The Hyperspectral Microwave Photonic Instrument (HyMPI): Technology Developments for Improved Planetary Boundary Layer Sounding

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Motivation:

This work presents an overview of the Hyperspectral Microwave Photonic Instrument (HyMPI) which aims at developing the very first hyperspectral microwave sensor to augment thermodynamic sounding capability from space, with a focus on the Earth's Planetary Boundary Layer.
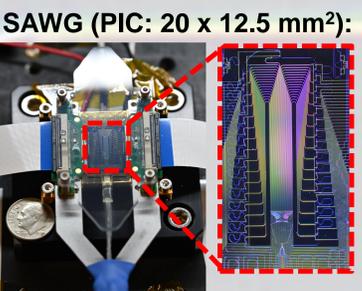
Methodology

Antenna + G-Band Rx

EOM:

SAWG (PIC: 20 x 12.5 mm²):

ASIC:

Block	Description	Domain
Antenna	Captures MW spectrum.	RF domain
G-Band Rx	Down-converts between 0-40 GHz and amplifies 40 GHz range spectra.	RF domain
Laser / EOM	Up-converts microwave spectrum to optical domain.	Optical domain
SAWG	Separates spectrum into 10 x 4 GHz sub-bands.	Optical domain
Laser / BPR / ASIC	Sub-bands with structure are mixed with a new optical tone and digitized (Hi-Res Channels).	Baseband domain (0 – 4 GHz)
PD	Sub-bands with minimal structure are measured directly (Lo-Res Channel).	

Lo-Res Channel   Lo-Res Channel
Hi-Res Channel

Rx: receiver - EOM: electro-optical modulator - SAWG: serial arrayed waveguide grating - BPR: balanced photoreceiver - ASIC: application specific integrated circuit - PD: photodiode
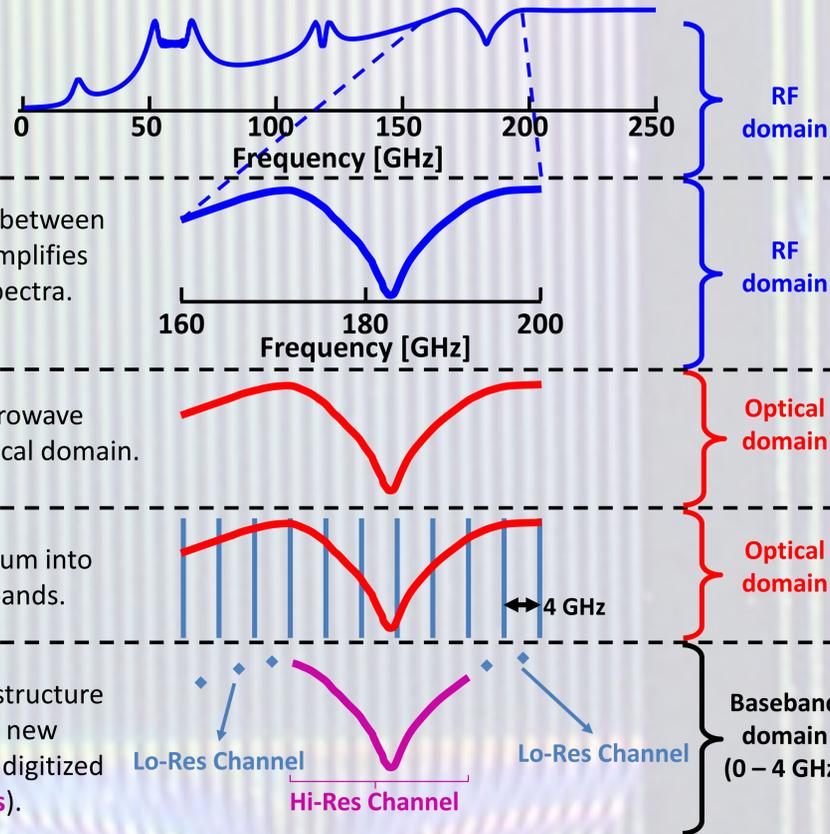
- The instrument is based on photonic integrated circuits (PIC) – minimize size, weight and power consumption and cost (SWaP-C)

- HyMPI covers is a <u>modular</u> design, with simultaneous 40 GHz coverage

- It can be applied to multiple parts of the spectrum to obtain full coverage of the MW thermal domain

- PICs + ASICs = "PICASIC": full, contiguous, <u>hyperspectral resolution (thousands of channel) ultra-wideband coverage</u>

