# VALIDATION OF SCIAMACHY WATER VAPOR AND METHANE PROFILES BY BALLON-BORNE IN-SITU MEASUREMENTS WITH THE “CHILD” SPECTROMETER ONBOARD TRIPLE

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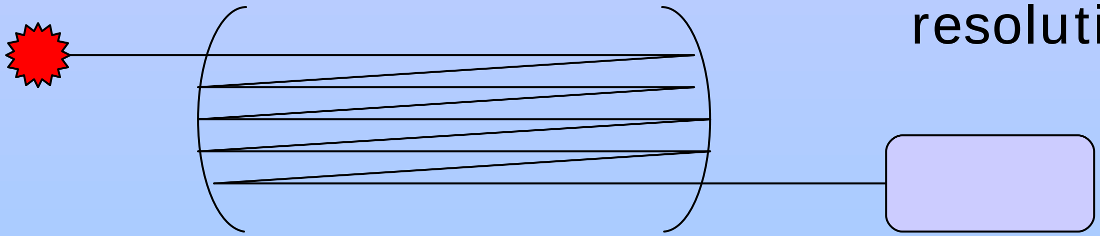
supported by TRIPLE (A. Engel, C. Schiller, F. Stroh)

# CHILD key components & function

**C**ompact **H**igh-altitude **I**n-situ **L**aser **D**iode spectrometer

monochromatic
tunable
light source

detector
(no spectral
resolution)



absorption path
(multireflection)
open to the
atmosphere

## Key features:

- in-situ measurement delivers altitude resolution of a few meters

- fast response time (seconds)

- absorption cell open to the atmosphere avoids sampling errors
  (no deposition by adsorption, condensation)

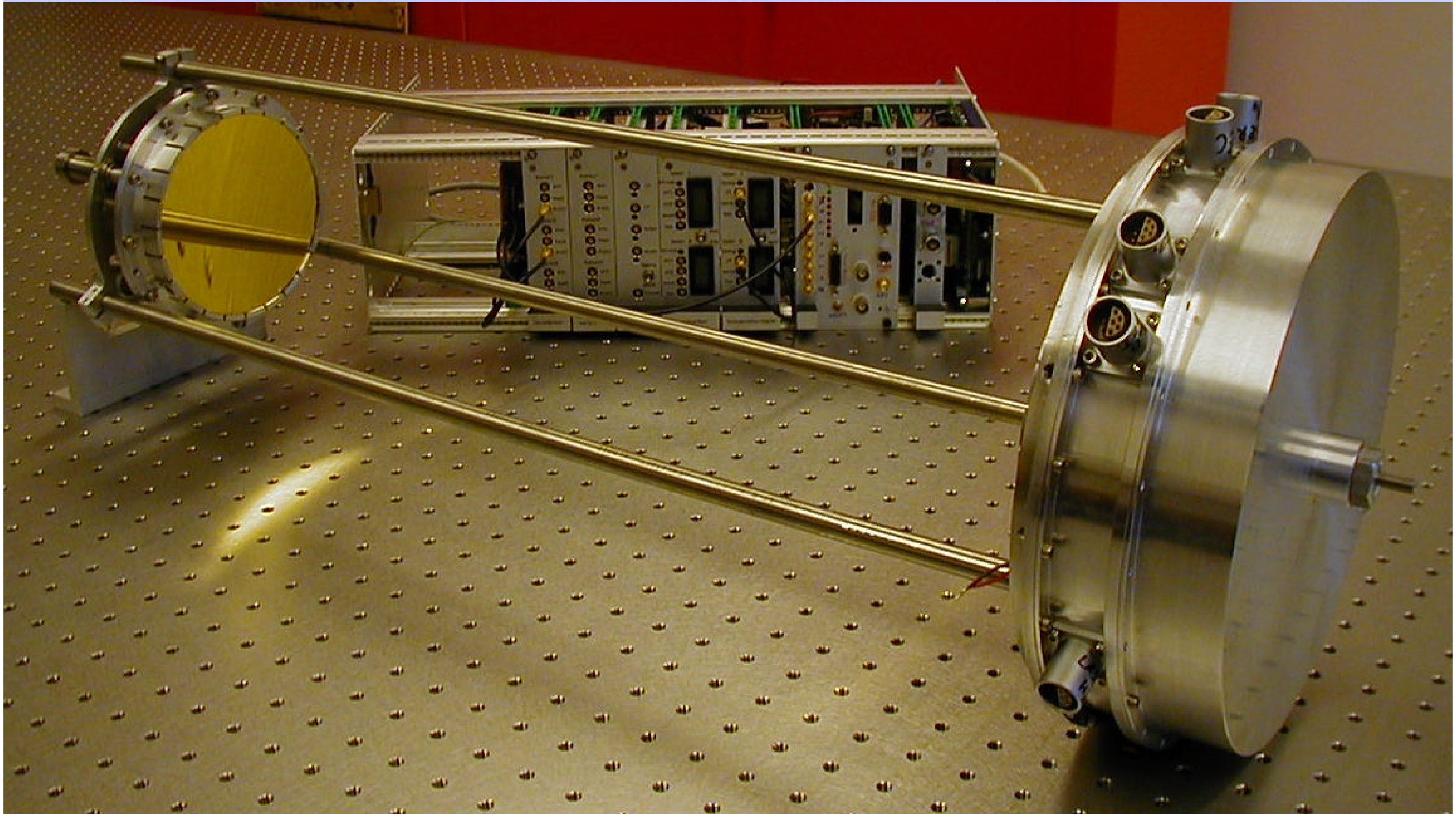
- same NIR absorption features as SCIAMACHY, uncertainty of
  spectroscopic parameters removed from validation

