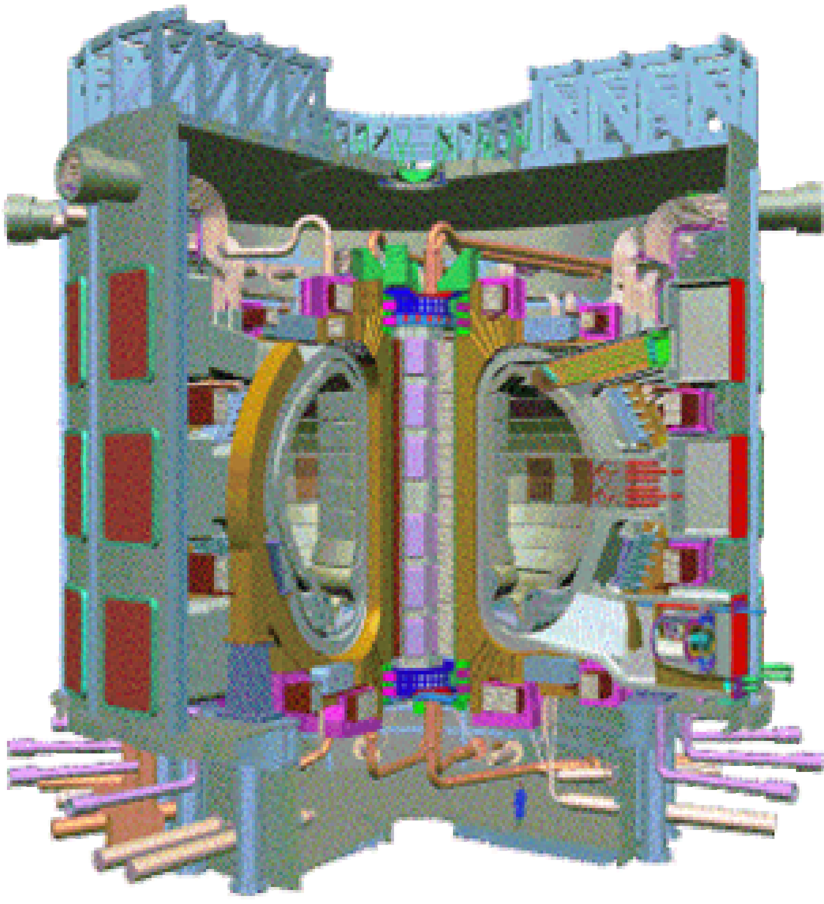
ITER Project Status

Positioning the US for ITER

Ned Sauthoff
U.S. ITER Planning Officer

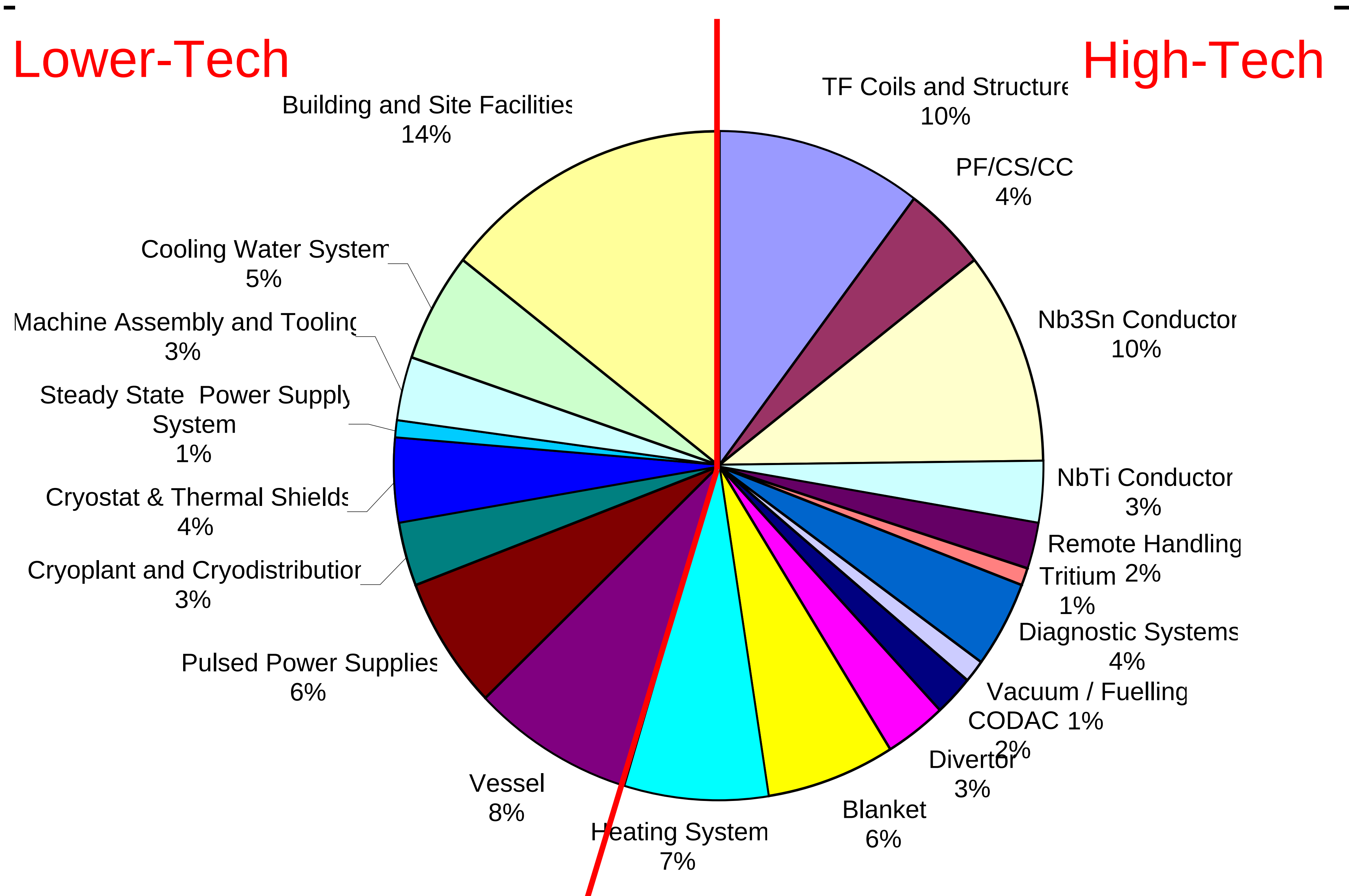
FESAC
3/30/04



Last time at FESAC: Overview of NSSG-Groups

Area	US emphasis
• Management Structure	*effectiveness*
• Staffing	*accessibility*
• Procurement Systems/Methods	*in-kind/in-cash; changes*
• Procurement Allocations	*project success and US interests*
• Resource Management Regulations	*visibility and changes*
• Risk	*recognition and management*
• Intellectual Property	*benefits and protection*
• Decommissioning	*amount and timing of the funds*

ITER value is about 50% in "high-tech systems"



Guidelines for the US in-kind offers

- **The total value of the US offers matches the negotiated percentages**

- **The cost of the the US offer is within the Administration's dollar-limit**
  - in-kind contributions
  - construction management, and
  - US domestic agency, contingencies, reserves, …

- **The scope is consistent with US export controls, US Trade Representatives' guidelines, etc.**

- **The scope is of interest to the US**

- **The scope is consistent with US capabilities**

Burning Plasma Progam Advisory Committee

- **Membership**
  - Stewart Prager (U. Wis.), chair
  - Mohamed Abdou (UCLA)
  - Réjean Boivin (GA)
  - Harold Forsen
  - Jeffrey Freidberg (MIT)
  - Richard Hawryluk (PPPL)
  - E. Bickford Hooper (LLNL)
  - Stan Milora (ORNL)
  - Gerald Navratil (Columbia)
  - Tony Taylor (GA)
  - George Tynan (UCSD)
  - Michael Ulrickson (Sandia)
  - James Van Dam (UTex)

BPPAC criteria, metrics and priorities for US contributions

1. US research positioning (High)

- Metric: Extent to which activity positions the US for key science/technology roles in ITER

2. ITER-value per dollar (High)

- Metric: ITER value/(US cost of full scope of ITER-specific R&D + design + fab + contingency)

3. Relative value or strength of US contribution to ITER (High/Medium)

- Metric: High relative strength to meet a critical need of the ITER project

4. Contributions to US fusion research program (Medium)

- Metric: Enhancement of US capability for activity both in ITER and outside ITER

5. Enhancement of fusion-relevant capability of US industry (Medium/Low)

- Metric: Extent activity increases industrial capability in fusion areas

6. Development of US fusion workforce (Low)

- Metric: Extent to which activity builds a suitable US fusion science and technology work force.

