Filterbank spectrometers for Hyperspectral Microwave Atmospheric Sounding (HYMAS)

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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

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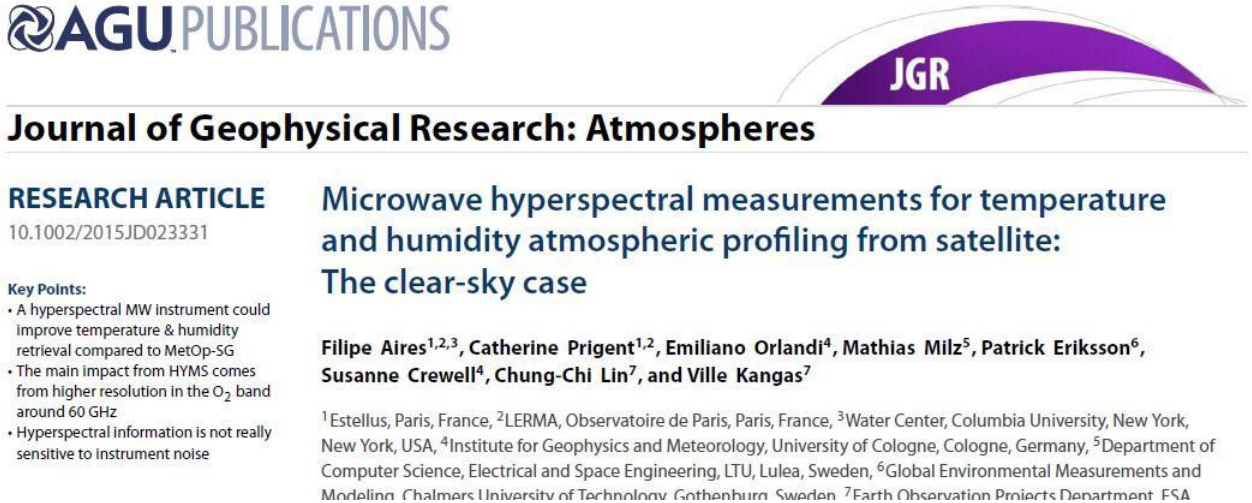
Hyperspectral sounding for meteorology

- 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_2 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[1,2,3], Catherine Prigent[1,2], Emiliano Orlandi[4], Mathias Milz[5], Patrick Eriksson[6], Susanne Crewell[4], Chung-Chi Lin[7], and Ville Kangas[7]

[1]Estellus, Paris, France, [2]LERMA, Observatoire de Paris, Paris, France, [3]Water Center, Columbia University, New York, New York, USA, [4]Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany, [5]Department of Computer Science, Electrical and Space Engineering, LTU, Lulea, Sweden, [6]Global Environmental Measurements and Modeling, Chalmers University of Technology, Gothenburg, Sweden, [7]Earth Observation Projects Department, ESA

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_2 temperature sounding line
    - Photon-noise-limited detection – NEP ~few x 10^{-17} $WHz^{-1/2}$
    - **Demonstrate** channel resolution of up to 1000 (nu/Dnu)
    - NEDT of ~20mK 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.

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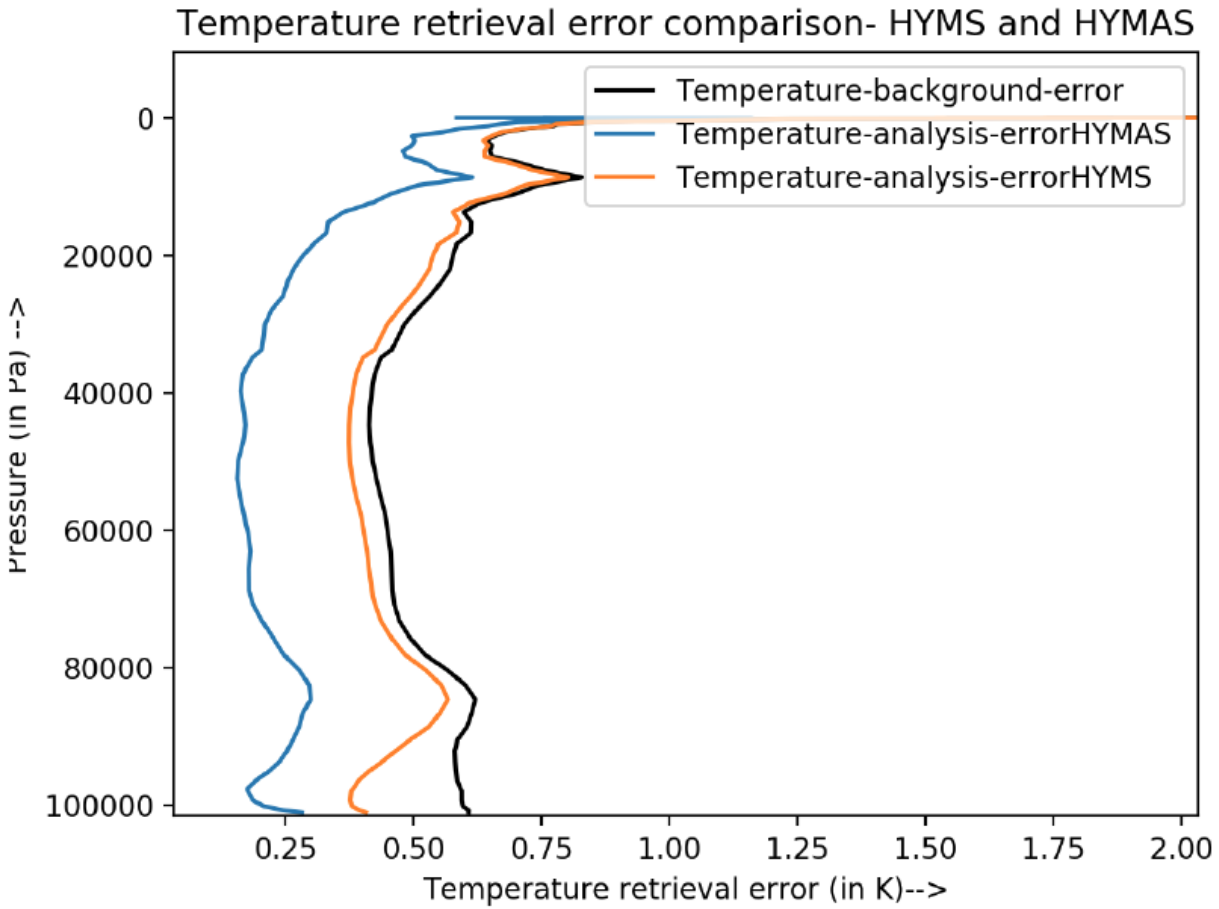
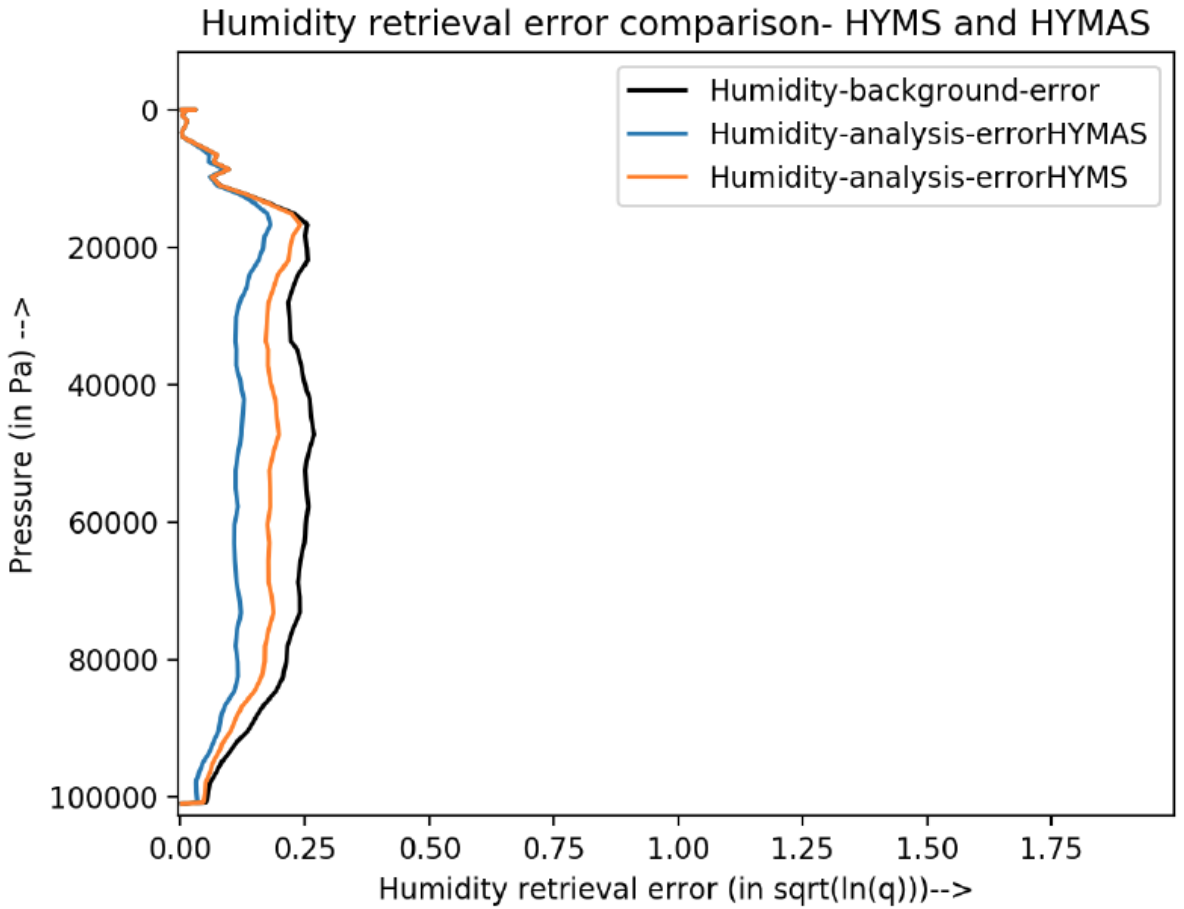
Performance predictions – HyMAS vs HyMS