- high spectral resolution (laser linewidth < 30 MHz)

- low weight, low power consumption, small size

- combined TRIPLE payload enables sensor intercomparison

# CHILD Herriott-cell and control unit



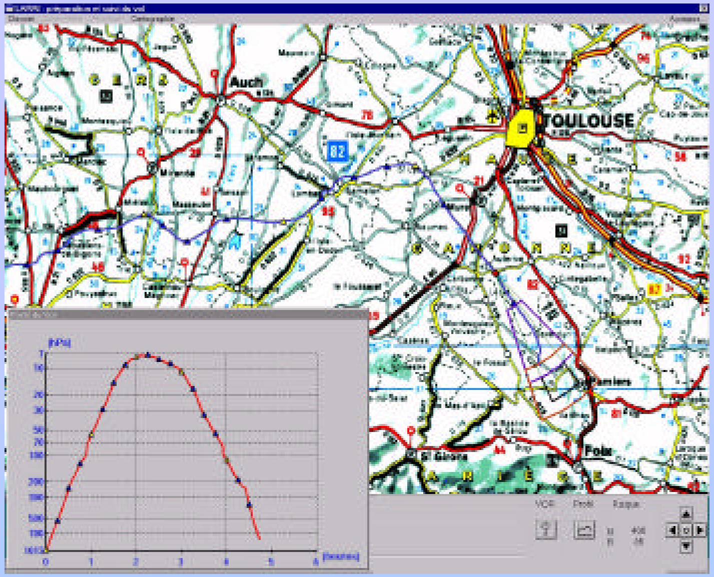
| CHILD specification | CH4 | H2O |
|---|---|---|
| wavelength | 1648.2 nm | 1392.53 nm |
| absorption pathlength | 74.0 m | 35.9 m |
| scan-range | +/- 8.5 GHz | +/-7.5 GHz |
| MDA | 4 x 10 E-5 | 4 x 10 E-4 |

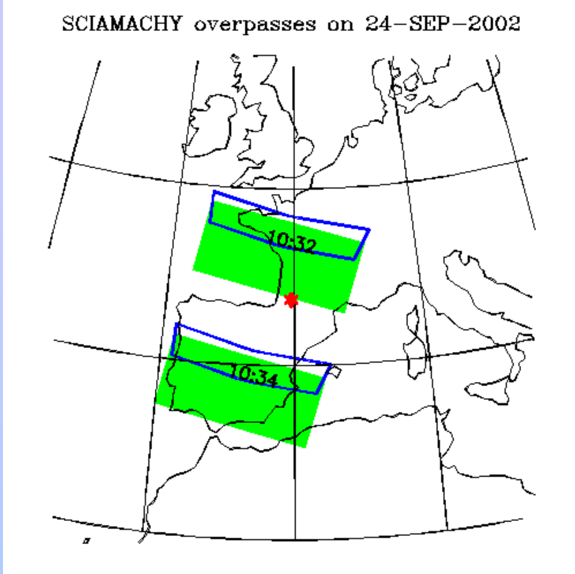
| | |
|---|---|
| weight | 25 kg with batteries |
| power consumption | 40 watts |
| telemetry | RS-232 9600 bps |

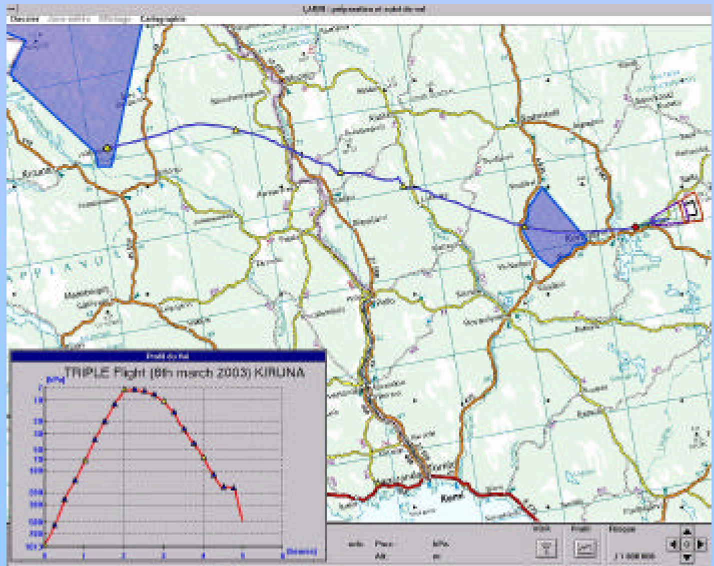
Table 2: Campaigns with CHILD onboard the TRIPLE gondola

