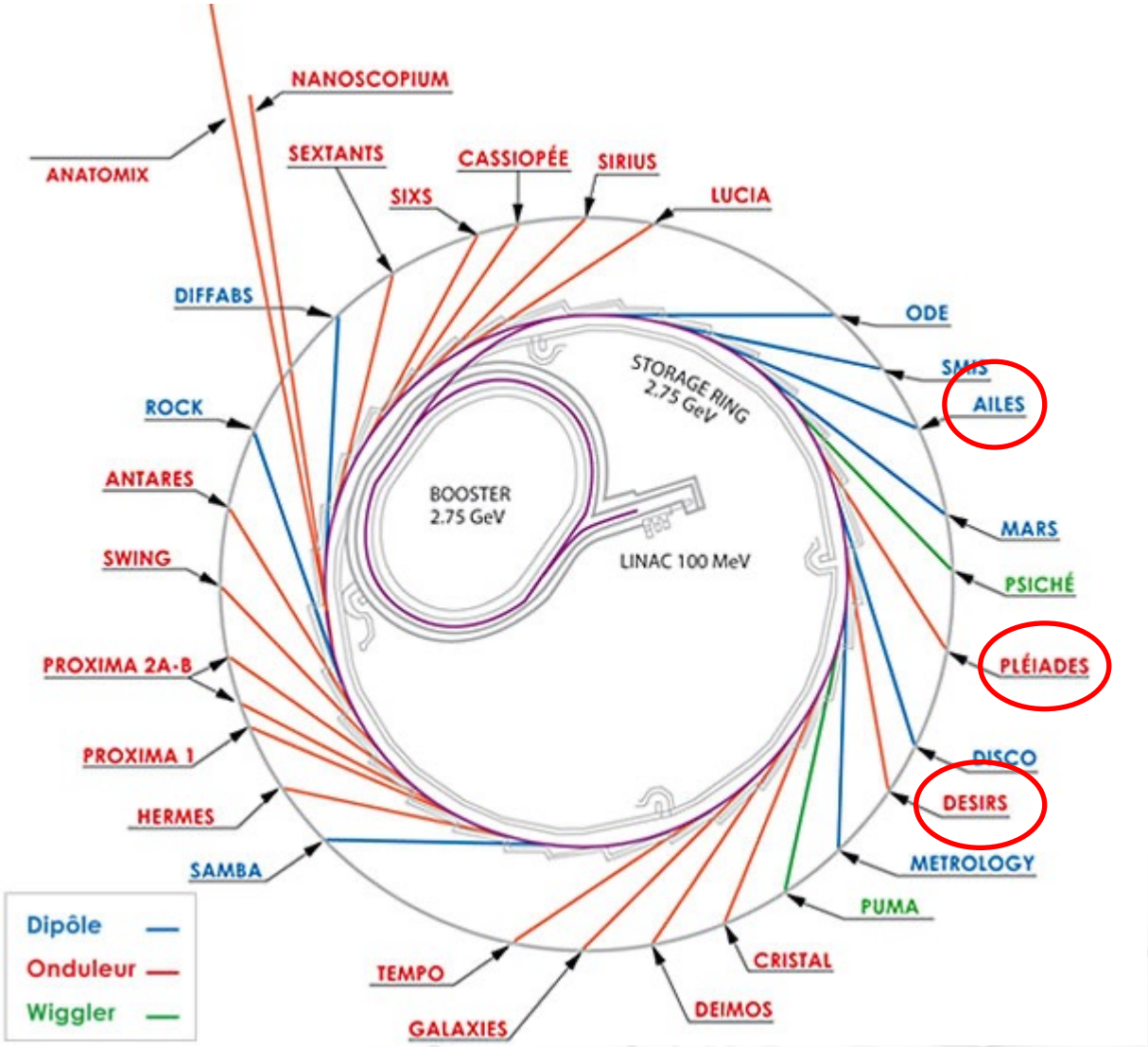
HIGH RESOLUTION VACUUM ULTRAVIOLET ABSORPTION SPECTROSCOPY ON THE DESIRS BEAMLINE @ SOLEIL

29 beamlines



Outline

- The DESIRS beamline
- Absorption spectroscopy in the UV-VUV
  - The VUV-FTS branch
  - Spectroscopy of Radicals : OH
  - … and atoms : XeII
- Conclusion

Valence-shell excitations in the gas and condensed phase (5-40 eV)

