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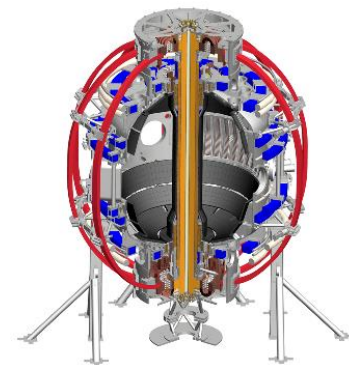
# ORNL Boundary Physics Program: Diagnostics Plans for FY16-18

M.L. Reinke, T. Gray, J.W. Ahn  
and the ORNL NSTX-U Team

NSTX-U Collaborator Diagnostics Meeting  
NSTX-U Control Room Annex  
5/17/2016

 **OAK RIDGE**  
National Laboratory

 **PPPL**



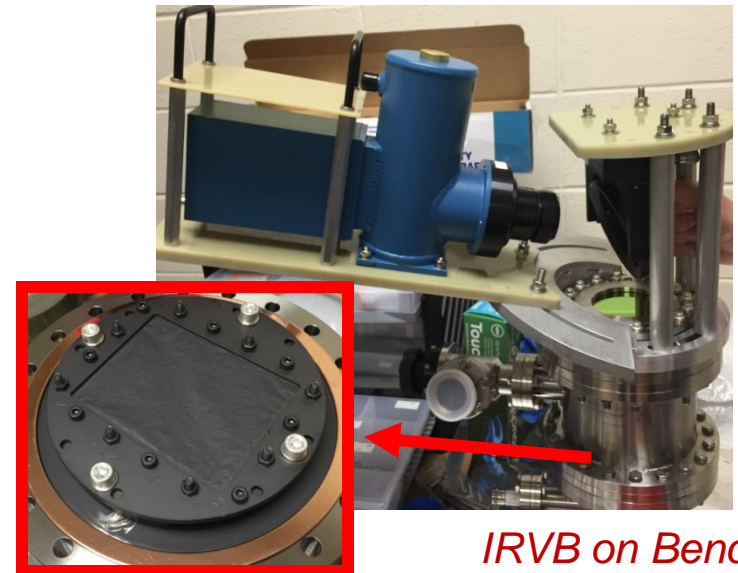
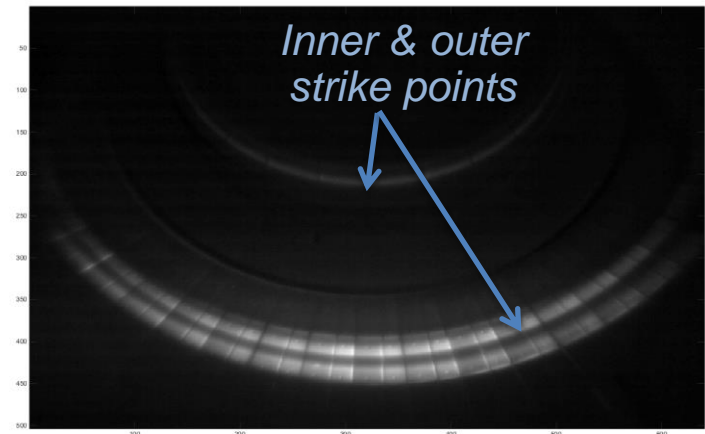
# ORNL Boundary Research: Team + Goals

- ORNL maintains two independent but coordinated research teams on NSTX-U (coordinates w/ UT-K)
  - Boundary Physics Program (J. Canik – today)
  - Heating and Current Drive Program (J. Caughman – 5/26)
- three main thrusts of boundary physics research
  - (1) power and particle exhaust, (2) H-mode pedestal physics (3) effects of 3D fields on the edge plasma
  - some evolution of this expected as LAB 09-29 expires and new scheme developed (use RoD with NSTX-U group)
- boundary research program is supported by:
  - on-site staff (Reinke, Gray, Ahn) for diag. develop. & support
  - multiple off-site staff for modeling, physics support

