Brazilian Multipurpose Research Reactor

INAC 2024

Rio de Janeiro - Brazil

José Augusto Perrotta

07/May/2024

RMB
Reator
Multipropósito
Brasileiro

Nuclear Technology at the Service of Life

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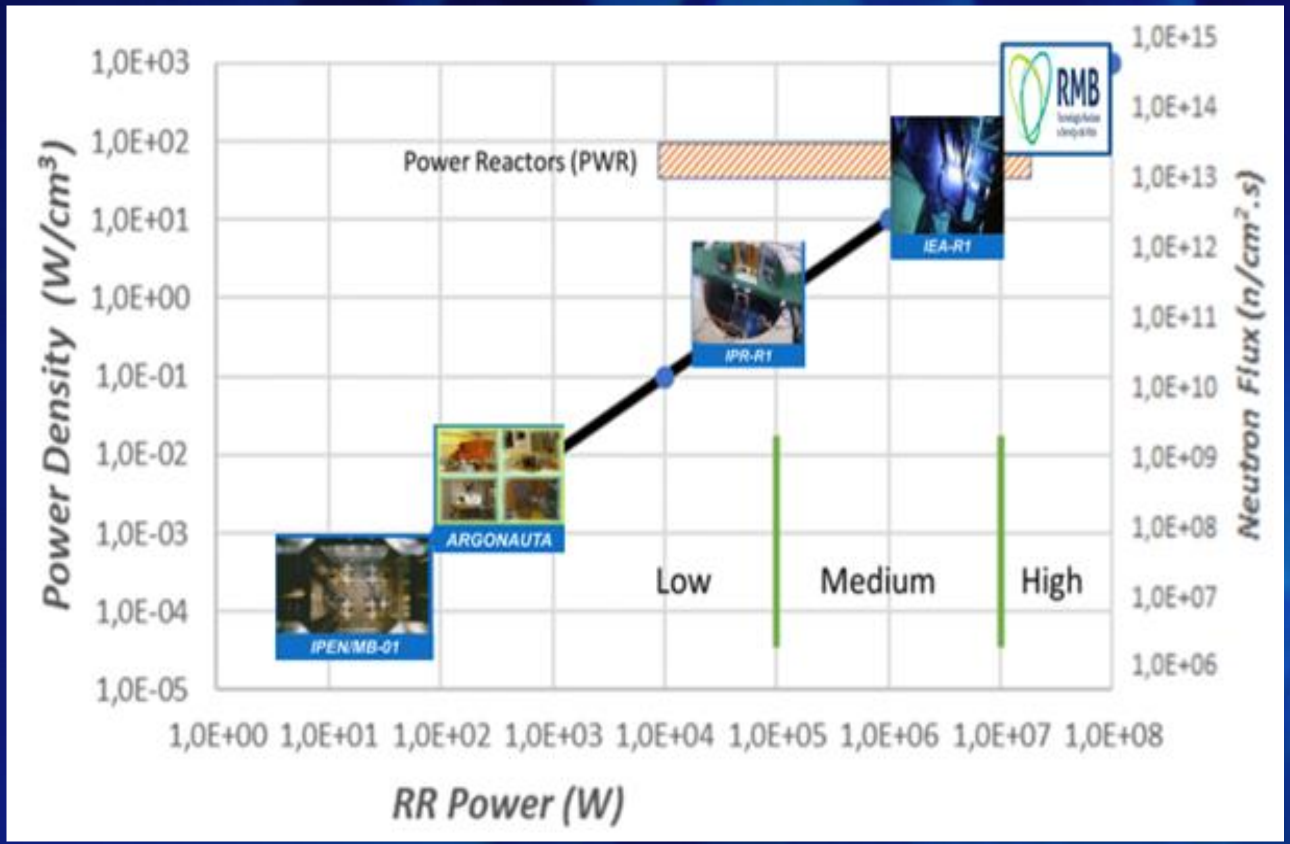
Science
To Discover

Technology
To Develop

Innovation
To Create

Society
To Utilize
(Products and Services)

Research Reactors in Brazil



Utilization	Power				
Material and Fuel Testing					
Neutron Scattering					
Radioisotope Production					
Neutron Activation Analysis					
Education and Training					
	< 1 kW	100 kW	1 MW	10 MW	>10 MW

No capability	Some capability	Full capability

“Graded Approach” in Research Reactor Management

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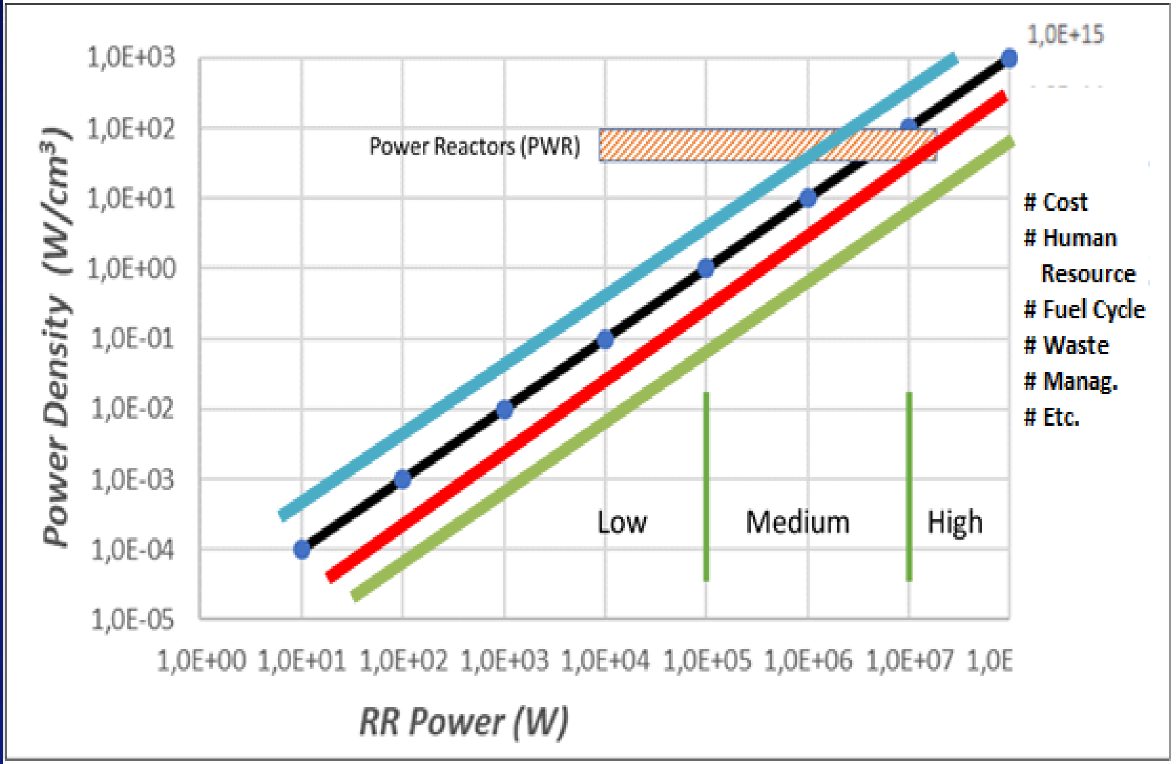

Intensity

Areas with importance to management	Power				
Decommissioning Planning	Not intense	Not intense	Some intensity	Very Intense	Very Intense
Fuel Cycle	Not intense	Not intense	Some intensity	Very Intense	Very Intense
Finance Management	Not intense	Not intense	Some intensity	Very Intense	Very Intense
Radioactive Waste	Not intense	Some intensity	Some intensity	Very Intense	Very Intense
Human Resources Development	Not intense	Some intensity	Some intensity	Very Intense	Very Intense
Integrated Management System	Some intensity	Some intensity	Some intensity	Very Intense	Very Intense
Security	Some intensity	Some intensity	Very Intense	Very Intense	Very Intense
Utilization	Very Intense	Very Intense	Very Intense	Very Intense	Very Intense
Safety	Very Intense	Very Intense	Very Intense	Very Intense	Very Intense
Operation	Very Intense	Very Intense	Very Intense	Very Intense	Very Intense
	< 1 kW	100 kW	1 MW	10 MW	>10 MW

Legend: Not intense | Some intensity | Very Intense

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Why a new research reactor in Brazil?

