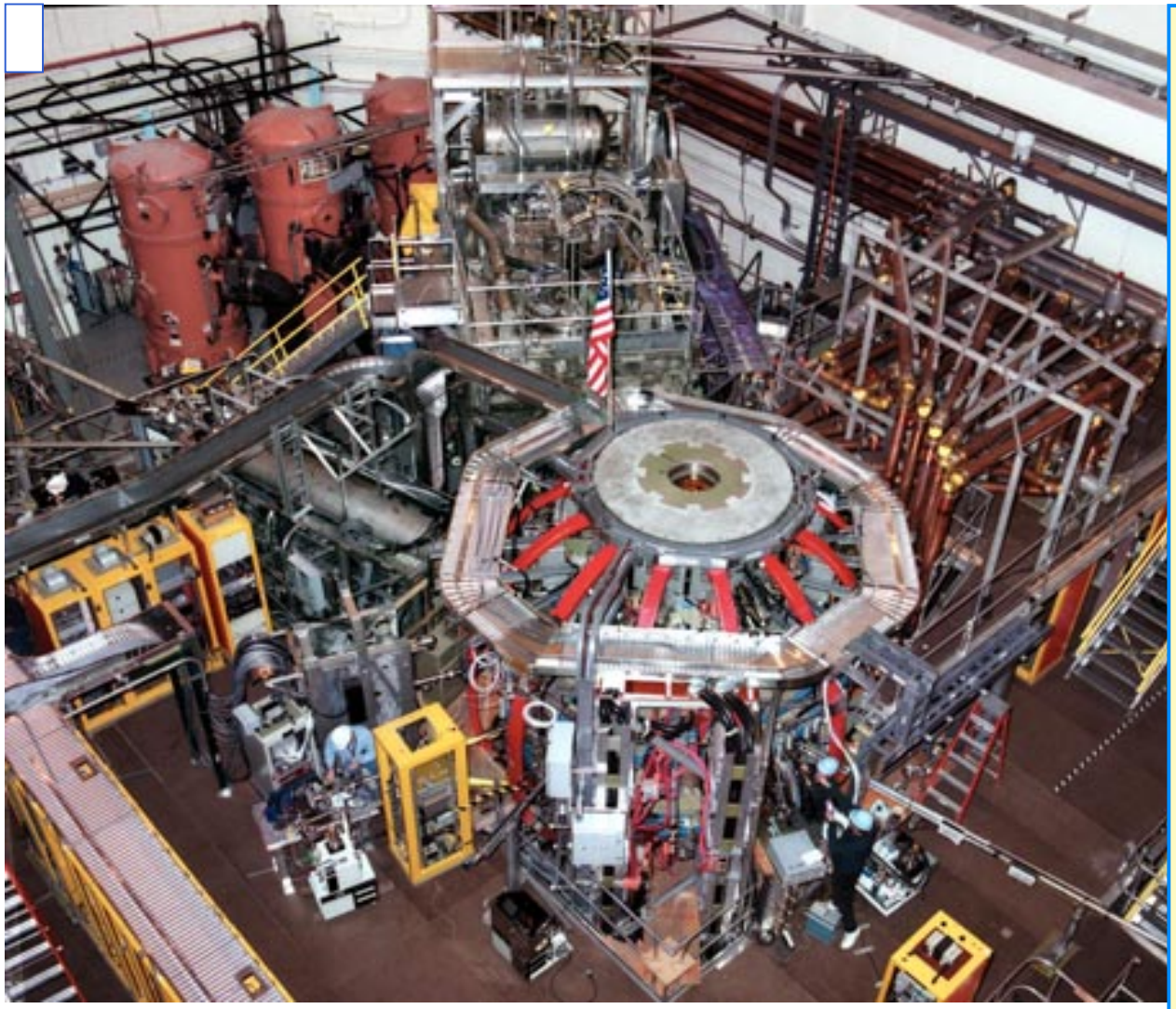
Facility / Diagnostics Talk Outline

- FY 02 Accomplishments
  - Facility Upgrades and Operation Summary
  - Diagnostic Summary
- Facility / Diagnostic Status and FY 03 Plan*
  - Plasma equilibrium
  - MHD Mode Stabilization
  - Confinement and Transport
  - Impurity Diagnostics
  - Non-inductive Current Drive Systems
  - Boundary Physics
- Summary

* The FY 03 plan assumes the Presidential Budget with 21 run weeks.

