



THE UNIVERSITY *of York*



# Demonstration of infrared-laser occultation for trace gas measurements by a long-range link experiment

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La Palma: 28.40 N, 17.52 W  
Tenerife: 28.19 N, 16.34 W

- The ESA-IRDAS-EXP project:  
SWIR Long Range Differential Absorption Experiment  
for Trace Gas Measurements



Laser transmitter near Northern  
Optical Telescope (NOT);  
2392 m above sea level

Laser receiver using the 1 m  
diameter telescope at ESA's  
Optical Ground Station (OGS);  
2410 m above sea level

campaign planned in April 2011

## ■ Project Goals:

- demonstrate experimentally the feasibility of infrared-laser long path measurements of trace gases in the SWIR spectral region
- measure CO<sub>2</sub> (<sup>12</sup>CO<sub>2</sub>, <sup>13</sup>CO<sub>2</sub>, C<sup>18</sup>OO), H<sub>2</sub>O, and CH<sub>4</sub> concentrations (optionally line-of-sight wind, e.g., <sup>13</sup>CO<sub>2</sub> line)

## ■ Are achieved by:

- designing, constructing, testing of Tx and Rx breadboards
- implementation of software components for hardware, data acquisition, data processing and trace gas retrieval
- detailed spectroscopy of the wavelength ranges in use
- deployment of the experiment at Canary Islands
- gathering of local measurements required for validation
- retrieval of link-average trace gas concentrations & validation

## ■ The results will allow...

- to assess technical feasibility aspects of the IR-laser part of the ACCURATE mission concept and to test scientific performance

