

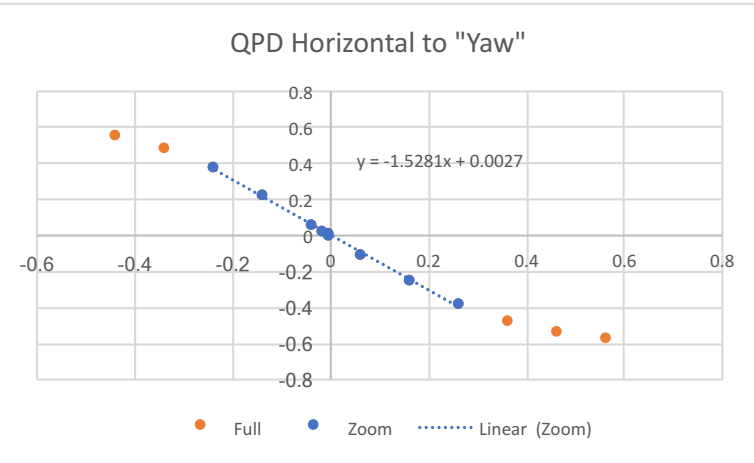
Calibration and Diagonalization of BS TILT OL

Calibration of QPD

Horizontal Movement of QPD

Data by Shoda-san and Mark

Micrometer	Zeroed	QPD*100	QPD
8.14	-0.435	55	0.55
8.24	-0.335	48	0.48
8.34	-0.235	37	0.37
8.44	-0.135	22	0.22
8.54	-0.035	5.5	0.055
8.56	-0.015	2	0.02
8.575	0	-0.5	-0.005
8.575	0	0	0
8.64	0.065	-11	-0.11
8.74	0.165	-26	-0.26
8.84	0.265	-38	-0.38
8.94	0.365	-48	-0.48
9.04	0.465	-54	-0.54
9.14	0.565	-58	-0.58

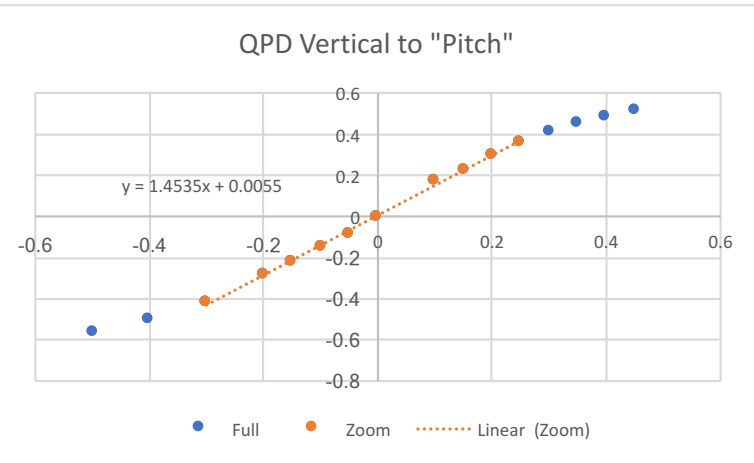


Slope: -1.528133 cts/mm

Vertical Movement of QPD

Data by Shoda-san and Mark

Micrometer	Zeroed	QPD*100	QPD
4.32	-0.5	-56	-0.56
4.42	-0.4	-50	-0.5
4.52	-0.3	-42	-0.42
4.62	-0.2	-28	-0.28
4.67	-0.15	-22	-0.22
4.72	-0.1	-15	-0.15
4.77	-0.05	-8	-0.08
4.82	0	0	0
4.92	0.1	17	0.17
4.97	0.15	23	0.23
5.02	0.2	30	0.3
5.07	0.25	36	0.36
5.12	0.3	41	0.41
5.17	0.35	45	0.45
5.22	0.4	49	0.49
5.27	0.45	52	0.52



