INSTITUTO DE FÍSICA
Universidade Federal Fluminense

Nuclear Physics in Brazil

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On behalf of the proposed
Virtual National Institute of Nuclear Physics and Applications (INCT-FNA)

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Size of the Brazilian Nuclear Physics Community

- Around 200 PhD researchers and more than 200 graduate students. Half of those are experimentalists and the other half is formed by theoreticians.

Distribution of nuclear physicists in Brazil

- **The State with the largest number of nuclear physicists is São Paulo, especially for experimentalists.**
- **The institution with the largest number of nuclear physicists is the Universidade de São Paulo.**
- **In the State of Rio de Janeiro, the two largest institutions with activities in Nuclear Physics are the Universidade Federal Fluminense, in Niterói and the Universidade Federal do Rio de Janeiro.**
- **In the South region there are important research centers in Nuclear Physics in the States of Paraná, Santa Catarina and Rio Grande do Sul.**
- **There are also institutions in the North-East region.**
- **In total, there are more than 30 institutions in Brazil where Nuclear Physics research is developed.**

International collaborations

This community has collaborations with hundreds of senior researchers all over the world, and participates in experiments at CERN, GANIL, GSI, JINR and other major laboratories.

We do hope that the collaboration with JINR increases!!

Main Research Areas - 1

High energy nuclear physics

- **Low energy hadron physics**
- **QCD phenomenology at high energies**
- **Phase diagrams and QCD**
- **High energy astrophysics and Astro-particles**
- **Detectors and Accelerators for high energies**

Main Research Areas - 2

Low and intermediate energy nuclear physics

- **Nuclear Structure**
- **Nuclear Reactions**
- **Multifragmentation**

Main Research Areas - 3

Applied Nuclear Physics

- **Accelerator Mass Spectrometry (AMS) Applications**
- **Ionizing radiation effects in satellite and electronics**
- **Nuclear Instrumentation for Medical Physics**
- **Paleoclimatology, Climatic changes, environmental radiation**
- **Energy**
- **Radiation in Nanotechnology**
- **Hadronterapy**
- **Radiological Image and Monte Carlo simulations in Medical Physics**
- **Archaeometry and Archaeology**
- **Physics in soils, food and environment.**

What is investigated in each institution- 1

- São Paulo state:

1-Universidade de São Paulo (IF-USP):

Effects of ionizing radiation on satelites and electronic devices, Nuclear Instrumentation for Medical Physics, Environmental Radiation, Hadrontherapy, Radiologial imaging and Montecarlo Simulations in Medical Physics, Archeometry and Archeology (E), Low-energy Hadron Physics, Effective Models, QCD Sum Rules, Gluonic Excitations, Hydrodynamics, Hadronic Equation of State, AdS/CFT QCD Phenomenology at High Energies, Phase Diagram and QCD, High-Energy Astrophysics and Astro-Particles (T), Nuclear Structure and Nuclear Reactions (T and E).

(See talks by M. Hussein, N. Medina)

What is investigated in each institution- 2

São Paulo state:

2-Instituto de Física Teórica-Unesp (IFT): Effective Models, QCD Sum Rules, Gluonic Excitations, Hydrodynamics (T).

(See talk by L. Tomio)

3-Instituto Tecnológico de Aeronáutica (ITA): Effects of Ionizing Radiation on Satelites and Electronic Devices, Environmental Physics (E), Low-Energy Hadron Physics, QCD Phenomenology at High-Energies, Phase Diagrams and QCD, High-Energy Astrophysics and Astro-particles, Nuclear Structure and Nuclear Reactions (T).

(See talk by T. Frederico)

What is investigated in each institution- 3

São Paulo state:

4-Universidade de São Paulo- Lorena (EEL-USP): QCD Phenomenology at High-Energies, Phase Diagram and QCD (T).

5-Universidade de São Paulo – São Carlos (USP-SC): Phase Diagram and QCD (T).

6-Universidade Federal do ABC (UFABC): Reactor Physics.

