Balanced calibration using an internal variable reference

- The radiometer MIRA2
- The calibration technique
- Typical results

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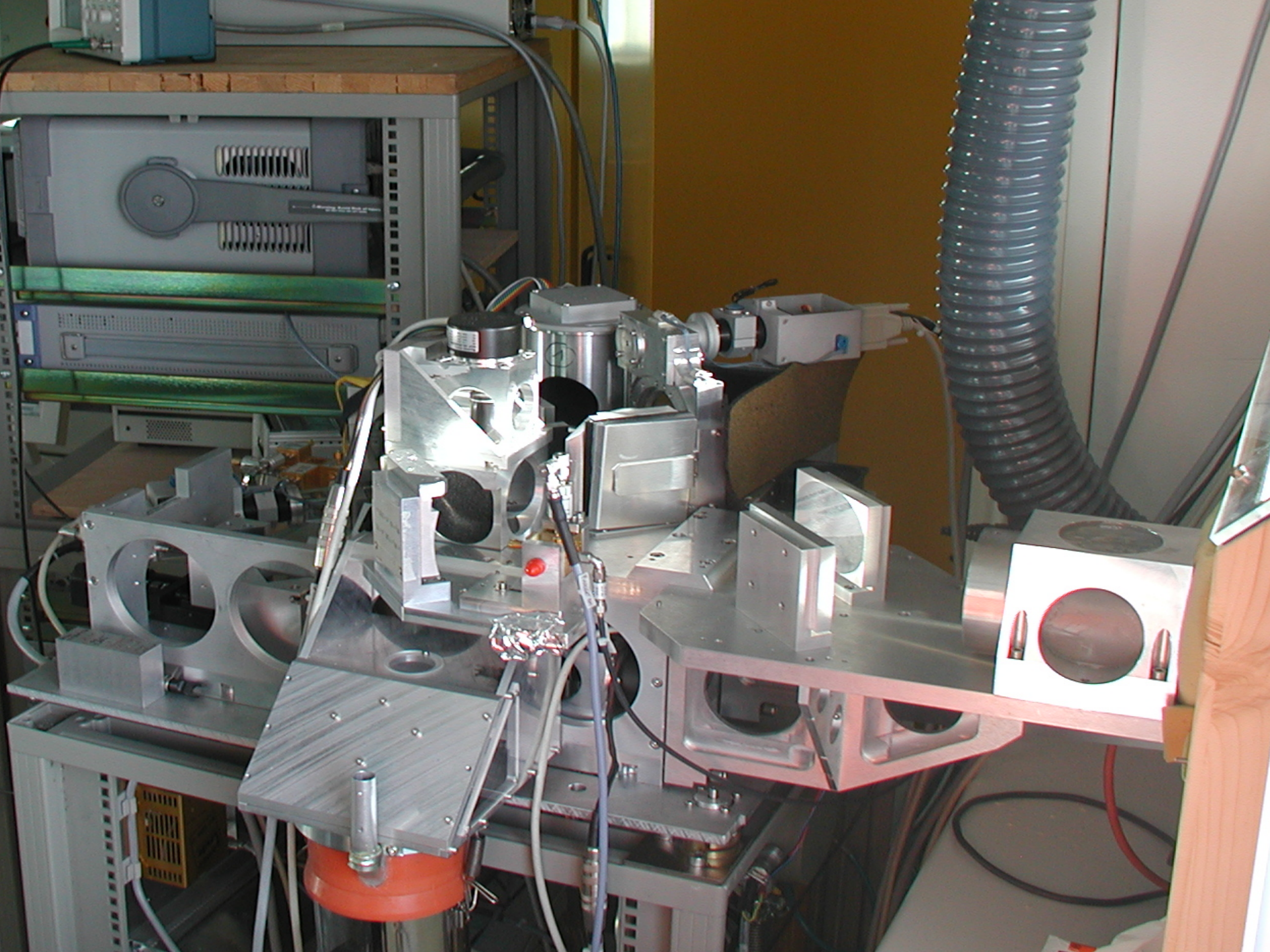