Slope: 1.45351171 cts/mm

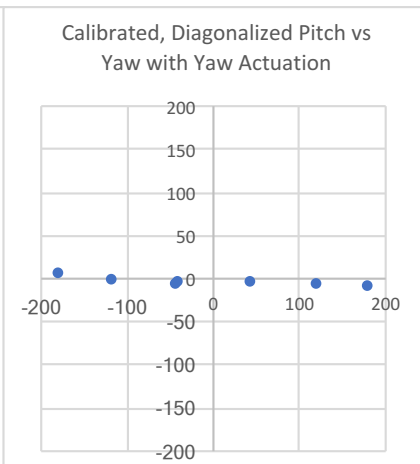
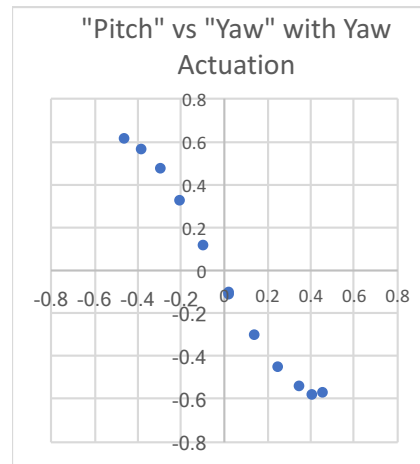
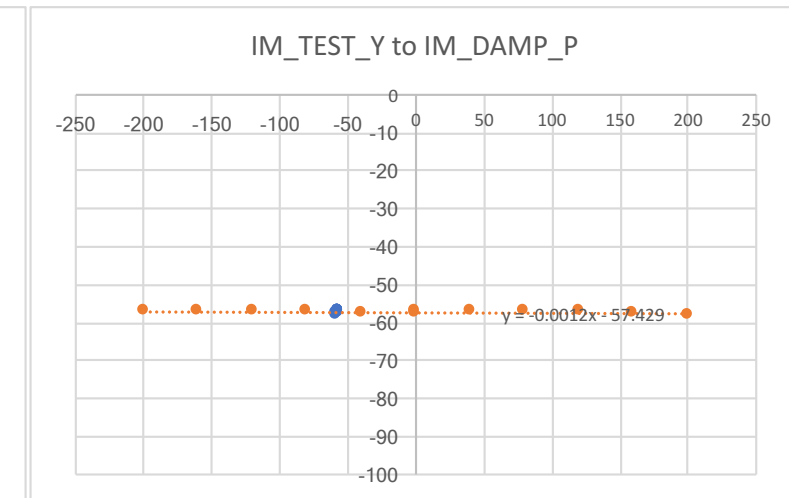
