Highlights of Spanish Astrophysics VI, Proceedings of the IX Scientific Meeting of the Spanish Astronomical Society held on September 13 - 17, 2010, in Madrid, Spain. M. R. Zapatero Osorio et al. (eds.)

PANIC: current status

M. C. Cárdenas[1], J. Rodríguez Gómez[1], and the international PANIC team[2]

[1] Instituto de Astrofísica de Andalucía (IAA-CSIC), P.O. Box 3004, E-18080 Granada, Spain (conchi@iaa.es)
[2] Max-Plank-Institut für Astronomie (MPIA-MPG), Königstuhl 17, 69117 Heidelberg, Germany (see www.iaa.es/PANIC/index.php/gb/panic_team)

Abstract

PANIC, the PAnoramic Near Infrared Camera, is a new instrument for Calar Alto Observatory (CAHA) is a wide-field infrared imager for the CAHA 2.2 m and 3.5 m telescopes. The optics is a folded single optical train, pure lens optics, with a pixel scale of 0.45 arcsec/pixel (18 μm) at the 2.2 m telescope and 0.23 arcsec/pixel at the 3.5 m. A mosaic of four Hawaii-2RG detectors provides a field of view (FOV) of 0.5×0.5 degrees and 0.25×0.25 degrees, respectively. It will cover the photometric bands from Z to K_s (0.8 to 2.5 μm) with a low thermal background due to cold stops. Here we present the current status of the project.

1 Introduction

The PANIC project was born in October 2006, when its kick-off meeting was celebrated, as the first instrument to be built in the program of development of new instrumentation in collaboration between IAA (CSIC) and MPIA (MPG). A new Near Infrared (NIR) camera for the 2.2 m telescope was suggested by the astronomical community, supported by the Scientific Advisory Committee and approved by the Executive Committee. PANIC is the first joint project between IAA and MPIA. IAA is responsible for optics and software and MPIA for design, cryo-technique, mechanics, detectors and electronics. The camera is a general purpose wide-field infrared imager usable for surveys, but not tailored to a special application. At the beginning the scientific projects showed interest in work at the 2.2 m telescope and PANIC was designed for that. However more scientific projects arose expressing their interest in work at the 3.5 m telescope too. Therefore, currently PANIC is also usable at the 3.5 m telescope with half the pixel scale (see Fig. 1). The instrument had been described in previous papers [1, 3, 2] when it was still in the planning phase. PANIC has passed several reviews: the Preliminary Design Review (PDR), in November 2007; the Optics Final Design Review (FDR), in September 2008; the Mechanics-Cryogenics-Electronics-Detectors FDR, in

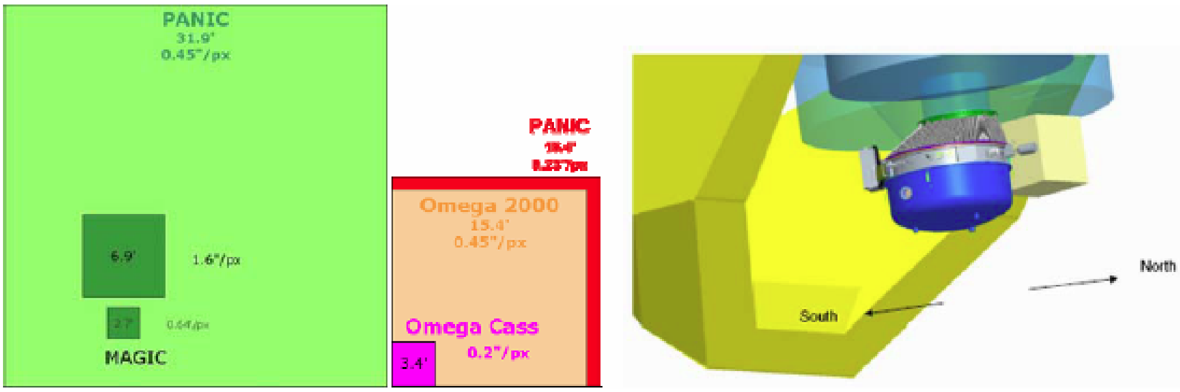

Figure 1: *Left*: FOV and Plate Scales of the CAHA's infrared instruments at the telescope. *Middle*: Idem at the 3.5 m telescope. *Right*: The cryostat with the telescope adapter in operating position attached to the 2.2 m telescope.

