JET PROPULSION LABORATORY **SIRTF IPF REPORT**

JPL ID504121
December 4, 2003

SIRTF INSTRUMENT POINTING FRAME KALMAN FILTER EXECUTION SUMMARY

IPF RUN NUMBER: 504121
REPORT TYPE: IOC EXECUTION (FINE)

PRIME FRAME: MIPS_SED_center (121)
INFERRED FRAMES: (105) (106) (122) (123) (125) (126)

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1 IPF EXECUTION SUMMARY

This report summarizes the SIRTF Instrument Pointing Frame (IPF) Kalman Filter execution associated with run file: RN504121. In particular, this Focal Point Survey calibrates the instrument: MIPS_SED_center (121), as part of the IOC Fine Survey. The main calibration results from the IPF filter execution have been documented in IF504121 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 16 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.

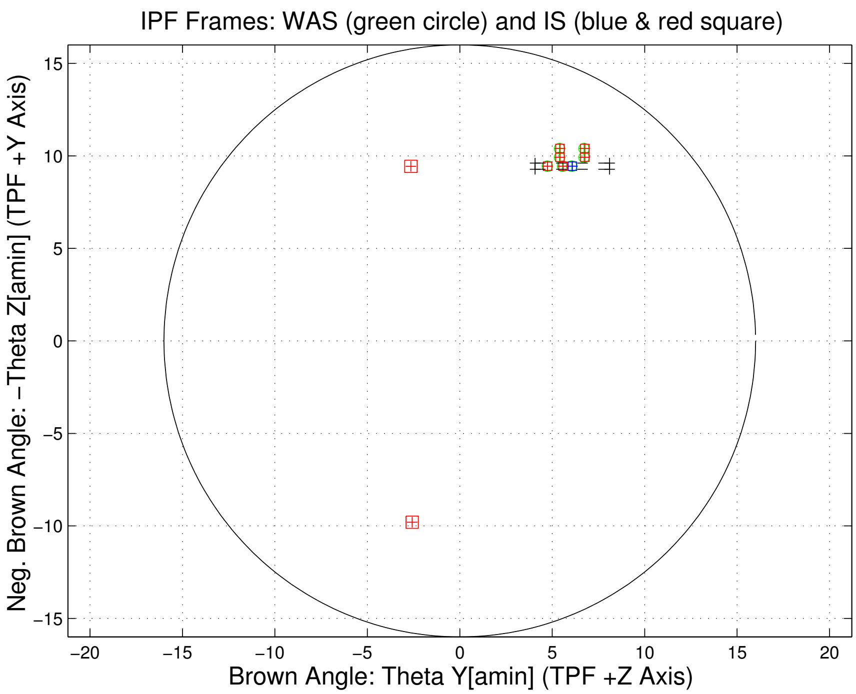

Figure 1.1: A-priori and a-posteriori IPF frames

RAW	FINAL (After Editing)
AA501121	AA501121
AS501121	AS501121
CA502121	CA502121
CB501121	CB501121
CS502121	CS502121

Table 1.1: IPF filter input files

EXECUTION CONFIGURATION ITEM	CURRENT STATUS
IPF Filter Version Used	IPF.V3.0.0B
Frame Table Version Used	BodyFrames_FTU_14a
Scan-Mirror Employed?	YES
IPF Filter Mode	NORMAL-MODE(0)
SLIT-MODE Operation	ENABLED
Kalman Filter Operation	ENABLED
Least-Squares Data Analysis	ENABLED
IBAD Screening	ENABLED
User-Specified Data Editing	DISABLED
Total Number of Iterations	75
LS Residual Sigma Scale	4.07818575E-001
Total Number of Maneuvers	8

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	1	1
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	
0	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	

Table 1.3: IPF filter execution mask vector assignment

FOCAL PLANE SURVEY ANALYSIS: IOC Fine Survey.
INSTRUMENT NAME: MIPS_SED_center NF: 121

PIX2RADW: 4.88144360E-005[rad/pixel] = 1.0069E+001[arcsec/pixel]
PIX2RADV: 4.88144360E-005[rad/pixel] = 1.0069E+001[arcsec/pixel]

FRAME	DESCRIPTION	IPF[1]	SF[2]	TOTAL	REQ
121(P)	MIPS_SED_center	0.3895	0.0855	0.3988	1.10
105(I)	MIPS_SED_9	0.3895	0.0855	0.3988	N/A
106(I)	MIPS_SED_10	0.3895	0.0855	0.3988	N/A
122(I)	MIPS_SED_1	0.3895	0.0855	0.3988	N/A
123(I)	MIPS_SED_2	0.3895	0.0855	0.3988	N/A
125(I)	MIPS_SED_3	0.3895	0.0855	0.3988	N/A
126(I)	MIPS_SED_4	0.3895	0.0855	0.3988	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	2.9299	2.6647	2.6790	arcsec
W-Axis	2.7292	2.5932	2.5964	arcsec
V-Axis	1.0658	0.6133	0.6602	arcsec
Radial	0.2910	0.2647	0.2661	pixels
W-Axis	0.2711	0.2575	0.2579	pixels
V-Axis	0.1058	0.0609	0.0656	pixels

Table 1.5: Science 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: 0.407819. 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 0.0699 arcseconds, given that ARW = 100 $\mu deg/\sqrt{hr}$, with 5.435000e+002 second Maneuver time (max), and 8 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_14a					
NF	NAME	WAS	IS	CHANGE	UNIT
121	theta_Y	+6.055286	+6.090493	+0.035207	arcmin
121	theta_Z	-9.441871	-9.446430	-0.004558	arcmin
121	angle	+0.000049	+0.000049	-0.000000	deg
105	theta_Y	+5.561100	+5.587058	+0.025958	arcmin
105	theta_Z	-9.441900	-9.446430	-0.004530	arcmin
105	angle	-0.000000	+0.000049	+0.000049	deg
106	theta_Y	+4.737300	+4.747999	+0.010699	arcmin
106	theta_Z	-9.441900	-9.446431	-0.004531	arcmin
106	angle	+0.000000	+0.000049	+0.000049	deg
122	theta_Y	+6.714265	+6.761740	+0.047475	arcmin
122	theta_Z	-9.923538	-9.931406	-0.007868	arcmin
122	angle	+0.000049	+0.000049	-0.000000	deg
123	theta_Y	+5.396308	+5.419246	+0.022939	arcmin
123	theta_Z	-9.923538	-9.931406	-0.007868	arcmin
123	angle	+0.000049	+0.000049	-0.000000	deg
125	theta_Y	+6.714265	+6.761740	+0.047475	arcmin
125	theta_Z	-10.395205	-10.406314	-0.011109	arcmin
125	angle	+0.000049	+0.000049	-0.000000	deg
126	theta_Y	+5.396308	+5.419247	+0.022939	arcmin
126	theta_Z	-10.395205	-10.406314	-0.011109	arcmin
126	angle	+0.000049	+0.000049	-0.000000	deg

Table 1.6: IPF Brown angle summary

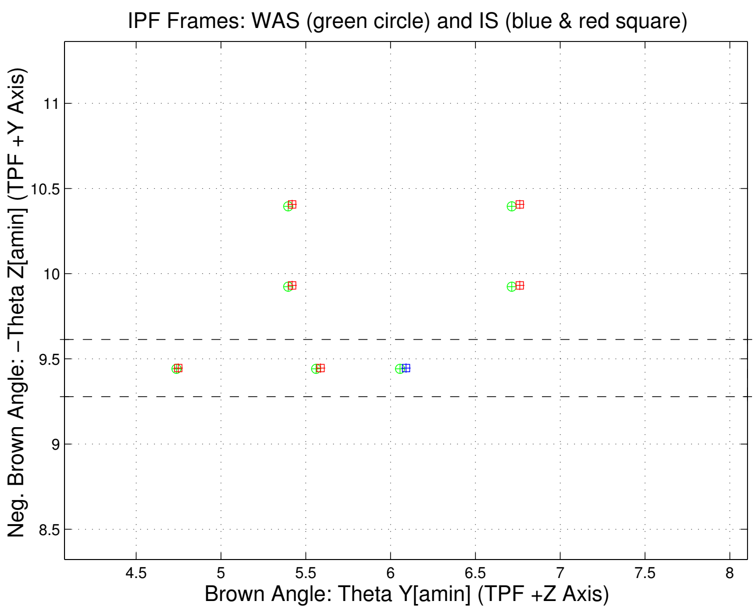

Figure 1.2: A-priori and a-posteriori IPF frames (ZOOMED)

2 IPF INPUT FILE HISTORY

WAS	SIZE	IS	SIZE	REMOVED	PATCHED
AA501121	UNCHANGED	AA501121	UNCHANGED	0	0
CA502121	UNCHANGED	CA502121	UNCHANGED	0	N/A
CB501121	UNCHANGED	CB501121	UNCHANGED	0	N/A