Hyperspectral performance:
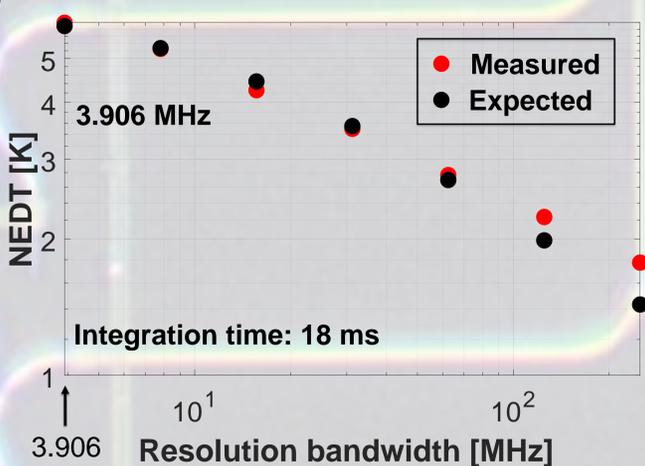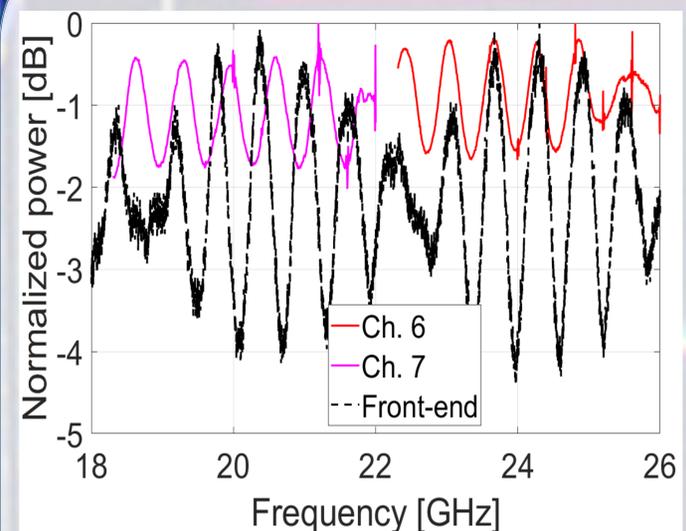
3.906 MHz

Integration time: 18 ms

- The Noise Equivalent Differential Temperature (NEDT) values are related to the noise figure of the front-end
- The photonic link add only marginal noise

Window channels performance:
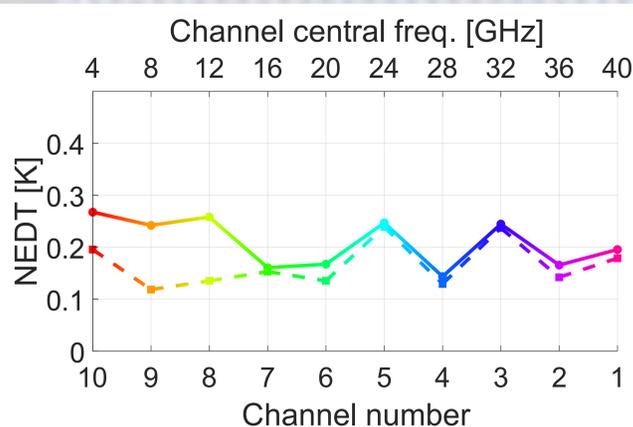
- The Noise Equivalent Differential Temperature (NEDT) values are related to the noise figure of the front-end

Spectrometric performance

- Add comment here…

Conclusions:

- We demonstrated the full <u>end-to-end system performance</u> at <u>hyperspectral-resolution</u> of HyMPI

- We demonstrated that <u>PICs overcome the limitation of the current MW technology</u>: they enhance the performance of the system and minimize SWaP-C

Next step: AURORA Pathfinder

Space-based technology demonstration of broad-spectrum and hyperspectral microwave photonics-based sounders for future NASA science missions
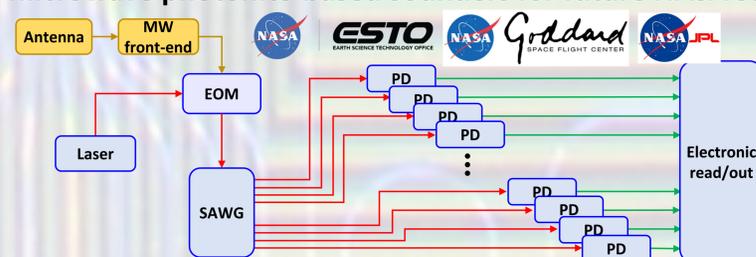
Project start: December 1 2024

Lead: NASA GSFC In collaboration with NASA JPL