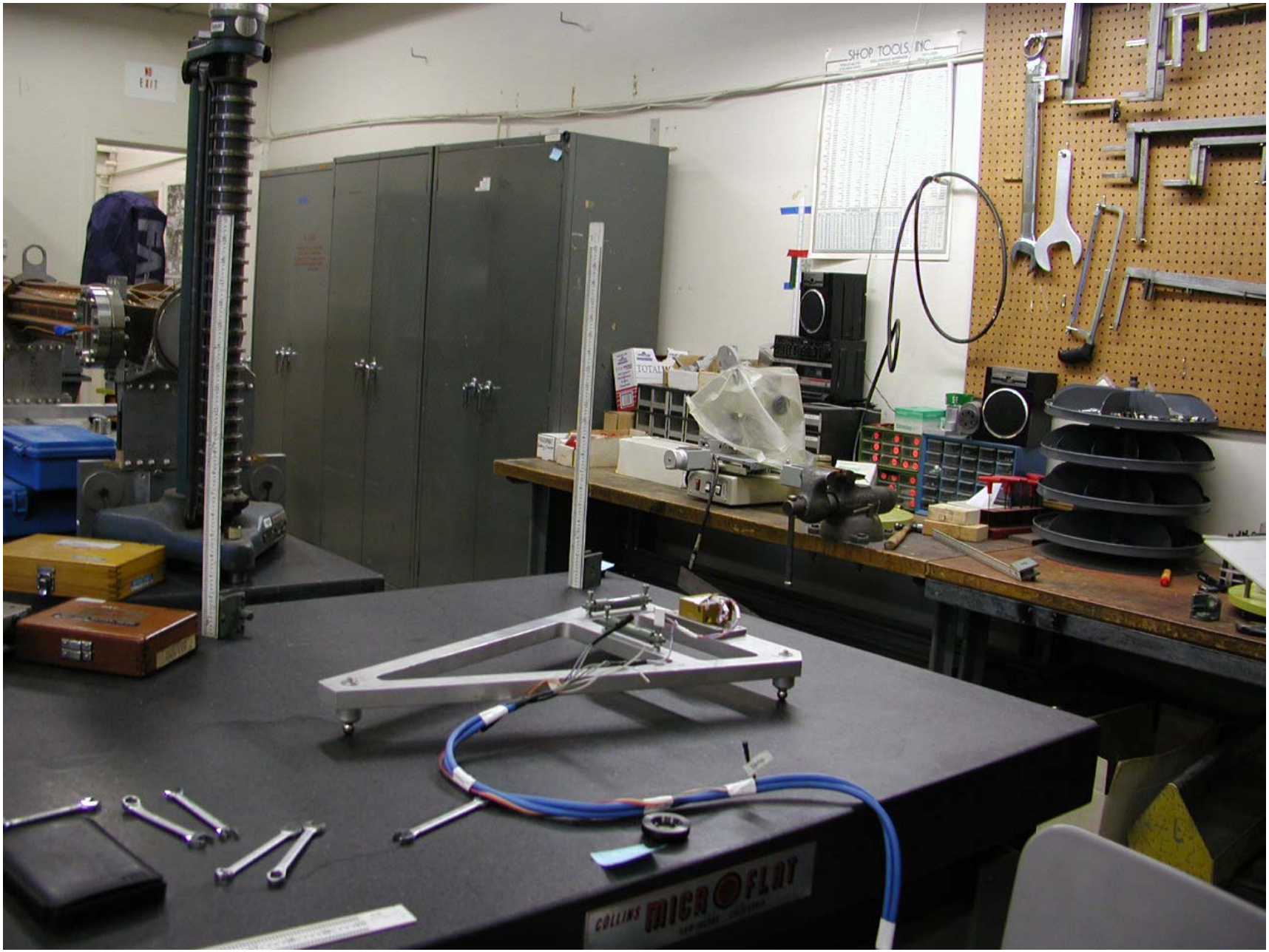
Tiltmeter Study

Results from short study in the AEG lab in Building 26

April 15 and 19 2004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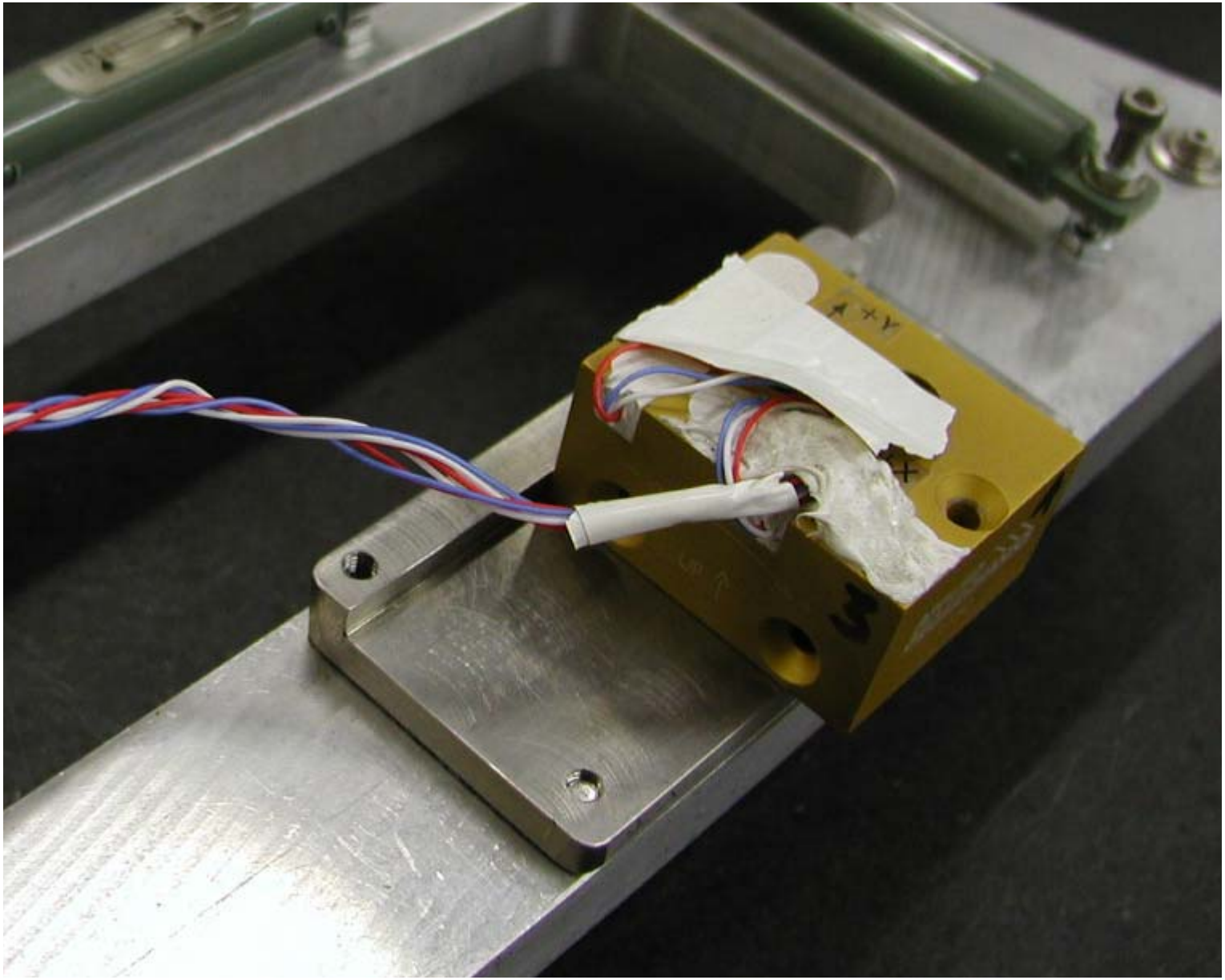

