MEASURING THE SPECTRAL BASELINE OF THE MILLITECH OZONE AND ClO INSTRUMENTS

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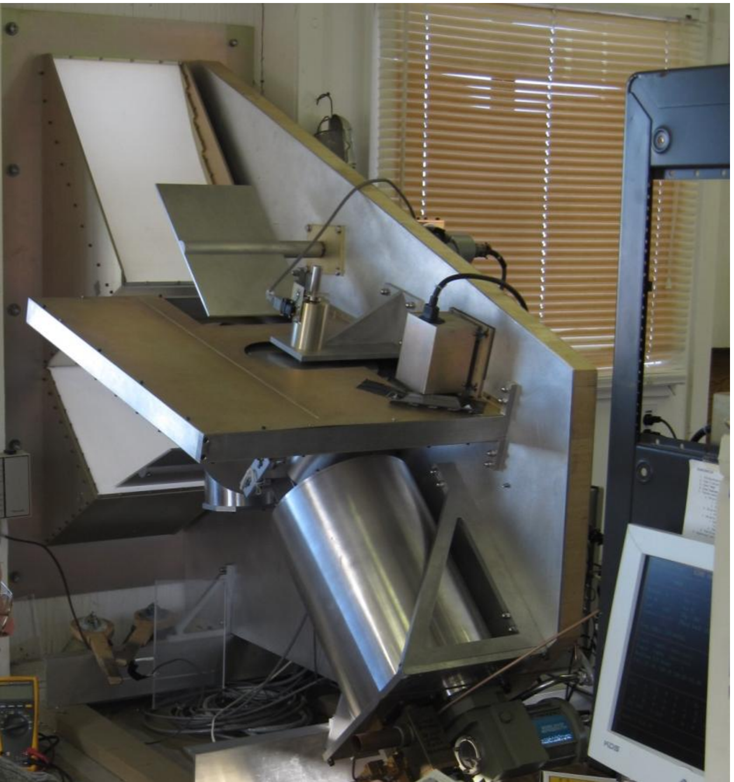
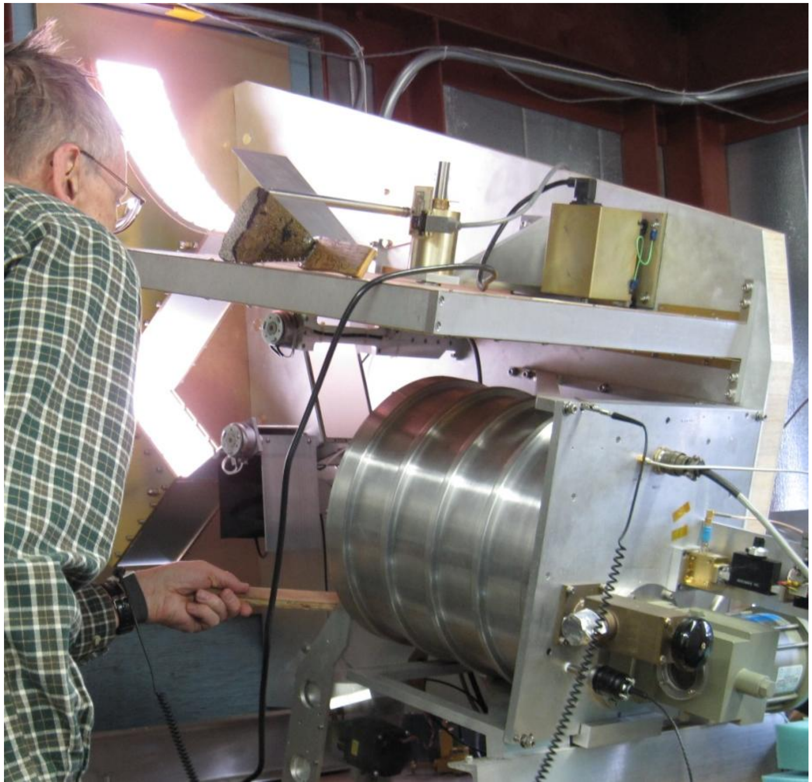
MILLITECH INSTRUMENTS AT NDACC STATIONS:

OZONE
110.8 GHz
Mauna Loa, Hawaii
Lauder, New Zealand

ClO
278.6 GHz
Mauna Kea, Hawaii
Scott Base, Antarctica



Photos by
Mike Gomez

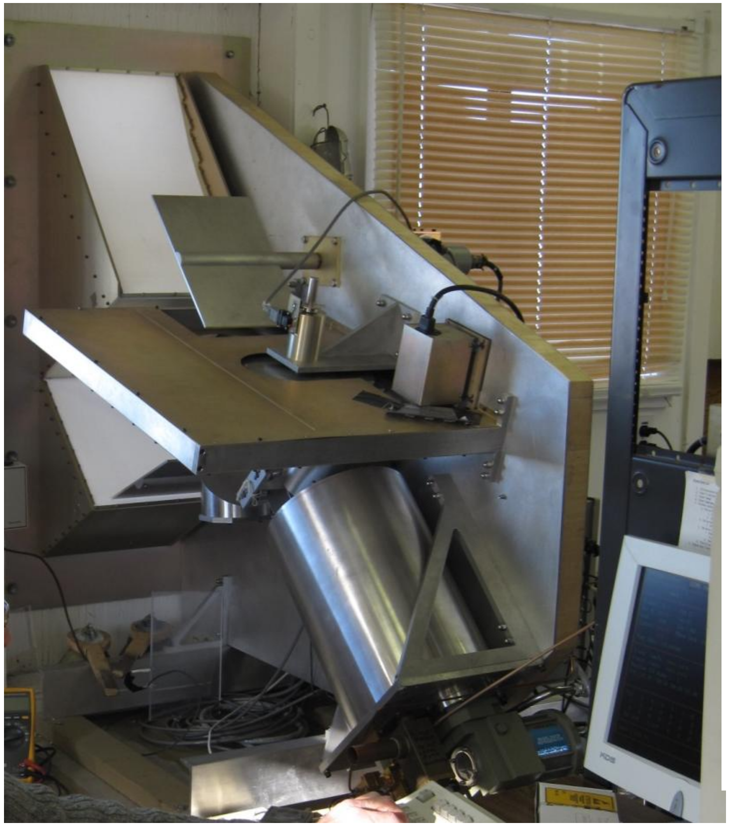


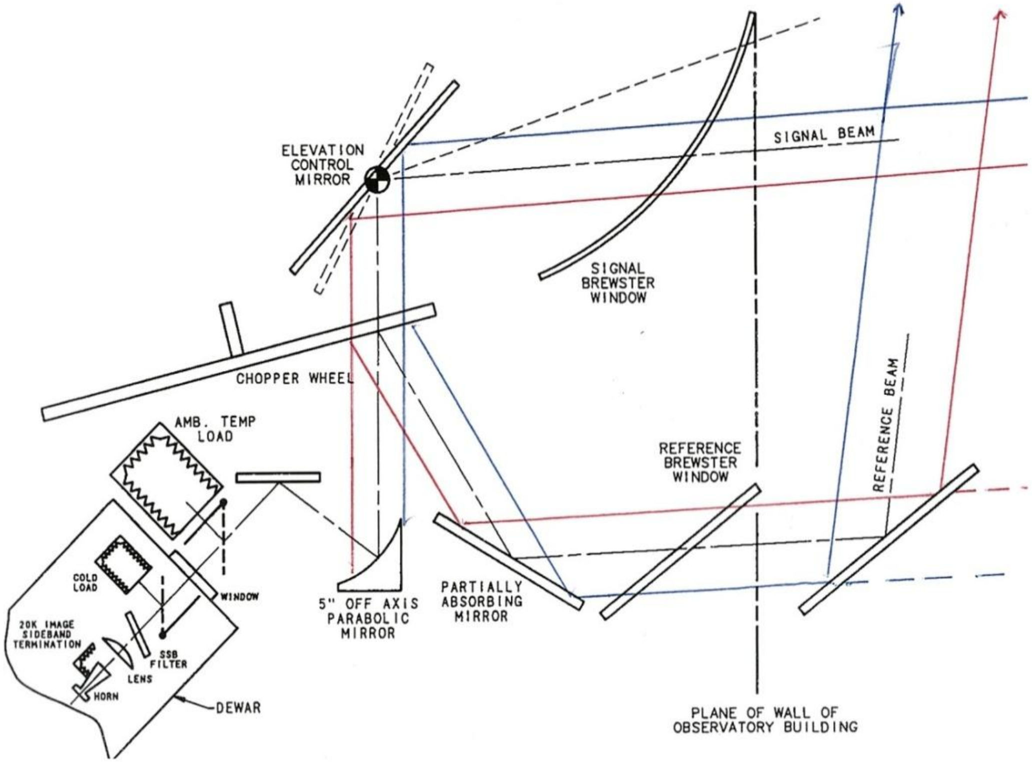
Standing waves in the receiver dewar make the antenna pattern frequency dependent.

