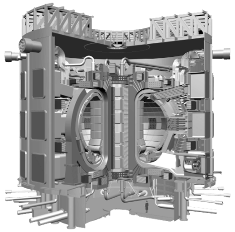


International Thermonuclear Experimental Reactor

ITER-FEAT: Current Status of the Machine and Diagnostics

presented by

A E Costley

ITER JWS, Naka, Japan

First Meeting of the ITPA Topical Group on Diagnostics
St. Petersburg, Russia, November 14 – 16, 2001

OUTLINE

ITER-FEAT

- Goals
- Current Status of Machine
- Operation Scenarios and Phases
- Project Developments since March 2001 (14^{th} EG Mttg)
- Time schedules: Construction and Initial Operation

Diagnostics

- Requirements for Plasma and First Wall Measurements
- Current Status of Design
- Outstanding R&D
- Overall Assessment of Performance
- Key Point on Resources and Timing
- Diagnostic work during the CTA (including role of the ITPA Group)

Concluding Remarks

ITER - FEAT GOALS

Plasma Performance

- achieve extended burn in inductively driven plasmas with the ratio of fusion power to auxiliary heating power of at least 10

- for a range of operating scenarios

- with duration sufficient to achieve stationary conditions on the time scales characteristic of plasma processes.

- aim at demonstrating steady-state operation using non-inductive current drive with the ratio of fusion to current drive power of at least 5

- the possibility of controlled ignition should not be precluded

Technology

- demonstration of integrated operation of technologies essential for a fusion reactor
- testing of key components for a fusion reactor
- testing of concepts for a tritium breeding module

Key Design Requirements

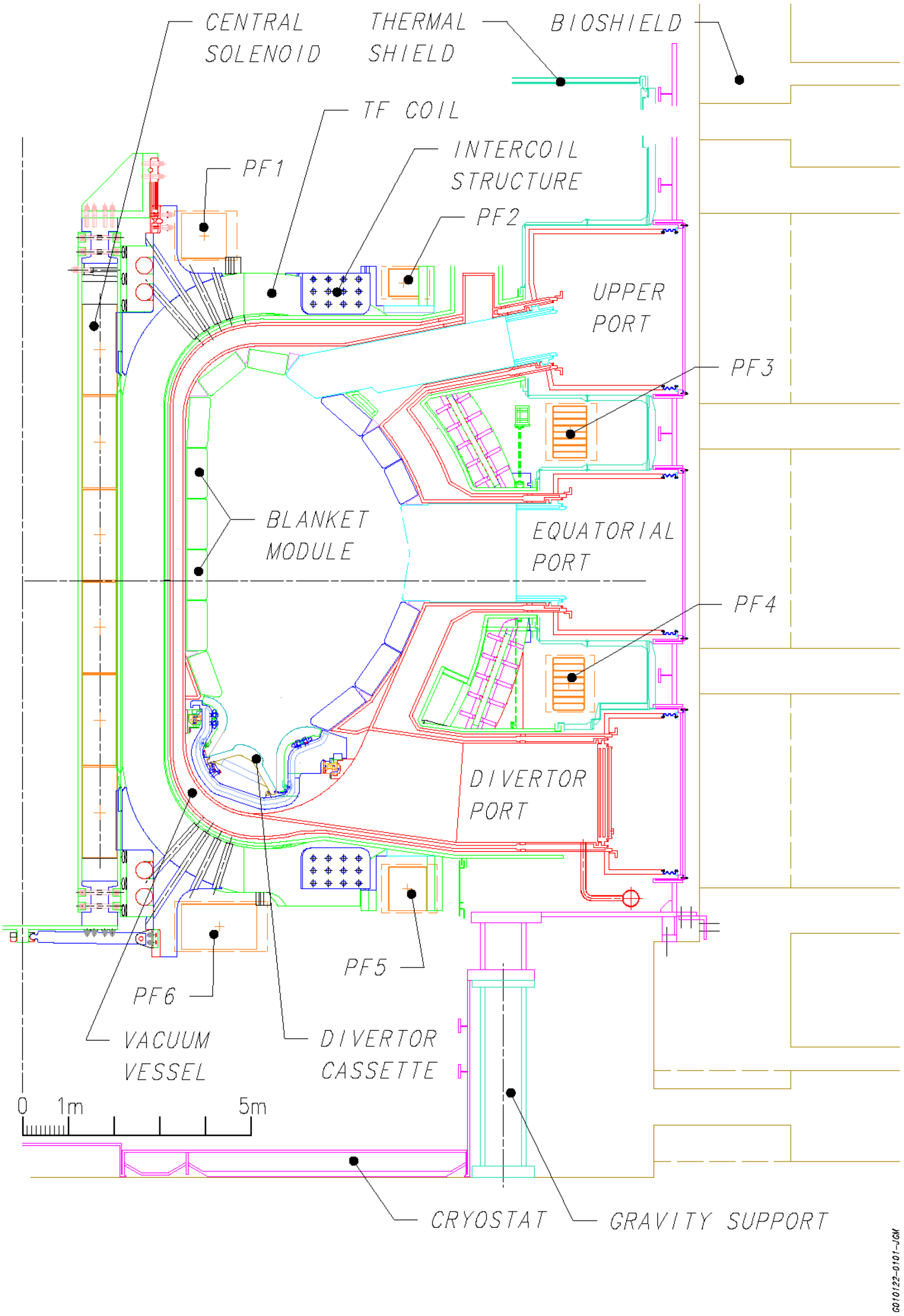
- An inductive flat-top capability during burn of 300 to 500 s.
- The design should be capable of supporting advanced modes of plasma operation under investigation in existing experiments, and should permit a wide operating parameter space to allow for optimising plasma performance.
- For nuclear and high heat flux component testing
- average neutron flux $\geq$ 0.5 MW/m^2
- average neutron fluence $\geq$ 0.3 MWa/m^2

Main Device and Plasma Parameters

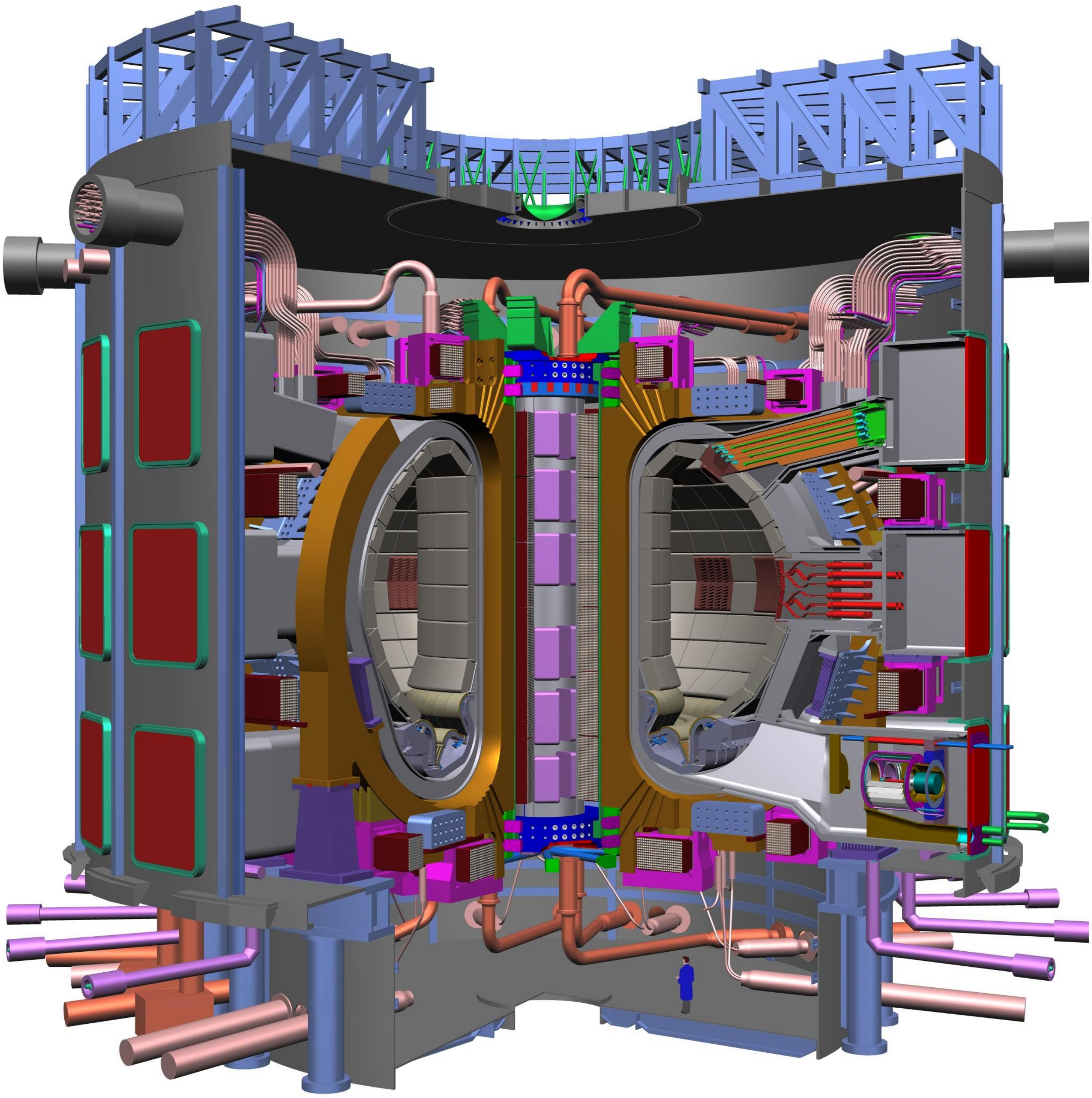
Total Fusion Power	**500 MW *(700 MW)***
Q — fusion power/additional heating power	**$\geq$ 10**
Average 14MeV neutron wall loading	**0.57 MW/m^2 *(0.8 MW/m^2)***
Plasma inductive burn time	**$\geq$ 400 s**
Plasma major radius (R)	**6.2 m**
Plasma minor radius (a)	**2.0 m**
Plasma current (I_p)	**15 MA *(17 MA [(1)])***
Vertical elongation @95% flux surface/separatrix (κ_{95})	**1.70/1.85**
Triangularity @95% flux surface/separatrix	**0.33/0.49**
Safety factor @95% flux surface (q_{95})	**3.0**
Toroidal field @6.2 m radius (B_T)	**5.3 T**
Plasma volume	**837 m^3**
Plasma surface	**678 m^2**
Installed aux. heating/current drive power	**73 MW [(2)]**

