

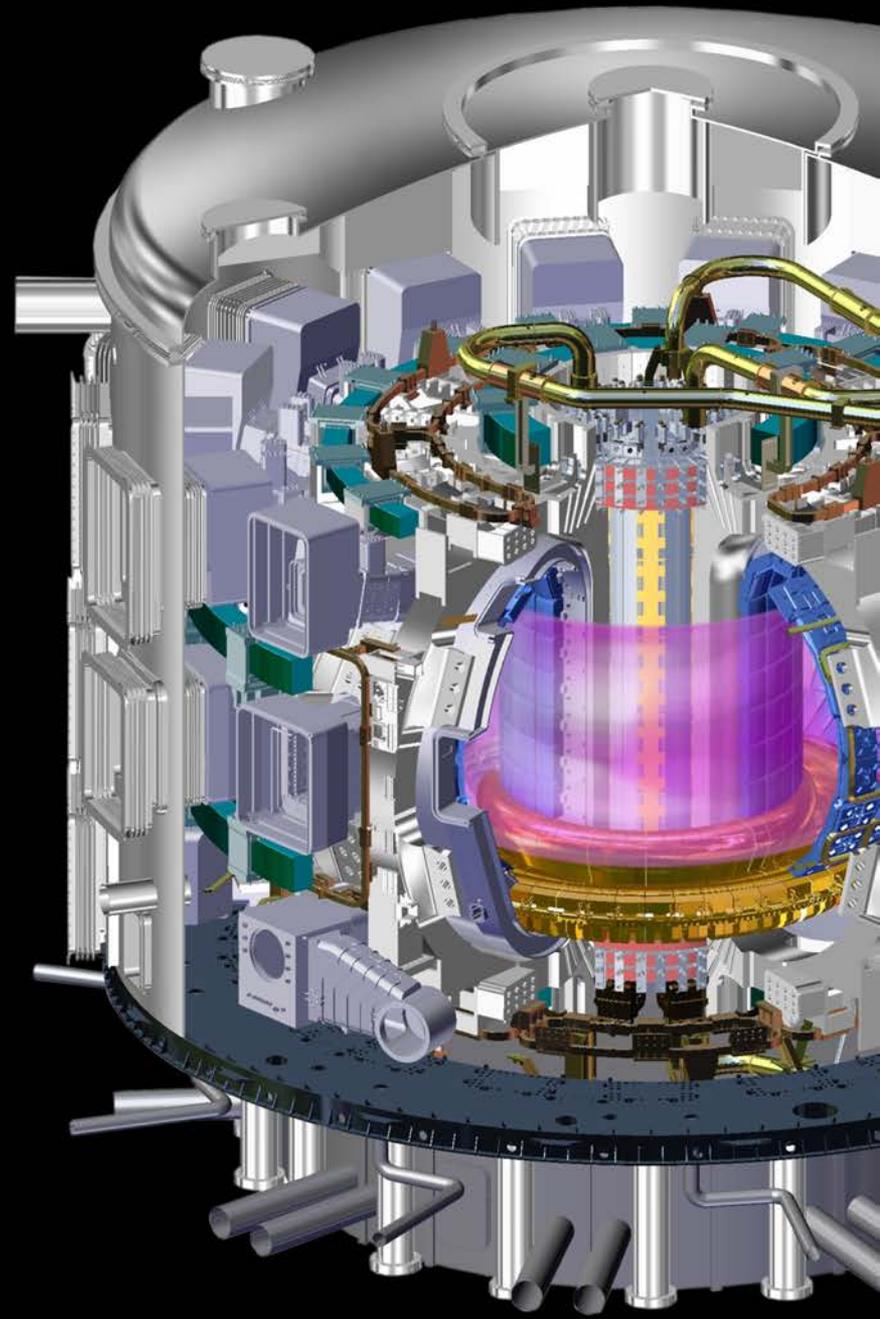
US Contributions to ITER

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Fusion Power Associates

December 16, 2014

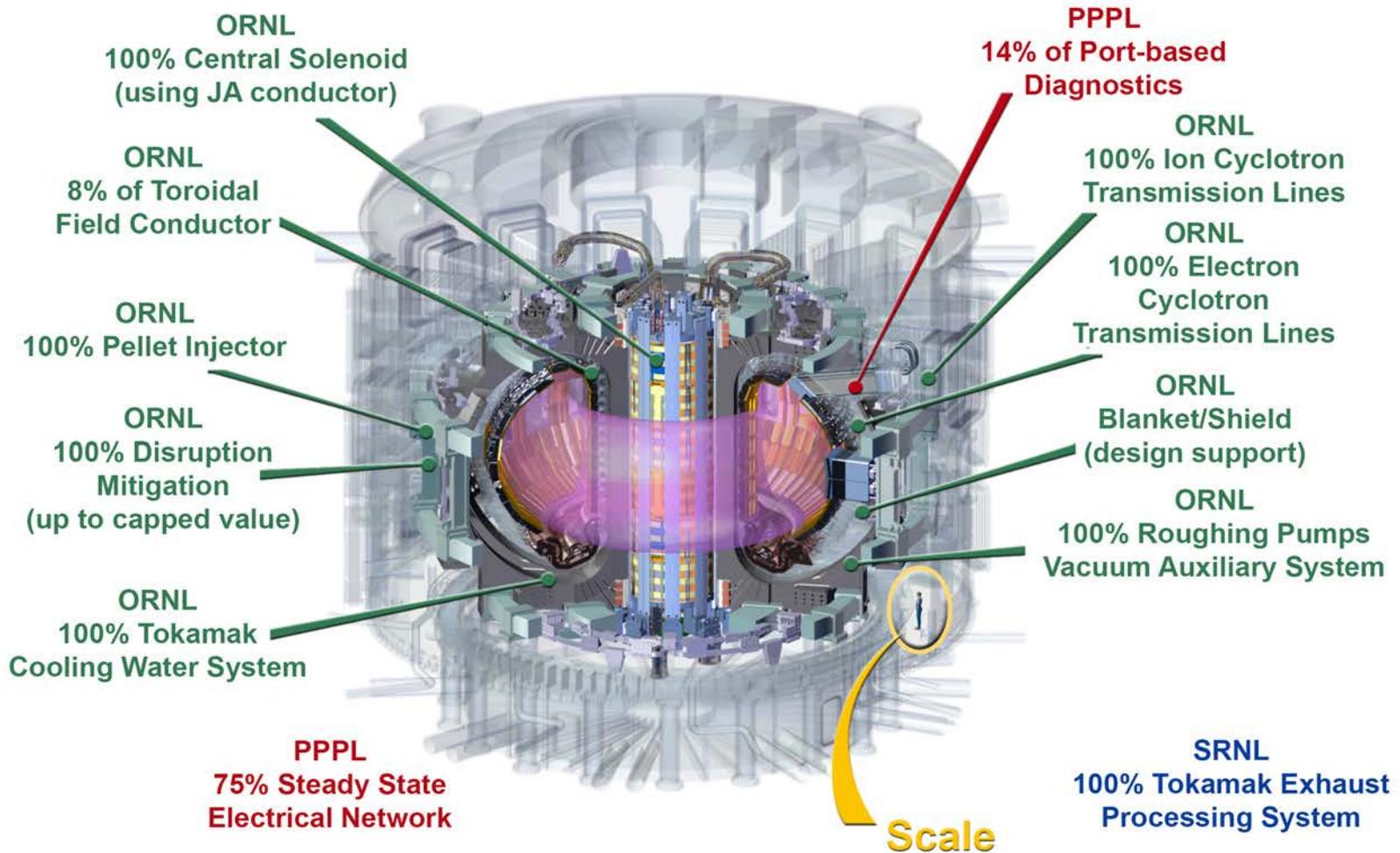


Overview

- US Scope
- Deliveries in FY14 and 15
- Fabrication Investments and Progress
- State of the Project



US Scope



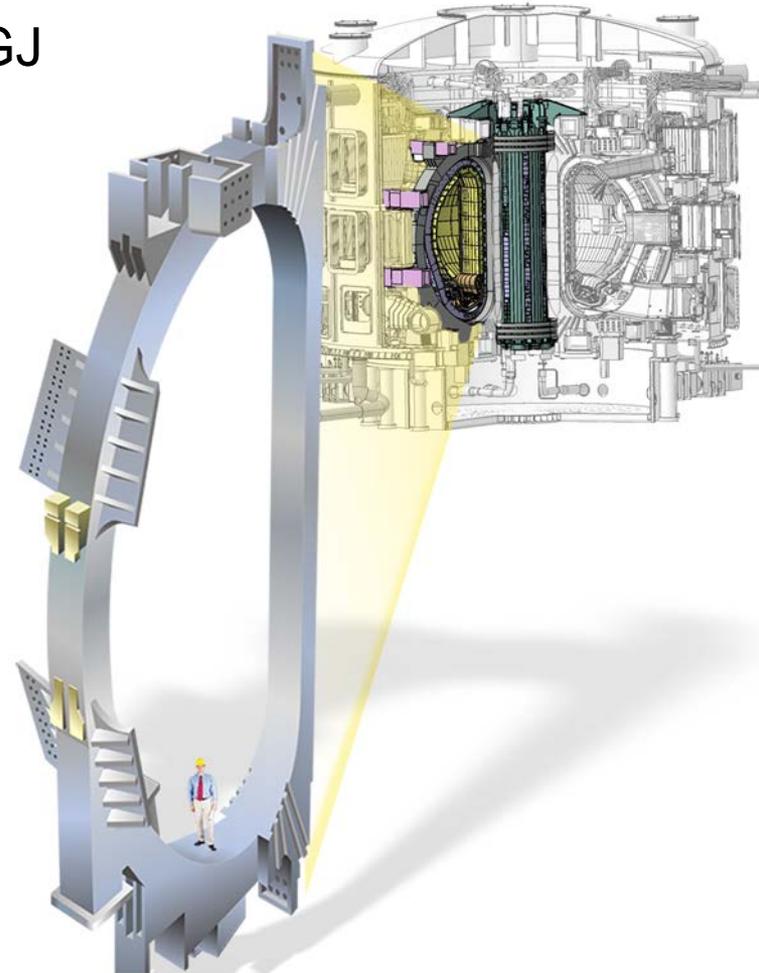
Deliveries in FY14 and 15

- Toroidal Field (TF) Coil Conductor
- Steady State Electrical Network Components
- Tokamak Cooling Water System Drain Tanks



Toroidal Field Coil

- Total Magnetic Energy of all TF Coils: 41 GJ
- Maximum Magnetic Field: 11.8 T
- Number of Coils: 18
- Total TF Coil Weight: 6540 t
- TF Coil Height: 16.5 m
- TF Coil Width: 9 m
- Operating Temperature: 4.7 K
- Current in 1 TF Coil: 9.1 MA
- Number of turns in 1 TF coil: 134



FY 2013 US Achievements: *Completion of Toroidal Field Strand*



Production conductor strand
at Luvata Waterbury Inc. in
Newark, NJ



Production conductor strand at Oxford
Superconducting Technology in Carteret, NJ

FY 2014 US Achievements: *Toroidal Field Cable*



Production conductor cabled at
New England Wire Technologies
in Lisbon, NH



FY 2014 US Achievements: *Toroidal Field Conductor Jacketing*



High Performance Magnetics jacketing and integration facility in Tallahassee, Florida

Photo: US ITER

FY 2014 US Achievements:

TF Shipments to EU Winding Facility



US TF 800 m Dummy Conductor

US TF 100 m Active Conductor (Oxford)

US contribution includes over 4 miles of conductor, which is constructed from 40 tons (over 4,000 miles) of niobium-tin superconducting strand