NSTX Facility Has Continued Rapid Progress in Operational and Experimental Capabilities



Baseline Parameters
(Achieved)

Major Radius 0.85 m

Minor Radius 0.68 m

Elongation = 2.2 (2.5)

Triangularity = 0.6 (0.8)

Plasma Current
1 MA (1.5 MA)

Toroidal Field
0.3 to 0.6 T (≤0.6 T)

Heating and CD
5 MW NBI (7 MW)
6 MW HHFW (6MW)
0.5 MA CHI (0.4 MA)

Pulse Length
= 1 → 5 sec (1.1 sec)

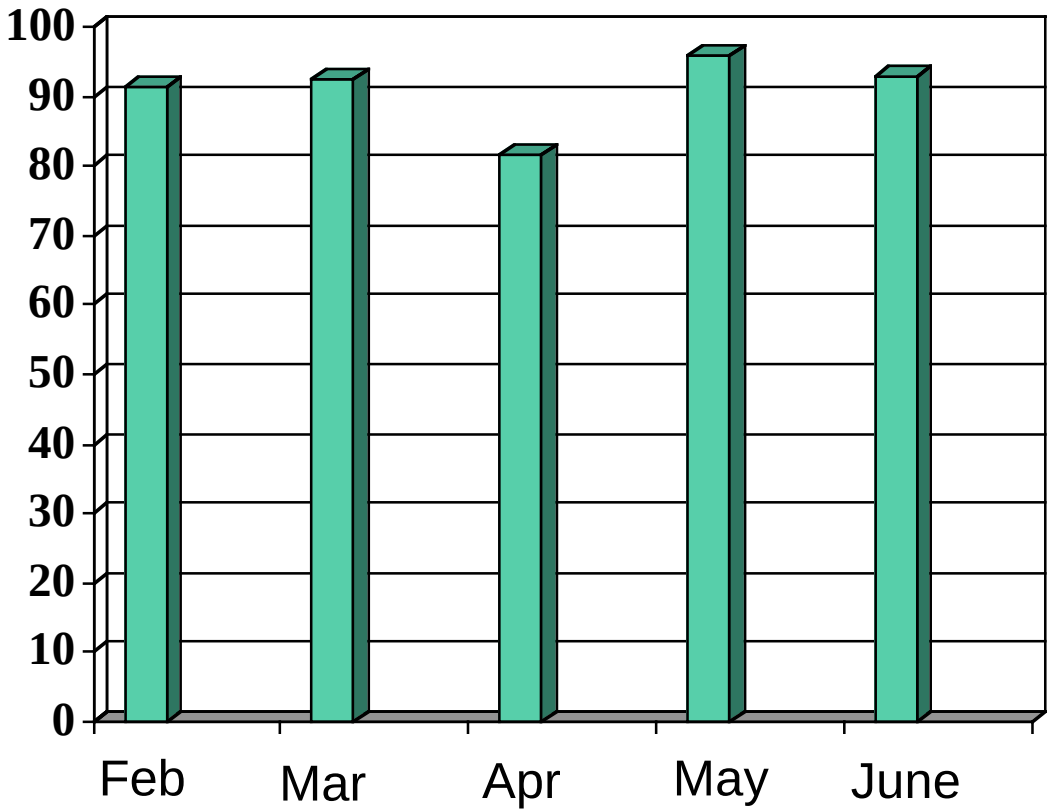
Facility Investment Paid-off for the FY 02 Run

- 350 °C (high pressure He) bake out system commissioned.
- PF 5 realignment reduced the n=1 error field by a factor of ten.
- I_p = 1.5 MA achieved (50% over the base design).
- Plasma discharge duration of over 1 sec at 800 kA achieved.
- Strong shaping (κ = 2.5 and δ = 0.8) and broad pressure profile obtained.
- Inner-wall gas feed improved H-mode access and quality.
- NBI operations reached 100 kV and 7 MW injected power.
- Flourinert inner TF cooling system implemented.
- 6 kG operations commenced.
- HHFW digital phase control system commissioned.
- Real time plasma control system with rEFIT commissioned.
- 12 plus run weeks achieved meeting a major facility milestone.

90% Facility Availability Achieved In FY 02

FY 02

Availability (%)



	Feb	Mar	Apr	May	June	
# of Run Days:	13	5	20	15	10	
Extended Days:				1	4	
# of Shots:	372	159	543	508	388	(Total of 1970 shots)

Diagnostic / Boundary Physics Achievements

- 20-channel / Two laser (60 Hz) MPTS
- iCHERS
- Scanning neutral particle analyzer
- GEM x-ray detector *[ENEA/Frascati, Jones Hopkins]*
- Fast reciprocating Langmuir probe *[UCSD]*
- PSI ultra-fast camera for edge imaging *[PSI, LANL]*
- Divertor fast cameras *[U. Hiroshima]*
- FIReTIP: two additional sightlines at Bays G, I *[UCD]*
- Transmission grating VUV spectrometer *[JHU]*
- Fast ion loss probe
- X-ray pinhole camera
- Tile-mounted Langmuir probes *[UCSD, ORNL, U. Hiroshima]*
- Divertor bolometer: first data
- IR Cameras *[ORNL]*
- Fast ion gauges *[U. Washington]*
- Diamond neutral particle detector *[Triniti]*
- Dust sample collection after the run *[INEL]*

Three papers at 15th PSI meeting and seventeen papers (one invited) at the 14th Annual High Temperature Plasma Diagnostics Conference.

