

ONERA



THE FRENCH AEROSPACE LAB

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Ground plasma tank modelling with SPIS

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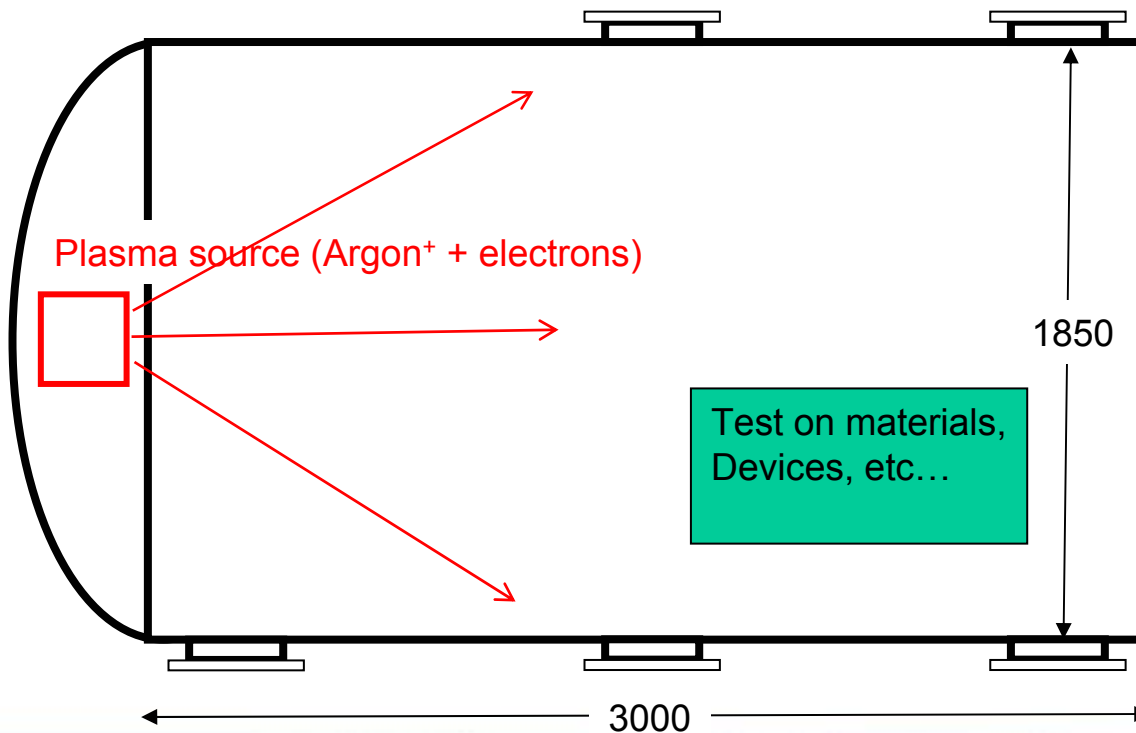
r e t u r n o n i n n o v a t i o n

Scientific context

- Ionosphere simulation tank JONAS

Experiments achieved in 2002 (CNES study)

SPIS development 2002-2007 → numerical simulations



Pressure $\sim 5 \cdot 10^{-6}$ mbar
Plasma density $\sim 10^4 - 10^6$ cm⁻³
Ion energy 10 - 25 eV
Electron temperature $\sim 1500^\circ\text{K}$

Objectives

- Characterization of the tank
 - experiments
 - numerical simulations → SPIS
- Understanding the physics inside, for every study