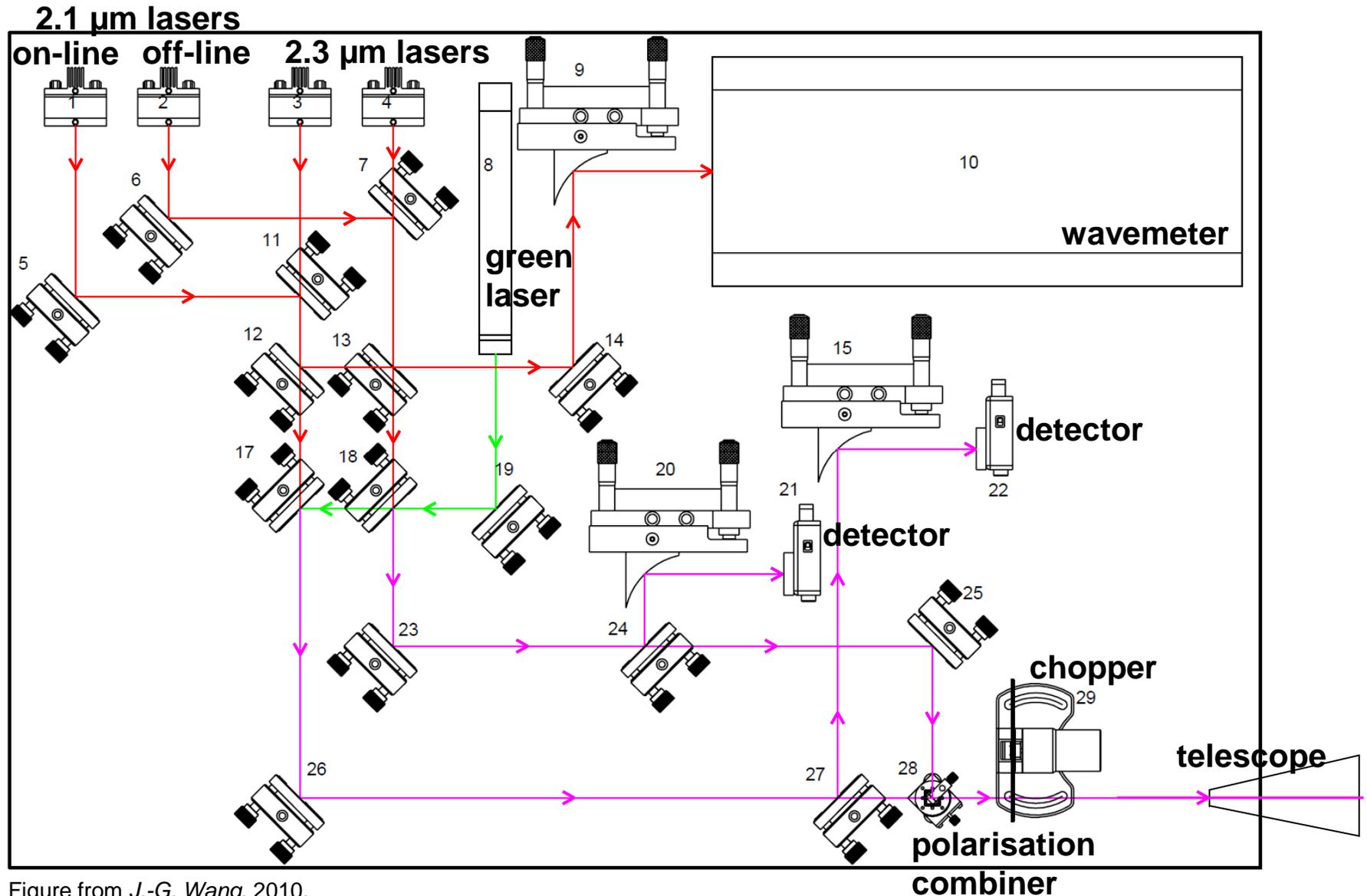


Figure from J.-G. Wang, 2010.

- 2.1  $\mu\text{m}$  region
- DFB lasers, polarised
- ~ 3 mW power
- tunable over ~  $10 \text{ cm}^{-1}$

Units: $\text{cm}^{-1}$	ACCURATE	IRDAS-EXP
$^{12}\text{CO}_2$	4771,621441	4772,656976
$^{13}\text{CO}_2$	4723,414953	4766,641016
C1800	4767,041455	4767,041455
H <sub>2</sub> O	4775,802970	4771,968190
CO <sub>2</sub> -H <sub>2</sub> O-Ref	4770,15	4770,15
CH <sub>4</sub>	4344,163500	4348,165800
CH <sub>4</sub> -Ref	4322,927	4322,927

