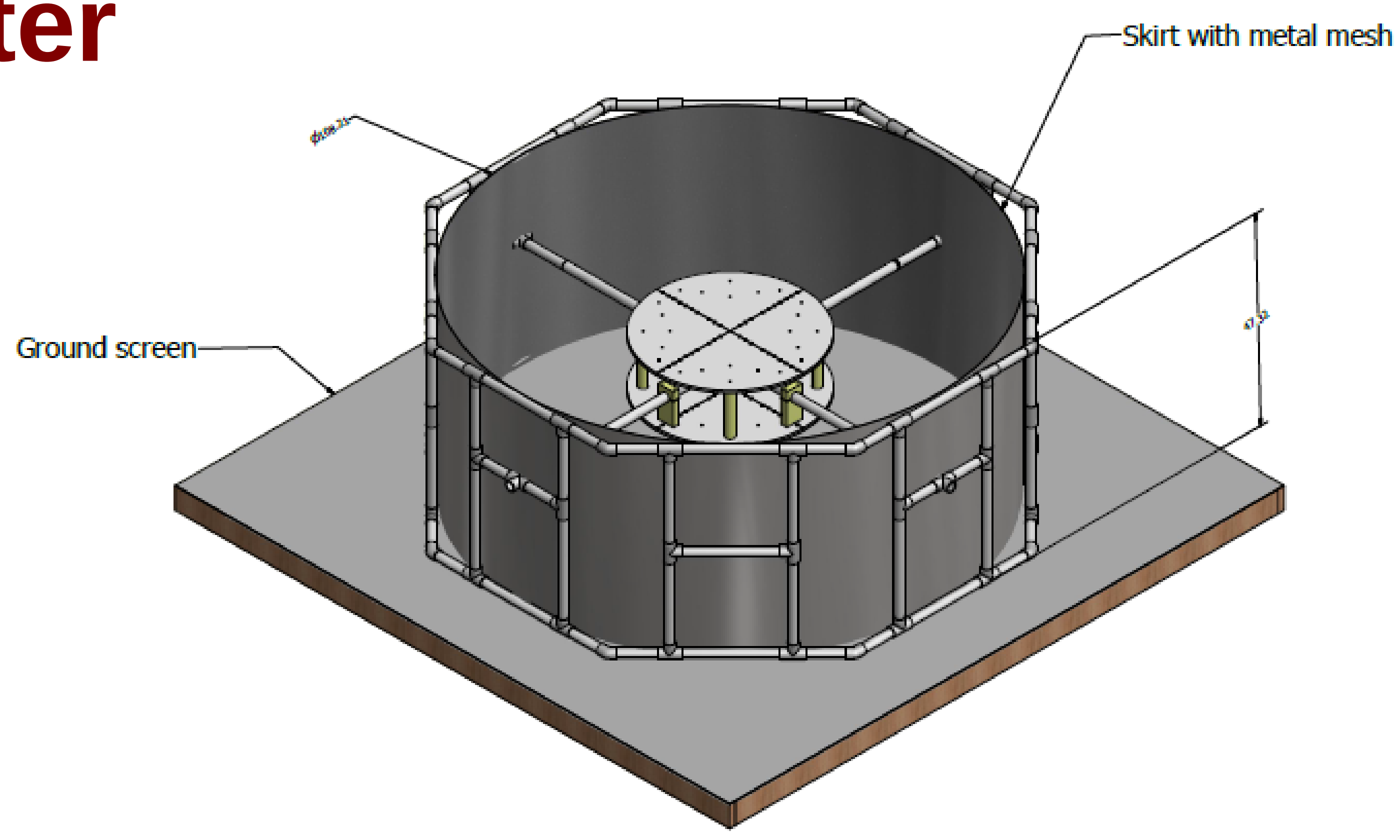
CDL

Cosmic Twilight Polarimeter

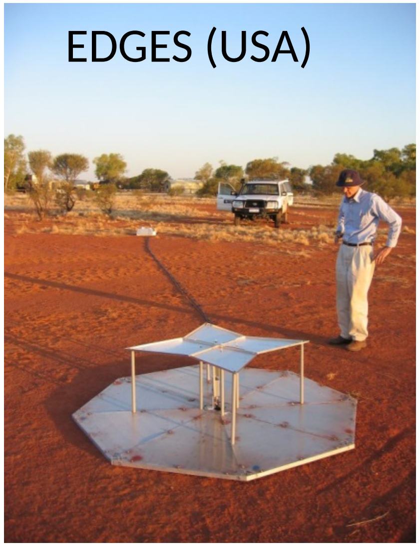
A Brief Overview of the Proof-of-Concept System: Instrument, Methodology, and Results