HyMS – F. Aires et al. DOI: 10.1002/2015JD023331
HyMAS modelled as HyMS channel set, HyMAS noise





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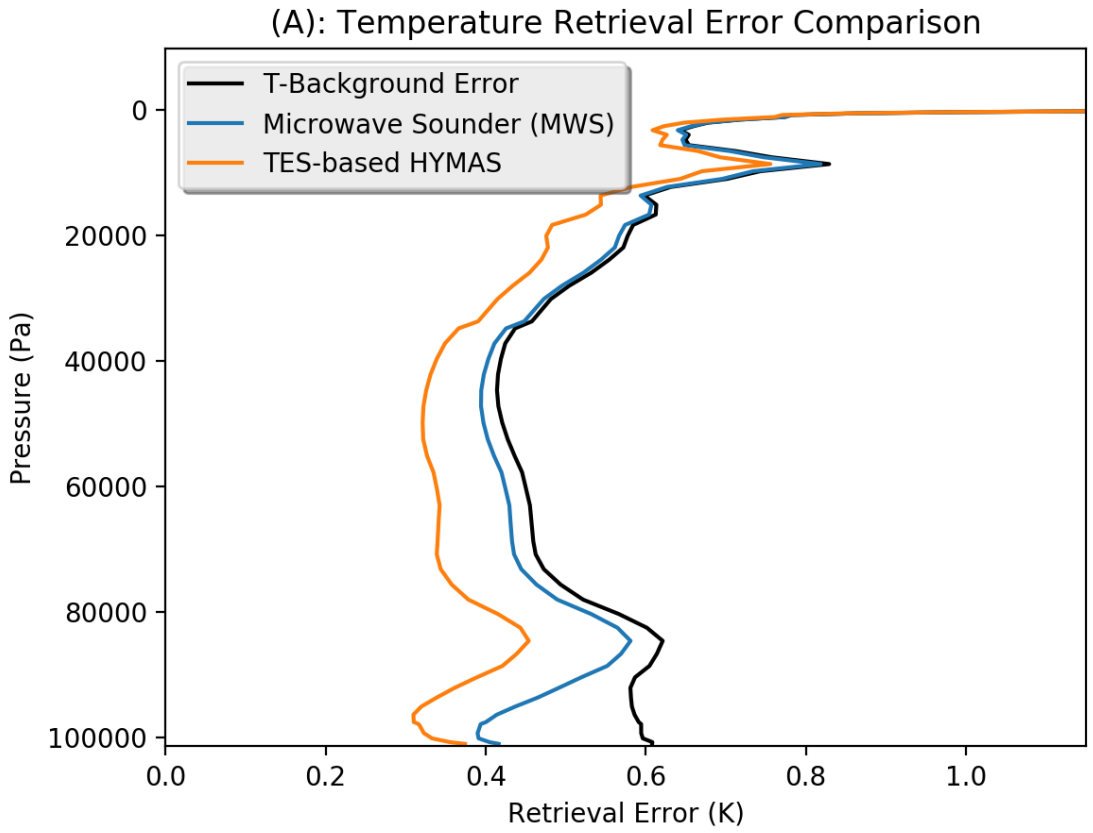
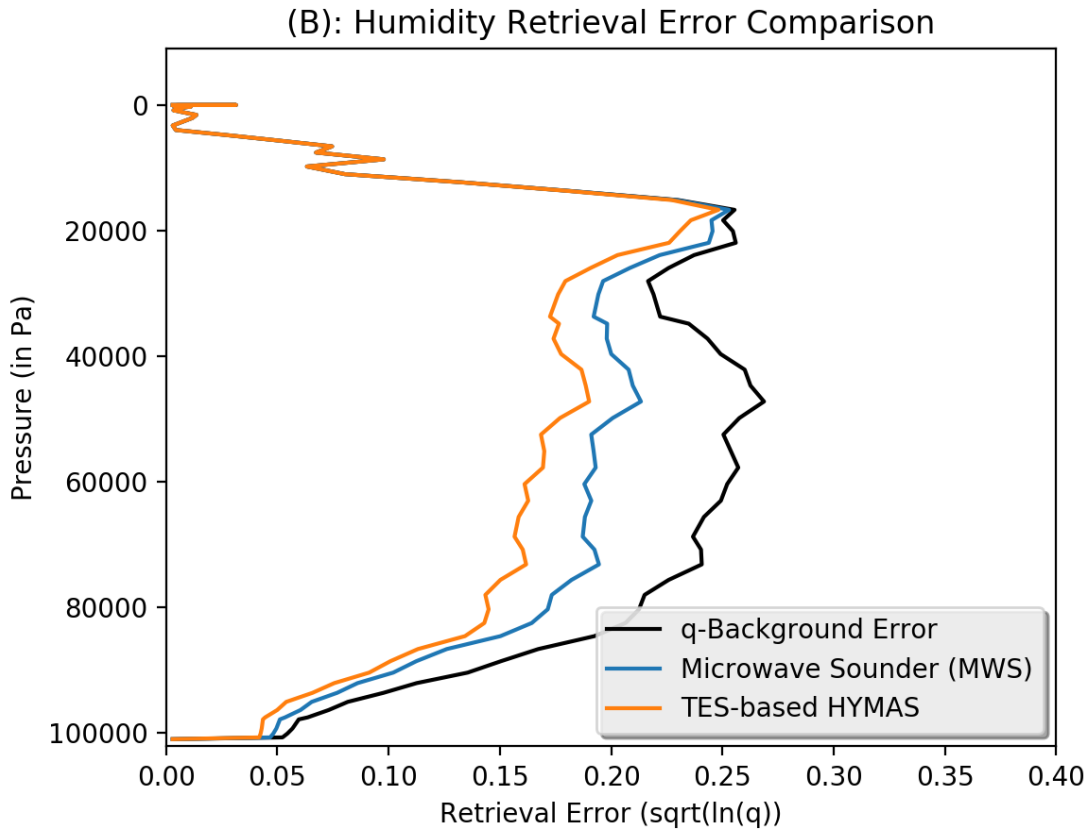
Performance predictions – HyMAS vs MWS