Table 2.1: IPF input file editing status

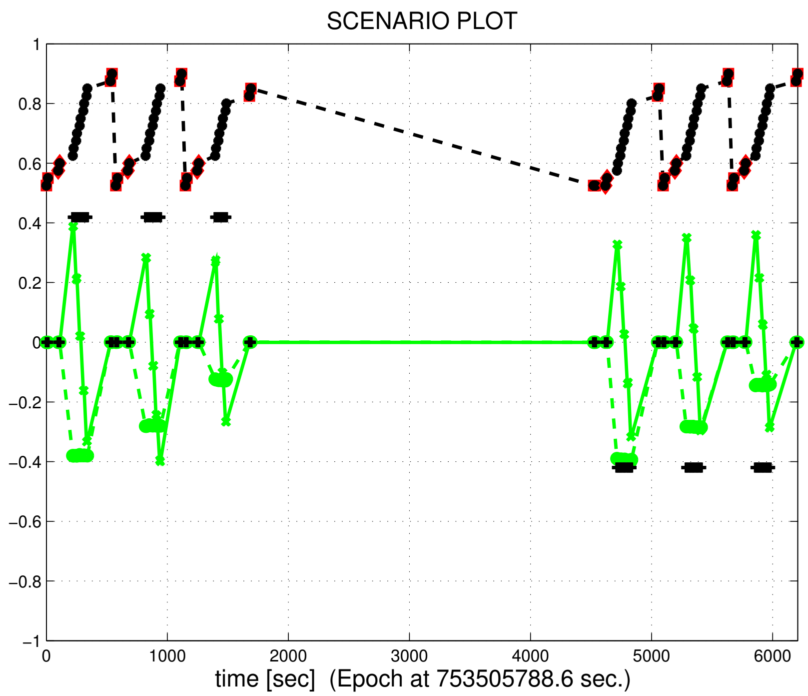

Figure 2.1: Scenario Plot

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
Figure 3.4	A-priori prediction error
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
IPF filter performance (post run results)	
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	A-Posteriori Science Centroid Prediction Error Quiver (Att. Cor.)
Figure 3.21	Normalized A-Posteriori Science Centroid Prediction Errors
Figure 3.22	KF innovations with (o) and w/o (+) attitude corrections (PCRS)
Figure 3.23	Histograms of PCRS a-posteriori residuals (or innovations)
Figure 3.24	A-posteriori PCRS Prediction Summary
Figure 3.25	A-posteriori PCRS Prediction (PCRS 1 Only)
Figure 3.26	A-posteriori PCRS Prediction (PCRS 2 Only)
Figure 3.27	A-Posteriori PCRS Prediction Errors Quiver (Att. Cor.)
Figure 3.28	Normalized A-Posteriori PCRS Prediction Errors
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Figure 3.30	V-axis KF innovations and 1-sigma bound
Figure 3.31	Array plot with (solid) and w/o (dashed) optical distortion corrections
Figure 3.32	Optical Distortion Plot: total (x5 magnification)
Figure 3.33	Optical Distortion Plot: constant plate scales (x5 magnification)
Figure 3.34	Optical Distortion Plot: linear plate scale (x5 magnification)
Figure 3.35	Optical Distortion Plot: gamma terms (x5 magnification)
Figure 3.36	Scan Mirror Chops
Figure 3.37	IPF Frame Reconstruction
Figure 3.38	Center Pixel Reconstruction
IPF parameter trending plots	
Figure 3.39	Estimated attitude corrections (Body frame)
Figure 3.40	Estimated attitude error sigma plot (Body frame)
Figure 3.41	Systematic error attributed to thermo-mechanical boresight drift (equiv. angle in (W,V) coords)
Figure 3.42	Systematic error attributed to thermo-mechanical boresight drift (equiv. angle in Body frame)
Figure 3.43	Systematic error attributed to gyro drift bias (equiv. rate in (W,V) coords)
Figure 3.44	Systematic error attributed to gyro drift bias (equiv. angle in (W,V) coords)
Figure 3.45	Systematic error attributed to gyro drift bias (equiv. angle in Body frame)

Table 3.2: Table of figures II (IPF run)

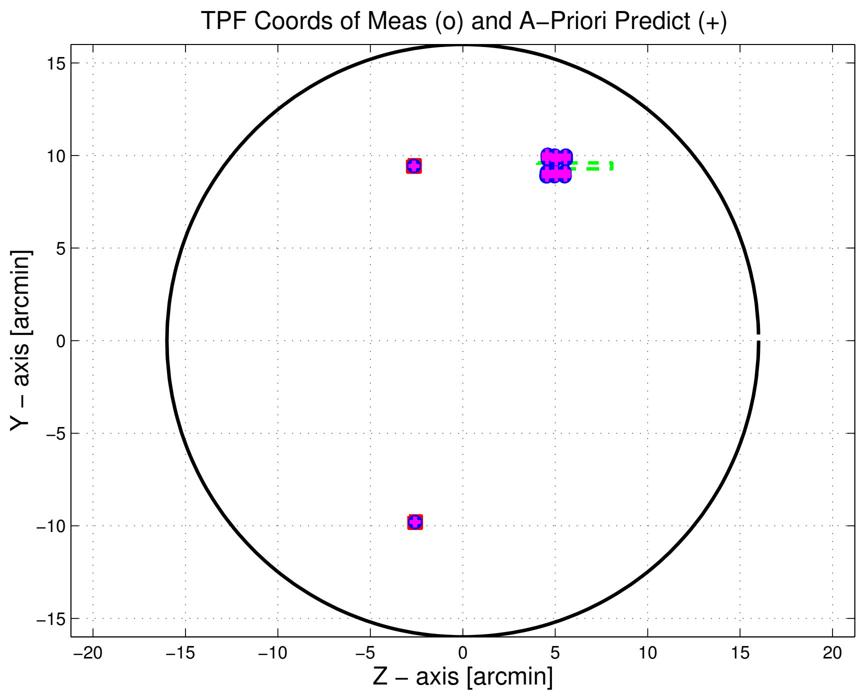

Figure 3.1: TPF coords of measurements and a-priori predicts

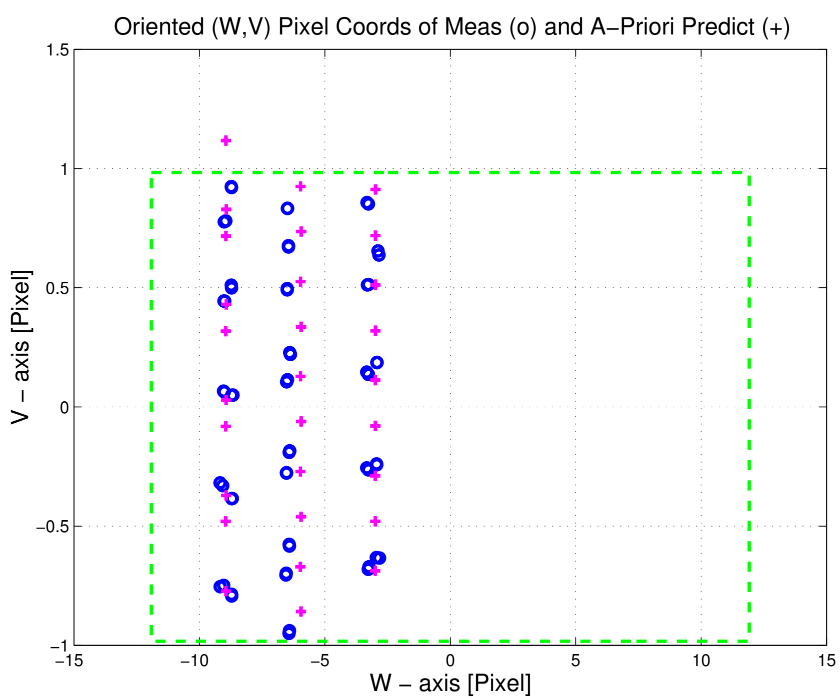

Figure 3.2: Oriented Pixel Coords of measurements and a-priori predicts

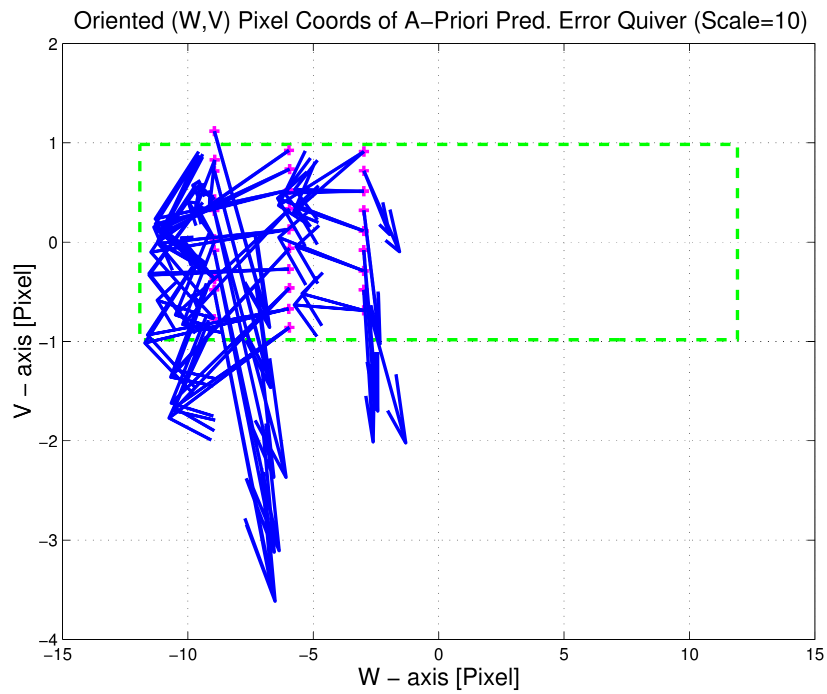

Figure 3.3: Oriented (W,V) Pixel Coords of A-Priori Prediction Error Quiver Plot

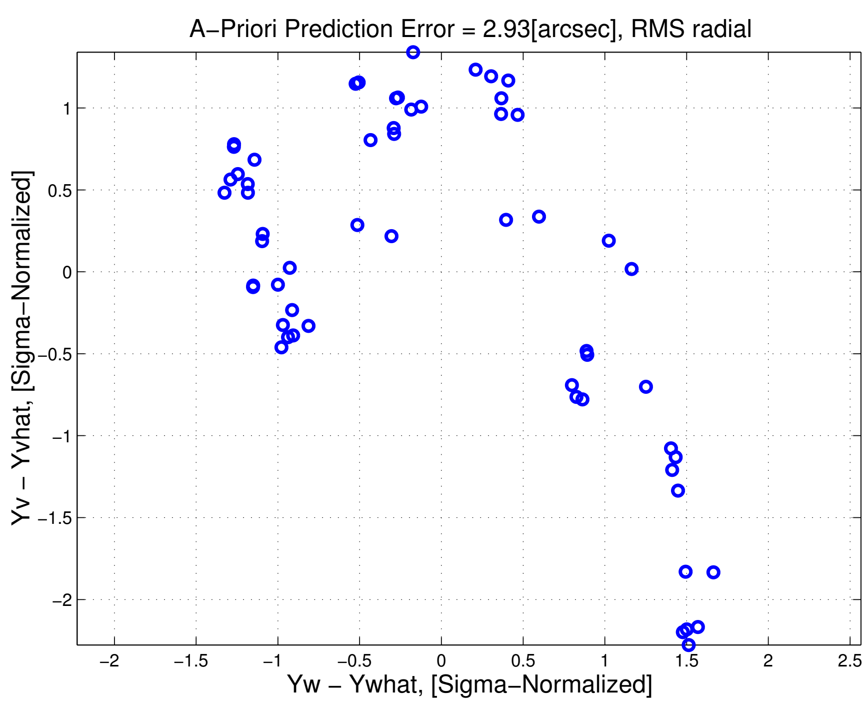

Figure 3.4: A-priori prediction error (Science Centroids)

