# High current production with 2.45 GHz ECR Ion Source

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## Introduction

In the framework of a scientific collaboration with PANTECHNIK, a new test bench has been installed at LPSC dedicated to 2.45 GHz ECR Ion Sources characterization. The goal of the bench is to study adaptability of 2.45 GHz source to industrial purposes. Several magnetic structures have been tested around the same plasma chamber. In this poster, Mono1000 (lent by GANIL) design and test results are presented. The design of a new 2.45 GHz ECRIS, named SPEED, presenting a dipolar magnetic field at the extraction is presented along with its early firsts plasma ignition.

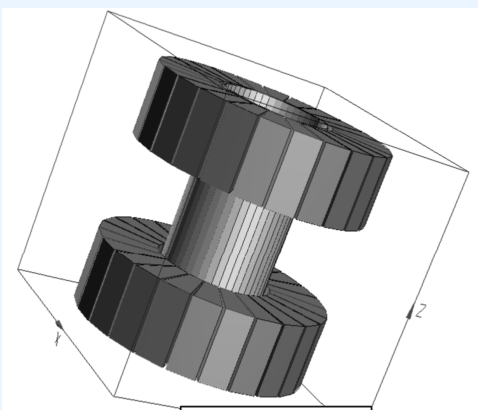
## Magnetic field simulations

- Calculations with RADIA (ESRF)
- The main idea is to study simple structures using permanent magnets giving a closed 2.45 GHz ECR Magnetic surface ($B_{ECR}$ =87.6 mT )

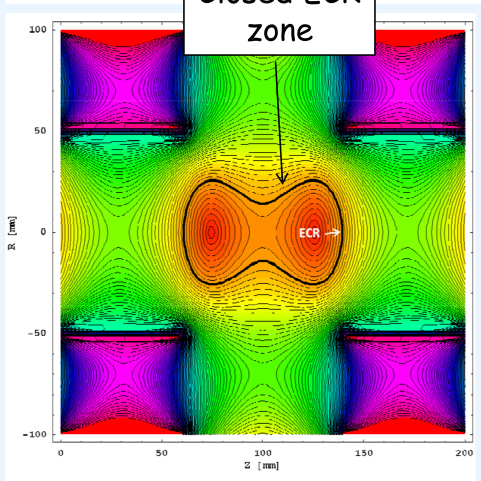
### Mono 1000 ion source (GANIL)

P. Jardin et al., Rev. Sci. Instrum. 73, 789 (2002)

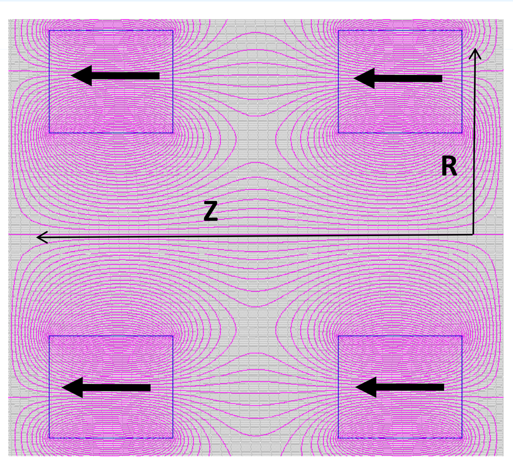
The magnetic field of the source is generated by two coaxial NdFeB permanent magnet rings. (Br=1.29T for each individual magnet). This configuration provides an axi-symmetric Minimum |B| structure.



