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Strategic Projects at CNEN
RMB, LFN, CENTENA and GRANIOTER

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Comissão Nacional de Energia Nuclear
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CNEN Comissão Nacional de Energia Nuclear
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

Nuclear Technology in Service of Life

COMISSÃO NACIONAL DE ENERGIA NUCLEAR
DIRETORIA DE PESQUISA E DESENVOLVIMENTO
Dra. Patrícia da Silva Pagetti de Oliveira
Dr. José Augusto Perrotta

RMB
Reator
Multipropósito
Brasileiro

Project Owner:

- NATIONAL COMMISSION FOR NUCLEAR ENERGY - CNEN
- Federal autarchy linked to the Ministry of Science, Technology and Innovation (MCTI)

Project Responsible:

- DIRECTORATE FOR RESEARCH AND DEVELOPMENT – DPD/CNEN
- Research Institutes / Technical-Scientific Units: CDTN, CRCN-NE, IEN, IPEN and IRD

Technical Partnership:

- CTMSP (Brazilian Navy technology center – U enrichment)
- INB (Nuclear fuel industry – fuel supply)
- AMAZUL (Engineering company – conventional systems design)

Cooperation Agreement:

- CNEN (Brazil) and CNEA (Argentina)
  Technical Cooperation Agreement on the Project of a New Multipurpose Reactor (2011, 2014)

Contracted Engineering Companies (Design Phase):

- INVAP S.E. (Argentina)
- INTERTECHNE (Brazil)
- IBQN (Brazil)

RMB RESPONSABILITIES

RMB
Reator Multipropósito Brasileiro

Main Purposes of RMB Project

APPLICATIONS IN STRATEGIC AND INDUSTRIAL AREAS

SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

SOCIAL APPLICATIONS

- **Production of radioisotopes for applications in health, industry, agriculture and the environment**
- **Emphasis on the production of Mo-99 to ensure the radiopharmaceutical Tc-99m supply**
- **Testing and qualification of nuclear fuel and other materials to be used in nuclear reactors**
- **Expansion of national capacity in research and applications of nuclear techniques - Neutron Beam National Laboratory and Neutron Activation Analysis Laboratory**

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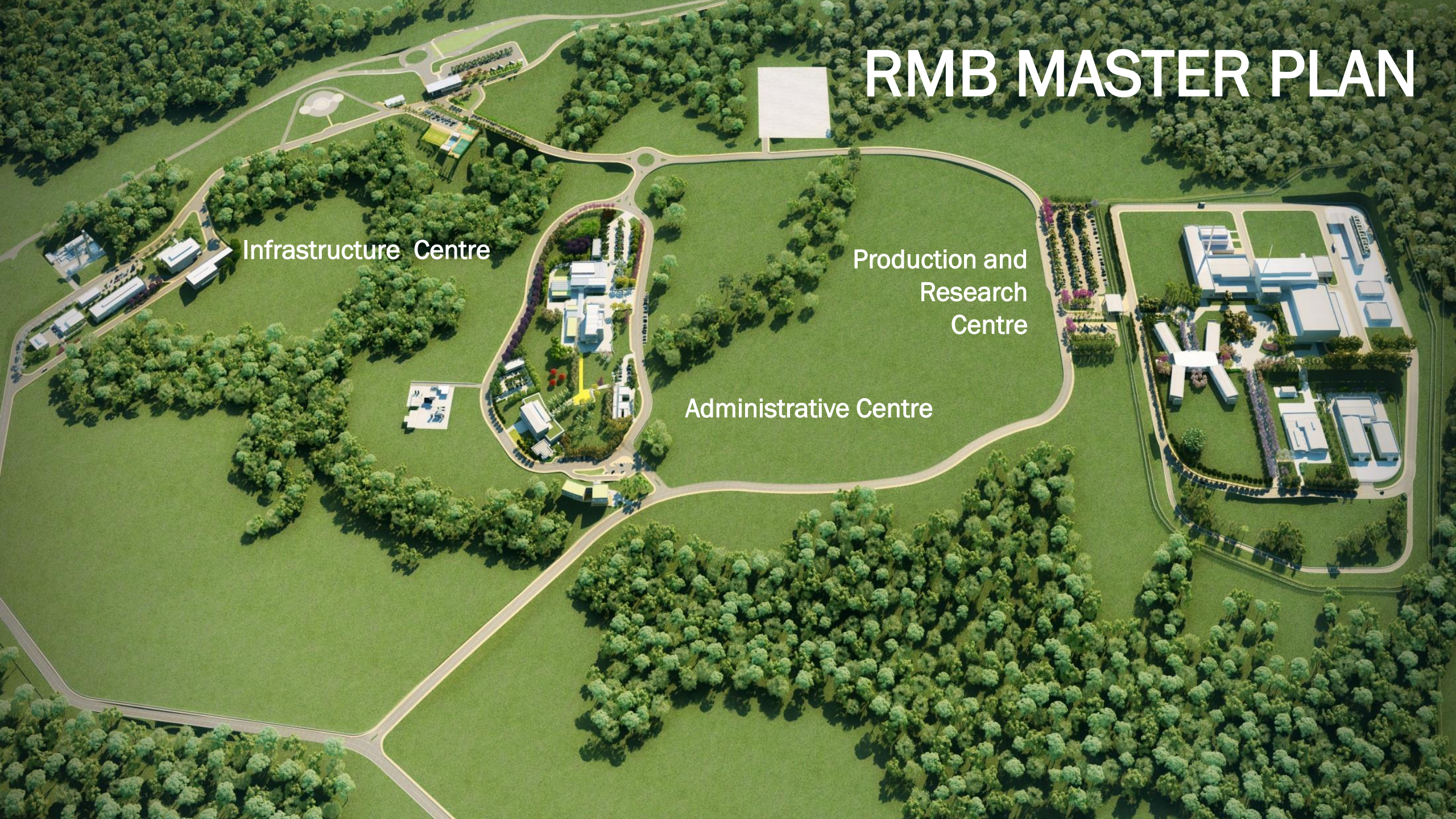
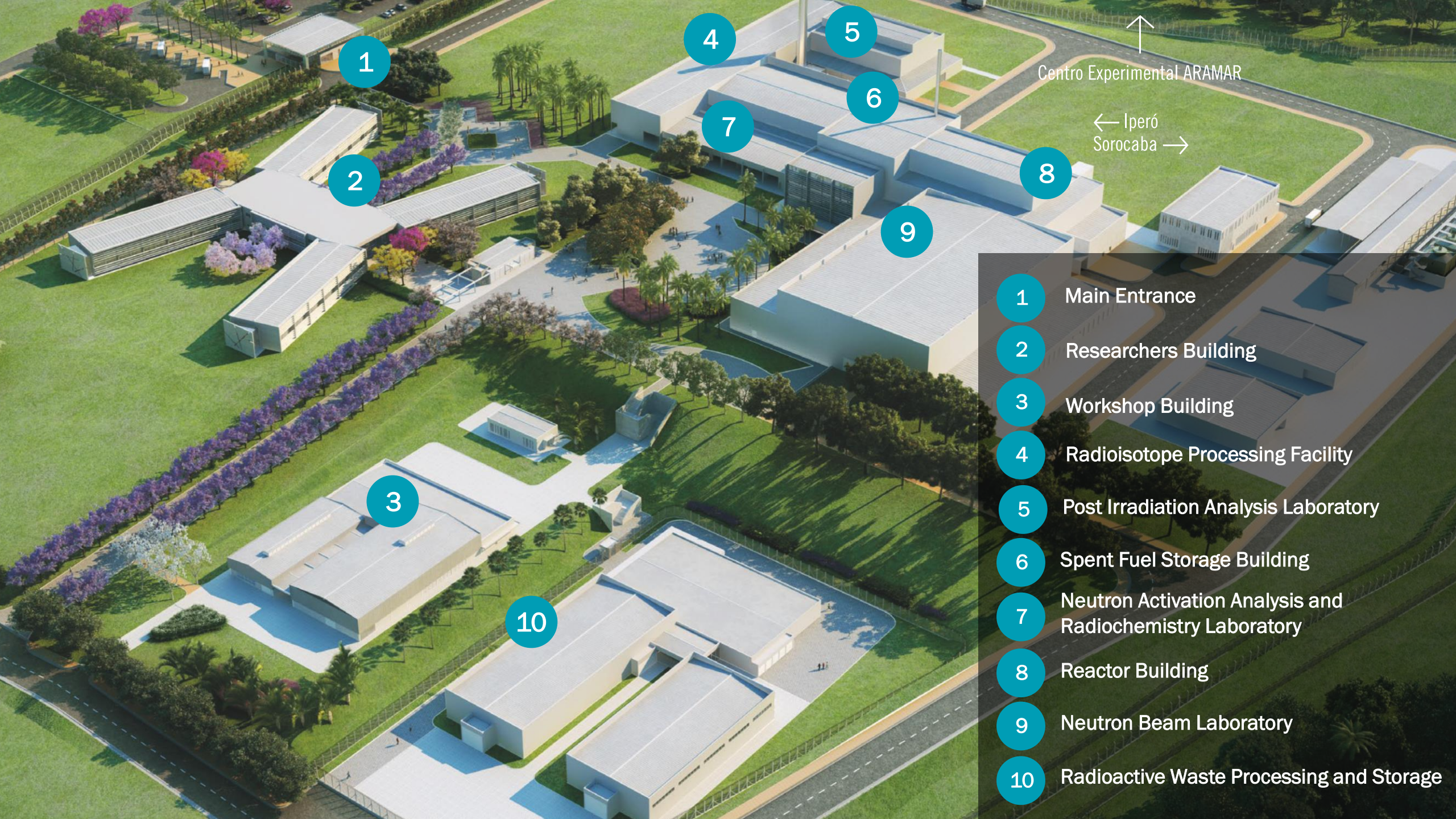
RMB Location

Iperó (SP)

SOROCABA REGION
STATE OF SÃO PAULO
125 Km far from the City of São Paulo


RMB MASTER PLAN
Infrastructure Centre
Production and
Research
Centre
Administrative Centre



