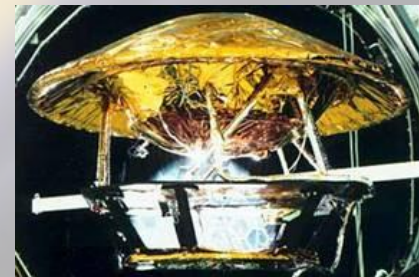


# LISA-GPCOS Titan's Investigations

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Fifth Workshop on  
'Titan - Observations, Experiments, Computations, and Modeling'  
Poipu Koloa, Kauai, Hawaii, April 11-14, 2011

# Aim of the studies - outline

determine the nature and estimate the relative abundances of organic species present in the atmosphere of the satellite

☞ Low temperature high resolution spectra (UVIS data)

☞ New infrared line list (CIRS data)

establish their mechanisms of formation and evolution in Titan's environmental conditions

☞ Titan's laboratory simulations:

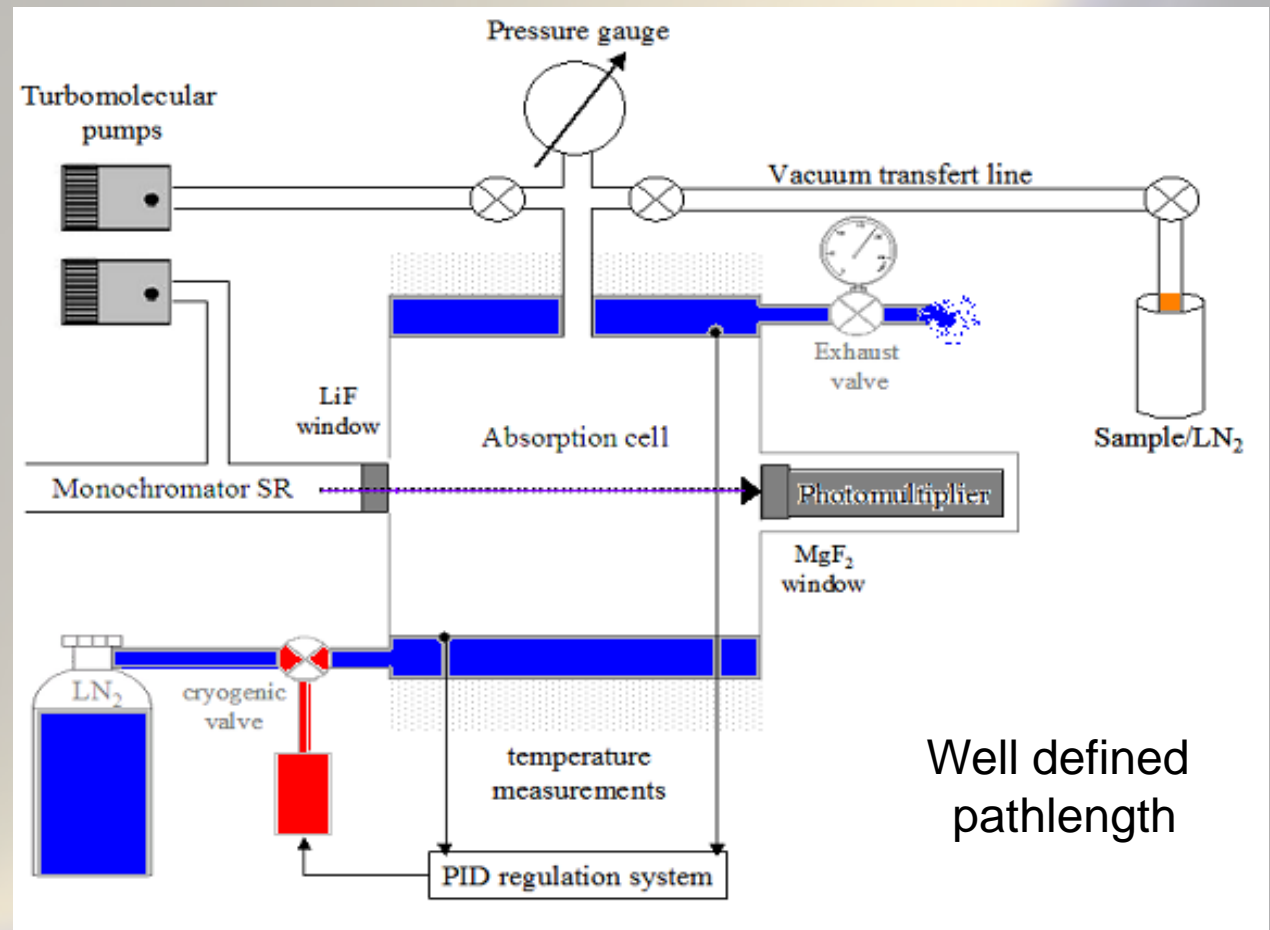
★ DC Current plasma experiments-tholins

★ Microwave plasma experiments-gas phase

★ Afterglow plasma experiments-gas phase