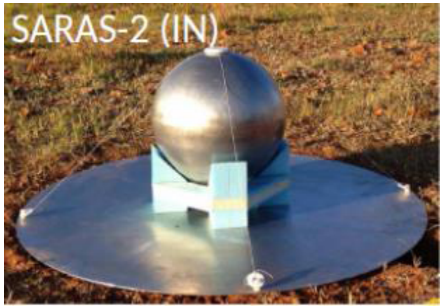


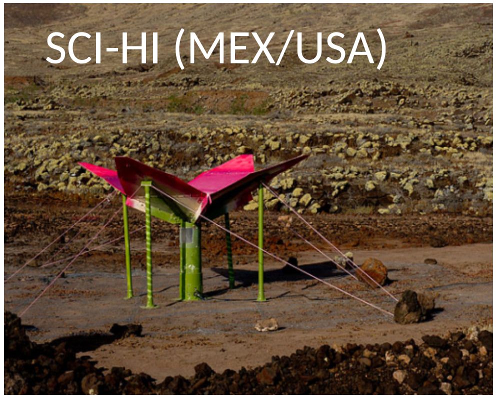
***Richard F. Bradley* - NRAO CDL & University of Virginia**

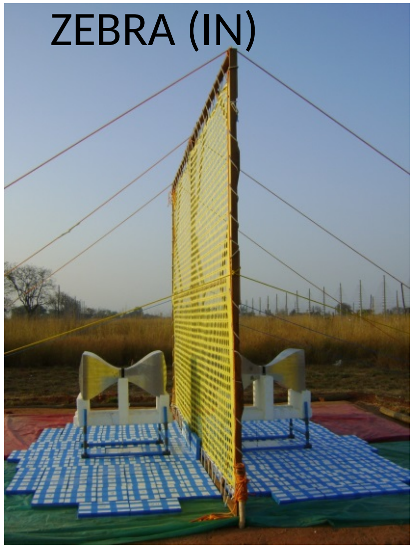
Ground-Based 21-cm Global Signal Experiments

an exciting time for small-scale instruments









Cosmic Twilight Polarimeter (CTP)

how does it differ from other global signal experiments?