STRATEGIC AND INDUSTRIAL AREAS

SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

SOCIAL APPLICATIONS

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SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

- RMB expands national capacity in science, technology and innovation
- Activation Analysis Laboratory available to the national scientific community
- Expansion of existing national capacity in research and applications of nuclear techniques
- Creation of a National Laboratory of research with neutron beams to complement the research done at the National Laboratory of Synchrotron Light with X-Ray – LNLS/CNPEM

STRATEGIC AND INDUSTRIAL AREAS

Creation of national capacity

to test and qualify:

- Nuclear fuels for power reactors
- Nuclear fuels for ship-propelled reactors
- New fuels for research reactors
- Materials to be used in nuclear reactors

SOCIAL APPLICATIONS

- National autonomy in the production of radioisotopes for applications in health, industry, agriculture and the environment
- Emphasis on the production of the radioisotope Mo-99 to ensure the supply of the radiopharmaceutical technetium-99m
- Expansion of nuclear medicine in the country for the benefit of society

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STRUCTURING AND TECHNOLOGICAL DRAG PROJECT

RMB DEPLOYMENT PHASE

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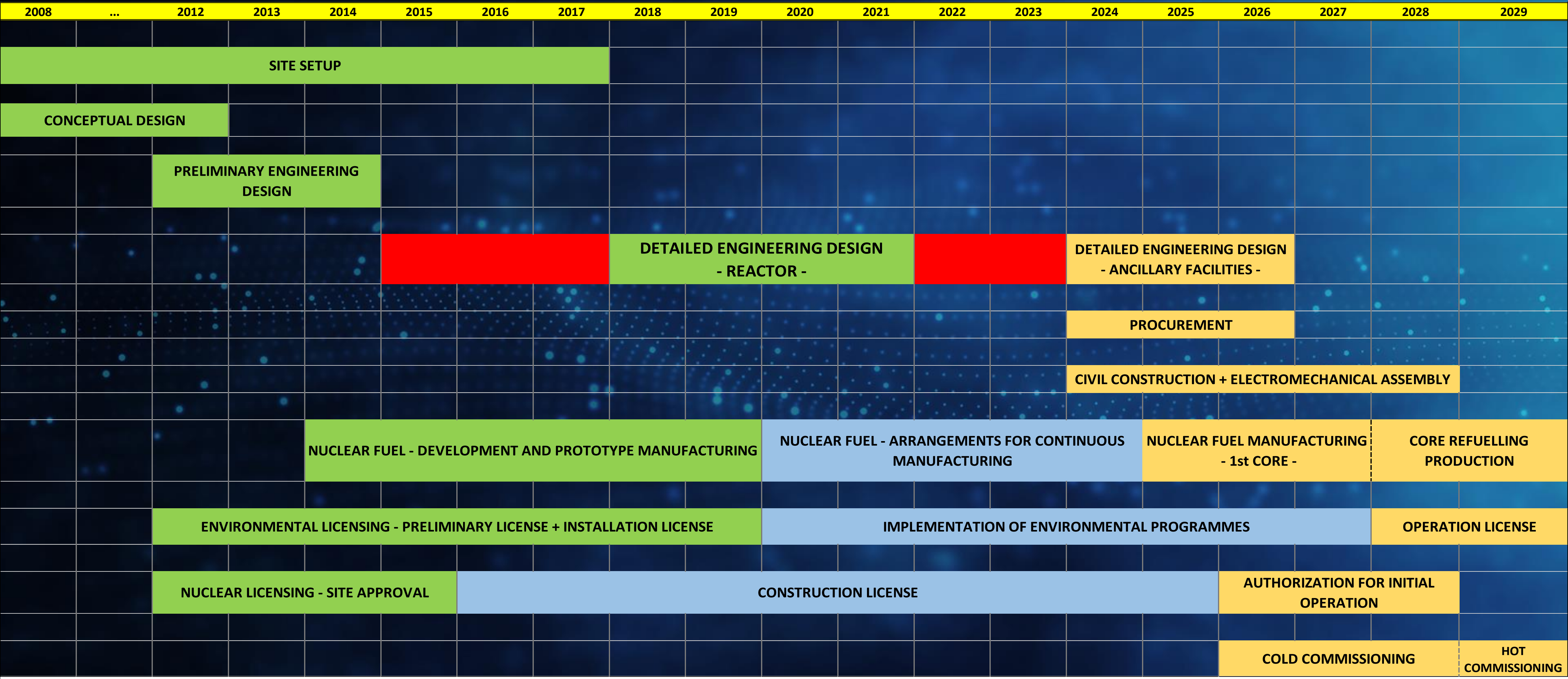

COMPLETE
IN PROGRESS
NOT INITIATED / INTERRUPTED
PLANNED

RMB Location

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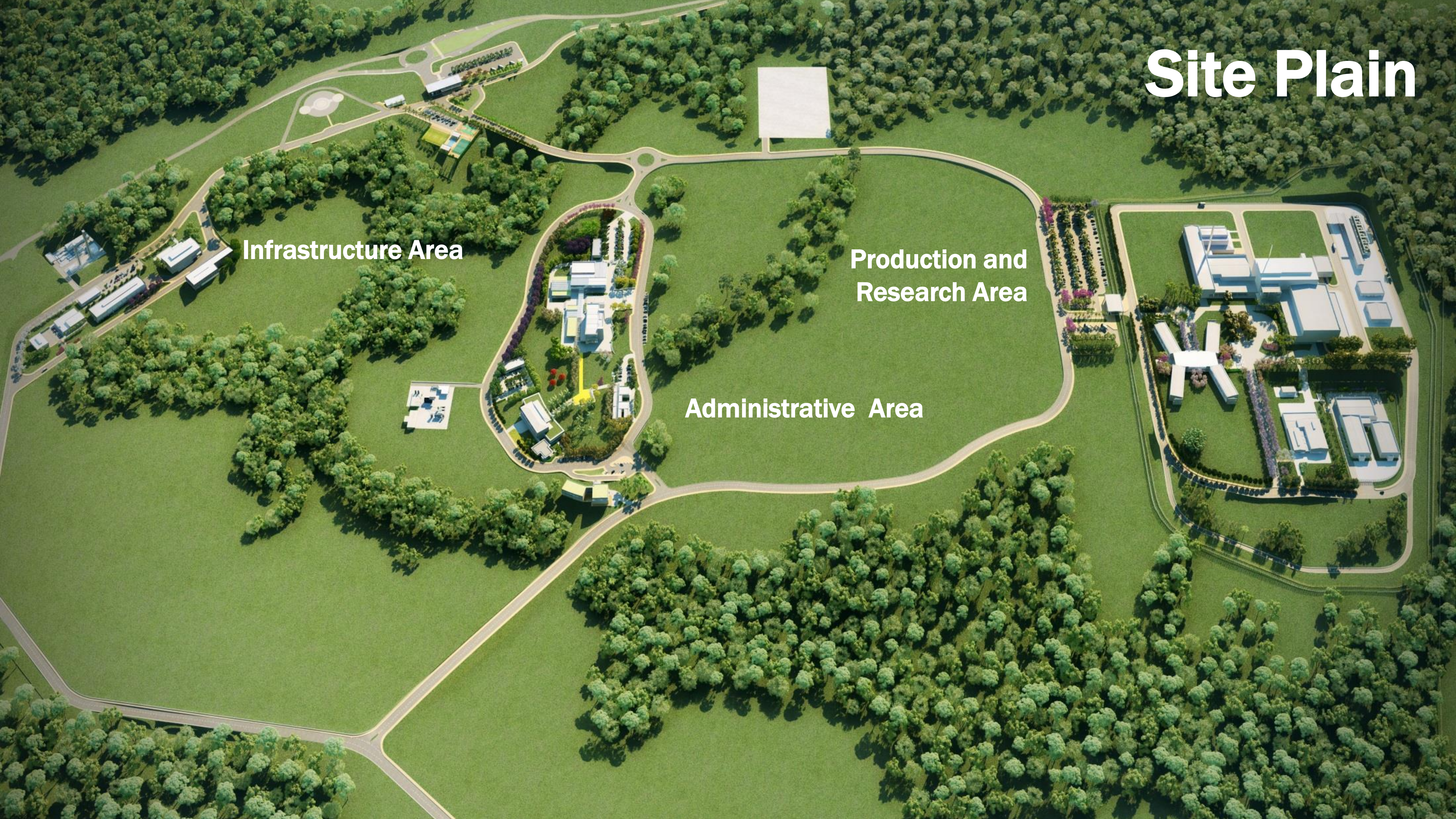
RMB Location

