Acadimia Sinica Press Release

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

(Release time: Taiwan time June 23, 2016, 09:00 am)

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.

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中央研究院新聞稿

臺灣電波天文儀器開發技術已居世界領導地位 - 本院天文所研發第一頻段接收機獲得 ALMA 核定採用

(新聞發布時間：2016 年 6 月 23 日 09:00)

由本院天文所主導之國際團隊為阿塔卡瑪大型毫米及次毫米波陣列（簡稱"ALMA"）研發的「第一頻段接收機」最近已通過 ALMA 董事會正式認可並採用。第一頻段接收機安裝於 ALMA 後，其可觀測範圍之波長將延展為目前的 2 倍，亦即可偵測到紅移更高的遙遠天體，在宇宙距離尺度上倍增，因此可觀測的宇宙空間也能擴展為目前的 8 倍之多。ALMA 第一頻段接收機將可以偵測遙遠的宇宙早期恆星誕生雲氣團，並可觀測鄰近恆星的行星系統形成初始階段。天文所團隊藉由臺灣提供實物製作的方式，確保臺灣所有天文學家以觀測計畫競投即可取得 ALMA 此世界最先進天文儀器之使用權。

望遠鏡是看宇宙用的人造眼，望遠鏡越大視力越敏銳，可以看得到更暗的天體，並能發現更多微小細節。建造單座非常大的望遠鏡相當困難，且花費不貲。ALMA 設計以 66 座天線形成干涉儀，天線可用不同方式排列，讓 ALMA 看到不同的細節，其視力和一座直徑達 16 公里的望遠鏡不相上下，非僅靈敏度極高，其清晰度也非常好，為哈伯太空望遠鏡的十倍。

ALMA 在每座天線的後面配備靈敏的接收機，來自宇宙的毫米電波由接收機偵測並轉換成信號。每座 ALMA 天線將會配備十組不同的接收機來觀測十個頻段(Band)。此前已發展了七組，並持續發展其他頻段（第一、二、五頻段）。

由天文所研發的第一頻段接收機特色為「低雜訊、高靈敏度、高動態範

團」，最近已通過 ALMA 董事會的認可，選作 ALMA 第一頻段接收機。共將製作 73 套，預計 2019 年底前安裝於 ALMA 的 66 座天線上，另外 7 具為備用。第一頻段接收機是由「ALMA」東亞成員（附註）貢獻。

第一頻段接收機計畫研發經理黃耀德表示，由於第一頻段的物理特性使然，該頻段的技術要求遠比現有任何接收機系統更嚴苛，「我非常感謝所有第一頻段工作夥伴長期辛勤努力，使得計畫得以從概念到實現，我期許我們的團隊繼續如此優異的表現，迎接我們在 2019 年年底如期將全部接收機完成交貨的下一個挑戰。」

第一頻段接收機上線後，ALMA 將可以偵測宇宙最遙遠、最早期的恆星誕生雲氣團，還能觀測鄰近恆星附近公分尺度的星際塵埃顆粒之生成過程，這會是行星系統形成的第一個初始階段。

中研院天文所自成立以來，利用臺灣之優秀電子工程技術，發展電波天文儀器。經歷二十年來努力，從學習階段逐步提升到國際領導地位。73 套接收機將由天文所與國家中山科學研究院航空研究所合作製造及整合測試，提供天文學家觀測研究各項關鍵性的課題。ALMA 望遠鏡採用中研院天文所研發之接收機，肯定臺灣的電波天文儀器研發，居世界領導地位，國人可引以為榮。

ALMA 第一頻段接收機從零組件到系統的研製，歷經十年歷程，而在八年前由本所與日本國立天文台、智利大學、美國國家電波天文台、加拿大赫茲堡天文物理研究所及國家中山科學研究院組成國際合作團隊，本所並與國立臺灣大學、國立中央大學、國立中正大學、國立臺北大學合作開發接收機內部使用的毫米波電子積體電路與濾波器元件。計畫經費由本院與科技部支持。