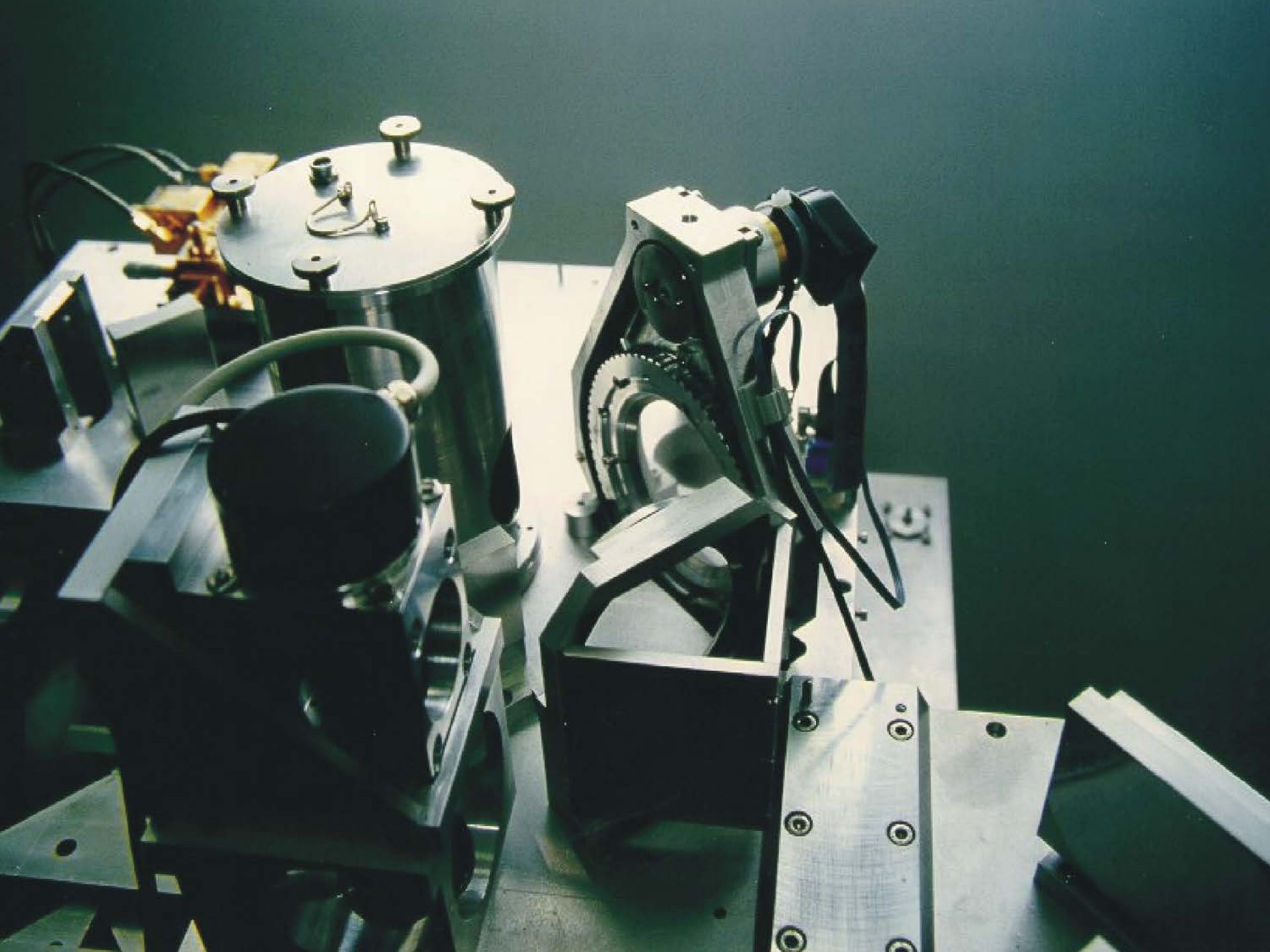
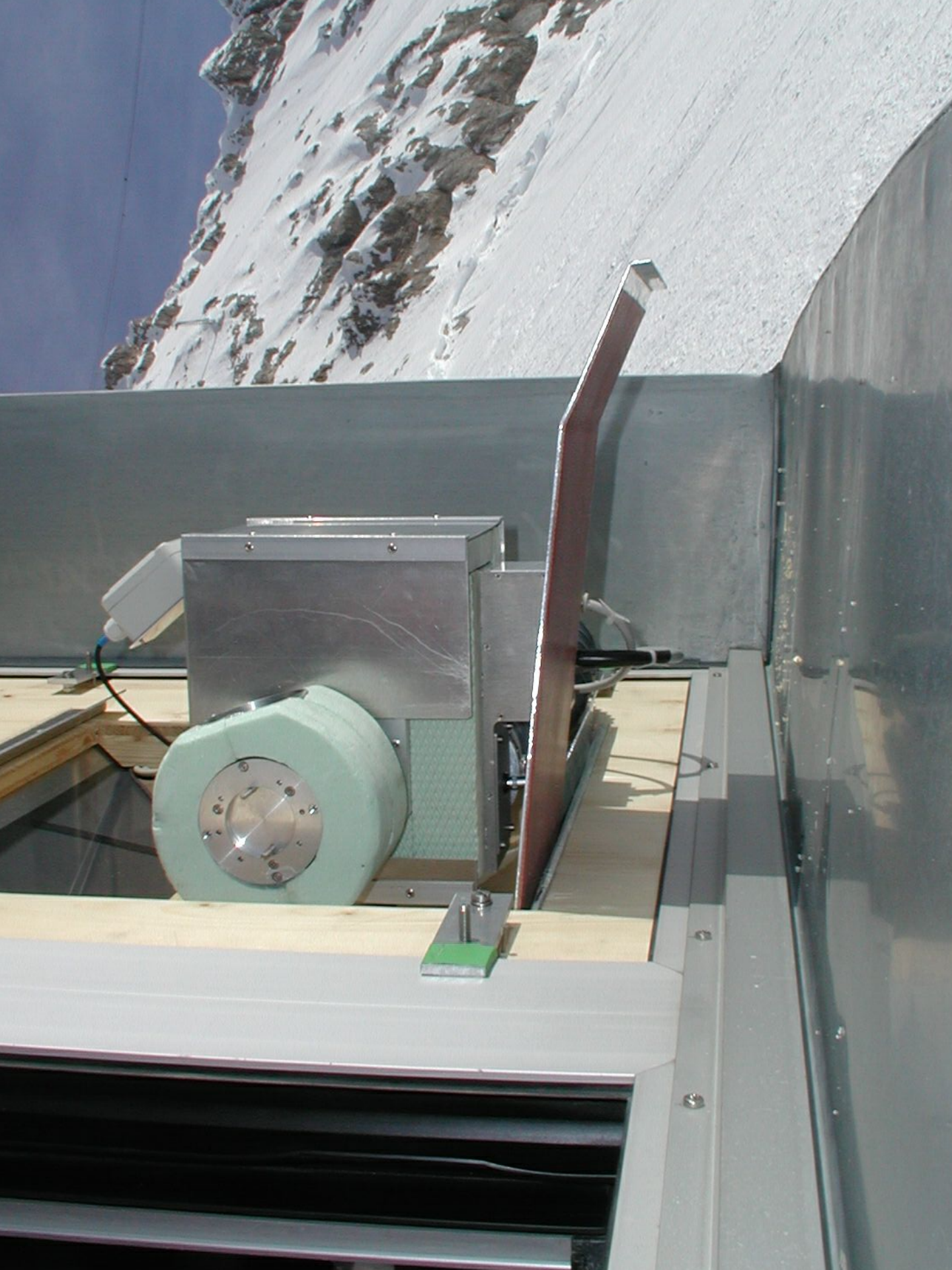
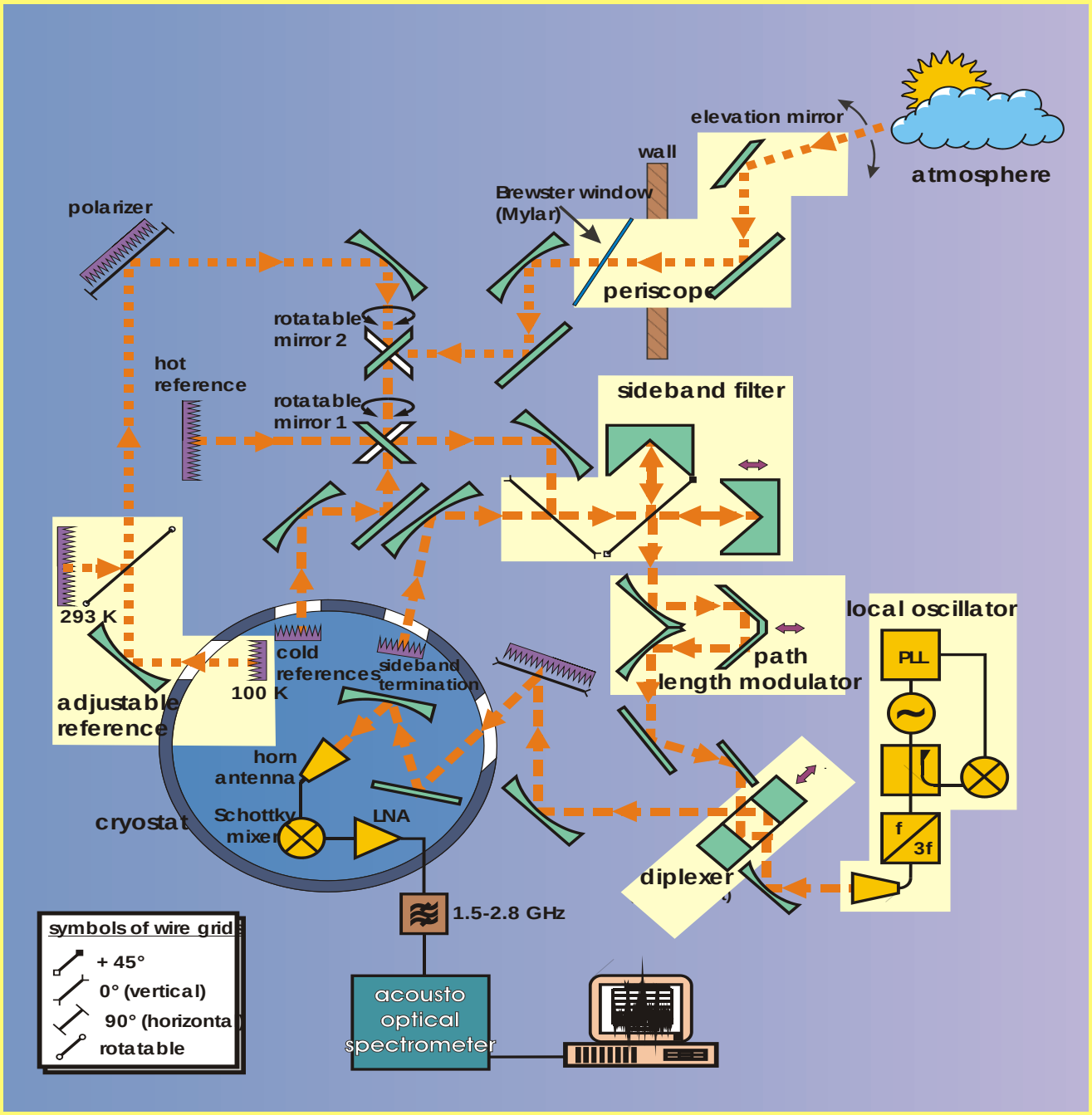
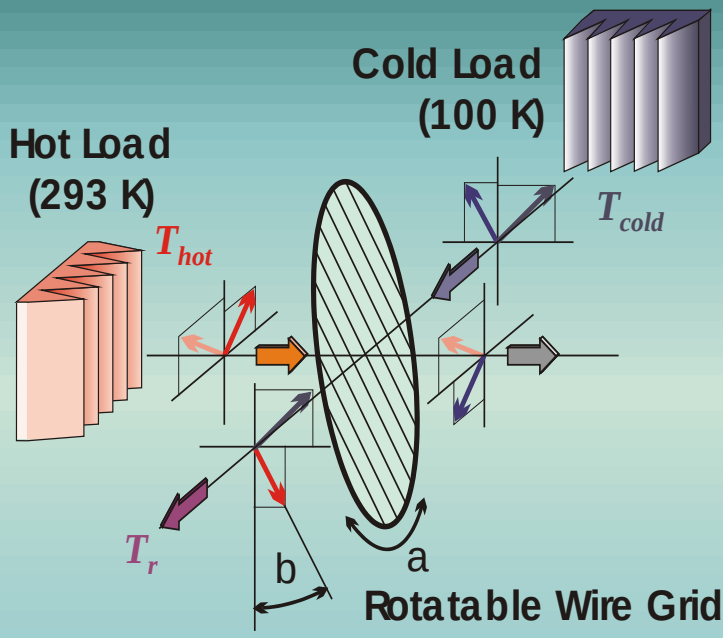




