This project has received funding from the European Union's Horizon 2020 Research and Innovation programme u

WP12.1 - A Strategy for Implementing Novel Societal Applications of Accelerators

Rob Edgecock - HUD

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https://indico.cern.ch/event/1204855/

Objectives, Tasks, Deliverables and Milestones

Task 12.1:

A Strategy for Implementing Novel Societal Applications of Accelerators

- Study some new and important societal applications of accelerators with the aim of developing roadmaps for their innovation:
  - Novel forms of radiotherapy for cancer treatment
  - Reduction of environmental pollution
  - New imaging techniques
  - Improved methods for radioisotope production.

- Develop a strategy to deliver these roadmaps.

- Study the barriers which discourage the use of accelerators in industry.

Objectives, Tasks, Deliverables and Milestones

12.1 Sub-Tasks

- **Subtask 1** Coordination and Communication — Rob Edgecock - HUD
- **Subtask 2** Novel forms of radiotherapy — Angeles Faus-Golfe - CNRS
- **Subtask 3** Environmental applications of EB — Toms Torims – RTU, Andrzej Chmielewski - INCT
- **Subtask 4** Accelerator imaging — Graeme Burt - ULANCS
- **Subtask 5** Accelerator production of radioisotopes for imaging and therapy — Conchi Oliver – CIEMAT, Diego Obradors
- **Subtask 6** Barriers to accelerator adoption by industry — Andrzej Chmielewski – INCT, Andrea Sagatova – STU

Objectives, Tasks, Deliverables and Milestones

12.1 Deliverable and Milestones

D12.1	Strategy for Implementing Novel Societal Applications of Accelerators	R	M28	In preparation

MS57	Projects identification for development funding	12.1	M10	Abstract of proposals	Done
MS58	Completion of strategy documents for each application area	12.1	M40	Report	

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Subtask 2: Novel forms of Radiotherapy

Angeles Faus-Golfe (CNRS)

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Subtask 2: Novel forms of Radiotherapy

CNRS

- Study the **novel forms of RT** for cancer treatment with the aim of developing a roadmap for the innovation (Mini-beams with e-/p, FLASH RT, cost-effective ion RT, BNCT, combined RT, flexible machines..)
- Develop a strategy to deliver a **roadmap** (brainstorming writing meeting/workshop with identified experts, accelerator dedicated workshop…)
- Study the **barriers** which discourage the use of these **new techniques** in **industry** in collaboration with medical doctors as users

it is highly timely to have a **follow up**

VHEE2023 @ DESY 11-13 July 2023

The list of topics to be explored are:

- VHEE Current State of the Art
- Treatment Planning, Modelling and Imaging
- VHEE current conventional facilities at intermediate (Flashtron IC , Antwarpen..) and high (CLEAR, CLARA, ARES, PITZ, ..) energies
- VHEE current non-conventional facilities LPA (DRACO, LOA)
- VHEE planned future facilities (DEFT, FRIDA,...)
- Accelerators R&D and Technologies: distributed coupling, cryogenic copper, millimetric waves or THz sources...
- Industries

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Subtask 3: Environmental applications of EB

Andrzej Chmielewski (INCT)
Toms Torims (RTU)

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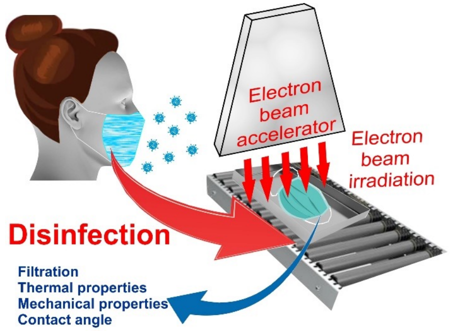
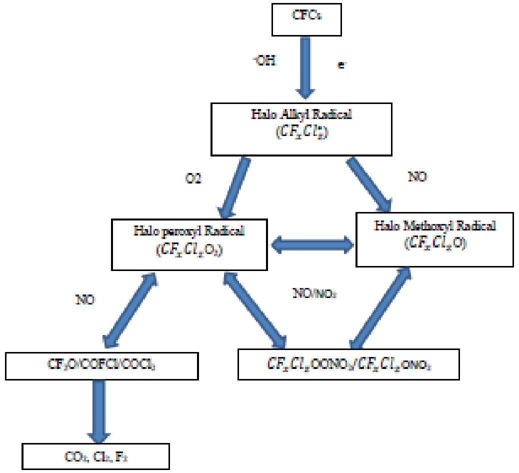
Subtask 3: Environmental applications of EB

RTU, INCT, STU, HUD





- The removal of pathogenic bacteria and invasive marine species from the the ballast water of ships.