(1) The machine is capable of a plasma current up to 17MA, with the parameters shown in parentheses) within some limitations over some other parameters (e.g., pulse length).

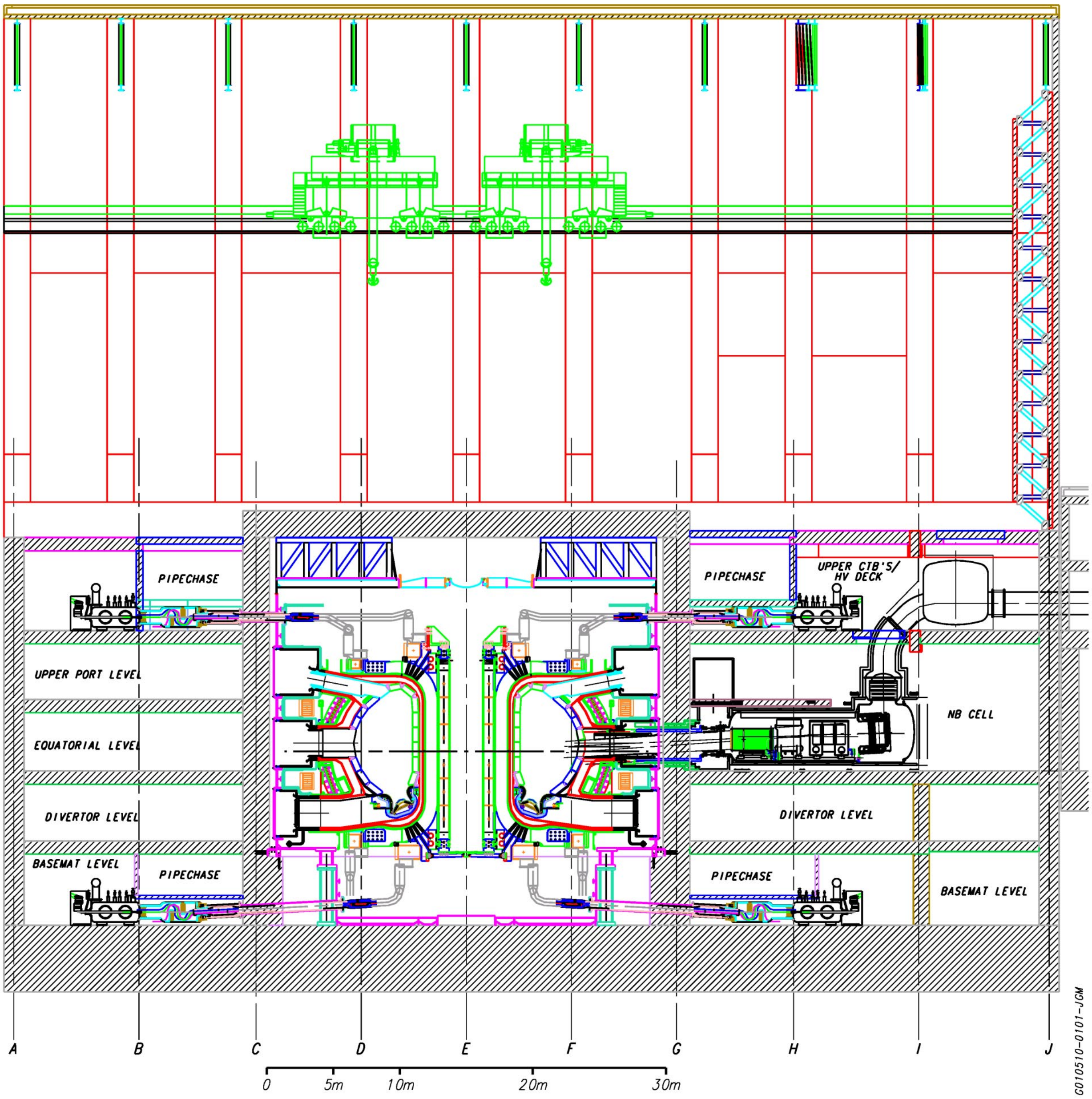
(2) A total plasma heating power up to 110MW may be installed in subsequent operation phases.



