The GBT as the Short-Spacing Instrument for the ngVLA

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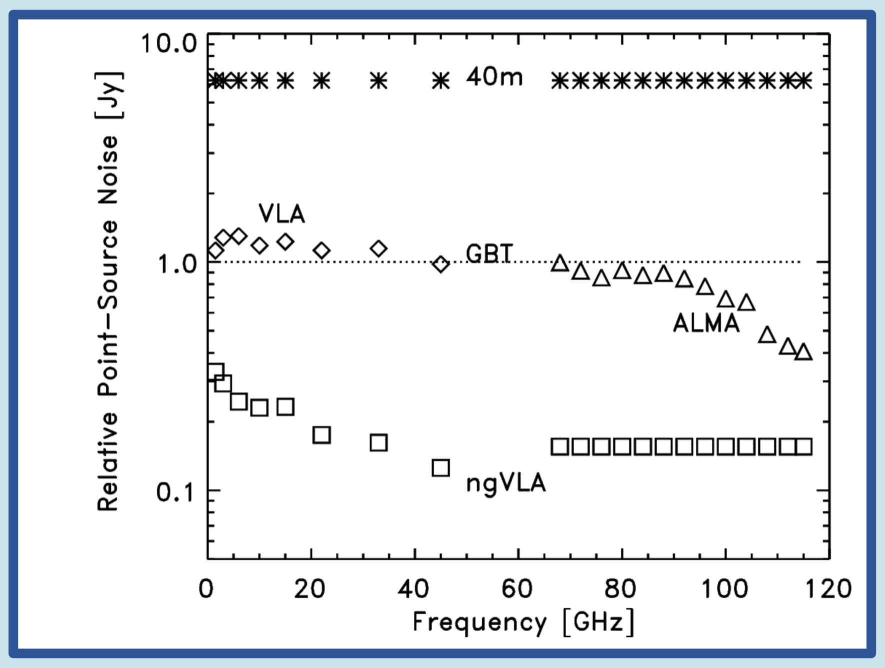