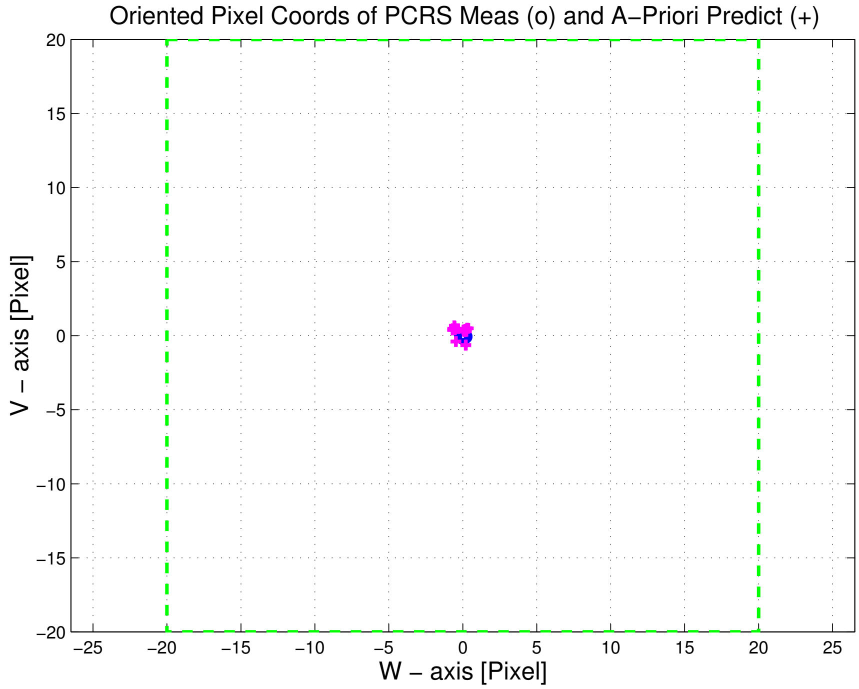

Figure 3.5: Oriented Pixel Coords of measurements and a-priori predicts (PCRS only)

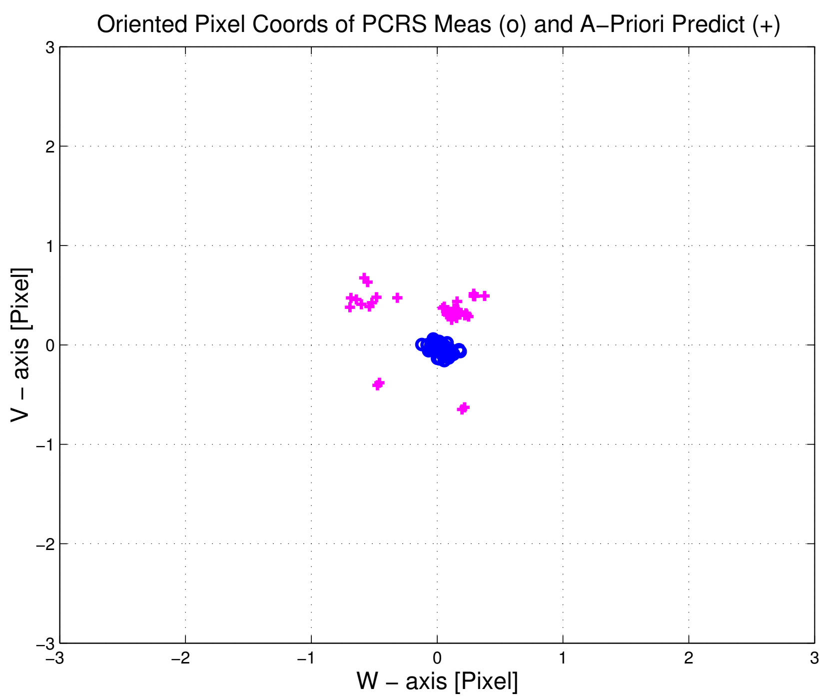

Figure 3.6: Oriented Pixel Coords of measurements and a-priori predicts (Zoomed, PCRS only)

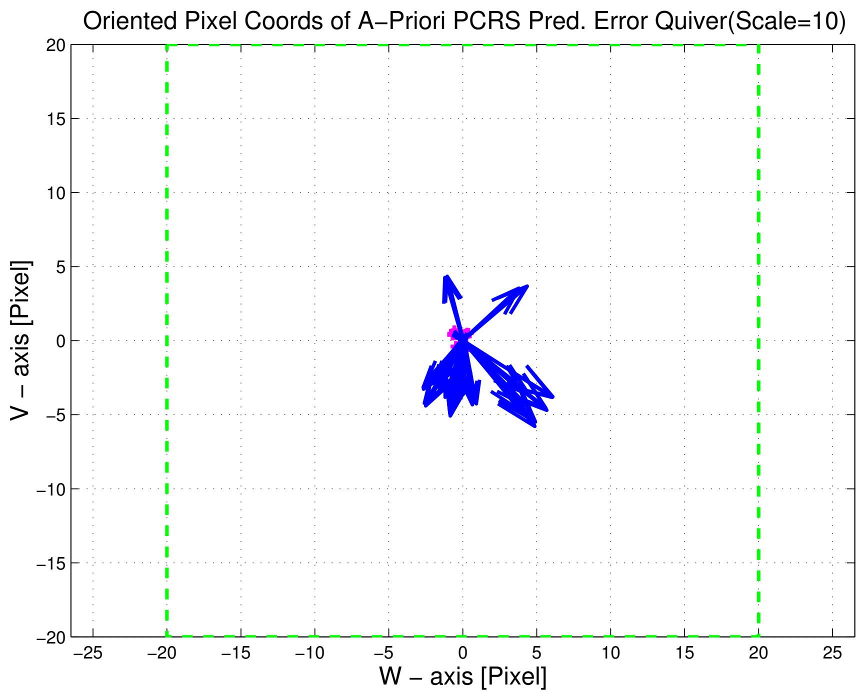

Figure 3.7: Oriented (W,V) Pixel Coords of A-Priori PCRS Prediction Error Quiver Plot

