

USA OF

**GROUPEMENT D'INTÉRÊT  
SCIENTIFIQUE KIDS**

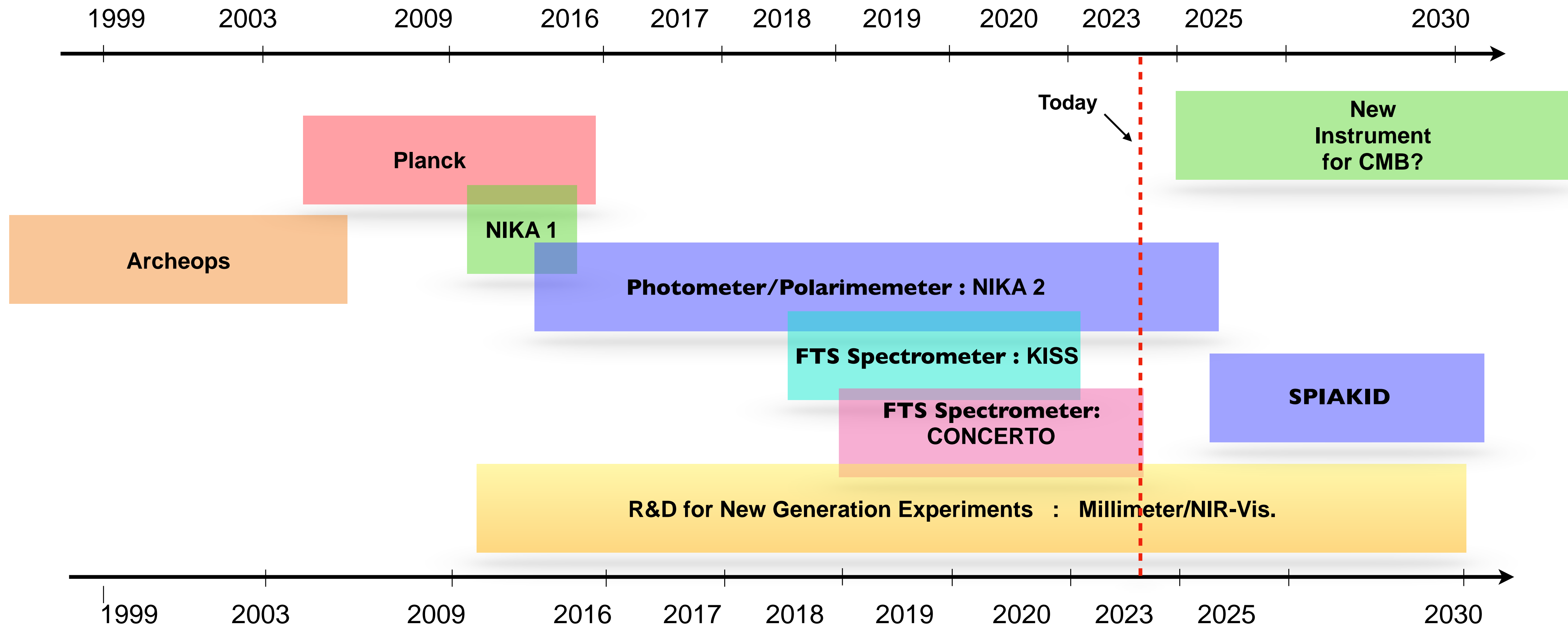
*Développement de matrices de Détecteurs à Inductance Cinétique et de leur Electronique multiplexée*



# Activités KID at IN2P3

# Background

**Our activities are always driven by real instruments...**



- Most of this work has been developed in a strong collaboration between institut Néel (INP), LPSC (IN2P3) and IPAG (INSU). These three labs together with IRAM are consolidating through a GIS (*Groupement d'intérêt scientifique*).
- Since 2015 APC started an R&D activity on KID for parallel development on Antenna-Coupled KID for mm science application and LEKID for visible and NIR bands for spectro-photometric imaging.

