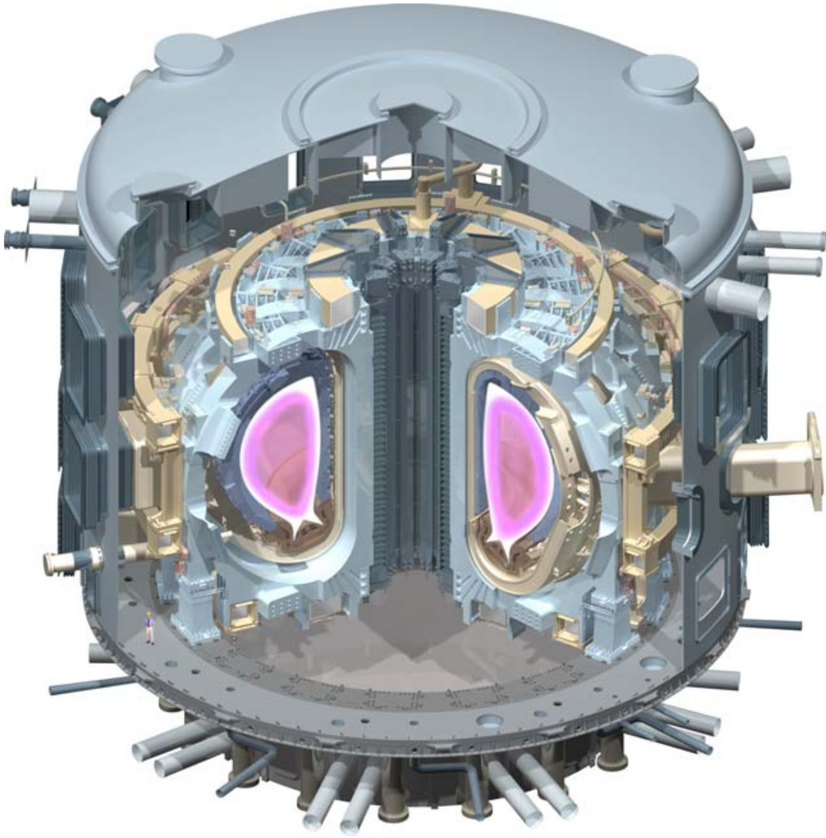
# Status of the ITER Project: U.S. Domestic Agency



**Ned Sauthoff**

**Director, U.S. ITER Project Office**

**FESAC**

**Gaithersburg, MD**

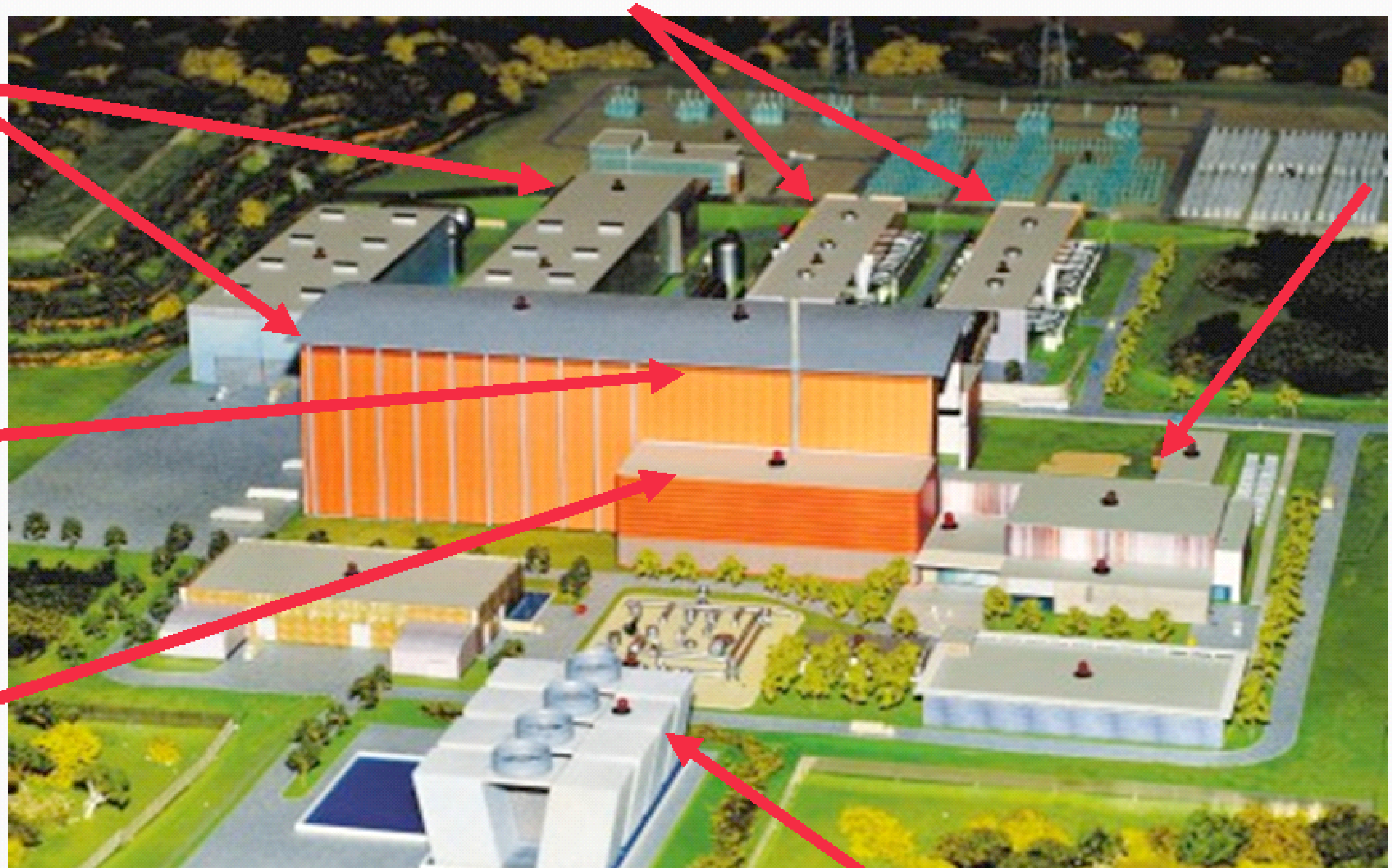
**November 6, 2008**

# Model of the ITER Site

Magnet power convertors buildings

Cryoplant buildings

Hot cell



Tokamak building

Tritium building

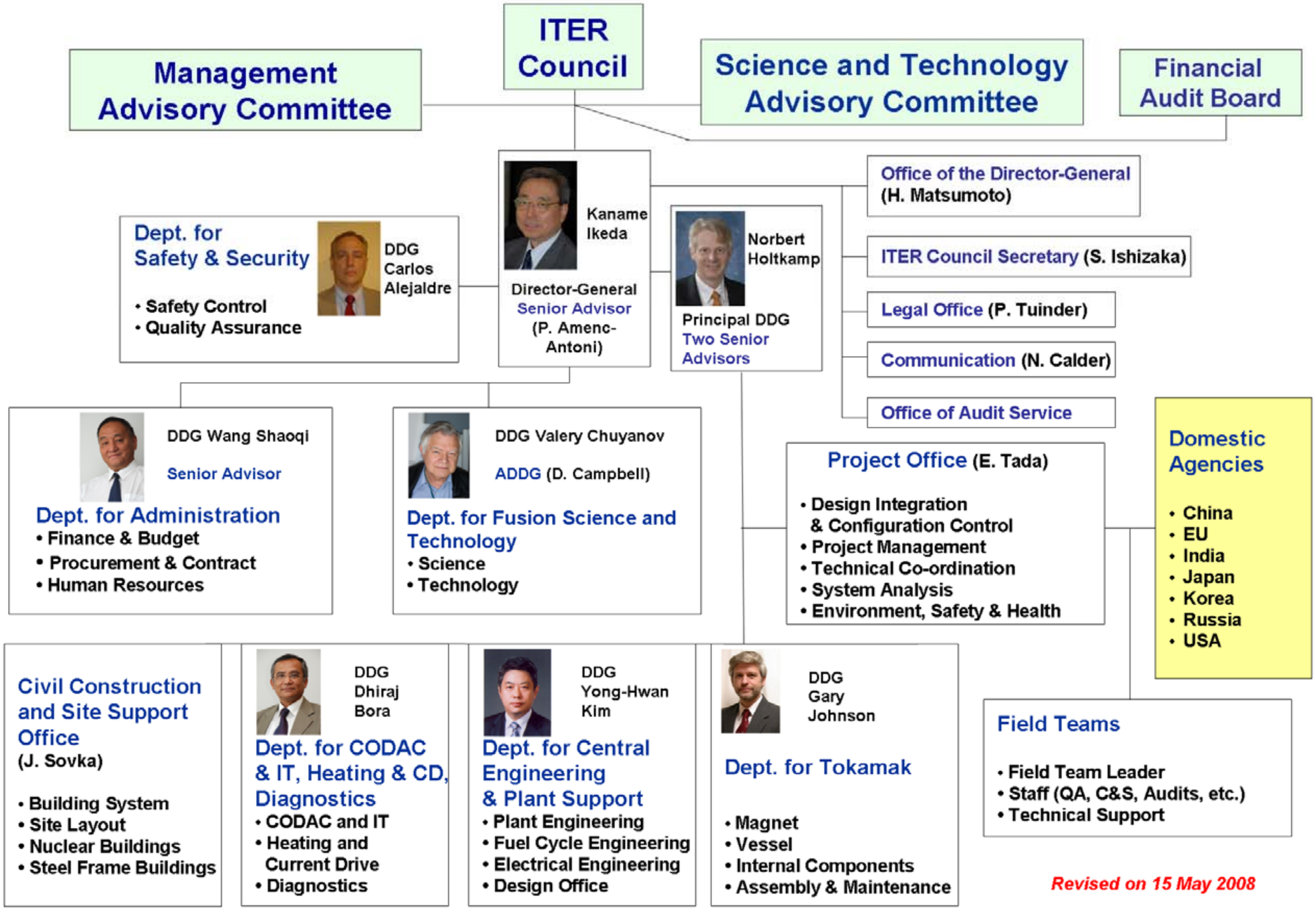
Cooling towers

- Will cover an area of about 60 ha
- Large buildings up to 170 m long
- Large number of systems

# ITER Construction Site / AIF



# ITER Organization




*Revised on 15 May 2008*

# Staffing Status
## by the end of 30 September 2008

- As of 30 September 2008, IO has a total of 276 staff, including 207 professional staff and 69 technical support staff;
- 104 posts were in the recruitment process (80 new and the rest replacement or reposted positions) .

