MOSAIC

an on-chip ultra-wideband multi beam spectrometer for the LMT

MOSAIC/Deshima team

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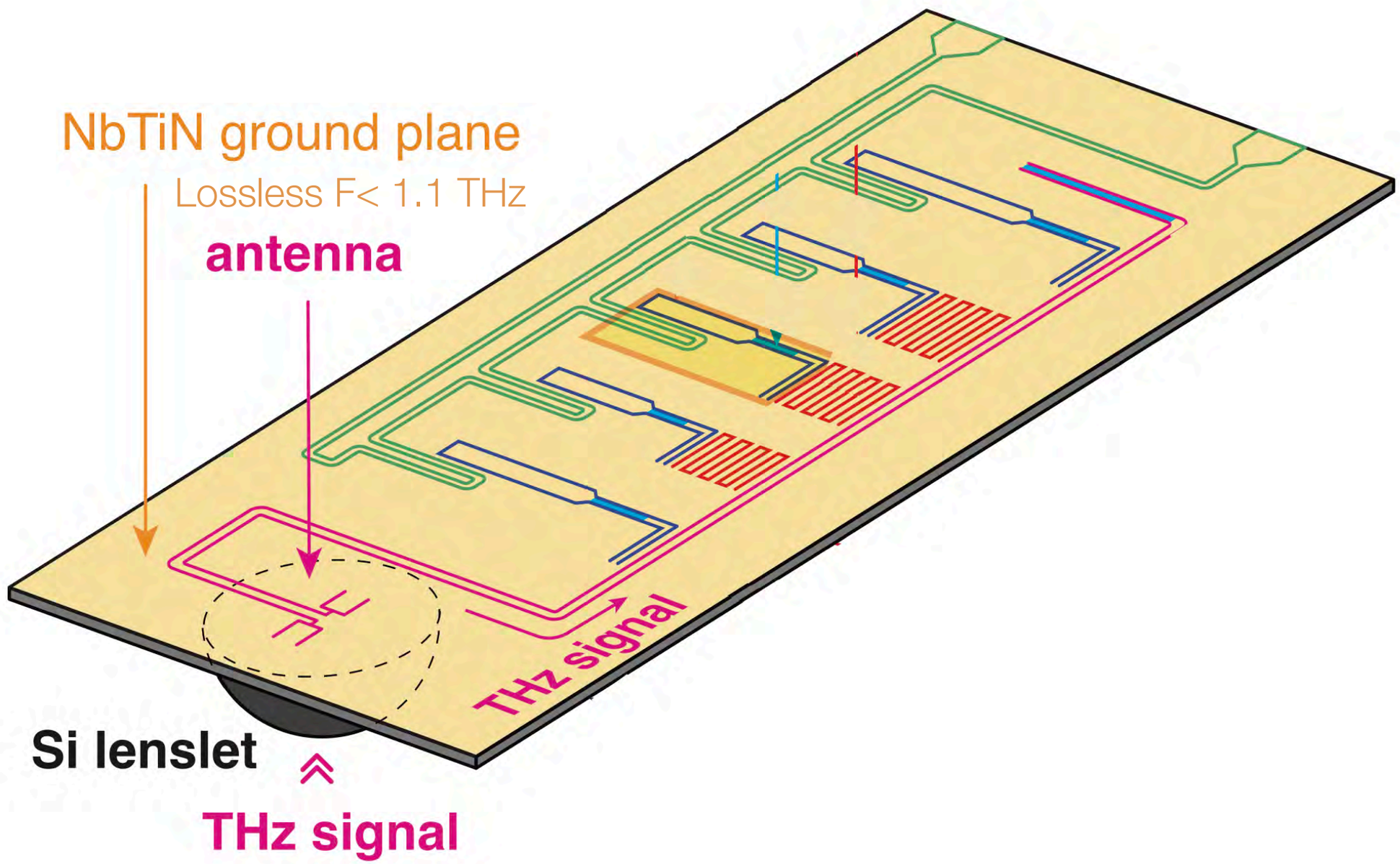
Shun Ishii
Kahwuy Chin

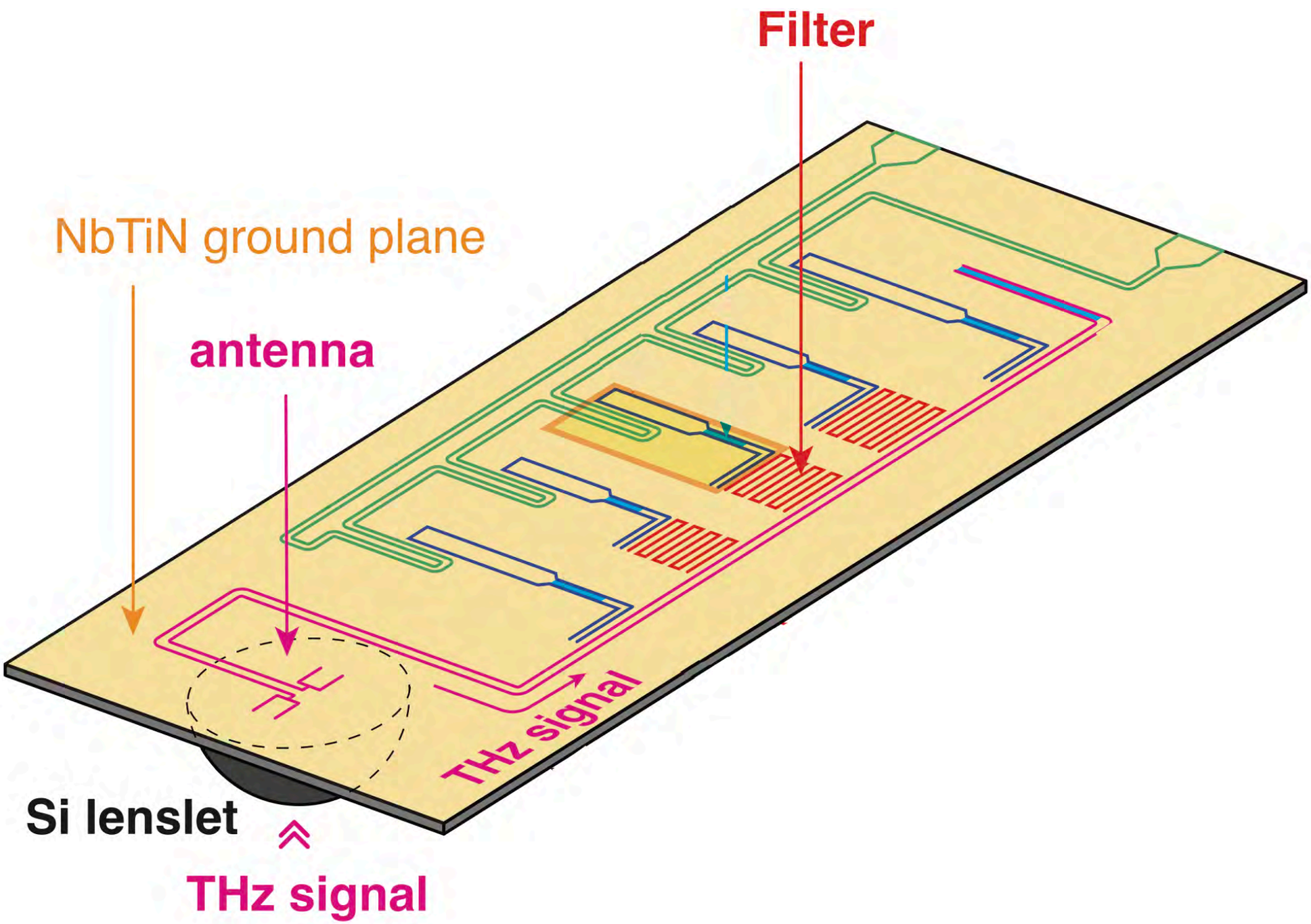
KEK Inter-University Research Institute Corporation High Energy Accelerator Research Organization

Junya Suzuki

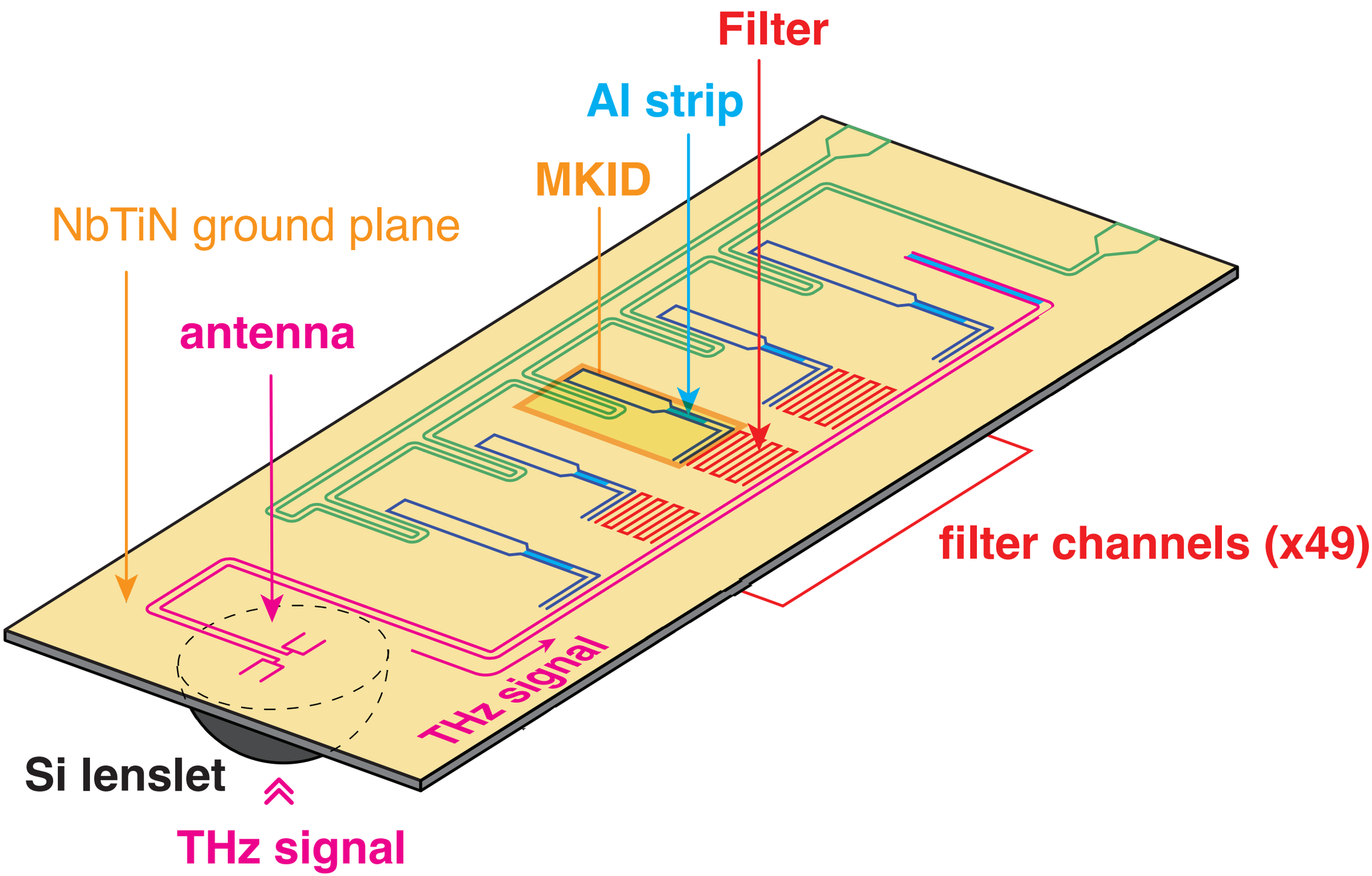
Ultra-wideband spectroscopy: On-Chip spectrometer



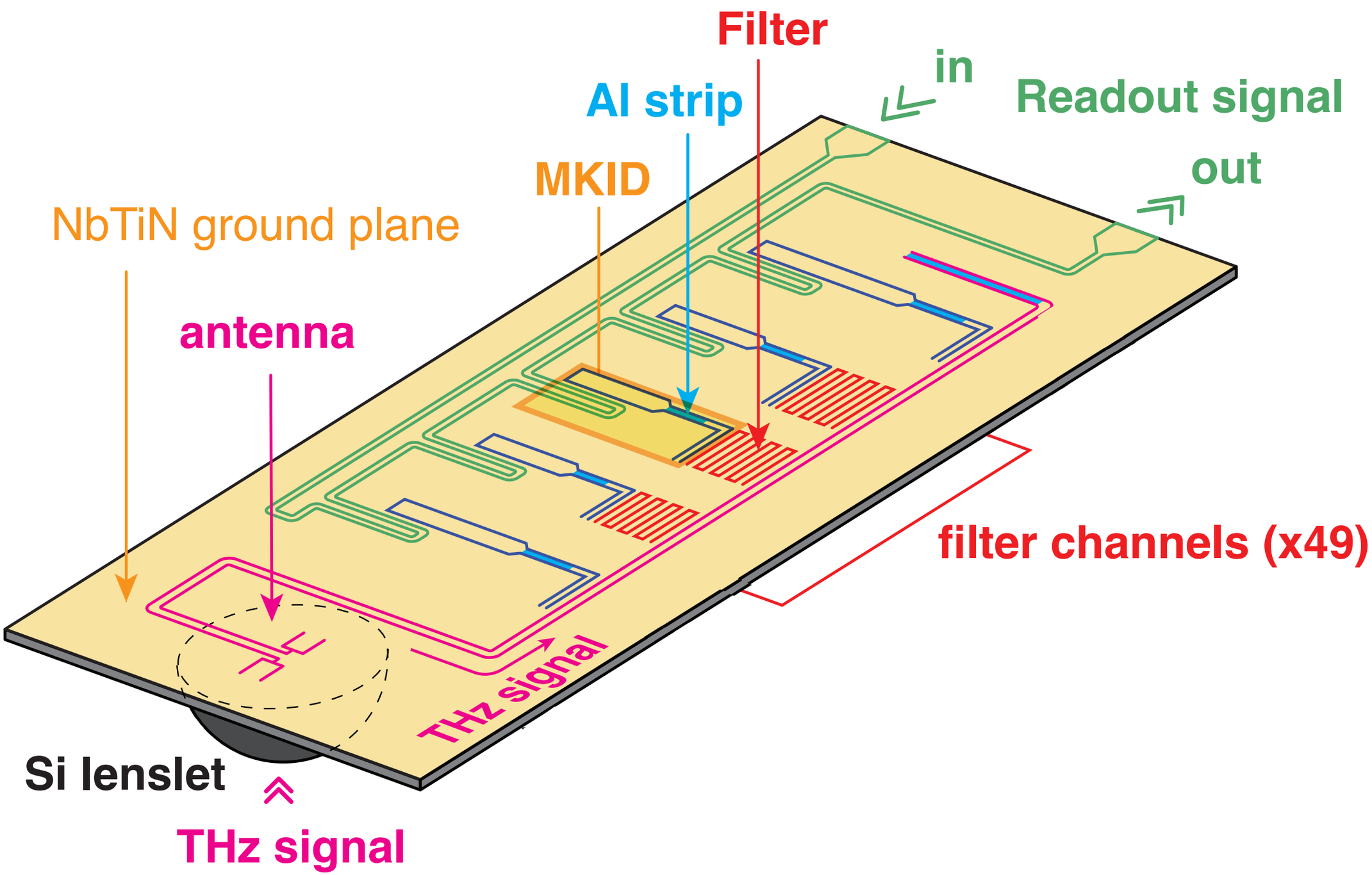
Ultra-wideband spectroscopy: On-Chip spectrometer



