Multipurpose Research Reactor (RMB)

Project Status

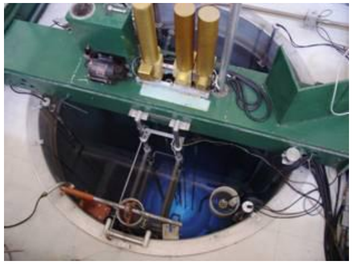
José Augusto Perrotta
CNEN - Brazil

November 2011

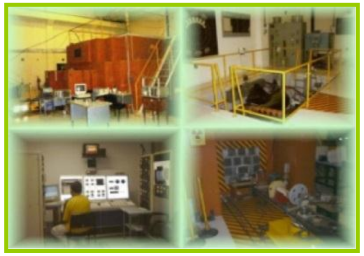
Research Reactors in Brazil

Name	Utilization	Power	Location	Startup	Type
IEA-R1	Research – Radioisotope Production	5 MW (2 MW)	IPEN/CNEN-SP São Paulo	1957	MTR Pool Type Reactor
IPR-R1	Research – Training	100 kW	CDTN/CNEN-MG Belo Horizonte	1960	TRIGA MARK-I
ARGONAUTA	Research – Training	500 W	IEN/CNEN-RJ Rio de Janeiro	1965	Argonaut
IPEN/MB-01	Critical Facility – PWR Core Analysis	100 W	IPEN/CNEN-SP São Paulo	1988	Pin Type Open Core

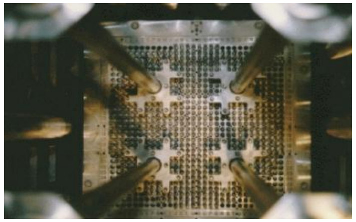
Research Reactors in Brazil



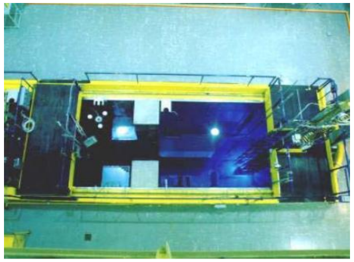
IPR-R1 Research Reactor



ARGONAUTA Research Reactor



IPEN/MB-01 Research Reactor



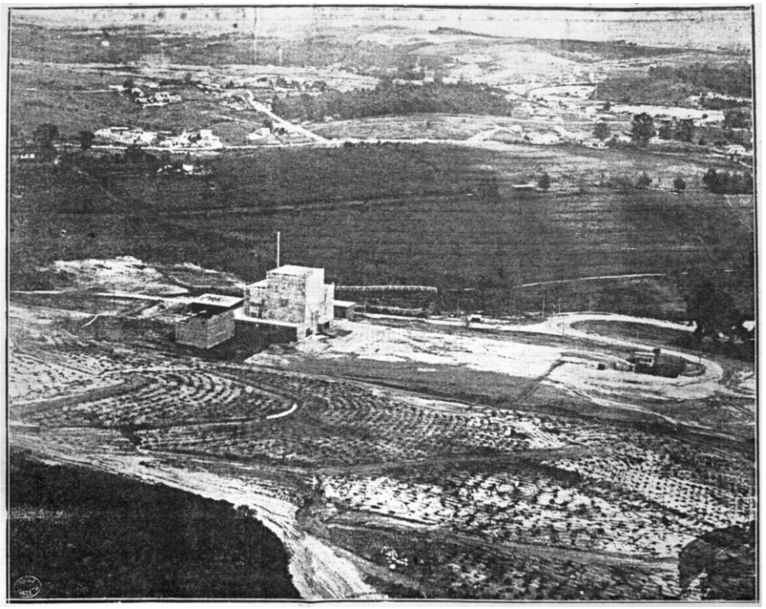
IEA-R1 Research Reactor

Research Reactors in Brazil

IEA-R1	IPR-R1	ARGONAUTA	IPEN/MB-01
•Specific radioisotope production for medical, industry, agriculture and engineering applications •Neutron activation analysis •Neutron radiography •Neutron Beam Utilization •Silicon Doping •Fuel irradiation and NDT analysis inside the pool •Teaching and training in reactor physics •Neutron Flux < $5x10^{13}$ $n/cm^2.s$ (thermal)	Specific radioisotope production for medical, industry, agriculture and engineering applications •Neutron activation analysis. •Teaching and training in reactor physics. •Training of the Brazilian nuclear power reactor operators.	•Teaching and training in reactor physics •Neutron activation analysis	•Validation of reactor physics methodology and nuclear data associated for PWR core analysis •Teaching and training in reactor physics

Research Reactors in Brazil

IPEN: IEA-R1 Reactor (1958)



Future Perspectives for RR Utilization

Brazilian Nuclear Program Review

- Electricity produced by nuclear power plants
  - Brazil will continue to use nuclear energy in its electrical power matrix.
- Nuclear Fuel
  - Brazil has a significant uranium ore reserve and domains the fuel cycle technology, including U enrichment.
  - Increase of industrial activities for supplying the nuclear power plants needs.
- Nuclear Techniques Utilization
  - Increase of nuclear techniques applications and radioisotope utilization in the benefit of the society.
  - Increase of autonomous technology development

Electricity Production Capacity

2008

Source	N. Units	kW	%
Hydro	765	77.508.375	71,46
Gas	119	11.779.831	10,86
Oil	759	4.749.025	4,38
Biomass	319	4.772.052	4,40
Nuclear	**2**	**2.007.000**	**1,85**
Mineral Coal	8	1.455.104	1,34
Wind	21	338.350	0,31
Solar	1	20	0,00
Import	-	5.850.000	5,39
Available Capacity	**1.994**	**108.459.757**	**100,00**

2030 Prevision

Source	Installed capacity (MW)	
	2020	2030
Hydro	116.100	156.300
Big Units	**116.100**	**156.300**
Thermal	26.897	39.897
Natural Gas	**14.035**	**21.035**
Nuclear (2+1+4)	***4.347***	***7.347***
Mineral Coal	**3.015**	**6.015**
Other	**5.500**	**5.500**
Alternatives	8.783	20.322
Small Hydro	**3.330**	**7.769**
Wind	**2.282**	**4.682**
Sugar Cane Biomass	**2.971**	**6.571**
Urban Residues	**200**	**1.300**
Import	8.400	8.400
TOTAL	**160.180**	**224.919**

Nuclear Medicine

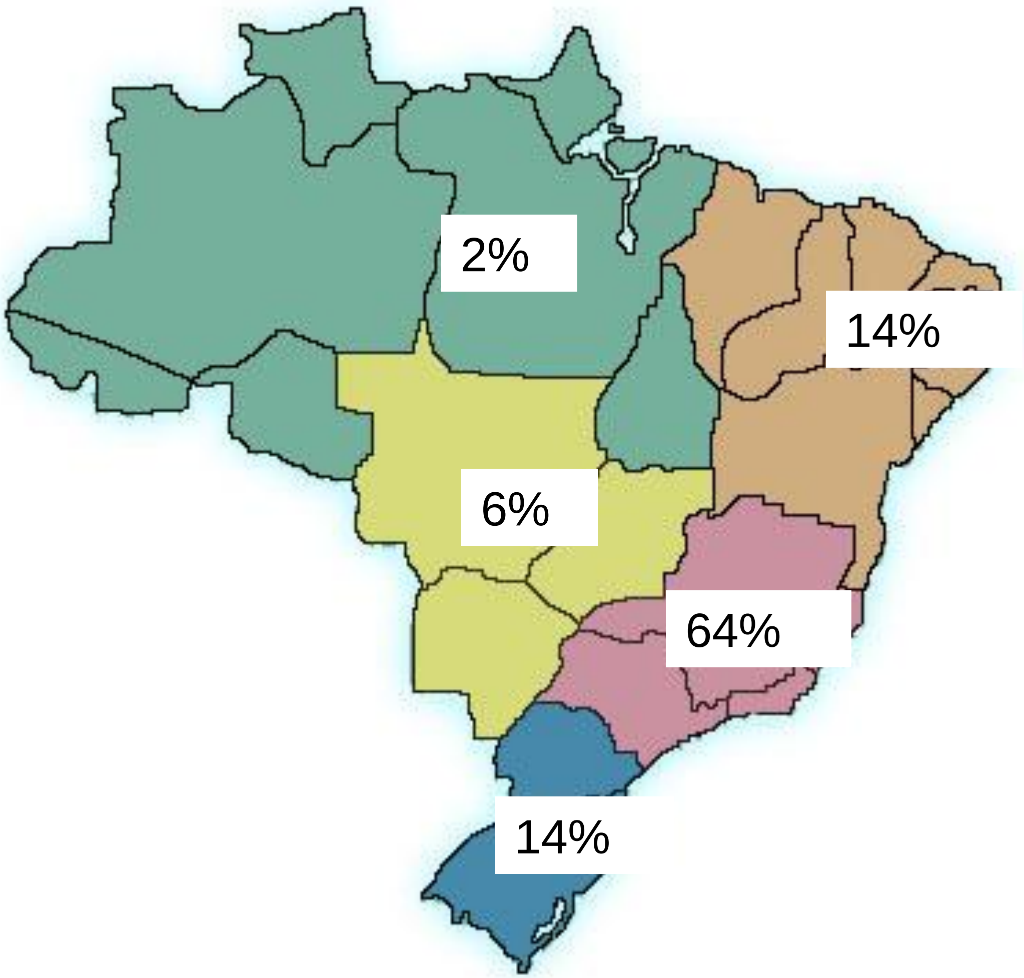
^{99}Mo/^{99m}Tc Generator

- More than 330 generators per week
- 250,500,750,1000,1250,1500 and 2000 mCi

Produced by IPEN/CNEN-SP, with imported Mo99

Nuclear Medicine

Regional Distribution of Radiopharmacals produced by IPEN



More than 300 clinics

More than 1,5 million procedures per year

Future Perspectives for RR Utilization

WHY a New Multipurpose Research Reactor?