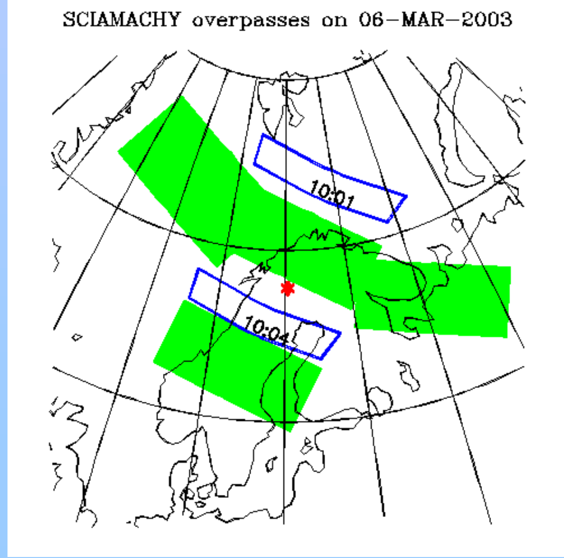
| | |
|---|---|
| Aire sour `l Adour fall 2001<br>(France, mid-latitude) | technical test |
| Aire sour `l Adour fall 2002<br>(France, mid-latitude) | ENVISAT validation,<br>Flight 24.09.2002 |
| Kiruna spring 2003<br>(Sweden, high-latitude) | ENVISAT validation<br>Flight 06.03.2003 |
| Kiruna summer 2003<br>(Sweden, high-latitude) | ENVISAT validation<br>Flight 09.06.2003 |

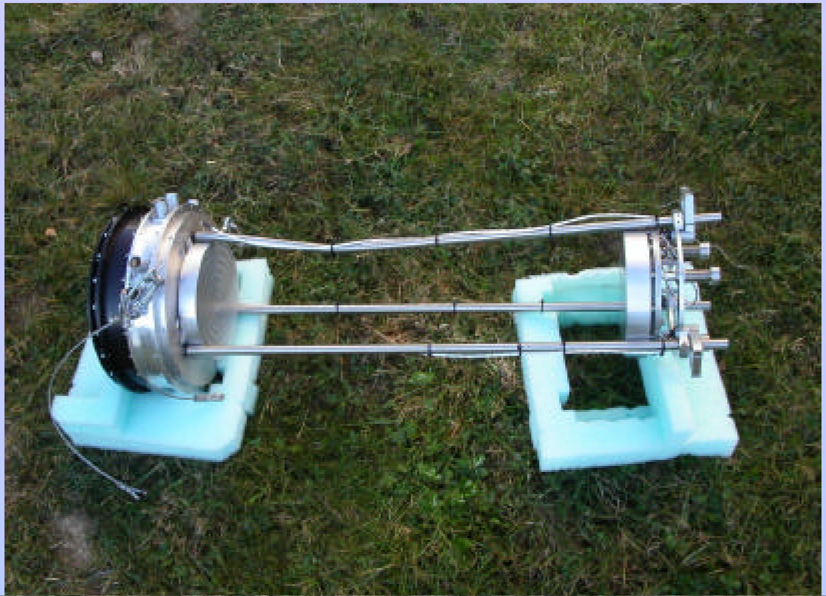
# Validation flights with TRIPLE & SCIAMACHY overpasses