The tropospheric thermal emission is ~[(1/sin(elevation angle)].

The convolution of the frequency-dependent antenna pattern with the angle-dependent tropospheric emission produces artifacts in the measured spectrum.

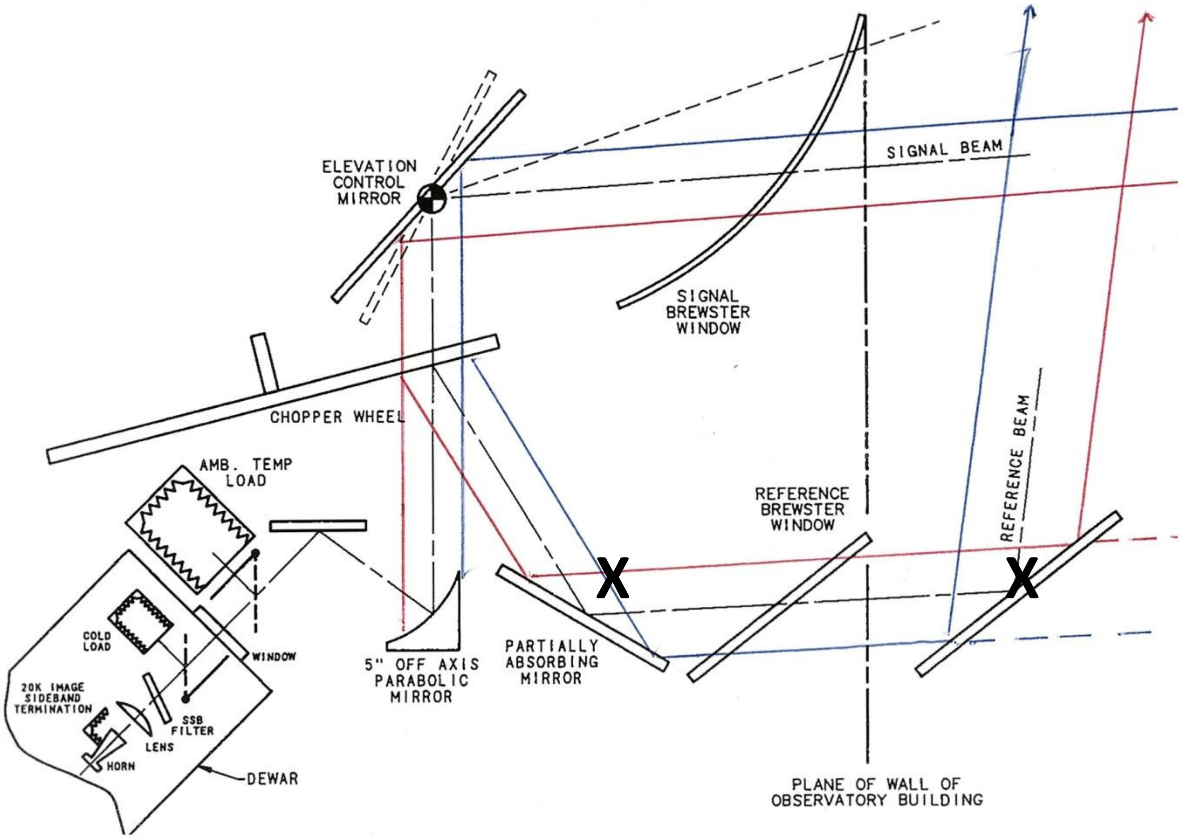
By reconfiguring the instrument, we can measure the spectrum of the baseline artifact:





Adapted from Parrish, Proc. IEEE, *82*, 1915-1929, 1994, Fig. 4.

