What is the absolute astrometric accuracy of ALMA?

In observations with standard ALMA calibration and observing setups (the default in the ALMA-OT) in the more compact configurations (angular resolutions coarser than about 0.15\textquotedbl{}), in favorable ALMA observing conditions, and for science targets that are compact and relatively strong radio sources, the nominal rms absolute positional accuracy, $\text{pos}_{\text{acc}}$, can be approximated by the relationship:

$$ \text{pos}_{\text{acc}} = \frac{\text{beam}_{\text{FWHP}}}{\text{SNR}} / 0.9 $$

Here,

- $\text{beam}_{\text{FWHP}}$ is the Full Width Half Maximum synthesized beam size in arcseconds,
- SNR is the signal-to-noise ratio of the image target peak (up to a SNR~20; see below), and
- 0.9 is a factor to account for a nominal 10\% signal decorrelation.

Favorable ALMA observing conditions imply a stable atmosphere (rms phase variation over the array of ~30 degrees with a timescale of about 30 seconds) and a calibrator-target separation of less than about four degrees. Under these conditions, the atmospheric phase fluctuations limit the ($\text{pos}_{\text{acc}} / \text{beam}_{\text{FWHP}}$) ratio to ~0.05 at best so that an image with SNR>20 will not improve the absolute target positional accuracy beyond about 5\% of the synthesized beam and a lower SNR will degrade the accuracy.

For example, for an observation with 0.27\" angular resolution (e.g. using the C-4 configuration and Band 7 (345 GHz)) and for SNR≥20, the nominal expected absolute astrometric accuracy is ~15 mas.

Important to note is that for more extended configurations (angular resolutions finer than about 0.15\") , the absolute positional accuracy can be up to a factor of about 2 poorer, due to atmospheric phase stability degradation with increasing baseline length.

In general, actual absolute positional accuracies may be a factor of two or more poorer than the nominal values above depending on the actual atmospheric phase conditions during the observation and the separation of the science target from the phase calibrator (particularly if the separation is more than four degrees), plus any errors in the antenna positions and the delay model used in the correlation of the data. Moreover, if a science target has extended structure, the position accuracy of a given component of the science target will be poorer than the nominal expected values. Tests are ongoing to further characterize ALMA's astrometric accuracy.
Higher than nominal absolute astrometric accuracy may be achieved for astrometric-type projects by use of special observing and calibration techniques, which since Cycle 8 2021 can be requested by selecting the “Enhanced positional accuracy option” in the ALMA-OT.

Further details about "Enhanced positional accuracy" and ALMA's astrometric accuracy in general can be found in the ALMA Proposer's Guide Section A.9.5 and ALMA Technical Handbook, Chapter 10.5.2 Astrometric Observations.