# determination of near VUV absorption coefficients (and their T dependence)

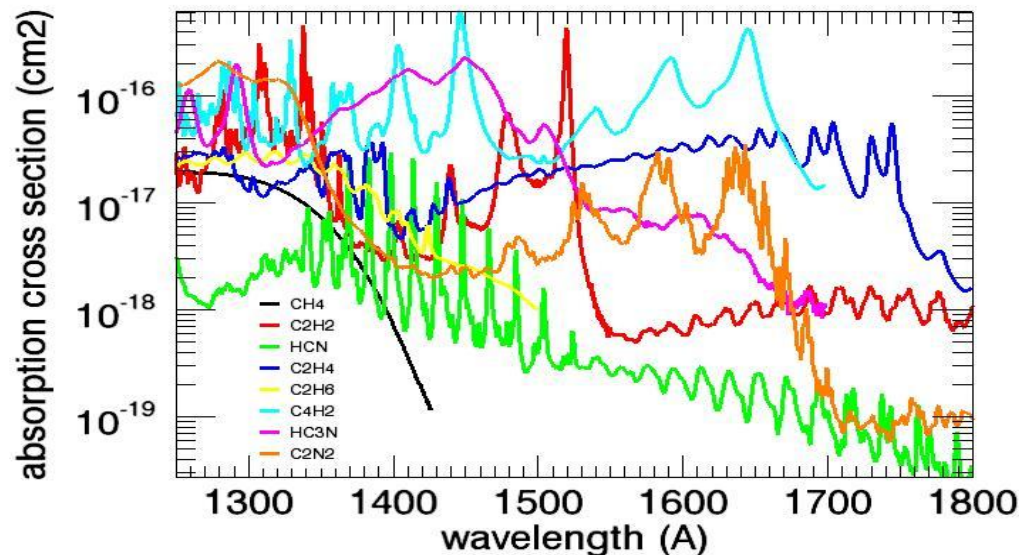
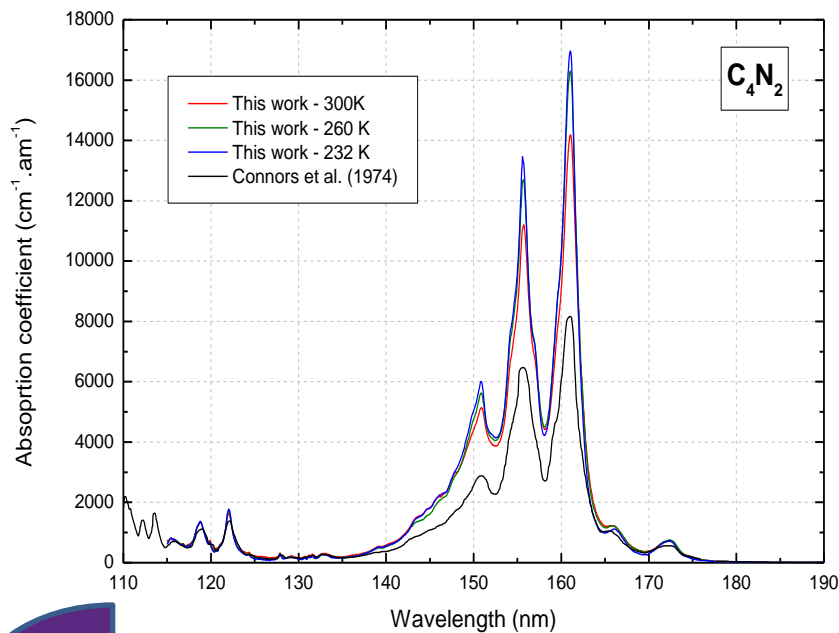
Synchrotron radiation (VUV-UV)



Studies on gas phase species  $\text{HC}_3\text{N}$ ,  $\text{HC}_5\text{N}$ ,  $\text{C}_4\text{H}_2$  already published

# New results:

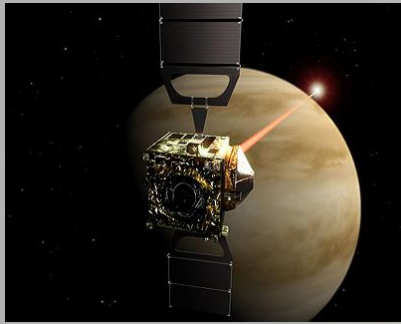
	Wavelength range (Å)	Resolution (Å)	T(K)
HCN	1150-1850	0.6	295, 195
C <sub>2</sub> N <sub>2</sub>	1150 -1900	1	298, 185
C <sub>4</sub> N <sub>2</sub>	1150-1850	1	300, 260, 232



Temperature variations !  
Saturation !

➔ Still a lot to do  
...on longer chains species such as C<sub>6</sub>H<sub>2</sub>  
....as well as C<sub>6</sub>H<sub>6</sub> ...

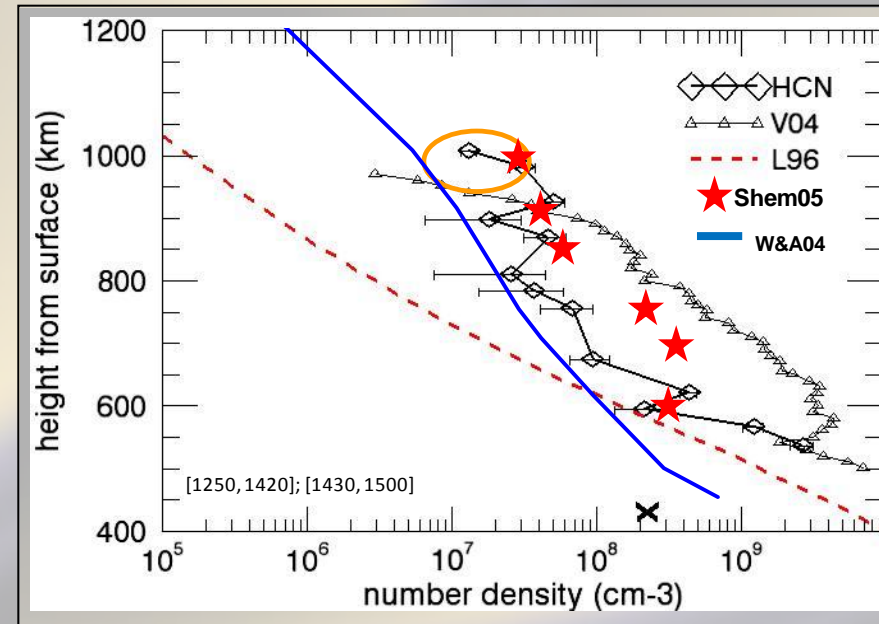
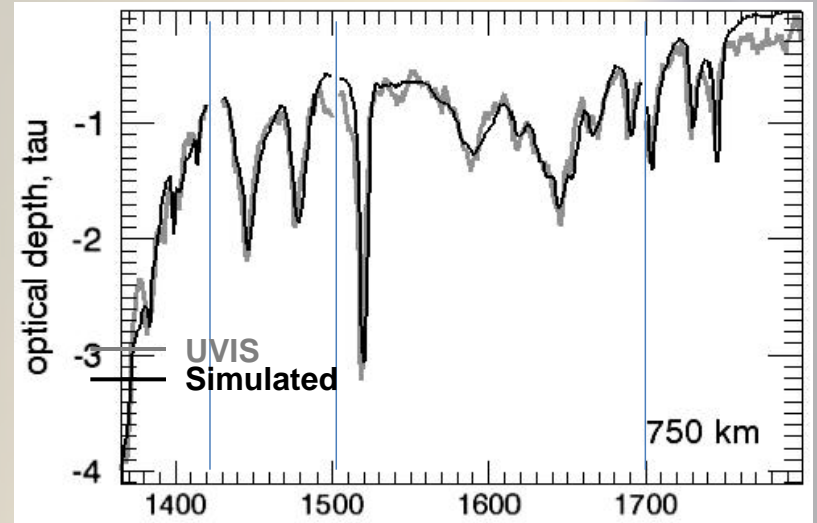
# Application to UVIS occultation data