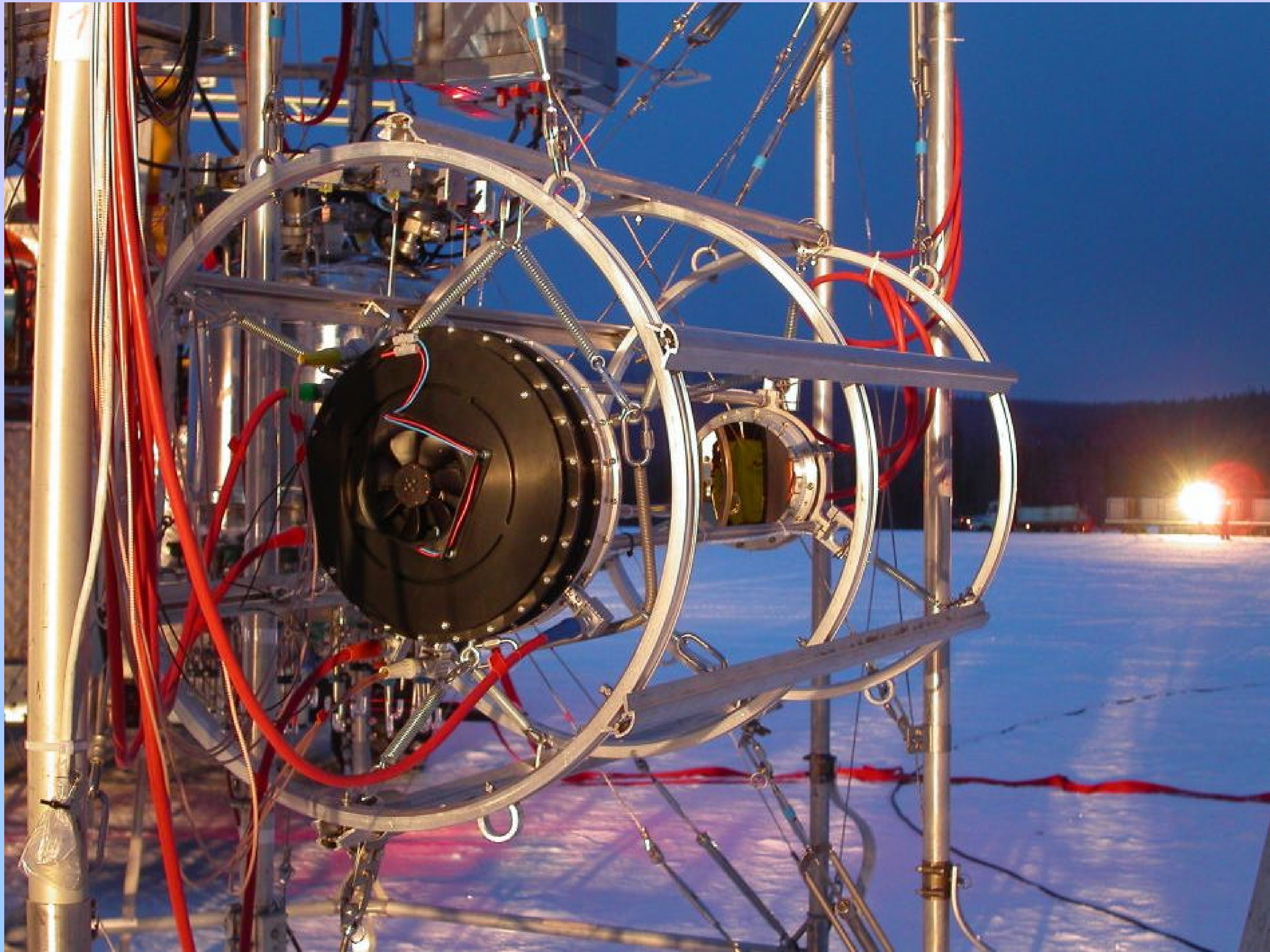


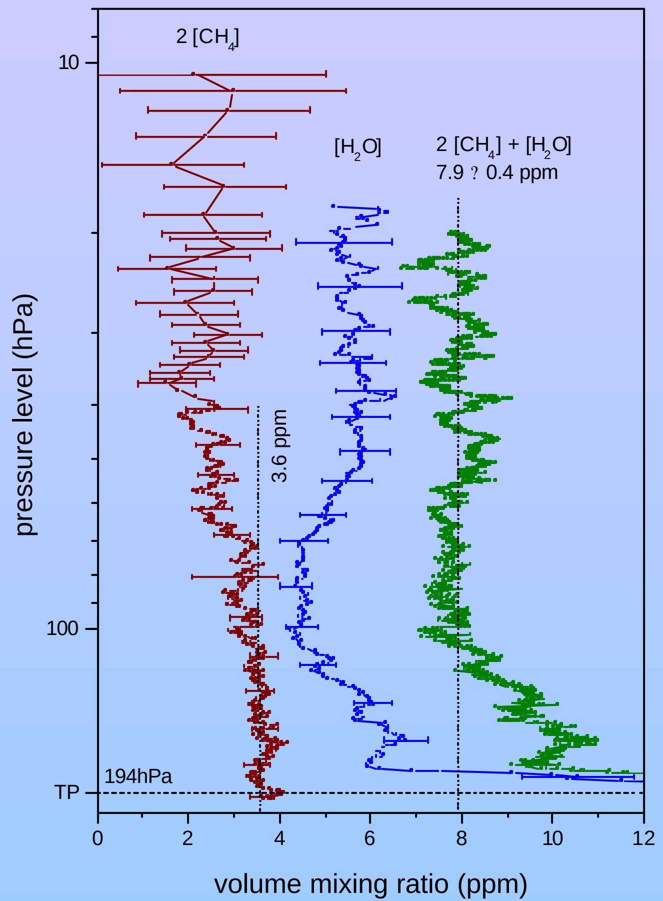



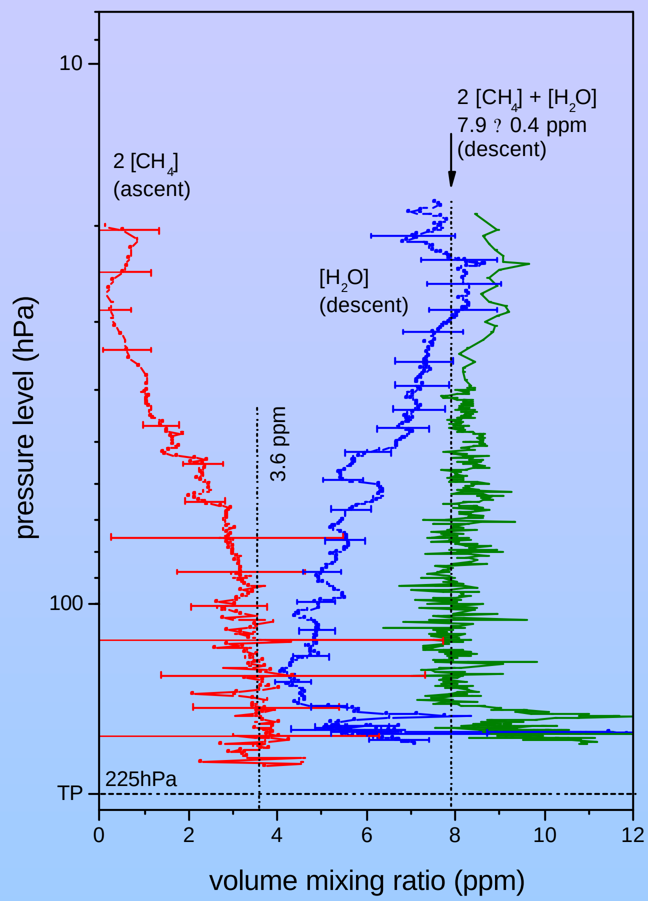




# Flight Results




ASA 24 September 2002




Kiruna 06 March 2003

## Conclusion

- three succesful validation flights with TRIPLE so far

- SCIAMACHY level-2 data (to be validated) not yet available

- intercomparisons of validation sensors are possible and useful

# SCIAMACHY SOLAR IRRADIANCE VALIDATION USING RADIOMETRIC CALIBRATION OF BALLOONBORNE SPECTROMETERS

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## General Concept

- use existing balloonborne instruments for additional measurements