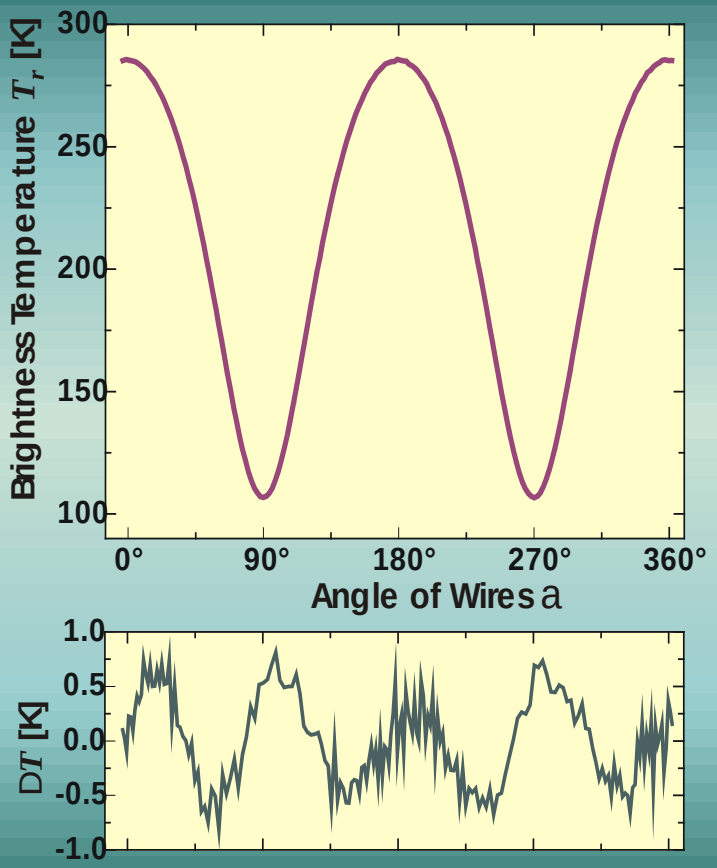



elevation mirror
atmosphere
wall
Brewster window
(Mylar)
polarizer
periscope
rotatable
mirror 2
hot
reference
rotatable
mirror 1
sideband filter
293 K
cold
references
100 K
sideband
termination
adjustable
reference
path
length modulator
local oscillator
PLL
horn
antenna
cryostat
Schottky
mixer
LNA
f
3f
diplexer
1.5-2.8 GHz
symbols of wire grid
+ 45°
0° (vertical)
90° (horizontal)
rotatable
acousto
optical
spectrometer

