Mopra Holography

Interim report #1

mjk, 22/may/1994

1. Hardware.

George Graves and Les Reilly have overhauled the Scientific Atlanta receiver and transformed it to a respectable holography unit. (Amongst other repairs, the phase meter no longer averages -180 and +180 degrees to report a phase angle of 0!)

The AUSSAT 4.5m (reference) antenna has been activated: 2 coax cables were installed to pipe the 5 MHz out and the 1 GHz IF back to the control room, from whence the IF was dispatched up to the vertex room. In spite of these long runs the phase stability was excellent. On may 18 the phase gradient was -64 degrees/hour from 16 to 19h (UT), changing to +100 degrees/hour from 19 to 20 (UT); this slow gradient was easily calibrated with a boresight observation every 3 minutes.

The amplitude stability was excellent, with a slow gradient of about 2% over the four hours.

Future enhancements. In the constant pursuit of excellence, George would like to rework the amplitude measuring unit.

2. Software.

Two computers are involved: the μVax to drive the antenna and a PC to collect the data.

The Vax pointing utility POINT has an option to execute a holography raster, with boresight calibrations bracketting each scan. In addition, the Optus-B1 ephemerides are used to ensure that the observations are correctly referenced to true satellite position. (The full satellite excursion is about 8 arcmin in az and 2 arcmin in elevation). A logfile is produced with the time-stamped antenna positions at regular intervals.

The PC data logging task collects data at a rate of 8 samples/sec while the antenna is scanning at a rate of 1 degree/minute.

A second PC task merges the Vax and PC data files to produce a (position/data) file for the holography task.

The PC holography task is a close relative of the AIPS task HOLGR.

Future enhancements.

a. POINT requires some further attention to strengthen the "on-source" checks. On may 18 we lost 3 boresight scans because of a incorrect "on-source" message.

b. The high data quality means that CLEANing the image is now warranted. The dirty image is corrupted primarily in the amplitude domain, not the surface (phase) domain, so the main gain will be aesthetic.

3. **Results.**

We have now produced 3 images - a 14x20 image in april; a 41x41 image on may 17 and a 71x71 image on may18.

For the april run we raised one panel by 3mm. The panel is in ring 2, roughly in line with the hoist. The panel is very evident in the image, and confirms that the various sign ambiguities have been resolved: the panel shows up in the right place with the right sign. The panel was returned to its original position after the imaging. The image is given in figure 1.

The may 17 image has a spatial resolution of about 70 cm; the may 18 image's resolution is 35 cm. The two images are consistent, given the different resolution. The data quality on may 18 is excellent. Figure 2 shows the boresight calibration data, and figures 3a and b give some indication of the data. Fig 3a is the central scan, with amplitude in the upper panel, COS(phase) in the middle panel and SIN(phase) in the third; fig. 3b shows the last scan - offset by 3 degrees in azimuth from boresight; we appear to be measuring quality phase at signals 50 dB below the peak.

Figure 4 shows the amplitude image of the may 18 data, and fig. 5 the corresponding surface map. Fig 6 has the error distribution histogram.

Discussion.

a. Amplitude. The illumination is uniform to a high degree - the image is now dominated by the imaging artefact: the convolution with the windowing function. This is a SINC(x)*SINC(y) function with about 35cm from peak to the first zero. We can expect to see a series of parallel bands adjacent to the discontinuities: the feed leg shadows, the subreflector and the antenna rim. The spacing between peaks is about 70cm.

b. Surface. There are three aspects to the surface distribution:

i). the imaging artefacts. Several features seem related to the windowing function.

ii). the feed function. There is a central depression extending over the inner two rings of panels. This could well be related to the phase distribution over the feed. (It amounts to about 6 degrees phase).

iii). the true surface error. There are a number of localised errors which are probably real - they are present in all the images produced so far, differing only to the extent of the different resolution. There are also several large scale features which are probably real; in particular, what looks like low level astigmatism, with depressions on the "N-S" axis and raised regions on the "E-W" axis.

The RMS based on the may 18 data, with no corrections for i) and ii) is 0.37mm; at this level Ruze would expect a 50% loss of efficiency at 100 GHz. (That is, 50% in addition to the other losses, such as blocj\kage and illumination).

