The NIKA2 instrument at 30m IRAM telescope: performance and first results

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on behalf of NIKA 2 collaboration

IRAM-30m Telescope

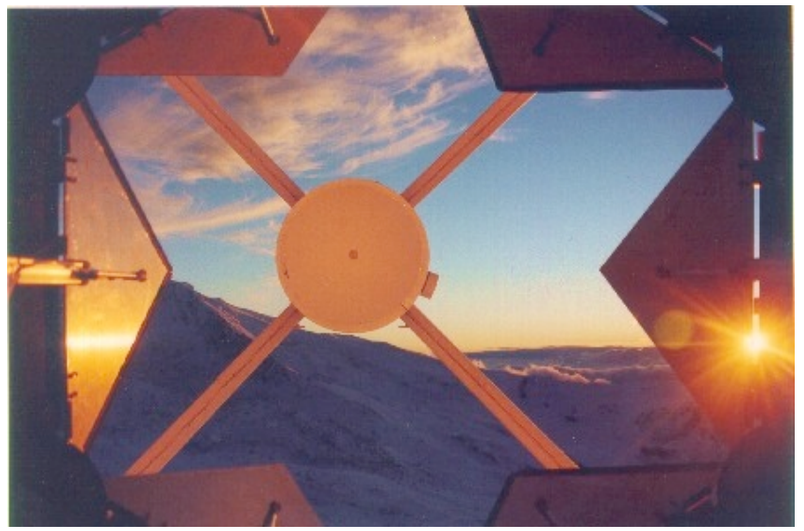
The New IRAM KID Arrays 2 Project

Goal: install the most powerful ever continuum instrument at the 30 m telescope, with features never available before (FOV, multi-band, polarisation)

Status: NIKA2 is installed at 30 m IRAM telescope since 10/2015 (science verification achieved!)

Schedule: expected to be available for the general community in late 2017

Science: the NIKA 2 consortium redeemed as guaranteed time observations (GTO) of 1300 h in 5 large programs corresponding to our scientific interests.



(IRAM-30m Subreflector view at sunset from vertex)

Galactic : Study of star forming regions in the galaxy: filamentary structure and fragmentation, magnetic fields Resolved mm emission from nearby galaxies: dust emission, radio diagnostic of the SFR

Extra-Galactic : Deep survey to map the dusty star formation at high redshift

Cosmology : Understand bias in galaxy cluster cosmology via the Sunyaev-Zeldovich effect

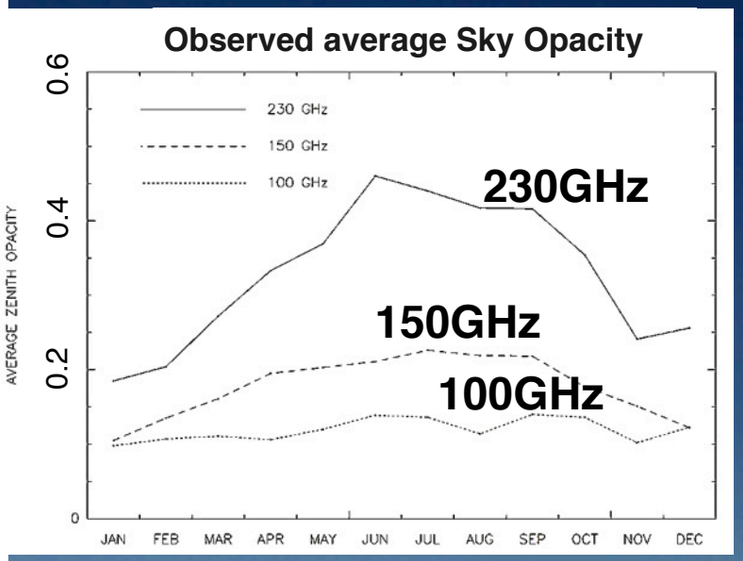
Requirements (Goals)	260 GHz	150 GHz
beam (FWHM)	12” (10”)	18” (16”)
FOV (diameter)	6.5’	6.5’
# of detectors	2 x 1140	1020
Sensitivity	30 (15) mJy.s	20 (10) mJy.s
Polarisation	YES	NO

Telescope IRAM-30m

Located on Pico Veleta in the Spanish Sierra Nevada.

Altitude of 2850m - Longitude: 3:23:55.51 West, Latitude: 37:04:06.29 North

Telescope rotates on an alt-azimuth mechanism with a tracking precision of less than 1 arcsecond.



420 aluminium (on a honeycomb structure) panels with a surface precision of 55 microns

Working Bands

- 80-360 GHz

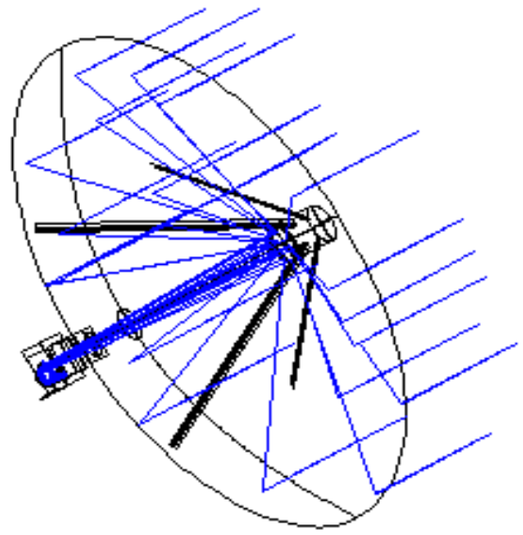
EMIR multi-band heterodyne

- **260 GHz : 150 GHz**

NIKA 2 Camera

Angular Resolution

From 7 to 25 arcsec

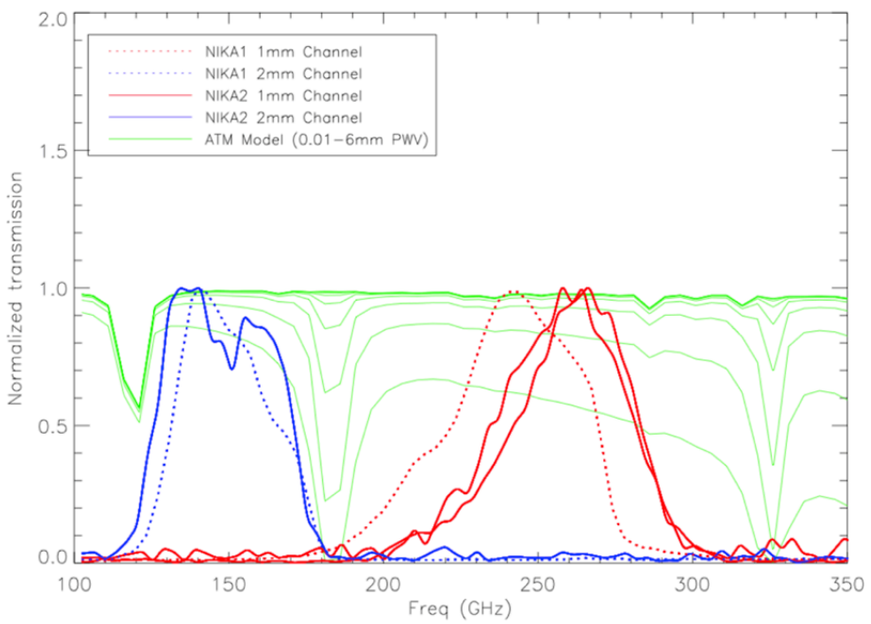


Signals are distributed to the various receptors by a series of high precision mirrors.