1 Main Entrance

2 Researchers Building

3 Workshop Building

4 Radioisotope Processing Facility

5 Post Irradiation Analysis Laboratory

6 Spent Fuel Storage Building

7 Neutron Activation Analysis and Radiochemistry Laboratory

8 Reactor Building

9 Neutron Beam Laboratory

10 Radioactive Waste Processing and Storage

REACTOR BUILDING

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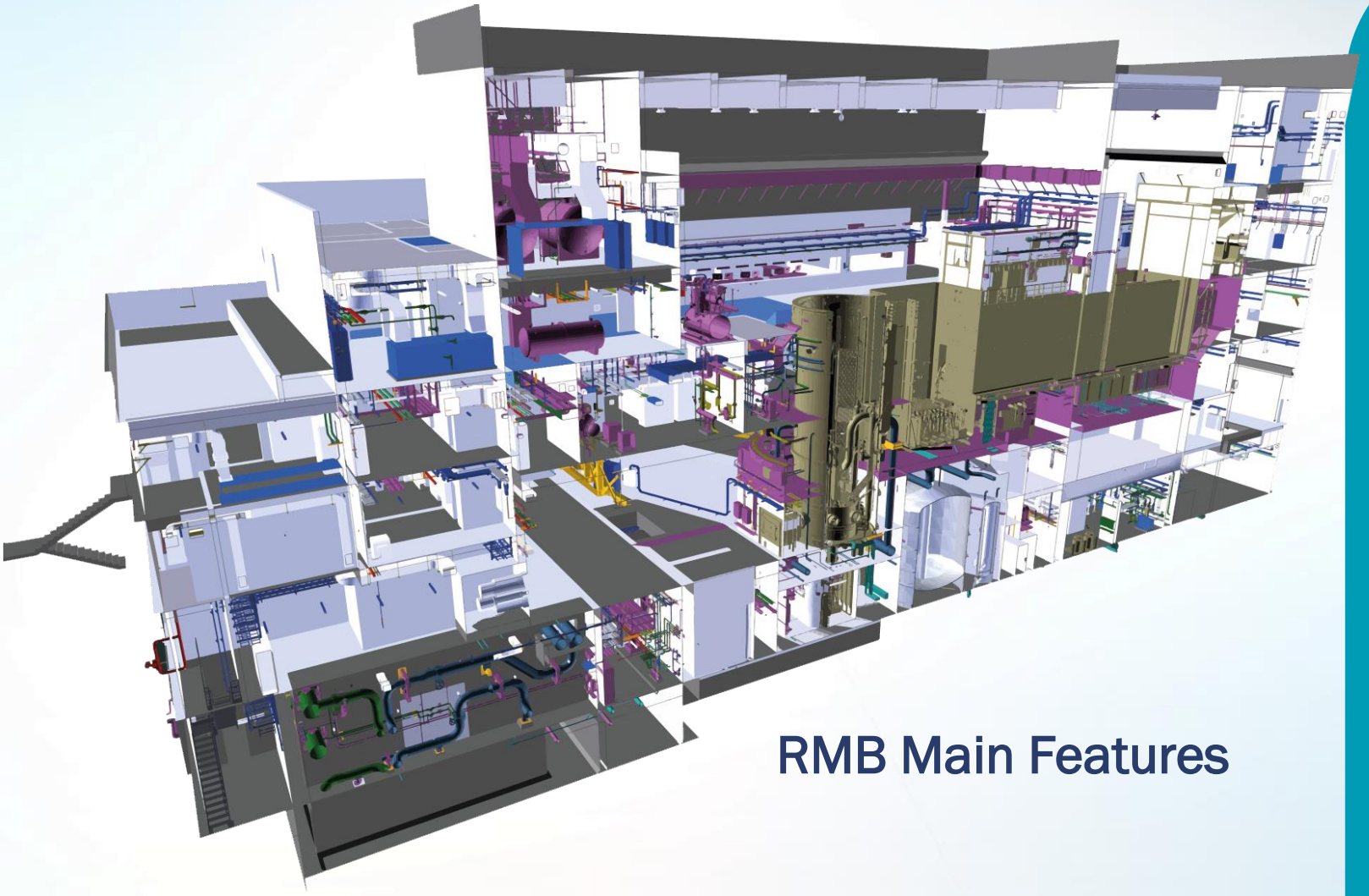
RMB Reator Multipropósito Brasileiro



RMB Main Features

Power
30 MW

Reactor Pool Diameter and Height
5,10 m x 14,0 m

Reflector
Heavy Water (D_2O) e beryllium

Core cooling flow rate
3100 m^3/h

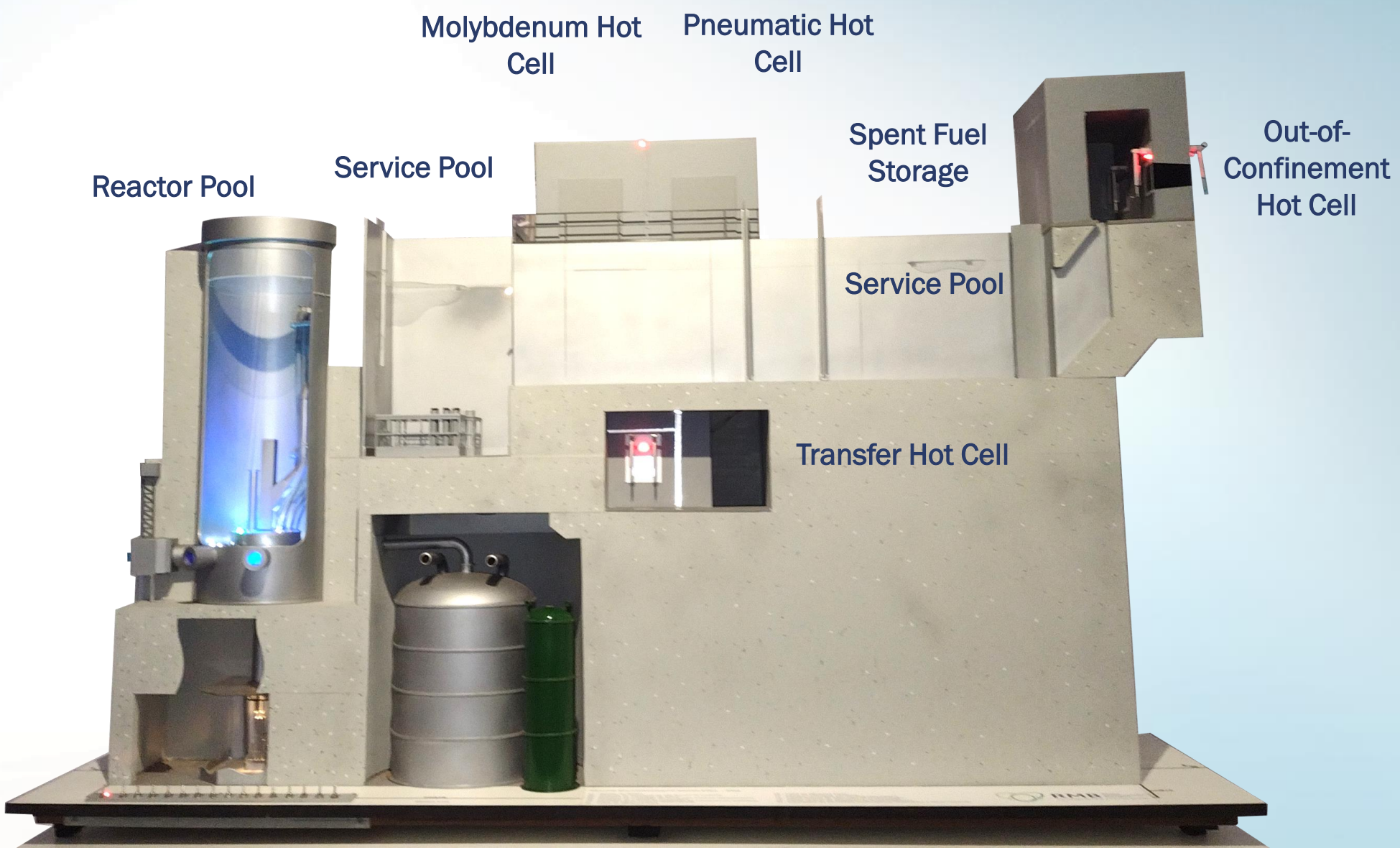
Core Array 5 x 5
(23 fuel elements and 2 in-core irradiation positions)

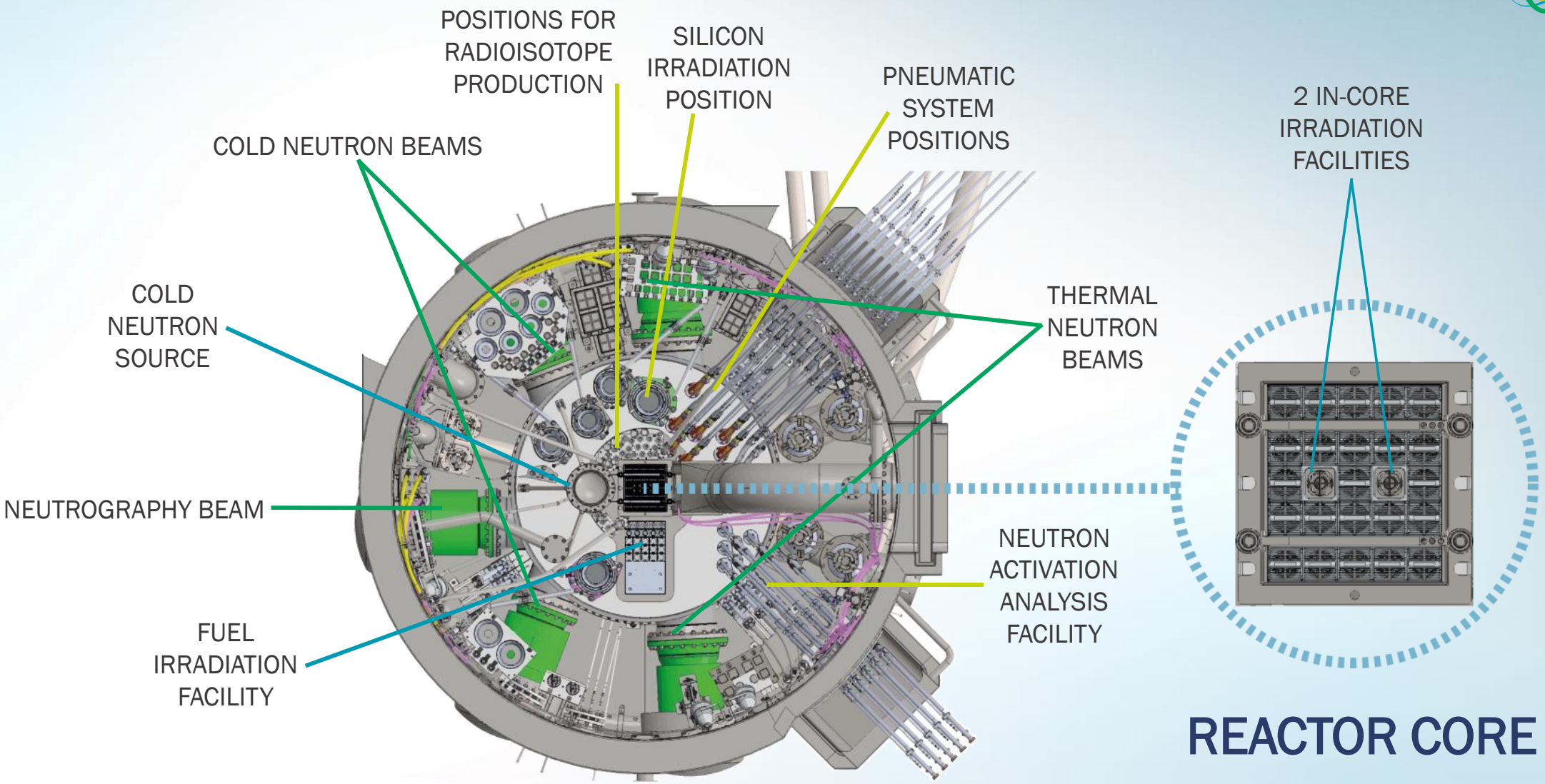
Fuel Element (LEU)
U_3Si_2 – Al

First Shutdown System
6 hafnium plates

Second Shutdown System
Reflector Tank (D_2O) partial drainage

Spent fuel pool / 100 year-storage

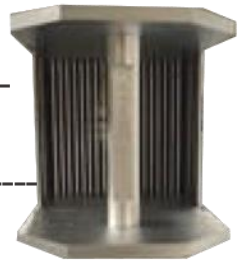

Molybdenum Hot Cell
Pneumatic Hot Cell
Reactor Pool
Service Pool
Spent Fuel Storage
Out-of-Confinement Hot Cell
Service Pool
Transfer Hot Cell

