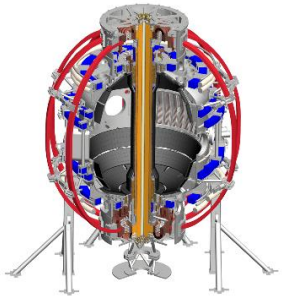
NSTX-U is sponsored by the
U.S. Department of Energy Office of Science
Fusion Energy Sciences

PFCR-WG Update

M.L. Reinke

PFCR-WG Meeting
B-252
5/21/2018

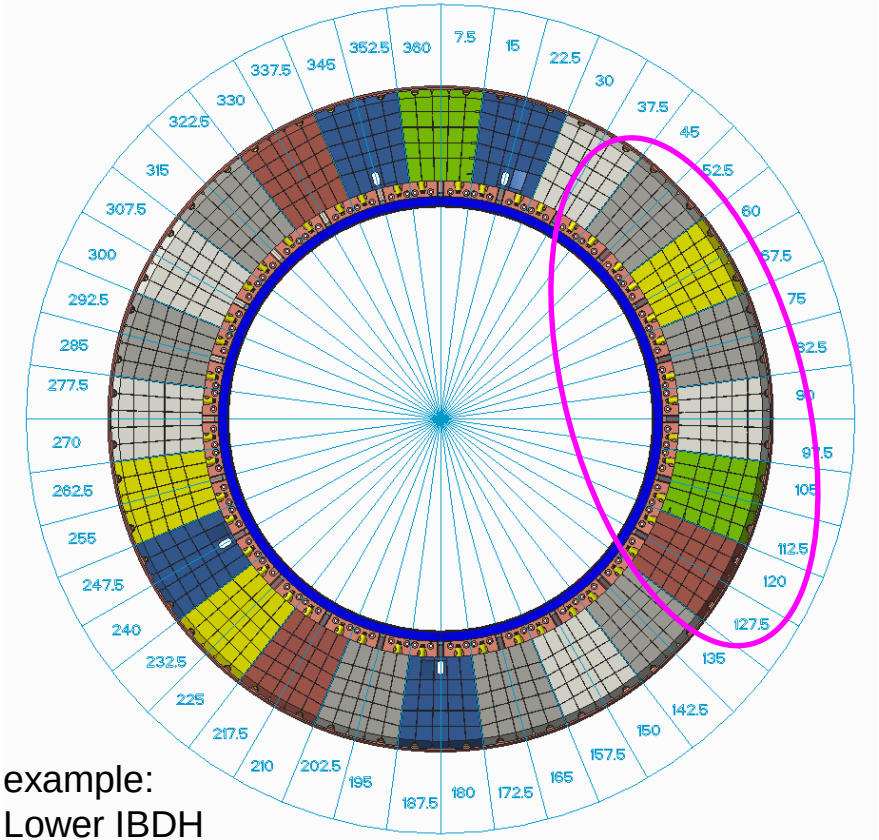


Goals of the Meeting

- update on the status of the PFC Engineering activities
- recent MEMO's
- discuss status of R18-1 Milestone Work
  - T. Looby (UT-K): Heat Flux Model Validation Using Embedded Thermocouples
  - D. Boyer (PPPL): Scoping PCS Heat Flux Control
  - A. Wingen (ORNL): Tool for Calculate Heat Flux to 3D PFCs
  - (wrap up with some discussion on priorities and future work)

