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Development of a drift tube mass spectrometer associated with plasma microjets

Joel Lemaire¹; Bessem Brahim¹, Michel Heninger¹, Essyllt Louarn¹, Helene Mestdagh¹, Gérard Bauville², Nicole Blin Simiand², Et-Touhami Es-Sebbar², Michel Fleury², Stephane Pasquiers², Joao Santos Sousa², Elsa Bauchard³, Julien Leprovost³

¹ LCP, UMR8000, CNRS-Université Paris Sud, Orsay, France

² LPGP, UMR8578, CNRS-Université Paris Sud, Orsay, France

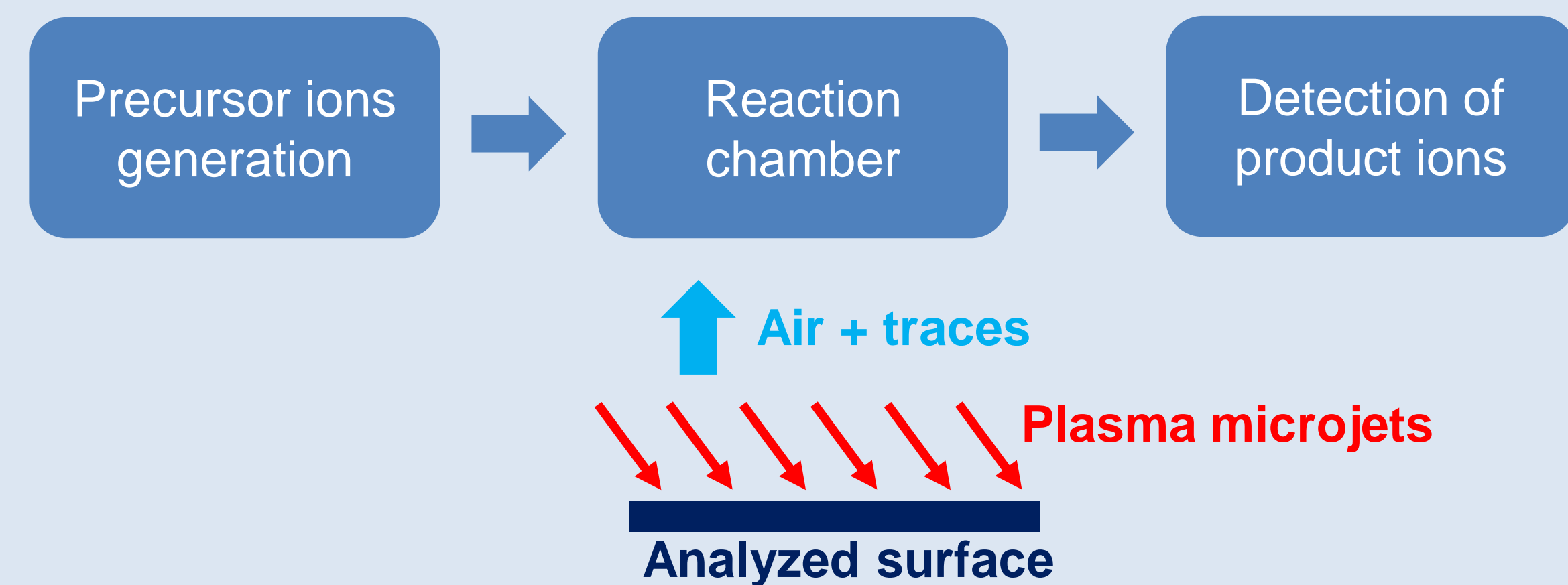
³ AlyXan, Juvisy sur Orge, France

Introduction.

The objective of our instrument is the detection of Volatile Organic Compounds (VOCs) at trace level either in air or deposited on surfaces. The mass analyzer is a drift tube associated with a linear quadrupole and we are designing a linear ion trap for a more compact version. We will use plasma microjets in order to desorb molecules of low volatility deposited on surfaces.

