Echidna Testing Summary : Input for Upgrade/Re-termination Works

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- Ver.2.0 : 2007/08/25 : After additional tests with Echidna rotated 90 degree on supporting jig. This report closed.
- Ver.1.0 : 2007/07/04 : First version circulated AAO/Kyoto/Subaru.

This is a summary of the results of the Echidna testing at Hilo base facility before the upgrade/retermination works from 2007 August. Echidna is on the supporting jig and the electronics enclosure is not attached above the module plate. This report is closed on 2007/08/25, and feedbacked to the upgrade/retermination works.

1 Checking basic operation

Three science fibres (No.15, No.270, No.441) could not be back-illuminated. For No.15, spare fibre was used for the spine, thus LED was not connected. For No.270 and No.441, LEDs could not be turn on. They were temporaly deactivated in INACTIVE_SPINE_LIST temporarily. On 2007/08/23, No.15 spare fibre is connected to the LED by Graham, complated. For No.270, the problem is not with the LED. There is a short circuit in the distribution board on the side of the connector housing made in Oxford. The short circuit is fixed by Rolf. For No.441, there is also no problem with the LED. The strange behaviour of the back-illumination for the fibre is still under investigation (needs to be fixed during Rolf is here).

I did calibration at zenith and more than 10 random-home pair positioning tests at zenith. I recorded the ID numbers of the fibres which are seriously off from the home position after the random-home positioning tests. Spines recorded more than 3 times are No.4, No.14, No.34, No.123, No.125, No.133, No.199, No.213, No.216, No.233, No.242, No.277, No.297, No.342, No.347, No.350, No.352, No.410, No.474, No.476. Spines recorded one or two time(s) are No.90, No.96, No.159, No.161, No.184, No.200, No.202, No.212, No.218, No.236, No.328, No.450.

I did random positioning tests at 60deg for the filming. I found that several spines came off from the 3-pt mount (judged by touching the tip of the spines with white "pencil-like" bar for bad-behaving spines; No.123, No.199, No.244, No.250, No.342, No.347, No.350, No.363, No.415, and No.474,). Most of them look recovered when Echidna returned to the zenith, but one fibre (No.350) looks still off from 3-pt mount even at the zenith.

After Echidna is rotated 90deg on the jig I did random-home positioning tests at −30deg, 30deg, 60deg. Spines could not recovered to the home positions at least one time were No.152, No.154, No.180, No.194, No.319, No.363, No.370, No.395, No.450, No.466, No.467, No.474, No.478, No.499.

2 Checking basic properties in details

2.1 Repeatability of the spine position measurements

Repeatability of the spine position measurements are evaluated with measuring the position of all of the spines close to home positions at zenith multiple times moving the FPI camera. Results are shown in Figure 1. The consistency between two measurements is rms of 1μm (p-p about $\pm 2\mu$m) for each direction. The differences between the measurements decreases if multiple measurements are averaged. This result indicate that the position measurements are still dominated by random error.

In order to evaluate the origin of the random error, measure the position of a spine (No.283) multiple times without moving FPI. The resultant rms in X and Y-directions are 0.9μm and 0.8μm, which is similar to the random error observed above. The result indicates that the random error is still dominated by the error due to the centroid measurement. Therefore, measuring positions of spines with averaging multiple images may improve the spine position measurement further. If we average 4 measurements, the rms will be 0.7μm and 0.3μm.

2.2 Spine position variation due to the elevation change

Movements of the spine tips due to the elevation change is measured. Two measurements were done and the results are shown in figures 2 and 3. Guide spines, re-terminated spines, and not-reterminated spines are shown with black filled squares, red open squares, and blue crosses, respectively. The variation of the spine position is thought to reflect the bend of the spine due to gravity (this tims in X-direction), and flexure inside FPI gantry.

Several spines show very large offset between two angles. The numbers are shown in the captions of the figures. For most of the spines, the spread is as large as $\pm 10\mu$m changing between zenith distance (ZD)=30deg and 0deg (at zenith). Clearly, reterminated and not-reterminated spines have different stiffness; reterminated spines are stiffer than not-reterminated ones.

Spines recorded more than three times are No.29, No.57, No.165, No.197, No.351, No. 491.

2.3 Spine position stability

For short term stability, no creaping of spine positions larger than 1μm is observed just after completing configuratoin.

The position of the spines are measured multiple times with 1 or 2 hours separation. An example of measured vibration during the testing is shown in figure 5. Large vibration is due to the FPI movement. The measured vibration (black) is compared with the measured vibration at the top of the telescope (red; 5Hz with 7mG). In the current setup, the accerelation during the FPI measurement is larger than the accerelation due to the telescope vibration. But the frequency is higher, thus the swinging amplitude is smaller. The results are shown in figures 6, 7, and 8. All of the spines are at home-position. Systematic offset of a few μm is observed at ZD=60.

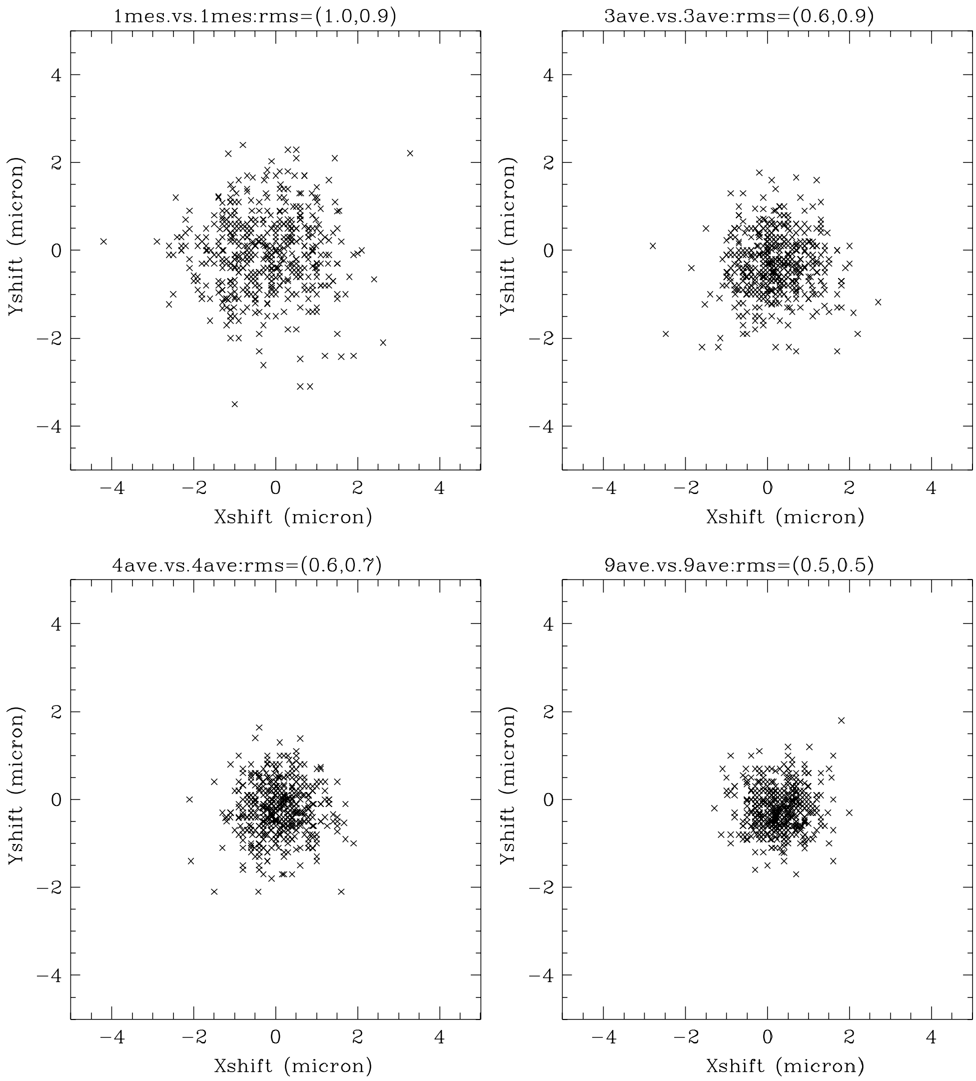

Figure 1: The differences of the measured positions of spine tips. Top-left) 1 measurement vs. 1 measurement, Top-right) Average of 3 measurements vs. average of 3 measurements. Bottom-left) Average of 4 measurements vs. average of 4 measurements. Bottom-right) Average of 9 measurements vs. average of 9 measurements.

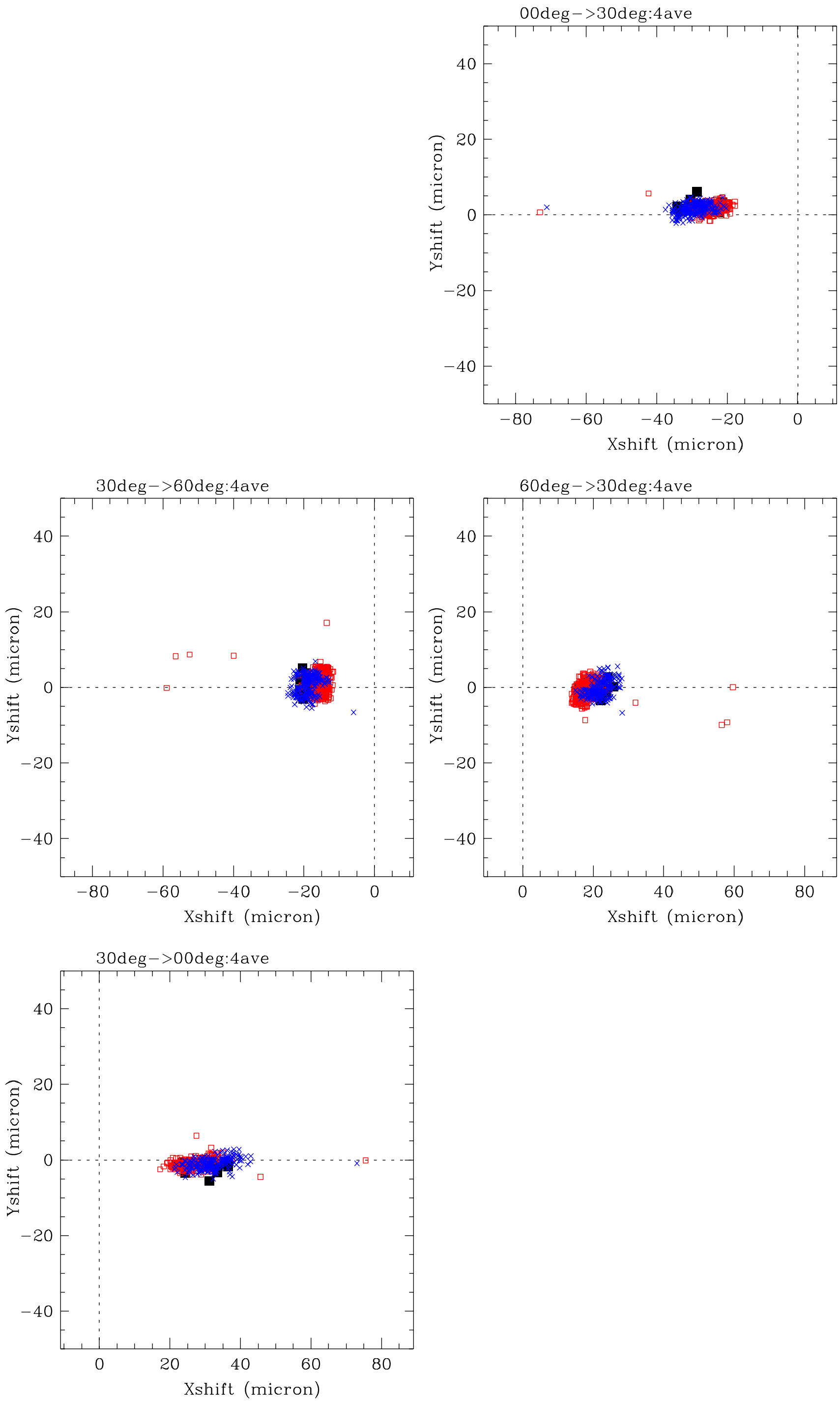

Figure 2: Effect of the elevation movement (20070621). Black filled square: guide-spines, red open square: reterminated spines, and blue crosses: not-reterminated spines. Several spines show very large offset; in 0 to 30 deg, No.165(-42.3μm in X) No.197(-71.2μm in X) No.491(-73.1μm in X), in 30 to 60deg, No.29(-58.9μm in X) No.57(-52.4μm in X) No.351(-56.4μm in X) No.283(-13.6μm in Y), in 60 to 30deg, No.29(59.6μm in X) No.57(56.5μm in X) No.351(58.0μm in X), in 30 to 60 deg, No.197(73.0μm in X) No.491(75.5μm in X).

