

TSGW - Tsukuba Global Science Week

Superconducting Kinetic Inductance Detectors for (millimetre) Astrophysics

Institut Néel Grenoble – CNRS - France
LPSC Grenoble – CNRS - France
IPAG Grenoble – CNRS - France
IRAM – CNRS, Max-Planck Institut & Spain

List of the made-in-Grenoble KID-based instruments

1) **NIKA0**, 1st KID camera seeing astronomical light **2009 – 2010**
(30 pixels, single band, 150GHz)

2) **NIKA1** (30-meters IRAM telescope Spain) **2011 – 2015**
(300 pixels, dual-band, 150GHz and 250GHz)

3) **NIKA2** (30-meters IRAM telescope Spain) **2015 –**
(3000 pixels, dual-band 150-250GHz + polarisation)

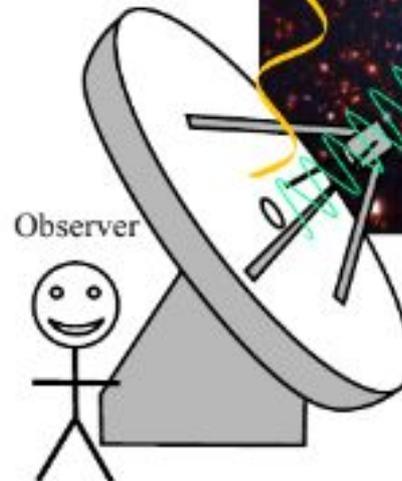
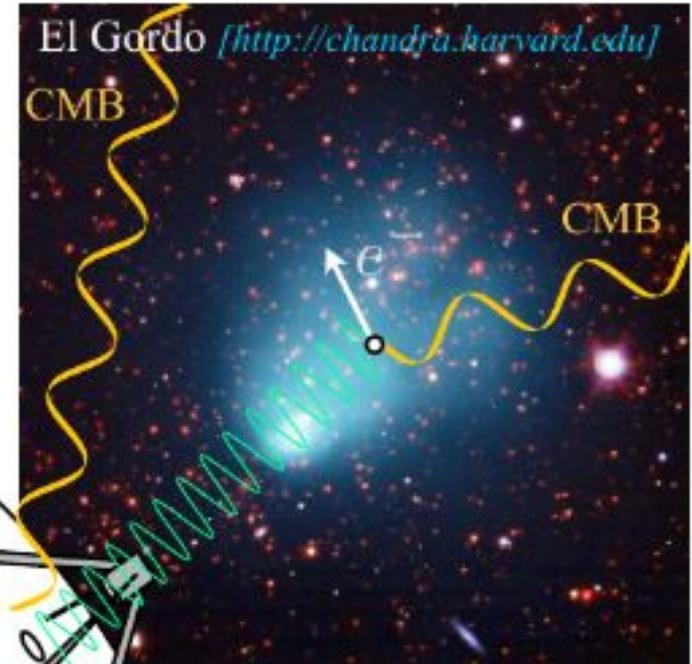
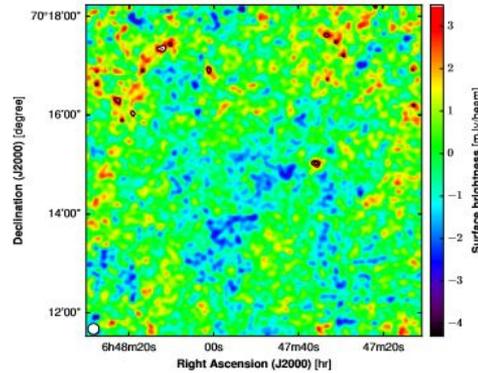
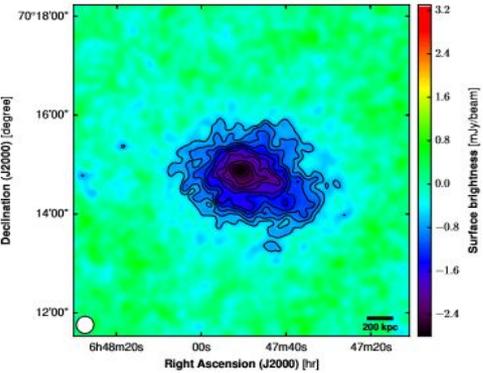
4) **KISS** (2.5-meters QUIJOTE telescope Canaries) **2018 – 2021**
(600 pixels × 50 spectral bins □ eq. to 30 kpixels)

5) **CONCERTO** (12-meters APEX telescope Chile) **2021 –**
(4000 pixels x 100 spectral bins □ eq. to 0.4 Mpixels)

PATHFINDERS
OR
DE-COMMISSIONED

OBSERVING AND AVAILABLE TO THE COMMUNITY

Galaxies clusters: the Sunayev-Zeldovich effect



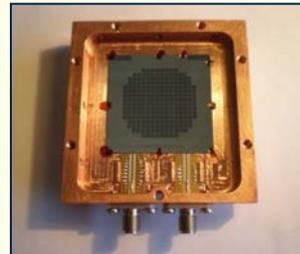
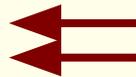
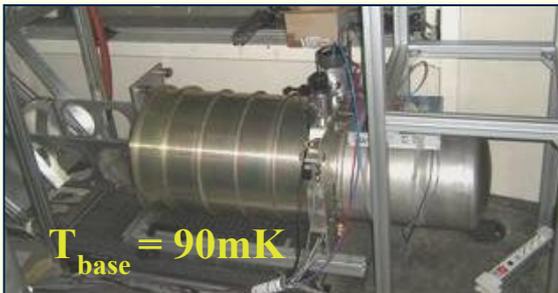
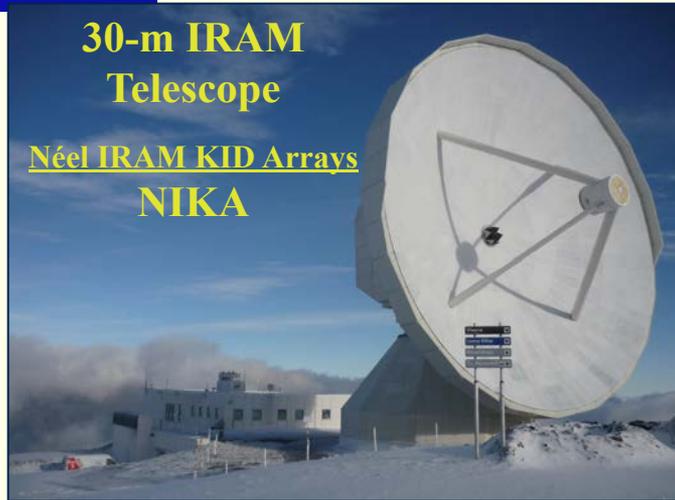
➔ SZ = probe for intracluster gas

