NIKA
A High-Resolution Millimetre Camera for the IRAM 30m Telescope

F.-Xavier Désert
IPAG, Institut de Planétologie et d'Astrophysique de Grenoble, France
P. Mazzotta,
Dipartimento di Fisica, Universita' di Roma "Tor Vergata", Roma, Italy
on behalf of the NIKA Consortium

The NIKA collaboration
Néel IRAM KID Array

A. Benoit, A. Bideaud, N. Boudou, M. Calvo, P. Camus, C. Hoffmann, C. Hoarau, A. Monfardini, L. Swenson - **Institut Néel**
F.X. Désert, N. Ponthieu – **IPAG Grenoble**
S. Leclercq, M. Roesch, K. Schuster – **IRAM Grenoble**
O. Bourrion, A. Catalano, J. Macias-Perez, L. Perrotto, C. Vescovi – **LPSC Grenoble**
P. Ade, S. Doyle, P. Mauskopf, E. Pascale, C. Tucker - **University of Cardiff**
A. Barishev, J. Baselmans, A. Endo, L. Ferrari, S. Yates – **SRON and Delft**
A. Cruciani, P. Debernardis, S. Masi - **Università di Roma**
C. Giordano - **FBK Trento**
F. Pajot, A. Beelen, F. Boulanger, H. Dole, N. Aghanim – **IAS Orsay**
Ph. André, J.B Melin, L. Rodriguez, V. Reveret – **CEA, Saclay**
+ a scientific consortium

The working principle of a Kinetic Inductance Detector

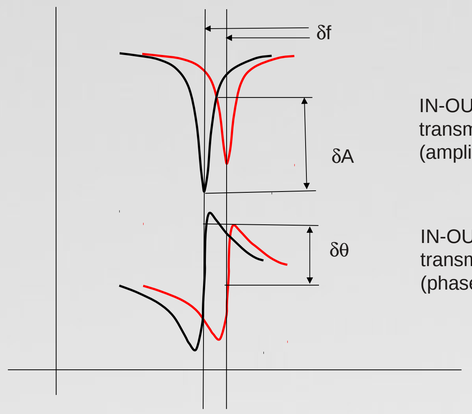
Dark, $T << T_c$

Light: **increase in R**
Change in amplitude (ΔA) and phase

From the theory :

$\delta f \propto \delta L_K \propto \delta P$

δf = frequency shift
δP = incoming power

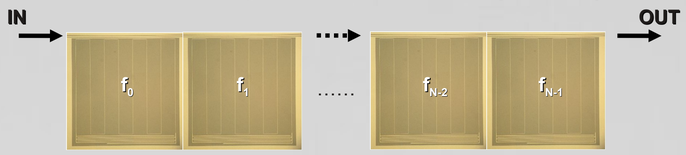


The incoming photons break Cooper pairs (supercurrent carriers) in a superconducting LC resonator → measurable signals

ABSTRACT

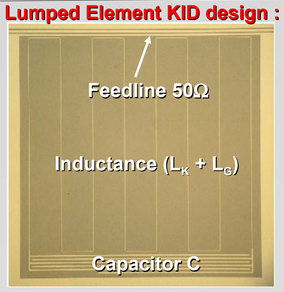
A consortium of European laboratories lead by Alain Benoit (CNRS-Institut Néel, Grenoble) is building a new continuum dual-band camera for the IRAM 30m telescope. It will map the sky simultaneously at 150 and 230 GHz (2 and 1.3 mm), with an angular resolution of 15 and 10 arcseconds and a field-of-view of 6.5 arcminutes in diameter. It is based on new Kinetic Inductance Detector arrays (1000 pixels at 2 mm, 3000 at 1.3 mm) cooled to 100 mK. It will provide in 2015 a high-resolution ground-based follow-up of the numerous clusters of galaxies detected with the SZ effect by the Planck satellite and ACT at the same frequency (150 GHz). A prototype camera is already being tested that provides a sensitivity for the *y* compton parameter of about 10^{-5} (1 sigma, 1 hour, 1 beam).

The Lumped Element KID (LEKID)



One multiplexed line of detectors
IN, OUT: coaxial input and output

Lumped Element KID design :



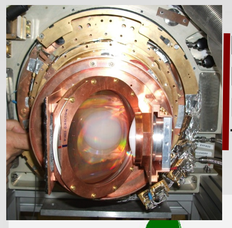
One pixel: 2x2 mm

High-Q superconducting (R ≈ 0) LC resonator :

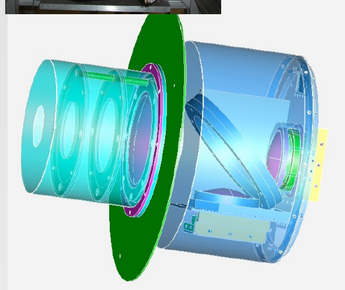
$$f_{res} = \frac{1}{\sqrt{L \cdot C}}$$

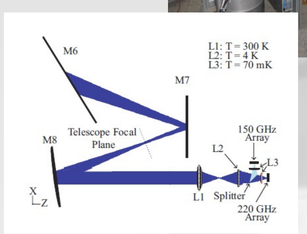
One of the C lines is modulated by lithography to adjust each resonance (e.g. $f_{res} \approx 1.5 \pm 0.2$ GHz)
→ **natural frequency-domain multiplexing**
→ **since $f/\Delta f \approx 10^5$, a large multiplexing factor is possible**
→ **Fabrication with one layer of Aluminum on a silicon wafer**

