

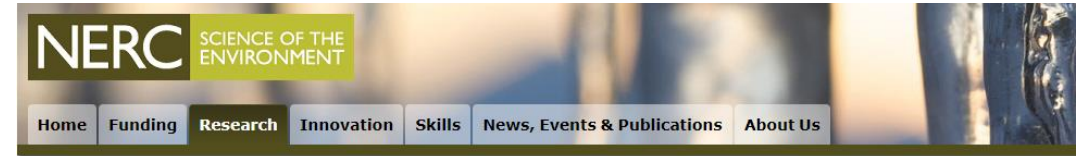
# Filterbank spectrometers for Hyperspectral Microwave Atmospheric Sounding (HYMAS)

Peter Hargrave, Prateek Dongre, Angiola Orlando, Rashmi Sudiwala – Cardiff University

Stafford Withington, Chris Thomas, David Goldie – University of Cambridge  
Stephan Havemann – UK Met Office

# Application areas

- Climatology – the role of cloud feedbacks in the Global climate system
  - Now a NERC strategic priority
- Meteorology – measurements of temperature & humidity profiles with high (3-D) spatial resolution and accuracy



Home / Research / Funded research / Research announcements / NERC invests £12 million to improve climate change predictions

## NERC invests £12 million to improve climate change predictions

8 October 2018

Today, NERC announces it is investing in a new large-scale strategic research programme - Reducing Uncertainties in Climate Models from Clouds.

Cloud feedbacks are a fundamental and persistent problem in climate science and are the dominant uncertainty in assessing global and regional climate sensitivity. The Reducing Uncertainties in Climate Models from Clouds programme will enable a step change in quantifying and reducing uncertainty in cloud feedbacks under climate change by exploiting existing and new observations, together with new capacity in climate modelling.

Research outputs will include:

- improving our quantitative physical understanding of cloud responses to warming
- translating new understanding into more realistic high-resolution cloud models that can inform and underpin development of robust and verifiable model parameterisations at the global scale
- exploiting new and existing observations to test and refine model processes, leading to more tightly constrained values of cloud feedback and climate sensitivity.

# Hyperspectral sounding for meteorology

- Hyperspectral MW sounder should have significant impact on NWP ability
  - Studies on hypothetical instruments...
- Several hundred channels observing major lines & continuum simultaneously

 AGU PUBLICATIONS

 JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2015JD023331

Key Points:

- A hyperspectral MW instrument could improve temperature & humidity retrieval compared to MetOp-SG
- The main impact from HYMS comes from higher resolution in the O<sub>2</sub> band around 60 GHz
- Hyperspectral information is not really sensitive to instrument noise

Microwave hyperspectral measurements for temperature and humidity atmospheric profiling from satellite: The clear-sky case

Filipe Aires<sup>1,2,3</sup>, Catherine Prigent<sup>1,2</sup>, Emiliano Orlandi<sup>4</sup>, Mathias Milz<sup>5</sup>, Patrick Eriksson<sup>6</sup>, Susanne Crewell<sup>4</sup>, Chung-Chi Lin<sup>7</sup>, and Ville Kangas<sup>7</sup>

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**F. Aires et al. DOI: 10.1002/2015JD023331**

**Information content analysis for a novel TES-based Hyperspectral Microwave Atmospheric Sounding Instrument**

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**Dongre et al. DOI: 10.1117/12.2500516**

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# Technology development under CEOI programme

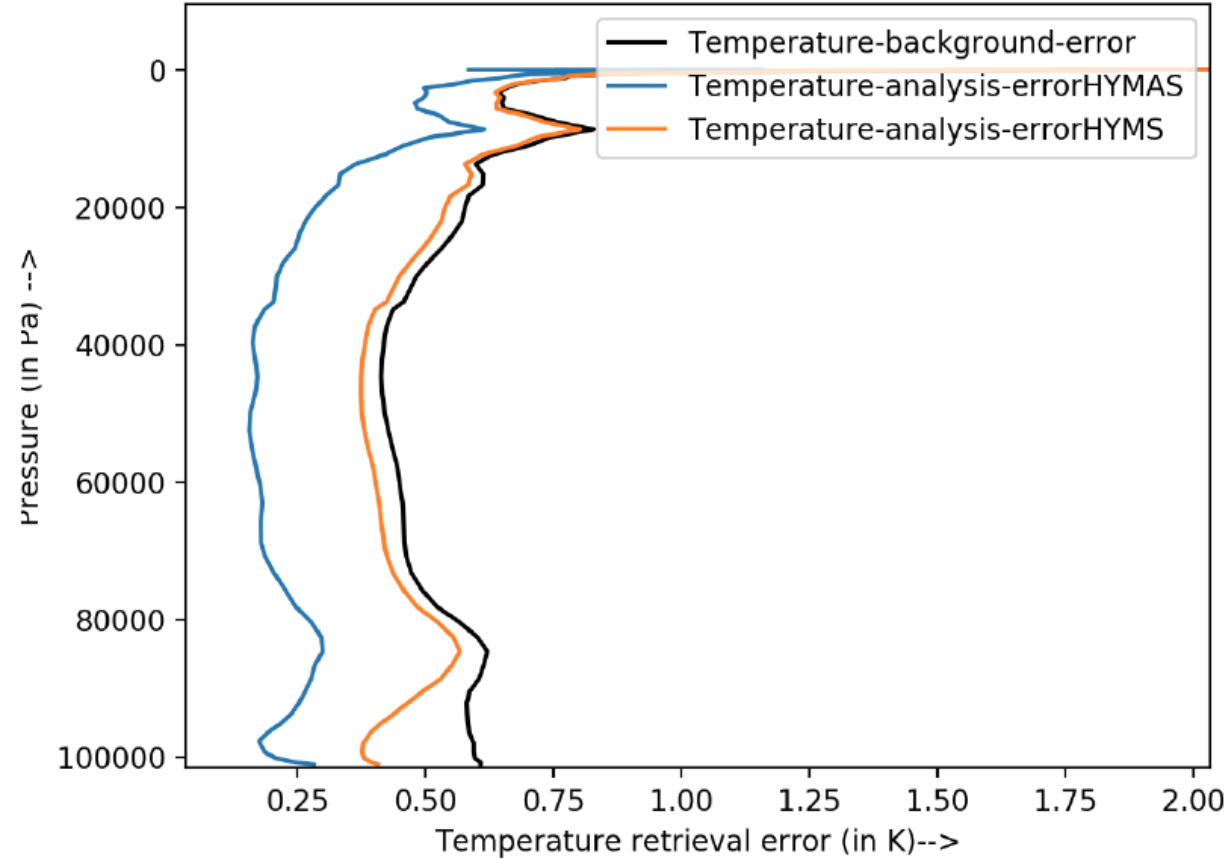
- Novel on-chip filterbank spectrometers
  - Priority – **demonstration** of hyperspectral sampling in 50-60 GHz region - O<sub>2</sub> temperature sounding line
    - Photon-noise-limited detection – NEP  $\sim \text{few} \times 10^{-17} \text{ WHz}^{-1/2}$
    - **Demonstrate** channel resolution of up to 1000 (nu/Dnu)
    - NEDT of  $\sim 20\text{mK}$  per channel for example implementation – high spatial resolution conical scan
  - Achieved by single spatial antenna coupled to filterbank, readout by superconducting Transition-Edge-Superconducting detectors.

