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Title: "NEW ARCHITECTURE FOR THE GEOSTATIONARY SYNTHETIC THINNED ARRAY RADIOMETER (GEOSTAR)"

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Abstract:

The Geostationary Synthetic Thinned Array Radiometer (GeoSTAR) is an interferometric "Y" array microwave radiometer concept to observe the Earth's atmosphere from Geostationary Earth Orbit (GEO) in bands from 50 GHz to 183 GHz. These microwave bands have been utilized for many years by low earth orbiting (LEO) and aircraft sensors to provide temperature and water vapor soundings, as well as rainfall [1, 2, 3], yet the coverage and timeliness of these measurements has been a problem—particularly in the tropics where storm dynamics are severely undersampled by LEO spacecraft. This problem was recently recognized in the NRC Decadal Survey, which now recommends a mission called PATH (Precipitation and All-weather Temperature and Humidity) [4]. PATH is specified as a GEO "microwave array spectrometer"—which essentially describes GeoSTAR. GeoSTAR is an interferometer array which can produce the necessary spatial resolution using Fourier synthesis from a minimal, fixed-geometry, thinned array radiometer package that is compatible with existing GEO spacecraft.

In 2005, our team completed a 50 GHz, 24-element demonstrator of the GEOSTAR instrument which established the basic feasibility of our measurement approach [5]. We are now developing a new 183 GHz laboratory instrument to advance the technological readiness for a spaceborne system. The general goals of this effort are to demonstrate the low mass and power, high precision, and noise performance that will be necessary for the spaceborne system. The specific areas that we have focused on include receiver noise performance, ASIC correlator performance, and packaging technologies. At the time of writing, we have made significant advances in all of these areas which we expect to

publish, and will be touched upon during this talk. The main focus of this talk will, however, be of recent advances in the system architecture of GeoSTAR.

The performance goals of GeoSTAR translate to 25 km ground resolution and 0.3 Kelvin radiometric sensitivity with refresh rates of one earth image every 15 minutes in the spaceborne system. To meet these goals, this new 183 GHz array will incorporate some major architectural changes which are based on lessons learned in the 50 GHz array demonstrator. These changes include the division of the array into two parts: a small "low resolution, high precision" array, and a much larger "high resolution, modest precision" array. Such a division addresses the contrasting needs for high precision in the shortest interferometric baselines where a small number of visibility samples (or correlators) contribute to the majority of the signal amplitude within an image, versus noise performance in the longer baselines where a large number of visibility samples contribute a relatively small signal amplitude to the image. There are several advantages to dividing the array this way. One advantage is that one removes the restriction where all antenna elements must be equal to or smaller in diameter than the fundamental visibility grid spacing. This was a restriction in the original GeoSTAR, and it lead to a signal to noise problem in which only about 40% of the antenna energy would originate in the earth disk, when observing the Earth from GEO. In the new configuration only the small array faces this restriction, whereas the larger array can be "opened up" using a new geometry which provides more physical space between antenna elements. With this configuration one can optimize the antenna gain to match the image area and remove aliasing. This new geometry greatly improves the sensitivity of the overall system. The smaller array contributes relatively few visibility samples to the image synthesis, so smaller (lower gain) antennas of that array have little impact on sensitivity. Another advantage to the new architecture is that the internal calibration subsystems systems need only be applied to the smaller array, since the calibration needs of the larger array are relatively modest and can be accomplished by a one-time calibration of receiver noise and phase—as was demonstrated previously using the 50 GHz demonstrator array and which we intend to demonstrate with the new system.

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