

3rd International Conference on
**Applications of Radiation
Science and Technology**

7—11 April 2025

Vienna, Austria

Summary Report

as presented at the Closing Session

11 April 2025

#ICARST2025



#ICARST2025 in sum

Tzanka Kokalova-Wheldon

Director

Division of Physical and Chemical Sciences

3rd International Conference on **Applications of Radiation Science and Technology**

7—11 April 2025

Vienna, Austria

#ICARST2025



ICARST in numbers

499 registered in Vienna
367 registered online

} (105 Member States)

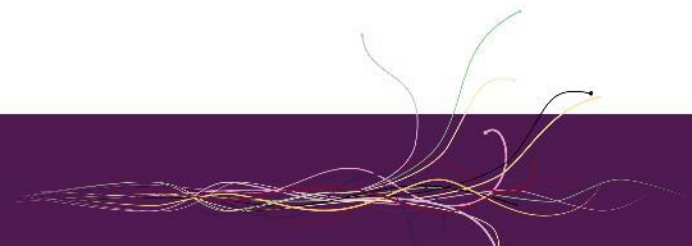
120 exhibitor staff

Permanent Missions

IAEA technical staff

1,000+ participants

+ thousands of online viewers





Dr. Carla Bravo de Rueda • 2nd

Animal Health Technical Officer

1d • Edited •

[+ Follow](#) [...](#)

Today during the 3rd International Conference on Applications of Radiation Science and Technology [#ICARST2025](#), we presented our work on [#irradiated](#) [#vaccines](#). After 9 years of advancing our research under [#CRPs](#) administered ...more



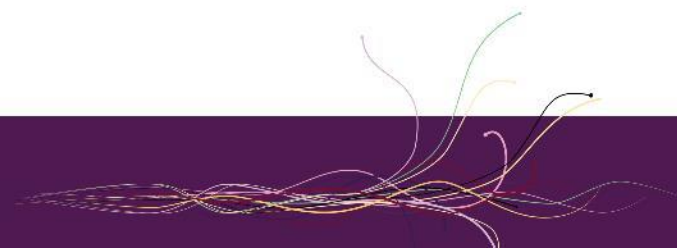
[with Viskam Wijewardana and 1 other](#)



Anna Grigoryan and 26 others

1 repost

#ICARST2025





Wei PENG • 2nd
ThreeRays - Founder & CEO
1d • 🌐

+ Follow ...

ThreeRays and Aerial Sign Letter of Understanding to Expand Dosimetry Market in China and Asia ...more



👍❤️ Valeriia Starovoitova and 19 others



 [NEW ONLINE COURSE]

The [International Atomic Energy Agency \(IAEA\)](#) launches a brand new ...more

E-Learnig • 2 pages

E-Learning: Discover Radiation Polymer Processing

Practical uses and benefits
of radiation polymer processing

A comprehensive
overview of how ionizing
radiation is used in the
polymer industry

THE COURSE COVERS
THE BASICS OF:

- Radiation chemistry
- Radiation polymer chemistry





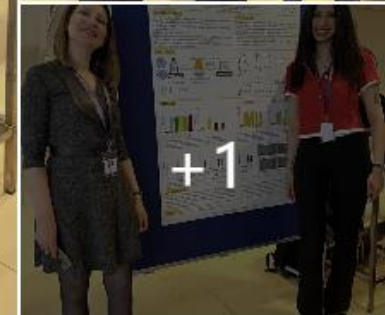
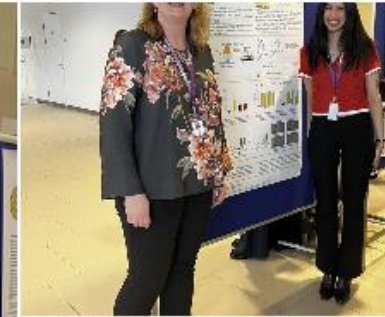
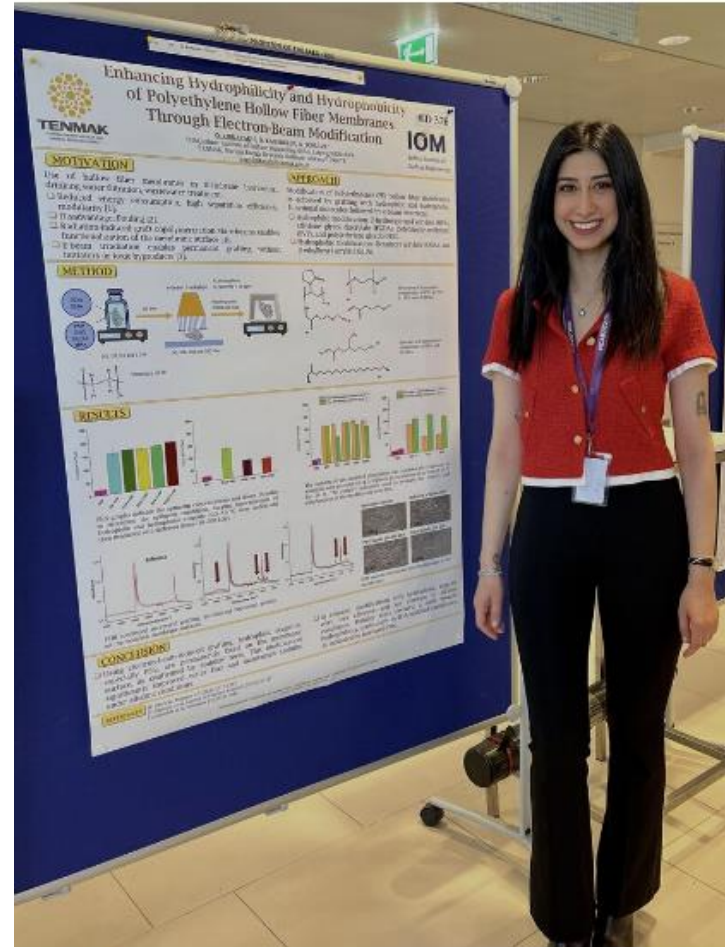
Ozgu Kirkayak • 2nd

Chemist

1d •

+ Follow ...

Excited to have attended [#ICARST2025](#), where I had the opportunity to present a poster on my master's thesis: Enhancing the hydrophilicity and hydrophobicity of PE hollow fiber membranes. It was a rewarding experience to share my ...more



100

2 comments

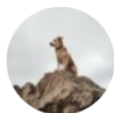
#ICARST2025



3

6

18



Juan PadrePerruno @ecojuanmart · Apr 7



La tecnología de radiación es clave para los ODS. [#ICARST2025](#) será un espacio crucial para innovación y colaboración global. ¡Espero ver avances transformadores! 🧬



Rafael MarianoGrossi @rafaelmgrossi · Apr 7



Radiation tech sterilizes half of all medical equipment, protects food from parasites & spoilage, and can even help [#BeatPlasticPollution](#). We must focus on scaling access—tackling infrastructure, awareness, and financing barriers so no country is left out.



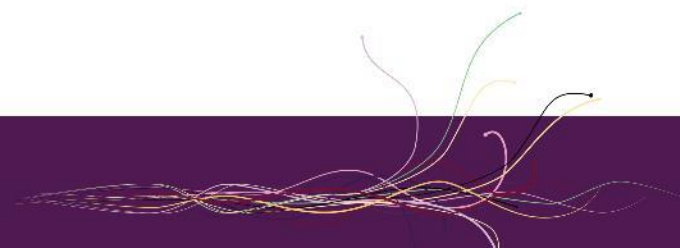
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5

1.3K



#ICARST2025





PMissionJapan Vienna @JapanMissionVie · Apr 8



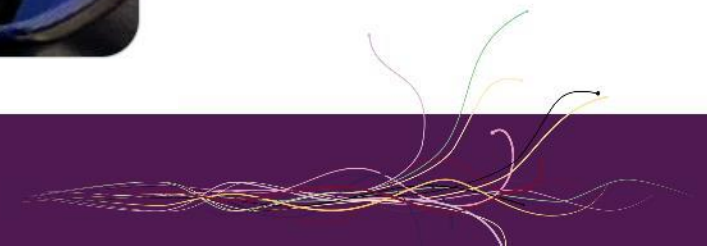
The energy in this crowd is incredible! 🙌 This level of attendance is a clear sign that the [#NUTECPlastics](#) initiative is being recognized as a milestone endeavor in the fight against marine plastic pollution! 🌊🌍

[#ICARST2025](#)



IAEA – International Atomic Energy Agency  and 7 others

#ICARST2025





Raluca Nicoleta Darie-Niță • 3rd+

Senior Researcher II at "Petru Poni" Institute of Macromolecular ...

2d • 🌐

[+ Follow](#) ...

Excited to attend the insightful lectures, parallel sessions, numerous side events, exhibitions and 300 posters presented by around 1000 outstanding participants from Academia, companies, agencies, embassies discussing the latest findings on applications of radiation science and technologies at [#ICARST2025](#), @IAEAorg in Vienna this week.

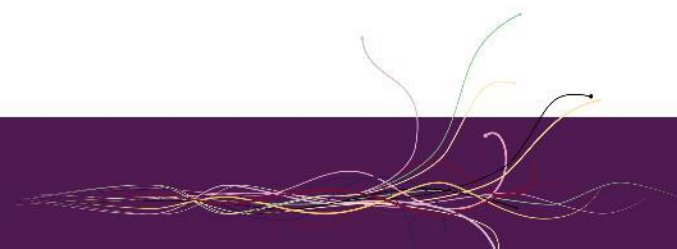


Danilo Matos Carvalho • 2nd

Pharmacist | Radiopharmacy Specialist | Hospital Pharmacist

5d ...

Excellent and of great importance! The possibility of following online is magnificent!



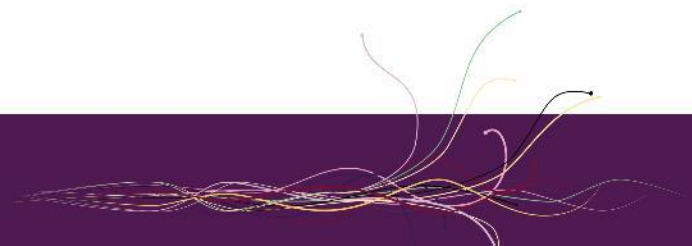
#NUTECplastics

#Atoms4Food

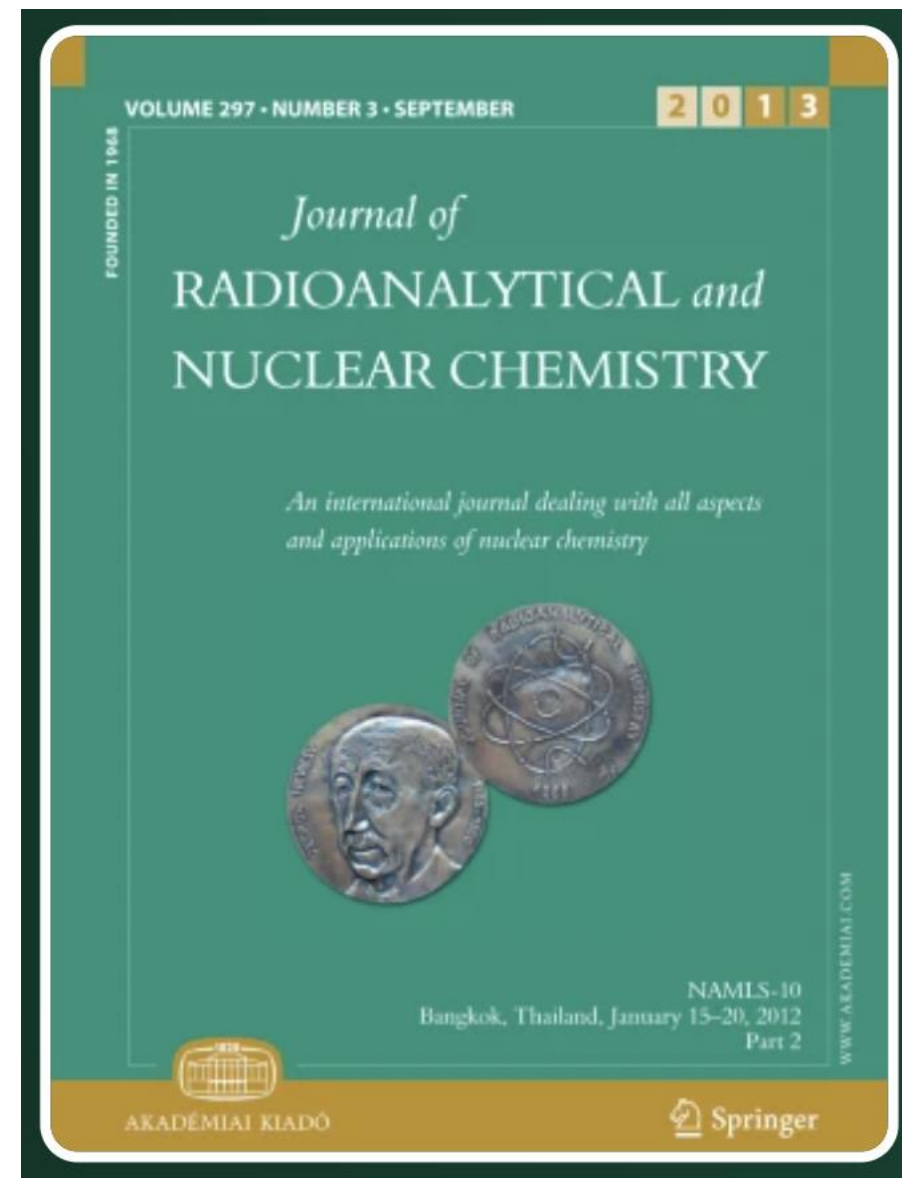
#ZODIAC

#Atoms4Climate

#Atoms4Heritage



841 submitted abstracts
620 accepted abstracts
170 oral presentations
300 poster presentations