Experiments based on the ballast water samples taken from 10 ships entering Shipyard in Gdańsk has been performed and the concept elaborated.

- The removal of acid rain causing chemicals and volatile organic contaminants from the exhaust gases of marine diesel engines and other combustion offgases .

The use of EB with wet scrubbing for simultaneous treatment of SOx, NOx and VOC from marine diesel engine and waste incineration flue gases.

- Decontamination of water damaged books and papers.

Dose of 5 kGy is sufficient to eliminate microbiological bioburden and does not influence paper praperties.

- Possibility for N-95 mask re-sterilization with electron beam irradiation was checked.

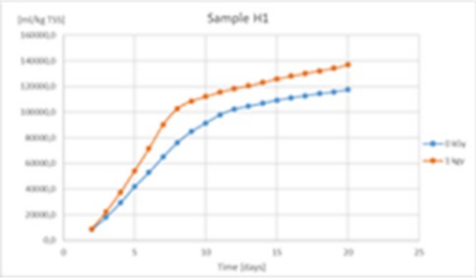
Presented results confirmed that the decrease in filtration efficiency after irradiation of all respirators results from elimination of the electric charge from the polypropylene (PP) fibers in the irradiation process. Moreover, the applied doses may affect thermal stability of PP fabrics, while filtering materials structure and integrity have not changed after irradiation.

Subtask 3: Environmental applications of EB

INCT, STU

Design of advanced electron accelerator plant for biohazards treatment

- Sludge desintegration via EB irradiation – increase in biomethane production
- Sludge hygenization by EB to produce safe organic fertilize
- Review of industrial EB accelerator technologies and selection of high-voltage DC accelerator: low price per watt & high electrical efficiency (80%)



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

Subtask 3: Environmental applications of EB

EURO-LABS project

EURO-LABS
EUROPEAN LABORATORIES FOR ACCELERATOR BASED SCIENCES

- **WP 3 “Access for Accelerators” Task 3.4 “Application”** INCT offers access to **INCT RAPID Centre for Radiation Research and Technology infrastructure:**
  - linear electron beam accelerator **LAE 10** with nanosecond pulse radiolysis UV/VIS detection set-up,
  - **ELEKTRONIKA 10-10** linear electron beam accelerator,
  - a pilot plant facility equipped in **ILU 6 accelerator**,
  - additional infrastructure (gamma cells, infrastructure for dose measurements, EPR etc.).
- Total numer of access unites offered by INCT – **600h**
- 2 projects have already been approved for realization at INCT :
  - **EURO-LABS-RAPID-2023-1** „Crosslinking of self-assembled fatty acids on copper by electron beam irradiation” – 25 +25 access unites assigned
  - **EURO-LABS-RAPID-2023-2** „One electron oxidation of S-adenosylmethionine” – project completed in March 2023, 25 h access unites provided
- 2 additional submitted for evaluation by Scientific Panel

- Project realization 09.2022 – 09.2026
- https://web.infn.it/EURO-LABS/

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Subtask 4: Accelerator Imaging

Graeme Burt (University of Lancaster)

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Subtask 4: Accelerator Imaging

ULANCS

- First mini-project has been funded
- **Project proposal: multi-energy fast neutron images (Dynaxion)**
  Fast neutron imaging is a growing field of interest for non-destructive testing (NDT) and security screening. Due to its high penetration capabilities and specificity for certain elements it is able to make images of items that no other imaging techniques (such as X-ray imaging) can.
- This project has two main aims:
  - Produce high quality fast neutron images of relevant objects to enhance the adoption of this imaging technique,
  - Show that using multiple energies for the imaging of objects will provide additional information about the contents of the object, similarly as multi-energy imaging with X-rays.

