The role of IAEA in the development of radiopharmaceutical sciences

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Radiopharmaceutical Chemist
The MEDICIS-Promed Final Conference
"Ettore Majorana Foundation and Centre for scientific Culture"
Erice (Sicily), Italy, 30th April - 4th May 2019
How does the IAEA operate?

- Board of Governors
  - General Conference
- Secretariat
- Department
  - Division
  - Section/Lab
- UN Agencies; Partners
  - Medium Term Strategy
- Standing Advisory Groups

Priorities, demand, needs

Support, provision of services

- Millennium Development Goals
- National, Regional Priorities
- Post-2015 Development Agenda
Serving Member States: How?

- **Applied R&D**
  - >12 NA labs
  - >20 Collaborating Centres
  - >100 Coordinated Research Projects per year

- **Validation**

- **Activities**
  - Dosimetry
  - Plant varieties; insect strains
  - Audit missions
  - Reference materials

**Education and Training**
- Guidelines; curriculum
- E-learning
- >400 trainees per year (NA labs)

**Provision of Services**
- >130 LMI Member States
- €39.95 million in 2015 (NA)

**Technical cooperation programme**
- >400 trainees per year (NA labs)
Programme 2.5 Radioisotope Production and Radiation Technology

Programme description/objectives

Sub-programme 2.5.1: Radioisotope Products for Cancer Management and non-Communicable Diseases

- 2.5.1.001 Development and production of medical radioisotopes
- 2.5.1.002 Development of diagnostic and therapeutic radiopharmaceuticals

Sub-programme 2.5.2: Radiation Technology for Health Care and Industrial Applications

- 2.5.2.001 Industrial applications of radioisotopes and radiation techniques
- 2.5.2.002 Radiation technologies for health care and environmental applications
IAEA Projects: RPRT Section

- Coordinated Research Projects (R&D) 15
- Technical Cooperation Projects (implementation) 160
- Regular program activities

- Participation in complimentary international activities
- Meetings / Conferences
- General Conference side-events and Scientific Forum
- Missions
- Collaborating Centers (8)
- Publications
- Networks & coalitions
Our section duties

Radioisotope production

Radiopharmaceutical production

Diagnostic or therapeutic application
Production of radioisotopes

Cyclotrons / Accelerators

Research reactor

Radionuclide generator
Production of radiopharmaceuticals

Synthesis module

Hot cell

Layout
Collaborating Centres
Collaborating Centres in a nutshell

- **Objective:**
  Assist the IAEA in implementing its regular budget programme through research and development and capacity building in a relevant nuclear technology

- **Specificity:**
  At no cost to IAEA; workplan linked to existing IAEA projects; visibility for national institution

- **Duration:**
  Up to 4 years, redesignation possible
IAEA

Malaysian Nuclear Agency (MNA) on: "Radiation Processing of Natural Polymers and Nano-materials"

Institute of Nuclear Chemistry and Technology (INCT) on “Radiation Technology and Technological Dosimetry”

Advanced Radiation Technology Institute (ARTI) of KAERI, in the three areas: environment remediation, advanced materials and food irradiation.

National Institute of Nuclear Research (ININ), Mexico in the field: Safe Operation, Maintenance and Upgradation of Gamma Irradiation Facilities

National Center for Electron Beam Research (NCEBR), TAMU, US

One CM every year
NDT and radiotracers for industry

IAEA

Indonesia BATAN NDT

MNA Malaysia NDT

INSTN France NDT, Radiotracers
Other delivery possibilities

- **Practical Arrangements:** Non-legally binding instrument negotiated with an institute or an organization. Arrangements to cooperate on issues of common interest (EC).

- **Memorandum of Understanding:** Legally binding instrument. Used when funding is involved for cooperation (Fukushima Prefecture).