# Present FY16 Diagnostics & Status

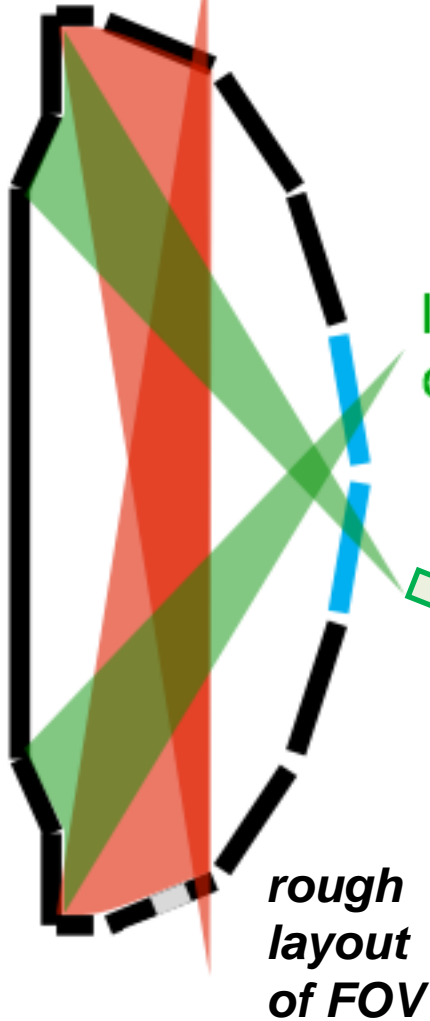
- wide-angle IR camera (Bay H-Up)
  - 30 Hz, 180°  $\Delta\phi$  coverage
  - first data taken (right), working on ensuring data stability
- fast-IR cameras (Bay H-Upper) and Bay-G Lower)
  - 1.6 kHz, narrow FOV for outer target
  - lower div. (Bay-H) installed, first data taken, debugging alignment and noise
  - upper div. (Bay-G) needs mechanical work for periscope
- prototype imaging bolometer for div. radiated power (Bay J-Upper)
  - mech. installed, first data June+
  - shares IR camera with upper-div.

*Image from wide angle IR camera during an NSTX-U discharge*



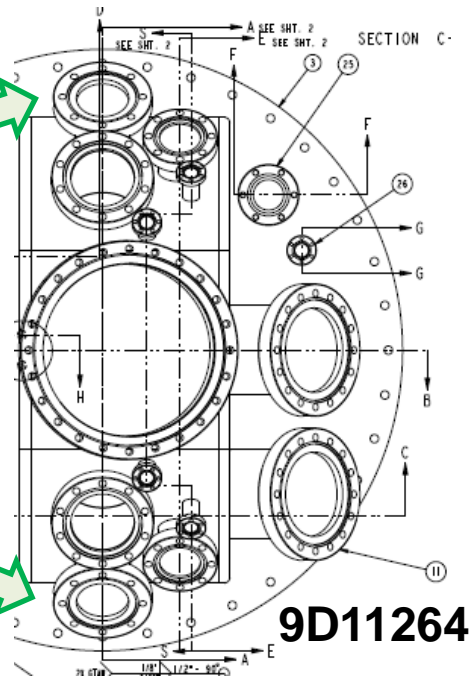
# FY17+ Expansions to IR Imaging

IR Cameras



Inner SP cameras

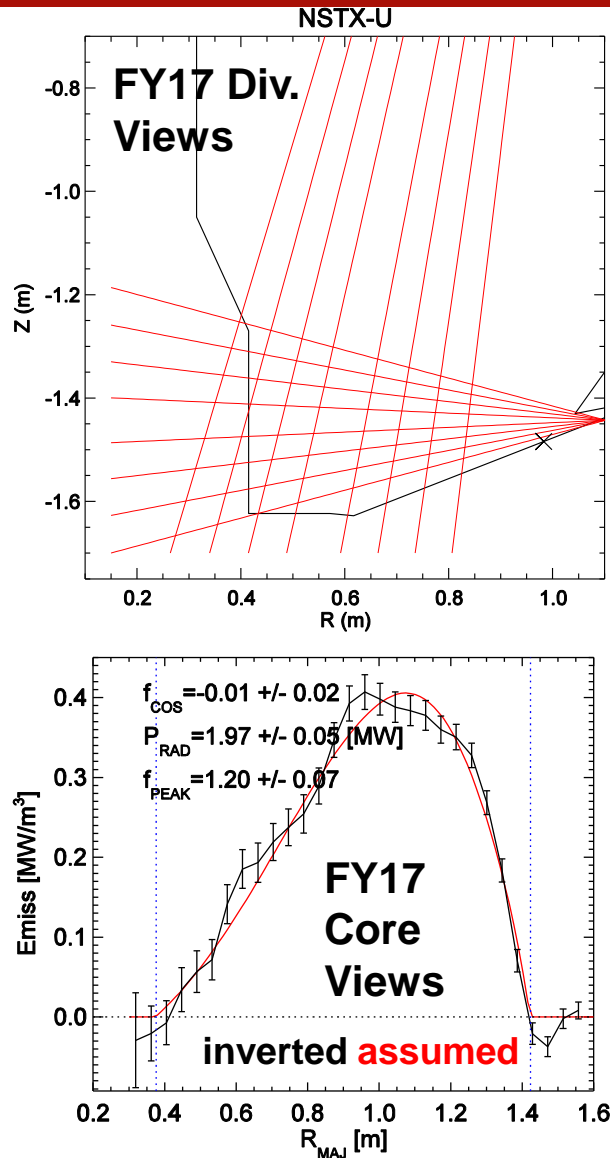
- expanding coverage to include inner divertor (upper + lower) (Bay I-Mid)



