SPECTROSCOPY AND ATMOSPHERE:

PARALLEL ROADS?

OF COURSE NOT!

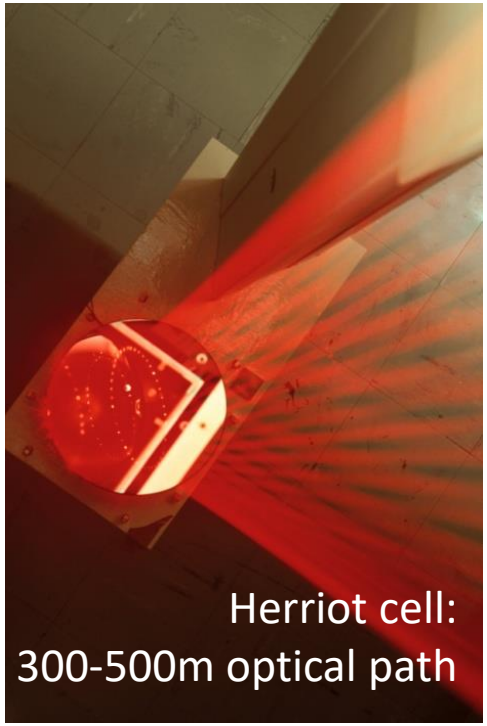
→ A LOT OF INTERSECTIONS (INTERACTIONS)

Valéry Catoire, Prof. LPC2E, Orléans

V. Catoire, C. Robert, et al. (>20 persons during 25 years)

→ **Flying IR lasers spectrometers**: SPIRALE, SPIRIT, SPECIES

SPIRALE:
SPectromètre **I**nfra**R**ouge d'**A**bsorption à 6 diodes **L**asers **E**mbarquées under balloon for upper troposphere & stratosphere studies



Gondola characteristics

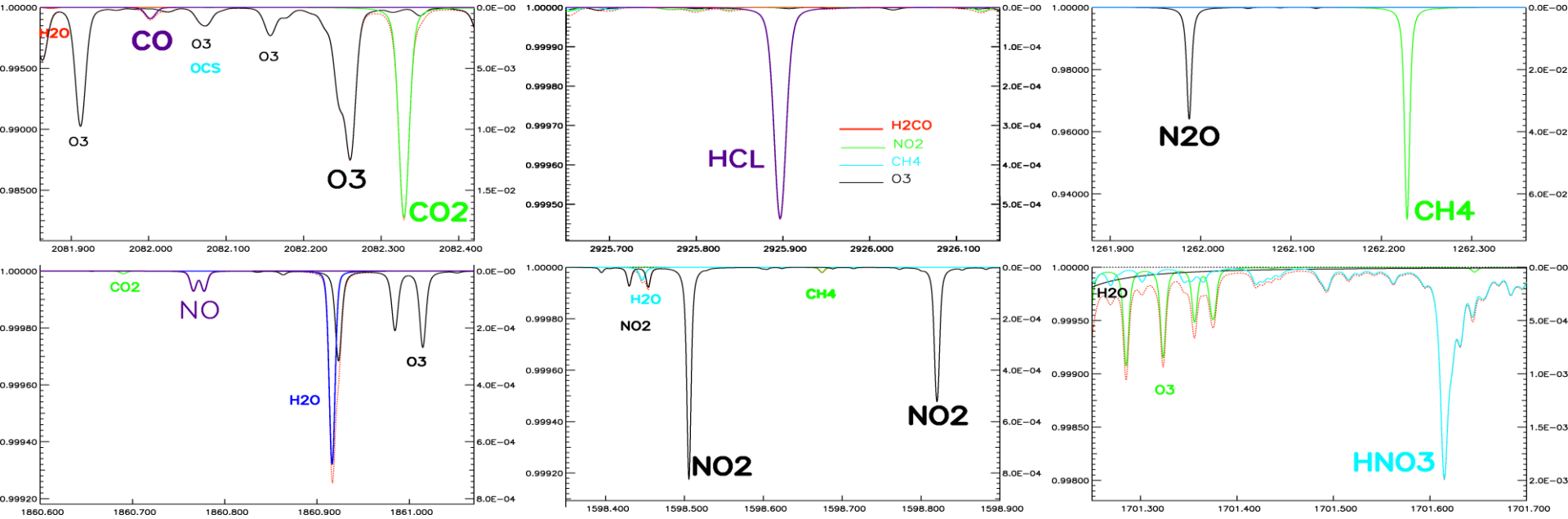
Weight = 500 kg
Height = 3.6 m (+ 3.5 m)
Horizontal width = 2.5 m

