IAEA-CN290

Side Event (S03) “Education and Training in Radiation Science and Technology through IAEA Collaborating Centres”

Recent progress in the radiation technology development achieved by INCT, Poland - R&D, service, collaboration, education and promotion.

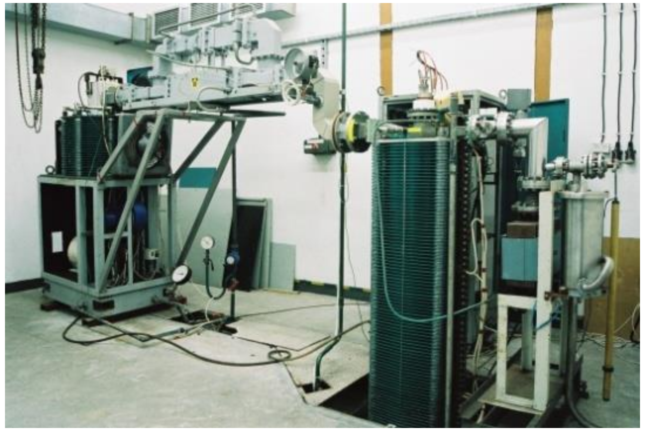
Collaborating Centre RAPID „Radiation Processing and Industrial Dosimetry”

Andrzej G. Chmielewski

Institute of Nuclear Chemistry and Technology, Warsaw, Poland

(A.Chmielewski@ichtj.waw.pl)

World leader in the application of electron accelerators



ELECTRON ACCELERATORS FOR R&D STUDY AND RADIATION PROCESSING APPLIED IN POLAND

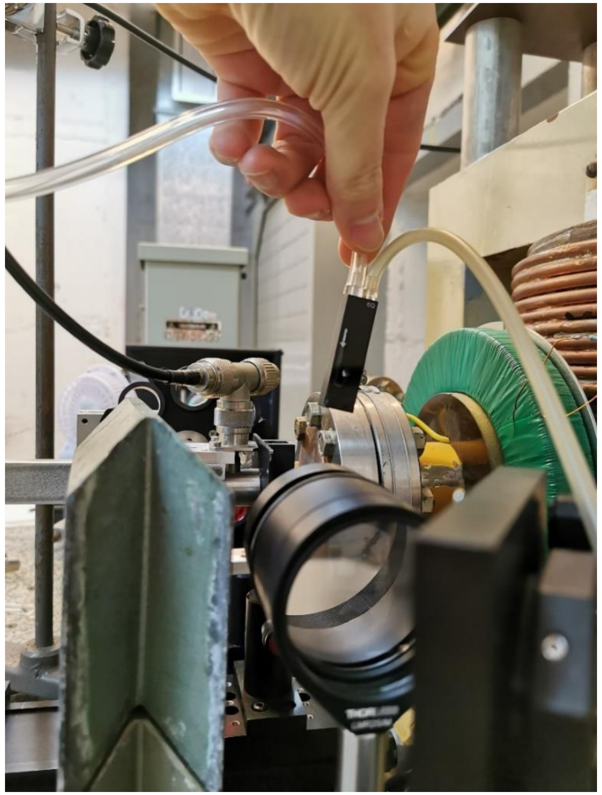
Type of accelerator	Place and year of installation	Energy and beam power	Remarks
LAE 13/9 linac	INCT, Warsaw, 1971	5-13 MeV 9 kW	R&D
IŁU 6 UHF	**ZUT, Człuchów, 1983**	**0,5-2 MeV 20 kW**	**Heat shrinkable tubes**
ELU 6 linac	MITR, Łódź, 1984	4-7 MeV 5 kW	R&D
AS 2000 electrostatic	INCT, Warsaw, 1987	0,1-2 MeV 0,2 kW	R&D
IŁU 6 UHF	INCT, Warsaw, 1988	0,5 - 2 MeV 20 kW	Pilot plant; polymer modification, R&D
EAK 400/100 transformer	IPJ, Świerk, 1988	0,2-0,4 MeV 40 kW	R&D
PILOT linac	INCT, Warsaw, 1990	10 MeV 1 kW	Pilot plant, food processing, R&D
ELW 3A transformer	EC Kawęczyn, Warsaw, 1991	0,5-0,7 MeV 50 kW	Pilot plant, flue gas treatment, R&D
Elektronika linac	**INCT, Warsaw, 1993**	**10 MeV 15 kW**	**Radiation sterilization**
Elektronika linac	**INCT, Warsaw, 1993**	**10 MeV 10 kW**	**Food processing**
LAE 10 linac	INCT, Warsaw, 2001	10 MeV	R&D
NHV transformer	**EC Pomorzany Szczecin, 2002**	**0,7 MeV 4 x 262.5 kW**	**Flue gas treatment**

Pulse Radiolysis in INCT

Goals:
- Mechanistic approach to radical reactions
- Kinetic and thermodynamic controls of radical reactions
- Spectral and kinetic characterisation of radicals and ion radicals

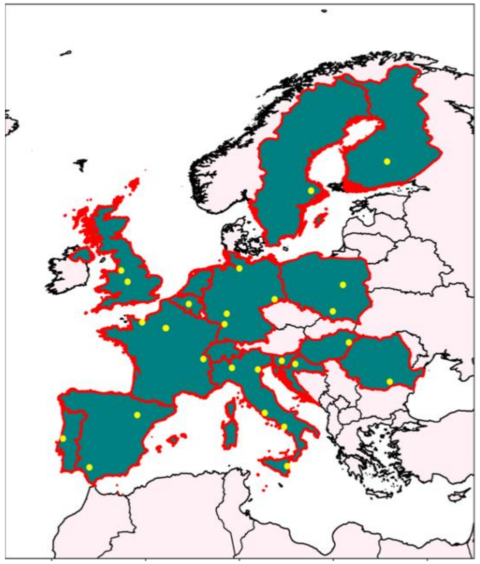
Research include:
- One-electron redox reactions in proteins and nucleic acids
- Mechanisms of radiation-induced reactions in ionic liquids
- Application of ionizing radiation for removal of toxins from water

Research recognition:
- 2020-2022 **>10** publications, including:
  - Chem. Eng. J. **2020**, 379, 122303; IF = **10,652**
  - Chem. Eng. J. **2021**, 403, 126169; IF = **10,652**
  - Advanced Healthcare Materials **2021** ; IF = **7,367**



Project EURO-LABS

- **EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCE**
- Budget about 15 000 000 Euro
- HORIZON-RIA HORIZON Research and Innovation Actions
- Coordinatior: Istituto Nazionale di Fisica Nucleare (INFN), Italy
- 34 participating organizations
- Realization – **from 1st September 2022 (48 months)**



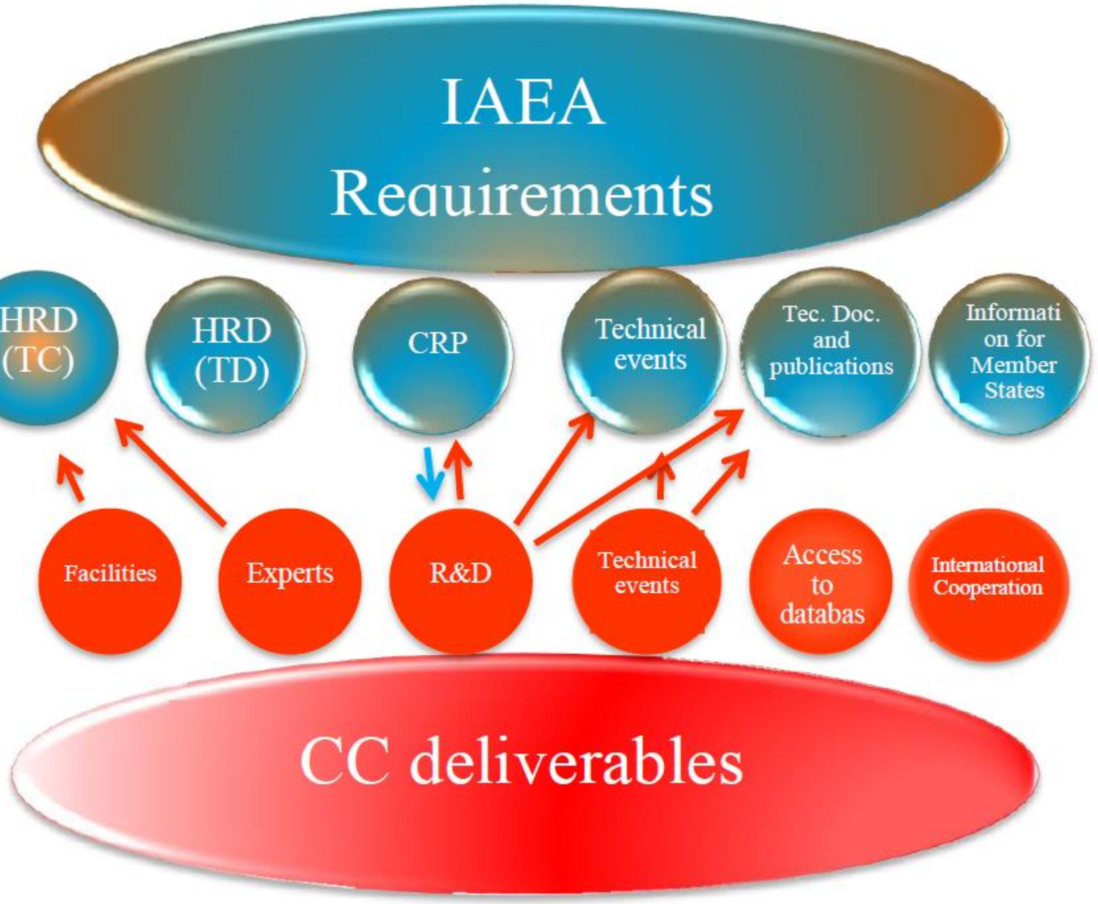
INCT – leader of task **3.4 “Applications”** in WP 3 – Access for accelerators.

INCT – access to RAPID infrastructure

- Linear electron beam accelerator LAE 10 with nanosecond pulse radiolysis UV/VIS detection set-up,
- Linear electron beam accelerator (Elektronika, Toriy, Russia) emits beam of electron of energy 10 MeV, beam power up to 15 kW,
- A pilot plant facility equipped in ILU 6 accelerator. The accelerator can emit a beam of electrons of energy ranging from 0.15 to 2 MeV, beam power up to 20 kW,
- Additional infrastructure of the Laboratory for Measurements of Technological Doses, Electron Spin Resonance Spectrometer, Gamma Cell.

