Austrian Academy of Sciences
Space Research Institute
Department of Experimental Space Research

ROSETTA-MIDAS
Enhanced Calibration Report

Issue 1.1
22/10/2018

1. Introduction ***p3***

2. XY Calibration ***p4***

3. Z Calibration ***p11***

4. Tip Imaging ***p17***

5. Appendix ***p18***

Table 2. List of scans recalibrated in Z and correction factors *p18*

1. Introduction

Two commercially made AFM standard calibration targets are available for scanning on the flight model (FM). The XY calibration target consists of a chessboard-like array of square pillars separated by 3 micro meters (Figure 1 top row), while the Z calibration target consists of rectangular steps of a known height of 106 nm (Figure 1 bottom row). In addition, a tip imaging target consisting of an array of shape tips, characterised by strict symmetry of tip sides, small cone angle (less than 20 degrees) and small curvature radius of the tips (less than 10 nm) over the whole active area, and of height 700 nm, as represented schematically in Figure 1, is available for imaging of the MIDAS tips. We discuss the use of each calibration target in the following sections.

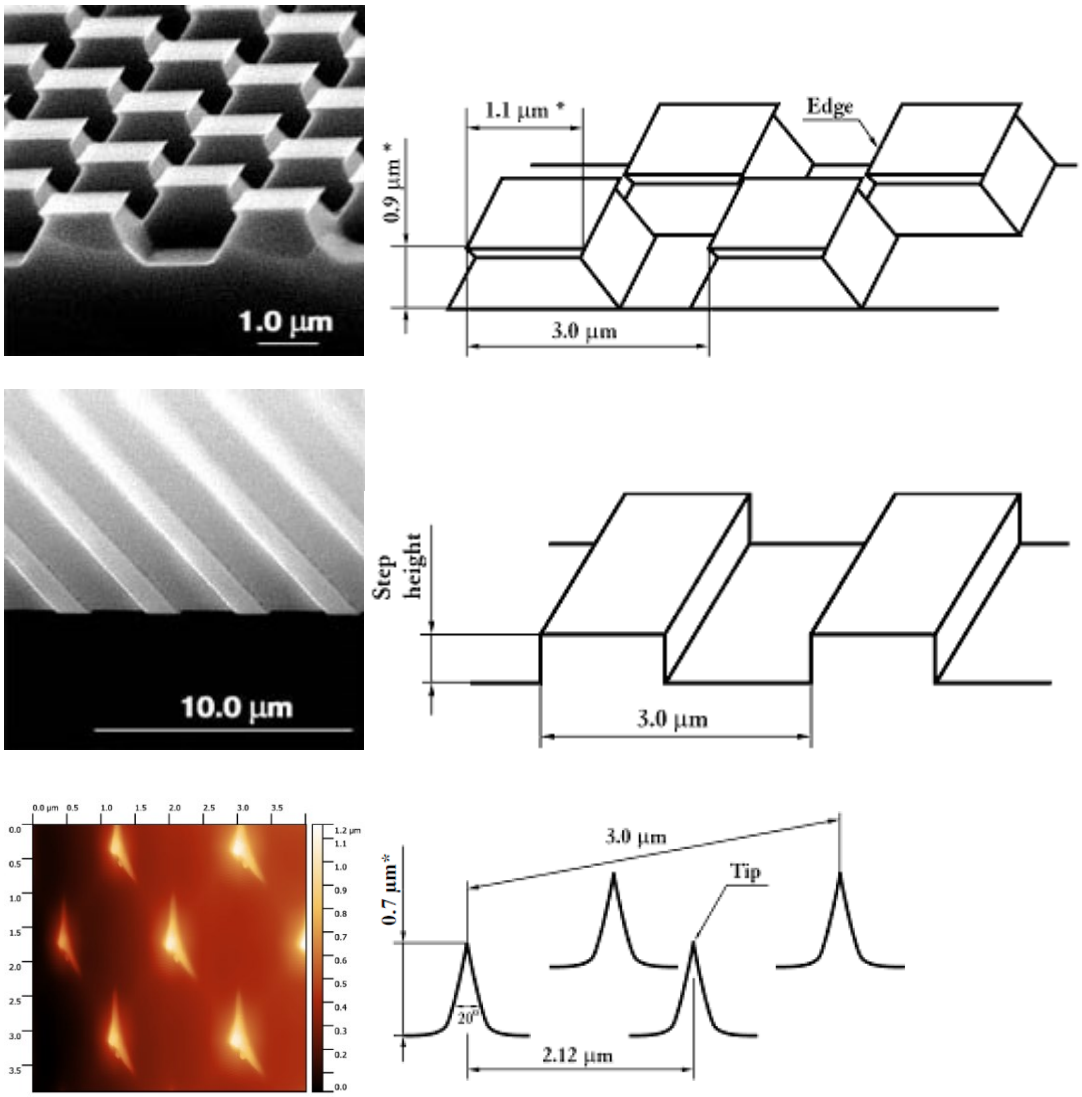


Figure 1: Top row: Scanning Electron Microscope (SEM) images of the XY calibration target (left hand side) and schematic of its known dimensions (right hand side). Middle: corresponding figures for the Z calibration target. Bottom: Typical image of a sharp MIDAS tip using the tip imaging target (left hand side) and schematic of the tip imaging target (right hand side).

2. XY Calibration

Figure 2 shows the 3d and 2d topology of a typical FM scan of the XY calibration target. To determine if any non-linearity's have appeared in the X & Y piezos, we compare the measured distance between squares in a scan to the known value. There are 38 scans of the XY calibration target for which we have good enough resolution and image quality to determine the distance between squares. This was achieved through a manual process of selecting the corners of a series of squares in each image, as shown in Figure 3, from which we determine the average distance between the squares separately in the X and Y directions, and the mean correction factor needed to return the square distances to 3 µm.

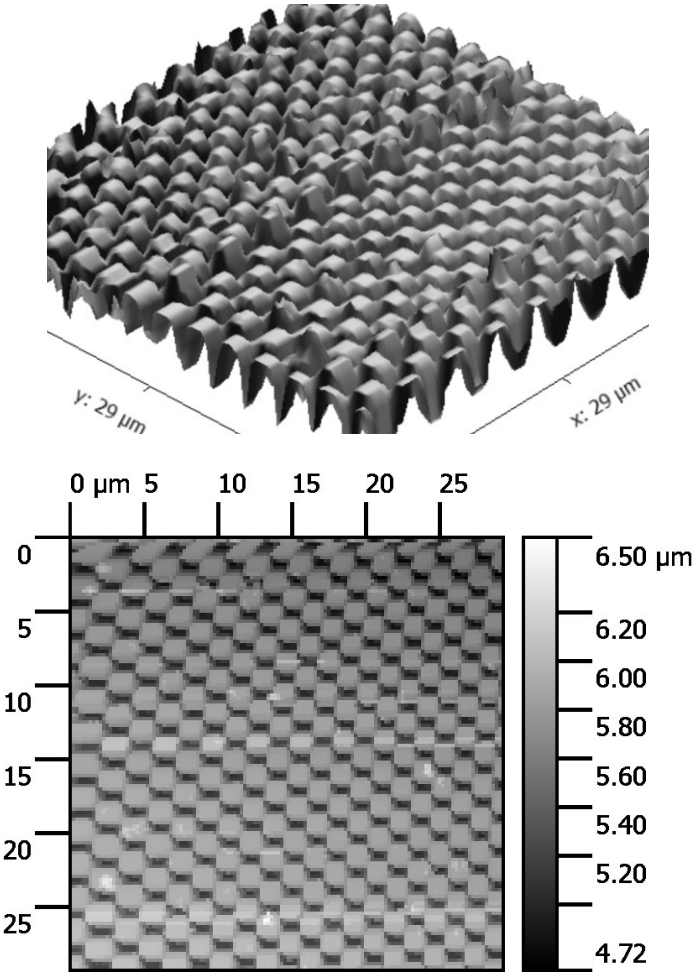


Figure 2: Example of a typical scan of the XY calibration target.

