U.S. DEPARTMENT OF ENERGY | Office of Science

NSTX-U

JHU Diagnostic Research

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NSTX-U Diagnostic Research Plans
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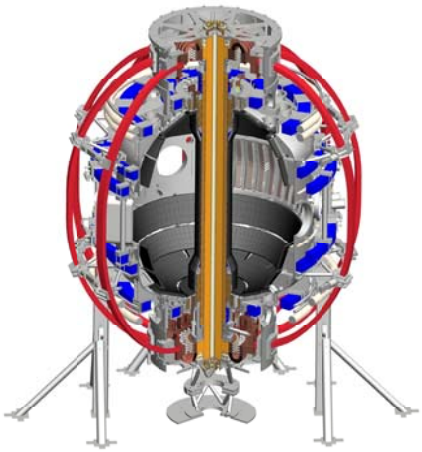
JOHNS HOPKINS UNIVERSITY

PPPL



JHU research uses X-ray diagnostic expertise to address broad physics issues

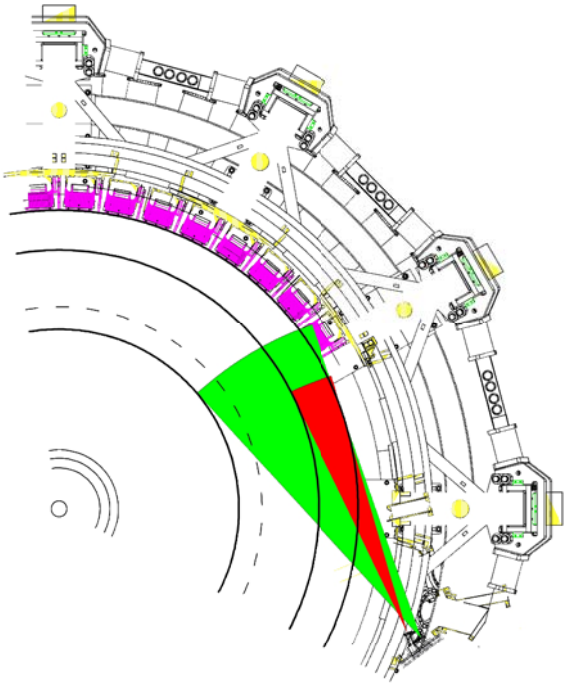
- Macroscopic Stability topics enabled by high-speed internal X-ray measurements
  - measurements of Resistive Wall Mode (RWM) internal structure
  - plasma response to external 3D fields
  - localization of rotating tearing modes, magnetic islands
  - dynamics of plasma disruption, thermal quench

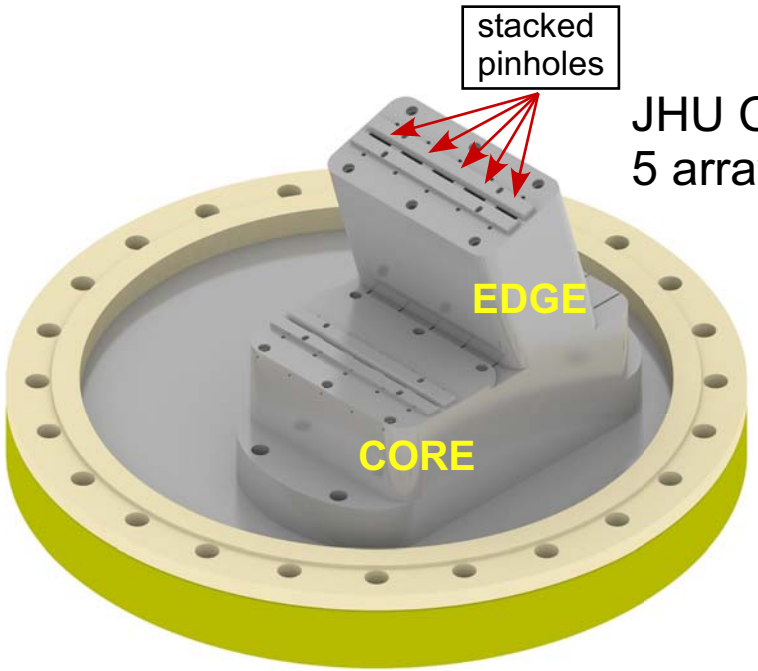
- Multi-scale Transport Physics topics enhanced using new X-ray diagnostics, fast T_e profile analysis
  - fast T_e profile diagnostic for thermal transport measurements
  - investigation of CAE/GAE effects on electron thermal transport
  - X-ray/VUV measurements of edge/core impurity transport

