OWPS – ANALYSIS_ENABLE 3

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Abstract

This paper shows test results of first measurements with the implemented "analysis mode 3" in the data analysis software of the optical wire position sensor of Open Source Instruments Inc. The results are compared to measurements with the previous analysis mode.

Key words : oWPS, optical wire position sensor, Open Source Instruments

1. INTRODUCTION

Test series on the optical wire position sensors (oWPS) of Open Source Instruments (OSI) have been carried out. Different targets have been used, as for example steel pins, carbon-peek wire or vectran wire. Detailed test results are described in the document *Optical Wire Position sensor (oWPS) test* (https://edms.cern.ch/document/1065106/1).

Two main problems have been identified during these tests. First, the detection of the vectran wire is difficult as it is basically transparent to the infra-red light used by the camera. Second, steps have been observed during measurements on stainless steel pins as well as on carbon-wire (https://clic-pral.web.cern.ch/clic-pral/doku/doku.php?id=optical_wps).

OSI provided for these test an analysis method called *analysis_enable 2* in order to see the vectran wire. With this method, both edges of the wire have been detected correctly in most cases. Nevertheless, some detection did not provide complete edge detection along the image. This was identified as a possible source of problems of the calculation of the wire position.

An improved *analysis_enable 3* mode has been established by OSI, especially for the needs of the vectran wire. The test results obtained with this new analysis mode are shown and compared to the old analysis mode.

2. MEASUREMENTS

Figure 1 shows the measurements of the y axis of oWPS sensor P201. This sensor is the generation WPS1-B and the latest available at CERN. Three measurement configurations are tested, taking into account the different modes and proposals given by OSI.

a) Old configuration as used in previous tests

```
analysis_enable 2
analysis_threshold "30 # 10"
daq_flash_adjust 1
```

b) New configuration with automatic flash adjustment

```
analysis_enable 3
analysis_threshold "30 # 10"
daq_flash_adjust 1
```

c) New configuration with fixed exposure time

```
analysis_enable 3
analysis_threshold "30 # 10"
daq_flash_adjust 0
daq_flash_seconds 0.5
```

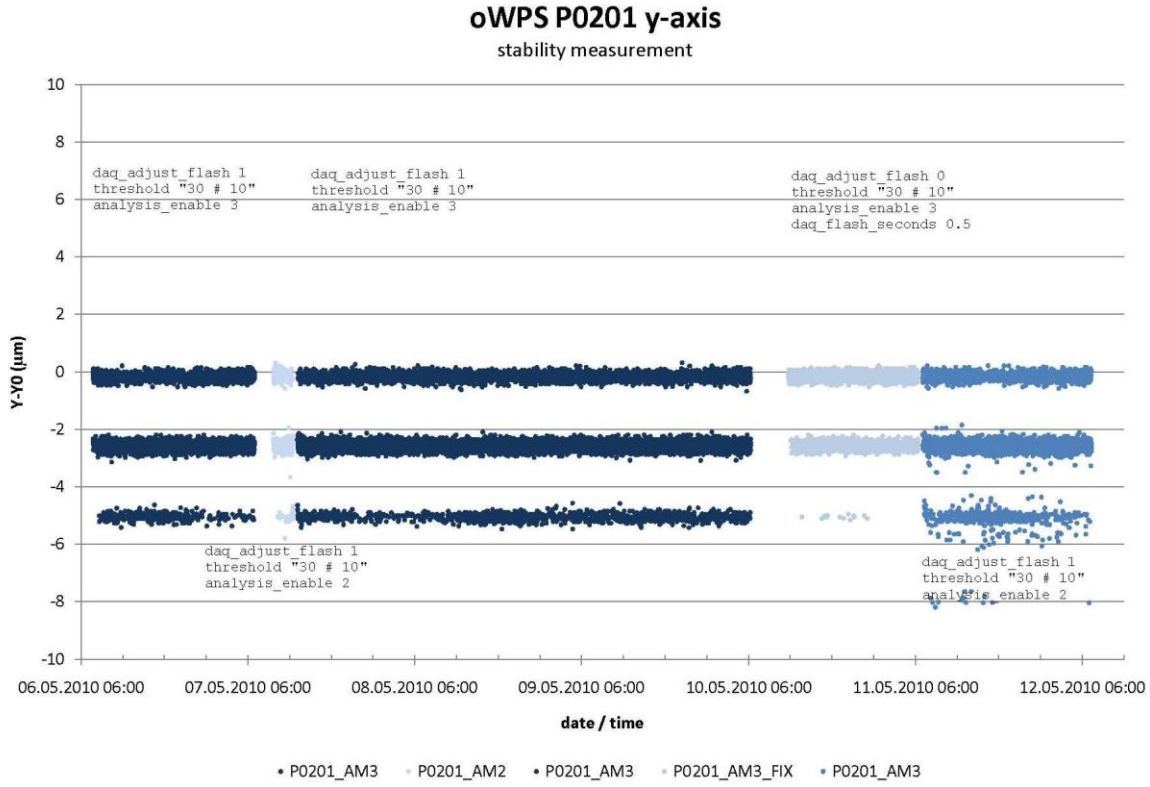


Figure 1: measurements of oWPS P0201 in different modes

Figure 1 shows coherent measurements for the first and third set of measurements, shown in dark blue, in configuration *b*. Compared to the measurement with *analysis_enable 2*, as shown in the fifth measurement on the right hand side of the figure, the variation of the measured position has been improved.

During all measurements in the different modes, one can observe at least three bands of valid wire position determinations. They vary by approximately 3 µm between bands.

An example of the three bands is given in Figure 2. The horizontal axis provides the number of the image that corresponds to the calculation of the position. For post-processing, the images are available.

