This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

Internal RF Ion Source for Cyclotrons

WP 12.3 IFAST-KickOff meeting 04/05/2021

Rodrigo Varela, CIEMAT.

IFAST

Table of contents

Partners

GOBIERNO DE ESPAÑA

MINISTERIO DE CIENCIA E INNOVACIÓN

Ciemat

Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

CYCLOMED

Project Objectives

- Design & manufacture a RF based ion source to replace current internal Penning ion sources in cyclotrons.
- Experimental characterization (plasma & beam) of the RF based ion source.

We aim to reduce the maintenance of internal PIG ion sources due to cathode sputtering!

H^- for Cyclotrons: State of the Art

- Why H^-? Negative hydrogen is excellent from the extraction point of view:
  - Thin carbon foil removes the 2 electrons of H^-.
  - The stripped proton changes rotation direction.

- Internal Sources:
  - Inside vacuum chamber -> direct particle injection.
  - Poor vacuum due to gas evacuated by chamber pumps

Widespread among "industrial" cyclotrons due to its simplicity

- External sources:
  - Complex injection system.
  - Good vacuum in chamber if pumped outside

H^- for Cyclotrons: State of the Art

- H^- is produced in a plasma, either in the plasma volume or the walls surface.

- Volume Production:
  - H_2 roto-vibrationlly excited molecules generated in plasma.
  - Collision with slow electrons produce dissociative attachment ($H_2 + e^- \rightarrow H^- + H$)

- Surface production:
  - Cs monolayer on Mo surface (WF below 2 eV).
  - H atom in the surface is detached and takes an additional electron with it.

H^- for Cyclotrons: State of the Art

- H^- is produced in a plasma, either in the plasma volume or the enclosure surface.

Use and handling of Cs adds a lot of complexity to an "industrial" machine.

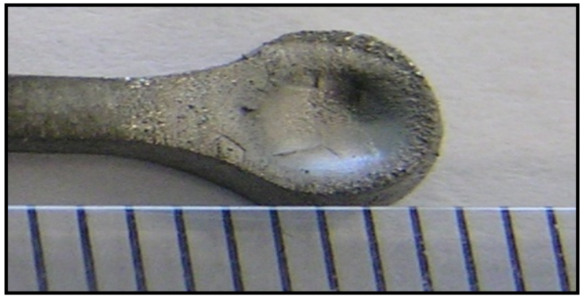
- Volume Production:
  - H_2 roto-vibrationlly excited molecules generated in plasma.
  - Collision with slow electrons produce dissociative attachment ($H_2 + e^- \rightarrow H^- + H$)
- Surface production:
  - Cs monolayer on Mo surface (WF below 2 eV).
  - H atom in the surface is detached and takes an additional electron with it.

H- for Cyclotrons: State of the Art

- **Volume Production:**
  - H_2 roto-vibrationlly excited molecules generated in plasma.
  - Collision with slow electrons produce dissociative attachment ($H_2 + e^- \rightarrow H^- + H$)

Penning Ion Sources

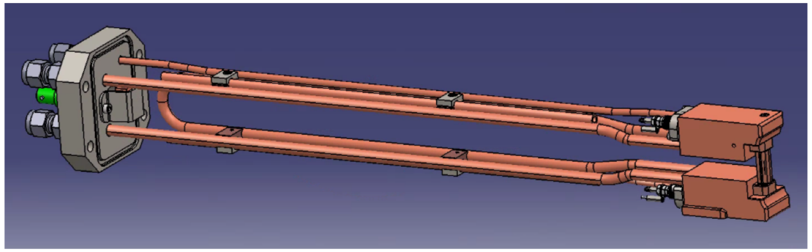
- DC plasma ignited at High Voltage ☺
- Simple and robust ☺
- Cathode sputtering due to back-bombardment of ions ☹
- Periodical maintenance to change cathodes:
  - Machine stops ☹
  - Technician irradiation ☹

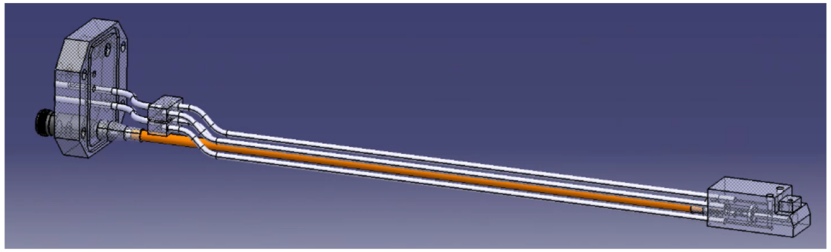


Worn off Ta cathode. Courtesy of D. Obradors.

