Proposed Development of a National Standard for Microwave Brightness Temperature

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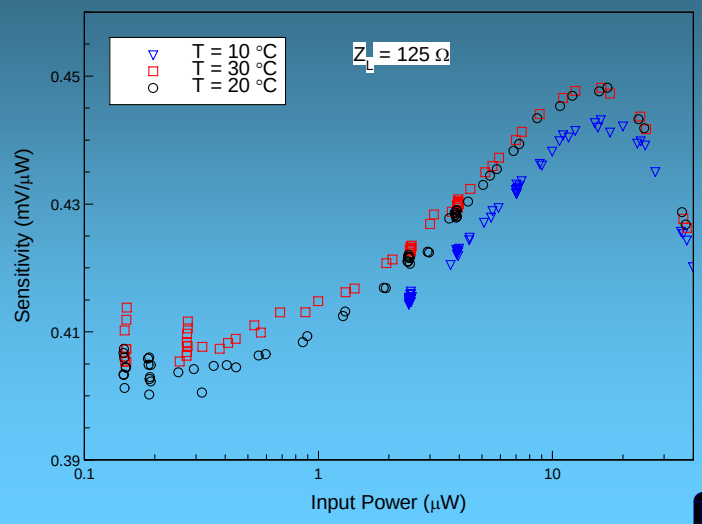
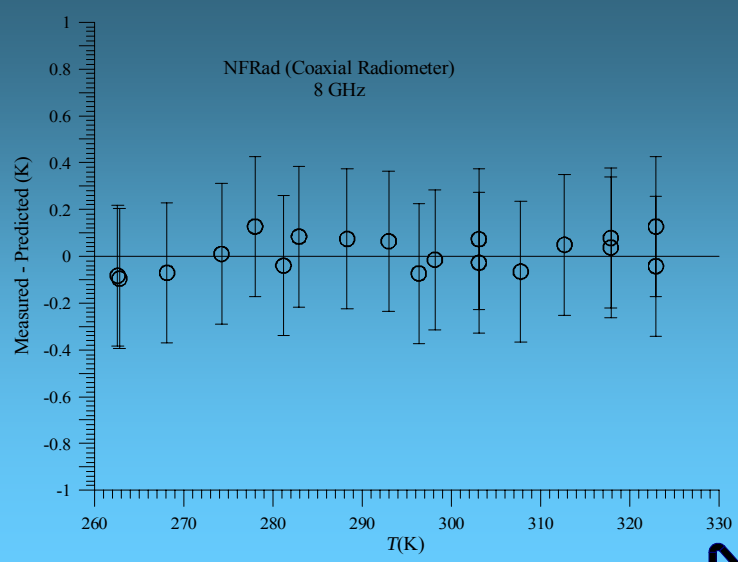
I. INTRODUCTION

- NIST microwave radiometry effort
  - 30^+ years experience in noise and antenna metrology at NIST; ~4 years' R&D on remote-sensing radiometry, combining the two.
- Developing microwave radiometry cal stds:
  - Randa *et al*., "Standard Radiometers and Targets for Microwave Remote Sensing," IGARSS-04
  - Randa *et al*., "Linking microwave remote-sensing measurements to fundamental noise standards," 2004 CPEM.
  - Cox *et al*., yesterday's microwave radiometry session: Evaluation of target thermal and E-M properties
  - Complete list of publications at: http://boulder.nist.gov/div818/81801/Noise/index.html

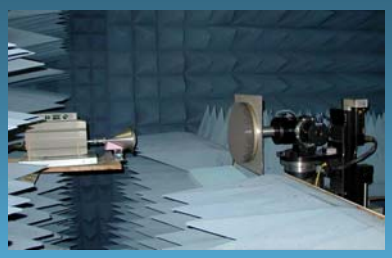
Detector nonlinearity study

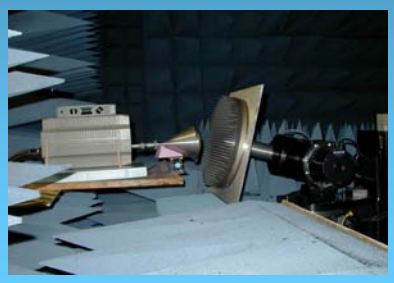


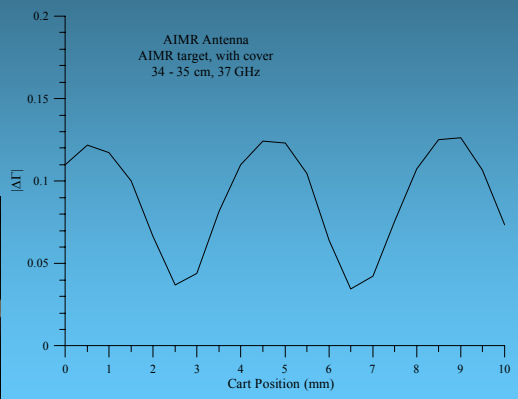
Noise measurements near ambient



Target reflectivity effects







Standard terminology for microwave radiometry

- Developed in cooperation with CEOS WGCV
- Link at:

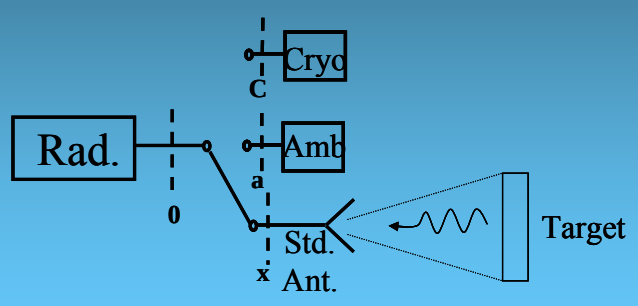
http://boulder.nist.gov/div818/81801/Noise/index.html

MOTIVATION

- SI traceability is a recognized asset (BIPM, 1998; CGPM, 1995)
- No national standards exist for μW T_B (at NIST or any other NMI)
  - "traceability" usually established thru calibrated PRT's in a non-ambient μW calibration target
- …in contrast to Vis/IR:
  - J. P. Rice and B. C. Johnson, "NIST activities in support of space-based radiometric remote sensing," Proc. SPIE, vol 4450, pp. 108 – 126, 2001.
- ASIC3 Workshop, May '06: R.S. community needs SI traceability for μW radiometry

"Standard Radiometer" approach

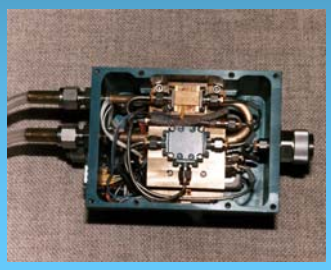
- Preliminary development using existing NIST radiometer linked to primary noise standards:



NIST Noise Radiometer + Characterized Antenna

NIST Radiometers

Coaxial (1-12.4 GHz):



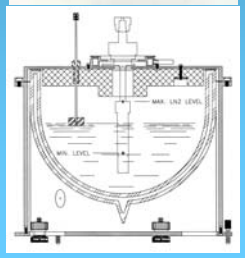
NIST Radiometers

Waveguide (12.4 – 67 GHz):

Thermal Noise Primary Standards

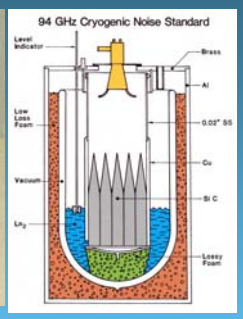
- Ambient & cryogenic (liquid nitrogen) standards.

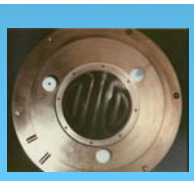
$u_{TCry} \approx 0.65$ K $\quad u_{TAmb} \approx 0.1$ K