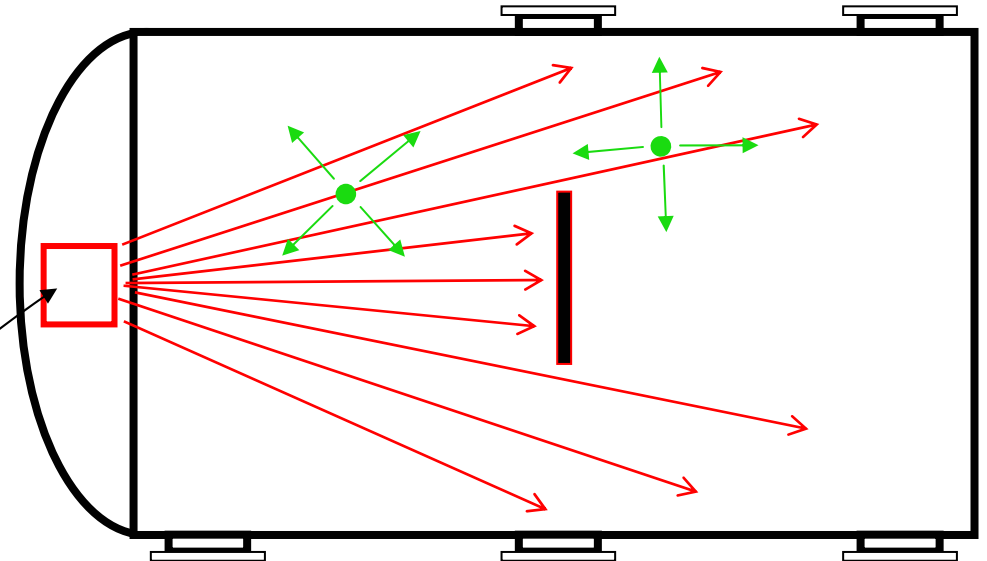
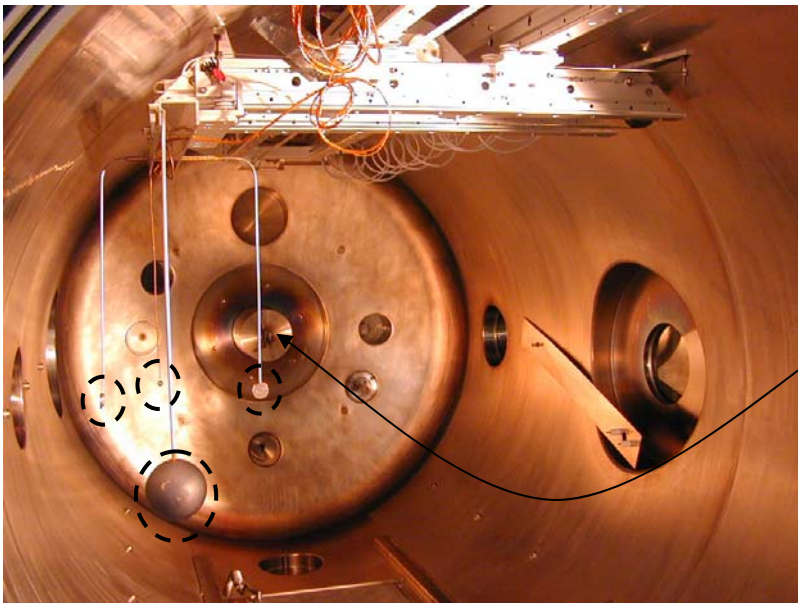
Experimental studies

- Plasma I-V characteristics using Langmuir probes (4)
 - plasma density
 - electron temperature
 - plasma potential