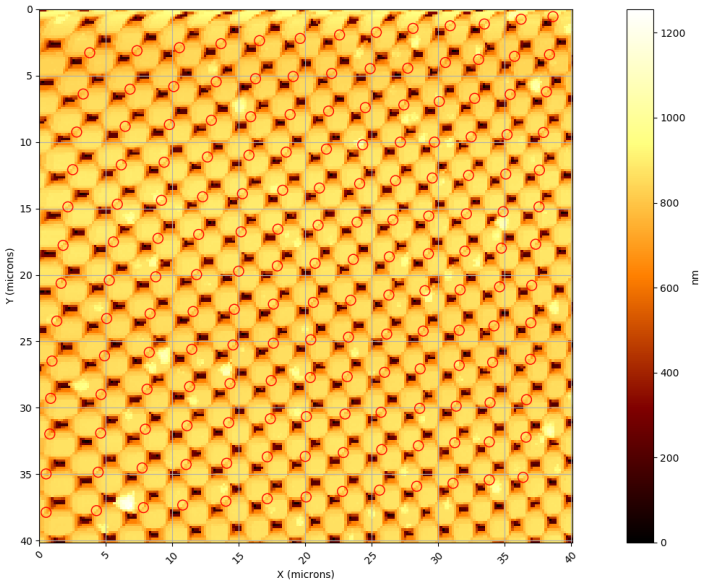


Figure 3: Example manual selection of corners of XY calibration target squares.

Several (39) scans of the XY calibration target mounted on the Flight Spare (FS) were also made, and the same procedure has been applied to these images to give a comparison to the FM data.

MIDAS can be set to operate with the fast scanning direction in X or Y, and with Y in open or closed loop mode (X is always open), we discuss the correction applied to each separate mode below.

2.1 Y correction for closed loop

There are 11 scans of the XY calibration target made on the FM with Y in closed loop mode for which we are able to determine a mean correction factor in the Y direction. These are shown in Figure 4, the red points show scans made with the fast direction in X (5 scans) and the blue points with fast direction Y (7 scans). Figure 4a shows that the FM scans of the XY calibration target are well-spaced in time throughout the mission, and cover a good range of scan sizes (lengths of 10-80 µm in the Y direction). The correction factor for all 11 scans ranges between values greater than 0.96 and less than 1.04, i.e. a correction of less than 4%. Since the corrections for all scans are small, and no correlations could be found with fast direction, time, temperature or image size (as well as other parameters), we do not apply a correction factor to the Y dimension for scans with closed loop in operation. There are a total of 455 scans of dust collection targets made in this mode during the operations phase of the mission (a variety of test scans where made during the cruise phase of Rosetta, prior to wake-up in January 2014. We do not apply enhanced calibration in X, Y or Z to the scans made in this testing phase).

(a)

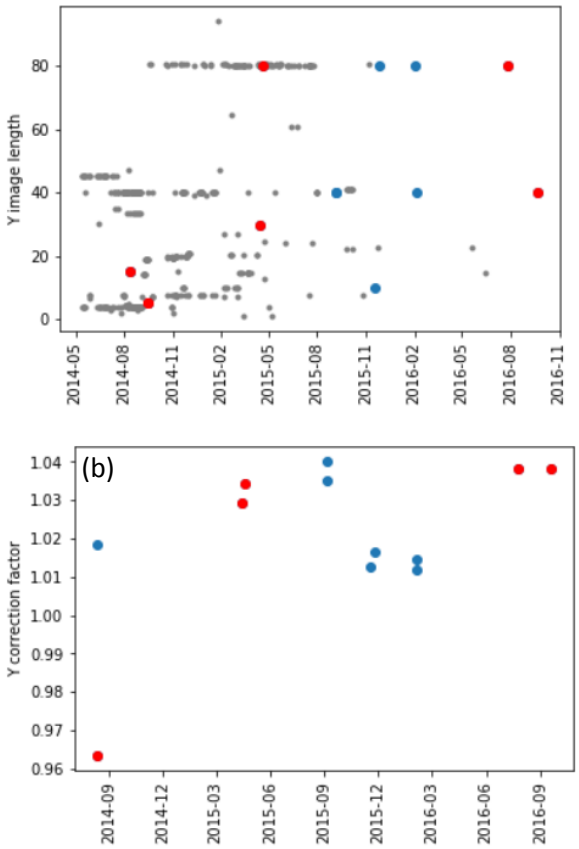


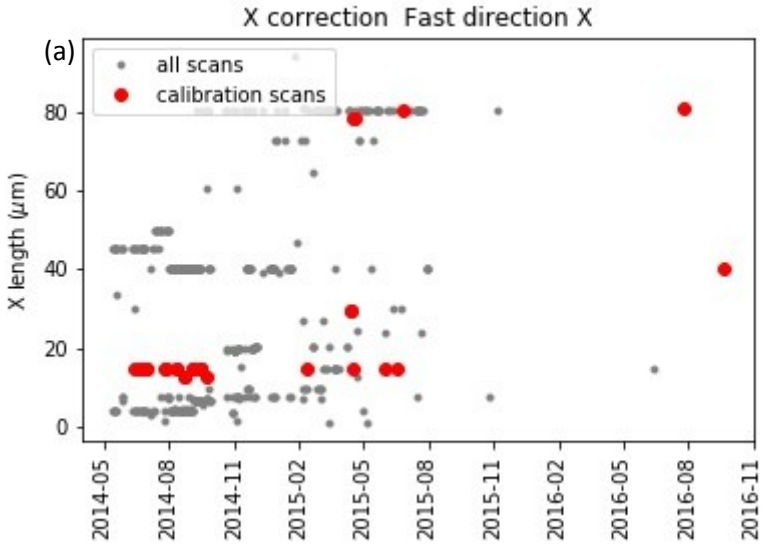
Figure 4: FM scans made with Y in closed loop operation. (a) Scan Y length vs. scan start time, (b) Y correction factor vs. scan start time. Grey represents all scans, red and blue the XY calibration target scans with fast directions in X and Y respectively.

