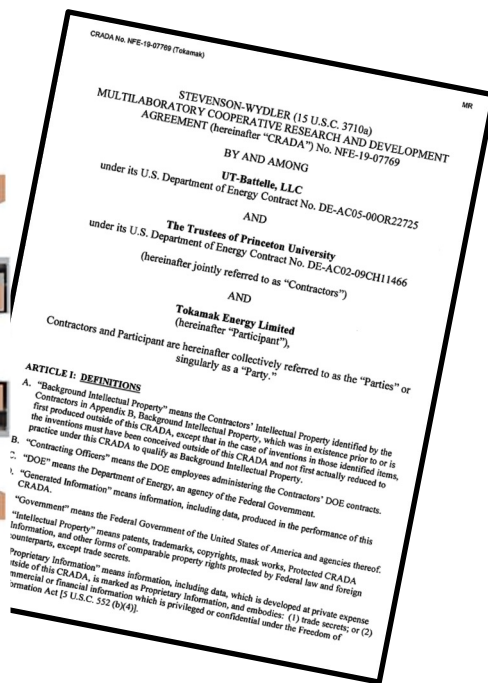
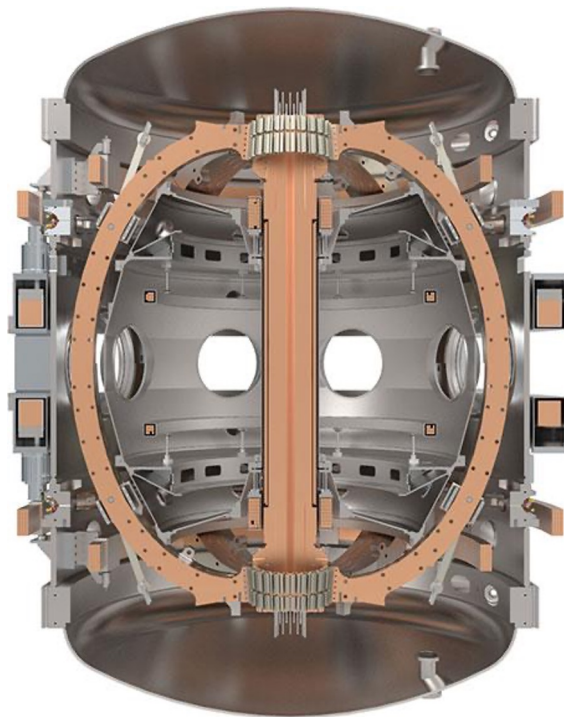


# CRADA Development (TE/PPPL/ORNL)

S.M. Kaye (PPPL), M. Reinke (ORNL now CFS), S. McNamara (Tokamak Energy)

2/29/24

# In 2019 PPPL, ORNL, and Tokamak Energy Ltd (UK) signed a Cooperative Research and Development Agreement (CRADA)



- FES awarded a total of \$3.9M to PPPL and ORNL to carry out open public research on ST40
- The three-year agreement was extended two years to August 2024

# Timeline for CRADA development

- ~2015: Initial discussions between TE and Reinke (at U. York, UK then) on divertor physics
- Early 2018: More serious discussions for collaboration began
  - One overriding factor for formalizing collaboration was delay in NSTX-U Recovery
  - Left a gap for addressing NSTX-U (ST) mission elements
    - Assessment of confinement at low collisionality
    - High- $\beta$ , high- $\kappa$  route to sustained non-inductive, high-performance operations
    - Testing innovative divertor solutions for handling high heat fluxes in compact devices
  - Second factor was request by TE to ORNL for help in designing divertor

# J. King (FES) visit to TE in Sept. 2018 ignited CRADA development activities

- Impressed by ST40 capabilities (compact ST at high  $B_T$ , planned diagnostic suite), assurance of open scientific research
- ST40 team indicated they needed help to fully exploit facility beyond Business Milestone (plasma performance:  $T_{i0} \sim 100M \text{ } ^\circ\text{C}$ )
  - (Then) limited scientific staff
  - Diagnostic and post-shot data reduction coverage, but not enough resources for “fundamental research”
- ORNL, PPPL asked to produce White Papers on proposed ST40 research under the following guidelines
  - Access to all ST40 science data (no IP component or concern)
  - Scientific productivity through first author publications and presentations
  - Reasonable chance to achieve science objectives
- And considering
  - Expertise and availability of PPPL and ORNL personnel
  - Alignment of proposed efforts with ST40 scope and resource needs
  - Alignment of proposed efforts with ST mission elements
- DOE objective was to provide funding in FY19