http://nstx-u.pppl.gov/program/working-groups/pfc-requirements-working-group

Layout of IBDH and IBDV w/ Diagnostic Tiles



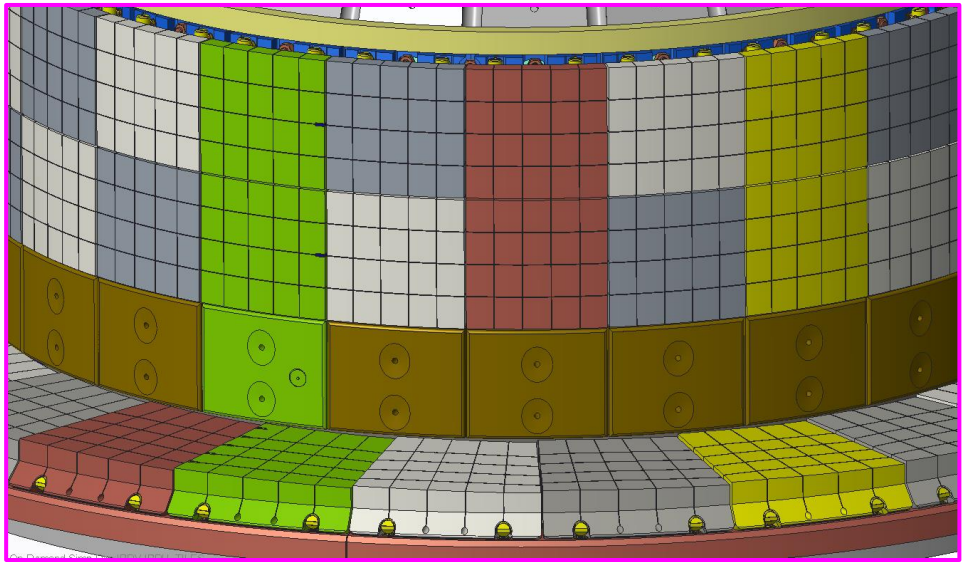
example:
Lower IBDH

Thermocouple

Mirnov

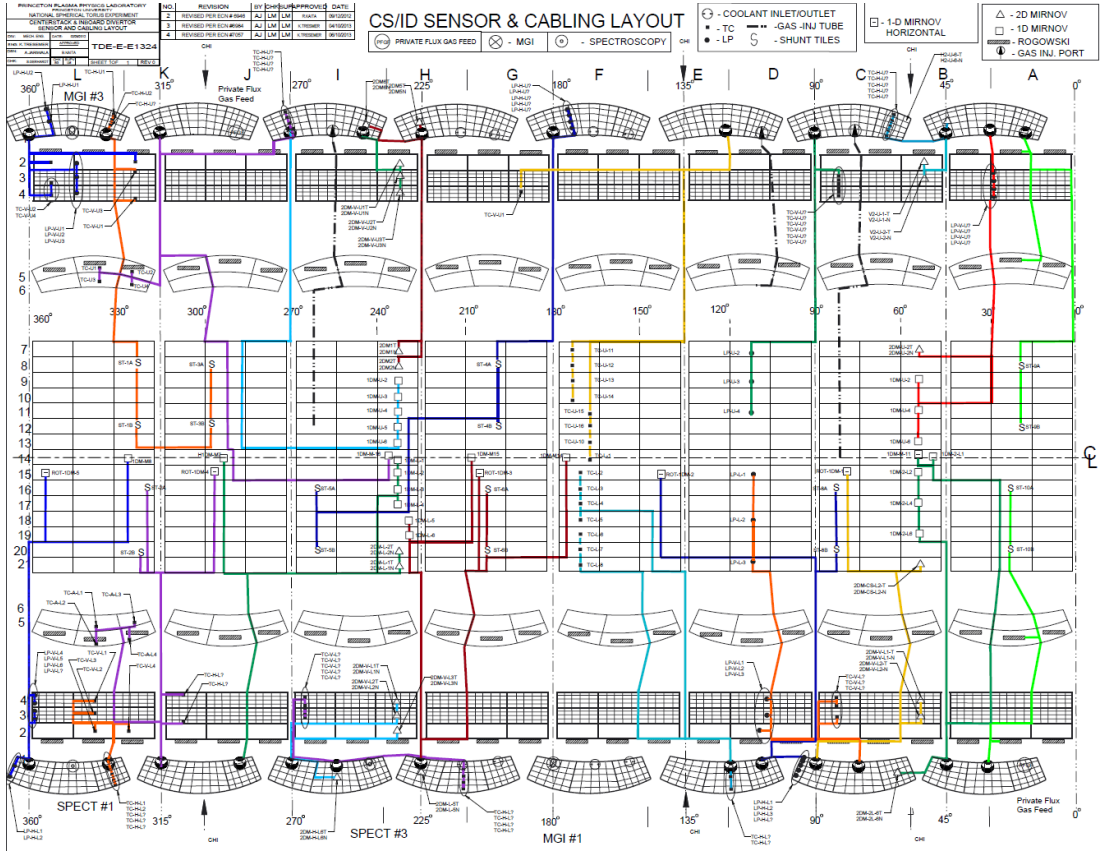
Langmuir

Line of Site



See full presentation by M. Messineo & A. Khodak

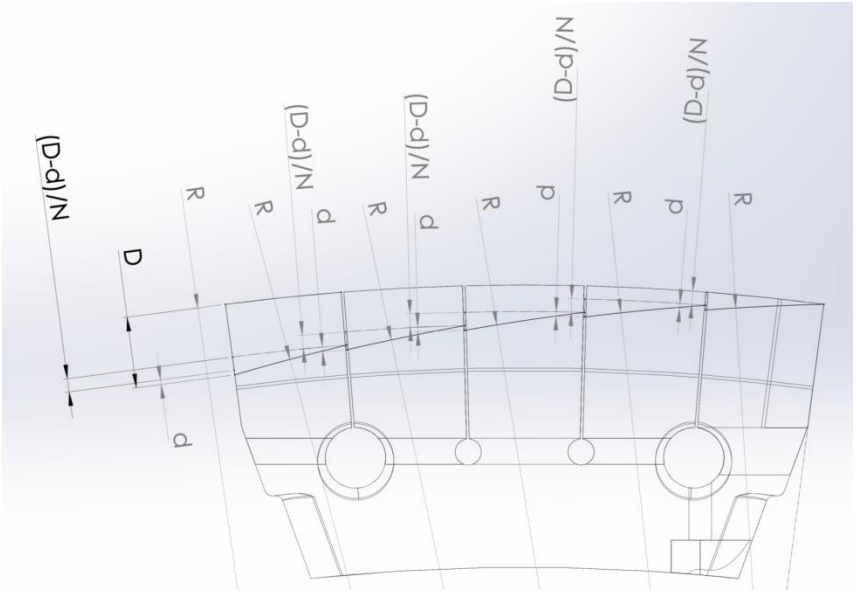
Update CS/ID Sensor and Cable Layout Generated



- Link to PDF (WIP version) from T. Edgemon
  - take a closer look if interested
- generated (and checked) to meet new PFC Diagnostic and Fueling Requirements (NSTX-U-RQMT-RD-004)
- wire-ways being engineered into IBDV PFCs and support structures
- iterating to make sure that all sensors can be brought down and out the organ pipes

Other Areas of Activity

- PFC team is continuing to finalize other designs: CSFW, CSAS, ODB
  - I'm trying to get a full poloidal integrated layout for WG to examine for 'known unknowns'
- ORNL engineering staff is helping by running ANSYS analysis on 'tile variants' to keep schedule
- discussions of final PFC shaping strategy - 'do we fishscale per tile AND per castellation?'
  - for IBDH, D ~ 0.03" and d ~ 0.002"
  - discussions of erosion, ablation, leading edges, requirements, etc.



PFC Final Design Review a "Notable Outcome", needs to happen in FY18, and is scheduled for mid/late-August

Recent MEMO's Issued

- PFCR-MEMO-021: Initial Requirements and Guidance for Scoping Image-Based Heat Flux Control for R18-1/1-G5
  - gives background and mock requirements to allow K. Erickson to examine necessary enhancements for the control system so that image-based PFC monitoring could be implemented

R18-1 Milestone Work

- each of these presentations is work in progress
  - specific goals identified to deliver the milestone (PFCR-MEMO-014)
  - MEMO's written to try to outlines objectives for each of the three people presenting
- working on a separate but linked part of the problem of "how do we operate NSTX-U to be within some set of PFC engineering limits"
- TODAY: give feedback on work completed so far
  - examine where the work is linked and next steps to be made
  - what work (and resources) are needed in the future?