Ultra-wideband spectroscopy: On-Chip spectrometer



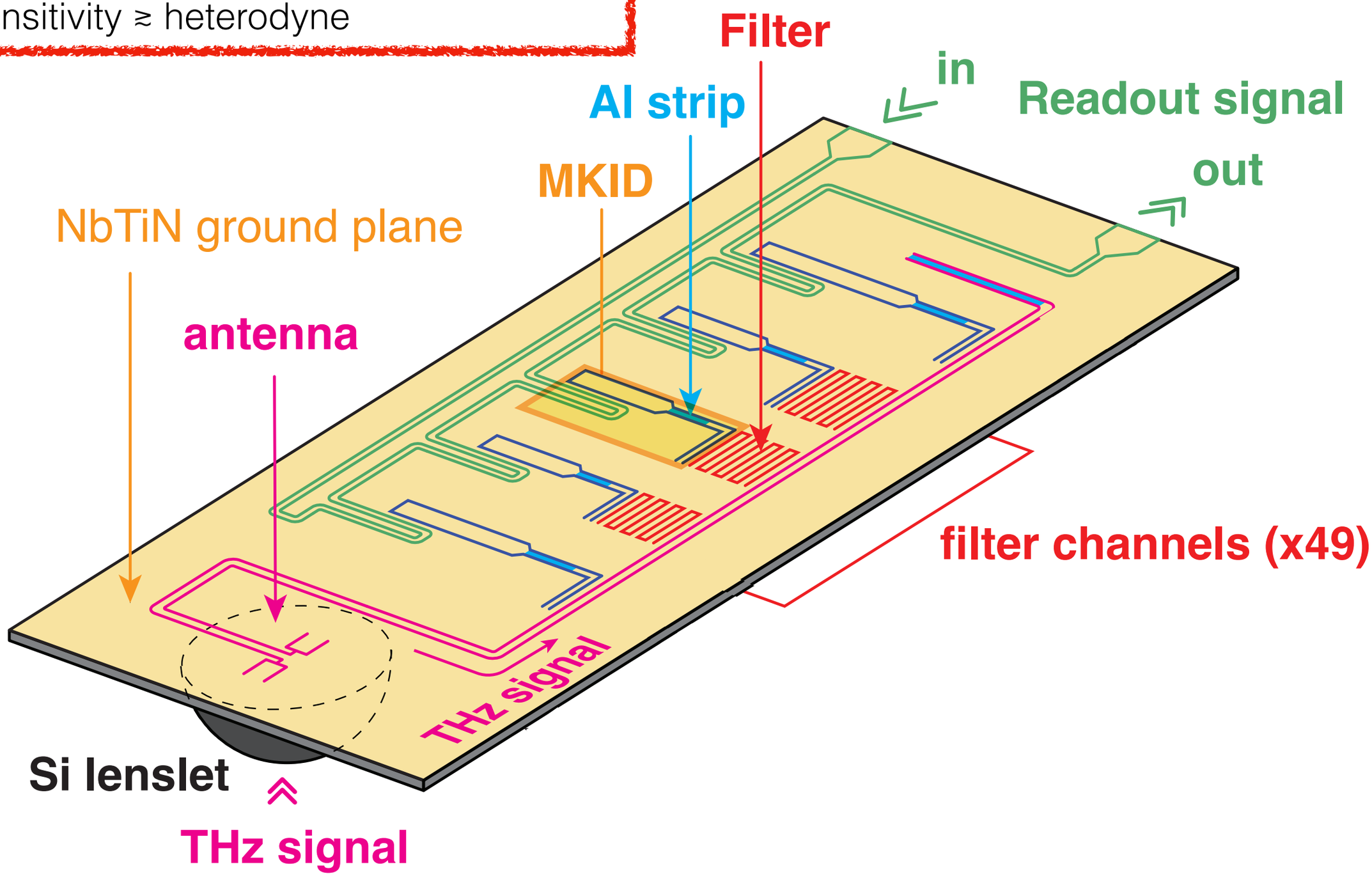
Ultra-wideband spectroscopy: On-Chip spectrometer



Ultra-wideband spectroscopy: On-Chip spectrometer

185 - 360 GHz, R = 500 Spectrometer

- 350 detectors
- 300 MHz readout bandwidth
- sensitivity ≳ heterodyne



End 2017

First light of DESHIMA on ASTE

on-chip filterbank spectrometer for submillimeter wave astronomy

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Kaui Chin, Akio Taniguchi, Tatsuya Takekoshi, Kotaro Kohno (Univ. Tokyo)
Takashi Tsukagoshi, Shun Ishii, Jun Maekawa, Ryohei Kawabe, Tai Oshima, Toshihiko Kobiki,
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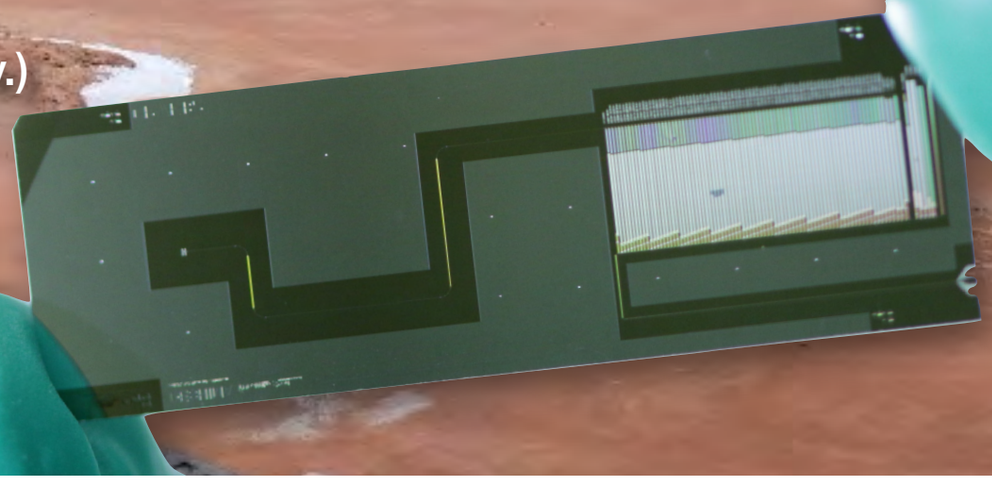
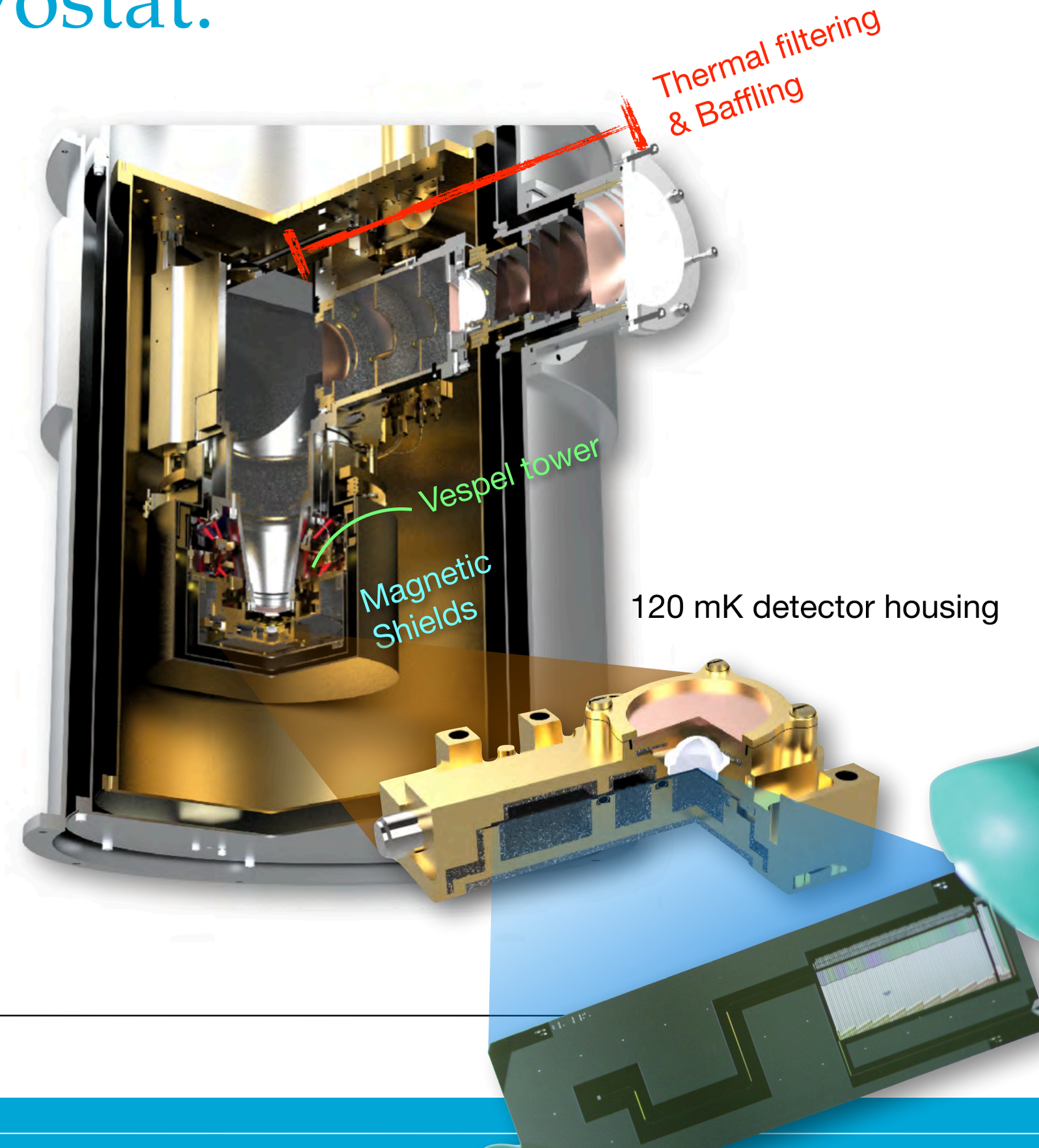
Masato Naruse (Saitama Univ)
Kazuyuki Fujita, Akira Kouchi (Hokkaido Univ)
Shunichi Nakatsubo (ISAS/JAXA)
Paul van der Werf (Leiden Univ.)

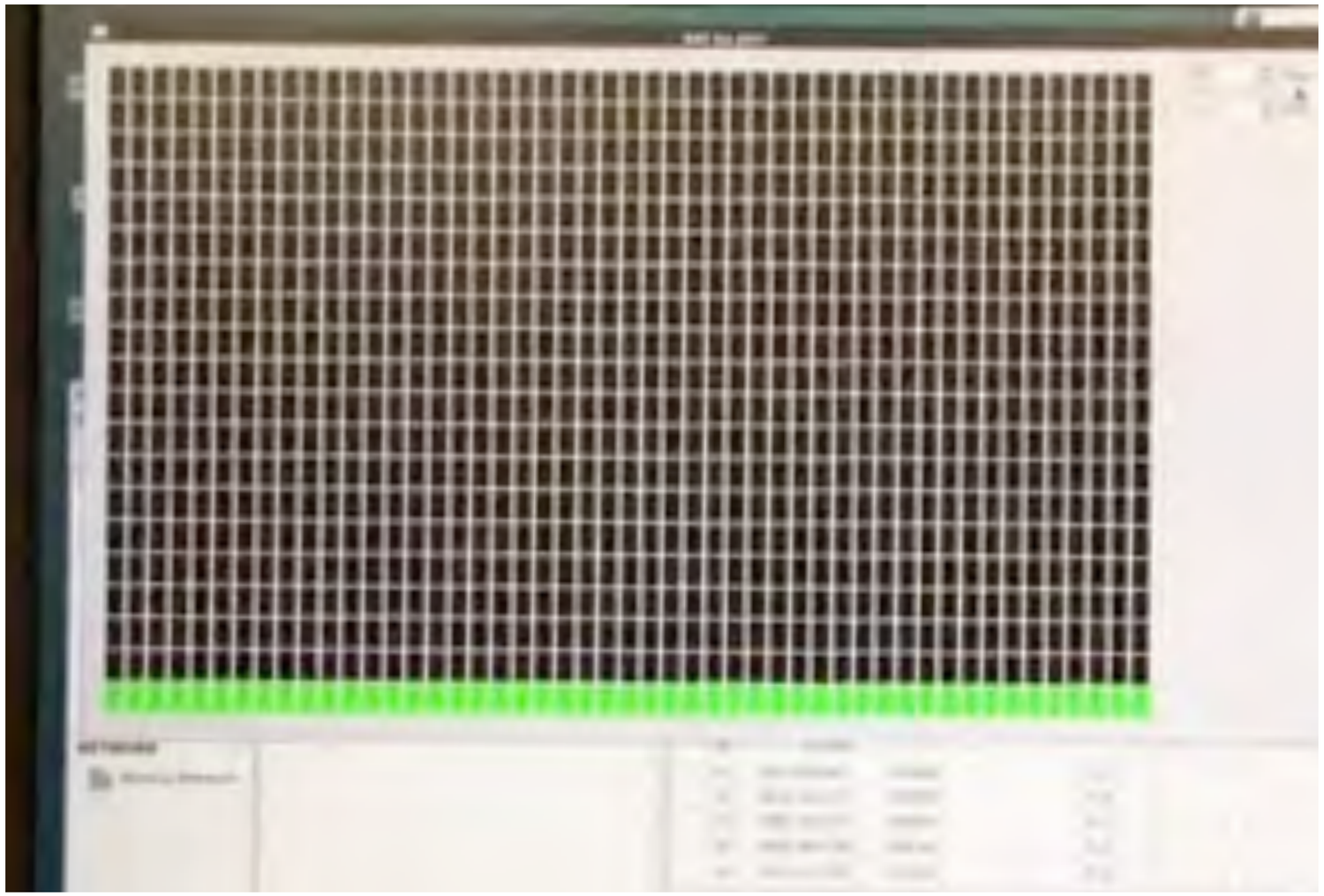


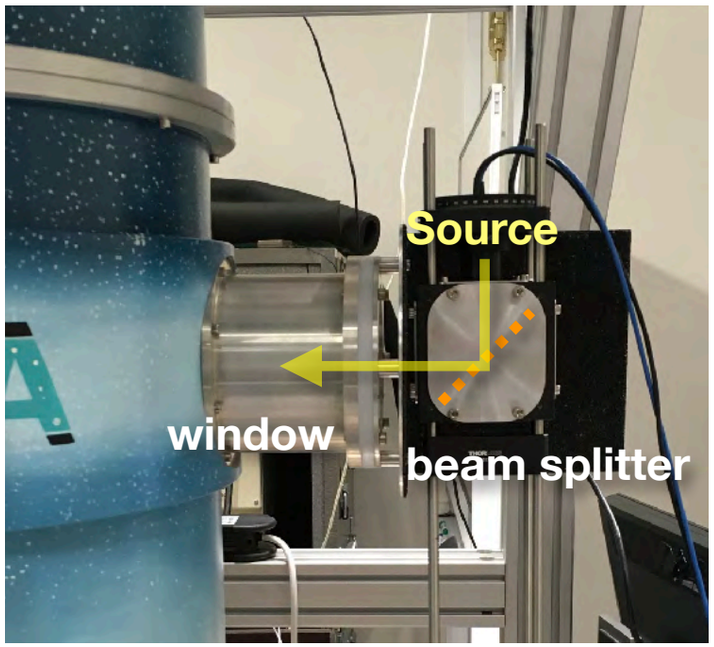
TU Delft Delft University of Technology · SRON Netherlands Institute for Space Research · Universiteit Leiden · 東京大学 The University of Tokyo · 名古屋大学 Nagoya University · NAOJ 国立天文台