- Boundary Physics topics expanded with high-resolution edge measurement capabilities
  - effects of 3D fields, ELMs, Li pellets on pedestal T_e, n_e profiles
  - edge/SOL T_e, n_e profiles using advanced He line ratio analysis

JHU contributes to NSTX-U research with new diagnostic suite

- Multi-Energy Soft X-ray (MESXR) diagnostic enables 10kHz, high-resolution T_e profile measurements
  - tangentially-viewing, vertically stacked filtered diode arrays
  - complimentary core and high-resolution edge MESXR systems
  - unfiltered AXUV arrays used for diode-based bolometric P_{rad}
  - compact JHU-designed electronics selected for PPPL diode-based bolometer, UC-Irvine SSNPA



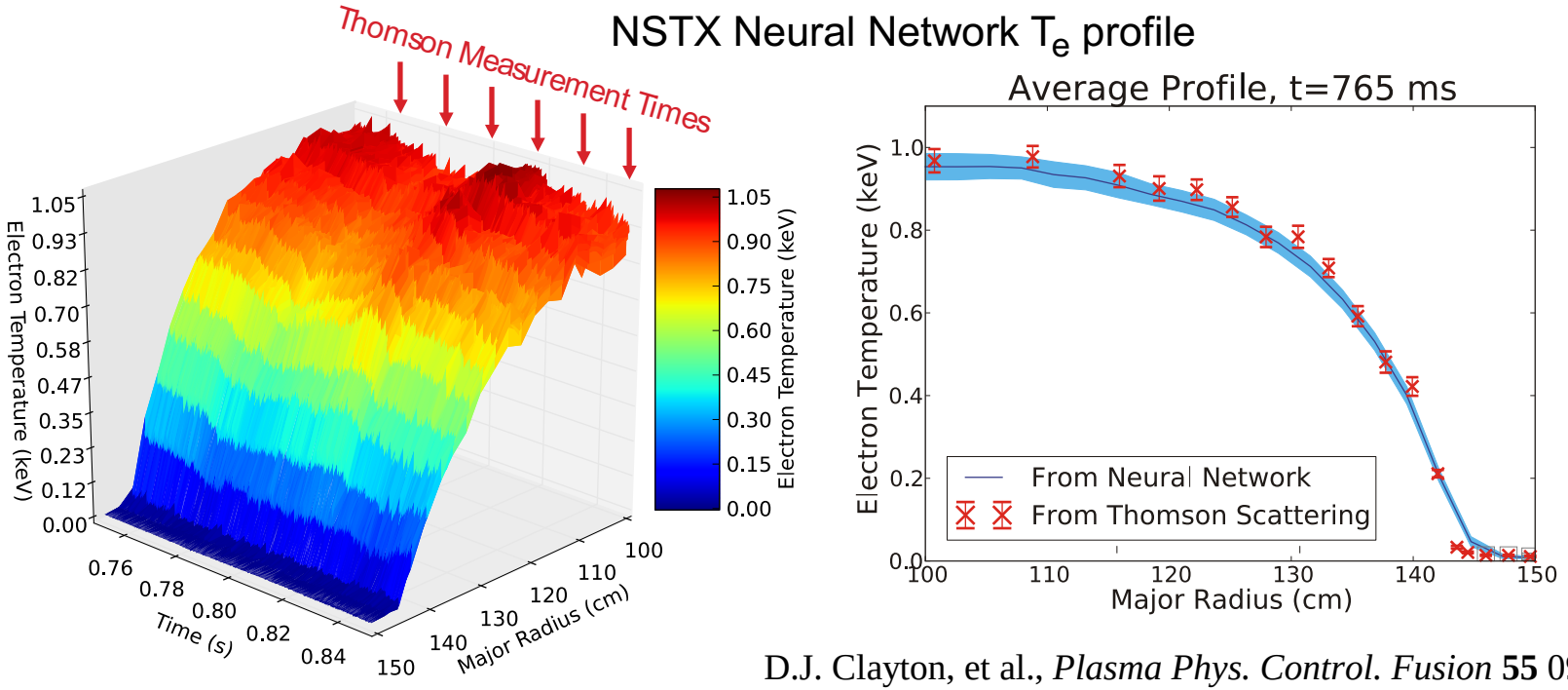


JHU Core/Edge MESXR
5 arrays, 100 channels each

K. Tritz, et al., *Rev. Sci. Instrum.* 83, 10E109 (2012)

Neural Network (NN) analysis uses MESXR measurements to provide fast T_e

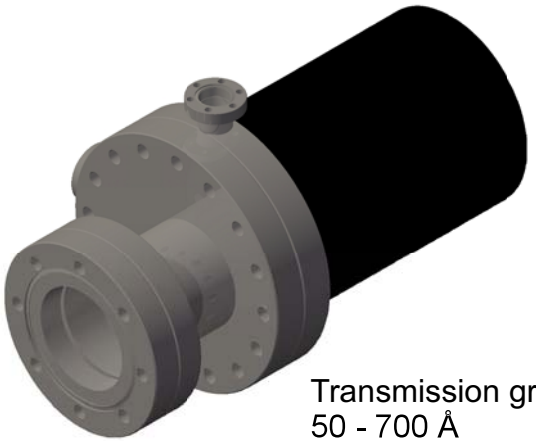
- Machine Learning discerns complex relationship between filtered X-ray measurements and T_e profile