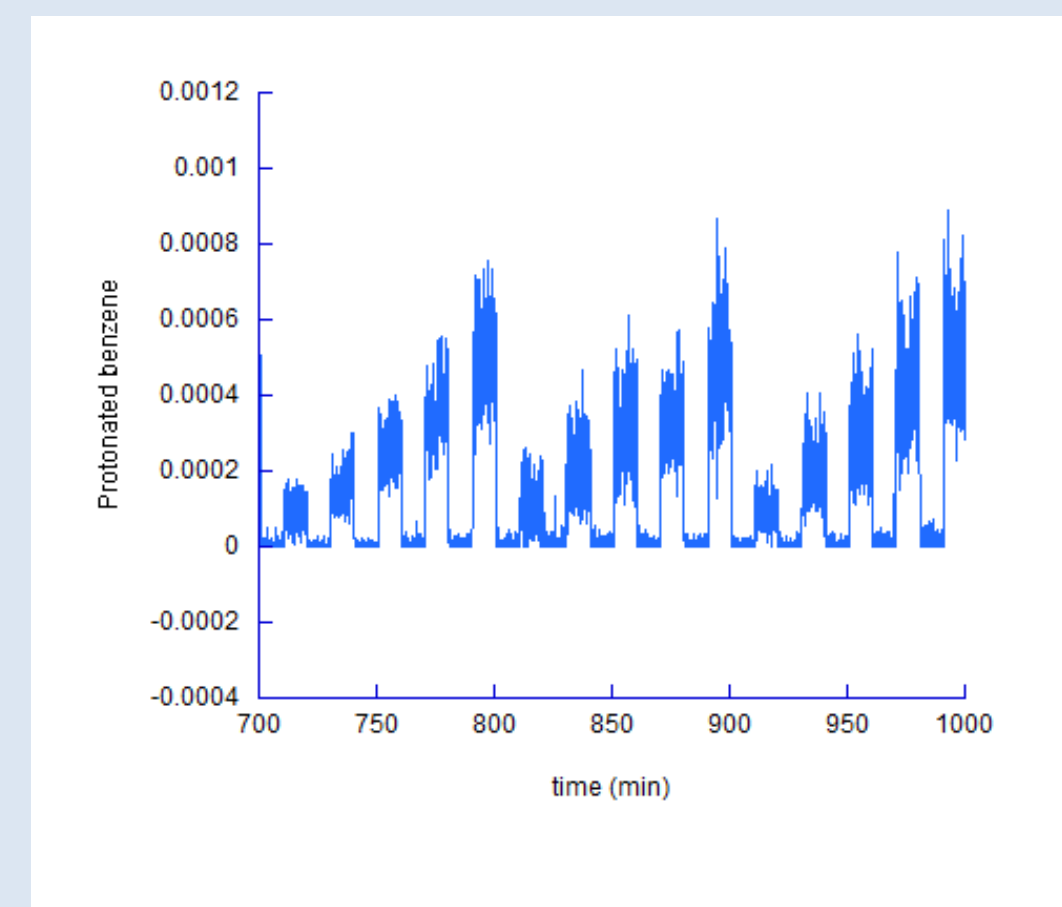
In the first version of our instrument precursor ions are formed in a glow discharge, then react with the air at a pressure of about 1 mbar in the drift tube and are then mass analyzed with a quadrupole mass filter.

In the next version we will use a micro hollow cathode for the production of the precursor ions and an ion trap for the mass analysis.



