Nuclear Science in Latin-America

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IUPAP-WG9 Meeting-on-the-web
10,11 June 2021
News from ALAFNA (Association of Latin American Nuclear Physics and Applications)

ALAFNA was very informal until recently, no bylaws, chairs reelected every 2 years etc.

In January 2020 Sotirios Charisopoulos from IAEA invited ALAFNA to a Consultancy Meeting with IAEA, to realize in November 2020.

During 2020 we performed steps to formalize ALAFNA:

Bylaws were proposed and voted. Some ideas from the bylaws:

1. ALAFNA is a regional association of professionals attached to organizations in nuclear science in Latin America. In exceptional situations, they can also be Latin American scientists working in a nuclear science organization in other countries.

2. The Latin American countries that have organized LASNPA meetings can be represented in ALAFNA (until now Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Peru, Uruguay, and Venezuela).

3. The number of ALAFNA members from a member country is at most 3 with a 4 year term. Each country chooses its own method of naming its representatives. In exceptional cases, a country may propose to be represented by a Latin American nuclear scientist working in another country.

4. ALAFNA is governed by a Board composed of four members (Chair, Vice-Chair, Past-Chair, Secretary) elected for one term of 2 years by the members among the current membership by a simple majority. No immediate reelection for the same or a different position in the Board is permitted.

Due to pandemic no representatives were yet chosen, no elections for Board.
Consultancy Meeting IAEA-Physics Section with ALAFNA (16-18/11/2020 online)

Realized with the participation of:
• members of the Physics Section staff,
• Marek Lewitowicz, as NuPECC chair,
• Milko Jaksic, as RBI director
• representatives from all ALAFNA member countries (11).

Detailed description of existing nuclear science activities:
• concerning possible collaborations with IAEA-Physics Section
• of ALAFNA
• of next LASNPA
• of each Latin American ALAFNA member countries

Very fruitful meeting with good perspectives of future interaction between ALAFNA and IAEA.
Nuclear Science in Latin-America

This talk is built from contributions of representatives of each ALAFNA country at the Consultancy Meeting

Argentina: Andres Kreiner
Brazil: Alinka Lépine-Szily
Chile: Hugo Arellano
Colombia: Diego Torres
Costa Rica: Mario Cubero
Cuba: Ana Cabal
Ecuador: Edy Ayala
Mexico: Roelof Bijker
Peru: Modesto Montoya
Uruguay: Raul Donangelo
Venezuela: Haydn Barros
Nuclear installations in Latin America

1. Research reactors:

**Argentina** 6 in operation, 1 in construction RA-10
- RA-0, built 1964, 0.01 kWt, tank type, owned and operated by Universidad Nacional de Cordoba
- RA-1 built 1957, 40 kWt, tank type.
- RA-2, built 1965, 0.03 kWt, critical assembly type (shut down on 1983/09/01)
- RA-3, built 1963, 5,000 kWt, pool type.
- RA-4 (former SUR-100), built 1971, HOMOG type, owned and operated by Universidad Nacional de Rosario
- RA-6, built 1978, 500 kWt, pool type.
- RA-8, built 1986, 0.01 kWt, critical assembly type
- RA-10, under construction, 30 MW. Radioisotope production and LAHN: Lab for neutron beams.

**Brazil** : 4 in operation, 1 in project phase
- São Paulo – IEA-R1 – Pool-type reactor, 5MW – IPEN-Instituto de Pesquisas Energéticas e Nucleares, São Paulo, SP (criticality 1957)
- Belo Horizonte – IPR-R1 – TRIGA Mark I, 250 kW - CDTN-Centro de Desenvolvimento de Tecnologia Nuclear, Belo Horizonte, MG (criticality 1960-11-06)
- Rio de Janeiro – ARGONAUTA – Argonaut class reactor, 100 kW – IEN-Instituto de Engenharia Nuclear, Rio de Janeiro, RJ (criticality 1965-02-20)
- São Paulo – IPEN/MB-01 – Critical assembly, 0.1 kW – IPEN-Instituto de Pesquisas Energéticas e Nucleares, São Paulo, SP (criticality 1988-11-09)

