Report on INGRID commissioning

June 2001

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1 Abstract

We report on the astronomical commissioning of INGRID, INGs near-infrared camera for the WHT, as performed during 6, 8, and 22 March and in early April 2001, but looking back at the March 2000 commissioning as well. We summarize those areas which were successfully commissioned, as well as those where further tests must be performed. We also give a brief summary of parameters measured during commissioning. Apart from the foreoptics commissioning which was successfully repeated on March 22nd, no areas failed their commissioning. In appendices, we give an overview of all commissioning tasks, and list outstanding work.

2 Introduction

INGRID was originally commissioned on the WHT during March 2000. Although the commissioning went well in that INGRID worked and could be used subsequently for science runs, many parameters were not or poorly characterised, and most commissioning results were never properly analysed. A commissioning report was never written. Furthermore, INGRID was originally commissioned with temporary foreoptics.

One further commissioning night was allocated on March 6th, 2001, mainly to commission the new aspheric, and test integrity of the system after the standdown in January/February 2001.

During the March 6th 2001 commissioning night we followed the commissioning programme as used for the March 2000 commissioning, written by Packham and Thompson. An updated version of this is appended to this document.

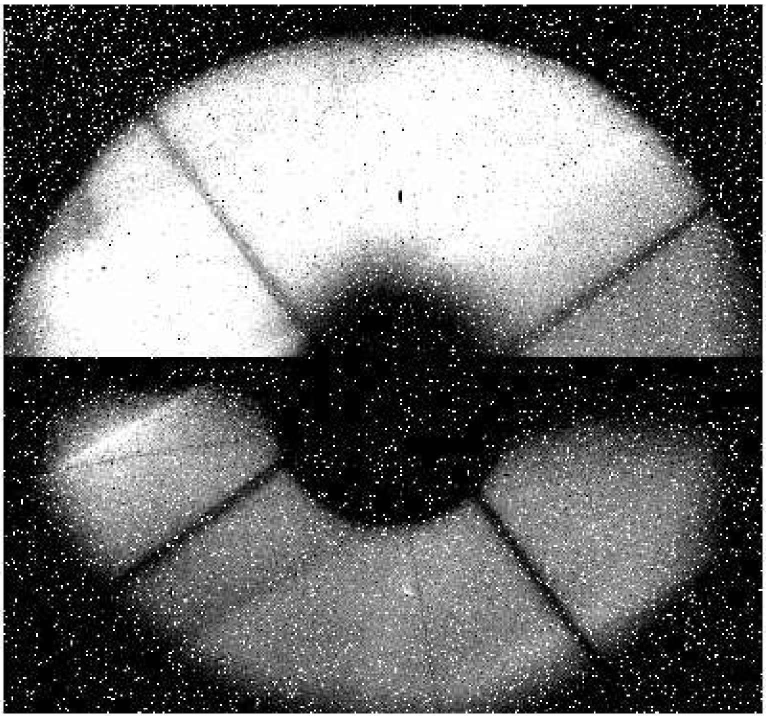

Figure 1: Test 1.2.1. Image with pupil imager deployed.

3 Results March 6th 2001

Most of the tests as listed in the commissioning document were performed in March 2001, and results are described in the updated document. Some areas were not tested, and all those which can be considered important enough to consider in future are listed in Section 7. Details are given in the commissioning document, but some additional information is given here in Figures 1–8 and the captions to these Figures.

