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Internal RF Ion Source for Cyclotrons

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Partners





MINISTERIO DE CIENCIA E INNOVACIÓN



Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas







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:
 - H₂ roto-vibrationlly excited molecules generated in plasma.
 - Collision with slow electrons produce dissociative attachment (H₂ + e⁻ -> 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:

- H₂ roto-vibrationlly excited molecules generated in plasma.
- Collision with slow electrons produce dissociative attachment (H₂ + e⁻ -> H⁻ + H)
- Surface production:
 - eV).
 - H atom in the carries is detached and takes in additional electron with it.



H- for Cyclotrons: State of the Art

Volume Production:

- H₂ roto-vibrationlly excited molecules generated in plasma.
- Collision with slow electrons produce dissociative attachment (H₂ + e⁻ -> H⁻ + H)
 - DC plasma ignited at High Voltage 🙂
 - Simple and robust 😳
 - Cathode sputtering due to backbombardment of ions ☺
 - Periodical maintenance to change cathodes:
 - Machine stops 😕
 - Technician irradiation ☺

Rodrigo Varela– I.FAST Kick-off Meeting May 2021



Worn off Ta cathode. Courtesy of D. Obradors.

Penning

Ion Sources

Ion Source Proposal

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

-AST





Working Schedule

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24
WP1																								
Study of cyclotron market context																								
Internal ion sources benchmarking																								
Project IP definition																								
WP2																								
Design specification																								
RF simulations																								
Thermomechanical simulations																								
3D modelling and tooling design																								
WP3																								
Ion source manufacturing																								
RF system definition																								
Ancillary systems purchase																								
WP4																								
Assembly and integration																								
Experimental plan definition																								
Test and first plasma ignition																								
MILESTONE 1 (Plasma Ignition)																								
WP5																								
Ion source characterization																								
Long term studies																								
Discussion of results																								
Report writing																								
DELIVERABLE 1 (Report)																								



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Thanks for your attention!



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