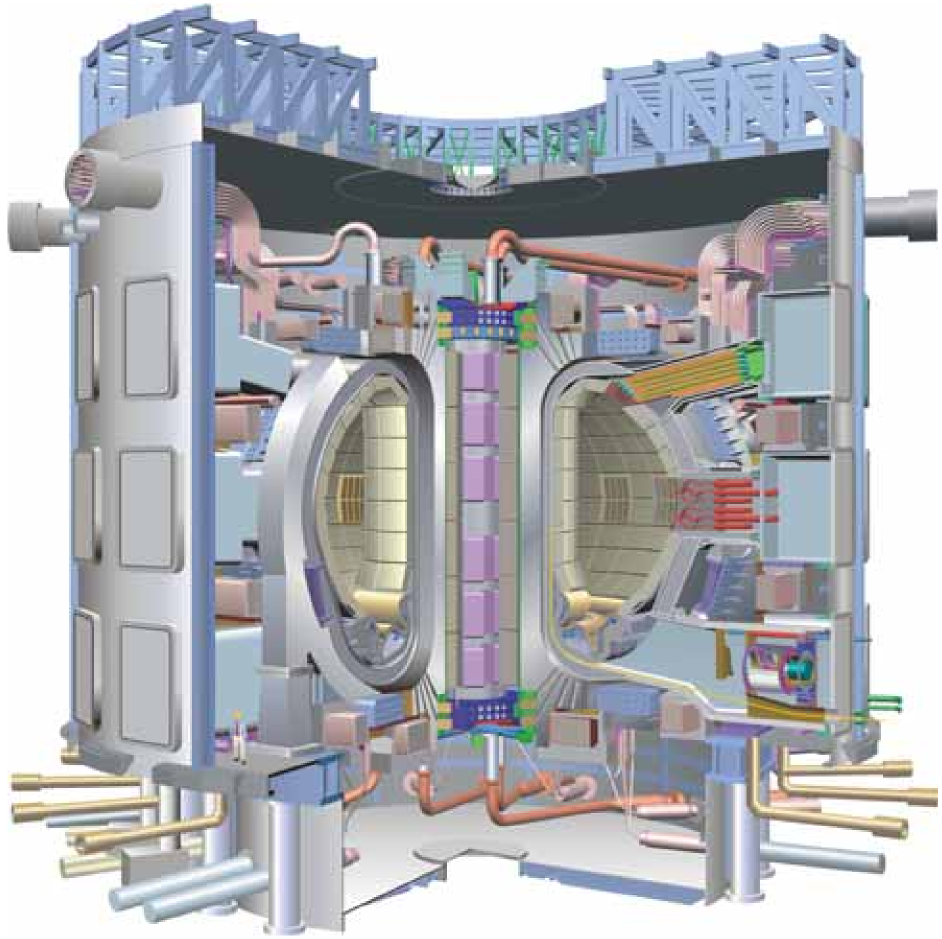
Overview of ITER Project Activities in the U.S.
&
ITER Institutional Issues



Enabling burning plasma studies
by
US Contributions to ITER

Ned Sauthoff

OFES Budget Planning Meeting

March 15, 2005

Outline

- **The Evolution from ~$500M to $1.122B**

- **A range of budget scenarios**
  - “Presidential Request”
  - “Intermediate Analysis”
  - “Community Request”

The Evolution from ~$500M to $1.122B

- **The "$500M perception" was related to the ITER Value from the 2001 ITER Final Design Report**

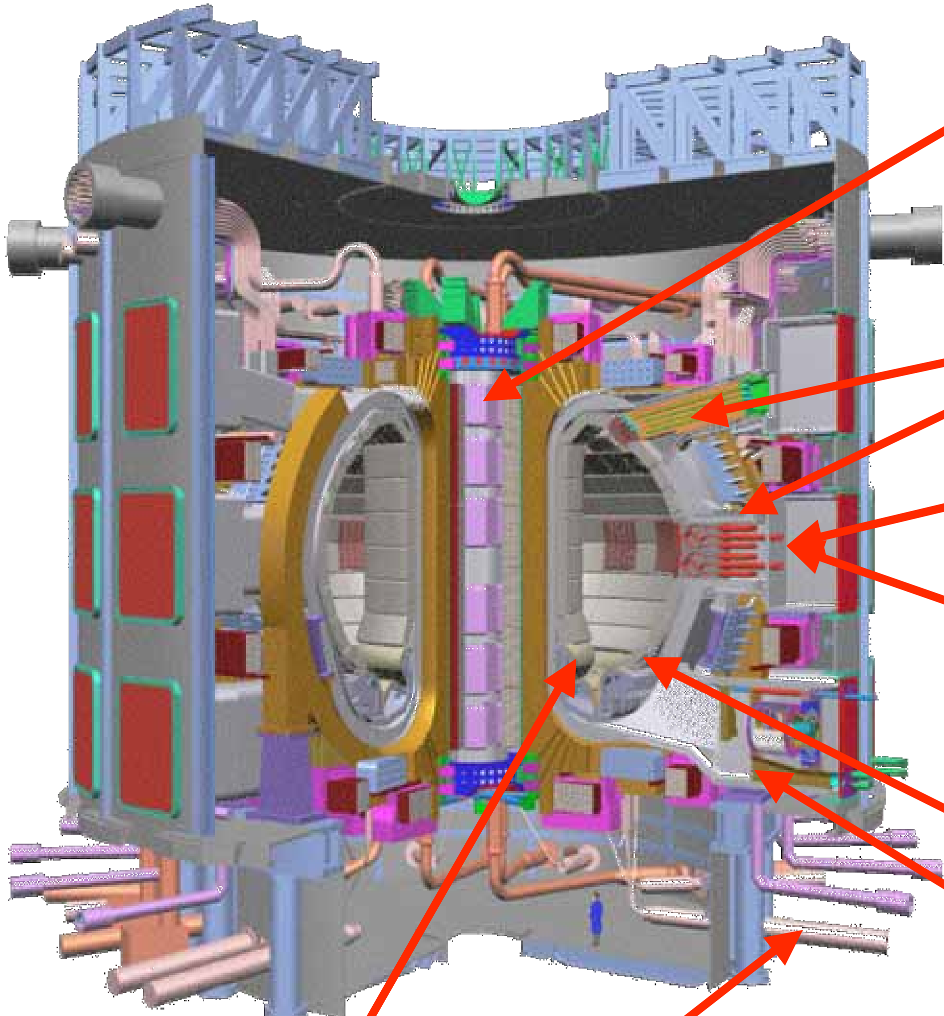
- **The $1.122B in the President's Budget Request was based on cost-estimates for the full scope related to US contributions**

  → In-kind contributions (R&D, design, fabrication, oversight, and delivery with contingency and escalation)

  – Cash to the ITER Organization for common expenses

  – Staff for the ITER Organization at expected US rates

Provisional US In-kind Contributions



(4 or 7) of 7 Central Solenoid Modules

Steady-state power supplies

15% of port-based diagnostic packages

44% of ICRH antenna + all transmission lines, RF-sources, and power supplies

Start-up gyrotrons, all transmission lines and power supplies

Baffle (Module 18)

Roughing pumps, standard components

Tokamak exhaust processing system

(1 or 0) Cooling for divertor, vacuum vessel, …

pellet injector

Evolution of the ITER cost from $500M to $1.122B: Sum of all components ($M)

Whereas the FDR cost focused on fabrication, cash and secondees, the US estimate included all US costs:

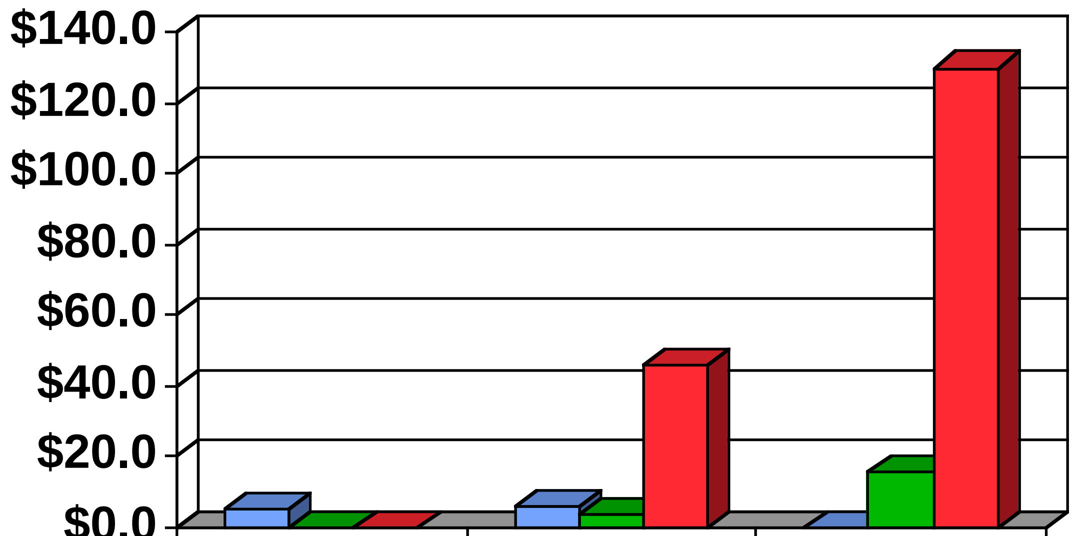
	2001 FDR ($M '02)	Basis for US Request ($M '05)
R&D and design		$75
Industrial Fab	$388	$473
Procurement Follow		$36
Procurement administration		$30
Assembly, installation, other		$14
Adjustment for progress since 12/03		-$18
Cash (to bring total value to 302.07kIUA)	$46	$46
Secondees - professionals (180 ppy)	$39	$72
Secondees - support (276 spy)	$30	$30
Project office		$36
Contingency		$132
Escalation		$197
TOTAL	$503	$1,122