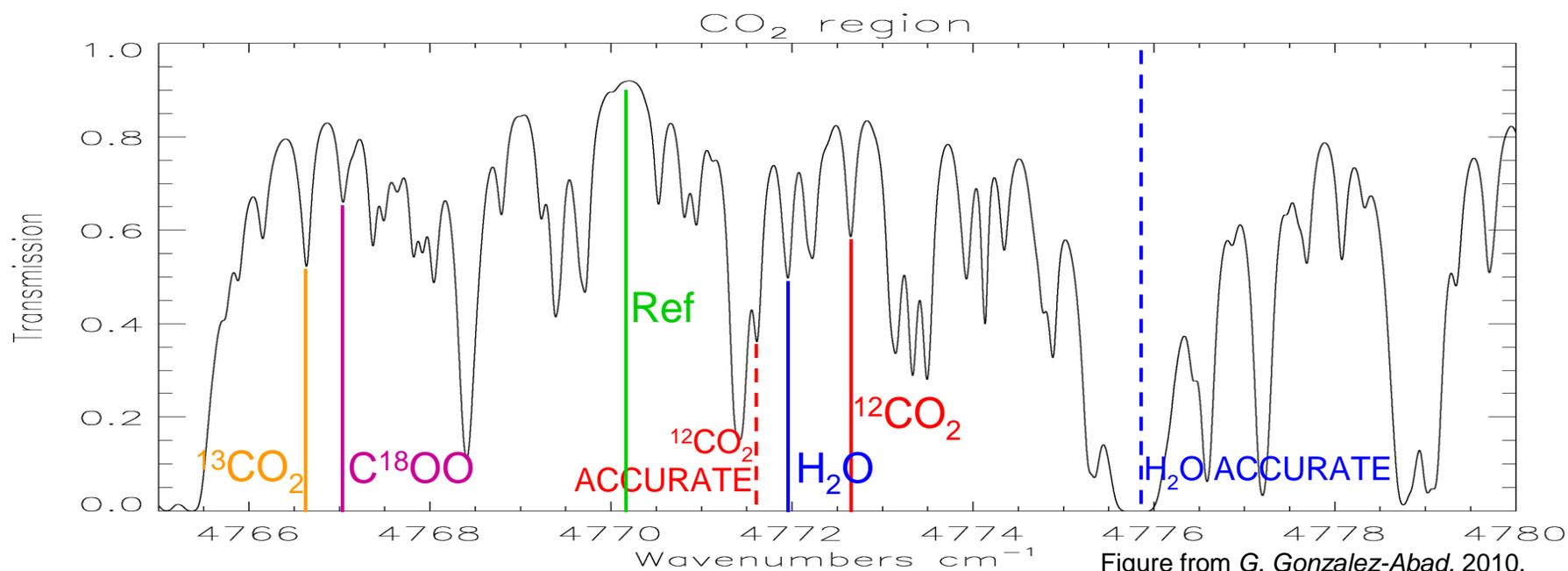


Figure from G. Gonzalez-Abad, 2010.

- 2.3 μm region

Units: cm <sup>-1</sup>	ACCURATE	IRDAS-EXP
12CO2	4771,621441	4772,656976
13CO2	4723,414953	4766,641016
C1800	4767,041455	4767,041455
H2O	4775,802970	4771,968190
CO2-H2O-Ref	4770,15	4770,15
CH4	4344,163500	4348,165800
CH4-Ref	4322,927	4322,927

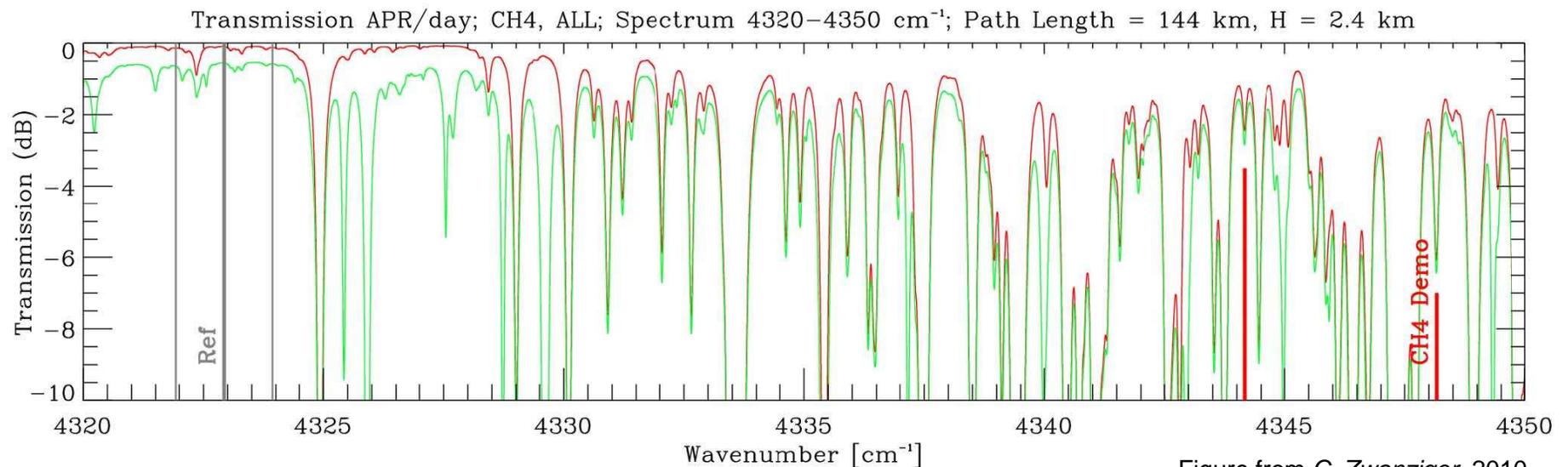


Figure from C. Zwanziger, 2010.