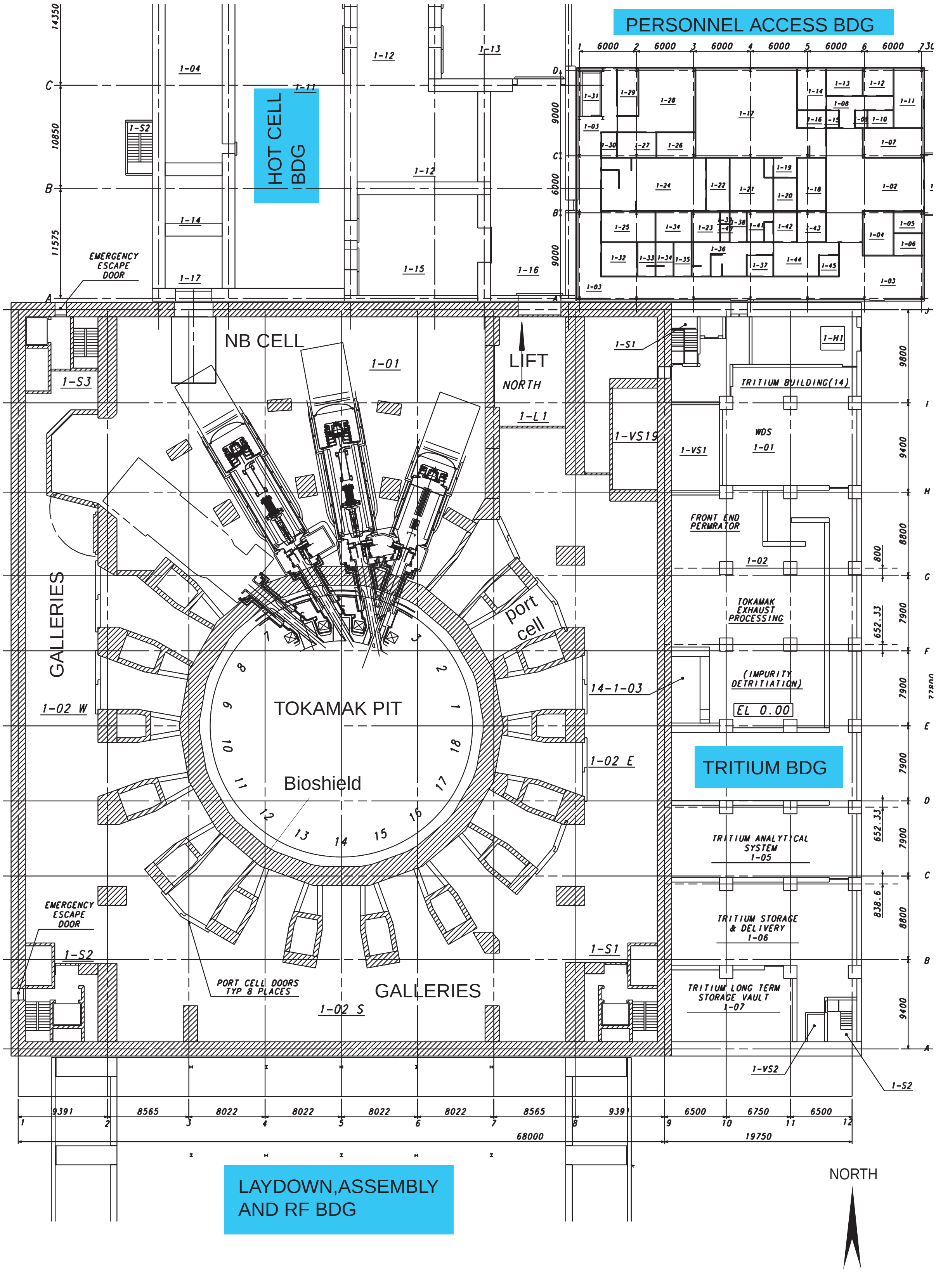
Tokamak Poloidal Cross-Section



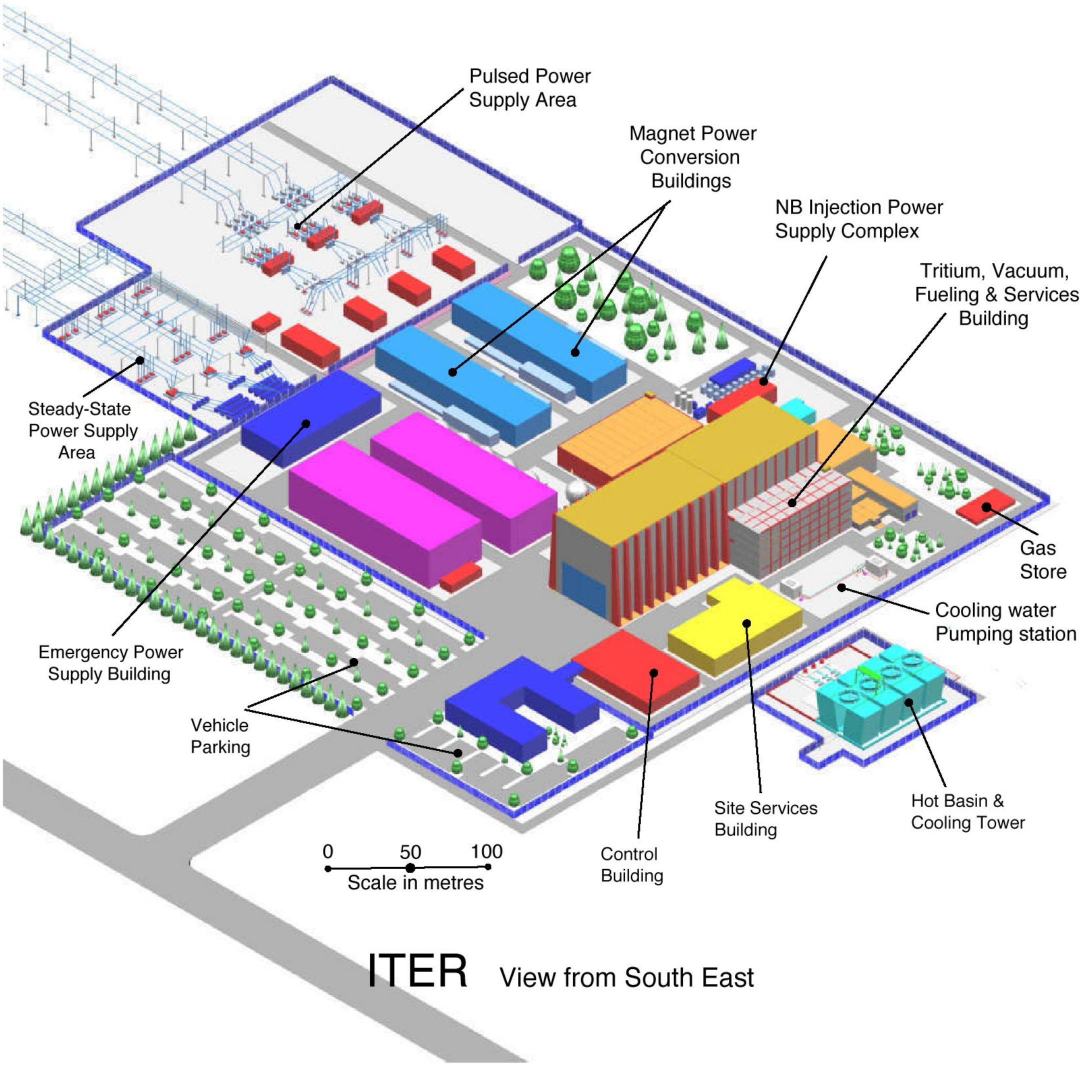
ITER Tokamak Cutaway



Cross-section NS Through the Tokamak Building



Tokamak Building – Plan View of the Equatorial Level



Generic ITER Site View

Heating and Current Drive Parameters

<table>
<tr><th></th><th>NB (1MeV)</th><th>EC (170 GHz)</th><th>IC (~ 50 MHz)</th><th>LH (5 GHz)</th></tr>
<tr><td>Power injected per unit equatorial port (MW)</td><td>16.5</td><td>20</td><td>20</td><td>20</td></tr>
<tr><td>Number of units for the first phase</td><td>2</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>Total power (MW) for the first phase</td><td>33</td><td>20</td><td>20</td><td>0</td></tr>
<tr><td colspan="5">The 20 MW of EC module power will be used either i) in up to 3 upper ports to control neoclassical tearing modes at the q = 3/2 and q = 2 magnetic surfaces, or ii) in one equatorial port for H&CD mainly in the plasma centre.</td></tr>
</table>

Operation Scenarios and Phases

The design of ITER allows for operation in various scenarios.

1. Inductive operation I: 500 MW, Q=10, 15 MA operation with heating during current ramp-up

2. Inductive operation II: 400 MW, Q=10, 15 MA operation without heating during current ramp-up

3. Hybrid operation

4. Non-inductive operation I: weak negative shear operation

5. Inductive operation III: 700 MW, 17 MA, with heating during current ramp-up.

6. Non-inductive operation II: strong negative shear

Operation Phases

H Phase

This is a non-nuclear phase, mainly planned for full commissioning of the tokamak system in a non-nuclear environment. Develop full DT phase reference operation. Check partial detached divertor operation in a DT plasma.

D Phase

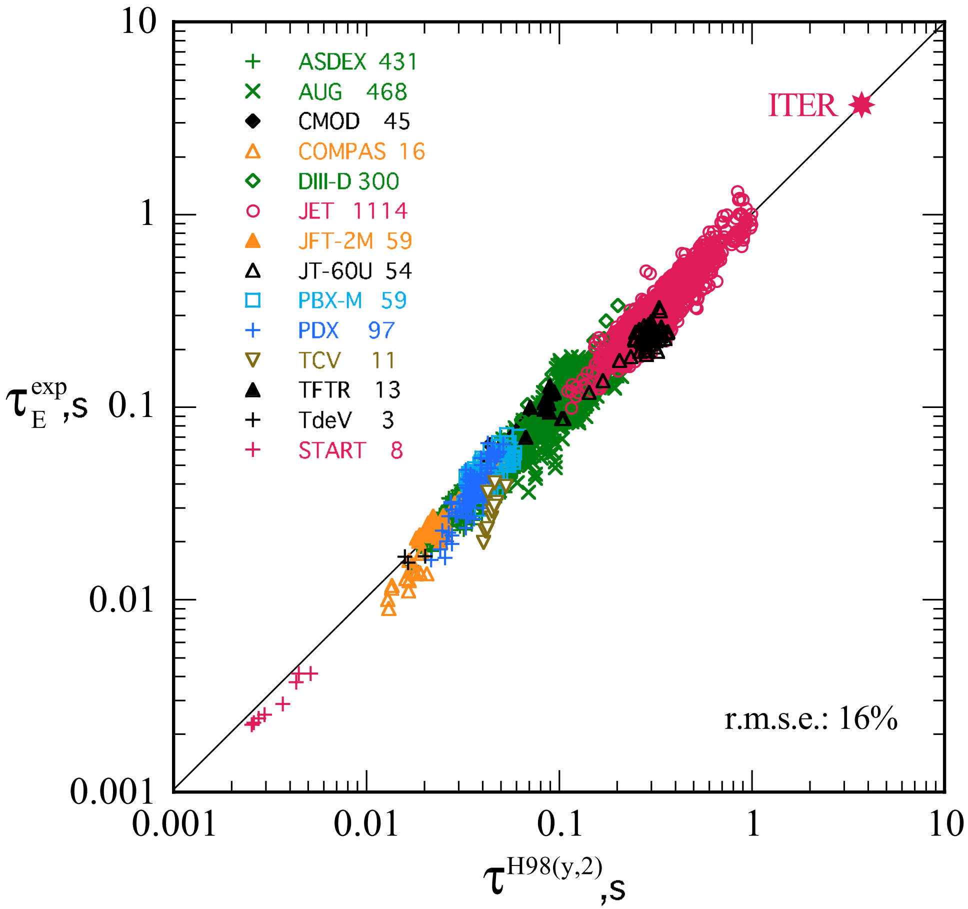
Tritium produced from DD reactions → DT reactions. Reference DT operational scenarios can be established.