**Chile**: : 2 in operation
- RECH 1 – Pool-type reactor, 5 MWt MTR – Comisión Chilena de Energía Nuclear, Santiago (criticality 1974)
- RECH 2 – Pool-type reactor, 10 MWt MTR – Comisión Chilena de Energía Nuclear, Santiago (criticality 1977, refurbished 1989)

**Colombia**: 1 in operation
- Bogotá – IAN-R1, 100 kW – TRIGA, Institute of Nuclear Science (installed in 1997)

**Mexico**: 3 in operation
- Mexico City - TRIGA Mark III, National Institute for Nuclear Research
- Mexico City - National Polytechnic Institute - Subcritical research reactor
- Zacatecas - Autonomous University of Zacatecas - Subcritical research reactor
1. Research reactors (cont.):

Peru: 2 in operation
- RP-0 - Located in Lima, built by Argentine INVAP
- RP-10 - Located in Huarangal built by Argentine INVAP

Uruguay: no nuclear installation
- URR reactor - A small pool-type research reactor placed in Centro de Investigaciones Nucleares (CIN). In operation since early '70 up to 1997 when it was dismantled and returned to United States due law of 1997 against use of nuclear energy in Uruguay.

Venezuela: no nuclear installation
- RV-1 pool-type reactor (shut down 1994)

Planned research reactors: Argentina 1 RA-10, Brasil 1 RMB
- RMB - Reator Multipropósito Brasileiro
  - medical radioisotope production ($^{99}$Mo, 2.5 x consumption)
  - irradiation tests of advanced nuclear fuel/materials, neutron beam research, material research
  - Power: 30 MW, Cost: U$ 500 M; Local: Iperó, SP;

Nuclear power plants: Argentina: 3 in operation, 1 SMR (CAREM) under construction, 2 planned (?). 5-6 % of total energy production.
Nuclear power plants: Brazil: 2 in operation, 1 in construction, 4 planned until 2025 4% of total energy production, 92% is hydroelectric.
Argentina-Brazil cooperation: ABACC agency for mutual inspection.
Nuclear power plants: Mexico: 2 in operation, 4 planned until 2025 4% of total energy production
Nuclear power plants in Latin America:

Brazil:
ANGRA I (657 MW)
ANGRA II (1350 MW)
in operation, ANGRA III in construction

Argentina:
Atucha I (1974) 362 MW
Atucha II (2014) 745 MW
2. Research (basic and applied) Accelerators:

Argentina:

- Tandar 20MV Commision Nacional Energia Atomica (CNEA) Buenos Aires, exp. nucl. phys., AMS
- 0.72 MV high-intensity accelerator for Boron Neutron Capture Therapy
- FN tandem 8MV CNEA Ezeiza AMS
- 25 MeV Electron Linac CNEA Bariloche neutron production
- 1.7 MV Tandem accelerator CNEA Bariloche IBA

Brazil:

- 8 MV Pelletron tandem at University Sao Paulo (USP-IF) Sao Paulo RIBRAS exp. nucl. phys. stable/radioact. beams, irrad. electr. Devices
- 1.7 MV Pelletron tandem at USP-IF Sao Paulo, IBA
- 4 MV Van de Graaff accelerator installed at PUC-Rio de Janeiro astrophysics
- 1.7 MV Pelletron tandem installed at LACAM-UFRJ Rio de Janeiro atom/molecule collisions, IBA
- 3 MV HVEE tandetron installed at LII-UFRGS Porto Alegre IBA
2. Research (basic and applied) Accelerators (cont.):

Brasil:
- 500 kV HVEE and 250 kV ion implanter at UFRGS. IBA
-250 kV SSAMS electrosatic accelerator at UFF Niteroi 14C AMS

Chile:
-0.3-3.7 MV Van de Graaf accelerator Universidad Tecnologica Metropolitana UTEM. M Sc in nuclear technology.

Mexico:
-5.5 MV Van der Graaff Accelerator (p, d, $^3$He, $^4$He) at Universidad Nacional Autonoma de Mexico UNAM - IF. exp. nucl.atom. phys., astrophys
-3.3 MV Pelletron Tandem (NEC) UNAM-IF IBA
-1MV Tandetron UNAM-IF AMS, exp. nucl. phys.

