

# Tungsten Tile Testing (T<sup>3</sup>) Campaign Overview

Opportunities for Large-scale Sample Exposures during W Tile Testing Campaign

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**Sandia  
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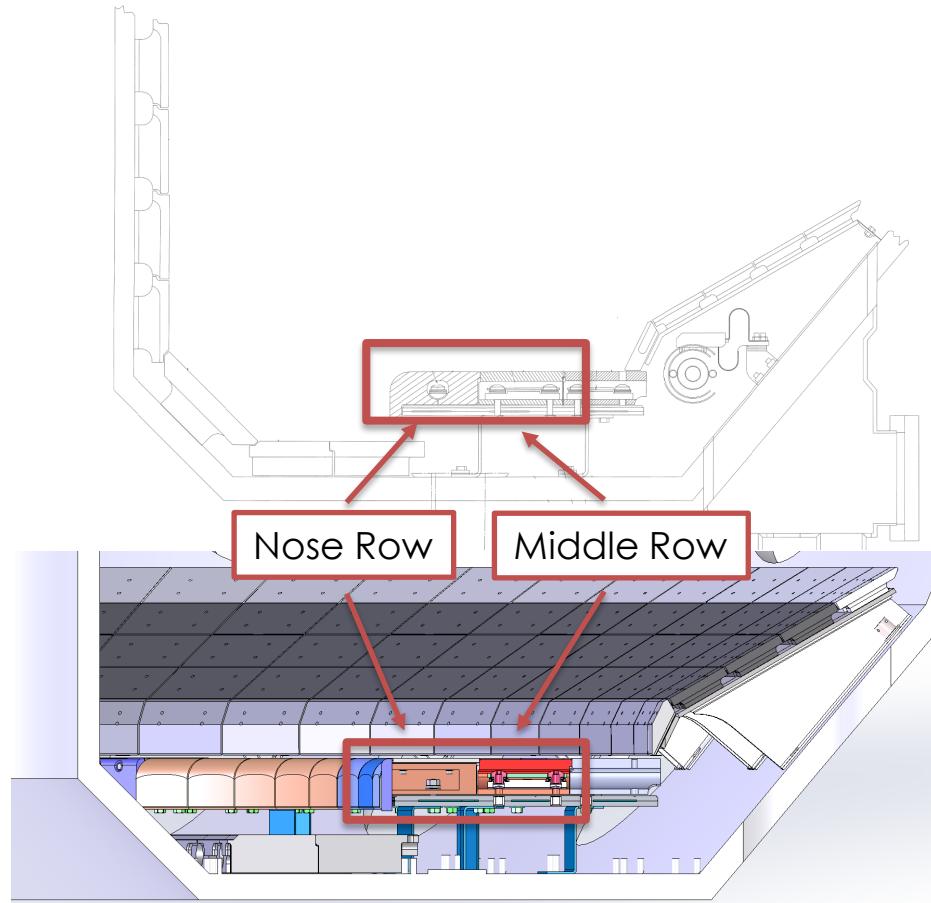


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# Tungsten Tile Testing (T<sup>3</sup>) Campaign Overview

- Department of Energy has requested that DIII-D decarbonize through a First Wall Change Out (FWCO) project
- The **Tungsten Tile Testing (T<sup>3</sup>)** campaign will test a range of materials, coating techniques, and tile designs to reduce risks for FWCO
- Two rows of tiles will be replaced along the lower divertor shelf
- W tiles for DIII-D will be selected based on expected needs of the FWCO



# T<sup>3</sup> Campaign – Scope

- **~2 weeks of installation, 2 weeks of operation (June 2026)**
  - **1<sup>st</sup> Phase:** lower heat flux tests on nose tile ring → surface T cycling from 300 – 800 °C
  - **2<sup>nd</sup> Phase:** higher heat flux tests on middle shelf ring → T cycling > 800 °C

