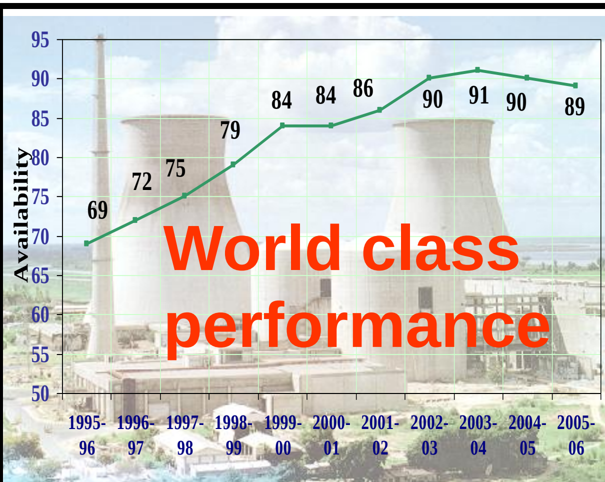
Fifteen Years of Operating Experience of KAMINI Reactor

P.N.Manoharan, K.V.Suresh Kumar, G.Srinivasan
Reactor Operation and Maintenance Group,
Indira Gandhi Centre for Atomic Research, Kalpakkam, India

Three Stage Nuclear Power Programme



Stage – I PHWRs

- 14 - Operating
- 4 - Under construction
- Several others planned
- Scaling to 700 MWe
- Gestation period has been reduced
- POWER POTENTIAL ≅ 10,000 MWe

LWRs

- 2 BWRs Operating
- 2 VVERs under construction

Stage - II
Fast Breeder Reactors

- 40 MWth FBTR - Operating since 1985 Technology Objectives realised
- 500 MWe PFBR- Under Construction
- POWER POTENTIAL ≅ 530,000 MWe

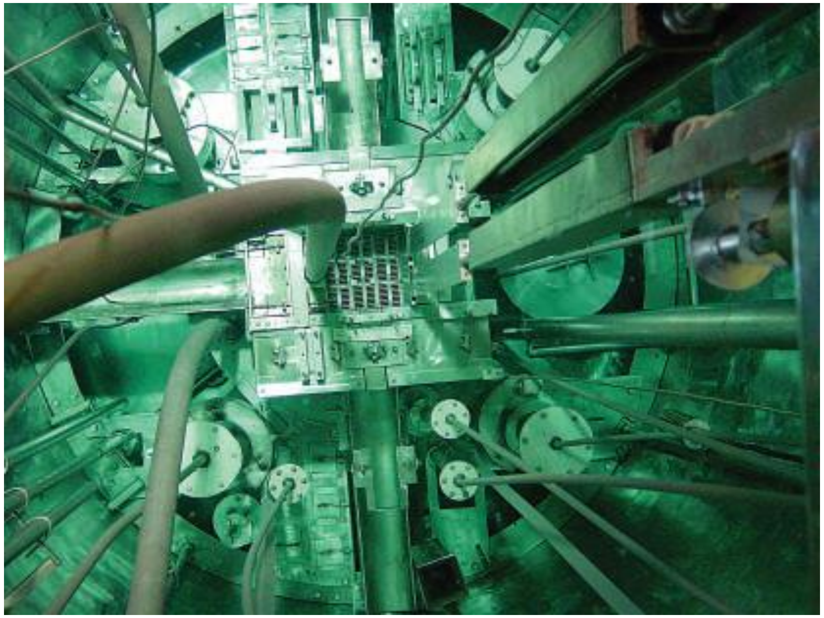
Stage - III
Thorium Based Reactors

- 30 kWth KAMINI- Operating
- 300 MWe AHWR- Under Development

POWER POTENTIAL IS VERY LARGE

Availability of ADS can enable Early introduction of Thorium on a large scale

KAMINI (Kalpakkam Mini reactor) is a Uranium-233 fueled, Globally Unique (30 kW) research reactor Operating in Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam,INDIA



