Reference Front End Design for a Next Generation Very Large Array
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The ngVLA will provide near-continuous frequency coverage from 1.2 – 116 GHz in multiple bands, with a gap at the atmospheric absorption band between ~50 – 70 GHz. Maximizing sensitivity for each band, while also minimizing the overall operating cost are the primary design goals. Therefore, receivers and feeds are cryogenically cooled, with multiple bands integrated into common cryostats. Using feed horn designs with broad bandwidths and high aperture efficiencies are key to meeting these goals.

The proposed ngVLA Reference Front End is implemented as six separate bands, each having an integrated feed. The upper five bands (2 – 5) are co-located within a single compact cryostat, while the lowest-frequency band (1) occupies a second cryostat of similar volume and mass. The Band 1 feed is cooled to 80K, while all other feeds are cooled to 20K.

For optimum performance at higher frequencies, waveguide-bandwidth (~1.66:1) receivers are proposed for Band 3 (12.3 – 20.5 GHz), Band 4 (20.5 – 34 GHz), Band 5 (30.5 – 50.5 GHz) and Band 6 (70 – 116 GHz). Excellent low noise performance is achievable, by using waveguide through the signal path and well-optimized low-noise amplifiers (LNAs), without adding undue size or weight. An axially-corrugated conical feed horn with wide opening angle (~55^0) is also used, scaled from a design for the Canadian DVA-1 antenna. Aperture efficiency is comparable to traditional corrugated feed horns, but is simpler to fabricate, and very compact in size.

For continuous coverage between 1.2 – 12.3 GHz, waveguide or even octave-bandwidth receivers are not cost-effective, given the > 10:1 frequency range. For Band 1 (1.2 – 3.5 GHz) and Band 2 (3.5 – 12.3 GHz), wideband LNAs mated to a Caltech-designed quad-ridge feed horn (QRFH) are used. These feeds are highly compact, and cooled to reduce loss. Aperture efficiency and receiver noise temperature are not as highly optimized as on the other bands: on the other hand, very significant cost savings are realized, by effectively halving the number of receivers and cryostats required per antenna.

The cryostats incorporate traditional Gifford-McMahon (G-M) cryocoolers that are run at variable speed, to reduce both the average running cost and mechanical wear on the units. The helium compressor supplying the cryocoolers will also be a modern variable-speed scroll-type unit, for the same reasons. This combination will substantially reduce the overall operations cost of the ngVLA cryogenic system.