# Development of ALMA Band 1 Corrugated Horns based on Metal 3D Printer

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Additive Manufacturing (AM) technology has grown dramatically and is now used in a wide variety of industrial applications. In the aerospace industry, it has been applied to fabrication of antennas and waveguide components and is now being put to practical use, as is the case with the remarkable example of the development of the satellite antenna by Boeing [1]. The application of the AM technology to radio astronomical instrument is also under consideration. This technology benefits shorter development periods, cost reductions, realization of complex shapes that are difficult to be fabricated with conventional technology, and reduction in the number of parts by integrating multiple parts. On the other hand, since a component is fabricated by melting and solidifying materials, verification of material properties is an important item.

In order to verify feasibility of this AM technology, we have tried to manufacture corrugated horns used in a frequency range of 35 to 50 GHz in the period of 2016-2018, and successfully obtained promising performance for the radio astronomical application [2]. Based on the result, we have developed the corrugated horn to be implemented into the Band 1 receiver (35-50 GHz, up to 52 GHz as best effort) for the Atacama Large Millimeter/submillimeter Array (ALMA) [3]. One of the major conventional manufacturing methods of corrugated horns is milling or electro-forming that are mature technologies in recent, while they provide long lead time, high costs and design limitation. Through this development, we have tried to fabricate the 3D-printed corrugated horns that met ALMA technical specifications, but also verified whether if the AM technology could mitigate the risks of existing technology. In addition, for the practical use, it is important not only for the horn performance but also the material properties. Since the component is made by repeatedly melting and solidifying material powder by laser irradiation, the physical properties may have changed from the original ones. Besides, the corrugated horn is located and operated in the cryogenic stage at around 15 K, and thermal cycling between room temperature and operation temperature is assumed for the receiver maintenance. Thus, we have investigated material properties at both warm and cryogenic temperatures, and obtained the beneficial information for the component design and practical use.

In this symposium, the development process, benefits and risk of 3D-printed components, measured material properties and the beam performance of the horn individual and the receiver implemented 3D printed horn will be presented.

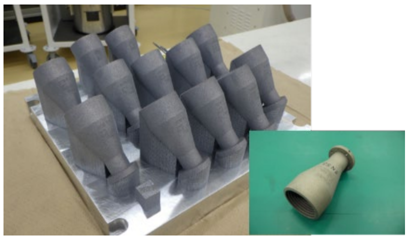

Fig. 1. ALMA Band 1 corrugated horn fabricated by 3D printer

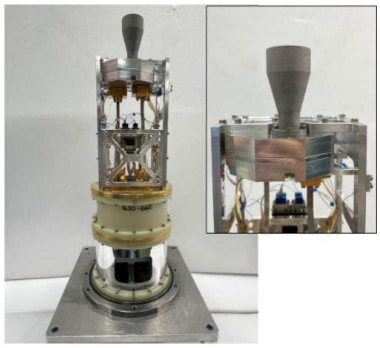

Fig. 2. ALMA Band 1 receiver with 3D printed horn

## REFERENCES

[1] https://3dprint.com/239651/boeing-creates-the-first-3d-printed-metal-satellite-antenna-saves-on-mass-time-and-costs/
[2] A. Gonzalez, et al., "Metal 3D-Printed 35–50-GHz Corrugated Horn for Cryogenic Operation", JIMTW, 42:920-973, 2021.
[3] Y.-J. Hwang, et al., "Band 1 receiver front-end cartridges for Atacama Large Millimeter/submillimeter Array (ALMA): design and development toward production", SPIE conference on Astronomical Telescopes + Instrumentation 2016, 2016

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