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### An update on project progress

Fusion Power Associates, Washington, DC 7 December 2017 Bernard Bigot, Director-General, ITER Organization

## **Presentation Outline**

- Organizational update
- Worksite progress
- Manufacturing progress
  - ITER "Value": the U.S. investment



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## **Organizational Update**

#### 2015-16: managing the need for change

- Integrated structure, clear decision-making processes
- Comprehensive integrated scientific/technical review
- Finalization of design for critical path components
- Delivery of updated resource-loaded schedule
- Promotion of ITER-wide project culture
- Strengthened risk management, systems engineering, Central Integration Office



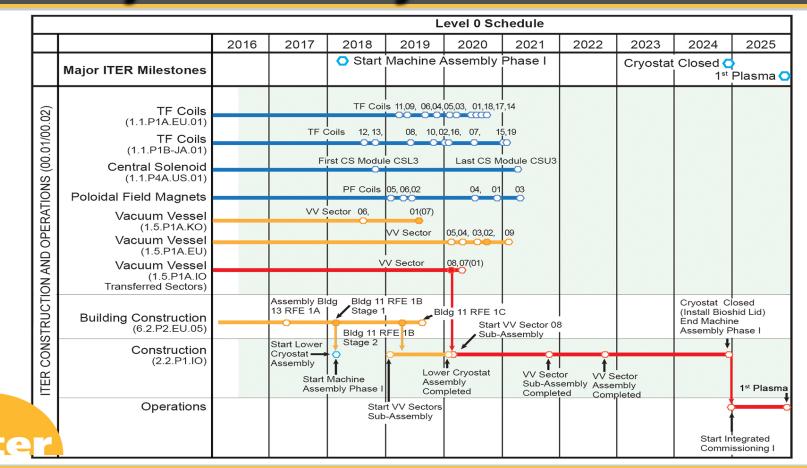
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#### 2016-17: external validation, performance to commitments

- External validation:
  - ITER Council Independent Review Group (April 2016)
  - Positive report, U.S. Secretary of Energy (May 2016)
  - ITER Council approval of overall project schedule and cost (November 2016)
  - Communication from European Commission Energy Directorate (June 2017)
  - External reviews: Risk Management (Apr. 2017); Interface Freezing (Sept. 2017)
  - Fast-paced physical progress: successful delivery of all Project Milestones
    - Project remains on schedule, on budget (November 2017)

#### November 2017: reached 50 percent of "total construction work scope through First

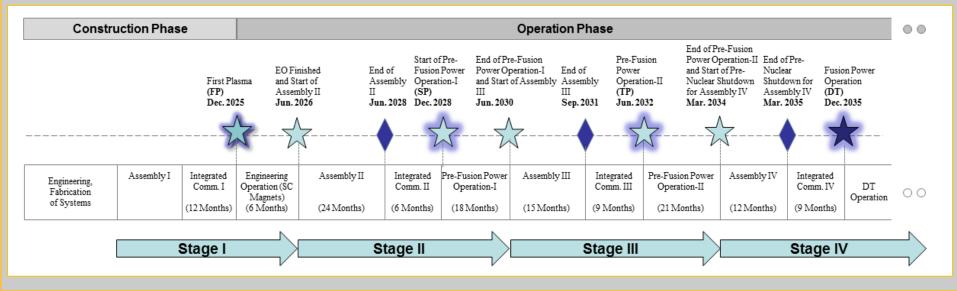
#### **Major assembly milestones**



### Staged approach to DT plasma

#### Extensive interactions among IO and DAs to finalize revised baseline schedule proposal

- Schedule and resource estimates through First Plasma (2025) consistent with Members' budget constraints
- Use of 4-stage approach through Deuterium-Tritium (2035) consistent with Members' financial and technical constraints



#### Worksite Progress

The European Domestic Agency, Fusion for Energy, has now completed 42 percent of work on site and signed 74 percent of work contracts.