Drift tube

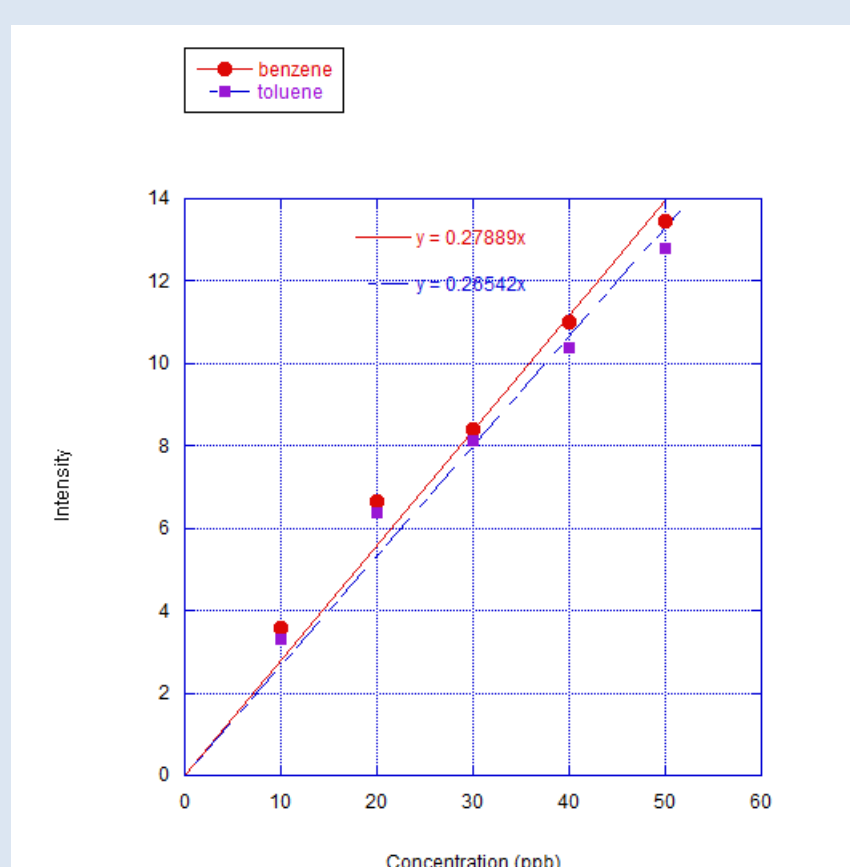
Precursor ions are produced in a glow discharge and react with the air sample to be analyzed in the drift tube at a pressure of about 1 mbar. Here water vapor is introduced in the glow discharge, leading to the formation of H_3O^+ precursor ions. They will react by proton transfer with the organic compounds present at trace level in air.



The detection with the drift tube is characterized using benzene /toluene/xylene diluted in air at concentrations between 10 ppb and 50 ppm (10 to 50 ppb on the figure)



