# Ultra-Compact THz Multi-Pixel Local Oscillator Systems for Balloon-borne, Airborne and Space Instruments

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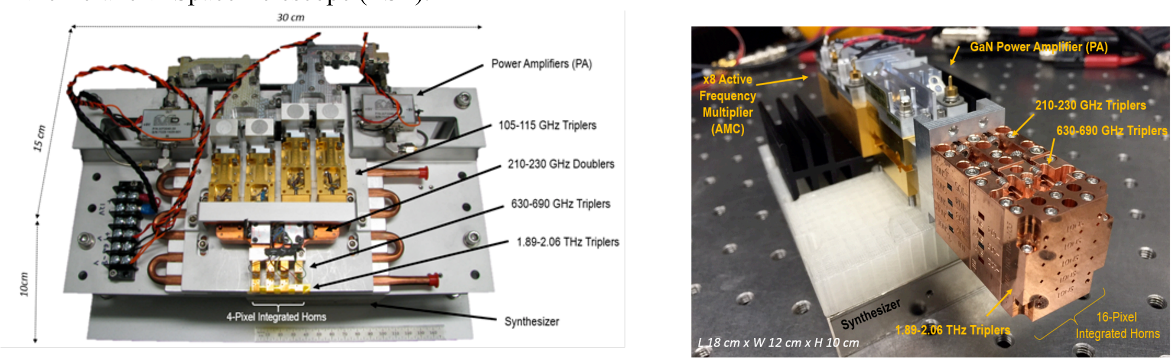
***Abstract***—Multi-pixel heterodyne receivers with dramatically increased mapping speeds are required to provide astronomers with the capability of obtaining large-scale high-angular resolution spectrally-resolved images of molecular clouds, and carrying out surveys of nearby galaxies. Since most important tracers of star forming regions lie in this frequency range ([CII] at 1.9 THz, [OI] at 2.06 THz, [NII] at 1.46 THz, etc.), the development of these receivers is key to understanding the processes governing the formation of interstellar clouds and stars, which is crucial for unraveling the evolution of galaxies. High mapping speeds are indeed extremely important for missions with limited observation times, such as balloon-borne and airborne astrophysics missions. These kinds of missions have lower costs and faster implementation plans than space missions. Therefore, they have become the primary driving force to enhance the capabilities of terahertz heterodyne receiver technology, which will greatly benefit future space instruments. The development of array terahertz local oscillator (LO) sources is key to enabling these systems. These sources need to be multi-pixel, compact, broadband, able to operate at room-temperature, have low dc power consumption, and exhibit state-of-the-art performance.

Recently, two 4-pixel local oscillator systems at 1.46 THz and 1.9 THz have been successfully flown on board the Stratospheric Terahertz Observatory (STO-2). STO-2, a balloon-born terahertz heterodyne instrument, was launched from Antarctica on December 2016 to look for carbon, oxygen and nitrogen in star forming regions of our galaxy. The sources operated in a temperature range of 0-45C with output power levels per pixel of > 20 μW. This is the first time that integrated multi-pixel LO sources have been successfully flown. Building upon the successful STO-2's LO designs, we have recently demonstrated a high-efficient ultra-compact 16-pixel source that can be easily extended up to 64-pixels. This new module will be the baseline for GUSTO, another balloon-borne mission currently under Phase A studies. GUSTO, a NASA Explorer Mission of Opportunity, will feature 8-pixel receivers at 1.56 THz, 1.9 THz and 4.7 THz and is planned to launch from Antarctica in 2019.

In this paper, we will present the development, integration and test of the STO-2 local oscillator subsystem. We will focus on some key operational aspects and lessons learned that were taken into account in the design of our new 16-pixel 1.9 THz-2.016 THz LO module, which is the largest pixel count local oscillator source demonstrated so far in the terahertz range. The new 16-pixel module is also approximately five times smaller in size than the 4-pixel LO module delivered for STO-2. Its power consumption per pixel is around 10 times lower and each pixel delivers around 30 μW output power that can be individually adjusted, The performance of this new LO module will also be presented together with a roadmap to extend this scheme to 64- 128- or even 256-pixel local oscillator systems, taking advantage of the recent progress on backend receiver technology and low power low noise amplifiers. This will be a major step forward for future airborne instruments on-board SOFIA, as well as future NASA missions under concept study, such as the Cosmic Origins Space Telescope (CST) and the Terahertz Space Telescope (TST).




(a) (b)

Fig. 1. (a) JPL 4-pixel 1.9 THz local oscillator source flown on-board STO-2 (dc power consumption is 28 Watt/pixel); (b) New generation ultra-compact 16-pixel 1.9 THz local oscillator source recently demonstrated at JPL (power consumption is only 2.3 Watt/pixel).

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