4 Results March 22nd 2001

During one twilight hour on this scheduled PATT night, we tested the image quality of INGRID now fitted with the aspheric foreoptics in the correct position. Image quality was found decent, although the seeing did not allow

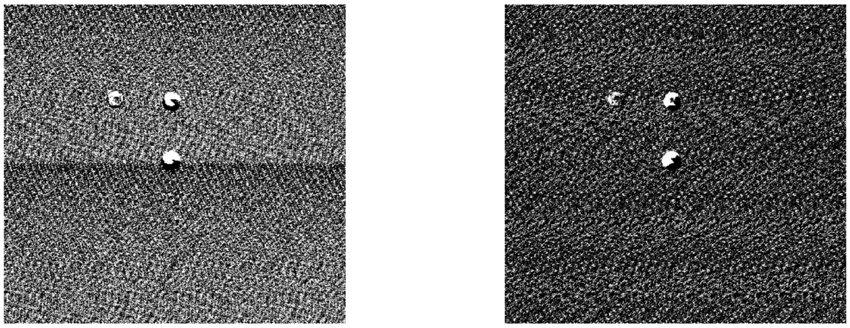

Figure 2: Test 2.6.1 (confirmation of array focus: flexure). Difference between pairs of pinhole images, with Cass rotator rotated by 180 degrees (left) and 90 degrees (right). Shift is 1.5 pixel or well within spec.

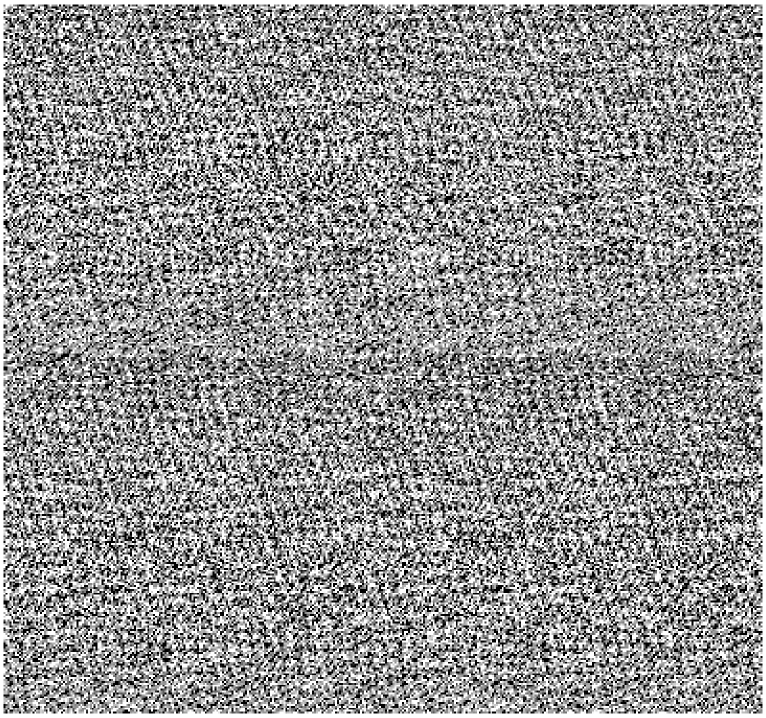

Figure 3: Test 2.8.2. Image shows difference of two successive dark (or bias) frames. The structure is noise at a level of less than 5 counts RMS, within spec.

