XI Latin American Symposium on Nuclear Physics and Applications
Medellín, Colombia
30 November - 4 December 2015

Contents

1 Monday 30 November
1.1 Plenary talks: Application of nuclear sciences and technologies . . . . . . . . 3
1.2 Monday parallel session 1: Applications: Medical I ............................. 3
1.3 Monday parallel session 2: Applications I ........................................ 4
1.4 Monday parallel session 3: Nuclear structure I .................................. 5
1.5 Monday: Radiopharmaceuticals work group .................................... 5

2 Tuesday 1st December
2.1 Plenary talks: G. Viesti’s in memorian session and nuclear structure . . . . 6
2.2 Tuesday parallel session 1: Applications: Medical II .......................... 6
2.3 Tuesday parallel session 2: Applications II ...................................... 7
2.4 Tuesday parallel session 3: Nuclear structure II and heavy ions .............. 8
2.5 Tuesday parallel session 4: Instrumentation .................................... 8

3 Wednesday 2nd December
3.1 Plenary talks: Facilities and detectors ........................................... 9
3.2 Wednesday parallel session 1: Nuclear structure III .......................... 10
3.3 Wednesday parallel session 2: Nuclear structure and reactions of exotic nuclei .......................................................... 11
3.4 Wednesday parallel session 3: Hadron structure ................................ 11
3.5 Wednesday parallel session 4: Panel - Innovation and entrepreneurship: challenges and horizons” ......................................................... 12

4 Thursday 3th December
4.1 Plenary talks: Fundamental symmetries and hadron structure ............... 13
4.2 Thursday parallel session 1: Hadron structure and interactions II ........ 13
4.3 Work groups .................................................................................. 14
4.4 Thursday: Poster session ............................................................... 14

5 Friday 4th December
5.1 Plenary talks: Nuclear structure, nuclear reactions and nuclear astrophysics 17
6 Abstracts
1 Monday 30 November

1.1 Plenary talks: Application of nuclear sciences and technologies

Place: Main Auditorium

Chair: Fernando Cristancho (UNAL, Colombia)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 - 9:30</td>
<td>OPENING</td>
<td></td>
</tr>
<tr>
<td>9:30 - 10:00</td>
<td>Andrés Kreiner</td>
<td>Research, Applications and Technology Development of Accelerators in Argentina, p. 76</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>COFFEE BREAK</td>
<td></td>
</tr>
<tr>
<td>Chair: Marcia García (OFRO, Chile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:30 - 11:00</td>
<td>Patricia Nicolucci</td>
<td>Monte Carlo simulation of dosimetric parameters in brachytherapy, p. 103</td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>Oswaldo Baffa</td>
<td>What happens when spins meet for radiation dosimetry?, p. 23</td>
</tr>
<tr>
<td>11:30 - 12:00</td>
<td>Carlos Granja</td>
<td>Imaging and characterization of primary and secondary radiation in ion-beam therapy, p. 67</td>
</tr>
<tr>
<td>12:00 - 12:30</td>
<td>Beatriz Sánchez</td>
<td>Neutron and photon peripheral doses in radiotherapy. Dosimetric and modelling issues, p. 118</td>
</tr>
<tr>
<td>12:30 - 14:30</td>
<td>LUNCH</td>
<td></td>
</tr>
</tbody>
</table>

1.2 Monday parallel session 1: Applications: Medical I

Place: 2nd Floor, Auditorium 1

Chair: Ignacio Espinoza (U Pontificia Católica, Chile)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 -14:50</td>
<td>Marcia García</td>
<td>Implementation of a gamma spectrometry system for measuring accumulated activity in thyroid of patients treated with $^{131}$I in one nuclear medicine unit of Chile, p. 51</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Gloria Díaz-Londoño</td>
<td>Estimate of the effective dose in patients treated with $^{131}$I from in vivo measurements, p. 42</td>
</tr>
</tbody>
</table>
15:30 - 15:50  Hernán Olaya  
(UNAL, Colombia)  
Monte Carlo simulation of simultaneous radiation detection in the hybrid tomography system ClearPET-CT, p. 104

15:50 - 16:20  COFFE BREAK

Chair: Jorge López (UTEP, USA)

16:20 - 16:40  Edy Cuevas Arizaca  
(USP, Brazil)  
Radiation detectors based on natural silicate minerals: Application in monitoring processes in nuclear medicine, p. 40

16:40 - 17:00  Carlos González Lorenzo  
(IPN-Lyon, France)  
Synthetic crystals production of CaSiO$_3$, CdSiO$_3$ and its application in radiation dosimetry, p. 64

19:30 -  
Welcome dinner

1.3 Monday parallel session 2: Applications I

Place: 2nd Floor, Auditorium 2

Chair: J. Roberto Morales (UCh, Chile)

14:30 - 14:50  Marcilei Guazelli da Silveira  
(FEI, Brazil)  
Radiation effect mechanisms in electronic devices, p. 68

14:50 - 15:10  Nilberto Medina  
(USP, Brazil)  
Single event effect measurements in electronic devices, p. 90

15:10 - 15:30  Carlos Granja  
(IEAP-CTU, Czech Republic)  
Mapping of space radiation in LEO orbit by SATRAM/Timepix payload on board the ESA Proba-V satellite, p. 66

15:30 - 15:50  Vanessa García  
(USB, Venezuela)  
New approach to characterize the alpha particles registered in LR-115 detectors, p. 54

15:50 - 16:20  COFFE BREAK

Chair: Peter Geltenbort (ILL, France)

16:20 - 16:40  Laszlo Sajo-Bohus  
(USB, Venezuela)  
Neutron dose study at the RFX-MOD external field by nuclear track methodology, p. 115

16:40 - 17:00  Nayibe Lucía Buitrago-Montañez  
(CONICET, Argentina)  
Hydrogen diffusion profiles in Zr based alloys by neutron imaging, p. 28
<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>17:00 - 17:20</td>
<td>Juan Sebastian Gómez-Muñoz</td>
<td>Neutron detector arrays used in the Neutron Backscattering Technique, p. 63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19:30 -</td>
<td></td>
<td>Welcome dinner</td>
</tr>
</tbody>
</table>

### 1.4 Monday parallel session 3: Nuclear structure I

**Place:** Main Auditorium

**Chair:** Zsolt Podolyak (Surrey, UK)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Silvia Lenzi</td>
<td>Quadrupole correlations in proton- and neutron-rich nuclei, p. 79</td>
</tr>
<tr>
<td></td>
<td>(INFN - Padova, Italy)</td>
<td></td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Greg Lane</td>
<td>Nuclear isomers and shape changes in neutron-rich A = 180 to A = 190 nuclei, p. 77</td>
</tr>
<tr>
<td></td>
<td>(ANU, Australia)</td>
<td></td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Parviz Gulshani</td>
<td>A microscopic derivation of nuclear collective rotation-vibration model and its application to deformed nuclei, p. 72</td>
</tr>
<tr>
<td></td>
<td>(NUTECH Services, Canada)</td>
<td></td>
</tr>
<tr>
<td>15:30 - 15:50</td>
<td>Sanjay Kumar Chamoli</td>
<td>Shape transition in A ~ 190 nuclei; a study via lifetime measurement in $^{188}$Pt, p. 35</td>
</tr>
<tr>
<td></td>
<td>(Delhi - India)</td>
<td></td>
</tr>
<tr>
<td>15:50 - 16:10</td>
<td></td>
<td>COFFEE BREAK</td>
</tr>
</tbody>
</table>

**Chair:** Jose Oliveira (USP, Brazil)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:10 - 16:30</td>
<td>Modesto Montoya</td>
<td>Coulomb and even-odd effects in cold and super-asymmetric fragmentation for thermal neutron induced fission of $^{235}$U, p. 92</td>
</tr>
<tr>
<td></td>
<td>(UNI, Peru)</td>
<td></td>
</tr>
<tr>
<td>16:30 - 16:50</td>
<td>Wilmar Rodríguez</td>
<td>Level lifetime and side-feeding time measurements of $^{83}$Y using the Doppler shift attenuation method, p. 112</td>
</tr>
<tr>
<td></td>
<td>(UNAL, Colombia)</td>
<td></td>
</tr>
<tr>
<td>16:50 - 17:10</td>
<td>Zully Elisa Johana Guevara</td>
<td>Lifetime measurements of excited states of $^{106}<em>{48}$Cd$</em>{58}$ using the Doppler Shift Attenuation Method, p. 70</td>
</tr>
<tr>
<td></td>
<td>(UNAL, Colombia)</td>
<td></td>
</tr>
<tr>
<td>19:30 -</td>
<td></td>
<td>Welcome dinner</td>
</tr>
</tbody>
</table>

### 1.5 Monday: Radiopharmaceuticals work group

**Place:** 3rd Floor, Auditorium 2
2 Tuesday 1st December

2.1 Plenary talks: G. Viesti’s in memorian session and nuclear structure

Place: Main Auditorium

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 8:30</td>
<td>Laszlo Sajo-Bohus</td>
<td>Applied advanced nuclear technique in education and research. Beppe’s contribution</td>
<td>114</td>
</tr>
<tr>
<td>8:30 - 9:00</td>
<td>Nilberto Medina</td>
<td>Search for the nuclear hyper-deformation in the 90’s</td>
<td>88</td>
</tr>
<tr>
<td>9:00 - 9:30</td>
<td>Joseph Natowitz</td>
<td>Giuseppe Viesti. An appreciation</td>
<td>100</td>
</tr>
<tr>
<td>9:30 - 10:00</td>
<td>Luca Stevanato</td>
<td>An overview of nuclear physics applications in different national and EU Project</td>
<td>124</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chair: Joseph Natowiz (Texas A&M - USA)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 - 11:00</td>
<td>Piet Van Isacker</td>
<td>Symmetries of the nuclear shell model</td>
<td>132</td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>Stefan Frauendorf</td>
<td>Open questions on nuclear collective motion</td>
<td>50</td>
</tr>
<tr>
<td>11:30 - 12:00</td>
<td>Peter Butler</td>
<td>Studies of shapes of heavy pear-shaped nuclei at ISOLDE</td>
<td>31</td>
</tr>
<tr>
<td>12:00 - 12:30</td>
<td>Zsolt Podolyak</td>
<td>Structure of neutron rich $N \geq 126$ nuclei</td>
<td>107</td>
</tr>
<tr>
<td>12:30 - 14:30</td>
<td>LUNCH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2 Tuesday parallel session 1: Applications: Medical II

Place: 2nd Floor, Auditorium 1

Chair: Carlos Granja (IEAP-CTU, Czech Republic)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Luis Agulles</td>
<td>1D spatial resolution parameters dependence of a hybrid low field MRI-gamma detector</td>
<td>20</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Germán Ricaurte</td>
<td>In vivo absolute quantification of a muscular metabolite using proton magnetic resonance and a flexible coil</td>
<td>109</td>
</tr>
<tr>
<td>Time</td>
<td>Speaker</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Andrea Abril (UNAL, Colombia)</td>
<td>2D dose distribution images of a hybrid low field MRI-gamma detector</td>
<td>18</td>
</tr>
<tr>
<td>15:30 - 15:50</td>
<td>Fracisco Torres Hoyos (Unicórdoba, Colombia)</td>
<td>3-D in vivo brain tumor geometry study by scaling analysis</td>
<td>127</td>
</tr>
<tr>
<td>15:50 - 16:20</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:20 - 16:40</td>
<td>Helman Amaya (UNAL, Colombia)</td>
<td>Diffusion processes in tumors: A Nuclear Medicine approach</td>
<td>21</td>
</tr>
<tr>
<td>16:40 - 17:00</td>
<td>Andrés Guerrero (Uniquindio, Colombia)</td>
<td>Study of electronic braking in liquid water under the formalism of Lindhard, for use in Proton computed tomography</td>
<td>69</td>
</tr>
</tbody>
</table>

### 2.3 Tuesday parallel session 2: Applications II

**Place:** 2nd Floor, Auditorium 2

**Chair:** László Sajó-Bohus (USB, Venezuela)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>José Roberto Morales (UCh, Chile)</td>
<td>Comparison of natural radioisotope concentrations in volcanic pyroclast samples from Chilean volcanoes</td>
<td>93</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Roberto Linares (UFF, Brazil)</td>
<td>Radiocarbon measurements at LAC-UFF: recent performance</td>
<td>83</td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Oscar Sierra (SGC, Colombia)</td>
<td>Improvement of Analytical Capabilities of the Neutron Activation Analysis Laboratory at the Colombian Geological Survey</td>
<td>121</td>
</tr>
<tr>
<td>16:00 - 16:30</td>
<td>COFFEE BREAK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.4 Tuesday parallel session 3: Nuclear structure II and heavy ions

Place: Main Auditorium

Chair: Silvia Lenzi (INFN-Padova, Italy)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Sam Tabor (FSU, USA)</td>
<td>Neutron excess, shell mobility and correlation energy in $s-d$ nuclei, p. 125</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Ronald Fernando García-Ruiz (Manchester, UK)</td>
<td>Laser spectroscopy studies in the calcium region and future perspectives, p. 52</td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Martha Liliana Cortés (GSI, Germany)</td>
<td>Inelastic scattering of neutron-rich $^{72,74}$Ni off a proton target, p. 38</td>
</tr>
<tr>
<td>15:30 - 15:50</td>
<td>Fitzgerald Ramírez (UNAL, Colombia)</td>
<td>Multiple-bands structures in the $^{223}$Th nucleus. Quadrupole-octupole collectivity in the $A \sim 200$ mass region of the nuclear map, p. 108</td>
</tr>
<tr>
<td>15:50 - 16:20</td>
<td></td>
<td>COFFEE BREAK</td>
</tr>
</tbody>
</table>

Chair: Peter Butler (Liverpool, UK)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:20 - 16:40</td>
<td>José Benlliure (USC, Spain)</td>
<td>Fission dynamics investigated in complete kinematic measurements, p. 25</td>
</tr>
<tr>
<td>16:40 - 17:00</td>
<td>Diego Torres (UNAL, Colombia)</td>
<td>A comment about the use of alpha transfer reactions to populate excited states in radioactive nuclei, p. 126</td>
</tr>
<tr>
<td>17:00 - 17:20</td>
<td>Gurgen Adamian (Dubna, Russia)</td>
<td>Extracting integrated and differential cross sections in low energy heavy-ion reactions from backscattering measurements, p. 19</td>
</tr>
</tbody>
</table>

2.5 Tuesday parallel session 4: Instrumentation

Place: 3rd Floor, Auditorium 2

Chair: Philip Cole (ISU - USA)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Jürgen Gerl (GSI, Germany)</td>
<td>Novel applications from latest nuclear physics developments, p. 57</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Gianluigi Maggione (INFN-LNL, Italy)</td>
<td>Germanium Detectors for Nuclear Spectroscopy, p. 87</td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Elton Smith (JLab, USA)</td>
<td>Development of Silicon Photomultipliers and their Applications to GlueX, p. 122</td>
</tr>
<tr>
<td>15:30 - 15:50</td>
<td>Daniel Napoli (INFN-LNL, Italy)</td>
<td>SPES: Status of the project, technical challenges, instrumentation and scientific program, p. 99</td>
</tr>
<tr>
<td>15:50 - 16:20</td>
<td>COFFEE BREAK</td>
<td></td>
</tr>
<tr>
<td>Chair: Daniel Napoli (INFN-LNL - Italy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:20 - 16:40</td>
<td>Carlos Bula Villarreal (ISU, USA)</td>
<td>PREX thin quartz detector development, p. 30</td>
</tr>
<tr>
<td>16:40 - 17:00</td>
<td>A. Salas-Bacci (Virginia, USA)</td>
<td>Studies of free neutron decay with the Nab experiment, p. 117</td>
</tr>
<tr>
<td>17:00 - 17:20</td>
<td>Diana Herrera (UNIZAR, SPAIN)</td>
<td>Development of a Micromegas Time Projection Chamber filled with Xe-trimethylamine (Xe+TMA) for Rare Event Searches, p. 73</td>
</tr>
</tbody>
</table>

3 Wednesday 2nd December

3.1 Plenary talks: Facilities and detectors

Place: Main Auditorium

Chair: Latifa Elouadrhiri (JLab, USA)

| 8:00 - 8:30 | Pieter Doornenbal (RIKEN, Japan) | Overview of In-beam gamma-ray spectroscopy at the RIBF, p. 45 |
| 8:30 - 9:00 | Paer-Anders Söderström (RIKEN, Japan) | Status and results from the decay spectroscopy project EURICA (EUroball-RIken cluster Array), p. 123 |
| 9:00 - 9:30 | Paul Garrett (U of G, Canada) | From the $8\pi$ to GRIFFIN spectrometers; nuclear structure studies using beta-decay measurements at TRIUMF-ISAC, p. 55 |
| 9:30 - 10:00 | Navin Alahari (GANIL, France) | Towards New Horizons @ GANIL, p. 102 |
| 10:00 - 10:30 | coffee break |

Chair: Paul Garrett (U of G, Canada)

<p>| 10:30 - 11:00 | Silvia Lenzi (INFN-Padova, Italy) | The AGATA spectrometer: Results and Perspectives, p. 80 |</p>
<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 - 11:30</td>
<td>Augusto Macchiavelli</td>
<td>GRETINA physics program, p. 85</td>
<td>85</td>
</tr>
<tr>
<td>11:30 - 12:00</td>
<td>Alinka Lépine-Szily</td>
<td>Radioactive Ion Beams in Brasil (RIBRAS) - recent results, p. 81</td>
<td>81</td>
</tr>
<tr>
<td>12:00 - 12:30</td>
<td>Philipp Schmidt-Wellenburg</td>
<td>The quest for an electric dipole moment of the neutron, p. 120</td>
<td>120</td>
</tr>
<tr>
<td>12:30 - 14:30</td>
<td></td>
<td>LUNCH</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Wednesday parallel session 1: Nuclear structure III

Place: **Main Auditorium**

Chair: Gurgen Adamian (Dubna - Russia)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Ebhelixes Valencia Marín</td>
<td>Total absorption gamma-ray spectroscopy studies of neutron rich nuclei for applications, p. 128</td>
<td>128</td>
</tr>
<tr>
<td>14:50 - 15:10</td>
<td>Luis Gerardo Sarmiento</td>
<td>Quantum-Selective Nuclear Spectroscopy: The $^{53}$Co$^{m}$ and $^{213}$Ra case, p. 119</td>
<td>119</td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Nikolay Antonenko</td>
<td>Perspectives of production of superheavy nuclei, p. 22</td>
<td>22</td>
</tr>
<tr>
<td>15:30 - 16:00</td>
<td></td>
<td>COFFEE BREAK</td>
<td></td>
</tr>
</tbody>
</table>

Chair: Brett Carlson (Instituto Tecnológico de Aeronáutica - Brazil)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:00 - 16:20</td>
<td>Jorge López</td>
<td>Isospin-dependent phase diagram of nuclear matter, p. 84</td>
<td>84</td>
</tr>
<tr>
<td>16:20 - 16:40</td>
<td>Raul Donangelo</td>
<td>The Statistical multifragmentation model: origins and recent advances, p. 44</td>
<td>44</td>
</tr>
<tr>
<td>16:40 - 17:00</td>
<td>Héctor Múnera</td>
<td>Unified field theory from the classical wave equation: preliminary application to atomic and nuclear structure, p. 96</td>
<td>96</td>
</tr>
<tr>
<td>19:30 -</td>
<td>ALAFNA’s meeting (“Sala de juntas”)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 3.3 Wednesday parallel session 2: Nuclear structure and reactions of exotic nuclei

**Place:** *2nd Floor Auditorium 1*

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 14:50</td>
<td>Edna Pinilla</td>
<td>Breakup of the three-body exotic nuclei $^{22}$C</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>(UNAL, Colombia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:50 - 15:10</td>
<td>Paulo Gomes</td>
<td>Limitations of Reduction Methods for Fusion and Total Reaction Cross Sections</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>(UFF, Brazil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:10 - 15:30</td>
<td>Kenneth Whitmore</td>
<td>Study of the one-neutron halo $^{19}$C via single-proton knockout of $^{20}$N</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>(NSCL-MSU, USA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:30 - 15:50</td>
<td>L. Canton</td>
<td>Alpha-scattering on $^6$He and on other light nuclei in the low-energy regime</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>(INFN-Padova, Italy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19:30 -</td>
<td>ALAFNA’s meeting ( “Sala de juntas”)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.4 Wednesday parallel session 3: Hadron structure

**Place:** *2nd Floor Auditorium 2*

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 15:00</td>
<td>David Mack</td>
<td>Very light mesons in hall D at Jefferson Lab</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>(TJNAF, USA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:00 - 15:30</td>
<td>Latifa Elouadhriri</td>
<td>Hall B 12 GeV Upgrade science program</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>(JLab, USA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:30 - 16:00</td>
<td>Carlos Muñoz-Camacho</td>
<td>New Deeply Virtual Compton Scattering results from Jefferson Lab</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>(IPN-Orsay, France)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00 - 16:30</td>
<td></td>
<td><strong>COFFEE BREAK</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Chair:** Roelof Bijker (ICN-UNAM, Mexico)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>16:30 - 17:00</td>
<td>Shalev Gilad</td>
<td>Tagged EMC - Exploring the correlation between the EMC effect and Nucleon-Nucleon short-range correlations</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>(MIT, USA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17:00 - 17:30</td>
<td>Ezequiel Rodríguez</td>
<td>Analysis of the matrix $V_{PMNS}$ in the 2HDM-III</td>
<td>111</td>
</tr>
<tr>
<td></td>
<td>(Unison, Mexico)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Speaker</td>
<td>Topic</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>17:30 - 18:00</td>
<td>Roelof Bijker (ICN-UNAM, Mexico)</td>
<td>Hadron spectroscopy in the unquenched quark model, p. 27</td>
<td></td>
</tr>
<tr>
<td>18:00 - 18:30</td>
<td>Neelima Kelkar (Uniandes, Colombia)</td>
<td>Proton radius revisited, p. 75</td>
<td></td>
</tr>
<tr>
<td>19:30 -</td>
<td>ALAFNA’s meeting (”Sala de juntas”)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.5 Wednesday parallel session 4: Panel - Innovation and entrepreneurship: challenges and horizons”

Place: 3rd Floor Auditorium 2*

Chair: Diego Torres (UNAL - Colombia)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:00 -</td>
<td>Claes Fahlander (Lund, Sweden)</td>
<td>Engaging local industry in the development of basic research infrastructure and instrumentation – The case of HIE-ISOLDE and ESS Scandinavia, p. 47</td>
</tr>
<tr>
<td></td>
<td>Mirka Fahlander (Lund, Sweden)</td>
<td>Dissemination of research results from Lund University to industry and society, p. 48</td>
</tr>
<tr>
<td></td>
<td>Fernando Monserrat (Nucleoeléctrica, Argentina)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Several other speakers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td></td>
</tr>
<tr>
<td>16:00 - 16:30</td>
<td></td>
<td>COFFEE BREAK</td>
</tr>
</tbody>
</table>

*Organized with the support of the Direction of Research and Extension of Universidad Nacional de Colombia, Bogotá, and Lund University Commissioned Education, LUCE.
4 Thursday 3th December

4.1 Plenary talks: Fundamental symmetries and hadron structure

Place: Main Auditorium

Chair: Oscar Naviliat-Cuncic (MSU)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 - 9:00</td>
<td>José Oliveira</td>
<td>Gamma-particle coincidence measurements - results with weakly bound</td>
</tr>
<tr>
<td></td>
<td>(USP, Brazil)</td>
<td>stable beams and future plans, p. 105</td>
</tr>
<tr>
<td>9:00 - 9:30</td>
<td>Eduardo Gómez</td>
<td>Weak interaction studies with francium, p. 61</td>
</tr>
<tr>
<td></td>
<td>(UASLP, Mexico)</td>
<td></td>
</tr>
<tr>
<td>9:30 - 10:00</td>
<td>Martín González</td>
<td>New physics searches in nuclear beta decay in the LHC era, p. 65</td>
</tr>
<tr>
<td></td>
<td>(IPN-Lyon, France)</td>
<td></td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>coffee break</td>
<td></td>
</tr>
</tbody>
</table>

Chair: Lídia Ferreira (ULisboa - Portugal)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 - 11:00</td>
<td>Pawel Moskal</td>
<td>Status and perspectives of the search for eta-mesic nuclei, p. 95</td>
</tr>
<tr>
<td></td>
<td>(UJ, Poland)</td>
<td></td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>Philip Cole</td>
<td>What nucleons resonances teach us about the nucleon structure, p. 37</td>
</tr>
<tr>
<td></td>
<td>(ISU, USA)</td>
<td></td>
</tr>
<tr>
<td>11:30 - 12:00</td>
<td>Peter Geltenbort</td>
<td>Probing early universe particle physics with neutrons at the Institut</td>
</tr>
<tr>
<td></td>
<td>(ILL, France)</td>
<td>Laue-Langevin, p. 56</td>
</tr>
<tr>
<td>12:00 - 14:30</td>
<td>LUNCH</td>
<td></td>
</tr>
</tbody>
</table>

4.2 Thursday parallel session 1: Hadron structure and interactions

II

Place: 2nd Floor Auditorium 1

Chair: Lídia Ferreira (ULisboa - Portugal)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:30 - 15:00</td>
<td>Oscar Naviliat-Cuncic</td>
<td>Searches for physics beyond the Standard Model in nuclear beta decay,</td>
</tr>
<tr>
<td></td>
<td>(MSU, USA)</td>
<td>p. 101</td>
</tr>
<tr>
<td>15:00 - 15:30</td>
<td>José Patricio Valencia</td>
<td>The role of $g_{9/2}$ intruder state in the nuclear matrix elements of $^{76}\text{Ge} \rightarrow ^{76}\text{Se}$ $2\nu\beta\beta$ decay, p. 130</td>
</tr>
</tbody>
</table>
15:30 - 16:00 | Jossitt Vargas-Cruz (USC, Spain) | In-medium excitation of nucleon resonances using isobaric charge-exchange reactions at relativistic energies, p. 133

16:00 - 16:30 | COFFEE BREAK

16:30 - 17:30 | Poster session

19:30 - | Panel: Nuclear science and society in Latin America.
Auditorium 2, 2nd Floor

