Nuclear Physics in Brazil:
From Fundamental Research to Applications and International Opportunities

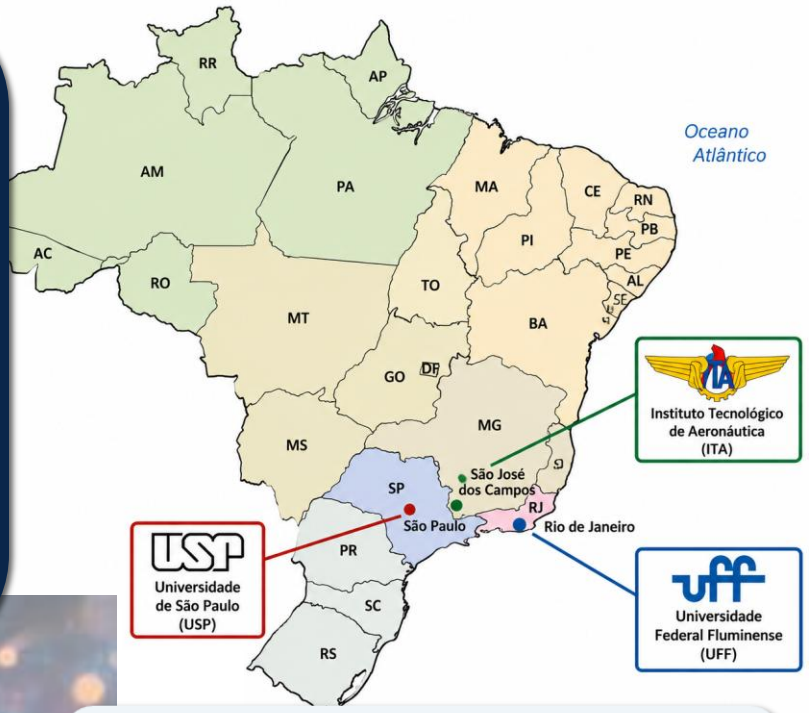
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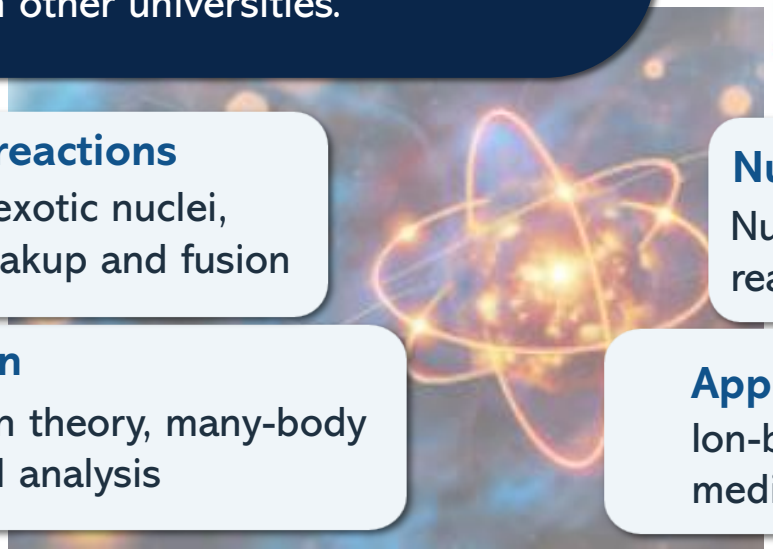


Nuclear Physics Research in Brazil

A broad scientific landscape — from fundamental questions to societal applications

- Institute of Physics (IFUSP) – University of São Paulo:
  Experimental groups (low and high energy and applied nuclear physics
- Federal Fluminense University (UFF):
  Experimental and theoretical nuclear physics groups.
- Instituto Tecnológico de Aeronáutica (ITA):
  Theoretical few-body nuclear physics and nuclear astrophysics
- Few researchers in other universities.