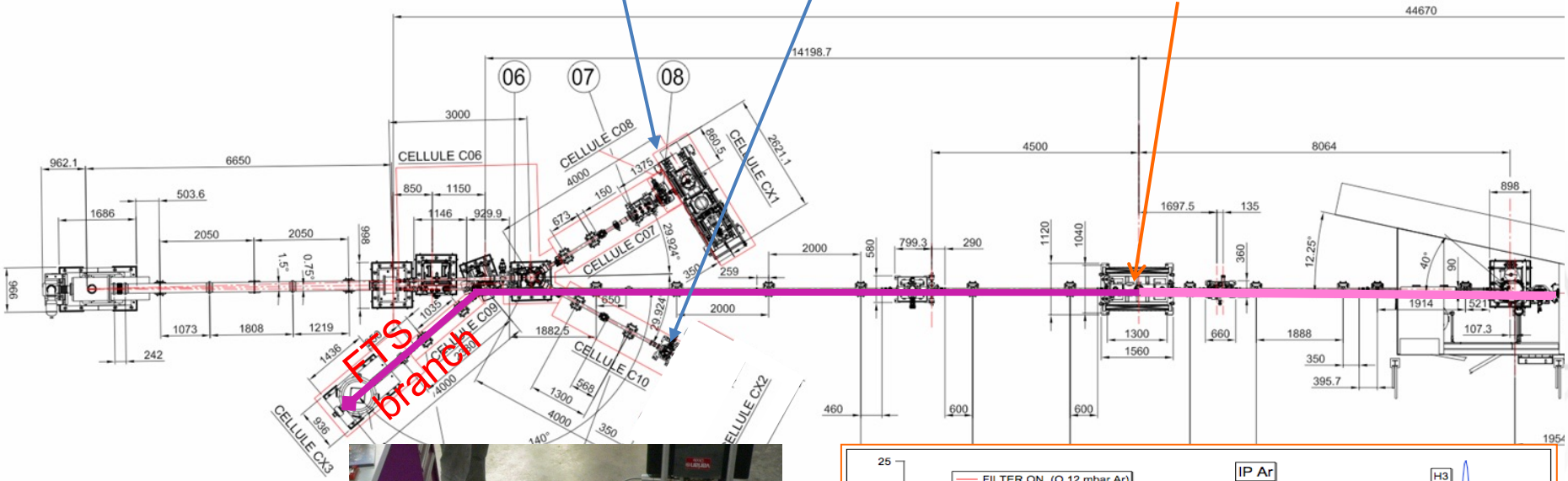
1. **High resolution spectroscopy : VUV-FTS**
   - **$CO, CO_2, N_2, H_2, HD, D_2, He, C_2H_4, C_2H_2$ etc…**
   - **Transient species.**
2. **Spectroscopy, fragmentation and reactivity of state-selected ions : DELICIOUS**
3. **Tandem Mass Spec : SRMS2**
4. **Chemical reactivity : ion/neutral, neutral @ RT, cold neutrals**
5. **Photoionization dynamics (AR-PES/ i2PEPICO) : DELICIOUS**
   - **cold molecules, laser-excited species, clusters, nanoparticles**
6. **Dichroism & chirality : DELICIOUS**
   - **gas phase (PECD, CDAD) , condensed matter/homochirality**
7. **Excitation and relaxation in the condensed phase**

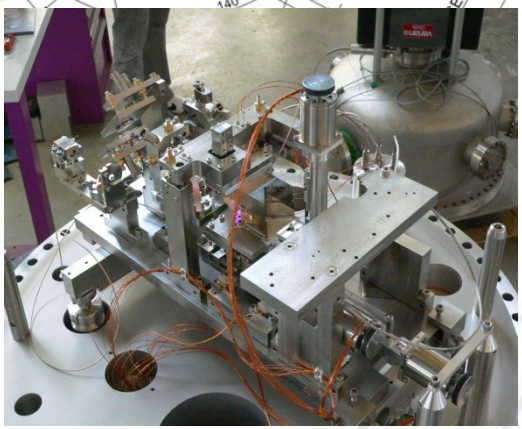
35 % of the proposals are astro-related:
astrophysics, astrochemistry, astrobiology

