Advanced Filterbank Spectrometer Technology for Hyperspectral Millimetre-Wave Atmospheric Sounding: HYMAS-X (HYMAS eXtended)

CEOI Pathfinder Project (RP1G0435A201)

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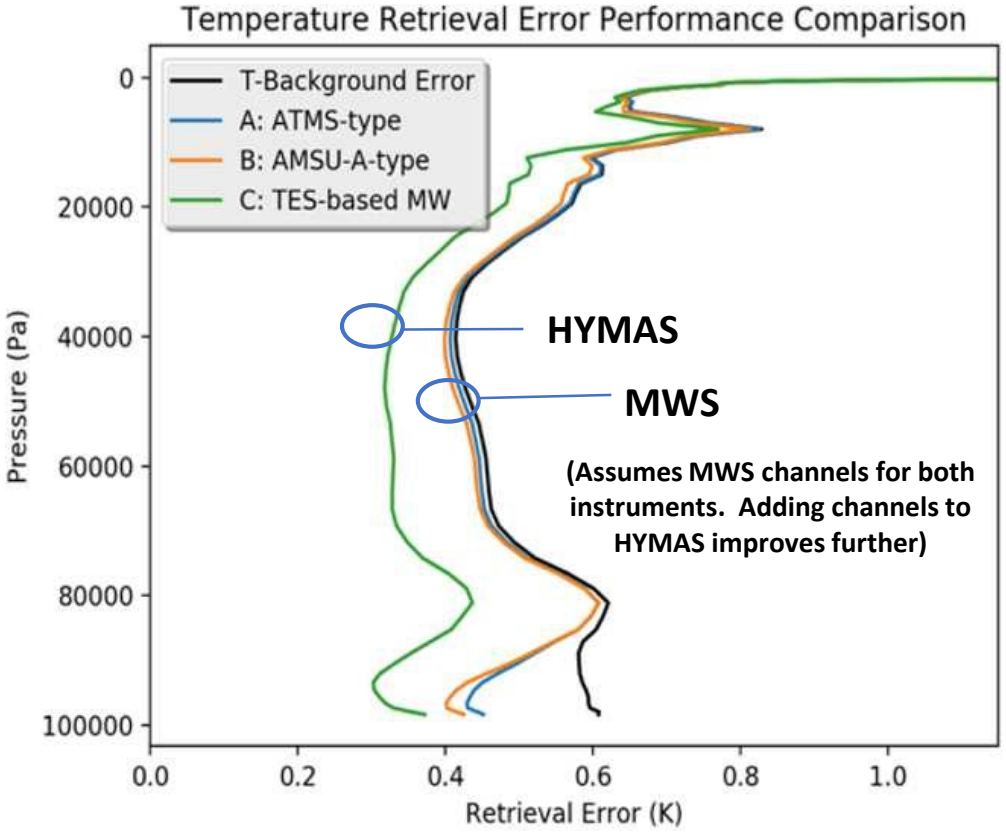
Objective

Develop <u>superconducting</u> on-chip spectrometer technology for hyperspectral microwave sounding.

- MW sounders provide crucial cloud-penetrating capability.
- Aim to provide:
  - **More channels with flexible configuration.**
  - **Improved sensitivity**.
- Would result in significant improvement in error and vertical resolution of recovered temperature and humidity profiles.
- Impact on numerical long range weather forecasting.



