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The I&C system of the FRM-II

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SIEMENS got the approval for the erection of a modern digital processor based I&C system for the research reactor FRM-II in October 97.
In this presentation firstly the system architecture and the main features will be outlined roughly. The modular structured I&C system described in the licensing documentation consist of

- the operational I&C system (out of many different possible systems we decided to use the TELEPERM XP system for the FRM-II)
- the new developed I&C system for safety related applications TELEPERM XS (reactor protection and limitation, safety.related interlocks, class 1 annunciation's)
- the neutron flux density measuring system (a combination of SINUPERM N power channels and Campbell wide range channels)
- the radiation and activity monitoring system (SINUPERM M)
- the accident instrumentation (conventional analogue technic allocated in the main control room and the emergency control room)

and the decentralised subsystems like

- the fire protection system
- the communication systems
- the access control and physical protection systems
- the I&C of the ventilation systems and
- the I&C for experiments like cold source, hot source, neutron converter system, silicon doping system.

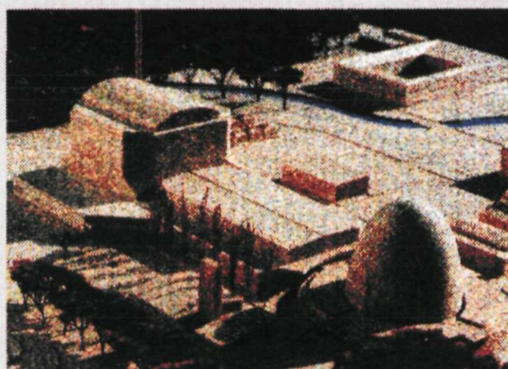
Secondly the diversity- and redundancy- structure of the reactor protection system (two separated reactor protection subsystems -each of them is working of 2 out of 3 principle) depend of the process requirements (failure mode analyses) will be illustrated.

Last but not least the location of the main detection channels in the primary loop and the reactor pool (neutron flux density power range detectors (PR) and wide range detectors (WRC), Gamma dose rate detectors and conventional measures like temperature, pressure, mass flow) will be explained.

Figure 1

The I&C system of the Research reactor FRM-II

owner: Munich university
reactor type: research reactor
thermal power: 20 MW
electrical power: ----
cycle: 52 full power days
commissioning: 2001