- LPMA and DOAS = combined payload for tracegas measurements in occultation geometry, covering SCIAMACHY channels

- LPMA : Fourier Transform IR spectrometer
- DOAS : two channel UV-VIS grating spectrometer
- use same entrance optics to track the solar disc during sunrise or sunset from stratospheric float position

- solar irradiance measurements require radiometric calibration of LPMA-DOAS
- after correction for atmospheric effects (absorptions + scattering), top-of-atmosphere solar irradiance for validation of the corresponding SCIAMACHY level-1 product

# Calibration Sources & Procedures

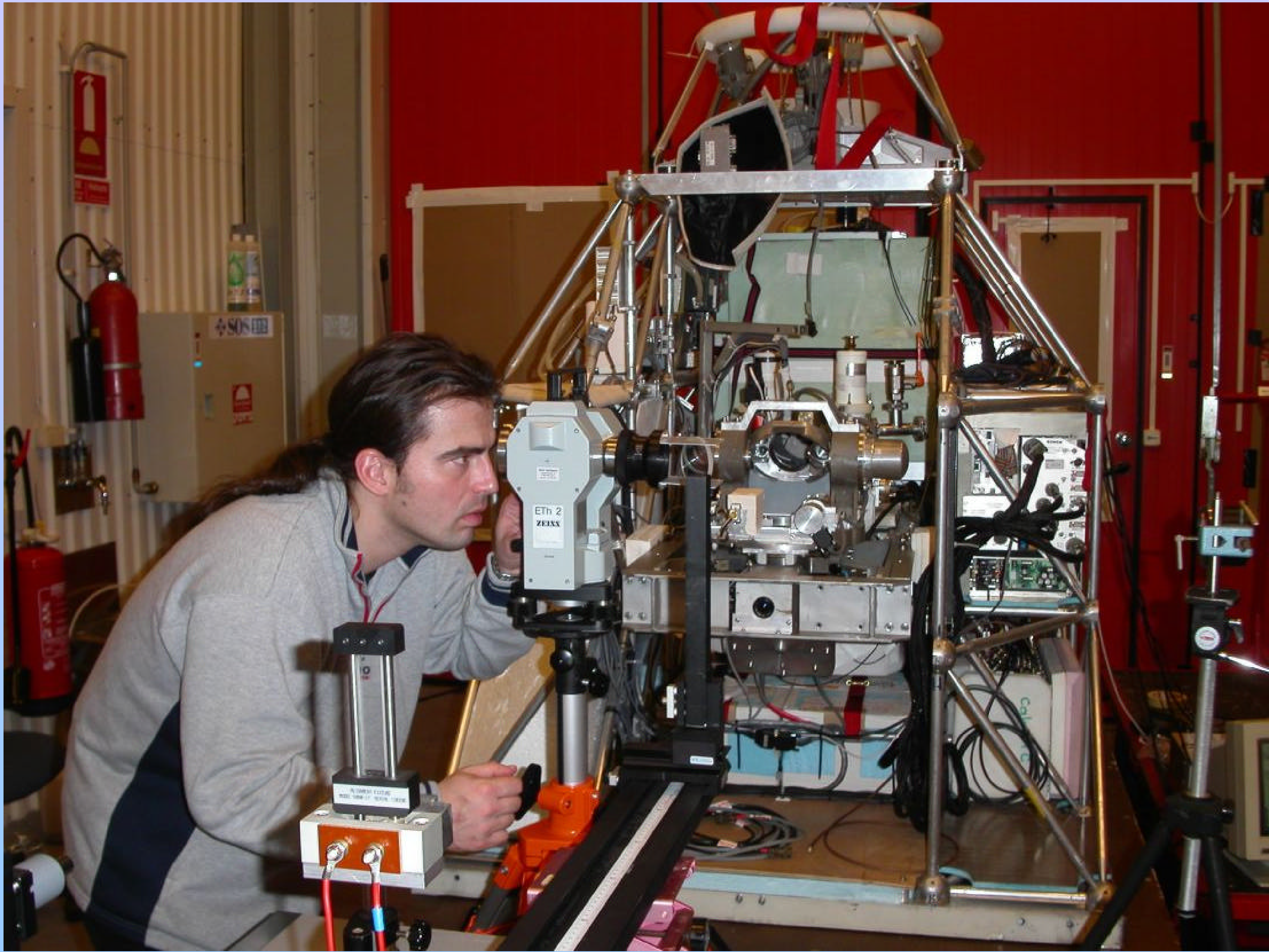
- absolute calibration of LPMA-DOAS before each flight