Spectral deformation of the CMB

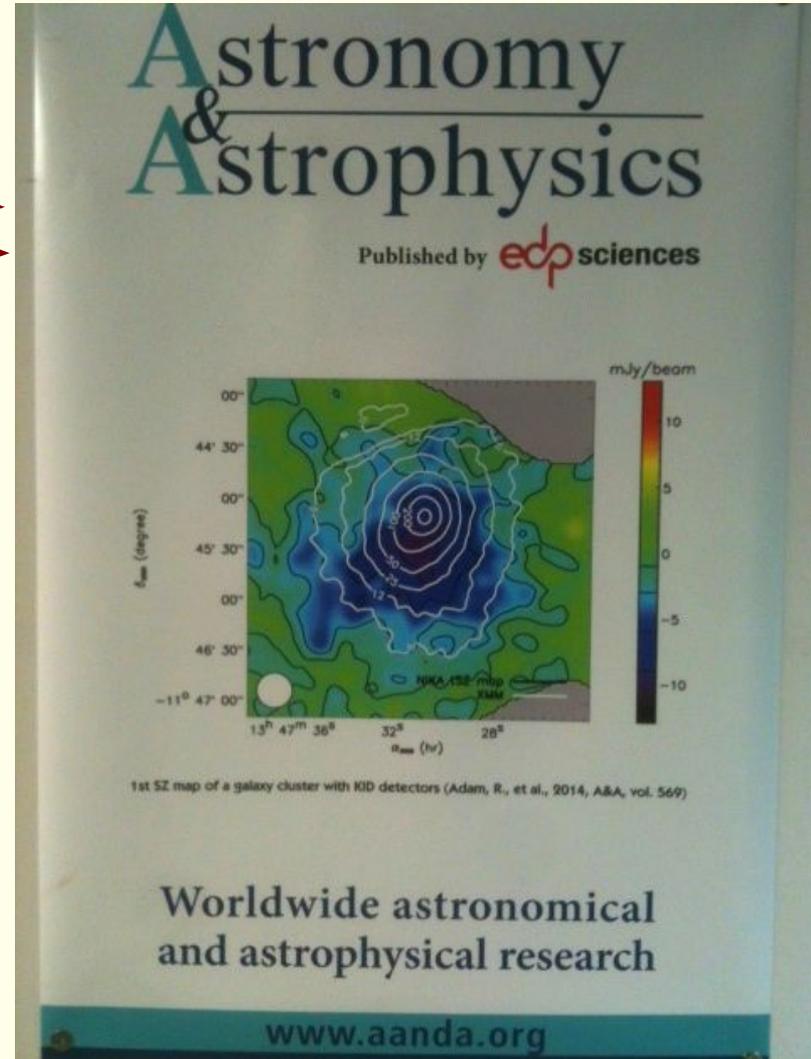
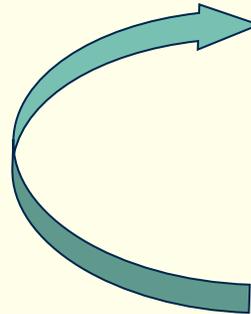
- A **NEGATIVE** signal at 150GHz
- A **NULL** signal at 220GHz
- A **POSITIVE** signal at >250GHz

Important tool to study the largest g-bound structures in the Universe
e.g. 85% DM, 12% IGM, 3% galaxies

NIKA: the international pathfinder for mm-wave KID (2010 - 2015)

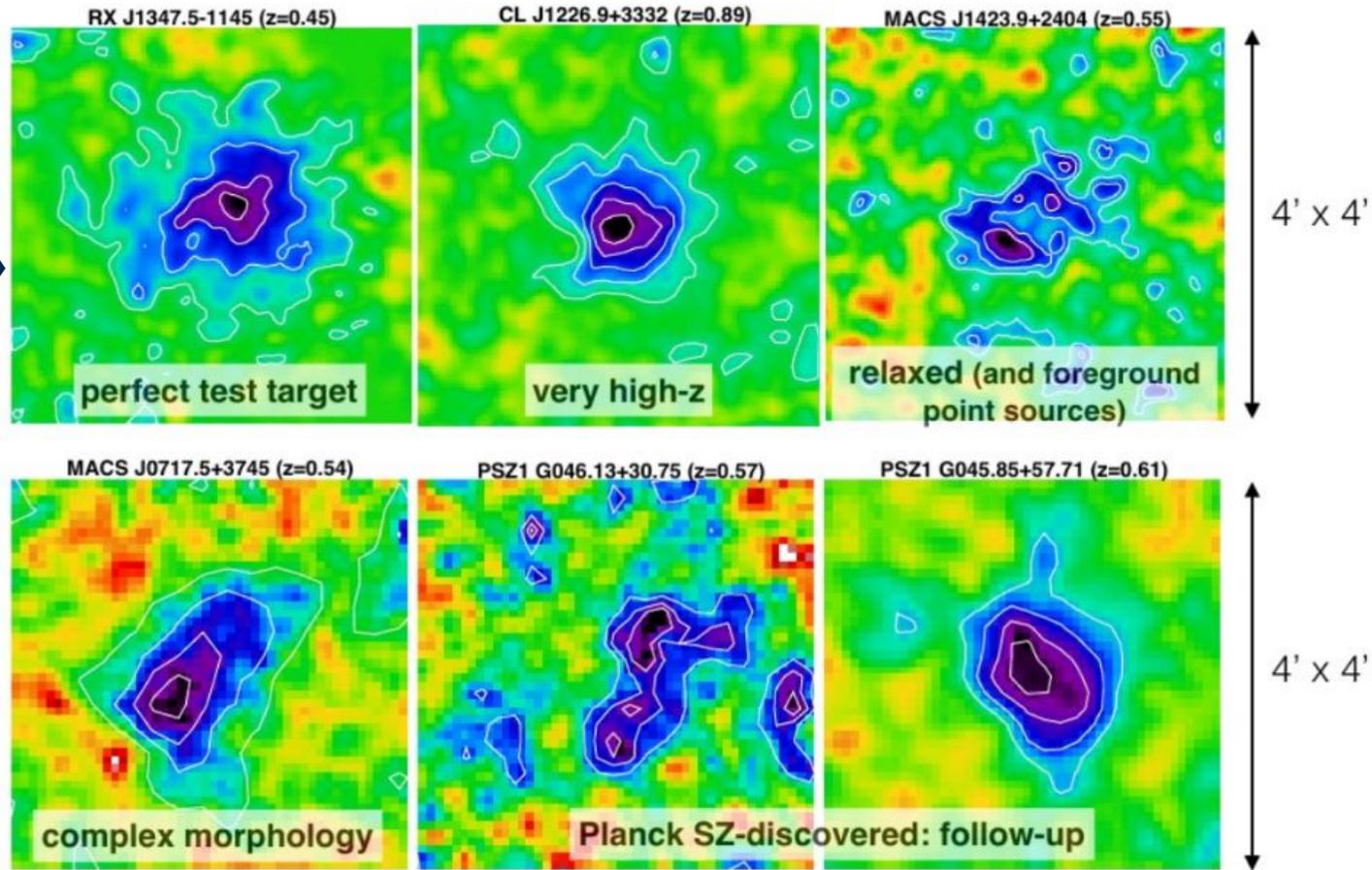


120 - 300 GHz



around 300 pixels

NIKA galaxies clusters sample



Taken from:
 J. Macias-Perez,
 Proceedings of the
 «mmUniverse@NIKA2»
 Conference (2019)