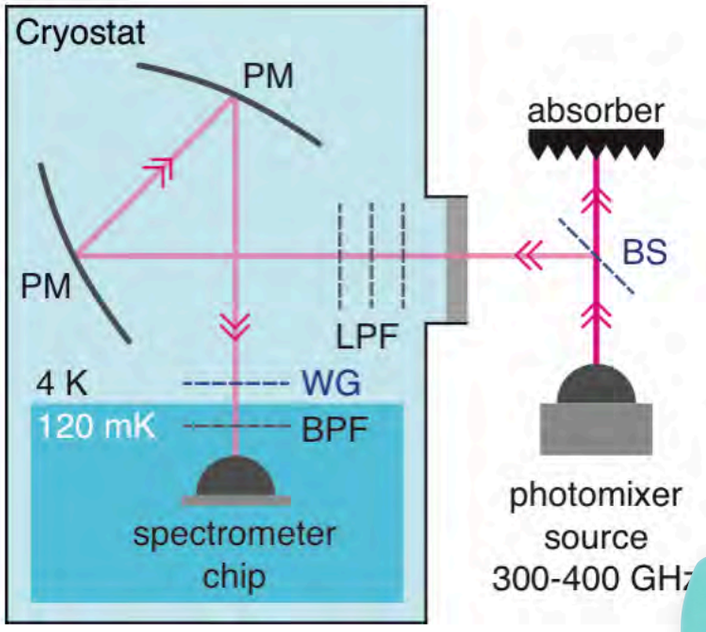
DESHIMA Cryostat:

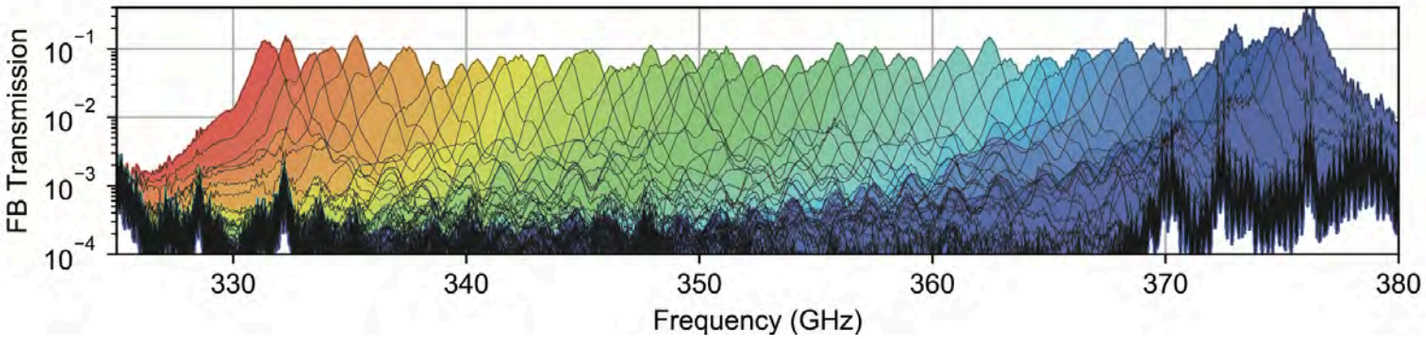


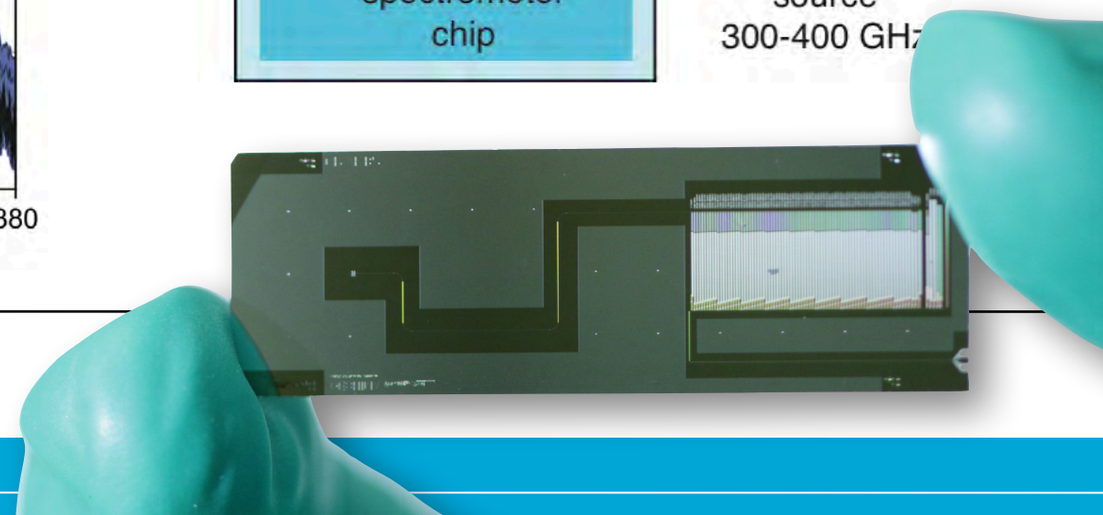
On-chip filterbank Frequency Response



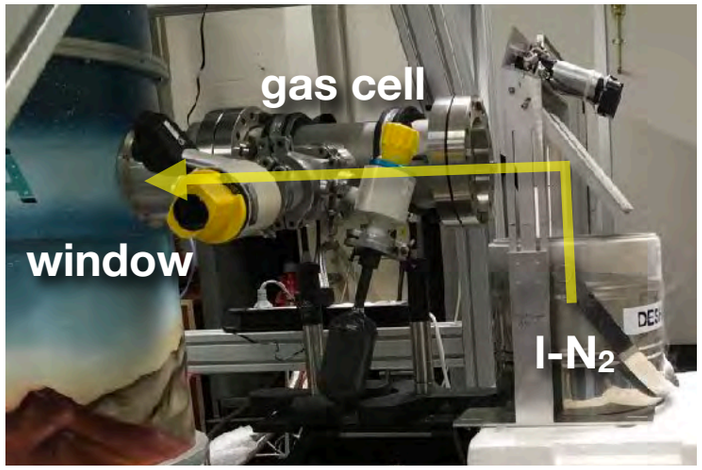


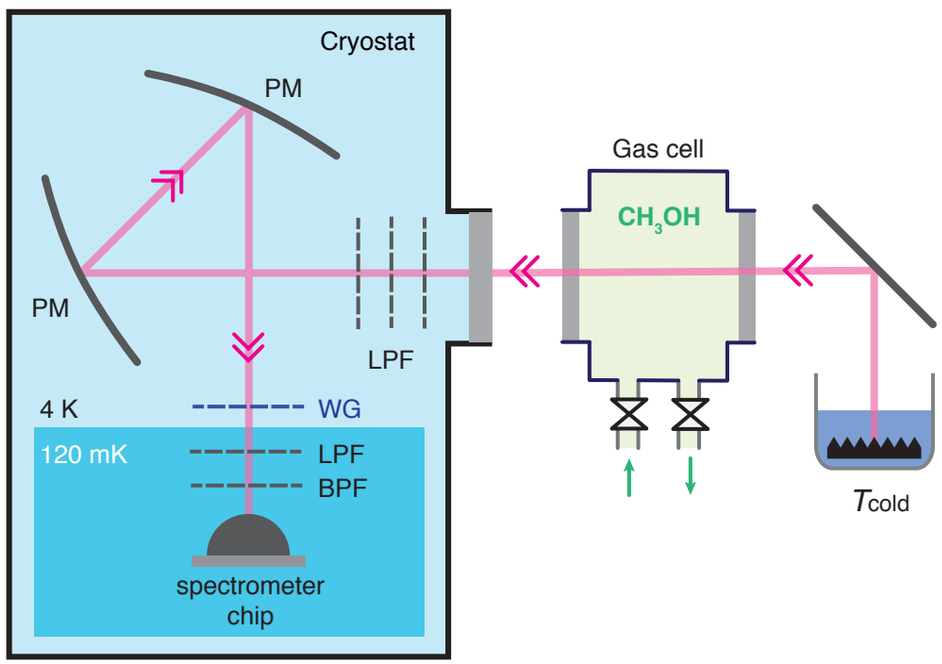


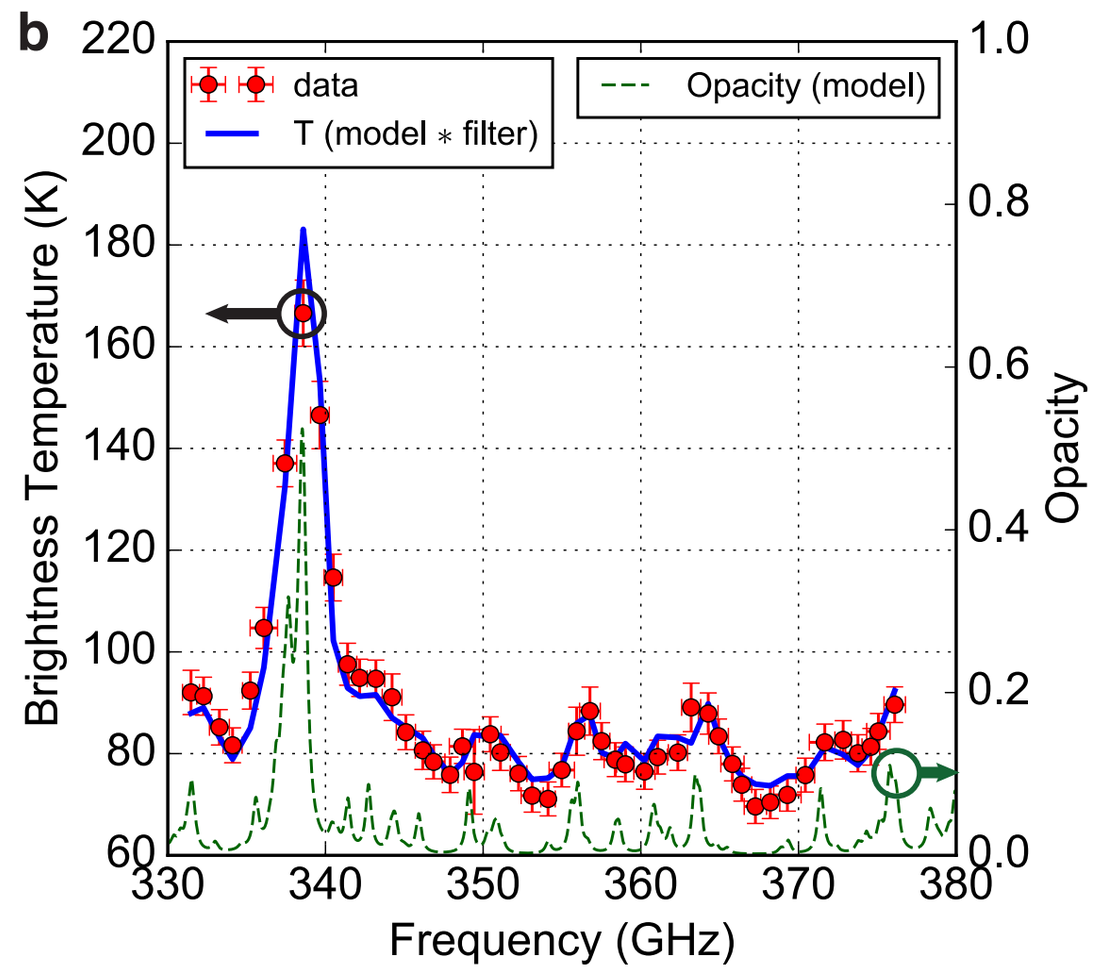




Detection of Methanol Emission Spectrum

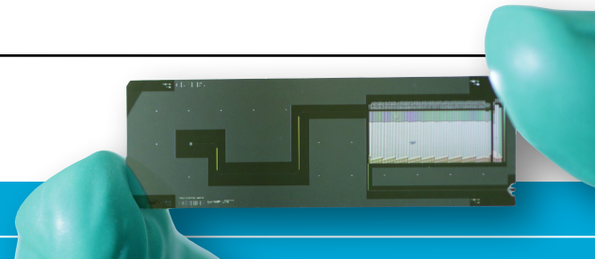






40GHz in single shot

Detected in a 2 GHz band

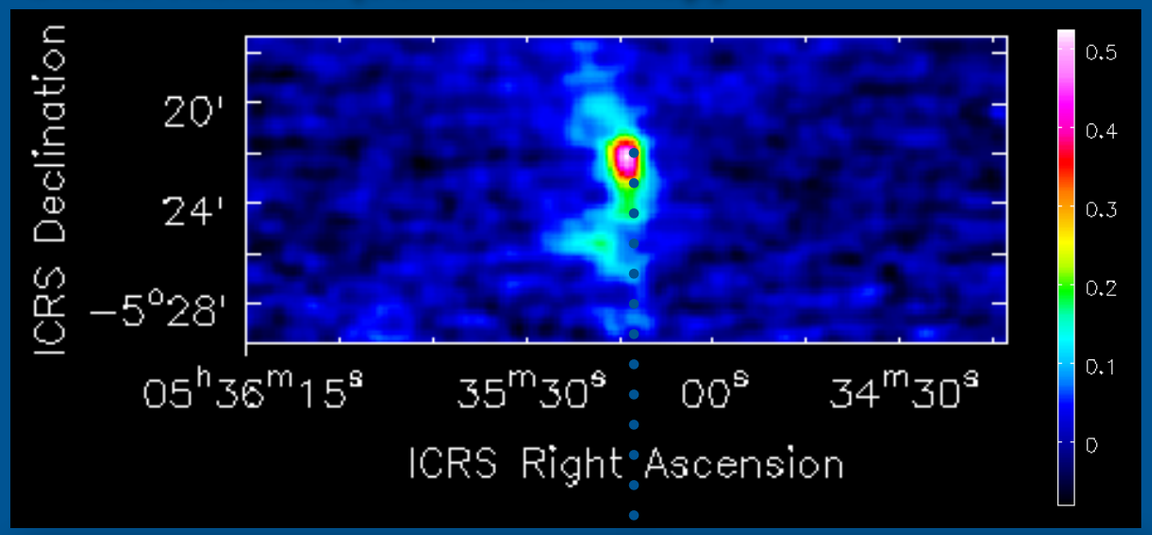


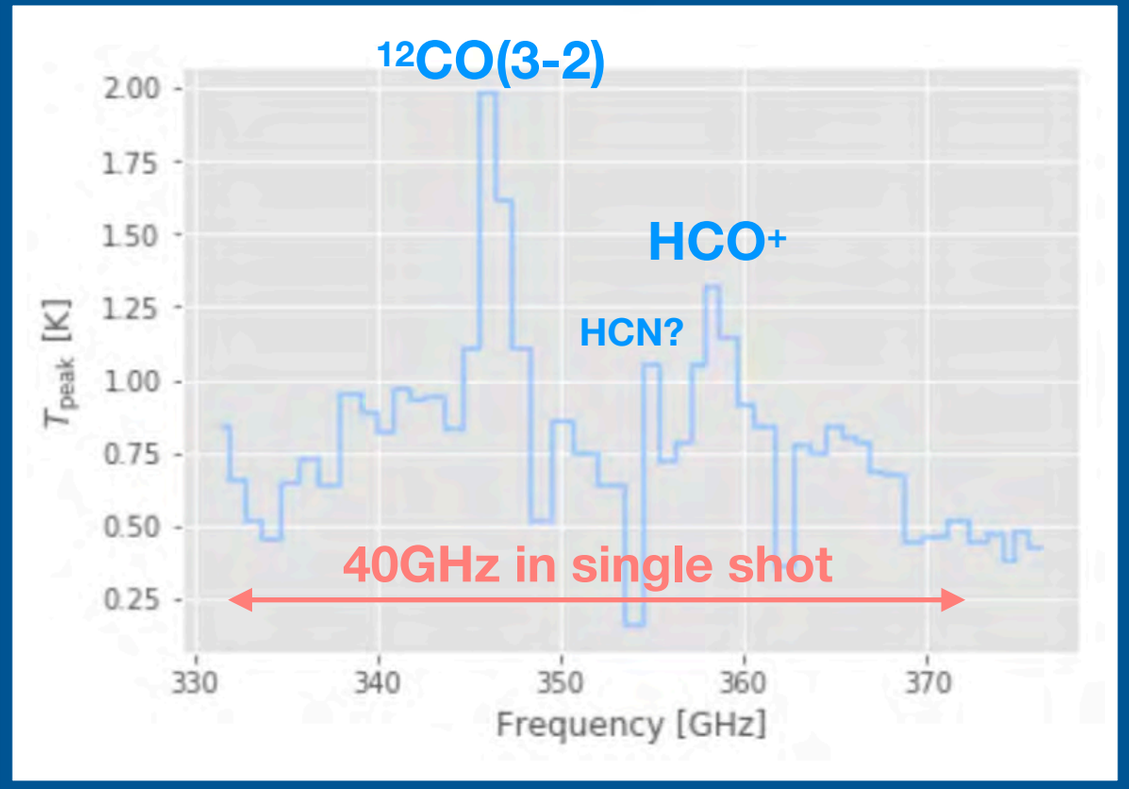
DESHIMA on ASTE system

DESHIMA

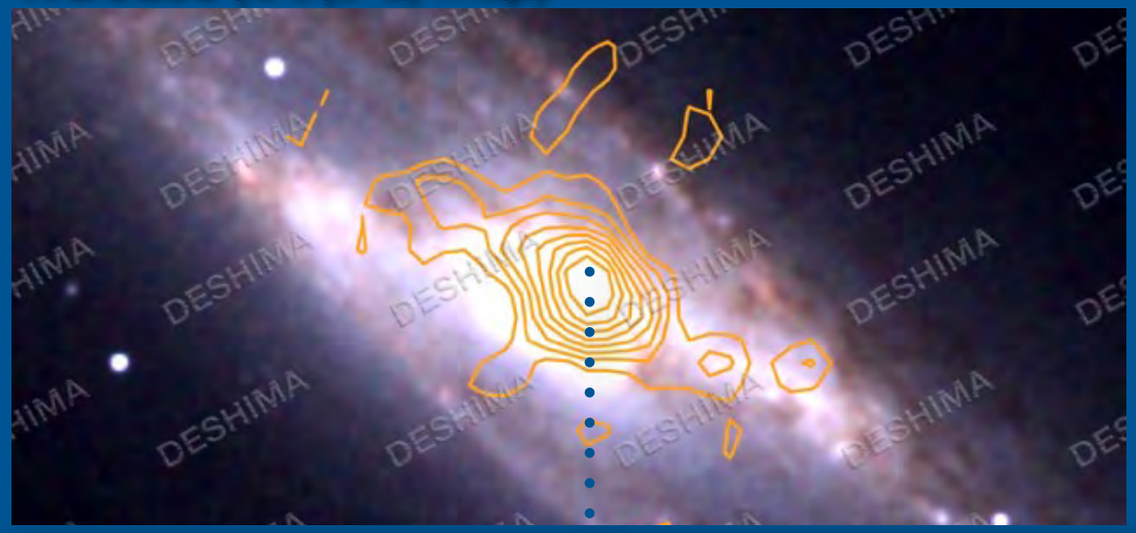
Showcase:
First Astronomical Spectra taken with DESHIMA

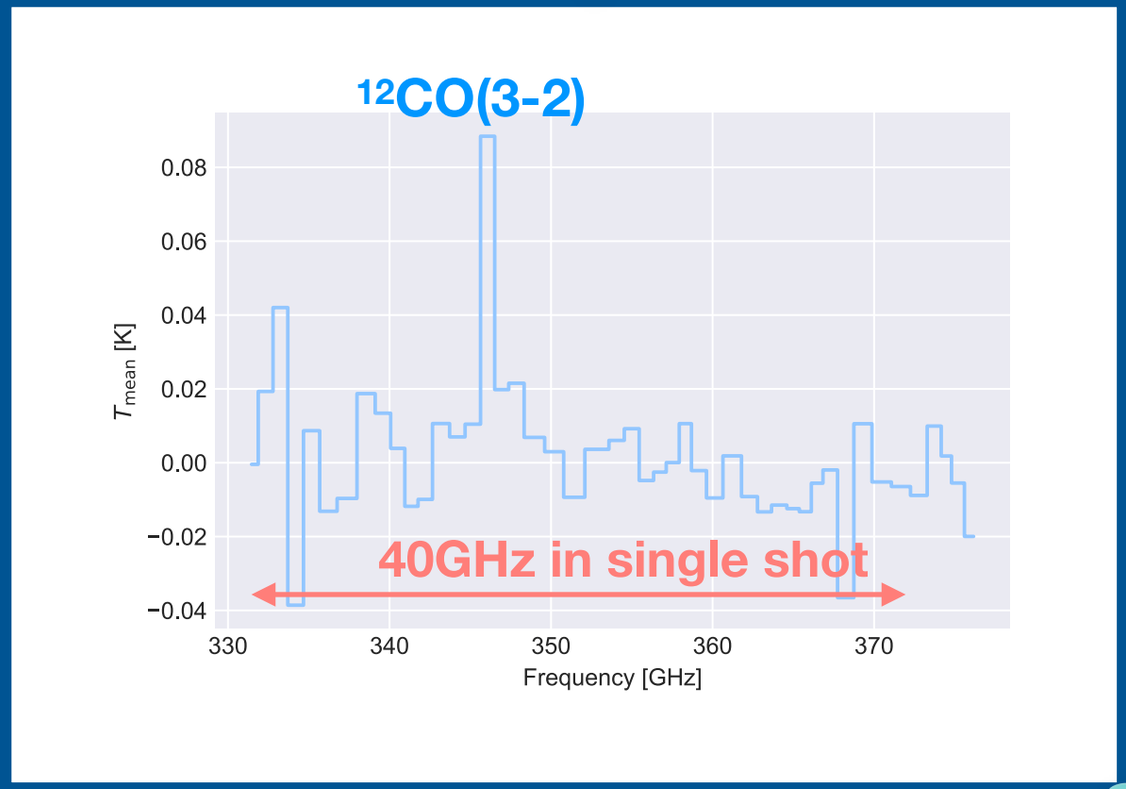
Orion Nebula (continuum map)





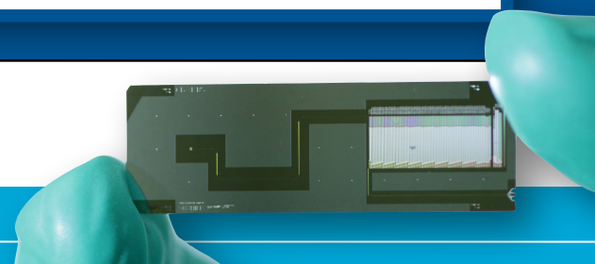
NGC253 (CO(3-2) map)





DESHIMA

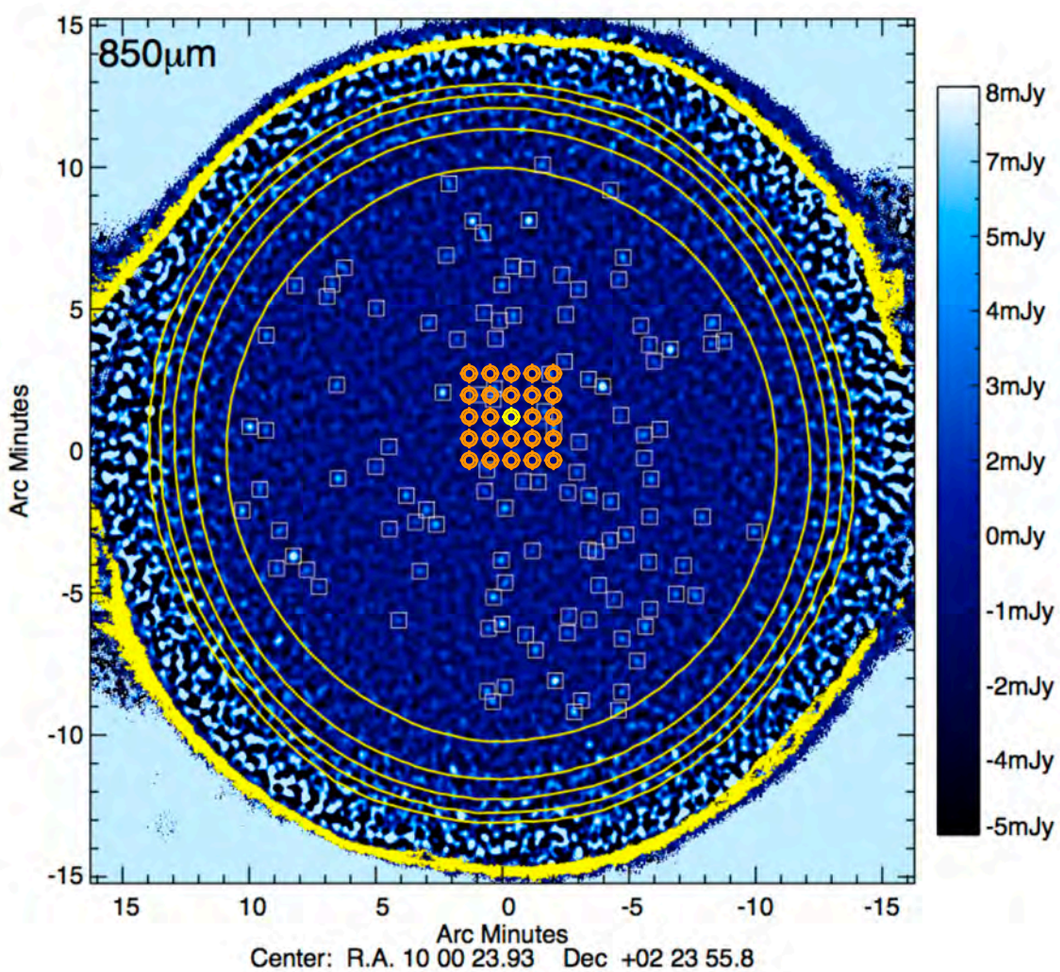
Various papers in (final) preparation

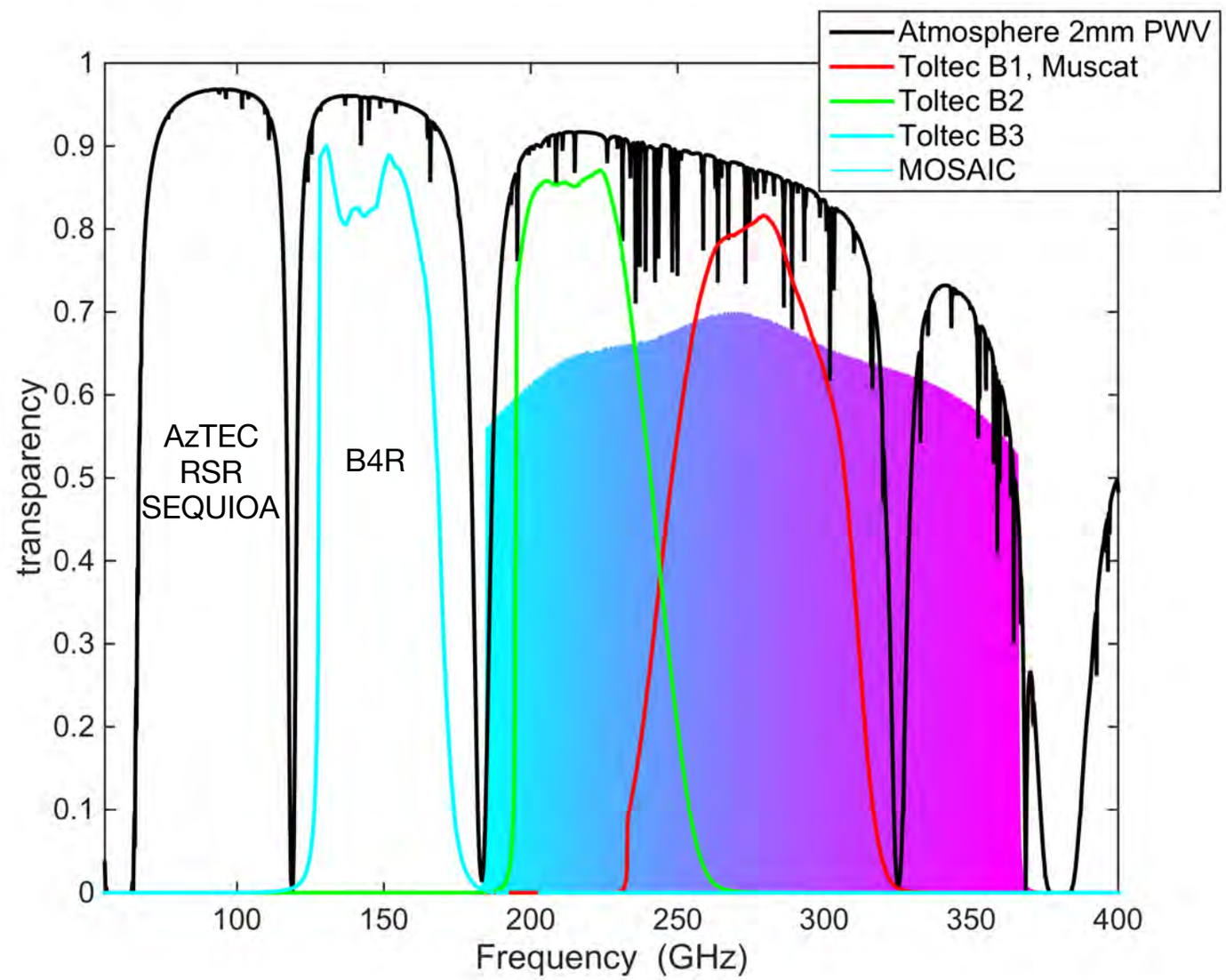


MOSAIC

an ultra-wideband multi beam spectrometer for the LMT

- 5x5 = 25 spaxel imaging spectrometer
- Frequency range: 185 - 365 GHz
  - ALMA Bands 5,6,7
  - 350 spectral channels (detectors) per spatial pixel
- Resolution: R = 500 (~ 600 km/sec)
- 8750 Detectors
- 4 backends
  - 2-4 GHz bandwidth each





C. M. Casey et al. 2013 Astro-ph, 1302.2619

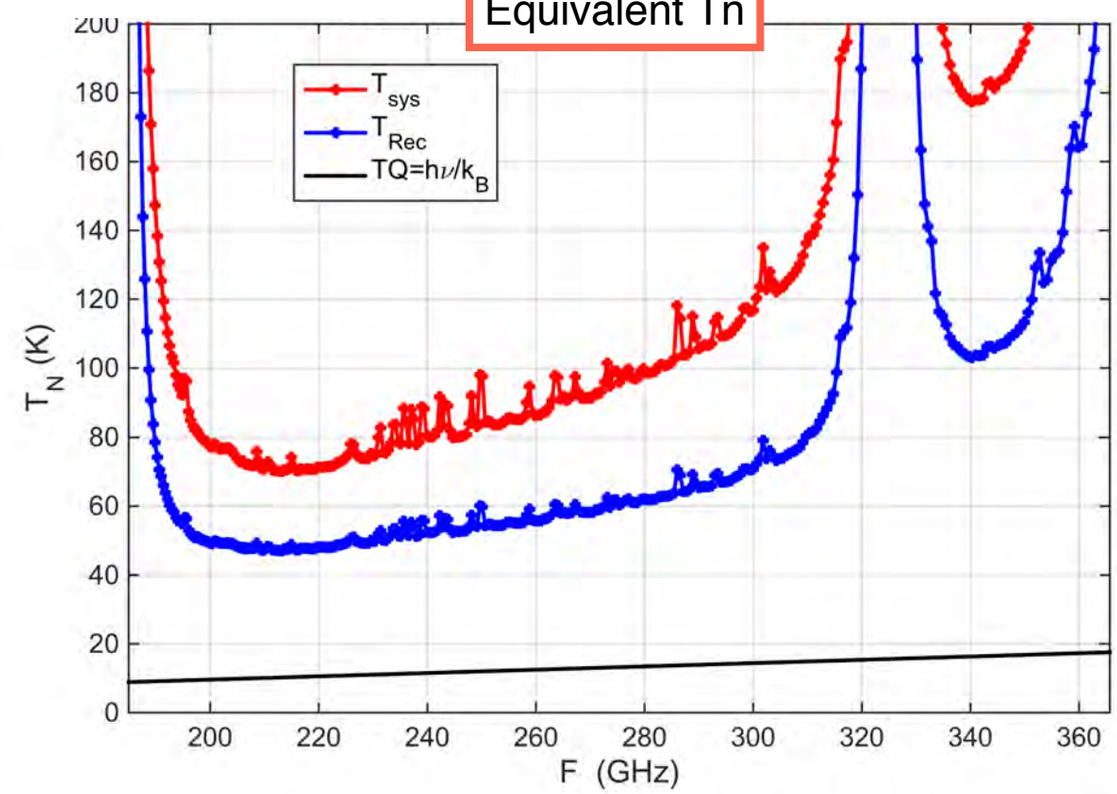
MOSAIC: Estimated single pixel sensitivity