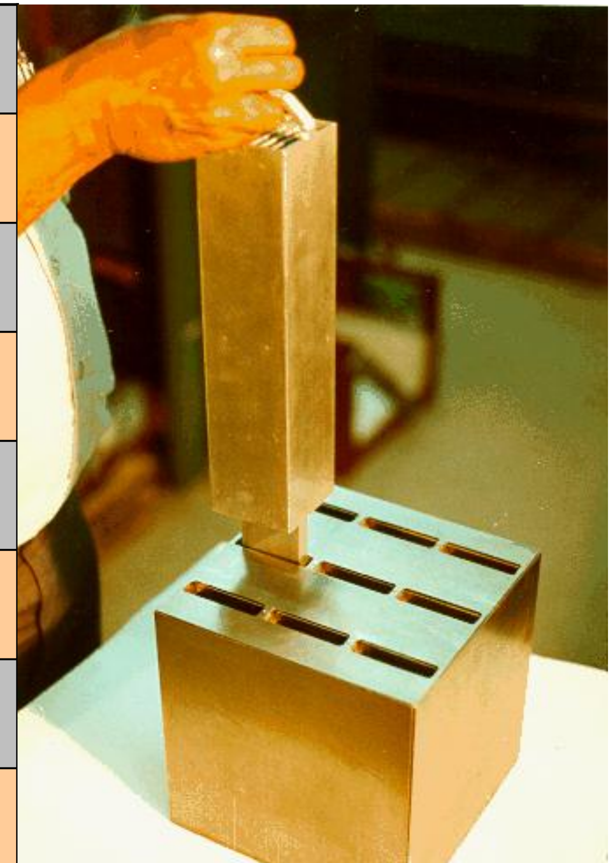
- **This reactor functions as a neutron source with a flux of 1.0 E 12 neutrons.cm-2.sec-1 at core centre facilitates carrying out**
- **neutron radiography of radioactive and non-radioactive objects**
- **neutron activation analysis.**
- **Shielding Physics studies**

Reactor Specifications

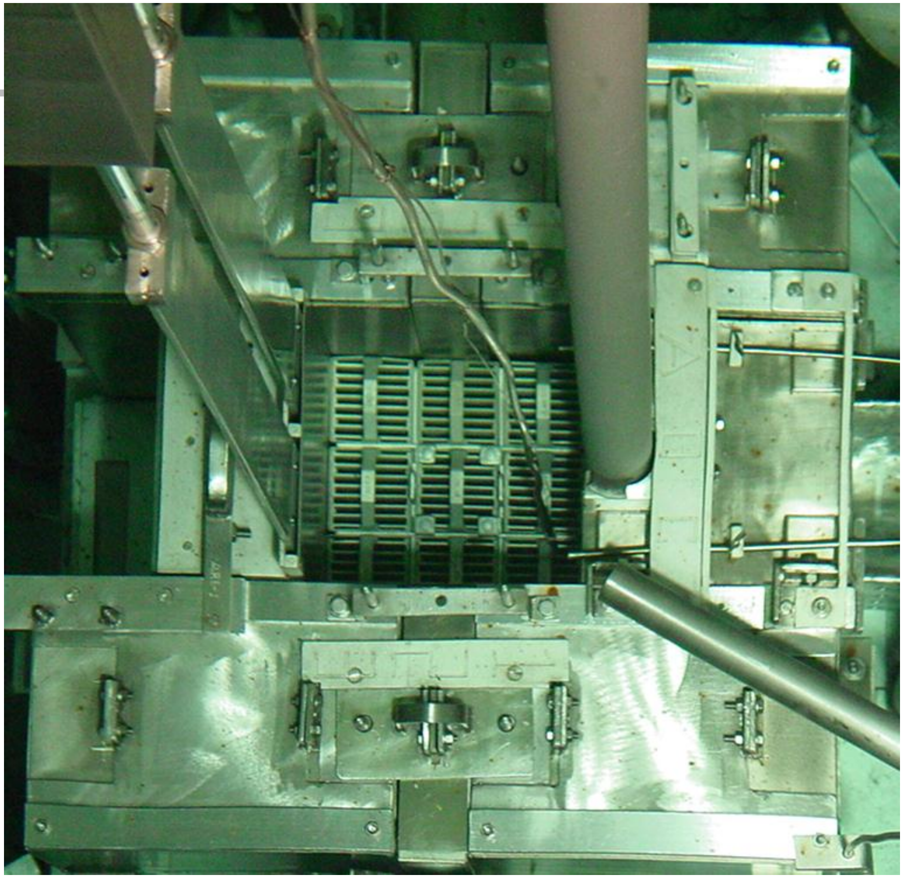
Nature of reactor system	*Tank type*
Nominal power	30kW
Fuel	U 233 (20 Wt %)-Al alloy
Number of fuel per subassemblies	9
Number of fuel plates per subassembly	8
Reflector material	200 mm thick BeO encased in Zircaloy
Moderator/ Coolant/Shield material	Demineralized water
Core cooling mode	By natural convention
Absorber	Cadmium
Beam tubes	3
Flux at outer end of beam tube	10^{6} to 10^{7} n cm-^{2} s-1
Flux at irradiation sites	10^{11} to 10^{12} n cm-^{2} s-1
Core flux	10^{12} n cm-2 s-1