  - NN trained using Thomson Scattering reference profiles
  - additional impurity information added from JHU TGIS
  - trained network can reconstruct 10kHz T_e profiles from MESXR
  - pseudo Monte-Carlo NN technique improves reconstruction
  - Goal: between shot fast T_e profiles for NSTX-U



D.J. Clayton, et al., *Plasma Phys. Control. Fusion* **55** 095015 (2013)

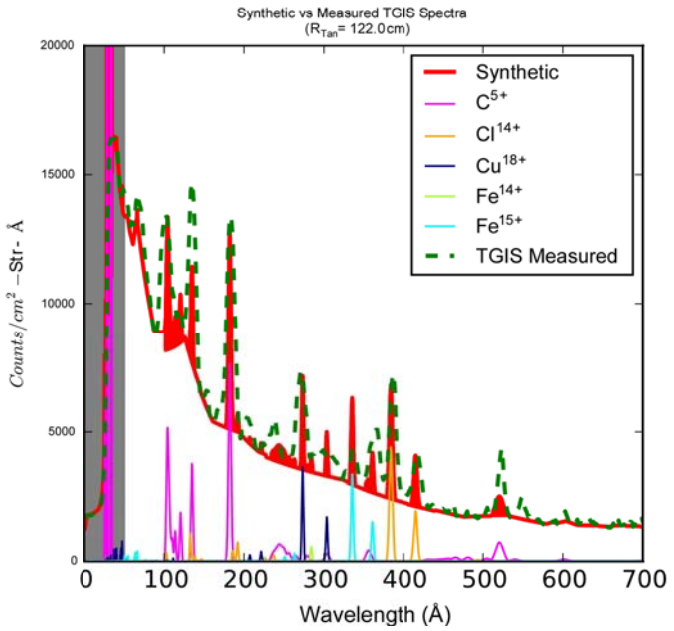
Transmission Grating Imaging Spectrometer measures VUV/XUV impurity emission

- TGIS upgrade uses high sensitivity direct detection XUV CCD
  - midplane spatially & spectrally resolved impurity measurements
  - intrinsic med. to high-Z line emission, low-Z charge exchange
  - useful monitor for core impurity accumulation, transport
- Advanced atomic collisional radiative physics modeling code developed for TGIS analysis
  - in-situ calibration using CHERS carbon impurity measurement
  - provides quantitative measurements of impurity concentration
  - Z_{eff} from Bremsstrahlung spectrum