Each pixel

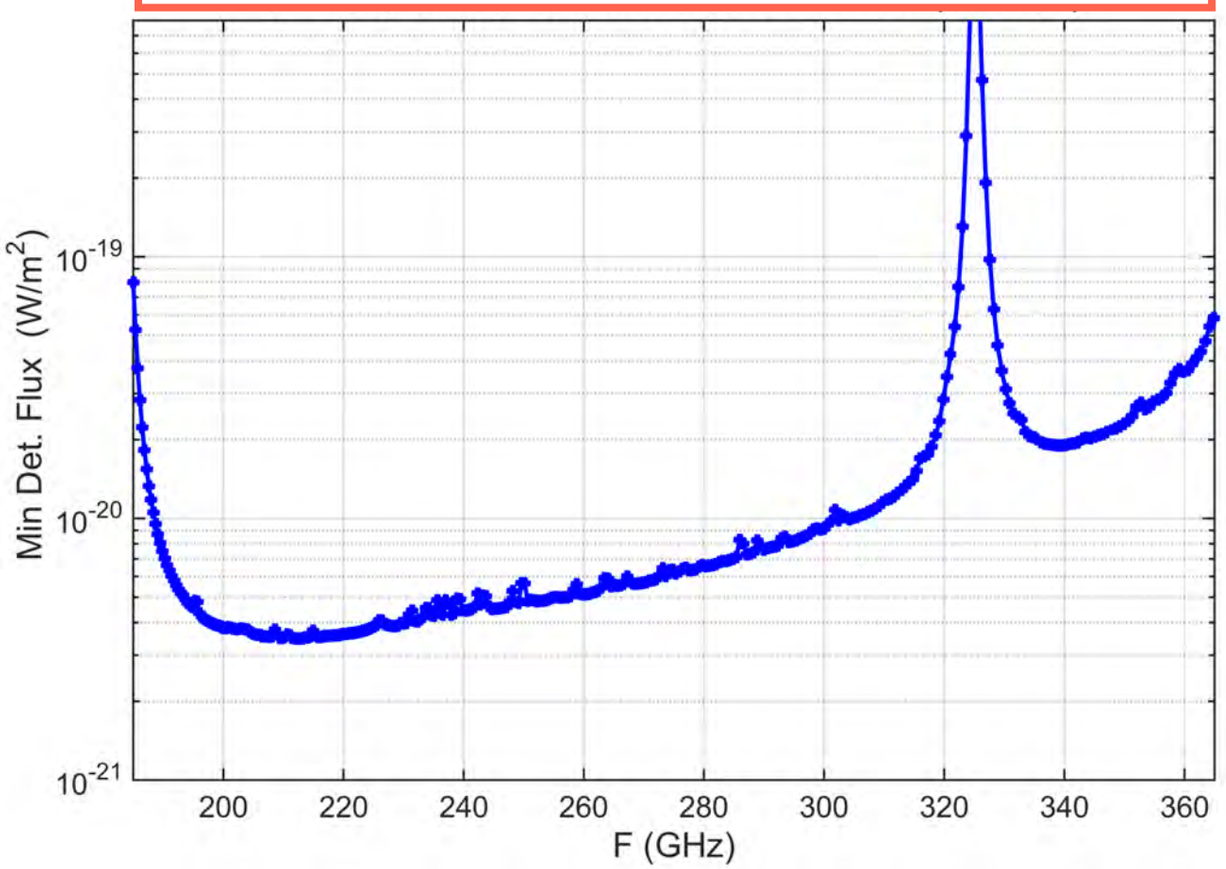
- T_{rec} ~ 50-100 K
- min. det. Flux < 10^{-20} W/m^2
  - 5σ, 8 hours, 40% on-source

=> allows huge discovery space

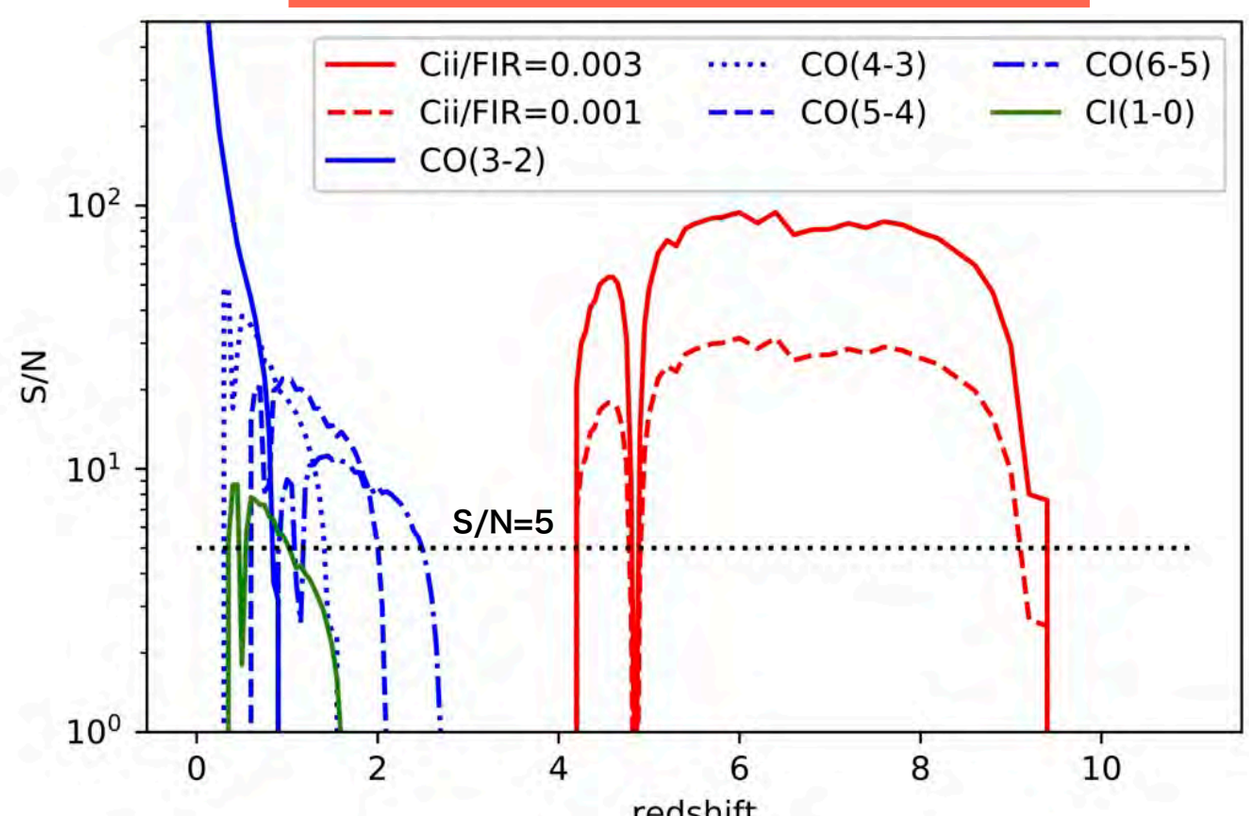
Equivalent Tn



Min. Det 5σ flux in 8 hours (40% duty cycle) 2mm PWV



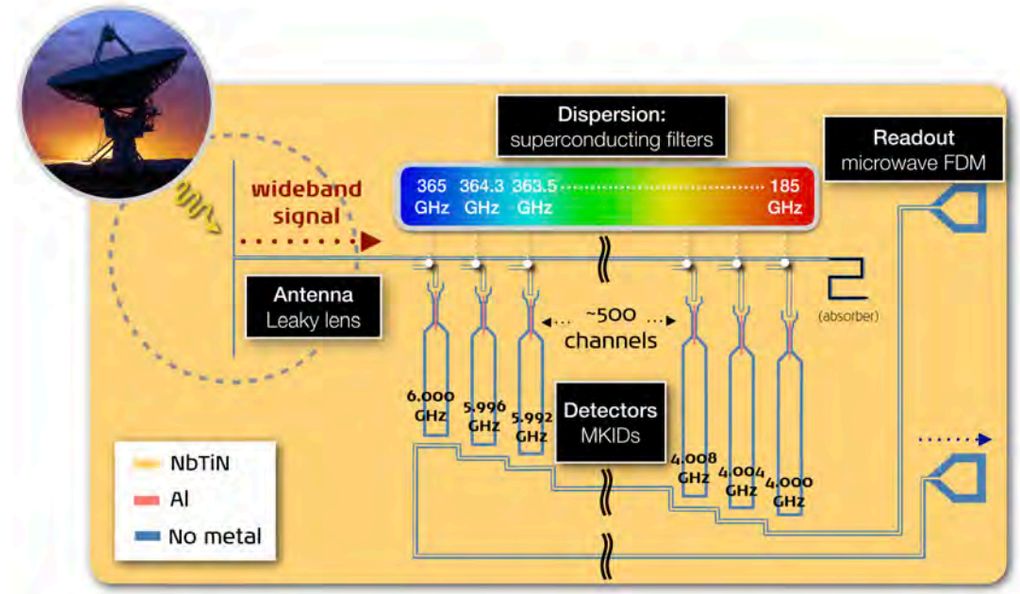
SNR for L_{FIR} ~ $5x10^{12}$ L_{sun} ,8 hours total