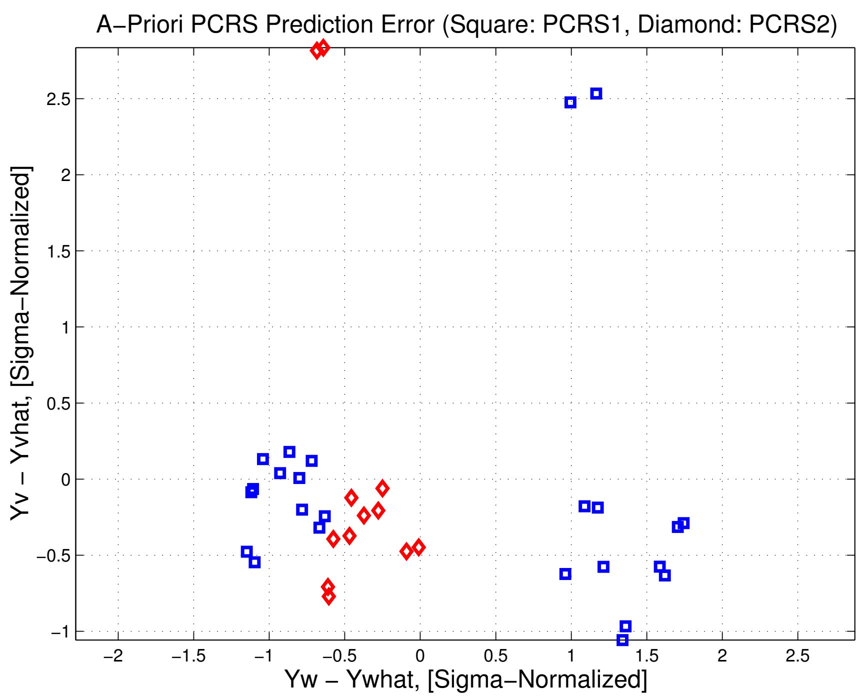

Figure 3.8: A-priori PCRS prediction error

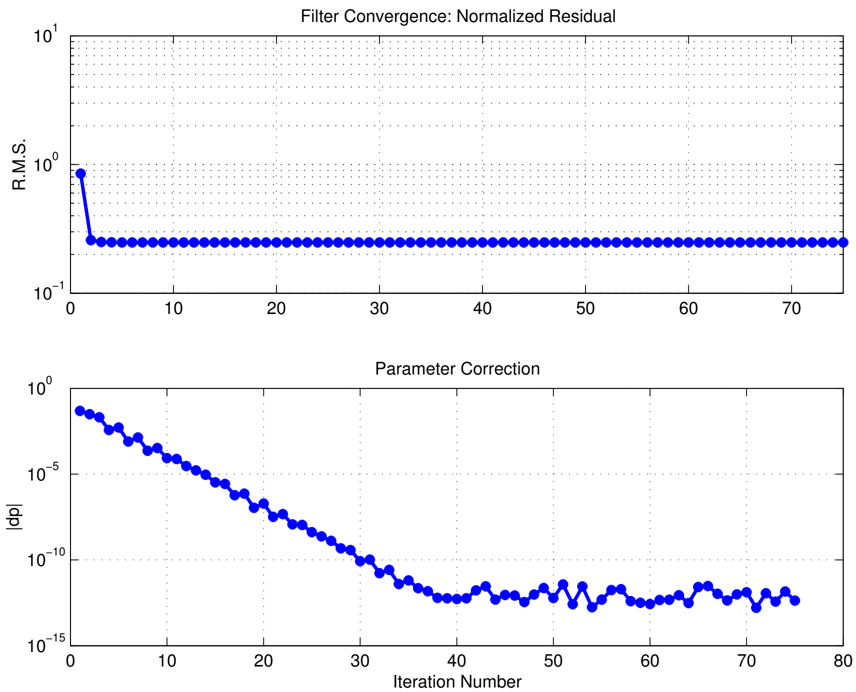

Figure 3.9: IPF execution convergence, chart 1

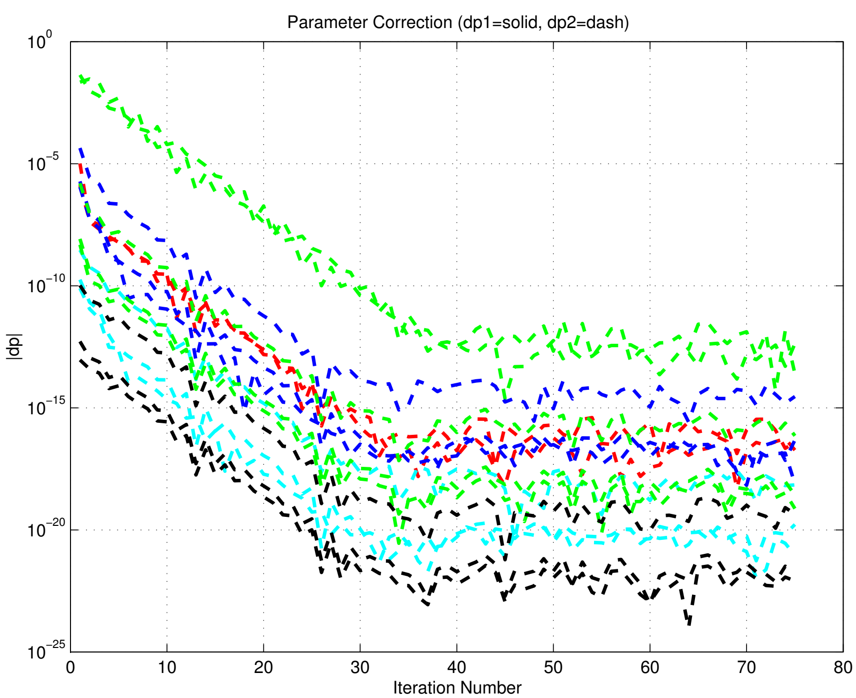

Figure 3.10: IPF execution convergence, chart 2

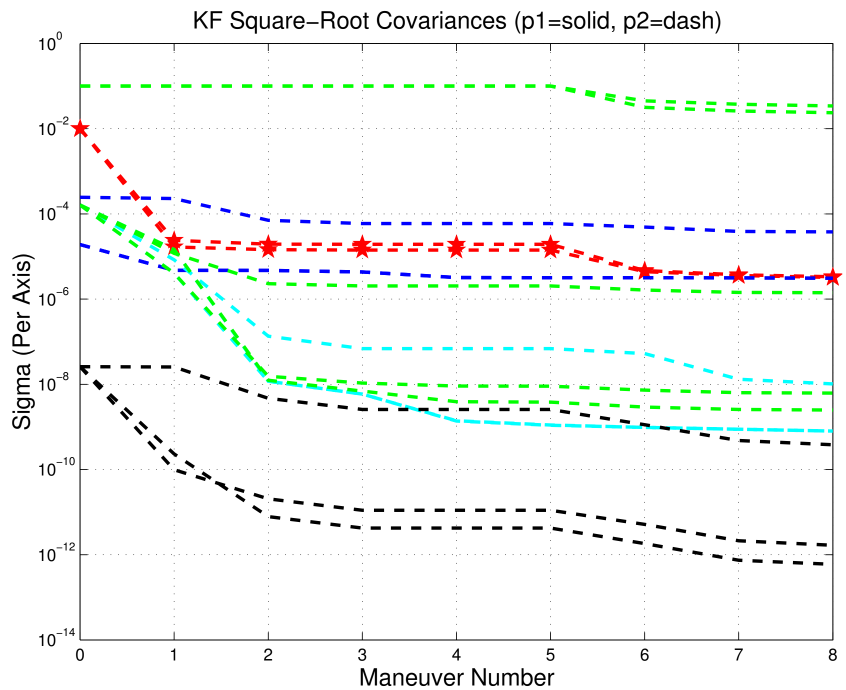

Figure 3.11: Parameter uncertainty convergence

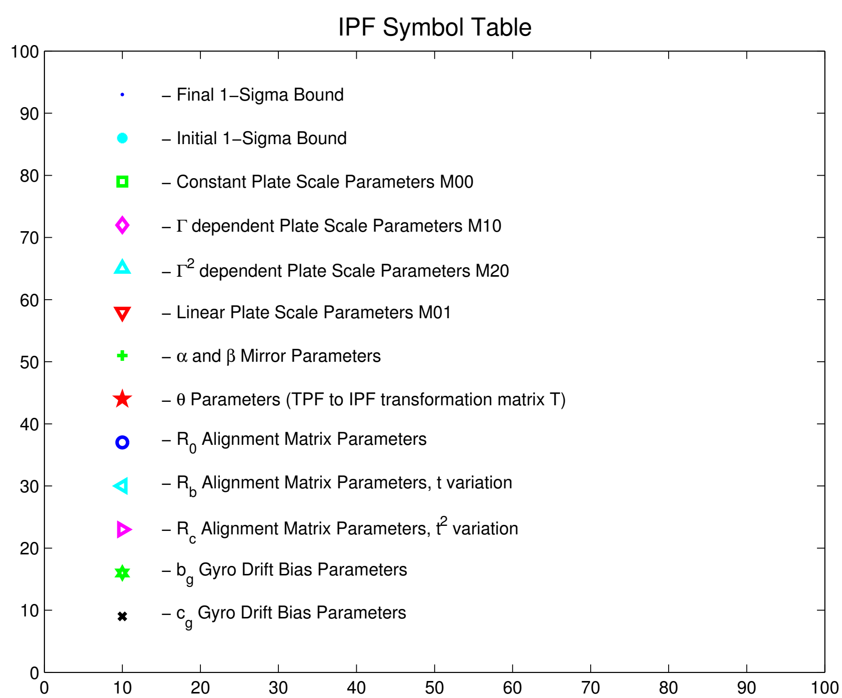

Figure 3.12: IPF parameter symbol table

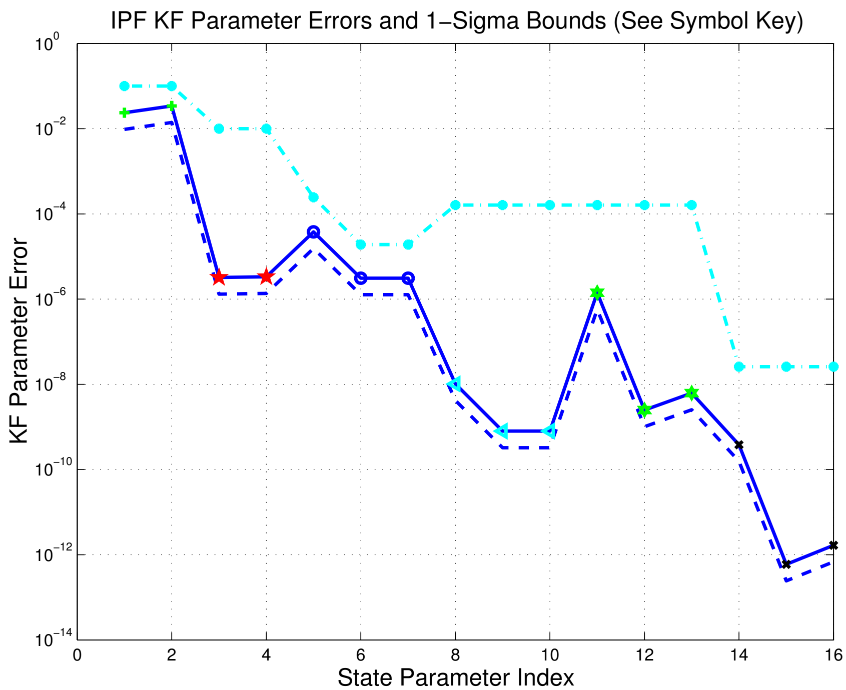

Figure 3.13: KF parameter error sigma plots

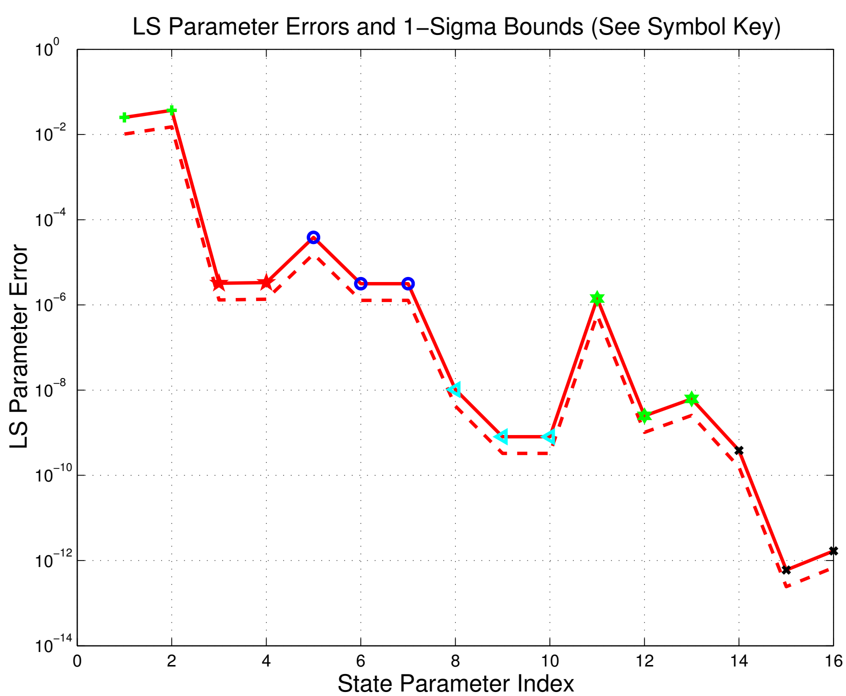

Figure 3.14: LS parameter error sigma plot

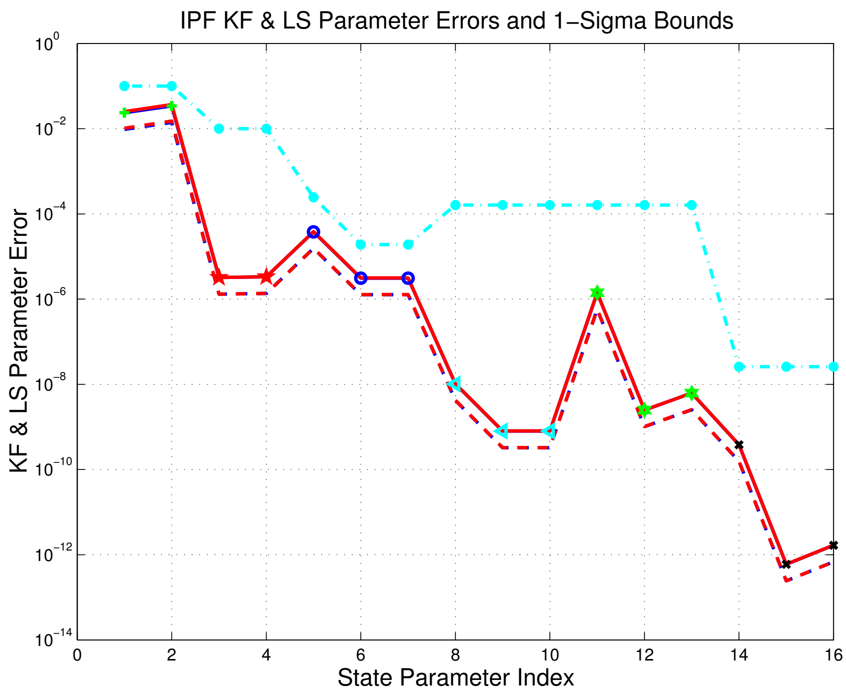