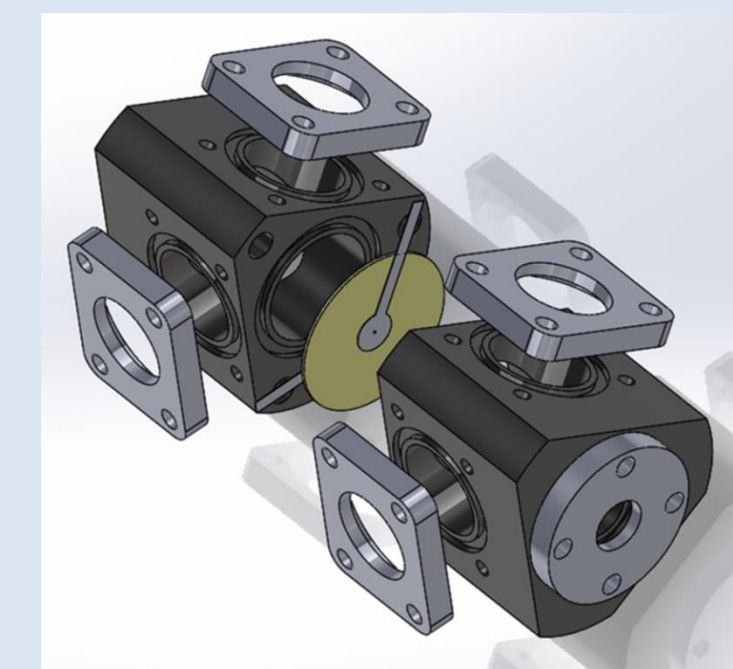
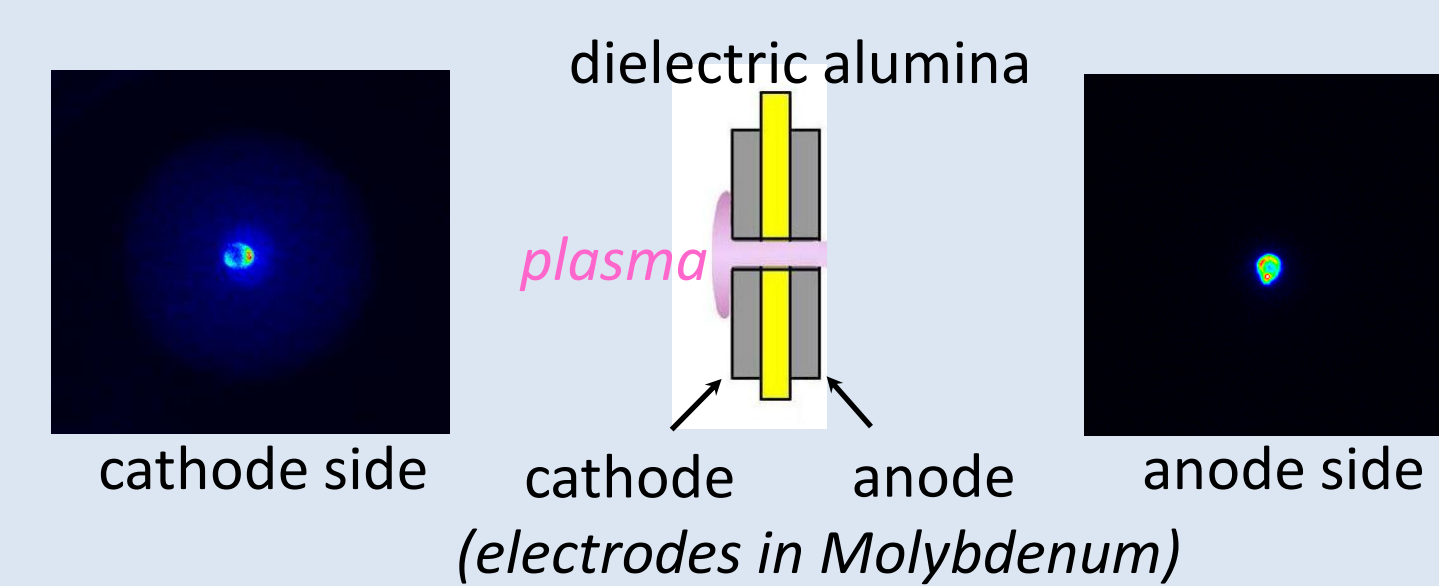
A gas diluter (Zephyr from Alytech) and a zero air generator (Quad service) are used to generate samples at known concentration in the ppb range by dilution of a bottle containing the COVs at 20ppm in air.



Benzene and toluene ion signal intensity versus concentration. With the current configuration the LOD is ~10ppb