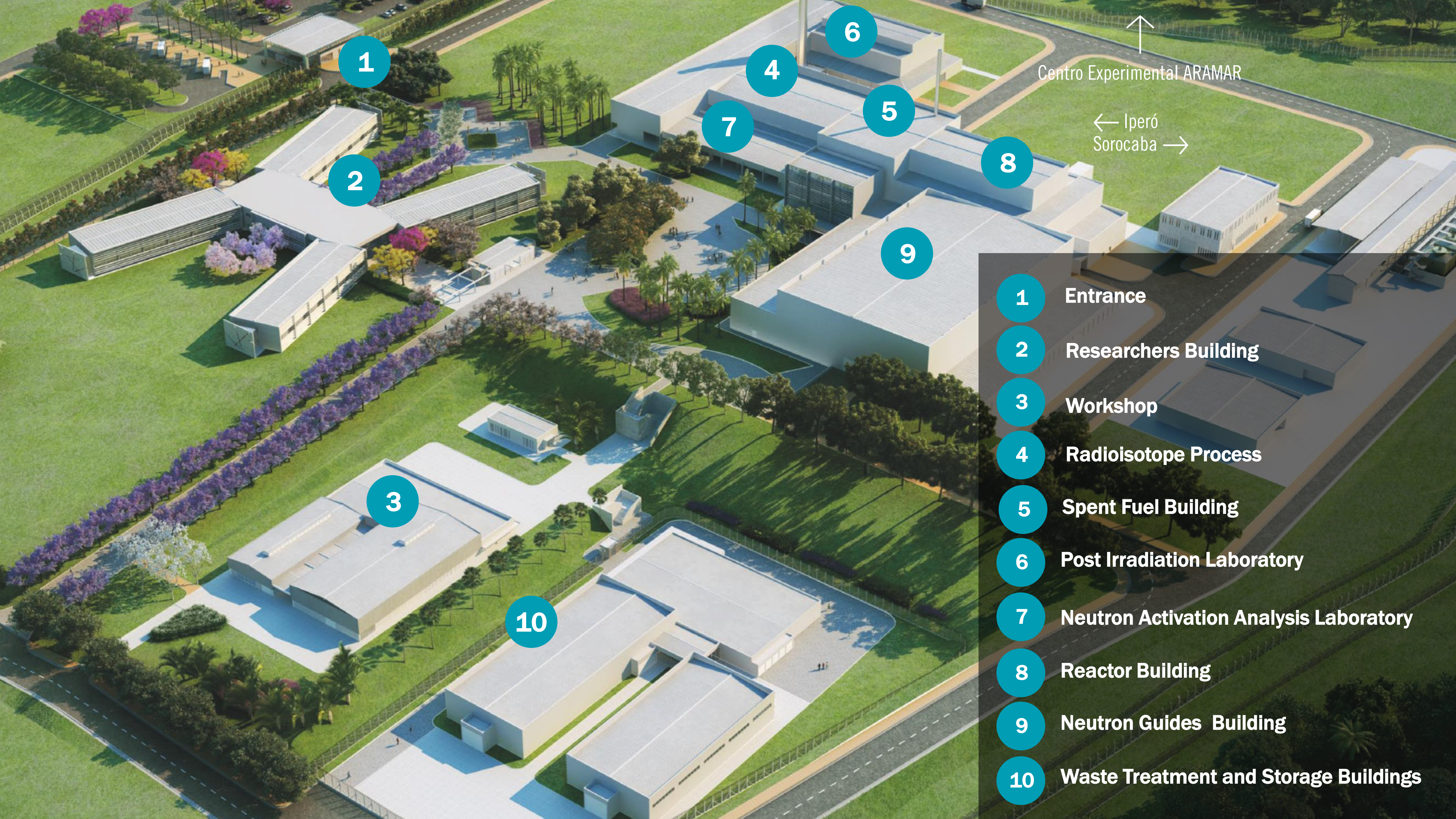
Iperó (SP)

REGIÃO METROPOLITANA DE SOROCABA
125 KM from SÃO PAULO

Site Plain


Infrastructure Area
Production and
Research Area
Administrative Area

Production and Research Area


Centro Experimental ARAMAR
← Iperó
Sorocaba →
1 Entrance
2 Researchers Building
3 Workshop
4 Radioisotope Process
5 Spent Fuel Building
6 Post Irradiation Laboratory
7 Neutron Activation Analysis Laboratory
8 Reactor Building
9 Neutron Guides Building
10 Waste Treatment and Storage Buildings

Reactor and Laboratories View

RMB Technical Data

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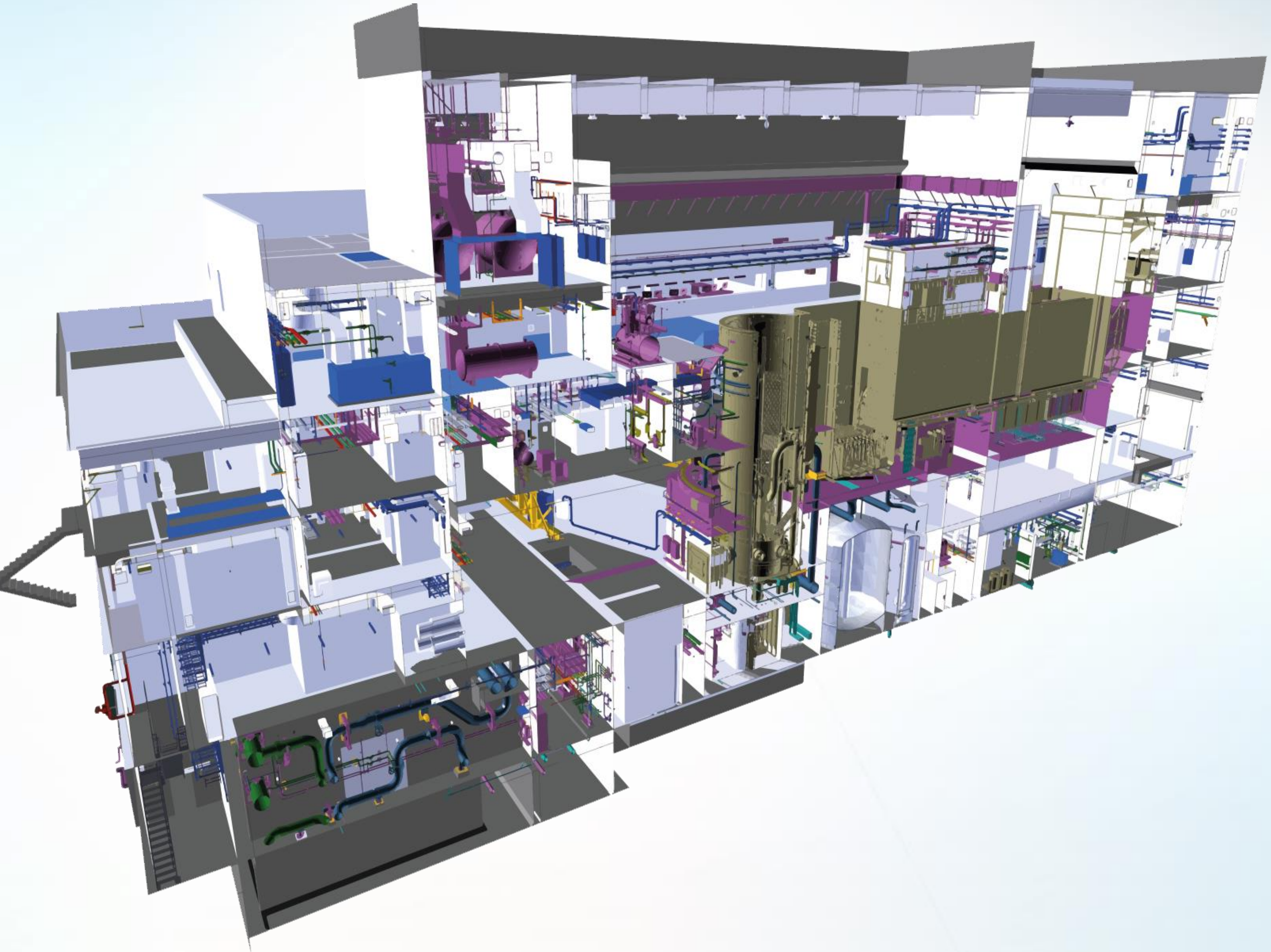