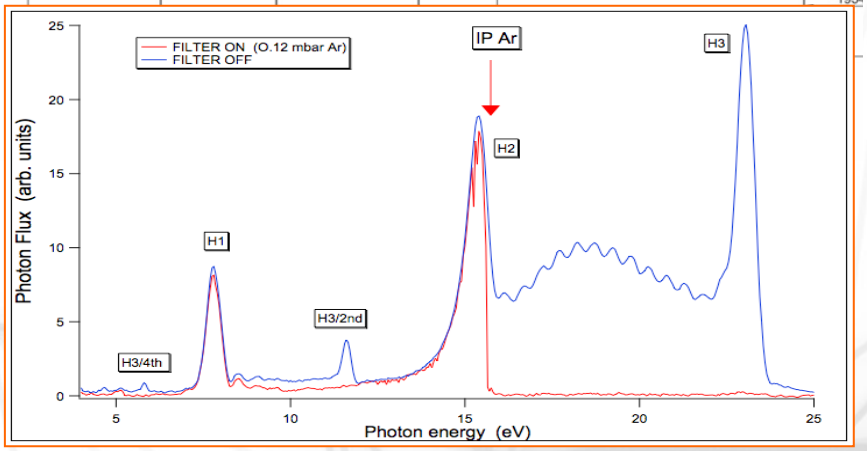
The DESIRS beamline

DELICIOUS

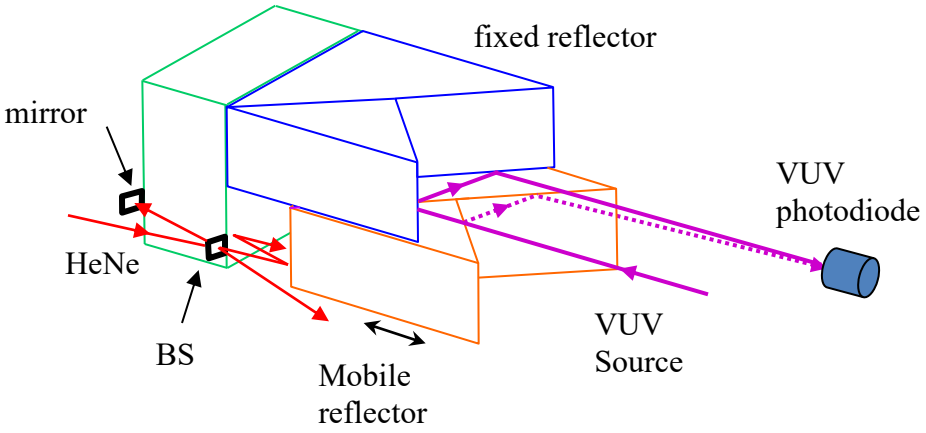
SRMS2 – ion trap

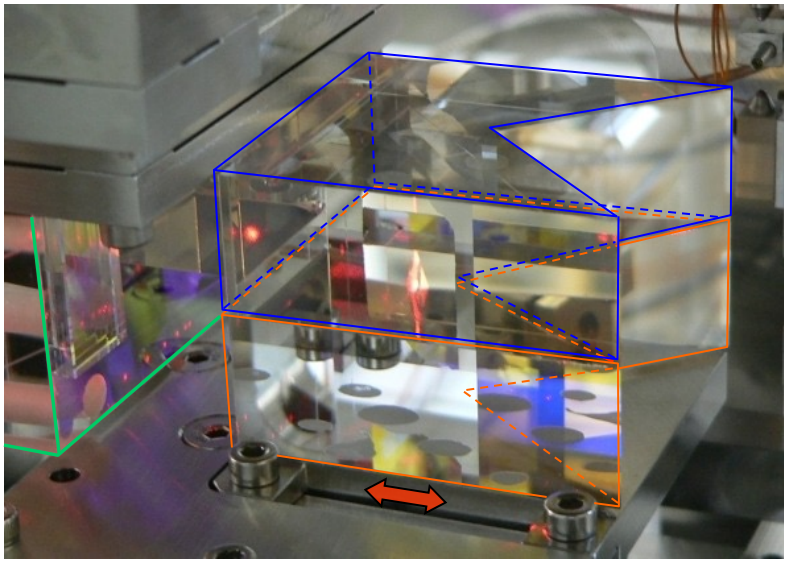


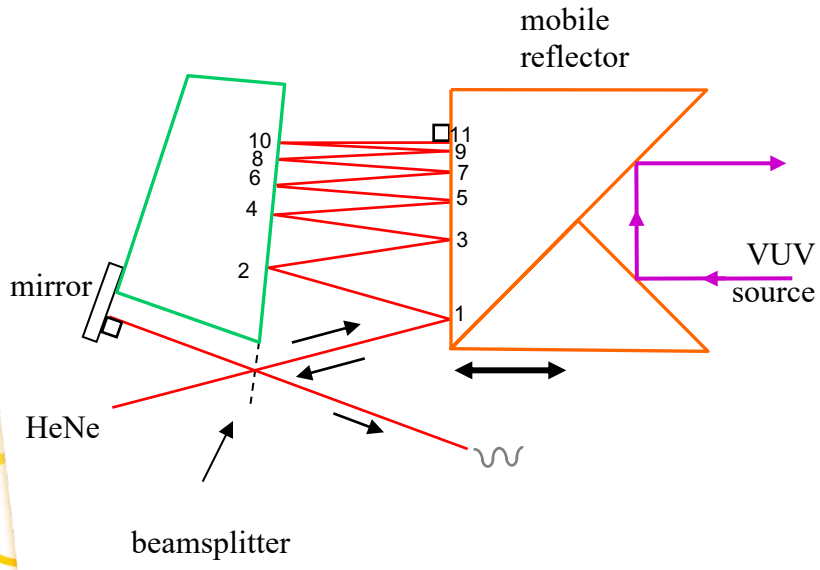




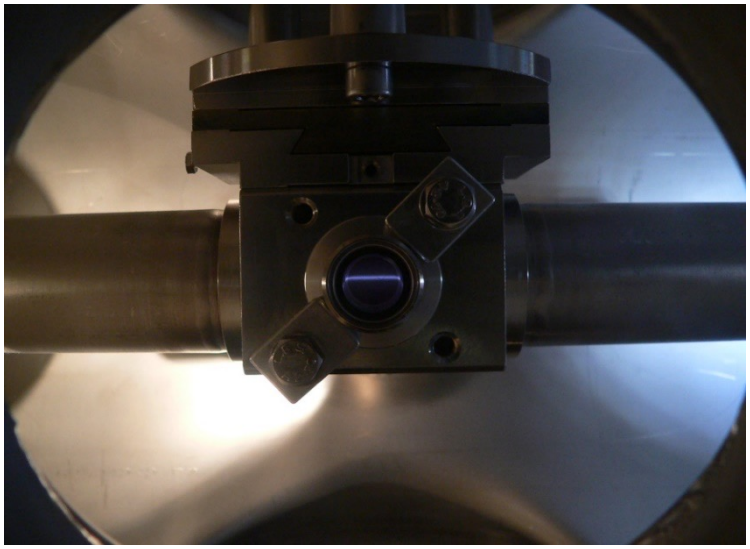
VUV-FTS : Principle for a scanning WD interferometer