Deadline: 18 May 2025

3rd International Conference on
**Applications of Radiation
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7—11 April 2025

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Thank you & Goodbye!

from the IAEA

#ICARST2025



Conference Highlights

Piotr Ulański

Institute of Applied Radiation Chemistry
Lodz University of Technology
Lodz, Poland

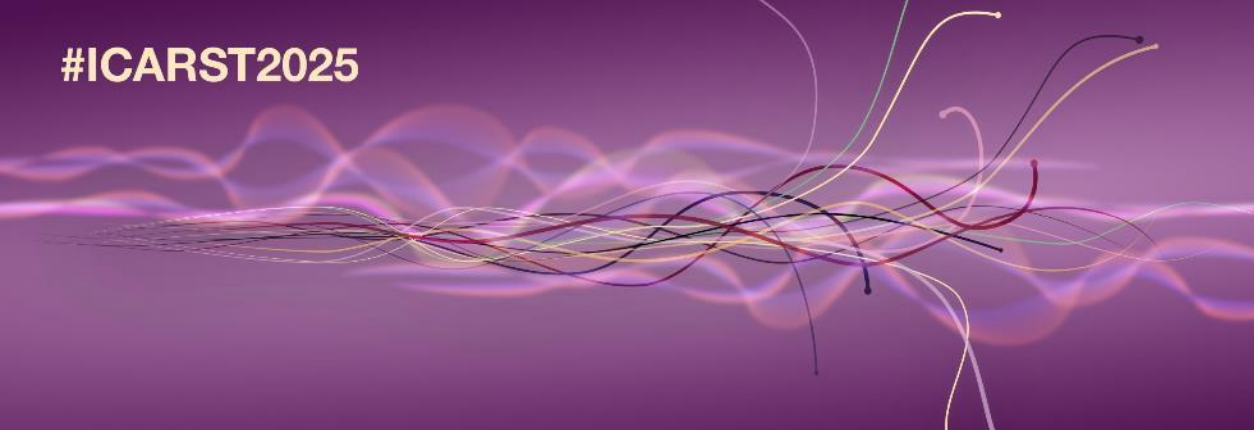
3rd International Conference on
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#ICARST2025



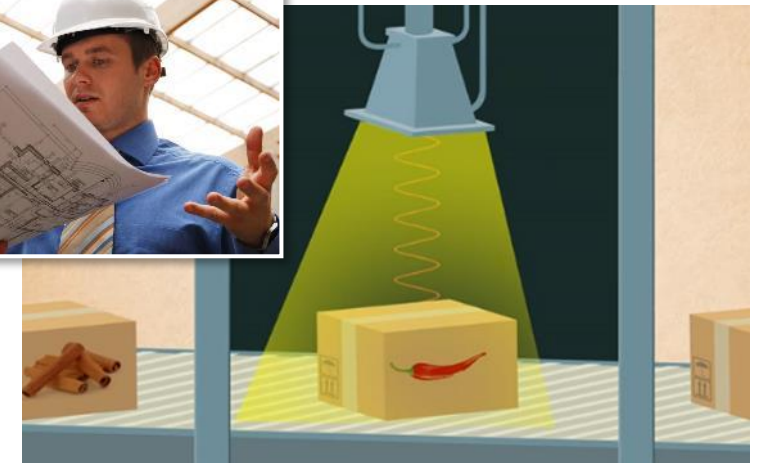
Impressions of young investigators (from their first international conference)

- "As PhD students and young doctors, we feel noticed and appreciated. The competition for the best talk and the mentoring session were an excellent opportunity to talk to outstanding specialists. We were warmly welcomed by the more experienced generation and invited to an active discussion."
- "The opportunity to listen to the achievements of teams from all over the world was extremely inspiring. Scientists tried to respond to local challenges, using available raw materials to support their communities."
- "Among the key aspects that we should keep in mind when developing new technologies, scalability, cost-effectiveness and ecological compatibility were particularly highlighted. Experiments should be wisely planned so that our ideas can be transformed into industrial solutions."



Impressions of a not-so-young investigator (that's me)

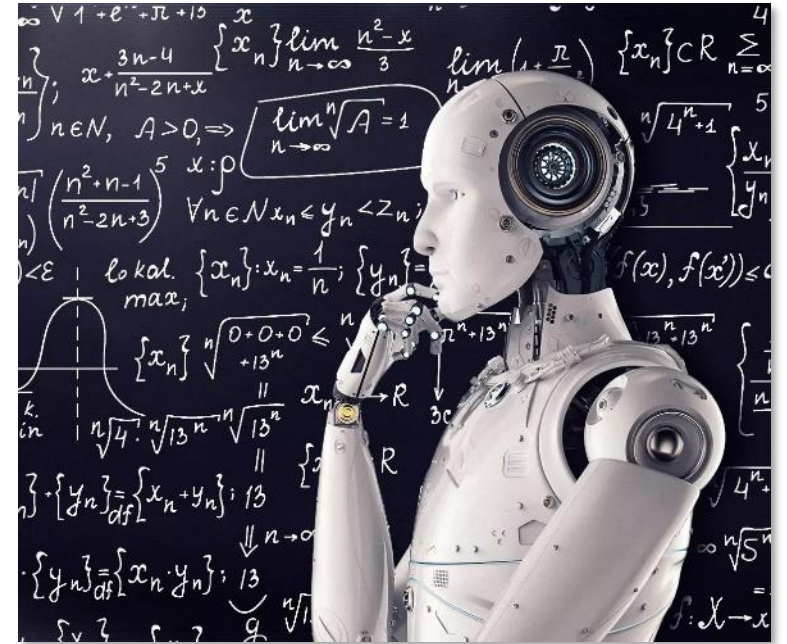
- ICARST is a truly unique meeting
- The largest radiation chemistry/technology event worldwide, becoming more popular than the well-established conferences of long history (1950')
- Diverse audience (from hardline basic science researchers to the creators of innovative, very practical technologies, technology & equipment providers, as well as industry representatives)
- All continents represented, good gender and age balance
- Very interesting and novel ideas



Highlights – the tools

(a personal perspective)

- Low-energy electron beam treatment
- Gamma is doing well, with steps being taken to assure ^{60}Co availability now and in future (low use of electrical power, low greenhouse emissions, +99% cobalt sources being recycled)
- New electron accelerators – based on the solid-state technology (reliability, performance, no need of tuning, high electrical efficiency)
- Importance of computation & simulation tools, as well as Artificial Intelligence and Machine Learning; synergy with experimental studies



Highlights

(a personal perspective)

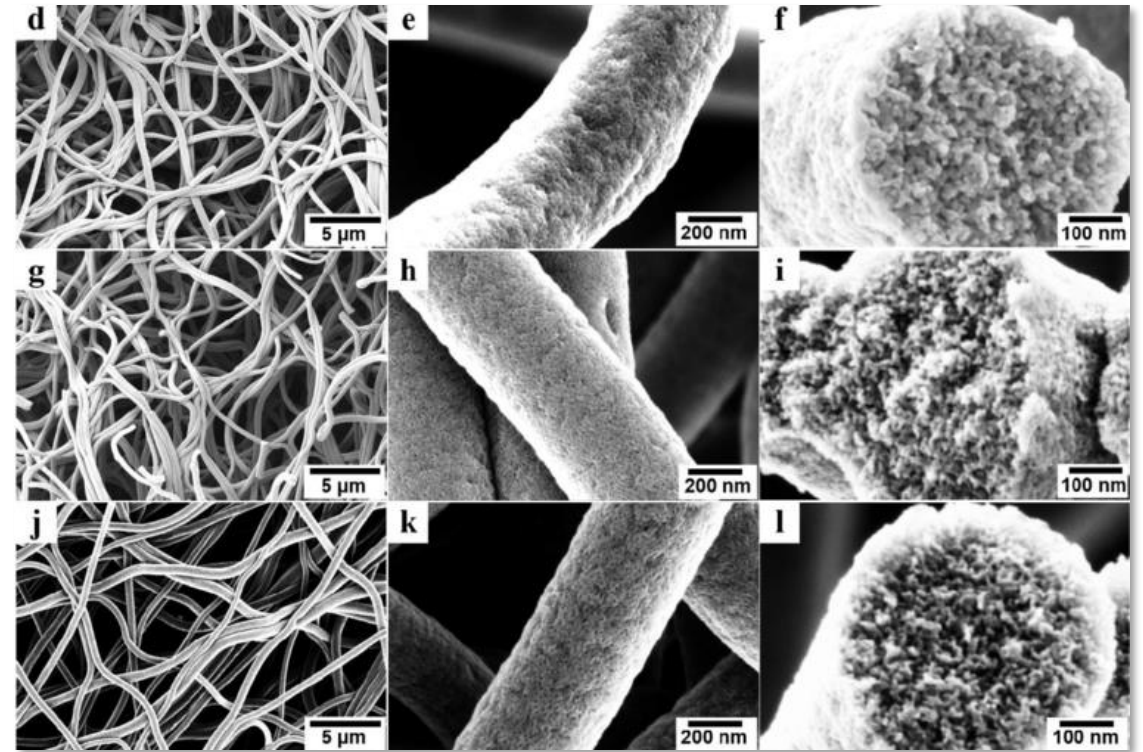
- Information on new pilot plants and radiation processing facilities in many countries (e.g. China (wastewater), Ghana, Paraguay)
- Strong involvement of the radiation community in actions related to environment protection, waste treatment (water, sludge, pesticides, antibiotics, gas, plastics, biomass), circular economy, CO₂ capture
- New solutions for human health (e.g. elaboration of new vaccines, new antibacterial products)
- Nanomaterials (graphene oxide-based composites, carbon nanodots, diatomite-based antibacterial products, silk fibroin nanofibers, conductive nanocomposites)



Highlights – Stream A

(a personal perspective)

- New classes of materials synthesized or modified by radiation technique
 - *Porous carbon fibers*
 - *Nanomagnetic bioadsorbents*
 - *3D printed materials*
 - *Modified polymer membrane filters*
 - *Composite silk fibroin polypeptide/polyethylene oxide fibres and membranes*



Highlights

(a personal perspective)

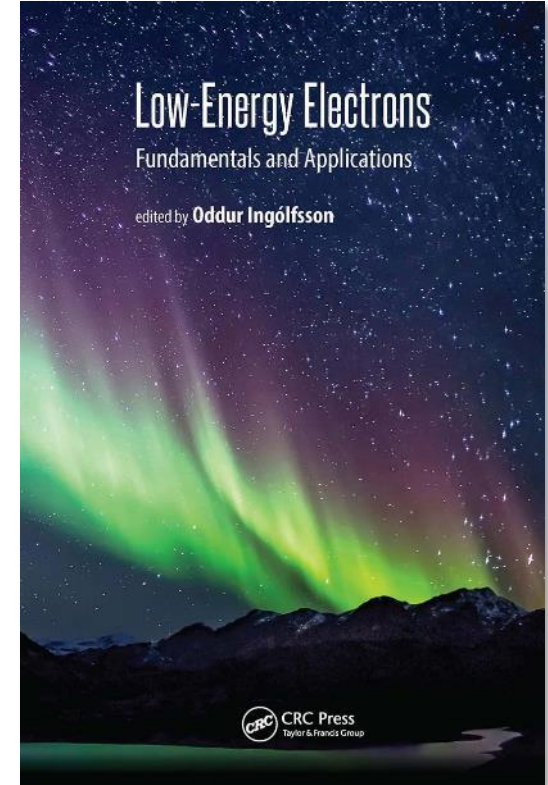
- The NUTEC programme – one of the most important global initiatives in our field in recent years



- A very successful Side Event and eye-catching stands; lectures on new technologies and products
- TRL5 in sight for the leading technologies; industry involved

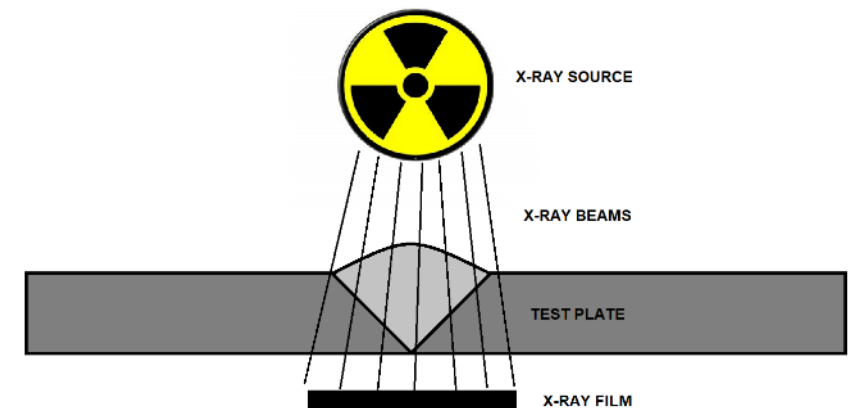
Highlights – Stream B

- Presentations were in two areas:
 - Applications, especially the environment, food, polymer recycling
 - Technology: accelerators and dosimetry
- Good progress since ICARST 2022
- Main developments are:
 - Growing interest in the use of low energy electrons
 - The importance of sustainability
 - New IAEA interest on mitigating greenhouse gases using radiation technology



Highlights – Stream C

- New technology development is seen in both radiotracer R&D, monitoring equipment construction and data interpretation methods.
- Machine learning, neural network approaches and artificial intelligence methods are taken into use for better understanding of experimental data.
- The Stream C demonstrated an impressive diversity of problem-solving activities both for industrial, civil society and environmental purposes over many orders of scale.
- Radiotracer Technology and Sealed Source Technology and NDT in general, are under steady improvement and development.