Balloon : V = 150 000 m^3
diameter ~ 70 m
aerostat total length ~ 100 m

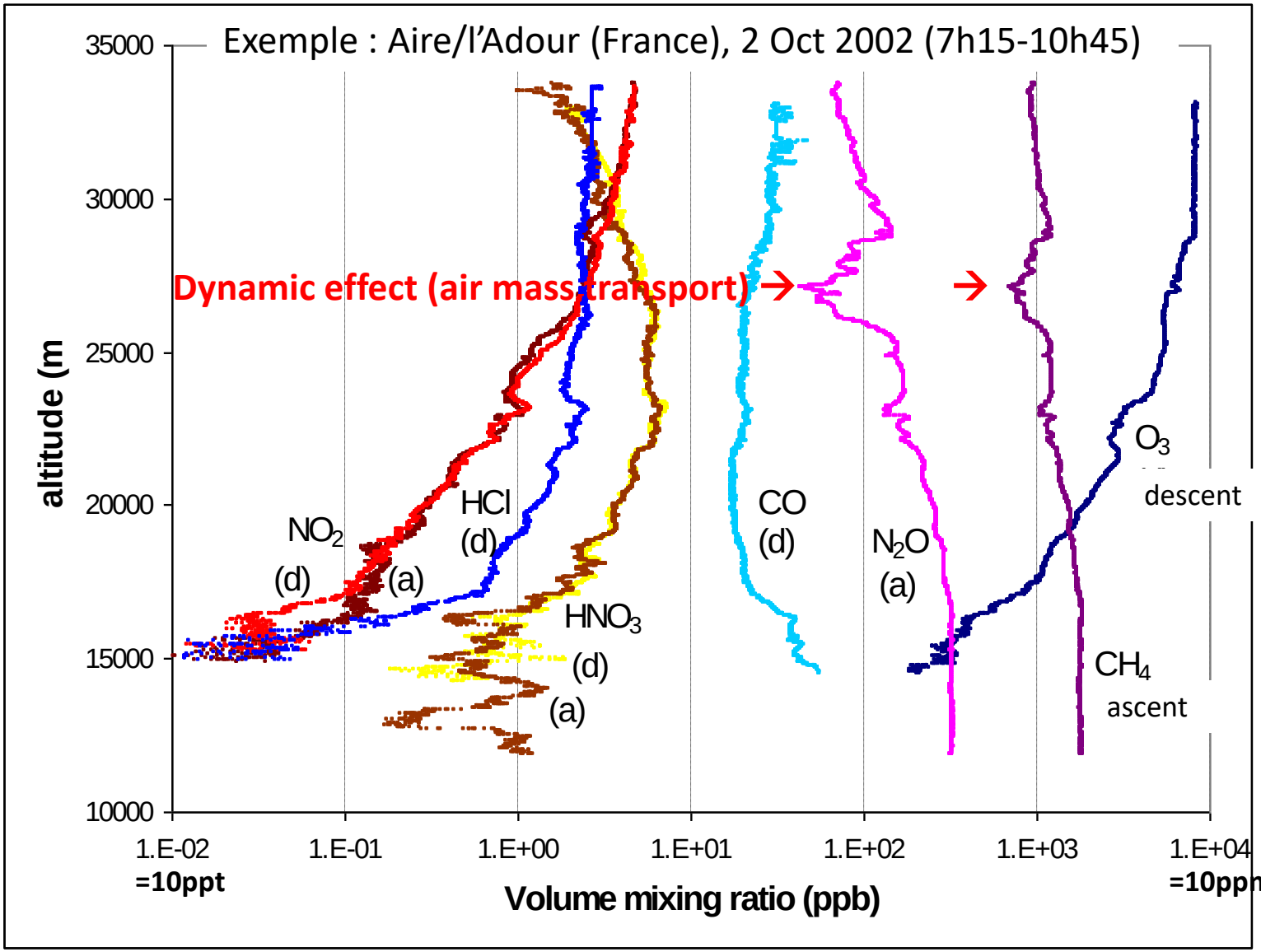
9 scientific flights (2001-2011)
at different latitudes:
68°N: Kiruna (Sweden)
44°N: Aire/l'Adour or Gap (France)
5°S: Teresina (Brazil)

Built for satellite validations and ozone layer issue

6 channels measuring absorption spectra every second : 2 to 5 m vertical resolution
→ Each laser emits in a micro-domain (~ 0.5 cm^{-1}) containing absorption lines of the molecules with ultra-high spectral resolution (0.0001 cm^{-1})



Performances of SPIRALE instrument : vertical profiles



+ Profiles not shown of
- CO_2
- NO
- H_2O_2
- HOCl
- COF_2

68°N: Kiruna (Sweden)