-6 MV Tandem Van de Graaff at Instituto Nacional de Investigaciones Nucleares (ININ) exp nucl phys, IBA.
-2 MV Tandetron at ININ IBA
-1 MV Pelletron accelerator for electrons at ININ

No intermediate/high energy accelerator in Latin America.
Argentina
NUCLEAR PHYSICS AND APPLICATIONS IN ARGENTINA

- Institutions and locations
  1. National Atomic Energy Commission (CNEA) (3500 people)
     1.1 Buenos Aires (Centro Atomico Constituyentes), Physics Department (currently Gerencia de Investigacion y Aplicaciones, Laboratorio TANDAR). Sábato Institute. PhD program in Physics
     1.4 Pilcaniyeu (Centro tecnológico, Uranium enrichment demo plant)
  2. School of Science and Technology-National University of San Martin (ECyT-UNSAM). Medical Physics
     Prov. Buenos Aires, Miguelete Campus.
  3. Faculty of Exact and Natural Sciences- University of Buenos Aires (FCEyN-UBA). Physics. HE. Medical Physics.
  4. Faculty of Sciences- National University of La Plata. Physics. HE. Medical Physics.
  5. Favaloro University. Medical Physics
Argentina: autonomy in research reactor technology

**INVAP**: high technology company of the state established in 1976. Develops multi-discipline technological projects in the nuclear, space, industrial services, medicine and education fields.

INVAP has built in Argentina and exported several Nuclear Research Reactors to Peru, Algeria, Egypt, Australia and The Netherlands.

On July 2000 INVAP was awarded an international tender for the construction of a Replacement Research Reactor (OPAL) by ANSTO, the Australian Nuclear Science and Technology Organisation. Open Pool Australian Light-water reactor (OPAL) is a multipurpose facility particularly oriented toward radioisotope production, Power 20MW, Operational from November 2006 and inaugurated in April 2007.

Tender for PALLAS in The Netherlands won by INVAP as part of a consortium.
1.1 Research and Development Programs

**Basic Nuclear and HE Physics** and its applications are:

- **Low-energy nuclear physics**: Nuclear structure, nuclear reactions, collective nuclear excitations and giant resonances, break-up reactions and their influence on fusion reactions involving weakly bound nuclei; fusion barrier distributions. **TANDAR Lab**.

- **High-energy nuclear physics**: Hadronic models based on QCD. Phase structure of strong interactions. Collaboration with ATLAS at CERN.

- **Astroparticle physics** (Auger project and extensions like AMIGA). Cosmic ray studies. Large charged particle observatory for extremely high energy particles. International collab.

- **ANDES project**: Underground laboratory for neutrino physics, ultra low background laboratory for biology and astrophysics studies. Installation of a low-energy and high current accelerator for measurement of very small (subcoulomb) cross sections of astrophysical interest. International collaboration: Argentina, Brazil, Chile,..
Facility's major experimental instrumentation and its capabilities:

- **QDD magnetic spectrometer.**

- **Microbeam facility** (beam spots of about $1\mu^2$) with high resolution X-ray detection.

- **External beam irradiation facility** with on-line dose determination.

- **Heavy-ion identification based on a time-of-flight facility** (start and stop signals derived from microchannel plates) followed by a Bragg spectrometer or solid state detectors.

- **30-inch diameter multipurpose scattering chamber.**

- **Irradiation chamber for the simulation of outer-space environmental conditions.**
1.1 R&D Programs

- **Applied Nuclear Physics:** A result of basic research activities has been the application of various experimental nuclear physics techniques to other fields of knowledge (multidiscipline): Medical Physics, radiobiology, environmental science, material science, nuclear astrophysics...

- **Reactor physics and applications:** RA-10 new research reactor for isotope production and for neutron studies in biology, materials science, chemistry, etc. LAHN: Laboratorio de Haces Neutrónicos (Lab for neutron beams). **3 nuclear power reactors. Heavy water plant. Fuel production...**

- **Accelerator-based Analytical techniques developed and available:** Ion Beam Analysis (HIRBS, PIXE, NRA,..); External Beam Irradiations, Neutron Production, Accelerator Mass Spectrometry (AMS). Proton irradiations to qualify satellite components (solar cells and electronic circuits).