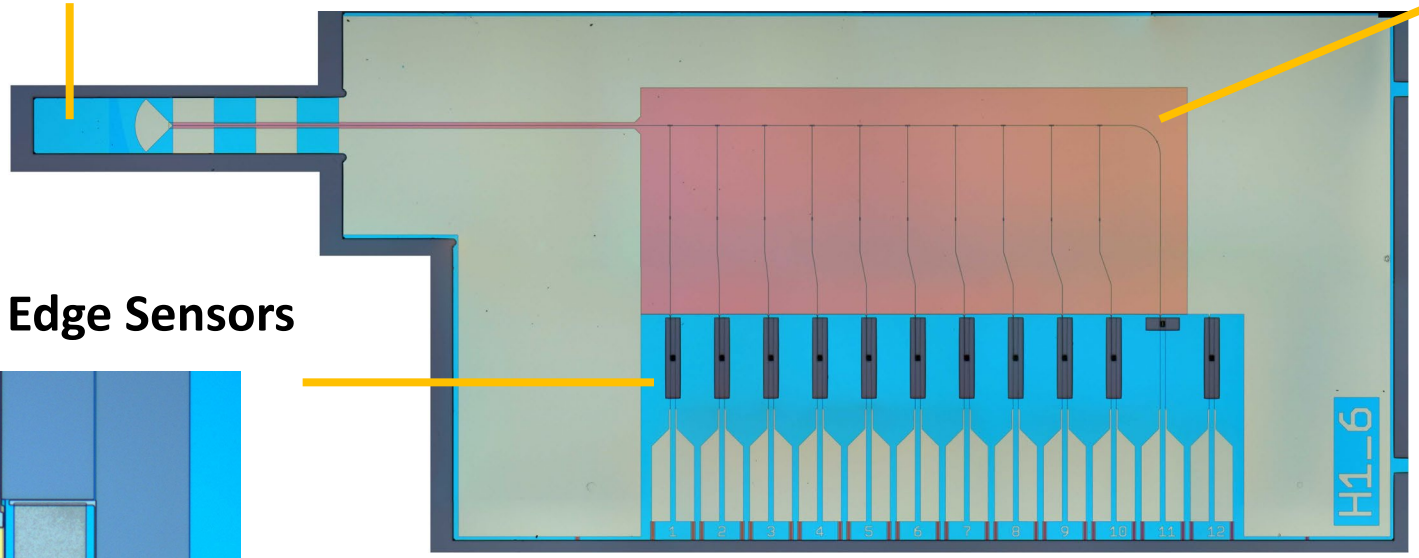
See https://doi.org/10.1117/12.2500516

Technology: Superconducting on-chip spectrometers

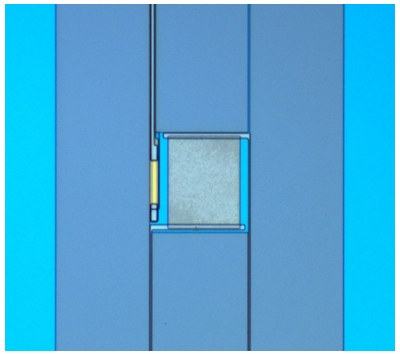
Wideband radial waveguide probe

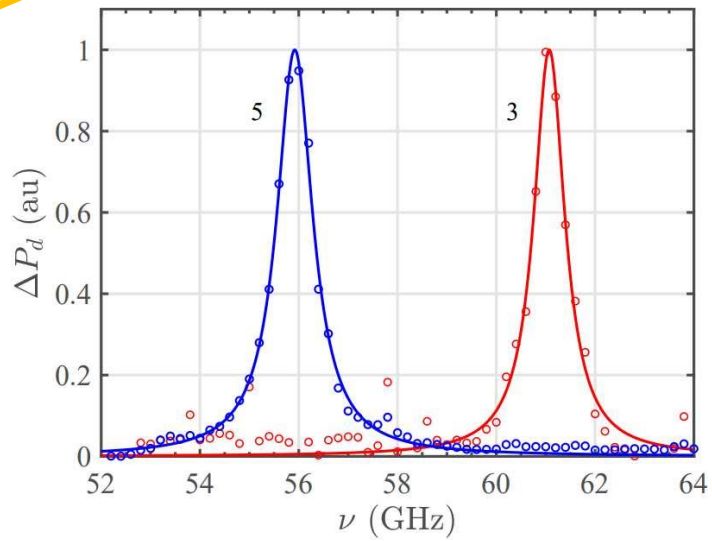
Superconducting MMIC!

Superconducting filter bank



Transition Edge Sensors





- **Highly sensitive power detectors** (NEP = 10aW/Hz$^{0.5}$)
- Excellent scientific performance (linearity, dynamic range, calibration)

