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I.FAST Period 2 Review, 15.07.2024

WP12 organisation

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

HUD, CNRS, INCT, RTU, ULANCS, CIEMAT, STU

Task 12.2: Design of an advanced electron accelerator plant for biohazards treatment

INCT, STU

Task 12.3: Design of Internal RF Ion Source for Cyclotrons

CIEMAT, CYCLOMED, GE

WP12 objectives and status

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

- Develop strategies for delivering new and important societal applications of accelerators
- On time and completes in M48

Task 12.2: Design of an advanced electron accelerator plant for biohazards treatment

- Basic engineering of e-beam municipal sludge processing line based on industrial electron accelerator
- Completed on time

WP12 objectives and status

Task 12.3: Design of Internal RF Ion Source for Cyclotrons

- Design of an Internal RF Ion Source for Cyclotrons.
- Manufacture and characterization of an operative prototype of the Internal RF Ion Source
- Completed with approx. 6 months delay:
  - Change in foreseen manufacturing process
  - Very long delivery times due to World-wide supply chain restrictions
  - Repair of incorrect brazing of a component

WP12 deliverables and milestones

Deliverables:

Deliverable	Title	Task	Month	Status
D12.2	Basic engineering of e-beam sludge processing line	12.2	M24	Done
D12.3	Prototype of Internal RF Ion Source for Cyclotrons	12.3	M24	Done – in M31
D12.1	Strategy for Implementing Novel Societal Applications of Accelerators	12.1	M28	Done

Milestones:

Milestone	Title	Task	Month	Status
MS59	Approval of basic engineering	12.2	M24	Done
MS60	First Plasma achieved on the prototype	12.3	M19	Done – in M31
MS58	Completion of strategy documents for each application area	12.1	M40	In preparation

Activities in P2

Subtask 12.1.2: Novel Forms of Radiotherapy

- Main focus: Very High Energy Electrons (VHEE) ~140-200 MeV
  - Good depth dose profile
  - Ability to deliver flash and mini-beams
  - Ability to focus the beam
  - Compact linac possible
  - Growing world-wide interest
  - Clinical facility under development
  - Publication planned:

"Challenges in VHEE RT" in frontiers

A follow up of VHEE2017 and VHEE2020

VH2023 @ DESY 11-13 July 2023

https://indico.desy.de/event/38194/

The list of topics explored:

- VHEE Current State of the Art
- Treatment Planning, Modelling and Imaging
- VHEE current conventional facilities at intermediate (Flastron 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 involved

Activities in P2

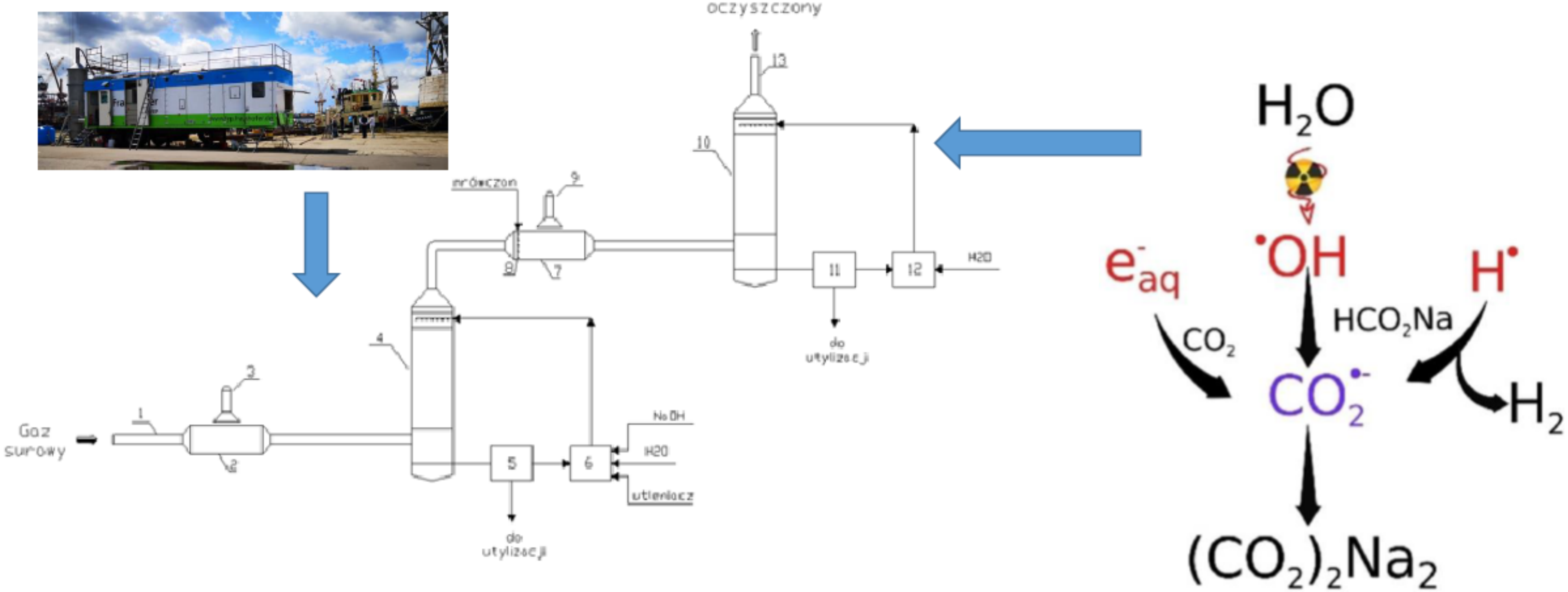
Subtask 12.1.3: Environmental Applications

- Range of applications studied
- Very recent update on marine diesel engine exhaust gas treatment
- Removal of CO_2, as well as NOx, SOx and VOC
- Needs further study, but potentially very important

Activities in P2

Subtask 12.1.3: Environmental Applications

Catalyst Free Cardbon Dioxide Chemical Transformation
Two stage removal SOx and NOx (1) and CO2 (2)



1st stage 2nd stage

Activities in P2

Subtask 12.1.4: Accelerator Imaging

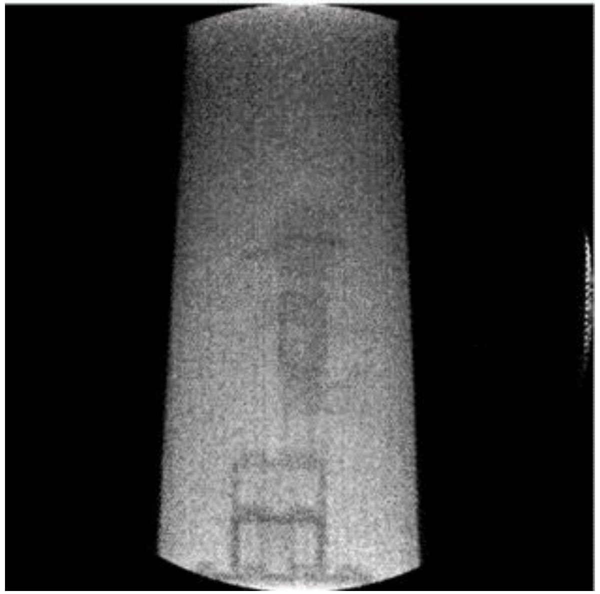
- First mini-project has been completed
- **Project proposal: multi-energy fast neutron images (Dynaxion)**
  Fast neutron imaging is a growing field of interest for non-destructive testing (NDT) and security screening. Due to its high penetration capabilities and specificity for certain elements it is able to make images of items that no other imaging techniques (such as X-ray imaging) can.

This project had 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.

Activities in P2

Subtask 12.1.4: Accelerator Imaging



Activities in P2

Subtask 12.1.5: Accelerator Production of Radioisotopes for Imaging and Therapy

- Market analysis has shown that 225Ac stands out for Targeted Alpha Therapy:
  - 9.9 day half-life
  - 4 alphas and 2 detectable gammas in decay
- Current main source: 229Th/225Ac generator from 233U decay – likely shortage very quickly
- Several research efforts have been dedicated to exploring avenues to increase the production:
  - Moderate energy proton interactions with 226Ra (via nuclear transmutation).
  - Subjecting 226Ra to high-intensity gamma radiation (through photonuclear channels).
  - High-energy (60-140 MeV) proton interactions with 232Th (via spallation).
- 226Ra has many issues: scarcity, safety and handling, including radon emanation
- 232Th has fewer problems, but limited number of accelerators
- Possibility of an online workshop before the end of IFAST?

Activities in P2

Subtask 12.1.6: Barriers to Accelerator Adoption by Industry

- Main problems identified:
  - Lack of knowledge and experience
  - Perceived complexity, cost, etc
  - (Currently) long lead time for delivery
  - RI technology still not being exploited (e.g. SC RF)
- Most being addressed, not just in IFAST
- Introduction of new technology needs more emphasis and perhaps future EU funding?
- NB DOE Office of Radiological Security have replaced 42% of gamma sources in US with accelerators, see https://alttechwg.org/