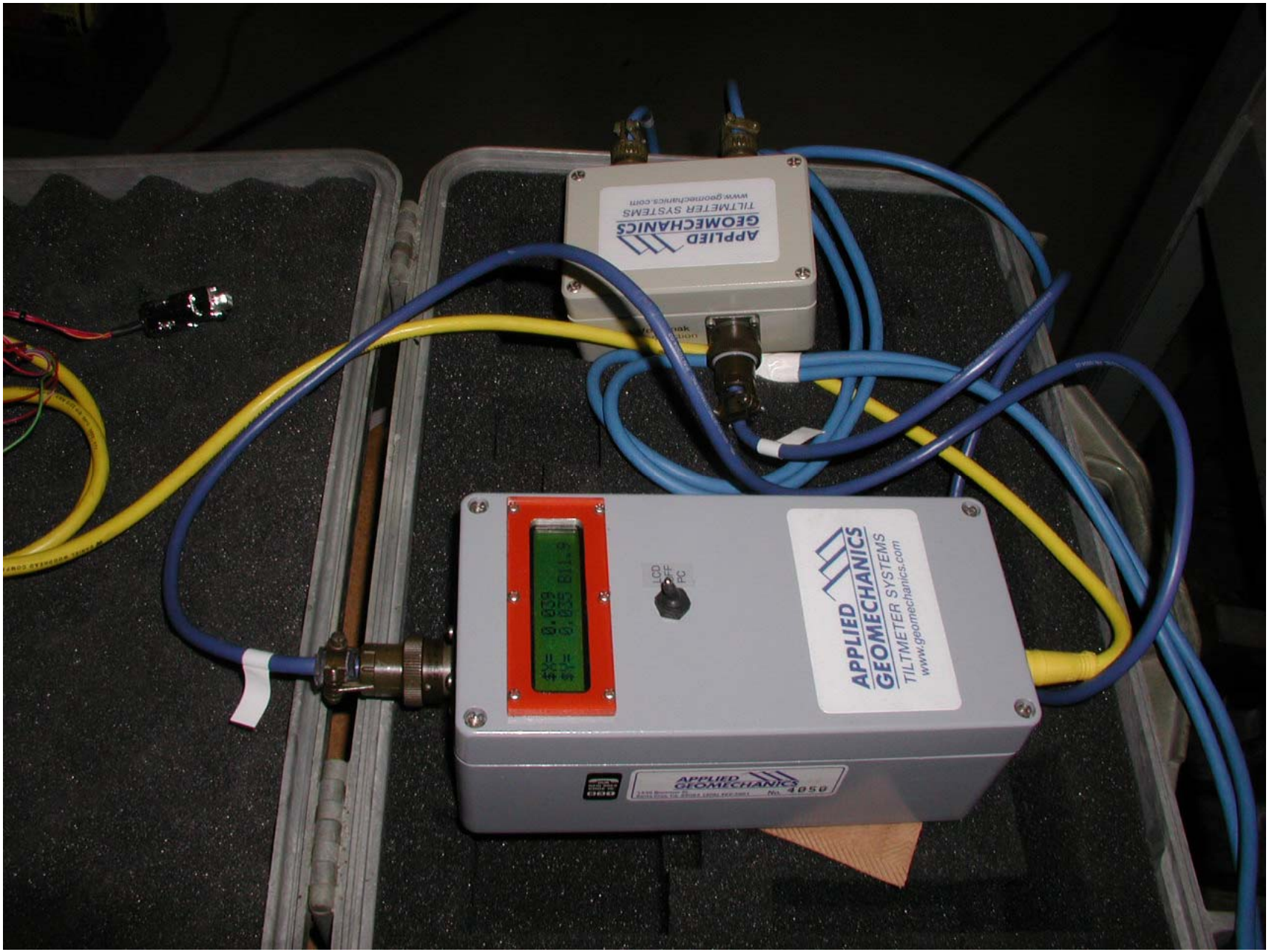
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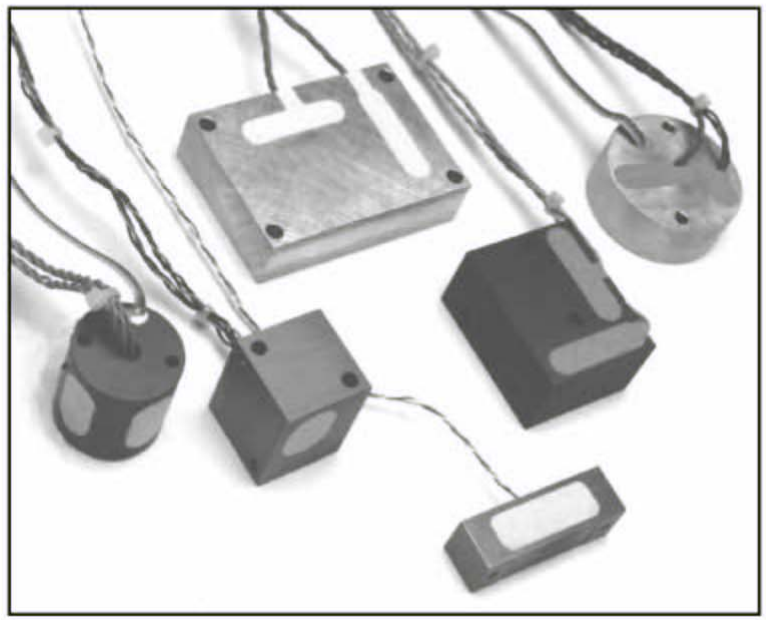
755-Series High-Gain Miniature Tilt Sensors
756-Series Mid-Range Miniature Tilt Sensors