## Worksite progress

Erecting the steel skeleton of the Assembly Building

MANANANA

#### February 2015

Storage Area 2

### Worksite progress

PF Coils Building

ITER HQ

Transformers

400 kV switchyard

Storage Area 3

Assembly Hall (Under construction)

Foundation works Cleaning Facility

> Cryostat Workshop (now receiving components)

Preparatory works RF Heating Building

**Batching Plant** 

Preparatory works Cooling Water Building

> Preparatory works Control Building

Tokamak Complex (Under construction)

Magnet Conversion Power

**Preparatory works** 

Foundation works Cryogenics Building

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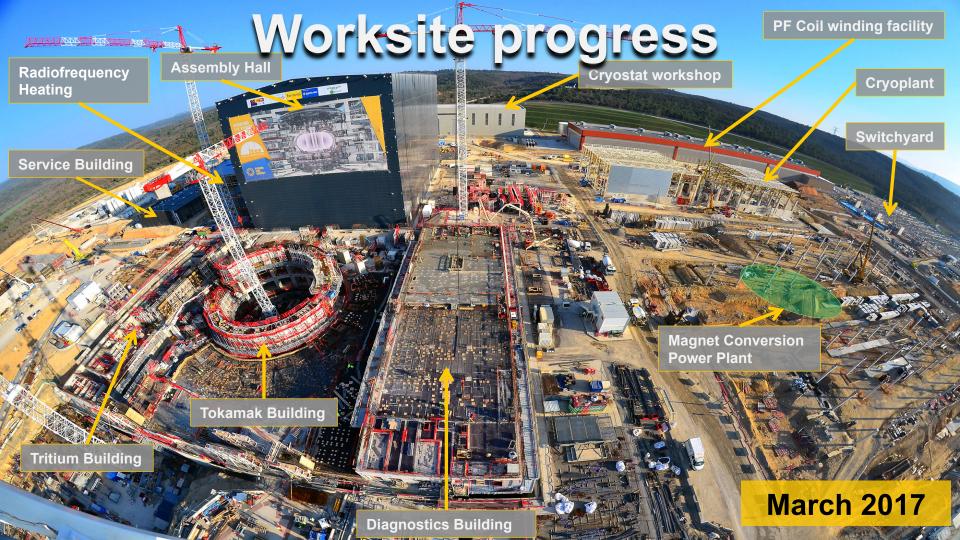
Subcontractors Area

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HQ Extension

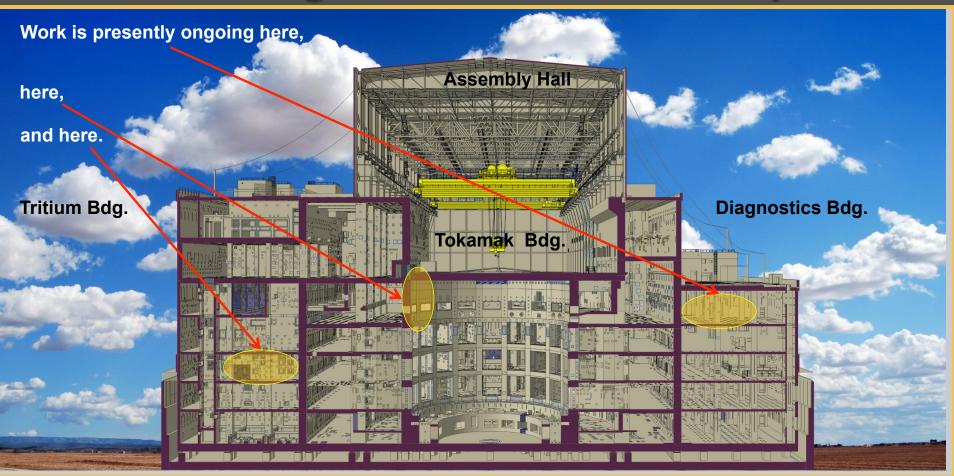
Storage Area 1







#### Worksite Progress: Tokamak Complex



#### Worksite Progress: Tokamak Complex



The openings in the bioshield wall are for the cryostat bellows that will connect the machine to the port cells designed to give access to systems such as remote handling, heating and diagnostics.