# Late 2018/Early 2019: FES urges moving forward with developing collaboration framework and scope

- Bilateral discussions to refine task workscopes (TE-ORNL, TE-PPPL)
  - Additional discussions with Universities for subcontract workscope
- It was decided that a CRADA was most suitable formal collaborative framework
  - CRADA among PU Trustees (PPPL), ORNL, TE
  - CRADA would serve as umbrella for workscope; funding through proposal/FWP
- ORNL had experience with CRADA, so M. Reinke took lead on writing CRADA tasks, deliverables, timeline
  - PPPL (S. Kaye) took lead on writing proposal text for actual funding
  - University workscope included in proposal and, where appropriate, in CRADA
- Proposal submitted through PAMS May 2019; FES indicated intent to fund July 2019
- CRADA submitted to ORNL, PU approval systems at approximately same time
  - Signed off by Site Offices in Aug/Sept 2019, after attorney, Site Office reviews
- Three-year funding arrived in Sept. 2019

# CRADA Tasks

- Task 1: Setup ST40 Data Access, Exchange and Storage
- Task 2: Establish ST40 Interpretive TRANSP Capability
- Task 3: Divertor Heat Flux Measurement
- Task 4: High Speed Thomson Scattering Capability
- Task 5: Scope Core Turbulence Measurements
- Task 6: Modeling of ST40 RF Scenarios
- Task 7: Non-Axisymmetric Fields
- Task 8: Energetic Particles
- Task 9: Scope Coaxial Helicity Injection Capability
- Task 10: Examine the Effects of Li Conditioning
- Task 11: Engineering Design Review Support
- Task 12: ST40 Operations and Measurement Support
- Task 13: Execute P3 ST40 Experiments
- Task 14: Analysis and Publication of Experimental Results
- Task 15: Closeout of CRADA Activities

# CRADA was/is scientifically productive and impactful

- First authors on ST40 presentations and publications
  - 4 publications (PPPL), 12 recent conference presentations (PPPL & ORNL)
- PPPL/ORNL co-authors on ST40 presentations and publications
  - 14 recent conference presentations, including APS, EPS, workshops, and recent S. McNamara NF paper
- PPPL, ORNL researchers helped ST40 achieve first internal Milestone ( $T_{i0} \sim 100M \text{ } ^\circ\text{C}$ )
  - PPPL involved in plasma operation to achieve milestone
  - PPPL researchers were consulted for the x-ray crystal spectroscopy that measures  $T_i$ ,  $T_e$
  - ORNL researchers were consulted for the CXRS diagnostic that measures  $T_i$
  - The TRANSP code was used to help verify high central  $T_i$ , using data from mirrored server
  - PPPL software engineers provided hardware for TS real-time data acquisition

# CRADA was scientifically productive and impactful

- CRADA targeted non-IP, open-science tasks
- Excellent working relation with ST40 Team and Management
  - Supportive of the CRADA goals – provided run time
    - PPPL: 2.5 run days in last physics campaign
    - PPPL & ORNL preparing proposals for run time in next campaign
  - Treated as ST40 Team members; included in Program planning activities
  - Receptive to input, suggestions
  - Responsive in a timely fashion to our data, runtime needs
- General considerations for Public-Private Partnerships
  - Physics campaigns can be focused on internal Milestones
  - Short- and long-term plans can change often and significantly
    - Run campaign, facility/device plans and capabilities
  - Doing things “quicker” could lead to reliability issues (operations stoppages/limitations), diagnostic availability timing (ops outpacing diagnostic implementation)





# CRADA with Tokamak Energy helped build links between fundamental research and commercial application

- Collaborative work with ST40 through CRADA was/is scientifically productive, mutually beneficial, impactful, and enjoyable
  - Did not include any IP-related issues, which made CRADA development easier
  - ST40 team extremely cooperative and excellent to work with
  - Access to novel private facility to explore new regimes
  - Led to involvement with TE in other ways (INFUSE, Milestone Program)
- Private entity mission can be driven by internal Milestones, and plans can change rapidly and significantly
  - Collaborating partners interested “fundamental research” need to link to internal Milestones and retain flexibility for changes to run campaigns
  - CRADA should be general enough to accommodate