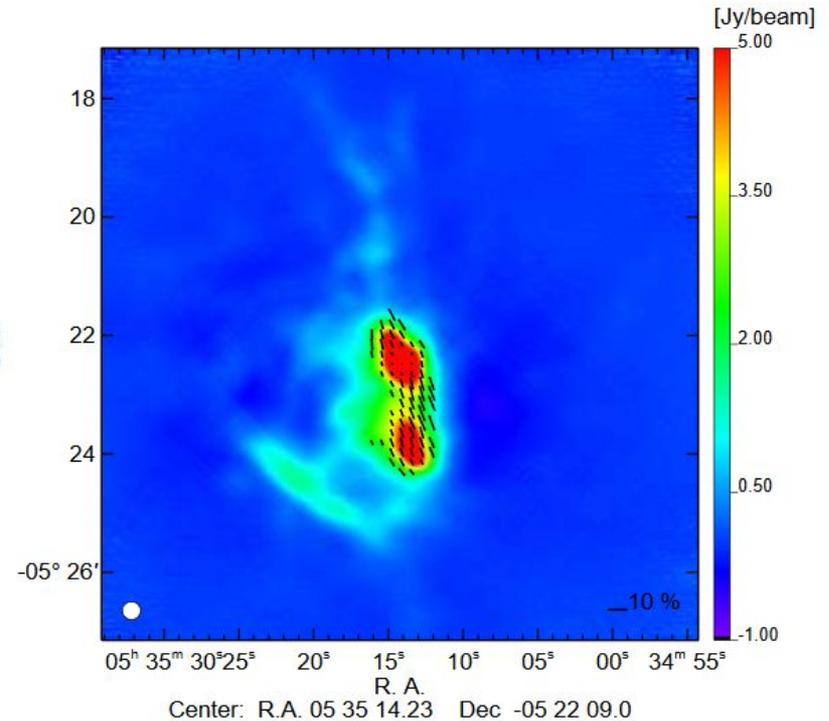
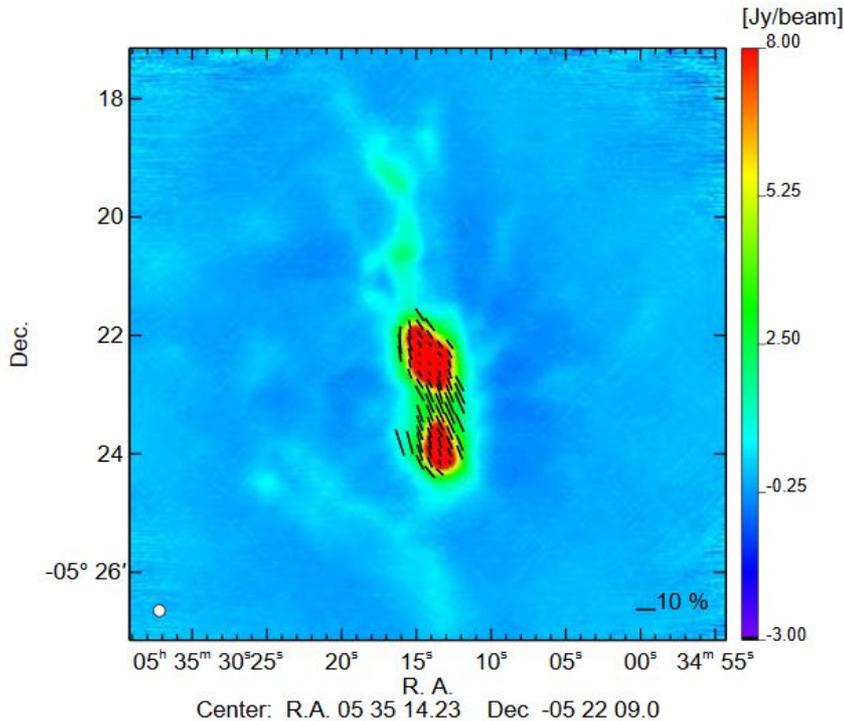
**NIKA mapped
 for the first time
 the kinetic SZ effect !**

And produced many
 other results

Plus technology
 demonstrator for NIKA2

Taken from:
 A. Ritacco,
 Proceedings of the
 «mmUniverse@NIKA2»
 Conference (2019)

NIKA polarization



Orion star forming region OMC-1.
 The closest site of OB (hot, massive) star formation.

The NIKA2 installation (2015)



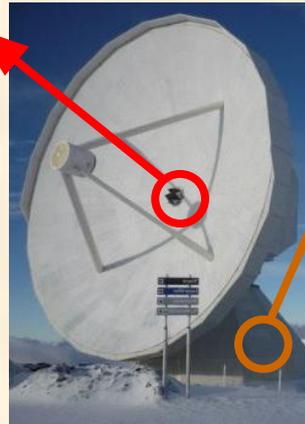
The cryostat in the receivers cabin



The 40 COAX cables



60 meters of pipes

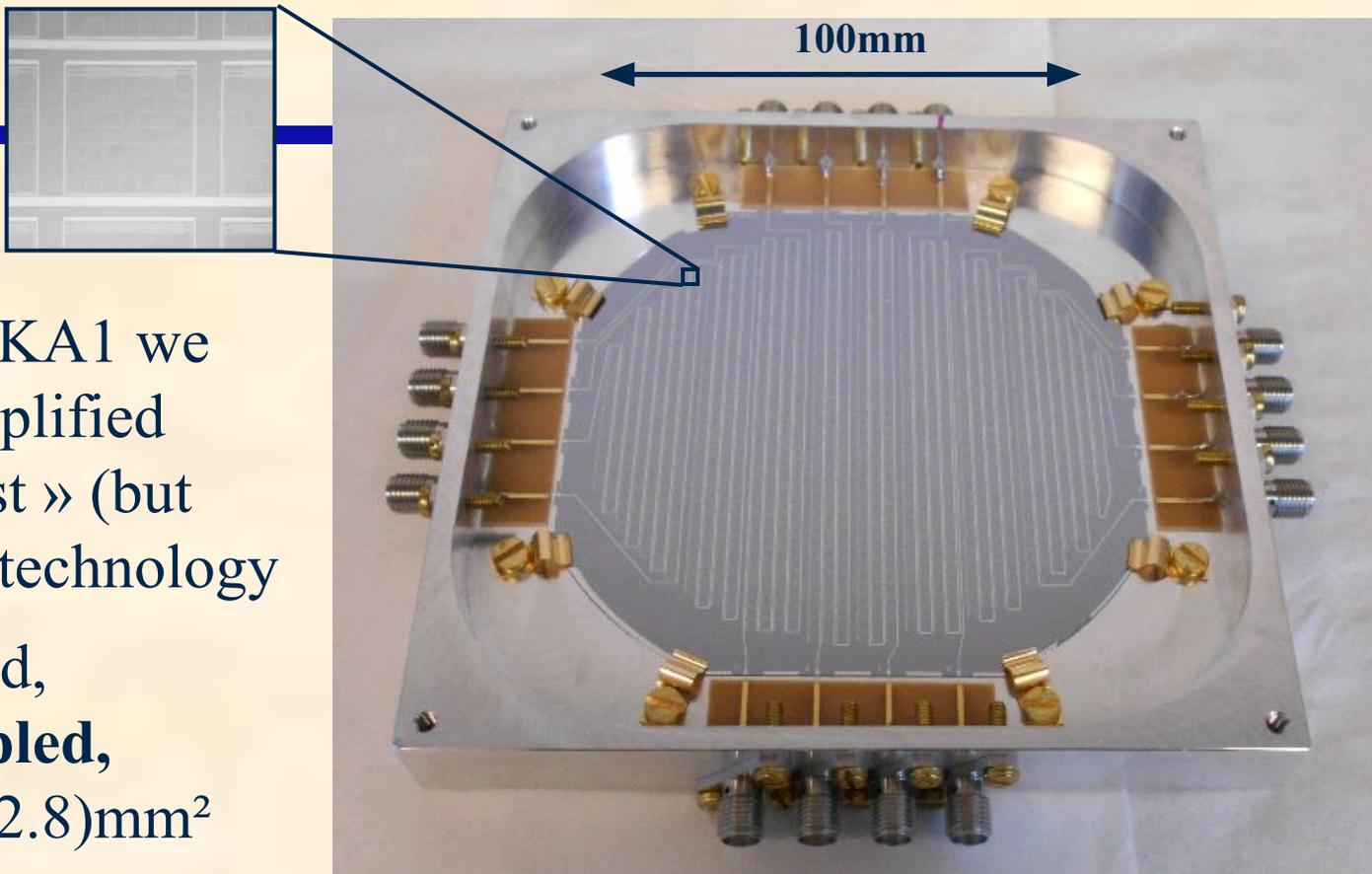


The dilution gas handling in the basement

NIKA2 figures:

- 3000 pixels over 3 arrays
- 1.2 tons; 2.5 m long; 3000 pieces
- Two Pulse Tubes
- Fully remote control
- Completely cryogen free
- Base T \approx 100 mK

NIKA2 detectors



Compared to NIKA1 we have further simplified our already « fast » (but efficient !) KID technology