#### Worksite Progress: Tokamak Complex



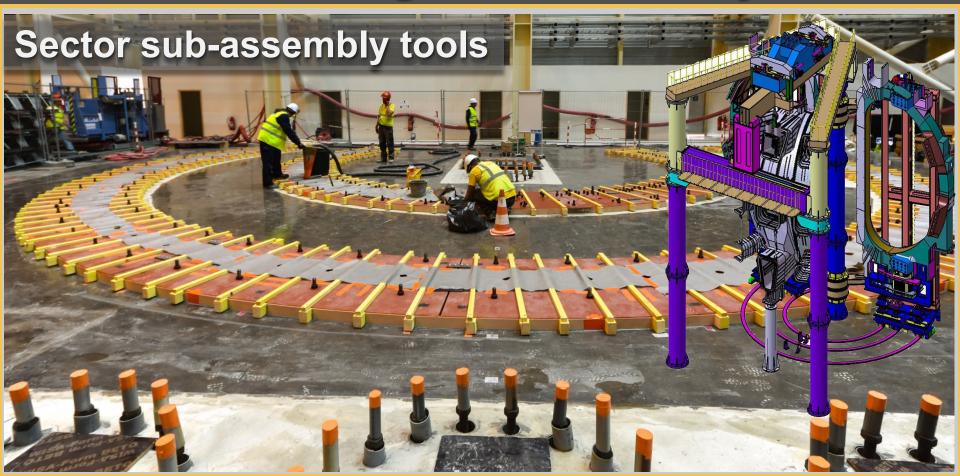
Eighteen massive columns will provide structural support to the Tokamak Complex. Here at the L2 level of the Tokamak Building, concrete is being poured into one of these "mega columns."

#### Worksite Progress: Assembly Hall



Before being integrated in the machine, the components will be prepared and pre-assembled in this 6,000 m2, 60-metre high building. The Assembly Hall is equipped with a double overhead travelling crane with a total lifting capacity of 1,500 tons.

#### Worksite Progress: Assembly Hall



#### Worksite Progress: Cryostat Workshop

May 2017: Tier-1 of the cryostat base (front) is being finalized; a second assembly frame for the lower cylinder (back) is being prepared.

#### Worksite Progress: Cryostat Workshop

Manufactured in India, the 30 m x 30 m cryostat (the insulating vacuum vessel that encloses the machine) is being assembled and welded on site. The base is in the last stage of completion.

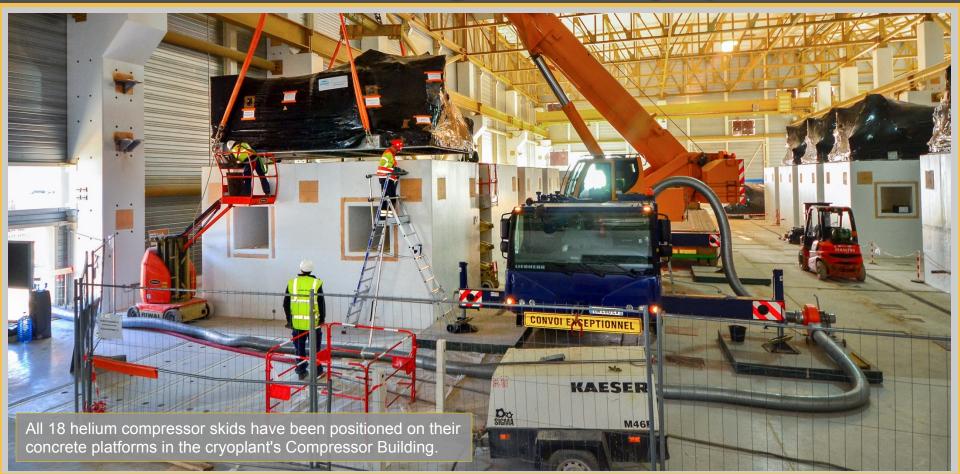
November 2017

#### Worksite Progress: Cryoplant

The ITER Cryoplant will be the largest single platform cryofacility in the world. It will distribute liquid helium to various machine components (superconducting magnets, thermal shield, cryopumps, etc.).

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#### Worksite Progress: Cryoplant



#### Worksite Progress: Radiofrequency Heating



systems (microwave and radio frequency) is ready to be equipped.

#### Worksite Progress: Electrical Network



#### **Worksite Progress: Magnet Power Conversion**

1000 min Two large Magnet Power Conversion buildings will host the AC/DC transformers and converters feeding power to the ITER magnets.

#### Worksite Progress: PF Coil Winding



Too large to be transported by road, four of ITER's six ring-shaped magnets (the poloidal field coils, 8 to 24 m in diametre) will be assembled by Europe in this 12,000 m<sup>2</sup> facility.