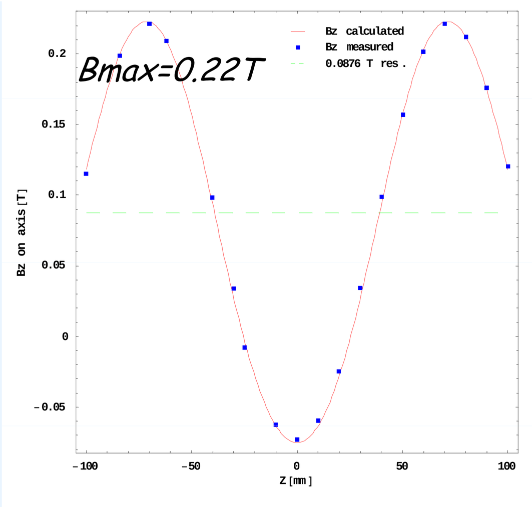
Closed ECR zone



Iso-|B| lines



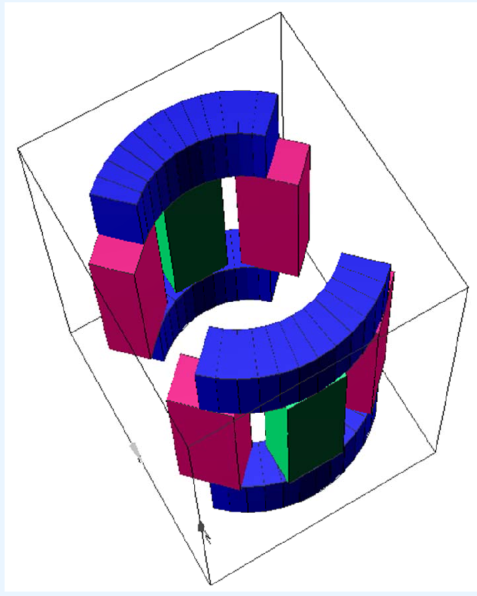

Magnetic field lines

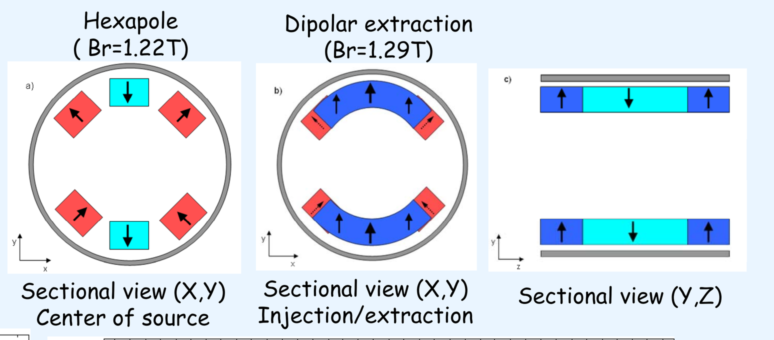



$B_z$(z)on axis

### SPEED ion source

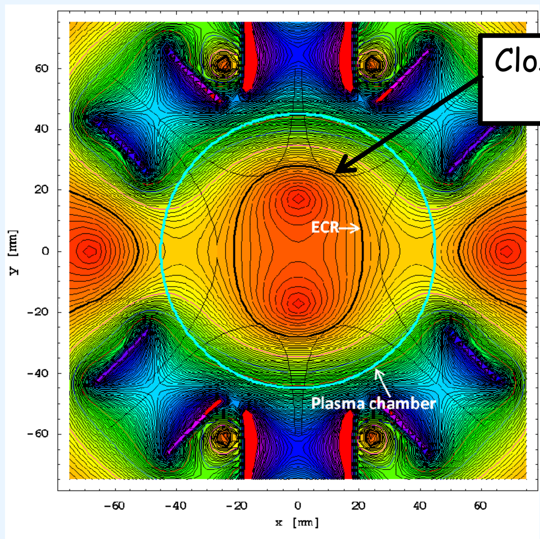
The magnetic field of the source is generated a hexapole structure in the center. The ECR zone is closed by using dipolar ring magnets on the injection and extraction side. So the ion extraction is done in a transverse magnetic field.