The Adjustable Reference Load



$$T_r = \frac{2\,T_{hot} + T_{cold}\tan^2\alpha}{2 + \tan^2\alpha}$$

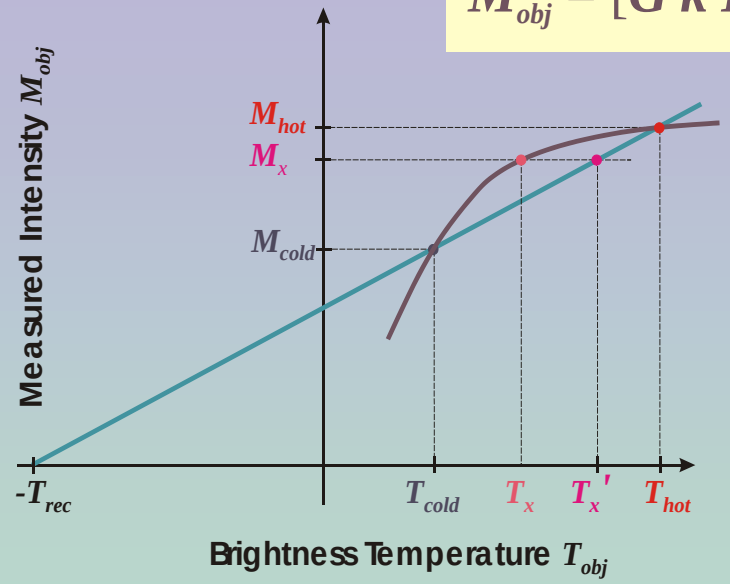


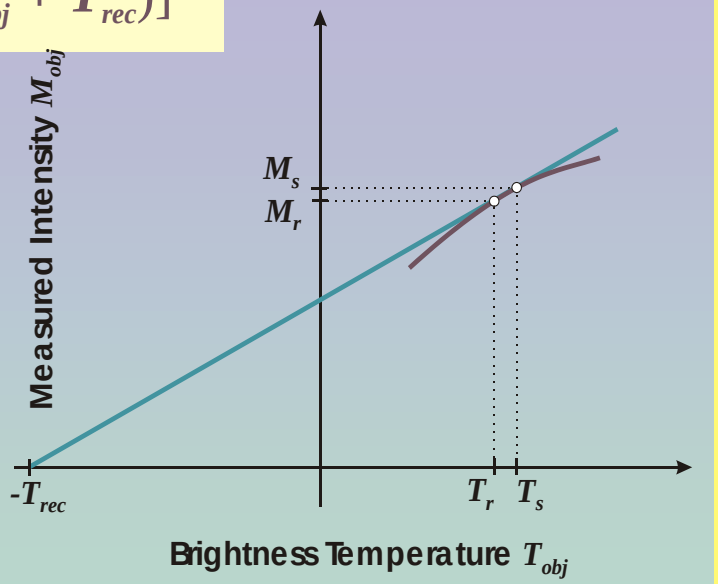
Effect of Nonlinearities Dependent on Calibration Principle

Hot-Cold Calibration

$$M_{obj} = [G\,k\,B\,(T_{obj} + T_{rec})]^{b}$$

Balanced Calibration

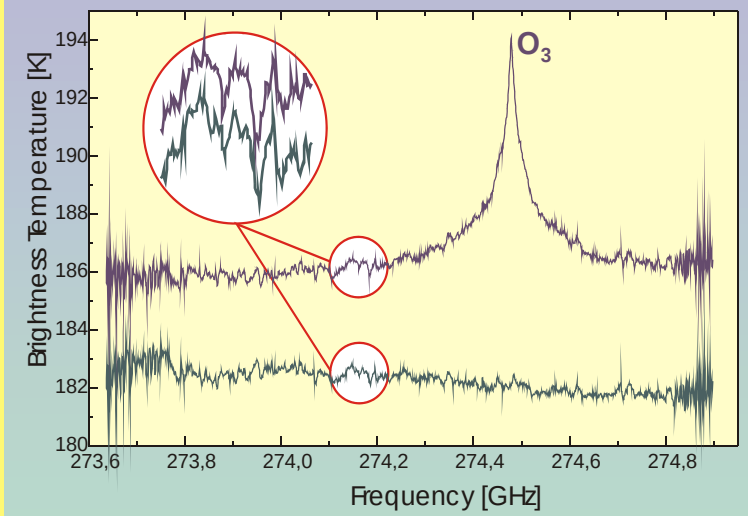




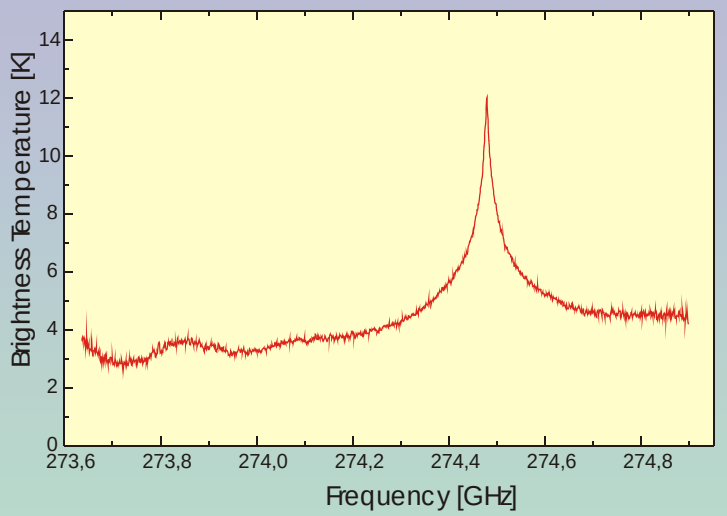
$$T_{line} = T_s - T_r = \frac{M_s - M_r}{M_r}(T_r + T_{rec})$$