Future work.

a. Correct for the feed's phase distribution.

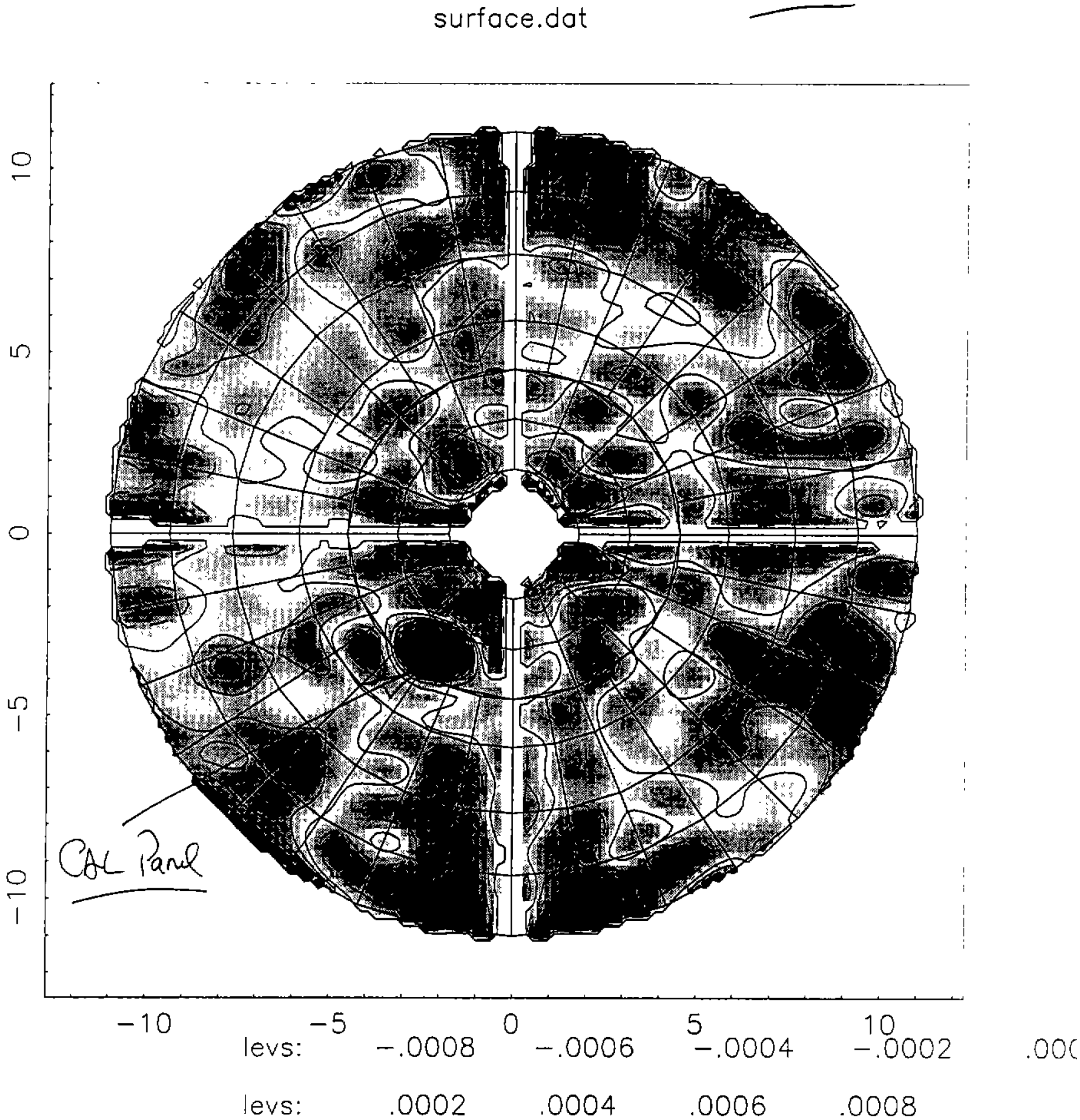
b. Correct for the windowing function.

c. Derive the panel correction tables.

d. Prepare for 30 GHz.