Working Idea for PFC Monitoring

- model-based control of PFC surface temperature
  - know in RT: equilibrium, P_{IN}, P_{RAD}
  - no real-time temperature information needed
  - a heat flux model ('Eich' model used to define requirements?) computes heat flux to PFCs in RT, and surface temperature is computed in RT
    - logic on what to do (e.g. sweep, terminate), how to plan will be a future task
- post-shot update and confirm of model parameters using embedded thermocouples
  - castellated tiles act as natural calorimeters, but can we get away with only knowing the ΔT?
- method has the advantage of being robust and in Recovery scope
  - can be tested numerically and in e-beam facility and is not (as) impacted by surface layers (BZN, Li) as IR thermography
  - can be complimented by information from other tools (e.g. WIDE-IR, FAST-IR)

Discussion: Focus of Remaining FY18 Work

- R18-1/2-G1: Export/Extend W_PFC to allow for comparisons to non NSTX/NSTX-U heat flux measurements
  - extend W_PFC to read from EFIT time histories
- R18-1/2-G4: Extend validated high heat flux (HHF) ANSYS simulation to allow for arbitrary surface heat flux as a function of space and time
  - Combine ORNL work on PFC engineering for FDR with approach that Looby developed, using more accurate 'Eich model'
- R18-1/2-G5: Compare detailed ANSYS model against semi-infinite solid predictions and evaluate role of temperature dependent thermal properties.
- R18-1/3-G2: Describe monitoring approach that uses optical (NIR/IR) measurements to determine if an NSTX-U discharge is approaching temperature limits

- ***Other? New Goals?***

Discussion: Focus of For New FY19 Work?

Early FY19, PFCs should be being fabricated…

- should we continue the WG activities?
  - likely still have scope on PFC monitoring, but perhaps focus on implementation, testing TC model validation w/ e-beam?
- what are people interested in working on?

Extra Slides

R18-1 Executed Within the PFCR-WG

R(18-1): Develop and Benchmark Operations-Focused Reduced Heat Flux and Thermo-Mechanical Models for use in PFC Monitoring

The NSTX-U Recovery Project will deploy new plasma facing components (PFCs) to meet updated heat exhaust requirements driven by narrower scrape-off-layer widths, increased heating power, and longer pulse durations relative to NSTX. Inter-shot monitoring or intra-shot control of heat flux to PFCs is anticipated for a range NSTX-U operating space, necessitating reduced models that can be run between shots or even in real-time. Monitoring requires a reliable instrumentation suite which can support or contradict model predictions and confirm PFC integrity. The goals of this milestone are three-fold: (1) Develop tools for pre-shot planning and confirmation of post-shot PFC thermal observations which use reduced models to predict time-evolving heat fluxes to shaped PFCs and estimate distances from engineering limits. Assess additional effort needed for implementation of reduced models in PCS. (2) Where feasible, benchmark reduced models against boundary physics (e.g. SOLPS, UEDGE) and finite element analysis (e.g. ANSYS) tools, and validate using experimental data from relevant tokamaks and results from Facility Milestone F(18-1). (3) Evaluate examples of discrete monitoring systems that are sufficient to capture the evolution of the PFCs relative to engineering limits. Compare the ability for different techniques (e.g. thermocouples vs. imaging) and technologies (e.g. near vs. long-wave infrared cameras) to achieve NSTX-U PFC monitoring objectives.

1. ~~define which (additional) parameters need to be specified in an updated requirements document for the NSTX-U PFCs~~
2. facilitate generation of updated requirements utilizing:
   a) available reduced models, empirical scalings, boundary simulations
   b) ultimately, a validated model for specifying heat loads to all plasma facing components for arbitrary NSTX-U scenarios
3. in preparation for operations, develop:
   a) instrumentation plan for intra and inter-shot PFC monitoring
   b) a reduced model for heat loading for pre-shot planning
   c) guidance on how to best integrate monitoring with operations
   d) control, diagnostic requirements for real-time heat-flux control
4. work closely with engineers and analysts to develop and implement requirements

Outer Divertor Interface