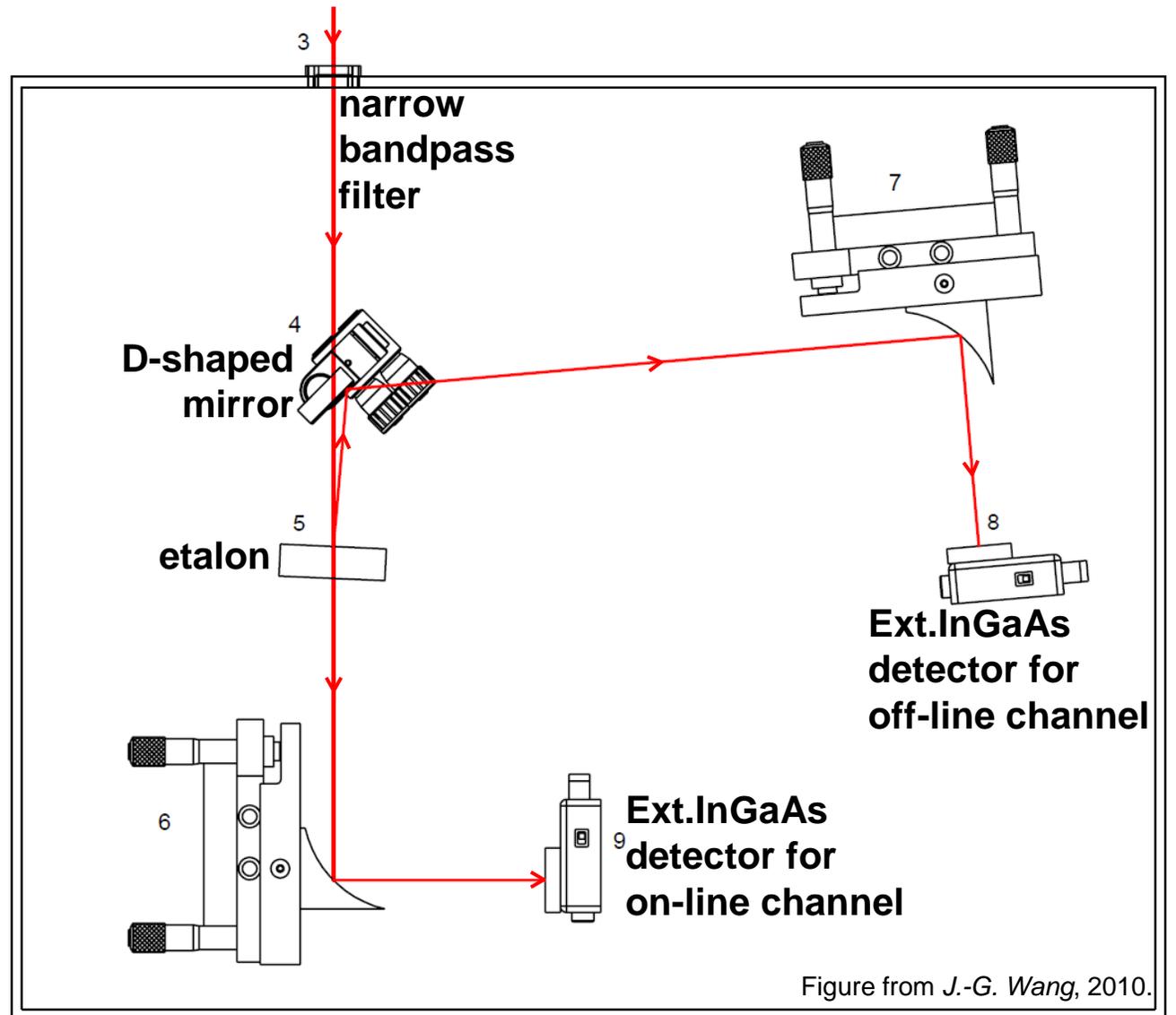


Figure from J.-G. Wang, 2010.