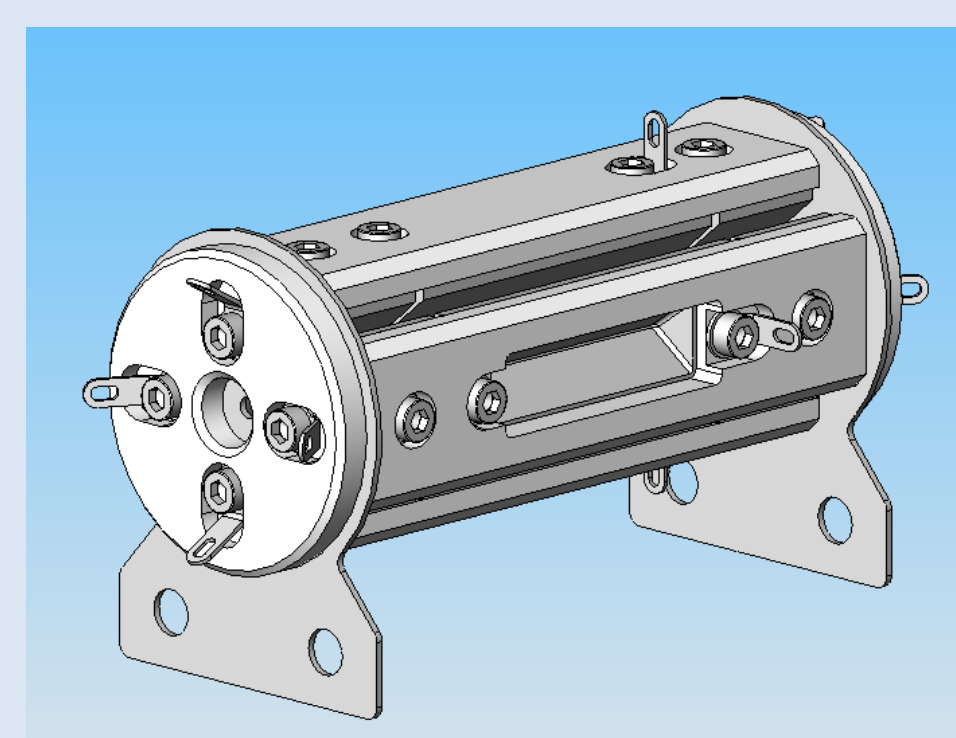
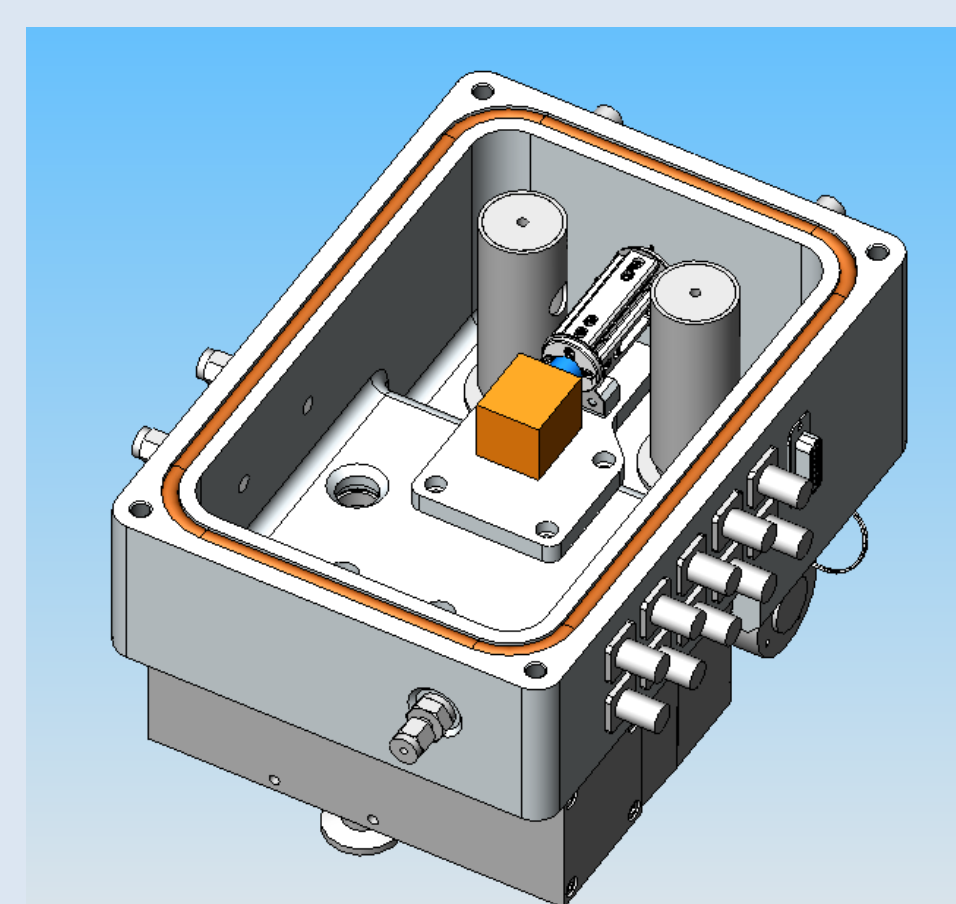
We plan to test the addition of an Einzel lens or a small ion guide to further improve the transmission.