- **Accelerator science & technology:** In the biomedical area a project is worth mentioning related to Accelerator-based Boron Neutron Capture Therapy (AB-BNCT), including the development of a high intensity low-energy proton/deuteron accelerator, high intensity neutron production targets and a SPECT tomograph.

- **Comprehensive program on BNCT activities** (computational dosimetry, irradiation with research reactor beams, prompt gamma analysis, microdosimetry, clinical research).
Main areas of research:

125 res. in basic NP, ~200 res. in Applications

Theory – Nuclear Structure/Dynamics
nuclear reaction theory, fusion, breakup, weakly bound nuclei, heavy ion reactions,
~16 researchers

Theory – High Energy Nuclear Physics/Hadron Physics
Nuclear equations of state applied to astrophysics, QCD phase transitions, effective hadronic and quark models, coherent scattering, diffractive pp collision, Particle production in the low x-region, Colour-glass-condensates
12 experimentalists at RHIC, Alice, CMS
68 theorists

Experimental – Local activities in nuclear structure/reactions
Nuclear astrophysics (nucleosynthesis), Nuclear reactions, Structure and reactions of exotic and weakly-bound stable nuclei, Gamma ray spectroscopy, electromagnetic moments,
~29 researchers

Applied Physics – radiation effects in electronic devices, cultural heritage studies (Raman, gamma and X-ray fluorescence spectrometry), Accelerator mass spectrometry, interaction of radiation with matter, nuclear instrumentation,
92 +40 (CNEN), 69 medical physics
Basic and applied nuclear research in Brazil is performed mainly at public Universities (state or federal), public research institutes and at National Commission of Nuclear Energy (CNEN).

At Universities, research institutes

125 basic and 92 applied researcher in 24 institutions 11 states

São Paulo state: 11 Universities/research institutes (USP, UNICAMP, UNESP, ITA, CNPEM etc)

Rio de Janeiro state: 4 Universities/research institutes, (UFRJ, UERJ, UFF, CBPF)

South region: 6 Universities (UEL, UNICENTRO, UFSC, UFRGS, FURG, UFPel) Paraná state, Santa Catarina state, Rio Grande do Sul state

Northeast region: 3 Universities (UESC, UFBa, UFPe). Bahia state

Pernambuco state
NATIONAL COMMISSION OF NUCLEAR ENERGY (CNEN)
(1664 employees, 40 researchers in Applications of Nuclear Science)

15 units in 9 Brazilian states. 4 active research reactors (RR), 1 in project phase, Brazilian Multipurpose Reactor (RMB). 5 cyclotrons produce radioisotopes in CNEN units, 10 more cyclotrons producing radioisotopes, some at private companies.

The most important units from the point of view of R&D are the following

- **Institute of Nuclear and Energy Research (IPEN)**; São Paulo, (625 employees, 38% Ms, PhD), Graduate courses, research, radioisotope production by RR and cyclotrons, 2 Research reactors IEA-R1 (5MW), IPEN/MB-01 (100W) and 2 Cyclotrons.

- **Center of Nuclear Technology Development (CDTN)** Belo Horizonte, MG, (248 employees, 44% Ms, PhD), 1 Research Reactor Triga IPR-R1 (100kW), 1 Cyclotron; Graduate Courses, Research

- **Institute of Nuclear Engineering (IEN)** Rio de Janeiro, RJ (155 empl., 39% Ms, PhD) Research reactor Argonauta (500W) and CV-28 Cyclotron, Graduate courses, Research

- **Institute of Radioprotection and Dosimetry (IRD)** Rio de Janeiro, RJ, (182 empl., 46% Ms, PhD) Radioprotection, Dosimetry, Metrology, Graduate courses, Research
Participation in ALAFNA

The **Nuclear Structure and Reactions community** participates very **actively** in ALAFNA, whereas the community active in **Nuclear Physics Applications** has a **limited** participation. **The High Energy Nuclear Physics groups** practically has **no participation** in ALAFNA. Among the future plans of ALAFNA are activities aiming at its establishment in the Nuclear Physics Division of the Brazilian Physical Society.