NIKA 1-2 Project Schedule

- 2009-2015 : NIKA 1 (opened to community in 2014)

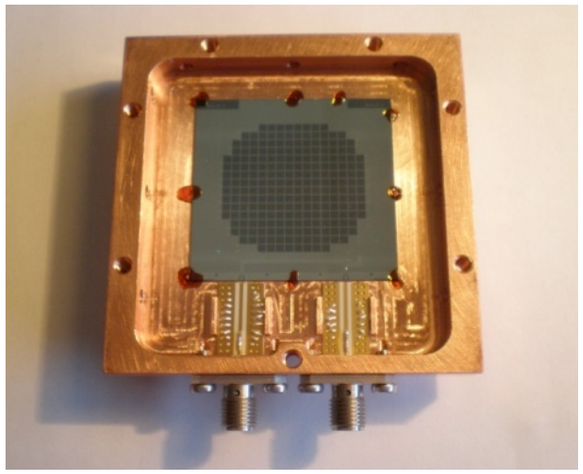
2-color Camera: FOV = 1.9 arcmin



KID Arrays:

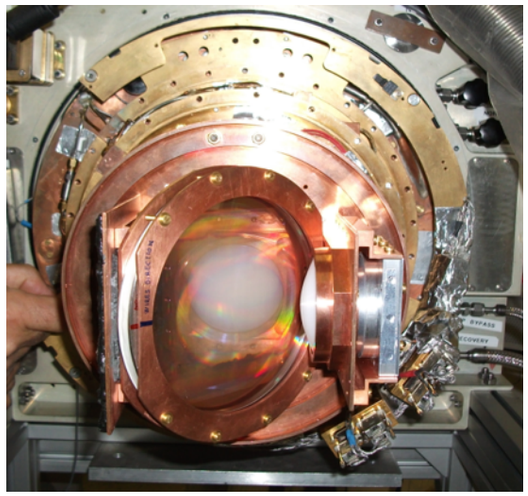
125 valid pixel @ 2.14mm

190 valid pixel @ 1.25mm



Dilution Cryostat

3He-4He (100 mK)



- 2012-2015 : NIKA2 development.
- February 2015 : new telescope cabin optics.
- October 2015 installation of NIKA2 and first light.
- October 2015 - May 2016 : first commissioning phase
- July - September 2016 : upgrades
- April 2016 : final intensity commissioning run and science verification.
- Winter 2017-2018 : opening to the community (intensity) - End of polarisation commiss.

February 17th 2015 - **Bye Bye NIKA1**

Thanks to NIKA1 we acquired:

Monfardini et al. 2010, A&A, 521, A29
Monfardini et al. 2011, ApJS, 194, 24

Data Processing skills :

- Photometry Accuracy

Calvo et al. , A&A 551, L12 2013

- Tuning Procedure& Sky Opacity Correction

Catalano et al. , A&A 569, A9 2014

- Polarisation Systematics control

Ritacco et al. , A&A 599, A34 2017

Astrophysical results

- Sunyaev Zeldovich Effect

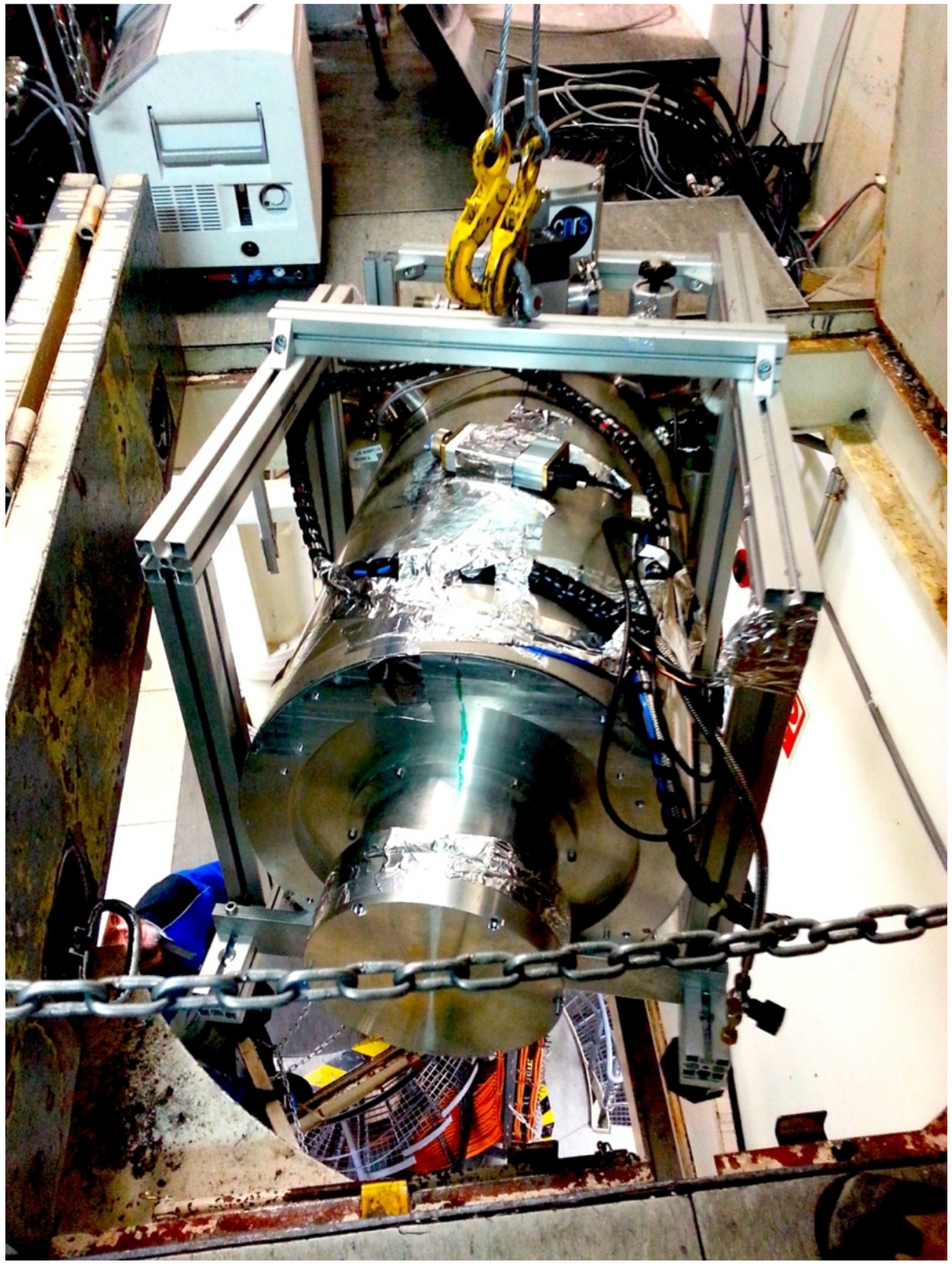
Ruppin et al. , A&A 597, A110 2017
Adam et al. , A&A 598, A115 2017
Adam et al. , A&A 586, A122 2016
Adam et al. , A&A 576, A12 2015
Adam et al. , A&A 569, A66 2014