- Laser characterisation:
  - linewidth, frequency knowledge/stability/drift, power stability, tuning range, intensity distribution/drift
  - measured by use of wavemeter, Fourier-transform spectrometer, power meter / beam profiler
  
- Tx and Rx tests
  - over short path in laboratory air (White-type multiple reflection cell with suitable gas mixture; 50 m achievable)
  - switching between 2.1  $\mu\text{m}$  and 2.3  $\mu\text{m}$  lasers
  - outside over modest path length
  
- Functional tests of all elements (hardware, software, data gathering and processing)

Example beam profile

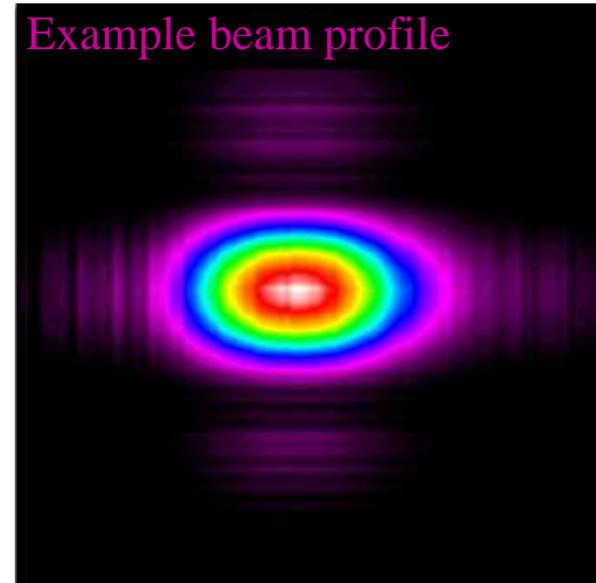
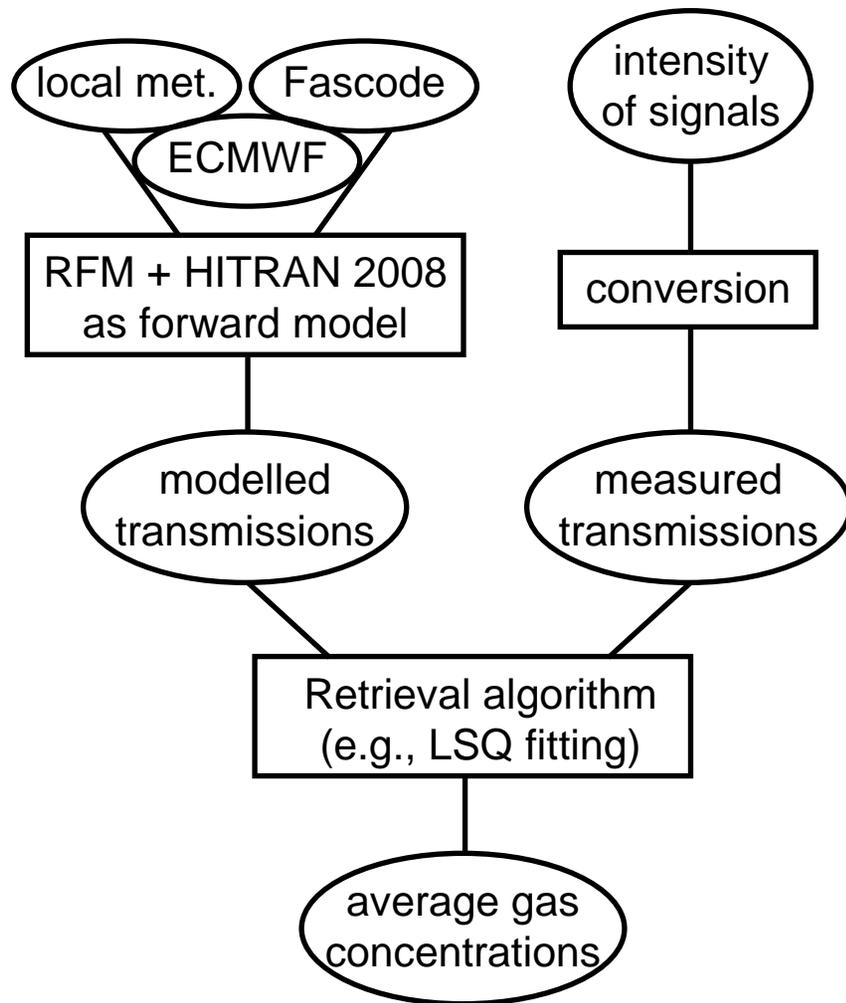
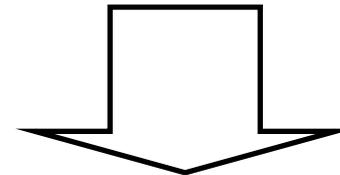