Nuclear structure & reactions

Nuclear spectroscopy, exotic nuclei, scattering, transfer, breakup and fusion

Nuclear astrophysics

Nuclear processes in stars, reaction rates, nucleosynthesis

Theory & computation

Nuclear models, reaction theory, many-body methods, computational analysis

Applications

Ion-beam analysis, radiation detection, medical physics, materials research

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Nuclear Physics at IFUSP

Research groups, accelerator-based activities and scientific training

LAFN (Open Laboratory for Nuclear Physcis)

8 MV Tandem Accelerador

About 20 researchers



Research directions

- ❑ Exotic nuclei
- ❑ nuclear astrophysics
- ❑ Direct reactions
- ❑ heavy-ion collisions (fusion)
- ❑ Gamma-ray spectroscopy

& laboratories

- ❑ **Exotic Nuclei and Nuclear Astrophysics Group (NEAN)**
- ❑ **Direct Nuclear Reactions and Exotic Nuclei Group (RIBRAS)**
- ❑ Nuclear Reactions, Applications, and Computing Group (GRENAC)
- ❑ Accelerator-based applied physics
- ❑ Ion Beam Analysis Laboratories – radiation dosimetry
- ❑ Gamma-Ray Spectroscopy Group
- ❑ Nuclear Reaction with Heavy ions
- ❑ High Energu Physics Group



Experimental and interdisciplinary environment

IFUSP brings together nuclear reaction studies, accelerator-related techniques, materials characterization and applications of radiation.

Research training Undergraduate research, graduate studies, postdoctoral research, scientific schools

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RIBRAS – Radioactive Ion beams in Brazil

Production of light radioactive ions.

Several elastic-scattering experiments with:

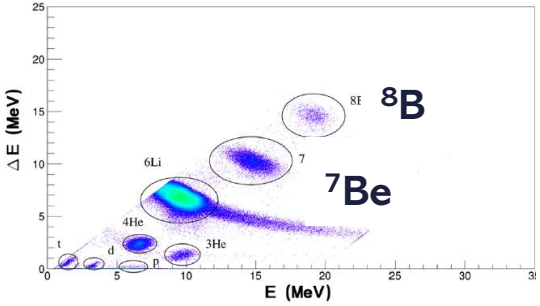
Secondary beams: ^{6}He, ^{7}Be, ^{8}Li, ^{8}B, ^{10}C, ^{12}B

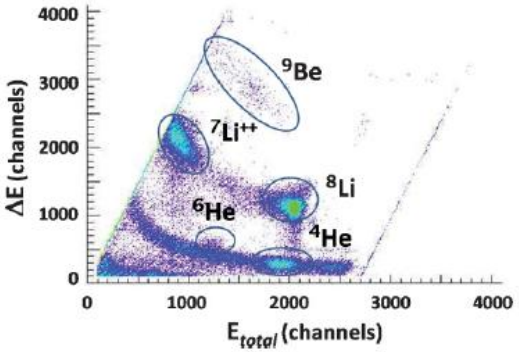
10^{3} to 10^{6} pps and with about 3 to 4 MeV/nucleon

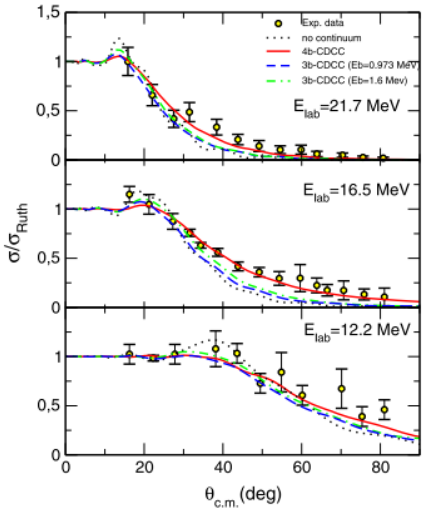
on different targets: ^{9}Be, ^{12}C, ^{27}Al, ^{51}V, ^{58}Ni, ^{120}Sn



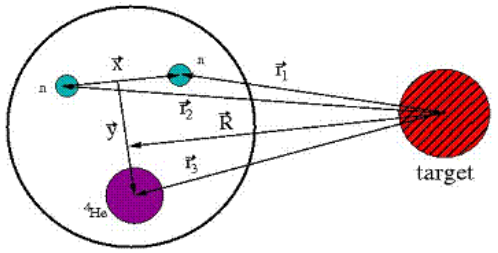
Rubens Lichtenthaler, Kelly C. C. Pires, Osvaldo B. dos Santos