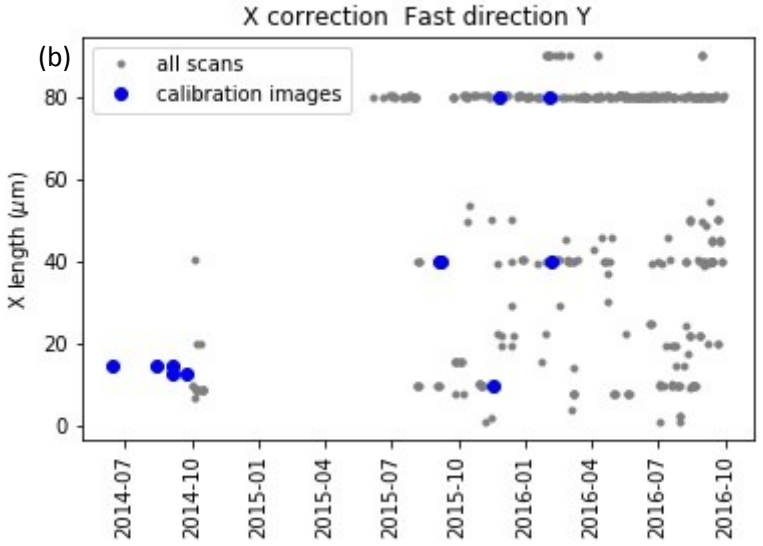
2.2 Y correction for open loop and fast direction Y

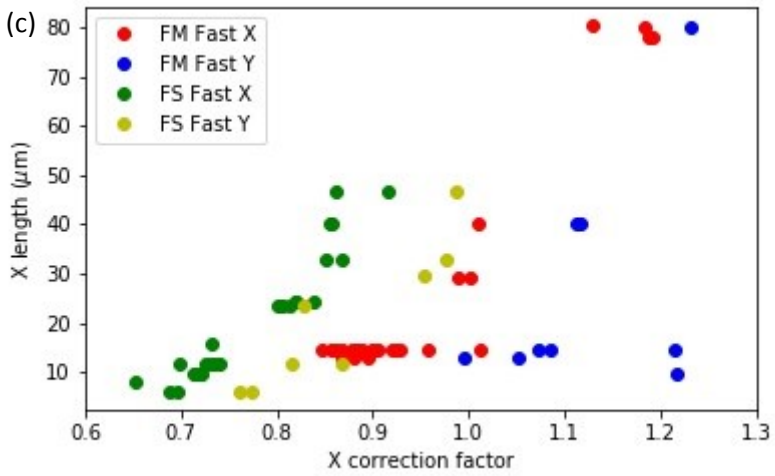
Only 14 dust collection target scans were made in this mode during the entire mission, with just 4 showing possible commentary dust, and only 4 XY calibration scans were made in this mode, all taken at the same time and with the same scanning parameters/conditions. The four calibration scans were taken more than a year prior to the scans of the dust collection targets. Due to the low number of scans made in this mode, and lack of calibration scans, we do not apply corrections to these images.

2.3 X Correction (open loop) fast direction X and Y, & Y correction for open loop and fast direction in X

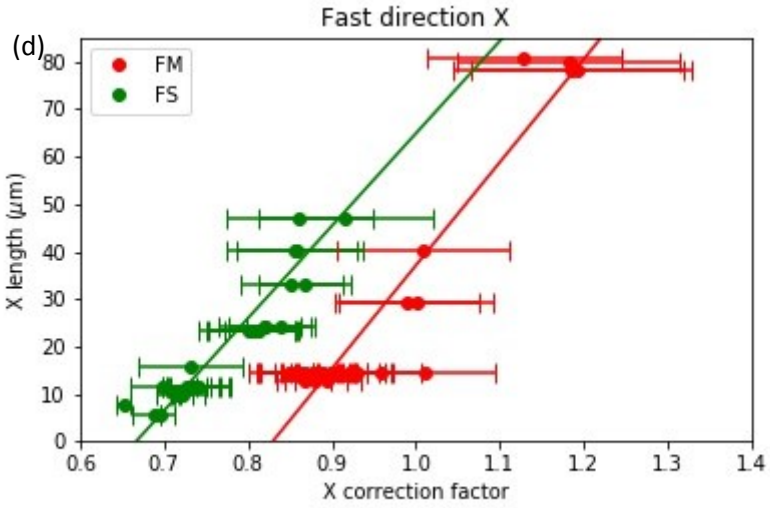
Figure 5 shows summary plots of the X correction (always open loop) for fast direction in X and Y, the Y correction for open loop and fast direction in X.


X correction Fast direction X
(a)
all scans
calibration scans
X length (µm)
0
20
40
60
80
2014-05
2014-08
2014-11
2015-02
2015-05
2015-08
2015-11
2016-02
2016-05
2016-08
2016-11

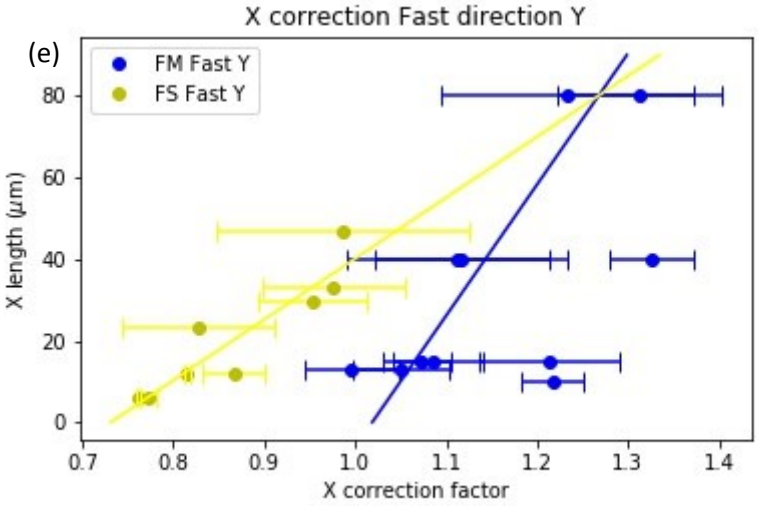

X correction Fast direction Y
(b)
all scans
calibration images
X length (µm)
0
20
40
60
80
2014-07
2014-10
2015-01
2015-04
2015-07
2015-10
2016-01
2016-04
2016-07
2016-10


(c)
FM Fast X
FM Fast Y
FS Fast X
FS Fast Y
X length (µm)
10
20
30
40
50
60
70
80
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
X correction factor

(d)


Fast direction X
FM
FS
X length (µm)
X correction factor
0
10
20
30
40
50
60
70
80
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4

(e)


X correction Fast direction Y
FM Fast Y
FS Fast Y
X length (µm)
X correction factor
0
20
40
60
80
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4