Outline

- **The Evolution from ~$500M to $1.122B**

- **A range of budget scenarios**
  - "Presidential Request"
  - "Intermediate Analysis"
  - "Community Request"

The President’s Budget ($M)



	FY05	FY06	FY07
ITER Prep	$5.0	$6.0	$0.0
MIE/OPC	$0.0	$3.5	$16.0
MIE/TEC	$0.0	$46.0	$130.0

- **ITER Prep: Operating funds to prepare for the US ITER project**
- **MIE/OPC: “Other Project Costs”**
  - Operating funds to cover Research
- **MIE/TEC: “Total Estimated Cost”**
  - Equipment funds for Design, Fabrication, and Delivery

The President's Budget Request is based on an optimistic schedule of international agreement

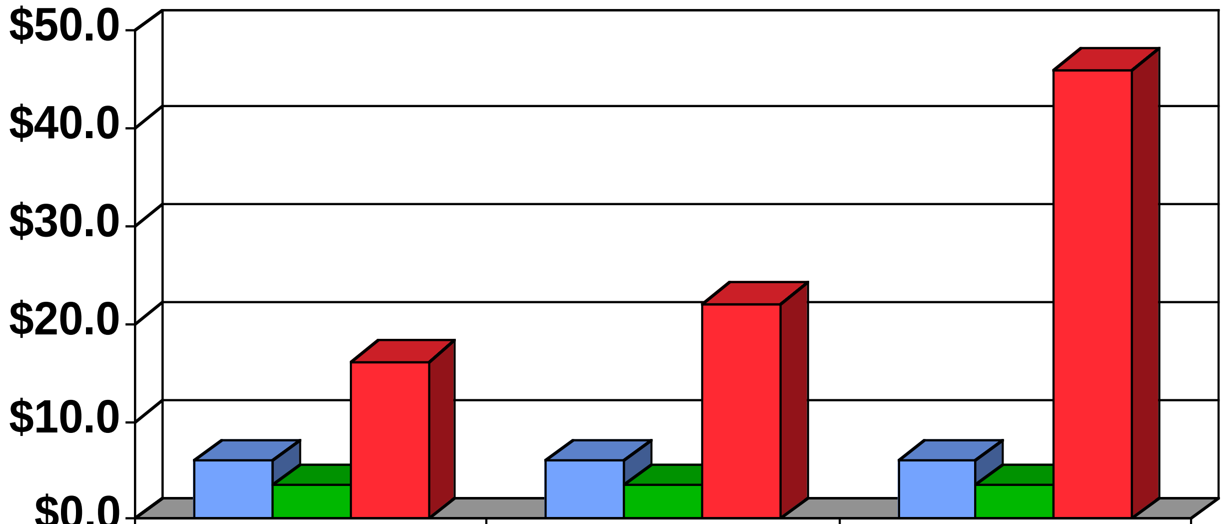
- **If the ITER site decision were early and senior-management engagement were quick, then procurement of some long-lead components/materials could be compatible with FY06. Consider the following scenario:**
  - April 2005: Site decision in April 2005, along with a path to DG selection
  - July 2005: DG and some DDGs begin working with the International Team and parties provide staff to address technical issues and work toward decisions
  - October 1, 2005: Parties initial International Agreement, which is provided for second Circular 175 and to Congress for review
  - February 2006: 120-day Congressional review of the International Agreement completed
  - May 2006: Technical reviews of ITER, leading to specifications for long-lead procurements
  - June 2006: US receives proposed procurement agreements for long-lead procurements from the ITER team
  - July 2006: US initiates procurement of long-lead materials, such as superconducting strand

- **However… If the site decision and/or senior management engagement were delayed, construction scope would slip beyond FY06; <u>BUT</u> R&D and design activity would still be needed in FY06**

FY06 priorities

- **To prepare for ITER procurements:**
  - Need to perform manufacturing R&D especially on conductor for superconducting magnet.
  - Need to perform final design specifications for U.S. procurements.
  - Need to prepare procurement packages for bid.
  - Need to contribute team members to international ITER Organization to coordinate R&D and design and to oversee procurement preparations.
- **To initiate procurements of long-lead-time components
IFF the international project has finalized the specifications
AND other parties are positioned to engage in the critical-path activity
AND the associated budget does not damage the US program**

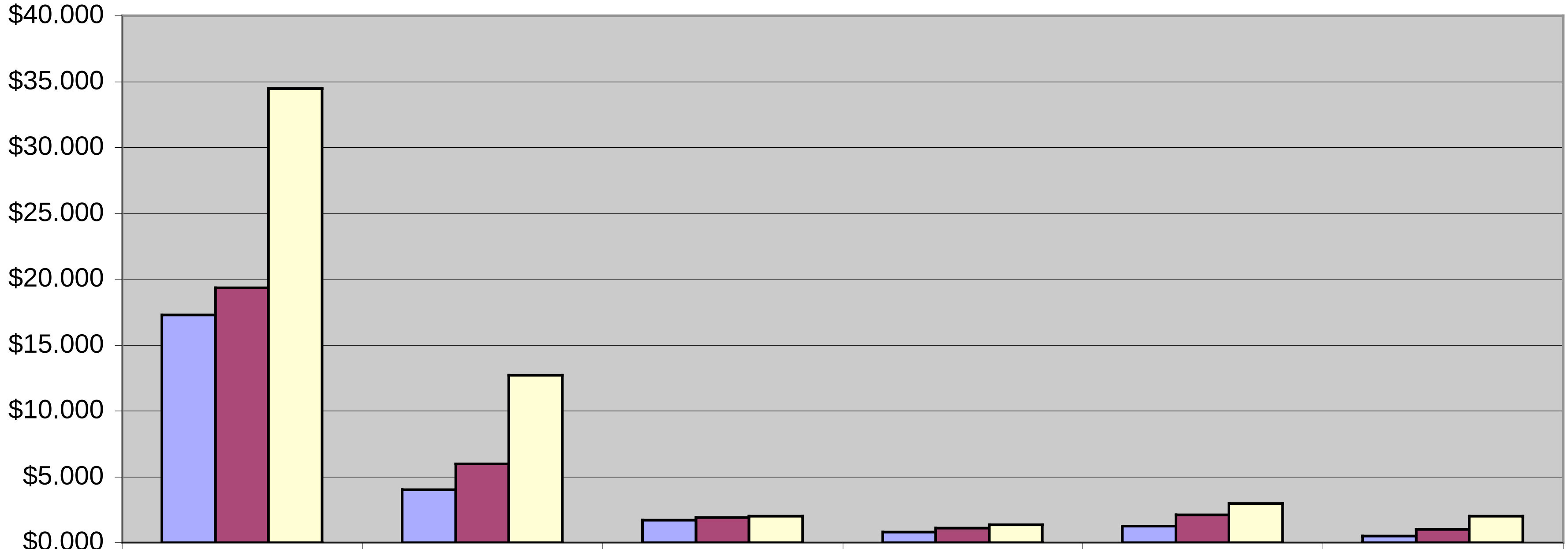
Uncertainty in the international schedule motivates consideration of a range of FY06 ITER budgets ($M)



	Community	Intermediate	President's
ITER Prep	$6.0	$6.0	$6.0
MIE/OPC	$3.5	$3.5	$3.5
MIE/TEC	$16.1	$22.0	$46.0

- "ITER Prep" supports preparation early in FY06 (same in all cases)
- "MIE/OPC" supports Research for the last third of FY06, sustaining level "VLT-staff" support of ITER (same in all cases)
- "MIE/TEC" supports more intensive design, prototyping, and procurement of long-lead materials (only in "President's") aiming at readiness to start construction in 2007

Representative distributions and evolutions ($M)



	in-kind contributions	Secondees	project management	design integration	WBS Managers	Cash to the ITER Organization
Community	$17.309	$4.000	$1.729	$0.800	$1.260	$0.500
Intermediate	$19.351	$6.000	$1.929	$1.120	$2.100	$1.000
President's	$34.472	$12.726	$2.000	$1.360	$2.940	$2.000