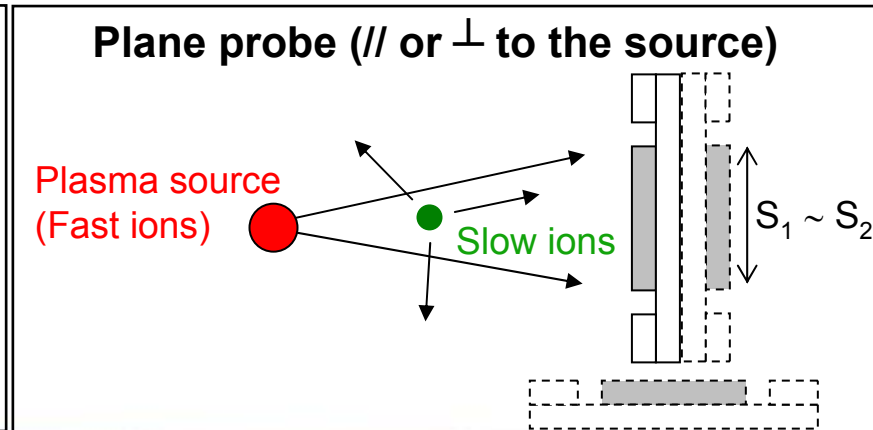
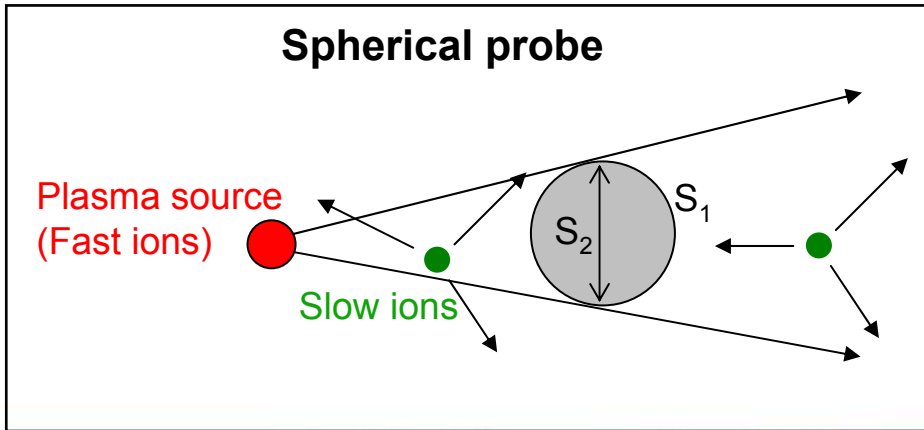
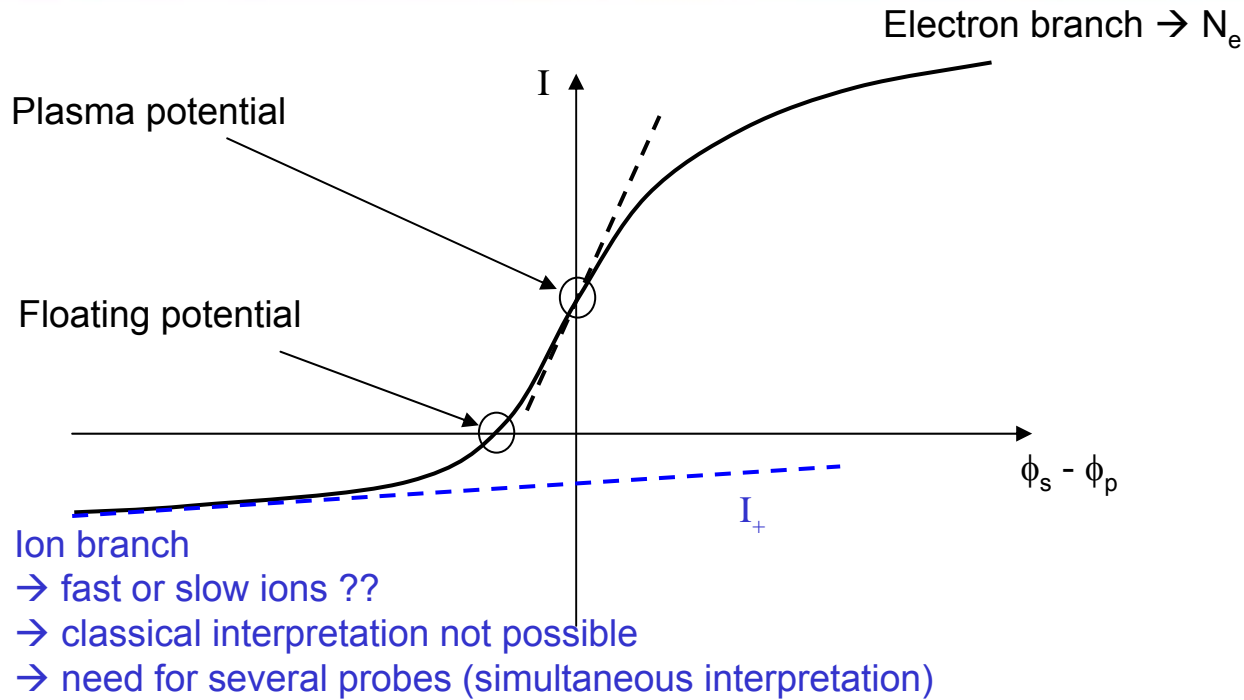
- Wake effect using a plate

