

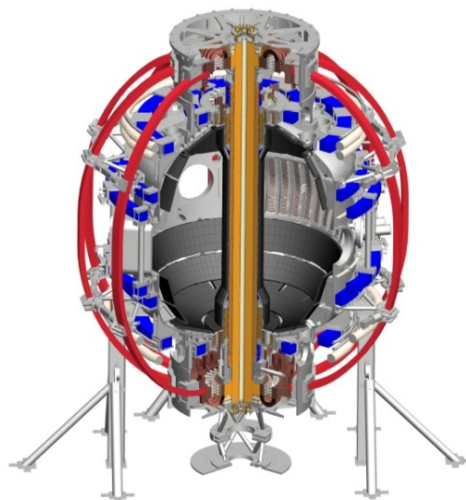
Diagnostics

B. Stratton

and the NSTX Research Team

**Operations/Diagnostics + XMP/XP Status Meeting
PPPL
January 28, 2015**

Coll of Wm & Mary
 Columbia U
 CompX
 General Atomics
 FIU
 INL
 Johns Hopkins U
 LANL
 LLNL
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 MIT
 Lehigh U
 Nova Photonics
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 York U
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 Kyushu U
 Kyushu Tokai U
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 KAIST
 POSTECH
 Seoul Natl U
 ASIPP
 CIEMAT
 FOM Inst DIFFER
 ENEA, Frascati
 CEA, Cadarache
 IPP, Jülich
 IPP, Garching
 ASCR, Czech Rep

Outline

- NSTX-U diagnostic website
- Overview of status of diagnostic installations
- Status of some specific diagnostics
 - Exceptions:
 - Magnetics diagnostics: Research Operations talk (S. Gerhardt)
 - Boundary Diagnostics: Boundary Operations talk (R. Kaita)
 - RF-Specific Diagnostics: RF Operations talk (J. Hosea)
- Brief discussion of future diagnostics for second NSTX-U campaign and beyond
- Summary

NSTX-U Diagnostics Website

Some useful links:

The screenshot shows the NSTX-U website interface. At the top, there is a search bar and navigation tabs for Home, Meetings, Drag & Drop, Calendars, Phone Book, and Sitemap. A left sidebar lists various web pages, with 'Diagnostics' highlighted. The main content area is titled 'Diagnostics' and contains two columns of links. Red arrows point from text annotations to specific elements: 'Diagnostic link' points to the 'Diagnostics' menu item; 'Lists of diagnostics by type' points to the top-left column of diagnostic categories; 'Downloadable complete diagnostic list' points to the 'here' link in the second column; and 'Downloadable port map' points to the 'here' link at the bottom of the second column.

NSTX-U Web Pages:

- Home
- Overview
- Mission
- Accomplishments
- Collaboration Info
- Data Management Plan
- Diagnostics**
- Five Year Plans
- Group Links / Files / Email
- Joint Research Targets
- Milestones
- Operations
- Organization
- Program
- Project
- Publications & Presentations
- Remote Connection Info
- Reports
- Run Coordination
- Run Schedule Calendar
- Science Groups
- Scientific Conferences
- Software

Diagnostics

Lists of diagnostics by type

- Equilibrium: magnetics, MSE
- MHD Instabilities: fluctuations, disruptions
- Electrons: density, temperature
- Ions: temperature, rotation, impurities
- Turbulence: high-k, low-k, GPI
- Boundary: recycling, probes, first-wall
- Energetic Particles: neutrons, f(v,r,t)

Downloadable complete diagnostic list

- Systems supporting active diagnostics are tabulated [here](#)
- A complete list (.pdf) of NSTX-U diagnostics as of January 2015 is available [here](#)
- Additional information for a subset of NSTX-U diagnostics is located [here](#)
- A map (.pdf) showing the assignment of diagnostics to NSTX-U ports is available [here](#)

- Send corrections and updates to B. Stratton

NSTX-U Diagnostics Lists

- Organized by physics measurement
- Contains specific information on parameters measured, time and spatial resolution, precision, and contact person(s)
- Lists only systems expected to be operational during 2015 NSTX-U run

[Diagnostics >](#)

Electron Diagnostics

Routinely available to support experiments early in run

Will operate early in run but will likely require some development to be routinely useful

NSTX-U Electron Diagnostic Measurement Capabilities – January 2015

(black – available for experiments, blue – under active development)