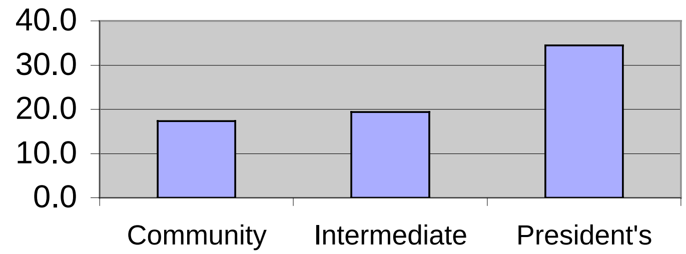
- **Largest budgets and increases are in-kind contributions and secondees**
- **President's Request enables procurements of long-lead materials and greater US staff-participation in the ITER Organization**

Overviews in each cost category

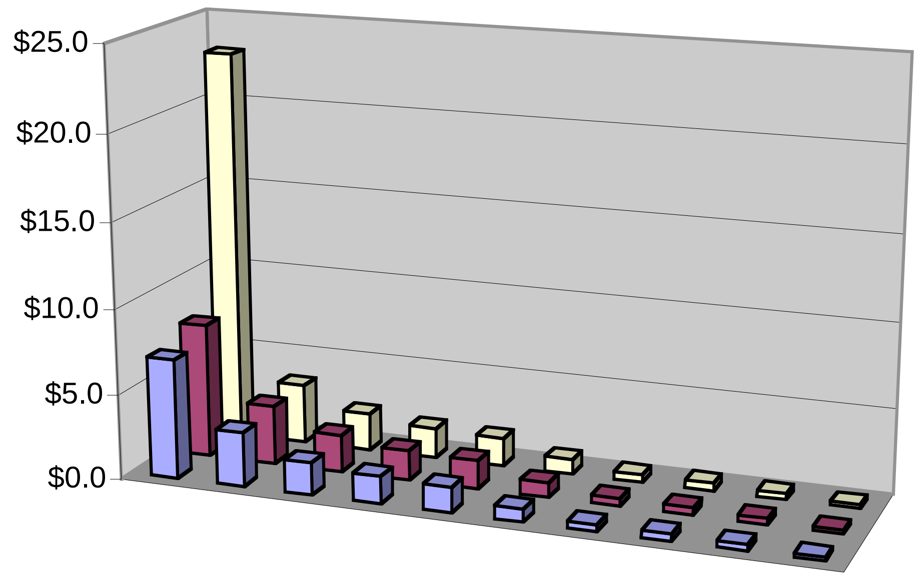
- in-kind contributions
- secondees
- project management
- design integration
- WBS Managers
- cash to the ITER Organization

in-kind contributions ($M)

- **FY06 in-kind-contribution work focuses on preparations for fabrication of US components**
- **The President's budget permits start of procurement of long-lead materials**



	Community	Intermediate	President's
in-kind contributions	17.3	19.4	34.5

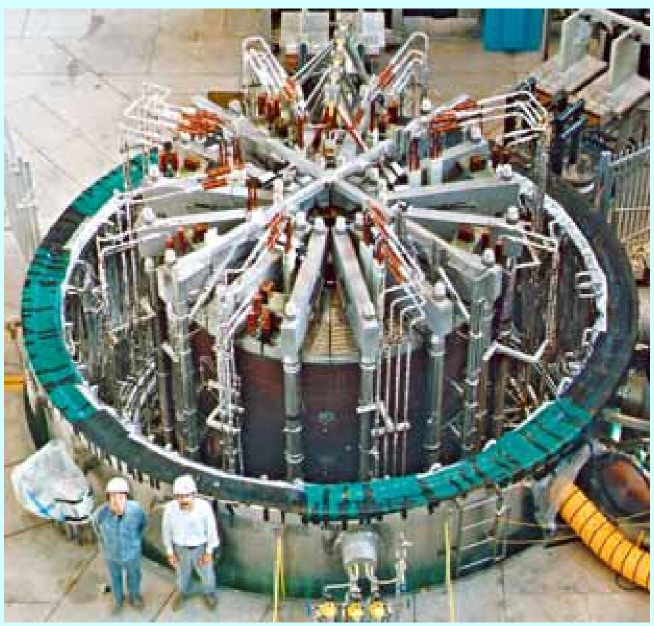


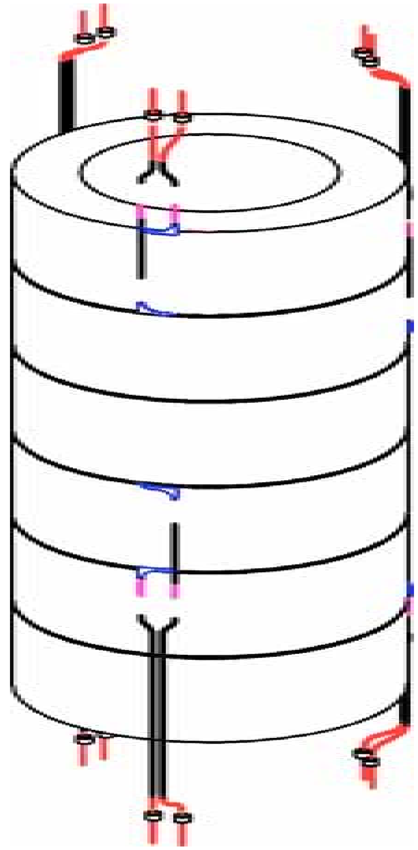
	magnet	blanket/ shield/ PFC	diagnostics	ECH	ICH	Tritium	cooling water	steady state power	vacuum/ fueling	safety
Community	$7.0	$3.2	$1.9	$1.6	$1.5	$0.8	$0.4	$0.4	$0.4	$0.2
Intermediate	$7.9	$3.5	$2.2	$1.8	$1.7	$0.9	$0.5	$0.5	$0.4	$0.2
President's	$23.0	$3.5	$2.2	$1.8	$1.7	$0.9	$0.5	$0.5	$0.4	$0.2

Overview of Central Solenoid

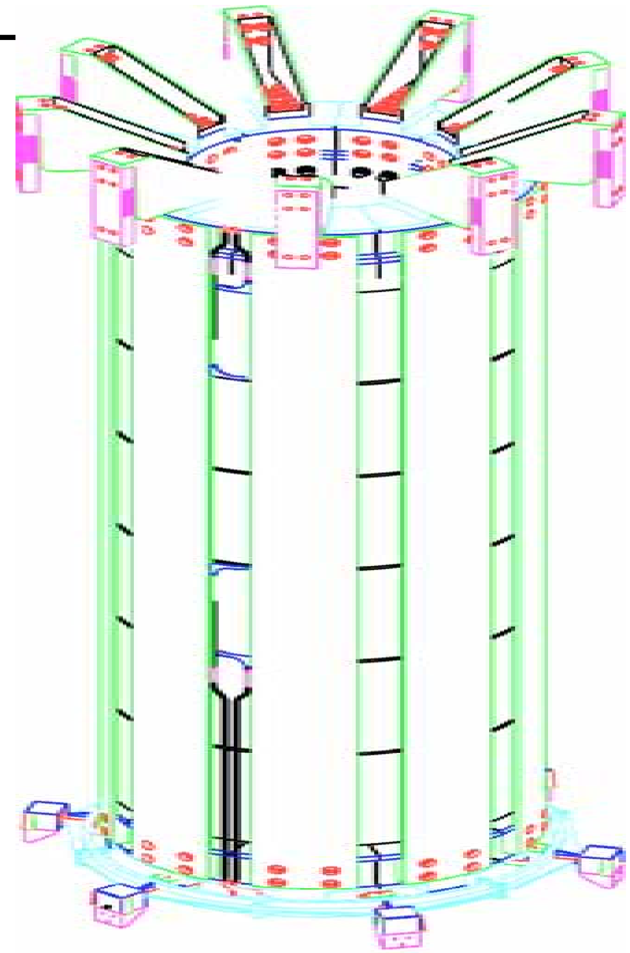
- Max. B: 13.0 T (IM)
- Max. I: 45.0 kA (EOB)
- Nb_3Sn CICC,
- Conduit: JK2LB
- 6 independent modules
- 9 tie-plates (SS316LN)