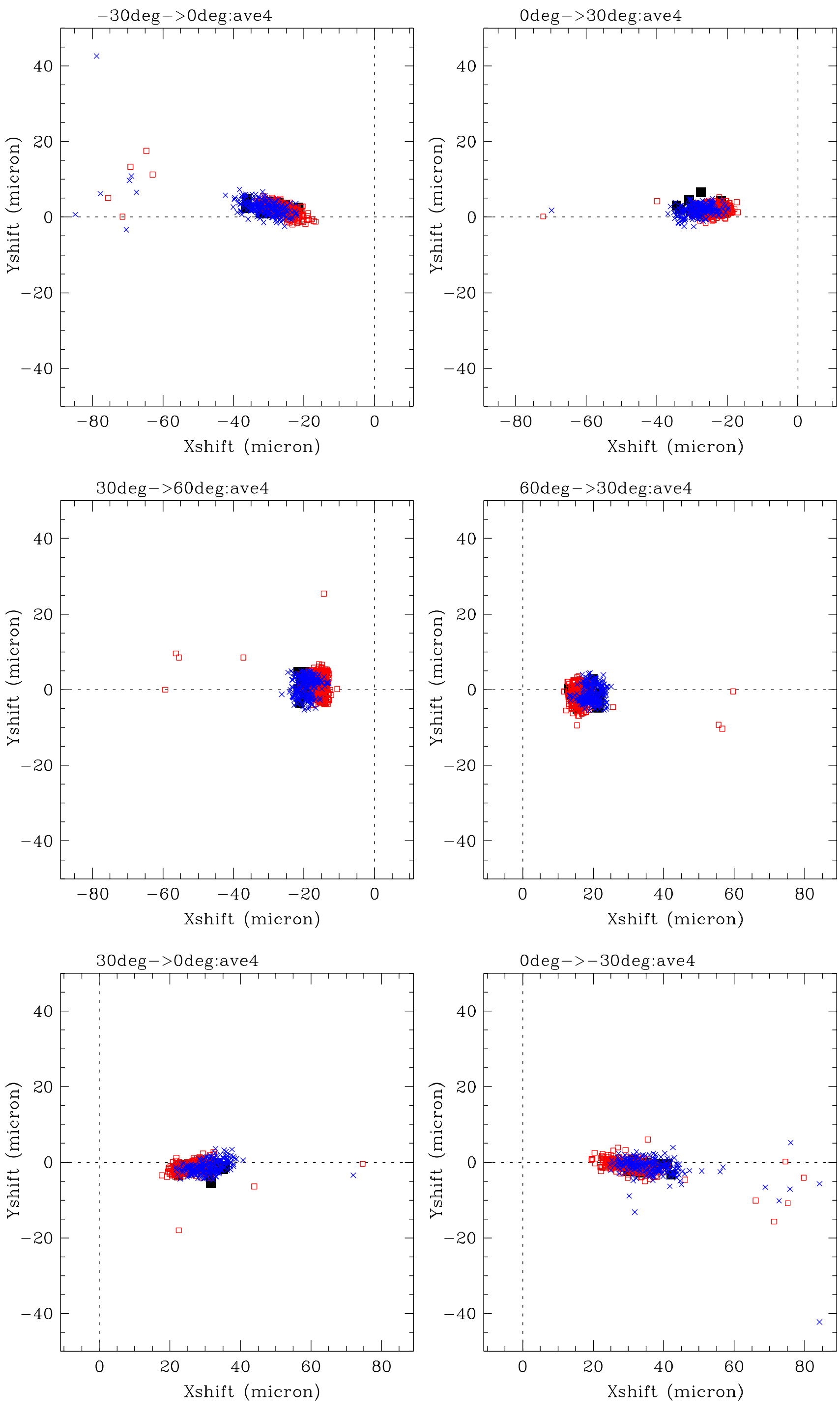

Figure 3: Effect of the elevation movement (20070627). Black filled square: guide-spines, red open square: reterminated spines, and blue crosses: not-reterminated spines. Several spines show very large offset; in -30 to 0 deg, No.71, No.86, No.113, No.212, No.239, No.242, No.254, No.281, No.365, No.380, No.407, No.414. in 0deg to 30deg, No.197, No.491, in 30deg to 60deg, No.29, No.57, No.351 in 60deg to 30deg, No.29, No.57, No.351 in 30 to 0 deg, No.165, No.197, No.491, No.497, in 0 to -30 deg, No.71, No.86, No.113, No.212, No.239, No.242, No.254, No.281, No.365, No.380, No.407, No.414, No.422, No.464, No.470.

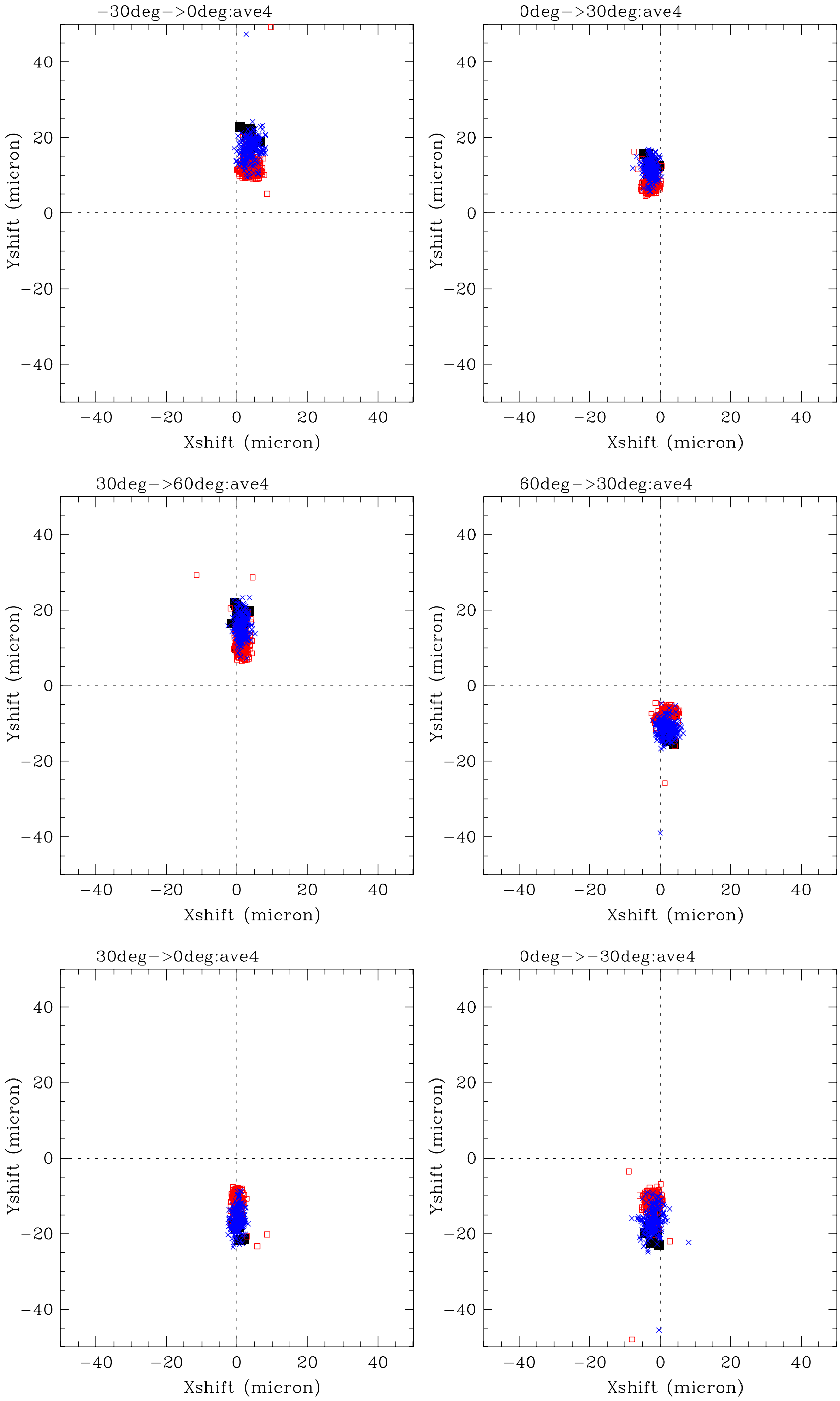

Figure 4: Effect of the elevation movement, after Echidna is rotated on the jig (20070821). Several spines show very large offset; in −30 to 0 deg, No.51, No.211, No.224, in 30 to 60 deg, No.165, No.284, in 60 to 30 deg, No.218, No. 284, in 30 to 0 deg, No.16, No.165, in 0 to −30 deg, No.51, No.211, No.224, No.363.

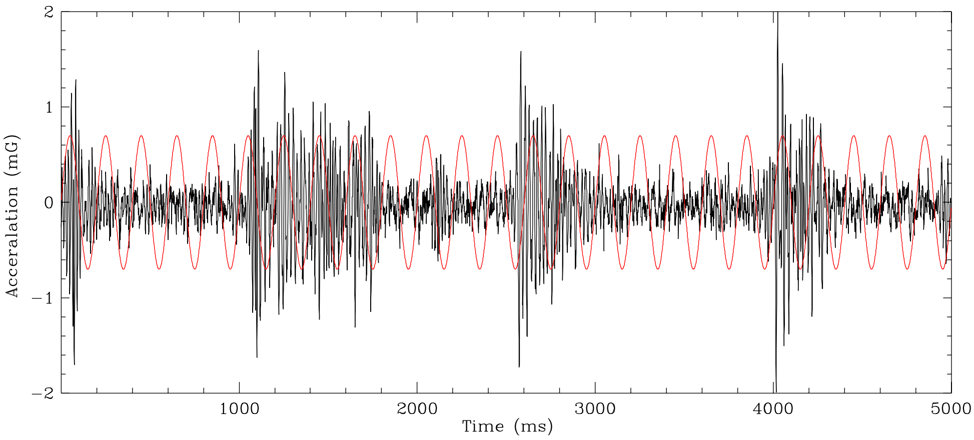

Figure 5: An example of the measure vibration during FPI measurements. 60Hz noise is filtered out. Red solid curve indicate the typical vibration observed at the top of the telescope (7mG peak 5Hz vibration)

2.4 Step-size variation with the EL change

The step sizes of the spines in the fine and the coarse modes are measured using the calibration procedure.

COARSE_VOLTAGE 7.0

COARSE_TRIG_FREQ 70

COARSE_RAMP_FREQ 150

COARSE_DROP_FREQ 5000

FINE_VOLTAGE 2.75

FINE_TRIG_FREQ 15

FINE_RAMP_FREQ 150

FINE_DROP_FREQ 5000

With these parameters, the average step size in the fine mode is larger than 10μm.

No systematic increase or decrease of the step size is observed between different ZDs.

Spines with small step sizes are listed in the captions of the figures. Spines recorded more than 5 times are No.1, No.3, No.4, No.28, No.34, No.38, No.125, No.133, No.148, No.164, No.204, No.233, No.268, No.277, No.347, No.359, No.467, No.474, No.478.

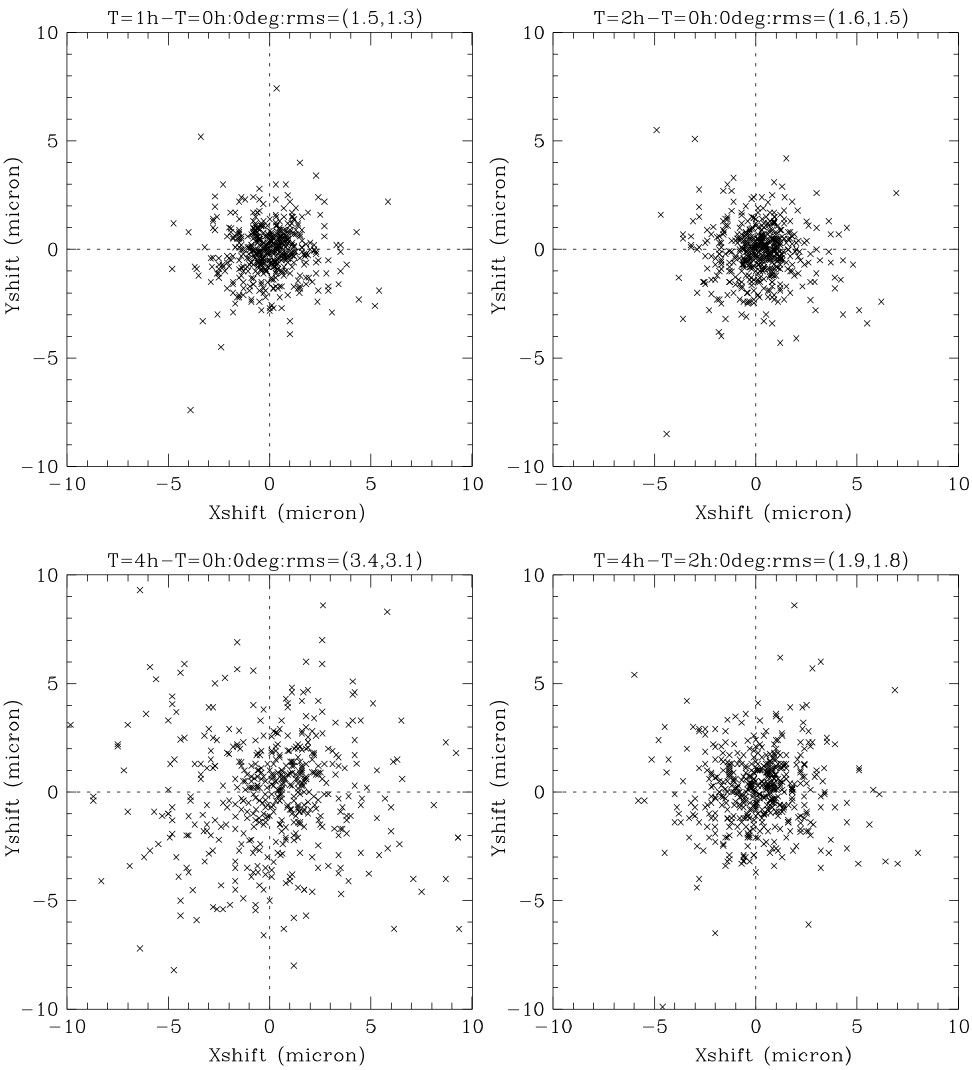

Figure 6: Spine position long-term stability at ZD=0.