中研院合作參加 ALMA 計畫，是有史以來最大規模的地面型天文望遠鏡計畫。此計畫由東亞、歐洲南天天文臺會員國、北美及智利等 22 個國家

合作，建置在智利北部海拔 5000 公尺之阿塔卡瑪沙漠中。ALMA 自 2013 年三月起正式啟用，將運轉至少 50 年。

附註：ALMA 東亞團隊成員包括日本、臺灣、韓國。

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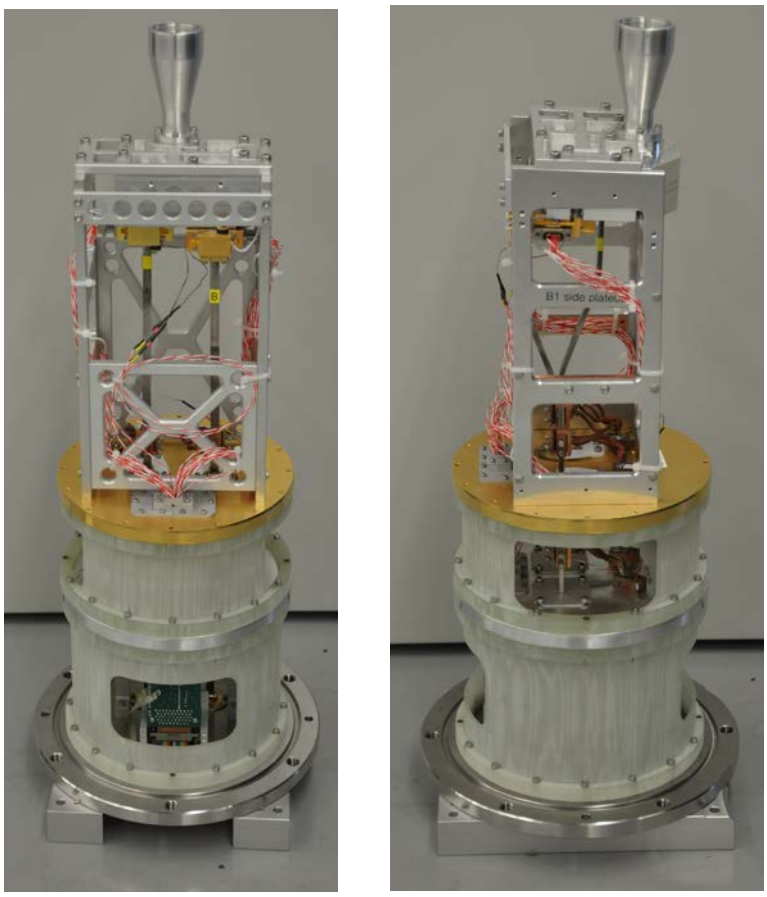
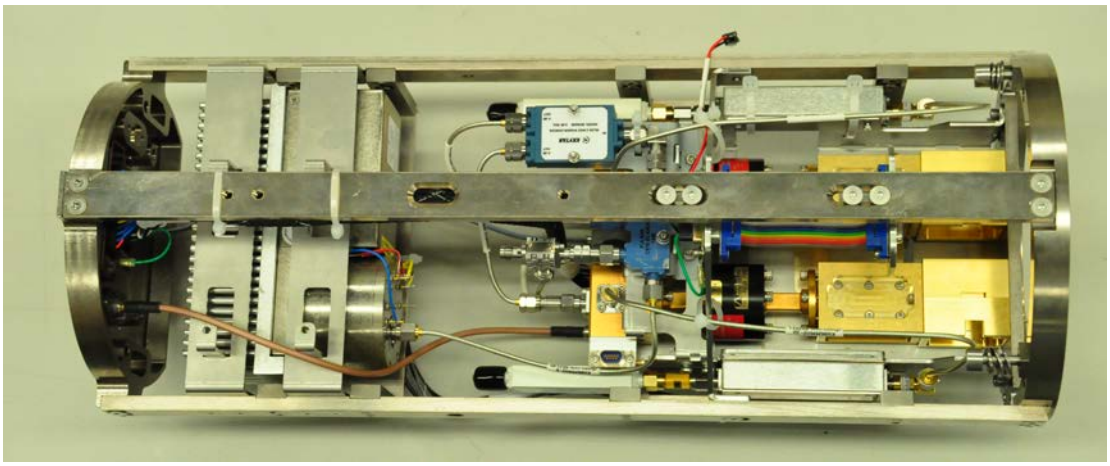
Image 1