MWS – MetOp-SG (NEDT ~300-1800 mK)
HyMAS modelled with MWS channels, HyMAS noise (better than ~21mK per channel)





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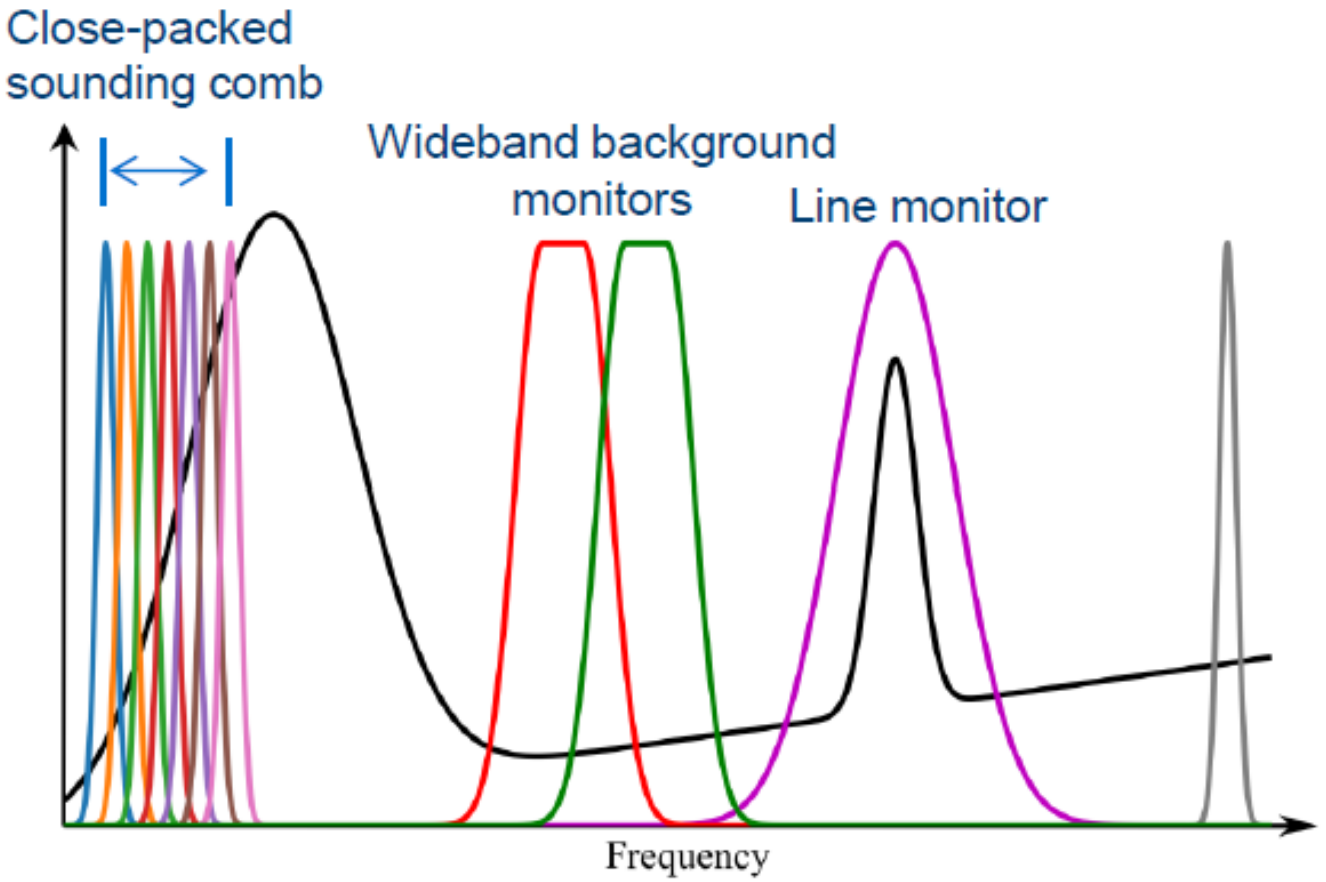