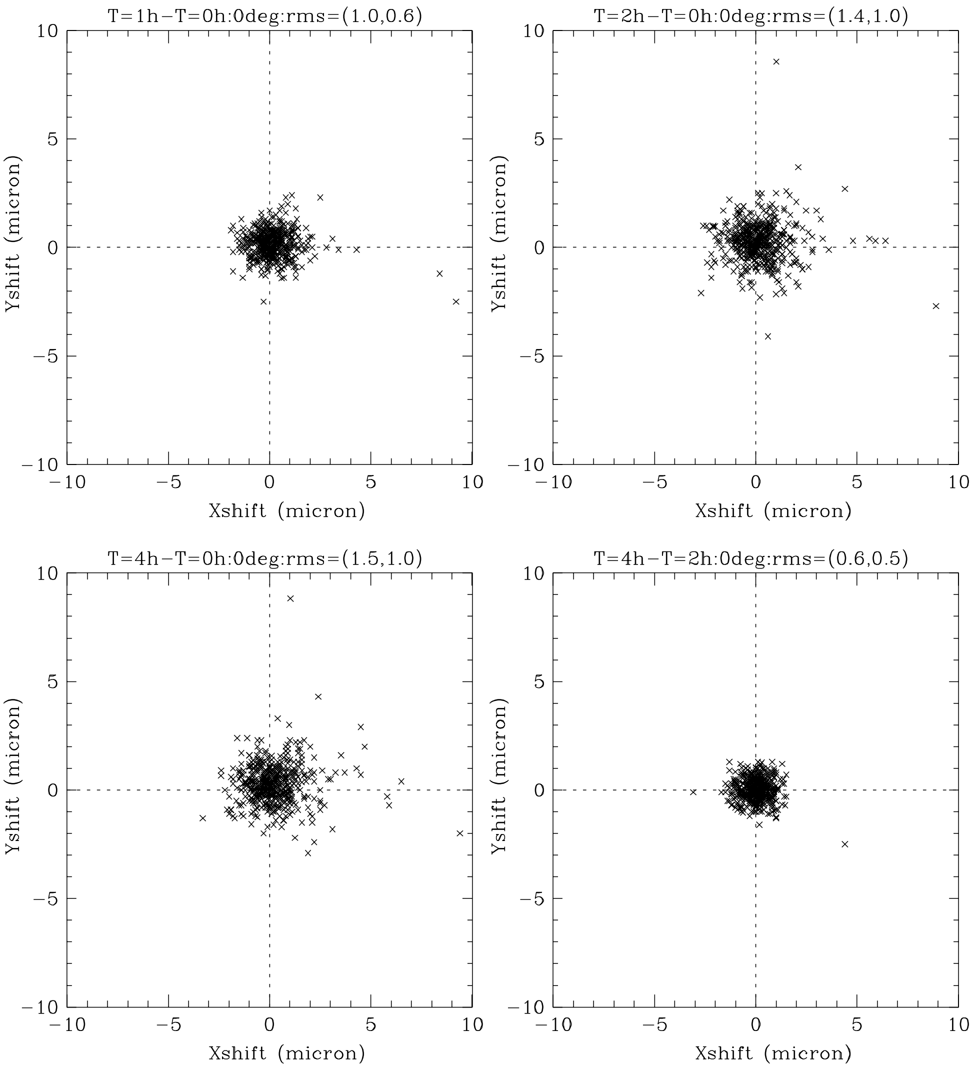

Figure 7: Spine position long-term stability at ZD=30.

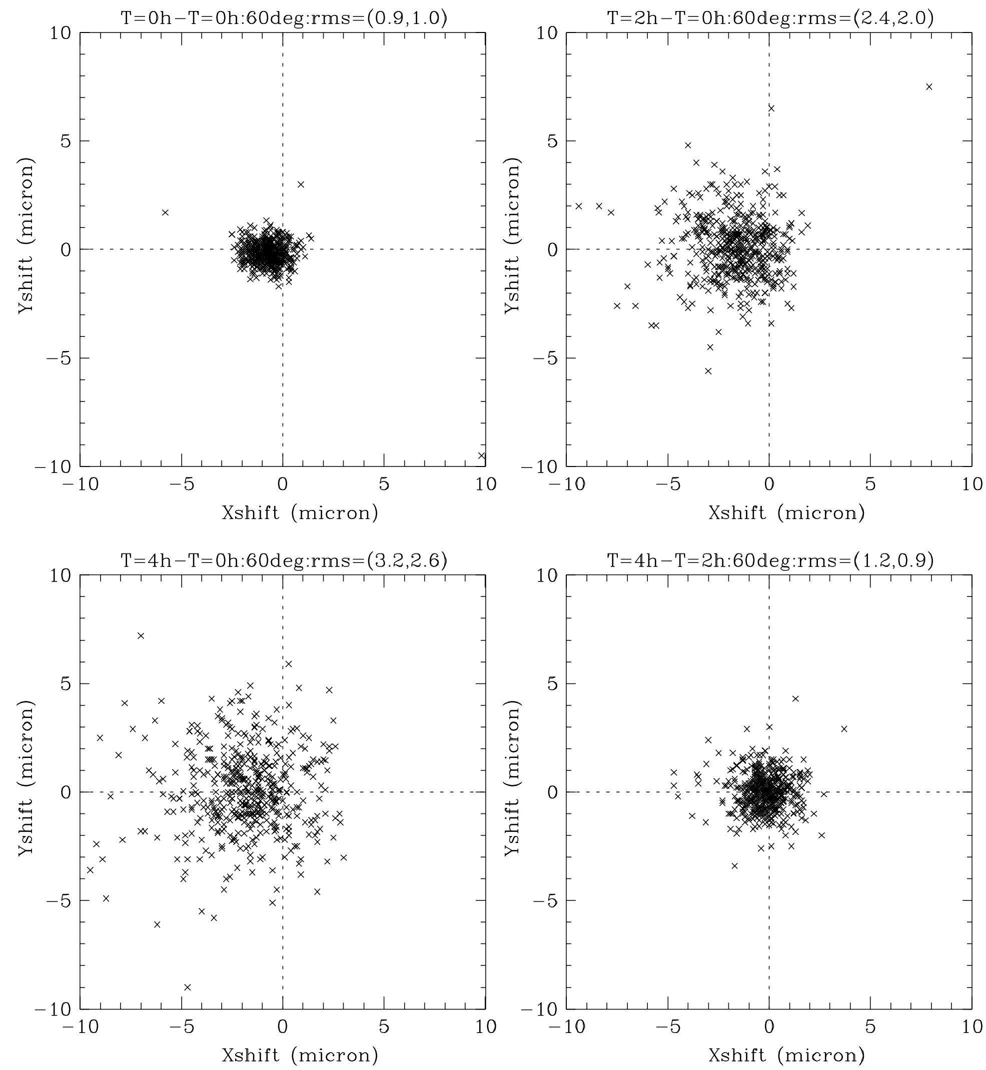

Figure 8: Spine position long-term stability at ZD=60.

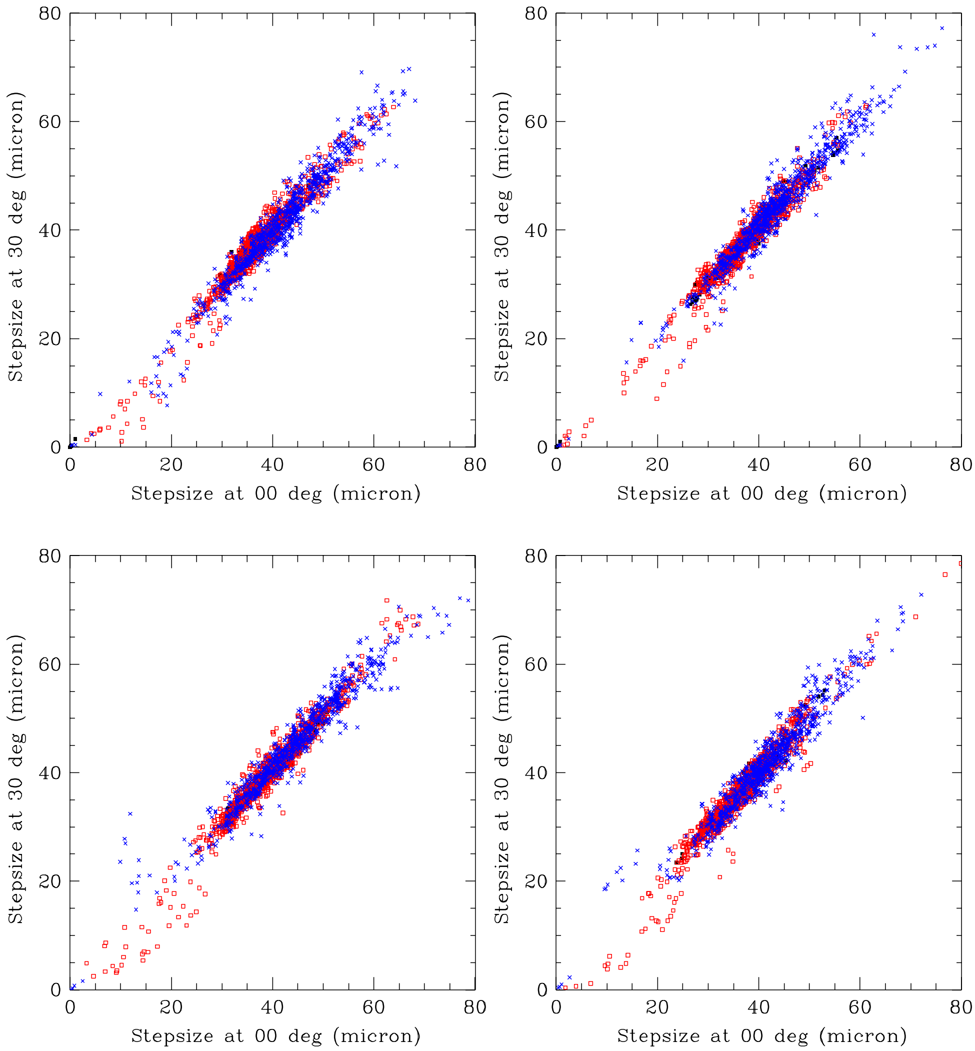

Figure 9: Stepsize difference at zenith and ZD=30, coarse-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.4, No.28, No.34, No.38, No.125, No.133, No.154, No.216, No.233, No.256, No.277, No.297, No.342, No. 347, No.359, No.396, No.467 and No.474 show step size smaller than 20μm with step number even larger than 5.

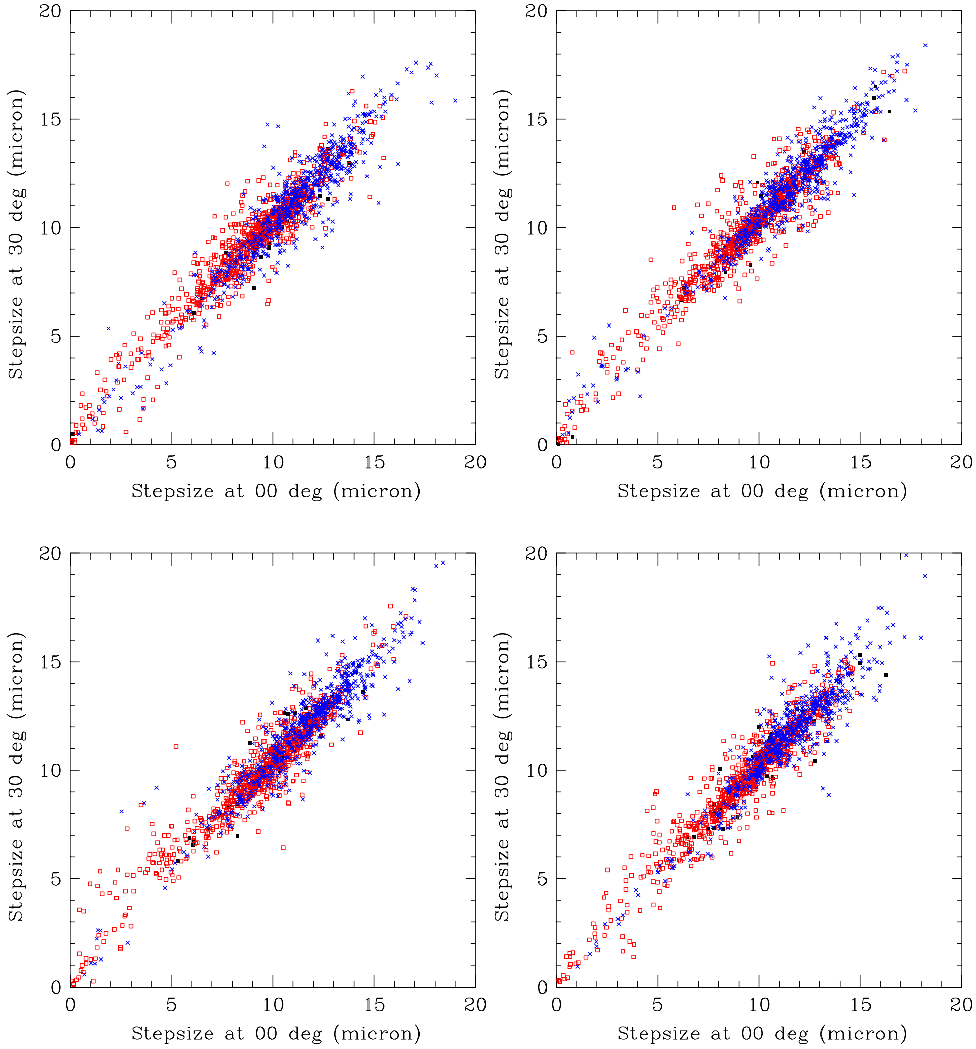

Figure 10: Stepsize difference at zenith and ZD=30, in fine-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.4, No.8, No.13, No.18, No.27, No.28, No.34, No.36, No.38, No.49, No.125, No.133, No.148, No.158, No.164, No.204, No.233, No.256, No.268, No.269, No.277, No.285, No.287, No.290, No.323, No.324, No. 347, No.359, No.387, No.404, No.408, No.410, No.426, No.467, No.474, No.478, and No.492 show step size smaller than 5μm with step number even larger than 5.

2.5 Step-size long-term stability

The step sizes measured at 20070615 and 20070820 at zenith are compared in figures 25 and 26.

3 Positioning test results

The positioning accuracy is checked with home to random positioning tests. Spines with bad properties are removed in the test (No.4, No.14, No.28, No.125, No.133, No.154, No.213, No.233, No.256, No.347, No.359, No.375, No.408, No.410, No.463). Seven iterations are applied. The residual distance after each iteration is shown in figure 27. 28 with MODE_SWITCH_THRESHOLD of 40 and 150, respectively. The horizontal axis is in logarithmic scale.

There are still more than 10 spines which do not reach the target within 10μm even though bad behaving spines are de-activated. The positioning path of the spines with residual distance larger than 10μm are shown in figure 29. Most of the spines once reach the target position but they are kicked out from the position due to neighboring spines (or vibration due to movement of other spines).