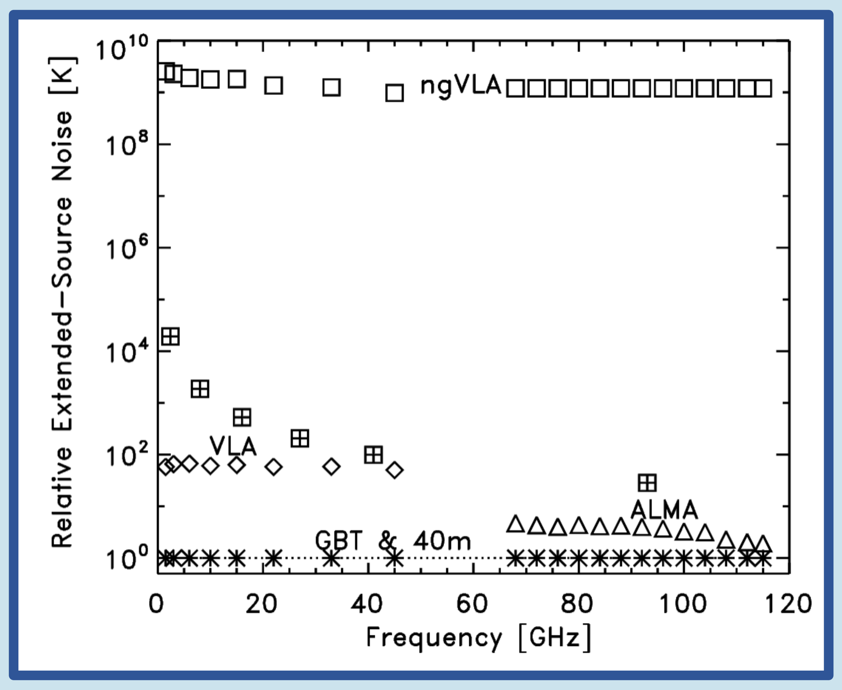
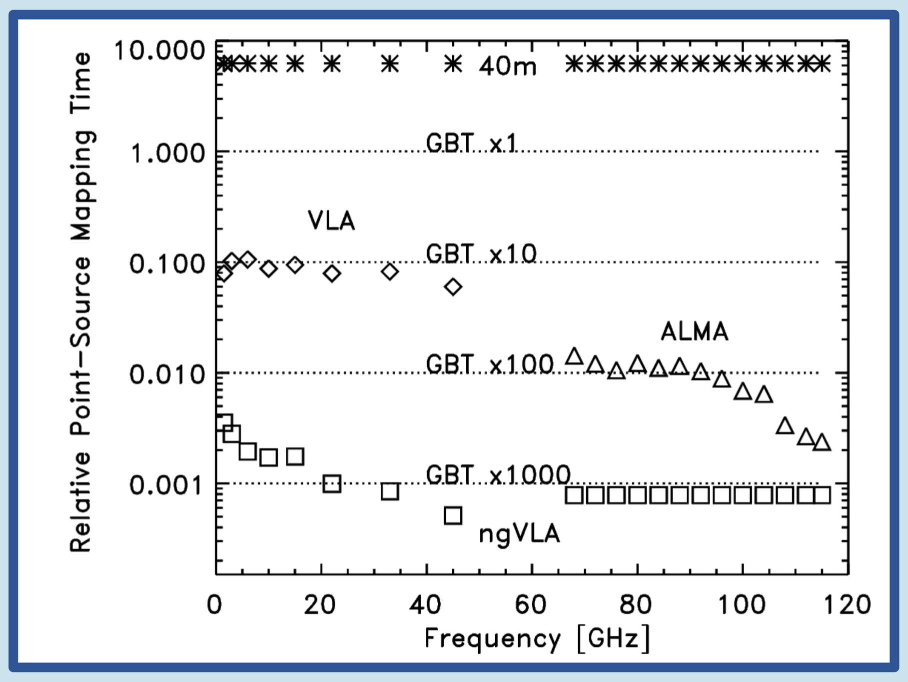
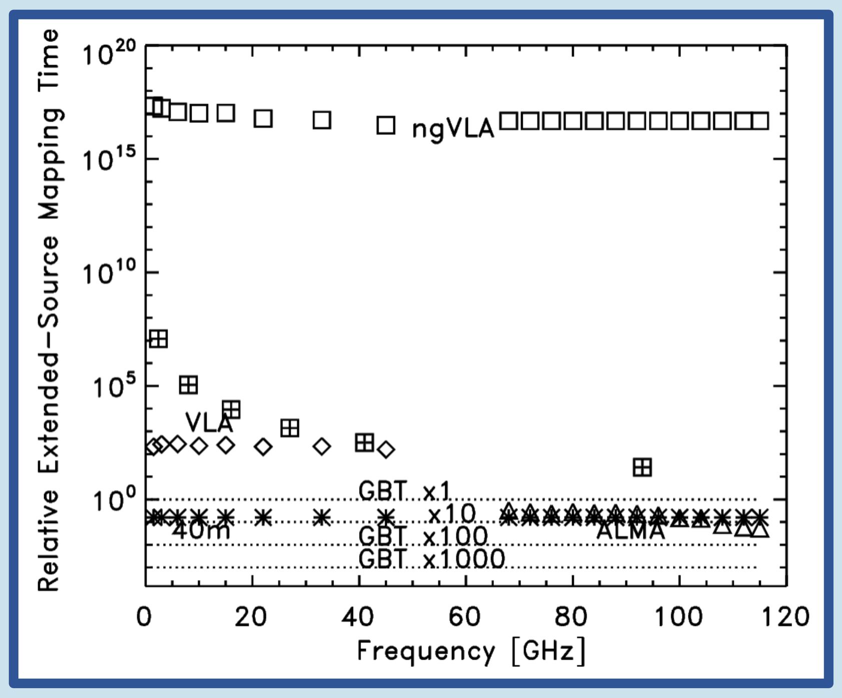
Abstract