To create the proposed images the following aspects need to be addressed in this project:

- Access to a fast neutron source with variable energy
- A high resolution fast neutron imaging system

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Subtask 5: Accelerator production of radioisotopes for imaging and therapy

D. Obradors & C. Oliver (CIEMAT)

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Subtask 5: Accelerator production of radioisotopes for imaging and therapy CIEMAT

- Russia´s invasion of Ukraine has brought new urgency to search new production capacity for critical isotopes, some of which are solely sourced from Russia or rely on precursor from the country.
- Impressive progress in the radioisotope production technologies owing to the introduction of high-energy and high-current cyclotrons and the growing interest in the use of linear accelerators for radioisotope production.
- Advances in imaging instrumentation and technology in SPECT. Development of other production routes of 99mTc.
- The actual trend in the nuclear medicine research field is the use of radiometals for PET tracers such as Galium-68, Copper-64, Scandium-44, Yttrium-86, Manganese-52, etc., for therapy, such as Lutetium-177, Ytrium-90, Strontium-89, actinium-225, radium-223, etc., and for theranostics, such as Cupper-67, Scandium-47.
- Significant achievements in production of radiometals using liquid targets.
- Development of high power electron accelerators resulted in availability of theragnostics beta emitters such as ^{47}Sc and ^{67}Cu.
- Scientists and professional working in nuclear medicine has given special attention to α-emitting radionuclides as Astatine-211, Bismuth-212, Bismuth-213, Actinium-225, Radium-223, Lead-212, Thorium-227 and Terbium-149.
- IBA and SCK CEN´s launch **PANTERA** company for a large-scale production of Actinium-225.

→

- Development of technetium-99 radiopharmaceuticals, automated synthesis of fluorine-18 labelled compounds radiopharmaceuticals labelled with gallium-68, labelled peptides and monoclonal antibodies for accurate diagnostics and treatment tumours
- Biomolecules development for specific molecular target and labelled with theragnostic radionuclides provide significant information for diagnosis, therapy, dosimetry and post therapy planning making personalised medicine.

Subtask 5: Accelerator production of radioisotopes for imaging and therapy CIEMAT

- Continuous research/analysis of particle accelerators technology, programmes and projects related to emerging radionuclides into medical diagnostics and treatment.

- Regular monitoring and continuous analyses of the radiopharmaceutical market and needs, identifying new developments and trends.

- Radioisotpes users survey: To understand the isotope production needs and potetial suply shortages in the next years. With this information we will gain a clearer understanding of future market demand and how the particle accelerators can better serve industrial and research entities by taloring isotope production to meet their expressed needs To define new challenges or common dificulties

- Webinar / Workshop (funding dependency): ***Radiopharmaceutical market and future trends***. To provide scientists and professionals working in the fields of production of radioisotopes and radiopharmaceuticals an international forum for discussing the most recent developments in the field. Several topics could be covered including development, production, and uses of diagnostic, therapeutic and theragnostic radioisotopes as well as issues related to their production.

- International cooperation is encouraged and collaborations are welcome.

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Subtask 6: Barriers to accelerator adoption by industry

Andrzej Chmielewski (INCT)
Andrea Sagatova (STU)

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Subtask 6: Barriers to accelerator adoption by industry

INCT, STU

Done:

Study on technological, financial, knowledge and legislative barriers:

Barriers identified:

- The technologies that are in principle feasible and proven from research accelerators on laboratory scale must be available at reasonable cost before they can be used in machines for industrial and societal applications.
- Absence of in-house specialized and auxiliary facilities and equipment for accelerator service and maintenance.
- Absence of in-house accelerator experts and staff for accelerator operation, service and maintenance.
- Lack of awareness of benefits of new radiation technologies by professionals and missing transfer of knowledge to authorities.
- Thank to adoption of EU directive 2013/59/EURATOM on safety standards for protection against the dangers arising from exposure to ionising radiation, the legislative barriers for radiation processing should be overcome in European Union.

Solution:

- Offering machines which are reliable, reproducible, simply operable.
- Development of the remote customer-support technologies.
- Introduction of dedicated educational schemes and study programs bringing together accelerator experts, IT engineers and users.