The high-precision sensors in our 500- and 700-Series Tiltmeters are available as standalone modules for applications with size or weight constraints. These small modules attach directly to the elements you want to measure, without unbalancing them or affecting their performance. Uniaxial and biaxial models are both available, as are a range of convenient shapes. Most models also come in vacuum-compatible versions. Biaxial units include a temperature sensor. Miniature Tilt Sensors are operated by a variety of signal conditioners that may be located as far as 100m from the sensors.



AEG Sensor Type

	755-Series High-Gain Type	756-Series Mid-Range Type
TOTAL RANGE	±0.9 degree	±10 degrees
RESOLUTION	0.1 microradian (0.02 arc second)	1.0 microradian (0.2 arc second)
REPEATABILITY	1 microradian (0.2 arc second)	2 microradians (0.4 arc second)
LINEARITY	1% of half span, 7% of full span (typical)	0.5% of half span, 2% of full span (typical)
NATURAL FREQUENCY	0.8 Hz	1.3 Hz
TIME CONSTANT	0.6 second	0.35 second
TEMPERATURE COEF.	Scale Factor: +0.04%/°C, Zero: ±3 μradians/°C	Scale Factor: +0.05%/°C, Zero: ±10 μradians/°C
CONNECTIONS	12-inch (30 cm) wires with tinned ends or mini connectors; 1-meter wires on vacuum-compatible units	
ENVIRONMENTAL	-25°C to +80°C operational and storage, 0 to 100% humidity	
MATERIALS	Anodized 6061-T6 aluminum; stainless steel available on request. Vacuum-compatible sensors are unanodized and have Kapton wires.	
SIGNAL CONDITIONING	Model 781 Bench-top Unit, Model 786 Rack Mount Unit, Model 775 Readout/Electronics Unit, Model 84800 Card (1-channel), Model 84828 Card (1-channel) or Model 83162 Card (2-channel)	

AEG Model Type

MODEL	CHANNELS	MOUNTING	DIMENSIONS	WEIGHT
-1129	2 tilt, 1 temp. (biaxial)	Horiz. surface or vert. tube; hole dia.= 0.18" (4.4 mm)	1.98" dia. Cylinder x .75" high (50.3 x 19.1 mm)	4 oz. (114 g)
-1150	2 tilt, 1 temp. (biaxial)	Horiz. or vert. surface; hole dia.= 0.18" (4.4 mm)	1.62" x 2.00" x 1.00" (41.2 x 50.8 x 25.4 mm)	5 oz. (142 g)
-1172	1 tilt (uniaxial)	Horiz. or vert. surface; hole dia.= 0.17" (4.3mm)	2.00" x 0.62" x 0.62" (50.8 x 15.7 x 15.7 mm)	1.5 oz. (42 g)
-1326	2 tilt, 1 temp. (biaxial)	Horiz. surface or vert. tube; mounting hole dia.= 0.15" (3.9 mm)	1.37" dia. cylinder x 1.25" high (34.8 x 31.8 mm)	2.8 oz. (80 g)

1336 Brommer Street, Santa Cruz, CA 95062, (831) 462-2801, FAX: (831) 462-4418
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Simple Repeatability Test