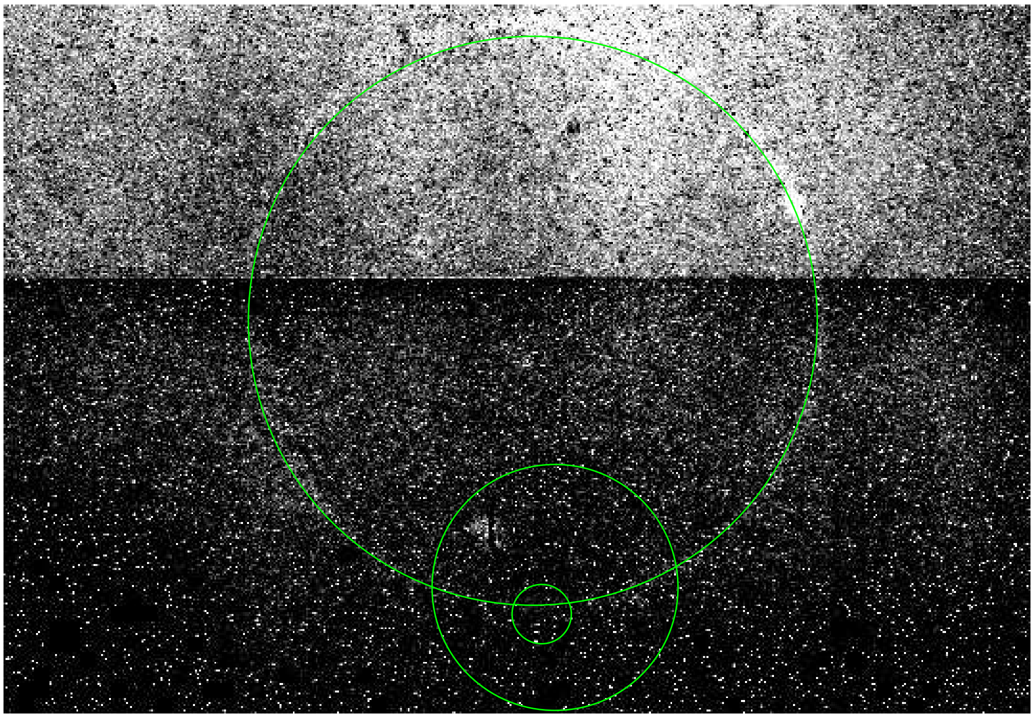

Figure 4: Test 3.1.3 (all-in-one flexure test). Result of a long exposure of a star while making a full rotation with the de-rotator. A perfect circle is superimposed. The x-size of the star trail is 386 pixels, y-size is 402. Test failed - see Sect. 3

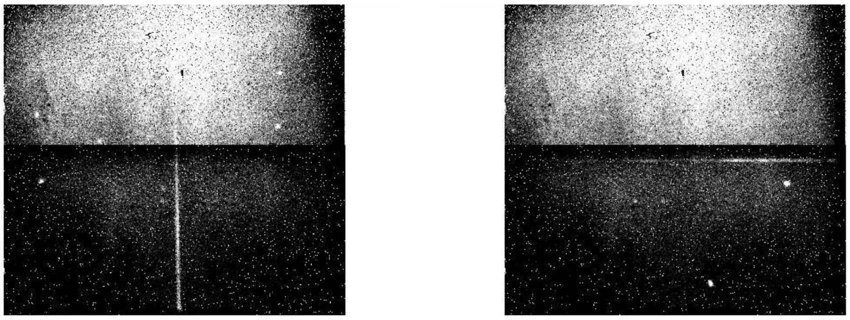

Figure 5: Test 5.2 (ghost mapping). Images of bright (mag$\sim$ 2) star located just off the array: below (left) and above (right).

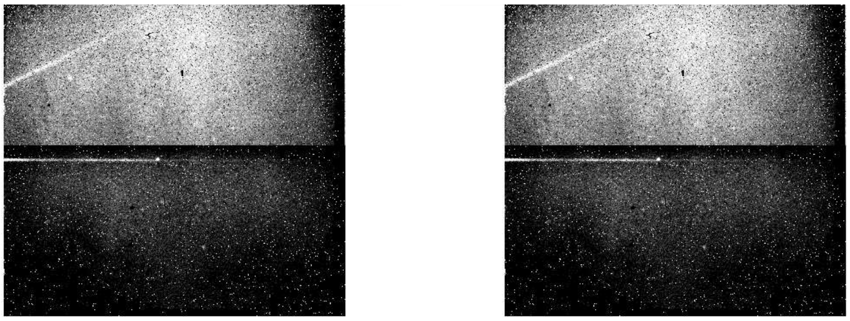

Figure 6: Test 5.2 (ghost mapping). Images of bright (mag$\sim$ 2) star located just off the array: left (left) and right (right).