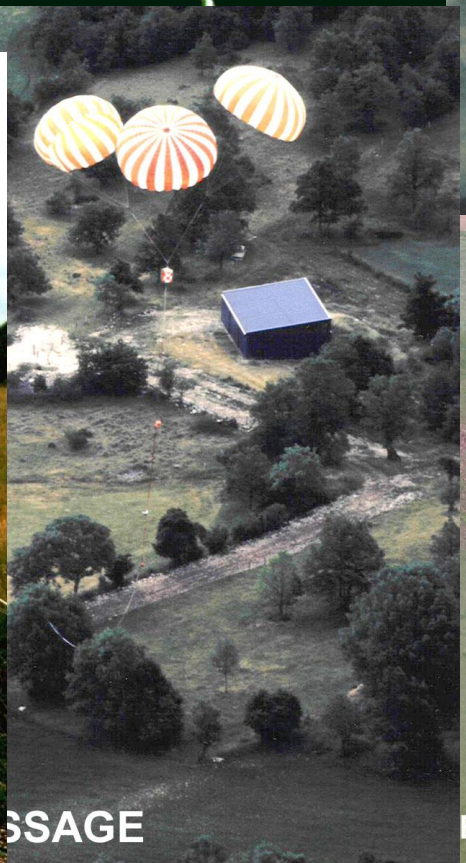
Launch

Landing

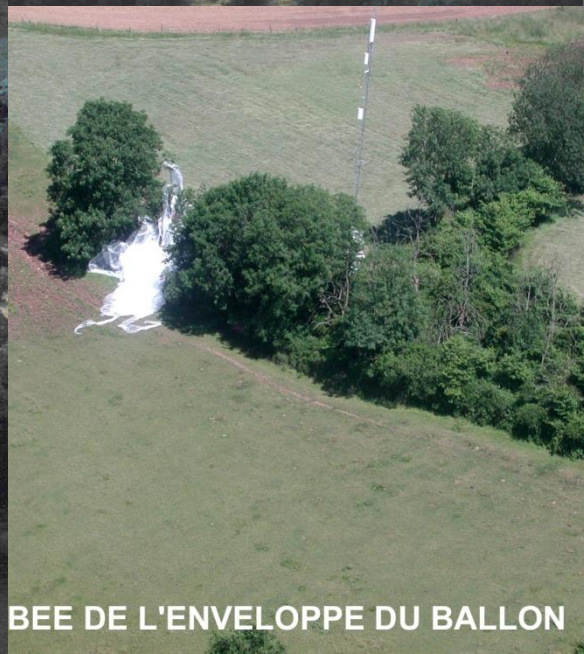
5°S: Teresina (Brazil)