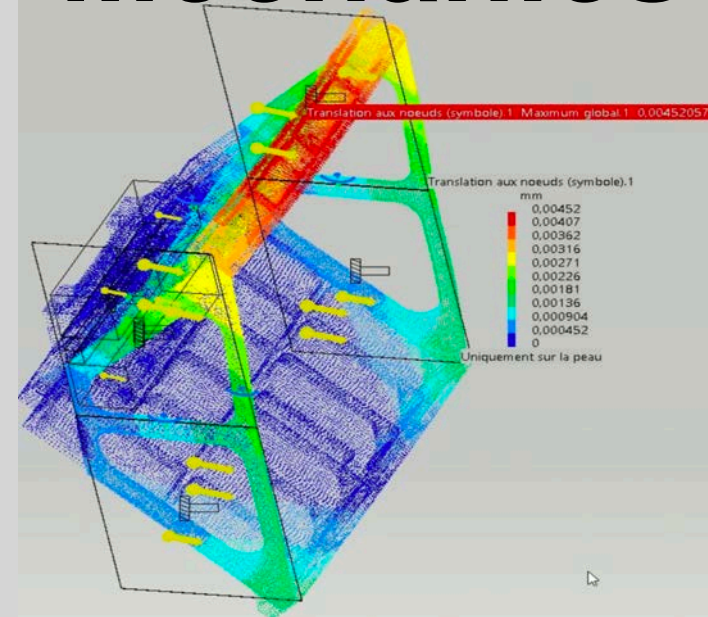


# Core Technology: KID

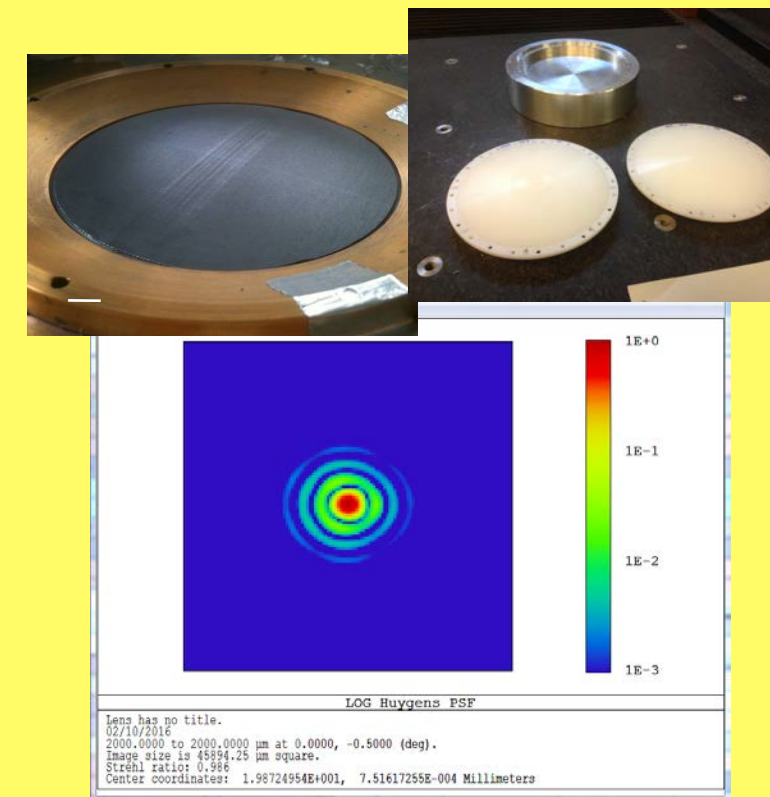
## Cryogenics



## Mechanics

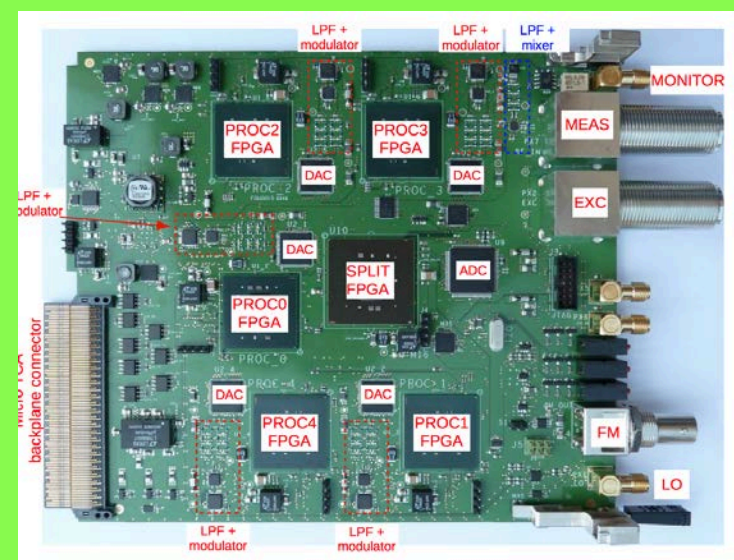


## OPTICS

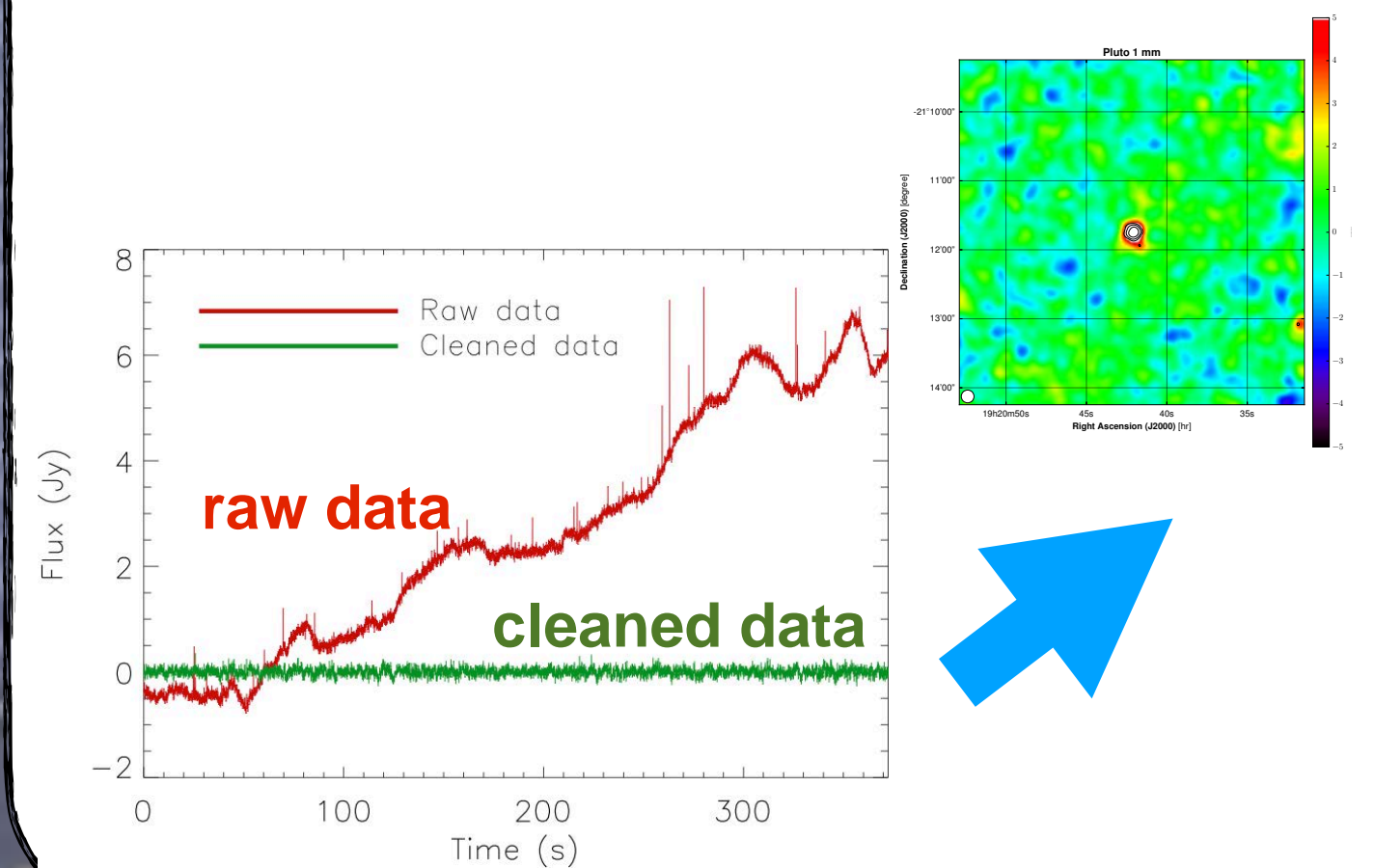


# KID

## Electronics



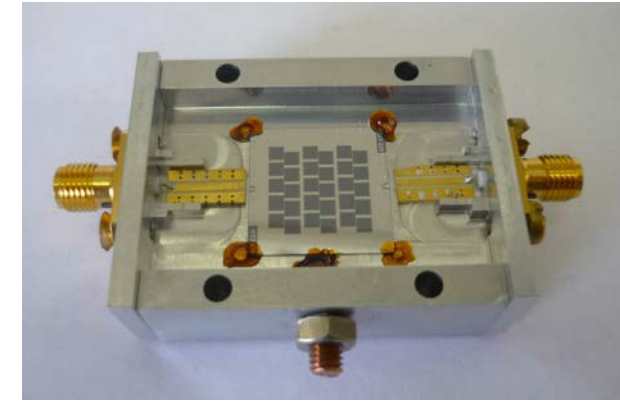
## Data Acquisition-Pipeline



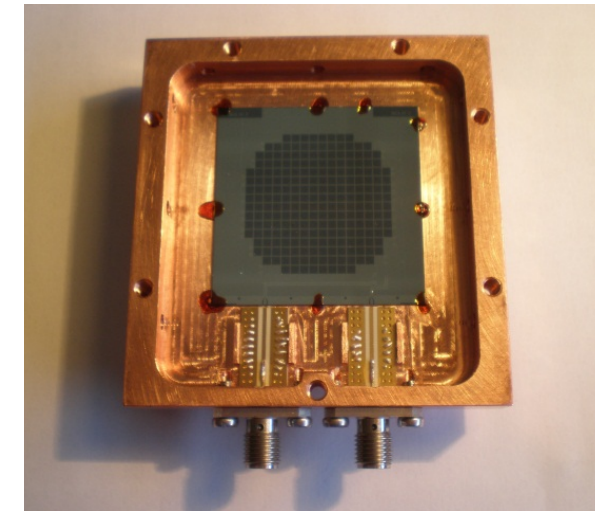
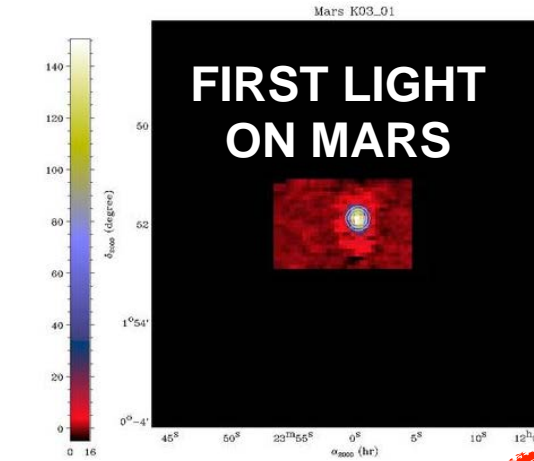


# KIDs Development

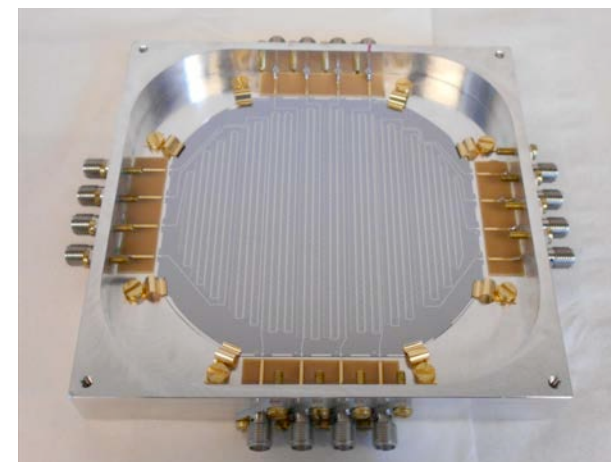
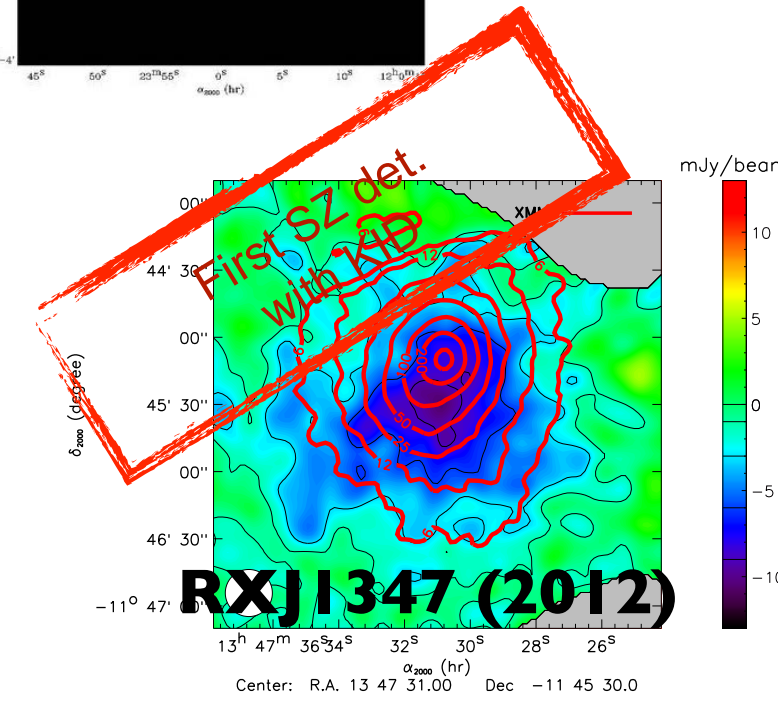
**KID has been validated in several bands**



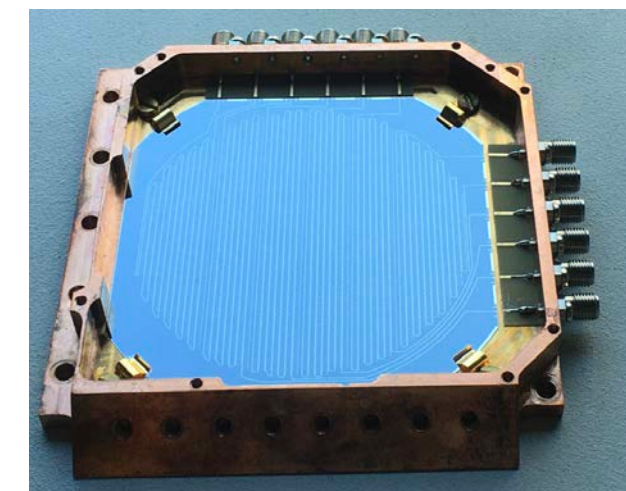
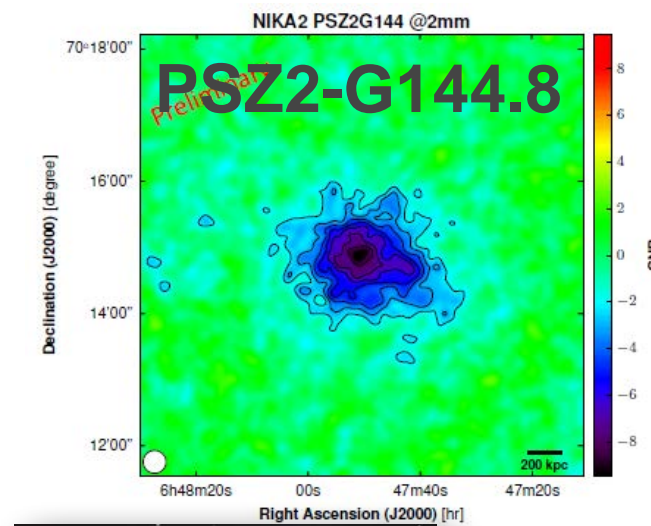
**2009**  
→  
**30 Pixels**