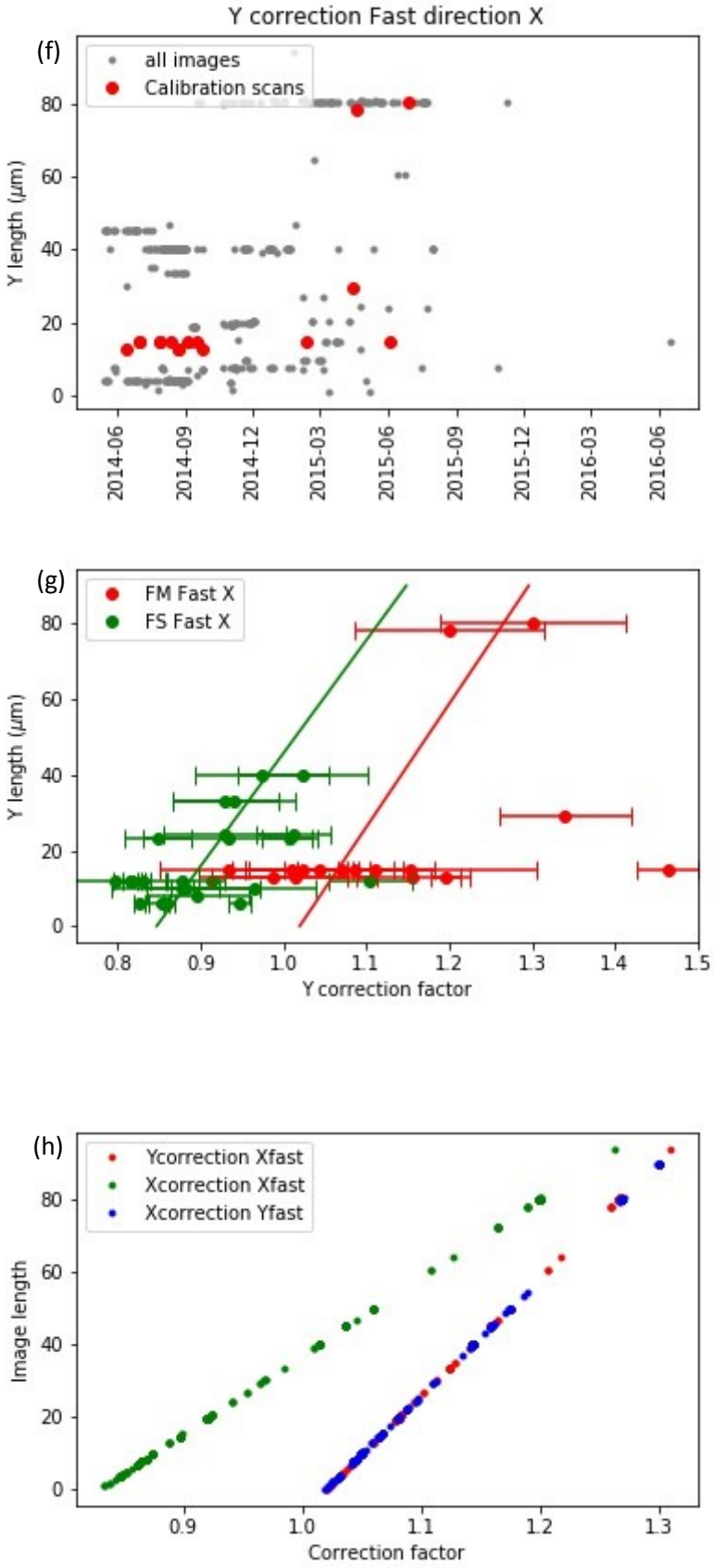


Figure 5: Summary plots of XY calibration for different modes of operation, horizontal bars show the standard deviations and solid lines in d, e and g show a fit to mean correction values. (h) shows the actual correction values determined for all scans in different modes determined from the fits.

While there is a clear shift in correction factor between the FS and FM scans, a clear correlation between correction factor and image length is found in both. The effect of other scanning parameters, as well as the average and change in temperature during scans, on correction factors was extensively investigated, but no consistent or clear correlations or relationships could be found. Since there is a clear and strong correlation between correction values and image length, we use this correlation to determine a mean correction factor for all images. For each of the three scanning modes, the mean correction factor is determined in three image length ranges (< 20 microns, 20-50 microns, >50 microns), to which we then apply a linear fit (shown by the solid lines Figures 5 d, e, g) to determine the average relationship between correction factor and image/scan length. To determine the correction factor for each image made during the operational phase of scanning, the fit for the relevant mode is used. The correction applied to all scans per mode, vs. image length, is shown in Figure 5h. The correction factor is applied to the original (determined during pre-flight calibration) horizontal and vertical dimension pixel scaling factors (1.388889 closed loop, 3.81384 open loop) to create the enhanced/corrected images found in the /DATA/IMG/ directories of this dataset. The new scaling factor can be found in the image label file.

3. Z Calibration

The Z calibration target consists of regular gratings with a step height of 106 nm, shown in Figure 6.

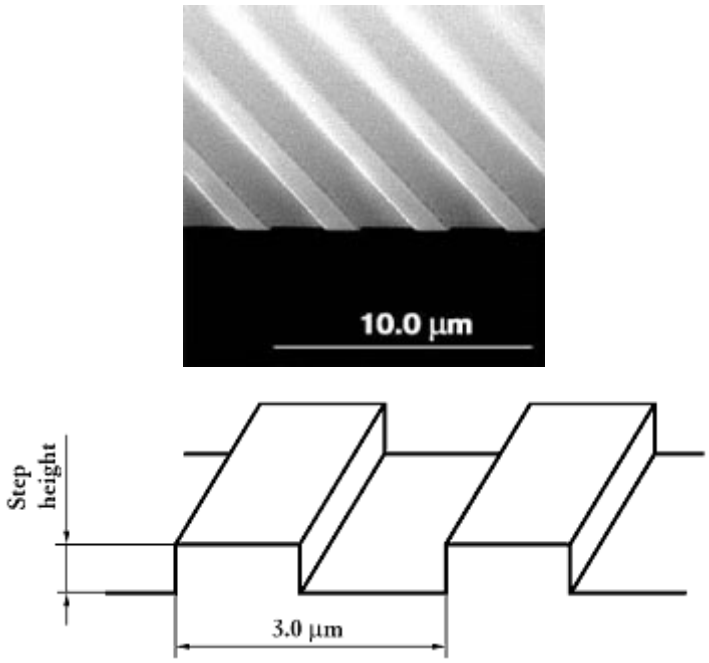


Figure 6: Top: SEM image of the Z calibration target. Bottom: schematic of the Z calibration target.

Three series of high resolution scans of the Z calibration target were made in-flight; these are listed in Table 1. All scans were made with the same scanning resolution (38.1 nm in X, 37.5 nm in Y, and 0.656 nm in Z). All scan setting were kept constant, except for the Z piezo centre position (the extent of piezo extension at the start of each full scan), which was deliberately set to different values as shown in Table 1.