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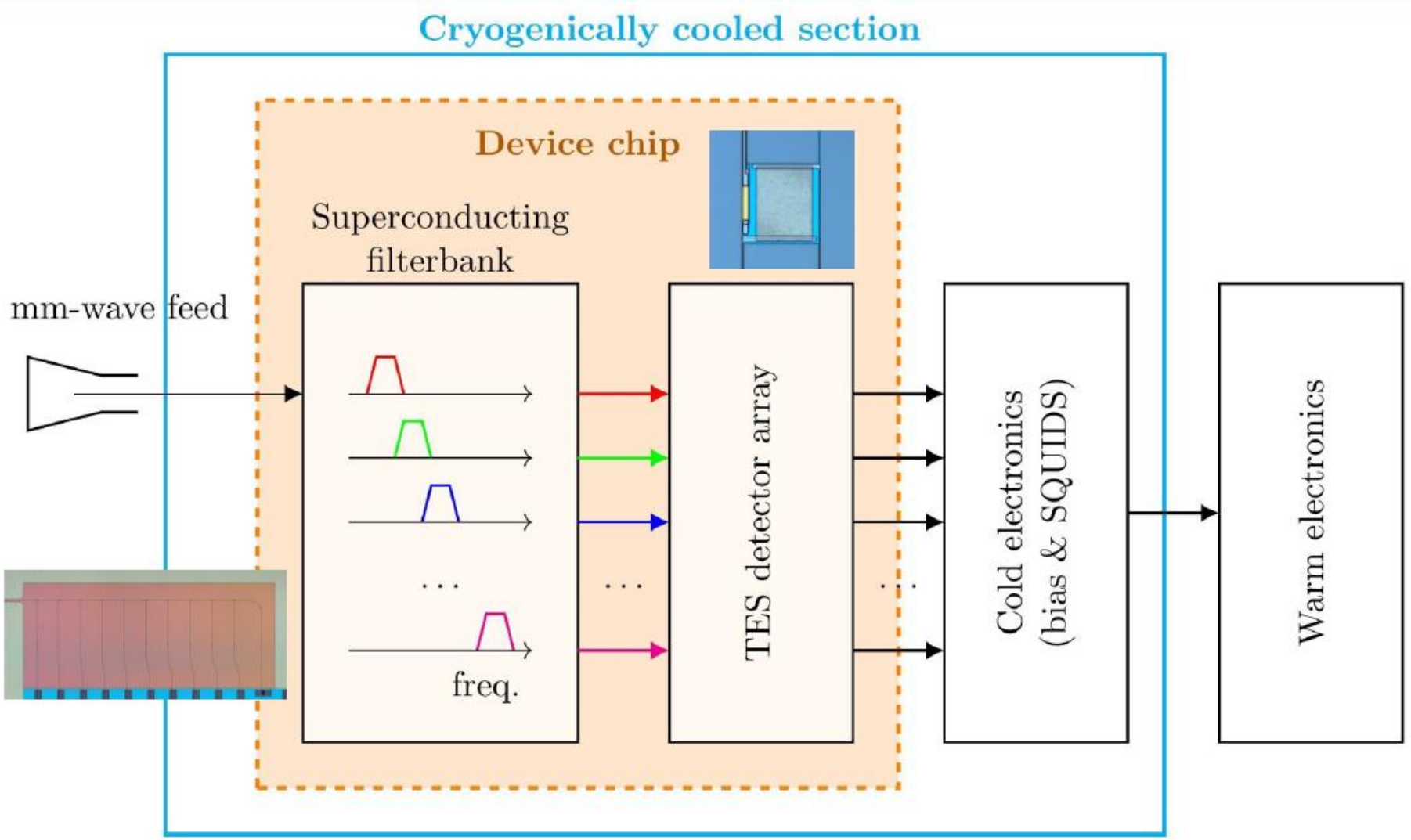
Filterbank spectrometer



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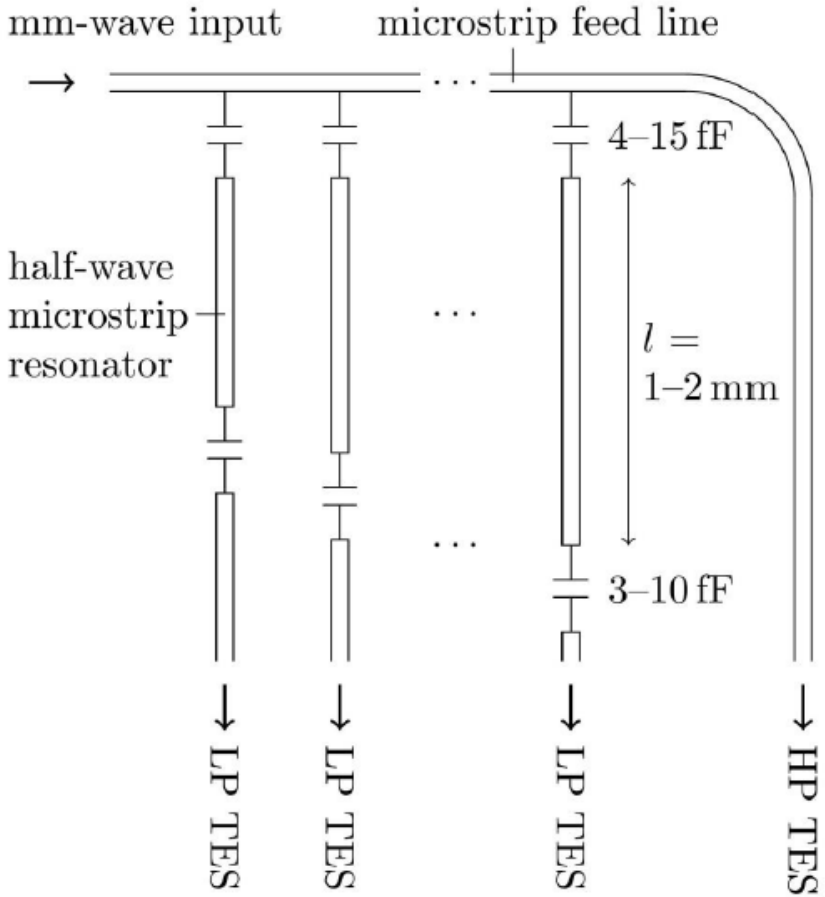
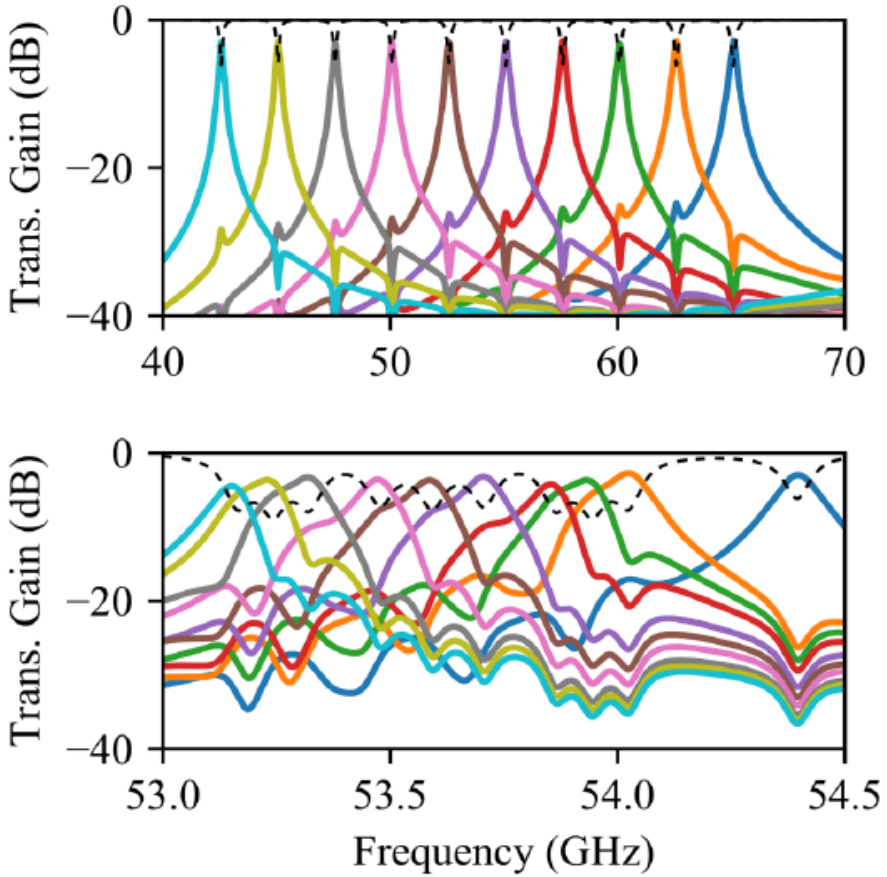
Filterbank