Truck arriving at ASG in Italy with US TF 800 m dummy conductor



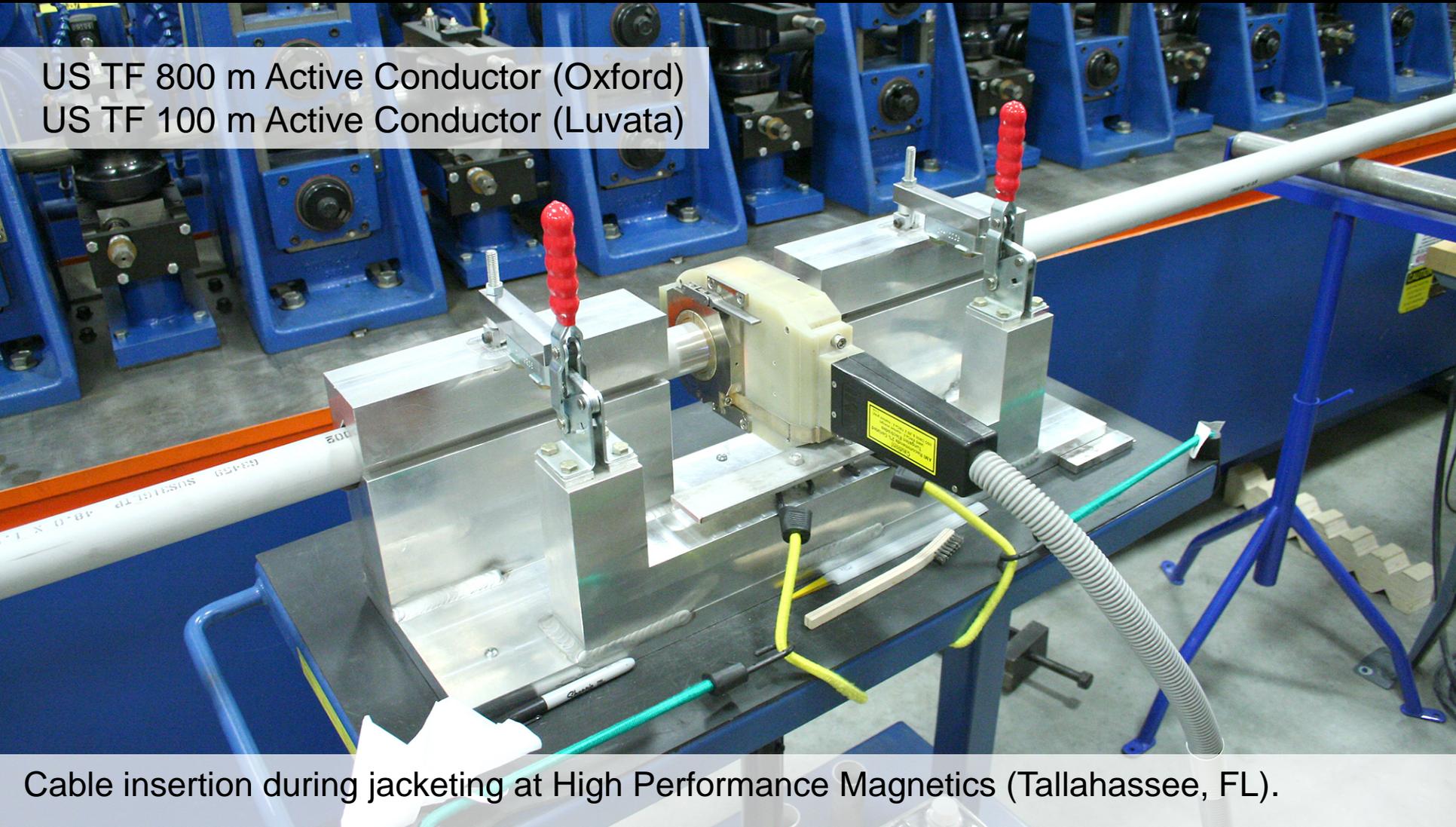
US TF 800 m dummy conductor – delivery at ASG in Italy

FY 2015 Deliveries

TF Shipments to EU Winding Facility



US TF 800 m Active Conductor (Oxford)
US TF 100 m Active Conductor (Luvata)



Steady State Electrical Network



ITER Switchyard

- AC distribution system providing 120MW of power to supply all the conventional loads
- Receives input power from 400kV French grid via four 75MVA substation transformers that step down to 22kV for distribution throughout the ITER facility
- All SSEN equipment has to comply with IEC standards and operates at 50Hz

FY 2014 US Achievements: *Steady State Electrical Network*



High voltage surge arresters, delivered by the US on September 4, 2014, were the first plant components delivered to the ITER site. Photo: ITER Organization