Series	Scan Start time	Mean Step Height (nm)	Mean piezo extention	Mean correction
1	2016-06-30 13:10:57	55.70	-2.11	1.90
	2016-06-30 15:24:48	68.17	-1.09	1.56
	2016-06-30 17:38:39	72.73	-0.23	1.46
	2016-06-30 19:52:31	74.00	0.71	1.42
	2016-06-30 22:06:19	82.40	1.77	1.29
2	2016-07-13 07:09:42	76.57	2.99	1.38
	2016-07-13 09:23:55	75.87	1.81	1.40

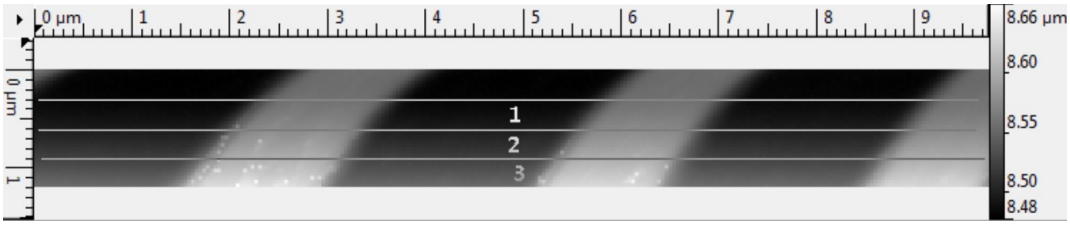
	2016-07-13 11:38:07	72.00	0.81	1.47
	2016-07-13 13:52:19	68.33	-0.33	1.55
	2016-07-13 16:06:28	61.53	-1.25	1.72
	2016-07-13 18:20:36	52.83	-2.04	2.01
	2016-07-13 20:34:46	36.78	-2.99	2.88
3	2016-09-14 12:20:49	111.80	3.16	0.95
	2016-09-14 14:26:59	79.37	2.26	1.34
	2016-09-14 16:33:11	75.87	1.37	1.40
	2016-09-14 18:39:22	68.82	0.24	1.54
	2016-09-14 20:45:29	62.03	-0.56	1.71
	2016-09-14 22:51:42	49.47	-1.53	2.14

Table 1. All high resolution FM scans made of the Z calibration target.

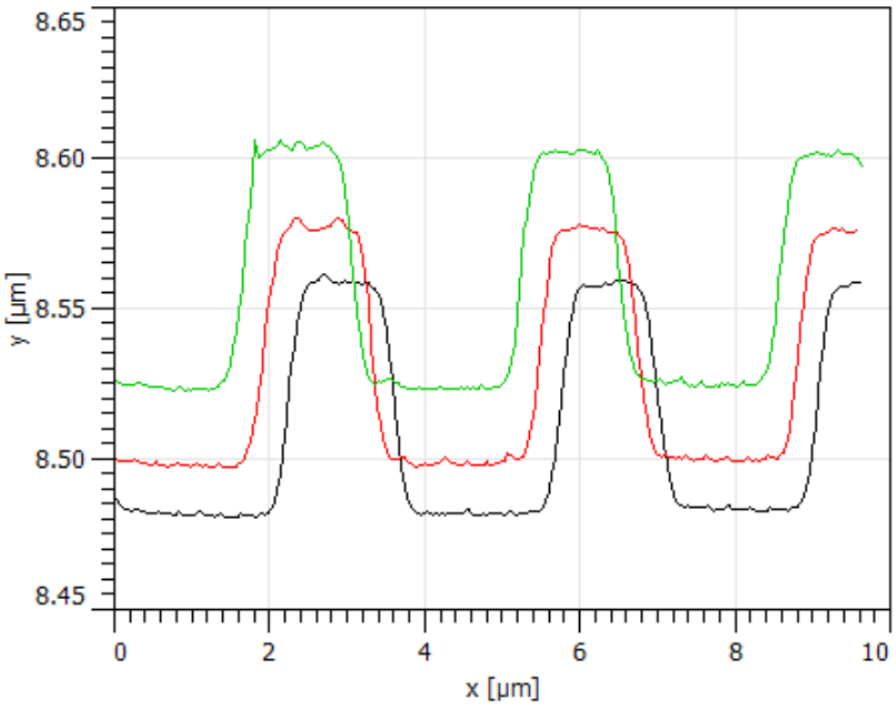
The Z piezo centre position is ideally set to 0 (range: -5 fully extended, to +5 fully retracted) so that the full range of the piezo is available during a scan. However, the height of many of the dust particles scanned by MIDAS were found to be higher than expected, such that in order to image the particle as fully as possible it was necessary to set the Z piezo centre position at different values.

A FM scan of the Z calibration target is shown in Figure 7a. To determine the height of the steps measured, in each scan we use the open source Gwyddion AFM software to take three evenly spaced line profiles of the image in the X direction, as shown in Figures 7a-b. For each line profile we determine the average step height by eye (Figure 7c), and the mean step height from all three line profiles (the average measured step heights varied by less than 3 nm between each line profile for all scans).

(a)



(b)



(c)

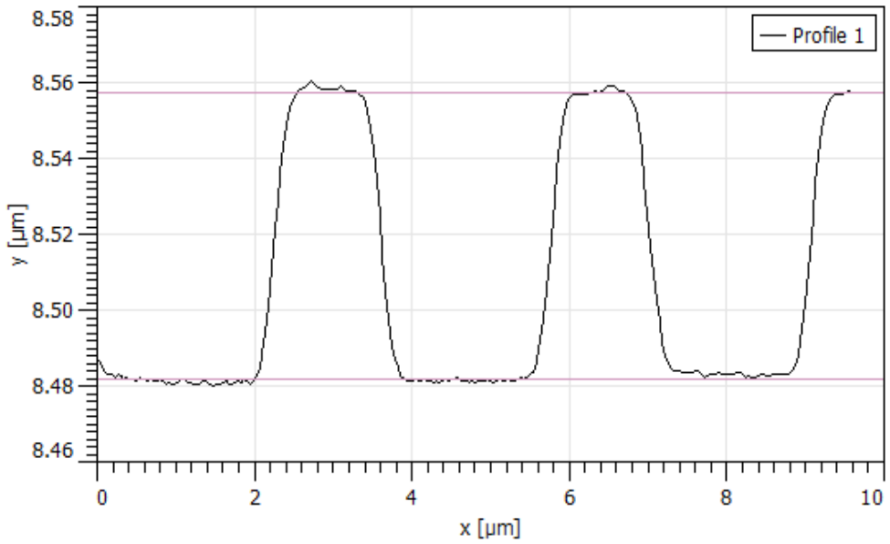


Figure 7: (a) FM scan of the Z calibration target, showing line profiles taken. (b) Three line profiles of the Z calibration target shown in a. (c) measurement of the step heights of one line profile.

As we know that the real height of the steps is 106 nm, a mean correction factor can be determined for each scan that will return the measured heights to the expected 106 nm value. Figure 8 shows the average measured heights of the Z calibration steps for each scan vs. the mean value of the Z piezo

extension when the surface of the target is detected (for all calibration scans the standard deviation of the mean piezo extension at the surface, i.e. when the tip detects the steps on the target and the height is measured, are less than 0.05, with a maximum range of values in any one scan of 0.18), and the mean correction factor needed to return the step height to 106 nm.