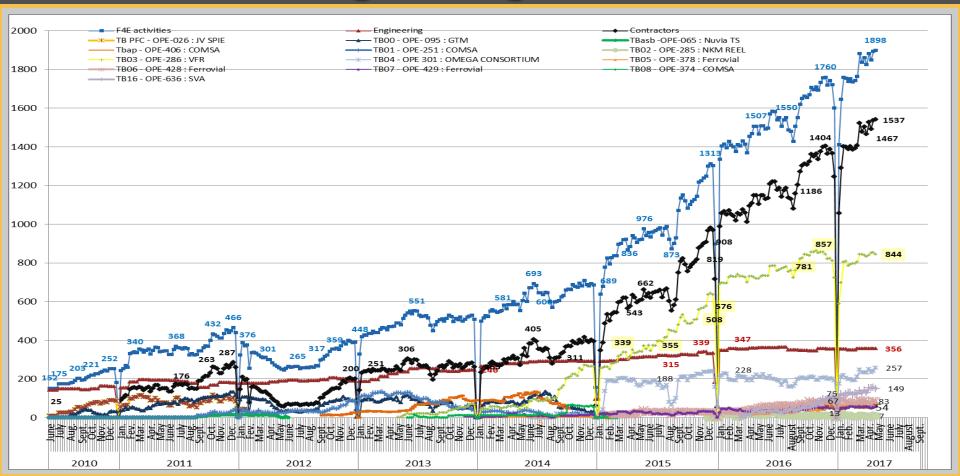
### Worksite Progress: Cooling water system



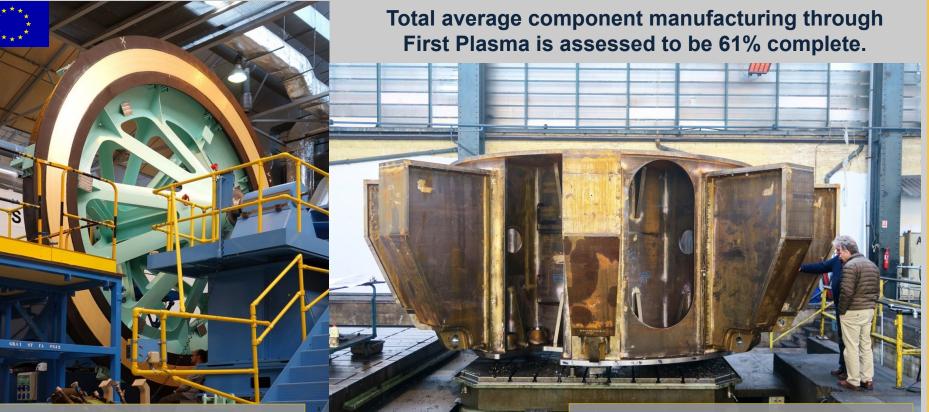
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#### Worksite Progress: growth in workers



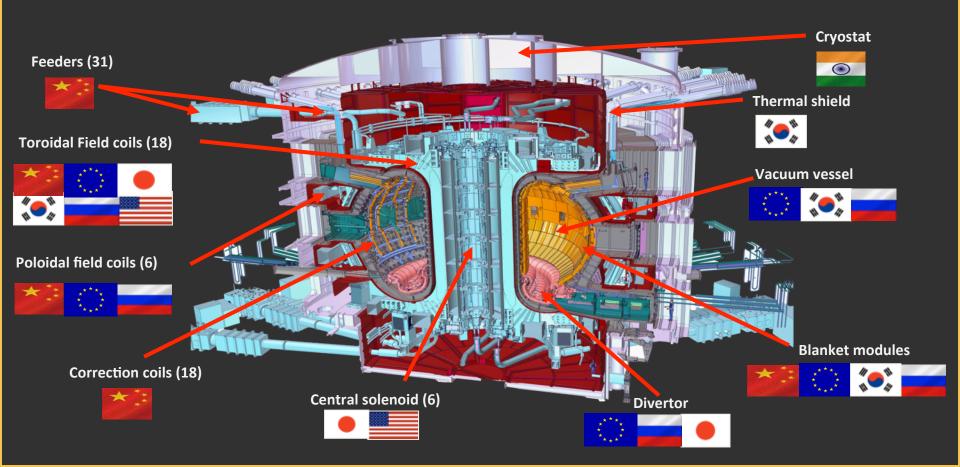
### **Manufacturing Progress**



Testing of pre-compression rings in Europe

US supplies specially designed platform for on-site assembly of central solenoid structure

#### Who manufactures what?





General Atomics is fabricating the 1000-ton Central Solenoid (CS). Pictured is the first production module. Each module requires approximately 6,000 meters of niobium-tin (Nb3Sn) conductor.



