Perspectives and Planning

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Roadmap for this Talk

- Planning—where we are and where we are going
  - Component fabrication
  - Site construction and assembly
  - System commissioning
- Perspectives—what will we do when we get there?

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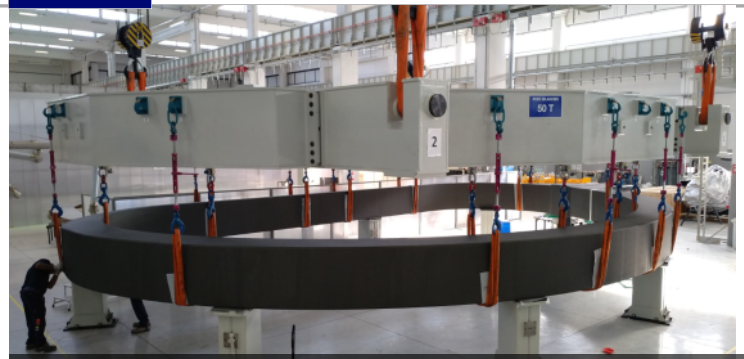
Toroidal Field Coil Fabrication

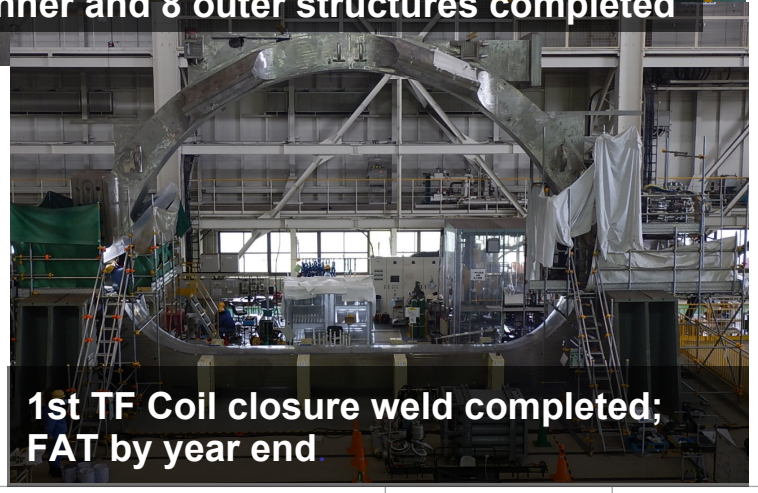


6th (of 10) Winding Packs ready for final assembly; 4WP successfully cold tested.

10 inner and 8 outer structures completed

1st TF coil closure weld completed

- 1st TF coil at IO in Jan 2020
- 8 TF coils by end 2020



1st TF Coil closure weld completed; FAT by year end

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Central Solenoid Progress

CS Module 1 in the Test Station at General Atomics. Photos: GA

- First coil ready for final factory testing
- Expect delivery to IO site by end 2020

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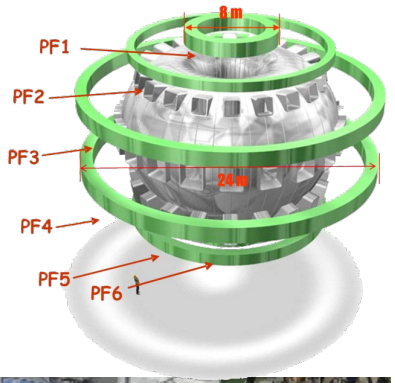
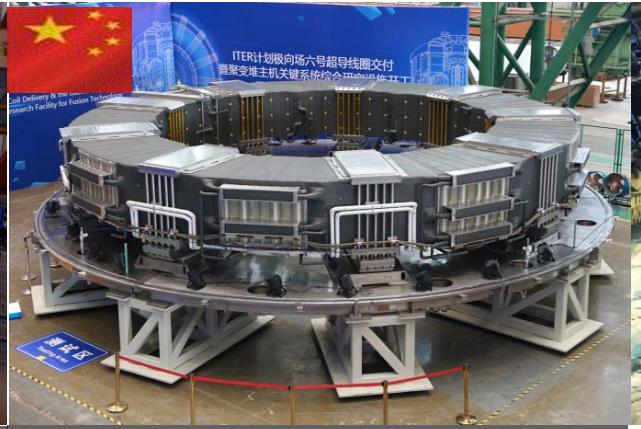
Poloidal Field Coil Production

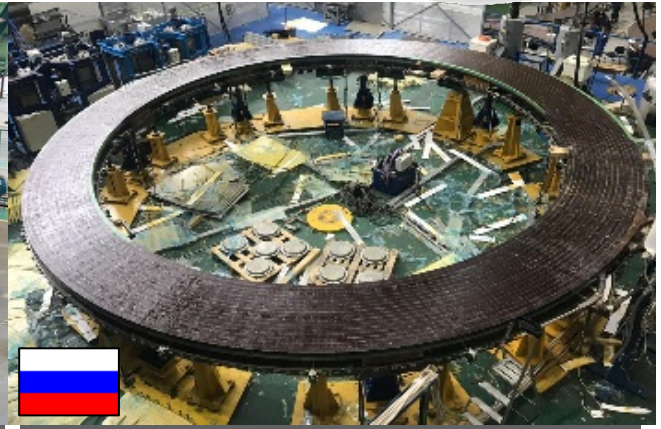
- PF1: final winding and impregnation complete; preparing for assembly; deliver to IO at end 2020
- PF2: 4 of 6 winding assemblies complete; 1 impregnated
- PF5: Completion of winding pack in progress; finalized 2020
- PF6: final assembly complete; undergoing factory testing; delivery 2020



