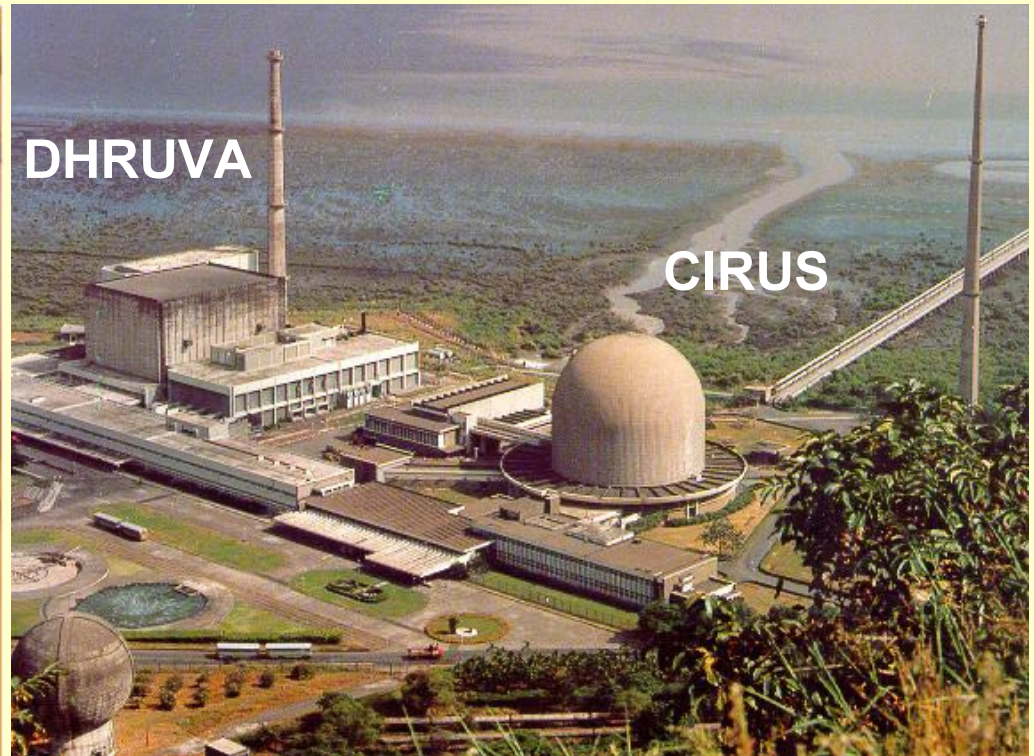
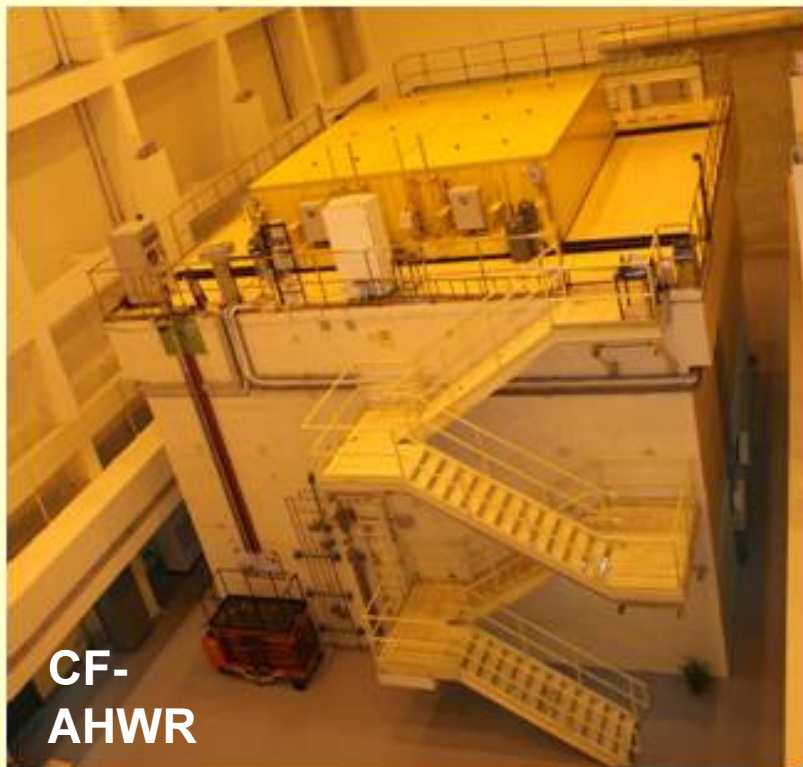
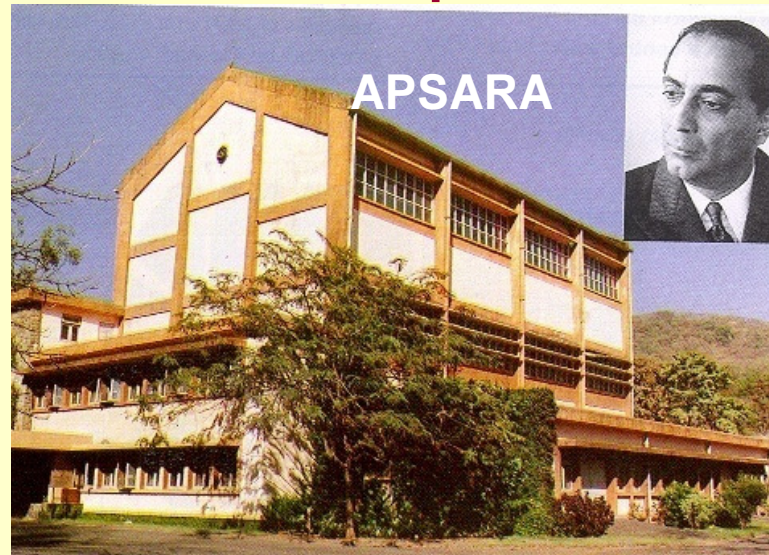