4.3 Work groups

1. Energy planning work group
   Place: Engineering Room
   Hour: 9:00

2. NORM work group
   Place: 3rd Floor Auditorium 2
   Hour: 15:00

4.4 Thursday: Poster session

Place: 2nd Floor Hall

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pablo Aguilera</td>
<td>Results on the neutron energy distribution measurements at the RECH-1</td>
<td>138</td>
</tr>
<tr>
<td>(UCh, Chile)</td>
<td>Chilean Nuclear Reactor</td>
<td></td>
</tr>
<tr>
<td>Dany Apaza</td>
<td>Radioablative therapy with Iodine-131 on a patient with thyroid cancer</td>
<td>139</td>
</tr>
<tr>
<td>(UNSA, Peru)</td>
<td>and chronic renal failure in hemodialysis first experience in Peru</td>
<td></td>
</tr>
<tr>
<td>Yolma Banguero</td>
<td>Development of an automated system of blocks for radiotherapy</td>
<td>140</td>
</tr>
<tr>
<td>(Udelar, Uruguay)</td>
<td>improving the patient radioprotection</td>
<td></td>
</tr>
<tr>
<td>Yolma Banguero</td>
<td>Development of optimization treatment process, extern of the planning</td>
<td>141</td>
</tr>
<tr>
<td>(Udelar, Uruguay)</td>
<td>system</td>
<td></td>
</tr>
<tr>
<td>Yolma Banguero</td>
<td>Dose volume histogram and its dependency with the calculus grid in the</td>
<td>142</td>
</tr>
<tr>
<td>(Udelar, Uruguay)</td>
<td>system mirs V5.1.</td>
<td></td>
</tr>
<tr>
<td>Frank Bautista</td>
<td>Measurement of the concentration of natural radionuclides by γ-ray</td>
<td>143</td>
</tr>
<tr>
<td>(UNAL, Colombia)</td>
<td>spectroscopy using a NaI detector</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Institution</td>
<td>Project/Task</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Judilka Bermudez</td>
<td>(LNL - INFN, Italy)</td>
<td>Beam Line Radioactivity Study for the Spes Project</td>
</tr>
<tr>
<td>Félix Charry</td>
<td>(UNAL, Colombia)</td>
<td>Systematic analysis of elastic scattering angular distributions with the São Paulo potential</td>
</tr>
<tr>
<td>José Díaz</td>
<td>(UNAL, Colombia)</td>
<td>Geant4 calculation of depth dose percentage in brain tumors treatments using Protons and carbon ions</td>
</tr>
<tr>
<td>Katerine Díaz</td>
<td>(UNAL, Colombia)</td>
<td>Effect of sample thickness on 511 keV simple Compton-scattered gamma rays</td>
</tr>
<tr>
<td>Ana Gómez</td>
<td>(Uniquindio, Colombia)</td>
<td>Can we trust the parametrizations utilized to perform Magnetic Moments measurements using the Transient Field technique?</td>
</tr>
<tr>
<td>Nicolás Guarín</td>
<td>(UNAL, Colombia)</td>
<td>Simulation of physics process in a nuclear reactor in Geant4</td>
</tr>
<tr>
<td>Gianluigi Maggioni</td>
<td>(UNIPD at INFN-LNL, Italy)</td>
<td>$^{6}$LiF nano-particles in siloxane scintillators for thermal neutrons detection</td>
</tr>
<tr>
<td>Andrés Navarro</td>
<td>(UNAL, Colombia)</td>
<td>A practical method of energy calibration of $\gamma$ spectrum of plastic scintillators using Compton scattered $\gamma$-rays and Monte Carlo simulations</td>
</tr>
<tr>
<td>Pamela Ochoa</td>
<td>(UNAL, Colombia)</td>
<td>Design of a model to scale animal biodistribution to human of the radiopharmaceutical $[^{68}\text{Ga}]\text{Ga-PSMA-HBED-CC}$</td>
</tr>
<tr>
<td>Diana Ortegón</td>
<td>(UNAL, Colombia)</td>
<td>Design of a preclinical study in mice to model the biodistribution of the radiopharmaceutical $[^{68}\text{Ga}]\text{Ga-PSMA-HBED-CC}$</td>
</tr>
<tr>
<td>Pablo Ortiz</td>
<td>(UCh, Chile)</td>
<td>Simulation of a coaxial HPGe detector using FLUKA code</td>
</tr>
<tr>
<td>Pablo Ortiz</td>
<td>(UCh, Chile)</td>
<td>Experimental validation of the intrinsic spatial efficiency method over a wide range of sizes for cylindrical sources</td>
</tr>
<tr>
<td>Pablo Ortiz</td>
<td>(UCh, Chile)</td>
<td>Validation of the intrinsic spatial efficiency method for non cylindrical homogeneous sources using MC simulation</td>
</tr>
<tr>
<td>Isabel Paredes</td>
<td>(UNAL, Colombia)</td>
<td>Image Quality Assessment for CT scanner used on small animals</td>
</tr>
<tr>
<td>Victor Ramos</td>
<td>(UNAL, Colombia)</td>
<td>Software Implementation for 3d Individualized Internal Dosimetry in $^{177}\text{Lu-DOTATATE}$ Radiation Therapy</td>
</tr>
<tr>
<td>Jaime Romero</td>
<td>(UCh - CCHEN, Chile)</td>
<td>Calculation of self-shielding factor for neutron activation experiments using Geant4 and MCNP</td>
</tr>
<tr>
<td>Name</td>
<td>Institution/Location</td>
<td>Title</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>William Saenz</td>
<td>UNAL, Colombia</td>
<td>Comparison between γ-ray spectra obtained from PIN photo-diode and photomultiplier tube arrangements</td>
</tr>
<tr>
<td>Laszlo Sajo-Bohus</td>
<td>USB, Venezuela</td>
<td>NTM in low energy photo-transmutation of Th and U fuel study for gamma driven-MSR</td>
</tr>
<tr>
<td>Johnny Salas</td>
<td>Venezuela</td>
<td>Proposal for an efficiency calibration of a Well Type HPGe detector by Monte Carlo Method using Geant4</td>
</tr>
<tr>
<td>Oscar Sierra</td>
<td>SGC, Colombia</td>
<td>Characterization of HPGe Gamma Spectrometric Detectors Systems for Instrumental Neutron Activation Analysis (INAA) at the Colombian Geological Survey</td>
</tr>
<tr>
<td>D. Alonso</td>
<td>SGC, Colombia</td>
<td>Assessment of uranium content in energetic minerals through the delayed neutron counting system</td>
</tr>
<tr>
<td>Andrea Vargas</td>
<td>UNAL, Colombia</td>
<td>Standardization of parameters for the use of thermoluminiscent detectors TLD-400 (CaF2:Mn)</td>
</tr>
<tr>
<td>Luz Veloza</td>
<td>UNAL, Colombia</td>
<td>Radiation Dose Assessment of 99mTc-labeled Tetrofosmin in Patients Undergoing Rest-Stress Myocardial Perfusion Scintigraphy</td>
</tr>
<tr>
<td>Carmen Villalba</td>
<td>USB, Venezuela</td>
<td>Characterization of neutron and gamma components of radioisotopic sources using analogic PSD</td>
</tr>
</tbody>
</table>
5 Friday 4th december

5.1 Plenary talks: Nuclear structure, nuclear reactions and nuclear astrophysics

Place: Main Auditorium

Chair: Paulo Gomes (UFF, Brazil)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 8:30</td>
<td>Lidia Ferreira (ULisboa, Portugal)</td>
<td>Theoretical studies of proton radiactivity, p. 49</td>
<td></td>
</tr>
<tr>
<td>8:30 - 9:00</td>
<td>Carlos Bertulani (Texas A&amp;M, USA)</td>
<td>Selected topics in reaction theory</td>
<td></td>
</tr>
<tr>
<td>9:00 - 9:30</td>
<td>Pierre Descouvemont (ULB, Belgium)</td>
<td>Microscopic Description of $^{6}$He elastic scattering on heavy targets, p. 41</td>
<td></td>
</tr>
<tr>
<td>9:30 - 10:00</td>
<td>Brett Van Carlson (Instituto Tecnológico de Aeronáutica, Brazil)</td>
<td>Limits to the formation of a hot compound nucleus, p. 34</td>
<td></td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td></td>
<td>coffee break</td>
<td></td>
</tr>
</tbody>
</table>

Chair: Carlos Bertulani (Texas A&M - USA)

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 -11:00</td>
<td>Mahir Hussein (USP, Brazil)</td>
<td>The role of simple 2p-1h doorway resonances in thermal neutron capture reactions, p. 74</td>
<td></td>
</tr>
<tr>
<td>11:00 - 11:30</td>
<td>Iris Dillman (TRIUMF, Canada)</td>
<td>Beta - delayed neutron emission of very neutron-rich isotopes, p. 43</td>
<td></td>
</tr>
<tr>
<td>11:30 - 12:00</td>
<td>Liliana Caballero (U of G, Canada)</td>
<td>Neutrino emission, nucleosynthesis, and the role of strong gravity, p. 32</td>
<td></td>
</tr>
<tr>
<td>12:00 - 12:30</td>
<td></td>
<td>Summary talk</td>
<td></td>
</tr>
<tr>
<td>12:30 - 14:30</td>
<td></td>
<td>LUNCH</td>
<td></td>
</tr>
</tbody>
</table>
6 Abstracts

2D dose distribution images of a hybrid low field MRI-gamma detector

A. Abril, L. Agulles-Pedros
Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia.

Hybrid systems like MRI/PET and PET/CT, offer advantages combining the resolution with the better contrast and functional information of nuclear techniques. This work presents the design of a low field NMR system made up of permanent magnets compatible with a gamma radiation detector based on gel dosimetry. The design is performed using the software femm for estimation of the magnetic field of a 2D array of permanent magnets, and GEANT4 for the physical process involved in radiation detection and effect of magnetic field. As a result, the system described allows a complete 2D integrated radiation detector within the MRI system and image acquisition technique. In our hybrid proposal, the spatial resolution strongly depends on the Pb collimator arrangement, sample distance, geometry and size. We present the simulated 2D dose distribution for different samples to study the feasibility of the experimental set up.
Extracting integrated and differential cross sections in low energy heavy-ion reactions from backscattering measurements

G.G. Adamian

*Joint Institute for Nuclear Research, Dubna, Russia*

Based on the reaction theory, we suggest an useful method for extracting total and partial reaction and capture (complete fusion) cross sections from the experimental elastic and quasi-elastic backscattering excitation functions taken at a single angle [1–3]. The methodology is developed for addressing complementary reaction observables, for example, the elastic-scattering differential cross section.


Hybrid systems like MRI/PET and MRI/gamma camera, offer advantages combining the resolution and contrast capability of MRI with the better contrast and functional information of nuclear techniques. This work presents the design of a low field NMR system made up of permanent magnets compatible with a gamma radiation detector based on gel dosimetry. The design is performed using the software femm for estimation of the magnetic field, and GEANT4 for the physical process involved in radiation detection and effect of magnetic field. The homogeneity in magnetic field is achieved with an array of NbFeB magnets in 1D configuration. The final magnetic field in the homogeneous zone is ca. mT.

Common radiation detectors are expensive and need an electronic set-up, which can interfere with the NMR process and vice versa. To avoid these problems, gel dosimetry is used as radiation detector, which is the innovative part.

As a result, the system described allows a complete integrated radiation detector within the MRI system and image acquisition technique. In our hybrid proposal, the spatial resolution strongly depends on the Pb collimator arrangement. We present the in silico 1D spatial resolution dependence on the collimator geometry; like height, width, gap, sample position and size among others. These results will contribute define the better arrangement for the final 2D planar images.
Fused positron emission and computed tomography (PET/CT) images have an important role in external beam radiotherapy (RT), especially for target volume delineation. For contouring on PET/CT images, the source-background algorithm is currently the used method, but its sensitivity to partial volume effects may produce inaccuracies when applied on small lesions. The goal of this research was to develop a computational algorithm based on the Canny’s edge detection tool for processing PET/CT images. The software was implemented using the data analysis framework ROOT and the Grassroots DiCoM GDCM libraries (CERN, Geneva, Switzerland). First, a preprocessing Gaussian smoothing was applied to these images. Then directional derivatives and gradients were computed on the basis of multivariate calculation tools. Upon completion of this process, the boundaries of uptake regions having cylindrical shape within an Agar phantom were automatically sought by searching for the gradient magnitude and laplacian upper a pre-defined gradient threshold.

The mean diameters calculated by using the developed software have differences below 3% respect to the measured value (69 mm) for all the gradient thresholds between 15% and 55%. The diameters delimitated with the source-background algorithm are different to the measured value and only are similar when a source-background threshold of 35% is defined. Images from the gradient magnitude and Laplacian of counts for the Agar Phantom with 18F-FDG PET-CT, are associated with diffusion processes explained by the Fick laws. According to the obtained results, methods of delimitation of tumors with 18F-FDG PET-CT are still useful, even in the presence of diffusive phenomena.
Perspectives of production of superheavy nuclei

N.V. Antonenko*

Bogoliubov Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, 141980 Dubna, Russia

Isotopic trends are studied in the production of superheavy nuclei in actinide-based complete fusion reactions with Ca, Ti, and Cr beams. The evaporation residue cross sections are estimated. We consider the possibilities of production of unknown isotopes of superheavy nuclei in the gap between those produced in cold and hot fusion reactions. The perspectives are studied to use the radioactive beams in producing superheavy isotopes.
What happens when Spins meet for Radiation Dosimetry?

Oswaldo Baffa

*University of São Paulo, Ribeirão Preto, Brazil*

Electron spin resonance (ESR) and magnetic resonance imaging (MRI) can be used to measure radiation dose deposited in different milieu through its effects. Chemical bonds are broken and if they produce stable free radicals, ESR can measure their concentration through their spins, and a dose can be inferred. The amino acid and alanine has been used for this sake due to its suitable properties. Ionizing radiation can also promote polymerization and in this case proton relaxation times can be measured and an image weighed by T2 can be produced. An end-to-end test using a composite Gel-Alanine phantom, in order to validate 3-dimensionally the dose distribution delivered by a single isocenter VMAT technique on the simultaneous treatment of multiple brain metastases will be presented. The results obtained with the gel and alanine dosimeters are consistent with the expected by the treatment planning system, showing the potential of this multidosimetric approach and validating dosimetrically the multiple brain metastases treatment using VMAT.
A preliminary assessment of a weighted index of beam angulation in radiation therapy

G. Píriz¹,², Y. Banguero¹, A. Quarnetí, y R. Doldan²

¹Universidad de la República, Uruguay.
²ONCOSUR

Radiotherapy as a tool for cancer treatment focuses in radiating the tumor while delivering the least possible radiation exposure to the organ at risk. There are multiple beam sets that can achieve acceptable doses distributions during the clinical practice; nevertheless, during the planning stage, the purpose is to strive to find which of these possible beam sets is better to the patient. To aid in this process, there has been developed planning indexes that assess among various options which is the most suitable for the patient.

Optimization methods have been introduced to radiotherapy to calculate independently from the person the most suitable treatment. Most of these models are used after choosing the direction of the input beams. This work introduce an index that can be used to find the most convenient angle beam and evaluate diverse plans that are likely to be given to the patient, helping to determine which one could be the most suitable.

The index is defined as the Planning Target Volume area seen from the beam weighted by its Percentage of dose in depth, less the projected area of this field on the organ at risk weighted by the percentage of dose in depth of this organ. After chosen an angle, the index is modified considering a function that impedes to choose again the same angle.

The application of this index to select the coplanar irradiation on a convex phantom, leads to consider classic fields into analyzed beams with or without intensity modulated radiation therapy.
A complete description of the fission process still represents a real challenge despite the recent progress based on microscopic quantum dynamic models [1]. Statistical models, proposed soon after the discovery of fission [2], provide an optimum tool to describe fission probabilities at excitation energies around the fission barrier, for which statistical times dominate over the typical time scales for the coupling between intrinsic and collective degrees of freedom (\(\sim 10^{-21} \text{ s}^{-1}\)). At high excitation energies, pre- and post-scission particle emission [3] and fission probabilities [4] indicate that simple statistical approaches are not valid anymore and models describing the dynamics of the process are required. These models are based on transport equations (e.g. Fokker-Planck or Langevin) including dissipative and stochastic terms where the main ingredients are the potential landscape and the friction and inertia tensors [5]. The friction or viscosity parameter is particularly interesting since it quantifies the magnitude of the coupling between collective and intrinsic degrees of freedom in fission.

During the last years several experiments have addressed this topic taking advantage of proton induced reactions at relativistic energies for producing highly-excited fissioning nuclei with low angular momentum [6] [7]. Under such conditions presaddle dissipative effects clearly manifest. More recently, the SOFIA experiment at GSI allowed for the first time the complete identification in atomic and mass number of both fission fragments [8]. The use of inverse kinematics and state-of-the-art tracking and time-of-flight detectors made possible to perform this challenging measurement. These high-quality data are used to investigate pre-
and post-saddle dissipative effects.

Hadron spectroscopy in the unquenched quark model

Roelof Bijker

ICN-UNAM, AP 70-543, 04510 México DF, Mexico

The constituent quark model (CQM) describes the nucleon as a system of three constituent, or valence, quarks. Despite the successes of the CQM (e.g. masses, electromagnetic coupling, magnetic moments), there is compelling evidence for the presence of sea quarks from the measurement of the flavor asymmetry of the proton and the so-called proton spin crisis. In this contribution, I present the unquenched quark model as an extension of the CQM that includes the effects of sea quarks via a $^3P_0$ quark-antiquark pair-creation mechanism. Particular attention is paid to the spin and flavor content, magnetic moments, and $\beta$ decays of baryons, as well as the strangeness suppression in the proton.
Hydrogen diffusion profiles in Zr based alloys by neutron imaging

N L Buitrago¹, A Tartaglione¹, M Schulz²,³, M R Daymond⁴, J R Santisteban¹

¹CONICET and Instituto Balseiro, Centro Atomico Bariloche, Argentina
²FRM II, Lichtenbergstr. 1, 85748 Garching, Germany
³Technische Universität München, Physik Department E21, James Franck Strasse, 85748 Garching, Germany
⁴Department of Mechanical and Materials Engineering, Queen’s University, Kingston, Canada

K7L 3N6

Neutron radiography is a technique similar and complementary conventional X-ray radiography (RX). This is because X-ray beams are mainly attenuated via interactions with the electrons surrounding the nuclei, so the attenuation coefficient increases with the atomic number Z. On the other hand, a neutron beam is attenuated via interactions with the atomic nuclei, with complex dependence on the nucleon number and spin state of the nucleus. This results in an attenuation coefficient dependent on the particular isotope, with no dependence on Z, which is particularly large for hydrogen. So the neutron attenuation coefficient in zirconium hydride is ~25 times larger than in metal Zr. This large difference has been exploited here to quantify very low content H profiles in Zr alloys by neutron radiography experiments. Zr based alloys are widely used in the nuclear industry, in fuel cladding and structural components of nuclear power reactors, because it’s low neutron absorption. Hydrogen (H) or deuterium (D) ingress due to waterside corrosion, and subsequently precipitates as a hydride phase that embrittles these alloys. In particular, these alloys are affected by a stress-corrosion cracking mechanism known as Delayed Hydride Cracking (DHC). DHC involves the diffusion of H into crack tips, followed by precipitation and rupture of hydrides into the stressed region ahead of the crack. Diffusion of H at operating temperatures determines the crack growth velocity. H diffusion coefficients in Zr alloys have been previously determined by measuring diffusion-induced H concentration profiles by destructive techniques. In this work, we have used neutron radiography to determine H diffusion profiles in Zr₂.₅Nb, a material used for pressure tubes of CANDU nuclear power plants. The experiments were performed at the Antares beamline of the FRM-2 reactor, Munich, Germany, on specimens of dimensions (10x7.5x4mm). The diffusion profiles measured for three temperatures near the operation temperature (350°C, 300°C and 250°C) are shown in Figure 1, together with the analytic diffusion profiles refined by least-squares fits to the data.
Figure 1: Profiles diffusion for 3 different annealing treatments with curve fitting.
The high luminosity requirements of Parity Violating electron Scattering (PVeS) experiments, such as the Jefferson lab $^{208}$Pb Radius Experiment (PREX), create several challenges for detector design. High purity, thin quartz Cherenkov detectors are extremely radiation hard and give a robust response for each electron with 20 - 25% resolution. These characteristics make them a good choice for PVeS experiments in which a high rate electron flux ($\sim 1$ GHz for PREX) needs to be counted. PVeS can map the distribution of weak charge in the nucleus, providing largely model-independent neutron densities. From the PREX measurement, the neutron skin of $^{208}$Pb can be determined—which is the difference between the nuclei’s neutron radius and proton radius. A clean measurement of the neutron skin of $^{208}$Pb has broad-based interest from fundamental nuclear structure and neutron star physics communities. This talk will introduce the PREX measurement and the design of its thin quartz detectors.
For certain combinations of protons and neutrons there is a theoretical expectation that the shape of nuclei can assume octupole deformation, which would give rise to reflection asymmetry or a “pear-shape” in the intrinsic frame, either dynamically (octupole vibrations) or statically (permanent octupole deformation). In this talk I will briefly review the historic evidence for reflection asymmetry in nuclei and describe how recent experiments carried out at REX-ISOLDE [2] have constrained nuclear theory and how they contribute to tests of extensions of the Standard Model. I will also discuss future prospects for measuring nuclear shapes from Coulomb Excitation: experiments are being planned that will exploit beams from HIE-ISOLDE [2] that are cooled in the TSR storage ring [3] and injected into a solenoidal spectrometer similar to the HELIOS device developed at the Argonne National Laboratory [4].

Neutrino emission, nucleosynthesis and the role of strong gravity

O. L. Caballero
Department of Physics, University of Guelph, Guelph, Ontario N1G 2W1, Canada

L. Lehner
Perimeter Institute for Theoretical Physics, Waterloo, Ontario N2L 2Y5, Canada

C. Palenzuela
Universitat de les Illes Balears, Atomic molecular and nuclear physics, Spain

S. Liebling
Long Island University, Department of Physics, Brookville, NY 11548 USA, USA

D. Nielsen
Brigham Young University, Department of Physics and Astronomy Provo, UT 84602, USA

E. O'Connor
North Carolina State University, Department of Physics Raleigh, NC 27607, USA

M. Anderson
Indiana University, Department of Physics, Bloomington, IN 47405-7105, USA

Neutron-star mergers are interesting for several reasons: they are proposed as the progenitors of short gamma-ray bursts, they have been speculated to be a site for the synthesis of heavy elements, and they emit gravitational waves possibly detectable at terrestrial facilities. The understanding of the merger process, from the pre-merger stage to the final compact object-accreting system involves detailed knowledge of numerical relativity and nuclear physics. In particular, key ingredients for the evolution of the merger are neutrino physics and the matter equation of state. In this talk, I shall discuss some aspects of neutrino emission from black hole accretion disks focusing on the effects that strong gravitational fields have on r-process nucleosynthesis. I’ll also show the impact that the equation of state has on neutrinos emerging from binary mergers and possible neutrino signals in water-Cherenkov detectors.
Alpha-scattering on $^6$He and on other light nuclei in the low-energy regime

L. Canton

*Istituto Nazionale di Fisica Nucleare, Sezione di Padova, Italy.*

Yu. A. Lashko

*Bogoliubov Institute for Theoretical Physics, Nat. Acad. of Sci. of Ukraine.*

K. Amos

*School of Physics, University of Melbourne, Victoria, Australia.*

P.R. Fraser

*Department of Physics, Astronomy and Medical Radiation Sciences, Curtin University, Western Australia, Australia.*

S. Karataglidis

*Department of Physics, University of Johannesburg, South Africa.*

J.P. Svenne, and D. van der Knijff

*Department of Physics and Astronomy, University of Manitoba, Canada.*

The multi-channel algebraic scattering (MCAS) method has been used mainly for nucleon-nucleus processes. Recently, it has been modified to solve coupled Lippmann-Schwinger equations for the $\alpha$-nucleus twocluster system. A collective-type Hamiltonian has been found that gives good agreement with the known bound states and the first few low-lying resonances for $^{10}$Be, described as $\alpha-^6$He. We have also found a reasonable reproduction of low-energy differential cross sections. The approach is now being extended to other $\alpha$-nucleus systems. In MCAS the Orthogonalizing Pseudo Potential (OPP) is used to offset the forbidden states. But there are more than just forbidden states if one looks at the microscopic cluster approaches. We have used an algebraic version of the resonating-group method to analyze microscopically the $\alpha+^6$He system and to derive the eigenvalues of the anti-symmetrization (norm) kernel in the Schroedinger equation. The deviation from unity of the Pauli-allowed eigenvalues introduces an effective inter-cluster interaction, genuinely generated by the Pauli/exchange effects, which can be used to qualitatively interpret the structure of the corresponding OPP. We discuss here the progresses obtained in this direction.