- pre-CDR, need PPPL mech. & design support
  - coordinating w/ UT-K
- examining choices for IR cameras
  - speed, spatial coverage are to be determined
  - physics goals vs. cost

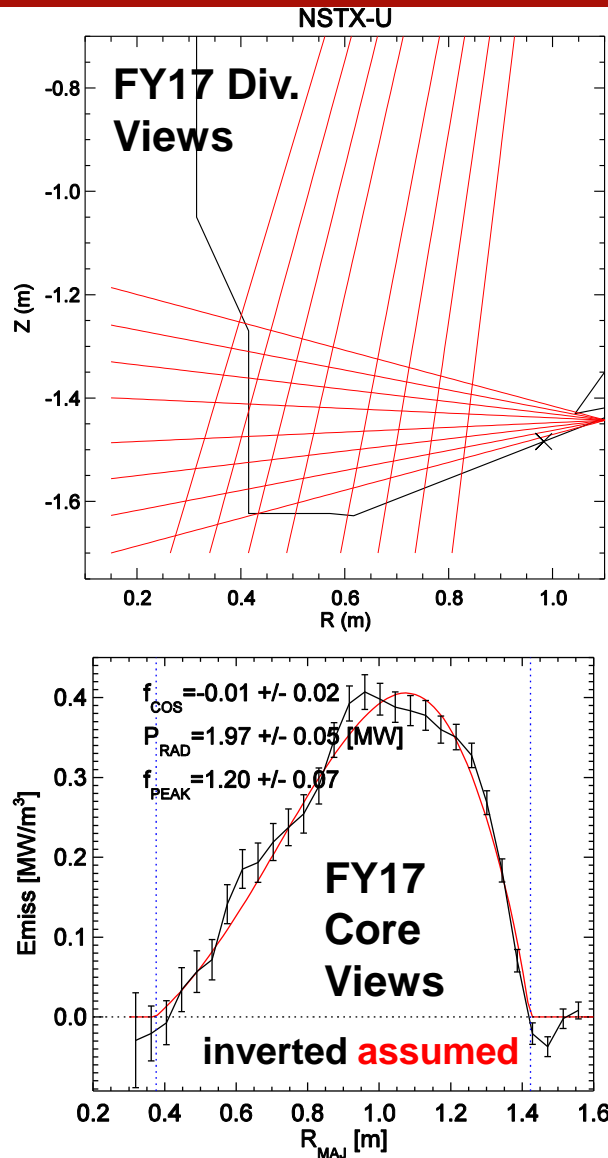
- investigate multi-color, spectral IR techniques to avoid impact of coatings

# FY17+ Resistive Bolometry



- installing upgraded versions of the lower divertor viewing resistive bolometers
  - Bay J-Upper, Bay I-Lower (8 ch. each)
  - NSTX-U views, new thermal management
- new tangentially-viewing midplane resistive bolometer array
  - Bay G-Midplane (24 ch), full midplane array
- utilize new D-tAcq elec. ( $P_{\text{RAD}} < 100$  Hz)
  - real-time output possible, but not anticipated until late FY17 or beyond
- will need to expand coverage in FY18+ to ensure full plasma coverage
- *no present plans for tools necessary to study disruption mitigation radiation*