☞ All spectra obtained used for reanalysis of TB data: Lambda Scorpio -> nice fit obs/updated model data

☞ new retrieval of density profiles from UVIS observations of Titan's atmosphere

example HCN



Models: Lara et al. (1996), Wilson & Atreya (2004)

Observations: UVS Vervack et al. (2004), UVIS Shemansky et al. (2005)

# determination of IR linelists

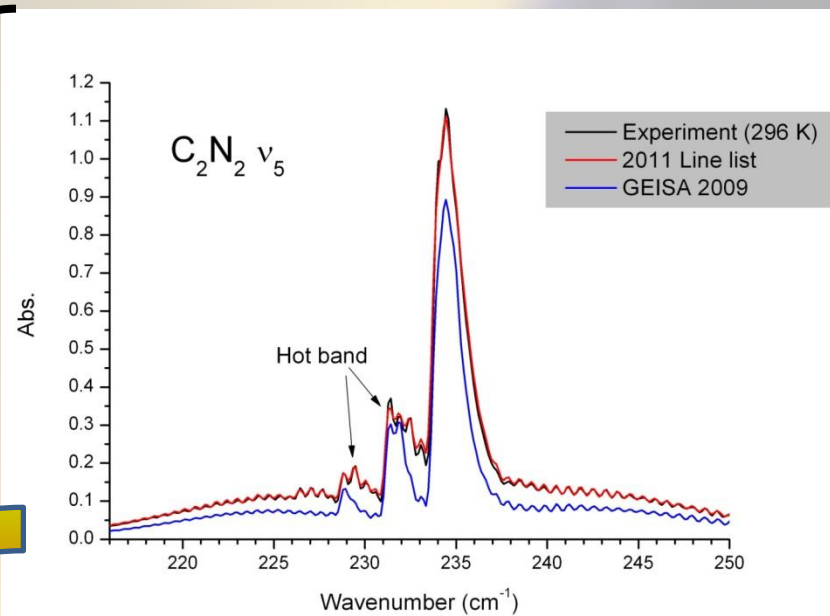
Linelist for  $\text{HC}_3\text{N}$  ( $+^{13}\text{C} + ^{15}\text{N}$ ),  $\text{C}_2\text{HD}$  and  $\text{C}_4\text{H}_2$  ( $+^{13}\text{C}$ ) already published

**New results:  $\text{C}_2\text{N}_2$**

Soleil Synchrotron facility (AILES):

band intensity measurement for  $\text{C}_2\text{N}_2$  and  $^{15}\text{N}$  isotopologue (resolution: 0.1 and 0.5  $\text{cm}^{-1}$ )

high resolution spectra: 0.0015  $\text{cm}^{-1}$  and complete analysis of the  $\nu_5$  band system



New line list allowed a better agreement with exp data than the one of Geisa database

• First line list for the  $+^{13}\text{C} + ^{15}\text{N}$  isotopologues now available -> A. Jolly

# CIRS detection and quantification in Titan using new line list

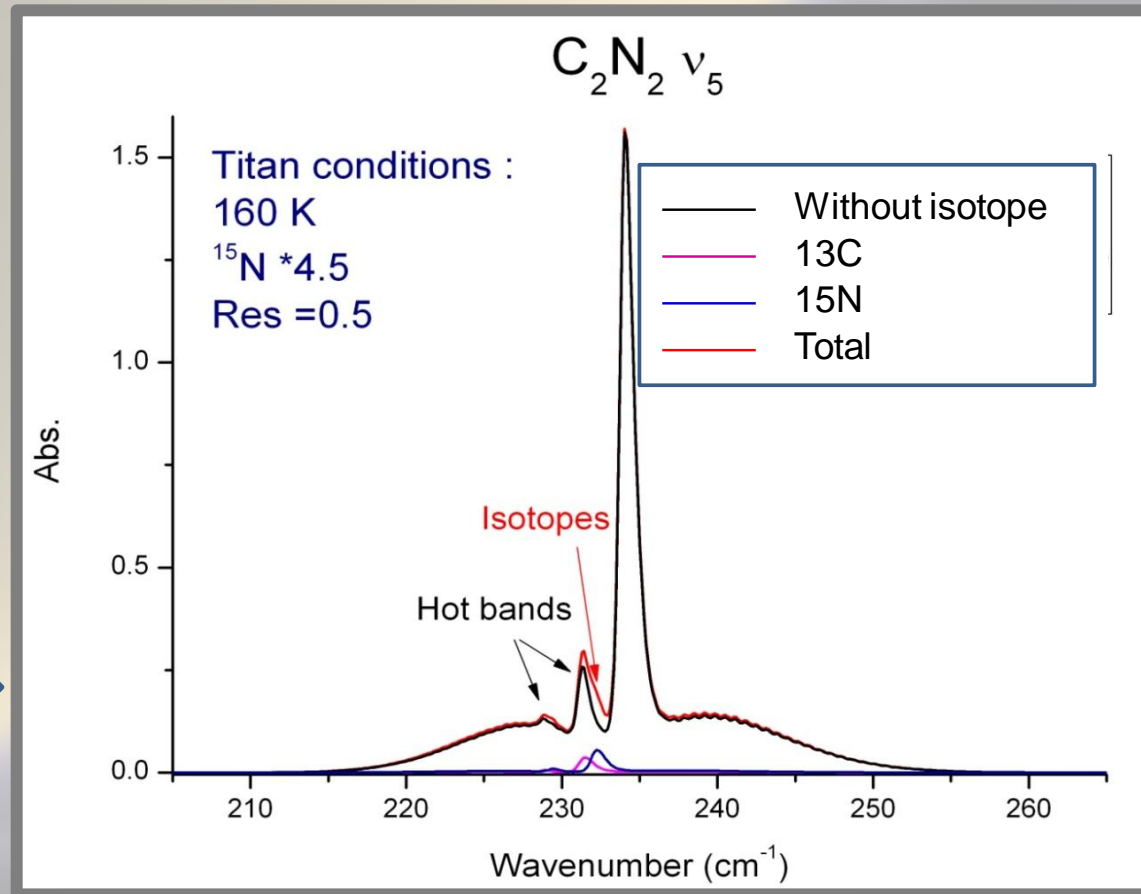
already done for  $\text{HC}_3\text{N}$  ( $+^{13}\text{C}$ ),  $\text{C}_2\text{HD}$  and  $\text{C}_4\text{H}_2$  ( $+^{13}\text{C}$ )