Research Reactors Operational at BARC



Planned Project Activities

- **APSARA UPGRADATION**
- **30 MW MULTI PURPOSE RESEARCH REACTOR**

APSARA UPGRADATION

- Apsara is the first research reactor built in India
- Attained its first criticality on August 4, 1956
- Apsara has completed more than Fifty years of operation

UPGRADATION PROGRAMME

- Extensive refurbishment of the reactor to extend its useful life and upgradation of the systems to meet the current safety standards
- Increasing reactor power to 2 MW to enhance maximum available thermal neutron flux to 6.5×10^{13} n/cm²/s
- Replacement of the existing HEU fuelled core by a LEU fuelled core
- Strengthening of Reactor building and associated structures to meet the current seismic standards – two alternatives -- either retrofit the building or make new building.
- Seismic qualification of a scaled down model of the Apsara building fitted with the suitably designed Elasto- plastic dampers
- Up gradation of coolant systems and Modernization of Control & Instrumentation system
- The upgraded reactor will provide enhanced facilities to carryout research, calibration & testing of neutron detectors

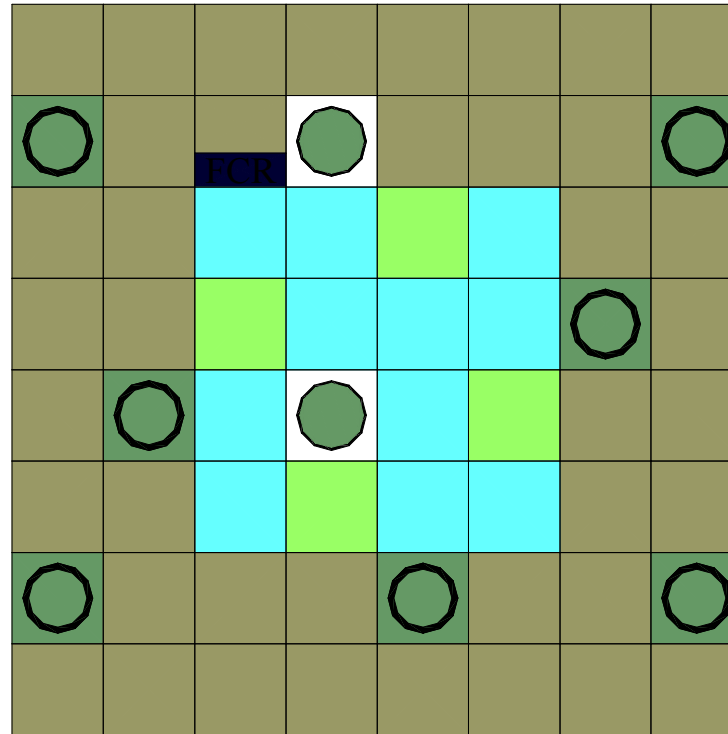
Shake table Test –