Fast ions (10-25 eV) emitted from the source can not reach the region behind the plate,

Slow ions created by charge exchange reactions (CEX) are present in the whole tank \neq LEO

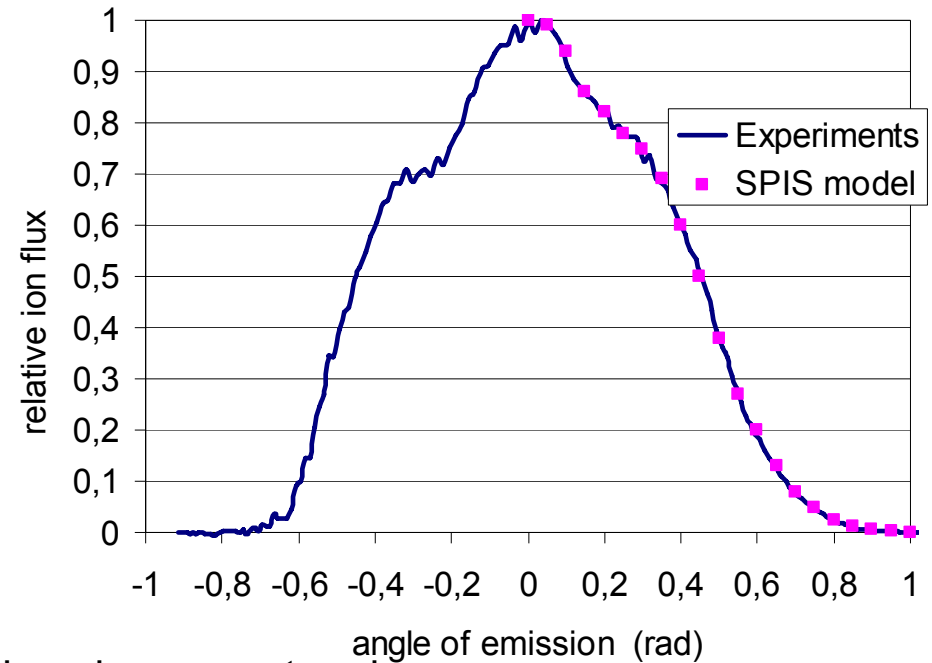
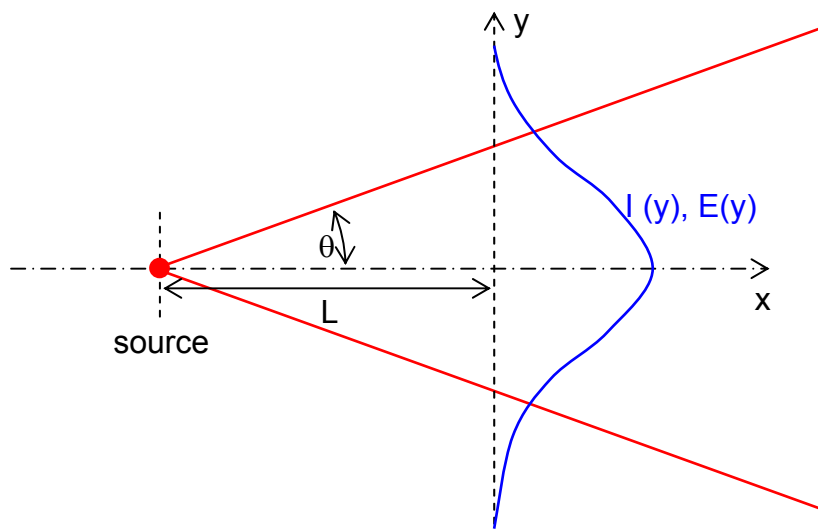