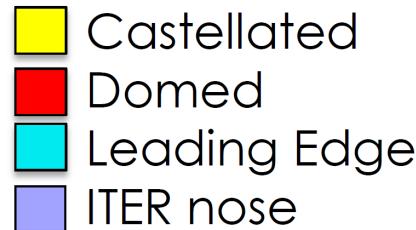
**T<sup>3</sup> is primarily an ENGINEERING Experiment Campaign**

- **Engineering (+ some research) Scope:**
  - Material integrity (macroscopic) of bulk W and coatings from various manufacturers
  - Tile shaping and alignment tolerances in high heat flux regions
  - Suitable high power operating scenarios with W
  - Impact of W on diagnostics
  - Qualification of ITER W PFCs for Start of Research Operations (SRO)
  - And probably much more...

# T<sup>3</sup> Campaign – Experiment Plan

## Nose tile ring

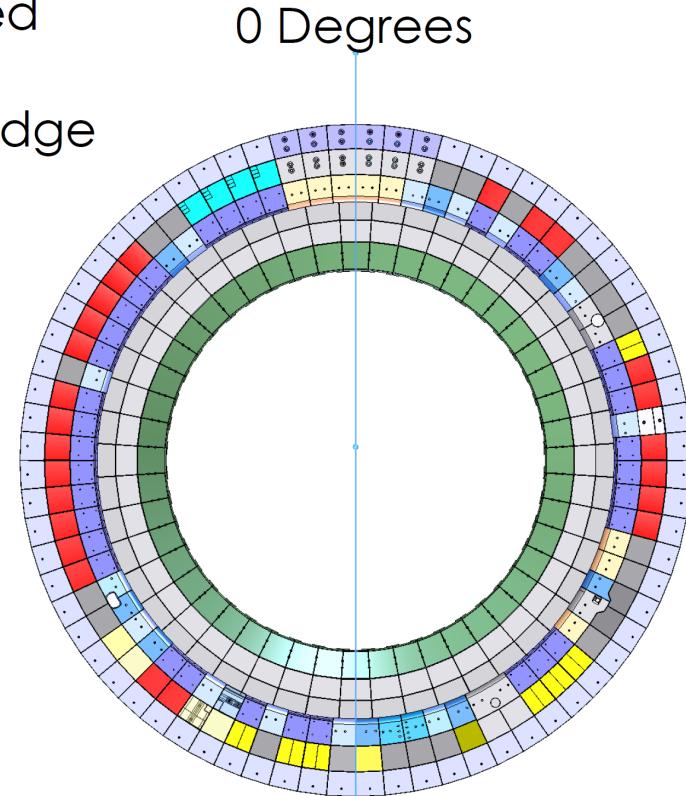
- **Predominantly ITER tiles**
- **Mimic ITER low heat flux zone to test coatings + W-alloys**
  - VPS, PVD, cold-spray, W heavy alloy, etc.



72 tiles  
per row

## Middle ring

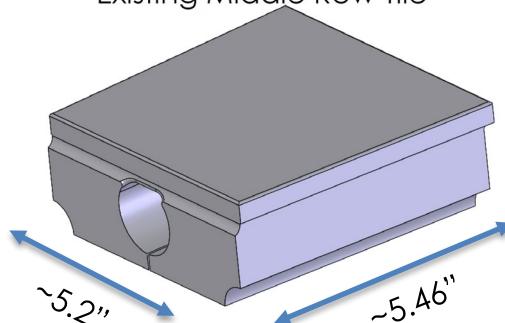
- **Predominantly GA tiles**
  - GA: W alloys, W on TZM, W on SS, W heavy alloys
  - Some ITER tiles (~20): bulk W, W heavy alloys
- **Mimic DIII-D high-power ops, ITER loads at startup areas**
- **Here, there will be opportunities for including novel tiles from industry**