Dynamic Polarimetry

Tone Injection Based Gain Tracking

Front-End Temperature Stability

Calibration using Models and Lab Measurements

Signal Estimation using Modern Pattern Recognition

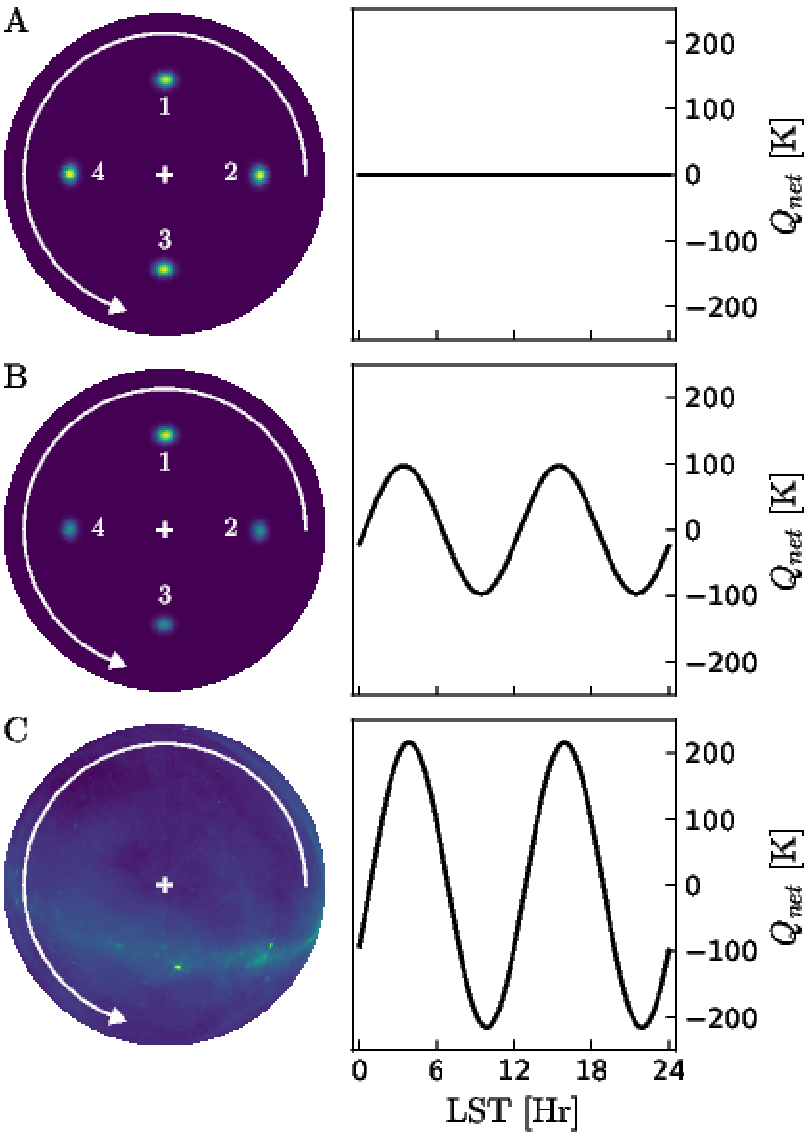
Dynamic Polarimetry

isolating the foreground power spectrum from the 21-cm

Equal flux, equidistant from bore sight

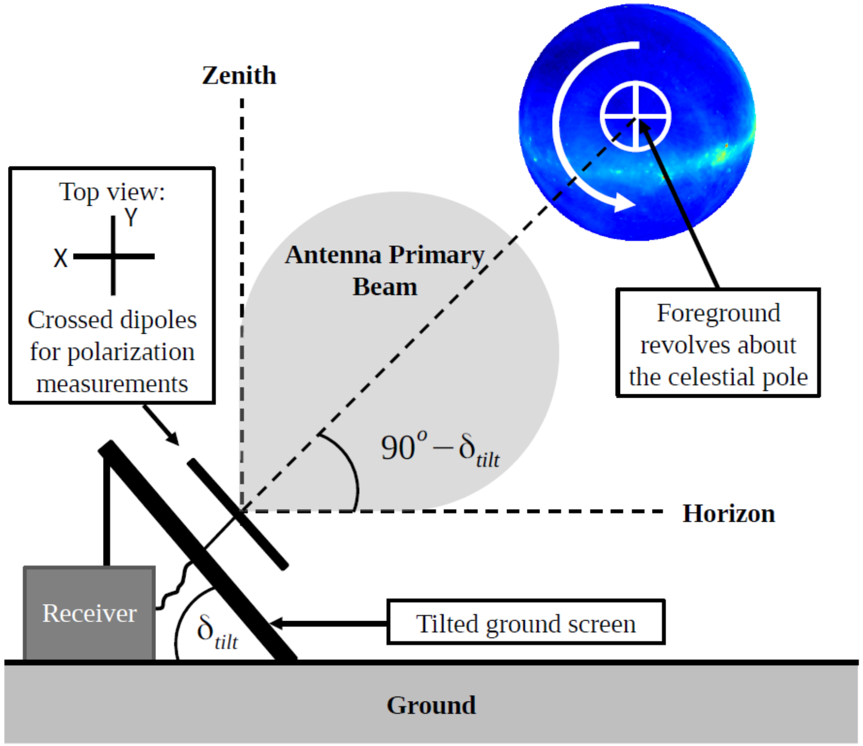
Unequal flux, equidistant from bore sight

Full sky flux, Haslem Map



Dynamic Polarimetry

isolating the foreground power spectrum from the 21-cm



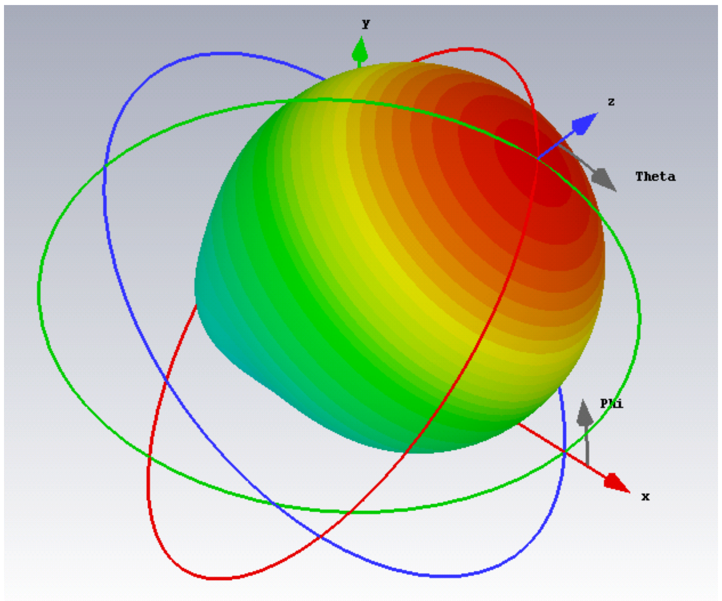
Polarimetry Process to measure Foreground