**2010-2013**  
→  
**200 Pixels**



**2014-2015**  
→  
**1000 Pixels**



**2015-Today**  
→  
**2000 Pixels**



**Today**  
→  
**8000 Pixels**

**Prototype**

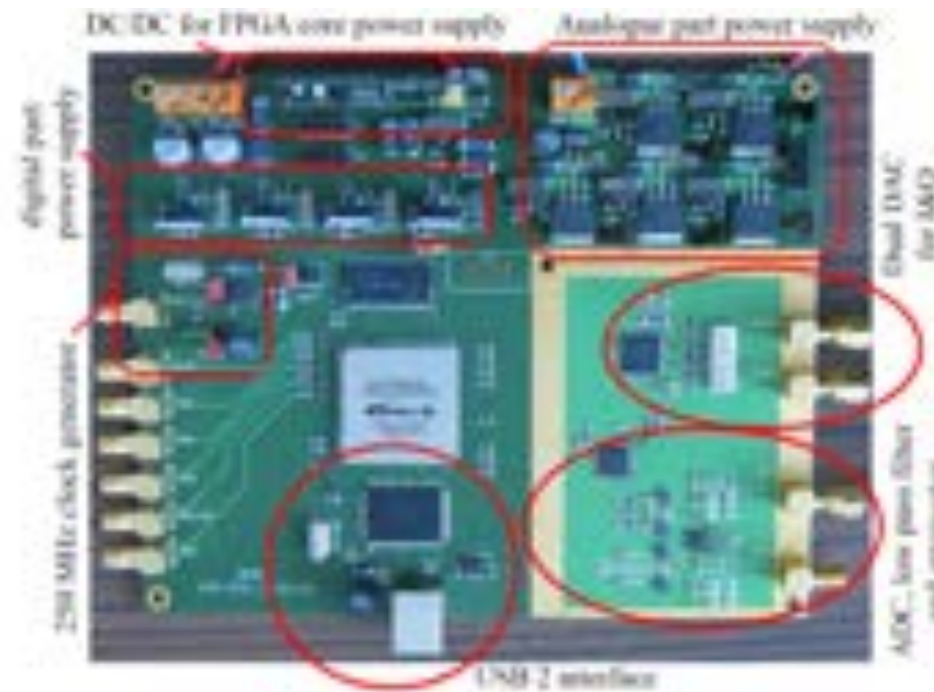
**2023-2030**

**Acquiring a new evaporation machine. Up to 20 cm wafer**



# READOUT Development

2011: NIKEL proto



128 pixels  
500 MHz bandwidth  
external RF

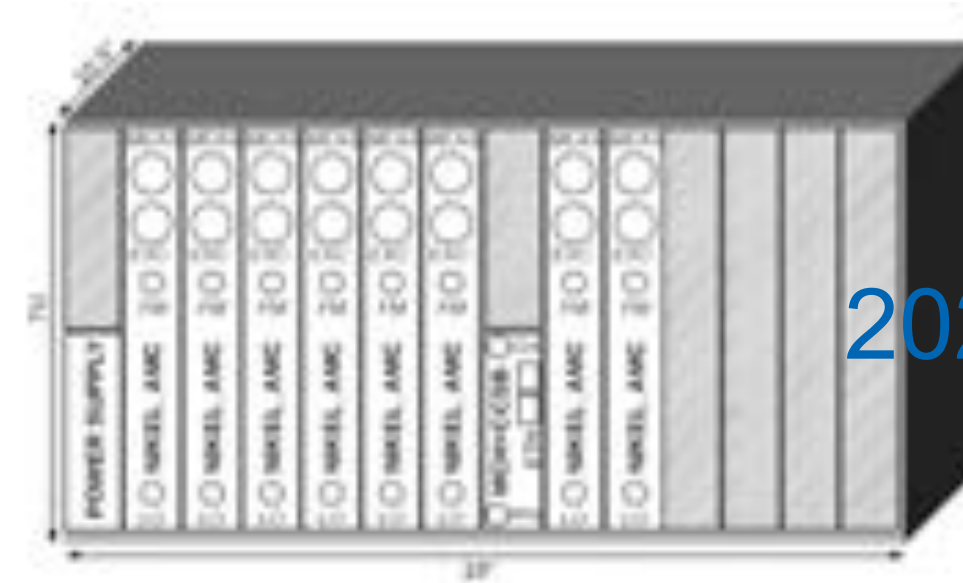
[Bourrion+2011, 2012, 2016, 2022,  
Bounmy+2022]

2012: NIKEL  
(NIKA)



400 pixels  
500 MHz bandwidth  
external RF

2016: NIKEL AMC (NIKA2/KISS)



400 pixels  
500 MHz bandwidth  
RF in the board  
Compact crate with up to 10 boards

2020: NIKEL AMC v2 (CONCERTO)



400 pixels  
1 GHz bandwidth  
30 watts power



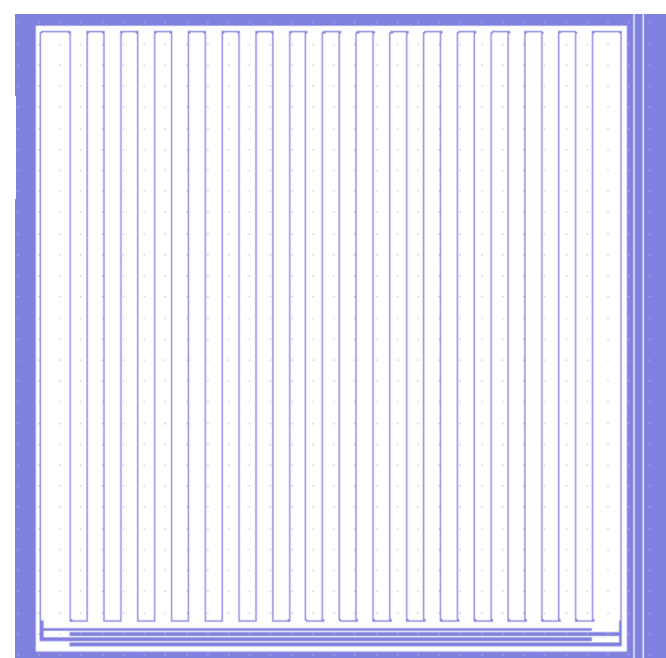
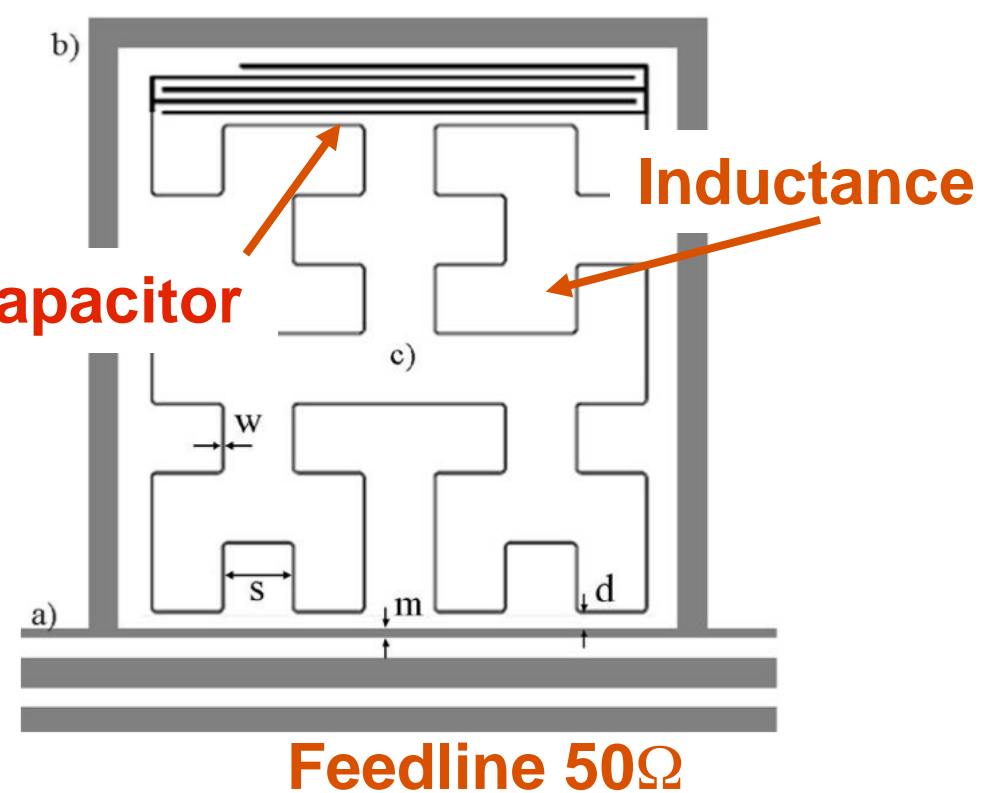
# Our approach on KID development:

# Photometers / Polarimeters

## Lumped Element KID

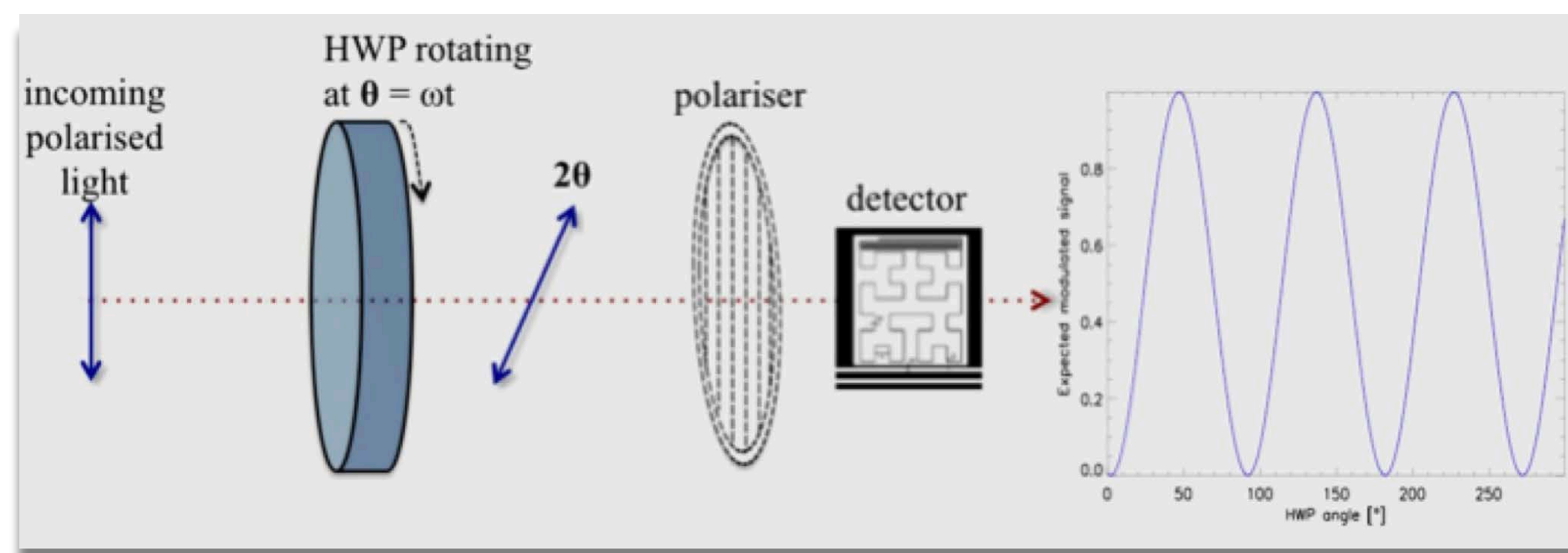
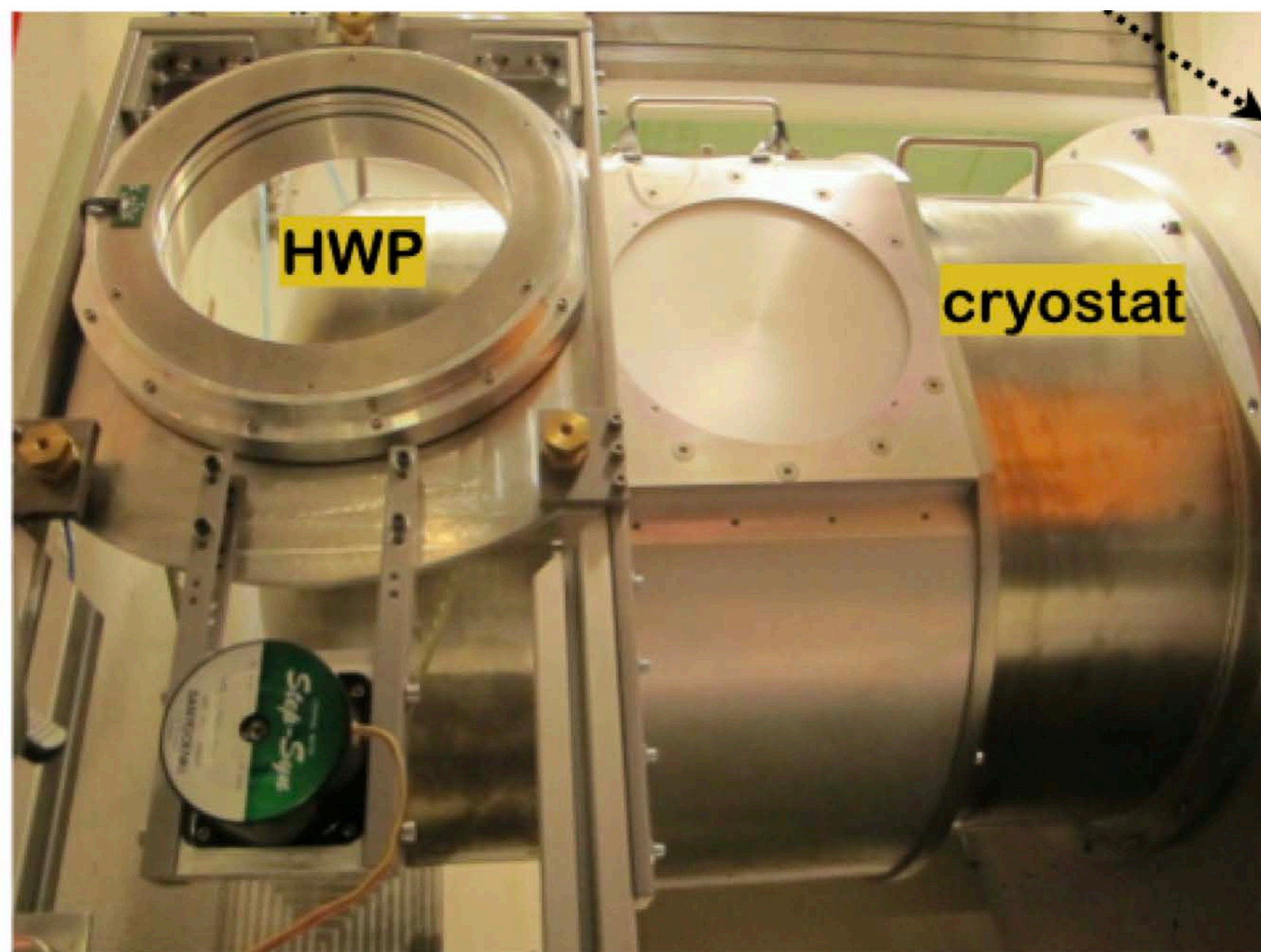
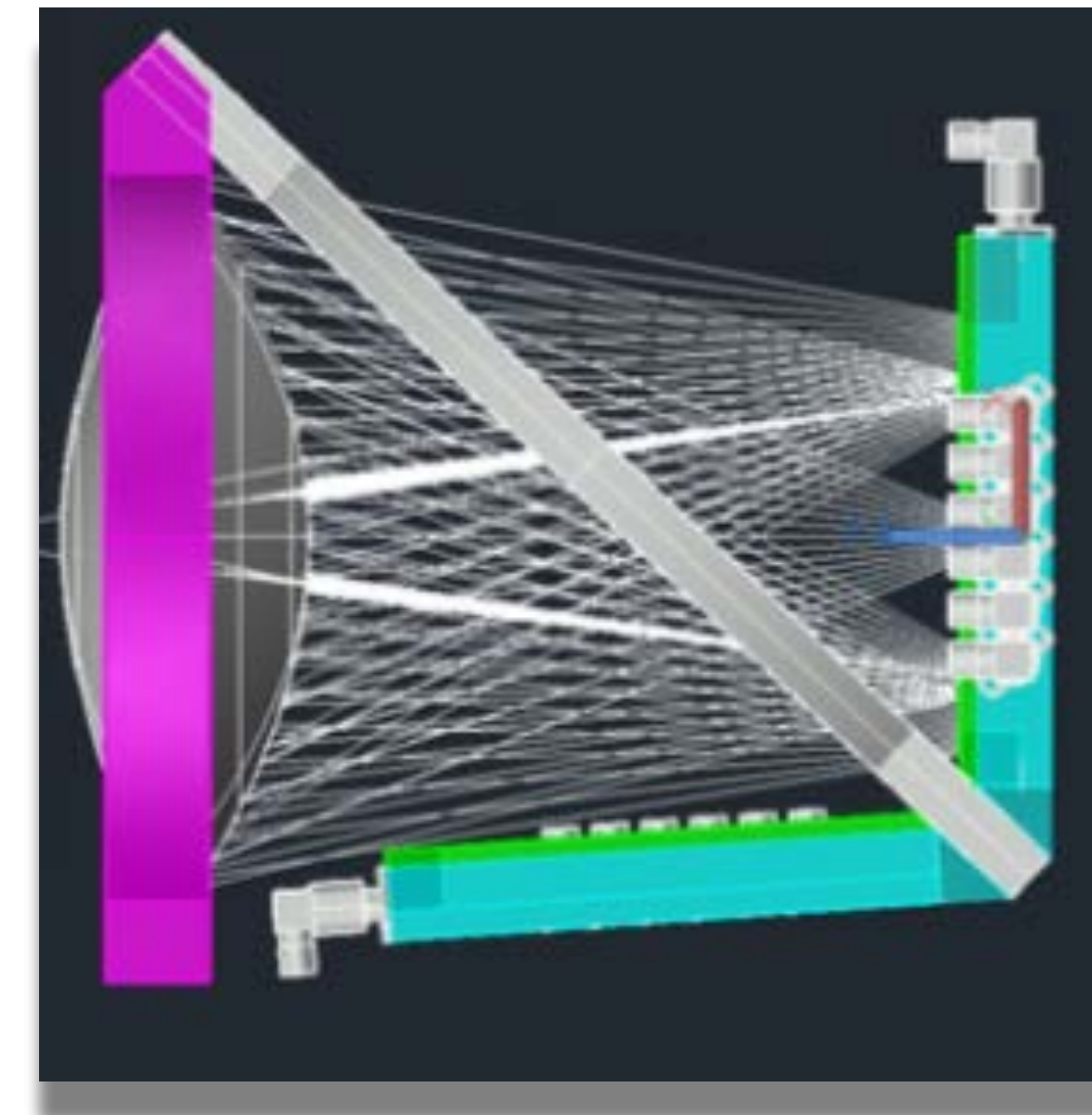
Dual Polarisation  
(3rd-order Hilbert pattern)

Single Polarisation



## Filled arrays LEKID:

- Large filling factor
- Very high quantum efficiency in a 30% mm-band
- Easy to fabricate



