ALMA Memo 489

Problems with the Homogeneous Array Simulations in ALMA Memo 488

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ALMA Memo 488 seeks to justify the building of the ACA (an array of 12 7~m antennas designed to improve the short baseline (u,v) coverage) based on its purported improvement in ALMA's imaging quality. Specifically, simulations of four different model sources are performed with the 64-element ALMA plus total power on the one hand (called ALMA+SD in Memo 488, also known as the homogeneous array), and the 64-element ALMA plus the ACA plus total power on the other hand. In several cases, adding the ACA appears to improve the image fidelity by a factor ranging from about 2 to 10 over the image quality of the 64-element ALMA without the ACA.

It should be pointed out that these simulations are not at all fair to the homogeneous array. In Section 2, "Simulation Procedures", it is explained that for the ALMA+SD simulations, the 64-element ALMA interferometric data for 19 pointings is supplemented with a pointed total power observation for each field (ie, 19 additional total power points). However, when the ACA is used, a single dish OTF map is also used. I assert that some of the dramatic differences seen in the results of ALMA Memo 488 are due to the different ways the total power data was included in the two observing strategies, rather than entirely due to the ACA as we are led to believe.

Cornwell, Holdaway, and Uson (CHU, 1993) state that when performing a homogeneous array mosaic, the interferometric pointings should extend beyond the source of interest (ie, a guard band of pointings must surround the source), and the total power measurements should extend even further beyond the interferometric pointings. While ALMA Memo 488 does not mention what the distance between the pointings is, it likely does not provide a guard band for the interferometric pointings (a spacing of lambda/2D results in a range of 39 arcsec to 45 arcsec between pointings on the opposite side of the model source which is gridded on a 70 arcsec image -- and the model sources have structure which approaches or exceeds 70 arcsec in size). The homogeneous array simulations certainly do not provide the additional guard band for total power observations which extends further beyond the interferometric pointings.

Furthermore, the observational details used in the simulations presented here are the absolute worst case for homogeneous array mosaicing. Good homogeneous array mosaicing requires foreshortening of baselines by projection, and these observations are of an object at dec=-23 deg which transits at zenith, and the hour angle range of +/- 0.15 hours means that all observations are within 9 minutes of transit at the zenith. Hence, there is essentially no foreshortening of the interferometric baselines due to projection.

There are still many reasons why homogeneous array mosaics will be desirable, mostly related to the fact that the total power and interferometric data will be taken at nearly the same time:

- one will never have to wait for ACA observations to be completed before making the images.
- the atmospheric conditions present for the total power observations will be similar to the interferometric observations' atmospheric conditions.
- if quasars are used to transfer the flux scale calibration from interferometer top single dish, they won't vary between the total power and interferometric observations for homogeneous array observing.
- it may be difficult to get enough SNR to calibrate the ACA and the four associated 12m total power antennas, but using the 64 12 m dishes both interferometrically and in total power will provide better SNR for more accurate calibration of the total power antennas.
- for a great many observations, adding ACA data may not make a noticeable improvement.

There are some disadvantages to the homogeneous array:

- Extra observing time will need to be allocated for guard band observations.
- High SNR sources will be imaged better by adding the ACA data.

Aside from calibration issues, adding ACA data should never result in an image which is worse than what the homogeneous array alone can produce.

While it is too late to change the ALMA design concerning the ACA, it should be kept in mind that homogeneous array mosaics will be made with ALMA, and we must not design homogeneous array mosaics out of the project. Specifically, the SSR needs to consider source blocks which drive both the interferometric and the total power sides of the mosaicing process for the 64-element ALMA.

References

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"Wide-Field Imaging of ALMA with the Atacama Compact Array: Imaging Simulations",
Takahiro Tsutsumi, Koh-Ichiro Morita, Tetsuo Hasagawa, and Jerome Pety,
ALMA Memo 488, 2004.

"Radio-interferometric Imaging of Very Large Objects: Array Design",
T.J. Cornwell, M.A. Holdaway and Juan Uson, Astronomy and Astrophysics,
271, 697, 1993.