Position 1

X	Y
116	68
114	74
119	58
125	48
120	61
123	71
125	58
127	54

Position 2

X	Y
60	97
64	98
80	83
70	94
66	96
70	105
66	94
67	96

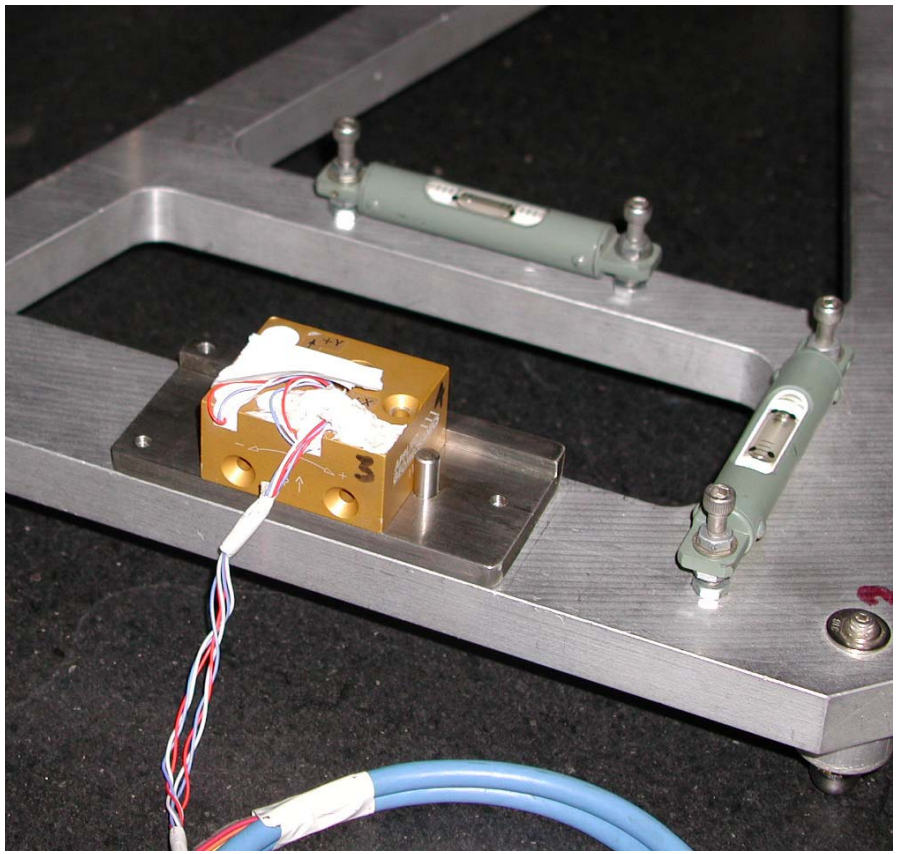
Position 3

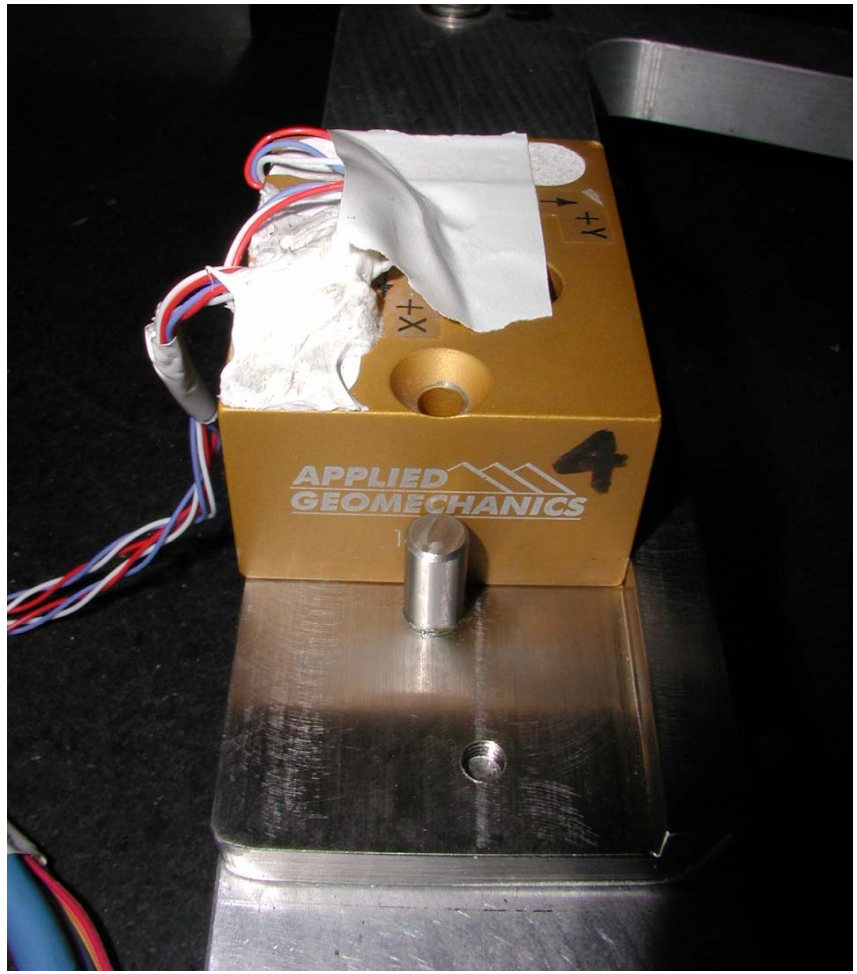
X	Y
32	47
34	48
30	53
31	53
28	53
30	57
33	48
33	49