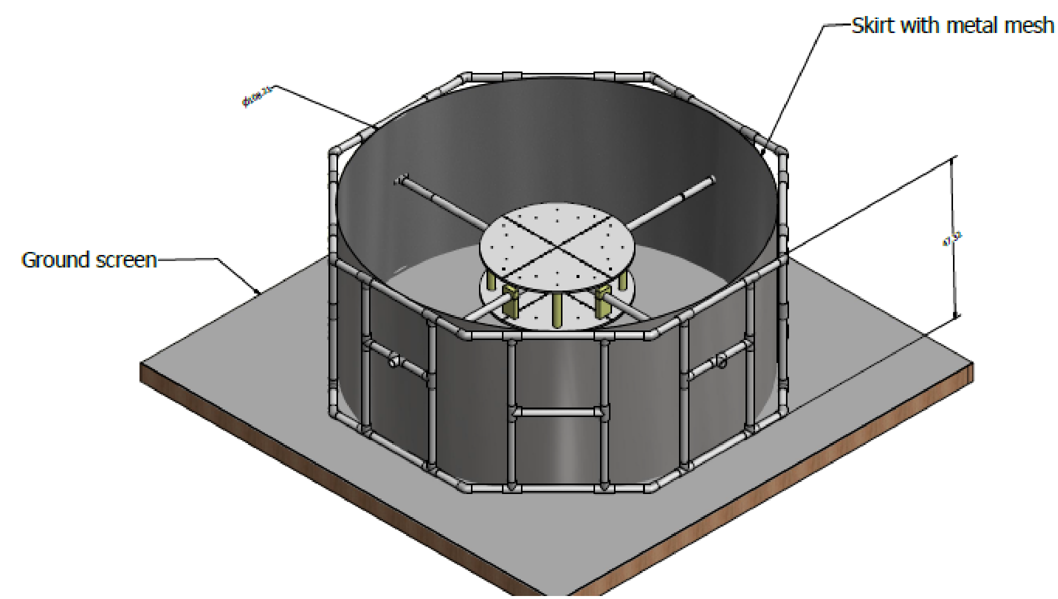
1. Measure "polarization leakage" caused by ν-dependence of power patterns of linearly polarized dipoles. Rotation of sky to measure modulated Stokes Q, U, V.
2. Harmonic decomposition of modulated Q, U signal, scale to Stokes I, and subtract.

Nhan, Bradley, & Burns, 2017, ApJ, 836, 90.

