Plans for US Contributions to ITER

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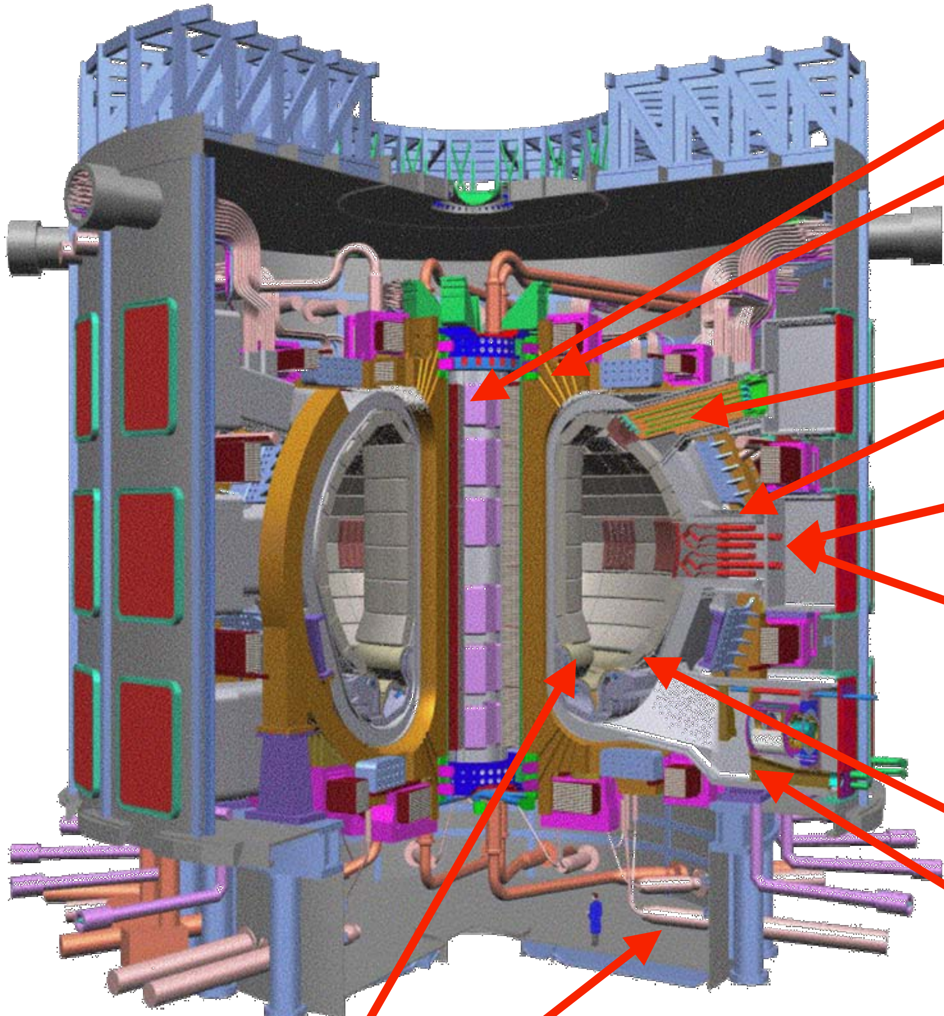
U.S. ITER Project Manager

Fusion Power Associates

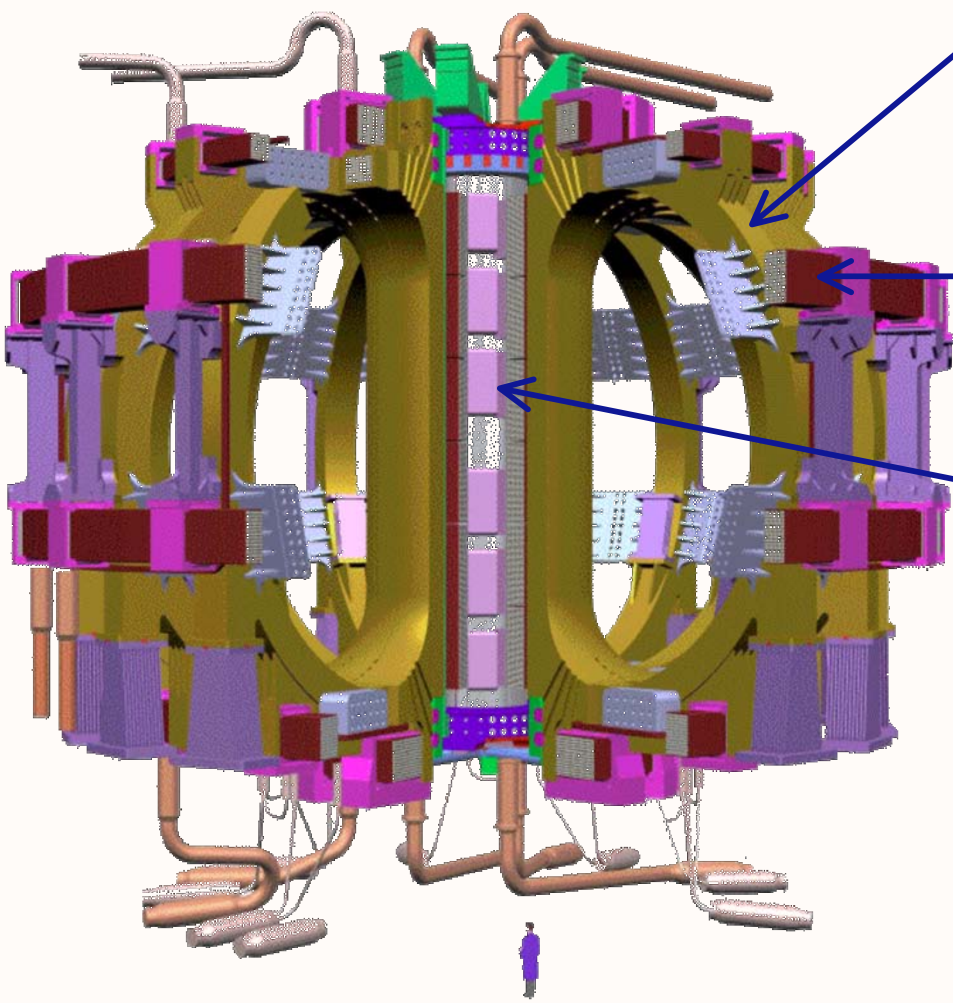
Oak Ridge, TN

December 4, 2007

U.S. 2006 ITER In-kind Hardware Contributions



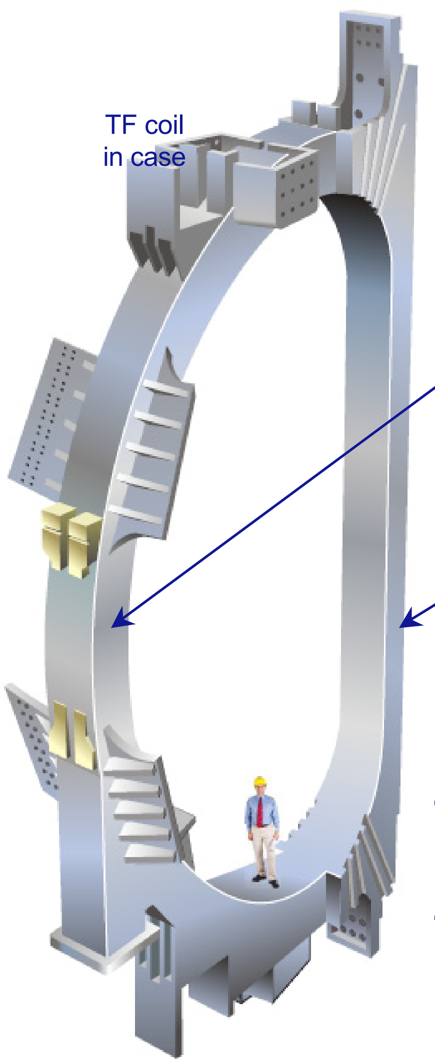
ITER's Magnet system

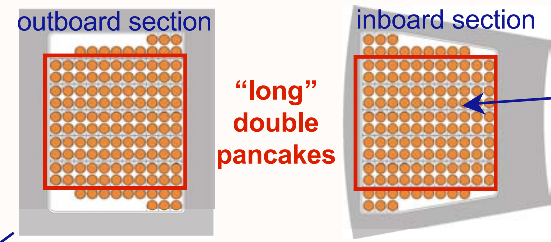


- Nb_3Sn toroidal field (TF) coils produce confining/stabilizing toroidal field
- NbTi poloidal field (PF) coils position and shape plasma
- modular Nb_3Sn central solenoid (CS) coil induces current in the plasma.

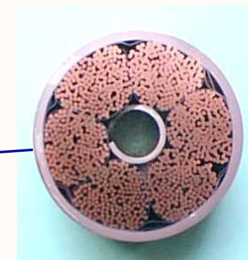
- Magnet system weighs ~ 8,700 t.

Toroidal Field Coil Conductor





TF CICC, section

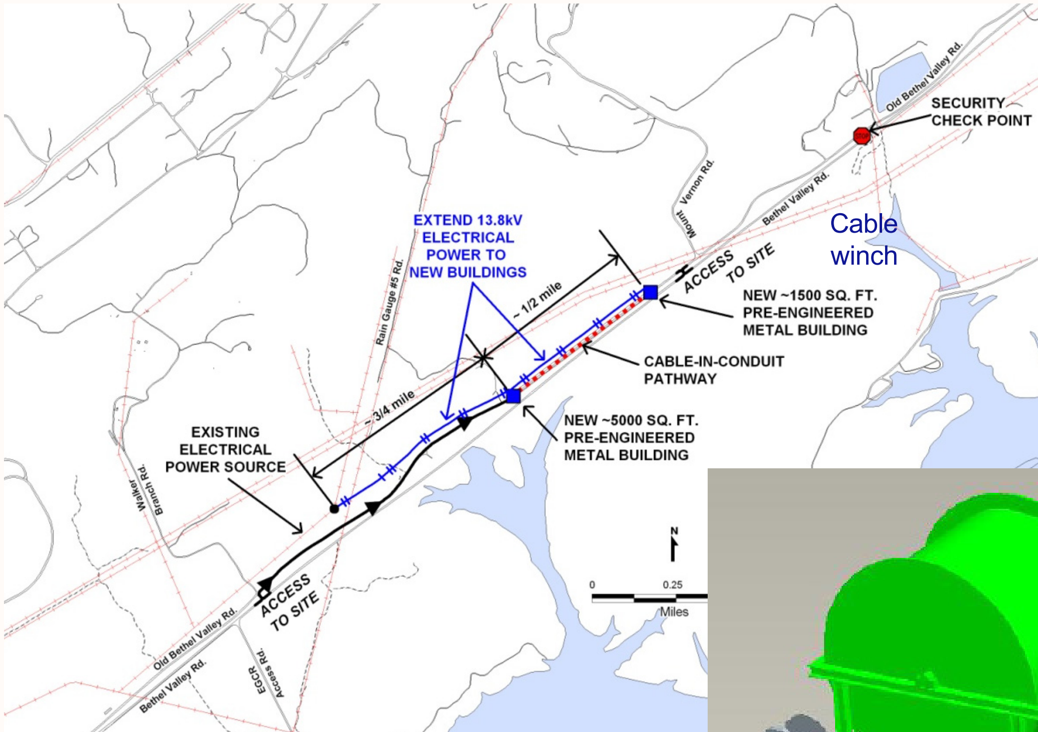


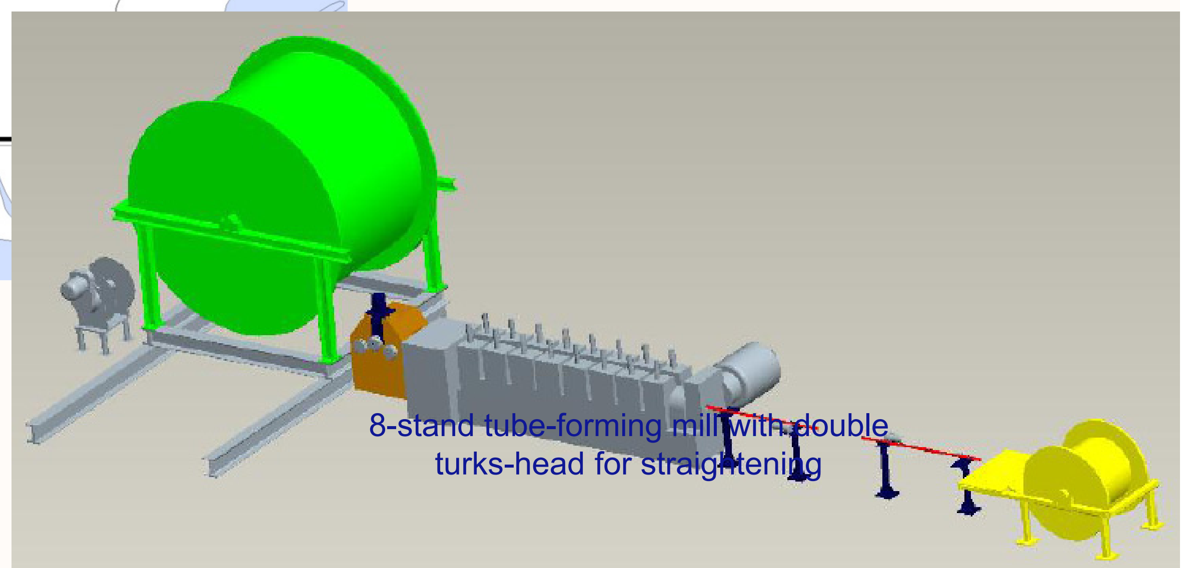
Exploring:

- Seam-less tube conduit

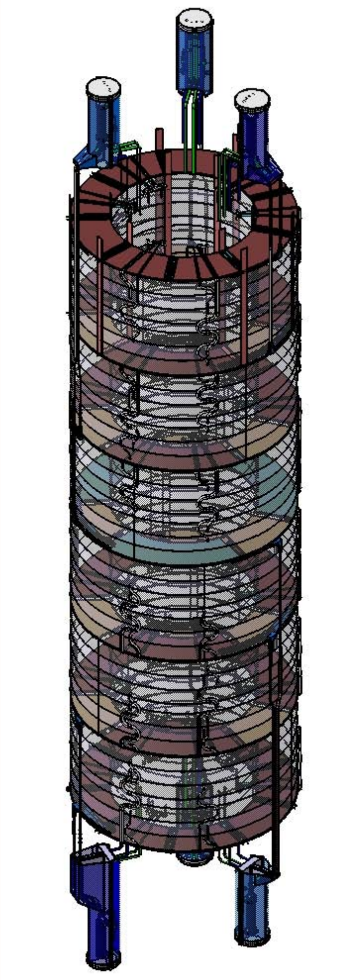
- Perforated central cooling tube

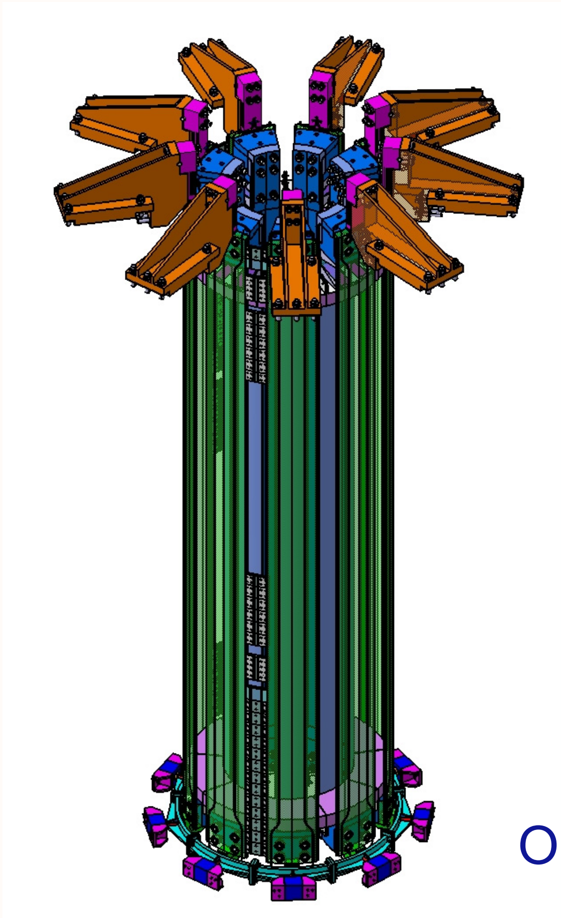
Fabrication of TF Conductor

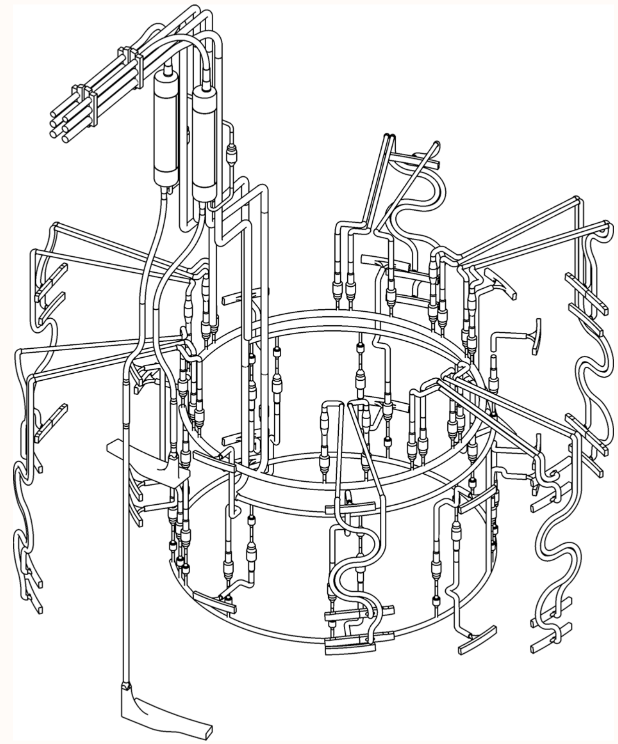




Central Solenoid Coil



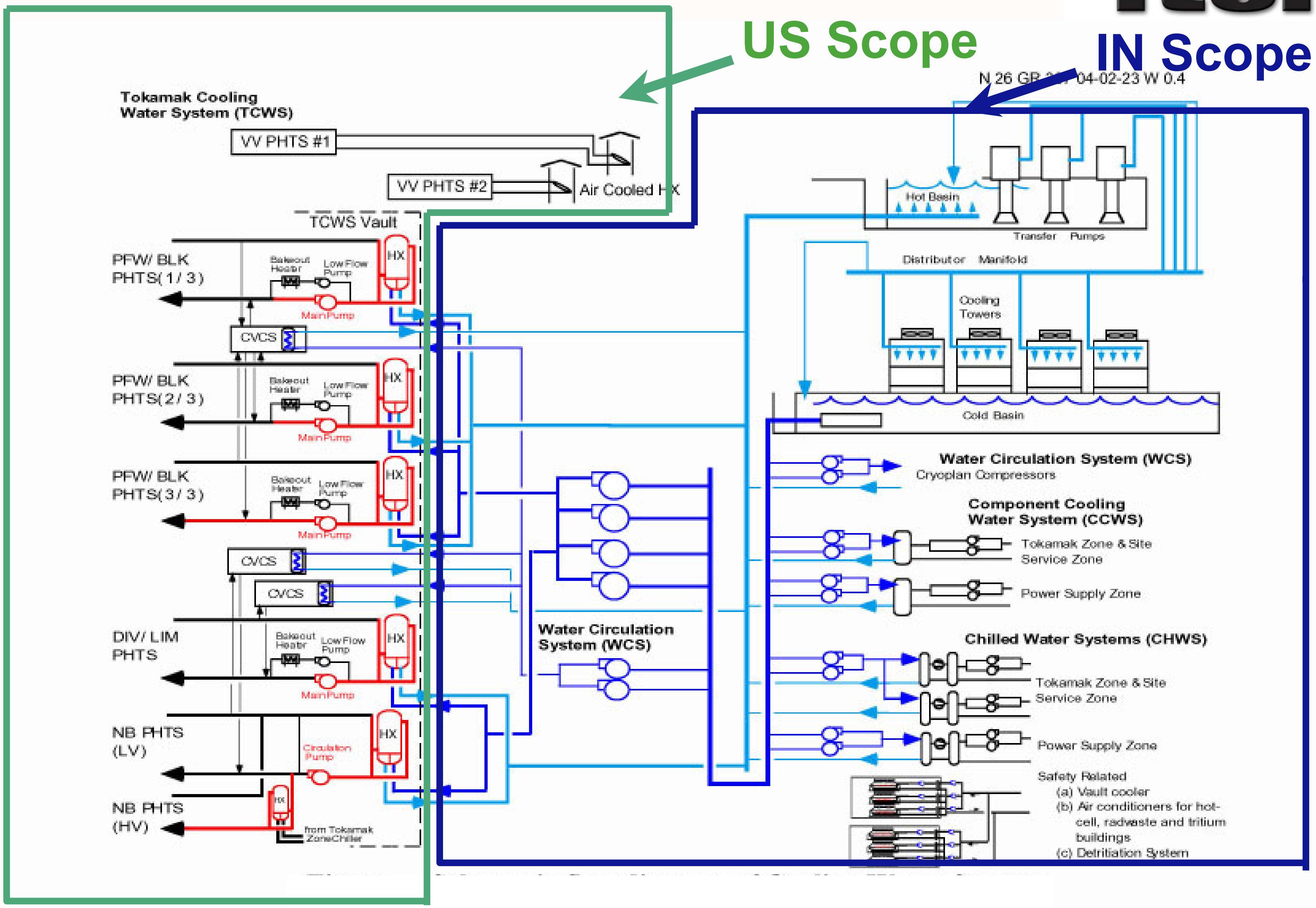




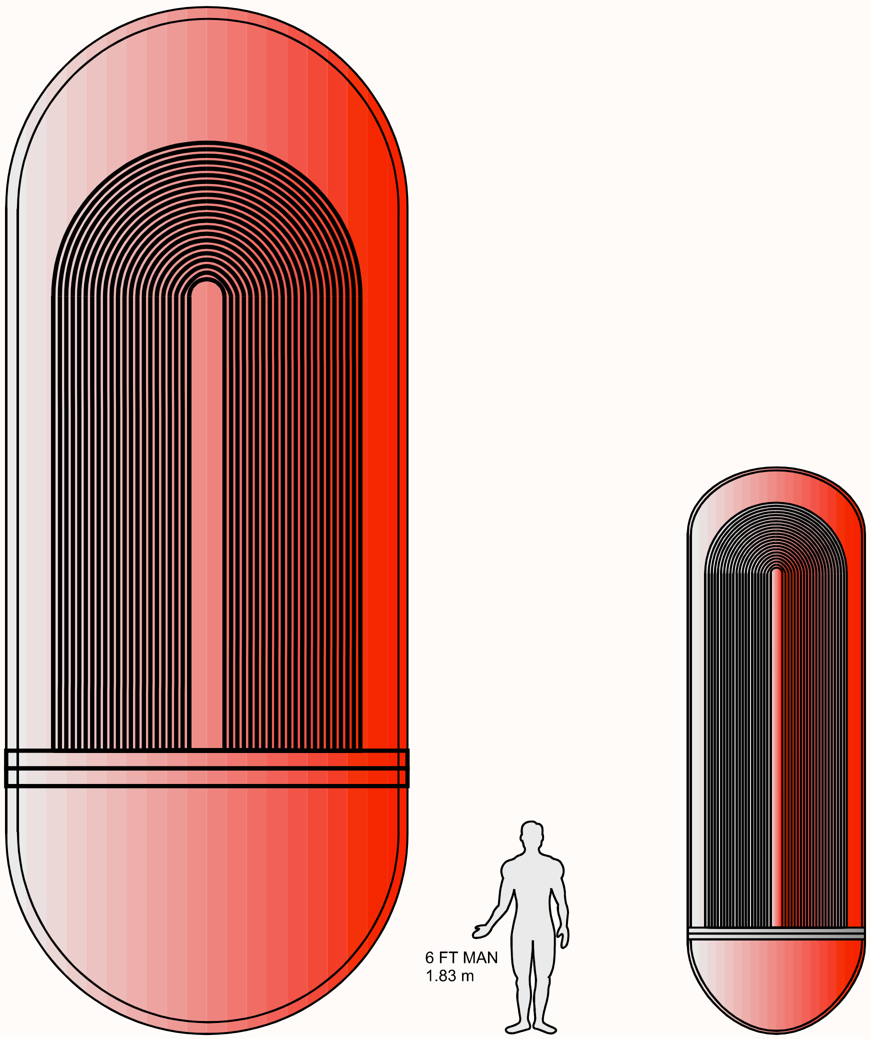
Originally, all JA-supplied Conductor

Exploring US supplying
initial CS cable

Cooling Water System



Industry design review recommendation: simplify design



Current design

- Failure of any one of 14 components can shut down plasma operation

System re-design is required to:

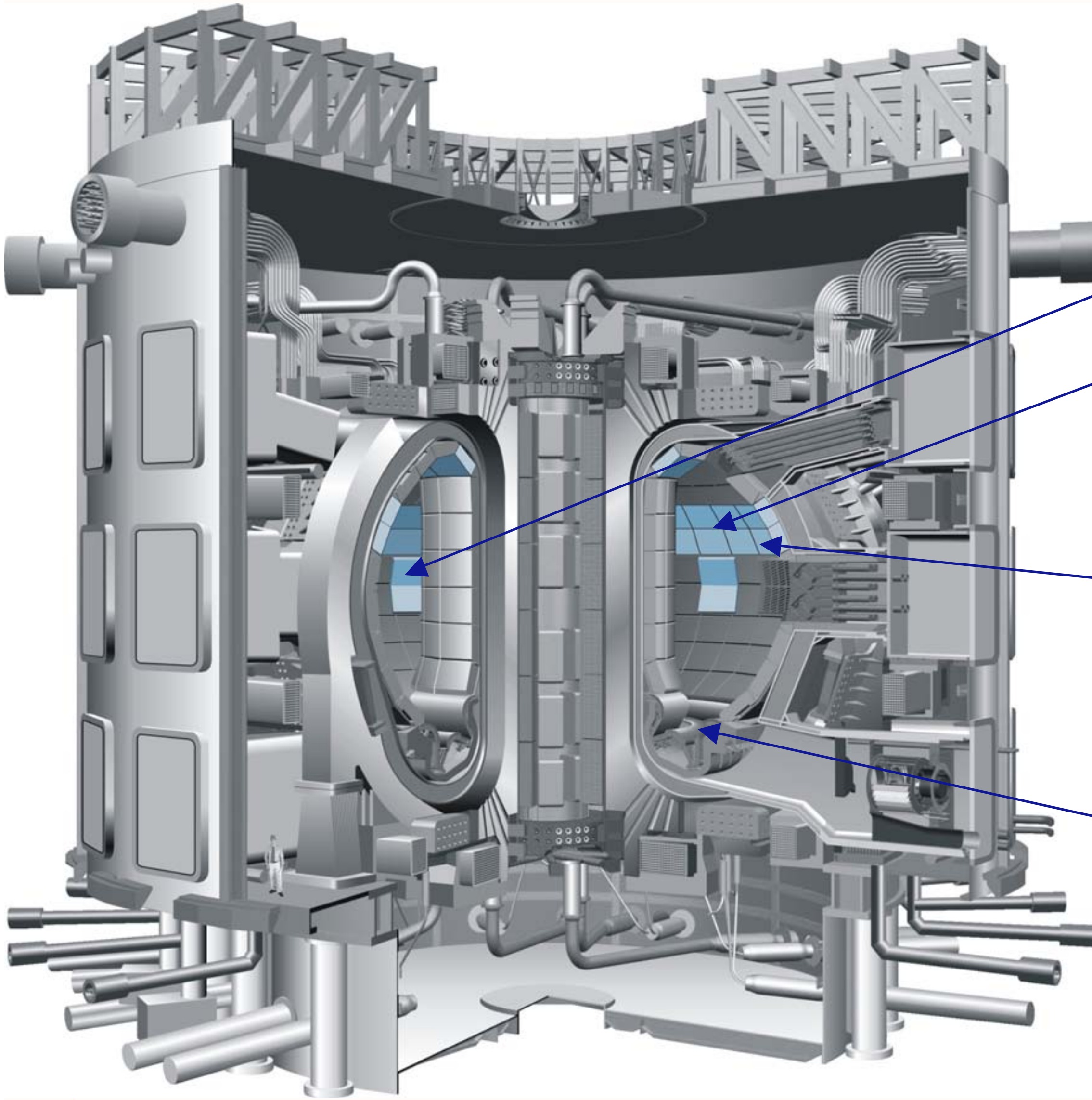
- Improve availability, reliability, operational flexibility
- Reduce capital equipment and maintenance costs through standardization
- Improve flexibility of schedule and construction

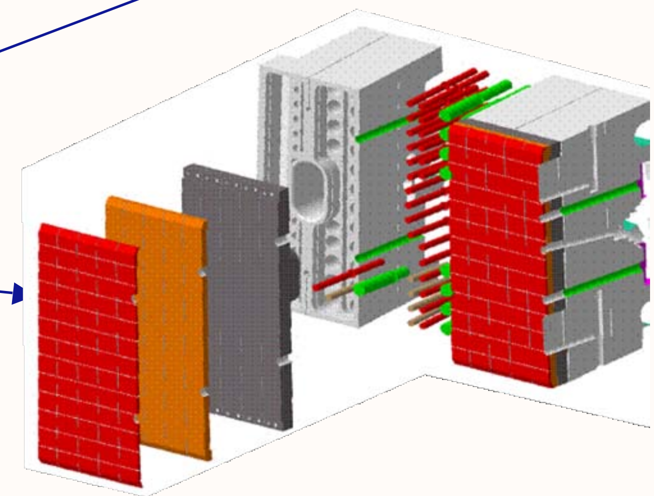
Revised Design Concepts:

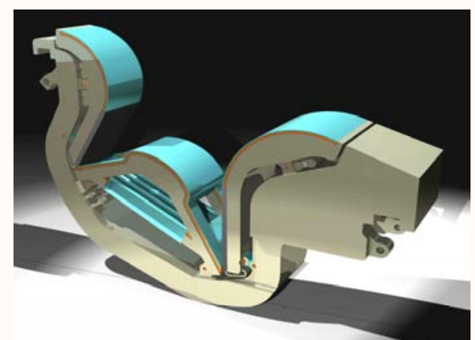
- Replace unique components with standard, off-the-shelf equipment

Plans for US Contributions to ITER
December 4-5, 2007

Blanket, Port Limiter and Divertor Systems

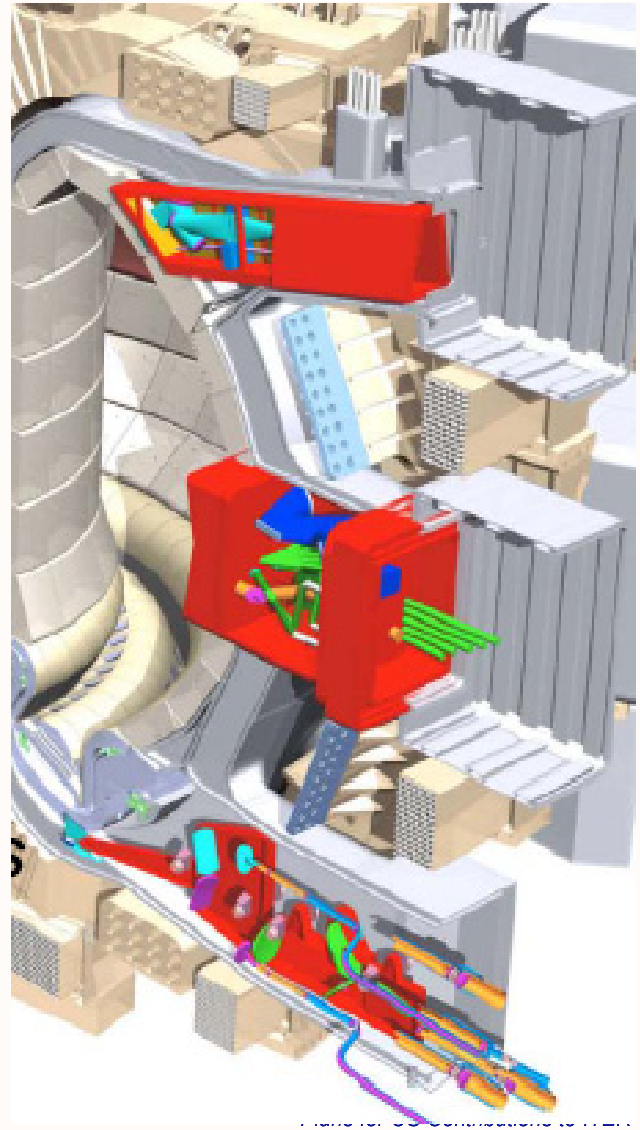






US ITER Diagnostics Scope

Instrumentation	Purpose
Upper IR/Visible Cameras	monitor for hot spots on outer target surface
Low Field Side Reflectometry	pedestal and SOL density profiles, fluctuations
Motional Stark Effect	safety factor q(R)
Electron Cyclotron Emission	$T_e(R)$, and MHD
Divertor Interferometer	line density, several chords across divertor throats
Toroidal Interferometer/ Polarimeter	line density along tangential chords at midplane
Residual Gas Analyzer	gas composition in pumping ducts
Port Plugs	**Comments**
Upper Ports (U5, U17)	Includes design, fabrication, assembly and testing. Also includes integration of both US and other party's instruments in US plugs and support for US instruments in plugs provided by other parties. Also includes integration in interspace and port cell areas.
Equatorial Ports (E3, E9)	
Lower Port Structures (L8)	



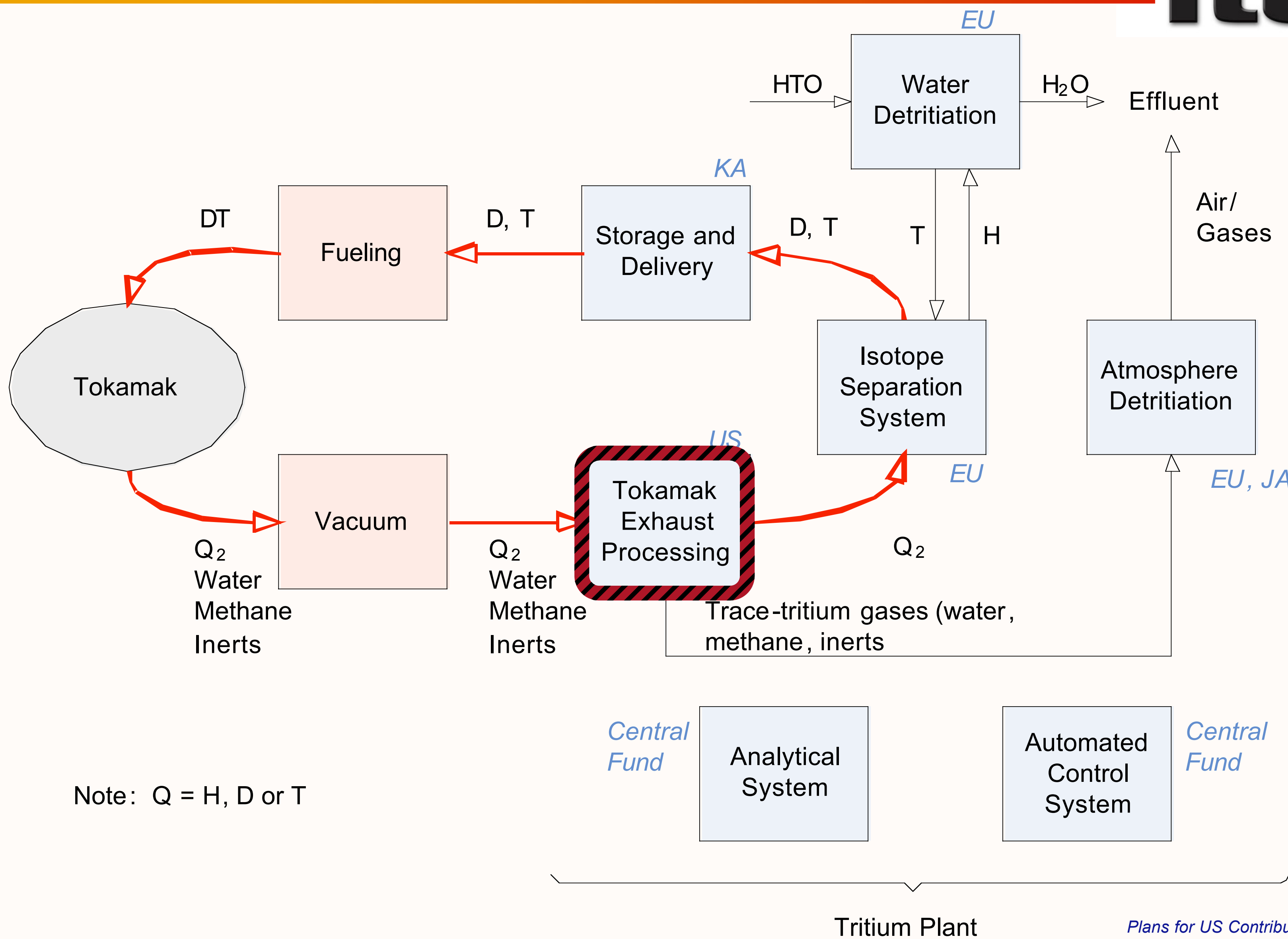
Recent Progress and Near-Term Challenges