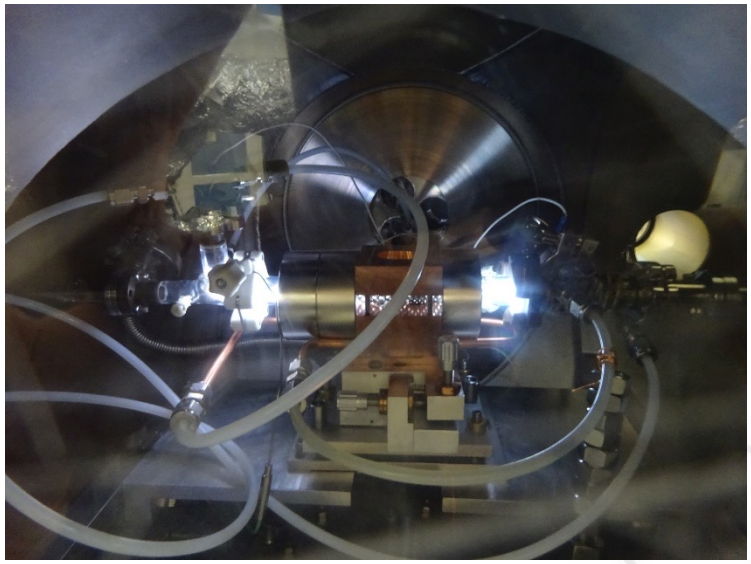


Various set-ups for the production of transient species



A photo-induced Xe plasma is generated in the DESIRS beamline gas filter.

The synchrotron beam is producing the plasma, and is recorded downstream by the FTS



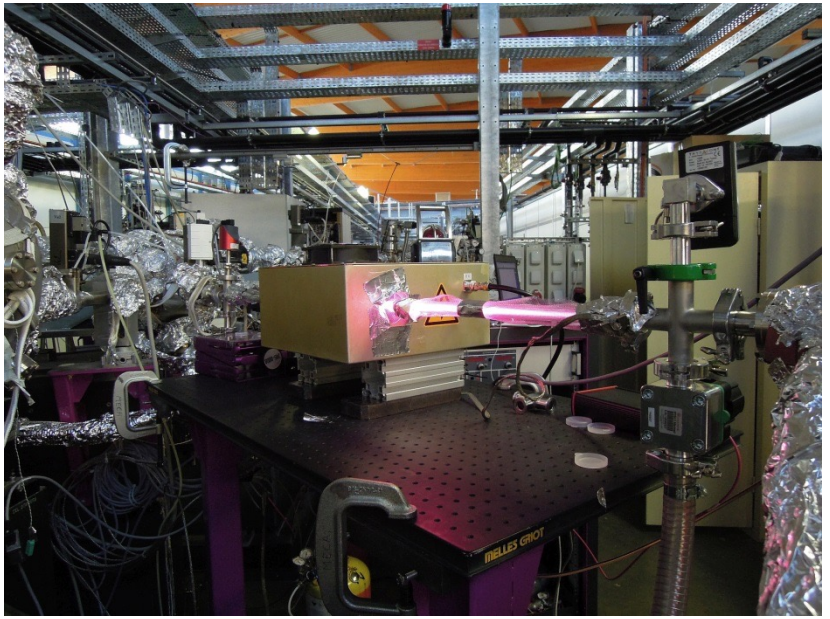
A windowless DC discharge installed in-vacuum in the environmental sample chamber of the FTS experimental branch.

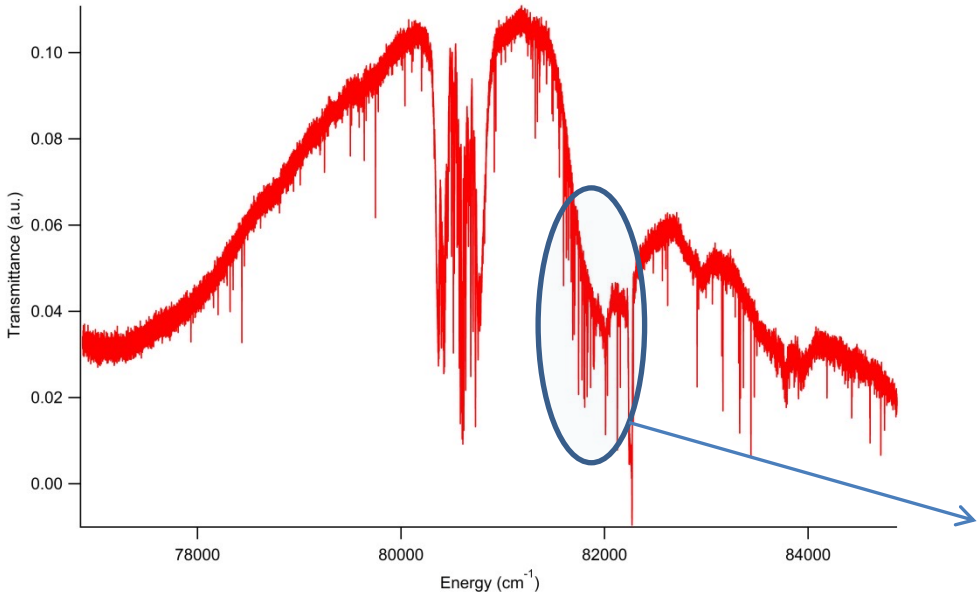
Production of the OH radical inside a windowed RF discharge cell