2nd pass – after correcting for satellite drift & Cal φ errors

APRIL



Contours at 0.2 mm spacing.
Negative contours dashed.

Fig. 1

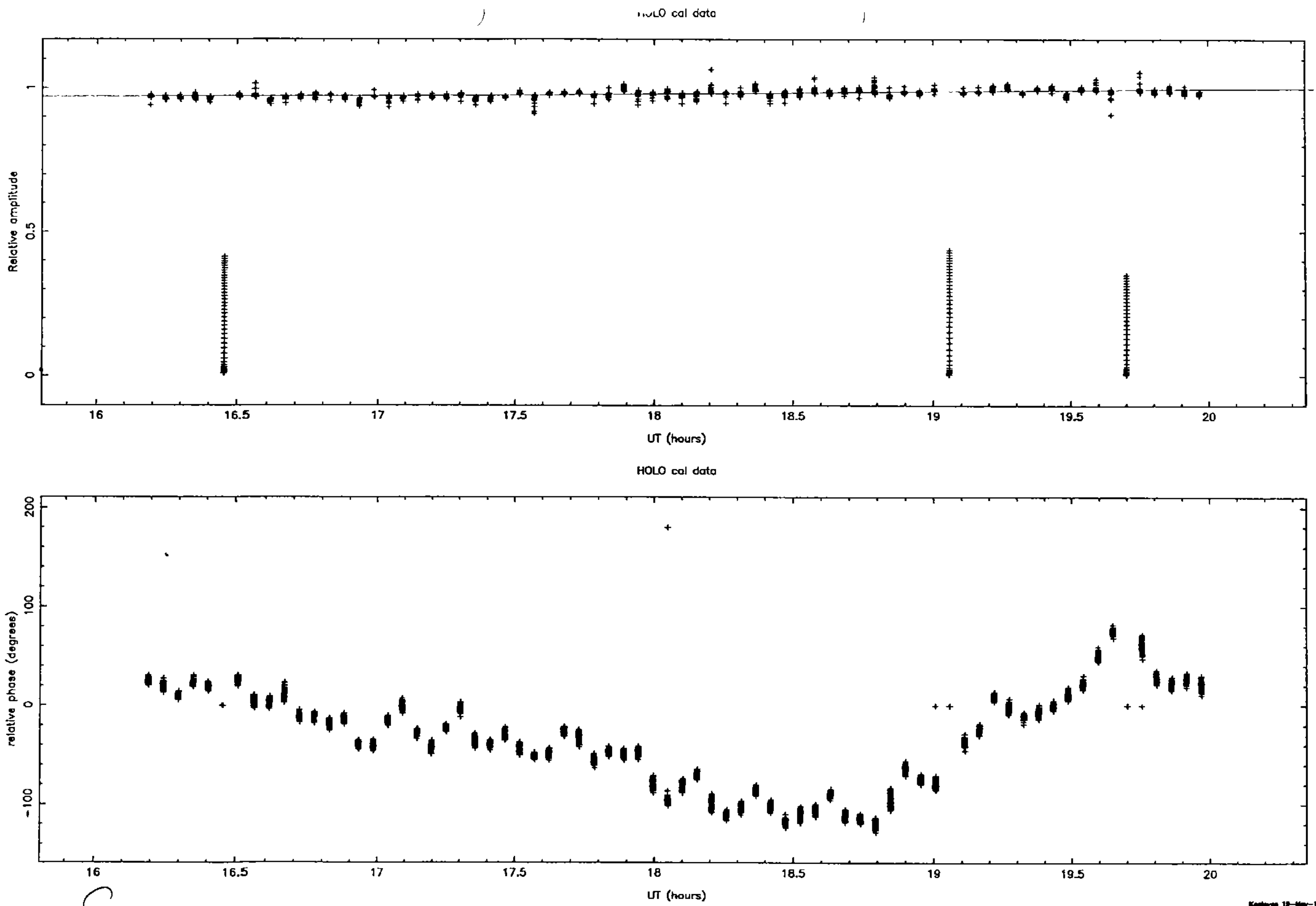

HOLO cal data
Relative amplitude
1
0.5
0
16
16.5
17
17.5
18
18.5
19
19.5
20
UT (hours)
HOLO cal data
relative phase (degrees)
200
100
0
-100
16
16.5
17
17.5
18
18.5
19
19.5
20
UT (hours)