Photo from University of Manchester, 2010.



## Additional measurements:

- location & time (from GPS)
- visibility
- local trace gas concentrations
- signal phases
- transmitted wavelengths
- laser power (emitted intensity)
- SNR



## Used for:

- validation
- system performance under different experimental conditions (different SNR, comparison single-channel vs. channel pair, etc.)

- Basic:

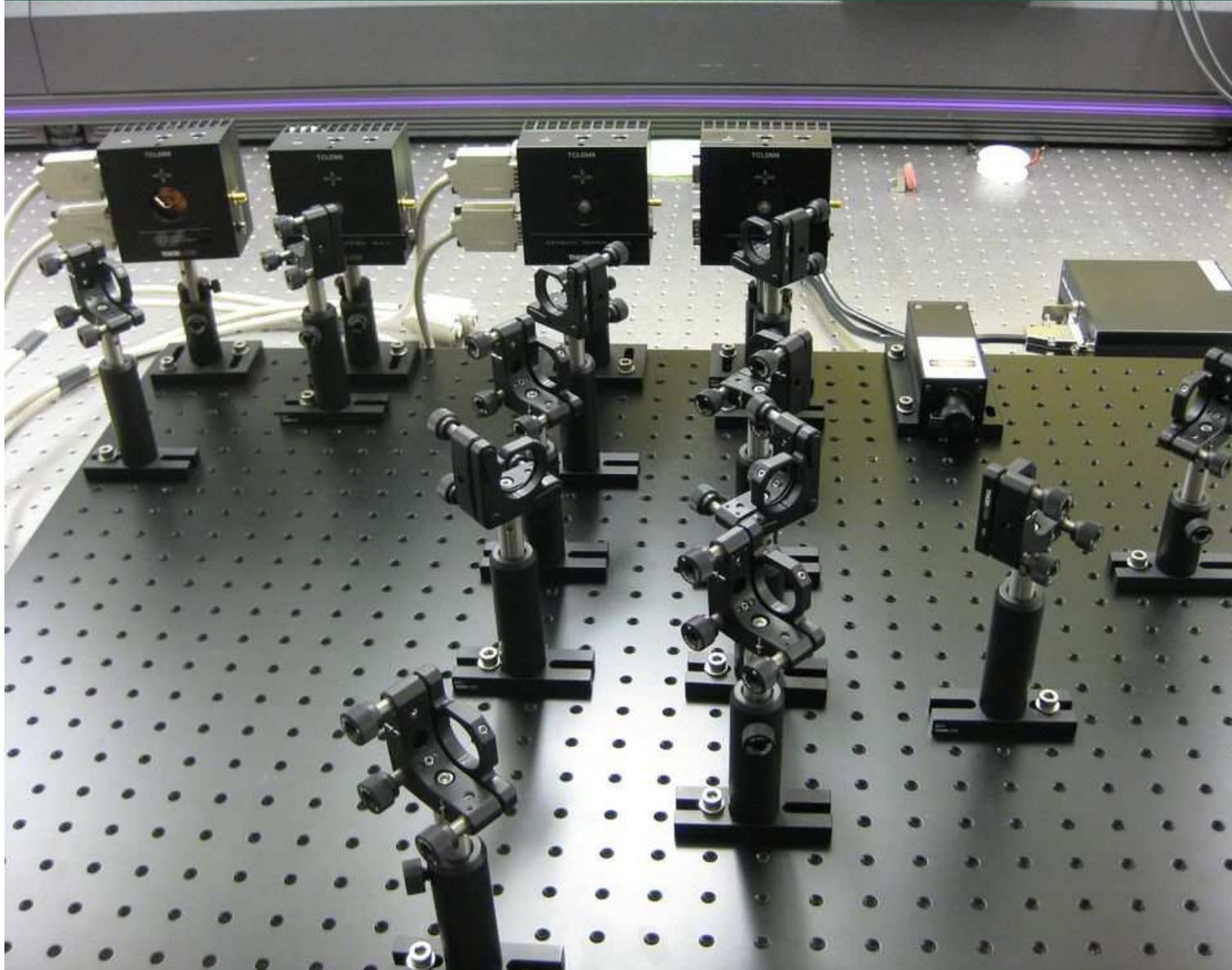
- 16 sampling flasks at Tx site (one sampling a day)
- T, p, rH, V from observatory weather stations (both sites)
- continuous CO<sub>2</sub> and CH<sub>4</sub> measurements from the Spanish weather service (in Canaries, but not in-situ)