Position 4

X	Y
92	37
86	53
84	36
58	71
74	58
60	76
67	57
70	56

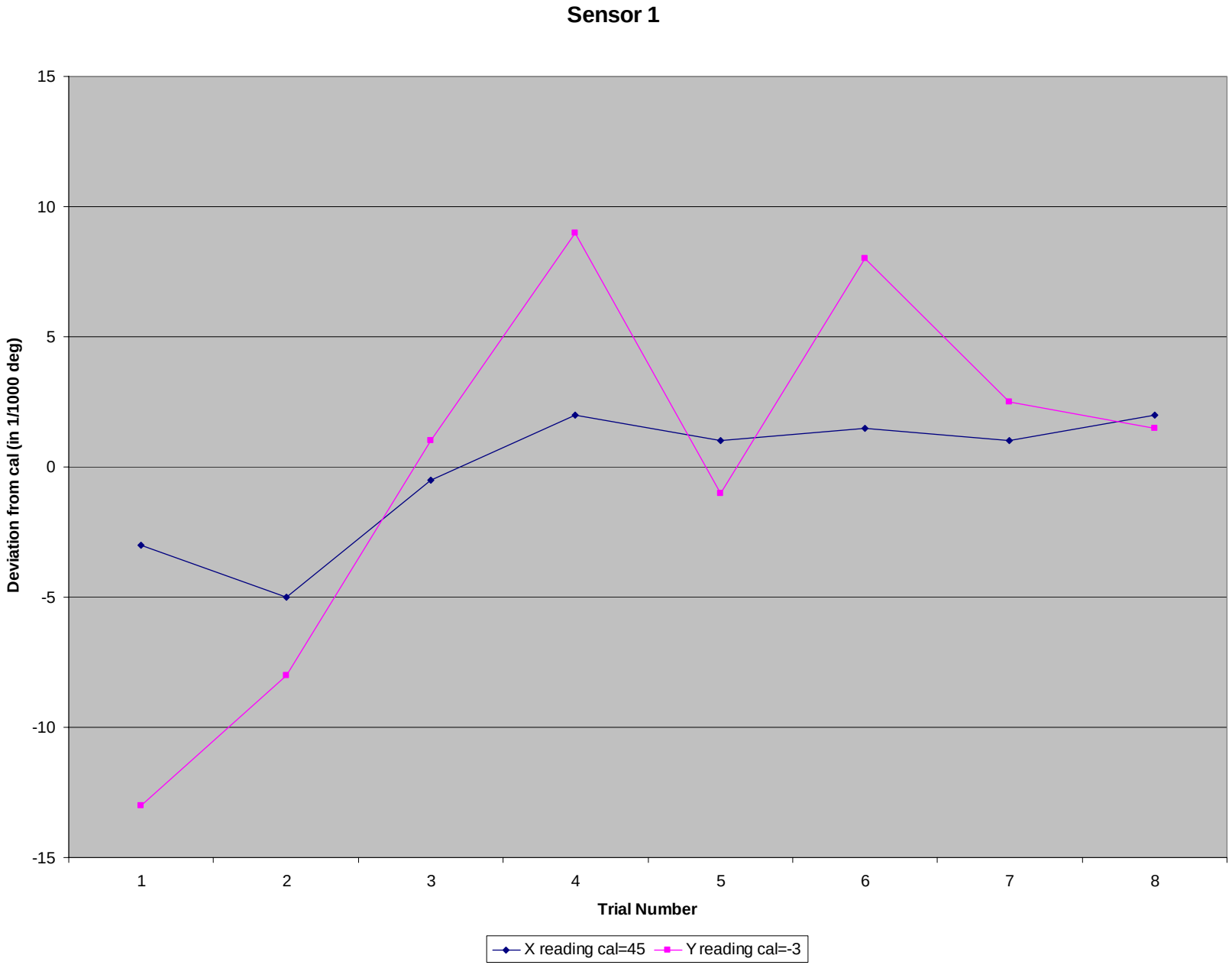
Tiltmeter in Position 4

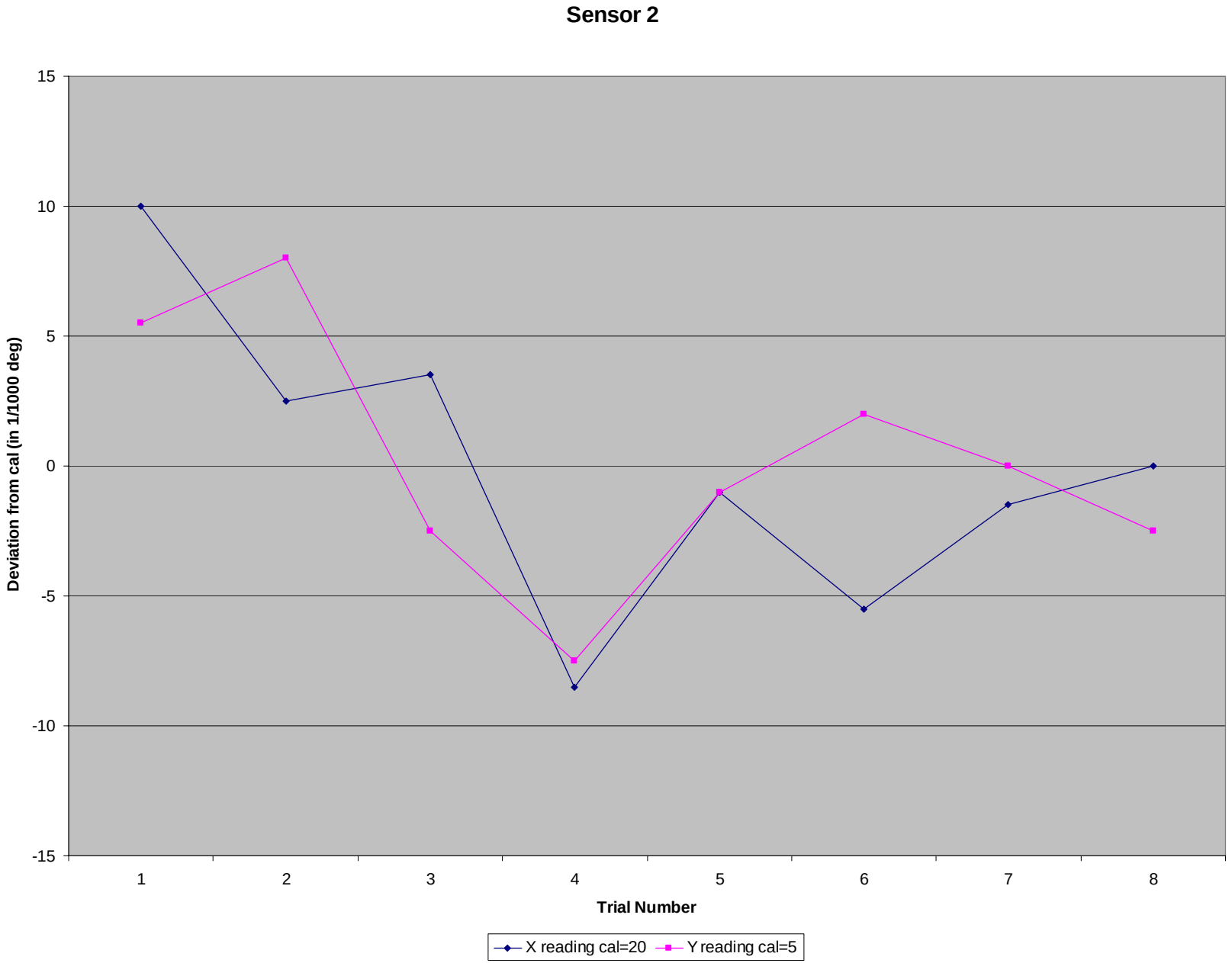




Naming Convention

- Sensor 1 has:
  - X readings in positions 1 & 3 leading to a temporary rough X calibration value of 45/1000 degrees.
  - Y readings in positions 2 & 4 leading to a temporary rough Y calibration value of -3/1000 degrees.
- Sensor 2 has:
  - X readings in positions 2 & 4 leading to a temporary rough X calibration of 20/1000 degrees.
  - Y readings in positions 1 & 3 leading to a temporary rough Y calibration of 5/1000 degrees.