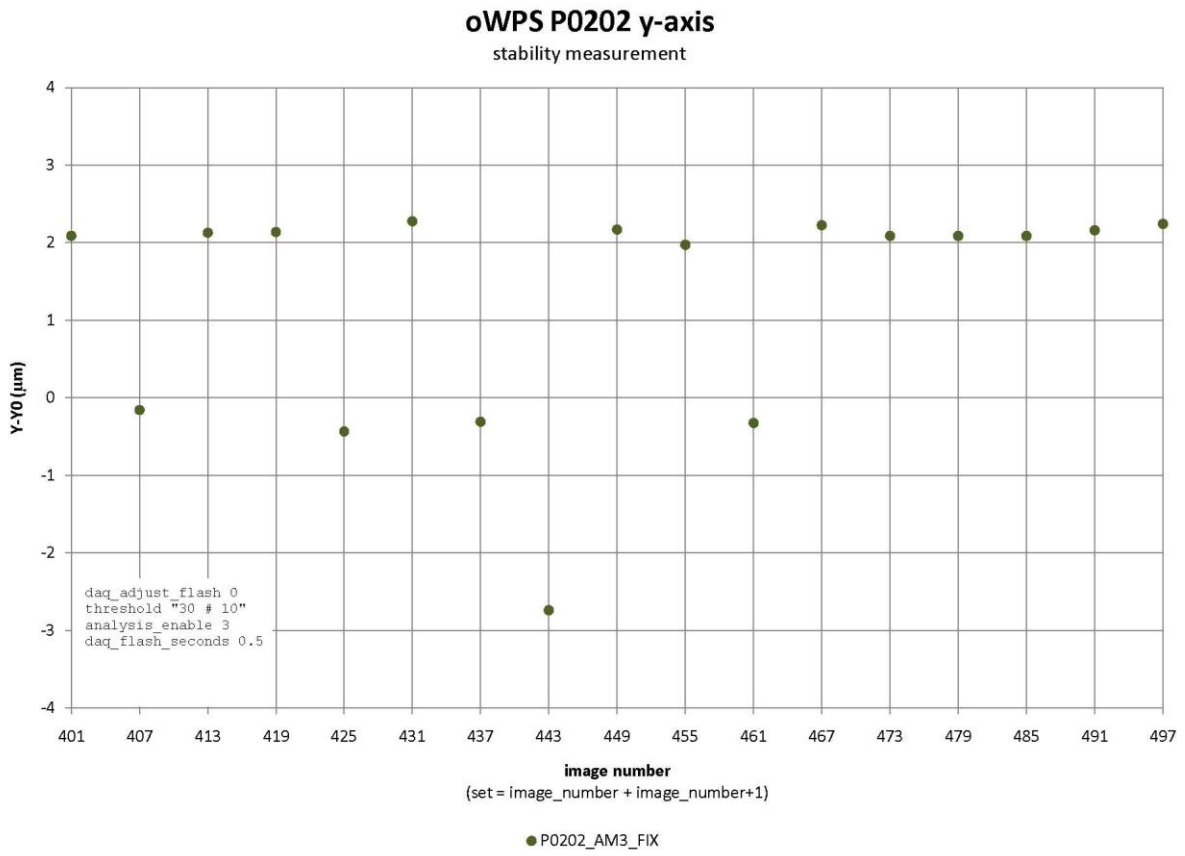


Figure 2: oWPS P0202 wire determination bands

As shown in Figure 4, all three sensors installed on the same test bench and measuring the same wire see the three bands. The layout of the stability bench is as shown in Figure 3. The motorized stages have been replaced by fix anchor points. The detailed graph for each sensor is shown at the end of this document.