PF5: WP under ground insulation



PF6: Coil during final testing



PF1: Final double pancake

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Vacuum Vessel Progress

- 3 sectors to be delivered in 2020

VV S6 Segment Assembly

S5 Segment-4 T-rib Welding & Segment-2

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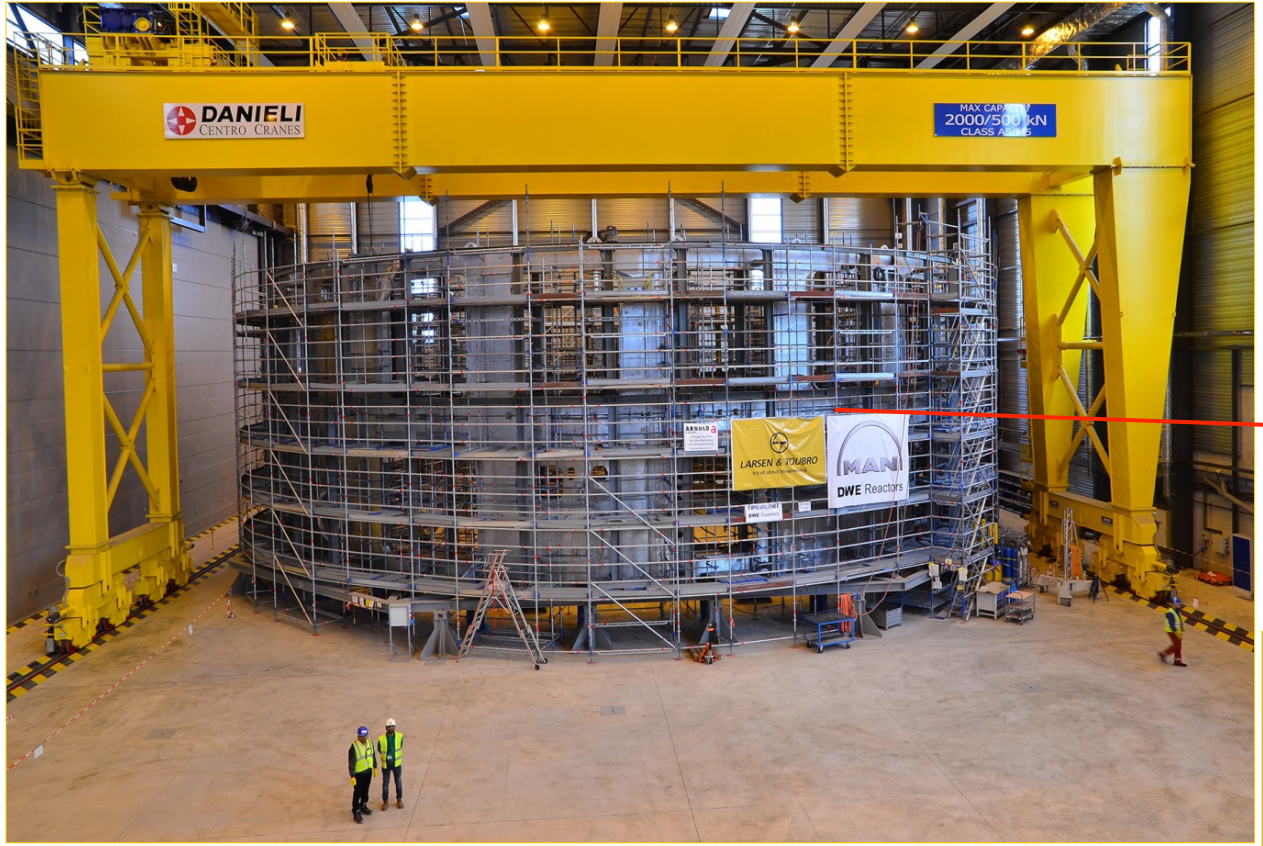
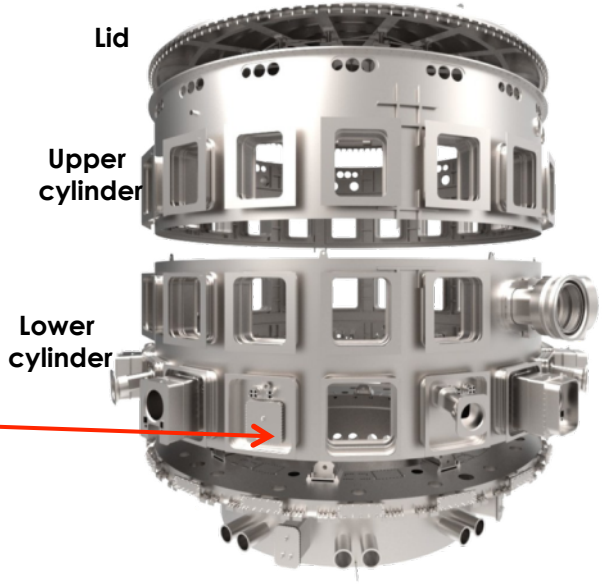
Cryostat Progress





Base section

Base and lower cylinder handed over; upper cylinder welding proceeding on site, lid sectors being fabricated in India

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Rapid Progress Is Being Made in Building Construction

- Concrete works in Tokamak Building are complete

- View in Oct. 2018:

- View in Nov 2019:

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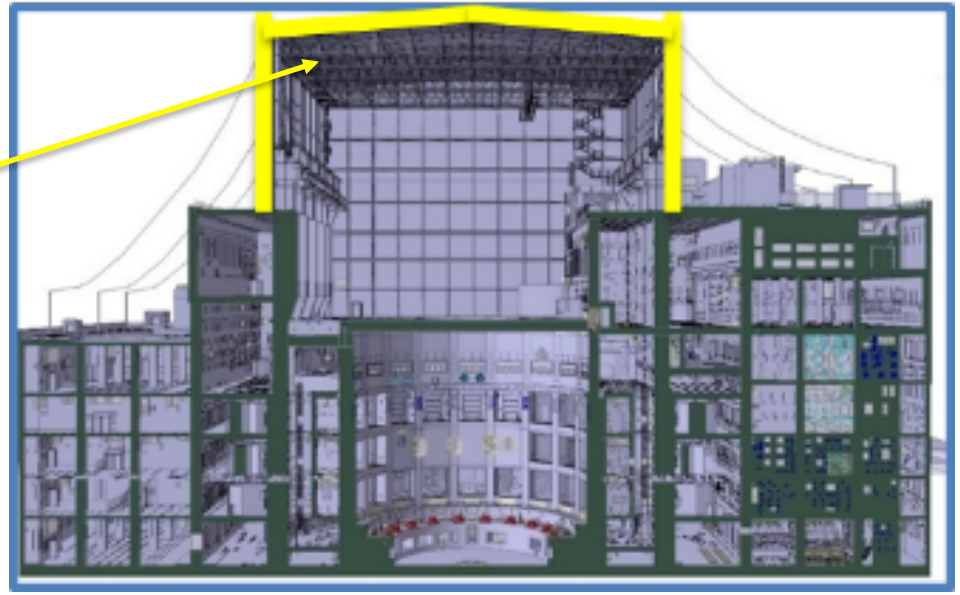
Crane Hall Roof (B11) Steel Structure Progressing



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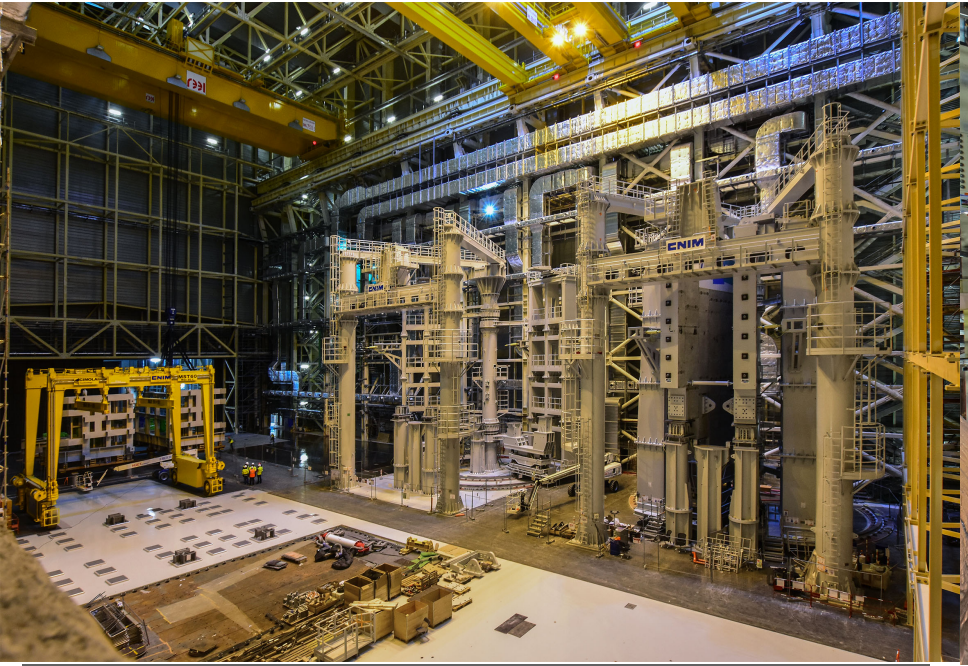
Progress on Assembly Hall and Tools

