04-05-2021 / I.FAST 1st Annual Meeting

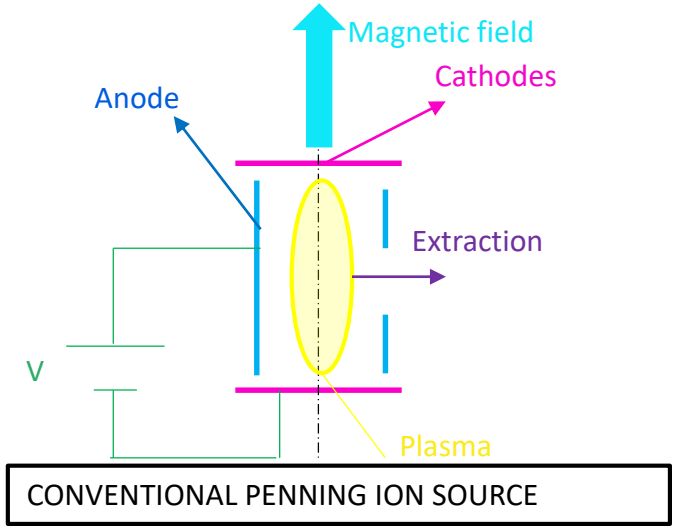
Daniel Gavela (Ciemat) on behalf of RF ion source developing team:

- Tomas Eriksson (GE)
- Pedro Calvo, Daniel Gavela, Miguel León, Diego Obradors, Concepción Oliver, José Manuel Pérez (Ciemat)

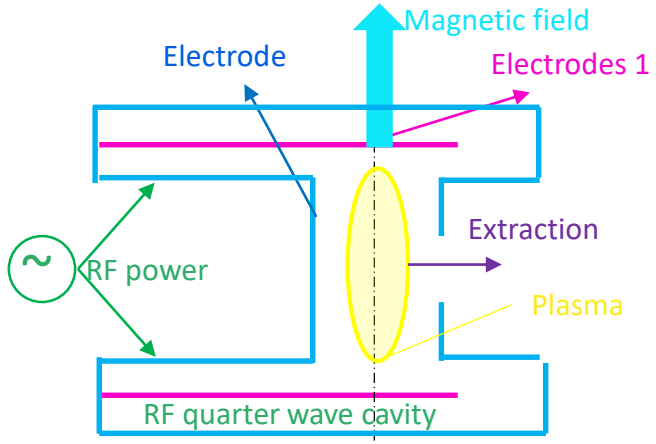
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

CYCLOMED

RF Ion Source Concept



CONVENTIONAL PENNING ION SOURCE



PROPOSED RF ION SOURCE

Worn off Ta cathode. Courtesy of D. Obradors.

Expected advantages of RF ion source versus Penning:

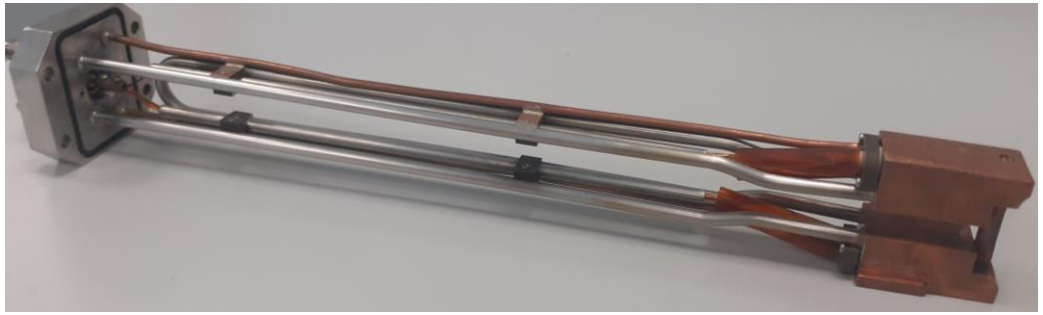
- **Lower cathode wear** (sputtering). Less maintenance time, irradiation and cost. **Cathode** is **heated by RF currents**, no need for ions impact.
- Lower electron energies (~ 10 eV) -> **better efficiency** of producing H^-, leading to reduction of H_2 flow needed and **better vacuum** in the cyclotron.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