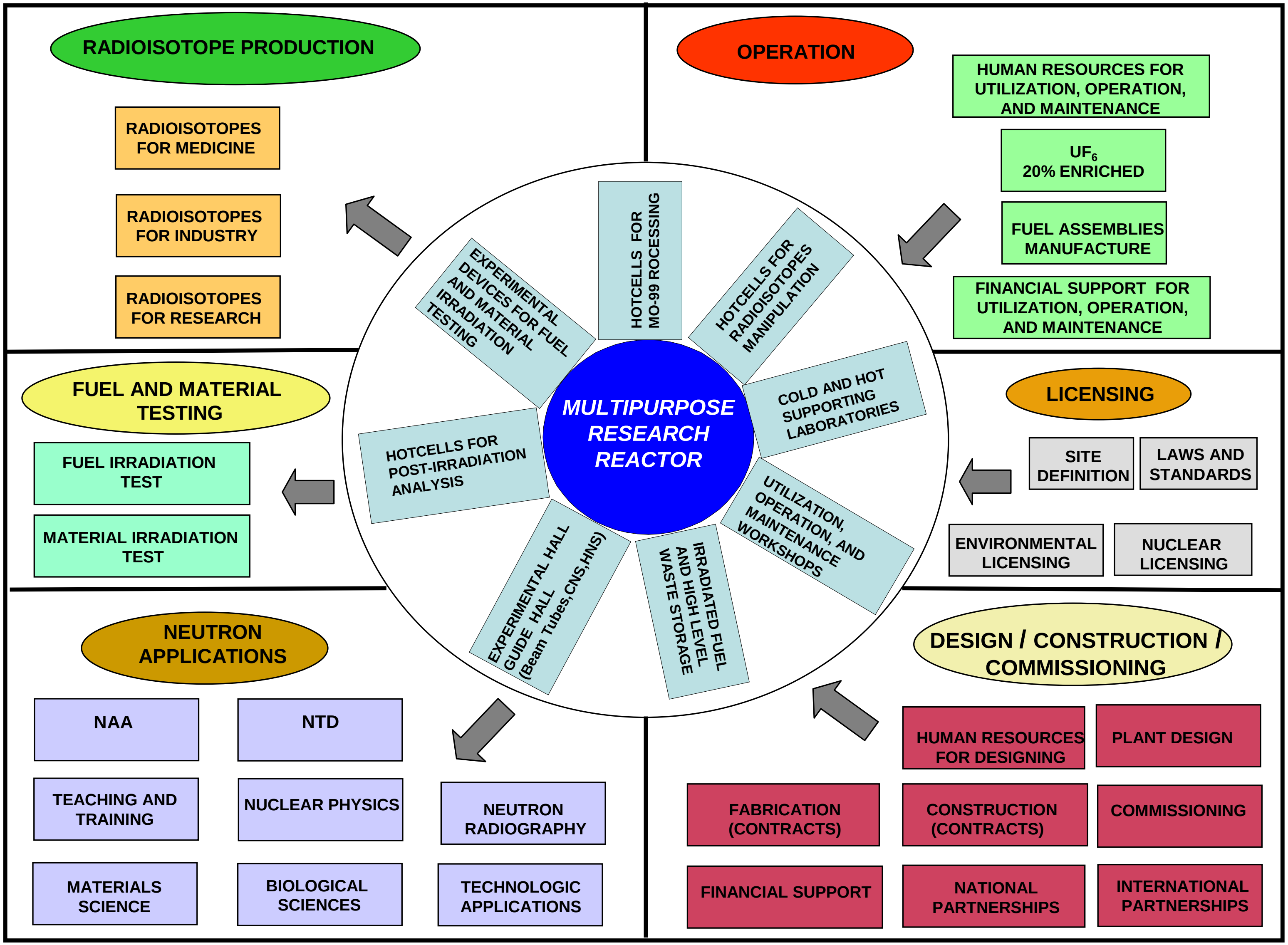
- To support the Brazilian nuclear program proposal of increasing activities in the nuclear sector for the next decades (structuring project);
- To support the nuclear medicine in Brazil through the radioisotope production for radiopharmaceuticals application that today is strongly dependent on international suppliers;
- To support the industrial application of power reactors and nuclear fuel technology that requires fuel and material testing under irradiation for an autonomous development;
- To improve fundamental and technological research through neutron beam utilization which is limited by the existing infrastructure of the nuclear research institutes.

Future Perspectives for RR Utilization

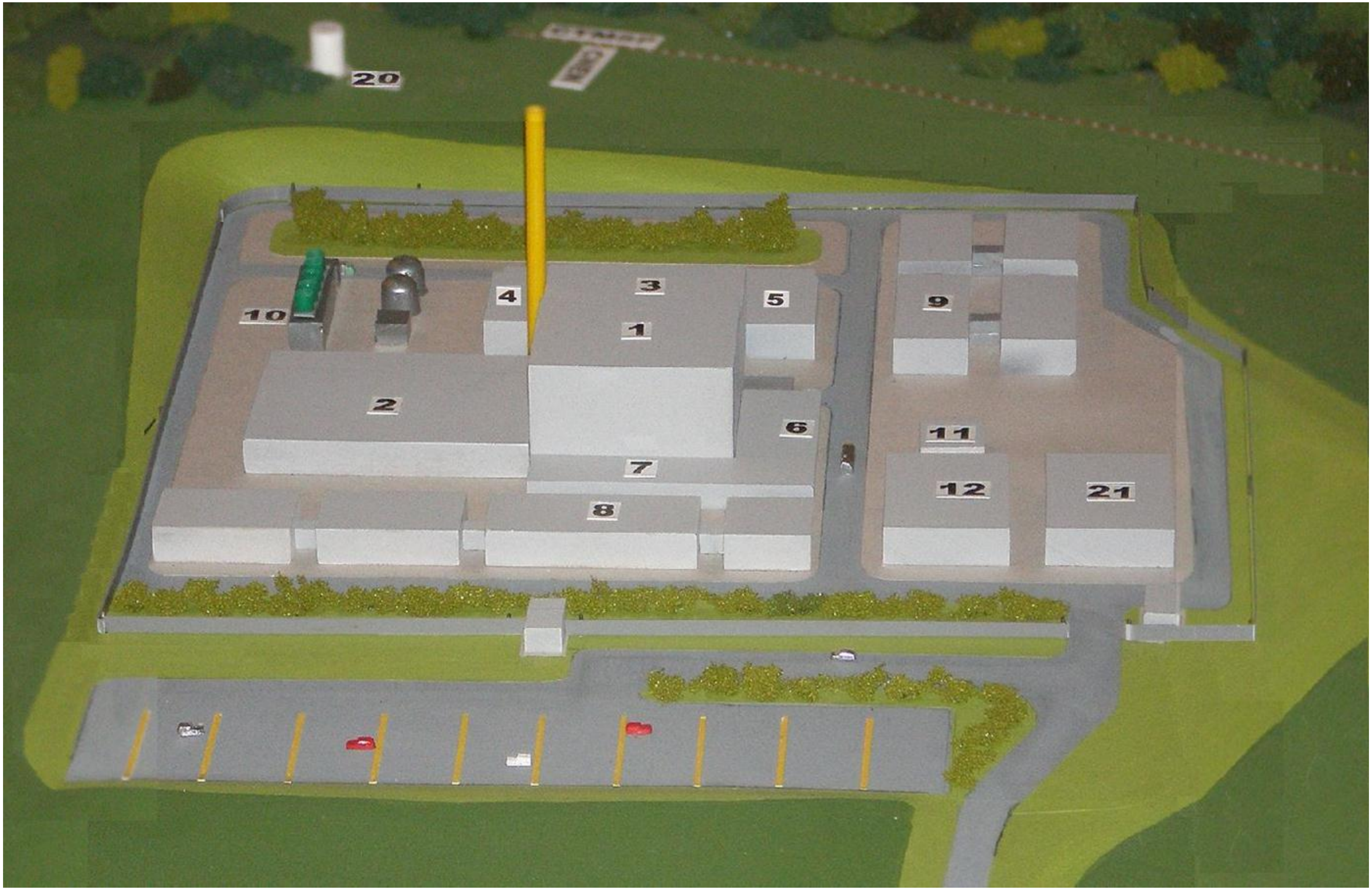
Decision on the New Multipurpose Research Reactor!

- ✓ The Science Technology and Innovation Ministry has decided to support the new research reactor construction in accordance to the Brazilian Nuclear Program
- ✓ The Brazilian Nuclear Energy Commission (CNEN) is in charge of implementing the new research reactor.
- ✓ The State of São Paulo is giving support to the project.
- ✓ This new research reactor shall have neutron fluxes compatible to the multipurpose uses and application needs.

RMB Scope


RADIOISOTOPE PRODUCTION
RADIOISOTOPES FOR MEDICINE
RADIOISOTOPES FOR INDUSTRY
RADIOISOTOPES FOR RESEARCH
OPERATION
HUMAN RESOURCES FOR UTILIZATION, OPERATION, AND MAINTENANCE
UF_6 20% ENRICHED
FUEL ASSEMBLIES MANUFACTURE
FINANCIAL SUPPORT FOR UTILIZATION, OPERATION, AND MAINTENANCE
FUEL AND MATERIAL TESTING
FUEL IRRADIATION TEST
MATERIAL IRRADIATION TEST
LICENSING
SITE DEFINITION
LAWS AND STANDARDS
ENVIRONMENTAL LICENSING
NUCLEAR LICENSING
MULTIPURPOSE RESEARCH REACTOR
HOTCELLS FOR MO-99 ROCESSING
HOTCELLS FOR RADIOISOTOPES MANIPULATION
COLD AND HOT SUPPORTING LABORATORIES
UTILIZATION, OPERATION, AND MAINTENANCE WORKSHOPS
IRRADIATED FUEL AND HIGH LEVEL WASTE STORAGE
EXPERIMENTAL HALL GUIDE HALL (Beam Tubes, CNS, HNS)
HOTCELLS FOR POST-IRRADIATION ANALYSIS
EXPERIMENTAL DEVICES FOR FUEL AND MATERIAL IRRADIATION TESTING
NEUTRON APPLICATIONS
NAA
NTD
TEACHING AND TRAINING
NUCLEAR PHYSICS
NEUTRON RADIOGRAPHY
MATERIALS SCIENCE
BIOLOGICAL SCIENCES
TECHNOLOGIC APPLICATIONS
DESIGN / CONSTRUCTION / COMMISSIONING
HUMAN RESOURCES FOR DESIGNING
PLANT DESIGN
FABRICATION (CONTRACTS)
CONSTRUCTION (CONTRACTS)
COMMISSIONING
FINANCIAL SUPPORT
NATIONAL PARTNERSHIPS
INTERNATIONAL PARTNERSHIPS

RMB Buildings

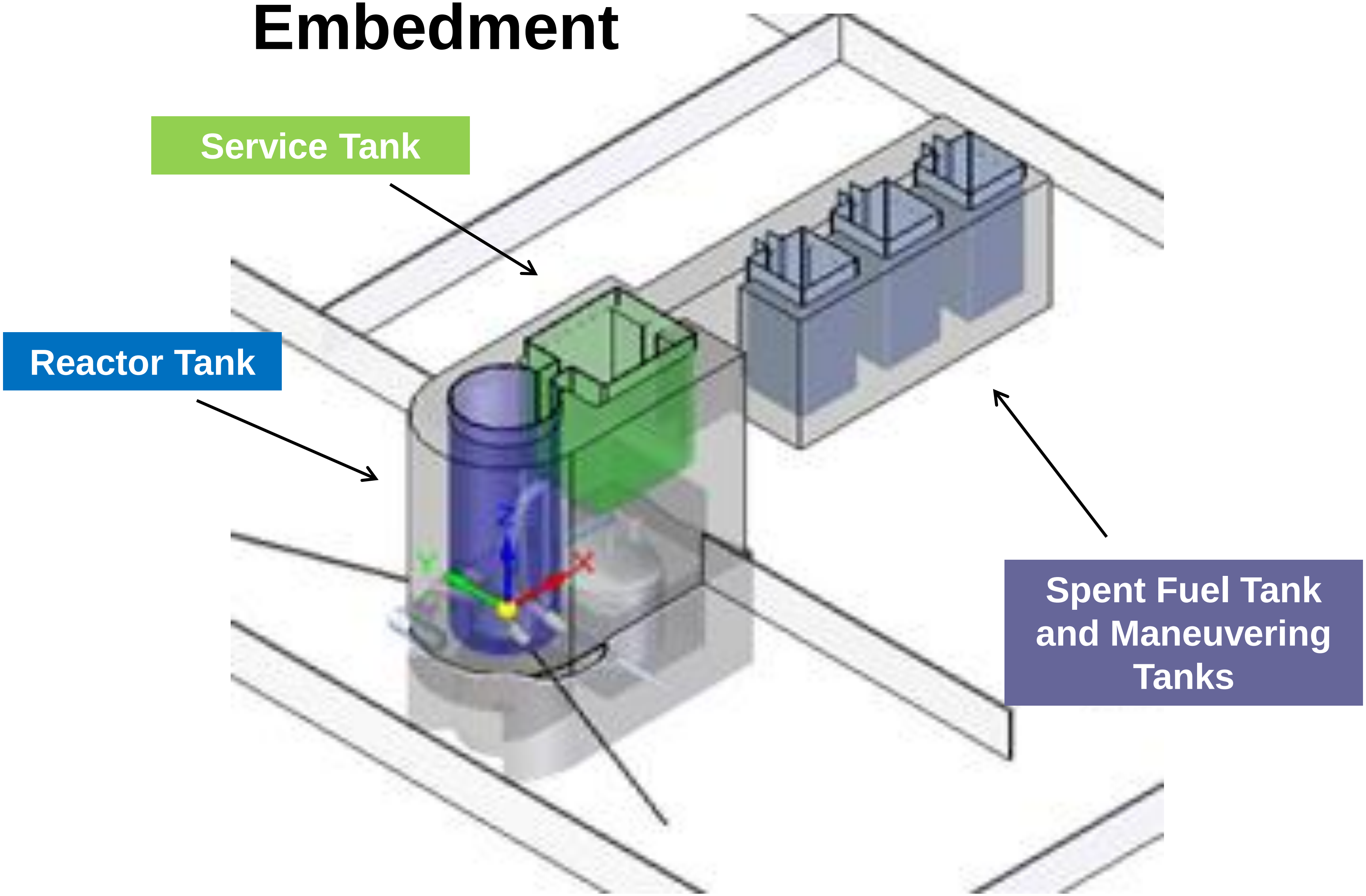


Reactor Characteristics

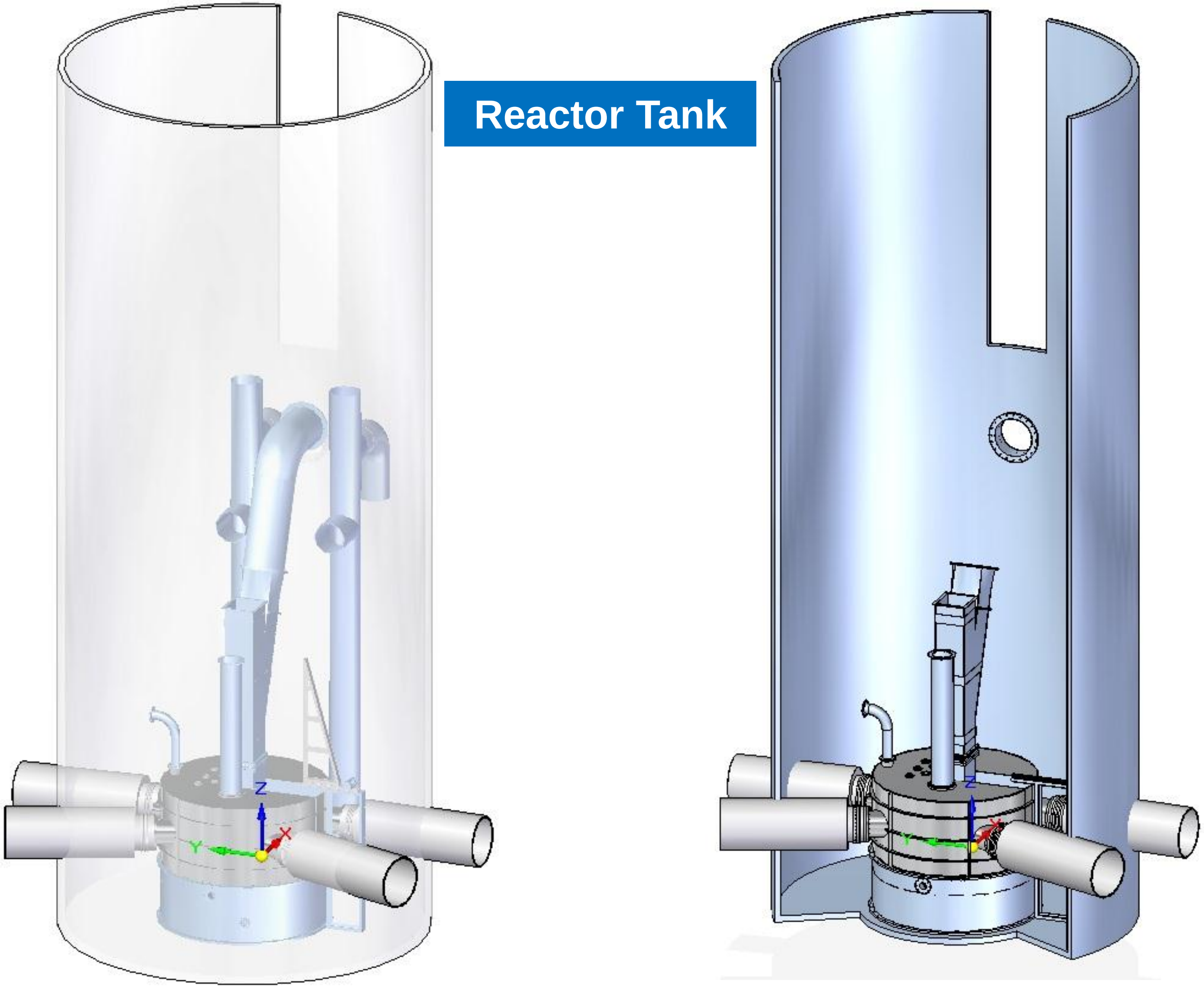
- Open pool multipurpose research reactor with a primary cooling system through the core – OPAL RR as a reference model for conceptual design.
- The reactor core will be compact, using MTR fuel assembly type, with planar plates, U_3Si_2-Al dispersion fuel with maximum 4,8 gU/cm^3 density and 20 % U-235 enrichment.
- The reactor core will be cooled and moderated by light water, using heavy water as reflector and light water and/or beryllium in one side of the core .
- Neutron flux (thermal and fast) higher than $2x10^{14}$ $n/cm^2.s$.
- Maximum Thermal Power - 30 MW

Reactor Characteristics

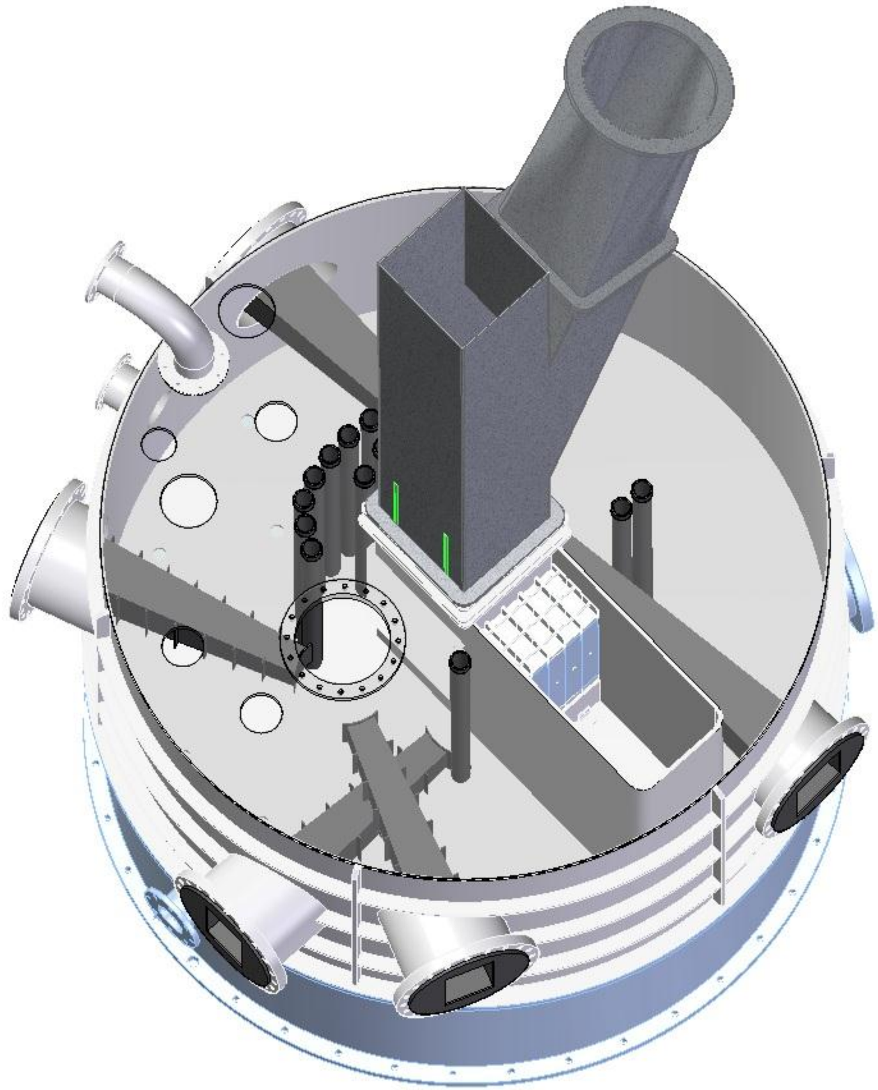
Embedment



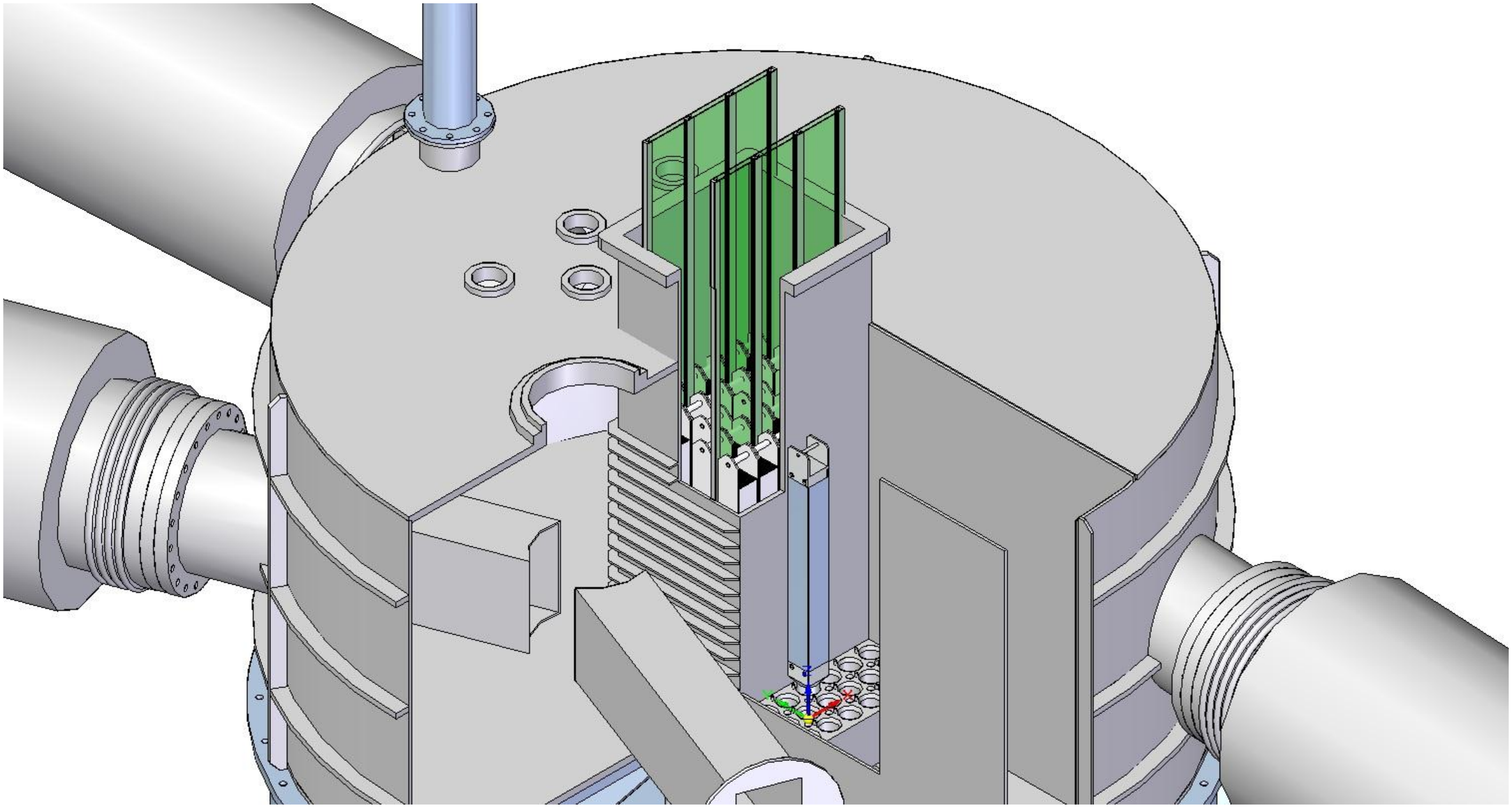
Reactor Characteristics



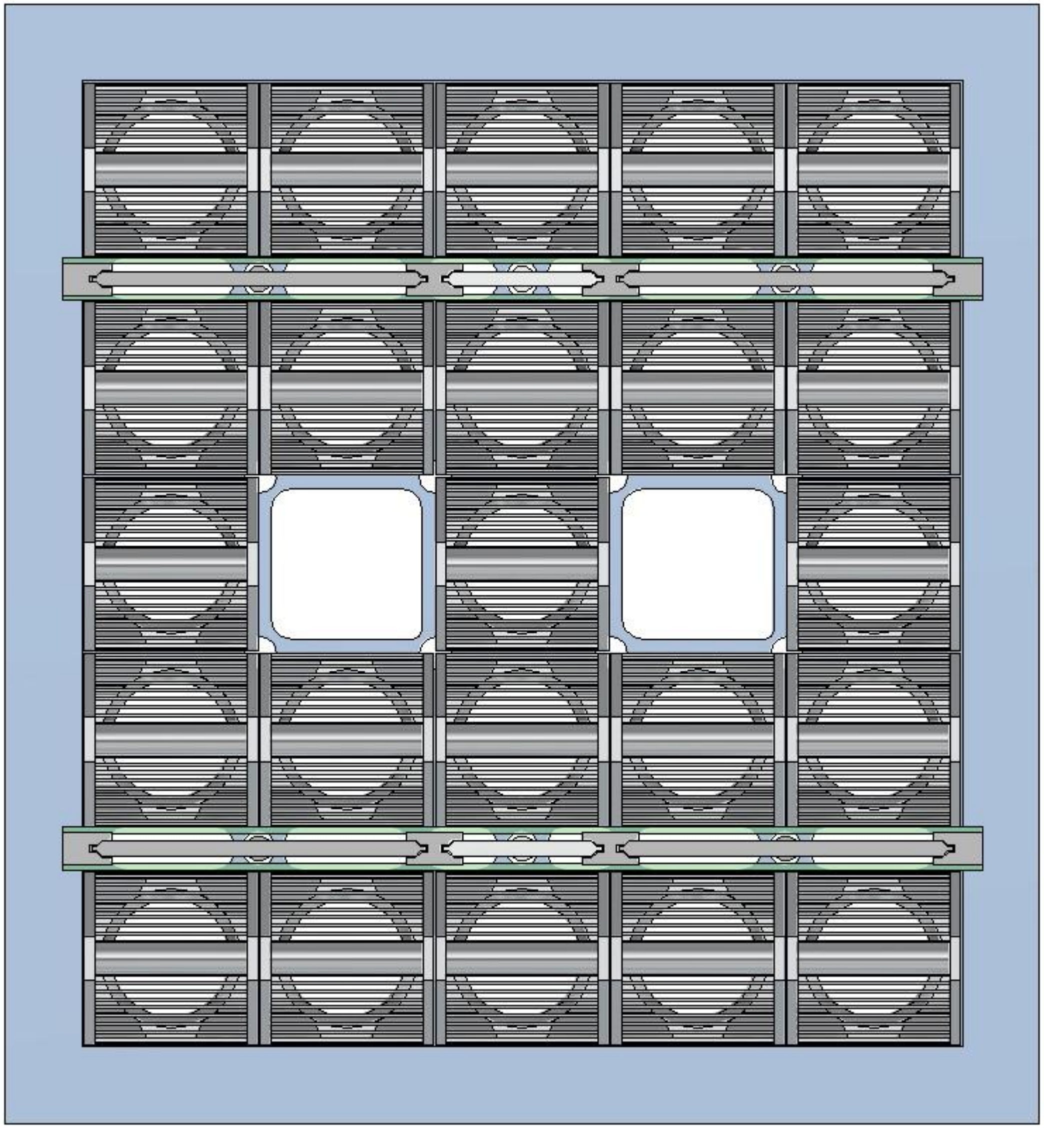
Reactor Characteristics



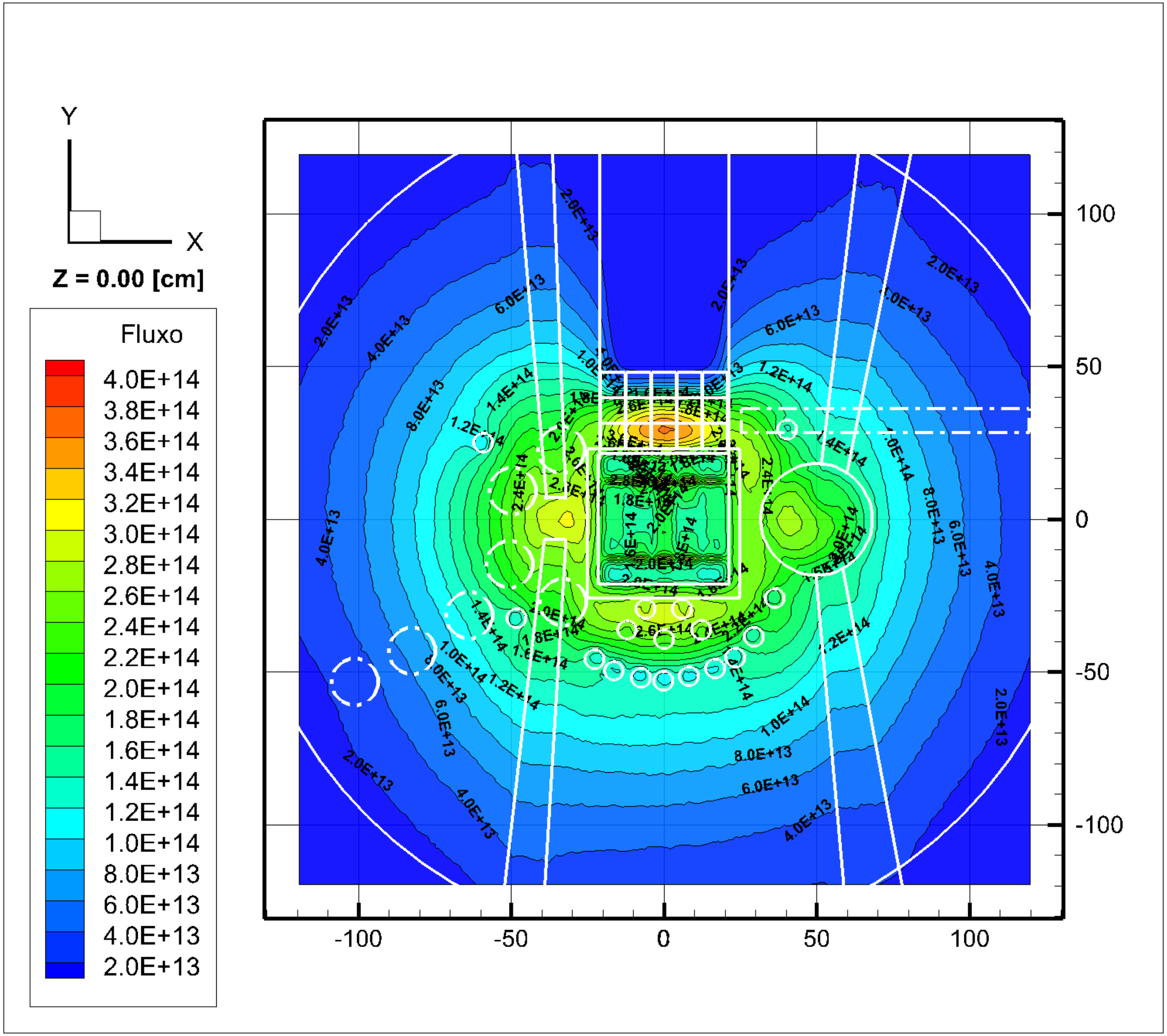
Reactor Characteristics



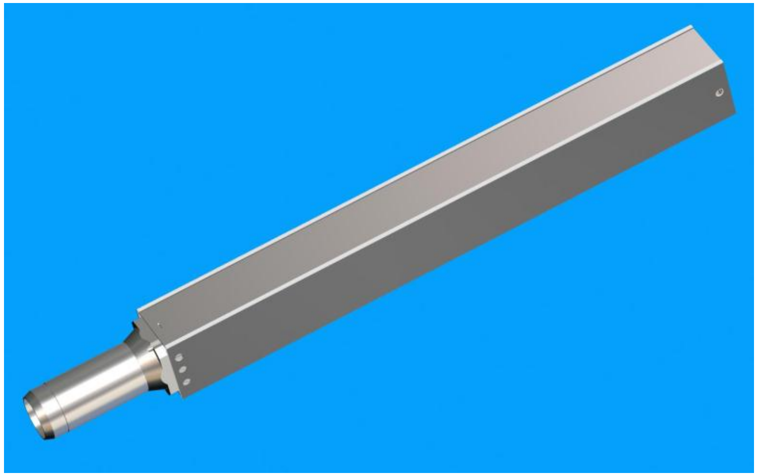
Reactor Characteristics



Reactor Characteristics



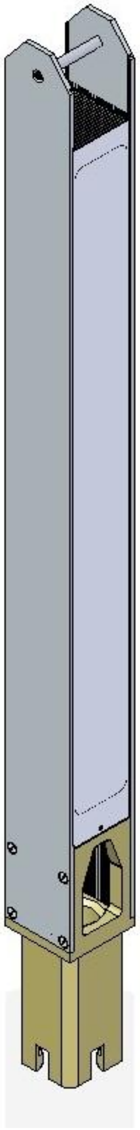
Fuel Assembly Manufacture



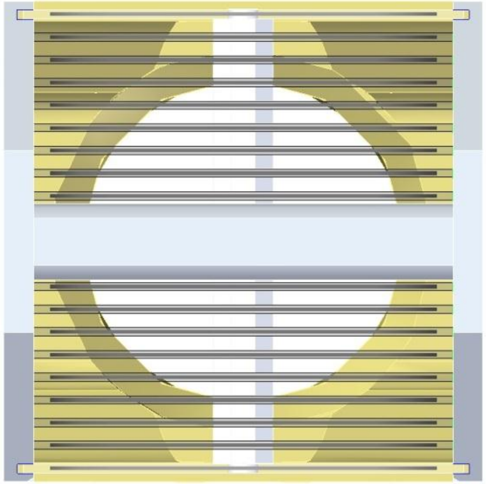
Natural UF_6 – USEXA / CTMSP

20% Enrichment UF_6 – LEI / CTMSP

Manufacturing and Assembling – IPEN



IEA-R1



RMB

Radioisotope Production

- **Radioisotope for Injectable Radiopharmaceuticals**
  - ^{99}Mo , ^{131}I, ^{51}Cr, ^{153}Sm, ^{177}Lu, ^{166}Ho, ^{90}Y, ^{188}W, ^{32}P
    - ✓ ^{99}Mo obtained by LEU target irradiation and processing
    - ✓ 1000 Ci/week (Today 350 Ci/week imported by IPEN and 450 Ci/week before the international crisis)

- **Radioisotope for Brachtherapy**
  - ^{125}I, ^{192}Ir

- **Radioisotope for Industry**
  - ^{192}Ir, ^{60}Co

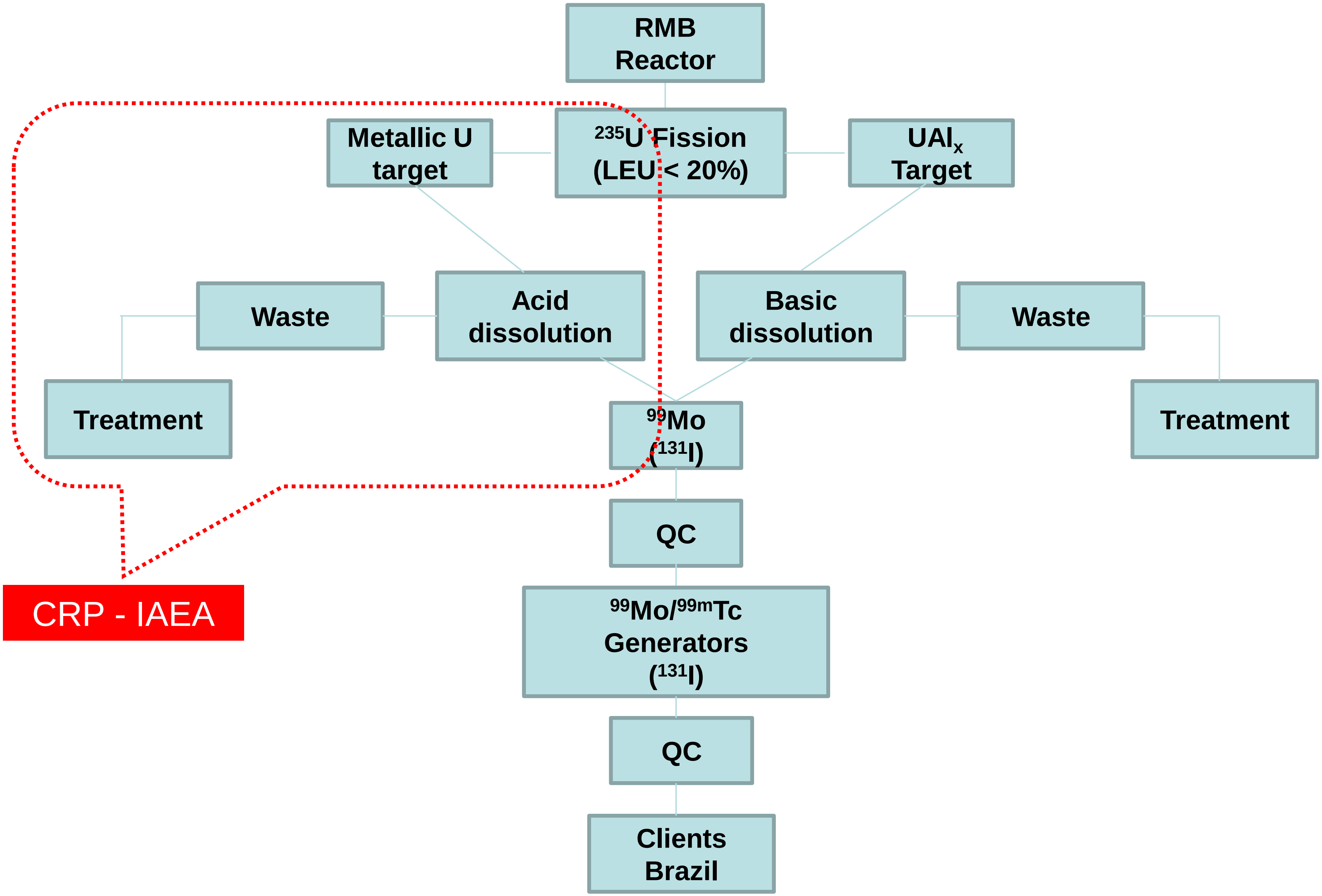
- **Tracers**
  - ^{203}Hg , ^{131}I, ^{82}Br

Radioisotope Production

Infrastructure

- Processing hot cells for irradiated U targets (LEU) to produce ^{99}Mo and ^{131}I;
- Hot cells for handling and transport preparation of produced radioisotopes;
- Special hot cells for radioactive sources processing and sealing;
- Hot cell and special devices for ^{125}I production;
- Shielded casks for radioisotope transportation;
- Irradiation devices for in core and in reflector radioisotope production;

Production methods of ^{99}Mo (Development)



Nuclear Fuel and Materials Irradiation Test

Materials	Test Objective
Nuclear Fuels	Fuel Performance Characterization and Specification Optimization
Structural Materials	Life Extension of Nuclear Power Plants Characterization of Materials and Performance under Irradiation
All	Safety Analysis

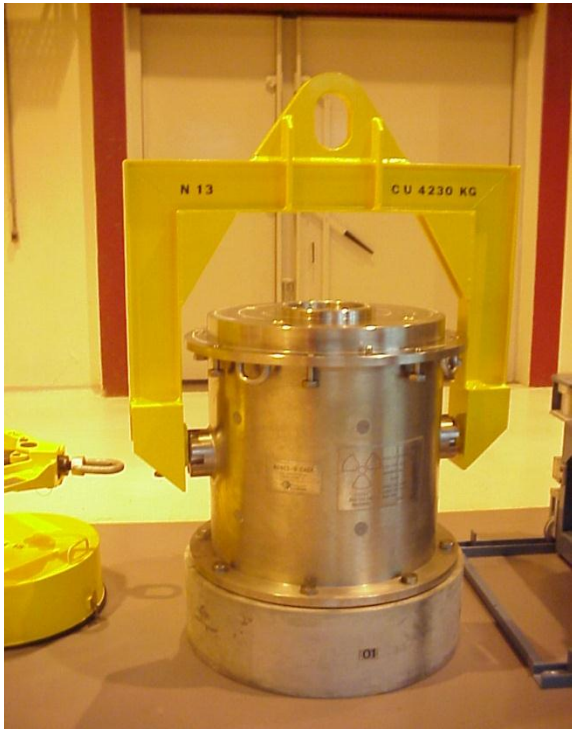
Irradiation Systems

- Pressurized irradiation loops for fuel testing with pressure and cooling temperature control
- Irradiation capsules for fuel specimens testing
- Horizontal displacement devices for simulating power ramps and loading following
- Irradiation capsules with temperature control for structural materials testing
- Irradiation experiments control room and data collection systems
- Experimental devices for underwater nondestructive analysis (visual inspection, gamma scanning, sipping, etc)

Post-irradiation Examination

- One hot cell laboratory for irradiated fuel and one hot cell laboratory for irradiated materials examination
- The hot cells laboratory shall allow:
  - Nondestructive physical characterization analysis of irradiated specimens
  - Puncturing and fission gas collection
  - Sample preparation for metallographic analysis
  - Optical microscopy
  - Physical and mechanical properties characterization equipment

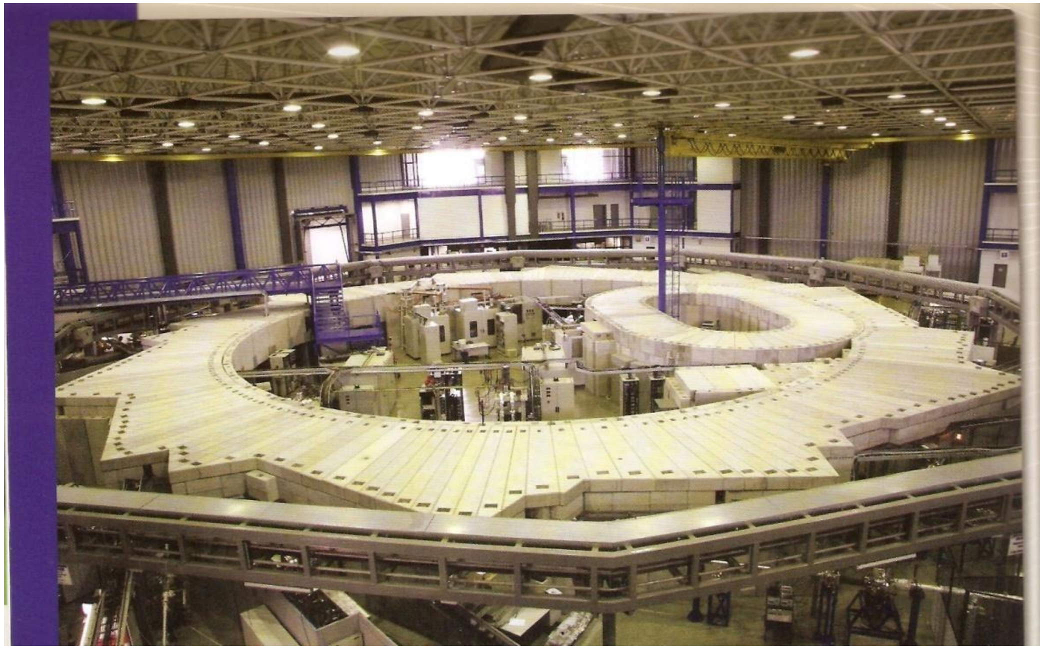
Fuel Post Irradiation Laboratory

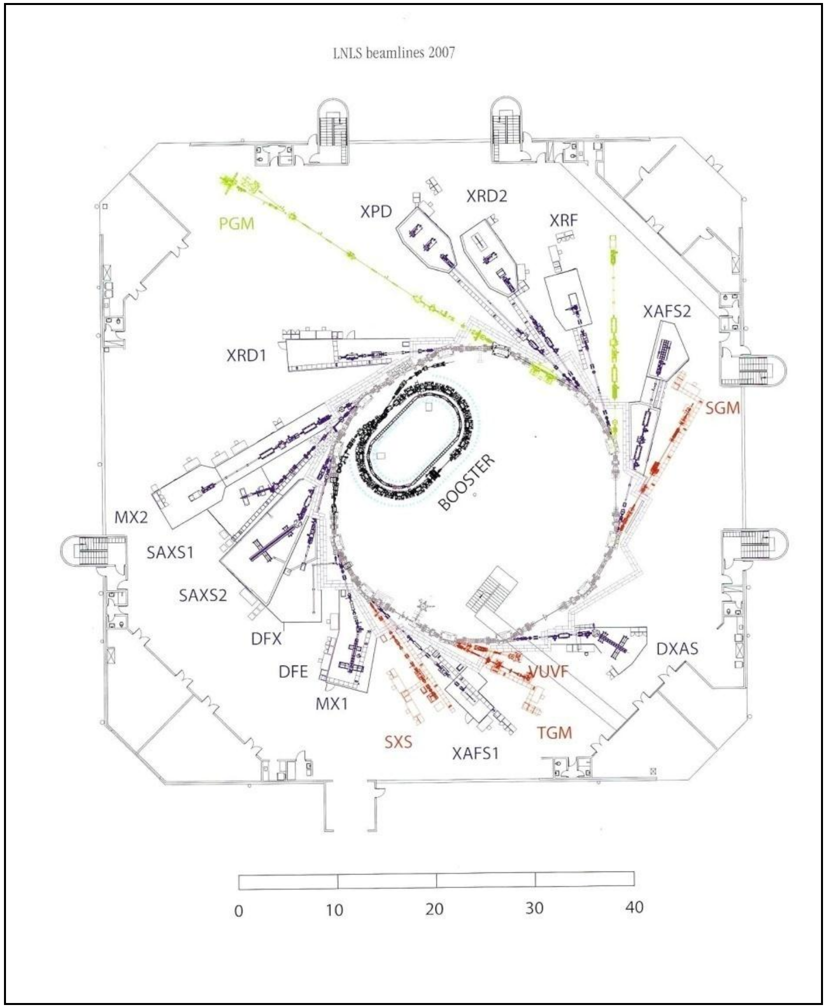


Materials Post Irradiation Laboratory

Cel 1	Reception, Visual Inspection, Dimensional Analysis, Hardness
Cel 2	Sample Preparation
Cel 3	Storage
Cel 4	Uniaxial Mechanical Tests
Cel 5	Uniaxial Creep Tests, Relaxation Tests
Cel 6	Burst Tests, Biaxial Creep Tests
Cel 7	Fracture Mechanics Tests
Cel 8	Fatigue Tests
Cel 9	Charpy Tests.
Cel 10	Microstructural Analysis

Neutron Beam Utilization





LNLS- Laboratório Nacional de Luz Sinchrotron

RMB a National Laboratory for Neutron Beam Utilization as a Complement to the LNLS

Neutron Beam Utilization

- To allow the possibility of at least three beam holes (today proposed 5)
- To project two beam holes with neutron guides: one for thermal and one for cold neutrons. Each beam hole shall have capacity for at least 2 neutron guides (today with 3 guides)
- The technical characteristics of each beam hole (dimensions and position) will be established during the conceptual design of the reactor.
- Each beam hole shall have a flux higher than:
  - $1x10^9$ n/cm^2.s outside the reactor shielding; or
  - $1x10^{14}$ n/cm^2.s at the point of tangency near the core.

Neutron Beam Utilization

Initial Equipment Proposal

Thermal Neutrons Beam	
Guide Hall	**Experimental Hall**
High Resolution Diffractometer	Three Axis Spectrometer
High Intensity Diffractometer	Neutron radiography
Laue Diffractometer	
Residual Stress Diffractometer	
Cold Neutrons Beam	
Small Angle Neutron Scattering	
Prompt Gamma Analysis	

Neutron Activation Analysis

- Neutron Activation Analysis at irradiation positions with thermal neutron flux in the range of 10^{11} to 10^{13} $n/cm^2.s$.
- One irradiation position with cadmium filter for epithermal neutrons activation.
- Pneumatic stations with transit time of 10 seconds, and one very fast station with transit time less than 10 seconds for analysis of radioisotopes with very high decay constant.
- Pneumatic stations for transportation of samples (long irradiation) from core to the radiochemical laboratory.
- Fission delayed neutron measurement system for samples containing U and Th.

Project Management

- Project managed by the Research and Development Directorate of the Brazilian Nuclear Energy Commission (DPD-CNEN)
- Scope and preliminary design, licensing process managing and commissioning verification performed by the Research Institutes of CNEN: IPEN, CDTN, IEN, CRCN
- Basic and detailed design, manufacturing, construction, assembling and their management will be carried out by national and international companies.
- Project technically supported by Brazilian Academy
- Project Cost estimation of US$ 500 million (R$ 850 million)
- Project time span of at least 6 years after the first contract signature and availability of funds. (2012)

Project Status

- CNEN Institutes technicians are developing the scope and preliminary design of the reactor systems and main facilities.

- R$ 30 million allocated by the MCTI (FNDCT- FINEP) to contract the conceptual and basic engineering design of systems, buildings and infrastructure of the RMB (except basic engineering design of pure nuclear systems and components). Work contract under development.

- Brazil-Argentina Agreement (CNEN-CNEA) signed for common basic engineering design of the RMB and RA-10 (pure nuclear part). OPAL reactor adopted as a reference model, and Argentine company INVAP will be contracted by both parties for this project step.

Project Status

- Environmental licensing process started. Term of Reference for EIA/RIMA approved by IBAMA (Ministry of Environment). Work contract under development.

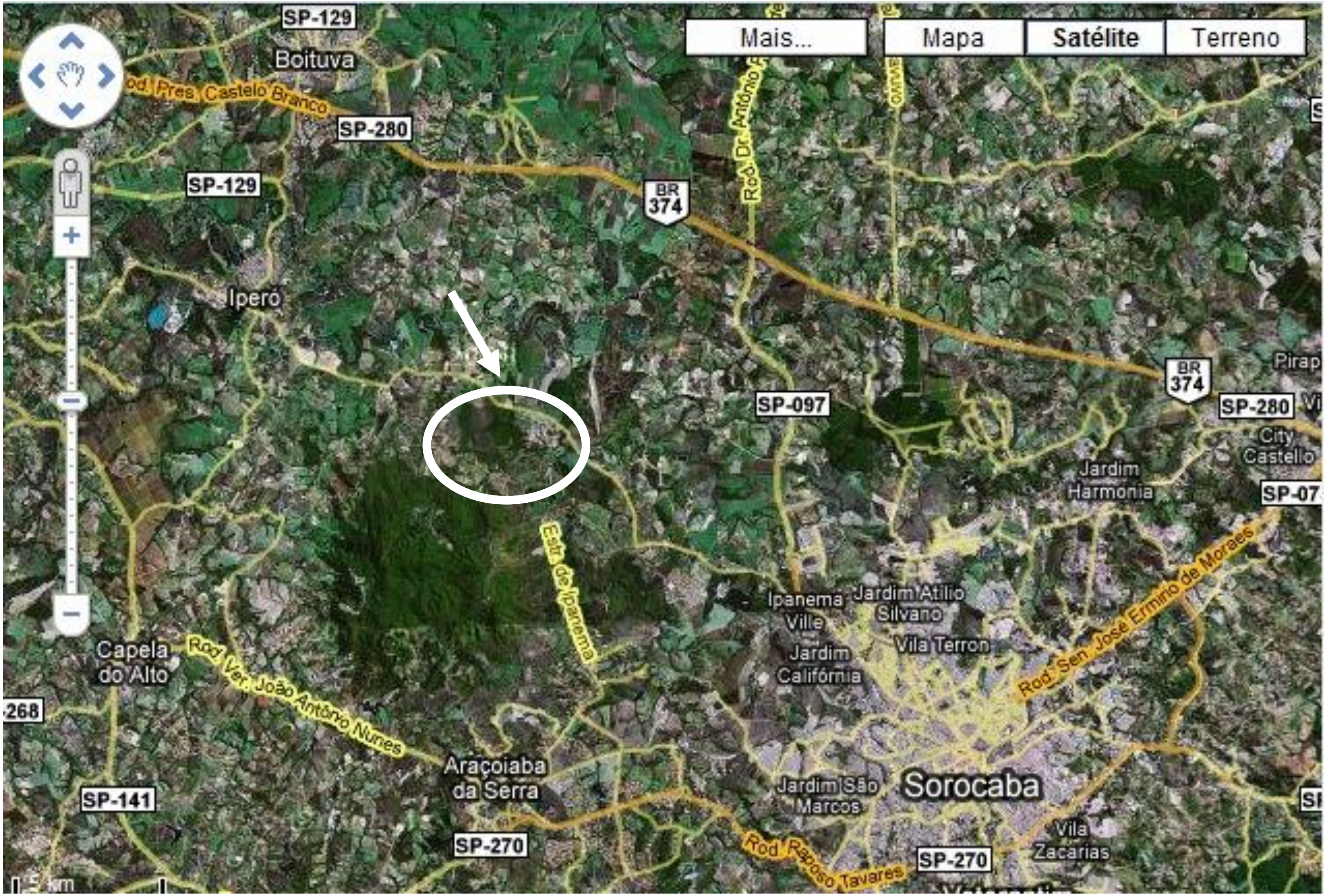
- A sustainability study (costs and benefits) related to the development and construction of a new research reactor in Brazil has been accomplished by CNEN, with a favorable opinion by the Ministry of Planning.

- The government included the RMB project in the four year governmental budget planning (2012-2015) ensuring the continuity of the project for these years. (up to 50% of the total project) (under Congress analysis for approval)

Site

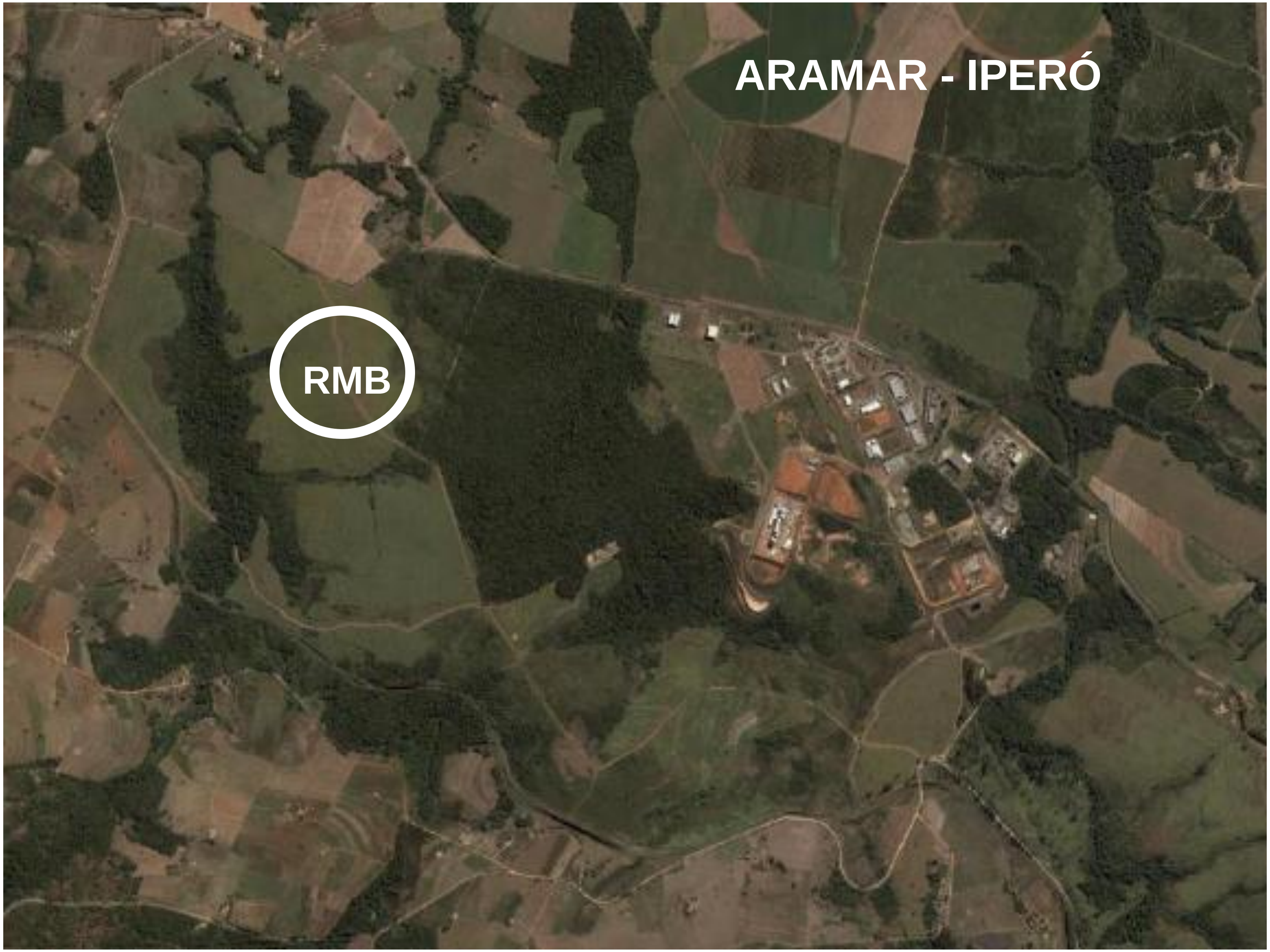
Iperó
State of São Paulo

Site



Mais...
Mapa
Satélite
Terreno
SP-129
Boituva
Rod. Pres. Castelo Branco
SP-280
SP-129
BR 374
Rod. Dr. Antônio
Iperó
SP-097
BR 374
SP-280
City Castello
Jardim Harmonia
SP-07
Estr. de Ipanema
Rod. Sen. José Ermírio de Moraes
Ipanema Ville
Jardim Atílio Silvano
Vila Terron
Jardim Califórnia
Capela do Alto
Rod. Ver. João Antônio Nunes
268
Araçoiaba da Serra
Jardim São Marcos
Sorocaba
SP-141
SP-270
Rod. Raposo Tavares
SP-270
Vila Zacarias
5 km

Site



Site

Thank you!