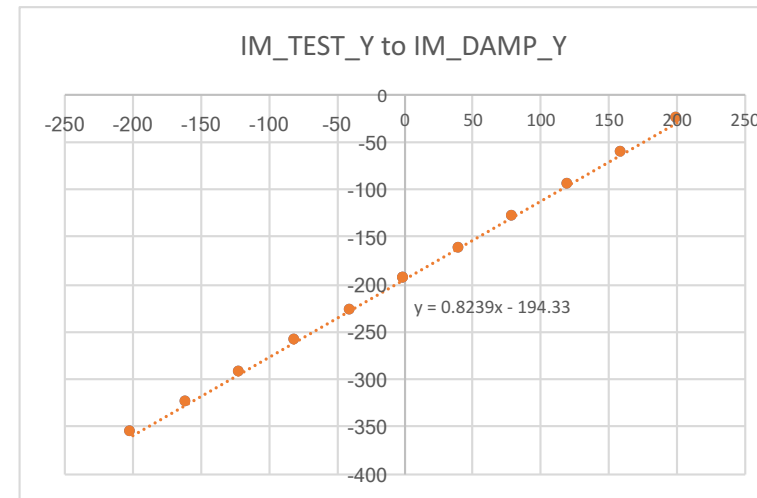
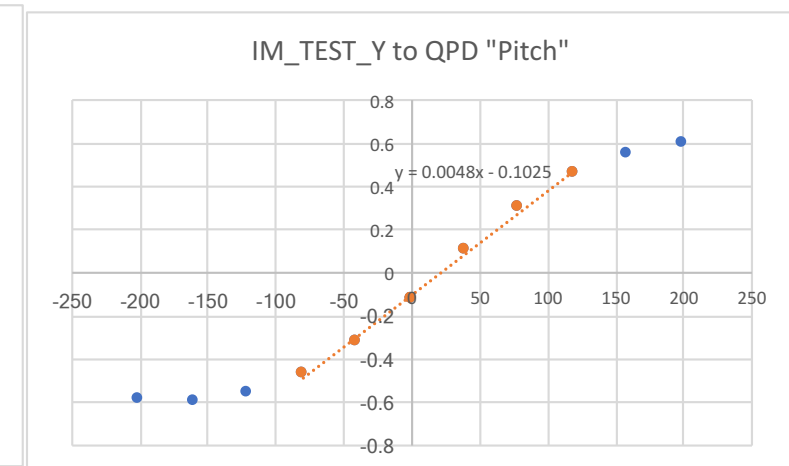
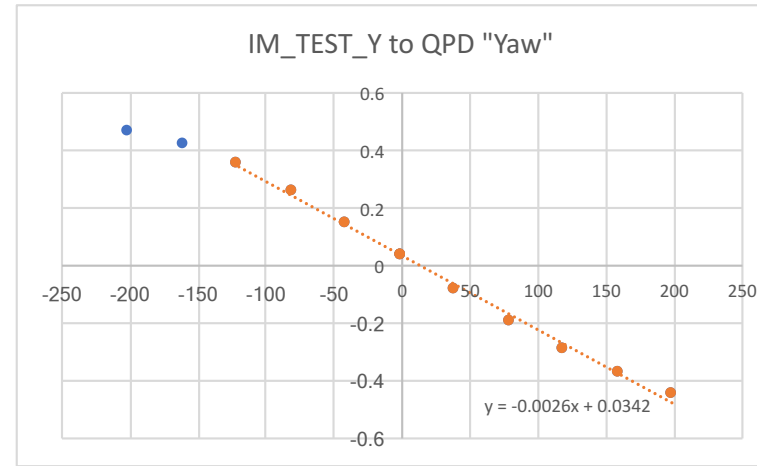
Response to Torques at IM