Highlights

(a personal perspective)

- Diverse forms of activities
- Fascinating side events, very well attended
- Panel discussions on important issues, as equal opportunities and education & training, including various perspectives (not only researchers and industry representatives, but also politicians)
- Important information on IAEA programmes (Maria Skłodowska-Curie fellowship program, Lise Meitner program) and educational activities
- Kick-off of the Networking in Radiation Science and Technology



Highlights

(a personal perspective)

- Exhibitors, stands
- Diversity
- Irradiation- and analytical equipment
- Services
(including by research institutions)
- Highlighting achievements
- Promoting IAEA activities, publications, e-learning tools



”High dose rate” schedule

- Intense program
- No bilocation skills (yet)
- Skipping our lunch
- Dropping in to the IAEA shop
- Exercising
- Simply taking some rest, anywhere



Trace amounts of free time — The Blue Danube

(An der schönen blauen Donau)



Selected opinions

- Positive (there is a long, long list):
 - There were many presentations on new materials, including polymer modifications. The significance of some presentations was more obvious than others, but it is a living and developing area, something to build on.
 - Many young people. We have complained that we miss new blood, but this meeting has proven that it is here. The future looks bright!



Selected opinions

- What could be possibly still optimized:
 - It would be even better if we had more time for questions and discussions during lecture sessions.
 - A laptop/screen and a mouse at the lectern would facilitate pointing out elements of the slides (virtual laser pointer).
 - In many cases, measurement results did not include statements about measurement uncertainties.
 - Cafeteria (M) could have opened before nine.
 - There is room for improvement!



Some statistics

Number of participants in the event container: 866 (499 in person, on-line 367)

Number of participants from Member States 853

Number of participants from Organizations 13

Number of member states: 104

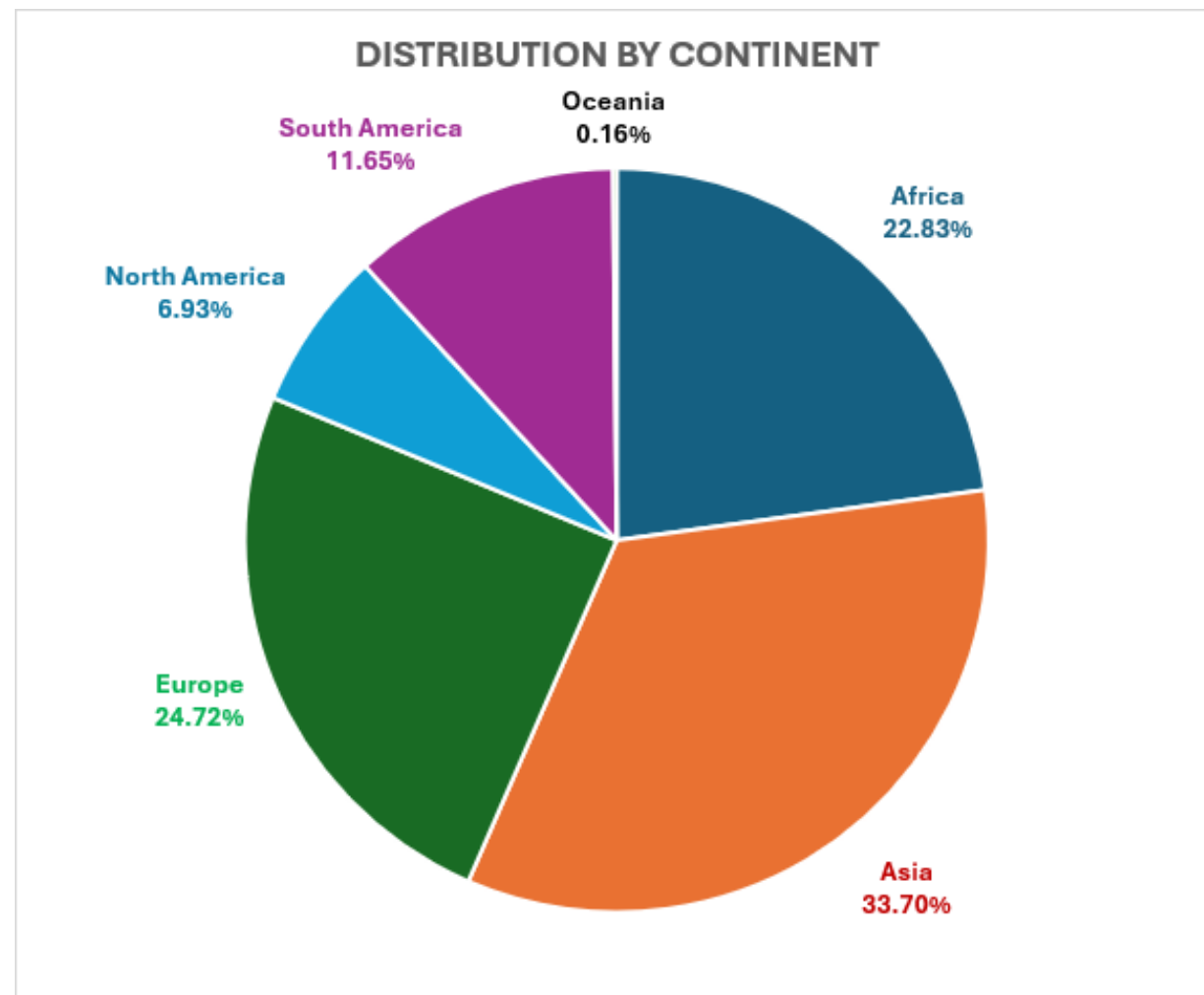
Nr of organizations 7

Gender - male: 539, Female: 327 (38%)

53 exhibition stands

Overall statistic for accepted abstract:

- Abstracts accepted: 644
- Posters: 245 in-person poster presenters
- Oral presentations: 170



Our sincere thanks to the Organizing Committee

Steering Committee:

A. Chmielewski, POL
C. Caballero, ARG
C. Ratnam, MAL
H. Abd El Rehim, EGY
J. Thereska, ISTR
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V. Feldman, RUS
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L. Abad, PHI
L.M. Ferreira, POR

M. Zhai, PRC
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M. Al-Dahhan, USA
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O. Potier, FRA
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P. Brisset, ISTR
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P. Ulański, POL
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S. Sabharwal, IND
T. R. Edgecock, UK
T. Jentsch, GER
T. Bjørnstad, NOR
U. Gryczka, POL
U. Gohs, GER

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G. Maghella, IAEA
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M.H. Casimiro, IAEA
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V. Starovoitova, IAEA

Scientific Secretaries:

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H. Affum, NAPC

Administrative Support:

F.J. Perez de la Maza, NAPC

Conference Services:

Division of Conference and Document
Services (MTCD)
International Atomic Energy Agency

Conference Coordination:

J. Zellinger, MTCD

Exhibition Coordination:

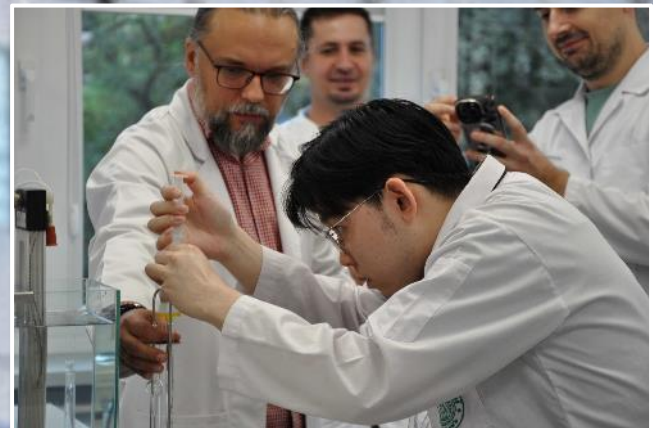
E. Paniagua-Miranda, MTCD

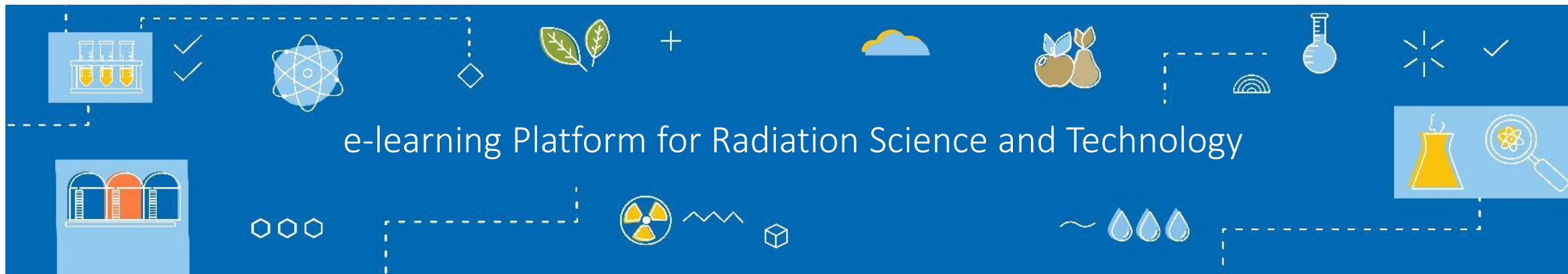


Have a safe journey home.



We wish you success in all your professional endeavors.
See you soon (but not later than at the next ICARST).





- NEW: E-Learning Course on Practical Uses and Benefits of Radiation Polymer Processing – Level A
- This course will familiarize the participants with the practical uses and benefits of radiation processing of polymers.
- It is an introductory course designed to provide a conceptual overview for the general public and non-technical staff, requiring no scientific background. The course covers the basics of radiation chemistry, radiation polymer chemistry, and provides a comprehensive overview of how ionizing radiation is used in the polymer industry.
- Three different levels of complexity (Level A, Level B and Level C)

Thank you

Acknowledgements

IAEA

ICARST'2025 Committees & Organizers

All colleagues who provided their inputs & opinions regarding Conference Highlights (Tor Bjørnstad, Azillah Binti Othman, Mark Driscoll, Rob Edgecock, Arne Miller, Wanvimol Pasanphan, Karolina Pietrucha and many others)

3rd International Conference on

Applications of Radiation Science and Technology

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7—11 April 2025

Vienna, Austria

Summing up Stream C

Tor Bjørnstad

Stream C

Slogan:

Control without damaging – diagnose without disturbing

General Subjects

Applications of radiotracer and sealed-source (NDT) technologies in industry, civil society and environment

Some statistics

**Number of oral sessions of
Stream C: 10**

**Number of oral presentations in
Stream C: 50**

**Number of posters relevant to
Stream C: 78**

Presentations per region

9

19

6

8

8

0

***Presentations
per country (31)***

A world map with red circular markers containing numbers indicating the number of presentations per country for 31 countries. The markers are distributed across North America, South America, Europe, Africa, Asia, and Oceania. The numbers range from 1 to 4.