December 2009; and the Software FDR, in February 2010. Currently the project is immersed in the Assembly, Integration and Verification (AIV) of the instrument. First light at telescope is foreseen for the second half of 2011. Now all details are fixed and we describe the current status of the instrument.

2 Instrument parameters

The basic specifications for PANIC are:

- Detector size: 4096×4096 pixels.
- Image scale: 0.45 arcsec/pixel @ 2.2 m telescope, 0.23 arcsec/pixel @ 3.5 m telescope.
- FOV: 31.9 arcmin @ 2.2 m telescope, 16.4 arcmin @ 3.5 m telescope.
- Image quality (IQ): EE80 $\leq$ 2 pixels @ 2.2 m telescope, EE80 $\leq$ 3 pixels @ 3.5 m telescope.
- Cold field and pupil stops.
- $Z - K_s$ band, allow narrow band (1%) filters.
- Distortion $\leq$ 1.5% Fit the 2.2 m telescope, i.e. weight $<$ 400 kg, length $<$ 1100 mm.
- Operating temperature: 80 K (liquid nitrogen).
- Fast read-out mode (few ms).
- Software: pipeline.

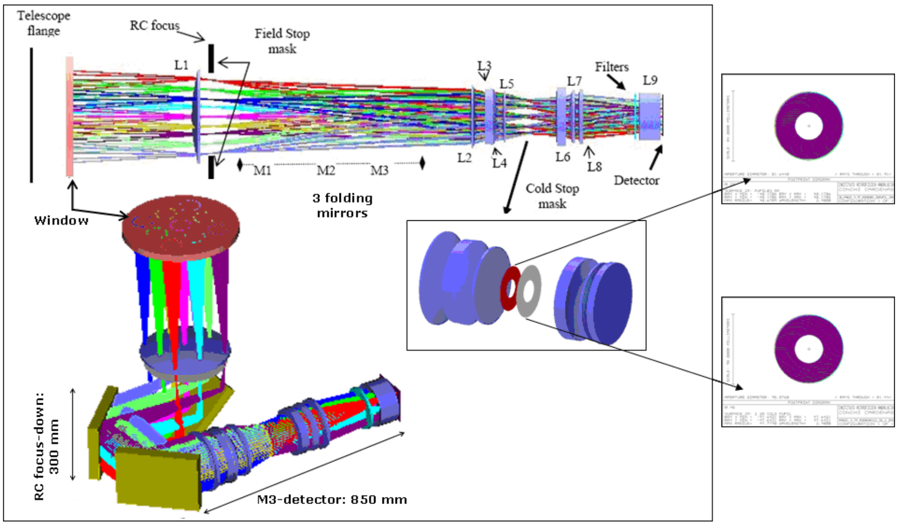

Figure 2: PANIC optics layout, including the unfolded layout.

3 Optics, mechanics and cryogenics

The camera optical design [3, 2, 4] is a single optical train pure optics. An image of the telescope primary mirror is formed between the lenses L5 and L6. At this position a cold stop mask blocks light rays which do not come from the main mirror and therefore reduces the thermal background in the K bands. Two cold-stop masks are mounted on a wheel which allows changing between the two cold stops required for the two different telescopes. Figure 2 shows the optical straight layout (1890 mm long), the folded solution, as well as the cold stop masks for each telescope. Figure 3 displays the table with the system data of the optics used for manufacturing the optical elements and to feed the mechanical design. The optical design IQs for both telescopes are shown in the table of Fig. 4. PANIC uses 4 HAWAII-2 RG detectors which operate at a temperature of 77–80 $\pm$ 0.1 K. To provide the cold environment for optics and the detector the complete instrument is built into two nitrogen bath cryostat (Fig. 5), one for the optics and opto-mechanics and another for the detector in order to have the required precision on its temperature. The instrument's cold opto-mechanics consists of 9 lenses, up to 255 mm diameter, and three rectangular folding mirrors. It will be operated at about 80 K, achieved by liquid nitrogen cooling. A compact filter unit, located between L8 and L9, can carry up to 18 filters distributed over four filter wheels. One of the filter wheels carries a pupil imager lens which serves to control the alignment of the cold stop masks with the primary mirror when PANIC is mounted at the telescope.