US cost-estimation for procurement-areas of interest

Magnet Systems
[Minervini/Antaya (MIT)]

Diagnostics
[Young/Johnson (PPPL)]

Ion Cyclotron H&CD
[Swain (ORNL) /
Hosea (PPPL)]

Electron Cyclotron H&CD
[Temkin (MIT) /
Hosea (PPPL)]

US area experts (labs and universities)

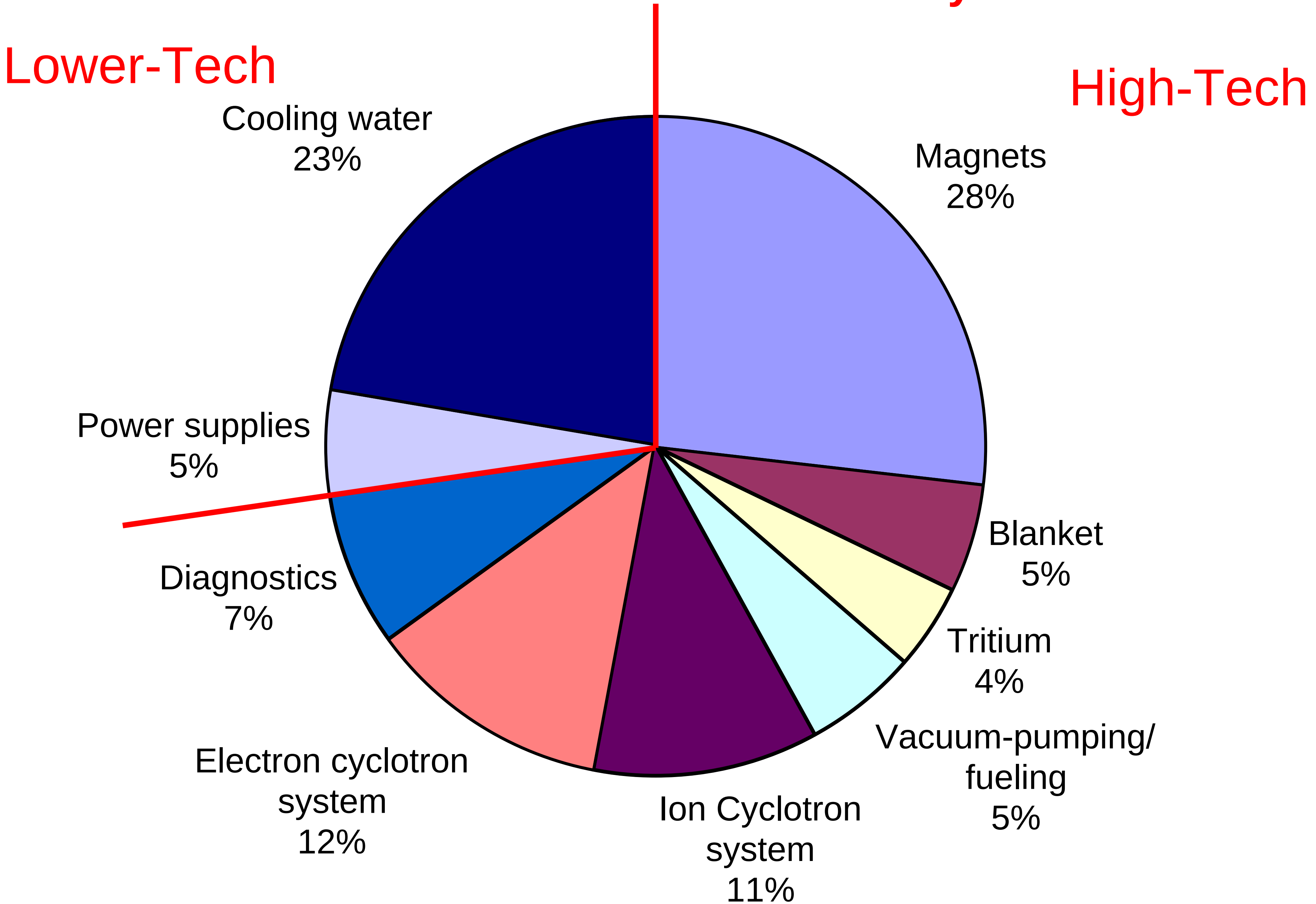
Divertor
[Ulrickson (SNL)]

Tritium
[Willms (LANL)]

Vacuum Pumping and Fueling System
[Gouge (ORNL)]

Cooling water, power supplies
[Hill (LLNL)]

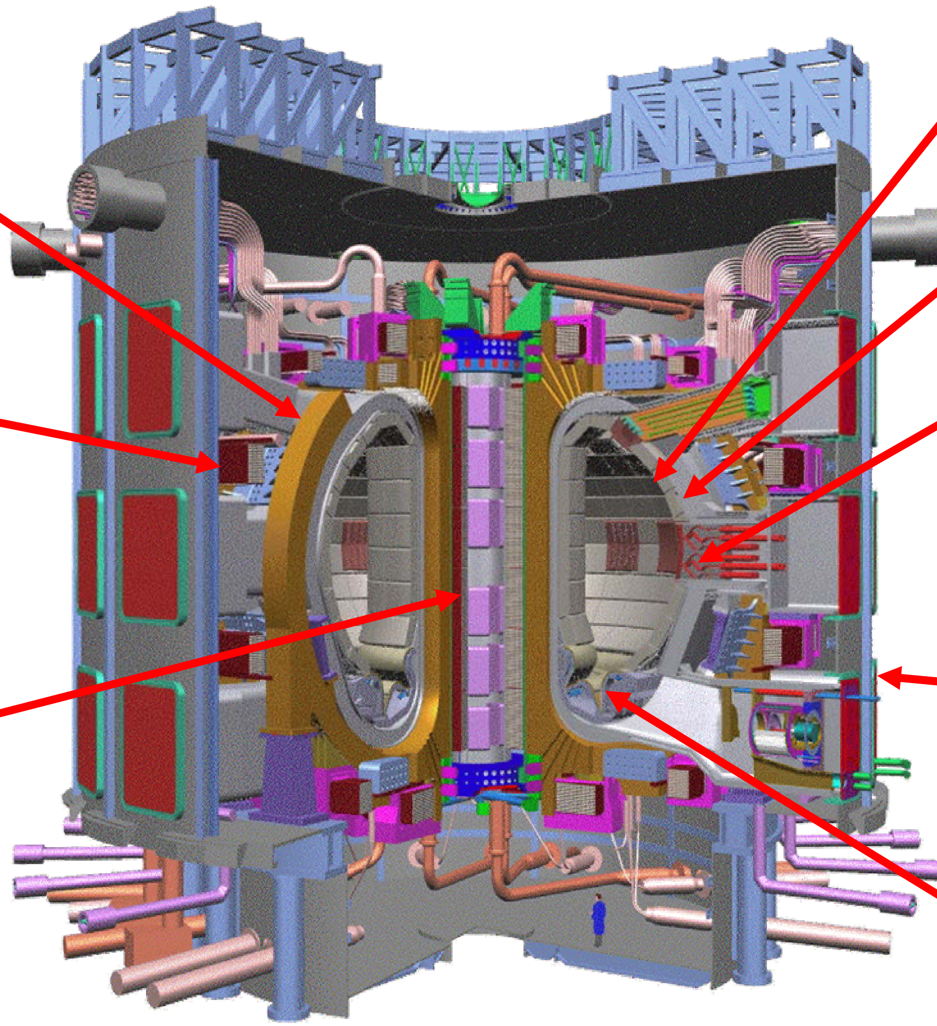
Tentative US in-kind contributions by Value

