CNPEM – Brazilian Research Center in Energy and Materials

James Citadini
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Director of Technology

CNPEM

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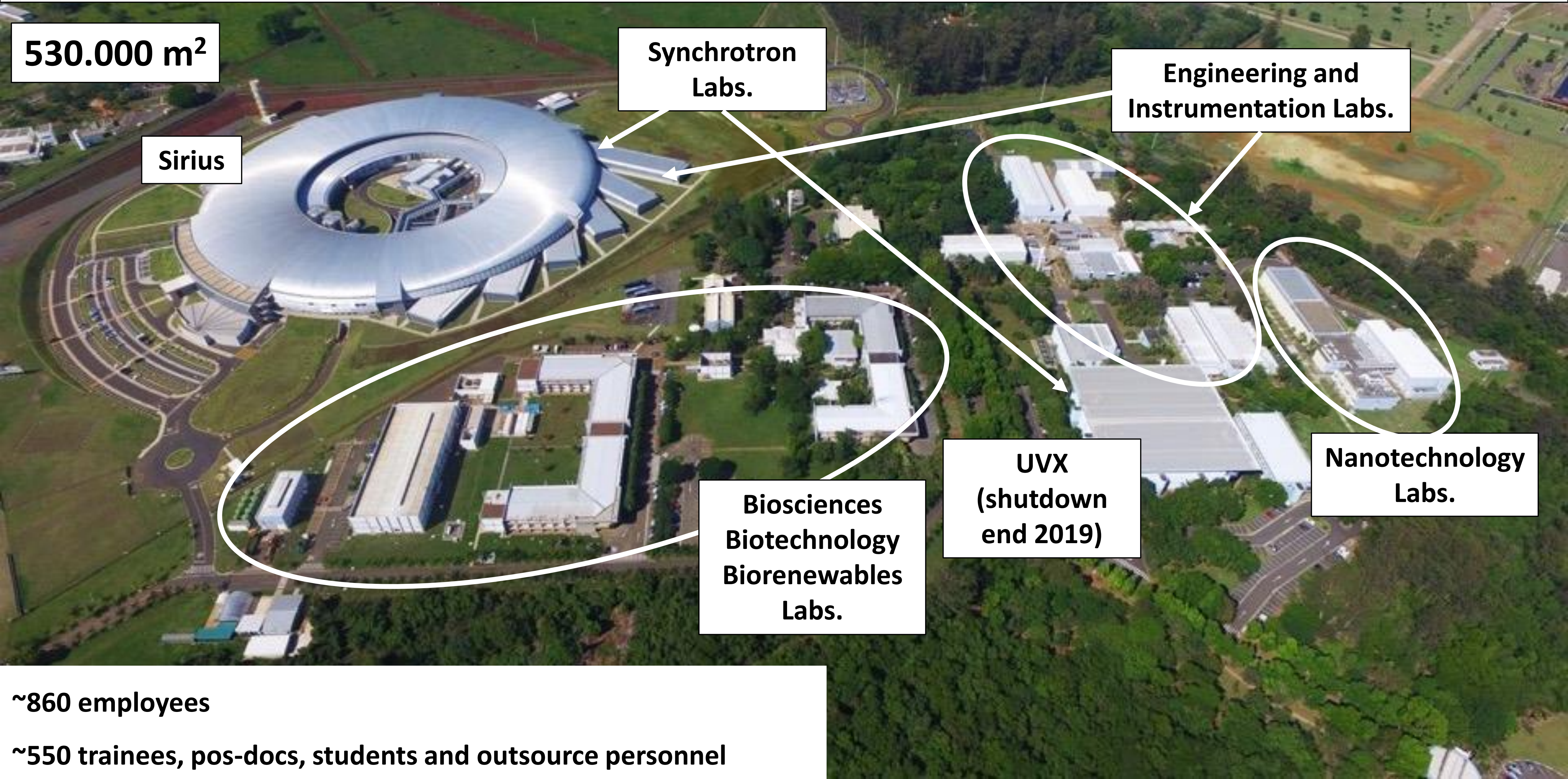
CNPEM is similar to a DOE National Lab in the USA. It is a private, nonprofit organization working under contract with the Brazilian Ministry of Science, Technology, Innovation (MCTI)



~860 employees

~550 trainees, pos-docs, students and outsource personnel

Important Turning Point in the Brazilian Science - "Big facility", in house development

LNLS – A pioneering lab in Brazil

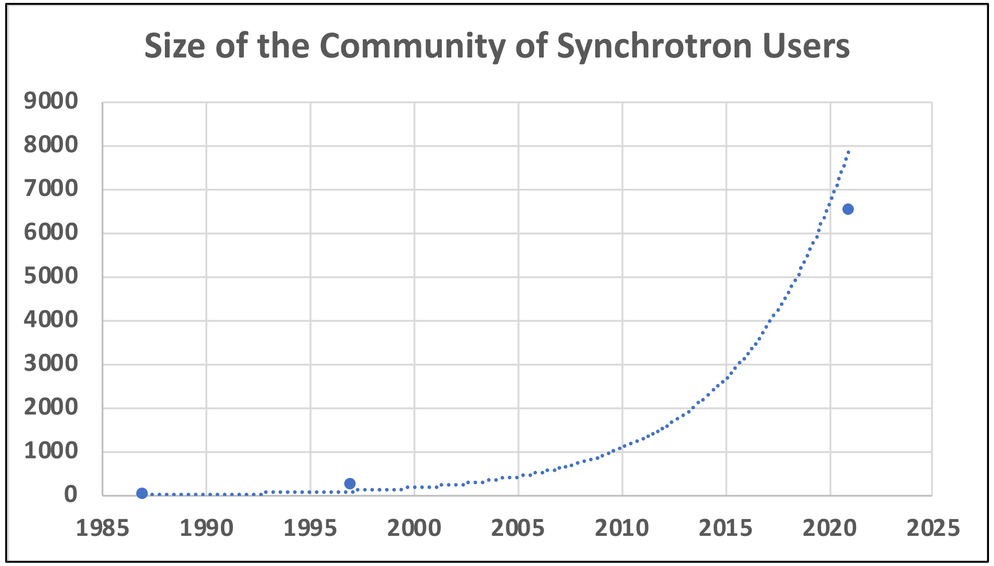
First synchrotron light source in the southern hemisphere

Still the only one in Latin America

Built between 1987-1997

Around 85% built in house

1.37 GeV



Training of human resources

But not yet competitive at an international level...

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CNPEM – A bit of history

1987

Initial developments of UVX's equipments at a temporary building

Hiring and training of technical personnel. Also training of future users.

1993-1996

Construction of UVX at current CNPEM's site.

Strong in house instrumentation

Assembly of ring concluded

1997

Opening of the Brazilian Synchrotron Light Laboratory

(Some) Nanotechnology landmarks at LNLS

1995 Electron Microscopy Lab.
2000 Scanning probe microscopy (STM/AFM) Lab.
2001 Microfabrication Lab. Opened
2006 New Electron Microscopes acquired
2008 Cesar Lattes Building constructed – C2Nano

(Some) Biology landmarks at LNLS

1997 MX1 beamline
2000 CeBiME
2001 NMR Lab.
2002 Mass Spectrometry Lab.
2006 Protein Crystallography Lab. (robots)
2006 Micro-array Lab.
2007 MX2 beamline

(Some) CTBE (LNBR today) landmarks at LNLS

2005 Study requested by MCT to CGEE to identify factors that limit the expansion, on a large scale, of the Brazilian production of ethanol
2007 CTBE starts activities at LNLS

LNLS: UVX (1st Light Source in South Hemisphere)

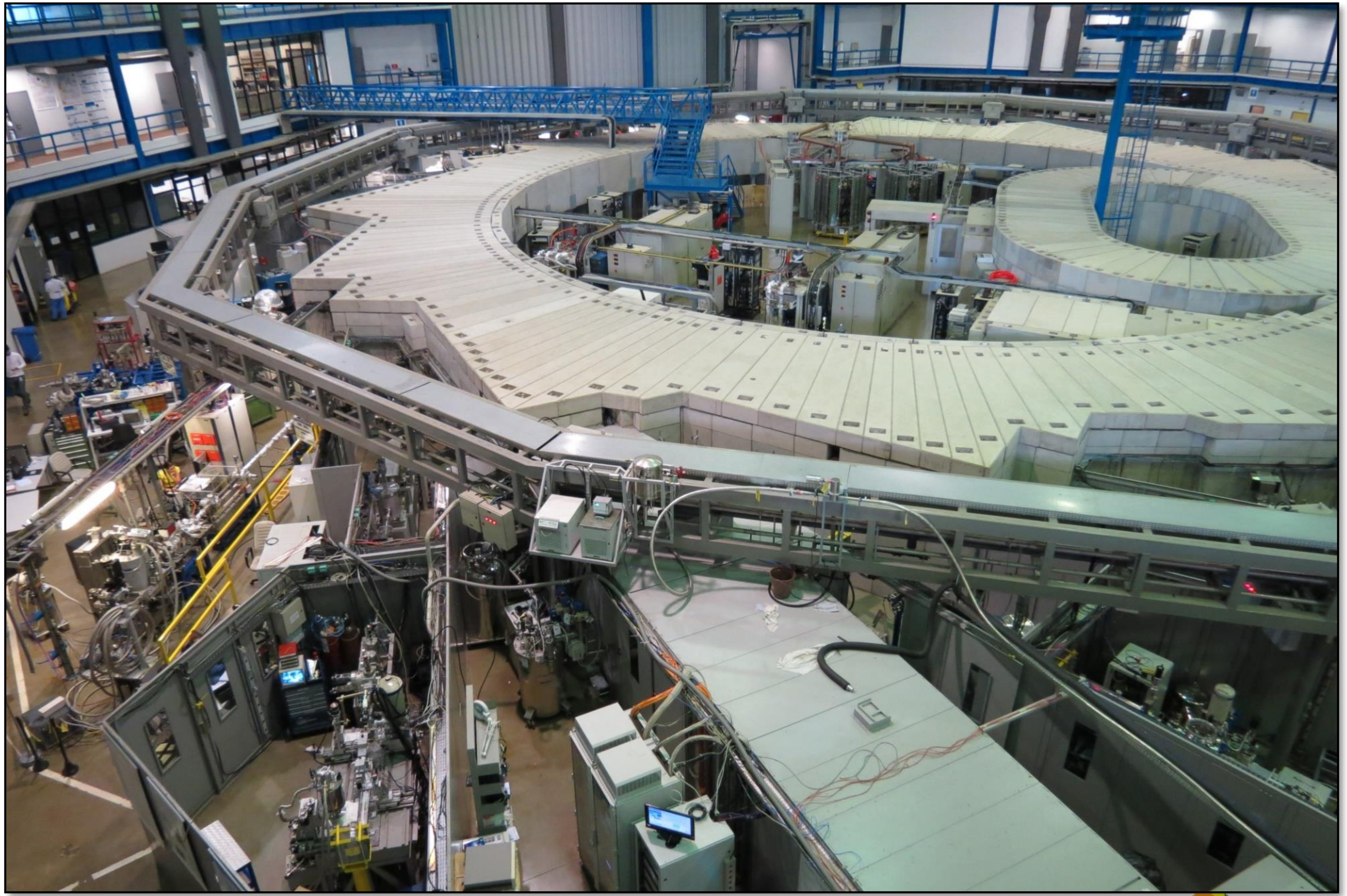
1.37 GeV

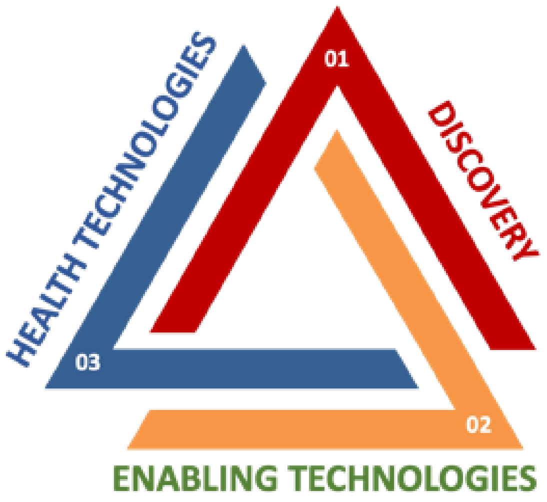
16 beamlines

93 m circumference

Users' operation:

1997 - 2019





01 DISCOVERY

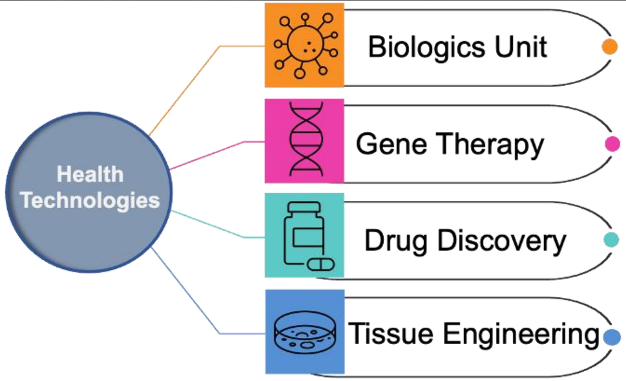
- Molecular Virology
- Protozoan Parasites Targets
- Pathogenic Bacteria Tasgets
- Cancer
- Neurosciences
- Cardiovascular Sciences

02 ENABLING TECHNOLOGIES

- Computational Biology
- Bioimaging
- Preclinical Models Unit
- HTS/HCS Unit
- Protein Characterization Unit
- Synthesis of Biomolecules Unit
- NMR
- Mass Spectrometry

03 HEALTH TECHNOLOGIES

- Biologics Unit
- Drug Discovery Unit
- Gene Therapy Unit
- Tissue Engineering Unit



Monoclonal Antibodies
Vaccines

Viral Vectors
Genome edition

Natural Products Collections
Validated Lead Compounds

iPS Cells Technology
Tissue Bioprinting

Biosciences Laboratory

- We aim to provide the **link between academic research and clinical development**, to allow all our collaborators and users to make rapid progress into preclinical and clinical trials.

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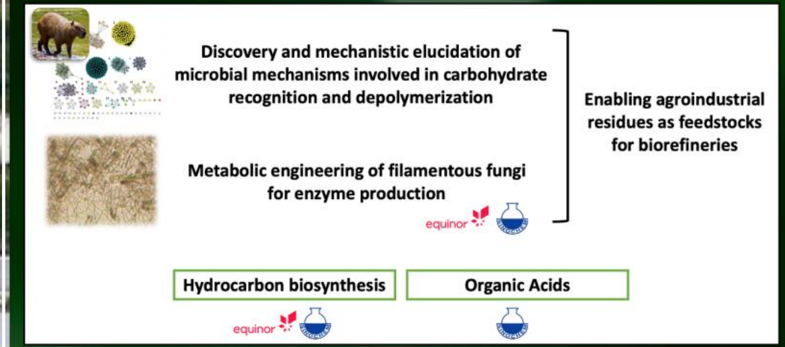
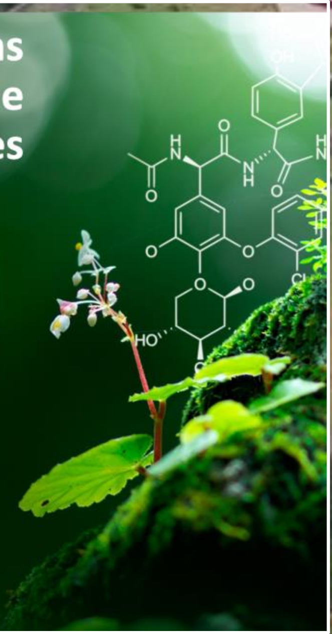
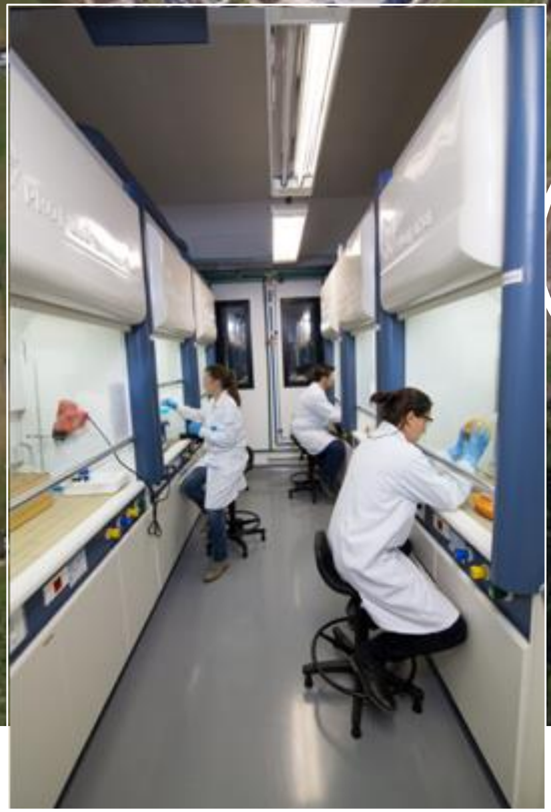
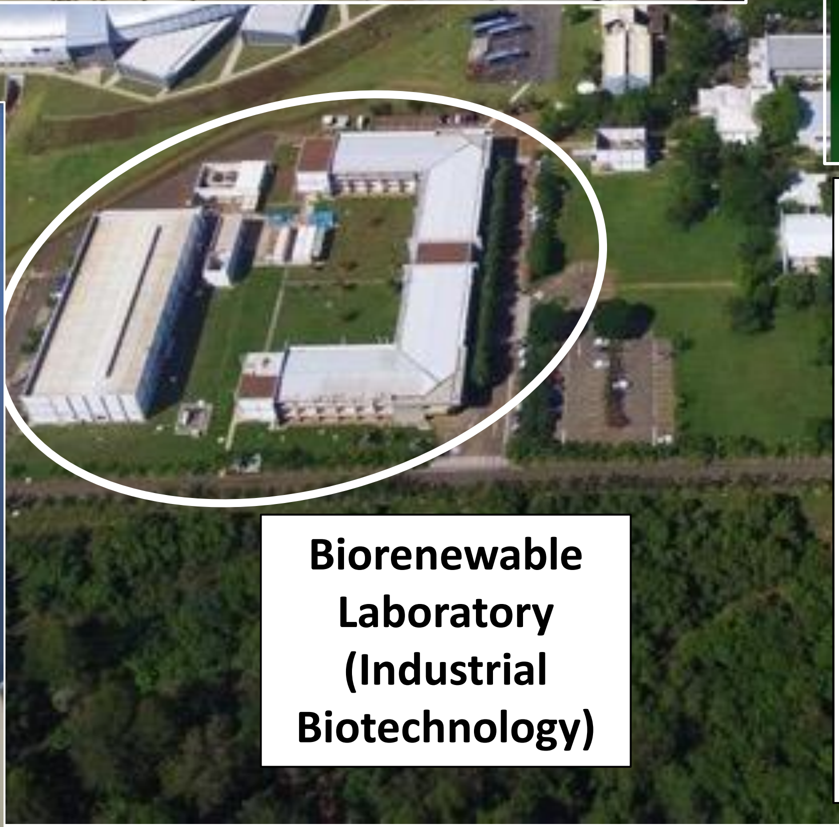
Discovery of novel enzymatic systems from Brazilian biodiversity and the development of microbial cell factories for enzyme production

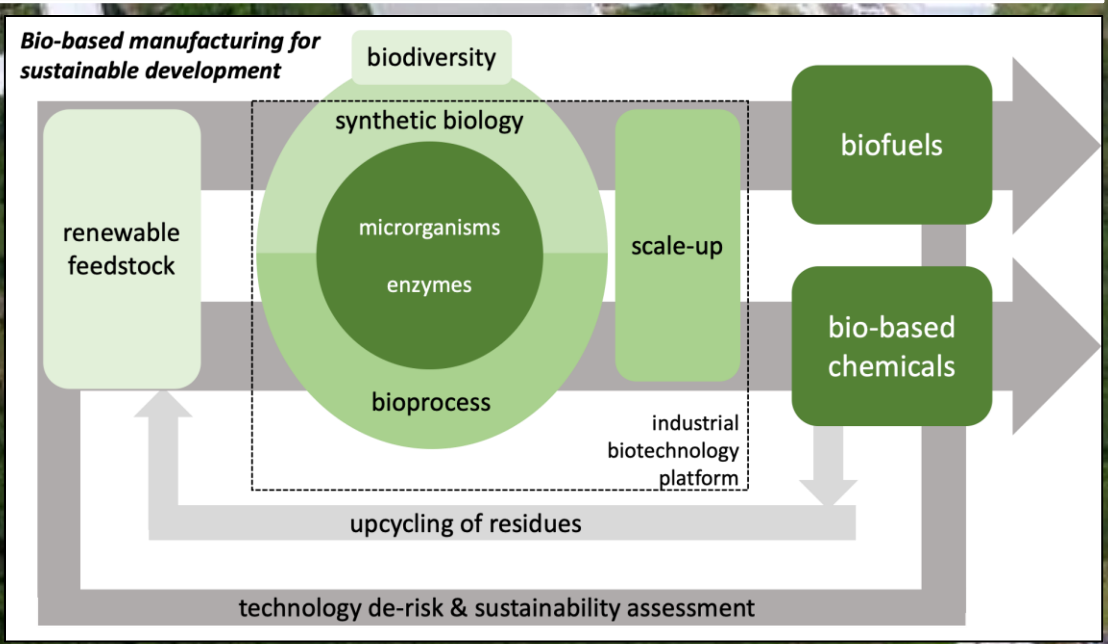








Biorenewable Laboratory (Industrial Biotechnology)



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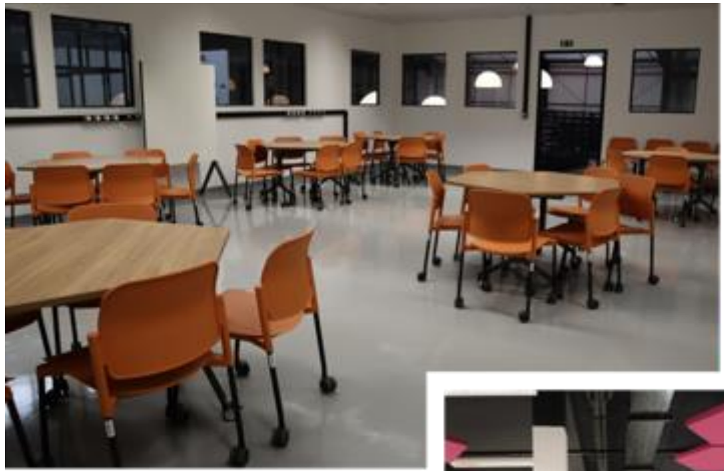
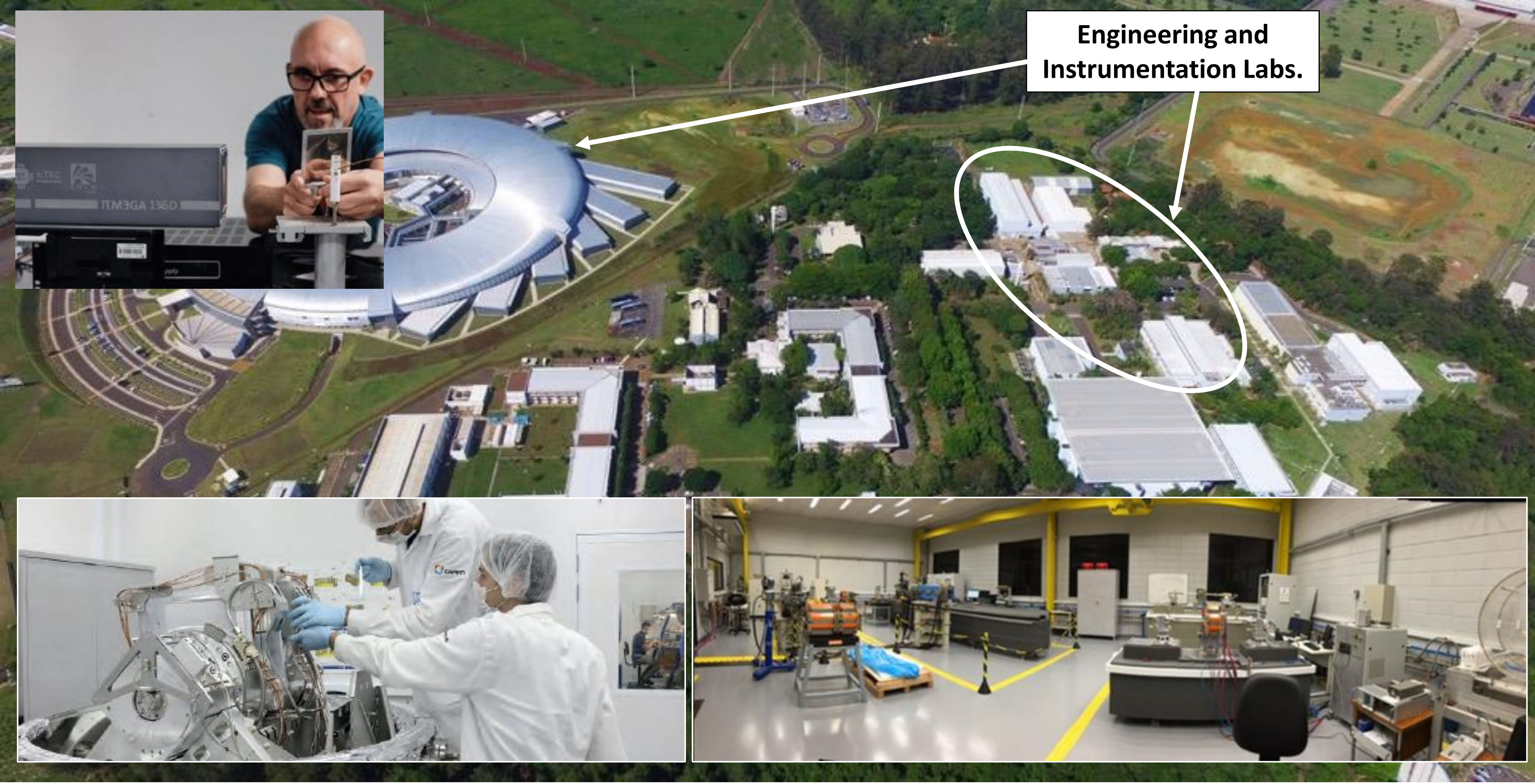
- Ilum – School of Science
- New Bachelor of Science connected to CNPEM
- 40 students/year
- Multidisciplinary approach
- Project-based learning




Engineering and
Instrumentation Labs.

CNPEM
Brazilian Center for Research in Energy and Materials

Council

Director General
Jose Roque

- ilum school of science — *Adalberto Fazzio*
- Shared Services Unit — Renata Vasconcelos
- Technology Unit — James Citadini
- LNLS Brazilian Synchrotron Light Laboratory (sirius) — *Harry Westfahl*
- LNBIO Brazilian Biosciences National Laboratory — *Sandra Dias*
- lnbr brazilian biorenewables national laboratory — *Eduardo Couto*
- LNNano Brazilian Nanotechnology National Laboratory — *Rodrigo Capaz*

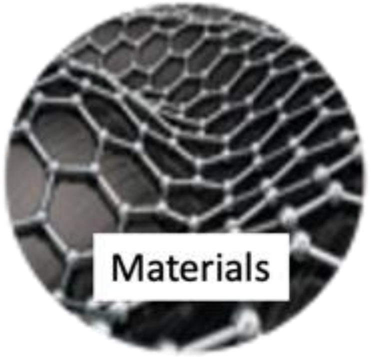
CNPEM MISSION

01 Open Facilities

02 Research and Development

03 Support for Innovation

04 Education, Training and Outreach



Research Programs in Strategic Areas

Health	Renewable Energies	Renewable Materials	Agri-environmental	Quantum Technologies
Drug Development Pharmaceuticals and Biopharmaceuticals	Liquid Biofuels	Biotransformation	Microbiota, Nutrients and Soil Emissions	Superconducting Equipments
Diagnostics	Hydrogen	Biopolymers’ Functionalization	Environmental Remediation	Quantum Devices
Regenerative Medicine			Ecotoxicity	

Crossover, Integration, and Synergies

Enabling Technologies

Science with Synchrotron	Bioimaging	Micro e Nano Fabrication	Synthesis and Characterization	Engineering and Scientific Instrumentation	Particle Accelerators

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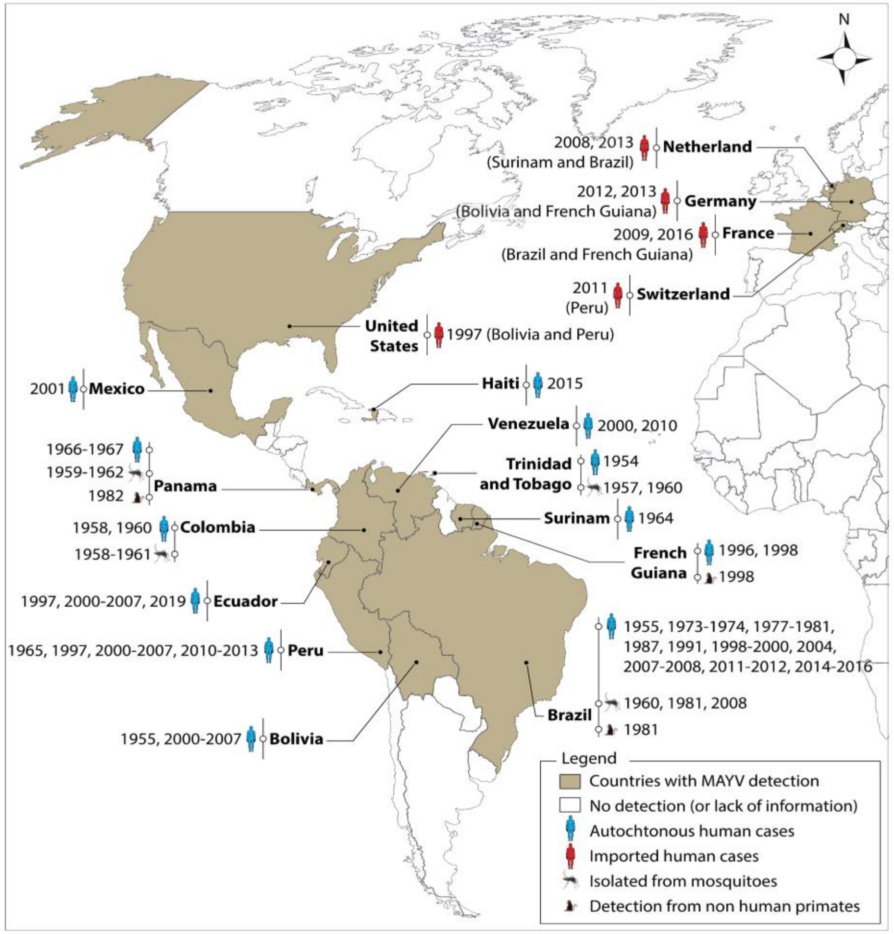
Mayaro Virus (MAYV)



- Mayaro´s Fever
  - An emerging arboviral disease
  - Transmitted by mosquitoes
  - Few studies
  - No public monitoring or control policies
  - Endemic to Central and South America
  - Increase in the number of human cases
  - **No vaccine or specific treatment available**

nature COMMUNICATIONS

NATURE COMMUNICATIONS | (2021)12:3038

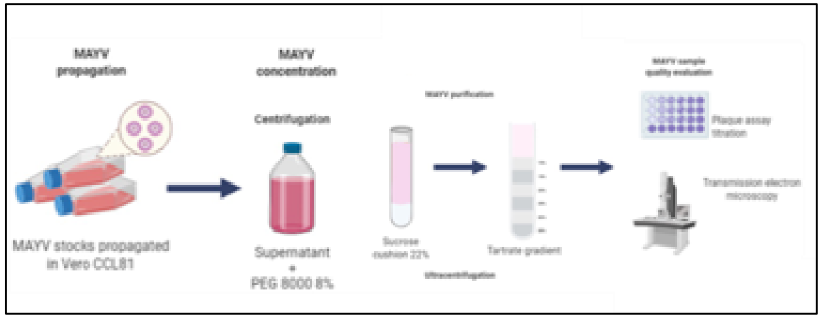

ARTICLE

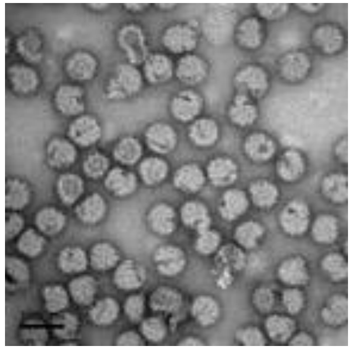
OPEN

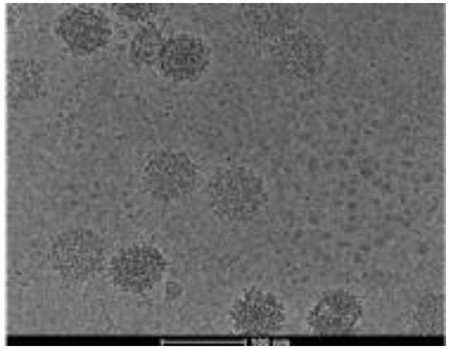
Cryo-EM structure of the mature and infective Mayaro virus at 4.4 Å resolution reveals features of arthritogenic alphaviruses

Helder V. Ribeiro-Filho[1,3], Lais D. Coimbra[1,3], Alexandre Cassago[2], Rebeca P. F. Rocha[1], João Victor da Silva Guerra[1], Rafael de Felicio[1], Carolina Moretto Carnieli[1], Luiza Leme[1], Antonio Cláudio Padilha[2], Adriana F. Paes Leme[1], Daniela B. B. Trivella[1], Rodrigo Villares Portugal[2], Paulo Sérgio Lopes-de-Oliveira[1] & Rafael Elias Marques[1]

Biological procedures







Electron Microscopy

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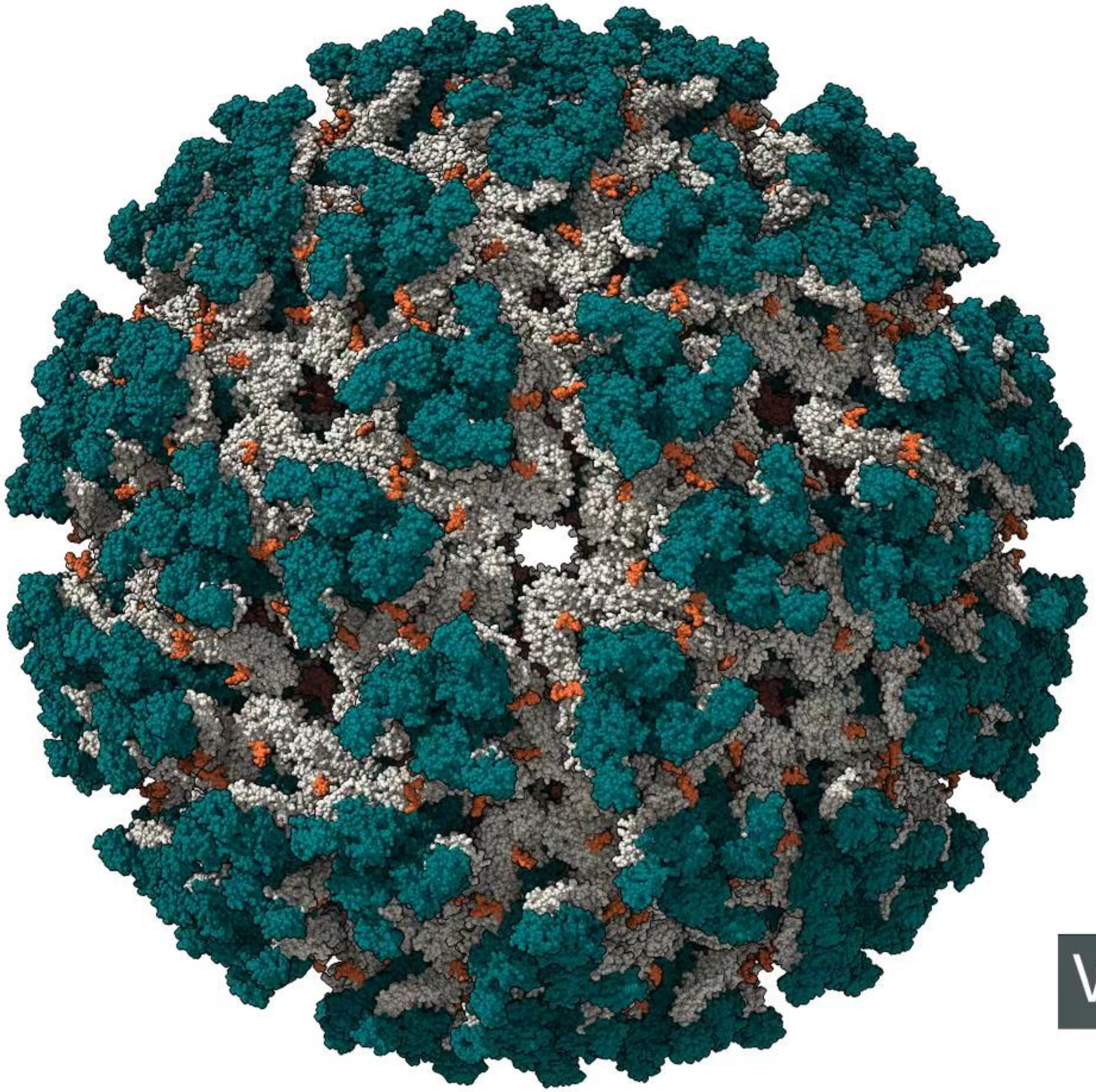
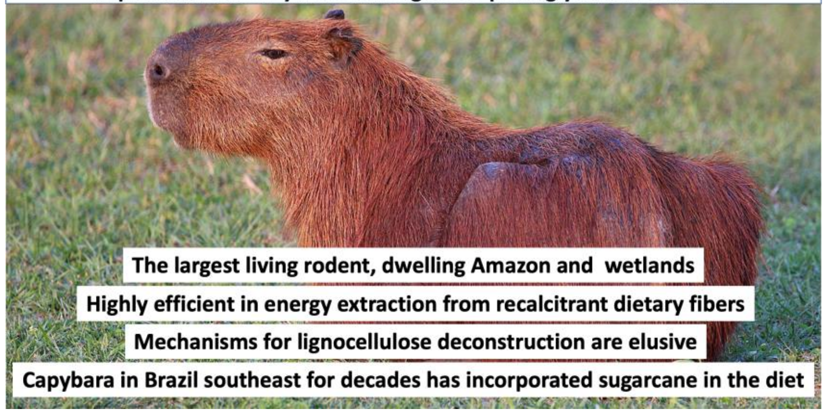


Vírus Mayaro

Brazilian biodiversity is an unique source of biotechnological solutions

nature COMMUNICATIONS
NATURE COMMUNICATIONS | (2022)13:629

Gut microbiome of the Amazon Master of the grasses harbors unprecedented enzymatic strategies for plant glycans breakdown



Microorganisms inhabiting the intestine of capybaras throughout evolution have developed highly effective molecular strategies for the degradation and utilization of biomass of great industrial and economic importance.