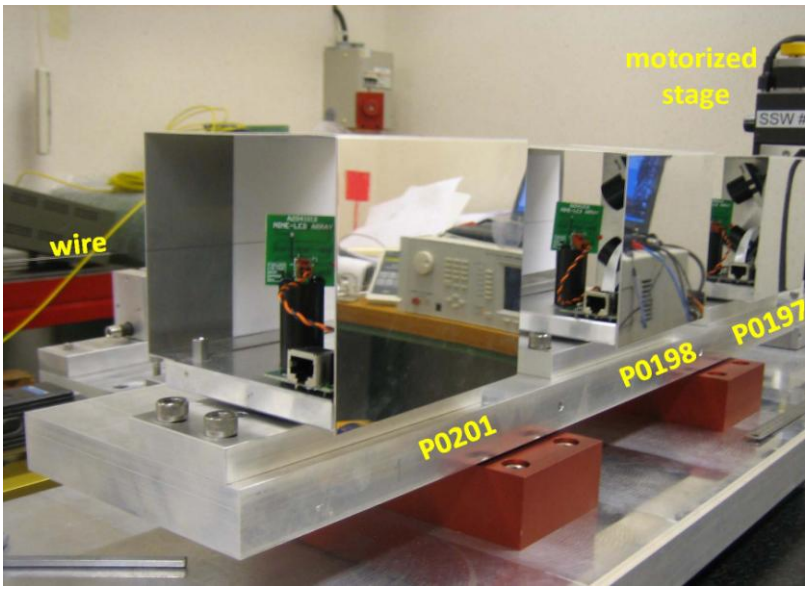


Figure 3: oWPS stability test bench

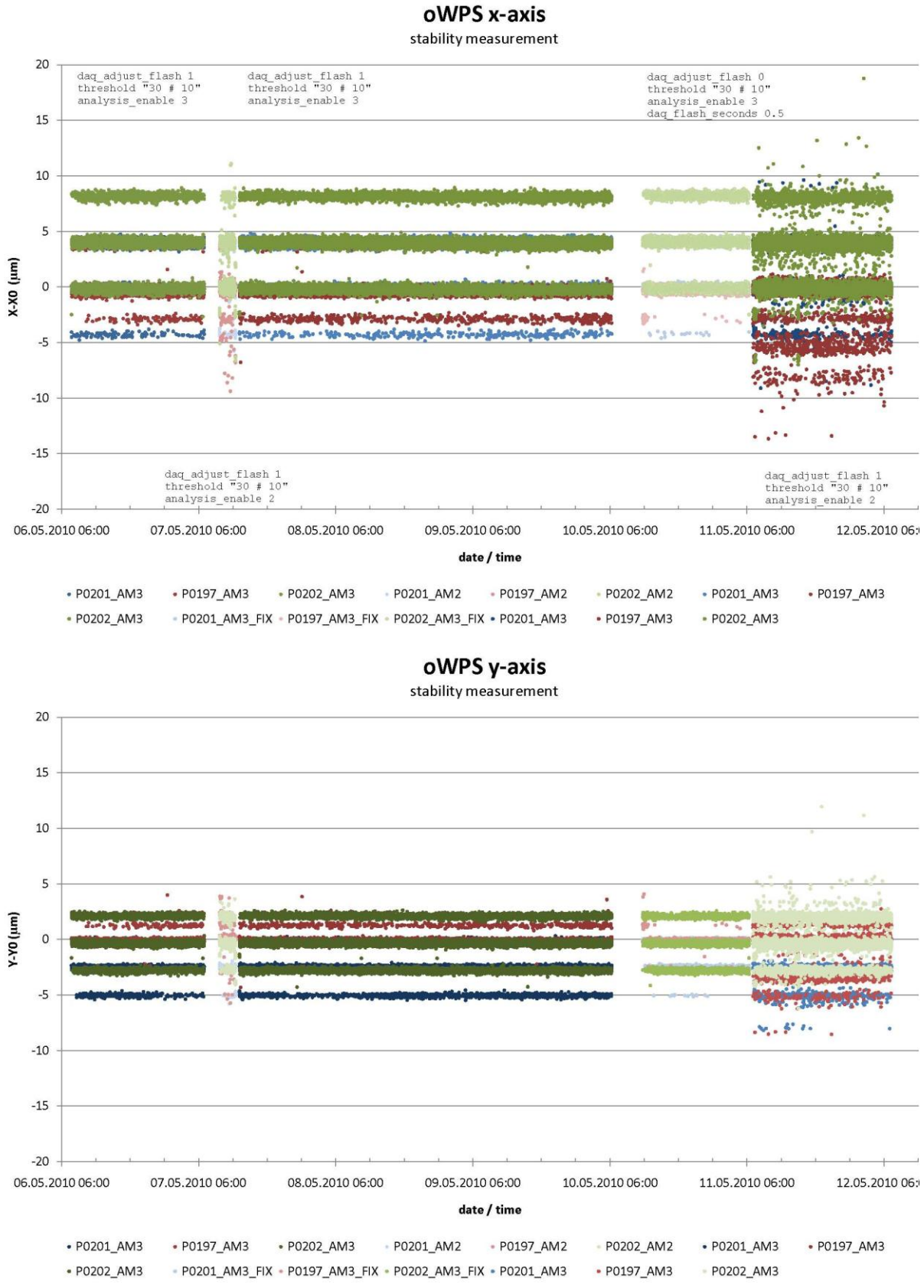


Figure 4: set of three sensors during stability measurements

3. EDGE DETECTION

As proposed by Open Source Instruments, edge detection shall be carried out for the sensors. Therefore a script provided is used and run in toolmaker.

(http://www.opensourceinstruments.com/WPS/WPS1/index.html#Low-Contrast%20Images)

The script is designed as follows:

```
button $f.stop -text Stop -command "set count 100"
pack $f.stop
for {set count 1} {$count <= 100} {incr count} {
    LWDAQ_print -nonewline $t "$count "
    set LWDAQ_config_WPS(analysis_enable) 2
    set LWDAQ_config_WPS(analysis_threshold) "30 \# 10"
    set result [LWDAQ_acquire WPS]
    LWDAQ_print -nonewline $t "[lindex $result 1] [lindex $result 7] "
    set LWDAQ_config_WPS(analysis_enable) 3
    set result [LWDAQ_analysis_WPS]
    LWDAQ_print $t "[lindex $result 0] [lindex $result 6] "
}
```

The script takes an image and analyses it in the old mode, *analysis_enable 2*, and then calculates again in the new mode, *analysis_enable 3*. The output is provided in a file with the number of the measurement, left and right edge detection in mode 2 and left and right edge detection in mode 3.

```
14 1994.37 2078.51 1994.47 2078.51
15 1995.41 2078.62 1995.41 2078.62
16 1994.90 2078.90 1994.90 2078.90
17 1994.91 2078.98 1994.91 2078.98
18 1995.16 2078.93 1995.16 2078.93
19 1995.14 2078.31 1995.14 2078.83
```

The three sensors with six cameras installed on the bench have been tested. The results are shown in the following tables:

SOCKET 1 - ELEMENT 1

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1792.922	1792.922	1875.822	1875.822
STDEV	0.163	0.163	0.209	0.209
SPEAD	0.690	0.690	1.040	1.040
THICK	82.900	82.900	0.000	

SOCKET 1 - ELEMENT 2

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1843.210	1843.210	1922.551	1922.551
STDEV	0.130	0.130	0.198	0.198
SPEAD	0.680	0.680	1.010	1.010
THICK	79.341	79.341	0.000	

Figure 5: oWPS - P0201

SOCKET 2 - ELEMENT 1

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1719.654	1719.592	1802.928	1802.811
STDEV	0.180	0.459	0.238	0.660
SPEAD	0.870	3.690	1.110	4.370
THICK	83.274	83.219	0.054	