Package	Design/R&D Task Summary	Institution(s)	Phase 1 Cost	Phase 1 Design	Phase 1 R&D	Phase 2 Cost	Phase 2 Design	Phase 2 R&D
Upper Visible/IR Camera	assess optical design, central tube concept	LLNL		C		C	O	
LFS Reflectometer	determine optimum frequency bands and polarizations	UCLA		C				
LFS Reflectometer		ORNL	C					
LFS Reflectometer	optimize front-end configuration, WG tests	?					P	
MSE	assess usefulness of |B| determination	NOVA			C	C		O
MSE	performance simulation of conventional polarimetry approach	PPPL		C				
MSE	optimization of optical design	LLNL		C		C	O	
ECE	investigate non-thermal issues, use of oblique view	PPPL			C			
ECE	review reference design, hot source R&D	U.Texas, U. Md, MIT		C				O
ECE		ORNL	C					
ECE	refine front end design	?					P	
Divertor Interferometer	develop conceptual design	UCLA/GA		C		C		
Divertor Interferometer	refine front-end design	?					P	
Tang. Interfer./Polarimeter	optimize reference design	GA/UCLA		C		C		
Tang. Interfer./Polarimeter	refine front-end design	?					P	
RGA	develop conceptual design	ORNL		C		C		
Neutronics Analysis	develop neutronics models for plug integration using ATILLA	UCLA			C			O
First Mirror R&D	model erosion/deposition on 1st mirrors	ANL			C			O
Shutter R&D	develop candidate shutter concepts	PPPL						P

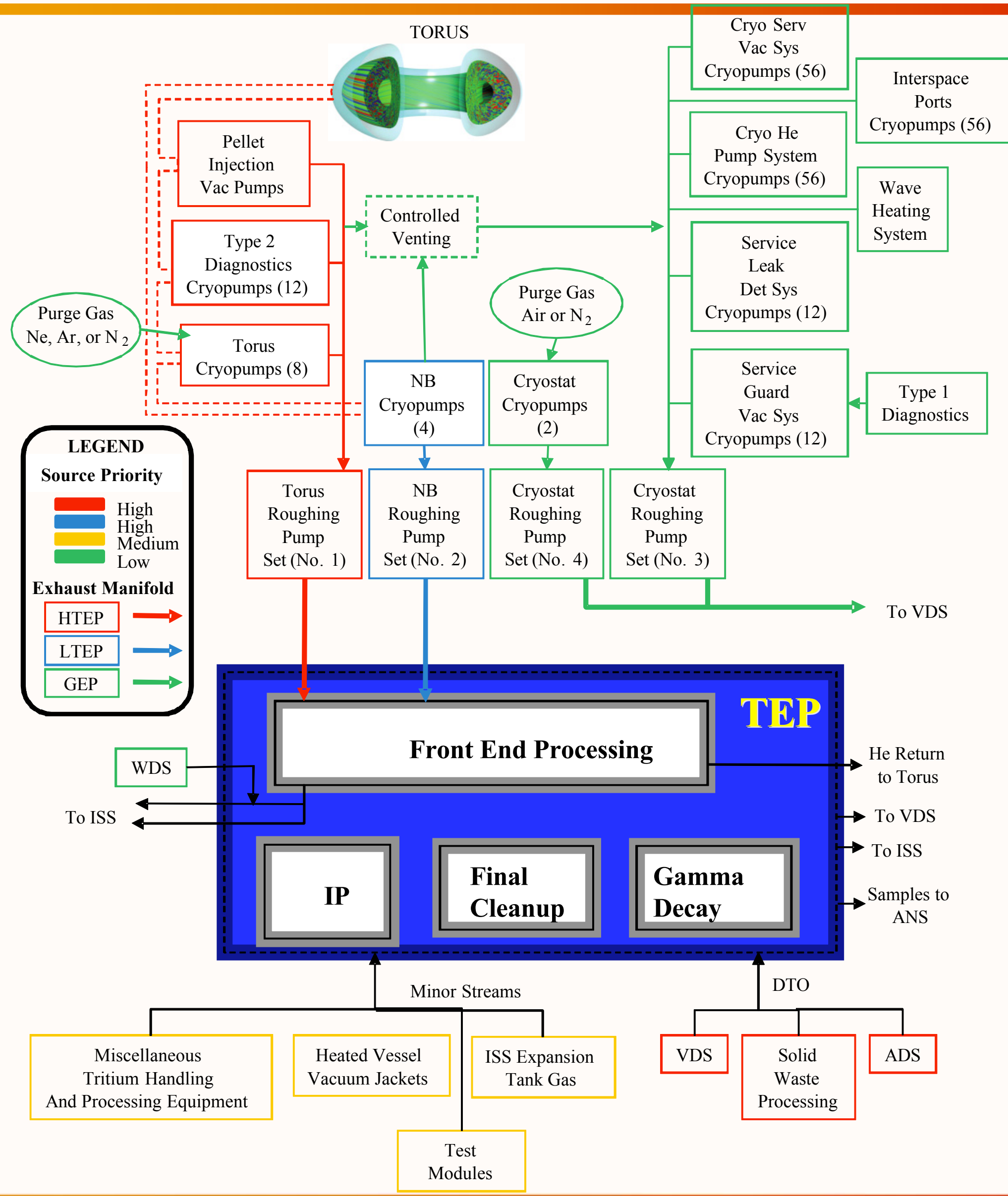
C - complete, O - ongoing, P - planned

- **Progress** in advancing diagnostics designs comes through broad community involvement in short-term performance assessments, cost studies, & R&D tasks.
- **Near-term challenge** is to obtain authorization to proceed to detailed design.
  - Activity presently delayed due to slip in schedule for issuance of diagnostic procurement arrangements by ITER Organization to July, 2009.
  - In many areas, scope definition is also incomplete pending PAs.

Tritium Processing System

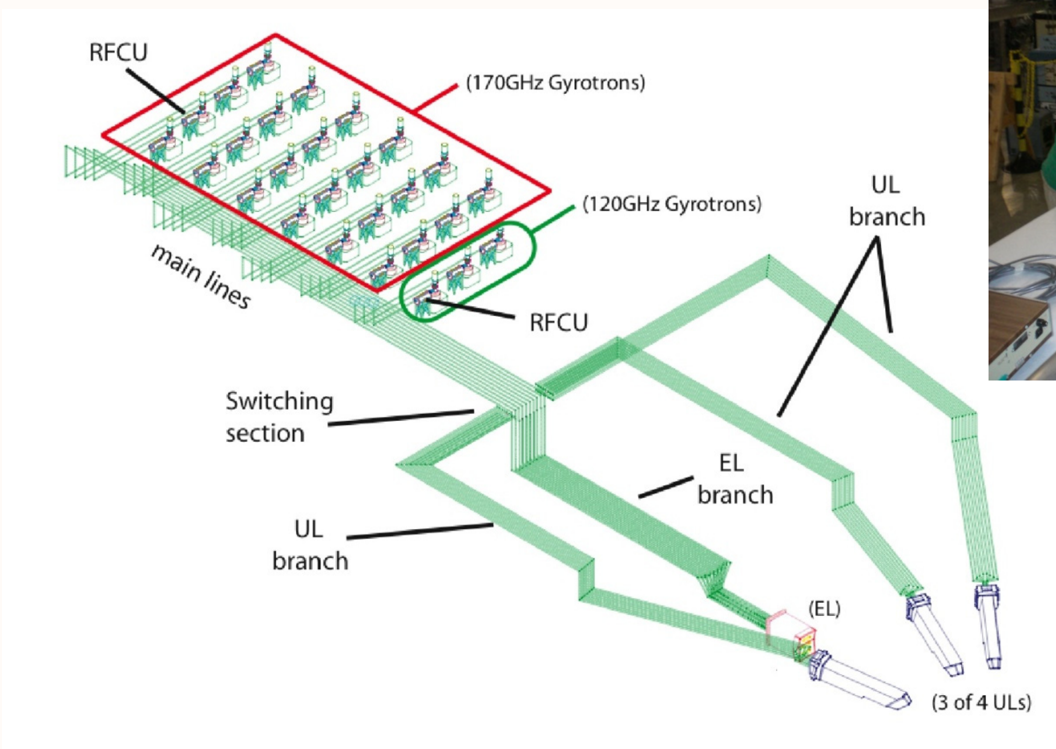


Tokamak Exhaust Processing Interfaces



Electron Cyclotron Transmission Line and Mode Control

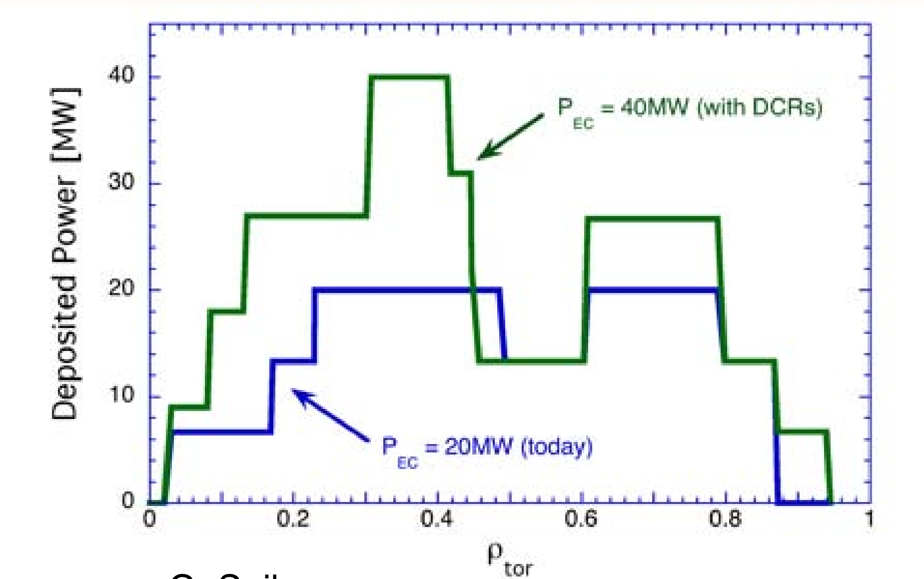
1 or 2 MW transmission lines from the gyrotrons to the launchers
24 lines to the equatorial launcher (EL); 32 lines to the upper launchers (UL)



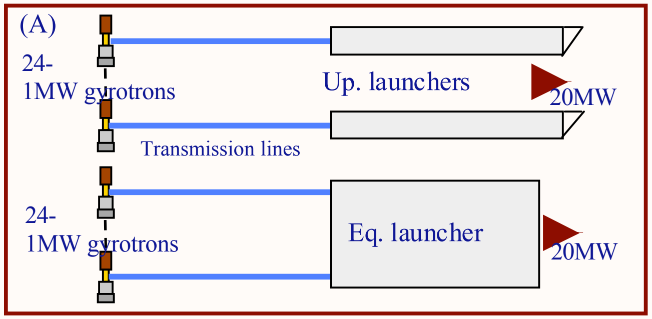
US ITER ECH Test Facility to develop and qualify T-line components with long pulse gyrotrons (140 GHz and 170 GHz)

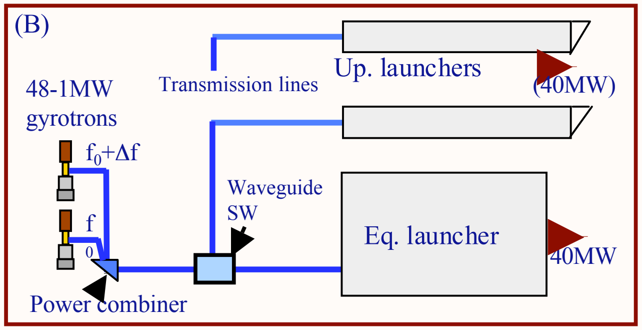
Likely upgrades to ECH system impact the Transmission Lines

