LNLS-2

A New High Performance Synchrotron Light Source for Brazil

Pedro F. Tavares

Brazilian Synchrotron Radiation Laboratory - LNLS

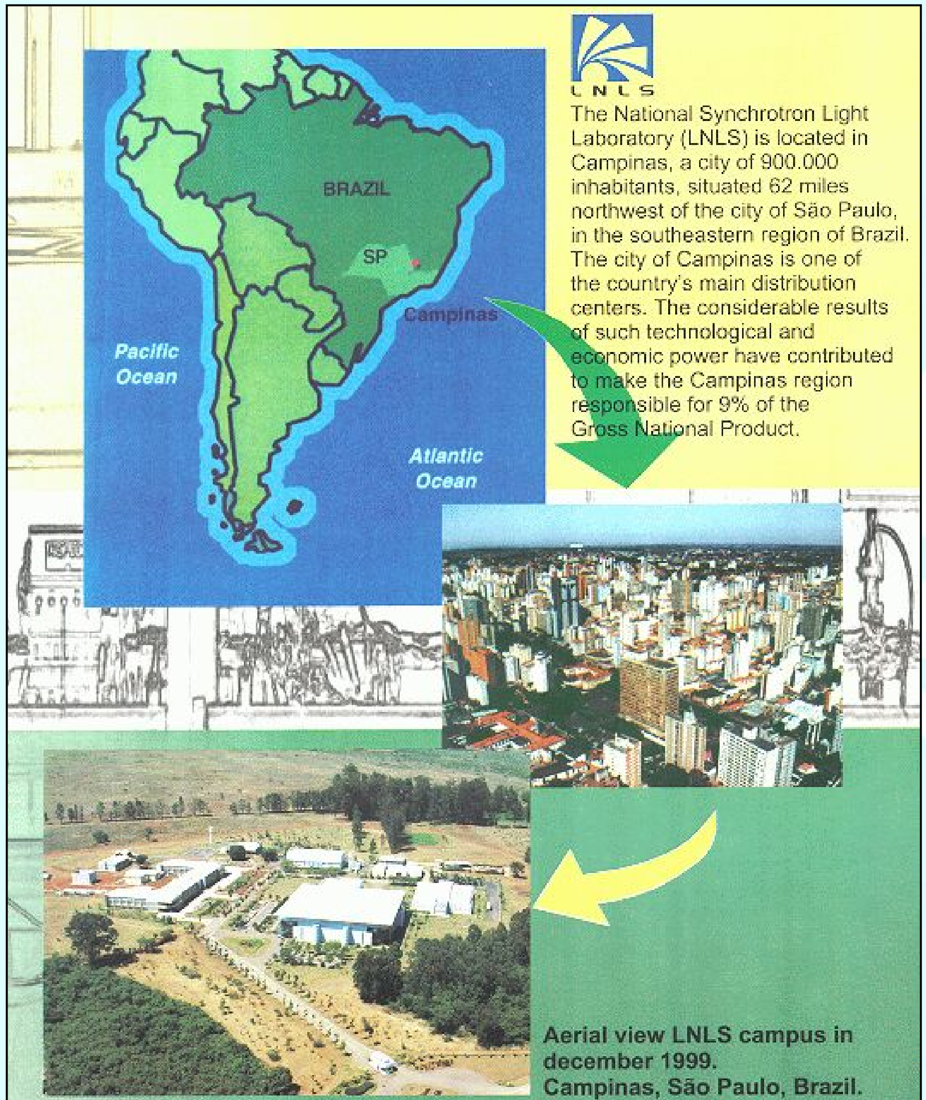
Summary

- Overview of LNLS and the LNLS-1 Light Source.
- Basic Requirements for LNLS-2.
- The LNLS-2 Project
  - Basic Parameters – Parameter choice rationale.
  - Storage Ring Lattice
  - Storage Ring Subsystems
  - Schedule and Budget

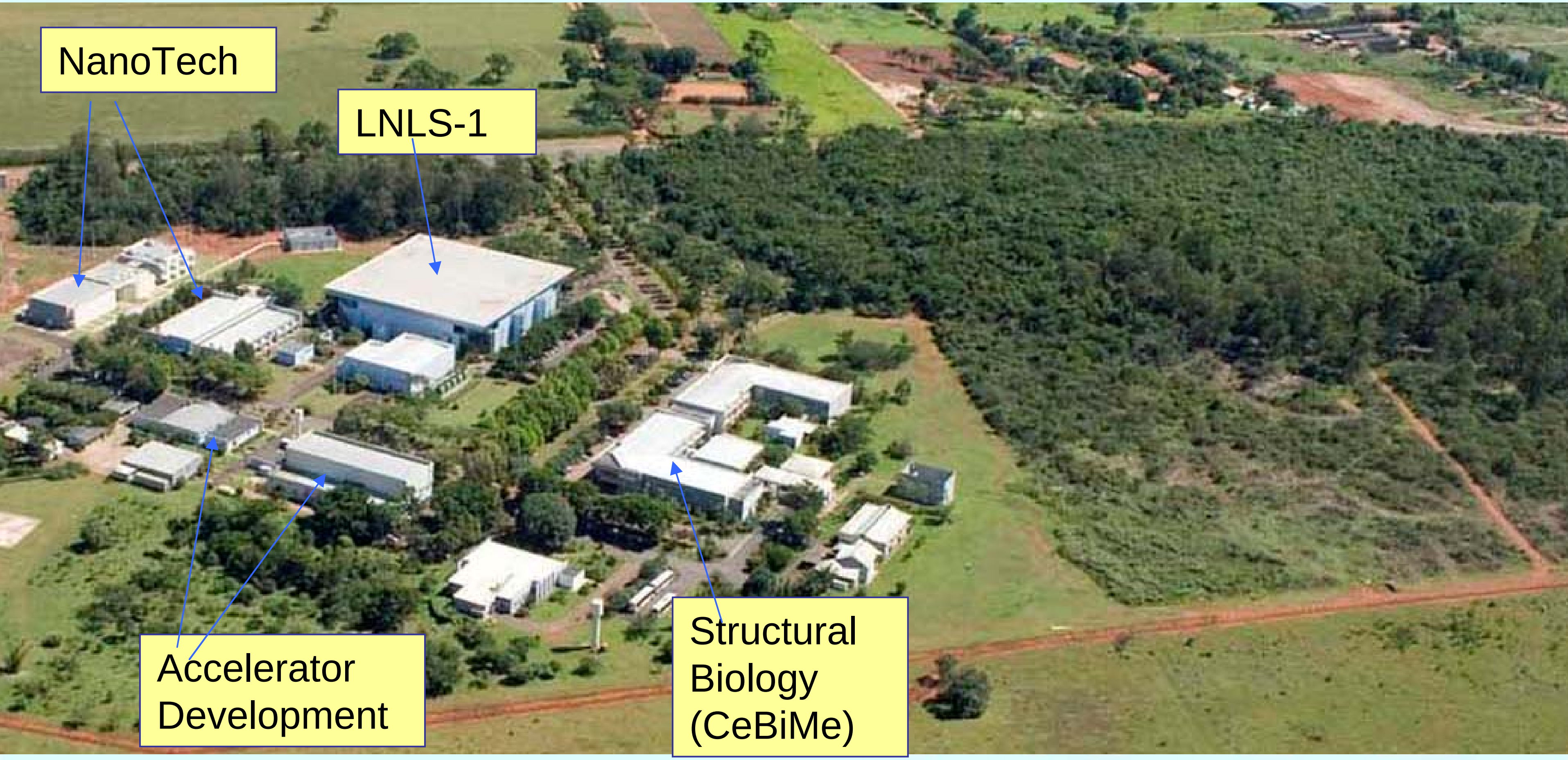
LNLS
Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia

The Brazilian Synchrotron Light Laboratory

LNLS2



The LNLS Campus



E= 1. 37 GeV; C = 93 m

B = 1.67 T

2 keV critical energy

2.0 T MW; EPU; SCW

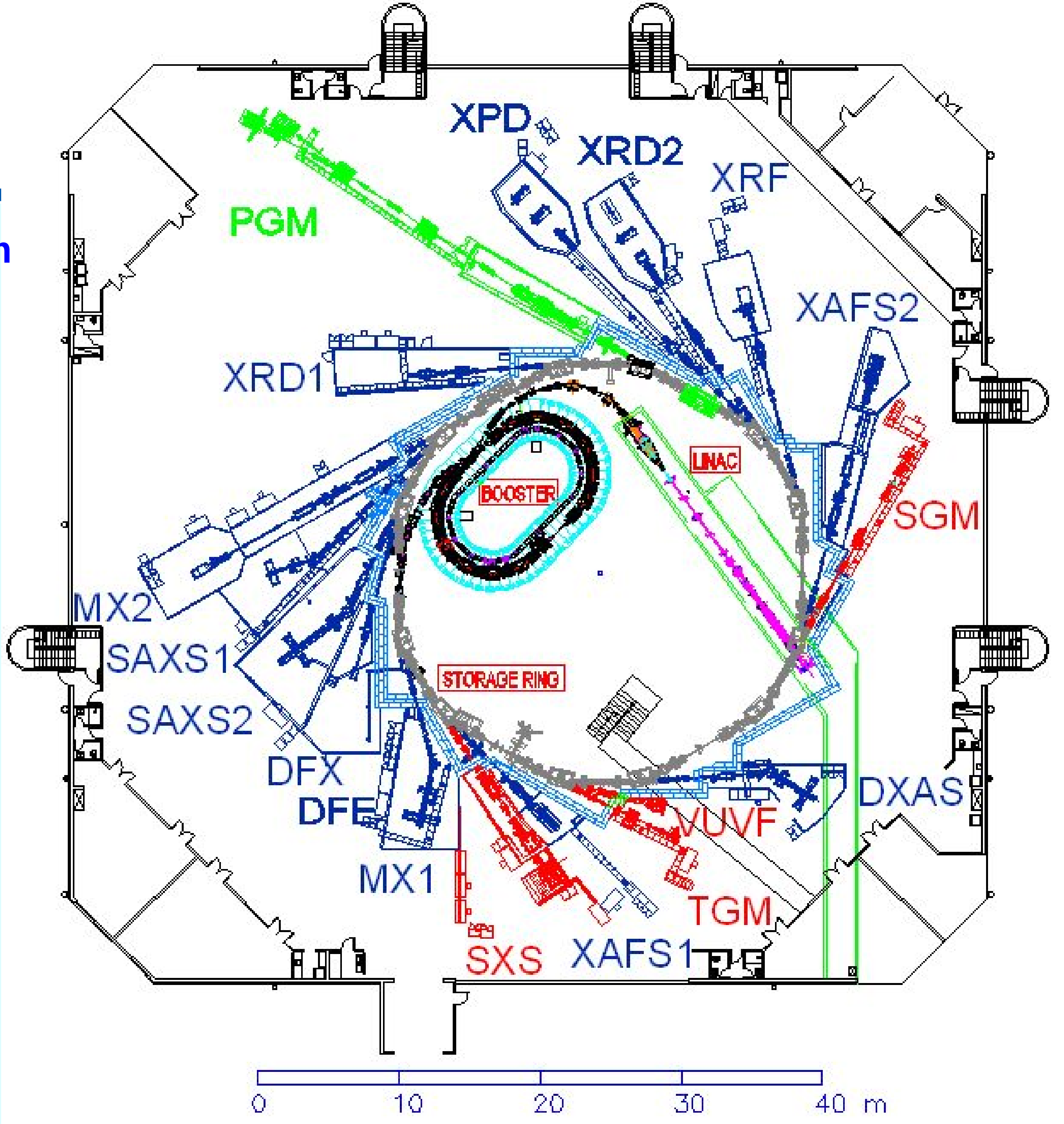
BeamLines

6 - VUV/Soft X-Ray

- 3 in operation
- 1 commiss.
- 1 construction
- 1 diagnostics

13 - Hard X-ray

- 10 in operation
- 1 in commiss.
- 1 refurbishment
- 1 diagnostics



Basic Requirements.

- **General**
  - Designed to meet the **present** and **future** (time scale of 15 to 20 years) demands of the Brazilian and Latin-American scientific communities.
  - Consider the possibility of **future upgrades** to new concepts not yet completely established such as the so called **fourth-generation sources**.
  - Consider the possibility of manufacturing a significant fraction its components in Brazil, emphasizing the **involvement of Brazilian industry**.

- Design for **high reliability** of the facility (comparable to the reliability reached in the present source). The design must be conservative where possible without compromising the required performance.
- Design must be **optimized** with respect to both **capital investment** and **future operational costs.**
- Make the most out of the **existing LNLS infrastructure** in reducing capital investment costs for the project.
- LNLS-2 should have a **complementary character** with respect to LNLS-1, allowing the present light source limitations to be overcome, both with respect to its spectral coverage as well as with respect to the brightness of the radiation.

Radiation Properties

- Generate **high brightness beams**, **comparable to or higher** than what can be achieved in present day third-generation sources. This implies **very low emittance**– on the order of or below **1 nm.rad**.
- Provide – with the use of a combination of conventional permanent magnet, in-vacuum and superconducting undulators – optimal photon beam brightness, i.e. brightness above

  10^{21} photons/sec/0.1%/mrad^2/mm^2 in the

  1 to 20 keV photon energy range.
- Produce high brightness in excess of

  10^{19}photons/sec/0.1%/mrad^2/mm^2 in the

  100 eV to 1 keV spectral range.