- INCT total access offered – 600 access units (hours)
- Estimated number of users – 60
- INCT offers an infrastructure service “free of charge” to selected researchers or research teams (user-groups).

Fits well to Collaborating Centres Idea



Laboratory of Radiation Modified Polymers

Projects: Educate, Investigate, Implement

TeamCables – European Tools and Methodologies for an efficient ageing management of nuclear power plant Cables Horizon 2020 Euratom Research and Training Programme 2014-2021 Electricité de France.

Development of biocidal and antiviral compositions and technology for producing biodegradable packaging materials (POIR.01.01.01-IP.01-00-005/20)

Comparison of gamma and e-beam radiation effects on polymer materials commonly used in medical devices, IAEA Research Contract No: 24388

Development of an innovative method of treating Epidermolysis Bullosa and chronic wounds of other origins with a biological dressing made from human material" STRATEGMED2 /269807/14/NCBR/2015

Application of ionizing radiation in assessing the stability of properties of materials used in road construction, implementation doctorate DWD/5/0593/2021

Dissemination of the Knowledge on Application of Ionising Radiation for Sterili-zation of Medical Equipment, Personal Protection Equipment and other Micro-biologically Infected Objects, knowledge-dissemination grant CEI 305.3938-20

Radiation Sterilisation Plant of Medical Devices and Allografts

- Authorisation to manufacture human and veterinary medicines
- GMP Certificate
- ISO 13485: 2016 Certificate


CERTIFICATE
No. M - 7/10/2022
Instytut Chemii i Techniki Jądrowej (IChTJ)
Zakład Naukowy - Centrum Badań
i Technologii Radiacyjnych,
Stacja Sterylizacji Radiacyjnej
Wyrobów Medycznych i Przeszczepów
ul. Dorodna 16, 03-195 Warszawa
PN-EN ISO 13485:2016-04
designing and performing
of radiation sterilization process
of medical devices


GŁÓWNY INSPEKTORAT FARMACEUTYCZNY
CERTIFICATE OF GMP COMPLIANCE OF A MANUFACTURER
Chief Pharmaceutical Inspector
Instytut Chemii i Techniki Jądrowej
Instytut Chemii i Techniki Jądrowej

XVI SCHOOL OF RADIATION STERILIZATION AND MICROBIOLOGICAL DECONTAMINATION
December 8-9, 2021
60 participants (on-line)

Radiation Sterilisation Plant of Medical Devices and Allografts (2021)

MEDICAL DEVICES

40 000 000 pcs /year
(80 Companies)

COSMETICS

10 000 kg / year
(10 Companies)

MEDICINAL PRODUCTS (FARMACEUTICALS)

400 kg/year
3 Companies

POLYMER MODIFICATION

12 000 kg/year
2 Companies

ALLOGRAFTS

14 000 pcs / year
(4 Tissue bank)

Extraordinary CEI Action 2020 connected to the global COVID-19 outbreak
Central European Initiative (CEI) (Triest, Italy, www.cei.int)

INCT Project: DISSEMINATION OF THE KNOWLEDGE ON APPLICATION OF IONISING RADIATION FOR STERILIZATION OF MEDICAL EQUIPMENT, PERSONAL PROTECTION EQUIPMENT AND THE OTHER MICROBIOLOGICALLY INFECTED OBJECTS : 03.07.2020 - 02.02.2021 The action addressing 17 Member States of CEI: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Italy, Moldova, Montenegro, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia and Ukraine

WEBINARS: Two cycles of **hybrid** Webinars were arranged in the frame of the project (in English (4 lectures) and in Polish (5 lectures)). Ca 120 participants attended English lectures (67 from CEI countries) and 143 participants attended Polish lectures.
Subject: character of ionizing radiation, radiation devices, antibacterial and antiviral effect, physicochemical changes in materials, practical use for sterilization and radiation modification

SCIENTIFIC MATERIALS: **brochures and leaflets**, edited and printed **in 5 languages** (*English, Albanian, Polish, Ukrainia*n, *Russia*n (for Belarus),). *At present*: request for printing the materials in *Croatia*n (we are in the process of agreeing this possibility with CEI.

The postal adresses of possible interested institution (i.e. scientific institutes, hospitals and producers of medical equippment, sanitary and epidemiological stations, tissue banks, etc.) were collected, approx. 3,500 copies were distributed among responsible persons.

WEB-PAGE: A website was organized with full **lectures in Polish and Eng**lish, short version of English lectures, lecture summaries, and information materials **(booklets and leaflets) in five languages**
http://www. ichtj.waw.pl/drupal/?q=node/1080
Send also to CEI, to be placed at CEI Web-page

COVID 19 Effect of electron beam irradiation on filtering facepiece respirators integrity and filtering efficiency

- three different filtering facepiece respirators (surgical, FFP1, FFP3) were irradiated with electron beam of 12 and 25 kGy.
- results confirmed that the decrease in filtration efficiency after irradiation of all respirators results from elimination of the electric charge from the polypropylene (PP) fibers in the irradiation process.
- the applied doses may affect thermal stability of PP fabrics, while filtering materials structure and integrity have not changed after irradiation.

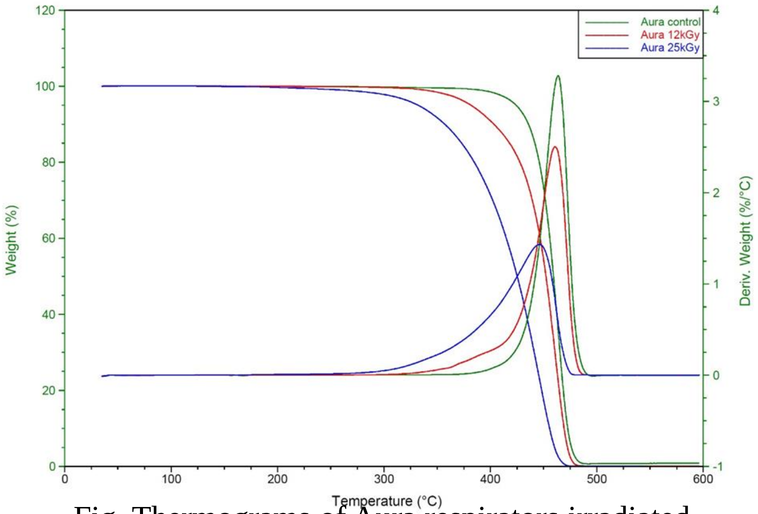


Fig. Thermograms of Aura respirators irradiated with different doses.

Table. Changes of tensile strength for Aura mask, VFlex mask and surgical masks for different irradiation doses.

Mask type	Aura		VFlex		Surgical	
Dose [kGy]	Tensile strength [MPa]	SD	Tensile strength [MPa]	SD	Tensile strength [MPa]	SD
0 (control)	1.91	0.14	3.17	0.34	2.20	0.16
12	2.35	0.66	2.78	0.33	2.21	0.32
25	2.05	0.32	2.51	0.20	2.07	0.22

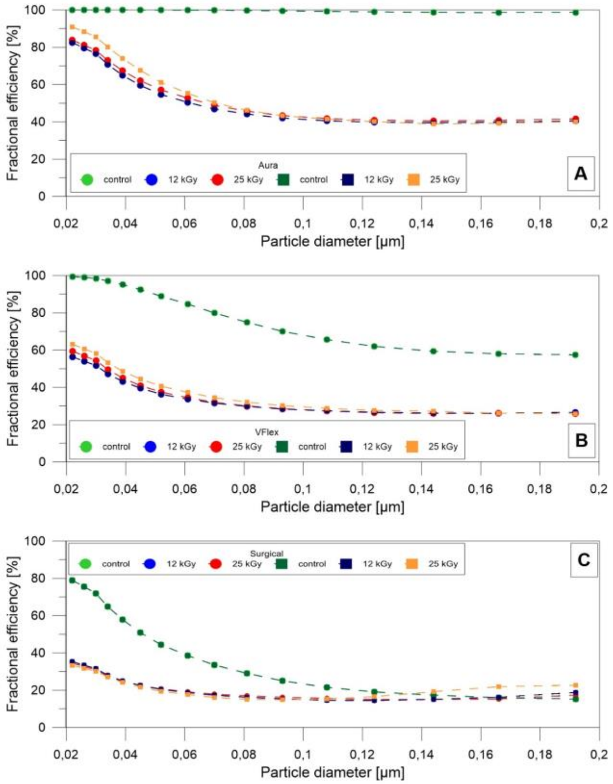


Fig. Fractional efficiency of removal KCl and DEHS particles for Aura (A), VFlex (B) and surgical (C) respirators before and after irradiation with EB.

D. Chmielewska, Ł. Werner, U. Gryczka, W. Migdał
„Effect of electron beam irradiation on filtering facepiece respirators integrity and filtering efficiency"
NUKLEONIKA 2022;67(2):23-33

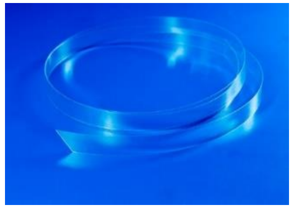
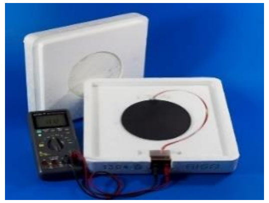
Accredited Laboratory for Measurements of Technological Doses (LMTD)

The LMTD is accredited by the Polish Centre for Accreditation (PCA) as a testing laboratory according to the requirements of the PN-EN ISO/IEC 17025:2018-02 „General requirements for the competence of testing and calibration laboratories" standard.

The scope of the LMTD accreditation includes measurements of absorbed doses of gamma and EB radiation by using:

- Fricke (20 - 400 Gy)
- CTA (10 - 80 kGy)
- Alanine (50 Gy - 150 kGy)
- Calorimetry (1.5 - 40 kGy)



All results of the dose measurements are traceable to the National Physical Laboratory (NPL) primary standards.


POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

PCA

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
LABORATORIUM BADAWCZEGO
ACCREDITATION CERTIFICATE OF TESTING LABORATORY
Nr AB 461

Potwierdza się, że: / This is to confirm that:

INSTYTUT CHEMII I TECHNIKI JĄDROWEJ
LABORATORIUM POMIARÓW DAWEK TECHNOLOGICZNYCH
ul. Dorodna 16, 03-195 Warszawa

spełnia wymagania normy PN-EN ISO/IEC 17025:2018-02
meets requirements of the PN-EN ISO/IEC 17025:2018-02 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AB 461
Accredited activity is defined in the Scope of Accreditation No AB 461

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AB 461
This accreditation remains in force provided the Laboratory observes the requirements of Accreditation Body defined in the Contract No AB 461

Akredytacji udzielono dnia 27.02.2004 r.
Accreditation was granted on 27.02.2004

POLSKIE CENTRUM AKREDYTACJI

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI
LUCYNA OLBORSKA

Warszawa, 6 lutego 2020 r.