Dynamic Polarimetry

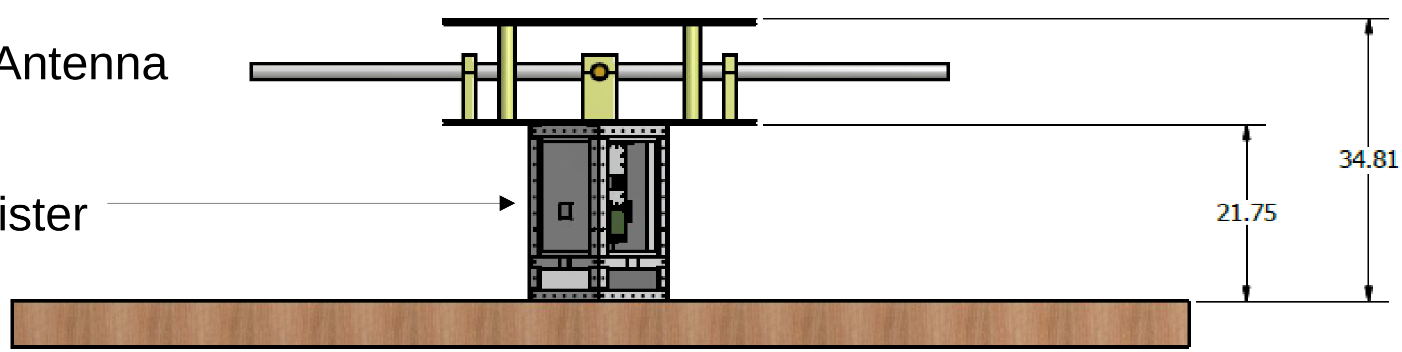
with a dual polarization antenna





Sleeved Dipole Antenna

Instrument Canister



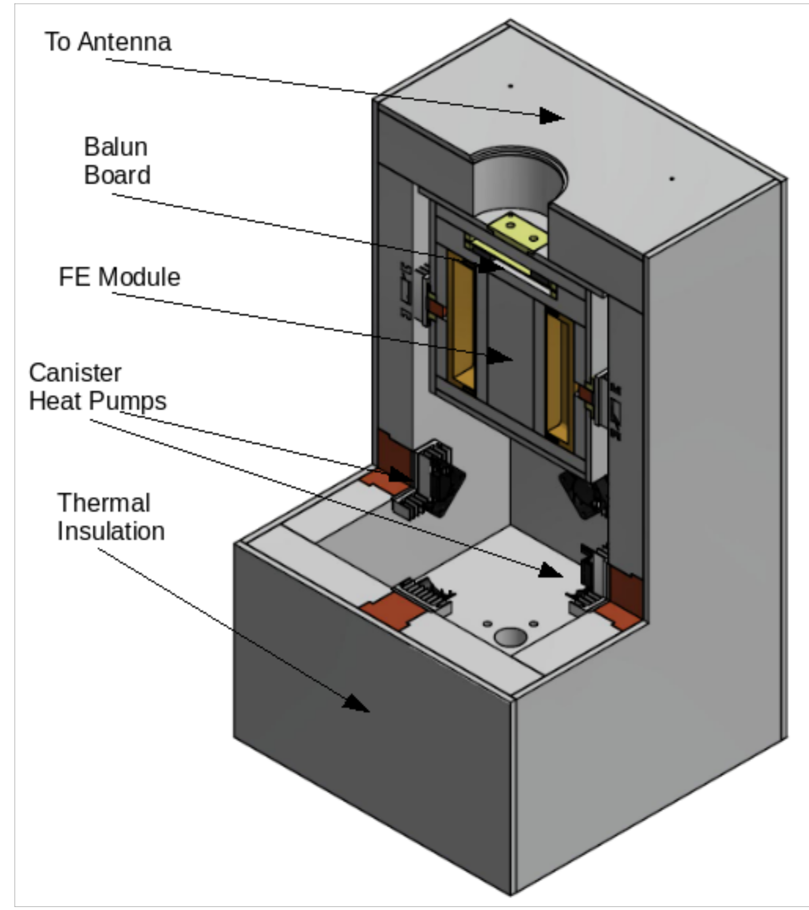
Radiometer Stability – Temperature Control