Experimental studies- Langmuir probes interpretation



Experimental studies

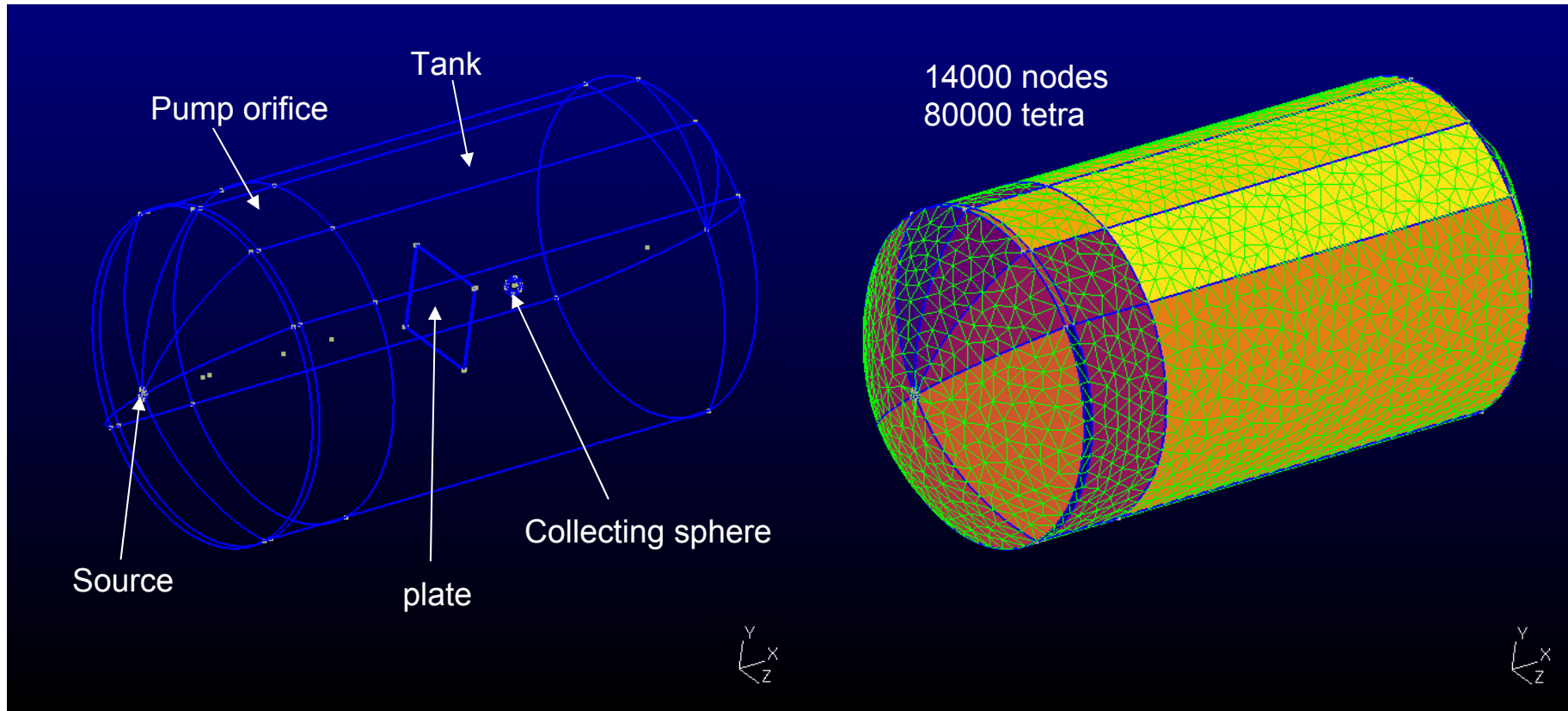
- Preliminary study:
 - considering **only** the fast ions
 - using a spherical probe
 - model of ion source for simulations with SPIS



→ Angular distribution : ion current and energy

Numerical simulations (SPIS Model)