- calibration has to be done on the campaign site because integration of optical components (LPMA, DOAS and suntracker) takes place in the field

- setup of a mobile optical calibration lab in the field

- first campaign using this approach: Kiruna spring 2003 ENVISAT validation campaign with two LPMA-DOAS flights

- different calibration procedures for the LPMA and the DOAS spectrometer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## Calibration of LPMA (Fourier Transform IR spectrometer)

- requires a collimated optical input

- advantage of collimated calibration source:
  produces same results when used at different distances
  (taken aside absorptions along the lightpath)

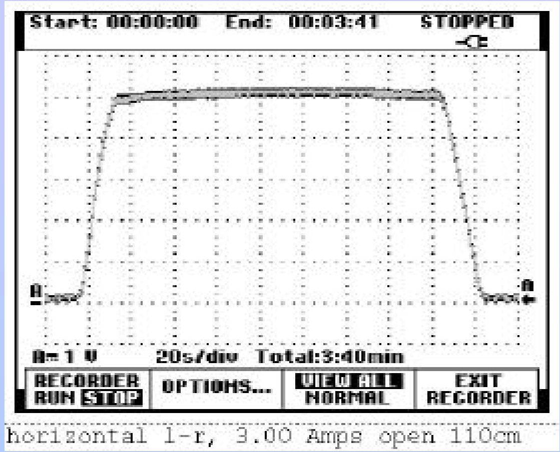
- source with 1000 watts inicial optical power and beam forming
  with mirror optics specially developed for this purpose

- selected lamps, special delivery by Phillips

- solar simulation, solar disc appears at a viewing angle of
  0.54°

- highly uniform light beam, diameter approx. 16 cm

# Results of LPMA radiometric calibration




beam cross-section

- usable radiation is produced from UV (300 nm) to IR (beyond 3000 nm)

- stability and reproducability better than 0.5 %

- distance to target not critical (measured variation of 1% when distance to target was varied from 1.2 to 2.2 meters)

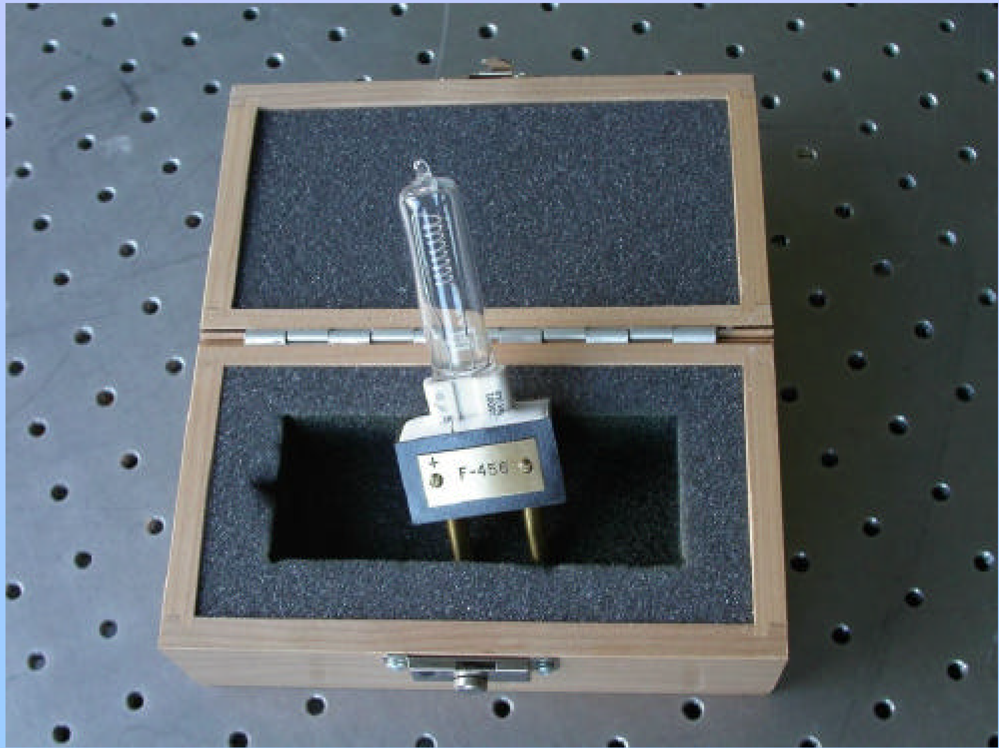
- optical output sufficient to operate LPMA in flight gain