- Dust with KIDs

Bracco et al., 2017, submitted to A&A

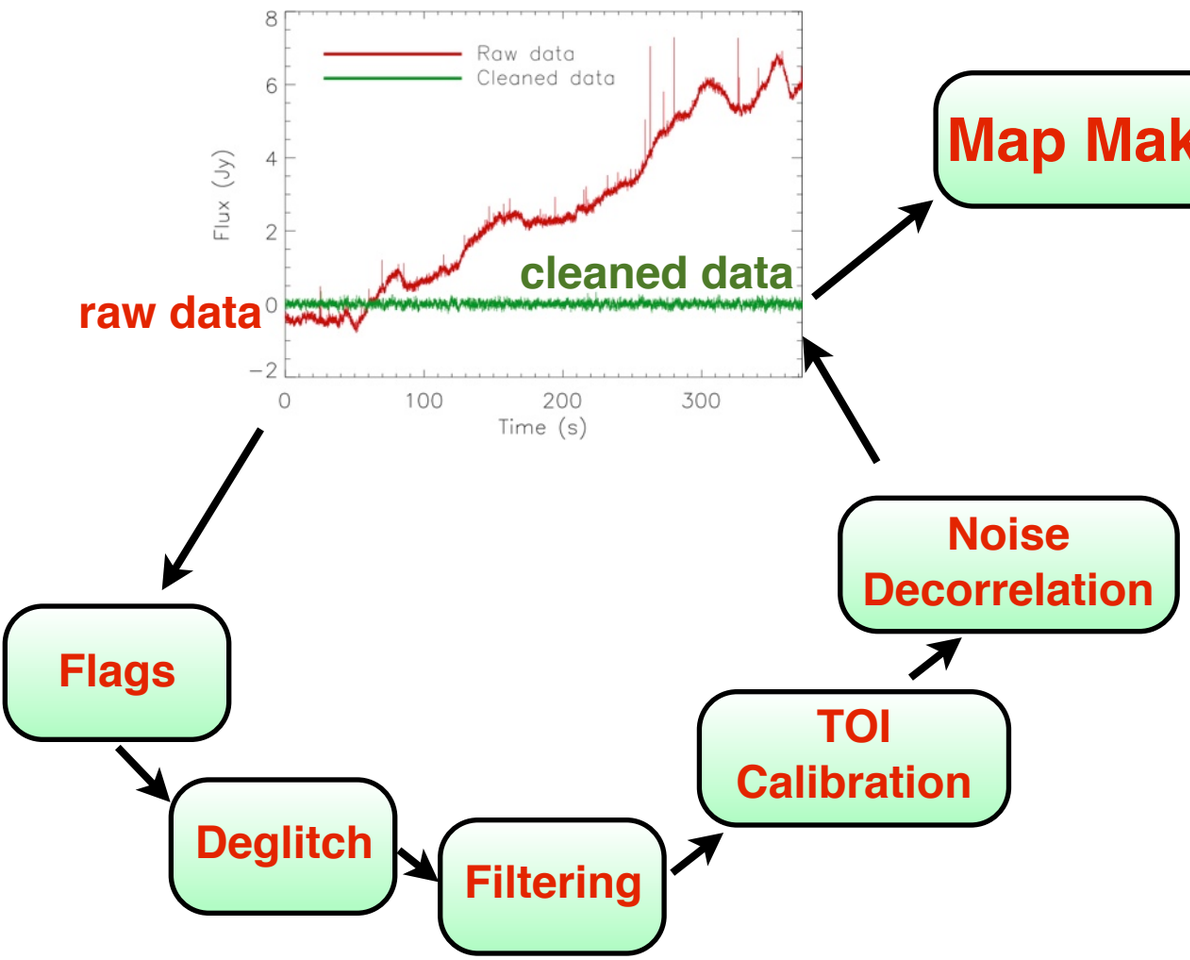
- Observation of extended source in pol

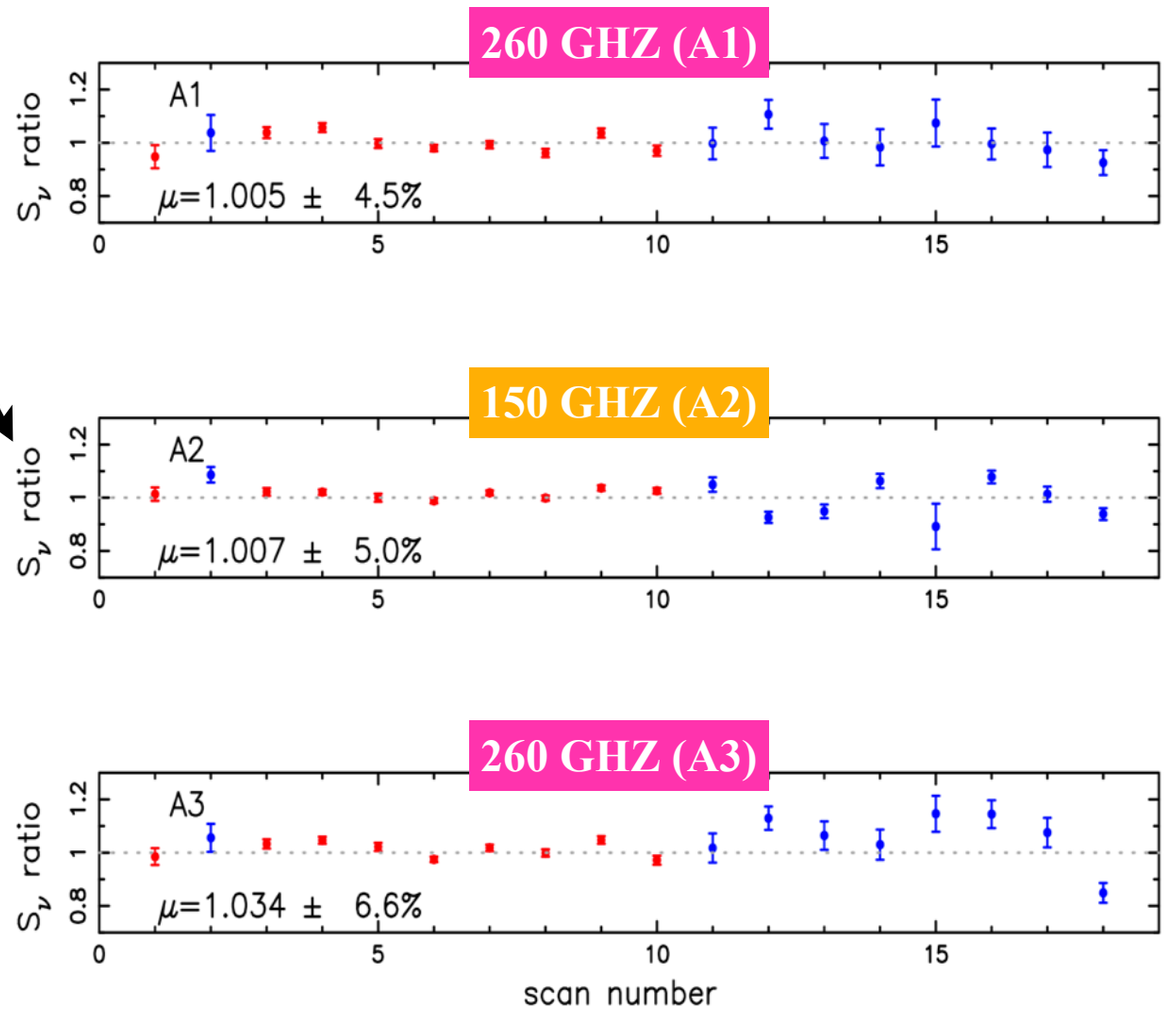
Ritacco et al., 2017, submitted to A&A



The Full Calibration Process

....A dedicated Pipeline



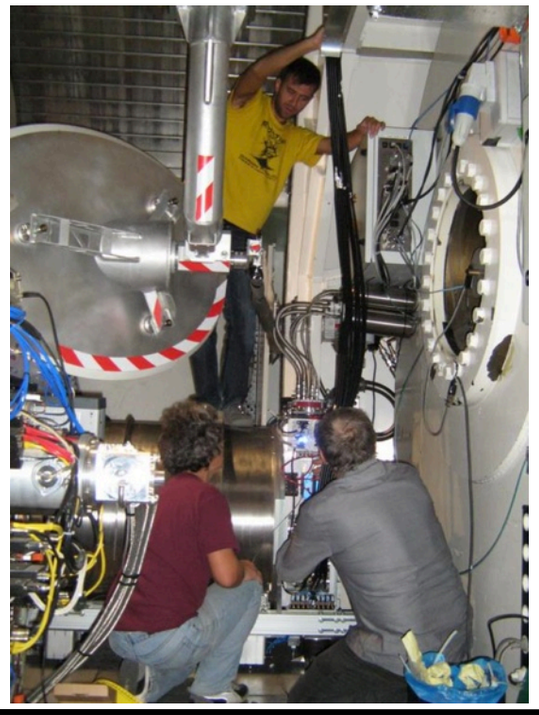


Comparison of measured and reference flux densities of the primary calibrators Uranus (**red**) and Neptune (**blue**).

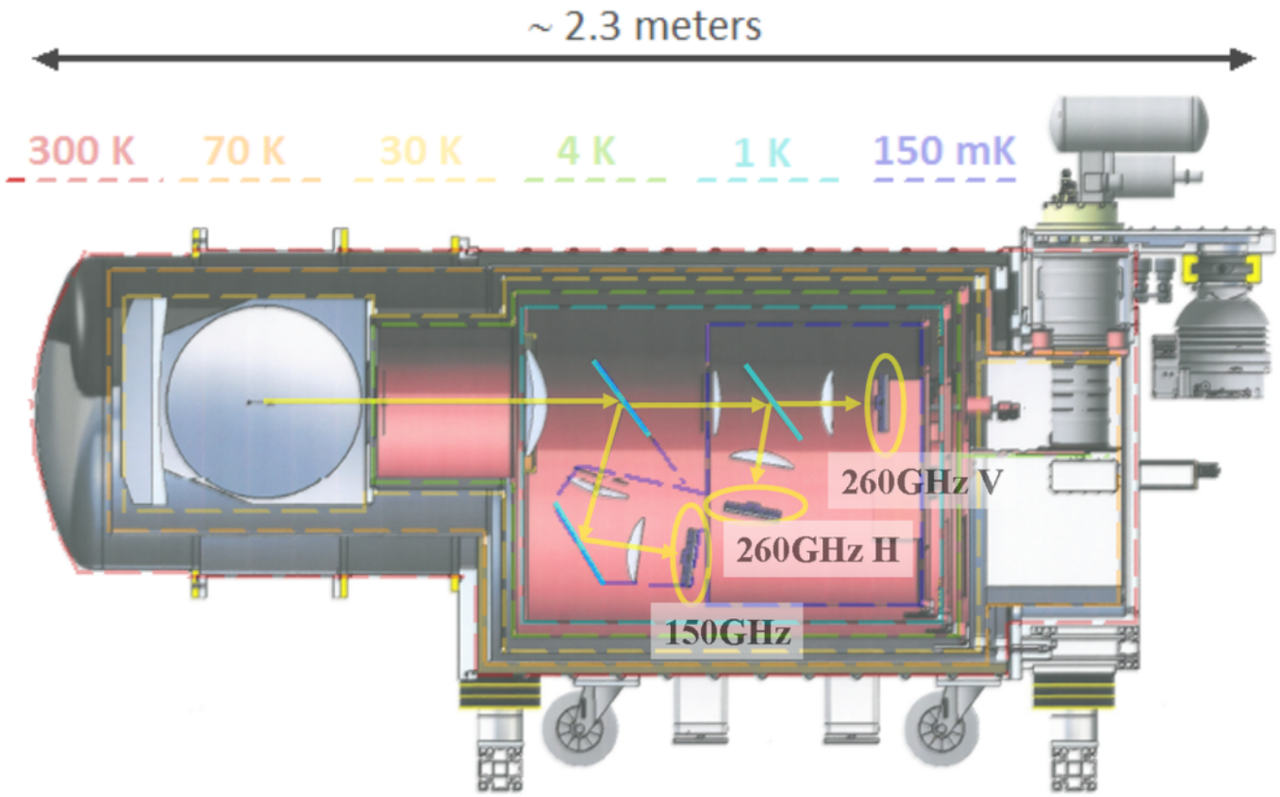
The NIKA 2 Final Instrument

