ACA/ALMA Calibration Coordination

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1 Goals

The goals of the ACA/ALMA Calibrations Coordinations are:

1. Establishing common observation strategy and software reductions for the basic calibrations that may be done independently by the ACA and ALMA. Incorporation of this data into the ALMA pipeline and archive should be transparent to the array used.

2. Placing independent and non-simultaneous ACA and ALMA interferometric observations on the same amplitude and position registration scale.

3. ACA semi-stable calibration needing high sensitivity will incorporate some or all of the ALMA antennas; egs. primary beam mapping.

4. ACA and ALMA use of the WVR data should be treated in a compatible manner.

5. ACA temporal amplitude, reference pointing, and phase calibrations may need addition sensitivity, especially at the highest frequency.

6. The tracking of the primary calibrator sources and bootstrapping the flux density of secondary calibrators (quasars and galaxies) is best done using the ACA lower resolution array. However, accurate positions and structures will need the ALMA array.

7. The gain calibration methods of the ACA four 12-m TP antennas needs more work. It will probably use occasional simultaneous observations of a bright calibrator using the TP antenna in the appropriate switching mode, compared with interferometric observations with some ACA and/or ALMA antennas. How often these simultaneous observations are needed is unclear.

2 Introduction

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The calibrations needed by the ACA (7-m array) and ALMA (12-m array) arrays have been discussed in other supporting documents. Although all of the calibrations can be made independently for the ACA and ALMA arrays, there are several reasons why coordination and/or simultaneity of the calibrations are useful: (1) images and data obtained from independent ALMA and ACA experiments should have the same amplitude scale and positional registration; (2) Some ACA calibrations may need the additional sensitivity that correlation with

additional ALMA antennas will provide; (3) Some ALMA calibrations may need the short spacings provided by the ACA; (4) Simultaneous and cross-correlation of ACA and ALMA scientific programs naturally provide a common amplitude and positional registration of the data.

3 ACA and ALMA Calibration Comparison and Combination

Many calibrations associated with stable or semi-stable array parameters can be made independently by the ACA and ALMA using relatively strong sources; for example, the nominal antenna pointing parameters, nominal bandpass calibration for all bands, antenna and electronic delay calibration, focus and subreflection alignments, and these have been discussed in related documents. The WVR data from both arrays must be treated in a compatible fashion. Those calibrations which require coordination between the two arrays are emphasized in this document.

If observations of the same field are made at different times using the ACA (with or without the TP antennas) and the ALMA antennas, it is useful if the same calibrator source is used for both observations. Thus, the flux density of the calibrator at the two epochs must be determined. This may involve brief ALMA observations during the ACA observation period, or vice-versa. Use of the overlap (u-v) coverage between ALMA and the ACA is also possible, but is more complicated (and probably less accurate) than having a common calibrator for a short period of time.

Some calibrations require high SNR in order to obtain good quality results. Hence, these calibrations for the ACA will require the use of some or most of the ALMA antennas, even if the ACA alone is being calibrated. These calibrations are: 1) Primary beam calibration for total intensity and polarized intensity; 2) Reference pointing at the highest frequencies; 3) phase referencing with a close calibrator at the highest frequencies; 4) Multifrequency calibration when a lower frequency calibrator is used to calibrate an ACA and/or ALMA observation at the highest frequencies; 5) accurate bandpass calibration at the highest frequencies. 6) Accurate polarization calibration at the beam center.

Other calibrations which require ACA and ALMA coordination are: 1) Occasional combined antenna location calibrations to keep both arrays on the same terrestrial grid; 2) ACA monitoring, with its low resolution, of the flux density of the standard flux calibrators (planets, asteroids, etc., that may be heavily resolved with ALMA), and the determination of the flux density of secondary flux calibrators (not very variable quasars and bright, small galaxies at weekly or monthly intervals; 3) ALMA determinations of the accurate position and structure of the calibrators for use with all antennas.

4 Total Power Calibration

The total power observations measure the zero-spacing flux density, to obtain high quality images of extended radio sources whether single pointing, mosaicking or on-the-fly imaging. The ACA total-power TP (four 12-m antennas) are specially designed to determine this total power, although the fifty 12-m ALMA antennas will also acquire this data from the antenna auto-correlations, but with somewhat less stability because of the lack of any type of switching.

The gain calibration of the TP antennas in total power mode can be accurately determined from a simultaneous observations of a bright compact source with the TP antennas in the appropriate switching mode (position, nutation or frequency switching), compared with interferometric observations with some or all of the ACA/ALMA array. The flux density of the calibrator need not be accurately known. The precise method of this calibration has not yet be described in detail, but the appropriate results in a TP measurement of the flux density density of the calibrator, after correcting for switching and other total power methods, with that obtained from the interferometric observations. The effective resolution of the TP results depends on the switching and reduction methods and must be accurately determined. This TP flux density calibration need be done occasionally (every few hours?) since changes in the relative gain of the TP antennas can be monitored electronically with reasonable accuracy over the few hours. More of this total power calibration method is needed.

Switched polarization TP measurements are possible. Once the gain of the two parallel hand receivers have been obtained using the above strategy, interferometric observations of the TP antennas with some or all of the ACA/ALMA array should determine the on-axis polarization leakage terms. This type of observation has been rarely done, so that more experience is needed to determine the efficacy of TP polarization measurements.