MHCD ion source



The Micro Hollow Cathode Discharge (MHCD) will be operated using an Ar/ H_2O mixture to produce the H_3O^+ precursor ions.

Linear Ion Trap



In a second version of the instrument the linear quadrupole will be replaced by a linear ion trap.

The ion trap will be operated with air as the buffer gas. As the ion trap works at much higher pressures than the linear quadrupole the instrument will be much more compact (and the pumps smaller)

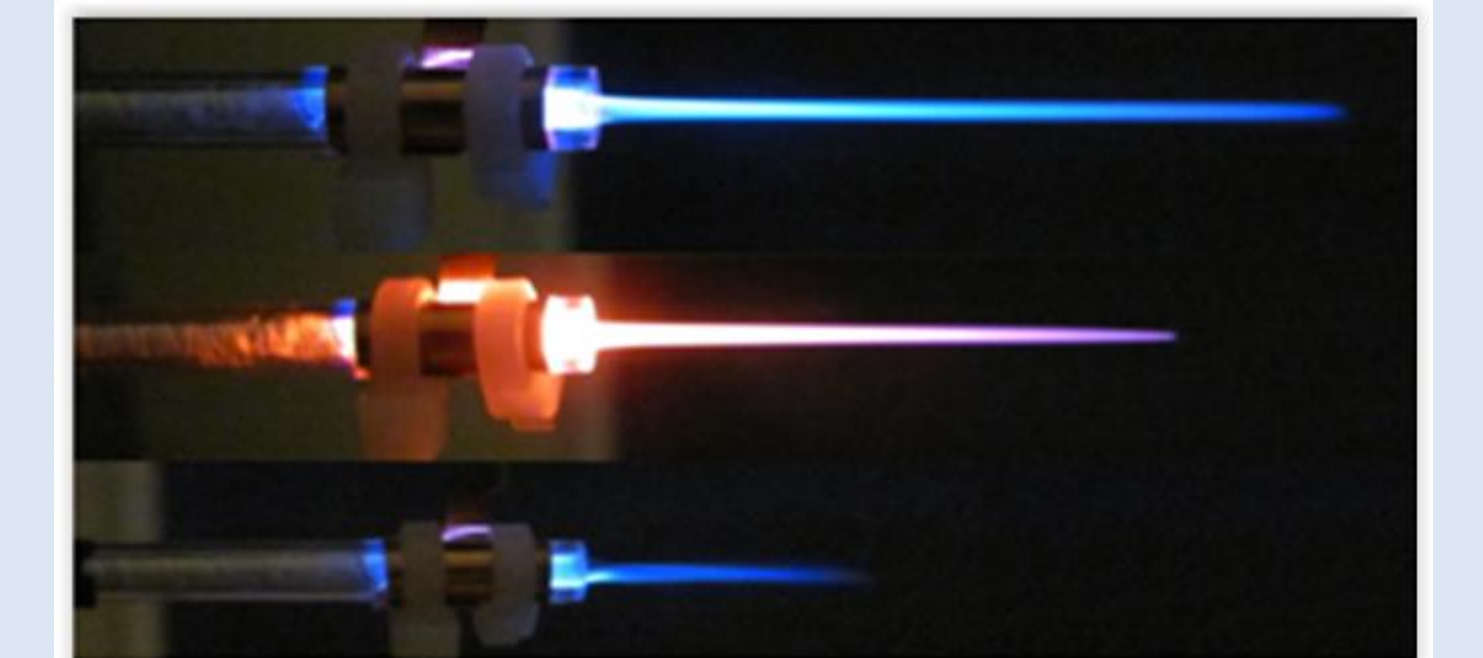
It will also be possible to do MS/MS experiments for a better identification of the organic molecules present in air.