- **Cryostat :** 3He-4He dilution system (100 mK), with intermediate temperature stage using 2 cryorefrigerators.
- **Large LEKID arrays:** Total pixel count of 2896
- **Warm electronics:** 20 NIKEL boxes, 40 cables between cryostat and electronics
- **Field-of-view :** 6.5 arcmin
- **Linear polarisation @260 GHz** : rotating HWP at 300K and wire grid at 100 mK .
- **Foreseen data rate :** 700 Gb/day at most.

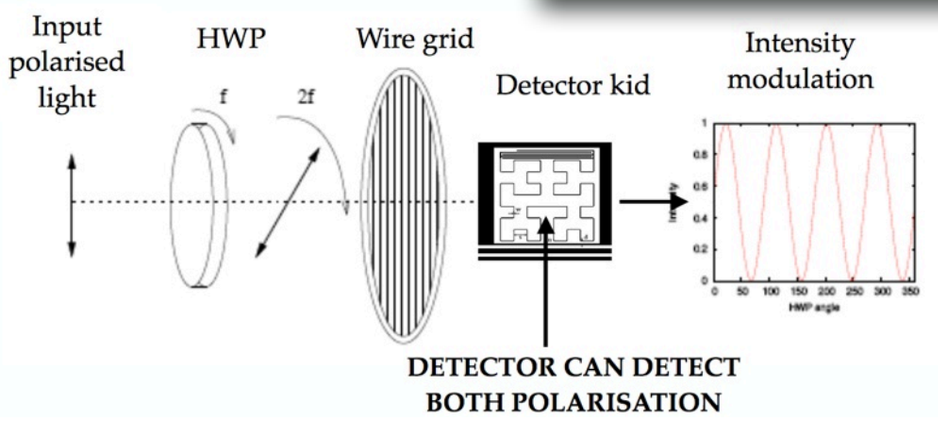
NIKA 2 Installation beginning of October 2015