The top plate of the central solenoid assembly platform during fabrication at Robatel.

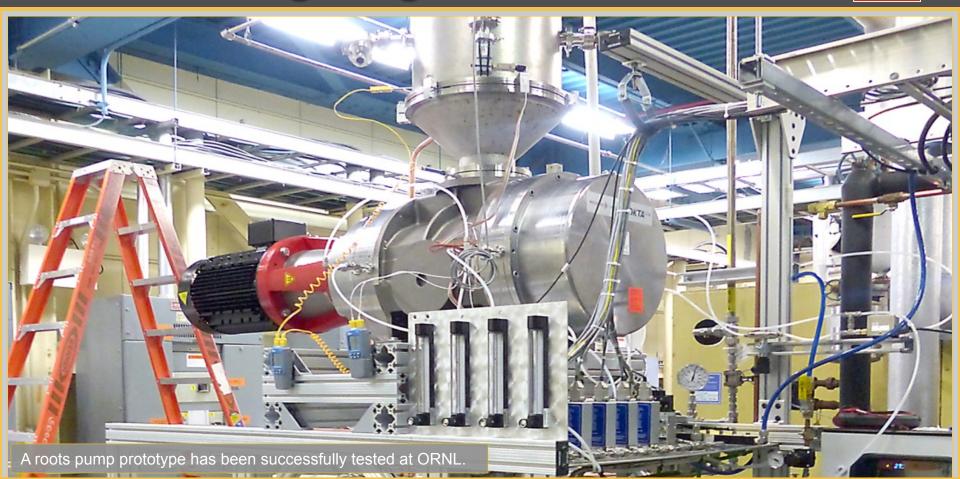


Forging of a tie-plate first article. The tie-plates are part of a substantial structural cage surrounding the central solenoid magnet.



Fabrication of Tokamak cooling water system piping is underway at Schulz Xtruded Products in Robinsville and Hernando, Mississippi. Thirty-six kilometres of nuclear grade stainless steel piping is required







The U.S. completed its 35<sup>th</sup> and final shipment of components for the steady state electrical network in October.

The U.S. is contributing 75% of components for the SSEN; Europe will contribute the remaining 25%.



#### **Manufacturing Progress – China**



The series production of poloidal field AC/DC converters is underway in China, following the successful testing of the first prototype unit.

### **Manufacturing Progress – China**



The heaviest of ITER's ring magnets, poloidal field coil #6, is taking shape at the Chinese Institute of Plasma Physics ASIPP.

#### **Manufacturing Progress – Europe**



The first toroidal field coil winding pack – the 110-ton inner core of ITER's TF Coils - was completed in April.

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## Manufacturing Progress – Europe



The pre-production cryopump was delivered in August. More than 15 companies in Europe were involved in its manufacturing,

## **Manufacturing Progress – India**



Cryolines being loaded in India; and then, following a one-month sea voyage and a brief trip along the roads of Provence, the first batch of cryolines has been unloaded on site. Five kilometres of these complex multi-process vacuum-insulated lines will deliver cooling power from the cryoplant to systems that need it such as the ITER magnets and cryopumps.



## **Manufacturing Progress – India**





## Manufacturing Progress – Japan

At Mitsubishi Heavy Industries' Kobe plant one of the world's largest milling machines is turning out the main structural element of the TF magnet system

## Manufacturing Progress – Japan



## Manufacturing Progress – Korea



Four of nine vessel sectors are under construction at the Hyundai Heavy Industries shipyard in Ulsan.

## Manufacturing Progress – Korea



Elements for the massive 800-ton Sector Sub-Assembly Tools are being delivered to ITER. The first tool is now being assembled.

### Manufacturing Progress – Russia

Manufacture of 18 extensions for port subs (PSE) have been subcontracted to a German company. PSE #12 is shown being finalized.