Niels Bohr introduced the concept of the compound nucleus in order to explain reactions in which an outgoing particle had lost all information of the incoming state (excepting conserved quantities). This could be understood as a process in which the incoming particle is absorbed by the target nucleus to eventually form a long-lived equilibrated system in which all nucleons are bound - the compound nucleus. The system decays when, through their mutual interaction, sufficient energy is given to one of the particles to allow it to escape. The compound nucleus has been found to play an important role in nuclear reactions over a large range of projectile-target combinations and energies. The limits that angular momentum places on the formation and existence of the compound nucleus are, for the most part, well understood. The limits on its excitation energy are not as clear. Here we briefly analyze general geometrical and thermodynamical features of a hot compound nucleus. We then discuss the manners by which it can decay and close by speculating on the limits to its existence.
Shape transition in $A \sim 190$ nuclei; a study via lifetime measurement in $^{188}$Pt

S.K. Chamoli, Aman Rohilla, C.K. Gupta  
*Department of Physics & Astrophysics, University of Delhi, New Delhi-110007, INDIA*

S. Chakarborty, S.K. Tiwari, H.P. Sharma  
*Banaras Hindu University, Varanasi - 221005, INDIA*

R.P. Singh, S. Muralithar  
*Inter University Accelerator Center, New Delhi - 110067, INDIA*

A. Kumar, I.M. Govil  
*Department of Physics, Panjab University Chandigarh - 160014, INDIA*

D.C. Biswas  
*Nuclear Physics Division, Bhabha Atomic Research Center, Trombay, Mumbai - 400085, INDIA*

The nuclei in mass region $A \sim 190$ are well known for the prolate-oblate shape co-existence/transition phenomena. The shape transitions phenomena has been observed through high spin gamma ray spectroscopy and lifetime measurements in nuclei like Hg & Tl of this mass region [1]. The calculations done for Pt nuclei in [2] indicate a smooth change of shapes from the prolate deformed $^{186}$Pt to nearly spherical $^{202-204}$Pt through the region of triaxially deformed $^{188-198}$Pt and slightly oblate $^{200}$Pt. A clearly change of shape from prolate to oblate in Pt nuclei is expected at $A = 188$. In recent high spin spectroscopic investigations, signatures of significant amount of reduced prolate collectivity has been observed in $^{188}$Pt [3]. The level lifetimes provide valuable information about the nuclear shape and also the shape change with increase in spin along a band. So, to study the shape transition phenomena in $^{188}$Pt and other nearby Pt isotopes, it is required to perform lifetime measurements. With this objective, an RDM lifetime measurement experiment has been performed at Inter University Accelerator Center (IUAC), Delhi using the $^{174}$Yb($^{18}$O, 4$n$)$^{188}$Pt reaction, at a beam energy of 84 MeV. For these measurements a thin target [4] of 700 µg/cm$^2$ of enriched $^{174}$Yb material evaporated on a 3.5 mg/cm$^2$ thick backing of natural Ta is used. A highly pure natural gold foil of thickness $\sim$8 mg/cm$^2$ is used as stopper. The data is taken for different target–stopper distances ranging from 8 - 10,000 µm in 22 unequal steps. The results obtained are very encouraging and do indicate a somewhat low deformation for the yrast sequence in $^{188}$Pt nucleus. However a sharp reduction in the collectivity with increasing spin in $^{188}$Pt, contrary to the other light neighboring Pt nuclei, indicates the volatile nature of deformation in Pt nuclei near $A \sim 190$ at high spins which needs further theoretical investigations. The detailed analysis of the results and other interesting conclusions drawn will be discussed during the presentation.


An energetic photon incident on a nucleon can interact directly with one of the quarks inside, causing the quark to undergo a flip in spin or endowing the quark with an orbital or radial excitation, and thus, by exciting the quarks to a higher energy state, the nucleon becomes more energetic. These excited states are called baryon resonances (N*s) and are short lived ($\sim 10^{-24}$ s). These N*s will dominantly decay into a ground-state nucleon and one or more mesons. The types of mesons produced and how they are distributed in space in the decay process provide key information on the internal symmetries of the quarks in the nucleon. The study of these excited states is called spectroscopy. And just as ordinary optical spectroscopy proved to be the incisive tool for understanding the electronic structure of the elements, we expect nucleon spectroscopy will reveal many of the basic features of the quark substructure of matter, and, in turn, it will provide a critical testing ground for theoretical models describing these systems.

In this talk, I will present the underlying physics ideas of baryon resonances from the perspective of the complementary transatlantic experiments CLAS (JLab) and BGO-OD (ELSA). I will discuss the two main directions of current experimental baryon resonance research, the search for new states through meson photoproduction and the study of resonance transition form factors obtained in electroproduction,
For decades, one of the fundamental pillars of nuclear structure has been the concept of single-particle motion in a central potential. This view leads to the appearance of shell structure governed by a mean-field with strong spin-orbit interaction. Nevertheless, shell structure changes as one moves away from the stability line. Phenomena such as neutron skins, halos, and changes in the ordering and spacing of energy levels have been observed on the neutron-rich side of the nuclear chart. Of paramount importance to study these shell-evolution effects, are nuclei around doubly-closed shells, for example nuclei around \(^{78}\text{Ni}\) \((Z = 28, N = 50)\). In order to experimentally access these exotic nuclei, advanced facilities

*Electronic address: m.l.cortes@gsi.de
such as RIBF at RIKEN, Japan, or the future FAIR facility at Darmstadt, Germany, are needed.

Inelastic proton scattering off $^{72,74}$Ni was performed at RIKEN as part of the first SEASTAR campaign at the RIBF. Isotopes were produced by the in-flight fission of a beam of $^{238}$U ions incident on a 3 mm thick Beryllium target. After production, neutron-rich radioactive isotopes were selected and identified on an event-by-event basis using the BigRIPS separator. Selected isotopes were focused onto the liquid hydrogen target of the MINOS device and gamma rays from inelastic ($p,p'$) reactions were detected with the DALI2 array consisting of 186 NaI crystals. Outgoing beam-like particles were identified using the ZeroDegree spectrometer. Gamma rays produced in the reaction were Doppler corrected and the first $2^+$ and $4^+$ states in both isotopes were identified. Using detailed Geant4 simulations, exclusive cross-sections for inelastic proton scattering were obtained from which deformation lengths can be extracted. The ongoing data analysis for both isotopes will be presented and a discussion on the implications of the measured cross sections on the independent motion of protons and neutrons on neutron-rich Nickel isotopes will be shown.
Radiation detectors based on natural silicate minerals: Application in monitoring processes in nuclear medicine

Edy E. Cuevas Arizaca, S. Watanabe
Institute of Physics, University of São Paulo, São Paulo, Brazil.

Claudio Meneghetti, Edemar Zanardo
INCOR – Heart Institute, University of São Paulo, São Paulo, Brazil

Cecil C. Robilota
CNN- Center of Nuclear Medicine, University of São Paulo, São Paulo, Brazil

Cecilia M. K. Haddad
Hospital Sírio-Libanês – Radiotherapy Section

Natural (or synthetic) silicate minerals are very sensitive materials concerning their thermoluminescence (TL) properties, both for low and high dose radiation. In the present work, green quartz was studied. It responds to centigray doses as well as to hundreds of kGy doses. We have produced chips by pressing quartz powder with about 11 tons/cm² pressure and then sintering at 1200 °C. Each chip is about 50 mg in weight and 6 mm diameter and 1,0 mm thickness. The calibration curve was obtained by irradiating several chips with gamma doses varying from 0,1 to 1,0 Gy. The resulting curve shows that a fraction of 0,1Gy can be measured.

For the first application, two sets of 12 chips each, were exposed to gamma rays emitted by $^{99m}$Tc used in scintillographic measurements of the heart of one patient and of the liver of another patient. The results have shown that they are adequate to detect emitted gamma rays, although physically they presented unexpected result, not understood as yet. The glow curves of the chips irradiated with $^{60}$Co γ-ray and with β-ray present peaks at 110, 230 and 310 °C. In our experiment peaks below 250 °C were eliminated. We repeat the experiment at Nuclear Medicine Center, University of São Paulo, using a phantom with solution of $^{99m}$Tc. A same result was obtained. We then took the chips to be irradiate with high energy X-Ray produced by a 6 MeV linear accelerator. This time 230 °C peak has been detected with peak height indicating a dose – value of 1.027 Gy white the dose measured by a ion chamber indicated 0,971 Gy

Acknowledgement: Financial support by FAPESP, CAPES and experimental facilities support by IPEN are gratefully acknowledged.
Microscopic description of $^6$He elastic scattering on heavy targets

P. Descouvemont

*Physique nucleaire theorique et physique mathematique, CP229 Universite Libre de Bruxelles B1050*

*Brussels, Belgium*

$^6$He elastic scattering on heavy targets ($^{58}$Ni, $^{120}$Sn, $^{208}$Pb) is investigated with fully microscopic $^6$He wave functions, defined in a three- cluster $\alpha+n+n$ model. Breakup effects are simulated by a discretization of the three-body continuum. The model is based on nucleon-target optical potentials, which are well known for the targets considered. Equivalent polarization potentials are presented and discussed.
Estimate of the effective dose in patients treated with $^{131}\text{I}$ from *in vivo* measurements

Gloria Díaz-Londoño*, Marcia García, Sebastián Bahamonde, and Gianina Sirandoni

*Departamento de Ciencias Físicas. Universidad de La Frontera, Francisco Salazar 01145, Temuco, Chile.*

Thyroid cancer and some benign thyroid diseases are treated with $^{131}\text{I}$ therapy, which is administered orally or intravenously, concentrating mainly in the thyroid. Experts are currently discussing the use of high or low of 131 in therapy activities. To contribute to this debate, it is necessary to obtain information on doses in patients for which this study establishes a methodology for estimating the effective dose in patients with thyroid diseases who are treated with $^{131}\text{I}$ in Dr. Hernán Henríquez Aravena Hospital, in Temuco, Chile, from in vivo measurements using a calibrated gamma spectrometry system and specifically implemented for that purpose.

Keywords: Nuclear medicine, gamma spectrometry, effective doses.

*Electronic address: gloria.diaz@ufrontera.cl*
Beta-delayed neutron emission of very neutron-rich isotopes

Iris Dillmann and collaborators
TRIUMF Vancouver, Canada

Beta-delayed neutron (bn)-emitters play an important, two-fold role in the stellar nucleosynthesis of heavy elements in the “rapid neutron-capture process” (r process). On one hand they lead to a detour of the material beta-decaying back to stability. On the other hand, the released neutrons increase the neutron-to-seed ratio, and are re-captured during the freeze-out phase and thus influence the final solar r-abundance curve. For this reason the neutron branching ratio of very neutron-rich isotopes is a crucial parameter in astrophysical simulations.

A large fraction of the isotopes for r-process nucleosynthesis are not yet experimentally accessible and are located in the “Terra Incognita”. With the next generation of fragmentation and ISOL facilities presently being built or already in operation, one of the main motivations of all projects is the investigation of very neutron-rich isotopes at and beyond the border of presently known nuclei. However, reaching more neutron-rich isotopes means also that multiple neutron-emission becomes the dominant decay mechanism.

The investigation of bn-emitters has recently experienced a renaissance. I will show some results from the measurement of the heaviest bn-emitters identified so far with the BELEN setup at GSI Darmstadt [1]. Other high-accuracy measurements of neutron branching ratios of isotopes labelled by the IAEA as “high priority” have been carried out at the IGISOL facility in Jyvaskyla/Finland. And last but not least I will talk about two neutron detection setups which will start taking data in 2016- the BRIKEN array at RIKEN/Japan and the GRIFFIN gamma-spectrometer with its neutron detector DESCANT at TRIUMF/Canada.

We review the Statistical Multifragmentation Model (SMM), developed in 1984 [1], which considers a generalization of the liquid-drop model for hot nuclei and allows one to calculate thermodynamic quantities characterizing the nuclear ensemble at the disassembly stage. We show how to determine probabilities of definite partitions of finite nuclei and how to determine, through Monte Carlo calculations, observables such as the caloric curve, multiplicity distributions, heat capacity, among others.

The experimental measurement of the caloric curve [2] confirmed the SMM predictions of over 10 years before, leading to a surge in the interest in the model. However, the experimental determination of the fragmentation temperatures relies on the yields of different isotopic species, which were not correctly calculated in the schematic, liquid-drop picture, employed in the SMM. This led to a series of improvements in the SMM, in particular to the more careful choice of nuclear masses and energy densities, specially for the lighter nuclei [3]. Other, more recent developments, in particular the consideration of different temperatures for the fragments and the one associated to their motion [4] are also reviewed.

At the Radioactive Isotope Beam Factory stable primary beams are accelerated up to 345 MeV/nucleon and incident on a target to produce secondary beam cocktails with the fragment separator BigRIPS [1] ranging from the lightest nuclei up to the uranium region. For in-beam gamma-ray spectroscopy, the secondary beams impinge on a reaction target at energies between 100 and 300 MeV/nucleon. Reaction residues are detected with the ZeroDegree spectrometer and gamma-rays detected with the NaI(Tl) based DALI2 array [2]. Since spring 2014, in-beam gamma experiments are also performed with the liquid hydrogen target system MINOS [3]. This device includes a time projection chamber around the reaction target which enables the reconstruction of the vertex position, thus allowing for very thick reaction targets that result in a luminosity of about a factor three higher than with conventional solid reaction targets. In my presentation I will give an overview of latest experiments performed at the RIBF employing this technique and recent results including the measurements including spectroscopy around the doubly magic $^{78}\text{Ni}$, $^{100}\text{Sn}$, and $^{132}\text{Sn}$.

The 12 GeV Upgrade of the Continuous Electron Accelerator Facility (CEBAF) at Jefferson Lab, located in Newport News, Virginia, United States, will enable a new and exciting experimental program with substantial discovery potential in nuclear, hadronic and electroweak physics. In this talk, we will focus on the novel construction and operation of the CEBAF Large Acceptance Spectrometer, CLAS12. With the advent of new detector technologies and high rate electronics, this facility offers a powerful combination of experimental tools that far exceed the capabilities of previous experiments. This opens up the study of new landscapes of the nucleon structure and allows us to move far beyond the simple one dimensional patron distribution function of the past. In this talk, we will present the status and plans for the 12 GeV upgrade at Jefferson Lab, and discuss the CLAS12 science program. Its mission is to break new ground in our understanding of the complex structure of the nucleon and the formation of hadrons and their properties with special emphasize on the multi-dimensional imaging of the nucleon.
Engaging local industry in the development of basic research infrastructure and instrumentation – The case of HIE-ISOLDE and ESS Scandinavia

Claes Fahlander

Department of Physics, Lund University, Sweden.

Two world-class particle accelerators, the European Spallation Source, ESS, and the MAX-IV facility, are being built in southern Sweden. They will primarily, when completed, be used for research in the fields of material sciences, life sciences and medicine. Their construction, however, will create new business opportunities for companies in Europe in general and in Sweden, Denmark and Norway in particular in many different sectors. An Interregional Fund within the European Union have funded the project CATE, Cluster for Accelerator Technology. The main purpose of CATE was to strengthen the skills of companies in the Oresund-Kattegat-Skagerrak region in Scandinavia in the field of accelerator technology such that they will become more competitive and can take advantage of the potential of these two research facilities. The skills development was achieved through technology transfer from the academy to the companies in several steps to be discussed in the talk. The project is based on the knowledge and experience of the participating research groups of the universities in the region, combined with the knowledge and experience of the accelerator experts from the involved research facilities, including HIE-ISOLDE at CERN, and of the regional councils and business organisations in mapping out relevant companies. All together fourteen partners were involved in CATE. CATE is strategically important to the Oresund-Kattegat-Skagerrak region and has already helped to create partnerships between business, cross-border partnerships and new business opportunities that would not have happened without CATE.
Sweden is top ranked as the most innovative nation in the world (Global Innovation Index 2015). The academic staff at Swedish universities has the right to their inventions (research-ownership of patent rights) as opposed to far more diffused university-ownership. Since 1998 the Swedish Higher Education Act imposes Swedish universities a so-called Third task, that in addition to education and research collaborate with the society and to inform the society about their activities. How does the largest university in Scandinavia deal with dissemination of research results to industry and society?

The presentation will touch upon technology transfer, professional education and regional development as well as commercialization of research results.
Theoretical studies of proton radioactivity

Lídia S. Ferreira

CEFEMA / Instituto Superior Tecnico, Univ. Lisboa, Portugal

In the present talk, we will discuss the most recent theoretical approaches developed by our group, to understand the mechanisms of decay by one proton emission, and the structure and shape of exotic nuclei at the limits of stability.
Open questions in nuclear collective motion

S. Frauendorf

Department of Physics, University Notre Dame, IN 37556, USA

The phenomenological description of the quadrupole mode in the framework of the Bohr-Hamiltonian will be reviewed with focus on evidence for triaxial shapes (seniority doublets, wobbling excitations). The foundations of the IBM (constructing s- and d- bosons from the fermionic valence space, boson counting) will be critically discussed. Microscopic calculations of the the collective quadrupole excitations in the frame work of the ATDHF and GCM methods will be reviewed, where the severe limitations due to the adiabatic approximation will be exposed. The Tidal Wave concept and the Projected Shell model will be presented as new approaches that take the strong coupling between the collective and quasiparticle degrees of freedom into account.
Implementation of a gamma spectrometry system for measuring accumulated activity in thyroid of patients treated with $^{131}$I in one Nuclear Medicine Unit of Chile

Marcia García*, Gloria Díaz-Londoño, Sebastián Bahamonde.
Departamento de Ciencias Físicas. Universidad de La Frontera, Francisco Salazar 01145, Temuco, Chile.

Pablo Andrade, and Felipe Ruíz.
Departamento de Ingeniería Mecánica. Universidad de La Frontera, Francisco Salazar 01145, Temuco, Chile.

The accumulated activity in the thyroid of patients treated with $^{131}$I can be obtained from \textit{in vivo} and \textit{in vitro} measurements, or through images. Given the conditions of the infrastructure of the Nuclear Medicine Unit of the Regional Hospital of Temuco, in Chile, the feasibility of implementing a system of gamma spectrometry in the isolation room of the patient to direct measures in thyroid was studied. For this purpose the design, construction and calibration of this experimental system, considering the different characteristics of the patients in the study, is presented in this work.

Keywords: Nuclear medicine, gamma spectrometry, accumulated activity.

*Electronic address: marcia.garcia@ufrontera.cl.
Laser spectroscopy studies in the calcium region and future perspectives

R. F. Garcia Ruiz\textsuperscript{1,2}
on behalf of the COLLAPS and CRIS collaborations at ISOLDE-CERN

\textsuperscript{1}Instituut voor Kern-en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.

\textsuperscript{2}School of Physics and Astronomy, The University of Manchester, Manchester M13 9PL, UK.

Nuclei in the vicinity of magic numbers are of particular importance since their simple structure provides an ideal test to our knowledge of the nuclear force, and constitute a benchmark for the development of many-body methods.

The properties of stable nuclei in the neighborhood of the two naturally occurring doubly-magic calcium (\(Z = 20\)) isotopes, \(^{40}\text{Ca}(N = 20)\) and \(^{48}\text{Ca}(N = 28)\), have been extensively studied, both from experiment and theory. Recently, special attention has been given to the evolution of nuclear structure on neutron-rich isotopes beyond \(N = 28\), where evidence of two additional closed-shells at \(N = 32\) \cite{Wienholtz2013} and \(N = 34\) \cite{Steppenbeck2013} have been reported. This contribution presents the latest results from laser spectroscopy experiments in this region.

Measurements of the hyperfine structure spectra and isotope shifts of K (\(Z = 19\)) and Ca (\(Z = 20\)) isotopes were obtained by using an optical detection technique in collinear laser spectroscopy at ISOLDE, CERN. From these new experimental results, the nuclear ground-state spins, the ground-state electromagnetic moments and the changes in the root-mean-squared charge radii were extended up to \(N = 32\) \cite{Papuga2013a,m3-m7}.

With relatively low production yields, the \(^{51}\text{K} (\sim 4000 \text{ ions/s})\) and \(^{52}\text{Ca} (\sim 250 \text{ ions/s})\) isotopes are at the limit of the optical detection techniques. In order to extend these measurements further away from stability, ultra-sensitive particle detection schemes need to be employed.

The current developments in this direction and the perspectives for future experiments using collinear resonance ionization spectroscopy \cite{Flanagan2013} \cite{Flanagan2015} in the Ca region will be discussed.

\begin{thebibliography}{9}
\end{thebibliography}
New approach to characterize the alpha particles registered in LR-115 detectors

Vanessa García†, Daniel Palacios, Laszlo Sajo-Bohns

Universidad Simón Bolívar, Nuclear Physics Laboratory, Sartenejas, Caracas, Venezuela

We propose a new method for determining the energy and incident angle of the alpha particles that induce visible tracks in LR-115 detectors. The method is based on data of geometric shapes of etched tracks since they provide all information regarding the characteristics of alpha particles registered in the passive detectors, i.e. energies and angles. The studied geometric parameters were the major and minor axes of surface and bottom openings of simulated tracks and the corresponding axes of track images projected on detector surface. The last case corresponds to how tracks are visualized by a transmission optical microscope focused on detector surface. The geometric parameters were extracted from tracks simulated with the TRACK_TEST program, considering the standard etching conditions (2.5 N NaOH solution at 60° for 2 hours) and the Durrani and Green V function with the best constants describing experimental results. The “ImageJ” software was used for digitalized image processing. The particle energy and incident angle was estimated applying an interpolation process and successive approximations in concordance to known parameters of the associated track. The uncertainties in the calculated values were lower than 5%. Although simulated tracks were used, the proposed approach to characterize the alpha particles registered in LR-115 detectors in principle is also valid for experimental tracks since it is not derived from any model or particular mechanism of etched track formation. The comparison of alpha particle characteristics obtained by direct measurements of parameters of track images projected on detector surface, or indirectly, using the parameters of surface and bottom openings of tracks, showed that the latter method offer several advantages.

†Electronic address: dpalac@usb.ve
Nuclear Structure Studies with $\beta$-decay at TRIUMF-ISAC

Paul E. Garrett

Dept. of Physics, University of Guelph, Guelph, ON, N1G2W1, Canada

The $8\pi$ spectrometer at TRIUMF-ISAC was the world’s premier device for $\gamma$-ray spectroscopy following $\beta$-decay at the TRIUMF-ISAC radioactive beam facility. Its highly successful operation involved measurements of Fermi super-allowed $\beta^+$ emitters for fundamental symmetry tests, and a number of experiment focused on nuclear structure studies. While no longer a state-of-the-art device, through development of specialized auxiliary detectors and careful attention to the data acquisition system, it became the world’s most sensitive spectrometer for $\beta$-decay studies achieving unmatched precision in $\gamma$-ray half-life measurements, routinely observed $\beta$-decay branches at the parts-per-million level, and individual $\gamma$-ray branches from excited states at the 0.01% level.

While the $8\pi$ was a world-leading spectrometer, it represented 30-year-old technology in its Ge detectors. In January 2014 it was decommissioned and in September 2014 we commissioned a new spectrometer, GRIFFIN, composed of 16 large-volume clover HPGe detectors that represents a gain of more than two orders of magnitude in $\gamma$-$\gamma$ coincidence efficiency at 1 MeV.

This presentation will focus on some examples of research with the $8\pi$ spectrometer, focusing on the high-statistics studies for nuclear structure studies, and provide an overview of GRIFFIN with some very early results.
Low energy experiments at the “precision frontier” provide a powerful probe of early universe. A brief introduction to the Institute Laue-Langevin (ILL) in Grenoble, France, which is a world leader in academic research with neutrons will be given. The scope of fundamental physics studies with neutrons is outlined. The main instruments provided for such studies are described and some past and current flagship experiments with ultra-cold neutrons (UCN) in this field (lifetime, electric dipole moment, quantum states) are highlighted. A brief outlook on future projects is given.
Novel applications from latest nuclear physics developments

J. Gerl

Department of Gamma Spectroscopy,
GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany.

Experimental nuclear physics requires sophisticated particle and radiation detectors, forefront electronics and high performance data acquisition systems. This high-tech instrumentation can serve for a multitude of practical applications. The NUSTAR collaboration develops and constructs novel experimental set-ups for the current nuclear structure, astrophysics and reactions programme at GSI and its proposed continuation and extension at the FAIR facility. R&D efforts result already now in improved detectors and enables the NUSTAR collaboration to steadily enhance the sensitivity and selectivity limit of their experiments. Interesting technologies derived from these developments find applications in medicine and biology, security and environment, industrial control and quality assurance. Recently realized products, latest developments and future perspectives will be discussed.

*Electronic address: j.gerl@gsi.de
Tagged EMC - Exploring the correlations between the EMC effect and nucleon-nucleon short-range correlations

Shalev Gilad and Barak Schmookler

Massachusetts Institute of Technology

A linear correlation is observed between the slope of the EMC universal curve for $0.3 < x_B < 0.7$ in deep-inelastic (DIS) lepton scattering, $d[F_2(A)/F_2(d)]/dx_B$, and $a_2(A/d)$, the per-nucleon inclusive electron scattering cross-sections ratio of nucleus $A$ to deuterium for $1.4 < x_B < 2$. The value of $a_2(A/d)$ is associated with the number of short-range correlated nucleon pairs in nuclei. This correlation is surprising because of the vastly different energy and distance scales of EMC and short-range nucleon-nucleon correlations (SRC).

A possible explanation of this correlation is that the modification of $F_2(A)$, the nucleon structure-function in the nuclear medium, depends on the virtuality of nucleons and is pronounced for short-range correlated nucleons that are highly virtual.

We are studying this hypothesis by studying EMC events “tagged” by high-momentum protons recoiling backward to $q$. Such protons have been shown to be spectators from scattering off their short-range correlated partners.

The data were collected using the CLAS6 detector in Hall B of JLab and have not been previously analyzed. They consist of DIS off several nuclei and are being analyzed now as part of the “data mining” project. We shall present results of inclusive DIS $A(e,e'X/d(e,e')X$ (“normal” EMC) and semi-exclusive DIS $A(e,e'_{recoil})X/d(e,e'_{recoil})X$ (“tagged” EMC). We shall discuss these results with respect to our hypothesis that the EMC effect, to a large extent, is related to DIS from highly virtual, short-range correlated nucleons.
Limitations of Reduction Methods for Fusion and Total Reaction Cross Sections.

P.R. S. Gomes, L. F. Canto*, D. Mendes Jr., J. Lubian, P. N. de Faria

Instituto de Física, Universidade Federal Fluminense, Niterói, R.J., Brazil.

*M Instituto de Física, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil.

M. S. Hussein

Instituto de Física, Universidade de São Paulo, São Paulo, S.P., Brazil.

We show results of the investigations of the three most frequently used methods to reduce fusion and total reaction excitation functions. These methods are widely used in the literature, especially to compare the cross sections of weakly and tightly bound systems, and then to find out the effects of the breakup of the weakly bound nuclei on these reaction processes. We calculate theoretical cross sections obtained by single channel calculations based on standard optical potentials. The methods considered as successful if the cross sections for different systems are about the same. In the case of fusion excitation functions, we confirmed that the fusion function method is the only one that works very well, for any system at any energy regime. Regarding total reaction excitation functions, none of the methods was satisfactory. Their reduced reaction cross sections kept a strong dependence on the atomic and mass numbers of the collision partners. Next, we used the three methods to reduce experimental fusion and reaction cross sections for many systems, over a broad mass range. Our conclusions were consistent with the ones reached in our theoretical cross sections, resulting from single channel calculations. That is, the fusion function method is the best for fusion data, whereas none of the three methods works for total reaction. Finally, we make a revision of conclusions of tens of published papers on total reaction cross sections, when we find that several of them are not correct, since some of the effects described as owing to the breakup process are, in fact, consequences of the limitations of the reduction methods used.