The CRYOSTAT



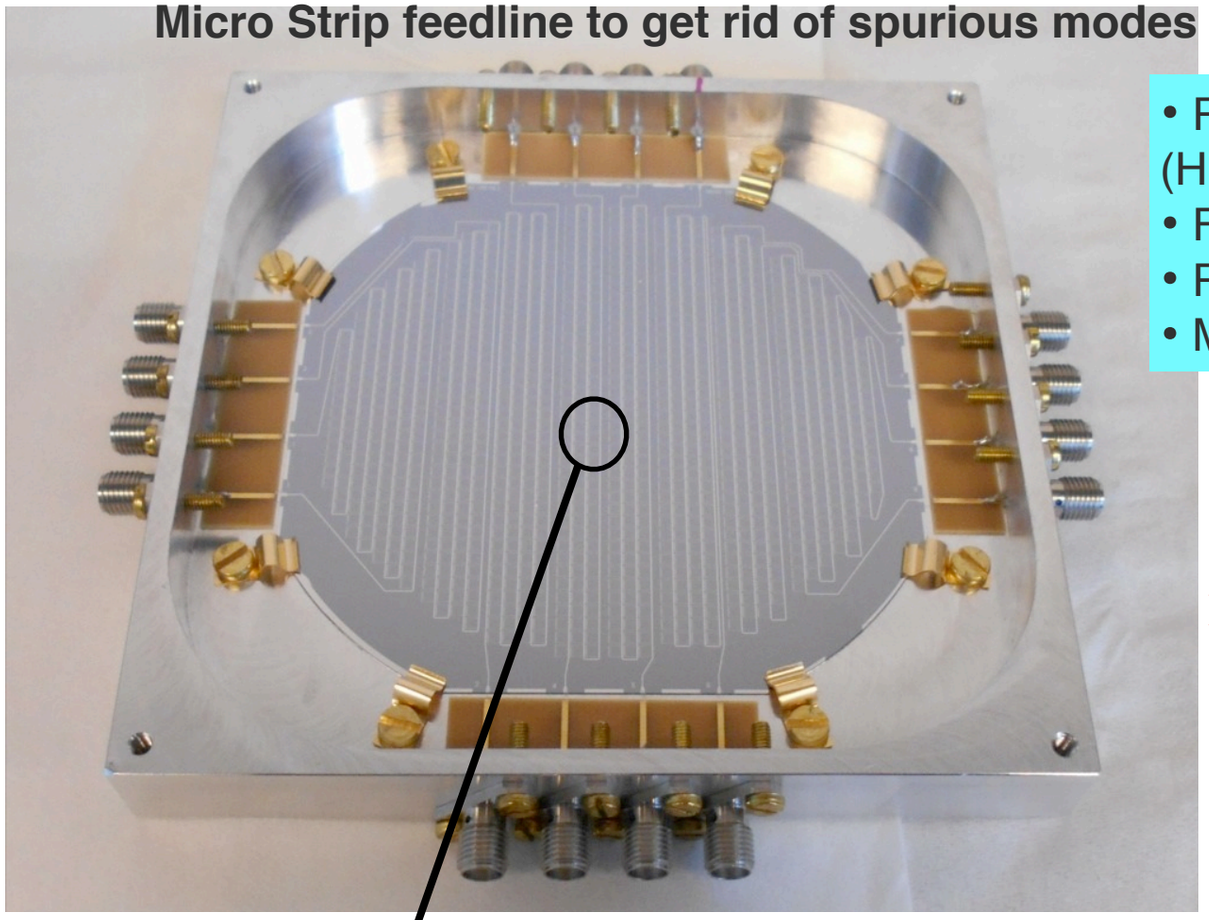
Polarisation Strategy



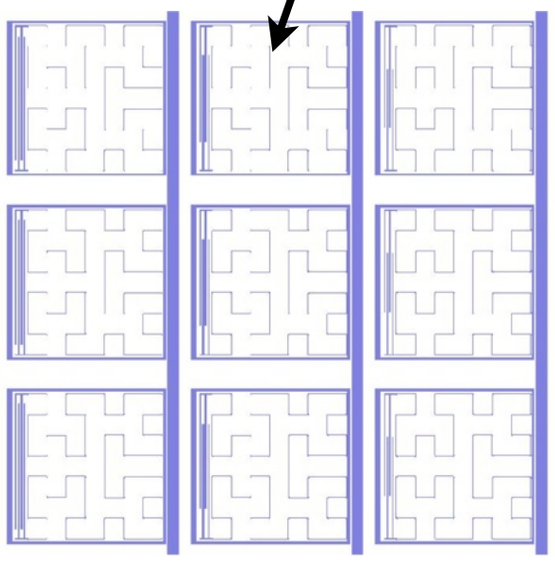
$$S = \frac{1}{2}(I + Qcos4\omega t + Usin4\omega t)$$

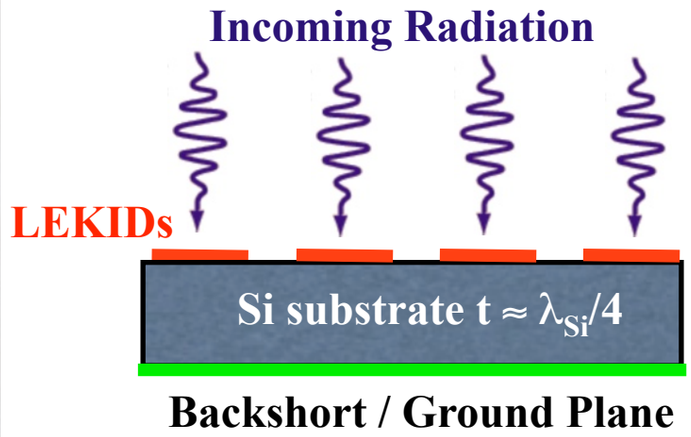
POLARISED SIGNAL MODULATED AT 4 TIMES THE ROTATIONAL FREQUENCY

NIKA 2 : Detectors & Readout

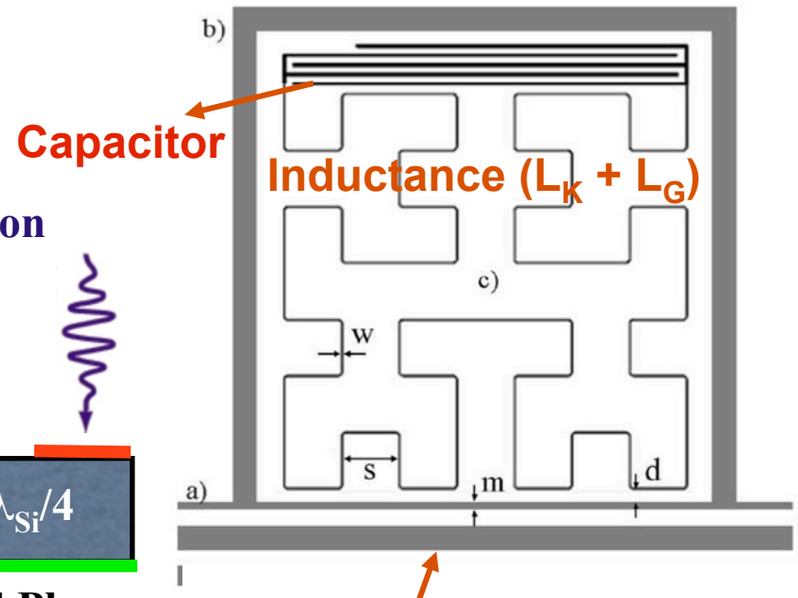


- Pixels similar to NIKA1 (Hilbert LEKID)
- Films: thin Al (18÷25 nm)
- Pixels Size (1 Fλ)
- Micro Strip feedline