**Professional staff by Members by 30 September, 2008: Total 207**

CN: 15

EU: 122

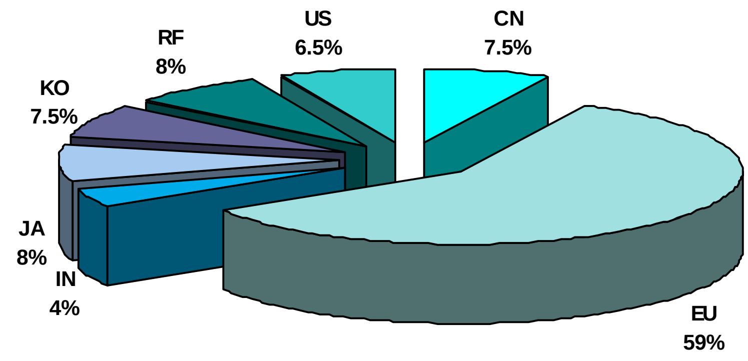
IN: 8

JA: 17

KO: 15

RF: 16

US: 14

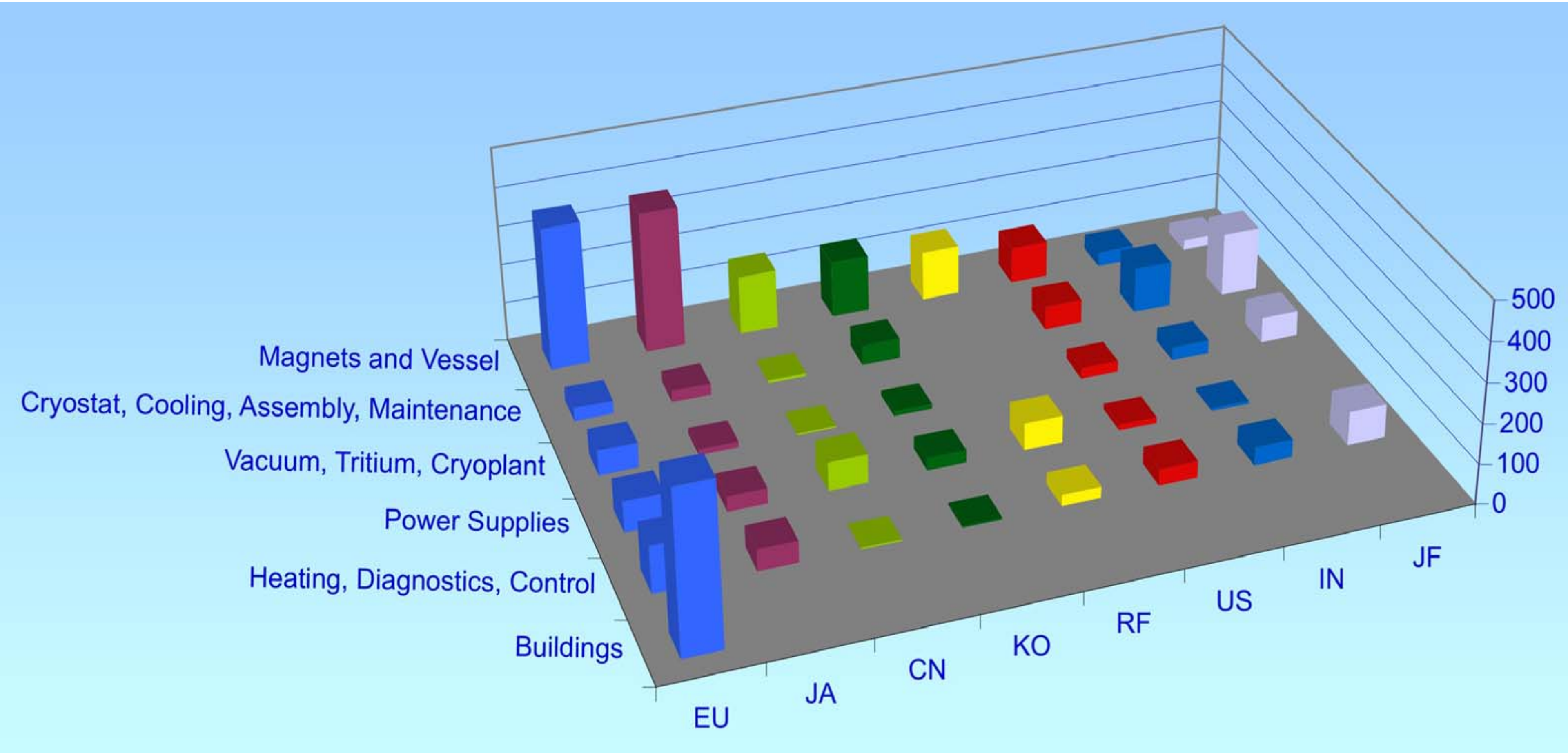


# Procurement Sharing

How the overall costs are shared:

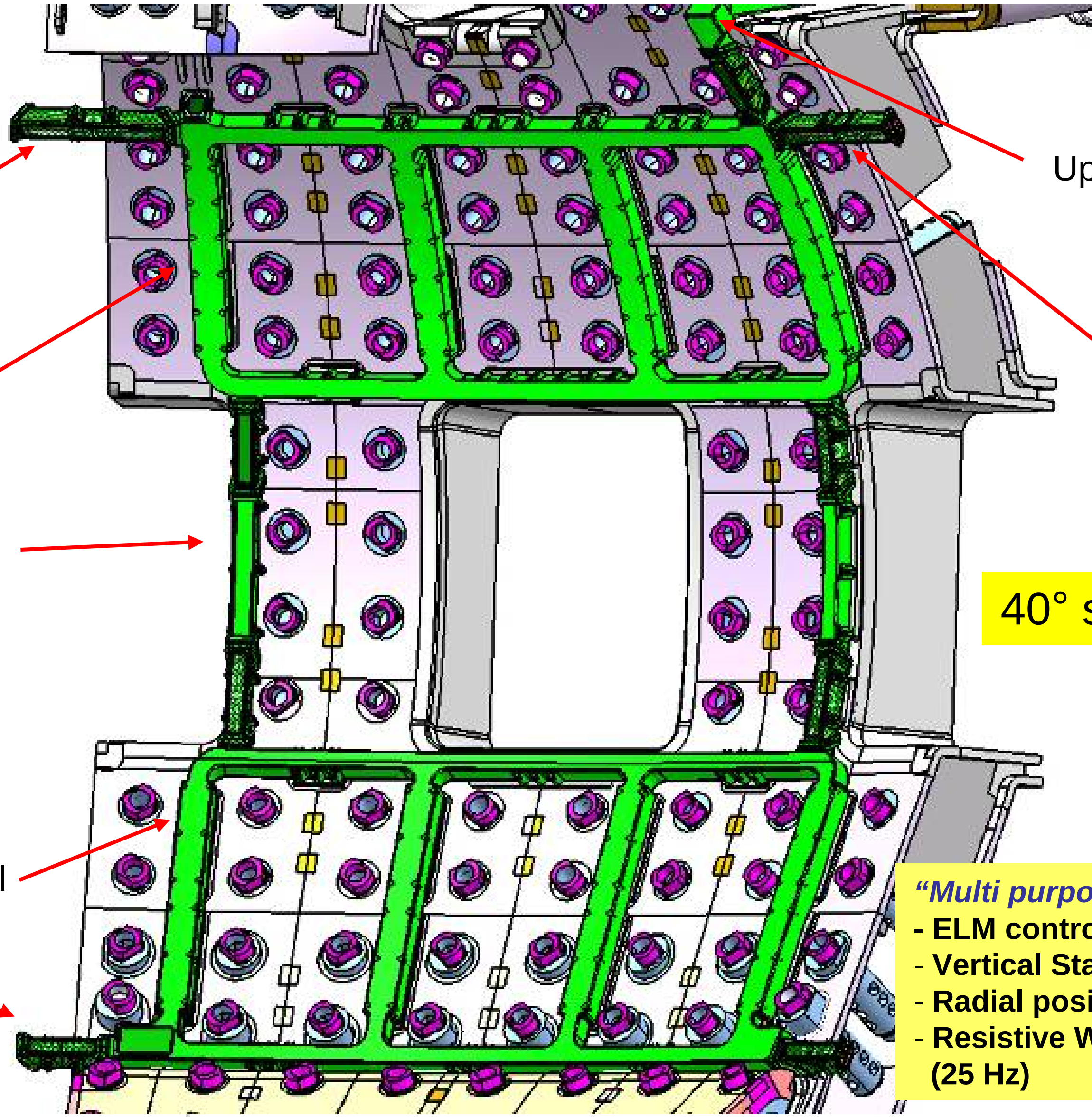
EU 5/11, other six parties 1/11 each. Overall contingency of 10% of total. Total amount: 3577 kIUA (5.365 Mil € / 2008)

A unique feature of ITER is that almost all of the machine will be constructed through *in kind* procurement from the Parties