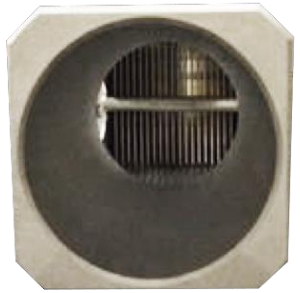

POSITIONS FOR RADIOISOTOPE PRODUCTION
SILICON IRRADIATION POSITION
PNEUMATIC SYSTEM POSITIONS
COLD NEUTRON BEAMS
COLD NEUTRON SOURCE
THERMAL NEUTRON BEAMS
NEUTROGRAPHY BEAM
NEUTRON ACTIVATION ANALYSIS FACILITY
FUEL IRRADIATION FACILITY
2 IN-CORE IRRADIATION FACILITIES
REACTOR CORE
REACTOR POOL

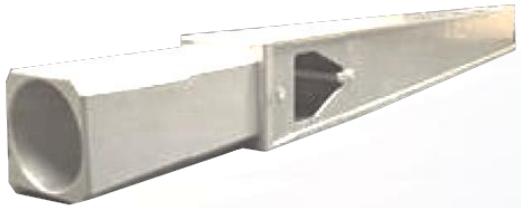
FUEL ELEMENTS

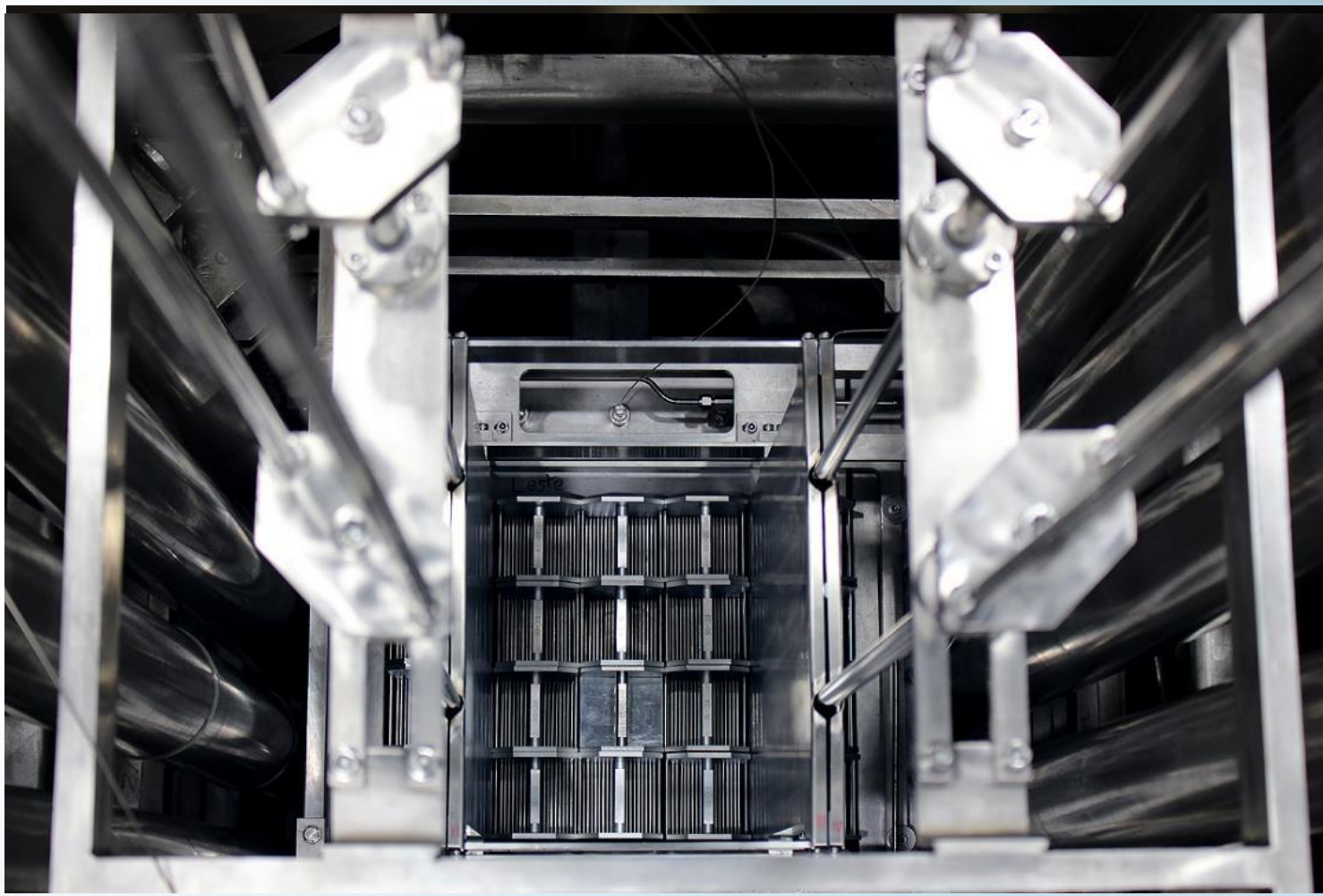
Fuel Plates ----------

Cooling Channels ----------





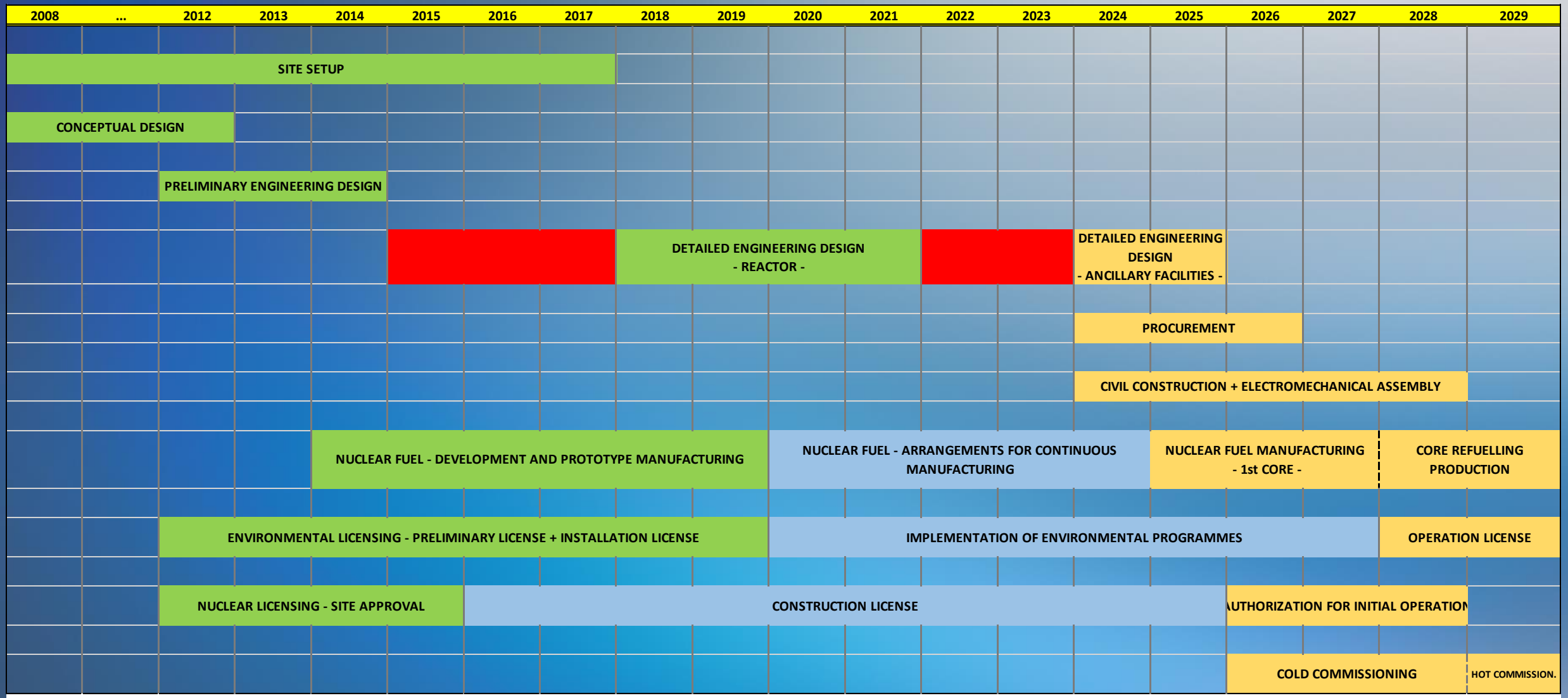




IPEN/MB-01 Reactor Core (RMB core model)

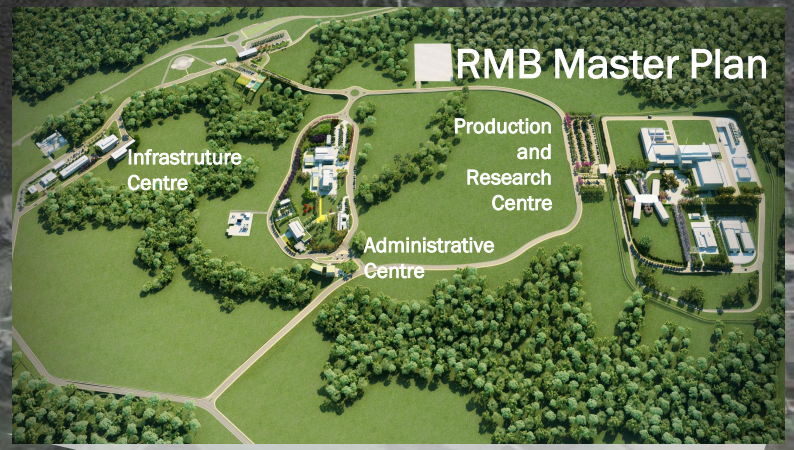
RMB DEPLOYMENT PHASE

RMB
Reator
Multipropósito
Brasileiro



COMPLETE
IN PROGRESS
NOT INITIATED / INTERRUPTED
PLANNED

A NUCLEAR TECHNOLOGY CENTRE FOR THE FUTURE



ARAMAR
Nuclear Industrial Centre
Brazilian Navy

CNEN

CURRENT PROPOSAL

- RMB Reactor
- Neutron Beam National Laboratory
- Radioisotope National Laboratory
- Post-Irradiation Analysis Laboratory
- Neutron Activation Analysis Laboratory