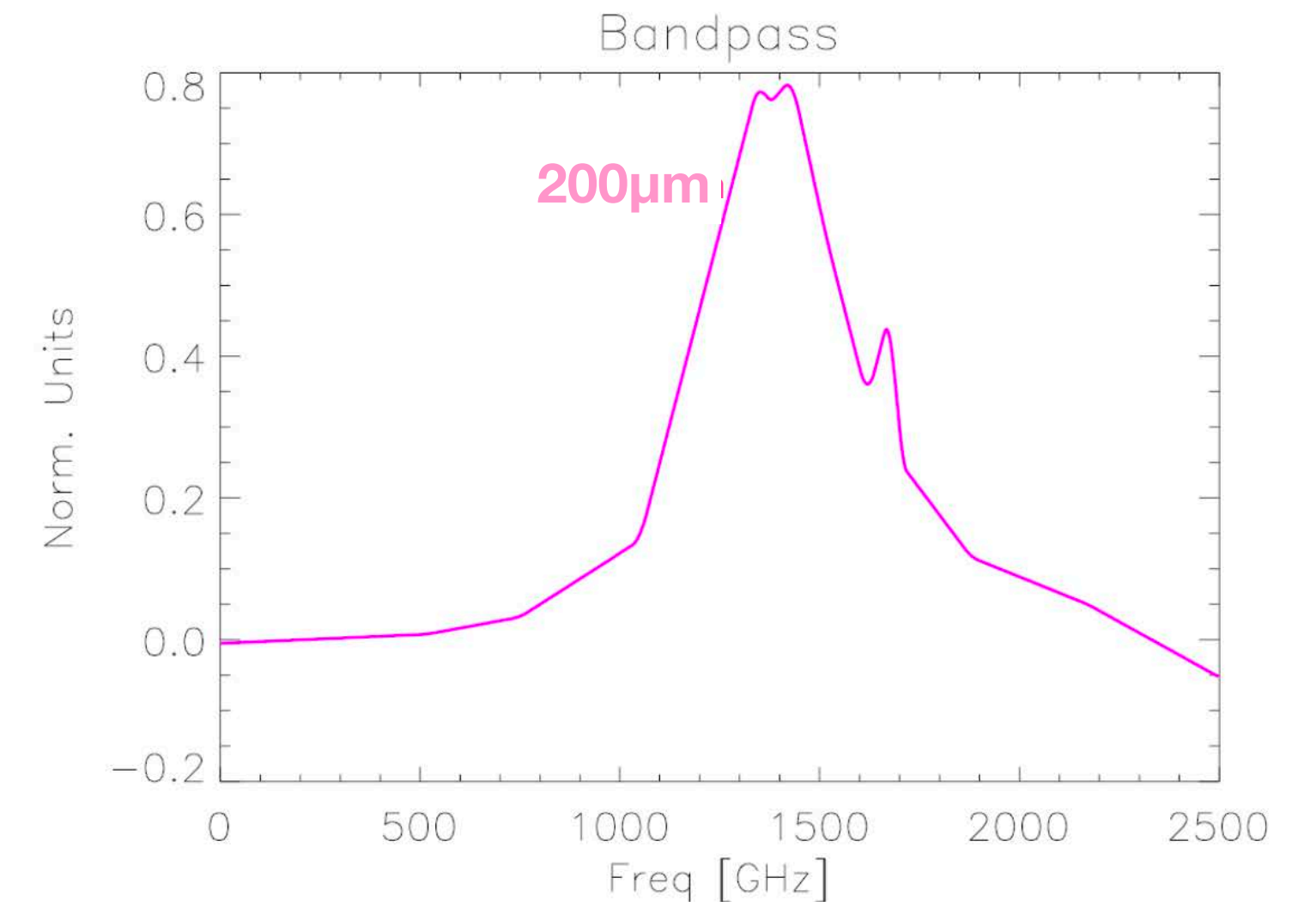
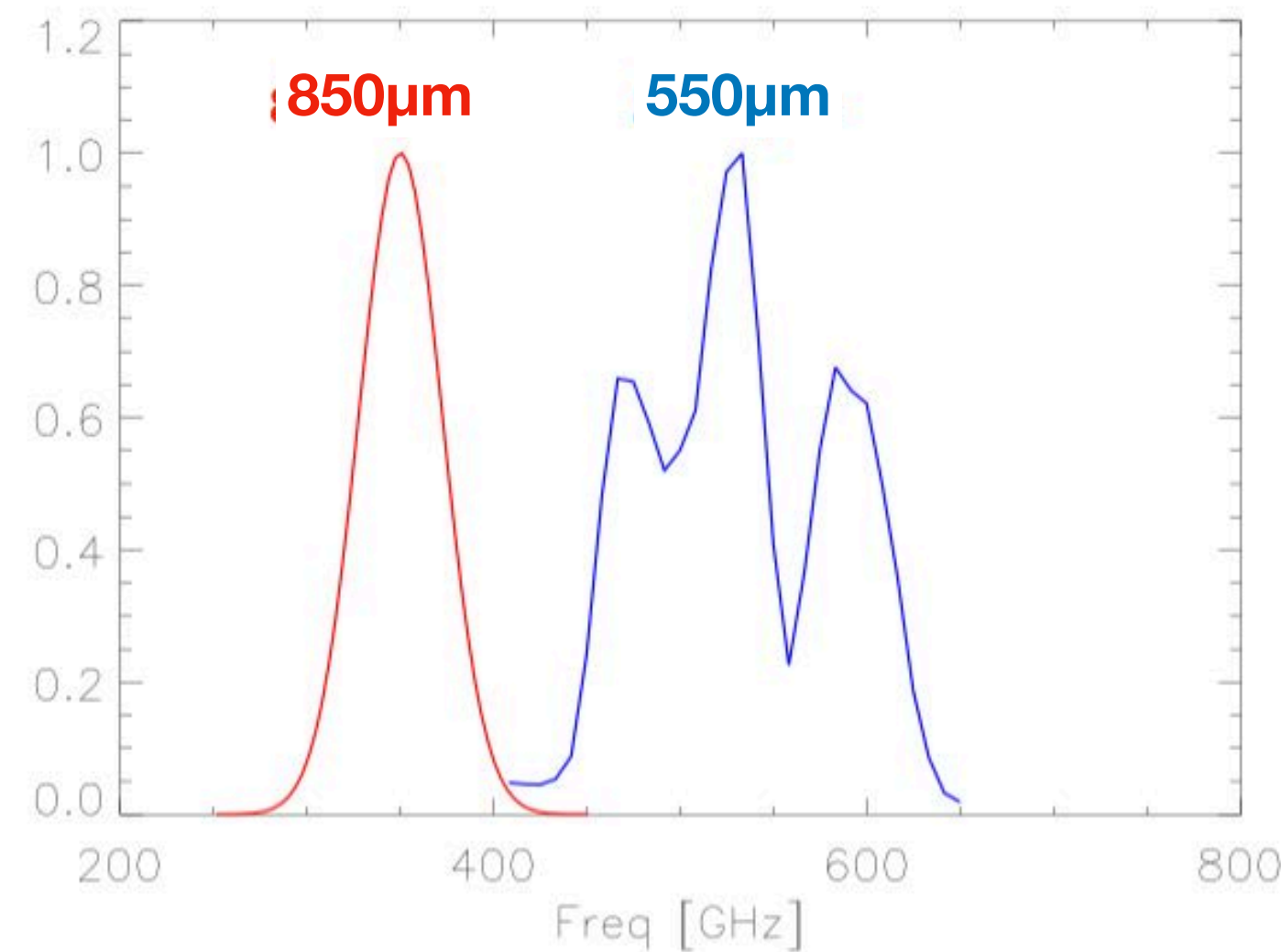
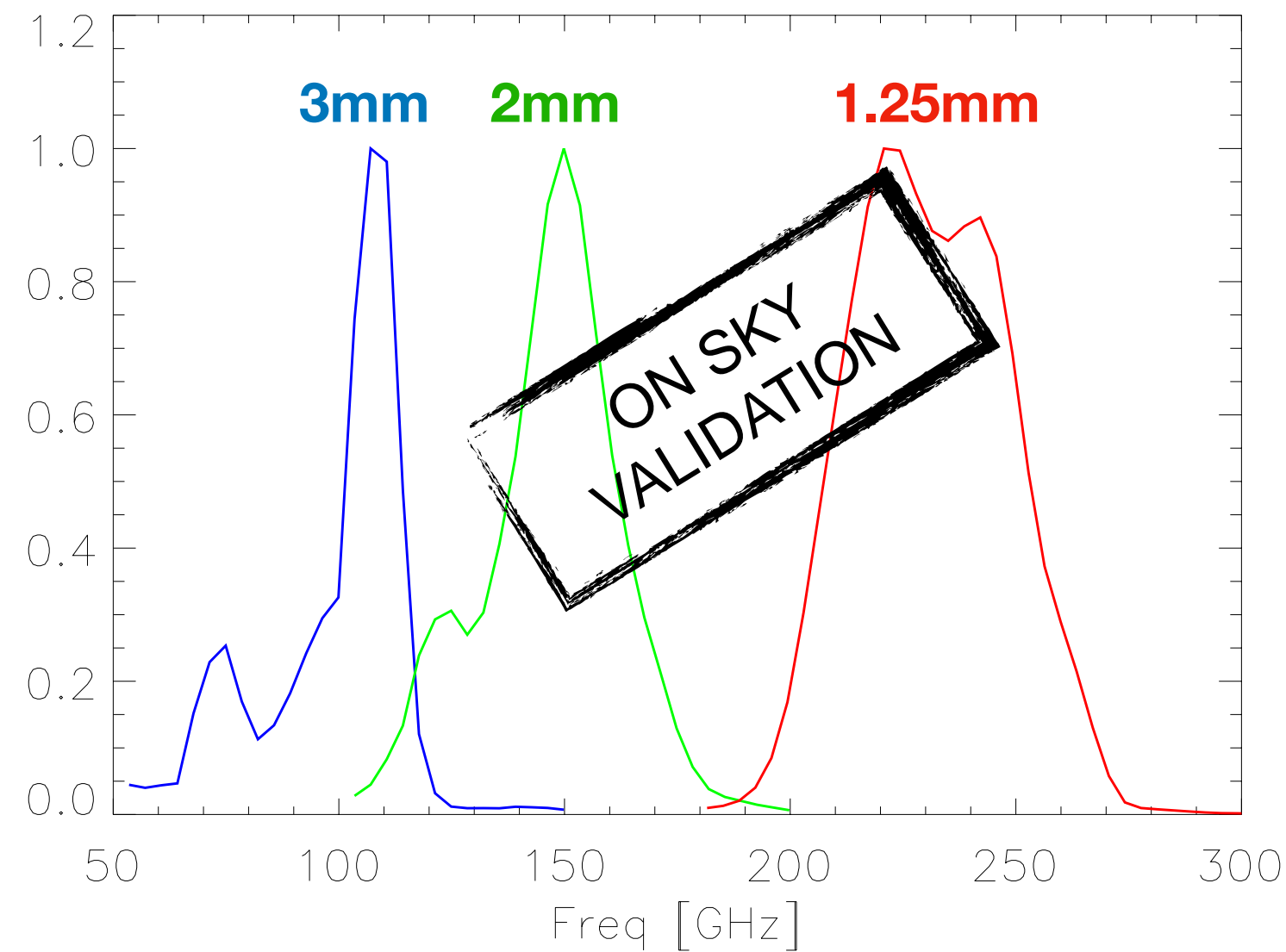
Continuous Rotation of an HWP permits quasi-simultaneous Observations of I, Q, U Stokes parameters



# KID/Readout Development

[Catalano et al., A&A 2020]