- for characterisation, SCIAMACHY optical stimuli are available at IUP University of Bremen, calibrated results expected 08/2003

## Calibration of the DOAS spectrometer

- no collimated source required

- NIST standard lamp (1000 watts QTH quartz tungsten halogen) used as the calibration source



## Setup & procedure for DOAS calibration

- optical axis of DOAS aligned with NIST lamp

- NIST lamp mounted on optical rail (3 meters) with center of filament aligned with DOAS center of field of view

-for absolute calibration distance between source and target must be known

- this distance could not be measured directly using e.g. a ruler

- lamp could be moved on the optical axis to produce different intensities according to inverse square law

- intensity per unit area varies in inverse proportion to the square of distance X from source to target

## Calculation of unknown distance X between source and target

$$X = [d_1 (E_1/E_2)^{1/2} - d_2] / [1- (E_1/E_2)^{1/2}]$$

$d_1$ and $d_2$ are two known variations of the distance measured relatively to point X

$E_1$ and $E_2$ are the corresponding intensities (instrument readings)

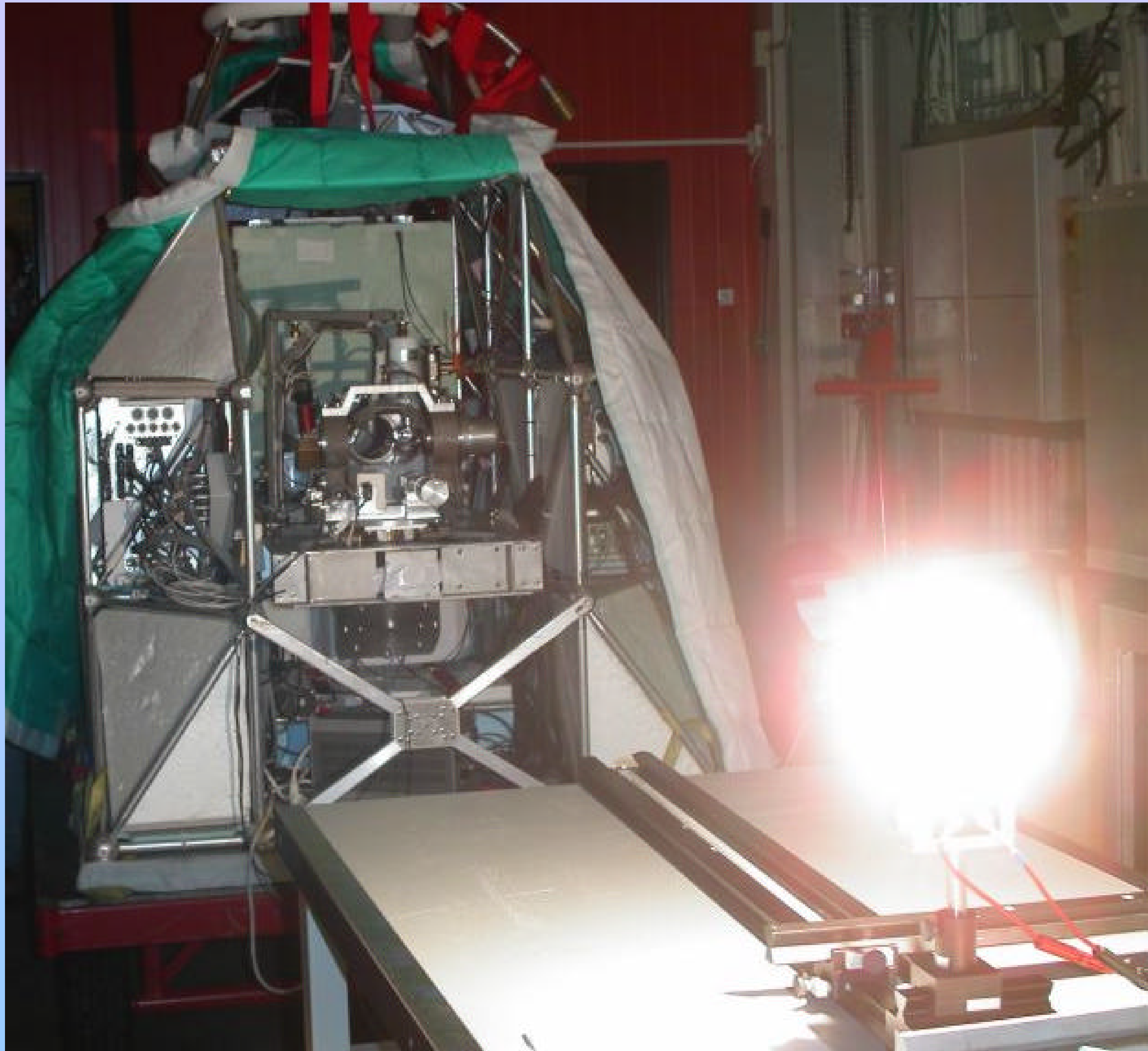
- with known distance X spectral irradiance of NIST lamp on DOAS can be calculated
- instrument´s spectral response then is known on absolute scale