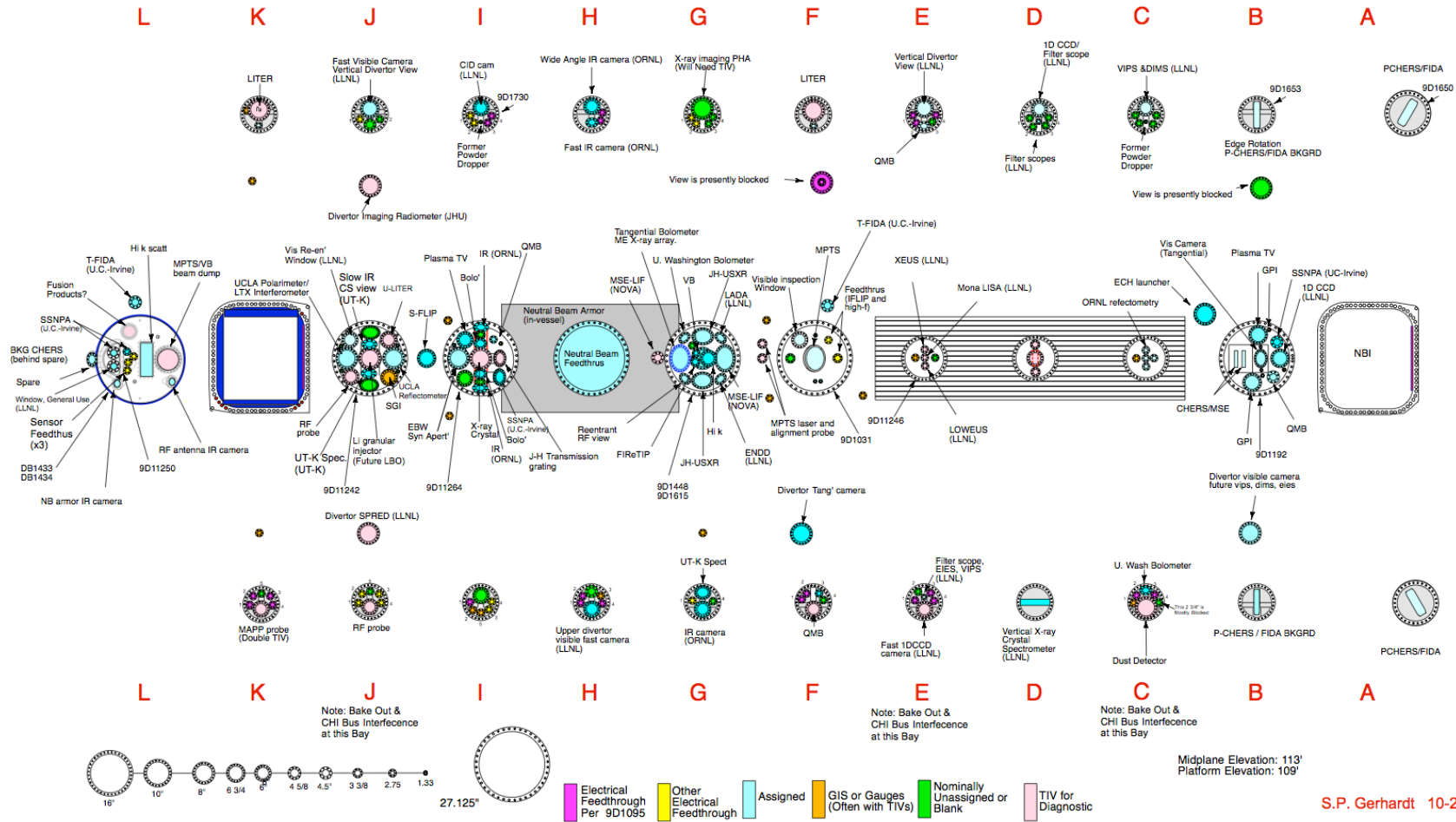
Physics Measurement	Typical range and coverage	Spatial; Temporal Resolution	Typical Precision	Available Diagnostic Techniques	Comment	Contact
Electron density line integral	>2x10 ¹¹ cm ⁻²	4 MHz	2x10 ¹¹ cm ⁻²	Tangential interferometry, polarimetry (FIReTIP)	FIR laser with retro-reflector in 1 tangential chord with R _{tan} =0.64 m	C. Domier – UC Davis, Y. Ren - PPPL
Electron density profile	5x10 ¹¹ - 5x10 ¹⁴ cm ⁻³	3.0 cm core, 0.9 cm edge, 2 30 Hz lasers	>3%	Thomson scattering	60 Hz Nd:YAG, laser nearly radial on horizontal midplane, 42 of 48 channels implemented	B. LeBlanc, A. Diallo, M. Coury – PPPL