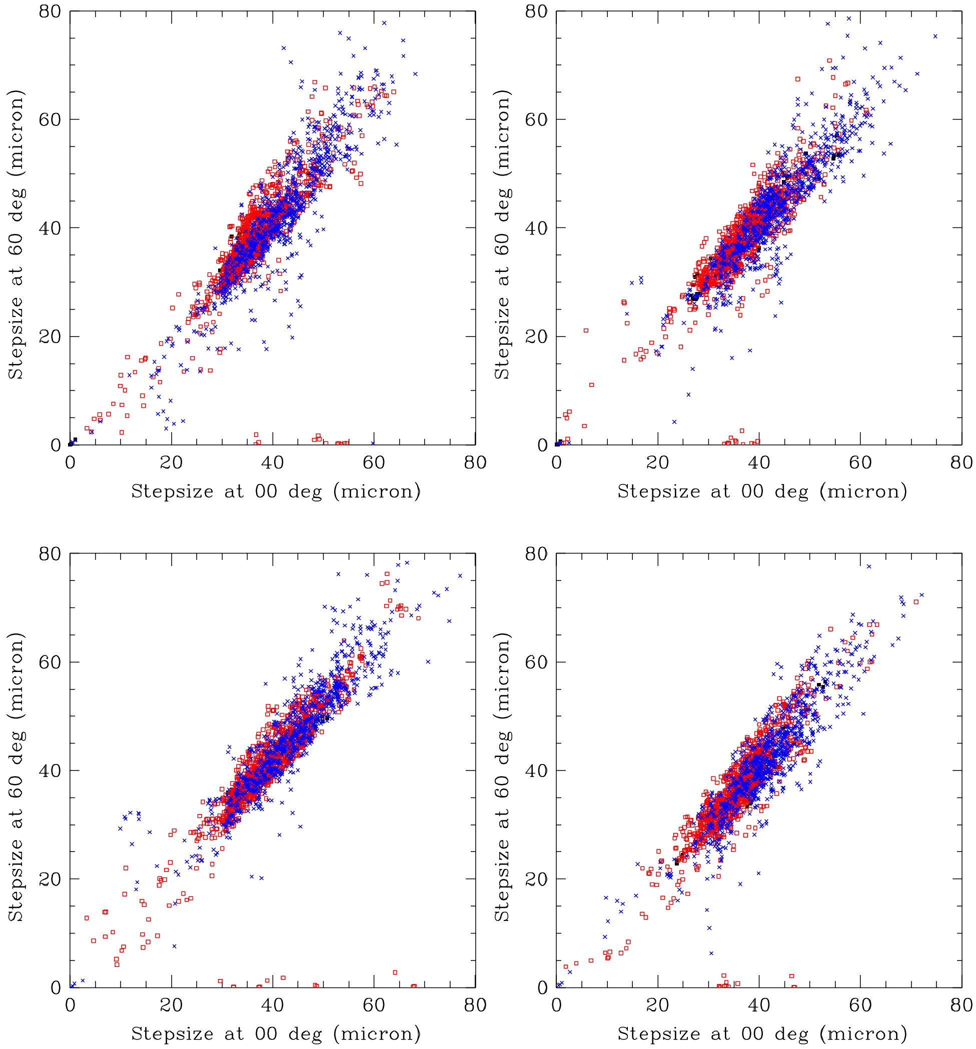

Figure 11: Stepsize difference at zenith and ZD=60, in coarse-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. Results around X=50, Y=0 are No.94, No.95, No.115, No.116, and their measurements can be affected by a bad behaving spine No.96. No.1, No.3, No.4, No.28, No.34, No.38, No.125, No.133, No.154, No.213, No.216, No.233, No.256, No.277, No.297, No.342, No. 347, No.359, No.396, No.467 and No.474 show step size smaller than 20μm with step number even larger than 5.

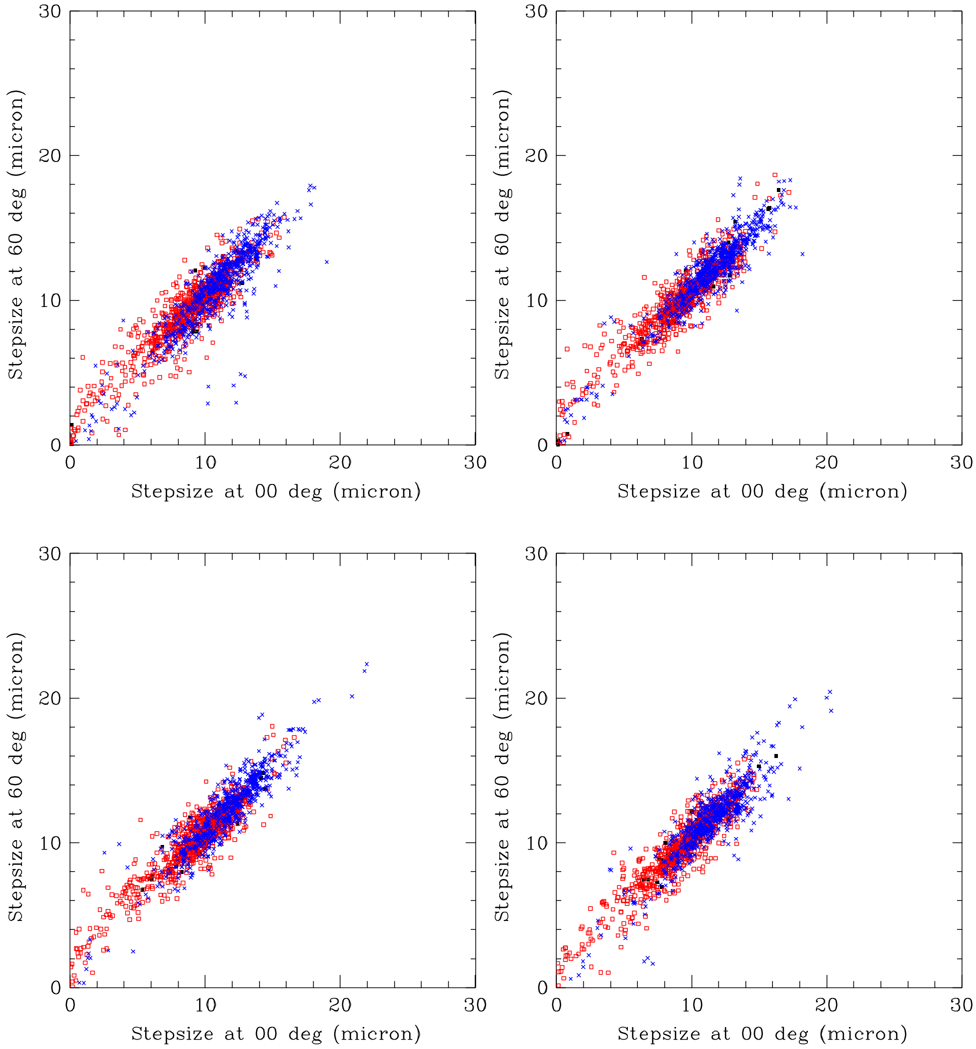

Figure 12: Stepsize difference at zenith and ZD=60, in fine-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.4, No.8, No.13, No.18, No.27, No.28, No.34, No.36, No.38, No.49, No.125, No.133, No.148, No.158, No.164, No.204, No.233, No.256, No.268, No.269, No.273, No.277, No.285, No.287, No. 347, No.359, No.404, No.408, No.410, No.426, No.467, No.474, No.478, No.492, and No.495 show step size smaller than 5μm with step number even larger than 5.

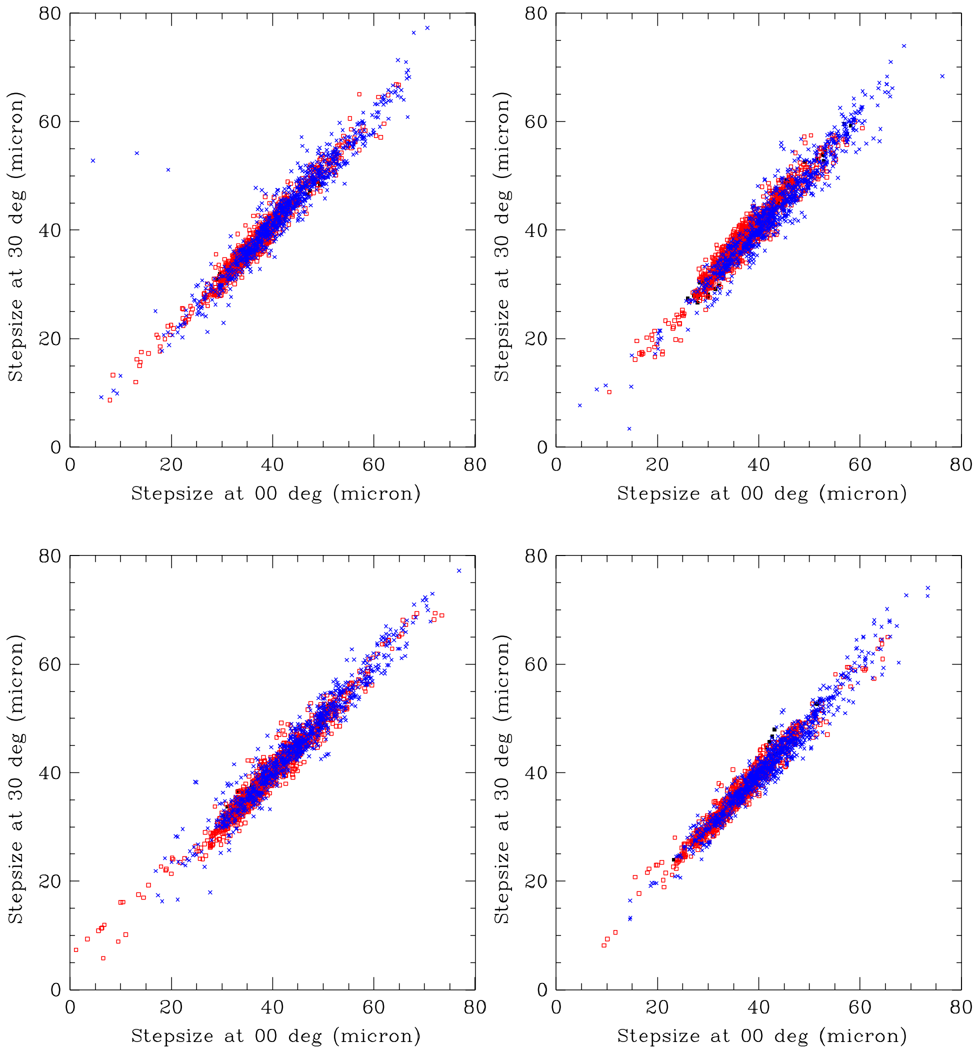

Figure 13: Stepsize difference at zenith and ZD=30, coarse-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.34, No.38, No.74, No.148, No.152, No.154, No.164, No.204, No.268, No.277, No.396, No.467, show step size smaller than 20μm with step number even larger than 5.

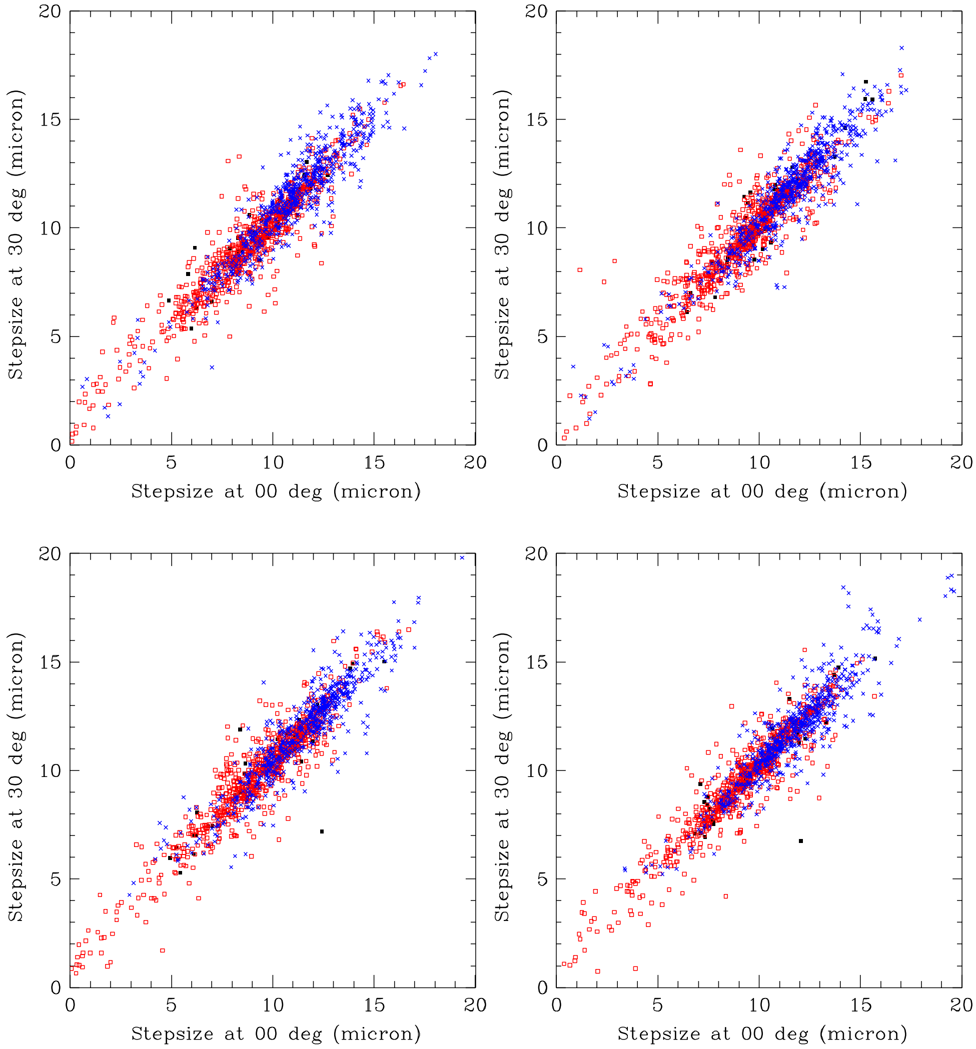

Figure 14: Stepsize difference at zenith and ZD=30, in fine-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.5, No.8, No.13, No.33, No.34, No.36, No.37, No.38, No.49, No.59 No.141, No.148, No.158, No.164, No.204, No.220, No.221, No.226, No.268, No.277, No.285, No.287, No.290, No.291, No.308, No.323, No.324, No.387, No.404, No.467, No.478, No.479, No.492, No.496 show step size smaller than 5μm with step number even larger than 5.