DT Phases

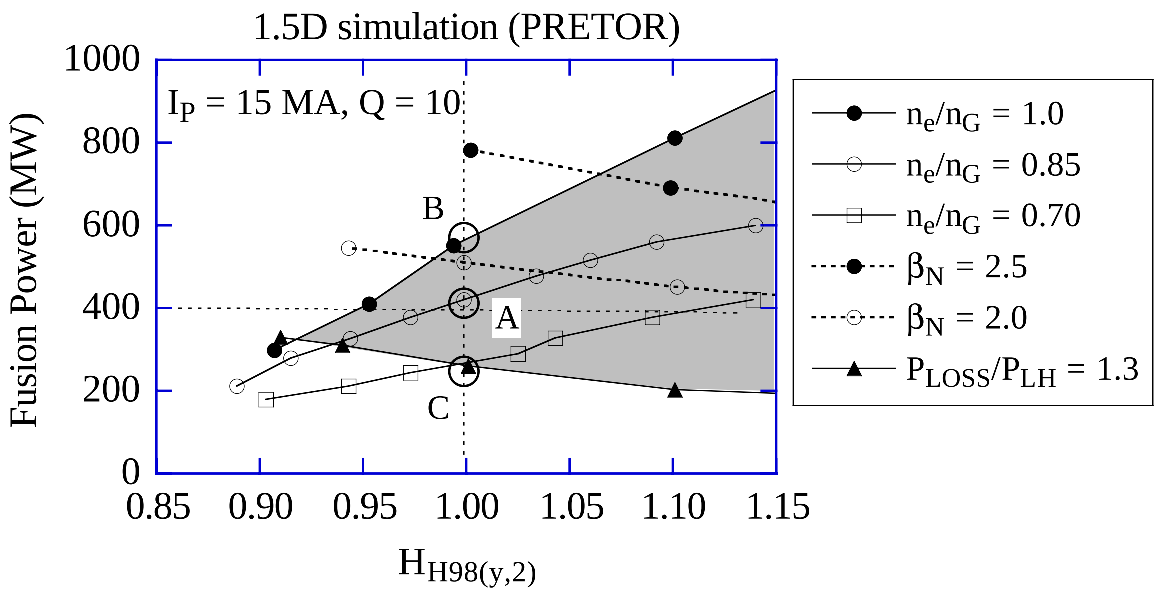
During the first phase of DT operation the fusion power and burn pulse length will be gradually increased until the inductive operational goal is reached. Non-inductive, steady-state operation developed.

Second phase of full DT operation, beginning after a total of about ten years. Emphasize improvement of the overall performance and the testing of components and materials with higher neutron fluences

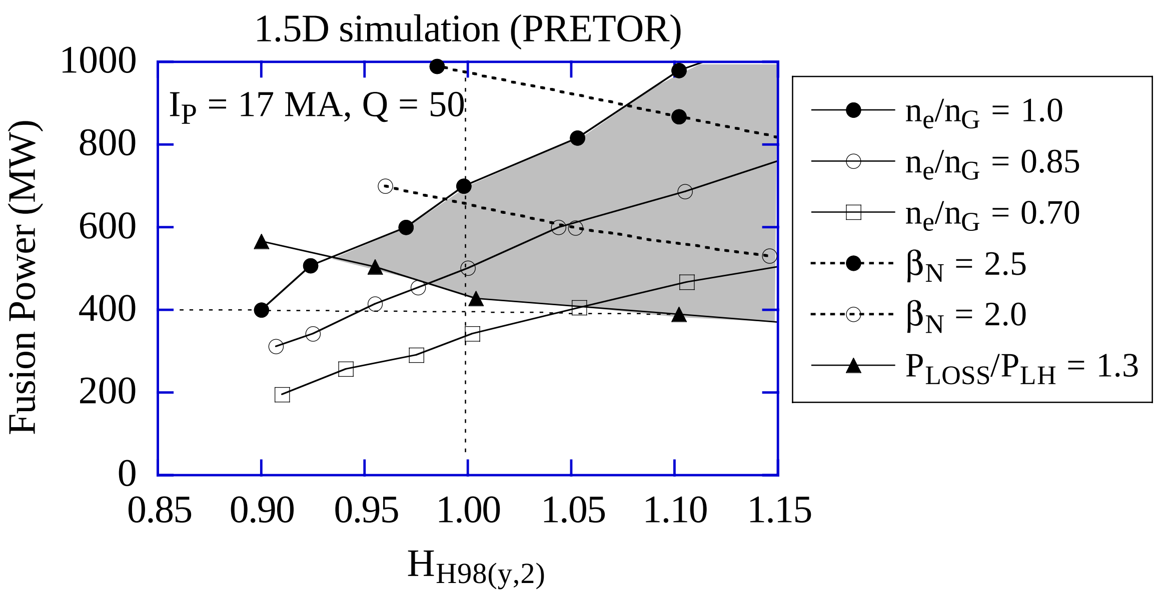
Performance and Operation Domains



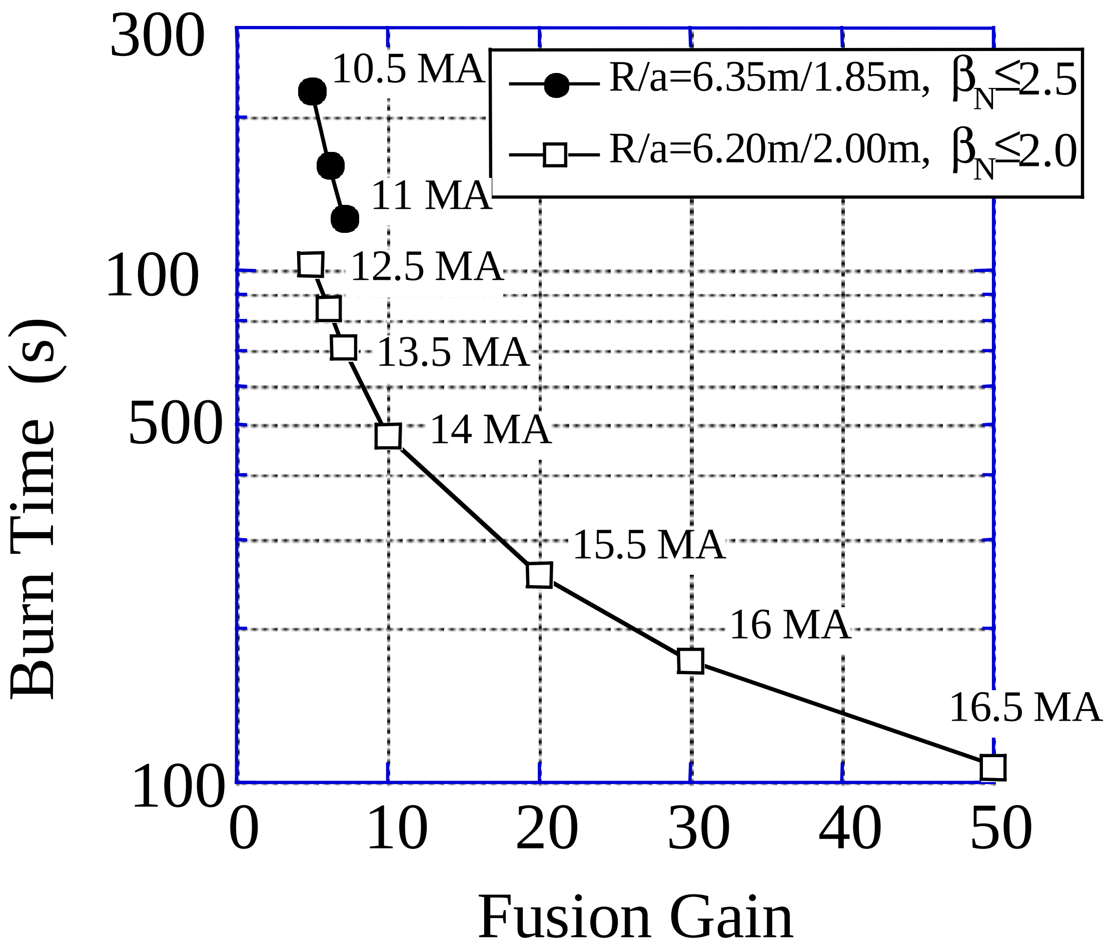
Comparison of Experimental and Predicted by Scaling ITERH-98P(y,2) Confinement Times for the Extended ELMy Standard Dataset of the H-mode Database DB3 [from O. Kardaun, et al., 18th IAEA Fusion Energy Conference, Sorrento, Italy (2000) IAEA-CN-77/ITERP/04]



Operation Domain in H_H-Factor and Fusion Power Space when I_P = 15 MA and Q = 10



Operation Domain in H_H-Factor and Fusion Power Space when I_P = 17 MA and Q = 50



Pulse length versus fusion gain Q.

Each plasma current given in the figure is the minimum value for the corresponding Q value with H_H=1.0 n_e/n_G = 0.85, $\beta_N \leq 2.0$ or 2.5, $P_{loss}/P_{LH} \geq 1.3$ and $\tau^*_{He}/\tau_E = 5$. The fusion power is in the range 400-700 MW.

Project Developments Since March 2001

The EDA was formally concluded in July

The Final Design Report of ITER-FEAT was delivered to the Parties

The site offer from Canada remains. Additional site offers are expected from Japan, France and Spain.