## ...a closer look at the inverse square law

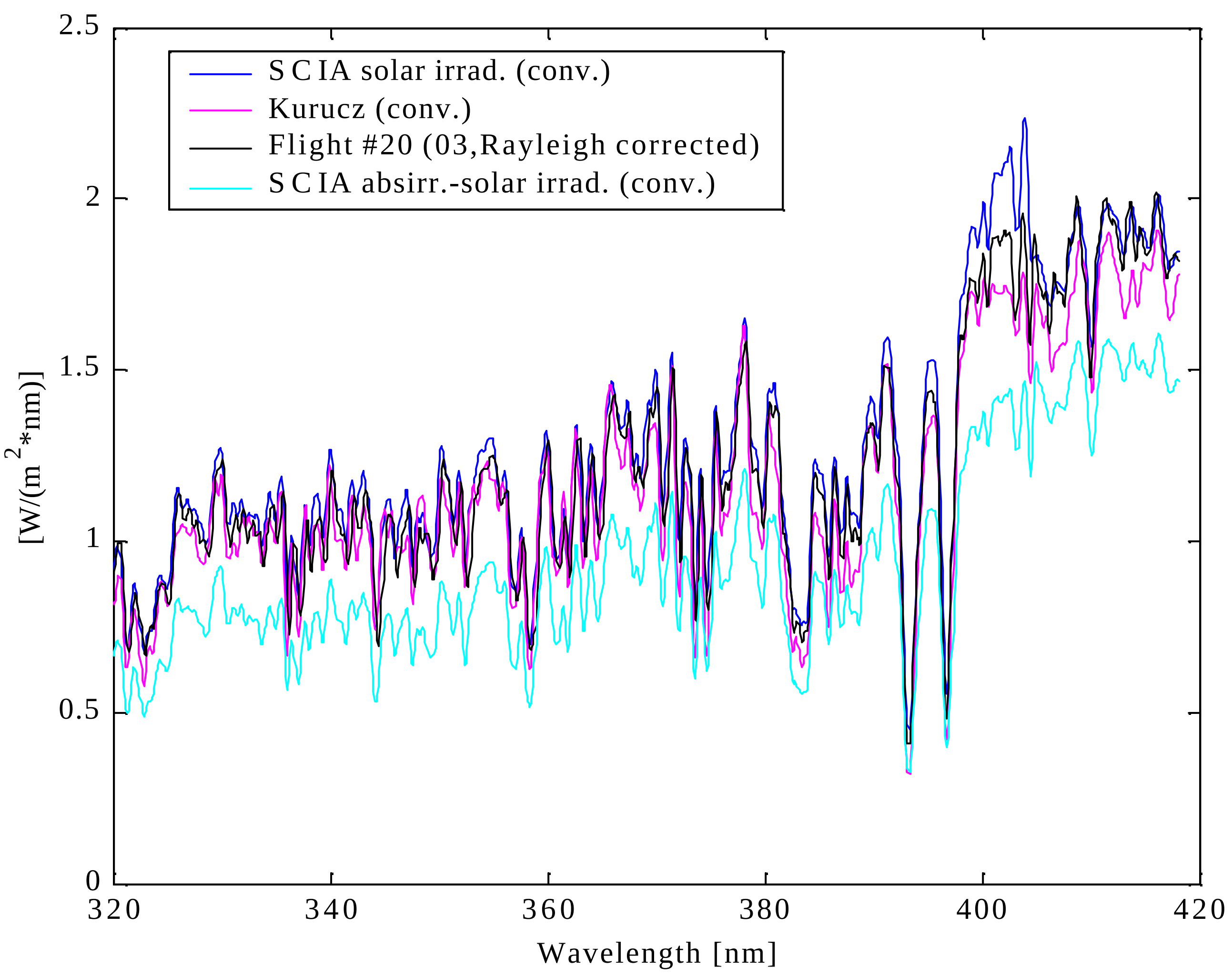
1) source must be point source, not an area source
   (source must be completely inside DOAS FOV, 3° for UV)
   long inicial distance of 2 meters needed, long integration times

2) optical axis must be known exactly. Suntracker could not be used due to limited dynamic range, manual optimisation. DOAS optical telescopes were not perfectly aligned with the suntracker. Quantitative measurement of this misalignment with collimated source

3) linearity of the instrument to be calibrated. DOAS showed some linearity problems for short integration times (used during flight) clarification required additional measurements



# Solar irradiance results with calibrated DOAS measurements



## Error budget of calibrated irradiance spectra from DOAS

1) uncertainty of irradiance standards used (~1%)

2) standard drift and ageing errors (0.5% per 24 h operation)

3) positioning errors in optomechanical setup, measured by reproduceability (1%)

4) errors by not completely satisfying inverse square law (DOAS linearity errors 3%, definition / reproduceability of optical axis 2%)

errors are in part systematic (linearity error, integration time error) and can be reduced by further investigation

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