Country	Presentations
Canada	1
USA	1
Mexico	1
Brazil	1
Argentina	2
Chile	3
Spain	3
Portugal	1
France	4
Germany	1
Italy	1
UK	1
Netherlands	1
Sweden	2
Switzerland	1
Austria	1
Belgium	1
Poland	1
Czech Republic	1
Slovakia	1
Hungary	1
Croatia	1
Slovenia	1
Finland	1
Denmark	1
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Iceland	1
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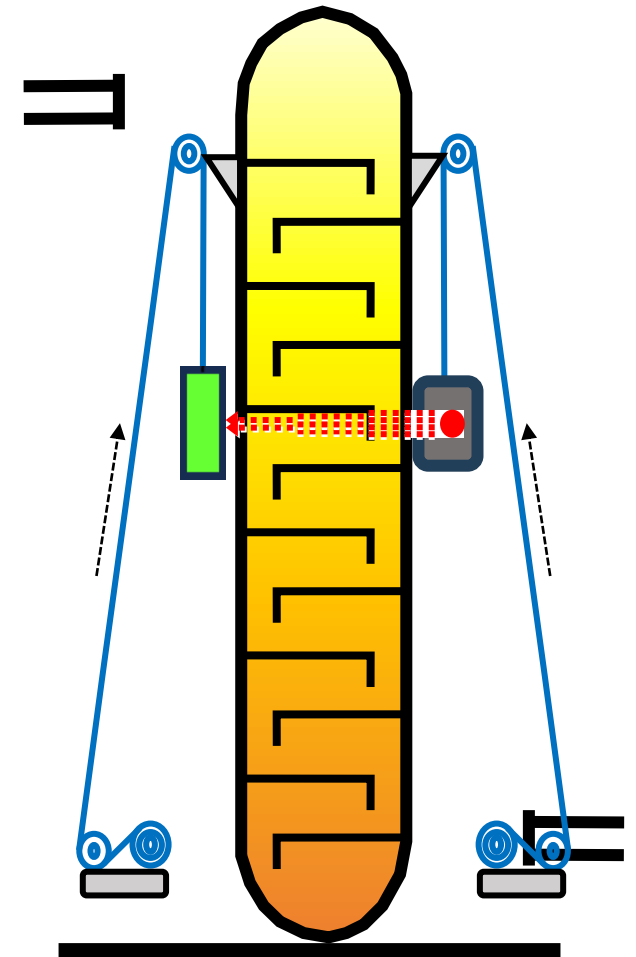
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Keywords for Session C01

- **Advances in radiotracer technology and sealed source applications**

Papers mainly dealing with **gamma scanning** and **gamma tomography** – main take-aways:

- Traditional methods enhanced by **dual-source technology** and/or more innovative so-called **laminography**.
- **Machine learning** and **AI** are started to become important elements in experimental result evaluation.
- **Scaling up - scaling down** of industrial process equipment: Risky with only CFD. Radiotracer-based RTD is needed.

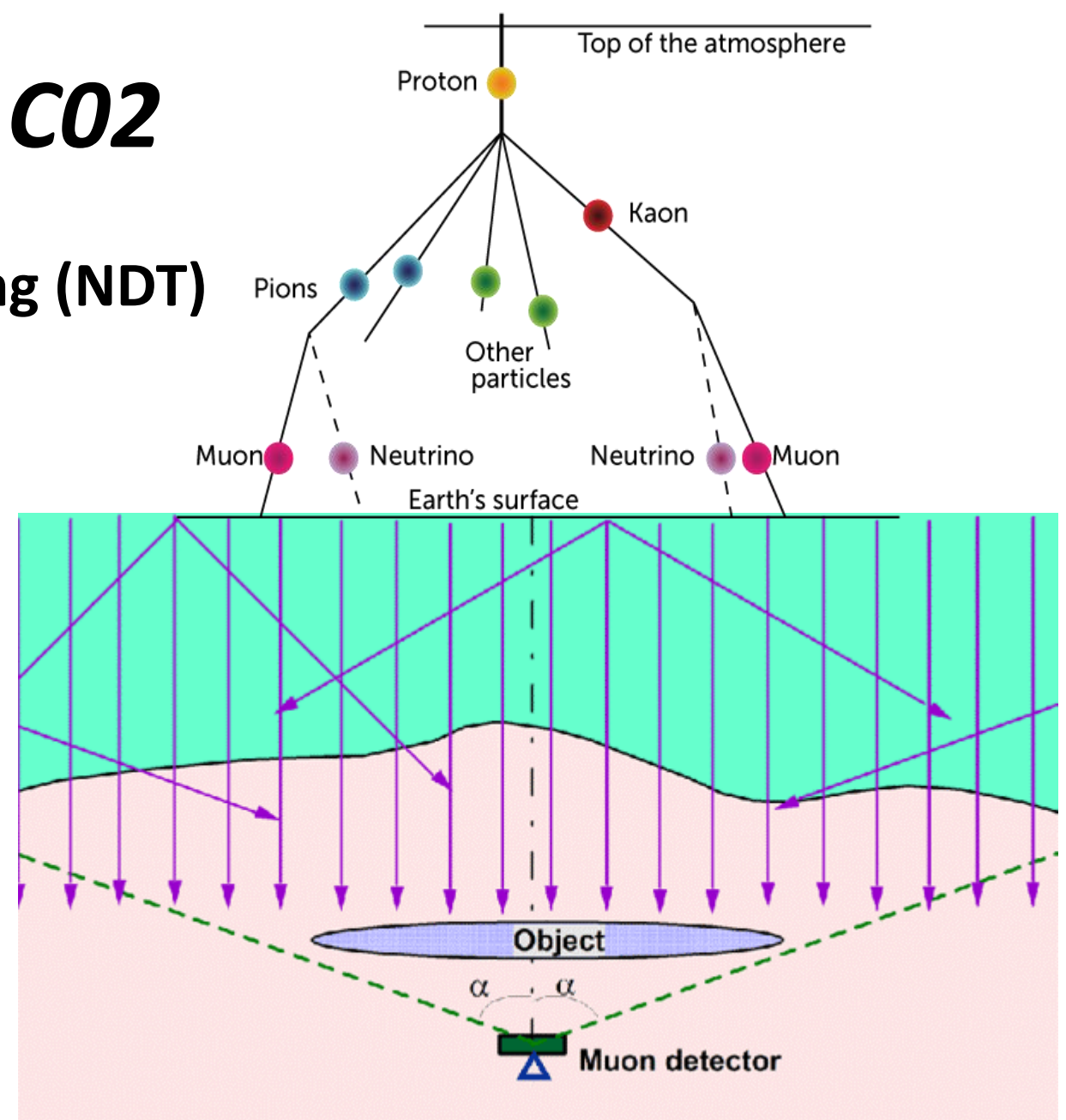


Keywords for Session C02

- Trends in non-destructive testing (NDT) in civil engineering

The session treated **NDT-application** of **industrial facilities** – main take-aways:

- Innovative **NDT** in **nuclear installations** and **heavy industrial facilities**
- **neutron radiography** for fire behavior of **concrete**
- **muon tomographic** methods for dam examination.

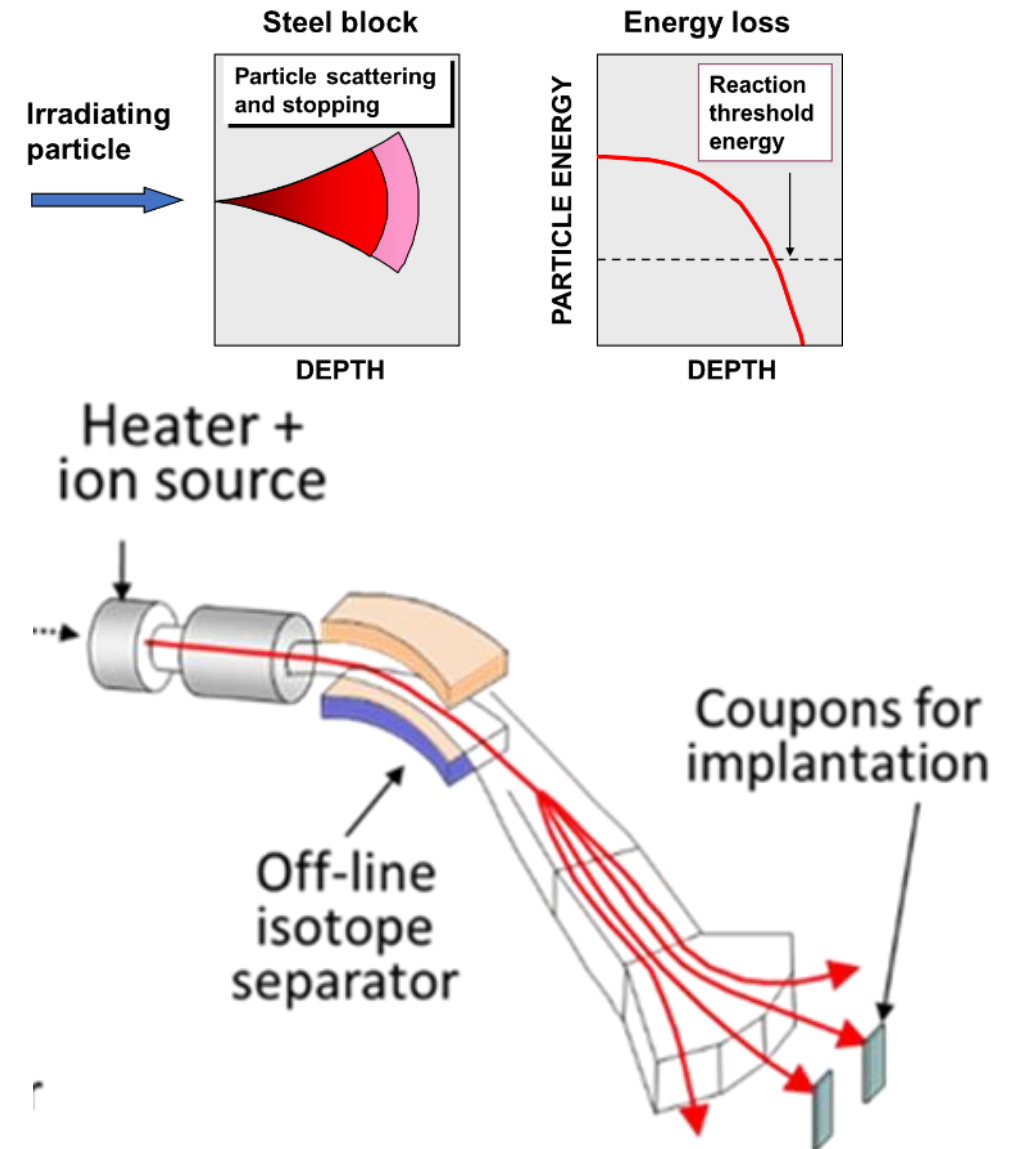


Keywords for Session C03

- **Imaging technologies and thin layer activation (TLA)**

The session treated **trouble shooting** and **damage preventing** in process vessels – main take-aways:

- **Detached coating** detection in water pipelines with **gamma tomographic** imaging
- Tribology technology (study of **wear**, **erosion** and **corrosion**) by thin layer activation (TLA) for metals and innovative radionuclide implantation for soft materials
- **Corrosion inhibition** techniques by chemical complexation

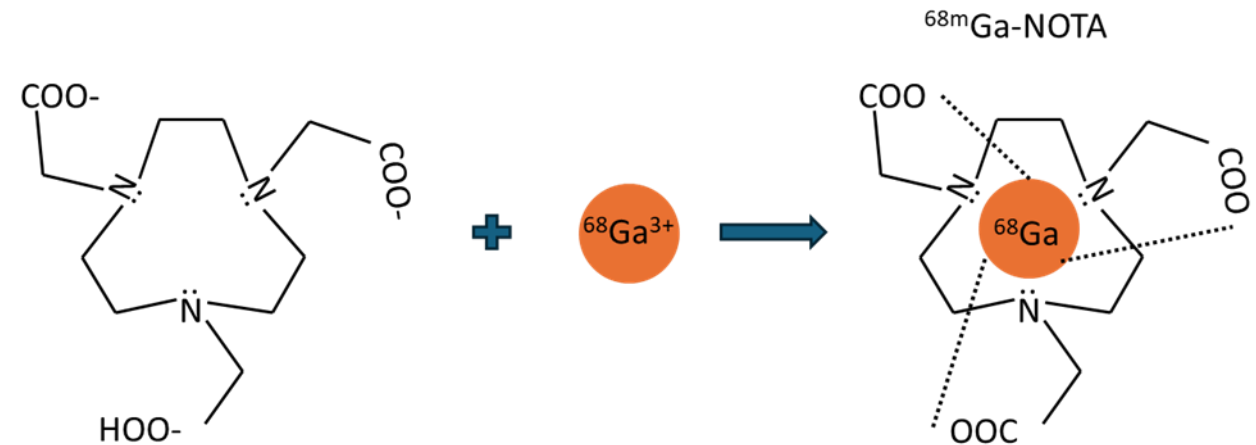


Keywords for Session C04

- **New tracers and methods for mass flow monitoring**

The session treated **tracer R&D**, artificial and natural **radiotracer applications** and innovative **pipeline transport diagnoses** – main take-aways:

- Development of **new radiotracers** (for water flow),
- detection of **micro-leakages** (35 μm) with radioactive gas tracer,
- diagnosing of pipeline flow using radiotracers and **deep-learning** techniques like **neural networks** and **AI** models,
- application of natural radionuclide ^7Be
- to study **constructed wetland** performance
- study of **coastal sediment transport**
- and dynamics by natural radionuclides ^{40}K , $^{226,228}\text{Ra}$



Keywords for Session C05

- **Radiotracer studies for sediment dynamics**

The session treated **sediment transport** in rivers, canals and shore-lines using natural radionuclides – main take-aways:

- Evaluating alternative to artificial radiotracers based on the ^{40}K activity and **feldspar/quartz ratio** and **grain sizes**
- Observed relationship between K, U, and Th activities and grain size opens the possibility of generating a **granulometric mapping** using in situ gamma spectroscopy
- Natural radionuclides effective in tracing sediment movement confirming dam contamination from tailings at a decommissioned mine
- A gamma spectrometry method proposed ^{214}Bi (from ^{238}U)/ ^{208}Tl (from ^{232}Th) ratio as an **erosion proxy** (controversial?).
- **Multivariate analysis** (PCA) of natural radionuclides of gamma spectrometry results was used to explain the subaqueous **sedimentary dynamics** in a river system.

