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ONERA
THE FRENCH AEROSPACE LAB

Propulseur plasma ECRA comme source de plasma magnétisé

GdR EMILI

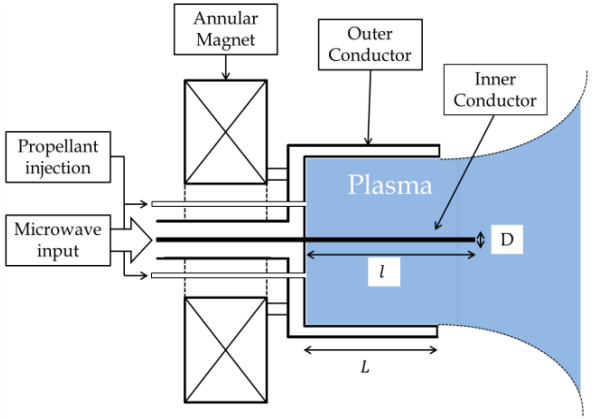
Atelier de recherché - Plasma Magnétisés

Définition d'une source modulable

11-12/10/2022

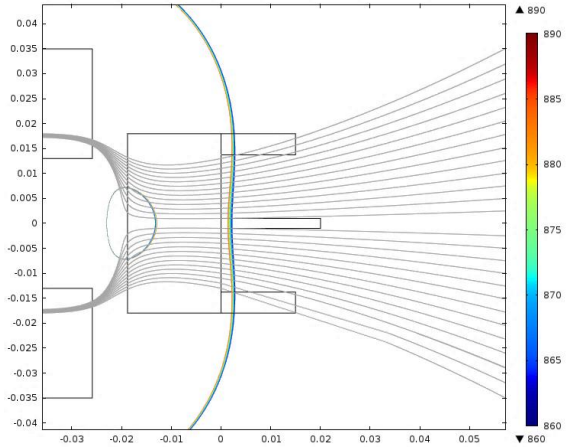
V. Désangles, P.Q. Elias, F. Boni, D. Packan

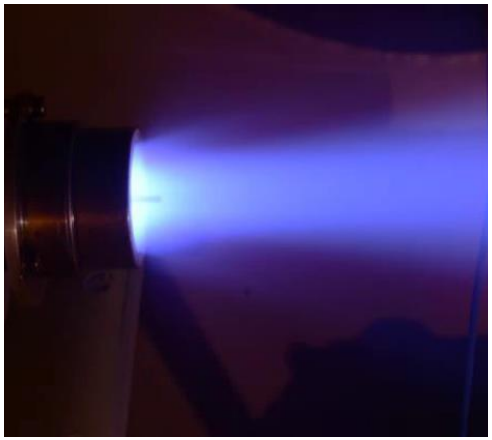
ECR thruster working principle



Thruster characteristics:

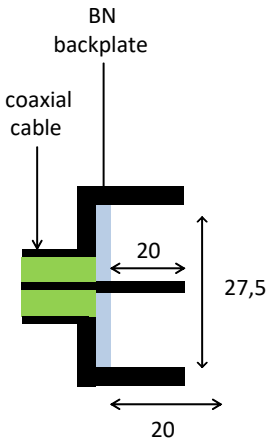
- MW Frequency = 2.45 GHz
- ECR conditions at 875 Gauss
- Permanent magnet
- Floating source