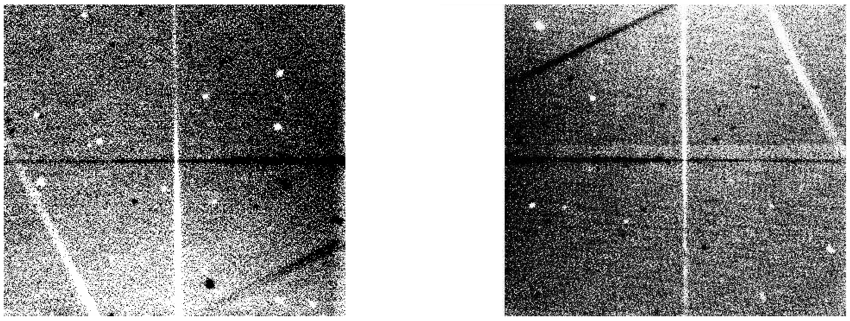

Figure 7: Test 5.2 (ghost mapping). Two difference images of bright (mag$\sim$ 2) star located just off the array.

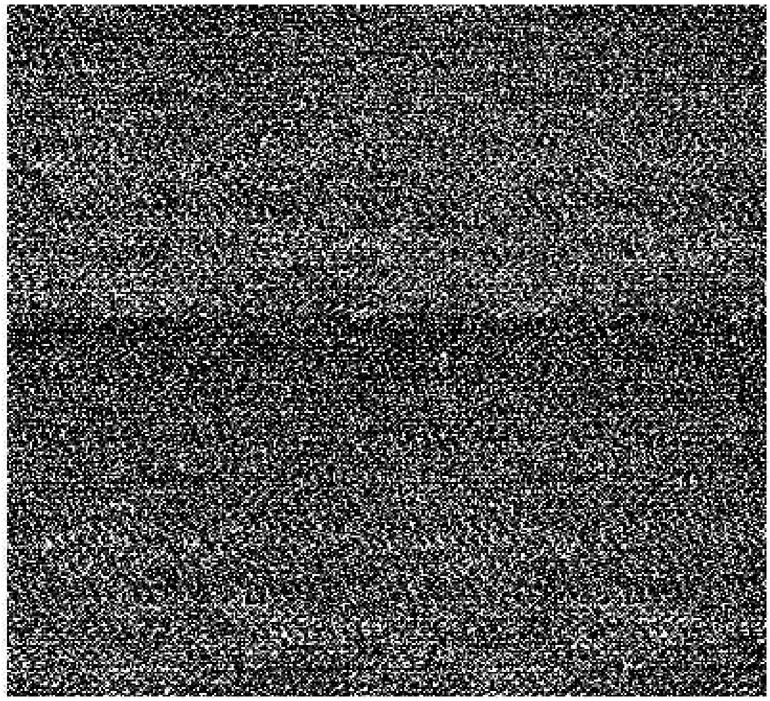

Figure 8: Test 5.11 (remnants). Shown is the difference between an image taken 62s after a very bright star (mag$\sim$ 2) and one taken 47s after the star. No remnants are seen at any level.

us to measure a direct difference with the old foreoptics. It was clear though that the image quality was indeed similar to what it was during 2000, and thus much better than during the night of March 6th 2001. It was decided to leave INGRID with the aspheric, and analysis of standard star data in combination with later confirmation by further testing, showed that the aspheric slightly improved image quality but vastly improved throughput (by about 30-35%) as compared to the old foreoptics.

5 Results April 2001

Before and during service nights we performed linearity tests and standard star measurements. Results are described in the next section, which is a compilation of results from the different nights used in the 2001 commissioning programme.

6 On-sky parameters

6.1 Plate scale

The plate scale (ps) has been determined using Brγ images of two astrometric standard pairs (HIP66162 and HIP68327). The plate scale value obtained for each of the images was:

$ps1_{H66162a}$=(0.2385±0.0004) "/pix
$ps2_{H66162b}$=(0.2385±0.0004) "/pix
$ps3_{H68327}$=(0.238±0.002) "/pix

yielding a mean value of:

plate scale=(0.2383±0.0009)"/pix

Thus the plate scale has changed with respect to the previously determined value (0.242"/pix), presumably due to the new foreoptics.