Design R = 300 -1000

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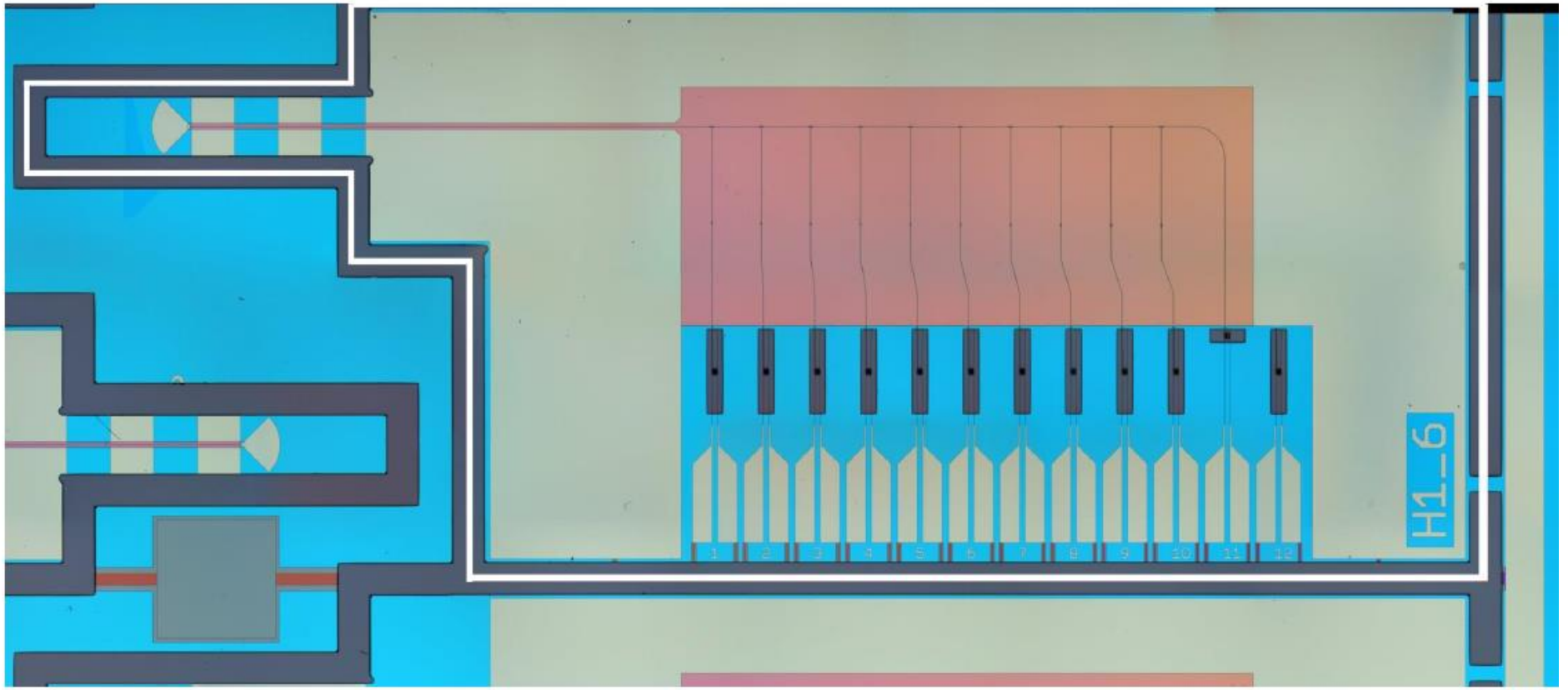
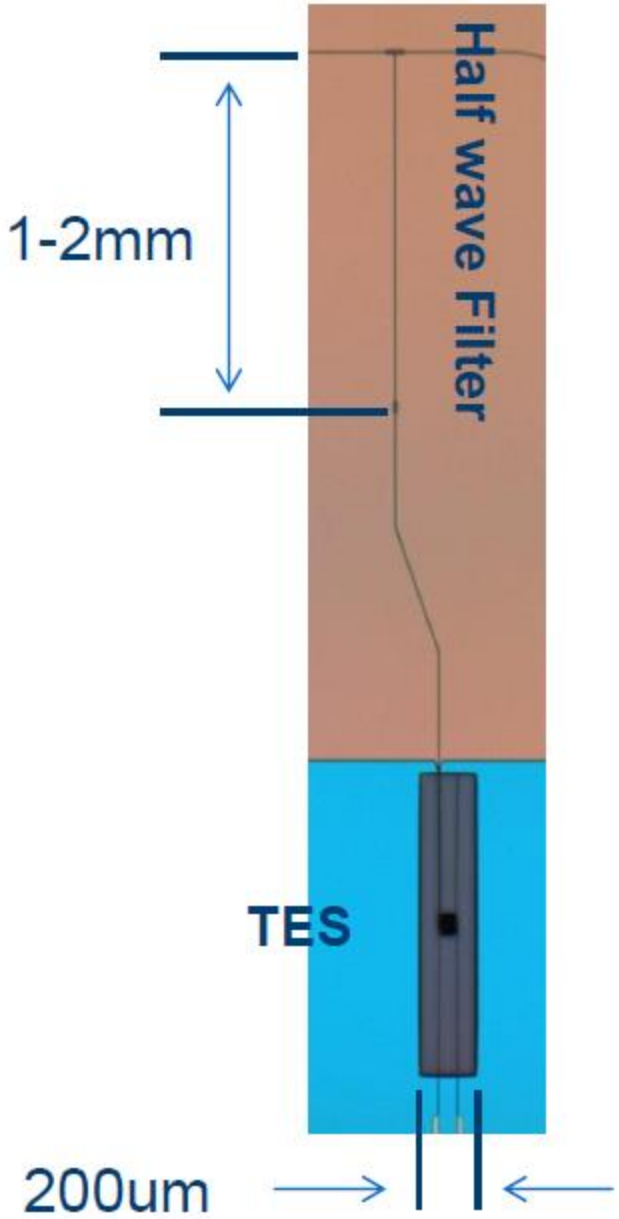
Filterbank spectrometer chip