- Generate **high flux radiation** (e.g. using superconducting wigglers) up to **100 keV**.
- High degree of **transverse coherence** for X-rays up to about 10 keV
- Allow **manipulation of the radiation time structure** with various storage ring filling modes.
- Availability of very long beamlines.
- Priority must be given to obtaining **high photon beam stability**.

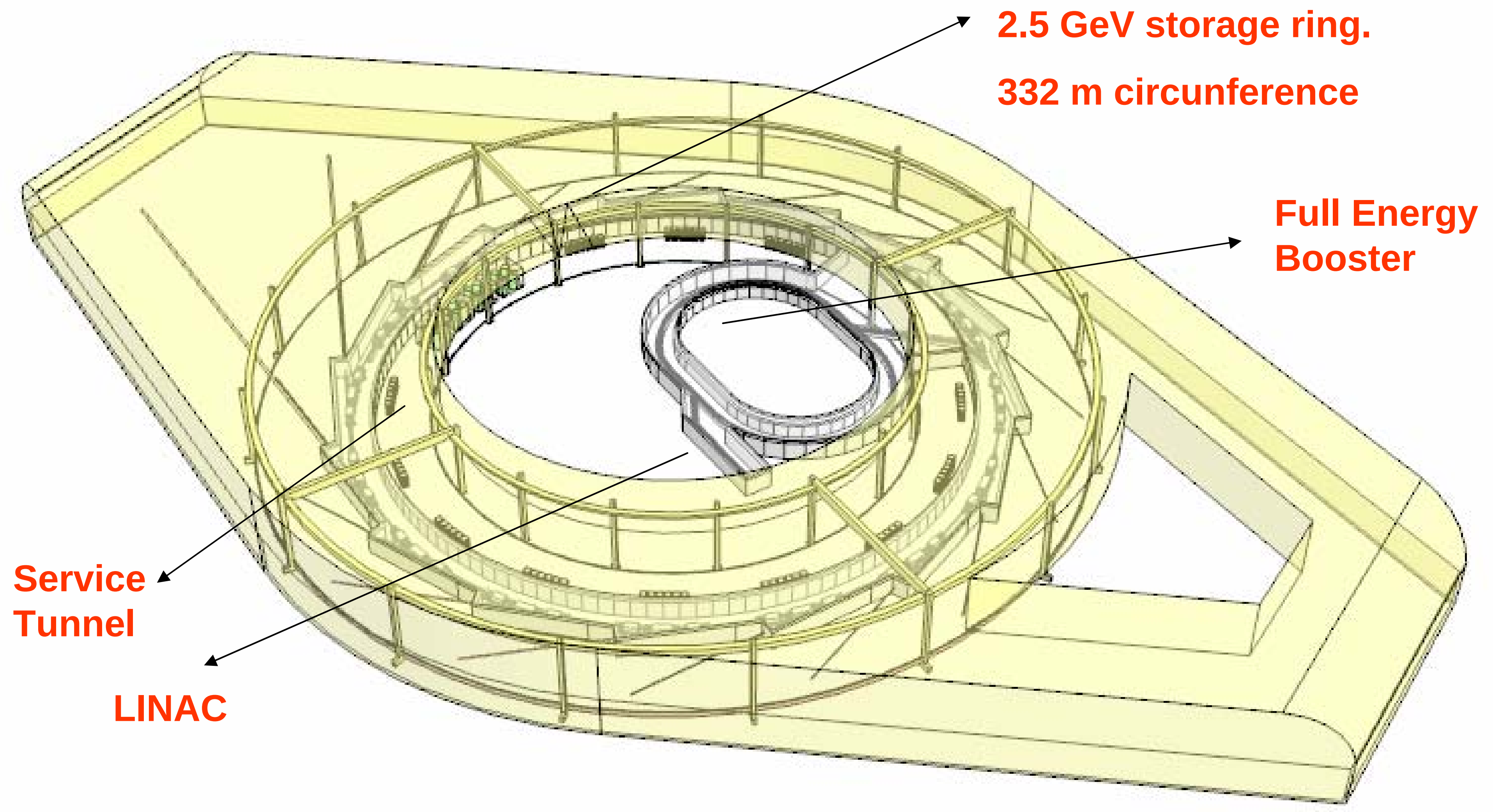
Accelerator Characteristics

- **Full energy injector – Top-Up** injection.
- Intensive use of narrow gap undulators, including **in-vacuum undulators** and **superconducting undulators**.
- Large scale use of **small aperture permanent magnet technologies**.
- **Damping wigglers** to reduce emittance.
- **Superconducting RF system** – reduce power consumption and Higher Order Mode (HOM) related effects and **Solid State RF** power source.
- **Flexible** Magnet lattice.
- High reliability and stability requirements translate into **system redundancy** and **tight component tolerances**.
- New materials/techniques for vacuum chamber: **NEG, copper.**

Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia

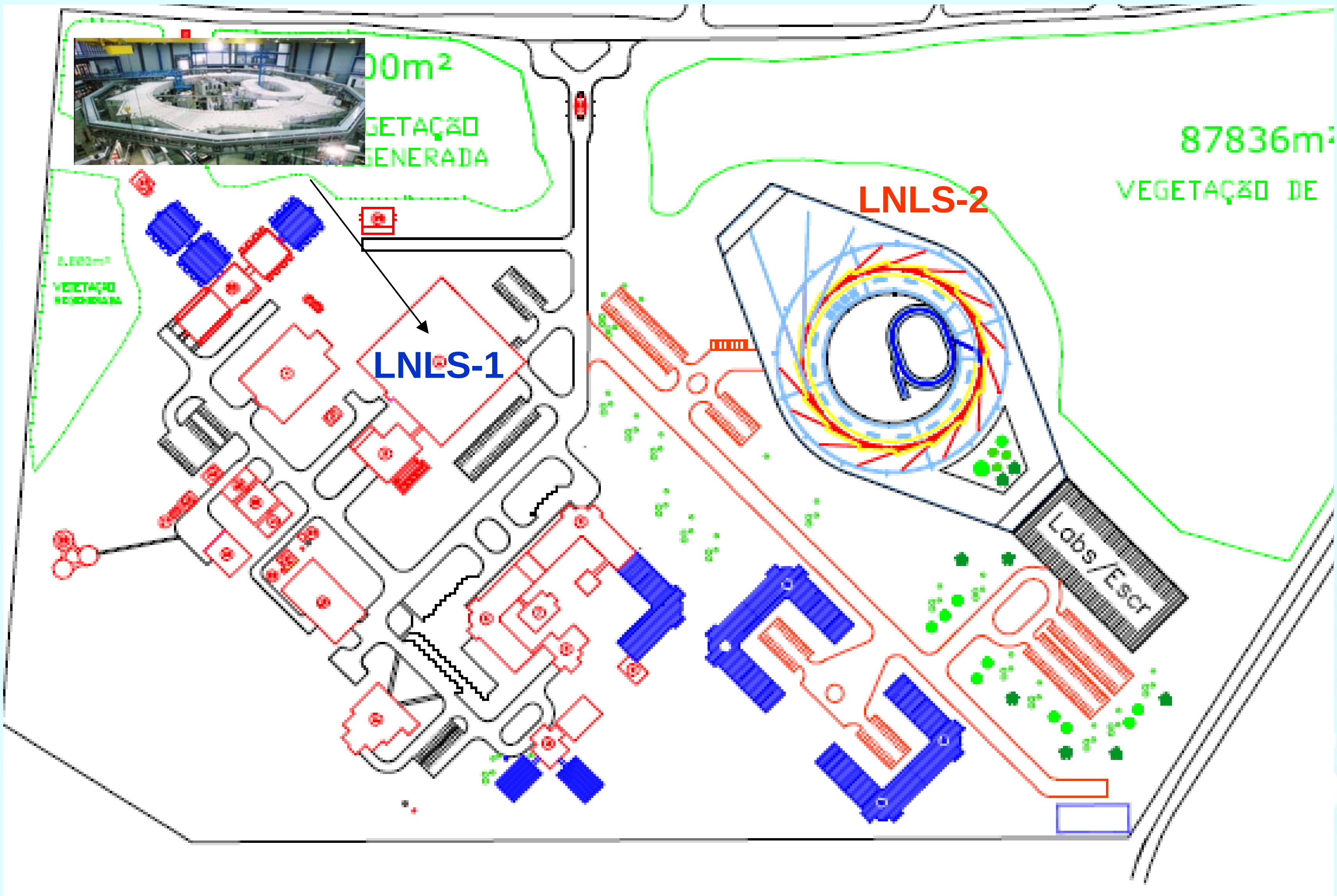
LNLS2

LNLS-2 *(Version 1.0)*



LNLS
Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia

LNLS2



Parameter	Value	Unit
Beam Energy	2.5	GeV
Beam Current	500	mA
Bending Field	0.45	T
Natural Emittance Without Damping Wigglers	2.62	nm.rad
Natural Emittance With Damping Wigglers	0.84	nm.rad
Circunference	332	m
Number of Dipoles per Achromat	3	
Number of Dipoles	48	
Bending Radius	18.5	m
Critical Energy From Dipoles	1.87	keV
Harmonic number	554	
RF frequency	499.995	MHz
RMS Horizontal Beam Size at the Insertion Straight	162.9	microm
RMS Vertical Beam Size at the Insertion Straight	3.4	microm
Synchrotron Radiation Power From Dipoles	93	kW
Synchrotron Radiation Power From Damping Wigglers	242	kW
Total Synchrotron Radiation Power	384	kW

Lattice Functions

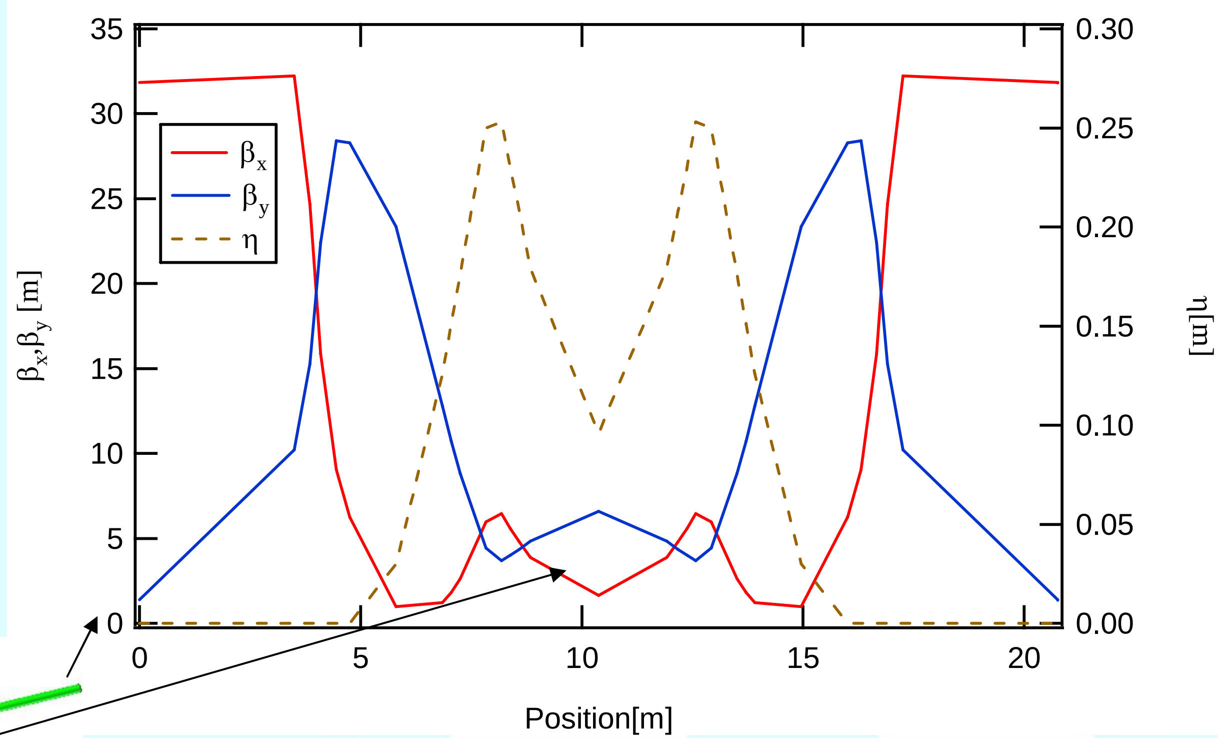
48 dipoles

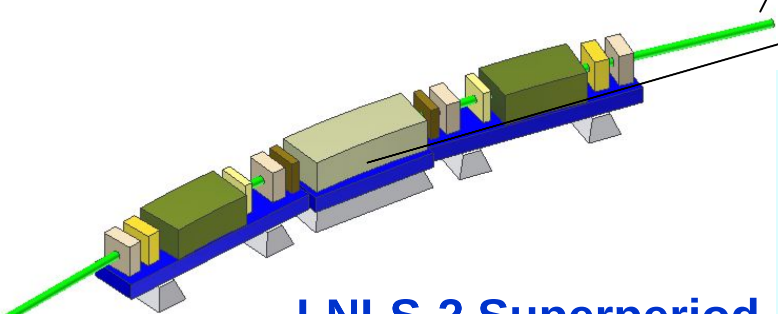
16 periods

14 straight sections

(7 m long)