- Advanced:

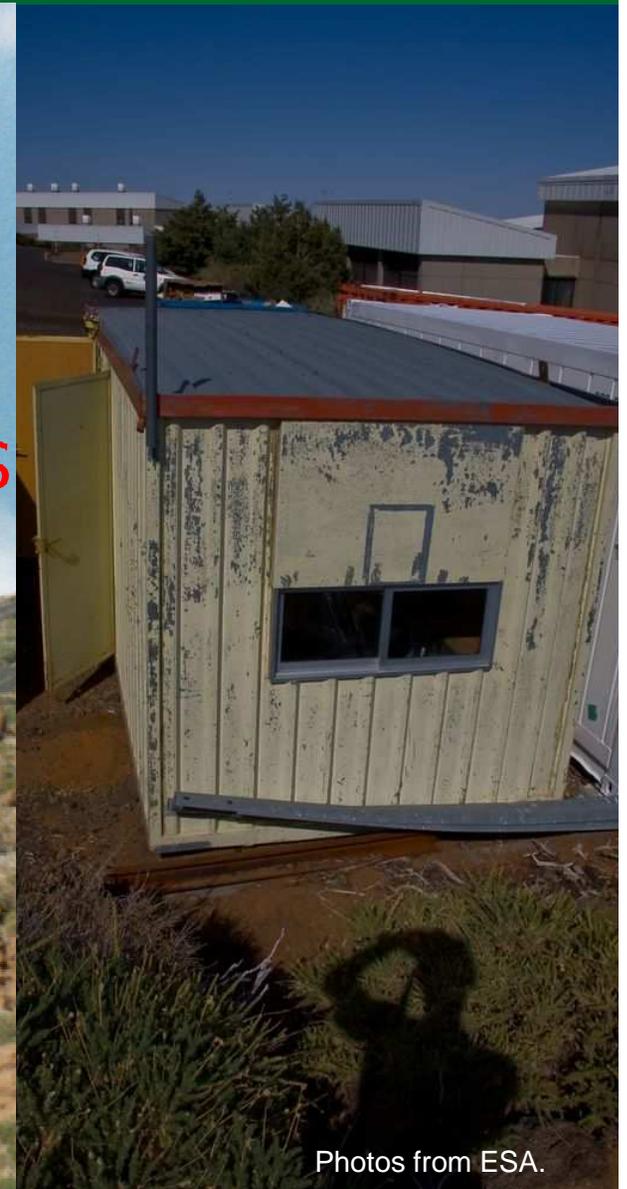
- cavity ringdown spectroscopy (CRDS) instruments at one or both sites for continuous measurement of CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>O (from MPI Biogeochemistry, Jena)
- continuous high precision in situ sensor from UK FAAM aircraft (Facility for Airborne Atmospheric Measurements)
- Additional flasks from Jena at Rx site



# Preliminary hardware assembly



# La Palma: NOT and porter cabin



Photos from ESA.



Photos from ESA.

a pile of work...

