OAK RIDGE National Laboratory

ORNL's NSTX-U Research Plan (2021-2025): Evaluation of Core/Edge Integration on NSTX-U Through Scenario Development & PFC Analysis

With contributions from:

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Overview & Motivation: Research effort built off historic ORNL/NSTX(-U) collaboration & major research directions at ORNL

- On route to an FPP, NSTX-U's flexibility allows progress in scientific understanding of low-A core & pedestal physics coupled with acceptable power exhaust solutions & taming plasma material interactions
- Our work-scope continues to focus on boundary science & begins to address needs for future FPP options through core/edge integration & PFC development
- Leading to the following task breakdown:

		Integrated FTEs	
Research Task #	Description of Research Tasks	Staff	PD/PhD
RT/1	Investigate the impact of high core radiation fractions on the H-mode pedestal with respect to divertor heat flux mitigation	0.9	0/0
RT/2	Develop and validate HEAT to help assess performance of new PFCs and inform strategies to operate NSTX-U at high power	~1	2.50/2.00
		Total: ~6.5	

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- Our work-scope continues to focus on boundary science & begins to address needs for future FPP options through core/edge integration & PFC development
- Leading to the following task breakdown & integration with NSTX-U Research Program:

Research Task #	Description of Research Tasks	**NSTX-U Research Objectives/Tasks**
RT/1	Investigate the impact of high core radiation fractions on the H-mode pedestal with respect to divertor heat flux mitigation	**3.2; 2.1**
RT/2	Develop and validate HEAT to help assess performance of new PFCs and inform strategies to operate NSTX-U at high power	**3.1**

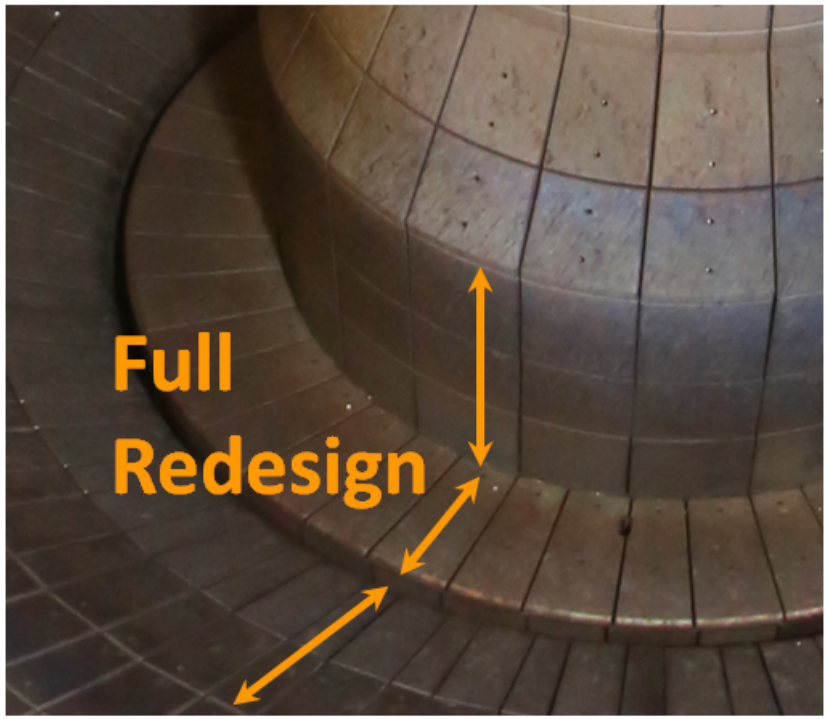
RT/1 (Impact of high core radiation fractions on pedestal coupled with heat flux mitigation) Outputs