Power 30MW

Fuel
U_3Si_2 – disperse in aluminum – 20% ^{235}U

Reactor Pool Dimensions
5,10m X 14,0m

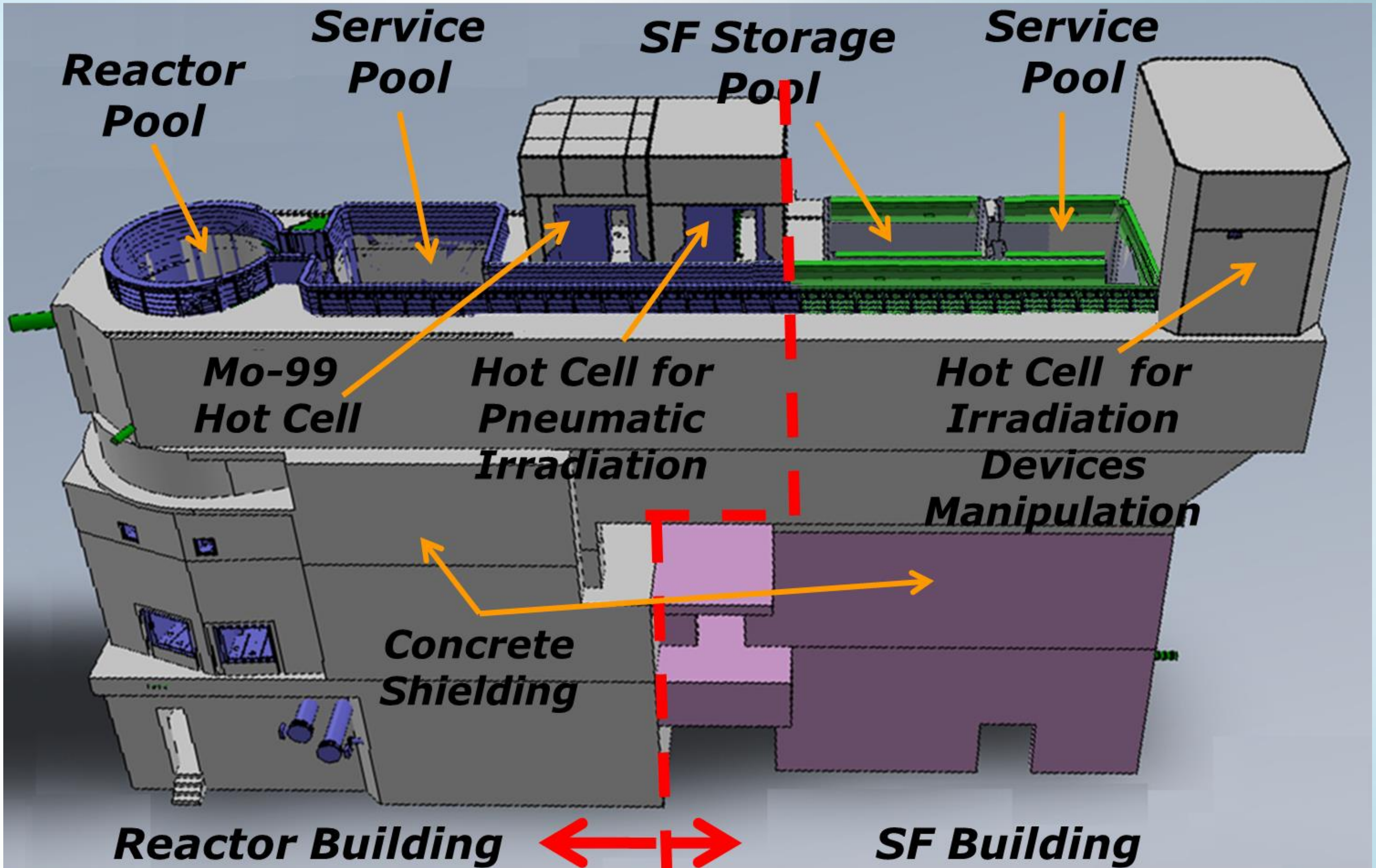
Reflector Material
Heavy water (D_2O) and berílium

Reactor Water Flow
3100 m^3/h

Core array 5 x 5
(23 fuel assemblies and 2 material irradiation positions)

First Shutdown System