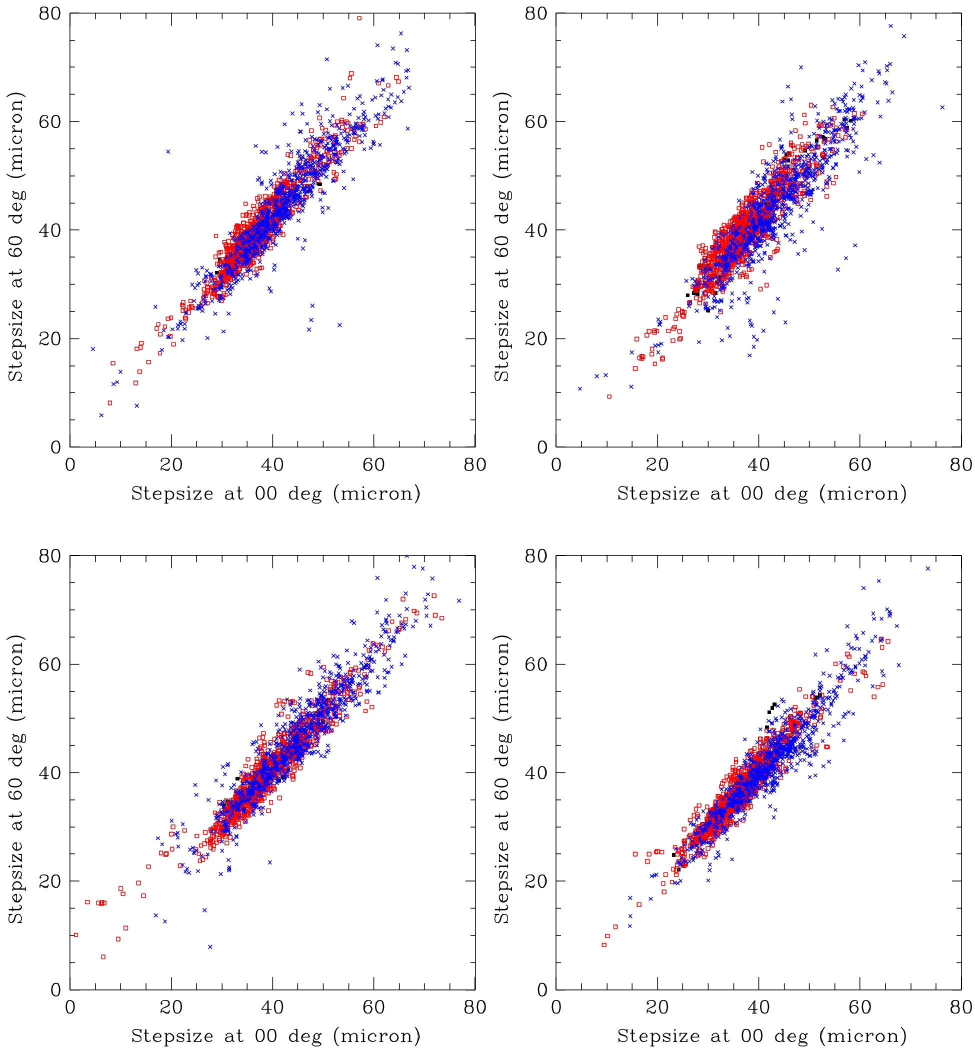

Figure 15: Stepsize difference at zenith and ZD=60, in coarse-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.34, No.148, No.164, No.204, No.268, No.277, No.320, No.396, No.398, No.467, No.476 show step size smaller than 20μm with step number even larger than 5.

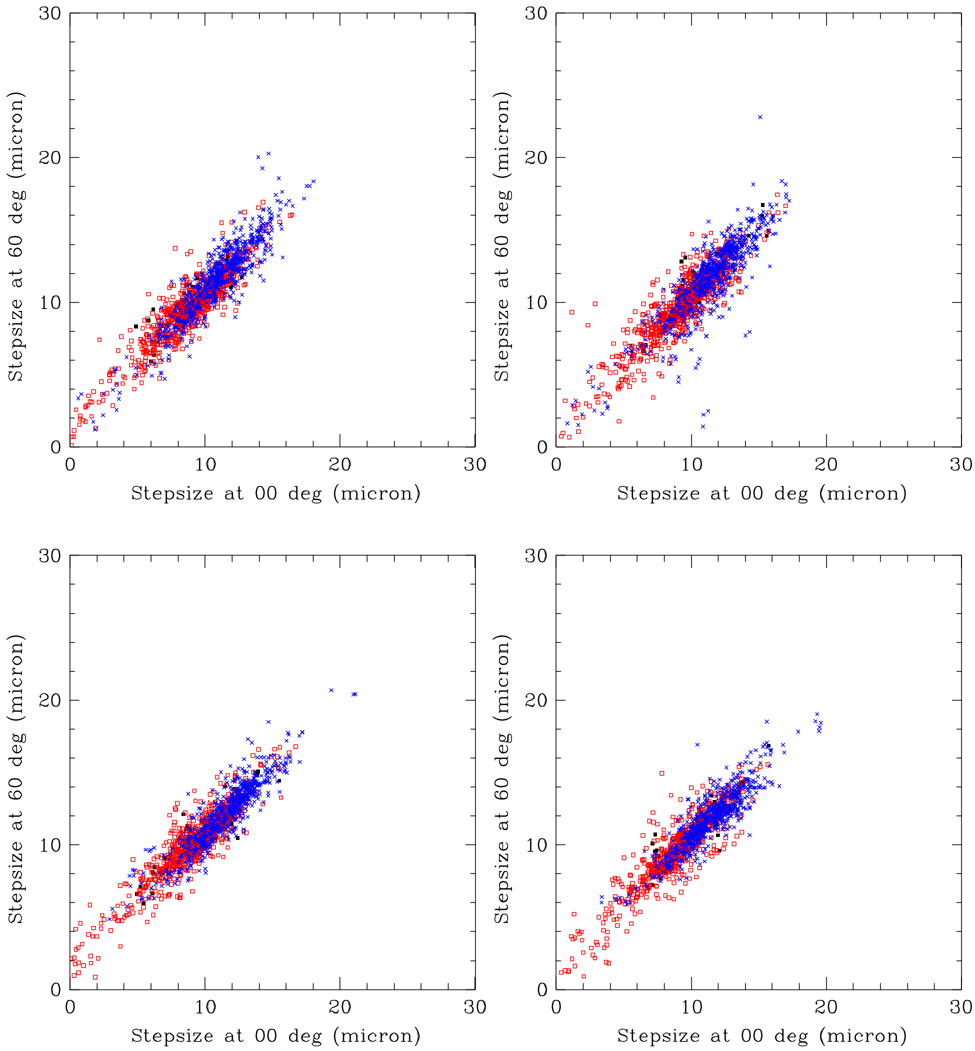

Figure 16: Stepsize difference at zenith and ZD=60, in fine-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements. No.1, No.3, No.5, No.8, No.13, No.33, No.34, No.36, No.37, No.38, No.49, No.141, No.148, No.158, No.164, No.204, No.220, No.221, No.226, No.268, No.277, No.285, No.287, No.290, No.291, No.308, No.323, No.324, No.387, No.404, No.467, No.478 show step size smaller than 5μm with step number even larger than 5.

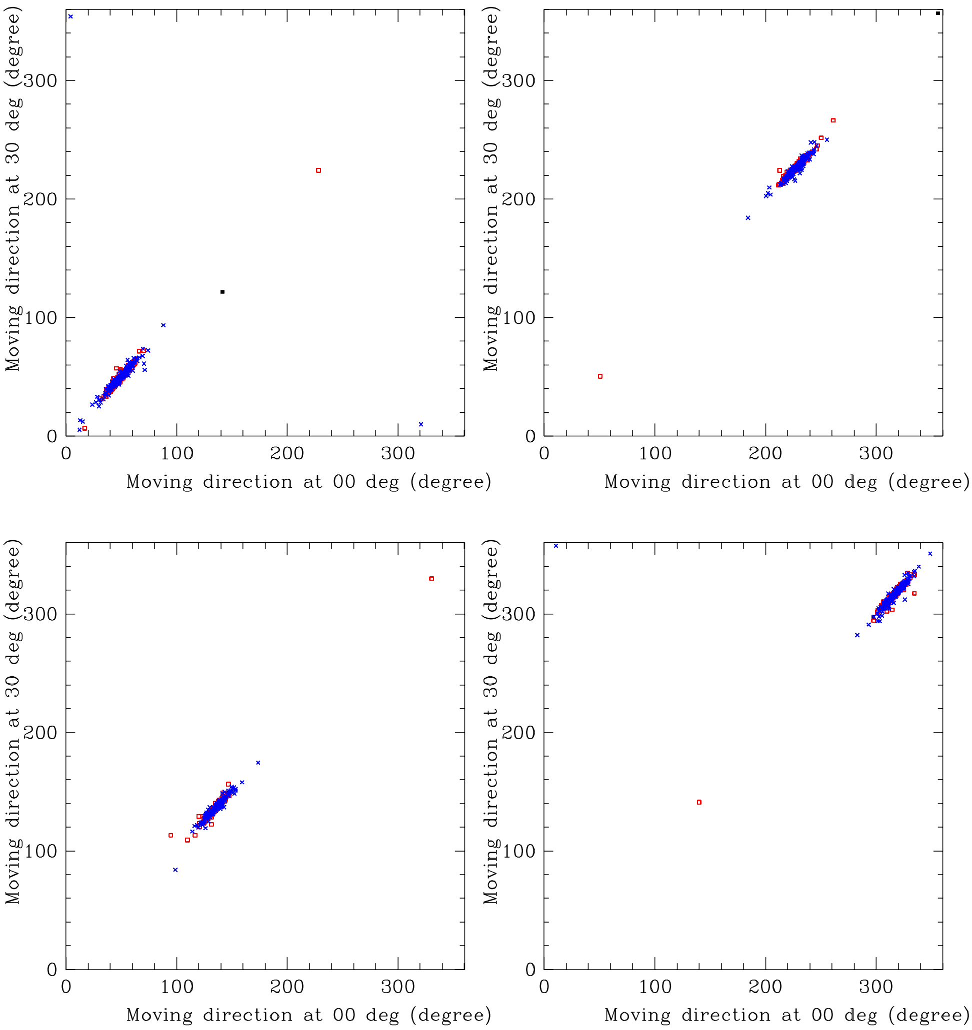

Figure 17: Step angle difference at zenith and ZD=30, in coarse-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

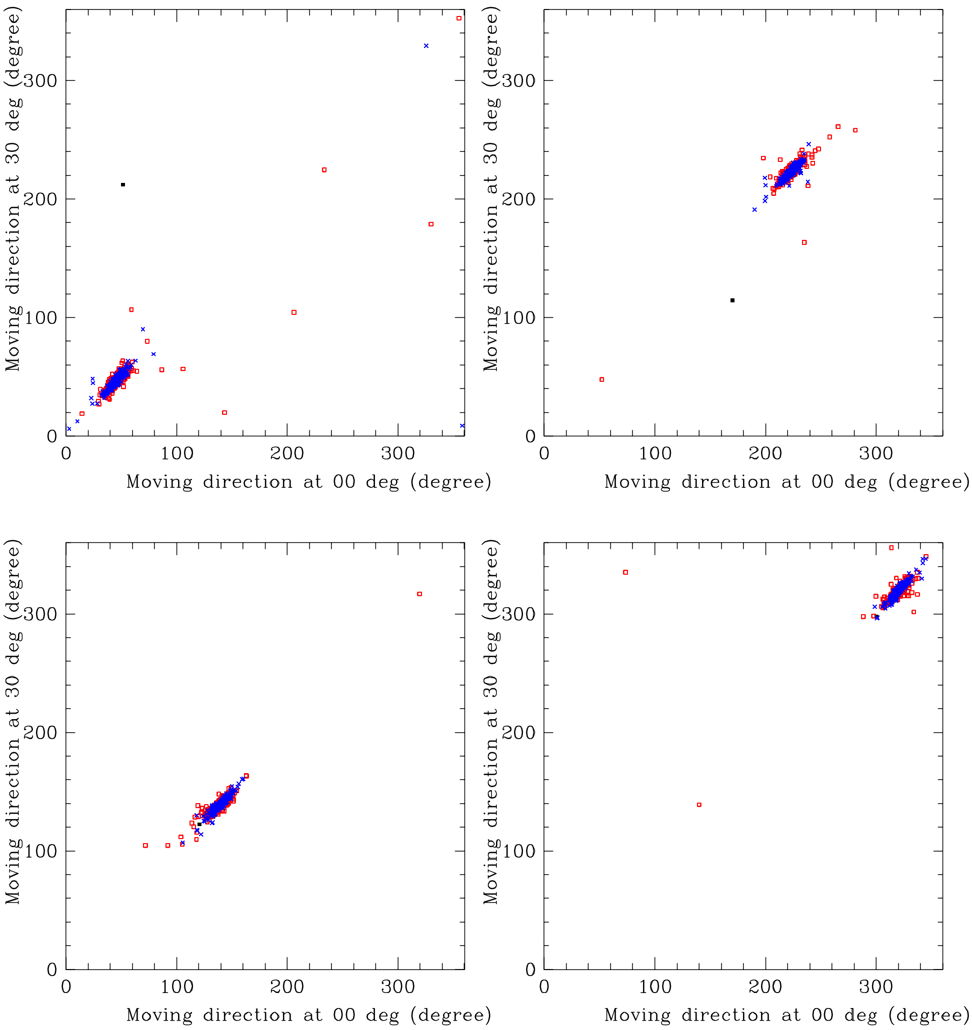

Figure 18: Step angle difference at zenith and ZD=30, in fine-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