- CAD model and mesh using Gmsh



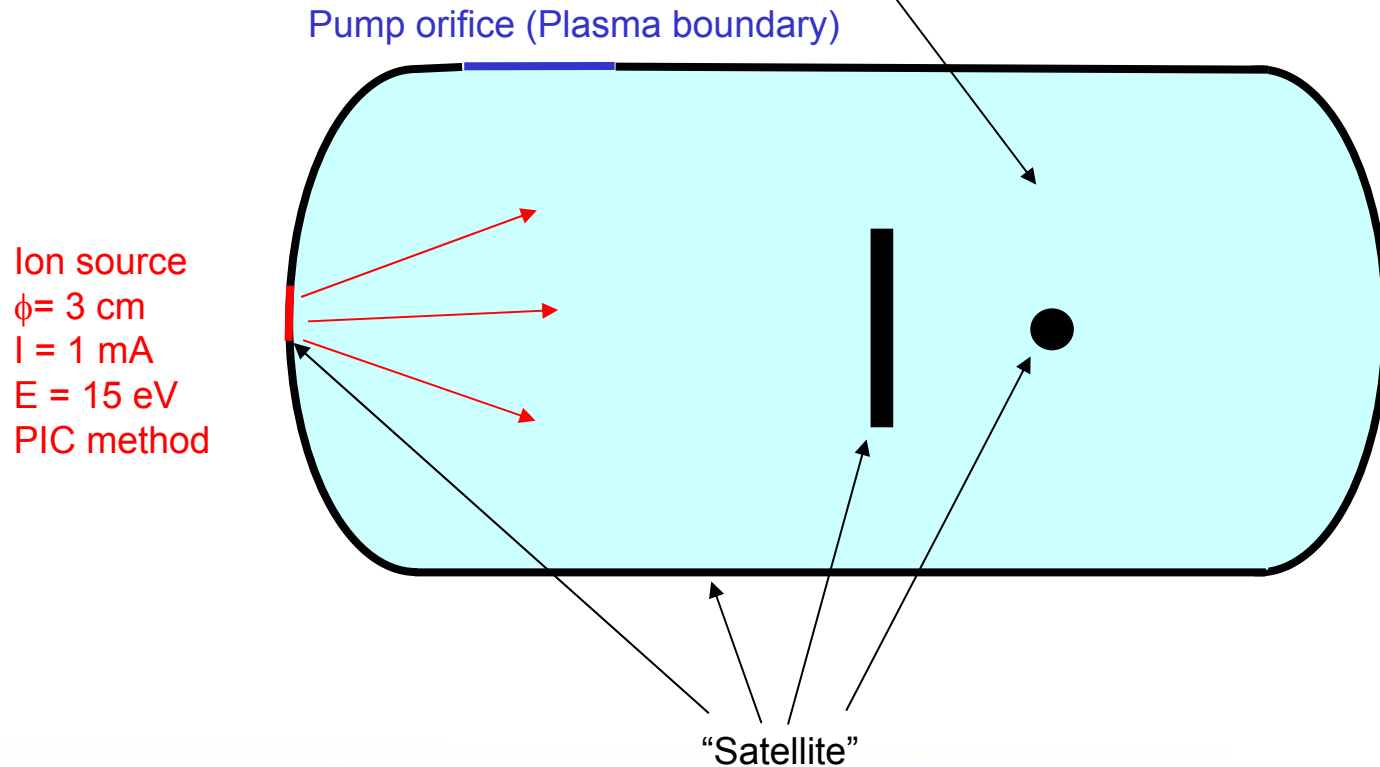
11th SPINE meeting and SPIS training - 18-20/04/2007

Numerical simulations (SPIS Model)