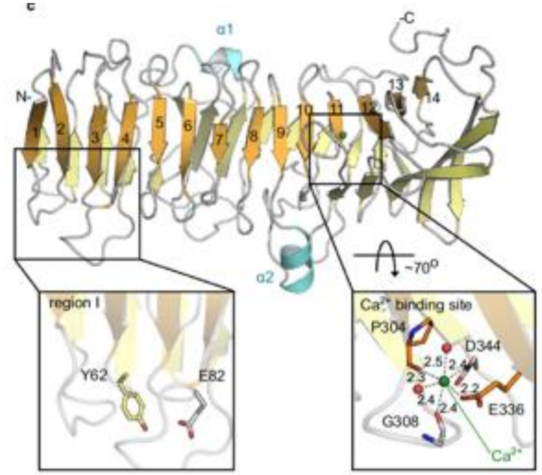
The details of the animal's microbiota metabolism that contribute to this feature had not yet been elucidated.

ARTICLE
https://doi.org/10.1038/s41467-022-28310-y OPEN

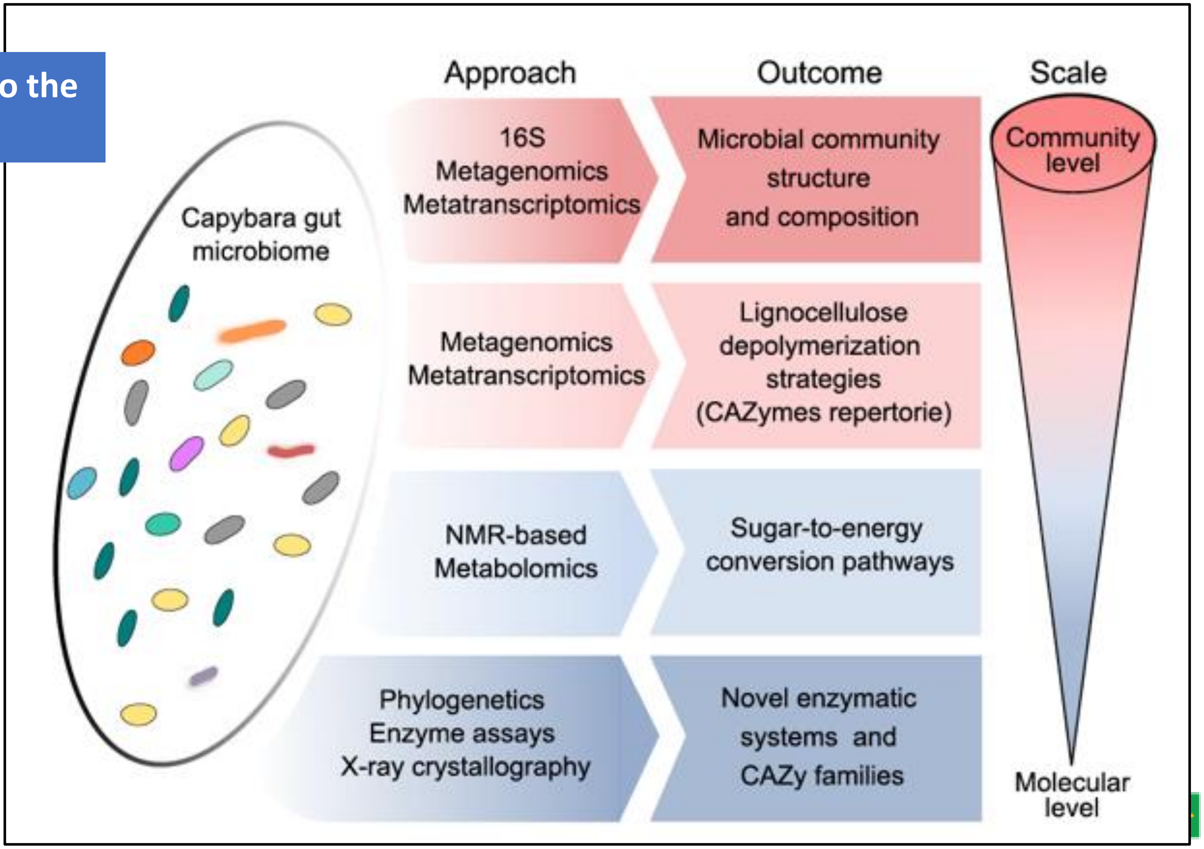
Gut microbiome of the largest living rodent harbors unprecedented enzymatic systems to degrade plant polysaccharides

Lucelia Cabral[1,8], Gabriela F. Persinoti[1,8], Douglas A. A. Paixão[1,8], Marcele P. Martins[1,2], Mariana A. B. Morais[1], Mariana Chinaglia[1,2], Mariane N. Domingues[1], Mauricio L. Sforca[3], Renan A. S. Pirolla[1], Wesley C. Generoso[1], Clelton A. Santos[1], Lucas F. Maciel[1], Nicolas Terrapon[4,5], Vincent Lombard[4,5], Bernard Henrissat[6,7] & Mario T. Murakami[1]

Complete survey of the bacteria present in the capybara intestine, in addition to the expressed genes and metabolites produced from plant fibers.



To understand the processes of depolymerization of lignocellulosic fibers and the efficient transformation of sugars into energy, a wide combination of techniques and methodologies was used, with an integrated multi-omics approach from the community to the molecular level.

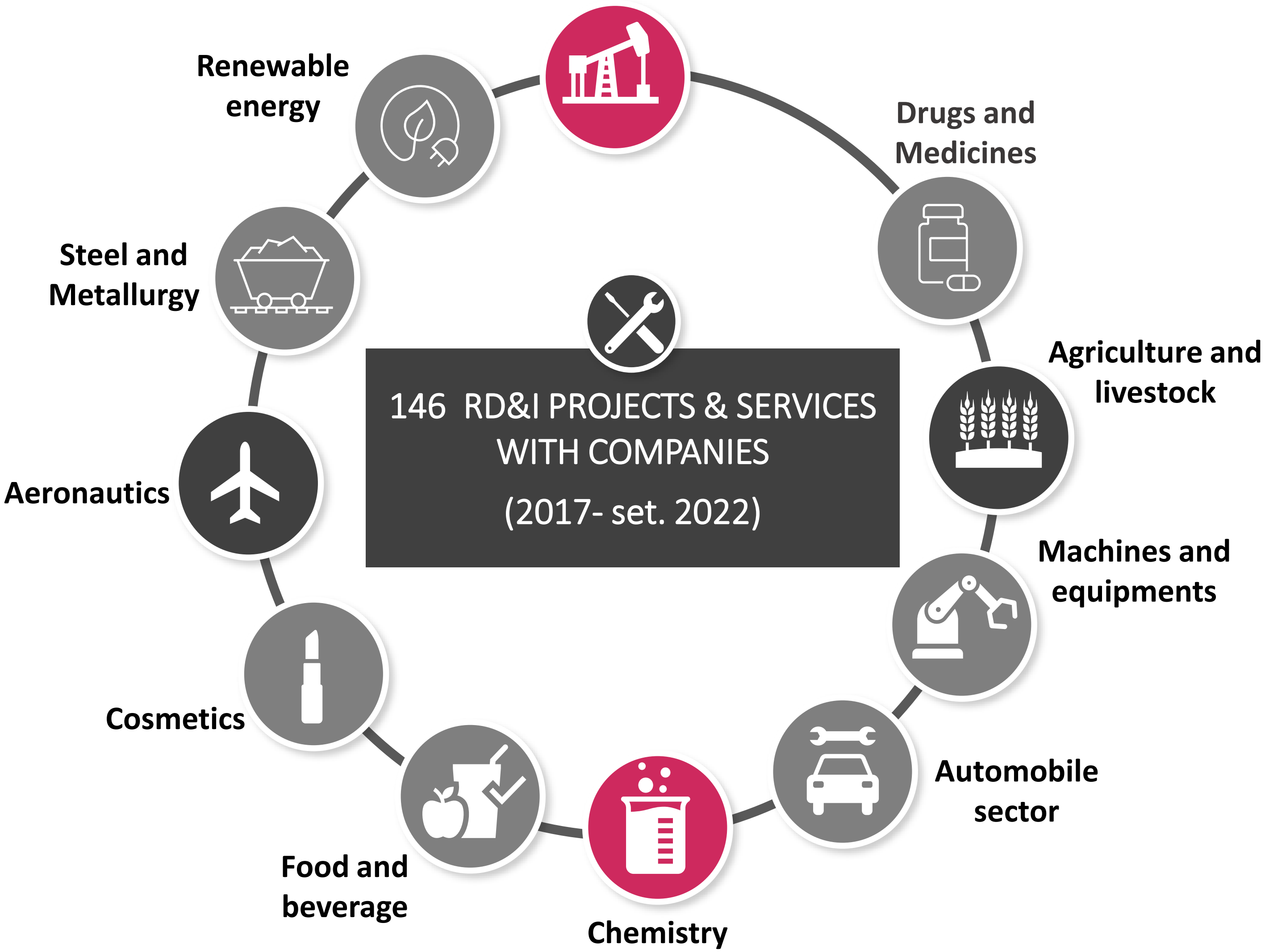


The elucidation of the entire digestive process of capybara revealed new microorganisms and two new families of enzymes, with potential use in biotechnological applications.

CNPEM EFFORTS TO PROMOTE INNOVATION

R&D Projects and Technical services with companies

Projects Areas



Support for Innovation and Tech Transfer Office

Support in R&D Projects and Services with Companies
Support for IP protection and licensing
Support for market and strategic analysis
Support in Fund raising

Some Partners

Co-funding Mecganisms

DRUG DISCOVERY FROM THE BIODIVERSITY

SOME SUCCESSFUL CASES Healthcare

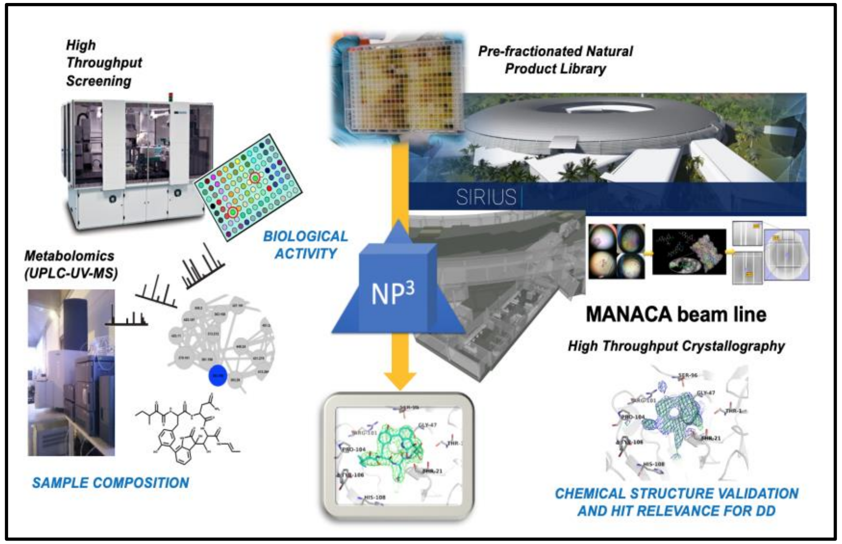
PHARMACEUTICALS AND BIOPHARMACEUTICALS

Co-funded by EMBRAPII

Phytobios — Science with focus on results
aché — mais vida para você

First Project Completed (2022) & Second Project Ongoing

- Synthesis of **anticancer drugs** through assays surveying **Brazilian biodiversity**
- Project uses CNPEM´s Drug Discovery Platform to explore Brazilian Biodiversity which includes Sirius Manacá Beamline Analysis using **Sirius**



A proprietary workflow for High Throughput Screening of natural products libraries and Structure-Activity Relationship assessment with the aid of Sirius Manacá Beamline

DERMOCOSMETICS

Phytobios — Science with focus on results
aché — mais vida para você

Ongoing

- Development of **dermocosmetics** from **Brazilian biodiversity**

natura

Completed in 2022

- Development of an alternative method to the use of animals for the evaluation of cosmetic toxicology

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SOME SUCCESSFUL CASES
Healthcare

Nintx | **R&D Colaborative Projects (ongoing)**

Co-funded by EMBRAPII

Brazilian startup

Target Drug Candidates Aimed at **Immunotherapy Potentiators** for **Cancer Treatment**

Targeted Drug Candidates for the Treatment of **Heart and Liver Disease**

Targeted Drug Candidates Targeting the Treatment of **Coronavirus Viral Infections**

SOME SUCCESSFUL CASES

Industrial Biotech Projects

BIOFUELS AND BIORENEWABLES R&D COLABORATIVE PROJECTS

Co-funded by EMBRAPII

PETROBRAS

Completed in 2022

Development of Critical Steps in the **2nd Generation Ethanol Production** Process

1 patent being filed

SINOCHEM

Completed in 2022

Enzymatic Strategies for **Advanced Biofuels**

2 patent filed

VALE – Instituto Tecnológico Vale

Ongoing

Development of a **Selective Bioreagent for Iron Ore Flotation**

Optimization of microorganisms and processes and at the pilot plant scale

SOME SUCCESSFUL CASES
Industrial Biotech Projects

BIOFUELS AND BIORENEWABLES R&D COLABORATIVE PROJECTS

Co-funded by EMBRAPII

equinor

Ongoing

Biotechnological route for the use of **agroforestry by-products**

SINOCHEM

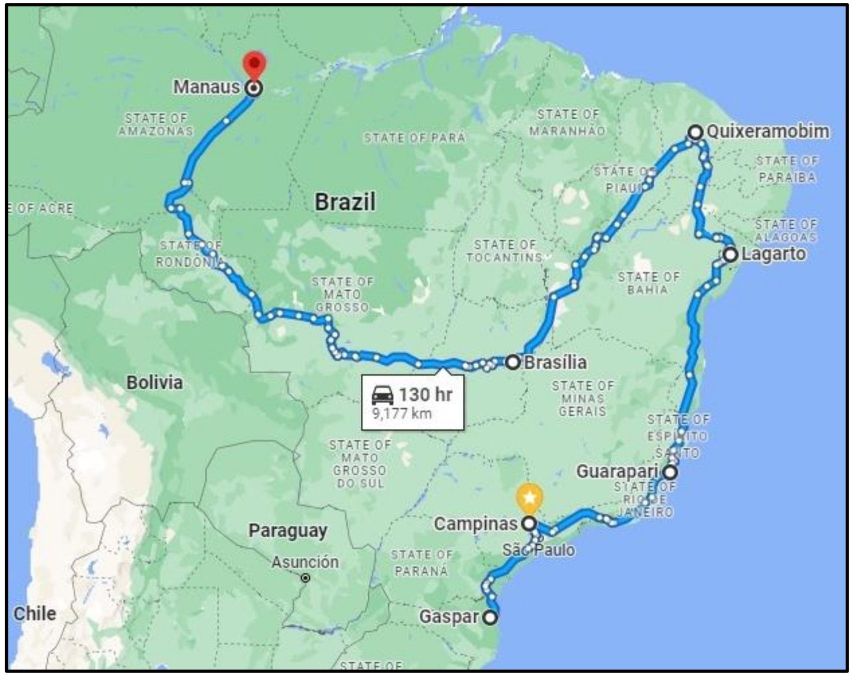
Ongoing

Agroindustrial Biorefinery: Technological Routes for the **Valorization of By-products** via the **Generation of Advanced Sugars** and the **Production of Biofuels and Biochemicals**

Education, Training and Outreach

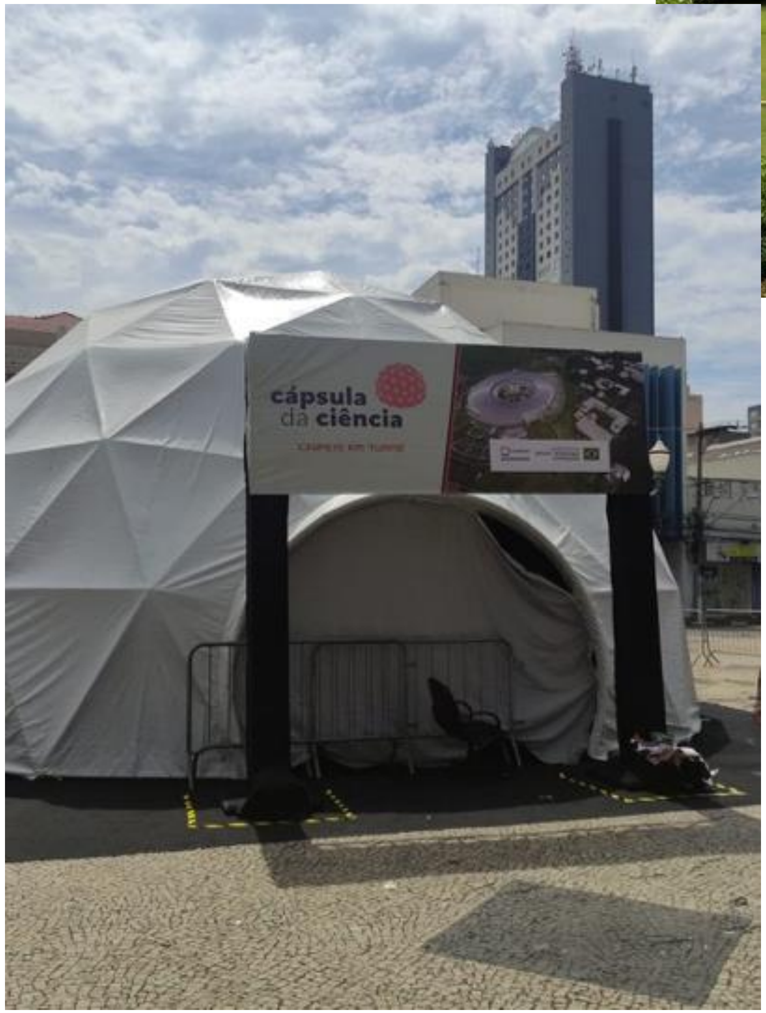
https://cnpem.br/events/#top

High-School Teachers´ School at CNPEM



cápsula da ciência

CNPEM EM TURNÊ



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CNPEM Technology Unit

The Technology Unit is responsible for multidisciplinary equipment development and implementation of scientific infrastructures.

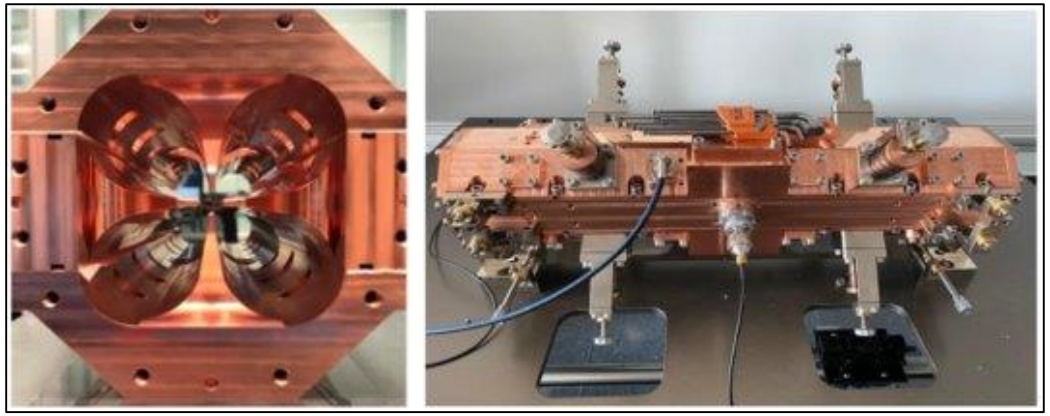
Through six areas of activity, it complements itself from creating projects to delivering final products.

- System Engineering
- Materials Engineering
- Mechanics and Advanced Manufacturing
- Instrumentation and Electronics
- Automation, Robotics and Computing
- Infrastructure and Installations

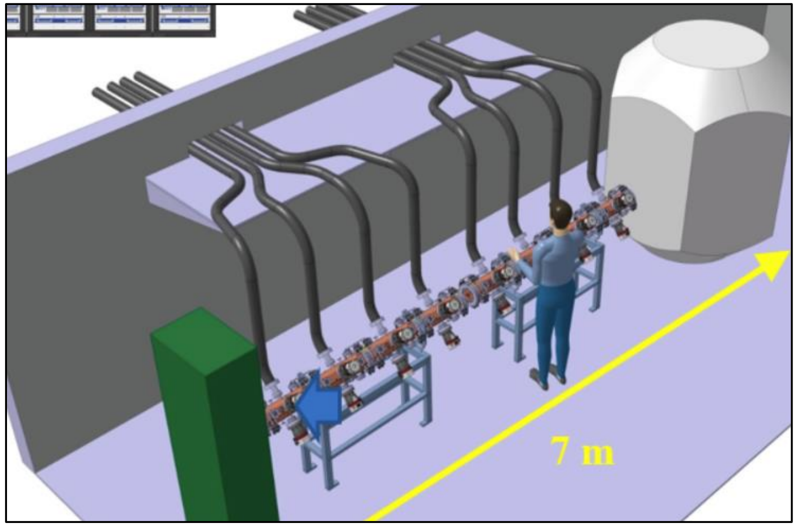
System Engineering

Radioisotope production:

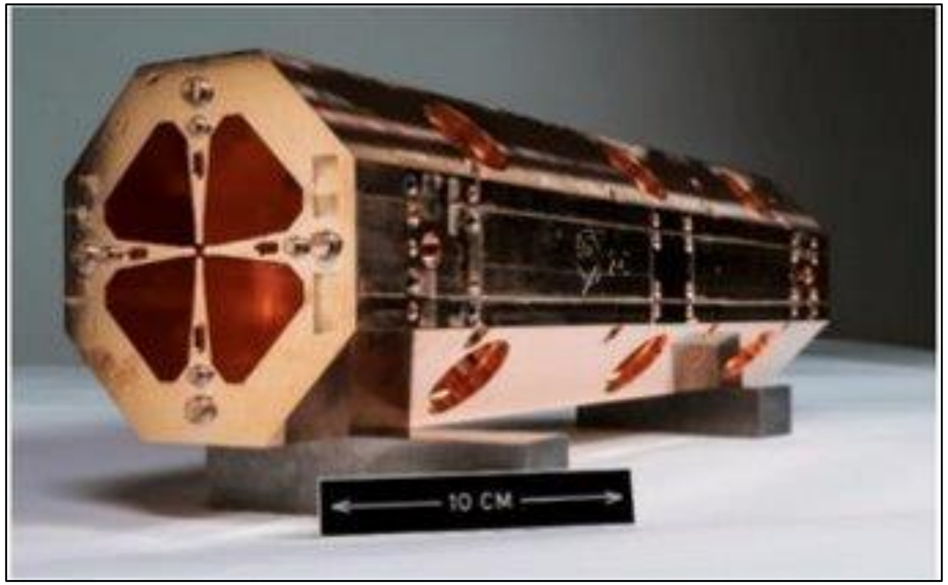
- Design and construction of an RFQ linear accelerator;
- Partnership with CERN;
- RFQ cavity optimization using PARMTEQ (Los Alamos – LANL).



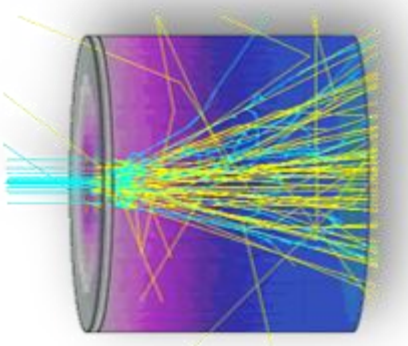
RFQ example



RFQ accelerator sketch



RFQ proposed by CERN

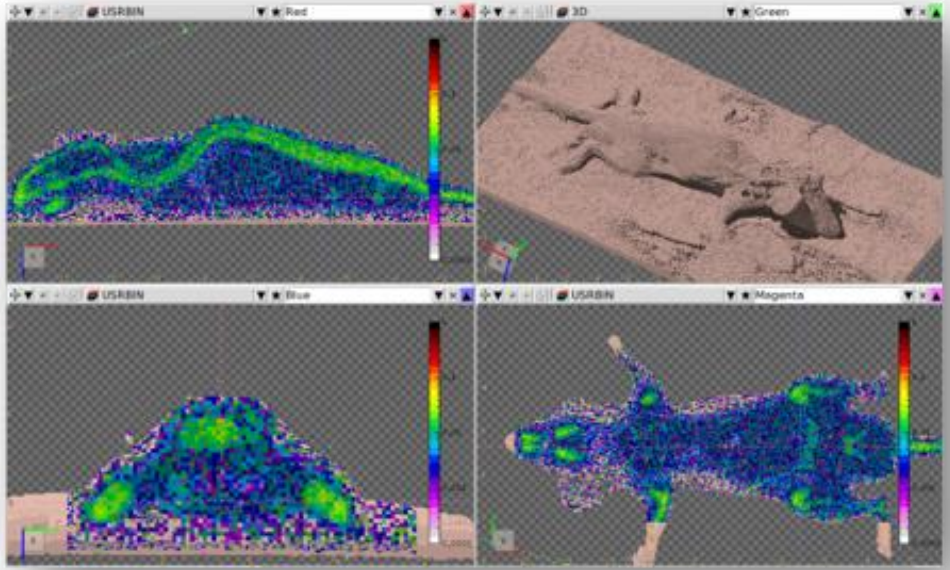


FLUKA simulation

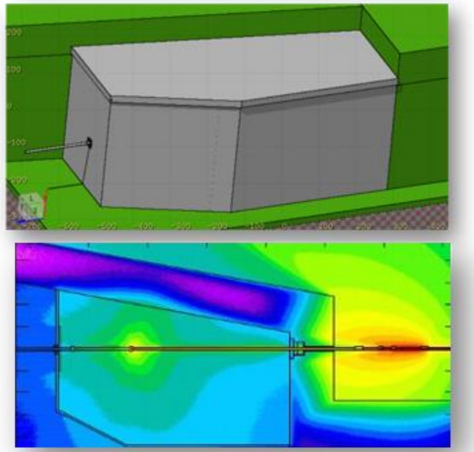
System Engineering

FLUKA simulations:

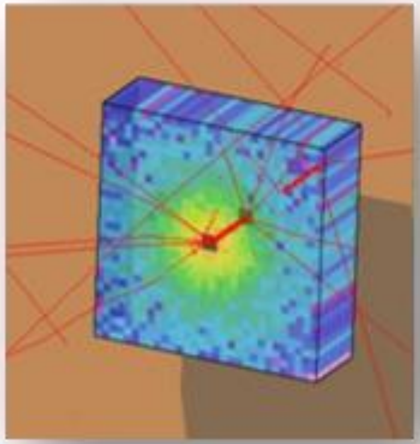
- Radiation transport;
- Radiation protection;
- Dose in the equipment;
- Performance of materials exposed to radiation;
- Dosimetry;
- Proton Therapy;
- Medical images;
- Accelerator based radioisotopes production.



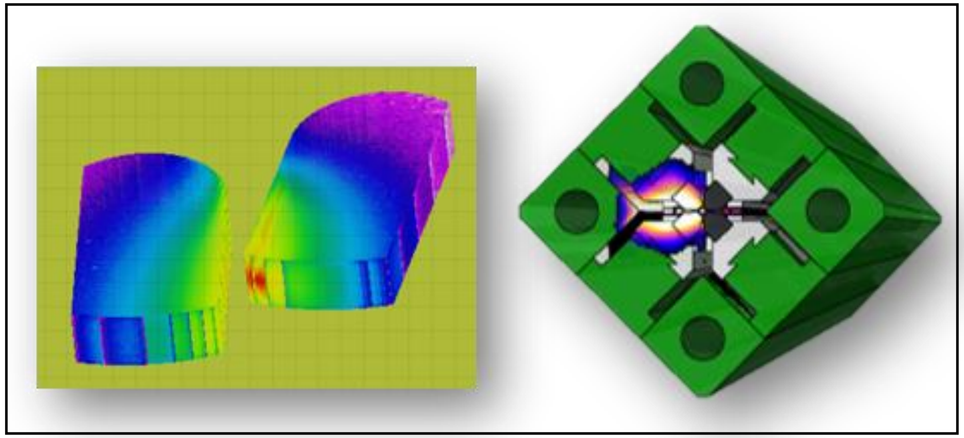
Medical images and Proton Therapy



Radiation Protection



Dosimetry



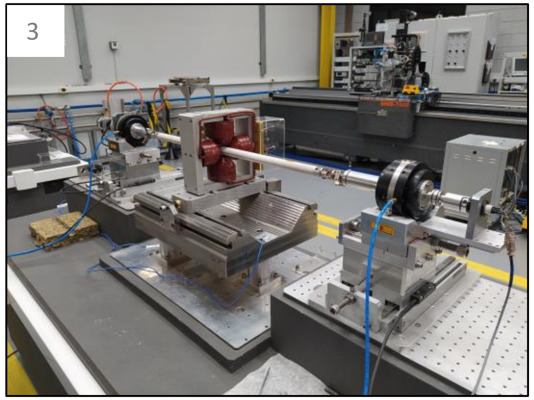
Radiation dose in equipment

System Engineering - Magnets

Infrastructure

1. Magnet characterisation lab
2. 7 m long Hall probe bench
3. 2 Rotating coil benches
4. Stretched wire bench
5. Helmholtz coil system
6. NMR Teslameter
7. Permeameter
8. Magnets assembling area

8


3


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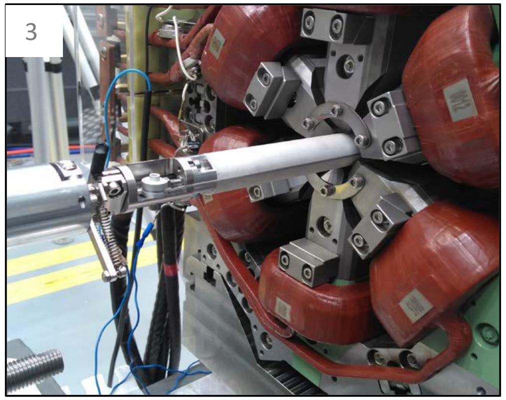

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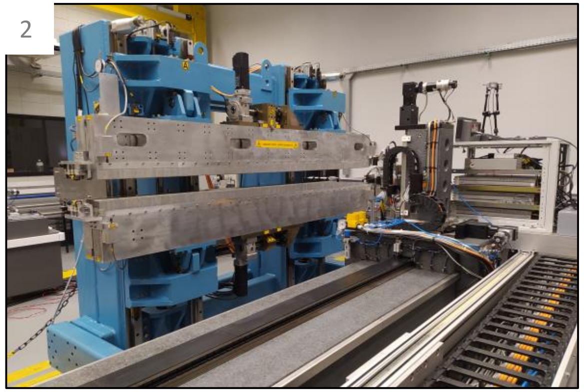

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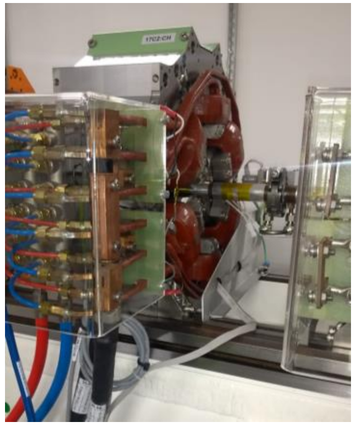
4

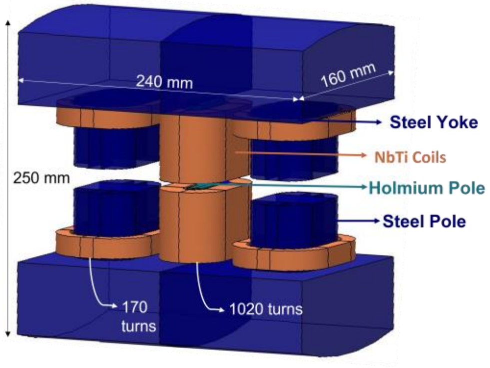

System Engineering - Magnets

Deliverables

- Magnetic simulations
- EM and PM Magnet design, fabrication and characterisation
- Insertion devices
- Magnet characterisation benches
- R&D in SC magnets

