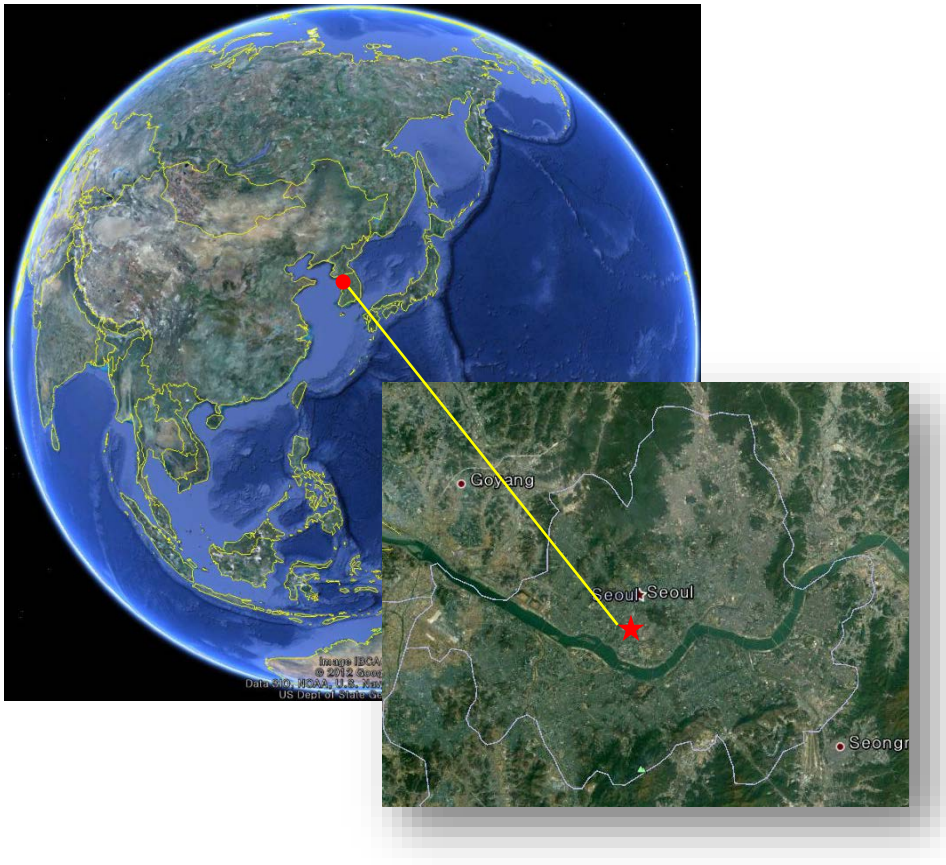
SOOKMYUNG WOMEN'S UNIVERSITY

Ozone and Water Vapor In Seoul

Jung Jin Oh

Sookmyung Women’s University

RIGE : Measurement place

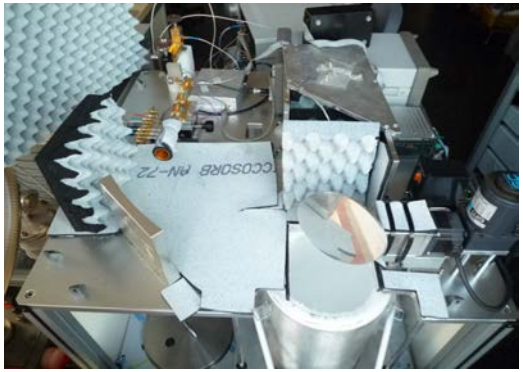


Research Institute of Global Environment
Sookmyung Women's University
Seoul, Korea
(37.32 ˚N, 126.57 ˚E, 52m)

MW Radiometers in RIGE

- SWARA (Seoul Water Vapor Radiometer)
  - 22.235 GHz H_2O Radiometer
  - Since Oct. 2006
  - NDAAC (Sep. 2012)

- SORAS (Stratospheric Ozone Radiometer in Seoul)
  - 110.836 GHz O_3 Radiometer
  - Since Jul. 2008



SORAS

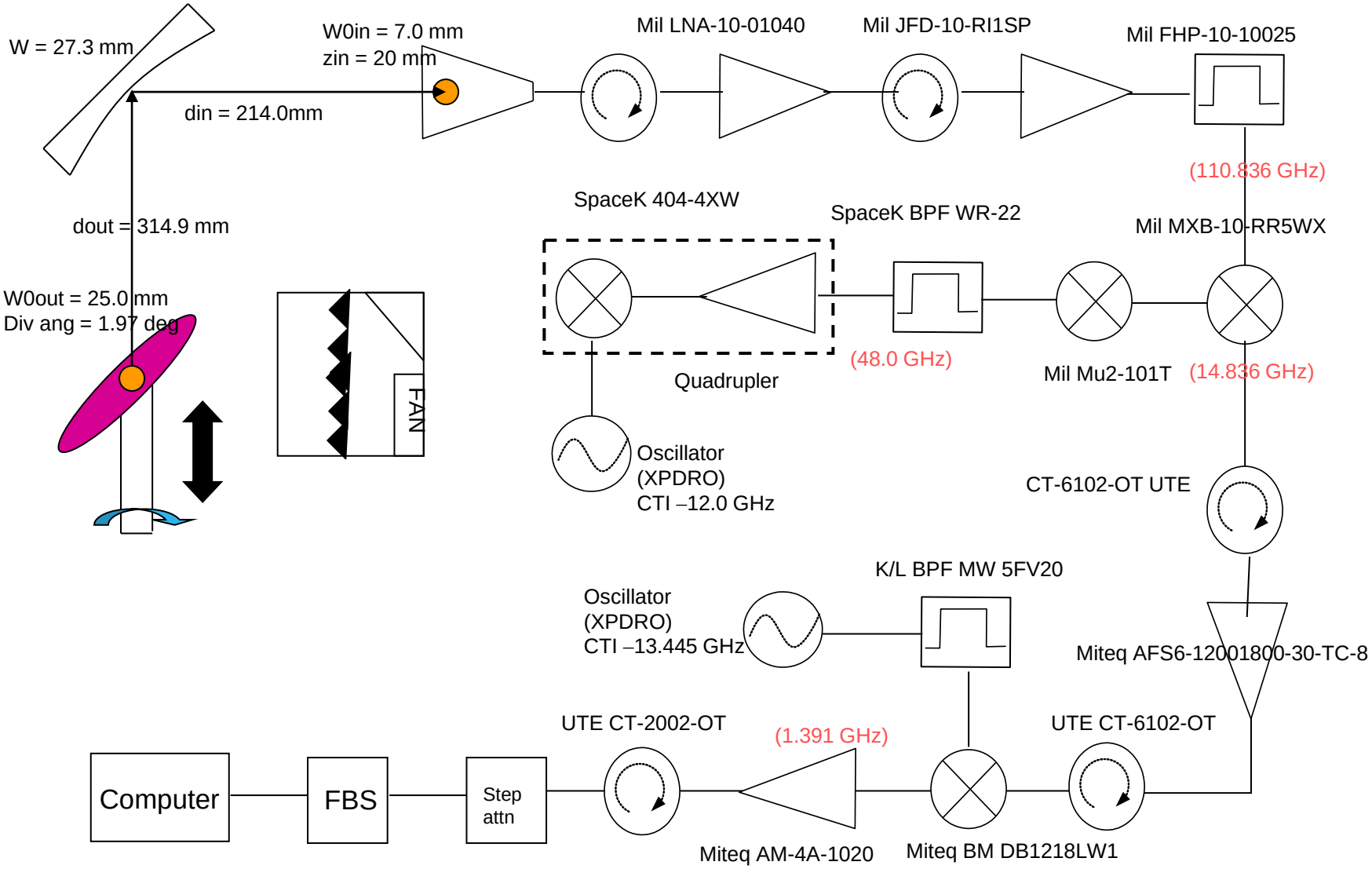
- 110.836 GHz Radiometer (Ozone 615-606 Transition)

- Quasi-optics: Plane mirror, Ellipsoidal mirror,
  Corrugated horn antenna (FWHM: 8.3˚)

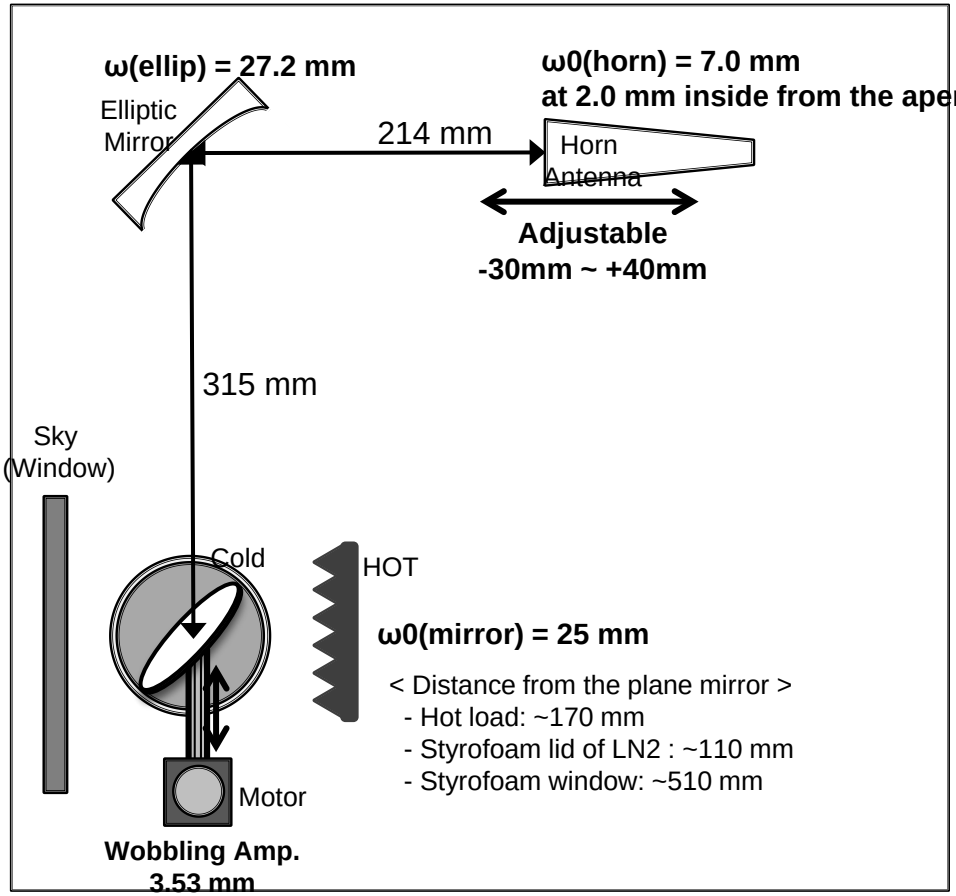
- RF: 110.836 GHz (110.227 GHz ~ 111.227 GHz)
- IF: 14.836 GHz
- LO: 96 GHz Gunn oscillator w/ Phase lock loop

- FFT Spectrometer (Acqiris AC240)
  - 16235 channels w/ 61 kHz resolution
    (1 GHz bandwidth)