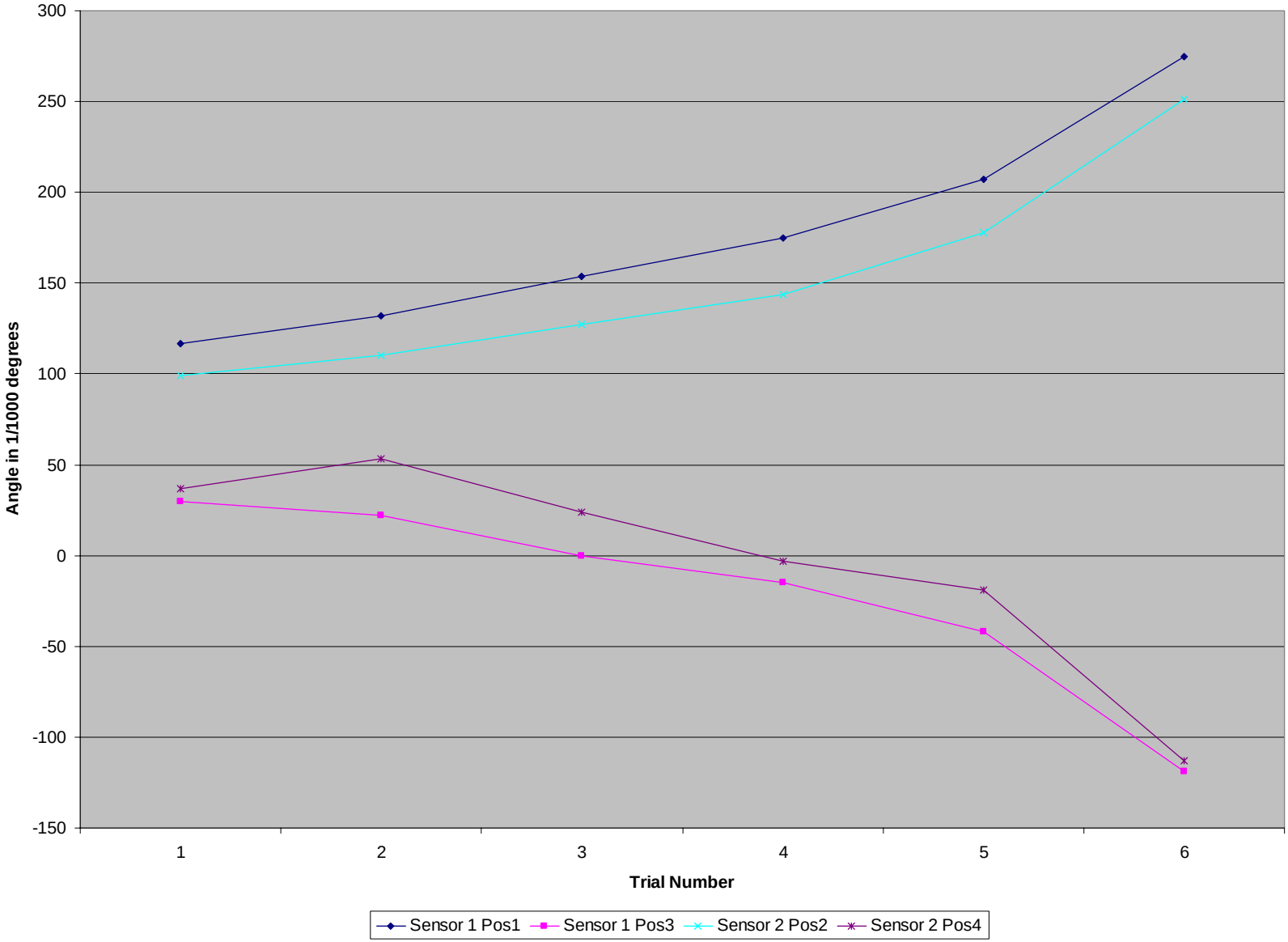

Sensor 1
15
10
5
0
-5
-10
-15
Deviation from cal (in 1/1000 deg)
1
2
3
4
5
6
7
8
Trial Number
X reading cal=45
Y reading cal=-3