Plasma microjets

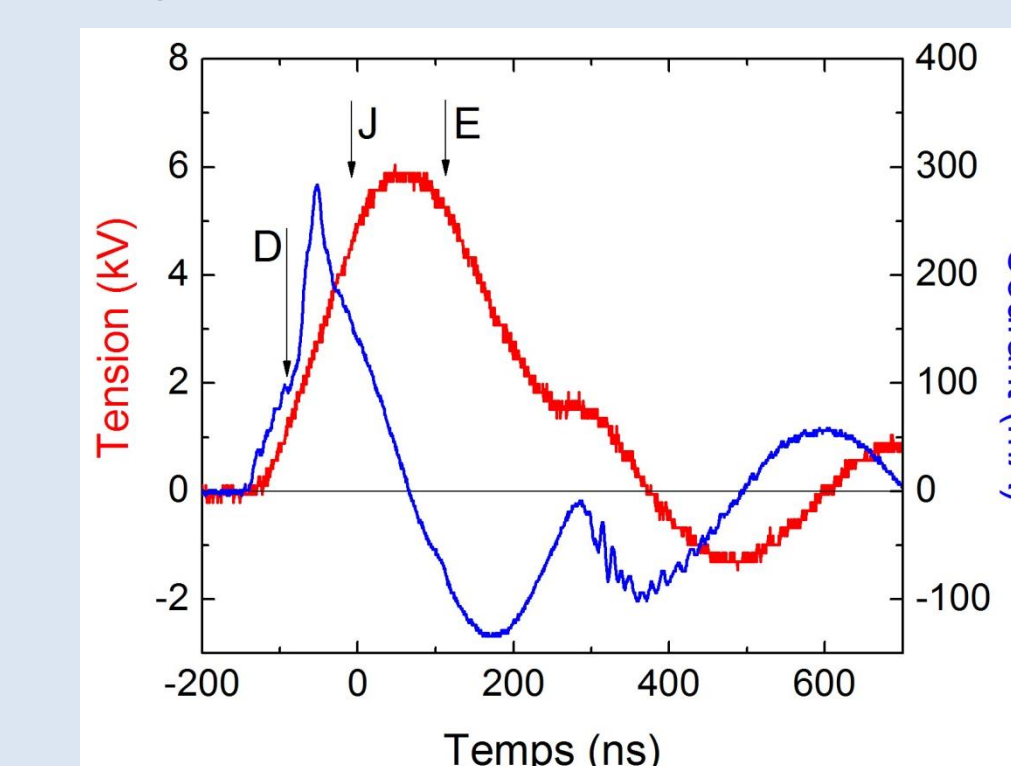
Helium
Flow 2000 sccm – 6kV

Neon
Flow 500 sccm – 6kV

Argon
Flow 200 sccm – 6kV

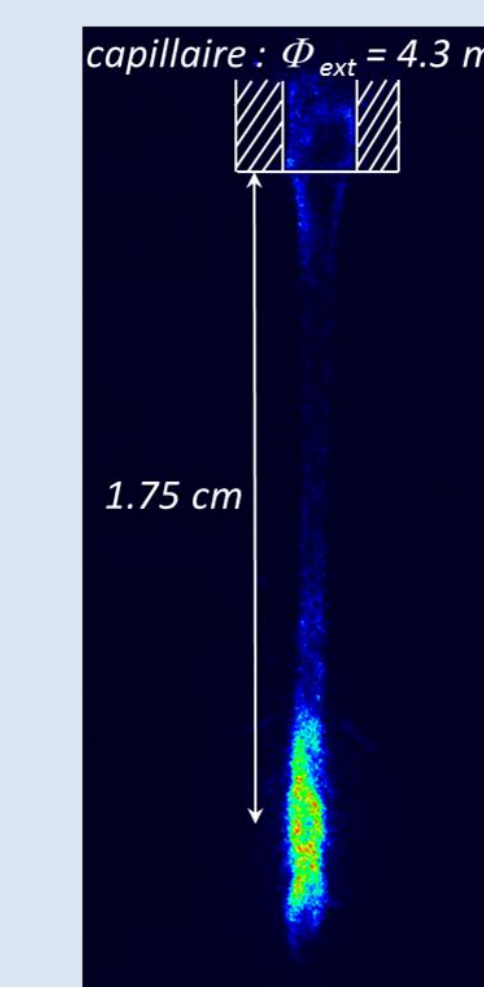


Argon plasma microjets have been studied and will be used to desorb molecules deposited on surfaces. With argon the microjet can be operated with a smaller gas flow.

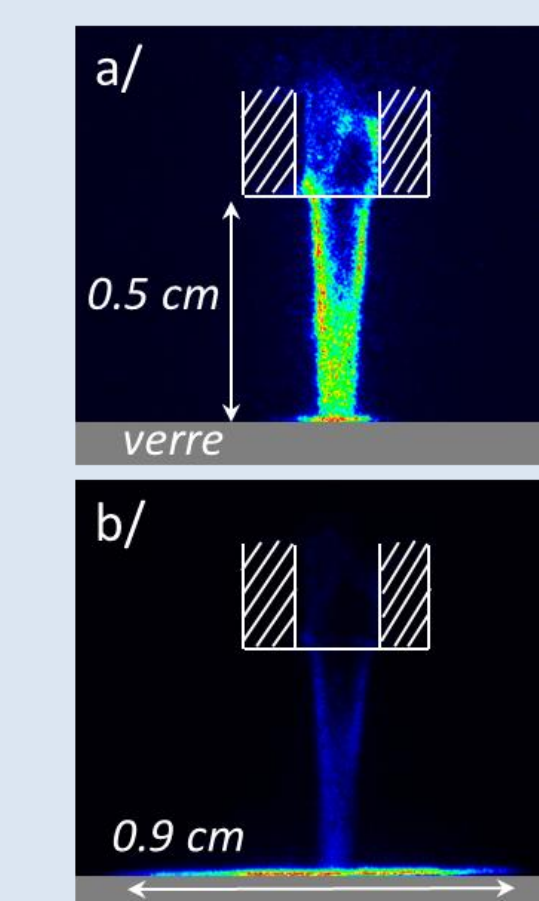


The electrical behavior of the argon microplasma jet is shown here (temporal evolutions of voltage and current for a frequency of 20 kHz)

D : beginning of the dielectric barrier discharge.
J : beginning of the plasma propagation out of the quartz capillary.
E : example of plasma fluorescence shown below



The ionization front of the plasma is followed as a function of time using an intensified camera to visualize the fluorescence of plasma excited species. The image is for an argon microjet free in air and corresponds to time E.



Interaction of the plasma microjet with surfaces:

When a glass surface is placed at a short distance from the exit of the quartz capillary the interaction of the plasma with the surface is seen.

The propagation of the plasma is followed using the time resolved camera. At longer times the plasma spreads on the surface.

Contact : joel.lemaire@u-psud.fr

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