KAMINI fuel subassembly (SA) specification

Fuel Material	Al-20 wt.% U alloy
Fuel Material Al-20 wt.%	U alloy
Fuel meat dimensions (mm)	1 x 55 x 250
Al clad thickness	0.5 mm
Fuel plate dimensions (mm)	2 x 62 x 260
Nominal water gap between plates	6
Number of fuel plates per	8
Fuel subassembly outer dimensions (mm)	66 x 66 x 275
Nominal weight of uranium per plate (g)	8.5
Nominal weight of uranium per SA (g)	68
Number of fuel SAs in core	9



Fuel performance

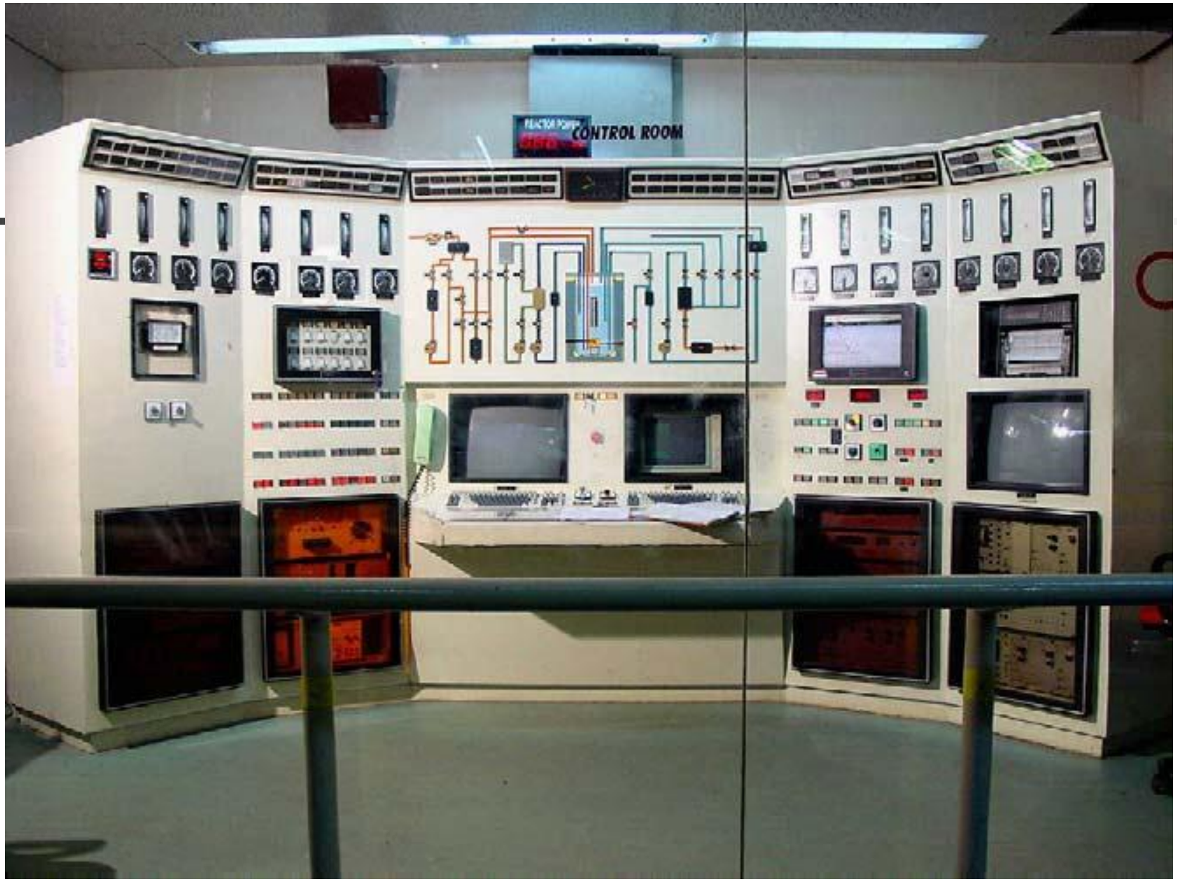


- Operation experience has indicated that the low delayed neutron fraction of the fuel does not pose any problem for smooth power control.

- The xenon evolution is lower compared to U-235 based fuel resulting in no post-shutdown build up of xenon though the flux level is 5.3×1.0 E12 n.cm-2.s-1.

- This is because, I-135 yield which is precursor to Xe-135 is 4.9% for U-233 fission which is less compared to 6.2% for U-235 fission.

Instrumentation and control system



All essential operations such as start up of reactor, shutdown and power control etc are done from the control Room. The control panels are provided with emergency power supply from the diesel generators Battery backup is provided for important Indications in the control room required for ascertaining safe shutdown after power failure

Reactor system performance

Performance of instrumentation and control systems is satisfactory. To prevent neutron detector failure due to moisture ingress, mineral insulated cables were replaced by moisture resistant polyethylene cables. Noise pickup problems were solved by replacing electronic components and rerouting of cables.