Project Objectives

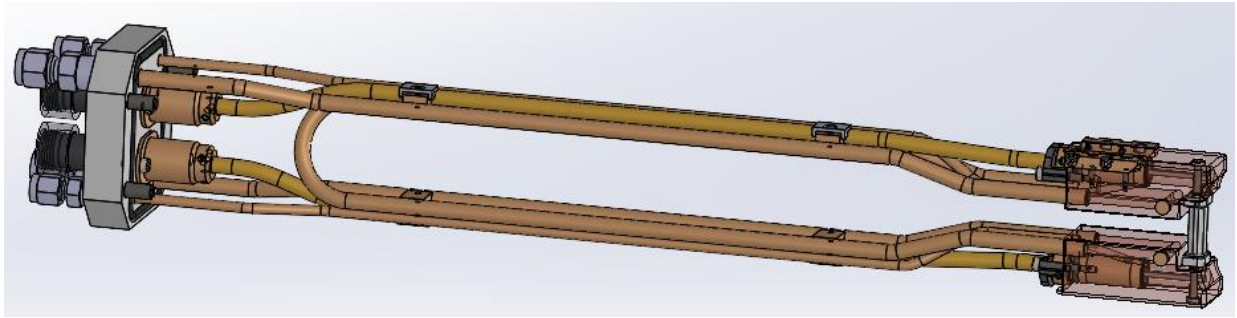
- Design & manufacture a RF based ion source to replace current internal Penning ion sources in cyclotrons
- Experimental characterization (plasma & beam) of the RF based ion source

Ion Source Proposal. Design spec

- 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:
  - λ = 12.5 – 12 cm, compatible with current ion sources dimensions
  - Readily available power generators
- Retrofit into existing cyclotrons

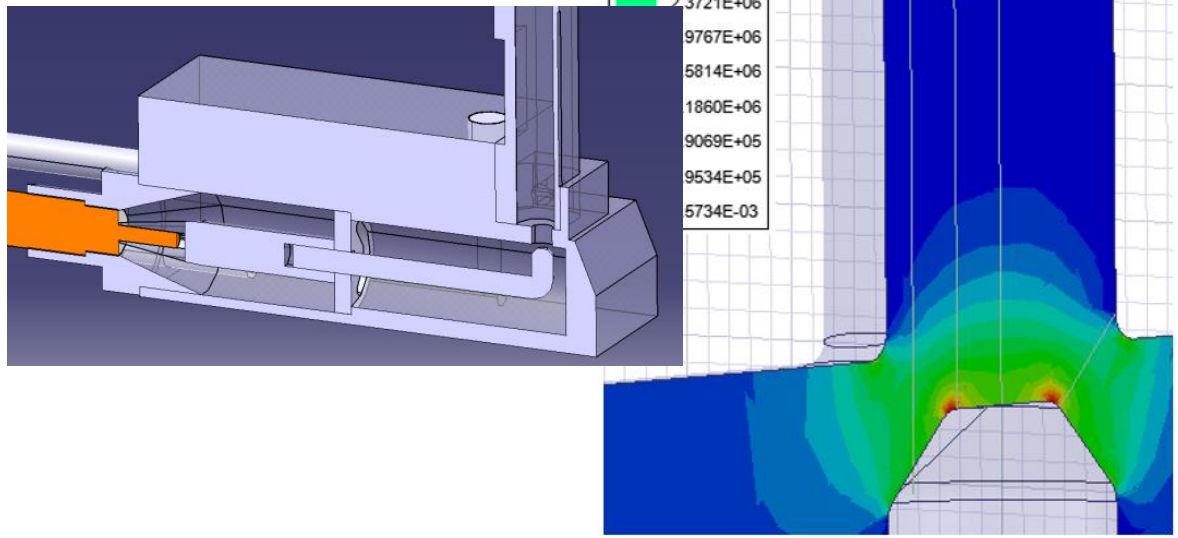


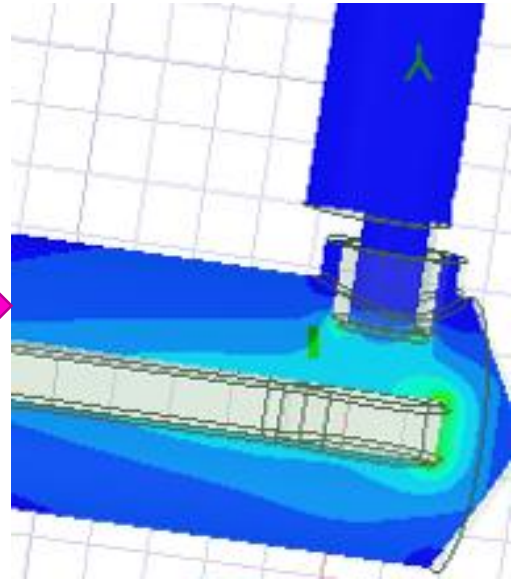
AMIT cyclotron ion source

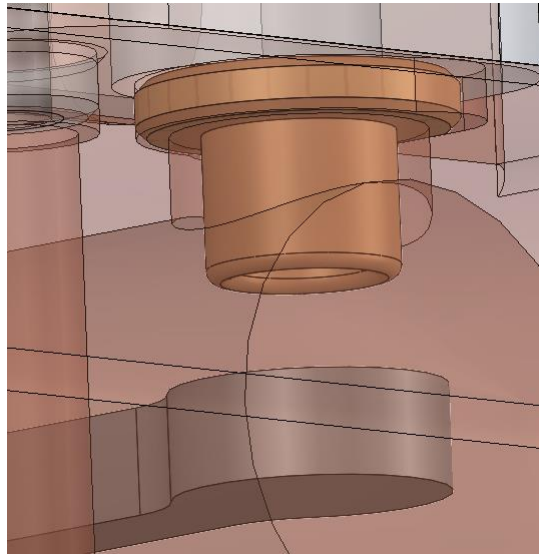


RF proposed ion source

RF design







Electrode design change

- Easier manufacturing
- More robust to dimensional errors
- Interchangeable part for plasma column definition

