SIRTF INSTRUMENT POINTING FRAME
KALMAN FILTER EXECUTION SUMMARY

IPF RUN NUMBER: 01P107
REPORT TYPE: IOC EXECUTION (PRECOARSE)

PRIME FRAME: MIPS_70um_center (107)
INFERRED FRAMES: (108) (111) (112) (115)

IPF TEAM

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1 IPF EXECUTION SUMMARY

This report summarizes the SIRTF Instrument Pointing Frame (IPF) Kalman Filter execution associated with run file: RN01P107. In particular, this Focal Point Survey calibrates the instrument: MIPS_70um_center (107), as part of the IOC Precoarse Survey. The main calibration results from the IPF filter execution have been documented in IF01P107 typically stored in the mission archive DOM collection IPF_IF. This report only summarizes the main aspects of the run, and does not substitute for the full information contained in the IF file.

Section 1 summarizes the filter execution results. The filter configurations are tabulated in Table 1.2 and the mask vector assignments are tabulated in Table 1.3. A total of 3 state parameters are estimated in this run. The overall End-to-End pointing performances are tabulated in Table 1.4. The prediction residuals throughout the estimation processes are tabulated in Table 1.5. Section 3 summarizes resulting plots, a mini summary of the IF IPF output file, and the execution log. Section 4 captures the user comments that are specific to this particular run.

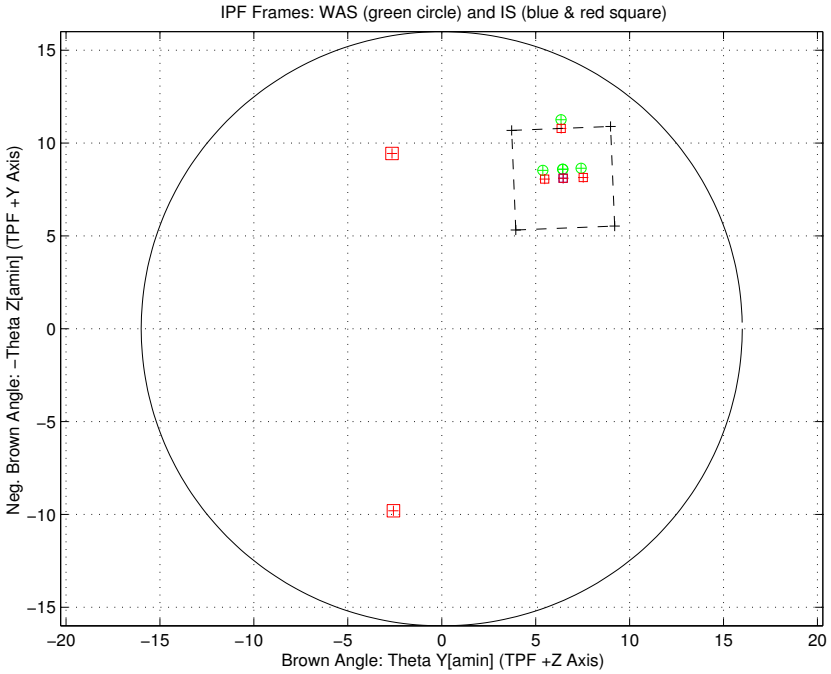

Figure 1.1: A-priori and a-posteriori IPF frames

RAW	FINAL (After Editing)
AA01P107	AA01P107
AS01P107	AS01P107
CA02P107	CA02P107
CB01P107	CB01P107
CS02P107	CS02P107

Table 1.1: IPF filter input files

EXECUTION CONFIGURATION ITEM	CURRENT STATUS
IPF Filter Version Used	IPF.V2.0.0C
Frame Table Version Used	BodyFrames_FTU_07f
Scan-Mirror Employed?	NO
IPF Filter Mode	LITE-MODE(3):FLT
SLIT-MODE Operation	DISABLED
Kalman Filter Operation	ENABLED
Least-Squares Data Analysis	ENABLED
IBAD Screening	ENABLED
User-Specified Data Editing	DISABLED
Total Number of Iterations	20
LS Residual Sigma Scale	9.77997034E-001
Total Number of Maneuvers	1

Table 1.2: IPF filter execution configuration

Con. Plate Scale			Γ Dependent				Γ^2 Dependent				Linear Plate Scale						Mirror	
a_{00}	b_{00}	c_{00}	a_{10}	b_{10}	c_{10}	d_{10}	a_{20}	b_{20}	c_{20}	d_{20}	a_{01}	b_{01}	c_{01}	d_{01}	e_{01}	f_{01}	α	β
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IPF (T)			Alignment R								Gyro Drift Bias							
θ_1	θ_2	θ_3	a_{rx}	a_{ry}	a_{rz}	b_{rx}	b_{ry}	b_{rz}	c_{rx}	c_{ry}	c_{rz}	b_{gx}	b_{gy}	b_{gz}	c_{gx}	c_{gy}	c_{gz}	
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 1.3: IPF filter execution mask vector assignment

FOCAL PLANE SURVEY ANALYSIS: IOC Precoarse Survey.
INSTRUMENT NAME: MIPS_70um_center NF: 107
`PIX2RADW: 4.79044679E-005[rad/pixel] = 9.8810E+000[arcsec/pixel]`
`PIX2RADV: 4.79044679E-005[rad/pixel] = 9.8810E+000[arcsec/pixel]`

FRAME	DESCRIPTION	IPF[1]	SF[2]	TOTAL	REQ
107(P)	MIPS_70um_center	1.6394	0.0855	1.6417	2.65
108(I)	MIPS_70um_minusY_edge	1.9527	0.0855	1.9545	N/A
111(I)	MIPS_70um_default_small_FOV1	1.6865	0.0855	1.6887	N/A
112(I)	MIPS_70um_default_small_FOV2	1.7462	0.0855	1.7483	N/A
115(I)	MIPS_70um_default_large_FOV1	1.6394	0.0855	1.6417	N/A

Table 1.4: IPF calibration error summary ([arcsec], 1-sigma, radial)

RMS METRIC	A PRIORI[3]	A POSTERIORI[3]	ATT. CORRECTED[4]	UNITS
Radial	29.9750	5.3593	4.8466	arcsec
W-Axis	4.3432	4.3309	3.7298	arcsec
V-Axis	29.6587	3.1569	3.0949	arcsec
Radial	3.0336	0.5424	0.4905	pixels
W-Axis	0.4395	0.4383	0.3775	pixels
V-Axis	3.0016	0.3195	0.3132	pixels

Table 1.5: Measurement prediction error summary (1-sigma)

[1]IPF filter removes systematic pointing errors due to: thermomechanical alignment drift (Body to TPF), gyro bias and bias drift, centroiding error, attitude error, and optical distortion. IPF SIGMA presented here is "Scaled" by the Least Squares Scale factor. The Least Squares Scale Factor was: 0.977997. It is assumed that the gyro Angle Random Walk contribution is captured with the Least Squares scaling. The gyro ARW contribution can be approximately calculated as 0.7557 arcseconds, given that ARW = 100 $\mu deg/\sqrt{hr}$, with 7931 second Maneuver time (max), and 1 independent Maneuvers.

[2]Gyro Scale Factor(GSF) assumes 95 ppm error over 0.250 degree maneuver.

[3]This can be interpreted as estimate of "pixel to sky" pointing reconstruction error if no science data is used.

[4]This can be interpreted as estimate of achieved S/I centroiding error

IPF BROWN ANGLE SUMMARY					
FRAME TABLE USED: BodyFrames_FTU_07f					
NF	NAME	WAS	IS	CHANGE	UNIT
107	theta_Y	+6.445000	+6.465320	+0.020320	arcmin
107	theta_Z	-8.592000	-8.103026	+0.488974	arcmin
107	angle	+0.000000	-2.285674	-2.285674	deg
108	theta_Y	+6.348000	+6.358283	+0.010283	arcmin
108	theta_Z	-11.259000	-10.784699	+0.474301	arcmin
108	angle	-0.000000	-2.285674	-2.285674	deg
111	theta_Y	+7.423000	+7.534911	+0.111911	arcmin
111	theta_Z	-8.647000	-8.145717	+0.501283	arcmin
111	angle	-0.000000	-2.285674	-2.285674	deg
112	theta_Y	+5.385000	+5.478006	+0.093006	arcmin
112	theta_Z	-8.533000	-8.063618	+0.469382	arcmin
112	angle	+0.000000	-2.285674	-2.285674	deg
115	theta_Y	+6.445000	+6.465320	+0.020320	arcmin
115	theta_Z	-8.592000	-8.103026	+0.488974	arcmin
115	angle	+0.000000	-2.285674	-2.285674	deg

Table 1.6: IPF Brown angle summary

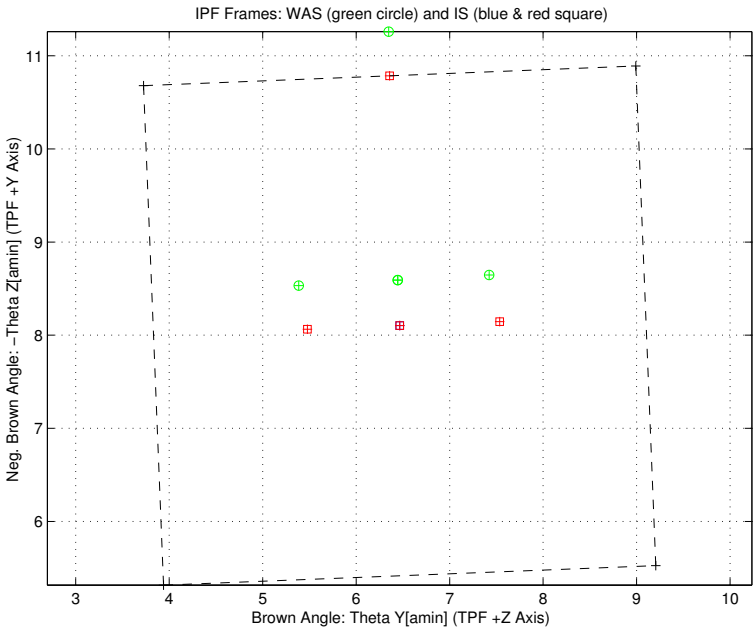

Figure 1.2: A-priori and a-posteriori IPF frames (ZOOMED)

2 IPF INPUT FILE HISTORY

WAS	SIZE	IS	SIZE	REMOVED	PATCHED
AA01P107	UNCHANGED	AA01P107	UNCHANGED	0	0
CA02P107	UNCHANGED	CA02P107	UNCHANGED	0	N/A
CB01P107	UNCHANGED	CB01P107	UNCHANGED	0	N/A

Table 2.1: IPF input file editing status

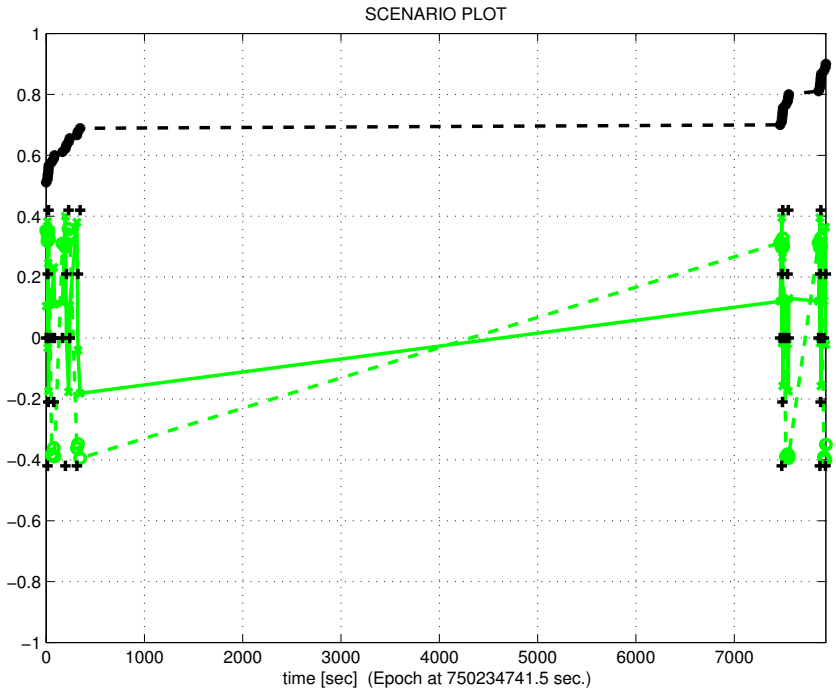

Figure 2.1: Scenario Plot

3 IPF EXECUTION RESULTS

3.1 IPF EXECUTION OUTPUT PLOTS

This subsection summarizes the IPF filter results. As shown in Table 3.1, the output plots are segmented to three groups: predicted performance, post-run results and IPF trending plots.