# Performance predictions – HyMAS vs HyMS

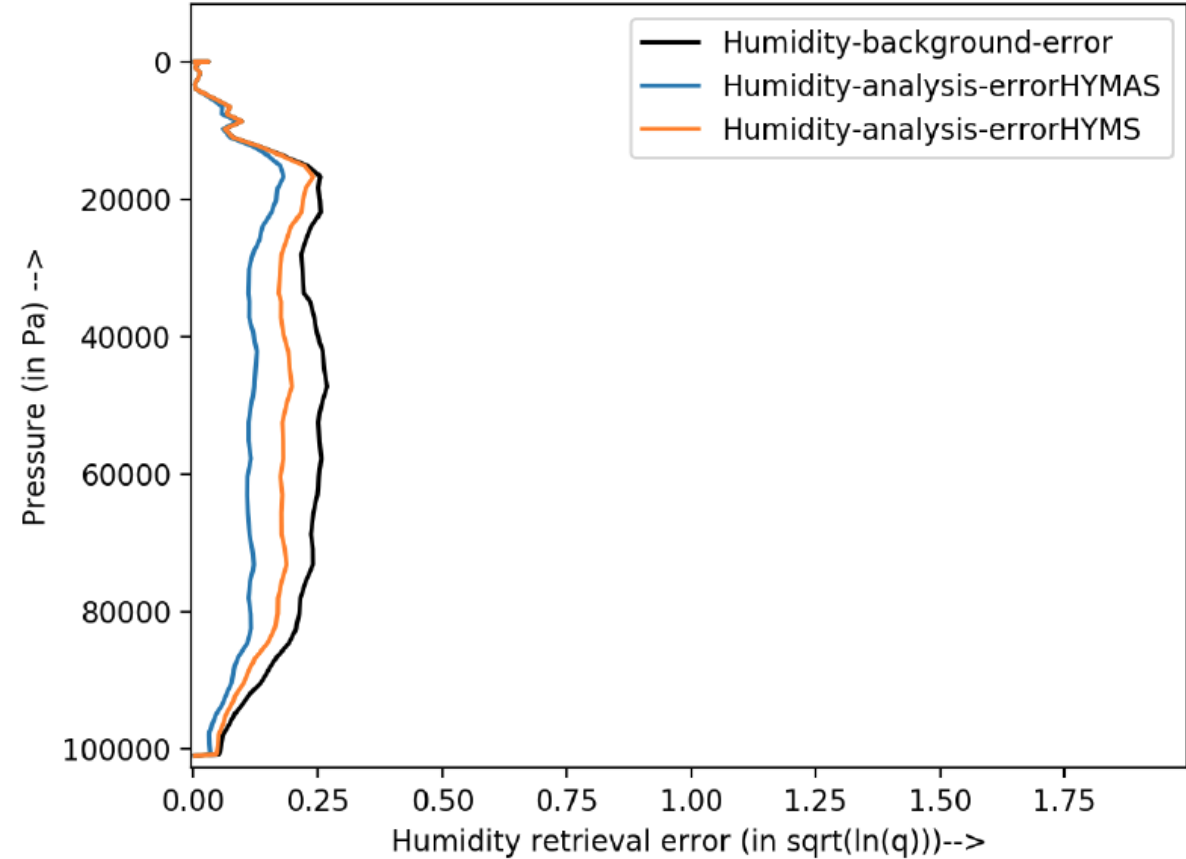
HyMS – F. Aires et al. DOI: 10.1002/2015JD023331

HyMAS modelled as HyMS channel set, HyMAS noise

Temperature retrieval error comparison- HYMS and HYMAS



Humidity retrieval error comparison- HYMS and HYMAS

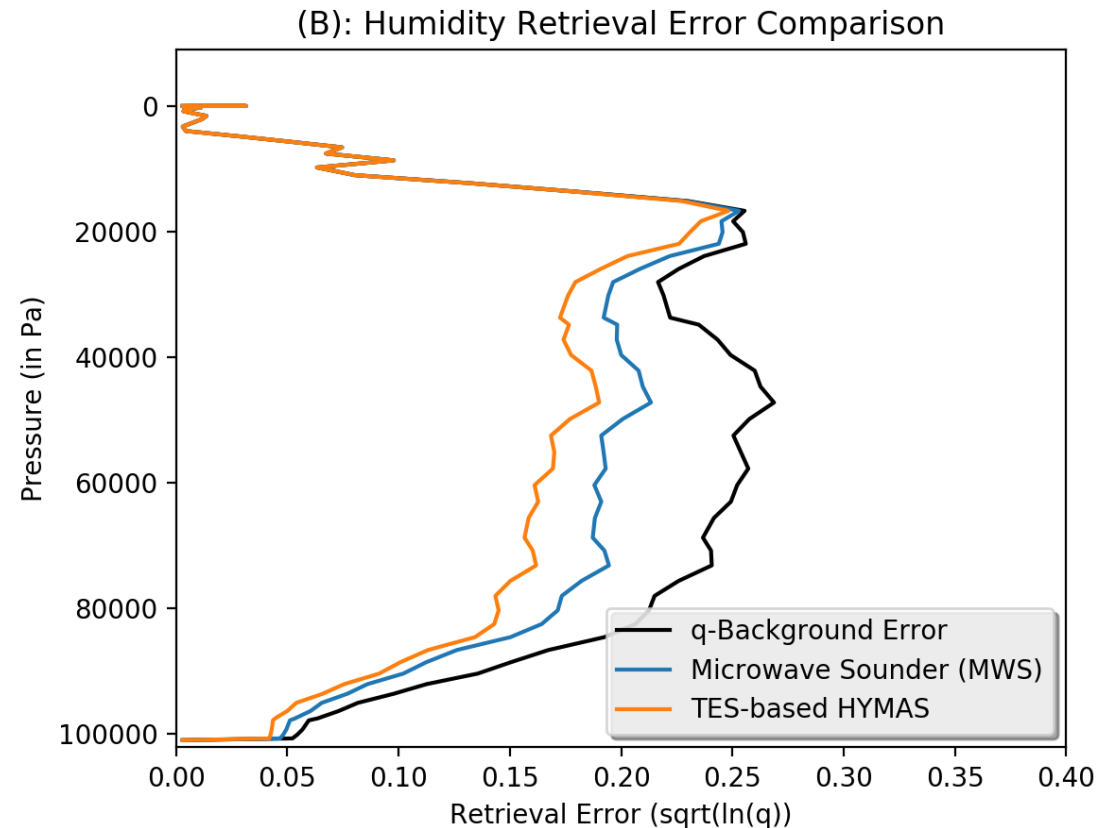
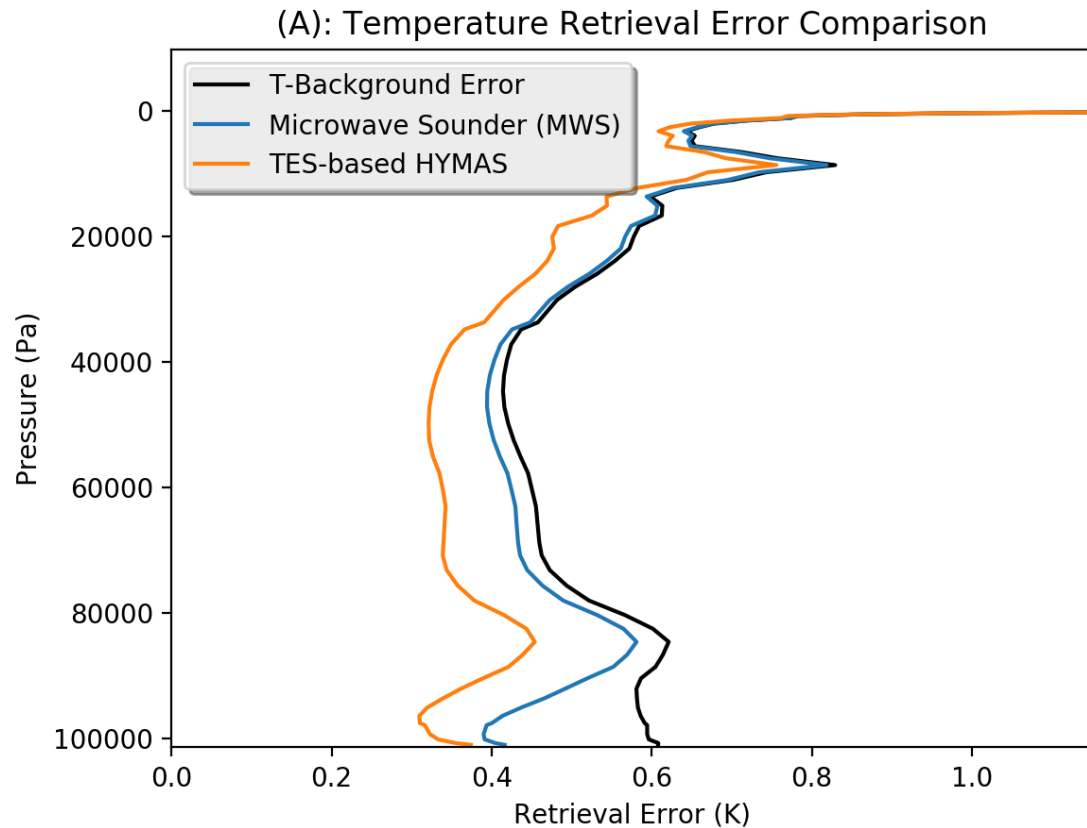