Looking for  $^{15}\text{N}$  species: (it turns to be difficult for  $\text{HC}_3\text{N}$ )

☞ The recent work on  $\text{C}_2\text{N}_2$  should provide the opportunity to search for  $\text{C}_2^{15}\text{N}_2$  even if this task remains difficult as the line between the isotopes are still close...



Important to provide new constraint on  $^{15}\text{N}/^{14}\text{N}$  in Titan's atmosphere

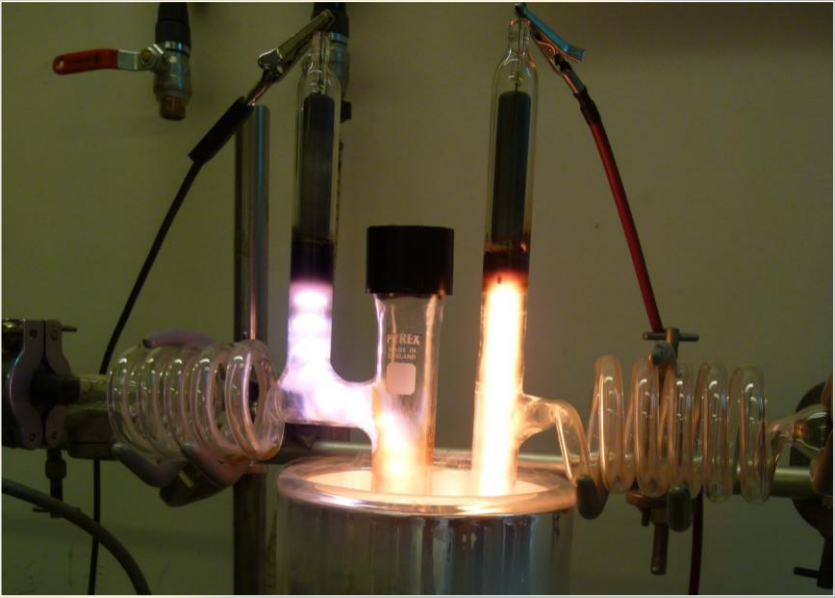


# Direct current plasma discharge experiments

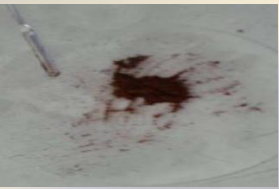
👉 Devoted to the characterization of Titan's Tholins

May Titan's aerosols efficiently interact with the surface to produce compounds of Astrobiological interest ???

**$N_2 + 2\% CH_4$**   
**low P (~ 1 mbar)**  
**-room or low T (~ 200Km)**



recovery  
➔



Solution of  
➔  
10 mg of  
tholins



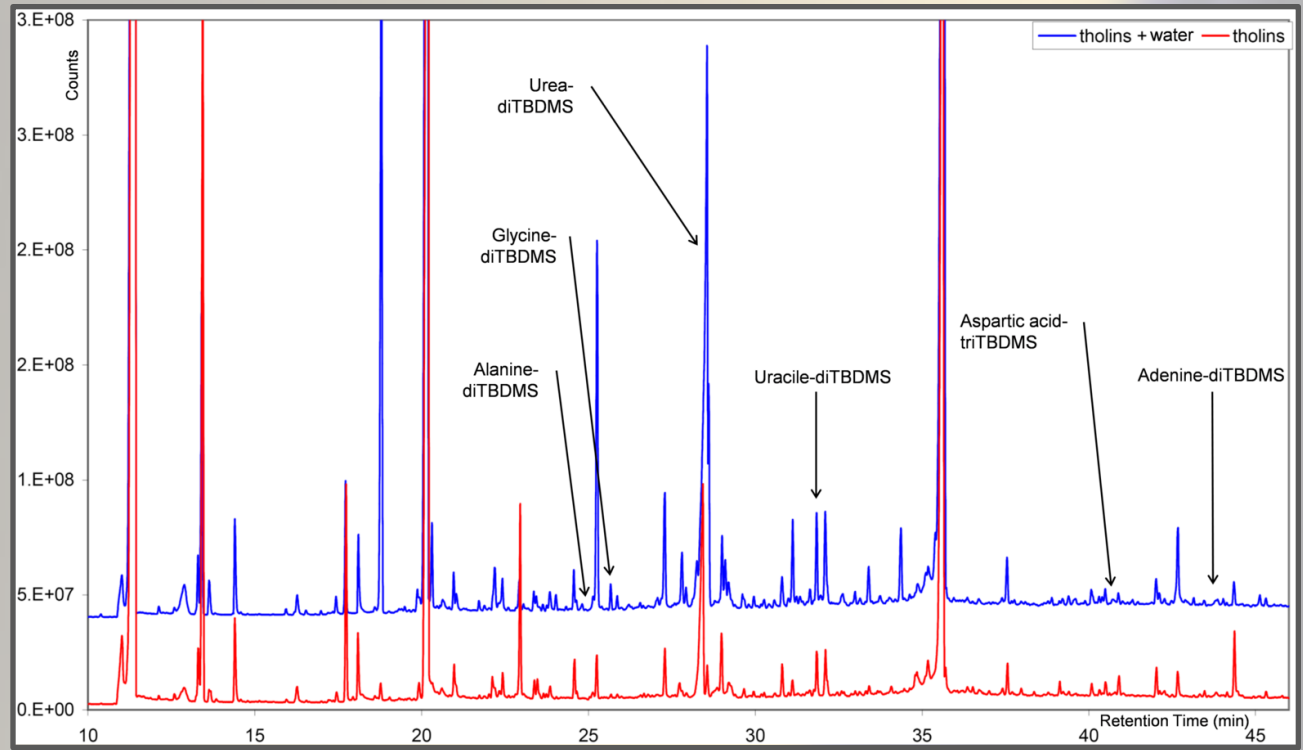
➔ GCMS  
analysis  
after  
derivatization

in liquid water (4 mL) to 6°C  
in ammonia 25% (4 mL) to 6°C and -20°C  
for 10 weeks