FIGURE NO.	DESCRIPTION
Predicted performance prior to IPF run	
Figure 3.1	Meas. and a-priori predicts in TPF coords
Figure 3.2	Meas. and a-priori predicts in Oriented Pixel Coords including rectangular array boundary approximation
Figure 3.3	A-Priori Prediction Error Quiver Plot in Oriented Pixel Coords including rectangular array boundary approximation
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Figure 3.5	Oriented Pixel Coords of measurements and a-priori predicts (PCRS only)
Figure 3.6	Oriented Pixel Coords of measurements and a-priori predicts (Zoomed, PCRS only)
Figure 3.7	Oriented (W,V) Pixel Coords of A-Priori PCRS Prediction Error Quiver Plot
Figure 3.8	A-priori PCRS prediction error
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Figure 3.9	IPF execution convergence, chart 1: (top) normalized residual error vs. iteration number and (bottom) norm of effective parameter corrections
Figure 3.10	IPF execution convergence, chart 2: parameter correction size vs. iteration number
Figure 3.11	Parameter uncertainty convergence: square-root of diagonal elements of covariance matrix vs. maneuver number
Figure 3.12	IPF parameter symbol table
Figure 3.13	KF parameter error sigma plot (a-priori-dashed, a-posteriori-solid). Includes true parameter errors (FLUTE runs only)
Figure 3.14	LS parameter error sigma plot. Includes true parameter errors (FLUTE runs only)
Figure 3.15	KF and LS parameter errors sigma plot (Figure 3.13 & Figure 3.14 combined)
Figure 3.16	Measurements and a-posteriori predicts in Oriented Pixel Coords including rectangular array boundaries (a-priori-dashed, a-posteriori-solid)
Figure 3.17	Attitude corrected meas. and a-posteriori predicts in Oriented Pixel Coords including rectangular array boundaries (a-priori-dashed, a-posteriori-solid)

Table 3.1: Table of figures I (IPF run)

FIGURE NO.	DESCRIPTION
IPF filter performance (post run results) - CONTINUE	
Figure 3.18	KF innovations with (o) and w/o (+) attitude corrections
Figure 3.19	Histograms of science a-posteriori residuals (or innovations)
Figure 3.20	KF innovations with (o) and w/o (+) attitude corrections (PCRS)
Figure 3.21	Histograms of PCRS a-posteriori residuals (or innovations)
Figure 3.22	A-Posteriori Science Centroid Prediction Error Quiver (Att. Cor.)
Figure 3.23	Normalized A-Posteriori Science Centroid Prediction Errors
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Figure 3.25	Normalized A-Posteriori PCRS Prediction Errors
Figure 3.26	W-axis KF innovations and 1-sigma bound
Figure 3.27	V-axis KF innovations and 1-sigma bound
Figure 3.28	Array plot with (solid) and w/o (dashed) optical distortion corrections
Figure 3.29	Optical Distortion Plot: total (x5 magnification)
Figure 3.30	Optical Distortion Plot: constant plate scales (x5 magnification)
Figure 3.31	Optical Distortion Plot: linear plate scale (x5 magnification)
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IPF parameter trending plots	
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Figure 3.36	Systematic error attributed to thermo-mechanical boresight drift (equiv. angle in Body frame)
Figure 3.37	Systematic error attributed to gyro drift bias (equiv. rate in (W,V) coords)
Figure 3.38	Systematic error attributed to gyro drift bias (equiv. angle in (W,V) coords)
Figure 3.39	Systematic error attributed to gyro drift bias (equiv. angle in Body frame)

Table 3.2: Table of figures II (IPF run)

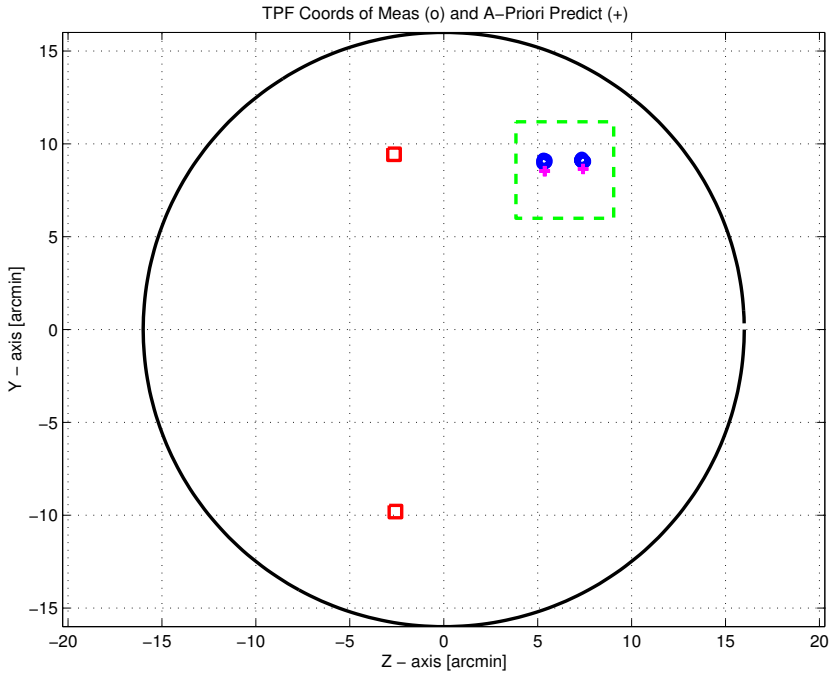

Figure 3.1: TPF coords of measurements and a-priori predicts

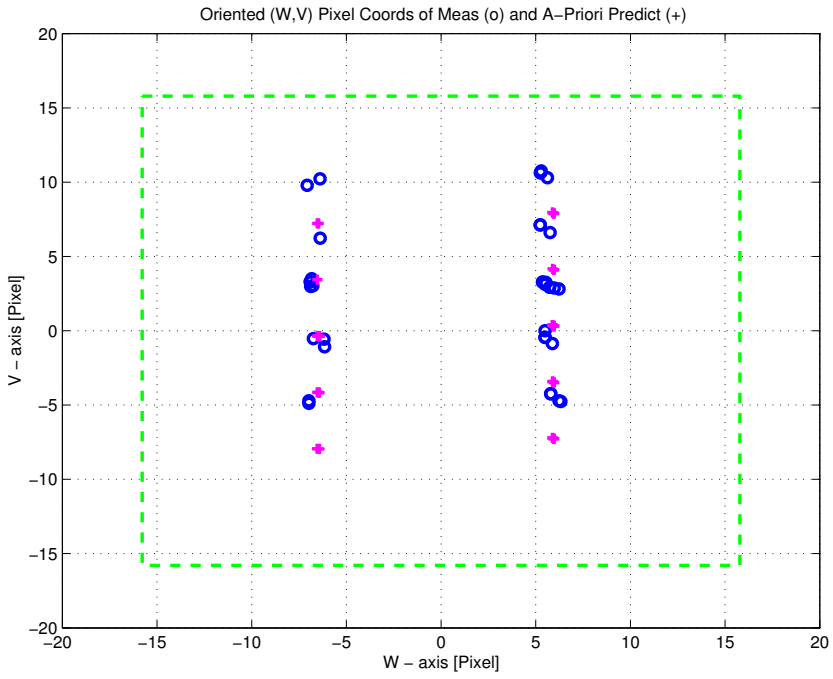

Figure 3.2: Oriented Pixel Coords of measurements and a-priori predicts

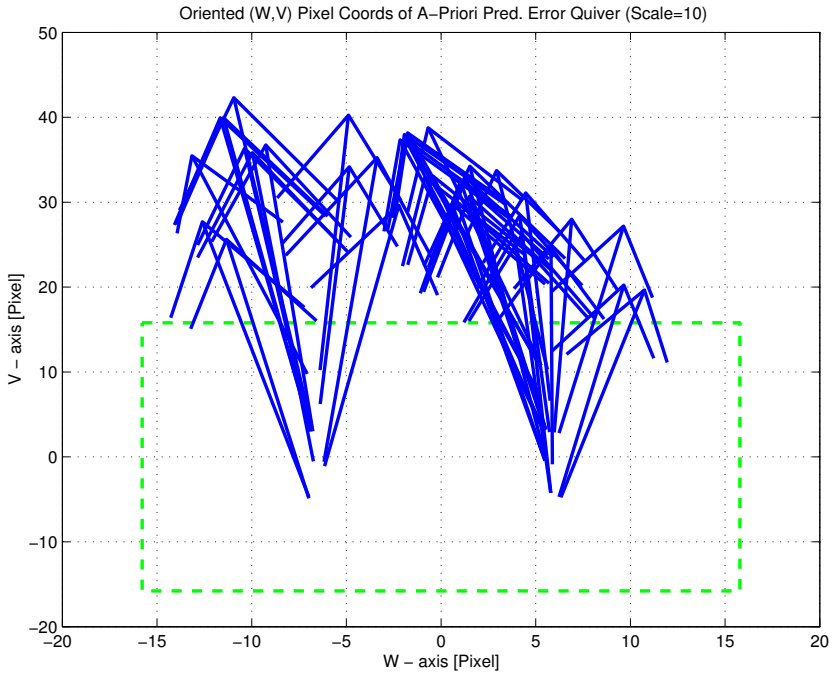

Figure 3.3: Oriented (W,V) Pixel Coords of A-Priori Prediction Error Quiver Plot

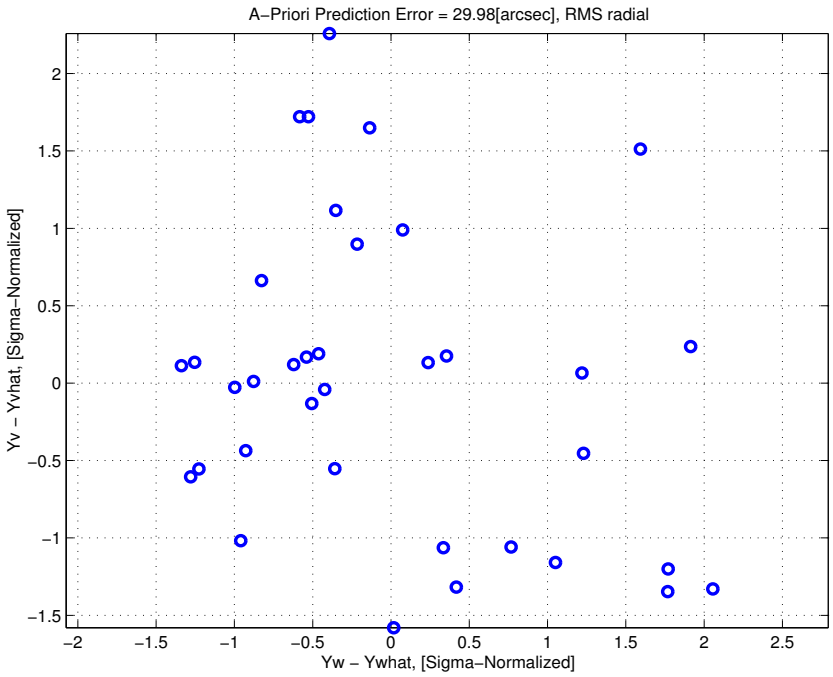

Figure 3.4: A-priori prediction error (Science Centroids)

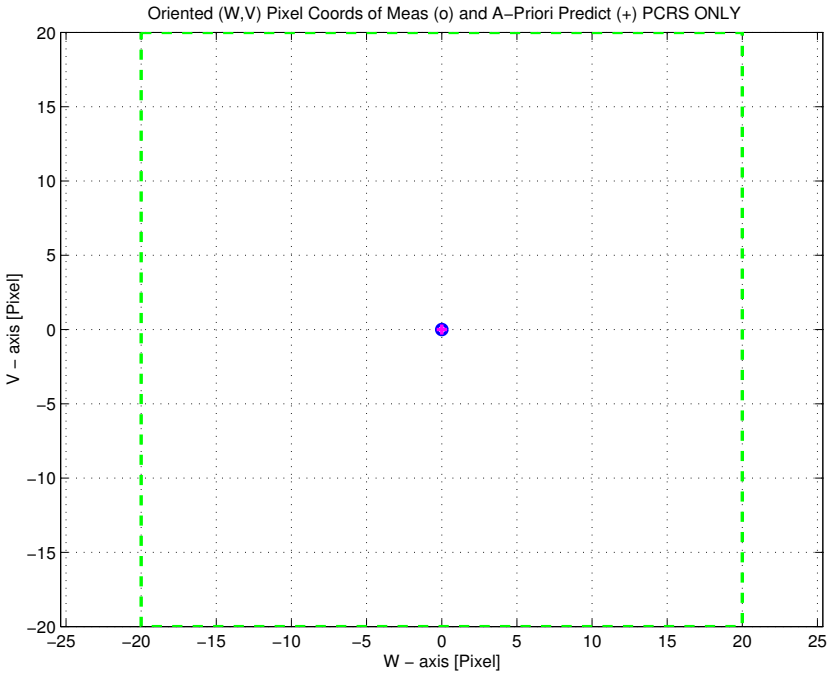

Figure 3.5: Oriented Pixel Coords of measurements and a-priori predicts (PCRS only)

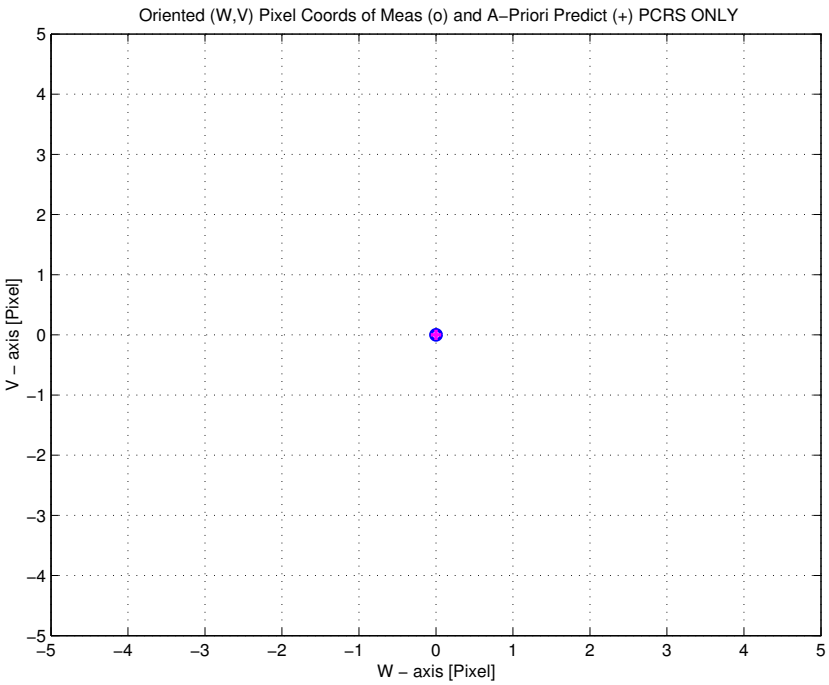

Figure 3.6: Oriented Pixel Coords of measurements and a-priori predicts (Zoomed, PCRS only)

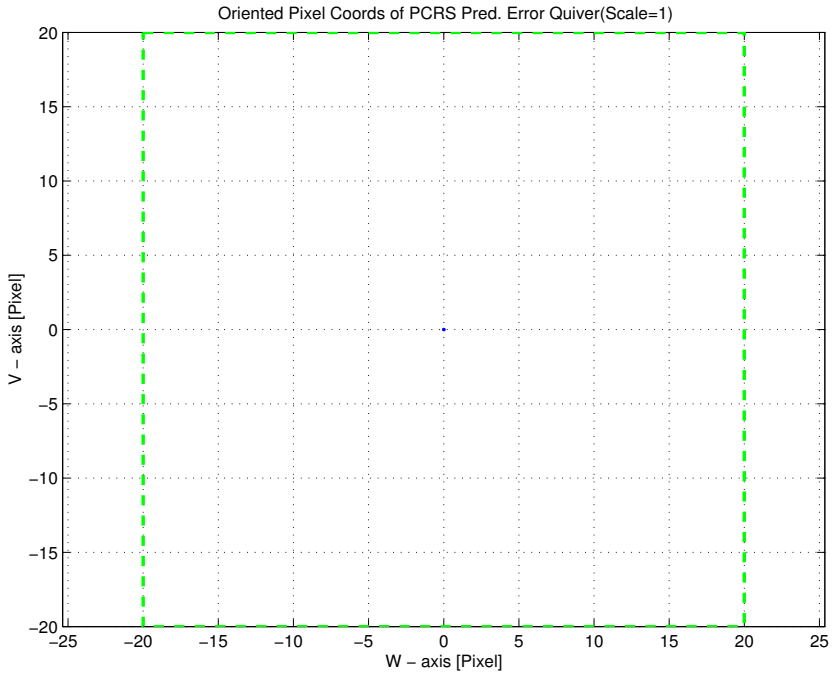

Figure 3.7: Oriented (W,V) Pixel Coords of A-Priori PCRS Prediction Error Quiver Plot