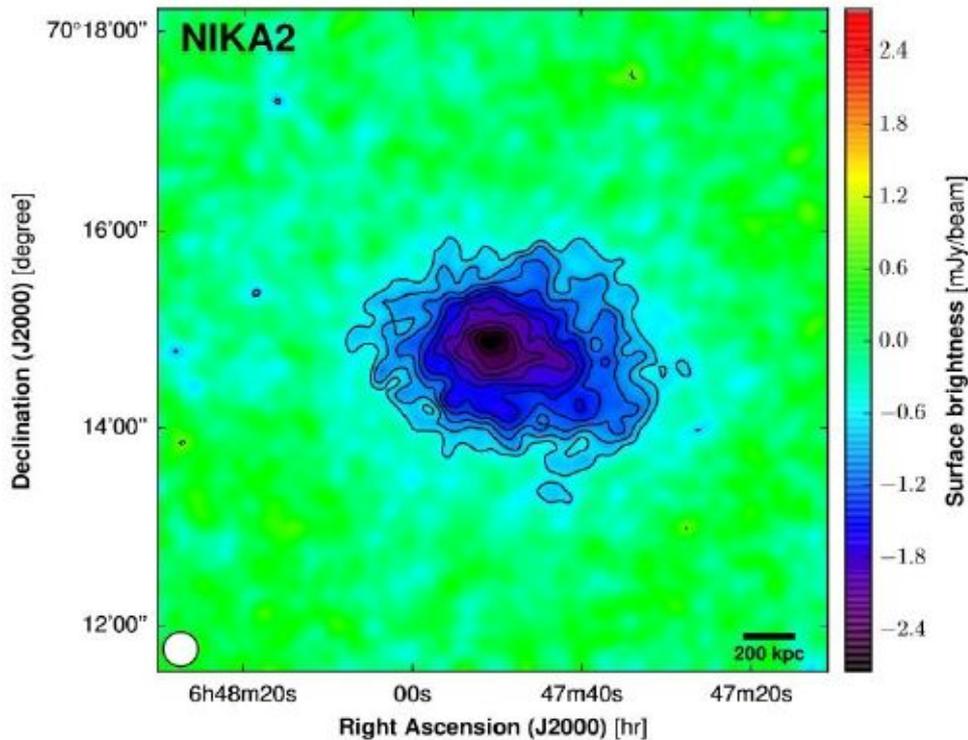
Front-illuminated,
microstrip coupled,
 pixels $2(2.8) \times 2(2.8) \text{mm}^2$

ADVANTAGES: single mode, easy packaging, robust, no penalties for sensitivity for selected applications (e.g. NIKA2, CONCERTO)



NIKA2: clusters and deep fields

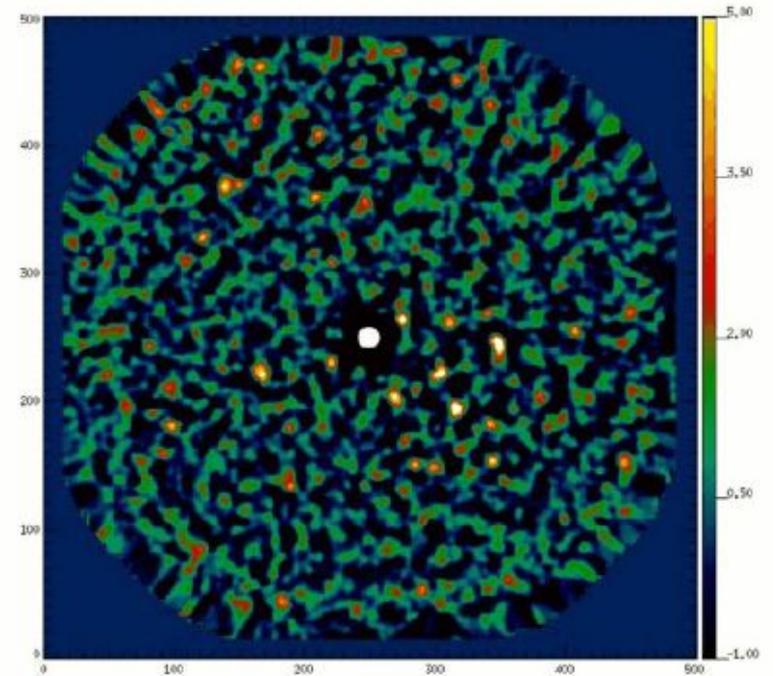
PSZ2G144.83+25.11 (run 10)



Integration time: $\approx 11h$

Ruppin et al., A&A 615, A112 (2018)

HLS091828 (run 9)

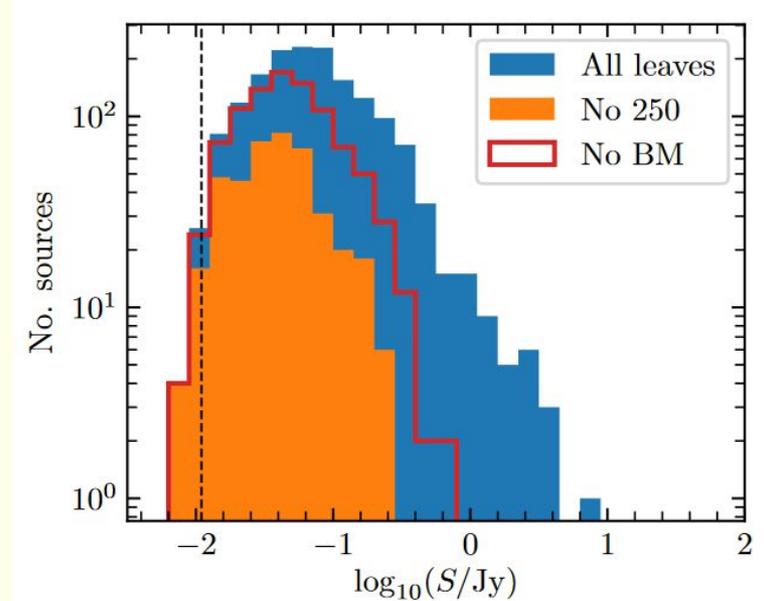
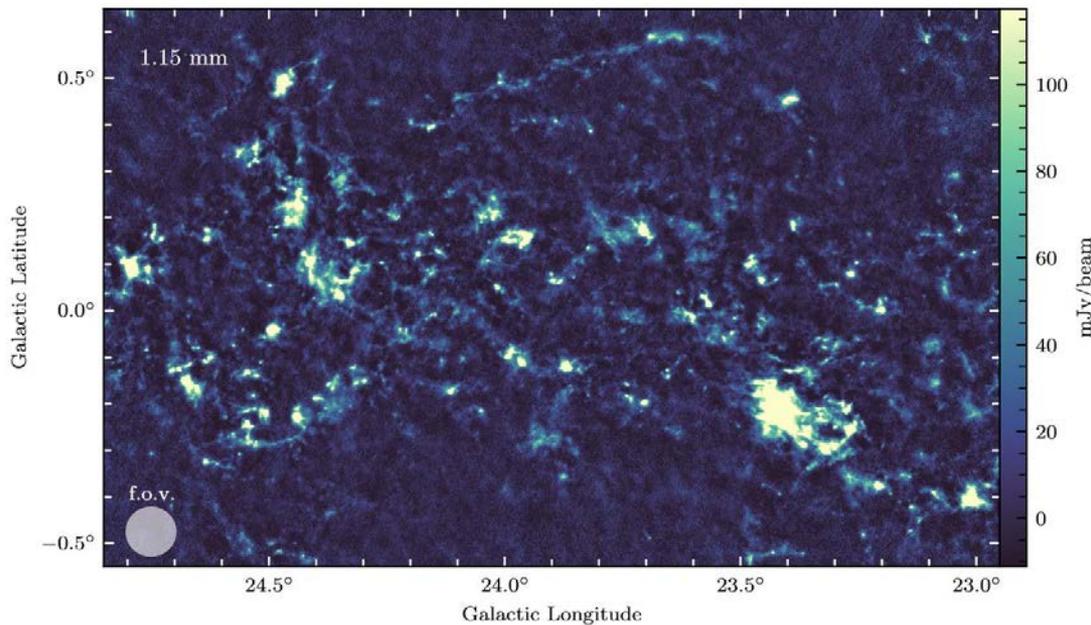


