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For IRAM use
Registration N°:
Date:

PROPOSAL FOR 30M TELESCOPE

Deadline: 12 Sep 2013 Period: 01 Dec 2013 — 31 May 2014

TITLE

NIKA polarization 2014 October run

Type: *Solar system:* continuum ○ lines ○ other ● *Extragalactic:* continuum ○ CO lines ○ other ●
Galactic: continuum ○ lines ○ circumstel. env. ○ young stel. obj. ○ cloud struct. ○ chem. ○ other ●

ABSTRACT

This is an internal IRAM document to plan the next NIKA polarization 2014 October technical run to be performed between 4 and 14 October 2014. We request 56 hours of observational time to test the NIKA polarization capabilities with a new multi-layers HWP and an additional optical element (Wollaston prism). In addition we plan to observed 9 astrophysical sources (3 extended sources and 6 point sources) with a noise level for the degree of polarization of about 1 %. Two accompanying sessions using XPOL are requested, to be adjacent to this NIKA polarization session in order to cross-calibrate the two experiments in terms of the polarization angle and the degree of polarization.

Is this a resubmission of a previous proposal ? no ● yes ○ – proposal number(s): .....
Is this a continuation of (a) previous proposal(s)? no ● yes ○ – proposal number(s): .....

Hours requested for this period

Total 64 EMIR 8 HERA ☐ GISMO ☐ NIKA 56

LST range(s) and number of intervals

from: to: intervals:
from: to: intervals:

Special requirements: Large Program ○ pooled obs ○ service obs ○ remote obs ○ polarimeter ●

Scheduling constraints: None

Receivers: EMIR ● HERA ○ GISMO ○ NIKA ● Other ○

List of Objects (give most common names)

Source	Epoch: J2000.0 RA	DEC	V_{LSR} or z
Venus			
Uranus			
Mars			
Crab	05:34:31.950	+22:00:52.1	
CasA	23:23:27.850	+58:48:42.8	
KL	05:35:14.500	-05:22:30.0	
DR21_OH	20:39:01.100	+42:22:50.2	
3C84	03:19:48.154	+41:30:42.1	6 Jy@1mm, 5.3%
3C286	13:31:08.300	+30:30:33.0	0.3 Jy, 14.4% Pol. Ref. quasar
3C345	16:42:58.800	+39:48:37.0	2.6 Jy, 7.1%
1921-293	19:24:51.056	-29:14:30.1	6.2 Jy, 7.8% =OV-236
2200+420	22:02:43.291	+42:16:39.9	5.5 Jy, 12% =BL LAC

(for additional sources which do not fit here

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Expected observer(s) Catalano, Ponthieu, Ritacco, Benoit

Technical Summary

Variables used: T_A^* expected line antenna temperature; T requested telescope time per setup; Δv required velocity resolution; pwv precipitable water vapor: 1, 2, 4, 7, or 10 mm.

⋆ EMIR

Note that up to 8 IF signals can be recorded and up to 2 EMIR (always dual polarization) bands can be combined in one EMIR setup. For a summary of EMIR connectivity consult the EMIR webpage at www.iram.es/IRAMES/mainWiki/EmirforAstronomers or the Call for Proposals.

Transitions

setup	band	species	transition	frequency GHz	T_A^* mK	rms mK	Δv km s^{-1}	backend [a]
1	E0,E2	HCN	1-0	88.6,260	100	10	1.0	V, XPOL

[a] V: VESPA, W: WILMA, 4: 4 MHz filterbank, FTS50 or FTS200: FTS @ 50 or 200 kHz resolution

Observing parameters

map size in arcmin

setup No.	map size $\Delta x \times \Delta y$	mapping mode [a]	switching mode [b]	pwv mm	T hours	remark
1	2.0 × 2.0	OTF	PSw	7	8	—
Total EMIR time requested:					8	

[a] none, OTF (on–the–fly), R: Raster

[b] PSw: position switching, FSw: frequency switching, WSw: wobbler sw.

⋆ NIKA

Mapping parameters

S_ν = expected source flux density

setup	1.3 mm S_ν mJy	1.3 mm aimed for rms mJy	2 mm S_ν mJy	2 mm aimed for rms mJy	map size [a] $\Delta x \times \Delta y$	
1	500-1000	10	-	-	2.5	2.5

[a] use minimum size ($1.0' \times 1.0'$) for compact ($\leq 40''$) sources.