Data by Mark

Yaw Torque at IM

#	IM_TEST_Y	QPDY*100	QDPD*100	IM_DAMP_Y	IM_DAMP_P	QPDY	QDPD
12	-200	46	-58	-356.5	-57.3	0.46	-0.58
11	-160	41.6	-59	-325	-57.35	0.416	-0.59
10	-120	35	-55.5	-293	-57.4	0.35	-0.555
9	-80	25.5	-46.5	-261	-57.45	0.255	-0.465
8	-40	14.5	-31.5	-228.5	-57.55	0.145	-0.315
1	0	3	-11.5	-196	-56.95	0.03	-0.115
7	0	3	-12	-196	-57.55	0.03	-0.12
2	40	-8.5	10.5	-163	-57	-0.085	0.105
3	80	-19.5	31	-129.5	-57.1	-0.195	0.31
4	120	-29	46	-95.5	-57.45	-0.29	0.46
5	160	-37.5	55.5	-61.5	-57.9	-0.375	0.555
6	200	-45	60.25	-26.5	-58.15	-0.45	0.6025

Slopes: 0.82386364 -0.0012159 -0.0025753 0.0048125
 μrad/ct(A) μrad/ct(A) ct/ct(A) ct/ct(A)



Calibrated, diagonalized QPD data

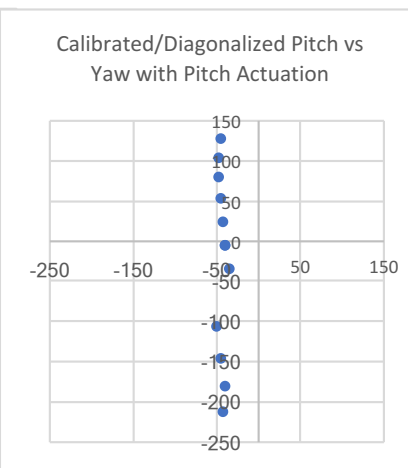
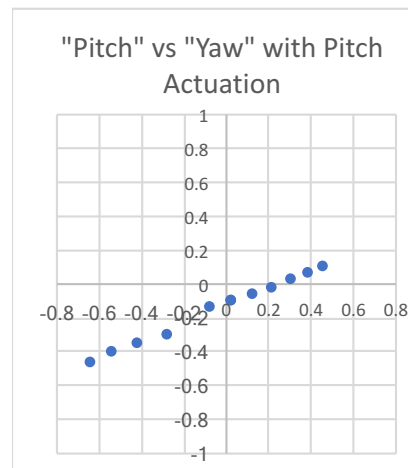
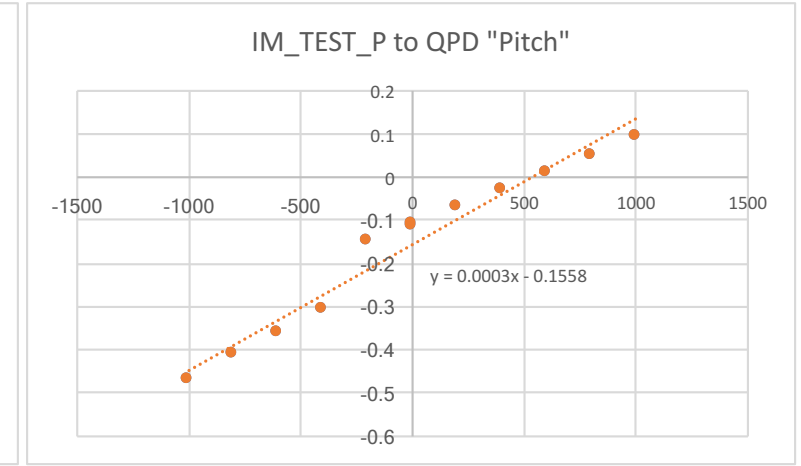
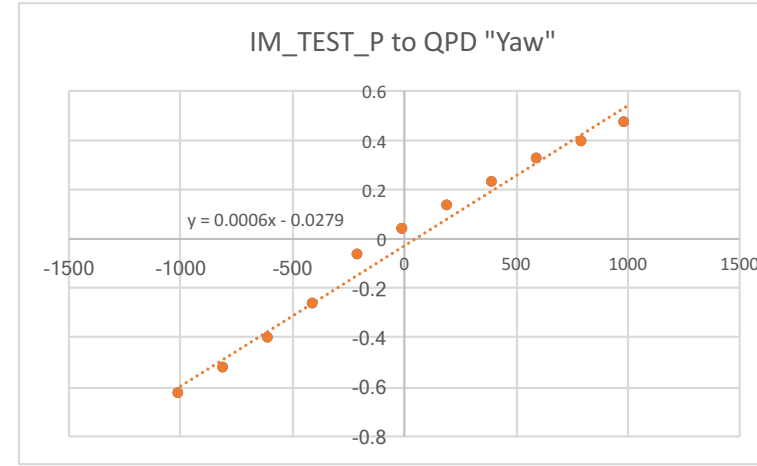
QPDY	QDPD
-243.71807	38.3813412
-239.84237	26.2721786
-219.1869	14.5517212
-177.69444	2.78718226
-116.05847	-4.9342215
-38.802839	-7.4419417
-40.287031	-8.0862703
44.38956	-7.3723472
122.351646	-8.0061359
181.654408	-12.038731
223.075584	-20.699736
248.841461	-33.022656