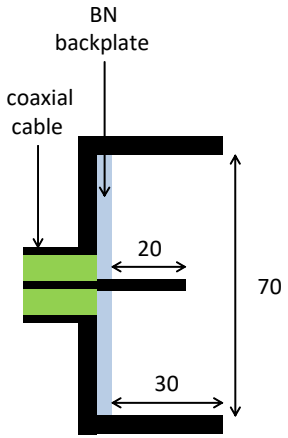
Dimensions / power

Version 30W



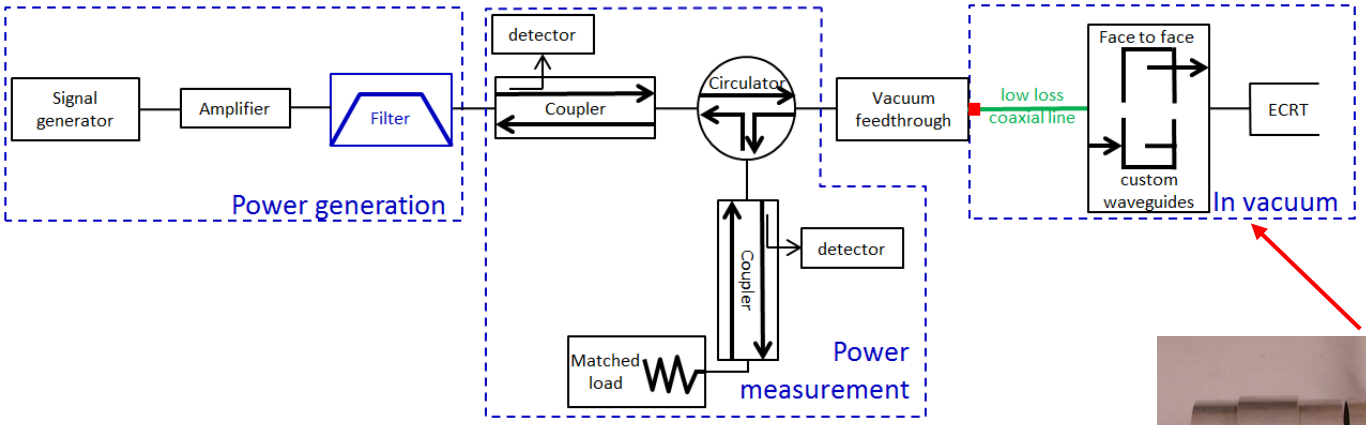
- 0.06 to 0.4 mg/s Xe (0.6 to 4 sccm)
- 10 to 50 W MW power (typ. 30 W)

Version 200W



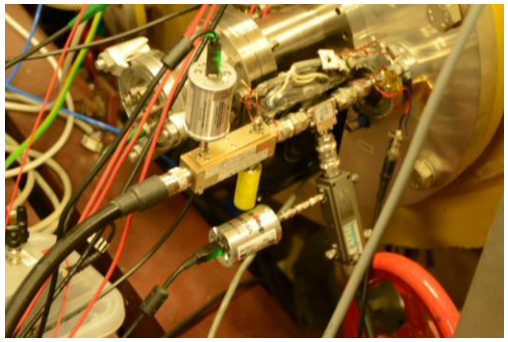
- 0.2 to 0.6 mg/s Xe (2 to 6 sccm)
- 110 to 230 W MW power (typ. 175W)