Figure 3.15: KF and LS parameter error sigma plot

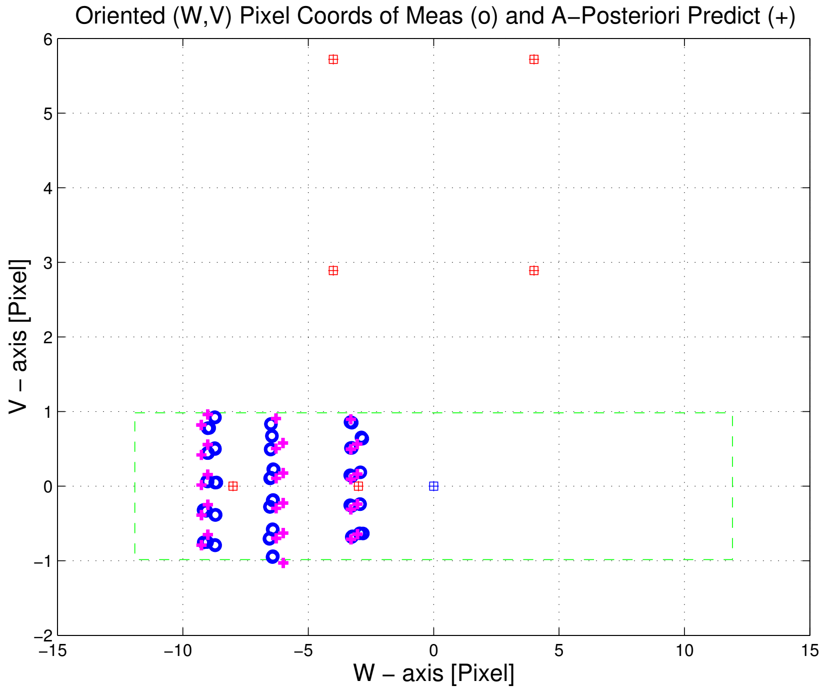

Figure 3.16: Oriented Pixel Coords of meas. and a-posteriori predicts

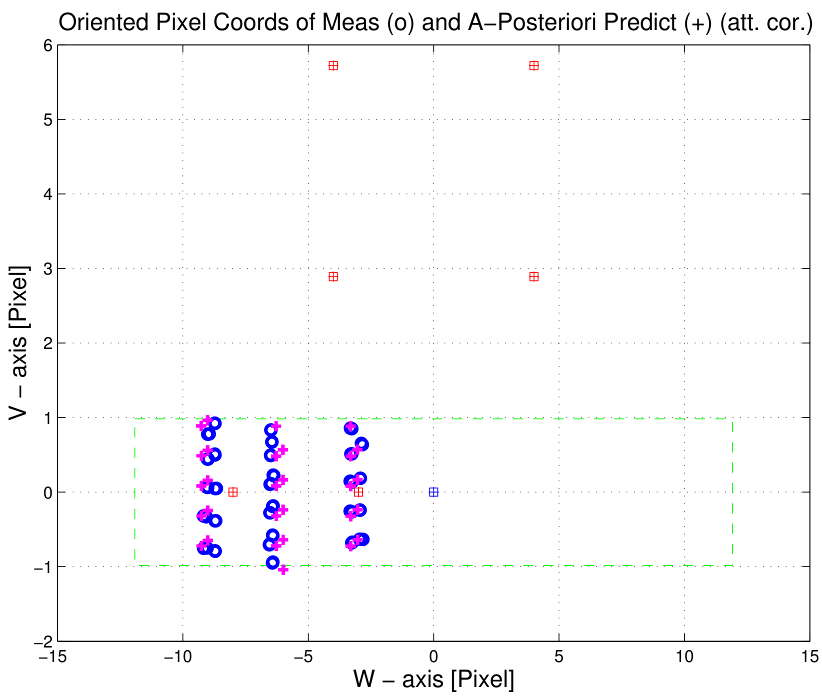

Figure 3.17: Oriented Pixel Coords of meas. and a-posteriori predicts (attitude corrected)

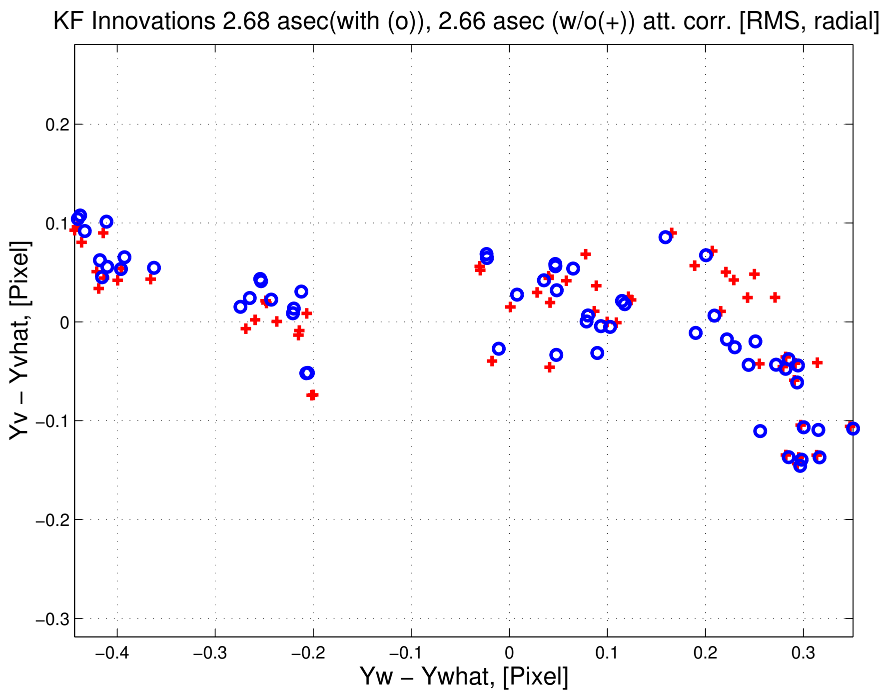

Figure 3.18: KF innovations with (o) and w/o (+) attitude corrections

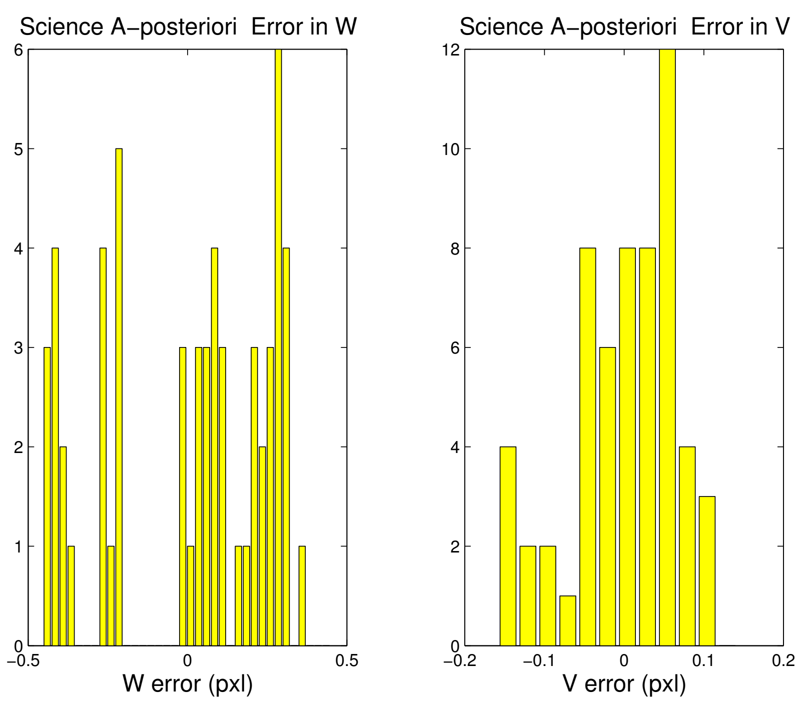

Figure 3.19: Histograms of science a-posteriori residuals (or innovations)

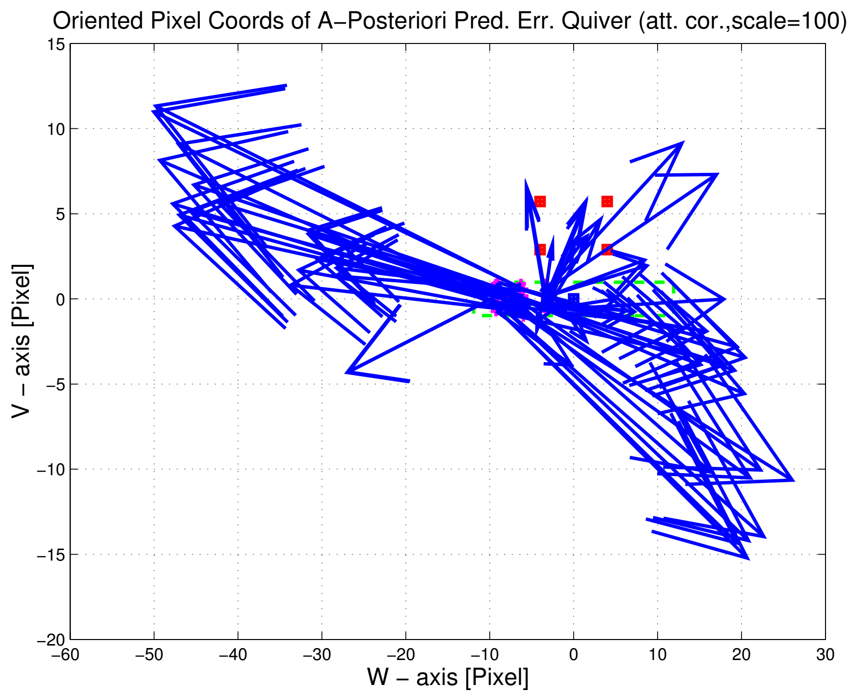

Figure 3.20: A-Posteriori Science Centroid Prediction Error Quiver (Att. Cor.)