Influence of Nonlinearities on Hot-Cold-Calibrated Spectra

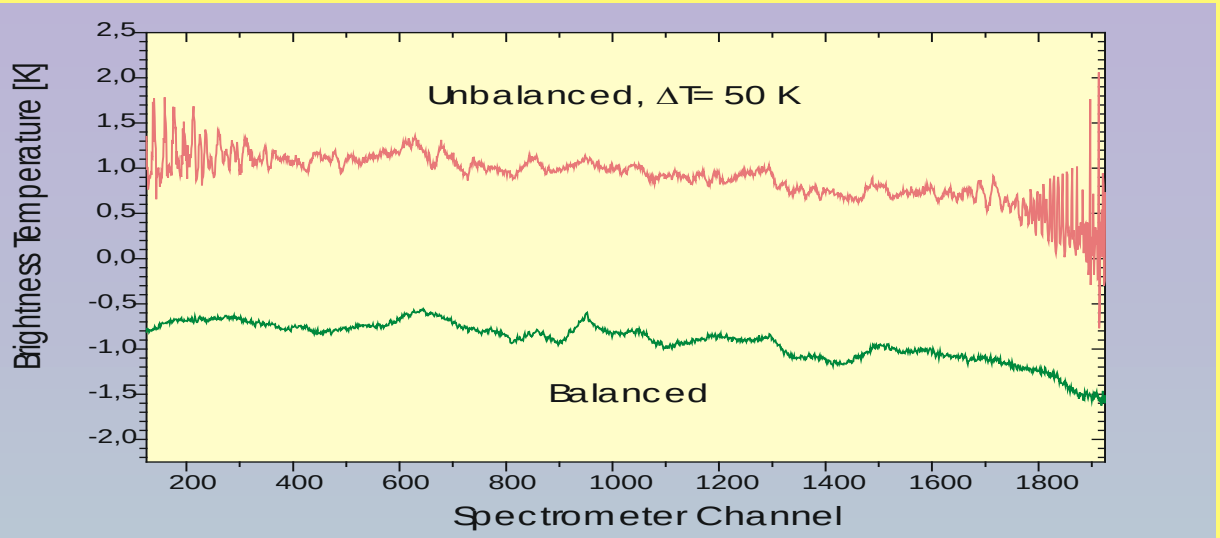
Hot-Cold-Calibrated Measurements of the Atmosphere