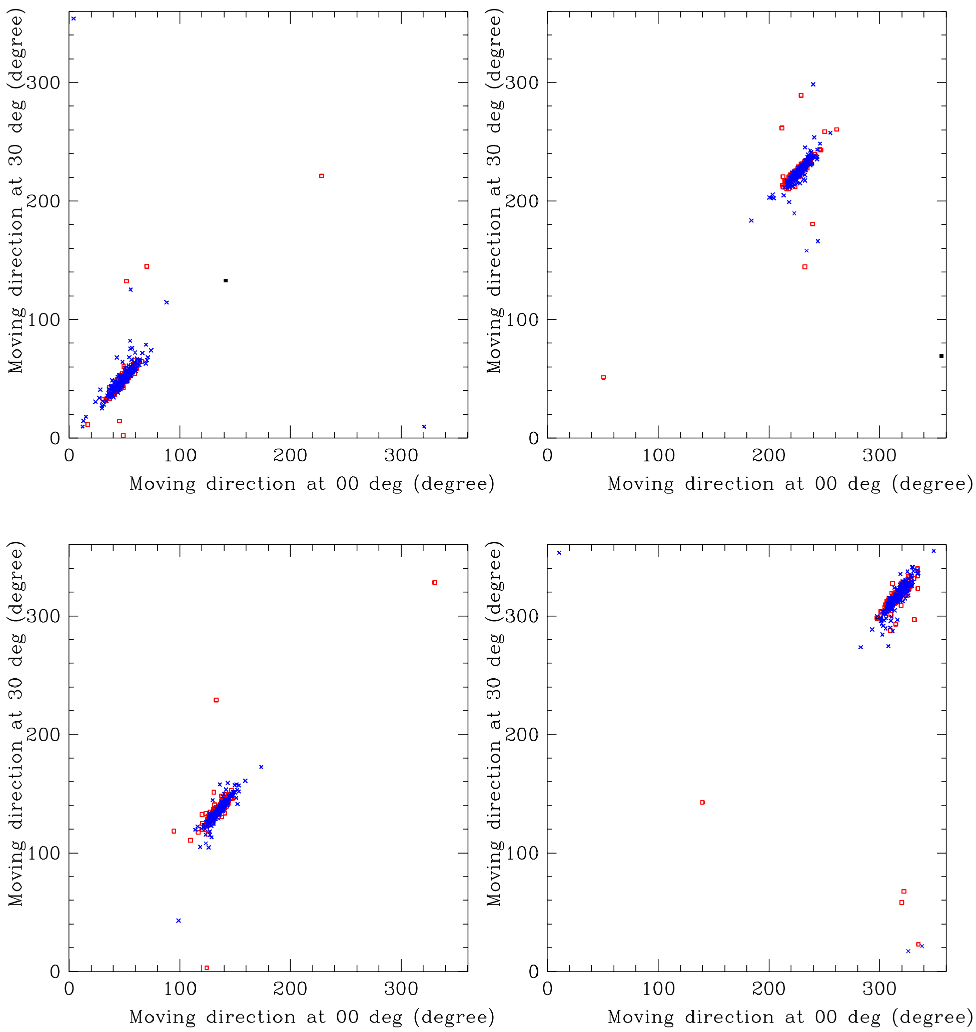

Figure 19: Step angle difference at zenith and ZD=60, in coarse-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

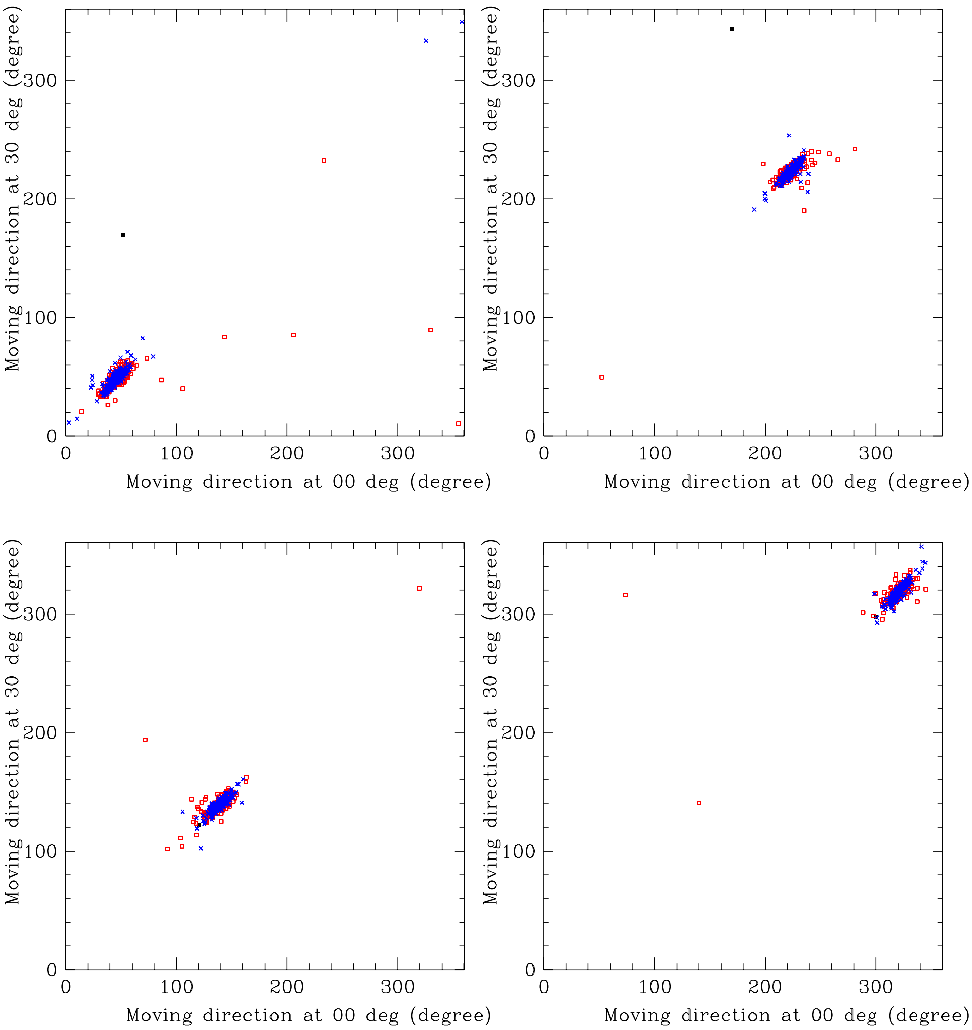

Figure 20: Step angle difference at zenith and ZD=60, in fine-mode. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

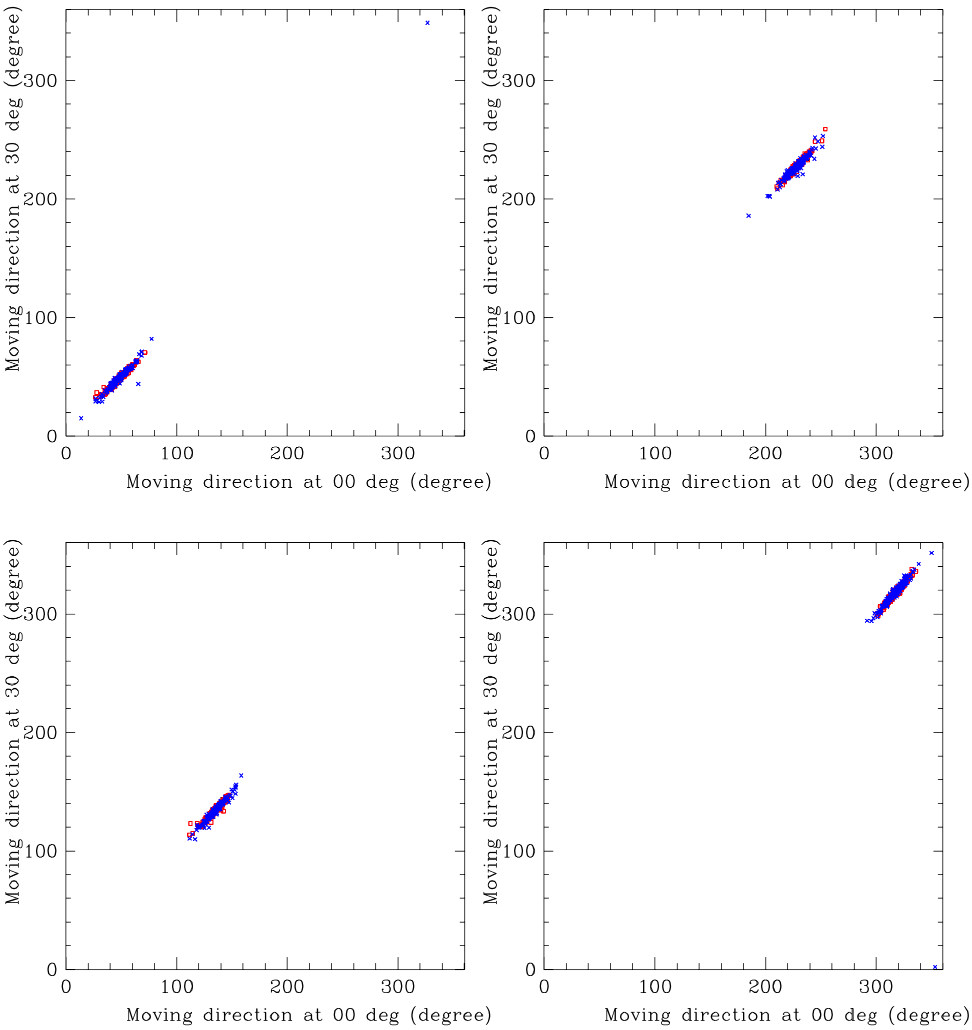

Figure 21: Step angle difference at zenith and ZD=30, in coarse-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

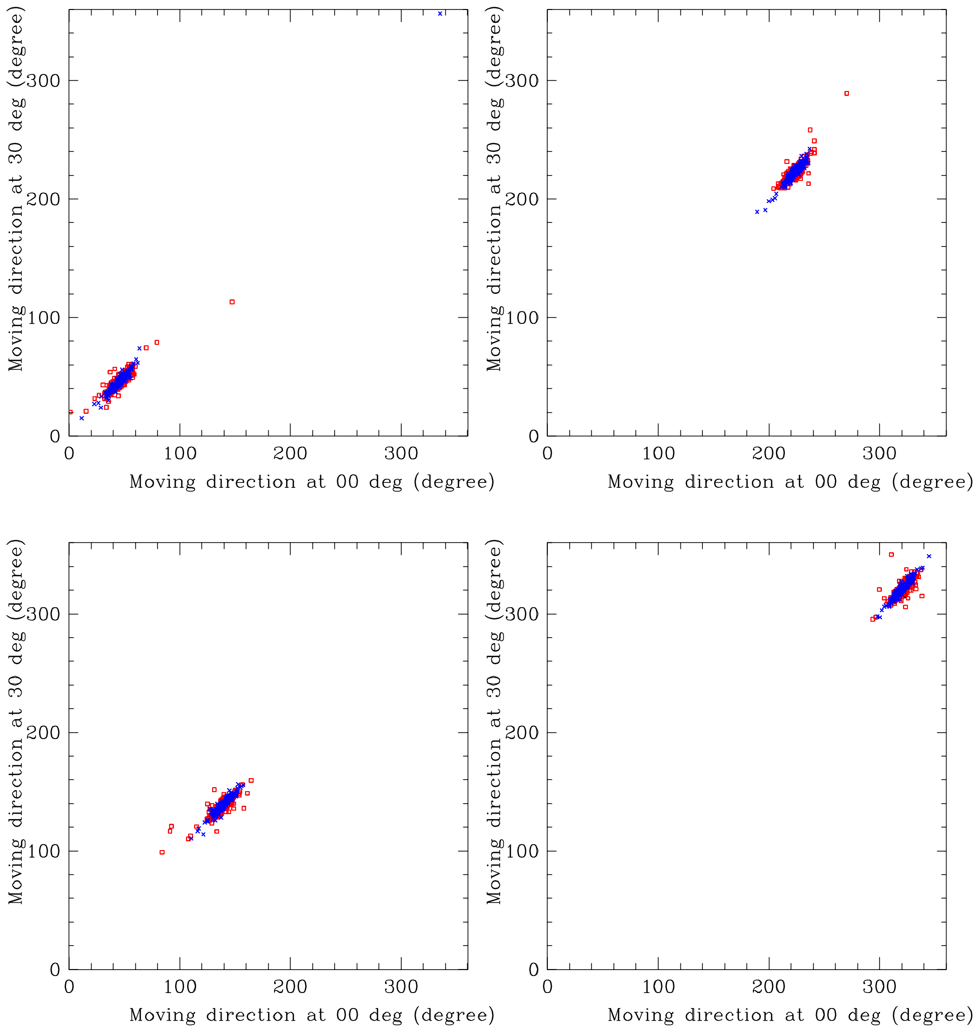

Figure 22: Step angle difference at zenith and ZD=30, in fine-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

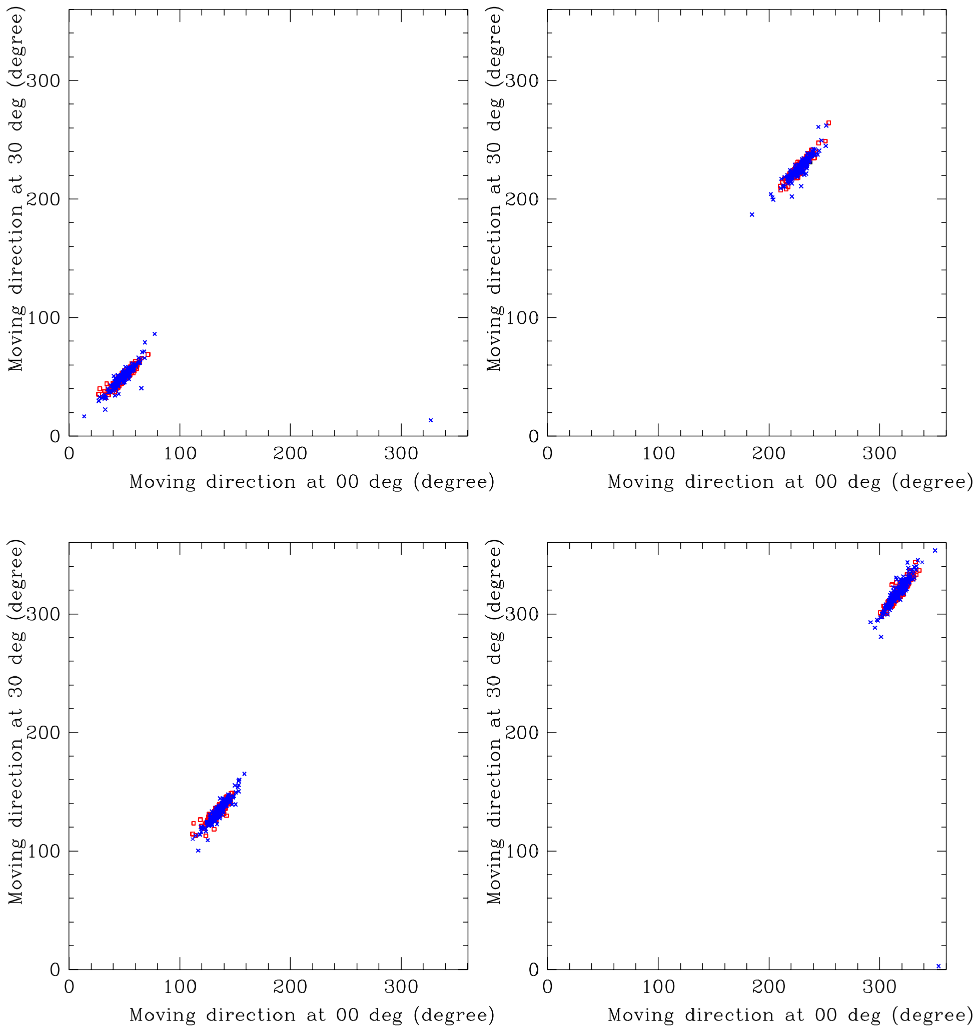

Figure 23: Step angle difference at zenith and ZD=60, in coarse-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