The mass limit of 400 kg for the complete instrument at the 2.2 m telescope drove the design of the cryostat, because of that for the cryostat there is only a budget of 180 kg including the nitrogen filling. After optics packaging the diameter of the cryostat is about 1100 mm. The low mass design required was designed as follows: a vacuum vessel with dished ends, a separate small LN2 vessel for cooling of the detector only, thickness of the walls was optimized with FEA (Finite Analysis Element) and all parts are light weighted and

Element	Curvature radius		Center Thickness	Material	Full ∅
	Front face	Rear face			
Cryostat window	Infinity	Infinity	20.00	IR FS	330.00
L1	443.731	Infinity	27.40	IR FS	255.00
Field stop	Infinity	--	--	--	--
M1	Infinity	--	30.00	Zerodur	238 x 174
M2	Infinity	--	30.00	Zerodur	236 x 170
M3	Infinity	--	35.00	Zerodur	236 x 170
L2	437.470	-257.410	34.00	CaF2	179.50
L3	-177.250	-437.470	10.00	S-FTM16	162.50
L4	-146.740	-140.789	13.00	IR FS	167.00
L5	290.990	Infinity	18.80	BaF2	153.40
Cold stops	Infinity	--	--	--	--
L6	420.230	138.050	10.00	S-FTM16	140.00
L7	158.460	-1323.490	27.70	BaF2	143.50
L8	290.990	Infinity	18.30	IR FS	150.00
Filter	Infinity	Infinity	8.30	IR FS	125.00
L9	-116.310	251.760	30.80	IR FS	130.00

Figure 3: Optical system data at warm for manufacturing (units in mm).

	Criteria		
	< 36 μm	< 2 pix	<0.90"
Filter	EE80 (μm)	EE80 (pix)	EE80 (arcsec)
Z	20.74	1.15	0.52
Y	15.82	0.88	0.40
J	16.95	0.94	0.42
H	23.74	1.32	0.59
K_s	32.14	1.79	0.80
Polychromatic	25.52	1.42	0.64

	Criteria		
	< 54 μm	< 3 pix	<0.69"
Filter	EE80 (μm)	EE80 (pix)	EE80 (arcsec)
Z	28.68	1.59	0.37
Y	29.14	1.62	0.37
J	30.84	1.71	0.39
H	34.96	1.94	0.45
K_s	40.76	2.26	0.52
Polychromatic	36.32	2.02	0.46

Figure 4: *Left*: PANIC IQ at the 2.2 m telescope. *Right*: Idem at the 3.5 m telescope.

made of aluminum wherever possible. We ensured that this design confirms with European pressure vessel regulations. The cryostat had been successfully tested. A first cool down of the cryostat showed a very good hold time and temperatures as expected. The highest temperature at the radiation shield was 89 K and the temperature at the small vessel was below 78 K. The evaporation rate was about 0.7 l/h, lower than the expected 1.2 l/h because these tests were done without cabling, preamplifiers and transparent entrance window all of which are heat sources.