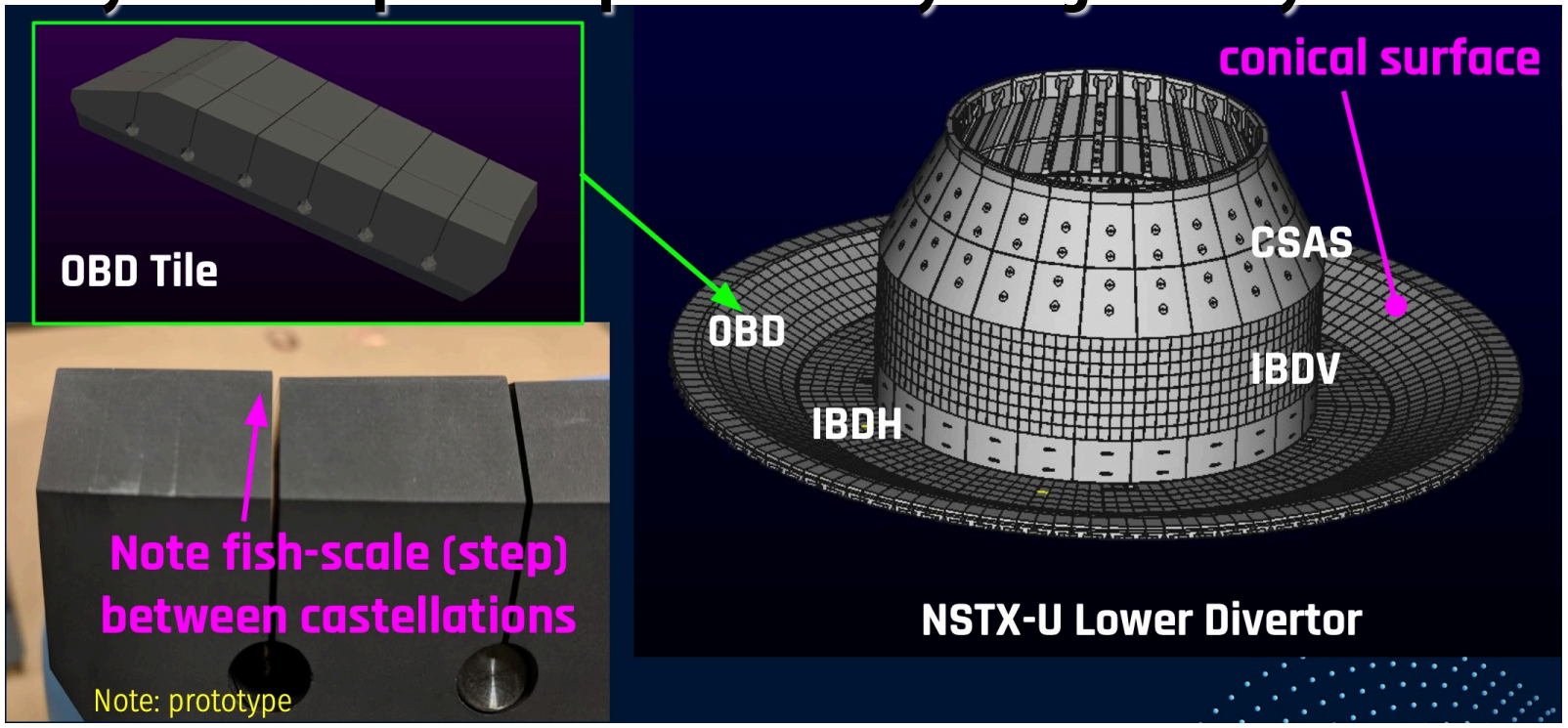
- Goal: Improving understanding of pathways for heat flux mitigation at low-A compatible with solid PFCs to be integrated into long pulse scenarios through use of impurity seeding
- Leads to the following areas of emphasis:
  1. Contribute to completion of FDR of NSTX-U bolometry diagnostics
  2. Perform first series of dedicated experiments using high-Z, noble gas seeding in H-mode plasmas
     - *Includes time-dependent boundary simulations describing plasma response to impurity gas injection*
  3. Perform assessment of pedestal linear microstability in high core radiation scenario