## Manufacturing Progress – Russia

Prototypes of electrical equipment (fast discharge systems, DC power supply bars, etc.) have been tested and qualified at the Efremov Institute in St. Petersburg.

## **ITER "Value": Economic Benefits**

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Over € 8,5 billion in construction and fabrication contracts

**ITER** 

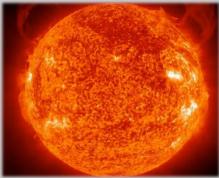
## ITER "Value": the U.S. Investment

#### The ITER Mission: a "burning plasma" at full scale

• A unique opportunity fir research to experience the associated phenomena and properties. For optimization

#### **The Promise of Fusion Power**

• A clean, safe, and virtually unlimited energy source





#### The ITER Cost Structure: highly leveraged, lowered risk

- Unlike most other U.S. multinational engagements
- U.S. pays only 9.09% of ITER cost; Europe covers 45.46%
- Nearly 90% of U.S. ITER Funding has remained in the U.S.

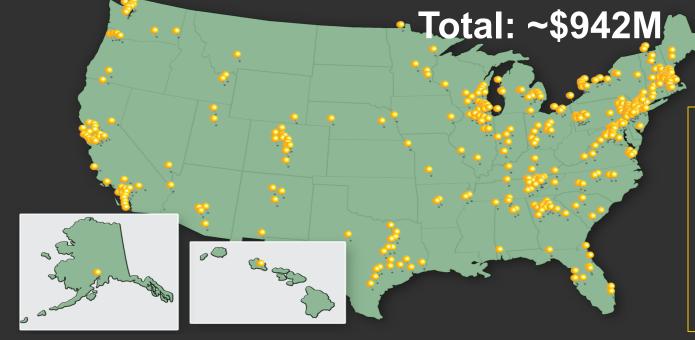
Credibility as an International Partner in Big Science

- No ITER Member capable of building ITER alone
- Pooling of scientific expertise, industrial capabilities
- An unprecedented model of constructive cooperation

Our commitment: to provide best "return on investment" to the U.S. and all ITER partners.

## ITER "Value": the U.S. investment

600+ contracts awarded to U.S. industry and universities and obligated to DOE national labs in 44 states; 500+ direct jobs and 1100+ indirect jobs created or maintained per year.



Another \$55 million awarded to U.S. companies by other ITER Members

About \$145 million paid to ITER for design, construction, and installation.

## ITER "Value": the U.S. Investment

#### Expanded industrial capacity and expertise

• Materials science, superconductors, robotics, cryogenics, explosive metal forming, power electronics, etc.

#### Spin-off technologies that emerge from ITER

- Ground-breaking science, cutting-edge engineering
- Constant stream of technology innovation
  - Example: General Atomics created the new EMALS system for launching jets from U.S. aircraft carriers based on expertise gained in fusion R&D.





china eu india japan korea russia usa

## **Compare**: ITER's overall construction cost is in the range of **€20 billion**.

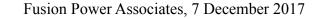
- Roughly **\$1 trillion** spent on 3,400 deep water oil wells. *(Houston Chronicle,* March 2017);
- Europe spends <u>€1 billion per day</u> on petroleum imports.

## **ITER is moving forward!**

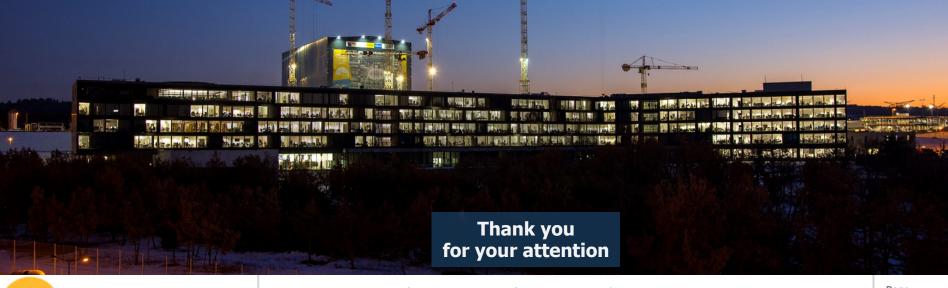
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# **ITER is moving forward!**



# ITER is moving forward!



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