for insertion devices



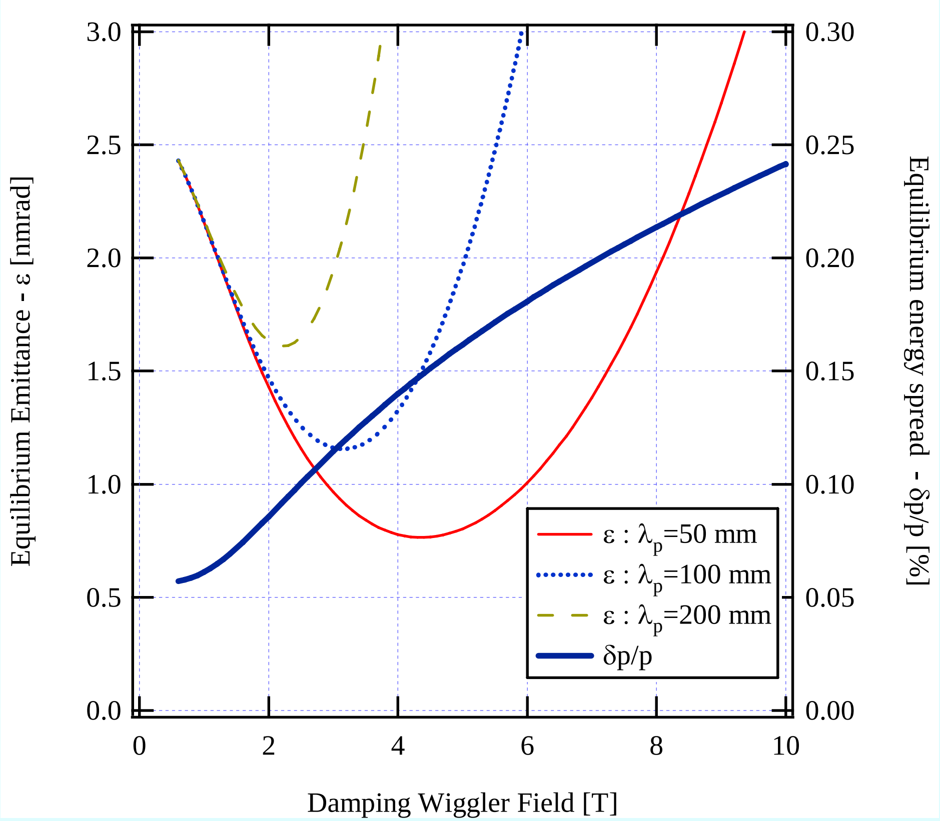


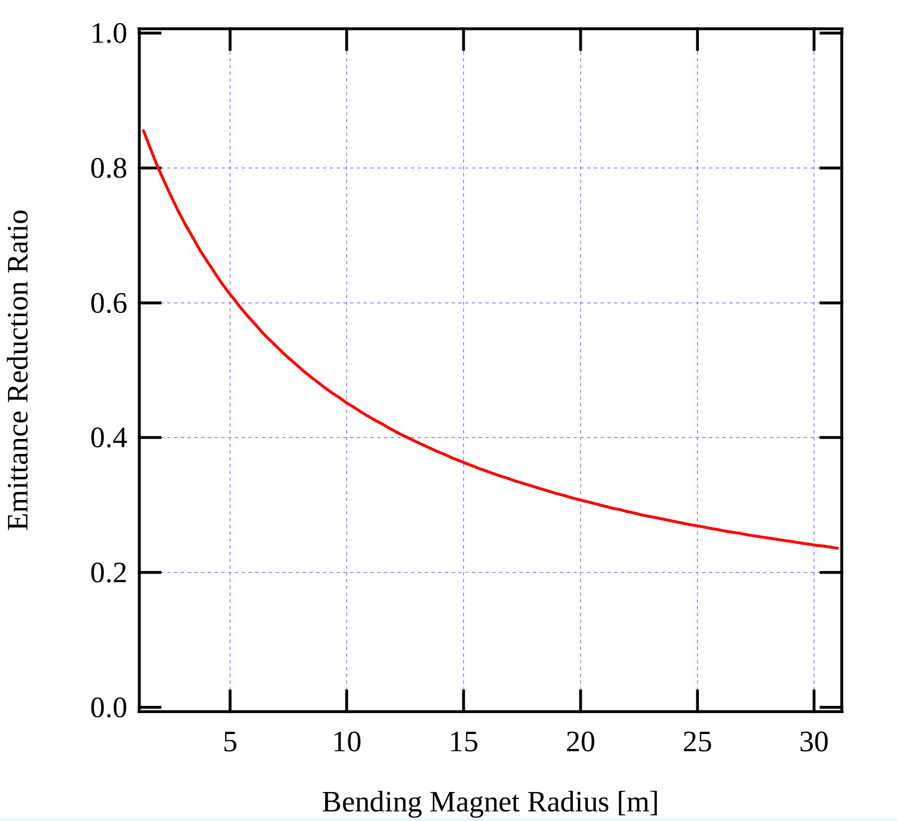
LNLS-2 Superperiod

Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia

LNLS2

Optimizing Wiggler Parameters and Bend Radius

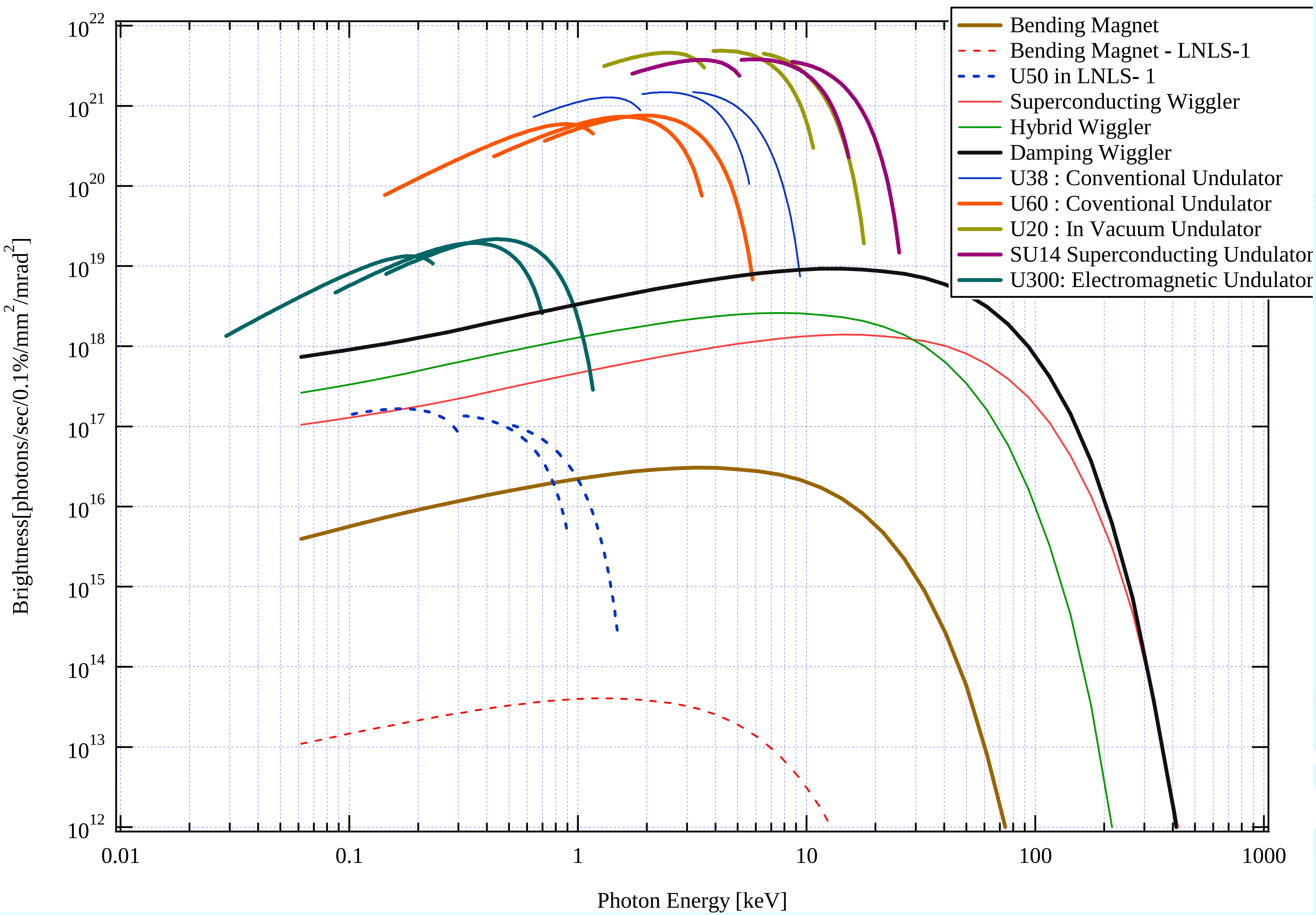




Insertion Devices for LNLS-2

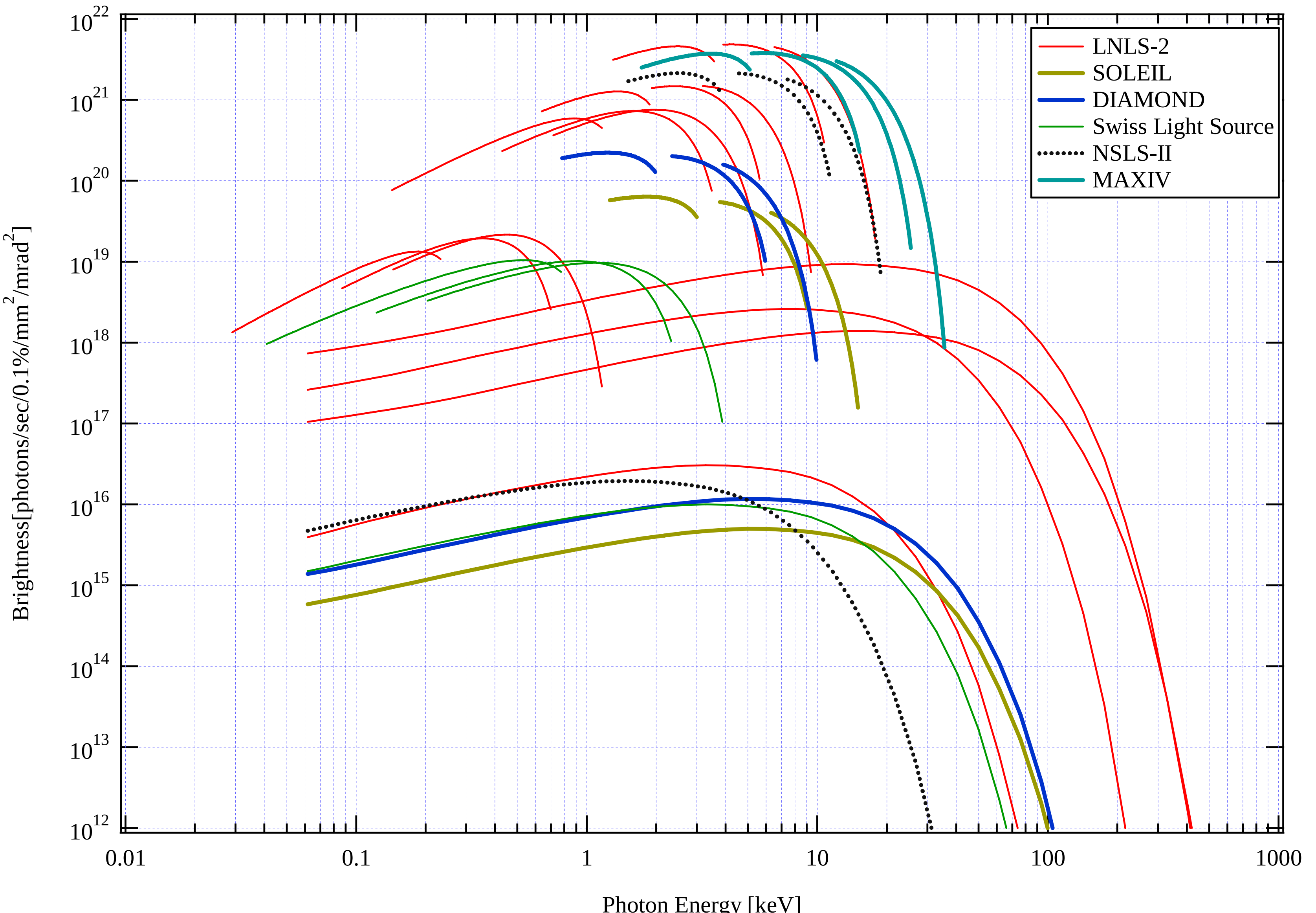
Device Name - Description	Period [mm]	Gap [mm]	Peak Field [T]	Length [m]	Power [kW]
U38 Conventional Permanent Magnet Undulator	38	15	0.6	5.13	4.1
U60 Conventional Permanent Magnet Undulator	60	21	0.8	6	6.8
U20 In-Vacuum Permanent Magnet Undulator	20	5	1.1	5	12.9
SU14 Superconducting Undulator	14	5	1.7	5.04	29.5
EU300 Electromagnetic Undulator	300	20	0.2	6	0.3
W180 Hybrid Wiggler	180	22	2.0	5.04	39.9
DW50 Damping Wiggler	50	18.4	3.5	5	121.1
SW60 Superconducting Wiggler	60	18.4	4.0	0.9	28.5