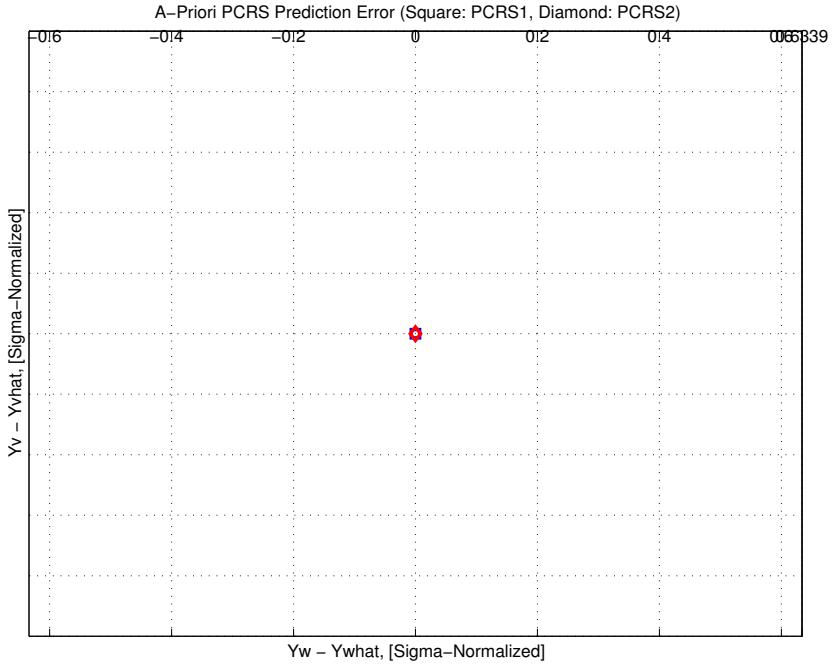

Figure 3.8: A-priori PCRS prediction error

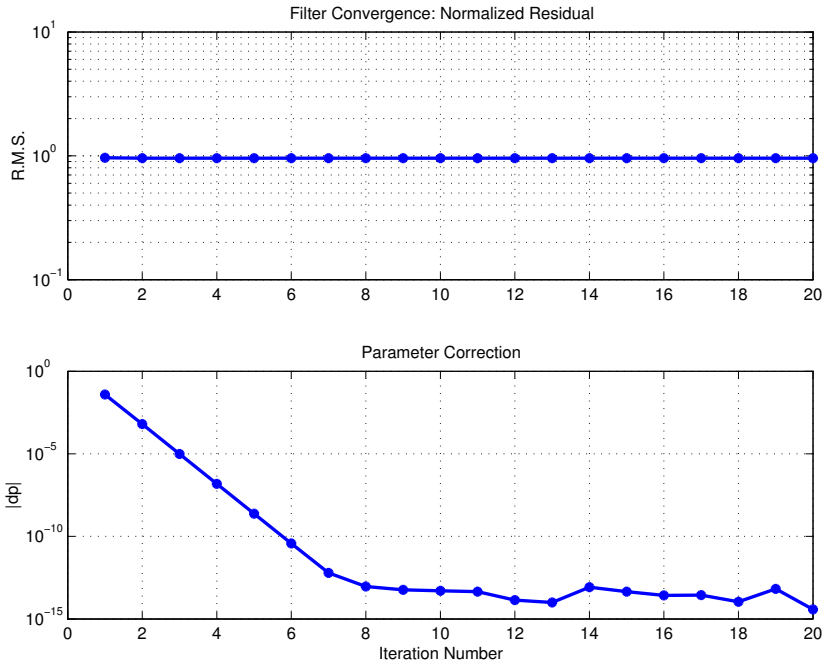

Figure 3.9: IPF execution convergence, chart 1

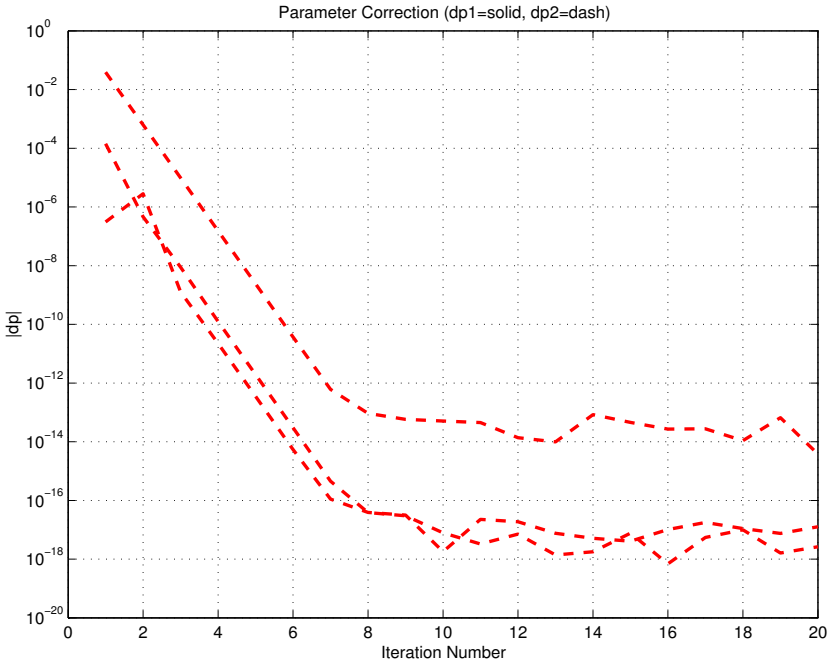

Figure 3.10: IPF execution convergence, chart 2

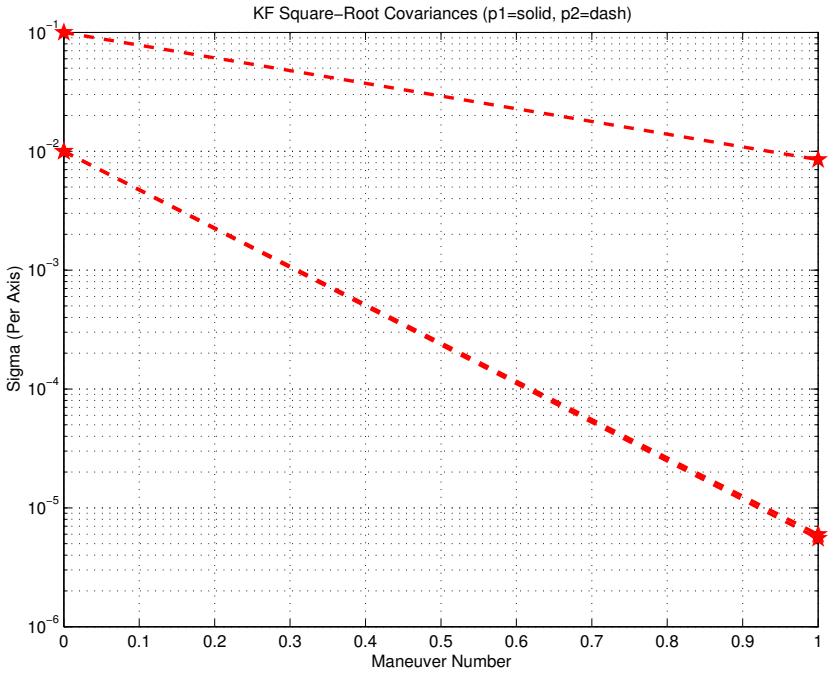

Figure 3.11: Parameter uncertainty convergence

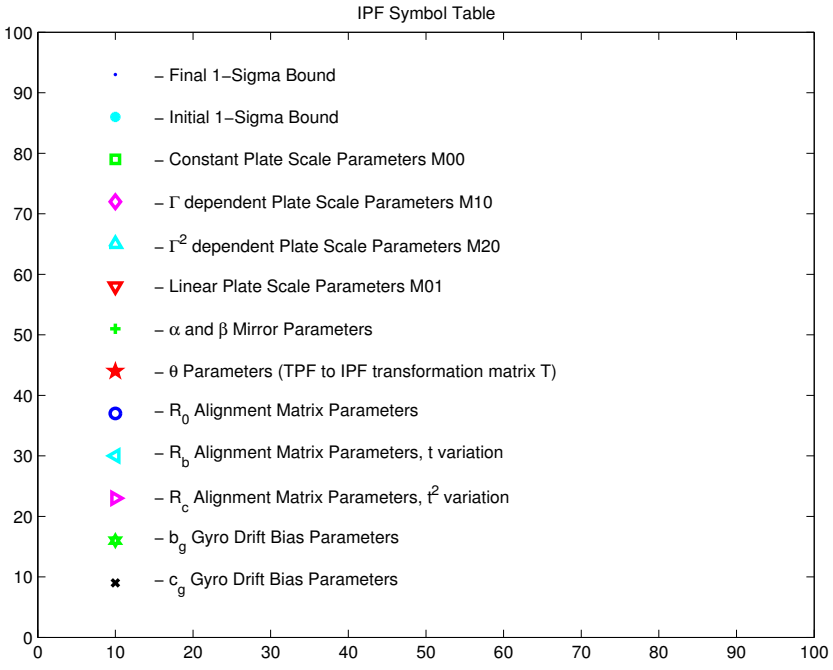

Figure 3.12: IPF parameter symbol table

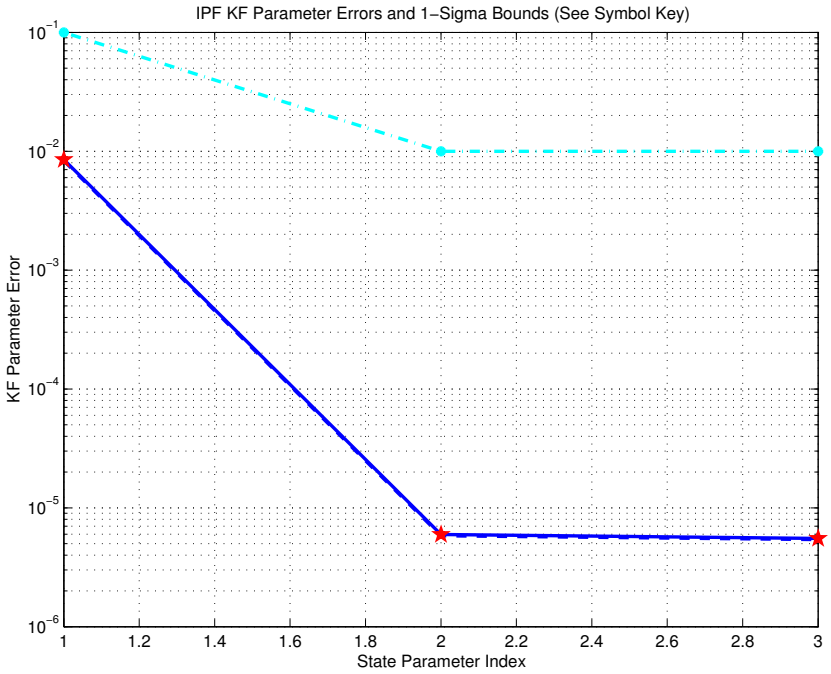

Figure 3.13: KF parameter error sigma plots

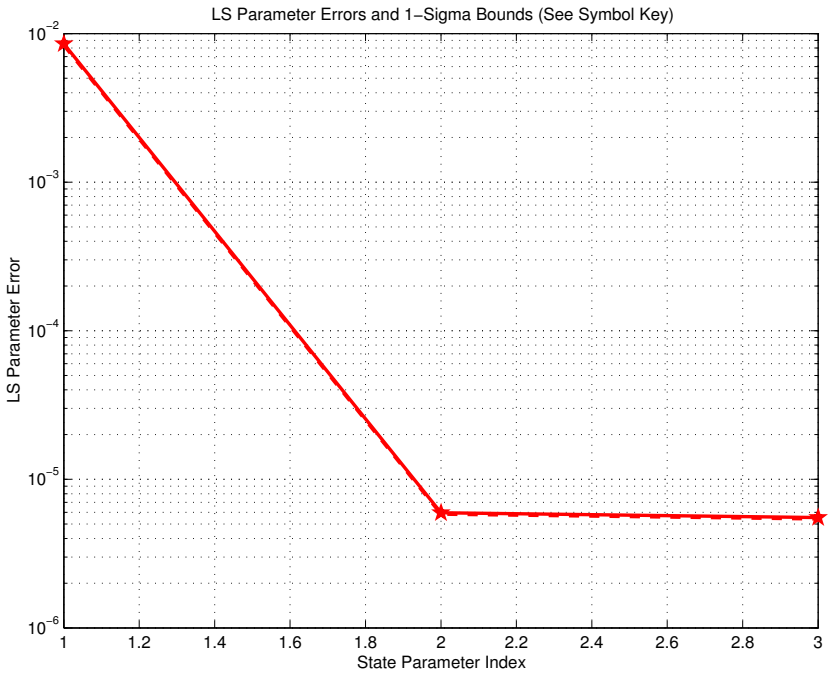

Figure 3.14: LS parameter error sigma plot

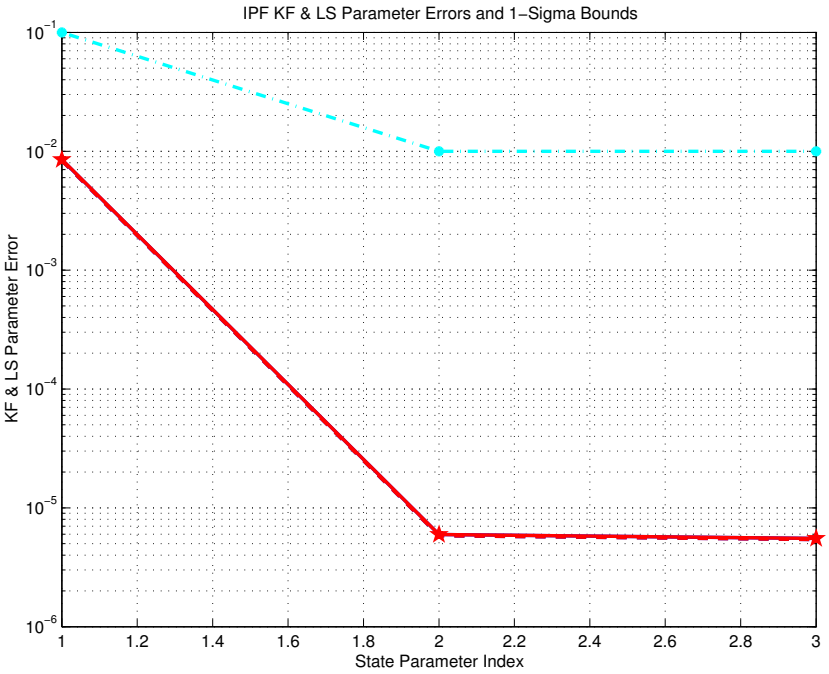

Figure 3.15: KF and LS parameter error sigma plot

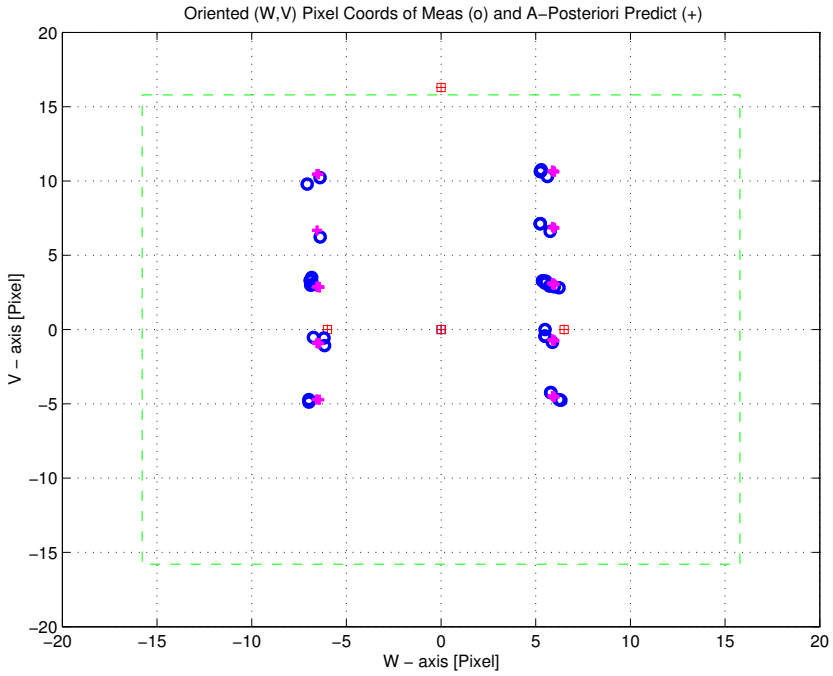