November 2019



Both Sector Assembly Tools in Place and Tested

Up-Ending Tool Received

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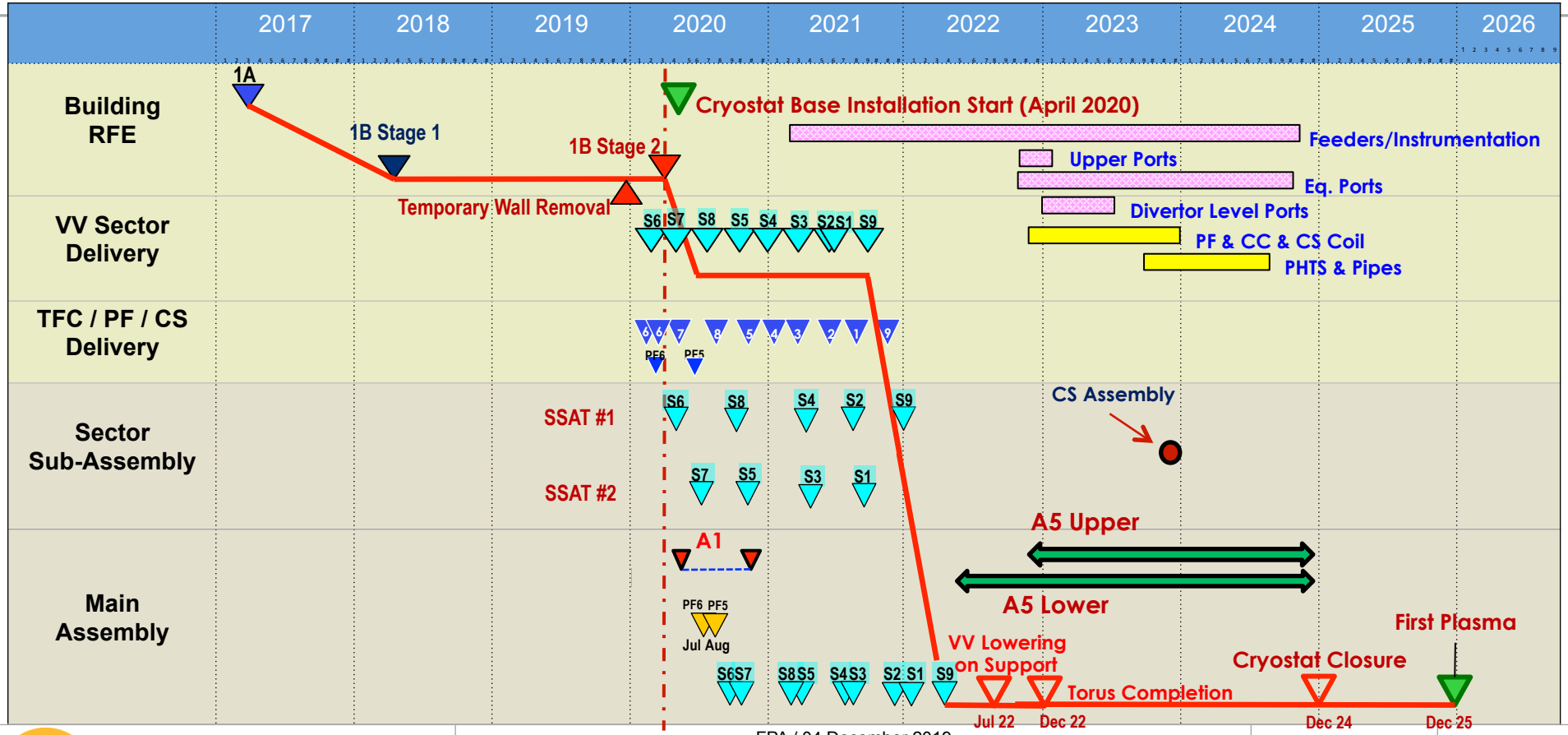
Tokamak Assembly Sequence



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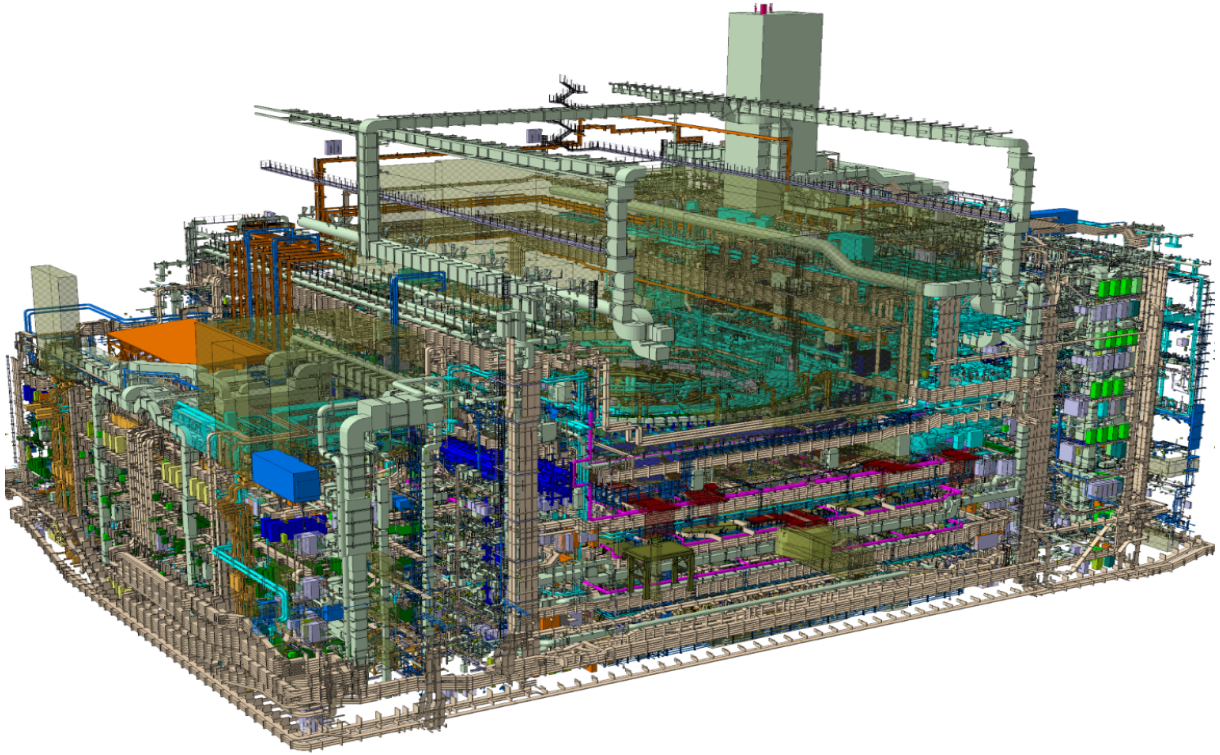
Challenges of Installation