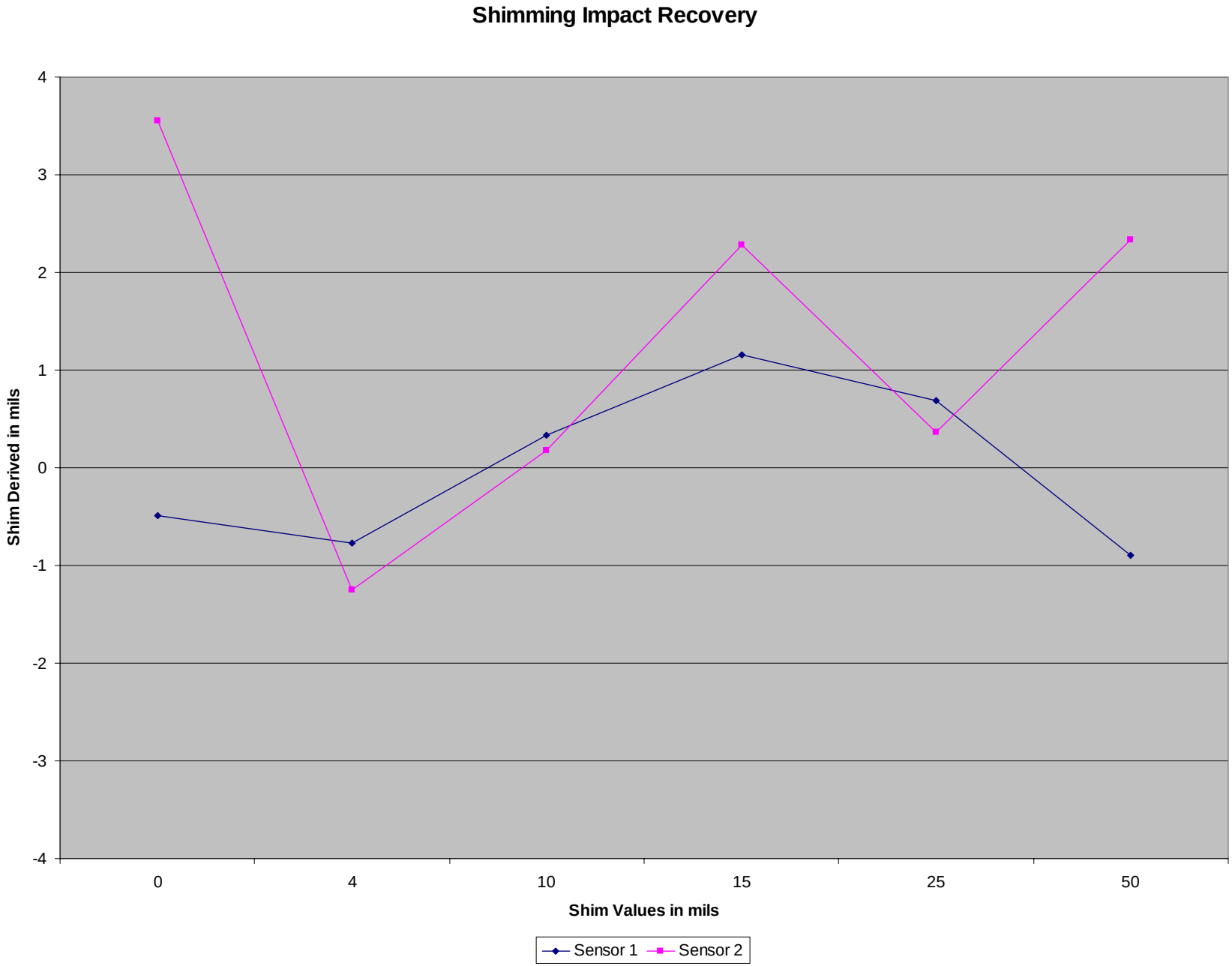

Sensor 2
15
10
5
0
-5
-10
-15
Deviation from cal (in 1/1000 deg)
1
2
3
4
5
6
7
8
Trial Number
X reading cal=20
Y reading cal=5

Shim Test

- Simulate roll by using shims under one foot of the triangular fixture shown previously.
- Shim values of 0, 4, 10, 15, 25 and 50 mils with a lever arm of 18.510 inches.
- Read the 4 positions and compute the derived roll for each sensor.

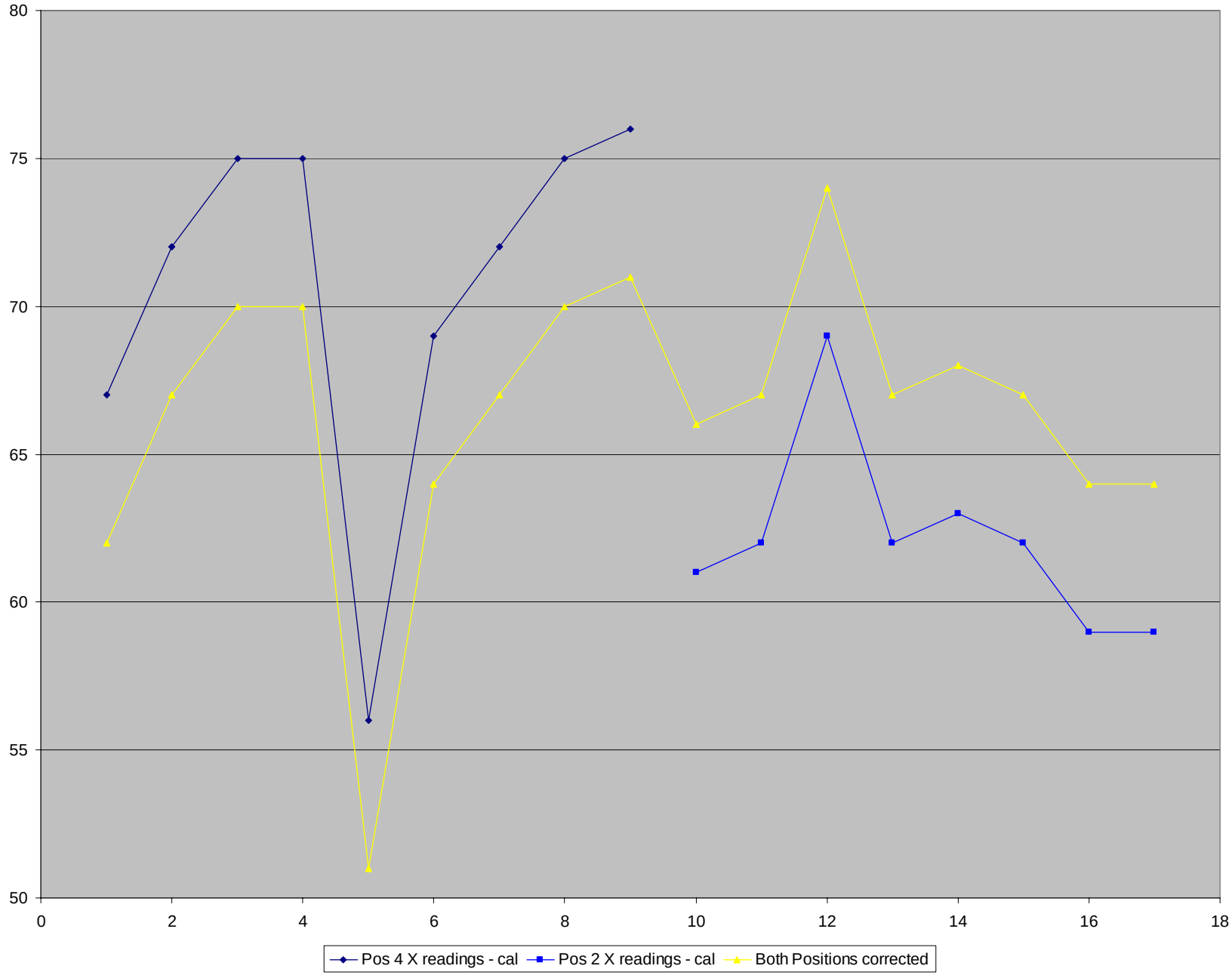
Fixture Roll through Shimming - Direct Measurement

