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Plans for FY18 PFCR Working Group Activities

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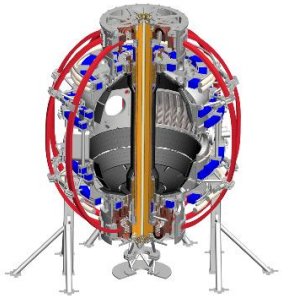
PFCR-WG Meeting
B-252
11/3/17



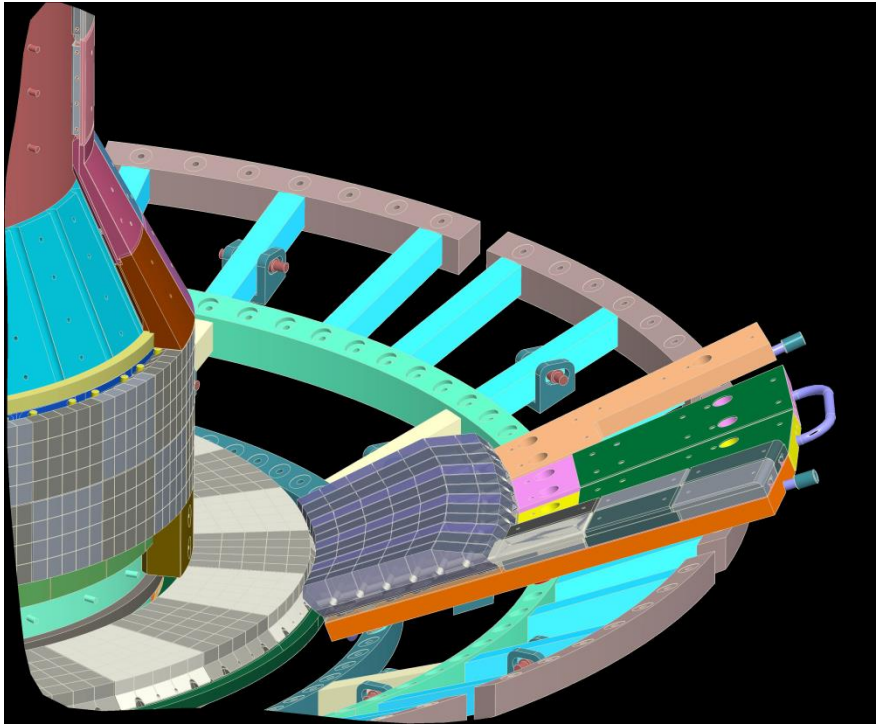
Goals of the Meeting

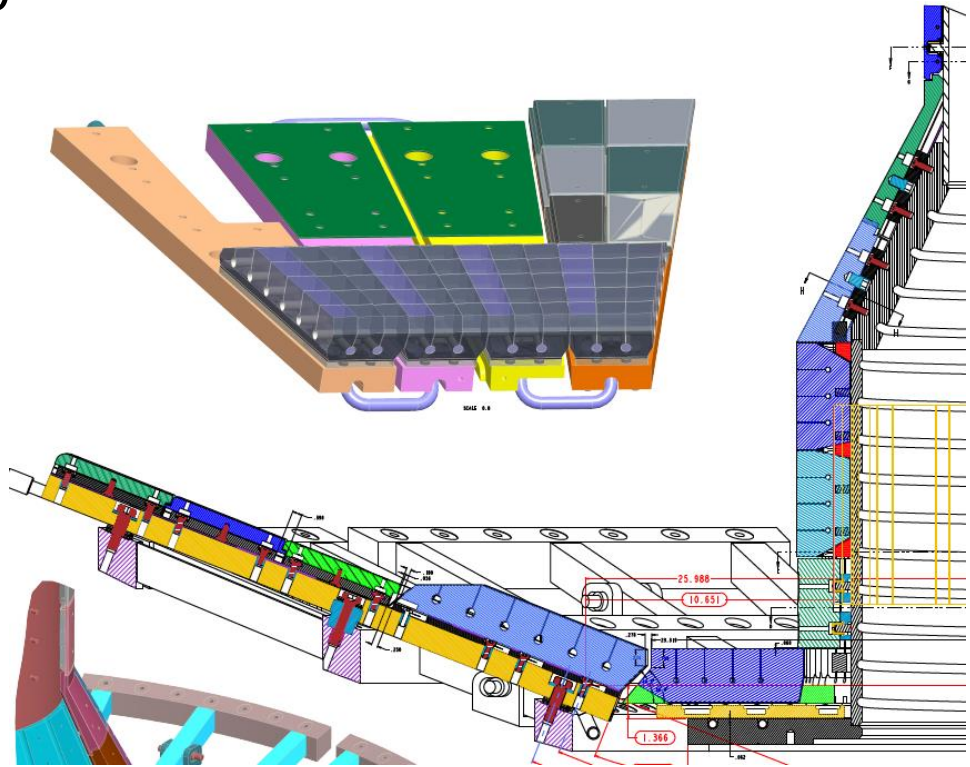
- discuss open ACTIONS & MEMOs
  - MEMOs and ACTION ITEMS
  - R(18-1) Milestone Updates
- overview of new ‘Dimensional Control’ Working Group
- overview of PFC Diagnostics & Fueling RD