Port Map

NSTX Cat. 4 Tile Diagnostics: NSTX345
 NSTX Cat. 3 Tile Diagnostics: ED1324
 NSTX Vessel Mounted Diagnostics: 9D11266
 NSTX RWM Coil Details: DC1329

13 1/4" Port Cover Drawings
 9D11270
 9D1730
 9D1917
 9D1598

Port assignment for 2015 Operations Gas Injectors and Ion Gauges on Separate Port Drawing



S.P. Gerhardt 10-24-2014

Overview of Current Status

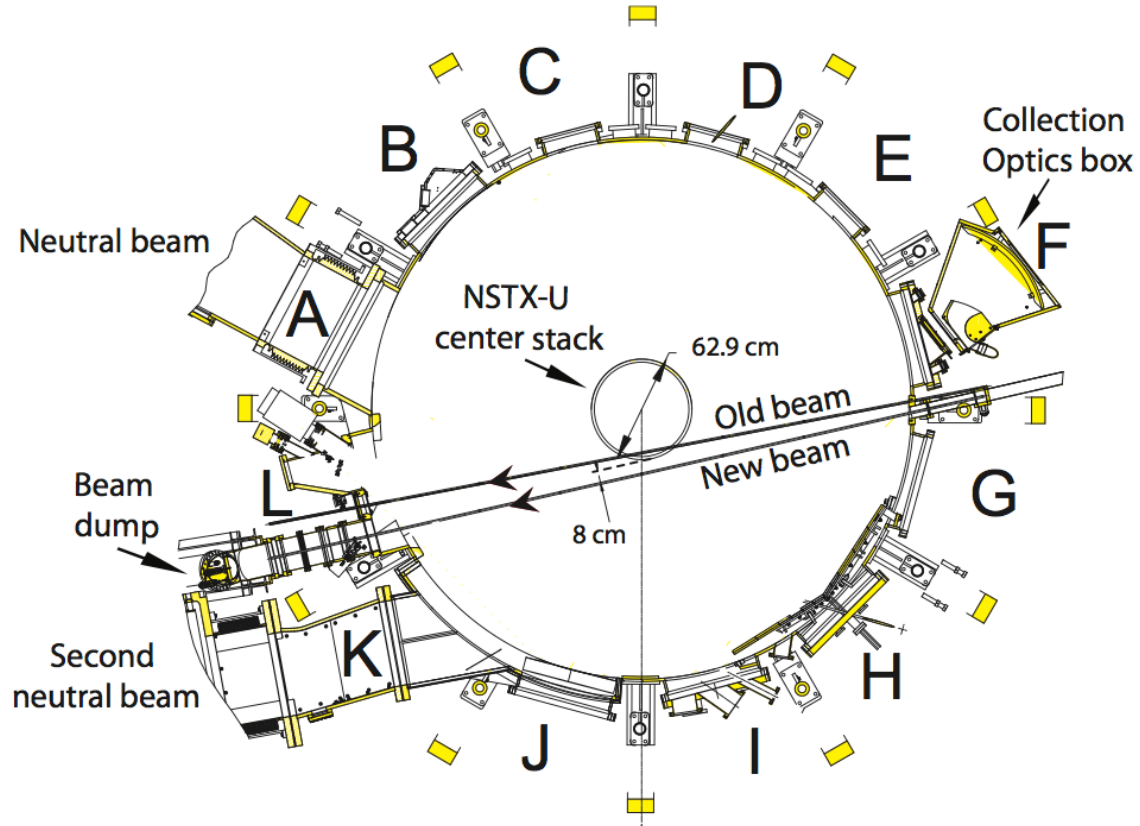
- Nearly all diagnostics were removed from NSTX at the start of the upgrade to allow construction to proceed
- Nearly all NSTX diagnostics being re-installed for NSTX-U
- New diagnostics added
- Extensive rearrangement of diagnostics required to accommodate loss of port space due to installation of second neutral beam at bay K
 - Required new port covers at Bays I and J to accommodate more systems
 - Initial assignment of diagnostics to ports and design of new Bay I and J port covers performed by L. Roquemore
 - Subsequent development of plan and management of diagnostic installations provided by R. Ellis, S. Gerhardt, R. Kaita, and B. Stratton

Overview of Current Status - Continued

- Diagnostic installations started summer 2014
- Diagnostic work since then has focused on completion of in-vessel installations, in-vessel calibrations, installation of vacuum interfaces (windows and TIVs), and installation of diagnostic hardware that is directly coupled to vacuum vessel
- Small number of vacuum interfaces remain to be installed in short vacuum vent before vessel bake
- Emphasis has shifted to installation work outside the vacuum boundary
- Goal is to have diagnostics ready for start of physics program in June 2015
- Remainder of talk will review status of some specific diagnostic systems