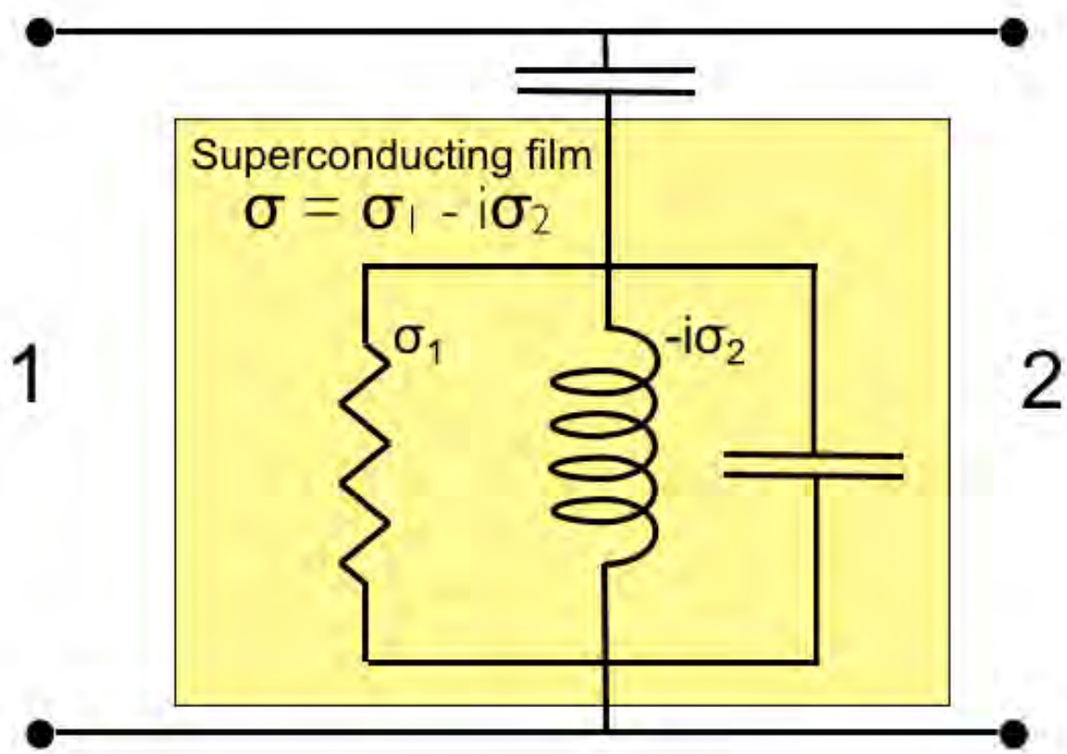


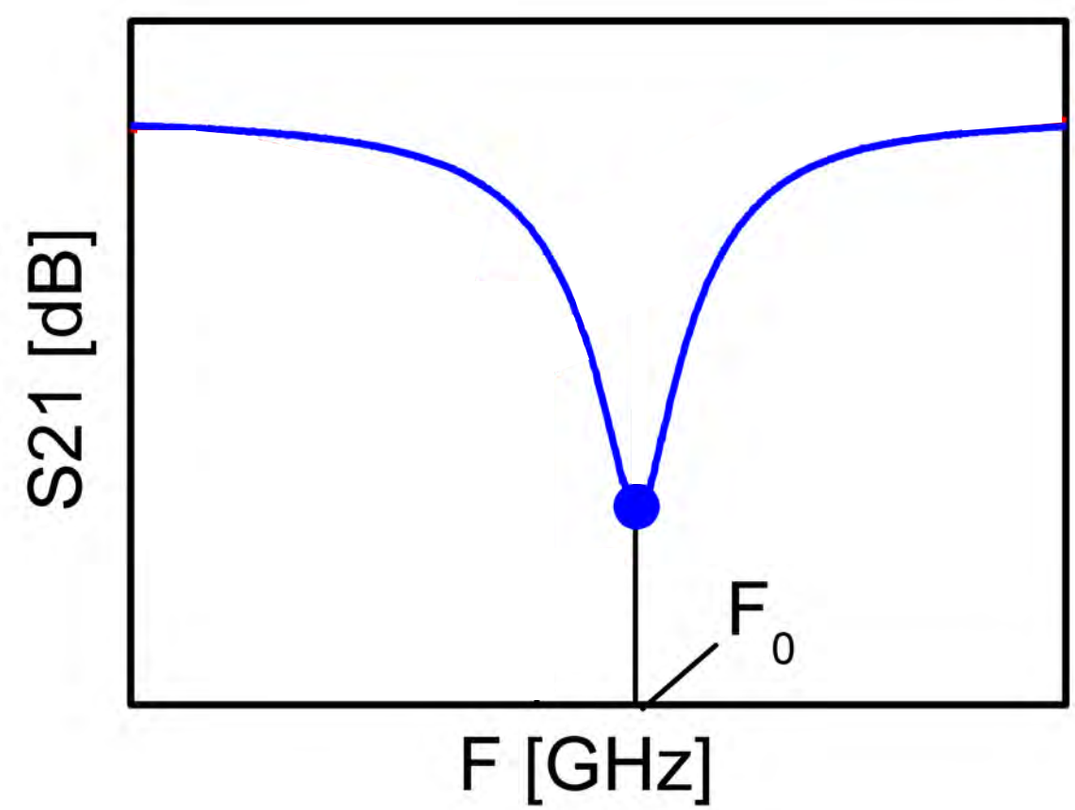
MKIDs

Superconducting microwave resonance circuit

- Capable of coupling to radiation







Day et al., Nature **425** *817 (2002)*

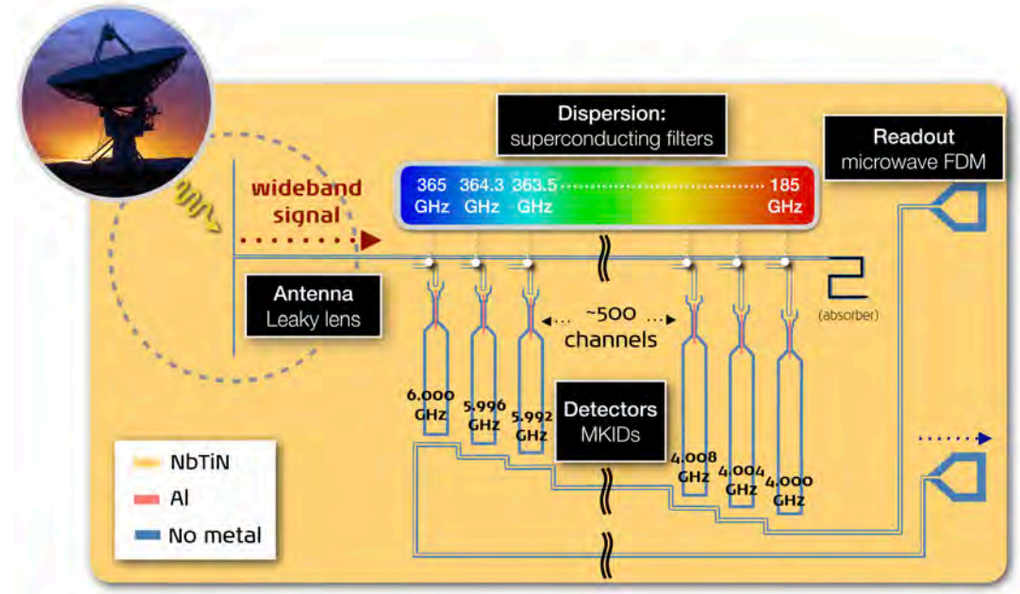
MKIDs

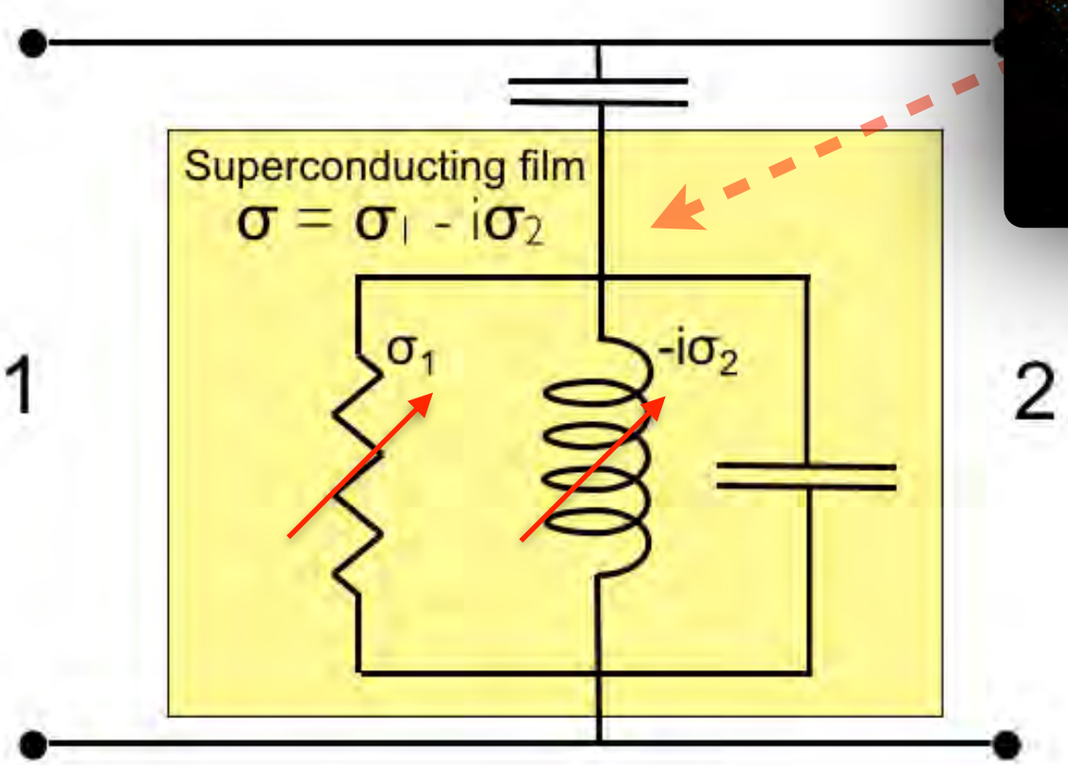
Superconducting microwave resonance circuit