Completed FY14 and FY15 Deliveries

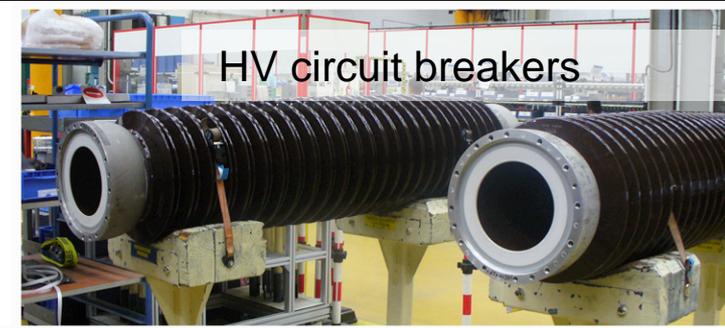
Steady State Electrical Network



HV substation hardware



HV switches



HV circuit breakers



UPS batteries



HV control and protection



HV current transformers



Earthing resistors

Upcoming FY15 Deliveries

Steady State Electrical Network

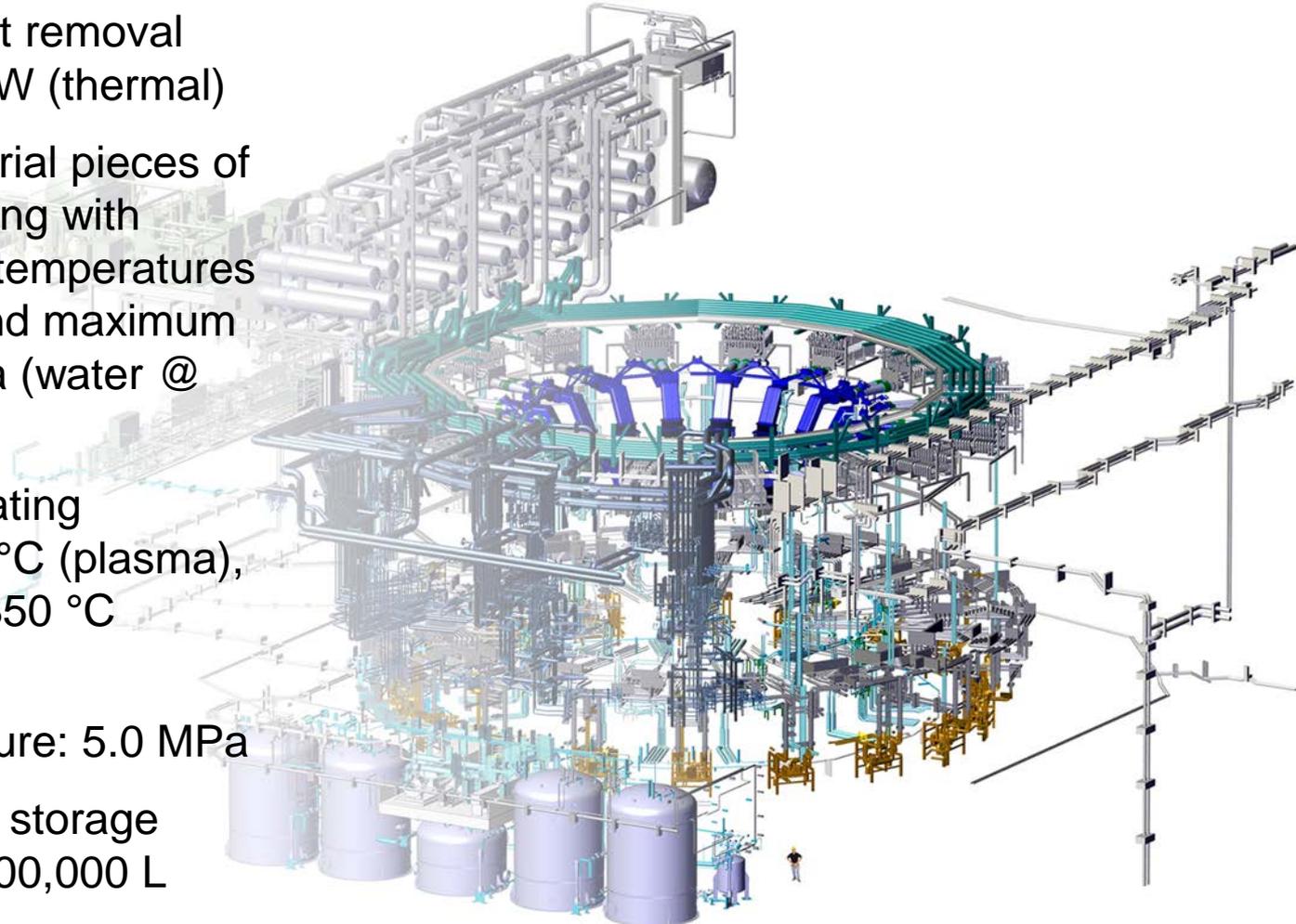


HV substation transformer units are in transit and will be the first highly exceptional loads delivered to the ITER site.

Tokamak Cooling Water System



- Total installed heat removal capacity: 1,000 MW (thermal)
- 100+ major industrial pieces of equipment operating with maximum design temperatures of 400 °C (gas) and maximum pressure of 5 MPa (water @ 240 °C)
- Max coolant operating temperature: 126 °C (plasma), 240 °C (baking), 350 °C (gas baking)
- Max design pressure: 5.0 MPa
- Radioactive water storage capacity: over 1,000,000 L



FY 2014 and 15 Progress: Tokamak Cooling Water System



All drain tanks (four 61,000 gallon drain tanks and one ~30,000 gallon tank) will complete fabrication by February 2015. At left, a completed tank undergoes a lifting test. At right, tanks in earlier stages of fabrication.

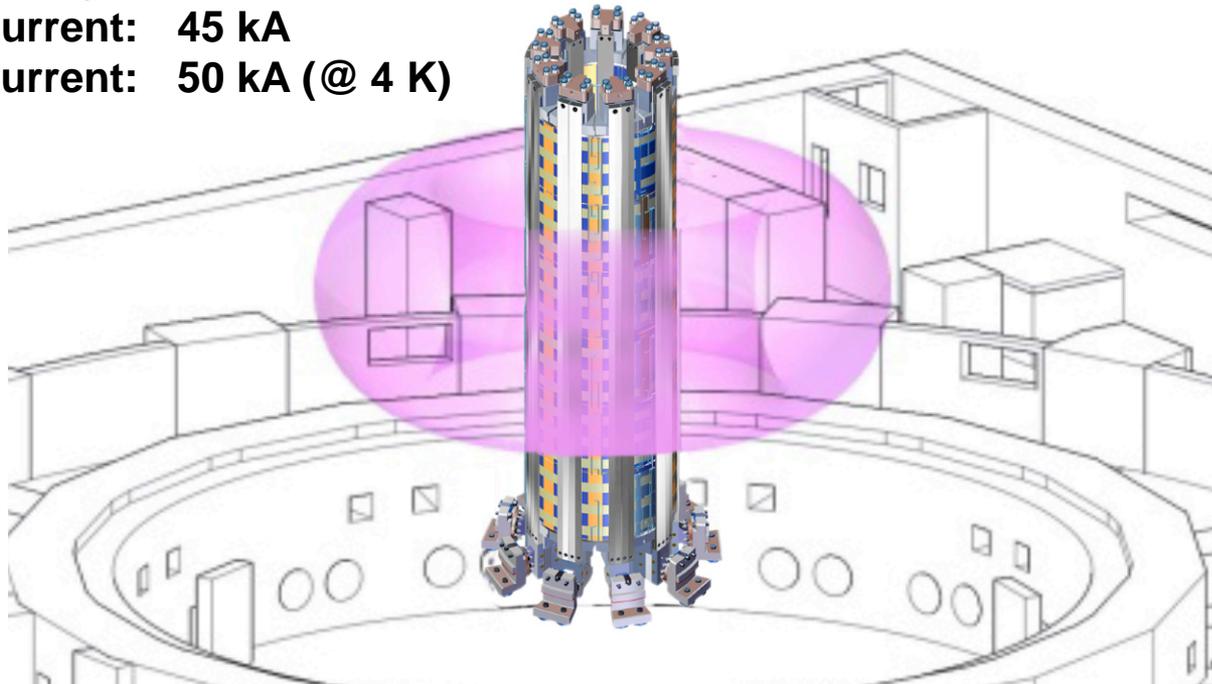
Photo: US ITER

Central Solenoid

The Heartbeat of ITER

Coil Packs: 6 + 1 spare
Field Strength: 13 T
Operating Voltage: 14 kV
Test Voltage: 30 kV
Operating Current: 45 kA
Test Current: 50 kA (@ 4 K)