Plans for future:

In-depth studies of identified barriers;

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Task 12.1: A Strategy for Implementing Novel Societal Applications of Accelerators

Conclusions and Outlook

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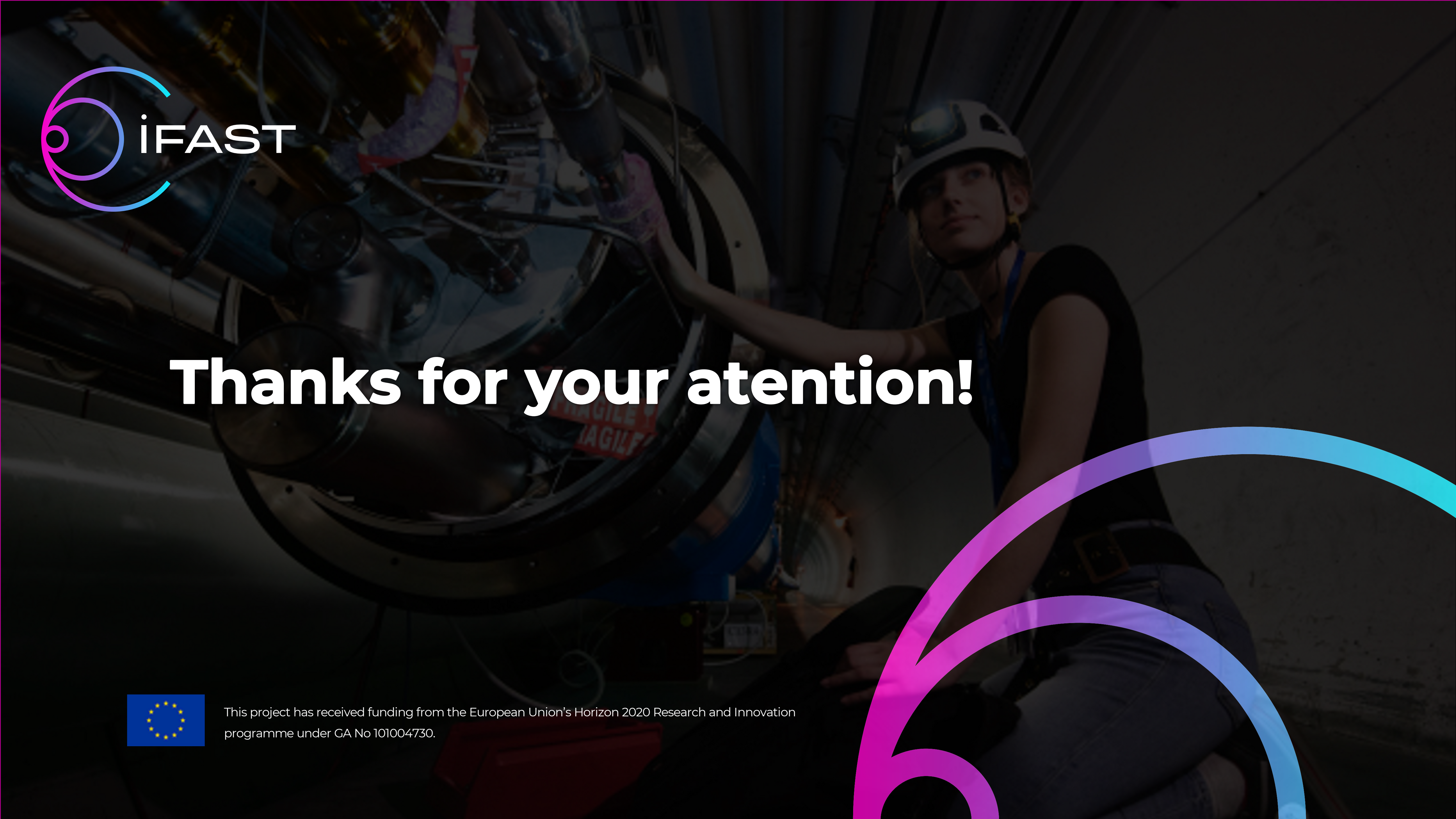
Task 12.1: Conclusion and Perspectives

- Task 12.1 has made good progress in the first two years
- Aims and milestone have been achieved
- Some highlights:
  - VHEE: 1st facility to be built at CHUV to do clinical trials with Flash (CHUV, CERN, THERYQ (ALCEN Group))
  - Strong development and much interest in environmental applications of accelerators, in particular for sludge
  - Growing interest in low energy electron beams, e.g. virus inactivation for vaccine development
  - New imaging techniques being developed
  - Obstacles to accelerator use in industry being addressed

- Workshops planned on:
  - VHEE023
  - Introducing environmental applications to relevant industry (with WP4)
  - Trends in radioisotope use



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Thanks for your atention!

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