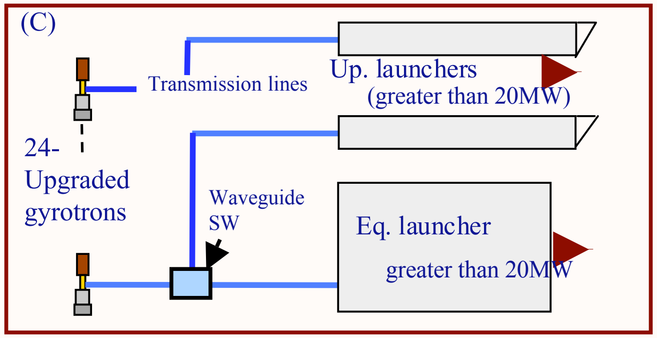
- Increase sources from 24 to 48 MWs as a substitute for NBI power.
- 2 MWs per line (increased cooling)
- Three possible T-line options



G. Saibene

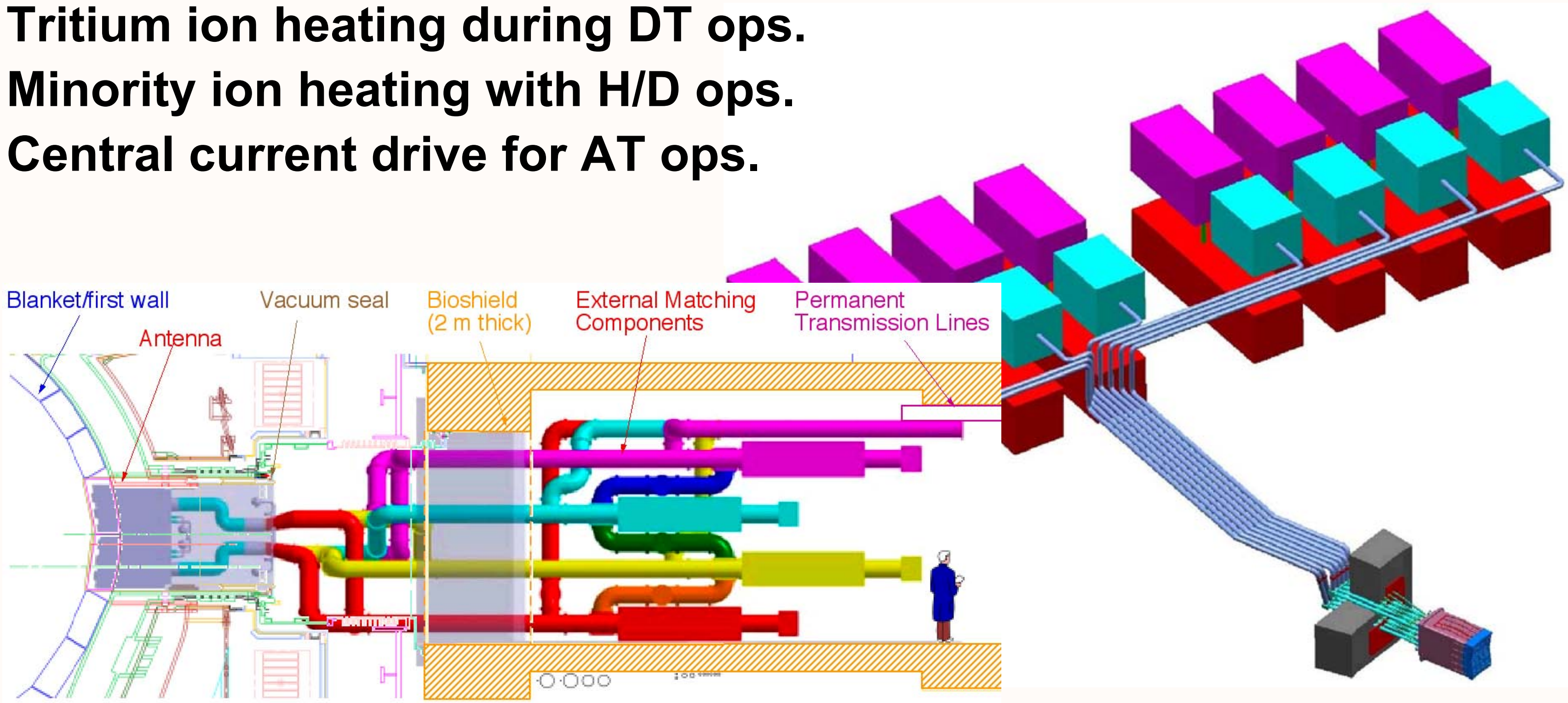






ICH Transmission lines and Tuning/Matching System

Tritium ion heating during DT ops.
Minority ion heating with H/D ops.
Central current drive for AT ops.

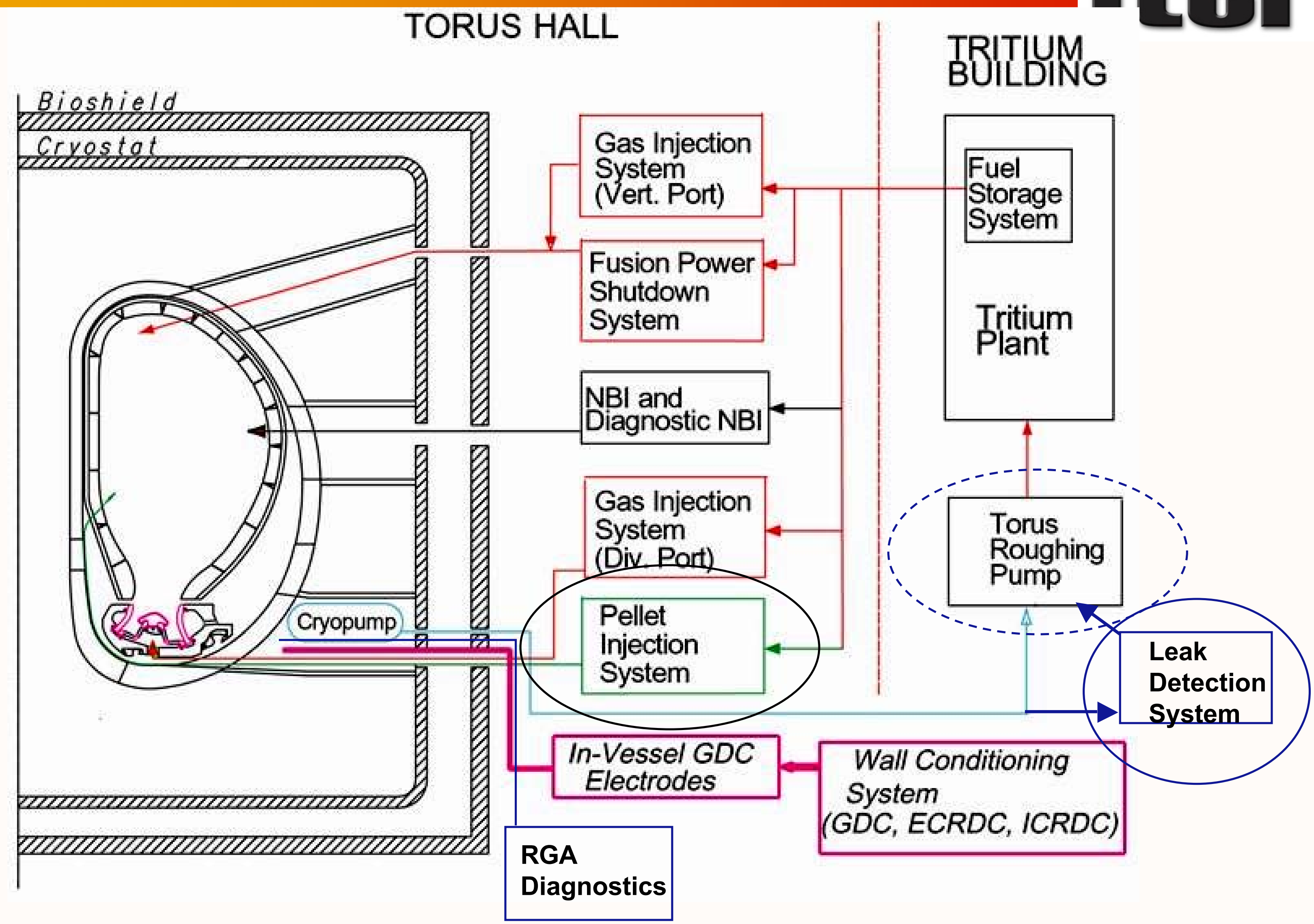


5 or 2.5 MW transmission lines from the sources to the antenna
4 or 8 lines feed an <u>ELM tolerant</u> tuning/matching (T/M) system
Conjugate T or 3 dB T/M connected to 24 strap antenna array

40-55 MHz High Power, Long Pulse, facility used to develop and qualify components

High power resonant ring and shorted T-line can test components to > 5 MWs for full pulse length

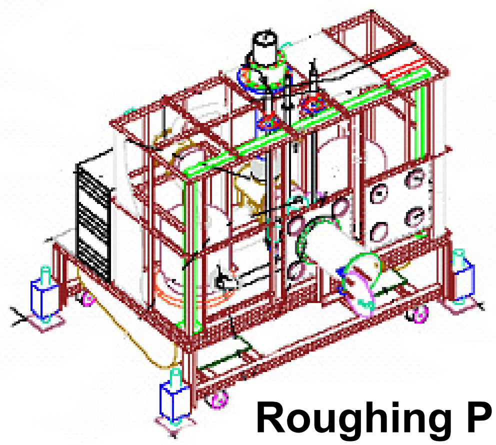
ITER Pumping and Fueling Systems



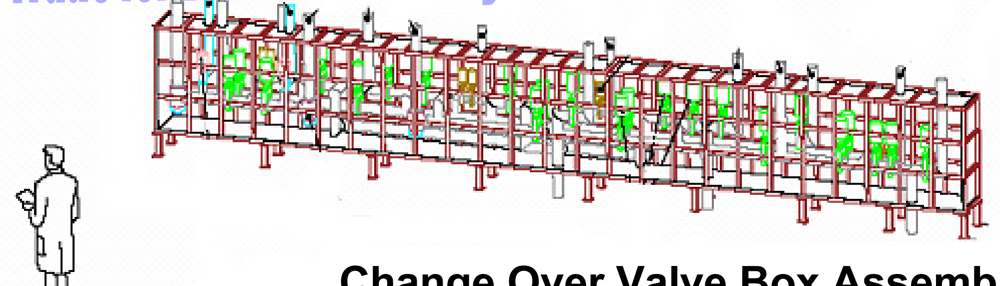
Roughing Pump System
Leak Detection System

- **Roughing pump sets - 4 identical pump assemblies**
  Piston pumps, Blowers, glove box assemblies with associated valves, instrumentation and controls. Needs to be tritium compatible.