Without Elasto-Plastic Dampers on Apsara RB Model.wmv

Shake Table Test -
With Elasto-Plastic Dampers on Apsara RB Model.wmv

Salient Design features of the upgraded reactor

| | |
|-------------------------------------|--|
| Reactor Type | Pool type |
| Reactor power | 2 MW |
| Max. thermal neutron flux | 6.5×10^{13} n/cm ² /s |
| Fuel | LEU (17.0 % w/w U ²³⁵) U ₃ Si ₂ Dispersed in Al, Plate type |
| Coolant | Light Water |
| Moderator | Light Water |
| Reflector | BeO |
| Control element material | Hafnium |
| Experimental/Irradiation facilities | Beam tubes Irradiation Positions (In-core & Reflector region) Thermal column Shielding corner |



 STANDARD FUEL ASSEMBLY

 CONTROL FUEL ASSEMBLY

 BeO REFLECTOR

 IRRADIATION POSITIONS

 HOLLOW GRAPHITE PLUG

 FINE CONTROL ROD

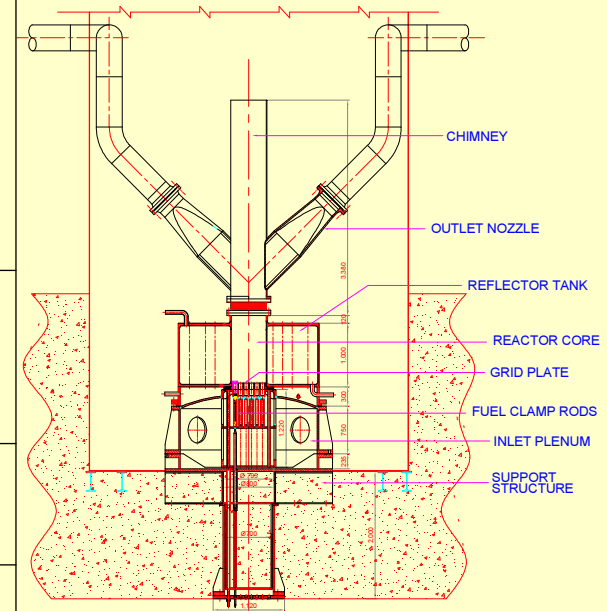
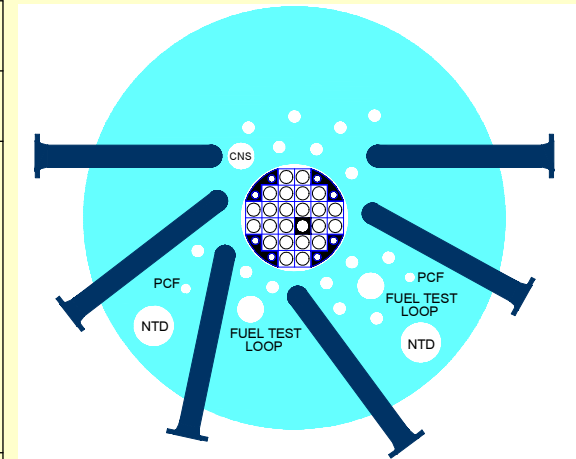
UPGRADED APSARA CORE

30 MW Multi Purpose Research Reactor

- Design and development jobs pertaining to the project are in progress
- Project proposal included in the 11th National plan
- Preparation of detailed project report completed
- The feasibility of introducing an external neutron source with the 30 MW high flux research reactor is under study.