# Performance predictions – HyMAS vs MWS

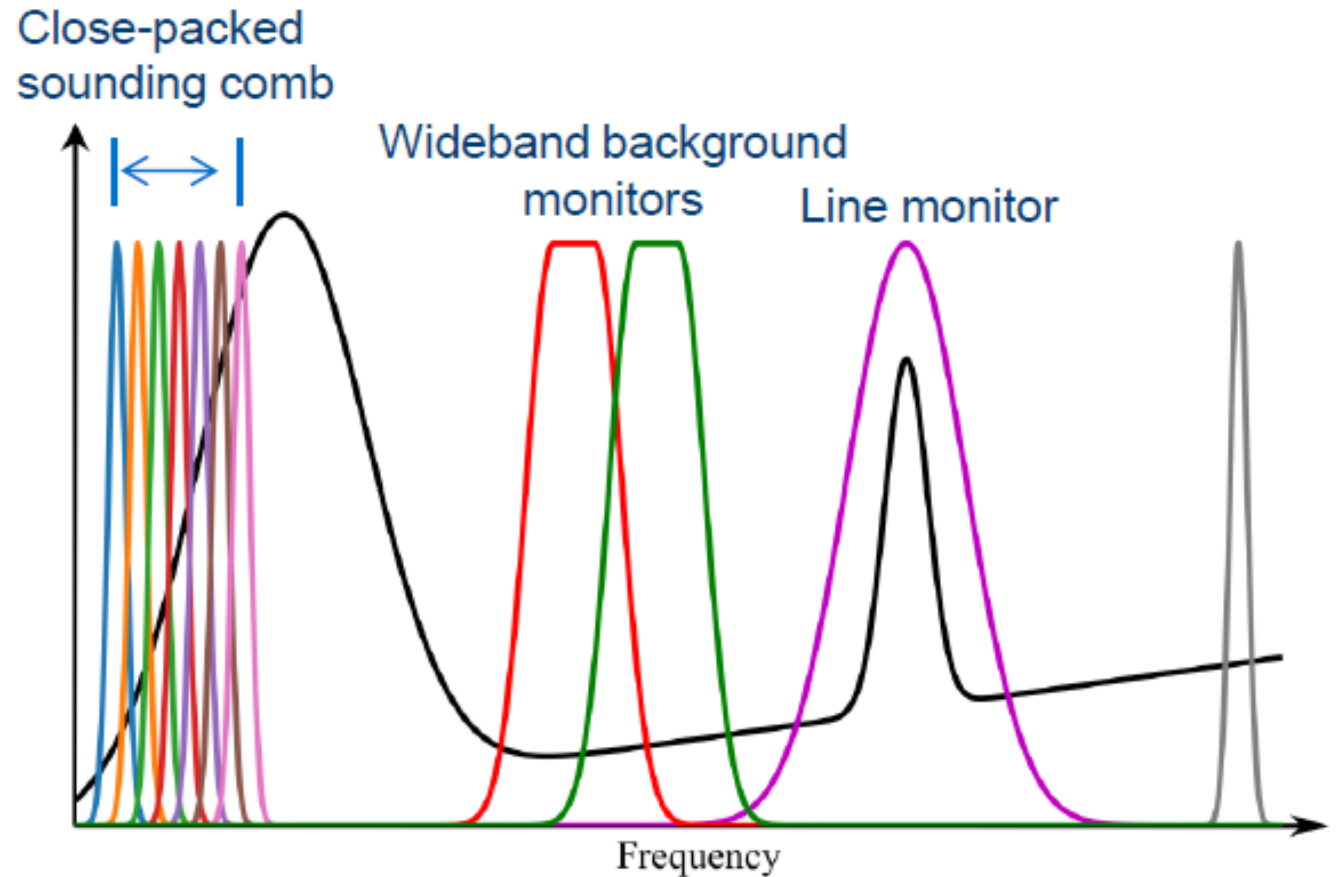
MWS – MetOp-SG (NEDT ~300-1800 mK)

HyMAS modelled with MWS channels, HyMAS noise (better than ~21mK per channel)