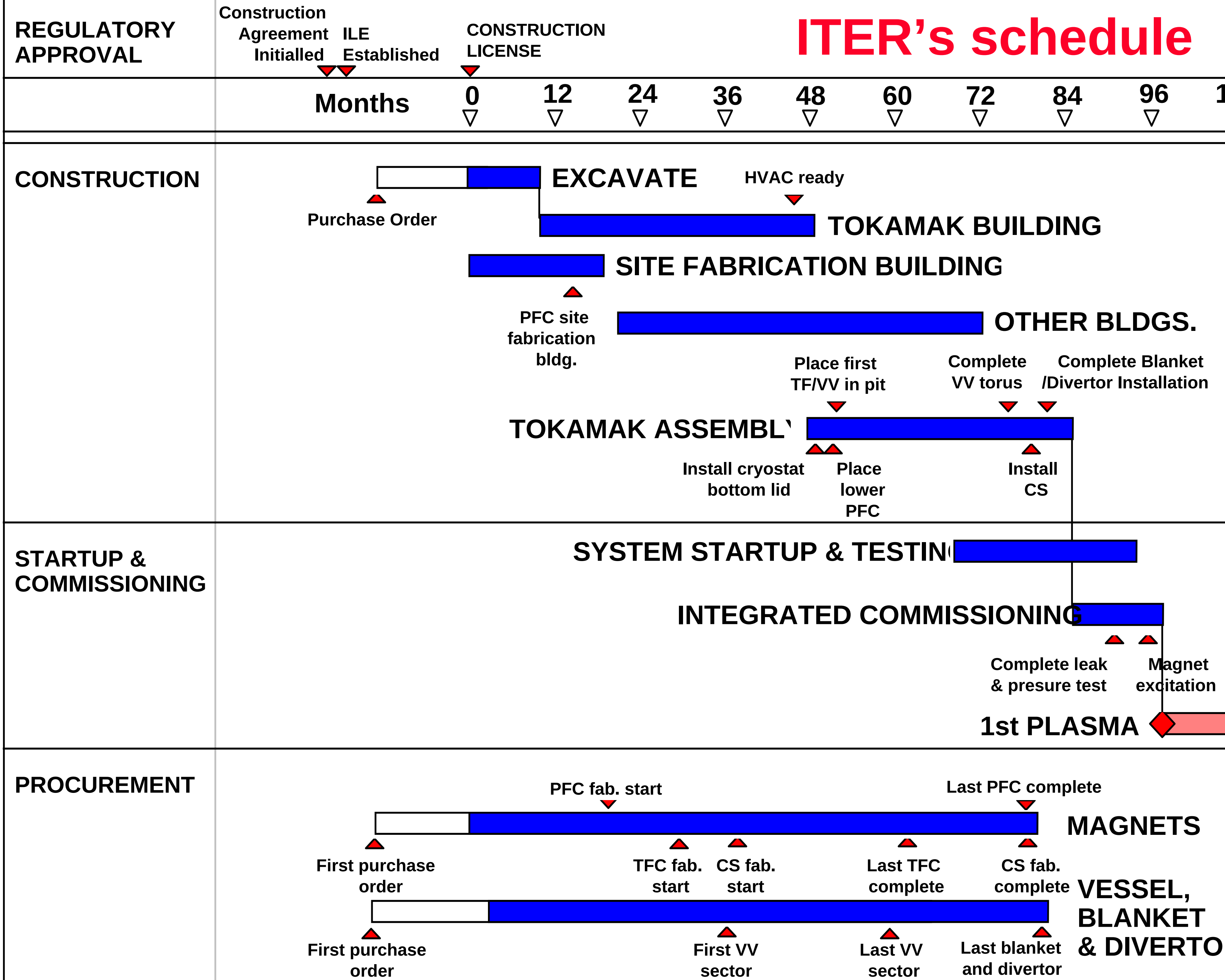


Overview of tentative US in-kind contributions

System	Description of US portion
Magnets	4 of 7 Central Solenoid Modules
Blanket/Shield	Module 18 (baffle)
Vacuum-pumping/ fueling	Roughing pumps, standard components, pellet injector
Tritium	Tokamak exhaust processing system
Cooling water	Cooling for divertor, vacuum vessel, …
Power supplies	Steady-state power supplies
Ion Cyclotron system	44% of antenna + all transmission/RF-sources/power supplies
Electron cyclotron system	Start-up gyrotrons, all transmission lines and power supplies
Diagnostics	Diagnostics Working Group recommended

Major Components of ITER




ITER's schedule
REGULATORY APPROVAL
Construction Agreement Initialled
ILE Established
CONSTRUCTION LICENSE
Months
0
12
24
36
48
60
72
84
96
CONSTRUCTION
EXCAVATE
HVAC ready
Purchase Order
TOKAMAK BUILDING
SITE FABRICATION BUILDING
PFC site fabrication bldg.
OTHER BLDGS.
Place first TF/VV in pit
Complete VV torus
Complete Blanket /Divertor Installation
TOKAMAK ASSEMBLY
Install cryostat bottom lid
Place lower PFC
Install CS
STARTUP & COMMISSIONING
SYSTEM STARTUP & TESTING
INTEGRATED COMMISSIONING
Complete leak & presure test
Magnet excitation
1st PLASMA
PROCUREMENT
PFC fab. start
Last PFC complete
MAGNETS
First purchase order
TFC fab. start
CS fab. start
Last TFC complete
CS fab. complete
VESSEL, BLANKET & DIVERTOR
First purchase order
First VV sector
Last VV sector
Last blanket and divertor

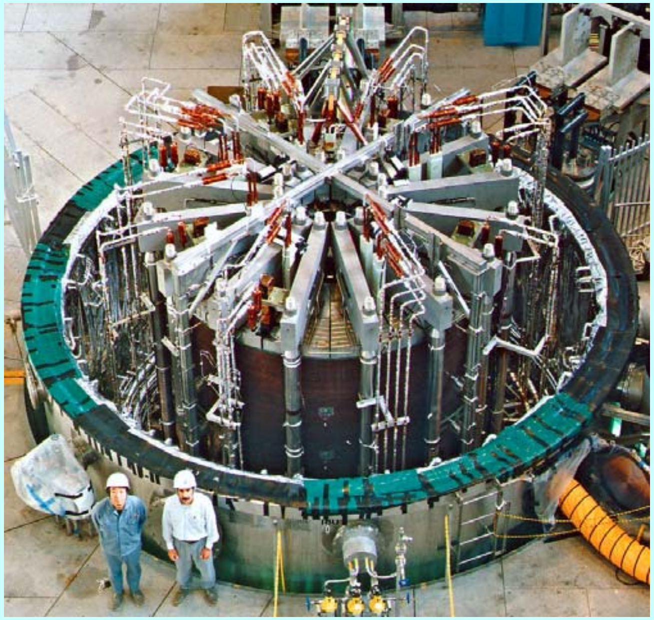
Magnets:
Central Solenoid

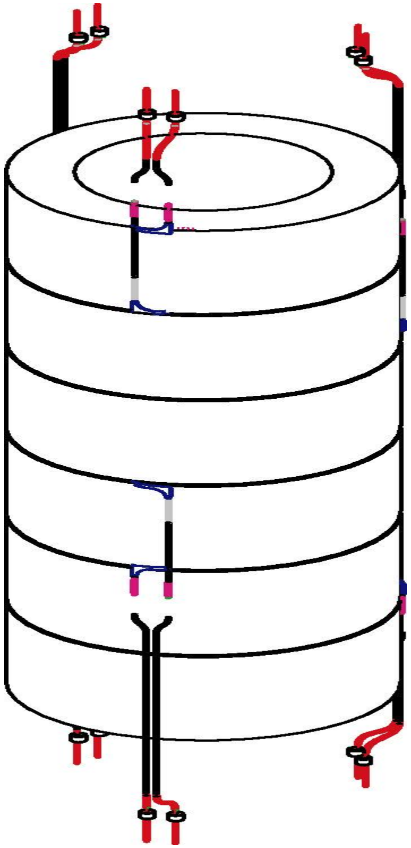
Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
4 of 7 Central Solenoid Modules	9% of full system; 57% of central solenoid	74.2 [$107M]