All the current ITER Parties (Ca, Eu, Ja and the RF) have a government backed mandate to start the negotiations towards ITER construction. Negotiations have begun

The Coordinated Technical Activities (CTA) has commenced

The International Team (IT) has been established. It is approximately half the size of the former JCT and resides at the Garching and Naka ITER Joint Work Sites

The key elements of the Work Programme and the deliverables have been determined

Outline proposals of specific work have been drawn up

A method of joint work between the Participating Teams (PT) and the IT on key topics has been proposed

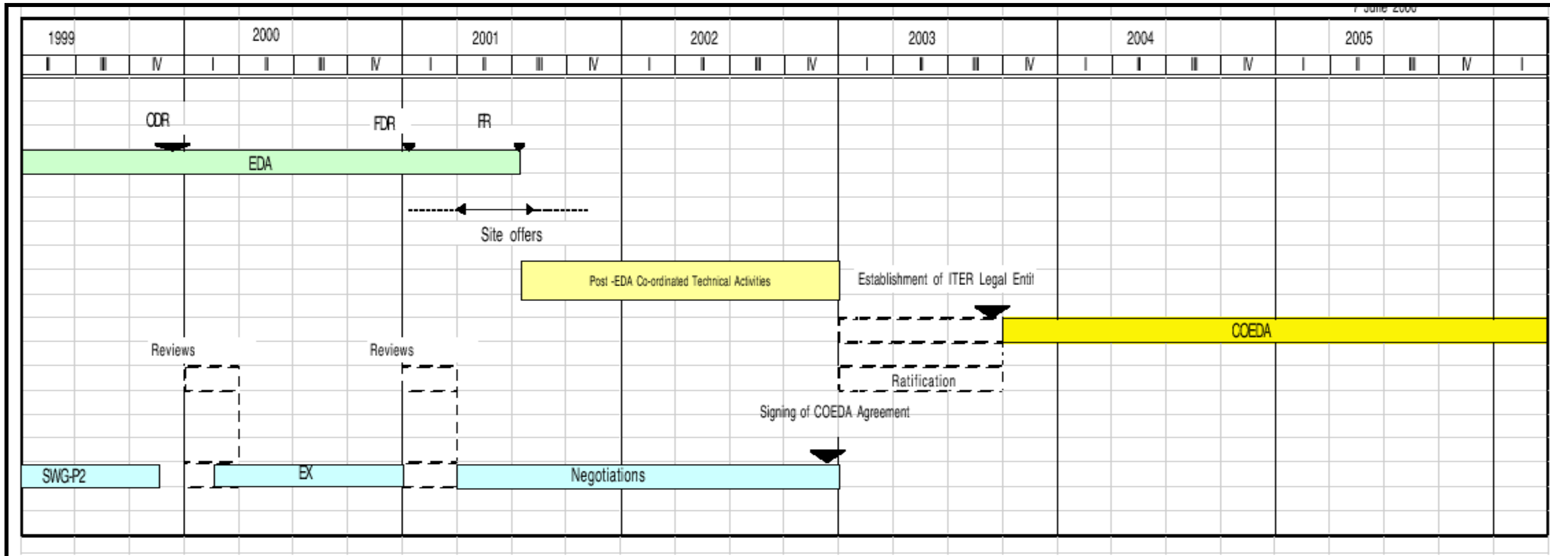
The key elements of the CTA Work Programme are:

- Site adaptations and design changes
- Key systems specifications
- Preparation for licensing
- Other Systems Interfaces
- Necessary Tasks in specific areas

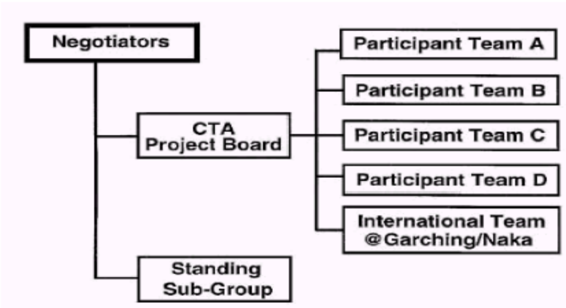
The principal deliverables are:

- Revised Construction Schedule and Costs
- Technical Definition of All Interfaces
- Definition of Skeleton Procurement Packages
- Results, Planning and Definition of Qualifying R&D
- Developed and Reviewed DDDs