- Significant integration issues for installation of services in the tokamak building
- Special IO team in place to resolve conflicts
- Major assembly and installation contracts signed or nearly finalized



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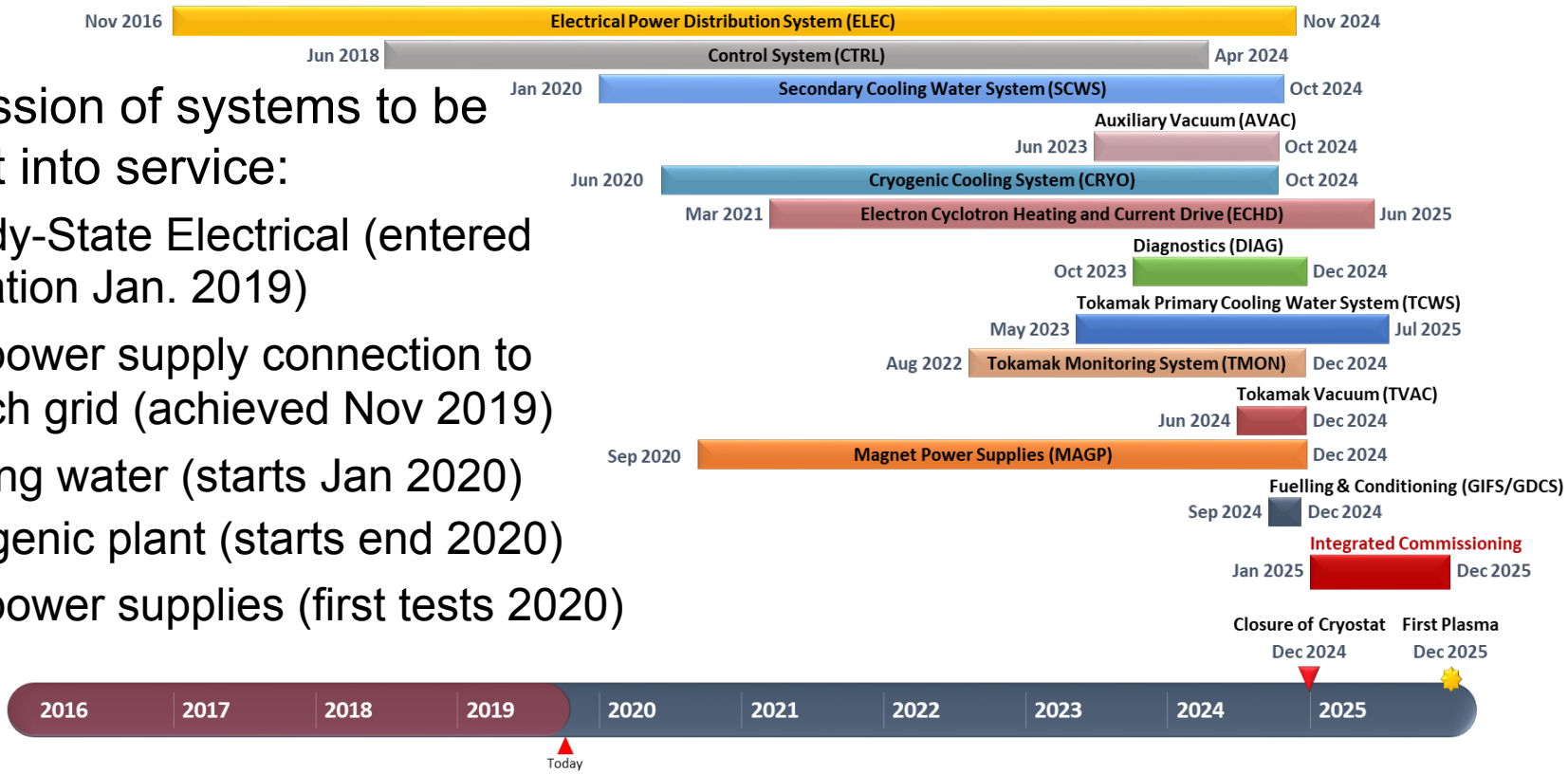
Master System Commissioning Schedule

- Progression of systems to be brought into service:
  - Steady-State Electrical (entered operation Jan. 2019)
  - Coil power supply connection to French grid (achieved Nov 2019)
  - Cooling water (starts Jan 2020)
  - Cryogenic plant (starts end 2020)
  - Coil power supplies (first tests 2020)