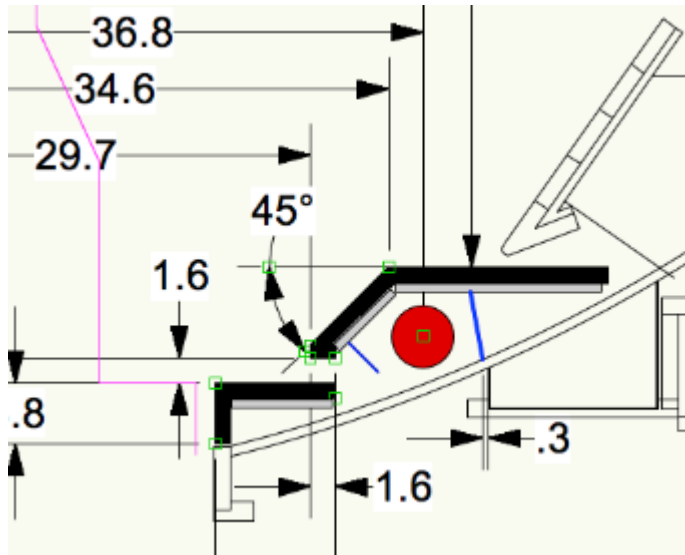
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*radiated power measurements couple with IR thermography to enable power balance studies*

# Anticipated Impact of Cryopump Upgrade



- increased divertor closure means greater diagnostic challenges
  - lose Bay-I Lower bolometers,
  - may impact lower divertor IR views
- need to identify impacts and discuss port space reallocation

## ***new geometry may require diagnostic R&D to find solutions***

- tangentially viewing imaging bolometer for lower divertor  $P_{\text{RAD}}$ 
  - use FY16 Bay-J IRVB prototype results and further bench-top testing
- tangentially viewing IR imaging for outer strike-point/duct
- new (in-vessel) fiber-optic based techniques for  $P_{\text{RAD}}$ ,  $\Delta T_{\text{tile}}$ 
  - ORNL LDRD support for fiber-optic bolometer development

# Expanded ORNL Involvement in High-Z PFCs

- looking to engage the wider ORNL materials group as NSTX-U ramps up the high-Z mission
- examining near-term options for FY17 initiatives
  - small material inserts into diagnostic tiles?
  - post campaign analysis of tungsten re-distribution?
- discussing range of longer-term options
  - engineering and materials development platforms linking p-MPEX
    - low heat flux areas (passive plates), supporting any MAPP upgrade?
  - deploying large area isotopic high-Z & collectors (links to DIII-D)
  - design/operation of a high-Z PFC damage avoidance systems
    - real-time monitoring of surfaces, shot-to-shot guidance (JET/AUG/WEST)
- these initiatives will require expanding resources beyond ORNL personnel presently involved



# What to Do About AXUV Diode $P_{\text{RAD}}$ ?

- multiple groups supporting ' $P_{\text{RAD}}$ ' via AXUV diodes arrays
  - LLNL via “LADA” in the lower divertor
  - JHU & PPPL via ME-SXR and AXUV on the midplane
- FY17 port requests/map shows desire to increase this
  - MIT interested in bringing system to study MGI radiation asym.
  - PPPL interested in expanding to multiple poloidal views
- AXUV diodes complement resistive bolometers, but requires close coordination of diagnosticians (Reinke: C-Mod, Bernert: AUG)
- to guide FY17 and beyond deployment need to develop:
  - operations and physics missions for AXUV diodes
  - roles and responsibilities for physics results vs. diag. hardware
    - EX: JHU has unfiltered AXUV diodes for ME-SXR mission, but  $P_{\text{RAD}}$  is not the main focus

# Summary/Discussion

- ORNL boundary physics research on NSTX-U supports experimental and computational work on power and particle exhaust, H-mode pedestal physics and effects of 3D fields on the edge plasma
- NSTX-U diagnostic support utilizes two main techniques:
  - heat flux to plasma facing components using IR thermography
  - radiated power loss from plasmas using resistive and infrared bolometers
- FY16 diagnostic goals: bring the lower divertor fast-IR and slow, wide-angle IR on-line, test prototype divertor IR imaging bolometer and demonstrate upper divertor fast-IR
- FY17 diagnostic goals: expand coverage of fast/slow IR imaging and deploy core/divertor resistive bolometers
- ORNL interested in expanding diagnostic set to establish power balance and extend program to support NSTX-U high-Z mission