Dual-band prototype NIKA 2010



Bands : 1.25 – 2.05 mm
Pixels : 144 x 2
Field-of-view : 2 arc-min
T_{base} = 60mK

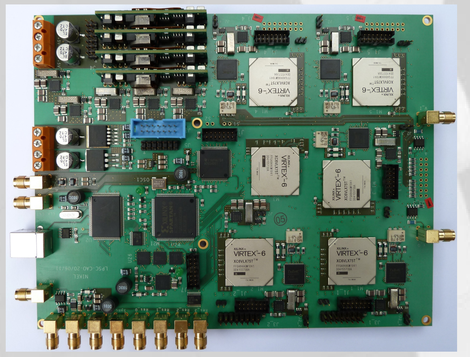




Final NIKA array: v0

1,000 pixels (150 GHz)

NIKEL the final NIKA read-out



NIKEL board v1 (2012). 500 MHz, 400 channels (ADC 12 bits, DAC 16 bits)
→ **First board being tested. Results at SPIE 2012 (Olivier Bourrion).**
***For NIKEL v0 see:* O. Bourrion et al., Journ. of Instrum. 6, Issue 06, 6012 (2011)**

NIKA in a nutshell

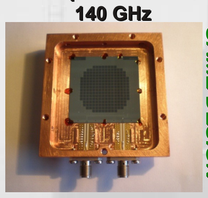
Millimetric dual-band camera at the Nasmyth focus of the IRAM 30 m telescope, Granada, Spain. It fills the available focal plane with 2 filled arrays made of KIDs via a a dichroic. The two atmospheric bands (2 and 1.3 mm) are thus observed simultaneously. The detectors are cooled down to 70 mK via a mechanical cryocooler (4K stage) and a closed-cycle dilution fridge. They are read by 16 readout boxes. Each of them read 256 detectors. The SZ mapping of clusters is done at 2 mm thanks to the 1.3 mm band which is dedicated to sky noise reduction

Band	A	B
Central Frequency *GHz*	140	240
Beam (FWHM) *arcsecond*	17	12
Ndetectors	1000	3000
FOV diameter *arcminute*	6.5	6.5
NEFD: mJy $s^{1/2}$ /beam	12	18
ySZ 1σ 1h /beam	10^{-5}	
dTCMB 1σ 1h/beam	30 uK	

One of the main goals of NIKA: follow-up of Planck clusters of galaxies via the SZ effect. Use the angular resolution to characterize cluster substructures, the core radius and individual galaxy contaminants.
Do snapshot follow-up of Planck clusters (200 at present are public in the Early SZ catalog) at the Planck frequencies (mostly 143 GHz). Measure the kinematic SZ effect in individual clusters

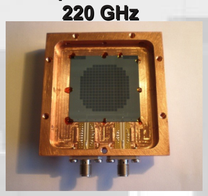
Prototype NIKA run 3 – October 2011

132 pixels LEKIDs 140 GHz



SAME DESIGN

132 pixels LEKIDs 220 GHz



NEFD ≈ 20 mJy· $s^{0.5}$/beam 100 mJy· $s^{0.5}$/beam

Design: Grenoble
Fabrication: Grenoble
Electronics: Grenoble-US

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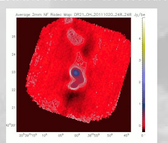
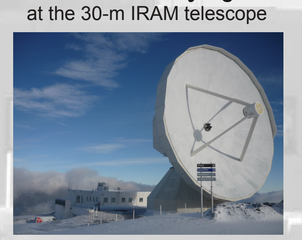


DR21(OH) star-forming region

Sensitivity at 150 GHz now comparable to state-of-the-art TES (e.g. NASA Goddard).
NEP ≈ 10^{-16} W/Hz$^{0.5}$

M. Calvo et al., to be submitted to A&A (2012).

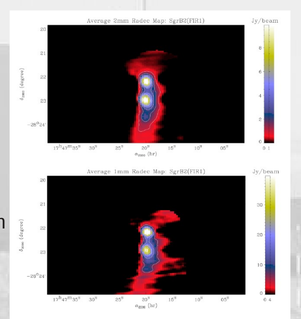
One week « **mostly nights** » run at the 30-m IRAM telescope



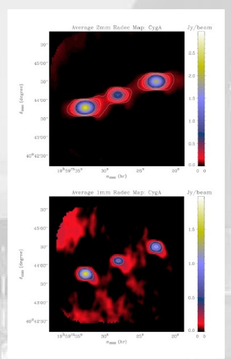
NIKA 2011 :
- **cryogen-free cryostat**
- **magnetic screening**
- **improved photometry (< 10%)**
- **dual polarisation**

Prototype NIKA 2010 – selected results

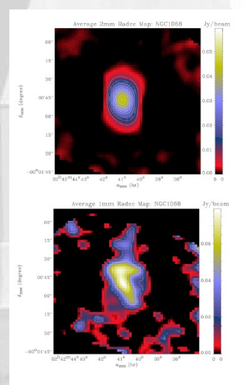
2mm
1mm



The galactic center



Cygnus A



NGC 1068

Monfardini et al., Astrophysical Journal Suppl. 194, Issue 2, id. 24 (2011) arXiv:1102.0870v2

Perspective

- The project is approved by IRAM and funds are being sought (France and Europe grants)
- If financed, NIKA would be commissioned by the end of 2014.
- The NIKA consortium will get a privileged access to the telescope for the next 4 years in order to optimise the performance of the instrument and realise key observing programs (including 250 hours on a SZ follow-up)
- It will also be a common user facility and will have a polarimetric extension at 1 mm