MPTS

- MPTS laser had to be re-aimed to miss new centerstack
 - New ports on vacuum vessel required
 - Light collections optics needed to be re-aimed and focused
 - New beam dump required



MPTS - Continued

- Status of installation
 - New ports installed on vessel
 - Light collection optics box rebuilt and re-installed
 - Laser beam entrance flight tube nearly complete
 - New laser optics box on south wall of TC installed
 - Laser exit flight tube complete up to TIV
 - “Phase 3” polychromators rebuilt – improved error bars expected
- Installation of remainder of exit flight tube will start soon
- 42 spatial channels – improved spatial resolution in pedestal
 - Implemented in 2011
- Plan to have system ready for calibration in April
- M. Coury will join MPTS group

CHERS Diagnostics

- Toroidal CHERS: $T_i(R)$, $V_{\text{tor}}(R)$
- Edge Doppler Spectroscopy (ERD): $T_i(R)$, $V_{\text{tor}}(R)$
- Poloidal CHERS: $V_{\text{pol}}(R)$
- Real-Time Toroidal CHERS: $V_{\text{tor}}(R)$
 - 4 channels
 - Up to 5 kHz sampling rate
 - Will be used for feedback control and will produce archived data
 - Implemented in 2011
- All systems re-installed and calibrated
- Issue for Toroidal CHERS is unwanted contribution of heating beam 2 light to signal from heating beam 1. An XMP is planned to explore ways of dealing with this.

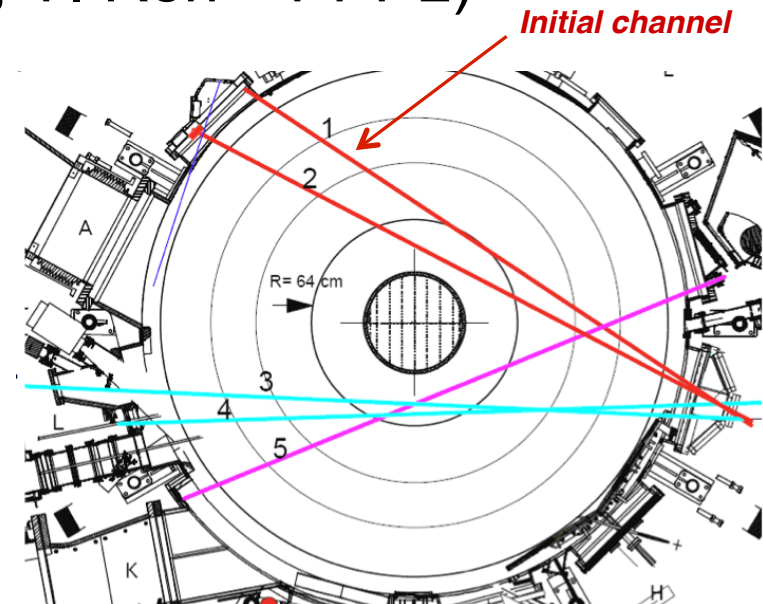
MSE

- MSE/CIF: B-field pitch, $q(R)$ with reconstruction, 18 spatial channels
- MSE/LIF: B-field pitch, $|\mathbf{B}|$, $q(R)$ with reconstruction, pressure profile, 10 spatial channels to be expanded to 32 over time
 - Implemented in 2011
- MSE/CIF & MSE/LIF: $E_r(R)$
- Both systems re-installed and spatial calibrations performed
- Y. Sechrest will join Nova Photonics MSE group

Electron Density

- FReTIP (C. Domier – UC Davis, Y. Ren – PPPL)

- System had to be moved due to loss of Bay K for diagnostics
- Will have one spatial channel with $R_{TAN}=0.64$ m for 2015 run with additional channels in the future
- 4 MHz sampling rate
- 5 kHz for real-time control