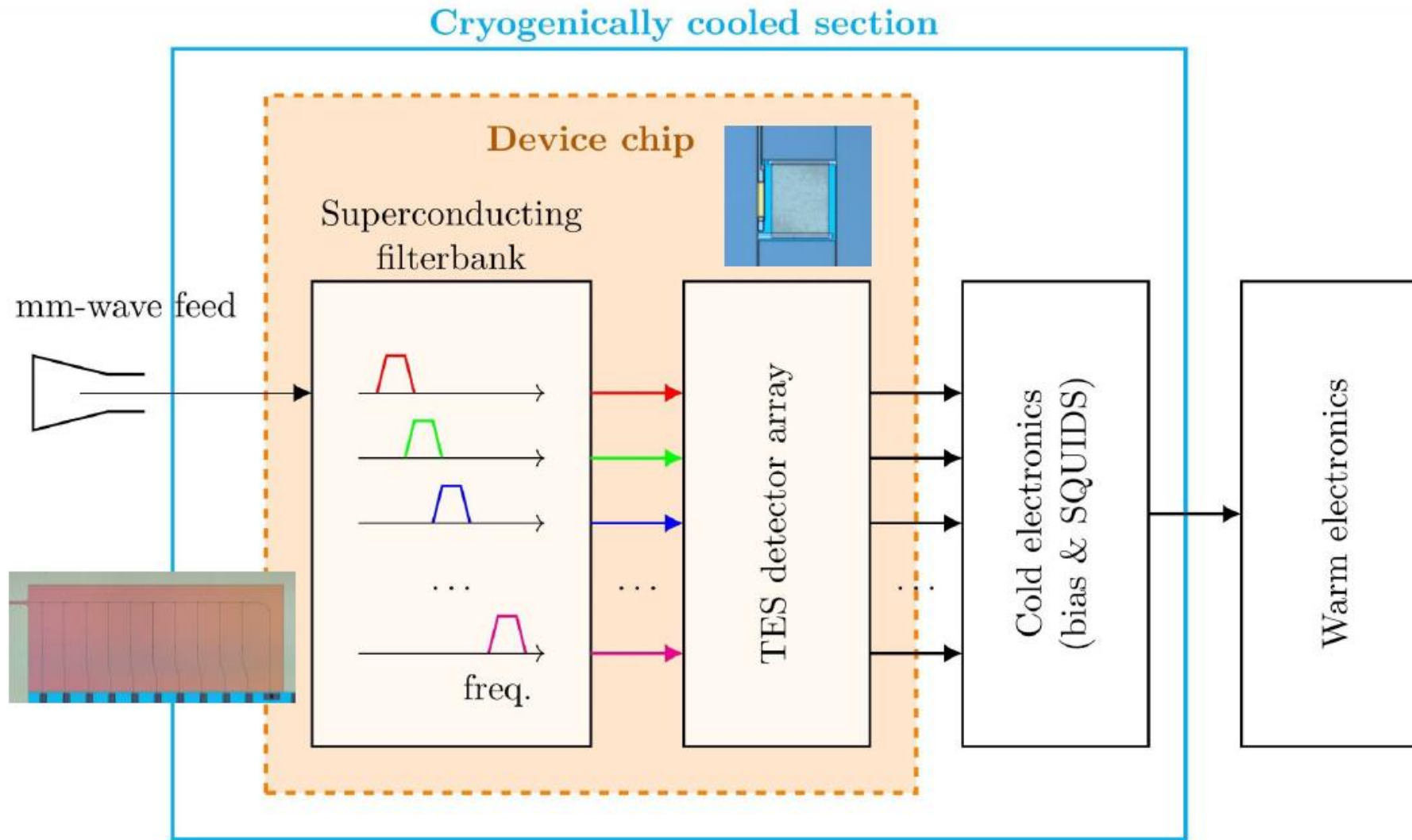


# Technology development under CEOI programme

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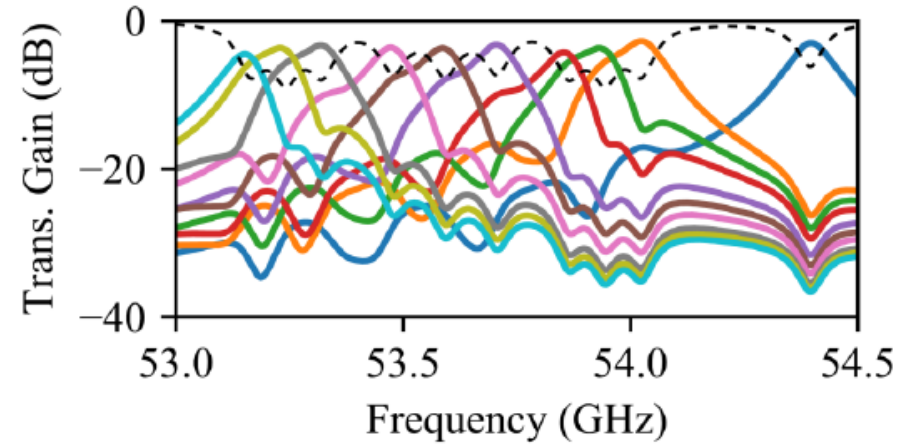
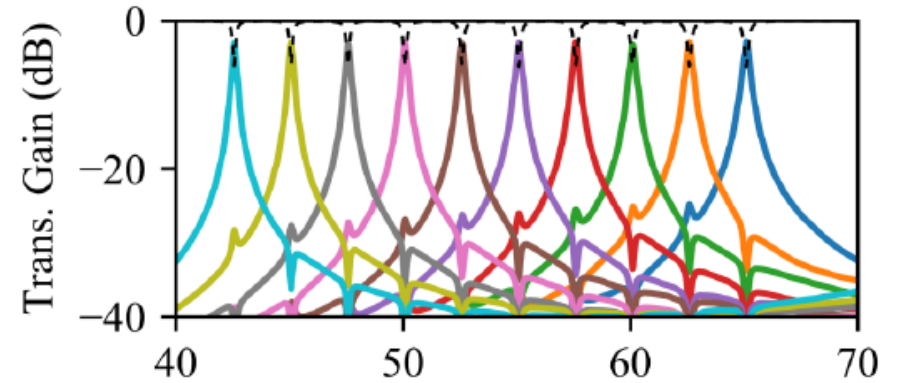
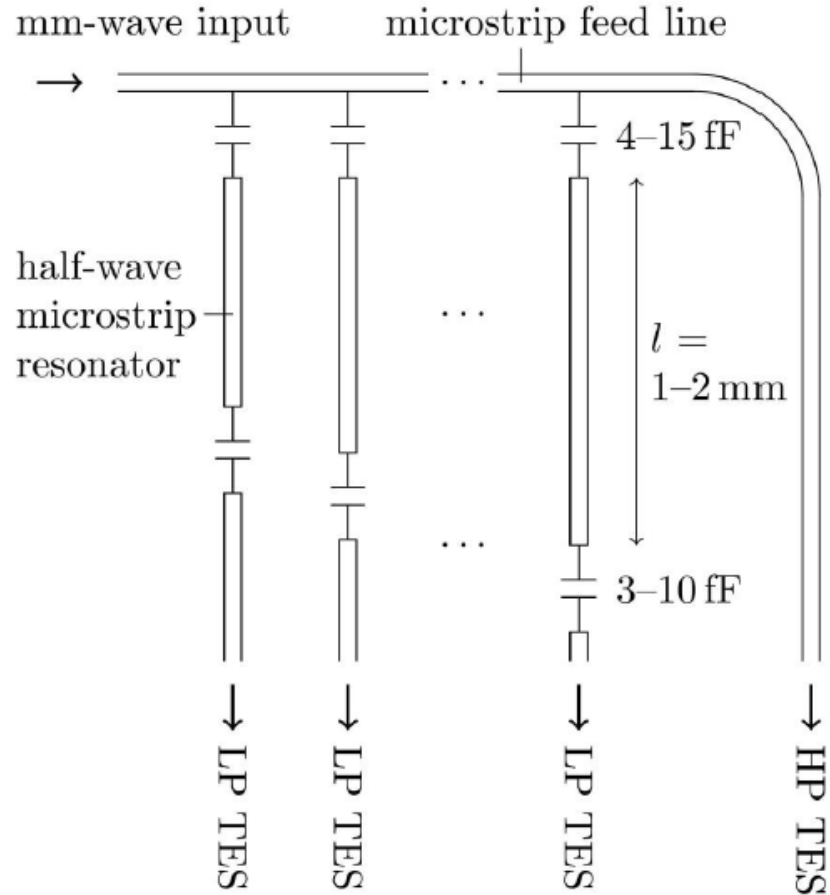