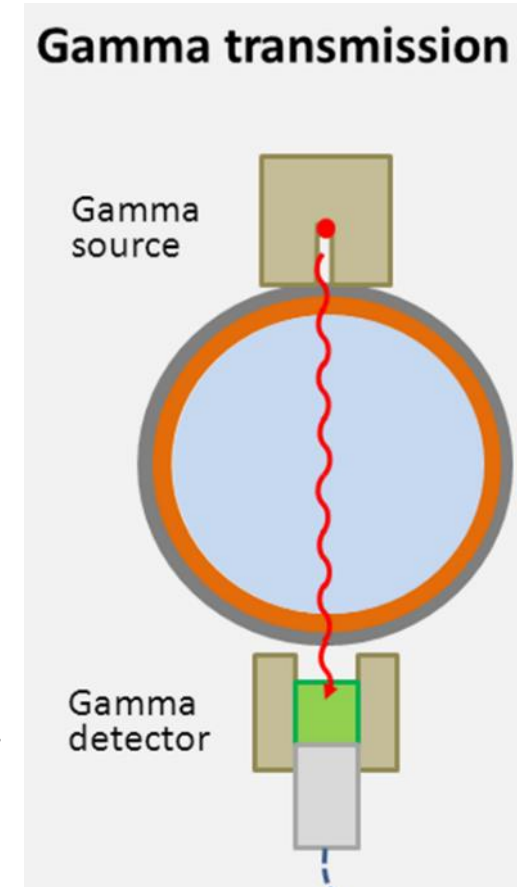


Keywords for Session C06

- **Radiotracer investigation in process industries**

The session treated **radiotracers in industry, wastewater treatment, Dirac and non-Dirac** tracer injection and detection of **mineral scaling** – the main take-aways:

- **RTD/radiotracer** experiments enables **optimization** of industrial processes)
- A **demineralization** study using new noncharged tracer compound based on ^{68}Ga was successfully performed.
- **Radiotracer/RTD** revealed **large dead volumes** and suboptimal mixing. **Reduced flow** solved the problem.
- RTD measurements in multi-vessel systems can be simplified by using **non-Dirac tracer injection** as measured in phosphate industry.
- Obstruction to flow like **mineral precipitation** (scaling) can be detected by non-intrusive gamma transmission in transportation pipelines for water/vapor from geothermal plants.

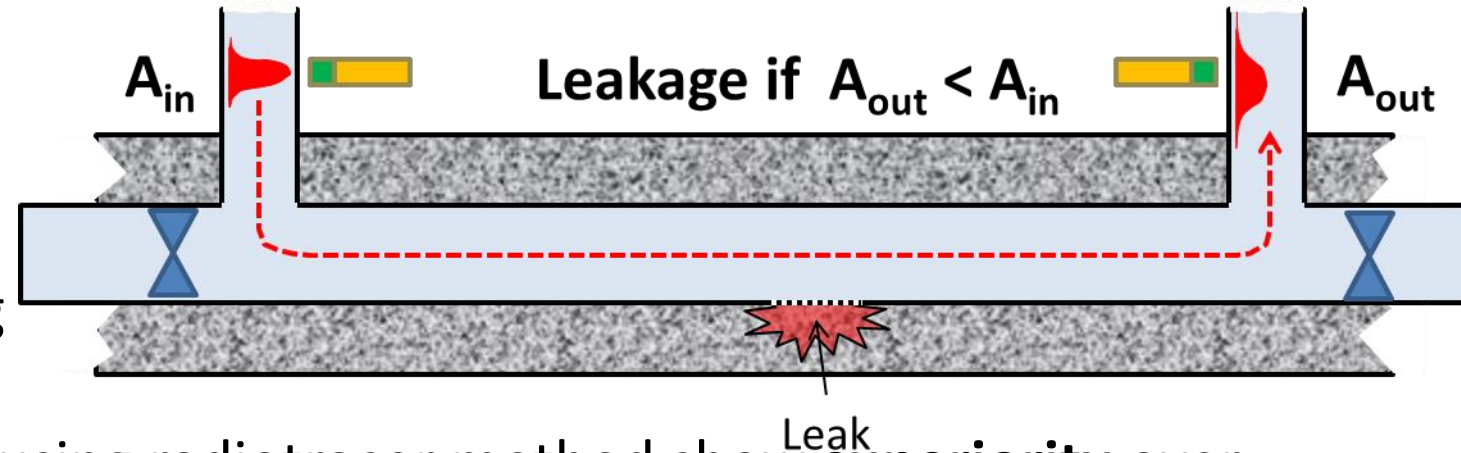


Keywords for Session C07

- **Sealed sources and radiotracer techniques in industry**

Main take-aways are:

- **Machine learning** introduced for interpreting results from a naphta splitter column scanning
- **Leak detection** in underground pipelines have been conducted using radiotracer method show **superiority** over other methods.
- The uncertainty determination of the **mean residence time** in RTD experiments involves many variables that have to be taken into account, of importance mao for fiscal metering.
- Large **Eddy Simulation** (LES) using CFD has been introduced to provide the comprehensive behaviour of **scour erosion** around vertical structure under waves and currents.



Keywords for Session C08

- **NDT monitoring for civil infrastructures**

Main take-aways are:

- **Acoustic Emissions** from the structure itself coupled to machine learning can reveal **crack structures** in concrete.
- **AI** used before and after rehabilitation operations in “**hydraulic structure health monitoring**”
- "Real world" application of infrastructure management, that has allowed a temporary bridge to remain in service for over 70 years.
- “Practical application” of the **AI in Civil Engineering** being developed and used more and more – examples from Mexico
- Underlining the importance of a **support network** and people being trained “and used” in real time application of new skills, to facilitate recovery from many natural (and man-made) disasters.

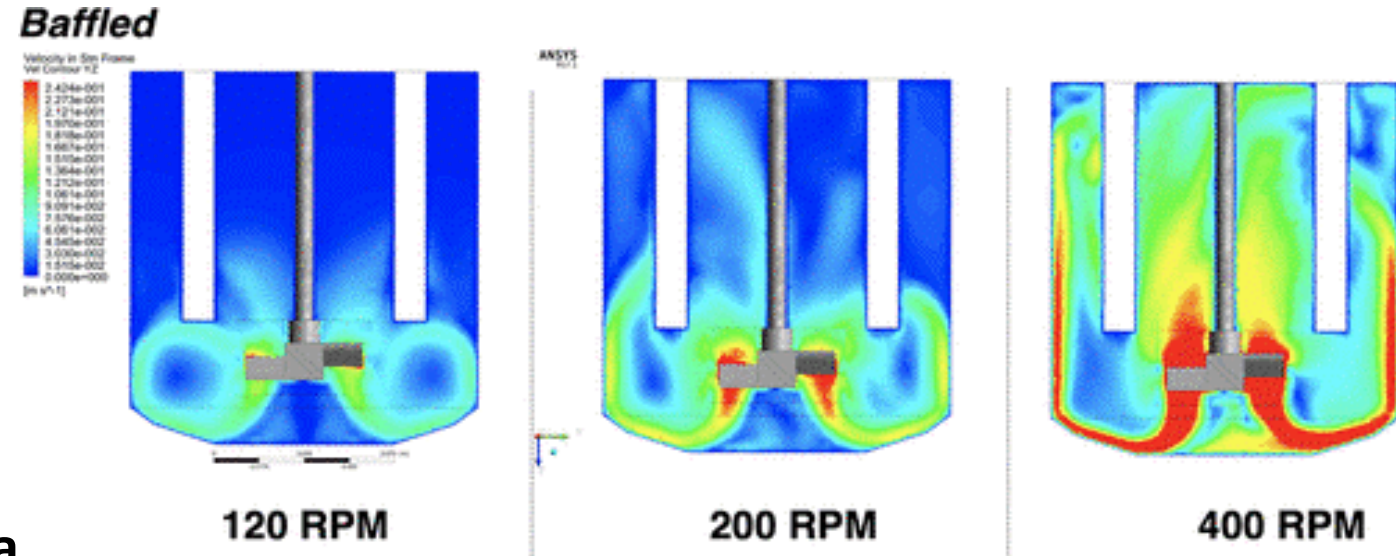


Keywords for Session C011

- Mass flow modelling: RTD and CFD

Take-aways are:

- **Numerical tracing** to be compared to radioactive tracing soon. Showed one-layer porous media better than more layers (dead zone) for horizontal CW
- Simulation CFD of **continuous stirred tank reactor (CSTR)**: Comparison of **numerical** tracing (CFD) to **experimental** tracing of CSTR. Good agreement. Can be useful for next design of CSTR.
- Simulation CFD: **Comparison** of numerical tracing (**CFD**) to 2 experimental tracing techniques (**radiotracer** $^{99m}\text{TcO}_4^-$ and salt NaCl). Good agreement between the three techniques.
- Development: new **gamma-ray densitometer** design using GEANT4-based **Monte Carlo simulations**. Evaluation of various parameters. Results validated with experimental data from a gas-liquid bubble column.



Keywords for Session C012

- **Diagnostic methods for cultural heritage**

Take-aways:

- Non-destructive testing was applied to the safeguarding and conservation of **wooden roofs** of Italian historic architecture
- **Fluoroscopic Dual-Energy CT (DECT)** of fossils enabled determination of structural and mineral composition.
- NDT techniques were used to assess the structural and mechanical status of **building damaged by earthquake**
- Heritage Building Information Management (**HBIM**) integrating various NDT techniques encompassing all factors across the entire lifecycle stages is developed to provide **effective maintenance** protocols for Historical Buildings.
- A diagnostic plan involving NDT technologies is formulated to ensure the preservation of Sursock Palace after 2020's **explosion in Beirut** port serves as a model approach for safeguarding cultural heritage sites affected by catastrophic events.



Summary

Global observations and take-aways from Stream C are:

-  New technology development is seen in both radiotracer R&D, monitoring equipment construction and data interpretation methods.
-  It is a clear trend that machine learning, neural network approaches and artificial intelligence methods are taken into use for better understanding of experimental data.
-  The Conference Stream C managed to show an impressive diversity of problem-solving activities both for industrial, civil society and environmental purposes over many orders of scale.
-  The management of all these diverse challenges would not have been possible without the inventory of our nuclear-based methods which, in short, is referred to as **Radiotracer Technology** and **Sealed Source Technology** and **NDT** in general, and these methods are under steady improvement and development.

