ngVLA Cryogenic Subsystem Concept

First D. Urbain[(1)], W. Grammer [(1)], and Steven Durand[(1)]
(1) National Radio Astronomy Observatory, Socorro, NM 87801,
http://www.nrao.edu

The NRAO has been operating the Very Large Array (VLA) for more than 35 years. Over time, nearly all of the instrumentation on the telescope has been dramatically upgraded. However, the cryogenic subsystem equipment and technology have remained virtually unchanged. While adequate for a 27-antenna array, scaling the current system for an array 10 times larger will be prohibitively expensive, in terms of operating cost and maintenance. Our objective with a next-generation VLA (ngVLA) is a redesigned cryogenic system that minimizes per-antenna power consumption and maximizes reliability, to keep the overall operating cost within reason. A key result is that though the number of cryocoolers is an important driver for the operating cost, a more relevant factor is the total required helium flow.

Several complementary approaches for improvement over the VLA system are possible. The first and most obvious is to reduce the total number of cryocoolers per antenna. This implies either combining multiple receiver bands in a single dewar, designing broader-bandwidth receivers to reduce the number of bands, limiting the frequency coverage, or a combination of all three. Second, the application of modern technologies such as variable-speed scroll compressors and cryocooler motor drives allow system cooling capacity to be dynamically matched to the thermal loading in each dewar. This results in significantly reduced power consumption, while also extending the maintenance interval of the cryocoolers. Third, minimizing thermal loading by design in the receivers becomes extremely important, as savings here translate directly to lower operating cost when variable-speed drives are used. Multi-layer insulation (MLI) on radiation shields and improved IR filters on feed windows can significantly reduce heat loading.

As to the cryocooler itself, the Gifford-McMahon type remains the preferred option because of the lower achievable temperatures (and hence lower receiver noise), its relative immunity to physical orientation, and the low cost and simplicity of maintenance, making it more cost-effective in the long term.

The ngVLA will cover a much larger expanse than the VLA, and likely have a significant fraction of its antennas in distant and remote locations. Software tools for automated analysis of monitor data for problem diagnosis, predictive maintenance and site coordinated maintenance scheduling will be essential to maximize efficiency and reduce downtime.