The next generation Very Large Array project (ngVLA) would represent a major step forward in sensitivity and resolution for radio astronomy, by providing the ability to achieve sub-milli-arcsec resolution at 100 GHz. However, the trade-off between spatial resolution and surface-brightness sensitivity is unavoidable for interferometers. Large single-dishes complement interferometers by enabling science on spatial scales that are resolved out by interferometers. The Green Bank Telescope (GBT) is the only facility currently operating over the full range of proposed ngVLA frequencies (1-116 GHz). The GBT would be an ideal short-spacing instrument for the ngVLA.

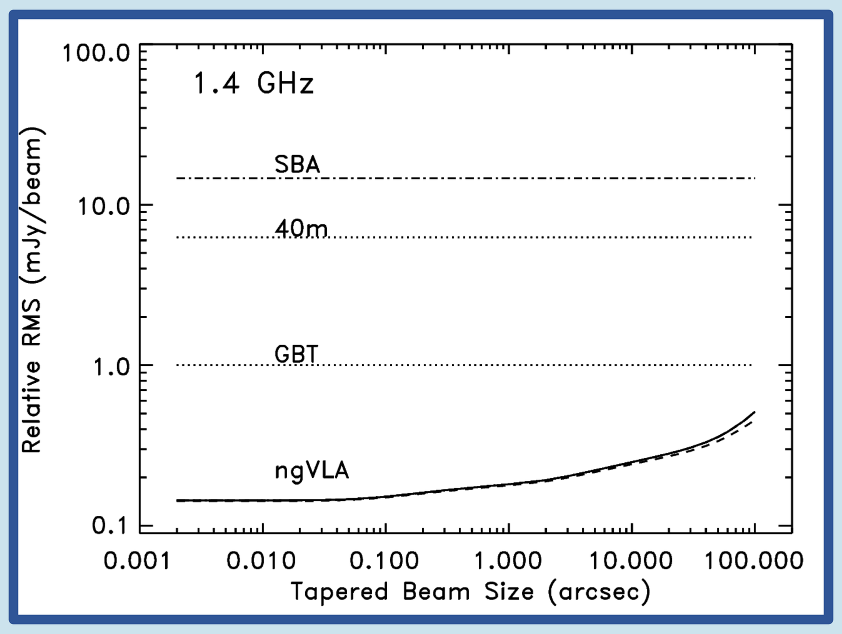


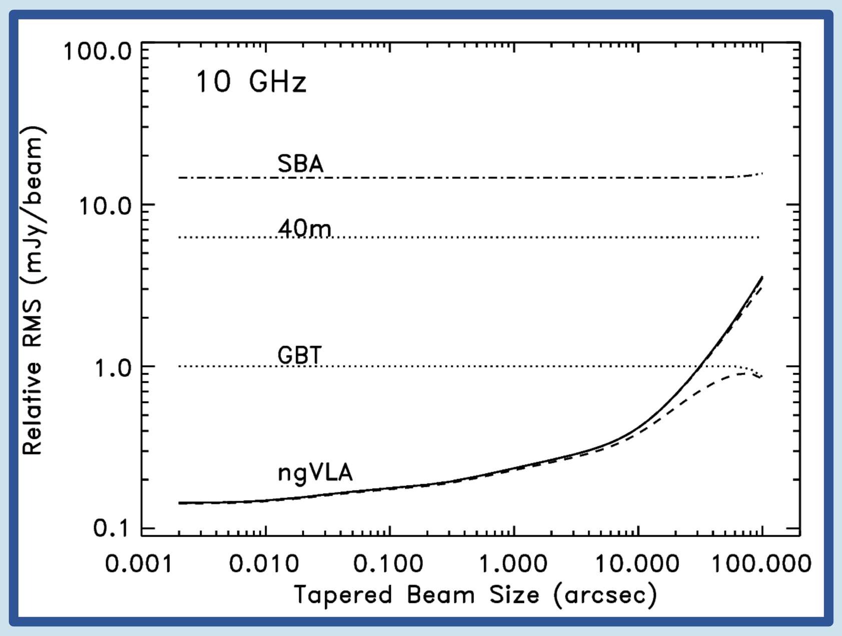


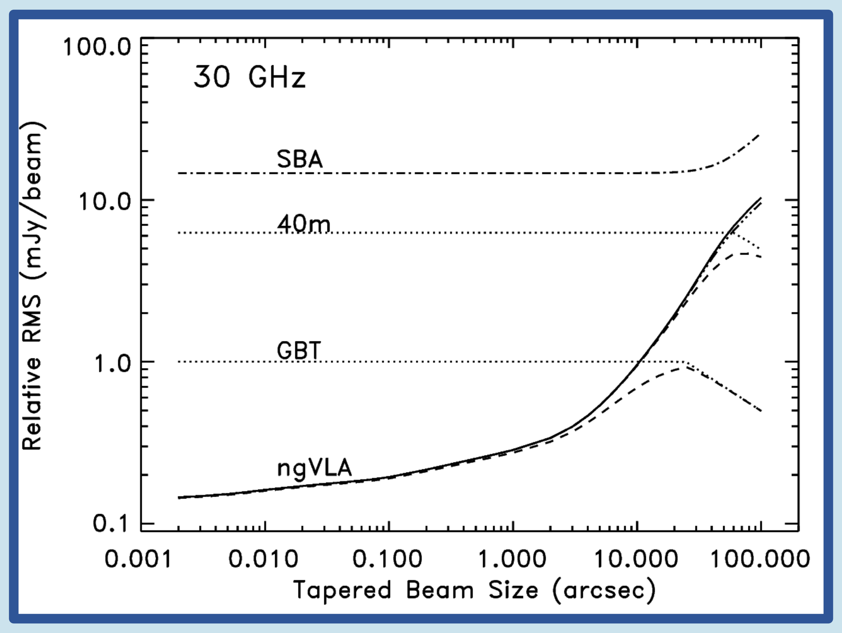


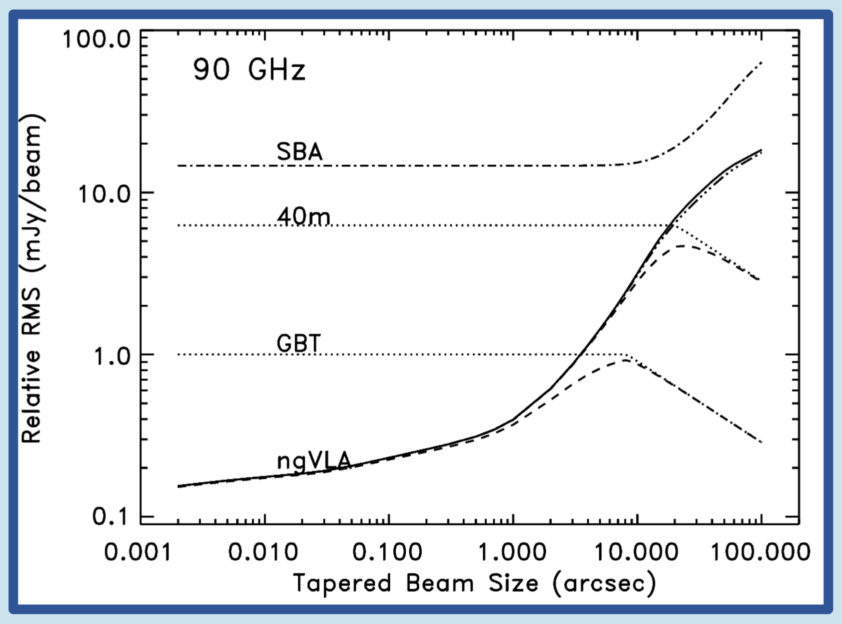


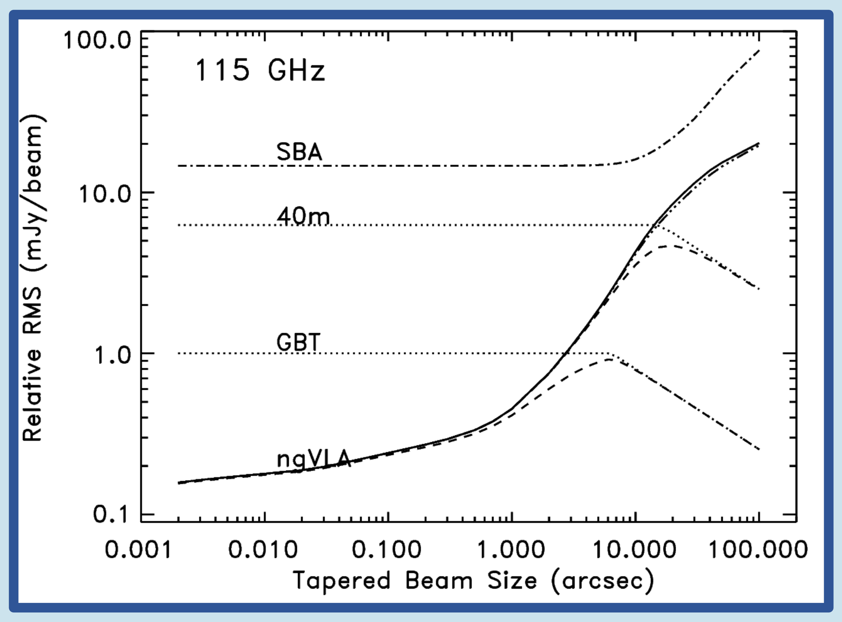
Sensitivity and mapping speed comparisons of the GBT, VLA, ALMA, ngVLA, and a generic 40m telescope. (Top-left) The GBT has a similar point-source sensitivity to the VLA and ALMA. The ngVLA will significantly improve the point-source sensitivity. (Bottom-left) Large single dishes require multi-pixel cameras to yield competitive point-source mapping speeds. A 10 pixel camera on the GBT provides a similar mapping time to the VLA, while a 100 pixel camera on the GBT is similar to ALMA, and a 1000 pixel camera on the GBT would be similar in point-source mapping speed with the ngVLA. (Top-right) The extended source sensitivity in K for the ngVLA, VLA, and ALMA compared to a single-dish. The boxes with crosses show the estimated ngVLA sensitivity when tapered to 1 arcsec resolution. (Bottom-right) The slow mapping speeds of extended sources with interferometers highlight the need for single-dishes in radio astronomy. Interferometers sacrifice surface-brightness sensitivity for spatial resolution.