Salient Features of HIGH FLUX RESEARCH REACTOR

| | |
|---|---|
| Reactor type | Pool type |
| Thermal Power | 30 MW |
| Maximum Neutron Flux Thermal flux (in core) Fast flux (in core) Thermal Flux (in Reflector region) | 6.7×10^{14} n/cm ² /sec 1.7×10^{14} n/cm ² /sec 3.5×10^{14} n/cm ² /sec |
| Core Lattice | Circular with 32 positions 19 standard fuel assemblies (SF) 4 control fuel assemblies (CF) 1 irradiation position 2 Adjuster rods (in BeO filler) 2 Shut-off-rods (in BeO filler) 4 irradiation positions (in BeO filler) |
| Fuel | 19.75% (LEU) U ₃ Si ₂ dispersed in Al, Plate type Fuel loading density – 3.5 gm/cc. |
| U ²³⁵ mass in Equilibrium core | 6.0 kg |
| Annual requirement of Uranium | 110 kg |

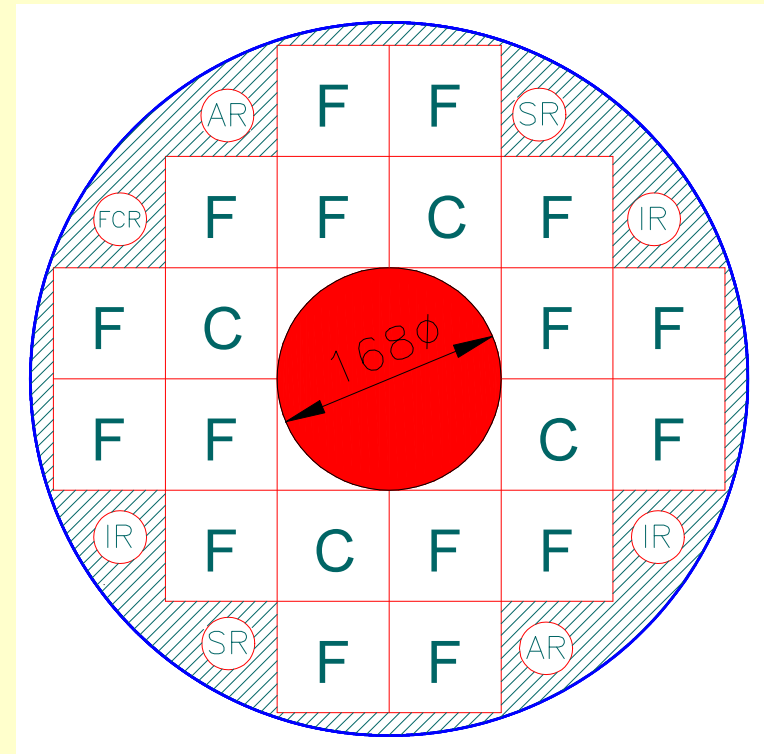


**Coupling of Spallation Neutron
Source
in
High Flux Research Reactor**

Aspects considered for coupling of ADS in High Flux Research

Reactor

- Maximum four central fuel assemblies can be removed to accommodate the spallation target module. Accordingly, space available for locating the spallation target assembly is 168 mm.
- LBE as target has been considered since this technology is under development in BARC.
- Over-all diameter of the LBE target is 140 mm and the window diameter is 40 mm.