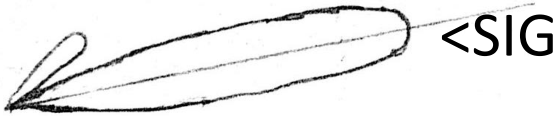
TO MEASURE THE BASELINE, REMOVE THE OUTSIDE MIRROR AND THE ABSORBER FROM THE FIXED INSIDE MIRROR



EXPLANATORY BEAM POLAR DIAGRAMS:

<REFERENCE BEAM

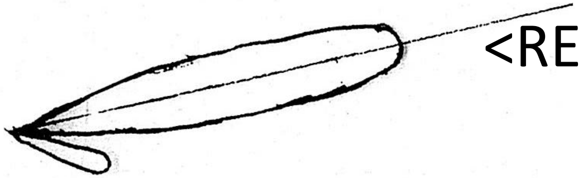
ASSUMED SIDELOBE WITH
<FREQUENCY-DEPENDENT
AMPLITUDE



<SIGNAL BEAM

<NORMAL OPERATING CONFIGURATION

Frequency dependent antenna patterns have been reported by De Wachter *et al., IEEE Geos. & Rem. Sen. Ltrs, 6*, 3, 2009.



<REFERENCE BEAM

<SIGNAL BEAM

<BASELINE MEASUREMENT CONFIGURATION

WHEN PRESENT, THE SIDELOBE MOVES THE CENTROID OF THE SIGNAL BEAM DOWN AND THE REFERENCE BEAM UP.