Spurious trips on log *P* from one of the redundant neutronic channels due to fleeting loose contact in the relay base were eliminated by providing clamps to secure the relay to its base to ensure tight contact

Research Facilities in KAMINI

Neutron Radiographic Facilities

To qualify critical components' of Nuclear, Space ,Core Sectors
(Over 10,000 components' Have been inspected)

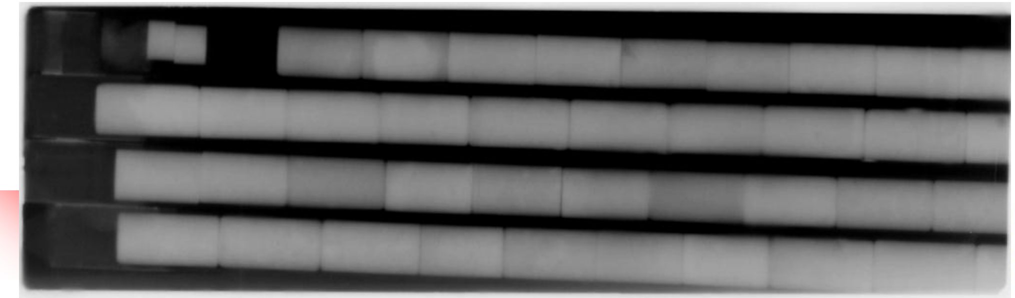
Neutron Activation Analysis

Analysis of geological samples like ores, rocks and chemical samples from the forensic laboratories and standardisation of neptunium (Np-237) development

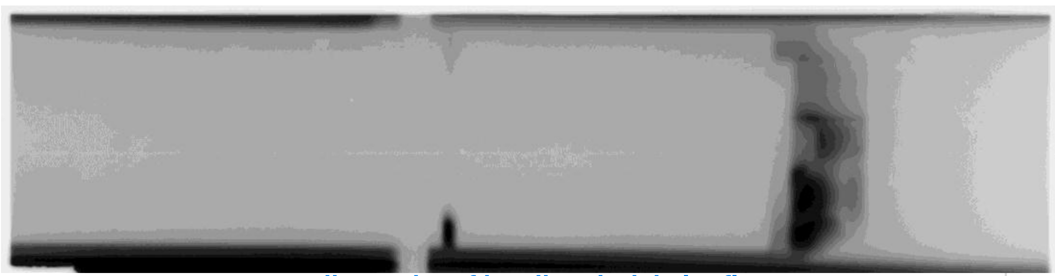
Shielding Experiments

Shield material evaluation, neutron and gamma streaming and Testing & calibration of detectors