^{6}He



Four-body effects in the ^{6}He + ^{58}Ni scattering

V. Morcelle [a,b], K.C.C. Pires [c,d], M. Rodríguez-Gallardo [e], R. Lichtenthäler [d,*], A. Lépine-Szily [d], V. Guimarães [d], P.N. de Faria [b], D.R. Mendes Junior [b], A.M. Moro [e], L.R. Gasques [d], E. Leistenschneider [d], R. Pampa Condori [d], V. Scarduelli [d], M.C. Morais [f], A. Barioni [g], J.C. Zamora [i], J.M.B. Shorto [h]

Physics Letters B 732 (2014) 228–232

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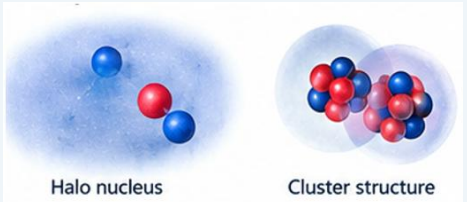
NEAN group

Exotic Nuclei and Nuclear Astrophysics, experimental nuclear physics.

Coordinator: Valdir Guimaraes

Scientific questions

- ❑ How do weak binding and clustering shape nuclear structure?
- ❑ What do reactions reveal about exotic nuclei and resonances?

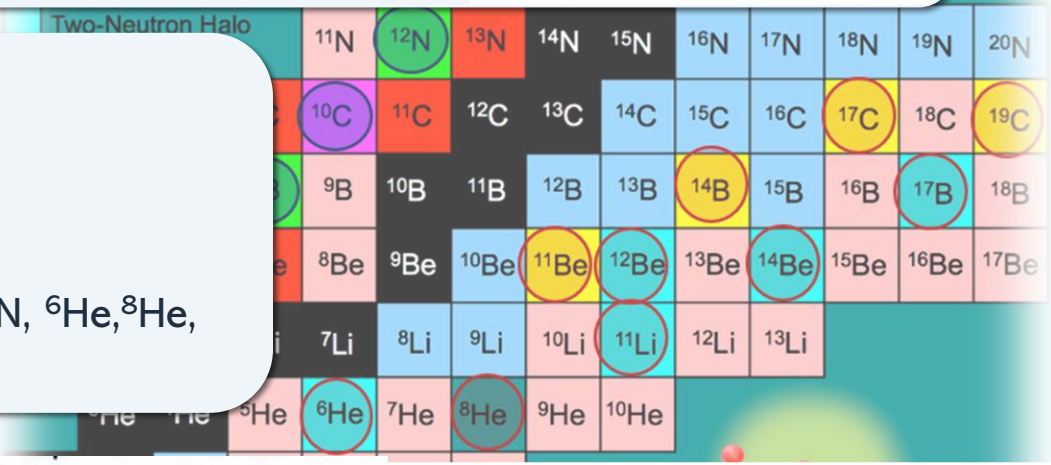


Experimental approaches

- ❑ Elastic and inelastic scattering
- ❑ Breakup and transfer reactions
- ❑ Resonant scattering and spectroscopy

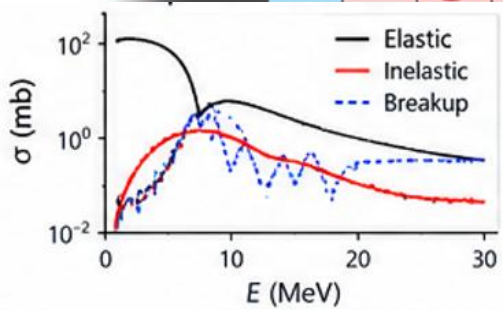
With light radioactive ion beams ^{8}B, ^{10}C, ^{12}N, ^{6}He,^{8}He,

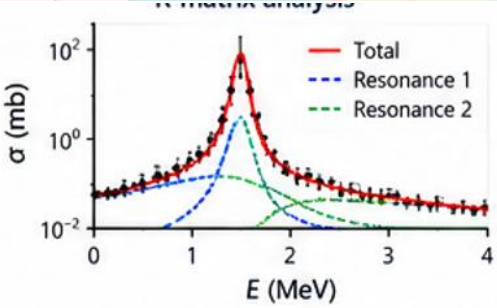
Experiments in diferente Labs



Analysis & interpretation

- ❑ Optical model
- ❑ coupled channels
- ❑ CDCC/DWBA
- ❑ R-matrix , Bayesian inference