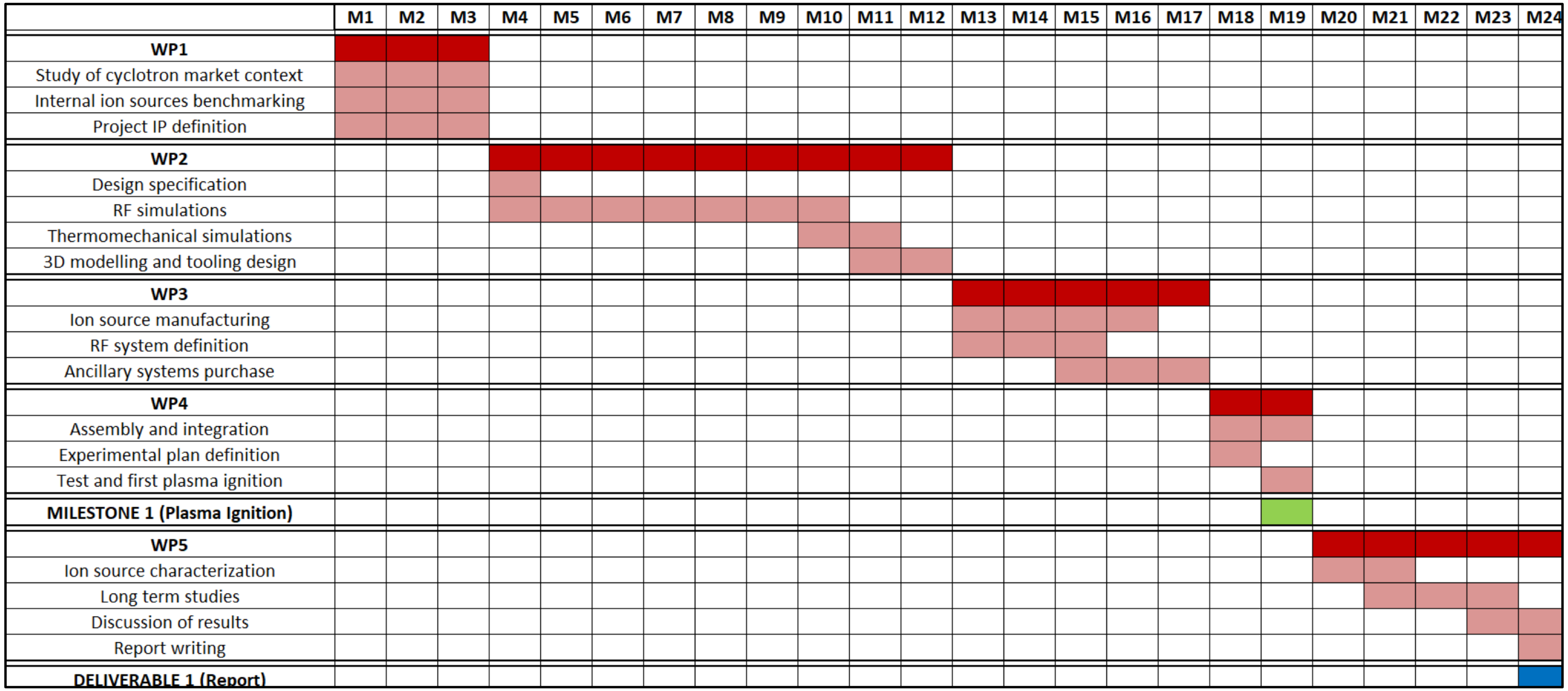
Ion Source Proposal

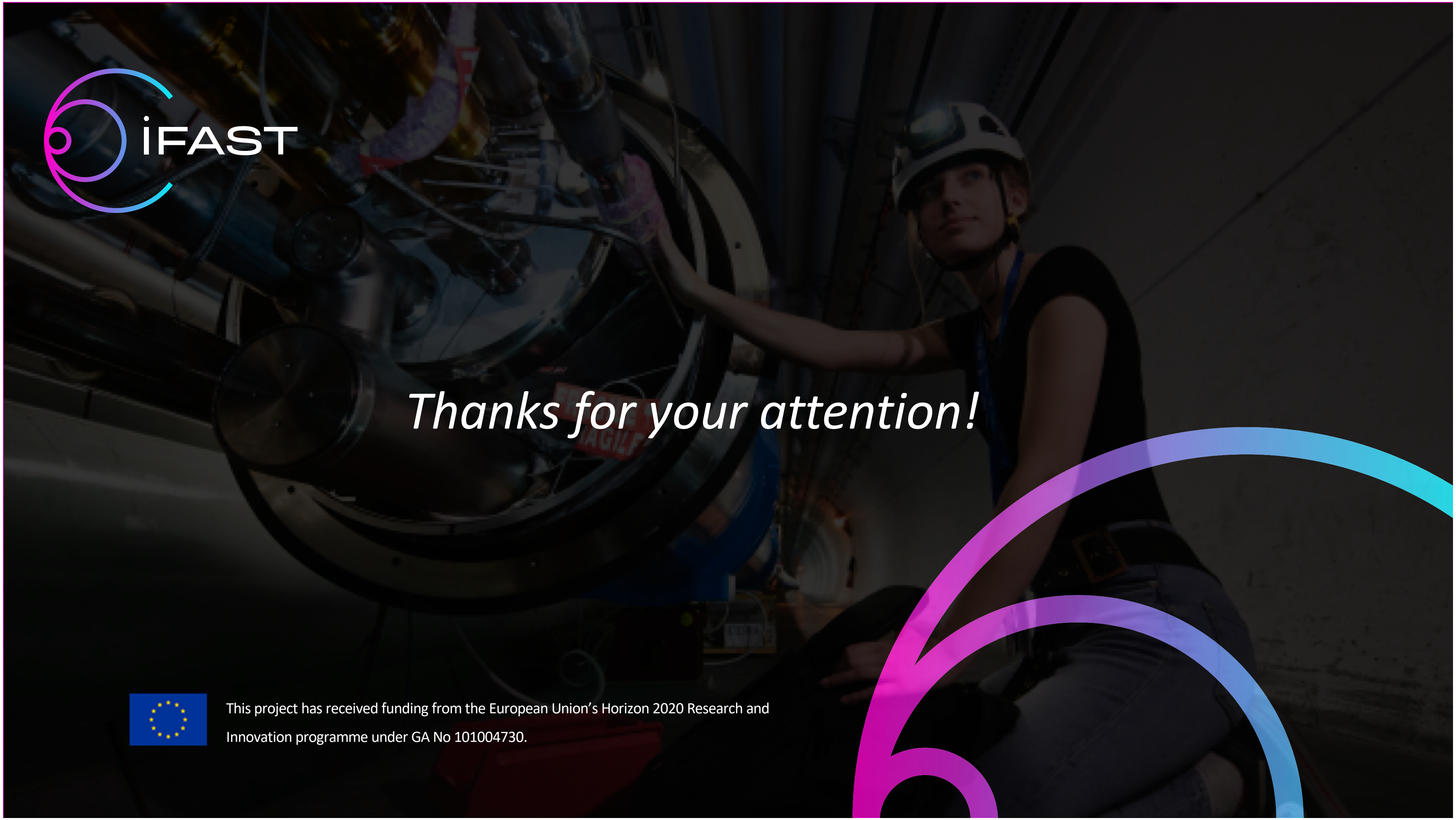
- Capacitively Coupled Plasma at High Frequency.
- λ/4 Cavity resonator to enhance E field for plasma ignition.
- Frequency in the 2.4-2.5 GHz range:
  - λ = 12.5 – 12 cm, compatible with current ion sources dimensions.
  - Readily available power generators.
- Retrofit into existing cyclotrons.





Working Schedule





Thanks for your attention!

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.