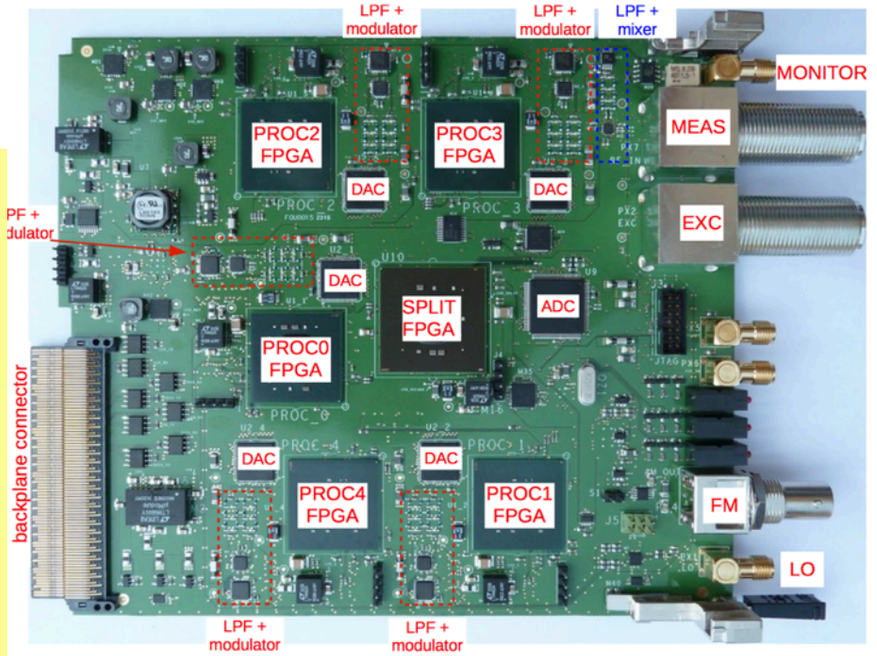
Dual Polarisation
(3rd-order Hilbert pattern)
Roesch, M. et al. 2012, ArXiv 1212.4585



Frequency Multiplexing Read-Out Electronics : NIKEL

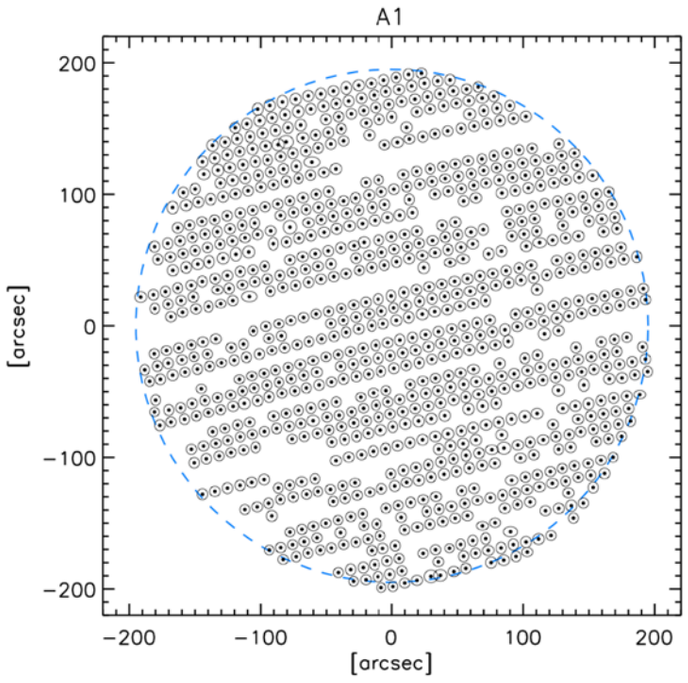
- Based on *NIKEL* boards (NIKA 1)
- Miniaturized board
- Board = **250 tones per board**
- 150 GHz: 4 feedlines - 260 GHz: 8 feedlines - 20 complete RF lines (coax in/out + LNA)

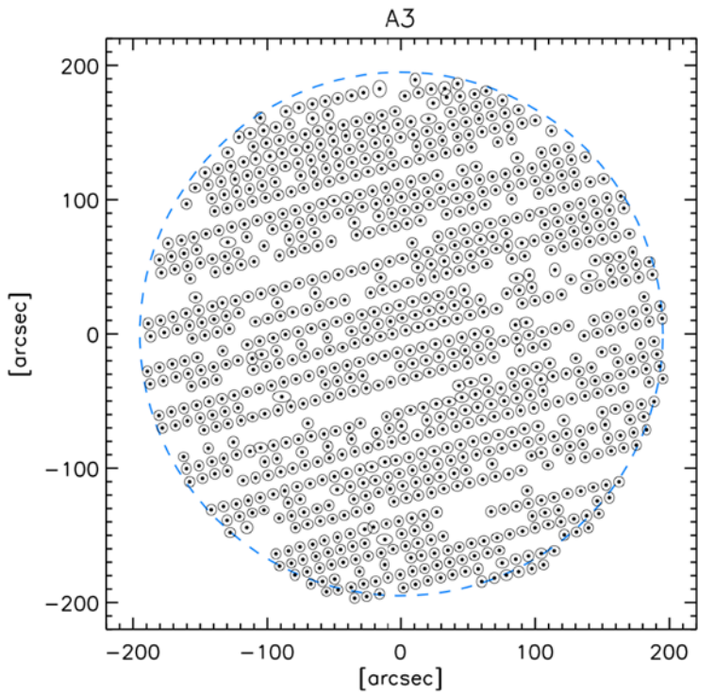
O. Bourrion et al., 2016 arXiv:1602.01288

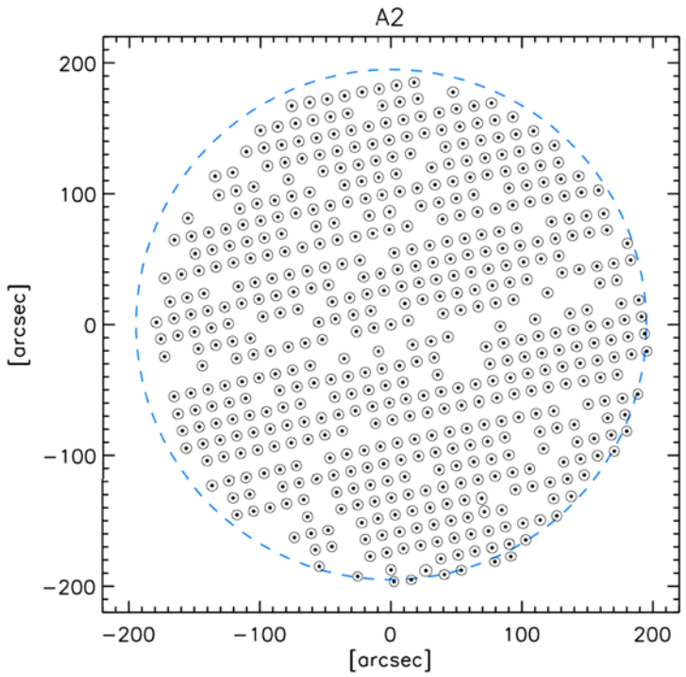


Commissioning Phase : Photometry

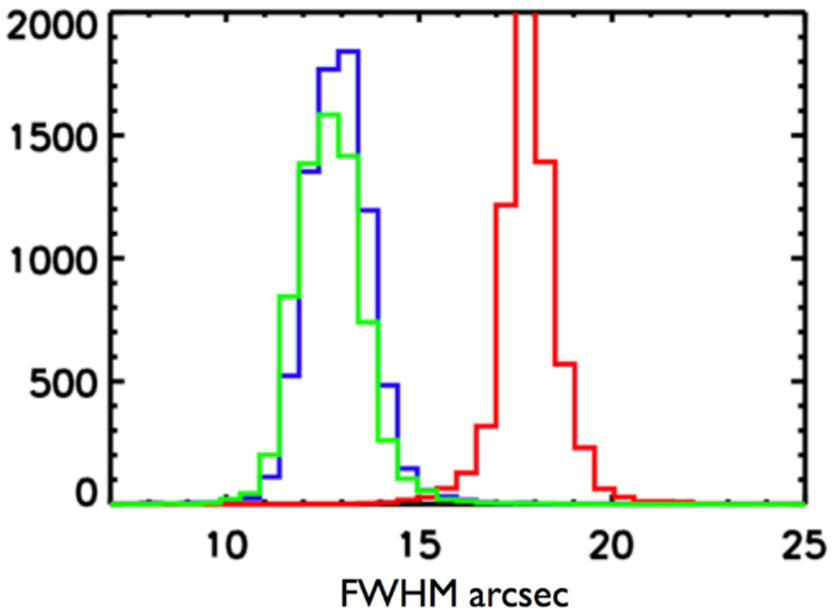
KID statistics: Between 83-85 % of valid KIDs