The mechanics for the optics are grouped in several parts (see Fig. 6) which are individually adjustable. All optical elements are mounted to this bench in order to minimize flexure effects. The tolerances are derived from optical analysis, done for each optical element and for each group. This analysis resulted in tight but not extremely challenging tolerances for each interface in the order of 50 microns for some elements. Generally several smaller parts

Figure 5: *Left*: The layout of PANIC with cryostat open and turned upside down (left). Light enters from below, is folded by 3 mirrors (to the upper left) parallel to the optical bench, passes cold stop and filter wheels and is focused on the detectors. *Right*: real PANIC cryostat with its lab's caddy at the laboratory. PANIC optics layout, including the unfolded layout.

are integrated into a group using dowel pins and fitting diameters. This ensures good positional accuracy. These groups are then integrated into the next higher level using adjustment devices to compensate the remaining mechanical tolerances and to ensure maximum optical performance. The detector module of PANIC has no focussing mechanism of its own since focussing is done with the telescope secondary mirror.

Up today several optical elements have been delivered: the three mirrors, the entrance window, the exit window (located in the cryostat at the position of the detector and used only for AIV) and several lenses (see Fig. 7). At the same time the mechanical parts are being manufactured in a queue driving by the AIV plan. Therefore, the optics is being verified, tested and finally integrated with the mechanics. The mirror structure is integrated and aligned (see Fig. 8) and the cryogenics tests for lenses acceptance will be soon performed (see Fig. 9).

4 Detectors and electronics

The detector is a HAWAII 2RG from Teledyne which is four detectors of 2k×2k mounted side by side in a 2×2 mosaic with a small gap of 167 pixels. The pixel size is 18 micron. Flatness over all four detectors mounted in the mosaic is specified to ±40 microns from the best fit plane. The detectors are sensitive from 0.3 to 3 microns. PANIC will have the Read-out Electronics (ROE) recently developed by the MPIA team. It is a further development of the Omega2000s ROE. The system is modular, it uses FPGA technology and it is able to

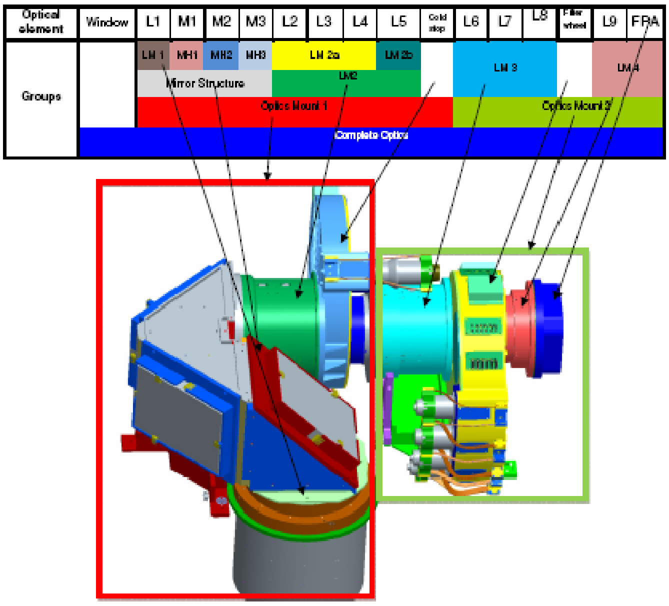

Figure 6: The grouping of the mechanics corresponding to optical groups.

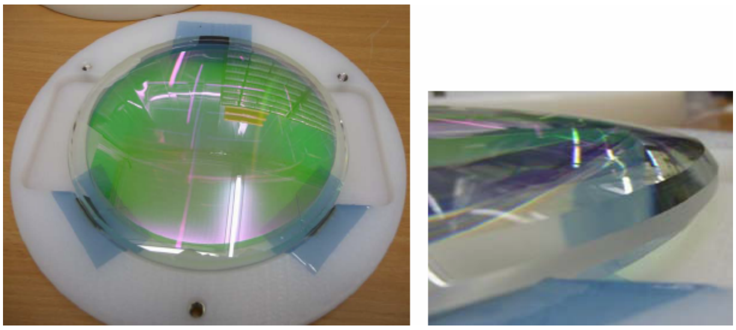

Figure 7: L8 in its packaging from manufacturing. *Right*: a detail showing the chambers of the lens.