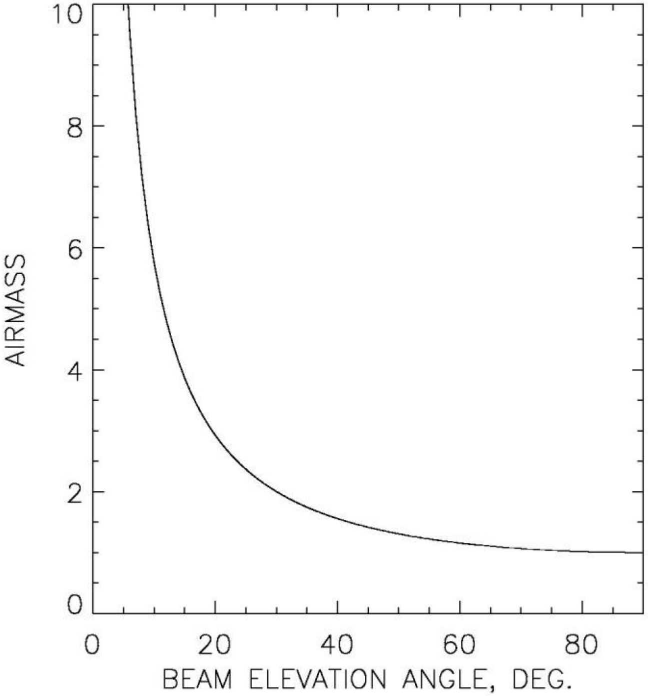
THE DEPENDENCE OF TROPOSPHERIC EMISSION ON BEAM ELEVATION ANGLE

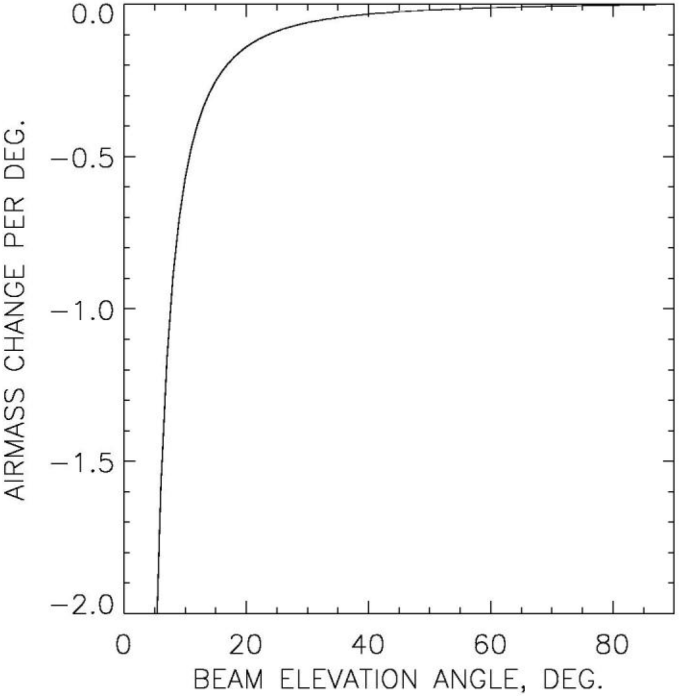
Assume the troposphere is isothermal.

Then its brightness temperature $T_b = T_{trop} * (1 - \exp(-A*\tau_z))$

$T_b \sim T_{trop} * A * \tau_z$ for small τ_z

The derivative of the tropospheric emission is much larger at the signal beam elevation than at the reference beam elevation.





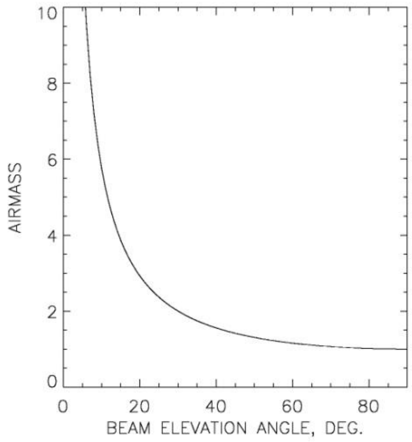
BASELINE MEASUREMENTS: SCALING THE BASELINE SPECTRUM

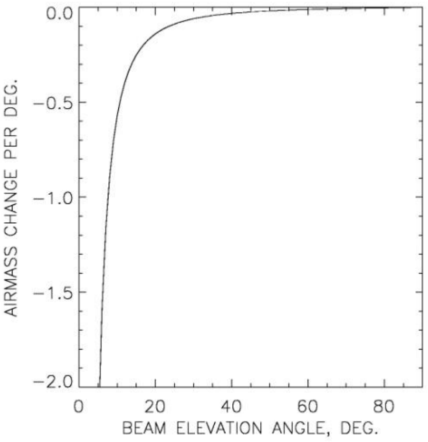
We measure (Sig. – Ref.)/Ref. , so in baseline mode the spectral lines cancel and the baseline contribution in the two beams add.

We therefore initially scale the baseline spectrum by a factor of 0.5.