# ELM & VS coils – layout of reference option

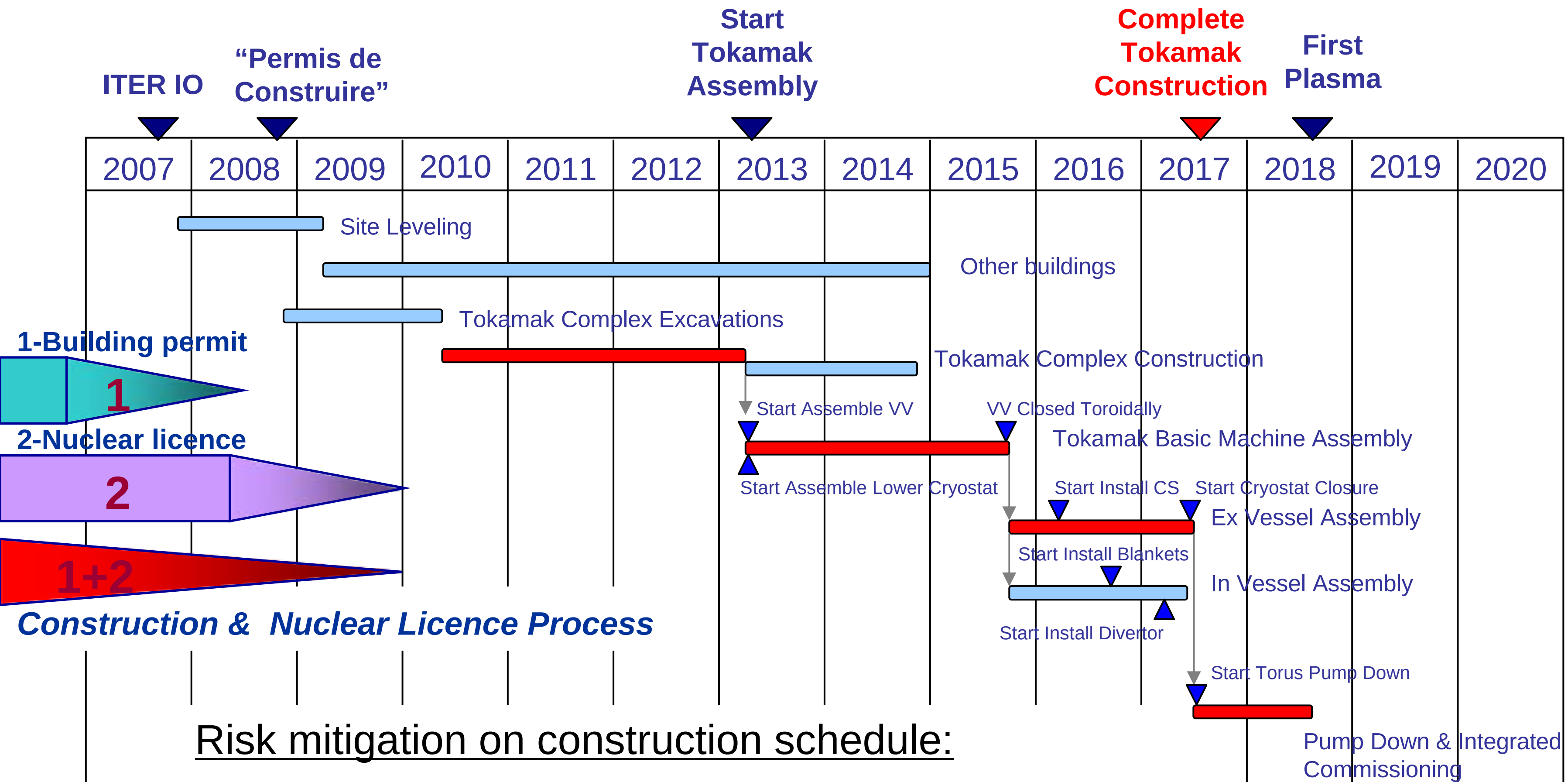
**VAC-02 - 3 rows – 9 coils**




***"Multi purpose" in vessel coils:***

- **ELM control (~2Hz),**
- **Vertical Stability control**
- **Radial position control**
- **Resistive Wall Mode (RWM) control (25 Hz)**

# The Schedule




<u>Risk mitigation on construction schedule:</u>

- Parallel Approach to Construction and Nuclear Operation Permit: Agreed with ASN!
- Pre A/E contract (>6M€ from EU) signed and manpower started to mobilize

# Design Review and STAC issues

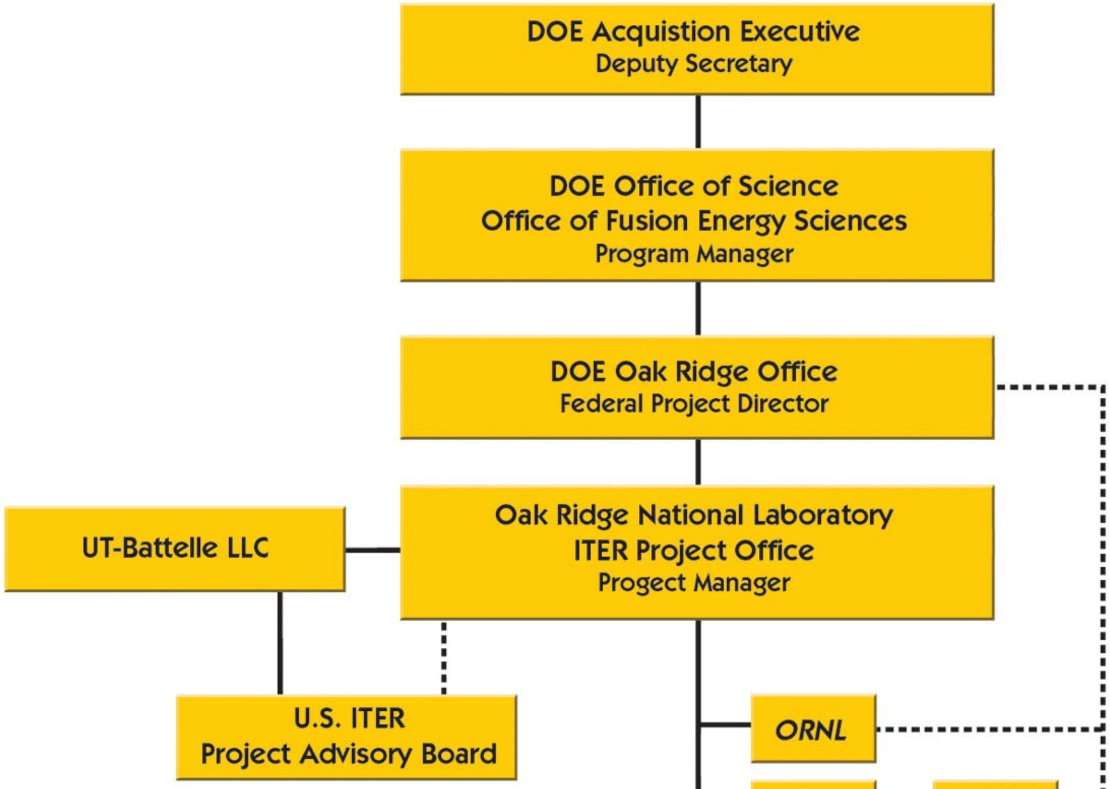
- **Design Review**
  - Completed September 2007
  - U.S. provided roughly 25% of the professional person years provided by the parties
- **Resolution of issues identified by the Science and Technology Advisory Committee**
  - U.S. provided 36% of the professional person years provided by the parties

# Areas of On-going Advancement

- **IO-DA project refinements**
  - cost-estimate
  - schedule
  - project management tools/systems

- **IO-DA completion of the design**
  - distributed design (including DA responsibility)
  - integrated Product Teams
  - integrated decision-making and reviews

# U.S. Organizational Structure




| | |
|---|---|
| *LLC* | Limited Liability Company |
| *ORO* | Oak Ridge Office |
| *PSO* | Princeton Site Office |
| *ORNL* | Oak Ridge National Laboratory |
| *PPPL* | Princeton Plasma Physics Laboratory |
| *SRNL* | Savannah River National Laboratory |
| *SROO* | Savannah River Operations Office |

# U.S. Contributions to ITER Project

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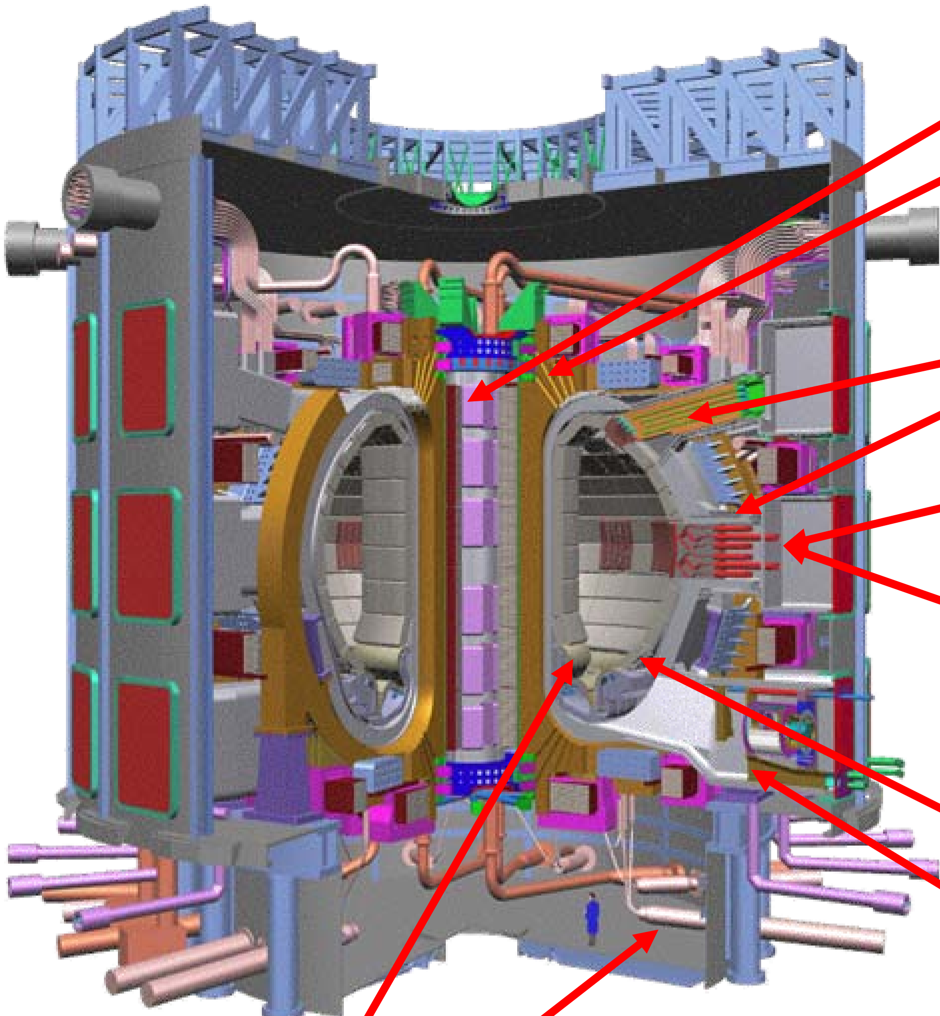
| U.S. ITER Project Advisory Board | U.S. ITER Technical Advisory Committee |
| --- | --- |
| Harold K. Forsen, Chair | Charles C. Baker, Chair |
| Charles C. Baker | Lee Berry |
| Robert C. Iotti | Eugene (Gene) R. Desaulniers |
| Milton Johnson | Kathryn A. McCarthy |
| David G. McAlees | Gerald A. Navratil |
| Edward I. Moses | Miklos Porkolab |
| Satoshi Ozaki | Stewart C. Prager |
| James R. (J. R.) Thompson | Bruce E. Warner |
| | M. C. Zarnstorff |