Spectral range covering, sensitivity, Cosmic Rays impact, polarisation study



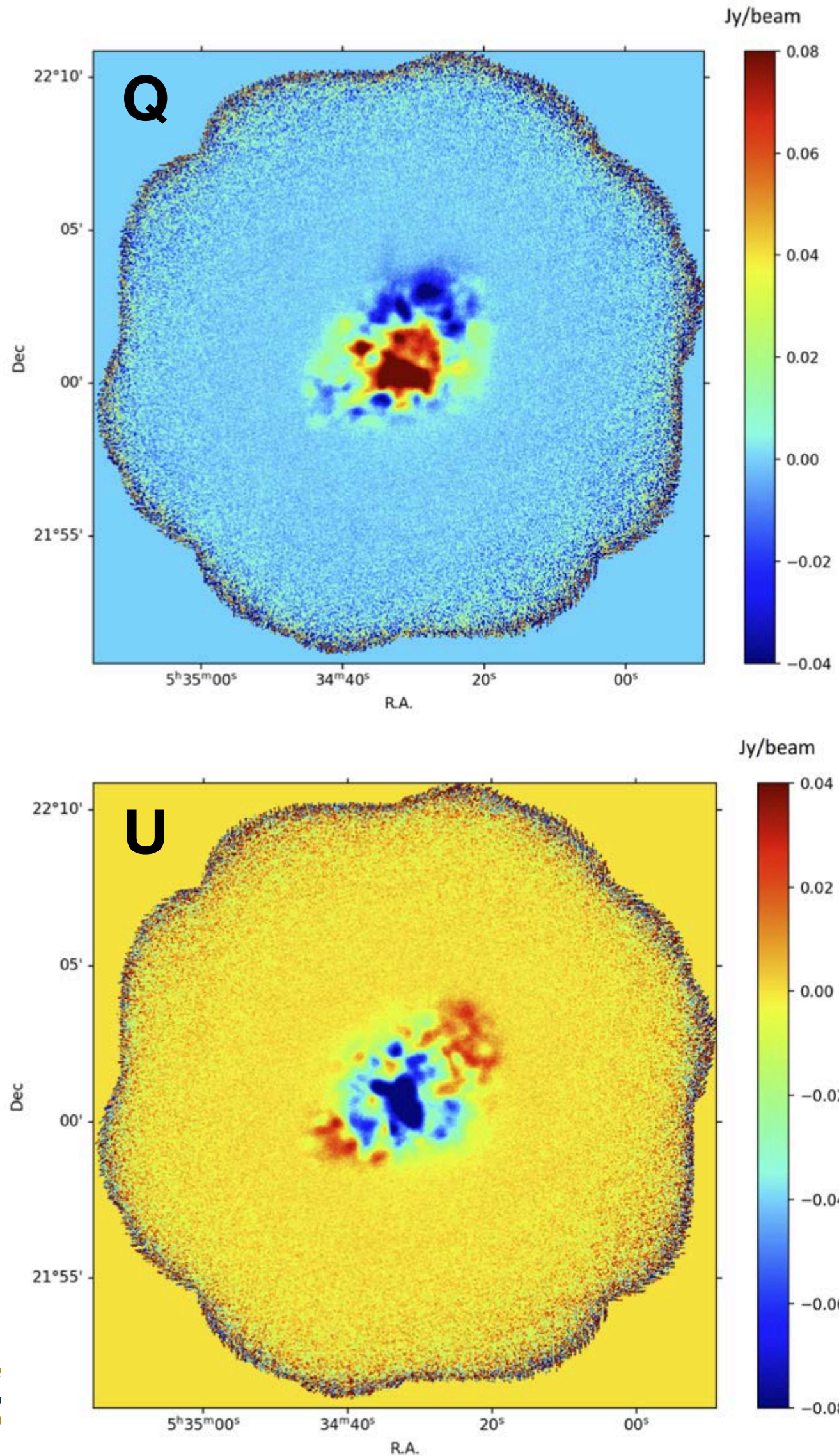
- **Photon noise Detectors in 6 bands** (for ground-based or space borne typical optical loads)
- **Few tens of  $\mu\text{s}$  time constant** (compared to the  $\sim\text{ms}$  of Bolometers/TES)
- **About ten time less impact of cosmic rays for space application**  
(not thermal detectors and fast time constant)
- **Very low sensitive to the base temperature fluctuations** (About 2 order of magnitude less requirements for the stability of the base temperature.)



# KID/Readout Development : Polarisation

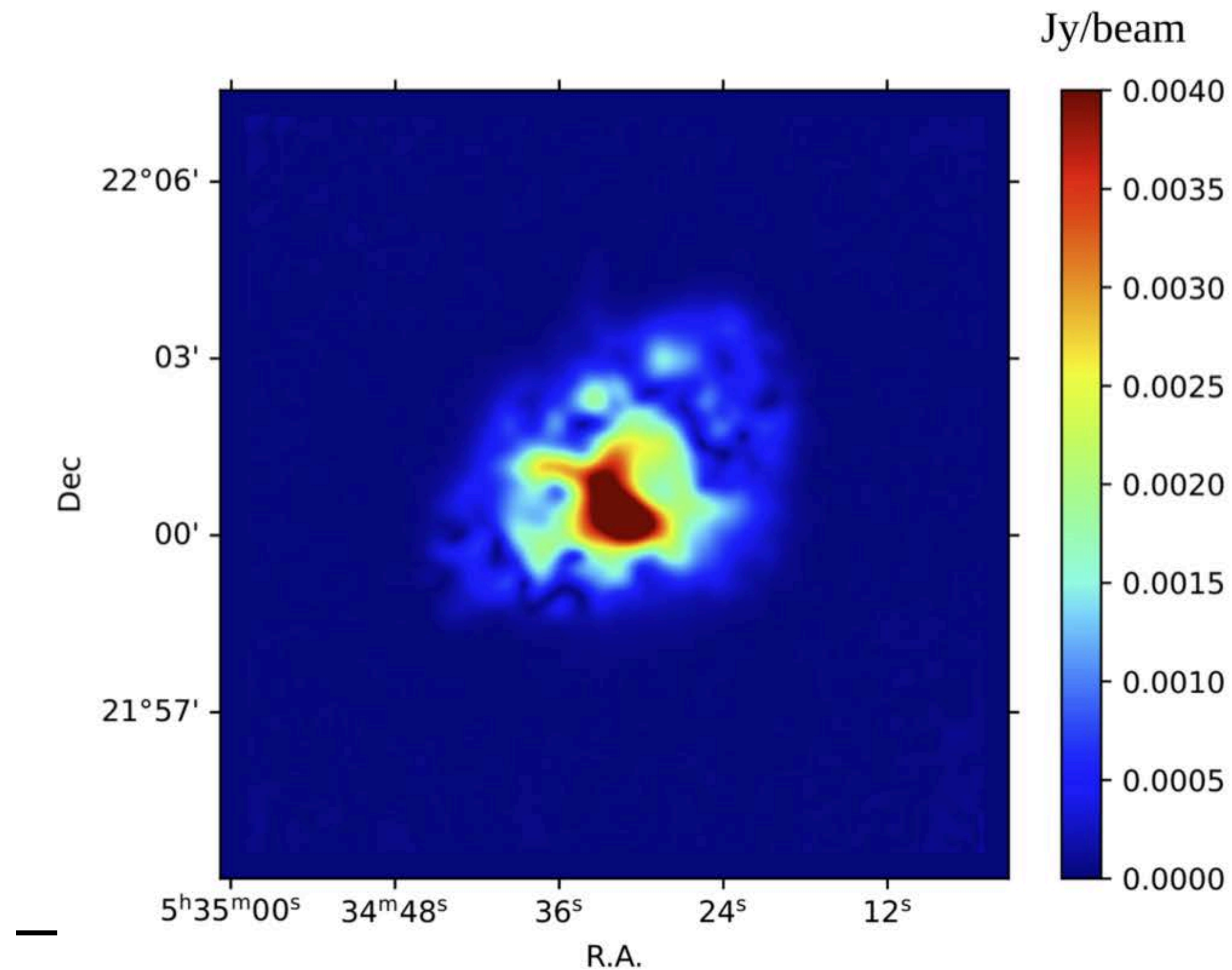
Ritacco et al. (2021) - ArXiv 2111.02143

Stokes Q and U maps  
of the Crab nebula observed at 260 GHz

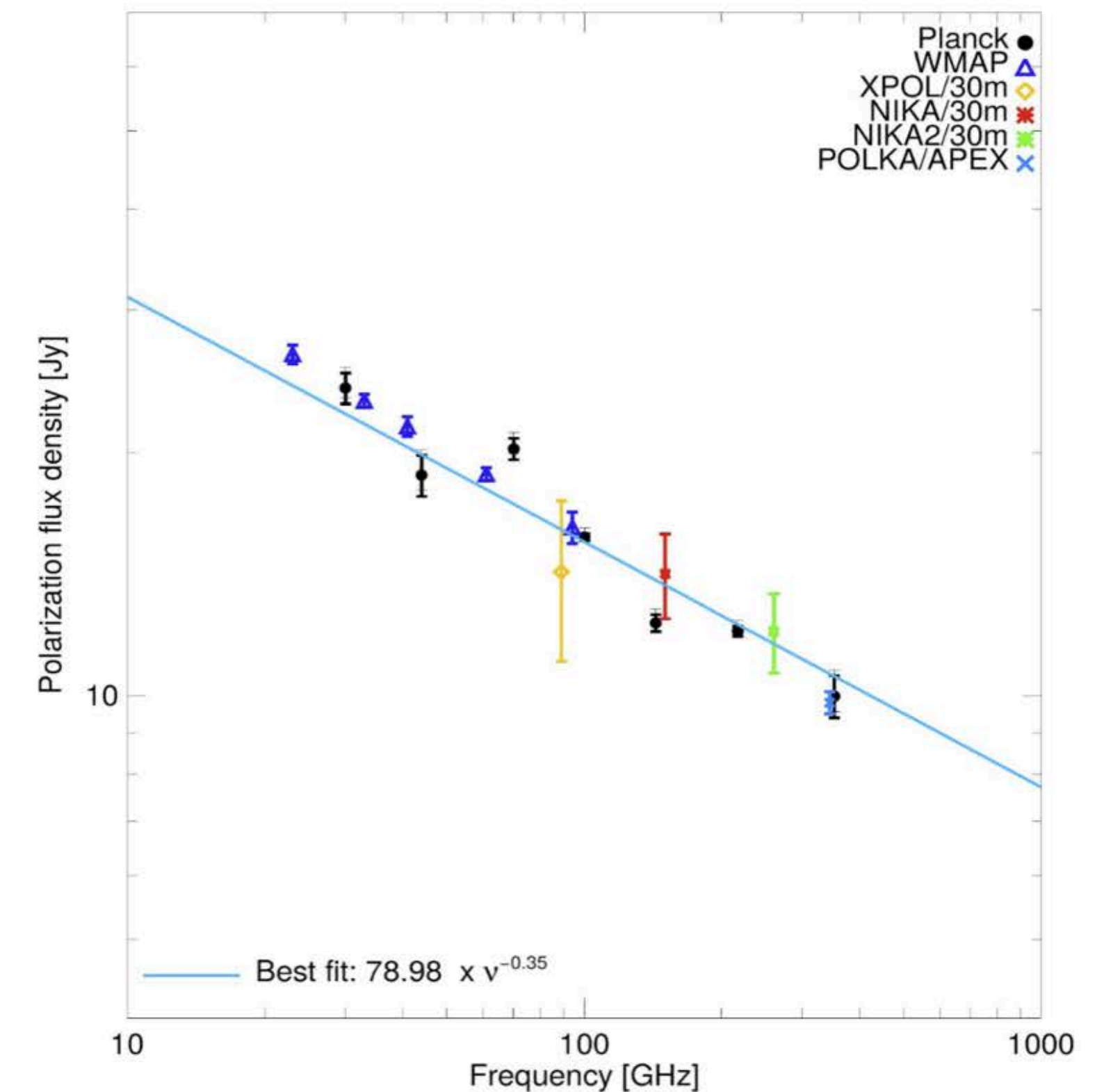


- **Final Sensitivity:**  $\sim 20 \text{ mJy} \cdot \sqrt{s}$  (better than phot. Sensitivity)
- **Polarization Leakage :**  $< 1\%$  (mainly due to the Tel.)
- **Error on the pol. angle reconstruction :**  $\sim \pm 0.5 \text{ Deg.}$