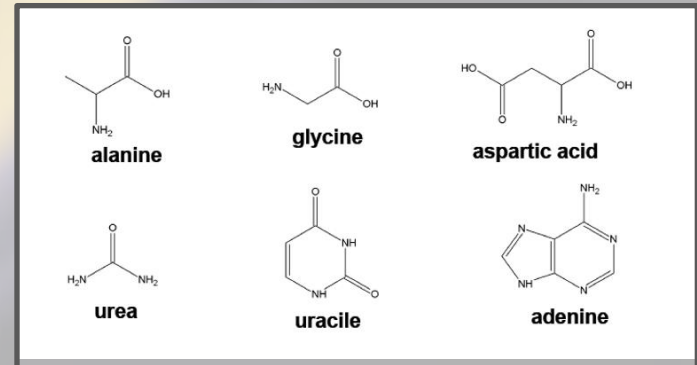
# Results:

Chromatogram  
Tholins hydrolyzed  
in water

Identification  
and  
quantification  
by  
standards



Formation of compounds of prebiotic interest,  
Urea = main compound of tholins hydrolysis in  
ammonia (production yield 10%);  
amino acids: glycine, alanine and aspartic acid  
(low yields < 0.35%)



After sedimentation on Titan's surface, the aerosols could undergo  
chemical evolution in liquid ammonia-water aera leading to molecule  
of astrobiological interest

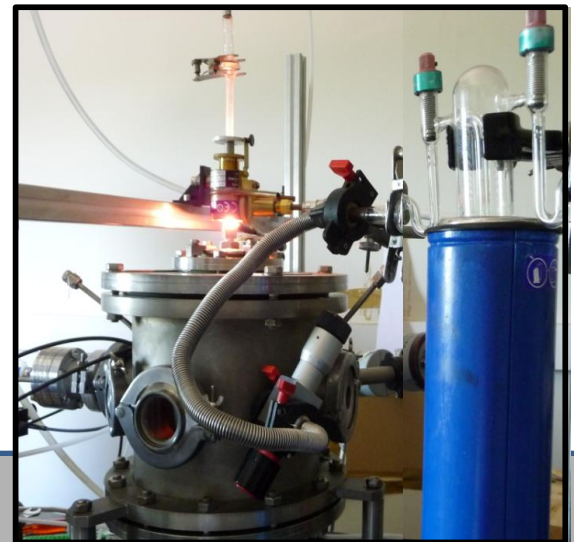
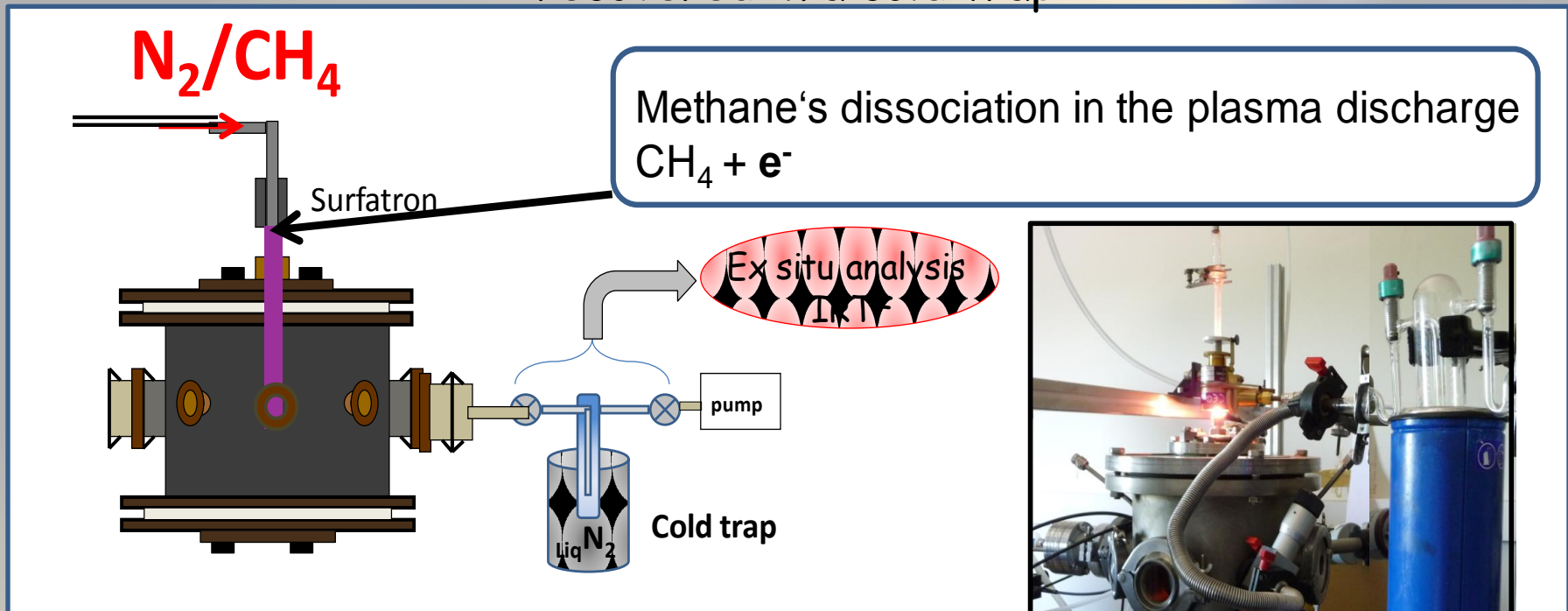
# Microwave plasma discharge experiments

(S.E.T.U.P. Experimental and Theoretical Simulations Useful of Planetology)