Connecting reaction dynamics, cluster structure and nuclear astrophysics

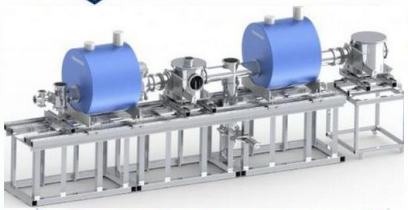
Valdir Guimaraes (valdirg@if.usp.br)

Our international collaborations

Experimental nuclear physics and collaborations



TEXAS A&M – Cyclotron Institute
Exotic nuclei, breakup and reaction mechanisms



Notre Dame
Resonant scattering, nuclear structure



GANIL (France)
Radioactive ion beams, exotic nuclei, reaction dynamics



MSU / NSCL / FRIB
Rare isotopes, reactions with radioactive beams



RIKEN / CRIB
Radioactive ion beams, cluster structure, resonances

- ❑ Experiments and partnerships with several laboratories
- ❑ Joint experiments at radioactive-ion-beam facilities •
- ❑ Reaction modeling and data analysis
- ❑ Research visits, international schools and student co-supervision



RAON (South Korea)
Rare isotope beams, nuclear structure and reactions



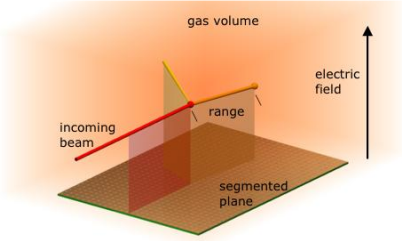
TANDAR (Argentina)
Ion beams, nuclear reactions and applied research

IFUSP
São Paulo, Brazil
NEAN



Argonne / ATLAS
Nuclear structure and reaction dynamics

TPC – Active Targets



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Emerging Opportunities in Applied Nuclear Physics

IPEN | High-Intensity Laser



15 TW laser system under installation

- ❑ Laser–plasma interactions
- ❑ Laser-driven ion acceleration
- ❑ Nuclear physics applications
- ❑ Nuclear and radiation Technologies
- ❑ Radioisotope production
- ❑ Research and training

LAMFI / IFUSP | Proton Beams



1.7 MV Pelletron-Tandem accelerator

Ion-beam techniques

Ion beam analysis techniques such as RBS, PIXE, and ERDA. Materials analysis, elemental characterization interdisciplinary applications

Proton therapy: perspectives

Accelerator technologies and future opportunities in particle-beam cancer treatment

Student projects • Graduate research • Instrumentation • Interdisciplinary collaborations

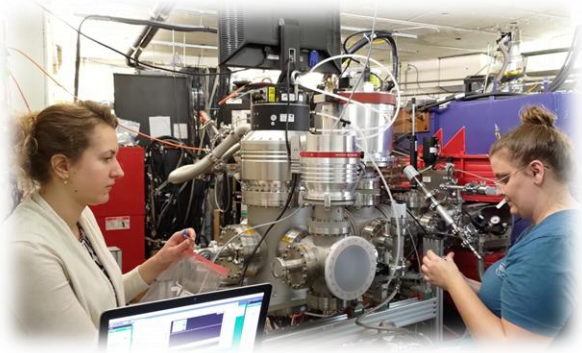
Valdir Guimaraes (valdirg@if.usp.br)

Opportunities for Students and Researchers

Training, research projects, mobility and diverse professional pathways

Academic training

Undergraduate research (scientific initiation)
MSc and PhD research at USP
Postdoctoral research positions







Research experience

Hands-on experiments and data analysis
Nuclear theory and simulations
International collaborations and mobility



Funding and access

FAPESP CAPES CNPq

Eligibility and calls vary;
explore research groups and current opportunities.

Career pathways

Universities and national laboratories
Medical physics and radiation technology
Industry, instrumentation and computing

Explore nuclear structure, reactions, astrophysics and applications in internationally connected research groups.

Valdir Guimaraes (valdirg@if.usp.br)

Final Remarks

Nuclear and particle physics in Brazil: a broad scientific landscape



"Nuclear and particle physics in Brazil offers many opportunities to contribute to fundamental knowledge, technological development and societal impact, in a collaborative environment with strong connections to the international scientific community."

Research diversity

From nuclear structure and reactions to astrophysics, hadron physics and applications.

International connections

Collaborative experiments and theory across leading international laboratories.

New directions and opportunities

Emerging laser infrastructure, ion-beam applications and interdisciplinary careers.

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