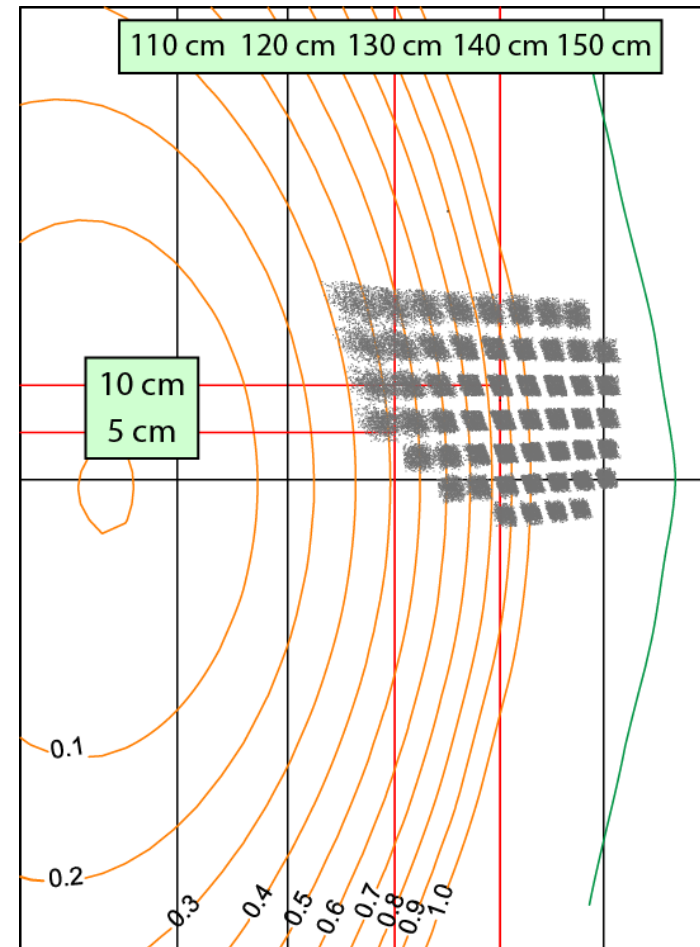
- Quadrature Reflectometer

- Measures density fluctuations
- 30-75 GHz, 16 channels
- $n_e l \sim 1.1-7 \times 10^{13} \text{ cm}^{-2}$
- 2.5 MHz bandwidth

(S. Kubota – UCLA)

Beam Emission Spectroscopy

- New 2-D fiber holder will provide better radial and poloidal coverage of $r/a \sim 0.4$ -SOL region
 - Fibers will be installed in new holder in February
- 48 detector channels
- D. Smith, G. McKee - UW



Impurities

- New tangential bolometer (L. Delgado-Aparicio)
 - 40 radial channels, 2-3 cm resolution
- New ME-SXR arrays (K. Tritz, J. M. Burgos - JHU)
 - Edge: $r/a \sim 0.6-1.1$, 1 cm resolution
 - Core $r/a \sim 0-1.1$, 3 cm resolution
- New EUV spectroscopy capability will cover 0.5-40 nm region with high spectral resolution (P. Beiersdorfer - LLNL)
 - XEUS (0.5-6-xx nm)
 - MonaLisa (6-22 nm)
 - LoWEUS (22-40 nm)
- Divertor SPRED spectrometer (V. Soukhanovskii - LLNL)
- Many other spectroscopic and filtered camera diagnostics listed in diagnostic tables

Neutron Detectors

- 4 fission chambers
 - 1 ms time resolution
 - 20% absolute accuracy
- 4 scintillator detectors
 - 4 μ s time resolution
- Fission chambers absolutely calibrated in November using new ^{252}Cf source
- Important role for fission chambers is to document total neutron fluence per year
 - Needed to ensure that PPPL remains classified as “below a Category 3 nuclear facility”
- D. Darrow is now responsible for neutron diagnostics

Fast Ion Diagnostics

- Solid State Neutral Particle Analyzers (D. Liu, G. Z Hao, W. Heidbrink – UC Irvine)
 - Bay I: active tangential view
 - Bay L: active radial view
 - Bay B: passive (background) view
 - 3 energy bands: >25 keV, >45 keV, >65 keV,
 - 10 ms time resolution in current mode
- sFLIP, Faraday Cups, s-FIDA, and t-FIDA reinstalled
- Measurement of fusion source profile via diode array will be implemented later in the run (W. Boeglin – FIU)
 - 6-8 channels initially
 - Will be expanded later

Future Diagnostics

- Pulse Burst Laser System for MPTS
- High-k Scattering
 - New implementation will provide improved k-theta measurement
- Additional FReTIP channel(s)
- Expanded bolometry
 - Poloidal arrays
 - Divertor bolometry
- Imaging X-Ray PHA
- Imaging X-Ray Crystal Spectrometer
- High-throughput Accurate wavelength Lens-based (HAL) Spectrometer (R. Bell)
- Others...

Conclusion

- Goal is to have diagnostics ready for start of physics program in June 2015
- The best information on the current status of a diagnostic and its capabilities is provided by the diagnostic contact(s)