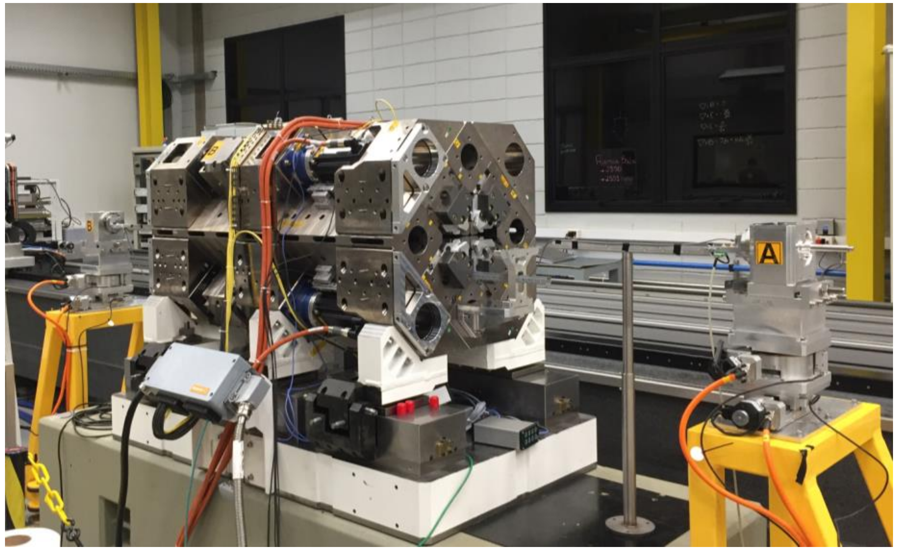


Sirius sextupole magnet

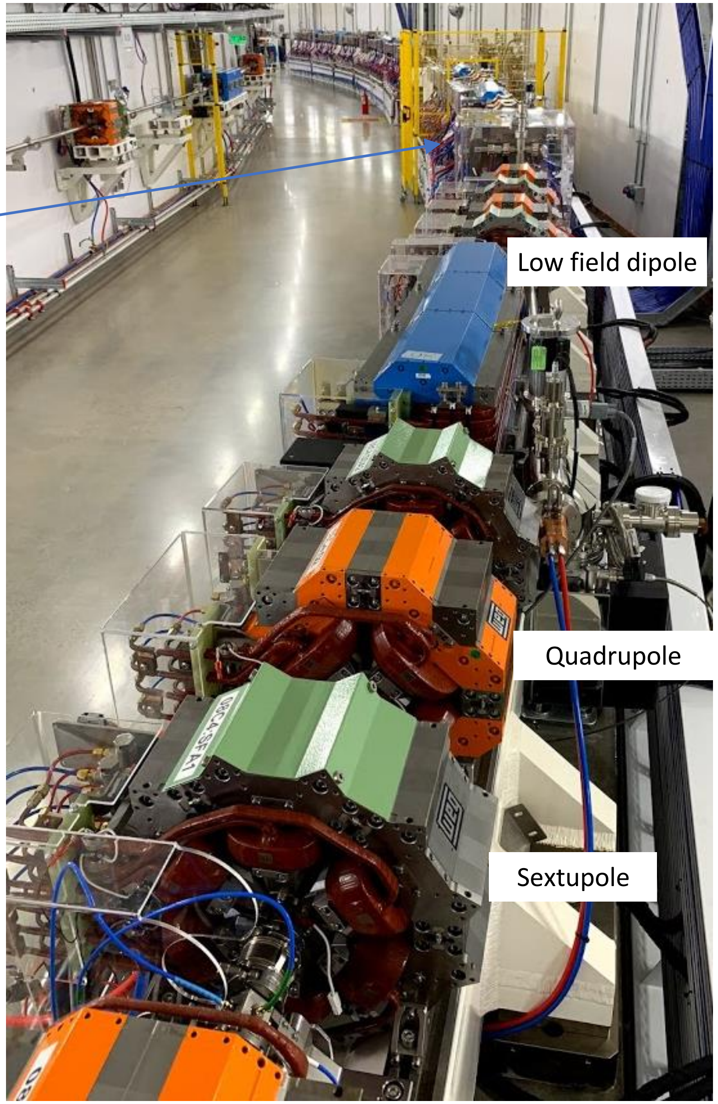


SC 7 Tesla WLS under design

PM 3.2 T high field dipole



52.5 mm period Delta Undulator in the stretched wire bench

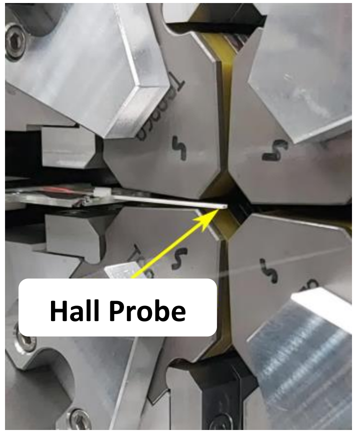


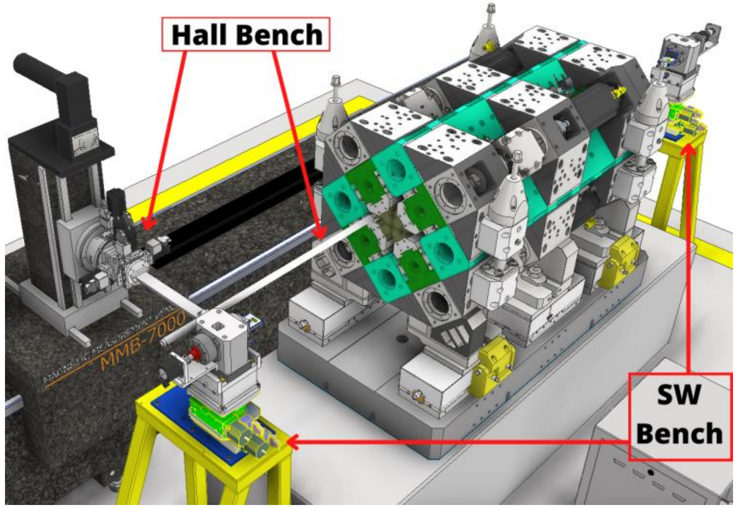
Sirius magnetic lattice

System Engineering - Magnets

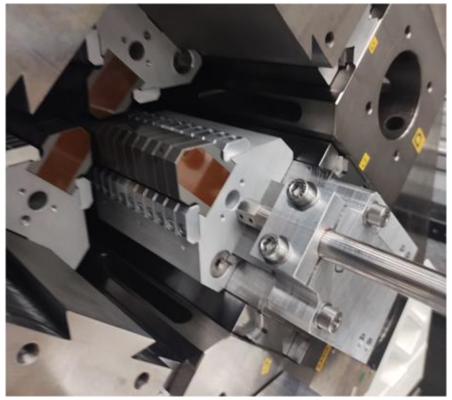
Delta Undulator

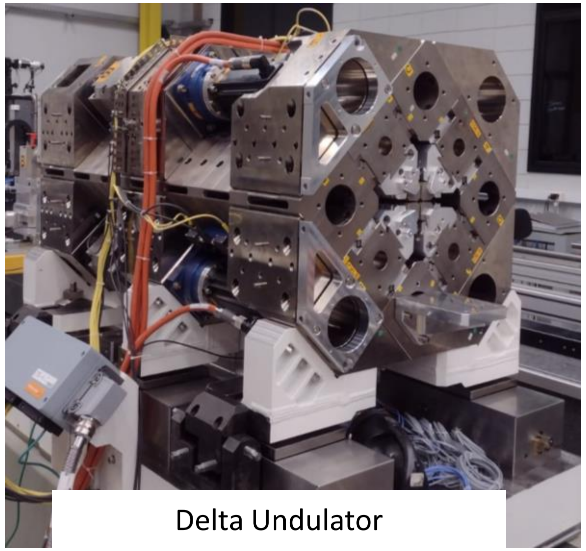
- Basic structure: longerons and longeron connectors
- Movable cassettes fixed by linear guides
- Keepers fixed on cassettes
- Dovetail used to fix the keepers

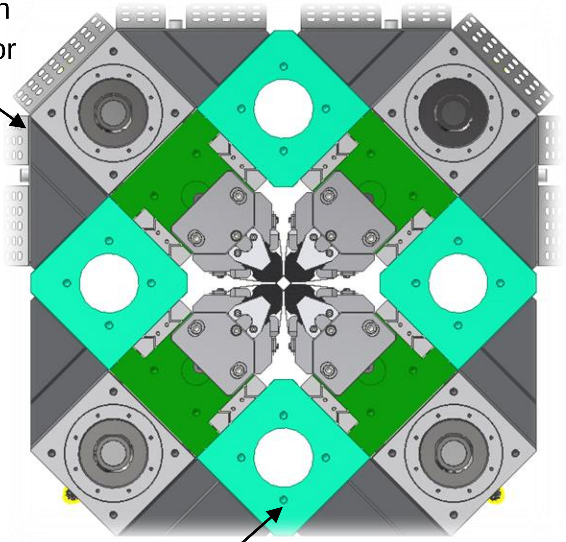


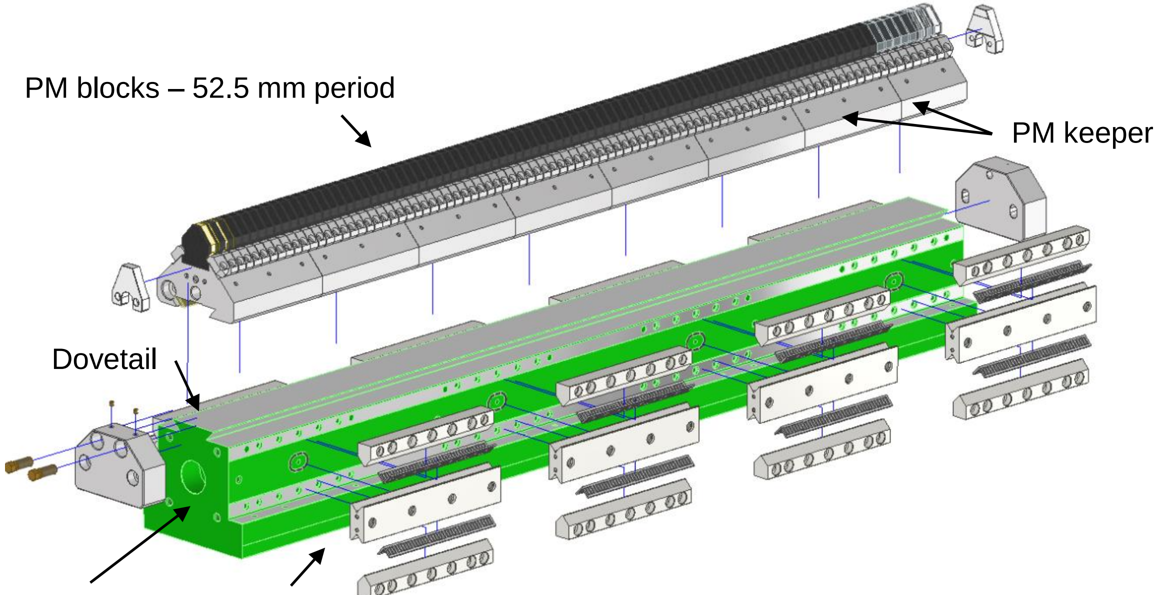



Keeper assembly


Undulator assembly


Delta Undulator





System Engineering – Pulsed Magnets

1. RF Test area
2. Amplifier measurement bench
3. Pulsed magnets measurement bench
4. E-gun test bench

1

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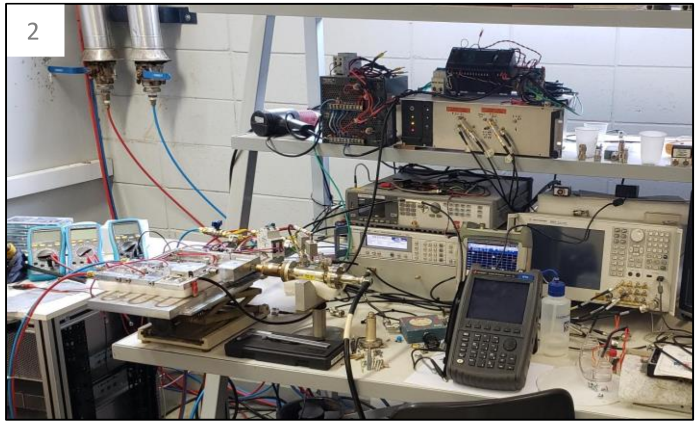


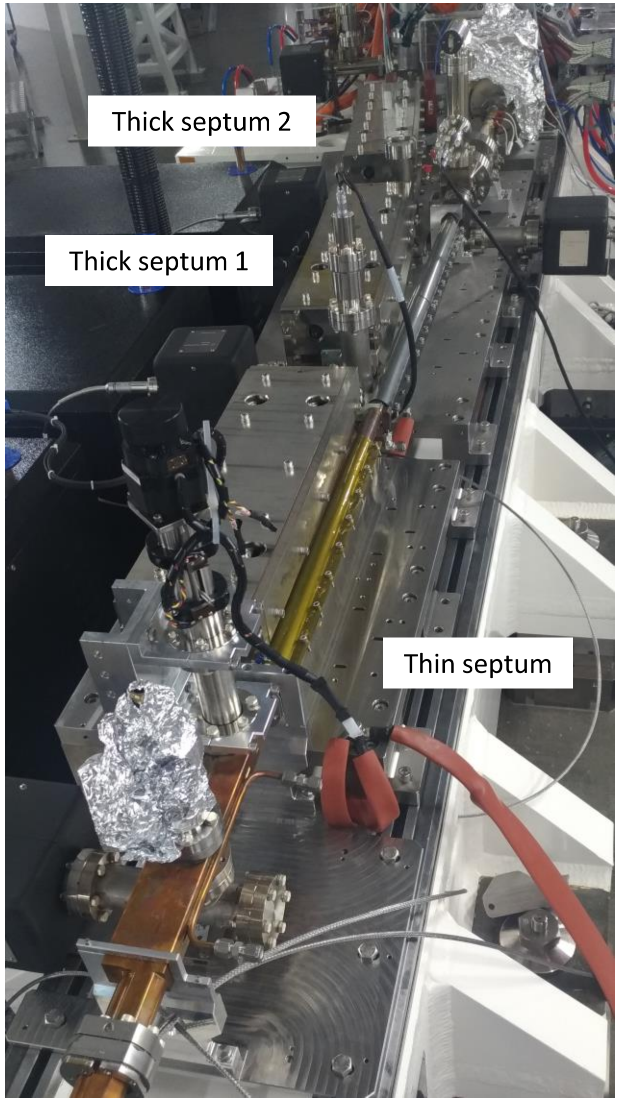
System Engineering – Pulsed Magnets

Deliverables

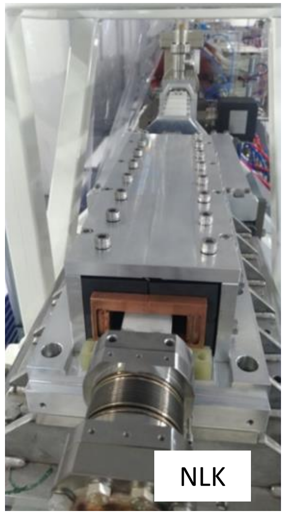
- HV Power supplies for injection pulsed magnets
- Pulsed magnets characterisation
- Linac modulators and e-gun maintenance and upgrades

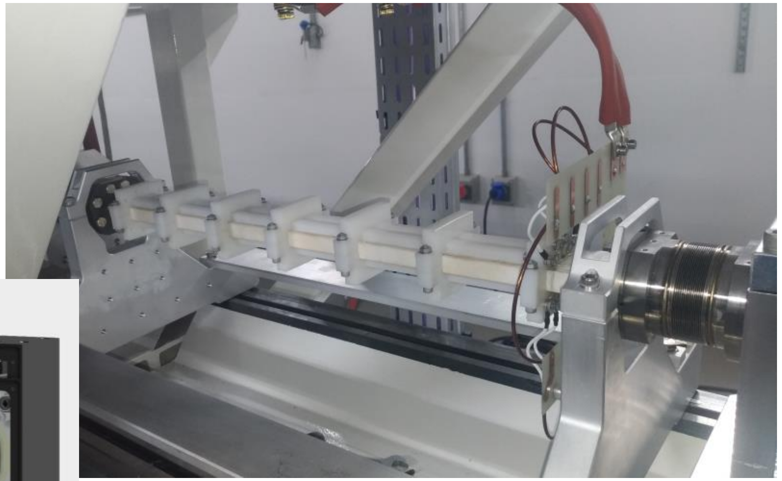
Extraction Septa HV Pulsed PS

Linac Klystron and modulator



Sirius injection section





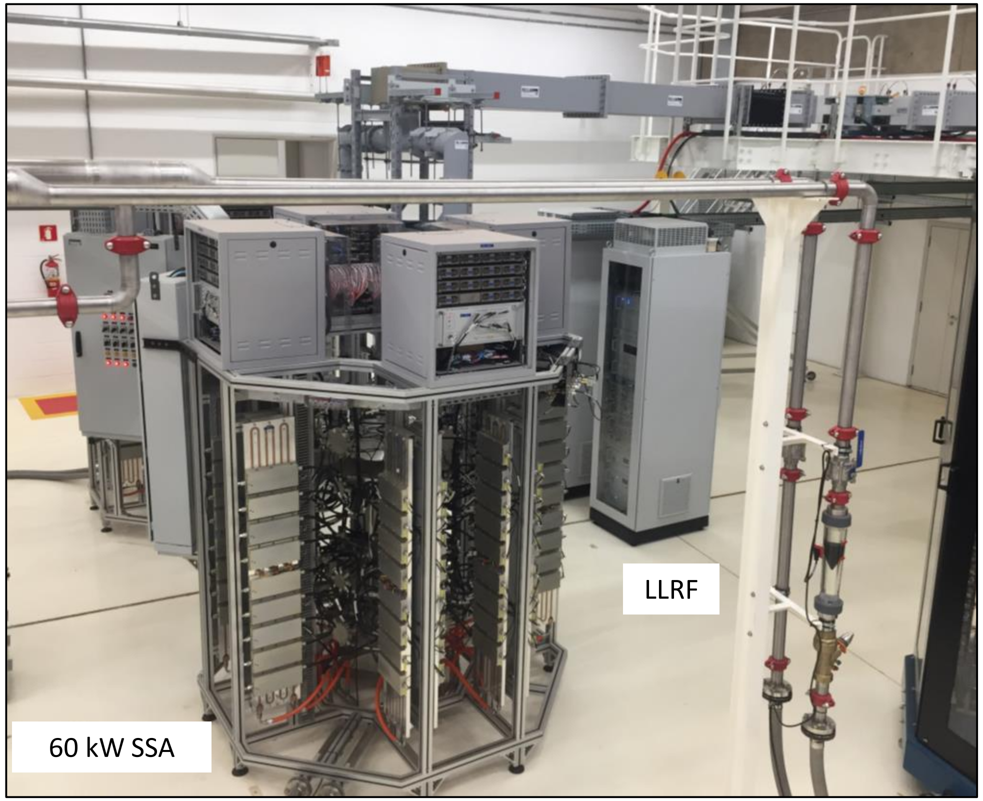
Non-linear Kicker

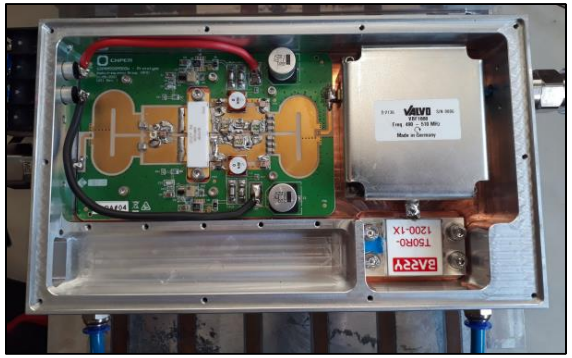
Variable inductor

System Engineering - RF

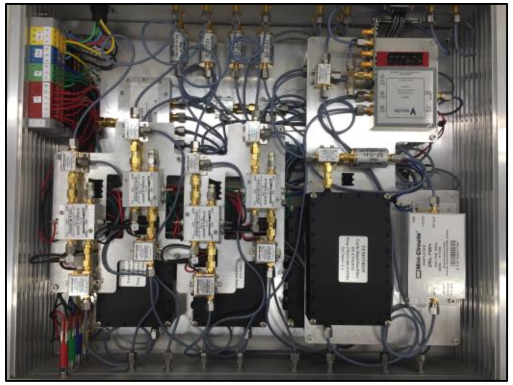
Deliverables

- Design, assembly and characterization of RF amplifiers
- Maintenance and upgrades of Sirius RF systems
- RF beam diagnostics systems
- Impedance simulations





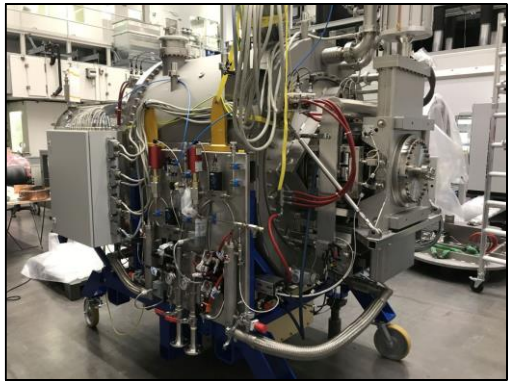
800W 500MHz amplifier module



LLRF up-conversion crate

Booster 45kW SSA

Current Sirius 7-cell RF cavity



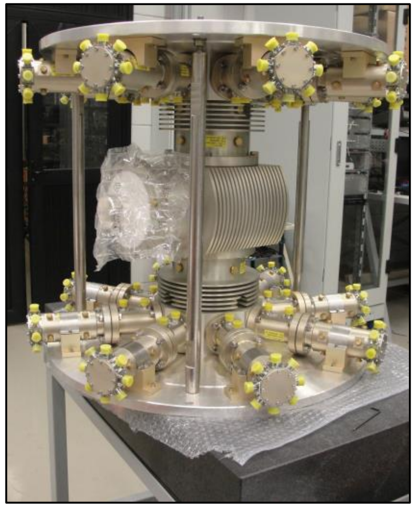
Sirius SC RF cavity

Circulator and load

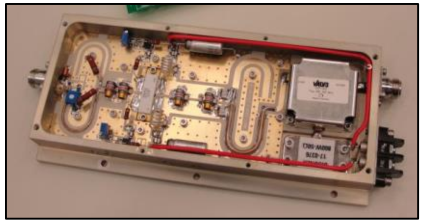
System Engineering - RF

Solid State Amplifiers

- Design, assembly and characterisation of high power amplifiers
- Design of amplifier modules
- Combining topology
- Power and interlock systems



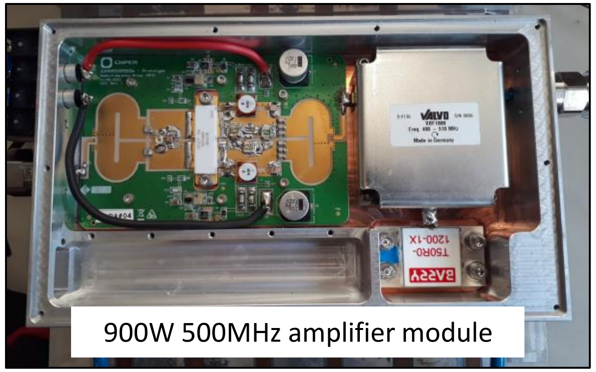
128:1 Combiner



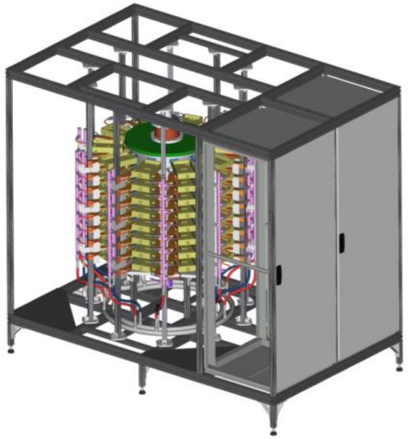
550W amplifier module

EIA 6-1/8” output port

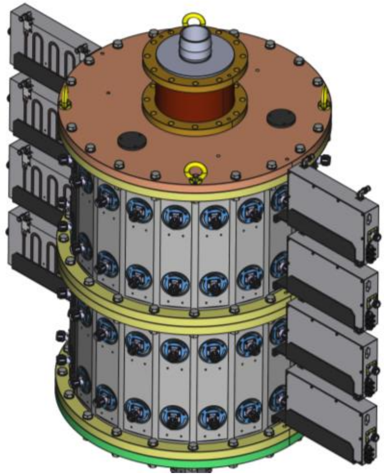
60 kW SSA structure



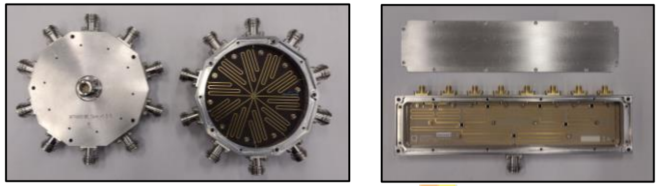
900W 500MHz amplifier module



Concept of the new amplifier



Cavity combiner for the new SSA

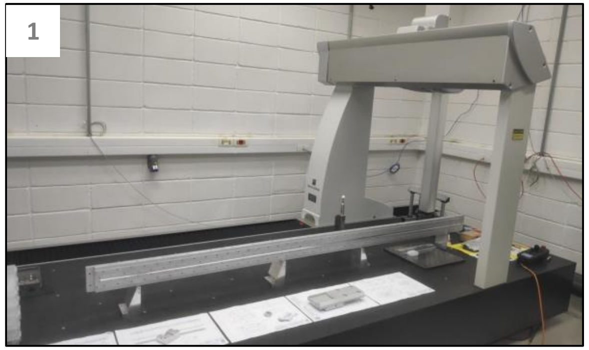


Dividers for the new SSA

Mechanics and Manufacturing

Infrastructure

- 1 – MMC
- 2 – Laser Tracker
- 3 – Measurement Arm
- 4 – Accelerometers
- 5 – Machining Center 4x (DMG)
- 6 – Machining Center 5x (Mori)
- 7 – CNC Lathe (ROMI)
- 8 – Zero point system – Fast machining setup
- 9 – High pressure clamping – Fast machining setup
- 10 – Laser Cutting machine and Bending machine
- 11 – Boiler shop and welding
- 12 – Mechanical project room
- 13 – Mechanical assembly room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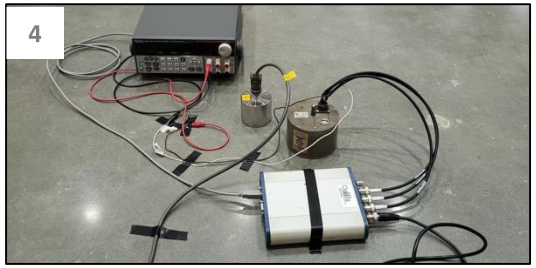
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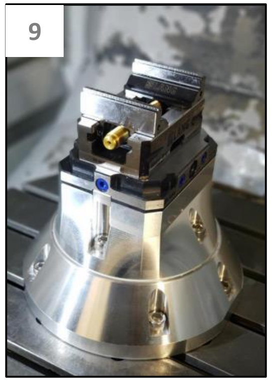
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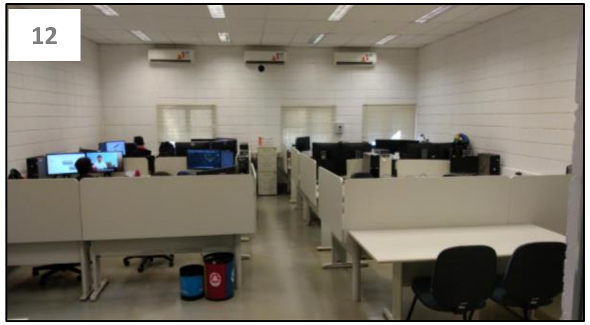
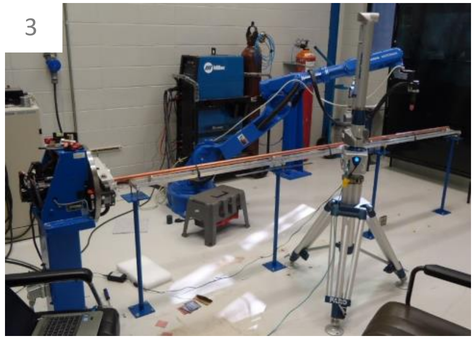

12


13

System and Materials Engineering

Infrastrutures

1. Ultrasonic baths
2. Galvanoplastic e chemical etching
3. TIG welding
4. Microplasma welding
5. FSW
6. Portable cleanrooms - ISO 7
7. Leak detectors
8. NEG coating facility
9. Vacuum furnaces
10. Microdurometers
11. Optical profilometers
12. Optical and electronic microscopes
13. Metallographic analysis
14. Gleeble, MTS, tensile testing
15. XPS
16. Optical emission spectrometer (elemental analysis)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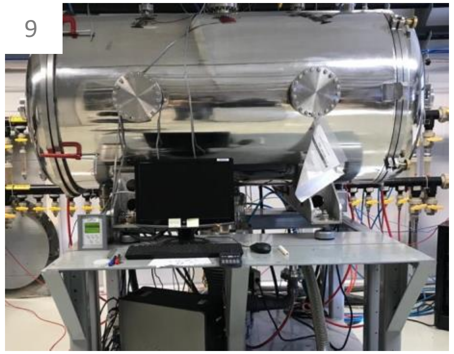
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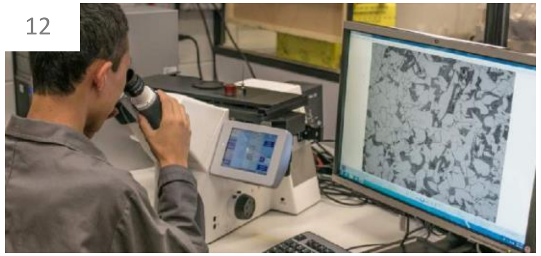
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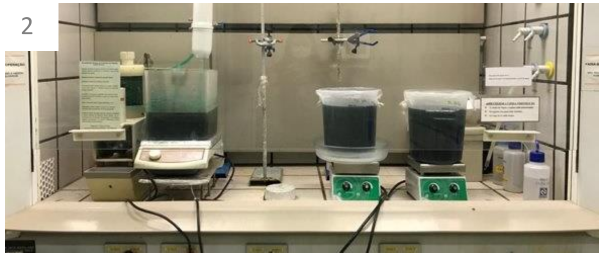
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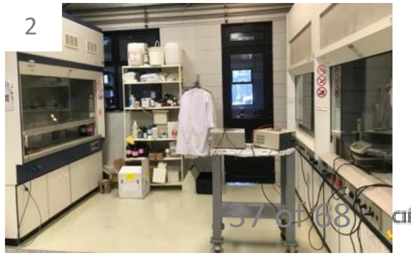
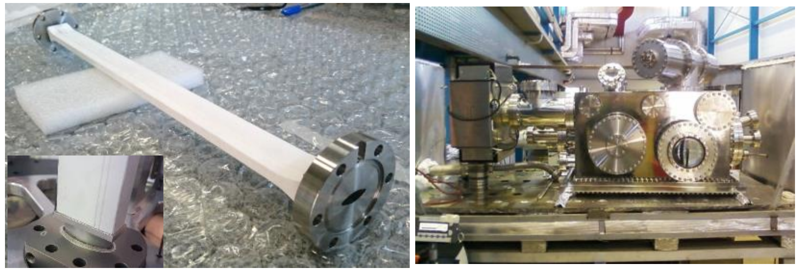

2

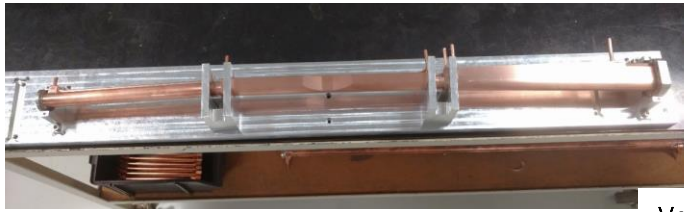
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES

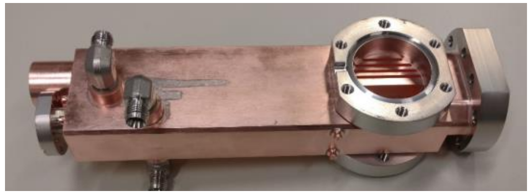
System and Materials Engineering

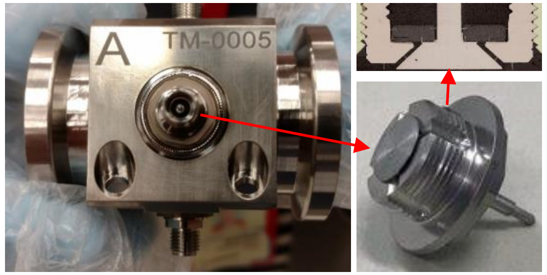
Deliverables

- Materials special joints
- Vacuum chambers manufacturing (e.g., SS, Al, Cu, alumina)
- Elemental, metallurgical and mechanical characterizatin of materials
- Leak detection
- Metallic film deposition (NEG, Ti)
- Heat treatments of materials

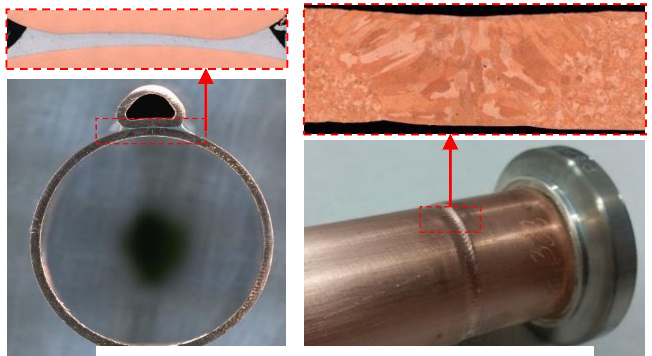






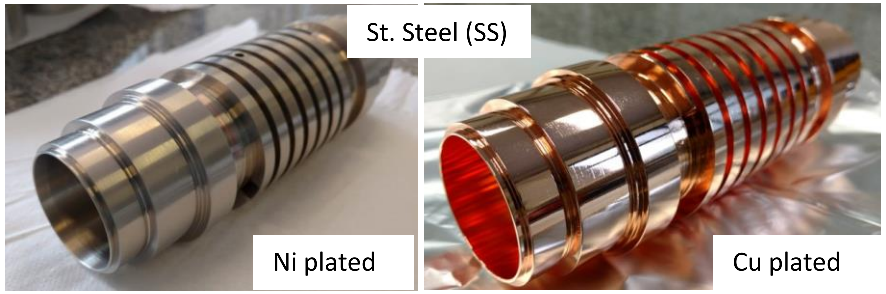


Vacuum chambers – Alumina, SS, Ti6-Al-4V

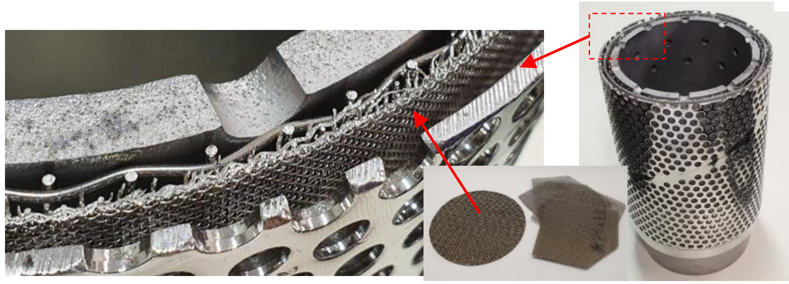


Special joints - similar materials – Cu-Cu

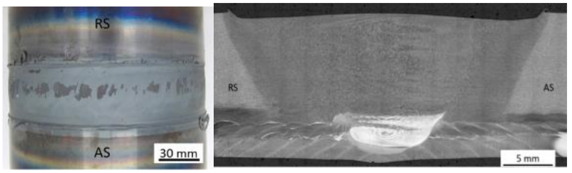
Special joints - dissimilar materials – Al-Inox, Cu-inox



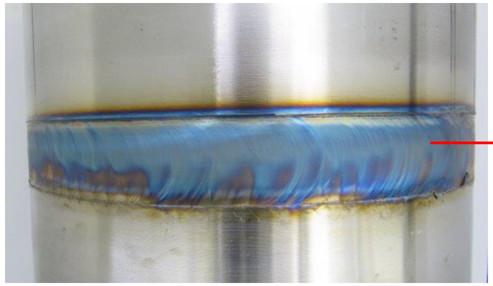
Diffusion bonding – Premium filters

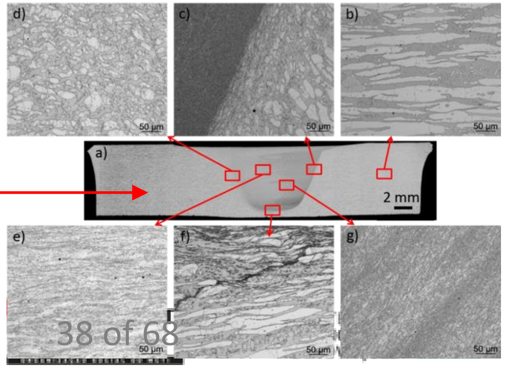


FSW - carbon steel cladded (overlay) w/ inconel



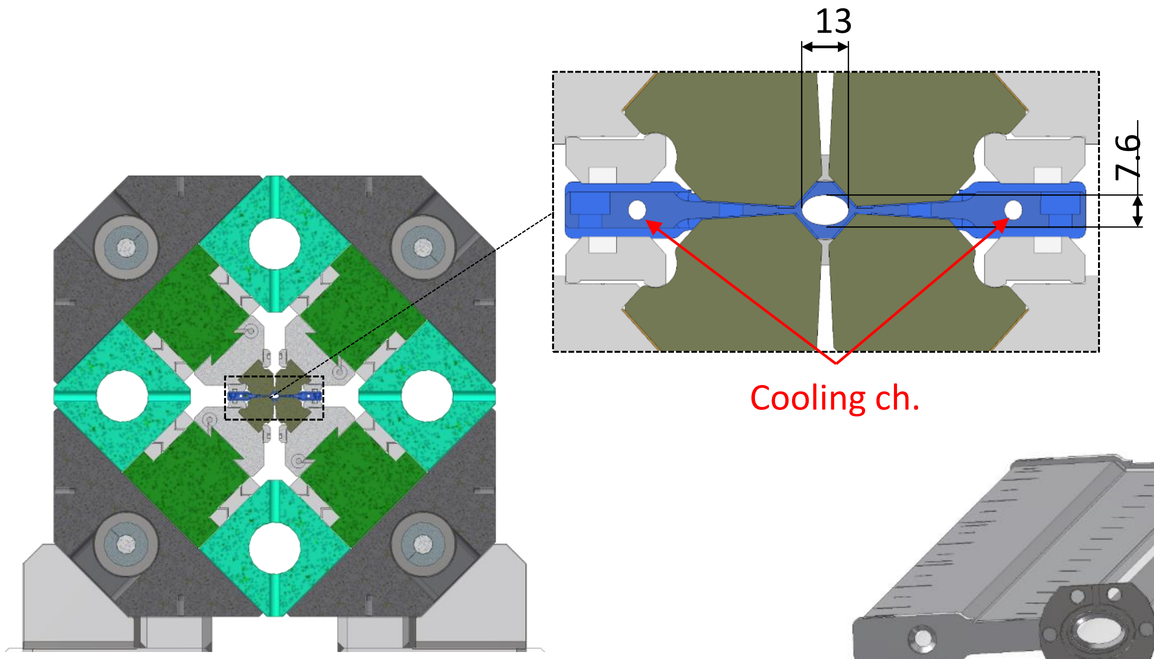
FSW - duplex SS tubes

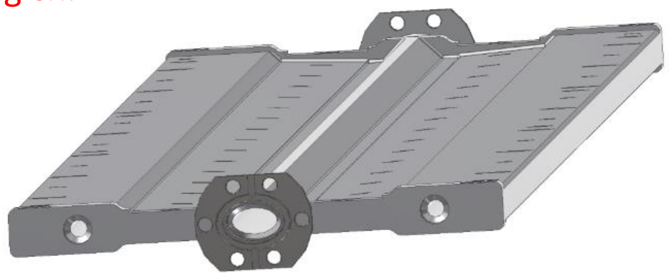


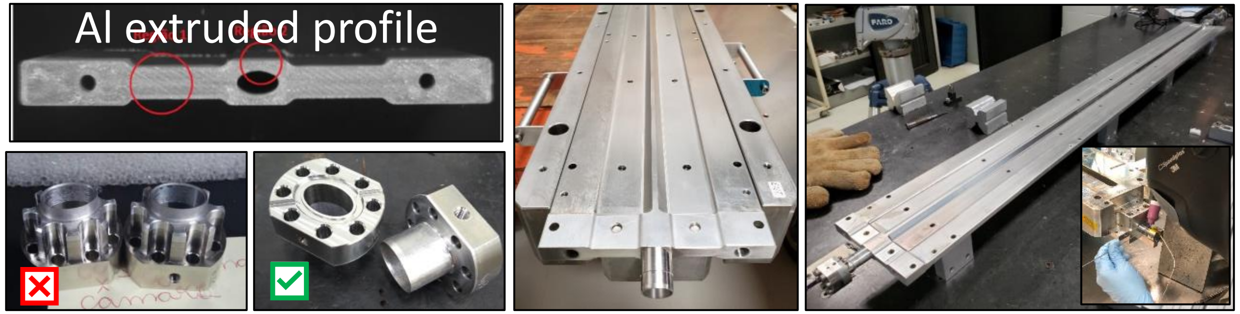


Vacuum chamber for the Delta Undulators – long period

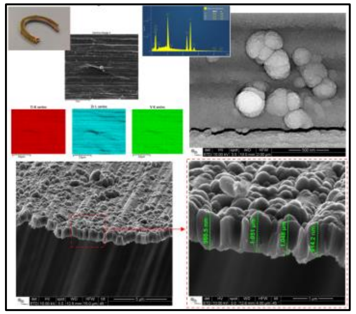
- Chamber fabrication (in-house)
  - NEG coating ✓
  - Machining process ✓
  - Welding ✓
  - Dimensional validation ✓
  - Bakeout cycles and endurance test ✓
  - Installation of the 1.3 m prototype ✓
  - 3.4 m long chamber fabrication is underway