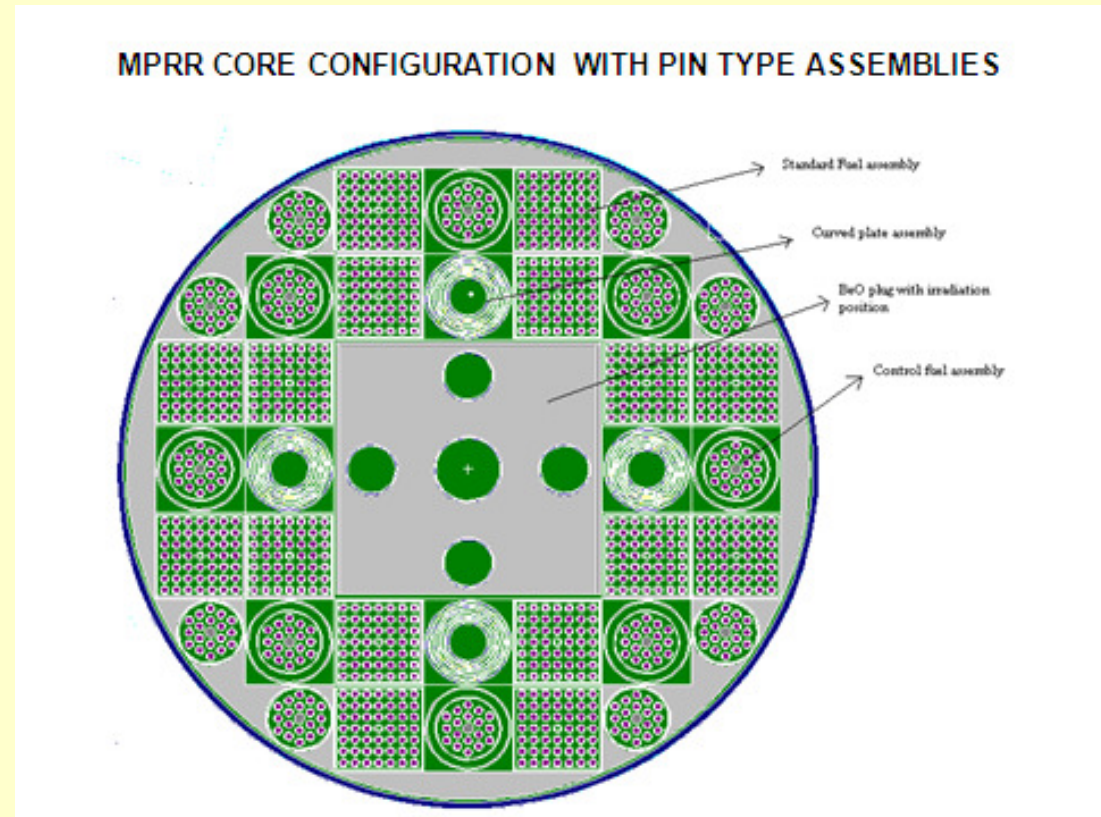
Reactor core physics calculation

Based on the spatial, energy and angular distribution of neutrons in the target available for 650 MeV proton beam, the core calculation was carried out with the following parameters.

