Ultra-High Current Density Produced by a 60 GHz ECR Ion Source

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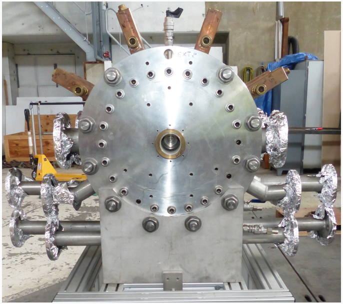
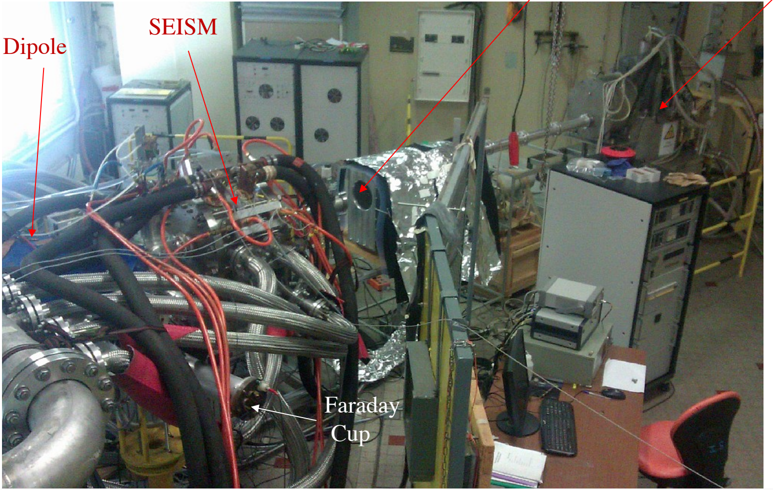
60GHz ECR ion source History

- **S**ixty gigah**E**rtz **I**on **S**ource using **M**egawatt magnets
- The source was developped during the EURISOL design study project
- Coils were constructed with the LNCMI, where the experiment is installed
- For the HF production, a Gyrotron, MW beam line, optical injection in the source done by IAP RAS Nizhny Novgorod
  - 60 GHz-300 kW/1 ms pulses/2 Hz
- First experimental session was performed in 2014 but stopped due to a metallic wire present in the water flow which damaged 2 of the 4 coils.
- The project restarted in 2019 with fresh IN2P3 funds

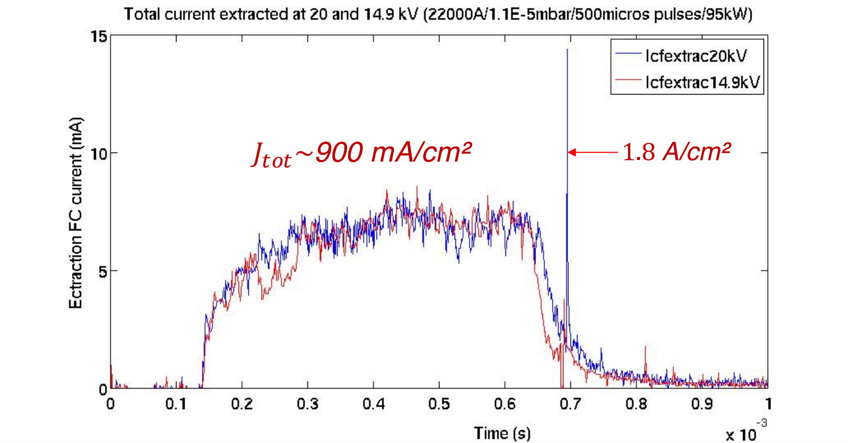


Find the source!



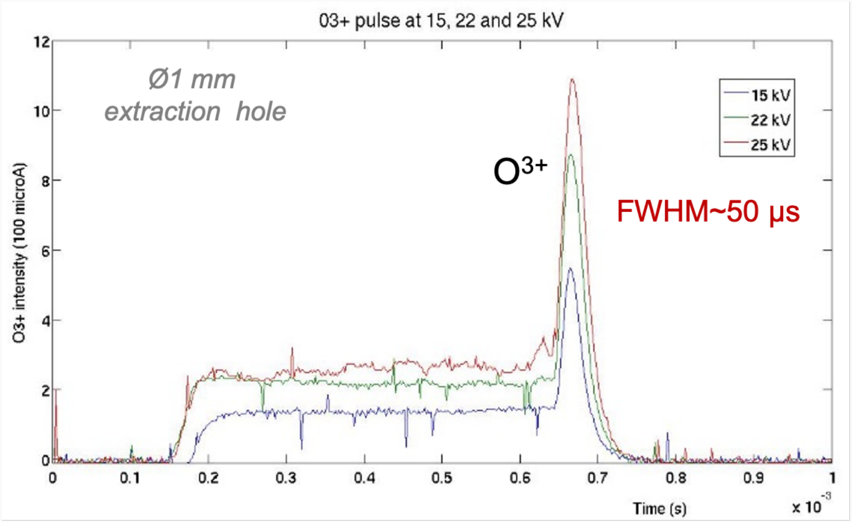
60GHz ECR ion source Experiments in 2014

- 1 mm diameter extraction electrode
- Observation of current densities up to 900 mA/cm^2 in steady plateau
- Observation of transient reproducible current densities up to 1.8 A/cm^2