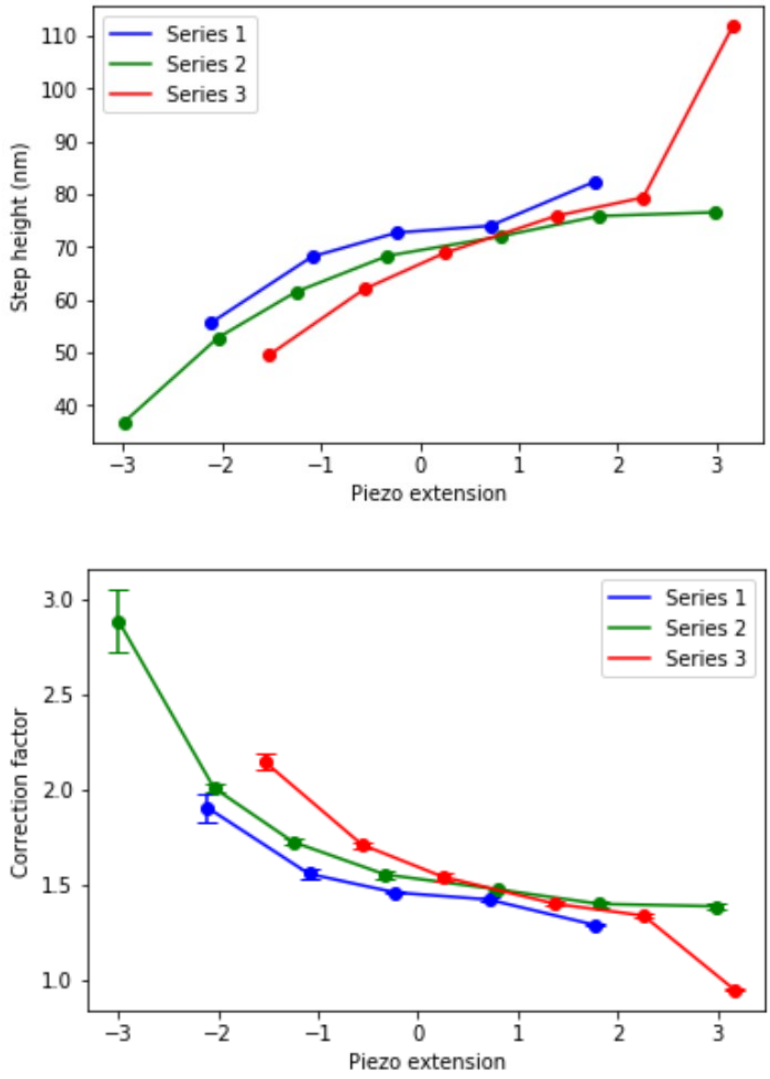


Figure 8: Top: Average measured heights of the Z calibration steps scanned at different piezo extensions. Bottom: The correction factor needed to return the step height to the known value.

At the furthest extension and retraction of the Z piezo used in these scans of the Z calibration target, -3 and +3, the behaviour of the heights measured becomes extreme, suggesting that the piezo does not measure heights well at these piezo extensions. However, there were only three scans taken at these values, and since the behaviour here changes, we restrict application of height correction to all FM scans with a mean piezo extension falling within the 'trusted' range of -2 to +2, and remove the calibration scans outside of this range in the determination of the correction factors below. A curve fit is applied to the remaining data points, Figure 9, giving the relationship between piezo extension and height correction factor for each series of calibration scans.

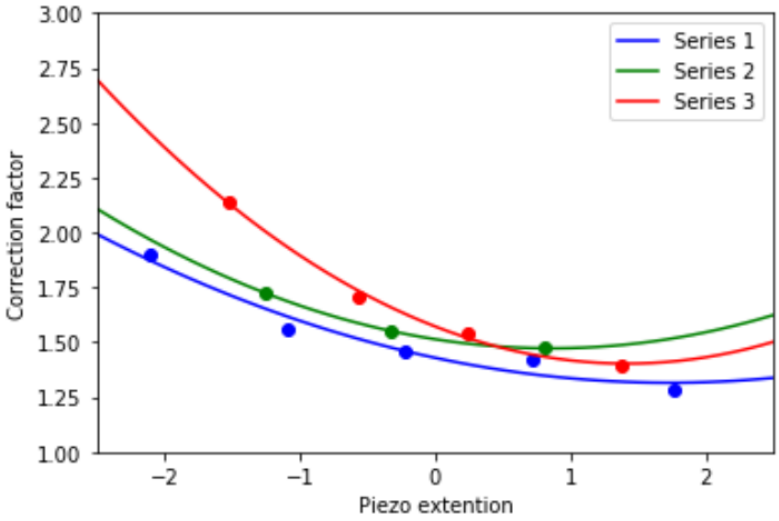


Figure 9: Curve fits to mean height correction factor and mean Z piezo extension, from which the height calibration factor is determined.

The three series of calibration scans are separated by a total of two and half months, from 2016-06-30 to 2016-09-15 (while the operational phase of scanning lasted for approximately 2 years, beginning in the summer of 2014 until September 2016). Figure 10 shows the difference in correction factor vs. piezo extension for the three curves of Figure 9.

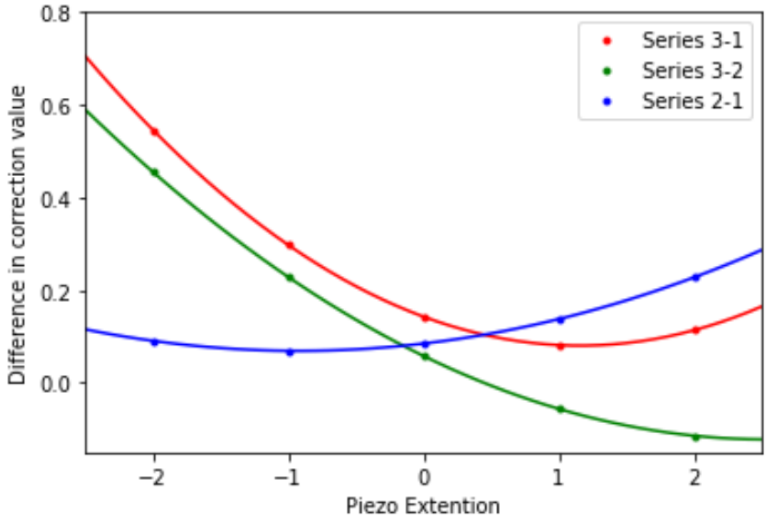


Figure 10: The difference in height correction factor between the three series of calibration scans; dots: difference between mean values, line: difference between the fits.

There is a significant difference in the correction curves between each series of scans. Several line scans of the Z calibration target mounted on the FS were made at good resolution, and covering a range of Z piezo extensions. The step heights measured at different piezo extensions were found to

be approximately the same height (within 10nm) and independent of the Z piezo extension. This suggests that the difference in heights seen on the FM is a FM phenomenon only. Piezo systems are known to be effected by wear, as well as temperature effects, and indeed the average temperature is gradually increasing over the time scale of the three series of calibration scans made by approximately 4 degrees. However, the threes series of Z calibration FM scans shown were the only scans of the Z calibration target made at good resolution such that we cannot investigate if the apparent relationships are consistent at earlier or later times in the mission. Therefore, we only apply updated height calibration to scans made within a time range of plus or minus three months from the first/last scan from the series of Z calibration scans (2016-04-01 until 2016-12-14). The correction factor for each scan is determined from the mean piezo extension in each scan, and the correction curve from the closest series of calibration scans used. Due to slopes of the scanned targets, or the large height of the particles scanned, the piezo extension in some scans can cover a large range. We do not apply updated height calibration to scans if the difference in the correction factor determined from the minimum and maximum piezo extension at the target surface in the scan is greater than 50%. Therefore, a total of 166 scans have updated height calibration (these are listed in Table 2 of the appendix). The correction factor for each scan is applied to the original piezo extension to real height scaling factor, and this value is recorded in the scan image labels in the /DATA/IMG/ directory of this dataset.