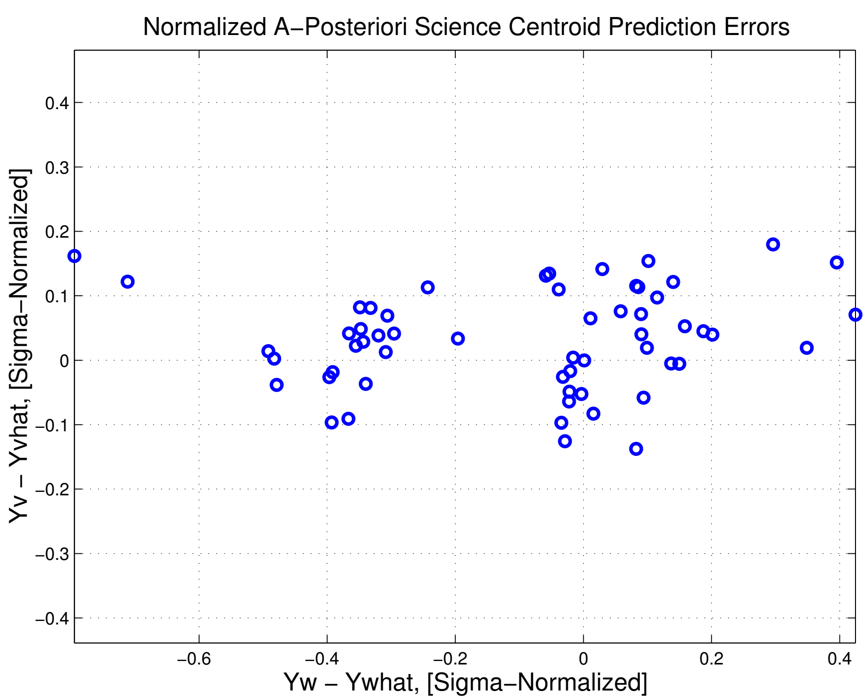

Figure 3.21: Normalized A-Posteriori Science Centroid Prediction Errors

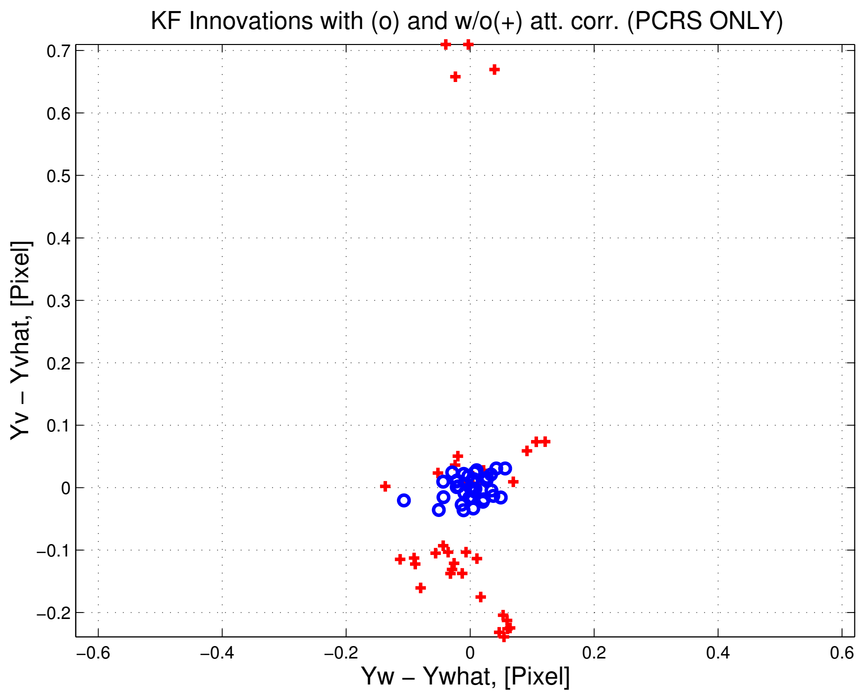

Figure 3.22: KF innovations with (o) and w/o (+) attitude corrections (PCRS)

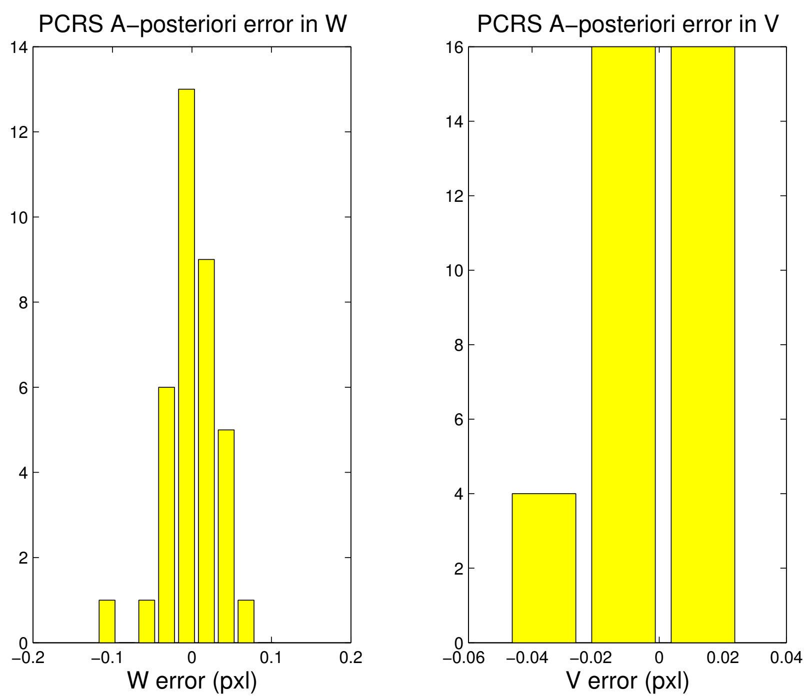

Figure 3.23: Histograms of PCRS a-posteriori residuals (or innovations)

IPF PCRS SUMMARY						
PCRS 1 (Total of 24 centroids)						
RMS	**MEAN**		**SIGMA**			
METRIC	APOST.	ATT. COR.	APOST.	ATT. COR.	STAT. CONF.	UNITS
Radial	0.0166	0.0045	0.2362	0.0377	0.0077	arcsec
W-axis	-0.0017	-0.0000	0.0663	0.0338	0.0069	arcsec
V-axis	-0.0165	0.0045	0.2267	0.0166	0.0034	arcsec
PCRS 2 (Total of 12 centroids)						
METRIC	APOST.	ATT. COR.	APOST.	ATT. COR.	STAT. CONF.	UNITS
Radial	0.0384	0.0099	0.3157	0.0318	0.0092	arcsec
W-axis	-0.0037	0.0000	0.0452	0.0245	0.0071	arcsec
V-axis	0.0382	-0.0099	0.3124	0.0202	0.0058	arcsec
Combined (Total of 36 centroids)						
METRIC	APOST.	ATT. COR.	APOST.	ATT. COR.	STAT. CONF.	UNITS
Radial	0.0029	0.0003	0.2666	0.0365	0.0061	arcsec
W-axis	-0.0024	-0.0000	0.0601	0.0311	0.0052	arcsec
V-axis	0.0017	-0.0003	0.2597	0.0191	0.0032	arcsec

Table 3.3: PCRS measurement prediction error summary

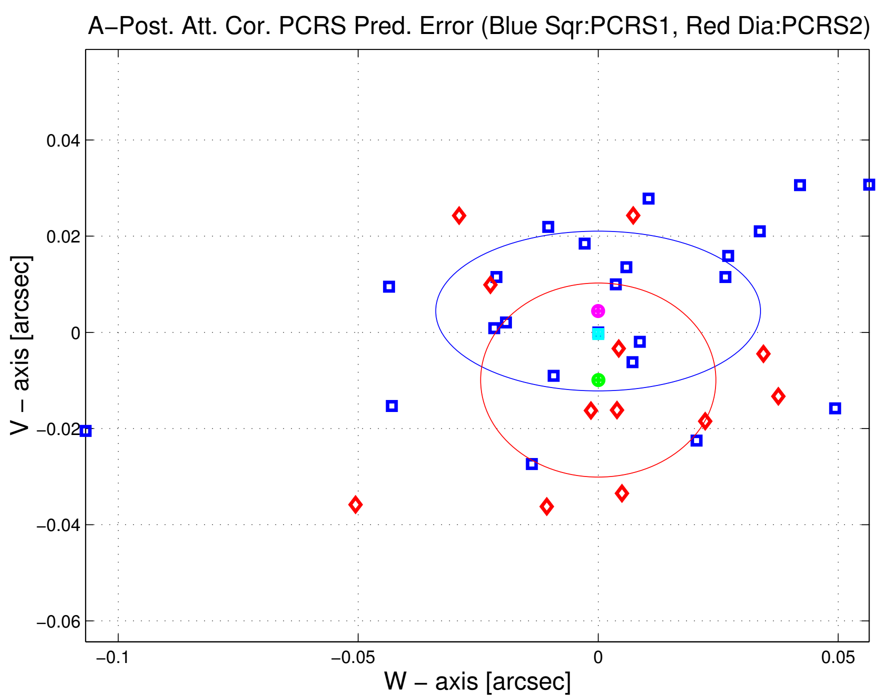

Figure 3.24: A-posteriori PCRS Prediction Summary

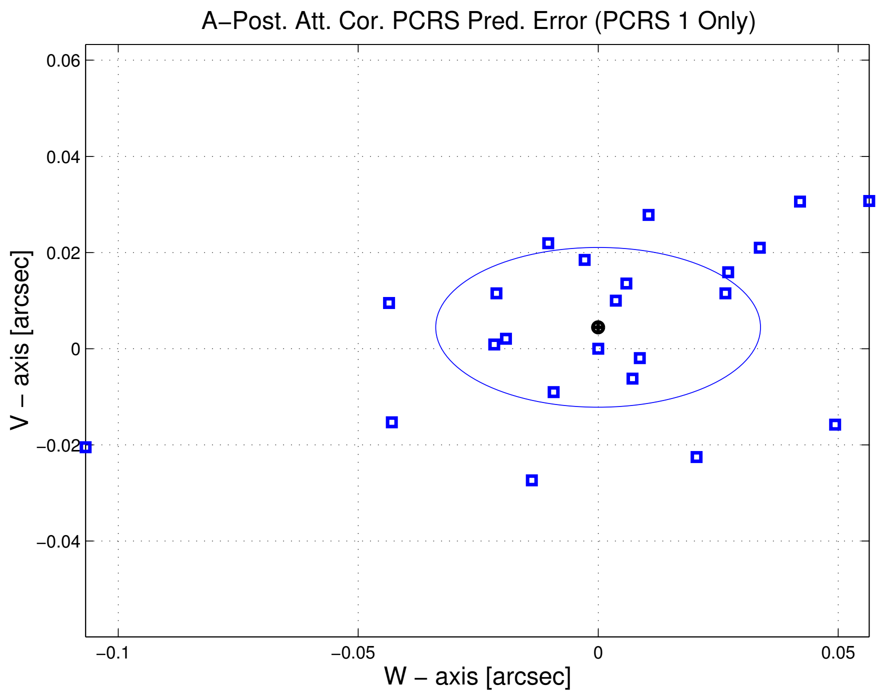

Figure 3.25: A-posteriori PCRS Prediction (PCRS 1 Only)