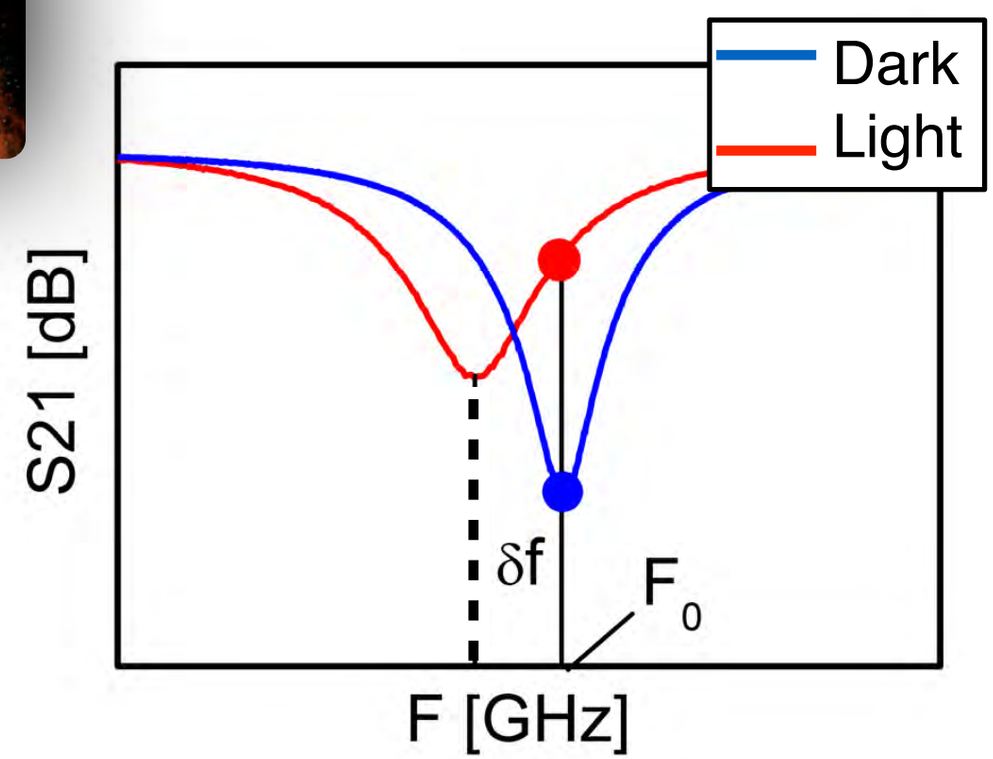
- Capable of coupling to radiation

Resonance changes upon radiation absorption

can be read out with 1 CW GHz tone

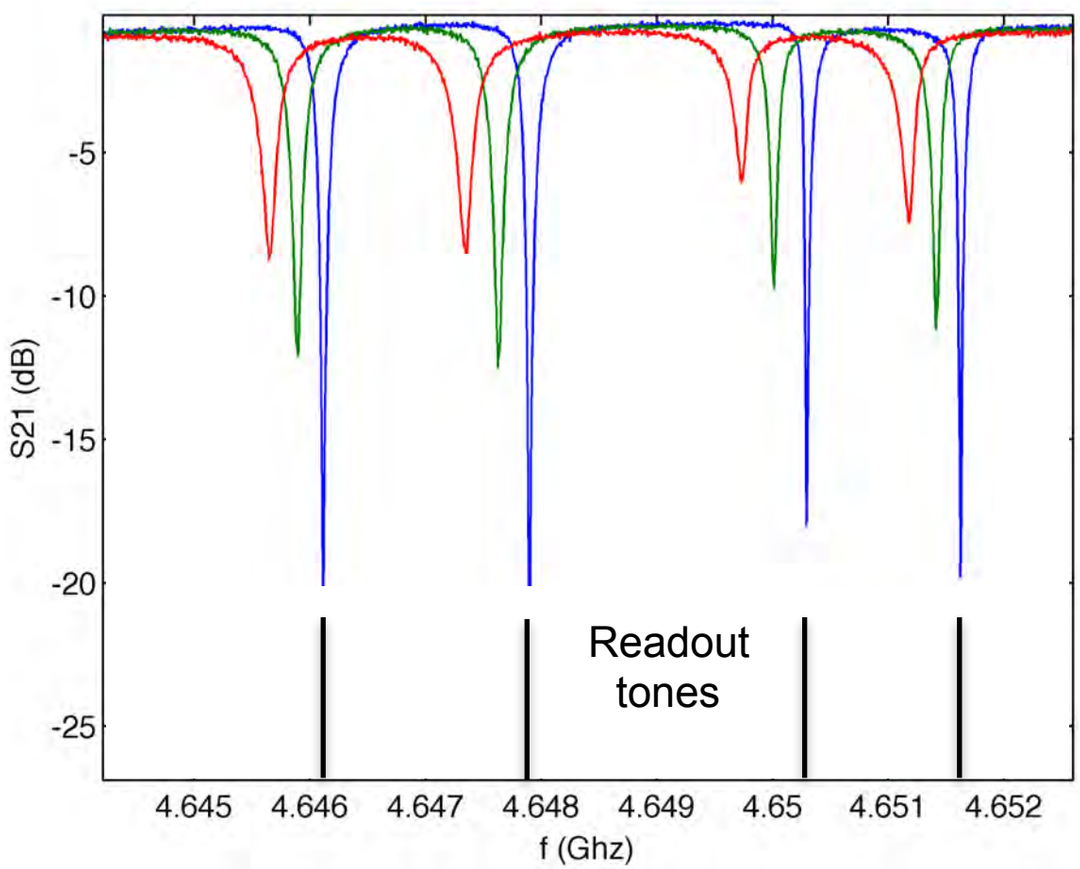


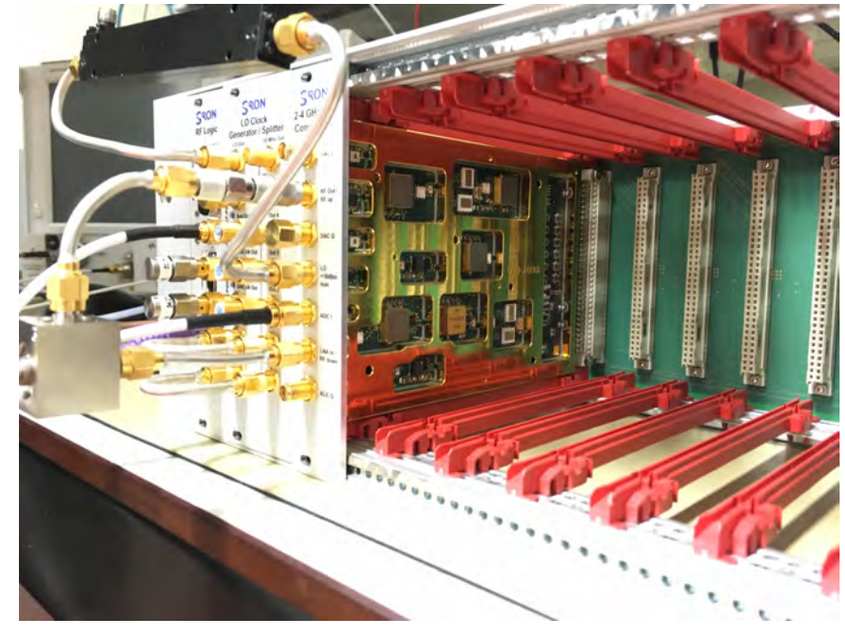


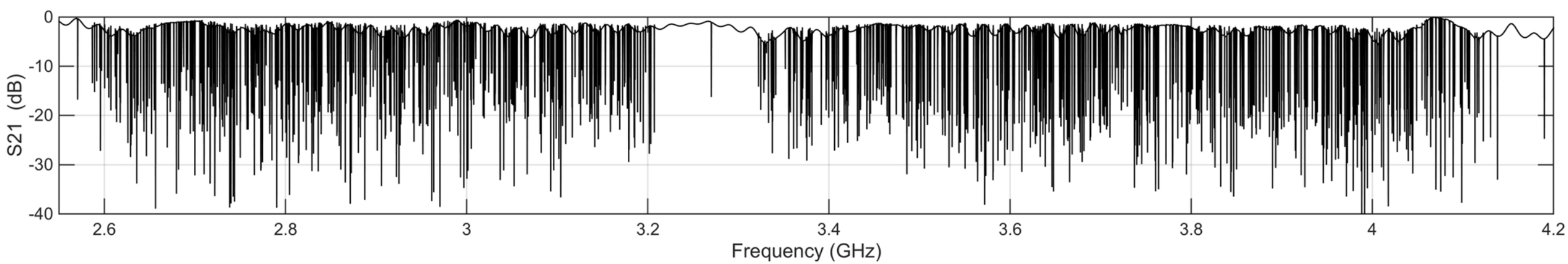


GHz FDM Readout

KIDs - high Q - small BW
~ 3000 KIDs per readout channel
SRON in-house system







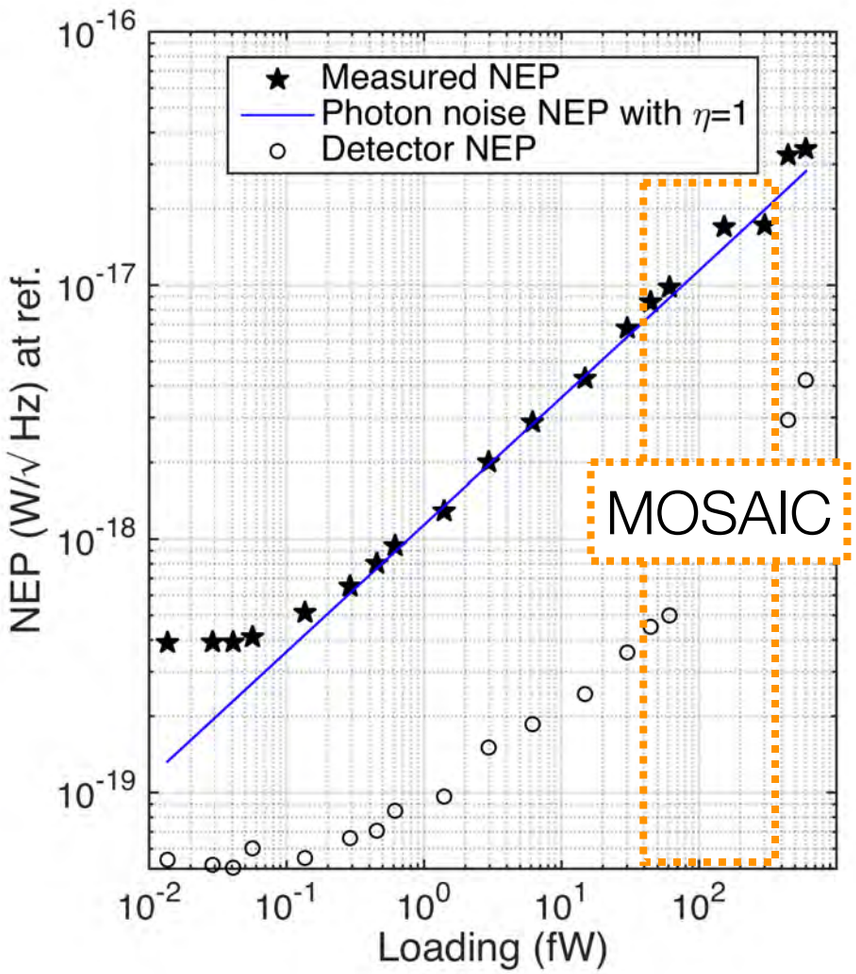
MKID + readout *system* sensitivity

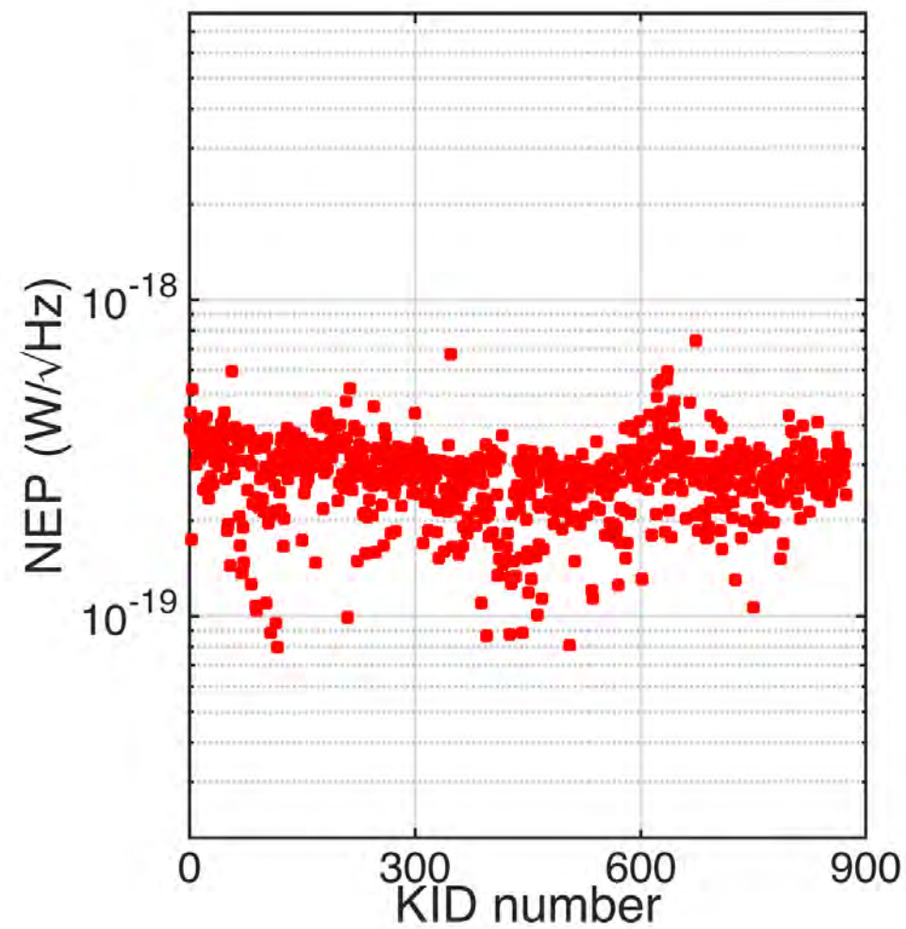
A&A 601, A89 (2017)
DOI: 10.1051/0004-6361/201629653

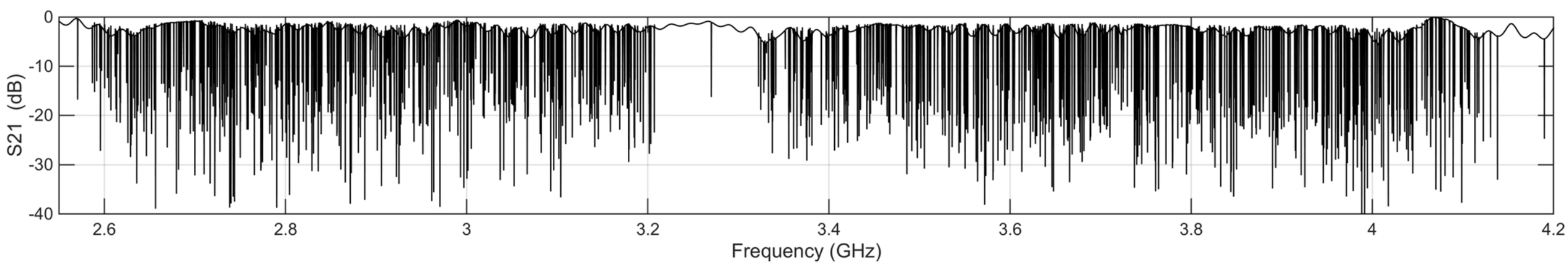
Astronomy & Astrophysics

A kilo-pixel imaging system for future space based far-infrared observatories using microwave kinetic inductance detectors

J. J. A. Baselmans[1,2], J. Bueno[1], S. J. C. Yates[3], O. Yurduseven[2], N. Llombart[2], K. Karatsu[2], A. M. Baryshev[3,4], L. Ferrari[2], A. Endo[2,5], D. J. Thoen[2], P. J. de Visser[1], R. M. J. Janssen[3,6], V. Murugesan[1], E. F. C. Driessen[7], G. Coiffard[7], J. Martin-Pintado[8], P. Hargrave[9], and M. Griffin[9].