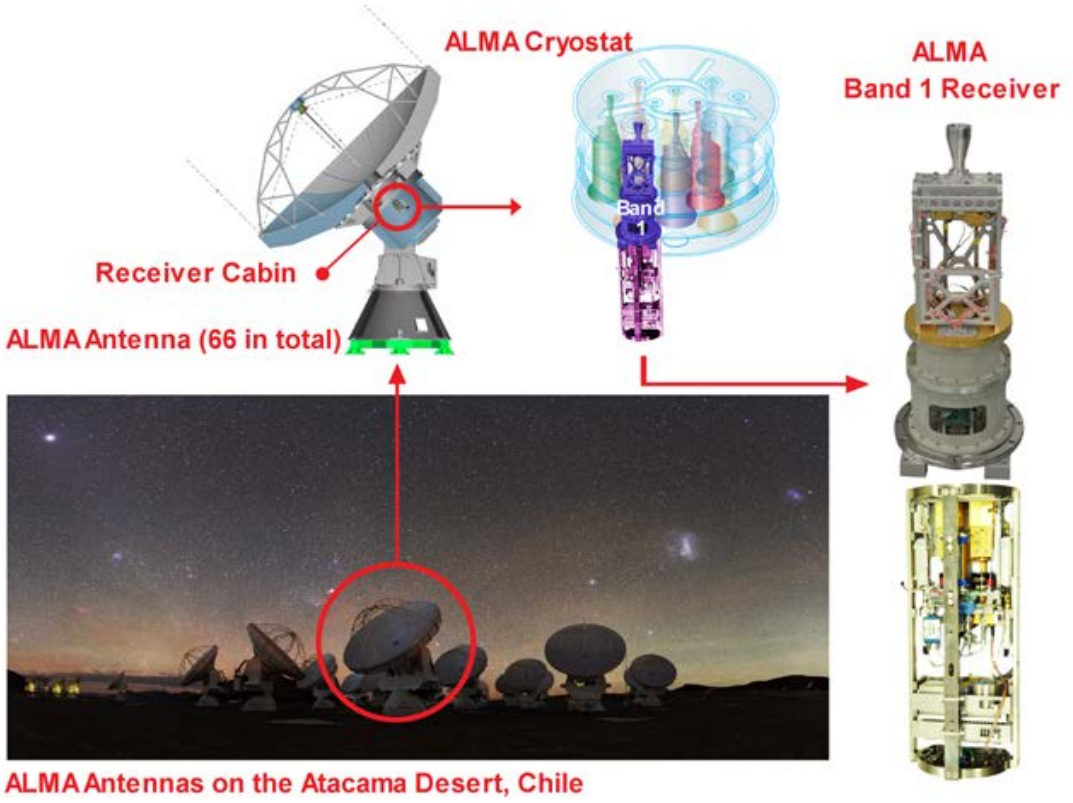
The ALMA Band-1 Receiver Cold cartridge Assembly developed by ASIAA. The Band 1 receiver cold cartridge is operated in a cryogenic cooled temperature at -258 degree C. This would ensure the signal received from conical horn antenna (at the top) staying at a very low loss rate, while maintaining signal quality in the amplification process. The cartridge provides low-noise high-sensitivity capability. (Image Credit: ASIAA)

Image 2



The ALMA Band-1 Warm Receiver Assembly developed by ASIAA cascaded with the cold cartridge that form the complete receiver front-end, which down-convert the weak astronomical radio signal for the back-end signal processing unit to further process and then become the data for astronomers. (Image Credit: ASIAA)