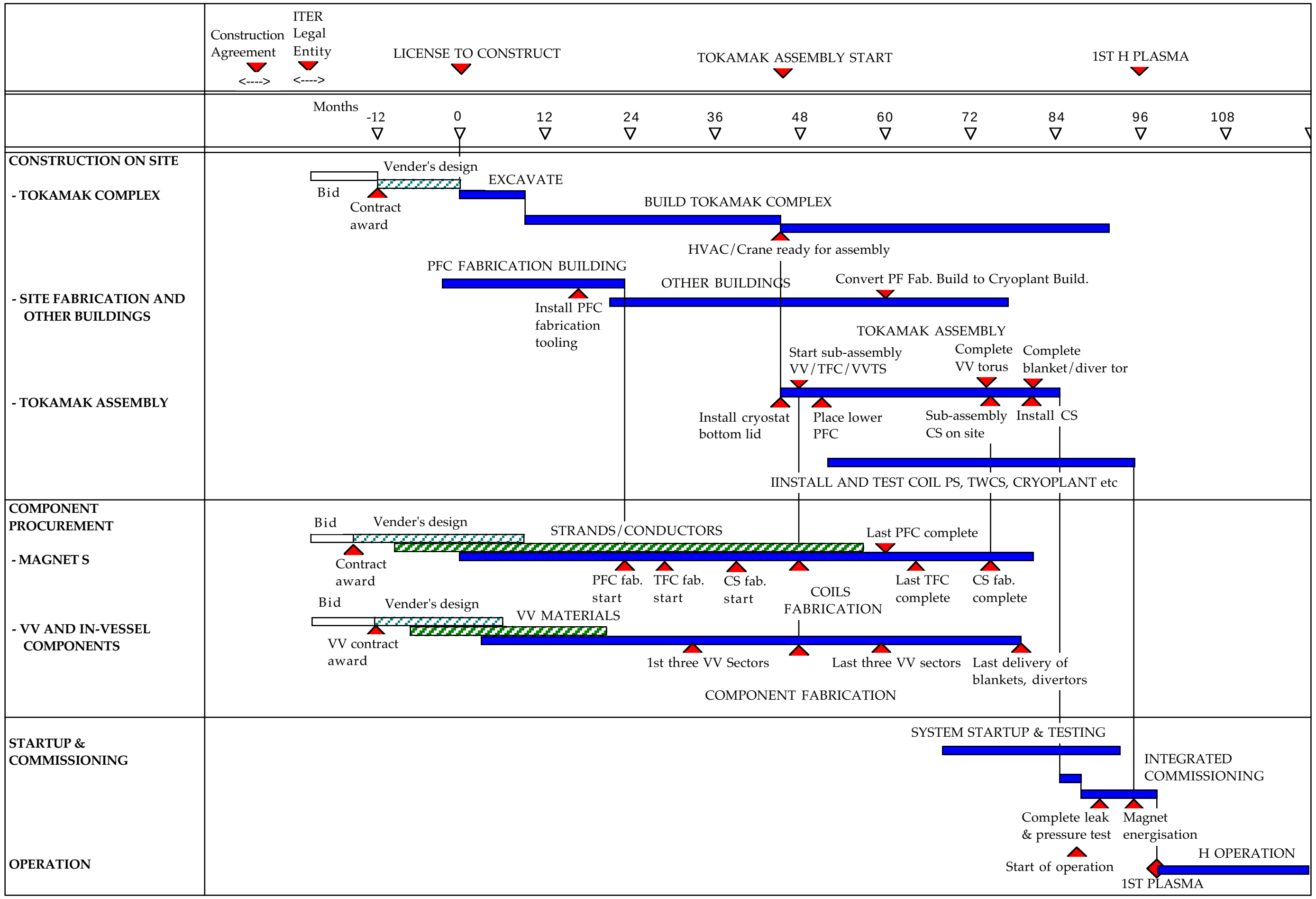
TIME SCHEDULES



Structure of ITER–system during CTA



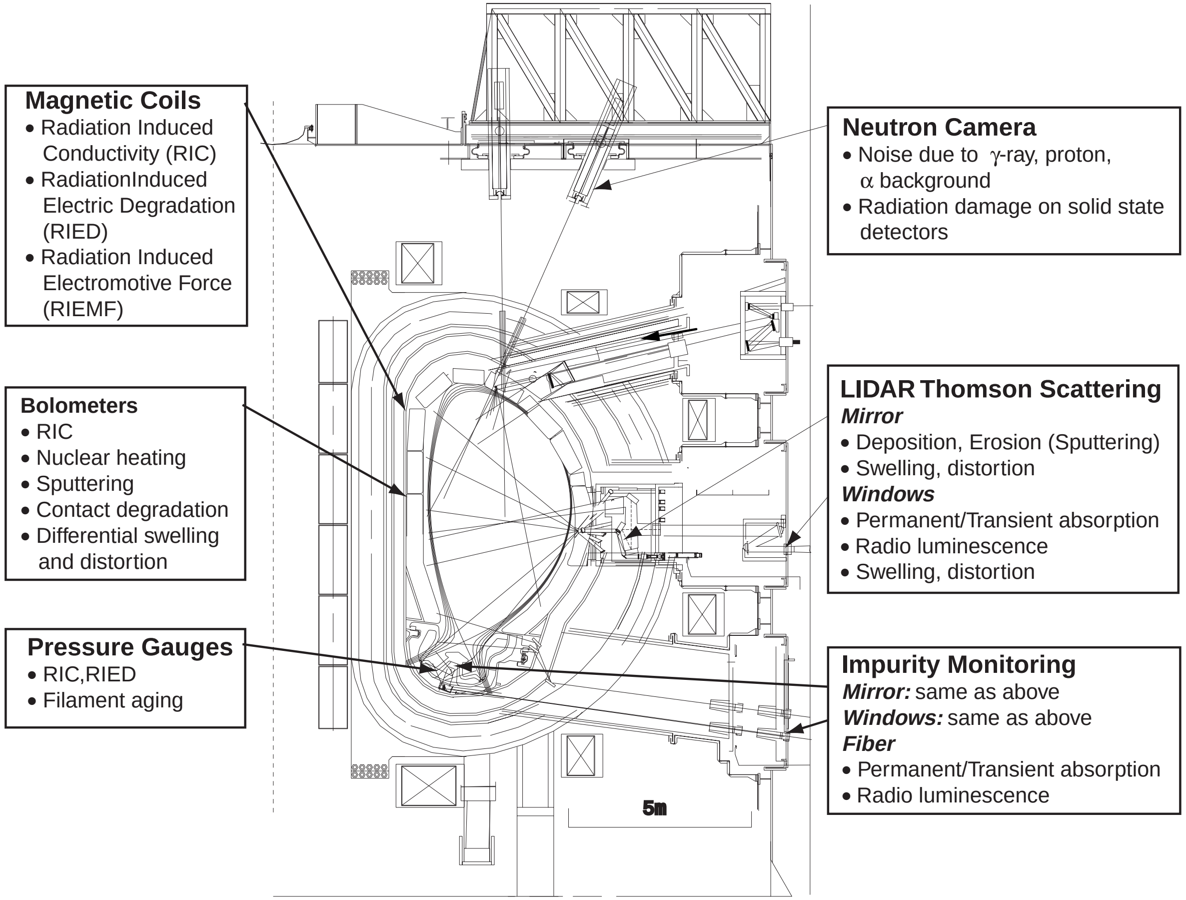
Overall Schedule to ITER Construction



Overall Schedule up to First Plasma

Plasma and First Wall Measurements required for a ITER

GROUP 1a Measurements For Machine Protection and Basic Control	GROUP 1b Measurements for Advanced Control	GROUP 2 Additional Measurements for Performance Eval. and Physics
Plasma shape and position, separatrix- wall gaps, gap between separatrixes Plasma current, q(a), q(95%) Loop voltage Fusion power $\beta_N = \beta_{tor}(aB/I)$ Line-averaged electron density Impurity and D,T influx (divertor, & main plasma) Surface temp. (div. & upper plates) Surface temperature (first wall) Runaway electrons 'Halo' currents Radiated power (main pla, X-pt & div). Divertor detachment indicator (J_{sat}, n_e, T_e at divertor plate) Disruption precursors (locked modes, m=2) H/L mode indicator Z_{eff} (line-averaged) n_T/n_D in plasma core ELMs Gas pressure (divertor & duct) Gas composition (divertor & duct)	Neutron and α-source profile Helium density profile (core) Plasma rotation (toroidal and poloidal) Current density profile (q-profile) Electron temperature profile (core) Electron density profile (core and edge) Ion temperature profile (core) Radiation power profile (core, X-point & divertor) Z_{eff} profile Helium density (divertor) Heat deposition profile (divertor) Ionization front position in divertor Impurity density profiles Neutral density between plasma and first wall n_e, T_e of divertor plasma Alpha-particle loss Low m/n MHD activity Sawteeth Net erosion (divertor plate) Neutron fluence	Confined α-particles TAE Modes, fishbones T_e profile (edge) n_e, T_e profiles (X-point) T_i in divertor Plasma flow (divertor) $n_T/n_D/n_H$ (edge) $n_T/n_D/n_H$ (divertor) T_e fluctuations n_e fluctuations Radial electric field and field fluctuations Edge turbulence MHD activity in plasma core Pellet ablation



ITER: Location of some representative diagnostic components and the principal, radiation

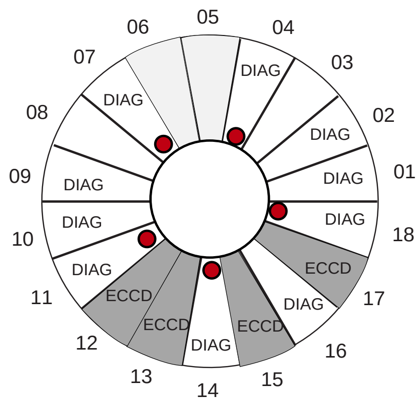
List of Diagnostic Systems

5.5.A	**Magnetic Diagnostics**
5.5.A.01	Vessel Magnetics *
5.5.A.02	In-Vessel Magnetics*
5.5.A.03	Divertor Coils*
5.5.A.04	Continuous Rogowski Coils*
5.5.A 05	Diamagnetic Loop*
5.5.A 06	Halo Current Sensors*
5.5.B	**Neutron Diagnostics**
5.5.B.01	Radial Neutron Camera*
5.5.B.02	Vertical Neutron Camera*
5.5.B.03	Microfission Chambers (In-Vessel)*
5.5.B.04	Neutron Flux Monitors (Ex-Vessel)*
5.5.B.07	Gamma-Ray Spectrometers
5.5.B.08	Neutron Activation System*
5.5.B.09	Lost Alpha Detectors
5.5.B.10	Knock-on Tail Neutron Spectrometer
5.5.C	**Optical/IR Systems**
5.5.C.01	Thomson Scattering (Core)*
5.5.C.02	Thomson Scattering (Edge)
5.5.C.03	Thomson Scattering (X-Point)
5.5.C.04	Thomson Scattering (Divertor)
5.5.C.05	Toroidal Interferometric/Polarimetric System*
5.5.C.06	Polarimetric System (Pol. Magnetic Field Meas.)
5.5.C.07	Collective Scattering System
5.5.D	**Bolometric System**
5.5.D.01	Bolometric Array For Main Plasma*
5.5.D.02	Bolometric Array For Divertor*
5.5.E	**Spectroscopic and NPA Systems**
5.5.E.01	CXRS Active Spectroscopy (based on DNB)
5.5.E.02	H Alpha Spectroscopy*
5.5.E.03	VUV Impurity Monitoring (Main Plasma)*
5.5.E.04	Visible & UV Impurity Monitoring (Divertor)*†
5.5.E.05	X-Ray Crystal Spectrometers*†
5.5.E.06	Visible Continuum Array*
5.5.E.07	Soft X-Ray Array
5.5.E.08	Neutral Particle Analysers*
5.5.E.10	Laser Induced Fluorescence
5.5.E.11	MSE based on heating beam
5.5.F	**Microwave Diagnostics**
5.5.F.01	ECE Diagnostics for Main Plasma*†
5.5.F.02	Reflectometers for Main Plasma*†
5.5.F.03	Reflectometers for Plasma Position*†
5.5.F.04	Reflectometers for Divertor Plasma
5.5.F.05	ECA for Divertor Plasma
5.5.F.06	Microwave Scattering (Main Plasma)
5.5.F.07	Fast Wave Reflectometry
5.5.G	**Plasma-Facing Components and Operational Diagnostics**
5.5.G.01	IR Cameras, visible/IR TV
5.5.G.02	Thermocouples*
5.5.G.03	Pressure Gauges*
5.5.G.04	Residual Gas Analyzers*
5.5.G.06	IR Thermography Divertor*
5.5.G.07	Langmuir Probes

