Recent Developments in Detector Technology for sub-mm Astronomy

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on behalf of many others

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What will I be talking about

*Kinetic Inductance Detectors*

- Large imaging arrays
- On-chip Spectrometers
- Ultra wideband THz-antenna
Large Imaging Arrays
Science case: Many Pixels, > few 1000

Each dip = 1 detector pixel
The Kinetic Inductance Detector

- Superconducting film
- Inside a microwave resonance circuit
- Capable of coupling to radiation
  - $Q \sim 10^4 - 10^6$
  - $F_0 \sim 1-10$ GHz

![Diagram of the Kinetic Inductance Detector](image)
The Kinetic Inductance Detector

- Superconducting film
- Inside a microwave resonance circuit
- Capable of coupling to radiation
  \[ Q \sim 10^4 - 10^6 \]
  \[ F_0 \sim 1-10 \text{ GHz} \]
**Implementation**

- **Transmission line**
- **Lenses**
- **CPW resonator**
- **Antenna**

- **Al:** $F_2\Delta \approx 80$ GHz
- **NbTiN:** $F_2\Delta \approx 1.2$ THz

200 µm
KID Imaging Array

- Resonators coupled to a transmission line
- Resonators have different length - different resonance frequencies
- All antenna’s are identical
- Covered with flies eye lens array
5 feedlines
5400 pixels
Si lens array
Readout ~1000 pixels / GHz
Sensitivity: Limited by noise in photon arrival rate
A-MKID

World’s largest submm camera, 2x4 segments, 25120 MKIDs
FOV: 15 arcmin x 15 arcmin
An On-Chip Spectrometer: Deshima
C$^+$ \((z=1; 7.7 \text{ Gyr})\)
$C^+ (z=1: 7.7 \text{ Gyr})$

$C^+ (z=5: 12.5 \text{ Gyr})$

The graph shows the relationship between frequency (THz) and flux density (Jy). The data points are plotted along the graph, with different colors representing different epochs of cosmic evolution.
C\(^+\) (\(z=1: 7.7\) Gyr)

C\(^+\) (\(z=5: 12.5\) Gyr)

0.3-1 THz: 1.5 Octave
A Microwave Trick:
Photon sorting with superconducting micro-filters

Signal from space

To separate detectors

~1000 more filters

100 µm

Filters

Cosmology with Nanotechnology
Deshima chip

KIDS

40µm

1 mm
Deshima chip

KIDS

40μm

1 mm

NbTiN

25μm

Ta

NbTiN

Ta

NbTiN
First laboratory demonstration:
Spectroscopy with an On-chip Filterbank

600-700 GHz tunable source
1.1 THz lowpass filter

chip behind lens @ 300 mK
A novel broad band THz antenna
The leaky lens antenna

Wide Band
Stable directive patterns
Stable phase centers.

Making the THz leaky

- SiN membrane 3 µm
- SiN layer 3 µm
- Si Chip 520 µm
- Ta superconductor 200 nm
  With KID and leaky feed
- Vacuum gap 35 µm
- Glue
- Si Spacer chip
- Si Lens
3 µm SiN membrane + 525 µm Si wafer

3 µm SiN membrane
RADIATION PATTERNS

350 GHz

650 GHz

850 GHz
Frequency dependent response

![Graph showing frequency dependent response](image)