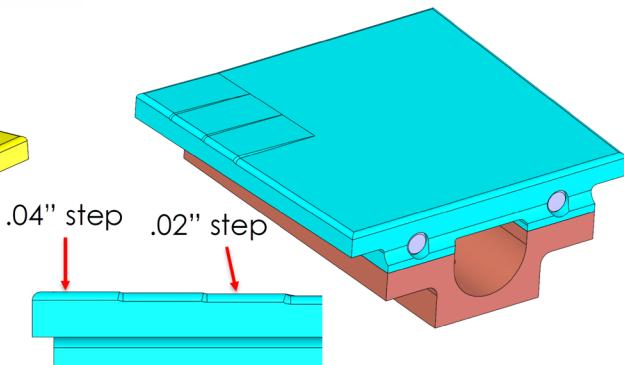
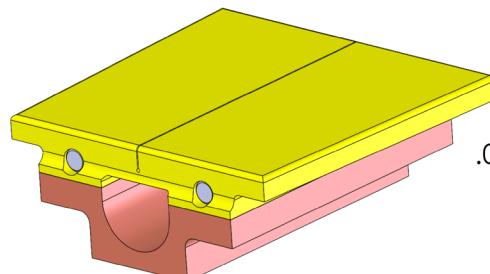
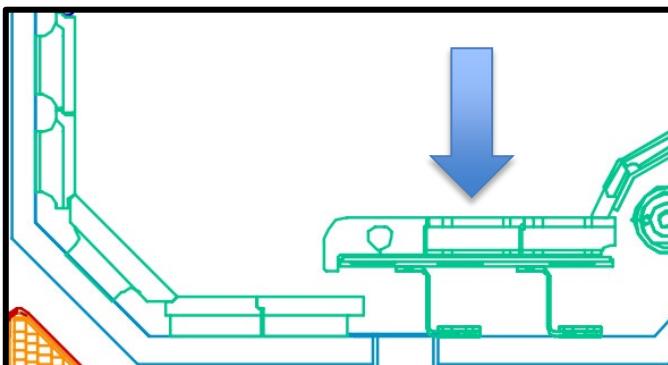
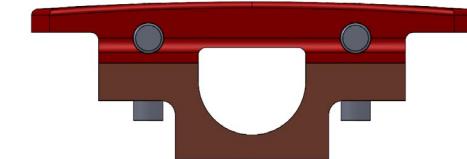
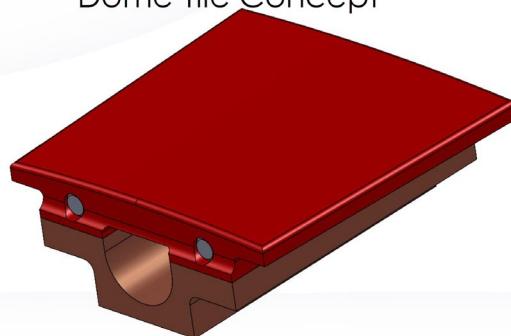
# T<sup>3</sup> Campaign – Experiment Plan

## Middle Row tile designs being considered:

Existing Middle Row Tile



Dome Tile Concept



Castellated Tile

# T<sup>3</sup> Campaign – Research Opportunities

**Runtime Guidance invites opportunity for limited number of novel tiles for testing by public and private partners**

- Main campaign focus is divertor, but wall tiles are also fair game
- Various materials and tile designs can be considered (i.e. not just W), with caveats:
  - Single-tile tests
  - Tile design must conform to current middle row design envelope (i.e. sizing)
  - Proposed materials must have reactor-relevant testing history (TRL > 2). Examples:
    - Prior DIII-D tests (DiMES, tiles), other tokamak exposures
    - Lab-scale fusion-relevant heat/particle flux tests (laser, e-beam, linear plasmas)
  - Tile concepts must complete Design Review process
- **To apply: contact J. Coburn and F. Effenberg**
  - Application will be a 2-3 slide template in SharePoint folder: [Tile Testing Campaign](#)
  - Proposals will be evaluated and prioritized by Research Division