Systems which provide Group 1a, Group 1b, and Group 2 measurements

Port Allocation for the FDR

NORTH



UPPER PORT

1 MSE
Neutron Act syst (^{16}N)

2 H-alpha spectroscopy
(inner edge)
Position Reflectometry

3 Neutron Camera

4 CXRS(poloidal rotation,
linked to DNB)
Wide angle viewing/IR (1 of 5) ●

5 Neutron Camera
Neutron Act syst (^{16}N)

6 Neutron Camera
Neutron Act syst (foil)

7 Neutron camera
Wide angle viewing/IR (2 of 5) ●

8 Bolometry
Main plasma Reflectometry (1 of 2)

9 H-alpha spectroscopy
(upper edge)

10 H-alpha spectroscopy
(outer edge)
VUV, X-ray Crys spectroscopy
Neutron Act syst (foil)

11 Edge Thomson scattering
Wide angle viewing/IR (3 of 5) ●

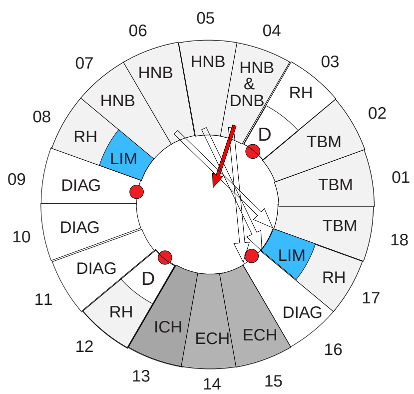
13 In-vessel diagnostic wiring

14 Wide angle viewing/IR (4 of 5) ●
Main plasma Reflectometry (2 of 2)

16 Bolometry (matches equ. port 16
& div 16)
Soft X-Ray (matches equ. port 16)

18 Wide angle viewing/IR (5 of 5) ●
Visible spectroscopy
(div port 15, outer leg)

NORTH



EQUATORIAL PORT

3 Wide angle viewing/IR ●
CXRS (with DNB)
MSE (with heating NB)
H-alpha /Vis. spectroscopy

4 DNB

7 Obscured port

8 RH plus Limiter
Neutron flux monitor

9 Wide angle viewing/IR
Tor./Intefer. polarimeter
ECE ●
Fast Wave Reflectometry

10 LIDAR Thomson Scattering
Polarimeter

11 X-ray Cryst spec
NPA
VUV (main & div.)
Reflectometry

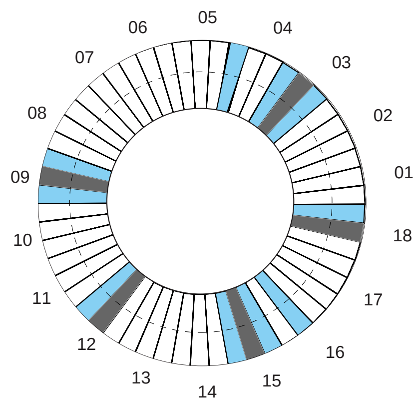
12 Wide angle viewing/IR ●
H-alpha spectroscopy (edge)
Visible continuum array

16 Wide angle viewing/IR ●
Radial Neutron Camera
Bolometry
Soft x-ray array
Visible spectroscopy
(div port 15, inner leg)

17 RH plus Limiter
Neutron flux monitor
Neutron Act syst (foil & ^{16}N)

Unassigned:
Collective scattering
Laser Induced Fluorescence

NORTH



DIVERTOR

3 Reflectometry, Interferometry
Magnetics, Langmuir Probes

4 Langmuir Probes, Thermocouples

9 Reflectometry, Interferometry
IR Thermography
Bolometry, Magnetics
Pressure Gauges

12 X-point LIDAR
Div. Thomson Scattering
Bolometry, Magnetics

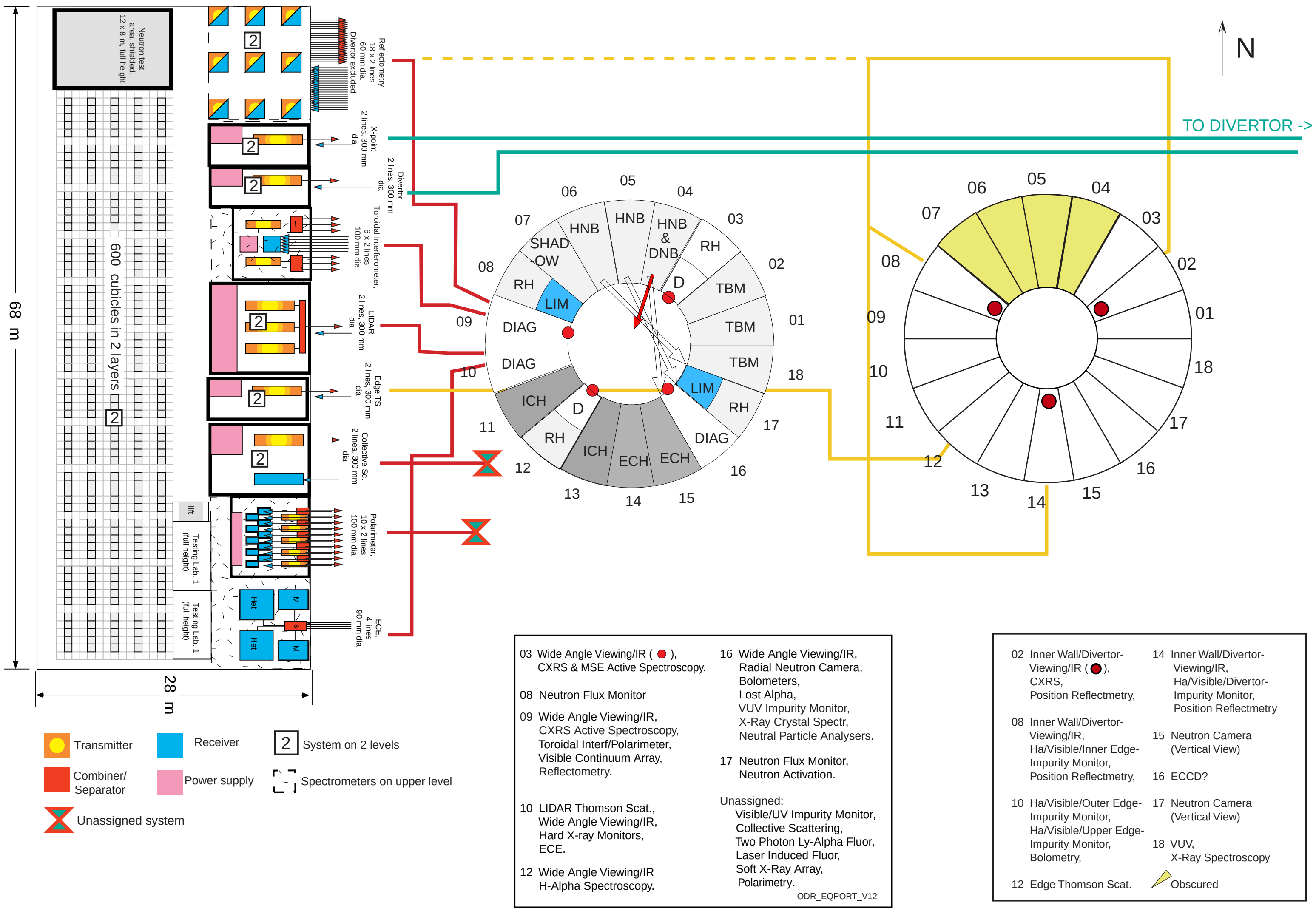
15 Visible Div. Impurity Monitor,
Bolometry, Magnetics
Pressure Gauges,

16 Bolometry, Langmuir Probes

18 VUV Impurity Monitor
Magnetics, Thermocouples
Pressure Gauges

Optical

Instrumented



Layout to diagnostic Hall (note port 11 is now a diagnostic port and houses the direct coupled systems).

Possible Changes to the Machine Design which will Affect Diagnostics (since March)

Reduction in the number of upper ports from 18 to 9

Removal of the cryostat seal plate

Reduction in the number of large ports at the divertor level from 18 to 9

A Design Review Meeting was held in Garching in October when all three points were considered.

Status of Diagnostic Design

Before procurement we need to take the diagnostic design through four phases:

Phase I   Initial Feasibility Assessment.

Determination of parameters to be measured; initial estimates of parameter ranges, s/n, space and time resolutions, accuracies; outline of system; identification of key problems of installation; and key areas of design and R&D.

Phase II   Concept/Scientific Design

Completion of the feasibility assessment; determination of the characteristics of the principal system components; estimation of the port and space requirements; determination of the design work that must be completed during the EDA; identification of the necessary R&D work; and preliminary determination of the system costs.

Phase III Engineering Design

Demonstration of engineering solutions to:

(a) the critical system components (eg first mirrors, antennas...),

(b) the transmission systems through the diagnostic ports and into the pit without causing unacceptable nuclear heating of the TF coils, and

(c) the principal interfaces with the major machine components - shield blanket modules, vacuum vessel cryostat etc;

Demonstration of feasible maintenance procedures; determination of the optimum location for the diagnostic hardware (sources, detectors...), determination of the space requirements and demonstration that suitable transmission systems can be constructed to the remotely sited diagnostic equipment; and further improvement of cost estimates.

Phase IV Integration

Integration of the different systems into the available ports, space in the pit, buildings etc.

