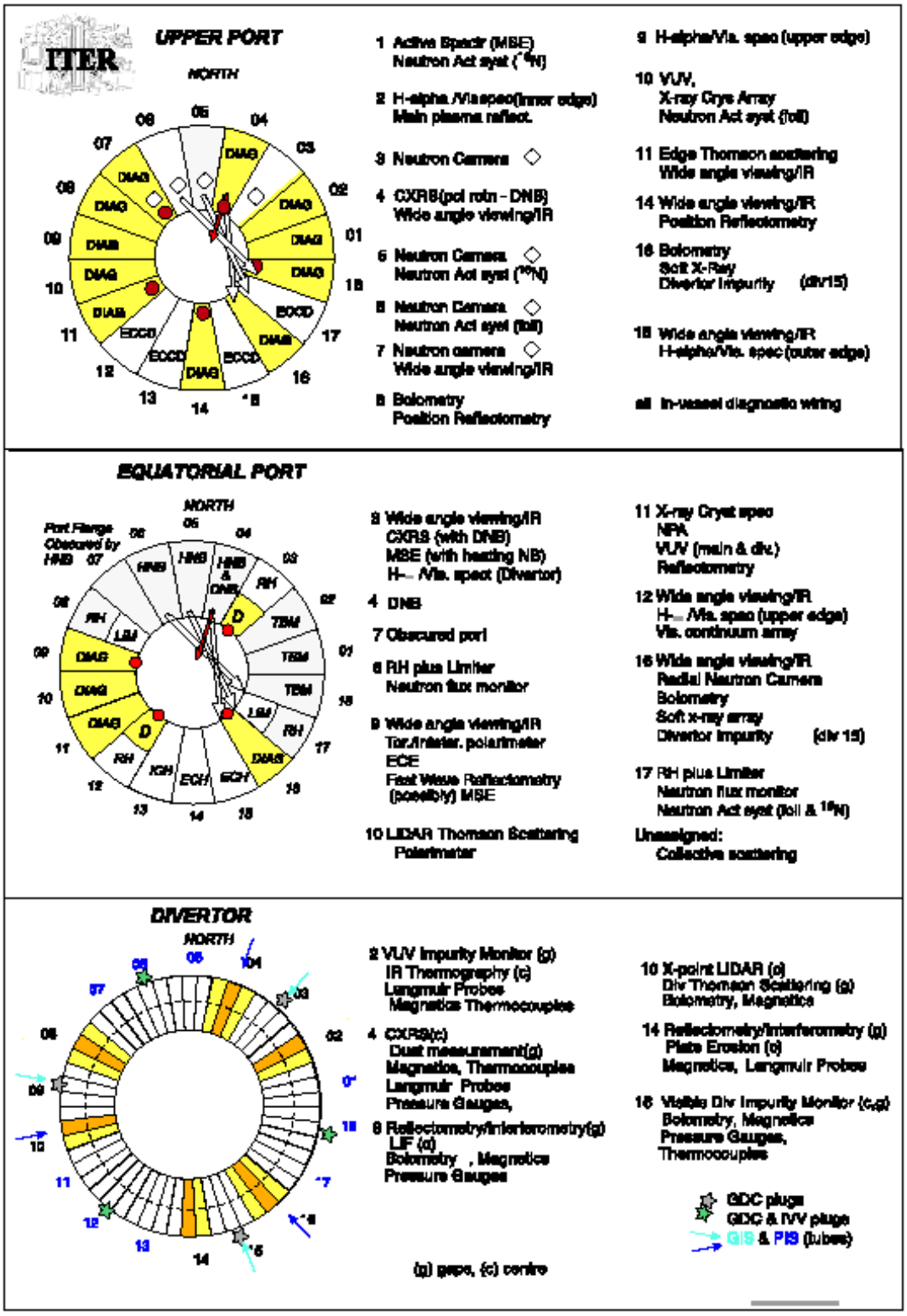
Diagnostics for Transport Studies in ITER

- **ITER Diagnostics are required to provide measurements for:**
  - machine protection and basic control
  - advanced control and performance optimization
  - performance evaluation and physics understanding

- **A comprehensive definition of measurement requirements and a matching set of diagnostic techniques has been developed in collaboration with the international physics community to meet these requirements**

Current Diagnostic Distribution in ITER



D J Campbell, EFDA CSU, Garching

Requirements for T_e

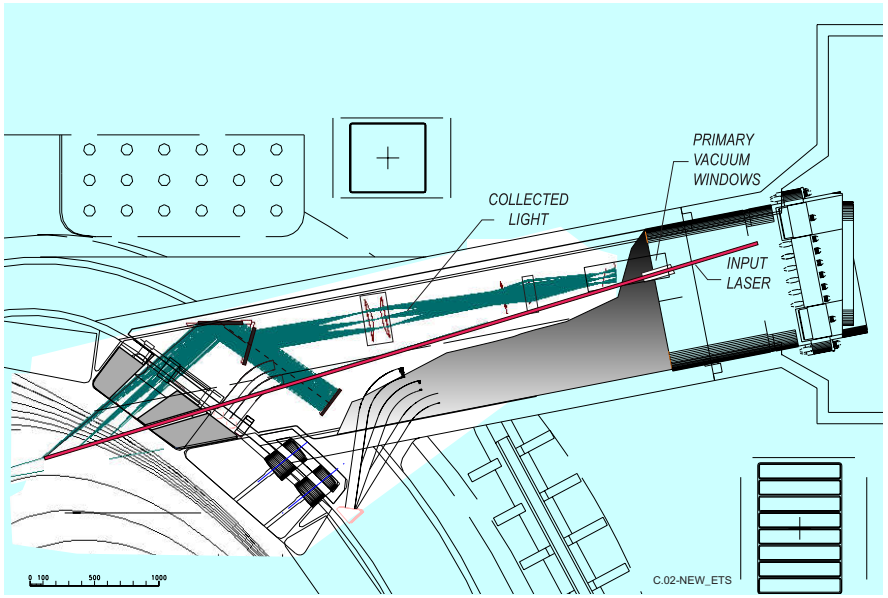
An example of the measurement specification for one parameter:

Operating Scenario	Requirements for T_e-measurement				
	Range	Bandwidth	Spatial Resol.	Temporal Resol.	Accuracy
H phase. Inductive Limited ELMY H Mode	r/a $\leq$ 0.9 r/a > 0.9 Div	0.5-30 keV 0.05-10 keV 0.3-200 eV	a/20 5 cm 5 cm	10 ms 10 ms 10 ms	10% 10% 20%
D/T phase. Inductive ELMY H Mode	r/a $\leq$ 0.9 r/a > 0.9 Div	0.5-30 keV 0.05-10 keV 0.3-200 eV	a/20 1 cm 0.6 cm	10 ms 10 ms 1 ms	10% 10% 20%
D/T Phase. Inductive ELMY H mode. High β	r/a $\leq$ 0.9 r/a > 0.9 Div	0.5-30 keV 0.05-10 keV 0.3-200 eV	a/30 0.5 cm 0.3 cm	10 ms 10 ms 1 ms	10% 10% 20%
Hybrid operation and steady state operation	r/a $\leq$ 0.9 r/a > 0.9 Div	0.5-30 keV 0.05-10 keV 0.3-200 eV	a/30 0.5 cm 0.3 cm	10 ms 10 ms 1 ms	10% 10% 20%

Diagnostics for Core T_e

Diagnostic	Δr	Δt
Core Thomson Scattering	10cm 20cm	10Hz 100Hz
Edge Thomson Scattering	5mm	100Hz
Electron Cyclotron Emission (Edge)	7-15cm 2-7cm	1μs-10ms 1μs-10ms

- **Design analysis of core electron temperature diagnostics indicates that many of measurement requirements can be met**



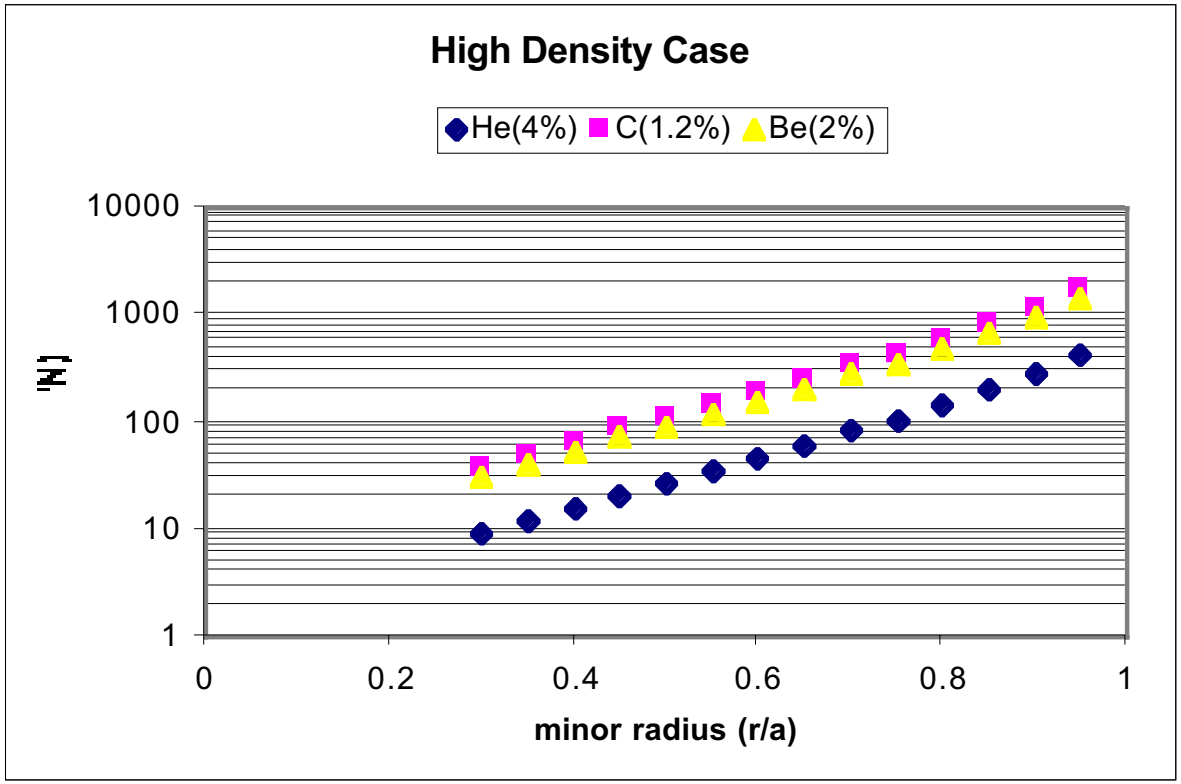
Investigation of MSE for ITER

- **Spectroscopy method is proposed by M von Hellermann et al using DNB as a complement to CXRS diagnostic**

- **Polarimetry method using HNB is proposed by Ph Lotte et al**
  ⇒ continuation of the work done by F Levinton from US Home Team for the previous ITER

- **Each method will have its own (dis)advantages.**
  ⇒ The two methods are complementary and might have to be installed on ITER

CXRS Studies of Light Impurities



- **Measurements of He, C and Be impurity concentration appears possible for r/a≥0.3 (100keV N-NBI, 1.5MW, 20Hz modulation, Δt=0.5s)**

Assessment of Measurement Capability

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

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