Figure 3.16: Oriented Pixel Coords of meas. and a-posteriori predicts

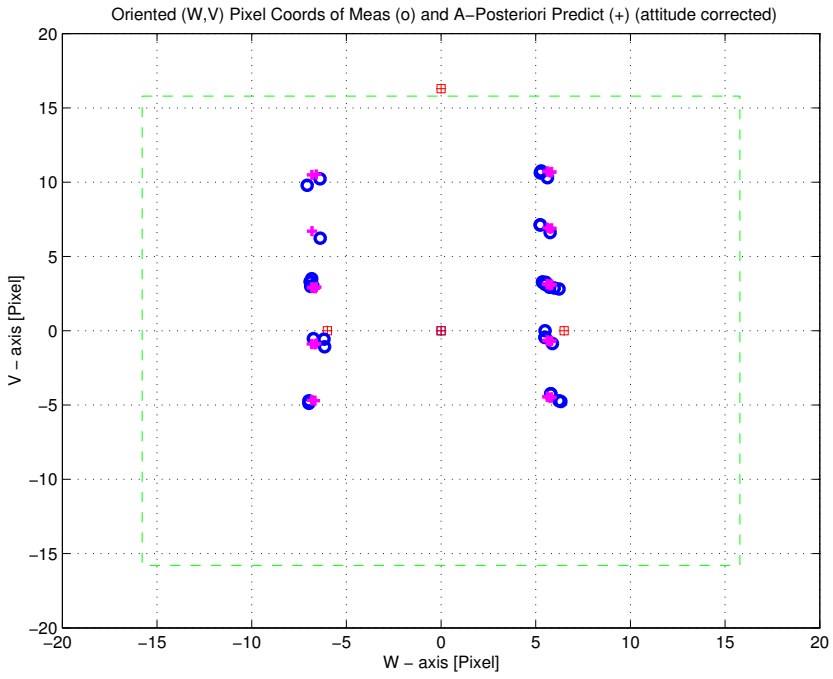

Figure 3.17: Oriented Pixel Coords of meas. and a-posteriori predicts (attitude corrected)

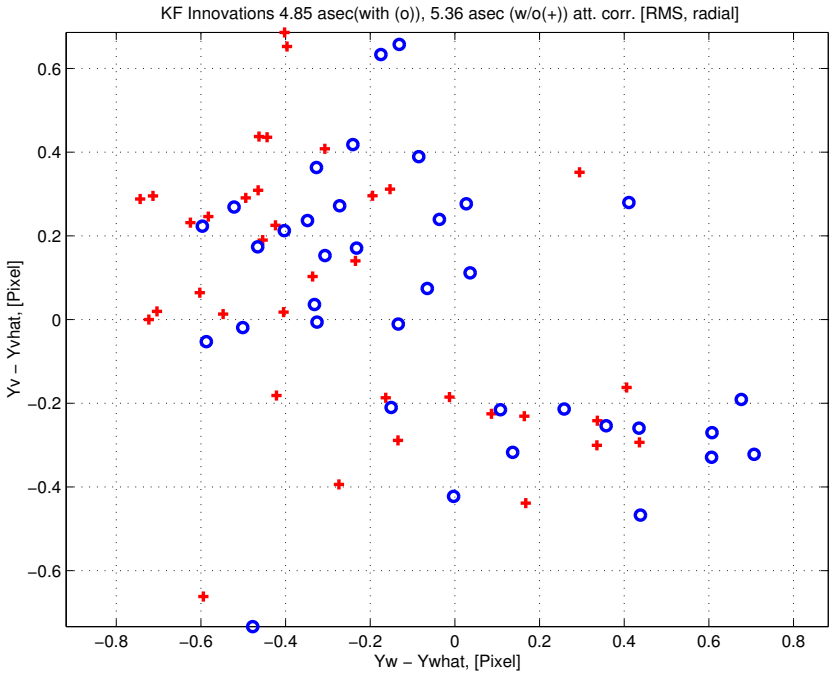

Figure 3.18: KF innovations with (o) and w/o (+) attitude corrections

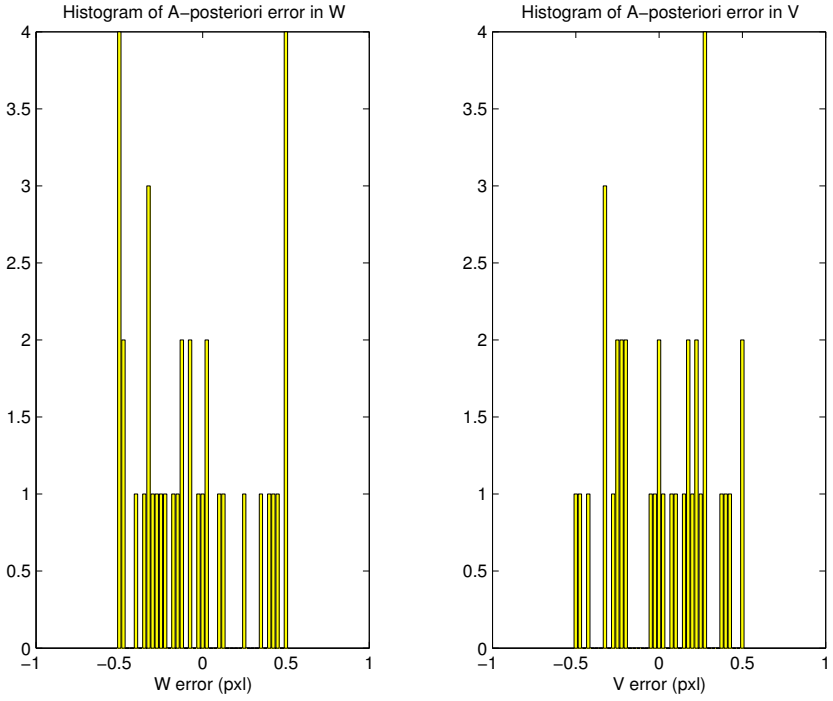

Figure 3.19: Histograms of science a-posteriori residuals (or innovations)

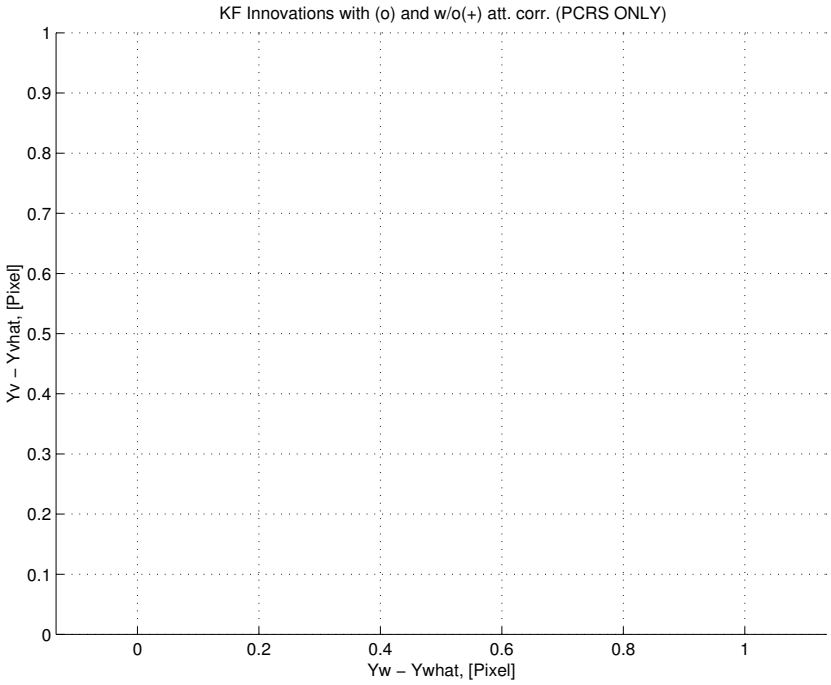

Figure 3.20: KF innovations with (o) and w/o (+) attitude corrections (PCRS)

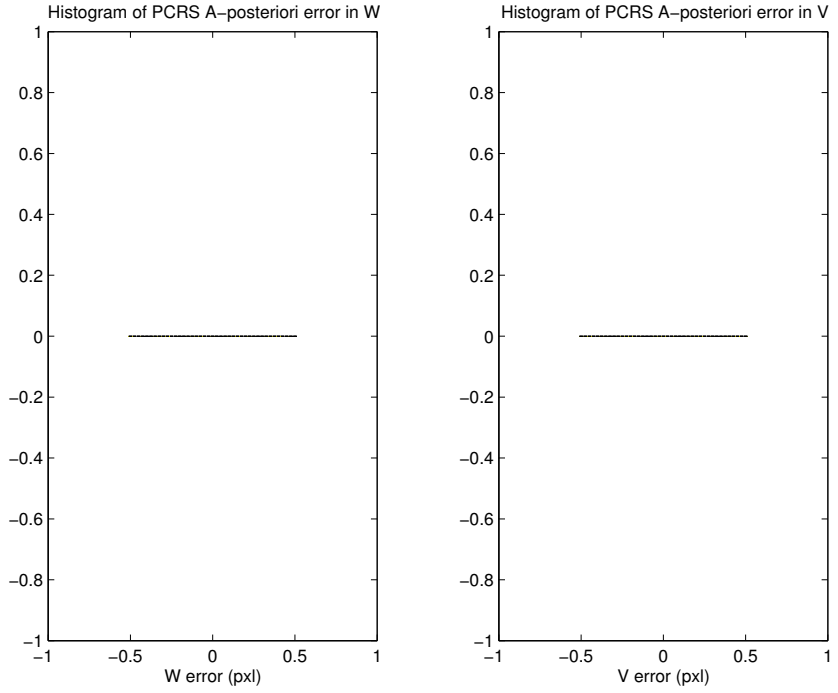

Figure 3.21: Histograms of PCRS a-posteriori residuals (or innovations)

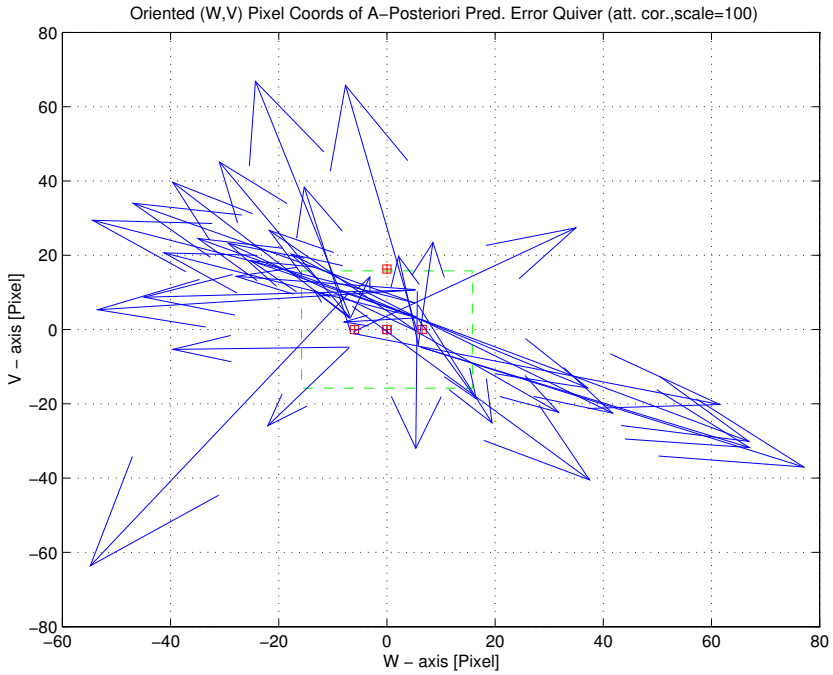

Figure 3.22: A-Posteriori Science Centroid Prediction Error Quiver (Att. Cor.)