SOCKET 2 - ELEMENT 2

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1586.913	1586.913	1665.254	1665.254
STDEV	0.167	0.167	0.172	0.172
SPEAD	0.970	0.970	0.790	0.790
THICK	78.341	78.341	0.000	

Figure 6: oWPS - P0197

SOCKET 3 - ELEMENT 1

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1994.905	1994.891	2078.627	2078.494
STDEV	0.260	0.347	0.261	0.386
SPEAD	1.190	2.270	1.240	1.910
THICK	83.722	83.603	0.119	

SOCKET 3 - ELEMENT 2

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1516.342	1516.347	1600.244	1600.211
STDEV	0.151	0.142	0.197	0.230
SPEAD	0.840	0.690	0.910	1.300
THICK	83.902	83.864	0.038	

Figure 7: oWPS - P0202

The wire detection is carried out with the vectran wire. The cameras see in three cases no variation between the two analysis modes, where as for three cameras differences for the wire position in the image can be seen. The wires are compared with their average position, *avg*, their standard deviation of the 100 samples, *stdev*, and the *spread* which is calculated as the difference between maximum and minimum value.

As a result, the standard deviation and the spread are either equal or less important in the analysis mode 3. The second camera of sensor P0202 has a better result in analysis mode 2, but not significantly better.

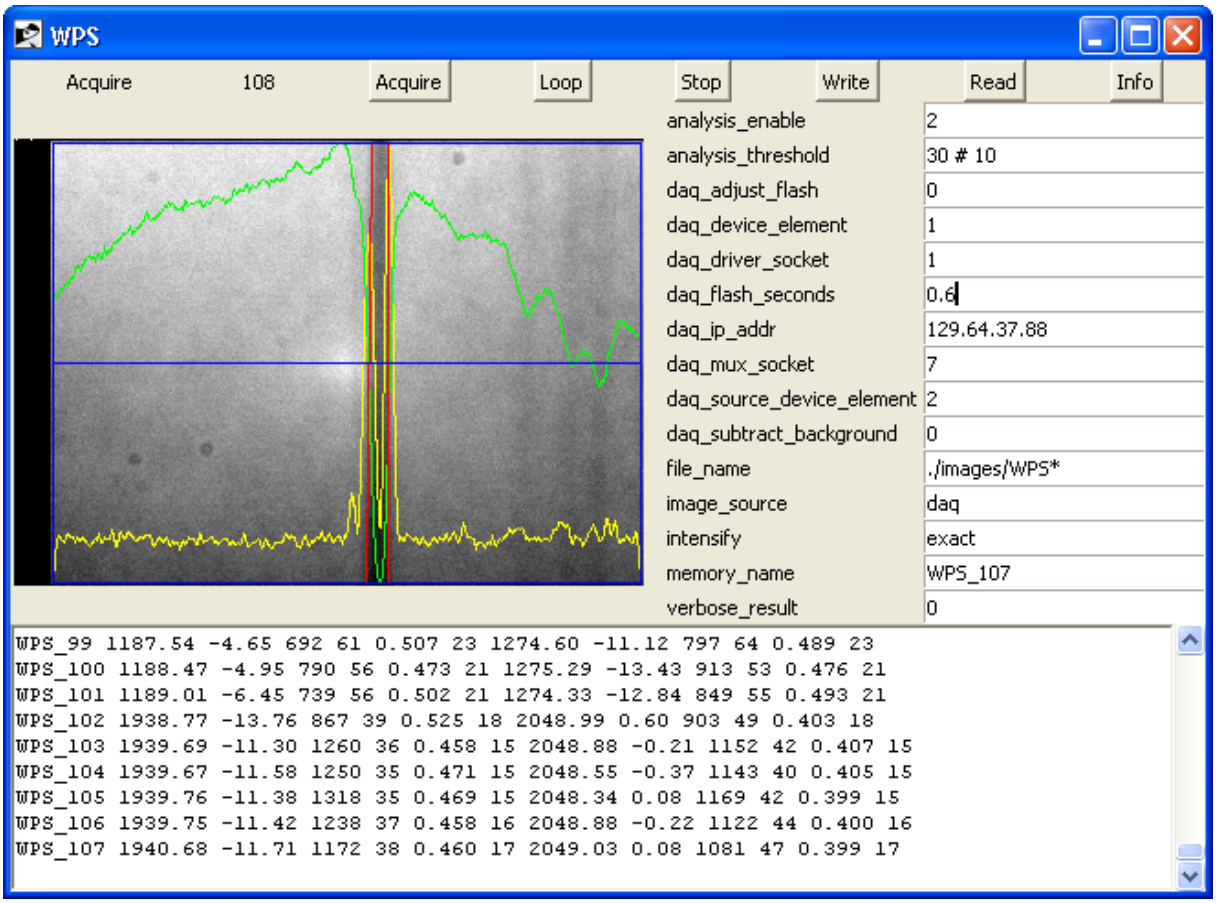


Figure 8: oWPS – OSI USA DAQ window

For comparison reasons, the OSI sensor accessible via the web has been measured as well. The results are shown in Figure 9. The used wire and the sensor generation are not known.

SOCKET 1 - ELEMENT 1

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1940.084	1940.083	2048.695	2048.689
STDEV	0.267	0.282	0.240	0.246
SPEAD	1.700	1.700	1.170	1.170
THICK	108.612	108.606	0.006	

SOCKET 1 - ELEMENT 2

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1190.068	1190.032	1275.241	1274.633
STDEV	0.195	0.318	0.481	0.354
SPEAD	0.940	2.730	2.290	1.670
THICK	85.174	84.601	0.572	

Figure 9: oWPS – OSI USA

During a set of measurements with 10.000 samples and sensor P0202, the wire detection algorithm failed sometimes as standard deviation and spread are very large. The results can be compared to Figure 7 where with the same algorithm 100 samples were measured.