**Funding situation**

The federal and most state funding agencies for science and technology have cuts in their budget year after year. This resulted in **budget reduction of 45% between 2014-2020**. The number of fellowships for the students decreases continuously.
CHILE
Activity centers

- CCHEN: Comisión Chilena de Energía Nuclear. State institution. 5 MW research reactor; radioisotope preparations; neutron irradiation; neutron detectors; Z-pinch plasma induced fusion; training and assistance. [https://www.cchen.cl](https://www.cchen.cl)


- U CONCEPCION: Applied physics lab (TXRF Bruker spectrometer). Nuclear theory (Nuclear structure - Interacting Boson Model)


- Medical physics not included (med school). No information from Universidad Católica; U Frontera.

- Accuracy within 20%.
# Nuclear physics activity in Chile

<table>
<thead>
<tr>
<th>Institution</th>
<th>Researchers</th>
<th>Students</th>
<th>PostDocs</th>
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<tr>
<td></td>
<td>Exp + Theory</td>
<td>%</td>
<td>PhD + M Sc</td>
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<tr>
<td>CCHEN</td>
<td>3 + 0</td>
<td>7</td>
<td>1 + 3</td>
</tr>
<tr>
<td>U T Metropolitana</td>
<td>5 + 0</td>
<td>12</td>
<td>0 + 3</td>
</tr>
<tr>
<td>U Chile</td>
<td>0 + 2</td>
<td>5</td>
<td>2 + 4</td>
</tr>
<tr>
<td>U Concepcion</td>
<td>1 + 1</td>
<td>5</td>
<td>0 + 1</td>
</tr>
<tr>
<td>U Santa Maria</td>
<td>5 + 3</td>
<td>19</td>
<td>3 + 8</td>
</tr>
<tr>
<td>CVVTVAl</td>
<td>11 + 12</td>
<td>53</td>
<td>20 + 21</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>25 + 18</strong></td>
<td><strong>100</strong></td>
<td><strong>26 + 40</strong></td>
</tr>
</tbody>
</table>

Graph showing researchers and students.
Final remarks

Situation in Chile:

1. Strong activity on HEP (Valparaíso) with close ties with active accelerators in the world. Strong international collaborations.

2. Fragile activities in medium and low energy physics (researchers and students). Mainly due to local boundary conditions (paid undergraduate education and lack of workplaces).

3. LASFNA symposia have been crucial to maintain and visibilize research and applications of nuclear activities in Latin America.
Colombia
## Facilities under the Direction of the Geological National Survey

<table>
<thead>
<tr>
<th>Facility</th>
<th>Responsible</th>
<th>Ref.</th>
<th>Contact</th>
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<tbody>
<tr>
<td>NUCLEAR RESEARCH REACTOR - IAN R1</td>
<td>Jaime Sandoval</td>
<td>IANR1-011</td>
<td><a href="mailto:fmosos@sgc.gov.co">fmosos@sgc.gov.co</a></td>
</tr>
<tr>
<td>GAMMA IRRADIATION PLANT</td>
<td>Azarias Moreno Machado</td>
<td>PI-008-M1</td>
<td><a href="mailto:amoreno@sgc.gov.co">amoreno@sgc.gov.co</a></td>
</tr>
<tr>
<td>LABORATORY OF ANALYSIS BY NEUTRONIC ACTIVATION</td>
<td>Guillermo Abel Parrado Lozano</td>
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</tr>
<tr>
<td>SECONDARY LABORATORY OF DOSYMERIC CALIBRATION</td>
<td>Julián Andrés Niño Castañeda</td>
<td>LSCD-009</td>
<td><a href="mailto:janino@sgc.gov.co">janino@sgc.gov.co</a></td>
</tr>
<tr>
<td>WAREHOUSE OF DISUSE FOUNTAINS - WAREHOUSE 1</td>
<td>Mary Luz Peña Urueña</td>
<td>AFD-001-M1</td>
<td><a href="mailto:mlpena@sgc.gov.co">mlpena@sgc.gov.co</a></td>
</tr>
<tr>
<td>CENTRALIZED INSTALLATION FOR THE MANAGEMENT OF RADIOACTIVE WASTE - WAREHOUSE 2</td>
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<td>ICGDR-001-M1</td>
<td><a href="mailto:mlpena@sgc.gov.co">mlpena@sgc.gov.co</a></td>
</tr>
<tr>
<td>ENVIROMENTAL RADIOMETRY</td>
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<td></td>
<td><a href="mailto:holaya@sgc.gov.co">holaya@sgc.gov.co</a></td>
</tr>
</tbody>
</table>
Basic and Applied Research in Colombia from the Academy

