

FIRE Vacuum Vessel

Cost estimate and R&D needs

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FIRE Design Review

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PPPL

Presentation outline

For each major element of vacuum vessel

- **Brief description of what is being costed**
- **Main assumptions**
- **Current cost estimate**
- **R&D summary**
- **Status : Issues, missing info, impending changes**

WBS 1.2 Vacuum vessel cost

WBS	Element	\$k	contingency	element total (\$k)
1.2.1	primary vv shell	14347	34%	19226
1.2.2	vv port extensions	9282	28%	11880
1.2.3	vv plugs	5366	28%	6868
1.2.4	vv htg/cooling	224	36%	305
1.2.5	vv supports	1324	42%	1880
1.2.6	VV local I&C	<u>363</u>	36%	<u>493</u>
	TOTAL	30905	32%	40652

Estimate updated October 2000

Assumed rates: Engr = \$100/hr, Outside Fab = \$100/hr, R&D = \$100/hr

Cost estimate methodology

- **Main vessel, port extensions and plugs scaled from ITER EDA cost estimate**
- **Copper cladding estimated with assistance from Boeing based on ITER experience with divertor structures**
- **Internal control coils based on coil configuration, number of joints, etc.**
- **Other estimates based on engr judgement, and scaled by number of flow circuits, sensors, etc.**

VV primary shell and port cost est.

cost category	WBS 1.2.1 primary vv shell		WBS 1.2.2 vv port extensions	
	hours	\$k	hours	\$k
In-house design	24680	2468	7380	738
R&D labor	4720	472	960	96
Procurement support	2960	296	1640	164
Assembly / Installation	13440	1344	15232	1523.2
Integrated systems testing	1280	128	2560	256
M&S				
equipment/materials		12408		6340
purchased services				
travel		50		25
subcontract/ matls OH	8.3%	1034	8.3%	528
SUBTOTAL		18200		9670
Contingency	34%	6188	28%	2708
TOTAL		47080		24388
				27772
				12378

Includes:

Torus shell

- Internal shielding
- Active coils
- Passive plates
- Octant to octant welds
- Port to octant welds
- Port extensions and docking flanges
- Mockups for:
 - Octant
 - Midplane port
 - Aux port
 - Vertical port
 - Active coil segment
 - IB passive plate

Does not include:

- Internal hdwe supports

VV port plug and support costs

cost category	WBS 1.2.3		WBS 1.2.5	
	vv plugs		vv supports	
	hours	\$k	hours	\$k
In-house design	6460	646	3720	372
R&D labor	920	92	680	68
Procurement support	1640	164	380	38
Assembly / Installation	2304	230.4	1440	144
Integrated systems testing	512	51.2	256	25.6
M&S				
equipment/materials		3832		722
purchased services				
travel		25		10
subcontract/ matls OH	8.3%	320	8.3%	61
SUBTOTAL		5361		1440
Contingency	28%	1501	42%	605
TOTAL	11836	6862	6476	2045

Includes:

- Port plugs for all ports
 - Midplane
 - Auxiliary
 - Vertical
- Mockup plugs
- Support links, hardware
- Support link fitup

Does not include:

- Modification of plugs for diag., heating systems
- VV support brackets on TF coil side

VV heating / cooling and I&C cost

cost category	WBS 1.2.4 vv htg/cooling		WBS 1.2.6 VV local I&C	
	hours	\$k	hours	\$k
In-house design	1000	100	1320	132
R&D labor	0	0	0	0
Procurement support	40	4	320	32
Assembly / Installation	640	64	1056	105.6
Integrated systems testing	160	16	400	40
M&S				
equipment/materials		415		112
purchased services				
travel		5		5
subcontract/ matls OH	8.3%	35	8.3%	10
SUBTOTAL		639		436
Contingency	36%	230	36%	157
TOTAL	1840	869	3096	593

Includes:

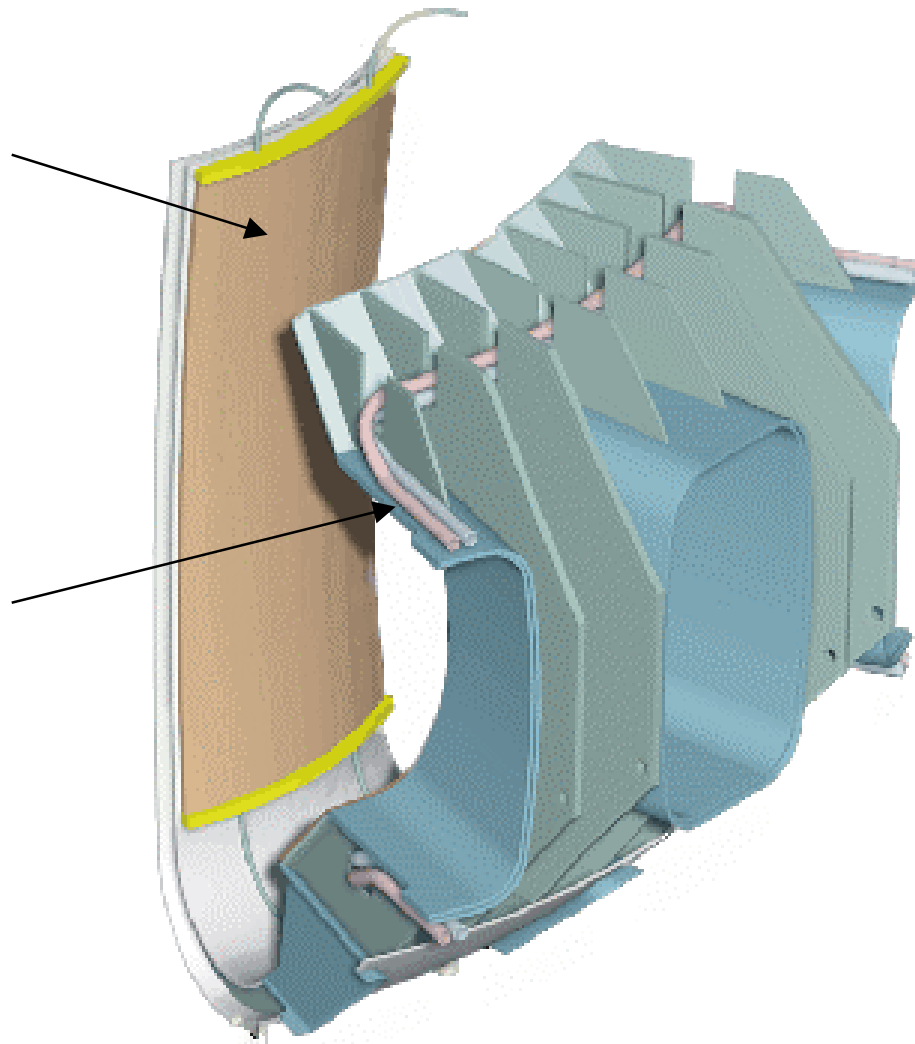
- Internal vessel cooling lines and manifolding inside cryostat (72 circuits)
- Local heaters on vessel
- Local I&C sensors
 - 192 temp sensors on vessel
 - 72 flow meters
 - 72 pressure transducers
 - 144 water temp sensors

Does not include:

- Signal conditioning
- Wiring

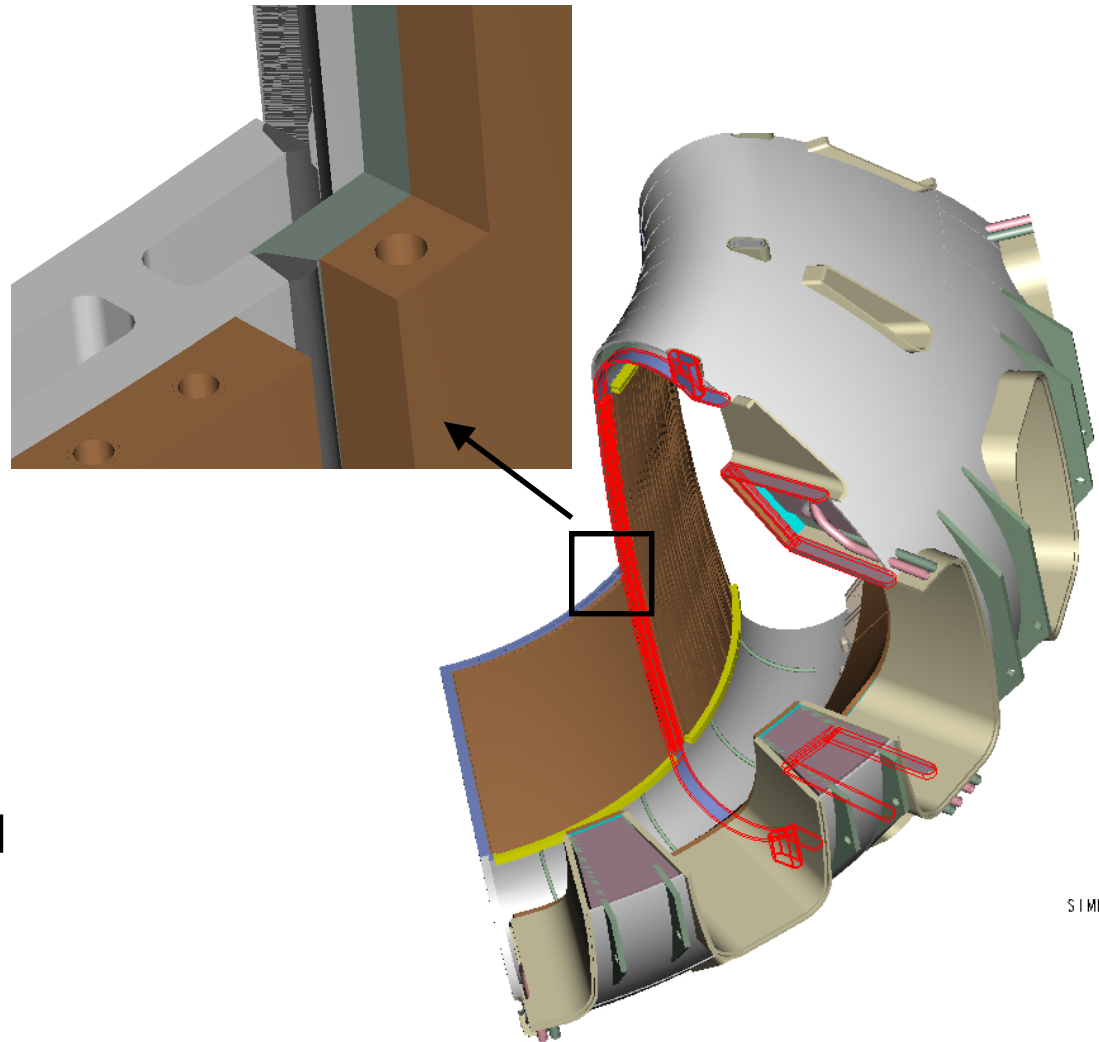
Cu cladding, IC coils need R&D

- **Copper bonding and integration of cooling must be prototyped and tested**
- **Active coil conductor forming, insulating and installing must be prototyped, alternatives to MgO will be considered**



