Experimental Research Operations: Status and Plans for FY'02

M.G. Bell

NSTX Experimental Research Operations Division

presented to the

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Topics

- Changes in device capabilities
  - Bakeout
  - Inner wall gas fuelling and plasma boronization
  - Real-time control
  - HHFW system
  - PF5 coil realignment
- Diagnostic status for FY'02
  - Relationship to FY'02 research milestones

High-Temperature Bakeout Commissioned

- New bakeout capability commissioned in December
  - Support structures for outer PFCs heated by high pressure helium
  - Tiles on outer divertor and stabilizer plates reached 320°C
  - Tiles on center column reached 330°C (resistive heating)
- Considerable acceleration of outgassing
- System operated well although some “teething problems” encountered
  - Heater power was limited: should be able to get 350°C next time
  - Small leaks opened on bakeout feed flanges during cooldown
    - Now sealed but need to assess permanent fix
- Subsequent GDC (D followed by He) removed adsorbed water
- Base pressure now lower than after previous bakeouts but not the best we have reached at the end of a run

Inner Wall Gas Fueling and Boronization

- Installed gas feed at midplane on centerstack
  - 3 mm feed tube routed behind inner divertor and center column tiles
  - Small (40 cm^3) high-pressure (~100 kPa) plenum with fast valve
  - ~ 1 s risetime for VV pressure
- Plasma boronization
  - Introduced 10% D-TMB + 90% He into sequence of 900kA discharges
    - Reduced P_{rad} and
    - H-mode transition in subsequent plasma
  - Procured pure D-TMB supply for tests in FY'02 run
    - Safety aspects reviewed and approved

Upgrades for Real-Time Control

- Problems with commercial vendor forced a redesign of data acquisition
- Use existing commercial modules for an interim upgrade while also developing a local solution for final capability
- 96 channels from Test Cell plus 64 channels from coil measurements
  - 5kHz/channel, 5μs latency, 12 bit precision
  - Devoted largely to magnetics data for equilibrium control
  - 18 channels available for other diagnostics (*e.g.* density analog)
- Tested rtEFIT in Plasma Control software with NSTX data *[GA]*
  - Code allows real-time algorithm switch to facilitate bringing online
- Incorporated control for Gas Injection System into real-time computer
  - Pulse-width modulation of piezo valves for better reproducibility
  - *A big improvement over previous manual setup for GIS*

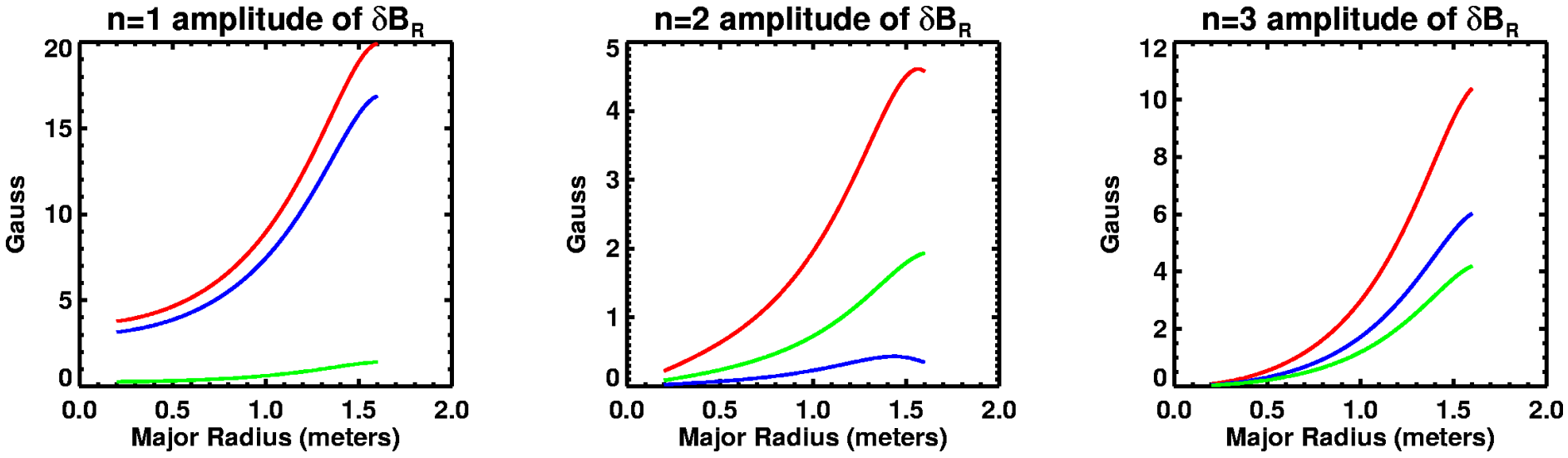
High Harmonic Fast Wave Status

- All 6 sources checked into dummy load after maintenance
- New master oscillator and antenna phase monitoring system
- Control of HHFW power, phase and timing from NSTX control room
- Preparing for operation with feedback to maintain programmed antenna phasing
  - Automatic compensation for loading changes
  - Closing of phase control loops will begin during operations
- *Ready to begin work on HHFW pulse extension and current drive*