Each Module is slightly larger than the complete CS Model Coil



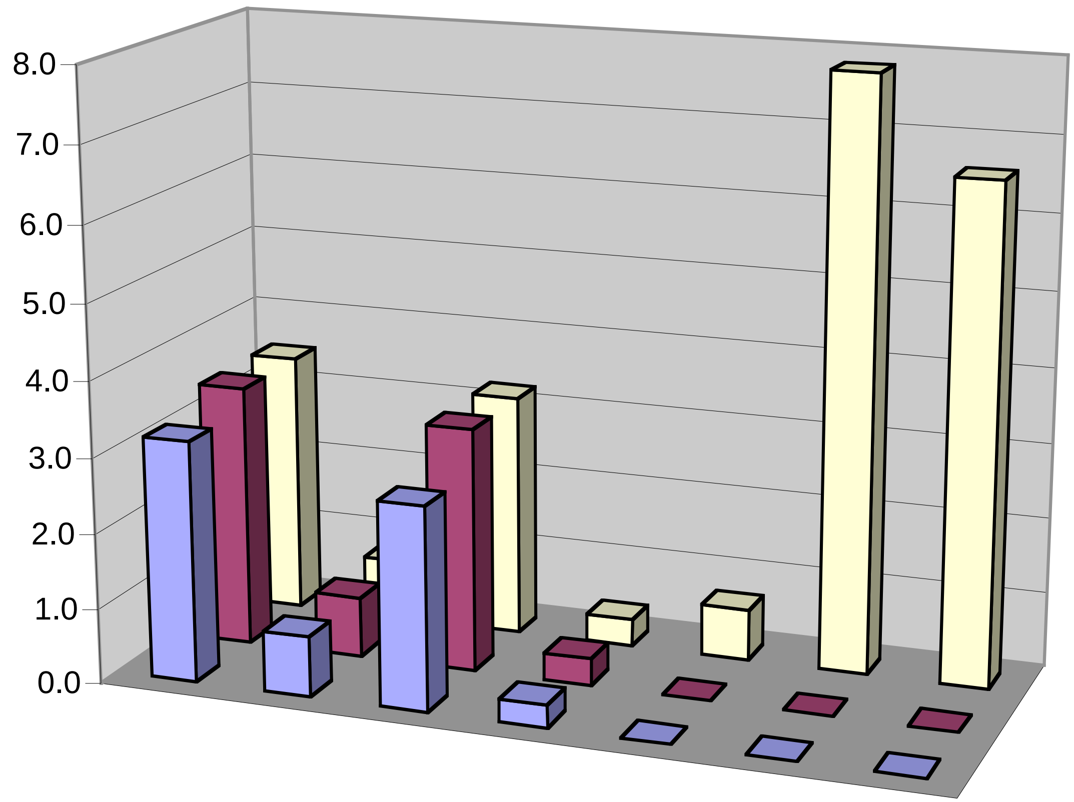


Before assembling structure



After installation in Tokamak

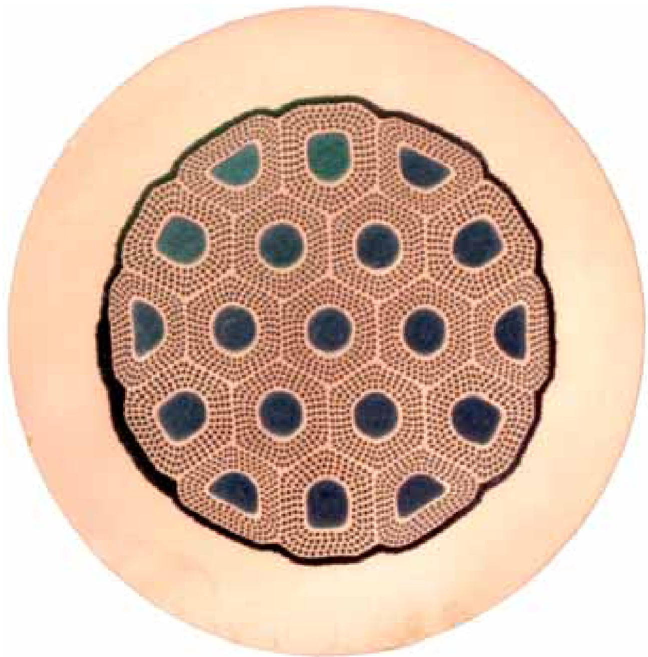
Magnet Scenarios ($M)



	R&D&D: fusion community	R&D&D: strand vendor (industry)	R&D&D: jacket/cable development (industry)	R&D&D: joint testing (industry)	procurement: fusion magnet community - engineering	procurement: magnet superconducting strand	procurement: CS conductor integration and tooling
Community	3.2	0.8	2.7	0.3	0.0	0.0	0.0
Intermediate	3.5	0.8	3.2	0.4	0.0	0.0	0.0
President's	3.5	0.8	3.2	0.4	0.7	7.8	6.6

Qualification of industrial suppliers of Nb_3Sn strands with increased value of J_c

- **FY04**
  - ordered 100kg lots of strand from 3 vendors at 1000 A/mm^2
- **FY05**
  - Test the 100kg lots (including contracts with NIST and UWisconsin)
- **FY06**
  - Procure somewhat higher quantity strand from successful vendors with processes extrapolable to production quantities and lower cost/kg
  - Test the larger quantity prototypes to enable qualification of strand vendors



Typical strand layout as proposed by OST. Diameter is ~0.8 mm.

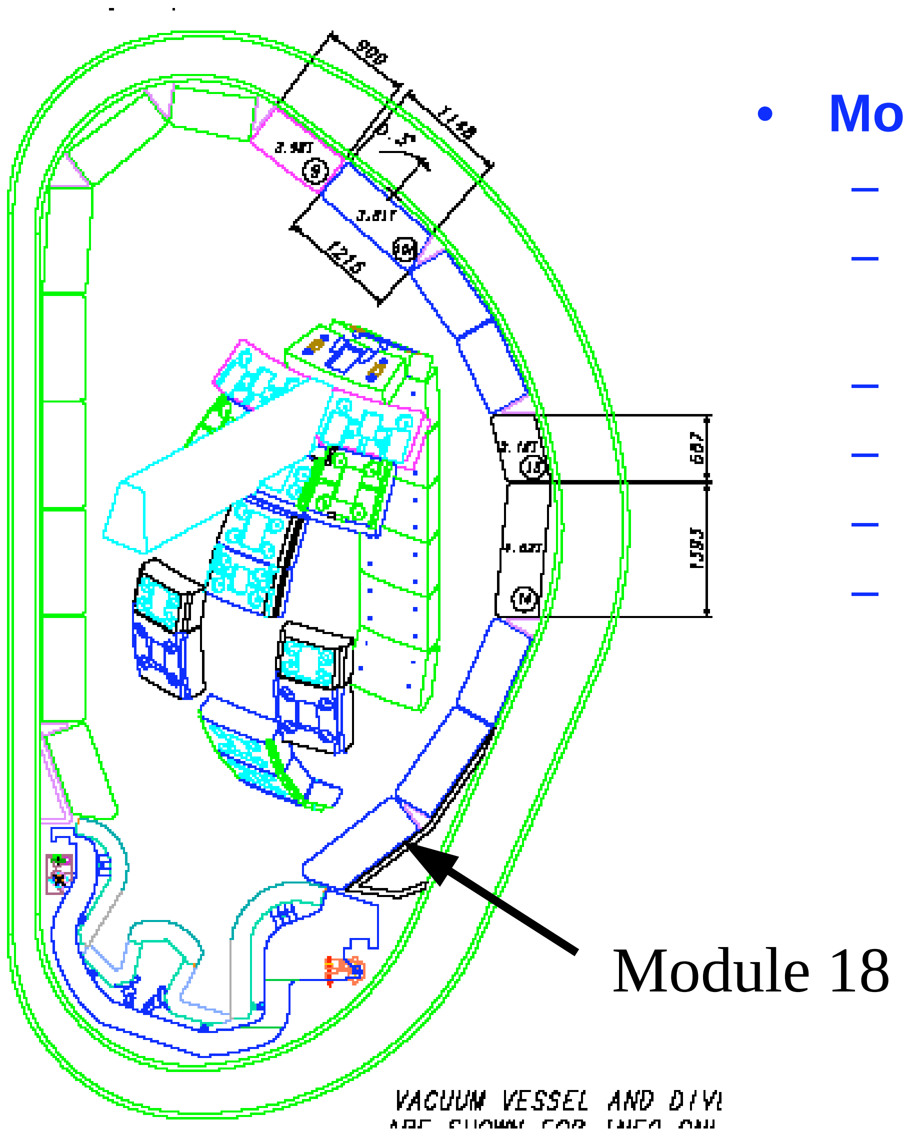
Conductor Performance and Design Criteria

- Test transverse load effects on the conductor
- Test and seek understanding of degradation of performance, to form the basis for design criteria

Additional Magnet activities in FY06+

- Jacket extrusions
- Butt Joint Test before and after Applied Tensile Strain
- Cable development
- Cable-In-Conduit-Conductor bending and forming
- High temperature process development and QA
- Insulation and vacuum impregnation process development and test
- Procurement of 8 tons of strand
  (industrial -- only in President's scenario)
- CS conductor integration line and tool development
  (industrial -- only in President's scenario)

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)