# USIPO is prepared to proceed….

- **Project Execution Plan**
- **Resource-loaded schedule**
- **Cost-estimate range**
  - Cited in the President's Budget Request
  - Includes Risk-based contingency
- **Project Control tools built on Spallation Neutron Source set**
  - Work Breakdown Structure
  - Configuration Control
  - Quality Assurance and Safety Plans
  - Risk Management….
- **Contracts, Business and other capabilities from ORNL, but co-located**

# US ITER In-kind Hardware Contributions



ORNL — 7 Central Solenoid windings

ORNL — 8% of Toroidal Field conductor

PPPL — 15% of port-based diagnostics

ORNL — 100% Ion Cyclotron transmission lines

ORNL — 100% Electron Cyclotron transmission lines

ORNL — 20% Blanket/Shield

ORNL — Roughing pumps, standard components

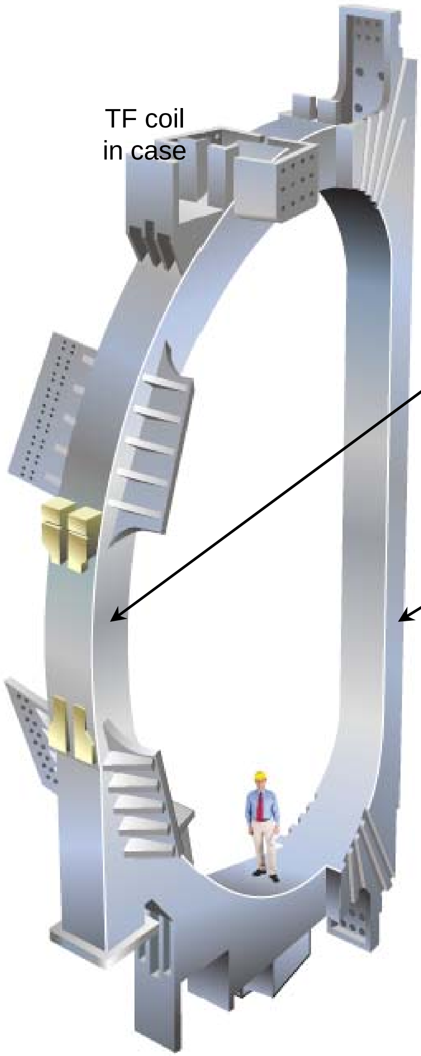
ORNL — pellet injector

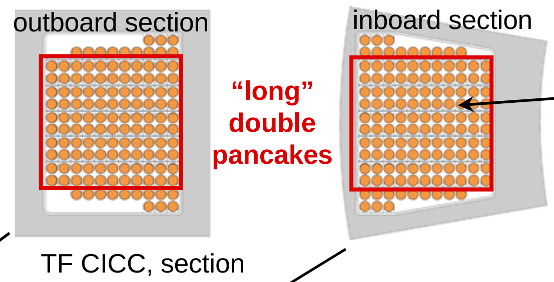
ORNL — 75% Cooling for divertor, vacuum vessel, …

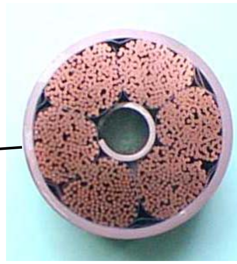
PPPL — Steady-state power supplies

SRNL — Tokamak exhaust processing system

# Toroidal Field Coil Conductor



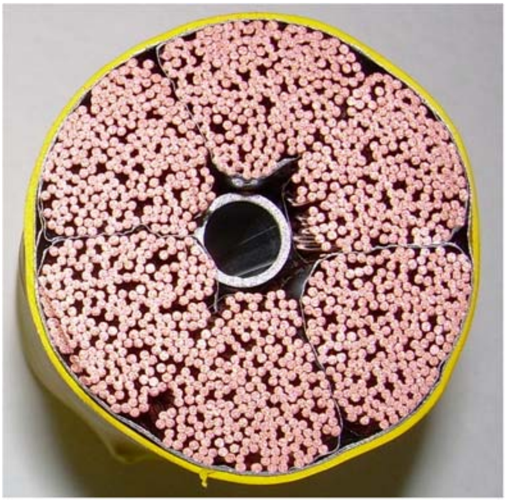



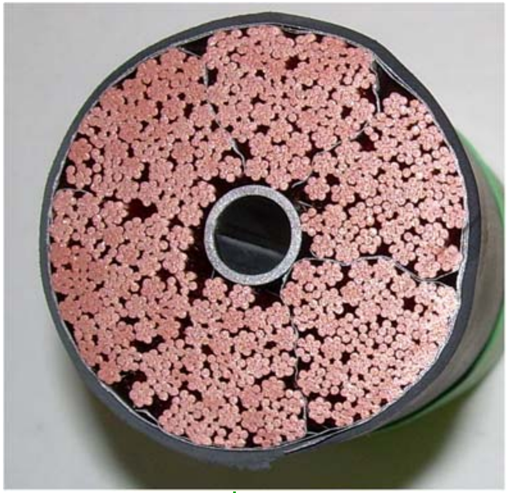
**U.S. supplies 40 tons of Niobium-tin superconducting wire**

# Cable pattern & strand support

Baseline geometry 3-based



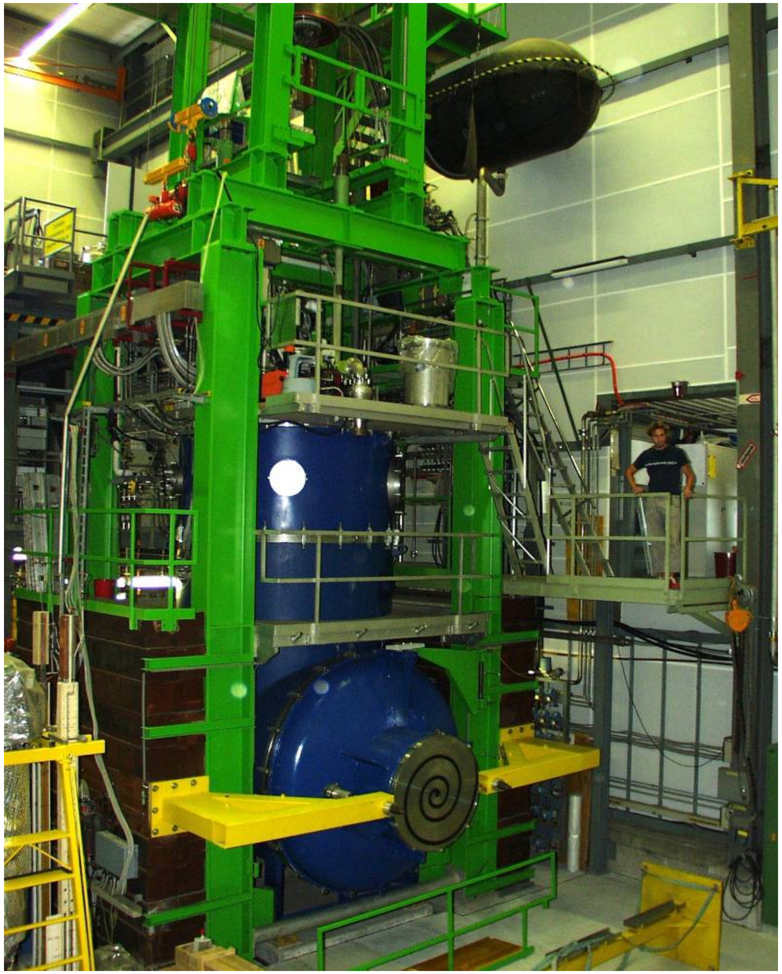
Alternate geometry 6+1 based



Alternate geometries substantially stiffer than baseline.

Better strand support?