Overview of Central Solenoid

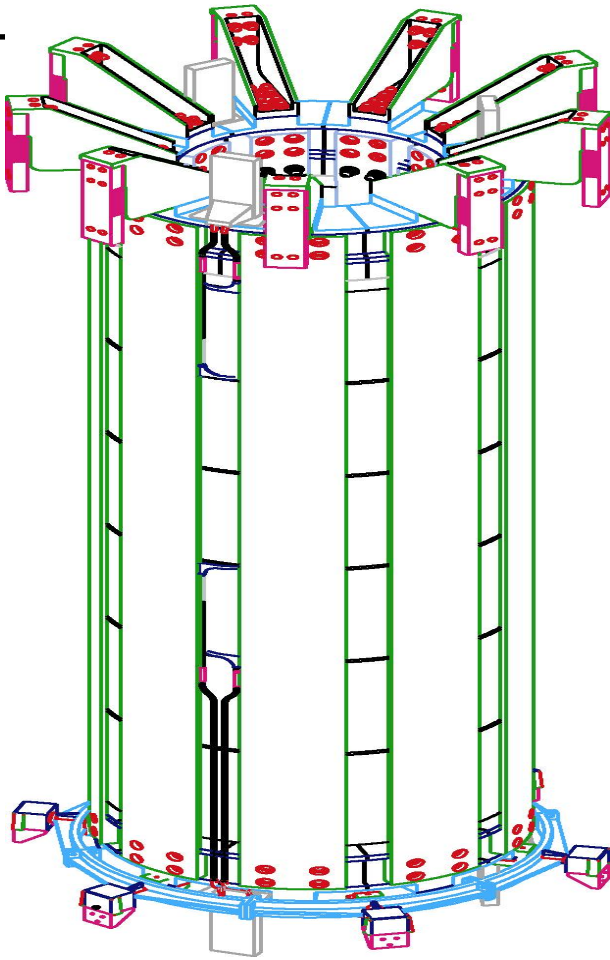
- Max. B: 13.0 T (IM)
- Max. I: 45.0 kA (EOB)
- Nb_3Sn CICC,
- Conduit: JK2LB
- 6 independent modules
- 9 tie-plates (SS316LN)

Each Module is slightly larger than the complete CS Model Coil



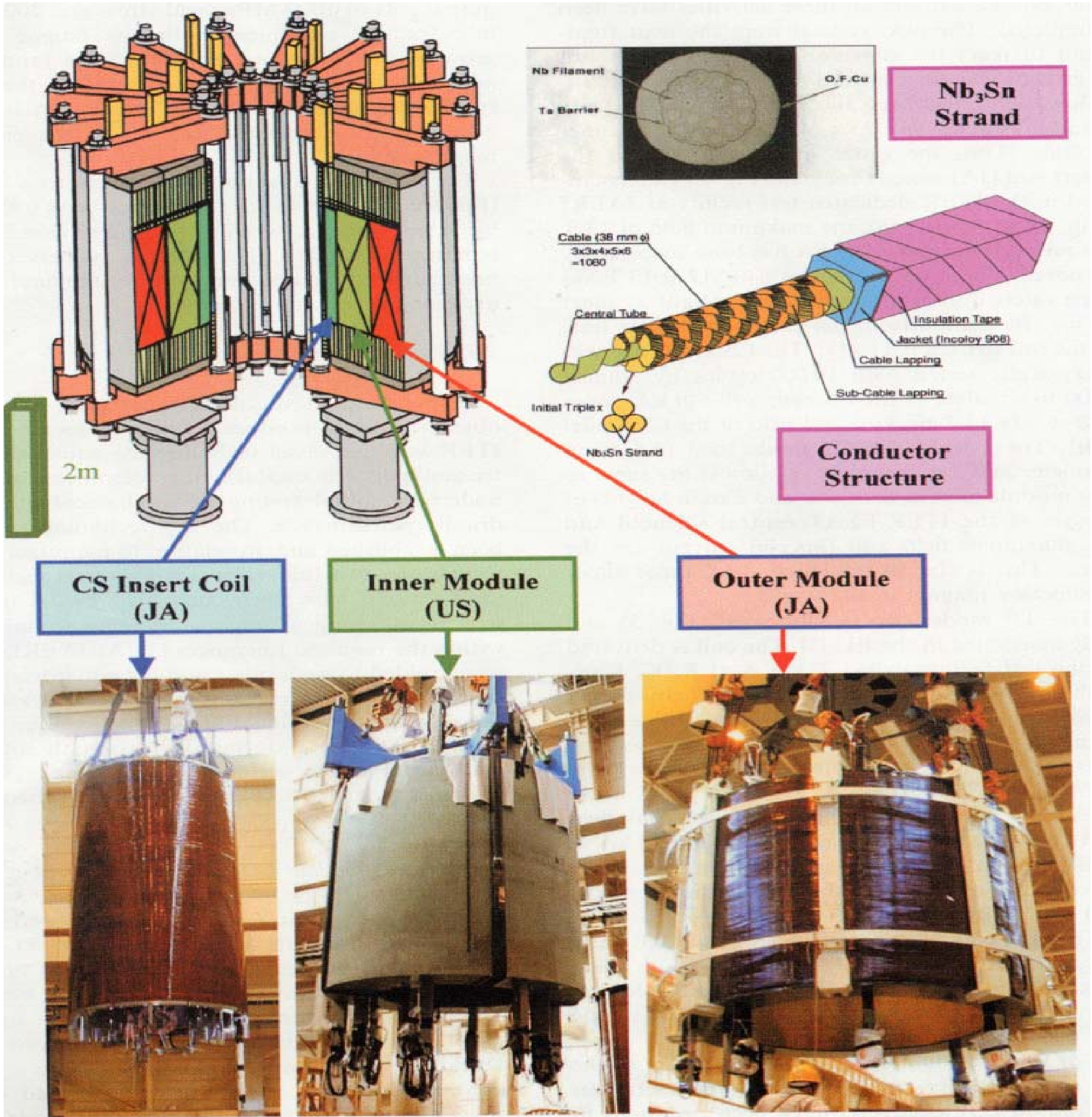


Before assembling structure



After installation in Tokamak

Central Solenoid Model Coil



Central Solenoid Conductor

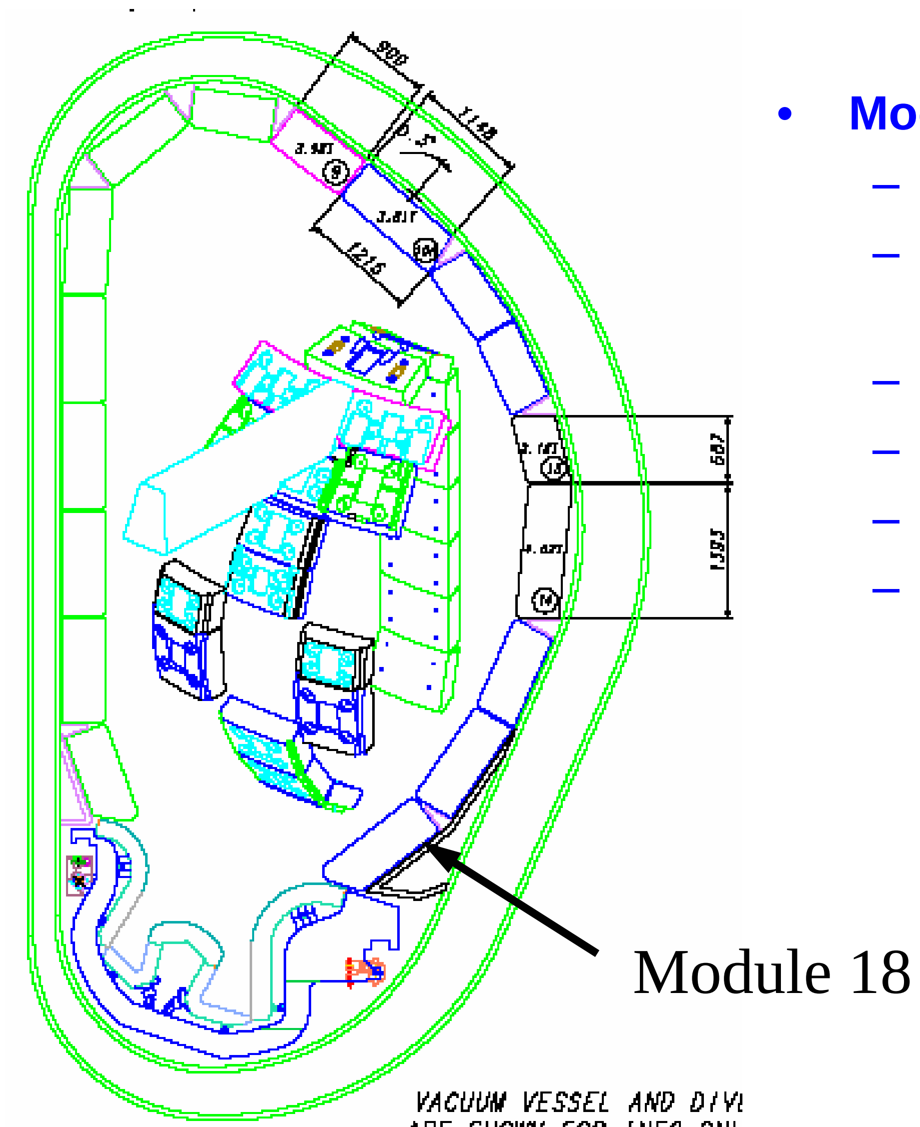
Changes from the FDR drive need for R&D and design