Mysterious Calibration Factor Difference: 2.17129214

Pitch Torque at IM

#	IM_TEST_P	QPDY*100	QDPD*100	IM_DAMP_Y	IM_DAMP_P	QPDY	QDPD
12	-1000	-63	-47	-194.8	-71.4	-0.63	-0.47
11	-800	-53	-41	-195	-69	-0.53	-0.41
10	-600	-41	-36	-195	-66.65	-0.41	-0.36
9	-400	-27.5	-31	-195.5	-64.3	-0.275	-0.31
8	-200	-7	-15	-195.5	-61.15	-0.07	-0.15
1	0	3	-11.5	-196	-58.35	0.03	-0.115
7	0	3	-11	-196	-58.8	0.03	-0.11
2	200	13	-7	-196	-56.2	0.13	-0.07
3	400	22.5	-3	-196.5	-54.1	0.225	-0.03
4	600	31.5	1	-196	-51.95	0.315	0.01
5	800	39	5	-196.5	-49.8	0.39	0.05
6	1000	46	9.5	-196	-47.6	0.46	0.095

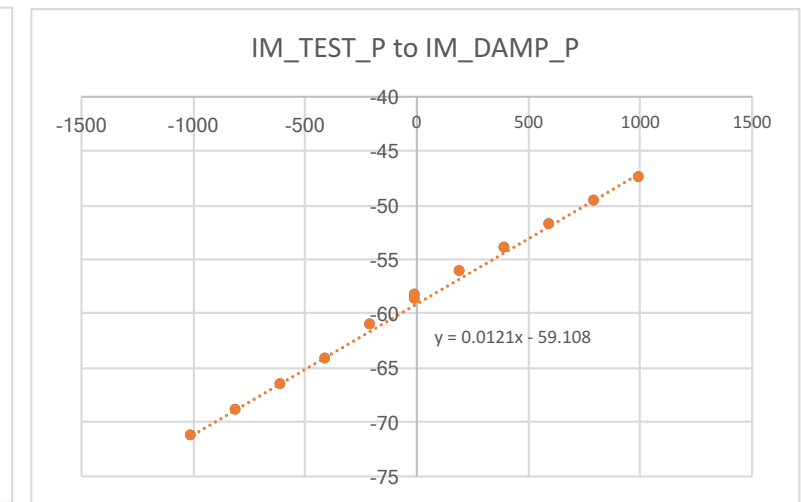
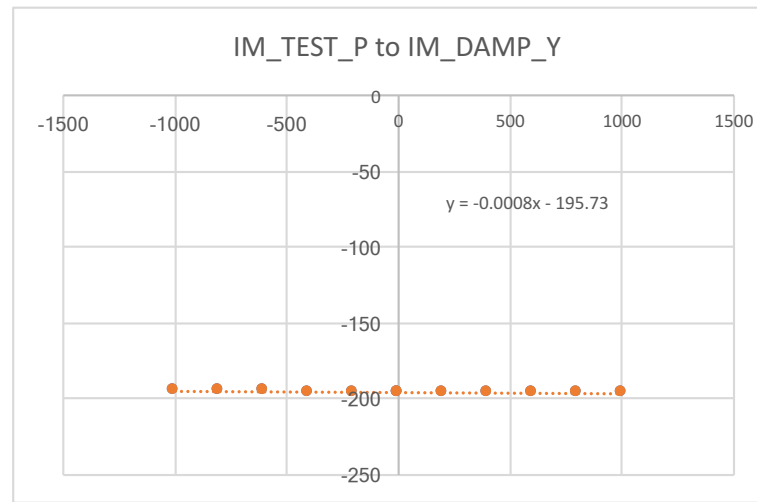
Slopes: -0.0007955 0.01205682 0.00056841 0.00029159
 μrad/ct(A) μrad/ct(A) ct/ct(A) ct/ct(A)