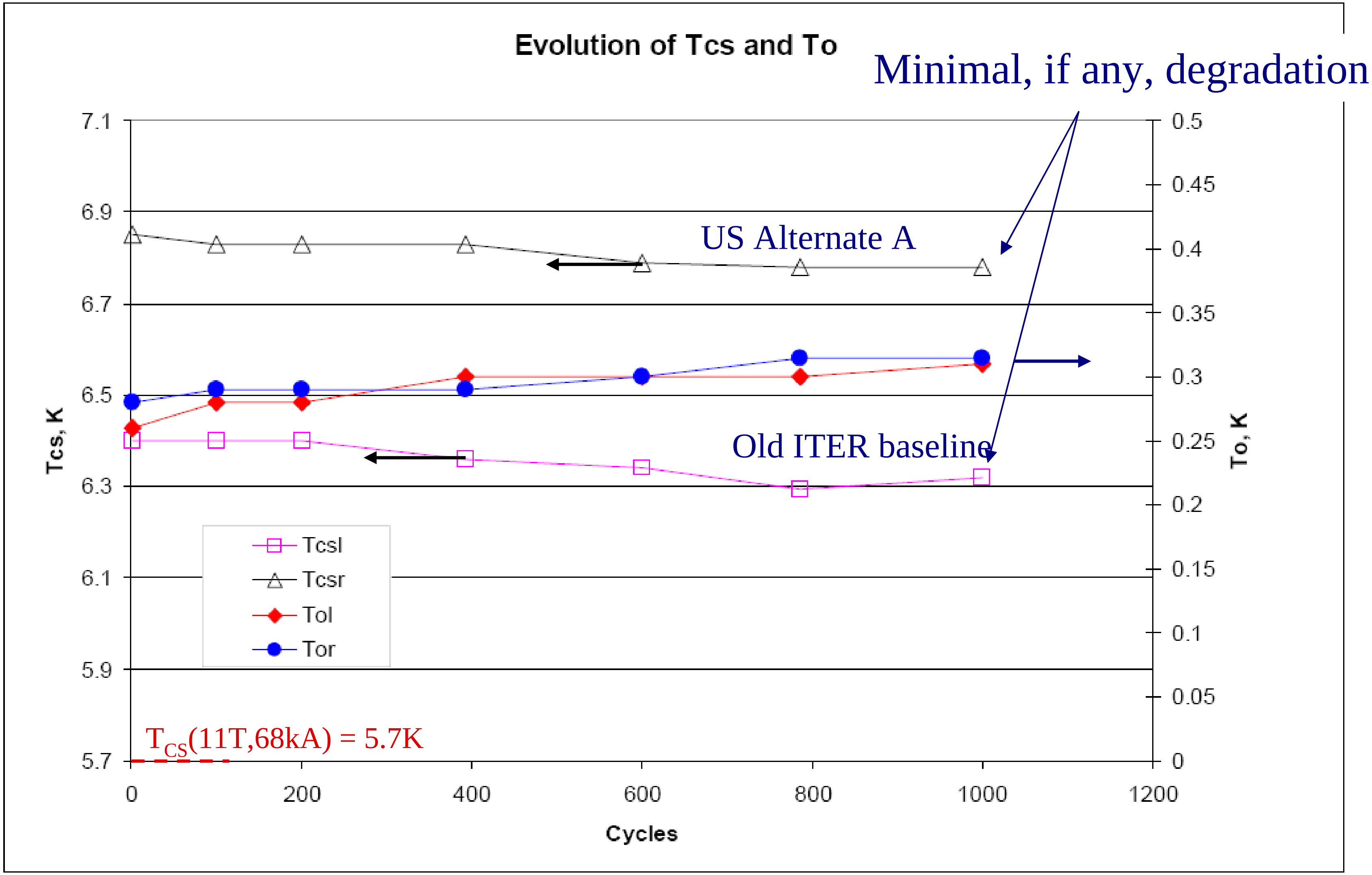
# Sultan Test Samples



Sultan Test Facility
*Photo courtesy CRPP/PSI*

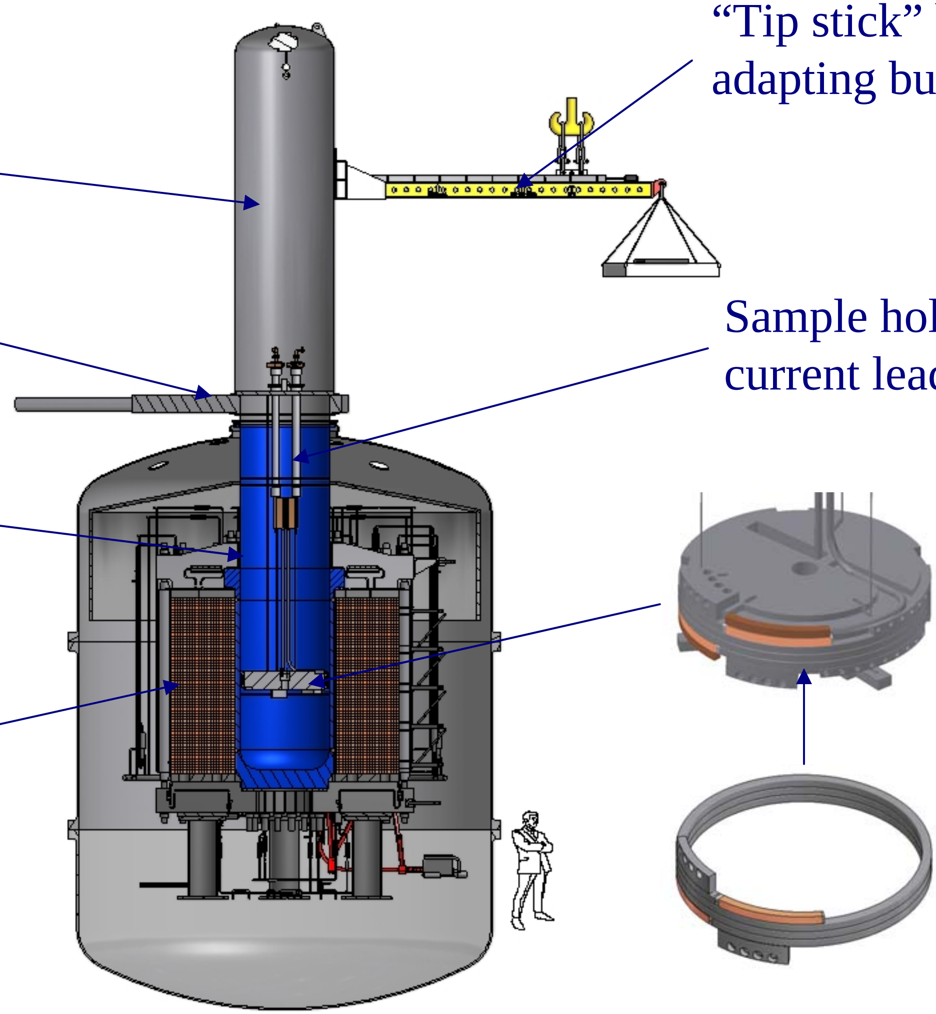
- **SULTAN facility continues to be key facility for QC. EU dipole and may be CSMC (or KO) facility will be used in the future too.**
- **All superconducting strands for the Toroidal Field Coils (TF) have to pass a Qualification Procedure.**
- **These tests are performed at the Superconductor Test Facility SULTAN, Located at the Paul Scherrer Institute in Villigen, Switzerland.**

# TFUS1 Testing



# Possible conductor test facility

Facility with sample lowered

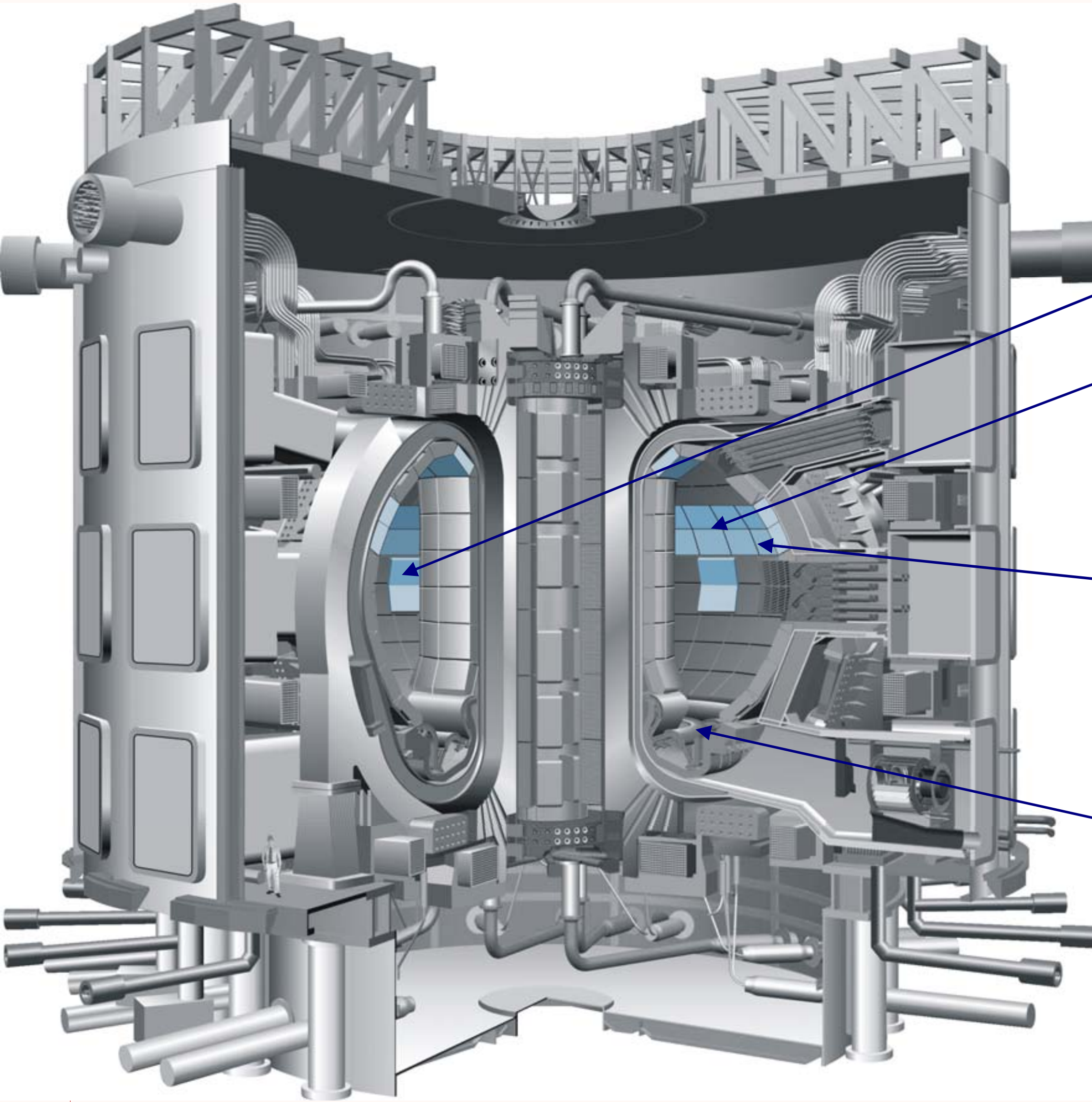


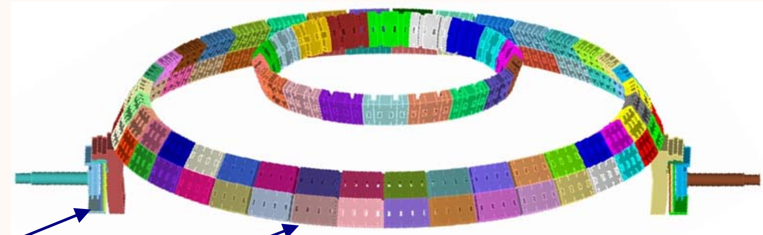
# Central Solenoid Options

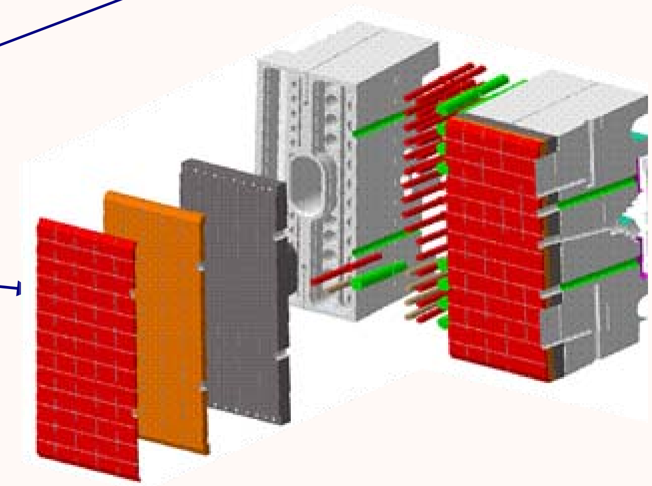
Reference Design, external structure based on inner & outer tie plates

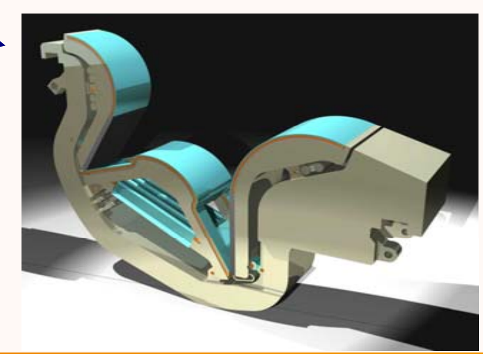
Alternate Design, external structure based on central tie rods and rigid end caps