Current research work

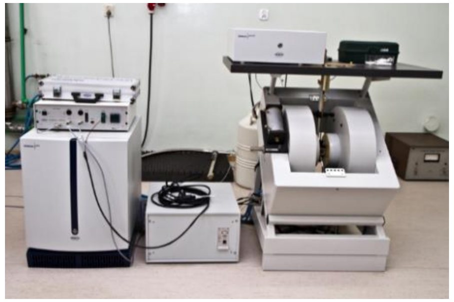
- Low-temperature alanine dosimetry with EPR reading
  Control the absorbed dose during radiation sterilization of tissue in dry ice
- Application of EPR-alanine dosimetry to measure absorbed doses of ionizing radiation in the range of 1-10 Gy
  Development of electron beam dosimetry in an accelerator intended for use in FLASH radiotherapy
- The use of waterproof ALANPOL dosimeter to measure absorbed dose in liquid media

Intercomparison dosimetry exercise under TC projects

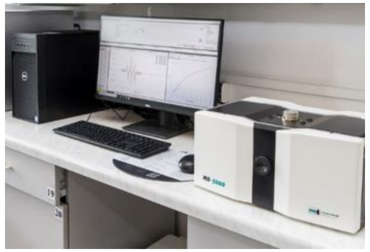
The objective of the dosimetry intercomparison exercise is to promote and harmonize quality control methods and procedures related to industrial radiation processing applications within European Member States (EMS).

2 rounds of dosimetry intercomaprison exercise in the frame of RER 1017 and RER 1019

- Gamma dosimetry: 12 participants from Belarus, Bulgaria, Croatia, Hungary, Portugal, Romania, Serbia, Turkey
- EB dosimetry: 5 participants from Russia, Kazakhstan, Ukraine, Slovakia



Third dosimetry intercomparison exercise in the frame of RER 1021 „Enhancing the Use of Radiation Technologies in Industry and Environment” (2020 - 2023)



$Dose_{Reference\ Lab.}$ vs $Dose_{Participant}$

$Dose_{Target}$ vs $Dose_{Refernce\ Lab.}$

This intercomparison is developed to evaluate two aspects:

- Possibility to obtain the desired dose by participants
- Possibility to accurately measure the dose with its dosimetry system

Results of first and second rounds of intercomaprison

Gamma facility

Country	δ_{av} in 1. round	δ_{av} in 2. round
1	-	5.1%
2	3.1%	6.7%
3	13%	11%
4	-	31%
5	1.5%	6.6%
6	3.2%	21%
7	4.5%	26%
8	1.8%	1.3%
9	2.0%	7.9%
10	2.2%	0.91%
11	3.1%	5.3%
12	4.2%	3.2%

EB facility

Country	δ_{av} in 1. round	δ_{av} in 2. round
1	-	35%
2	-	9.1%
3	20%	3.1%
4	10%	3.4%
5	5.7%	2.8%

To compare the results of the test from the first and second rounds, the average deviation was calculated for every participant using the equation:

$\delta_{av} = (\delta_1 + \delta_2 + \delta_3 + \delta_4)/4$

where:

$\delta_1, \delta_2, \delta_3, \delta_4$ - absolute values of deviations obtained by the particular participant for 4 different dose,

δ_{av} - the average deviation denoting the results of this participant.

INCT Food Irradiation Facility

- **Approved for food irradiation in EU**
  - 26 approved facilities in EU, but only 6 are equipped in e-beam accelerators
- **Irradiated products:**
  - Commercial irradiation of dried aromatic herbs and spices
  - Packaging for cosmetics
- **Education and promotion:**
  - Representative in the Polish Committee for Standardization (PKN) KT 235 "Food Analysis"
  - Member of the CEN/ISO committee CEN/TC 275/WG 8 Working group "Irradiated foodstuffs**"**
  - IAEA MAK5009 Virtual National Training Course, North Macedonia 15-19 XI 2021

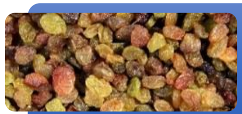
IAEA CRP D61024 DEXAFI (2016-2021) „Surface treatment of food by low energy electrons in view of their microbial decontamination„ IAEA CRP D61025 (2021-2026) „Development of control requirements for the process of low energy electron beam food irradiation”

Development of low energy electron beam (LEEB) food irradiation microbial decontamination technology

- Characterisation of the beam parameters for energies <300 keV, penetration ability of the beam, development of dosimetry methods and procedures
- Studying the LEEB irradiation of selected food products for microbial safety and nutritional properties, comparison with high energy electron beam for selected groups of fresh and dry food products

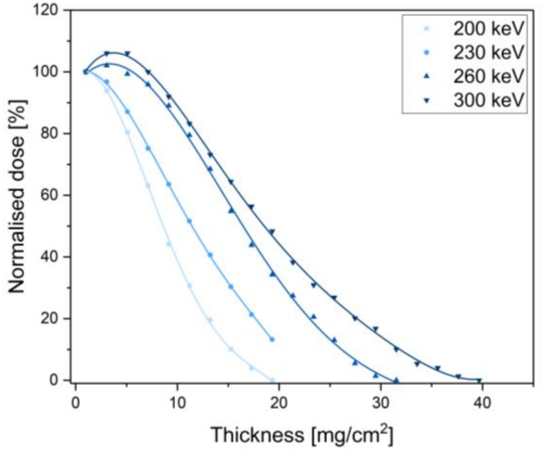
Herbs
- Low density and low thickness
- Range of LEEB can be grater than samples thickness

Spices
- Higher density and thickness, different internal structure
- Limited penetration of LEEB

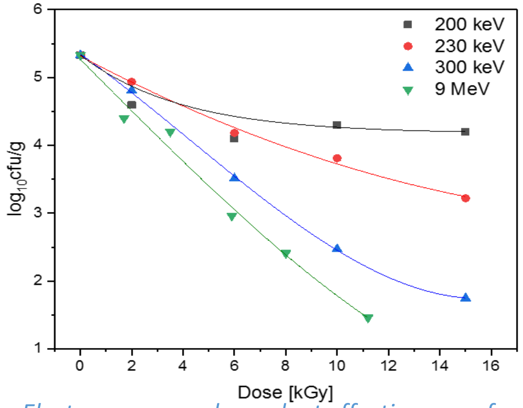


Dried fruits, cereals, seeds
- Density vary depending on water content
- Surface treatment

Fresh fruits and vegetables
- High water content
- Surface treatment



Depth dose profiles of LEEB as a function of electron energy for irradiation conditions in INCT



Electrons energy dependent effectiveness of microbial decontamination of black peppercorn with EB

Ref.:
- Gryczka, U., Kameya, H., Kimura, K., Todoriki, S., Migdał, W., Bułka, S. Efficacy of low energy electron beam on microbial decontamination of spices. Radiation Physics and Chemistry. Volume 170, May 2020, Article number 108662
- Gryczka U., Madureira J., Cabo Verde S., Migdał W., Bułka S. Determination of pepper microbial contamination for low energy e-beam irradiation. Food Microbiology. Volume 98, September 2021, 103782

Laboratory for Detection of Irradiated Food
National Reference Laboratory No.5

The SLINŻ is accredited by the Polish Centre for Accreditation (PCA) according to the requirements of the PN-EN ISO/IEC 17025:2018-02 - „General requirements for the competence of testing and calibration laboratories” standard.

POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
LABORATORIUM BADAWCZEGO
ACCREDITATION CERTIFICATE OF TESTING LABORATORY
Nr AB 262

Potwierdza się, że: / This is to confirm that:

Instytut Chemii i Techniki Jądrowej
Samodzielne Laboratorium
Identyfikacji Napromieniowania Żywności
ul. Dorodna 16, 03-195 Warszawa

spełnia wymagania normy PN-EN ISO/IEC 17025:2018-02
meets requirements of the PN-EN ISO/IEC 17025:2018-02 standard

Akredytowana działalność jest określona w Zakresie Akredytacji Nr AB 262
Accredited activity is defined in the Scope of Accreditation No AB 262

Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AB 262
This accreditation remains in force provided the Laboratory observes the requirements of Accreditation Body defined in the Contract No AB 262

Akredytacji udzielono dnia 25.10.1999 r.
Accreditation was granted on 25.10.1999

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI
LUCYNA OLBORSKA

Warszawa, 13 września 2019 r.

SCOPE OF ACCREDITATION No AB 262

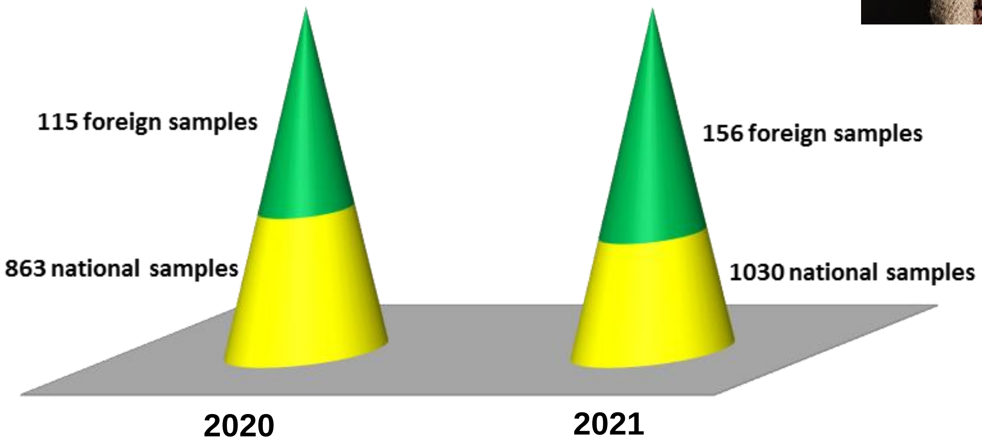
Object to be examined	Method	CEN European standard
Detection of irradiated food containing bone by ESR spectroscopy	Spectroscopy ESR	EN – 1786:200
Detection of irradiated food containing cellulose by ESR spectroscopy	Spectroscopy ESR	EN – 1787:2001
Detection of irradiated food containing crystalline sugar by ESR spectroscopy	Spectroscopy ESR	EN – 13708:2003
Thermoluminescence detection of irradiated food from which silicate minerals can be isolated	Thermoluminescence TL	EN – 1788:2002
Detection of irradiated food using photostimulated luminescence	Photostimulated luminescence PSL	EN – 13751:2009