# Filterbank spectrometer





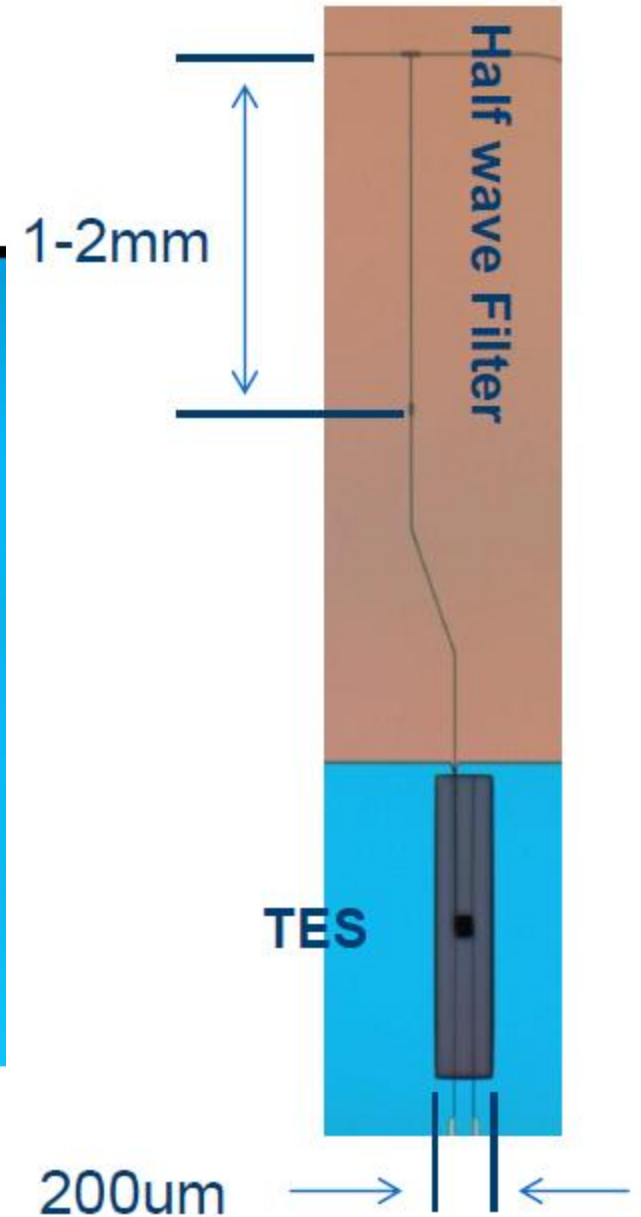
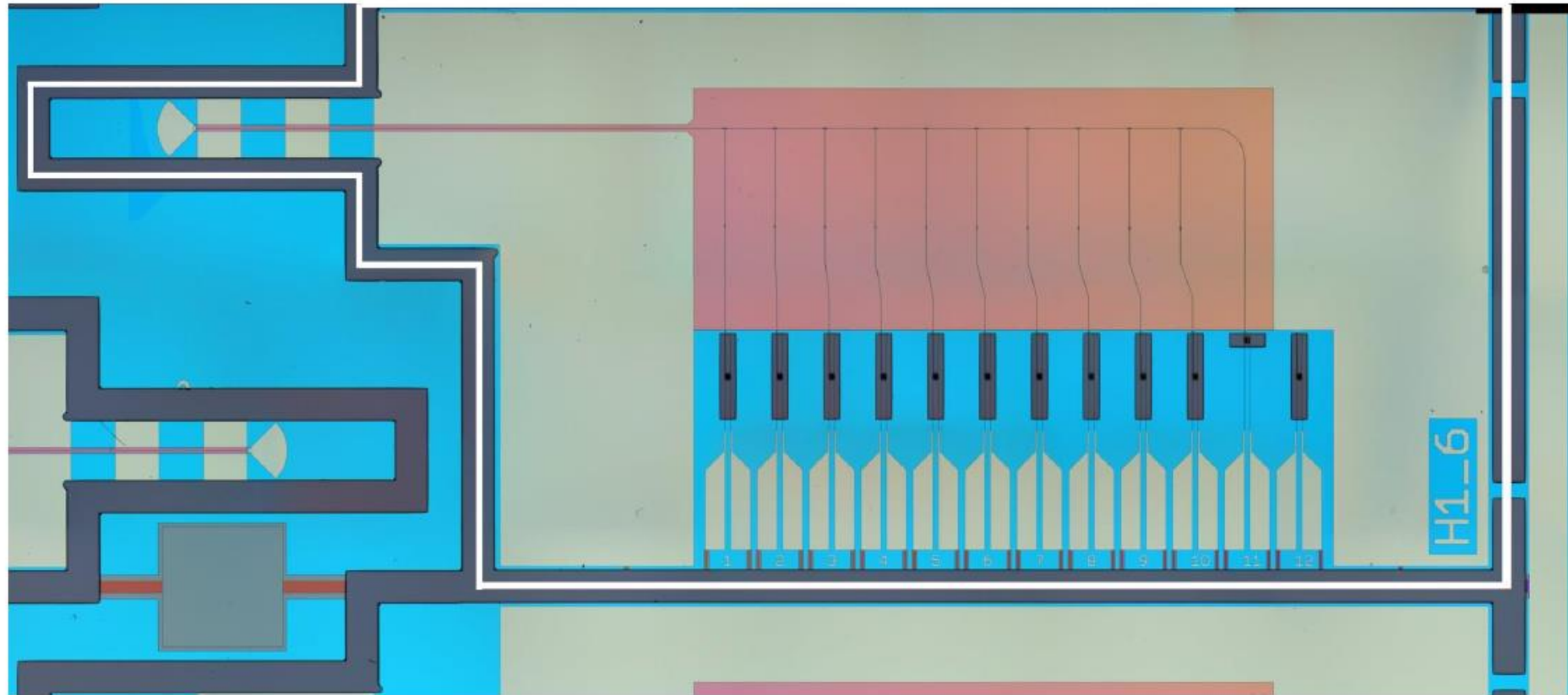
# Filterbank