6 hafinium plates

Second Shutdown System
Havy Water drained from Reflector Tank



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Main Structures

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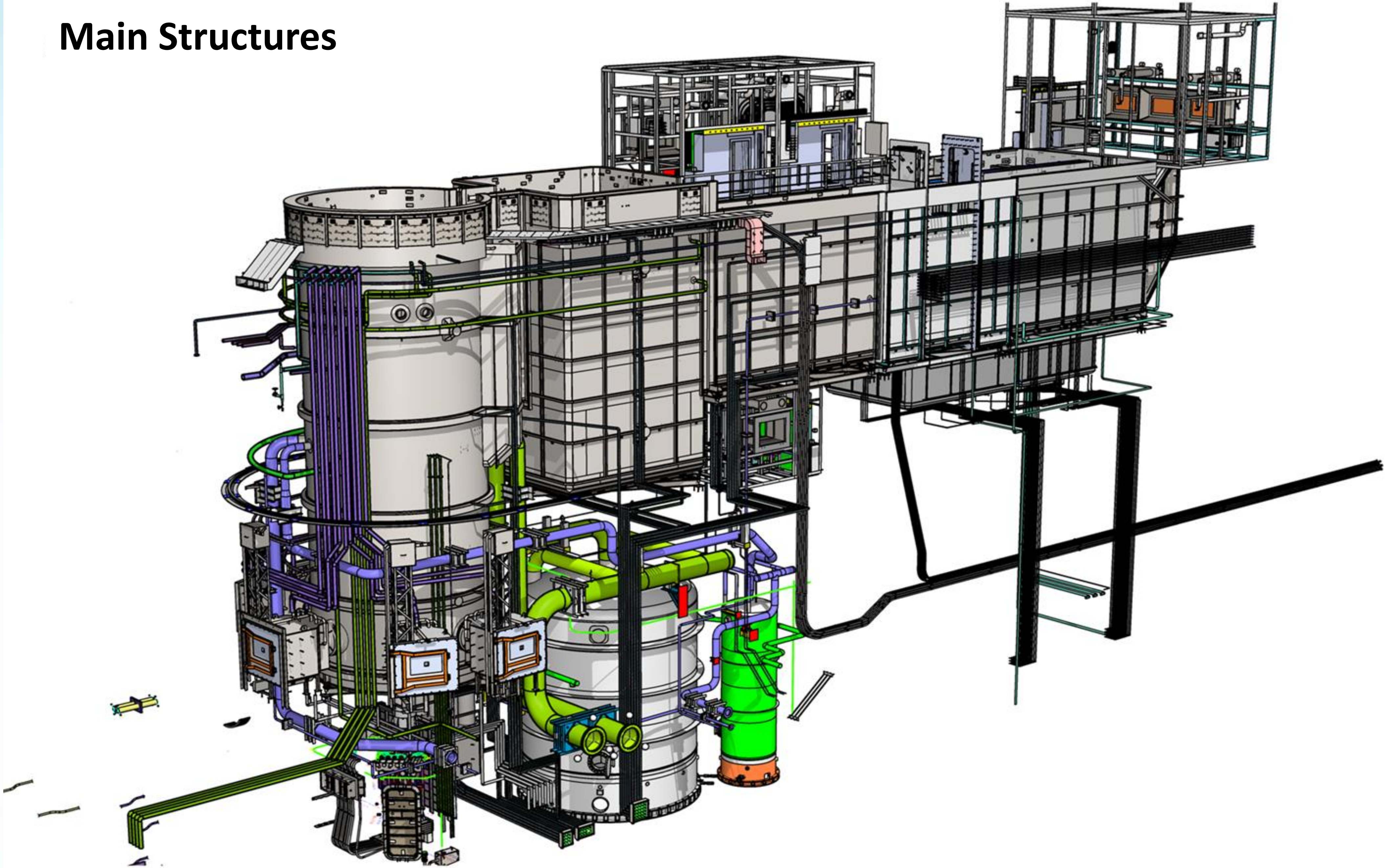
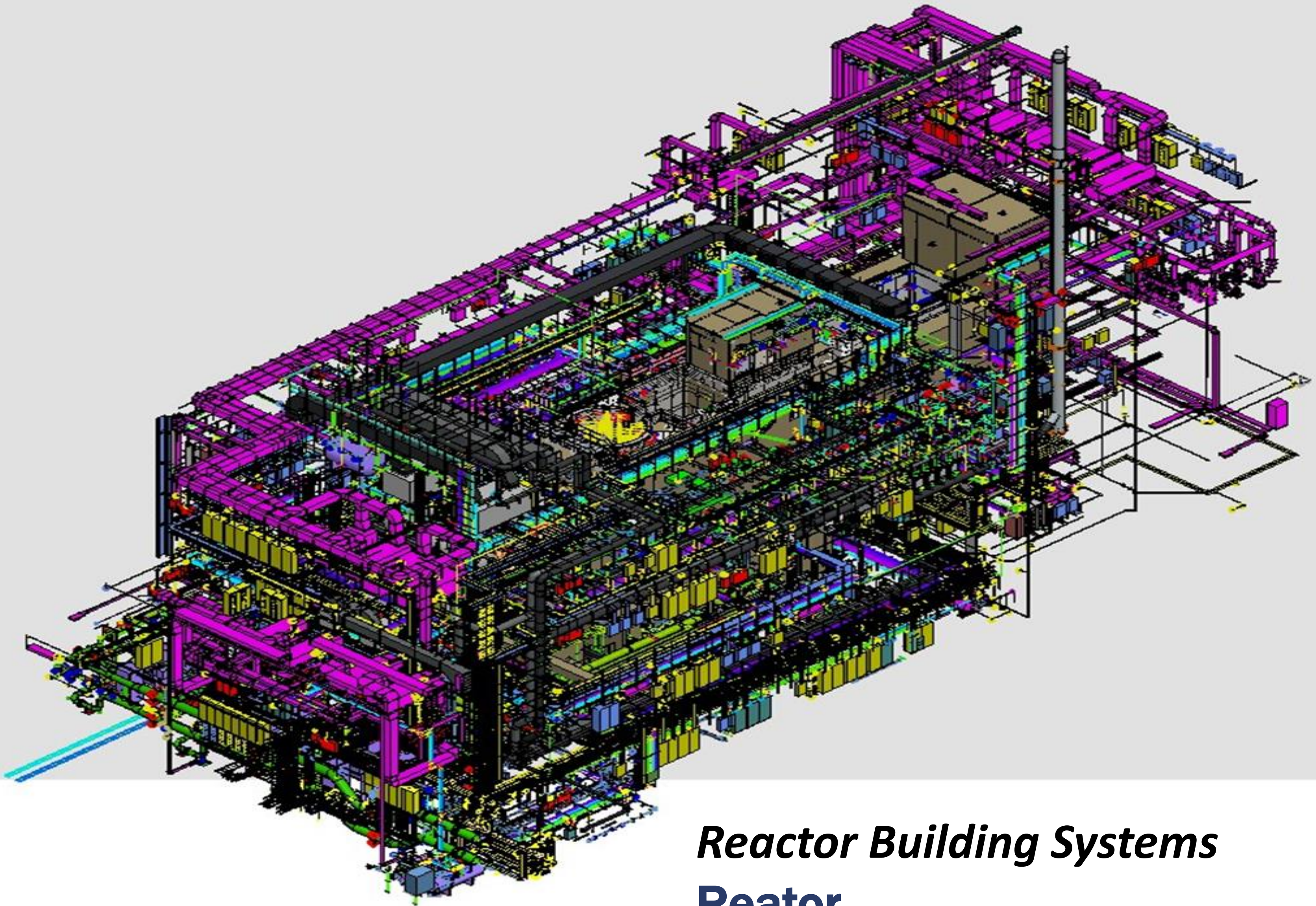
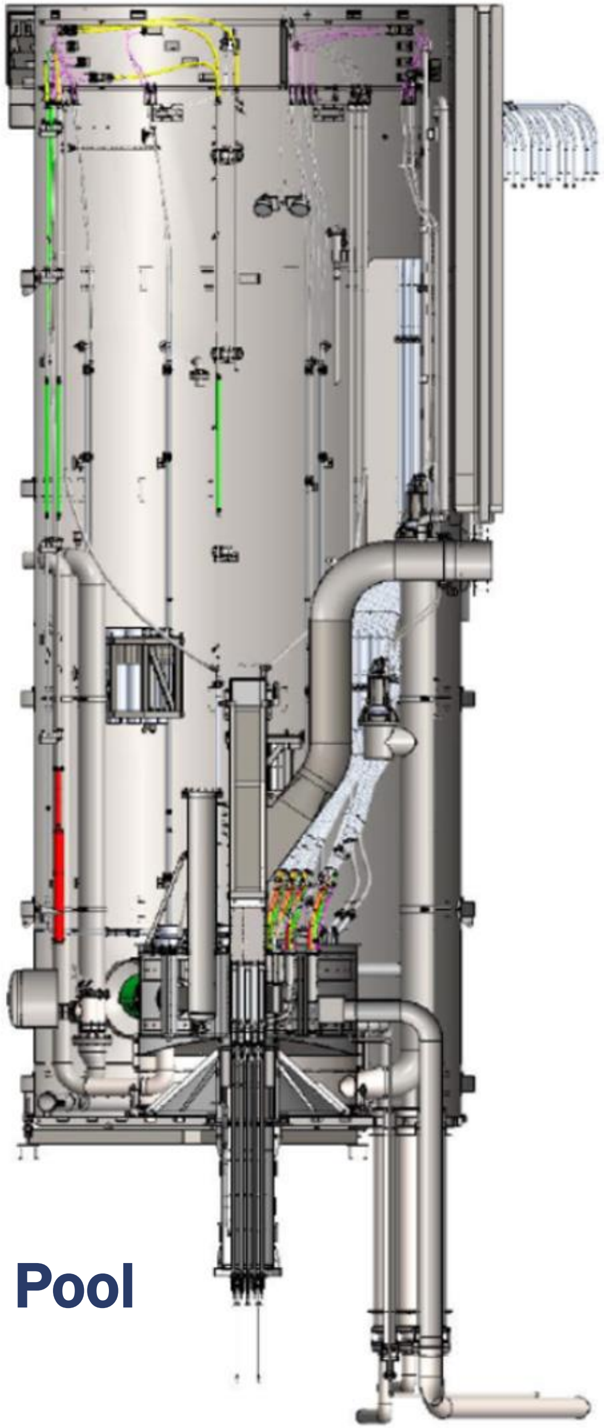