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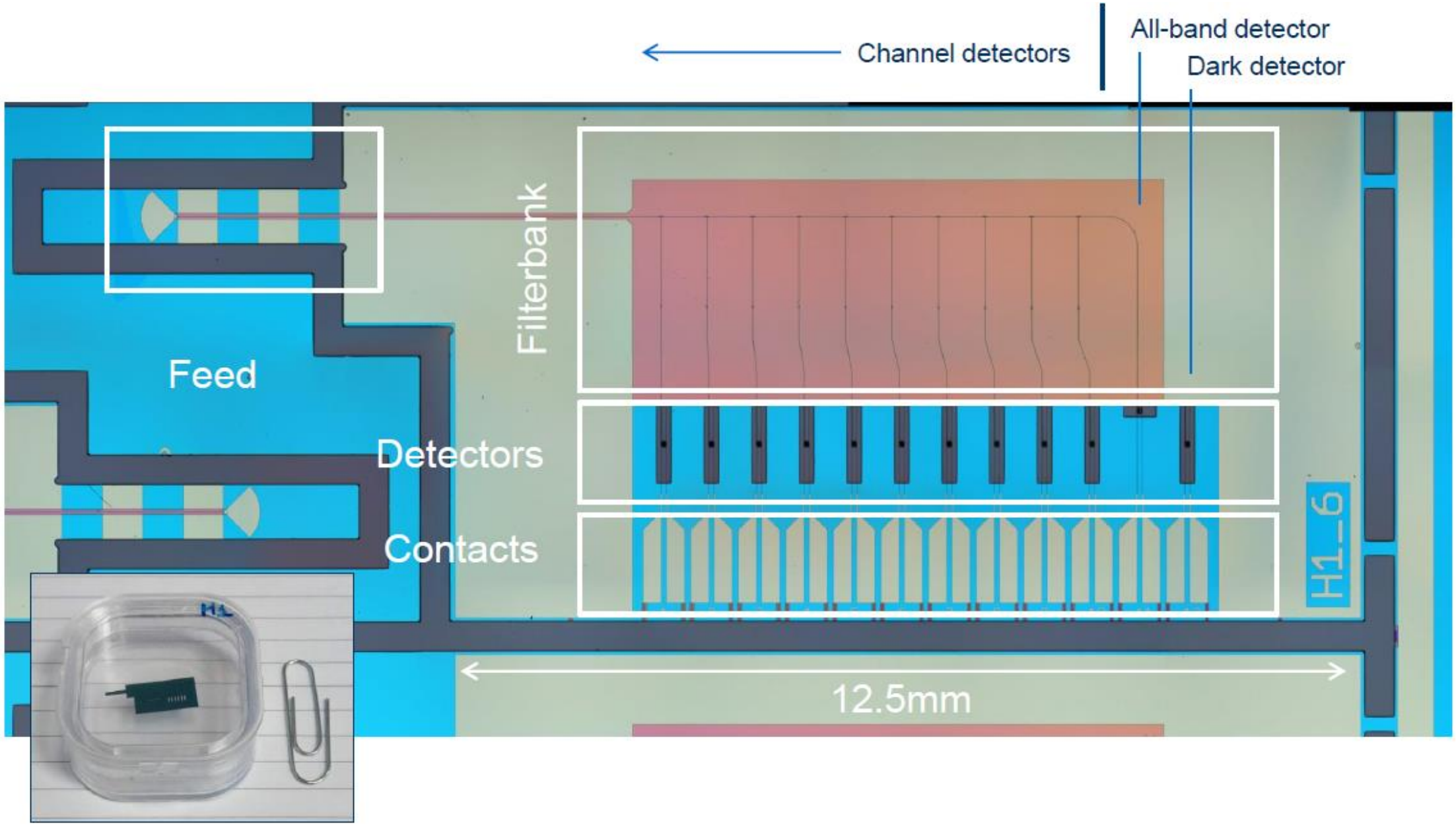

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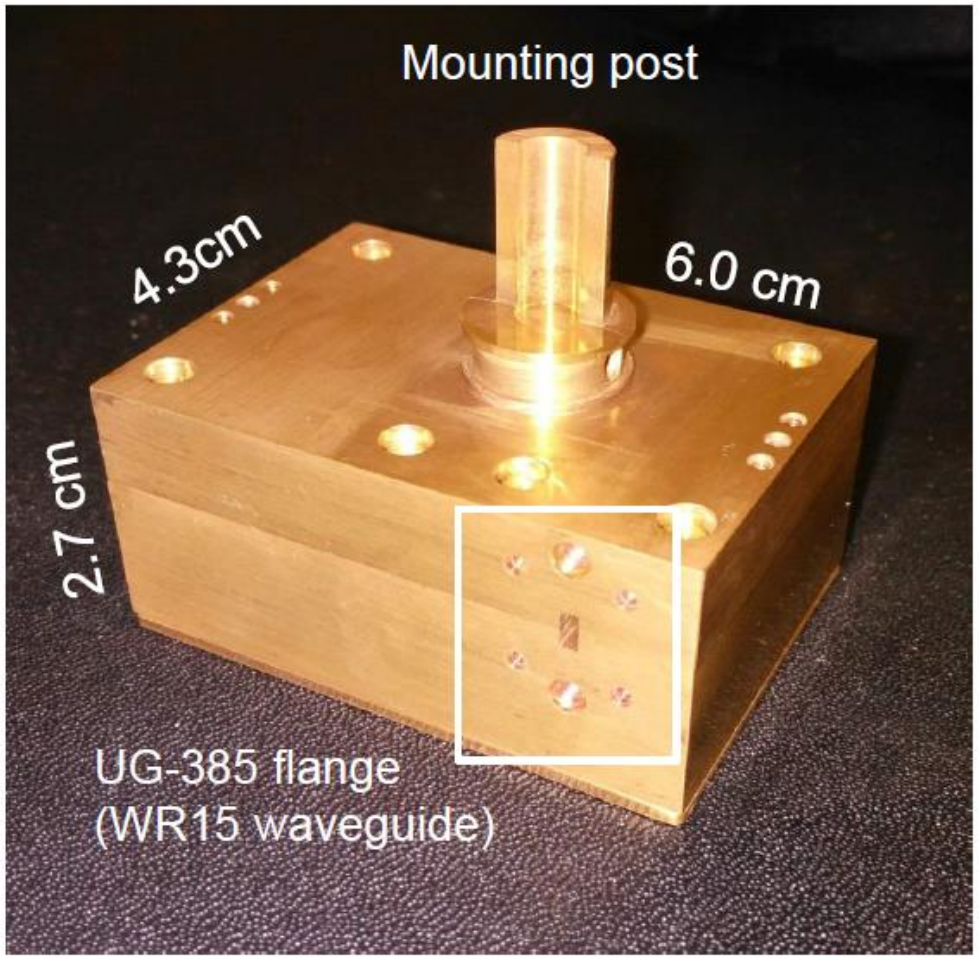
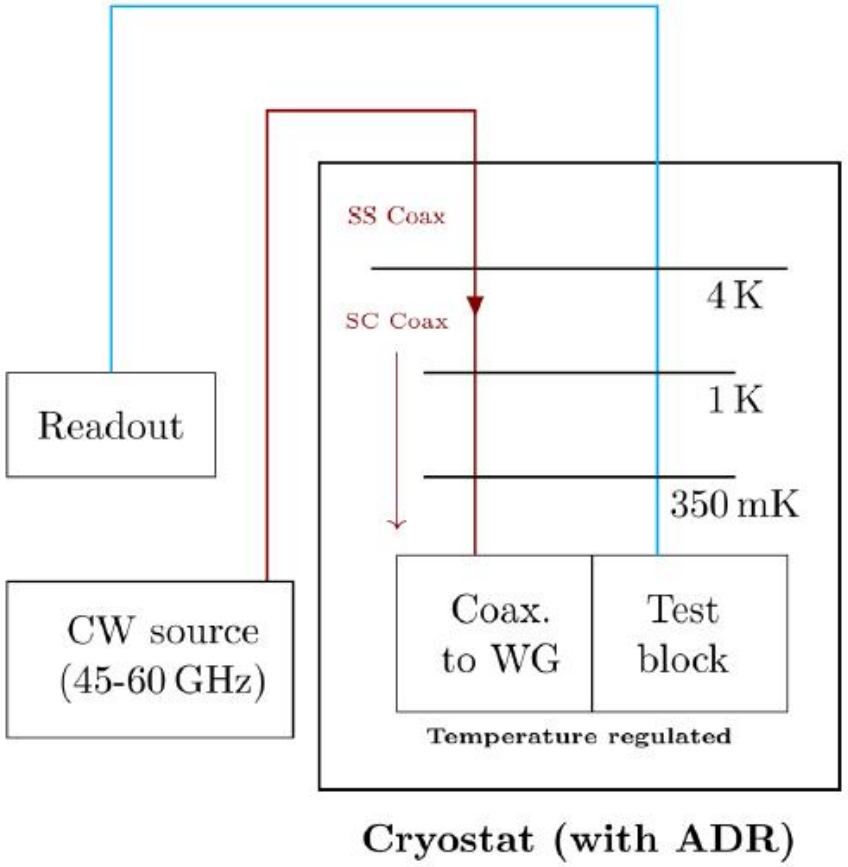
Test blocks