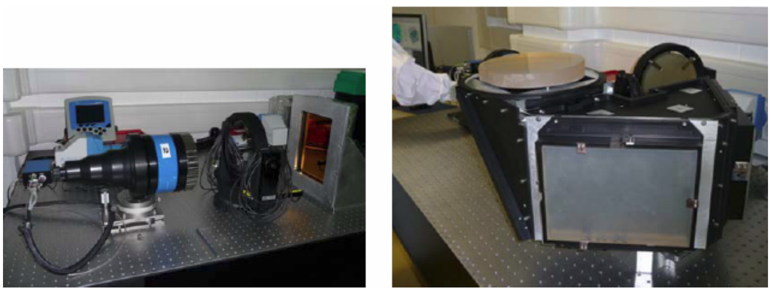

Figure 8: *Left*: doing an interferogram of one PANIC mirror. *Right*: Mirror structure integrated and aligned.

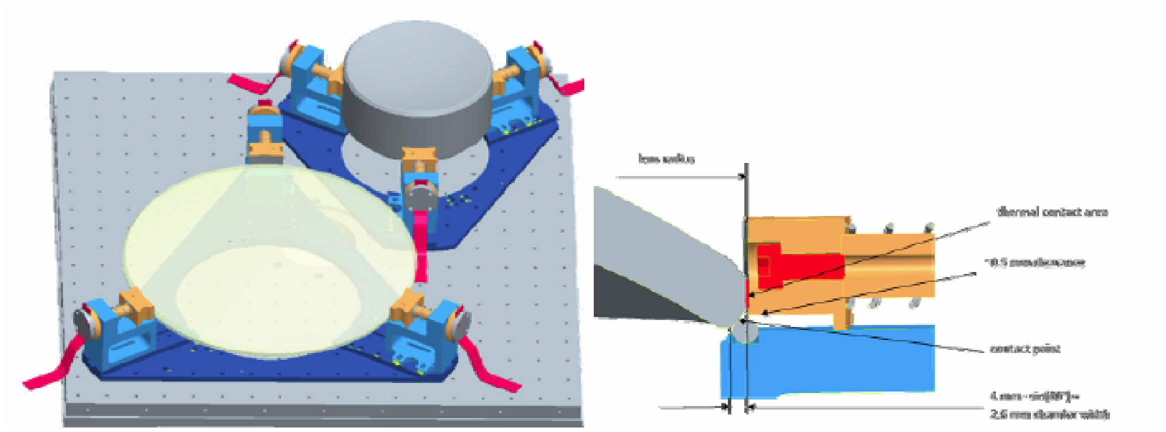

Figure 9: *Left*: set-up for the PANIC lenses cryogenic tests acceptance. *Right*: a detail of the mechanical low-stress mounting.

handle single or multiple detector systems up to 144 input channels. The read-out software is part of the PANIC software system (described in Section 5) and it is based on the GEneric InfraRed camera Software (GEIRS) used for all the infrared instruments at CAHA. It uses the new ROE special features and interface applications to implement new capabilities for the currently available IR-detectors. The software is also able to operate with the full-frame and sub-window readouts nested with different frame speeds useful for on-chip guiding. GEIRS also contains a package for control of the wheels and the cryostat temperature control. More information and characterization details of the detector, the ROE and the read-out software are given in [6]. The laboratory tests of the read-out electronics with a multiplexer and also with the science detectors have been very successful and showed that it works very well and is stable. The four filter wheels and one cold stop wheel mounted inside the PANIC cryostat are controlled with MPIAs standard motor control electronics which has been successfully used in many instruments. A novel concept, which uses resolvers for positional info, ensures high positional accuracy (see also [7]). All wheels are driven by Phytrons VSS 52.200.2.5-UHVC-HD-LTN-4Lp cryogenic stepper motors. Commercially available devices supplied by LakeShore are used to monitor and control the pressure and temperature of the cryostat and detector. Currently the cold stop wheel tests at cold have been successful and we are working in the filters wheels. The internal wiring of cryostat, including temperature and pressure sensor, switches, motors, connectors for the ROE, etc., have been installed.