4. Tip Imaging

Tip imaging was performed when the imaging quality of a given tip became suspect, or after instrument anomalies that may have resulted in unwanted tip/sample interactions.

The document MID_TIP_IMAGES.pdf provides a list and all images of tips made on the tip imaging target. Due to the limited time available, tip images could not be obtained more regularly. The decision on which tip to use was based partly on these tip images, but also on the requirement to revisit particular target locations, which was found to be challenging when switching tips. Therefore a poor tip was sometimes used in order to perform more accurate positioning.

In addition, the individual properties of some tips (e.g. high vs. low Q factor, magnetic coated or not) led to some tips being preferred for certain scan types.

5. Appendix

Table 2: List of scans recalibrated in Z and correction factors

Scan start time	Archive dataset	Archive file	Correction factor
2016-04-04 02:05:00.492485	RO-C-MIDAS-3-EXT1-SAMPLES-V3.0	IMG_1606823_1609700_047_ZS	1.31772803
2016-04-04 13:33:04.509859	RO-C-MIDAS-3-EXT1-SAMPLES-V3.0	IMG_1606823_1609700_050_ZS	1.315942422
2016-04-06 06:54:54.010886			1.357076463
2016-04-06 17:33:24.570257	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_001_ZS	1.464293549
2016-04-07 04:01:44.582420	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_005_ZS	1.454232378
2016-04-07 14:25:24.594492	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_009_ZS	1.469351819
2016-04-10 17:19:26.681481	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_029_ZS	1.379480672
2016-04-11 18:18:15.710493	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_033_ZS	1.322092716
2016-04-13 19:18:40.767409	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_041_ZS	1.408683731
2016-04-14 19:31:46.795536	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_045_ZS	1.360897734
2016-04-17 08:26:28.866278	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_047_ZS	1.317891158
2016-04-25 07:09:49.087781	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_075_ZS	1.395926285
2016-04-26 00:55:55.112637	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_083_ZS	1.428195956
2016-04-26 07:13:10.120027	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_087_ZS	1.317105812
2016-04-26 15:42:27.130003	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_091_ZS	1.320744935
2016-05-01 07:06:00.260923	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_097_ZS	1.317055908
2016-05-01 14:31:10.269643	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_101_ZS	1.331663923
2016-05-01 21:56:16.278362	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_105_ZS	1.363932359
2016-05-02 05:21:23.287081	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1609623_1612500_109_ZS	1.442324633
2016-05-04 08:35:03.347290	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_001_ZS	1.418948385
2016-05-07 15:36:34.440169	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_011_ZS	1.386213463
2016-05-09 22:16:33.504418	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_031_ZS	1.348719374
2016-05-11 12:09:28.548941	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_043_ZS	1.33991131
2016-05-12 13:53:58.579195	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_045_ZS	1.379975082

2016-05-14 16:49:31.639049	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_051_ZS	1.374425714
2016-05-15 18:23:09.669091	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_062_ZS	1.474989938
2016-05-16 14:49:42.693117	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_076_ZS	1.412419549
2016-05-17 23:24:14.726367	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_091_ZS	1.320913762
2016-05-18 17:27:44.747351	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_095_ZS	1.33421707
2016-05-19 02:35:00.757950	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_099_ZS	1.327666479
2016-05-19 12:27:08.769418	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_111_ZS	1.498683227
2016-05-19 20:54:52.779251	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_115_ZS	1.319013688
2016-05-20 02:41:28.785964	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_119_ZS	1.316084837
2016-05-20 16:24:24.801901	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_126_ZS	1.317377212
2016-05-21 06:08:05.817853	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_133_ZS	1.323998078
2016-05-21 19:52:47.833825	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_140_ZS	1.318250012
2016-05-22 22:30:40.864771	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_151_ZS	1.317382385
2016-05-25 07:40:54.931203	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_158_ZS	1.338106984
2016-05-26 12:42:50.964939	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_160_ZS	1.386717397
2016-05-27 22:50:28.004595	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1612423_1615300_167_ZS	1.357730033
2016-06-02 04:01:36.150061	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_015_ZS	1.4656876
2016-06-02 12:49:35.160286	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_022_ZS	1.360095078
2016-06-02 21:37:36.170512	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_029_ZS	1.430770275
2016-06-03 06:25:40.180739	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_036_ZS	1.39298635
2016-06-03 15:13:36.190964	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_043_ZS	1.461276592
2016-06-04 00:01:40.201191	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_050_ZS	1.334168541
2016-06-04 08:49:35.211415	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_057_ZS	1.429589267
2016-06-05 18:31:10.250566	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_078_ZS	1.425004254
2016-06-06 16:43:09.276362	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_092_ZS	1.3950569
2016-06-07 14:34:59.301768	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_106_ZS	1.316892889
2016-06-08 07:22:21.321278	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_110_ZS	1.317879525
2016-06-09 01:37:44.342492	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_124_ZS	1.530736081
2016-06-09 22:31:43.366777	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_138_ZS	1.344336777

2016-06-10 09:56:44.380044	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_145_ZS	1.323636197
2016-06-11 05:01:07.407165	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_152_ZS	1.380878883
2016-06-12 06:57:51.438186	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_159_ZS	1.350898696
2016-06-13 01:44:58.460646	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_173_ZS	1.317680476
2016-06-13 10:14:36.470802	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_177_ZS	1.324762448
2016-06-15 07:31:02.524933	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_193_ZS	1.691373031
2016-06-16 21:47:57.570704	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_209_ZS	1.350179251
2016-06-17 06:35:58.581226	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_216_ZS	1.359040111
2016-06-17 15:23:52.591746	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_223_ZS	1.334796098
2016-06-18 08:59:57.612791	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_237_ZS	1.359858167
2016-06-20 09:34:56.670878	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_269_ZS	1.324739666
2016-06-20 13:10:41.675178	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_276_ZS	1.352701072
2016-06-20 14:38:55.676936	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_280_ZS	1.337287469
2016-06-20 19:41:42.682970	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_287_ZS	1.316834476
2016-06-22 07:40:34.720514	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_290_ZS	1.405375385
2016-06-24 00:29:25.768384	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_306_ZS	1.316114007
2016-06-24 07:27:45.776561	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_310_ZS	1.390020421
2016-06-24 16:15:05.786870	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_317_ZS	1.436067666
2016-06-26 08:00:35.833502	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_326_ZS	1.610271706
2016-06-27 02:31:10.855211	RO-C-MIDAS-3-EXT2-SAMPLES-V3.0	IMG_1615223_1618100_333_ZS	1.373056086
2016-06-29 07:29:18.917338	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_001_ZS	1.356931917
2016-06-29 19:37:29.931572	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_005_ZS	1.318062972
2016-06-30 15:24:47.954782	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_011_ZS	1.615072398
2016-06-30 17:38:38.957398	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_015_ZS	1.460060479
2016-06-30 19:52:30.960015	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_019_ZS	1.354210055
2016-06-30 22:06:18.962631	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_023_ZS	1.315531362
2016-07-01 00:21:39.965276	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_027_ZS	1.350576801
2016-07-01 01:59:10.967183	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_034_ZS	1.322612576
2016-07-02 09:37:58.004300	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_047_ZS	1.327117863