Field weld RH must be demonstrated

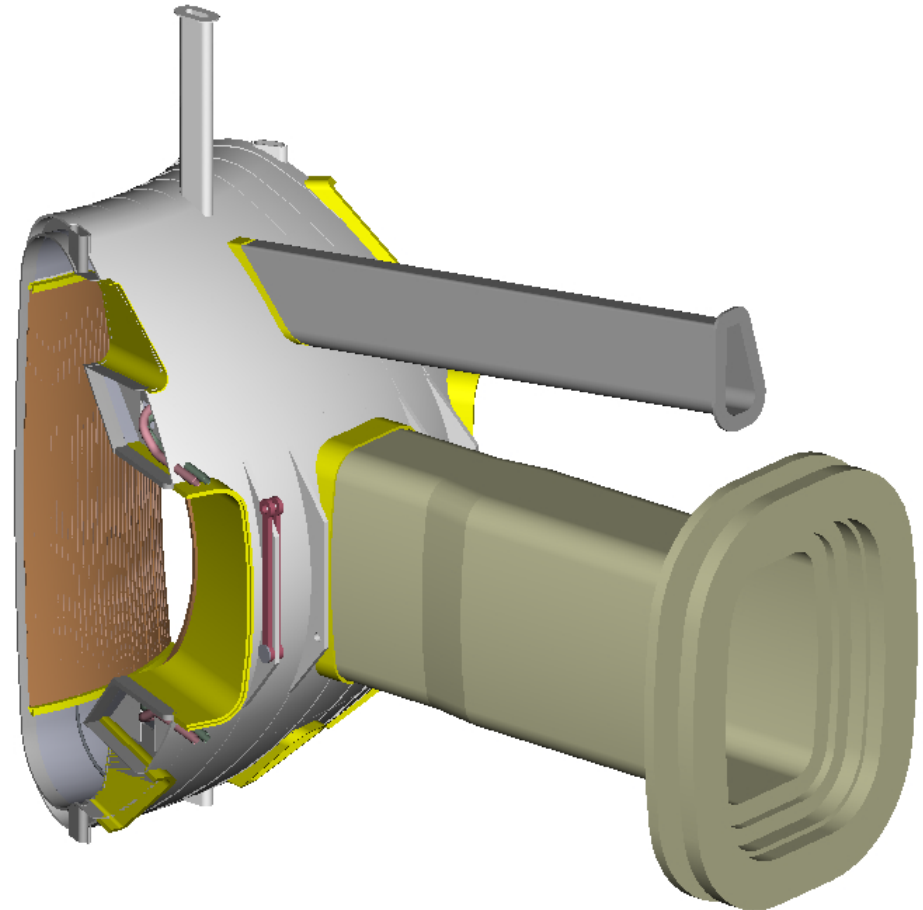
- Field welds must be made in double wall vessel, including copper stabilizing plates
- ITER developed welding and cutting tools that must be modified and demonstrated for FIRE
- Same tools can be used for initial assembly to ensure high quality welds



SIMPLF

Prototype of vessel octant needed for RH mockup

- **Vessel octant with port extensions contains all features needed for demonstrating fabrication**
- **Same prototype would be used for remote handling mockup to be used for demonstration of :**
 - Transfer cask docking
 - Divertor handling
 - FW tile handling / alignment
 - Recovery operations
 - Etc.



R&D Cost and schedule

- **Cost: Prototypes and mockups are assumed to cost ~2 times cost of production units**

- **Testing and development estimated by task:**

– Passive stabilizer bonding/ cooling integration/ testing	\$743k
– Internal control coil fabrication / testing	\$385k
– Octant fabrication	\$894k
– Octant field joint remote welding/cutting demo	\$287k
– Port extensions and demonstrations	\$779k
– Docking flange prototype and demo	\$204k
– Gravity support links prototypes and testing	<u>\$215k</u>

Total estimated R&D for vacuum vessel \$3445k

- **Schedule: Cu cladding, IC coil and welding/cutting begin during preliminary design, prototypes as part of fabrication subcontracts**

VV Cost / R&D summary

- **Total vessel cost = \$41M with 32% contingency**
- **Vessel cost developed by scaling ITER EDA estimate and adjusting for design changes**
- **R&D is required for specific details of**
 - Passive plate bonding and fabrication
 - Active coil fabrication and integration
 - Vessel field joint welding
- **Complete prototype octant with port extensions and docking flanges will be provided as first article and will serve as mockup for remote handling facility**