1,000 metric ton magnet induces the majority of magnetic flux charge needed to initiate and maintain plasma current



**The most powerful pulsed superconducting electromagnet in history
(5.5 Gigajoule stored energy capacity)**

FY 2014 US Achievement: Module Tooling Stations are Being Installed at General Atomics



1: Conductor receiving inspection



2: Winding (2)



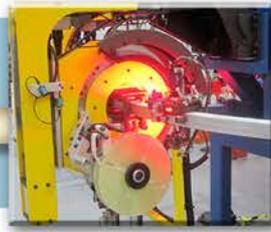
3: Joints & Terminals Preparation



4: Stack & Join/Helium Penetrations



5: Reaction Heat Treatment



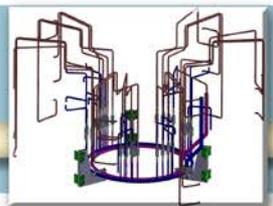
6: Turn Insulation



7: Ground Insulation



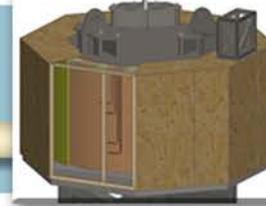
8: Vacuum Pressure Impregnation



9: Helium Piping & Measurement



10: Final Test at 50kA, full force



11: Shipping

Transfer Ownership

Fabrication Investments and Progress



Central solenoid fabrication facility
ramping up at General Atomics in
Poway, California

- 5 of 11 tooling stations in place
- 2 of 11 tooling stations in operation
- Mock-up winding underway

FY 2014 US Achievements: Central Solenoid–Japanese Conductor Ready for Winding



Dummy conductor shown loaded on winding machine – in prep for mock-up winding.



4 central solenoid active conductor spools and 1 dummy at General Atomics.

FY 2014 US Achievement: *1st Winding Station Installed*



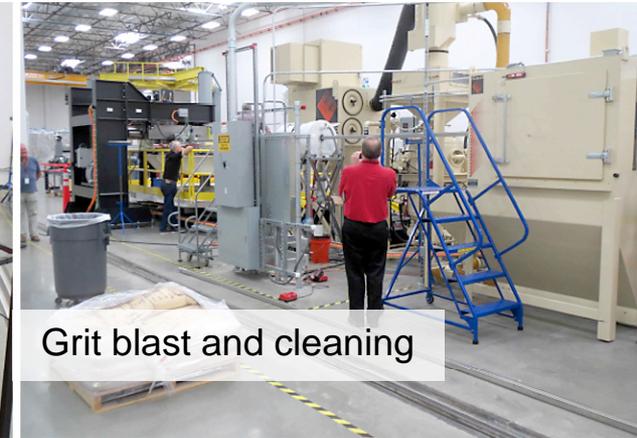
MRR Conducted in July 2014



De-spooler



Tractor drive and straighteners



Grit blast and cleaning



Forming head



300 m double pancake coil on winding table with cleaning grit blast and de-spooler stations behind

FY 2014 US Achievements: Central Solenoid – Mock-up Winding Began in August



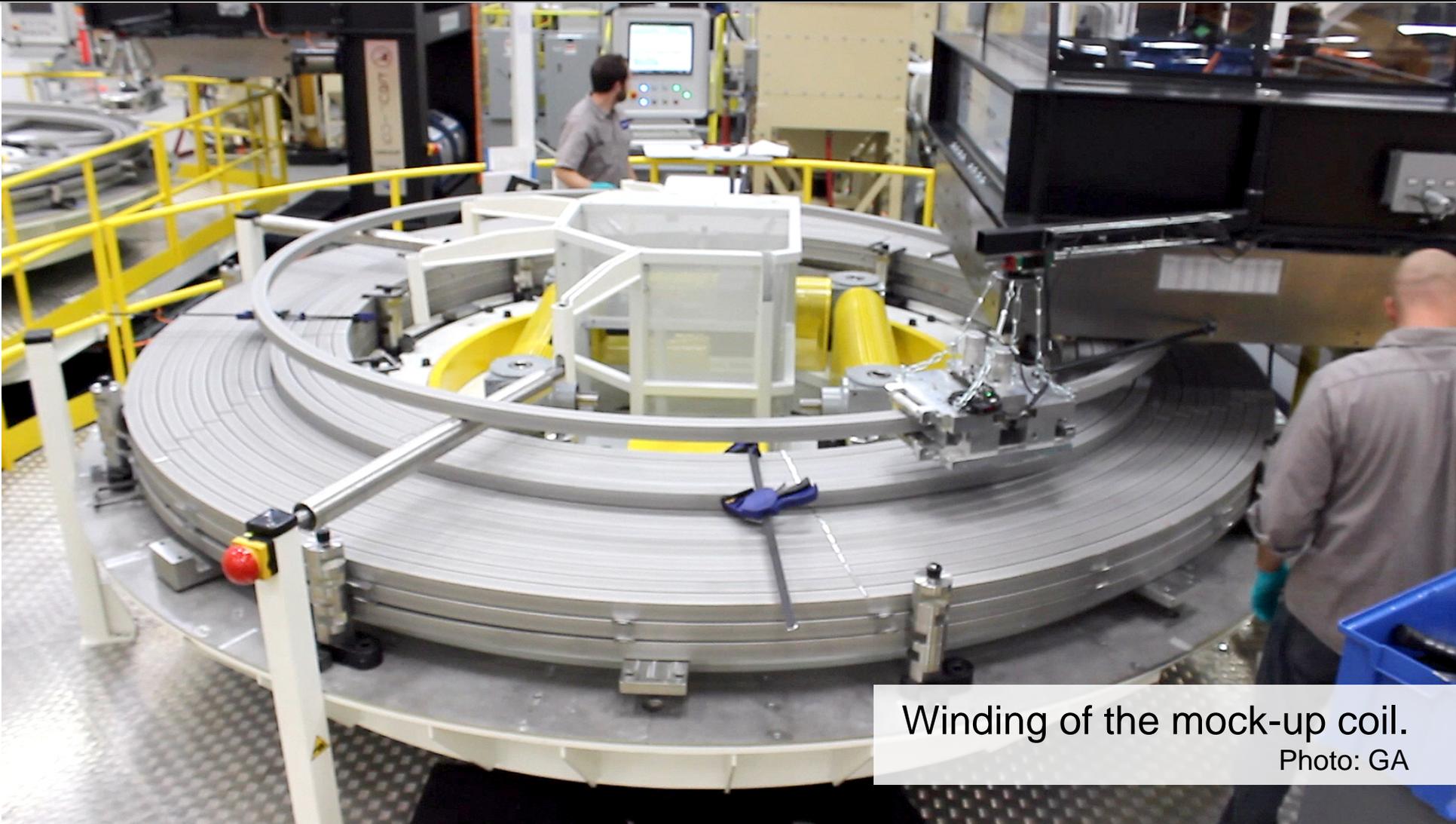
Conductor routed from the de-spooler of the winding station