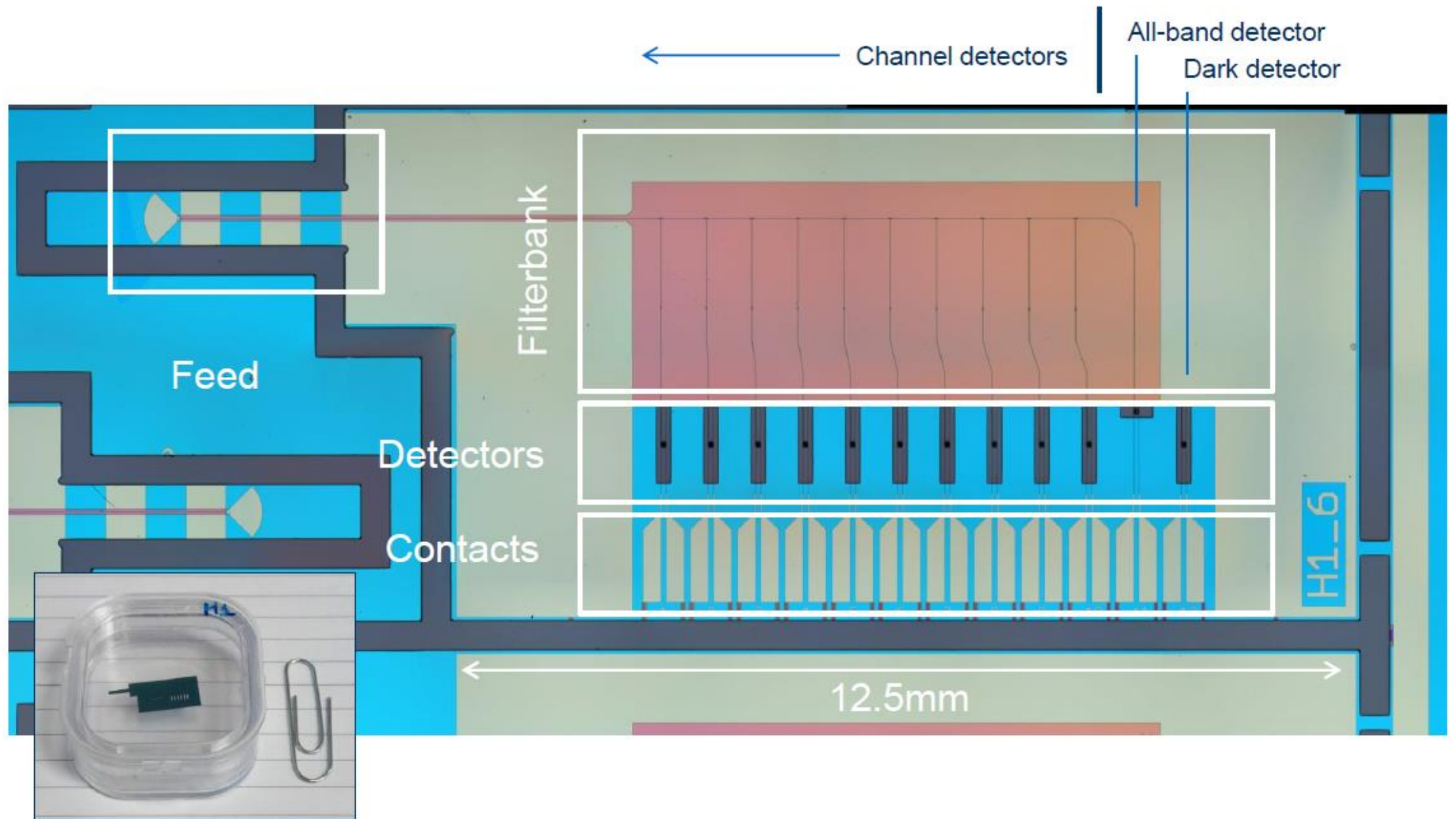


**Design R = 300 -1000**

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# Filterbank spectrometer chip