BALLON EN VOL

RECUPERATION



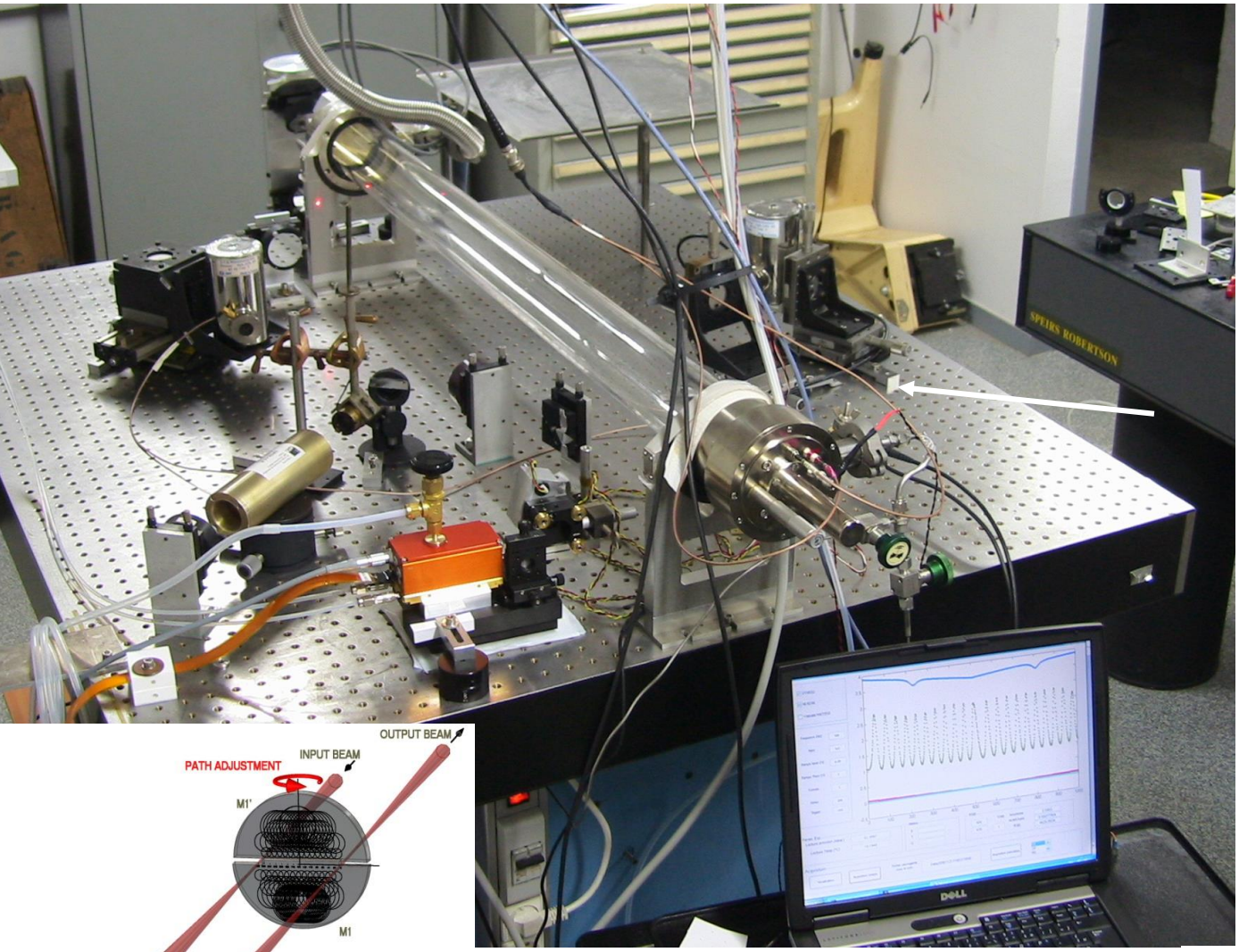
SSAGE

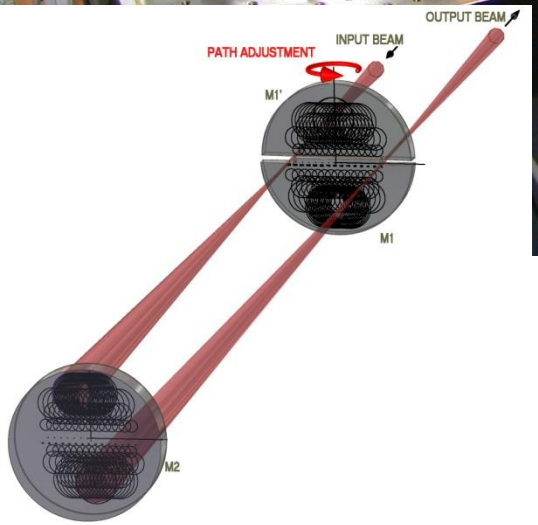


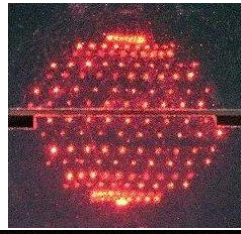
BEE DE L'ENVELOPPE DU BALLON

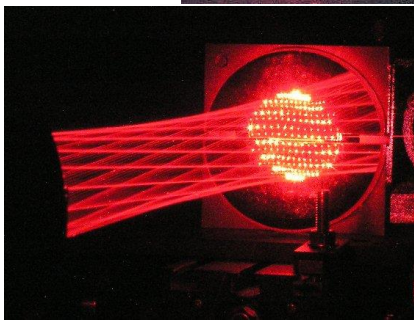
VIDEO: SPIRALE BALLOON LAUNCH, KIRUNA, Aug 7, 2009

Next generation
→ First: try in the lab!









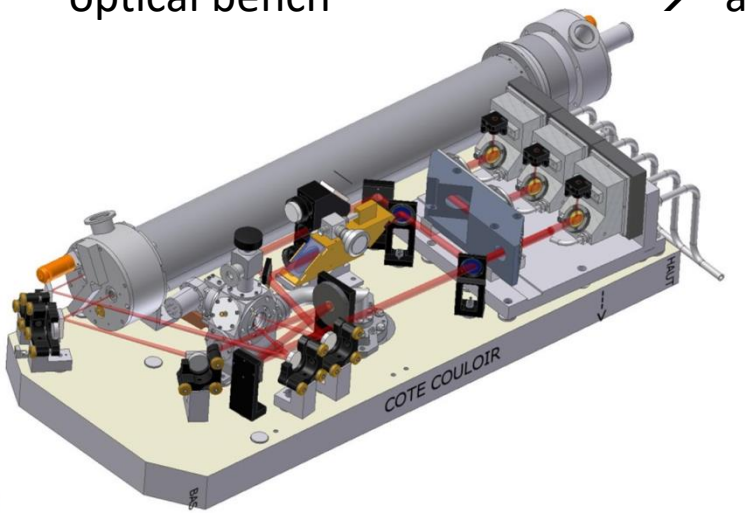
Multi-reflections Robert cell
(optical path: 151 m)