81.2 ± 0.4 & 16.0 ± 0.1 mJy à 1mm et 2mm

Credit: F. X. Desert and NIKA2 collaboration



NIKA2: galactic science

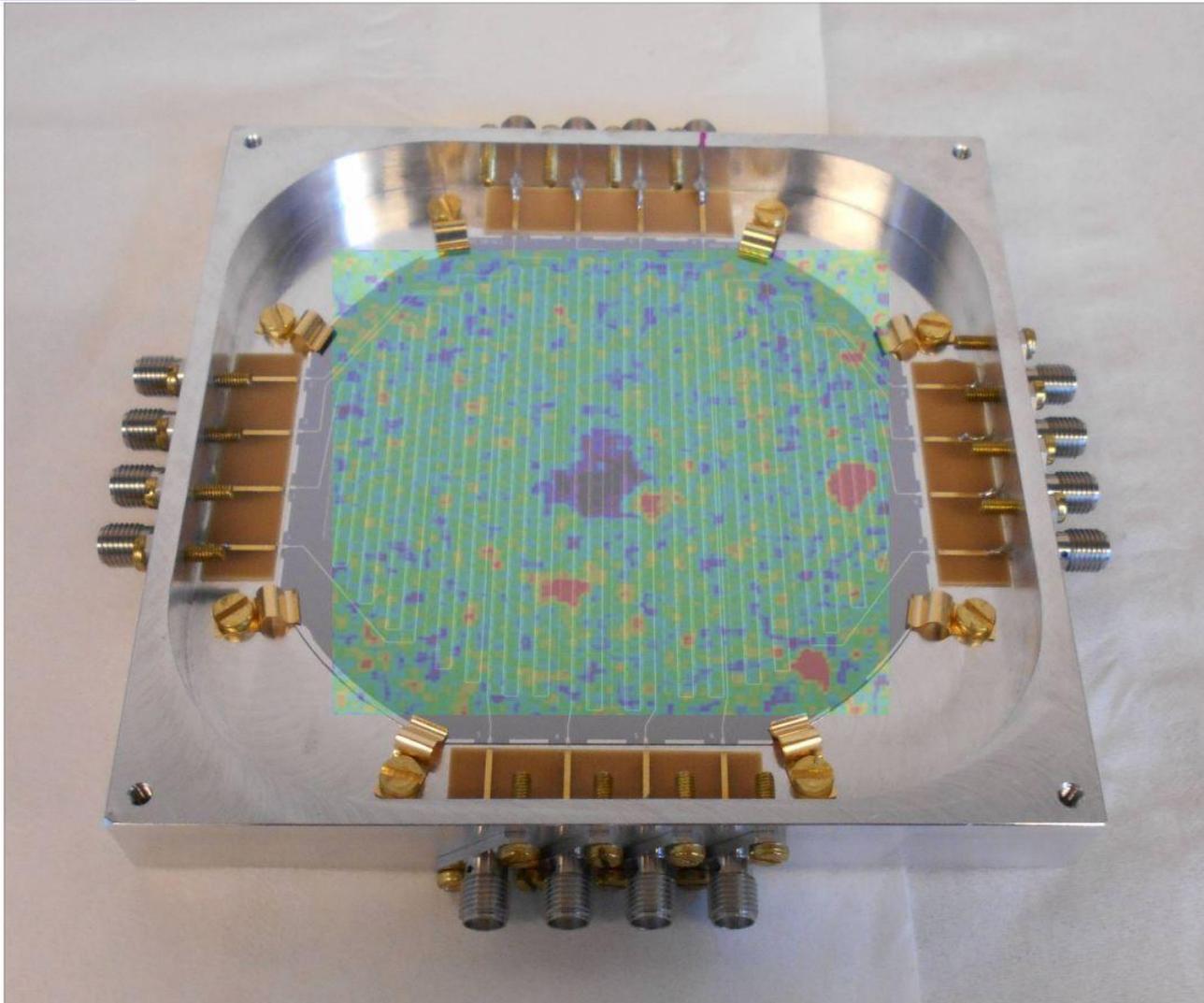


A new population (hundreds) of cold massive sources discovered. This sample of previously undetected sources opens up a brand new window on the characterisation of the earliest stages of star formation.

Taken from:
N. Peretto,
Proceedings of the
«mmUniverse@NIKA2»
Conference (2019)



NIKA2: a mapping machine



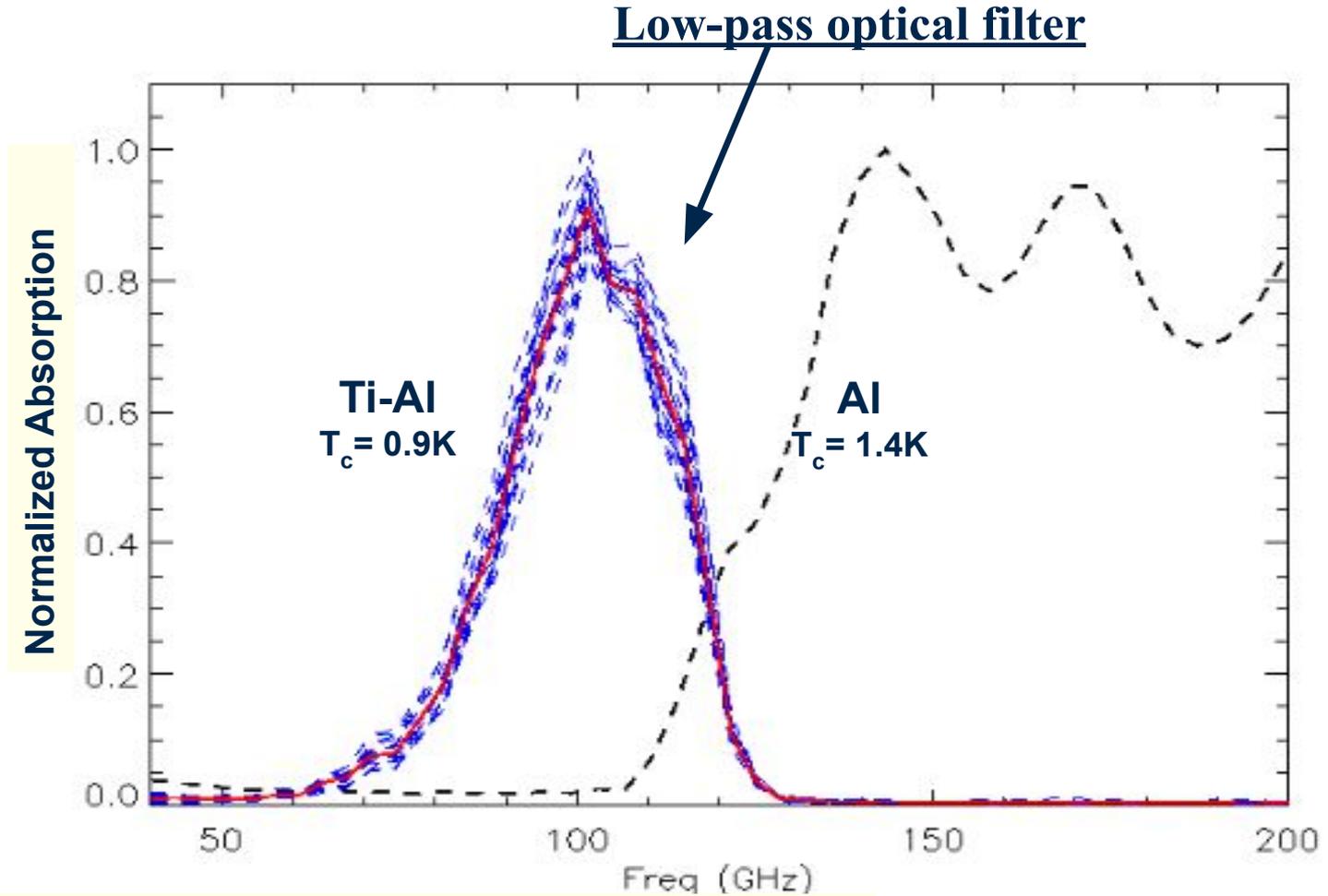
Left: a high- z ($z \approx 1$) cluster of galaxies

NIKA2 has mapped or is mapping at high resolution:

- tens of clusters;
- galactic regions;
- tens of nearby galaxies;
- star-forming filaments;
- and much more ..