Status of Diagnostc Design for ITER-FEAT: November 2001

ITER WBS	DIAGNOSTIC SYSTEM	Principal Party	I	II	III	IV
5.5.A	**Magnetic Diagnostics**					
5.5.A.01	Vessel Magnetics*	JCT	X	(X)	(X)	(X)
5.5.A.02	In-vessel Magnetics*	JCT	X	(X)	(X)	(X)
5.5.A.03	Divertor Coils*	JCT	X	(X)	(X)	(X)
5.5.A.04	Continuous Rogowski Coils*	JCT	X	X	(X)	(X)
5.5.A 05	Diamagnetic Loop*	JCT	X	(X)		(X)
5.5.A.06	'Halo' Current Sensors*	JCT	X	(X)		(X)
5.5.B	**Neutron Diagnostics**					
5.5.B.01	Radial Neutron Camera*	EU/JCT	X	X	(X)	(X)
5.5.B.02	Vertical Neutron Camera*	JCT	X	X	(X)	(X)
5.5.B.03	Microfis. Chambers (In-Ves.)* N/C	JA	X	X	(X)	(X)
5.5.B.04	Neutron Flux Mons (Ex-Vessel)*	RF	X	X		(X)
5.5.B.07	Gamma-Ray Spectrometers	RF	X	(X)		
5.5.B.08	Neutron Activation System	JA	X	X		(X)
5.5.B.09	Lost Alpha Detectors* N/C		(X)			
5.5.B.10	Knock-on Tail Neutron Spect. N/C		(X)			
5.5.C	**Optical/IR Systems**					
5.5.C.01	Thomson Scattering (Core)*	EU	X	X	(X)	(X)
5.5.C.02	Thomson Scattering (Edge)	EU	X	X	(X)	(X)
5.5.C.03	Thomson Scattering (X-Point)	RF	X	X	(X)	(X)
5.5.C.04	Thomson Scattering (Divertor)*	RF	X	(X)	(X)	(X)
5.5.C.05	Toroidal Interf/Polarim. System*		X	X	(X)	(X)
5.5.C.06	Polarim. Sys (Pol. Mag Field Meas.)	EU	X	(X)		(X)
5.5.C.07	Collective Scattering System N/C		(X)			
5.5.D	**Bolometric System**					
5.5.D.01	Bolom. Array For Main Plasma*	EU	X	X		(X)
5.5.D.02	Bolom. Array For Divertor*	EU	X	X		(X)
5.5.E	**Spectroscopic and NPA Systems**					
5.5.E.01	CXRS Active Spect. (based on DNB)	EU/RF	X	X		(X)
5.5.E.02	H Alpha Spectroscopy*	RF	X	X	(X)	(X)
5.5.E.03	VUV Impurity Monitor (Main Plasma)*	EU	X	X		(X)
5.5.E.04	Vis and UV Impurity Monitor (Div)*	JA	X	X	(X)	(X)
5.5.E.05	X-Ray Crystal Spectrometers*	EU/RF	X	X		(X)
5.5.E.06	Visible Continuum Array*		X	X		(X)
5.5.E.07	Soft X-Ray Array	RF	X	(X)		
5.5.E.08	Neutral Particle Analyzers*	RF	X	X	(X)	(X)
5.5.E.10	Laser Induced Fluorescence N/C	RF	X			
5.5.E.11	MSE based on Heating Beam		(X)	(X)		(X)

5.5.F	**Microwave Diagnostics**					
5.5.F.01	ECE Diagnostics for Main Plasma*	EU	X	X	(X)	(X)
5.5.F.02	Reflectometers for Main Plasma*	EU/RF	X	(X)	(X)	(X)
5.5.F.03	Reflectometers for Plasma Position		X	(X)		(X)
5.5.F.04	Reflectometers for Divertor Plasma	EU	(X)	(X)		(X)
5.5.F.05	ECA for Divertor Plasma	EU	(X)			(X)
5.5.F.06	Microwave Scatt. (Main Plasma)					
5.5.F.07	Fast Wave Reflectometry N/C					
5.5.G	**Plasma-Facing Components and Operational Diagnostics**					
5.5.G.01	IR Cameras, Visible/IR TV*	EU/RF	X	X	(X)	(X)
5.5.G.02	Thermocouples*	JCT	X			(X)
5.5.G.03	Pressure Gauges*	EU	X	X		(X)
5.5.G.04	Residual Gas Analyzers*		X	X		
5.5.G.06	IR Thermography Divertor*	EU	X	(X)		(X)
5.5.G.07	Langmuir Probes*	JCT	X	X	(X)	(X)
5.5.H	**Diagnostic Neutral Beam**	JCT/RF	X	X	(X)	(X)

Key

X phase completed
(X) phase in progress

* Start-up diagnostic

N/C Diagnostic which is based on a technique which is not yet established on existing tokamaks but which is under development.

Outstanding Issues Requiring R&D

There are many topics requiring R&D, key topics are:

- RIEMF
- Measurement of steady-state magnetic fields
- Deposition on mirrors
- Requirement for radiation hard bolometers and soft X-ray detectors
- Measurements in the divertor
- Measurements of confined and escaping alpha particles

A comprehensive list has been developed

Assessment of Measurement Capability (November 2001)

GROUP 1a Measurements For Machine Protection and Basic Control	GROUP 1b Measurements for Advanced Control	GROUP 2 Additional Measurements for Performance Eval. and Physics
Plasma shape and position, separatrix- wall gaps, gap between separatrixes Plasma current, q(a), q(95%) Loop voltage Fusion power $\beta_N = \beta_{tor}(aB/I)$ Line-averaged electron density Impurity and D,T influx (divertor, & main plasma) Surface temp. (div. & upper plates) Surface temperature (first wall) Runaway electrons 'Halo' currents Radiated power (main pla, X-pt & div). Divertor detachment indicator (J_{sat}, n_e, T_e at divertor plate) Disruption precursors (locked modes,m=2) H/L mode indicator Z_{eff} (line-averaged) n_T/n_D in plasma core ELMs Gas pressure (divertor & duct) Gas composition (divertor & duct)	Neutron and α-source profile Helium density profile (core) Plasma rot. (tor and pol) Current density profile (q-profile) Electron temperature profile (core) Electron den profile (core and edge) Ion temperature profile (core) Radiation power profile (core, X-point & divertor) Z_{eff} profile Helium density (divertor) Heat deposition profile (divertor) Ionization front position in divertor Impurity density profiles Neutral density between plasma and first wall n_e of divertor plasma T_e of divertor plasma Alpha-particle loss Low m/n MHD activity Sawteeth Net erosion (divertor plate) Neutron fluence	Confined α-particles TAE Modes, fishbones T_e profile (edge) n_e, T_e profiles (X-point) T_i in divertor Plasma flow (divertor) $n_T/n_D/n_H$ (edge) $n_T/n_D/n_H$ (divertor) T_e fluctuations n_e fluctuations Radial electric field and field fluctuations Edge turbulence MHD activity in plasma core

Expect to meet meas. reqs; maybe/mabe not; expect not to meet meas reqs.

Key Point on Resources and Timing

If ITER keeps to the planned time schedule, the diagnostic designs have to be completed in about 3 to 7 years.

Before that we have to get to the point where we know that there are no show stoppers and solutions will be found to all the outstanding issues.

To get to this point a substantial effort in both manpower (PPY) and R&D resources (IUA) are required at this time.

Procurement will commence in about 4 years.

Diagnostic Work during the CTA: Proposed Division of Activities and Responsibilities between the IT and the PTs

Function	Key Specific Tasks	IT responsibilities and activities	PT responsibilities and activities
Determination of measurement requirements	Requirements for measurements of • q(r) • divertor plasma params • plate erosion • dust	Determined in combined work with PT especially ITPA Diagnostics Group.	Background work on measurement specifications. ITPA advises IT on detailed requirements.
Technique choice and validation	Preferred technique for • q(r) measurement • confined alphas • escaping alphas • erosion and dust	Possible techniques reviewed in combined work with PT especially ITPA Diagnostic Group.	Development of relevant measurement techniques. Through ITPA Group, advises IT on choice of techniques.
R&D • **Radiation effects** • **Diagnostic Comps** • **Diagnostic Techns**	See separate sheets.	Specification and assessment of required studies. Dissemination of results to system designers.	Undertaking of required R&D including 'volunatry' work driven by the ITPA
Design of Some Critical System Components	For example: • typical first mirrors • retroreflectors • divertor optics	Specification and assessment of required design and possibly outline design	Undertaking of required design at the detailed level (including analysis)

Function	**Key Specific Tasks**	**IT responsibilities and activities**	**PT responsibilities and activities**
System designs and interfaces	For example: • magnetics • installation of retroreflectors • in-vessel waveguide	Design of systems which have a high degree of interface with the machine, eg magnetics. Design of interfaces of other systms.	Support of IT work.
System designs	For example: • Divertor Thomson scattering • Collective Scattering • Erosion measurement	Specification and assessment of required design	Undertaking of required design at appropriate level (including performance analysis where necessary) Reviewed by the ITPA
Integration	Integration of systems into the available ports, VV and divertor to meet required measurement capability.	Carry out integration. Specification of supporting studies, eg neutronic studies	Support of IT work and performance of necessary studies
Port Engineering	Design of ports and in-port structures including installation and maintenance procedures	Performance of design at the conceptual/feasibility level	Detail design at the appropriate level (including performance analysis where necessary)
Construction Schedule, Costing, Procurement Packages, DDDs	Revision and further development according to project needs	Specification, integration and preparation of high level project documentation.	Peformance of tasks and documentation at the detailed level

Concluding Remarks

Based on the extensive work done for the ITER98 the diagnostic designs for ITER-FEAT have been developed.

In terms of the available space, access and budget for diagnostics the situation in broad terms is at least as good and in many cases better than it was for the ITER98. The documentation and costing are also more complete although lack depth in some areas.

Many design and R&D issues remain and must be the focus of the next phase of the work. The CTA has commenced and will be the instrument to carry out this work.

Although it is several years before ITER goes to construction the work to do is substantial and enhanced effort is now required.

The support, contribution and drive of the ITPA group are essential.