using two-stage Peltier heat pumps

Balun

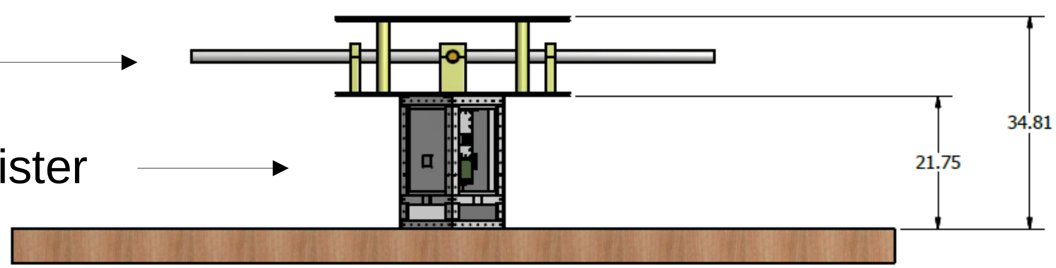
FE Module

2nd Stage



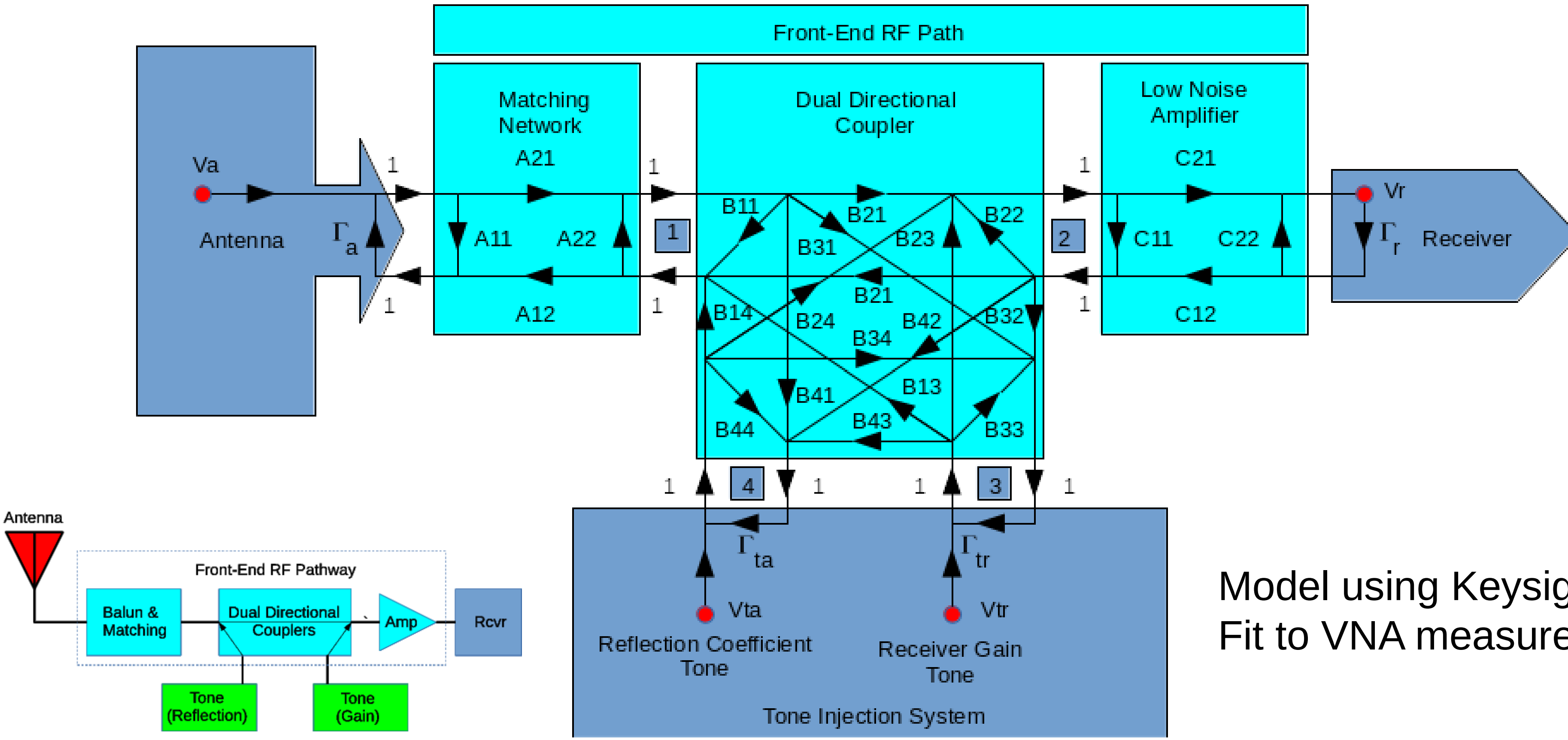
Antenna

Instrument Canister



Radiometric Calibration: Transducer Gain

through S-Parameter modeling and measurements



Model using Keysight ADS
Fit to VNA measurements

$$G_T = \frac{P_L}{P_{AVS}} = \frac{|S_{21}|^2(1-|\Gamma_L|^2)(1-|\Gamma_S|^2)}{|1-S_{22}\Gamma_L|^2\,|1-\Gamma_S\Gamma_{in}|^2}$$