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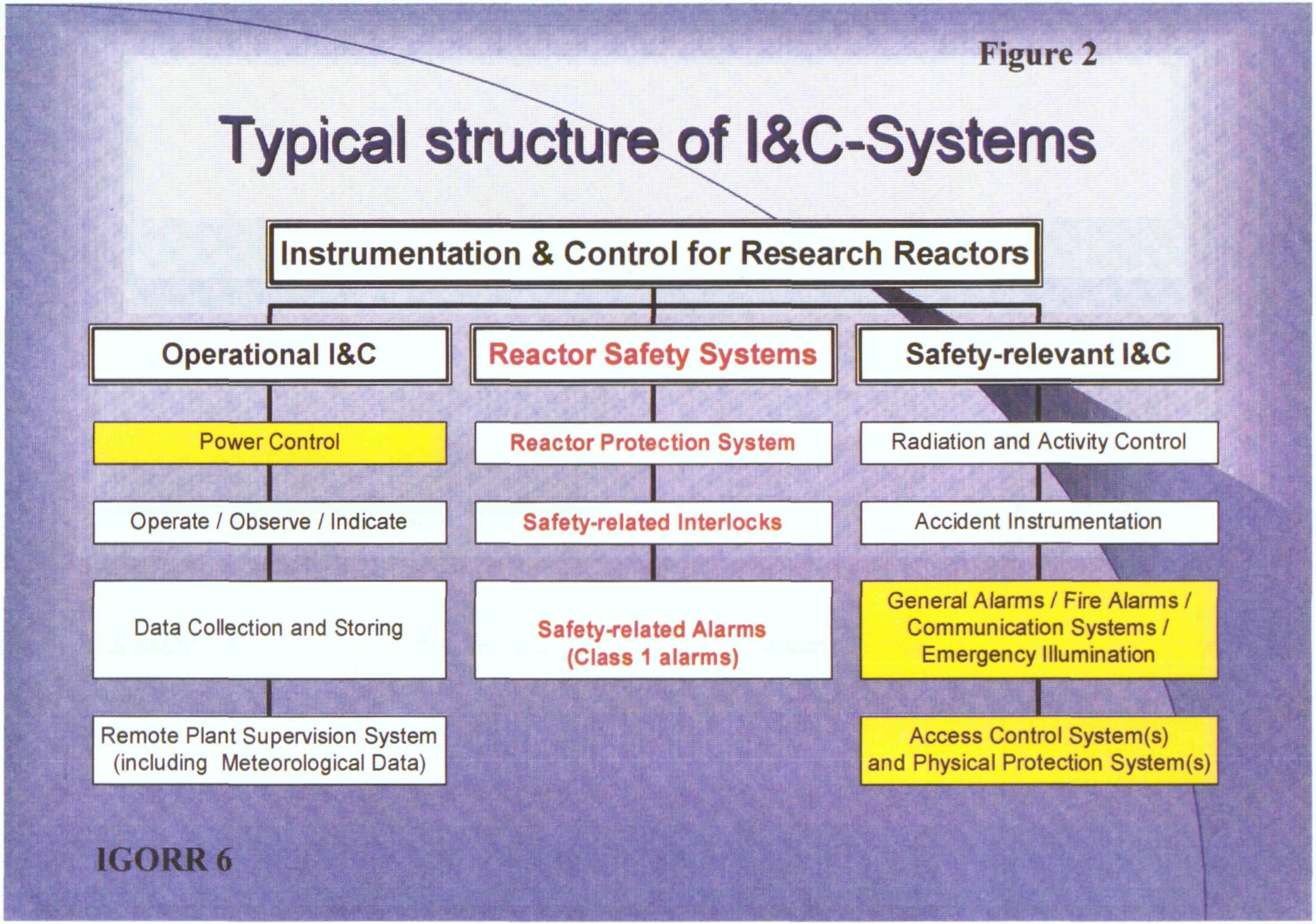
Figure 2
Typical structure of I&C-Systems
Instrumentation & Control for Research Reactors
Operational I&C
Reactor Safety Systems
Safety-relevant I&C
Power Control
Reactor Protection System
Radiation and Activity Control
Operate / Observe / Indicate
Safety-related Interlocks
Accident Instrumentation
Data Collection and Storing
Safety-related Alarms (Class 1 alarms)
General Alarms / Fire Alarms / Communication Systems / Emergency Illumination
Remote Plant Supervision System (including Meteorological Data)
Access Control System(s) and Physical Protection System(s)
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Figure 3