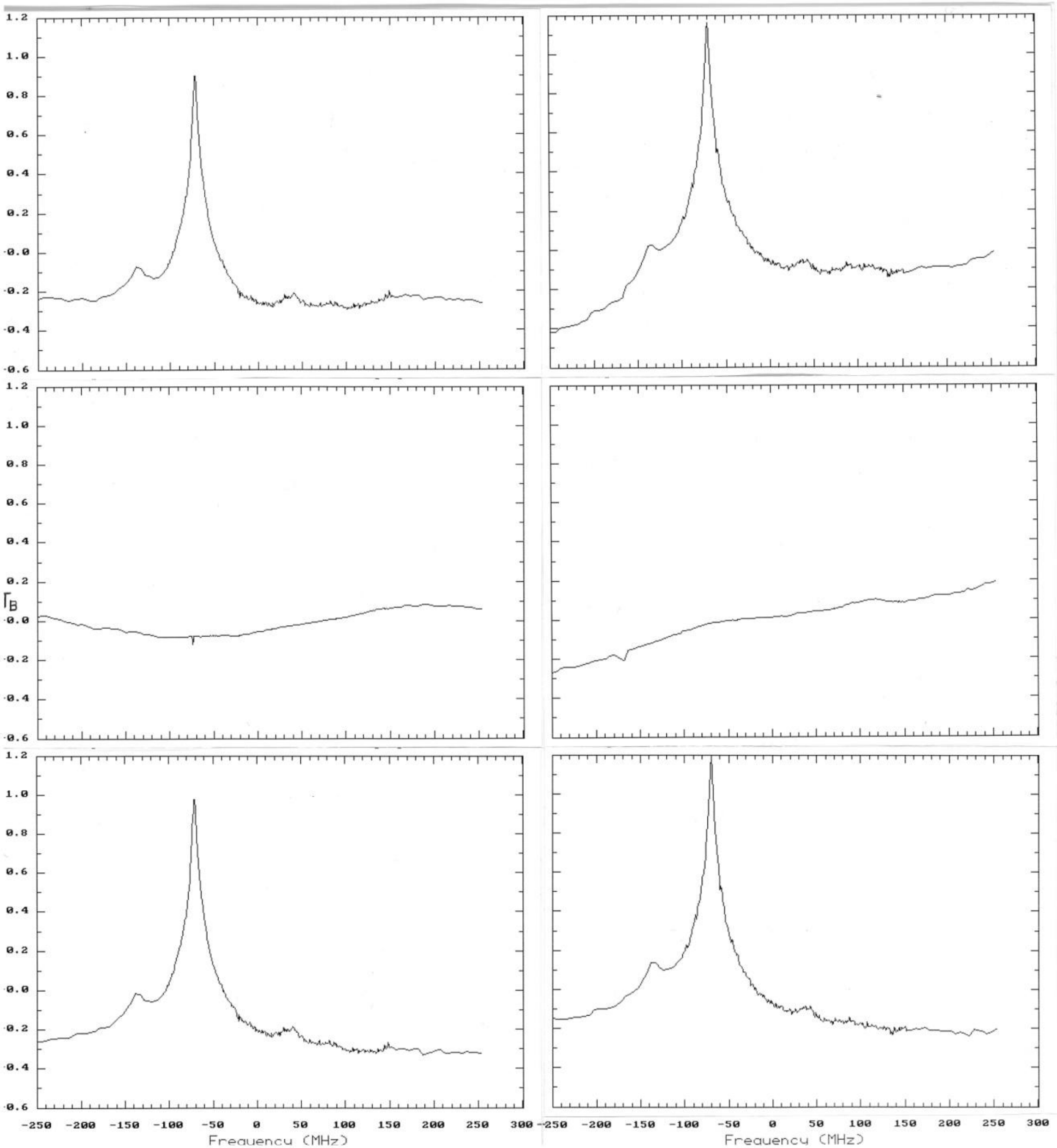
We also account for the fact that the signal beam elevation angle in normal operation is not the same as it is in baseline mode, by further scaling the baseline spectrum by

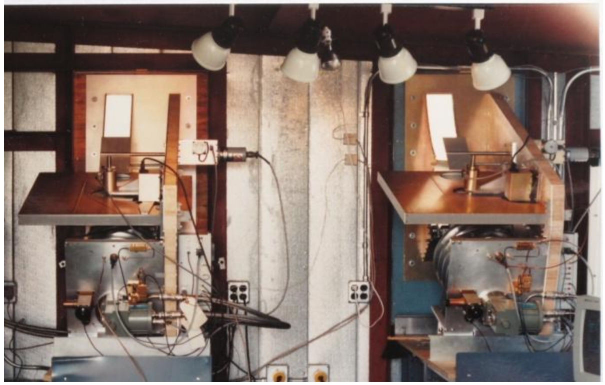
$$(\tau_{z\_op} * T_{atm\_op} * (dA/d\theta_{op}))/(\tau_{z\_base} * T_{atm\_base} * (dA/d\,\theta_{base})).$$





SYSTEM 1 (NOW AT SCOTT BASE) **SYSTEM 3** (MAUNA KEA)





<A: ClO and O_3 Spectra

Raw [(S-R)/R] *$T_{rx}(\nu)$

<B: Baseline Spectra

Insts.reconfigured to cancel spectral lines and show the baseline.