Fig 2

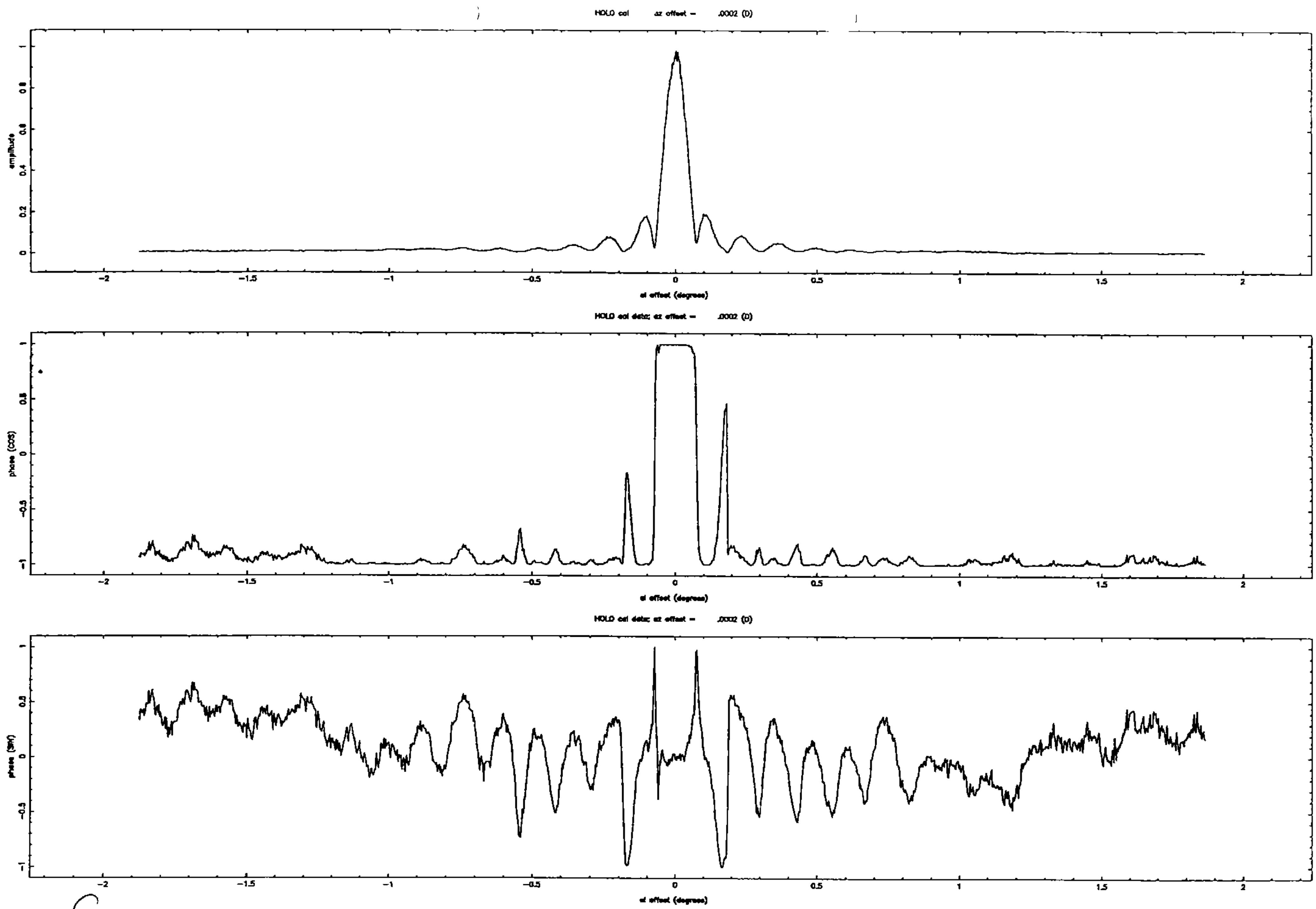

HOLO cal az offset = .0002 (D)
amplitude
el offset (degrees)
HOLO cal data; az offset = .0002 (D)
phase (COS)
el offset (degrees)
HOLO cal data; az offset = .0002 (D)
phase (SIN)
el offset (degrees)