Research reactor FRM-II
System architecture

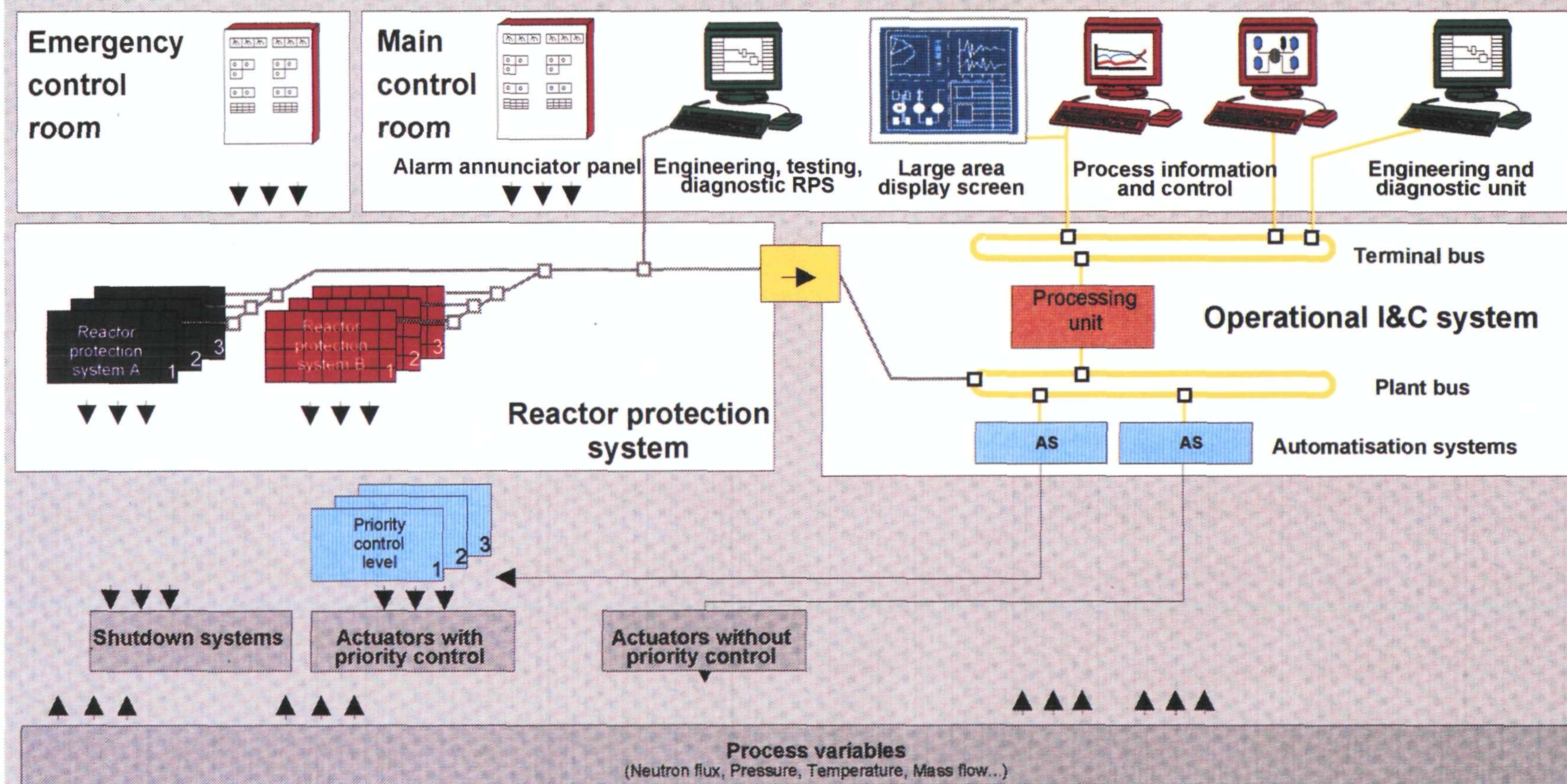

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Figure 4

Main components of the operational I&C system FRM-II

Number of I&C cabinets	10
Monitors in Operation desk and control room panel	9
Large-area display screen (2m x 1m)	1
Four channel recorders in at conventional control room panel	6
Coupling modules for analog/binary -input and -output	200
Drives (motors, closed-loop-control, actuators)	140
Binary signal inputs (without drives)	700
Binary signal outputs	150
Analog inputs	600
Analog outputs	60
Plant displays selectabel on all monitors	120
Short-term archive (internal RAM for approx. 400.000 events)	2
Long-term archive (magneto-optical disk approx. 6 weeks per disk)	2

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Figure 5

Failure modes and actuating parameters of the Reactor safety system FRM-II (Part 1)

Actuating parameter	Limit		Logik	Incident: Startup disturbance by control-rod malfunction	Control-rod malfunction during power operation	Faulty fast control-rod insertion	Faulty fast shutdown-rod insertion	Faulty moving of one shutdown-rod
Neutron flux density Startup range (WRC)	<min1	startup interlock circuit	1of3					
Neutron flux density Startup range (WRC)	>max1	startup interlock circuit	2of3					
Neutron flux density Startup range (WRC)	>max3	startup interlock circuit	2of3					
Neutron flux density midle range (WRC)	<min2	startup interlock circuit	2of3					
Neutron flux density midle range (WRC)	>max2	startup interlock circuit	2of3	B				
Neutron flux density power range (NF)	<min1	startup interlock circuit	2of3					
Period of the WRC-signal (log)	<max1	Power operation	2of3	B	B			B
N^{16}_{corr} (activity power range NF corrected)	>max1	Power operation	2of3		A			
Positive gradient N^{16}_{corr}	>max2	Power operation	2of3	A	A			A
Negative gradient N^{16}_{corr}	<min1	Power operation	2of3			A	A	
Difference NF - N^{16}	>max1	Power operation	2of3	B	B			B
Safety actions								
Reactor scram				x	x	x	x	x
Start of the emergency cooling system				x	x	x	x	x
Closing of air isolation flaps of the reactor hall and starting emergency air filtering and vacuum systems								

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Failure modes and actuating parameters of the Reactor safety system FRM-II (Part 2)