LNLS-2 Source Brightness



LNLS-2 vs Other Sources

Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia



LNLS-2 Subsystems

So far, preliminary design calculations have been performed on:

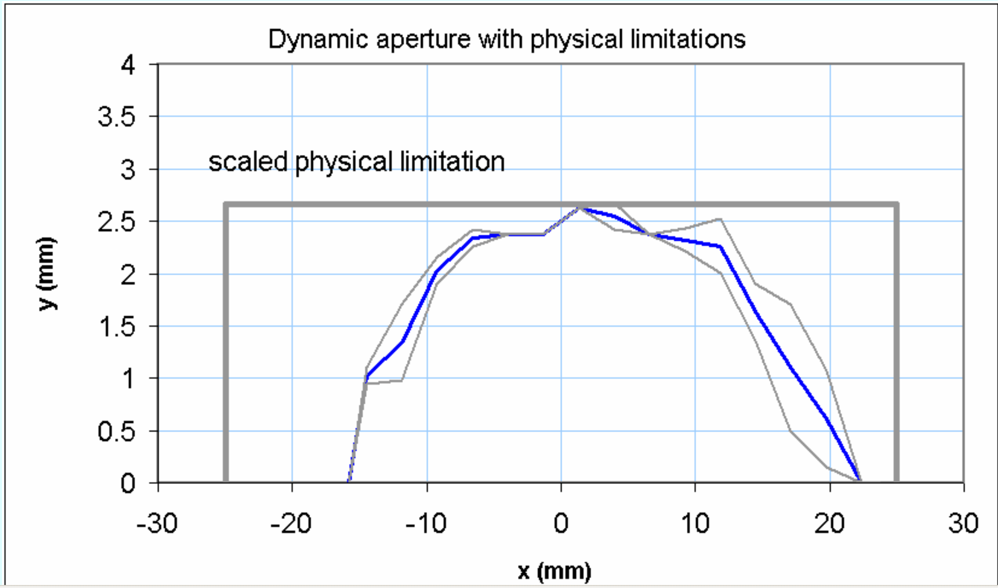
– Linear Lattice, chromaticity correction, dynamic aperture with errors, closed orbit correction.
– Magnet design.
– Vacuum system design.
– RF system design.
– Power suply specification.
– Control and Timing System specifications.
– Diagnostic System specifications.

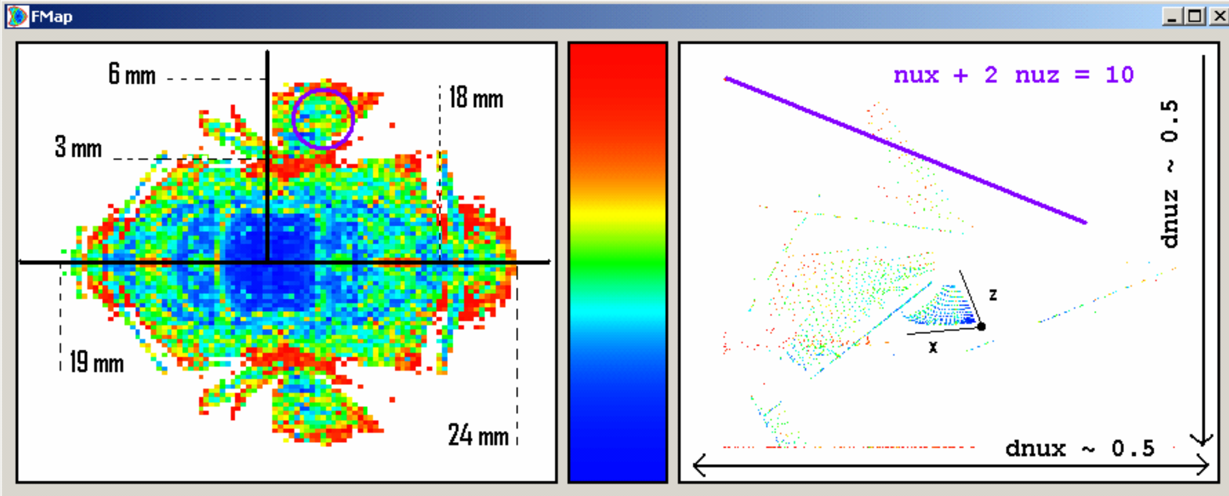
Lattice Sensitivity to Errors and Dynamic Aperture

Multipole comp. in **sextupole**: $(B_n/B_2)_{x=1\ cm}$		
	Systematic	Random
Octupole	-	2.0×10^{-3}
Decapole	-	6.0×10^{-4}
Dodecapole	-	1.0×10^{-4}
14-pole	-	2.0×10^{-4}
16-pole	-	3.0×10^{-5}
18-pole	-4.0×10^{-5}	
30-pole	3.0×10^{-7}	

Multipole comp. in **quadrupole**: $(B_n/B_1)_{x=1\ cm}$		
	Systematic	Random
Sextupole	-	1.3×10^{-4}
Octupole	-	4.8×10^{-5}
Decapole	-	7.8×10^{-5}
Dodecapole	-3.9×10^{-5}	5.6×10^{-5}
20-pole	-5.5×10^{-8}	4.2×10^{-8}

Multipole component in **dipole**: $(B_n/B_o)_{x=1\ cm}$		
	Systematic	Random
Quadrupole	-	1.5×10^{-5}
Sextupole	-2.1×10^{-5}	7.5×10^{-6}
Octupole	-	1.7×10^{-6}
Decapole	-9.2×10^{-6}	7.3×10^{-7}





Choice of Lattice Magnets Technology

Damping Wigglers → Large radius of curvature

→ **Low bending fields**

Aperture is limited by insertion devices, Top-Up

→ **Small Lattice Magnet Apertures**

Permanent Magnets for Lattice Magnets

- Permanent Magnets – **Low cost** to build and operate, **less flexibility**
- Conventional electromagnets: **higher** cost (power supply, cooling).
- **Preliminary calculations indicate that barium ferrite may be a cost-effecive solution for LNLS-2. A hybrid design with trim coils may provide *some* flexibility.**

Technological Issues Related to the Large Scale use of Permanent Magnets in a Storage Ring

- Repeatability.
- Temperature Compensation.
- Radiation Damage.