Neutron Radiography of Nuclear Components

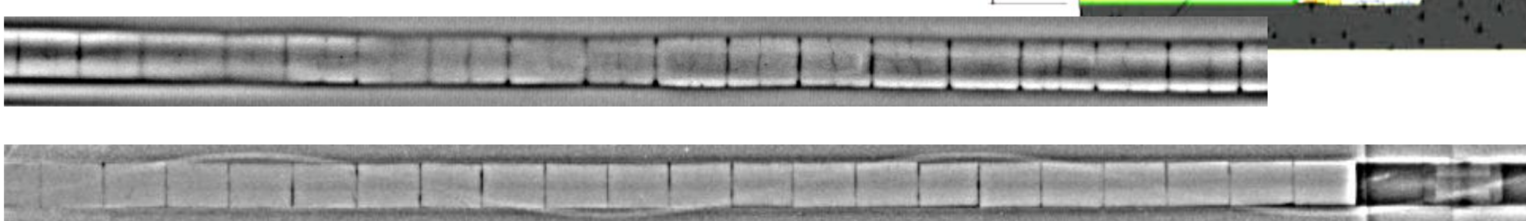


Neutron radiograph of lithium aluminate

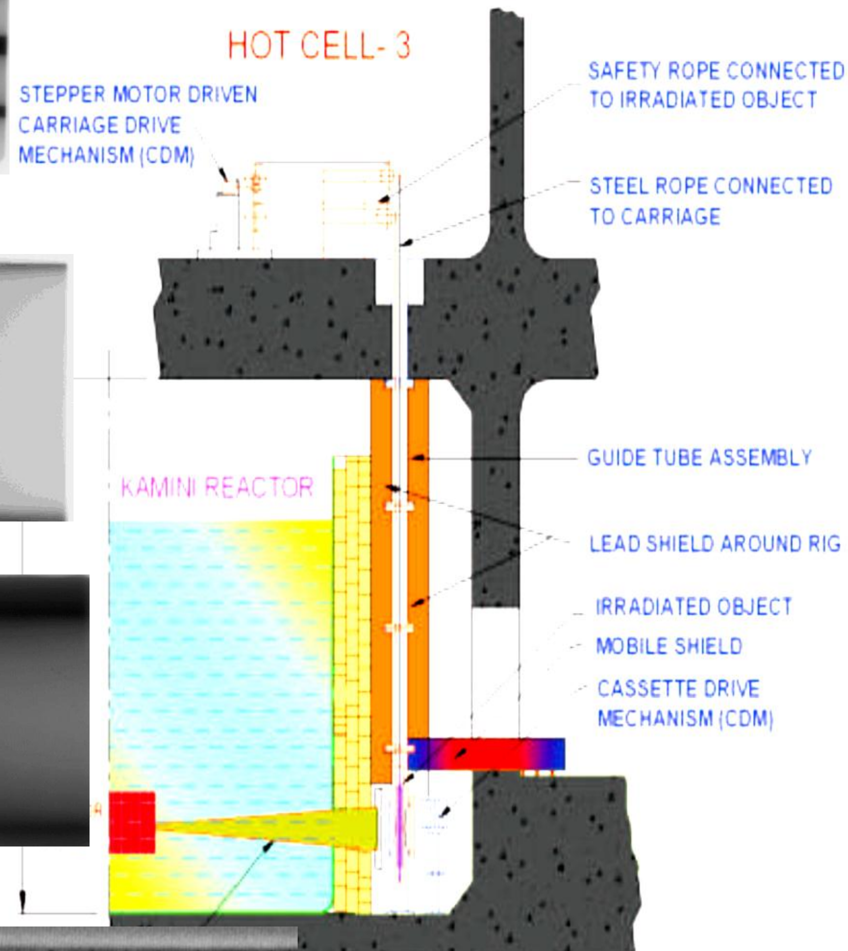


Neutron radiography of irradiated Nickel reflectors

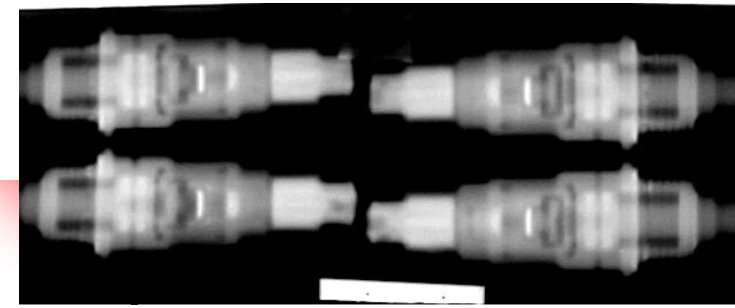
Neutron radiography of irradiated FBTR Control rod