SOCKET 3 - ELEMENT 1

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1982.821	1996.679	2067.765	2081.469
STDEV	158.129	6.279	152.604	9.262
SPEAD	2184.120	143.040	2112.850	209.640
THICK	84.944	84.791	0.153	

SOCKET 3 - ELEMENT 2

	LEFT EDGE		RIGHT EDGE	
	analyse 3	analyse 2	analyse 3	analyse 2
AVG	1516.354	1516.507	1600.717	1600.069
STDEV	0.288	0.468	0.417	0.653
SPEAD	2.360	4.040	3.100	4.990
THICK	84.363	83.562	0.801	

Figure 10: oWPS – OSI P0202

In order to have a better idea about the distribution of the variation, the numerical values of the histogram of sensor P0202 is plotted for both cameras and both edges. The variation is most important for camera 1.

	3-1		3-2	
	LEFT	RIGHT	LEFT	RIGHT
slot	*quantity*	*quantity*	*quantity*	*quantity*
less	75	161	0	0
-10	1	8	0	0
-8	1	1	0	0
-6	1	3	0	0
-4	1	4	0	0
-2	100	7	0	0
0	7600	353	5538	4191
2	2026	8557	4462	5809
4	17	829	0	0
6	2	21	0	0
8	5	10	0	0
10	7	11	0	0
more	164	35	0	0
sum	10000	10000	10000	10000

Figure 11: oWPS – P0202 histogram analysis

4. CONCLUSION

The stability test shows, that the wire is stable during measurements, as the sensors do not see a variation of the wire during each measurement period.

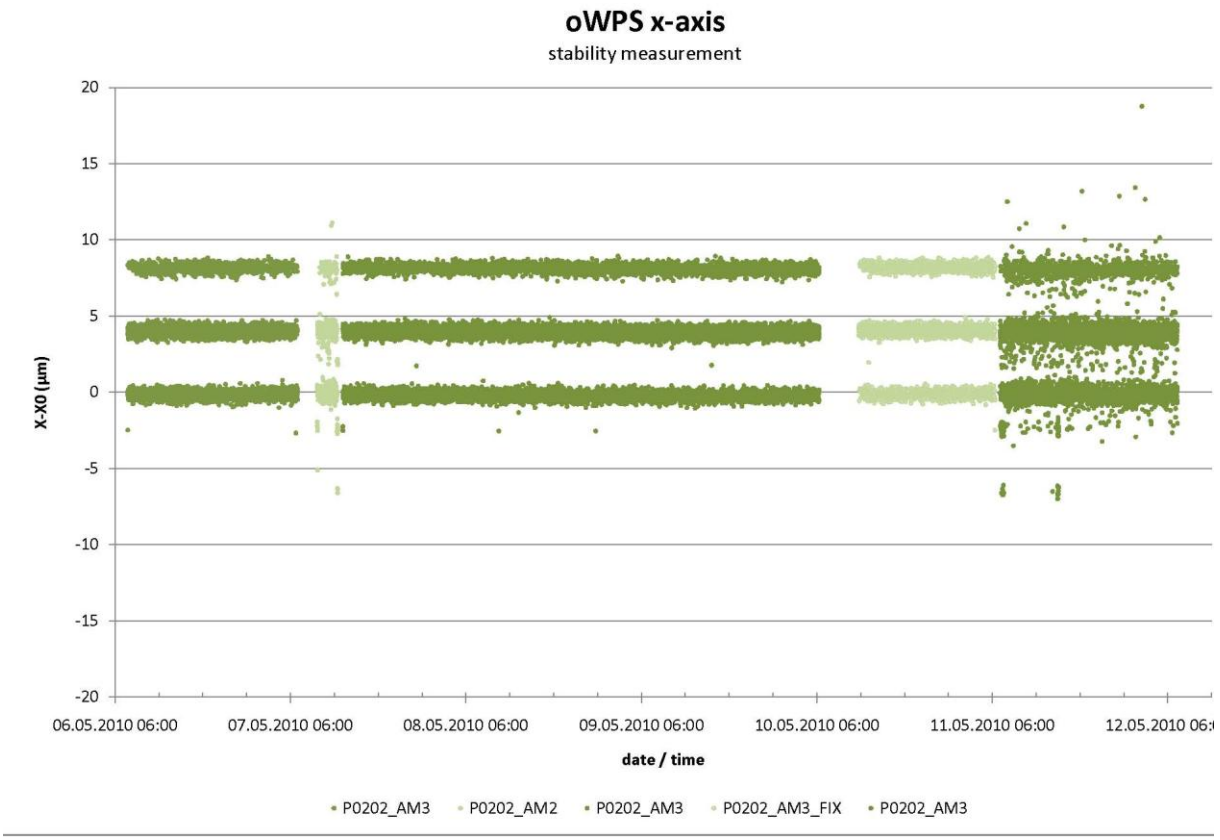
The use of the analysis mode *analysis_enable 3* is an improvement for the determination of the wire position. The variation and failure in the determination is reduced as the edge detection algorithm now finds in a reliable way the wire along the image.

A pattern of three bands of measurement results can be seen for the determination of the wire positions in X and Y. In this analysis the set of two images from camera 1 and 2 has been used to determine the coordinates of the wire.

Having variations of 3 µm between bands and comparing those to the edge detection of the wire in the images, this difference cannot be explained. The edge detection, as shown in paragraph 3, provides results for the wire detection of approximately 1 µm in analysis mode 3.

