Tolerance analysis of the ALMA Band 2 receiver optics

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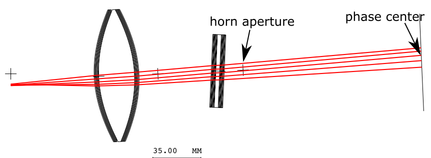
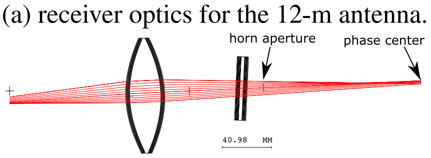
The Atacama Large Millimeter/submillimeter Array (ALMA) telescope [1] is the largest on-ground (sub)mm-wave telescope and it is located in the Atacama Desert in Chile. It consists of 54 12-m antennas and 12 7-m ones and works as an interferometer covering 35–950 GHz with 16-km-long baselines at maximum. The ALMA Band 2 receiver [2] is being developed for observations at 67—116 GHz and is in the last design and pre-production phases. National Astronomical Observatory of Japan (NAOJ) has provided the receiver optical designs for the 12-m antenna [3] and the 7-m antenna [4], as shown in Figure 1.

A tolerance analysis needs numerous cases of errors in a system of interest. Although we usually use time-consuming simulation as an estimator of optical performance, we have developed a tolerance simulation method in a combination of ray tracing and full-wave simulation, extending the method described in [5]. The developed method comprises two steps: calculating optical path lengths from the antenna aperture up to the feed horn aperture and calculating the beam coupling efficiency between the incoming beam and the horn beam. Aperture efficiency is calculated as the product of the beam coupling efficiency and the spillover efficiencies [6].

We carried out the developed method at six frequencies. We confirmed that the developed method could successfully calculate the beam coupling efficiency with a precision of about 1%. Figure 2 shows an analysis example of the ALMA Band 2 receiver optical system for the 12-m antenna with half-million cases, which cannot be achieved only by full-wave simulation. This presentation will provide the tolerance analysis results in detail.



(a) receiver optics for the 12-m antenna.



(b) receiver optics for the 7-m antenna.

Figure 1. Ray diagrams of the receiver optical systems.

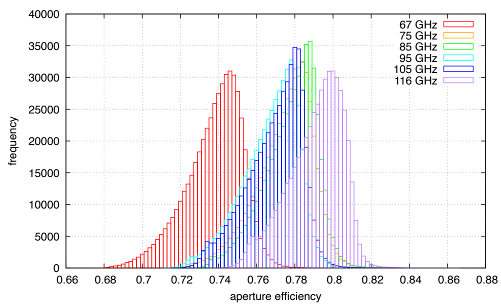


Figure 2. Histograms of aperture efficiency with half-million cases.

References

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