Calibrated, diagonalized QPD data
 QPDY QPDP

-41.519211	-215.49685
-39.263643	-183.17285
-43.087407	-147.2191
-49.244381	-107.57653
-33.637446	-36.5443
-38.802839	-7.4419417
-37.318647	-6.797613
-40.999847	22.9490736
-43.903311	51.4661574
-46.029038	78.7536383
-45.821554	102.352311
-43.352141	125.365709

Mysterious Calibration Factor Difference: 14.3219565



Analysis

Lever Arm Calc

			7-Nov	"Yaw"	"Pitch"
Internal to tank	976				
Viewport glass to beam spot on steering	105	7-Nov	335.1239	277.638804	μrad/ct
Steering mirror to beamsplitter: 28 mm	34	7-Nov			
Beamsplitter to TILT QPD	124	1-Dec			
Total lever arm:	1239				
Beam angle	rad	°			
	0.66322512	38	5-Dec		

QPD Calibration

Matrix from IM Torque [Y;P] to IM Angle [Y;P] - μrad/ct(A)

$$[Y;P] = \begin{bmatrix} 0.82386364 & -0.0007955 \\ -0.0012159 & 0.01205682 \end{bmatrix} \cdot [Y;P]$$

$$\begin{matrix} \text{rad} & \text{°} \\ -0.0014759 & -0.0845606 \\ -0.06588 & -3.774647 \end{matrix}$$

Matrix from IM Torque [Y;P] to Raw QPD ["Yaw";"Pitch"] - kct/ct(A)

$$["Yaw";"Pitch"] = \begin{bmatrix} -0.0025753 & 0.00056841 \\ 0.0048125 & 0.00029159 \end{bmatrix} \cdot [Y;P]$$

$$\begin{matrix} \text{rad} & \text{°} \\ 2.06215387 & 118.152713 & 61.8472867 \\ 1.096807 & 62.8424122 \end{matrix}$$

Matrix from IM Torque [Y;P] to Raw QPD ["Yaw";"Pitch"] - μrad/ct(A)

$$["Yaw";"Pitch"] = \begin{bmatrix} -0.0025753 & 0.00056841 \\ 0.0048125 & 0.00029159 \end{bmatrix} \cdot [Y;P]$$

$$\begin{matrix} \text{rad} & \text{°} \\ 1.07943879 & 61.8472867 \\ 1.096807 & 62.8424122 \\ \text{Average:} & 1.08812289 & 62.3448494 \end{matrix}$$

Diagonalization and Calibration

$$\text{Rotation Angle} = \begin{matrix} \text{rad} & \text{°} \\ 1.08812289 & 62.3448494 \end{matrix}$$

Rotation Matrix

$$[Yunc;Punc] = \begin{bmatrix} -0.4641488 & 0.88575722 \\ 0.88575722 & 0.46414884 \end{bmatrix} \cdot ["Y";"P"]$$

Calibration Matrix

$$[Y;P] = \begin{bmatrix} 335.1239 & 0 \\ 0 & 277.638804 \end{bmatrix} \cdot [Yunc;Punc]$$

Net Calibration*Rotation Matrix

$$[Y;P] = \begin{bmatrix} -155.54737 & 296.838414 \\ 245.920575 & 128.86573 \end{bmatrix} \cdot [Y;P]$$

Flipped form for typing into lower left corner of screen

$$[P;Y] = \begin{bmatrix} 128.86573 & 245.920575 \\ 296.838414 & -155.54737 \end{bmatrix} \cdot [TILT_P;TILT_Y]$$

Net Calibration*Rotation Matrix/100

$$[Y;P] = \begin{bmatrix} -1.5554737 & 2.96838414 \\ 2.45920575 & 1.2886573 \end{bmatrix} \cdot [Y;P]$$

For use if Simon's gains of 100 are kept in screen

$$[P;Y] = \begin{bmatrix} 1.2886573 & 2.45920575 \\ 2.96838414 & -1.5554737 \end{bmatrix} \cdot [TILT_P;TILT_Y]$$

cf:

For use if Simon's gains of 100 are kept in