Trade for Leak Detection System



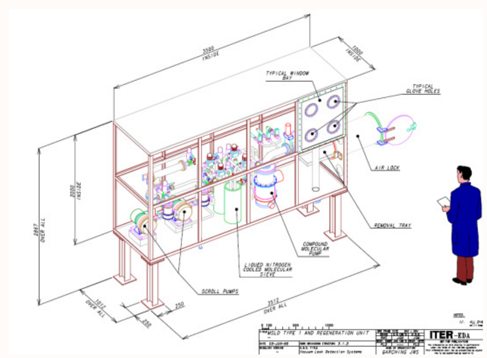
Roughing Pump Set Assembly



Change Over Valve Box Assembly

- **Leak Detection System - Mass spectrometers and RGAs, conventional vacuum hardware, all need to be tritium compatible. Some assemblies in glove boxes.**

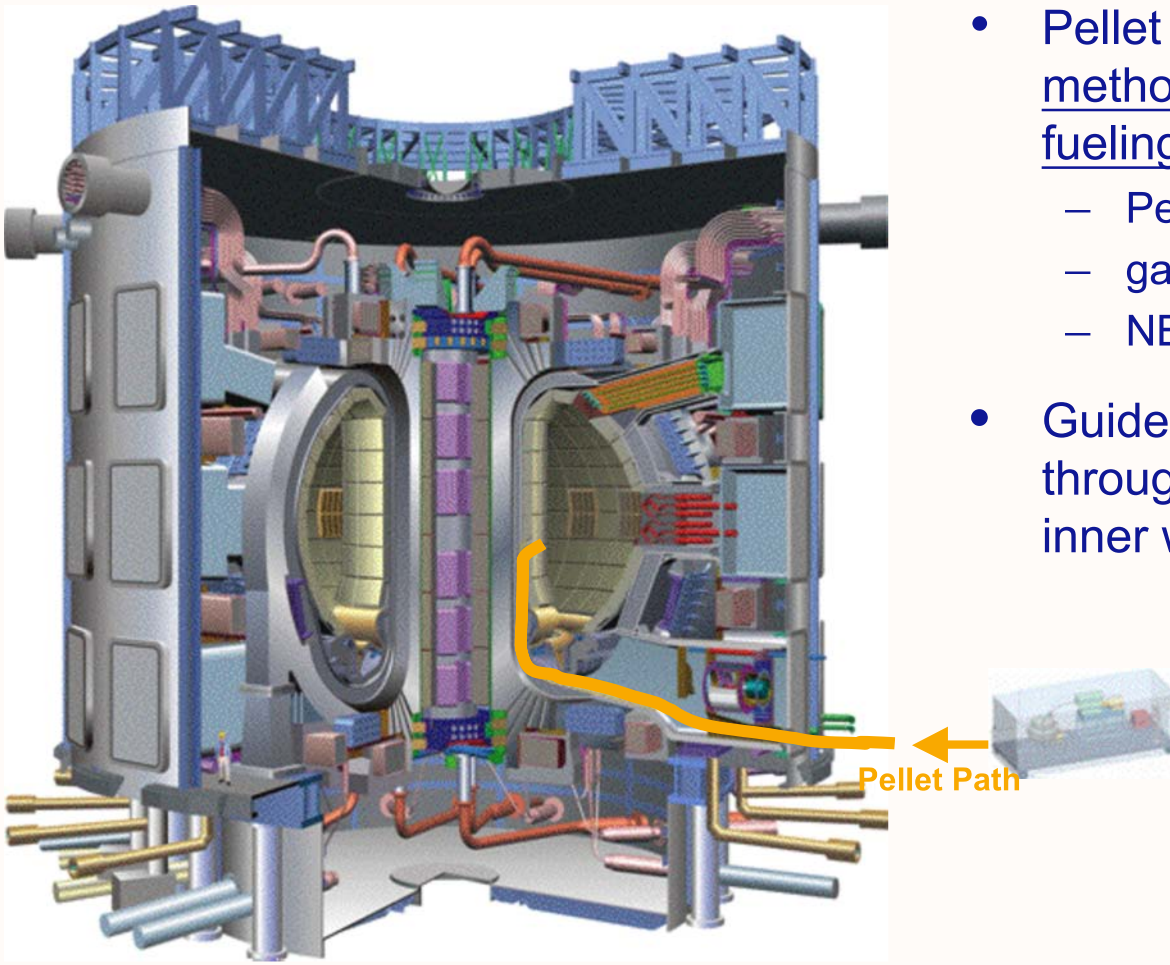
Mass Spectrometer
LD Type 1



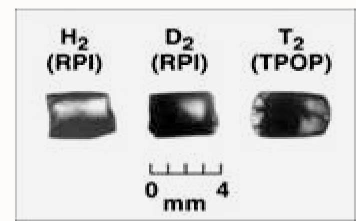
Standard Vacuum Components

- **Standard components consists of**
  - **ICRF vacuum system - 64 getter pumps and 32 valves**
  - **ECH vacuum system - 130 sputter ion pumps, 10 TMPs, 10 dry pumps & 220 valves**
  - **Guard and service vacuum system - 86 cryo pumps, 2 dry pumps and 1738 valves**

Pellet Fueling System



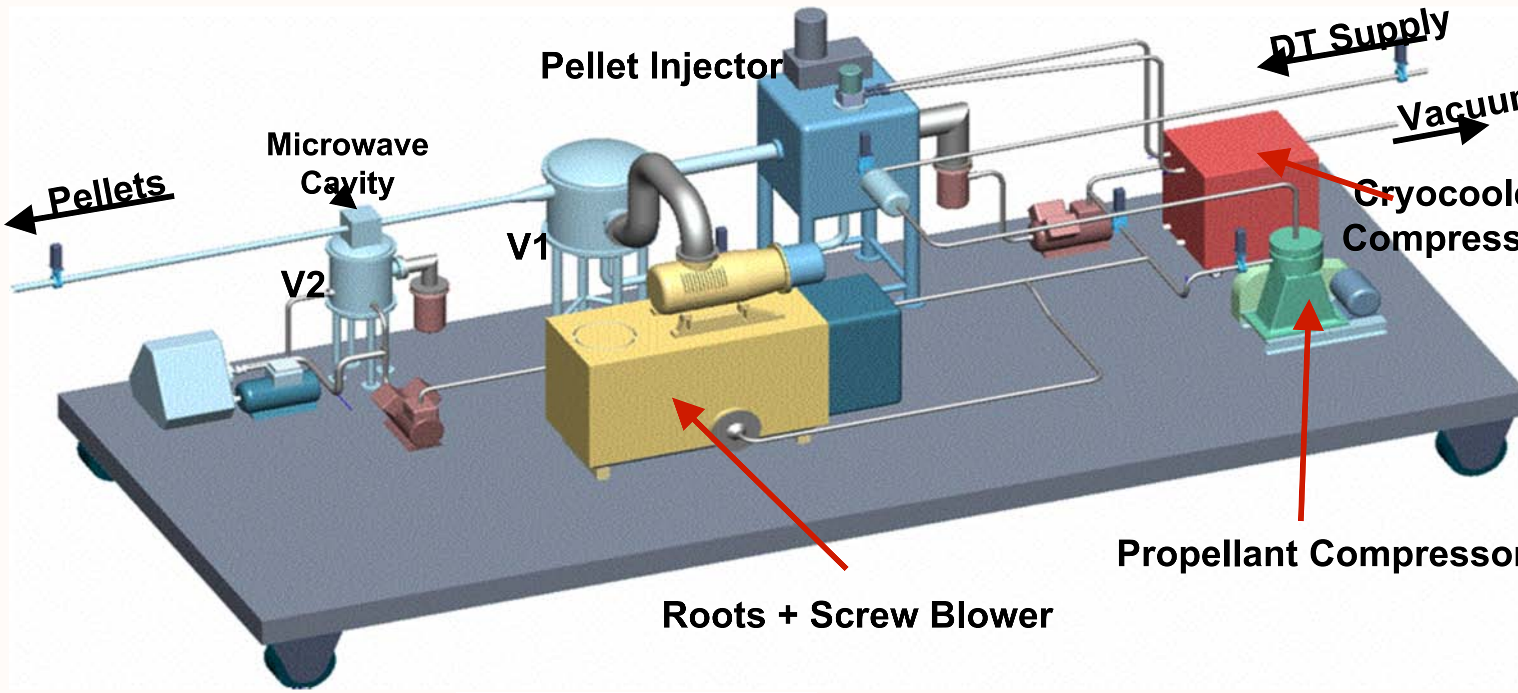
- Pellet injection the only known method to achieve efficient core T_2 fueling
  - Pellets ~90% efficient
  - gas puffing < 1% efficient
  - NBI fueling negligible
- Guide tubes bring the pellets through the divertor ports to the inner wall.



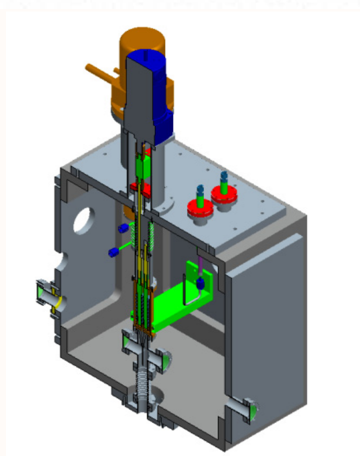
Hydrogen, Deuterium and Tritium Pellets

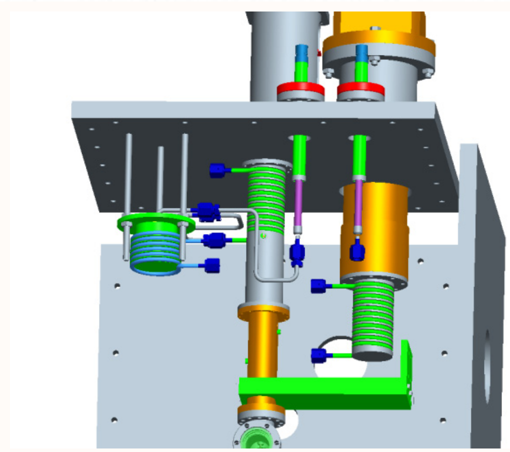
- 2 pellet injectors in 2 separate casks

ITER Gas Gun Pellet Injection System R&D and Design underway

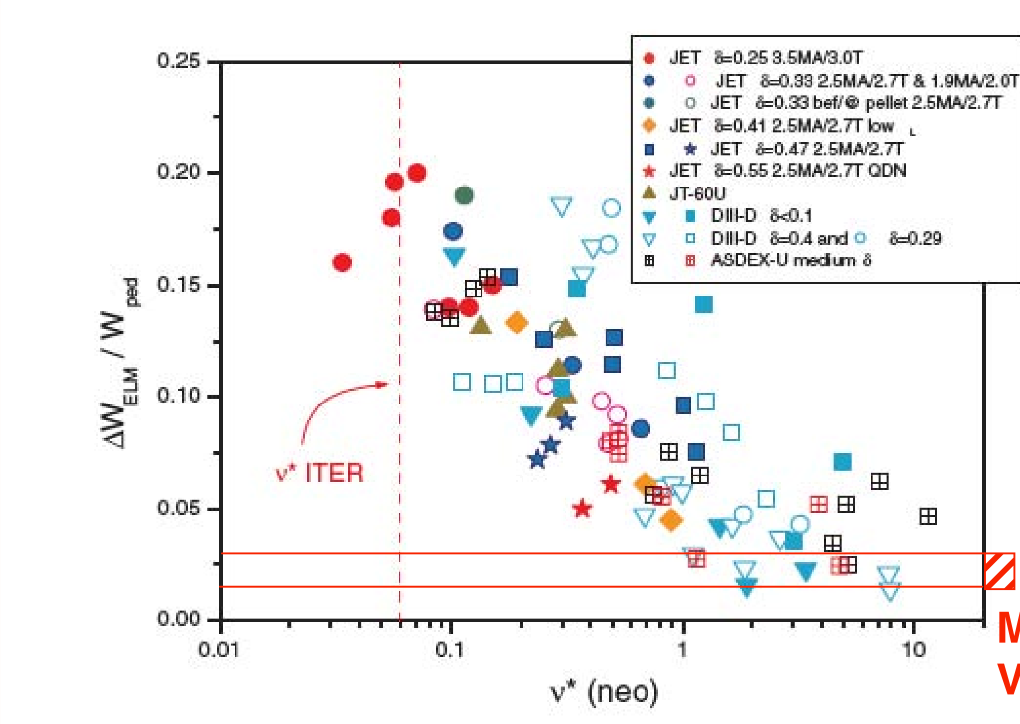


Prototype extruder is being tested

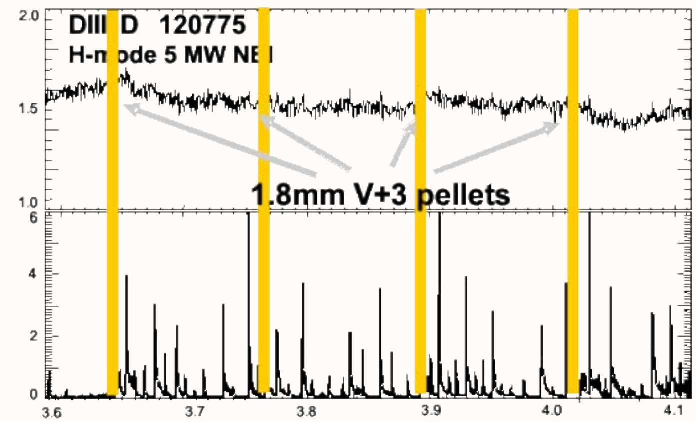




Control of Type 1 ELMs Is a Pressing Issue for ITER



Minimum Acceptable Value (?)