5 Software

The PANIC software system comprises four main packages: GEIRS, the Observation Tool (OT), the Quick Look tool (PQL) and a scientific pipeline (PAPI). A more extensive explanation of the software, including the PAPI, is described in [5]. GEIRS is used for the basic instrument control and the data acquisition as described in Section 4. The OT package is a tool developed in Java for support the observations and can be used for detailed definition and pre-planning the observations. This OT will allow high level control of the instrument based on a Graphical User Interface (GUI). It will provide a higher level of abstraction to the user in order to allow an easier observation procedure and also a set of predefined observation templates with some parameters that can be set by the user. Concerning the data handling, the PQL can be used for easy inspection of the data in real-time and for data control by a pre-reduction and visualization of the raw data. This tool will provide a fast preview of the data being acquired by GEIRS and it will perform a rough and ready data reduction. This package uses some parts of the PAPI procedures. The data produced by an observation run can be calibrated and processed in a on/off-line pipeline using PAPI in science reduction mode. The aim of the PAPI package is a NIR general purpose pipeline for complete reduction. Therefore, PAPI will provide basic reductions steps including dark subtraction, flat fielding, background subtraction, etc., but also the science reduction mode will include astrometry and photometry reduction stages. Python programming language is used for PQL and for PAPI. The first version of the PQL is currently being running. PAPI also in an advanced state of implementation using data acquired with O2000 at CAHA specially for PAPI testing.

6 Conclusions

PANIC has passed all reviews by the beginning of 2010. Currently the design is finished. The optical elements are being manufactured; the mirrors, the windows and some lenses have been received and tested. Many items of the mechanical parts have been fin-ished and the rest of them are in production. The cryostat had been manufactured and successfully tested. The detector array has been tested together with our own read-out electronics; we are currently optimizing the read-out process. Modifications of existing software for read-out of the flexibly programmable Hawaii-2 RG detectors are progressing. The activities on the wheels are also in an advanced state, the cold stop wheel is working properly at cold and the filters wheels go on. The internal wiring of cryostat is finished. The software is being implemented having a first version of the Quick-Look running with data from O2000 and PAPI is in a well advanced state. The AIV plan for the instrument is currently taking place. If no major problems are encountered we ex-pect first light on the telescope for the second half of 2011. Science with PANIC will benefit not only from the large field of view but also from the low thermal background which will make PANIC very efficient in the K-bands. Furthermore the ability to use narrow band filters will allow selection of objects with special narrow spectral features. The detector array has a very convenient footprint which makes PANIC perfectly suited for observations of extended objects, for e.g. near-by galaxies. Since PANIC is a universal general purpose instrument there is no scientific killer application. Many projects have been proposed, ranging from major pi-surveys in several colours or long term photemetric monitorings to pointed observations on few targets. These projects cover a wide range of astronomy, ranging from detection of high red-shift quasars, distribution of galaxies and galactic structure to stelar variability and planets.

References

[1] Baumeister, H., et al. 2008, Proc. SPIE, Vol. 7014, 70142R-9

[2] Cárdenas, M. C., Rodríguez Gómez, J. F., Lenzen R., & Sánchez-Blanco, E. 2008, Proc. SPIE, Vol. 7014, 70142Q-10

[3] Cárdenas, M. C., Rodríguez Gómez, J. F., Lenzen, R., Sánchez-Blanco, E., & the international PANIC team 2010, in *Highlights of Spanish Astrophysics V*, eds. J. M. Diego et al., Springer

[4] Fried, J. W., Baumeister, H., Huber, A., Laun, W., Rohloff, R., & Cárdenas, M. C. 2010, Proc. SPIE Vol. 7735, 77353V

[5] Ibáñez Mengual, J. M., Fernández, M., Rodríguez Gómez, J. F., García, A. J., & Storz, C. 2010, Proc. SPIE Vol. 7735, 7740-89

[6] Naranjo, V., et al. 2010, Proc. SPIE Vol. 7742, 77421R

[7] Wagner, K., Alter, M., Bideaux, A., Klein, R., Lehmitz, M., Mohr, L., & Ramos, J.R. 2010, Proc. SPIE 7735-141