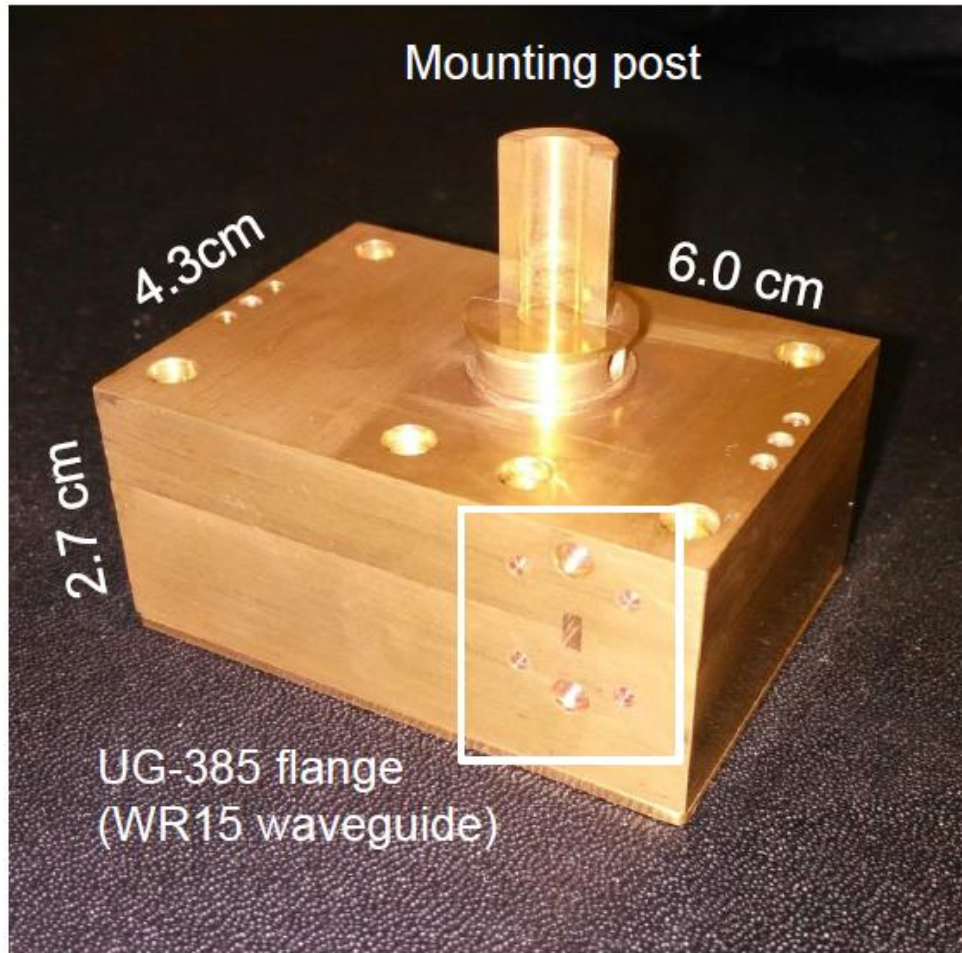




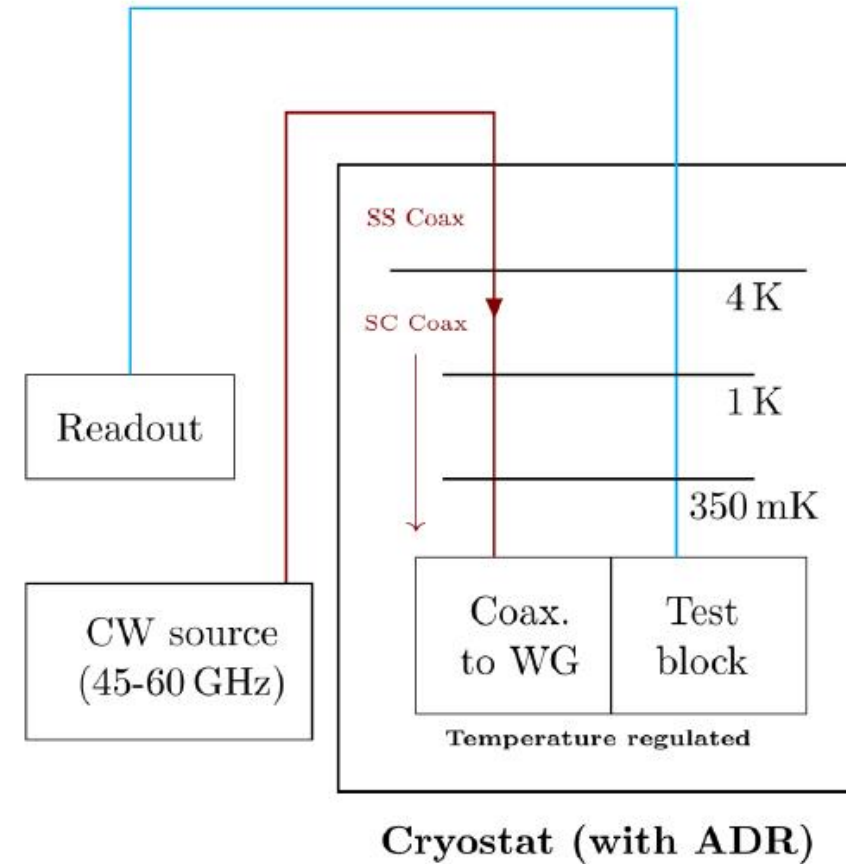


# Test blocks

Test block (chip + cold electronics)



Test arrangement



# Status

- Two devices to be fully characterised by March 2019
  - Devices fabricated – look good
  - Test facilities ready
  - Tests programme underway
- Design easily scales to hundreds of channels
- Next steps:
  - Airborne demonstrator – and extend up to ~1THz
  - Deployment on ground-based upward looking facility (?)
  - Applications to security sector, and astronomy

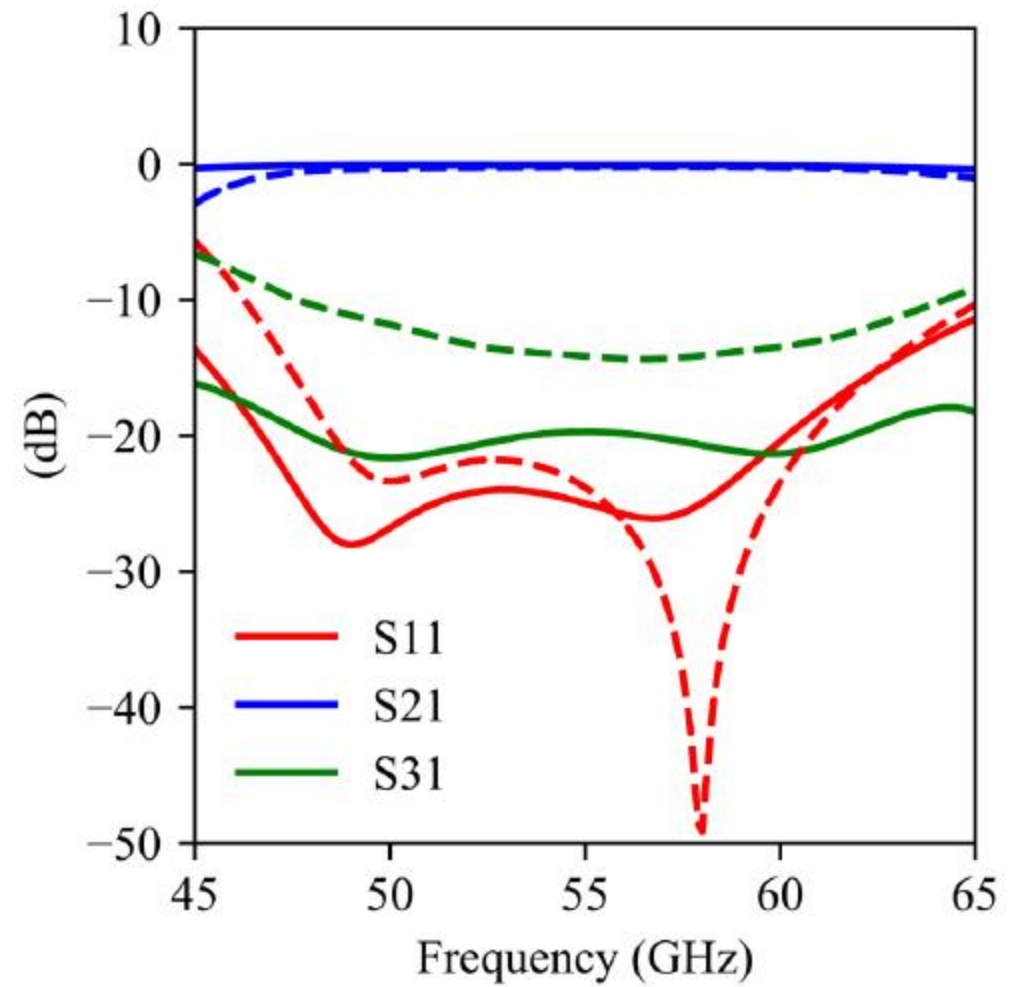
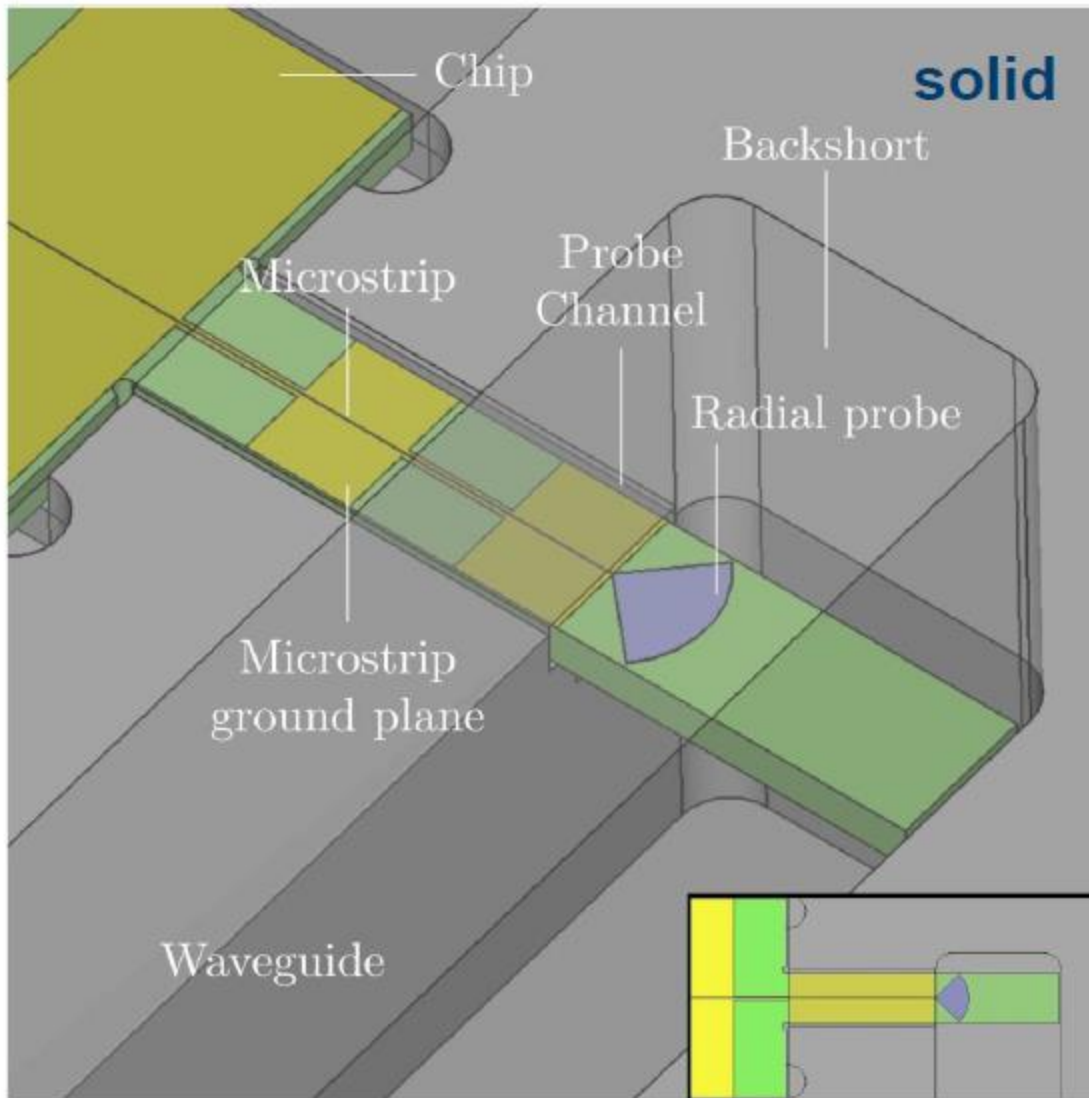