Observings times

setup	priority band [a]	pwv [mm]	number of sources	T [hours]	remark
1	1	4	12	56	
Total NIKA time requested:				56	

[a] Specify which of the two NIKA bands has scientific priority. Enter 1 (2) for the 1.3 mm (2 mm) band, or 0 if both bands have equal priority. Observing time and pwv requirement are to be based on the priority band.

NIKA polarization 2014 October run

Context:

The NIKA2 instrument will host a polarised channel at 1.2 mm. The adopted solution uses a rotating multi-layers Half Wave Plate (HWP) at 300 K in front of the NIKA2 cryostat window and a polariser located at 100 mK stage to split the polarizations in the two polarized arrays at 1.2 mm. This setup permits simultaneous measurements of the three Stokes parameters (I, Q, U) on a same area of sky through the same optical path in the telescope with Q and U modulated at 4 times the mechanical rotation frequency. The performance of the NIKA2 in polarization has to be tested in the NIKA prototype.

In the previous NIKA prototype technical run in January 2014 (the first polarization run), we have used a single layer HWP mounted at the exit pupil of the Telescope plus a polariser (Wire Grid) mounted at a distance of 6 cm from the HWP with its substrate plane at 10 degrees with respect to the optical axis, both at 300 K. This solution has shown a few problems: first, the sensitivity was degraded by at least a factor of 2 with respect to the NIKA continuum performance due to the additional background coming from the polariser in reflection. The evidence for this is shown in the fig. 3 on right, where it is reported the temperature intensity of Cassiopeia A observed in January.

Second, we observed a residual polarization of about 3% when observing Uranus, see the fig. 1 and 2. We do not yet fully understand the origin of this instrumental polarization. A technical report on this run will be given this Summer.

In the proposed October 2014 polarimetric run (the second one for NIKA), we plan to test the NIKA polarization performance with a new multi-layers HWP. This will help us discrimate the potential sources of instrumental polarization and this will allow us to better characterize the actual NIKA2 HWP design. In addition to the previous solution of using an HWP plus a polarizer, we also plan to test a new solution that minimizes the optical background. The proposed solution is the use of a Wollaston prism which consists of two orthogonal saphire prisms, glued together on their base to form two right triangle prisms with perpendicular optical axes. Outgoing light beams diverge (with a symmetrical deflection) from the prism, giving two polarized rays, with the angle of divergence determined by the prisms wedge angle and the wavelength. The dimensioning of the prism has been made in order to deflect a point source at the center of the field of view by 1 arcmin (that will be the separation of the two orthogonal polarization images on each array). The potential advantages of this solution are manifold: first, we reduce the background due to the use of a warm polariser. We estimated that the emission of a piece of saphire of 2 cm correspond to an additional background of about 15 K. Second, we double the flux of the astrophysical source because in this case both polarizations are transmitted to the KIDs arrays. Finally, this strategy could be adopted to the final NIKA2 instrument extending its polarization capabilities to the 2 mm channel, although in a gradient measuring mode.

Time Estimate:

We plan to dedicate :

- 16 hours to instrumental polarization measurements observing unpolarised sources (essentially Uranus and Mars).
- We need 8 hours to test the Wollaston solution.
- 16 hours will be dedicated to cross-calibrate NIKA with Xpol (orientation and degree of polarization). For that, we'll observe the reference sample drawn out of Agudo et al's catalalog (AA, 2014, 566, A59) and complemented by up-to-date observations from the Granada IRAM AGN data base.
- The final 16 hours, will be dedicated to the measurement of standard extended polarized sources : Crab, CasA, DR21OH and the Orion bar.