Very recently we have investigated the most frequently used methods to reduce fusion and total reaction excitation functions. These methods are widely used in the literature, especially to compare the cross sections of weakly and tightly bound systems, and then to find out the effects of the breakup of the weakly bound nuclei on these reaction processes. In the case of fusion excitation functions, we confirmed that the fusion function method is the only one that works very well, for any system at any energy regime. Regarding total reaction excitation functions, none of the methods was satisfactory. Their reduced reaction cross sections kept a strong dependence on the atomic and mass numbers of the collision partners. In the present work we make a revision of conclusions of almost twenty published papers on total reaction cross sections, when we find that several of them are not correct, since some of the effects described as owing to the breakup process are, in fact, consequences of the limitations of the reduction methods used.
itations of the reduction methods used. Then, possible general conclusions are also presented.
Weak interaction studies with francium

E. Gómez.

*Instituto de Física, Universidad Autónoma de San Luis Potosí, San Luis Potosí 78290, México*

S. Aubin

*Department of Physics, College of William and Mary, Williamsburg, Virginia 2319, USA*

J. Zhang, M. J. Kossin, L. A. Orozco

*Department of Physics, Joint Quantum Institute, University of Maryland, and National Institute of Standards and Technology, College Park, Maryland 20742, USA*

M. Tandecki, J. A. Behr, A. Gorelov, M. R. Pearson

*TRIUMF, Vancouver, British Columbia V6T 2A3, Canada*

R. Collister, K. L. Shiells, G. Gwinner

*Department of Physics and Astronomy, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada*

Y. Zhao

*Shanxi University, China*

We present progress on the FrPNC collaboration’s preparations to measure atomic parity nonconservation (PNC) and the nuclear anapole moment in a string of francium isotopes at TRIUMF. Atomic PNC experiments use parity-forbidden optical transitions to provide unique high-precision tests of the electroweak sector of the standard model at very low energies. Furthermore, measurements of spin-dependent atomic PNC can probe the weak force within the nucleus and measure the nuclear anapole moment, a parity-violating electromagnetic moment induced by the weak interaction between nucleons.

Francium is an excellent candidate for precision measurements of atomic PNC due to its simple electronic structure and enhanced parity violation: Both the optical PNC and anapole moment signals are expected to be over an order of magnitude larger than in cesium. Our approach differs significantly from other atomic PNC experiments: we target multiple isotopes and use cold atom traps, which benefit from compact sample volumes and long integration times.

The FrPNC collaboration has completed the construction of a high-efficiency laser cooling and trapping apparatus for collecting francium atoms produced from a uranium carbide target and delivered to an on-line shielded laser laboratory. A first laser cooling chamber neutralizes, collects, and cools the francium. This ultracold sample is then transferred 70 cm to a second laser cooling and trapping chamber: this “science chamber” features good optical access, a long trap lifetime, and a well-controlled electromagnetic environment for upcoming
optical and microwave PNC experiments. The apparatus is also compatible with rubidium, which we use for operational tests and assessments of systematic errors. Recent measurements and analysis of the hyperfine anomaly in a number of francium isotopes identify a favorable set (207-213Fr) with a relatively simple nuclear structure for the valence nucleons; these nucleons also play a key role in generating the anapole moment.

The weak mixing angle will be determined from an optical PNC measurement of the parity forbidden E1 transition amplitude for the 7s-8s transition – a method originally pioneered by Wieman and co-workers in cesium. The anapole moment can be measured through microwave spectroscopy of forbidden E1 transitions between hyperfine ground states or through the dependence of the optical PNC signal on the hyperfine states. The optical and microwave experiments are each implemented via their own modular sub-apparatus attachment to the science chamber.

Work supported by DOE, Fulbright, and NSF from USA, NSERC, NRC, and TRIUMF from Canada, and CONACYT from Mexico.
Neutron detector arrays used in the Neutron Backscattering Technique

J. Gómez-Muñoz*, and F. Cristancho

Universidad Nacional de Colombia, Bogotá D.C., Colombia

In Colombia, after decades of conflict, many geographical areas are believed to be contaminated by mines, Improvised Explosive Devices (IEDs) and other explosive ordnance. Mines laid by non-state armed groups are found around schools, houses and roads in rural areas. In some cases only the mined area is established however the exactly location of mines is unknown, this situation generates a latent threat to the civilian population. One of the nuclear techniques that are being investigated in different countries in the field of explosives detection and demining is the Thermal Neutron Backscattering Technique (NBT). The NBT is based on the fact that the buried target is Hydrogen-rich and therefore if it is in a media with different Hydrogen content and it is exposed to a fast neutron source, the number of backscattered thermal neutrons produced by the moderation process will give us a signal from which we can infer the presence of the Hydrogen-rich target. The NBT is used to locate buried hydrogen-rich objects using fast neutron source and two $^3$He neutron detectors arrays. The NBT has been used in controlled conditions with extensive detector arrays (four per array), also in different types of soil (sand and farming soil) and different soil water content [1], [2]. The use of NBT in real or field conditions requires the minimization of electronic modules and optimization of geometrical parameters. The geometrical location of detectors is important for the optimal technique development. Special problems need to be understood as well as is necessary to study the advantages, disadvantages and limits of the technique in the Colombian case. One of the most important issues that have to be investigated is the soil moisture. The results of experiments and Geant4 simulations are going to be presented with the purpose of showing different possibilities of the detector arrays location, number of detectors per array, dependence with different soils and the best performance in the data analysis.

Keywords: Neutron backscattering; Humanitarian demining; Soil moisture; Geant4


*Electronic address: jgomez@unal.edu.co
Synthetic crystals production of CaSiO$_3$ and its application in radiation dosimetry

Carlos Gonzales, Shigueo Watanave, and Nilo Cano

Instituto de Física, Universidade de São Paulo

Cecilia Haddade

Radiotherapy Section, Hospital Sirio-Libanês, São Paulo, Brazil

The use of different types of radiation is being increasingly widespread in various human activities such as the intensive development of radiation technologies; high energy nuclear physics, while in nuclear medicine low dose radiation are involved. The radiation, on the other hand can be harmful to human being and radiation dosimetry becomes very important one. There are different systems in the radiation dosimetry and that based on thermoluminescence crystals is one of the most important. Among many such crystals, like LiF, the silicate crystals with high sensitivity are becoming very useful for radiation dosimetry. In our laboratory several natural silicate minerals have been investigated. For example the green quartz was proved to be very sensitive dosimeters both for low (mGy) and for high and very high radiation doses. In this project we produced synthetic CaSiO$_3$ which proved to be very sensitive as far as TL is concerned, in other words, it can be a useful radiation dosimeter. For high dose radiation CaSiO$_3$ can detect up to 500 kGy. On the other hand 20 mg of this silicate crystal can detect X ray produced by 6 MeV electrons with a dose of test than 1 Gy. Therefore CaSiO$_3$ can be used in nuclear medicine imaging as well as in monitoring radiation in a radiotherapy session.

Acknowledgements: we are thankful to FAPESP and CAPES for financial support. We are also thankful to CTR-IPEN for irradiation of samples.
New Physics search with β decays in the LHC era*

Martín González-Alonso

/IPN de Lyon/CNRS, Universite Lyon 1, Villeurbanne, France

Precision measurements in nuclear and neutron beta decay offer a sensitive window to search for new physics beyond the standard electroweak model. This talk reviews the constraints on new physics obtained from these processes and from other low-energy searches. The degree of complementarity between them will be reviewed using a model-independent approach. Moreover, a direct comparison with LHC searches can be also performed assuming that the new interactions are mediated by very heavy particles. We find that depending on the interaction the LHC bounds are stronger or weaker than those from beta decays, showing a clear complementarity between both searches. The sensitivity requirements of new precision experiments in beta decay, to impact the search for new physics at the light of current and projected LHC results, will be discussed.


---

*This work was supported in part by the LABEX Lyon Institute of Origins (ANR-10-LABX-0066) of the Université de Lyon, within the program ANR-11-IDEX-0007 of the French government.
Mapping of space radiation in LEO orbit by the SATRAM/Timepix payload* on board the ESA Proba-V satellite

Carlos Granja†, Stepan Polansky, Stanislav Pospisil, Zdenek Vykydal
Institute of Experimental and Applied Physics (IEAP), Czech Technical University (CTU), Prague, Czech Republic

Alan Owens, Karim Mellab
European Space Research & Technology Centre (ESTEC), European Space Agency (ESA), Noordwijk, The Netherlands

The compact spacecraft payload SATRAM has been operating since launch in May 2015 in open space on board the Proba-V satellite from ESA. Equipped with the hybrid semiconductor pixel detector Timepix, the payload provides the composition and spectral characterization of the mixed radiation field with quantum imaging dosimetry sensitivity, single-particle energy loss capability, energetic charge particle tracking and directionality and wide dynamic range in terms of particle types, dose rates and particle fluxes. With a polar orbit (sun-synchronous, 98° inclination) at the altitude of 820 km the payload samples the space radiation field at LEO providing the planar visualization of the closer side of the inner Earth radiation belt over basically the whole planet (see Fig. 1). First results of long-period data evaluation in the form of time-and spatially-correlated maps will be presented.

Fig. 1. Earth map of space radiation in LEO orbit at 820 km measured by SATRAM/Timepix payload on board the Proba-V satellite. The total dose rate is shown (in units uSv/h displayed in color in log scale) for the Northern (a) and Southern (b) hemispheres. The polar horns of the radiation belts are revealed together with the South Atlantic Anomaly (b). Data displayed for the period January-July 2015. Regions and bins in black correspond to locations not covered by the satellite, or where data was not collected, respectively.

*Design and construction of the SATRAM/Timepix spacecraft payload was done by the Czech Space Research Center CSRC Brno and the IEAP CTU with funding by ESA grant 641-120004M. Research carried out in frame of the Medipix Collaboration.
†Electronic address: carlos.granja@utef.cvut.cz
Imaging and characterization of primary and secondary radiation in ion-beam radiotherapy

Carlos Granja

Institute of Experimental and Applied Physics, Czech Technical University in Prague

Imaging in ion beam therapy is an essential and increasingly significant aiding tool for the purposes of diagnosis and treatment planning. Current efforts aim at providing radiation field characterization and online monitoring of radiation dose distribution. This lecture (i) briefly reviews the principles and status of conventional existing techniques and (ii) presents the research and advanced techniques of radiation imaging, mixed radiation field characterization and high-resolution particle tracking for proton and light ion beam therapy developed by the IEAP CTU Prague and HIT Heidelberg group.
The development of the electronics industry worldwide achieved great advances from the 70s, with studies on oxidation process in field effect silicon transistors. Thus, there was a need for knowledge of the mechanisms that are present in oxides and interfaces between silicon and silicon oxides, as well as other compound semiconductors due to critical differences between the properties of silicon [1,2]. Against this background, many studies have been performed to understand reliability and ionization radiation effects on electronic devices. Reliability problems and effects of ionizing radiation on electronic devices are critical, depending on the environment in which the devices are exposed. This is the case of space, avionics, particle accelerators, nuclear reactors. This research area is strategic for space and defense areas [1], [2]. Thus, it is of fundamental importance to conduct tests to qualify electronic devices submitted to irradiation, based on Total Ionizing Dose (TID), Single Event Effects (SEE) and Displacement Damage (DD). This work shows tests using X-ray and ion beams to test commercial MOSFETs (Metal Oxide Semiconductor Field Effect Transistor). The integrated circuit: CD4007, pMOSFET: 3N163, and FPGA: Spartan 3E, were exposed to ion beams using the São Paulo 8UD Pelletron Accelerator and 10 keV X-ray radiation using a Shimadzu XRD-7000. The total dose effects due to ionizing radiation in MOSFET devices can lead to trapping of charges in the oxide and at the interface Si/SiO2, which increases or decreases the transistors off-current and leakage currents, and shifts the threshold voltage. Single Event Effects (SEE) are caused when a sufficiently high energy heavy ion beam create a high density of charge carriers within the sensitive volume. Characteristic curves of different parameters as a function of gate voltage and total ionizing dose, in different irradiation conditions, for p and n-MOSFET transistors, were studied, as well as the up the SEE cross section and upsets in the FPGA.


[2] M.A.G. Silveira et al., Nucl. Instr. and Methods in Physics Research B, 2011. This work was supported in part by Centro Universitário da FEI, CNPq, FAPESP and FINEP.
Study of electronic braking in liquid water under the formalism of Lindhard, for use in Proton computed tomography

A.F. Guerrero*

Department of Physics: Interdisciplinary Institute of Science, University of Quindio, Armenia, Colombia.

J. M. Hormaza

Department of Physics and Biophysics: Institute of Biosciences, Universidade Estadual Paulista Botucatu, Brazil.

Because of the behavior that have charged particles interacting with biological material, the proton therapy is shaping the future of radiation therapy in cancer treatment. The planning of radiation therapy is made up of several stages, the first is the diagnostic image, in which you have an idea of the density, size and type of tumor being treated.

The purpose of computed tomography with proton beam (PCT) is the measurement of the patient Stopping power $S_{\text{patient}}(E, \vec{r})$, as a function of incident beam energy and the relative position. Once done that, you can make accurate estimates of where is going to be the maximum dose of radiation (Bragg peak) being an important tool in planning treatments with this technique.

In this work is made the calculation of inelastic mean free path (IMFP) $\lambda(E)$, stopping power (SP) $S(E)$, and energy loss straggling (ELS) $\Omega^2(E)$, for a proton beam interacting with a liquid water target, in the range of proton energies $10^1$ eV $10^{10}$ eV, taking account all the charge states.

It is done a reconstruction of the experimental Bethe surface of liquid water, and by using the Lindhard dielectric formalism [2] and the Y. R. Waghmare model for the charge distribution of the proton [3]; it is found that normalizing the curves, the model of Lindhard provides a good approximation to more complex models and computationally expensive as the MELF-GOS [1] to the charge state H$^0$ but no for H$^+$. 

Keywords: Electronic braking in water, Tomography PCT, Lindhard formalism


*Electronic address: afguerreror@uqvirtual.edu.co.
Lifetime measurements of excited states of $^{106\text{cd}}_{48}$ using the Doppler Shift Attenuation Method

Z.E. Guevara*, D.A. Torres†, F. Ramirez
Departamento de Física, Universidad Nacional de Colombia, Carrera 30 No 45-03, Bogotá, Colombia

G.J. Kumbartzki, N. Benczer-Koller, Y. Y. Sharon
Department of Physics and Astronomy, Rutgers University, New Brunswick, New Jersey 08903, USA

K.-H. Speidel
Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Bonn, Germany

J. M. Allmond
Joint Institute for Heavy Ion Research, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA

P. Fallon, H.L. Crawford, L. Phair, A. Wiens
Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

I. Abramovic, A. Hurst, L. Kirsch, T. LaPlace, A. Lo, E. Matthew, I. Mayers
Department of Nuclear Engineering, University of California, Berkeley, CA 94720, USA

L. Bernstein
Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA

Department of Nuclear Engineering, University of California, Berkeley, CA 94720, USA

Lawrence Livermore National Laboratory, Livermore, California 94551, USA

J.M. Bevins
Department of Nuclear Engineering, University of California, Berkeley, CA 94720, USA

G. Gürdal
Physics Department, Millsaps College, Jackson, Mississippi 39210, USA

The proximity of the $^{106\text{cd}}_{48}$ isotope to the $Z = 50$ closed shell gives an excellent opportunity to study the interplay between collectivity and single particle behavior. In particular, the study of magnetic and electric moments, via g-factor and lifetimes measurements [1], allow us to understand the nuclear structure of complex nuclei such as $^{106\text{cd}}_{48}$Cd. The experimental setup to measure magnetic moments, using the Transient Field Technique, also permits to measure lifetime for states close to the $2^+$ states.

In this contribution, an example of the possibilities of using the Transient Field setup to measure lifetimes using the Doppler Shift Attenuation method in excited states will be presented. The experiments made use of a beam of $^{106\text{cd}}_{48}$Cd, accelerated with the 88 inch cyclotron.
at Berkeley National Laboratory. Preliminary results and perspectives to extend the technique using the alpha capture channel will be discussed.

We derive a microscopic version of the successful phenomenological hydrodynamic model of Bohr-Davydov-Faessler-Greiner for collective rotation-vibration motion of an axially symmetric deformed nucleus. The derivation is not limited to small oscillation amplitude. The nuclear Schrödinger equation is canonically transformed to collective co-ordinates, which is then linearized using a constrained variational method. The associated constraints are imposed on the wave function rather than on the particle co-ordinates. The approach yields three self-consistent, time-reversal invariant, cranking-type Schrödinger equations for the rotation-vibration and intrinsic motions, and a self-consistency equation. For harmonic oscillator mean-field potentials, these equations are solved in closed forms for excitation energy, cut-off angular momentum, and other nuclear properties for the ground-state rotational band in deformed nuclei. The results are compared with measured data.
Development of a Micromegas Time Projection Chamber filled with Xe-trimethylamine (Xe+TMA) for Neutrinoless Double Beta Decay and Dark Matter Searches

D C. Herrera on behalf of Zaragoza Group

Universidad de Zaragoza, Zaragoza, España.

The performance of a microbulk Micromegas High Pressure Time Projection Chamber (HP TPC) filled with Xe-trimethylamine (Xe+TMA) Penning mixtures was studied in a small TPC prototype (2.4 l of volume) towards Rare Event Searches. Two experiments were carried out, the first one for measurements of gas gain and energy resolutions and a second one for measurements of columnar recombination of \( \alpha \)-particles.

Gas gains and energy resolutions for 22.1 keV X-rays are measured for pressures between 1 and 10 bar and various relative concentrations of TMA from 0.3% to 15%. We observe stable operation at all pressures, and a strongly enhanced gas gain, at TMA concentrations ranging from 1.5 % to 3 %. The maximum gas gain reached values as high as \( 2 \times 103 \) (\( 5 \times 102 \)) at 1 (10) bar. Besides, the energy resolution achievable for 22.1 keV X-rays is substantially better than the one previously obtained in pure Xe, going down to 7.3% (9.6%) FWHM for 1 (10) bar. These results are of interest for calorimetric applications of high pressure gas Xe TPCs, in particular for the search of the neutrinoless double beta decay of \(^{136}\)Xe.

On the other hand, columnar recombination measurements were realized out with a novel configuration, formed by two symmetric drift regions with two microbulk-Micromegas readouts. With this setup, the recombination of \( \alpha \)- and \( \gamma \)-particles, emitted in coincidence by an \(^{241}\)Am source was studied. A gas mixture of 98%Xe+2%TMA is used, varying the pressure from 2 to 10 bar, and the reduced drift field within 10-400 V/cm/bar range. Both \( \alpha \)- and \( \gamma \)-particles exhibit recombination as the electric drift field decreases, being stronger for \( \alpha \)-particles. This is partially explained by columnar recombination due to the dependency observed with the track angle (relative to the direction of electric drift field). These results represent a first step towards the evaluation of the idea to use Xe+TMA mixture as medium gas for directional dark matter searches by virtue of the columnar recombination effect.
We discuss the existence of huge thermal neutron capture cross sections in several nuclei. The values of the cross sections are several orders of magnitude bigger than expected at these very low energies. We lend support to the idea that this phenomenon is random in nature and is similar to what we have learned from the study of parity violation in the actinide region. The idea of statistical doorways is advanced as a unified concept in the delineation of large numbers in the nuclear world. The average number of maxima per unit mass, $< n_A >$ in the capture cross section is calculated and related to the underlying cross section correlation function and found to be $< n_A > = \frac{3}{\pi \sqrt{2} \gamma_A}$, where $\gamma_A$ is a characteristic mass correlation width which designates the degree of remnant coherence in the system. We trace this coherence to nucleosynthesis which produced the nuclei whose neutron capture cross sections are considered here.

PACS numbers: 24.30.-v 24.60.-k 24.60.Dr
The structure of the proton plays an important role in atomic physics where experiments have reached very high precision. It can be theoretically included in the evaluation of atomic energy levels using various methods. One of them involves the Breit equation with form factors [1] which is a typical example of how one derives coordinate potentials from Quantum Field Theory (QFT). On the other hand, the unprecedented precision of the atomic physics experiments allows one to probe the static properties of the proton. One such precision measurement led to the so-called “proton radius puzzle” since the precise value of \( r_p = 0.84087(39) \text{ fm} \) obtained from muonic hydrogen spectroscopy [2] was smaller than the world average CODATA value of 0.8768(69) fm [3].

The Breit equation approach in [1] was revisited recently [4] with the objective of trying to resolve the discrepancy. It was noticed in [4] that the Fourier transform relating the densities and form factors is inherently a non-relativistic expression. The relativistic corrections to it can be obtained by extending the standard Breit equation to higher orders in its \( 1/c^2 \) expansion. Apart from this, the proton density distributions can be related to the Sachs electromagnetic form factors \( G_{E,M}(q^2) \) through Fourier transforms, only in the Breit frame and a Lorentz boost must be applied before extracting the static properties of the proton from the corresponding densities. The central value of the latest proton radius of \( r_p = 0.879 \text{ fm} \) as determined from e-p scattering was found in [4] to change to \( r_p = 0.8404 \text{ fm} \) after applying the above corrections. The present talk will discuss the status of the proton radius puzzle in light of the above results.


An overview of research activities and the numerous applications with accelerators and the accelerator technology development program in Argentina will be presented.

The multidisciplinary activity around the TANDAR accelerator will be discussed, encompassing basic nuclear physics, applications to material sciences, radiation damage studies for satellite components, heavy ion microbeam microanalysis and micromachining, radiobiology, ion-beam analysis techniques.

The current status of the accelerator technology development program will be described. It is centered on low-energy (up to 2.5 MV), high current (up to 30 mA) electrostatic machines, mainly intended for neutron production for several purposes. Among these are Accelerator-based Boron Neutron Capture Therapy and radioisotope production.

Other existing accelerator based facilities will also be mentioned, in particular the recently decided installation of a Protontherapy Centre in Buenos Aires.
Nuclear isomers and shape changes in neutron-rich $A = 180$ to $A = 190$ nuclei

G.J. Lane

Dept of Nuclear Physics, RSPE, Australian National University, ACT 0200, AUSTRALIA

Deformed nuclei in the $A \approx 180$ region are well known to exhibit isomers whose long lifetimes are caused by the fact that the only available isomeric decay transitions violate K-conservation, as discussed in recent reviews [1, 2]. Despite this progress, the possible limits to the existence of K-isomers in neutron-rich nuclei are not well defined. Isomers have been observed in some neutron-rich cases using methods such as relativistic fragmentation [3] and direct mass measurement [4], but the level schemes obtained, particularly for the most neutron-rich cases, are generally of limited extent. More detailed level schemes may be obtained using deep-inelastic reactions [5], albeit in slightly less neutron-rich cases, and it is this methodology that is the present focus.

Our program of measurements has utilised deep-inelastic reactions between beams of about 6 MeV/nucleon $^{136}$Xe ions incident on a range of the most neutron-rich, stable, rare-earth targets. These studies have been performed at Argonne National Laboratory and used Gammasphere to observe the gamma rays emitted from weakly populated neutron-rich nuclei in the presence of an intense background of more strongly populated nuclei closer to stability. The experiments have successfully probed the structure of K-isomers in regions that were previously inaccessible (see, for example, Refs. [6, 7] and references therein) and have resulted in detailed level schemes for nuclei up to 4 neutrons past stability. A summary of recent results from this program will be presented, focusing in particular on new results in neutron-rich tantalum, tungsten and rhenium nuclei that demonstrate how the nature of K-isomerism changes at the limits of the deformed region.

The new possibilities for the study of short-lived K-isomers provided by the availability of new lanthanum bromide detectors that have a balance between good energy and time resolution will also be discussed.

Research supported by the Australian Research Council as well as the DOE Office of Nuclear Physics under Contract No. DE-AC02-06CH11357.


Nuclear shape- and shell-evolution are intimately related to the single-particle orbitals available to the valence particles. The description of the spectroscopy of deformed nuclei within the shell model requires the choice of optimal model spaces that include all the relevant degrees of freedom and at the same time limits the dimensions of the matrices to be diagonalized.

It has been shown [1] that quadrupole correlations dominate in shell model spaces involving two variants of the SU3 symmetry. Within these spaces, several properties can be predicted [2]. In particular, the shape coexistence in proton-rich nuclei and the development of new regions of deformation in neutron-rich nuclei far from the valley of stability [3].

The AGATA spectrometer: results and perspectives

Silvia M. Lenzi
University of Padova and INFN, Padova, Italy.

The Advanced Gamma-ray Tracking Array (AGATA) is a new-generation high-resolution \(\gamma\)-ray spectrometer solely built from Germanium detectors, based on the novel technique of \(\gamma\)-ray tracking.

This opens up unique possibilities for a very rich physics program to be addressed, in particular on exotic nuclei where different nuclear degrees of freedom can be investigated. Since several years, the European \(\gamma\)-spectroscopy research community is involved in the construction of this powerful Ge-detector array which has started its physics campaign in 2010 in LNL (Italy) and continued in GSI (Germany), in configurations that include a fraction of the 180 detectors planned for the complete array. In 2014 AGATA was installed in GANIL (France), where started a new physics campaign with an increased number of detectors.

The AGATA research community is investing important resources on the research and development of different new techniques to cope with the complexity of the array and is also facing the specific challenges in view of experimental campaigns in the future radioactive beam facilities in construction in Europe.