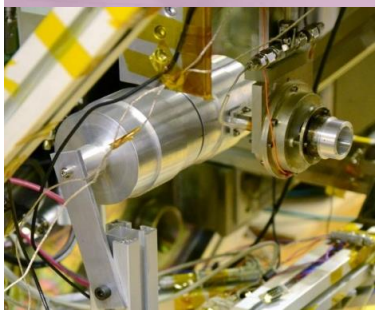
Hardware



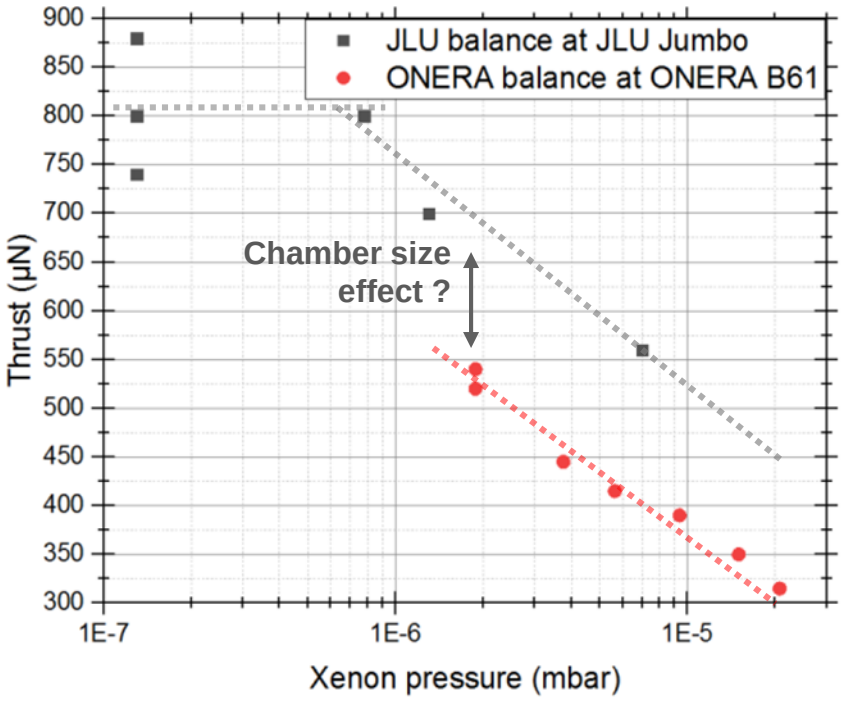
Specific experimental difficulties link to µwave

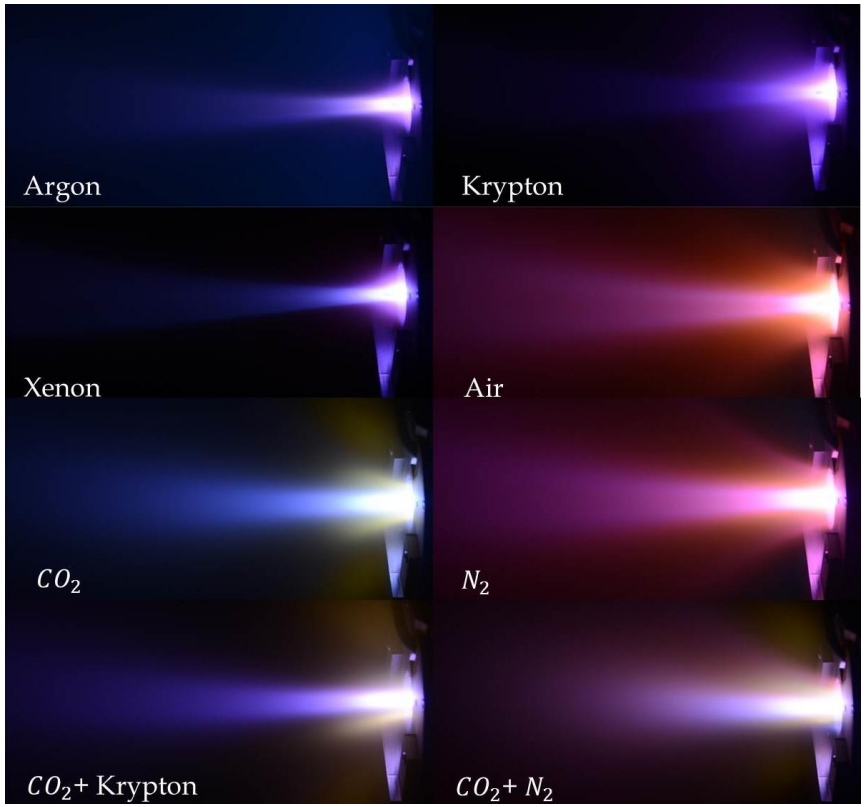
- power measurement is difficult
- power measurement setup is expensive
- power line prompt to failure