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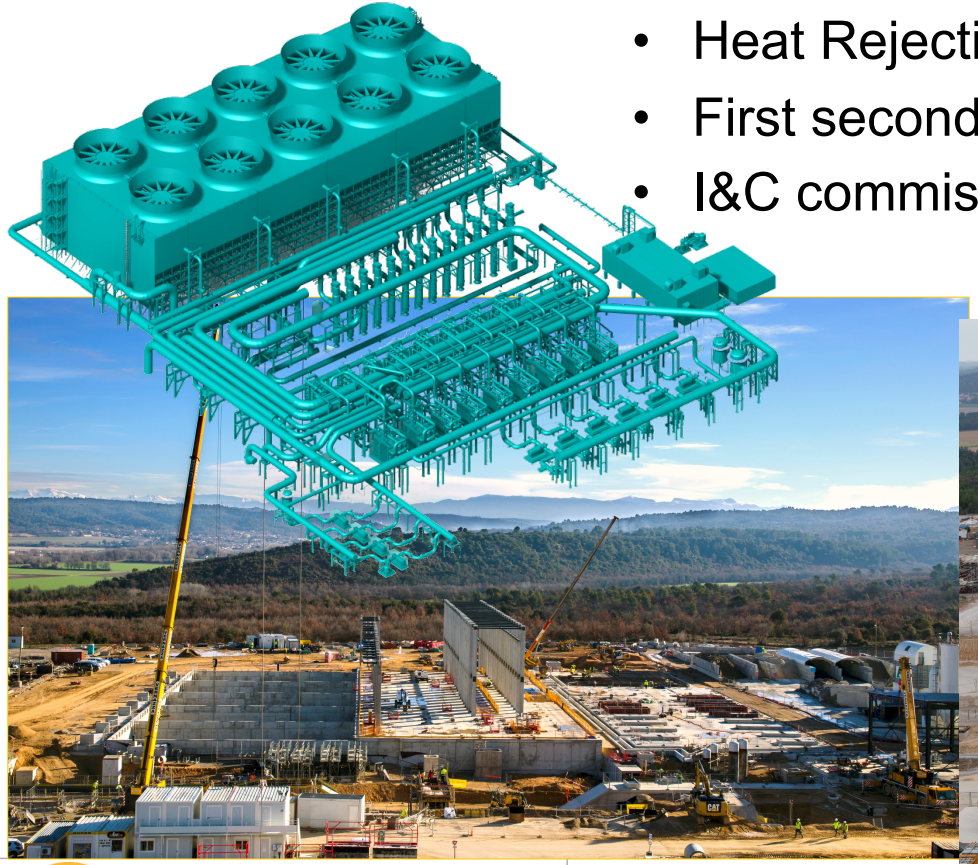
Cooling Water System Is Being Prepared for Operation

- Heat Rejection System complete in March
- First secondary and chilled water systems installed
- I&C commissioning scheduled to begin 6 Jan 2020



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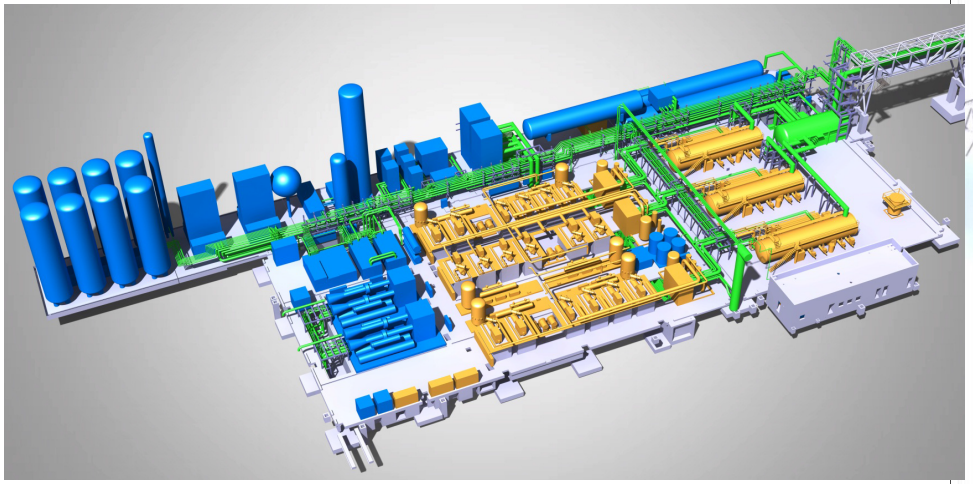
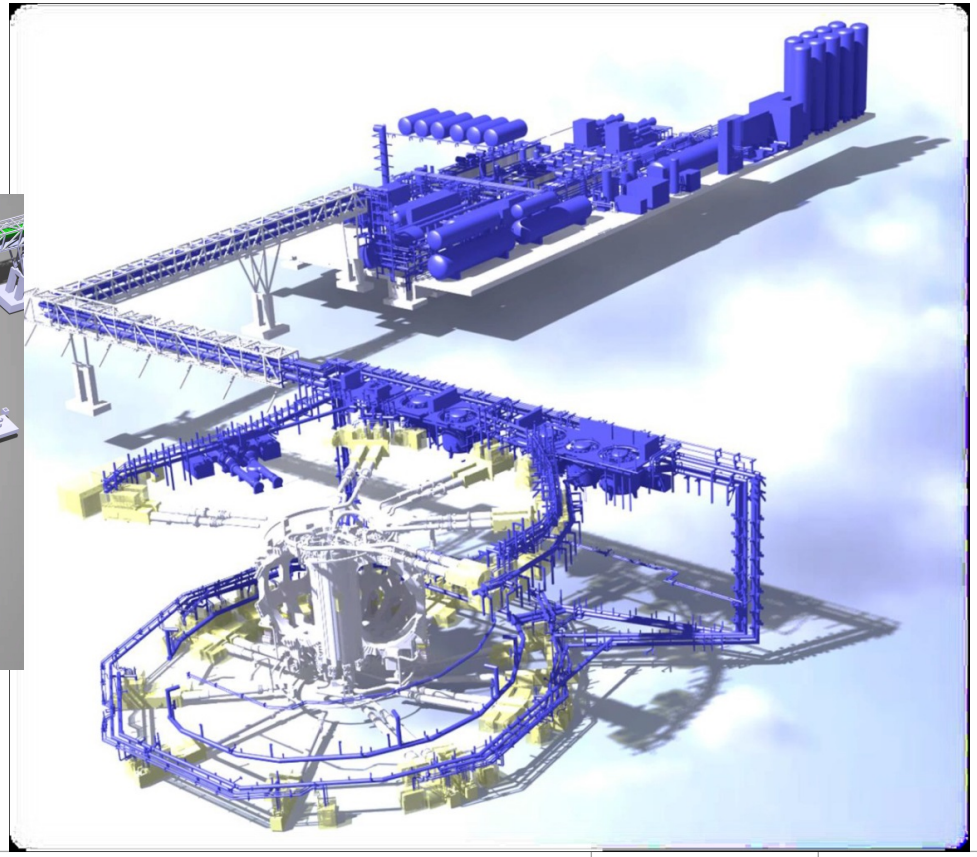
Cryogenic System Commissioning