FDR	Present Design
Continuous Solenoid ~12m Tall	Segmented Solenoid 6 Modules
Bucked by TF Coils Conductor in Compression	Free-Standing Solenoid Conductor in Tension
Layer Winding 4-In-Hand/Series Connected	Pancake Winding 6 Hexa-Pancakes and 1 Quad-Pancake Separate Power Supplies
Lap or Butt Joints	Butt Joints
Incoloy Alloy 908 Jacket SS was an option (2 Grades - 45 mm square and 49 mm square)	JK2LB Stainless Steel Jacket 49 mm x 49 mm
Nb_3Sn Strand 650 A/mm^2 J_c CSC Ratio - 1.5:1	Nb_3Sn Strand > 700 or 800 A/mm^2 J_c CSC Ratio - 1.0:1
2 K Temperature Margin	< 1 K Temperature Margin

Plasma-Facing Components: Baffle

Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
Module 18 (baffle)	10% of full system; 8.6% of full blanket	14.5 [$21M]

ITER FW/Shield Design



- **Module 18 of the FW/Shield**
  - 36 modules around torus
  - Shield module weight 3.6 Tonnes (316 LNIG steel)
  - PFC area 1.6m^2
  - PFC weight 0.8Tonnes (Cu+316)
  - 10% of the first wall area
  - 45 cm thick (PFC +shield)

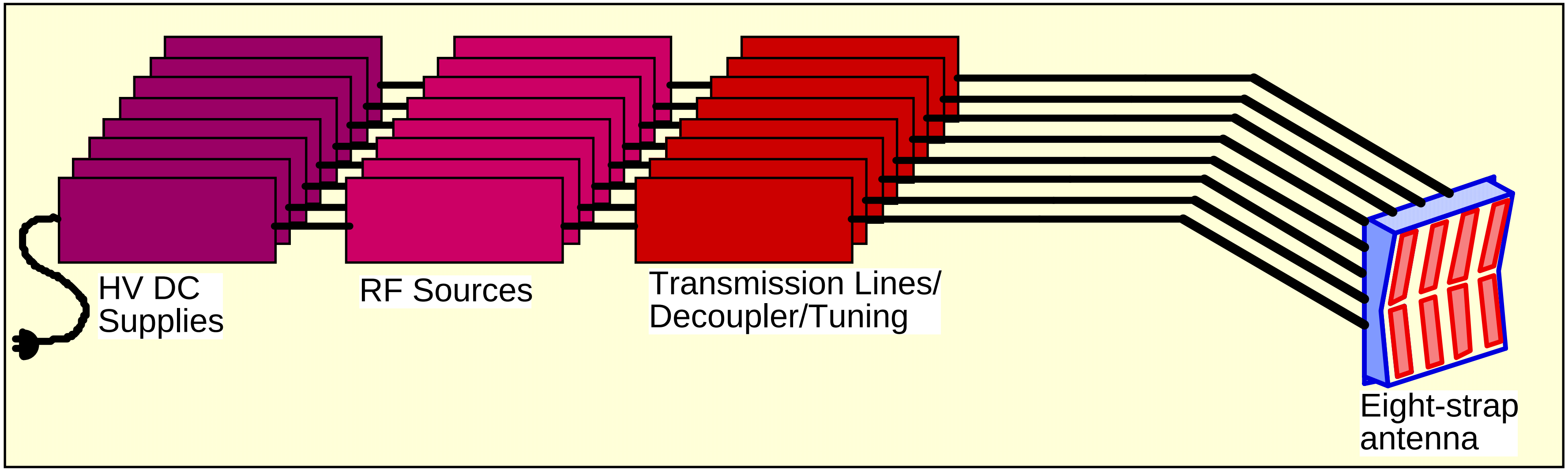
Ion Cyclotron System

Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
44% of antenna + all tranmission/RF-sources/power supplies	91% of full system	31.1 [$45M]

Overview of the ITER IC system

- **What it is:**
  - One antenna, eight current straps
  - Eight rf sources, each feeding one strap in the antenna
  - 35-65 MHz
  - 20 MW total power to the plasma
  - Variable phasing between straps
- **What it can be used for:**
  - Tritium ion heating during DT ops.
  - Minority ion heating during initial ops.
  - Current drive near center for AT operation
  - Minority ion current drive at sawtooth inversion radius