FUTURE EXPANSION

- Nuclear Fusion Laboratory
- Particle Accelerator Laboratory
- High Power Laser Laboratory
- Radiopharmaceutical Centre
- Integrated Diagnosis and Therapy Centre - Radiation Applications
- Nuclear Technology Post-Graduation Centre
- Training Programme in Nuclear Technology Applied to Health

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RMB
Reator Multipropósito Brasileiro

RESPONSÁVEL PELO EMPREENDIMENTO

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

EMPREENDEDOR

CNEN Comissão Nacional de Energia Nuclear

PARCEIRO TÉCNICO

AMAZUL

UNIDADES EXECUTORAS

CDTN CENTRO DE DESENVOLVIMENTO DA TECNOLOGIA NUCLEAR

ien INSTITUTO DE engenharia nuclear

ipen

IRD

CRCN|NE

COLABORADOR TÉCNICO

CTMSP

PATROCINADORES

GABINETE DE SEGURANÇA INSTITUCIONAL

GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

MINISTÉRIO DA SAÚDE

GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

GOVERNO DO ESTADO SÃO PAULO

Prefeitura do IPERO

Finep

APOIADORES

INB

ABEN ENERGIA NUCLEAR

SBMN Sociedade Brasileira de Medicina Nuclear

SBF

SBBN

The future CNEN Nuclear Fusion Laboratory will concentrate and coordinate studies on nuclear fusion in the country

- The executive project of the **Nuclear Fusion Laboratory (LFN)** was completed and its implementation depends only on the release of financial resources

https://www.youtube.com/watch?v=hxQZfXr_ZF8

Nuclear Fusion

- **Nuclear fusion,** the process taking place in the Sun, has the potential to become in the Earth a primary source of electricity supply with low environment impact and for which the resources deuterium and lithium are practically unlimited.

- The most suitable reaction for energy production is between **Deuterium and Tritium** which occurs at temperature in excess of **100 million degrees centigrade**. At these temperatures the gas becomes a **plasma**, which must be confined away from any material surfaces for a minimum period of time in order to allow the nuclear reactions to take place.

- The most advanced process to confine hot plasmas for fusion is using intense magnetic fields in a toroidal ring-shaped geometry, called **Tokamak**.

- **ITER** the International Thermonuclear Experimental Reactor, which is being assembled in Cadarache/France, is based on tokamak concept.

- Recently the high performance of plasma confinement in compact tokamaks, known as **Spherical Tokamak (ST)**, together with the development of **High Temperature Superconductor (HTS),** has attracted the attention of private companies in fusion energy. With high investments they are now foreseeing to produce electricity from fusion in ten years from now.

Fusion Energy in Brazil

- Presently, the fusion activities in Brazil are concentrated in the implementation of the **Laboratório de Fusão Nuclear (LFN)** and in the re-establishment of the **Rede Nacional de Fusão (RNF)**, both coordinated by Comissão Nacional de Energia Nuclear (CNEN).

- Three Institutes have experimental research activities in fusion: Instituto Nacional de Pesquisas Espaciais (INPE) with a Research Agreement with CNEN, operating the **Experimento Tokamak Esférico (ETE**), designed and assembled in Brazil; Universidade de São Paulo, with the **Tokamak Chauffage Alfvén (TCABR)**, brought from Sweden, and Universidade Federal do Espírito Santo, with the small **Tokamak NOVA**, brought from Japan.

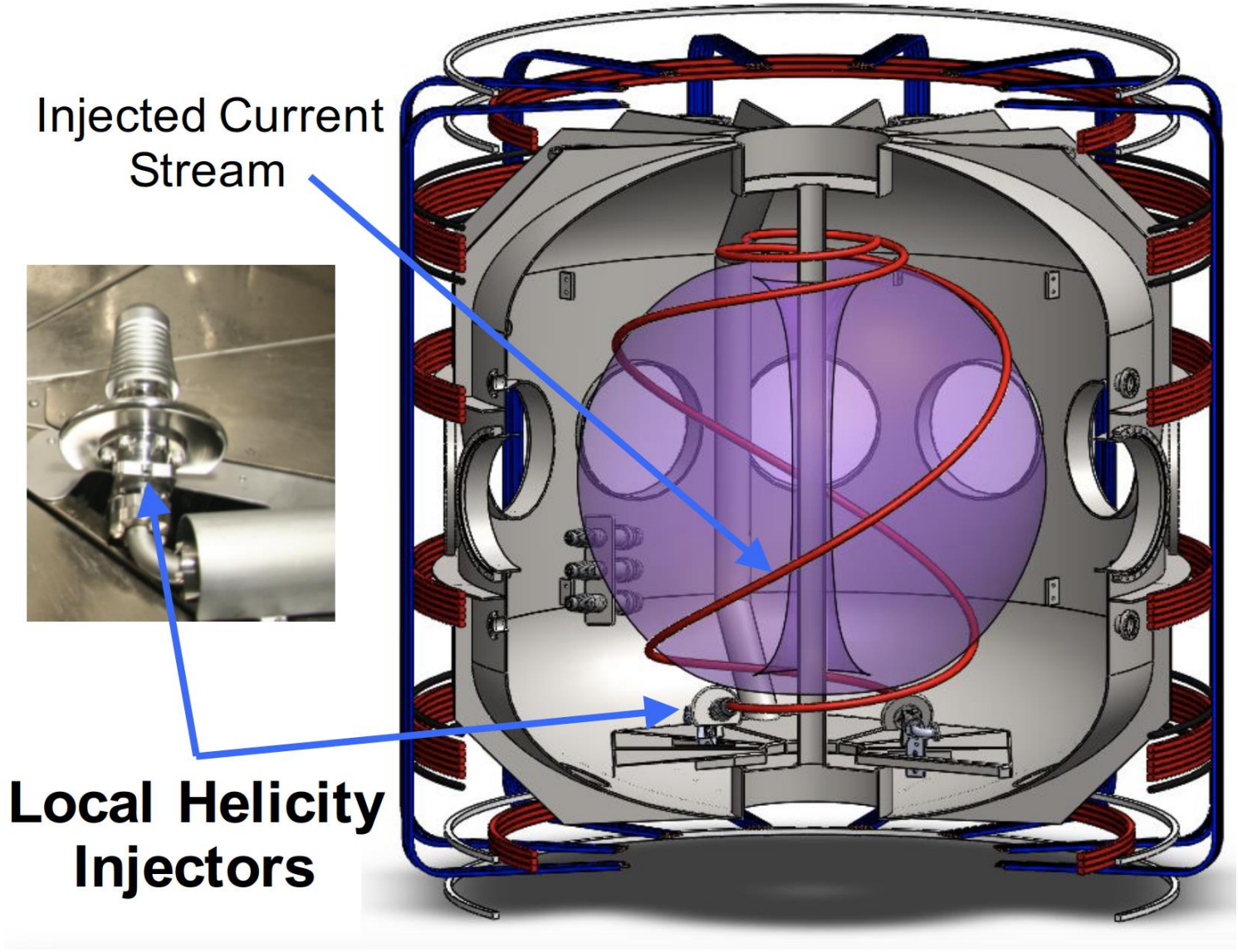
- The fusion plasma community is now evolved in the establishment of the **Programa Nacional de Fusão Nuclear (PNFN**) which was already submitted to MCTI.

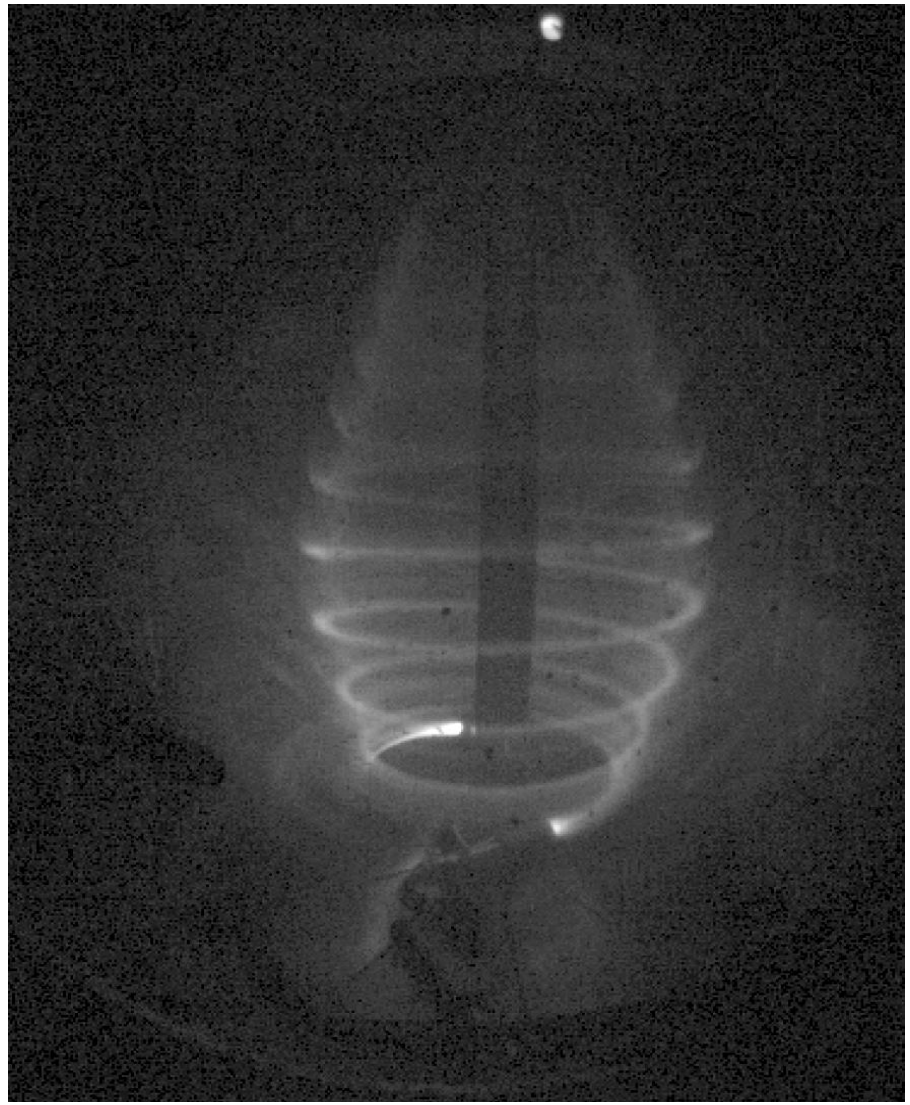
- It is also fundamental to implement the Nuclear Fusion Activities in the **Estratégia Nacional de Ciência, Tecnologia e Inovação (ENCTI) (23/30**).