The proceedings of the “mm Universe @NIKA2” conferences are on-line:
www.epj-conferences.org

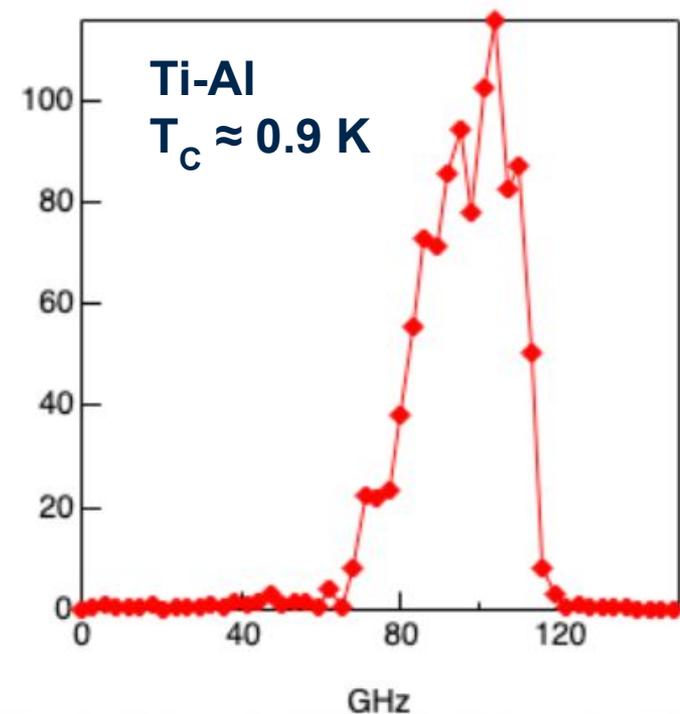
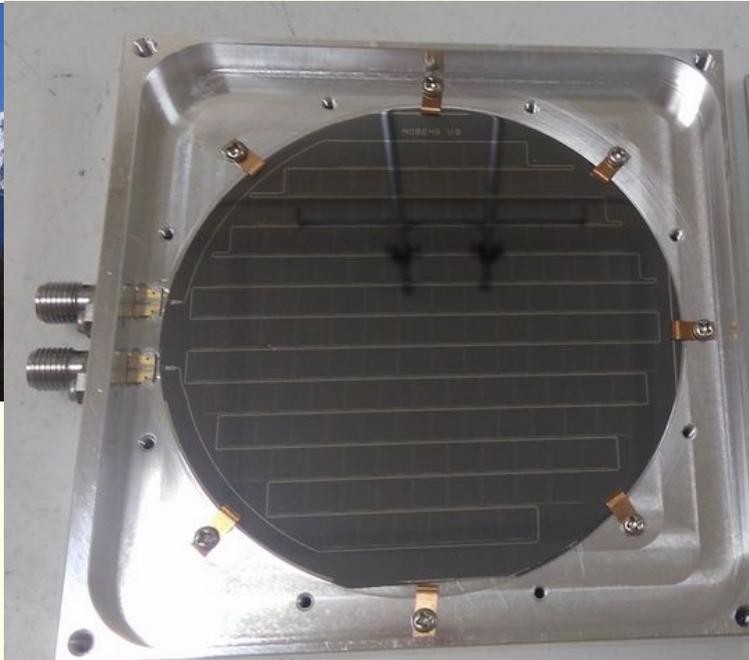
Observing at 90GHz: Ti-Al multilayers KID in lab



Multilayers KID developments



**45-m telescope
(90 GHz)
(complementing
30-m@IRAM)**

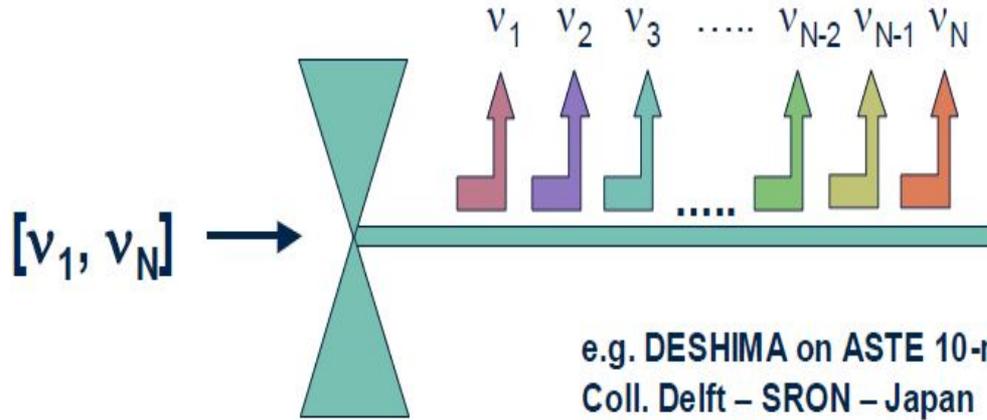


See Nagai-san presentation earlier today for the baseline solution (antennas). We propose a backup, i.e. using for the first time a Ti-Al 90 GHz LEKID camera on a telescope. Efficient collaboration on-going. Thanks !



Spectral imaging options

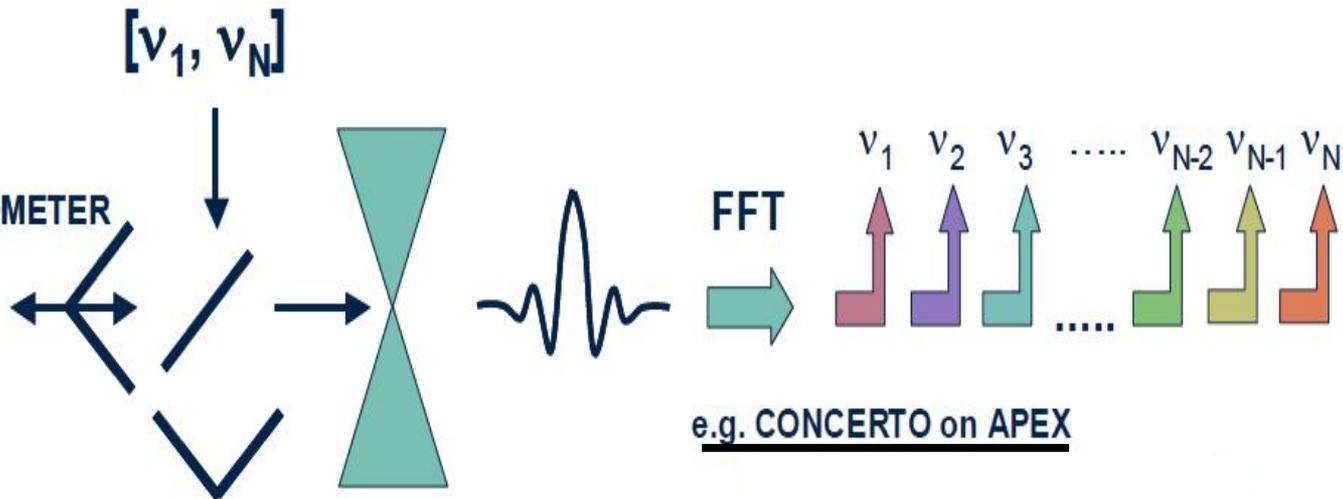
ON-CHIP



e.g. DESHIMA on ASTE 10-meters telescope
Coll. Delft – SRON – Japan
OR SuperSpec US coll.