Simulations of Titan's atmosphere

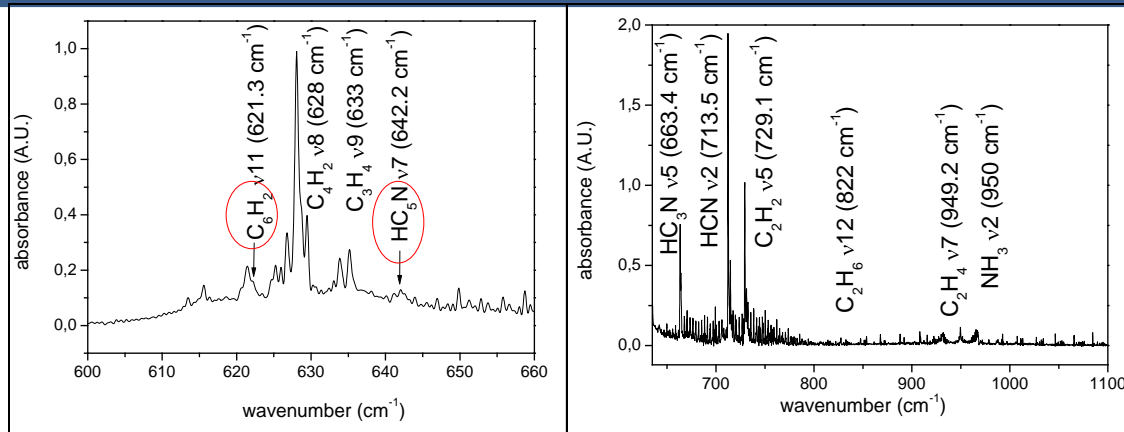
Experiment devoted to the characterization of the gaseous phase in terms of composition and evolution

$N_2/CH_4$  gas mixture with various mixing ratio, in flow conditions  
Ex-situ IRTF analysis of the resulting gas mixture  
recovered in a cold trap



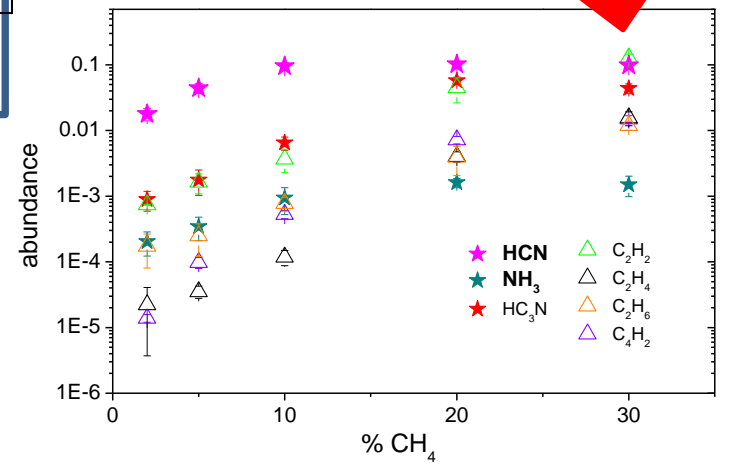
Exp conditions: 100W, Total pressure: 3.6 torr  
Total flow rate: 50 sccm

# New results:

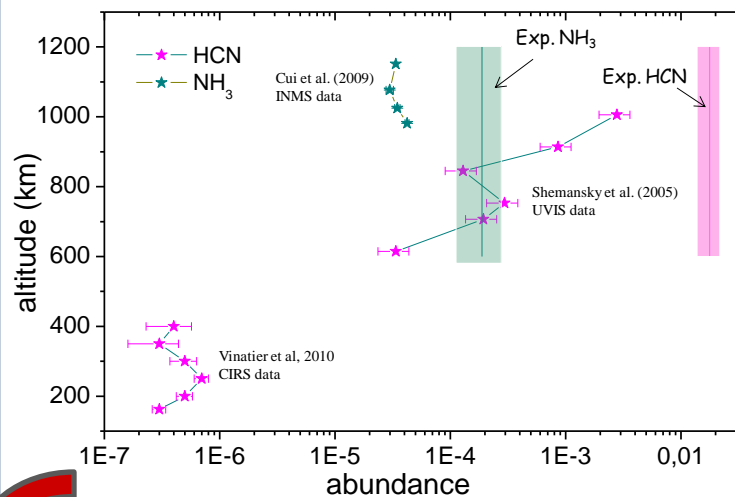


**N<sub>2</sub>/CH<sub>4</sub>: 70/30**

Typical spectrum obtained revealing the formation of several compounds including C<sub>6</sub>H<sub>2</sub> and HC<sub>5</sub>N. For each exp., the respective abundance of the products has been derived:



Comparison between exp. and obs. data:



Plasma experiments	Upper atmosphere
high energetic e <sup>-</sup>	high energetic e <sup>-</sup> + photons
T gas ~ 1000K	T lower than 180 K



**Microwave plasma exp. can not be considered as representative simulations**

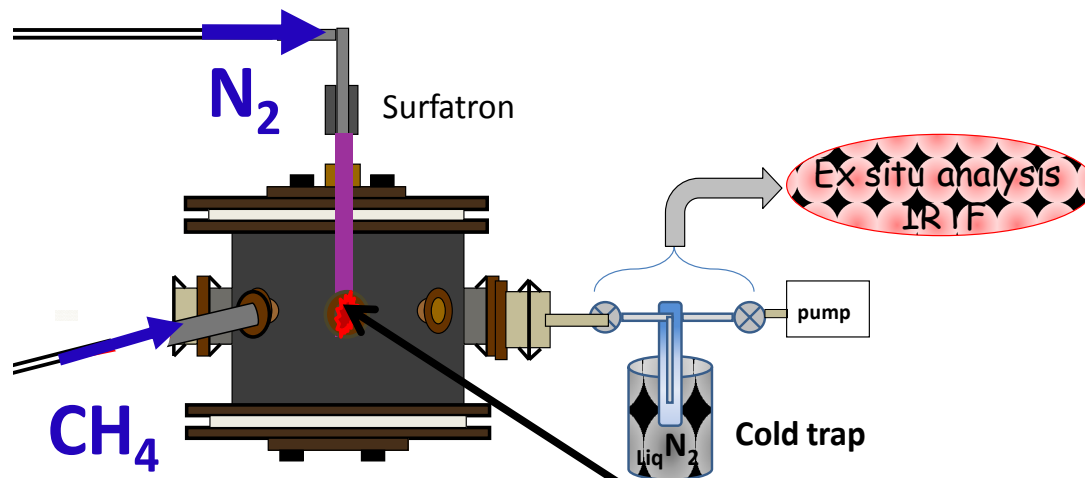
# Afterglow microwave plasma experiments