- **PUI projects:** Specific projects developed by technical Departments (NA, NE and NS), funded by donors, with impact at country level (VetLab; Iwave).
Practical Arrangements
PRACTICAL ARRANGEMENTS

between

THE INTERNATIONAL ATOMIC ENERGY AGENCY

and

THE OKAYAMA UNIVERSITY

on

COOPERATION IN THE AREA OF
RESEARCH AND HIGHER EDUCATION IN
BORON NEUTRON CAPTURE THERAPY
PRACTICAL ARRANGEMENTS

between

THE INTERNATIONAL ATOMIC ENERGY AGENCY

and

THE WORLD NUCLEAR UNIVERSITY

on

COOPERATION IN THE AREA OF
EDUCATION AND TRAINING
WNU, on Education and Training

**A leadership development programme**
for professionals in the radiation technologies field

**Applications are invited for the 5th WNU School on Radiation Technologies**
14 to 25 October 2019, Obninsk, Russia

in collaboration with Rosatom Technical Academy and International Atomic Energy Agency (IAEA)

**The Focus**
The World Nuclear University RT School aims to:
- Provide a broad overview of the field of radioisotopes production and radiation technologies as well as the trends and main issues encountered by practitioners in this area.
- Develop essential skills for leadership, communication and project management.
- Provide a unique opportunity to develop a worldwide network of radiation specialists.

**Apply online at**
world-nuclear-university.org

**Deadlines**
3 April 2019 for IAEA funded applications
16 August 2019 for Company funded applications

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**NUCLEAR OLYMPIAD 2019**
A unique opportunity for University students to build a top global professional network while contributing to nuclear communications.

**Stage 1:** Submit a up to 3-minute video on any aspect of radiation applications by 26th April 2019

**Stage 2:** Chat with us

**Stage 3:** Let us know about public opinion in your country

**Finalists will make an oral presentation at an international setting event**

Find more at:
world-nuclear-university.org
Cooperation / Training Activities
Inception of a Working Group of the Nuclear Community

Others
ALASBIMN, IANM
EU and IAEA Review Progress and Agree on Priorities in Nuclear Cooperation at Annual Meeting

3/2019
Luxembourg

Related resources
- Nuclear safety and security
- Review missions and advisory services
- Safeguards and verification
- Nuclear security conventions
Access to High Quality Education Increases for Nuclear Medicine Professionals

Oleksandra Gudkova, IAEA Office of Public Information and Communication

MAR
21
2017

Training opportunities in nuclear medicine and hybrid imaging will increase as a result of a cooperation agreement signed by the IAEA and the European Association of Nuclear Medicine (EANM) on 21 March 2017. (Photo: D. Calma/IAEA)

More nuclear medicine professionals from developing countries will have access to training courses and educational materials thanks to a new agreement signed between the IAEA and the European Association of Nuclear Medicine (EANM) on 21 March 2017.

Related Stories
- 3D Radiotherapy Increases Effectiveness and Safety of Cancer Treatment in Tanzania
- IAEA Curricula for Nuclear Medicine Professionals, Improving Nuclear Medicine Worldwide
- Building Capacity in Healthcare: How the IAEA Supports Training in Nuclear Medicine Professions

Related Resources
- Photo Gallery: IAEA and EANM Practical Arrangement Signing
- Human Health Programme
- IAEA Human Health Campus
Symposium on Opportunities and Approaches for Supplying Molybdenum-99 and Associated Medical Isotopes to Global Markets with NE

- 17-19 July 2017; IAEA HQ; 100 participants
- Trends in global demand and supply for Mo-99 and associated medical isotopes.
- Prospects and approaches for developing new global supplies of Mo-99 and associated medical isotopes.
- Technical, regulatory, economic, and policy considerations for producing Mo-99 and associated medical isotopes for global markets using uranium-fission and other processes.
Collaboration IAEA-WHO

- Update of monographs for radiopharmaceuticals
- Meeting ECSPP: 22-23 October 2018
- Review of general monograph for radiopharmaceuticals: meeting May 2019
- Guidelines on GMP for radiopharmaceutical production:
  - Meeting at IAEA in 05-09 November 2018 with experts
  - Meeting June 2019
Current/Active TC Projects by TO
2018 national and interregional

- Joao Osso: 23 projects
- Amir Jalilian: 36 projects
- Aruna Korde: 10 projects
- Bum Soo Han: 14 projects
- Patrick Brisset: 42 projects
- Sunil Sabharwal: 30 projects

Total: 155 projects (100 on RP,RI)

*Sunil retired at the end of 2018. All his projects are now managed by Bum Soo Han.
Workshop on Supply of Ac-225