Nearly 25 tons of liquid helium at 4 K will circulate in the ITER installation during operation.





Liquid Helium Plant
LN2 Plant and Auxiliary Systems
Cryolines, Warm lines & Cryodistribution

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Cryoplant Construction Nearly Complete

The ITER Cryoplant will be the largest single platform cryo-facility in the world. It will distribute liquid helium to various machine components (superconducting magnets, thermal shield, cryopumps, etc.). Installation of 11 helium and nitrogen tanks is now complete.

The installation of helium compressor skids on concrete pads was completed earlier this year. They will supply the cold boxes with gaseous helium at 21.8 bars and eventually provide the necessary gas flow for the supercritical helium cooling needs of the Tokamak.

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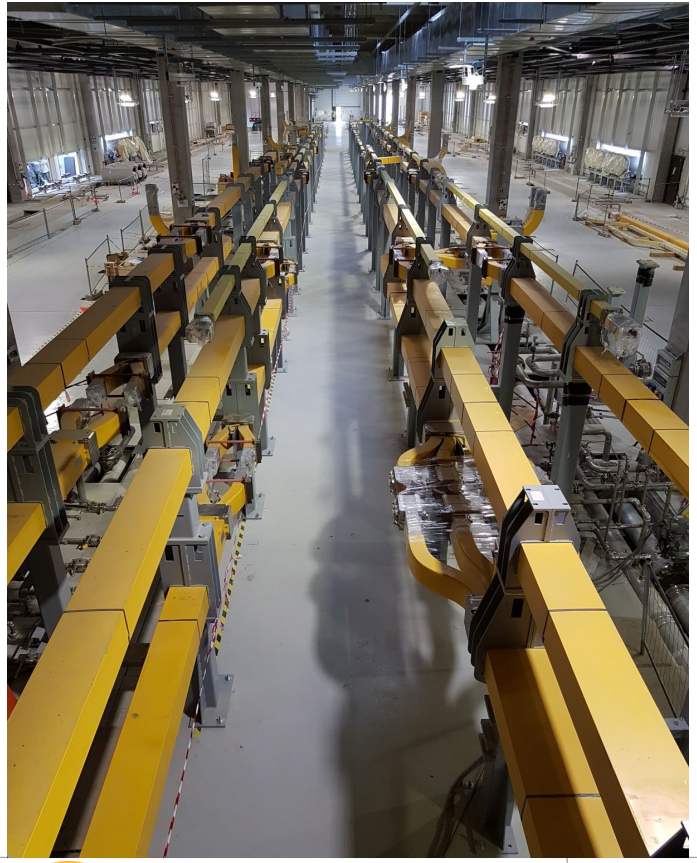
Coil Power Supply Progress



Installation of the DC Busbars in 1st of two buildings completed, works in 2nd ongoing

Installation of Reactive Power Compensation underway

First 400 kV, 300 MVA transformer connected to EU grid

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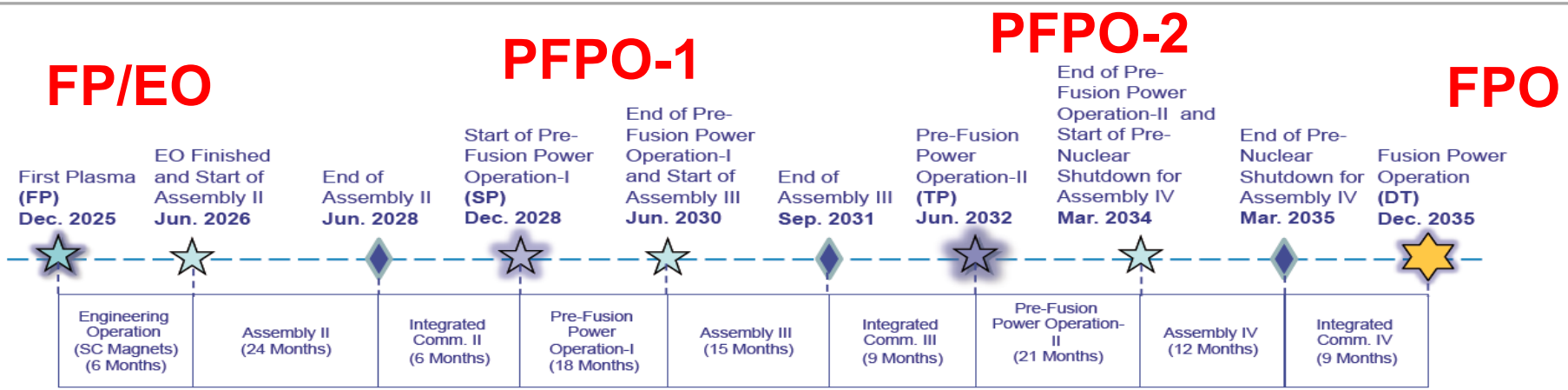
A "Staged Approach" to Full Operating Capacity