Fig 3a

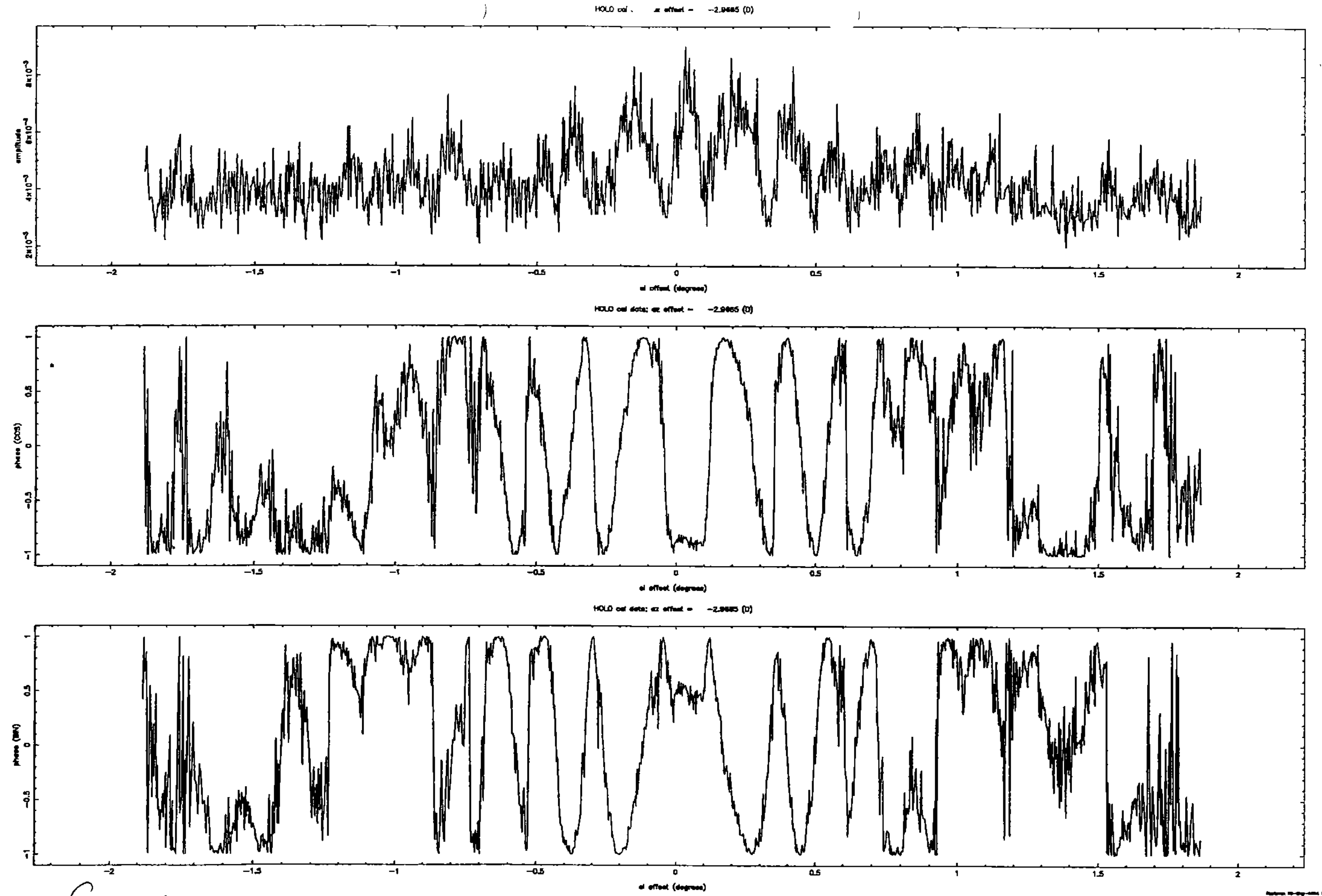
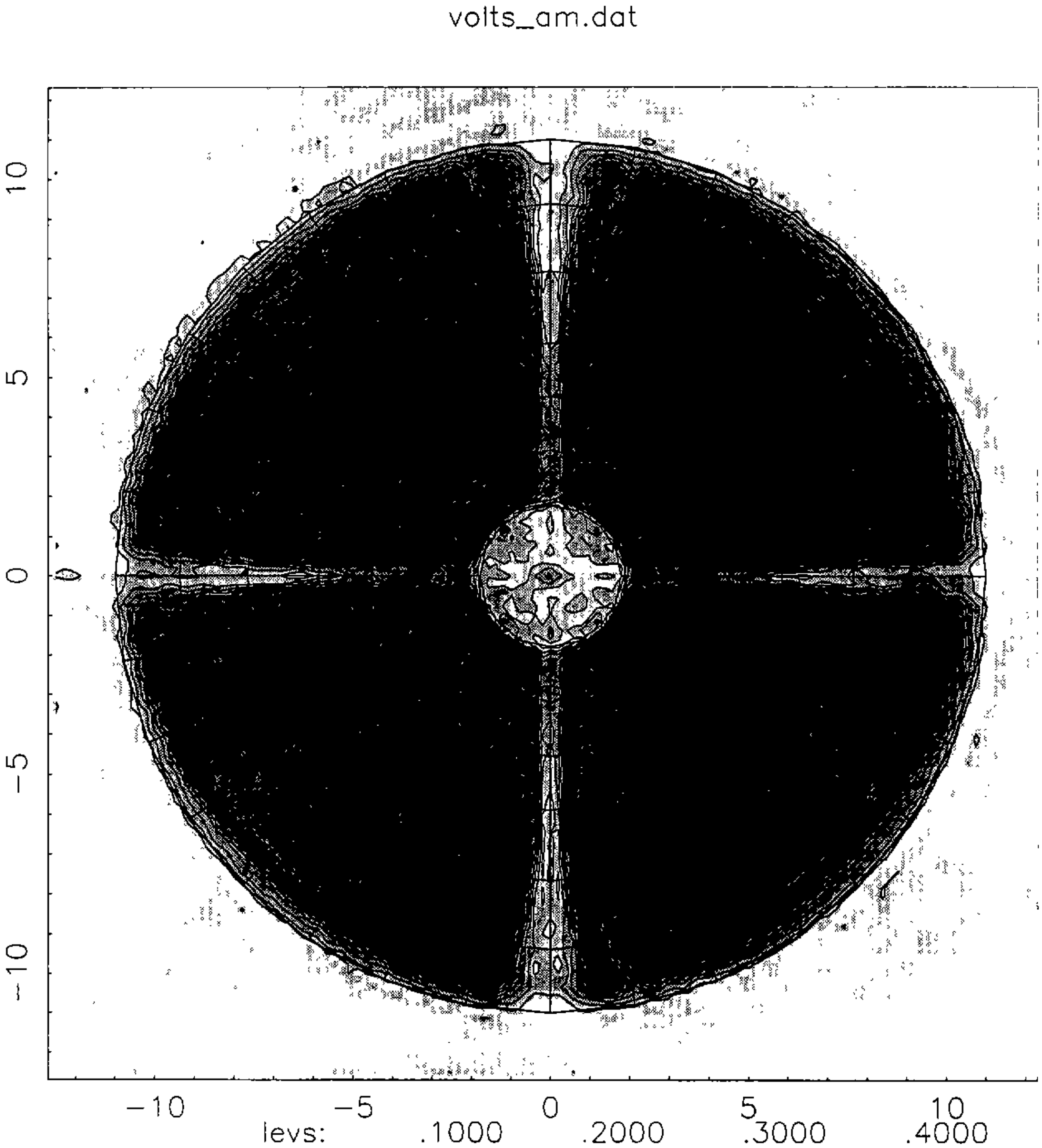

HOLO cal ; az offset = −2.9885 (D)
amplitude
el offset (degrees)
HOLO cal data; az offset = −2.9885 (D)
phase (COS)
el offset (degrees)
HOLO cal data; az offset = −2.9885 (D)
phase (SIN)
el offset (degrees)