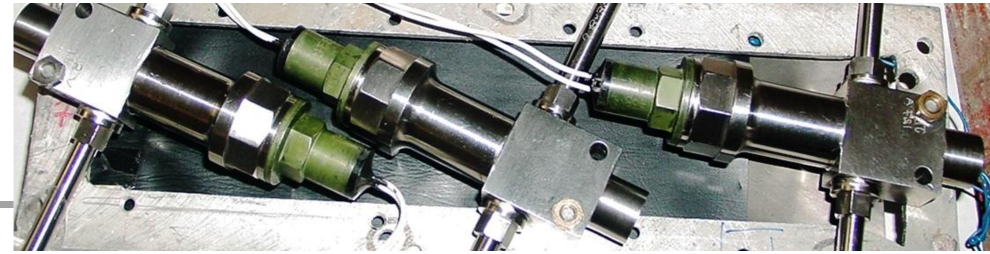


Neutron radiography of irradiated MOX Fuel Pin

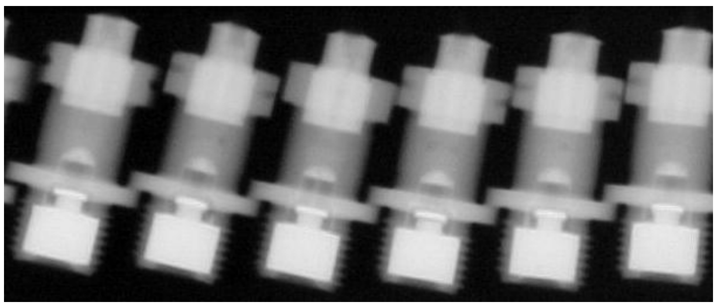


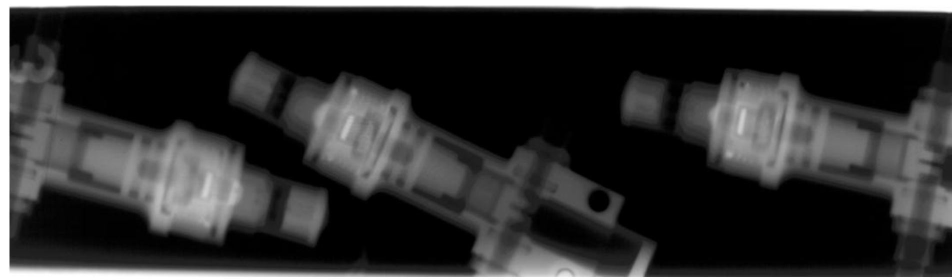
Neutron Radiography of Space Components





Dual Pyro Valve





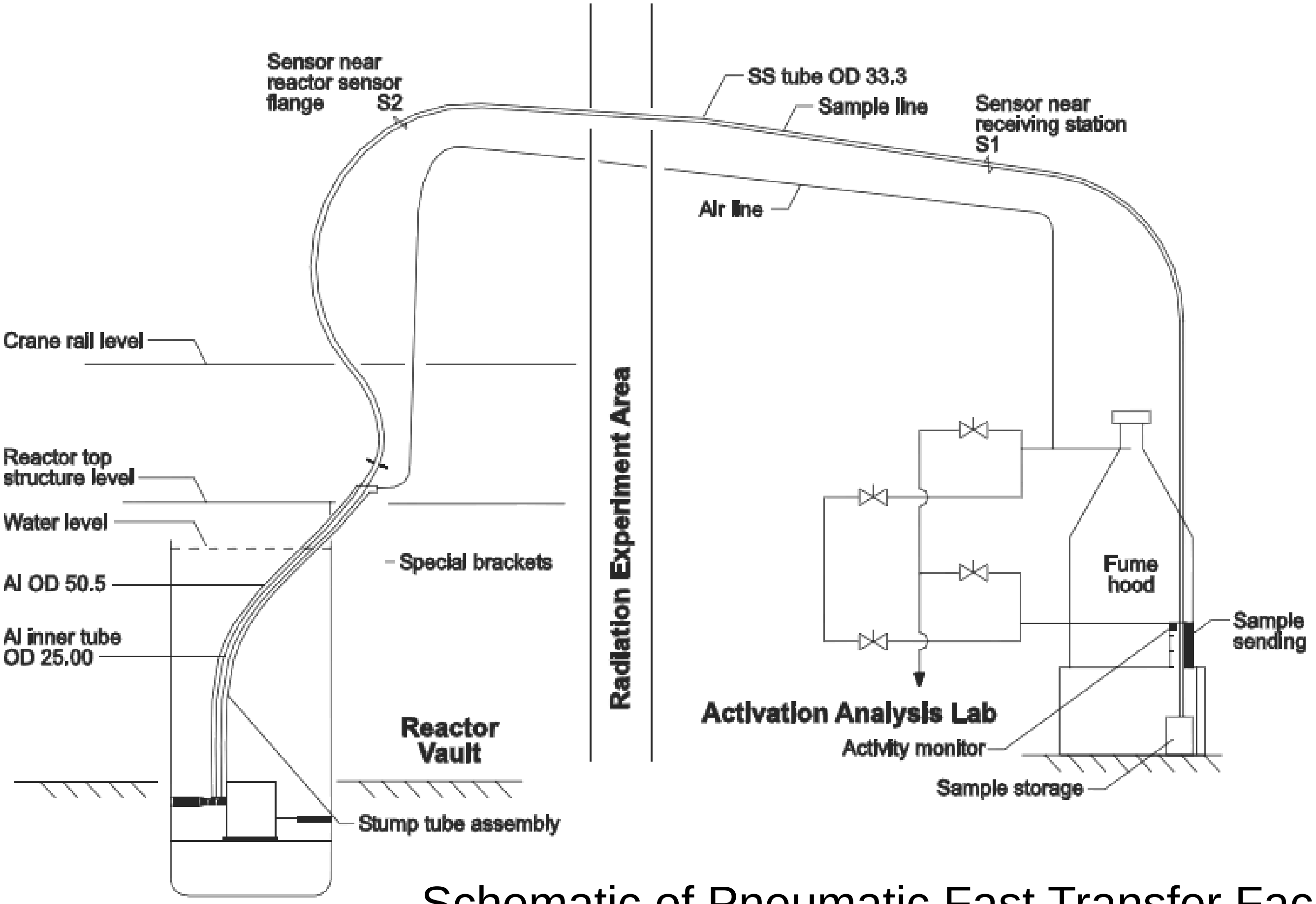
Satellite Pyro valve

Cartridge 600

Detonating Cartridge

Chandrayaan mission critical devices were successfully inspected at Kamini

Irradiation Facilities for Neutron Activation Analysis



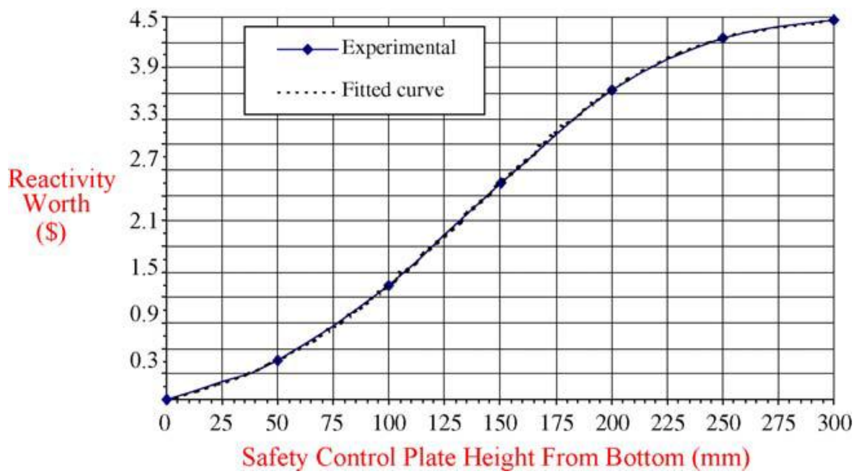
Schematic of Pneumatic Fast Transfer Facility

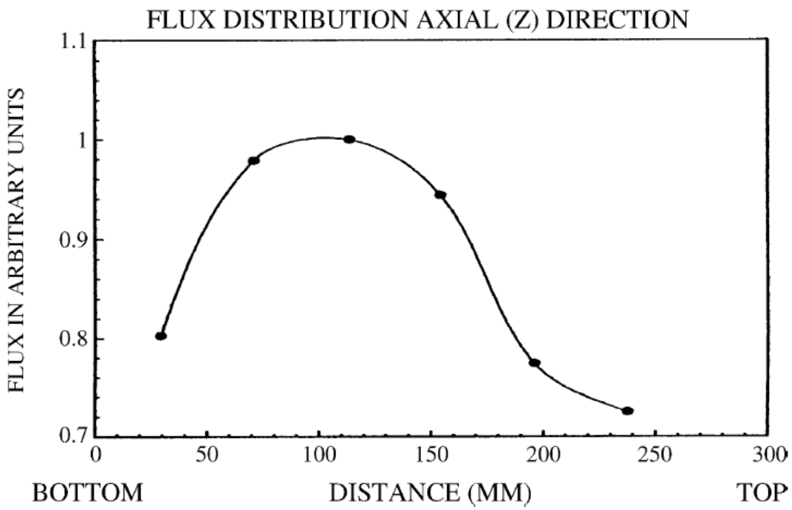
Analysis of geological samples like ores, rocks and chemical samples from the forensic laboratories and standardisation of neptunium (Np-237) development

Physics experiments

The safety parameters of utmost importance in KAMINI are the worth of the safety control plates, moderator temperature coefficient of reactivity and void coefficient of reactivity.

Changes in the core reactivity of KAMINI are usually estimated in terms of the changes in the position of the safety control plates. The integral worth of both the safety control plates was measured again by rod drop method and found to be 8±0.48 $