After a brief description of the AGATA concept, some recent results and the physics perspectives will be presented.
Radioactive Ion Beams in Brasil (RIBRAS)-Present and future

A. Lépine-Szily, R. Lichtenthaler, V. Guimarães, K. C. C. Pires, V. Scarduelli, L. R. Gasquez
Instituto de Física da Universidade de São Paulo, Caixa Postal 66318, 05315-970, São Paulo, SP, Brazil

D. R. Mendes Jr., P. N. de Faria, R. Pampa Condori
Instituto de Física, Universidade Federal Fluminense, Avenida Litoranea s/n, Gragoatá, Niterói RJ 24210-340, Brazil

E. Leistenschneider
The University of British Columbia, Dep. of Physics and Astronomy, Vancouver, BC V6T 1Z1, Canada

P. Descouvemont
Physique Nucleaire Théorique et Physique Matematique, CP 229, Université Libre de Bruxelles, B1050, Belgium

A. Barioni
Instituto de Física, Universidade Federal da Bahia, Salvador BA, Brazil

V. Morcelle
Universidade Federal Rural de Rio de Janeiro, Rodovia BR 465 RJ, Brazil

M. C. Morais
CEFET/RJ- Campus Petropolis, Rua do imperador, 971, Centro, 25652-003, Petropolis, RJ

M. Assunção
Departamento de Ciências Exatas e da Terra, Universidade Federal de São Paulo, Campus Diadema, Brazil

J. C. Zamora
GSI Helmholtz Centre for Heavy Ion Research GmbH, Planckstr. 1, 64291, Darmstadt, Germany

The Radioactive Ion Beams in Brasil (RIBRAS) system is installed [1] next to the 8UD Pelletron Tandem of the Nuclear Physics laboratory of the University of São Paulo. It consists of two superconducting solenoids with maximum magnetic field of $B = 6.5$ T. Light radioactive ion beams are produced through transfer reactions, using solid or gaseous production targets of Be, LiF, $^3$He etc. The solenoids make a magnetic rigidity selection and the use of the two solenoids with a degrader between them allows the production of pure secondary beams. Beams of $^6$He, $^8$Li, $^7$Be, $^{10}$Be, $^8$B, $^{12}$B are currently produced. We will present results of elastic, inelastic, and transfer reactions of radioactive projectiles on a variety of light, medium mass and heavy secondary targets. More recent data still in analysis is the simultaneous study of the $(p,p)$, $(p,\alpha)$ and $(p,d)$ reactions on $^8$Li at low energies. The experiment was performed using a thick hydrogen target and a radioactive $^8$Li beam. Recent upgrades of the RIBRAS system include the use of $\gamma$ detectors (HP Ge-detectors and NaI) installed in a well shielded $\gamma$-cave.
This will allow the measurement of fusion reactions with on and off-line detection of the γ-rays, dee-exciting the compound nucleus. The measurement of the fusion of $^{6}\text{He}+^{121}\text{Sb}$ is programmed for the next year. Another future upgrade includes the installation of the neutron wall next to RIBRAS for the detection of neutrons in the break-up of the neutron rich radioactive projectiles.

Radiocarbon measurements is a powerful source of information to many fields in science. A few years ago, the first Brazilian radiocarbon sample preparation laboratory for AMS technique was installed at the IF-UFF. In March 2012 a 250 kV Single Stage Accelerator Mass Spectrometry (SSAMS) system produced by NEC was installed at IF-UFF. Together with the preparation laboratory, we provide a complete infrastructure for the Latin American radiocarbon community. Since then the number of requests for radiocarbon measurements at LAC-UFF is increasing. We deal with soil, sediments, wood, charcoal and peats from Brazilian and Latin American groups from several areas like Geosciences, Oceanography and Archaeology South. We have already performed an inter-comparison exercise using shells, soils, vegetable fragments, charcoal and peats measured both with AMS at University of Georgia (UGAMS), and with liquid scintillation technique at CENA (Sao Paulo, Brazil). Regarding the SSAMS machine, typical currents are 50 µA 12C-1 measured at the low energy Faraday cup. The isotopic fractionation is corrected by measuring the δ13C on-line in the accelerator. Average machine background is 0.15 pMC and average precision is 0.8%. The transmission in the accelerator is of the order of 32%. We have been working to extend the sample background and to increase our precision. In this talk I’ll provide a status report of the laboratory and some recent works we have been developing.
Isospin-dependent phase diagram of nuclear matter

J.A. López
University of Texas at El Paso, El Paso, Texas 79968, U.S.A.

A. Rodríguez, and S. Terrazas Porras
Universidad Autónoma de Ciudad Juárez, Ciudad Juárez, Chihuahua, México

This investigation uses results from classical molecular dynamics studies of infinite nuclear systems with varying density, temperature and isospin content to extricate the isospin-dependent phase diagram of nuclear matter. This study was financed by the National Science Foundation grant NSF-PHY 1066031.
GRETINA Physics Program

Augusto O. Macchiavelli

Lawrence Berkeley National Laboratory, Berkeley CA 94720.

GRETINA [1] is a first implementation of a gamma-ray spectrometer which is capable of tracking gamma-rays through its active detector volume. It consists of seven, four-crystal modules (6×6 segments). Each crystal is individually encapsulated with all four crystals sharing a common cryostat. The irregular, tapered hexagonal crystals pack into a spherical shell with the seven modules spanning 1\(\pi\) solid angle.

GRETINA was constructed and commissioned at LBNL, and has already completed two physics campaigns, at NSCL/MSU and at ATLAS/ANL.

I will give a short overview of the project, discuss technical aspects and the performance of the array, and present highlights from the experimental program above. Future plans for GRETINA as well as its evolution into GRETA, a full 4\(\pi\) array, will also be discussed.

Very light mesons in hall D at Jefferson Lab

Dave Mack

Thomas Jefferson National Accelerator Facility, Newport News, VA 23606 USA, for the JEF/GlueX collaboration.

Commissioning of the GlueX detector in Hall D at Jefferson Lab in Newport News, Virginia, USA, is in progress. Although the main mission of GlueX is to use a linearly polarized, 9 GeV photon beam to search for 2-2.5 GeV mass mesons with the exotic quantum numbers of anticipated gluonic hybrids, it is also an impressive factory for light mesons. A brief overview of progress in isolating several light meson decay channels will be given, with emphasis on decays to photons. The \eta(548) is of particular interest to the JEF (JLab Eta Factory) working group as it provides a laboratory to study isospin violation and search for new flavor-conserving sources of C and CP violation.
Germanium Detectors for Nuclear Spectroscopy

G. Maggioni, S. Carturan
University of Padova and INFN Laboratori Nazionali di Legnaro, Italy.

D.R. Napoli
INFN, Laboratori Nazionali di Legnaro, Italy.

J. Eberth
Institut für Kernphysik, University of Cologne, Germany.

S. Riccetto
University of Camerino and INFN of Perugia, Italy.

High-purity Germanium (HPGe) detectors have reached an unprecedented level of sophistication and are still the best solution for high resolution gamma spectroscopy. In the present work we will show the results of the characterization of new surface treatments for the production of these detectors, studied in the framework of our multidisciplinary research program in HPGe detector technologies.
Search for the nuclear hyper-deformation in the 90’s

N.H. Medina

Instituto de Física da USP, São Paulo, SP, Brazil

Since the first experimental confirmation of a superdeformed (SD) structure in \(^{152}\)Dy at the Daresbury Laboratory in 1986 [1] many research groups start to search for nuclei presenting bands with a moment of inertia close to a rigid rotor with an axis ratio of 2:1. It was discovered superdeformed or even highly-deformed structures in more than 100 nuclei in several regions of the nuclide chart (see Ref. [2]). In the \(^{152}\)Dy nuclei it was discovered 6 SD bands. Rotational bands built upon hyperdeformed (HD) shapes, with an axis ratios of 3:1, were also predicted in nuclei [3, 4]. According to these calculations, the HD bands should be yrast at angular momenta larger than \(70\hbar\), therefore it is expected that their experimental identification be extremely difficult, since fission is the dominant channel at this high angular-momentum regime. The search for such exotic shapes is therefore not only interesting in itself but might be useful in defining the behavior of the fission probability at very high spin as it should yield information on the survival probability of the HD states. Many theoretical and experimental studies have been performed about these very elongated structures [5–15]. Nevertheless, the search for discrete gamma rays of rotational bands built upon HD shape is still a challenge. The contributions of prof. Giuseppe Viesti, together with the GASP group, to search for the hyper-deformation structure with GASP [16,17] and EUROBALL [18] gamma-ray spectrometers in the 90’s will be discussed.


Electronic circuits are strongly influenced by ionizing radiation and the need for radiation hardened devices is growing, particularly for applications in hazardous environments such as the space, nuclear reactors and high energy particle accelerators [1]. To understand the physical phenomena responsible for changes in devices exposed to ionizing radiation, several kinds of radiation should be considered, among them heavy ions, neutrons, protons, gamma-rays and X-rays. Radiation effects on electronic circuits are usually divided into three main categories: Total Ionizing Dose (TID), a cumulative effect that changes the response of electronic devices; Single Event Effects (SEE), a transient effect in which charge directly deposited into the device may disturb the behavior of the device or data corruption without physical damages or even may provoke a device permanent failure; and Displacement Damage (DD), which can change the arrangement of the atoms in the lattice [2], [3]. To study Single Event Effects (SEE), it is necessary to hit directly the active region of the device with a sufficiently high energy heavy ion beam to create a high density of charge. Various heavy ions with different Linear Energy Transfer (LET) values are used to evaluate the electronic device sensitivity to radiation. In order to probe the device under test (DUT) with distinct LET values, an experimental setup for SEE studies was prepared at the Laboratório Aberto de Física Nuclear of the Universidade de São Paulo (LAFN-USP), to produce low intensity in-vacuum and in-air external heavy ion beams [4]. To perform the first experiments a standard Rutherford scattering procedure was used to decrease the beam intensity. With this setup, it was possible to make the first SEE measurements with heavy ions in Brazil. In these experiments, it was tested an off-the-shelf 3N163 CMOS transistor [5] and a Spartan 3E FPGA [6]. To have a dedicated system to perform these studies and to achieve the requirements of the European Space Agency [7], such as large beam diameter (∼cm), low particle flux (10^2 to 10^5 part/s) and high uniformity, a new beamline, dedicated to qualify electronic devices has been constructed at the LAFN. The SAFIIRA facility (Sistema de Feixes Íonicos para Irradiações e Aplicações) has been designed to produce low-flux, high uniformity and high area heavy-ion beams up to 28Si by defocusing and multiple scattering techniques [8] and from 28Si to 107Ag by defocusing technique. The system was designed to operate for irradiation in-vacuum or in-air using a thin mylar window. A multi-axis motorized stage is used to manipulate samples in a low-noise environment. In this talk, it will be presented the results obtained with the
Rutherford scattering chamber and the status of the new beamline.


The Coulomb effects hypothesis is used to interpret even-odd effects of maximum total kinetic energy as a function of mass and charge of fragments from thermal neutron induced fission of $^{235}\text{U}$. Assuming spherical fragments at scission, the Coulomb interaction energy between fragments ($C_{\text{sph}}$) is higher than the $Q$-value, the available energy. Therefore at scission the fragments must be deformed, so that the Coulomb interaction energy does not exceed the $Q$-value. The fact that the even-odd effects in the maximum total kinetic energy as a function of the charge and mass, respectively, are lower than the even-odd effects of $Q$ is consistent with the assumption that odd mass fragments are softer than the even-even fragments. Even-odd effects of charge distribution in super asymmetric fragmentation also are interpreted with the Coulomb effect hypothesis. Because the difference between $C_{\text{sph}}$ and $Q$ increases with asymmetry, fragmentations require higher total deformation energy to occur. Higher deformation energy of the fragments implies lower free energy available to break pairs of nucleons. This explains why in the asymmetric fragmentation region, the even-odd effects of the distribution of proton number and neutron number increases with asymmetry. Based on a similar reasoning, a prediction of a relatively high even-odd effect in symmetric fragmentations is proposed.

Keywords: cold fission, asymmetric fragmentation, symmetric fission, kinetic energy, uranium 235
Comparison of natural radioisotope concentrations in volcanic pyroclast samples from Chilean volcanoes

J.R. Morales, P. Ortiz
Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago 7800024, Chile

R. Correa, P.A. Miranda, S. Camilla and J. Wachter
Departamento de Física, Universidad Tecnológica Metropolitana, Santiago 97279, Chile

During volcanic eruptions large amounts of pyroclastic material are emitted reaching in some cases long distances from the crater. The soil in those areas is covered mainly by ash, dust and lapilli, usually having a different chemical composition to the existing soil over which are deposited. In this process, natural underground radioisotopes are brought to surface, and their concentrations may modify the radiological background in the sites. In this work activity concentrations of U-238, Th-232, and K-40 have been determined in samples from four volcanoes which erupted in Southern Chile in last years. These volcanoes are: Lonquimay (1987), Hudson (1991), Chaitén (2008), Puyehue (2011), and Calbuco (2015).

A cooperative research project between the University of Chile (UCH) and the Metropolitan Technological University (UTEM) has been initiated to perform this type of studies. Activity measurements are done at the Nuclear Physics Laboratory of Faculty of Sciences, the University of Chile. Acquisition system is based on an ORTEC HPGe (GEM-10195) gamma detector with energy resolution of 1.95 keV at 1330 keV and a relative efficiency of 10% reported by the manufacturer. The detector is shielded by a cylinder of lead, 10 cm thickness with internal covers of cadmium and copper, 1 mm thickness each. Spectra are being analysed by the code ROOT-Cern [1]. Detector efficiency curve was obtained by using Certified Reference Material IAEA 447 [2].

A complete analysis of gamma spectra collected so far is being performed in order to determine activity concentration levels and associated doses from U-238, Th-232, K-40. Preliminary results show that in all cases, except Calbuco, concentrations are similar. The significant different values in Calbuco samples require additional studies.

Table: Activity concentrations determined in the analyzed samples

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Chaitén</th>
<th>Caüille</th>
<th>Calbuco</th>
<th>Hudson</th>
<th>Lonquimay</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Bq/kg]</td>
<td>[Bq/kg]</td>
<td>[Bq/kg]</td>
<td>[Bq/kg]</td>
<td>[Bq/kg]</td>
<td>[Bq/kg]</td>
</tr>
<tr>
<td>U-238</td>
<td>38.4</td>
<td>2.5</td>
<td>20.8</td>
<td>1.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Th-232</td>
<td>54</td>
<td>2.3</td>
<td>25.7</td>
<td>1.3</td>
<td>3.4</td>
</tr>
<tr>
<td>K-40</td>
<td>885</td>
<td>58</td>
<td>548</td>
<td>40</td>
<td>85</td>
</tr>
</tbody>
</table>

Status and perspectives of the search for eta-mesic nuclei

Pawel Moskal
Jagiellonian University, Poland

The negatively charged pions and kaons can be trapped in the Coulomb potential of atomic nucleus forming so called mesonic atoms. Observations of such atoms allows for studies of strong interaction of pions and kaons with atomic nuclei on the basis of shifts and widths of the energy levels. It is also conceivable that a neutral meson could be bound to a nucleus. In this case the binding is exclusively due to the strong interaction and hence such object can be referred to as a mesic nucleus. Here the most promising candidate is the $\eta$-mesic nucleus since the $\eta$-$\text{N}$ interaction is strongly attractive.

The $\eta$-mesic nucleus was predicted about 30 years ago. Many promising indications of the existence of such an object were reported, but so far none was independently confirmed. Initially the $\eta$-mesic nuclei were considered to exists for $A \geq 12$ only due to the relatively small value of the $\eta$ $\text{N}$ scattering length estimated in eighties. A decade later, large values of the $\eta$-nucleon scattering length (up to 1 fm) were extracted in some analyses. Such large value does not exclude the formation of bound $\eta$-nucleus states for such light nuclei as helium or even for deuteron. However so far there is no direct experimental confirmation of its existence.

The search of the $\eta$-mesic nucleus was conducted in many inclusive experiments via reactions induced by pions, protons, deuterons and photons. In the case of the eta-mesic helium the determined upper limits are close to the newly predicted values of total cross sections.

The status and perspectives of the search for the eta-mesic nuclei will be reviewed emphasizing the high statistics and exclusive measurements conducted with the WASA detector at COSY.

For references see the reviews:


Unified field theory from the classical wave equation: preliminary application to atomic and nuclear structure

Héctor A. Múnera

Centro Internacional de Física (CIF), Bogotá, Colombia.

The unification of gravitation and quantum theories is a major open problem in physics at the beginning of this century. Punctual issues in nuclear physics are not addressed here. Instead we propose a novel approach toward unification, thus opening new paths to study nuclear structure. Let us recall that Schrödinger’s first candidate for his quantum theory was “the most familiar one-dimensional wave equation ...” that he discarded by superposition considerations [1]. Since Nature inherently is non-linear those early considerations based on mathematical convenience are not relevant any longer. Our proposal is to resume Schrödinger’s initial idea in the context of current knowledge, and to postulate a fundamental electromagnetic fluid pervading the whole universe obeying the second-order time-dependent and three-dimensional homogeneous classical wave equation (HCWE)

\[ \Box \phi \equiv \left( \frac{\partial^2}{\partial w^2} - \nabla^2 \right) \phi = 0, \quad w \equiv Ct \]  

(1)

The local two-way average speed of electromagnetic signals used for measuring distance is \( C \). Instead of limiting to standard harmonic solutions of the HCWE, our analysis peruses novel solutions for the HCWE in spherical coordinates discovered twenty years ago [2–4], in particular the Lorentz & neo-Galilean Isomorphic & Quantized (LoGiQ) functions. Our LoGiQ functions provide the requisite mathematical basis for Boscovich’s unified force [5], which in the far field is gravitational, but in the near field is quantized in energy and distance — fact noted by Thomson [6] before Bohr’s quantum theory; of course, Boscovich force is consistent with experimental findings in the microscopic realm [7]. Gravitation [8] and Lorentz invariant quantum theory are thus unified under Eq. (1). Connections to current research at laboratory scale [9, 10], and to de Broglie’s pilot-wave quantum theory [11] are also noted.


The understanding of Quantum Chromodynamics (QCD) at large distances still remains one of the main outstanding problems of nuclear physics. Investigating the internal structure of hadrons provides a way to probe QCD in the non-perturbative domain and can help us unravel the spatial extensions of nature’s building blocks.

Deeply Virtual Compton Scattering (DVCS) is the easiest reaction that accesses the Generalized Parton Distributions (GPDs) of the nucleon. GPDs offer the exciting possibility of mapping the 3-D internal structure of protons and neutrons by providing a transverse image of the constituents as a function of their longitudinal momentum.

A vigorous experimental program is currently pursued at Jefferson Lab (JLab) to study GPDs through DVCS. New results from Hall A and Hall B recently released (April 2015) will be shown and discussed. Special attention will be devoted to the applicability of the GPD formalism at the moderate values of momentum transfer (Q2) available at JLab.

We will conclude with a brief overview of additional DVCS experiments under analysis and planned with the future Upgrade of JLab to 12 GeV, which will allow the full exploration of the valence-quark structure of nucleons and nuclei and promises the extraction of full “tomographic” images.
SPES: Status of the project, technical challenges, instrumentation and scientific program

D.R. Napoli

INFN, Laboratori Nazionali di Legnaro, Italy

SPES (Selective Production of Exotic Species) is the INFN project for a Nuclear Physics facility with Radioactive Ion Beams (RIBs) based on several technological innovations and challenges. The project is in advanced construction in Legnaro. It will provide mostly neutron-rich exotic beams, derived by the fission fragments (10**13 fiss/s) produced in the interaction of an intense proton beam (200 A) on a UCx target and reaccelerated with the superconductive linac ALPI. The expected SPES beam intensities, their quality and, eventually, their maximum energies (up to 11 MeV/A for A=130) will permit to perform forefront research in nuclear structure and nuclear dynamics, studying a region of the nuclear chart far from the stability valley.

Both nuclear physics and applied physics programs will give the international community a great opportunity to further improve in knowledge and technology development.
Giusseppe Viesti - An Appreciation

Joseph B. Natowitz

*Cyclotron Institute, Texas A&M University.*

Beppe Viesti was a close friend and long-time collaborator. He was a truly outstanding experimenter and mentor of students. I will attempt to review the many contributions in basic nuclear research which were made by his research group at the University of Padova.
Searches for physics beyond the Standard Model in nuclear beta decay

O. Naviliat-Cuncic

National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East-Lansing, MI, USA.

The measurement of the energy spectrum of beta particles from nuclear beta decay has regained much attention in the past few years, in connection with the reactor antineutrino anomaly and for searches of exotic couplings contributing to the weak interaction. The transitions which are sensitive to exotic tensor couplings are Gamow-Teller transitions and suitable candidates are the simple allowed transitions in $^6$He and $^{20}$F. We have explored a new technique for the measurement of the shape of the beta energy spectrum which eliminates the largest instrumental effect related with the backscattering of beta particles from the detectors. The technique uses fragmented beams from the National Superconducting Cyclotron Laboratory which are implanted in suitable detectors from which the beta particles cannot escape. This presentation will review the motivations for such searches and describe the experiments performed so far along with the status of the data analysis.

*This work is supported by the US National Science Foundation under grant number PHY-11-02511
Towards new Horizons @ GANIL

A. Navin

Grand Accélérateur National d’Ions Lourds, Caen, France.

Nuclei far from the valley of stability provide new vistas for searching and understanding the simple and regular patterns that are found in the structure of complex nuclei. These extremes of the nuclear landscape not only allow us to examine specific aspects of the nuclear interaction but also provide important inputs for the understanding of astrophysically important processes. In the last decade, reactions at high energies (>100 MeV/u) with Radioactive Ion Beams have been the workhorse for the production and characterization of nuclei very far from stability. In parallel, studies using reactions with beams far from the dripline (stable beams) coupled with improved sensitivity at energies around the Coulomb barrier have allowed us to probe nuclei under new conditions.

In this talk, we will first give a short flavor to the various activities at GANIL of probing the three axis of nuclear physics namely Excitation energy, angular momentum and the asymmetry of neutrons and protons using stable and radioactive beams both from ISOL and fragmentation. Atomic collision for pure and applied research will also be briefly touched on. The talk will focus in particular on new inroads at energies around the Coulomb barrier using a large acceptance spectrometer coupled with a gamma array, into exploring a) physics at a possible new frontier for nuclear physics namely BOTH high spin and isospin and b) potential of the production of new isotopes around and beyond the neutron shell N=126 for nuclei below Pb by multinucleon transfer. Status and future plans in these directions, using the measurements of prompt gamma rays in coincidence with isotopically-identified neutron-rich fragments produced in fission and multinucleon transfer will be presented.
Monte Carlo Simulation of Dosimetric Parameters in Brachytherapy

Patrícia Nicolucci
Department of Physics - Faculty of Philosophy, Sciences and Letters of Ribeirão Preto
University of Sao Paulo, Brazil

According to AAPM (American Association of Physicists in Medicine) Task Group 43, the characterization of brachytherapy sources can be performed using a number of dosimetric parameters that should be determined using both experimental and Monte Carlo simulation approaches. Several studies have used different Monte Carlo simulation packages, such as EGS4, PENELOPE and GEANT4, to assess dosimetric parameters of clinical brachytherapy sources and to study the viability of new sources and materials. The steep dose gradient near the sources, combined with requirements of high precision data for clinical use, imply long simulation times and/or the access to high performance computers. This work used the Monte Carlo package PENELOPE to obtain dosimetric parameters for the Varian GammaMed Plus $^{192}$Ir high dose rate brachytherapy source in reduced simulation times. A first step simulation used a segmented geometry around the source to both simulate relative doses at small distances from the source and to accumulate the phase-space files at different distances of interest from the source. A second step simulation was then performed using the phase-space files to speed-up simulations at regions of lower doses. A reduction of up to 40% in the simulation time for the same precision in the dosimetric parameter being calculated was achieved. Simulated relative doses were compared with data from the Varian BrachyVision treatment planning system with differences lower than 3.7% (at $r = 5$ cm and $\theta = 170^\circ$). The results show that a two-step simulation to register and use phase-space files of brachytherapy sources can speed-up the simulation of dosimetric parameters of clinical sources and have the potential to be used to improve accuracy in dose planning.
Monte Carlo Simulation of Simultaneous Radiation Detection in the Hybrid Tomography System ClearPET-CT

H. Olaya, A. Sevilla, H. Castro
Physics Department, Universidad Nacional de Colombia, Bogotá - Colombia

S.A. Martinez
Centre de Physique des Particules de Marseille, Université Aix Marseille, Marseille - France

Using the Geant4-based simulation framework SciFW1, a detailed simulation was performed for the detector setup in the hybrid tomography prototype for small animals, called Clear-PET / XPAD, which was built in the Centre de Physique des Particules de Marseille. The detector system consists of an array of phosphor scintillation detectors: LSO (Lutetium Oxy-orthosilicate doped with cerium Lu$_2$SiO$_5$: Ce) and LUYAP (Lutetium Ortaloaluminate de Yttrium doped with cerium Lu$_{0.7}$Y$_{0.3}$AlO$_3$:Ce) for Positron Emission Tomography (PET) and hybrid pixel detector XPAD for Computed Tomography (CT). Simultaneous acquisition of deposited energy, and the corresponding time-position for each recorded event were analyzed, independently, for both detectors. We studied the main geometrical and physical factors causing noise and artifacts in the diagnostic image due to interference between detection modules for PET and CT. Finally, we estimated the gamma radiation fluence for each module and analyzed associated behavior to different system configurations.

Keywords: computed tomography, positron emission tomography, Monte Carlo simulation, scintillation detectors, Geant4, SciFW1
Gamma-particle coincidence measurements - Results with weakly bound stable beams and future plans

José R. B. Oliveira

Instituto de Física da Universidade de São Paulo – São Paulo, SP, Brazil

The gamma-particle coincidence technique [1] is useful in nuclear reaction studies in several situations. Recent results of measurements performed at the Pelletron Tandem Laboratory of IFUSP (LAFN) with weakly bound stable beams such as $^6,^7\text{Li}$ and $^{10}\text{B}$ will be presented [2]. The gamma rays measured with high resolution can help to identify reaction processes and address open problems of nuclear reaction mechanisms, such as projectile break-up after particle transfers. A new particle detector system project is under development in order to improve the measurement capabilities, making use of kinematic coincidences. The system, with large angular coverage, will also be used with radioactive beams produced in the RI-BRAS system at IFUSP. Another project, developed in collaboration with the Laboratory Nazionali del Sud (Catania, Italy), in the framework of the NUMEN [3] project, will also be discussed, which consists in gamma calorimeter made of inorganic scintillators. The calorimeter, to be used in coincidence with the focal plane detectors of the MAGNEX spectrometer, will help to identify the events related to the population of excited states in Double Charge Exchange reactions. The system will be essential for the cases in which deformed nuclei are involved. The measurement of these reactions is important for the extraction of nuclear transition matrix elements which are relevant to neutrino physics, particularly in relation to neutrinoless double beta decay and the possible Majorana nature of neutrinos.

Among halo nuclei, the Borromean are made of three-body structures, a core and two loosely bound nucleons. They have a weakly bound state only, and no pair core-nucleon or nucleon-nucleon is bound [1]. In this talk, we analyze the breakup of the Borromean nucleus $^{22}$C within a four-body Coulomb corrected eikonal model [2]. The three-body ground and continuum states are described in hyperspherical coordinates [3], where the continuum is computed with the correct asymptotic behavior by using the three-body R-matrix method [4]. We show the dependence of the ground state energy and r.m.s radius of $^{22}$C, on the scattering length of the $0s_{1/2}$ virtual state and a presumed $0d_{3/2}$ resonance in $^{21}$C. The sensitivity of the dipole strength on the ground state energy of $^{22}$C is also analyzed.


Structure of neutron-rich $N \geq 126$ nuclei

Zsolt Podolyák

Department of Physics, University of Surrey, Guildford GU2 7XH, UK.

The understanding of how shell structure arises and develops is a major goal in contemporary nuclear physics. To this end, it is of particular importance to measure the properties of nuclei in the vicinity of closed shells.

To date, our knowledge of the properties of heavy neutron-rich nuclei at or near the $N=126$ shell is very limited. In the case of nuclei with $Z<82$ and $N>126$, excited states were previously reported only in $^{208}$Tl [1] and $^{209}$Tl [2,3]. Recently several experiments were performed to study this mass region, with the nuclei of interests being populated in relativistic-energy fragmentation. Gamma-ray spectroscopy following internal decays provided information on the yrast structure of $^{208}$Hg [4], $^{209}$Tl [4] and $^{210}$Hg [5].

The basic ingredients of shell model calculations are the single particle energies and two-body matrix elements (interaction between the particles). In the case of calculations performed for $Z \leq 82$ and $N \geq 126$ nuclei, the single particle energies are taken from the known experimental spectra of $^{207}$Tl and $^{209}$Pb. The one proton hole, one neutron particle nucleus $^{208}$Tl should provide the two-body matrix elements, therefore it is a key nucleus. However the knowledge in the structure of this nucleus is very scarce.

In 2014 an experiment to study $^{208}$Tl was performed at CERN-ISOLDE. $^{208}$Hg was populated by a 1.4 GeV proton beam impinging on a molten lead target. The structure of $^{208}$Tl was studied via the beta decay of $^{208}$Hg. The level scheme of $^{208}$Tl was obtained [6] and compared with shell-model calculations. The beta decay proceeds entirely through first-forbidden transitions.

The talk will focus on recent experimental results on heavy neutron-rich nuclei and their interpretation in the framework of the shell-model. The role of first-forbidden beat-decay transitions in the understanding of how heavy nuclei are produced in the rapid neutron capture process will be also discussed.

Multiple octupole-type band structures in the $^{223}_{90}$Th$_{133}$ nucleus

F. Ramírez*, and D.A. Torres

Universidad Nacional de Colombia, Bogotá, Colombia.

W. Reviol (for the GSFMA262 collaboration)

Washington University, St. Louis, MO 63130, USA

The yrast alternating-parity bands of the $^{223}$Th nucleus, which have been associated with a $K$ quantum number of 5/2, represent one of the best examples for parity-doublet structures. The nucleus has been revisited in an experiment using the 80 MeV $^{18}$O + $^{208}$Pb → $^{223}$Th + 3n reaction and the Gammasphere $\gamma$-ray and HERCULES evaporation-residue detector arrays.

The presentation will give a brief introduction on the experiment, a status report on the analysis, and will discuss the motivation for studying $^{223}$Th. Here, the aspects are: delineation of the high-spin behavior of the yrast structure (e.g. parity splitting as a function of spin), and search for a $K < 5/2$ structure (i.e. analogous to the detailed level scheme of $^{221}$Th).

Keywords: rotational band, simplex symmetry, parity doublet.

*Electronic address: framirezmo@unal.edu.co.
In vivo absolute quantification of a muscular metabolite using proton magnetic resonance and a flexible coil.

G. Ricaurte
Group of Biophysics, University of Antioquia.

G. Vega, J.C Calderon, R. Narvaez-Sanchez
Group of Physiology PHYSIS, Faculty of Medicine Universidad de Antioquia.

M. Estrada
Pablo Tobón Uribe Hospital.

J. Gallo
Group of sports medicine GRINMADE, Universidad de Antioquia. Medellín, Colombia.

There are different types of fibers in human skeletal muscle. A higher percentage of type II fibers is characteristic of strength athletes unlike endurance athletes. It has been demonstrated by biopsy a direct relationship between the concentration of intramuscular carnosine (dipeptide of beta-alanine and histidine) and the percentage of type II muscle fibers. A non invasive method for measuring carnosine concentration which is based on proton magnetic resonance spectroscopy ($^1$H-MRS) has been developed using volume coils [1–3]. However, volume coils are rigid (they do not adapt to different volumes of the body as surface coils do) and have a signal to noise ratio (SNR) up to four times lower than surface coils, at less than 6 cm distances from the area of interest [4].

The present work (involving groups of biophysics, physiology, radiology and sports medicine) was to standardize the absolute quantification of intramuscular carnosine by $^1$H-MRS using Siemens 3T Skyra spectrometer and a surface flex coil 4-A-3T as a receiver, to determine the proportion of fiber types in the vastus lateralis muscle of 17 healthy athletes, using water as an internal reference. Athletes were classified in ”strength” and ”endurance” according to field tests. The quantification of carnosine was made in vivo and in phantoms by measuring the area under the curve of the peak corresponding to C-2H core imidazole ring of histidine [5]. The parameters were selected trying to limit the maximum acquisition time to 10 minutes, given that SNR of the spectrum depends largely on patient immobility. The percentage of the deviation from the actual concentration obtained in phantoms was less than 6% and in humans, carnosine concentration was 10.5±1.7 mM ($n = 9$) for ”strength” while was 8.7±1.4 mM ($n = 8$) for ”endurance”, indicating higher proportion of type II fibers in the first ($p < 0.05$). The method was sufficient to discriminate ”strength” and ”endurance” individuals. The errors were similar to the ones obtained with rigid coils [1-3]. Essays done in phantoms with a 9T magnet suggest that the quantification error is determined essentially by the SNR and the number of repetitions of the experiment. It was for the first time in Colombia standardized a method for intramuscular carnosine quantification in humans, using
a surface coil.


Analysis of the matrix $V_{PMNS}$ in the 2HDM-III

E. González-Hernández, E. Barradas-Guevara
Facultad de Ciencias Físico Matemáticas, Benemérita Universidad Autónoma de Puebla, Apdo. Postal 157, 72570, Puebla, Pue. México.

O. Félix-Beltrán
Facultad de Cs. de la Electrónica, Benemérita Universidad Autónoma de Puebla, Apdo. Postal 1152, 72570 Puebla, Pue. México.

F. Gonzáles-Canales
Instituto de Física Corpuscular (CSIC-Universidad de Valencia), Spain.

E. Rodríguez-Jáuregui
Dpto. de Física, UNISON, Apdo. Postal 1626, 83000 Hermosillo, Sonora, México.

In this work, we show an universal treatment for mass matrices of leptonic sector, in the context of Two Higgs Doublet Model Type III (2HDM-III). We consider that the mass matrices of Dirac fermions are represented by a four-zeros texture matrix. Also, we are including a Majorana Lagrangian to give mass to the left-handed neutrinos through the type-I seesaw mechanism obtaining that Majorana particles are also represented by a four-zeros texture matrix. Then, the mass matrices of the neutrinos and charged leptons are reparametrized in terms of their eigenvalues. This allows us to get an analytical and explicit expressions for the lepton mixing matrix. Further, the conditions under which the known results of neutrinos physics that are outside recover the Standard Model are considered. All these results will be compared with those reported in the literature.

PACS numbers: 13.15.+g, 13.85.Tp, 14.60.Fg, 14.80.Cp
Level lifetime and side-feeding time measurements of $^{83}$Y using the Doppler shift attenuation method

W. Rodriguez, F. Cristancho

Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia.

S. Tabor

Department of Physics, Florida State University, USA.

G. Z. Solomon

Department of Physics, Florida State University, Tallahassee, Florida 32306.

J. Döring

Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556.

G. D. Johns

Los Alamos National Laboratory, Los Alamos, New Mexico 87545.

M. Devlin, F. Lerma, D. G. Sarantites

Chemistry Department, Washington University, St. Louis, Missouri 63130.

I.-Y. Lee, A. O. Macchiavelli

Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720.

Level lifetime and side-feeding time measurements were performed on the high spin states in $^{83}$Y using the Doppler-Shift Attenuation Method (DSAM). The high spin states in $^{83}$Y were populated using the fusion-evaporation reaction $^{58}$Ni($^{32}$S,$\alpha$3p)$^{83}$Y at 135 MeV. A stopper of $^{181}$Ta was put alongside the target in order to measure lifetimes using the DSAM. The experiment was carried out using the combination of GAMMASPHERE [1] and MICROBALL [2] arrays. The level lifetime measurements made use of the experimental line-shapes obtained at 35°, 53°, 127° and 145°. Side-feeding times were also measured by comparing the line-shapes gated with transitions above and below of the state under study. The determination of the level lifetime and side-feeding time were carried out by comparison of the experimental and the simulated line-shapes, the latter produced by the code AHHKIN [3]. For the discrete levels we calculate the quadrupole moments in the model of a rigid rotor and axially deformed nucleus. In addition we study the relation between the inertia and the quadrupole moments for the $^{83}$Y nucleus and compare these results with the same relation for other nuclei in the region $A \sim 80$.

Keywords: Gamma-ray Spectroscopy; DSA; Lifetime Measurements; Neutron-Deficient Nuclei


Applied advanced nuclear technique in education and research Beppe’s contribution

Laszlo Sajo-Bohus, Felix Pino Andrade
*Universidad Simon Bolivar, Nuclear Physics Laboratory, Caracas, Venezuela*

Fernando Cristancho
*Universidad Nacional de Colombia, Grupo de Física Nuclear, Dep.to de Física, Bogotá, Colombia*

Tony Viloria
*Universidad del Zulia, Maracaibo, Venezuela*

Cruz Diaz
*Universidad Pedagógica Experimental Libertador, Instituto Pedagógico de Barquisimeto, Venezuela*

Pedro Santiago
*Universidad Nacional Experimental, Fco de Miranda, Coro, Venezuela*

Several topics that we learned during Professor Viesti scientific visits to Latin America will be enlightened. Experiments and application to oil industry, elemental analysis and teaching with nuclear tools, developed during the last two decades for the benefit of students and scientists alike will be shown. Talk is given remembering Beppe human and personal characteristics with some anecdotal references.
Neutron Dose Study at the RFX-MOD External Field by Nuclear Track Methodology

E. Martines\textsuperscript{a}, W. Gonzalez\textsuperscript{a}, M. Zuin\textsuperscript{a}, H.R. Vega-Carrillo\textsuperscript{b}, F. Pino\textsuperscript{c,e}, A. Sajo-Castelli\textsuperscript{c}, J.K. Palfalvi\textsuperscript{d}, L. Stevanato\textsuperscript{e}, D. Cester\textsuperscript{e}, G. Nebbia\textsuperscript{e}, \textsuperscript{*}L. Sajo-Bohus\textsuperscript{e}

\textsuperscript{a}Consorzio RFX, corso Stati Uniti 4, 35127 Padova, Italy
\textsuperscript{b}UAEN, Universidad Autónoma de Zacatecas C. Ciprés 10 Fracc. La Peñuela 98068 Zacatecas, Zac. Mexico
\textsuperscript{c}Universidad Simón Bolívar, Nuclear Physics Laboratory, Caracas 1080A, Venezuela
\textsuperscript{d}HAS Centre for Energy Research, POB 49, H-1525 Budapest, Hungary
\textsuperscript{e}Dipartimento di Fisica ed Astronomia, Università di Padova Via Marzolo 8, I-35131 Padova, Italy

\textbf{Dedicated to the memory of Professor Giuseppe Viesti}

During the past year, technical and technological advancement did rise new interest in $D-D$ fusion energy. The most important occurring reaction $D(d,3He)n$, $Q=3.3\,\text{MeV}$, is accompanied by fast neutrons (peak $E_n$ is at $2.45\,\text{MeV}$) and these leaving the plasma confinement reaching the external hall. Staff personnel may be exposed to penetrating radiation since non negligible neutron field exists near the Revers Field eXperimental (RFX-Mod) facility a device for the magnetic confinement of thermonuclear plasmas. The area is monitored by nuclear track methodology with passive Nuclear Track Detectors-NTD's to determine possible health hazard due to secondary radiation exposure. The nuclear track methodology developed by Palfalvi et al., was selected since it has been shown in the past that etched tracks provide dose equivalence values of a fast neutron field without previous knowledge of the neutron energy spectrum. Resulting track density, related to neutron leakage from the fusion device during pulsed operation provide information also on radiation risk level, material activation and damage. The poly-allyl diglycol carbonate (PADC) as NTD for neutron dosimetry, can be employed for doses up to $250\,\text{mSv}$, in the neutron energy range (144 keV to 15 MeV), therefore it provides means to monitor the radiation in work places such as RFX-Mod facility, $\text{H}^*\,(10)$. Palfalvi et al., determined for the TASTRAK plastic, (etched after exposure in 6N NaOH at 70 °C for 6h) a $\text{H}^*$ calibration factor of $1.19\,\text{Sv}\,\text{cm}^{-2}$, with validity in the energy range of 200 keV and 20 MeV. The response rate $R$ for the C and O recoils was found to be $R = 2.4 \times 10^{-6}$, while for the charged particle reactions is $R = 4.8 \times 10^{-7}$. Passive neutron dosimeter offers a relatively low cost and simple method since neutrons interact mostly with the detector constituents by inelastic, elastic scattering or absorption leaving the so called latent track from which dosimetric information is derived. NTD size is 1 mm thick PADC-plastic (1x2cm$^2$) were employed to record charged particle tracks from $(n,p)$ and $(n,\alpha)$ reactions, from which neutron dose ($10.2 \pm 0.7\text{track}\,\text{cm}^{-2}\,\text{mSv}^{-1}$ or specific calibration of 1.2 tracks/mSv) was applied to resulting track density. Neutron field epithermal component resulted to be 60% higher than that corresponding to the thermal region nevertheless, neutron dose is well below the POE dose limits and dose related to

\textsuperscript{*}Electronic address: lsa@usb.ve
secondary radiation suggesting so far a negligible value during the experiments carried out at the mentioned facility.
The Nab collaboration experiment will measure the neutrino electron correlation coefficient and the Fierz parameter from neutron beta decay \( n \rightarrow p e \bar{\nu} \) at the Spallation Neutron Source, Oak Ridge National Laboratory. The results of our experiment will improve the neutron data set, and in turn, the precise knowledge of \( V_{ud} \)-CKM unitarity. The charged products of neutron beta decay, the proton and electron, will be measured and detected in coincidence using two large area, thick and 127-hexagonal-segmented Si detectors; setup that suppresses backgrounds. We will present the characterization of Si detectors for 30 keV proton detection and electron determination.
Neutron and photon peripheral doses in radiotherapy: Dosimetric and modelling issues

*Beatriz Sánchez-Nieto

*Instituto de Física. Pontificia Universidad Católica de Chile. Santiago, Chile

Leticia Irazola, Francisco Sánchez-Doblado


José A. Terrón

1 Hospital Universitario Virgen Macarena, Sevilla, Spain

Maite Romero-Expósito

Universitat Autònoma de Barcelona, Barcelona, Spain

It is well known that Ionizing radiation is a two-edge sword. It is one of the main tools to fight against cancer but also can induce a second cancer as a result of the radiation exposure during the first treatment for cancer. During photon radiotherapy, both scattered/leakage photons and neutrons (for energies above 10 MV) reach volumes outside the treatment field, which is associated to an increased risk of second cancer occurrence. Dosimetry of out-of-field neutrons has been traditionally neglected due to the large ratio of photons to neutrons and a lack of knowledge of neutron energy spectra. Our group has developed [1], and successfully applied to the clinic [2], a methodology, based on a digital detector, for the online estimation of equivalent neutron dose to organs. Further studies have shown promising results using another thermal neutron rate detector [3] based on a pair of commercial photo diodes. The neutron prediction model has been implemented in a commercial treatment planning system. Regarding the photon dose to organs, a simple and physics-based analytical model, applicable to isocentric intensity modulated treatments, has been proposed (article under revision). This photon model only requires of readily available clinical patient and treatment parameters and it has been implemented on a piece of software termed PERIPHOCAL. The simplicity of both the neutron and photon models should aid to the systematic estimation of out-offield doses data, the first step towards improving the understanding of mechanisms for second cancer occurrences.


*Electronic address: bsanchez@fis.puc.cl
Quantum-Selective Nuclear Spectroscopy: The $^{53}$Co$^{m}$ and $^{213}$Ra case

L.G. Sarmiento
Department of Physics, Lund University, 22100 Lund, Sweden

Branching ratios of exotic decay modes are difficult to measure experimentally given potentially low production cross section which in turn are typically challenged by separation and detection efficiency. A novel combination of existing equipment, JYFLTRAP [1] and the TASISpec [2,3] decay station, was used to experimentally determine the branching ratio of the $\ell = 9$ proton decay of the $I^\pi = 19/2^-$, 3174-keV isomer in the $N = Z - 1$ nucleus $^{53}$Co by means of quantum-state selective high-resolution particle-$\gamma$ decay spectroscopy. The technique has been pioneered in case studies using SHIPTRAP [4] and TASISpec at GSI [5].

The observation of a weak proton-decay branch in the decay of the $I^\pi = (19/2^-)$ $^{53}$Co$^{m}$ isomeric state marked the discovery of proton radioactivity in 1970 [6]. However, a branching ratio of $b_p \sim 1.5$ % could only be estimated based on model-dependent comparisons of anticipated peak cross-sections of different reaction products of the reaction $p + ^{54}$Fe [7].

The Geant4 simulation toolkit has been modified to include, for the first time, the decay mode proton emission. In this talk, the usefulness of virtual Geant4 experiments in low-energy nuclear structure studies will be presented, exemplified with the proton decay of $^{53}$Co$^{m}$ and weak $\beta^+/EC$ decay branches of $^{213}$Ra studies.

The quest for an electric dipole moment of the neutron

P. Schmidt-Wellenburg, on behalf of the nEDM collaboration @ PSI

Paul Scherrer Institute, Switzerland

Searches for electric dipole moments (EDM) of fundamental particles are considered one of the most sensitive approaches to physics beyond the Standard Model of particle physics (SM). A non-SM mechanism violating the combined symmetry of charge conjugation and parity inversion ($CP$-violation) could help to explain the huge discrepancy between observed and predicted baryon asymmetry of the Universe.

A discovery of an EDM of the neutron (nEDM) would indicate a violation of time reversal symmetry ($T$) and assuming CPT invariance a violation of $CP$-symmetry. No nEDM has yet been observed, while the current best upper limit $d_n < 2.9 \times 10^{-26} \text{ecm} \ (90\% \text{ C.L.})$ [1] was published in 2006.

In this overview talk I will explain the principal experimental techniques, give an overview of the world wide efforts and finally discuss newest results from the nEDM-collaboration currently data-taking at the UCN source at the Paul Scherrer Institute in Switzerland.

Improvement of Analytical Capabilities of the Neutron Activation Analysis Laboratory at the Colombian Geological Survey

Parrado G., Cañón Y., Peña M., Sierra O., Alonso D., Porras A., Herrera D.C.

Servicio Geológico Colombiano, Bogotá, Colombia.

Colombia has a large and diverse wealth mineral resources potential within the most highlighted are: gold; energy minerals (coal, hydrocarbons and uranium); industrial minerals (salt, gypsums, marbles, limestones, building materials, etc.); and other strategic minerals, especially rare earths including niobium and tantalum. One of the main goals of the Colombian Geological Survey (Servicio Geológico Colombiano, SGC in its Spanish acronym) is the exploration of minerals resources, for its sustainable use in energy sector and other economic sectors. For this reason a complete geochemical mapping of the country is in progress, so during the last years the Nuclear Safety Division of the SGC has been modernized; a new instrumentation for the Nuclear Reactor IAN-R1 was installed successfully, showing good performance and long term stability. At the same time, the Neutron Activation Analysis Laboratory (NAAL) has been launched again in order to analyze several types of samples with great accuracy and precision.

The changes carried out to the processes of irradiation, measurement and analysis towards the validation and accreditation of the Laboratory are presented in this work. The main changes introduced were the utilization of a new grating system for the irradiation process, in which 20 samples can be set closer to each other, so it is obtained a greater homogeneity in the neutron flux for all the irradiated samples. On the other hand, new systems of gamma-ray spectrometry were incorporated, four high-purity germanium (HPGe) detectors with high efficiency (two with 30%, and the other ones with 70%); in addition the positioning system of the samples was improved. The good performance in the first round of the inter-comparison exercise WEPAL-IAEA 2015 shows that all efforts towards the validation of the technique are on the right way.

Results recently published show that 96.6% of the data are in satisfactory level (\(|Z|-scores < 2\)), especially for 15 analyzed elements in soils matrices: arsenic, cerium, cobalt, chromium, cesium, iron, potassium, lanthanum, sodium, rubidium, antimony, scandium, thorium, uranium and zinc. These results are very promising taking into account that the method is in continuous development.
Development of Silicon Photomultipliers and their Applications to GlueX

Elton S. Smith on behalf of the GlueX Collaboration

Jefferson Lab, Newport News, VA 23606 USA

The GlueX experiment [1] is a photoproduction experiment in Hall D at Jefferson Lab that is being commissioned for use with the new 12 GeV accelerator. The purpose of the experiment is to search for Hybrid mesons, which are mesons with quark and gluon degrees of freedom. The barrel calorimeter of GlueX is instrumented with 4000 large-area (1.2 × 1.2 cm²) silicon photomultipliers (SiPMs) [2]. These photon sensors have properties similar to vacuum photomultipliers, but are unaffected by high magnetic fields. In our experiment they operate in magnetic fields exceeding 1 T. After extensive test with a variety of sensors, we chose the S12045(X) custom SiPM arrays manufactured by Hamamatsu Corporation, also known as multi-pixel photon counters (MPPCs) [3, 4]. We will give an overview of this new technology as well as the experience gained during two commissioning periods with beam.


Status and results from the decay spectroscopy project EURICA
(EUroball-RIken cluster Array)

P-A Söderström

Department of Physics and Astronomy, Uppsala University, SE-75120 Uppsala, Sweden and RIKEN
Nishina Center, 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan

β- and isomer-decay spectroscopy are sensitive probes of nuclear structure, and are often the only techniques capable of providing data for exotic nuclei that are produced with very low rates. Decay properties of exotic nuclei are also essential to model astrophysical events responsible for the evolution of the universe such as the rp- and r-process. The EURICA project (EUROBALL RIKEN Cluster Array) has been launched in 2012 with the goal of performing spectroscopy of very exotic nuclei. Since 2012, five experimental campaigns have been successfully completed using fragmentation of $^{124}$Xe beam and in-flight-fission of $^{238}$U beam, approaching for example the key nuclei $^{78}$Ni, $^{110}$Zr, $^{100}$Sn, $^{128}$Pd, $^{138}$Sn and $^{170}$Dy. This seminar highlights the experiments performed and results obtained within the EURICA project.
An overview of nuclear physics applications in different national and EU Project

L. Stevanato

Department of Physics, Padova University, Veneto, Italy.

In the last fifteen years Giuseppe Viesti and his research group at Padova University have been working on nuclear physics techniques applied to civil security.

The first two projects EXPLODET and DIAMINE, at the end of the 90’s, have dealt with the problem of humanitarian demining in the Balkans area. They are based on the neutron back-scattering technique: a low-activity neutron source ($^{252}$Cf) irradiates the soil and the yield of low-energy back-scattered neutrons depends on the relative density of light elements in the illuminated volume, in particular H atoms present in both the explosive and the plastic case of land-mines. The detection of the gamma originating from neutron capture on $^{14}$N atoms (particularly abundant in most explosives) was also studied.

Then the EURITRACK and ERITR@C projects were dedicated to develop a Tagged Neutron Inspection System (TNIS) to detect illicit materials, such as explosives and narcotics, in cargo containers. A compact sealed neutron generator based on the D+T reaction is used to induce inelastic reactions producing gamma-rays peculiar to specific elements thus providing the chemical composition of the investigated volume.

In the years 2000 SMANDRA and MODES_SN were developed as two high efficiency systems for detecting Special Nuclear Material (SNM). Both SMANDRA and MODES_SN are mobile systems with different peculiar characteristics for the detection of special nuclear material through identification of gamma, fast and thermal neutrons.

Recently the TAWARA_RT was financed with the aim of realizing a real time monitor of alpha/beta activity in tap water. The technology has been developed with a new detector foil, directly immersed in water to maximize the alpha detection efficiency.

The C-BOARD project was financed in the framework of the EU H2020 program. It is a toolbox including 5 different technologies. The Padova group is responsible of the neutron techniques.
Neutron excess, shell mobility and correlation energy in s-d nuclei

S. L. Tabor

*Florida State University, Tallahassee, Florida, USA*

Quantum shells and the gaps between them lie at the heart of nuclear structure, a structure made much richer by the fact that neutrons and protons fill separate shells. Evidence that the filling of one “flavor” of shell affects the positions and even ordering of the shells of the other “flavor” was seen early in the history of the shell model for a few limited examples, but the advent of large gamma detector arrays and radioactive beam facilities has allowed the experimental study of shell mobility to expand towards greater neutron excess and heavier nuclei. Intruder states provide a good tool for mapping out shell separations and can often be recognized by their different parities and higher spins. Results from our recent experimental investigations of $^{19}$O, $^{21}$F, $^{25}$Na, $^{31}$Si, $^{33}$P, and $^{34}$P will be presented along with comparisons with state-of-the-art shell model calculations which show varying degrees of agreement with the data.
A comment about the use of $\alpha$ transfer reactions to populate excited states in radioactive nuclei

D.A. Torres$^*$

*Universidad Nacional de Colombia, Bogotá, Colombia

The use of $\alpha$-transfer reactions, to populate excited states in radioactive nuclei, has been utilized to study magnetic moments in some isotopes that, otherwise, can not produced yet in the current radioactive beam facilities. The Transient Field technique, in inverse kinematic, is the experimental method that have been used to obtain information of the nucleon currents for some specific nuclei. The use of $\alpha$-transfer reactions gives an interesting opportunity to perform studies in radioactive species using unstable beams to initiate the reactions, but several challenges have to be addressed. A report on the status of the use of $\alpha$-transfer with the challenges and perspectives for future uses, will be presented in this talk.