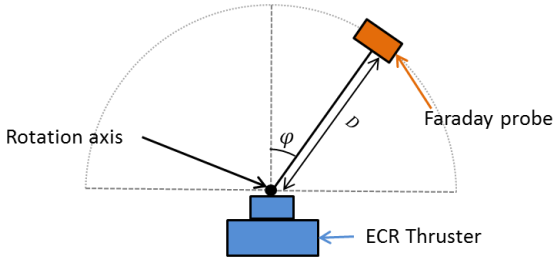
Gas type and background pressure

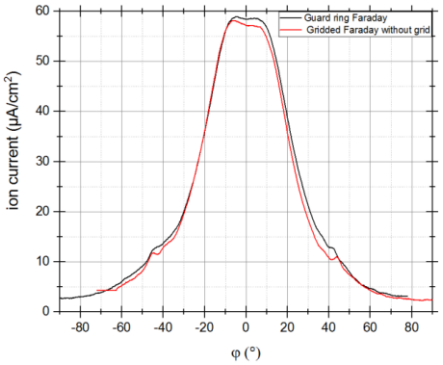




Main diagnostics

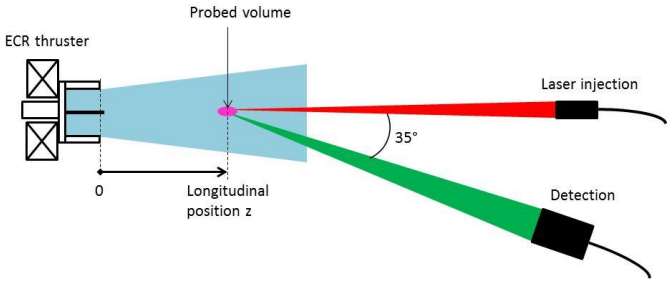
- **Angular scan of the ion current density**

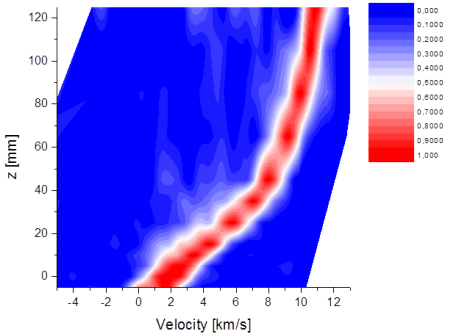




T. Vialis *et al.*, Journal of Propulsion and Power, **34**, 5 (2018)

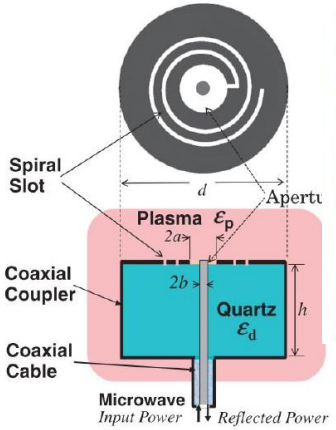
- **Ion velocity local, non-intrusive direct measurement by LIF**