NIKA2 polarized  
intensity map



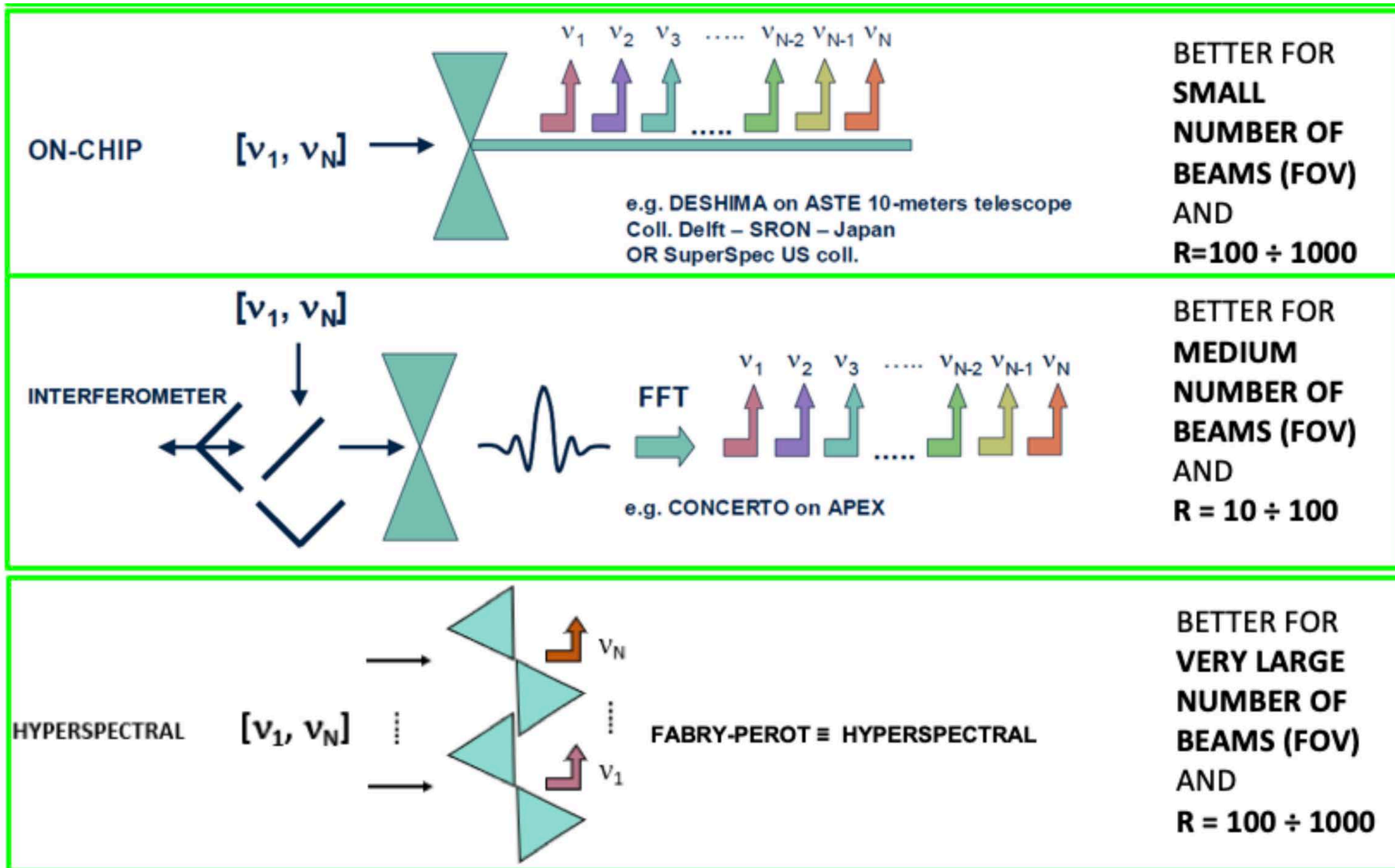
Spectral energy distribution  
obtained by previous measurements  
accounting for the new value  
obtained from NIKA2 (green).





# Our approach on KID development:

## Spectrometers



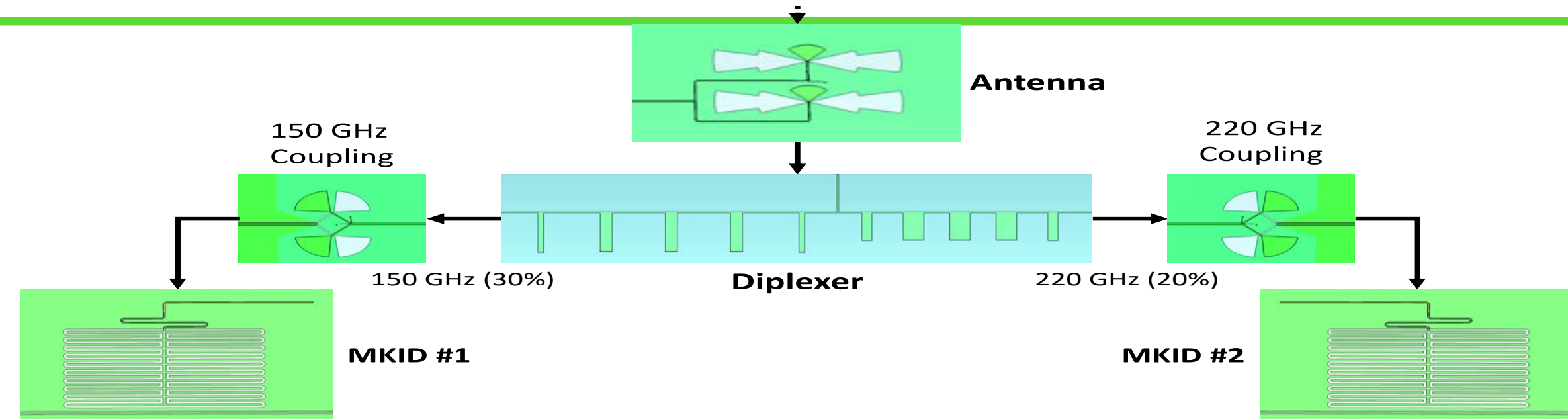


# Our approach on KID development:

# Spectrometers

## ON-CHIP - APC (R&D)

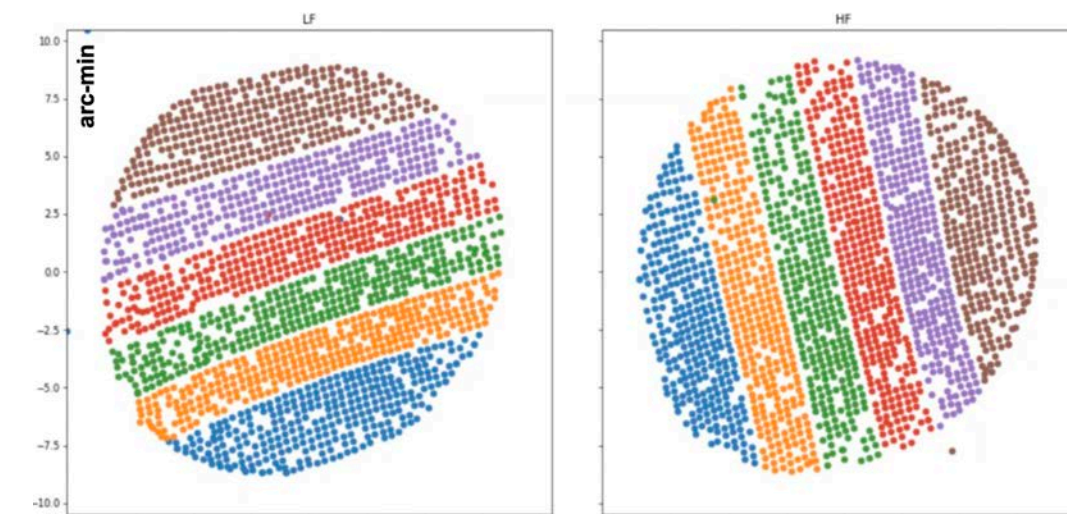
- **Total bandwidth:** Center 184.75 GHz, 60% (Range: 127.5 – 242 GHz)
- **Sub-bands:** 150 GHz, 30% (127.5 – 172.5 GHz) & 220 GHz, 20% (198 – 242 GHz)
- **Polarization-sensitive:** Linear
- **Return loss:** (S11) < -10 dB (> 90% power transmitted)
- **Farfield:** Symmetrical, sidelobes < -20 dB
- **Cross-polarization** < -15dB at 2 sub-bands 150 & 220GHz