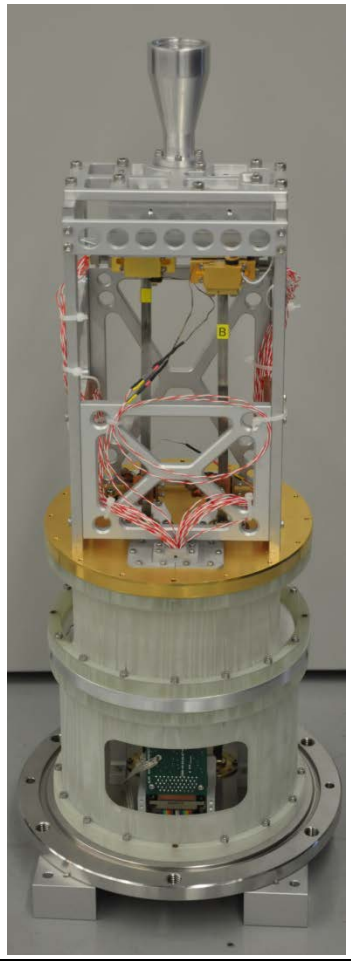
Image 3

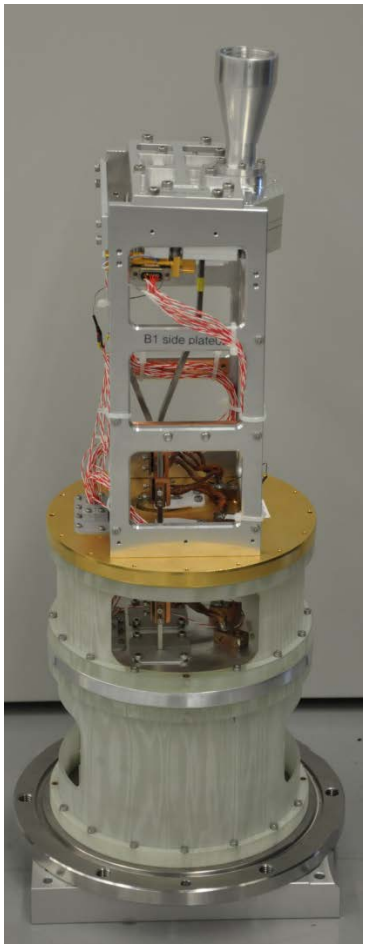


Caption: (Bottom left) ALMA telescopes located in the Atacama desert in Chile, (Top left) Receivers are installed in the back of the antenna, (Top middle) ALMA cryostat for ten receiver cold cartridges, (Right) The ALMA Band 1 receiver.

Credit: ASIAA/NAOJ/ESO/S. Guisard(www.eso.org/~sguisard)

圖一



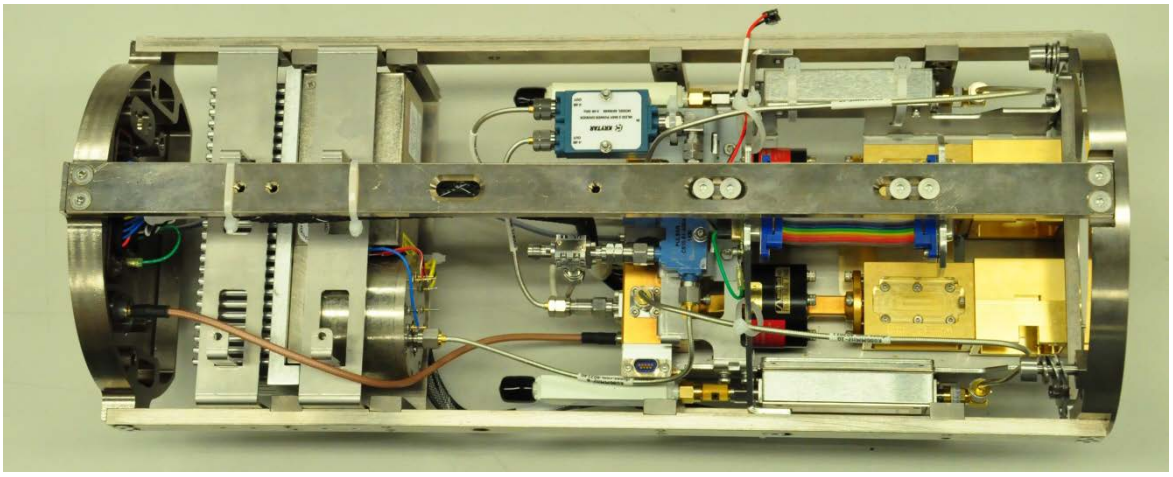


圖為中研院天文所所主導研發的「ALMA 陣列望遠鏡第一頻段接收機」的低溫前級模組，該模組需於極低溫（攝氏零下 258 度）及真空環境下操作，這可確保經最上方的圓錐形的號角天線所接收的訊號損耗極低，同時在訊號放大過程中仍維持高品質訊號。

中研院天文所主導國際團隊設計製作的「第一頻段接收機」取得 ALMA 認同，由其董事會正式核可並授權開始量產，視為臺灣電波天文儀器開發技術達世界領導地位的象徵。未來這批接收機將使 ALMA 望遠鏡可觀測宇宙距離倍增，因此可觀測的宇宙空間也能擴展為目前的 8 倍之多。天文所團隊藉由臺灣提供實物製作的方式，使臺灣天文學界得以觀測計畫競投取得 ALMA 此世界最先進天文儀器之使用權，亦為產學合作建立一個新里程碑。