<table>
<thead>
<tr>
<th>Place</th>
<th>Name of the Group</th>
<th>Head of the Group</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servicio Geológico Colombiano</td>
<td>Direction of Nuclear Affairs</td>
<td>HERNÁN OLAYA D.</td>
<td><a href="mailto:holaya@sgc.gov.co">holaya@sgc.gov.co</a></td>
</tr>
<tr>
<td>Universidad de Antioquia</td>
<td>Nuclear Physics Group - UdeA</td>
<td>Jose Patricio Valencia</td>
<td><a href="mailto:patricio.valencia@udea.edu.co">patricio.valencia@udea.edu.co</a></td>
</tr>
<tr>
<td>Pontificia Universidad Javeriana</td>
<td>Bio-physics &amp; Structural Biochemistry</td>
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</tr>
<tr>
<td>Universidad Distrital Francisco José de Caldas</td>
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</tr>
<tr>
<td>Universidad Nacional de Colombia Sede Medellin</td>
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</tr>
<tr>
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<td>Grupo de Física Nuclear Aplicada y Stimulación</td>
<td>FINUAS</td>
<td><a href="mailto:grupo.finuas@uptc.edu.co">grupo.finuas@uptc.edu.co</a></td>
</tr>
<tr>
<td>Universidad de los Andes</td>
<td>Grupo de Física de Altas Energías</td>
<td>Carlos Ávila</td>
<td><a href="mailto:cavila@untandes.edu.co">cavila@untandes.edu.co</a></td>
</tr>
<tr>
<td>Universidad Nacional de Colombia</td>
<td>Grupo de Física Nuclear de la Universidad Nacional de Colombia (GFNUN)</td>
<td>Fernando Cristancho Mejía</td>
<td><a href="mailto:fcrctstanchom@unal.edu.co">fcrctstanchom@unal.edu.co</a></td>
</tr>
<tr>
<td>Universidad Nacional de Colombia</td>
<td>Group of Physics of accelerators.</td>
<td>Javier F. Cardona</td>
<td><a href="mailto:jfcardona@unal.edu.co">jfcardona@unal.edu.co</a></td>
</tr>
<tr>
<td>Universidad Nacional de Colombia</td>
<td>Group of Medical Physics</td>
<td>Maria Cristina Plazas</td>
<td><a href="mailto:mcplazasd@unal.edu.co">mcplazasd@unal.edu.co</a></td>
</tr>
</tbody>
</table>

Applied research in applications for detection of Landmines is part of the research that have emerged from the peace process.

- There is a gap between the “liaison officer” at the Colombian government, the research groups and the IAEA, some efforts are being made in the promotion of ARCAL projects, but the consolidation of a system is needed.
- Medical physics is growing up in Colombia and the creation of Doctoral programs will appear in the forthcoming years.
- Basic research have strong international links, usually with Europe and USA, but not too strong with Latin America.
- Some basic research groups are also making applications, but are out of the scope of IAEA and the Colombian government.
Nuclear Physics Activities in Costa Rica

**Universidad de Costa Rica (UCR)**
- Center for Nuclear and Molecular Atomic Research (CICANUM)

**Universidad Nacional de Costa Rica (UNA)**
- Department of Physics

**Instituto Tecnológico de Costa Rica (TEC)**
- School of Physics

Medical physicist working at hospital are no taken into account here.

~ 1 physicist per topic = 13 physicists

November 16-18, 2020
Mario Cubero, Consultancy Meeting IAEA and ALFNA
Comments

- There are a very limited number of nuclear physicists in Costa Rica. Promoting nuclear research, for students and scientists, especially on unstable nuclei and high energy physics, will help the growth of the community and the dissemination of knowledge among the population.
- Costa Rica has a people and infrastructure to develop applied nuclear physics. This is a key point to support local development through interdisciplinary groups.
- Fundamental research is possible only with the facilities from other countries. Support for exchanges and scholarships are necessary.
- Medical physics has emerged due to the need of the country, and it is growing.
- ALAFNA provided a unique opportunity for professionals and students of Physics and other careers to be in close contact with the nuclear physics community.
Major centers related to education, research and application in nuclear science