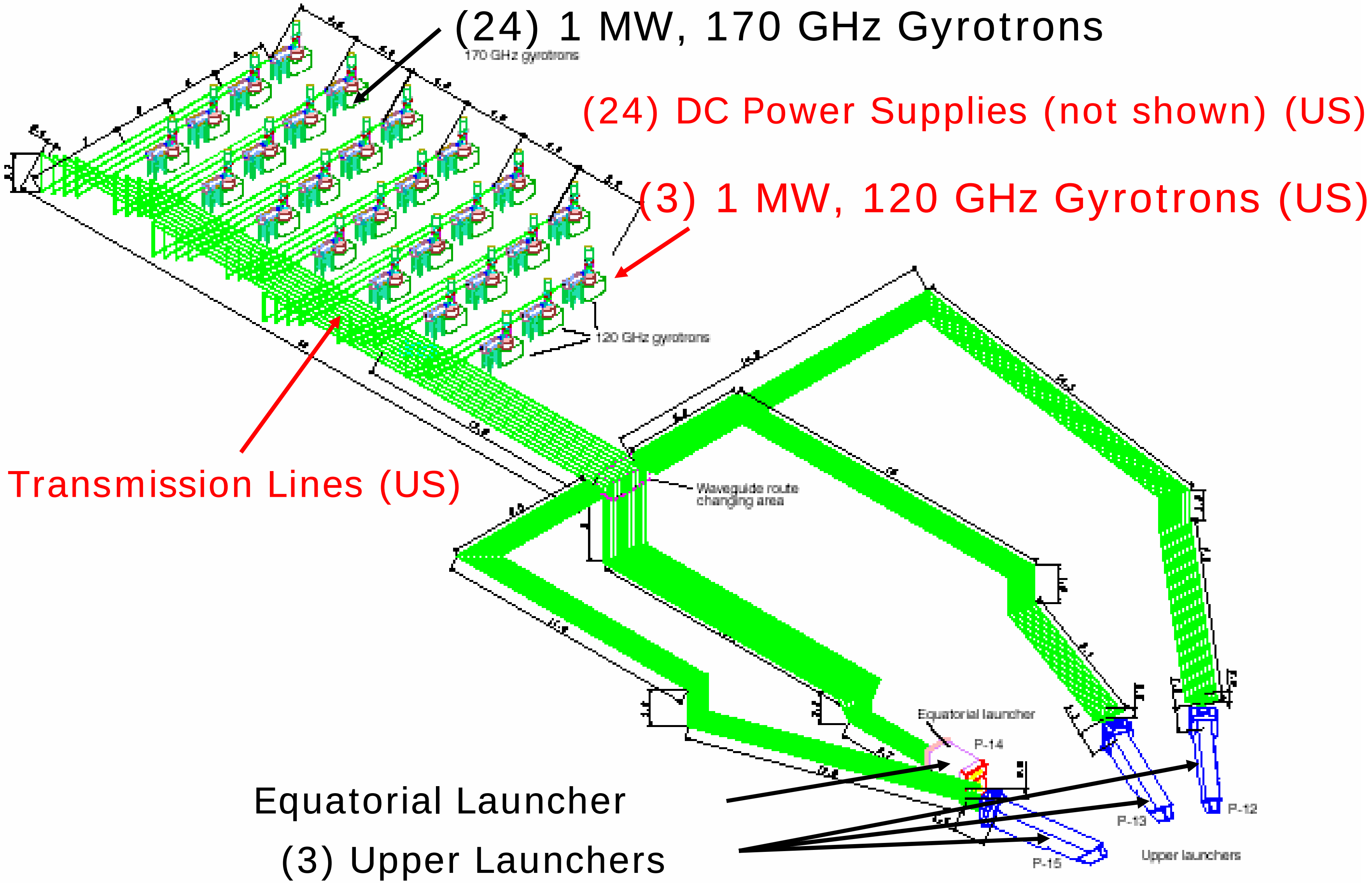
ITER ion cyclotron system block diagram



Electron Cyclotron System

Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
Start-up gyrotrons, all transmission lines and power supplies	40% of full system	32.3 [$47M]

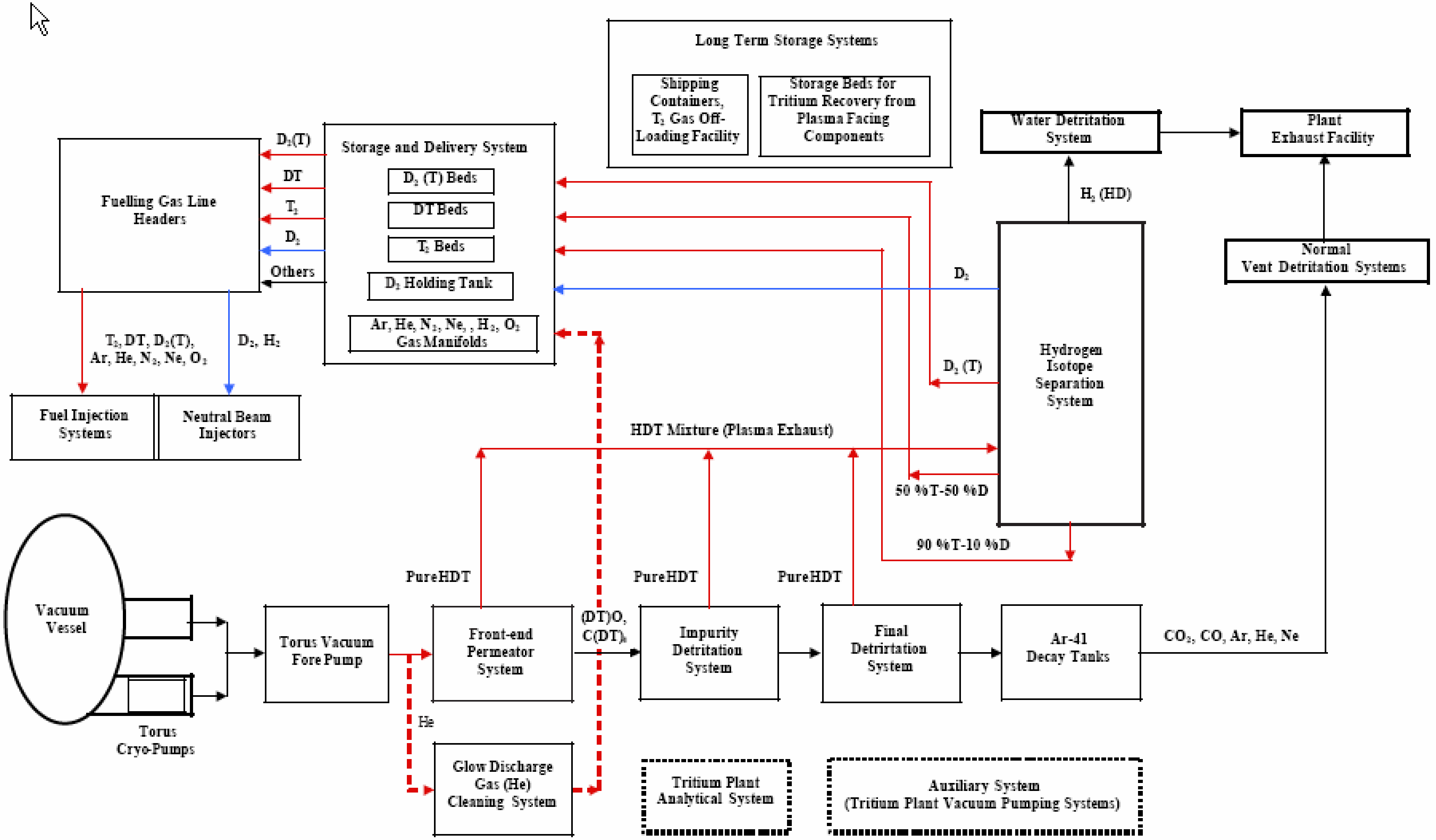
Electron Cyclotron System Configuration



Tritium:
Tokamak Exhaust Processing System

Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
Tokamak exhaust processing system	14% of full system; 88% of selected subsystems	11.4 [$16M]