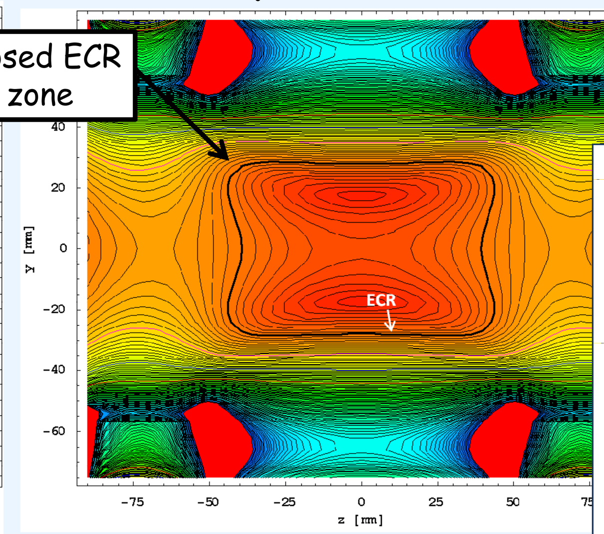



- Dipolar extraction limits to Penning discharge: the extraction electric field can be increased
- At injection, the dipolar form field protects HF window direct plasma flow

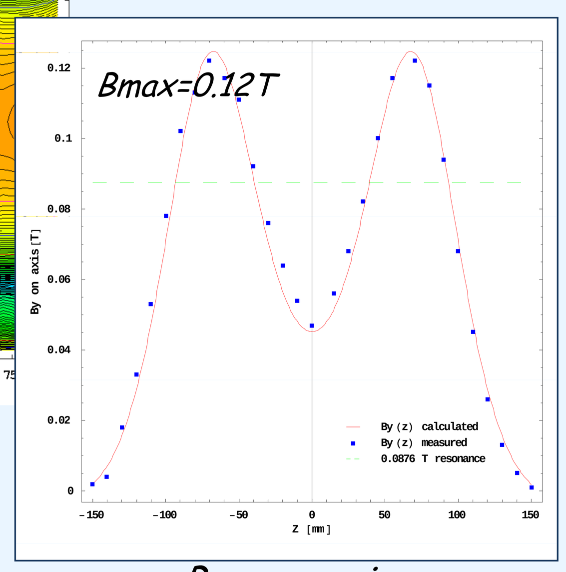
Closed ECR zone




(X,Y) sectional view



(Y,Z) sectional view

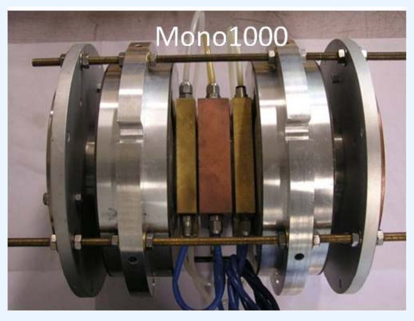


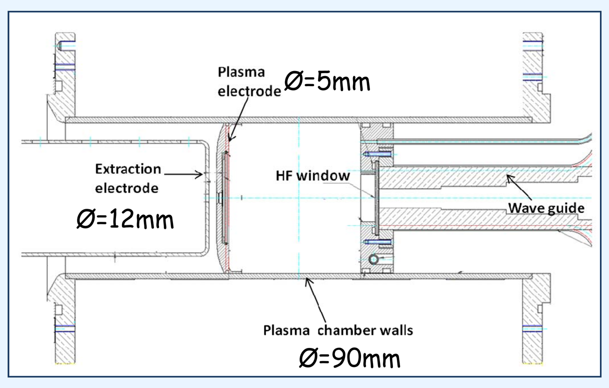

$B_{y\,(z)}$ on axis

## Beam experiments

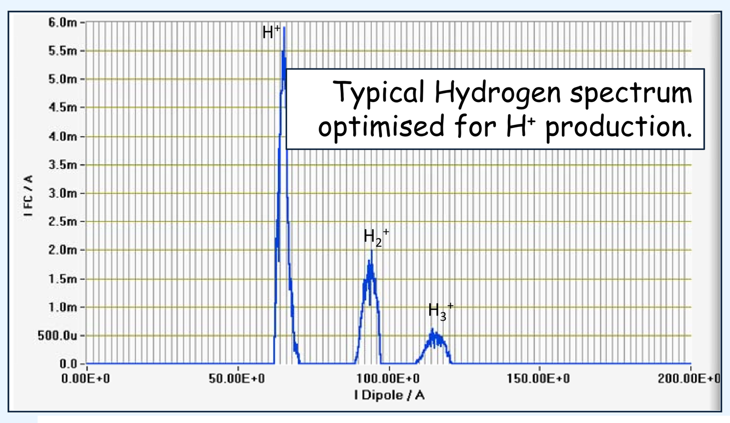
### Mono1000 test results

Simple diode extraction system (HV electrode/ground electrode).



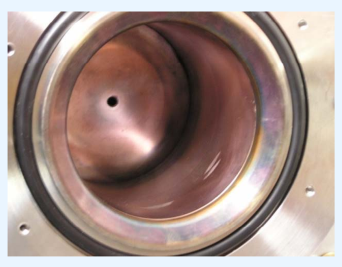