With the parameters used for the wire edge detection as described by OSI (http://www.opensourceinstruments.com/WPS/WPS1/index.html#Low-Contrast%20Images) similar standard deviations can be obtained as by OSI. The measurement with 10.000 samples shows, that different cameras on the same sensor have different quality in the edge detection.

□


oWPS x-axis
stability measurement
X-X0 (µm)
20
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08.05.2010 06:00
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10.05.2010 06:00
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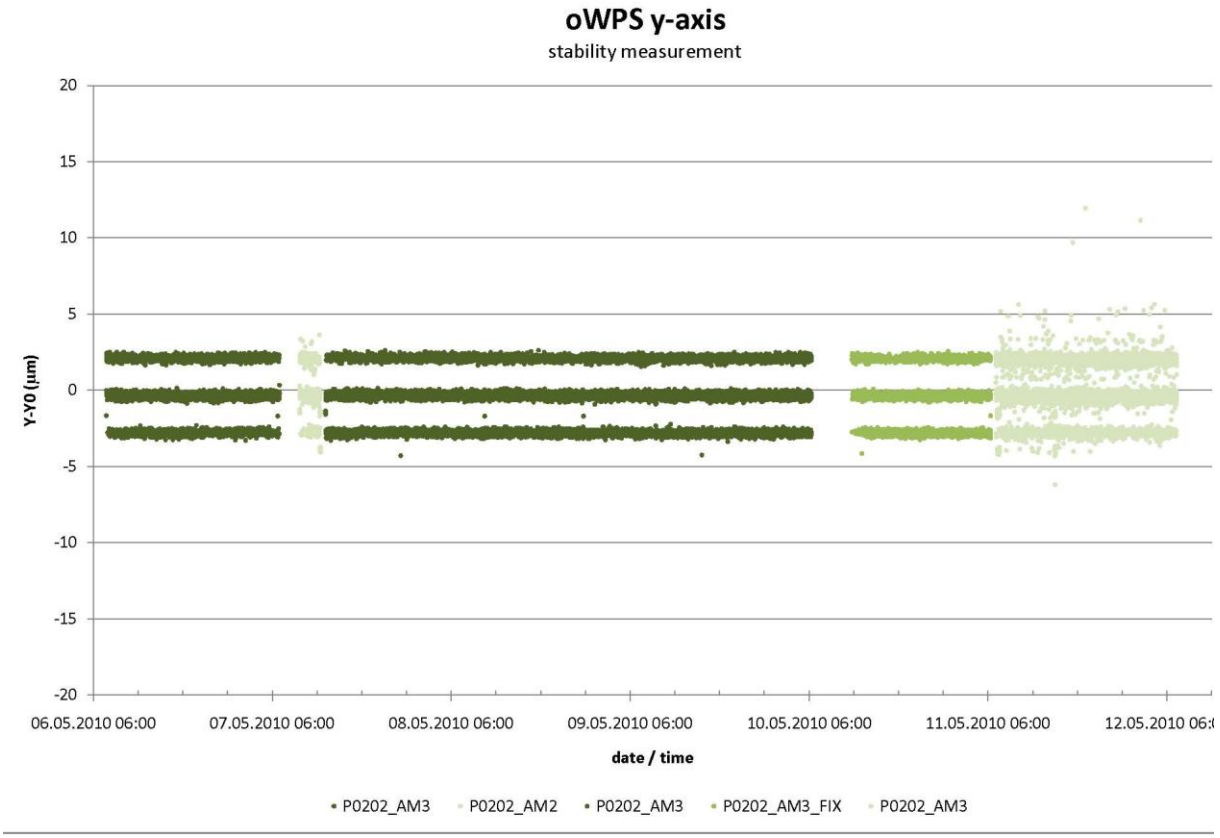
P0202_AM3
P0202_AM2
P0202_AM3
P0202_AM3_FIX
P0202_AM3


oWPS y-axis
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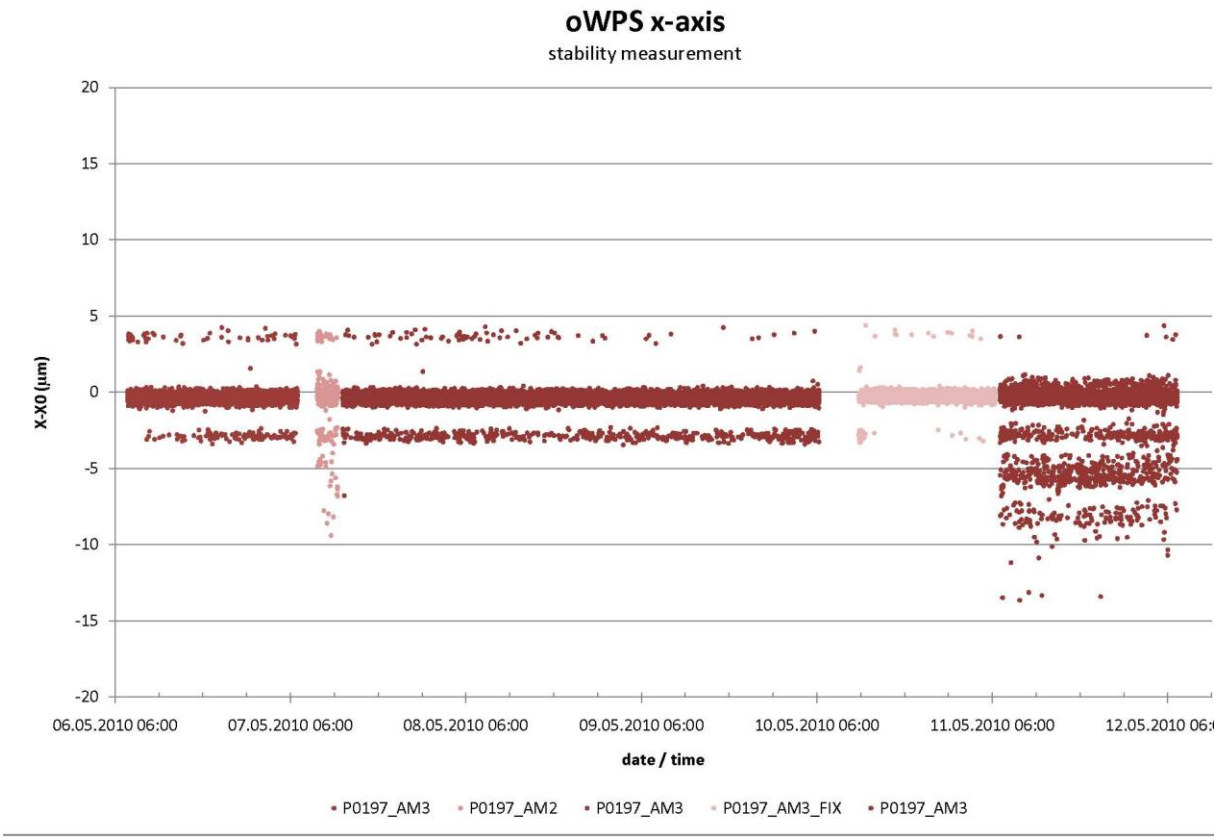
P0202_AM3