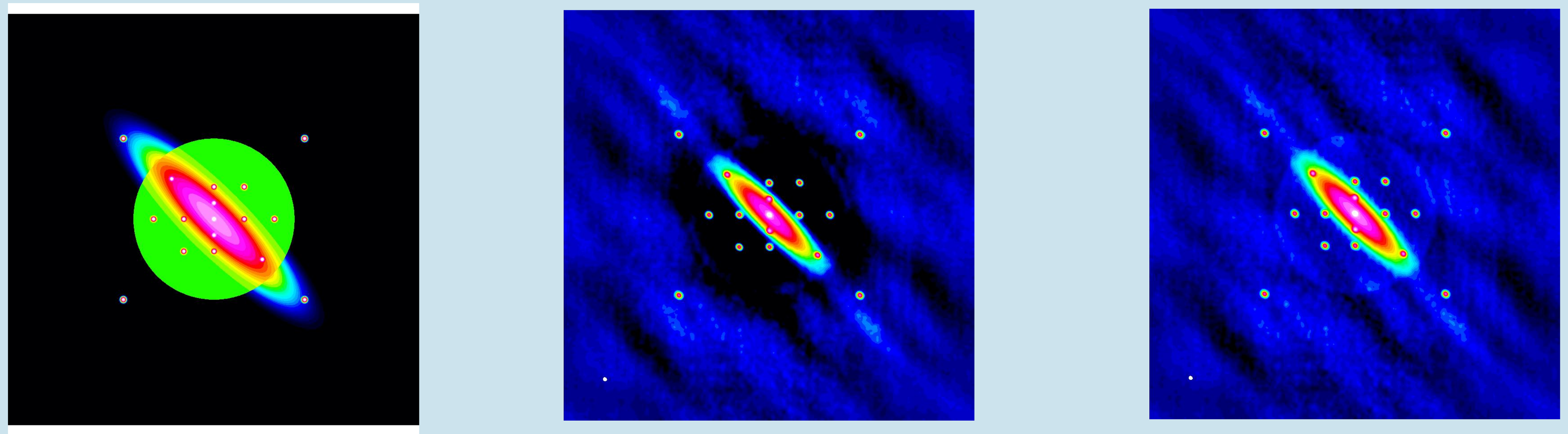


The plots assume the ngVLA-main configuration with 214x18m dishes configured with 94 of the antenna within the central 1km diameter core. The SBA assumes 19x6m dishes. The prescription for computing the tapered weights is provided in ngVLA Memo#14.

The above and left five panels show the relative noise level as a function of spatial scale matching the tapered beam-size of the ngVLA for 1.4, 10, 30, 90, and 115 GHz. At high frequency, the sensitivity of the ngVLA decreases rapidly with increasing spatial scales due to the lost of sensitivity of the longer baselines. The ngVLA short-baseline array (SBA, dashed-dotted line) does not have sufficient collecting area to provide high sensitivity, and its combination with the ngVLA (dashed-triple-dotted line) is unable to compete in terms of sensitivity with that provided by the combination of the ngVLA with a large single dish (dashed lines). The sensitivity provided by the GBT (100m) is superior to that provided by a smaller single dish. Although the SBA and including some 18m ngVLA dishes in total-power mode can provide short-spacing data, the sensitivity is lower than that would be provided by a large single-dish, such as the GBT.

Concluding Remarks

The updated ngVLA configuration with nearly half of the antenna within the 1km diameter core will greatly improve science being done on spatial scales of 1 arcsec and smaller. To study emission on large spatial scales, a large single dish is recommended. For the 18m ngVLA antenna, the recommended dish size is 45m or larger (ngVLA Memo#14). The current plans for using the SBA and a few 18m antenna in total-power mode for short-spacing data would have significantly lower sensitivity than that of a large single dish.



CASA simulations quantifying the importance of a large single dish. (Left) Truth image is comprised of extended elongated Gaussian, a large faint disk, and a sample of Gaussian point-sources where the brightness temperature increases from blue to green to red. (Middle) The image recovered using the ngVLA. (Right) The image produced with a combination of data from the ngVLA and the GBT. The ngVLA only image recovers a small fraction of the total emission and yielded large photometric errors (>20%) measured for point sources in the field, while in the ngVLA+GBT image all the flux was recovered, and the photometric errors (<5%) were limited by the input noise (see ngVLA memo#14).

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