J. Jarrige *et al.*, IEPC Proceedings, Oct 8- 12 2017, Atlanta

- **Curling probe (ne, ñe, ?Te-Ei?)**

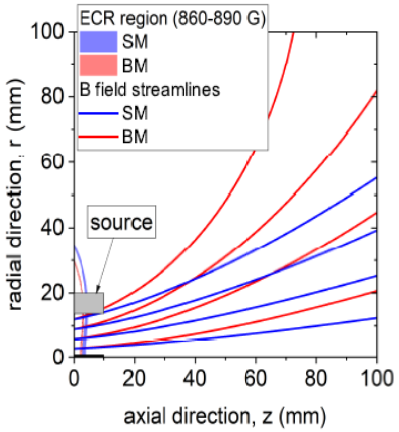


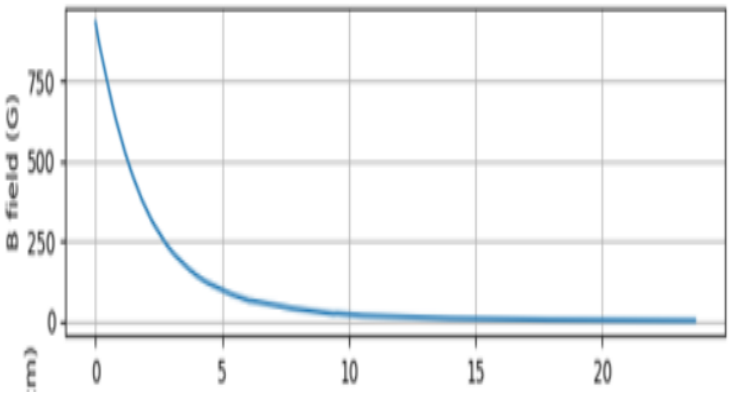
F. Boni *et al.*, Rev. Sci. Instrum. **92**, 033507 (2021)

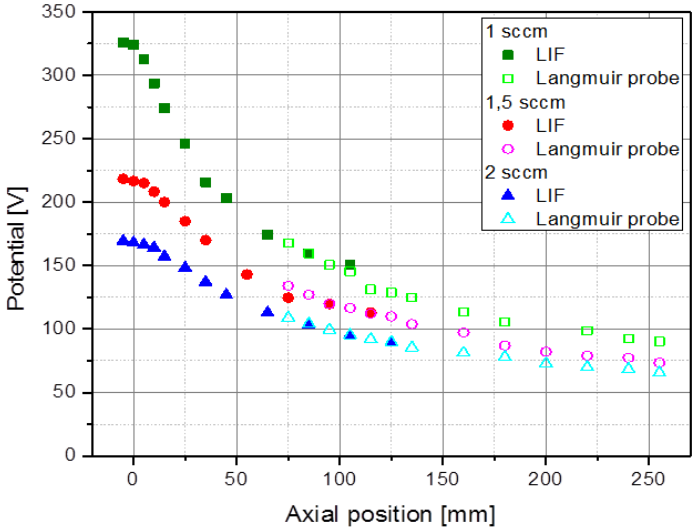
- **Langmuir probe (ni, ne, Te, Vf, Vp)**