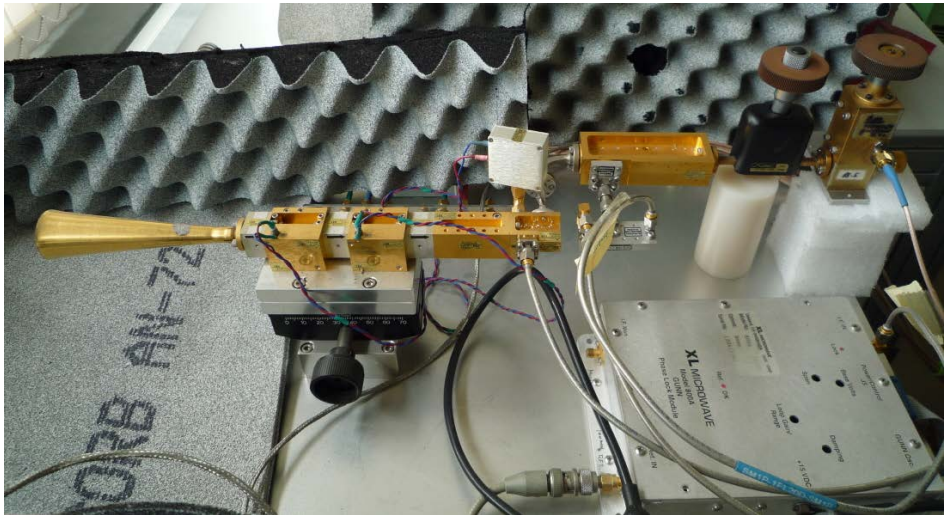
SORAS


W = 27.3 mm
W0in = 7.0 mm
zin = 20 mm
din = 214.0mm
Mil LNA-10-01040
Mil JFD-10-RI1SP
Mil FHP-10-10025
(110.836 GHz)
dout = 314.9 mm
SpaceK 404-4XW
SpaceK BPF WR-22
Mil MXB-10-RR5WX
W0out = 25.0 mm
Div ang = 1.97 deg
FAN
(48.0 GHz)
Quadrupler
Mil Mu2-101T
(14.836 GHz)
Oscillator
(XPDRO)
CTI –12.0 GHz
CT-6102-OT UTE
K/L BPF MW 5FV20
Oscillator
(XPDRO)
CTI –13.445 GHz
Miteq AFS6-12001800-30-TC-8
UTE CT-2002-OT
(1.391 GHz)
UTE CT-6102-OT
Computer
FBS
Step
attn
Miteq AM-4A-1020
Miteq BM DB1218LW1

Quasi-Optics



Frontend - RF System for 110.836 GHz



- RF system
  - 36 dB amplification
  - High pass filter (94.5 GHz ~)
  - Frequency conversion from 110.836 GHz to 14.836 GHz
  - 96 GHz LO signal generation with PLL system

- IF system
  - Frequency conversion from 14.836 GHz to 1.391 GHz with IF converter (LO: 13.445 GHz)
  - 31 dB amplification

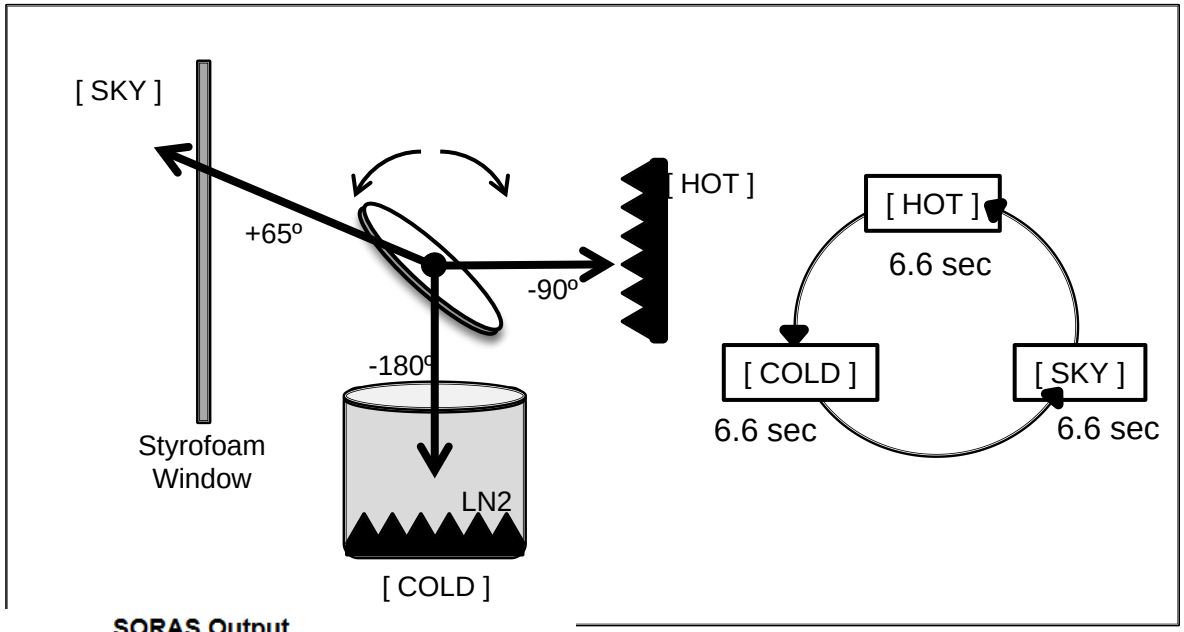
Spectrometer

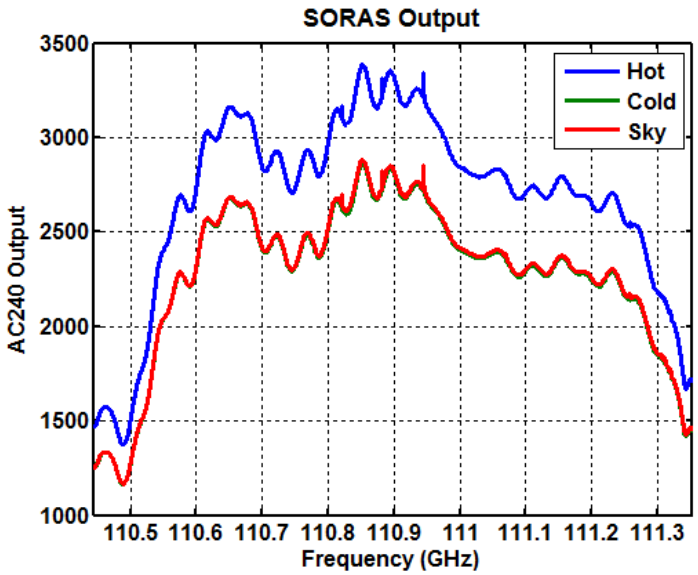
- FFT Spectrometer (Acqiris AC240)
  - Frequency range: 0 ~ 1 GHz
  - 61 kHz resolution (16384 channels)

- 2nd IF converter (baseband converter)

  - frequency conversion
    from 1.391 GHz to 0.609 GHz
    (LO: 2 GHz, bandwidth: 830 MHz)