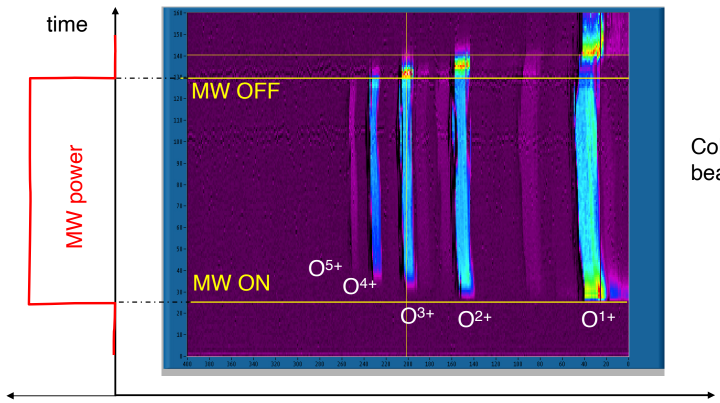


60GHz ECR ion source Experiments in 2014

- Observation of afterglow peaks
- Evidence of ion confinement in an ECR CUSP!

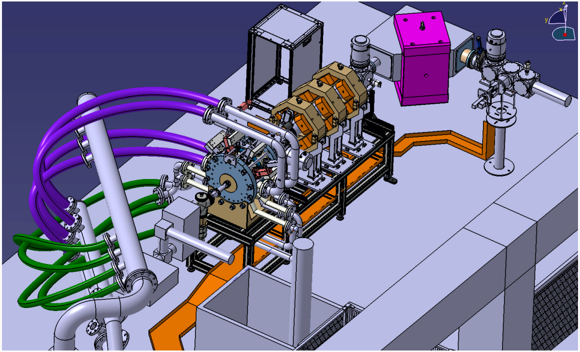


- Afterglow peaks of different charge states are not synchronous in a CUSP
  - AFG peaks are synchronous in a classical Min-B ECRIS
  - Effect yet not understood



Color is ion beam intensity

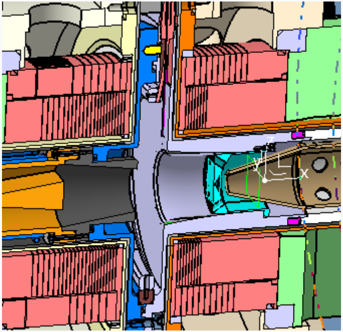
- New experiments to be scheduled in 2021
- Improve experiment:
  - New plasma chamber → improve the vacuum level ($10^{-5} \rightarrow 10^{-7}$ mbar)
  - Increase High voltage (30→40 kV)
  - Design of a new beam transport line → add of a quadrupole triplet and dipole with a larger gap (60→90 mm) → transmission improved
  - Installation of a new overhead crane → optimize implantation of the experiment



60GHz ECR ion source Experiments foreseen

- Reproduce previous data
- Investigate further afterglow peaks
- Make systematic measurements as a function of the source parameters
  - magnetic field, pressure, HF power, biased radial ring
- Measure beam emittance with a pepperpot
- Study plasma stability with appropriate detectors
  - RF trigger, time resolved xray counter
- Lost electron energy distribution measurements

Plasma chamber of SEISM source



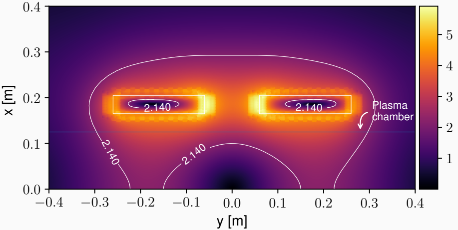
PACIFICS EQUIPEX: Joint CEA / IN2P3 Research program application filed in June 2020, including a work package dedicated to the enhancement of high intensity beams for the next generation accelerators

- Relocate the SEISM source at the LPSC $\rightarrow$ Replace the resistive coils by SC ones
- Upgrade the 60 GHz gyrotron HVPS to 20 kW - CW operation
- Open the future equipment to collaboration with other communities (Plasma, Astrophysics, ...)

Goal:

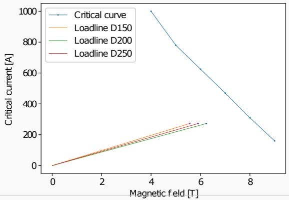
- Produce $>$100 mA of a medium charge state ion beam in CW operation extending the collaboration to CEA IRFU experts
- Investigate the 60 GHz ECR plasma with diagnostics
- Study beam emittance and space charge neutralisation

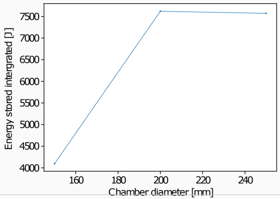
- Preliminary design under progress, NbTi wire @4K considered
  - Objectives: Closed CUSP minimum B surface at 60 GHz with ECR surface 1 cm away from the plasma chamber
  - Example: CUSP configuration for a 250 mm diameter plasma chamber

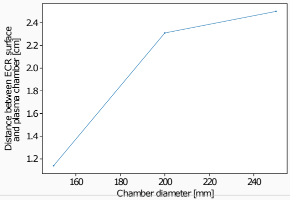


- Oxford cables
- Coil Loadlines <85%
- 75 % Cu cable
- 1.08*0.68 mm sec. insulated

Parametric study







THANK YOU FOR YOUR ATTENTION