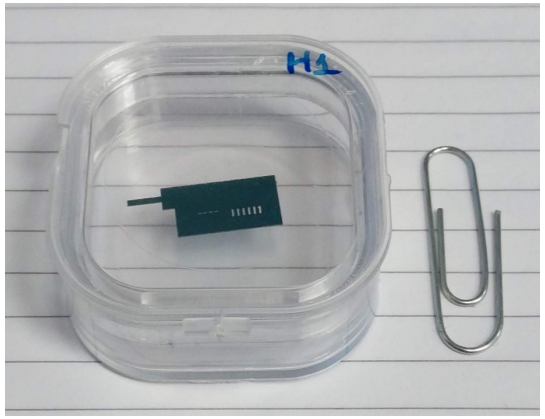
Cool to 300mK

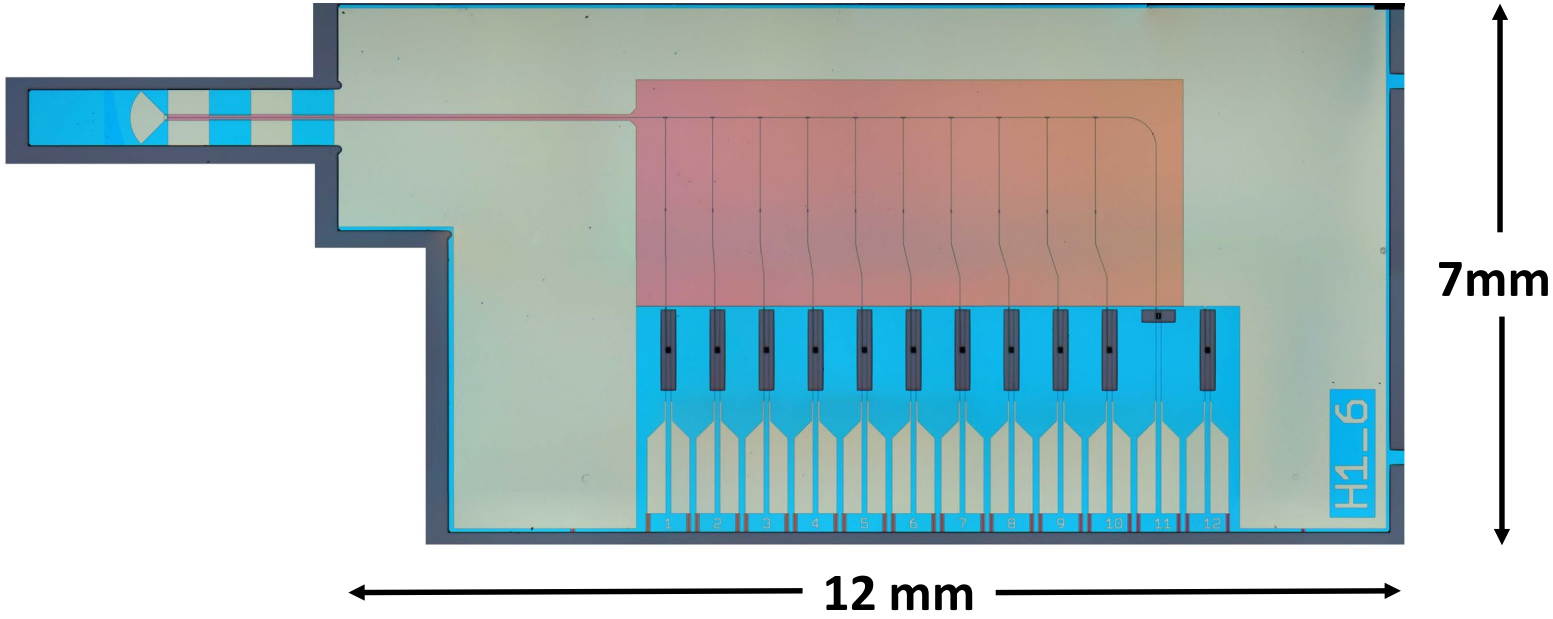
- Defines sounder channels.
- Low loss operation up to 700 GHz.
- **Flexibility in channel width, shape and placement.**

Further details at https://arxiv.org/abs/2001.08947

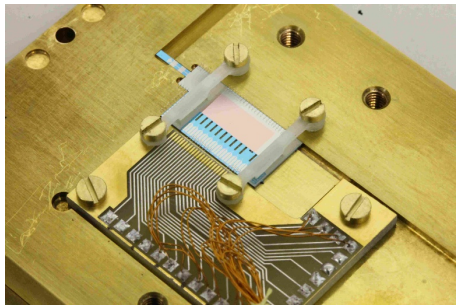
Technology: Superconducting On-Chip Spectrometers

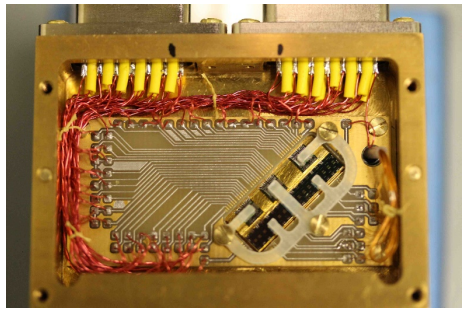
12 channel prototype!
(straightforward scaling)

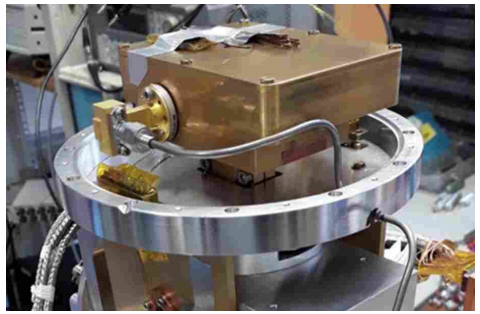




Packaging:

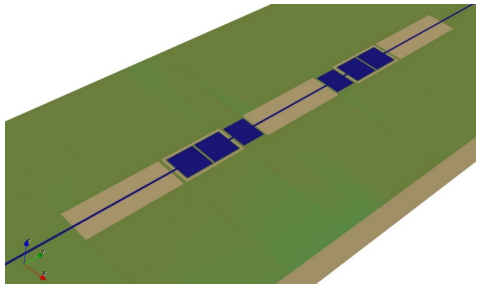




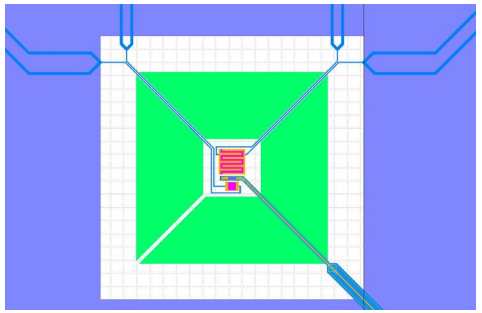


HYMAS-X developments

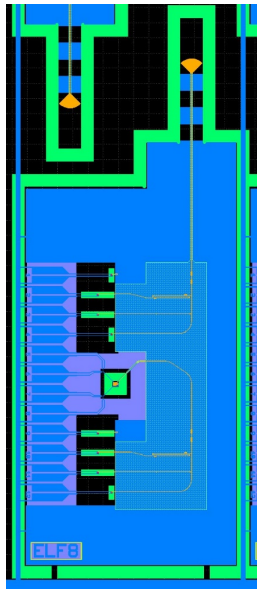
Low frequency (60GHz)



Wideband continuum channels



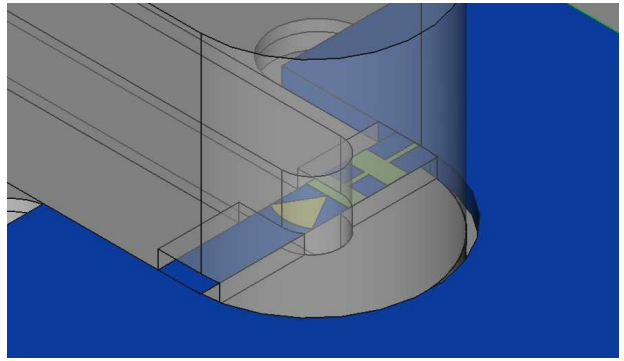
Fast on-chip radiometric load



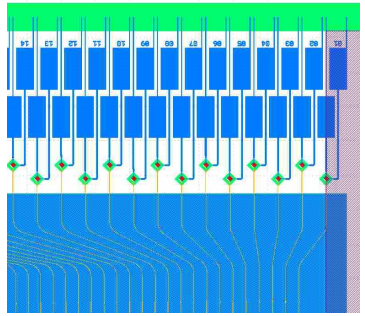
New lower loss filter architectures and improved detectors.

- Temp. sounding on O_2 line complex.
- **2nd generation chips**: enhanced detectors, new filter designs and on-chip calibrators.

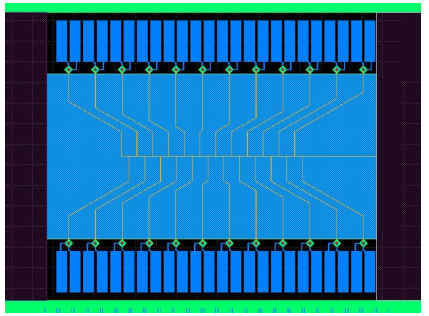
High frequency (183 GHz)



Membrane suspended radial probe for HF operation.



Increased channel count



- Humidity sounding on H_2O line.
- **Demonstrate high frequency operation**

Thank you for listening!

More information:

Motivation:

"Information content analysis for a novel TES-based hyperspectral microwave atmospheric sounding instrument" Dongre et al., Remote Sensing of Clouds and the Atmosphere XXIII. Vol. 10786. International Society for Optics and Photonics, 2018. https://doi.org/10.1117/12.2500516

Technology:

"First Characterization of a Superconducting Filter-bank Spectrometer for Hyper-spectral Microwave Atmospheric Sounding with Transition Edge Sensors", Goldie et al., To appear in Journal of Applied Physics in 2020
(pre-print at https://arxiv.org/abs/2001.08947)

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