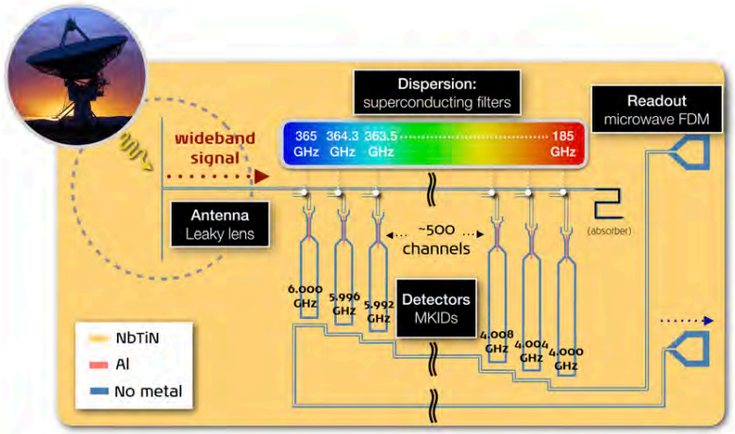


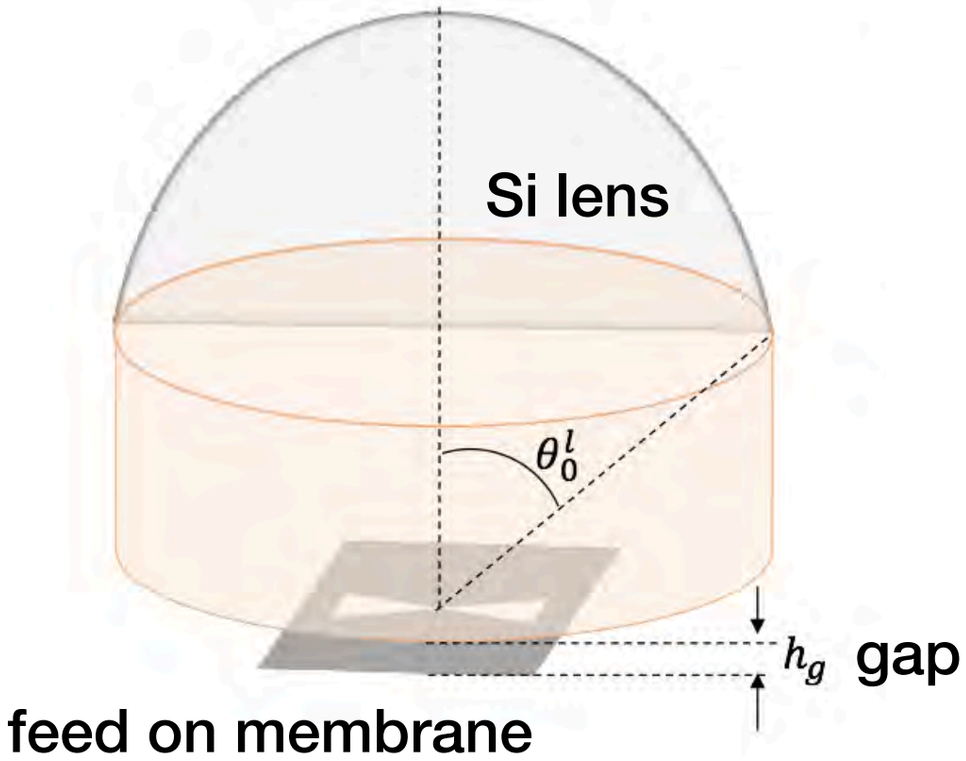


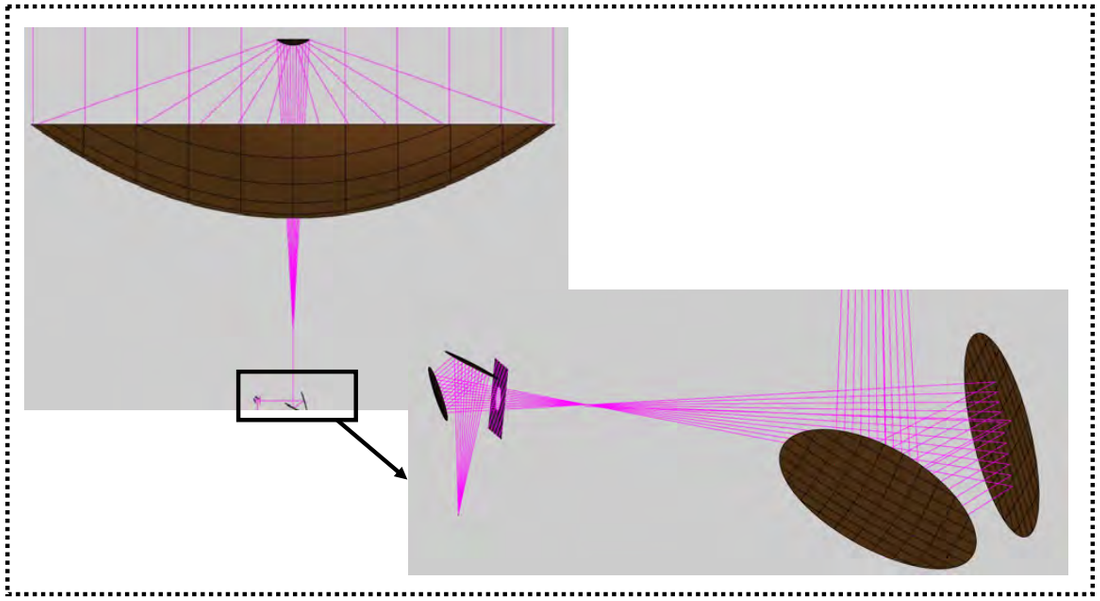


Broad band Antenna

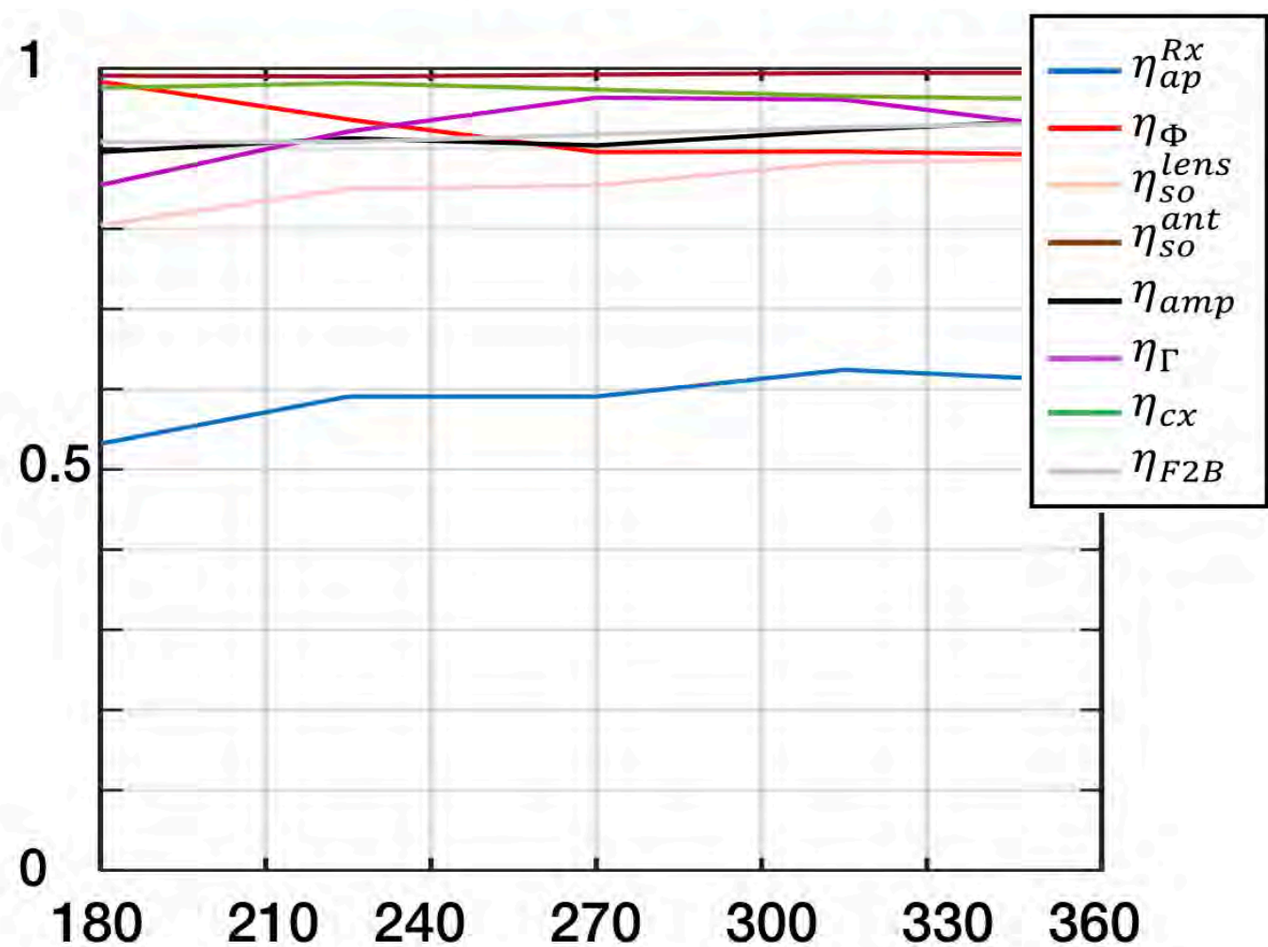
New concept: Leaky-wave antenna







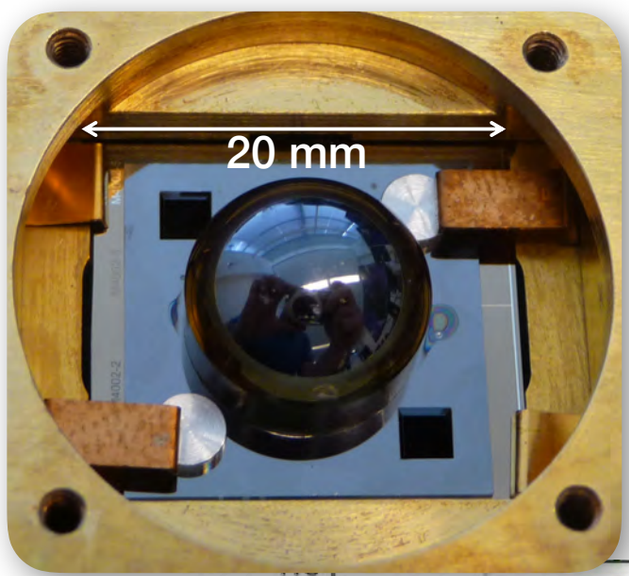
Simulated performance full optics

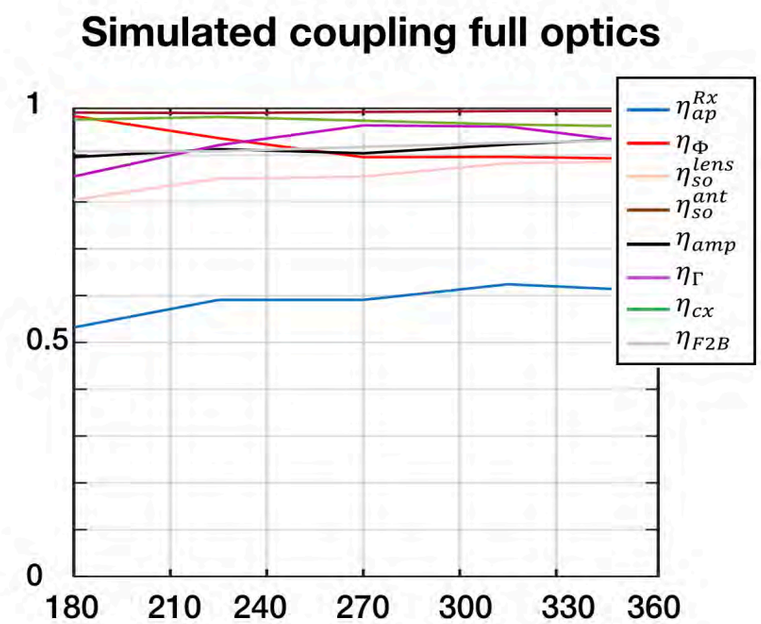


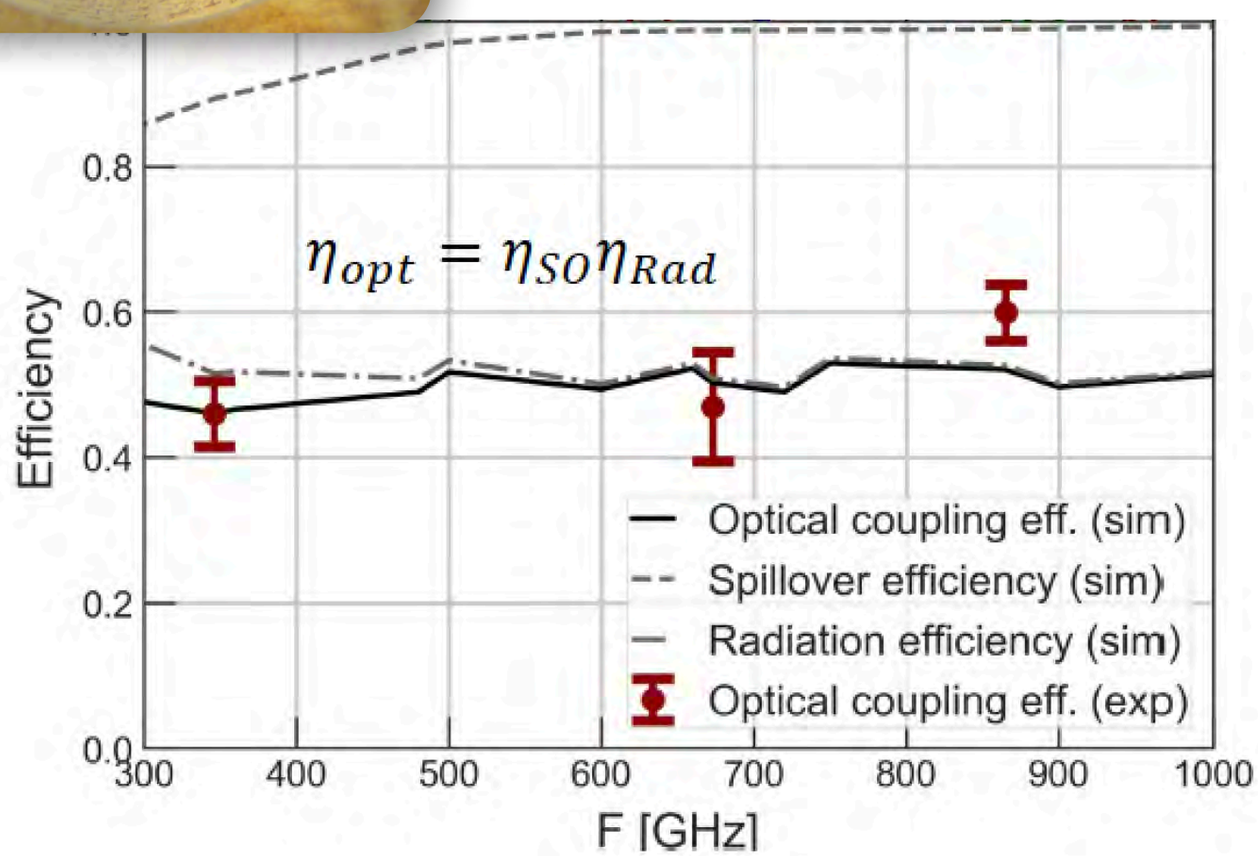
Broad band Antenna

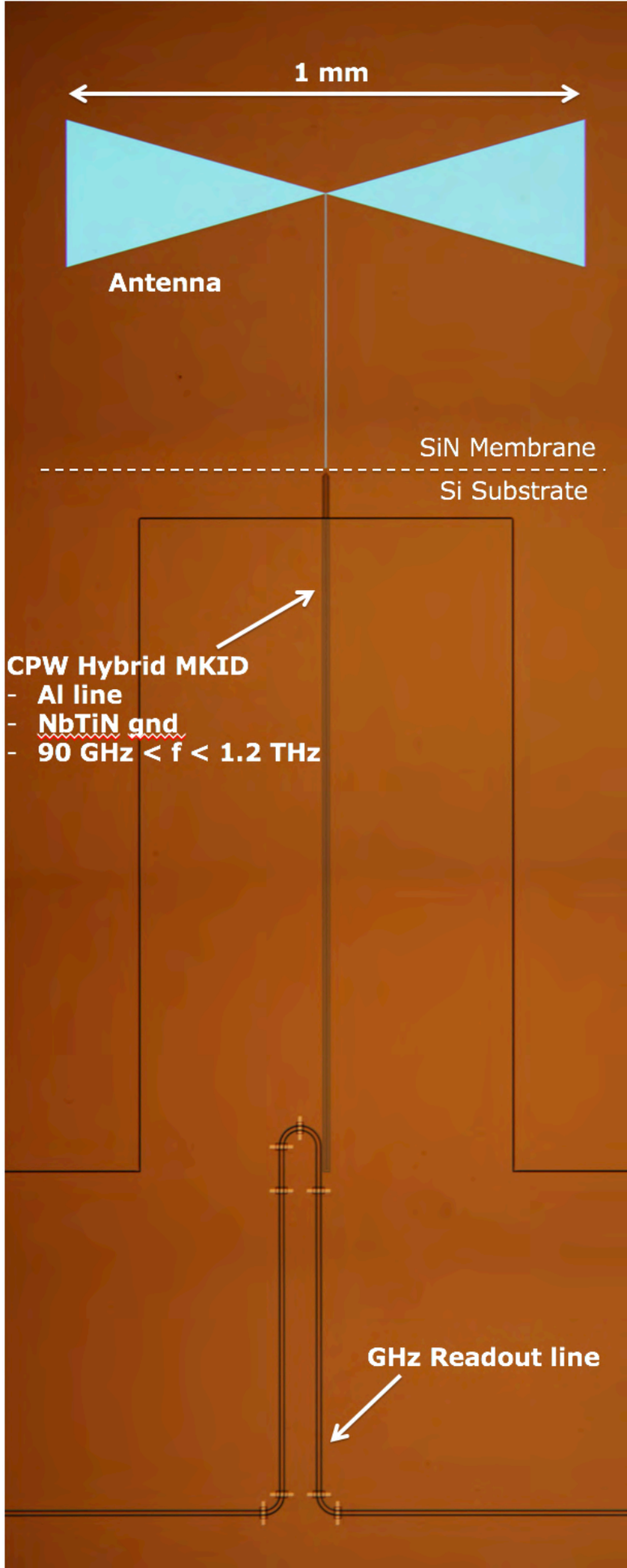
Experimental validation

- 1:3 bandwidth
- efficiency as predicted





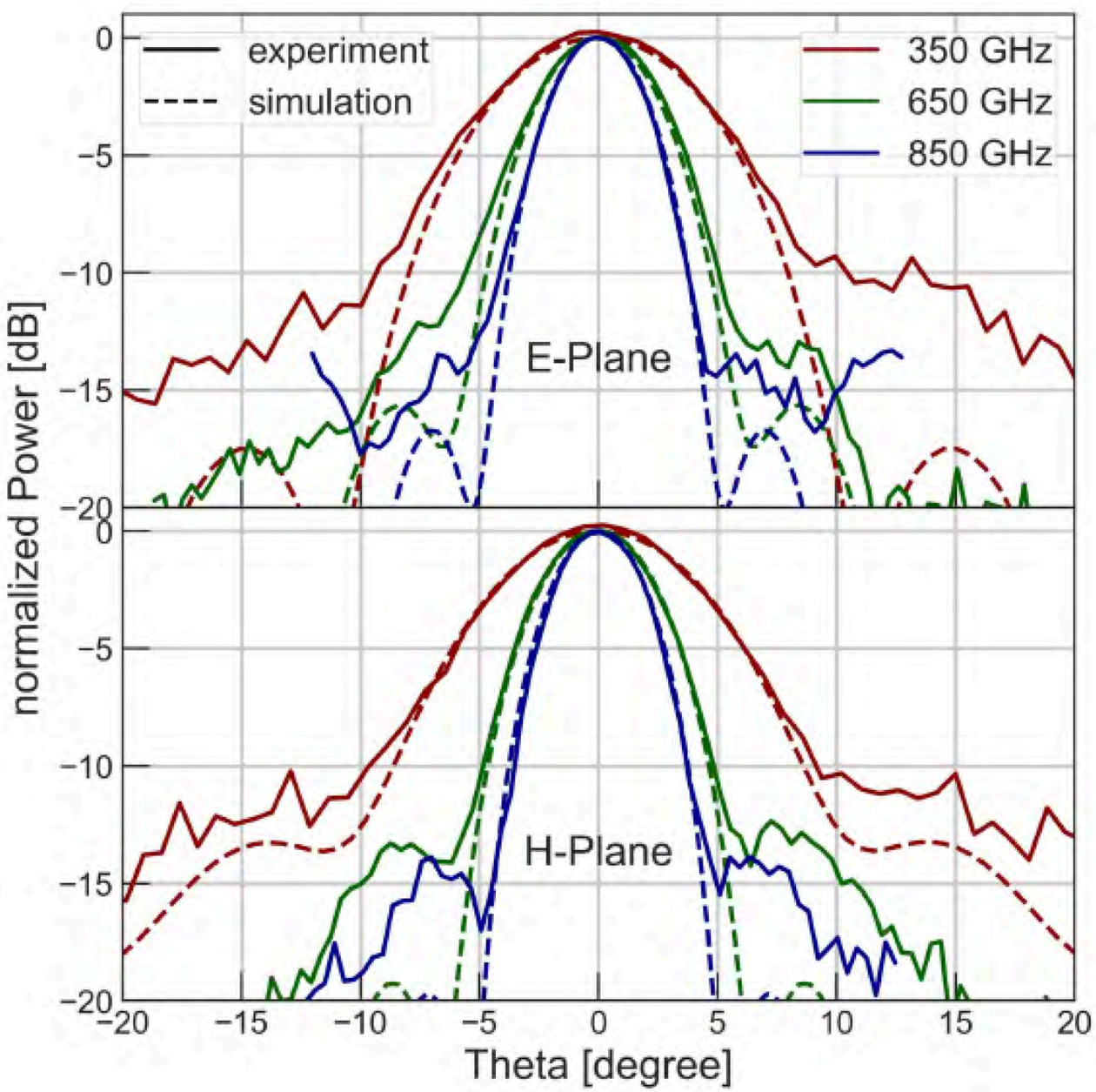


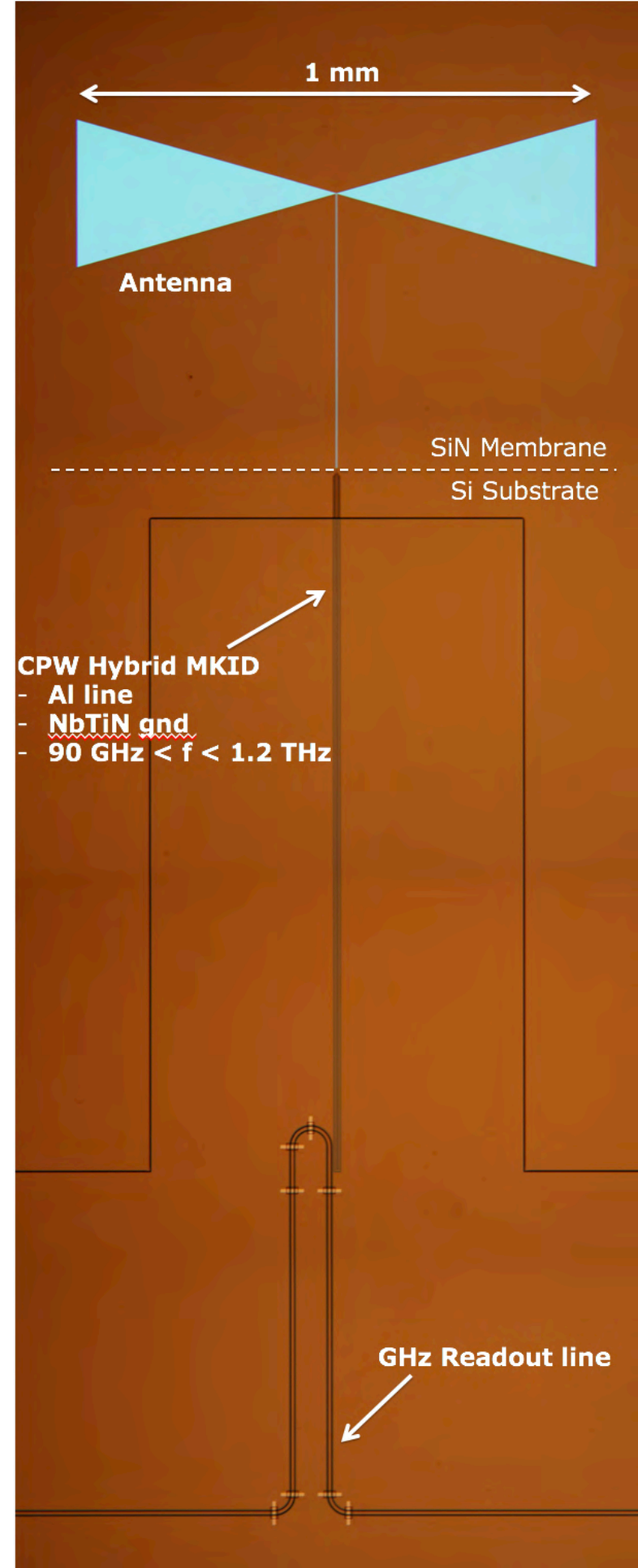


Broad band Antenna

Experimental validation

- x 3 bandwidth
- efficiency as predicted
- Lens - antenna patterns are good and follow simulations





MOSAIC

Large Japanese - Dutch team

- Building upon Herschel - HIFI, ALMA and Deshima heritage

Proposing ~25 pixel imaging spectrometer for the LMT

- 185-365 GHz, R = 500, (part) steerable
- synergetic with existing mm-wave spectroscopic LMT instruments and Deshima @ ASTE