# Blanket, Port Limiter and Divertor Systems

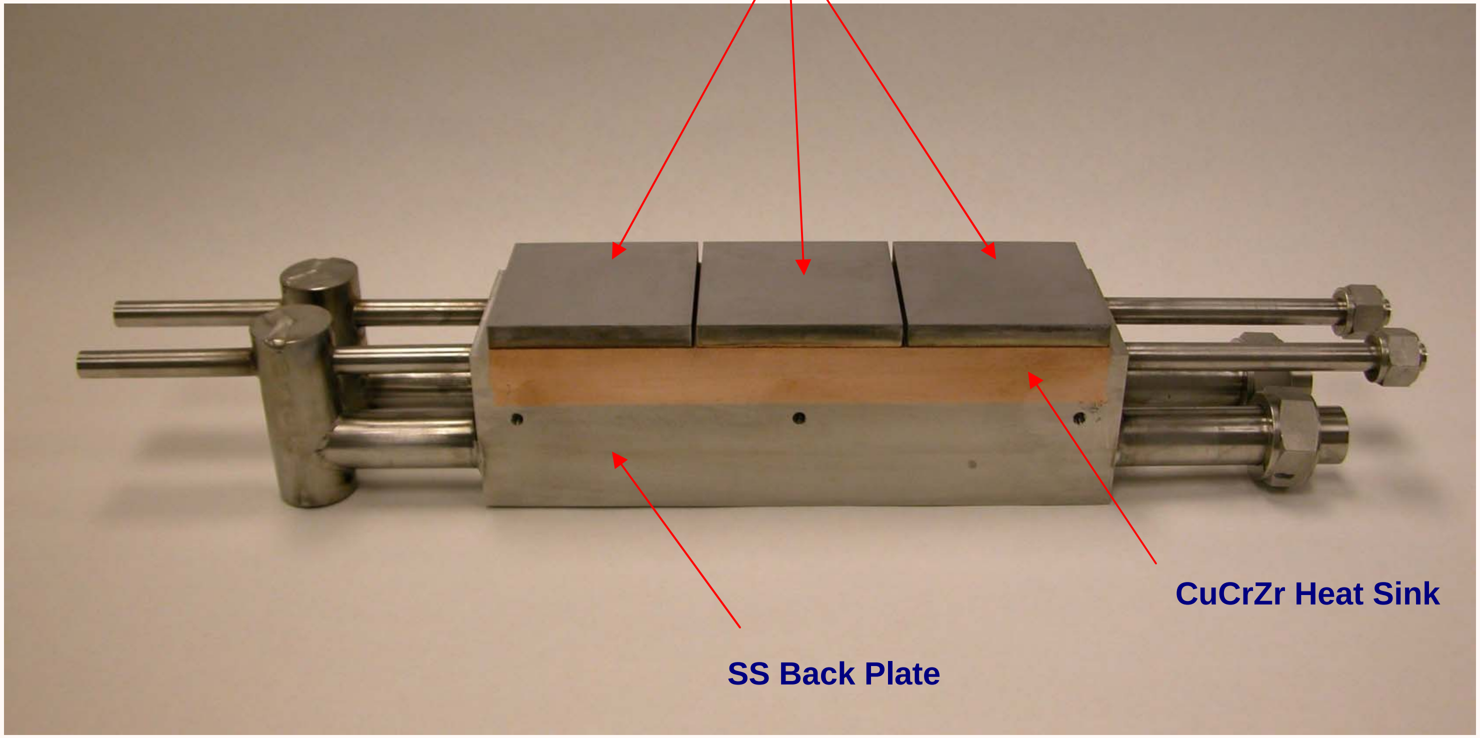






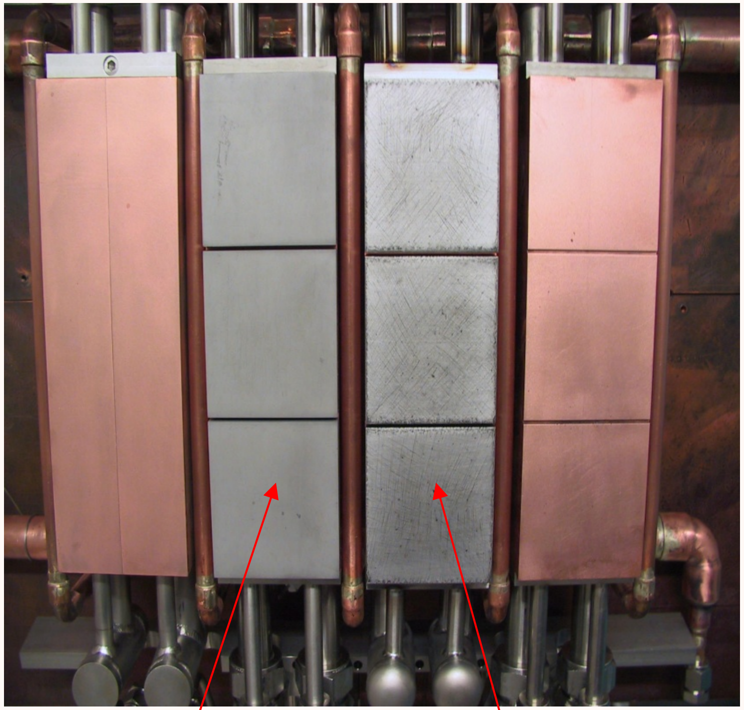


# First Wall Qualification Mockup



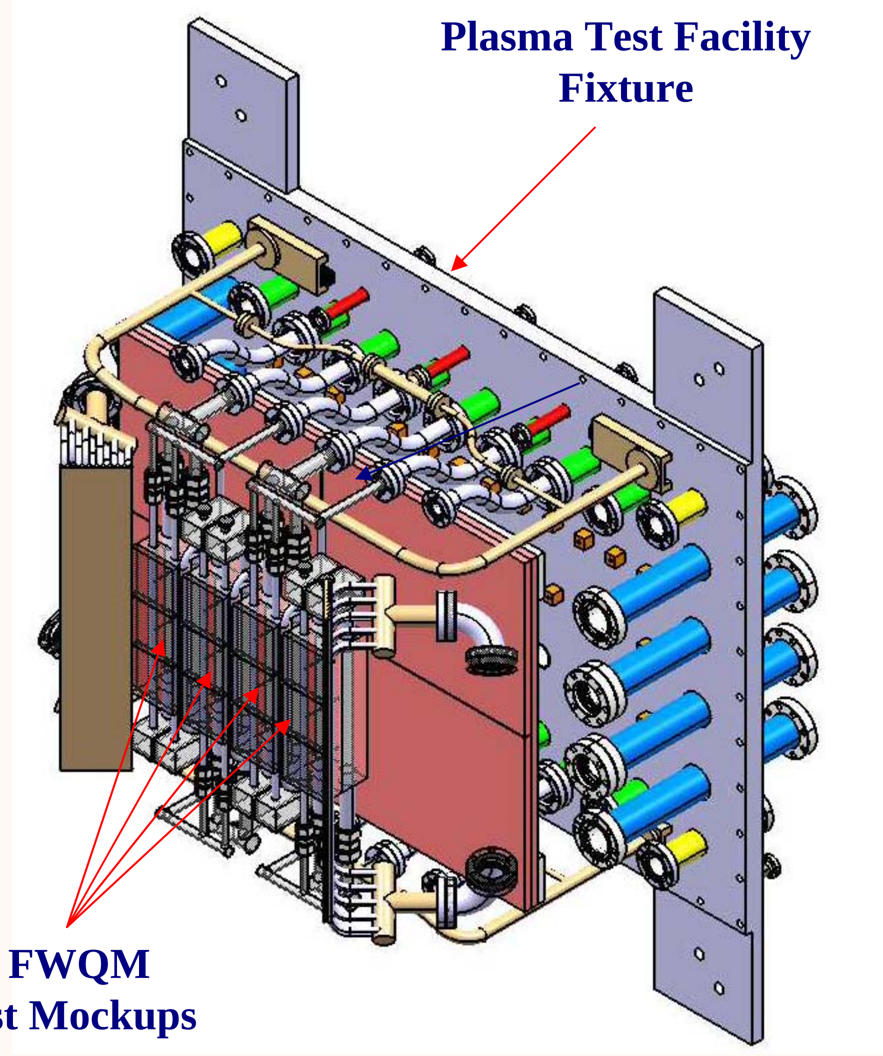

**First Mockup**
**FWQM US-1**

# FWQM Test Facility - SNL



US FWQM Mockup

EU FWQM Mockup

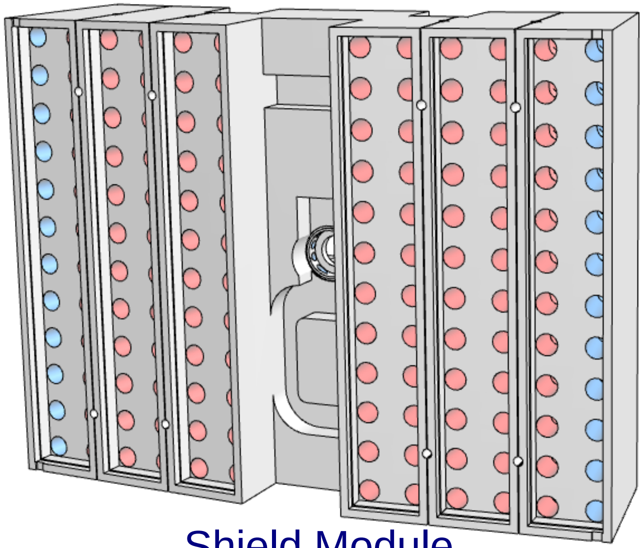


Plasma Test Facility Fixture

4 FWQM Test Mockups

# Possible new steel for cast components

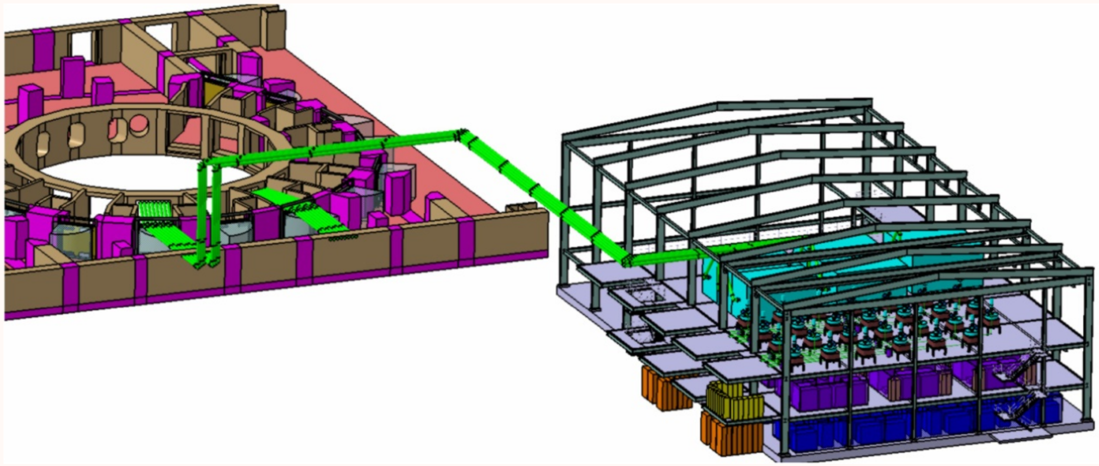
- Shield Modules (SM) are presently constructed out of stainless steel forgings and require considerable machining operations
- The use of casting is being explored as a more cost effective fabrication methodology
- A "science-based" approach has been applied to improving the cast stainless steel, reducing the involved as compared to the more
- The property improvements include strength, toughness, radiation and corrosion
- The next phase of the cast material qualification will involve the commercial fabrication of full scale p