Princeton Instruments
PIXIS 400B XUV camera

Transmission grating housing
50 - 700 Å



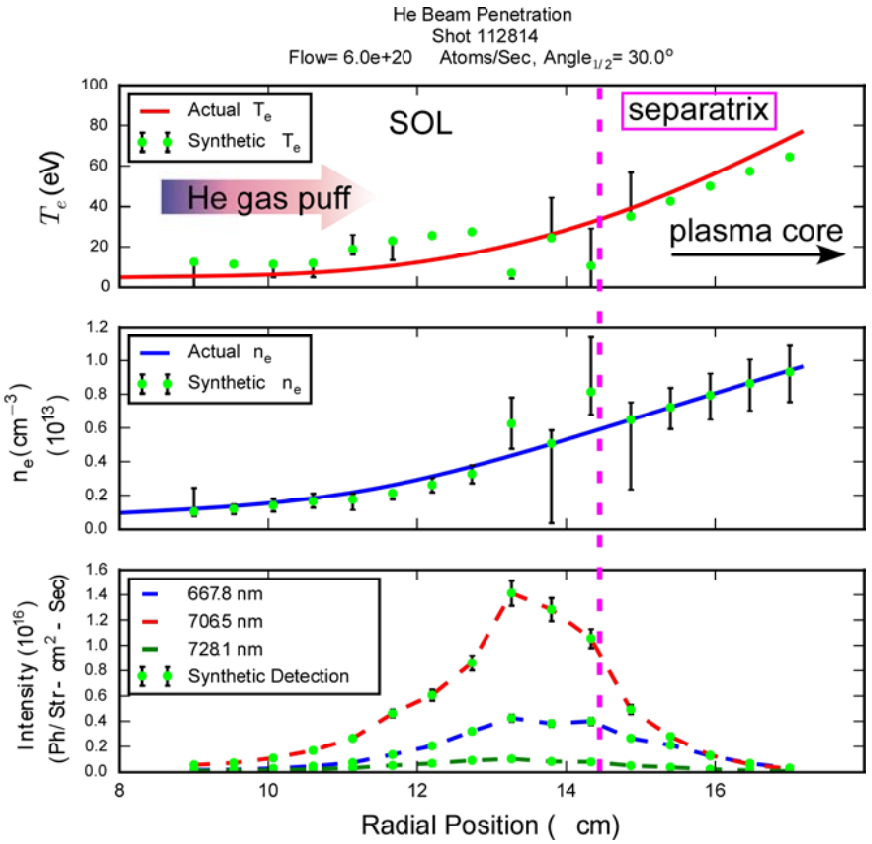
J.M. Muñoz Burgos, *Phys. Plasmas* **22**, 123301 (2015)

Advanced time-dependent atomic modeling code for He line ratio T_e, n_e profiles

- He line ratio measurements provide T_e, n_e profiles from SOL to plasma pedestal region
  - measures T_e < 100eV, compliments MESXR T_e > 100eV
  - analysis technique validated on TEXTOR, ready for NSTX-U mid-plane or divertor diagnostic

JHU provides analysis support for PPPL/collaborator hardware (FTU, ORNL, ...)

Synthetic modeling of He gas puff, line ratio measurements, and T_e, n_e profiles



J.M. Muñoz Burgos, *accepted Phys. Plasmas* (2016)

JHU FY16 research priorities

- Lead impurity and thermal transport XPs
  - XP 1551 “Core Impurity Transport Measurements at Fixed q-Profile”
  - XP 1574 “Correlation of *AE bursts with fast core Te profiles”

- Provide crucial measurements for collaborator XPs
  - XP 1550 “Impurity transport vs torque in NBI heated H-Modes”
  - XP 1574 “Correlation of *AE bursts with fast core Te profiles”
  - XP 1554 “Make contact with NSTX for n=1 tearing mode stability”
  - XP 1547 “Stabilization of radiated-induced tearing modes (RiTMs) using off-axis-heating”
  - XP 1548 “3D plasma response data for MHD and transport code validations”

JHU near term diagnostic plans

- Optimize TGIS FOV for charge exchange measurements
  - move diagnostic to Bay K midplane view if available
  - expand FOV for complete edge to core coverage

- Test diagnostic utility of TGIS divertor view
  - previous synthetic study indicated divertor transport and spectroscopic T_e measurements with seeded impurity

- Develop radiation hardened TGIS detector
  - increased P_{NBI} and pulse length boosts neutron flux ~x10
  - will test replacement of CCD detector with optically coupled image intensifier

- Support incoming LLNL laser blow-off system with MESXR
  - wide range of impurity injection capability coupled with high time/spatial resolution measurements will provide fantastic opportunities for low to high-Z impurity transport studies