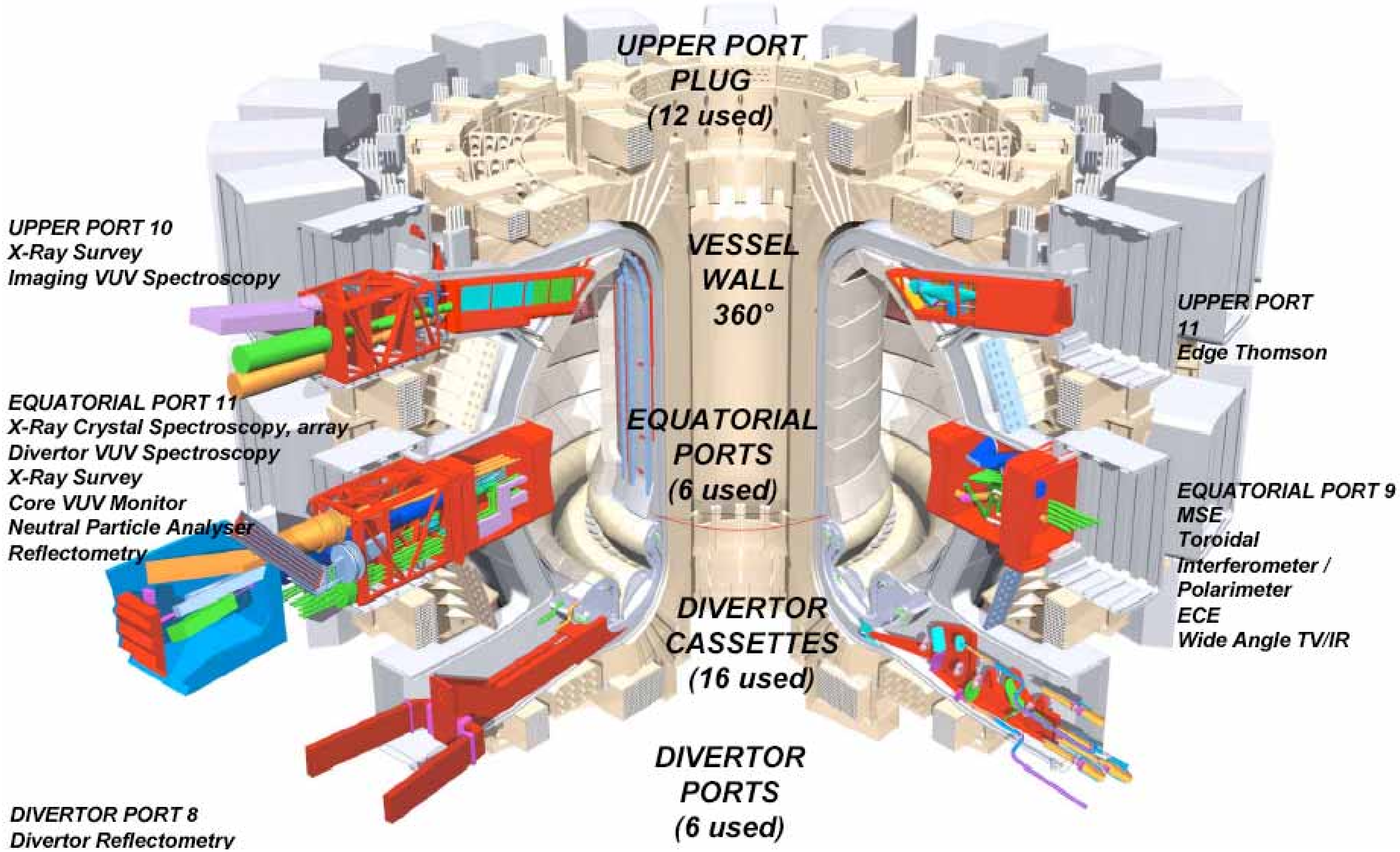
FY06 First Wall and Shield/Blanket activities

- **Shield**
  - Design of Module 18, including electromagnetic analysis of disruption loads and thermohydraulics
  - Improve shield block fabrication to reduce cost

- **First Wall activities**
  - Development of FW design that wraps around curves of Module 18
  - Development of FW fabrication methods (casting, welding, …) to reduce cost
  - Development and qualification of the FW panel fabrication methods (Beryllium-Copper-StainlessSteel, …) and to establish the NDT method for the FW panel.

- **Preliminary design ~12/06**
  Manufacturing specifications and QA/QC procedures ~9/07

ITER diagnostics landscape

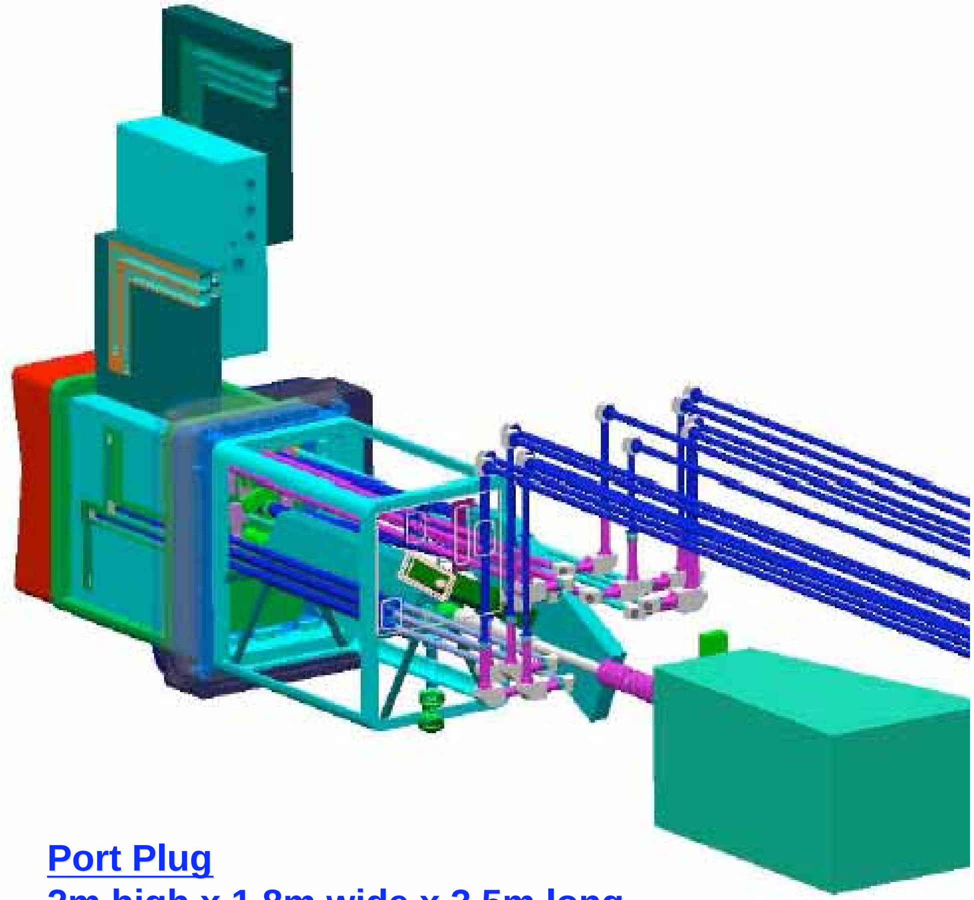


Diagnostics Activities

- **Participate in the Port Plug Engineering Task Force 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.**

- **Design Diagnostic Instruments**



Port Plug

2m high x 1.8m wide x 3.5m long

Weight	**66 tonne**
Side and bottom	**130mm thick**
Front & port flange	**200mm**