Falcon-20 DLR, München

Falcon-20 SAFIRE (INSU-Météo France) Toulouse

SPIRIT: SPectromètre InfraRouge In siTu

optical bench → aircraft certified rack



100 kg

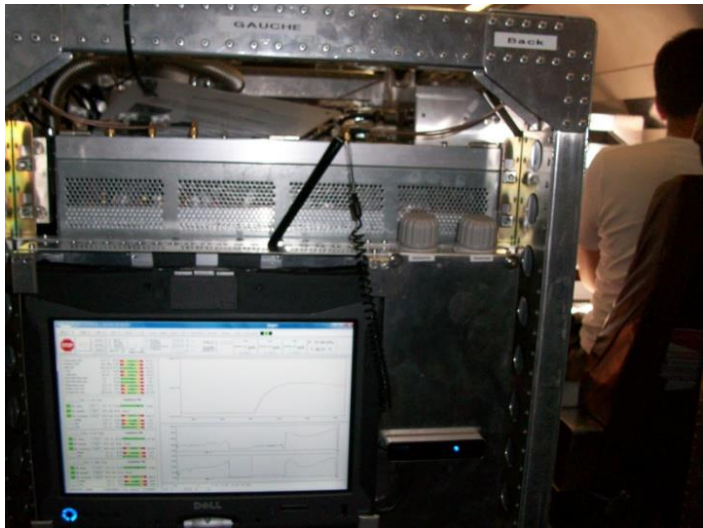
3 QCLs

pathlength:151 m

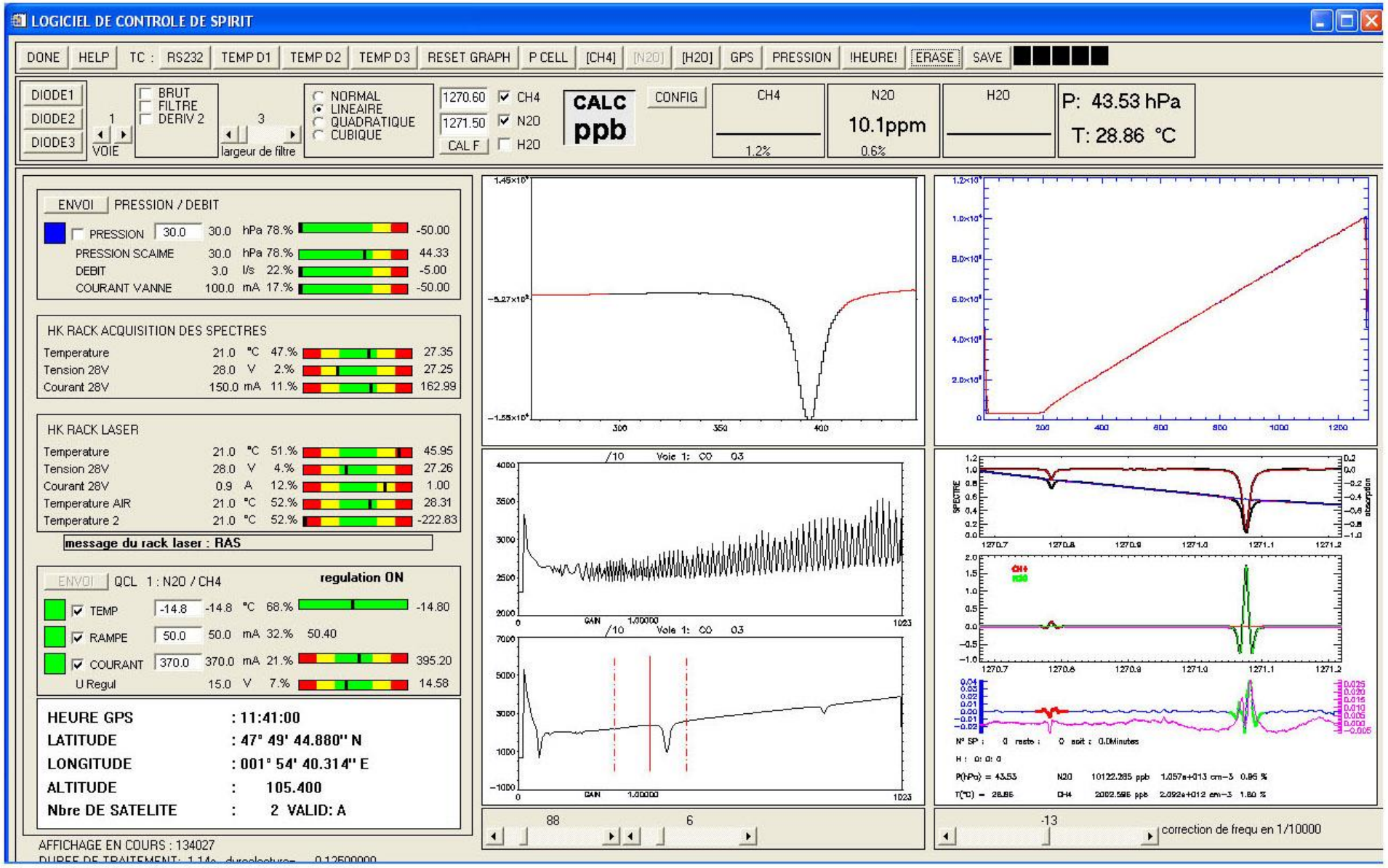
FP7-European Project

SHIVA

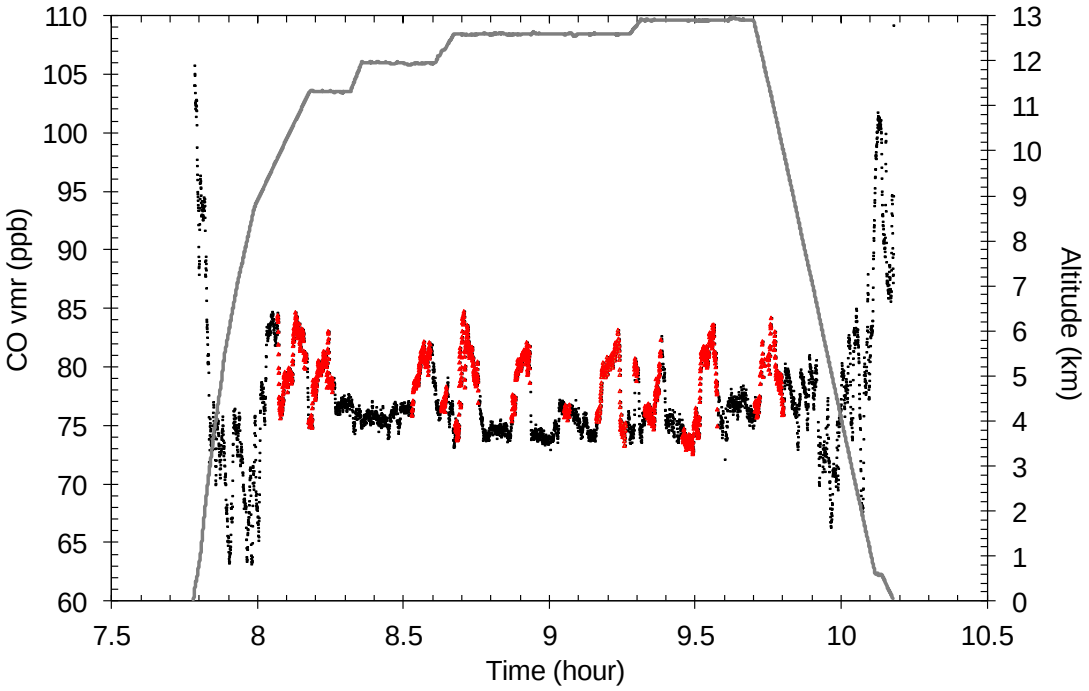
SPIRIT Live Control onboard



Command-Control software for SPIRIT



19 November 2011 · SPIRIT



SPIRIT:

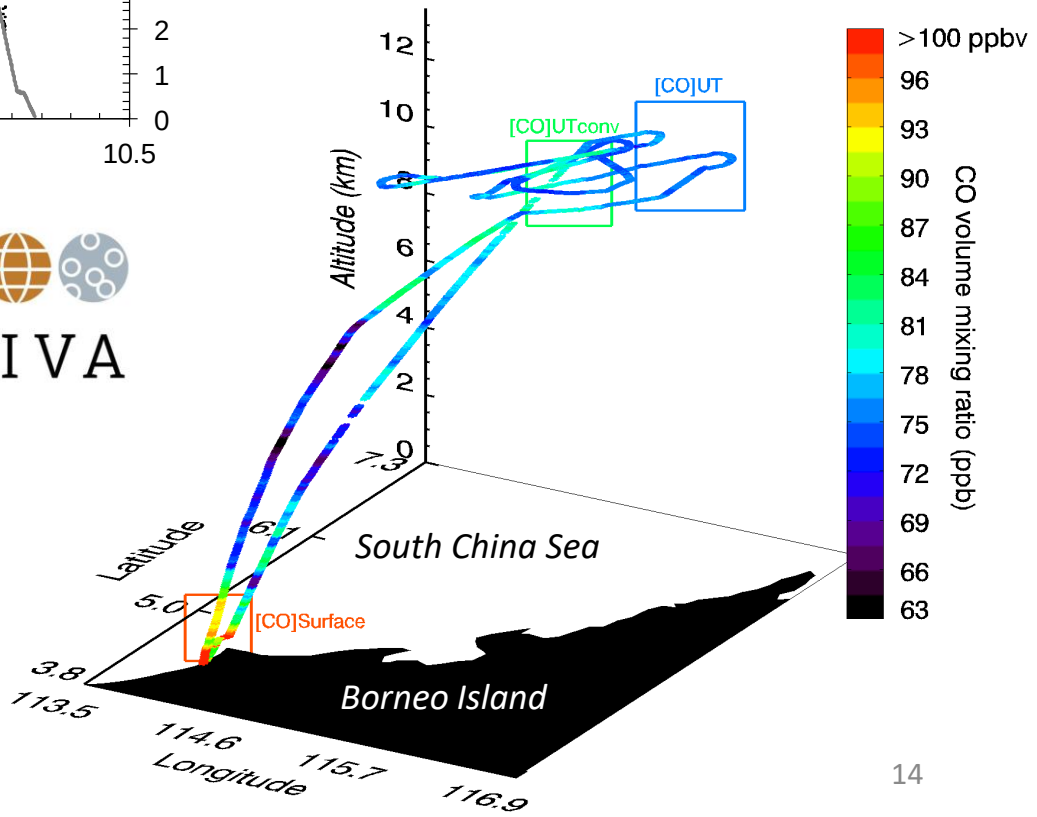
- **CO out of convective cloud**
- **CO in the convective cloud**
- **Altitude**