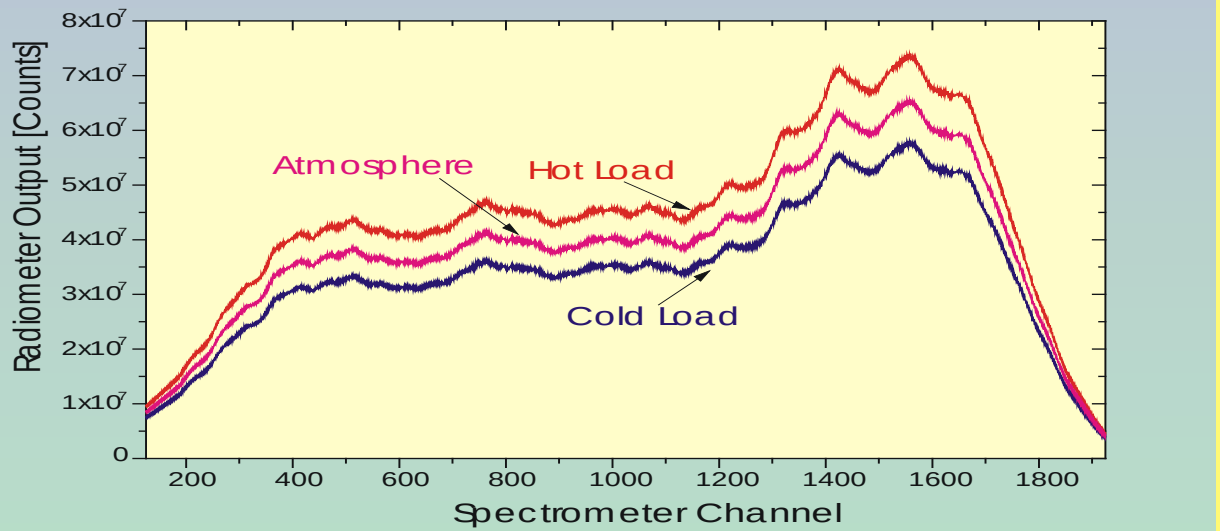


Difference



Influence of Balancing on Measured Spectra

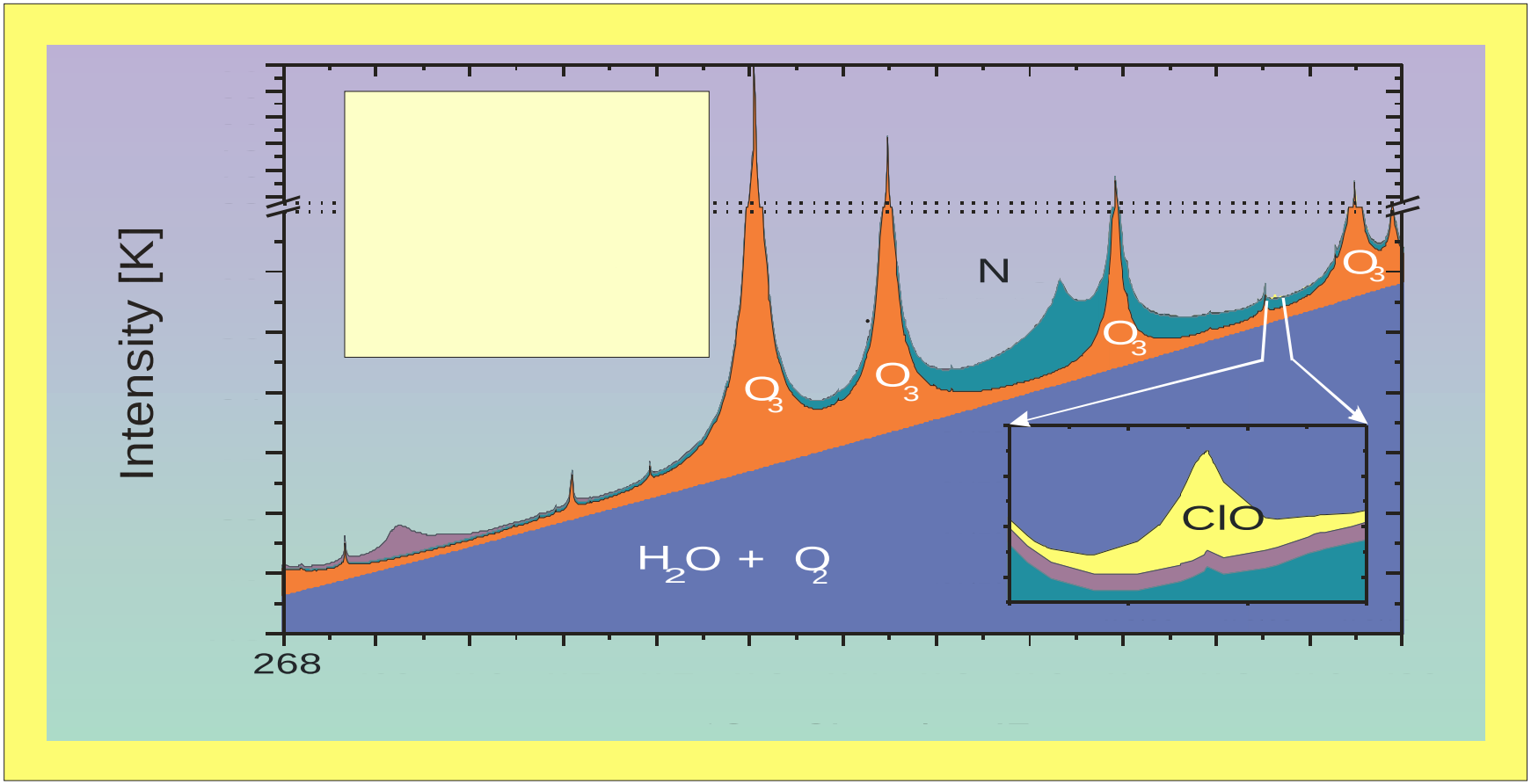


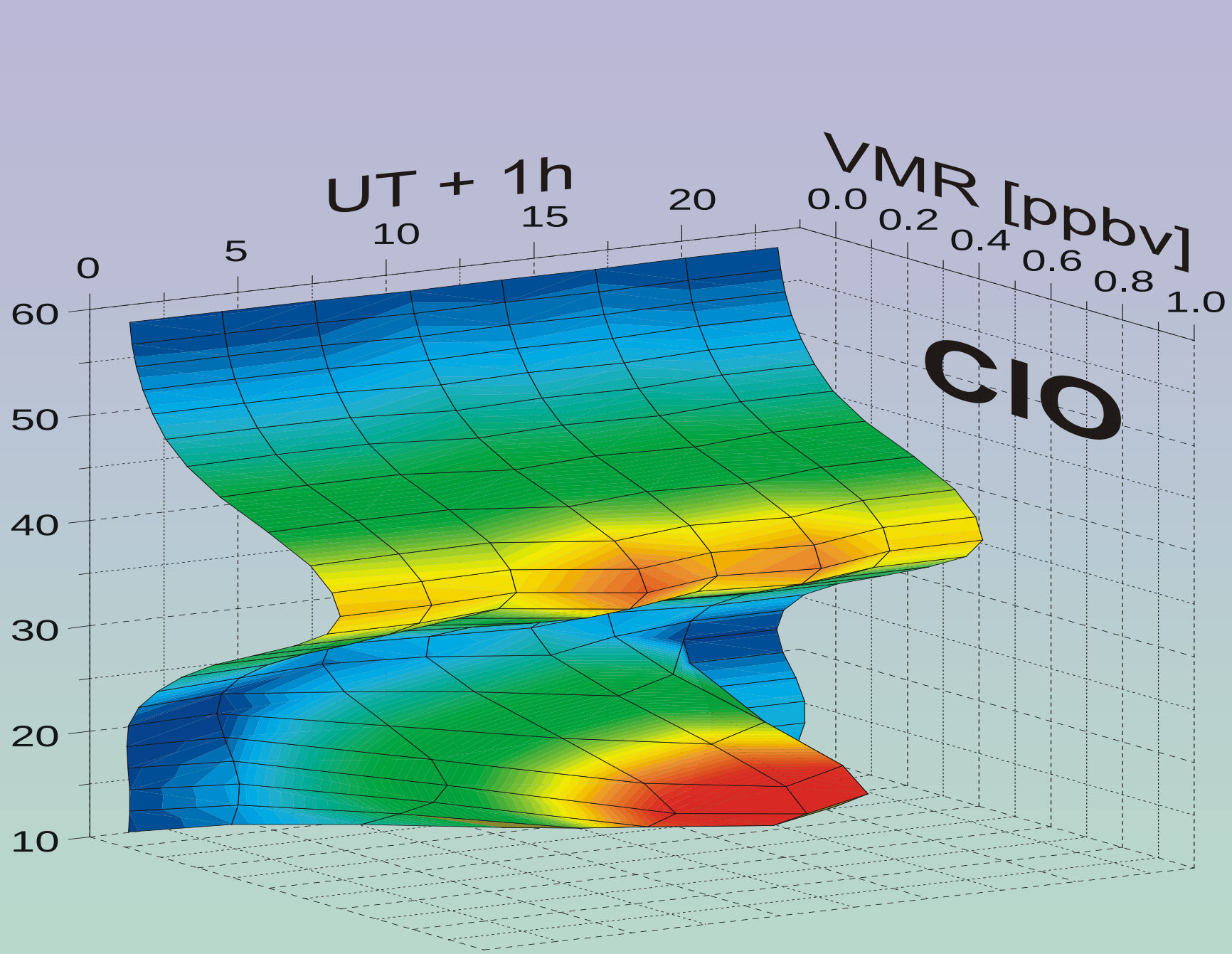


Conclusions

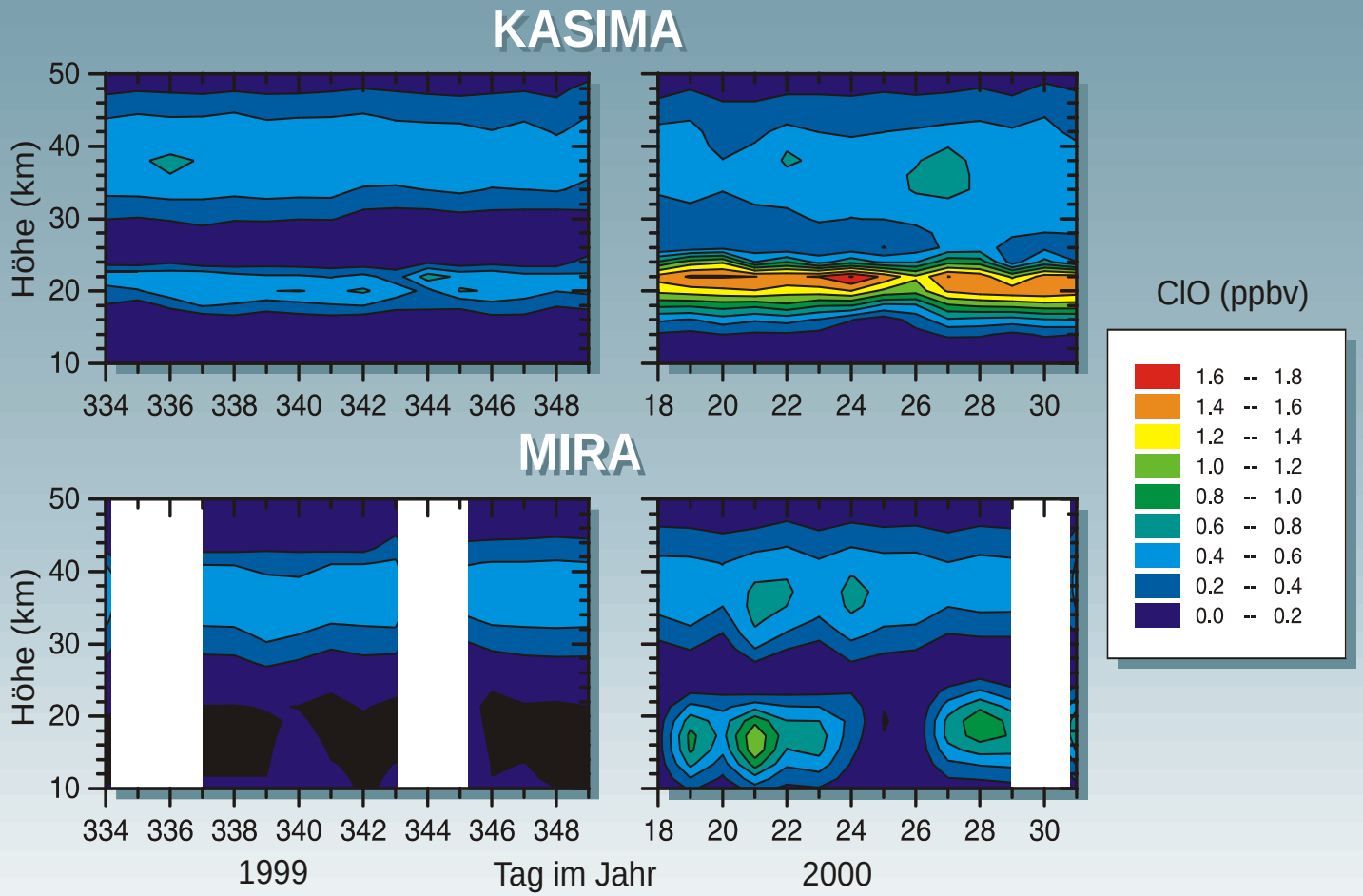
- Balanced calibration reduces disturbances of the measured spectra caused by nonlinearities of the radiometer system.
- IMK uses a quasi-optical, variable reference load for internal balanced measurements, whose brightness temperature can be mechanically adjusted between 300 K and 100 K
- Internal balanced calibration has been sucessfully applied during several measurement campaigns for the detection of weak trace gas signatures.
- The temperature range of the reference load can be modified

