

## **ASIAA's Production of Band 1 Receivers for ALMA has been Formally Approved by the ALMA Board**

An international team led by the Academia Sinica Institute of Astronomy and Astrophysics (ASIAA) has developed the Atacama Large Millimeter/submillimeter Array (ALMA) Band 1 Receiver which won ALMA Board approval officially. By adding Band 1 Receivers, ALMA will be able to see twice further into the universe - detecting distant objects with higher redshifts because of the sensitivity to twice longer wavelengths. The detectable universe by ALMA is therefore increased in volume by a factor of 8. Also, it will become possible for ALMA to detect the most distant and earliest star-forming gas reservoirs in the Universe, and the first steps of planet formation around nearby stars. Through previous arrangement, these Taiwan-manufactured-instruments allow all Taiwanese astronomers to compete for access to this advanced telescope.

A telescope is like an artificial eye to study the Universe - bigger telescopes are more sensitive, so that they can see fainter objects and reveal more details. With its revolutionized design, ALMA is a telescope with 66 antennas, which form an interferometer and allow it to see extremely fine details. ALMA has the same incredibly sharp eyesight as a single antenna of about sixteen kilometers across, so that it is able to see images ten times sharper than the Hubble Space Telescope.

At the back of each ALMA antenna is a set of sensitive receivers that detect the millimeter waves from the Universe and turn them into a signal. Eventually, each ALMA antenna will have ten different receivers for the observations of ten different “bands” (or, wavelengths). To date there are seven receivers that have already been developed and installed in each of the 66 ALMA antennas. The other three bands (i.e. Band 1, 2 and 5) are going to be completed.

Recently, the Band 1 Receiver developed by an international team led by ASIAA has been approved by the ALMA Board and been chosen as the ALMA Band 1 Receiver officially. The Band 1 Receiver, contributed by the East Asian ALMA [1], is remarkable in its low noise, high sensitivity and high dynamic range of signal-receiving. By the end of 2019, a total of 73 sets of receivers are to be manufactured and delivered: 66 for the 66 ALMA antennas, with 7 as “back-up” sets.

"Technical requirements for ALMA Band 1 receivers, due to the physical properties of this particular frequency band, are far more stringent than any other existing receiver systems, said Ted Huang at ASIAA, Taiwan, the project manager of the Band 1 receiver cartridge. “I deeply appreciate the long and hard working efforts of all Band 1 staffs in realizing the receiver design that is fully compliant with ALMA specification. I expect the team to continue their outstanding efforts in accomplishing our next challenge - full delivery of all Band 1 receivers by the end of 2019,” added Huang.

With Band 1 receivers installed on ALMA, it will become possible to detect the most distant and earliest star-forming gas reservoirs in the Universe, and to see dust grains grow to cm-sized pebbles around nearby stars: the first steps of planet formation.

Since its establishment twenty years ago, ASIAA has fully made use of Taiwan's outstanding electronic engineering technology in developing top-notch instruments for radio astronomers. Beginning as an "apprentice" in the field, through twenty years of hard-working efforts, ASIAA has gradually risen to the international leadership position in terms of instrumentation for radio astronomy. These 73 receivers, which are going to be jointly manufactured, integrated and tested by ASIAA & NCSIST (National Chung-Shan Institute of Science and Technology, the Aeronautical Systems Research Division) will ultimately facilitate astronomers' observations and studies in a wide range of topics. In winning the ALMA Board's approval, ASIAA's Band 1 development testifies Taiwan's top research ability and unique strength in radio astronomy instrumentation. This is a success that Taiwan can take pride of.

From components to system, the development of the ALMA band 1 receiver took ten years. Since eight years ago, ASIAA led the project which was joined by an international team of the National Astronomical Observatory of Japan (NAOJ), the University of Chile, the National Radio Astronomy Observatory (NRAO), the Herzberg Institute of Astrophysics (HIA) and NCSIST. Locally, ASIAA also collaborated with National Taiwan University (NTU), National Central University (NCU), National Chung-Cheng University (CCU) and National Taipei University (NTPU) in the joint development of key millimeter-wave electronic components. The research project was supported by Academia Sinica and grants from the Ministry of Science and Technology of Taiwan.

Academia Sinica has participated in the ALMA project, the largest ground based astronomical project ever carried out by 22 countries from East Asia, ESO Member states, and North America in cooperation with Chile. The telescope site is located on the Atacama Desert, 5000 meters altitude in northern Chile. ALMA was inaugurated in March 2013 and its expected lifetime is at least 50 years.

#### **Notes**

[1] East Asian ALMA partners include Japan, Taiwan and South Korea.