6.2 Throughput and background brightness

Zero points (zp) (i.e. zp= star mag + 2.5 log $Flux(counts/s)$) have increased by an amount between 0.25 and 0.35 mag in JHK, thus the throughput is ~25-35% higher in all these bands (see Table 1, and more detailed in Table 2).

Background brightnesses do not seem to have changed, except in H, with respect to the last year comissioning (March 2000). However, the sky brightness in H (and J) is highly variable due to airglow. Moreover, the background brightness in Ks depends on temperature. The fact that the background brightness in Ks has the same value with the aspheric and with the doublet (see below) could be due to low temperature in the last year doublet commissioning run, since a comparison of the new results with Johan's data shows that an increase equal to ~0.6 mag in the Ks background brightness with the new optics is possible. The background brightness, especially as a function of temperature, remains under vigilance.

Table 1: Summary of zero-points after and before the installation of the aspheric foreoptics

New results (T=7°C) (aspheric)			Old results (march 2000, tau, T~1°C) (doublet)		
band	zp (mag)	backg (mag/sq ")	band	zp (mag)	backg (mag/sq ")
J	23.35	16.1	J	23.14	14.6-16.1
H	23.43	14.7	H	23.09	13.7
Ks	22.69	12.5	Ks	22.46	12.44-12.59
K	22.78	12.1	K	22.52	12.15

6.3 Image quality

Measurements of the fwhm across the INGRID field through J,H and Ks bands show that the fwhm is always higher in the bottom right corner of the array, and smaller in the top left corner, with differences from ~0.4 up to 1 pix. This may indicate non-perfect alingment. See Table 3–5.

Table 2: Details of zero-point and other calibration information.

Name	*band*	*mag*	*exp. time*	*flux*	*error*	*backg.*	*airmass*	*T*	T_{array}
			(s)	(ADU)	(ADU)	$(ADU/s/pix)$		$°C$	$°C$
$FS33$	Ks	14.236[1]	10.264	24636.9	113	688.6	1.010	7.2	70.2
$FS33$	H	14.151	10.264	52810.9	292	183.7	1.014	7.2	70.6
$FS33$	J	14.039	10.264	54336.5	200	44.3	1.018	7.2	70.2
$FS33$	K	14.254	10.264	26498.4	220	1039.9	1.024	7.2	70.2

Table 2: (continued)

Name	*band*	*zp*	*backg. bright.*	*backg. backg.*	*date*	*seeing*
		(mag)	$(ADU/s/sq'')$	(mag/sq'')		(“)
$FS33$	Ks	22.687 ± 0.006	12156.6	12.47	1/4/01	0.6
$FS33$	H	23.430 ± 0.006	3243.1	14.65	1/4/01	0.6
$FS33$	J	23.348 ± 0.004	782.1	16.11	1/4/01	0.8
$FS33$	K	22.784 ± 0.009	18359.3	12.12	1/4/01	0.6

[1] Ks magnitude: interpolation from the JHK magnitudes given in Casali (1992, UKIRT Newsletter,4,33). We got it in http://www.mpia-hd.mpg.de/IRCAM/FAINTSTD/faintstd-kprime.html.

6.4 Linearity

As illustrated in Figs 9–11, we have reproduced the linearity characteristics as determined last year (200003) by T. Augusteijn, but assuming INGRID runs with a timing error of 0.264s. Thus, over the range 0-20000 ADU, INGRID is linear to within ±4%. Interestingly, Fig. 11 shows that INGRID is very linearly non-linear.

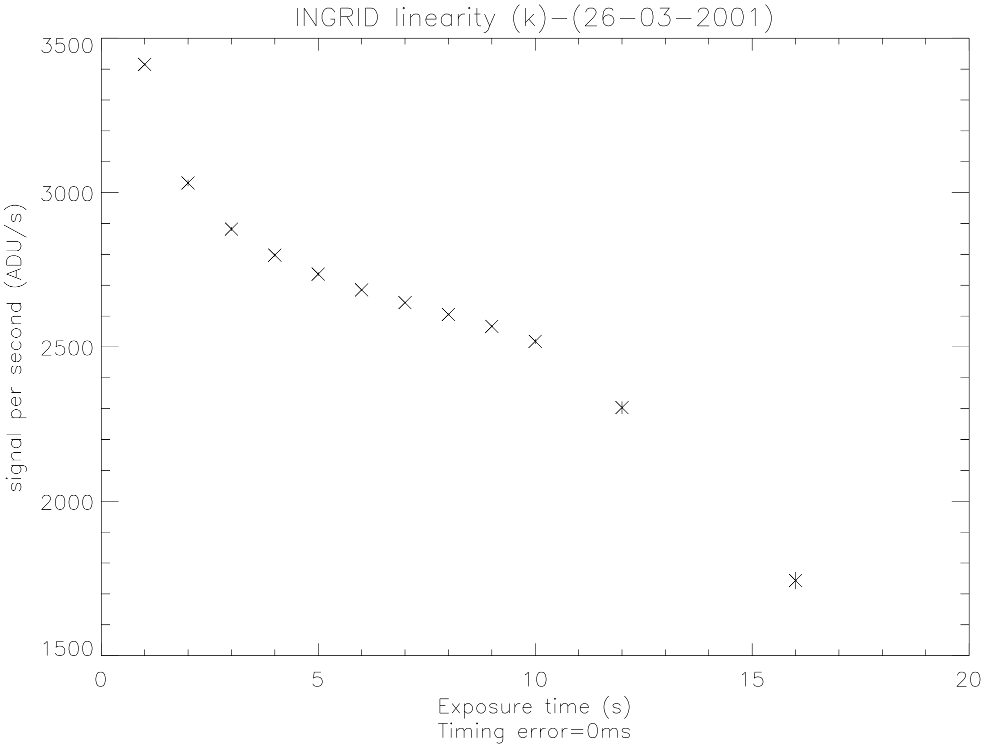

Figure 9: Linearity: plot of signal (in ADU) per second as function of exposure time (no timing correction). K filter, data taken on 20010326. This Figure shows that there is a timing error of some sort.