Analysed samples

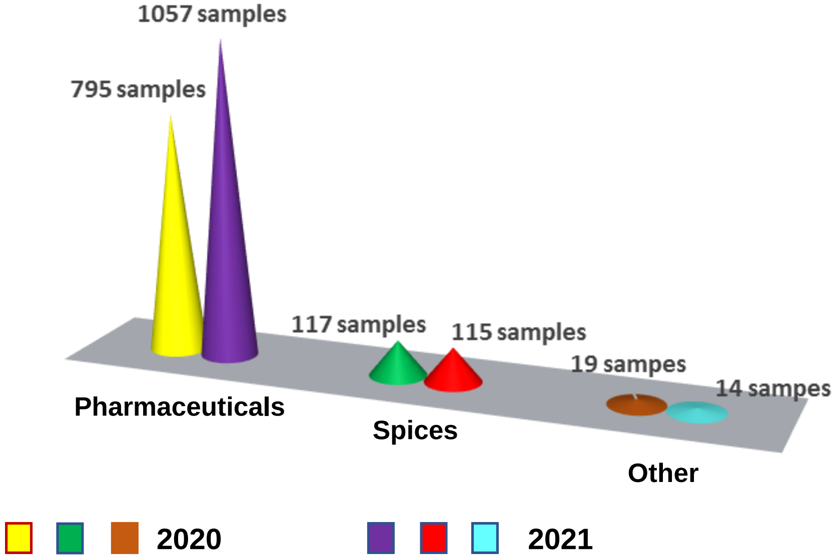
Risø TL/OSL DA-20 reader

SURRC PPSL - Irradiated Food Screening System

Orgin of samples for 2020-2021



Analysed assortment



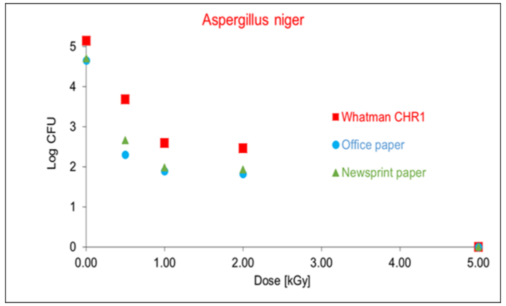
CRPs

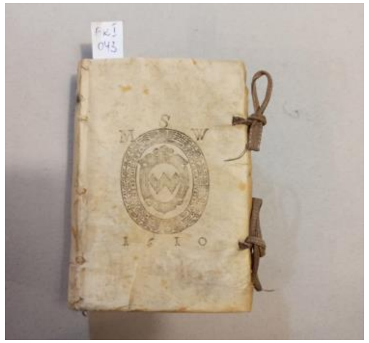
- "Comparison of gamma and e-beam radiation effects on polymer materials commonly used in medical devices„ (Contract 24388)
- „Development of radiation-induced grafted membranes for gas separation applications” (Contract No. 23589)
- „Radiation based technologies for emerging organic pollutants treatment” (Contract No. 23165)
- „Recycling of radiation crosslinked material from cable industry „ (Contract No. 24426)
- „A Method for Hygienisation of Sewage Sludge Based on Electron Accelerator Application” (Contract No. 22642)
- „Development of Radiation-Induced Grafted Membranes for Gas Separation Applications” (Contract No. 23589)

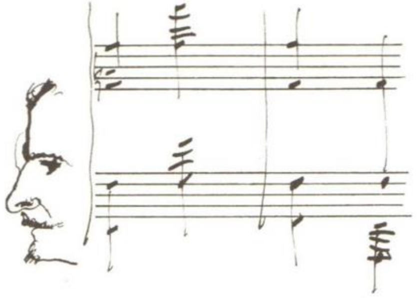
Application of electron beam irradiation for paper objects preservation in the INCT

- INCT contract 18493 „Electron beam for preservation of biodeteriorated cultural heritage paper-based objects" in the frame of the IAEA CRP F23032 „Developing Radiation Treatment Methodologies and New Resin Formulations for Consolidation And Preservation of Archived Materials and Cultural Heritage Artefacts"
- Optimization of product and process parameters for treatment of a variety of papers simulating the composition and storage conditions of archived materials. Multi-parametric analysis of the treated object (physico-chemical, thermal, mechanical properties, microbiological investigation, aging and post irradiation effects etc.)
- Investigation carried out in this work enabled the optimisation of irradiation procedur and estimation a dose of
- 5 kGy as sufficient for the complete elimination of micro-organisms from all types of paper and did not influence the studied parameters of different papers.
- 300 m^3 of CH objects treated for different institutions, e.g.

- collection of books and documents from The Sejm (Polish Parliament) Library
- collection of XV leather shoes and documents
- collection of XV/XVI century manuscripts and old prints
- original music notation composed by Ignacy Paderewski



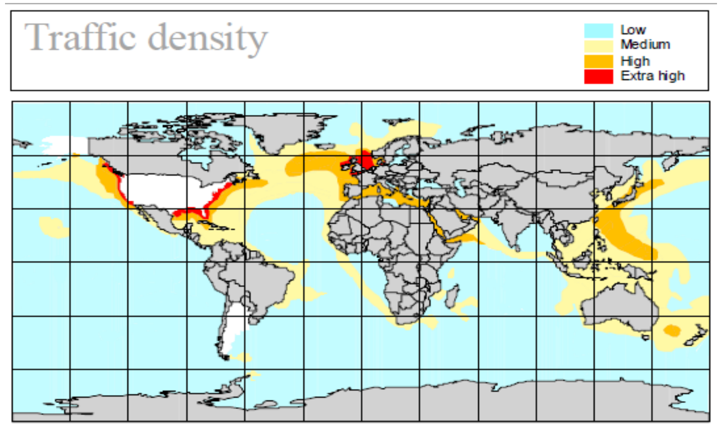


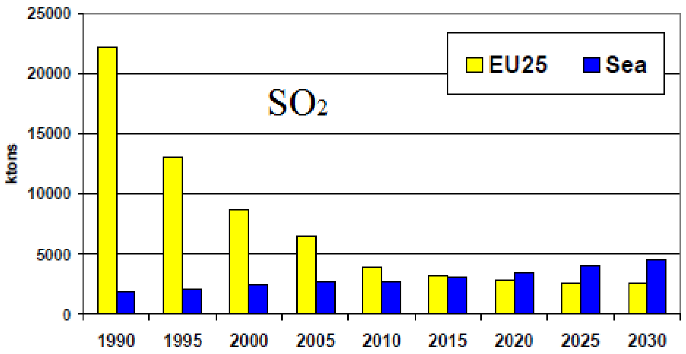


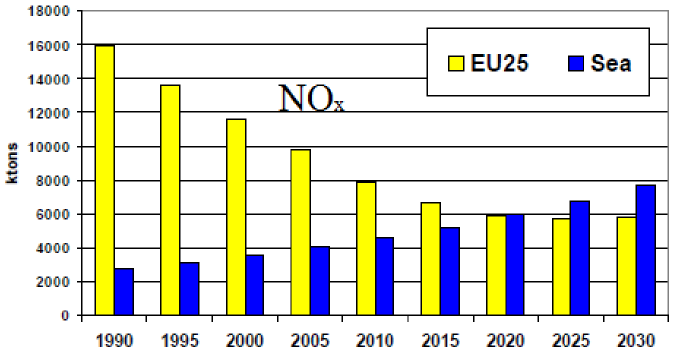
RADiation harvesting of bioactive peptides from egg prOteins and their integration in adVanced functional products (RADOV)

- To expand the application of ionizing radiation and to demonstrate the broad scope of its applications, new products containing bioactive proteins/peptides will be designed and developed with the use of electron beam irradiation to manufacture them. In particular, two target products will be developed as demonstrators of egg-derived bioactive peptides by radiation-induced fragmentation: peptide-laden antimicrobial/antioxidant hydrogel wound dressings and peptide-grafted active food packaging film.
- The project duration is 4 years beginning from the 1st of the September, 2022. Total budget of the RADOV project is 2 M € including 1.86 M€ EC contribution.
- INCT (Poland) – coordinator, KTH Royal Institute of Technology (Sweden); University of Palermo (Italy);Italian National Research Council (Italy);University of Huddersfield (UK);The Association of Instituto Superior Técnico for Research and Development (Portugal) & SME (KIKGEL Sp. z o.o. (Poland);DEKOFILM POLSKA SP. Z O.O. (Poland); }E.P.S. S.p.A. Egg Powder Specialists (Italy)