Review of Stream B

Rob Edgecock

On behalf of all Stream B Presenters and Participants

OB Consulting & Solutions

3rd International Conference on

Applications of Radiation Science and Technology

#ICARST2025

7—11 April 2025

Vienna, Austria



Introduction

- 49 presentations
- Lots of very interesting, new and important information
- Many developments since ICARST 2022
- Presentations on:
 - Applications
 - Technology
- For applications, I have grouped them via their impact on UN Global (non-political) Issues and SDGs
- Summary of technology development

Global Issues

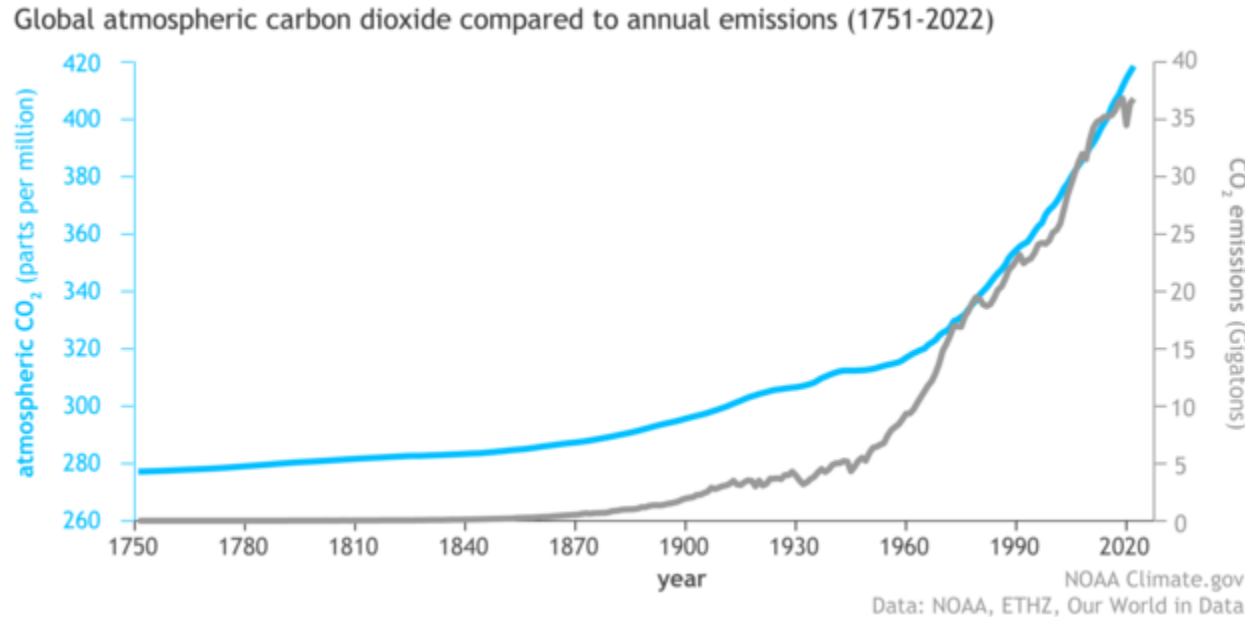
- Climate change
- Food
- Water
- Pandemics - AMR
- Healthy land and seas – plastics, POPs, PPCPs

Link between eBeam/X-ray Applications and Sustainable Development Goals

Oscar Acuna

UN Sustainable Development Goal (SDG)	SDG Description	Applications of Interest
Zero hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	• Phytosanitary treatment & food irradiation • Sterile Insect Technique (SIT) • Plant mutation breeding • Seed irradiation
Good health and well-being	Ensure healthy lives and promote well-being for all at all ages	• Radiotherapy • Blood irradiation • Medical research • Medical product sterilization
Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all	• Wastewater treatment
Industry, innovation, & infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	• Non-Destructive Testing
Life below water	Conserve and sustainably use the oceans, sea and marine resources for sustainable development	• Plastics/polymer reuse and recycling
Partnerships for the goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development	• NCEBR partners with countries to facilitate the adoption of eBeam/X-ray

(1) Climate Change



Olgun Güven

The National Academy of Sciences has estimated that to meet the Paris Agreement goals, **10 billion tons of CO₂** have to be removed globally each year **by 2050** and **20 billion tons** to be removed each year by **2100**.

The ever growing emissions from unaccounted sources as well as the risk of unpredictable emissions require the deployment of **DIRECT CAPTURE OF CO₂** from the atmosphere.

DAC is no longer an Option

IAEA-CRP

- First Research Coordination Meeting (RCM) on **Mitigating Greenhouse Gases using Radiation Technology** (F22080)
- 10-14 March 2025
Warsaw, Poland (EVT2304164)

Marc Metian: IAEA monitors CO₂ in the sea

Generation of Hydrogen and Carbon Black through Methane Pyrolysis using Ionizing Radiation from E-Beam and Cold Plasma for Advanced Materials with High Efficiency and Effectiveness
(*Mr Mariano Venturini, Argentina*)

Developing Innovative Radiation-Assisted Nanomaterials for Carbon Footprint Reduction and Climate Change Mitigation
(*Mr Hassan Ahmed ABD EL-REHIM, Egypt*)

Conversion of Gases Using Electron Beam Sustained Plasmas
(*Mr Goesta Mattausch, Germany*)
Hybrid Track-Etched Membranes with MOFs for Carbon Dioxide Capture
(*MR ILYA KOROLOV, Kazakhstan*)

Radiolysis Synthesis of Metal / Metal Oxides-Based Electrocatalysts for Electrochemical Reduction of Carbon Dioxide
(*Mr Thye Foo Choo, Malaysia*)

Studies on Possible Reduction of CO₂ Emission from Combustion of Fuel Oil in Marine Diesel Engines with Use of Electron Beam Technology
(*Mr Andrzej Pawelec, Poland*)

Study on the Decomposition/Conversion of Non-CO₂ and Indirect Greenhouse Gases by Electron Beam
(*Ms Sang-Hee Jo, Republic of Korea*)

Experimental and Machine Learning Modelling to Optimize Ionizing Radiation for Conversion of CO₂ and CH₄ to H₂, Methanol, and Acetic Acid
(*Mr Mohamad Al-Sheikhly, USA*)

(2) Food

UN: The world is still far off track to achieve Sustainable Development Goal (SDG) 2, Zero Hunger by 2030

Oscar Acuna

- Around 40% of food is lost or wasted from farm to table around the world.
- Around 1.2 billion tons of food (15.3%) are lost in the fields during, around and after harvest, representing \$1 trillion in annual economic losses.

(Source: FAO and WWF)

- *Lixin Shen*
- *Celina Horak*
- *Ariadnne Vargas Rivadeneira*
- *Monique Lacroix*
- *Saquib Majid*
- *Lassaad Mejri*
- *Bimo Saputro*
- *Cherin Balt*
- *+ multiple posters*

Uses in Agricultural Production and Food Marketing

- Mutation breeding
- Surface sterilization
- Soil treatment
- Seed germination improvement



- Insect sterilization
- Poultry vaccines
- Water reuse

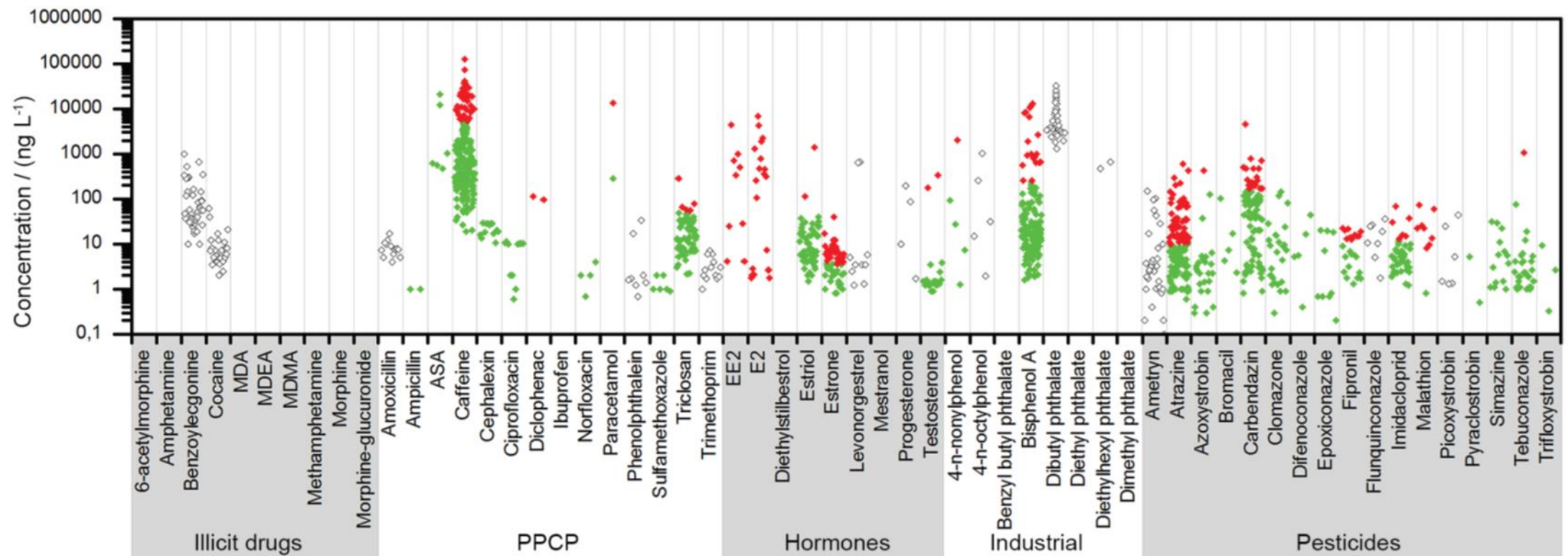
- Pest control in warehouses
- Long-term storage (grains/cereals)
- Improvement of bioplastics for packaging



- Elimination of pathogens in food
- Increased shelf life by eliminating microorganisms that accelerate ripening
- Elimination of phytosanitary pests

(3) Antimicrobial Resistance

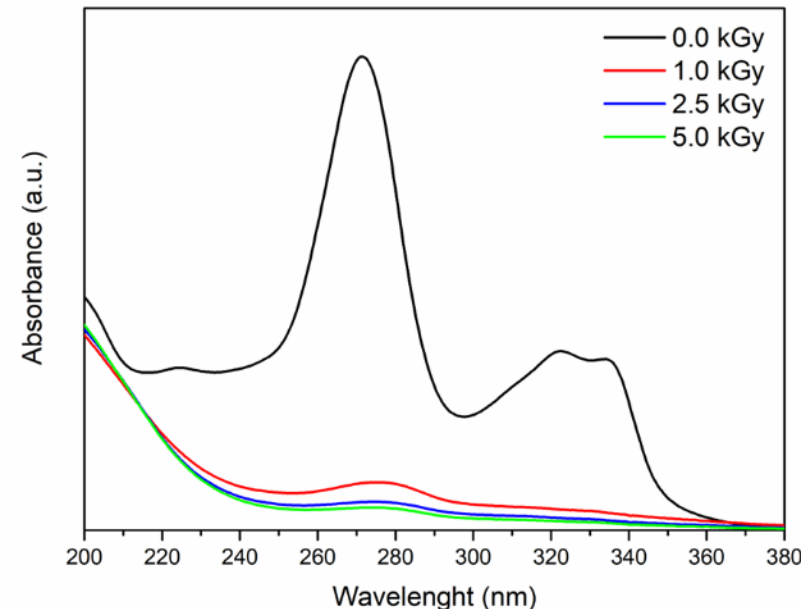
Sueli Borrelly: Concentrations of emerging contaminants in water in Sao Paulo, Brazil



Montagner CC et al, 2019

(3) Antimicrobial Resistance

- Many antibiotics included – through treatment, but also through farming
- Can be toxic to aquatic life
- Do produce AMR growth, especially in sludge treatment plants
- Two approaches:
 - Destruction at source: pharma plants, hospitals, etc
 - Treatment before/after AD for sludge



Ciprofloxacin: initial
concentration of 11.4
mg L⁻¹

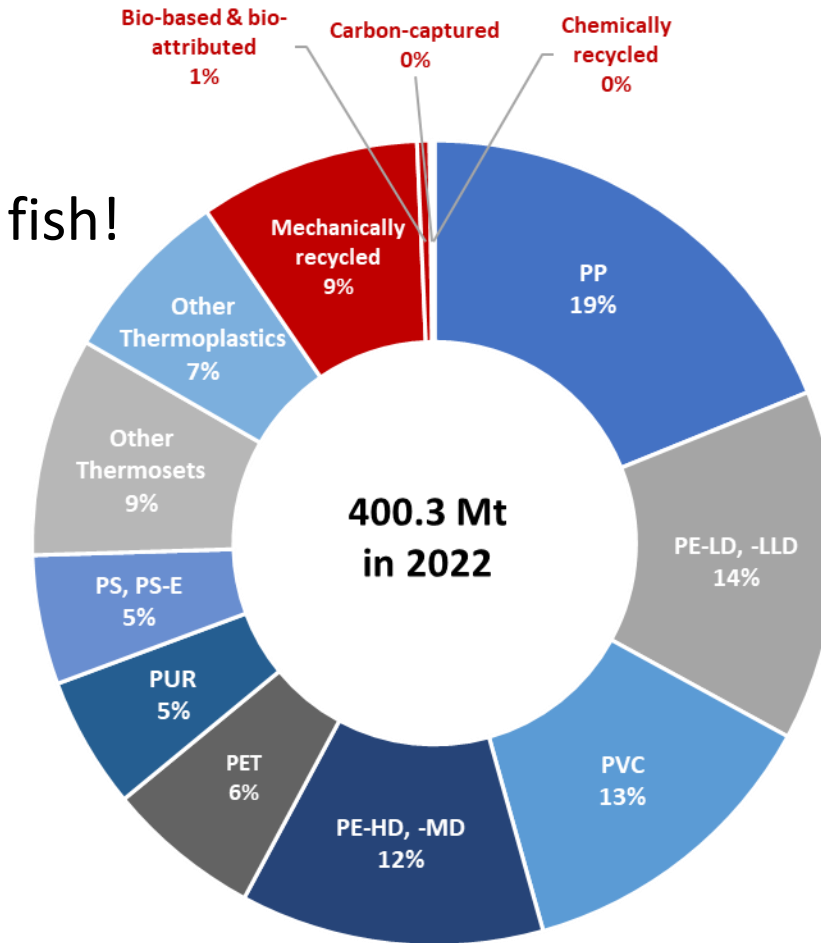


(4) Plastic Pollution

- Plastic waste:
 - 12.7 Mtons released into the oceans each year
 - Estimated that by 2050, more plastic in the oceans than fish!
- They're tough, so destruction not easy
- Particular focus on radiation-assisted recycling
- Many projects initiated through NUTEC Plastics