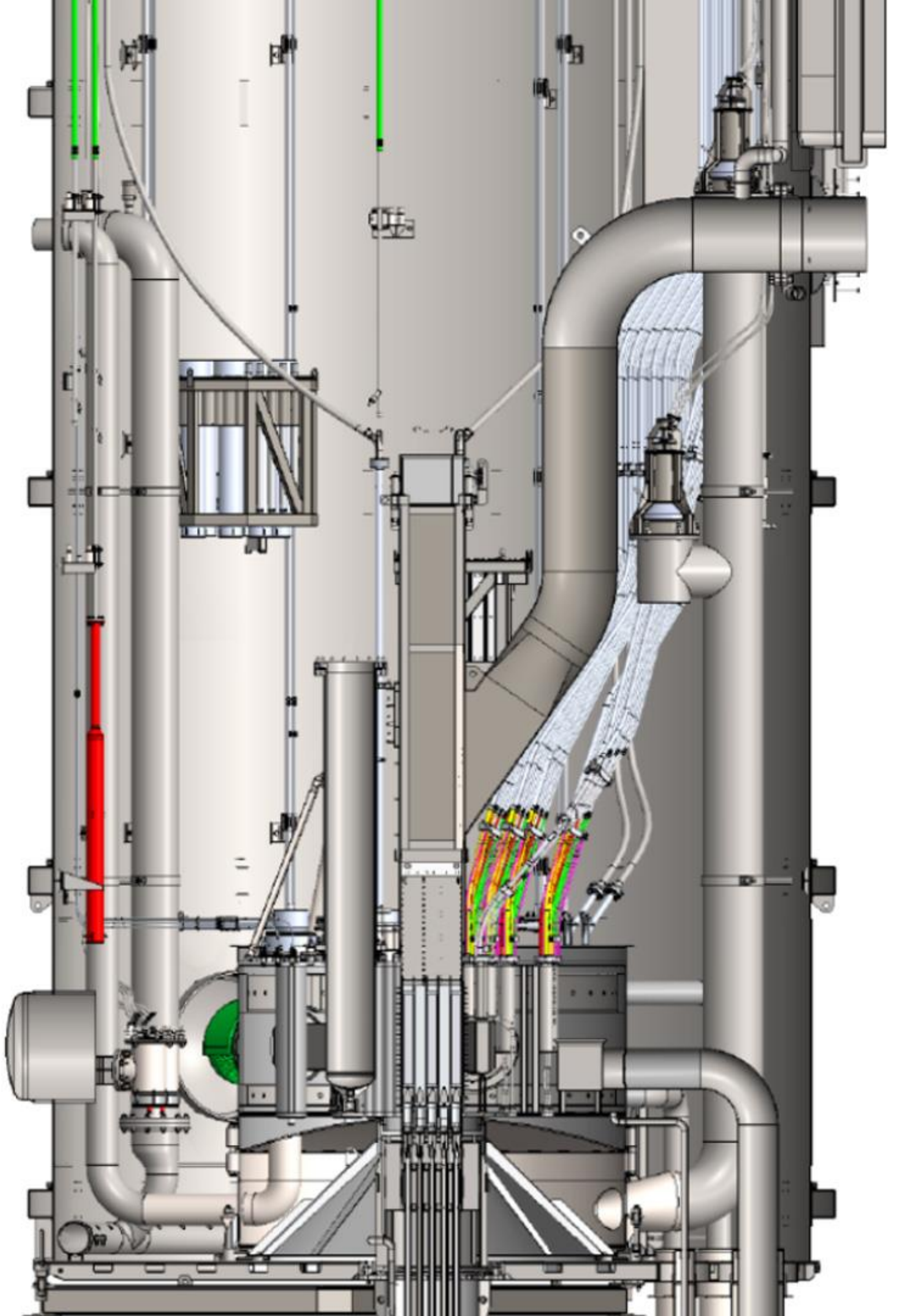


Reactor Building Systems

Reator

Reactor Building Systems





Reactor Pool Details

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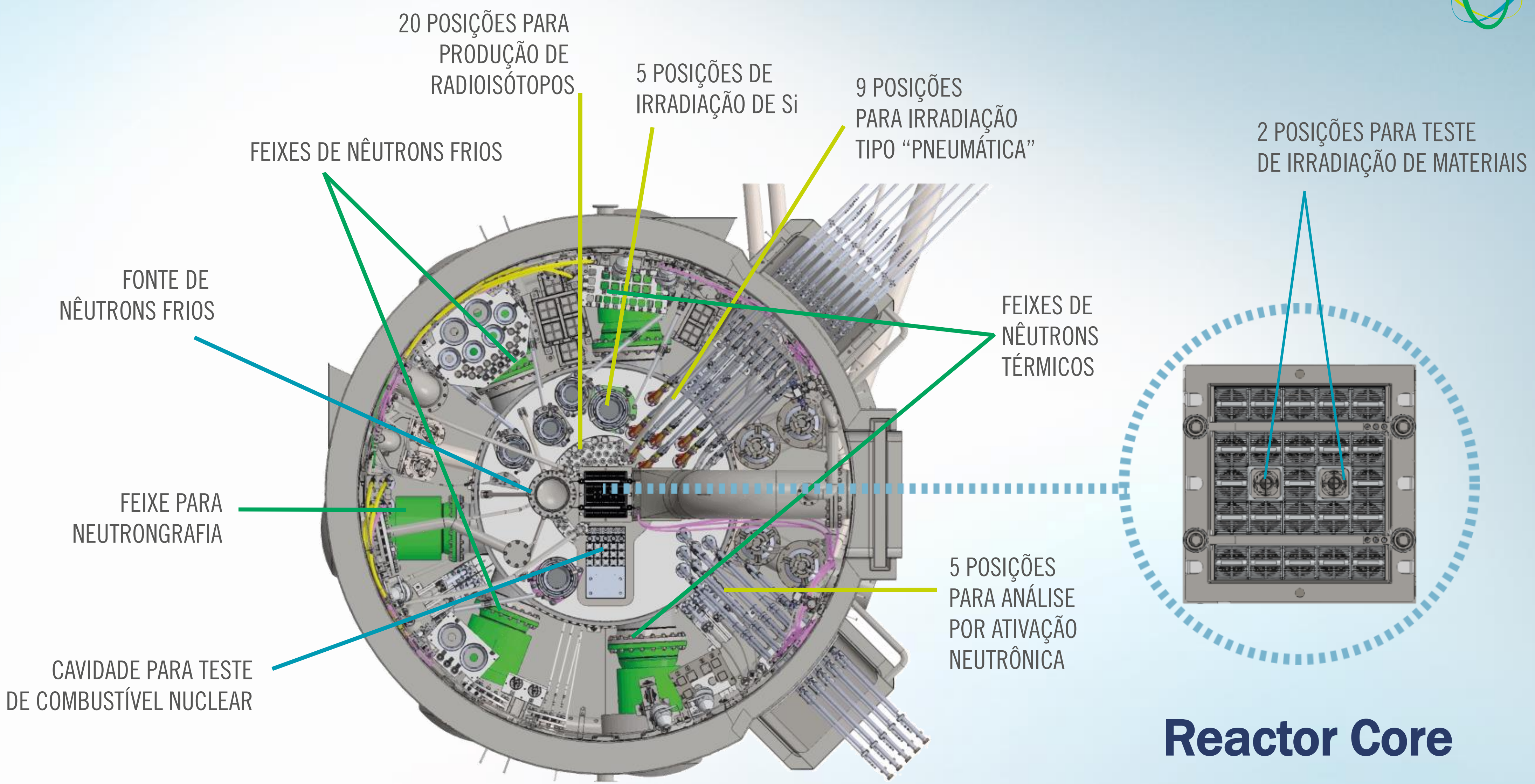
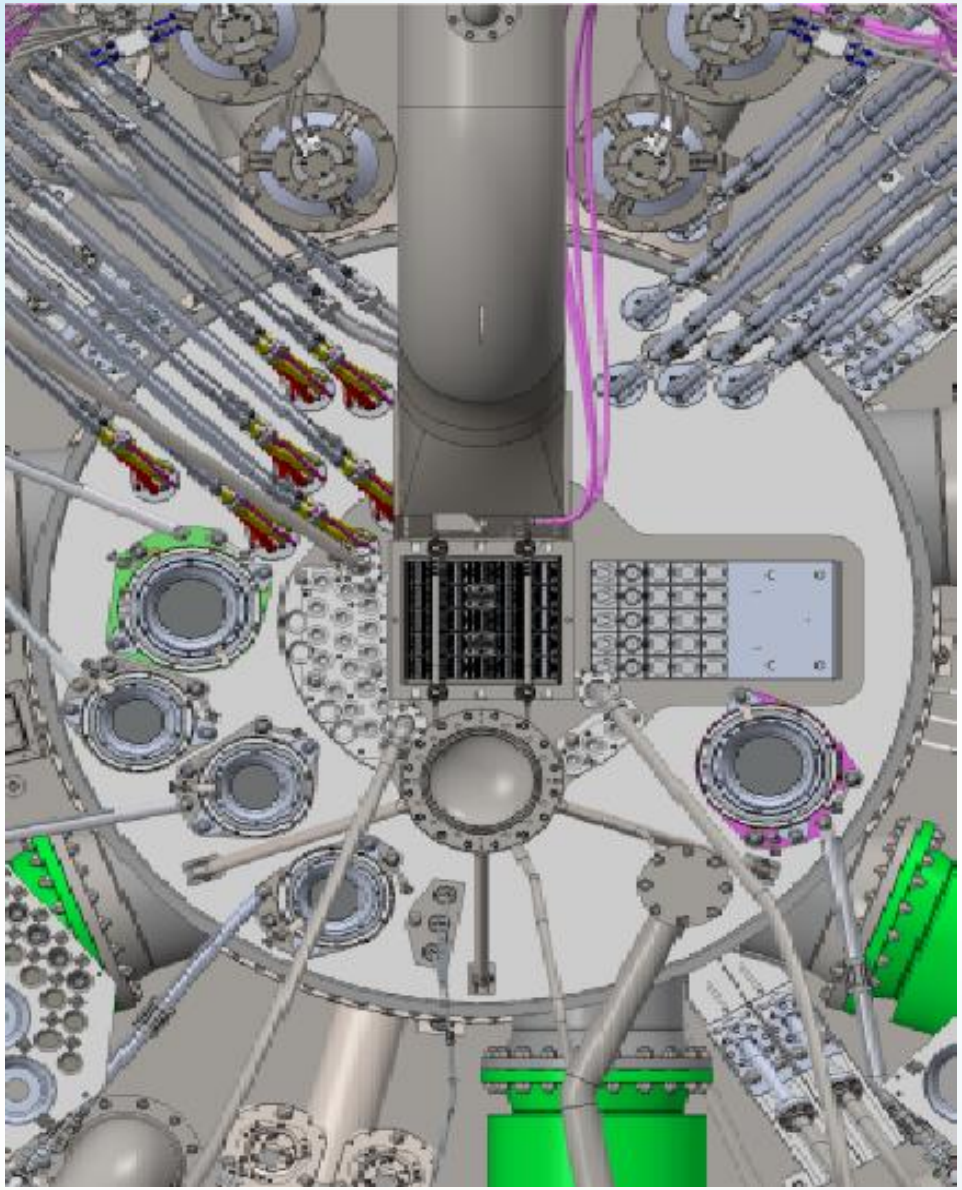
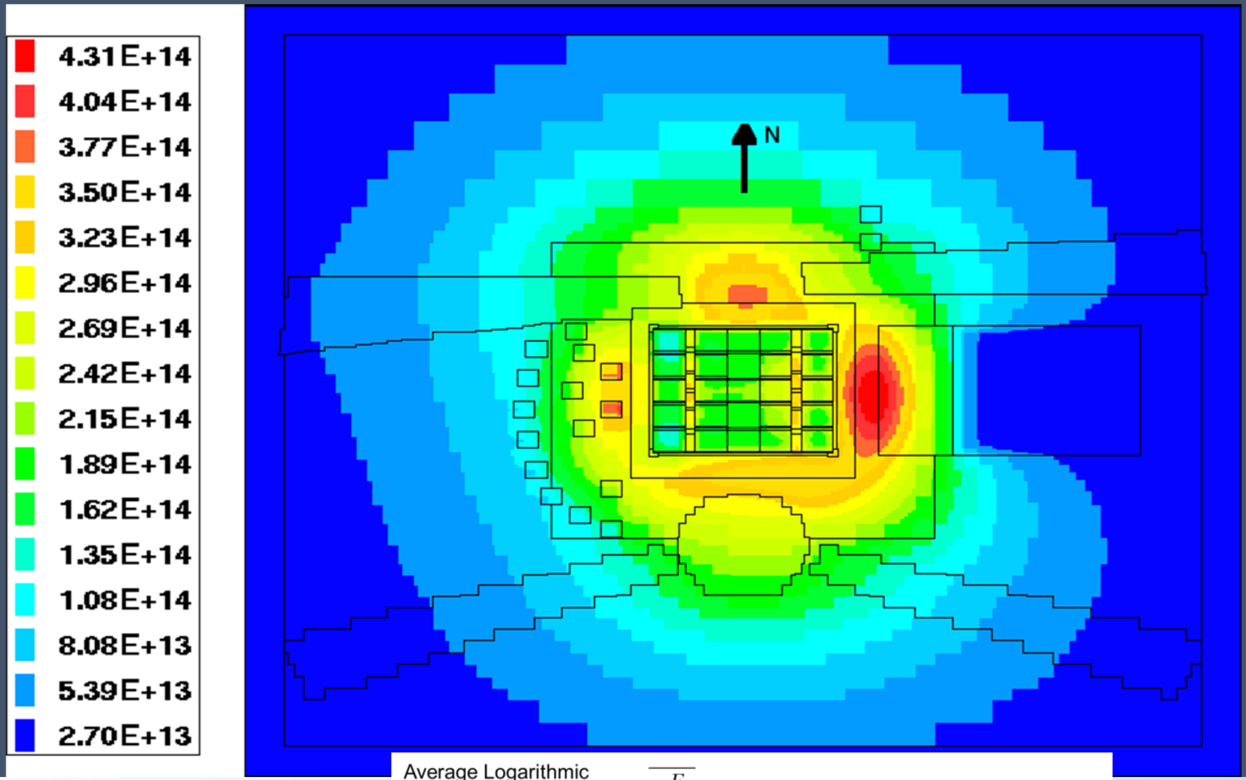