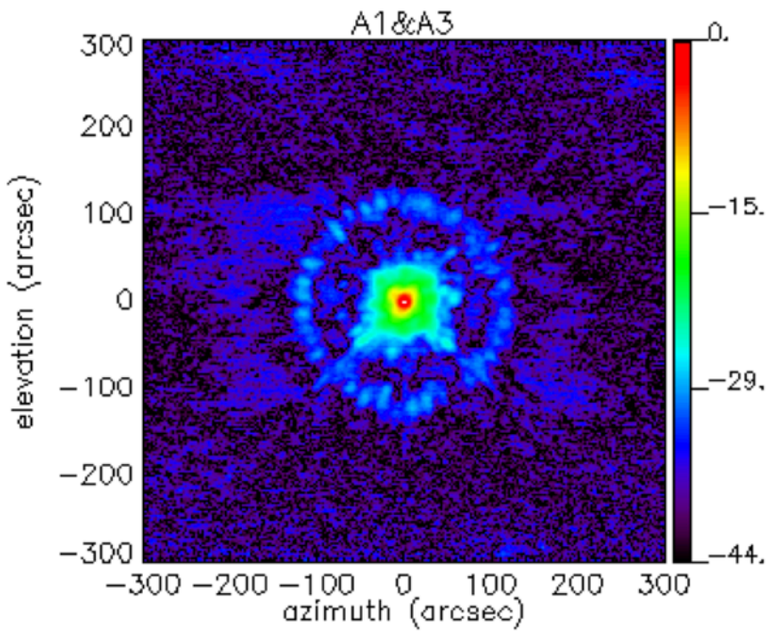


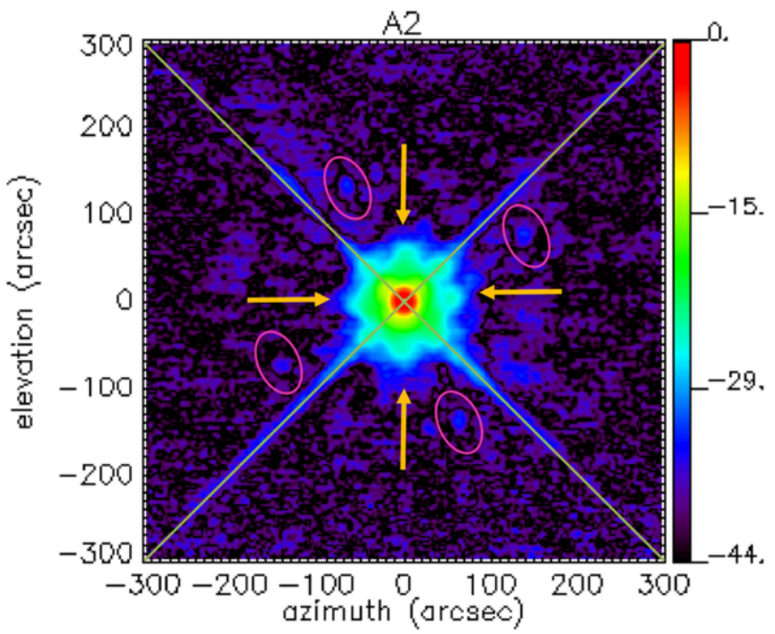
Main Beam FWHM distribution



FWHM (260 GHz) = 11.3”
FWHM (160 GHz) = 17.45”

Beam Efficiencies : ~ 55% @ 260 GHz (model 54.0 %)
~ 70% @ 150 GHz (model 74.1 %)





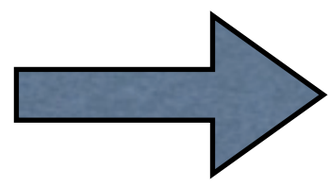
Commissioning Phase : Results

Weak Sources (10 mJy)

NEFD

260 GHz: 20 mJys$^{1/2}$

150 GHz: 6 mJys$^{1/2}$



Opacity = 0.2
Elevation = 60°

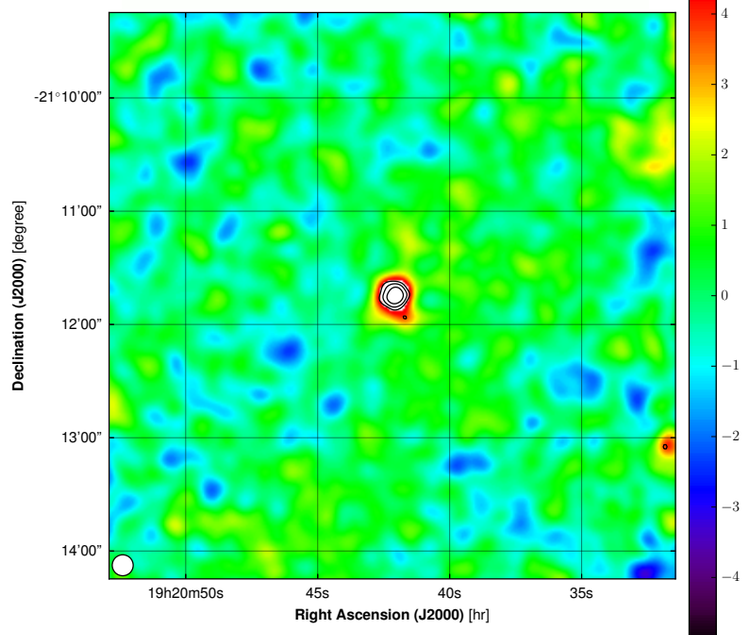
Caveats

Correlated noise observed in the maps

Positive

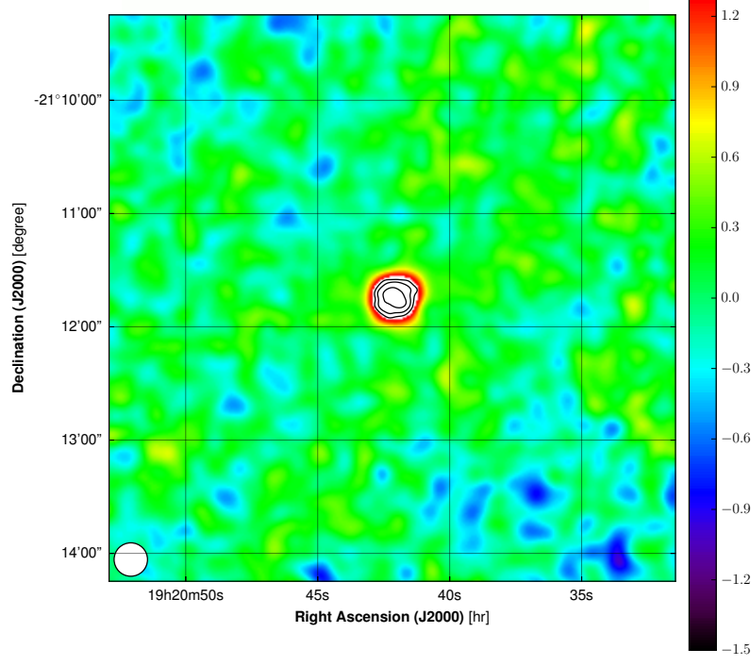
better than specifications, approacching goals.