Sectional view of the plasma chamber used to test MONO1000 and SPEED.
Several magnetic structures tested HF window, plasma electrode and extraction electrode positions can be moved in a wide range.



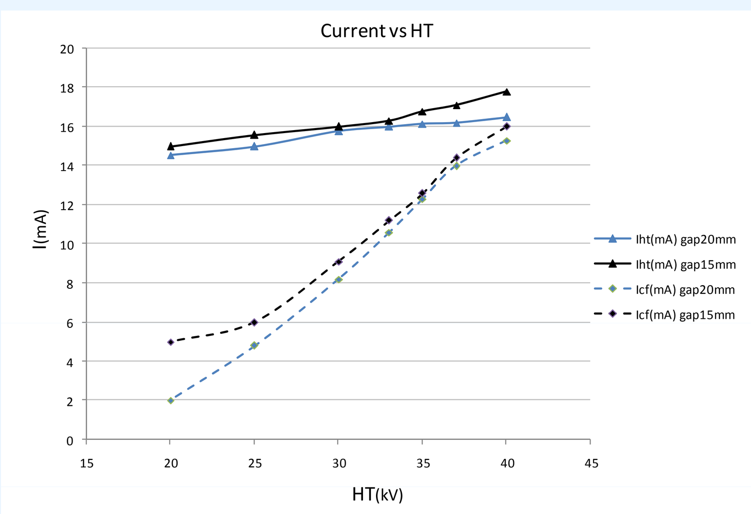

Typical Hydrogen spectrum optimised for H+ production.

$P_{HF}$=950W, HV=40 kV, Transmission~50%
$I_{FC\ TOT.}$=15mA measured, J=76mA/cm²



Plasma electrode after test

Melted Faraday cup after 20mA measurements

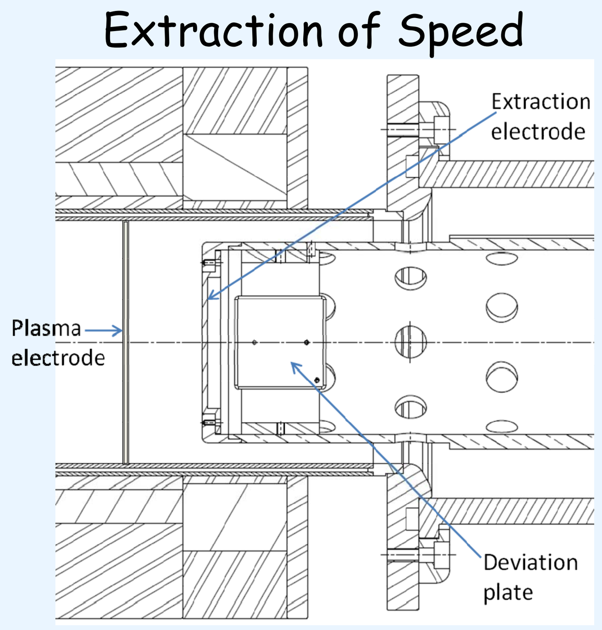



Total Current in the Faraday cup as a function of voltage extraction. The maximum extracted current density corresponding to the maximum extraction voltage (Child-Langmuir law).