Plasma Equilibrium

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

Magnetics

- Improved Pickup coils - uninsulated wire
- 9 on center stack and 16 on inner divertor replaced

- New coils - 4 on inner divertor and “2D” coils for coaxial helicity injection

Reconstruction

- Real Time EFIT (GA)
- Between-shots EFIT + DECON (Columbia/LANL)

Current Density

MSE/CIF (Nova)

2 Channel → 10 Channel

Additional current density diagnostics are under development
- *2-D tangential X-ray pinhole cameras (fast and slow)*
- *FIReTIP - Faraday rotation measurements*
- *1 mm interferometer - current density on axis*

Incremental Improvemens in FY 04

MHD Mode Stabilization

Opportunity Areas are Resonant Field and RWM Controls.

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

MHD Diagnostics

- Locked-mode coils
- High Frequency coils
- Poloidal Mirnov Array
- Ultra Soft-Xray Array (JHU)
- 2-D tangential gas electron multiplier (GEM) Imaging system - 50 kHz (Frascati, JHU)

- Wall-mode sensors 12 B_{pol} and 12 B_{rad} coils
- Divertor Mirnov Array
- 2D fast tangential X-ray pinhole camera - 100 kHz

EBW radiometer for T_e fluctuations under development

Resonant Field Control

Plasma Rotation + Wall + Modeling

MHD Mode Measurement + DIII-D/HBT-EP

Preliminary Resonant Field Control System

Incremental Improvemens in FY 04

Confinement and Transport

Exciting Opportunities For Advanced Fluctuation Diagnostics

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

Profile Diagnostics

- Thomson (20 ch, 60 Hz)
- 51 Channel Toroidal CHERs
- 2-D X-ray Crystal Spectrometer (KBSI)
- 4 Channel FIReTIP (UCD)

Energetic Particles

- Scanning Neutral Particle Analyzer
- Scintillator Fast Lost Ion Probe
- Neutron detectors
- Diamond detectors

Fluctuation Diagnostics

- Gas puff imaging (PSI, LANL)
- Fast reciprocating probe (UCSD)
- Microwave reflectometer (UCLA)

High k proto-type & low k imaging planned in FY 04

Under development:
- 1mm interferometer (UCLA)
- EBW radiometer

Impurity Diagnostics

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

Visible Spectroscopy

- Visible spectrometer (VIPS)
- Visible bremsstrahlung monitor
- Filtered fiberscopes ORNL)

Ultraviolet/Ultrasoft X-Ray Spectroscopy

- Vacuum ultraviolet Survey spectroscopy (JHU)
- Transmission grating Multi-chordal spectrometer ((JHU, Adv. Diag. Initiative))

X-Ray Spectroscopy

- X-ray crystal spectrometer (astrophysical applications - LLNL, MIT)

Radiated Power

- Tangential bolometer array - midplane view

Incremental Improvemens in FY 04

Non-Inductive CD Systems

Enhancement Opportunity areas are CHI and EBW

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

HHFW (6MW)

- Pre-programmed CD Phasing
- Antenna Feed-area improvements
- Plasma Feed-back phase control

CHI (I_T = 0.5 MA)

- New CHI Absorber Insulator Fabrication
- ⇑ Install
- Absorber field null control
- Dynamo-head For helicity transport

Incremental Improvemens in FY 04

EBW -E / -CD

- EBWE / Edge $n_e(r)$
- Optimized EBWE Antenna (Diag. Init.)
- **High Power EBWCD System Decision Point**

1 MW EBW System in FY 04?

Boundary Physics

Exciting Enhancement Opportunity in Core Fueling and Boundary Physics

Plasma Operations	FY 02	FY 03
(Run Weeks)	12	21

Wall Conditioning

(Gas/plasma Boronization, Between-shot GDC)

- 350°C Bakeout System
- In-board gas injector
- Realtime Gas Control
- Li/Boron Pellet Injector

CDX-U / APEX Lithium Exp.

Power/Particle Control

- Recip. edge probe (UCSD)
- Divertor bolometer array
- IR Cameras
- Divertor 1-D CCD Camera
- Divertor fast camera (Hiroshima Univ)
- Tile Langmuir probes
- Thermocouple probes
- Wall mounted sample exposure coupons (SNL)
- Edge flow spectroscopy
- Quartz microbalance deposition monitor

Advanced Power and Particle Handling Decision Point

Start of P& P System fabrication in FY 04?

Facility / Diagnostics Summary

FY 02 campaign was a great success!

- **The NSTX facility has met or exceeded the original design.**
- **The facility has met or exceeded all of the major operational milestones.**
- **The innovative NSTX diagnostic systems are rapidly ramping up.**
- **Facility /diagnostic enhancements and high availability contributed to the productive research output in FY02**

We are excited about the FY 03 Run:

- **The facility utilization enhancement budget (21 run weeks in FY 03 for the Presidential budget) will enable us to greatly increase the scientific output.**
- **The facility capability particularly the innovative diagnostics are being enhanced.**