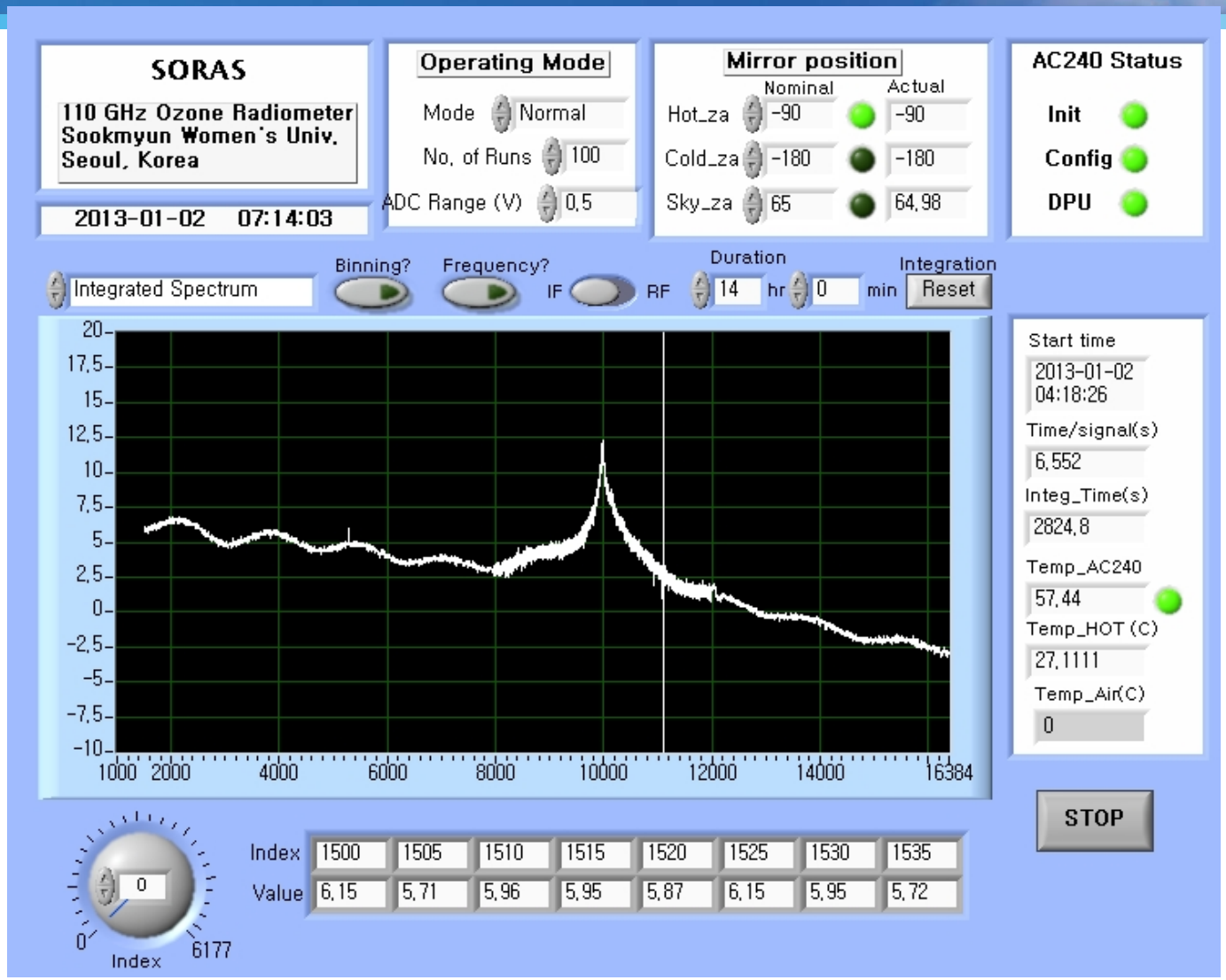
Calibration – Total Power Method



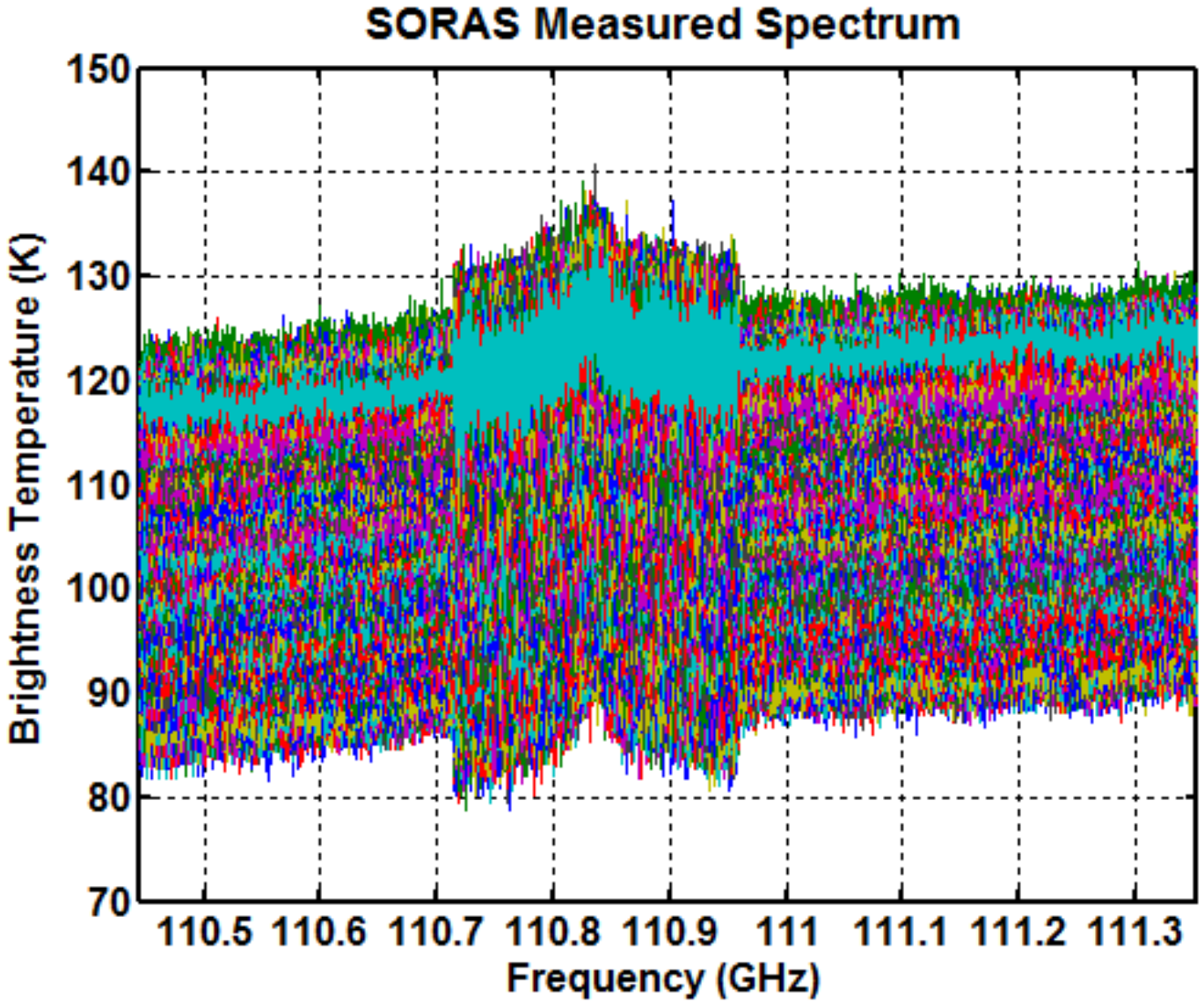


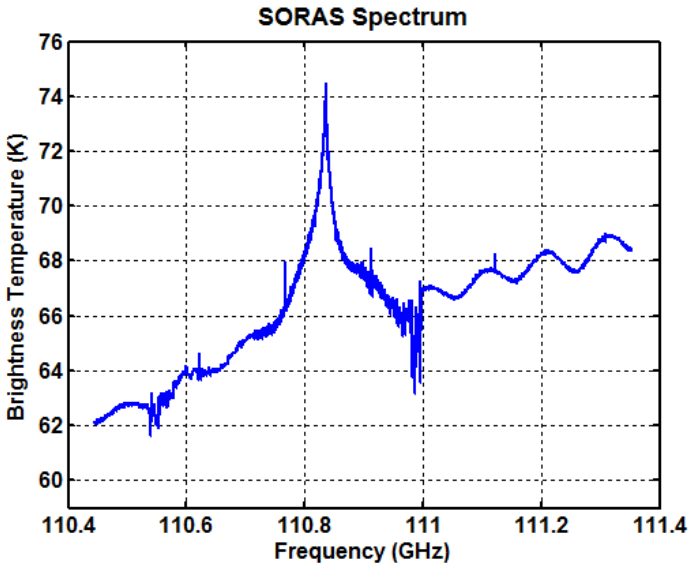
- Trec = ~1200 K
- Yfactor = 1.17

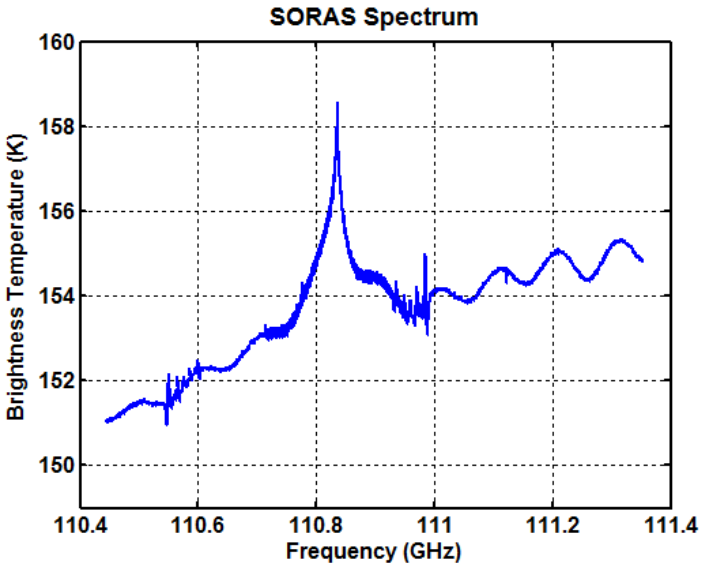
$$T_{B,atm} = T_{B,cold} + \frac{T_{B,hot} - T_{B,cold}}{P_{hot} - P_{cold}} (P_{atm} - P_{cold})$$

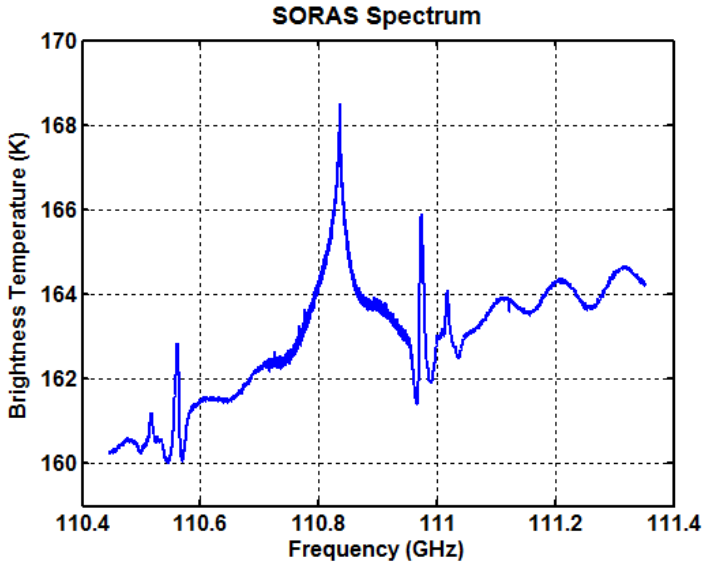

SORAS
110 GHz Ozone Radiometer
Sookmyun Women's Univ.
Seoul, Korea
2013-01-02 07:14:03
Operating Mode
Mode Normal
No. of Runs 100
ADC Range (V) 0.5
Mirror position
Nominal
Actual
Hot_za -90 -90
Cold_za -180 -180
Sky_za 65 64.98
AC240 Status
Init
Config
DPU
Integrated Spectrum
Binning?
Frequency?
IF
RF
Duration
14 hr 0 min
Integration
Reset
20
17.5
15
12.5
10
7.5
5
2.5
0
-2.5
-5
-7.5
-10
1000 2000 4000 6000 8000 10000 12000 14000 16384
Start time
2013-01-02 04:18:26
Time/signal(s)
6.552
Integ_Time(s)
2824.8
Temp_AC240
57.44
Temp_HOT (C)
27.1111
Temp_Air(C)
0
STOP
0
0
Index
6177
Index 1500 1505 1510 1515 1520 1525 1530 1535
Value 6.15 5.71 5.96 5.95 5.87 6.15 5.95 5.72

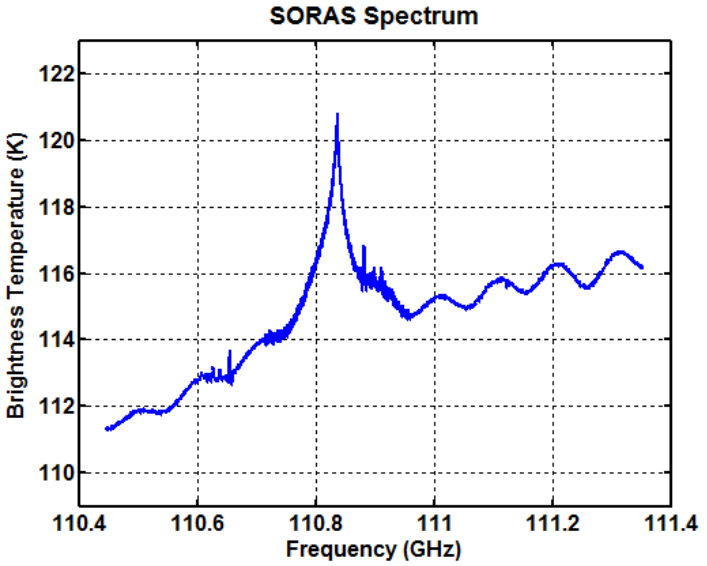
One day (20 seconds)