- 09-10 October 2018; IAEA HQ; 80 participants, 17 MSs
- Private companies from the US, Canada, Germany, Russia
- In collaboration with EC-JRC
- Cross cutting: NDS, PS, NEFW, NMDI, NS
- Trends in global demand and supply for Ac-225
- Motivation: excellent clinical trials results of Ac-225-PSMA
- Report finalized
- New TM in December 2019: guidelines
- New CRP with NAHU

CRP on Sharing and Developing Protocols to Further Minimize Radioactive Gaseous Releases to the Environment in the Manufacture of Medical Radioisotopes, as GMP with NEFW

- 2014 - ongoing
- Initiated as result of a request from a five Member States - May 2014
- First Research & Coordination Meeting - August 2015
- Second Research & Coordination Meeting – 06-10 March 2017
- Participants and observers from Australia, Belgium, Canada, France, Germany, Indonesia, The Netherlands, Pakistan, Poland, Rep. of Korea, USA.
Conference in 2019

- PS, NDS
- Safety, Safeguards
- NAHU, NEFW
- TC
Three African students started their Masters program on Radiopharmacy at the University of Stip, Macedonia.

22 Participants from 18 countries in Africa were trained in Radiopharmacy in Macedonia


CM in January 2015 on ‘Development of E-learning systems for radiopharmacy

E-learning modules are being developed for Radiopharmacy education: contract signed
Coordinated Research Projects (CRPs)

Finalised CRPs:

- Production and utilization of Emerging Positron Emitters for Medical Applications with an Emphasis on Cu-64 and I-124 (2010-2014)

- Accelerator-based Alternatives to Non-HEU production of Mo-99/Tc-99m (2011-2015)

- Development of Ga-68 based PET-Radiopharmaceuticals for Management of Cancer and other Chronic Diseases (2010-2015)

Accelerator-based Alternatives to Non-HEU production of Mo-99/Tc-99m

- 2011-2015
- 18 participants from 16 Member States
- Production of Tc-99m in cyclotron
- Technology to produce several (>30) Ci Tc-99m per run in medical cyclotrons of energies below 24 MeV proven;

Comparison of cyclotron- and reactor-based Tc-99m pertechnetate for the Univ. of Alberta Clinical Trial (cancer thyroid patients imaged post-thyroidectomy)
# Ongoing–CRPs

Therapeutic Radiopharmaceuticals Labelled with New Emerging Radionuclides ($^{67}$Cu, $^{186}$Re, $^{47}$Sc) – (2016)

<table>
<thead>
<tr>
<th>RN</th>
<th>Half-life</th>
<th>Imaging emissions</th>
<th>Therapy emissions</th>
<th>Production methods</th>
<th>Decay product</th>
</tr>
</thead>
</table>
| $^{47}$Sc | 3.3492 d  | $\gamma$ 159.38 keV (68.3 % 4)         | $\beta^-$ (100 %) $
E_{\beta_{\text{max}}} = 440.9$ keV (68.4 % 6) $
E_{\beta_{\text{max}}} = 600.3$ keV (31.6 % 6) $
E_{\beta_{\text{mean}}} = 162.0$ keV | $^{48}$Ti(p,2p) $^{49}$Ti(p,$^3$He) $^{50}$Ti(p,$\alpha$) $^{47}$Ti(n,p) | $^{47}$Ti (stable) |
| $^{67}$Cu | 61.83 h   | $\gamma$ 93.31 keV (16.1 % 2)          | $\beta^-$ (100 %) $
E_{\beta_{\text{max}}} = 377.1$ keV (57 % 6) $
E_{\beta_{\text{max}}} = 468.4$ keV (22.0 % 22) $
E_{\beta_{\text{max}}} = 561.7$ keV (20.0 % 20) $
E_{\beta_{\text{mean}}} = 141$ keV | $^{68}$Zn(p,2p) $^{70}$Zn(p,$\alpha$) $^{67}$Zn(n,p) $^{66}$Zn($\gamma$,p) $^{68}$Zn(n,x) | $^{67}$Zn (stable) |
| $^{186}$Re | 3.7183 d  | $\gamma$ 137.16 keV (9.47 % 3)         | $\beta^-$ (92.53 % 10) $
E_{\beta_{\text{max}}} = 932.3$ keV (21.54 % 14) $
E_{\beta_{\text{max}}} = 1 069.5$ keV (70.99 % 14) $
E_{\beta_{\text{mean}}} = 346.7$ keV | $^{186}$W(p,n) $^{186}$W(d,2n) $^{192}$Os(p,$\alpha$3n) | $^{186}$Os (stable) $^{186}$W (stable) |
Radioisotope production technologies