Plasma  $N_2$

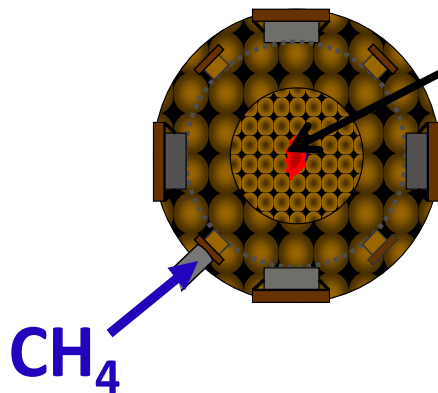
$CH_4$  added in the post discharge (afterglow region)

$T_{\text{gas}} \sim 300 \text{ K}$  (representativeness improved)

various ( $N_2/CH_4$ ) mixing ratio



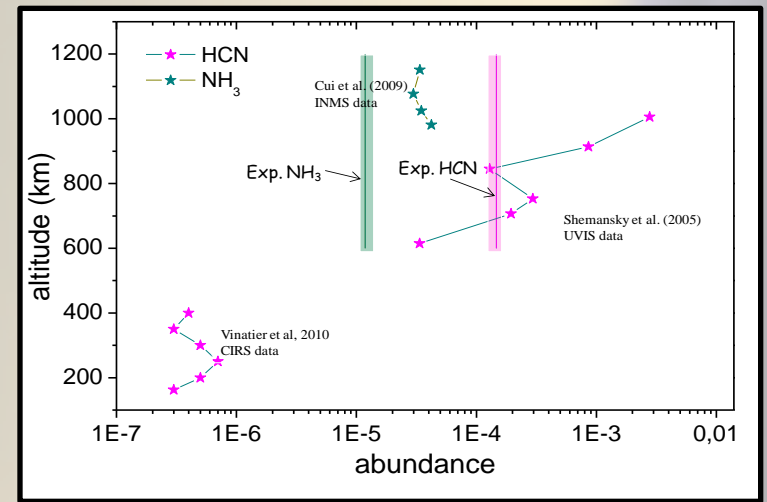
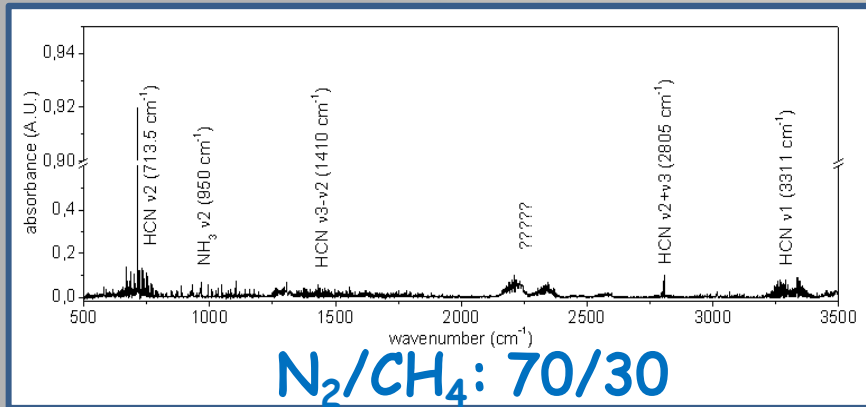
Methane's dissociation in the interaction zone  
 $CH_4 + N_2(A), N_2(a')$  and  $N(^2D)$



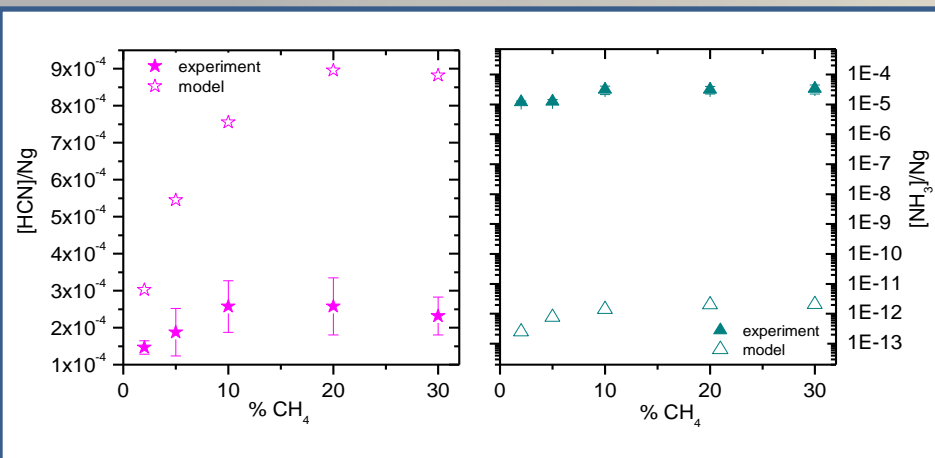
A self-consistent kinetic model for the afterglow of a flowing microwave discharge in pure  $N_2$ , in which various % of  $CH_4$  are introduced has been developed by Pintassilgo and co-workers

# New results:

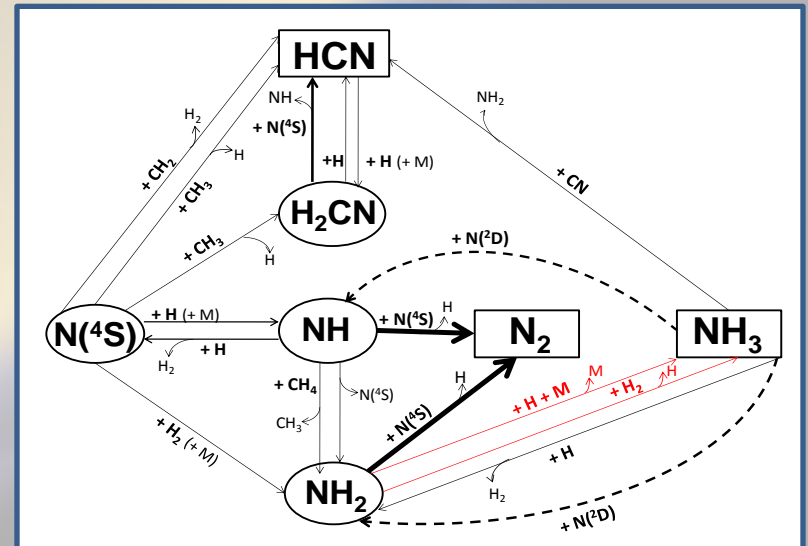
Only **HCN** and **NH<sub>3</sub>** are formed!