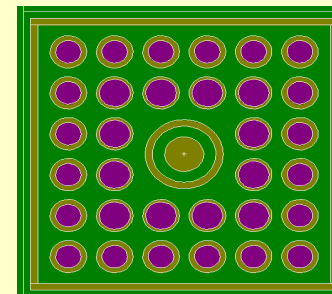
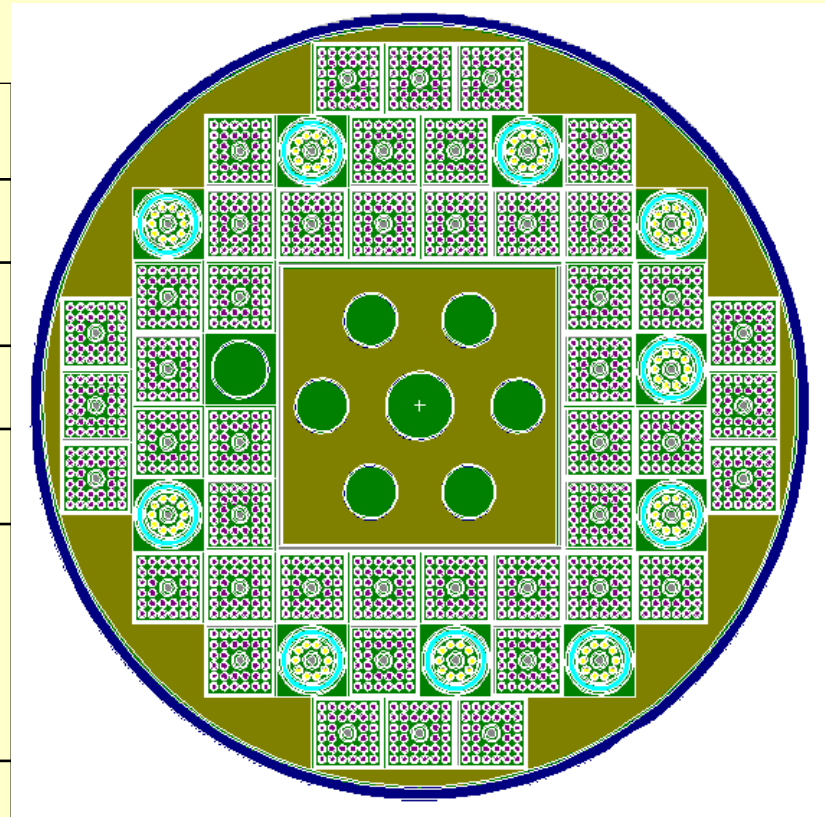
| | |
|------------------------------------|----------------------------|
| Proton beam energy | 650 MeV |
| Maximum beam current | 0.28 mA |
| Beam power | 182 kW |
| Heat deposited in the LBE & window | 130 kW |
| Size of target | 140 mm dia |
| Neutron/proton | 12.5 |
| Total external neutron source | 2.2×10^{16} n/sec |

Salient Features of the Core

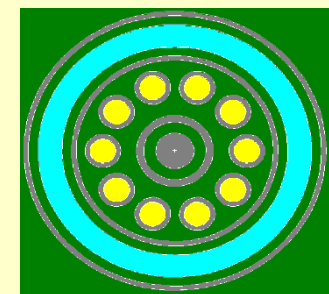
- Central square opening of 250 x 250 mm. for installation of spallation target assembly
- The space is filled with Beryllium reflector plug in the Critical Reactor
- In ADS core a dry thimble is installed in the central opening.