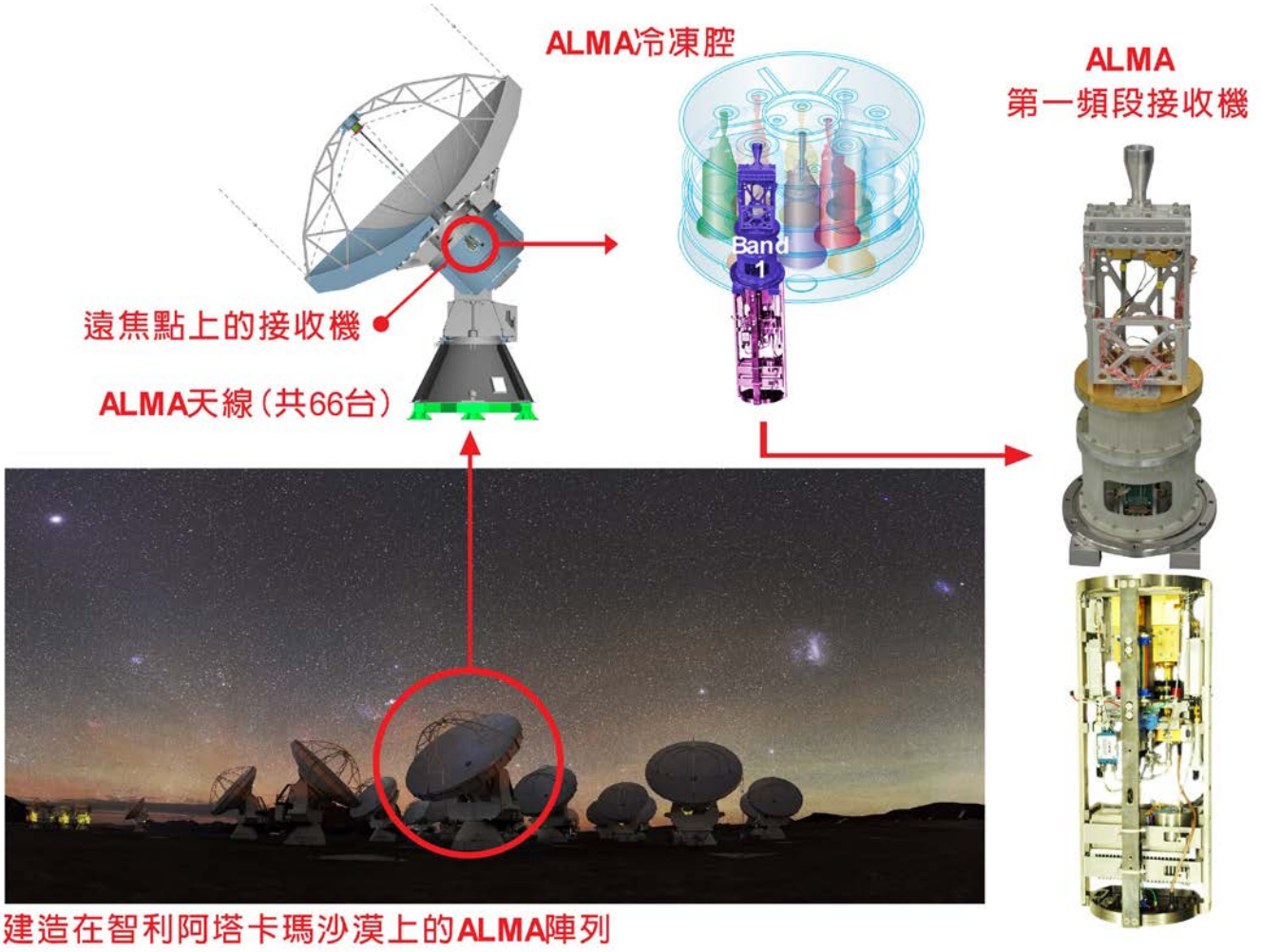
ALMA 第一頻段接收機遠可觀測宇宙早期恆星誕生雲氣團，近可觀測鄰近恆星的行星系統形成初始階段。ALMA 大型陣列望遠鏡以 66 座天線形成干涉儀，清晰度是哈伯太空望遠鏡的十倍。

圖二



圖為由中研院天文所主導研發之「ALMA 第一頻段接收機室溫前級模組」。與「低溫前級模組」串接共同操作時，兩者組成一完整之「接收機前級系統」，將接收到的天體電波訊號予以降頻，供後級信號處理單元進一步處理，成為天文學家所需的資料。

圖三



(左下)智利阿塔卡瑪沙漠上的ALMA陣列望遠鏡，(左上)望遠鏡示意圖，接收機配置於天線後面，(中上)存放十個不同頻段接收機低溫前級模組的冷凍腔，(右)ALMA第一頻段接收機包含低溫以及室溫前級模組。圖片來源：中研院天文所/NAOJ/ESO/S. Guisard(www.eso.org/~sguisard)