Conductor routed through tractor drive to the straightener

Photos: General Atomics

FY 2014 US Achievements: *Central Solenoid Tooling Stations*



Winding of the mock-up coil.

Photo: GA

FY 2014 US Achievements: Central Solenoid Tooling Stations



Specifications for heat treatment furnace:

- Height – 7 m
- Diameter – 5.56 m
- Weight – 132 Tonnes (including Module)
- Power 800 kW
- Medium – Argon
- Pressure – 1×10^{-2} mbar



Heat treatment furnace and associated equipment has been installed at General Atomics and is undergoing testing.

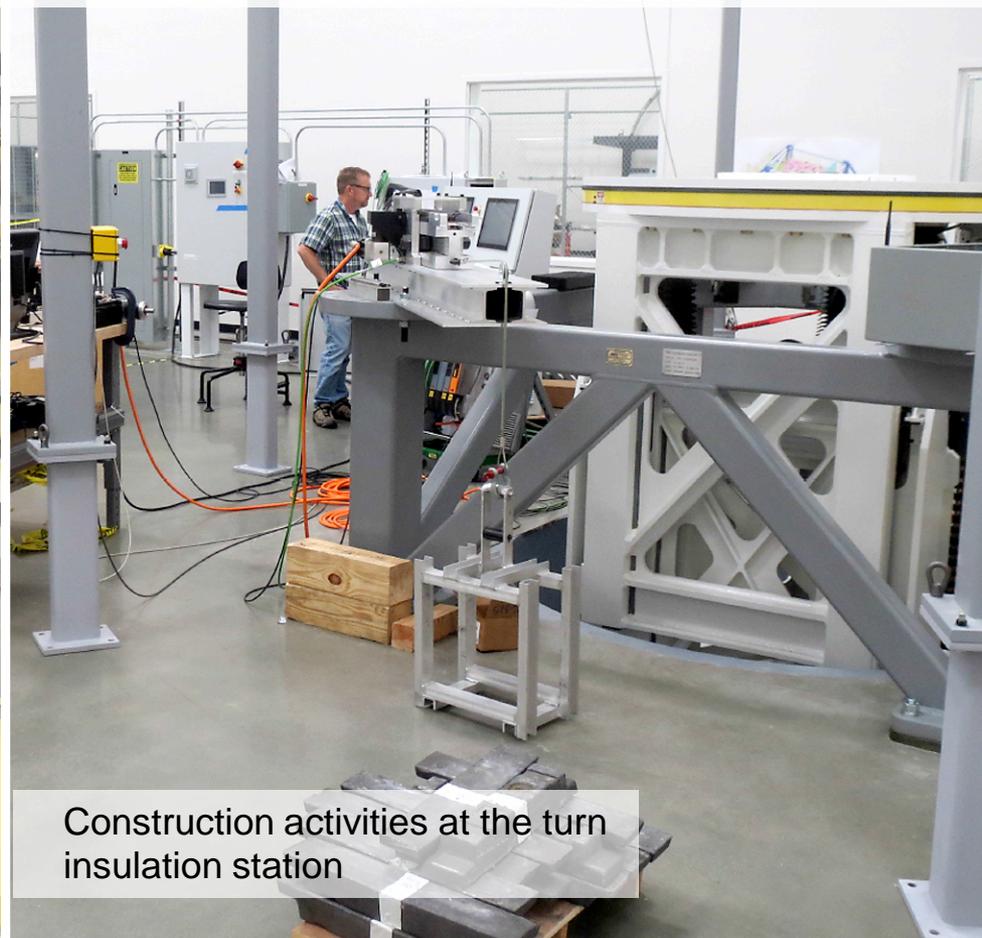
FY 2014 US Achievements: Central Solenoid Tooling Stations – Turn Insulation Station Being Installed



- Factory acceptance testing completed at vendors
- Units will be re-assembled and commissioned using mock hexapancake



Automated insulation taping heads

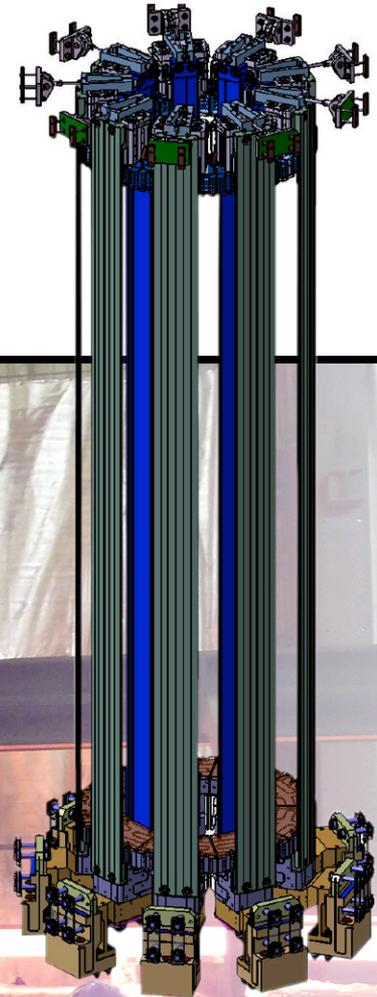


Construction activities at the turn insulation station

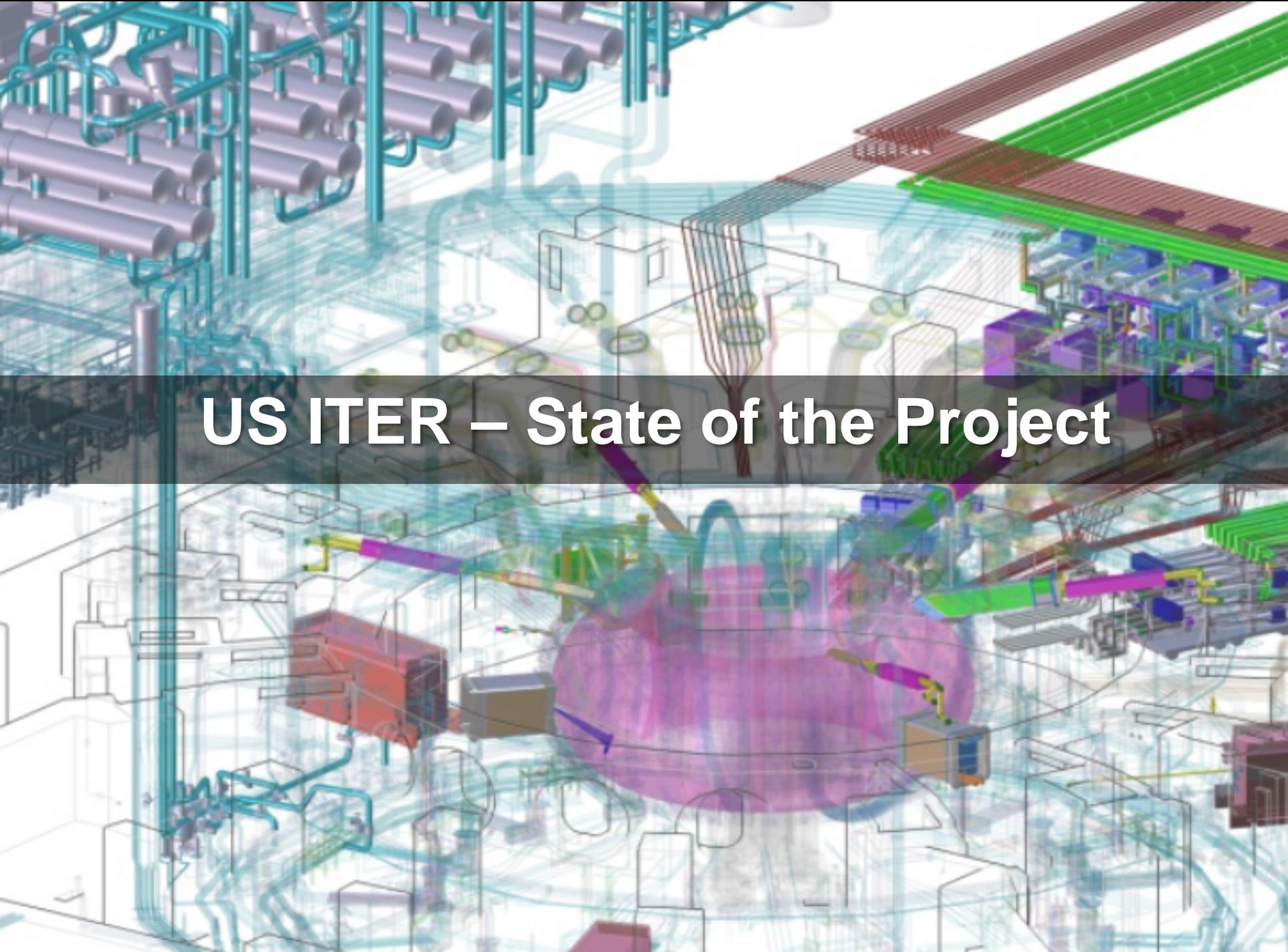
Central Solenoid Structures Contracts



- Placed first production contract with Peterson (Ogden, UT) for lower key blocks and isolation plates
- Issued RFP for tie-plate procurement; proposals received and under evaluation



One piece tie-plate prototype forged at Kind LLC (Gummersbach, Germany)

A detailed 3D CAD rendering of the ITER tokamak reactor structure. The image shows a complex network of pipes, structural supports, and components. A central, large, purple, toroidal structure is prominent, surrounded by various colored components like blue, green, and red. The rendering is semi-transparent, revealing the internal structure and components. The text "US ITER – State of the Project" is overlaid in white on a dark horizontal band across the center of the image.