**Fit exp/observational data improved**



**Strong disagreement for NH<sub>3</sub>**

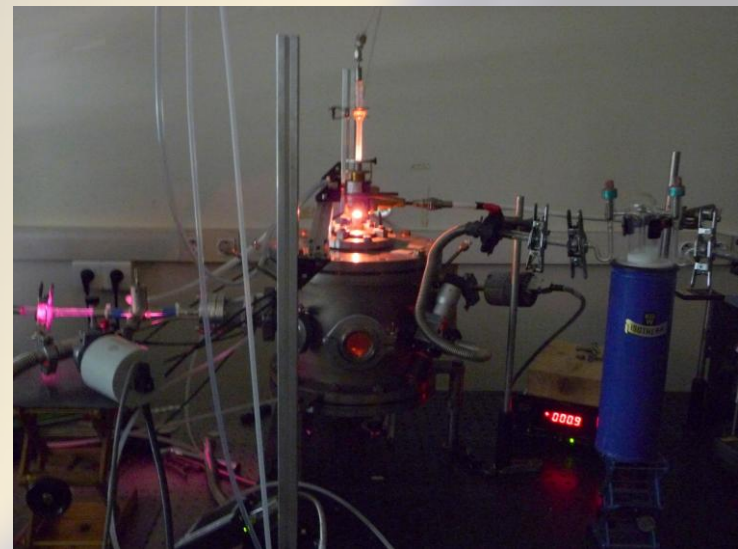
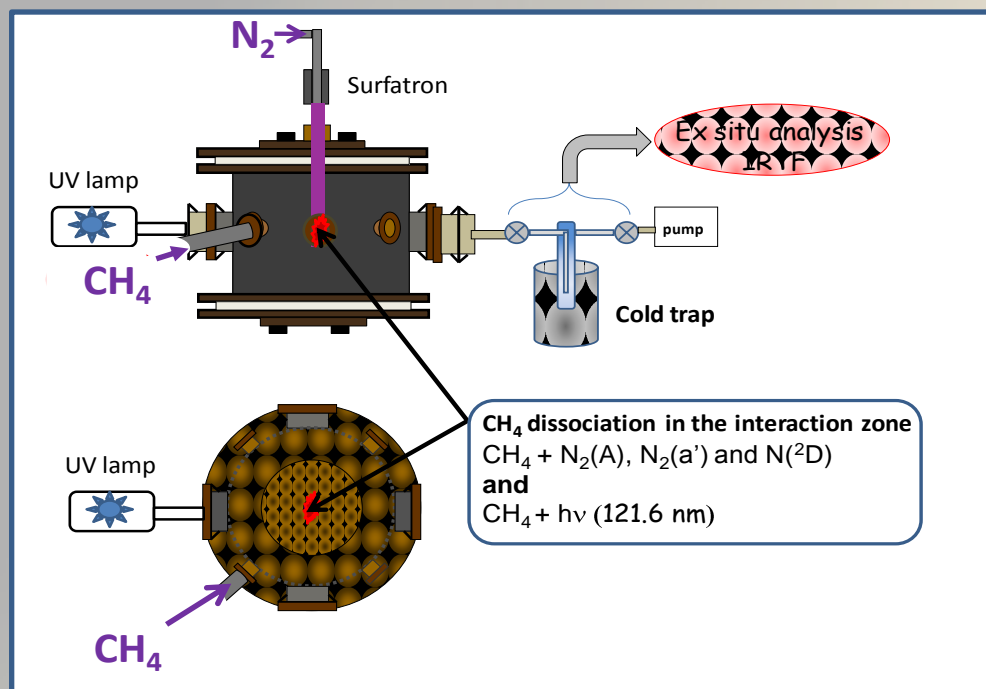


**Need for description of surface reactions**

## Work in progress:

**Coupled** experiments are currently performed:  $\text{CH}_4$  injected into the post discharge downstream from the  $\text{N}_2$  discharge is submitted to UV photons ( $\text{H}_2/\text{He}$  lamp)

-> disentangle the processes that occurs in the plasma from those due to the methane photochemistry itself.



## Next step:

Implementation of in situ analysis by CRDS time resolved technique (quantitative data)

→ Achieve a better understanding of the chemical mechanisms involved

# LISA TEAM COWORKERS



**Yves  
Benilan**



**Patrice  
Coll**



**Herve  
Cottin**



**Nicolas  
Fray**



**Antoine  
Jolly**



**Marie-Claire  
Gazeau**



**François  
Raulin**



**Robert  
Sternberg**



**Emmanuel  
Arzoumanian**



**Fernando  
Capalbo**



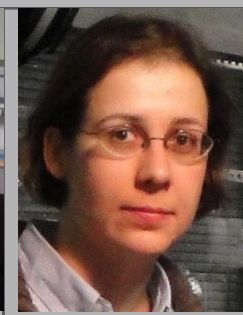
**Et touhami  
Es Sebbar**



**Yuan  
Guan**



**Olivier  
Poch**



**Claire  
Romanzin**

# THANKS TO COLLABORATORS!

Low temperature high resolution spectra (UVIS data)

Guillemin J.-C., Yelle R.

New infrared line list (CIRS data)

Fayt A., Jacquemart D., Nixon C.A., Jennings D.E., Teanby N.A

DC Current plasma experiments-tholins

Ramirez S., Buch A., Szopa C., Munoz O.

Microwave plasma experiments-gas phase

Afterglow plasma experiments-gas phase

Pintassilgo C.

fundings from



**THANKS FOR  
YOUR ATTENTION !**