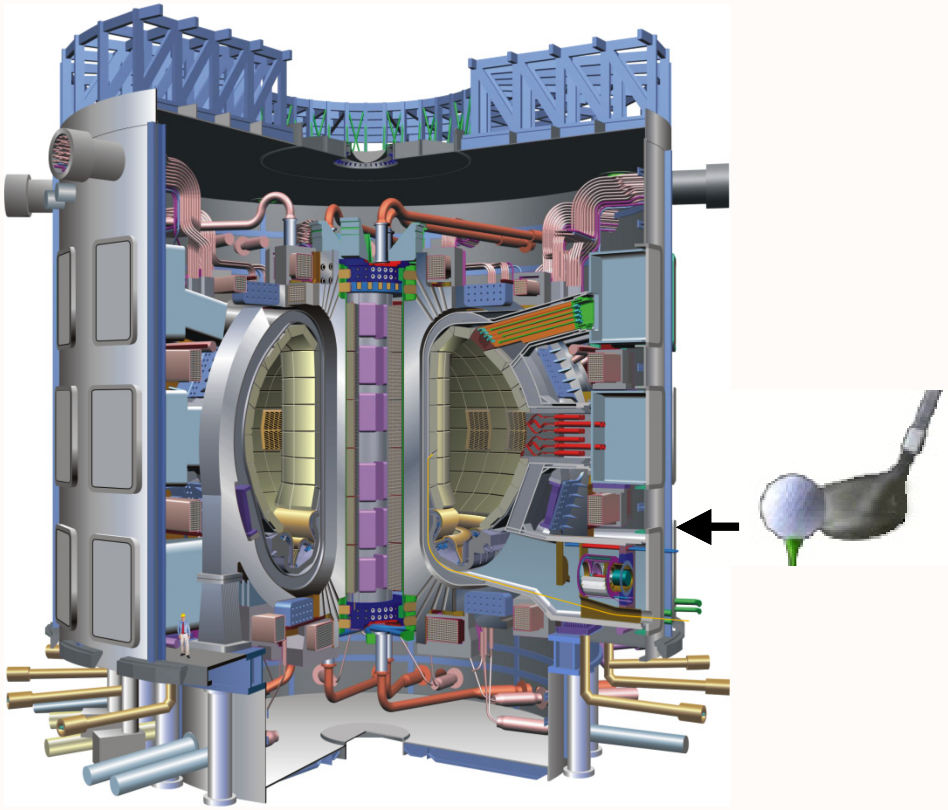


Pellet pacing to trigger ELMs

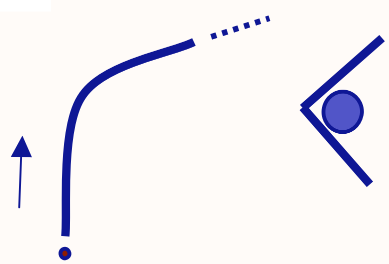
Loarte et al., Nuclear Fusion, ITER Physics Basis,Chapter 4

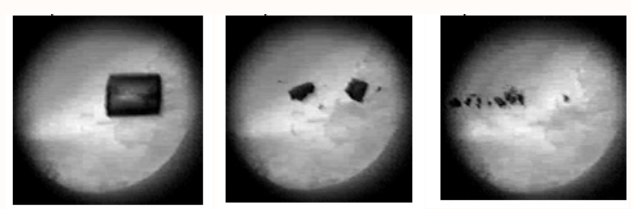
Reducing the energy loss to <1MJ using ~ 40 Hz pellet pacing has been proposed
Would require at least 2 additional injectors to provide high throughput of pacing pellets

Killer pellets have been proposed for Disruption Mitigation



- A “golf ball size” pellet made with D_2 or combination of D_2 and Ne or other impurity is an option to mitigate disruptions.
- A 10 cm^3 pellet with 10,000 torr-L is entirely possible.
- A reliable single stage gas gun can accelerate the pellet to 1 km/s speed.
- A “V” groove guide tube to produce quasi-liquid jet looks promising.

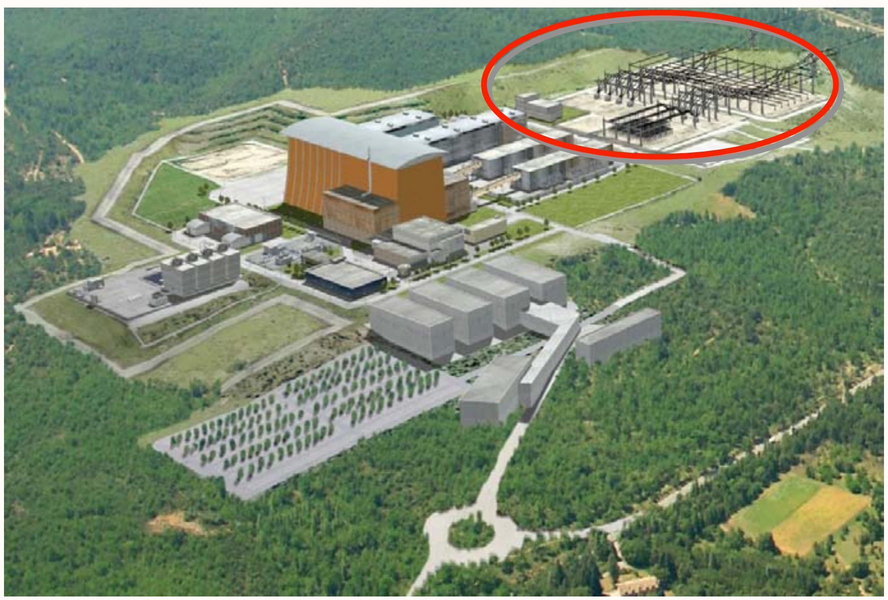




350 m/s 581 m/s 1115 m/s

SSEPN Scope

- 140MVA AC Substation & Power Distribution
- Design, installation, commissioning by EU
- Procurements shared by EU and US



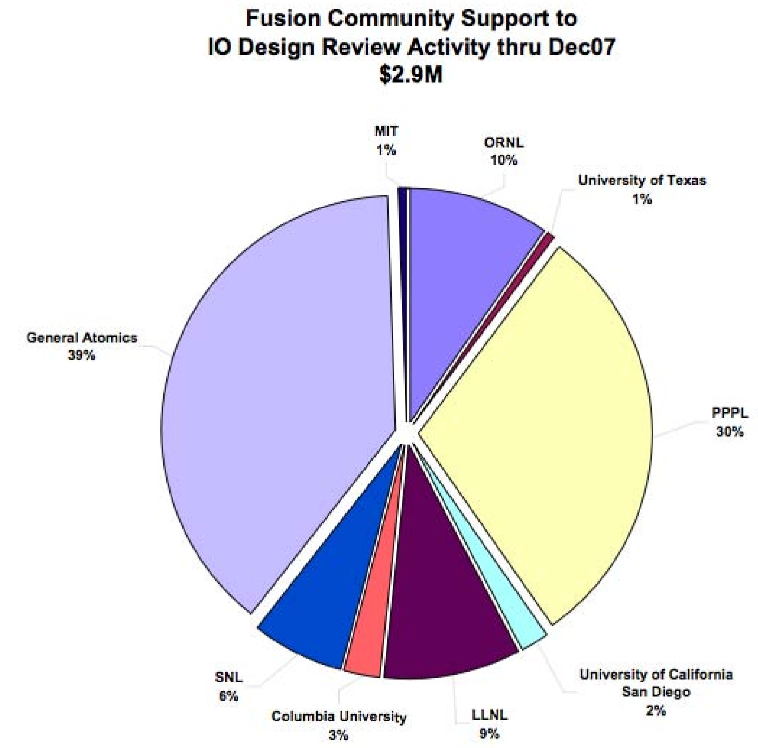
- *HV Switchgear*
- *HV Transformers*
- *MV Switchgear*
- *MV Transformers*
- *LV Load Centers*
- *LV Distribution Boards*

75% by US
~ $20M
equipment

25% by EU

Support of the Resolution of Design Issues

- The USIPO provided support for community participation in the "Design Review"
  - The Burning Plasma Organization was a major contributor, particularly in Working Group 1
  - The Virtual Laboratory for Technology contributed in the areas of expertise
  - The USIPO team participated in the US design areas and in general areas

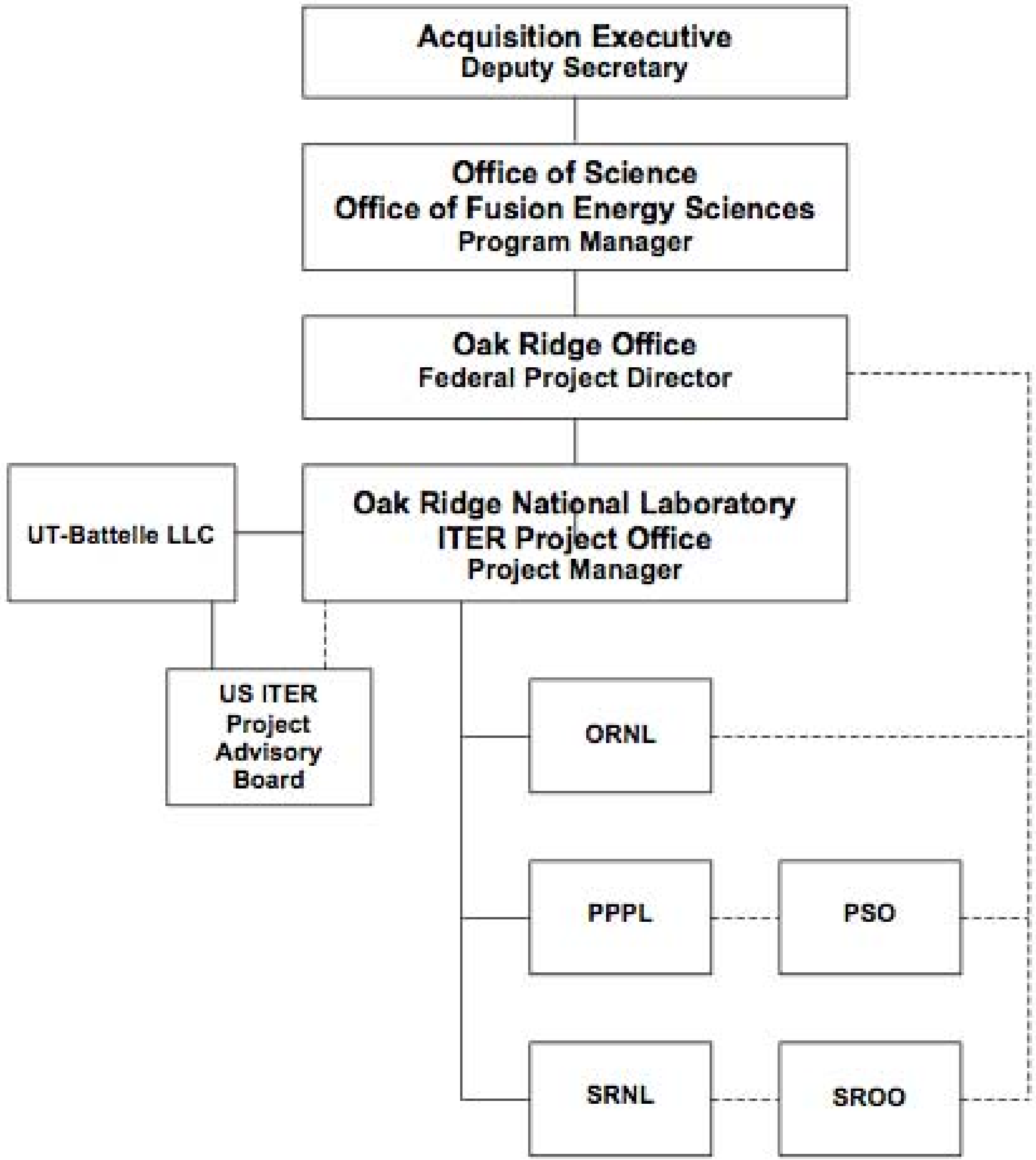


- The remaining issues are being addressed by the ITER Organization, Domestic Agencies, and the fusion communities of the ITER parties
  - International and domestic processes being developed
  - Target resolution by Spring 2008

Design Issues for Resolution

- Vertical Stability
- Shape Control/ Poloidal Field Coils
- Flux swing in Ohmic Operation and CS
- ELM control
- Remote Handling
- Blanket Manifold RH
- First Wall (C/W) strategy
- Capacity for 17MA discharge
- Coil cold tests
- Vacuum Vessel
- Other issues
  - TBM strategy
  - Hot cell Design
  - Buildings/ integrated logisitcs
  - Heating and current drive strategy related to research plan

The U.S. ITER Project Office (USIPO)