**AEN&TA**  Agency for Nuclear Energy and Advanced Technologies  
[http://www.aenta.cu/](http://www.aenta.cu/)

**InSTEC**  Higher Institute of Technologies and Applied Sciences  
[https://www.instec.cu/](https://www.instec.cu/)

**CEADEN**  Center for Technological Applications and Nuclear Development  

**CEAC**  Cienfuegos Center for Environmental Studies  
[https://www.ceac.cu/](https://www.ceac.cu/)

**CIAC**  Environmental Engineering Center of Camaguey  
[https://www.ciac.cu/](https://www.ciac.cu/)

**CPHR**  Center for Radiation Protection and Hygiene  

**CENTIS**  Isotope Center  

Various institutions of the Ministry of Public Health of Cuba
Research and Scientific Services

Application of nuclear and isotopic techniques for:
✓ environmental studies,
✓ climate changes,
✓ marine and coastal management,
✓ biodiversity,
✓ agriculture
Conclusions

Nuclear science in Cuba emphasizes on:

✓ Education.
✓ Applications, mainly in the Medical Field

Internationally recognized qualified researchers, but with limited experimental facilities
Groups and Institutions in Ecuador

Universities (Facilities and Collaborations)
- Escuela Politecnica Nacional (Linac, Co-60, CMS-CERN, LAGO),
- Escuela Superior Politecnica del Litoral (Synchrotron Campinas-BR)
- Escuela Superior Politecnica del Chimborazo (LAGO)
- Universidad SanFrancisco de Quito (Fermi Lab, CMS-CERN, LAGO)
- YACHAY TEC Universidad (KM3Net)

Institutions
- SOLCA (Oncological Hospitals)

Organizations
- SCAN (former CEEA)

At EPN Nuclear Sciences Department DCN (Chemistry Faculty) (8 researchers)
- Ionizing radiation Applications
- Linac Electron Accelerator, 60 Cobalt irradiation facilities
- Lab of organic chemistry and applied research

At EPN Physics Department
- BioPhysics & Radiation Physics (1 researcher)
- AstroPhysics (2 researchers)
- High Energy Physics (1 researcher)
Conclusions

No basic nuclear research is carried out in my country, but only applications

- Oncology Society SOLCA, Quito, Guayaquil, Cuenca [www.solca.med.ec](http://www.solca.med.ec)
- Other Hospitals (with oncological services), Quito, Guayaquil

Around 33 medical physicists (master degree)

- Nuclear Medicine
- Radiotherapy (electron, photon)
- Diagnostic

<table>
<thead>
<tr>
<th>Field</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Medicine</td>
<td>87%</td>
</tr>
<tr>
<td>Industry</td>
<td>9%</td>
</tr>
<tr>
<td>Others</td>
<td>3%</td>
</tr>
<tr>
<td>Teaching</td>
<td>1%</td>
</tr>
</tbody>
</table>
Research Programs

• Nuclear structure and reactions
• Nuclear astrophysics
• Fundamental symmetries and neutrons
• Relativistic heavy ion collisions
• Hadronic physics
• Dark matter
• Instrumentation for nuclear and hadronic physics

• Atomic Mass Spectrometry
• Applications
• Medical physics
International Collaborations

- NUMEN
- ALICE@LHC
- HAWC
- Auger
- NICA
- JPAC@JLab

- Notre Dame
- Yale
- Oak Ridge
- TRIUMF
- SNO Lab
- INFN, Italy
- ISOLDE@CERN
- ILL Grenoble
### Faculty & Students

<table>
<thead>
<tr>
<th>Faculty</th>
<th>Graduate Students</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Physics</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Hadron Physics</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Medical Physics</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>70</strong></td>
</tr>
</tbody>
</table>

Approximate numbers, estimates

### Academic Activities

Each one of the Divisions of the Mexican Physical Society has its own events, like seminars, workshops, conferences, schools

- **Nuclear Physics Lunch Seminar** (from 1975)
- **SNP**: Int’l Symposium on Nuclear Physics (from 1978)
- **EMFN**: Escuela Mexicana de Física Nuclear (from 2001)