Fig 3 h

Illumination

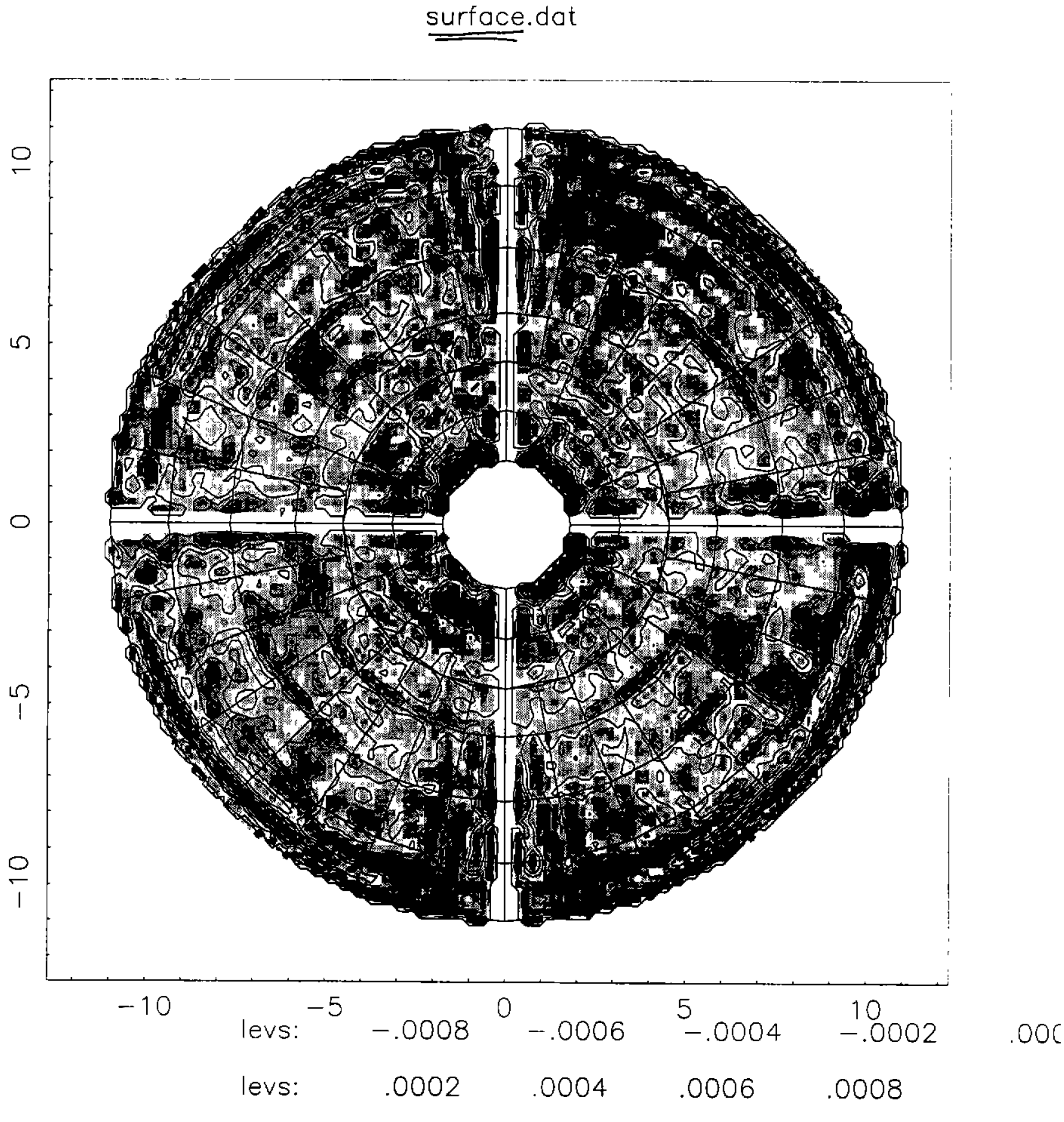


levs: .1000 .2000 .3000 .4000 .5000

levs: .6000 .7000 .8000 .9000

Contours at 10% spacing.