Permanent Magnet Dipole Simulation

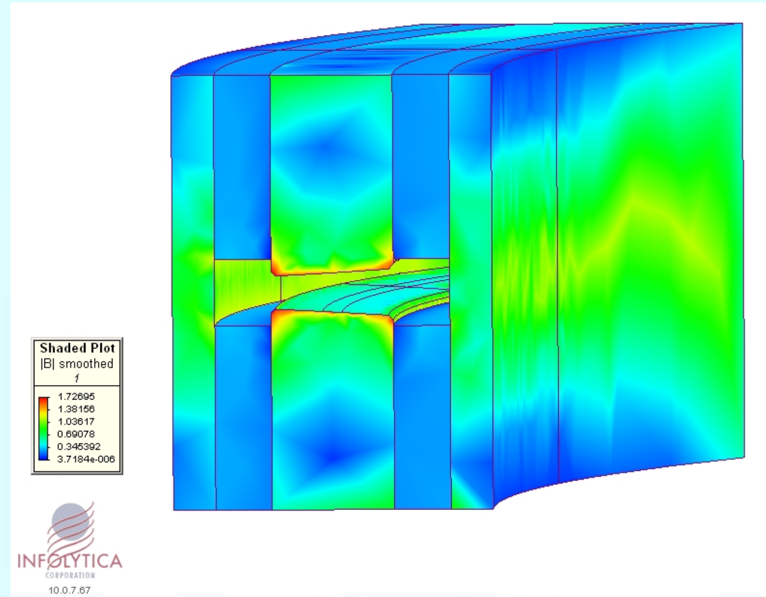
B = 0.45 T

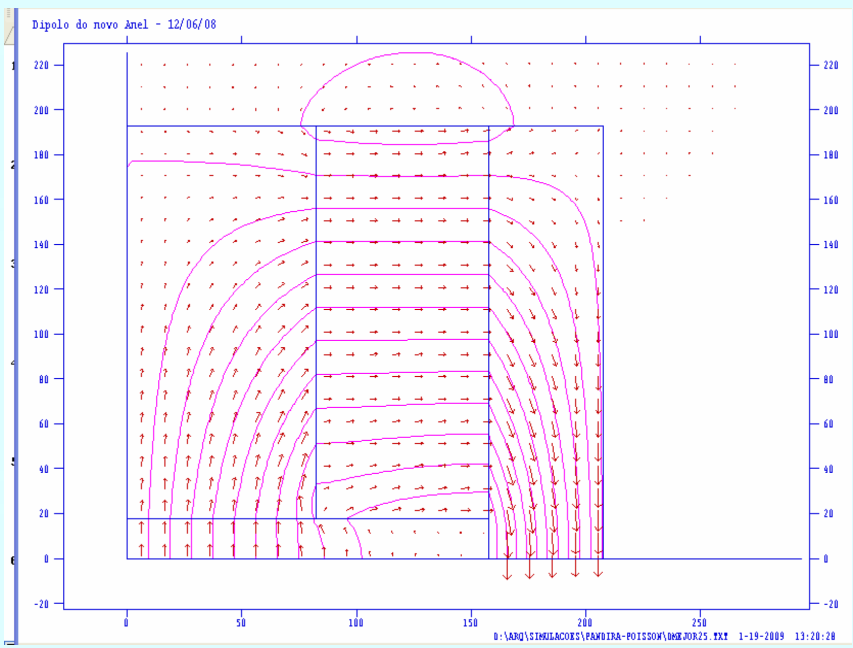
Gap = 35 mm

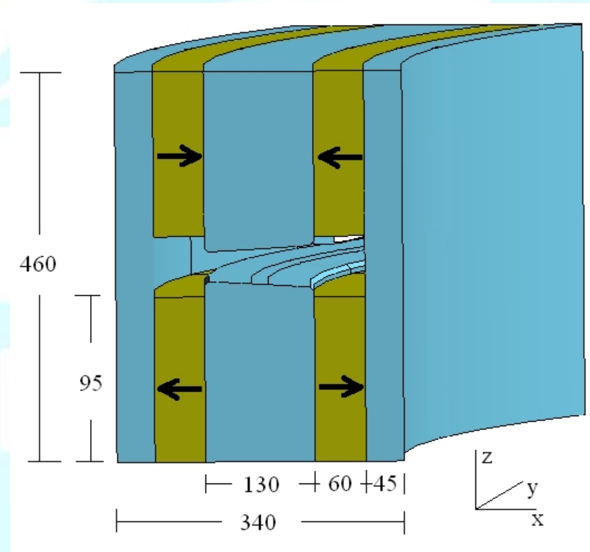
Barium ferrite Magnets

Hybrid Design

MO6PFP001







LNLS-2 Design and Construction	
Preliminary Budget	MUS$
Accelerators	100
Beamlines	50
Conventional Facilities	50
TOTAL	200

LNLS-2 Design and Construction	
Preliminary Shedule	
Phase 1 - Preliminary Conceptual Design	Oct 2008 - Mar 2009
Phase 2 - Conceptual Design	Apr 2009 - Mar 2011
Phase 3 - Detailed Engineering Design	Mar 2011 - Dec 2012
Phase 4 - Construction and Commissioning	2013-2017
Phase 5 - LIGHT SOURCE OPERATION	2018 -

Laboratório Nacional de Luz Síncrotron
Operado pela ABTLuS para o CNPq / Ministério da Ciência e Tecnologia

The search for professionals for the LNLS-2 project has already started!

LNLS-2:

Faça parte da equipe que construirá a nova Fonte de Luz Síncrotron do Brasil

O Laboratório Nacional de Luz Síncrotron (LNLS), localizado em Campinas, São Paulo, está iniciando o projeto de uma nova Fonte de Luz Síncrotron de alto desempenho para o Brasil, o LNLS-2. Para isso, procura físicos e engenheiros nas seguintes áreas: Física de Aceleradores, Controle e Automação, Mecatrônica, Microondas e Radiofrequência, Ultra-Alto Vácuo, Eletrônica de Potência, Instrumentação Eletrônica de Precisão, Magnetos para Aceleradores, Óptica de Raios X, Mecânica de Precisão e Programação Embarcada.

O LNLS opera desde 1997 a primeira Fonte de Luz Síncrotron do Hemisfério Sul, o LNLS-1. O LNLS-2 será uma nova Fonte de alto desempenho e classe mundial: com um anel de armazenamento de elétrons de maior energia e circunferência (~350m), ela será capaz de produzir um feixe de luz até dezenas de milhões de vezes mais brilhante que o feixe gerado pelo LNLS-1, possibilitando o desbravamento de novas fronteiras em diversos campos da ciência.

A candidatura de profissionais motivados e dinâmicos em início de carreira, bem como os já experientes, é incentivada. O trabalho é para início imediato e o LNLS oferece treinamento específico em suas próprias instalações, possibilitando também interação com outros síncrotrons do mundo. Além disso, proporciona um ambiente de estímulo à capacitação e à criatividade.

Envie seu currículo com pretensão salarial para lnls2@lnls.br
A análise dos currículos começa em 31 de janeiro de 2009
www.lnls.br

Thank You for Your Attention!