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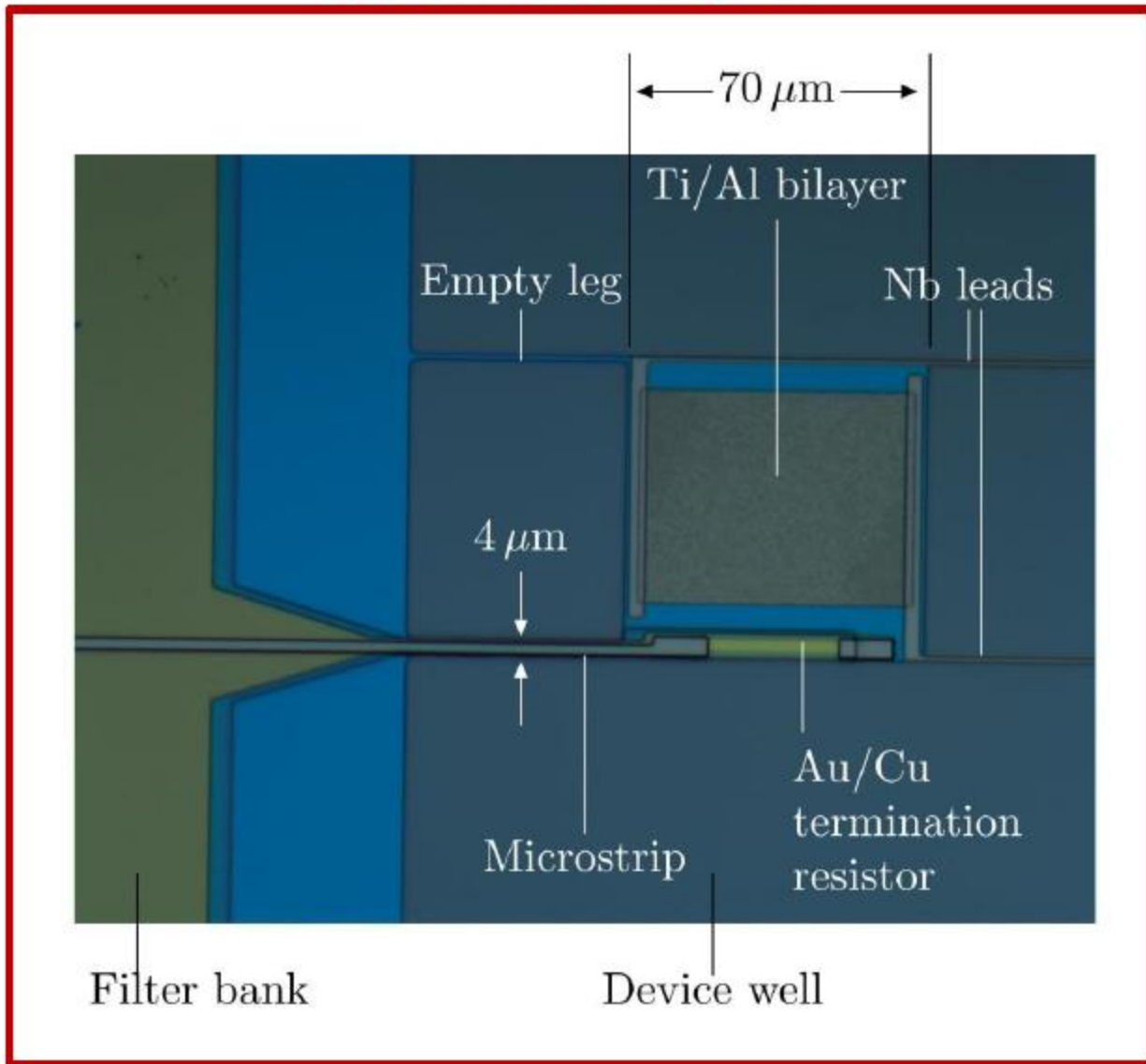


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**Simulated performance**

## Photo of HP device



## Design parameters (LP):

$$\text{Dark NEP} = 11\ \text{aW/Hz}^{0.5}$$

$$\text{Response time} = 0.5\ \text{ms}$$

## R versus T curve:

