Past & Present Status of Nuclear Data Studies in Mongolia

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NRC/NUM

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1. Historical Background and Milestones

1942: National University of Mongolia was established. (Pedagogical, Medical & Veterinary Faculties)

1956: First 5 physicists sent to JINR, Dubna.

1961: High Energy Physics group founded at the Mongolian Academy of Sciences

1965: Nuclear research group (later Nuclear Research Lab) at the NUM organized (Neutron generator from JINR)
1. Historical Background (cont)

**1968:** Nuclear education started by specialization of nuclear physics within physics program (5-6 students each year)

**1972:** Division of Theoretical Physics established at the Mongolian Academy of Sciences

**1977:** Department of Theoretical Physics founded at the National University of Mongolia

**1993:** Master program in nuclear physics & (non-power) nuclear technology started.
1. Historical Background (cont)


1997: Reorganized as the Nuclear Research Center, NUM by the Government Resolution No 1997/31.

1997: Bachelor program in nuclear (non-power) technology started.

Since 1970: about 220 students have been specialized in nuclear physics and majored in nuclear technology.
2. Nuclear Research Institutions in Mongolia

- 1956 Joint Institute for Nuclear Physics was established in Dubna, Russia and Mongolia is one of its founders;
- With assistance of the JINR and return researchers established:
  - Higher Energy Physics Section at Institute of Physics, MAS
  - Nuclear Research Laboratory at NUM
2.1. Nuclear Physics at Mongolian Academy of Sciences

- Division of High Energy Physics (1961): conduct out investigations on interactions elementary particles and relativistic nucleus within the collaborations with JINR (Dubna, Russia).
- They are participating in H1 collaboration from DESY, Hamburg Germany) for the study of neutral strange particles produced in deep elastic e⁻+p scattering at HERA.
- Division of Theoretical Physics (1972): conduct out research on nonlocal quantum field theory, stochastic theory and nuclear reaction by intermediate energies.
2.2. Department of Theoretical Physics of the National University of Mongolia

Research field on nuclear physics:

- Nuclear structure (Quasiparticle-phonon model)
- Mesoatom
- Scattering with light nuclei
2.3. Nuclear Research Center, NUM

The NRC/NUM is an educational and research institution in Mongolia, which carries out basic and applied research in low energy nuclear physics.

THE MISSION of NRC is to be the leading national institute that conducts both education/training and research to obtain new information and results, to develop new methodology and technology in basic and applied nuclear physics, and also to develop equipment and devices.
NRC: Resources

- Facility:
  - Electron accelerator – Microtron MT-22 (a source of neutrons, $10^8 \text{ cm}^{-2}\text{s}^{-1}$ and gamma-rays, $10^{12} \text{ s}^{-1}$)
  - 14 MeV neutron generator NA4, $10^{10} \text{ s}^{-1}$
  - Isotope source of neutrons - $^{252}$Cf
  - HP-Ge Gamma spectrometers
  - Total reflection X-Ray spectrometer
  - Atomic absorption spectrometer
  - XRA spectrometer Spectro Xepos for air PM analysis
  - Counters of small radio activities
  - General nuclear physics laboratories
14 MeV Neutron Generator
Electron Cyclic Accelerator – Microtron MT-22

\[ E_e = 22 \text{ MeV} \]
\[ I_e = 10-20 \mu A \]
\[ \Delta t_e = 3 \mu s \]
\[ \Phi_y = 2.5 \cdot 10^{13} \gamma/\text{cm}^2 \cdot \text{s} \]
\[ \Phi_n = 10^{7-8} \text{n/cm}^2 \cdot \text{s} \]
\[ N_n = 10^{11} \text{n/s} \]
Resources (cont)

- **Human Resources:**
  - Full-time Professor: 3
  - Emeritus Professor: 2
  - Senior Researcher: 5 (3 are part-time prof.)
  - Researcher: 12
  - Engineer: 3
  - Technicians: 2
  - Total (now): 25
<table>
<thead>
<tr>
<th>Name</th>
<th>Degree</th>
<th>Institution</th>
</tr>
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<tbody>
<tr>
<td>Enkhjin, Ms</td>
<td>Inspector</td>
<td>IAEA</td>
</tr>
<tr>
<td>Bayarbadrakh, Mr</td>
<td>PhD in NP ⇒ research</td>
<td>North Corolin Uni, USA</td>
</tr>
<tr>
<td>Erdemchimeg, Ms</td>
<td>PhD in NP</td>
<td>JINR, Dubna, Russia</td>
</tr>
<tr>
<td>Chadraabal, Mr</td>
<td>MS in NEE ⇒ Mongolia</td>
<td>Birmingham Uni, UK</td>
</tr>
<tr>
<td>Erdenechimeg, Ms</td>
<td>MS in NEE ⇒ PhD</td>
<td>Royal InstTech, KTH, Sweden</td>
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<tr>
<td>Munkhbat, Mr</td>
<td>MS in NEE ⇒ PhD</td>
<td>TIT, Japan</td>
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<td>Sainzaya, Mr</td>
<td>MS in NT</td>
<td>JINR, Dubna, Russia</td>
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<td>Ichinkhorloo, Ms</td>
<td>PhD in NP ⇒ research</td>
<td>Hokkaido Uni, Japan</td>
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<tr>
<td>Odsuren, Ms</td>
<td>Posdoc in NP</td>
<td>Hokkaido Uni, Japan</td>
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<tr>
<td>Altangerel, Mr</td>
<td>MS in NEE</td>
<td>Tokai Uni, Japan</td>
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<td>Badamsambuu, Mr</td>
<td>MS in NP</td>
<td>Guelph Uni, Canada</td>
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<tr>
<td>Odtsetseg Ms</td>
<td>MS/PhD in NEE</td>
<td>TIT, Japan</td>
</tr>
<tr>
<td>Enkhbat, Mr</td>
<td>MS in NT</td>
<td>KAIST, Korea</td>
</tr>
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</table>
# Students Majored in Nuclear Technology

<table>
<thead>
<tr>
<th>Level of Education</th>
<th>Entered</th>
<th>Graduated</th>
<th>Now studying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>375</td>
<td>157</td>
<td>100 (+8)</td>
</tr>
<tr>
<td>Master</td>
<td>75</td>
<td>37</td>
<td>20</td>
</tr>
<tr>
<td>PhD</td>
<td>17</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
</table>
NRC: Research and Development

Research Fields:

• **Basic research:**
  spectroscopy, nuclear reactions and neutron physics.

• **Development of nuclear analytical methods:**
  Use of X-ray, gamma- and neutron- activation analysis on geological, biological, agricultural, environmental (urban air pollution) samples.

• **Nuclear Energy:**
International Cooperation

**Main objectives:**
- Developing joint research
- Exchanging scientific information
- Sponsoring cooperative seminars, workshops and other academic meetings
- Developing and promoting educational programs
- Technical assistance

**Means/Level of Cooperation:**
- International Organizations
- Intergovernmental cooperation
- University level exchange Agreements
- Direct cooperation
International Cooperation

- International Organizations through Nuclear Energy Agency:
  - IAEA: TC & RCA projects - training, equipment, networks (ANENT)
  - JINR (Dubna, Russia) – joint research, job-training
    - Nuclear Reaction Lab
    - Neutron Physics Lab
  - ICTP (Trieste, Italy) - training
  - International Networks – FNCA (Japan)

- Intergovernmental cooperation:
  - Bilateral Cultural Agreements - HRD
  - Bilateral MOU and Agreements on NE & RAM: Russia, Japan, France, India, China, USA, Korea
  - Joint research agreements: FSF/Russia and SF/Mon
International Cooperation (cont)

- **University level exchange Agreements** (exchange of students, professors, and information):
  - Tokyo Institute of Technology (Japan),
  - Tomsk Polytechnic University, Russia
  - Hokkaido University, Japan

- **Direct Cooperation**
  - Applied Phys Inst and X-Ray Lab, Irkutsk, Russia
  - Faculty of Science, Hokkaido University, Japan
  - Center for Research into Innovative Nuclear Energy System, TIT

- **Open scholarships for students:**
  - KAIST (Korea), USA, EU... (UK, Sweden)
3. Nuclear Data Research

Nuclear data research in Mongolia was launched and is conducting in frame of cooperations with JINR (Dubna, Russia) and also with Peking University (China)

3.1. Nuclear Structure Studies

- Reactions induced by $\pi$-mesons (D.Chultem, J.Ganzorig)
- Search superheavy elements and decay of heavy elements (B.Dalkhsuren, O.Otgonsuren)
- Transmutation (D.Chultem, Ts.Damdinsuren, B.Tumendemberel)
- Radioactive decay studies of nuclei $A=150-190$ far from $\beta$-stability by means of $\beta$- and $\gamma$- on/off line spectroscopy and LTNO method (N.Ganbaatar, S.Davaa, J.Sereeter)
Lanunching nuclear database studies at JINR

Syntesis of light nucleus by Prof. N.Sodnom

\[ \text{He}^3 + \text{H}^3 \rightarrow \text{Li}^6 \rightarrow \left\{ \begin{array}{l}
\text{He}^4 + \text{H}^2 + 14.31\text{MeV} \quad 41\% \\
\text{He}^4 + \text{H}^1 + n + 12.08\text{MeV} \quad 55\% \\
\text{He}^5 + \text{H}^1 + Q_1 \\
\text{He}^4 + n + Q_2 
\end{array} \right. \]
Prof. D. Chultem, J. Ganzorig

- Investigation of the paramagnetism of mu-mesic atom and polarization of μ-mesons in H, O, Mn, S, Zn and Pb.
- Fission of heavy nuclei ($^{232}$Th, $^{238}$U and $^{235}$U) induced by stopped negative pions
- Excitation of metastable high spin states in $\pi^-$-capture by nuclei ($^{186m}$Ir and $^{190m}$Ir at reaction Pt ($\pi^-$, xn)$^{191m}$Tl and $^{193m}$Tl)
- Nuclear reactions of Ta and Pb with high energy $^{12}$C ions and protons
Prof. B. Dalksuren’s early works

- $^{164}\text{Yb} \rightarrow ^{164}\text{Tu} \rightarrow ^{164}\text{Er}$; $^{163}\text{Tm} \rightarrow ^{163}\text{Er} \rightarrow ^{163}\text{Ho} \rightarrow ^{163}\text{Dy}$; $^{161}\text{Tm} \rightarrow ^{161}\text{Er} \rightarrow ^{161}\text{Ho} \rightarrow ^{161}\text{Dy}$

  ⇒ identified new isotopes $^{155}\text{Ho}$, $^{164}\text{Tu}$

- Spontaneously Fissioning Isomers $^{242}\text{Am}$ and $^{244}\text{Am}$ at the Slow Neutron Capture

- Spontaneously Fissioning Isomer $^{236\text{i}}\text{U}$ in Reactions Induced by 14.7 MeV Neutrons.
Decay scheme of nuclei and spin/parity of excited levels are established: $^{148-154, 157, 161}$Ho, $^{161}$Tb и $^{150-155, 157, 159, 161}$Er;

New isotopes identified: $^{136}$Sm, $^{145}$Tb, $^{145}$Dy, $^{146}$Dy, $^{147}$Ho, $^{150}$Er, $^{152}$Tm;

Based on the upper limits measurements of positron energy spectra from 25 isotopes and determination of mass of 40 isotopes a **drip line of proton activity** was drawn firstly.
Decays of radioactive nuclides by means of low temperature nuclear orientation method studied.

- Multi-polarity & mixing ratios of γ-rays, and spin & parity of excited states were determined:
  - $^{167, 169, 171, 172, 173}$Yb, $^{169}$Tm, $^{147}$Ed, $^{152}$Sm, $^{154}$Sm, $^{152}$Gd, $^{166}$Er and $^{160}$Dy;
- Magnetic moments of ground states were determined:
  - $^{145-149}$Eu and $^{147,149}$Gd
Radioactive isotopes $^{112-118}$In by cyclic activation at the 14.7 MeV neutron generator in Mongolia was obtained and decay schemes of the ground & isomer states were verified.

Beta-decays of $^{147,153}$Tb, $^{160}$Er $\rightarrow$ $^{160}$Ho $\rightarrow$ $^{160}$Dy and $\alpha$-spectrum from $^{156-158}$Lu, $^{154-156}$Tm, $^{213}$Bi, $^{209}$Tl, $^{225}$Ac, $^{213}$Bi & $^{209}$Tl were co-investigated at the JINR facilities.
3.2. Neutron Physics

G.Khuukhenkhuu
B.Bayarbadrakh, M.Odsuren, J.Badamsambuu +

Show another file
Graduate students’ Study in the World Prestigious Universities

- B.Bayarbadrakh, Agvaanluvsan Undraa, D.Dashdorj – North Carolina University, USA:
  - Nuclear structure, neutron induced reaction for \( E_n \) up to 250 MeV, nuclear data and reaction modeling;
  - Nuclear resonances, random matrix theory, neutron capture and reaction
- J.Badamsambuu – University of Guelph, Canada -

- B.Erdemchimeg & E.Sansarbayar – JINR, Dubna, Russia: mechanism of the fragmentation and nucleon transfer reactions at the Fermi energy domain
Graduate students’ Study in Hokkaido University

Nuclear Data Center, Hokkaido University, Japan:
- D. Ichinkhorloo – PhD thesis: Analysis of n+\(^6\)Li and n+\(^7\)Li Reactions Using the CDCC Method;
- M. Odsuren – postdoc study: Investigation of \(^8\)Be Based on Complex Scaling Method.
Thank you for your attention!