*Celina Horak
Bumsoo Han
Jordan Madrid
Nugroho Adi Sasongko
Richard Zeumer
Maria Celeste Cingolani
Amira Zaouak*

Richard Zeumer



Global plastic production by polymer³

(5) Other Pollutants

- Pathogens
- PFAS
- PPCPs
- POPs

Shijun He

Ayşenur Genc

Suresh Pillai

Wilson Calvo

Hassan Abdelrehim

Laurent Cortella

Ömer Kantoğlu

Yuntao Liu

Lotte Ligaya Schaap

Ahmed Basfar

Marija Majer

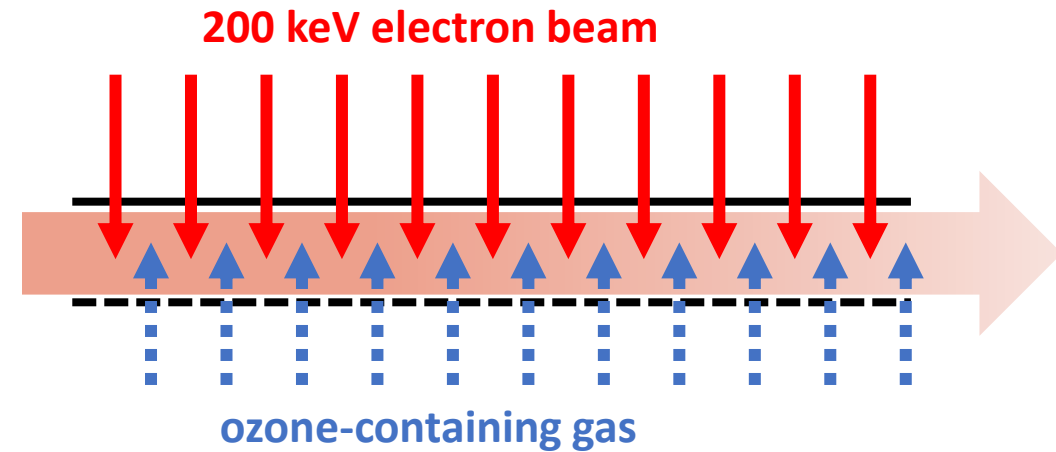


Figure 3. Low-energy EB + Ozone - Hybrid wastewater treatment module concept.

Low energy electron irradiation (200 keV)

Thin layer of waste water stream

Bubbled with ozone-containing gas flow

Reduced mass per area -> increased electron range

Homogenization of dose deposition in fluid

RESULTS

Significant degradation (>80%) achieved already at 2.2 kGy for all substances in deionized water and synthetic wastewater.

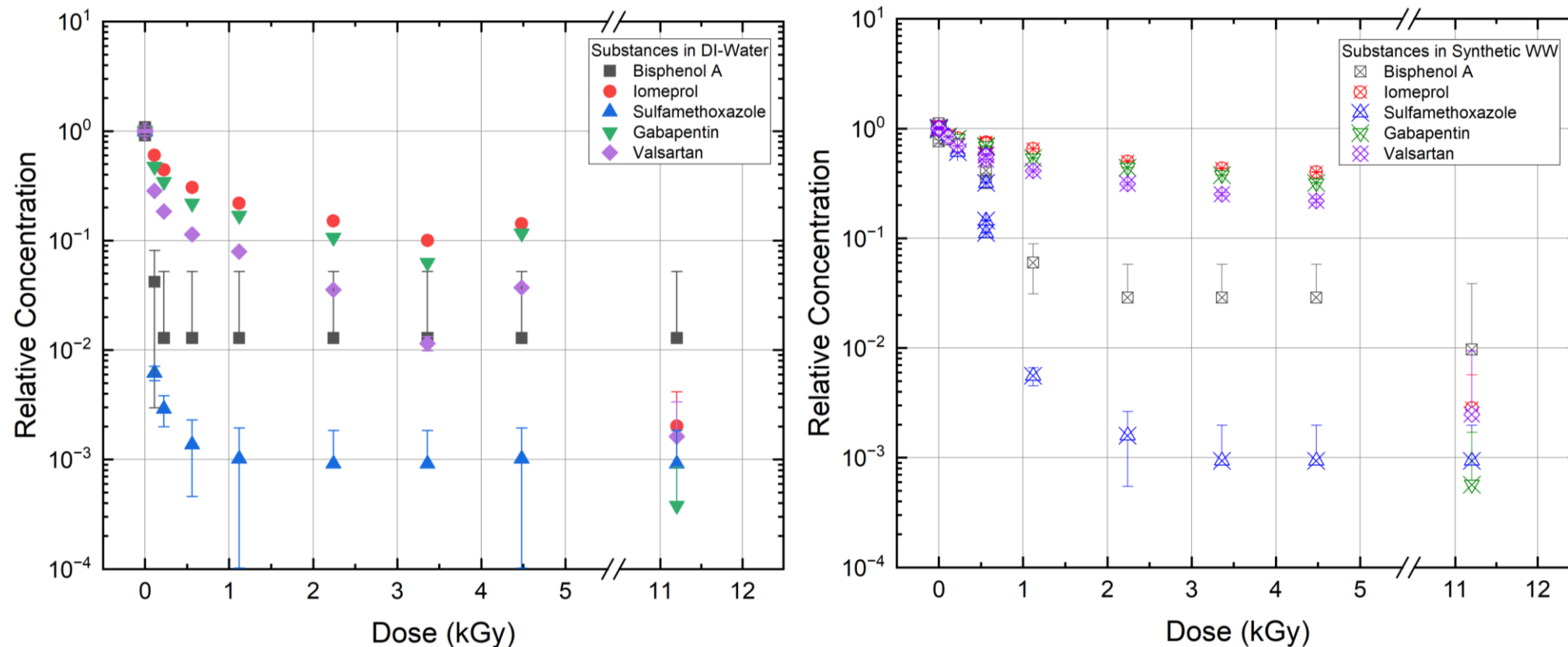


Figure 6. Relative concentration vs dose for five substances in deionised water and synthetic wastewater.

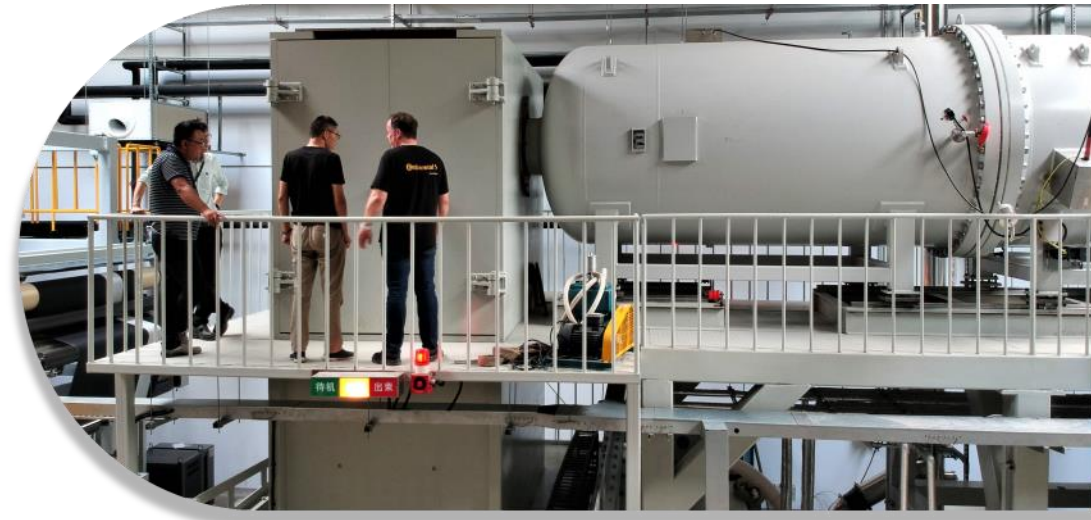
Technical Developments

- Radiation sources
 - Sustainability of cobalt supply – *Richard Wiens*
 - Accelerators – more compact, higher reliability
 - More development at lower energies

Zhenyi Zhang: <1 MeV EI Pont

- Sheet and foam material
- Battery diaphragm
- Films
- Coil and extrusion coatings
- Wires and cables
- Tyre prevulcanisation
- Panel coatings

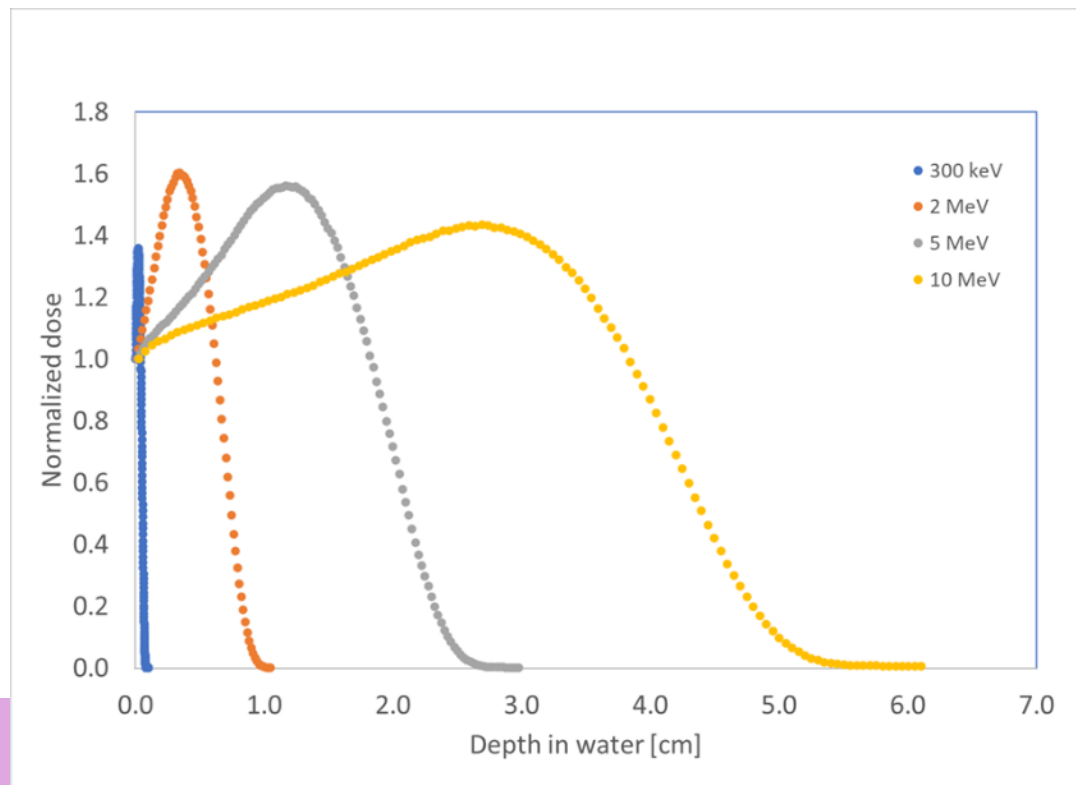
*Arnaud Pierard
Aleksandr Bryazgin
Richard Wiens
Cherin Balt
Wei Peng
RE
Sergey Kusaev
Lucie Delaunay
Sergey Taskaev
Zhenyi Zhang*