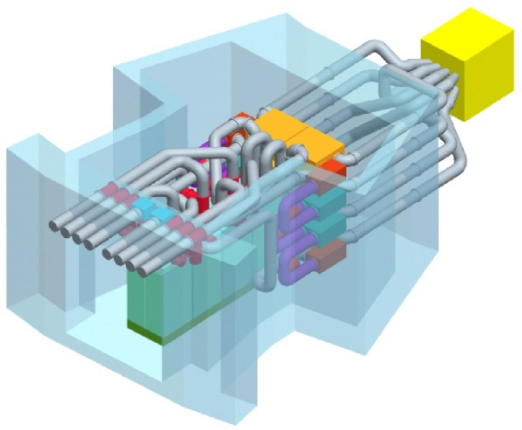


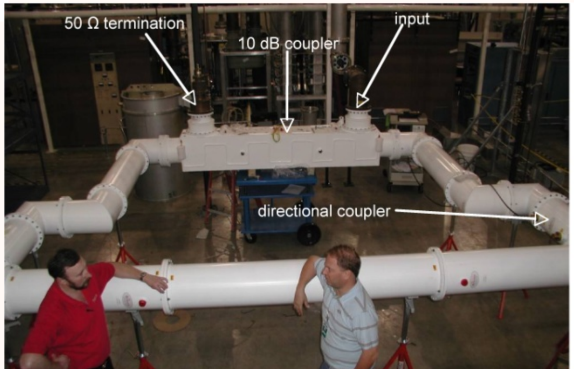
Shield Module

# ICH Transmission lines and Tuning/Matching System

5 MW transmission air cooled lines from the sources to the antenna
3 dB ELM tolerant matching connected to 24 strap antenna array

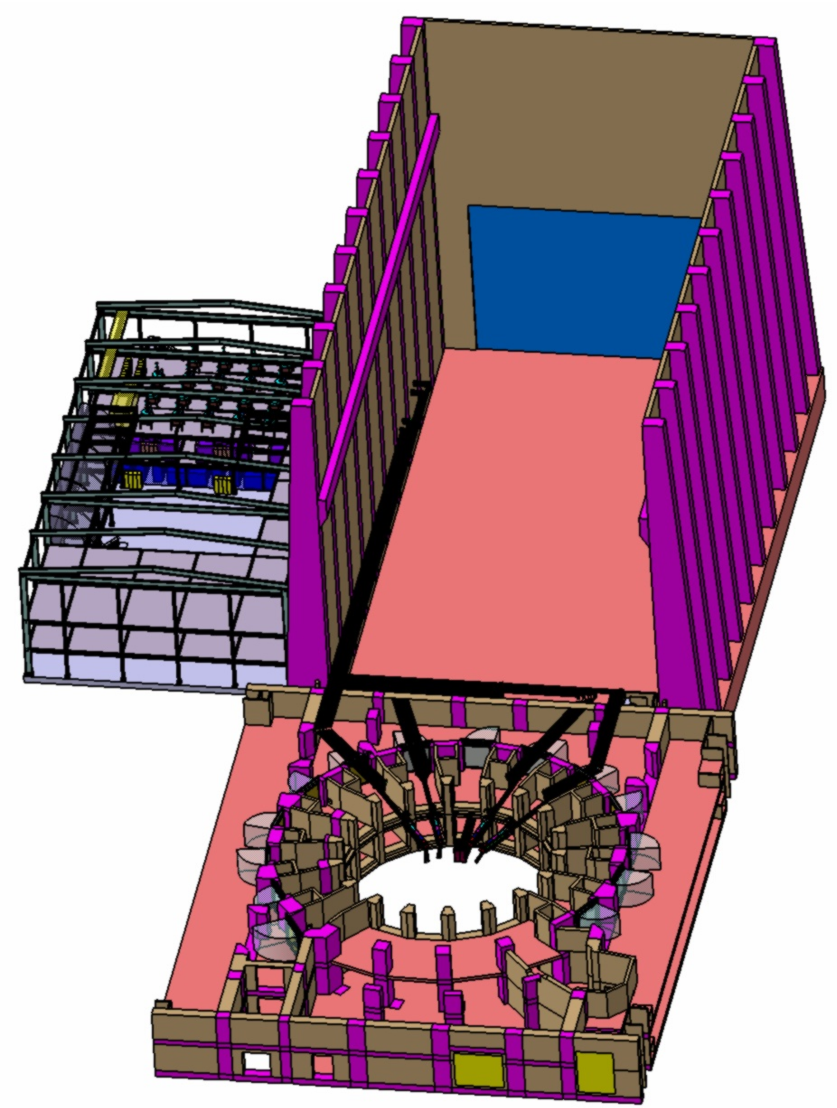




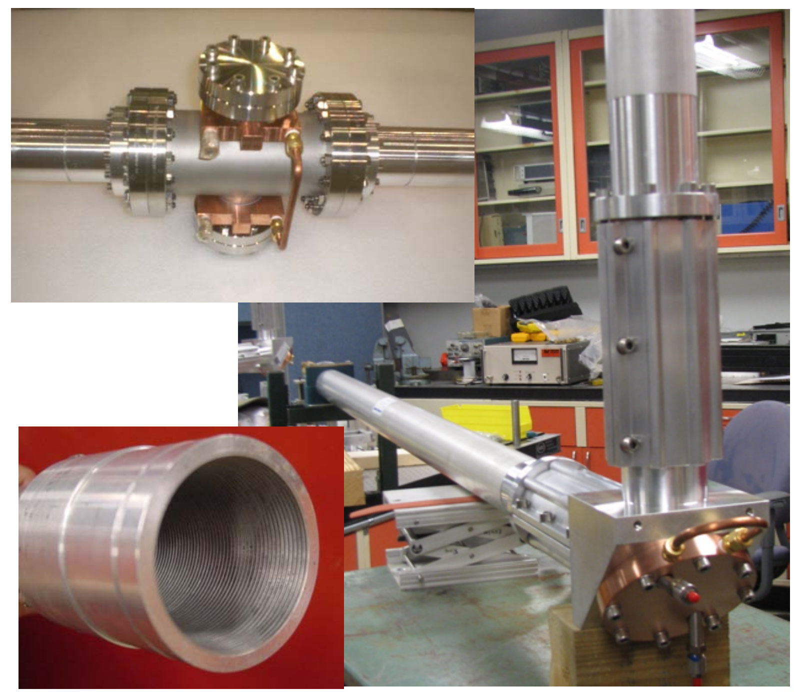



Long pulse; High power resonant ring tests components to > 5 MWs (ORNL)

# WBS 1.5.2. Scope - ECH Transmission line and Mode Control

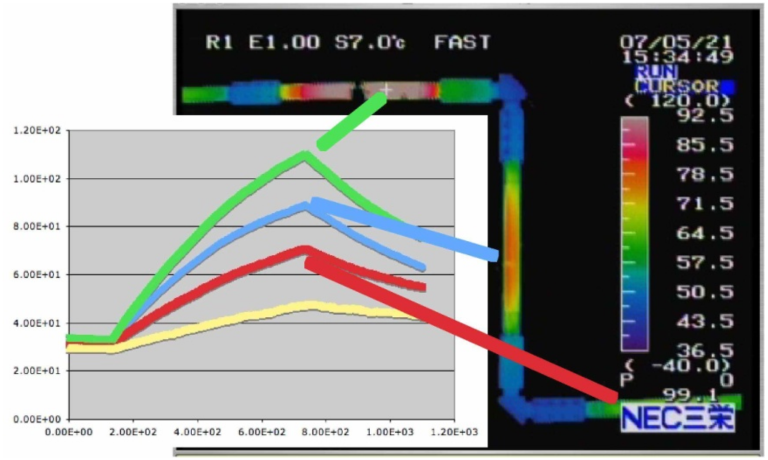


- 1-2 MW water cooled T-lines from the gyrotrons to the launchers
- 24 lines to the equatorial launchers
- 32 lines to the upper launchers
- Mode and polarization control are major technical challenges



# 140/170 GHz test stands used to develop and qualify components

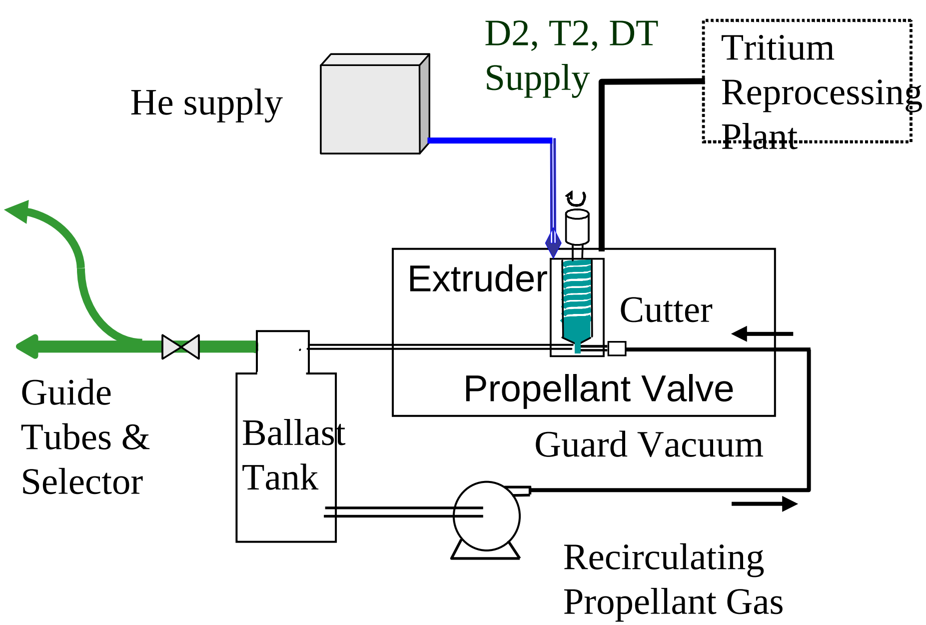
Long pulse; High power resonant ring tests components to > 2 MWs (ORNL)