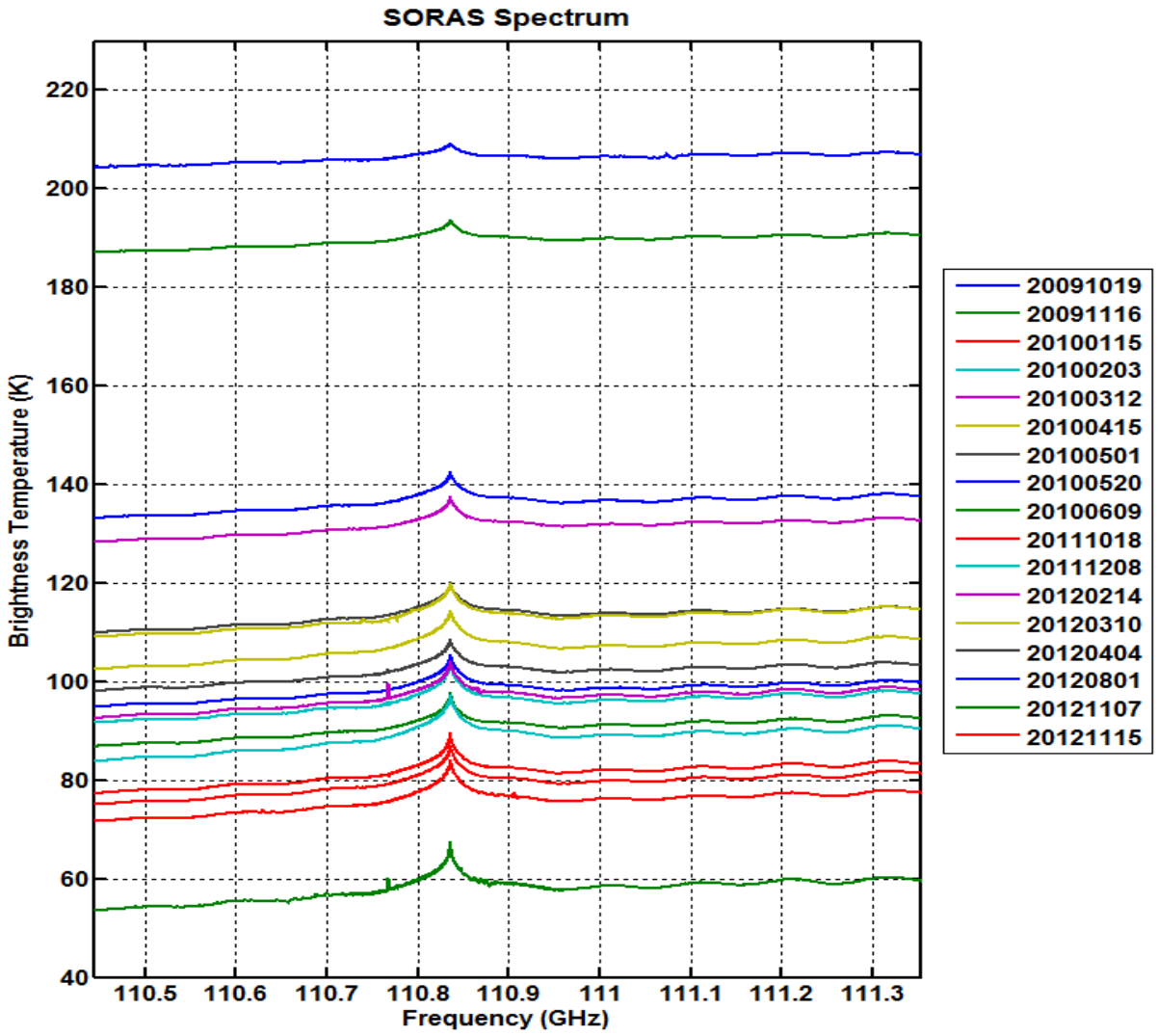

SORAS Spectrum
Brightness Temperature (K)
76
74
72
70
68
66
64
62
60
110.4
110.6
110.8
111
111.2
111.4
Frequency (GHz)


SORAS Spectrum
Brightness Temperature (K)
160
158
156
154
152
150
110.4
110.6
110.8
111
111.2
111.4
Frequency (GHz)

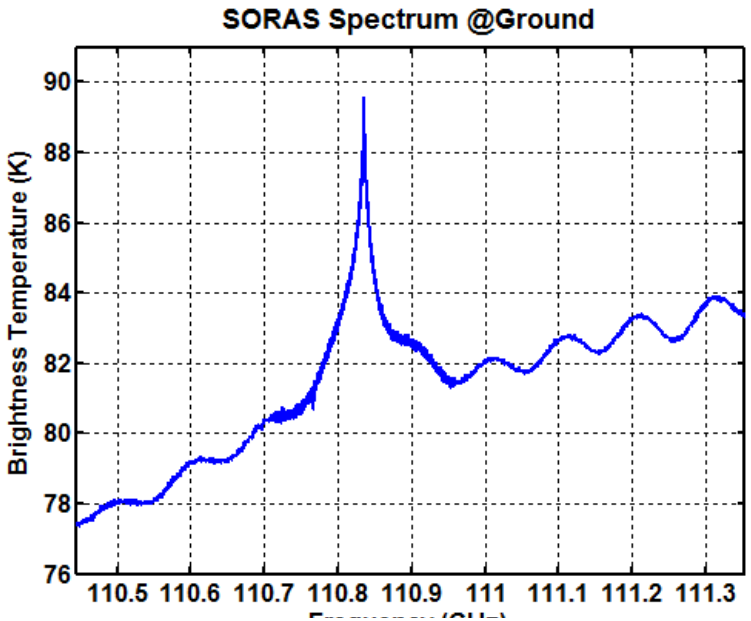

SORAS Spectrum
Brightness Temperature (K)
170
168
166
164
162
160
110.4
110.6
110.8
111
111.2
111.4
Frequency (GHz)

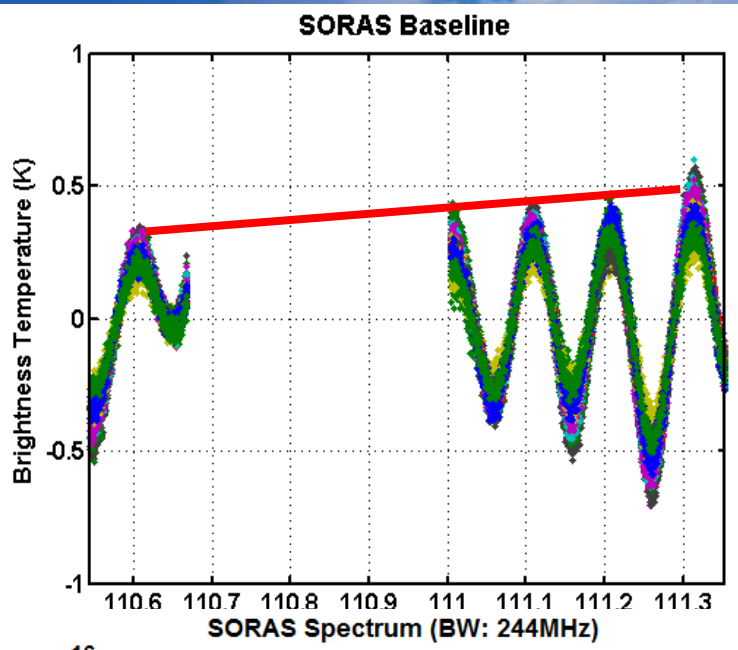

SORAS Spectrum
Brightness Temperature (K)
122
120
118
116
114
112
110
110.4
110.6
110.8
111
111.2
111.4
Frequency (GHz)