RT/2 (Heat-flux Engineering Analysis Toolkit development & validation) Outputs

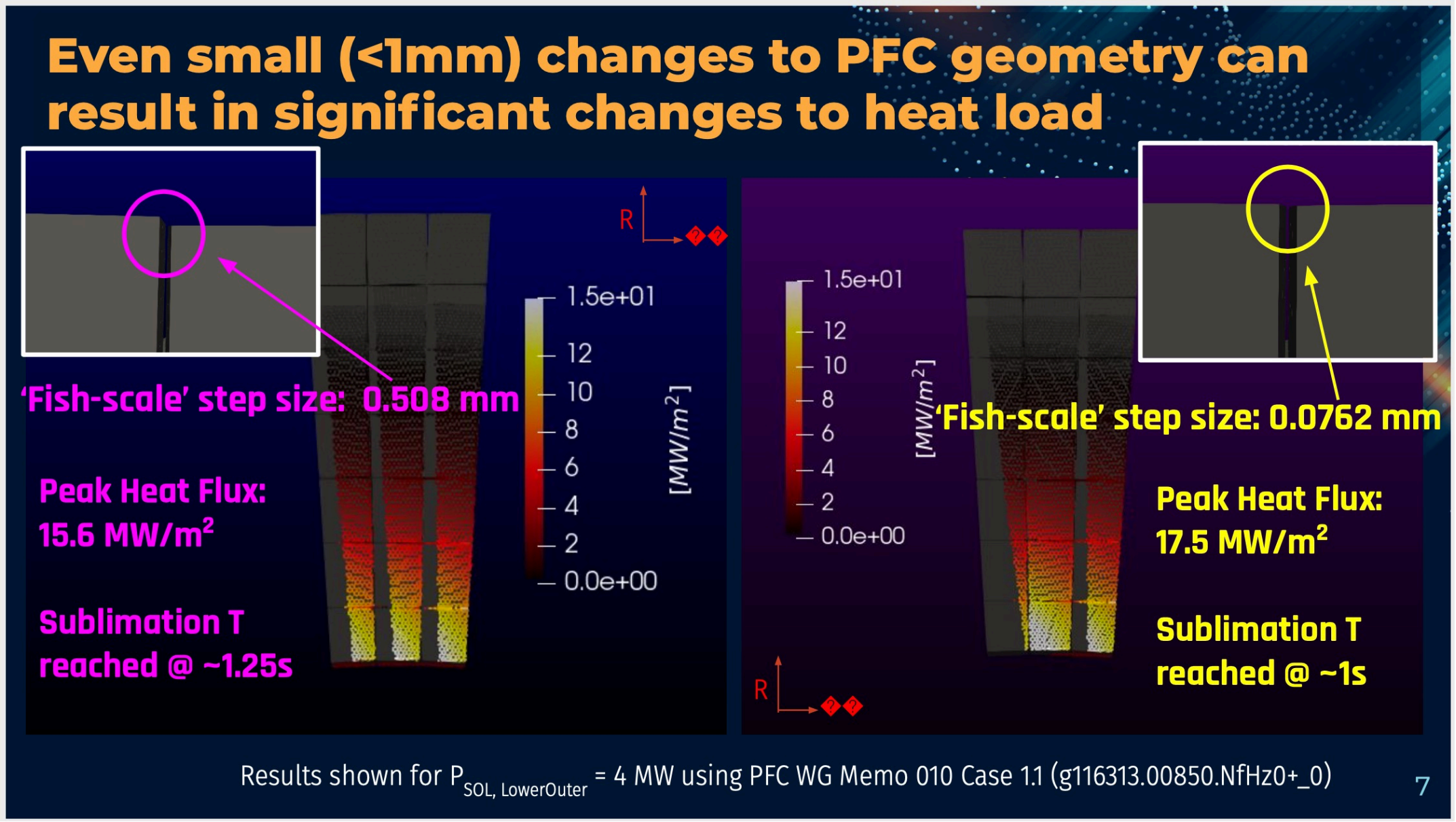
1. Completion of HEAT development & initial validation outside of NSTX-U
2. Integrate HEAT with output of boundary simulations and/or validated reduced models to provide initial core/edge/PFC scenario assessments
3. Perform initial comparisons of HEAT against NSTX-U thermocouple, IR thermography, & visible imaging diagnostics