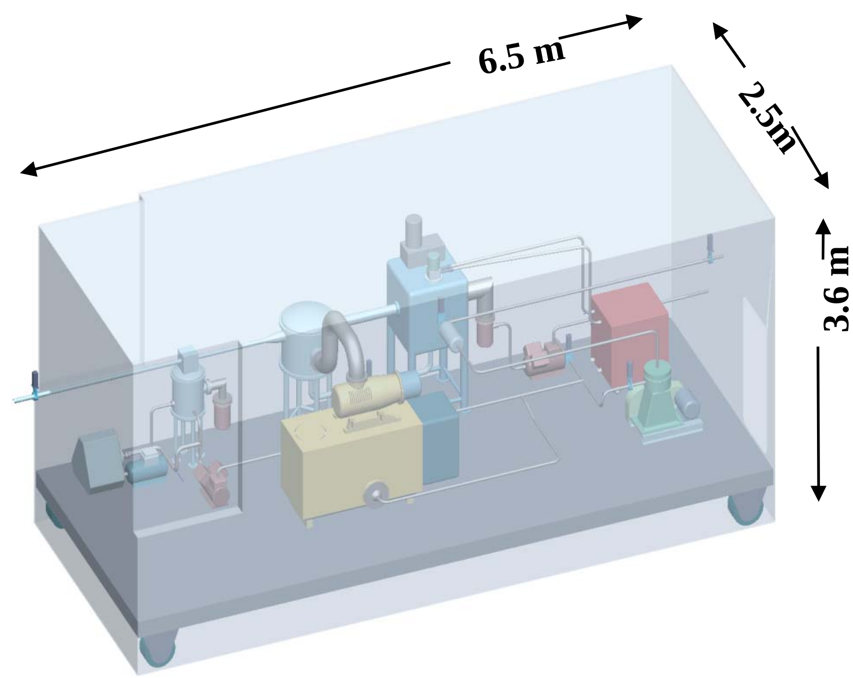



Infrared imaging shows ohmic & mode conversion hot spots (JAEA)

# Pellet Injector R&D to develop extruder, gas recirculation and injector reliability

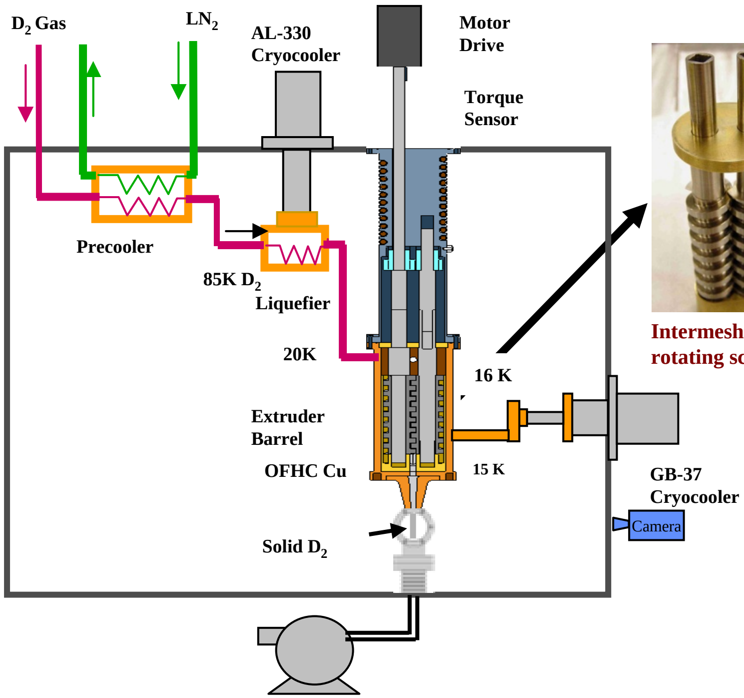
- **Technical challenges**
  - Extruder throughput and reliability (FY07-10)
  - Propellant gas recirculation to minimize impact on tritium plant (FY09-10)
  - Gas gun prototype (FY09-11)
  - Pellet survivability in guide tubes and guide tube selector (FY09-11)



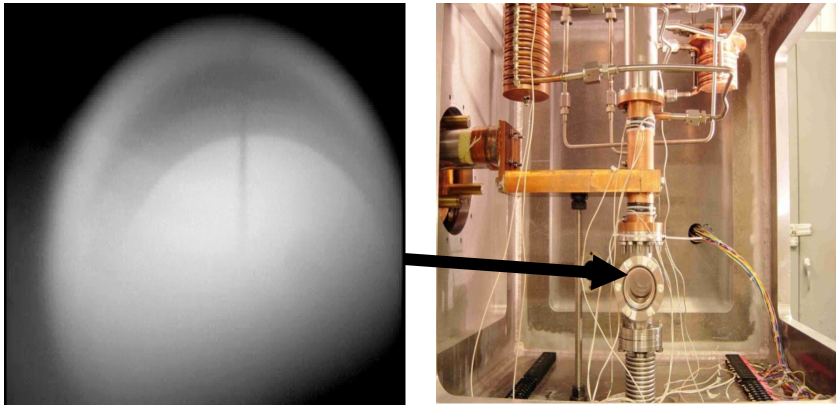



# Twin Screw Extruder Prototype R&D is making good progress towards goals

- Pellet injector twin screw extruder prototype has successfully produced solid deuterium extrusions for up to 30 minutes
  - Achieved 10% of the ITER required flow rate.
  - Further optimization will be undertaken to increase the flow rate up to the prototype’s design value of 30% of the ITER requirement.
  - Recirculating fuel loop will be added as the next step.



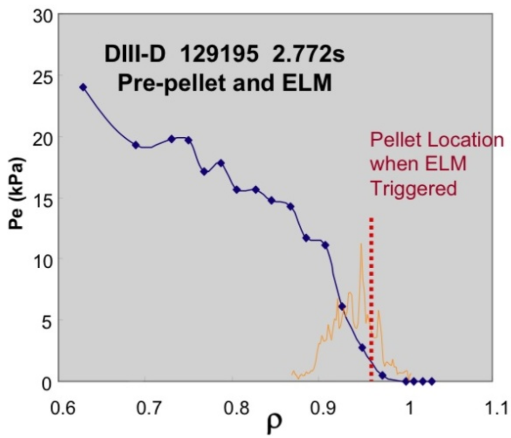

Intermeshed counter rotating screws

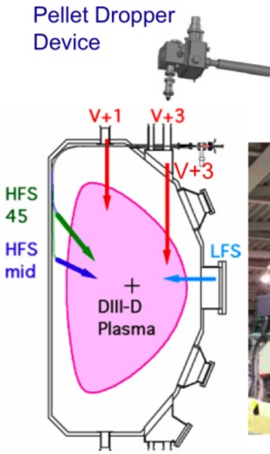


3mm $D_2$ Extrusion

# Pellet Pacing for ELM mitigation

- ELMs need to be limited to 1 MJ/event
- ELM pellet pacing frequency of 20-40 Hz is needed
- 4mm (cylindrical) pellet required to reach the 4 keV pedestal
- Recent experiments indicate shallower penetration with smaller pellets (~ 1 mm) may suffice
- High rep rate pellet dropper experiments underway at DIII-D



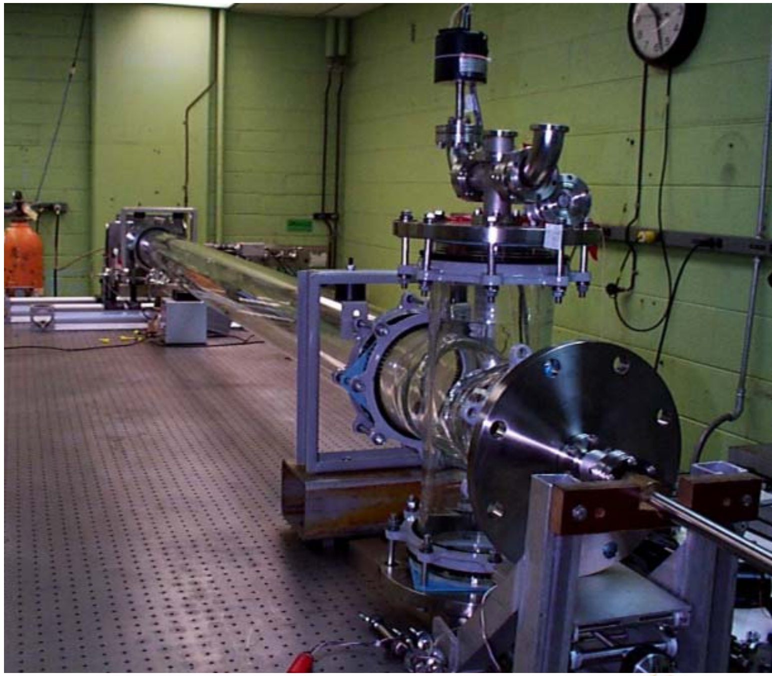

- Will require at least 2 additional pellet injection systems to meet increased requirements

# Disruption Mitigation
# (possible new/additional scope)

- Massive gas puff not likely to scale to ITER

- Large pellets may be required (wine cork size)

- Liquid jets have also been considered



# Next Steps

- **Engage US industry in design completion and optimization**
  - Incorporate industrial experience
  - Assure ITER design is compatible with US manufacturing methods
  - Focus on early-delivery / high-risk systems
    - superconducting magnets
    - plasma-facing components
    - power handling
    - diagnostic instrumentation

- **Place long-lead procurements for materials for early-systems**
  - Superconducting strand (for schedule reasons)
  - Stainless steel (as a cost-risk mitigation measure)

# U.S. ITER Project Office