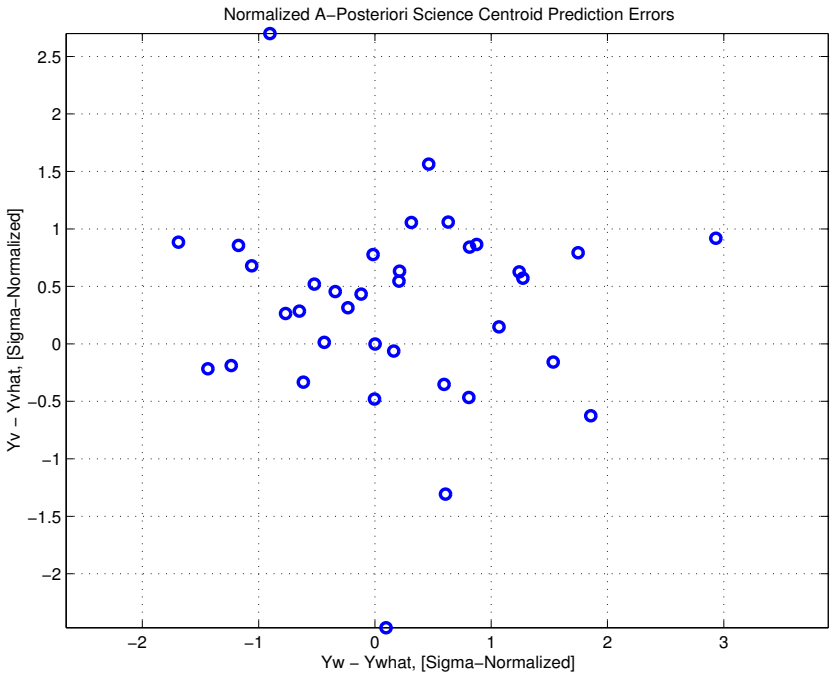

Figure 3.23: Normalized A-Posteriori Science Centroid Prediction Errors

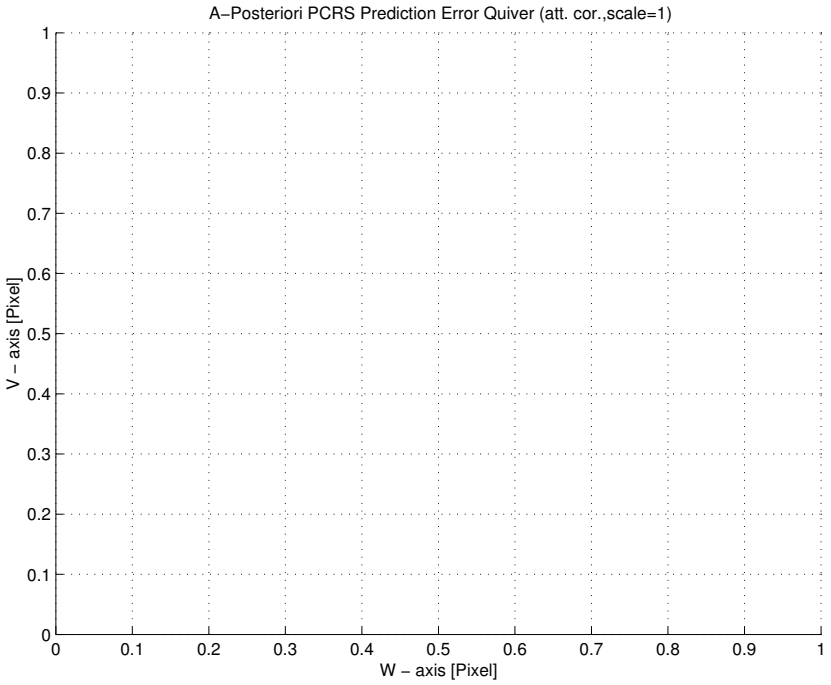

Figure 3.24: A-Posteriori PCRS Prediction Errors Quiver (Att. Cor.)

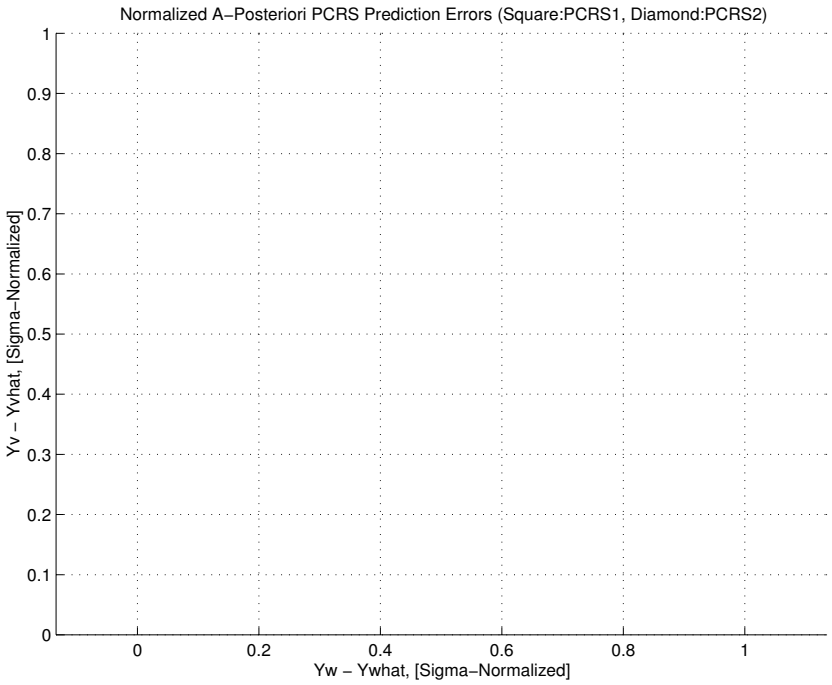

Figure 3.25: Normalized A-Posteriori PCRS Prediction Errors

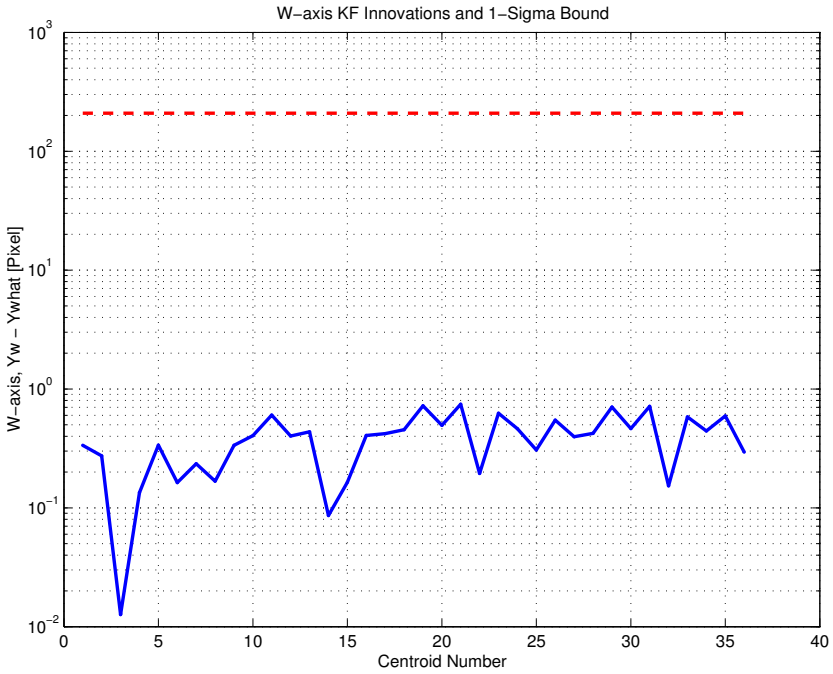

Figure 3.26: W-axis KF innovations and 1-sigma bound

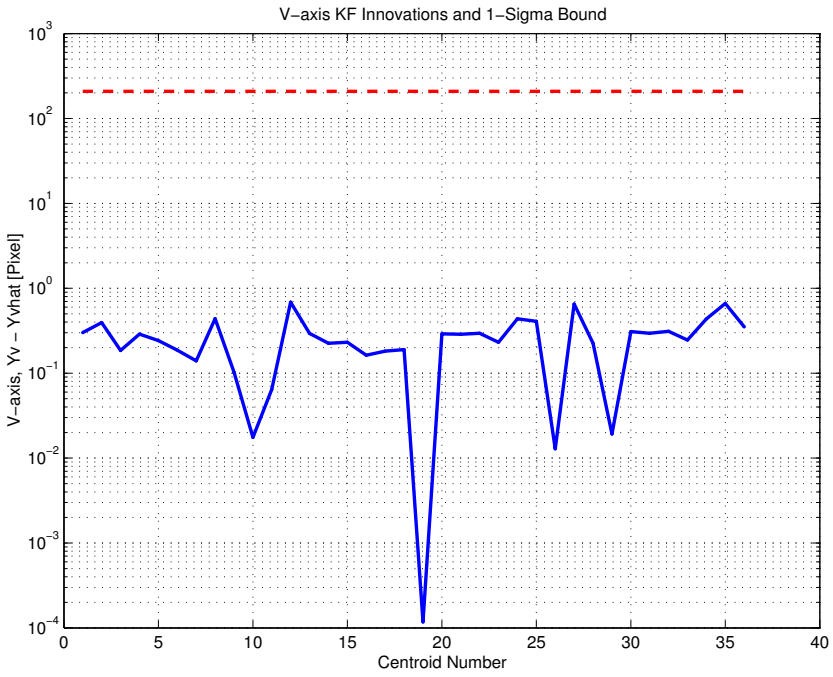

Figure 3.27: V-axis KF innovations and 1-sigma bound

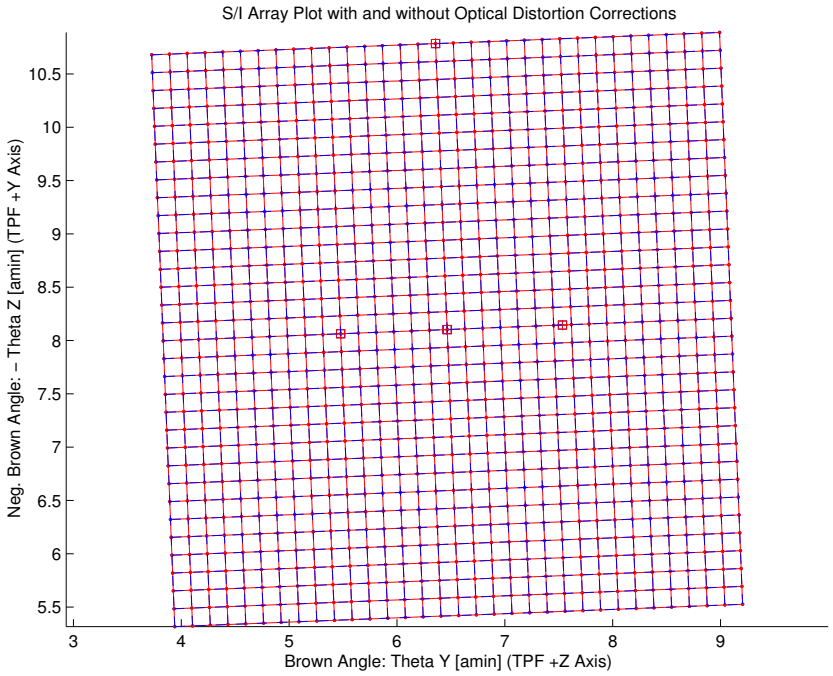

Figure 3.28: Array plot with (solid) and w/o (dashed) optical distortion corrections

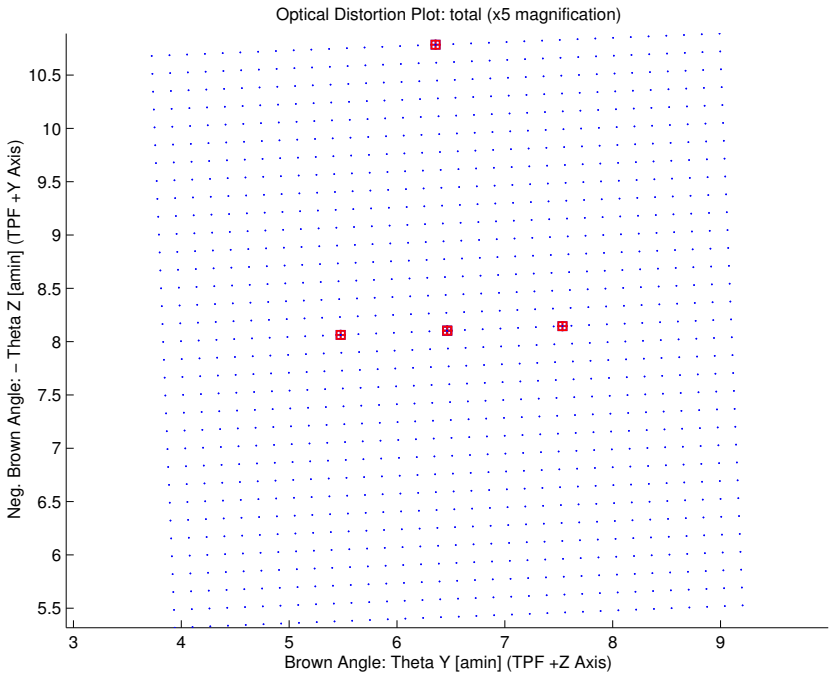

Figure 3.29: Optical Distortion Plot: total (x5 magnification)

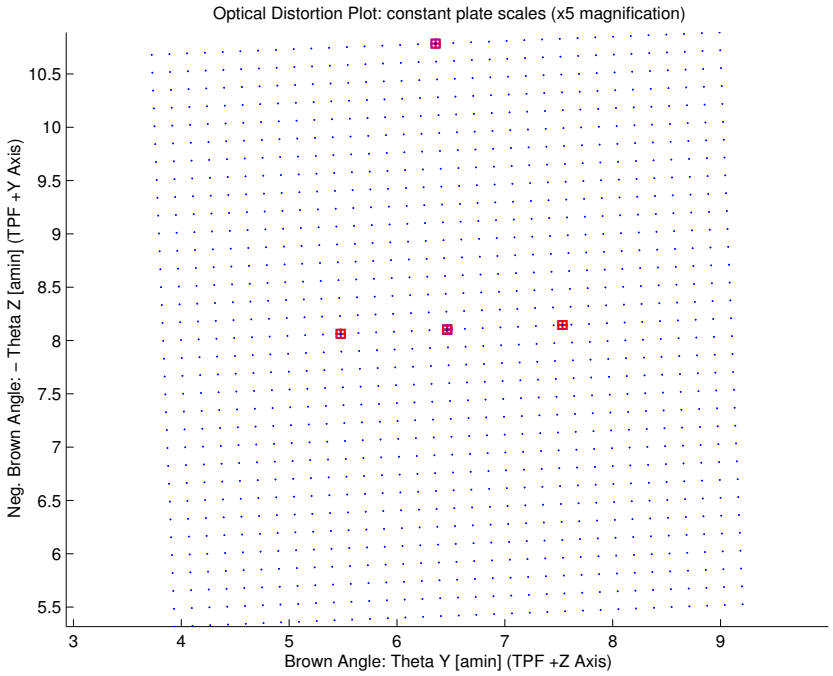

Figure 3.30: Optical Distortion Plot: constant plate scales (x5 magnification)