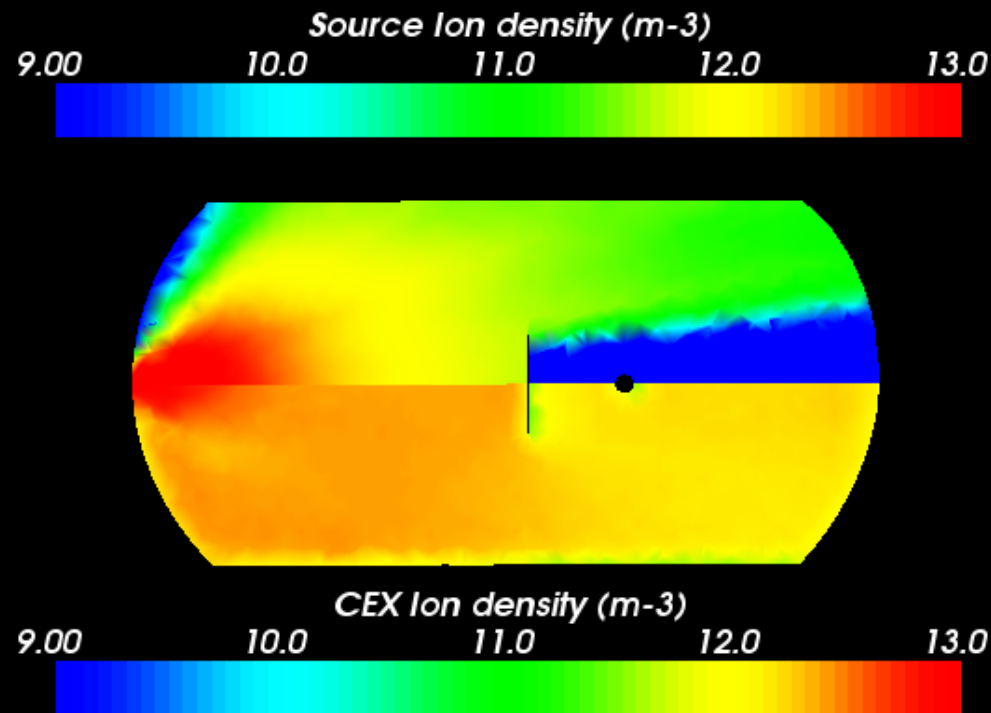
Plasma volume

- Electrons : Boltzmann distribution
- CEX reaction

*Supposes a uniform neutral density (SPIS improvement) obtained by exp.
Enables the prediction of slow ion production*



Numerical simulations (SPIS)



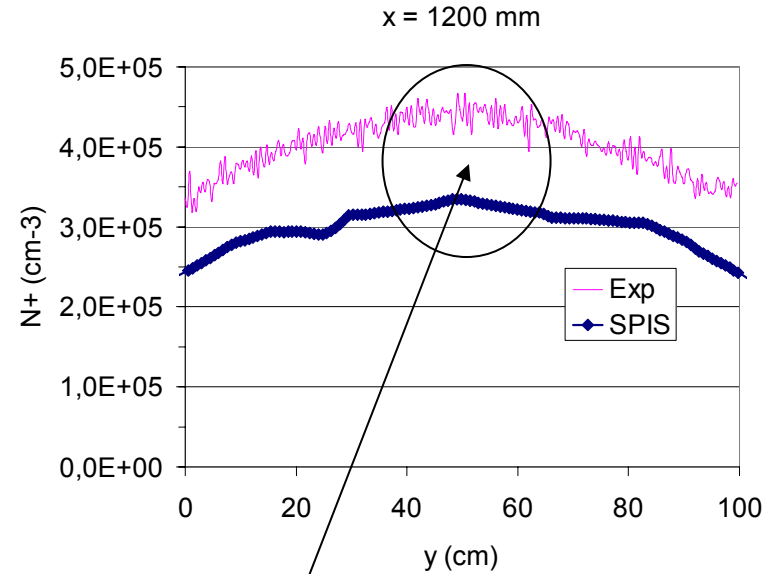
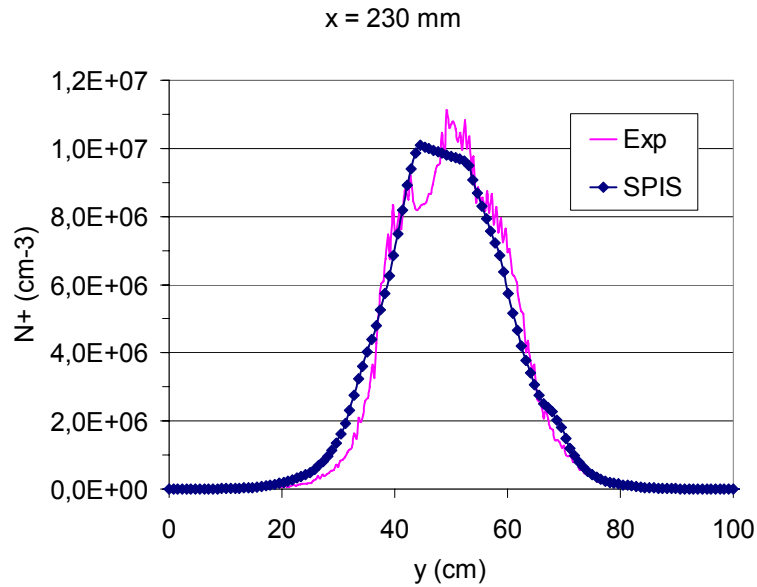
- Numerical results