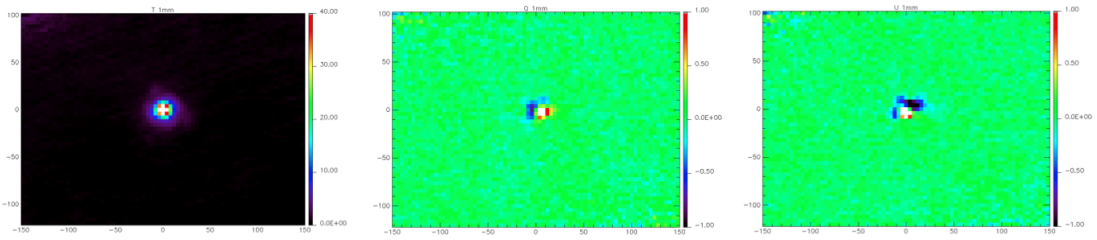

Figure 1: Intensity and polarization Q and U maps of Uranus for the 1mm channel. The value of the flux range is done in Jy and the x,y coordinates are in arcsec.

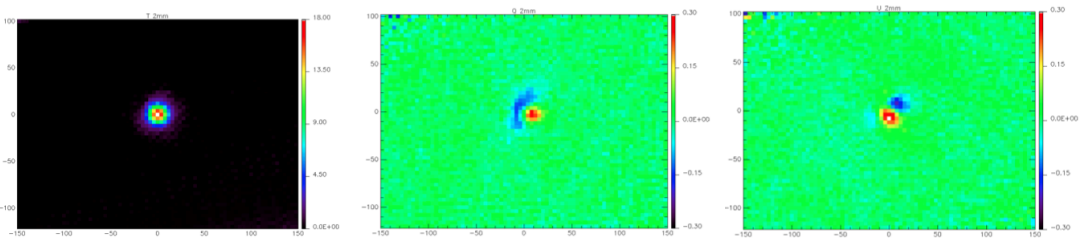

Figure 2: Intensity and polarization Q and U maps of Uranus for the 2mm channel. The value of the flux range is done in Jy and the x,y coordinates are in arcsec.

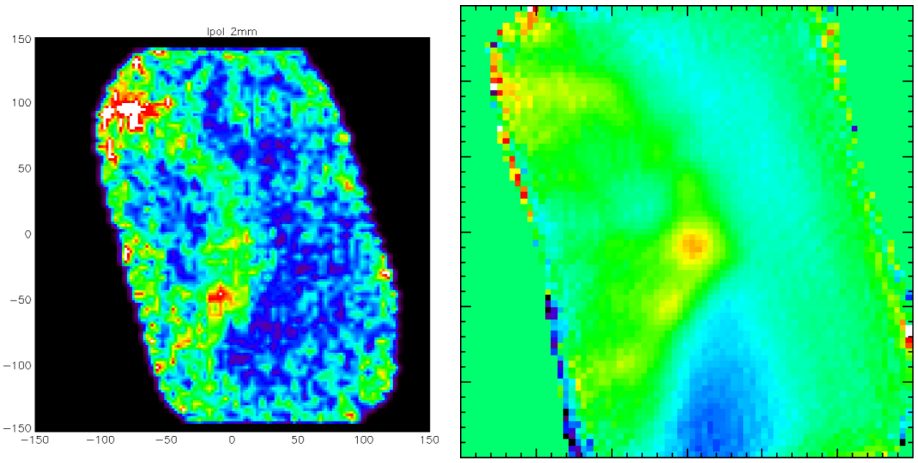

Figure 3: Polarization intensity on left and temperature intensity on right of Cassiopeia A for the 2 mm channel.The value of the flux range is not yet given because it has not been estimated with precision. The x,y coordinates are in arcsec.

Typically, to be able to estimate a level of polarization of about 1 % on a source of 1 Jy total flux, we need to reach a noise level of the order of 10 mJy. Assuming end of Summer conditions (pwv=4mm) we expect a point source sensitivity in polarized intensity of 120 mJy $\sqrt{s}$ in the NIKA 1.2 mm channel. The noise level can be reached in 144 second of integration on source. On the Fly maps will be done with a 20% efficiency. Several scans of 10 minutes each are necessary per source.

Additionnally we request an Xpol observing run of five quasars in order to do an absolute calibration of the degree and polarization efficiency with NIKA. NIKA measurements will be done at 1.2 and 2 mm (1.2 mm being the most polarization efficient channel). Xpol will perform 86 and 260 GHz continuum measurements of the 4 Stokes parameters. We propose to have 2 sessions of Xpol, of 4 hours each, one before the NIKA run and one after. The grand total of 64 hours is made of 56 hours for NIKA observations and 8 hours for Xpol.