Keywords: magnetic moments, alpha transfer reactions, radioactive nuclei, Transient Field Technique

$^*$Electronic address: datorresg@unal.edu.co
A new method, based on scaling analysis, is used to calculate fractal dimension and local roughness exponents to characterize in vivo 3-D tumor growth in the brain. Image acquisition was made according to the standard protocol used for brain radiotherapy and radiosurgery, i.e., axial, coronal and sagittal magnetic resonance T1-weighted images, and comprising the brain volume for image registration. Image segmentation was performed by the application of the k-means procedure upon contrasted images. We analyzed glioblastomas, astrocytomas, metastases and benign brain tumors. The results show significant variations of the parameters depending on the tumor stage and histological origin.
In nuclear reactors, fission products are the main contributors to the heating of the reactor during and after shutdown, and they are also important because of the delayed neutron emission. The knowledge of the heat produced by the decay of such nuclei is a key parameter for the safety of reactors. Our fundamental goal as in earlier studies [1] is to study the $\beta$-decay properties of several of these fission products. In this work we study $^{87,88}$Br and $^{94}$Rb. These nuclei, also have sufficient neutron excess so that the $\beta$-decay can proceed to states above the neutron separation energy ($S_n$) in the daughter nucleus, leading to the phenomenon of delayed neutron emission. Thus another goal of the experiment was to measure the possible $\gamma$-ray emission from neutron unbound states.

The Total Absorption Gamma-ray Spectroscopy (TAGS) technique allows the precise determination of the $\beta$-intensity distribution ($I_\beta$ or the related $\beta$-strength $S_\beta$) as a function of excitation energy in the daughter nucleus [2], since it measures the full disintegration $\gamma$-cascade rather than individual $\gamma$-rays. The $\beta$-decay probability is extracted in high resolution (HR) spectroscopy through the $\gamma$-ray intensity balance. Thus, for those decays with high fragmentation of the $\gamma$-intensity and primary $\gamma$-rays of high energy -large $Q_\beta$ value-, detecting weak $\gamma$-branches or $\gamma$-rays of high energy is difficult because of the limited peak efficiency of Ge detectors. As a consequence, the resulting level scheme is incomplete and a wrong assignment of excessive $\beta$-intensity to low-energy excited levels is done. TAGS technique overcomes this systematic and common error known as “Pandemonium effect” [3].

Our experiment was performed in 2009 using a novel and home-developed TAGS segmented detector. The entire set of measurements included several “decay heat” contributors with...
priority “1” (according to the International Nuclear Data Committee INDC [4]) and among them, the two bromines analyzed in this work. The experiment took place in Finland at the IGISOL-JYFL mass separator, with radioactive beams purified by a Penning trap system. The results confirm the strong presence of Pandemonium effect for two cases and reveal sizeable gamma branching ratios above $S_n$ in contrast with the common assumption of a negligible $\gamma$-deexcitation.


The role of $g_{9/2}$ intruder state in the nuclear matrix elements of $^{76}\text{Ge} \to ^{76}\text{Se} \; 2\nu\beta\beta$ decay

J.P. Valencia

*Instituto de Física, Universidad de Antioquia, Medellín, Colombia.*

In heavy deformed nuclei, the intruder states play a very important role in the $2\nu\beta\beta$ and $0\nu\beta\beta$ decays, as was shown in the $\widetilde{SU}(3)$ model studies [1]. Moreover, recently for the nuclei in the upper part of the pf-shell (say $^{76}\text{Ge}$ and $^{76}\text{Se}$, which are of our interest) measurements show a high occupancy of the $g_{9/2}$ orbits [2]: $6.48 \pm 0.30(\nu), 0.23 \pm 0.25(\pi)$ for $^{76}\text{Ge}$ and $5.80 \pm 0.30(\nu), 0.84 \pm 0.25(\pi)$ for $^{76}\text{Se}$, respectively. This indicates that in those nuclei the contribution of the intruder state must be taken into account. However, the previous study by $\widetilde{SU}(4)$ model (for the beginning part of the pf-shell) [3,4] neglects the contribution of $g_{9/2}$ due to its small component in the total wave function. Thus we propose a model for the upper-part of pf-shell, that consists of $p_{1/2}$, $p_{3/2}$, $f_{5/2}$ and $g_{9/2}$ single-particle orbits. While the pf-subshell (or $\widetilde{ds}$-shell, i.e. $p_{1/2}$, $p_{3/2}$, $f_{5/2}$) is governed by the $\widetilde{SU}(4) \otimes \widetilde{SU}(6)$ symmetry, the $g_{9/2}$ intruder state is by the seniority model.

By using this model we study the role of $g_{9/2}$ intruder state in the nuclear matrix element (N.M.E) of the $2\nu\beta\beta$ decay of $^{76}\text{Ge} \to ^{76}\text{Se}$. The nuclear states of $^{76}\text{Ge}$ and $^{76}\text{Se}$ are expressed as direct products of the $\widetilde{ds}$ subshell component and the $g$-subshell one. To limit the model space we assume that the $g_{9/2}$ shell is a seniority-zero state. The configurations are described as $(n_\pi, n_\nu)_g \; [M_\pi, M_\nu]_{\widetilde{ds}}$. The number of protons and neutrons in the $g_{9/2}$ subshell are chosen as $n_\pi = 0, 2$ and $n_\nu = 4, 6, 8$ for $^{76}\text{Ge}$ and $^{76}\text{Se}$, and the amplitudes of the corresponding configurations are determined by reproducing the experimental value of $g_{9/2}$ occupancy. The configuration in the $\widetilde{ds}$-subshell are $[(4 - n_\pi), (16 - n_\nu)]$ for $^{76}\text{Ge}$ and $[(6 - n_\pi), (14 - n_\nu)]$ for $^{76}\text{Se}$, respectively. Due to the property of the Gamow-Teller operator and the seniority-zero restriction for the $g$-subshell state, the two beta decays happen either both in the $g$-subshell or both in the $\widetilde{ds}$-subshell, which greatly simplifies the calculation.

The five-dimensional proton-neutron quasispin model is used for a classification in the $g$-subshell [5]. In the $\widetilde{ds}$-subshell, for each configuration $[M_\pi, M_\nu]_{\widetilde{ds}}$ we choose only the most symmetric $\widetilde{SU}(6)$ representations with total pseudo-spin $\widetilde{S} = 0$, therefore, all the configurations are given by $(0Y0) \; \{4P \; 2Y\}$ and $(0Y - 20) \; \{4P+1 \; 2Y-2\}$ for $^{76}\text{Ge}$ and $^{76}\text{Se}$, respectively with $Y = 6 - (n_\nu - n_\pi)/2$ and $P = (4 - n_\pi)/2$. We calculate the NME of the $2\nu\beta\beta(0^+ \to 0^+)$ in the closure approximation.


Symmetries of the nuclear shell model

P. Van Isacker

*Grand Accélérateur National d’Ions Lourds, CEA/DSM-CNRS/IN2P3 B.P. 55027, F-14076 Caen Cedex 5, France*

Ever since the pioneering studies by Wigner, Racah and Elliott, symmetry considerations have played a pivotal role in the development of nuclear models, in particular of the spherical shell model. Two types of interaction between the nucleons exist that allow an analytic solution of the nuclear many-body problem. The first is the pairing interaction, giving rise to Racah’s seniority model and its many offshoots. The second is the quadrupole interaction, at the basis of Elliott’s SU(3) model of rotation. In this talk the use of symmetry techniques in present-day studies of exotic nuclei is illustrated with some examples. A third type of interaction with an analytic solution is introduced, namely an octupole interaction in two major oscillator shells, leading to an octupole-deformed solution of the spherical shell model. It is shown that, in the limit of large oscillator shells, the algebraic octupole interaction tends to that of the geometric collective model.
In-medium excitation of nucleon resonances using isobaric charge-exchange reactions at relativistic energies


*Universidad Santiago de Compostela, Spain

Universidad Pedagogica y Tecnolgica de Colombia, Colombia


GSI Darmstadt, Germany

H. Lenske

**Jusatus-Liebig-Universität Giessen, Germany

I. Vidaña

Universidade de Coimbra, Portugal

A. Chatillon, J. Taieb

DAM/CEA, Arpajon, France

A new goal for nuclear structure physics is to broaden the focus into the direction of nucleon resonances in nuclear matter. The excited nucleon is an object of still ongoing hadron physics research, directed to understand the fundamental spectroscopic properties of the nucleon and baryons in general. The focus of nuclear structure research with excited nucleons is clearly different: Here, research are directed to explore in-medium properties of resonances, their interactions with a nuclear background medium, and the possibility to use resonances as probes for nuclear structure. In detail, such a program requires to investigate the production of nucleon resonances in a variety of nuclei, allowing to study their properties under variations of density and, especially, charge asymmetry.

In a recent experiment at the FRS@GSI the excitation of nucleon resonances was measured using secondary beams of short-lived exotic nuclei impinging on stable targets. Heavy ion charge exchange reactions were used to excite charge exchange states in the quasi-elastic and the resonance regions. Both \((p,n)\) and \((n,p)\)-type reactions were observed. The data clearly resolve the spectral distributions of nuclear and nucleon charge exchange excitations, better than the previous pioneering experiments e.g. at DIOGENE@SATURNE. In both charge exchange channels the Delta resonance is clearly visible, well separated from the quasi-elastic spectral component. Indications for the excitation of higher resonances are evident.

In this work we present the results obtained in the experimental measurements performed at FRS@GSI facilities and the its respective comparison with theoretical calculations where it is possible to disentangle the nucleon resonances production in the projectile and target as well as the resonance multiplets in the reactions of \(^{112}\text{Sn}(p,X)^{112}\text{Sb}\) and \(^{112}\text{Sn}(C,X)^{112}\text{Sb}\).
The data show that the FRS@GSI is an ideal, if not unique instrument to investigate the excitation mechanisms and production probability of nucleon resonances in cold nuclear matter at normal density and variable charge asymmetry. Even better conditions will be encountered in future at the Super-FRS once the FAIR facility comes in operation.
Study of the one-neutron halo $^{19}\text{C}$ via single-proton knockout of $^{20}\text{N}$

K. Whitmore$^{1,2}$, N. Kobayashi$^2$, H. Iwasaki$^{1,2}$, D. Bazin$^2$, B. A. Brown$^{1,2}$, A. Gade$^{1,2}$, A. Lemasson$^3$, C. Loelius$^{1,2}$, C. Morse$^{1,2}$, T. Otsuka$^{2,4,5}$, D. Smalley$^2$, T. Suzuki$^6$, J. A. Tostevin$^7$, and D. Weisshaar$^2$

1Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan, USA
2National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan, USA
3Ganil, CEA/DSM-CNRS/IN2P3, Bd Henri Becquerel, BP 55027, F-14076 Caen Cedex 5, France
4Department of Physics, University of Tokyo, Hongo, Bunkyo-ku, Tokyo, Japan
5Center for Nuclear Study, University of Tokyo, Hongo, Bunkyo-ku, Tokyo, Japan
6Department of Physics, Nihon University, Sakurajosui, Setagaya-ku, Tokyo, Japan
7Department of Physics, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford, Surrey, United Kingdom

With the advancements in fast radioactive beams, direct reactions have become powerful tools in the investigation of single-particle structure of nuclei far from stability [1]. In particular, single-nucleon knockout reactions serve as a means to investigate spins and parities of nuclear states. Several neutron knockout reactions have already been performed on the neutron-rich carbon isotopes [2,4]. The observations of the $1/2^+$ ground state in $^{15}\text{C}$ and $^{19}\text{C}$ and a low-lying $1/2^+$ state in $^{17}\text{C}$ establish the near-degeneracy of the neutron $s_{1/2}$ and $d_{5/2}$ orbitals as a general feature among these nuclei. Measurement of the proton spectroscopic factors in nitrogen can help to determine to what extent this feature persists beyond the carbon isotopes.

The structure of the one-neutron halo $^{19}\text{C}$ has been investigated after a one-proton knockout reaction from $^{20}\text{N}$ at 70 MeV/nucleon on a beryllium target. The experiment was performed at the National Superconducting Cyclotron Laboratory. $^{19}\text{C}$ fragments were identified with the S800 spectrograph [5], and exclusive cross sections were extracted by tagging coincident gamma rays with the gamma tracking array GRETINA [6]. Results on the cross section and momentum distributions will be presented and compared to state-of-the-art shell model and eikonal reaction calculations. The theoretical calculations provide strong support for the spin assignments of the states in both $^{19}\text{C}$ and $^{20}\text{N}$.


* This work was supported in part by grants from the NSF and DOE
†Present address: Department of Physics, University of Massachusetts, Lowell, Massachusetts, USA


The study of the β decay is an useful tool to study the nuclear structure of the nucleus, particularly in nucleus with $T_z < 0$. This decay allow us to see GT transitions in the energy windows available by the Q-value and is governned by the $\sigma\tau$ operator, and make it posible the cuantification of the intensity transition to the states to the daughter nuclei. Althought it can not populate any states higher than the Q-value of the β decay.

The charge exchange (CE) reactions ($p,n$)-type are also governned by the $\sigma\tau$ operator an they are analogous to the β decay, populating the same states in the daughter nuclei. In CE reactions, higher energy states can be archieved and relative GT strengths can be obtained through high resolution ($^3He,t$) reaction experiments [1].

In mirror nuclei transitions, the CE experiments and the β decay are complementary tools to obtain all states in the daughter nucleus and the absolute transitions strengths $B$(GT). This kind of studies have been successfully performed from $A=26-58$ [2–4].

In this work, preliminary results of the $T_z = -2$ $^{64}$Se β-decay γ-ray spectroscopy will be present. The $^{64}$Se was produced by the $^{78}$Kr fragmentation reaction at RIKEN during july 2015.


Results on the neutron energy distribution measurements at the RECH-1 Chilean Nuclear Reactor

P. Aguilera J.\textsuperscript{1,3}, Francisco Molina P.\textsuperscript{3}, José R. Morales\textsuperscript{1}, Jaime Romero\textsuperscript{2,3}, M. Zambra\textsuperscript{3}

\textsuperscript{1} Universidad de Chile, Facultad de Ciencias, Las Palmeras 3425, Ñuñoa, Santiago
\textsuperscript{2} Universidad de Chile, Facultad de Ciencias Físicas y Matemáticas, Almirante Blanco Encalada 2120, Santiago
\textsuperscript{3} Comisión Chilena de Energía Nuclear, Nueva Bilbao 12501, Santiago

The RECH-1 is a 5 MW pool-type experimental nuclear reactor. Its neutron flux have been measured at the reactor for three neutron energy regions: thermal, epithermal and fast [1]. Those measurements were made at 10 kW at the core by activation of samples of Au, In, and Au with Cd shield.

To obtain a detailed distribution, it is necessary to measure the saturation activity for $(n, \cdot)$ reaction of several materials and use the reaction cross-section from nuclear databases to unfold the neutron flux using the equation $A_i^\infty = \int_0^\infty \sigma_i(E)\Phi(E)dE$. This procedure has been performed in the IPEN/MB-01 reactor [2] using the SANDII, SANDBP unfolding codes. Those codes need additional information to start the iterations.

In this work, 19 saturation activities from different materials were measured by the neutron activation analysis experiments at standard operation power (5 MW). The reaction cross sections were obtained from the ENDF-B/VII.1 nuclear data base. To obtain the neutron flux, the expectation maximization method was successfully applied, using an uniform flux distribution as a first step of iteration. Convergence test of the iterative method will also be presented.


\textsuperscript{*}Electronic address: paguilera87@gmail.com
Radioablative therapy with Iodine-131 on a patient with thyroid cancer and chronic renal failure in hemodialysis first experience in Peru

1,2Apaza Veliz*, D.G; 1Cardenas Abarca, C.A; 1Herrera Vera, R.D; 1Oporto Gonzales, C.A; 1Aguilar Ramírez, C; 1Urquizo Baldomero, R.M
1Hospital Nacional Carlos Alberto Seguin Escobedo, Servicio de Medicina Nuclear, EsSalud Arequipa, Perú.
2Universidad Nacional de San Agustín de Arequipa, Escuela de Física. Arequipa, Perú.

The Iodine 131 (I-131) is a radioisotope used in radioablation therapies as a standard treatment of thyroid hyperfunction and radioablative therapy for thyroid cancer. Within these two diseases, thyroid cancer represents higher incidence in the southern region of Perú, among these we have patients treated on hemodialysis as a specific group. The dose of Iodine 131 is given orally to these patients, been absorbed mainly by the thyroid remnants and the rest, largely not incorporated, excreted primarily by renal excretion. The use of a high dose of radioactivity in the process, and the inability of excretion, represents a high risk of exposure to the patient, staff and hemodialysis equipment. In this paper we describe what was the procedure for the treatment of radioablation therapy for thyroid cancer simultaneously with a hemodialysis treatment, minimizing the risks for the patient and the staff involved. With the acquired experience, a procedure protocol has been established, for this type of treatment in clinical practice, since it is the first time that this multidisciplinary procedure has been done all over Peru. This clinical procedure will allow us to establish dosimetric measures, a plan on radiation protection and a treatment protocol for this specific type of patients.

Keywords: Radioablation therapy, Iodine 131, hemodialysis, dosimetry, radiation protection.

*Electronic address: dgav02@gmail.com
Development of an automated system of blocks for radiotherapy improving the patient radioprotection

Y. Banguero\textsuperscript{1}, M. Gomez\textsuperscript{2}, G. Píriz\textsuperscript{1,3}, A. Quarneti\textsuperscript{1}, y R. Doldan\textsuperscript{3}

\textsuperscript{1}Universidad de la República, Uruguay.
\textsuperscript{2}Instituto Tecnológico Superior, Uruguay.
\textsuperscript{3}ONCOSUR, Uruguay.

The use of blocks in radiotherapy comes from the needing to protect the organs at risk in the treatment fields. This need has been corrected by the use of Multileafs in the new accelerators, although for its cost there are centers do not count yet with. The use of blocks normally does in a place determined for this task and the material used must be melted to come to the forms that are needed.

The mold system has a milling machine, a planning program and a script. The milling is an inexpensive machine with Computerized Numerical Control (CNC) to cut the material. This CNC works with a G- code language and also it is used a Matlab script to take the points that define the curve block. The planning system used is MIRS V5.1. The molds are made with iron rods and the cutting models the structure until have the required shape.

The automatic cut developed allows more precision; by its design has less weight than traditional molds. About positioning, it is not necessary to make holes in the tray to adjust each block and does not require a mold room with a device that heats the material. One of the difficulties to be solved was having a count the beam divergence, initially on a single axis, later, to separate the block it was possible to solve the problem.

The method and the structure of the developed mold is a previous step to do IMRT for transmission. The CNC system will devastate expanded polystyrene (Styrofoam) to be filled with iron oxide powder.
Development of optimization treatment process, extern of the planning system

G. Píriz$^{1,2,3}$, Y. Banguero$^1$, L. Cardozo$^3$, A. Cortes$^2$, S. Merlo$^2$, A. Quarneti$^{1,3}$, y R. Doldan$^2$

$^1$Universidad de la República, Uruguay.
$^2$ONCOSUR, Uruguay.
$^3$Centro Hospitalario Pereira Rossell, Uruguay.

Treatment plans are base on dose prescription for target volume and organ at risk. The target volume dose is an objective and the organ at risk dose is a restriction. Searching for plans that with better doses distributions fulfill the prescribed treatment, radiotherapy has been advancing in more complex treatment techniques, where only one point ICRU it is not representative of the desired dose in the planning target volume. It is required to defined various points in the volume to be able to characterized the dose in the whole Planning target volume as happens, when it is utilized treatment fields that do not irradiate the whole planning target volume.

As illustration, when working on pelvis, the radiation with box technique has results inferior than those with cross-fire technique for example. In the context of the cross-fire technique the isocenter loses its position as representative point for all fields, due to not all irradiation fields reach the isocenter with high doses. Equitably, when working to insure the ganglionar dose for head and neck, no only is necessary treat patient with lateral photons fields, when using techniques such as Bellizona, conformal Parotid Gland-Sparin (ConPas), Field in Field (FiF), Forward-Planned Multisegments (FPMS) and arcotherapy but also is needed to put different prescription points for each field with successive complication in their weight election. The dose conformity for breast, made with tangential fields, differs greatly from the one using arc techniques with asymmetric field and blocking in the field center. The cases just mentioned are miscellaneous but share in common that fields have to be prescribed in diverse manners to be optimized; also it is not direct to determinate the field contribution in the planning.

In order to have a more automatic planning and optimization process, a spreadsheet is made as external tool from the treatment planning system. This aids to find the weight fields with the techniques mentioned above. This development is made using the planning system MIRS V5.1, with a excel spreadsheet that use the Solver tool to minimize an objective function, with this results is possible to modify the treated fields weights, avoiding the process trial-error. Therefore is possible optimize planning time and provides a standardize result.
Dose volume histogram and its dependency with the calculus grid in the system MIRS V5.1.

G. Píriz¹,², Y. Banguero¹, A. Cortes², A. Quarneti¹, y R. Doldan²

¹Universidad de la República, Uruguay.
²ONCOSUR, Uruguay.

Dose volume histogram is one of the most used tools to evaluate and make decisions during radiotherapy planning. The Dose volume histogram dependency along with the form and the grid dimension has been analyzed among diverse planning systems.

This study presents the dependency of the dose volume histogram in the planning system MIRS V5.1. related with grid size. Two water-filled phantoms were designed, one cylindrical and one anthropomorphic head phantom. Both phantoms were equipped with a set of interchangeable inserts with shapes of sphere, cone and cube.

Phantom tomography is used to do planning treatments using different grid sizes. Analysis of dose volume histogram was made taking in consideration the shape of the phantom inserts and the variation of the homogeneity indexes.
Measurement of the concentration of natural radionuclides by $\gamma$-ray spectroscopy using a NaI detector

F. Bautista, W. Rodríguez, F. Cristancho, S. Veloza
Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia
Grupo de Física Nuclear GFNUN, Bogotá, Colombia

We conducted a study to determine the concentrations of the radionuclides $^{238}\text{U}$, $^{232}\text{Th}$ and some of their decay daughters as well as the $^{40}\text{K}$ concentration by means of a NaI detector. An experiment with a high resolution (HPGe) $\gamma$-ray detector was conducted in order to delimit the regions of the spectrum which allow to measure the concentrations of each radionuclide. The determination of the concentrations was done by comparing the spectra of a sample and of the reference materials RGU-1, RGTh-1 and RGK-1 [1]. The concentrations and accuracy produced by measuring with the NaI detector were compared with the results found using a Ge detector. Due to the interference in the spectrum of the NaI detector, the concentrations of some radionuclides were not determined, instead of that an upper limit was established for their concentrations.

Keywords: Natural radioactivity, decay chain, $\gamma$-ray spectroscopy.

Beam Line Radioactivity Study for the Spes Project

J. Bermudez* et al.

In the framework of SPES project, calculations were performed for evaluating the radioactivity level along the beam transference line after 2 weeks planned operation. The study is required to produce relevant data for maintenance schedule, radioprotection protocol development and to program the control access to specific areas in the facility. Modelling is referred to a selected set of seven radioisotopes at RIB’s such as: $^{90}$Rb, $^{94}$Kr, $^{132}$Sn, $^{134}$Sn, $^{135}$I, $^{137}$Te, $^{138}$Xe. The isotopies production was calculated for each type of radioisotope starting from the activation of the UC target by energetic (70MeV) proton beam (200microAmp). Transport simulation along the 34 mts beam path was prepared using TraceWin® devices (Dipole ($\Delta M/M=1/200$)-HRMS $\Delta M/M=1/20000$). The ambient dose equivalent $H^*(\mu Sv/h)$ was determined at three locations along the beam line employing FLUKA code. Localized hotspots were identified and values determined at the 90° Dipole, High Resolution Mass Spectrometer (HRMS) and at the Charge breeder. Results are reported for different time-intervals after the end of planned two weeks irradiation of the target. Experimental results indicate that most of the set of radioisotopes carried by the beams and deposited at the mentioned hotspots induce a dosis is around 1 Sv$^{-1}$ after 30 days from beam shut-down.

*Electronic address: judilka.bermudez@lnl.infn.it
Systematic analysis of elastic scattering angular distributions with the São Paulo potential

F. E. Charry-Pastrana, E. C. Pinilla, and F. Cristancho
Universidad Nacional de Colombia, Sede Bogotá, Facultad de Ciencias, Departamento de Física, Grupo de Física Nuclear, Carrera 45 Nº 26-85, Edificio Uriel Gutiérrez, Bogotá D.C. Código Postal 111321, Colombia

Few-body descriptions of nuclei are based on nucleon-nucleus or nucleus-nucleus optical potentials. Some of them are not known since their parameters are taken from the adjustment to data of experiments of elastic differential cross sections that have not been performed. Thus a potential with high predictive power is needed. In this work we aim at describing systematically by collision energy and target mass, nucleon-nucleus elastic scattering angular distributions by using the São Paulo potential [1]. The charge and matter densities of the target are taken from Ref. [2]. The imaginary part of the potential is multiplied by a real factor which is fitted to describe experimental cross sections shown in Ref. [3].

Information of the percentage of depth dose (PDD) of ionizing radiations is essential for radiotherapist. For more than two decades, cancer treatments have been performed using photons and electrons. In the beginning, units of cobalt 60 were used, while in the present the use of LINACs is becoming standard for the generation of a beam of photons, with the subsequent apoptosis in the cancer cells.

In the PDD, due to the different energies and type of interaction of photons and electrons with matter, the most of the energy remains in the first centimetres of depth; and therefore in this kind of clinical treatments, a part of this energy hits the healthy tissue near to the tumor. An alternative is the use of hadrons and heavy ions, which deliver the most of their energy at the end of all interactions with the tissue, an effect known as Bragg peak; for this reason, in the last years, the so called hadron therapy is considered a suitable alternative for the treatment of tumors which need a high precision.

In this work, a Monte Carlo Geant4 code was used for the simulation of a water phantom and this way generate a Bragg peak using monoenergetic beams of different energies. Then an average human head simulation was made and was radiated with an pulsate beam of protons or carbon ions in order to calculate the energy dose distribution and deposit in each case. The PDD Dose distribution maps was obtained and analysed. The project looks for a method to estimate the dose in a cancer treatment using Open Source tools such as Geant4.
Effect of sample thickness on 511 keV simple Compton-scattered gamma rays

Katerine V. Díaz Hernández, F. Cristancho

Departamento de Física, Universidad Nacional de Colombia, Carrera 30 No 45-03, Bogotá, Colombia

Gamma backscattering experiments were performed on metal foils. A collimated beam from $^{22}\text{Na}$ source impinge on aluminum sheets of $333 \times 204 \times 10$ mm and iron sheets of $330 \times 200 \times 2$ mm. The backscattered photons are detected by a $51 \times 51$ mm CsI scintillator detector placed at $90^\circ$ to the incident beam. Saturation thickness of the materials studied for energy of 511 keV was obtained.
Can we trust the parametrizations utilized to perform Magnetic Moments measurements using the Transient Field technique?