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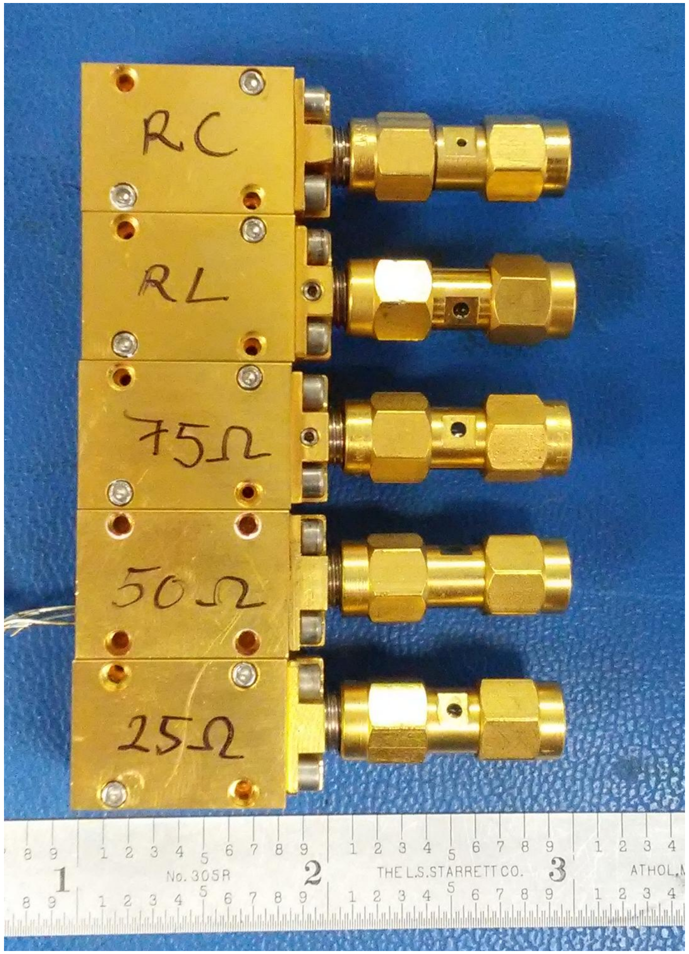
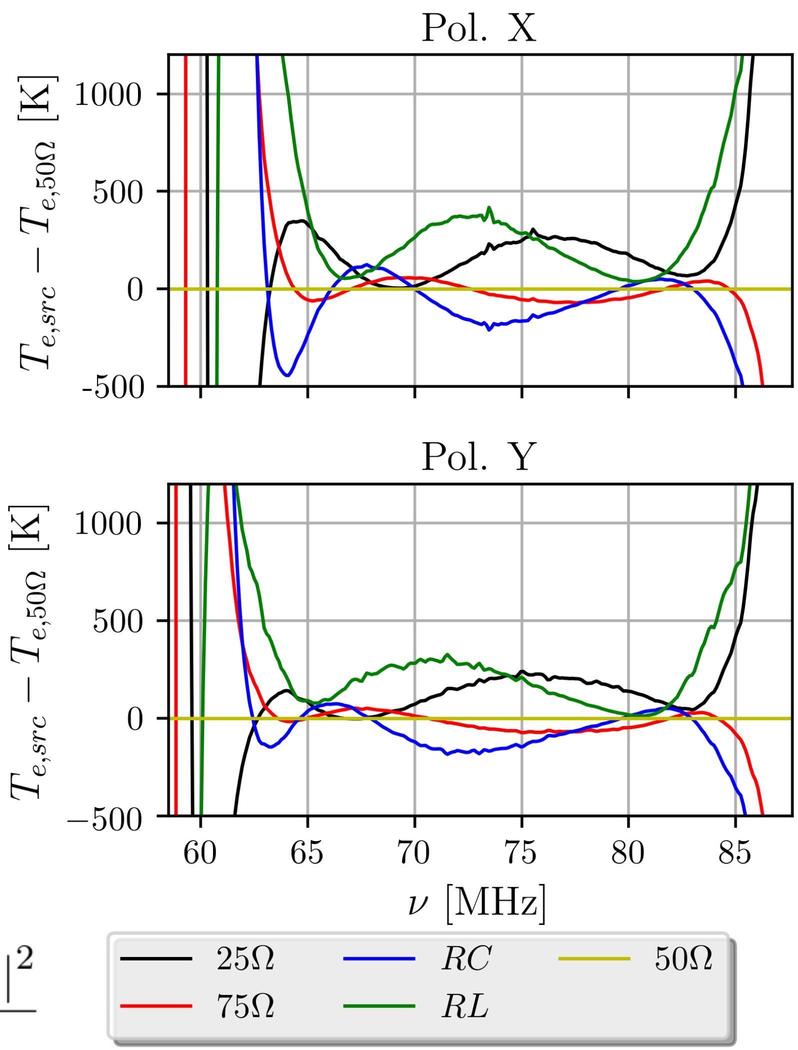
Radiometric Calibration: Noise Temperature