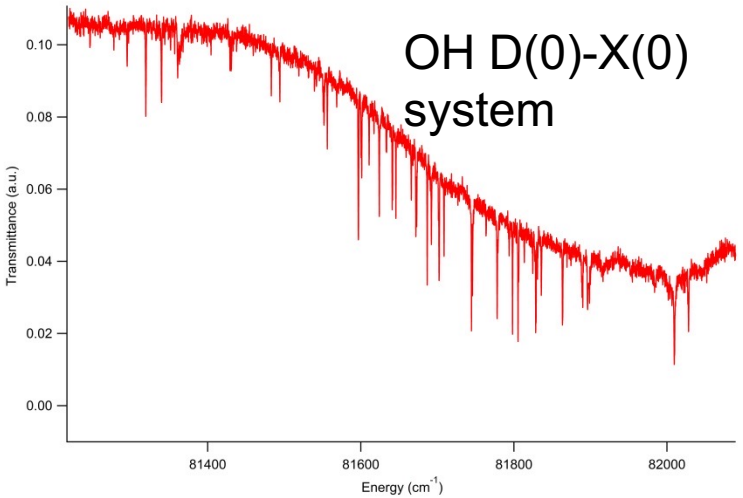
In collaboration with B. Gans et al. (ISMO), JC Loison et al. (ISM), A. Heays

OH spectrum from H_2O + He

Linewidth = 0.27 cm^{-1} (resolving power ~ 300000)
dOH ~ 1.5x10^{13} cm^{-3}







Experimental and theoretical OH $D^2\Sigma^-(v'=0) \leftarrow X^2\Pi\ (v''=0)$ band f-values

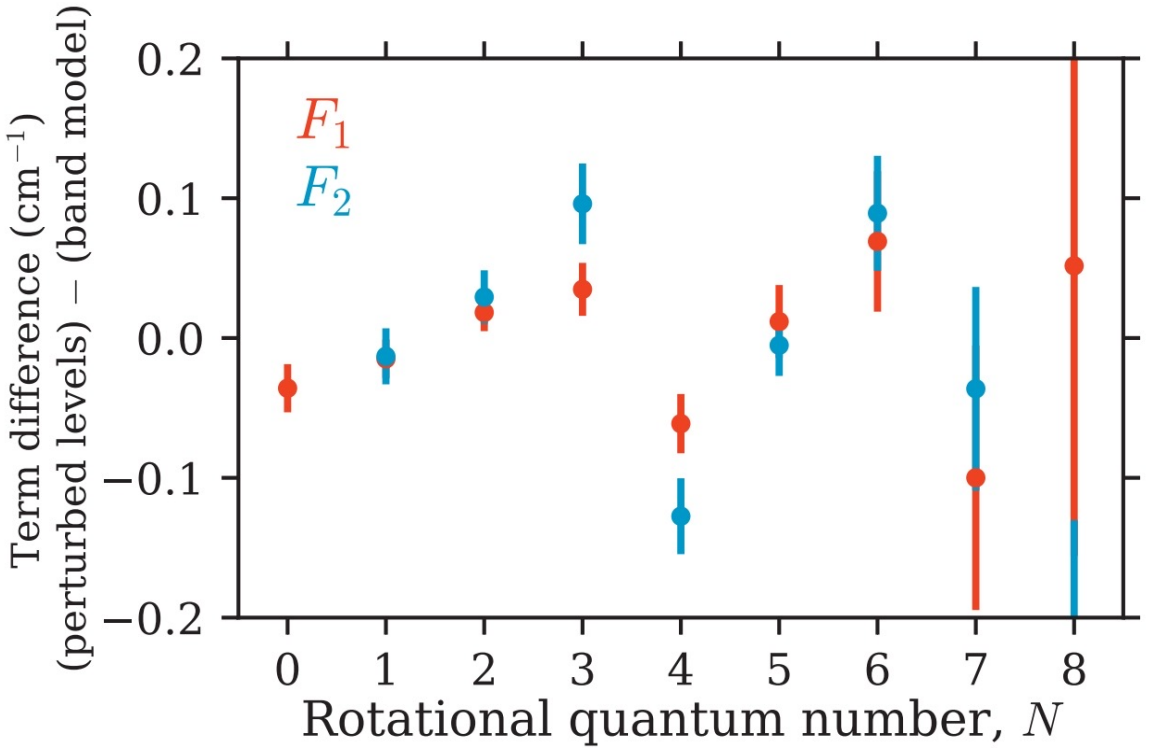
$f_{v'v''}$	Reference
0.0135(10)	This work (a)
0.008-0.013	Experiment (b)
0.015	Experiment (c)
0.012	Calculation (d)
0.013	Calculation (e)

(a) A.Heays et al., JQSRT, 204, 12 (2018)
(b) Lee et al., J. Chem. Phys. 81, 31 (1984)
(c) Chaffee et al., Astrophys. J., 213, 394 (1977)
(d) van Dishoeck et al., J. Chem. Phys. , 78, 4552 (1983)
(e) Van der Loo et al., J. Chem. Phys. , 123, 74310(2005)
(f) McRaven et al.,JPCA, 107,7138, (2003)
(g) De Beer E. et al. JCP 94, 7634, (1991)
(h) Van der Loo and Groenenboom JCP,123,74310 (2005)

From line broadening a 20 ps lifetime was determined [a]

- Compatible with a laser-based lifetime measurement [f] : < 8ns
- Incompatible with a REMPI measurement for low J [g] : > 500ps /J(J+1)
- A factor 5 shorter than a published theoretical prediction [h] : 100 ps

Local perturbation of OH $D^2\Sigma^-$ (v=0)