Electron Cyclotron System Configuration

(24) 1 MW, 170 GHz Gyrotrons

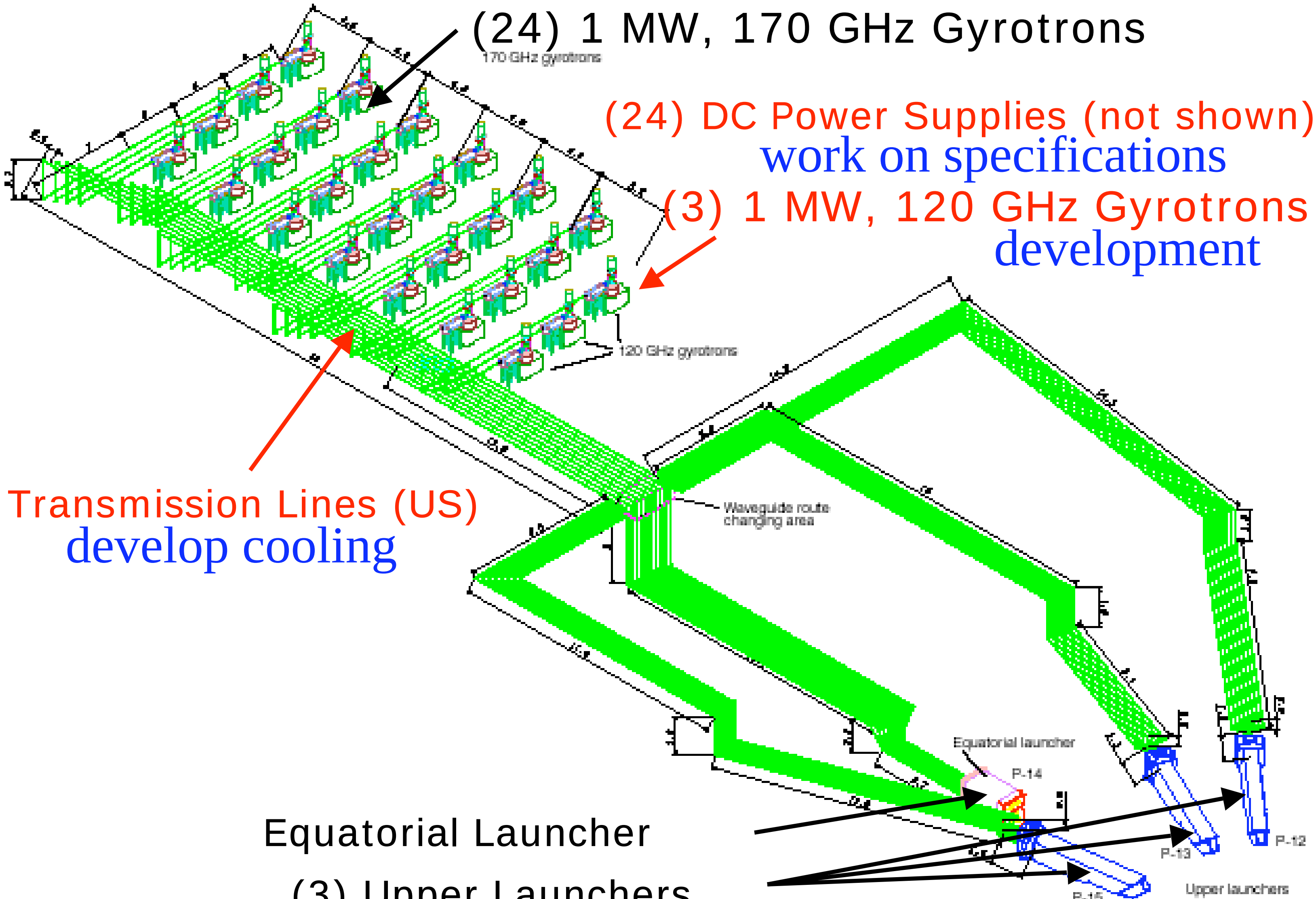
(24) DC Power Supplies (not shown) (US)
work on specifications