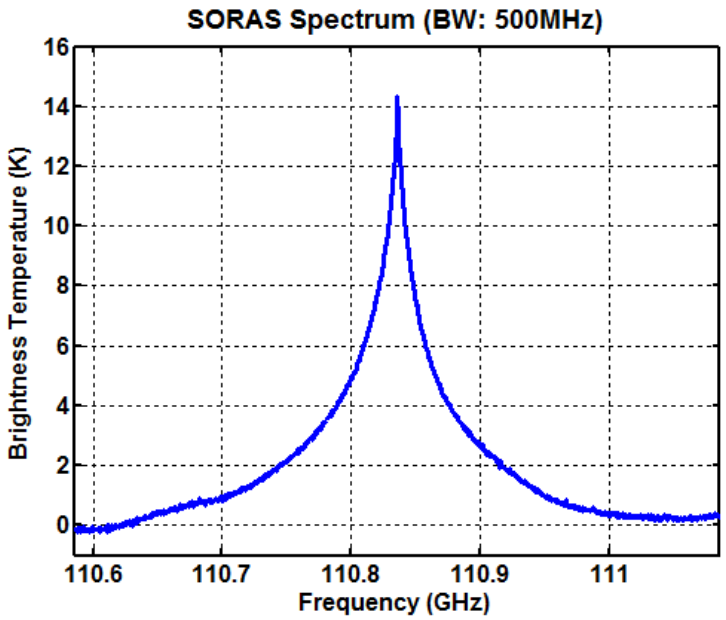
SORAS Spectrum

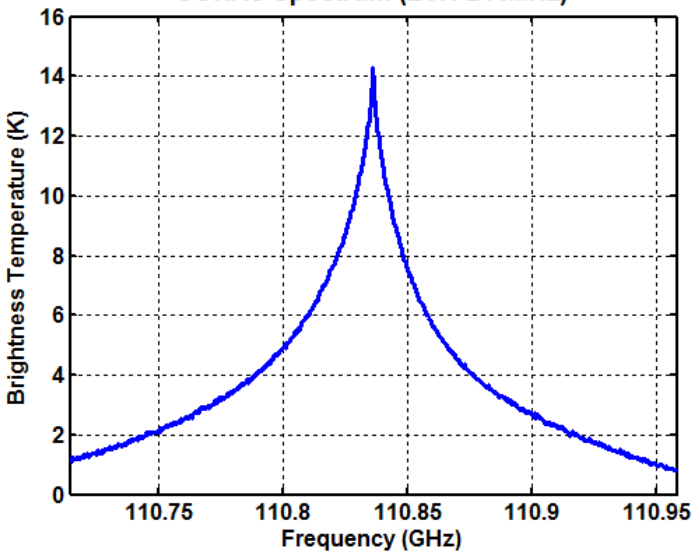


Baseline fitting

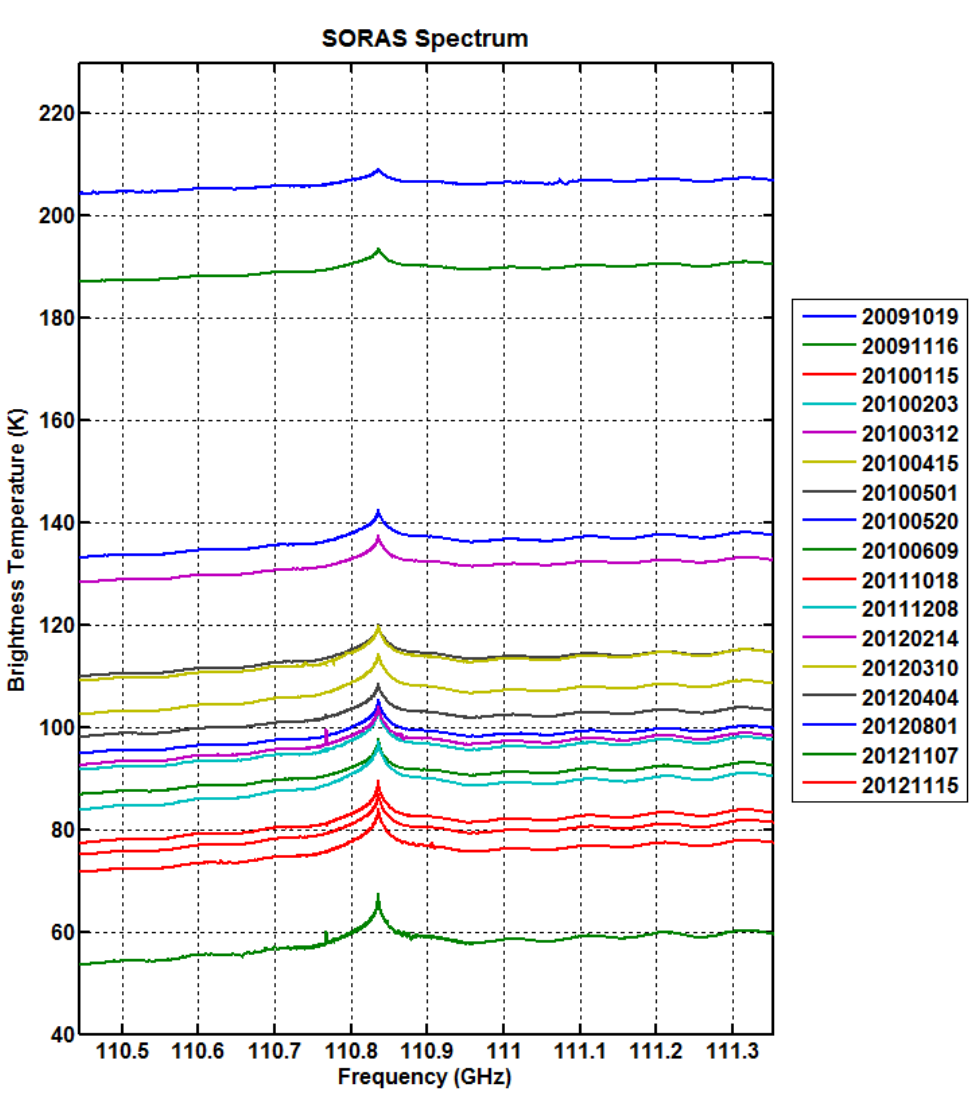


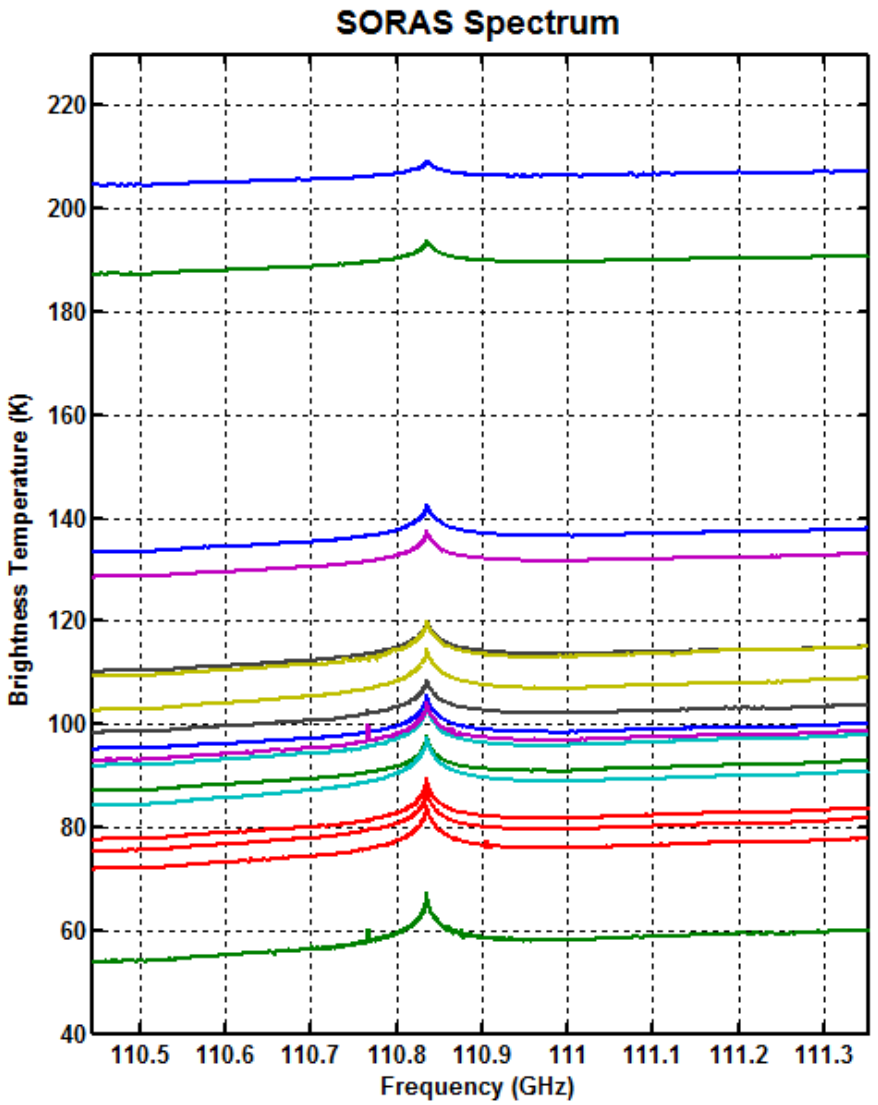






SORAS Spectra (2009~2012)



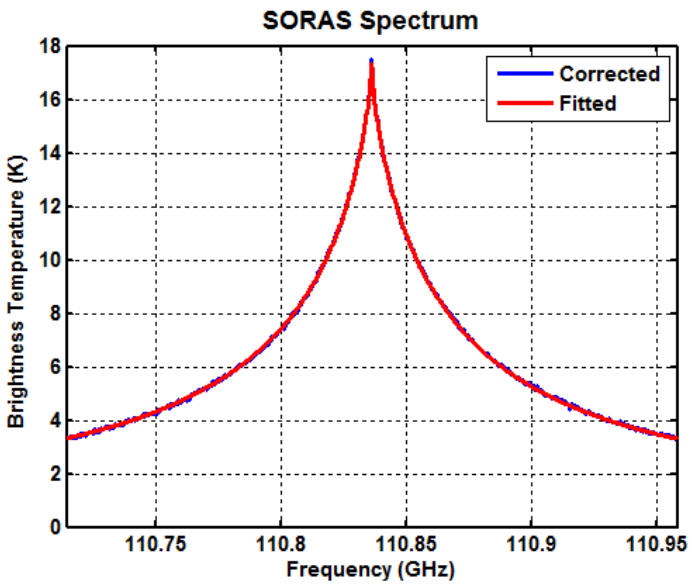


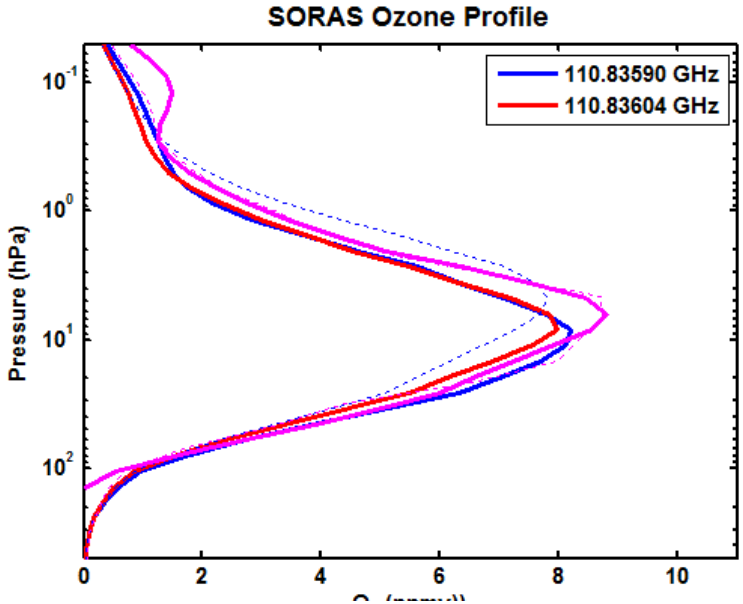
Retrieval

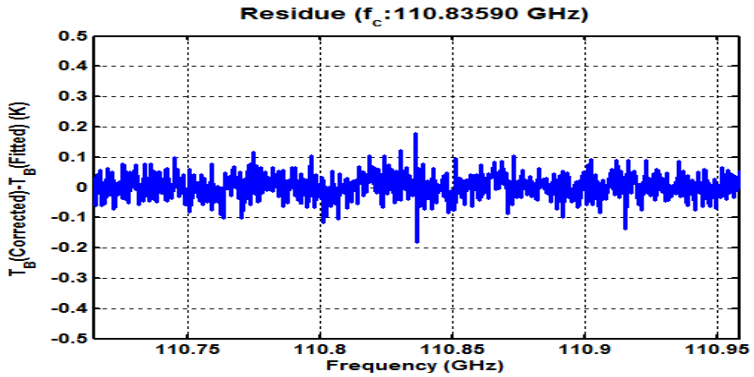
Parameters	Description
Basics	Optimal estimation method
A priori profile	**PTZ:** AURA MLS temperature profile (T) and geopotential profile (Z) (within ±1day and 35˚N ~40˚N and 120˚E~135˚E) **VMR:** U.S. standard atmosphere (1976) for O_3, N_2, O_2, CO_2 and H_2O (H_2O is modified value)
Spectroscopy	**Spectroscopic parameter:** JPL+HITRAN08
Sensor	**Antenna:** zero zenith angle and Gaussian antenna pattern with 8 degrees of FWHM **Mixer w/ sideband :** not considered **Backend:** 1259 binned channels for 900 MHz bandwidth
Grids for the forward model	**Pressure:** 80 levels between 101325 Pa and 0.01 Pa in regular log space **Beam angle:** 11 angles between -10 degrees and +10 degrees in 2 degree step **Frequency:** 1001 points from 110.44 GHz to 111.36 GHz

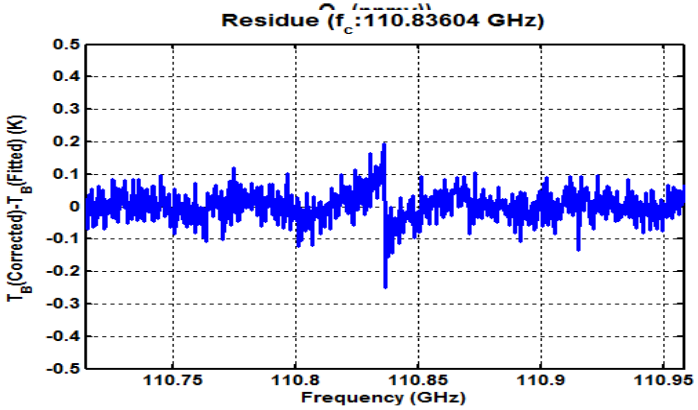
Parameters	Description
Grids for the inversion	**Pressure:** 50 levels between 101300 Pa and 0.1 Pa **Frequency:** Identical to Backend frequency definition in Sensor par
Covariance matrix	**A priori:** 50% for STD and 13 km for correlation length at 7 pressure level **Measurement:** ~0.7 K
Platform altitude	16000 m
Ground altitude	16000 m
Retrieval parameter	**Method:** Optimal estimation method