Ongoing—CRPs

“Cu-64 theranostic radiopharmaceuticals” (2016)
Ongoing CRP: New Ways of Producing Tc-99m and Tc-99m Generators

- First Meeting: 11-15 December 2017
- 18 approved proposals
- Recommendation from Technical Meeting on same topic (March 2016)
- Aimed as use of low specific activity Mo-99 for generator preparation and accelerator production of Tc-99m (Mo-100 ($\gamma$,n) reaction)

New CRP: Zr-89 Production and Zr-89 Radiopharmaceuticals (F22071)

Aruna Korde, IAEA Department of Nuclear Sciences and Applications

Schematic figure overview of a Zr-89 labelled monoclonal antibody. (Image: IAEA)

**CRP at a Glance**

This Coordinated Research Project (CRP) will identify important technical issues related to the production of Zirconium-89 (Zr-89) and the development of Zr-89 radiopharmaceuticals for the treatment of cancer.

**Related Stories**
- **New Technique to Fight Prostate Cancer**: IAEA organizes first-of-a-kind training for Radiopharmacists
- **How Radiopharmaceuticals Help Diagnose Cancer and Cardiovascular Disease**
- **African Radiopharmacists Put New Skills to Use**

**Related Resources**
- Radiopharmaceuticals for Cost Effective Management of Cancer
- Coordinated Research Activities
- Radioisotope Products and Radiation Technology Section
publications
Meetings 2019

Technical Meetings:

• Technical Meeting on Production of Alpha Emitters and Radiopharmaceuticals (Ac-225, Bi-213), 9-13 Dec 2019, Vienna, Austria
• Technical Meeting on Production of New Emerging Theranostic Radioisotopes, 25 – 29 Nov 2019, Vienna, Austria
• Consultancy Meeting “Radioisotope production using photodynamic route” Dec 2019, Vienna, Austria

Consultancy Meetings:

• Production of Ga-68 and Cu-61 using a medium size cyclotron (a new CRP proposed), April 2019
• IAEA-WHO meeting on International Pharmacopeia, March 2019
• Preclinical studies for radiopharmaceuticals; publication is in process
• Production on alternative radioisotopes using a medium size cyclotron; publication is in process
TM on Regulatory Aspects of Radiopharmaceutical Production

• 9-13 October 2017
• 12 participants from 12 Member States
  ❖ Belarus, China, Colombia, Egypt, Ethiopia, France, India, Indonesia, Macedonia, Morocco, Philippines, Syria
• 3 cost free observers, 1 consultant
• 6 participants from Societies/organizations
  ❖ WHO, CANM, EANM, SNMMI, ANZNM
• Task force
Successful training course on alpha and beta emitter peptides, Poland June 2018

New Technique to Fight Prostate Cancer: IAEA organizes first-of-a-kind training for Radiopharmacists

Aleksandra Peeva, IAEA Department of Nuclear Sciences and Applications

For the first time, radiopharmacists from across Central and Eastern Europe learned about an emerging technique in treating prostate cancer at an IAEA course organized at the National Centre for Nuclear Research in Poland last
Newly designed IAEA directory of cyclotrons

Cyclotrons used for Radionuclide Production

Database of Cyclotrons for Radionuclide Production

How to edit or add information

In order to add or edit information about your facility you can download and fill the dedicated form and send it via email to A. Jalilian, M. Haji-Saeid, D. Schlyer and J. Forneris.

Navigation tips

Below you will find the database of the Cyclotrons used for radionuclide production. Click on the facility name to display the full information data. By default, the database is sorted alphabetically by country, and then city. You can sort or filter by other criteria by clicking the dropdown menu next to each column header and selecting the desired function.

Cyclotrons database

https://nucleus.iaea.org/sites/accelerators/Pages/Cyclotron.aspx
INTERNATIONAL SYMPOSIUM ON TRENDS IN RADIOPHARMACEUTICALS
#ISTR-2019
IAEA Headquarters
Vienna International Centre
Austria
28 October – 1 November 2019

https://www.iaea.org/events/istr-2019
Thank you