Raw [(S-R)/R] *$T_{rx}(\nu)$*0.47

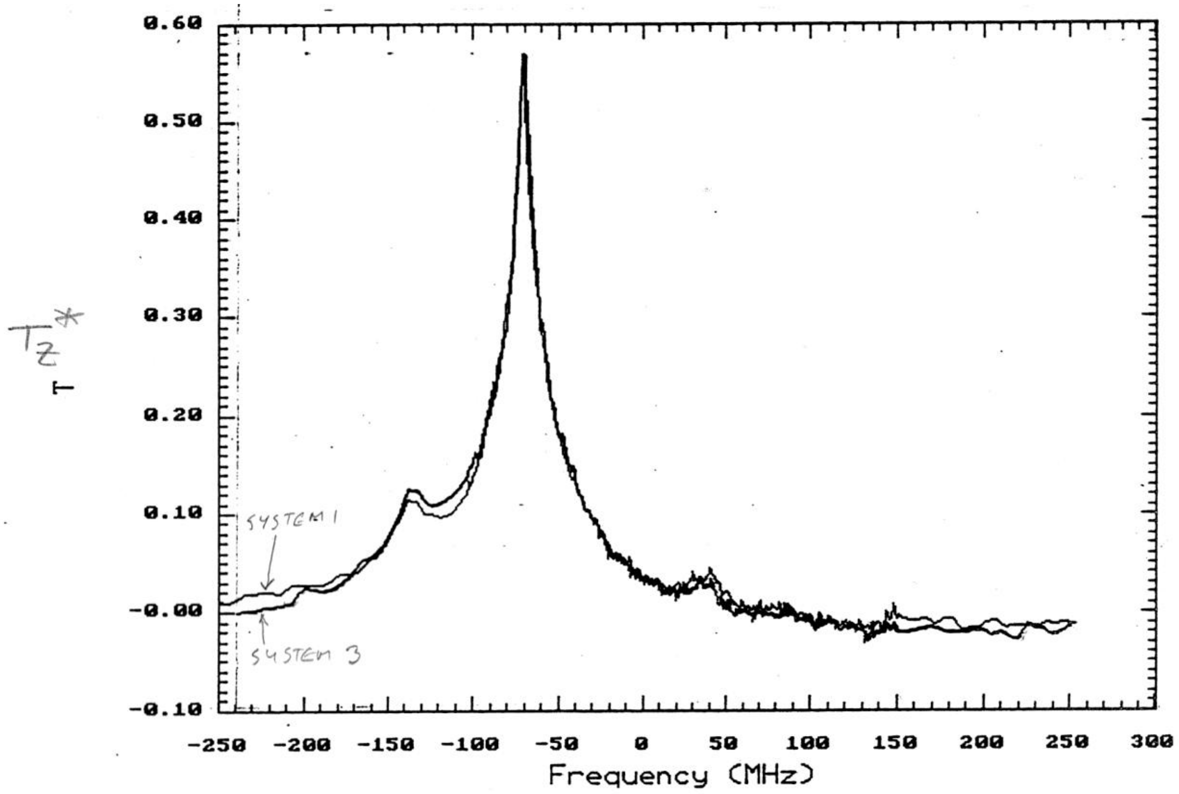
<C = A-B

Note: No slopes or zero offsets have been removed.

Data taken 1993 September.

NB: Scans are not fully calibrated.

BASELINE-CORRECTED SPECTRA FROM THE TWO INSTRUMENTS OVERLAID



CONCLUDING REMARKS: PRINCIPLES FOR MINIMIZING BASELINE ARTIFACTS IN NEW DESIGNS

1. The beamwidth should be minimized to reduce the change in continuum intensity across the beam at low elevation angles.

2. The optics should be designed so that the signal and reference beams can be mirror-imaged on the sky in the vertical plane at the same elevation angle.

3. There is a trade-off between maximizing signal (by increasing the airmass A) and minimizing the baseline by minimizing $dA/d\theta$. The best elevation angle may be ~15°.