7-Centro Universitário da FEI (FEI): Nuclear Strucure, Effects of Ionizing Radiation on Satelites and Electronic Devices (E).

8-Universidade Estadual de Campinas (UNICAMP): Non-Perturbative QCD, Schwinger-Dyson Equation, Hadron Physics at Low-Energies (T).

9-Unesp-Campus Botucatu (Unesp): Medical Physics (T and E).

10-Universidade Mackenzie: Hadronic Physics (T).

11-Unicsul: Hadronic Physics (T).

What is investigated in each institution- 4

Rio de Janeiro state:

1- Universidade Federal Fluminense (UFF):

Nuclear Reactions - theory (T) and experiment (E), few-body and Astrophysics (T), Mass Spectromety with Accelerators - AMS (E), Paleoclimatology (E), Climate Change (E), Enviromement Radiation (E), Hadrontherapy (E), Archeology (E).

(See my talk)

2- Universidade Federal do Rio de Janeiro (UFRJ):

Hydrodynamics, PP, pA and Glauber Amplitudes, Magnetic Field, Neutrino Scattering, Cosmic Rays, Semiclassical Approximations, Phase Diagram and QCD, Effective QCD Theories, Nuclear Reactions, Multifragmentation (T), Detectors and High-Energy Accellerators (E).

(See talk by T. Koide)

What is investigated in each institution- 5

Rio de Janeiro state:

3- Universidade do Estado do Rio de Janeiro (UERJ- Campi Rio e Resende):
Energy (E), low-energy Hadron Physics, Phase Diagram and QCD, High-Energy Astrophysics and Astro-particle physics (T).

4- Centro Brasileiro de Pesquisas Físicas (CBPF):
Reactors, hadrontherapy, image and medical physics, QCD and Astrophysics (T).

5- Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET):
Astrophysics, High-Energy Physics

What is investigated in each institution- 6

South region of Brazil - Santa Catarina state:

1-Universidade Federal de Santa Catarina (UFSC)- Florianópolis e Curitibanos:
Diffractive Scattering, Elementary Particle Phenomenology, Phase-Diagram and QCD, Astrophysics.

(See talks by D. Meneses, J. R. Marinelli)

2-Universidade Federal da Fronteira Sul (UFFS) – Chapecó:
Hadron Physics, Nuclear Astrophysics (T).

What is investigated in each institution- 7

- South region of Brazil - Grande do Sul states:

1-Universidade Federal do Rio Grande do Sul (UFRGS):
Diffractive Scattering, Elementary Particle Phenomenology, Hadron-Physics, Phase-Diagram and QCD, Astrophysics, High-Energy QCD Phenomenology, Multi-fragmentation (T).

2-Universidade Federal de Pelotas (UFPel): Hadronic Physics, Nuclear Astrophysics (T).
3-Fundação Universidade Federal do Rio Grande (FURG) – Rio Grande:
Diffractive Scattering, Elementary Particle Phenomenology, Nuclear Astrophysics (T), Nuclear Instrumentation for Medical Physics, Imaging and Medical Physics (E).

What is investigated in each institution-8

- South region of Brazil - Paraná state:

1-Universidade Estadual de Londrina (UEL): Applications of Mass Spectroscopy with Accelerators (AMS), Environmental Radiation, Archeometry and Archeology, Soil Physics, Food and Environment (E).

2-Universidade Estadual do Centro Oeste – Guarapuava-Irati (Unicentro):
Nuclear Reactions (T), Applications of Mass Spectroscopy with Accelerators (AMS), Environmental Radiation, Archeometry and Archeology, Soil Physics, Food and Environment (E).

What is investigated in each institution-9

North-East region of Brazil:

1-Universidade Estadual de Santa Cruz – Ilhéus- Bahia (UESC): Environmental Radiation, Radiation in Nanotechnology, Radiological imaging, Monte-Carlo Simulations in Medical Physics (E), Low-Energy Hadron Physics (T).

2-Universidade Estadual do Sudoeste da Bahia (UESB): Radiation in Nanotechnology, Radiological imaging, Monte-Carlo Simulations in Medical Physics (E).