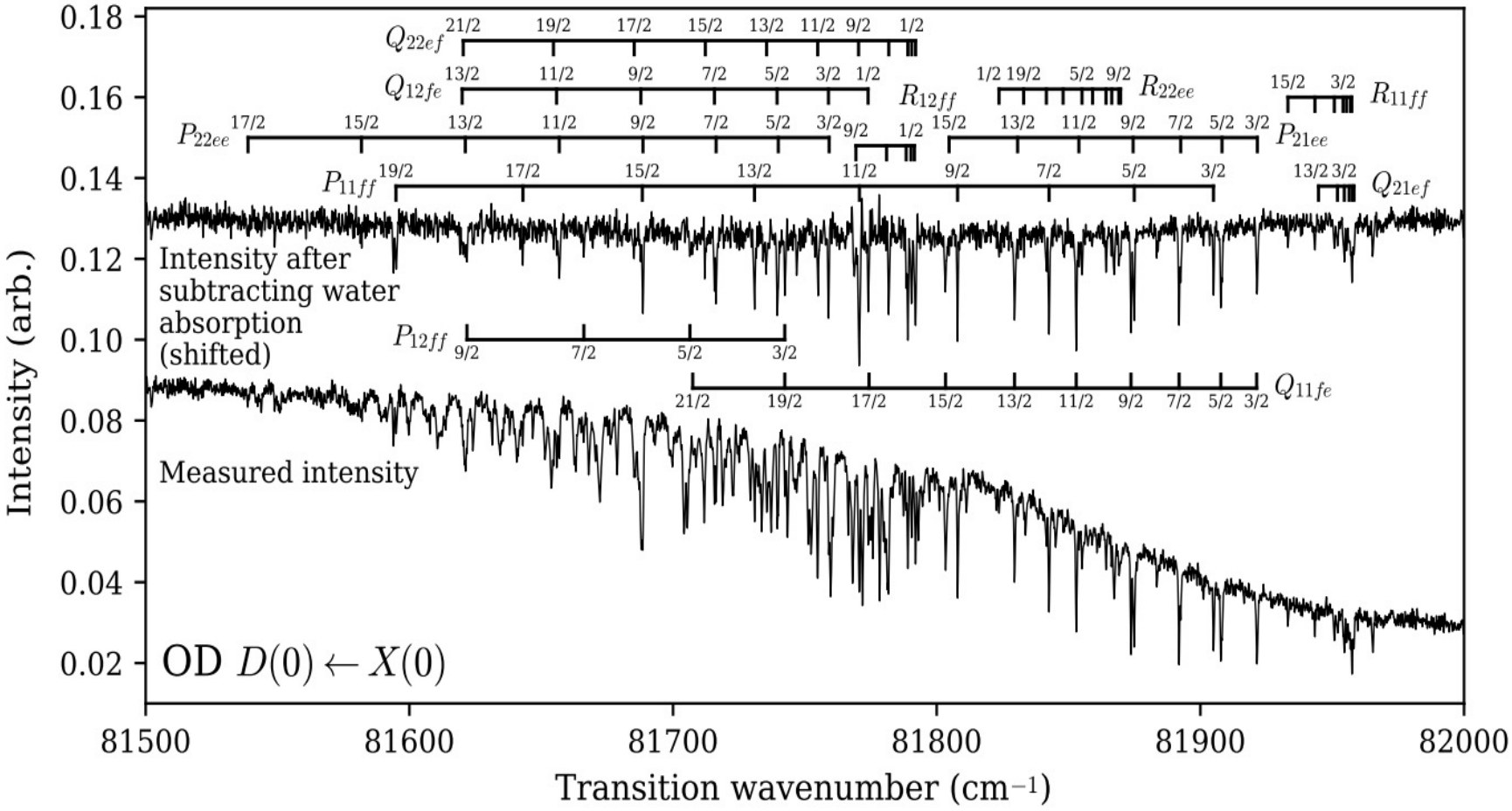


The *D* -state interacts with various repulsive excited-states, see Van der Loo et al. (J. Chem. Phys. , 123, 74310, 2005).

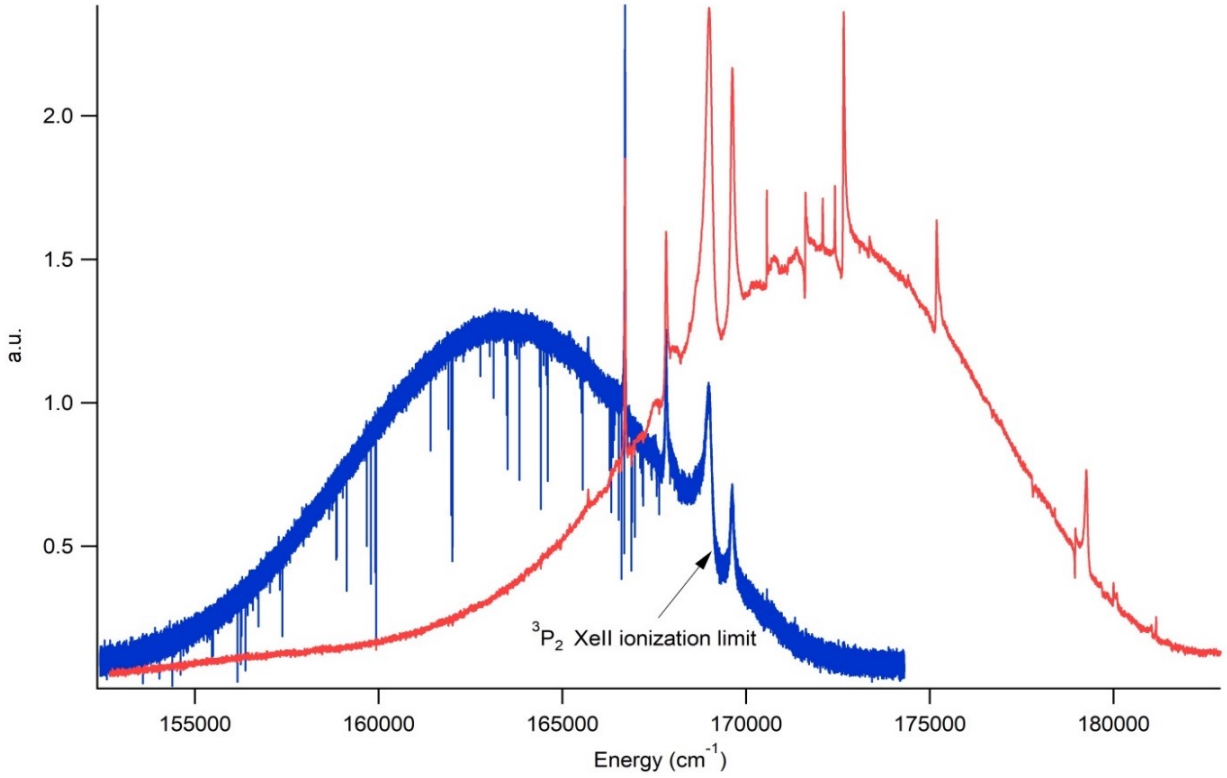
However, this does not explain the observed localized width peak and shifted energy levels of OH *D*(0) near *N* = 3 and 4 that would rather be the sign of a bound level in the vicinity of D(0). For a more detailed discussion see :
A.Heays et al., JQSRT, 204, 12 (2018)