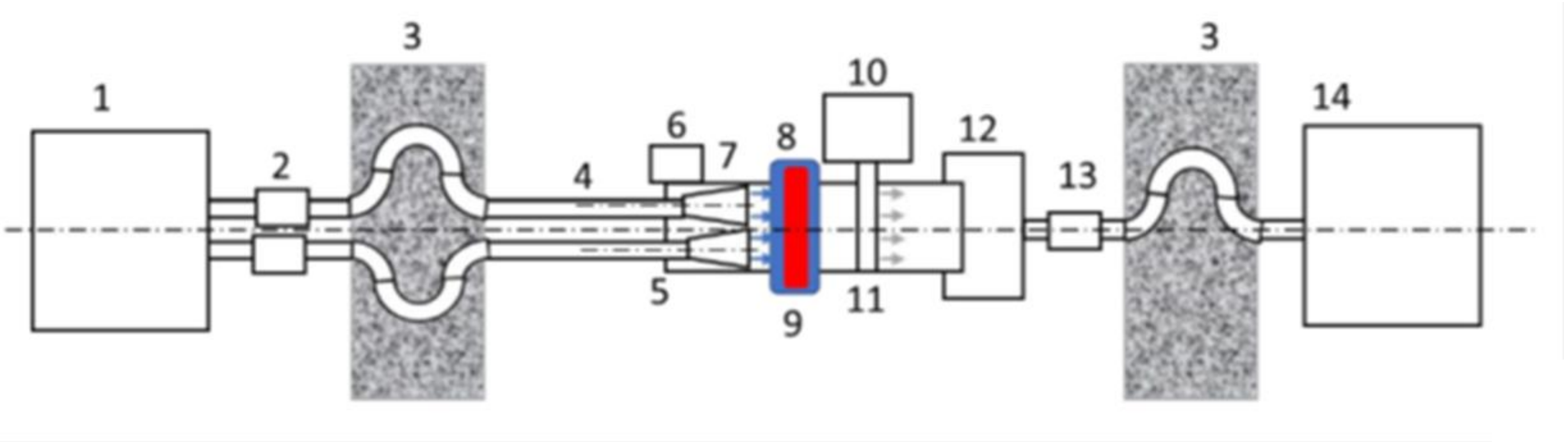
Activities in P2

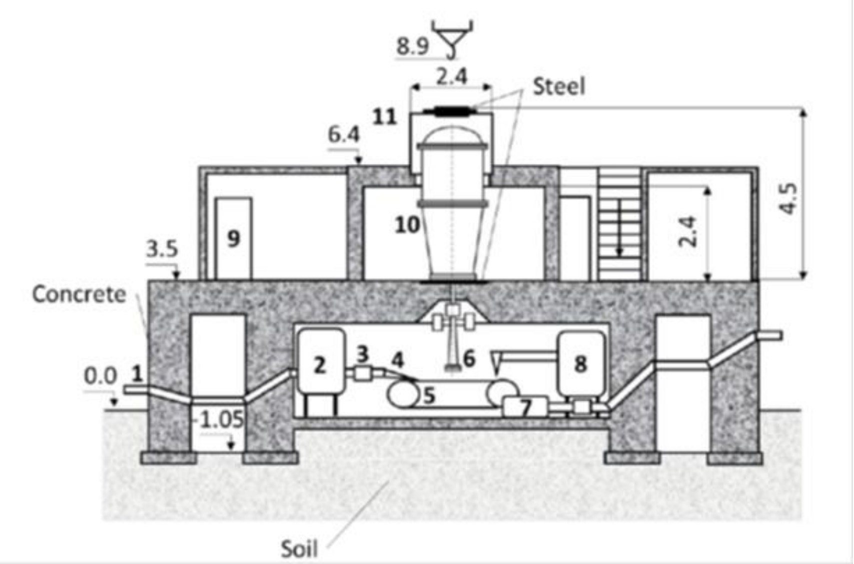
Task 12.2: Design of an advanced electron accelerator plant for biohazards treatment

- Aim: transition wastewater treatment plants to a circular economy
- Enhance the trend to turn sewage sludge into a valuable resource
- Electron beam treatment:
    - Much higher efficiency for pathogen destruction than anaerobic digestion (AD)
    - Increased capacity
    - Increase in bio-gas production:
        - Much more than enough to power the accelerator
        - Improved carbon footprint
    - Basic engineering of sludge treatment plant done

Activities in P2

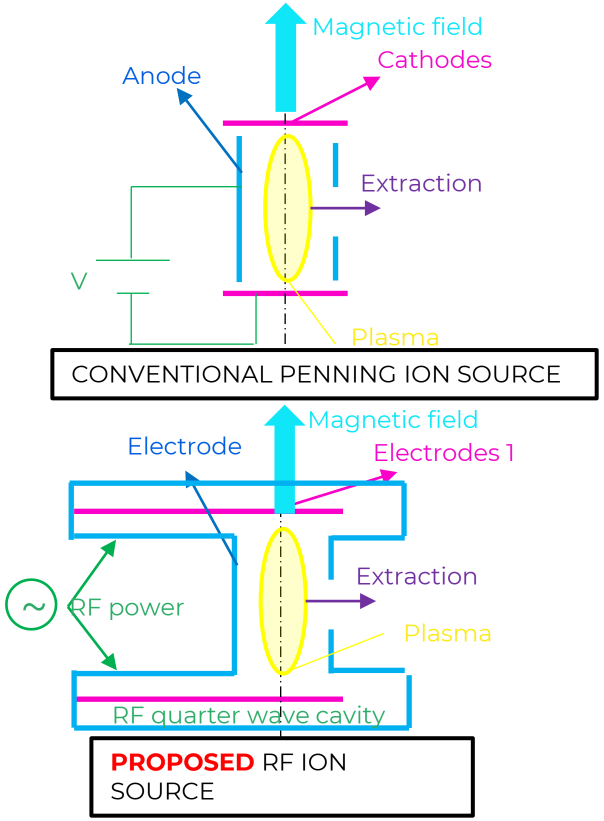
Task 12.2: Design of an advanced electron accelerator plant for biohazards treatment





Activities in P2

Task 12.3: Design of Internal RF Ion Source for Cyclotrons



A new concept of internal ion source based on RF for cyclotrons: Change DC voltage of conventional Penning ion source to a RF voltage

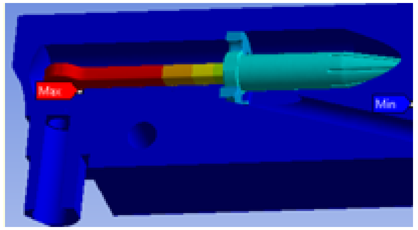
Expected advantages of RF ion source versus Penning:

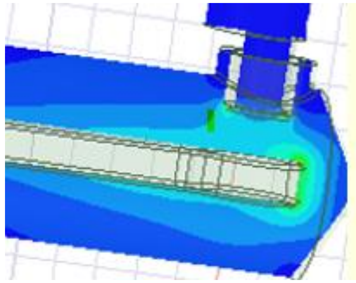
- **Lower cathode wear** (sputtering). Less maintenance time, irradiation and cost. **Cathode** is **heated by RF currents**, no need for ions impact.
- Lower electron energies (~ 10 eV) -> **better efficiency** of producing H^-, leading to reduction of H_2 flow needed and **better vacuum** in the cyclotron.
- **No high voltage**

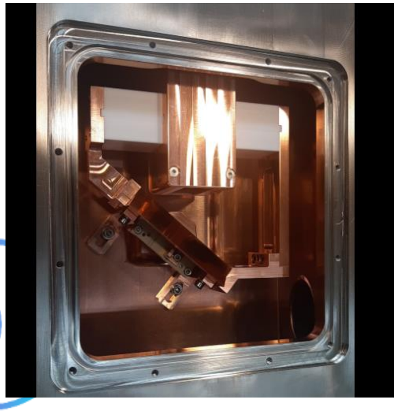
Activities in P2

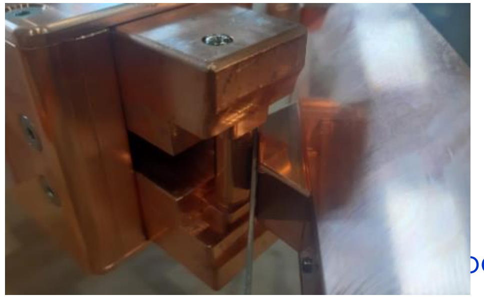
Task 12.3: Design of Internal RF Ion Source for Cyclotrons

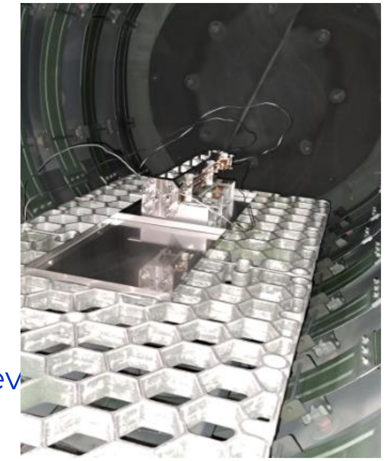
- All aims achieved and positive results obtained:
  - An initial demonstration of plasma production was performed with copper cathodes, 0.8 Tesla dipole field
  - RF power for plasma ignition: 70 W, 50% reflected power, 2 kV at each cathode
  - Plasma is kept for long time, even stopping hydrogen Flow (no extraction), until RF power goes down to about 2 W, 400 V at each cathode

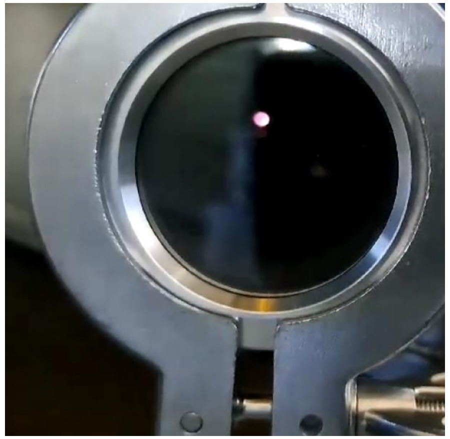












Conclusions

- WP12 is making very good progress
- Tasks 2 and 3 are completed and all objectives achieved
- Task 1 will achieve its objectives and no risks or delays are foreseen
- Strong interaction with industry
- Work is leading to new projects funded by other bodies
- Resources used as planned
- All our IFAST funding has been uniquely used for IFAST activities