- Extensive interactions among the ITER Organization and Domestic Agencies revised baseline schedule (2015-6); still holding to this
  - Schedule estimates through First Plasma (2025) up to DT operation (2035) consistent with Members' budget and technical constraints
- Required a new ITER Research Plan (completed in 2017)

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Perspectives

- ITER will achieve its Project Specifications (500 MW at Q≥10 for >300 s, Q≥5 in-principle steady-state)
- ITER strongly supports (requires?) thriving domestic fusion programs in the Members:
  - Conducting R&D in support of ITER operation
  - Training staff for ITER operation and research
- ITER will only ‘succeed’ if there is something following ITER on a path to fusion energy
  - Significant investments in technology required for fusion are needed to anticipate any potential next step
  - Knowledgeable and <u>experienced</u> scientists and engineers will be needed to translate the ITER results into fusion energy practice

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Challenges Ahead Until Construction Completion

- Maintain project schedule
  - Still holding to the First Plasma 2025 target 4 years into 9 year plan
  - In-kind supply is ~90% of ITER; must be what was specified when it is promised
  - Must execute complex installation and assembly effectively
  - Integrated Commissioning of the tokamak core in 1 year
- Satisfy licensing oversight
  - Must develop an appropriate operations and maintenance culture (beyond present fusion experience), building trust with the regulator

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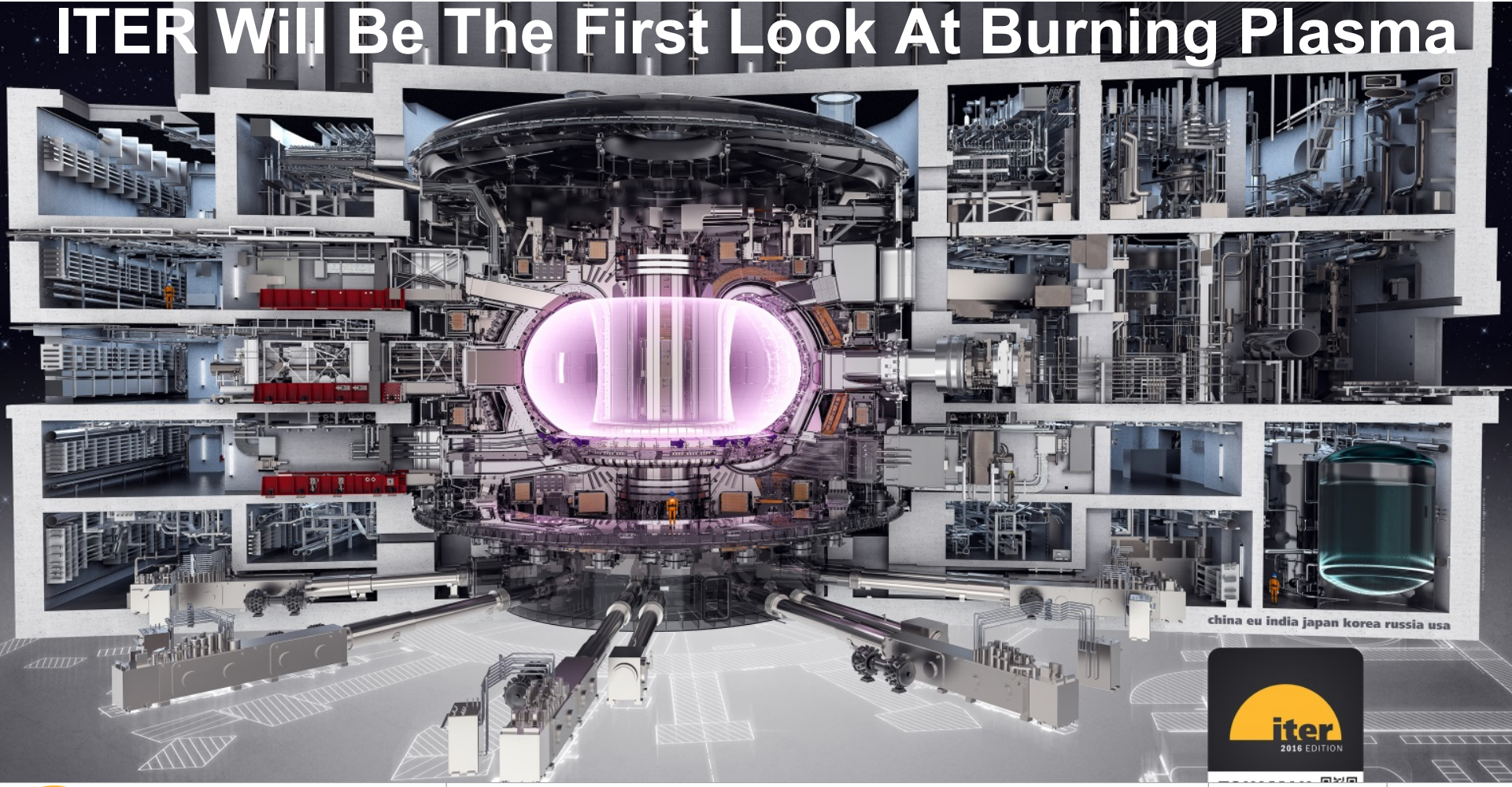
ITER Will Be The First Look At Burning Plasma



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