BETTER FOR
COMPACT
SOURCES
AND
 $R=100 \div 1000$

INTERFEROMETER



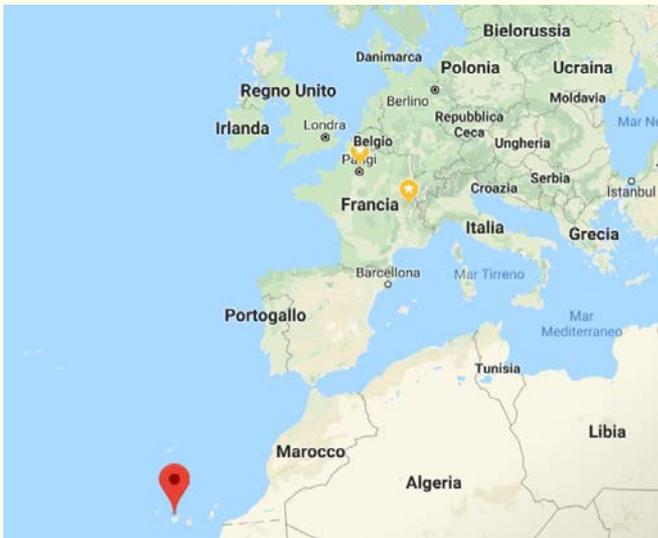
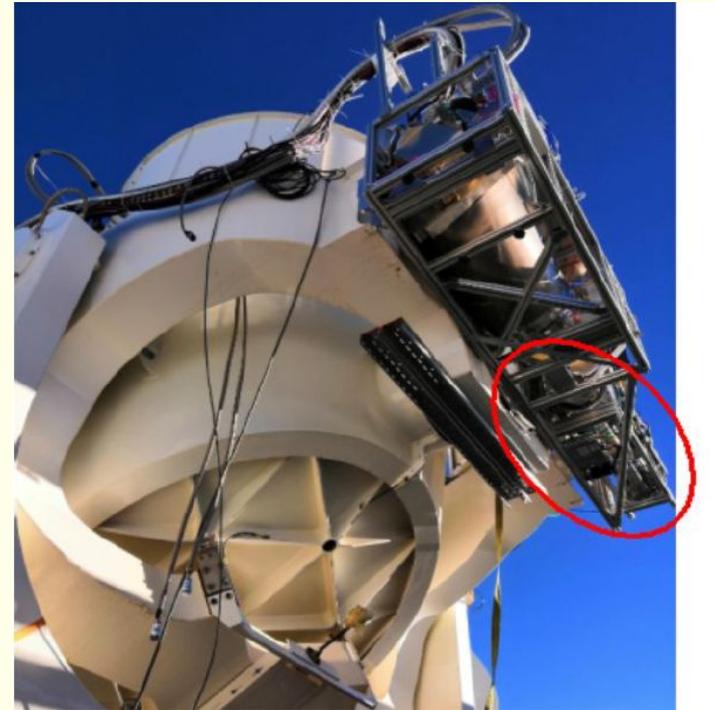
e.g. CONCERTO on APEX

BETTER FOR
LARGE
PATCHES
OF THE SKY
AND
 $R = 10 \div 100$

Pathfinder: KISS on QUIJOTE

Telescope: 2.5 m
 Field-of-view: 1 deg
 Pixel on Sky: 3 arc-min
 Band: 120 ÷ 180 GHz
 Readout rate: 4kHz
 Pixels: 632
 Spectral resolution: 20 ÷ 50

Equivalent to 12 ÷ 30 kpix



KISS was mounted on QUIJOTE at Teide
 Observatory between 11/2018 and 08/2021

APEX 12-meters sub-mm telescope



Cerro Chajnantor



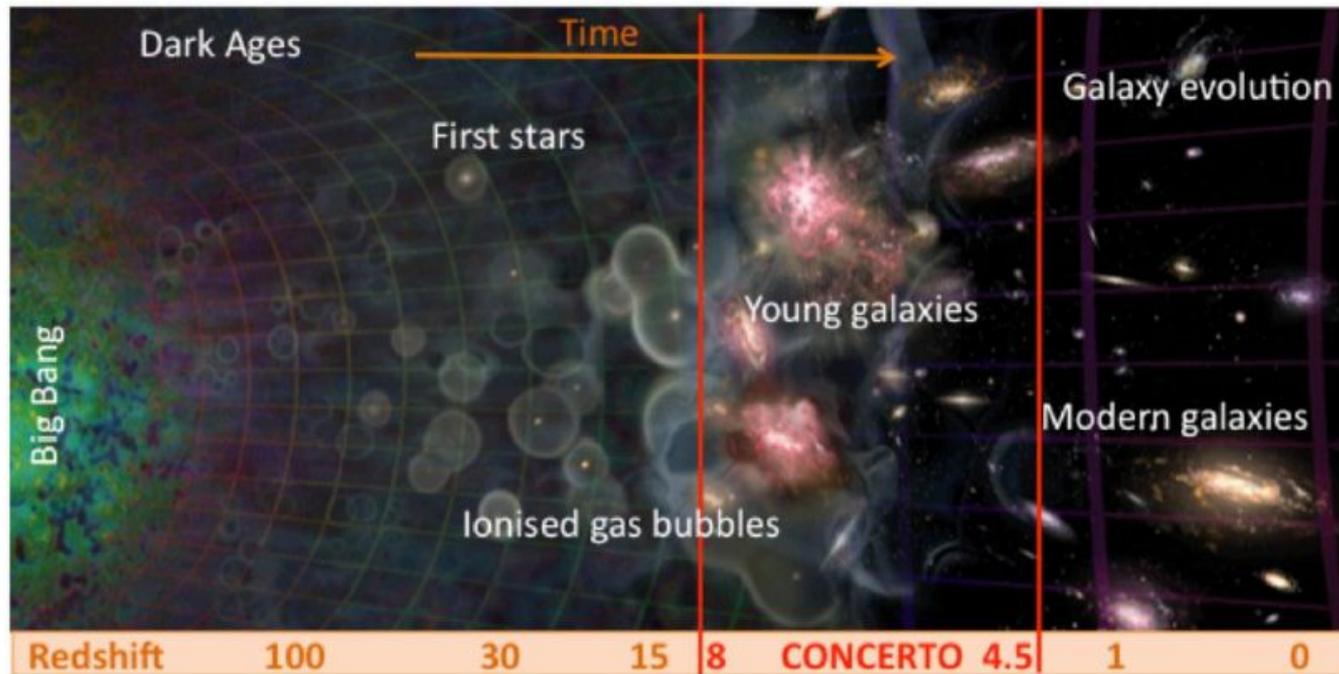
Observing up to THz. Unique tool for mapping ! Field-of-view 20 arc-min !