Reactor Core

Reactor Pool



Thermal flux [n/cm²s]En <0.625 eV - Midline of active length



Average Logarithmic Energy Decrease per Collision $\xi = \ln \overline{\frac{E_0}{E_1}}$

Moderation Power $= \xi.\Sigma_S$

Average number of collisions $C = \ell n \frac{E_0}{0.025eV} / \xi$

Moderation Ratio $= \frac{\xi.\Sigma_s}{\Sigma_a}$

Material	ξ	C	P.M.	R.M.
H_2O	0,920	20	3,17	143
D_2O	0,509	36	0,23	6922
${}^{12}_{6}C$	0,158	115	0,61	223
${}^{238}U$	0,0838	2100	-----	-----

National Capacity for RMB Fuel Assembly Fabrication

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- MCTI – FNDCT (FINEP) R$25 M grant (CNEN – CTMSP)
- UF_6 20% enrichment supply facility improved (CTMSP)
- Fuel fabrication facility improved (IPEN/CNEN-SP)
- Production of 19 plate type fuel for the IPEN/MB-01 Reactor

Reactor Physics Laboratory for the RMB Project

First Criticality 03/03/2020

Isotopic Enrichment Cascade Inauguration 08/12/2016

Presentation of the First Fuel Assembly 31/08/2017

Rigs Reactivity Testing at the Critical Facility

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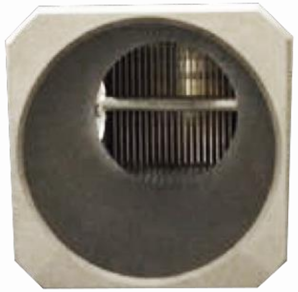
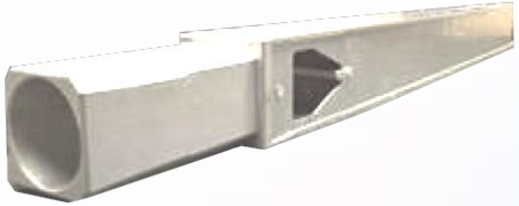
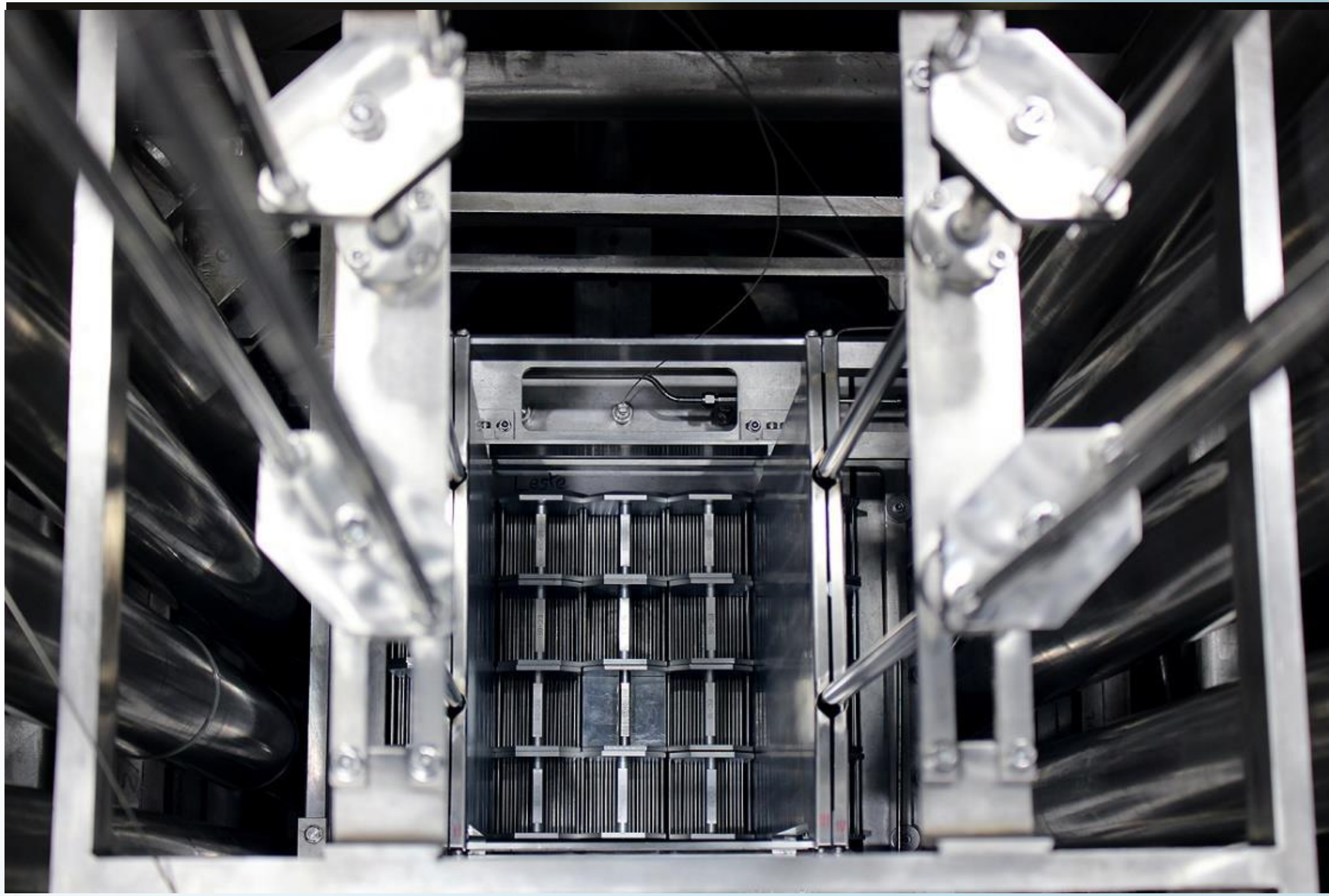
Fuel Assemblies

Fuel Plates.........

Cooling Channels ....







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

Project Main Phases

- *Design*
- *Procurement/Construction/Commissioning*
- *Operation*

Project Main Needs

- *R$* >>>>>>>>>>>> *(PAC – FNDCT)*
- *HR* >>>>>>>>>>>> *(Waiting for Government authorization)*
- *Governance* *RMB Provisional Structure for P/C/C*
  CNEN New Enterprise for Operation
  (Non-government-dependent enterprise)

Nowadays Project Main Tasks

- *Contract on Strategic Planning for Procurement/Construction/Commissioning*
- *Detailed Design of the Radioisotope Production Laboratory (N04)*
- *Ribeirão do Ferro Bridge Construction*
- *Earthworks and street construction*

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Strategic Planning for Procurement/Construction/Commissioning

- *Definition of the Organization Model for RMB Implementation.*
- *Study of the Current RMB Project Documentation Inventory*
- *Establishment of WBS for Implementation*
- *Responsibilities in the Organization Model for Deployment*
- *Establishment of the Execution Schedule for Implementation*
- *Budget Planning for Implementation*
- *Contracting Scope of Executing Companies*
- *Criteria for the Selection of Executing Companies*
- *Models and Criteria of the Contract with Executing Companies*
- *Organizational Structure Required by the RMB for the P/C/C Phase*
- *Human Resources Needs for RMB Implementation*
- *3D/BIM Model of the Project*
- *Tools for the management of the P/C/C Phase*
- *Licenses/Permits*