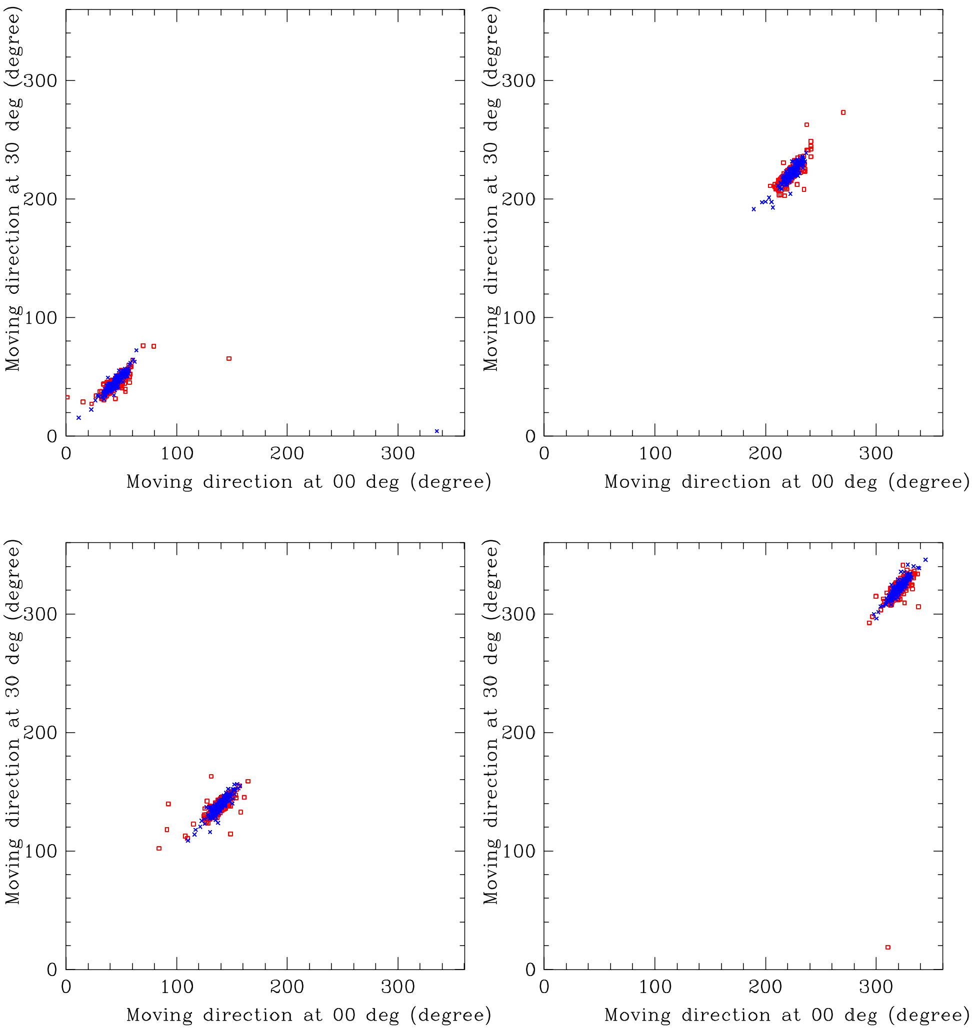

Figure 24: Step angle difference at zenith and ZD=60, in fine-mode, after Echidna rotated on the jig. From top left to bottom right, stepsizes in X+, X−, Y+, Y− movements.

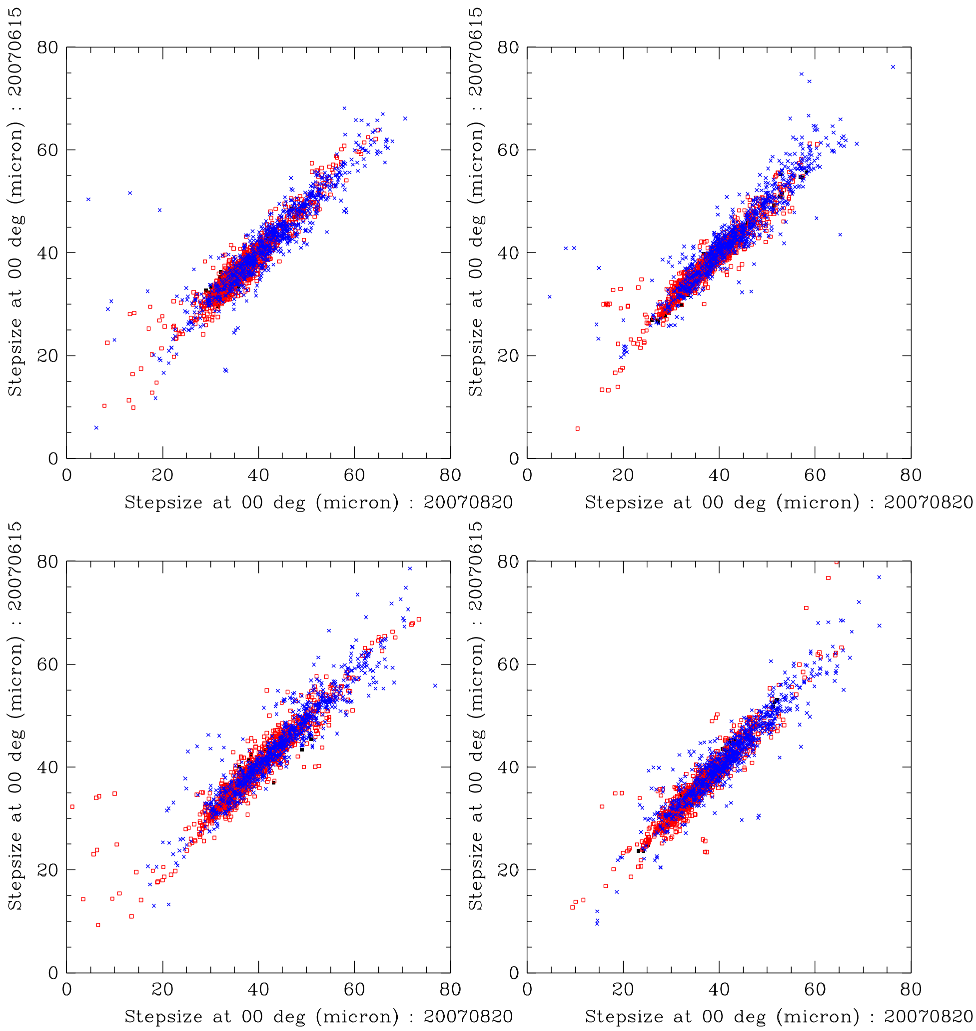

Figure 25: Stepsize difference at zenith measured at 20070615 and 20070820, in coarse mode.

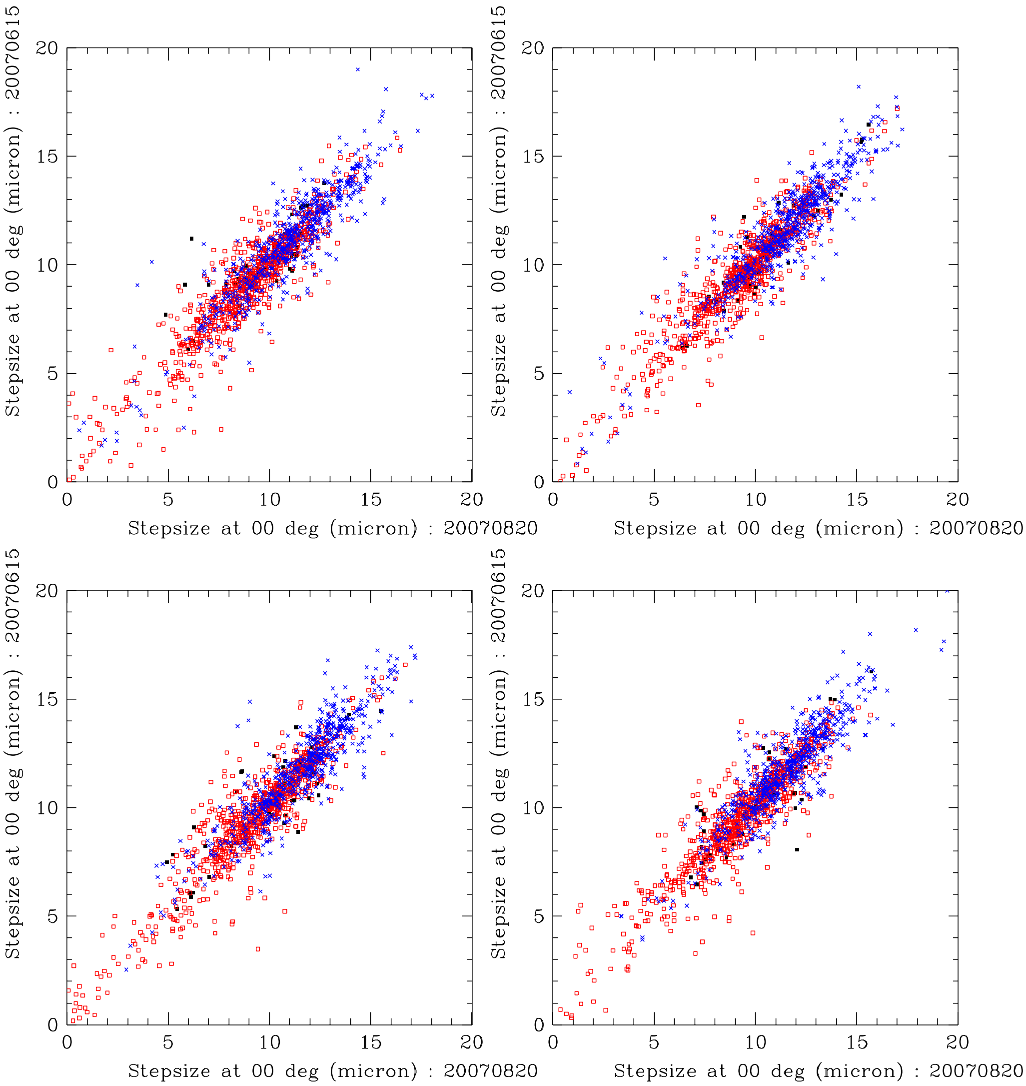

Figure 26: Stepsize difference at zenith measured at 20070615 and 20070820, in fine mode.

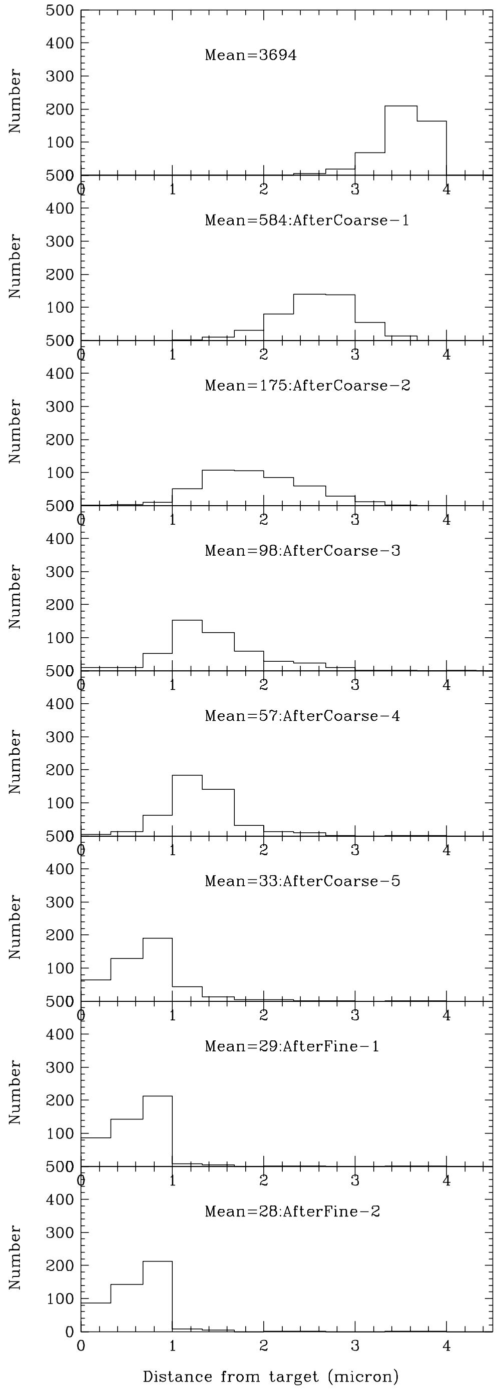

Figure 27: Results of a 7-iteration positioning test from home position to a random position (rand/rand.s002). Horizontal axis is distance to the target in log scale (1 means 10μm, 3 means 1000μm). Spines No.99, No.148, No.184, No.277, No.342, No.361, No.404, No.467, No.474, No.478, show positioning residual larger than 15μm out of 463 spines. One spine crossed.