Actuating parameter	Limit		Logik	Outage of one primary loop pump	Outage of all four primary loop pumps (emergency power supply)	Loss of the secondary heat sink	Loss of primary coolant	Leakage of the moderator tank (in- or outwards)	Leaking fuel element during reactor operation	Loss of the moderator cooling	outage of the neutron converting fuel plate cooling system
γ-dose rate primary loop	<max1	Power operation	2of3						A		
γ-dose above the reactor pool	>max1	Power operation	2of3						B		
Differential pressure fuel inlet-pool	<min1	Power operation	2of3	A	A						
Temperature heat exchanger outlet	>max1	Power operation	2x2of3			B					
Temperature fuel outlet	>max2	Power operation	2of3		A	A					
Temperature moderator	>max1	Power operation	2of3							A	
Water level reactor pool	>max1	Power operation	2of3				A				
Heavy water level moderator tank	<min1	Power operation	2of3					A			
Heavy water level moderator tank	>max1	Power operation	2of3					A			
Mass flow rate primary loop	<min1	Power operation	2x2of3	B	B						
Mass flow rate outlet converter plate	>max1	Power operation	2of3								A
Safety actions											
Reactor scram				x	x	x	x	x	x	x	x
Start of the emergency cooling system				x	x	x	x	x	x	x	x
Closing of air isolation flaps of the reactor hall and starting emergency air filtering and vacuum systems									x		

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Radial Position of the Neutron Detectors FRM-II