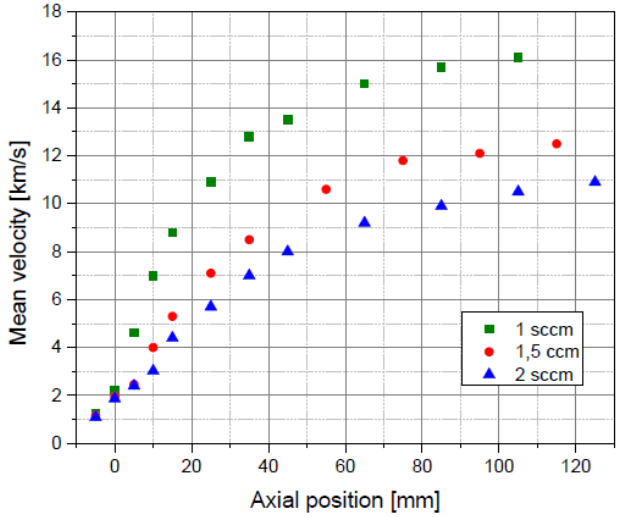
Average field: E and B

F. Boni, PhD Dissertation, Université Paris Saclay, 2022





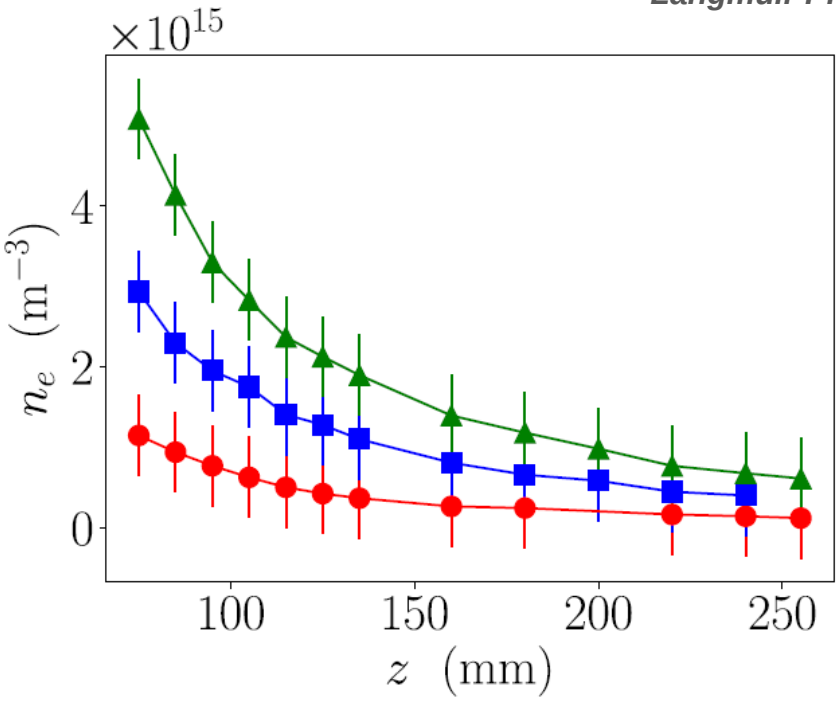


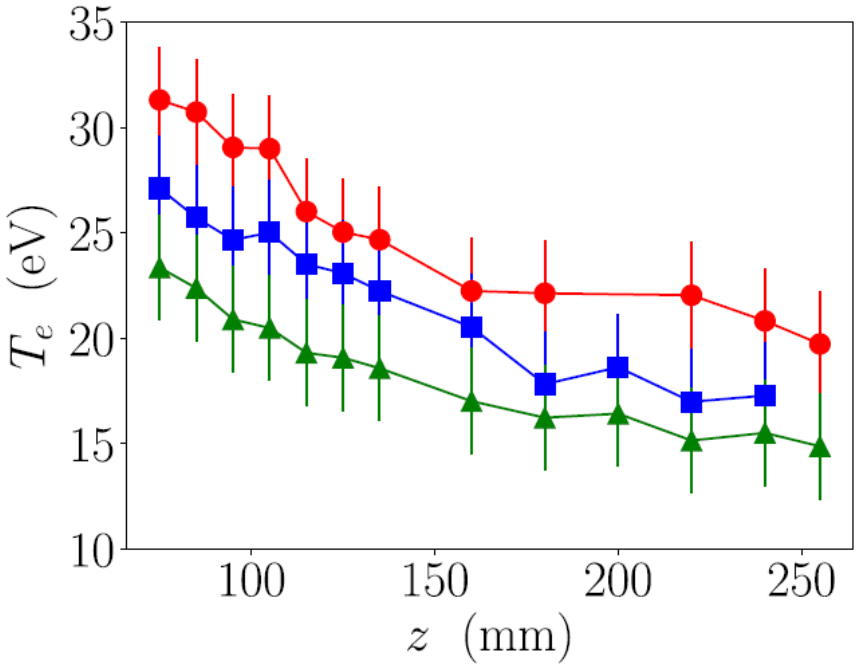


J. Jarrige *et al.*, IEPC Proceedings, Oct 8- 12 2017, Atlanta

Average field: ne and Te

Langmuir Probe measurements

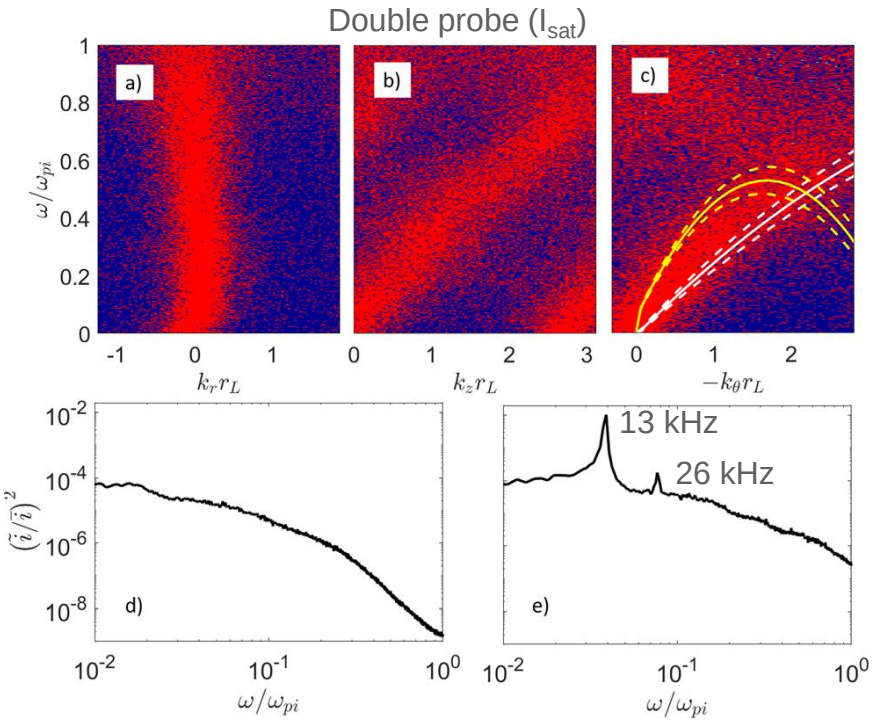




S. Correyero *et al.*, Plasma Sources Sci. Technol., 28, 095004 (2019)

Fluctuation field

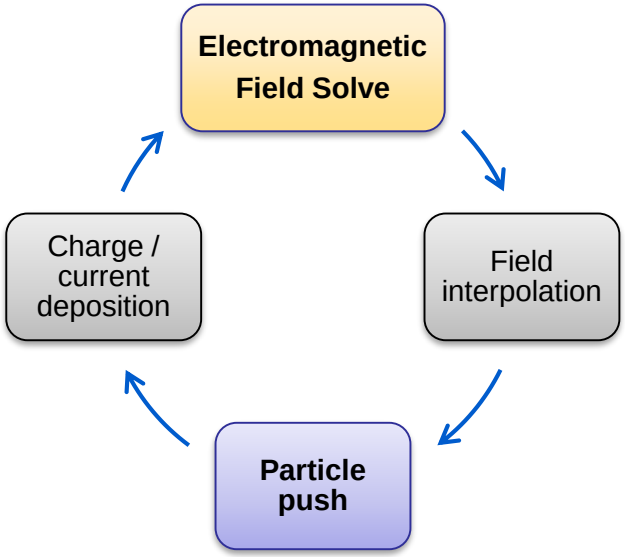
Observed at University of Michigan



r_L = 3mm, f_{pi} = 4,4 MHz, a) radial, b) axial, c) azimuthal

S. Hepner *et al.*, Appl. Phys. Lett., 116, 263502 (2020)

Simulation Maxwell PIC 2D3V - RHEI



Assumption :J NOT negligible

- plasma feedback
- EM fully coupled
- Electromagnetic PIC constraint $c\Delta t/\Delta x$

- ONERA's PIC/MCC code « *Rhei* »
  - Cartesian mesh, immersed boundaries
  - MPI / OpenMP (run ~ 44 cores)
- Maxwell Solver + Poisson solver (Gauss correction)
- Simulation domain :
  - Coaxial source (Ø30 mm L=20 mm)
  - Nozzle (L=80 mm, R=50 mm)
- Boundary conditions
  - Floating conductor (outer)
  - Nozzle BC (Andrews 2022)
  - Perfect Electric Conductor
  - Perfectly Matched Layers
  - TEM input port

Simulation Maxwell PIC 2D3V - RHEI

J. Porto *et al.*, IEPC Proceedings, June 19- 23, 2022, Boston