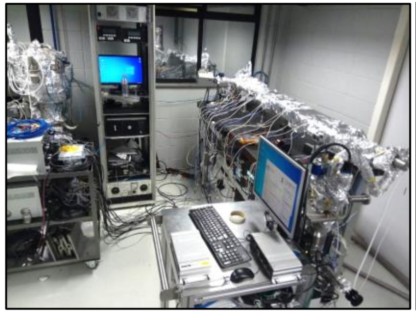




Fabrication



NEG Coating



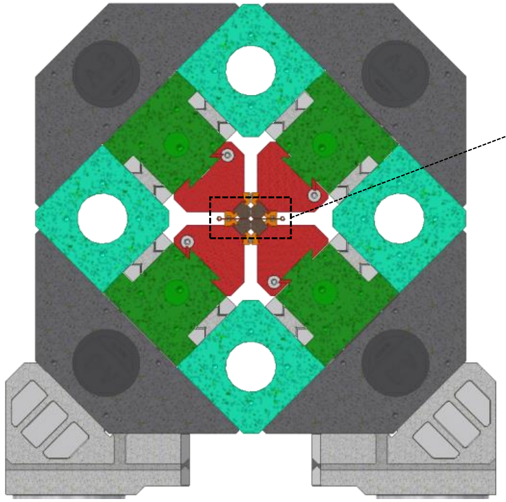
Bakeout cycles

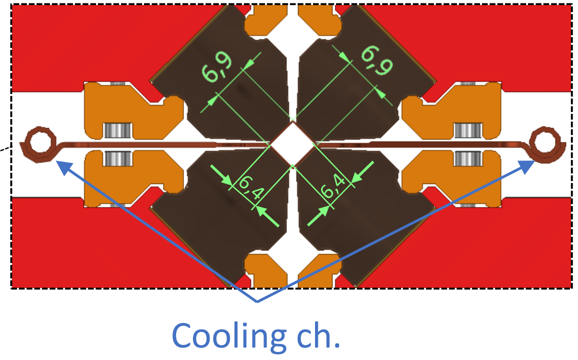
Installation of 1.3 m long prototype

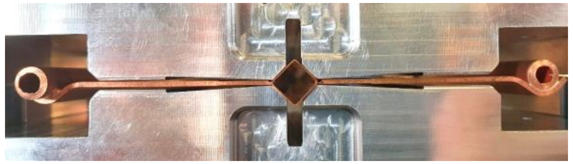
1.3 m chamber (Delta Sabia prototype) installed at Sirius

Vacuum chamber for the Delta Undulators – short period

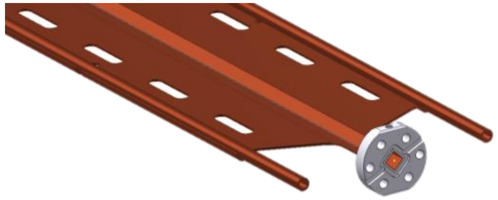
- Chamber fabrication (in-house)
  - NEG coating up to 2.6 m ✓
  - Machining of the components ✓
  - Flanges brazing ✓
  - Cooling system brazing ✓
  - Dimensional validation ✓
  - Bakeout cycles and endurance test
  - 2.6 m long chamber fabrication

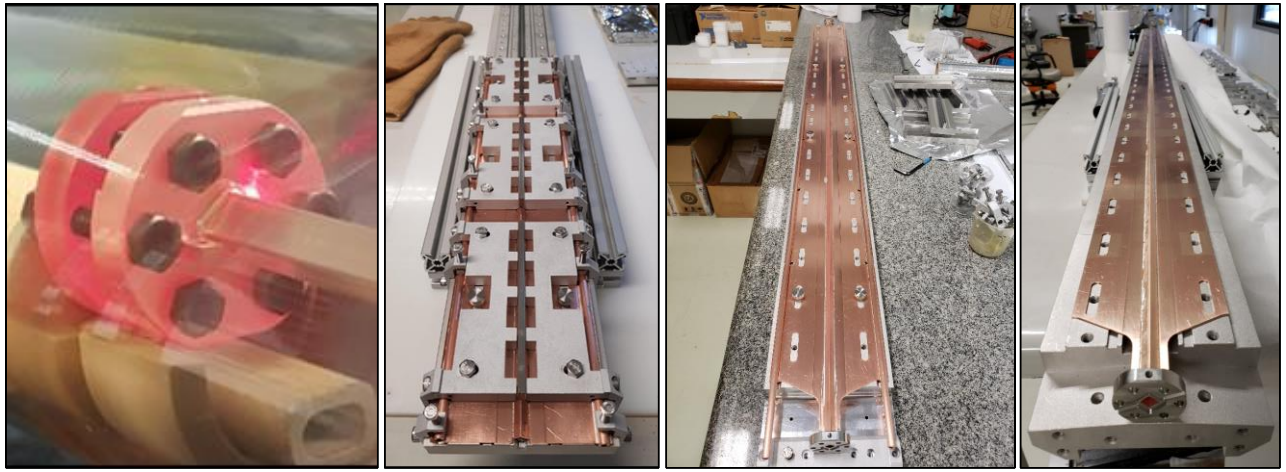




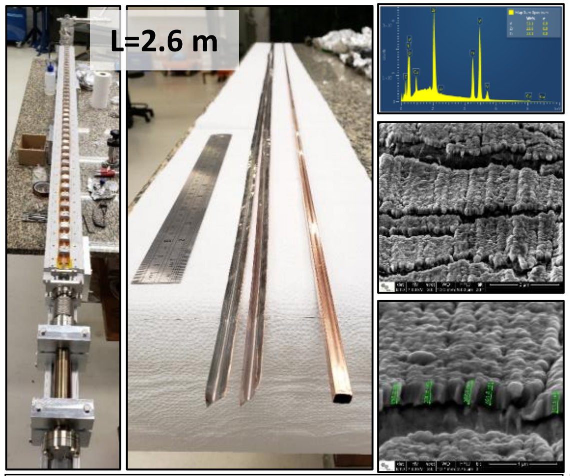


Patent pending!





Brazing



NEG Coating

Installation of 2.6 m long prototype

- **1st fully functional prototype of 1.3 m is ready**
- **2.6 m prototype w/o cooling ch. installed at Sirius**

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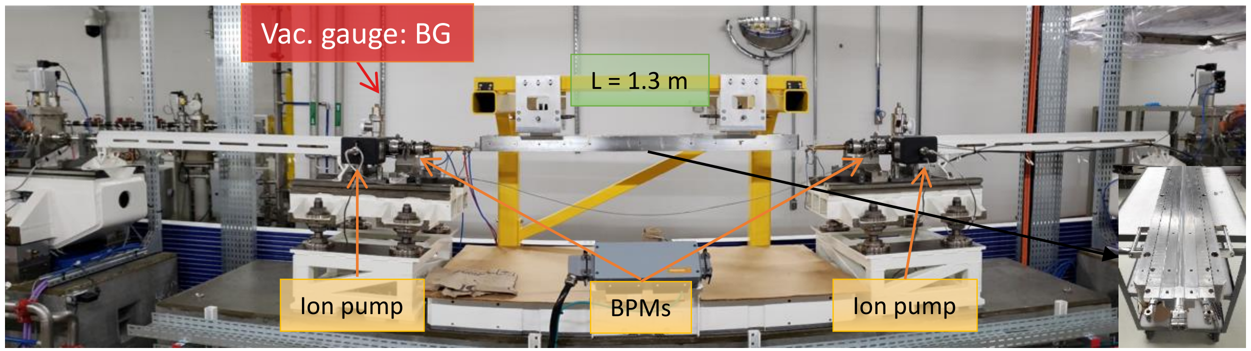
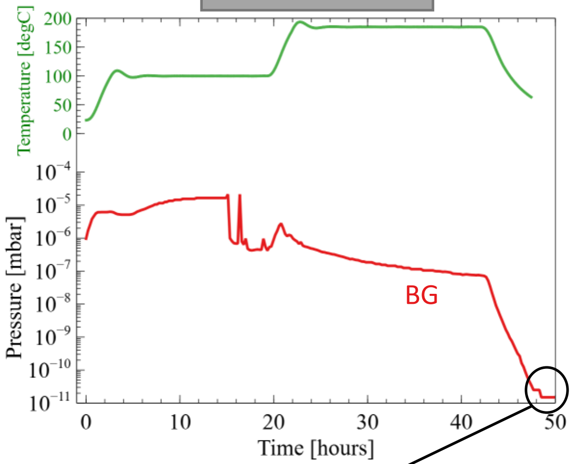
Installation and Vacuum Performance

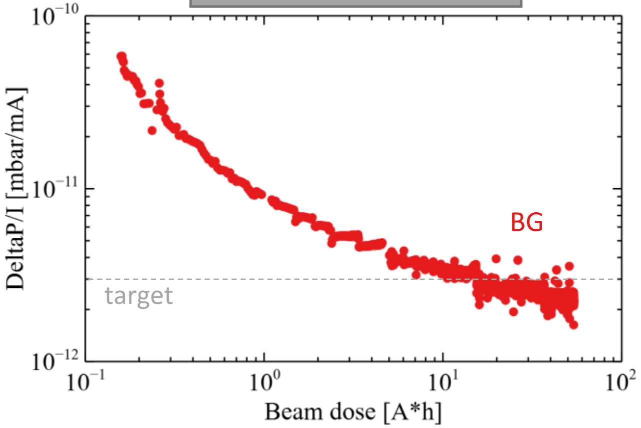
Delta **long period** vac. chamber installed at Sirius (Jan/2022)



NEG activation



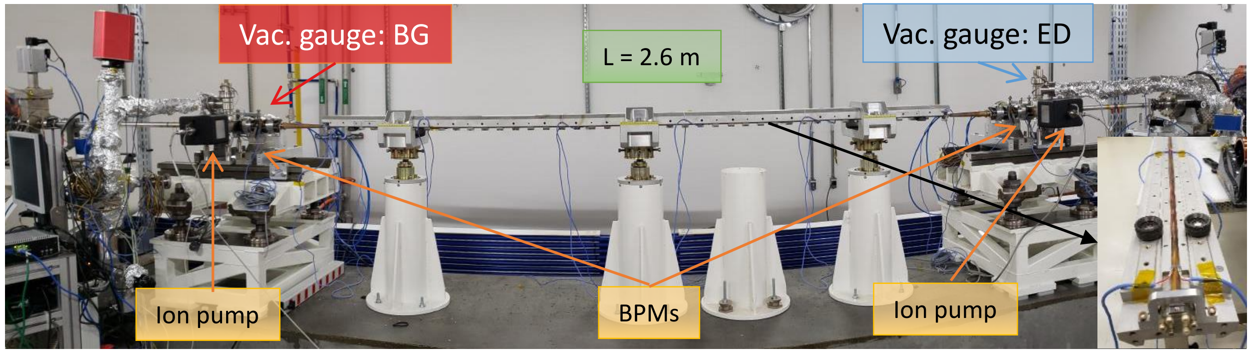
Conditioning w/ beam



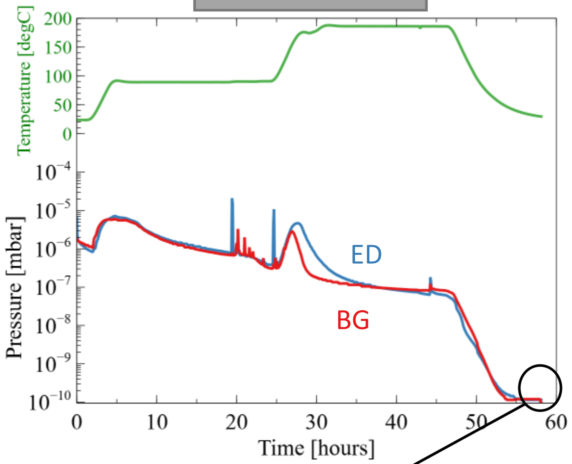
Final P = $1.5 \cdot 10^{-11}$ mbar

Achieved the design dynamic pressure of 3E-12 mbar/mA after 16 A*h

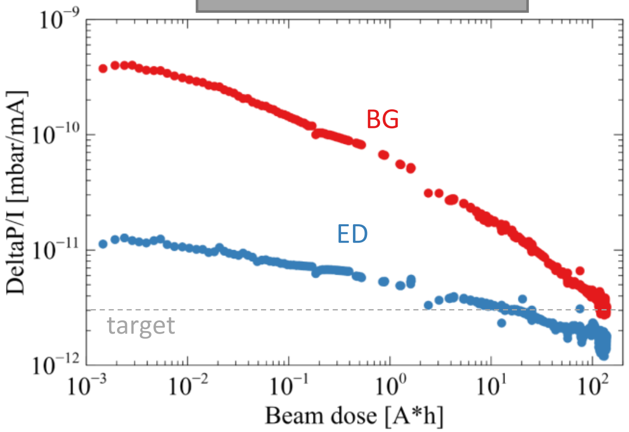
Delta **short period** vac. chamber installed at Sirius (Mar/2022)



NEG activation



Conditioning w/ beam



Final P = $1.0 \cdot 10^{-10}$ mbar

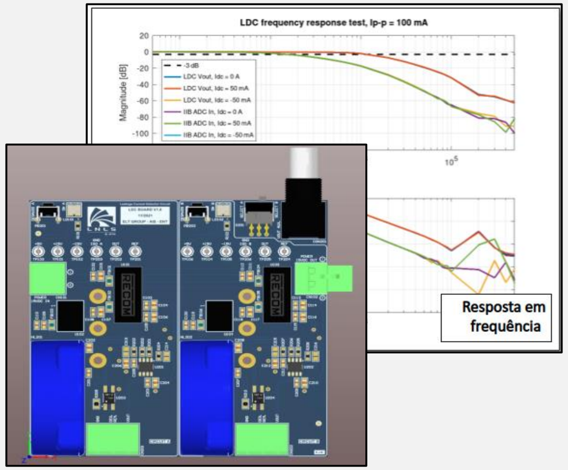
Achieved the dynamic pressure of 3E-12 mbar/mA after ~130 A*h (still under conditioning)

Instrumentation, Electronics, Automation, Robotics

In Operation

Personal Protect System

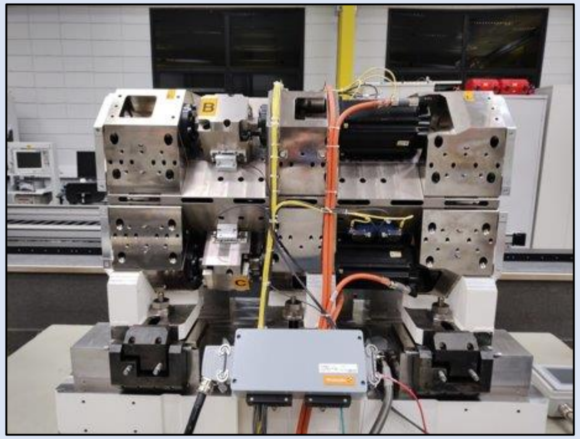
Sirius Control System nodes, for equipment control/monitor



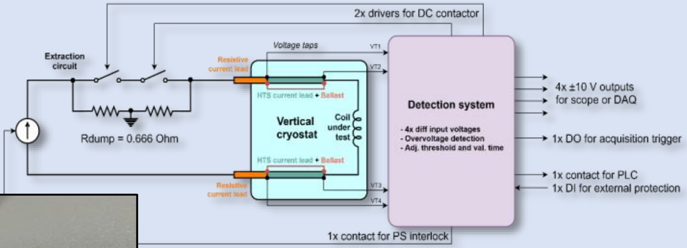
Ground Leakage Detection project and its frequency response analysis

Sirius Power Supplies

In Development

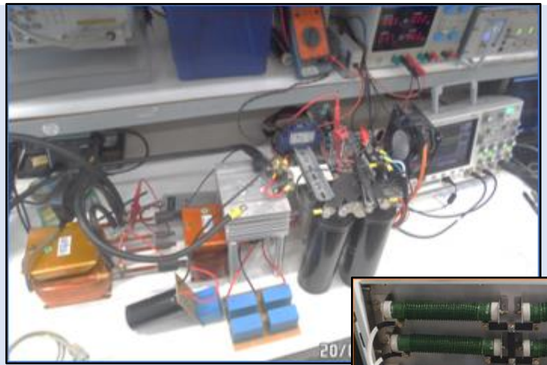


Delta Undulator Automation

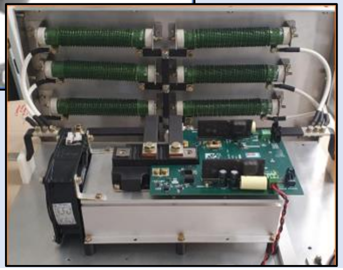


Cryogenic protection and detection electronics developments

Wearable devices in colaboration with LNNano

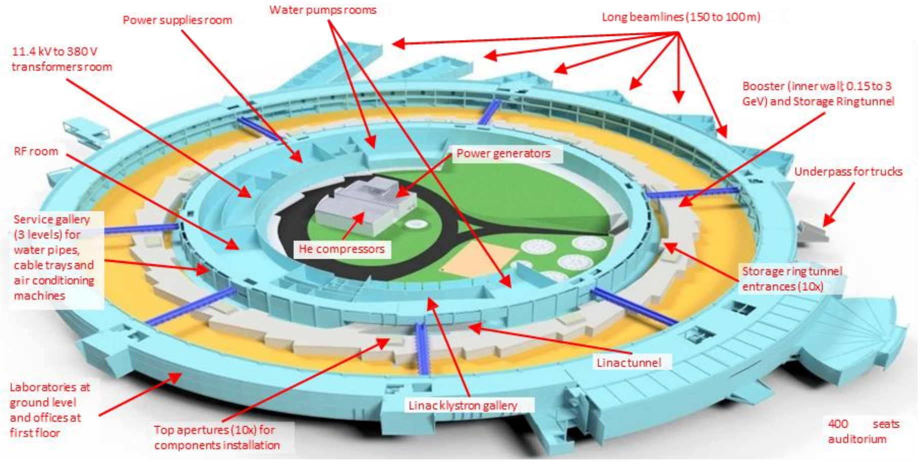


Power Supply and quench protection system for superconducting Wavelength Shifter



Infrastructure and Installations

In Operation

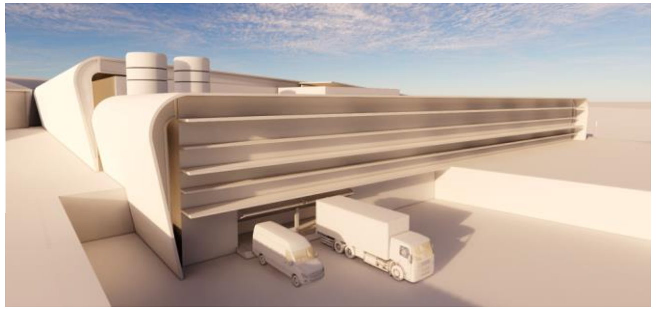


Maintenance Management of the Sirius Building Engineering systems

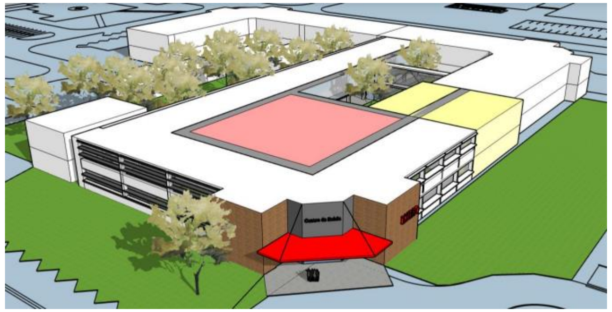
Management of CNPEM critical services (no breaks, Sirius air conditioning, etc)

In Development

Ilum's Conviviality Center



Maximum Biological Contention Laboratory



Health Technology Center

CNPEM

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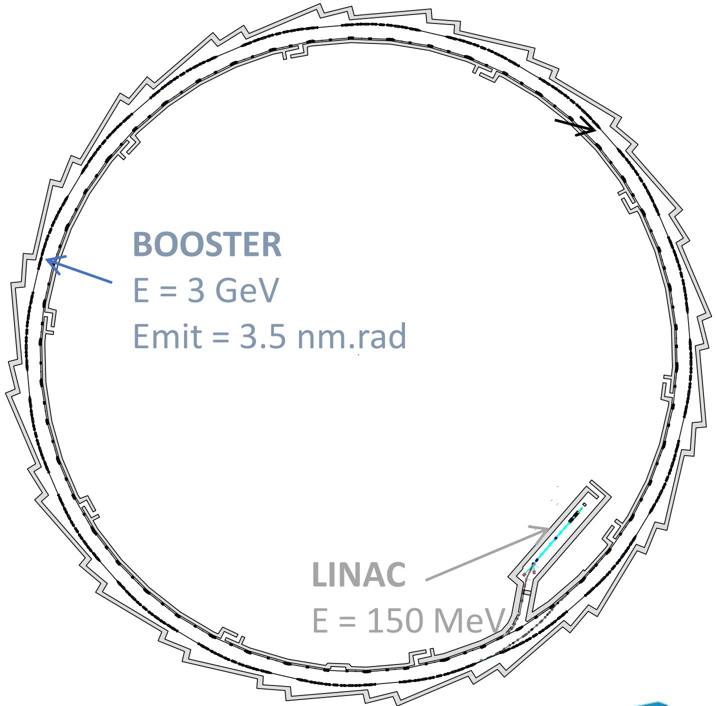
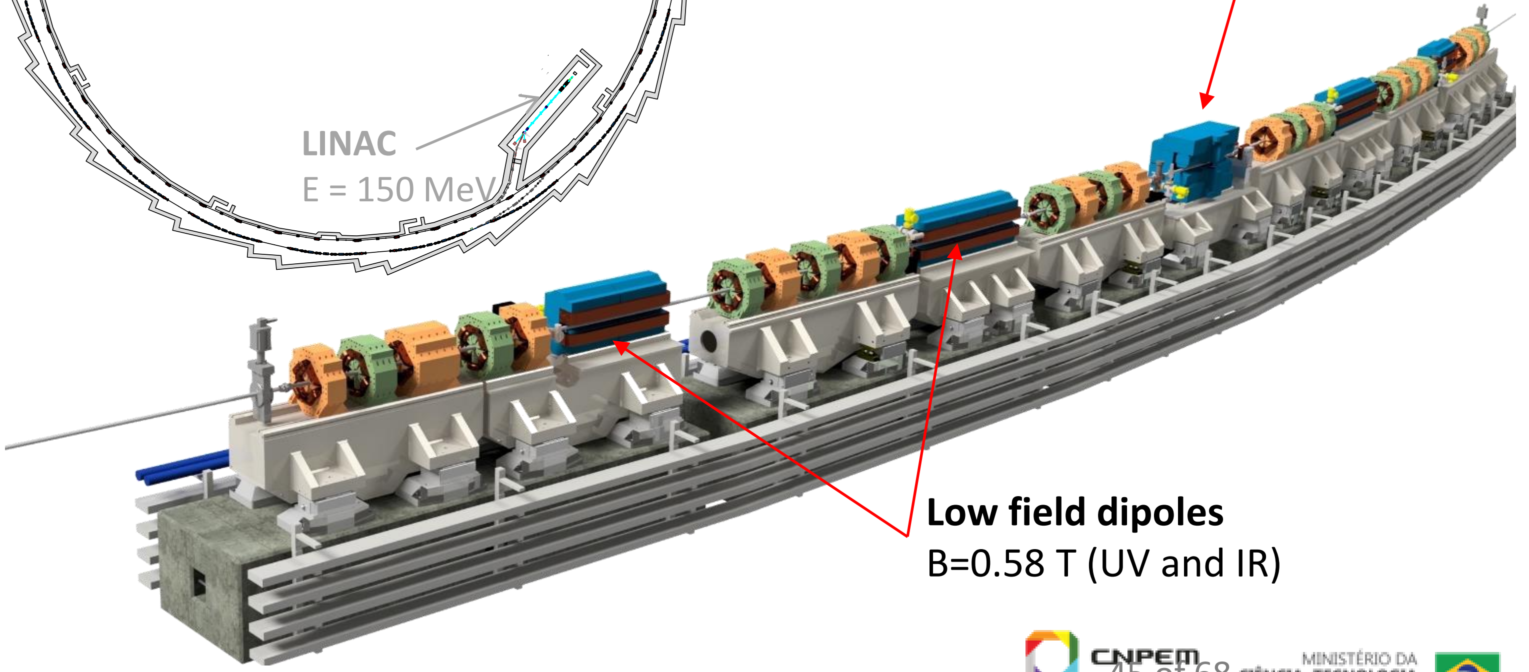
Sirius – a competitive synchrotron light source – 4^{th} generation

LNLS: Sirius Project

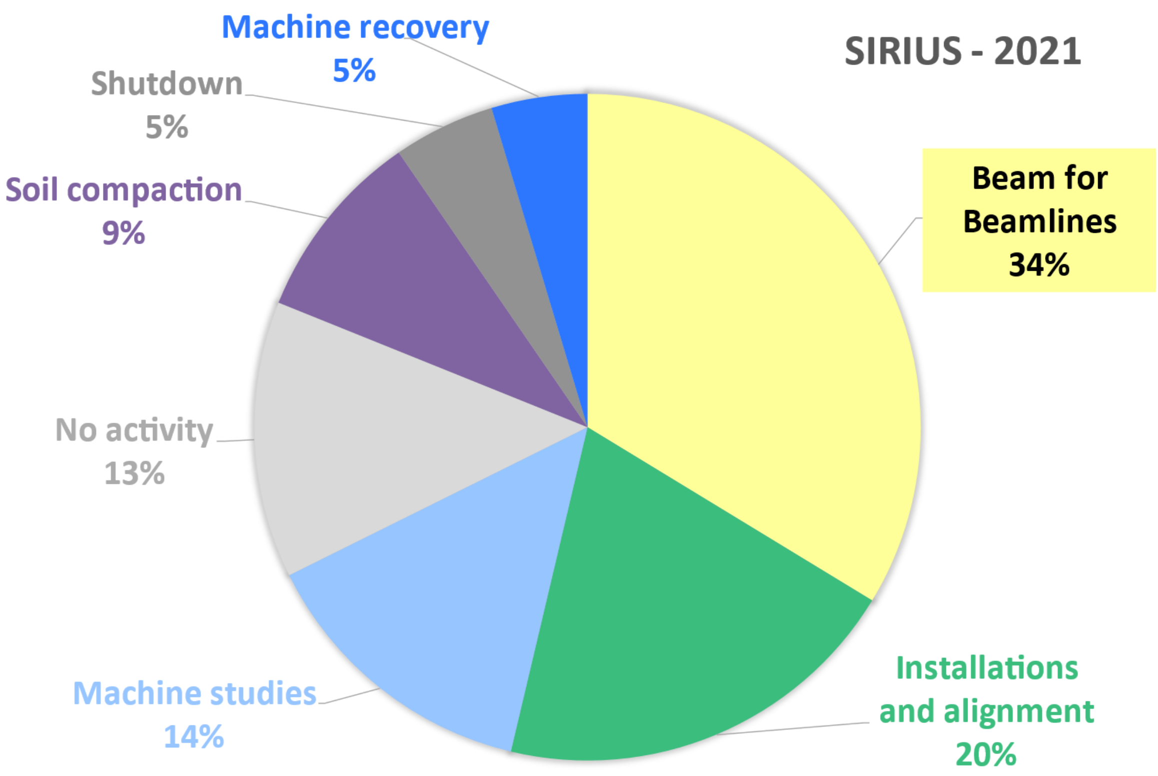
https://wiki-sirius.lnls.br

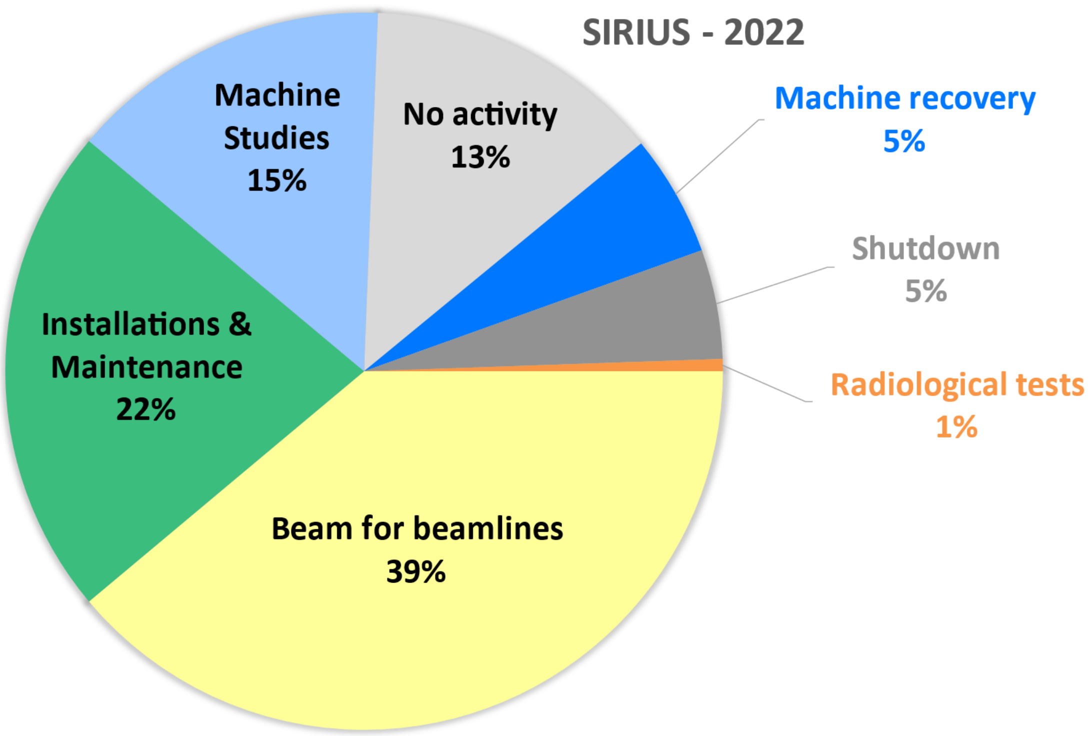
Storage Ring design parameters	
Beam energy	3.0 GeV
Circumference	518 m
Lattice	20 x 5BA
Current, top up	350 mA (100 mA, dm)
Bunch length	8 ps
Energy spread	0.09 %
RF frequency	500 MHz
Hor. emittance (bare⇢ ids)	**250 ⇢ 150 pm.rad**
Vert. emittance	**2.5 ⇢ 1.5 pm.rad**
Straight section low β_x/β_y	**1.5 m / 1.4 m**



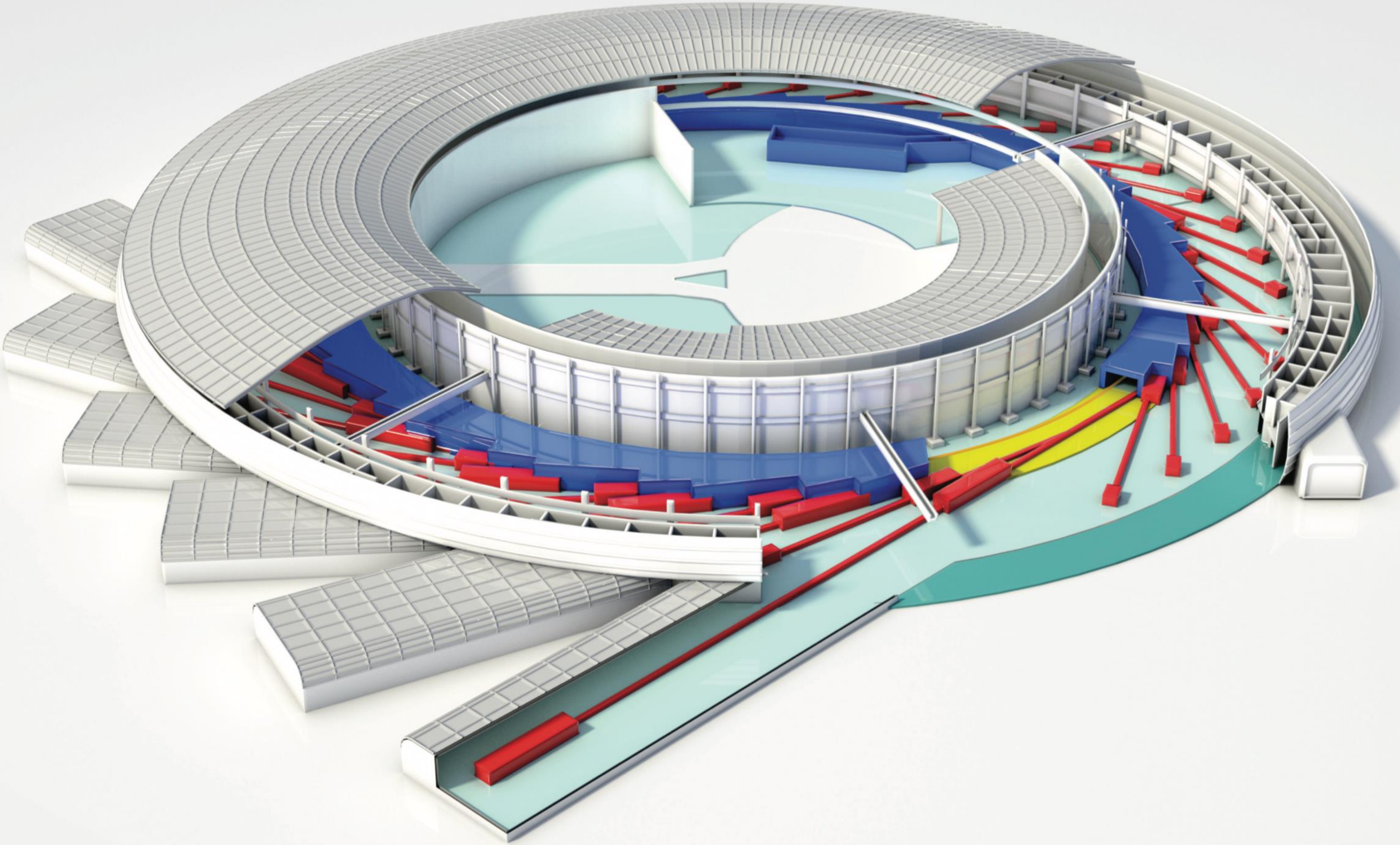


LNLS: Sirius Project





Operation



2015 – 2018 - Building – 68.000 m²

CNPEM
Brazilian Center for Research in Energy and Materials

MINISTRY OF SCIENCE, TECHNOLOGY, INNOVATION AND COMMUNICATION
PÁTRIA AMADA BRASIL
BRAZILIAN GOVERNMENT

LNLS sirius

CNPEM

Accelerator Tunnel

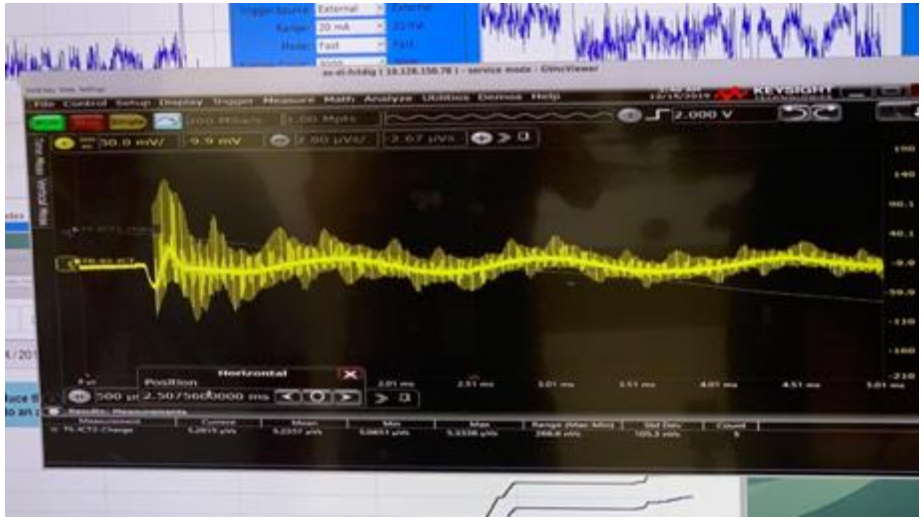
CNPEM
Brazilian Center for Research in Energy and Materials