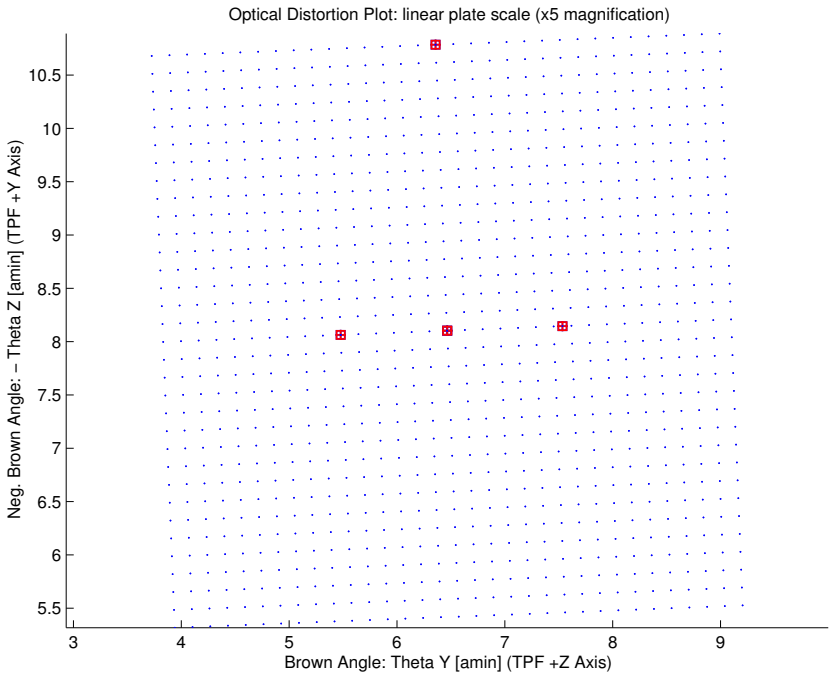

Figure 3.31: Optical Distortion Plot: linear plate scale (x5 magnification)

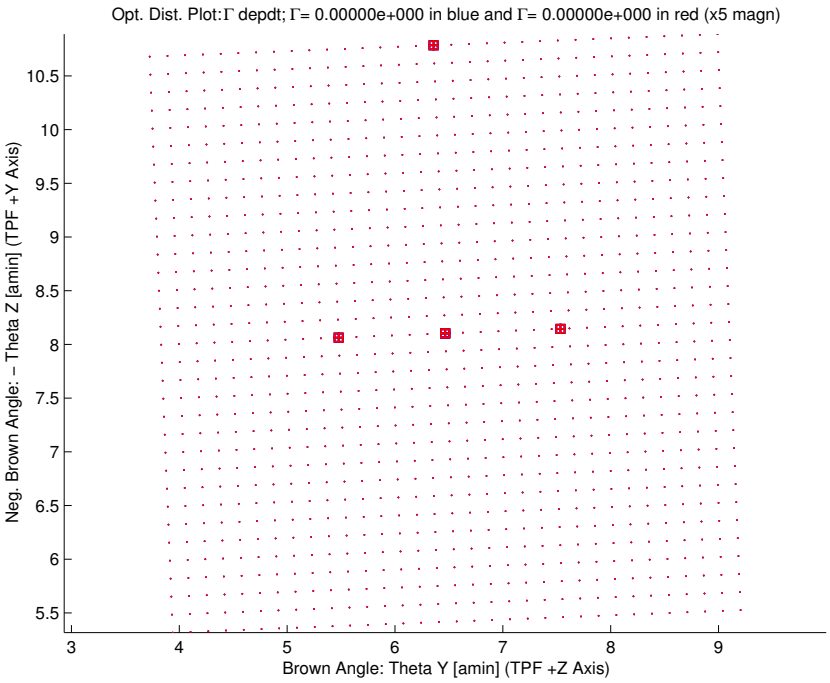

Figure 3.32: Optical Distortion Plot: gamma terms (x5 magnification)

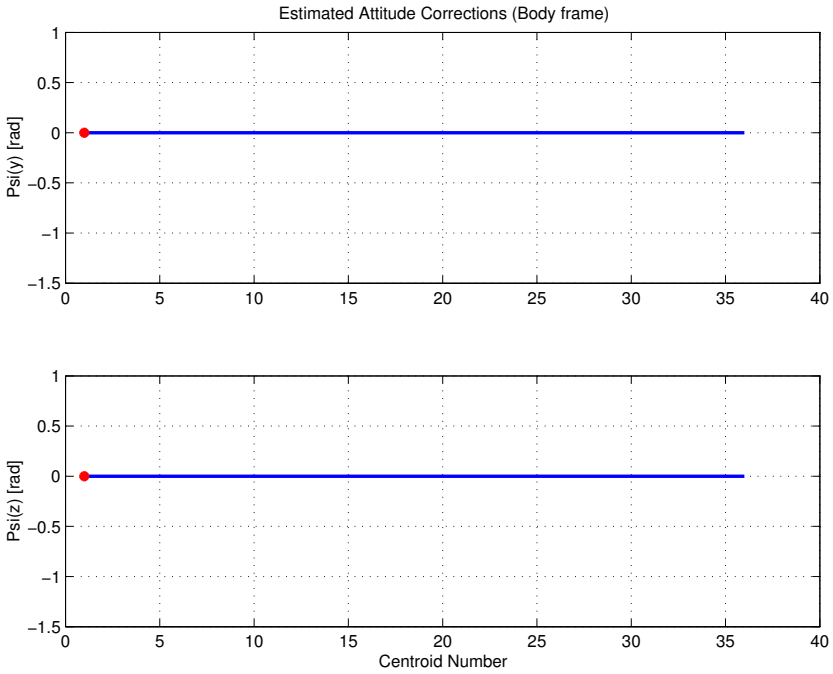

Figure 3.33: Estimated attitude corrections (Body frame)

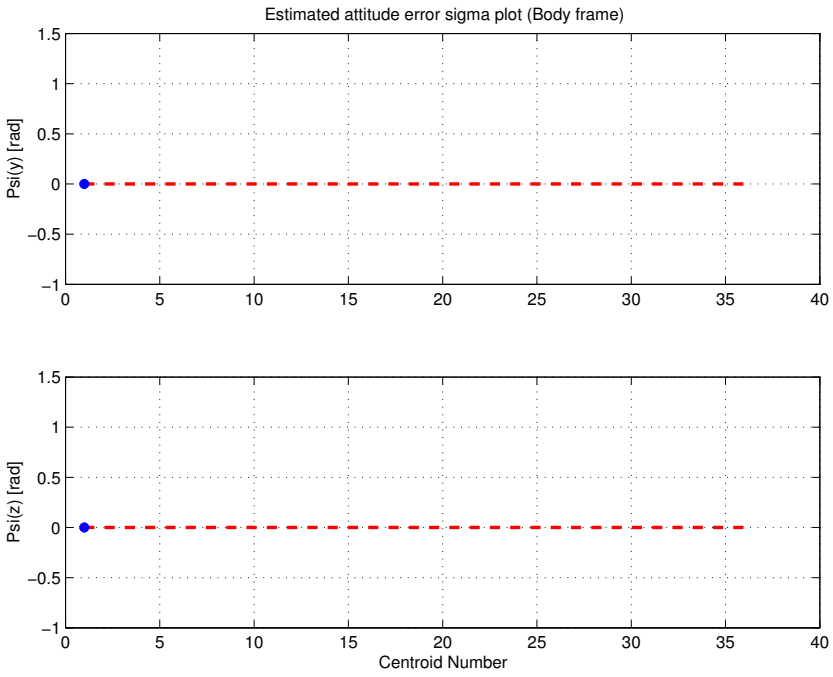

Figure 3.34: Estimated attitude error sigma plot (Body frame)

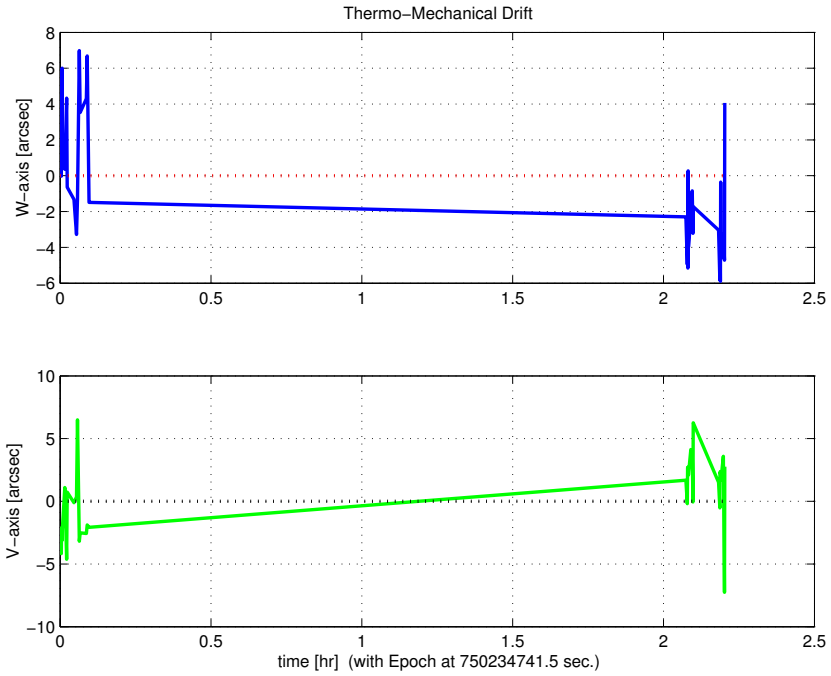

Figure 3.35: Thermo-mechanical boresight drift (equiv. angle in (W,V) coords)

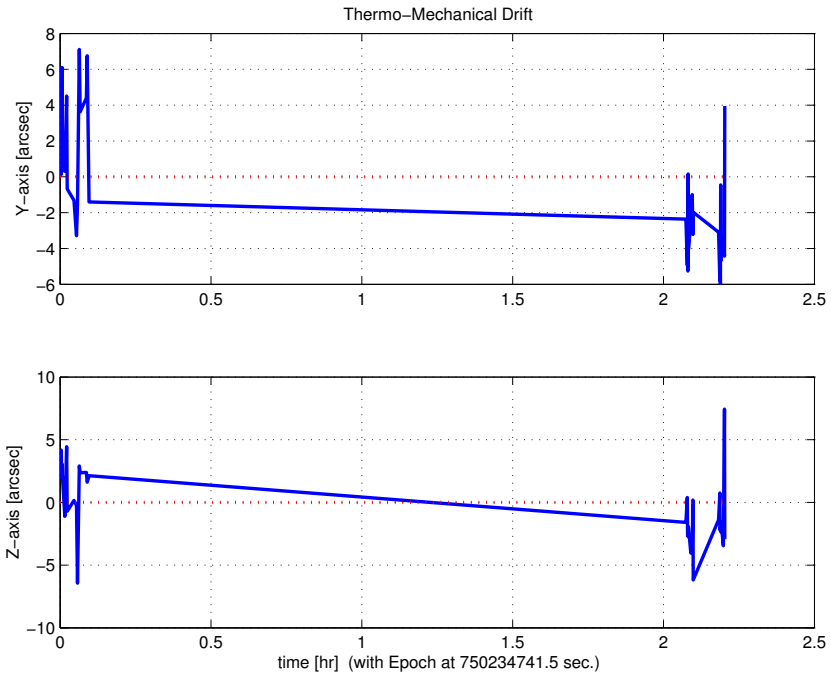

Figure 3.36: Thermo-mechanical boresight drift (equiv. angle in Body frame)

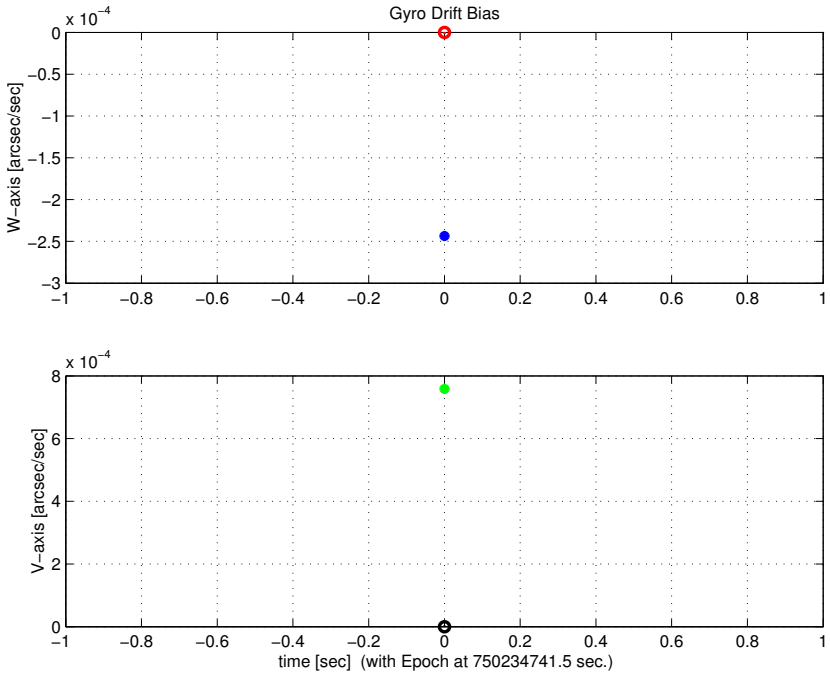

Figure 3.37: Gyro drift bias contribution (equiv. rate in (W,V) coords)