Cargo ships – big emitters







Laboratory set up

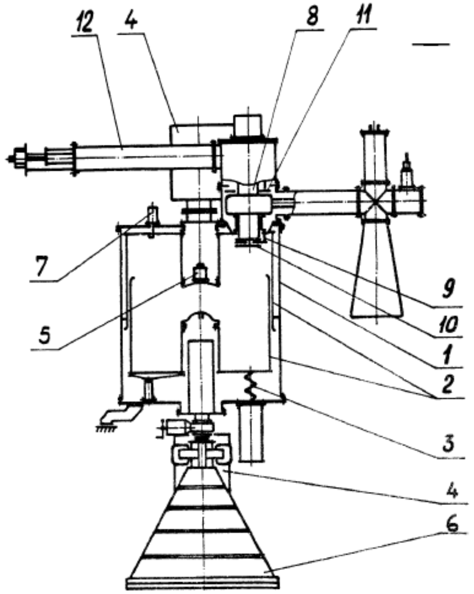
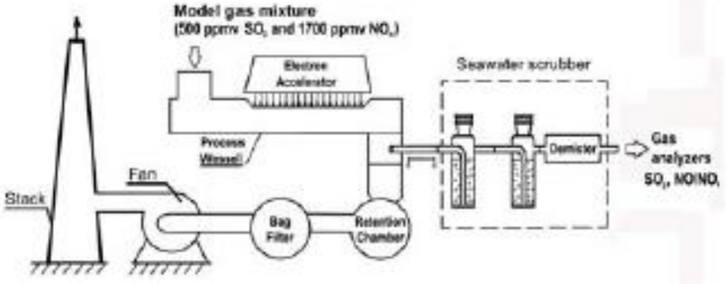
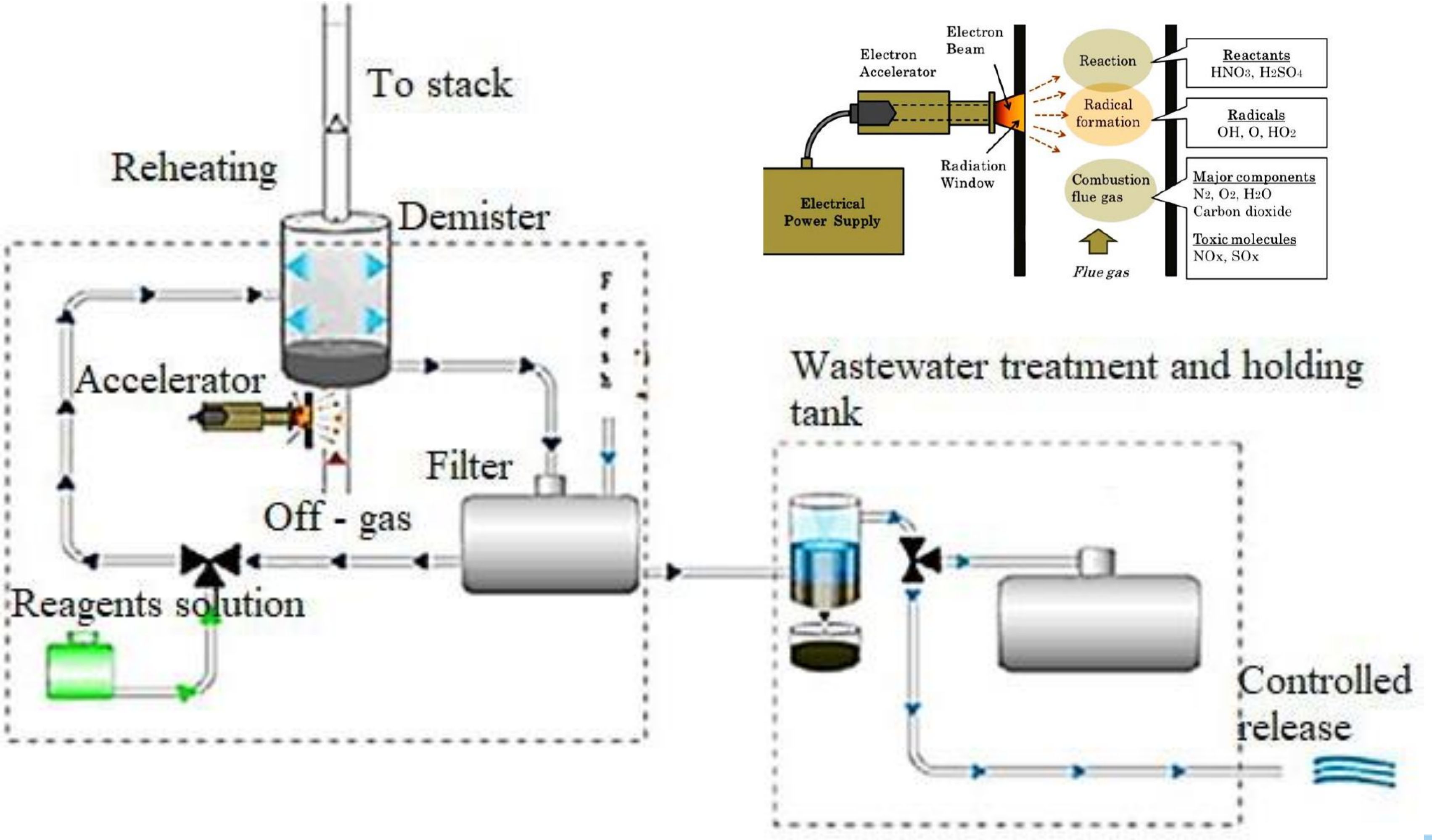


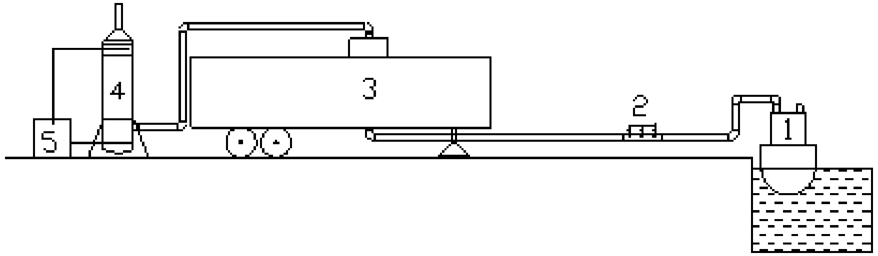
Figure 1: Main elements of ILU-6 electron accelerator:1 – vacuum tank; 2 – RF cavity divided into 2 halves; 3 – input of constant bias voltage for lower cavity half; 4 – high vacuum pumps; 5 – electron injector; 6 – scanning horn; 7 – measuring loop; 8 – RF generator; 9 – coupling loop; 10 – coupling vacuum capacitor; 11 – feedback circuit, 12 – cathode circuit tuning line.



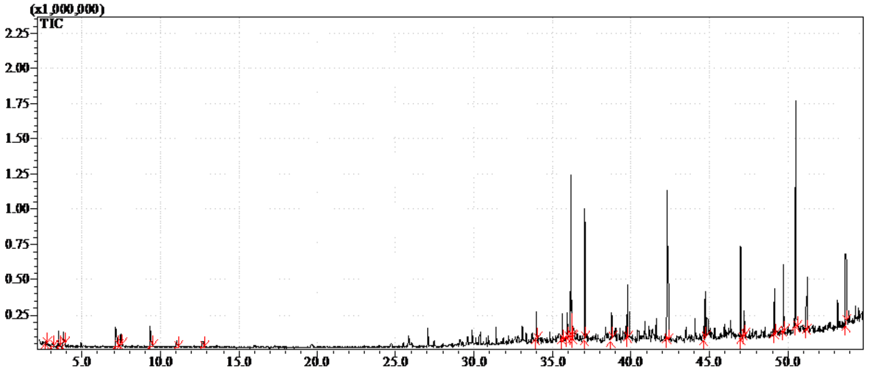
Conceptual scheme of the installation using EB technology for SOx and NOx removal as applied onboard, water closed or hybrid system



Field test Shipyard Riga, Latvia

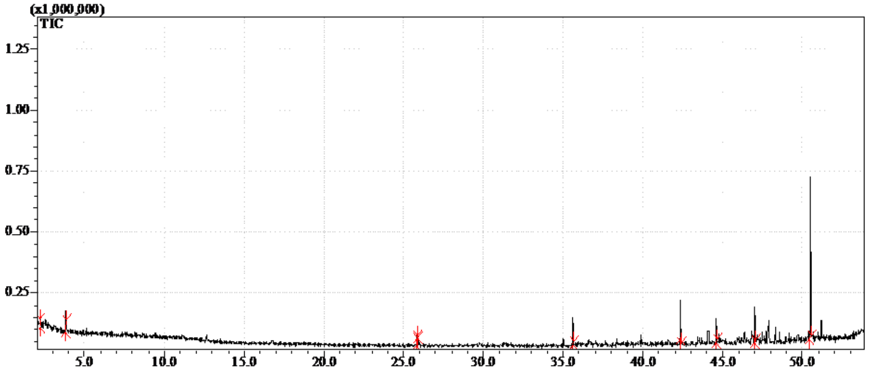


VOCs removal from ship emission under EB and EB hybrid –wet scrubber system

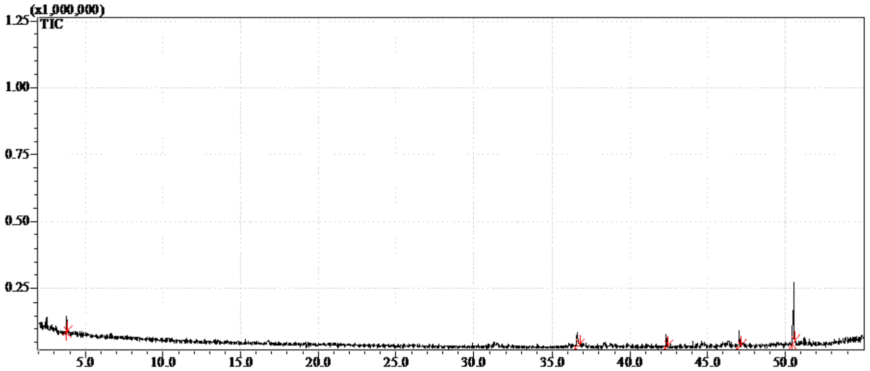


Off-gas from Ship emission

Double two-stroke 450kW diesel engines.
Gas flow rate: 4915 Nm^3/h,
Dose: 5.5 kGy, A mobile accelerator WESENITZ-II
Inlet concn: 298 ppm NO, 317 ppm NOx
Scrubber solution: 3 m^3 sea water, 3.3 g/L $NaClO_2$
R_{NOx}: 45.8% (after EB + wet scrubber process)



After EB (5.5 kGy)