(3) 1 MW, 120 GHz Gyrotrons (US)
development

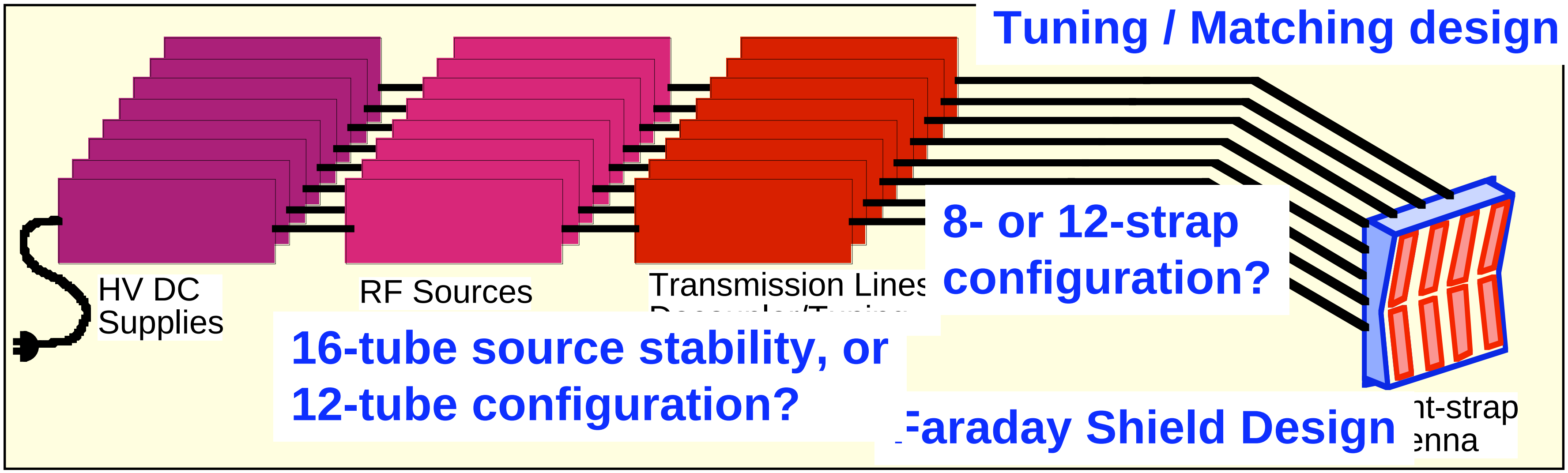
Transmission Lines (US)
develop cooling

Equatorial Launcher

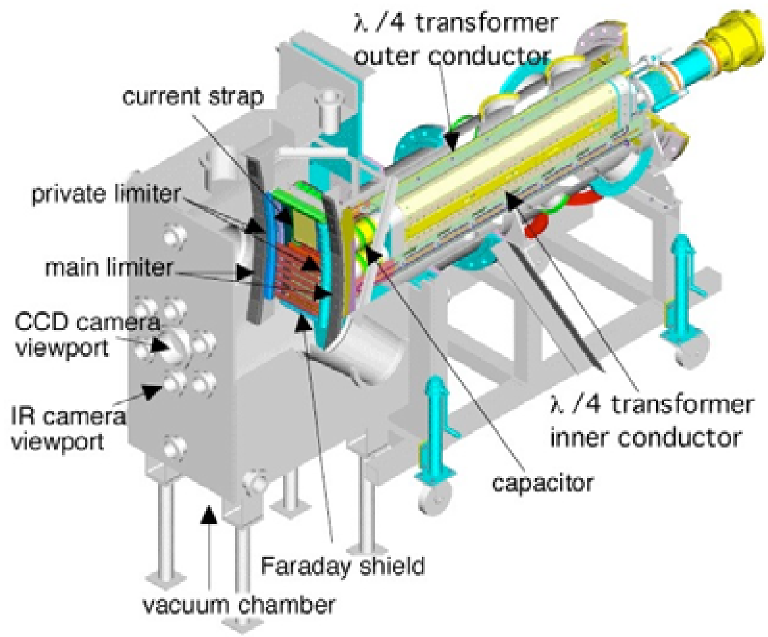
(3) Upper Launchers



Overview of the ITER IC system



ITER ion cyclotron system block diagram

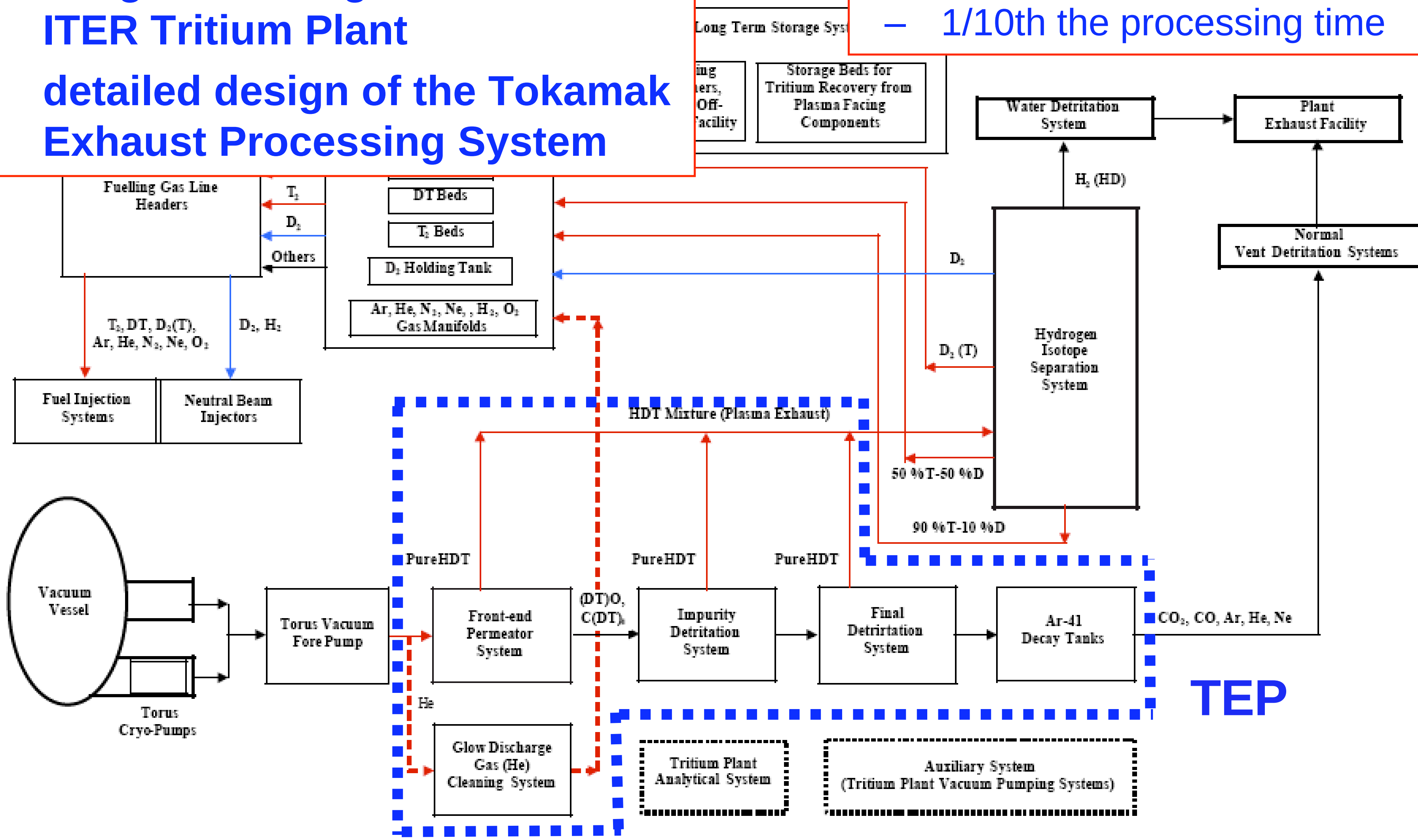


Overview of ITER Tritium Plant

FY05-06 activities

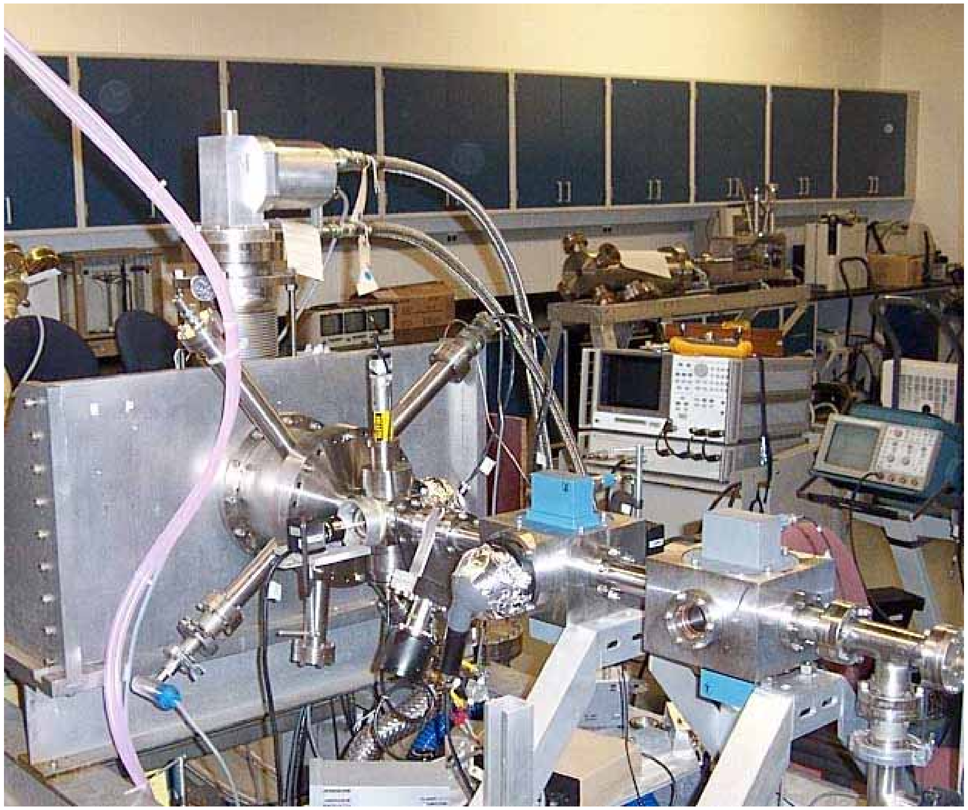
- **integrated design of the overall ITER Tritium Plant**
- **detailed design of the Tokamak Exhaust Processing System**

– 10x's flowrate
– 10x's inventory (initial ITER charge of tritium ~1000 gm, expensive, and ~5% of available supply)
– 1/10th the processing time



Pellet Injection and Pumping Activities

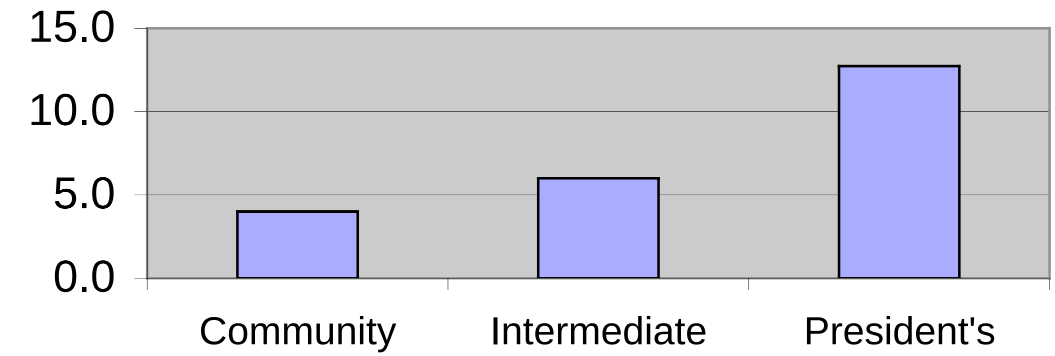
- **No R&D for the pumping system**
- **R&D needed for the pellet injector**
  - ITER class screw extruder mockup
- **Detailed design of pellet injection system**



Safety

- Dust Characterization, Mobilization and Transport
- Magnet safety
- Safety Code Support

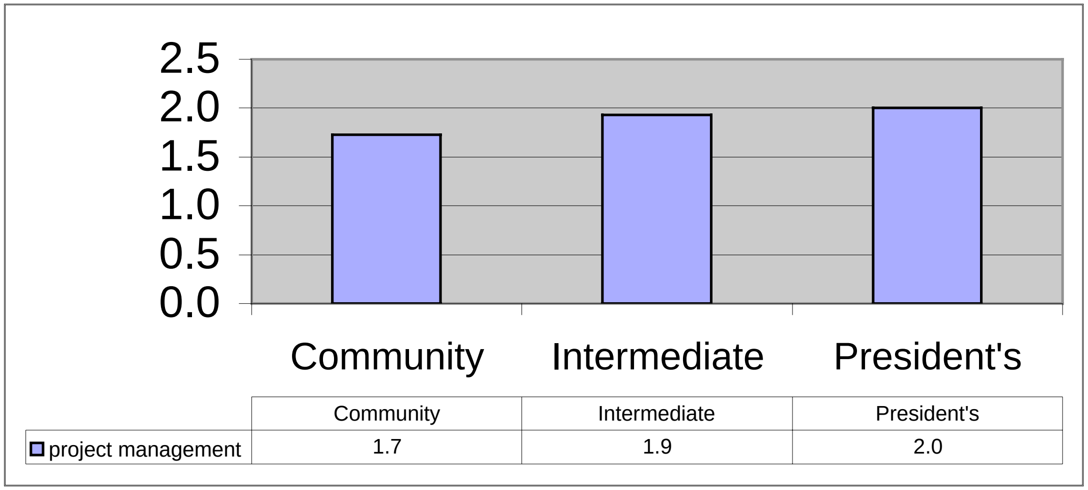
secondees



	Community	Intermediate	President's
Secondees	4.0	6.0	12.7

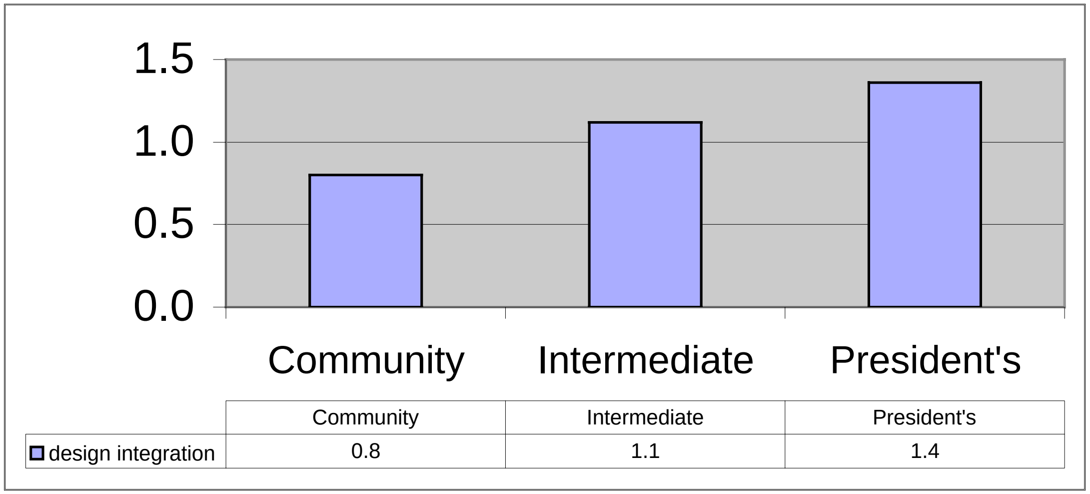
- **The US is responsible for providing 10% of the 2001 FDR's staff:**
  - 180 professional years
  - 276 support years
- **Averaged over 8 years, that would be:**
  - ~23 professional persons
  - ~35 support persons
- **At $400k/professional-year (based on US EDA experience) and $108k/support-year (2001 FDR rate), that comes to ~$12.7M/year**
  - President's budget would afford the steady-state level of staff for the full year
  - Intermediate and Community budgets would afford 47% and 31% of the steady-state level, consistent with ramp-up