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

Present, In-Progress HHF PFC Layout

preliminary design review on high heat flux PFCs on Nov 15th.





Ongoing WG Activities

- expand and continue scenario exploration started by Menard/Gerhardt for TSG input
  - presently no specific request, but ‘grumblings’ about how we may need to re-evaluate scenarios due to coil alignment tolerances
- need some specific work to motivate integrating new people into the heat flux modeling workflow
  - present: at 2 MA, 1 T, 10 MW we have static, large poloidal flux expansion examples and large strike point sweeping (artificially created)
  - goal: find a way to generate a continuum of solutions to allow for the physics impact to be determined quickly if/when requirements are forced to drop
  - need someone [?] to take lead on equilibrium generation and Reinke can work with them on integrating into present/future heat flux estimates

R18-1.1a Develop Reduced Models for Heat Flux

- STEP 1: non-axisymmetric PFCs, axisymmetric plasma
- STEP 2: non-axisymmetric PFCs, non-axisymmetric plasma
  - being investigated as part of the Dimensional Requirements activities since this influences the coil alignment tolerance
- PFCFlux (CEA): requires a collaboration w/ CEA
  - (Reinke) working w/ engineering to deliver a STEP file
- SMARDDA (CCFE): available now for any MAST collaborators
  - (stalled) have information on access/use from Freia cluster at CCFE
- DIV3D (ORNL): available now, but needs dusting off
  - (Ahn) discussing w/ Lore about using this
- EMC3 (various): have talent within our group (?)
- custom (?): advantage to developing something locally?

R18-1.1b Develop Reduced Models for Stress

- progression of complexity expected for PFC limits
  - STEP 0: simple semi-infinite model w/ $T < T_{crit}$?, $\sigma < E\alpha\Delta T$
  - STEP 1: finite-element (ANSYS) of castellation to $q_{||}(\mathbf{r},t)$ (FY18)
  - STEP 2: interpolation of full ANSYS simulations (TBD)
- work on this will be later in the FY, post-FDR, but we'll need to make sure we have the tools ready once designs are in place
  - engineering analysis will deliver final models and simulation methodology, but we'll have to spend the time adjusting inputs and analyzing outputs
  - some initial scoping of this [Reinke] as part of Mardenfeld/Allen TC placement optimization.