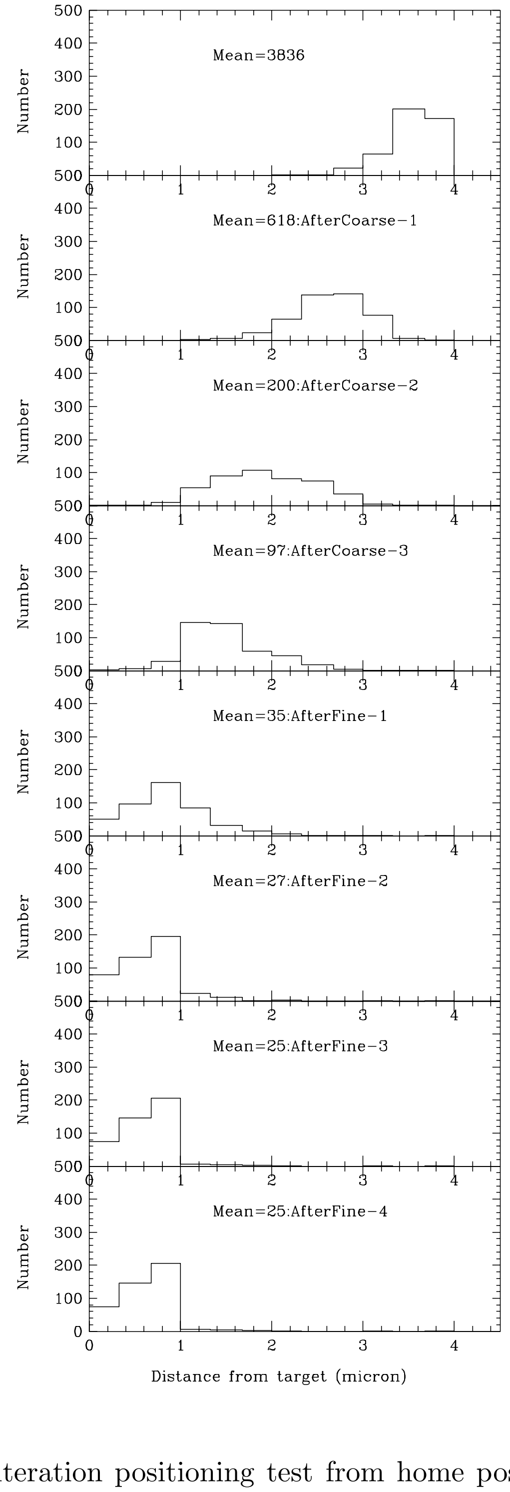

Figure 28: Results of a 7-iteration positioning test from home position to a random position (rand/rand.s003). Horizontal axis is distance to the target in log scale (1 means 10μm, 3 means 1000μm). Spines No.29, No.30, No.50, No.148, No.152, No.180, No.232, No.291, No.292, No.328, No.365, No.388, No.389, No.399, No.467 show positioning residual larger than 15μm out of 461 spines. Four spines crossed.

4 Accuracy of tweaking without iteration

In order to check whether it is possible to tweak the positions of the fibres without iterating with FPI, the step size stability of the fine mode movement is measured with the numbers of steps with 1 and 5. The results are shown in figures 30 and 31. The variation of the step size is as large as 20% and 4% in 1-step and in the 5-step movements, respectively. It should be noted that the measurement of the 1-step movement can be significantly affected by the random error of the measurements of the spine positions. The average variation of the 5-step movement is acceptable, and ~ 0.5" tweaking without FPI measurement can be done with < 0.1" accuracy.

5 Action Items

1. Can we limit the spine reachable area within $r = 7$mm mechanically at least for bad behaving spines even after retermination works ?
2. Vibrational interference in the coarse-mode ?

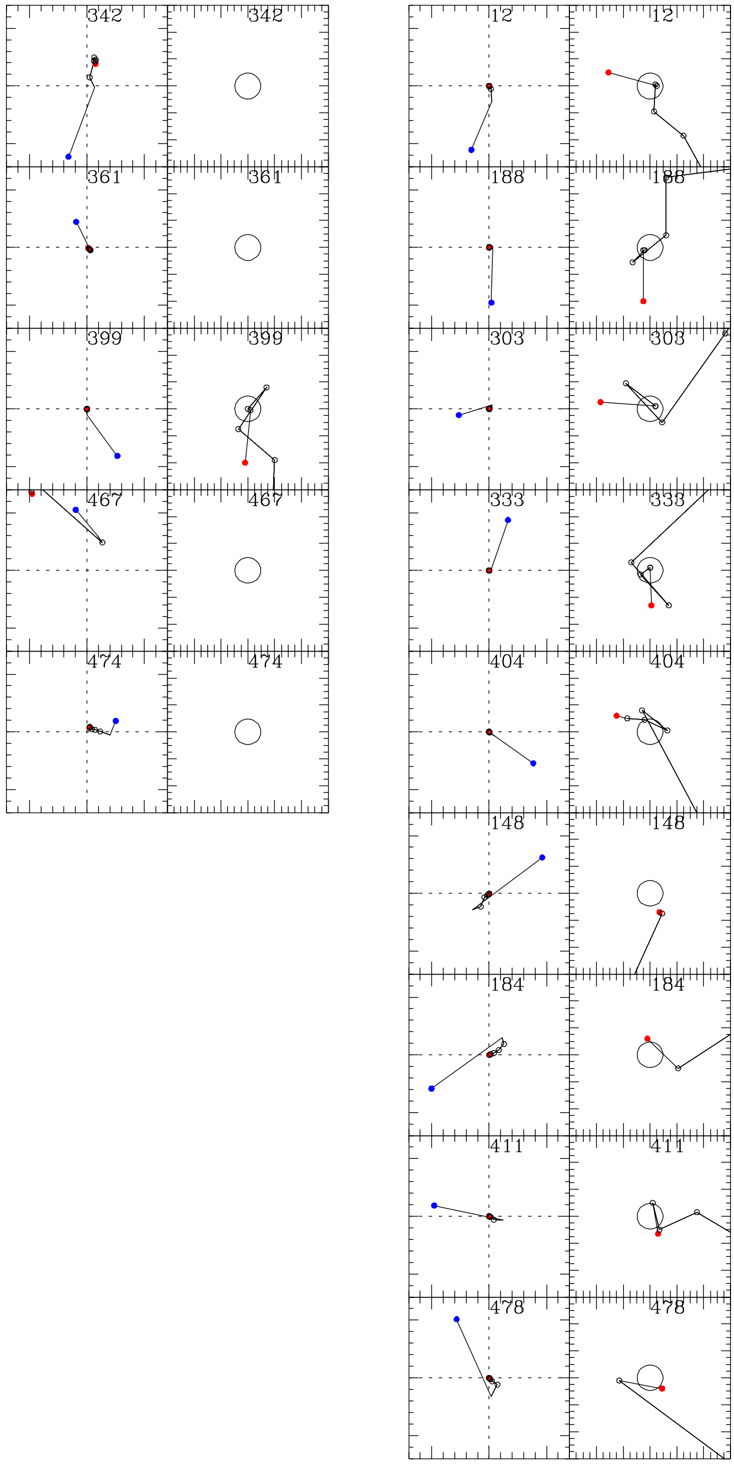

Figure 29: Positioing record of spines residual larger than 10μm in a positioning test. Left panels are 14mm×14mm fov and right panels are 120μm×120μm fov. The blue points indicate starting position and the red points indicate the final position after 7 iterations. The large circles in the right panels indicate $r = 10\mu$m area.

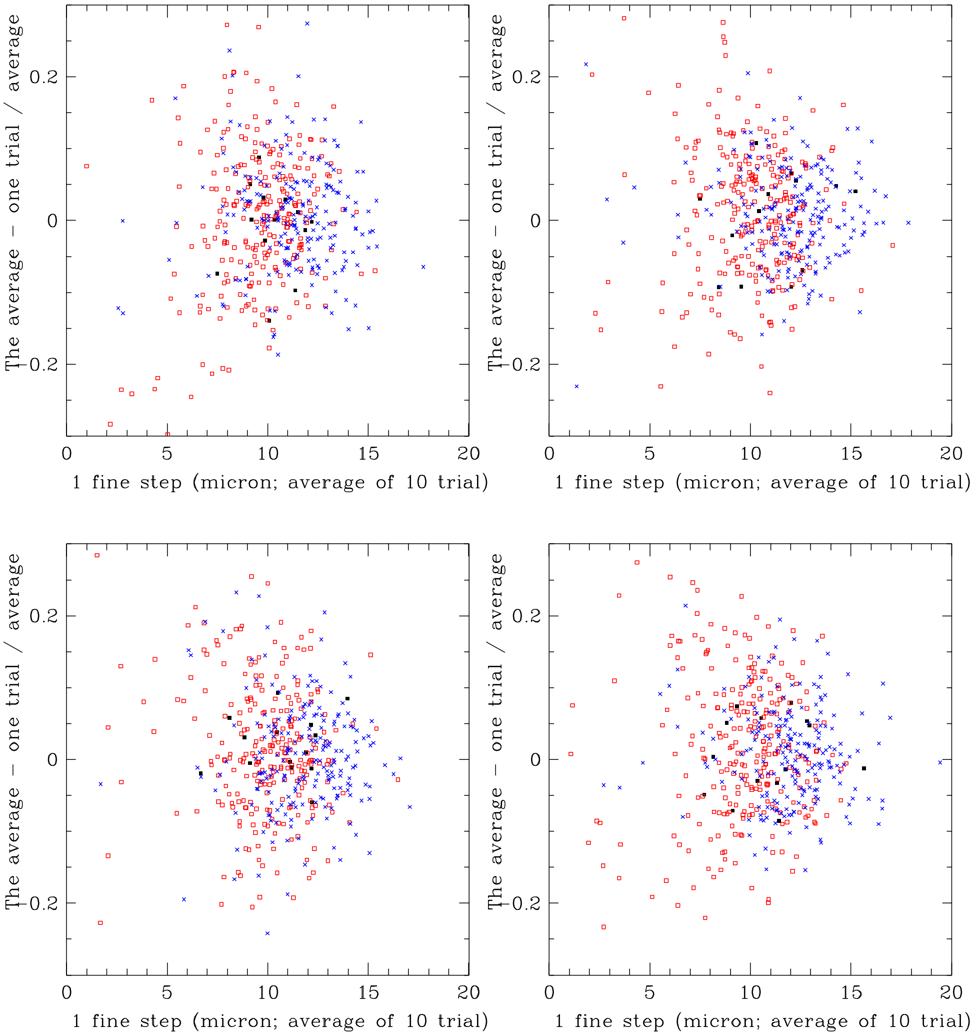

Figure 30: The mean step size with 1-step fine-mode movement vs. the difference between one measurement and the mean result, i.e. 0.2 corresponds to 20% stepsize variation in one measurement. The step size measurement can be significantly affected by the random error (rms=1.0μm) of the position measurements.

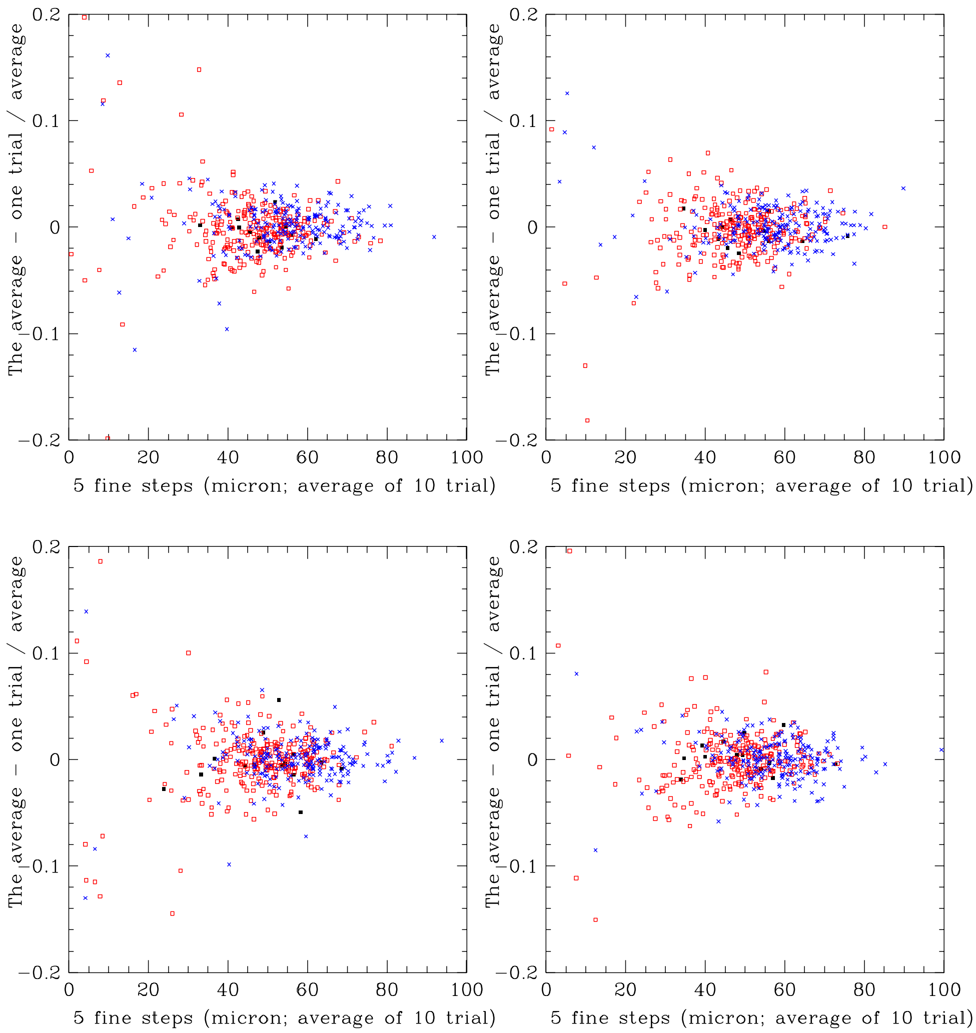

Figure 31: Same as the previous figure with 5-step fine-mode movement. Because the movement is larger, the measurement is not significantly affected by the random error of the position measurements.