**NNPSS (2020 -> 2021 ?)**: National Nuclear Physics Summer School (INT, DNP-APS)

**CHARM (2020 -> 2021 ?)**

**HADRON (2021 ?)**

**LASNPA (2021 ? -> 2022)**: Latin American Symposium on Nuclear Physics and Applications
1. Facilities

1.1 Reactors
1.1.1 10 MW Research Reactor (RP-10)
1.1.2 Subcritic facility RP-0.
1.2 Radioisotope production plant (PPR). Since 1990, produced $^{131}$I, $^{99m}$Tc, $^{153}$Sm, $^{192}$Ir.
1.3 Secondary Standard Dosimetry Laboratory (LSCD)
1.4 Multi-Use Semi Industrial Irradiation Plant (PIMU)
1.5 Gamma irradiators
1.6.1 Essalud 16 MV cyclotrons 18F, 11C.
1.6.2 Ciclotrón Perú S.A.. 11 MV cyclotron
1.6.3. Cancer Institute (INEN) a cyclotron under construction

2. Personal

Nuclear physicists: 2.
Reactor physicists: 4.
Medical physicists: 40.
Theoretical physicists: 6
Particle physicists: 6 (collaboration in Fermilab and CERN)
Uruguay
Nuclear-related Activities in Academic Institutions in Uruguay

Radiochemistry in several Faculties of the Udelar (Chemistry, Sciences, etc.)

Theoretical Nuclear Physics at the Faculty of Engineering.

Medical Physics program at the Faculties of Sciences and Medicine. Started in 2011, around 20 beginning students/year. Postgraduate courses at the MS and PhD level.

Main Estate Institution: The Uruguayan National Radioprotection Authority (ANUR)

Created in 2005 with the purpose of controlling all activities employing nuclear radiation (hospitals, clinics, industry, mines, etc.)

Operational problems of the ANUR

• Insufficient staff and low budget
• Reflected in that in the last years was able to perform less than half of the inspections to the radiotherapy clinics as per the IAEA recommendations.

Conclusions

• The quality of the nuclear activities in Uruguay is slowly improving. Much work must still be done.
Venezuela
Main institutions with activity in Nuclear Science

1. **Instituto Venezolano de Investigaciones Científicas – IVIC,**
   --Gamma Irradiation Facility (\(^{60}\)Co, installed in the former RV1 Nuclear Reactor site),
   --Secondary Laboratory of Dosimetric Calibration,
   --Sanitary Radiophysics Service,
   --Master Program on Medical Physics
   --Research in Dosimetry and Medical Physics.

2. **Simon Bolivar University   USB**
   --BSc, MSc and PhD programs in Physics and Engineering.
   Nuclear Reactions and Nuclear Structure, Neutron Physics and Nuclear Reactors
   Instrumentation, Detectors, Nuclear Geophysics and Geochemistry, Geochronology
   --Laboratory with full capacity for nuclear spectrometry (alpha, beta, gamma, RX, neutrons, muons, nuclear tracks and Radon),
   --Research in nuclear reactions, Th-MSR, NORM, Analytic Nuclear Techniques
   collaboration with several research groups mainly in LA and Europe.

3. **Universidad Central de Venezuela** (Caracas) and
4. **Universidad de los Andes** (Merida City) has some research groups in
   High Energy Physics and Particle Physics, collaboration with CERN, ICTP and LNFN,

In addition, there are some 12 institutions with groups using nuclear applied techniques
(geologist, geophysicists, hydrologists, biologists, agronomists, paleontologists, archeologists, etc.), and some dozens of hospitals using nuclear medicine, diagnosis or radiotherapy.
Conclusions

1. Most Latin American countries have a small number of local activity in Nuclear Sciences, mainly in applications and medical physics. Most of them have some representatives working in USA and Europe in Nuclear physics/High Energy Physics (LAS4RI).

2. Exceptions are Argentina, Brazil, Mexico and Chile, with more local activity in Low / High Energy Nuclear Physics, as well as applications. But even these are not strong when compared to Europe or North America.

3. The low energy accelerators dedicated to basic research in Argentina, Brazil and Mexico are active and should attract more students from the other LA countries.

4. The lack of funding for Science is dramatic in most Latin American countries.

5. ALAFNA-IAEA collaboration should help to increase the Latin American collaboration.