Forma química para o Cliente Recebedor(IPEN CR ou CETER)	Isótopo	T irrad	Embalagem	Pro-dução	Atividade na entrega ao Cliente	Prod. Anual	T ½ (dias)	Fluxo desejado	Forma química	Forma física	massa
Molibidato de Sódio	^{99}Mo	7 dias	Irradiador	S	2000 Ci**	104000 Ci	2,74	$1,2 \times 10^{14}$	UAlx-Al	Miniplacas de Al	1,77 g ^{235}U
Iodeto de Sódio	^{131}I-f	7 dias	Irradiador	S	100 Ci	5200 Ci	8,03	$1,2 \times 10^{14}$	UAlx-Al	miniplacas	1,77 g ^{235}U
processo de separação do I e Xe - Iodeto de Sódio*	^{125}I	30 horas	SS-Cp-Al	S	**3 Ci**	160 Ci	59,4	$1,0 \times 10^{13}$	^{124}Xe	Gás enriquecido	~50 mg
Cloreto de Lutecio (LuCl3)	^{177}Lu	40 dias	AQt-Cp-Al	S	**50 Ci**	2600 Ci	6,6	$2,0 \times 10^{14}$	Lu_2O_3	Sólida (pó)	100 mg
separação do Lu e Yb - Cloreto de Lutécio*	^{177}Lu from Yb	40 dias	AQt-Cp-Al	S	**50 Ci**	2600 Ci	6,6	$2,0 \times 10^{14}$	Yb_2O_3	Sólida (pó) - Vide Nota 6	100 mg
encapsulamento de fontes novas, solda em SS e inserir conjunto no irradiador*	^{192}Ir - Fontes (braquiterapia)	870 horas	Irradiador próprio	SD	15 Ci		73,83	$2,0 \times 10^{14}$	^{191}Ir-micro sementes	**Atividade esperada 10-12 Ci/seed** L 2 2 2 mm φ 0,2 0,3 0,6 mm	12,8 mg ^{191}Ir
encapsulamento de fontes novas, solda em SS e inserir conjunto no irradiador*	^{192}Ir (radiografia industrial	450 horas	Irradiador próprio	Q	600 Ci	14400 Ci	73,83	$2,0 \times 10^{14}$	^{191}Ir discos	Discos: (72 or 42 per cap) φ = 2,7 mm L = 0,25 mm φ = 4,8 mm L = 0,30 mm	0,1224mg ^{191}Ir
Cancelado em 26/3/24	^{75}Se										
Cancelado	^{3}H										
	^{131}I-c	3 dias	AQt-Cp-Al	SD	100 Ci		8,03	$9,0 \times 10^{13}$	TeO_2	Sólida (Pó metálico)	pendente
Vide nota 10	^{192}Ir fios (braquiterapia)	30 horas	Cp -Al (irradiador pendente)	SD	1250 mCi/Fio fios de 50 cm		73,83	$1,0 \times 10^{14}$	^{191}Ir	Fios - 0.1 mm de 80% Pt-20% Ir e capa Pt 0.3 mm **Atividade máxima 4 mCi/cm**	4,14 mg
Oxido de Samário - apenas manuseado-não processado	^{153}Sm	48 horas	Lâmina-Cp-Al	SD	4 Ci		1,93	$5,0 \times 10^{13}$	Sm_2O_3	Sólido depositado	15 mg
	^{198}Au	24 horas	pendente	SD	70 mCi		2,7	$9,0 \times 10^{13}$	^{197}Au	Folhas Au ultra-puro	100mg
Pesquisa	^{166}Ho	**5 dias**	Cp-Al	SD	100 mCi		1,18	$1,7 \times 10^{14}$	Ho_2O_3	Sólida (Pó compactado)	1 g
	^{60}Co	100 horas	Cp-Al	T	625 mCi/fonte	2,5 Ci	5.27 a	$2,0 \times 10^{14}$	^{59}Co	Pinos e Pellets	12 mg/pino
	^{32}P	5 dias	AQt-Cp-Al	SD	200 mCi		14,28	$2,0 \times 10^{14}$	K_2SO_4	Sólida (Pó)	0,5 g
	^{90}Y	5 a 7 dias	AQt-Cp-Al	SD	100 mCi		2,67	$2 - 5 \times 10^{14}$	Y	Sólida (Pó microesferas)	100 mg
	^{51}Cr	7 dias	AQt-Cp-Al	SD	100 mCi		27,7	$2,0 \times 10^{14}$	Cr_3O_4	Sólida (pó)	1 mg
	^{188}W	60 dias	Cp-Al	M	100 mCi	1,2 Ci	69,8	$2,0 \times 10^{14}$	WO_3	Sólida (Pó compactado)	2 g
	^{82}Br	2 horas	AQt-Cp-Al	SD	50 mCi		1,47	$2 - 7 \times 10^{13}$	KBr	Sólida (Sal anidro)	1,0 g
	^{40}K	4 horas	AQt-Cp-Al	SD	300 mCi		1.3E9 a	$6,0 \times 10^{13}$	K_2O_2	Sólida (Pó compactado)	0,2g
	^{42}K	8 horas	AQt-Cp-Al	SD	500 mCi		12.30 h	$6,0 \times 10^{13}$	K_2O_2	Sólida (Pó compactado)	0,2g
	^{24}Na	8 horas	AQt-Cp-Al	SD	250mCi		0,62	$6,0 \times 10^{13}$	Na_2CO_3	Sólida	100mg
	^{79}Kr	24 horas	AQt-Cp-Al	SD	1 Ci		1,46	$8,0 \times 10^{13}$	Gás Kr	gás	0,2g
	^{203}Hg	40 horas	AQt-Cp-Al	SD	70 mCi		46,61	$2,0 \times 10^{13}$	^{202}Hg	Líquida (metálico)	**130 g (nota 5)**
New - Proposta para Futuro	^{47}Sc	New								CaCO3>Ca-47>Sc 47 ou TiO2>Sc47	
New - Proposta para Futuro	^{67}Cu	New									
New - Proposta para Futuro - Cloreto de Tb	^{161}Tb	New									

FUTURE NUCLEAR TECHNOLOGY SITE OF RMB

- ✓ **RMB Reactor**
- ✓ **National Neutron Laboratory**
- ✓ **Radioisotope Production Laboratory**
- ✓ **Post Irradiation laboratory**
- ✓ **National laboratory for NAA**

- ✓ **Nuclear Fusion Laboratory**
- ✓ **Particles Accelerator Laboratory**
- ✓ **High Intensity LASER Laboratory**
- ✓ **Radiopharmacy Center**
- ✓ **Integrated Center for the Development of Diagnosis and Therapy Using Radiation**
- ✓ ***Postgraduation in Nuclear Technology***
- ✓ **Training of Technicians for the Nuclear Technology in Medicine**

RMB Startup Meeting

03/09/2008

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Comissão Nacional
de Energia Nuclear

RELATÓRIO DE GESTÃO

EXERCÍCIO DE 2023

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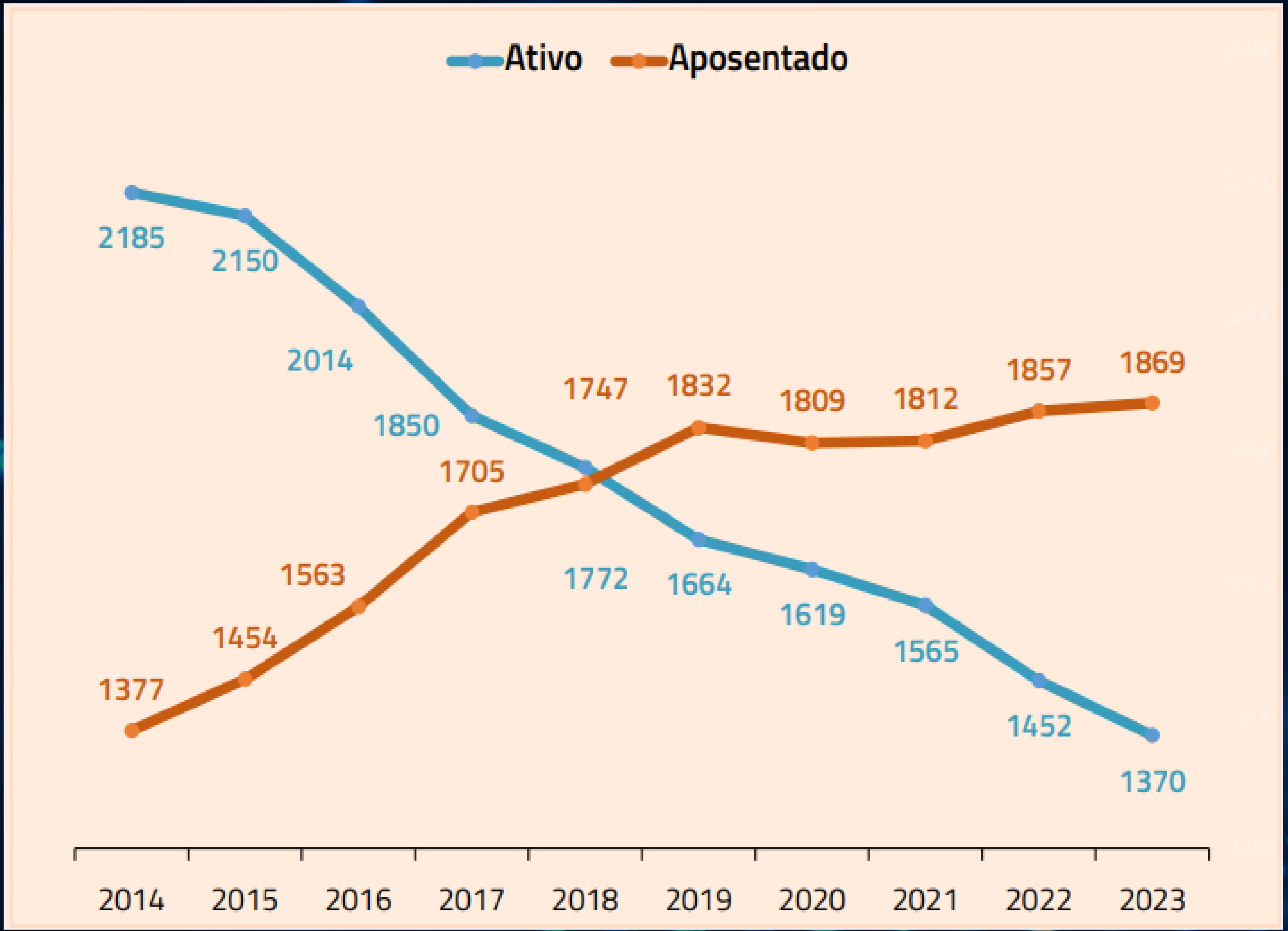

Servidores ativos

1.370

Abono de permanência

49%

(706 servidores)

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Nuclear Technology at the Service of Life

Thank you !