A.M. Gómez*

Programa de Física, Facultad de Ciencias Básicas, Universidad del Quindío, Armenia, Colombia.

D.A. Torres

Departamento de Física, Universidad Nacional de Colombia, Bogotá D.C., Colombia

Measurements of nuclear magnetic moments have been of vital importance to understand the main components of the nucleon currents inside the atomic nucleus. The study of such magnetic moments of excited states, with short lifetimes [1], is a challenging task that has been experimentally addressed using techniques such as the Transient Field, which makes use of hyperfine interactions to create strong magnetic fields that generates the Larmor precession of the nuclear spin [2]. The exact description of such magnetic fields, from first principles, is still a matter of theoretical research and is for this reason that the use of parametrizations is a common way to handle experimentally the lack of information [3].

In this contribution a review of the main parametrizations utilized in the measurements of Nuclear Magnetic Moments will be present, special emphasis will be made on the limits of the different parametrizations and the theoretical challenges to obtain a description from first principles [4].

Keywords: Nuclear Magnetic Moment, Transient Field, Transient Field Parametrizations, Nuclear Structure, $g$-factor.


*Electronic address: amgomez11@uqvirtual.edu.co
The recent licensing of the Colombian IAN-R1 reactor [1] has motivated technical activities to make it operational and has encouraged the start of scientific and academic activities towards the appropriation of the understanding of the physics of reactors.

Geant4, a powerful tool used in the simulation of the interaction of particles with matter was used to simulate the interaction of neutrons inside a nuclear reactor. In the present work $5 \times 10^5$ neutrons are emitted from a simulated source with an energy distribution in a range between 0.025 eV (thermal neutrons) and 10 MeV. The target is simulated as a rod of Uranium-zirconium hydride (UZrH) [2] of 38 cm of length. The results found were compared to theoretical calculations [3]. Data presented include the mean free path of the neutron within the fuel rod, the average number of neutrons produced by fission, an analysis of the spectroscopy of the released neutrons and $\gamma$-ray in the fission. Finally the cross sections of the $(n,\gamma)$ and $(n,f)$ reactions were used to determine the optimal range of energies in which the chain reaction occurs within the reactor.


--

*Electronic address: nguaring@unal.edu.co
The exceedingly high price/liter of $^3$He for the detection of moderated neutrons has triggered a widespread and intensive research work aimed at $^3$He substitution for the detection of moderated neutrons. Siloxane-based scintillators are in principle very simple and economic for particle detection, in general [1]. Their usefulness to detect thermal neutrons by loading with ortho-carborane has been demonstrated, though limited solubility of the organo-boron compound hampered their further development.

Herein, we report on the production of a siloxane scintillator, added with a suitable combination of primary dye and waveshifter, where $^6$LiF nanocrystals have been embedded. The entrapment of nanoparticles, which are known to minimize light scattering effects, has been herein exploited for the first time to circumvent the critical issue of light loss induced by opacity. The synthesis of the nanodiamonds of $^6$LiF has been pursued by two different routes: the co-precipitation method [2] and the surfactant-controlled thermolysis of Li trifluoroacetate (LiTFA) [3]. Highly monodisperse LiF nanocubes have been collected in good yield with both synthesis, as shown by Scanning Electron Microscopy and X-Ray Diffraction and dispersed by mechanical shear blender or by dissolution directly into the siloxane matrix.

Samples with different thickness and $^6$LiF content have been tested with a moderated Am-Be neutron source and promising results have been obtained.


A practical method of energy calibration of $\gamma$ spectrum of plastic scintillators using Compton scattered $\gamma$-rays and Monte Carlo simulations

A. A. Navarro*, F. Cristancho, D. Flechas

Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia

E. Fajardo

Grupo de Física Nuclear de la Universidad Nacional, Bogotá, Colombia

Plastic detectors are typically used in $\gamma$-ray experiments in order to obtain a time signal with no energy information at all. This is so because this type of scintillators do not produce a photopeak for $\gamma$-rays in the range between some keV and several MeV. Plastic detectors do produce, however, a Compton background as response function. In this work an energy calibration method for plastic scintillators (polyvinyl toluene (PVT)-based detectors) using Compton kinematics for $\gamma$-beams is proposed. The method is based on matching experimental data with a Monte Carlo n-particle (MCNP) simulation developed using the Geant4 toolkit. For that an algorithm was written that compares the shape of different Gaussian Energy Broadening (GEB) spectra with the measured one and also makes a $\chi^2$ fit in order to obtain the new bin size and its displacement; using the best parameters in the GEB and the $\chi^2$ fit for all used sources the final calibration is obtained. This calibration method is validated by applying it to spectra obtained with an NaI detector and comparing those results to the standard photopeak method [1–3].

Keywords: Energy Calibration, MCNP, Geant4, Plastic scintillators, $\gamma$ detectors


*Electronic address: aanavarroa@unal.edu.co
Design of a model to scale animal biodistribution to human of the radiopharmaceutical [68Ga]Ga-PSMA-HBED-CC

Pamela Ochoa Parra\textsuperscript{*}, Diana Ortegon Pineda\textsuperscript{†}, Lorena Sandoval\textsuperscript{‡}, Luz Stella Veloza Salcedo\textsuperscript{§}

Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia.

The second stage of testing the new radiopharmaceutical [68Ga] GaPSMA-HBED-CC, which will be implemented in Colombia, requires to perform data extrapolation to humans from the biokinetic model made in normal mice. In order to provide the more accurate prediction of the biodistribution in humans, the goal of this research was to design a protocol to map the activity data using the computer software OLINDA / EXM \textregistered.

The model allows to identify the critical organ (most radiosensitive), to calculate the maximum activity that can be administered to patients and to validate the quality of the radiopharmaceutical by comparison with the biokinetic reported in clinical trials.

Keywords: Dose assessment, biodistribution, PSMA, kinetic model, OLINDA/ EXM \textregistered.

\textsuperscript{*}Electronic address: lapochoap@unal.edu.co
\textsuperscript{†}Electronic address: djortegonp@unal.edu.co
\textsuperscript{‡}Electronic address: llsandovalc@unal.edu.co
\textsuperscript{§}Electronic address: lsvelozas@unal.edu.co
Clinical trials have demonstrated the potential of positron emission tomography (PET) imaging in the detection of prostate cancer (CaP) lesions by using based molecule inhibitors of prostate-specific membrane antigen (PSMA) labeled with Ga-68. In order to implement this new radiopharmaceutical in Colombia, a preclinical study using nonhuman species is required.

The goal of this research was to establish the protocol of a biokinetic study in normal mice with two different methods: a postmortem dissection and in vivo imaging. The protocol minimize the number of animals and the data collection points used allowing an accuracy determination of the dose profiles of the radiopharmaceutical in organs and tissues of the subjects.

Keywords: Prostate cancer; \(^{68}\text{Ga}\)-PET imaging; PSMA; HBED-CC; biokinetic model; organ dose.
The simulation of the spectroscopy systems using MC codes is a common practice in those days. The most popular softwares to do this are MCNP and Geant4 codes [1,2].

In this work we present the simulation of a gamma spectroscopy system based on a coaxial HPGe detector using FLUKA code [3]. The geometry characterization was realized from manufacturer information and using the intrinsic efficiency spatial distribution [4], which was used to determine the dimensions of the inner cavity of the detector.

The aim of this work is to characterize the detector without the necessity to apply a radiography or any other technique that is not directly associated to a nuclear physics laboratory. Due to the differences between the real and simulated response function we suppose that these are proportional. In the figure 1 we show a comparative graphic of the experimental and simulated absolute efficiency of the coaxial HPGe detector for a energy of 661.65 keV along the axial axis.

![Figure 1. Comparative graphic of the experimental and simulated absolute efficiency of the coaxial HPGe detector used in this study for a energy of 661.65 keV along the axial axis.](image)


Experimental validation of the intrinsic spatial efficiency method over a wide range of sizes for cylindrical sources

Pablo Ortiz-Ramirez, and Philippe Larroquette
Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago 7800024, Chile

S. Camilla
Departamento de Física, Universidad Tecnológica Metropolitana, Santiago 97279, Chile

The intrinsic spatial efficiency method is a new absolute method to determine the efficiency of a gamma spectroscopy system for extended sources [1]. In the original work the method was demonstrated and validated for homogeneous cylindrical sources containing $^{137}$Cs, whose sizes varied over a small range.

In this work we present an extension of the validation over a wide range of sizes. The dimensions of the cylindrical sources will vary between 10 to 60 mm height and 8 to 30 mm radius.

The aim of this work is to validate and show the reliability of the intrinsic spatial efficiency method for homogeneous cylindrical volume sources with sizes varying in a wide range.

The preliminary results shown a good agree with those obtained in the original work. Until the moment the analysis have been carried out for the sources of 10 and 20 mm height. In the table I we show the obtained results with those sources.

Table I. Obtained results for the cylindrical sources of 10 and 20 mm height and 8, 14, 18, 23 and 29 mm radius. It shows the values of the specific activity obtained in each case, in Bq/kg, and the relative bias to the expected value (11324 Bq/kg).

<table>
<thead>
<tr>
<th>Height mm</th>
<th>Radius mm</th>
<th>8</th>
<th>14</th>
<th>18</th>
<th>23</th>
<th>29</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10691±415</td>
<td>10625±180</td>
<td>10695±158</td>
<td>10749±125</td>
<td>10876±220</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.5%</td>
<td>6.1%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>3.9%</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10833±397</td>
<td>10372±226</td>
<td>10453±108</td>
<td>10393±90</td>
<td>10811±80</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.3%</td>
<td>8.4%</td>
<td>7.7%</td>
<td>8.1%</td>
<td>4.5%</td>
<td></td>
</tr>
</tbody>
</table>

Validation of the intrinsic spatial efficiency method for non cylindrical homogeneous sources using MC simulation

Pablo Ortiz-Ramirez, and Andrés Ruiz
Departamento de Física, Facultad de Ciencias, Universidad de Chile, Santiago 7800024, Chile

The Monte Carlo simulation of the gamma spectroscopy systems is a common practice in these days. The most popular softwares to do this are MCNP and Geant4 codes [1,2].

The intrinsic spatial efficiency method is a general and absolute method to determine the absolute efficiency of any extended sources, but this was demonstrated experimentally only for cylindrical sources [3].

In this work we present the validation of the intrinsic spatial efficiency method for sources with geometries different to the cylindrical. Due to the difficulty that the preparation of sources with any shape represents, the simplest way to do this is by the simulation of the spectroscopy system and the source. The MC simulation is carried out using the FLUKA code [4].

Until this moment we have simulated rings, planar discs and cylindrical shells sources of different sizes and positioned on different positions over the axial axis. Preliminary results shown an excellent agree between the absolute efficiencies determined by the standard method and the intrinsic spatial efficiency method [3]. The relative bias in all cases are lesser than 1%.


The acquisition of images using a CT scanner is nowadays necessary in almost any kind of medical study. Its purpose is to produce images with the best achievable quality which implies the increase of dose to the patient. Image quality can be measured quantitatively based on parameters such as noise, uniformity and resolution. This measure allows the determination of optimal parameters of operation for the scanner in order to get the best diagnostic image. This CT scanner is the first one minded for veterinary use exclusively in Colombia. The significant differences between a human adult and a small animal implies the use of an entire new protocol.

The aim in this project is to measure these parameters of the CT imaging system using a phantom and the computational tool MATLAB, as well as the dose as a function of the current in the tube. The scheme of operation for the CT scanner in small animals differs from the human adult protocol and approaches a pediatric one.
In recent years, the therapy of neuroendocrine tumors with the radiopharmaceutical $^{177}$Lu-DOTATATE, has yielded promising results. This therapy may be improved by using 3D individualized dosimetry that allows the optimization of the absorbed dose in the tumors and normal organs. An algorithm based on GDCM and ROOT was used to get a delimitation in SPECT-CT images for some simulated tumor volumes present in an agar phantom that can be filled with $^{177}$Lu-DOTATATE. The algorithm is useful to determine the cumulative activity at each voxel and then, the absorbed and effective doses are calculated with OLINDA. The voxel-based methods produce dose volume histograms (DVHs) and radiobiological parameters of great interest for radionuclide therapy, and an accurate dosimetry is also necessary to understand the influence of this parameters in the treatment response. The SPECT-CT voxel dosimetry is feasible and more accurate than conventional planar dosimetry, and this could contribute in the optimization of target radionuclide therapy.
Calculation of self-shielding factor for neutron activation experiments using
Geant4 and MCNP

Jaime Romero* 1,2, F.Molina2
1Departamento de Física–FCFM, Universidad de Chile, Av. Blanco Encalada 2008, Santiago, Chile.  
2Comisión Chilena de Energía Nuclear, Amunátegui 85, P.O. Box 188-D, Santiago, Chile.

In this work we calculated the self-shielding factor, $G$, as a function of the neutron energy, which is important to consider in precise neutron activation experiments. Twelve samples of pure metallic materials were simulated using the Geant4 Monte Carlo toolkit [1, 2] and the MCNP [3] code.

The self-shielding factor is defined as the ratio between the neutron flux in the sample volume and the flux in the surface of the sample,

$$G = \frac{\int_{E_1}^{E_2} dE \Phi_V}{\int_{E_1}^{E_2} dE \Phi_S}$$

We have simulated the behaviour of the self-shielding factor for different material thicknesses (from $10^{-8}$ m to $10^{-2}$ m), with neutron energies from $10^{-5}$ eV to 20 MeV.

Results obtained by running $10^7$ neutron events in Geant4 using the FTFPBERT-HP physics library and the ENDFB/VII.1 nuclear database, shows that the self-shielding factor is relevant to include in neutron activation analysis experiments for thermal neutron energies and for sample thickness greater than $10^{-4}$ m. Benchmark between Geant4 results and MCNP simulations are currently underway.

Acknowledgments: This work has been supported by FONDECYT Iniciacion under grant No 1130049. J.R. acknowledges support from Programa Nacional de Becas de Postgrado under grant No. 21151413.


*Electronic address: jaromero@ing.uchile.cl
Comparison between $\gamma$-ray spectra obtained from PIN photo-diode and photomultiplier tube arrangements

W. Saenz*, F. Cristancho

Departamento de Física, Universidad Nacional de Colombia, Bogotá, Colombia

E. Fajardo

Grupo de Física Nuclear de la Universidad Nacional, Bogotá, Colombia

The detection of $\gamma$-rays and its spectroscopy, depending on the application involved, is customarily performed with two types of detectors, solid state devices (HPGe), and scintillators (e.g. NaI, BGO). The use of photodiodes has become recently the choice in many cases because of the chances given by these small instruments in special geometrical setups. The present work aims to characterize an array of a silicon PIN photo-diode in conjunction with a scintillator. We show the performance of the combination with two different signal amplifiers: CsI-PIN, CsI-PM.
NTM in low energy photo-transmutation of Th and U fuel study for gamma driven-MSR

Laszlo Sajo-Bohus*, Eduardo D. Greaves, Felix Pino, Haydn Barros, Maria T. Barrera

Universidad Simón Bolívar, Nuclear Physics Laboratory, Apdo 89000, Caracas 1080A Venezuela

Jesus Davila

Física Médica C. A. and Universidad Central de Venezuela, Caracas, Venezuela

Nuclear track methodology (NTM) to determine neutron field spectra has been employed successfully during the past decades. Neutrons are detected by scattered protons or reaction products leaving nuclear tracks in PADC materials. From track density, the intensity of the neutron field is deduced employing a recently developed unfolding technique. This is employed in concomittance to radiotherapy linear accelerators as drivers for subcritical liquid fuel assembly. Bremsstrahlung photons with energies above 5.5MeV, induce (γ,n) and (e,e'n) reactions in heavy nuclei such as W-target. Recent results indicate that two dipole group of excitation state namely low laying or Pygmy Dipole Resonances (PDR) and Giant Dipole Resonances (GDR) are the mechanisms to induce neutron emission or photo-fission in molten salt fuel compounds. Both of these nuclear phenomena occurring in materials such as thorium and uranium isotopes, in principle, may produce the extra energy or δK required by a sub-critical assembly $K_{\text{eff}} = 0.995$, to reach criticality ($K_{\text{eff}} = 1$) so to maintain a chain reaction. NTM is employed to determine fission rates and neutron intensities with the aim to establish the feasibility of design for gamma driven molten salt sub-critical assemblies. To cope with these objectives, a 20 MV radiotherapy machine is available for experimental work. Results will support further development for a sub-critical assembly employing liquid thorium fuel. It is expected that acquired technological knowledge will contribute to the Venezuelan nuclear energy program.

*Electronic address: lsajo@usb.ve, sajobohus@gmail.com
Proposal for an efficiency calibration of a Well Type HPGe detector by Monte Carlo Method using Geant4

J. Salas, F. Pino, H. Barros and S. Hurtado

The activity concentration of radionuclides in the environment is routinely done with high pure Germanium (HPGe) detectors. For low energies, Well Type HPGe detectors are often chosen because of their improved efficiency. However they are liable to true coincidence summing. The standard experimental way to make an efficiency calibration is preparing calibration patterns, but it does not allow us to make a generalization of the obtained calibration to another source (Matrixes). In this work it is shown the experimental efficiency calibration for a matrix of sediments and we recreate this source-detector enclosure set-up and the sediment matrix with the software Geant4 developed at CERN to simulate propagation and interaction of particles within detectors for high energy physics applications. This program is also used for metrological applications, in particular to simulate the efficiency curve for radionuclides measurements with defined source-detector enclosure set-ups. For the simulation of monoenergetic sources we use the class \textit{G4GeneralParticleSource} and for the simulation of radionuclides we use additionally the class \textit{G4RadioactiveDecay} in order to account for the coincidences. With those results we propose a simple true coincidence summing (TCS) correction factor. Additionally, we try to improve the results of the percentual difference between the simulated and the experimental efficiency for the low energy range by using the result of the experimental efficiency for a matrix of water traced with the low energy radionuclide $^{210}\text{Pb}$ and some others. This method is known as efficiency transfer.
Characterization of HPGe Gamma Spectrometric Detectors Systems for Instrumental Neutron Activation Analysis (INAA) at the Colombian Geological Survey

Sierra O., Parrado G., Cañón Y., Porras A., Alonso D., Herrera D.C., Peña M

This work presents the progress carried out by the Neutron Activation Analysis Laboratory (NAAL) of the Colombian Geological Survey (SGC, in its Spanish acronym) towards the understanding of the nuclear instrumentation and metrological control of the HPGe detectors recently acquired. The study contributed to the validation process of the technique for geological matrices like rocks, sediments and soils, and the progress it was demonstrated in the good performance obtained for the first round of WEPAL-IAEA Proficiency Test.

In the last few years, the Technical Direction for Nuclear Affairs of the SGC (official entity that belongs to the Colombian National System for Science and Technology) has been committed with the renovation and actualization of the instrumentation of the NAAL. As part of this process, the Laboratory acquired four (4) state of the art gamma spectrometric systems: two with 30% efficiency at 1.33 MeV photon energy and resolution < 1.8 keV (FWHM); and two with 70% efficiency systems and resolution < 2.0 keV (FWHM). The characterization included empirical determination of the interaction point of the gamma radiation inside the Germanium crystal within the linear model, obtaining correlation coefficients r > 0.999; moreover, it was observed that the interaction point increases with the photon energy, remaining practically constant above 1 MeV. By this simple model the calculation of efficiency curves for point sources at several detector distances was done. In addition, the study of the random coincidence summing gives negligible effects on the counting performed within an interval of dead time between 10-40%. On the other hand, the NAAL designed its own measuring geometries which enhance both the sample positioning and the counting reproducibility.

The NAAL will be continued with this work in 2015, and the staff will evaluate several effects related with the counting process itself, including the real summing effects on efficiency calibration curves for sources closer to detectors, as well as to establish simple calculation algorithms for correcting the deviations from the point source approximation model. The corrections will include the difference of high filling and self-attenuation effect for the gamma radiation for samples and standards. Finally, the group is also exploring the possibility of simulating efficiency curves for extended sources, using codes like Geant4 or MCNP. The data presented here are the result of a continuous effort to improve the Laboratory protocols oriented to enhance both the spectrometric understanding and trueness for the radiometric step of INAA.
Submitted an impending shortage of oil and coal, Colombia should seek alternative energy sources, which means a research and technological challenge that already must be addressed. Research in the 1970s and 1980s by the Instituto de Asuntos Nucleares, INGEOMINAS y COLURANIO S.A. (and others) in some areas of Colombia (less than 40% of the country) indicate that there are promising sectors with significant contents of U that can be utilized as energetic minerals for the economic benefit of the country. The implementation of the technique Delayed Neutron Counting (DNC) facility for the determination of uranium contributes to geoscientific knowledge of Colombia in the areas of interest for the exploration of energy resources.

The DNC system consist of 4 BF$_3$ proportional counters confined in a 1 m$^3$ borated wax which decrease neutron-gamma dose in more than an order of magnitude. Preliminary work shows the irradiation conditions and reading and the handling irradiated material is very slow and only needs simple operating authorization; thus license management of radioactive material given by the regulatory body is not necessary.

With the establishment of the technique of counting delayed neutrons, U can be determined in a geological soil sample collected and/or underground where you can confirm or rule out its presence and determine its content in different concentrations. Thus, it is expected in the near future to consolidate the aforementioned analytical technique and conducted it towards the provision at the services and Geological Colombian Survey (SGC, in spanish acronym) of the country.
The thermoluminescence is a property present in some crystalline materials that allows them to absorb energy from ionizing radiation, which is then released as visible light when the material under ideal conditions is heated at high temperatures (eg: $300^\circ$C). This principle using TLD-400 crystals (CaF2: Mn) in radiotherapy clinical dosimetry allows verifying the doses received by patients. The doses quantification is a preventive tool to avoid biological and clinical effects in patients under or over exposed. The main purpose of this project is to present the time-temperature profile (TTP) found for high-doses (1-50 Gy) on the crystals. This was achieved using a Harshaw 4500 reader and a linear accelerator Varian-Clina iX. The TTP is related with the temperature of the crystals in the Glow Curve where the absorbed doses are obtained from the area under the curve with the appropriate correction factors. In addition, we present a practical guide for the correct use of the crystals indicating the parameters for their optimal response in vivo dosimetry. It will also provide the methodology for each crystal including the physical calibration-reading: annealing, RCF and ECC factors, and logistics processes: transport and care for their use. The principal aim is to provide a useful and clear guide for handling this type of crystals in practice.

Keywords: Thermoluminescence, TLD-400 (CaF2:Mn), Clinical dosimetry, In vivo dosimetry, Absorbed dose.
Radiation Dose Assessment of 99mTc-labeled Tetrofosmin in Patients Undergoing Rest-Stress Myocardial Perfusion Scintigraphy

Stella Veloza*

Department of physics, Universidad Nacional de Colombia, 111321 Bogotá, D.C., Colombia

Estrella Avila

Department of Nuclear Medicine, DALINDE Medical Centre 06760 Ciudad de México, D.F., México

Purpose: Tetrofosmin labeled with technetium-99m (99mTc) is a myocardial imaging agent. The goal of this research is to evaluate the differences between two methods for assessing radiation dose: internal dosimetry by using a dose calculation program and an analytical model based on patient’s weight.

Materials and methods: A biodistribution of 99mTc-Tetrofosmin as reported in the literature was used in OLINDA/EXM-1.0® to estimate patient-specific absorbed and effective radiation doses on 91 adults (33 female, 58 male) who were undergoing 99mTc-Tetrofosmin 8 mCi-rest/17 mCi-stress myocardial perfusion imaging. The dosimetry results were compared to the values calculated from scaling by a power function of body weight the values of effective radiation doses for adults from 99mTc-Tetrofosmin rest/stress provided by the International Commission on Radiological Protection (ICRP) publication 106.

Results: The mean effective doses estimated by dosimetry in female patients were 3.46 mSv and 5.91 mSv at rest/stress respectively. In male patients the mean effective dose estimated by dosimetry was 2.87 mGy at rest and 4.86 mGy at stress. For male and female patients of the same weight the dosimetry shows that the women’s effective doses are about 17% higher than for men. The effective doses estimated in patients with a weight of 100 kg by the analytical method differed from those based on dosimetry by up to 40% in women and 30% in men at rest and 35% in women and 25% in men at rest.

Conclusions: Even though the standard ICRP dose values are scaled by patients’ weight, the effective dose for overweight patients are underestimated, more for female patients than for male patients because ICRP values correspond to an adult male. These underestimations are an important factor to consider if an approach based on differences in patient’s weight is used to adjust the amount of activity to be administered.

*Electronic address: lsvelozas@unal.edu.co
Characterization of neutron and gamma components of radioisotopic sources using analogic PSD

C. Villalba∗, V. García, A. Romero, F. Pino, H. Barros, L. Sajo-Bohus

Nuclear Physics Laboratory, Simon Bolivar University, Sartenejas-Baruta, Venezuela.

The present work consists in characterization of the neutron and gamma components of the $^{252}$Cf and $^{241}$Am/Be sources installed at the Nuclear Physics Laboratory of the Simon Bolivar University. Different kind of spectrometric detectors were used to study the sources gamma component. Inorganic scintillators such as NaI(Tl) (4.5” x 4.5”), BGO (3” x 3”), BaF$_2$ (3” x 3”) and a well type HPGe semiconductor detector (3” x 3”) were employed. For the neutron component an organic liquid scintillator with pulse shape discrimination capability (NE-213, 2” x 2”) was used. Standard nuclear electronics modules (NIM type) were utilized to implement the analog pulse shape discrimination analysis technique to separate neutron from gamma events. All data acquisition and analysis were performed by employing the “root” framework. The results obtained of the sources characterization provide useful information to study the possible implementation of the fast neutron and gamma transmission technique to estimate and monitor in real time the sulphur concentration in the Venezuela’s oil. This application has very importance in the exploitation of heavy and extra-heavy oil, which contain high sulphur concentration (4 – 5%), as in the case of the Orinoco Petroleum Belt.

∗Electronic address: c.villalba11@gmail.com