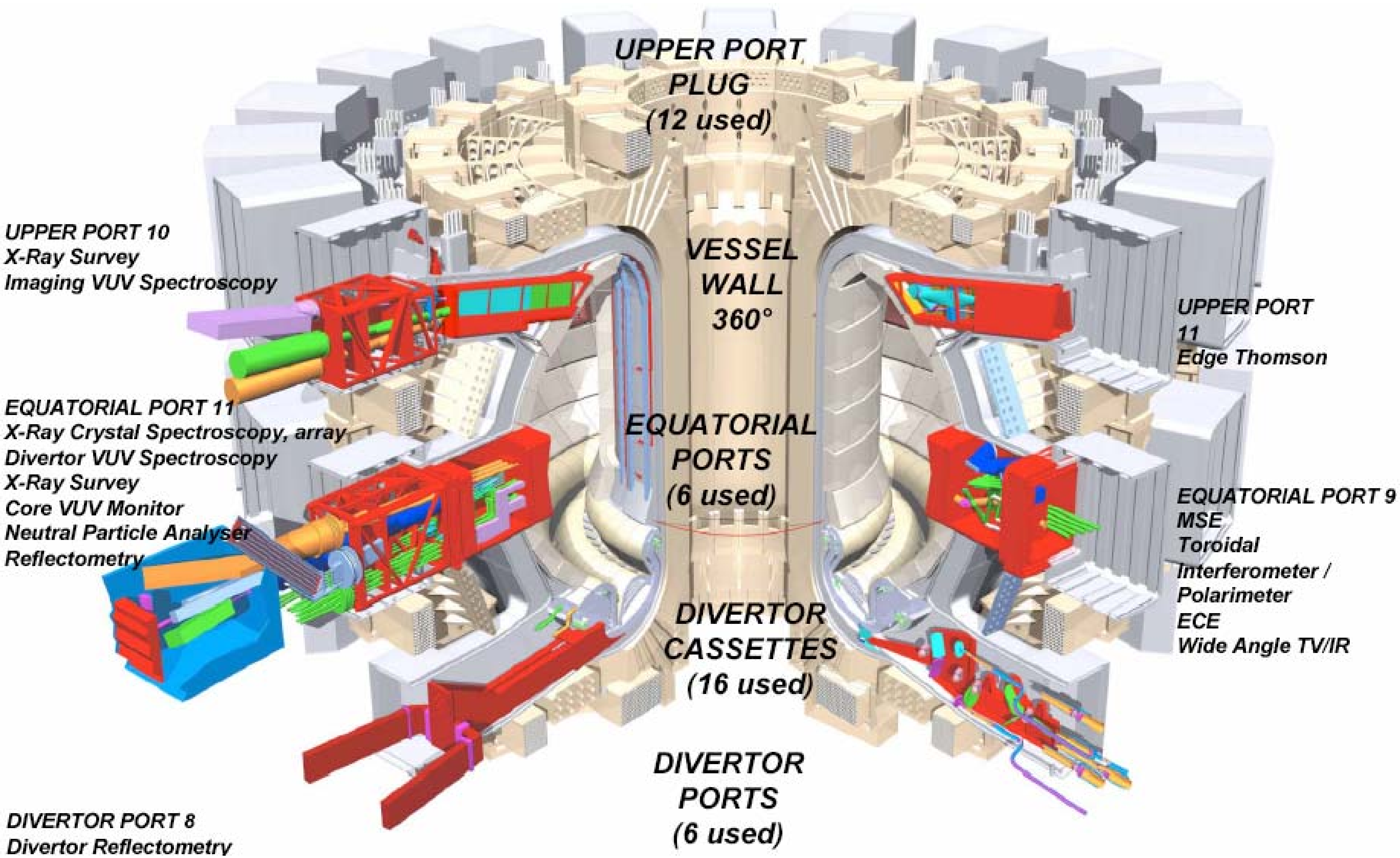
Overview of ITER Tritium Plant



Diagnostics

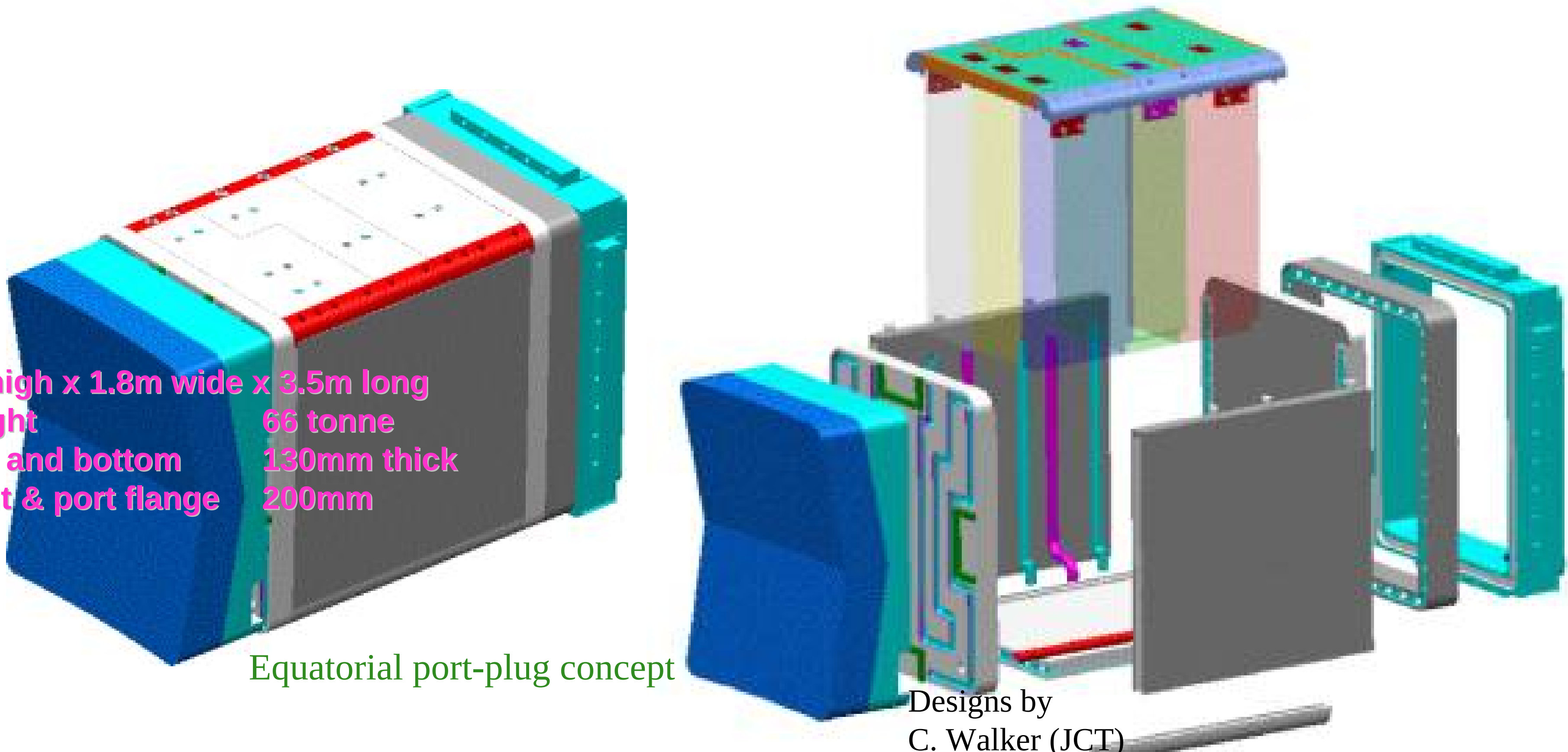
Description of US portion	US fraction of system (by ITER value)	US Value (kIUA) [$M]
Allocations being discussed	15% of full system (not including DNB)	20.6 [$30M]

ITER diagnostics landscape



ITER provides Unique Technical Challenges for Diagnostics

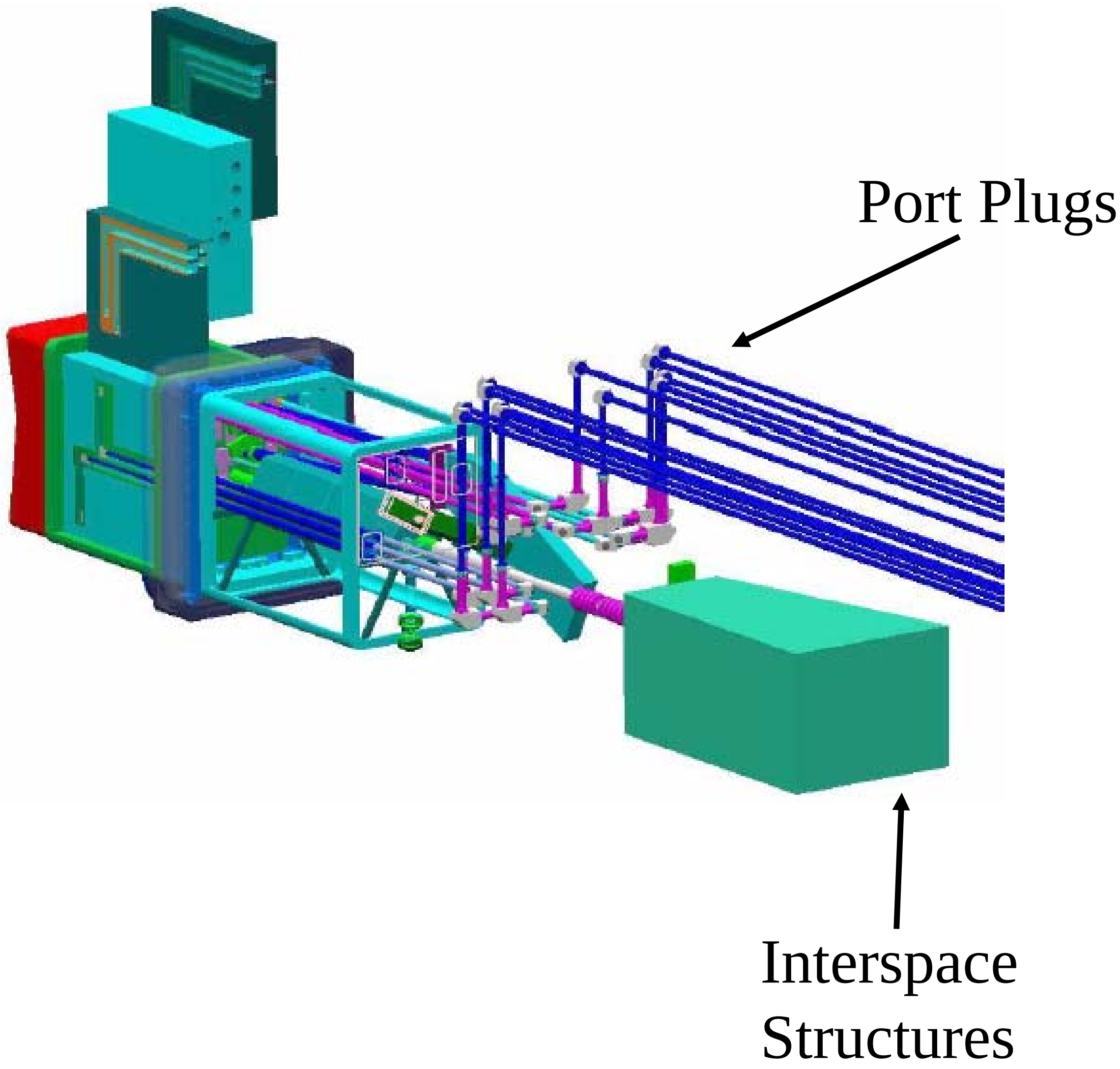
+ operation in radiation environment, presence of blankets,
+ reliability, calibration maintenance,
+ control data for machine protection.