## FTS (CONCERTO) - GISKID

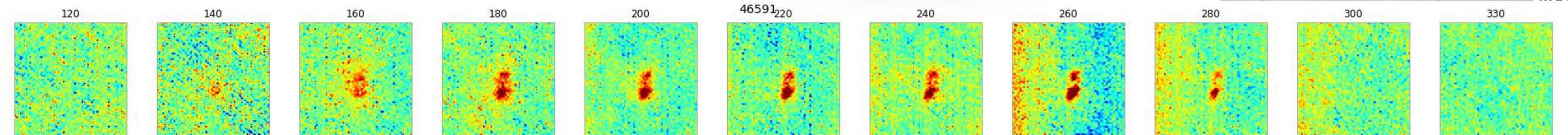
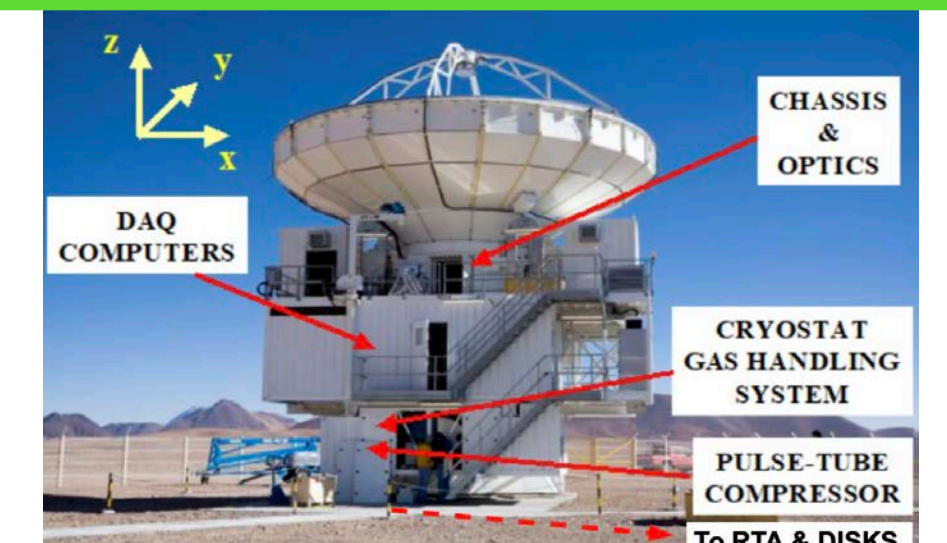
**Fundings:** ERC Advanced Grant  
**Duration of operation:** April 2021 - May 2023  
**P.I.:** G. Lagache (LAM) / A. Monfardini (IN)

- 1200 hours Observations of the CII-emission line at high redshift
- 50 hours SZ signal from galaxy cluster



**Focal Plane Geometry**  
 > 90 % Functional pixels

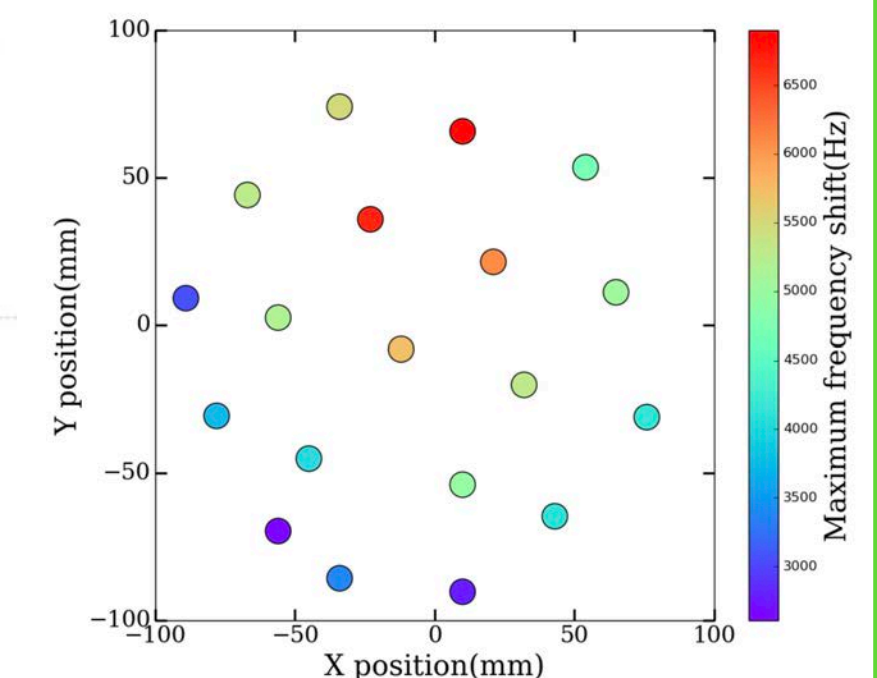
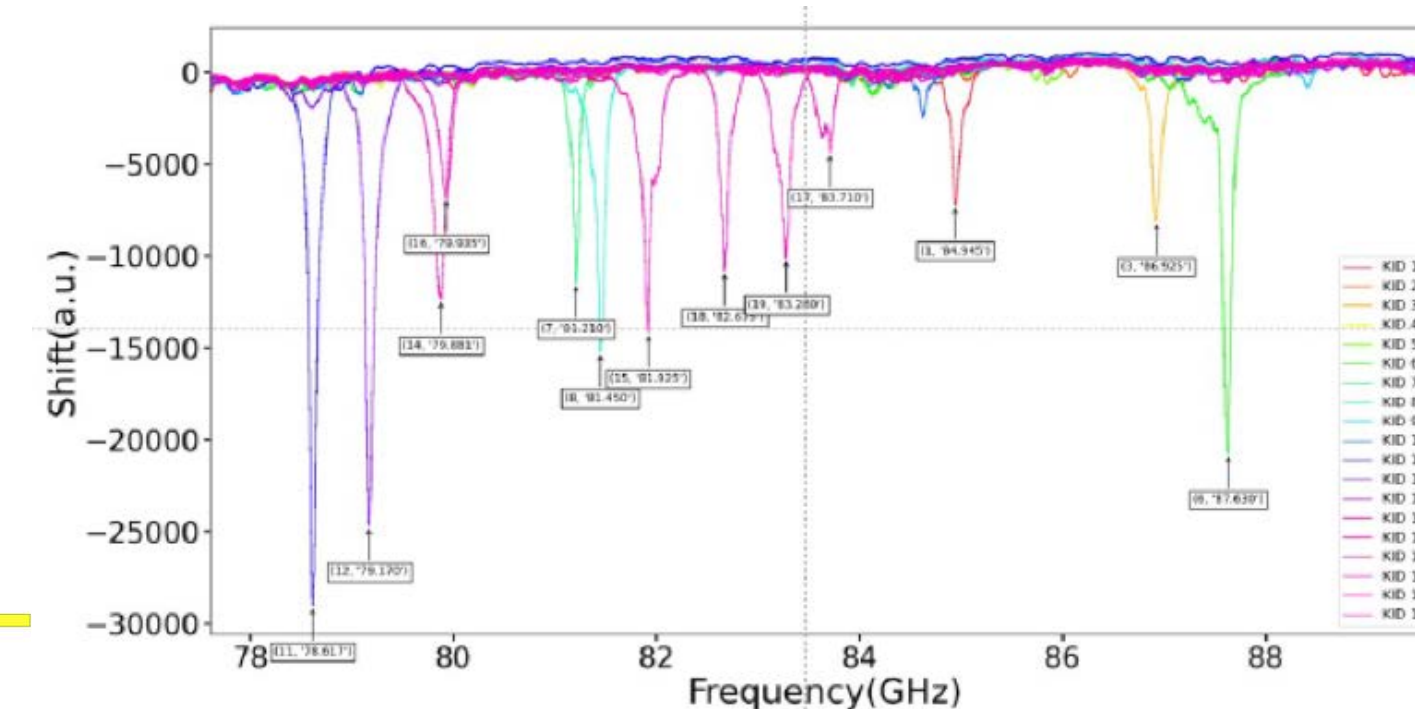
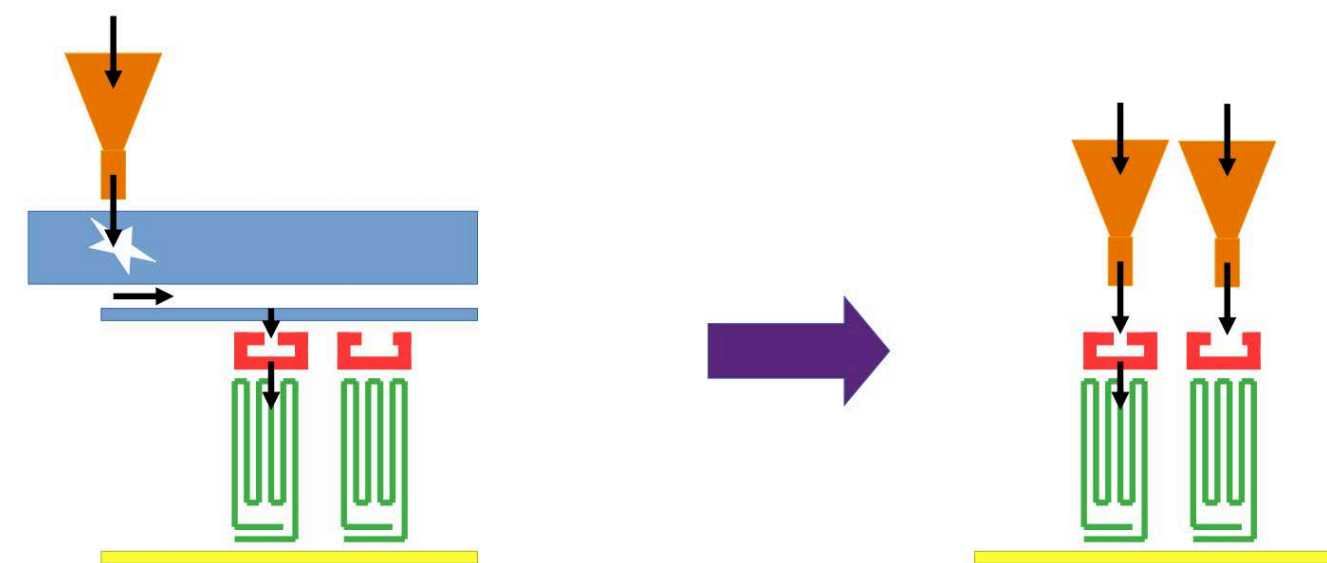
**ORION**



**Spectral: 1Map only (13 minutes integration)**

## HYPERSPECTRAL - GISKID (R&D)

- Direct Coupling of the Horn with the resonant filter
- Horn-Microstrip transition removed
- Very interesting for low resolution spectra on-chip
- NEP very raw:  $1 \cdot 10^{-17} \text{ W}/\sqrt{\text{Hz}}$





# Conclusions

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- **KID Technology at IN2P3**

- French KID technology represents the state-of-the-art worldwide for mm and sub-mm astrophysics.
- GIS LEKID technology has today a TRL high enough to be used for the next generation CMB experiments.
- KID are very promising for application in NIR and Visible.
- IN2P3 is deeply involved with technical services, especially for electronics and mechanics/optical elements.

- **What we ask to the IN2P3**

- **Organisation:** Need to have a dedicated master project.
- **Manpower/Permanent Position:** More support to the technical services.