Fig. 4



Contours at 0.2mm spacing.
negative contours dashed.

Fig 5

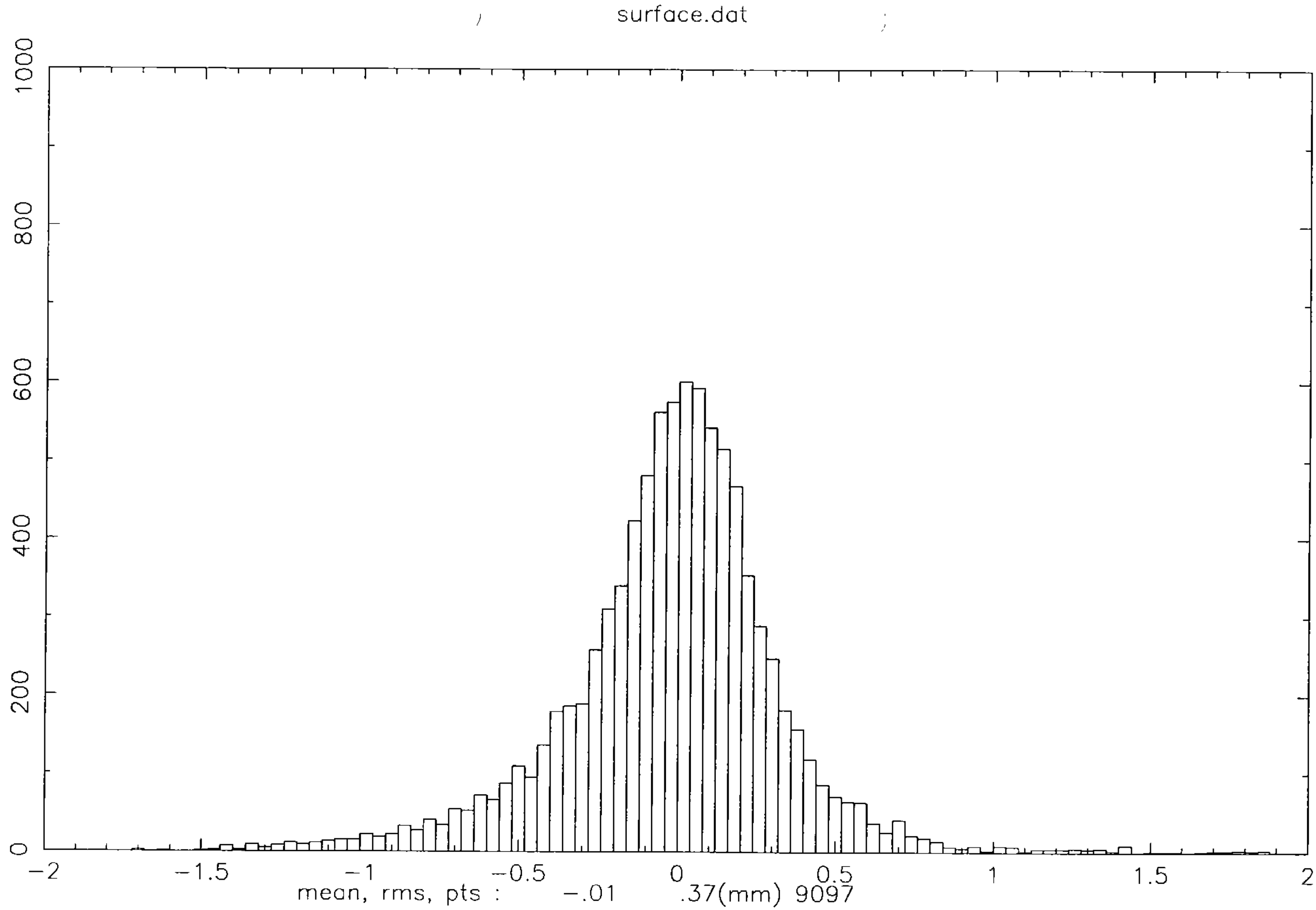

surface.dat
1000
800
600
400
200
0
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
mean, rms, pts : −.01 .37(mm) 9097

Fig. 6