MINISTRY OF SCIENCE, TECHNOLOGY, INNOVATION AND COMMUNICATION

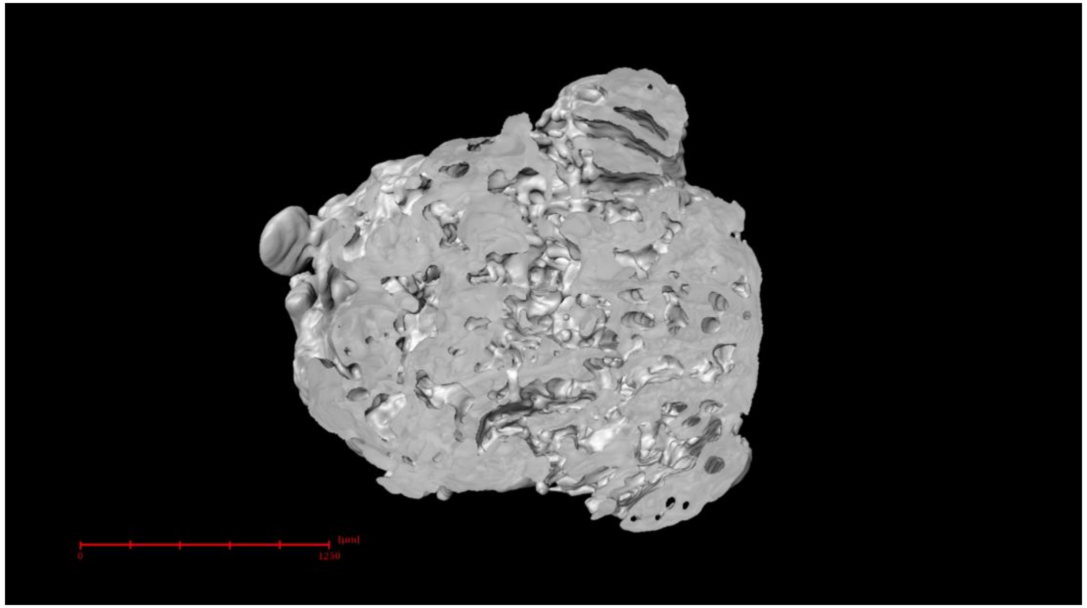
PÁTRIA AMADA BRASIL
BRAZILIAN GOVERNMENT

September 2019 - Storage Ring fully assembled and in vacuum

December 14th 2019 – Beam stored in the storage ring



December 16-17th 2019 – First tomographies (tests, low current)



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LNLS

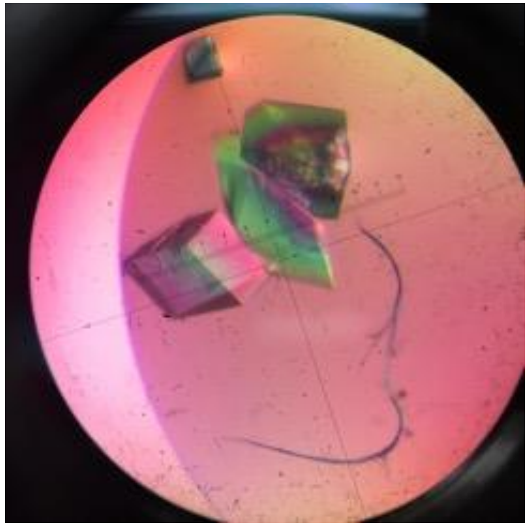
sirius

CNPEM

ORGANIZAÇÃO SOCIAL DO MCTI

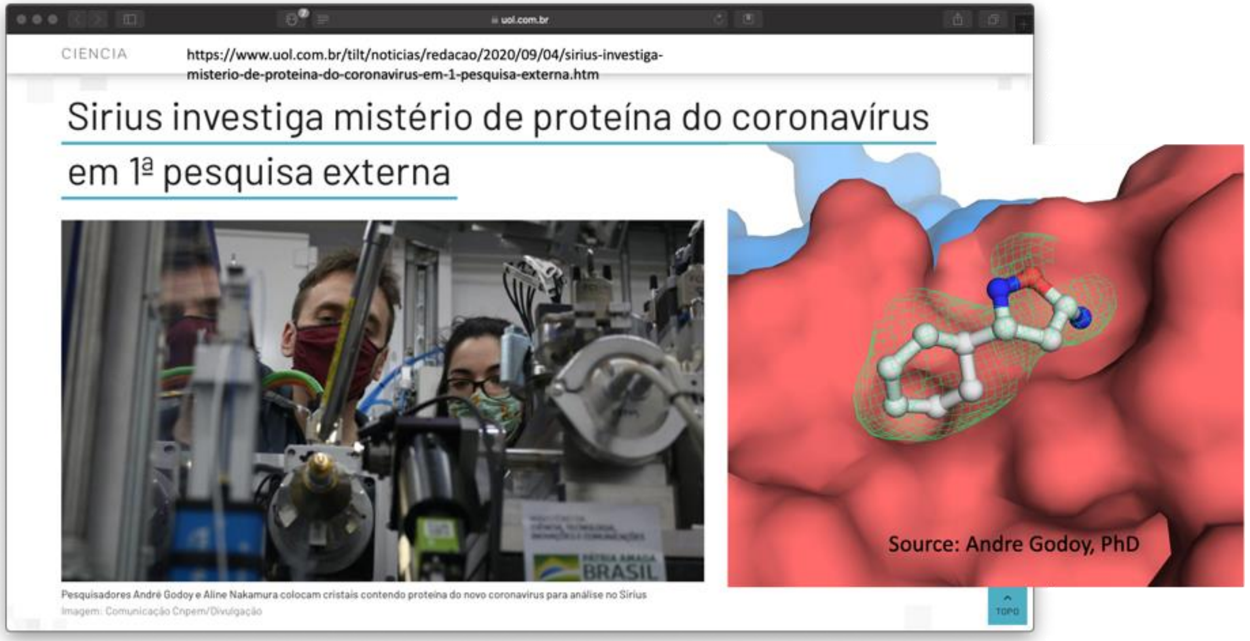
FIRST EXPERIMENTS – SARS-COV-2 3CL PROTEIN CRYSTALS

Structure solved at Manacá beamline on July 11th, 2020



3CL Protein Crystals (LNBio)

September 2020 – first external users for Covid related research on Manacá

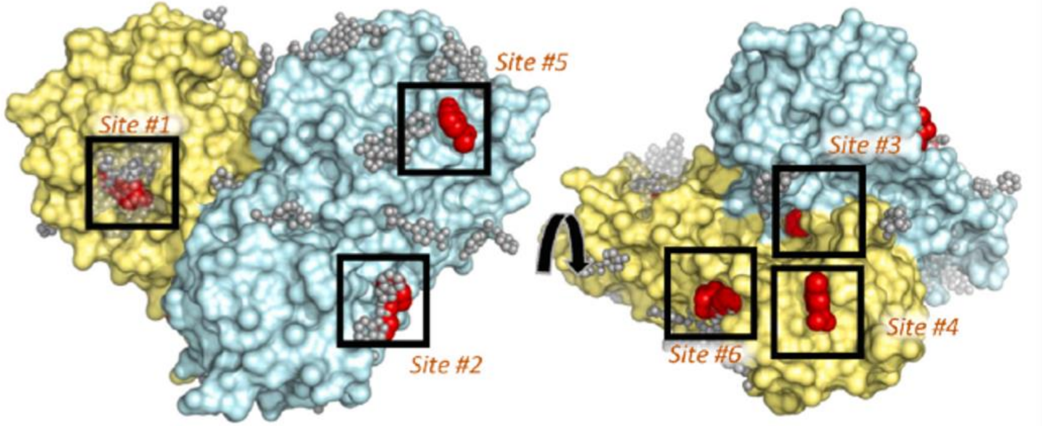


September 2021 - First scientific paper with data obtained from Sirius

A Crystallographic Snapshot of SARS-CoV-2 Main Protease Maturation Process

Journal of Molecular Biology (2021) 433, 167118

G. D. Noske [1‡], A. M. Nakamura [1‡], V. O. Gawriljuk [1], R. S. Fernandes [1], G. M. A. Lima [2†], H. V. D. Rosa [1], H. D. Pereira [1], A. C. M. Zeri [3], A. F. Z. Nascimento [3], M. C. L. C. Freire [1], D. Fearon [4,5], A. Douangamath [4,5], F. von Delft [4,5,6,7], G. Oliva [1*] and A. S. Godoy [1*]



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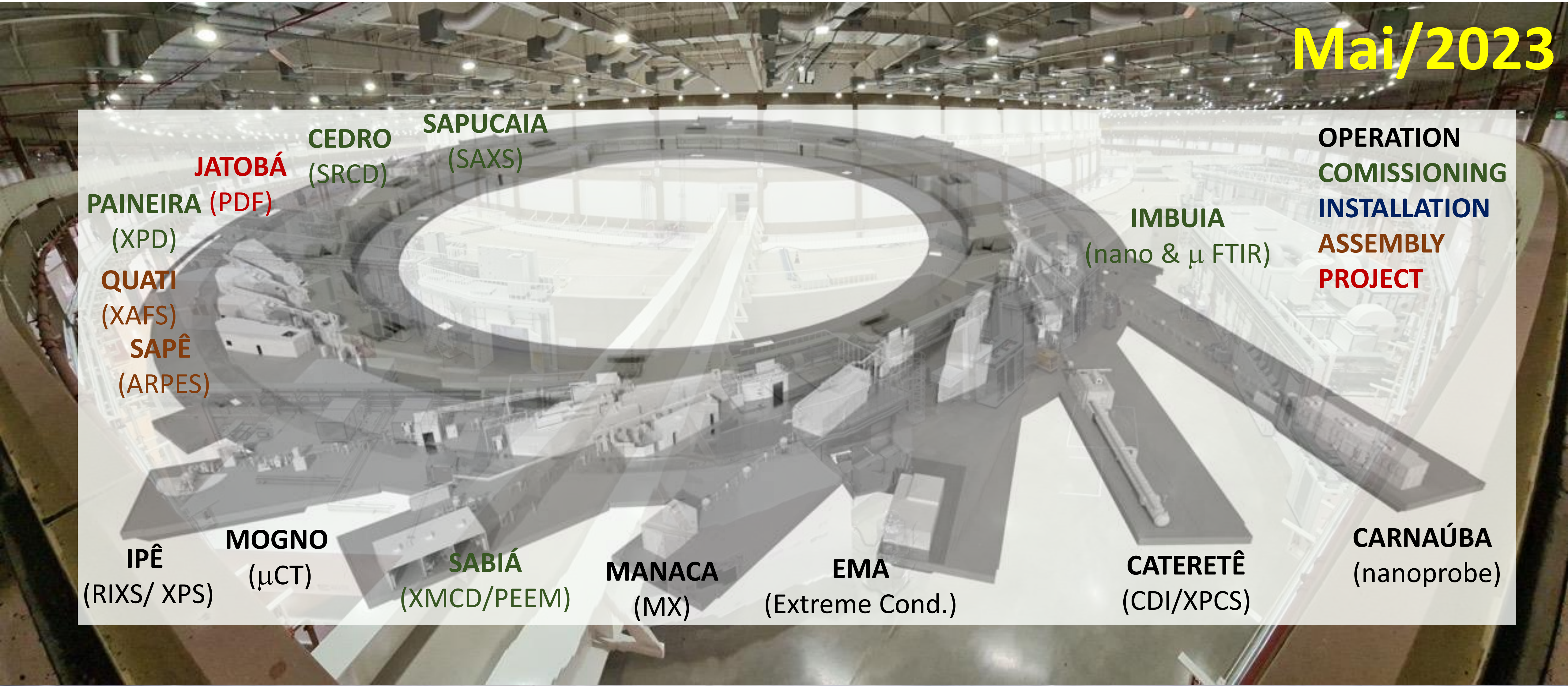
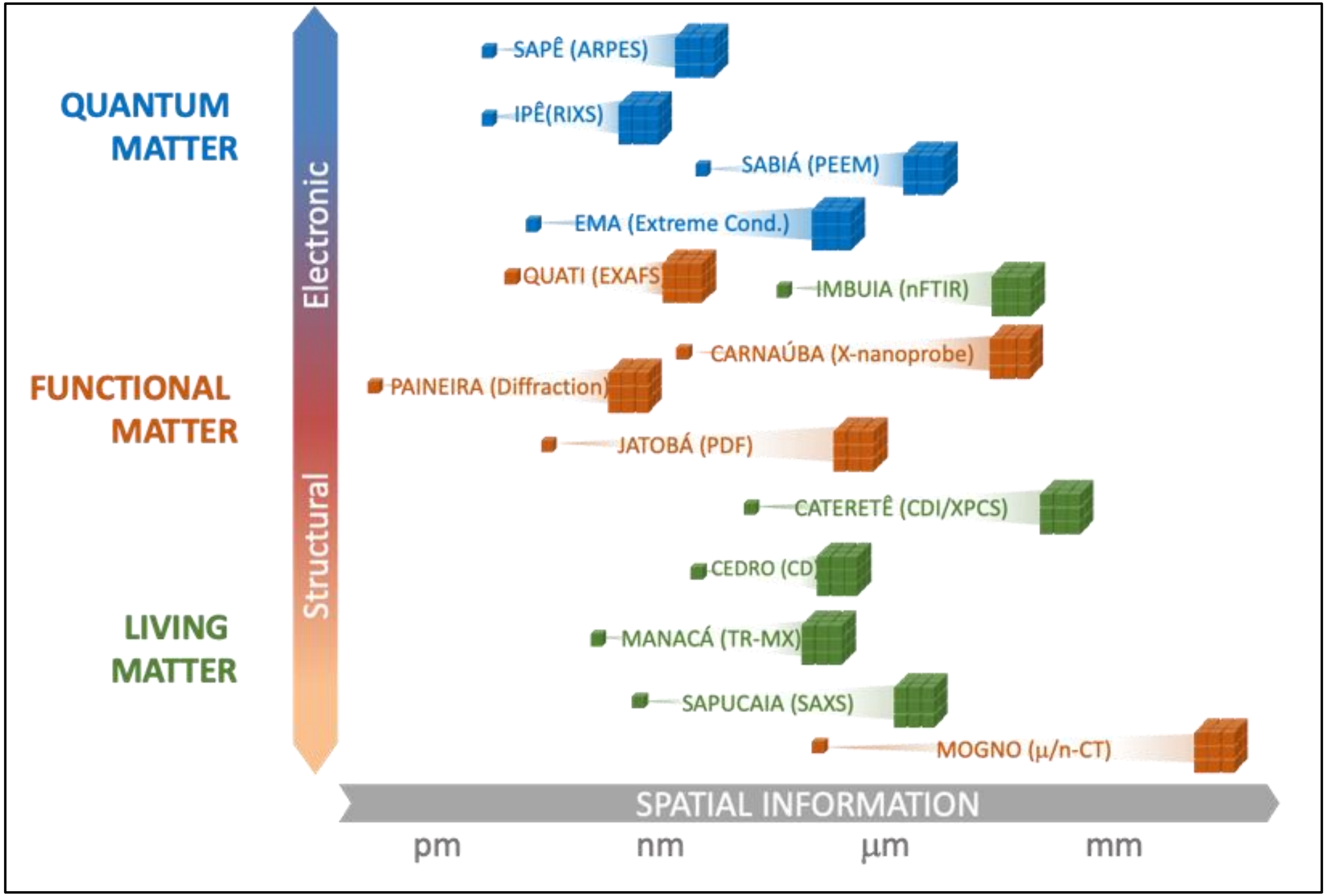
2018 to 2023


Mai/2023
SAPUCAIA
(SAXS)
CEDRO
(SRCD)
JATOBÁ
PAINEIRA (PDF)
(XPD)
QUATI
(XAFS)
SAPÊ
(ARPES)
IMBUIA
(nano & µ FTIR)
OPERATION
COMISSIONING
INSTALLATION
ASSEMBLY
PROJECT
IPÊ
(RIXS/ XPS)
MOGNO
(µCT)
SABIÁ
(XMCD/PEEM)
MANACA
(MX)
EMA
(Extreme Cond.)
CATERETÊ
(CDI/XPCS)
CARNAÚBA
(nanoprobe)

Sirius Phase 1 Beamlines



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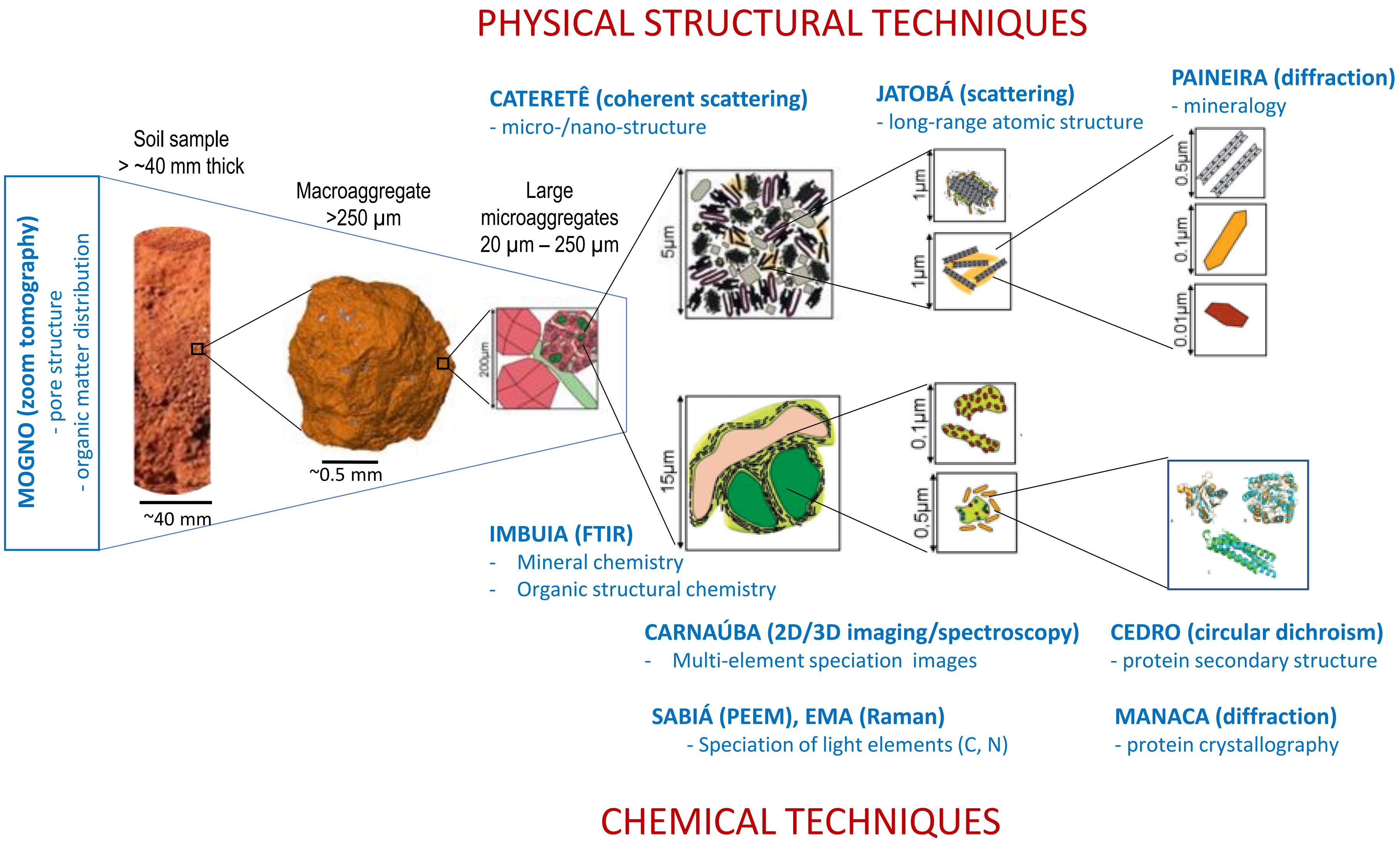
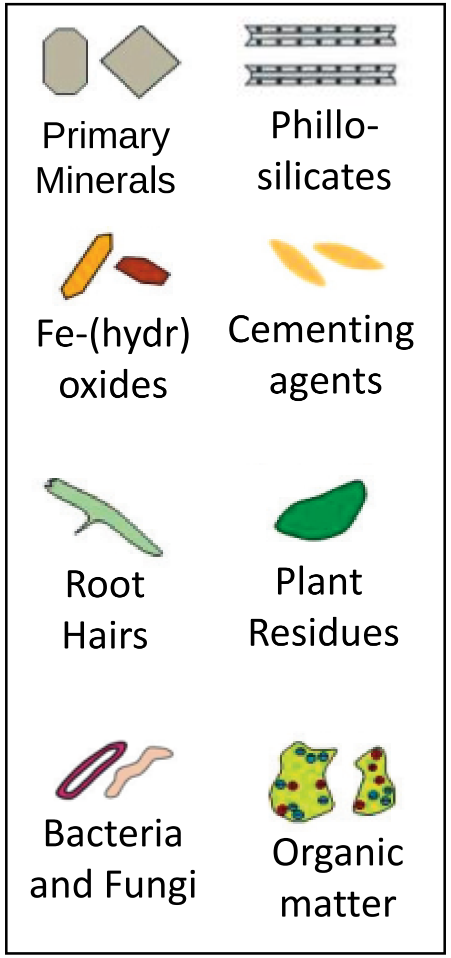
Example

Complementary Sirius beamlines for multimodal analyses of soil complexity and biogeochemical mechanisms



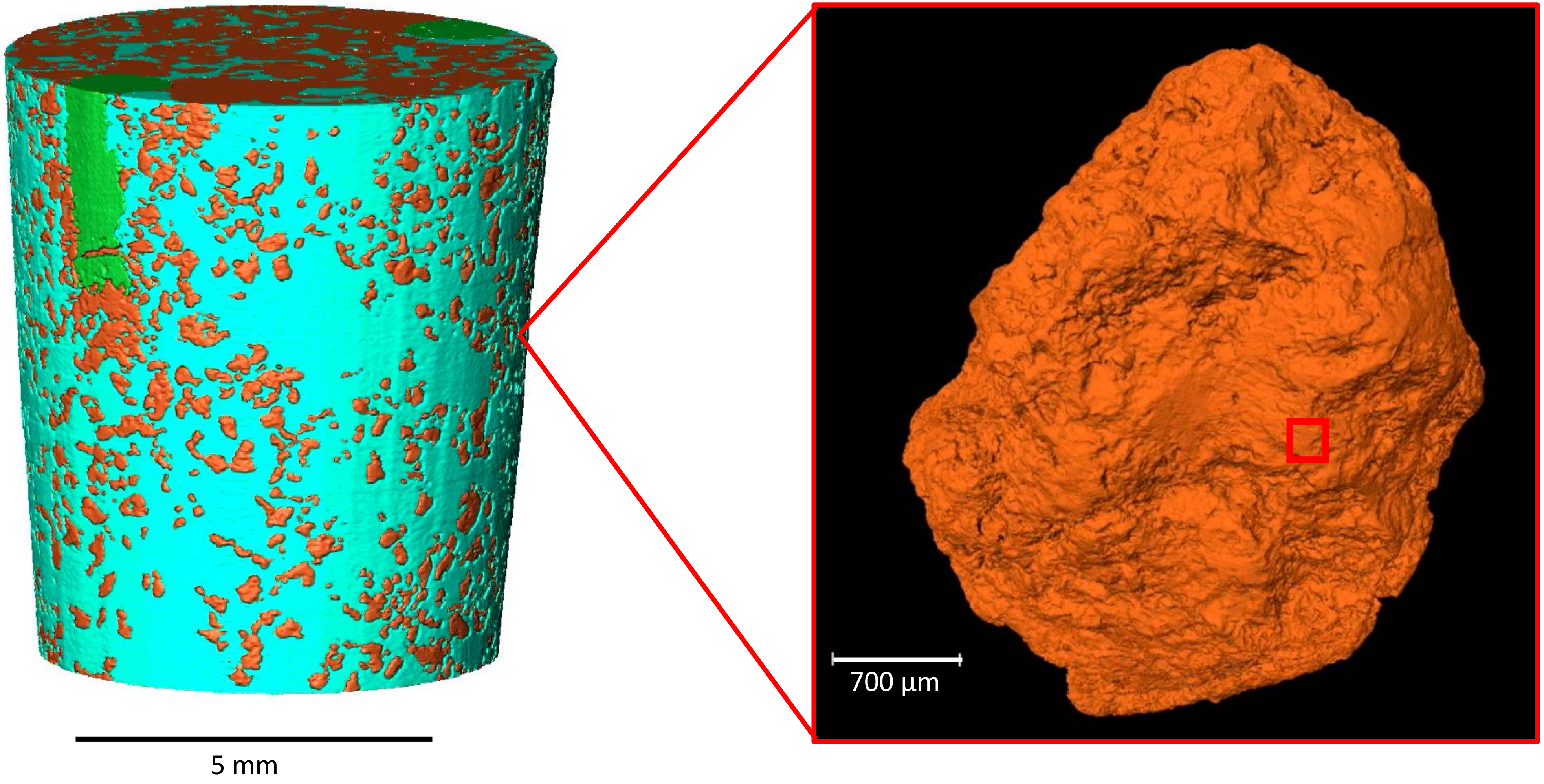


Adapted from Totsche et al. (2017)

Hesterberg, Ferreira, Bordonal, Souza-Filho. 2022
Tópicos em Ciência do Solo – Volume XI

3D Imaging from plant roots and soil agregates

@MOGNO



courtesy of Talita Ferreira and Harry Westfahl Jr.

Preliminary results

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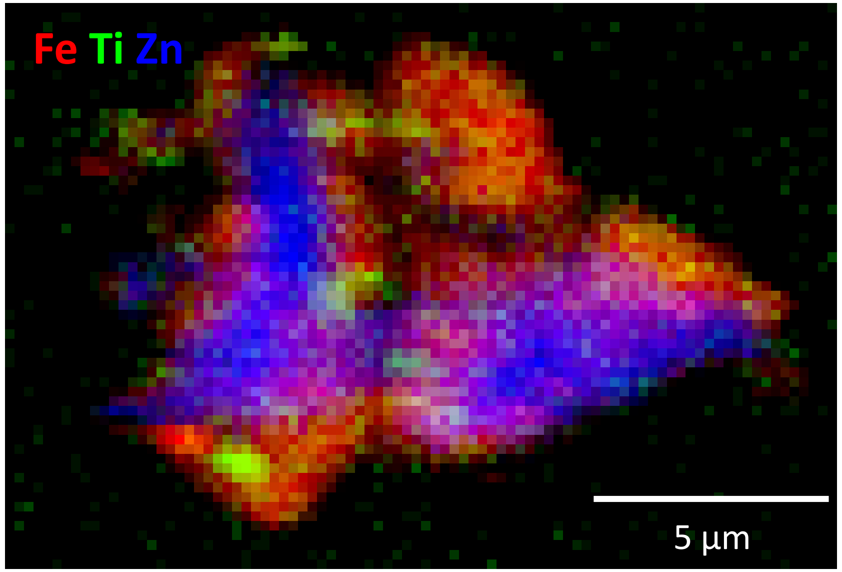
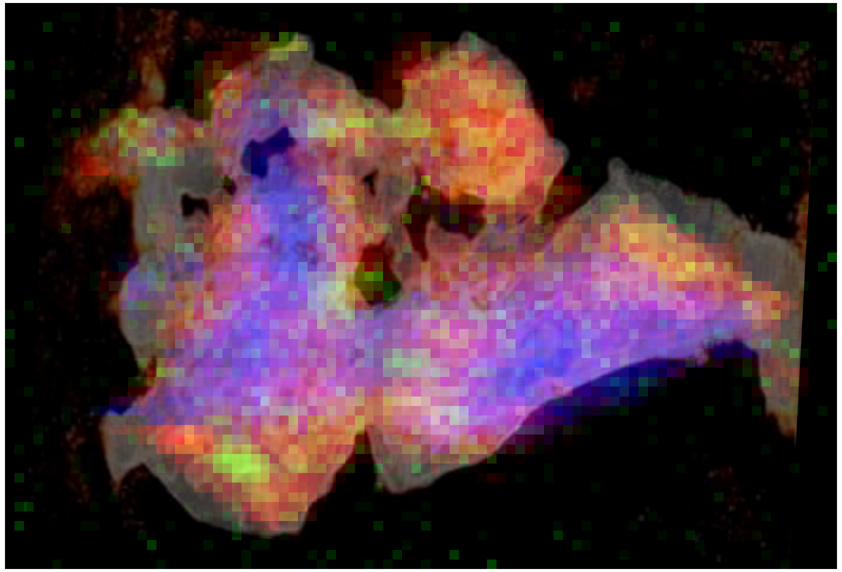
Integrating data on **micro**agregates

@ CARNAÚBA & CATERETÊ

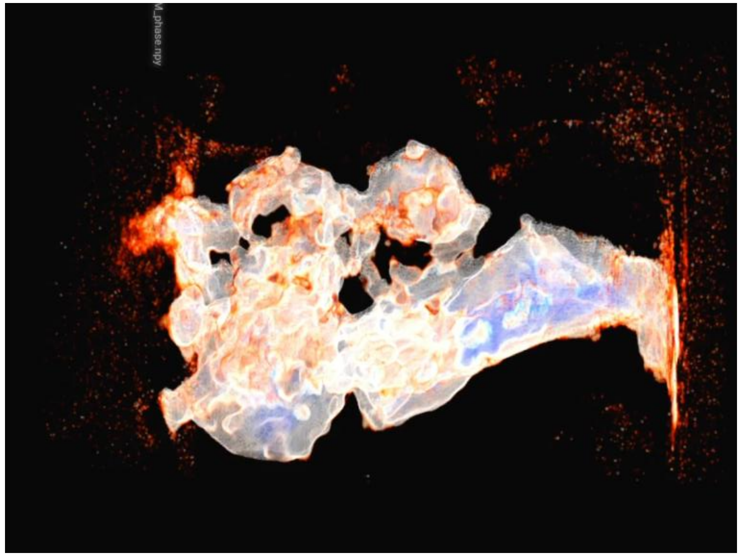
Chemical Image (μ-XRF)
CARNAÚBA

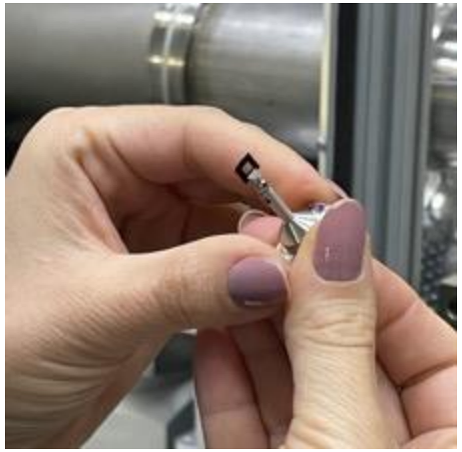


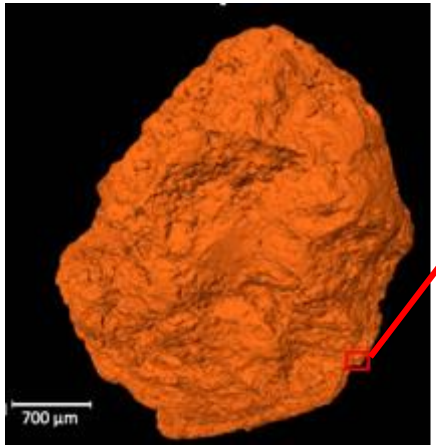
Overlay
CATERETÊ & CARNAÚBA



Diffraction image
CATERETÊ







Preliminary results

courtesy of Dean Hesterberg and Harry Westfahl Jr.