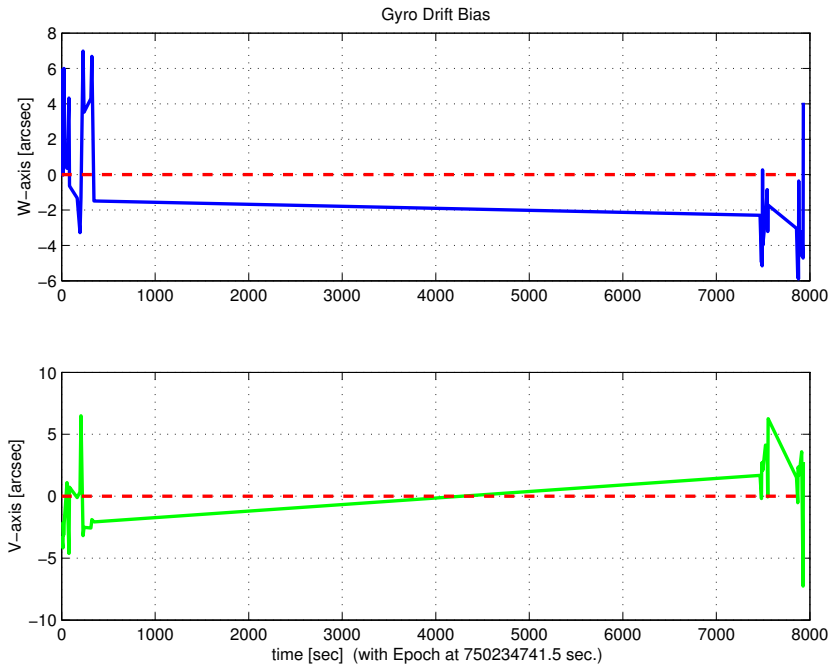

Figure 3.38: Gyro drift bias contribution (equiv. angle in (W,V) coords)

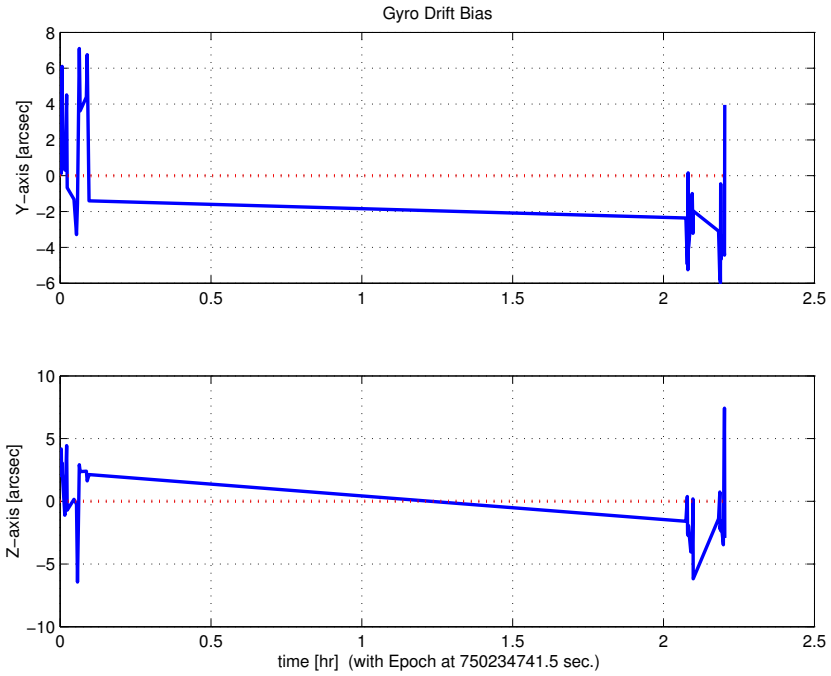

Figure 3.39: Gyro drift bias contribution (equiv. angle in Body frame)

3.2 IPF OUTPUT DATA (IF MINI FILE)

```
OUTPUT FILE NAME: IFmini01P107.dat   DATE: 12-Oct-2003   TIME: 15:33
INSTRUMENT NAME:  MIPS_70um_center   NF: 107
IPF FILTER VERSION: IPF.V2.0.0C       SW RELEASE DATE: August 1, 2003
FRAME TABLE USED: BodyFrames_FTU_07f
-------------------------------------------------------------------------------
---------------------------- IPF BROWN ANGLE SUMMARY ----------------------------
-------------------------------------------------------------------------------
         ------------ WAS ------------           ------------ IS -------------
Frame    theta_Y     theta_Z     angle           theta_Y     theta_Z     angle
Number   (arcmin)    (arcmin)    (deg)           (arcmin)    (arcmin)    (deg)
------  ---------------------------------       ---------------------------------
 107     +6.445000  -8.592000   +0.000000        +6.465320  -8.103026   -2.285674
 108     +6.348000 -11.259000   -0.000000        +6.358283 -10.784699   -2.285674
 111     +7.423000  -8.647000   -0.000000        +7.534911  -8.145717   -2.285674
 112     +5.385000  -8.533000   +0.000000        +5.478006  -8.063618   -2.285674
 115     +6.445000  -8.592000   +0.000000        +6.465320  -8.103026   -2.285674
-------------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  0             107            +0.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_center
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.445000        -8.592000       +0.000000
IS (EST)            +6.465320        -8.103026       -2.285674
dT_EST              +0.020320        +0.488974       -2.285674
T_sSIGMA            +0.020035        +0.018580       +0.476265
dT_EST/T_sSIGMA     +1.014262       +26.317024       -4.799162
-------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  1             108            +0.000           +16.000     pixels
OFFSET FRAME NAME: MIPS_70um_minusY_edge
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.348000       -11.259000       -0.000000
IS (EST)            +6.358283       -10.784699       -2.285674
dT_EST              +0.010283        +0.474301       -2.285674
T_sSIGMA            +0.026719        +0.018580       +0.476265
dT_EST/T_sSIGMA     +0.384854       +25.527307       -4.799163
-------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  2             111            +6.500            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_small_FOV1
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +7.423000        -8.647000       -0.000000
IS (EST)            +7.534911        -8.145717       -2.285674
dT_EST              +0.111911        +0.501283       -2.285674
T_sSIGMA            +0.020035        +0.019715       +0.476265
dT_EST/T_sSIGMA     +5.585895       +25.426436       -4.799162
-------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  3             112            -6.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_small_FOV2
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +5.385000        -8.533000       +0.000000
IS (EST)            +5.478006        -8.063618       -2.285674
dT_EST              +0.093006        +0.469382       -2.285674
T_sSIGMA            +0.020035        +0.021110       +0.476265
dT_EST/T_sSIGMA     +4.642274       +22.234616       -4.799162
-------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  4             115            +0.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_large_FOV1
```

```
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.445000        -8.592000       +0.000000
IS (EST)            +6.465320        -8.103026       -2.285674
dT_EST              +0.020320        +0.488974       -2.285674
T_sSIGMA            +0.020035        +0.018580       +0.476265
dT_EST/T_sSIGMA     +1.014262       +26.317024       -4.799162
-------------------------------------------------------------------
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
VARNAME             MEAN                      SIGMA                SCALED_SIGMA
del_theta1 -3.8033812210791496E-015 +8.4994081619935748E-003 +8.3123959752865722E-003
del_theta2 -1.2740930626256277E-017 +5.9589287481381692E-006 +5.8278146429697976E-006
del_theta3 +2.6322607627111451E-018 +5.5263441885756289E-006 +5.4047482266564814E-006
-------------------------------------------------------------------------------
LSQF RESIDUAL SIGMA SCALE =         +9.7799703424724838E-001
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
qT               qT(1)                     qT(2)                     qT(3)                     qT(4)
FrmTbl:   +1.1714108883076305E-006 -9.3738638321546567E-004 +1.2496548701431507E-003 +9.9999877983330654E-001
Estim:    -1.9943813499221360E-002 -9.6366071810333968E-004 +1.1595470044329500E-003 +9.9979996554904582E-001
DelTheta        deltheta(1)               deltheta(2)               deltheta(3)
         -3.9892800193744728E-002 -5.9109498922459950E-006 -1.4223663684096385E-004       [rad]
EulAngT         theta(1)                  theta(2)                  theta(3)                  [rad]
Mean      -3.9892533531809847E-002 -1.8806854357782737E-003 +2.3570746004731224E-003
SigmaT    +8.4994081619935748E-003 +5.9589287481381692E-006 +5.5263441885756289E-006
-------------------------------------------------------------------------------------------------------------
Initial Gyro Bias         Bg0(1)                    Bg0(2)                    Bg0(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000
Gyro Bias Correction      Bg(1)                     Bg(2)                     Bg(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000
Total Gyro Bias           BgT(1)                    BgT(2)                    BgT(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000

Initial Gyro Bias Rate     Cg0(1)                    Cg0(2)                    Cg0(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000
Gyro Bias Rate Correction  Cg(1)                     Cg(2)                     Cg(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000
Total Gyro Bias Rate       CgT(1)                    CgT(2)                    CgT(3)
                  +0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  1             108            +0.000           +16.000     pixels
OFFSET FRAME NAME: MIPS_70um_minusY_edge
qT               qT(1)                     qT(2)                     qT(3)                     qT(4)
WAS(FTB)  +1.5119196953387772E-006 -9.2327780520473960E-004 +1.6375537408473187E-003 +9.9999823298521595E-001
IS (EST)  -1.9943460826347958E-002 -9.5587458092396497E-004 +1.5498129478758375E-003 +9.9979945126704295E-001

DelTheta        deltheta(1)               deltheta(2)               deltheta(3)
Units             rad                       rad                       rad
          -3.9892788298855487E-002 -2.9912188124441226E-006 -1.3796842957331074E-004
EulAngT         theta(1)                  theta(2)                  theta(3)                  [rad]
Mean      -3.9892533531809847E-002 -1.8495495498475399E-003 +3.1371416758108122E-003
sSigmaT   +8.3123943845802763E-003 +7.7722958010732273E-006 +5.4047482473962737E-006
SigmaT    +8.4994065354995867E-003 +7.9471568204247798E-006 +5.5263442097820245E-006
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  2             111            +6.500            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_small_FOV1
qT               qT(1)                     qT(2)                     qT(3)                     qT(4)
WAS(FTB)  +1.3578036248737386E-006 -1.0796305229011367E-003 +1.2576541056642260E-003 +9.9999862635017700E-001
IS (EST)  -1.9943620087214384E-002 -1.1193190636310088E-003 +1.1626520471862240E-003 +9.9979980365214516E-001
```

```
DelTheta        deltheta(1)               deltheta(2)               deltheta(3)
Units             rad                       rad                       rad
          -3.9892848389503459E-002 -3.2553583605817357E-005 -1.4581695600649451E-004
EulAngT         theta(1)                  theta(2)                  theta(3)                  [rad]
Mean      -3.9892533531809840E-002 -2.1918167335756734E-003 +2.3694930341458141E-003
sSigmaT   +8.3123957540849353E-003 +5.8278146455160641E-006 +5.7348700512222867E-006
SigmaT    +8.4994079358153458E-003 +5.9589287507417215E-006 +5.8638930900606891E-006
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  3             112            -6.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_small_FOV2
qT              qT(1)                     qT(2)                     qT(3)                     qT(4)
WAS(FTB)  +9.7202971260263934E-007 -7.8321581857721488E-004 +1.2410738430199599E-003 +9.9999892315329675E-001
IS (EST)  -1.9943989889959324E-002 -8.1997606790425886E-004 +1.1566807910598268E-003 +9.9980009351673138E-001

DelTheta        deltheta(1)               deltheta(2)               deltheta(3)
Units             rad                       rad                       rad
          -3.9892747408788447E-002 -2.7054324039132392E-005 -1.3653746741811899E-004
EulAngT         theta(1)                  theta(2)                  theta(3)                  [rad]
Mean      -3.9892533531809840E-002 -1.5934873131029327E-003 +2.3456114438281752E-003
sSigmaT   +8.3123954641379505E-003 +5.8278146204351213E-006 +6.1407689197122304E-006
SigmaT    +8.4994076393451364E-003 +5.9589287250965073E-006 +6.2789238665112116E-006
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  4             115            +0.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_70um_default_large_FOV1
qT              qT(1)                     qT(2)                     qT(3)                     qT(4)
WAS(FTB)  +1.1714108883076305E-006 -9.3738638321546567E-004 +1.2496548701431507E-003 +9.9999877983330654E-001
IS (EST)  -1.9943813499221356E-002 -9.6366071810333968E-004 +1.1595470044329502E-003 +9.9979996554904582E-001

DelTheta        deltheta(1)               deltheta(2)               deltheta(3)
Units             rad                       rad                       rad
          -3.9892800193744721E-002 -5.9109498922459857E-006 -1.4223663684096341E-004
EulAngT         theta(1)                  theta(2)                  theta(3)                  [rad]
Mean      -3.9892533531809840E-002 -1.8806854357782737E-003 +2.3570746004731228E-003
sSigmaT   +8.3123959752865739E-003 +5.8278146429697967E-006 +5.4047482266564814E-006
SigmaT    +8.4994081619935765E-003 +5.9589287481381684E-006 +5.5263441885756289E-006
-------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
              q(1)                      q(2)                      q(3)                      q(4)
PCRS1A: +5.3376441636293240E-007 +3.7444188848489133E-004 -1.4254917867010713E-003 +9.9999891388248685E-001
PCRS2A: -5.2784065890448333E-007 +3.8463004289789228E-004 +1.3723320176524409E-003 +9.9999898438162671E-001
-------------------------------------------------------------------------------------
**********  CS-FILE PARAMETERS:  **********  **********  AS-FILE PARAMETERS:  **********
Row (01) PIX2RADX: +4.7904467948999998E-005  Row (1) TASTART:   +7.5023400039077759E+008
Row (02) PIX2RADY: +4.8792938470999998E-005  Row (2) TASTOP:    +7.5025100029079282E+008
Row (03) CX0:      +1.6500000000000000E+001  Row (3) S/C TIME:  +7.5023110219073486E+008
Row (04) CY0:      +1.6500000000000000E+001  Row (4) QR1:       +7.0861761923879385E-004
Row (05) BETA0:    +2.8047410000000001E-006  Row (5) QR2:       +1.2695450568571687E-003
Row (06) GAMMA_E0: +2.0070000000000000E+003  Row (6) QR3:       -1.6060027701314539E-004
Row (07) D11:      +1.0000000000000000E+000  Row (7) QR4:       +9.9999892711639404E-001
Row (08) D12:      +0.0000000000000000E+000
Row (09) D21:      +0.0000000000000000E+000
Row (10) D22:      -1.0000000000000000E+000
Row (11) DG:       -1.0000000000000000E+000
-------------------------------------------------------------------------------------
------------------------------------------------------------
INITIAL STA-TO-PCRS ALIGNMENT (R) KNOWLEDGE (1-SIGMA)
    SIGMA(X)        SIGMA(Y)         SIGMA(Z)
3.72482062E+000  3.96855444E-001  3.97055348E-001  [arcsec]
------------------------------------------------------------
```

```
PIX2RADX = 4.790446794900E-005[rad/pixel]
XPIXSIZE = 9.8810[arcsec]
PIX2RADY = 4.879293847100E-005[rad/pixel]
YPIXSIZE = 10.0643[arcsec]
CX0 = 16.5[pixel] = 163.04[arcsec]
CY0 = 16.5[pixel] = 166.06[arcsec]
------------------------------------------------------------
NOMINAL BETA0 = 2.804741000000E-006[rad/encoder unit]
ENCODER UNIT SIZE = 0.58[arcsec]
GAMMA_E0 = 2007.00[encoder unit] = 1161.09[arcsec]
------------------------------------------------------------
                | +1 | +0 |
FLIP MATRIX D = |----|----|   and   DG = -1
                | +0 | -1 |
------------------------------------------------------------
```

