

## The ALMA Phasing System, a Status Report

Jay Blanchard<sup>g</sup>, Geoff Crew<sup>d</sup>, Shep Doeleman<sup>d</sup>, Joseph Greenberg<sup>e</sup>, Michael Hecht<sup>d</sup>, Mareki Honma<sup>e</sup>, Makato Inoue<sup>a</sup>, Christophe Jacques<sup>f</sup>, Richard Lacasse<sup>f\*</sup>, Lynn Matthews<sup>d</sup>, Matias Mora<sup>f</sup>, Neil Nagar<sup>g</sup>, Nicola Pradel<sup>a</sup>, Helge Rottelman<sup>c</sup>, Chester Rusczyk<sup>d</sup>, Alejandro Saez<sup>b</sup>, Robert Treacy<sup>f</sup>

<sup>a</sup> Institute of Astronomy and Astrophysics, Academia Sinica, P.O. Box 23-141, Taipei 10617, Taiwan

<sup>b</sup> Joint ALMA Office, Alonso de Cordova 3107, Vitacura, Santiago de Chile, Chile;

<sup>c</sup> Max-Planck-Institut für Radioastronomie, Bonn, Germany;

<sup>d</sup> MIT Haystack Observatory, Westford, MA, USA;

<sup>e</sup> National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo, Japan;

<sup>f</sup> National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903, USA

<sup>g</sup> Universidad de Concepción, Concepción, Chile

An international group of collaborators, led by Haystack Observatory, has designed and implemented a system to phase-up the ALMA array, making it appear as a large single dish whose output can be recorded. This system includes both hardware and software. Hardware consists of a new hydrogen maser time standard, a suite of MK6 VLBI recorders, enhancements to the 64-Antenna Correlator and an optical link between the correlator at the ALMA high site and the recorders at the low site. The hydrogen maser provides enhanced timing stability to ALMA, which previously used a Rubidium time standard, making it suitable for Very Long Baseline Interferometry (VLBI). MK6 data recorders are the latest generation VLBI data recorders, using assemblies of disk drives as a recording medium, with each recorder capable of recording 16 Gbps. Enhancements to the correlator consist primarily of new modules to format the data using the VLBI Data Interchange Format (VDIF) standard. They also incorporate a new sub-system to distribute and use the VLBI time standard of one-pulse-per-second. The optical link combines 9 (8 plus one spare) 10 GbE channels of data onto one ALMA optical fiber spanning the 33 km distance between the high and low sites. Software consists of enhancements to the TeIcal program to provide real-time phase feedback to phase the antennas as well as enhancements to the ALMA control software. Both the hardware and software were designed to conform to the existing ALMA infrastructure, preserving the “look and feel” of the existing system. The system is capable of formatting and recording the entire ALMA bandwidth of 16 GHz or binary sub-multiples of this down to 62.5 MHz. The system was designed primarily with Very Long Baseline Interferometry (VLBI) in mind but is also well-suited to high frequency pulsar searches. Recently, system level tests have been successfully concluded, the system has provisionally been accepted by ALMA and commissioning has begun. This talk will describe the design of the phasing system and report its status.