project management



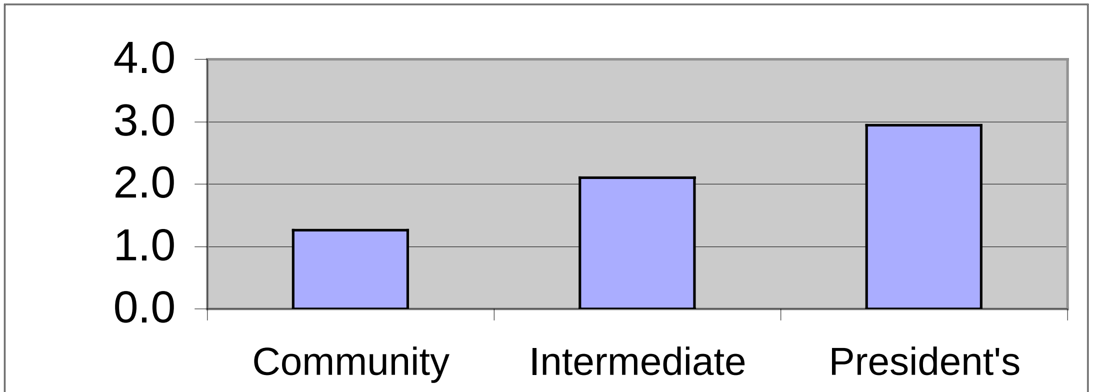
- **Supports**
  - Full time: project manager
  - Part-time:
    - project planning/control manager
    - project engineering manager
    - chief scientist
    - chief technologist
    - project control/cost-schedule support team

design integration



- **Supports**
  - Design integration manager
  - Tools and services for US access to ITER drawings and documents
  - CAD standards and tools
  - Neutronics services, including tool for neutronics interface to CAD
  - Thermohaudrualics services
  - Electromagnetic-loads analysis services
  - Materials

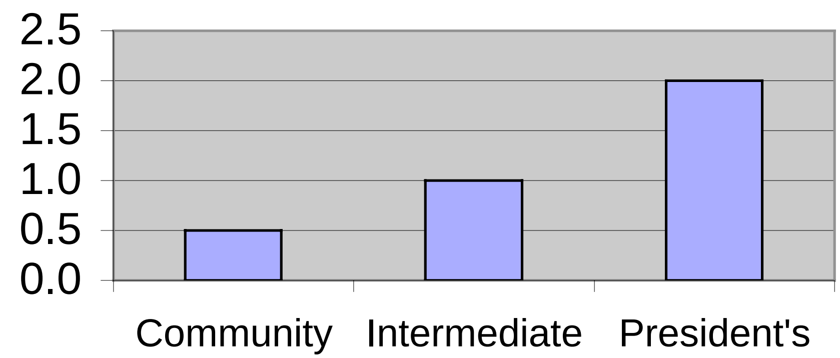
WBS Managers



	Community	Intermediate	President's
WBS Managers	1.3	2.1	2.9

- **Supports:**
  - President's Request: ~8.3 FTE team leaders
  - Intermediate: ~ 6 FTE team leaders
  - Community: ~ 3.7 FTE team leaders

cash to the ITER Organization



	Community	Intermediate	President's
Cash to the ITER Organization	0.5	1.0	2.0

- **To fulfill its 10% share of 3020.7kIUA for in-kind and cash contributions, the US should provide ~$45M ('02) to the ITER Organization**

- **Spread over 8 years, this would average ~$5.5M/year**

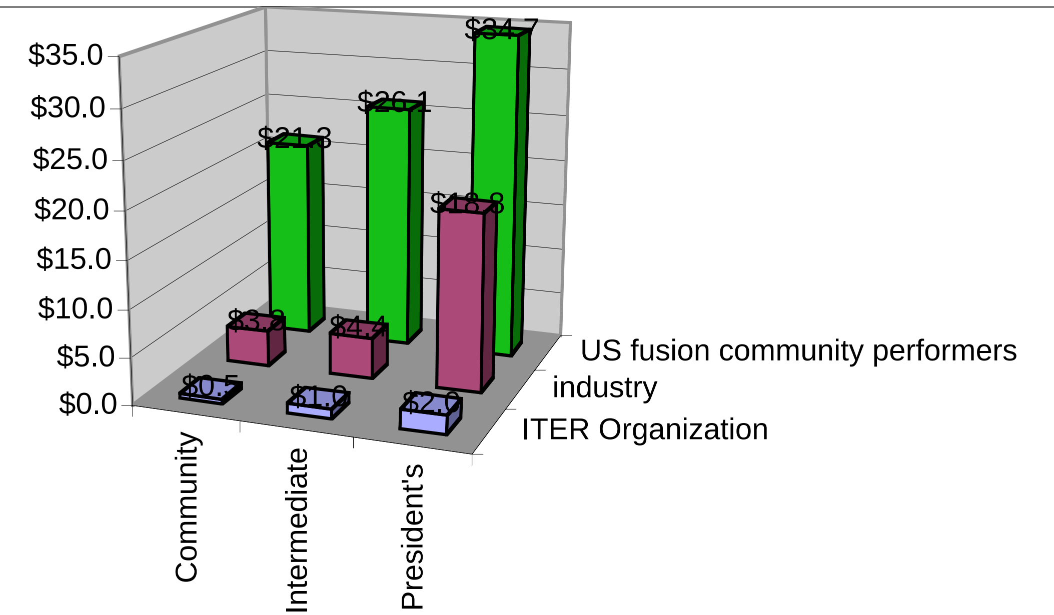
- **The scenarios provide the following percentages of that level:**
  - President's: 36%
  - Intermediate: 17%
  - Community: 9%

U.S. Critical Decision schedule
(from revised Mission Need, February 2005)

CD-0 Approve Mission Need	2nd Q FY 2005
CD-1 Approve Alternate Selection and Cost Range	2nd or 3rd Q FY 2005
CD-2 Approve Performance Baseline	1st or 2nd Q FY 2006
CD-3a Approve Start of Fabrication (long lead components)	3rd or 4th Q FY 2006
CD-3b Approve Start of Fabrication (remaining components)	TBD [~FY07]
CD-4 Approve Start of Operations*	4th Q FY 2013

*Note: should be considered for change to "Project Completion"

Institutional: Distributions among performers: US fusion community, industry, and ITER Org ($M)



	Community	Intermediate	President's
ITER Organization	$0.5	$1.0	$2.0
industry	$3.8	$4.4	$18.8
US fusion community performers	$21.3	$26.1	$34.7

- **Fusion community performers (including secondees) receive the majority of the resources in all 3 FY06 cases ($21M, $26M, and $35M)**
- **Industry receives a major fraction only in “President’s case”**
- **Cash for the ITER Organization is small in all cases**

How would the fusion community be engaged in community-scopes totaling ~$21M-$34M in FY06?

Magnet design	~$3.5M
Blanket/shield design	~$3M
Diagnostic design (instruments + plugs)	~$2M
Electron cyclotron design	~$1.5M
Ion cyclotron design	~$1.5M
Tritium processing design	~$0.8M
Vacuum/fuelling design	~$0.3M
Cooling water design	~$0.3M
Steady-State Electric Power	~$0.3M
Safety	~$0.2M
Secondees	~$4-13M
Design Integration	~$1M
WBS managers	~$1-3M
Project management	~$2M

Final Messages…

- Key R&D, design and prototyping is needed prior to the US ITER Project procuring long-lead materials/components
- Only if the ITER site selection is early and the engagement of senior staff prompt will the ITER Organization be positioned to approve specifications in FY06, a prerequisite for long-lead procurements
- The President's Budget ($49.5M MIE + $6M preparations) enables ~$14M of long-lead materials and components and a full-complement of US staff in the ITER organization
- At lower levels (($25.5M or $19.6M) MIE + $6M preparations), essential R&D, design and prototyping can be conducted to enable long-lead procurements in FY07 and less than a linear ramp of secondees
- The scenarios will support $21M - $35M of fusion community activity