2016-07-03 07:19:36.029745	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_054_ZS	1.323889233
2016-07-03 09:38:31.032460	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_061_ZS	1.32521228
2016-07-03 10:56:36.033987	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_065_ZS	1.330562495
2016-07-03 21:32:19.046414	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_074_ZS	1.502088762
2016-07-04 07:45:07.058393	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_081_ZS	1.356775609
2016-07-04 16:38:42.068823	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_088_ZS	1.32937409
2016-07-06 07:33:51.114471	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_090_ZS	1.356105658
2016-07-07 05:20:44.140018	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_096_ZS	1.389312066
2016-07-10 07:17:25.226747	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_116_ZS	1.320303604
2016-07-10 21:20:14.243222	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_121_ZS	1.319580449
2016-07-13 09:23:55.313667	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_142_ZS	1.315730813
2016-07-13 11:38:07.316290	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_146_ZS	1.346975335
2016-07-13 13:52:19.318914	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_150_ZS	1.473341858
2016-07-13 16:06:28.321536	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_154_ZS	1.649933745
2016-07-13 23:15:52.329930	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_166_ZS	1.409751396
2016-07-15 00:29:52.359526	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_181_ZS	1.445489174
2016-07-17 07:40:19.424239	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_183_ZS	1.43062165
2016-07-19 16:42:04.487042	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_192_ZS	1.41309728
2016-07-20 07:19:45.504204	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_196_ZS	1.413203394
2016-07-20 09:24:24.506641	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_200_ZS	1.425548526
2016-07-20 09:44:49.507040	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_204_ZS	1.420681754
2016-07-21 21:09:27.548583	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_216_ZS	1.424665654
2016-07-22 09:57:46.563606	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_223_ZS	1.471724329
2016-07-22 19:00:43.574222	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_230_ZS	1.494147564
2016-07-23 04:03:46.584841	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_237_ZS	1.498552279
2016-07-24 07:16:16.616761	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_251_ZS	1.413496259
2016-07-24 18:53:19.630390	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1618023_1620900_258_ZS	1.442988861
2016-07-27 21:42:43.718172	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_008_ZS	1.410916602
2016-07-28 11:48:20.734706	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_015_ZS	1.411259777

2016-07-29 01:50:39.751176	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_022_ZS	1.418378908
2016-07-29 16:26:07.768294	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_029_ZS	1.42545347
2016-07-30 08:35:16.787244	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_034_ZS	1.411950387
2016-07-31 07:24:42.814020	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_039_ZS	1.448007445
2016-07-31 16:06:51.824230	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_046_ZS	1.562703958
2016-08-02 03:16:08.865473	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_057_ZS	1.460499641
2016-08-02 08:14:17.871303	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_061_ZS	1.608034461
2016-08-02 12:50:32.876704	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_065_ZS	1.417129847
2016-08-02 16:46:08.881311	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_069_ZS	1.411362656
2016-08-03 07:06:36.898135	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_072_ZS	1.412689825
2016-08-03 14:42:17.907045	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_076_ZS	1.534467965
2016-08-04 08:12:56.927589	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_078_ZS	1.411821245
2016-08-04 20:30:43.942015	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_082_ZS	1.412975616
2016-08-05 08:07:53.955647	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_089_ZS	1.413104078
2016-08-08 05:31:22.037055	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_117_ZS	1.410901045
2016-08-08 08:52:23.040985	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_121_ZS	1.443283006
2016-08-08 10:42:45.043143	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_125_ZS	1.450744841
2016-08-08 14:37:27.047732	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_129_ZS	1.428858756
2016-08-08 21:53:07.056251	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1620823_1622300_133_ZS	1.411715865
2016-08-10 01:34:51.088743	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_001_ZS	1.532678096
2016-08-10 20:49:30.111320	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_010_ZS	1.528979876
2016-08-12 13:02:45.158506	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_012_ZS	1.419476036
2016-08-12 20:17:59.167017	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_015_ZS	1.427616101
2016-08-15 13:00:52.242939	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_037_ZS	1.462310816
2016-08-15 22:33:55.254143	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_044_ZS	1.498513488
2016-08-16 12:21:32.270326	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_051_ZS	1.415976728
2016-08-16 22:53:04.282674	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_056_ZS	1.483544094
2016-08-17 09:29:56.295127	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_061_ZS	1.411439129
2016-08-19 12:21:26.354793	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_085_ZS	1.430291673

2016-08-19 22:54:58.367180	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_090_ZS	1.507274657
2016-08-20 09:33:29.379665	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_095_ZS	1.417941834
2016-08-21 21:17:28.421587	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_111_ZS	1.559504662
2016-08-22 12:35:06.439529	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_118_ZS	1.46453315
2016-08-23 06:12:07.460197	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_132_ZS	1.490059013
2016-08-24 12:28:36.495715	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_153_ZS	1.439132655
2016-08-25 12:35:10.524000	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_167_ZS	1.411332918
2016-08-25 21:23:09.534323	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_174_ZS	1.416494336
2016-08-26 06:11:07.544647	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_181_ZS	1.416147444
2016-08-26 14:59:11.554972	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_188_ZS	1.420233006
2016-08-30 12:10:44.664304	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_245_ZS	1.347448312
2016-09-01 10:35:19.718751	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1622223_1624607_258_ZS	1.428202709
2016-09-03 12:29:16.777292	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_003_ZS	1.706051573
2016-09-11 12:11:04.002186	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_086_ZS	1.346832805
2016-09-11 17:39:30.008608	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_090_ZS	1.362369158
2016-09-12 00:35:03.016733	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_094_ZS	1.485982763
2016-09-13 07:25:46.057325	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_131_ZS	1.419918414
2016-09-13 09:29:10.059746	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_135_ZS	1.378175955
2016-09-13 10:21:19.060769	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_139_ZS	1.353935917
2016-09-14 16:33:11.096318	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_165_ZS	1.365885381
2016-09-14 18:39:22.098794	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_169_ZS	1.52919936
2016-09-14 20:45:29.101268	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_173_ZS	1.74813756
2016-09-14 22:51:42.103744	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_177_ZS	2.128483576
2016-09-20 00:37:24.247082	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1624607_1627007_233_ZS	1.47873433
2016-09-26 23:52:39.443973	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1627006_1627309_007_ZS	1.373111313
2016-09-27 18:43:05.466152	RO-C-MIDAS-3-EXT3-SAMPLES-V3.0	IMG_1627006_1627309_019_ZS	1.347597008