using perturbation modeling to estimate noise parameters



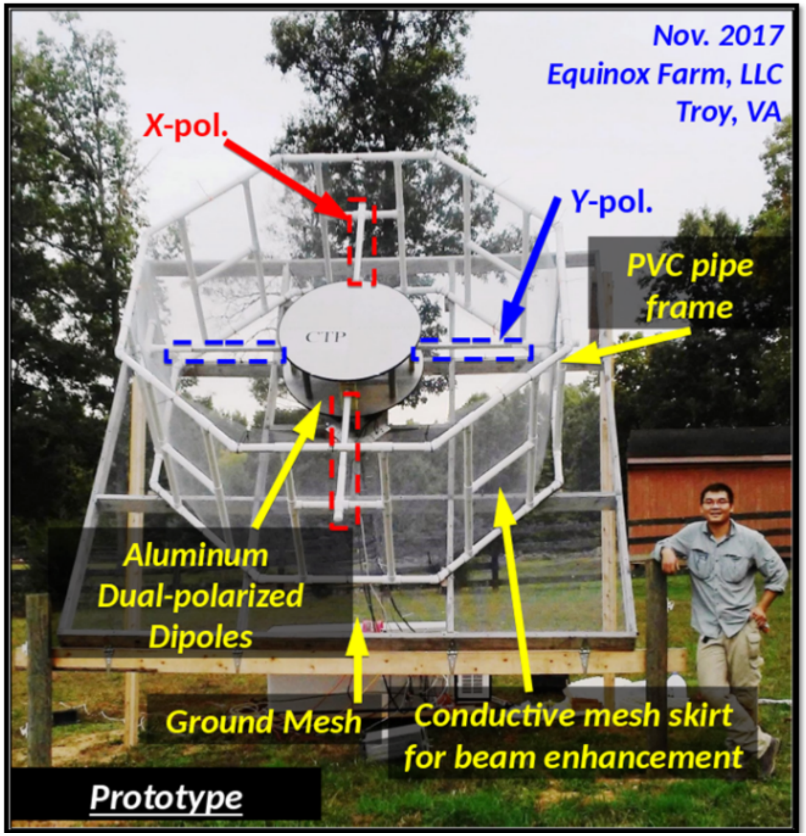


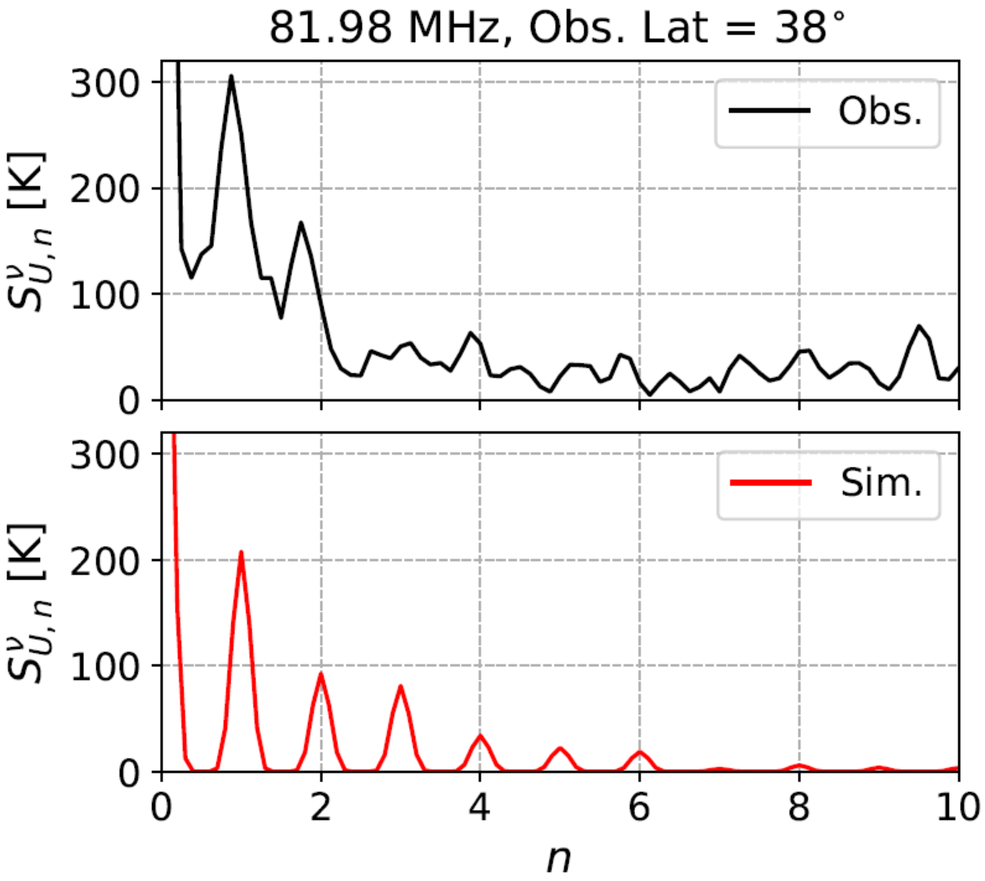
$$T_n = T_{MIN} + \frac{NT_{REF}\,|Z_s - Z_{opt}|^2}{R_s R_{opt}}$$

NRAO

Operations in Charlottesville, VA

proof of concept and results





Planned Operations in Green Bank, WV

gaining control of systematics

CTP deployment with minor upgrades

Bordenave to gain experience with the CTP
RFI mitigation activities
Reduced RFI environment – radio quiet zone
Initial input for SVD algorithm development

CTP scaled pair

Use of differential techniques on a pair of scaled antennas
Reduce reliance on antenna modeling

CTP on the 45' dish

Reduce ground effects
Easily point the CTP