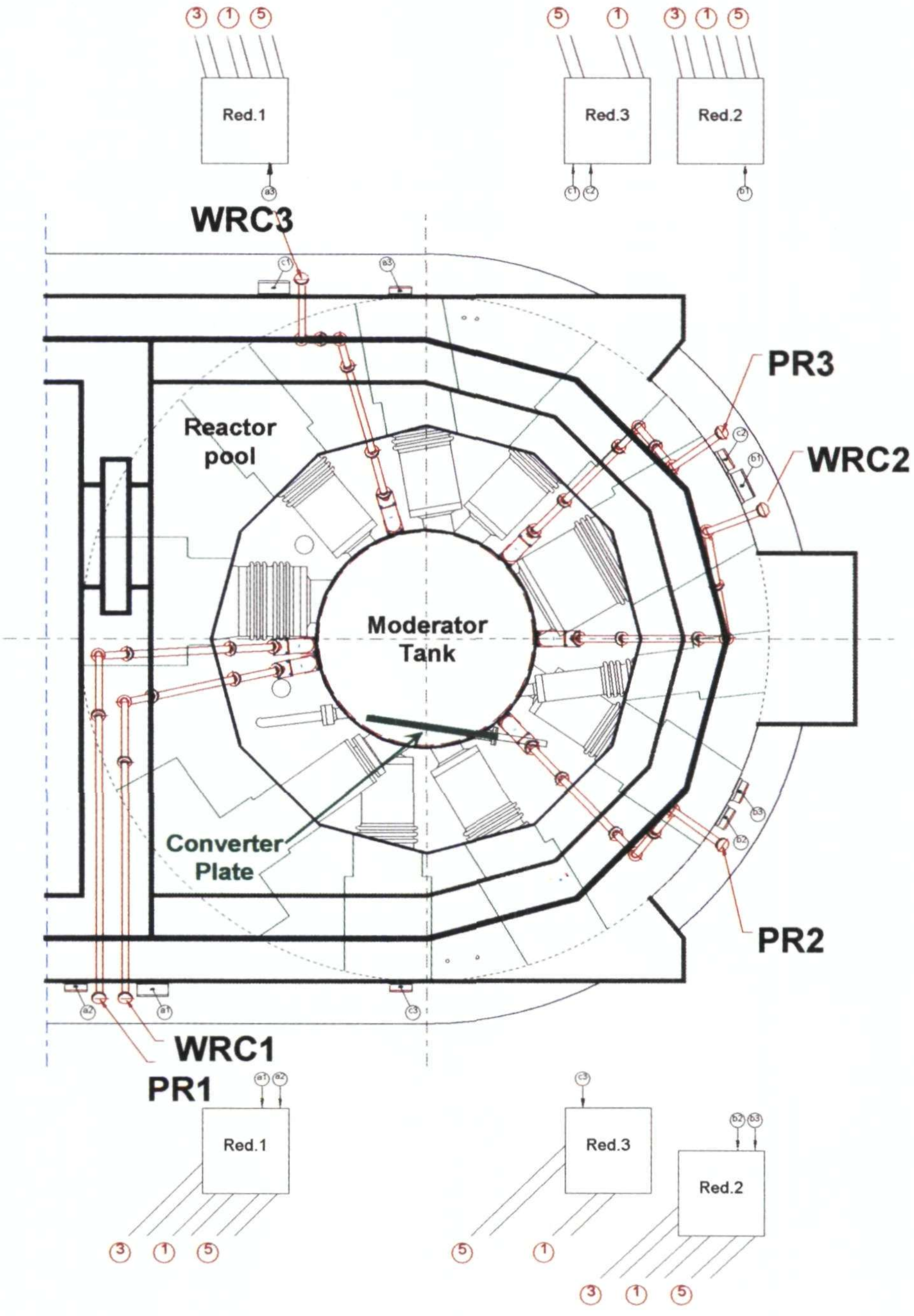

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Figure 8

Axial Position of the Neutron Detectors FRM-II

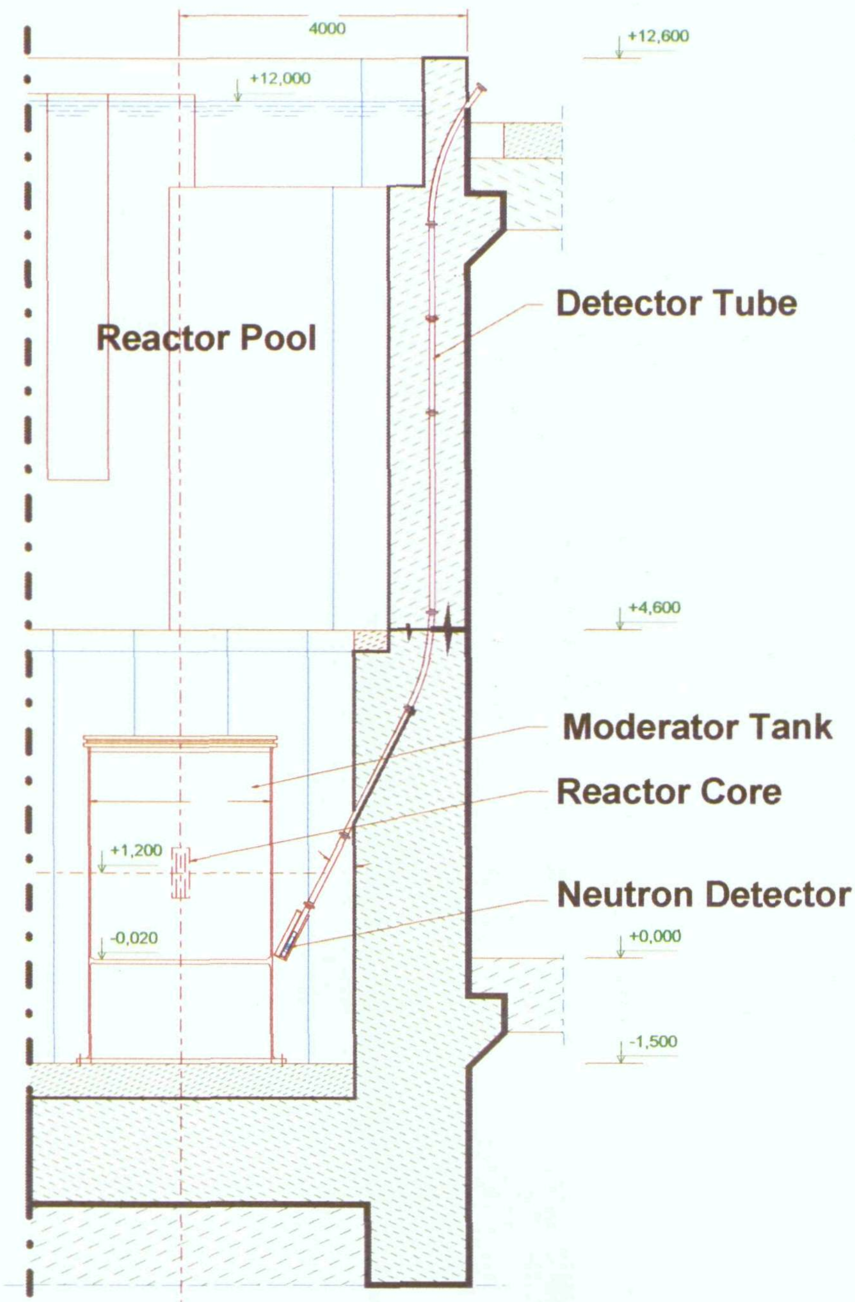

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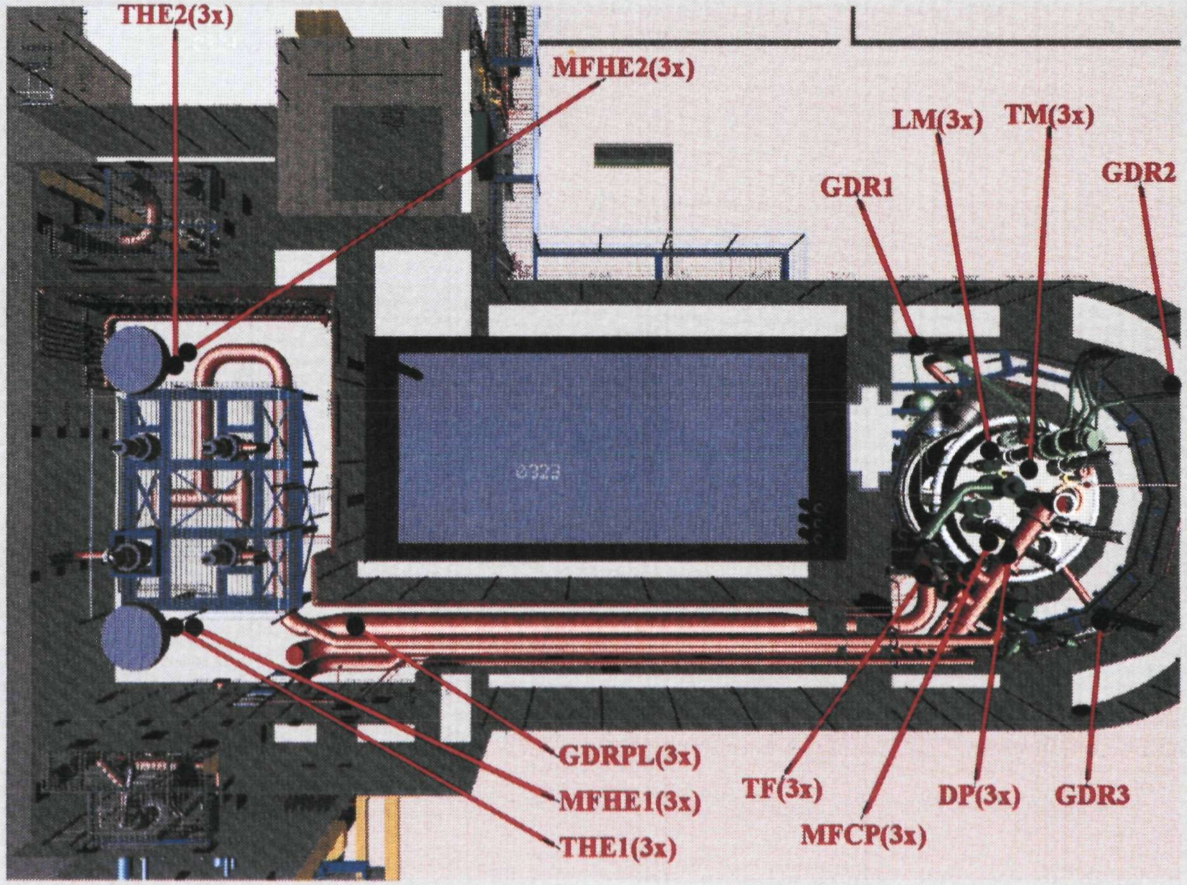
Figure 9

Location of RPS measuring channels



GDR1-3	Gamma dose rate above reactor pool
GDRPL	Gamma dose rate primary loop
THE1(2)	Temperature heat exchanger 1 (2) outlet
MFHE1(2)	Mass flow rate heat exchanger 1(2) outlet
TF	Temperature fuel outlet
DP	Differential pressure between pool and fuel inlet
LM	Level heavy water in the moderator tank
TM	Temperature heavy water
MFCP	Mass flow rate converter plate outlet

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