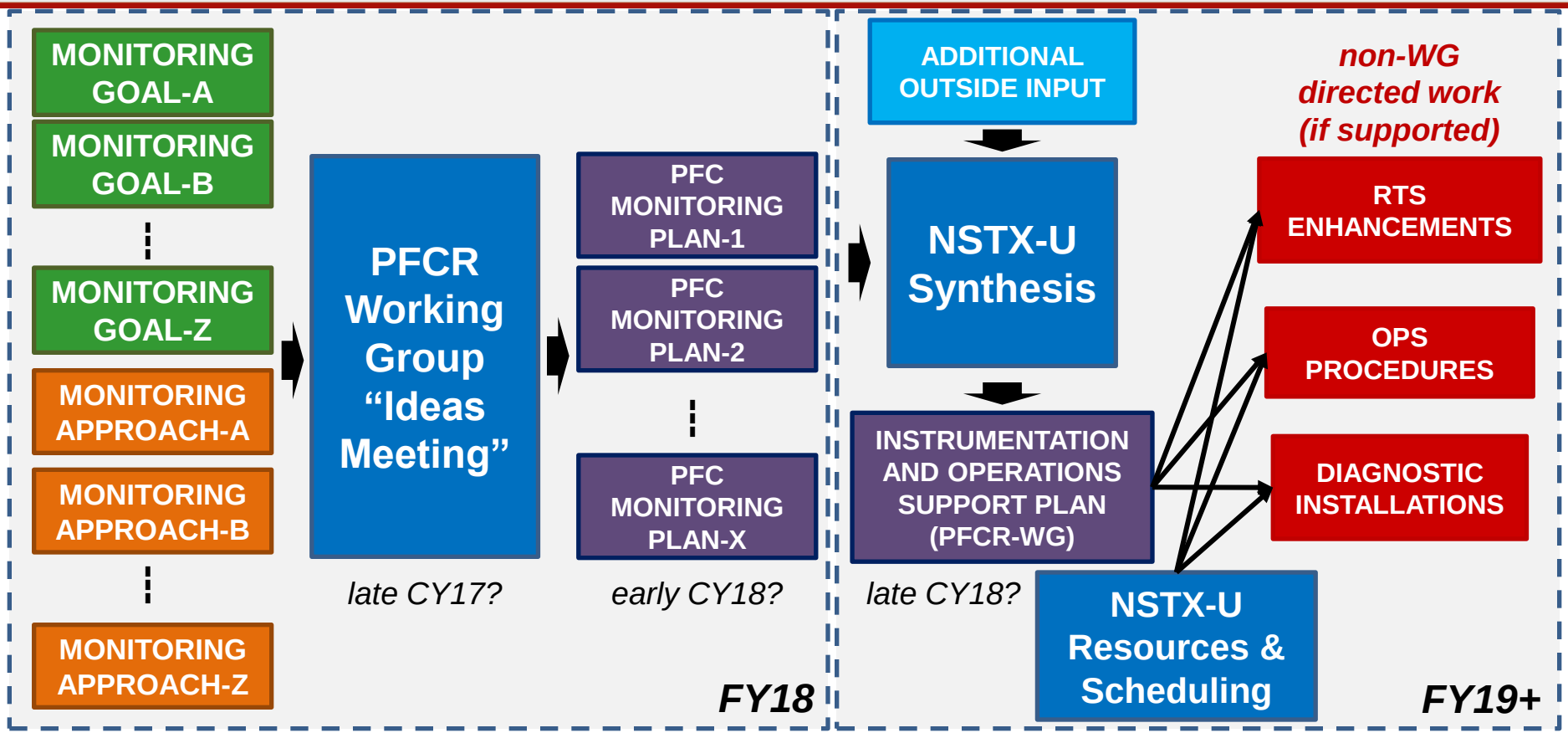
R18-1.2 Benchmark Reduced Models

- benchmark physics heat flux models
  - updates/opportunities from group?
  - have a pre-print on divertor sharing vs. dr_{sep} from C-Mod [Brunner] to work through
- benchmark engineering models (overlap w/ F18-1)
  - establishing our high heat flux testing capability facility at Applied Research Labs at Penn State
    - ORNL and PPPL subcontract(s) established for utilizing/enhancing e-beam
  - Gray and Jaworski there 11/1-11/7 to do materials characterization

R18-1.3 Evaluate examples of PFC Monitoring

- deliver the concept and design information to project to be able to quickly make future decisions
  - improve cost estimates ($, port space, time) based on vetted techniques
  - reasonable expectation of monitoring capabilities as PFC designs mature and limitations are better understood (or budget tradeoffs made)
- R(18-1) follows conventional technology
  - thermocouples, surface imaging (MWIR vs. NIR), bolometry
  - how do we combine proven discrete sensors & deliver monitoring goals?
- additional work under F(18-1) to consider new alternatives or techniques which haven't been previously shown to work
  - strain sensing to avoid inferring from temperature, new temp. sensors
  - surface monitoring in a Li coated environment (Magnum?)

Draft Flowchart to Develop PFC Monitoring



Develop ‘Teams’ On This Activity

- thermocouples + bolometry with ~PlasmaTV [Reinke]
  - model-based control w/ shot-to-shot checking of model predictions and visible tile integrity confirmation

Suggestions

- full coverage with NIR cameras running real-time [?]
  - watch and interlock for hot-spots on full (or sub) machine
- limited MW/LW IR thermography, etc [?]

define what ‘PFC monitoring’ means and how a given technology works to keep plasma within requirements

Extra Slides

R(18-1) Goals Map to PFCR-WG Charges

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