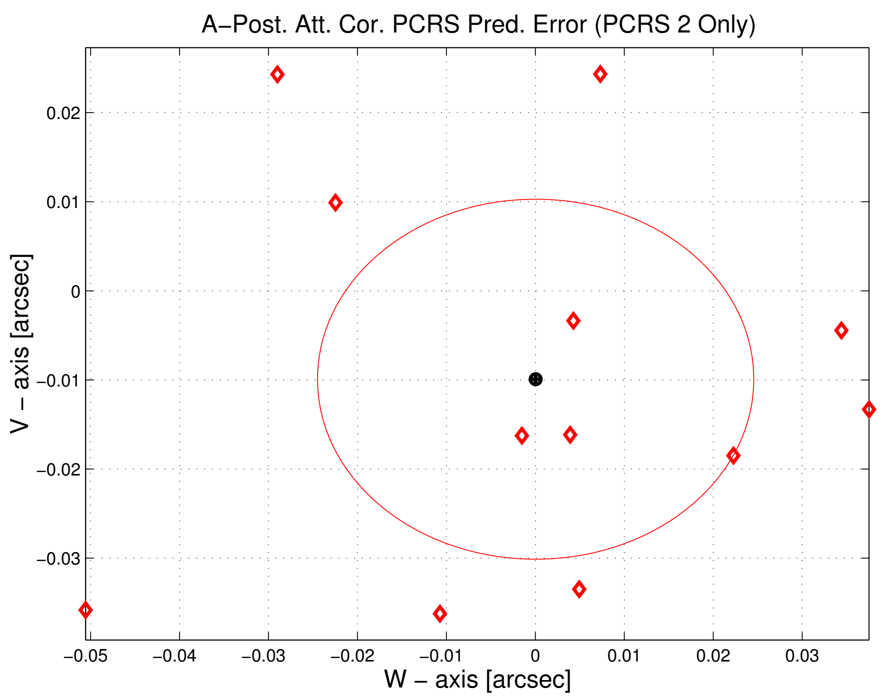

Figure 3.26: A-posteriori PCRS Prediction (PCRS 2 Only)

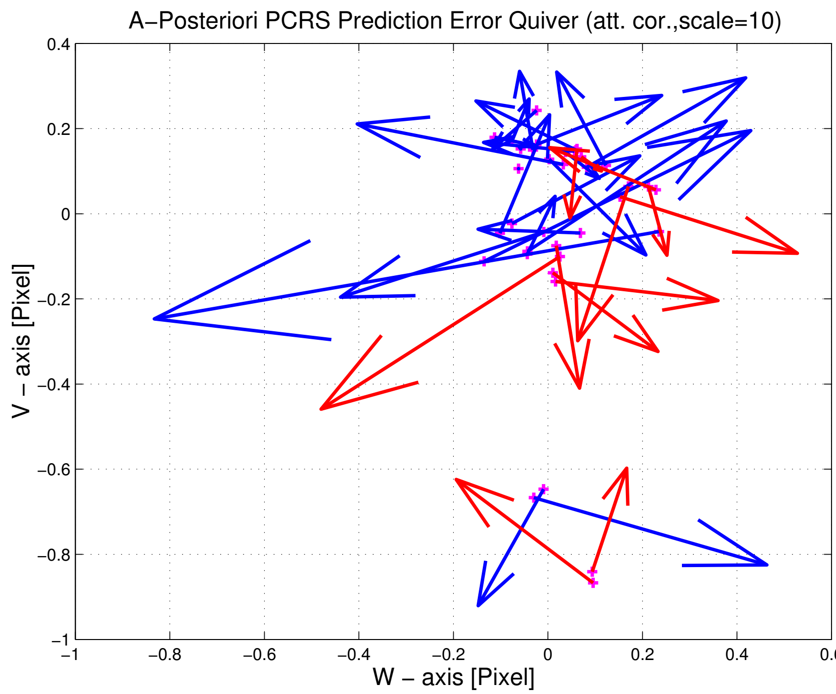

Figure 3.27: A-Posteriori PCRS Prediction Errors Quiver (Att. Cor.)