CONCERTO at APEX-Atacama

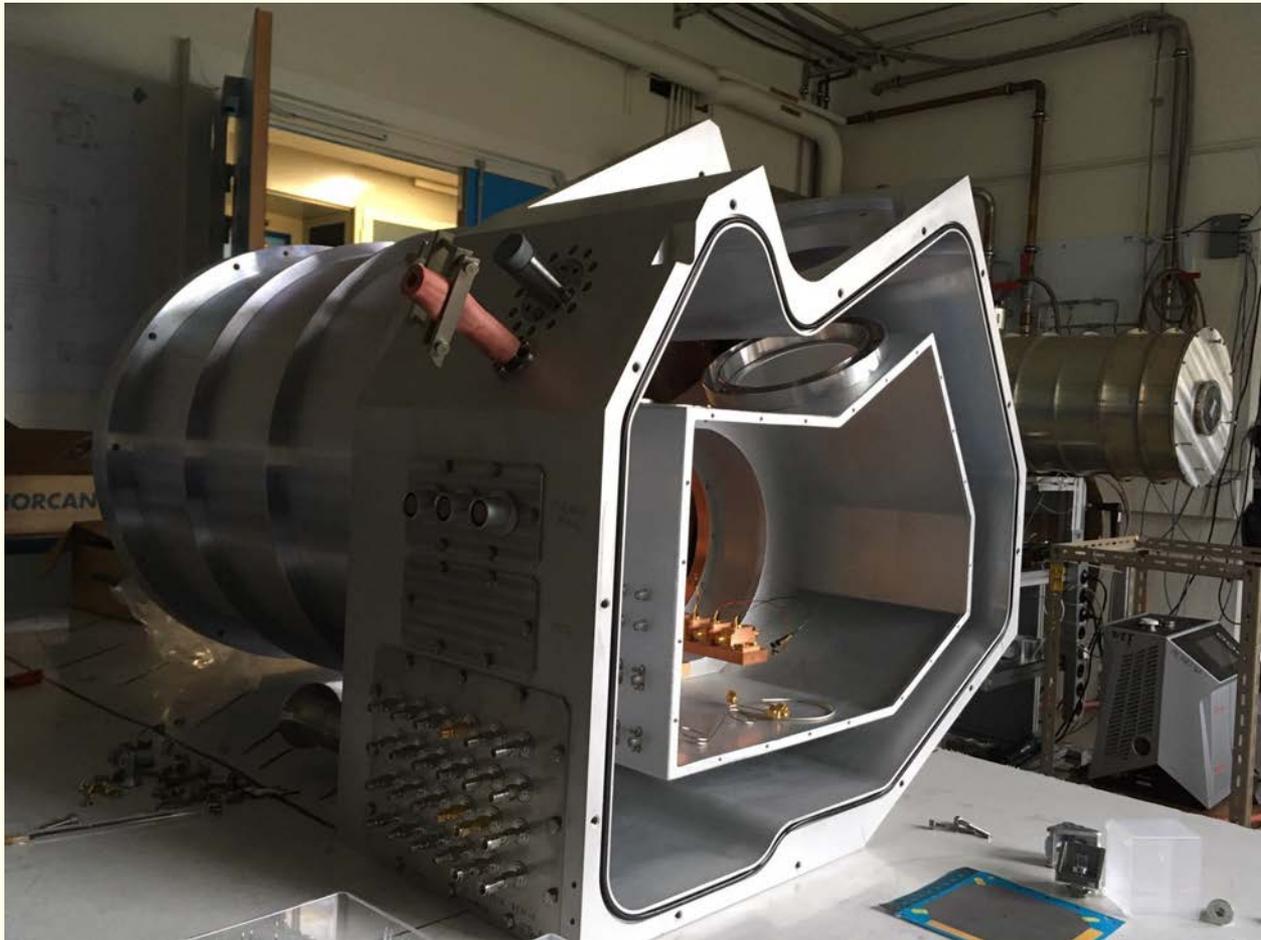
Young SMG have a strong emission line at 157 μ m due to CII

This line is redshifted to sub-mm wavelengths for $z=4-8$

By making 3D intensity maps of the CII line, CONCERTO will provide an unprecedented insight on the formation of the earliest galaxies



The CONCERTO cryostat: last week cold ! (old slide)



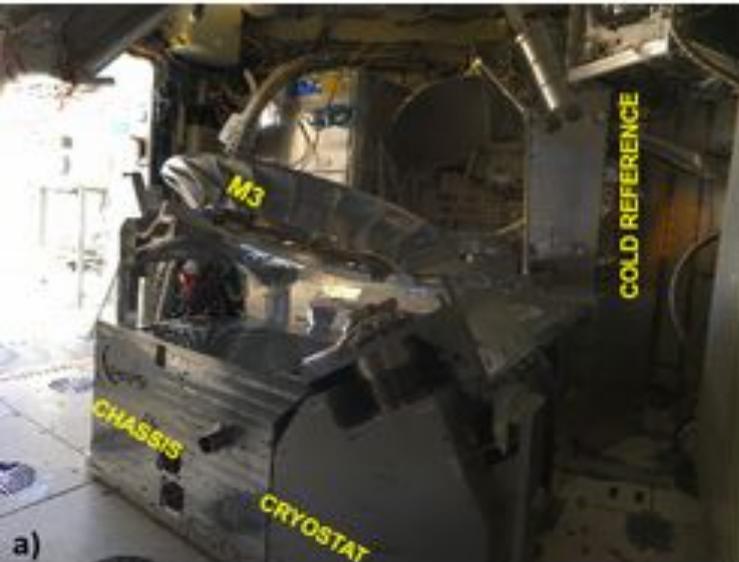
**The CONCERTO
Cryostat and the
visit of the 2018
Nobel Prize
Gérard Mourou**

19/02/2020

Paris

CONCERTO: installed in 2021 !!!

- 6th April, STARTING UNPACKING THE BOXES
- 10th April, START COOLDOWN
- 12th April, BASE TEMPERATURE → 60mK
- THEN TECHNICAL COMMISSIONING. 4th of May → CRAB
- END OF MAY ALREADY THE FIRST OBSERVATIONS IN REMOTE !!



**THE CRYOSTAT
WAS COLD FOR
TWO MONTHS
(APRIL-MAY)**

CONCERTO: some technology in it

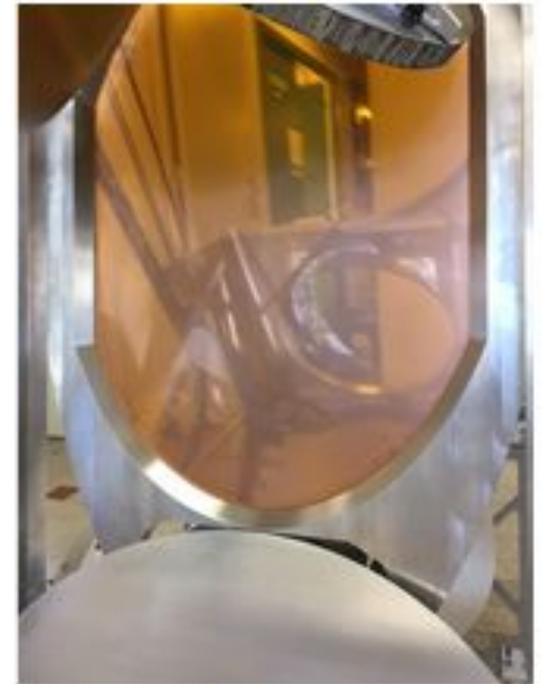
Home-made (literally)
mini dilution insert
(100% useful duty cycle)



“Chassis” Tilting. The cryostat
is designed to work up to 85
deg inclination → IT DOES



- 80cm POLARIZERS (Grenoble)
- Filters, e.g. notch (Cardiff)

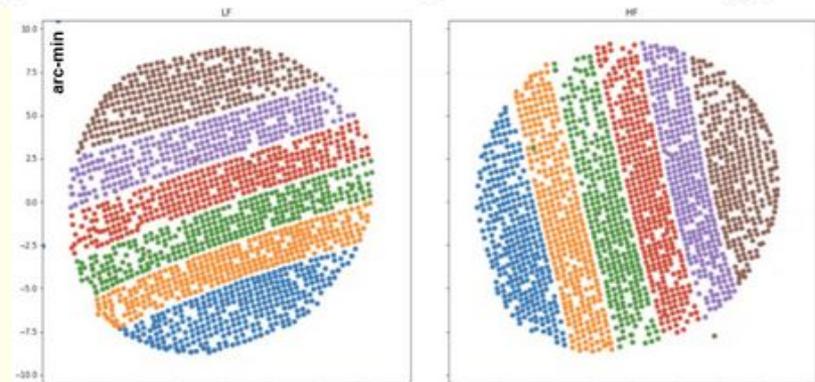


CONCERTO: now observing !!



CAT's PAW NEBULA (17 minutes integration)

CRAB NEBULA (3 minutes integration)



Left: The two CONCERTO focal planes geometries
 Around 90% of the 4,300 pixels exhibit a beam !

<https://www.eso.org/public/announcements/ann21010/>

Thanks !

A bunch of us (a few years/kg ago) at the telescope



Martino Calvo, Andrea Catalano, Alessandro Monfardini, Juan Macias-Perez, Nicolas Ponthieu
 ... many others missing