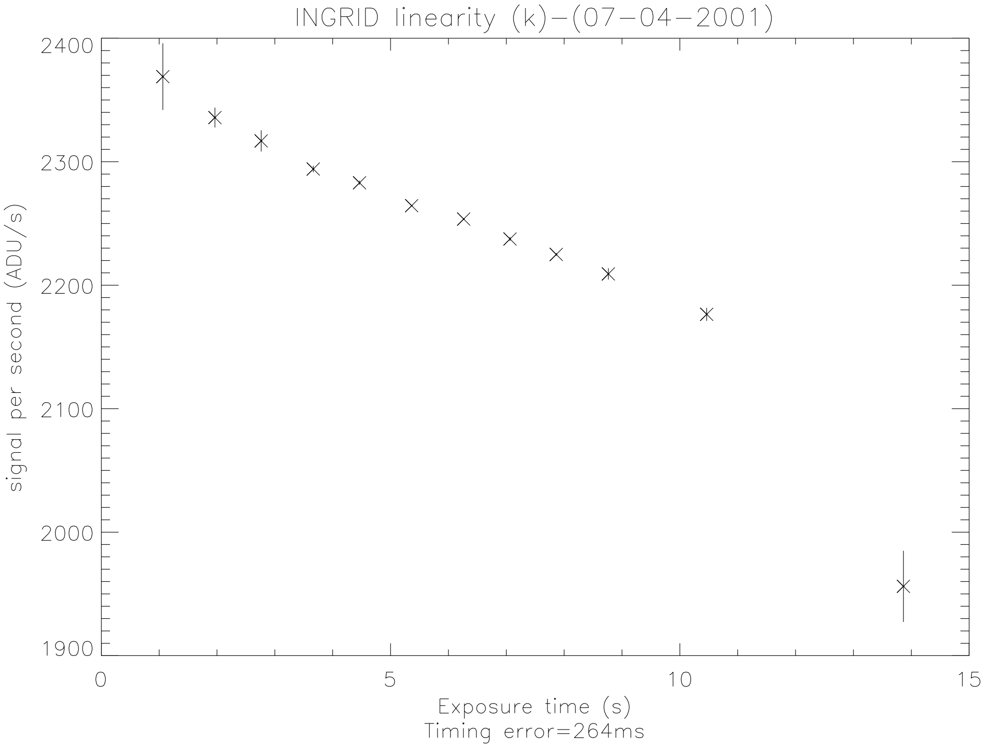

Figure 10: As Fig. 9, now with a timing correction of 0.264 s applied. K filter, data taken on 20010407. Result is now similar to what T. Augusteijn found in his first INGRID report, when no timing error was present.

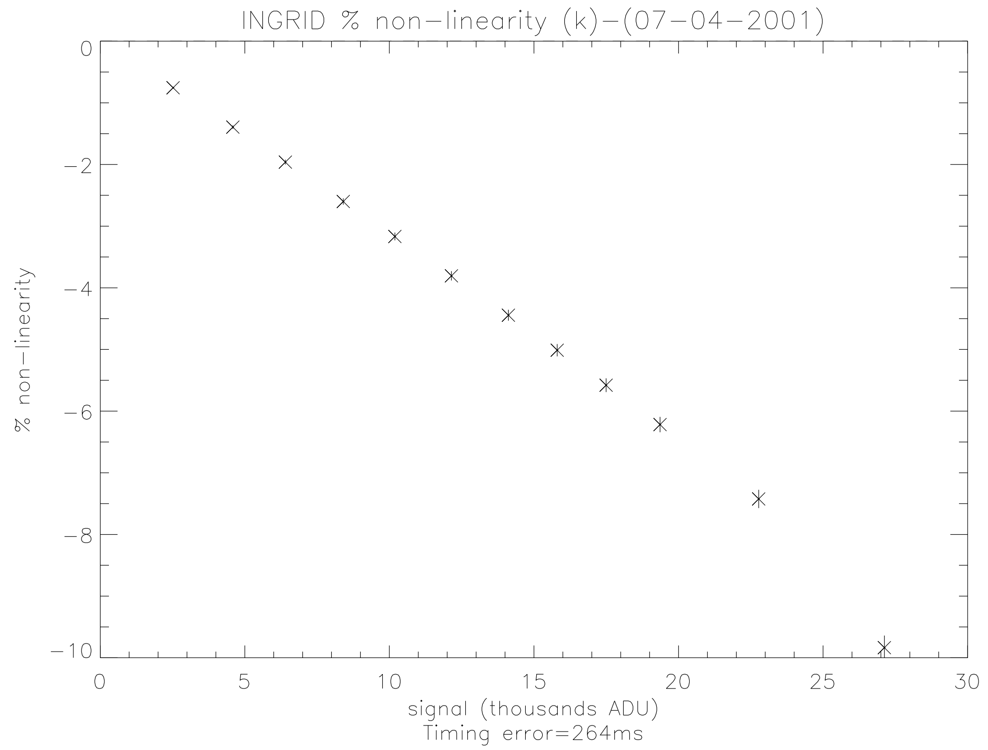

Figure 11: Fractional non-linearity, again corrected for a timing error of 0.264 s. This indicates the percentage deviation from the extrapolated countrate for a zero second exposure.