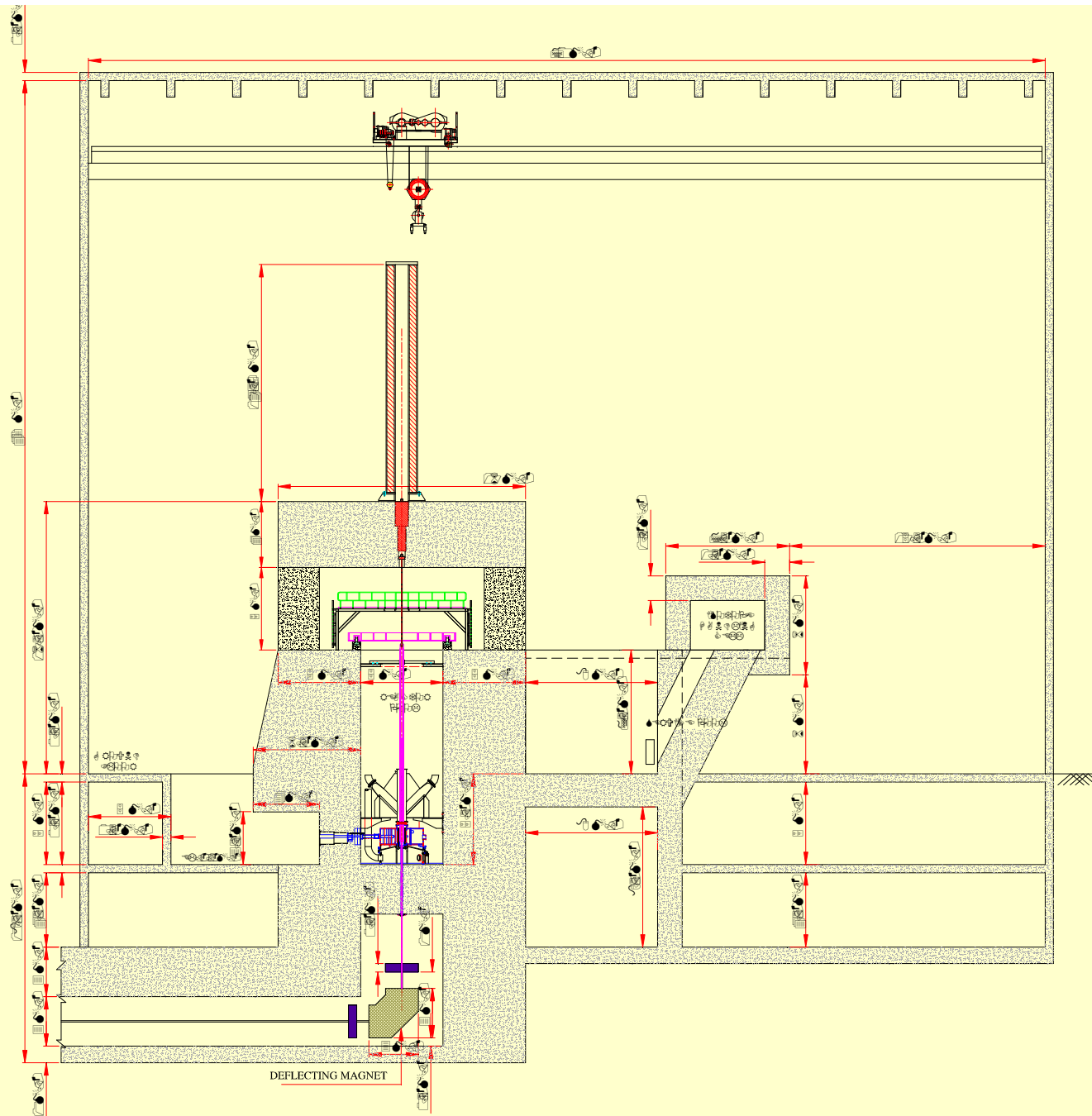
| | |
|---|-----------------------|
| Lattice positions | 56 |
| Active core height (mm) | 800 |
| Standard Fuel Assembly | 45 |
| Control Fuel Assembly | 10 |
| In-core irradiation positions | 8 |
| Max. Neutron Flux (in-core) | |
| Thermal flux (n/cm ² /s) | 4.8 x10 ¹⁴ |
| Fast flux (n/cm ² /s) | 1.0 x10 ¹⁴ |
| Max. Thermal Neutron Flux in Reflector (n/cm ² /s) | 2.2 x10 ¹⁴ |
| Standard Fuel Assembly | |
| Max. Clad surface temp (°C) | 114 |
| Max. Fuel centre temp (°C) | 297 |
| Control Fuel Assembly | |
| Max. Clad surface temp (°C) | 106 |
| Max. Fuel centre temp (°C) | 346 |



