Hydrogen Maser:

A Hydrogen Maser supplied by the APP will serve as the frequency reference for the entire ALMA facility. The APP has procured a modern Hydrogen Maser frequency standard (an iMaser 3000, commercially available from T4 Science) to be installed at the AOS. Space for this unit (WxDxH is 60 x 80 x 95 cm, 100kg weight) at the AOS has been identified; it requires 100W in normal operations and has a warrantee extendible in 7-year increments.

This maser provides two 5 MHz and four 10 MHz sine-wave outputs (13 dBm at 50 ohm) and a TTL compatible 1PPS signal. The current Rubidium frequency reference will be retained as a facility backup for the maser, which will enable ALMA to quickly recover from a failure of the maser.

This maser has low phase noise (−130 dBc at 1 Hz for the 5MHz output) and an Allan variance of 10^{-13} for integration times of 1 second and 2×10^{-14} at 10 seconds. Similar units are currently in use at other 1.3mm VLBI sites. It is estimated that coherence losses at 0.8mm (ALMA Band 7) due to the Maser alone will be <3% on 10 second time scales (Doeleman et al, PASP, v. 123, p. 582, 2011).

Aside from its physical control panel, it has an Ethernet device suitable for remote control and monitoring. Control of the maser frequency output and tuning of the maser will be run through this interface.

Of primary importance is the phase coherence of the ALMA Local Oscillator (LO) and the requirement that the excellent phase noise characteristics of the maser not be compromised in the ALMA LO chain. Tests of the ALMA Central Reference Generator (CRG) were carried out at Haystack Observatory by Haystack and NRAO personnel to assess the stability of fundamental ALMA LO signals derived by the CRG from the maser. These tests, done using the maser procured for the APP, are described in a memo by Bill Shillue (NRAO). In summary, the 10 MHz signals derived by the CRG for use in the ALMA LO were found to be insufficiently stable for VLBI work, primarily because of temperature sensitivity of components used in the CRG. Other signals (e.g., 5MHz, 125MHz, 2GHz) output from the CRG were found to be acceptable. The proposed solution will be to drive the necessary 10MHz inputs to the ALMA LO directly from the maser. The maser will also drive the 5 MHz input to the CRG so that all other signals normally output from the CRG will be present. This solution has been reviewed by JAO, NRAO and Haystack personnel.

We note that though this problem and proposed solution were direct results of a robust PDR process that provided scope for RFA's (Requests for Action), one of which dealt with the need for CRG stability tests.