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SIRIUS – TECHNOLOGY TRANSFER

Interaction with innovative Brazilian companies in product/process/production developments for Sirius

BIOTEC

FCA Brasil

Agreement between PITEC and CNPEM advances the development of state-of-the-art technology

UNDERSTANDING ESTABLISHES GENERAL CONDITIONS FOR COOPERATION IN TECHNOLOGICAL RESEARCH AND DEVELOPMENT IN X-RAY DETECTORS, ACCELERATOR ENGINEERING, AND BEAMLINES

THANKS TO THE INVOLVEMENT OF THE BRAZILIAN COMPANIES, THE PROJECT ACHIEVED A > 80% INDEX OF NATIONALIZATION

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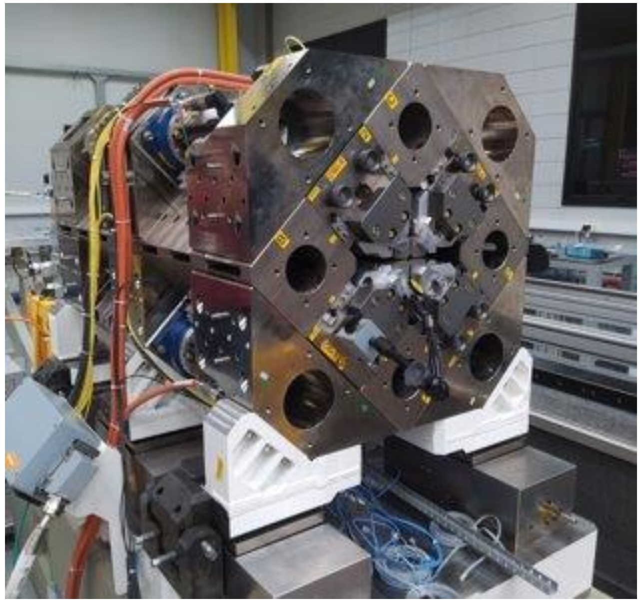
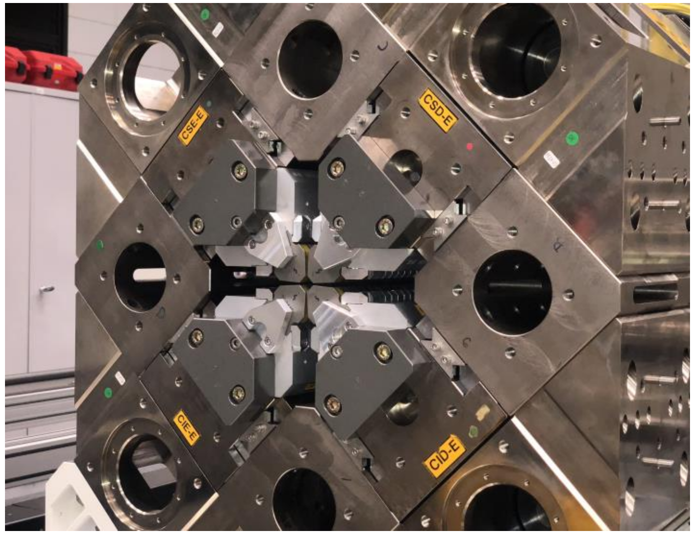
Insertion Devices – Current Developments

Insertion Devices R&D: Delta Undulator





	DU525 Prototype
Total length [mm]	1200
Period length [mm]	52.5
Number of periods	21
Magnetic gap [mm]	13.6
Maximum field [T]	1.25
Maximum K	6

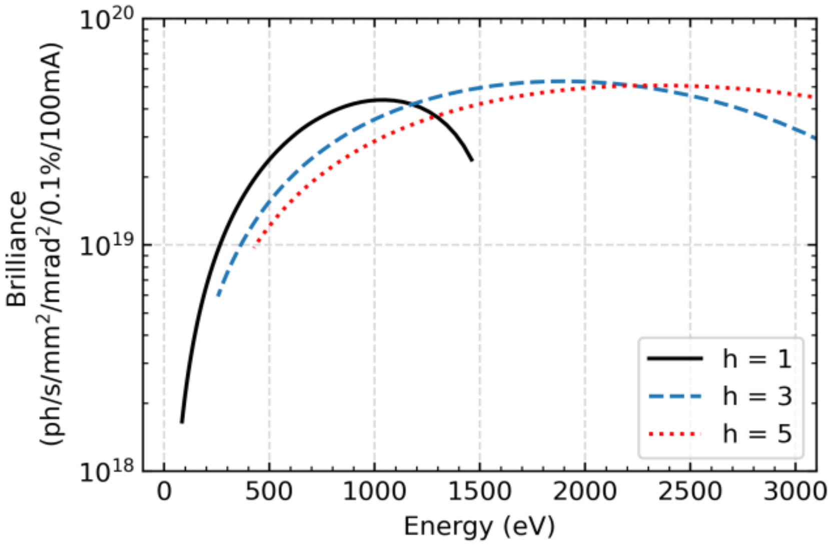
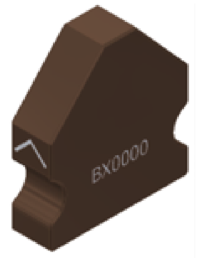


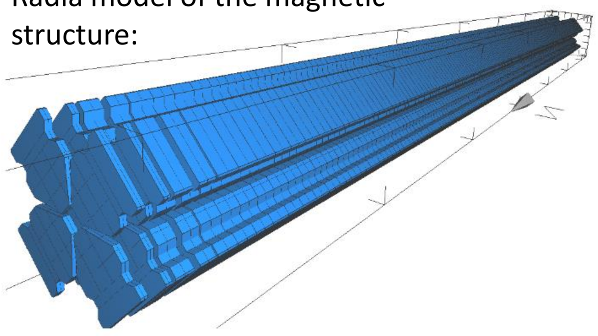
Fig. 2. Calculated brilliance of the Delta undulator in linear polarization mode for a 100 mA beam current (Sirius Phase-I).

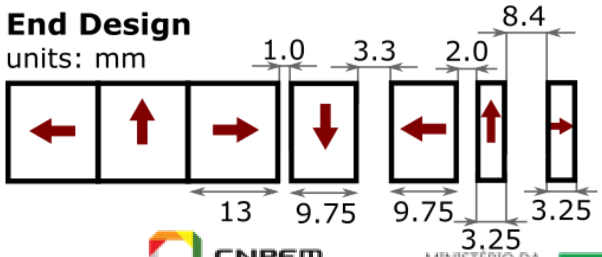


Regular PM block

NdFeB PM Block	
Br	1.37 T ± 1%
Angle tolerance	< 1°
Hcj	> 20 kOe

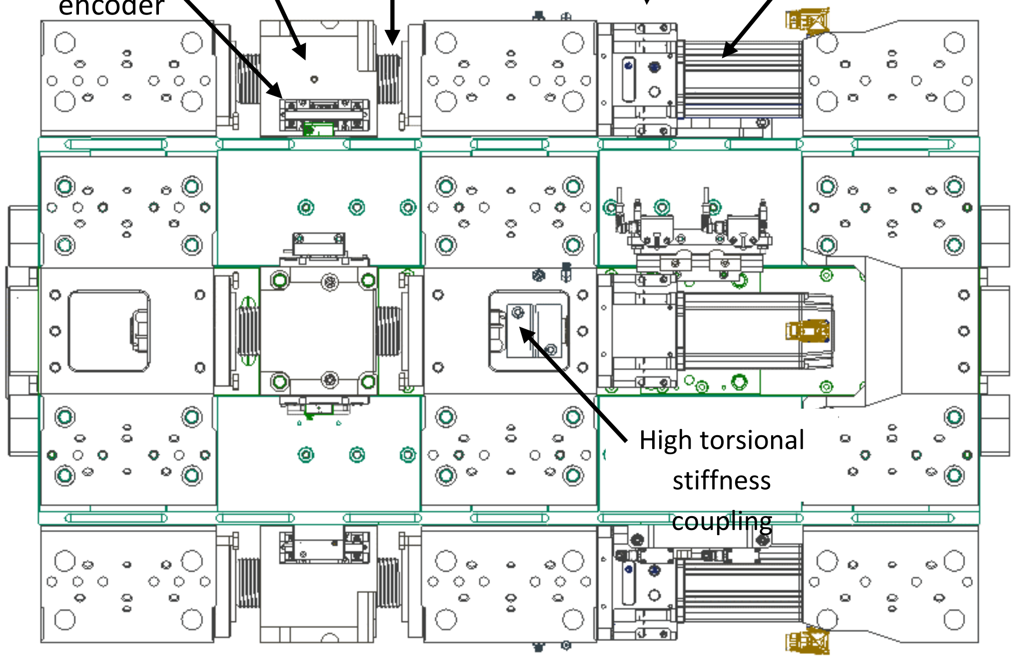
Radia model of the magnetic structure:



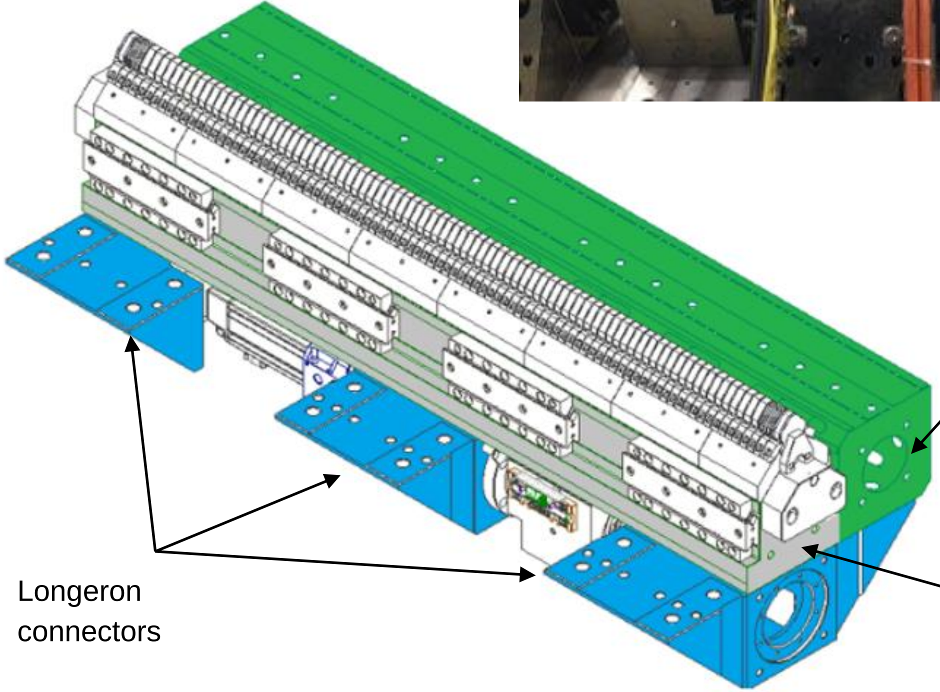


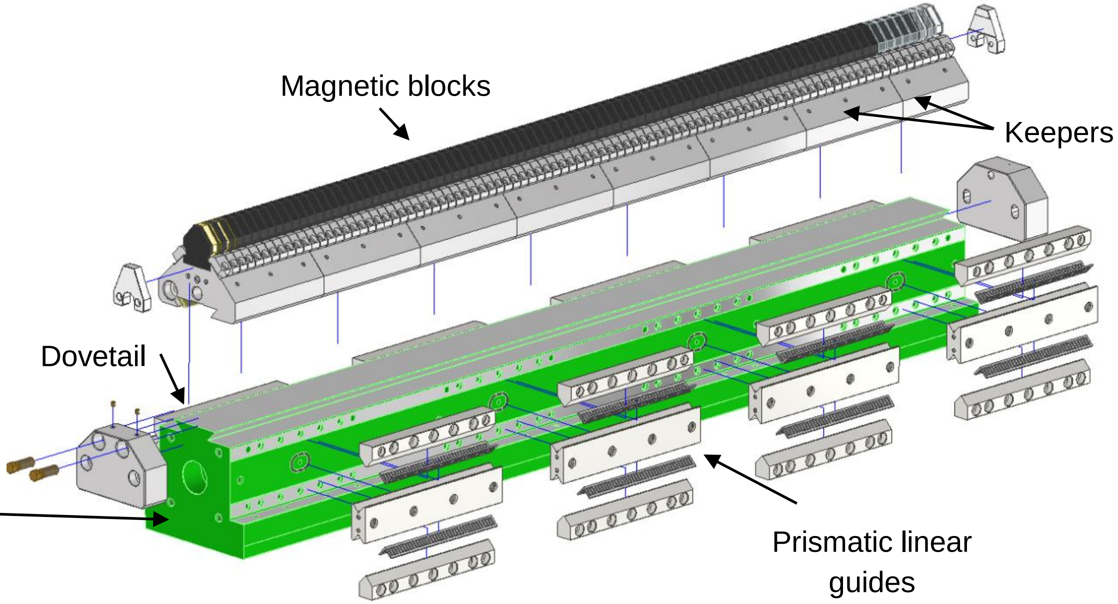
DU525 Mechanical Design

- **High Stiffness** (to avoid deformation by magnetic forces)
- **High dimensional stability** (machining and assembly with low dimensional variation – 20 μm)
- **High alignment accuracy** with respect to the beam
- **High precision** in automation control system

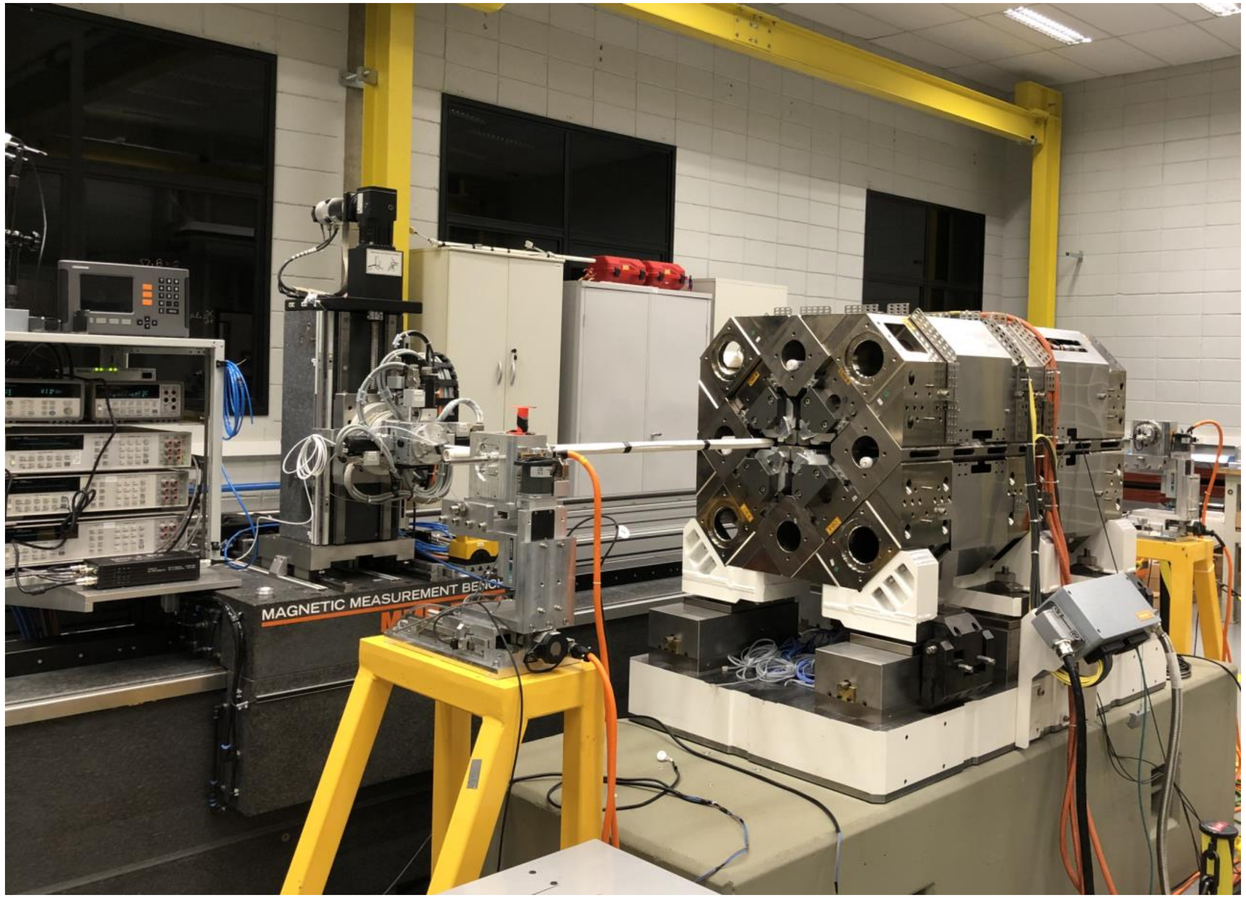


Transmission system

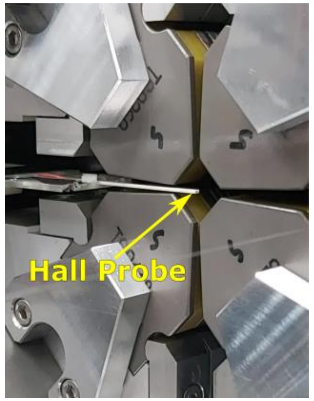




Delta Undulator



Magic fingers

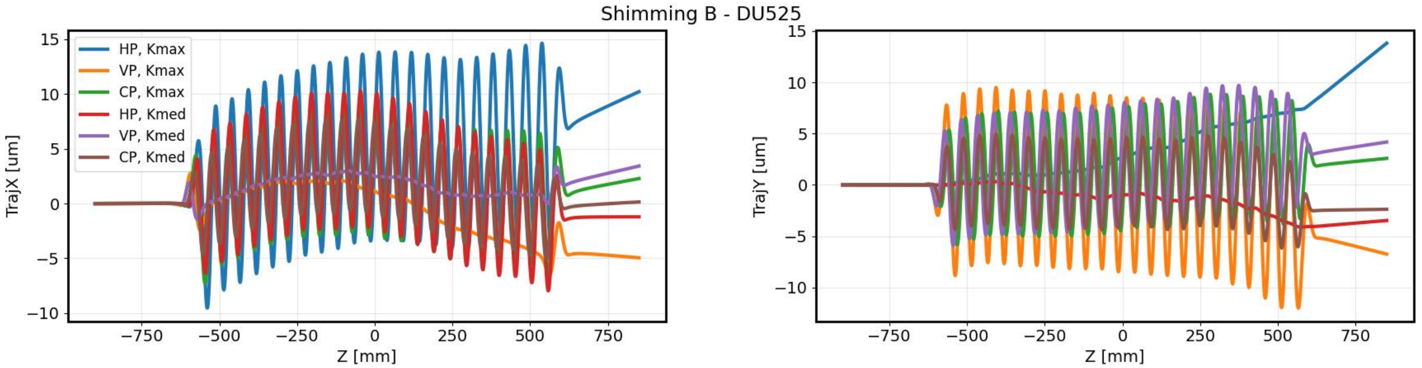


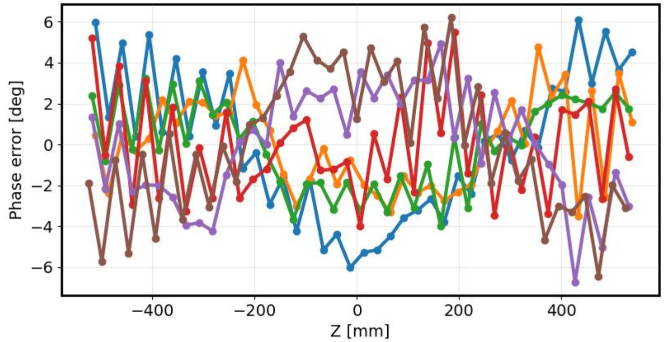
Hall probe

Stretched wire

Delta Undulator Measurement Results

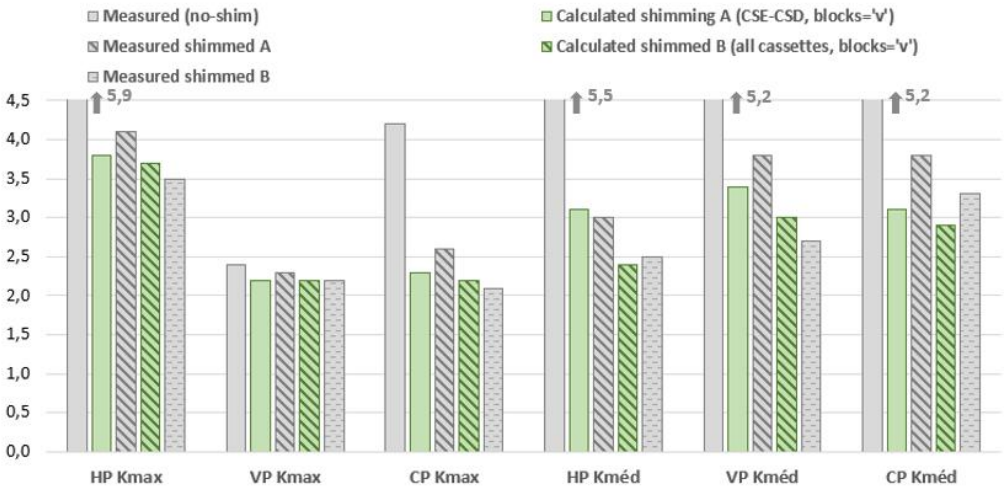
- Field is being corrected using an SVD based virtual shimming algorithmn;
- Two virtual shimming iterations were performed, reducing the RMS phase errors from roughly 5° to 3°;
- After optimizing the phase error and field integrals, magic fingers will be installed;





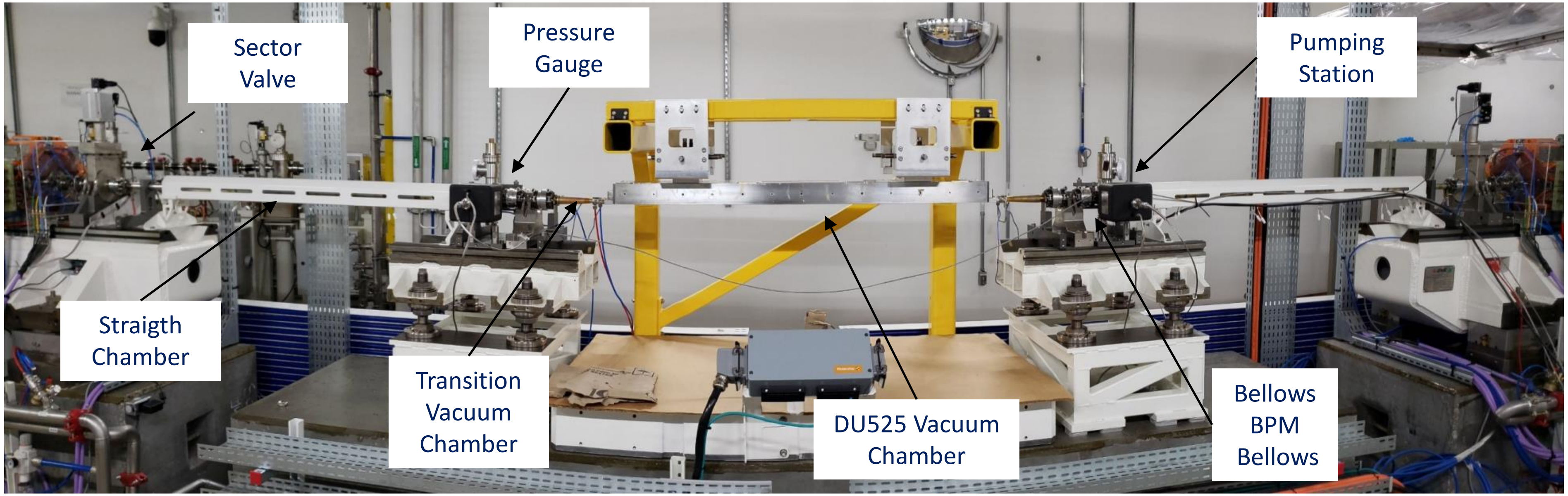
	HP, Kmax	VP, Kmax	CP, Kmax	HP, Kmed	VP, Kmed	CP, Kmed
IBx [G.cm]	-267.1	79.3	-20.5	-28.2	-49.3	-9.3
IBy [G.cm]	133.2	-21.3	54.5	2.7	64.3	12.9
IIBx [kG.cm2]	-16.5	7.0	-1.5	3.5	-4.4	2.0
IIBy [kG.cm2]	10.4	-4.8	2.4	-1.0	3.3	-0.1
PhaseErr [deg]	3.5	2.2	2.1	2.5	2.7	3.3

- Bar graph showing predicted phase errors from the virtual shimming algorithm (green bars) and measured phase errors (grey bars).

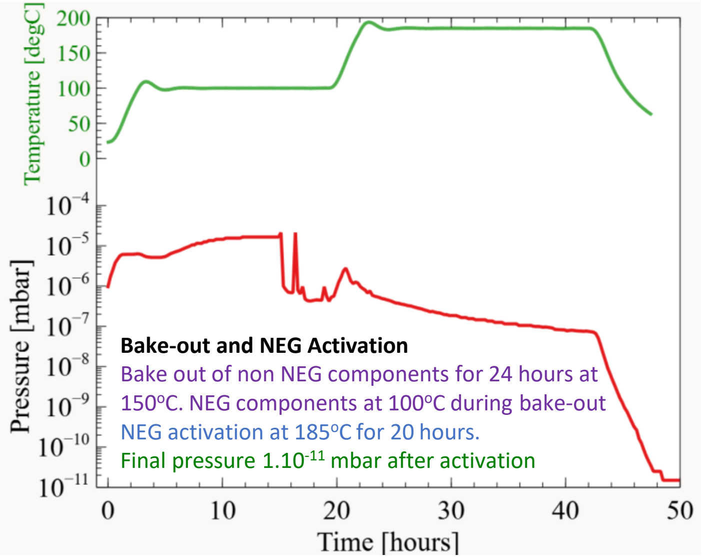


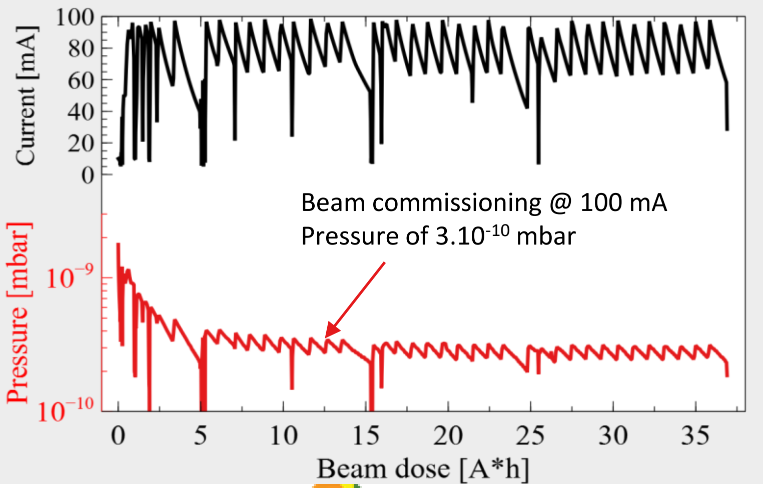
HP, Kmax:
Horizontal Polarization, K = 6
VP, Kmax:
Vertical Polarization, K = 6
CP, Kmax:
Circular Polarization, K = 4.2
HP, Kmed:
Horizontal Polarization, K = 4.2
VP, Kmed:
Vertical Polarization, K = 4.2
CP, Kmed:
Circular Polarization, K = 3

DU525 – NEG coated Vacuum chamber



DU525 vacuum chamber tested in the storage ring





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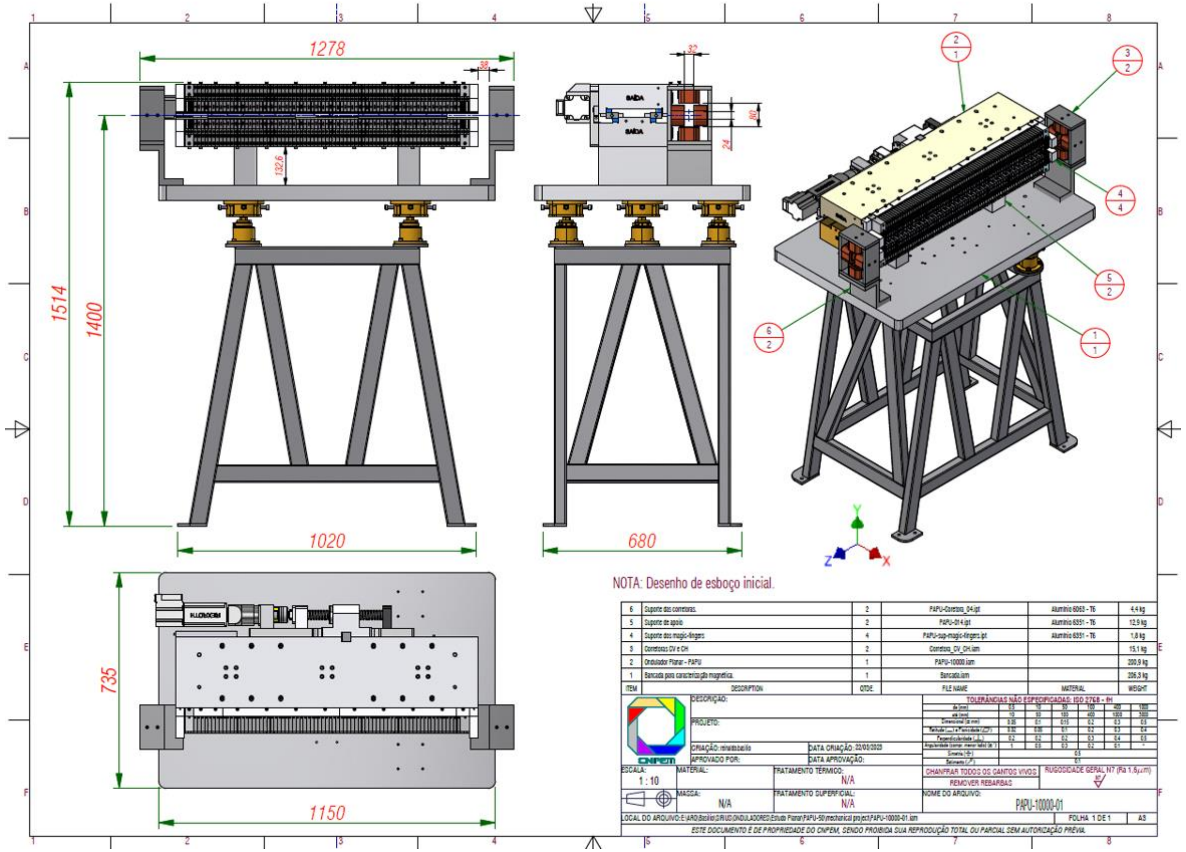
Commissioning APU

- Low cost commissioning APU;
- Use of spare and prototype parts of UVX EPU;
- NdFeB blocks, Br = 1.22 T;
- Currently under field optimization and automation commissioning;
- Will be installed in June.

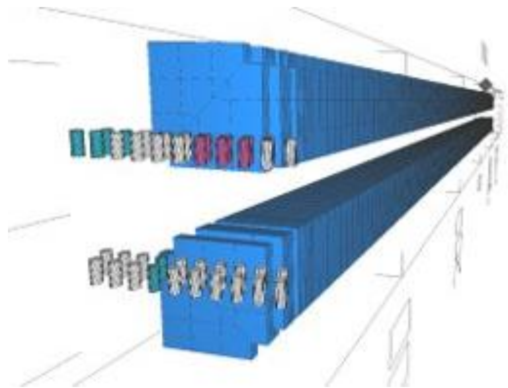
	DU525 Prototype
Total length [mm]	1100
Period length [mm]	50
Number of periods	18
Magnetic gap [mm]	24
Maximum field [T]	0.42
Maximum K	1.95



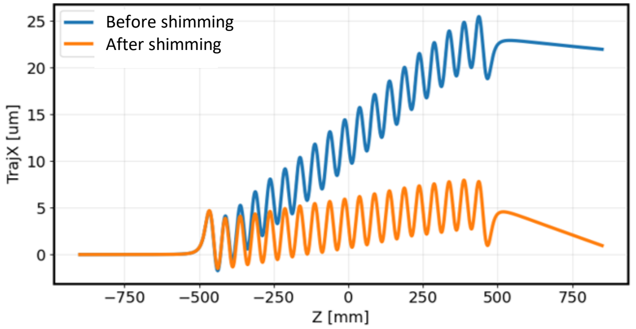
Commissioning APU

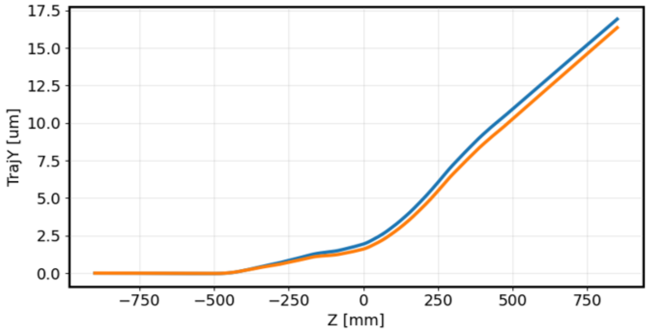
- A few virtual shimming iterations were performed at maximum K (phase = 0 mm), RMS phase error dropped from 9.6° to 2°;
- Maximum RMS phase error was measured at phase = 18.75 mm (3.5°);
- More virtual shimming iterations will be performed;
- After the reduction of the phase errors, field integrals will be minimized;
- Magic fingers will be installed to minimize the integrated multipoles.

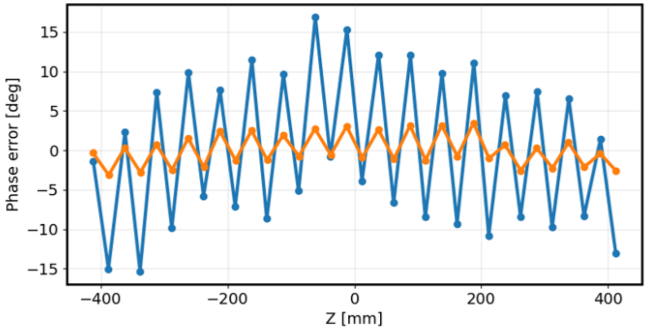
Magic fingers Radia model:



Hall probe measurements at phase = 0 mm, K = 1.95:

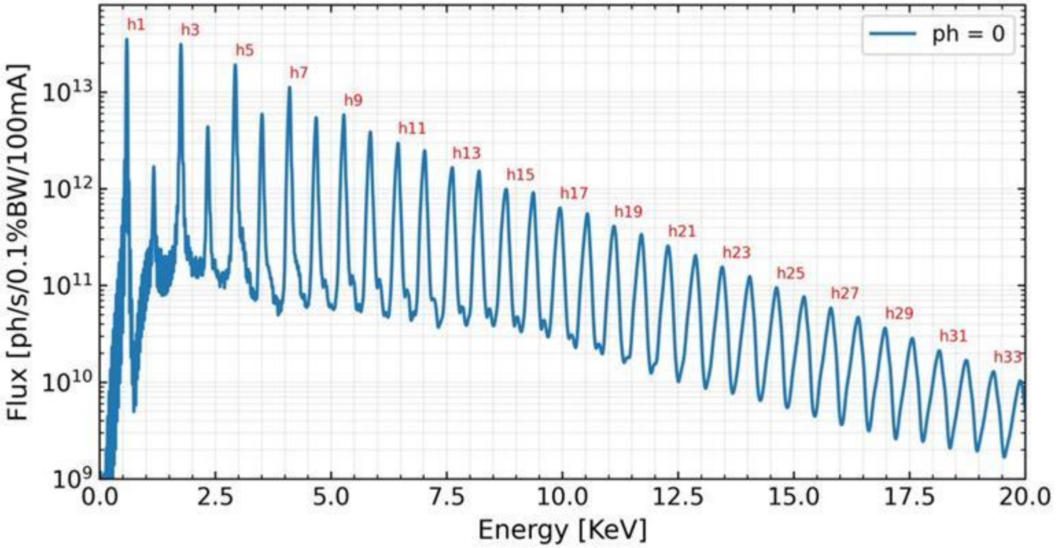






	Before shimming	After shimming
IBx [G.cm]	-169.3	-171.4
IBy [G.cm]	-30.4	-113.0
IIBx [kG.cm2]	-16.9	-16.2
IIBy [kG.cm2]	22.0	1.0
PhaseErr [deg]	9.6	2.0

Radiation spectrum (from fieldmap at phase = 0 mm, K = 1.95):

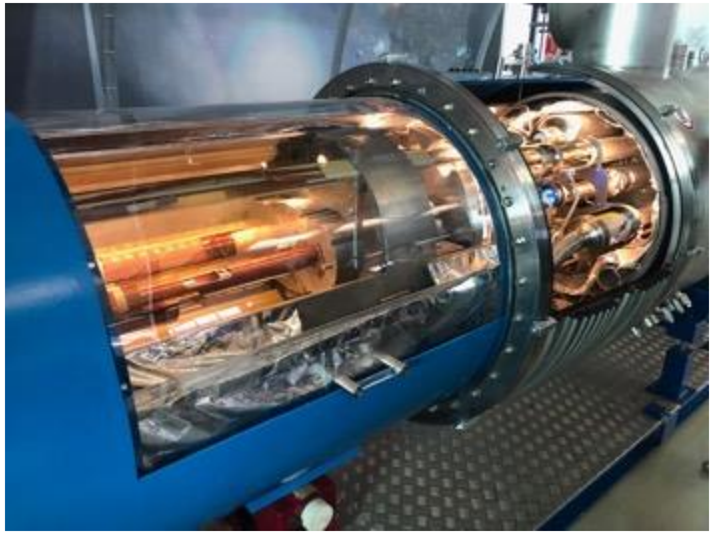


CERN – CNPEM - SUPERCONDUCTING DEVICES

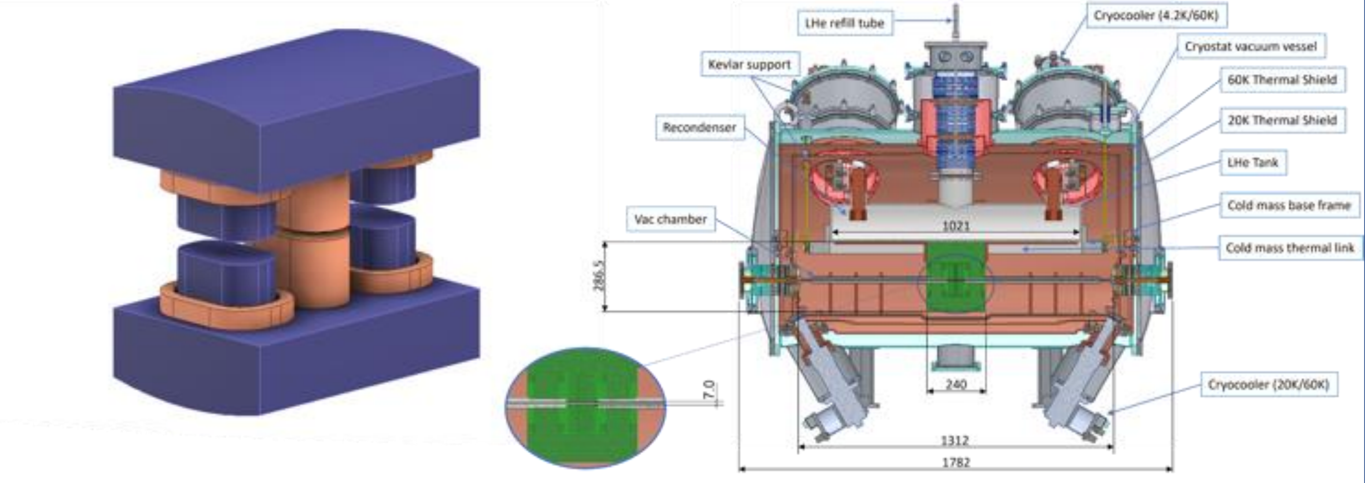
Agreement CERN – CNPEM – December 2020

LHC - CERN

Superconducting dipoles - LHC/CERN



Wavelengthshifter (WLS)



NbTi – Campo de 7.0 T

Superconductivity Initiatives

Superconductivity Initiatives

Motivation:

- Bring CNPEM into the scenario of designing and building superconducting devices
- Build a team capable of meeting the demands of CNPEM in superconducting technologies

Main fields of interest:

- **High-energy physics and accelerators:** magnets, insertion devices, RF cavities
- **Medical:** magnetic resonance devices (MRI and NMR), cyclotrons for therapy
- **Energy:** electric motors, power transmission lines, SMESs
- **Materials:** low and high temperature superconducting materials development and characterization

Main ongoing initiatives:

- Collaboration with CERN for transferring knowledge in superconducting technologies
- Collaboration with CBMM
- Design and fabrication of superconducting devices:
  - Current demand from Sirius: new X-ray high energy beamline -> needs photons with **critical energy of at least 39 keV**
- R&D in superconducting materials: wires development and characterization

Superconducting Devices - Superbend

Motivation:

- Introduce the ENT teams in superconducting technology
- New X-ray high energy beamline -> Need for photons with **critical energy of at least 39 keV**
  - Current non-superconducting magnets of **3.2 T** produce photons with **critical energy of 19 keV**

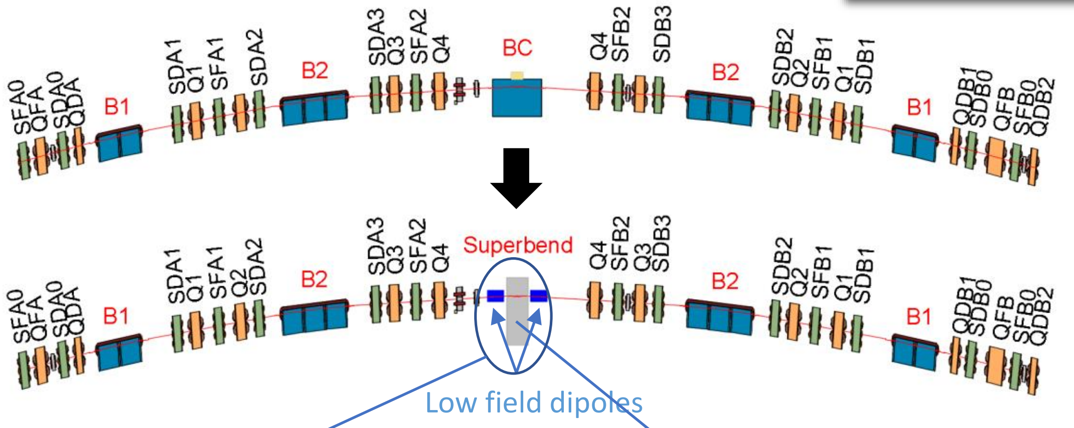
Design remarks:

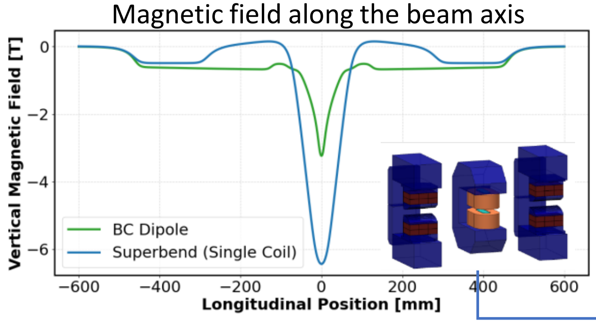
- Build a superconducting magnet with **magnetic field higher than 6 T to replace one BC dipole**
- Use **NbTi wires**
- **Match** the integrated field and integrated gradient of the **BC dipoles**
- Use of warm bore vacuum chamber for NEG coating activation –> **C-shaped magnet**

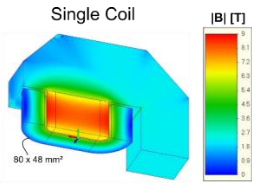
Collaboration CNPEM/CERN

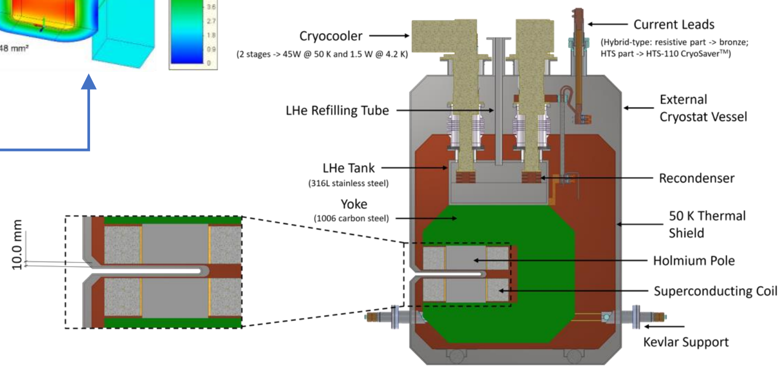
Sirius arc layouts

Project on hold!