Technical Developments

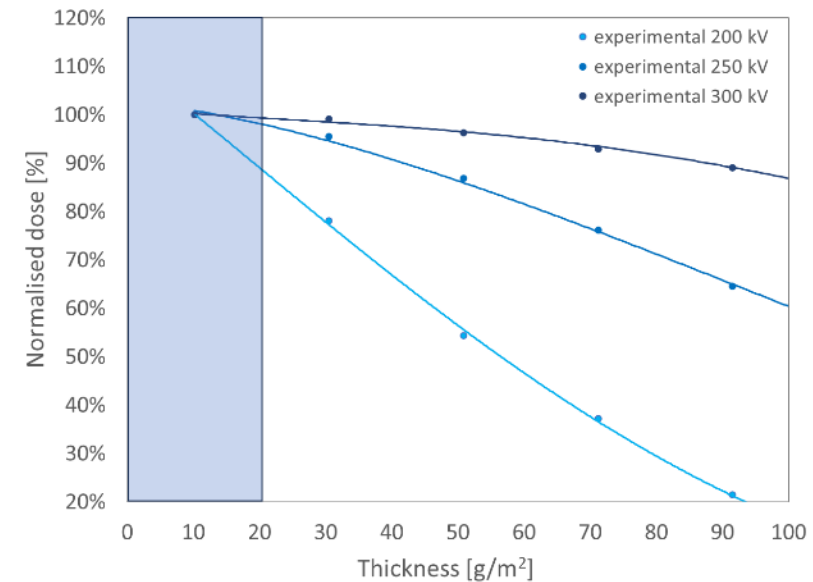
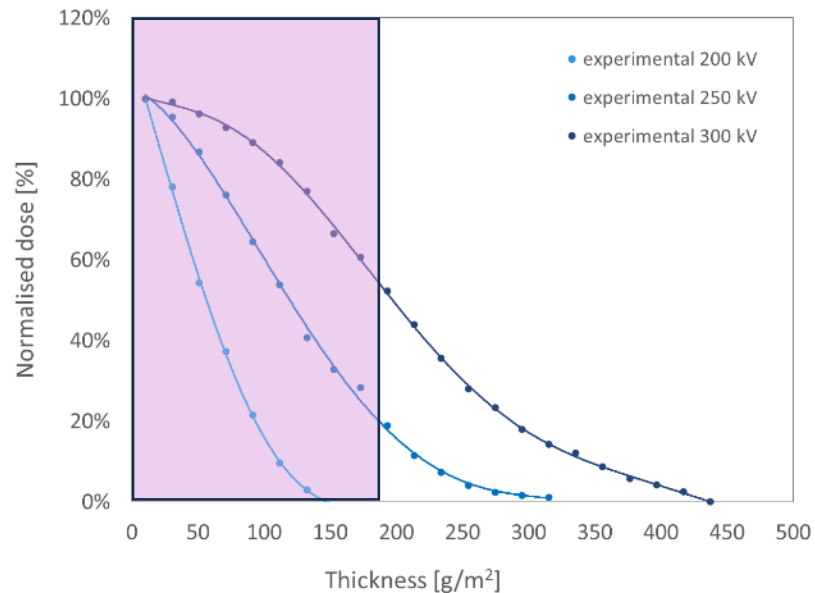
Florent Kuntz
Eva Pawlak
Urszula Gryczka
Arne Miller
Abbas Nasreddine
Kitaek Han

- Dosimetry: two new areas
 - Dose rate dependence on measured dose – *Abbas Nasreddine*
 - Dose measurement for very low energy electrons – *Arne & Urszula*



Results – Apparent dose measurements

	Thickness g/m ²	200 keV	250 keV	300 keV
B3 film (18µm thick, density 1.13 g/cm ³)	20.3	22.8 kGy	24.3 kGy	23.8 kGy
Alanine film (135 µm thick, density 1.4 g/cm ³)	189	8.1 kGy	16.4 kGy	21.85 kGy
Alanine pellet (2.4 mm thick, density 1.25 g/cm ³)	3000	0.86 kGy	1.70 kGy	2.51 kGy



Conclusions

- Lots of new information!
- Very interesting presentations and discussion
- Overall, ICARST has been excellent
- Thanks to the IAEA for organising this
- And to all the participants in Stream B for making it so interesting

3rd International Conference on
**Applications of Radiation
Science and Technology**

#ICARST2025

7—11 April 2025
Vienna, Austria

REVIEW OF STREAM A

OLGUN GÜVEN

Emeritus Professor

Hacettepe University, Ankara, TÜRKİYE

3rd International Conference on

Applications of Radiation Science and Technology

#ICARST2025

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Stream «A»

- A01: Advances in Radiation Science and Technology
- A02: Advanced Radiation Chemistry
- A03: Advanced Nanomaterials and Composites
- A04: Advanced Polymeric Materials
- A05: Radiation-modified Natural and Bio-based Polymer Materials
- A06: Radiation Sterilization and Decontamination
- A07: Microbiological Qualification
- A08: Tissue Engineering and Tissue Banking
- A11: Preservation of Cultural Heritage
- A12: Computational Tools for Radiation Processing

A01

- Radiation technology boosts the circular economy by offering eco-friendly solutions for treating flue gas, wastewater and sludge – key global environmental concerns.
- Radiation crosslinking of plastics is affected by competing actions of crosslinkers and stabilizers, requiring good analytical procedure to balance their effects effectively.
- Scaling up radiation-processed materials from lab to industry requires Material Informatics to optimize processes, enhance efficiency and reduce production costs.
- Kinetic studies of various catalysts in radiocatalytic oxidation systems are key to understanding physicochemical properties for effective organic compound degradation.
- Developing a radiokinetic model based on PFAS degradation reaction mechanisms and experimental data helps predict optimal treatment conditions for PFAS degradation.

A02

- Radiolytic degradation of two emerging pollutants, myclobutanil and fluoxetine reported. They were observed to be totally demineralized at 1.2 and 1.5 kGy doses resp..
- Accelerated ageing by irradiation has been used as a tool to determine reaction mechanism and screening of electrolytes in Li-ion batteries. A few hours of irradiation of electrolyte has been found to be equivalent of several weeks of calendar ageing.
- EBXL used for the preparation of high performance electrical materials, such as highly durable silicon rubber sheds, rapid curing of coatings based on PDMS.
- Radiation processing of biomaterials elaborated. One pot synthesis of protein nps, Au-198 nps capsulated by albumin, radiolytic production of melatonin, hydrogels with Ag nps.
- An overview on the effect of ionizing radiation on hydrophilic polymers such as PVP and PAA presented. Mechanism of radiolysis of PVP in solid state and in aqueous solution explained. The factors effecting the formation of PVP nanogels discussed.

A03

- Gamma radiation-induced reduction of GrO and Ni salts in aqueous dispersions was investigated. Ni/NiO nps deposited on rGO showed pseudocapacitor properties. TEM, SEM, XRD, XPS, TGA and Cyclic voltammetry used for characterization.
- Ag⁺ and Cu²⁺ adsorbed on diatomite reduced by EB irradiation. Chitosan used as the binder for the three species. Antimicrobial activity of the composites measured. The nanocomposites found to be very effective against some infectious diseases.
- Electrospun silk fibroin-PEO nonwoven nanofibers containing turmeric modified by LEEB. >50 kGy nanofibers become fragile. Controlled release of turmeric followed.
- 1.5 MeV EB irradiated multifunctional porous carbon fibers developed for structural batteries. EB stabilized pores, improved thermal behavior and structural integrity.
- Nanomagnetic bioadsorbents developed to recover REEs from industrial and mining wastewaters. Chitosan used to solubilize, homogenize ionic liquid/magnetite and irradiated to 6 and 10 kGy with good recovery of REEs.

A04

- Ag nanoparticles synthesized in the presence of PANI by irradiating suspensions at 50 kGy. 11 nm average particle size of Ag nps. Conductivity, antibacterial and antifungal properties enhanced with Ag nps.
- Adsorbent hydrogels prepared by irradiating cassava starch in the presence of PEO and PVOH. Swelling of hydrogels up to 70 times achieved. Adsorption and removal of phenol red found to be dependent on the pH of the medium
- PES and PVDF based flat sheet membranes hydrophilized by both grafting-from and grafting-to techniques. Hydrophilicity followed by water CA measurements. Biocatalytic activity imparted to membranes with increased fluxes.
- Importance of removal of CO₂ from natural gas and atmosphere emphasized. RIG shown to be an easy and effective way of developing fibrous adsorbents to this end. Experimental parameters optimized by Taguchi method.
- Effect of EB irradiation on tensile properties and crystallinity of PLA-based 3D printed materials investigated. Mechanical properties improved upon irradiation.

A05

- New results presented on the radiolysis of dry and wet lignin. Pulsed electron beam accelerator with 120 pulses per second and pulse width of 6 microsecond was used up to 1000 kGy. The effect of the presence of oxygen was discussed. Radiolysis of lignin in water produces low molecular weight products suggesting the important role of the hydroxyl radicals in degrading the lignin. Radiolysis of dry lignin, induces minor changes in the structure of the lignin.
- Gamma radiolysis (5-30 kGy) of neat poly lactic acid (PLA). mixture of PLA/ Microcrystalline cellulose, (MCC), and PLA/cellulose Nano whiskers (CNW) with 1% fiber content in the presence of (PLA-g-MA) used as the compatibilizer. Gamma radiolysis induces scission on the PLA. As the dose increases, the scission increases. Binary system of the PLA/MCC showed higher resistance to ionizing radiation.
- Ground tire rubber (GTR) recycled using ionizing radiation. Irradiation carried out in the presence of oxygen. After the radiation-induced oxidation, the irradiated GTR was mixed with natural rubber and vulcanized. The final product (the vulcanized mixture of the irradiated GTR and natural rubber) has shown good mechanical properties.
- Food packaging fabric composed of (PVA)/Chitosan-loaded with Moringa extract. This fabric showed good results on combating insect infestation and preserved Siwa date fruit during the storage and transportation. The best results obtained when 15% of Moringa extract was used. No radiation chemistry mechanisms were suggested or discussed on the radiolysis of PVA)/Chitosan. The use of ionizing radiation was not clarified, justified, neither the chain scission of PLA which would decrease the mechanical properties of the packaging.
- Radiation-induced functionalization of the activated carbon using Co-60 gamma rays and EB. Polysulfide (from glutinous rice) anchored onto functionalized activated carbon. The final product has been used in energy storage as capacitor and waste water treatment to remove methylene blue. It was noted that the irradiation dose was very high at 1500 kGy.

A06

- The current state of radiation sterilization in Argentina was reviewed. The irradiation facilities and various applications using gamma and EB described. Challenges and opportunities discussed.
- What is new in the 2025 version of ISO 11137-1 presented. Understanding the ecosystem of radiation sterilization standards emphasized. Key changes in ISO 11137-1 described. Evolving of standards with time noted.
- Factors impeding the transition to EB and X-ray such as filing data, education and tool gaps discussed. Progress of an international collaborative team-Team Nablo-updated.
- The role and the need of industry collaboration to enhance the security and sustainability of radiation processing emphasized. Security effectiveness assessment methodology and cyber security assessment and guidance described. The importance of collaboration to enhance sustainability.

A07

- The effect of radiation sterilization on Tibetan medicine Shiwei Ruxiang pill studied. 7 kGy of irradiation shown to meet the Chinese pharmacopia.
- Exposure to sub-lethal EB doses (<1 kGy) shown to exhibit enhanced conjugation of plasmids.
- Physicochemical and biological properties of gamma irradiated copolymers of poly(trimethylene carbonate) and poly(lactic acid) investigated.
- The growing role and importance of using ionizing radiation in vaccine development described.

A08

- The changing landscape of tissue banking described. Adoption of low dose irradiation sterilization stressed, average dose of 15 kGy and lower. The main problem of lack of tissue donation reminded.
- How to enhance the irradiation capacities for tissue engineering and tissue banking in Latin America and the Caribbeans articulated. The impact of an IAEA regional Project discussed.
- Incorporation of silver nanoparticles into radiosterilized pig skin and skin cells as an integral dressing for burns proposed. Pre-clinical and clinical pilot studies mentioned.
- Morphological analysis of micro computed tomography images of human tendon tissue sterilized by ionizing radiation presented.

A11

- Destructured books, paper collections of National Library of Romania irradiated with gamma rays up to 250 kGy. Low temperature irradiation for disinfestation of paper documents initiated. Irradiation at dry ice temperature showed less cellulose degradation.
- 10 MeV 2-25 kGy EB irradiation of old prints in Poland. Manuscripts from XIX century. Color of papers not affected up to 25 kGy.
- Radiation effects (1, 5, 10 kGy) on natural dyes used in rugs and carpets investigated. In this range color change due to irradiation not perceptible to eye. Experimental results confirmed by theoretical calculations.
- Polychrome wood sculptures disinfected and consolidated by radiation. New nanomaterials developed for cleaning old objects. Wooden sculptures of Sao Geronimo consolidated by in-situ radiation induced polymerization of a mixture of MMA+polyester.
- Leather samples irradiated to 3, 5, 10, 15 and 25 kGy with no color change. Archeological findings from Vinca protected by irradiation.

A12

- A simple dose distribution simulation software tool for ionizing radiation processes, PUFFIn, a useful interface introduced. Primarily an educational tool, showing how dose distribution in a material is influenced.
- Machine learning models developed for the optimization of radiation-induced grafting considering all parameters involved in radiation synthesis.
- For a sustainable plastic recycling assessment an innovative tool developed to bridge economics and circularity. ECO-BEAM, an excel-based economic assessment modeling described.
- Computer modelling of radiation-induced polymerization and crosslinking elaborated by considering creative aspects of irradiation.

Thank you

Special thanks go to

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S. Liu, IAEA
V. Starovoitova, IAEA

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