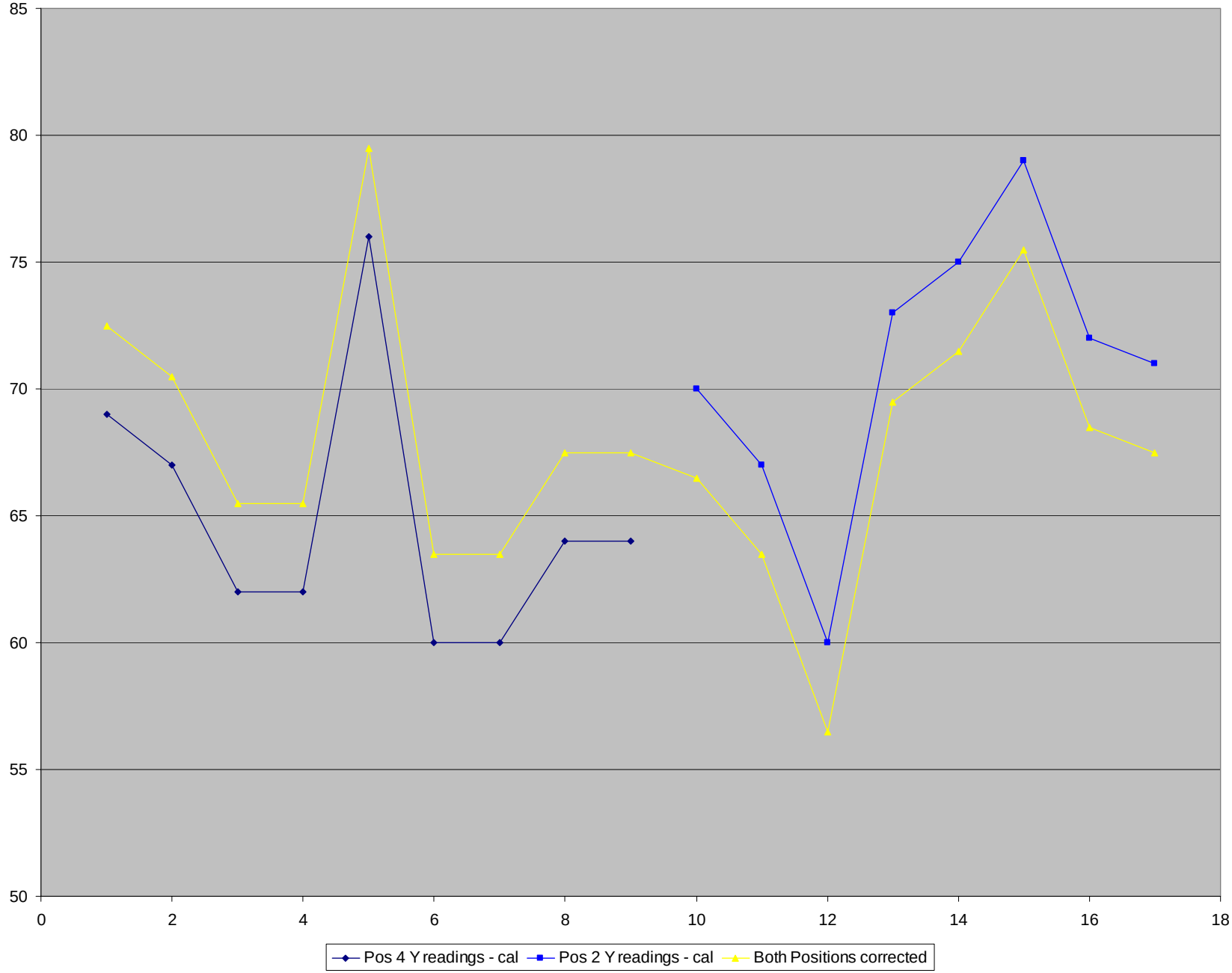



Shimming Impact Recovery
Shim Derived in mils
4
3
2
1
0
-1
-2
-3
-4
0
4
10
15
25
50
Shim Values in mils
Sensor 1
Sensor 2

Second Repeatability Test

- Concentrate on positions 2 and 4, making sure that the wiring is not hanging on the side.
- Wait at least 1 minute before making the readings.
- Check the ambient temperature.
- Use initially the calibration values from the first test. Then derive the specific ones (yellow curves in the next 2 slides).


80
75
70
65
60
55
50
0
2
4
6
8
10
12
14
16
18
Pos 4 X readings - cal
Pos 2 X readings - cal
Both Positions corrected


85
80
75
70
65
60
55
50
0
2
4
6
8
10
12
14
16
18
Pos 4 Y readings - cal
Pos 2 Y readings - cal
Both Positions corrected

Temporary Conclusion

- Current equipment is operational.
- Number of digits displayed (0.001°) is reasonable with the repeatability results and different from the reported resolution value (0.000057°).
- Further tests on temperature dependency and latency should strengthen the quality analysis of this sensor.