$$f = \frac{[CO]_{UT_{CONV}} - [CO]_{UT}}{[CO]_{surface} - [CO]_{UT}}$$

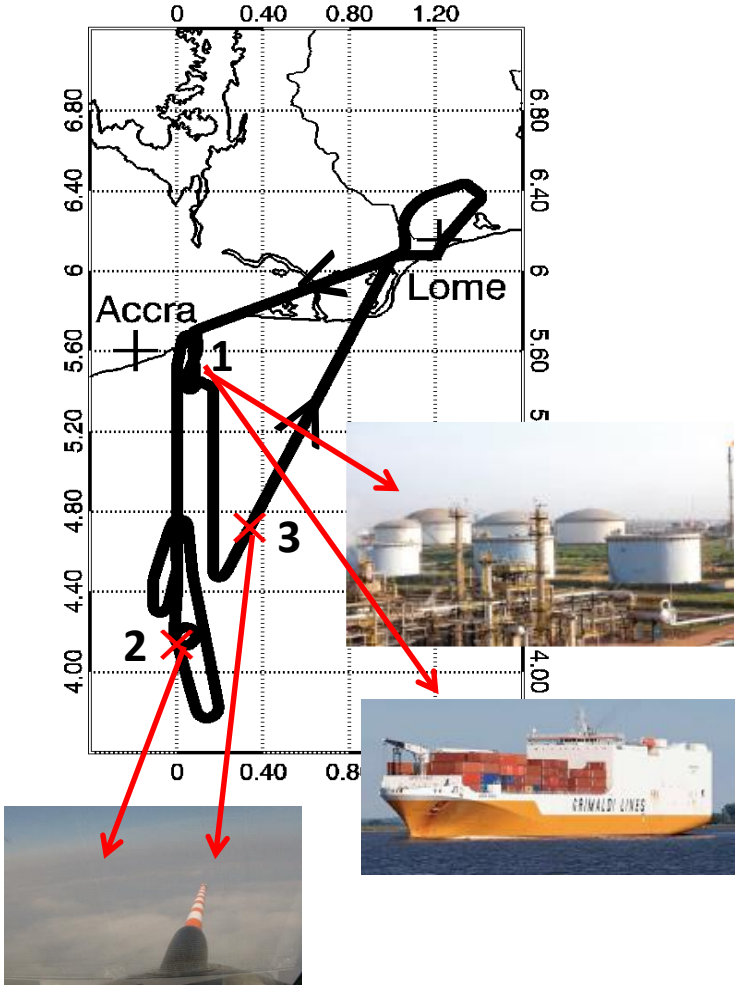
SHIVA

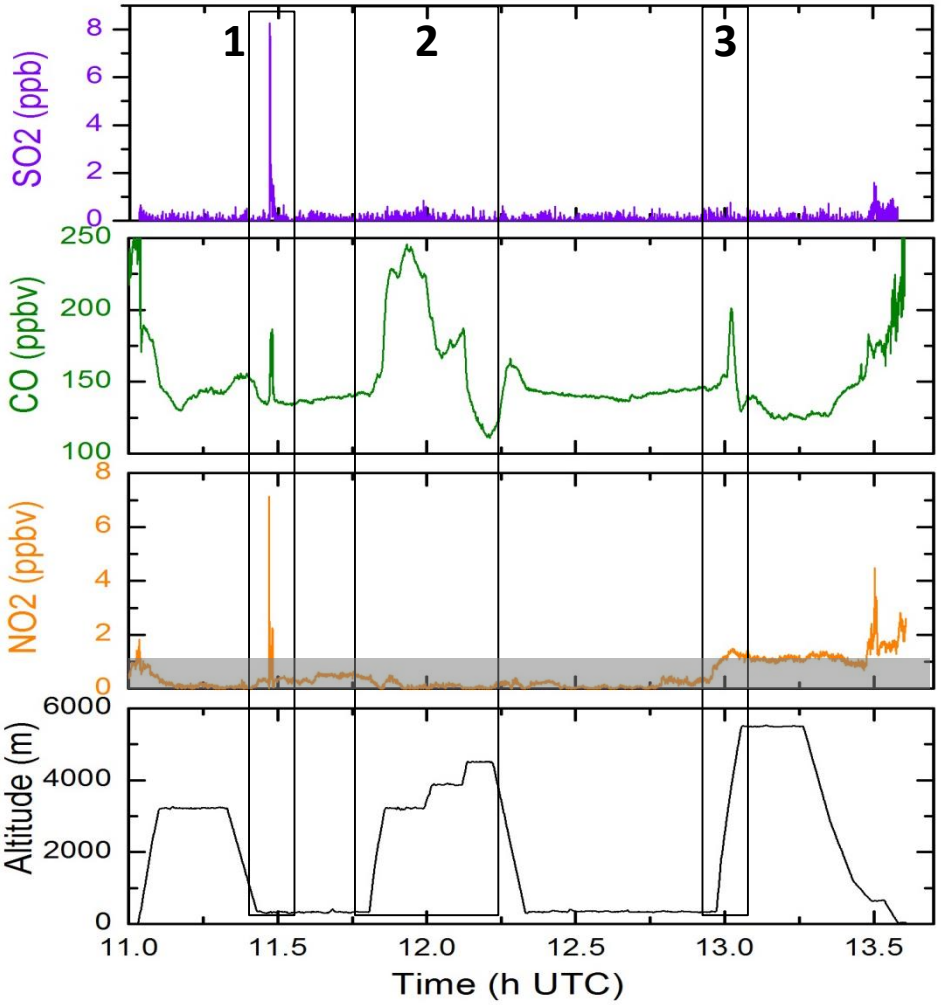
⇨ ~30% of upper tropospheric air comes from polluted surface

SPIRIT 3D CO



07/07/16 : Tanker/Oil Refinery and Biomass Burning emissions in West Africa



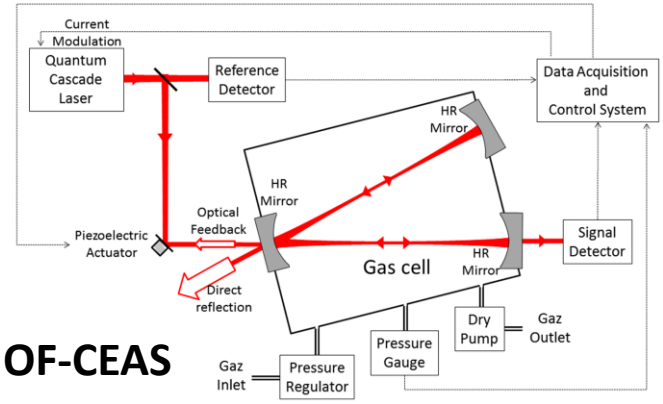


Next Generation → under development:
SPECIES: SPECtromètre Infrarouge à lasErs in Situ

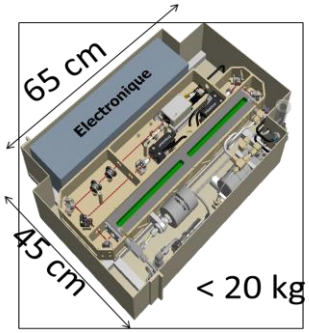
PIVOTS

LPC2E VOLTAIRE cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

→ Principle & mechanical design

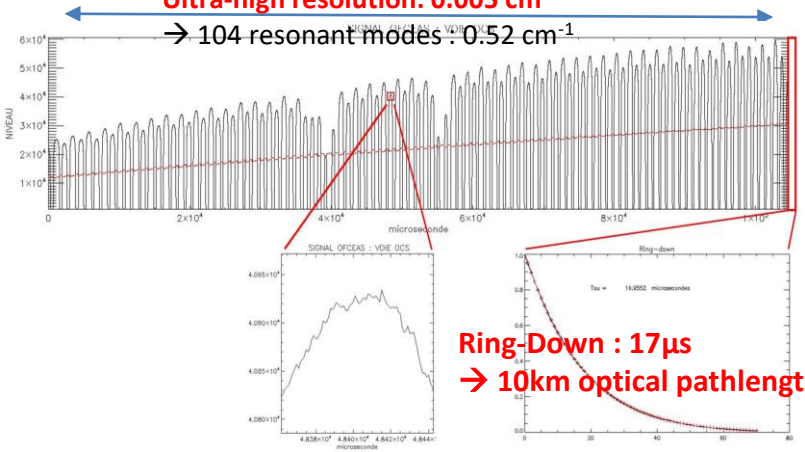


OF-CEAS



Ultra-high resolution: 0.005 cm^{-1}

→ 104 resonant modes : 0.52 cm^{-1}



Ring-Down : 17µs

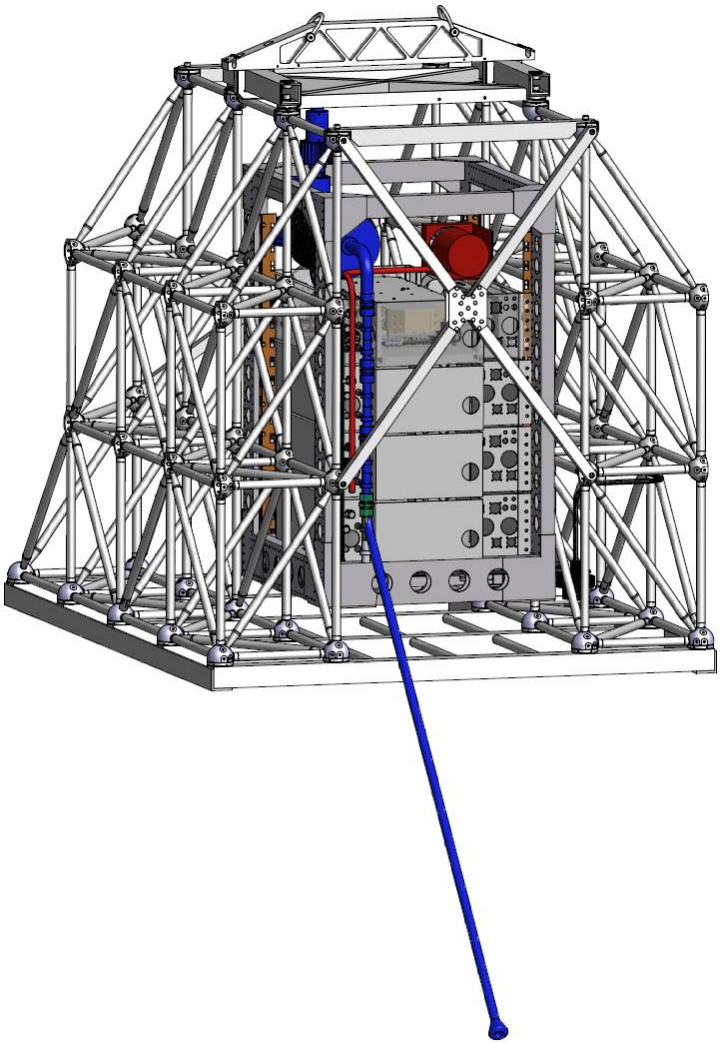
→ 10km optical pathlengt

- Modular design : 3 to 4 racks (19") : resonant optical cavities
- Each module can measure 1 to 2 gaseous species every 2 seconds

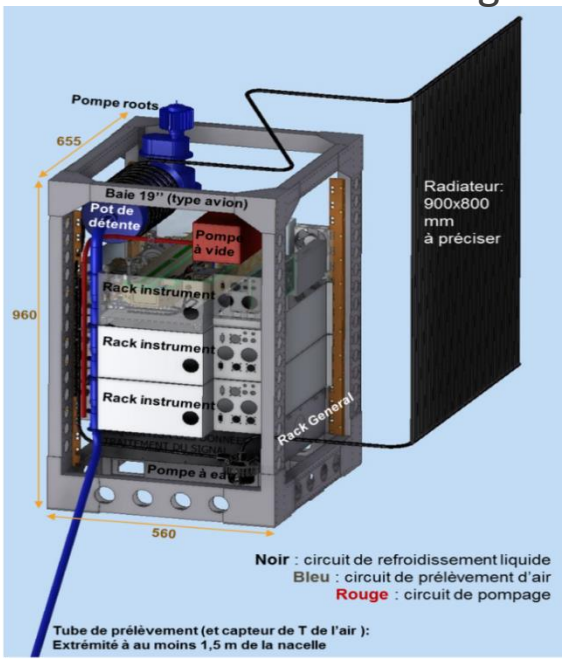
SPECIES: SPECtromètre Infrarouge à lasErs in Situ

Aircraft & Balloon
Measurements from surface to upper stratosphere

SPECIES BALLON



AIRCRAFT RACK + Cooling for balloon



4 Racks	wavelength (µm)
CH_4, CO	2,325
CH_4, HCHO	3,418
NO, CO_2	5,262
N_2O, $^{13}CO_2$	2.863

ANTICIPATING: can a molecule we are interesting in be detected, from the surface (boundary layer) to the upper stratosphere? → Using the home-made software ‘Base2020.exe’, with the database HITRAN2020 and a standard atmosphere (1976: less polluted than now)

Unzip the folder « base_2020_executable_specatmos »
Click on the directory "programme" and then on "base2020.exe" , click to continue
Choose the icones on the left "HITRAN2020", "raies moléculaires" : "toutes" or a particular molecule and the "Interval spectral"
Click on the icone "recherche" in the upper left, then choose in the left "altitude", "chemin optique", "pression de mesure"
Click on "spectres" (jour or nuit) in the upper part, then on "zoom" in the lower left part and a new window appears on which you can use your mouse to click right or left

$c = \lambda \nu = \nu / \tilde{\nu}$
wavenumber $\sigma = \tilde{\nu}$
$\nu = c \tilde{\nu}$