Test block (chip + cold electronics)



Test arrangement



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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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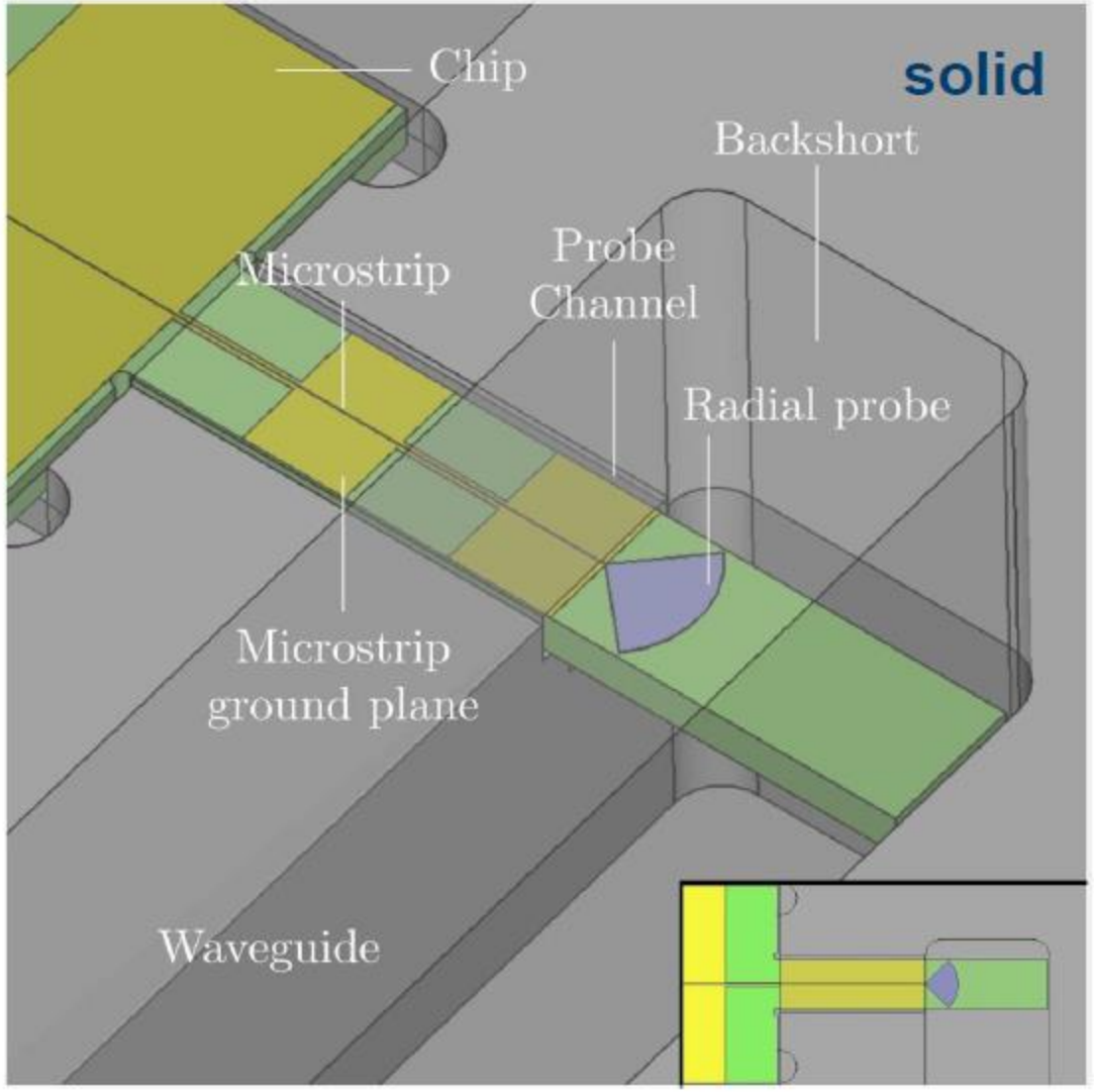

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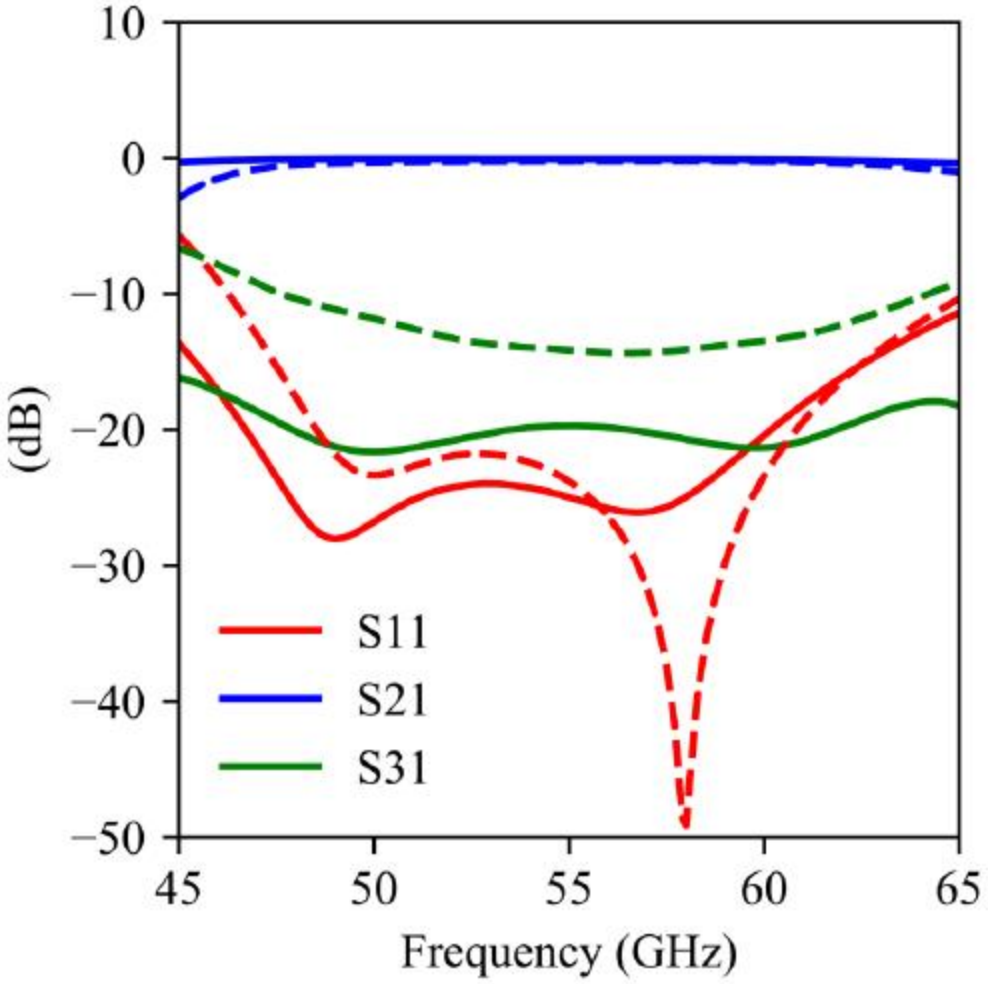