OD spectrum from D_2O + He

→ In this case, the OD band is completely entangled into a strong structured band from the precursor D_2O. The high spectral resolution spectrum gives access to the unambiguous radical signature.



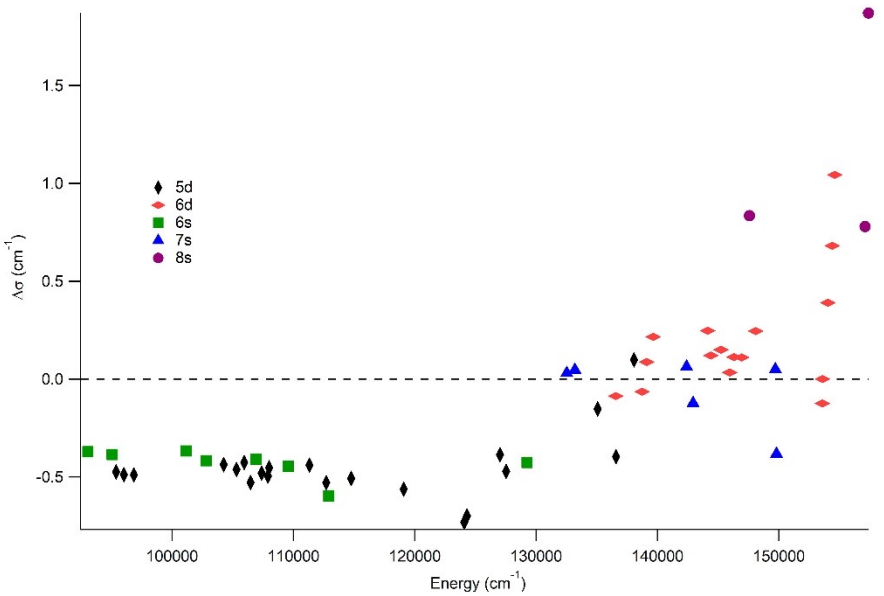
Xe^+ spectroscopy



Two undulator spectral windows recorded near the $^3P_2$ ionization limit

- spectral resolution : 0.27 cm^{-1} (blue trace) and 0.43 cm^{-1} (red trace)