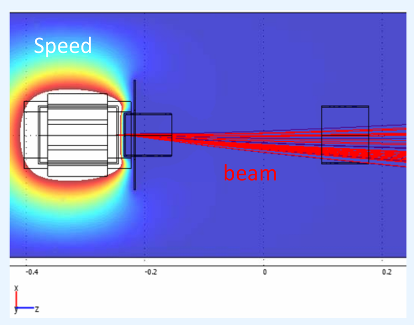
Best optimisation Ø=5mm
current density J=101mA/cm²
20 mA measured in the $FC_1$

### Speed first beam

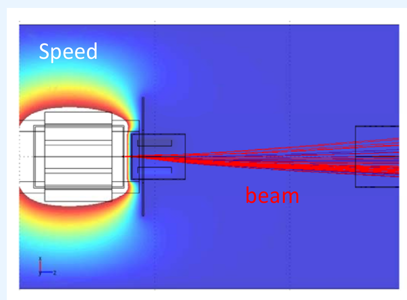
Extraction of Speed



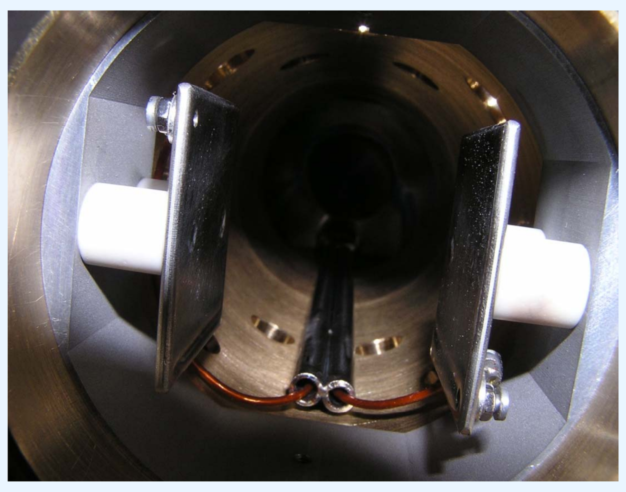

Deflected beam due at the dipolar extraction



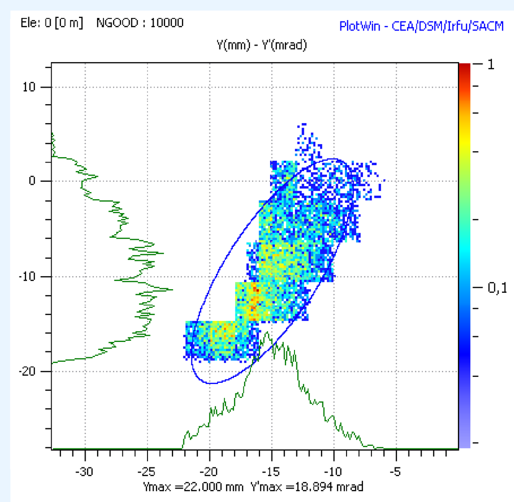

Beam back on axis through the deflection plates



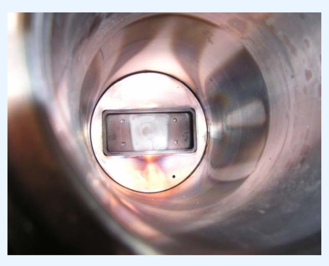

The Comsol Multiphysics simulation code is used to simulate the trajectory of the ion beam from the plasma source with the magnetic field and electrostatic field.