Trace Gas Signatures in the Tuning Range of MIRA2

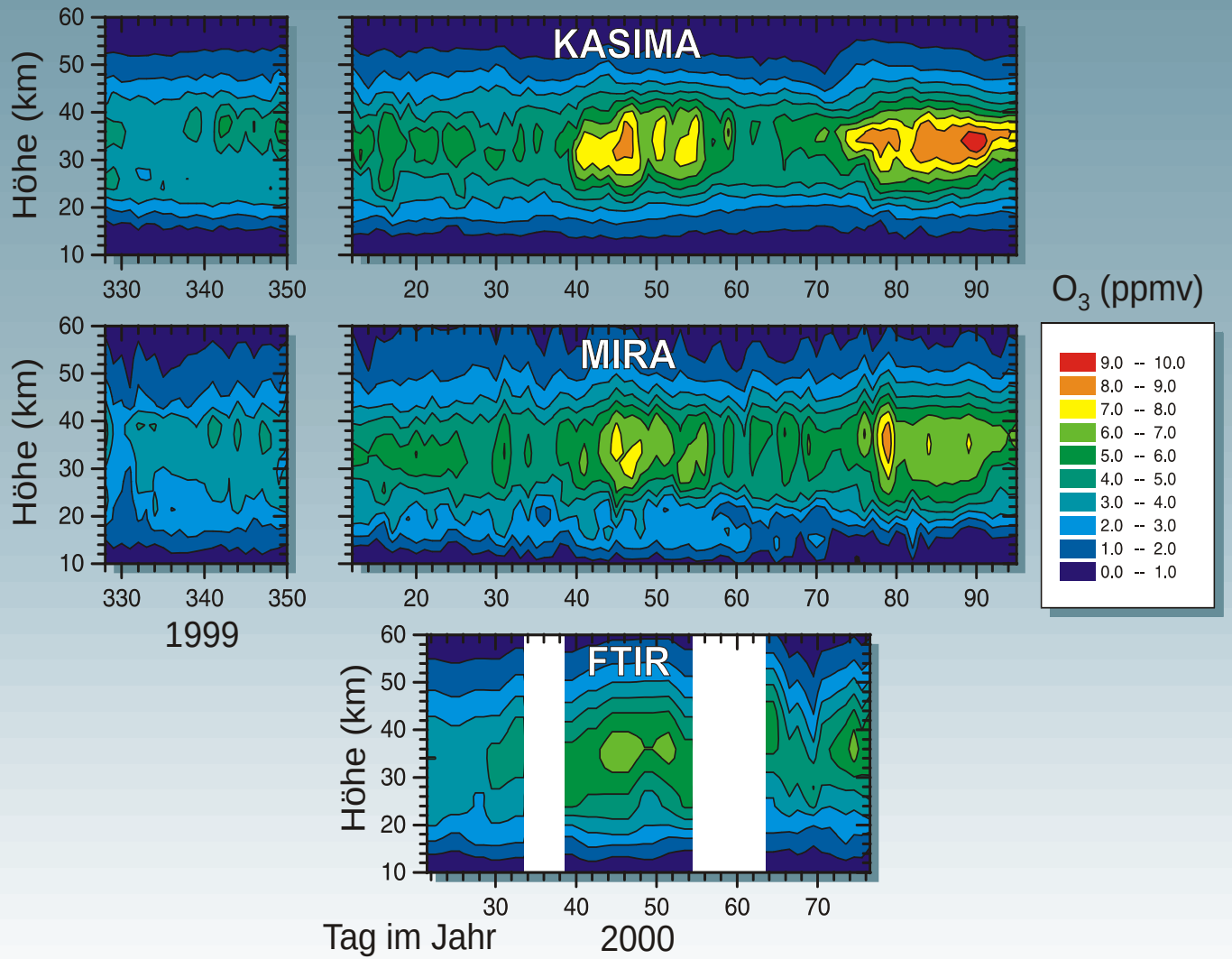



UT + 1h
0
5
10
15
20
VMR [ppbv]
0.0
0.2
0.4
0.6
0.8
1.0
ClO
60
50
40
30
20
10

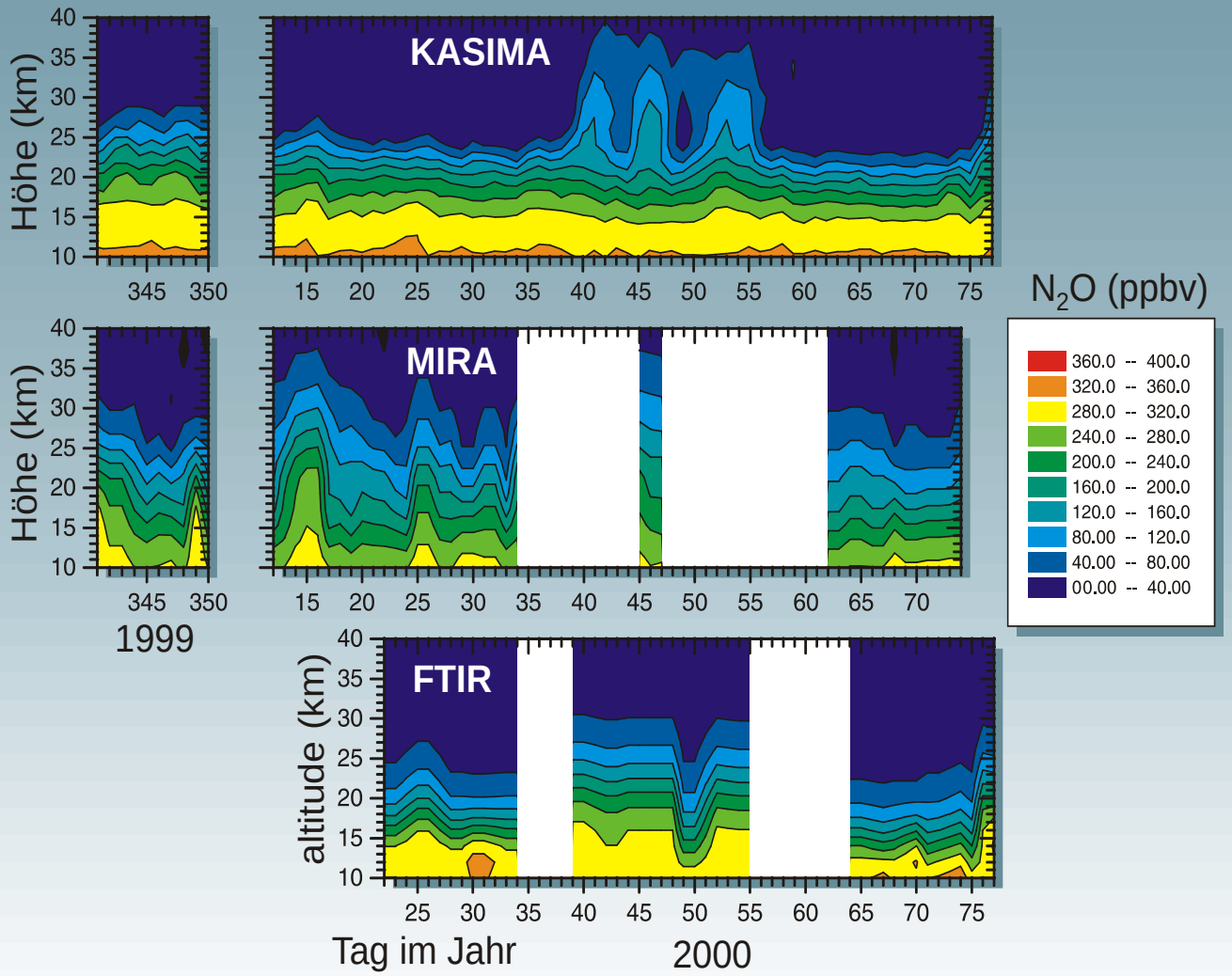
ClO über Kiruna im Winter 1999/2000



Ozon über Kiruna im Winter 1999/2000



N_2O im Winter 1999/2000 über Kiruna



HNO_3 über Kiruna im Winter 1999/2000