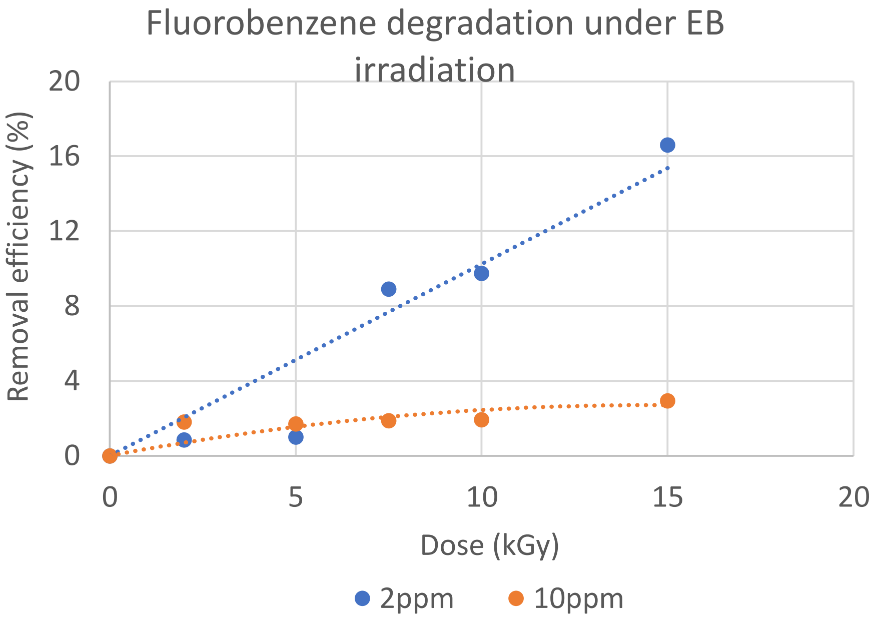


After EB (5.5kGy) + wet scrubber

A GC-MS spectrum of flue gas collected with the active carbon sorbents

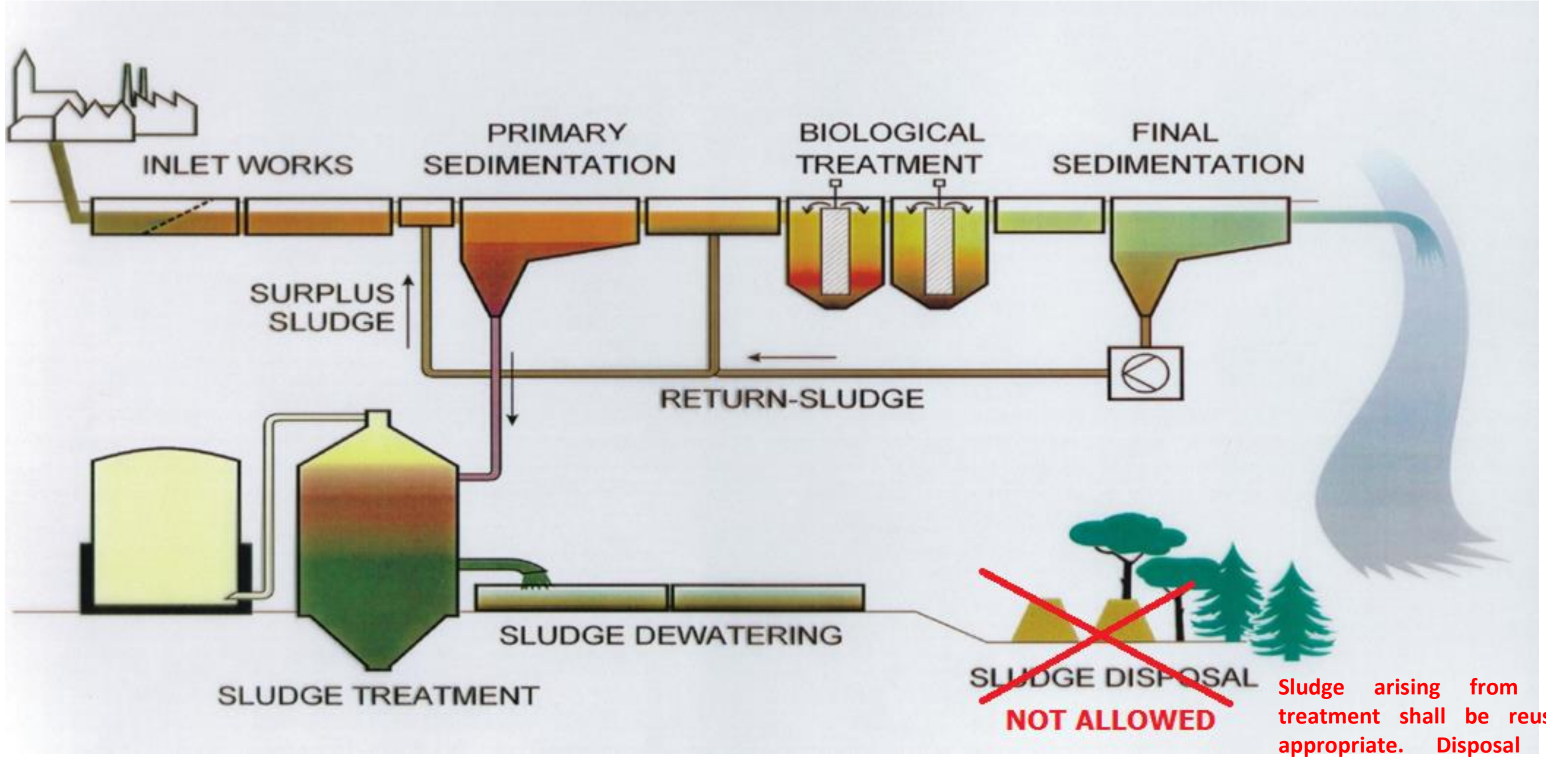
Ref.: Y. Sun, A.G. Chmielewski, et al, Nukleonika, 66(4), 193-199.

Destruction of Fluorobenzene in air under electron beam irradiation



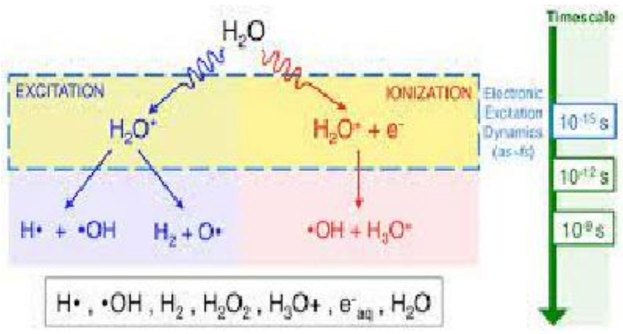
Electron beam ILU-6 accelerator
Energy: 1.65MeV
Current: 50mA
Frequency: 2 Hz

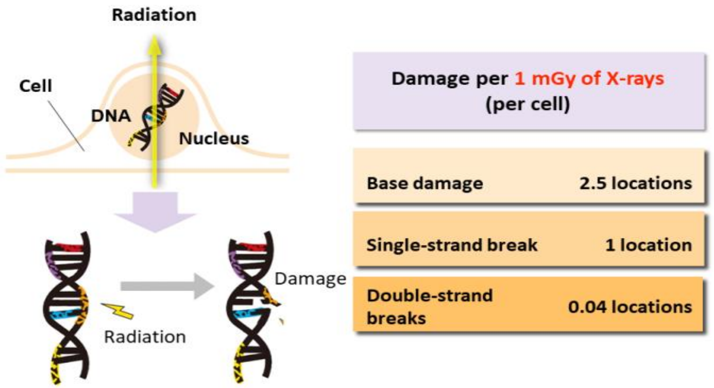
SCHEME OF A MUNICIPAL WATER TREATMENT PLANT

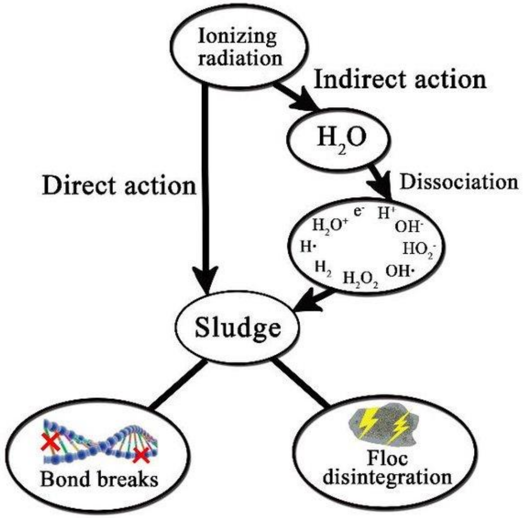


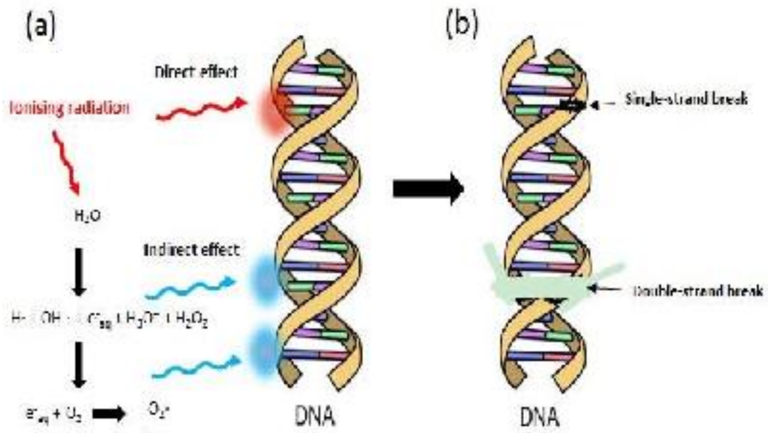
Sludge arising from waste water treatment shall be reused whenever appropriate. Disposal routes shall minimise the adverse effects on the environment !

Process chemistry and biochemistry



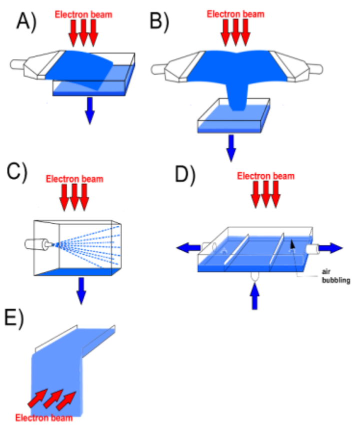




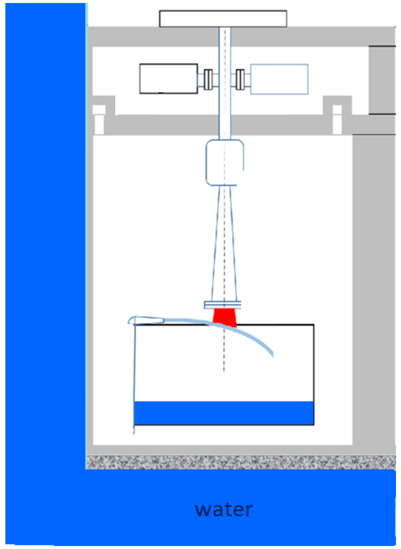


Irradiation of Waste Water with electron beam - Control of x-ray field

- The energy of electrons – critical parameter determining penetration depth in liquids (water, wastewater, sludge).
- Tests were performed for electrons of energy 800 keV (penetration about 3 mm in water) to determine irradiation conditions with reduced x-ray field generation
- In the experimental conditions, when the bottom of the water reservoir was a factor absorbing the energy of electromagnetic radiation, the X-ray background was not detected already for a water 14 cm layer.
- X-ray emission can be greatly reduced with application of an appropriate under beam system and irradiation room construction.



Different geometry of reactors for water irradiation: (a) jet injection, (b) two opposite jets injection,
(c) sprayer, (d) up-flow system with air bub-bling, (e) natural flow.