SIMILAR RF RESULTS:

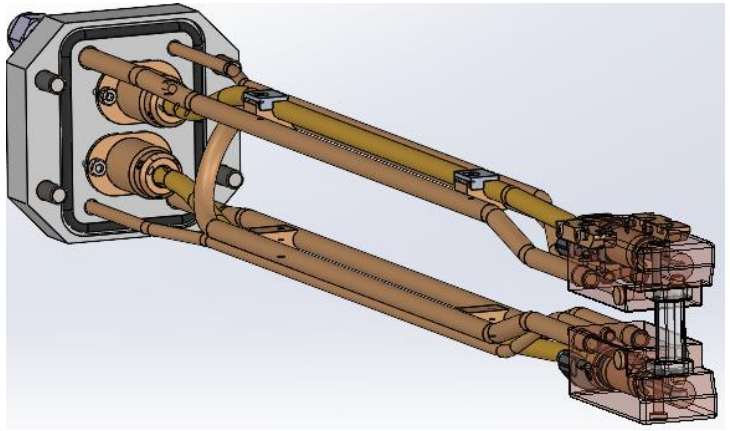
Resonant frequency ~ 2,497 GHz

Power for 1 kV voltage:

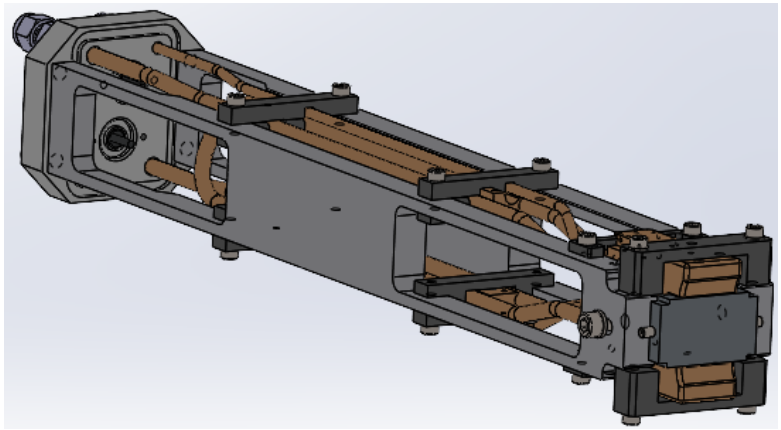
- Copper cathode: 68 W
- Tantalum cathode: 148 W

Detailed design

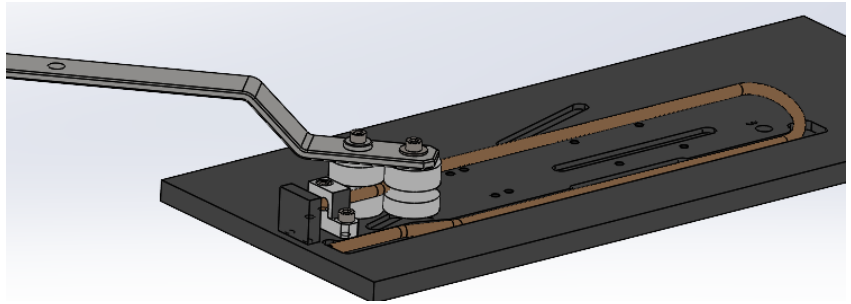
Detailed design, fabrication drawings and fabrication procedure -> **FINISHED**



Ion source



Tooling for welding



Tooling for water, H2 tubes bending

Test facility and plan

TEST BENCH:

- Vacuum chamber
- Dipole magnet up to 0,8 T
- RF extraction voltage up to 10 kV

1st step: plasma production and characterization (without extraction)

Emission spectroscopy of plasma

- Electrons density and temperatures
- Relative densities of neutral and ion species

Special instrumented chimney. Visible range light emmited brought to spectrometer through a fiber optic cable

2nd step: extraction current measurement and characterization

- RF extraction with up to 10 kV at 60 MHz
- Probes behind the puller connected to microamperimeter -> **measurement of positive and negative ions extracted current**

Milestones / Deliverables

Milestone: **1st plasma ignition** -> November 2022

Deliverable: **Report** -> May 2023

- Ion source characterization
- Discussion of experimental results
- Long term studies

Immediate actions (following months)

- Fabrication
- Set up of experimental facility
- Ion source installation and tests start

iFAST

Thanks

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