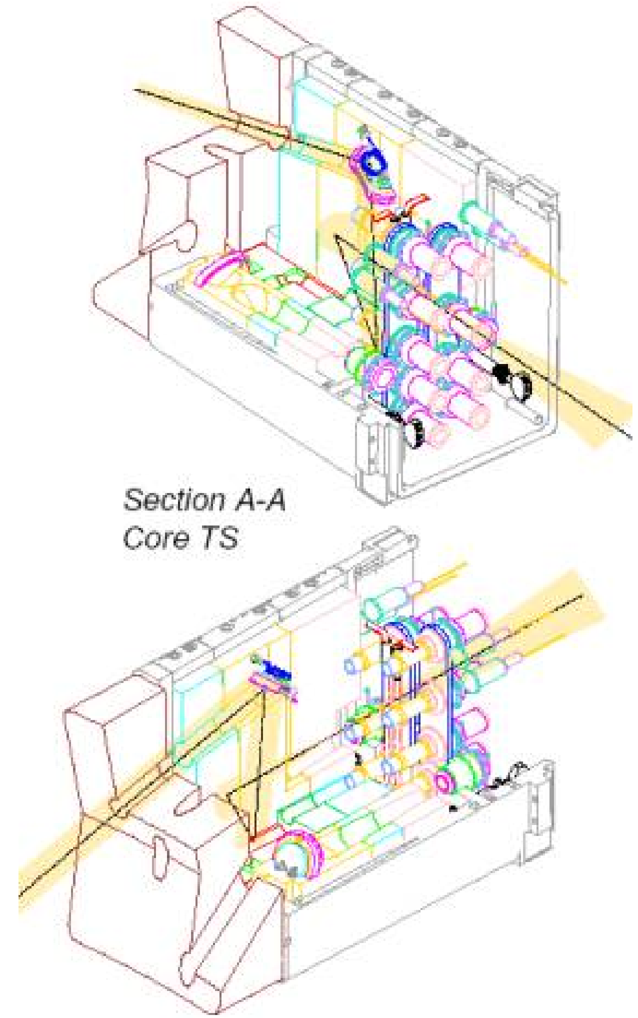


Equatorial port-plug concept

Designs by
C. Walker (JCT)

Port plugs and interface structures





Port-plug with penetrations for Thomson scattering, interferometry, etc.

IT-Leader-Requested 2003+ Tasks

- **Magnets**
  - Qualification of industrial suppliers of Nb_3Sn strands with increased value of J_c **US/IT-approved/5-month delay**
  - Stress Analysis of the Helium Inlet Regions **US/IT-approved**
  - Conductor Performance and Design Criteria **US/IT-approved/4-month delay**
  - CS Jacket Weld Defect Assessment **US/IT-approved/4-month delay**

- **Safety**
  - Support and assistance for the latest fusion versions of computer codes MELCOR and ATHENA **US/IT-approved/amendments**
  - Safety Design Integration **US-disapproved**
  - Magnet Safety **US/IT-approved**

- **Materials**
  - Support of materials activity **US-approved/awaiting IT**

IT-Leader-Requested 2004 Non-Physics Tasks (2/27/04)

- **Blanket Modules**
  - Qualification of the FW panel fabrication methods and to establish the NDT method for the FW panel.
  - Detailed design of blanket modules and thermal hydraulic analysis of the shield block and the total blanket system.
- **Divertor**
  - Tolerance Study of the Divertor
- **Fuelling**
  - Detail PIS component design
- **Water Cooling System**
  - Industrial design of WCS
- **Vacuum Pumping**
  - ITER VAC Assessment
- **Tritium Plant**
  - Detailed design and integration into overall fuel cycle of tokamak exhaust processing system based on the existing design
- **Safety**
  - Dust Characterization including mobilization and transport

IT-Leader-Requested 2004 Non-Physics Tasks (3/25/04)

- **Diagnostics**

  - To contribute to a Port Engineering Task Force (one or two members per PT) to determine the guiding principles for the design and engineering of the diagnostic ports.

  - Support the ITER IT in the writing of procurement specifications for diagnostic port-based procurement packages.

IT-Leader-Requested 2004 Physics Tasks (2/27/04)

1) NTM control in Inductive and Hybrid Scenario in ITER

2) RWM in Steady State Scenario in ITER

3) VDE, Disruptions and their mitigation in ITER

4) Plasma position and shape control with 3D model of vacuum vessel

5) Error Field Control in ITER

6) ITER Plasma Integrated Model for ITER

7) Development of Steady State Scenarios in ITER

8) Evaluation of Fast Particle Confinement of ITER

9) Assessment of Edge Pedestal and ELMs of ITER

Planned FY04 Part-time Secondees (~3 FTEs)

- **The present ITER international team consists of 63 persons: 27 from Europe, 19 from Japan, 13 from Russia, and 4 from China,**

- **Responding to requests from the ITER International Team Leader, the US is arranging for US persons (visitors/secondees? / all part-time):**
  - Magnets [Naka, Japan]
    - Nicolai Martovetsky (LLNL) and Philip Michael (MIT) **Approved**
  - First Wall/Blanket [Garching, Germany]
    - Dr. Richard Nygren (Sandia) and Mr. Thomas Lutz (Sandia) **In Prep**
  - Ion Cyclotron [Garching, Germany]
    - David Swain (ORNL) and Richard Goulding (ORNL) **Approved**
  - Port Plugs/diagnostics [Garching, Germany]
    - Douglas Loesser (PPPL) **Approved**

- **Note: if FDR level were spread over 8 years, then 10% would be 21 senior professionals and 36 junior professionals**

ITER Working Groups

- **International Tokamak Physics Activity - topical groups**
- **Magnet Working Groups**
  - TF Coil Windings - Nicolai Martovetsky
  - TF Coil Cases - Peter Titus
  - PF Coils Windings - Timothy Antaya (alternate - Nicolai Martovetsky)
  - Conductors - Timothy Antaya
  - Central Solenoid - Timothy Antaya
- **Test Blanket Working Group**
  - Mohamed Abdou, key member for the US participation
  - Michael Ulrickson
  - Dai-Kai Sze
- **Diagnostics Working Group**
  - David Johnson (PPPL) - member
  - Réjean Boivin (GA) - member
  - Steve Allen (LLNL) - participant
- **Codes and Standards**
  - David Petti (INEEL) - lead
  - Irving Zatz (PPPL)

Bottom Line….

- **Tentatively allocated in-kind contributions are well matched to US interests, capabilities, and capacities, and to ITER project success**

- **Combined ITER-project and VLT-ITER-relevant activities in FY04 and FY05 are covering many of the important tasks necessary for positioning the US to perform its ITER roles**
  - providing the basis for tentative allocations of in-kind contributions
  - R&D, design, manufacturing studies
  - qualification of US vendors in key areas, such as superconducting strand production
  - performance of ITER tasks requested by the leader of the ITER International Team
  - assignments of US persons to the ITER International Team

- **Partially non-project comment:**
  We need to move ahead with the US Burning Plasma Program!