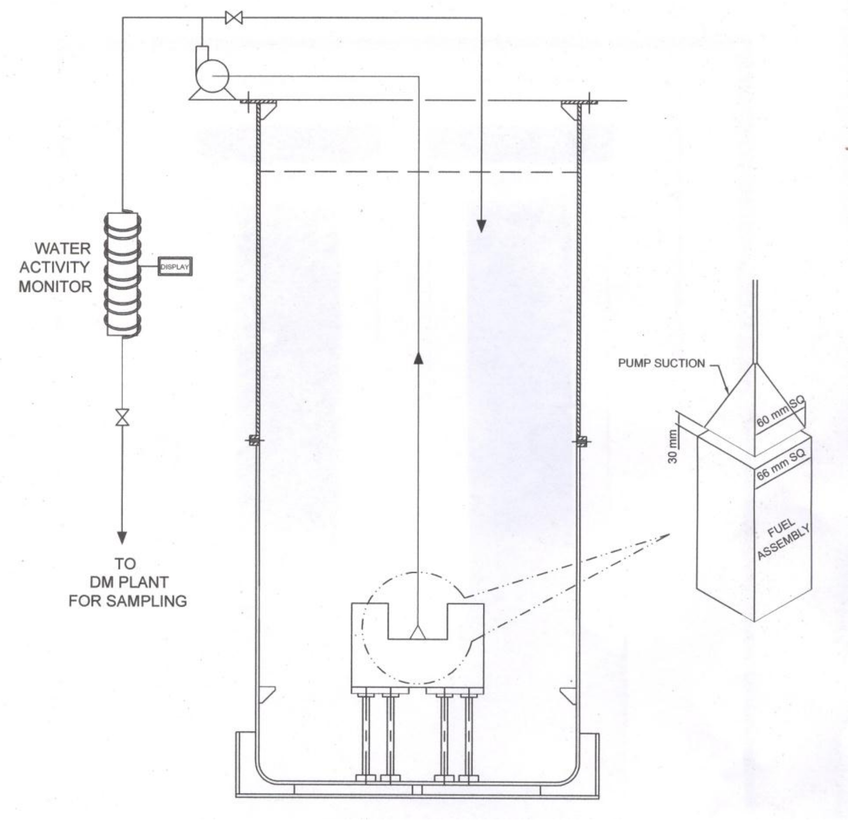
Revamping of Instrumentation systems

- The neutron detectors are having drift due to leakage current and the neutronic channels and its components are obsolescent, resulting in frequent failures and large downtimes. The two computer based systems in KAMINI, mainly Process Interlock and Reactor Regulation system and Alarm Annunciation and Operator Information system are also required to be replaced due to non-availability of spare cards and component obsolescence. Hence, it is planned to revamp these systems with the state-of-the-art systems to enhance the performance of the reactor and improve the operational safety.

Water Activity incident

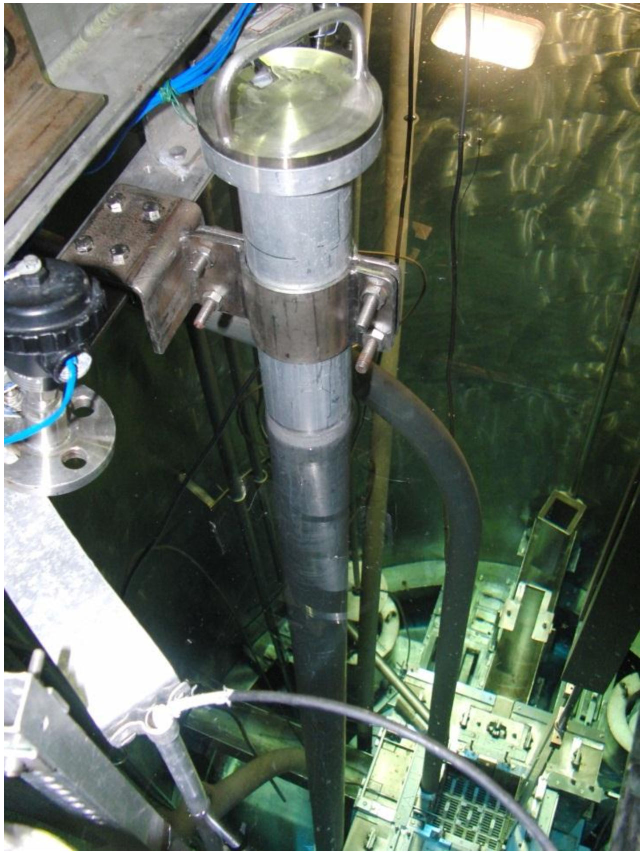
- An increase in Reactor tank water activity was observed during an eight hour reactor operation.
- After getting permission from the Safety authorities to operate the reactor for identifying the cause of high activity in Reactor tank water , Sipping experiments from the outlet of all fuel sub-assemblies were carried out during operation and shut down.
- Based on the spectral analysis of tank water samples, it was concluded that increase in water activity is from the increased amount of short lived Fission Product Noble Gases (FPNG) and its daughter products which is possibly leaching through the fuel clad.
- No solid radioactive fission product is detected in tank water samples.
- Fuel assembly in B1 location was showing the highest FPNG release.
- Possibility of FPNG leak through fuel clad or tramp fuel in the clad.
- The suspected fuel assembly will be subjected to Post irradiation tests to confirm the cause.

Water Activity incident



Fuel Assembly outlet Water sipping setup

In-Reactor Testing Location



- Insalation of two Aluminium Dry tube locations for testing of compensated iron chamber detectors

KAMINI is a very versatile and rich source of neutrons.

The Length by Diameter ratio of about 160 makes it possible to have very good contrast neutron radiographs.

The reactor has been utilized for radiography of irradiated fuel pins main objectives of setting up the reactor.

It has been in use and will continue to be used as a national facility for the radiographic examination and activation analysis of components from strategic departments like

- **Nuclear**
- **Space**
- **Forensic**
- **Science and**
- **Educational institutions**.

Conclusion

- .KAMINI is a unique 233U fuelled neutron source facility operating in India. It is providing R&D facilities for neutron radiography, activation analysis and radiation physics experiments. Fifteen years of operating experience with this facility has been excellent.


Thank You