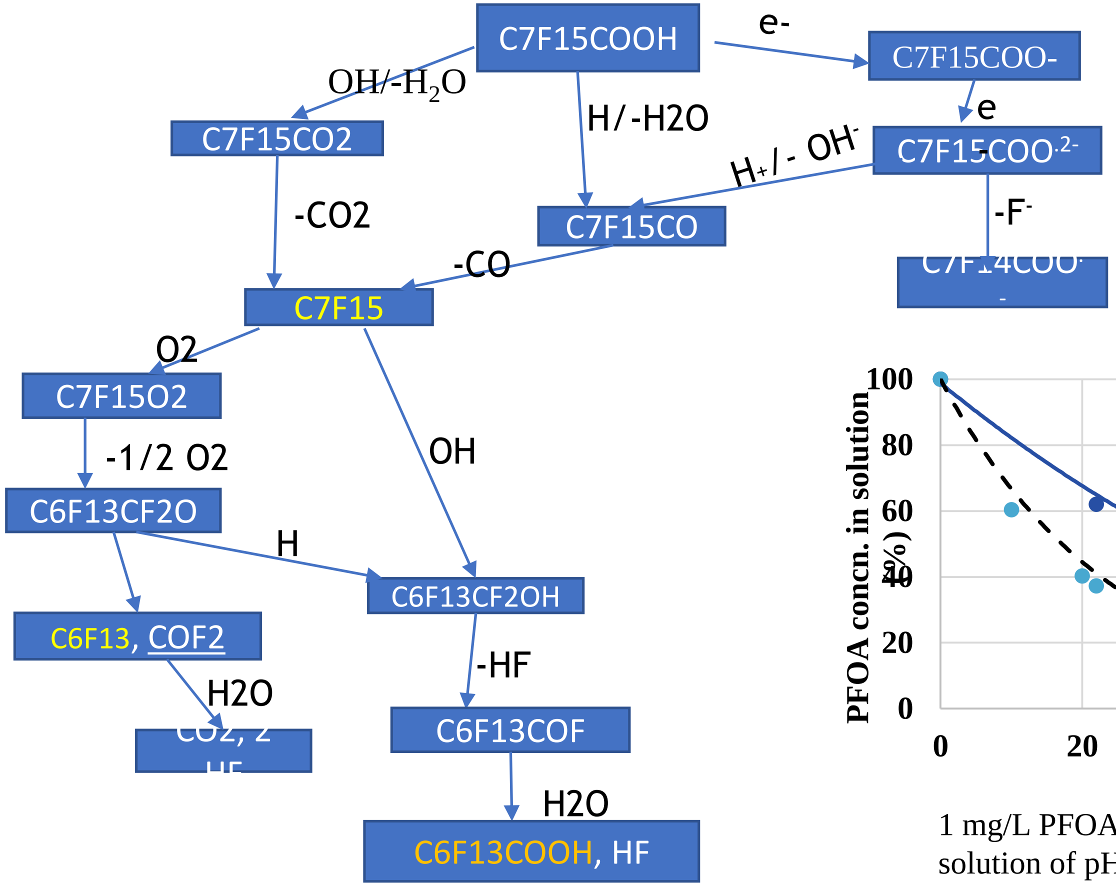
Scheme of the chamber for liquids irradiation with water shielding .

Dosimeter Position	Water	Steel
	Dose Rate [Gy/min]	
Under the target	4.0	36.8
Floor under the target	4.8	32.0
Wall in a distance of 1 m at the target level	3.2	19.2
Floor in a distance of 1 m	2.4	12.0

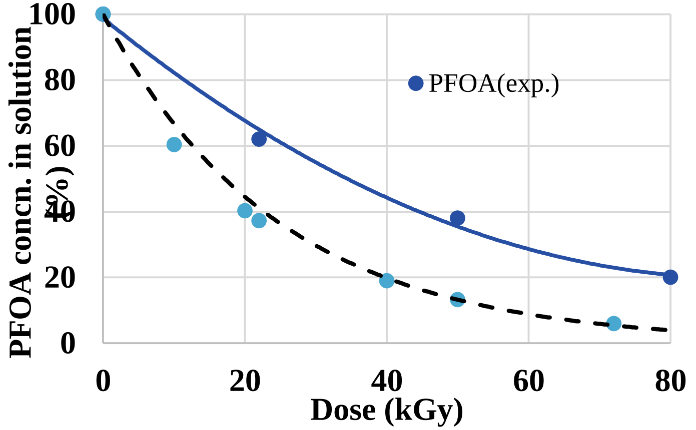
Dependence of the dose rate on the distance from the accelerator window and the target material.

Ref.: Gryczka, U.; Zimek, Z; Walo, M; Chmielewska-Śmietanko, D; Bułka, S. (2021). Advanced Electron Beam (EB) Wastewater Treatment System with Low Background X–ray Intensity Generation. *Applied Sciences.* 11(23):11194

CRP F23034 : Radiation based technologies for treatment of emerging organic pollutants



PFOA degradation pathway



1 mg/L PFOA decomposition in Ar saturated solution of pH 7 with 20 mg/L of t-butanol under EB irradiation

Can we use municipal sludge as fertilizer?

- Directive 91/271/EEC on urban waste water treatment

Sludge arising from waste water treatment shall be reused whenever appropriate. Disposal routes shall minimise the adverse effects on the environment

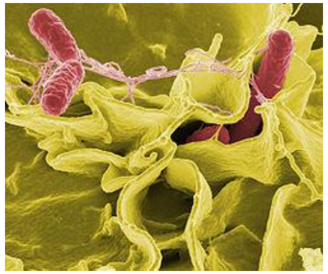
- Art. 96.4 Act from 14 December 2012 (law on waste)

Usage of municipal waste is possible only if they're stabilised and prepared directly to it's purpose and way of use, especially by biological, chemical, thermal or any other treatment that decreases tendency to rotting or eliminates threat for human health and environment.

Patogens to be removed

Pathogenic bacteria acceptable content

- **In Poland one pathogenic bacteria species is considered: *Salmonella***
- **None living cells of *salmonella* can be detected in 100g sample of municipal sludge**



Species of parasites which have to be detected:

- ***Ascaris sp.* – human parasitic roundworm**
- ***Trichuris sp.* – human whipworm**
- ***Toxocara sp.* – animal (mostly cats and dogs) parasitic worms**
- **Parasites and eggs acceptable content = 0**

Bacteria & living eggs of helminths

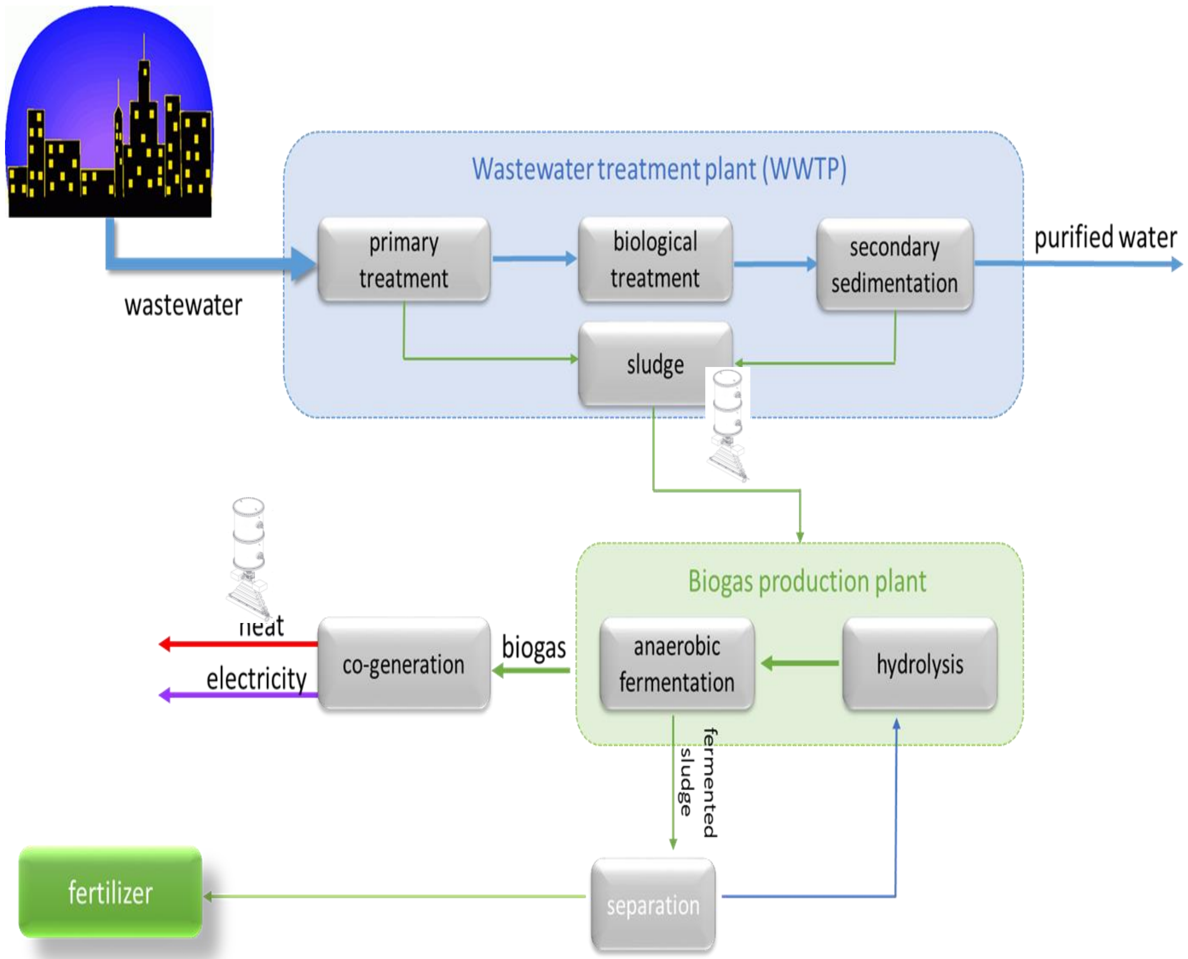
Dose (kGy)	Detected Species	Result (CFU)
0	*Escherichia coli*, *Salmonella* spp. *Clostridium perfringens*	6.2×10^4 9.2×10^2 1.1×10^2
2	*Escherichia coli*, *Salmonella* spp. *Clostridium perfringens*	9.8×10^3 1.3×10^2 0.9×10^2
3	*Escherichia coli*, *Salmonella* spp. *Clostridium perfringens*	1.4×10^2 0.4×10^2 ca.0.2×10^2
4	*Escherichia coli*, *Salmonella* spp. *Clostridium perfringens*	none detected none detected none detected
5	*Escherichia coli*, *Salmonella* spp. *Clostridium perfringens*	none detected none detected none detected