# T<sup>3</sup> Campaign – Research Opportunities

**In addition to novel tile testing, the T<sup>3</sup> campaign will afford many piggyback opportunities for Research**

- **Plasma-material interaction of fusion-relevant W tiles**
  - In-situ and post-experiment analysis of DIII-D/ITER tile performance
  - Piggyback DiMES & MiMES testing
- **Explore diagnostic impacts (reflection, impurities)**
  - Inform mitigation strategies for diagnostic systems in FWCO
  - Piggyback tests of diagnostic systems and changes
- **Scenario development for high power operation with W**
  - Modifying 2-3 reference discharges during 2-week campaign to combat W difficulties

# **Supplemental**

# T<sup>3</sup> Campaign – Experiment Plan

## Early thoughts on the 2-week experiment plan being developed:

- **~80 hours of operation → ~240 non-startup shots → 30 shots a day**
- **1<sup>st</sup> Phase: lower heat flux tests on nose tile ring**
  - Goal is to cycle surface temperature from 300 – 800 °C, at least 100 cycles
  - Start with low power L-mode plasmas,  $q_{\perp} \sim 1 \frac{MW}{m^2}$
  - Transition to H-mode. Loading (ITER-driven):  $q_{\perp} \approx 2 - 3 \frac{MW}{m^2}$ , 3s duration, with ELMs
- **2<sup>nd</sup> Phase: higher heat flux tests on middle shelf ring**
  - Test material integrity with temperature cycling > 800 °C
  - L-mode → mid-power H-mode → High-power H-mode
  - Peak loading conditions (DIII-D driven):  $4 - 5 \frac{MW}{m^2}$ , 3s duration, with ELMs
  - Increasingly impactful/misaligned tile features more radially outward
  - Reference shots need to be high power, but not rely on large set of diagnostics to run...
    - We're narrowing down reference shots, but let us know if you have suggestions!

# T<sup>3</sup> Campaign – Analysis Plan

- ❑ **Before measurements**
  - ❑ Bond strength, cuts, etc... --> measured by the coating supplier for all techniques
  - ❑ Possible additional measurements on spares to have the same measurement conditions
  - ❑ Measure surface roughness using confocal microscopy system, surface height map scan --> for a selection of tiles
  - ❑ Metrology scan of installed tiles pre-exposed (< 1 day)
- ❑ **All tiles after experiment (IO staff onsite, together with DIII-D staff)**
  - ❑ Visual inspection and pictures --> all tiles, in situ and after tile removal? (needed for PDR)
  - ❑ Hand held XRF, LIBS for elemental composition
- ❑ **Selection of coating and alloys tiles: ~10 in total, incl failed (1-2 per tech) and successful ones (1 per tech)**
  - ❑ Detailed surface inspection --> looking for cracks etc (needed for PDR)
    - ❑ 1st optical
    - ❑ SEM for selection of tiles/locations (top, together with cut measurement)
    - ❑ Possible additional, surface roughness using confocal microscopy system, surface height map scan
  - ❑ Metallographic cross sections --> looking for defects at interface of coating, structure of alloys (needed for PDR)
    - ❑ Optical microscopy to observe the grain structure, phase distribution, and defects
    - ❑ SEM (cut) micrographs (backscattered electrons) for more fine resolution
    - ❑ Combined with EDX at cross section
  - ❑ Hand-held XRF, LIBS for elemental composition --> identify origin of surface discoloration etc (needed for PDR)
  - ❑ Bond strength measurement and scratch tests --> looking for hidden defects (needed for PDR)
    - ❑ only of successful coatings (5 max)
- ❑ **Longer term - outside of first analysis 'contract' scope**
  - ❑ Thermal screening : only of successful coatings, looking for hidden defects (desired for FDR)
  - ❑ Retention