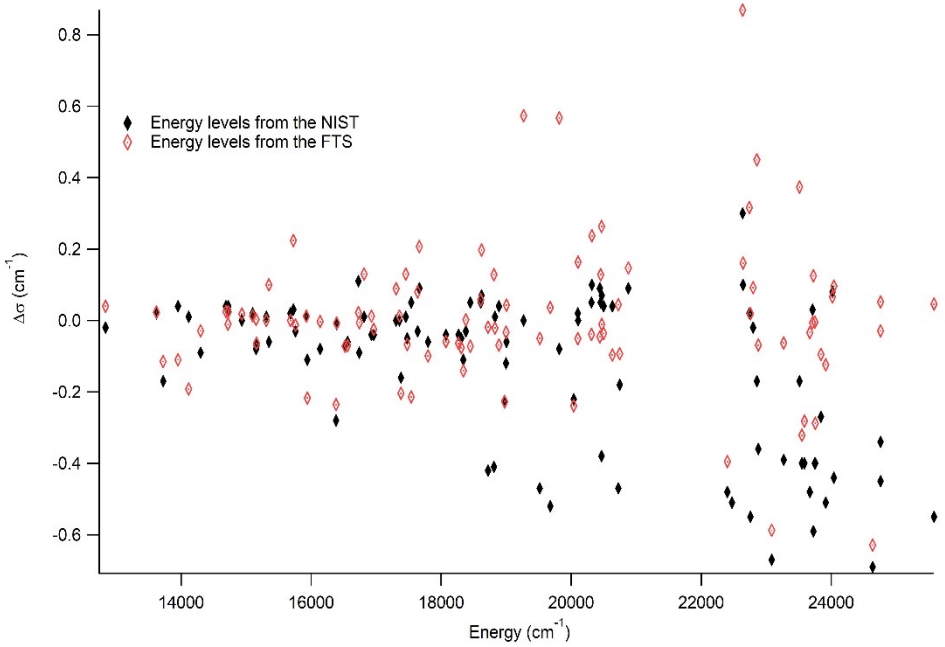
Xe^+ energy levels



Energy difference : FTS-NIST

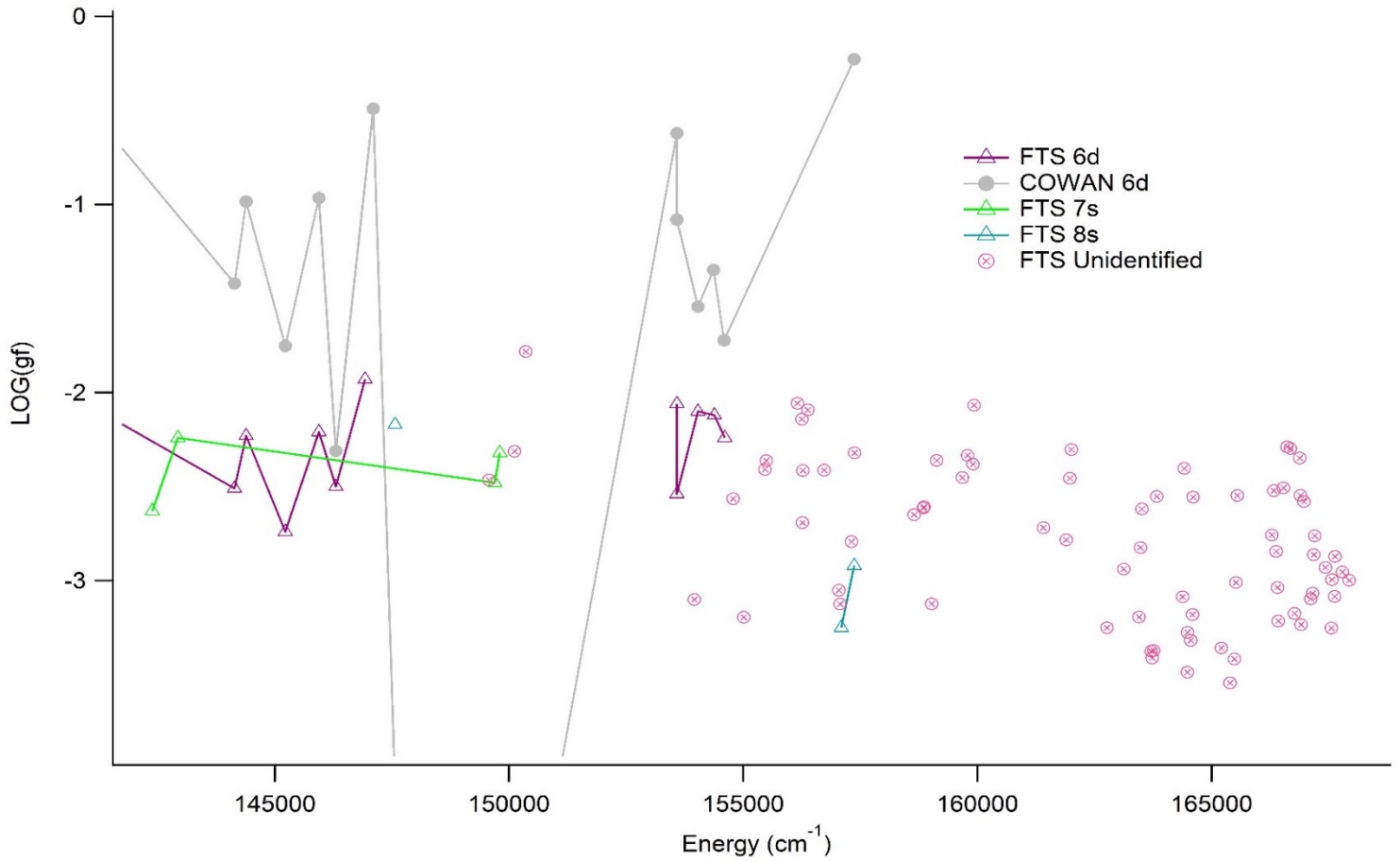
Astrophysical application : Observation in the visible of Xe^+ transitions from HgMn stars*

Identification of the lines using the FTS or the NIST levels



*Yuce et al. (2011) Astron Astrophys A37, 528

Xe^+ - calculation using the COWAN code*



Absolute scale propagated from the $5s5p^6$ 2S transition oscillator strength (Lauer S et al., J Phys B At Mol Opt Phys 32,2015, 1999)

76 transitions are still unattributed

*Cowan Code: 50 Years of Growing Impact on Atomic Physics, https://doi.org/10.3390/atoms7030064

Summary

- High resolution and sensitivity : UV-VUV absorption is a powerful tool for gas phase

- Complete the Xe^+ data analysis

- Project : collaboration with the LPSC (Grenoble) →Time resolved VUV-FTS for plasma diagnostics

2 calls per year :
mid-February & mid-September

http://www.synchrotron-soleil.fr/

DESIRS beamline :

L. Nahon , G.Garcia, J.-F. Gil

K. Ito, D. Joyeux, M. Vervloet, A. Chaterjee M. Roudjane, L. Archer, B. Pilette.

Thank you for your attention