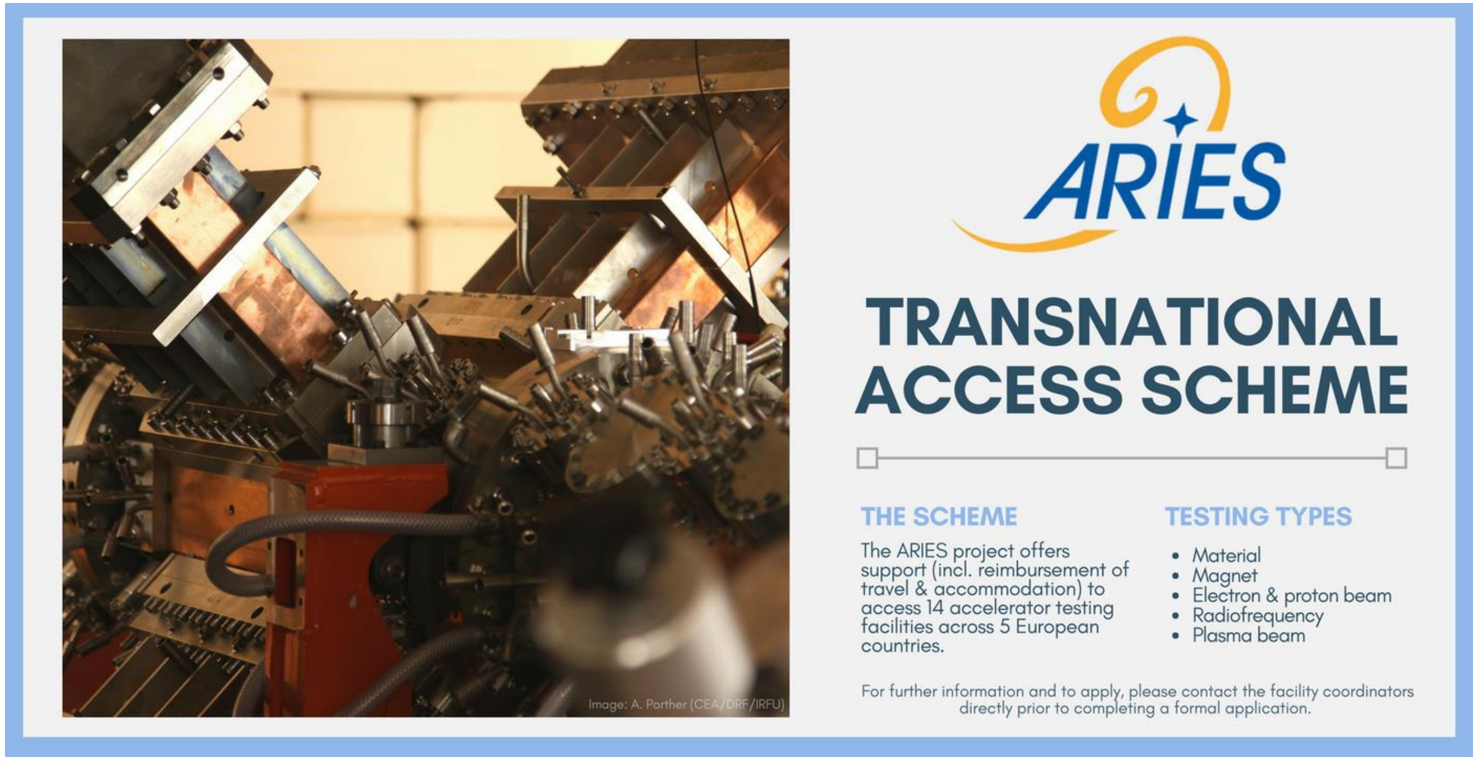
Dose (kGy)	Detected Species	Result (Number of Living Eggs)
0	*Ascaris* spp. *Trichuris* spp. *Toxocara* spp.	21 9 3
2	*Ascaris* spp. *Trichuris* spp. *Toxocara* spp.	16 4 1
3	*Ascaris* spp. *Trichuris* spp. *Toxocara* spp.	4 none detected none detected
4	*Ascaris* spp. *Trichuris* spp. *Toxocara* spp.	none detected none detected none detected
5	*Ascaris* spp. *Trichuris* spp. *Toxocara* spp.	none detected none detected none detected

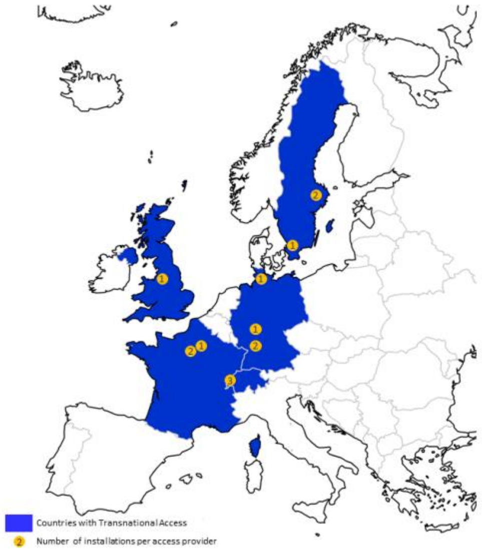
HYBRYD BIOGAS - EB SYSTEM

Advantage of proposed solution:

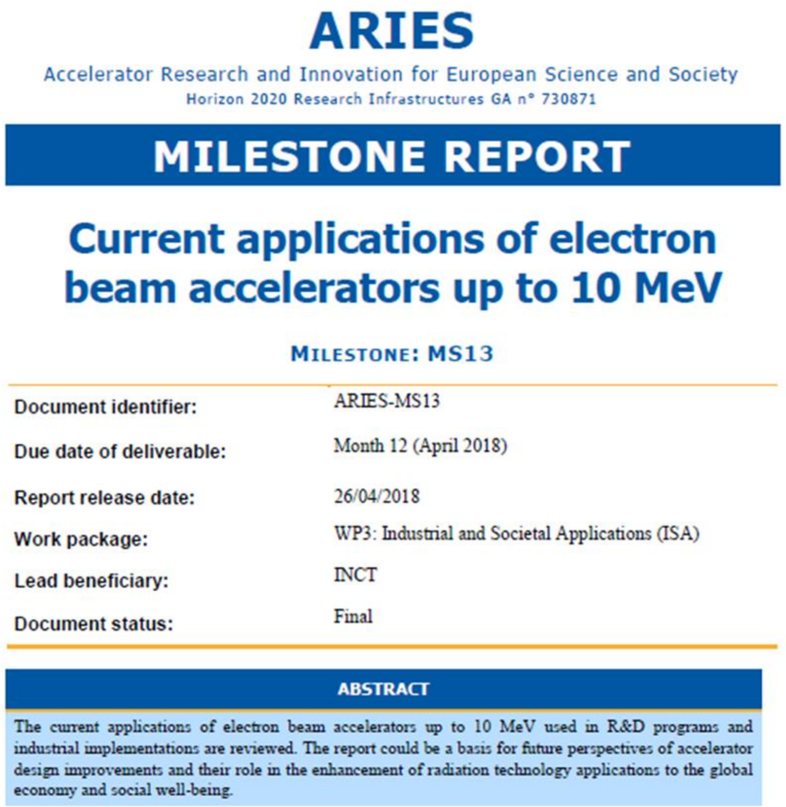
- **Environmental friendly technology**
- Biogas production is **disposal of problematic wastes**
- Production of **renewable power through combined heat and power cogeneration**
- Production of microbiologically safe organic fertilizer **due to electron beam hygenization**
- Technology can be applied in any place with sufficient biomass resources while there is **no need for external electric energy supply**




ARIES
TRANSNATIONAL ACCESS SCHEME
THE SCHEME
The ARIES project offers support (incl. reimbursement of travel & accommodation) to access 14 accelerator testing facilities across 5 European countries.
TESTING TYPES
• Material
• Magnet
• Electron & proton beam
• Radiofrequency
• Plasma beam
For further information and to apply, please contact the facility coordinators directly prior to completing a formal application.
Image: A. Porther (CEA/DRF/IRFU)


Countries with Transnational Access
Number of installations per access provider

WP3: Industrial and Societal Applications (ISA)


ARIES

Accelerator Research and Innovation for European Science and Society

Horizon 2020 Research Infrastructures GA n° 730871

MILESTONE REPORT

Current applications of electron beam accelerators up to 10 MeV

MILESTONE: MS13

Document identifier:	ARIES-MS13
Due date of deliverable:	Month 12 (April 2018)
Report release date:	26/04/2018
Work package:	WP3: Industrial and Societal Applications (ISA)
Lead beneficiary:	INCT
Document status:	Final

ABSTRACT

The current applications of electron beam accelerators up to 10 MeV used in R&D programs and industrial implementations are reviewed. The report could be a basis for future perspectives of accelerator design improvements and their role in the enhancement of radiation technology applications to the global economy and social well-being.

- **3.2 Low energy electron beam applications: new technology development (FEP, Germany)**
- **3.3 Low energy electron beam applications: new applications, (INCT, Poland)**
- **3.4 Medium energy electron beams (IFIC, Spain)**
- **3.5 Radioisotope production (CIEMAT, Italy)**

I.FAST - Innovation Fostering in Accelerator Science and Technology

- May 2021 – April 2025; TOTAL BUDGET: 18.7 M€l 48 participants
- I.FAST aims to allow Europe to maintain leadership in fundamental particle physics and other fields of science based on particle accelerators, providing European industry with a portfolio of advanced accelerator technologies, thus contributing to the construction and upgrade of the next generation of accelerator-based Research Infrastructures, the creation of jobs, and ultimately long-term growth.
- WP12: Societal applications; Objectives ; Study the barriers which discourage the use of accelerators in industry; Basic engineering of e-beam municipal sludge processing line based on industrial electron accelerator.;Design of an Internal RF Ion Source for Cyclotrons.;Manufacture and characterization of an operative prototype of the Internal RF Ion Source.
- WP12.1 - A Strategy for Implementing Novel Societal Applications of Accelerators R. Edgecock (HUD); 12.2 -Design of advanced electron accelerator plant for biohazards treatment A. Chmielewski (INCT); 12.3-Design of Internal RF Ion Source for CyclotronsJ. M. Perez (CIEMAT)

The International Conference on Development and Applications of Nuclear Technologies NUTECH 2020

- Conference NUTECH-2020 was held on **4-7 October 2020** at the Institute of Nuclear Chemistry and Technology in Warsaw
- Due to the COVID 19 pandemic, for the first time the NUTECH conference was organized in a **hybrid** form.
- 100 participants, 38 from abroad, half paricipants participants took part in the conference in person and half on-line
- IAEA supported participation within RER 1020 and RER 1021
- Book of abstracts:

http://www.ichtj.waw.pl/ichtj/publ/monogr/NUTECH-2020/NUTECH-2020-book-of-abstracts.pdf

- Selected manuscripts were published in a special issue of **NUKLEONIKA 2021 Vol. 66 no.4**

http://www.ichtj.waw.pl/nukleonikaa/?p=1544

NUTECH- 2023, Cracow, Poland

All invited !

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