110.83590 vs 110.83604

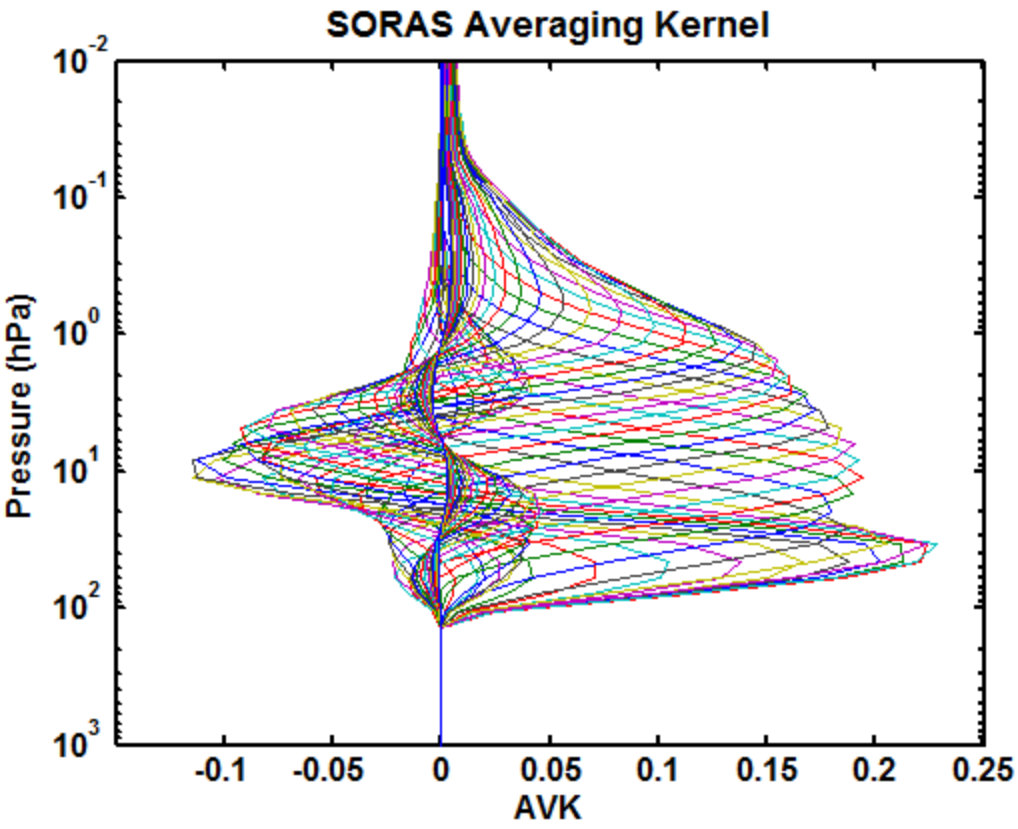








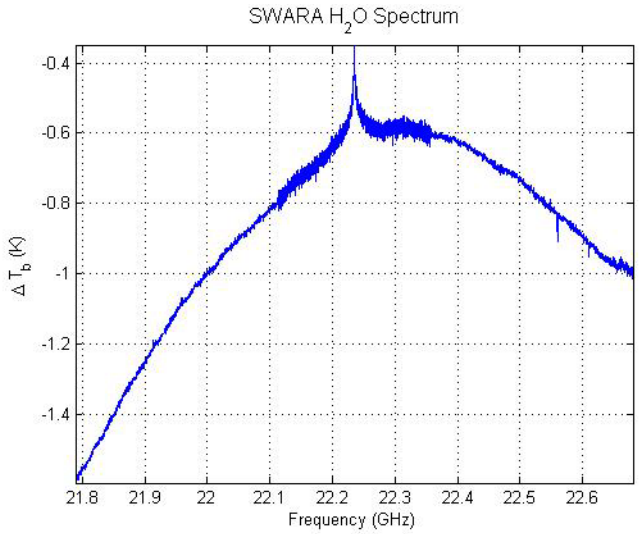
Retrieval


SORAS Averaging Kernel
Pressure (hPa)
10^-2
10^-1
10^0
10^1
10^2
10^3
-0.1
-0.05
0
0.05
0.1
0.15
0.2
0.25
AVK

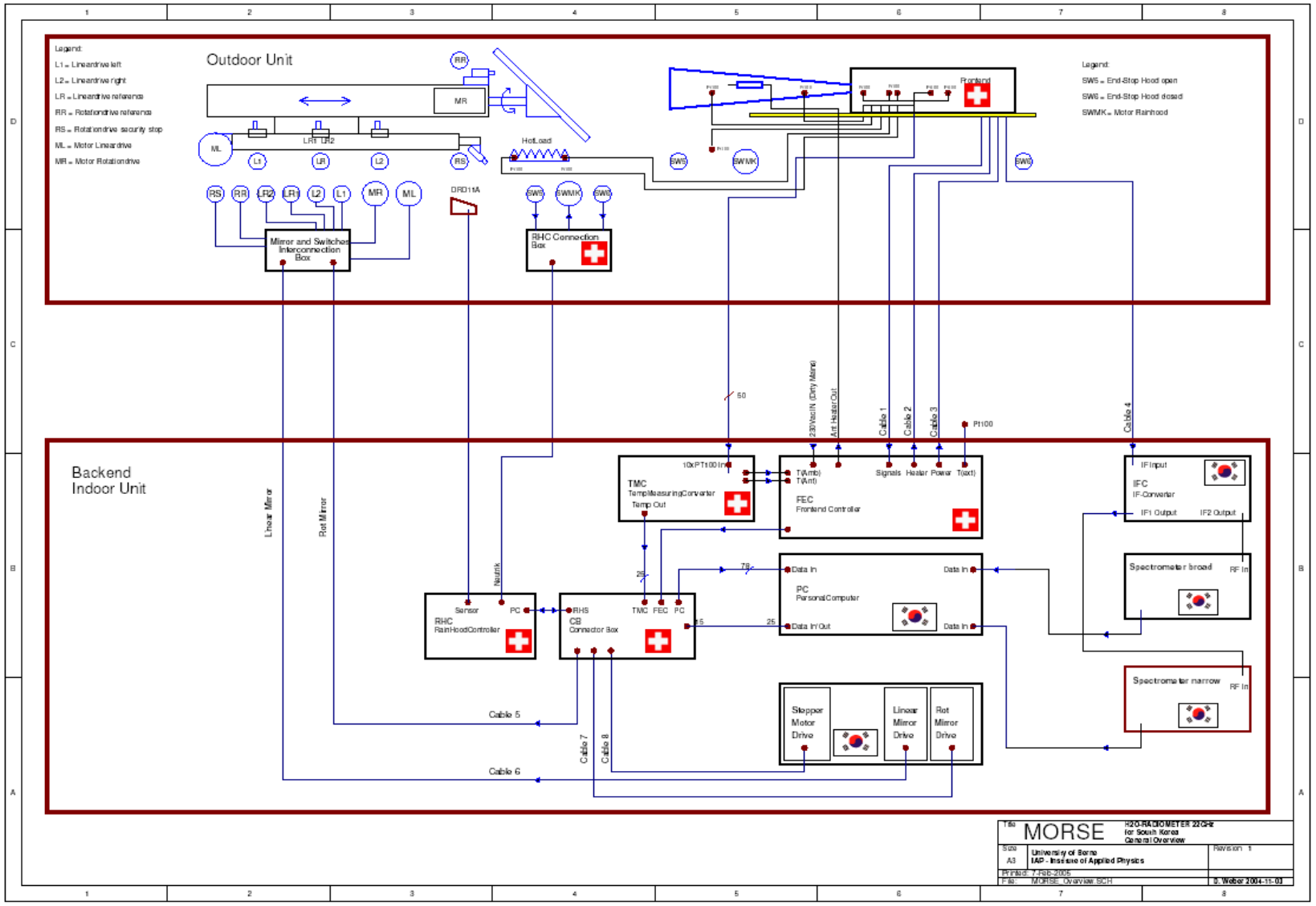
SWARA

- SWARA (Seoul WAter vapor RAdiometer)
  - 22.235 GHz radiation
  - Developed by the joint project with U. of Bern
    under Swiss-Korean Outstanding Research Efforts Award in 2003
  - Operated since 2006 in Seoul

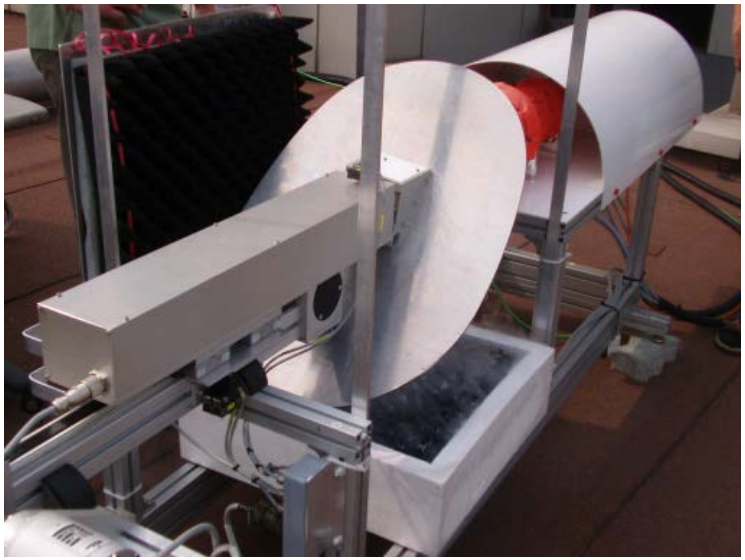
  - Total power heterodyne radiometer
  - Balancing calibration for nonlinear property
  - Tipping curve calibration to estimate tropospheric contribution
  - LN2 calibration to prove the tipping curve calibration



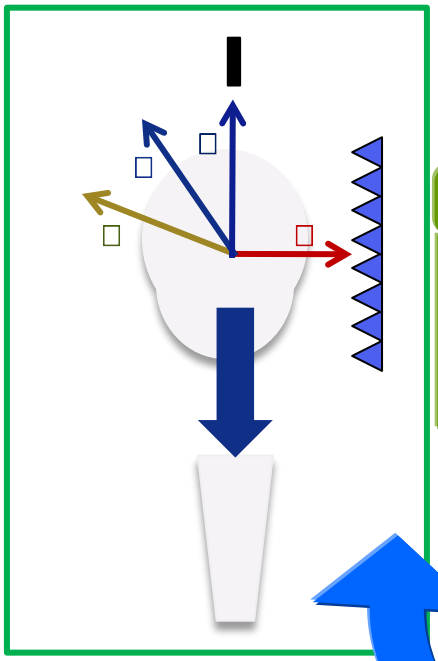
SWARA Scheme



SWARA setup (2006)



SWARA – Calibration



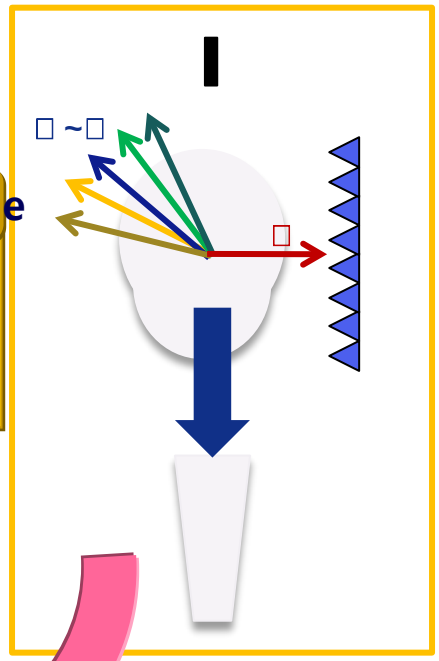
Balancing Calibration

Balancing Mode

- Hot (-90º),
- Cold(sky) (30º),
- Line (60~70º),
- Reference (0º)

Tipping Curve Mode

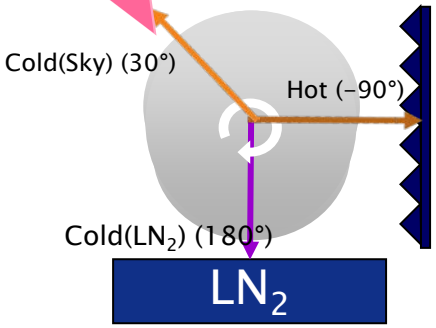
- Hot (180º),
- Signal (42º~60º)