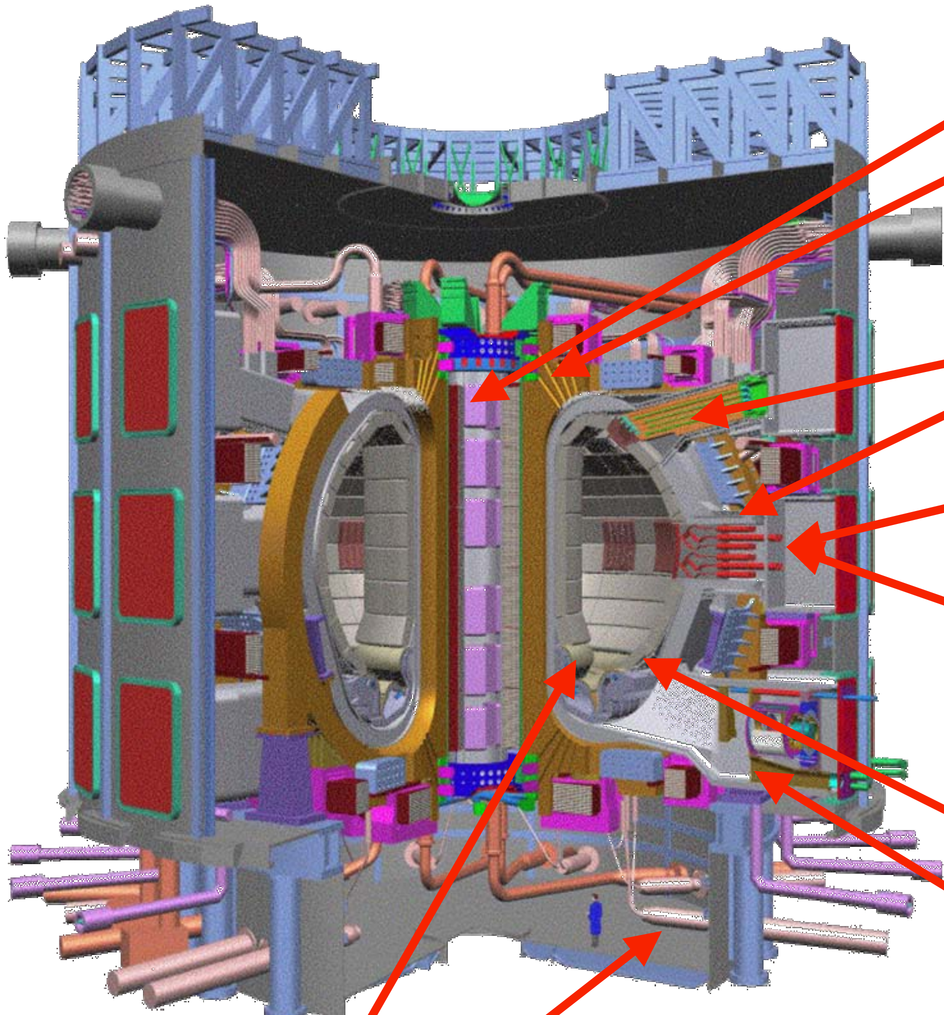


Legend:

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

US ITER In-kind Hardware Contributions



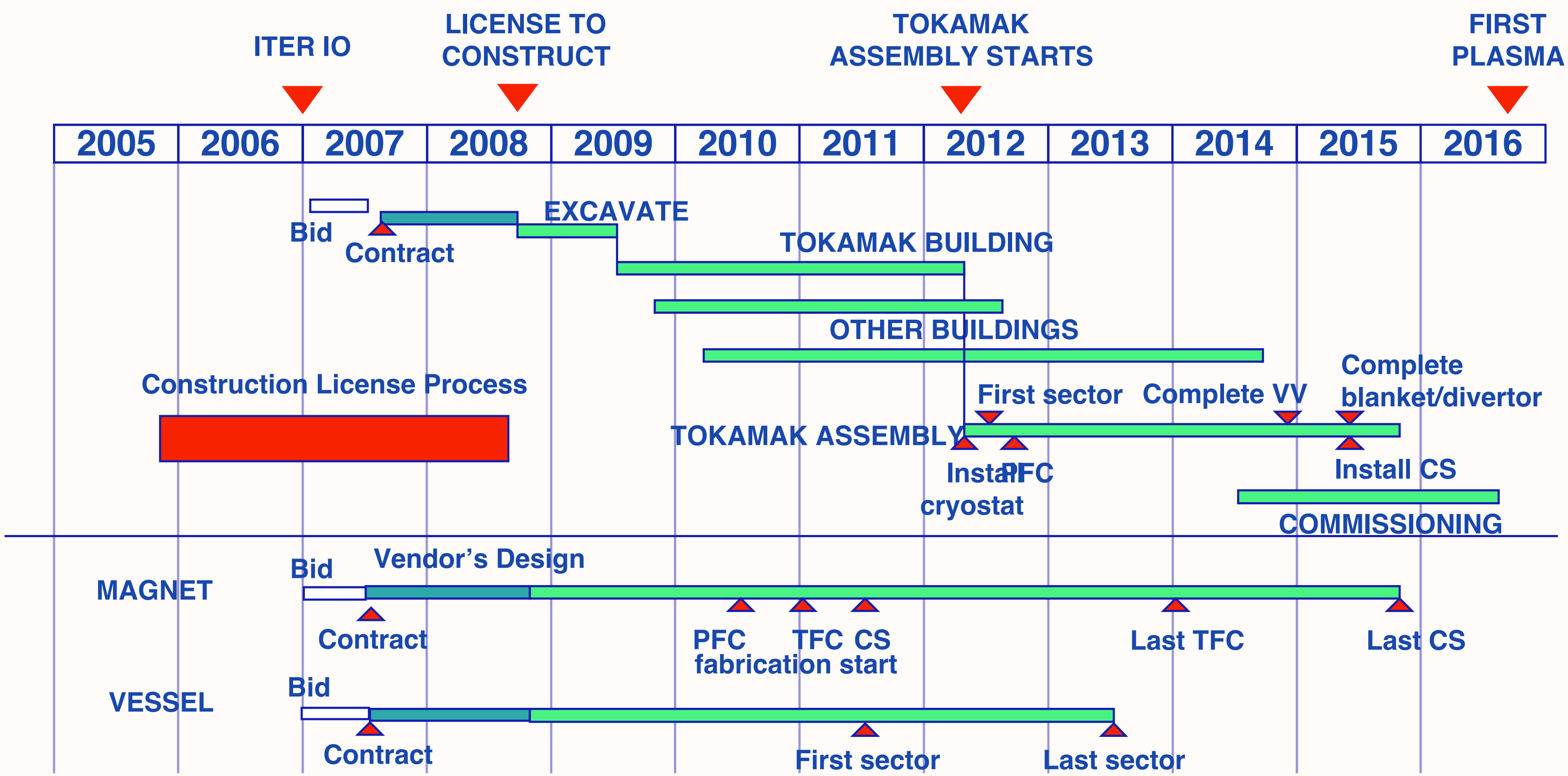
Procurement Procedures

- U.S. ITER procurements are governed by Department of Energy Acquisition Regulations (DEAR) as well as the Federal Acquisition Regulations (FAR)
- These DOE regulations are flowed down to the national laboratories through their contracts with DOE
- ITER Agreement terms also flow down through contracts
- Partner labs PPPL and SRNL will manage their own contracts with USIPO oversight

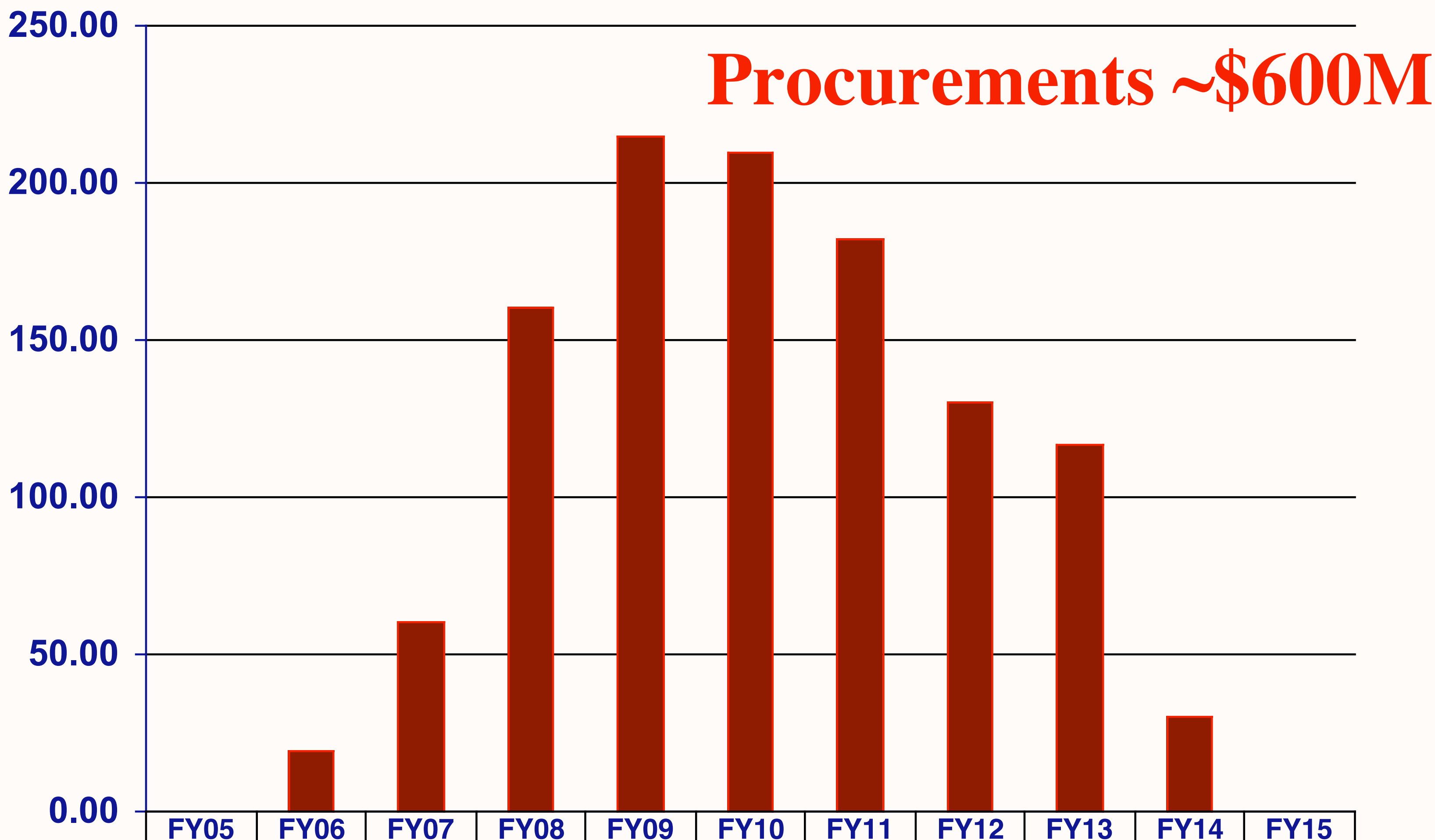
US ITER Procurement Practices

- USIPO and IO jointly perform R&D, design and Procurement Agreements
- USIPO completes enabling work and defines scopes for suppliers
- We expect detailed design, manufacturing design and fabrication to be done mostly by industry
- USIPO will be the contact with the suppliers for US scope
- We have the ability to offer incentives in contracts to motivate schedule performance
- USIPO provides information to the IO on milestones

Integrated Project Schedule



US ITER Budget Request ($M), summing to $1.122B



	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15
Budget request	0.00	19.32	60.00	160.00	214.50	209.32	181.96	130.00	116.90	30.00	0.00

To do business with U.S. ITER Project

- Procurement website – https://www.usiter.org/pro/

- Register on vendor database:
  - Business opportunities for U.S. ITER
    - ORNL
    - PPPL
    - SRNL
  - Business opportunities with International ITER

Summary

The U.S. Domestic Agency is ready to proceed:

- established and functioning, with a tightly integrated DOE/contractor team
- set up, staffed, and engaged with ITER planning:
  - Technical and Management staff in place
  - Procurement and QA staff in place
  - Plans developed, but dependent on others
- engaging the US fusion community
- actively supporting resolution of key requirements, technical issues, resolution of roles/responsibilities, and receipt of appropriate Procurement Arrangements from the ITER Organization