PLUTO@260GHz



Channel	260 GHz 1.15 mm			150 GHz 2 mm
Arrays	A1	A3	A1&3	A2
Number of designed detectors	1140	1140		616
Number of valid detectors[1]	952	961		553
FOV diameter [arcmin]	6.5	6.5	6.5	6.5
FWHM [arcsec]	11.3 ± 0.2	11.2 ± 0.2	11.2 ± 0.1	17.7 ± 0.1
Beam efficiency[2] [%]	55 ± 5	53 ± 5	60 ± 6	75 ± 5
rms calibration error [%]	4.5	6.6		5
Model absolute calibration uncertainty [%]	5			
rms pointing error [arcsec]	< 3			
NEFD [mJy.s$^{1/2}$] [3]			20	6
Mapping speed [arcmin^2/h/mJy^2] [4]			222	1885

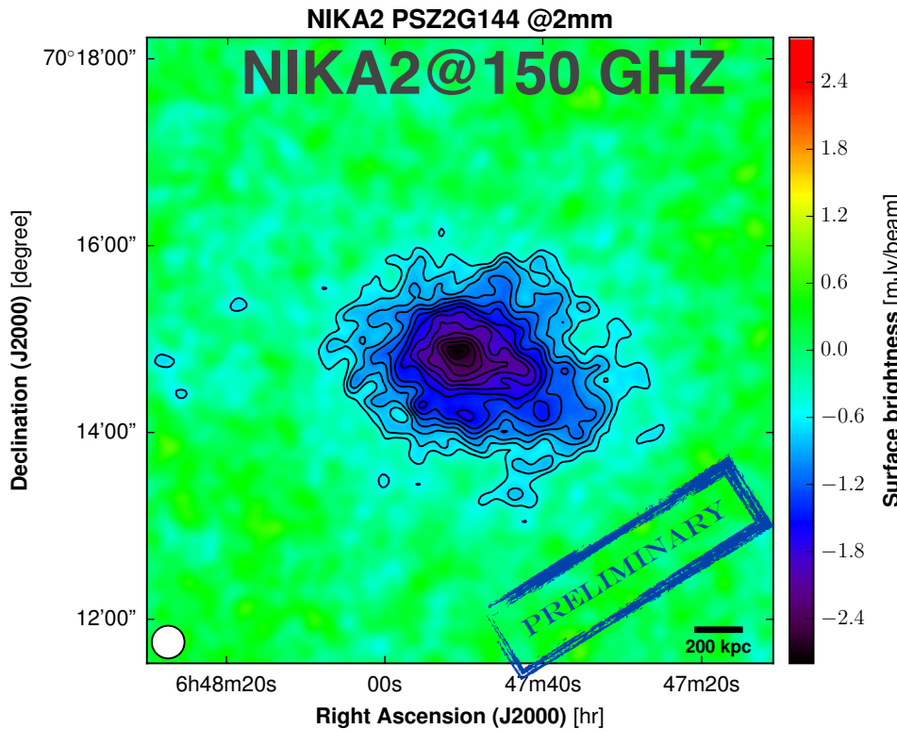
PLUTO@150GHz



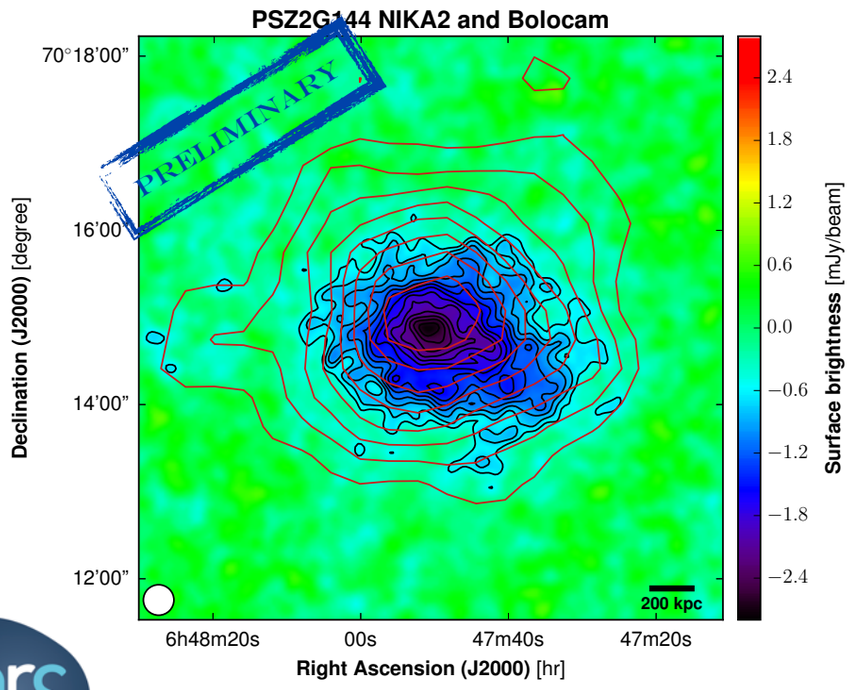
Science Verification

PSZ2-G144.8

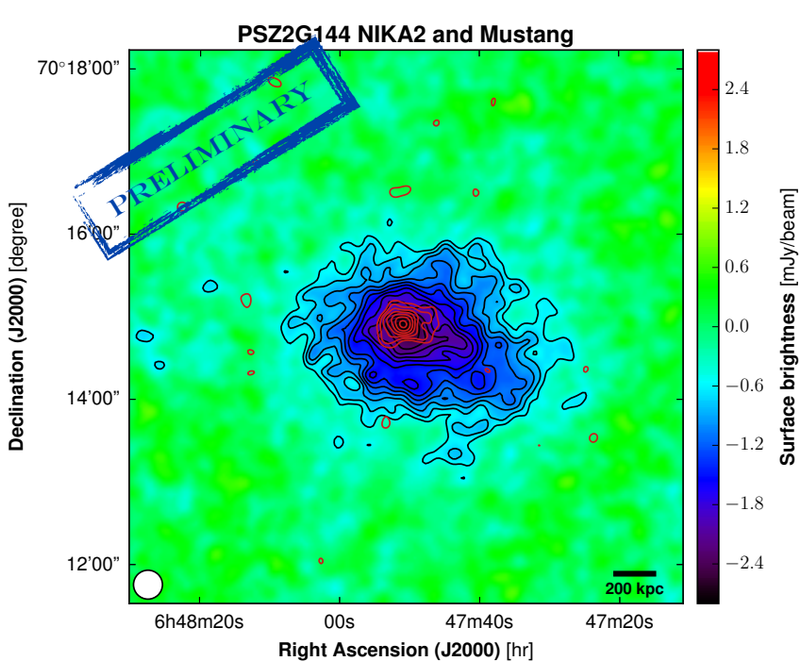
- High-redshift cluster, coupling the intrinsic scientific interest to the need of establishing the NIKA2 performance.
- Observations: April 2017.
- Integration time: about 11 hours



NIKA2 + Bolocam



NIKA2 + Mustang



Conclusions

The NIKA2 instrument is installed at the 30 m IRAM.
The commissioning phase for intensity observations is done!

• From the functional point of view, the commissioning has been a major success: all subsystem are operational and work as expected.

• A few upgrades in the hardware have been done in between July and September 2016:
- replace 150 GHZ array
- replace lenses and window by AR-coated ones.
- replace dichroic
- add dark pixels.

• The Analysis and the interpretation fo the results of Science Verification (April 2017) is in progress.

• Commissioning for Polarisation is encouraging but some work has to be done to finalize it.

• The instrument will be available for astronomers next winter season.

NIKA Collaboration - http://ipag.osug.fr/nika2/

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