US ITER – State of the Project

Near-Term (FY 2014-16) Summary

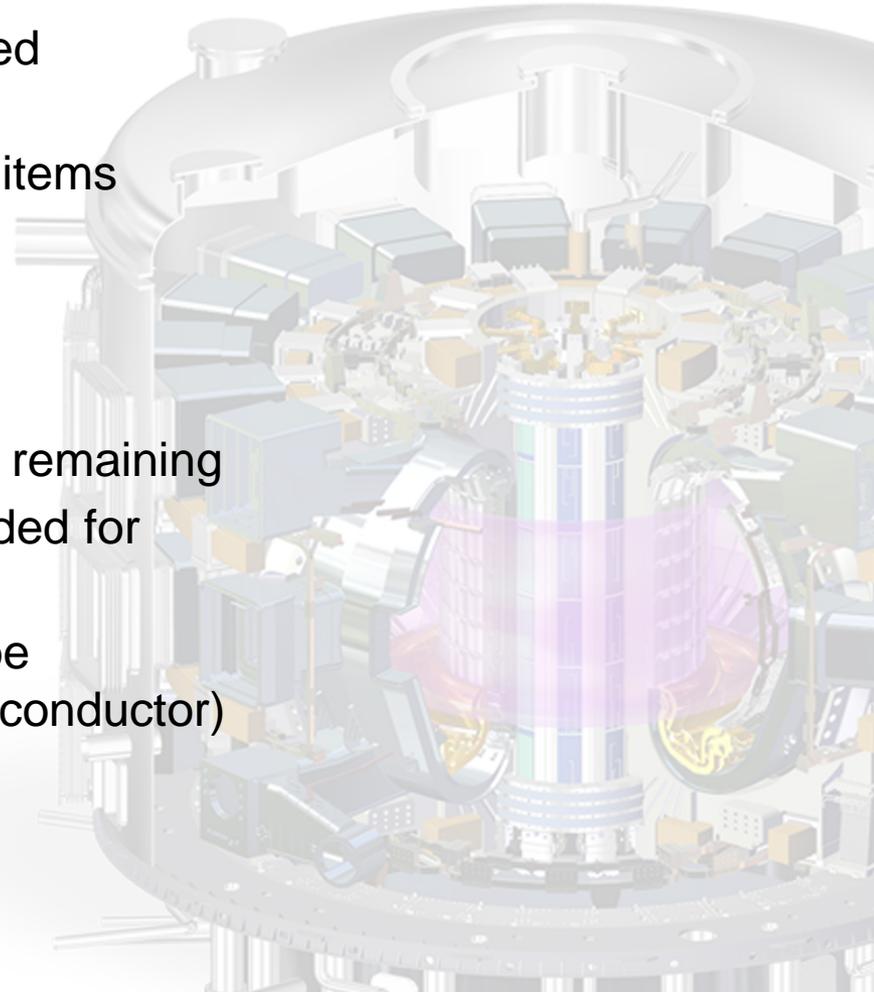


FY14

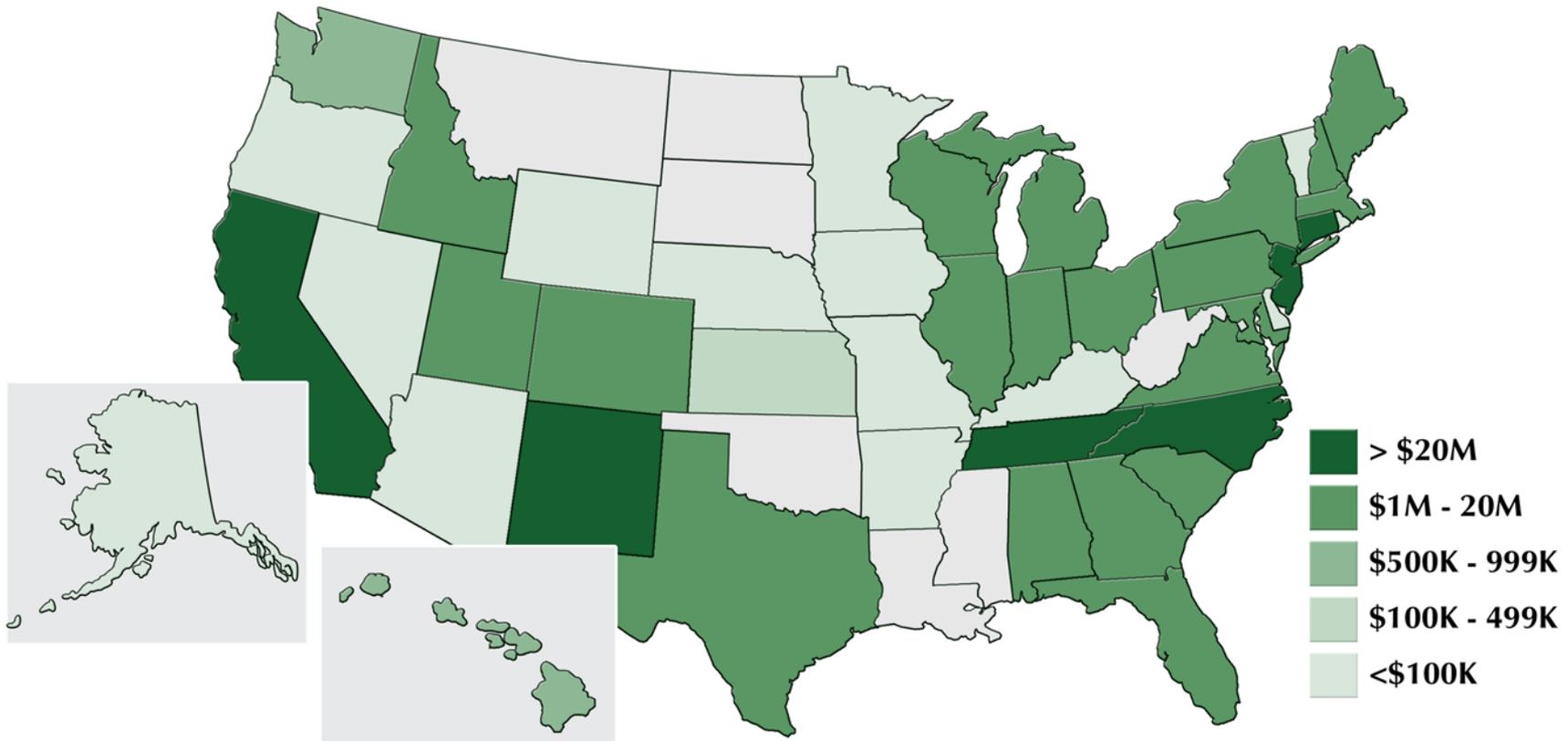
- ~1/2 (by value and number) of all planned contracts have been awarded
- Fabrication underway for critical-pacing items
- Key hardware deliveries on-going

FY15-16

- At the end of FY16
 - Only one procurement arrangement remaining
 - 28% of US hardware deliveries needed for 1st Plasma will be complete
 - One US hardware contribution will be complete in FY16 (toroidal field coil conductor)



Over \$682M in Awards and Obligations



US Industry and University Awards, and DOE Lab Funding: ~\$682M

Data as of September 30, 2014

Note: Data above does not reflect contracts awarded to US industry by the EU (>\$55M)