oWPS x-axis
stability measurement
X-X0 (µm)
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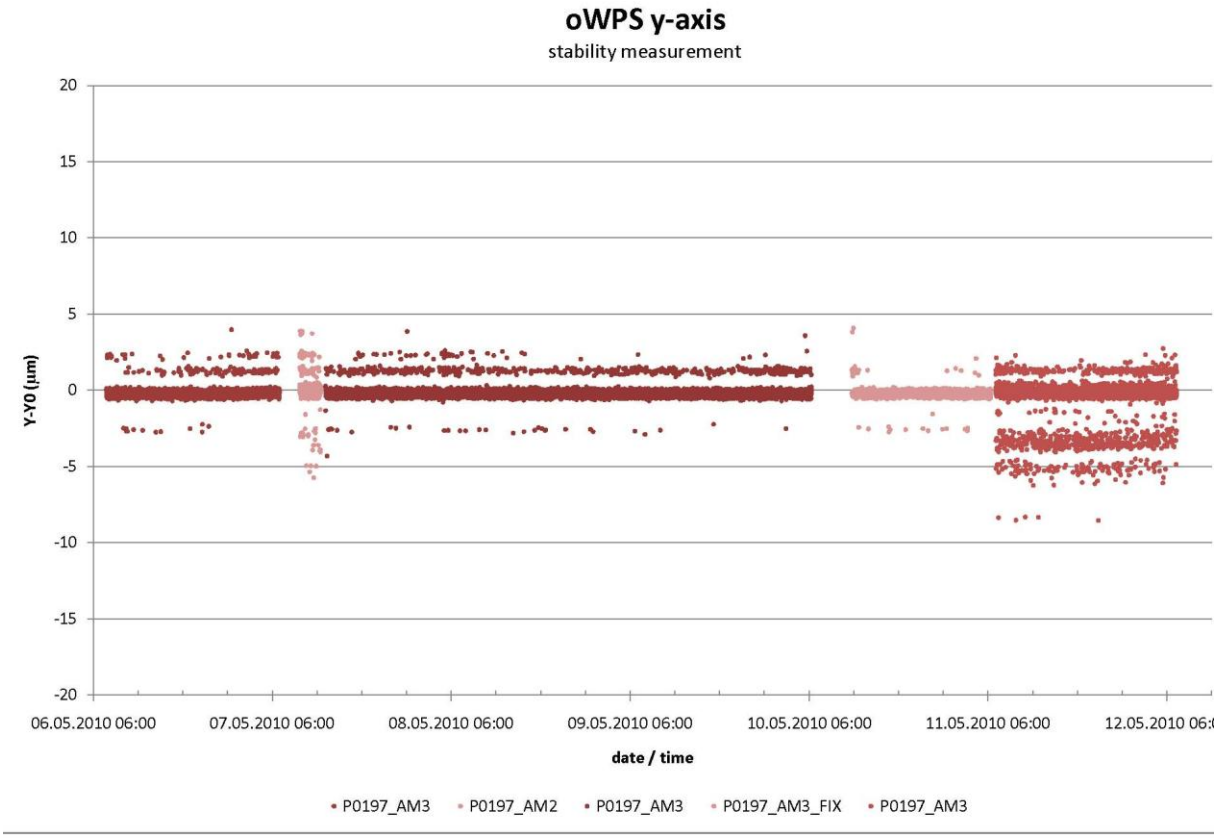
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P0197_AM3_FIX
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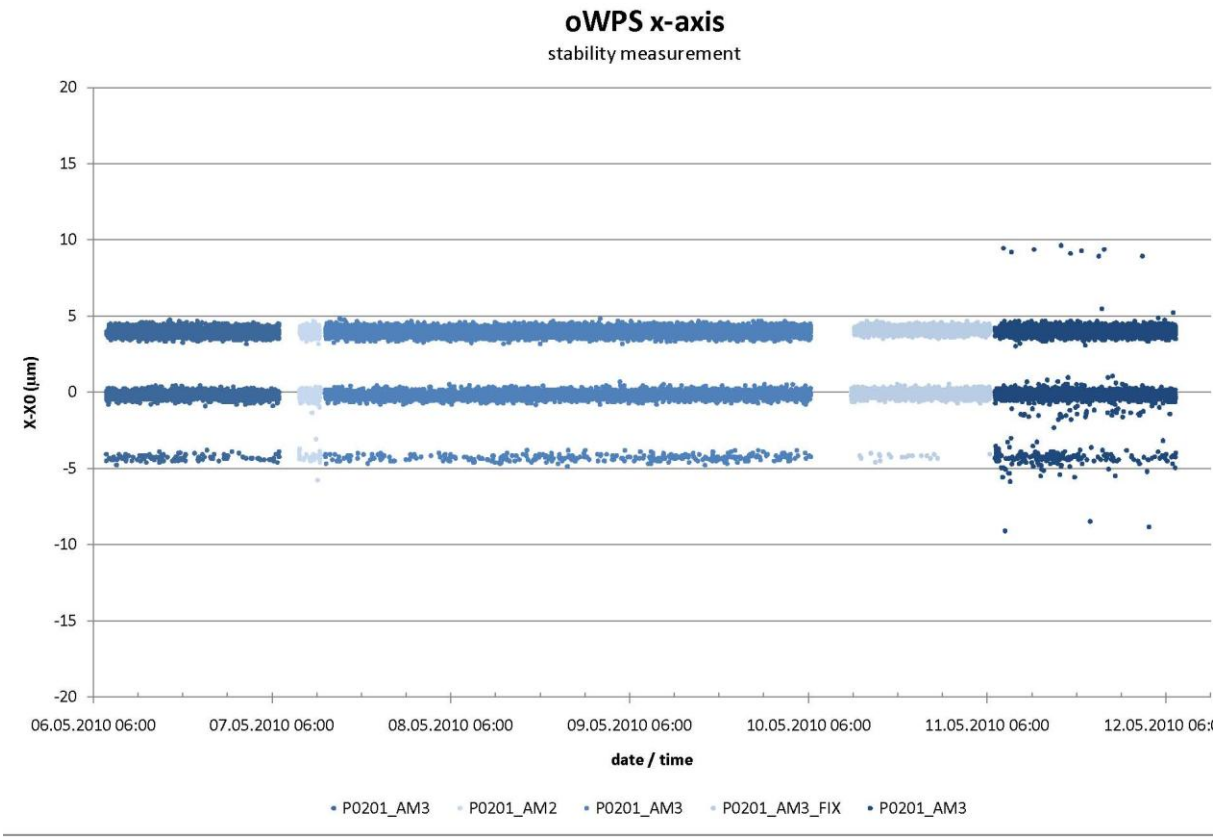