7 Outstanding work

The following are outstanding tasks as defined in the commissioning document:

- Mechanical:
  - 2.7.2 folding flat repeat
  - 4.5.1/2 pupil stop efficiency
  - 5.3 vignetting
  - 5.6 autoguider vignetting
  - 5.7 thermal background from secondary baffle
- Astronomy:
  - 3.0.2 focus offsets
  - 3.1.2 plate scale
  - 5.5 focus stability
  - 5.9 MNDR RON
- Software:
  - 4.1.2 dithering with autoguiding
  - 4.2.1 idem
- Detector:
  - 2.8.3 long-term bias consistency
  - 2.8.5 stability after power cycle
  - 2.8.7 flat field stability
  - 3.6 long term flat field stability

The usefulness of the remaining commissioning tests (listed above) will be analysed by the INGRID team. Further work on INGRID has been defined in the INGRID meeting on June 18th 2001 at ING.

Table 3: INGRID image quality - K filter

Filter K					
	left-down	left-up	right-down	right-up	all frame
			m5es-k.fit		
FWHM (pix)	2.76	2.66	3.30	2.71	2.80
ellipticity	0.07	0.14	0.08	0.20	0.11
num. stars	15	16	7	4	
			m5en-k.fit		
FWHM (pix)	2.87	2.53	2.96	2.99	2.86
ellipticity	0.12	0.05	0.31	0.12	0.13
num. stars	17	8	6	13	
			m5c-k.fit		
FWHM (pix)	3.28	3.06	4.08	3.49	3.38
ellipticity	0.12	0.14	0.20	0.15	0.15
			m5wn-k.fit		
FWHM (pix)	2.62	2.61	3.25	3.07	2.94
ellipticity	0.16	0.12	0.10	0.12	0.12
num. stars	9	6	13	7	
			m5ws-k.fit		
FWHM (pix)	2.77	2.58	3.17	3.00	2.90
ellipticity	0.13	0.16	0.11	0.12	0.12
num. stars	10	5	10	2	

Table 4: INGRID image quality - J filter

Filter J					
	left-down	left-up	right-down	right-up	all frame
m5wn-j.fit					
FWHM (pix)	3.18	2.86	3.78	3.75	3.21
ellipticity	0.19	0.05	0.10	0.12	0.08
num. stars	2	14	4	5	
m5ws-j.fit					
FWHM (pix)	3.33	3.09	4.17	3.37	3.51
ellipticity	0.13	0.1	0.04	0.12	0.102
num. stars	2	10	6	5	
m5es-j.fit					
FWHM (pix)	3.73	3.53	4.07	3.87	3.79
ellipticity	0.10	0.09	0.09	0.13	0.10
num. stars	7	10	11	4	
m5en-j.fit					
FWHM (pix)	3.29	3.11	3.58	3.48	3.32
ellipticity	0.07	0.06	0.08	0.11	0.08
num. stars	11	9	4	8	
m5c-j.fit					
FWHM (pix)	3.26	3.10	4.74	3.41	3.46
ellipticity	0.14	0.11	0.28	0.18	0.16
num. stars	20	9	6	6	

Table 5: INGRID image quality - *H* filter

Filter H	left-down	left-up	right-down	right-up	all frame
			m5c-h.fit		
FWHM (pix)	3.20	3.12	4.23	3.40	3.46
ellipticity	0.10	0.29	0.22	0.20	0.19
num. stars	26	17	17	20	
			m5en-h.fit		
FWHM (pix)	3.28	3.00	3.25	3.19	3.17
ellipticity	0.16	0.12	0.17	0.09	0.13
num. stars	12	10	2	8	
			m5wn-h.fit		
FWHM (pix)	3.37	3.33	3.99	3.66	3.63
ellipticity	0.15	0.14	0.19	0.05	0.14
num. stars	6	8	10	6	
			m5ws-h.fit		
FWHM (pix)	3.01	2.86	3.35	3.11	3.14
ellipticity	0.14	0.10	0.10	0.13	0.12
num. stars	16	3	10	8	
			m5eh-h.fit		
FWHM (pix)	3.29	3.37	3.64	3.35	3.41
ellipticity	0.07	0.08	0.07	0.13	0.08
num. stars	14	9	11	7	