Lower divertor Pre-recovery PFCs compared to post-recovery PFC geometry





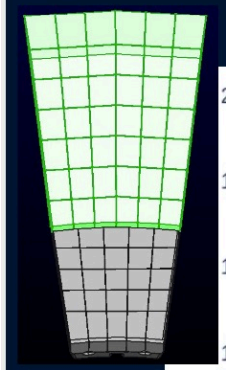
Using HEAT to assess PFC design details & potential divertor operations*

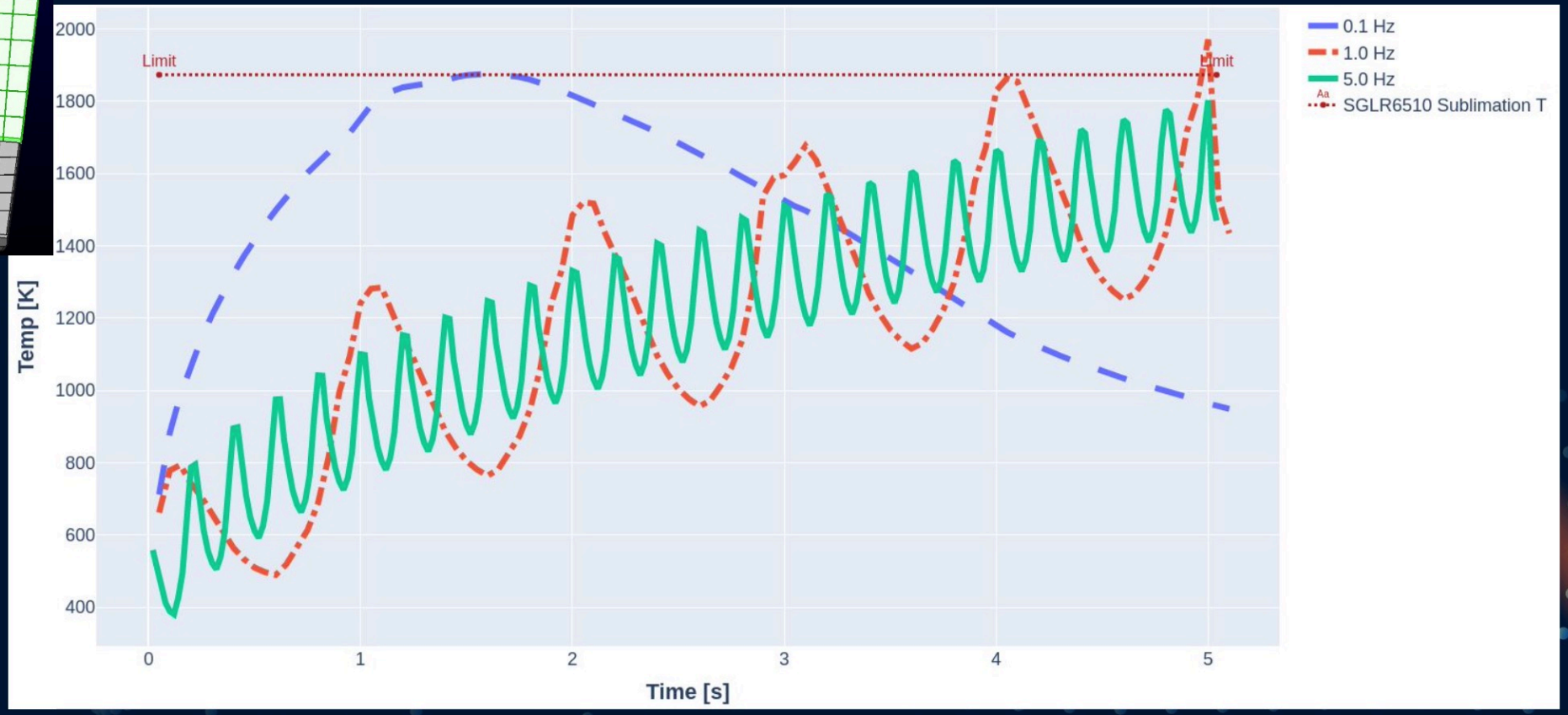


* More details in T. Looby et al., APS-DPP 2020 presentation

Using HEAT to assess PFC design details & potential divertor operations*

Strike point sweep frequency (f_{sweep}) can be used to prevent sublimation on Outboard Divertor (OBD)





Memo 010 Case 2 Scan 4 (g135111.00500_k2.<#>), P_{inj} = 10MW, f_{rad} = 0.3, B_T = 1T, I_p=2MA, DN, Res_{HF} = 2.5mm

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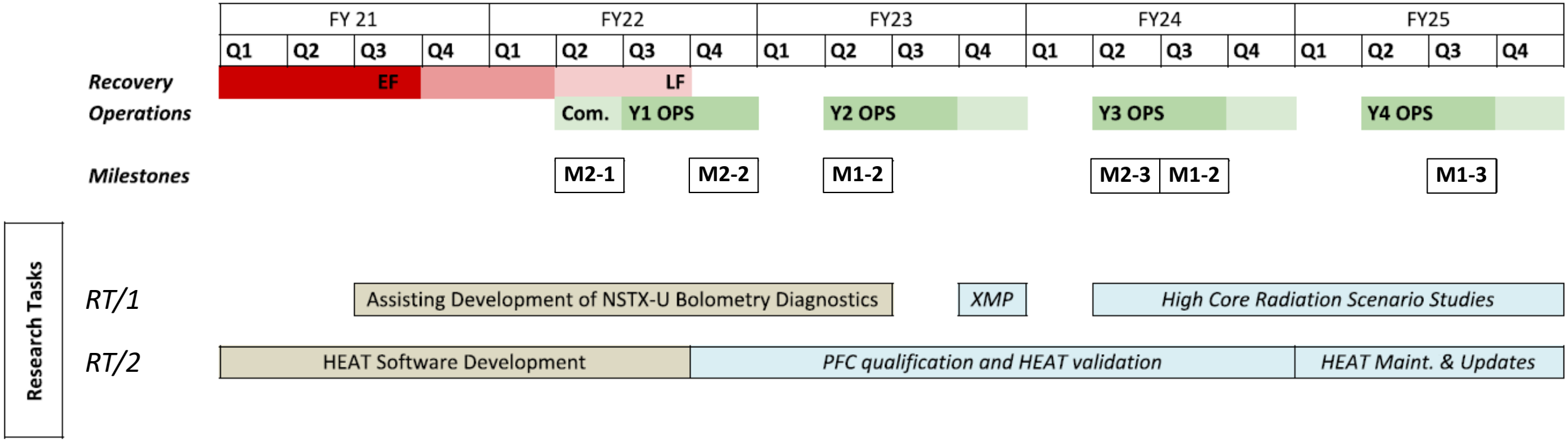
* More details in T. Looby et al., APS-DPP 2020 presentation

Timeline for ORNL's RTs over the NSTX-U 5-year plan schedule



- Note: NSTX-U recovery & operations are not updated
  - *Reassessment of detailed tasks/milestones needed after re-baselining occurs*

ORNL's work scope on NSTX-U continues to focus on boundary science & begins to address needs for future FPP options

- In coordination with the NSTX-U Research Program, our research focuses on core/edge integration & PFC development through the following efforts:
  1. Investigating impact of high core radiation fractions on the H-mode pedestal with respect to divertor heat flux mitigation
  2. Predicting heat flux to divertor components through integrated data processing and analysis, i.e., fully develop and use HEAT code
- Additionally, strong interest in continuing RF physics work & helping to address PMI as it relates to PFC survival and life-time but details not yet worked out