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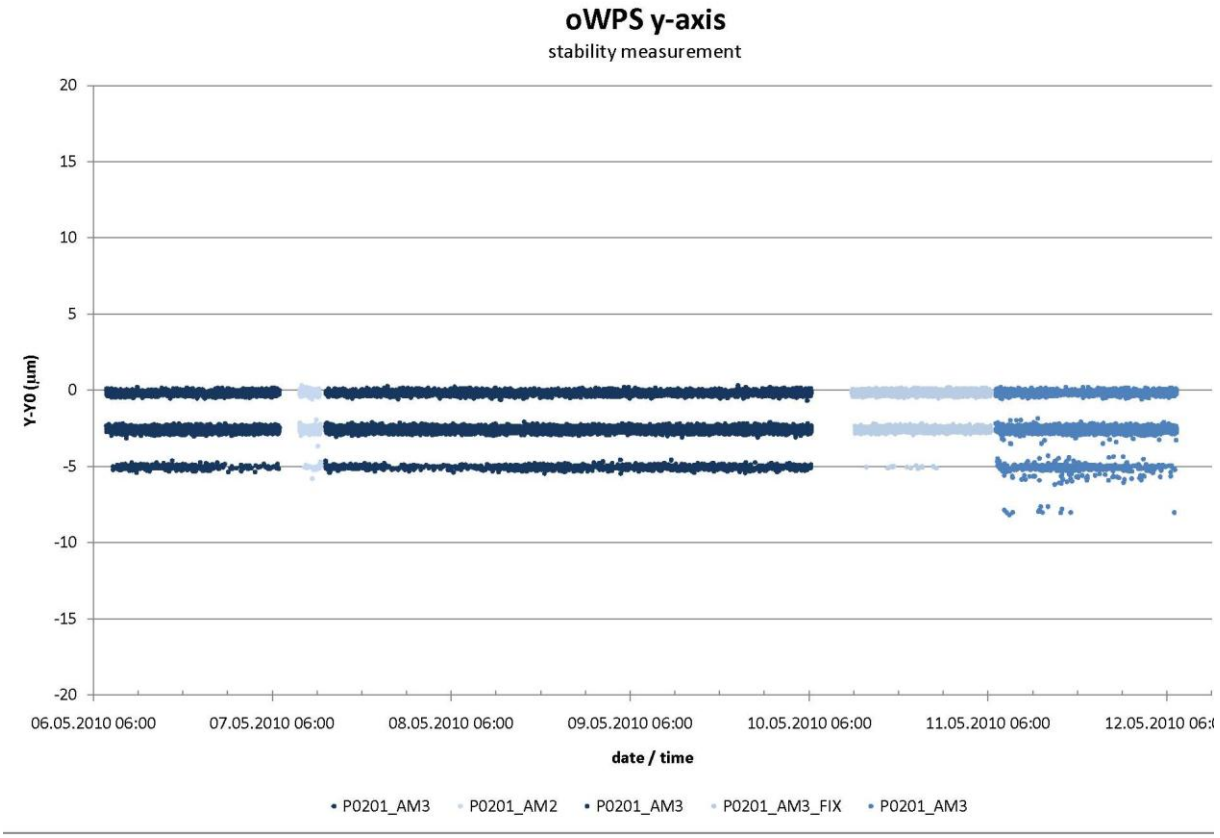
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stability measurement
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