At the Federal University of Espírito Santo, nuclear fusion research is carried out at the Thermal Plasma Laboratory

- **NOVA-UFES is a small tokamak that is being upgraded with a localized helicity injection system using plasma guns for plasma startup**

At the Federal University of Espírito Santo, nuclear fusion research is carried out at the Thermal Plasma Laboratory





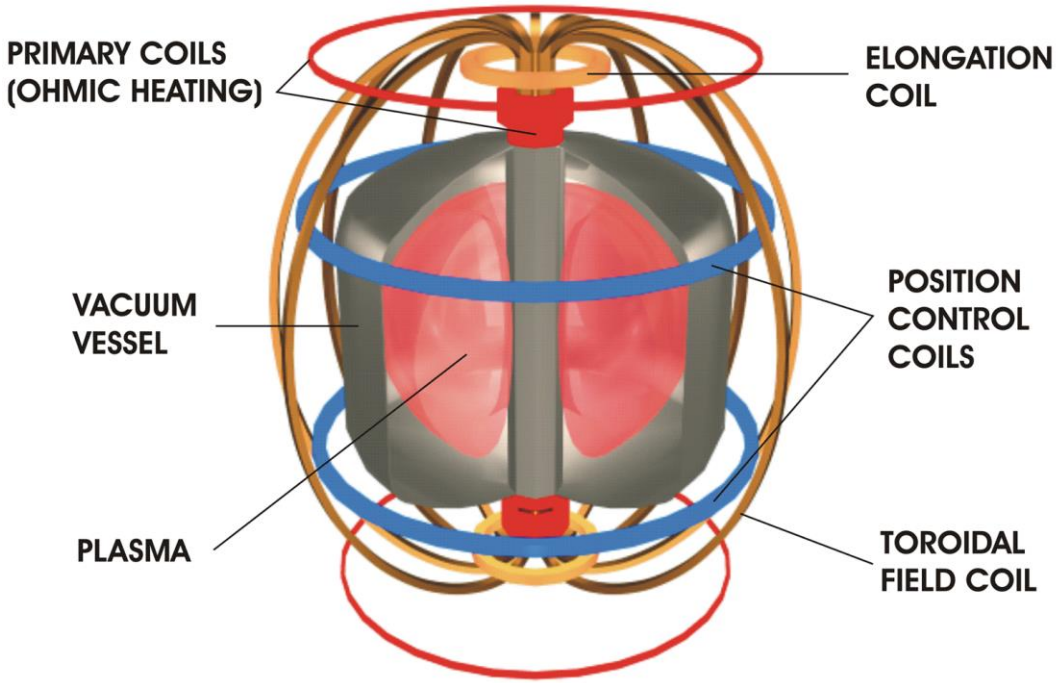
PEGASUS Experiment

At the National Institute for Space Research, nuclear fusion research is carried out at the Associated Plasma Laboratory

- The *Experimento Tokamak Esférico* (ETE) is a machine that exploits the advantages of low aspect ratio plasmas

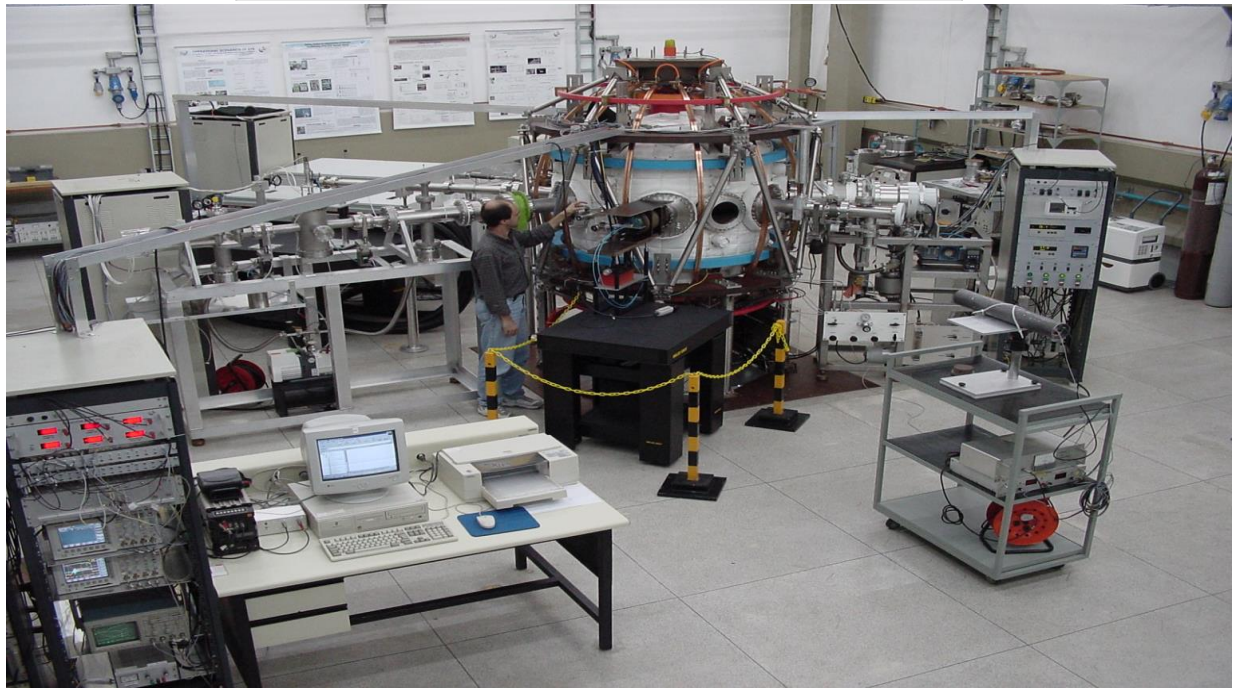
ETE Tokamak

Schematic view of the ETE



Main parameters of the machine

Major radius R_0 = 0.3 m
Minor radius a = 0.2 m
Aspect ratio A = 1.5
Magnetic field B_0 = < 0.8 T
Plasma current I_p = 0.4 MA
Pulse duration t < 50 ms

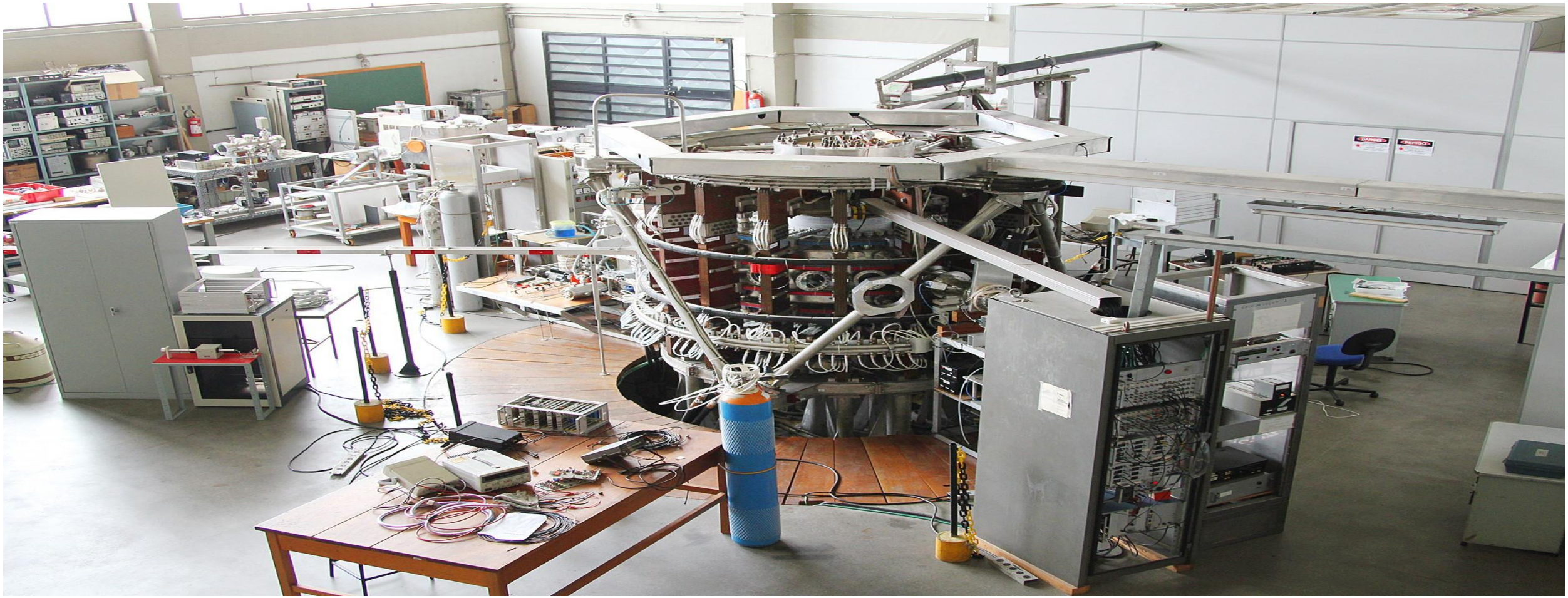


Objectives of ETE

- Explore the physics of low aspect ratio tokamak.
- Undertake diagnostics development.
- Formation of specialized researchers and technicians
- Follow worldwide spherical tokamak achievements

At the Institute of Physics of the University of São Paulo, research on nuclear fusion is carried out at the Plasma Physics Laboratory