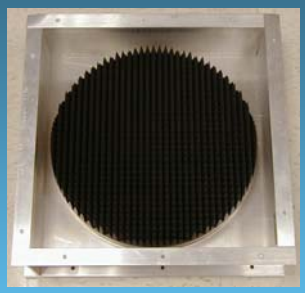
◀Coaxial

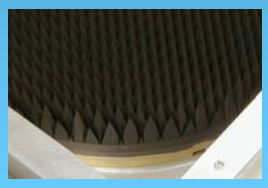
Waveguide▶

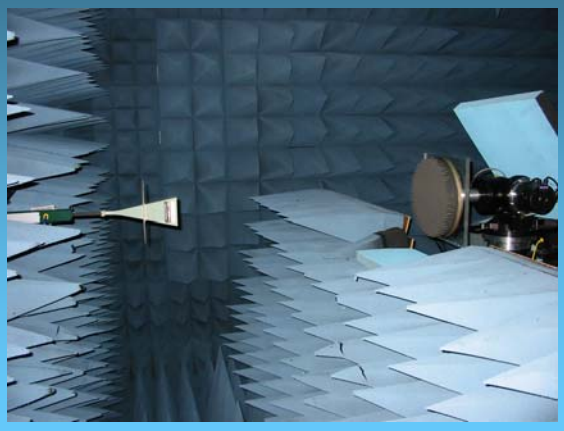


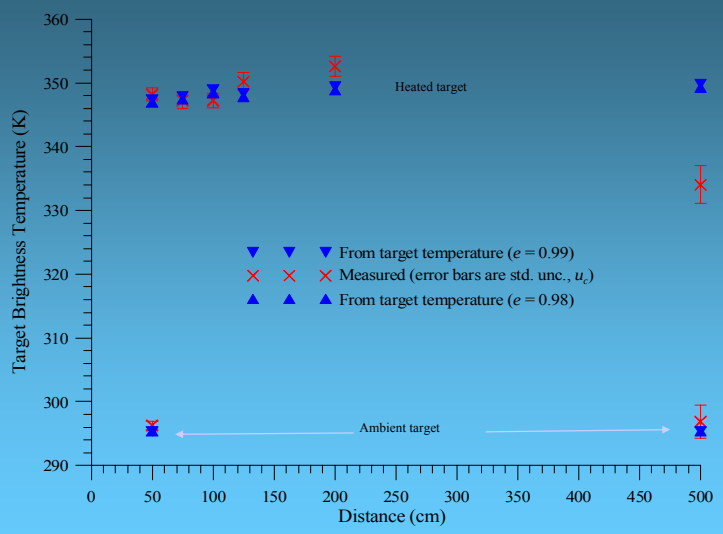


"Standard" radiometer with typical cal target



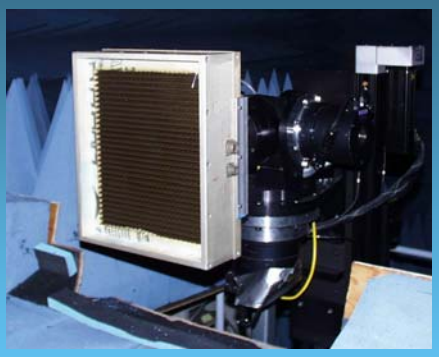


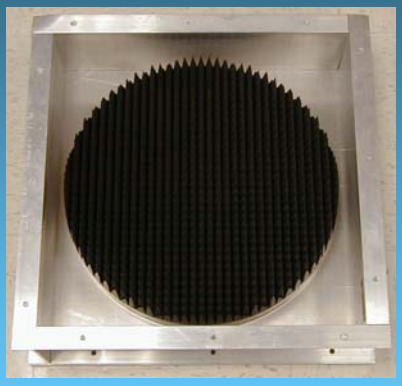




Measured & predicted brightness temperatures vs. separation distance.

Alternative: Standard Target



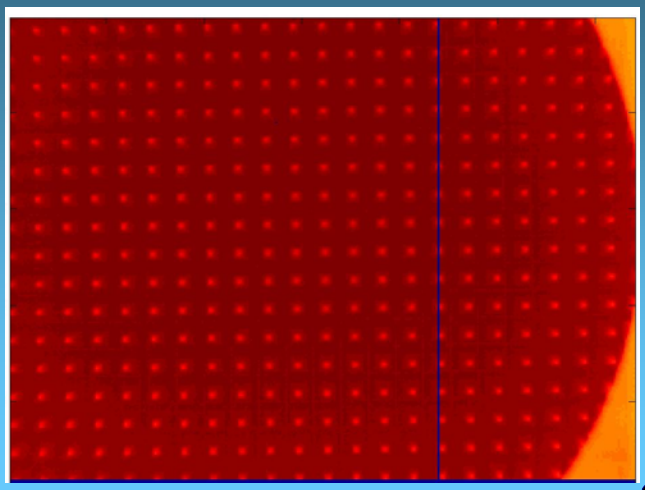


--Useful as check of standard radiometer, or as a means to transfer the standard to other users (original approach)

Standard Target—Issues NIST has addressed/published; work ongoing

- Proximity effects due to target's interaction with radiometer (esp. w/o input isolator)
- Target in antenna's near field vs. far field
- Physical temperature—PRT monitor(s) vs. front surface T; spacial (3-D) uniformity
- Accurate measurement of target emissivity—measuring absorber EM properties

IR Thermal Image of Target



Proposed Combined Standard—Radiometer and Target

- Independent realizations of T_B
- Independent, full uncertainty analyses
- Combined (full) standard would be a weighted average of the two
  - Possible √2 uncertainty improvement vs. single std.
- Transfering the T_B standard would involve either:
  - A second (portable) target calibrated with the full standard
  - Measuring a customer's target or radiometer at NIST with the full standard

Summary

- The need for a national (i.e., SI-based) T_B standard is being recognized and accepted in R.S. community
- Substantial progress made at NIST on various "foundational" aspects of a T_B standard
- We propose a combined standard radiometer+target
  - Potential reduction in uncertainty
  - Provides a means for checking and transfer
- Initial development would be 18-26.5 GHz band; extend up to 65 GHz
- Funding remains a major concern
  - NIST/NOAA Initiative possible in FY2008