- Fast ion density : 10^{11} - 10^{14} m⁻³
- Realistic decrease of ion density ($\sim 1/r^2$ for fast ions)
- Wake effect clearly demonstrated for fast ions
- Important amount of slow ions $> 10^{12}$ m⁻³, which is in agreement with measurements

Numerical simulations (SPIS)

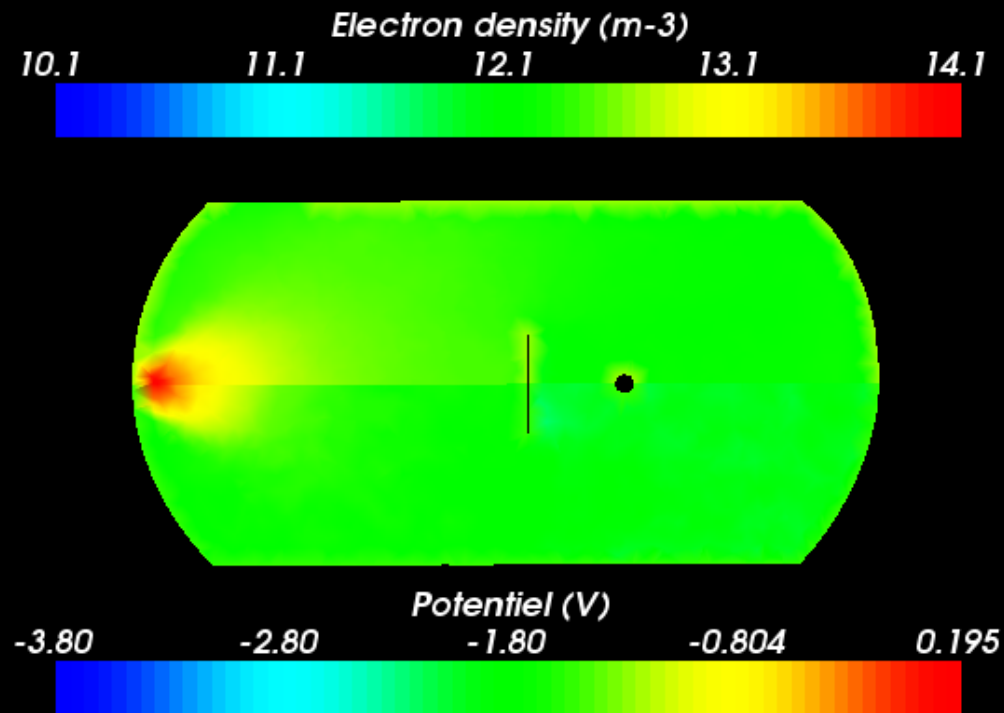
- Comparison with experiments: preliminary results

Fast ion density



Langmuir probe interpretation needs to be improved

Numerical simulations (SPIS)



- Numerical results

- Electron density and potential : Boltzmann distribution $N_e \propto N_0 \exp((V-V_0)/k_B T)$
- Quasi neutral plasma
- Tank and plasma potentials : $\Delta V \sim 0,5 - 1 \text{ V}$

Conclusion

- Preliminary results
 - Encouraging description of the plasma dynamics with a coarse mesh grid
- Future works
 - Exp: Finer interpretation of Langmuir probe measurements
 - Num: Finer mesh grid
 Neutral dynamics → prediction of pressure (later, DSMC required)
- The final model will help to simulate the experiments to be conducted in the ONERA tank