	BC Dipole	Superbend
Peak Field [T]	3.2	6.4
Integrated Field [T.m]	-0.7507	-0.7507
Integrated Gradient [T]	6.2508	1.8915

VIANNA, A. A., et al. Conceptual Design of a C-Shaped 6.4 T Superconducting Dipole Magnet. IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, v. 32, p. 1-5, 2022.

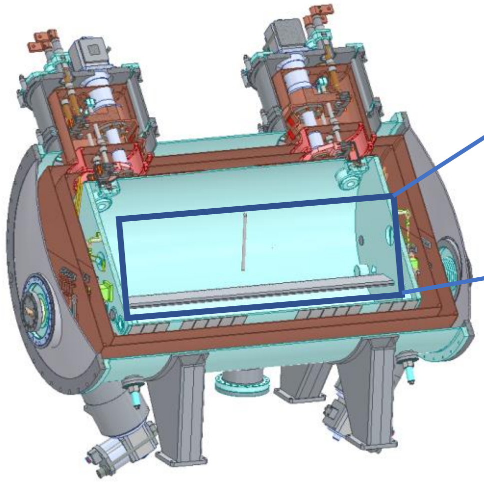
Superconducting Devices - Wavelength Shifter

Motivation:

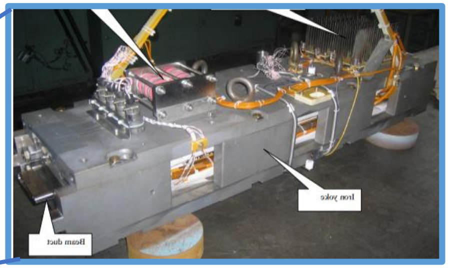
- New X-ray high energy beamline -> Need for photons with **critical energy of at least 39 keV**
  - Current non-superconducting magnets of **3.2 T** produce photons with **critical energy of 19 keV**

Design remarks:

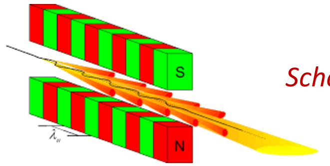
- Build a superconducting magnet with **magnetic field higher than 6 T to be installed in one of the Sirius straight sections**
- Use **NbTi wires**
- **Reuse**, as much as possible, components from **4 T Superconducting Wiggler**
- **Field profile must not impact** the Sirius emittance and beam dynamics



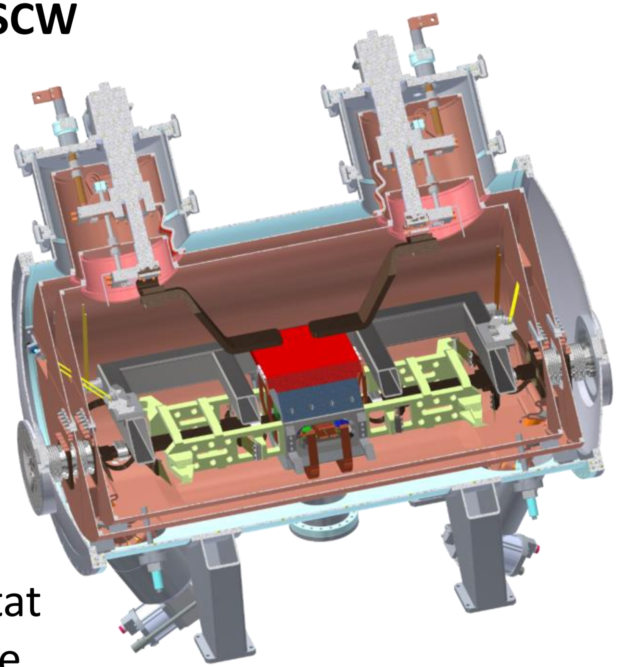
Current 4 T SCW



Cold mass
(immersed in LHe)

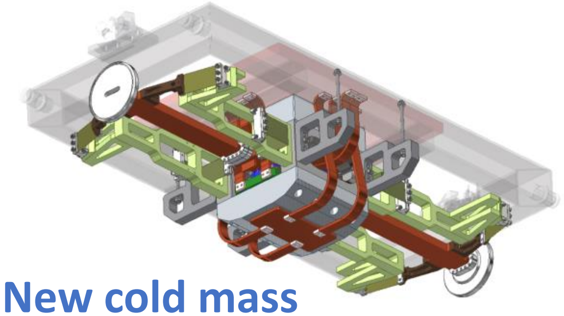


Schematic of a Wiggler

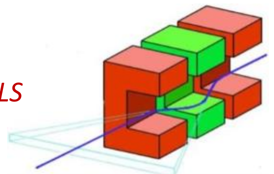


SWLS

- Same cryostat
- Cryogen-free



New cold mass



Schematic of a WLS

Collaboration CNPEM/CERN

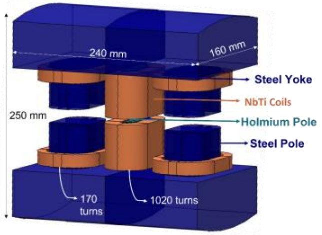
CNPEM

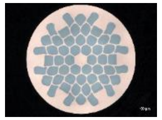
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES

Superconducting Devices - Wavelength Shifter

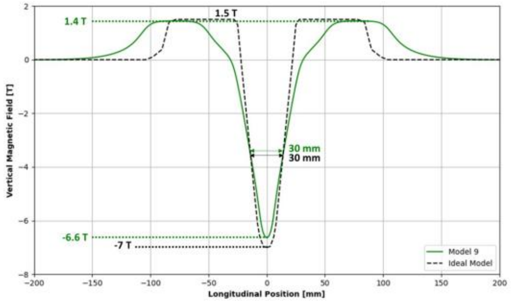
Electromagnetic Design

- **Compact design**
- **Holmium central pole** for intensifying the peak magnetic field
- **A very narrow central peak field** (Int.By lower than 20.1 T.cm)
- **Magnetic field profile** that meets the machine's **beam dynamics requirements**



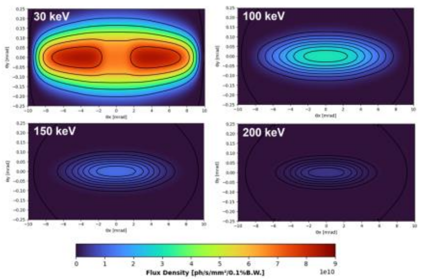


NbTi wire
Ø = 0.90 mm
Cu/NbTi = 0.97



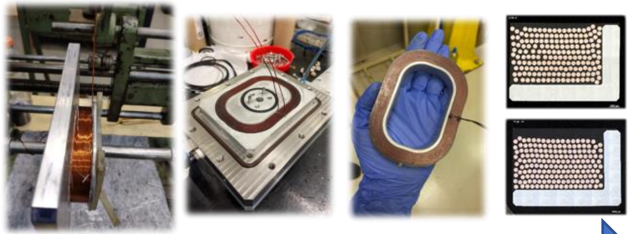
Magnetic field profile

Emitted flux density in diferent energies



Coils Prototyping

- Superconducting coils must be **carefully manufactured**:
  - The **wires** will be subject to **large magnetic forces**
  - **Small movements of the wires** (in the range of μm) **generates a small amount of energy**, which leads to a large increase in temperature (low specific heat)
- To avoid wire movements, **the coil must be impregnated with epoxy resin and fiberglass**
- Coils mandrels and clamps assist in the heat transport phenomena: copper and aluminum

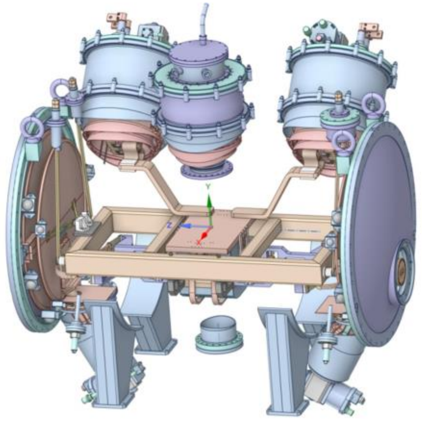


Coil winding and impregnation process

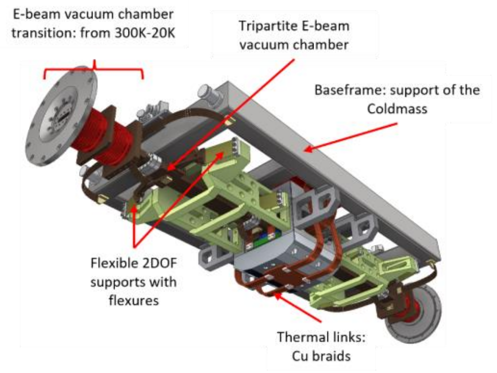
Collaboration CNPEM/CERN

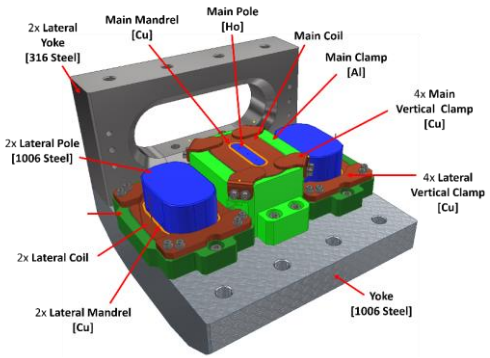
Mechanical Design

- **Reuse Wiggler Cryostat**
- **Many simulations** guided the **decisions** on the **mechanical model**
  - **High forces** due to thermal contraction and magnetic fields
- Narrow vac. chamber with only **6 mm external gap**
- Positioning and alignment **referenced to the center of the yoke. Flexible supports** for contraction movements



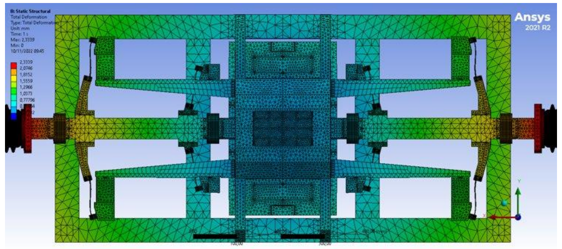
Cold mass





Coils clamping

Cooldown - total contraction



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Superconducting Devices - Wavelength Shifter

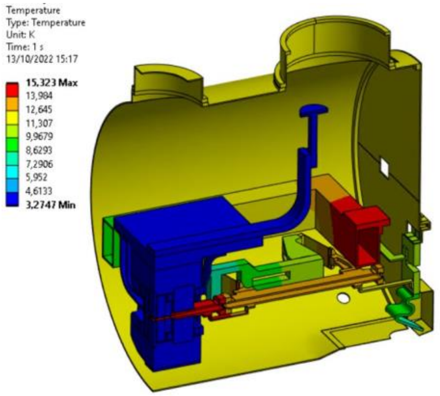
Cryogenic Design

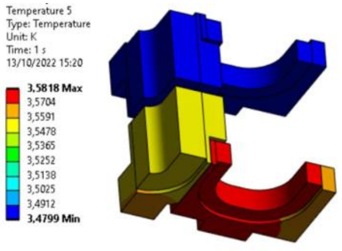
- **Cryogen-Free Conduction Cooled Magnet**
- 4 Cryocoolers as cooling source
- 2 Thermal Shields: first at **60 K**, second at **20 K**
- Conduction-Cooled Hybrid Current Leads
- Coil operating temperature: **3.58 K**
- Cooldown from ambient temperature: **~70 hours**

Static Heat Load

Source	60K [W]	20K [W]	4.2K [W]
Radiation	7.95	0.3	0.007
Vac. chamber Bellows	8.96	0.2	-
Vac. chamber	37.2	3.9	-
Vac. chamber supports	-	-	0.03
Kevlar supports	-	0.32	-
Thermal Shields spherical supports	4.36	0.25	-
Cold mass supports	-	-	0.03
Current Leads	26	-	0.4
Instrumentation	0.5	-	0.1
Total	84.97	4.97	0.567
Cooling Capacity	210	25	3

Temperatures distribution – steady-state



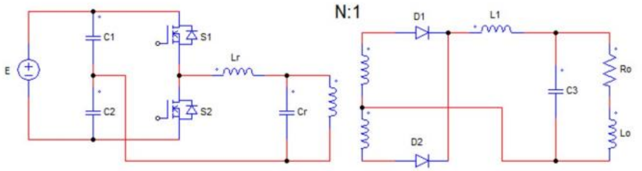


Coils and Clamps

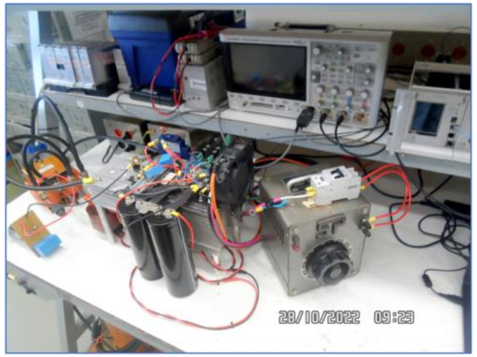
Power Supply

- **Reuse Wiggler Danfysik's power supplies - first approach**
- Design and build **new power supplies** (discontinuous parallel resonant converter) - second approach
- This **topology** guarantee **Zero Current Switching** (ZCS) in the turn on and turn off, which means very low switching losses (**higher efficiency**)

Discontinuous parallel resonant converter circuit



Prototypes being tested

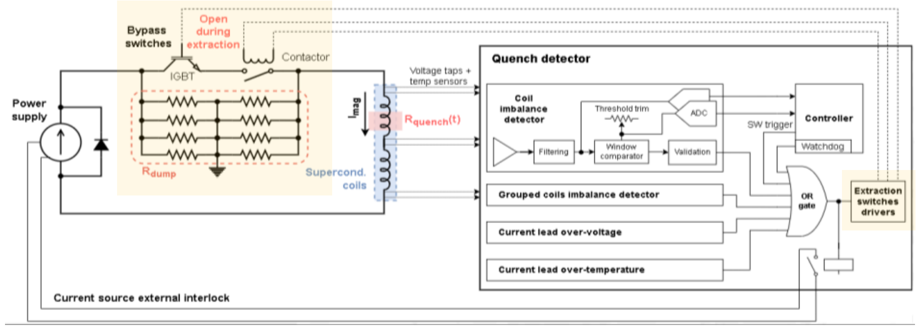


Collaboration CNPEM/CERN

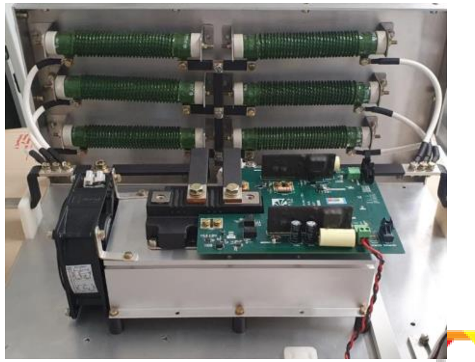
Quench Protection

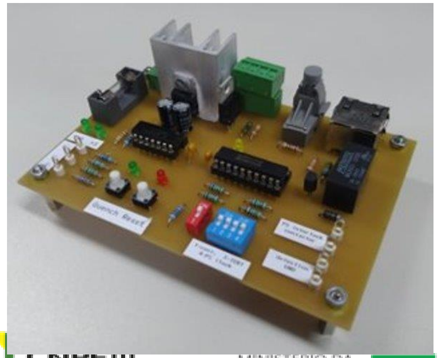
- **Active energy extraction concept**
- Design to keep **max hot-spot temp < 100 K**
- **Earth at dump center** to keep **max voltage-to-ground lower**
- Detection by **hardware** and **software** (Vdet = 100 mV)
- Redundancy: *extraction switches, dump resistors, instrumentation signals, detection methods*

Active energy extraction and detection circuits



Extraction and driver circuit prototypes





Vertical cryostat for testing superconducting coils

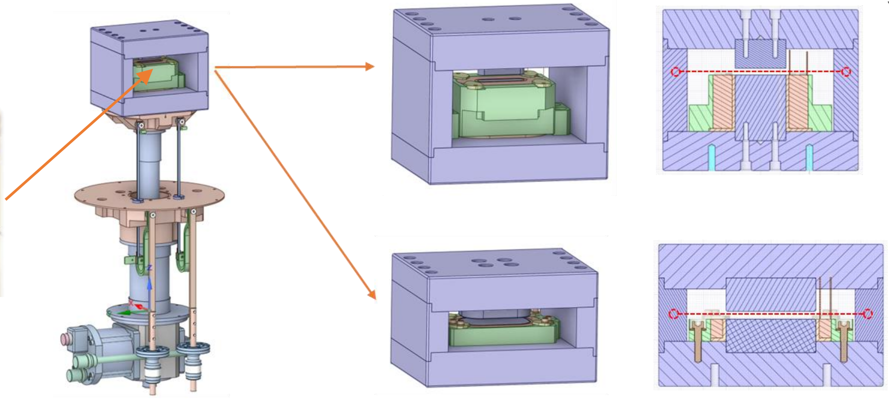
A small vertical cryostat is being built to test superconducting coils and run experiments in cryogenic environment

The main goals are:

- Test superconducting coils:
  - Test the coils at the specified margin
  - Assess the magnetic field
  - Quench training
- Perform other thermal experiments in cryogenic environment

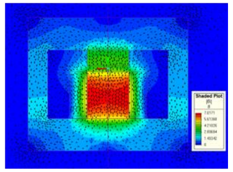
Magnet yoke designed to characterize the superconducting coils of the Wavelength Shifter

Side Coil



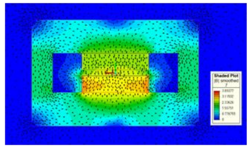
Yoke for Central Coil testing

Simulation Results (I = 228 A)
B gap = 4 T (steel)/4.3 T (Holmium)
B coil = 4.9 T
Margin (5K) = 28%
Inductance = 40 mH
Mag. Force = 9 kN (counter gap)

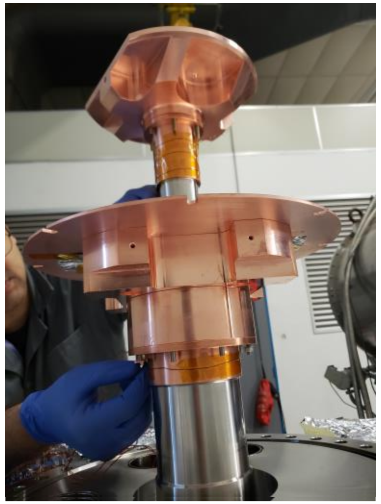


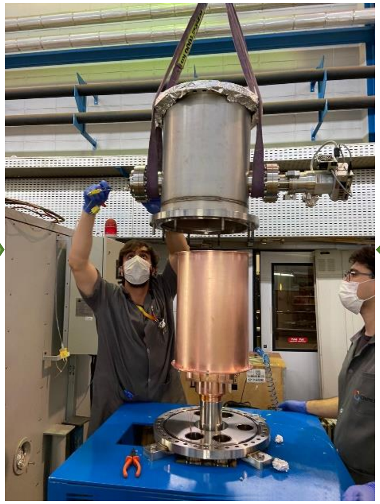
Yoke for Side Coil testing

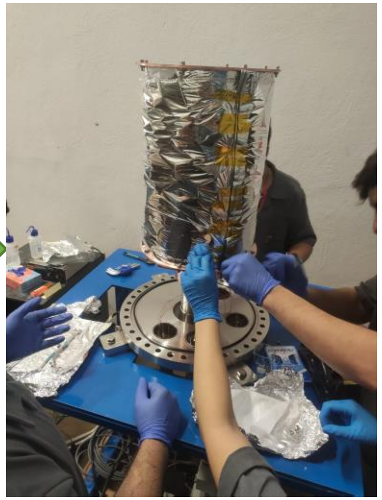
Simulation Results (I = 228 A)
B gap = 2.7 T
B coil = 2.0 T
Margin (5K) = 52%
Inductance = 5 mH
Mag. Force = 5.2 kN (counter gap)



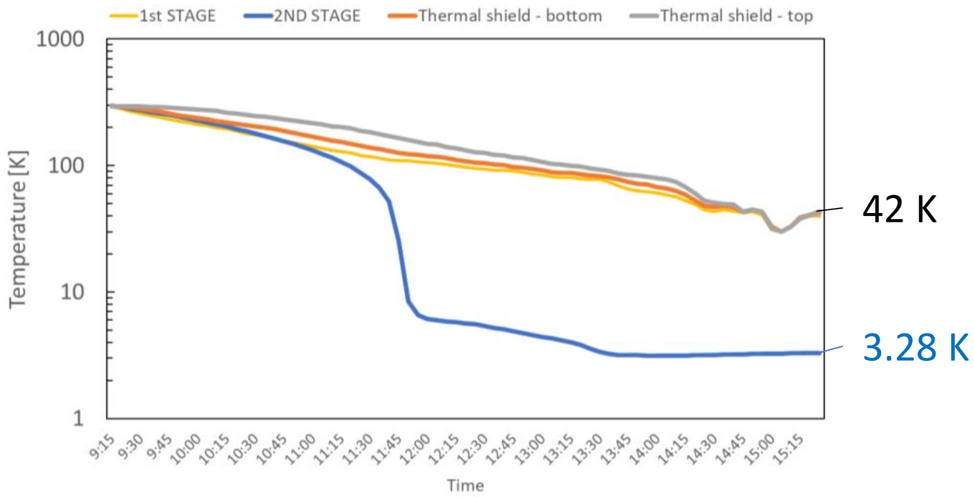
Cryostat layout and current status:







Cooldown without the magnet yoke



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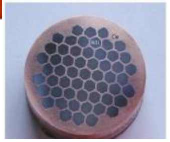
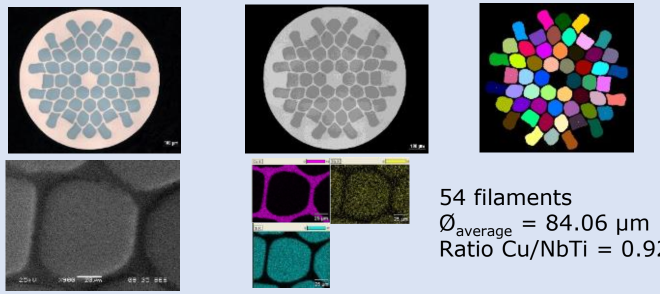
Manufacturing and characterization of superconducting wires

Superducting wires benchmark / performance tests → Manufacturing of a homogeneous NbTi alloy → Forging / extrusion of NbTi ingot → Manufacturing of a monofilament wire embedded in copper → Manufacturing of a multifilamentary superconducting wire

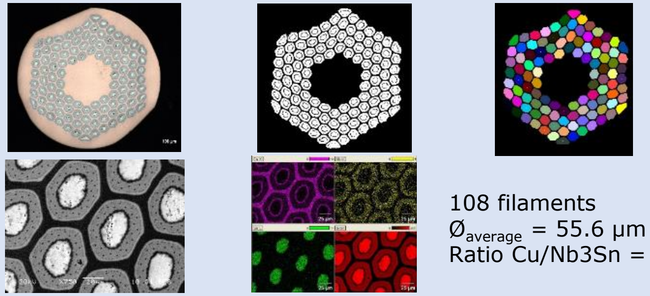


NbTi



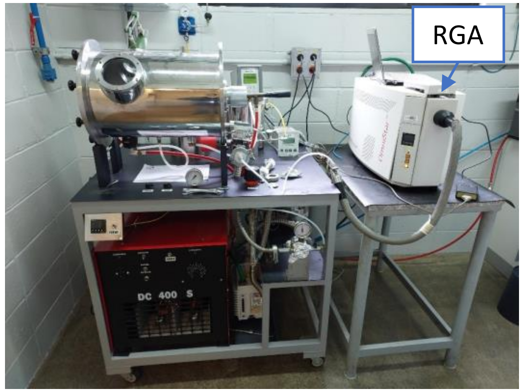
54 filaments
$Ø_{average}$ = 84.06 µm
Ratio Cu/NbTi = 0.92

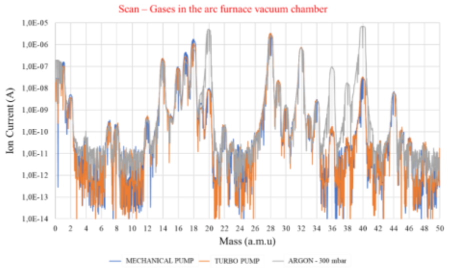
Nb3Sn



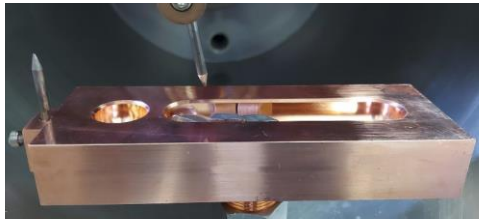
108 filaments
$Ø_{average}$ = 55.6 µm
Ratio Cu/Nb3Sn = 1.20

Superconducting commercial wires analyses



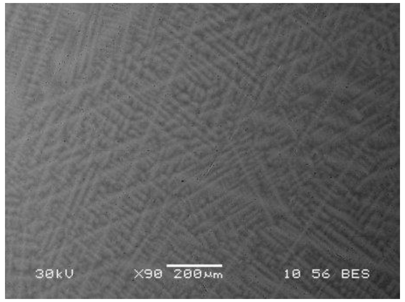


Vacuum Arc Melting Unit



NbTi melted ingots samples

4th NbTi melted ingot



Microstructural characterization

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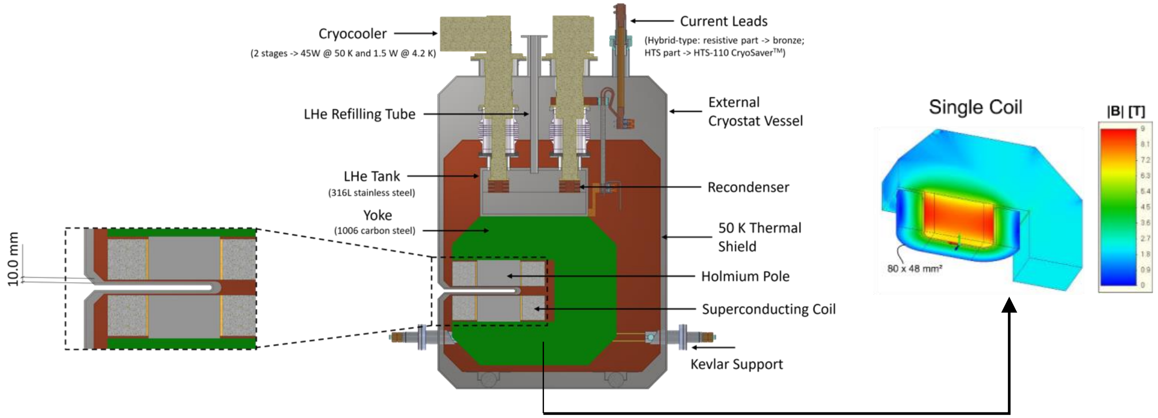
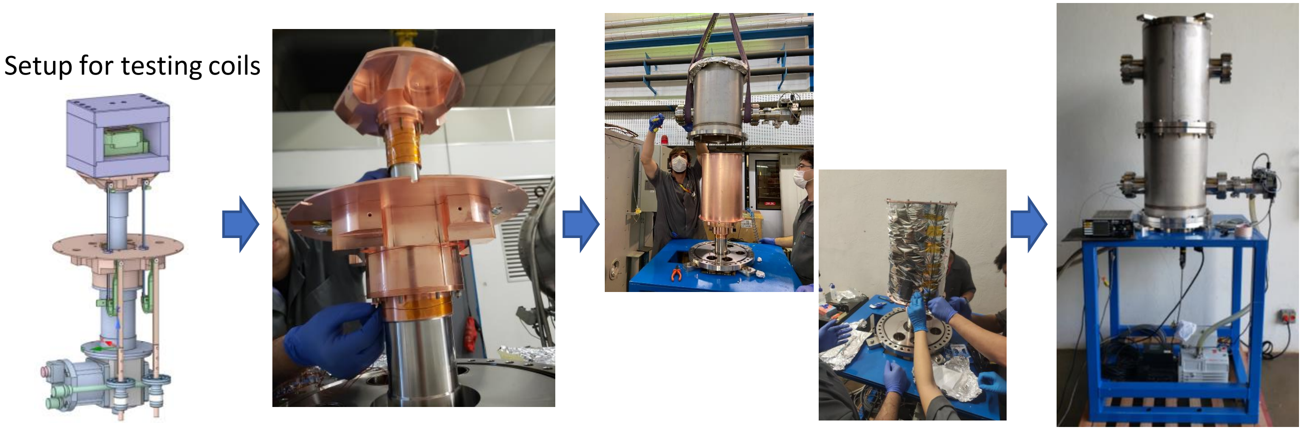
Superconductivity Initiatives – CNPEM/CERN partnership

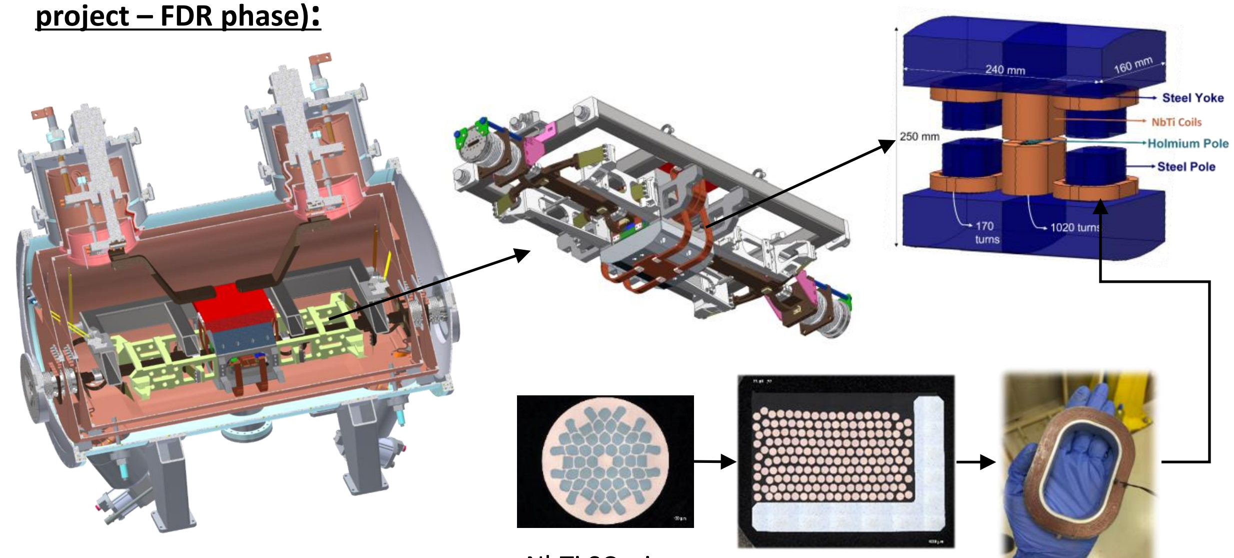
1st project – Superconducting Dipole of 6.4 T (project on hold):



3rd project – Vertical Cryostat for Testing Superconducting Coils (ongoing project):



2nd project – Superconducting Wavelength Shifter of 6.6 T (ongoing project – FDR phase):