Standard Fuel Assembly

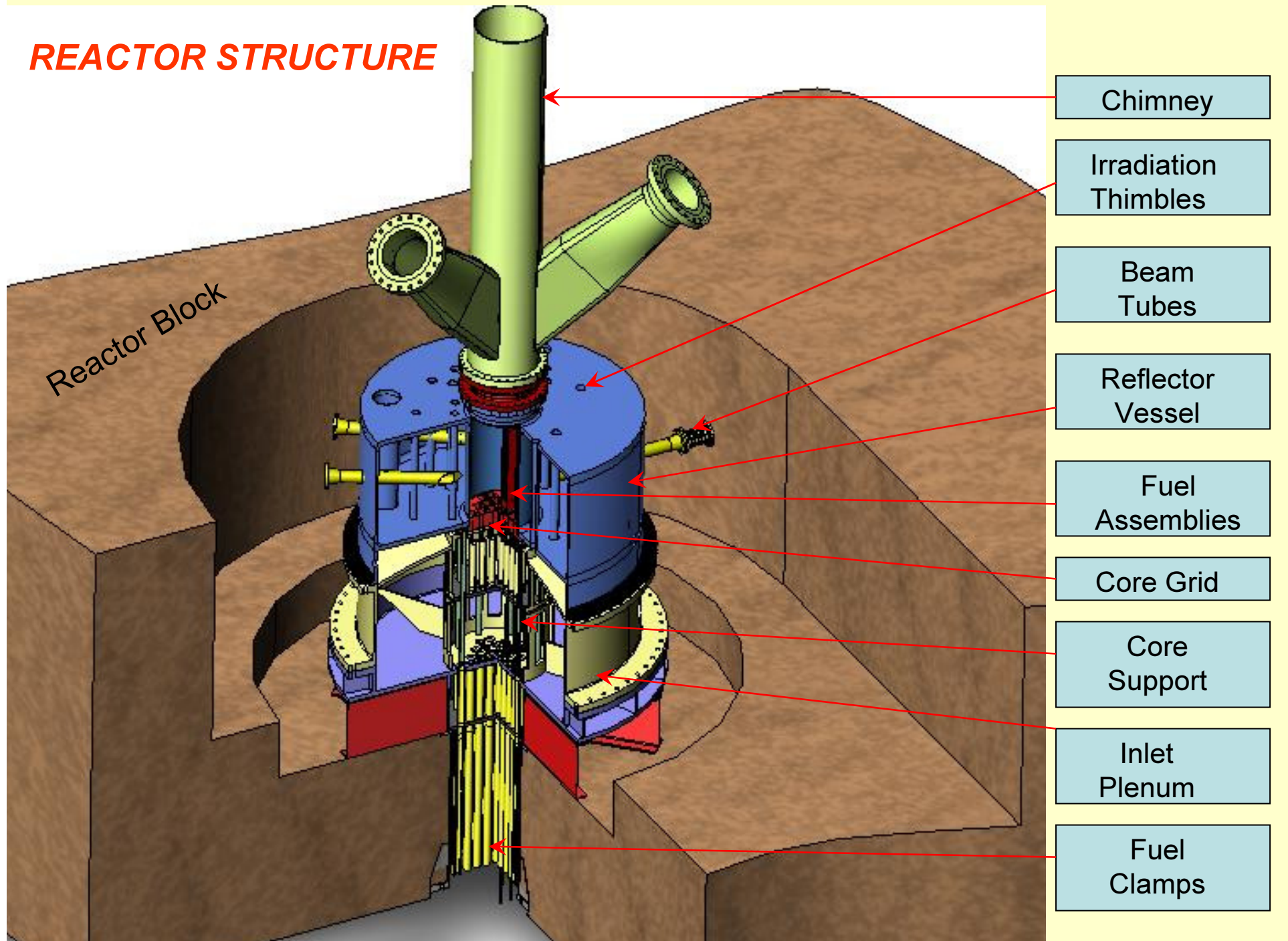


Control Fuel Assembly



ADS CORE

REACTOR STRUCTURE



Suggestions for future activities

- Conduct of an international conference to convince political and top level managements the need of new research reactors highlighting ageing of many RRs and emerging crisis for RIs.
- Organize IAEA-TM on futuristic RRs with innovations such as coupling with external source towards developing sub critical systems which can be a forerunner for safe NPP
- Conduct training course/Workshops to familiarize and exchange information on field level activities in use of various codes for RR design and analysis