Deviation plates positioned after beam extaction

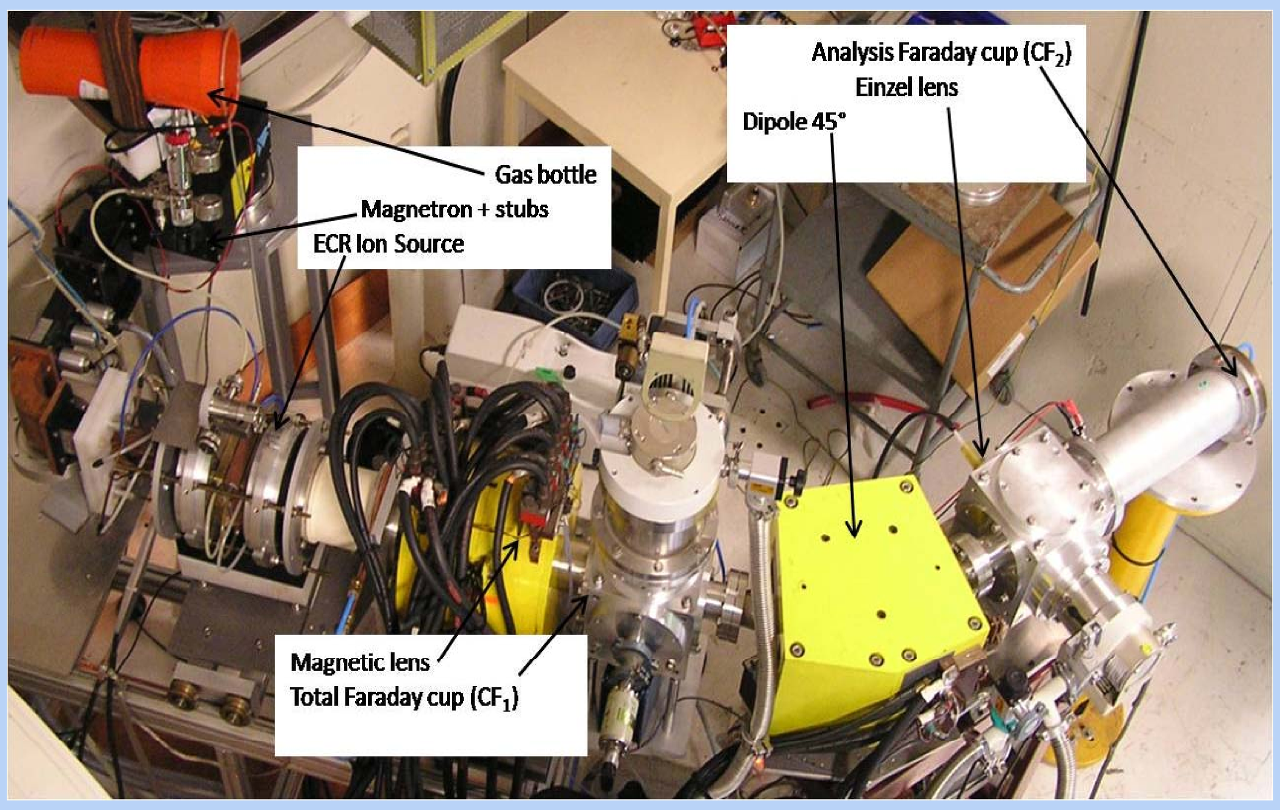


Speed first emittance
Emit [rms] = 0.0646 π.mm.mrad

Plasma chamber after first test: we can see the impact of plasma on the chamber walls with the shape of field lines .

## New Test Bench for 2.45 GHz ECRIS studies




## Conclusion and Prospects

- A new test bench is available to study 2.45 GHz ECRIS at LPSC
- Mono 1000 test shown high current densities beam production (~100 mA/cm²) with a diode extraction system
- Transmission between $FC_1$ and $FC_2$ is 50% (to be improved) at 40 kV
- Speed first beam has been measured for $H_2$ gas

Future plans:

- Test of MONO1000 with a multielectrode extraction system to improve total extracted current
- Emittance measurements
- Continuation of SPEED study (emittance measurements, beam optimization, microwave coupling…)