Tipping Curve Method

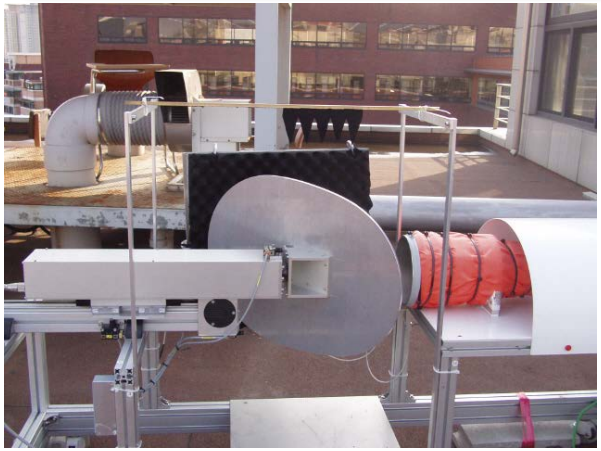
LN_2 calibration + Offset

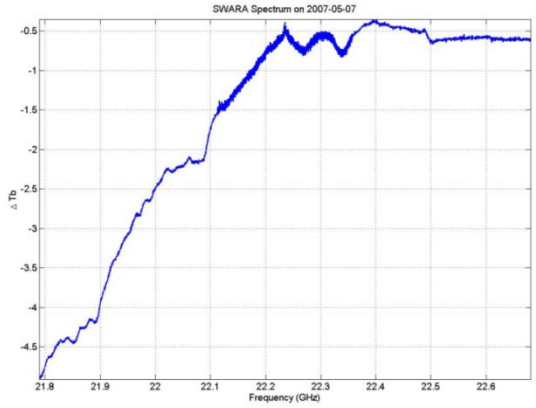
- LN2 Signal (180º)
- 50Ω load



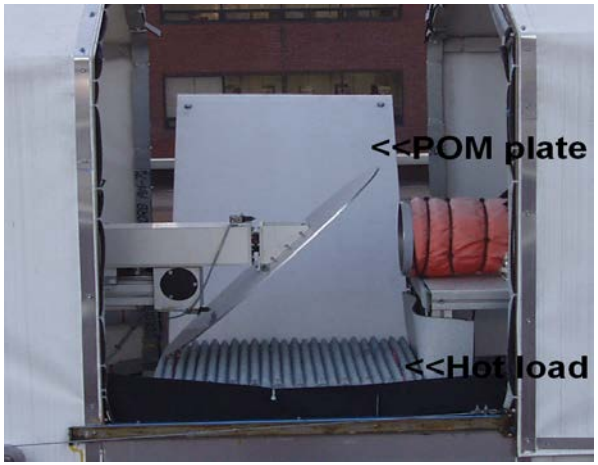
SWARA spectrum

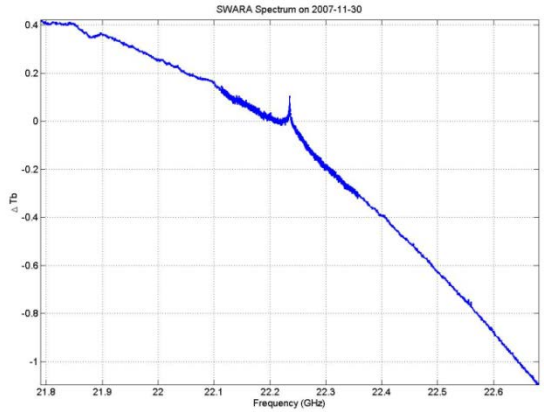
Normal Noise Source for the Balancing Calibration (~2007.10, 2008.05~)



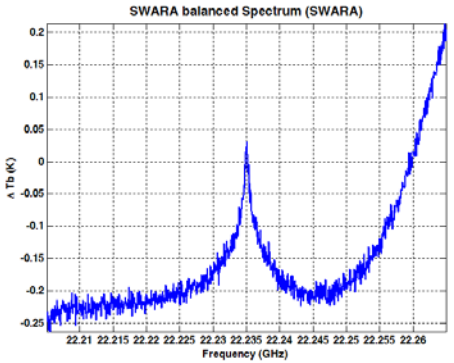


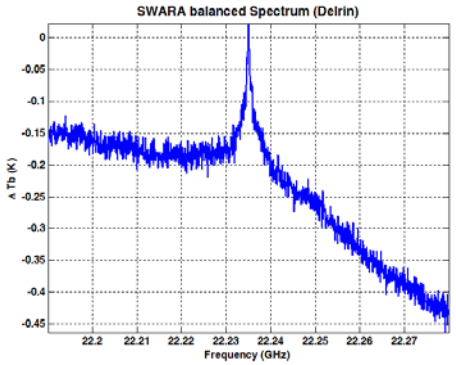
POM plate for the Noise Source (2007~2008)

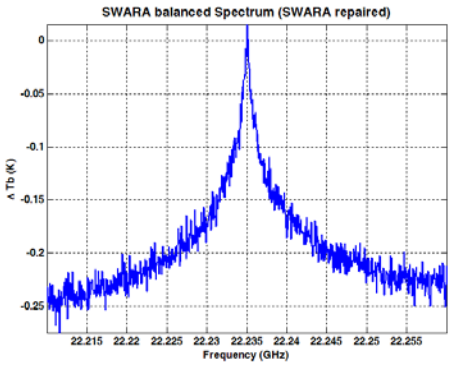


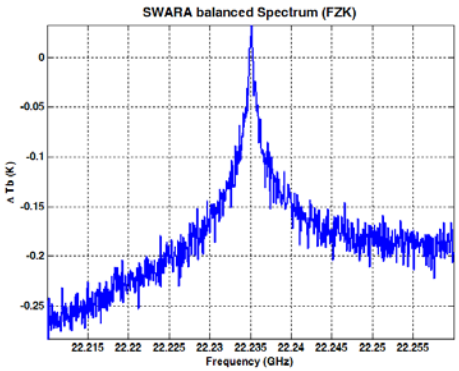


Baseline Fitting





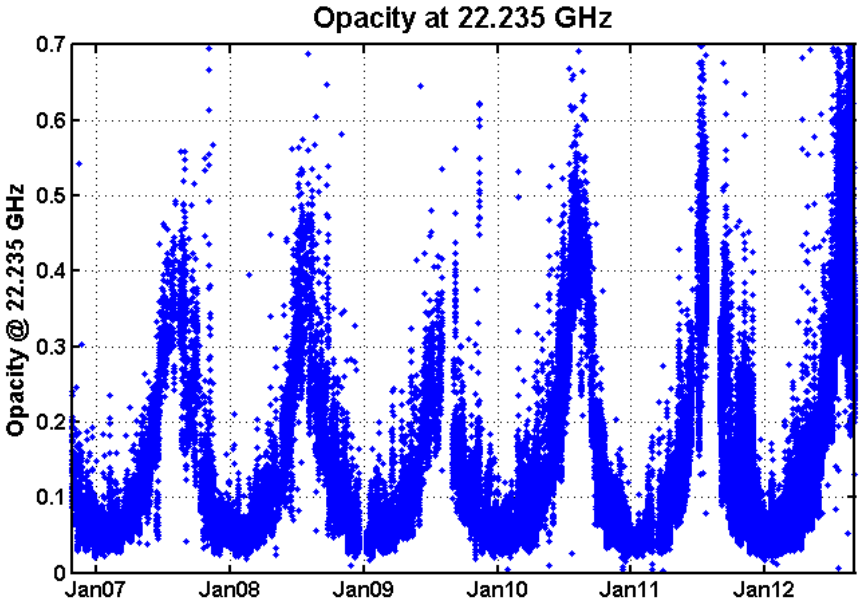


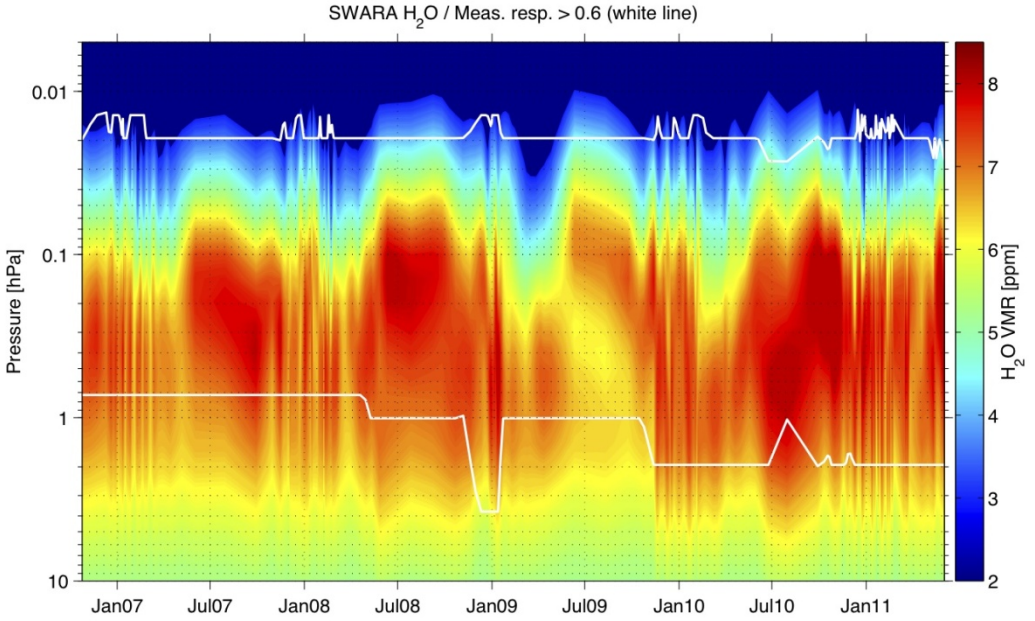


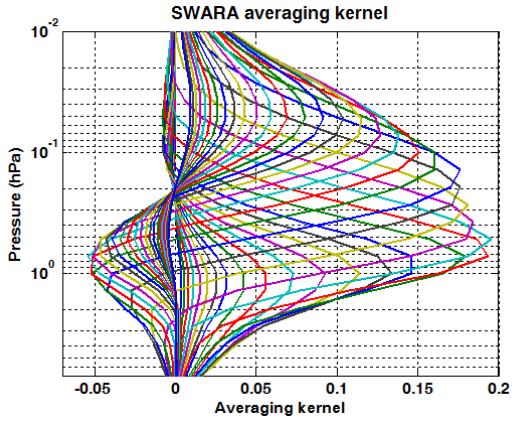
Antenna type	SWARA	Delrin®	FZK	SWARA repaired
Time	Oct. 2006~Oct. 2007	Nov. 2007~May 2008	May 2008~Nov.2008, Jan. 2009~Nov.2009	Nov. 2008~Jan. 2009, Nov. 2009~the current
Bandwidth	60	90	50	50
polynomial degree	4	3	3	2
sinefit degree	6	9	3	2

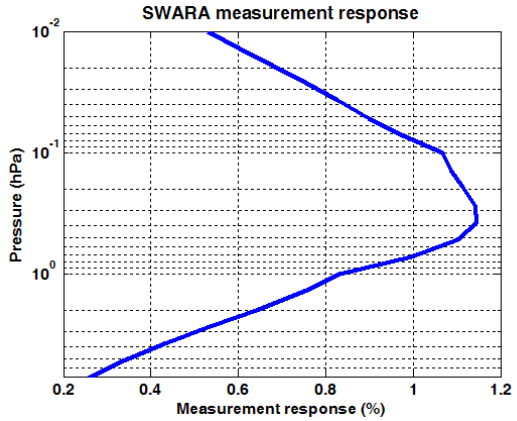
Opacity calculation

- 전파가 대류권을 통과하는 동안 받는 영향을 opacity를 계산하여 스펙트럼에 반영함.