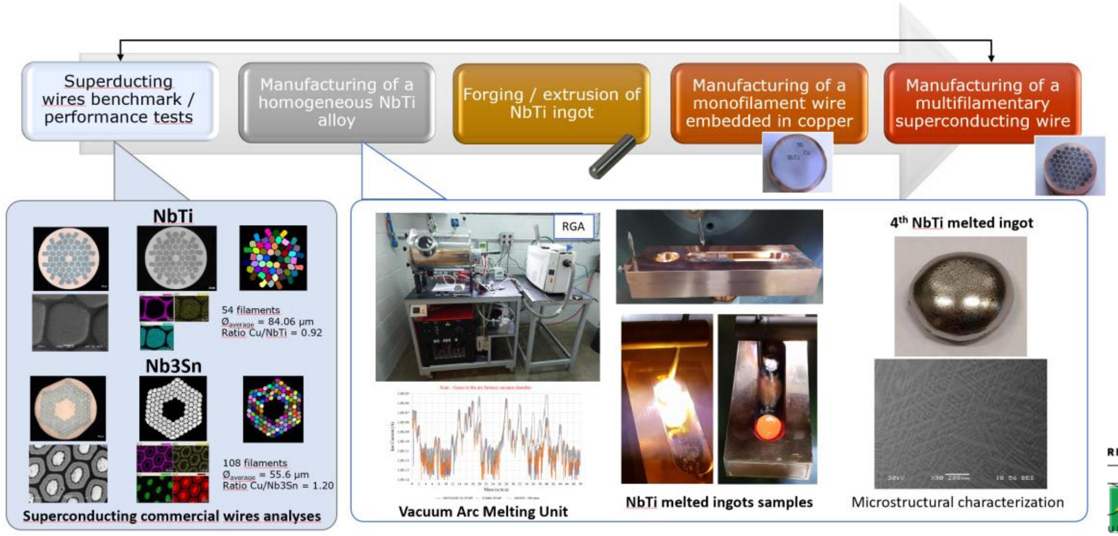
Cryogen-free concept

NbTi SC wire

Coil winding

Coil

4th project – Manufacture and Characterization of Superconducting Wires (ongoing project) – CNPq InovaNióbio Project



New Projects

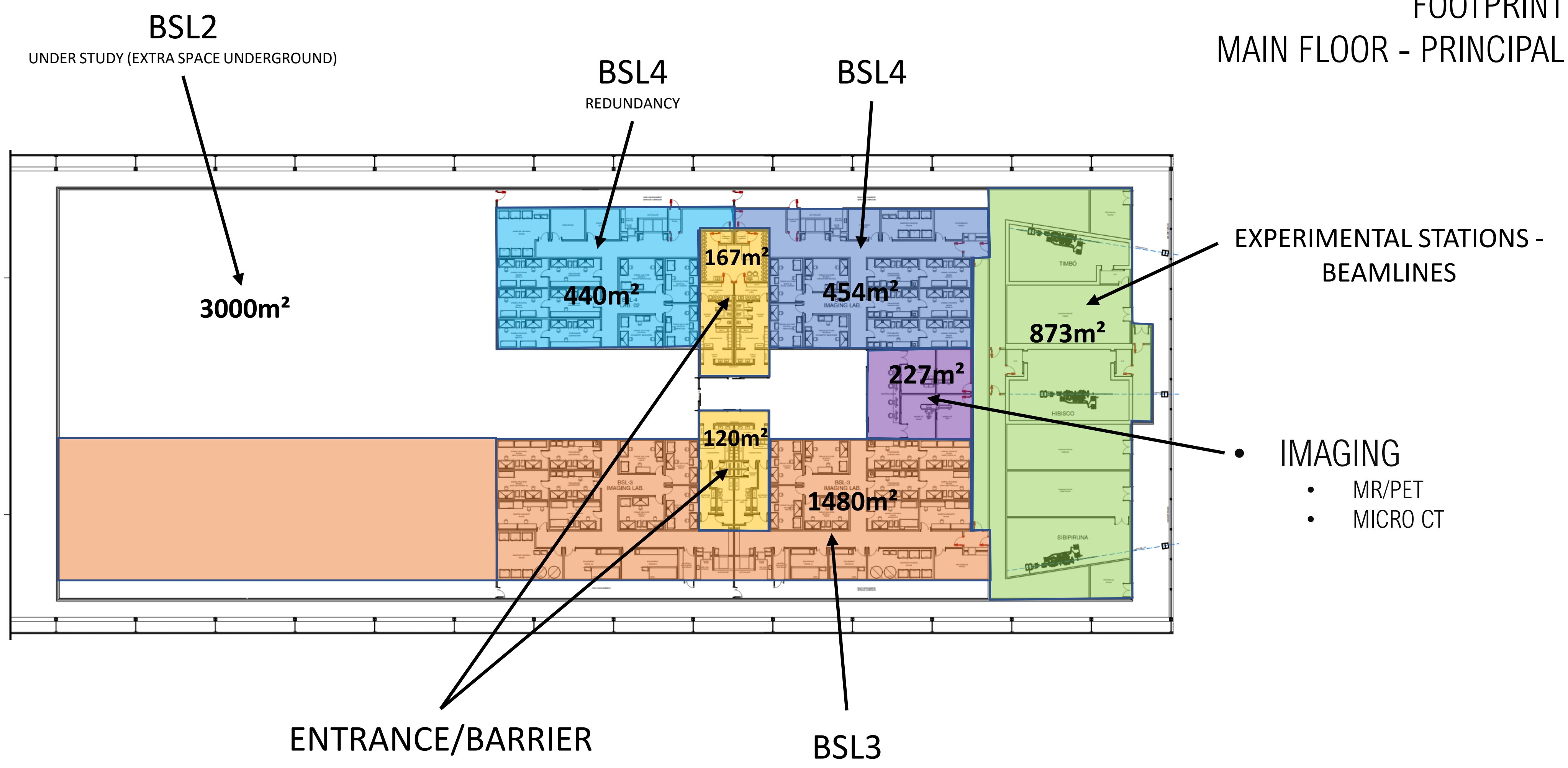
MAXIMUM BIOLOGICAL CONTENTION LABORATORY

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES

MAXIMUM CONTAINMENT BIOLOGICAL LABORATORY

MAXIMUM CONTAINMENT BIOLOGICAL LABORATORY

FOOTPRINT
MAIN FLOOR - PRINCIPAL



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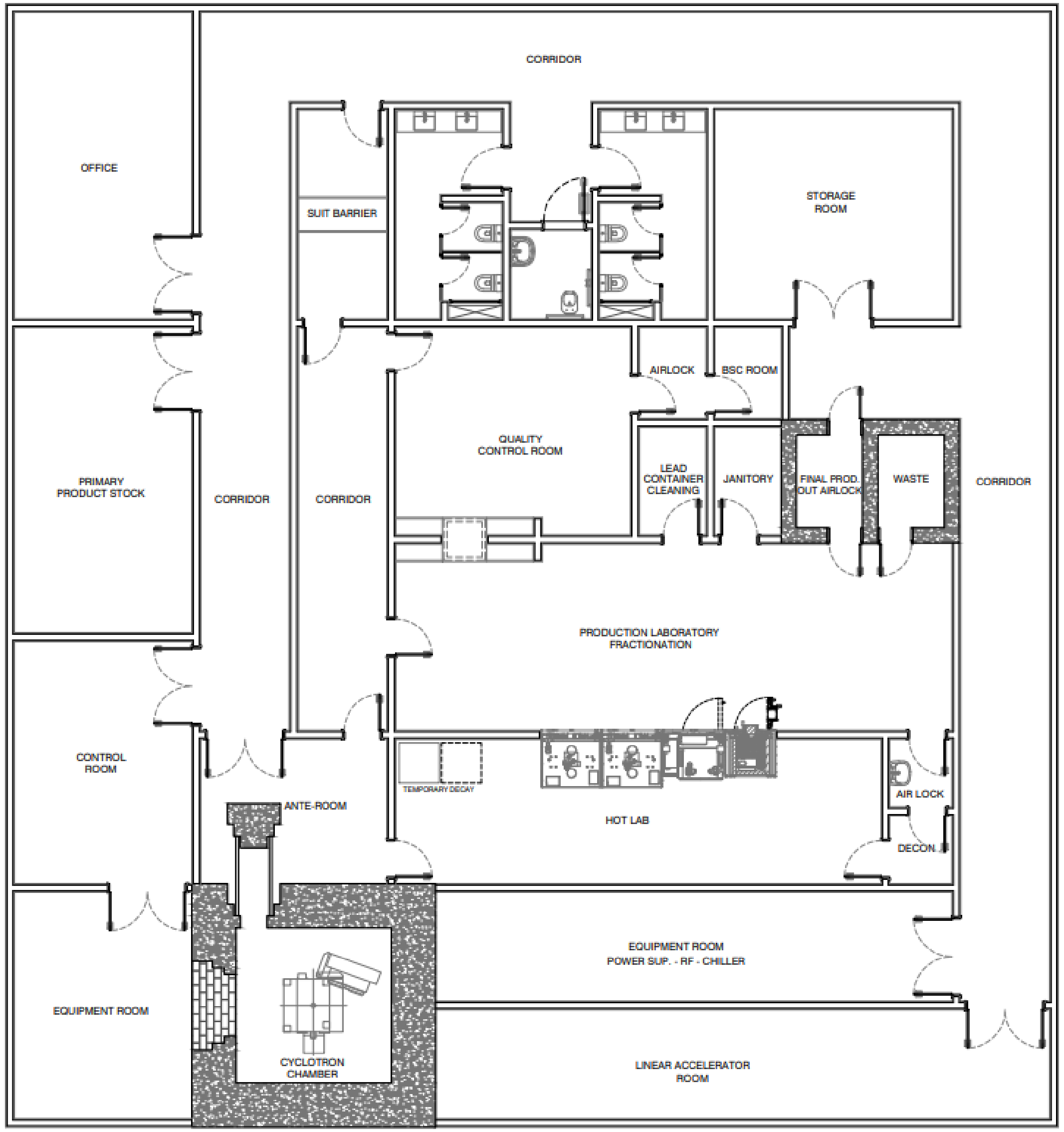
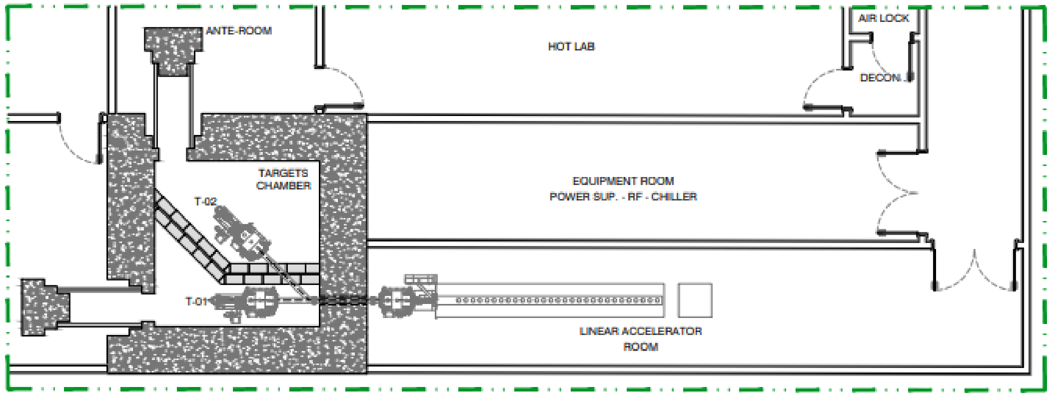
MAXIMUM CONTAINMENT BIOLOGICAL LABORATORY



FOOTPRINT
UNDERGROUND

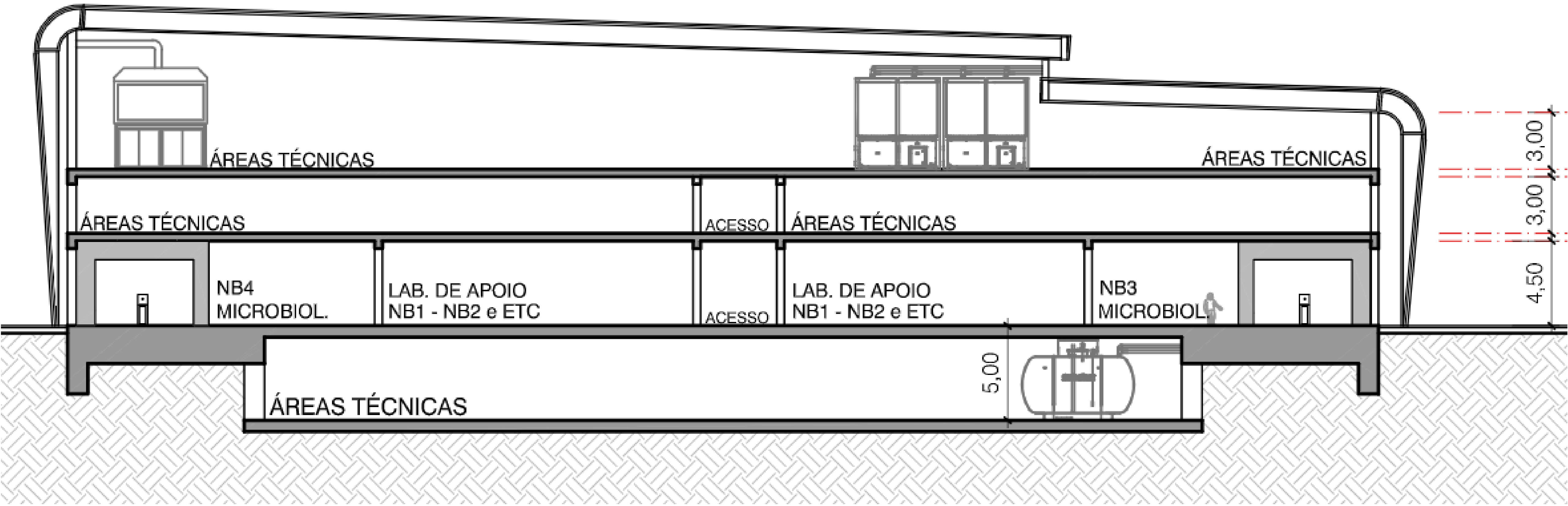
MAIN AREAS CONSIDERED UNDERGROUND

- BSL2
- BIOTERIUM
- TECHNICAL AREAS (EFLUENTES TREATMENT)
- CYCLOTRON/LINAC



MAXIMUM CONTAINMENT BIOLOGICAL LABORATORY

TRANSVERSAL CUT - CONCEPT



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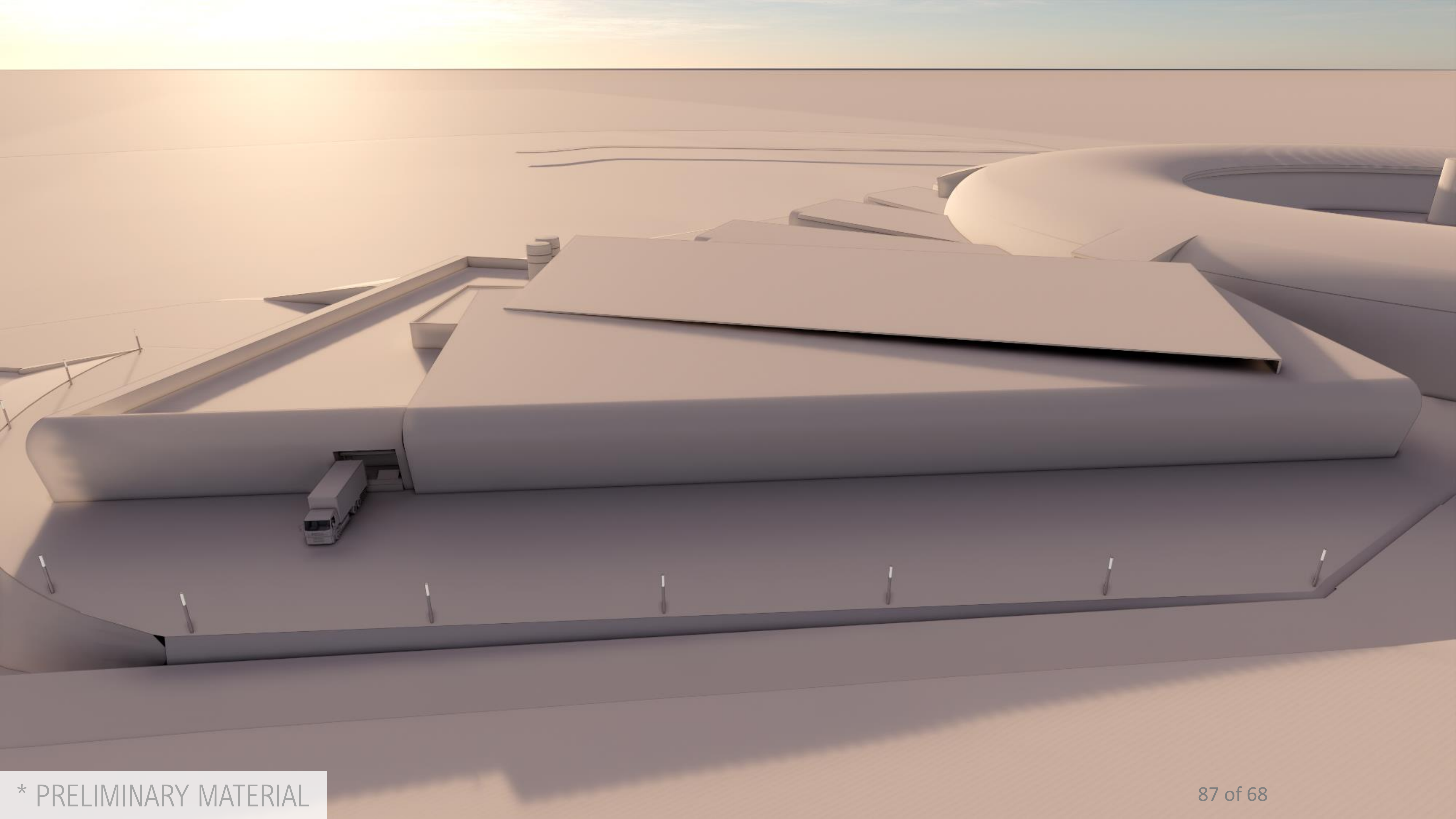
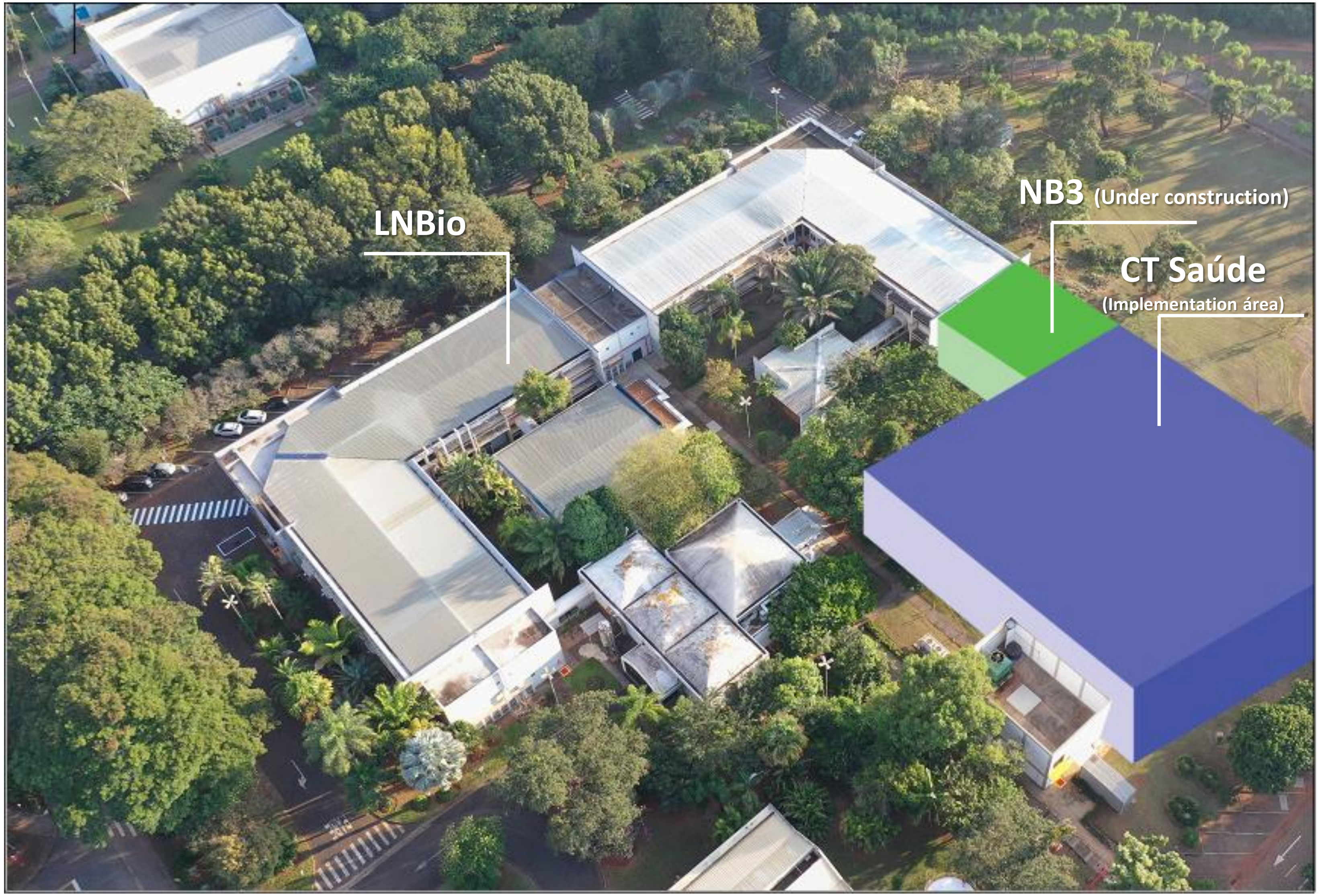


* PRELIMINARY MATERIAL

Health Technology Center
Program of requirements

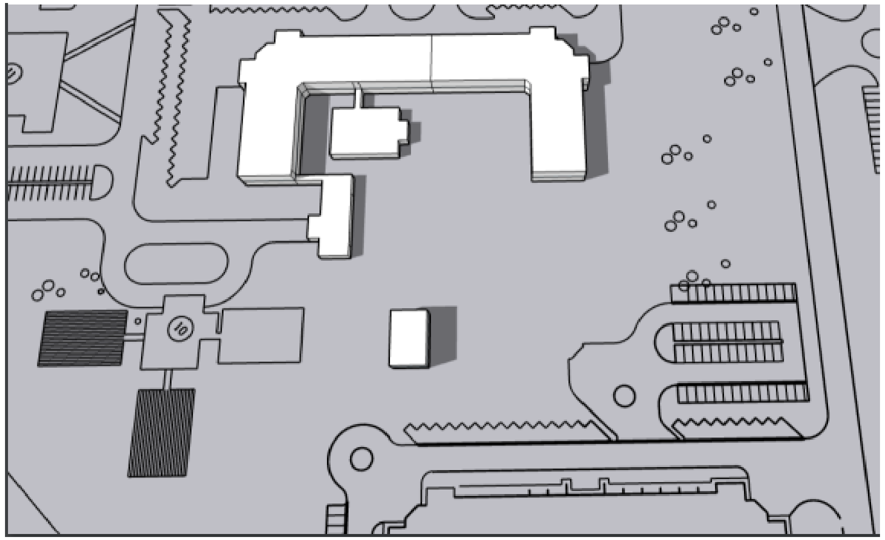


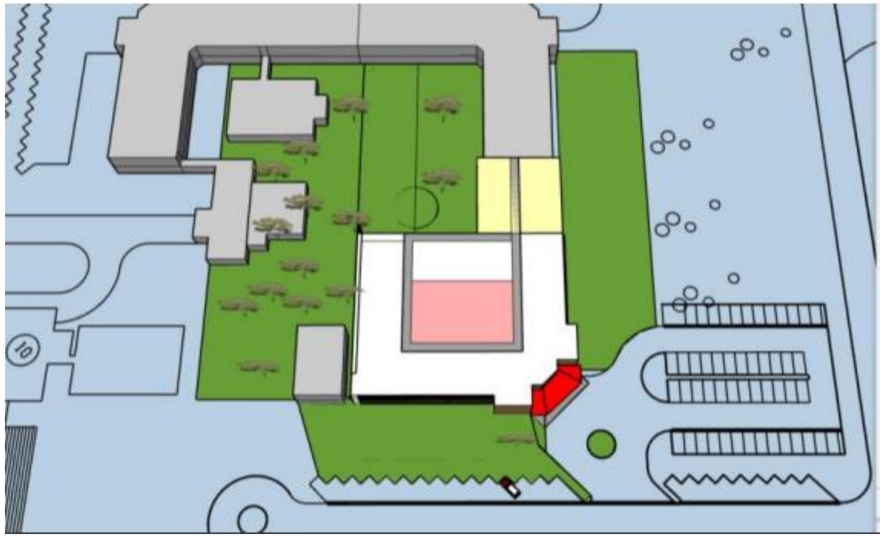
The project of the **Health Technology Center** (CTSaúde in Portuguese) will act at the interface between scientific advances and development of new tecnologies that will work for supply the demands of the national health system.

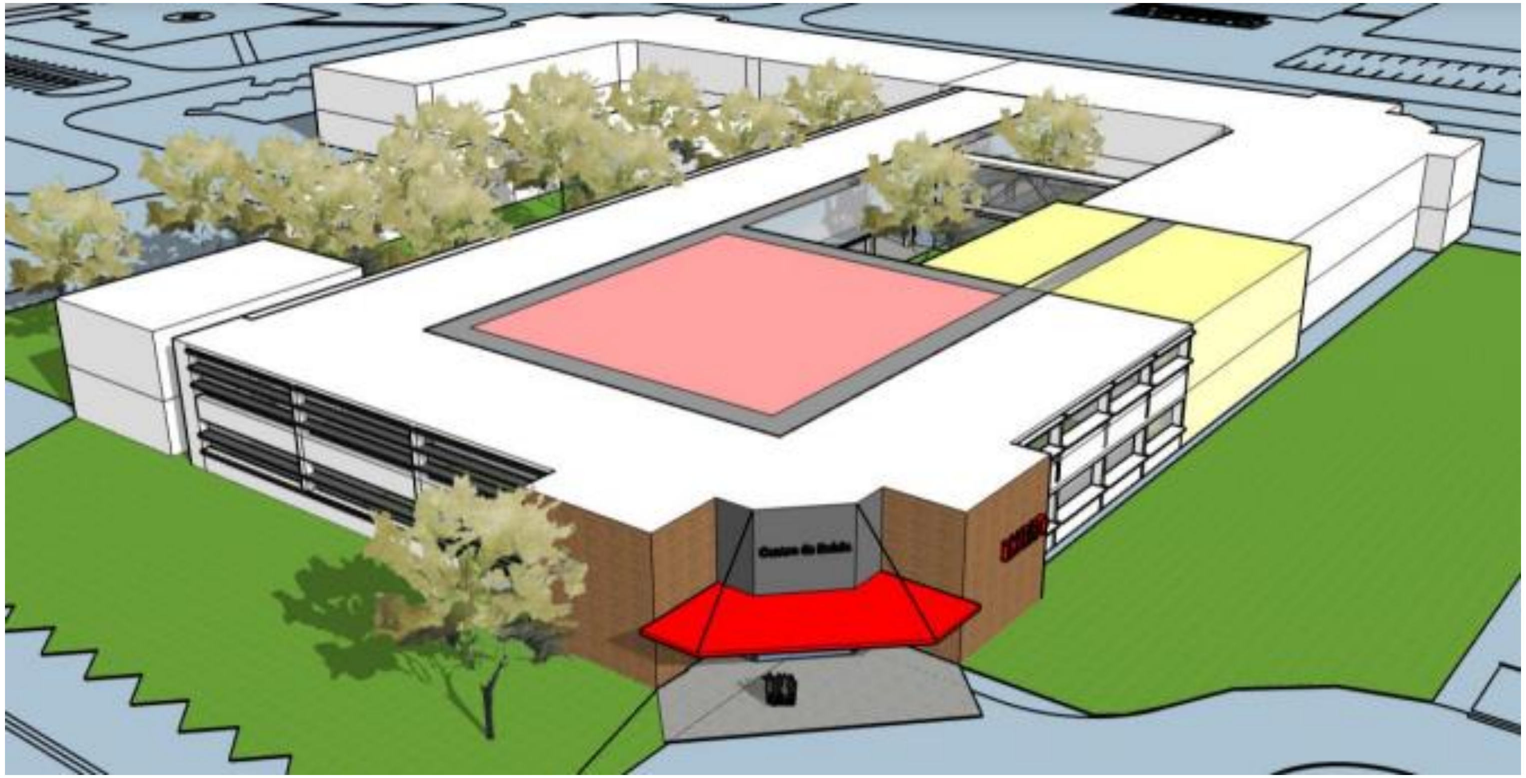
The objetive is to estabilish new competencies dedicated to the biomanufacturing of pilot batches of cell lines producing **monoclonal antibodies**, **vaccines** and inputs for **gene editing-based therapy**.

The Center will be assisted by complementary competencies of **CNPEM** which should maximize the chances of success about delivering solutions to the health system.

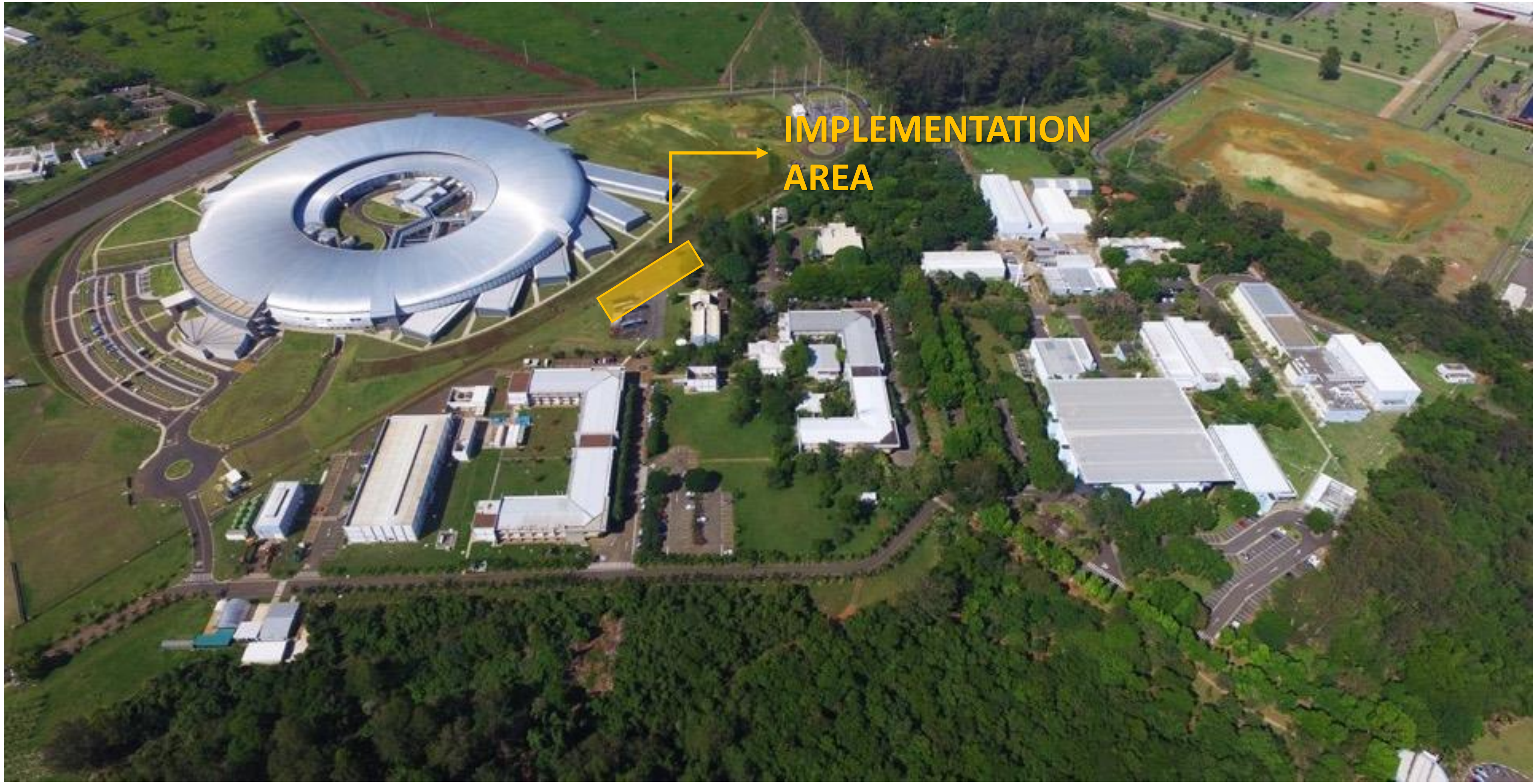
Health Technology Center
Conceptual Design Studies







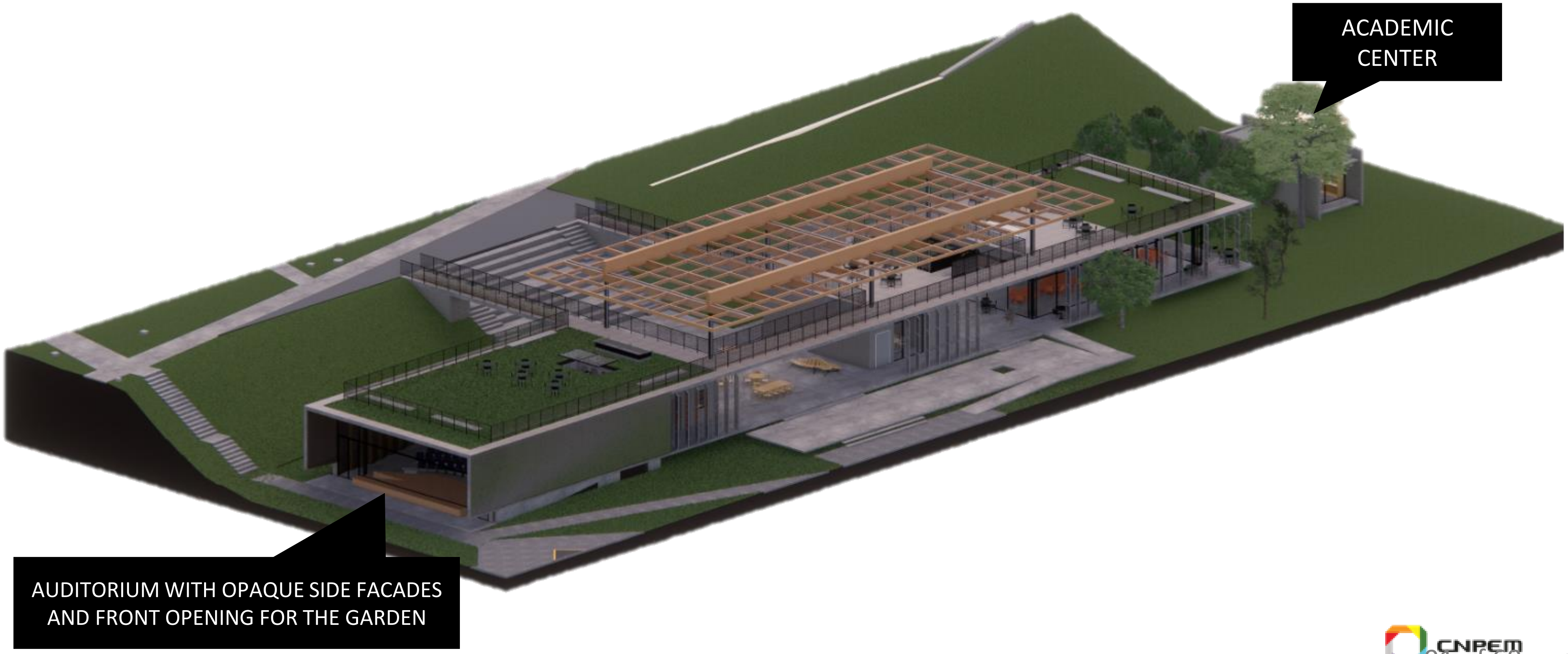
Ilum's Conviviality Center



The ILUM's Conviviality Center will be a base at the CNPEM Campus, for students of the technology and innovation college ,Ilum, a center of university education of excellence in the field of science and technology, and its proposal is to transform the space of the CNPEM (National Center for Research in Energy and Materials).

Ilum's Conviviality Center

The architecture proposal base itself on the idea of open and integrated space, aiming the idea at the spatial way as much as visual way. The basic idea is a building located in one level only, the level of the main way of intern access. The project is divided in two main floors: the ground floor , without different levels, with only one main stair to access the upper floor; the upper floor will be covered by a wood pergola and will allow a connection between Sirius and the Center, allowing the users a space of contemplation and leisure, without blocks for a free flow.



Ilum's Conviviality Center

Thank you

CNPEM
ORGANIZAÇÃO SOCIAL DO MCTI

MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÕES

PÁTRIA AMADA
BRASIL
GOVERNO FEDERAL