Simulated performance

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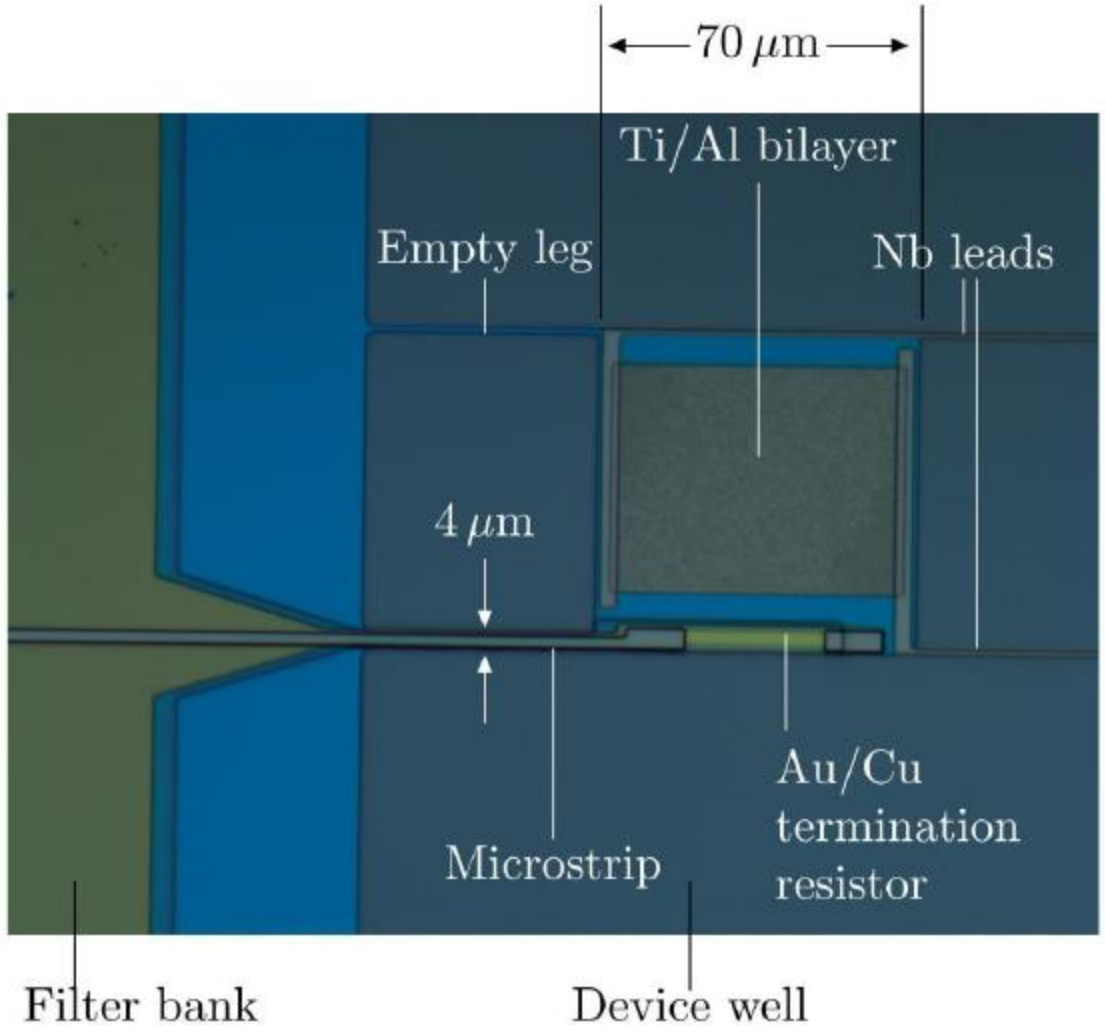
Photo of HP device

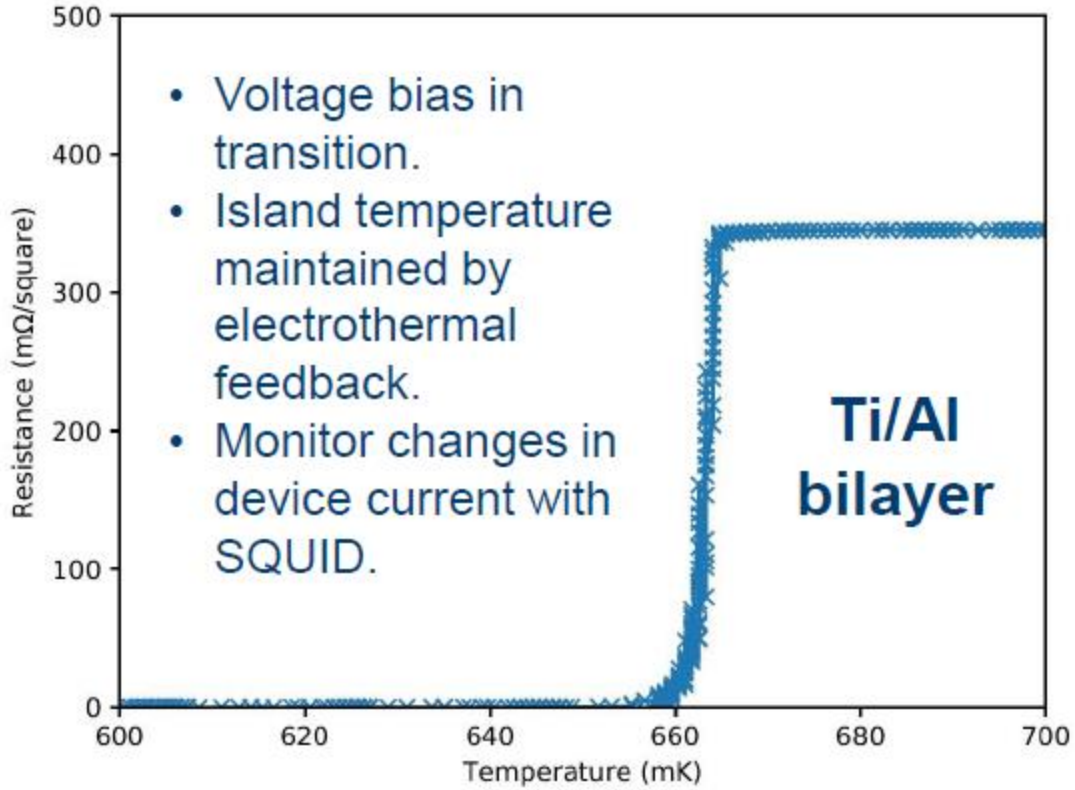


Design parameters (LP):

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

Response time = 0.5ms

R versus T curve:



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