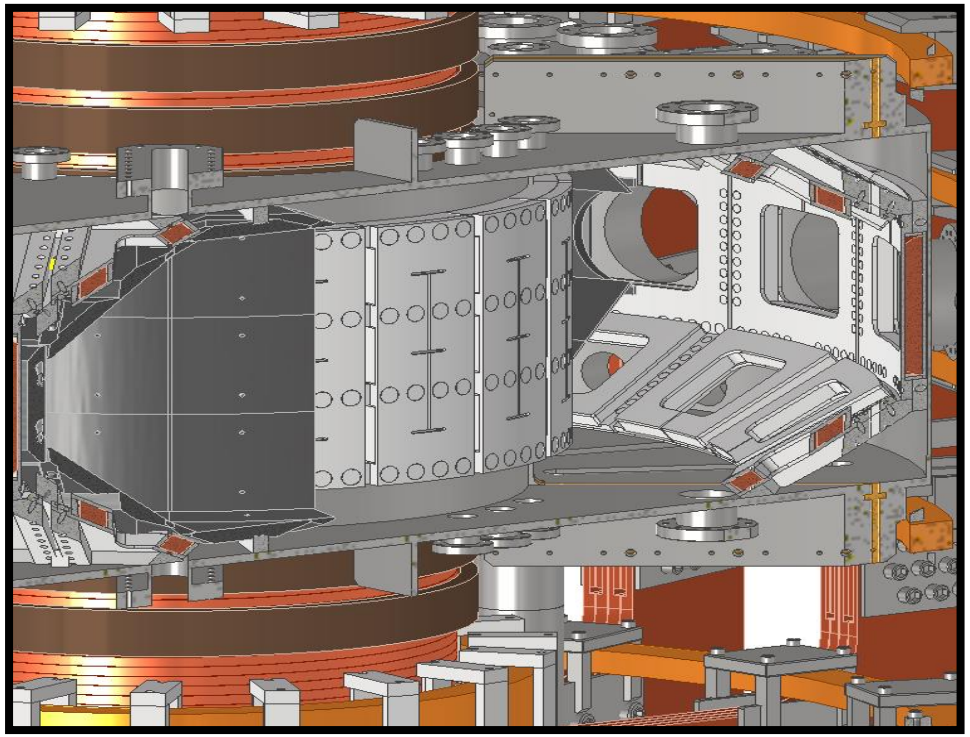
- **The *Tokamak à Chauffage Alfvén Brésilien* (TCABR) is the largest tokamak in Brazil**
  - TCABR is being upgraded with an innovative set of resonant magnetic perturbation (RMP) coils for controlling plasma edge instabilities



An innovative set of RMP coils will allow for detailed validation of physical models of tokamak plasma response to RMP fields

- **The new TCABR RMP coils system will make it possible to carry out unique studies on ELM suppression/mitigation**

- **There are lots of technological challenges construction of this coils**
  - *High current (DC: 2 kA; AC: 1kA)*
  - *High frequency (0 Hz - 10 kHz)*
  - *High voltage (4 kV)*
  - *High temperature (200 ^{o}C)*
  - *High vacuum (1x10^{-7} mbar)*
  - *Strong mechanical forces (6 kN)*



A mechanical failure can be catastrophic!

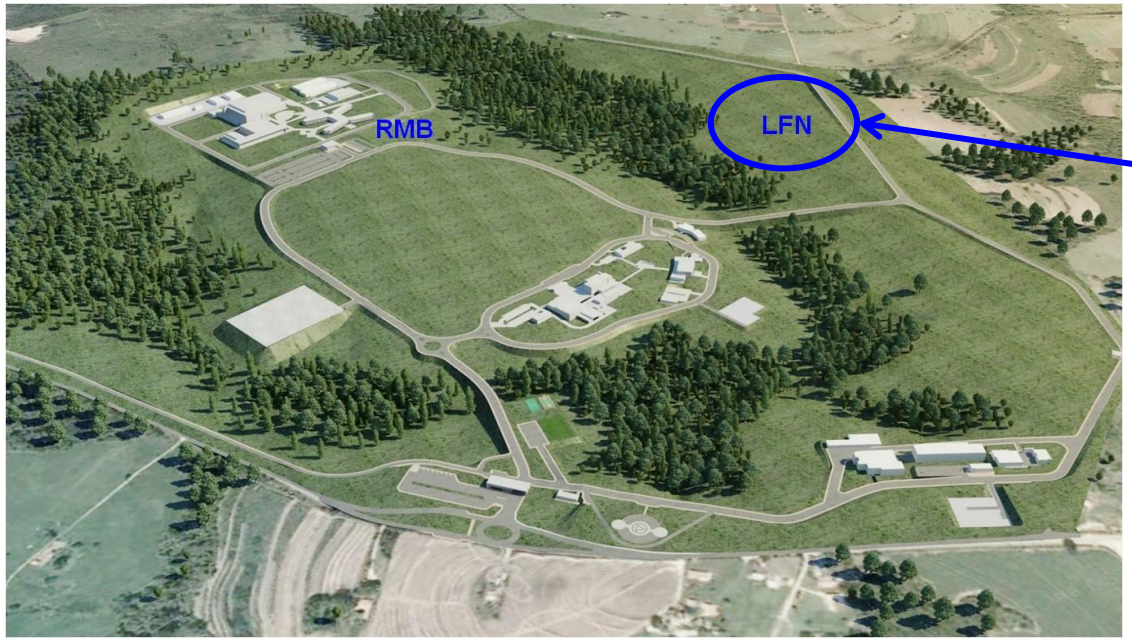
The materials selection and manufacturing processes of the coils are being discussed

LFN – Laboratório de Fusão Nuclear

- The LFN is planned to be a big Laboratory with national character, in order to provide the proper conditions for developing fusion relevant physics and technologies in Brazil. Its is expected to bring Brazil again to the main international scenario of the nuclear fusion development.

- The LFN is planned to be built in an area nearby the **Brazilian Multipurpose Reactor in Iperó/SP**.

- The Executive Project of the main building of LFN was completed in 2018. It has a useful area of about **8.000m²** and the costs for its construction are about R$120 millions already applied to the FNDCT.



CENTENA

A Centre for Research, Development and Innovation in the Management and Disposal of Radioactive Waste

Comissão Nacional de Energia Nuclear
Centro de Desenvolvimento da Tecnologia Nuclear
Dra. Clédola Cássia Oliveira de Tello
Dr. Rogério Pimenta Mourão

Present Scenario

- Two NPP in operation (Angra 1 and 2);
- Angra 3 under construction;
- R&D Institutions:
  - ✓ CRCN-CO – GO
  - ✓ CDTN and LAPOC – MG
  - ✓ CRCN-NE – PE
  - ✓ IEN and IRD – RJ
  - ✓ IPEN, CENA and CTMSP – SP;
- Three research reactors, one experimental facility;
- More than 2,100 radioactive installations;
- Brazilian Multipurpose Reactor (RMB).

Foto: Vanderlei Almeida/Getty Images)

Foto: Santiago. www.cdtn.br

www.cnen.gov.br

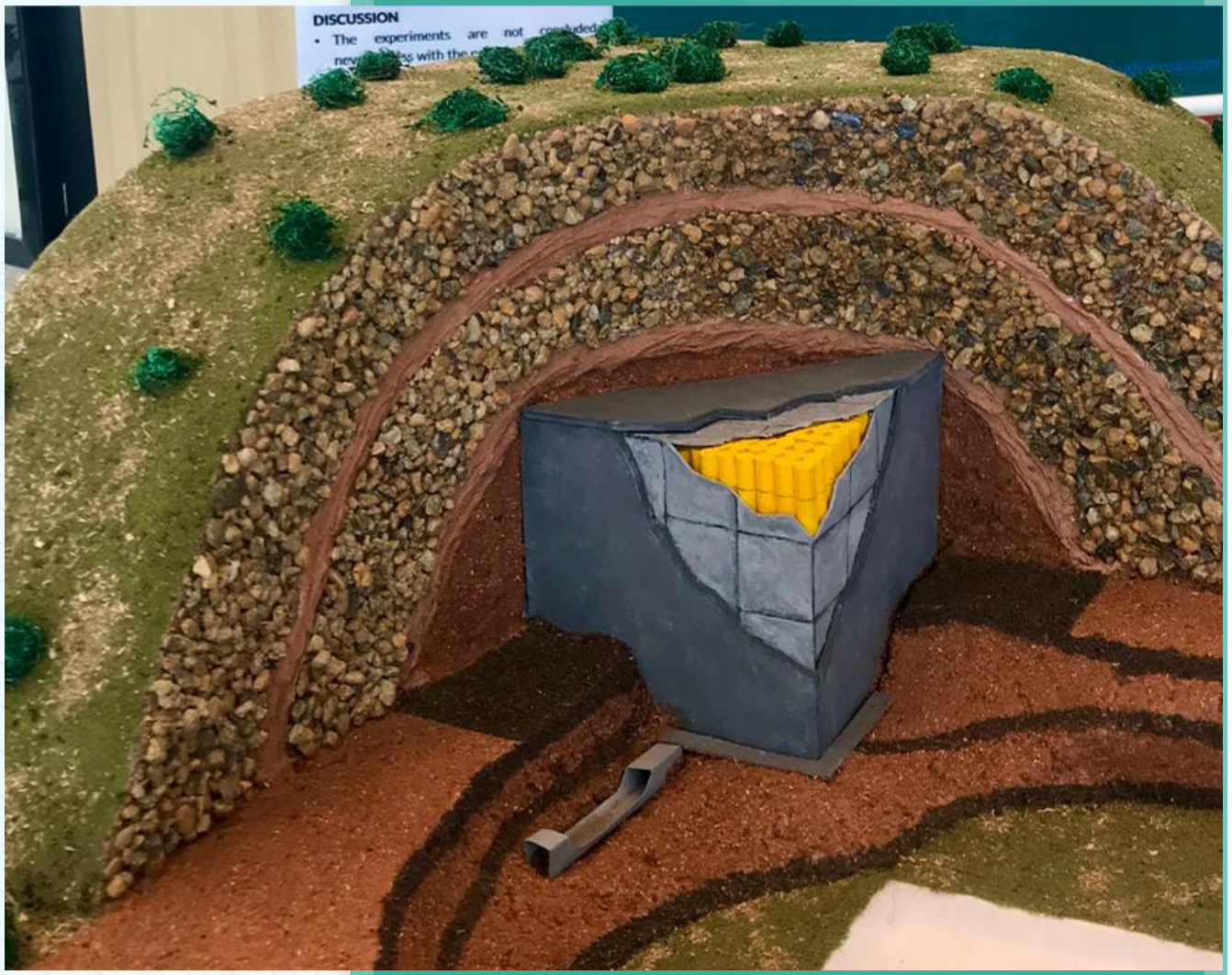

http://www.crcn-co.cnen.gov.br

JUSTIFICATION

- CNEN is legally responsible for the radioactive waste disposal and therefore it has to provide a national repository for this material.
    - The construction and commissioning of CENTENA meets Brazilian needs for the disposal of low- and intermediate-level radioactive wastes, generated by the use of nuclear energy in different areas.
        - This Center will contribute to the sustainability of the sector, since its implementation will complete the cycle of radioactive waste management in the country. Legal, technical, social, economic and environmental aspects will be met at national and international levels.

OBJECTIVE

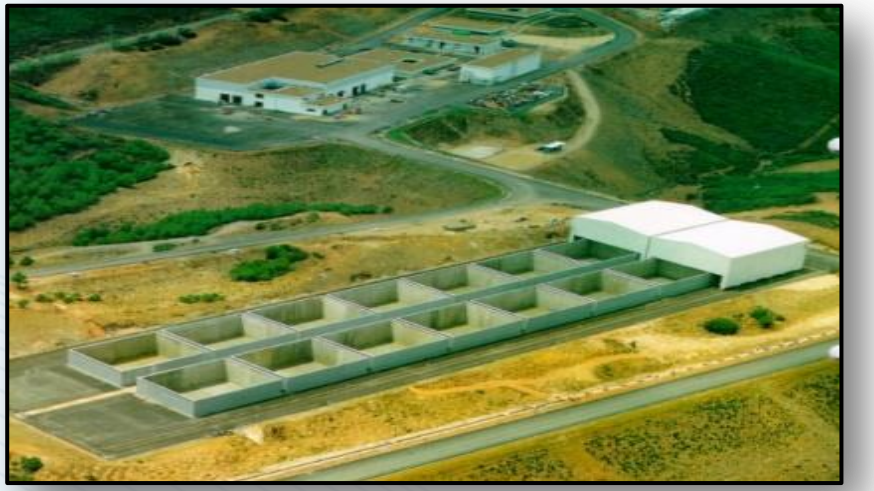
The CENTENA Project aims to design, build, license and put into operation the **CENTENA – Nuclear and Environmental Technological Center** – for disposal of low- and intermediate-level radioactive waste, resulting from the use of nuclear energy in Brazil, as well as for RD&I activities in Radioactive Waste area.



Repository: References

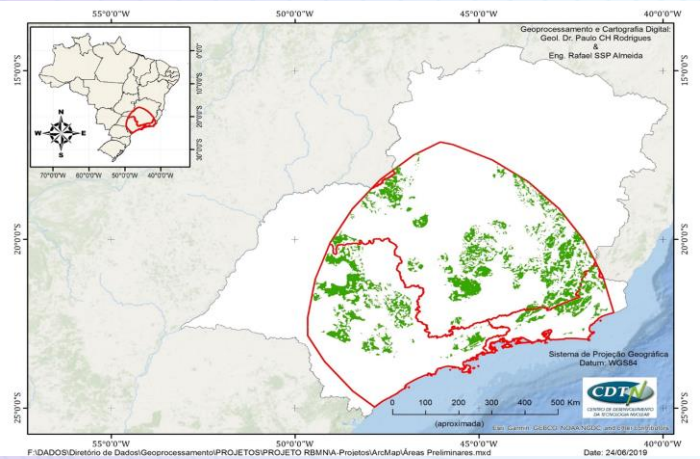
L'Aube
France

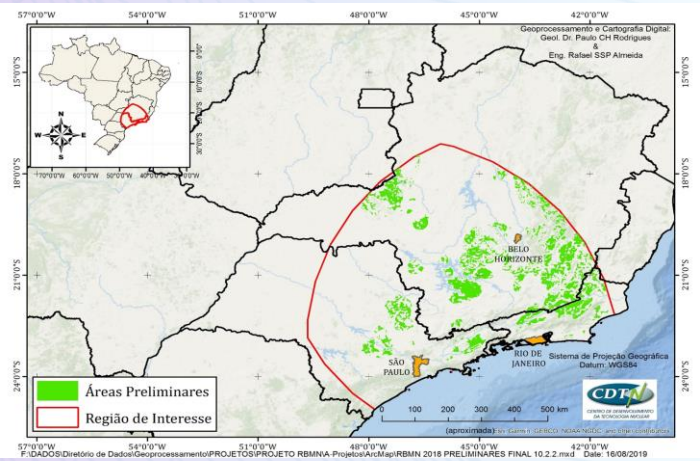
El Cabril
Spain

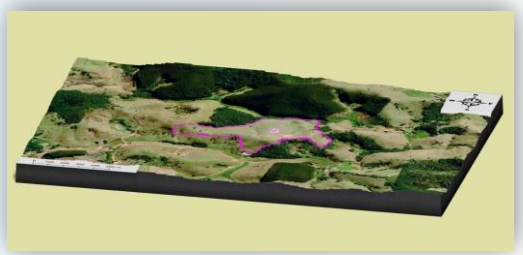


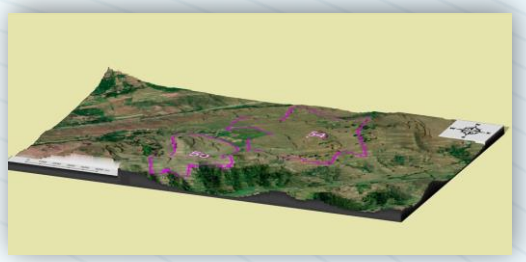
CRCN-CO
Abadia de Goiás - Brazil
(Cesium radiological accident in Goiania)

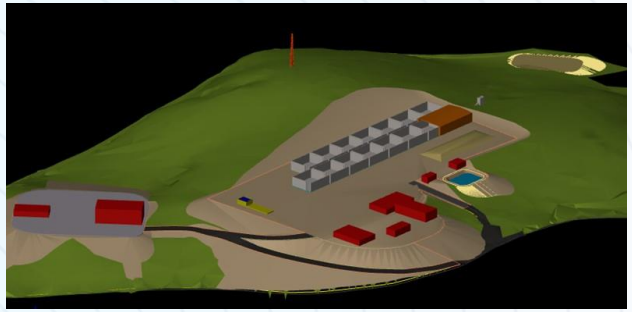
What happens till now?



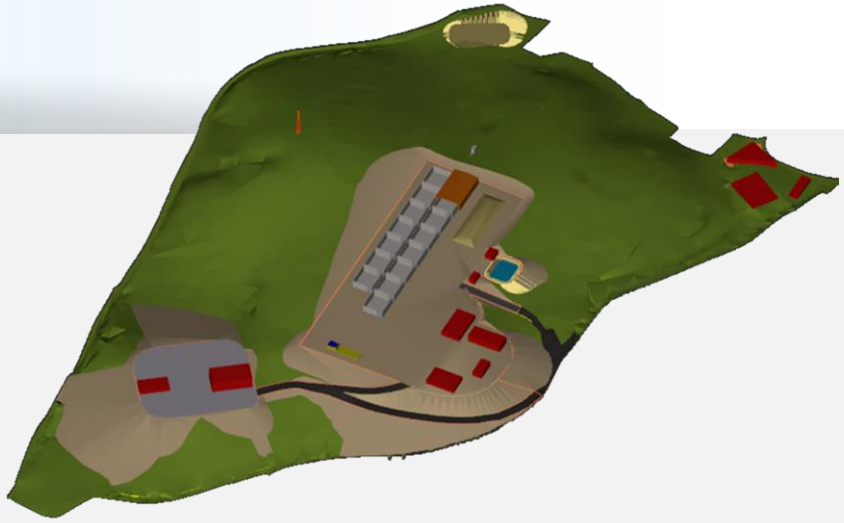




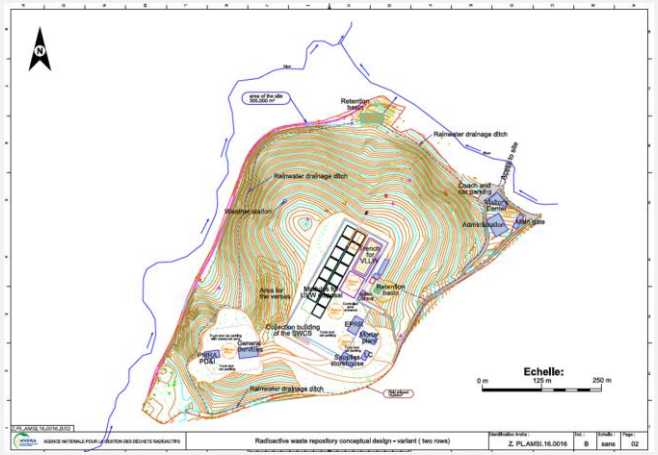




What happened till now?



- ✓ Preliminary Conceptual Design (ANDRA);
- ✓ Preliminary Communication Plan;
- ✓ Communication material;
- ✓ Workshop with the main RW generators;
- ✓ Establishment of a work group by GSI, which objective was to define the goals and responsibilities related to the execution of CENTENA;



What happened till now?

- ✓ Studies to define the Waste Acceptance Criteria (WAC);
- ✓ Study of the positive and negative impacts of the Repository in Abadia de Goiás – CRCN-CO;
- ✓ R&D activities to study the different barriers for the disposal system;
- ✓ Lato sensu Course - Specialization in “Radioactive waste management”;
- ✓ Preliminary Business Plan.

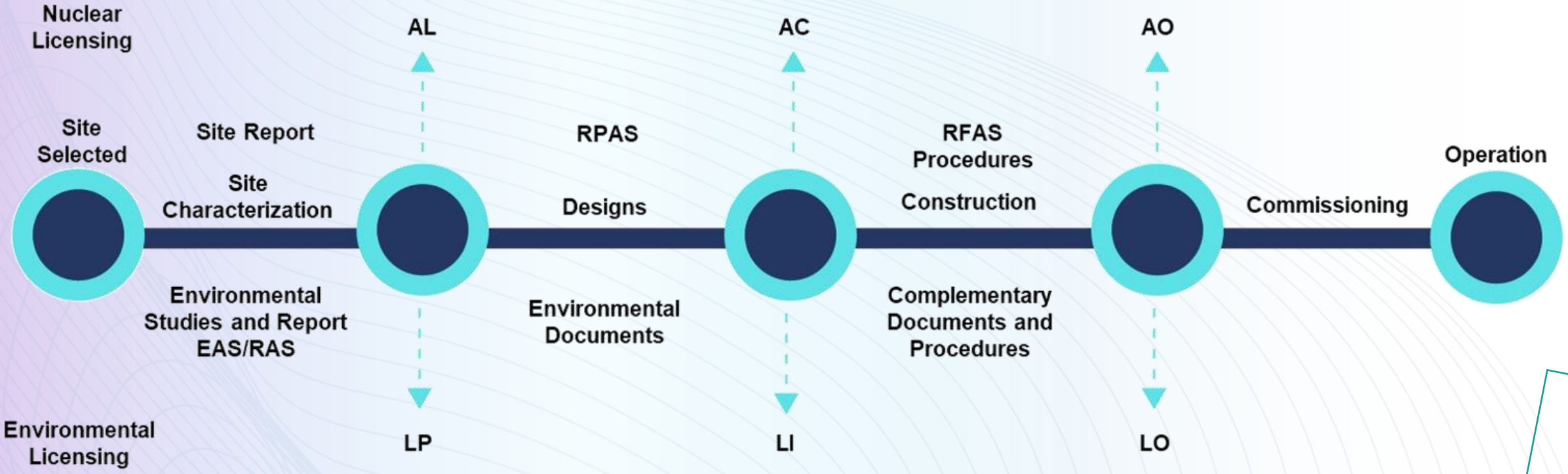
What happened till now?

- ✓ Themes for RD&I activities identified;
- ✓ Establishment of partnerships;
- ✓ Risk management plan;
- ✓ Workshop “Opportunities” with different stakeholders;
- ✓ Public Communication Program.

What comes next?

- ✓ Communication Program for the region;
- ✓ Characterization of the site;
- ✓ Environmental and radiological studies;
- ✓ Site Reports for both Regulators (IBAMA and CNEN);

CENTENA Project Status



Challenges

- ✓ The discussion with the stakeholders, especially those from the region where the repository will be installed, will require political negotiations, and certainly hearings, that can affect the schedule.
- ✓ It will be necessary optimize the resources and the time, preserving the quality, in order to give confidence to all stakeholders.

Sustainability of Nuclear Area

- ✓ *The waste management is a key component for achieving the sustainability in the nuclear area.*
- ✓ *Waste life cycle – from generation to disposal.*

L'Aube - France

Conclusion

- ✓ The CENTENA Project brings a national solution for the safe storage of radioactive waste (LILW) generated by the use of radioisotopes and nuclear energy in Brazil.
- ✓ Release of interim storage.
- ✓ Safe disposal .

Stakeholders

- ✓ CDTN: SEGRE, SEAMA, SEENG, SELOG, SEMAV, SENAN, SETEC, SETRE, ASCOM, DIFES (PG e BIC);
- ✓ CNEN, DPD and Institutes;
- ✓ MCTI, SUV, ASPAR;
- ✓ UFMG (LabGEO da EE), FUMEC (LESC);
- ✓ CETEM, FUNDEP, IEBT, AMAZUL, UNB.
- ✓ CNEN, CAPES, CNPq, FAPEMIG - specialization scholarships

granioter
HUB TECNOLÓGICO DE MATERIAIS AVANÇADOS E MINERAIS ESTRATÉGICOS

CDTN
CENTRO DE DESENVOLVIMENTO DA TECNOLOGIA NUCLEAR

CNEN
Comissão Nacional de Energia Nuclear

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

GraNioTer - Technological Hub on Advanced Materials and Strategic Minerals

COMISSÃO NACIONAL DE ENERGIA NUCLEAR
Centro de Desenvolvimento da Tecnologia Nuclear
Dr. Maximiliano Delany Martins

Academia

Industry
Market

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TECHNOLOGICAL HUB FOR ADVANCED MATERIALS AND STRATEGIC MINERALS

TRL0 — Nascimento da ideia

TRL1 — Início das pesquisas Observação e relato

TRL2 — Conceito e aplicação

TRL3 — Prova de Conceito Formulação e aplicações possíveis

TRL4 — Protótipo Funcionalidade

TRL5 — Aplicação dentro de um ambiente simulado

TRL6 — Demonstração de teste de protótipo com simulação

TRL7 — Demonstração dentro de ambiente operacional

TRL8 — Projeto aprovado mas ainda em fase pré comercial

TRL9 — Pronto para o mercado

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Objectives

Priority project of Ministry of Science, Technology and Innovation (MCTI) with FINEP funding

1.500 m² – Facilities
270 m² – Coordination Offices

Projects aimed at Graphene, Niobium and Rare Earths

GraNioTer/MCTI has as main objective support the development of products and processes based on Advanced Materials and Strategic Minerals.

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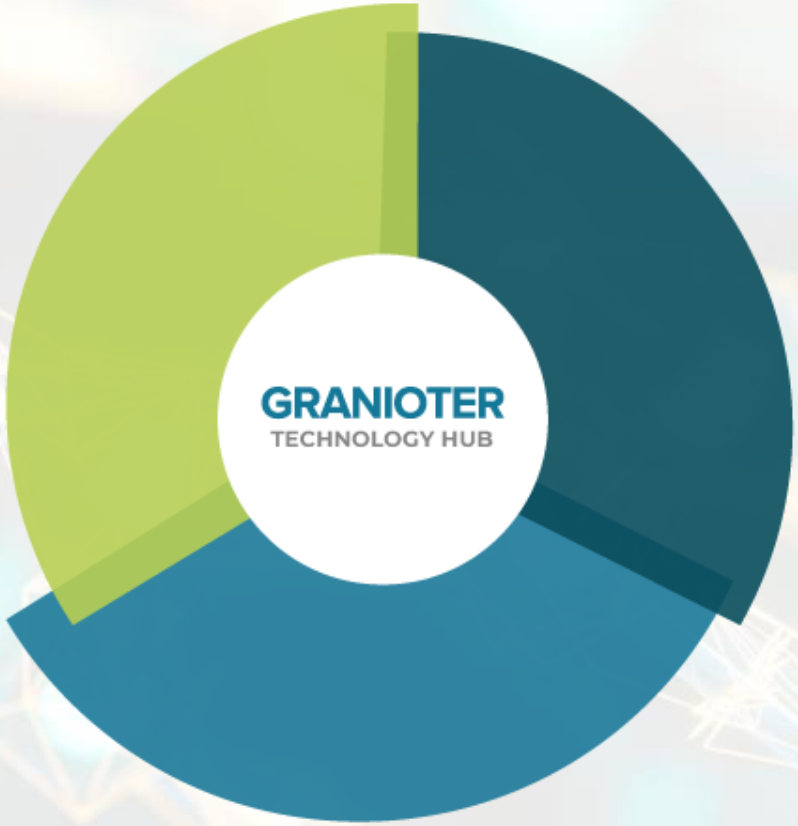

RD&I

- Spin-offs
- Science and Technology Institutions
- Scientific Community
- Startups

PARTNERS

- Public-Private Funders
- Strategic Partners
- Advanced Materials Manufacters
- Strategic Minerals Suppliers

MARKET

- Multinationals
- Large Companies
- Medium-sized Companies

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$ Support $

Implementation (Phase-1): R$ 12 million

➔Infrastructure renovation (1500 m^2), operation and maintenance

Consolidation (Phase-2): R$ 28 million

Additional budget (Calls) = R$ 4,3 million

TOTAL BUDGET = R$ 44,3 million (~ € 8,5 millions)

FAPEMIG

Finep
INOVAÇÃO E PESQUISA
EMPRESA PÚBLICA DO MCTI

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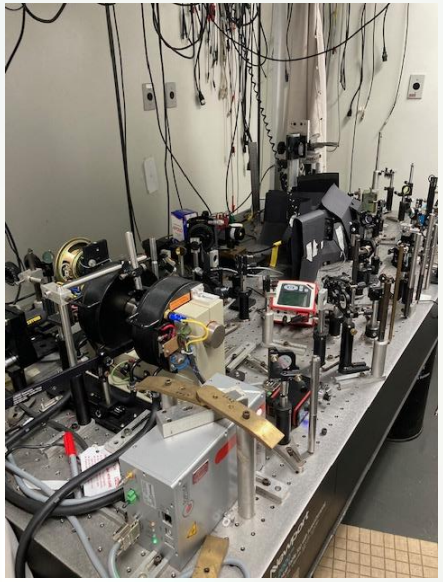
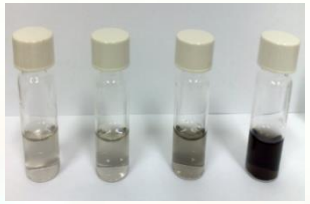
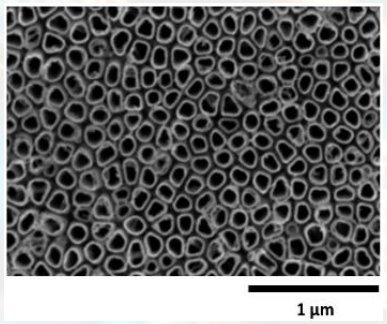
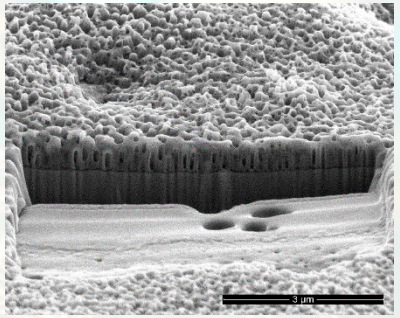
R&D Expertise

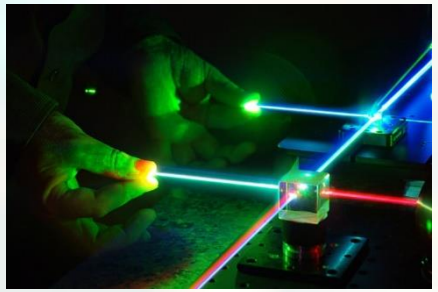
- Graphene & Carbon Nanomaterials
- Magnetic Materials & Nanomaterials
- Mineral processing of strategic minerals
- Applied Surface Science & Engineering
- *Structural Materials and Advanced Manufacturing*
- *Photonics*











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How to bring together academic researches and industry technologists?

Market Intelligence Coordination

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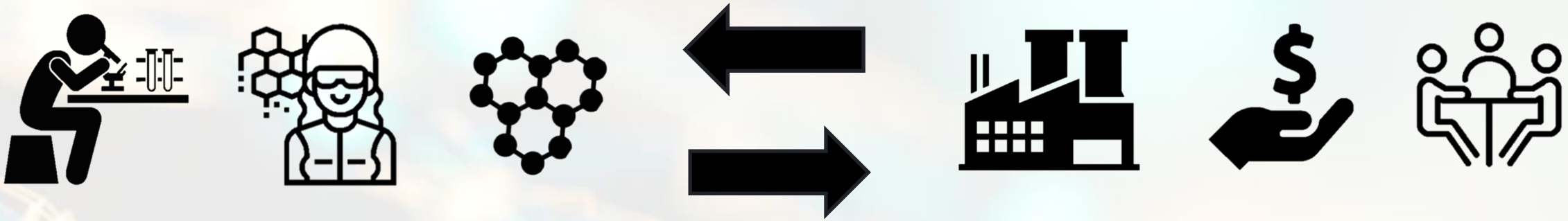
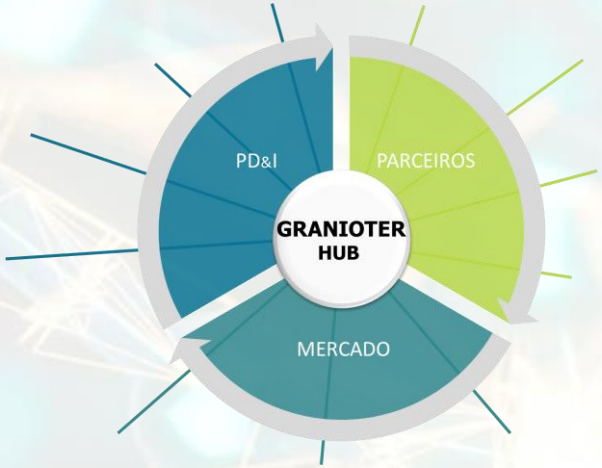


TECH PUSH



MARKET PULL

Market Intelligence Coordination

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- ✓ Prospecting of Partnerships and Collaborations in Brazil and worldwide
- ✓ Repository of know-how in Innovation and Technological Entrepreneurship
- ✓ Meeting/Events Organization:
  - **GraNioTer Meeting 2024 (5-6 Dec 2024)**
- ✓ Strategies to foster innovation in Advanced Materials

"Open Innovation Challenges"

2024 inac

INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE

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Thank you very much!

Wilson Aparecido Parejo Calvo

Diretoria de Pesquisa e Desenvolvimento

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CNEN Comissão Nacional de Energia Nuclear

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