3- Universidade Federal da Bahia – Salvador (UFBA): Applications of Mass Spectroscopy with Accelerators (AMS), Paleoclimatology, Climate Change (E).

4- Universidade Federal da Paraiba – João Pessoa (UFPB): Nuclear Structure and Nuclear Reactions (T).

5- International Institute of Physics – Univ. Fed. Rio Grande do Norte (IIP): Hadronic Physics (T).

Our proposal of National Institute of Nuclear Physics and Applications INCT-FNA

- This is a proposal to CNPq, within the INCT program (Science and Technology National Institutes).
- Nowadays there is no such INCT for Nuclear Physics
- We have applied and the result is expected to come out next November.
- More than 80% of Brazilian Nuclear Physics community are members of the proposed INCT-FNA team.
- The institution with more participants is USP, followed by UFF, UFRJ and UFSC.
- The resources are around US$ 3 M.
- The main aims are to coordinate the activities within the area, to enhance interactions and collaborations between members and Brazilian institutions and with foreign institutions and researchers, to promote workshops and to buy some equipments.

Institutes of CNEN
(National Nuclear Energy Commission)

- I do not know too much about it.

Accelerator facilities in Brazil – 1 (LNLS)

- **By far, the largest and most important facility in Brazil is the Syncrotron Radiation National Laboratory (LNLS), in Campinas, São Paulo State.**

- **Storage ring of 1. 37 GeV.**
- **500 MeVBooster Synchrotron**

- **15 beam lines**
- **Research in X-ray diffraction, cristallography, X-ray scattering, X-ray absorption, Fluorescence Spectroscopy, UV and soft X-ray spectroscopy etc.**

Accelerator facilities in Brazil – 2 (LNLS)

- **The LNLS projects, develops and build the accerator and peripherical equipents.**

- **New Project under development: SIRIUS**
- **A 3 GeV synchrotron light source with ultra-low emittance (0.28 nm.rad) and high brigthness.**

- **The development of accelerators is an excellent field for collaboration with JINR.**

(missing talk)

Accelerator facilities in Brazil – 3 (non-nuclear physics)

- **UFRGS (Porto Alegre): Ion Implantation Laboratory.**
- 3 MV Tandem and two ion implanters (250 kV and 500 kV)
- For material analysis, surfasse physics, interfaces, thin films, RBS, NRA, ERDA, PIXE etc.

- **UFRJ (Rio de Janeiro): Atomic and Molecular Colissions Laboratory (LACAM).**
- 1.7 MV Tandem.

- **USP (São Paulo): Linear Accelerator laboratory**
- 5 MV Microtron electron accelerator
- For Atomic Physics

Accelerator facilities in Brazil – 4 (basic and applied-nuclear physics)

- **USP, São Paulo: Nuclear Physics Open Laboratory**

- **8 MV Tandem**
- **A superconducting LINAC under construction**
  (see talk by Nilberto Medina)

- **Main equipments:**

. RIBRAS (Radioactive Ion Beam Brazil): superconducting solenoids for production of light radioactive beams. Only RIB facility in South Hemisphere. **(See talk by Medina)**

. QD3 magnetic spectrometer.

Accelerator facilities in Brazil – 5 (applied-nuclear physics)

USP- São Paulo – Laboratory (LAMFI)
1.7 MV Tandem + ion implanters
RBS, ERDA, NRA, PIXE

UFF (Niteroi) – 14C-AMS Laboratory (LAB-AMS)
250 kV SSAMS
Multidisciplinary projects in 14C-AMS and atomic collisions (applications in hadrotherapy)

(I can talk with interested people during coffee breaks)

Accelerator facilities in Brazil – 6 (ciclotrons used mainly for production of radio isotopes – medical applications)

- **4 ciclotrons of CNEN (Brazilian Nuclear Energy Commission)**

- **IPEN (São Paulo) :** CV 28 and Cyclone 30 (high current)

- **IEN (Rio de Janeiro):** CV 28 and RDS 111

Thank you