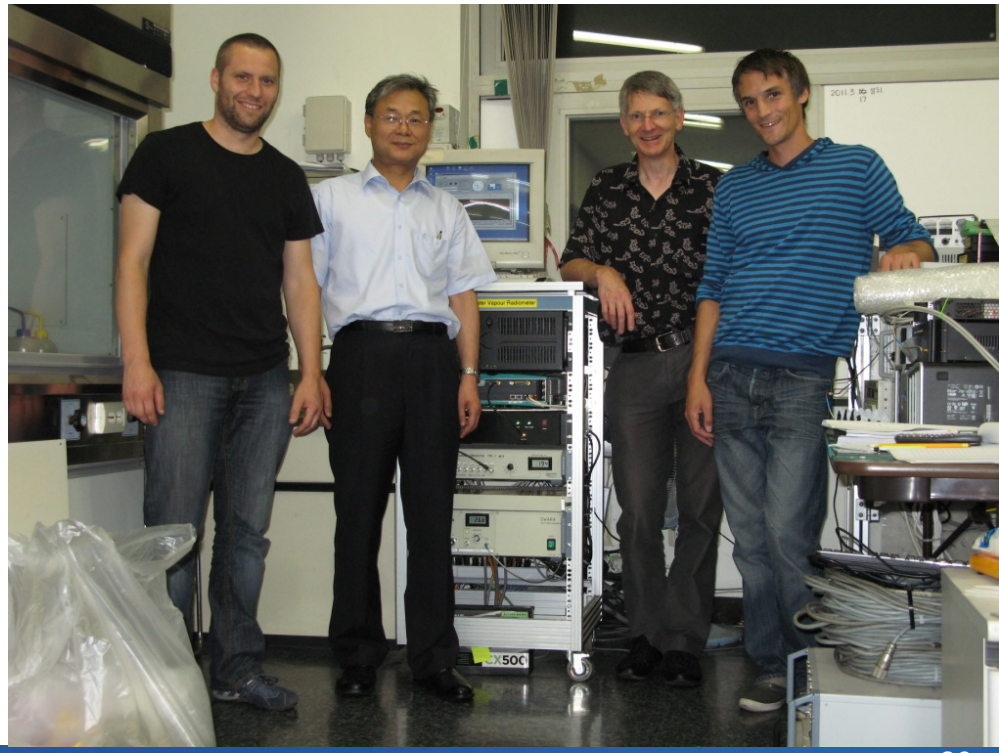




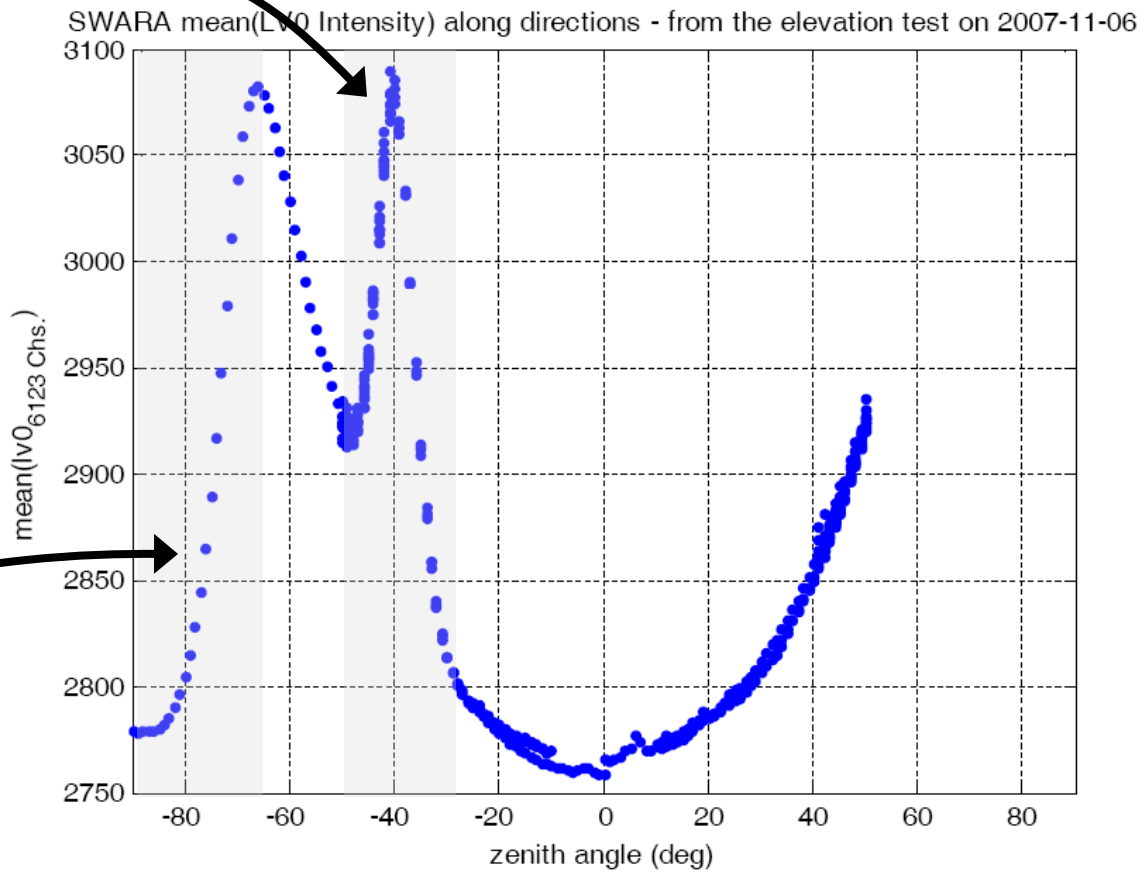
SKOREA (Swiss-Korea Outstanding Research Efforts Award)

- Prof. Nik Kaempfer

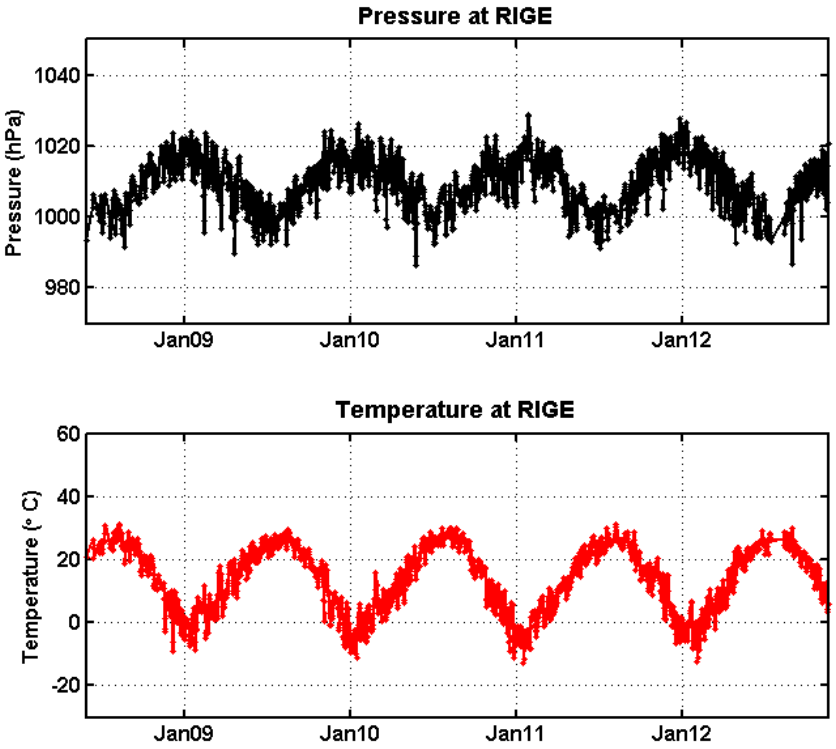
- Alexander Haefele
- Evelyn de Wachter
- Daniel Weber
- Andres Luder
- Dominik Scheiben

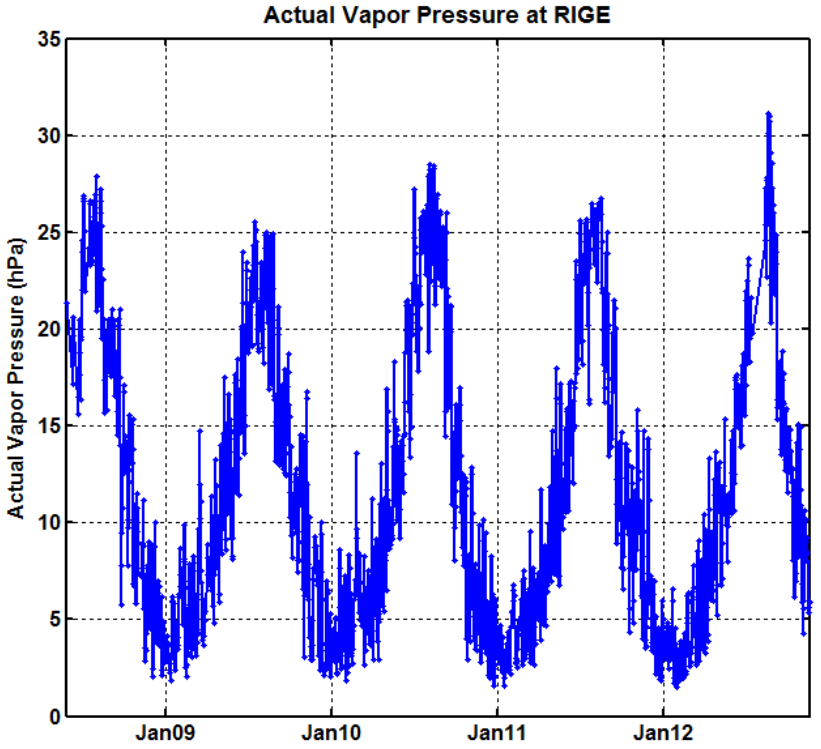


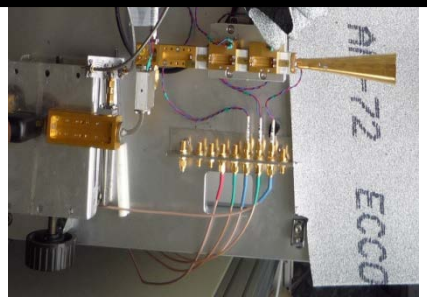
SWARA sky angle



Temperature - Pressure





	SORAS	SWARA
		
Target	O_3	H_2O
Measurement Frequency	110.836 GHz	22.235 GHz
Frequency Range	110.836 GHz ± 500 MHz	22.235 GHz ± 500 MHz
Frequency Resolution	61.035 kHz	61.035 kHz
Antenna Aperture	30 mm	190 mm
Antenna Length	120 mm	806 mm
Mirror Shape	Plane mirror (ellipsoidal shape)	Plane mirror (Gaussian beam optimized shape)
Spectrometer	Acqiris AC240 FFT analyzer	Acqiris AC240 FFT analyzer
Receiver Temperature	1200 K	140 K
Integration Time	6.6 sec	3.3 sec