3.3 IPF EXECUTION LOG

```
*********************************************************************
IPF EXECUTION-LOG FILE NAME:  LG01P107.dat
INSTRUMENT TYPE:              MIPS_70um_center
IPF FILTER EXECUTION DATE:    12-Oct-2003    TIME: 15:32
IPF FILTER VERSION USED:      IPF.V2.0.0C
*********************************************************************

------------------- Loading & Preparing Input Files -------------------
AAFILE:  AA01P107 Loaded!        AAFILE dimension = 170000 X 21
ASFILE:  AS01P107 Loaded!
CAFILE:  CA02P107 Loaded!        CAFILE dimension = 36 X 15
CBFILE:  CB01P107 Loaded!        CBFILE dimension = 0 X 0
CCFILE:  CC01P107 Created!       CCFILE dimension = 36 X 19
CSFILE:  CS02P107 Loaded!
Loading Input Files Completed!
-----------------------------------------------------------------------

------------------------ Selected Mask Vectors ------------------------
index =   1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20
-----------------------------------------------------------------------
mask1 = [ 0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 ]
mask2 = [ 0  0  1  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0 ]
-----------------------------------------------------------------------

---------------  Selected Initial Gyro Bias Parameters  ---------------
IPF Filter in LITE MODE# 3
IPF LITE MODE WITH FILTERED STA QUATERNION!
IPF Linearized Using Following Nominal Gyro Bias Estimates
bg0 = [+0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000 ]
cg0 = [+0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000 ]
-----------------------------------------------------------------------

---------------  Gyro Pre-Processor Run Completed  --------------------
     AGFILE CREATED:  AG01P107.m     ACFILE CREATED:  AC01P107.m
-----------------------------------------------------------------------
Total Gyro Preprocessor Execution Time: 2 seconds

FRAME TABLE ENTRIES FOR PCRS LOADED TO TPCRS
q_PCRS4 = [ +5.337644163629324OE-007     q_PCRS5 = [ +7.3379987833742897E-007
```

```
            +3.7444188848489133E-004                 +5.2236196154513707E-004
            -1.4254917867010713E-003                 -1.4047712280184723E-003
            +9.9999891388248685E-001 ];              +9.9999887687698918E-001 ];
q_PCRS8 = [ -5.2784065890448333E-007     q_PCRS9 = [ -7.1963421681856818E-007
            +3.8463004289789228E-004                 +5.3239763239987400E-004
            +1.3723320176524409E-003                 +1.3516841804518383E-003
            +9.9999898438162671E-001 ];              +9.9999894475050310E-001 ];
-------------------------------------------------------------------------------
------ Initial Conditions for State -----  ------   Inital Square-Root Cov (diag)   -----
p1(01)  = a00  = +0.0000000000000000E+000  Sigma_initial(01,01) = 9.9999000000000000E+004
p1(02)  = b00  = +0.0000000000000000E+000  Sigma_initial(02,02) = 9.9999000000000000E+004
p1(03)  = c00  = +0.0000000000000000E+000  Sigma_initial(03,03) = 9.9999000000000000E+004
p1(04)  = a10  = +0.0000000000000000E+000  Sigma_initial(04,04) = 9.9999000000000000E+004
p1(05)  = b10  = +0.0000000000000000E+000  Sigma_initial(05,05) = 9.9999000000000000E+004
p1(06)  = c10  = +0.0000000000000000E+000  Sigma_initial(06,06) = 9.9999000000000000E+004
p1(07)  = d10  = +0.0000000000000000E+000  Sigma_initial(07,07) = 9.9999000000000000E+004
p1(08)  = a20  = +0.0000000000000000E+000  Sigma_initial(08,08) = 9.9999000000000000E+004
p1(09)  = b20  = +0.0000000000000000E+000  Sigma_initial(09,09) = 9.9999000000000000E+004
p1(10)  = c20  = +0.0000000000000000E+000  Sigma_initial(10,10) = 9.9999000000000000E+004
p1(11)  = d20  = +0.0000000000000000E+000  Sigma_initial(11,11) = 9.9999000000000000E+004
p1(12)  = a01  = +0.0000000000000000E+000  Sigma_initial(12,12) = 9.9999000000000000E+004
p1(13)  = b01  = +0.0000000000000000E+000  Sigma_initial(13,13) = 9.9999000000000000E+004
p1(14)  = c01  = +0.0000000000000000E+000  Sigma_initial(14,14) = 9.9999000000000000E+004
p1(15)  = d01  = +0.0000000000000000E+000  Sigma_initial(15,15) = 9.9999000000000000E+004
p1(16)  = e01  = +0.0000000000000000E+000  Sigma_initial(16,16) = 9.9999000000000000E+004
p1(17)  = f01  = +0.0000000000000000E+000  Sigma_initial(17,17) = 9.9999000000000000E+004
-------------------------------------------------------------------------------------------
p2f(01) = am1  = +0.0000000000000000E+000
p2f(02) = am2  = +0.0000000000000000E+000  Sigma_initial(18,18) = 9.9999000000000000E+004
p2f(03) = am3  = +1.0000000000000000E+000
p2f(04) = beta = +1.0000000000000000E+000  Sigma_initial(19,19) = 9.9999000000000000E+004
p2f(05) = qT1  = +1.1714108883076305E-006  Sigma_initial(20,20) = 1.0000000000000001E-001
p2f(06) = qT2  = -9.3738638321546567E-004  Sigma_initial(21,21) = 1.0000000000000000E-002
p2f(07) = aT3  = +1.2496548701431507E-003  Sigma_initial(22,22) = 1.0000000000000000E-002
p2f(08) = qT4  = +9.9999877983330654E-001
p2f(09) = qR1  = +7.0861761923879385E-004  Sigma_initial(23,23) = 9.9999000000000000E+004
p2f(10) = qR2  = +1.2695450568571687E-003  Sigma_initial(24,24) = 9.9999000000000000E+004
p2f(11) = qR3  = -1.6060027701314539E-004  Sigma_initial(25,25) = 9.9999000000000000E+004
p2f(12) = qR4  = +9.9999892711639404E-001
p2f(13) = brx  = +0.0000000000000000E+000  Sigma_initial(26,26) = 9.9999000000000000E+004
p2f(14) = bry  = +0.0000000000000000E+000  Sigma_initial(27,27) = 9.9999000000000000E+004
p2f(15) = brz  = +0.0000000000000000E+000  Sigma_initial(28,28) = 9.9999000000000000E+004
p2f(16) = crx  = +0.0000000000000000E+000  Sigma_initial(29,29) = 9.9999000000000000E+004
p2f(17) = cry  = +0.0000000000000000E+000  Sigma_initial(30,30) = 9.9999000000000000E+004
p2f(18) = crz  = +0.0000000000000000E+000  Sigma_initial(31,31) = 9.9999000000000000E+004
p2f(19) = bgx  = +0.0000000000000000E+000  Sigma_initial(32,32) = 9.9999000000000000E+004
p2f(20) = bgy  = +0.0000000000000000E+000  Sigma_initial(33,33) = 9.9999000000000000E+004
p2f(21) = bgz  = +0.0000000000000000E+000  Sigma_initial(34,34) = 9.9999000000000000E+004
p2f(22) = cgx  = +0.0000000000000000E+000  Sigma_initial(35,35) = 9.9999000000000000E+004
p2f(23) = cgy  = +0.0000000000000000E+000  Sigma_initial(36,36) = 9.9999000000000000E+004
p2f(24) = cgz  = +0.0000000000000000E+000  Sigma_initial(37,37) = 9.9999000000000000E+004
-------------------------------------------------------------------------------------------

--------------------   IPF KALMAN FILTER STARTED  ---------------------
Iteration#001: |dp|= +3.925817373113E-002   RMS(|Res|)=+1.453231415869E-004
Iteration#002: |dp|= +6.249818191897E-004   RMS(|Res|)=+2.740354038489E-005
Iteration#003: |dp|= +9.756553778005E-006   RMS(|Res|)=+2.598164275463E-005
Iteration#004: |dp|= +1.523032183010E-007   RMS(|Res|)=+2.598276982065E-005
Iteration#005: |dp|= +2.377565095393E-009   RMS(|Res|)=+2.598278468231E-005
Iteration#006: |dp|= +3.708025437507E-011   RMS(|Res|)=+2.598278491395E-005
Iteration#007: |dp|= +6.091812873530E-013   RMS(|Res|)=+2.598278491756E-005
Iteration#008: |dp|= +9.250631405473E-014   RMS(|Res|)=+2.598278491760E-005
Iteration#009: |dp|= +5.770819512955E-014   RMS(|Res|)=+2.598278491763E-005
Iteration#010: |dp|= +5.059277713143E-014   RMS(|Res|)=+2.598278491760E-005
```

```
Iteration#011: |dp|= +4.505554490604E-014   RMS(|Res|)=+2.598278491761E-005
Iteration#012: |dp|= +1.369825861377E-014   RMS(|Res|)=+2.598278491761E-005
Iteration#013: |dp|= +9.856701822348E-015   RMS(|Res|)=+2.598278491760E-005
Iteration#014: |dp|= +8.354254805509E-014   RMS(|Res|)=+2.598278491761E-005
Iteration#015: |dp|= +4.527238042573E-014   RMS(|Res|)=+2.598278491760E-005
Iteration#016: |dp|= +2.687130225577E-014   RMS(|Res|)=+2.598278491760E-005
Iteration#017: |dp|= +2.769356546330E-014   RMS(|Res|)=+2.598278491759E-005
Iteration#018: |dp|= +1.092963530050E-014   RMS(|Res|)=+2.598278491760E-005
Iteration#019: |dp|= +6.595548805004E-014   RMS(|Res|)=+2.598278491761E-005
Iteration#020: |dp|= +3.803403472282E-015   RMS(|Res|)=+2.598278491761E-005
IPF Kalman Filter Completed with Error |dp1| + |dp2| = +3.8034034722820914E-015
-------------------------------------------------------------------------

----------------  IPF LEAST SQUARES FILTER STARTED  ------------------
Iteration#001   COND#=+1.600083865604E+003,   |dp|=+3.954381061048E-002
Iteration#002   COND#=+1.600350725008E+003,   |dp|=+3.463092505630E-004
Iteration#003   COND#=+1.600352691153E+003,   |dp|=+2.925357365182E-006
Iteration#004   COND#=+1.600352707739E+003,   |dp|=+2.471162536432E-008
Iteration#005   COND#=+1.600352707879E+003,   |dp|=+2.087969543522E-010
Iteration#006   COND#=+1.600352707881E+003,   |dp|=+1.718578986687E-012
Iteration#007   COND#=+1.600352707881E+003,   |dp|=+5.288992365636E-014
Iteration#008   COND#=+1.600352707881E+003,   |dp|=+4.682236023537E-015
Iteration#009   COND#=+1.600352707881E+003,   |dp|=+1.491201536639E-014
Iteration#010   COND#=+1.600352707881E+003,   |dp|=+6.732577925026E-014
Iteration#011   COND#=+1.600352707881E+003,   |dp|=+1.181707260385E-013
Iteration#012   COND#=+1.600352707881E+003,   |dp|=+4.409843557031E-014
Iteration#013   COND#=+1.600352707881E+003,   |dp|=+1.151065890023E-015
Iteration#014   COND#=+1.600352707881E+003,   |dp|=+2.650817196873E-014
Iteration#015   COND#=+1.600352707881E+003,   |dp|=+2.352590765782E-014
Iteration#016   COND#=+1.600352707881E+003,   |dp|=+3.619763802347E-014
Iteration#017   COND#=+1.600352707881E+003,   |dp|=+9.988593446356E-015
Iteration#018   COND#=+1.600352707881E+003,   |dp|=+1.642514060951E-014
Iteration#019   COND#=+1.600352707881E+003,   |dp|=+5.934800668523E-014
Iteration#020   COND#=+1.600352707881E+003,   |dp|=+8.044892043250E-014
IPF Least Squares Filter Completed with Error |dp1| + |dp2| = +8.0448920432504723E-014
-------------------------------------------------------------------------
Total Execution Time: 43 seconds
```

4 COMMENTS

This Pre-course run should be used for sanity checking, and to make first rough corrections to the focal plane quaternions. Only the frame table quaternion was estimated (including the Twist).

(1) Overall the data set ran well and the filter converged properly. No modifications were required to the centroid CA file. The attitude AAfile also looked very clean with tracker and gyro working to spec. We did not have to scale the GCF biases AA file for this run due to a correction made by MIPL to convert arcseconds to radians.

(2) The experiment design did not contain any PCRS measurements, motivating us to run in an IPF Lite mode. Since the systematic error seen earlier in the observer were gone, (indicating the PCS modifications were effective) we used Lite-Mode 3.

(3) There were limitations in the experiment design due to the centroids all being in a row for each value of gamma. This led to unobservable parameters in the sense that one could not physically separate the scan mirror scale factor from the pixel plate scale in the v direction.

(4) Errors were dominated by centroiding errors of 3 arcseconds (approx .3 pixel with 10 arcsecond pixels). This was a limiting factor which made us decide not to estimate plate scales and scan mirror parameters. Because of this, systematic errors of several arcseconds were not removed, and can be seen from the size and non-Gaussian character of the a-posterior residuals.

(5) We decided to estimate Twist Brown angle since it seemed to uniformly improve all centroids.

We recommend updating frames 107, 108, 111, 112, and 115 with the new quaternions listed in the IF file IF01P107.dat. In our best judgement, these frames will be accurate to better than 5 arcseconds (disregard accuracies quoted in the Tables which are not strictly valid due to the lack of PCRS measurements).

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