PF5 Coils Realigned to Reduce Field Errors

- Installed adjustment turnbuckles to brackets on outer VV
  - n=1 amplitude reduced by factor of 12
  - n=2 amplitude increased slightly: 2 Gauss at plasma edge
  - n=3 is largest predicted amplitude: 4 Gauss at plasma edge

Calculations for I_{PF5} = 10 kA



- **RED**: magnetic data
- **BLUE**: measured coil, **before correction**
- **GREEN**: measured coil, **after correction**

Many Diagnostic Installations & Upgrades Completed

- Magnetic sensors: non-magnetic, more robust coils; 7 higher frequency coils; repaired flux loops
  - 10 MHz D/A available for subset of coils (~2×f_{ci})
- Neutral Particle Analyzer: horizontal and vertical scanning
- Thomson scattering: additional 10 spatial channels
- Reciprocating edge probe *[UCSD]*
- FIReTIP: 4 lines of sight (3 instrumented) *[UCD]*
- Divertor bolometer: 4 channel prototype thermal detectors
- Divertor fast camera *[U. Hiroshima]*
- Density interferometer (1mm chirped) *[UCLA]*
- USXR cameras: additional camera, upgraded detectors *[JHU]*
- GEM x-ray detector (2-D) *[Frascati]*
- Reflectometer: additional channel (correlation meas't) *[UCLA]*

CHERS Upgrade and MSE Delayed to FY'03

- CHERS upgrade (51 ch.) and MSE share mounting for fiber optics
  - Fiber holder now in final fabrication
- CHERS fibers delivered (late) in September did not meet specification
  - Necessitated switch of vendor and local assembly into bundles
- MSE fibers delivered late; bundling is proceeding slowly
  - Expect to complete potting and polishing of 76 $\times$ 19 fibers by end Feb.
- MSE filter prototype complete but high-birefringence material delayed
  - Vendor plant was shutdown over summer because of market collapse
- Need VV opening for 6 – 8 weeks to install, calibrate collection optics
- Aim to install after FY'02 run in preparation for FY'03 experiments
  - MSE requires several months after first light to complete calibration
  - Should then be able to back-calibrate data taken earlier in run

Diagnostic Complement for FY'02 Experiments

Confinement Studies

- Magnetics for equilibrium reconstruction
- Diamagnetic flux measurement
- Thomson scattering (20 ch., 60Hz)
- CHERS: T_i and v_ϕ (17 ch.)
- Neutral particle analyzer (scanning)
- Density interferometer (1mm, single chord)
- FIReTIP interf'r/polarimeter (3 ch.) *[UCD]*
- VB detector (single chord)
- Midplane tangential bolometer array
- X-ray crystal spectrometer
- X-ray pulse height analyzer
- Electron Bernstein wave radiometer

MHD/Fluctuations

- High-n and high-frequency Mirnov arrays
- Ultra-soft x-ray arrays (4) *[JHU]*
- 2-D x-ray detector (GEM) *[Frascati]*
- X-ray tangential pinhole camera
- Reflectometer *[UCLA]*
- Fast ion loss probe (non-resolving)
- Locked-mode detectors

Edge studies

- Reciprocating Langmuir probe *[UCSD]*
- Fixed Langmuir probes (24)
- Edge fluctuation imaging *[LANL]*
- 1-D CCD H_α cameras (divertor, midplane) *[ORNL]*
- 2-D divertor camera *[U.Hiroshima]*
- Divertor bolometer (4 ch.)
- IR cameras (30Hz) (2)
- Tile temperature thermocouple array
- Scrape-off layer reflectometer *[ORNL]*

Plasma Monitoring

- Fast visible camera [LANL]
- VIPS-1: Visible survey spectrometer (reticon)
- VIPS-2: Visible survey spectrometer (CCD)
- SPRED: UV spectrometer
- GRITS: VUV spectrometer *[JHU]*
- Fission chamber neutron measurement
- Fast neutron measurement
- Visible filterscopes *[ORNL]*
- Wall coupon analysis *[SNL]*

New Capabilities Contributing to FY'02 Goals

Research Milestones	Operation & Diagnostic Capabilities
Study MHD modes without active feedback	• High freq. Mirnov coils • Locked mode coils • USXR arrays • Reflectometer
Assess effects of high beta and flow on transport	• 20 ch. MPTS • 17 ch. CHERS • FIReTIP (interferometry) • Z_{eff} profiles • Edge rotation (proto.)
Test CHI startup	• Control system development • X-ray arrays, cameras • Divertor camera • Divertor bolometer (proto.)
Test HHFW current drive efficiency	• Control system development • $k_{||}$ control • FIReTIP (polarimetry) • Scanning NPA

Summary

- We expect significant improvements for FY'02 run
  - Improved plasma control
  - Improved wall conditioning: 350°C bakeout,
  - Plasma boronization
  - Inner wall gas fuelling capability
  - Routine operation of HHFW system with advanced capability
    - Feedback control of launched fast-wave $\mathbf{k}_{||}$ spectrum
  - Reduction in error fields from PF5 coil realignments
- New and improved diagnostics will become available during the run