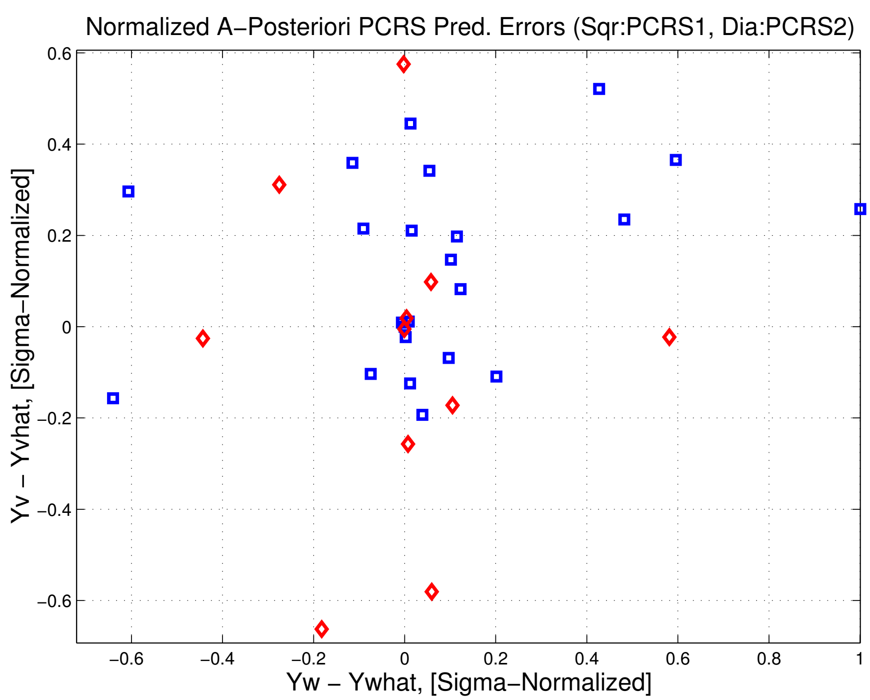

Figure 3.28: Normalized A-Posteriori PCRS Prediction Errors

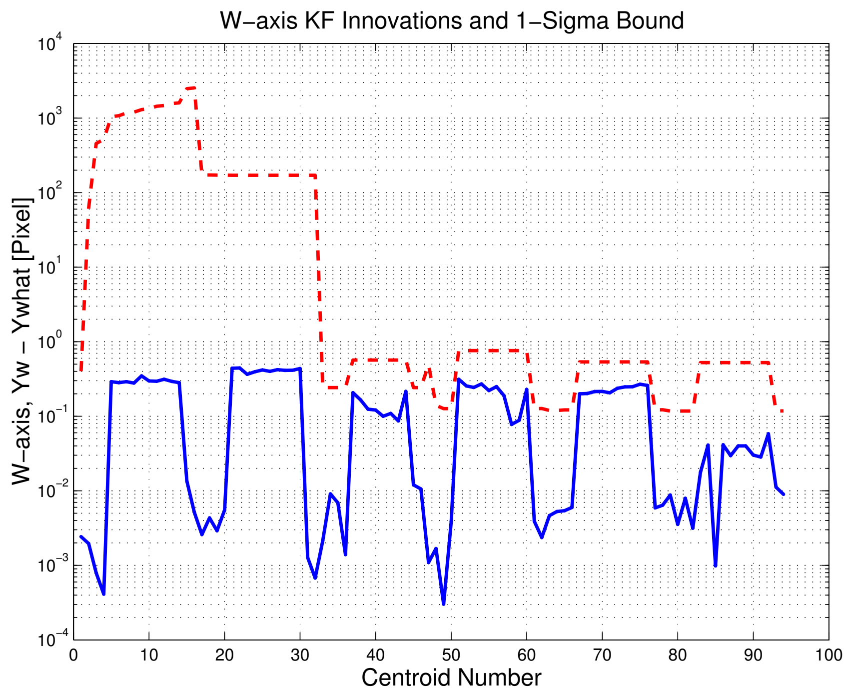

Figure 3.29: W-axis KF innovations and 1-sigma bound

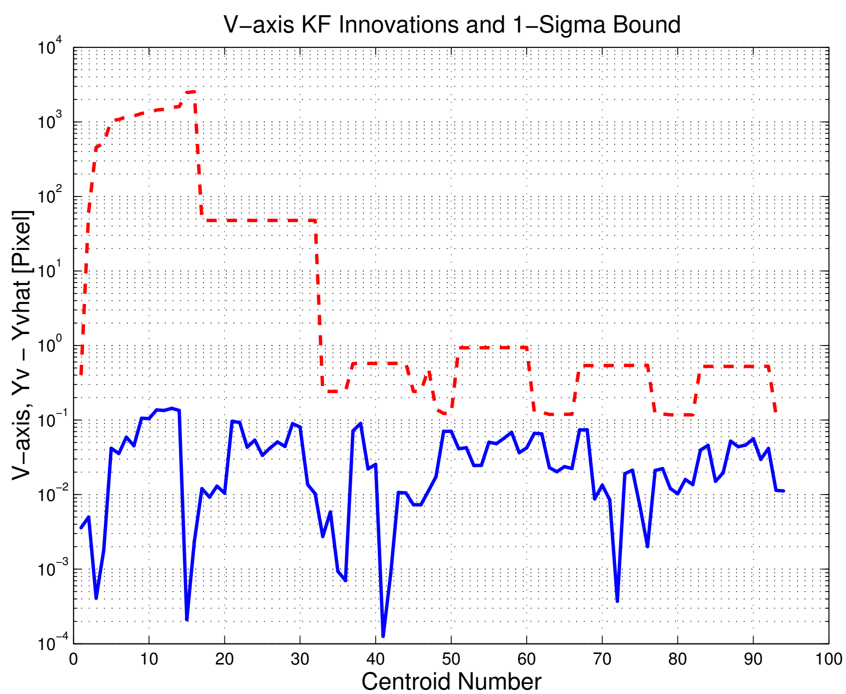

Figure 3.30: V-axis KF innovations and 1-sigma bound

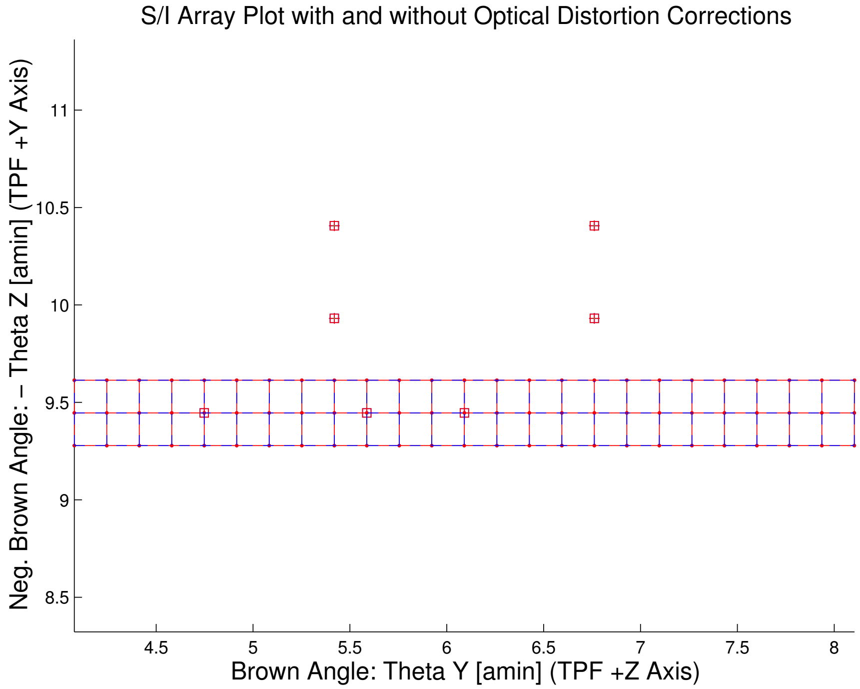

Figure 3.31: Array plot with (solid) and w/o (dashed) optical distortion corrections

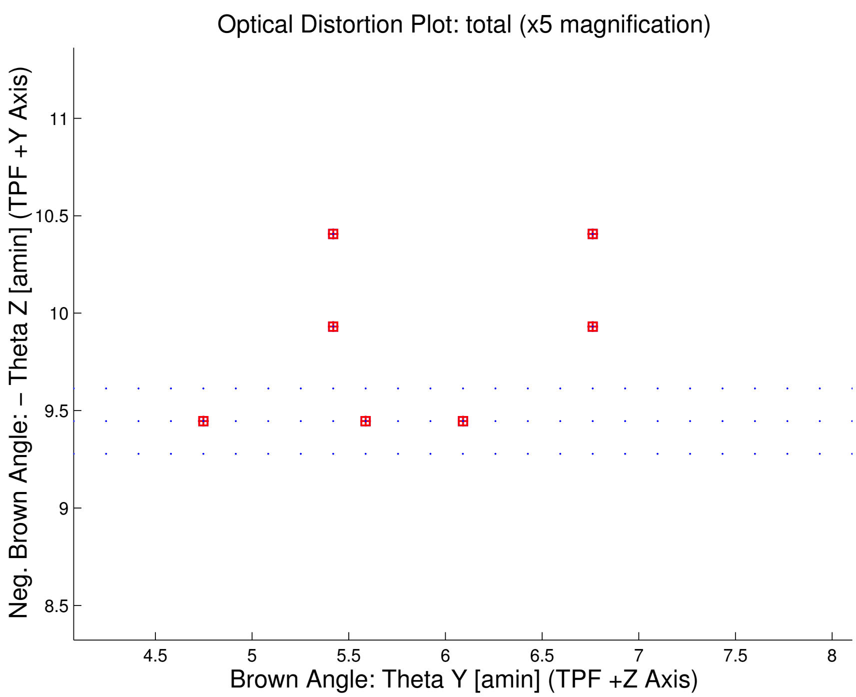

Figure 3.32: Optical Distortion Plot: total (x5 magnification)

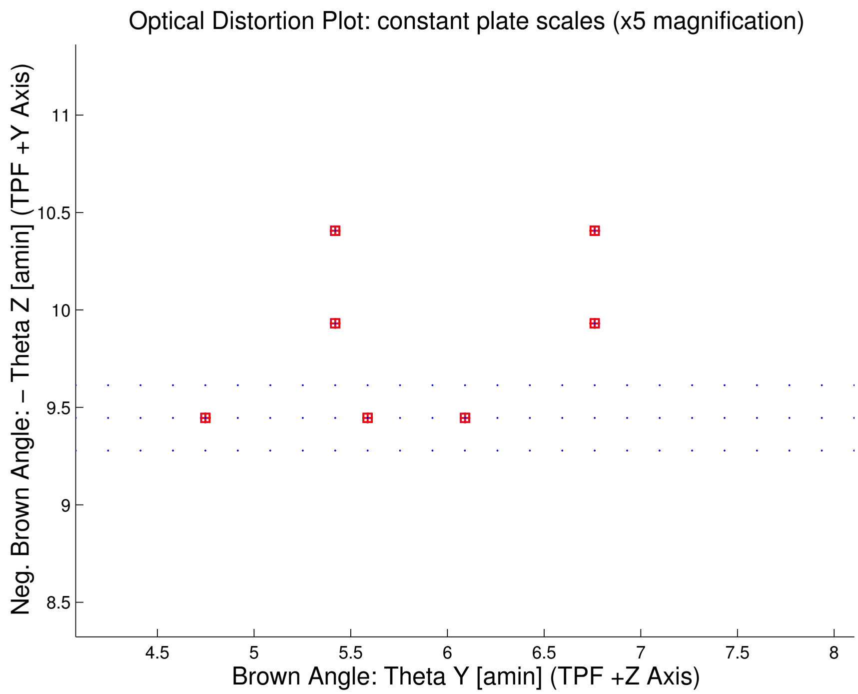

Figure 3.33: Optical Distortion Plot: constant plate scales (x5 magnification)

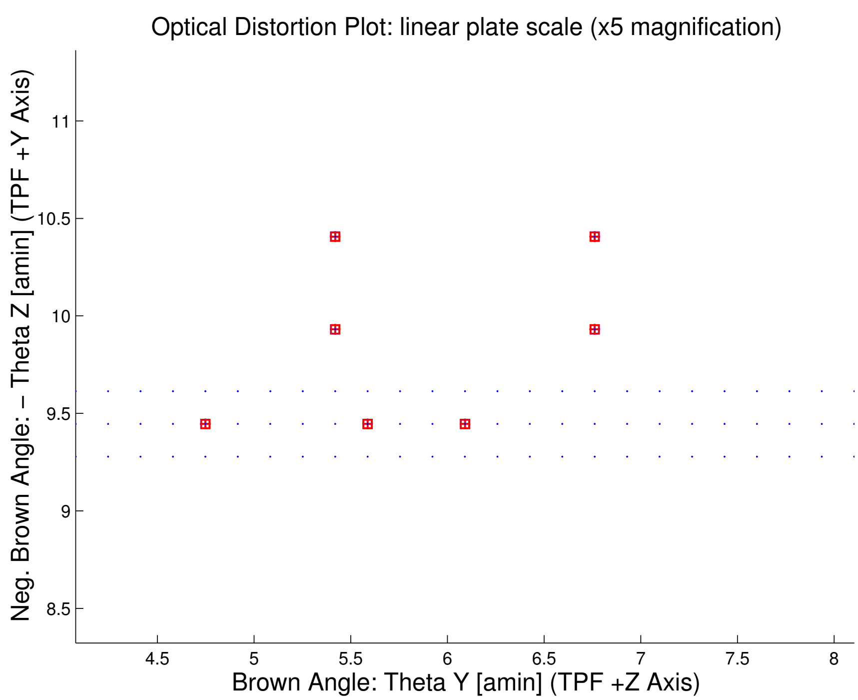

Figure 3.34: Optical Distortion Plot: linear plate scale (x5 magnification)

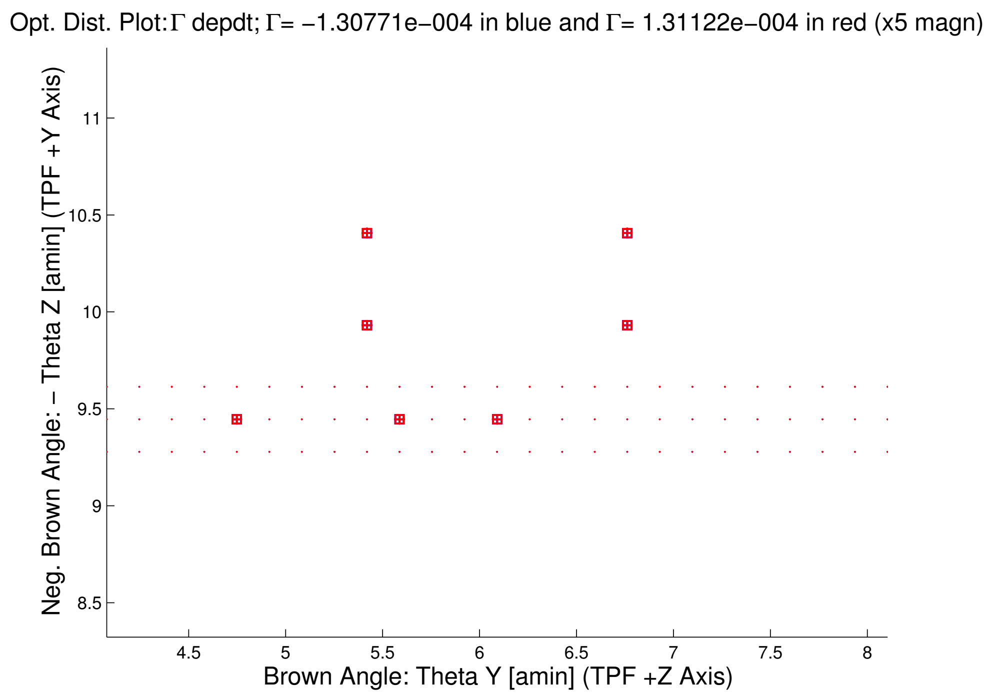

Figure 3.35: Optical Distortion Plot: gamma terms (x5 magnification)

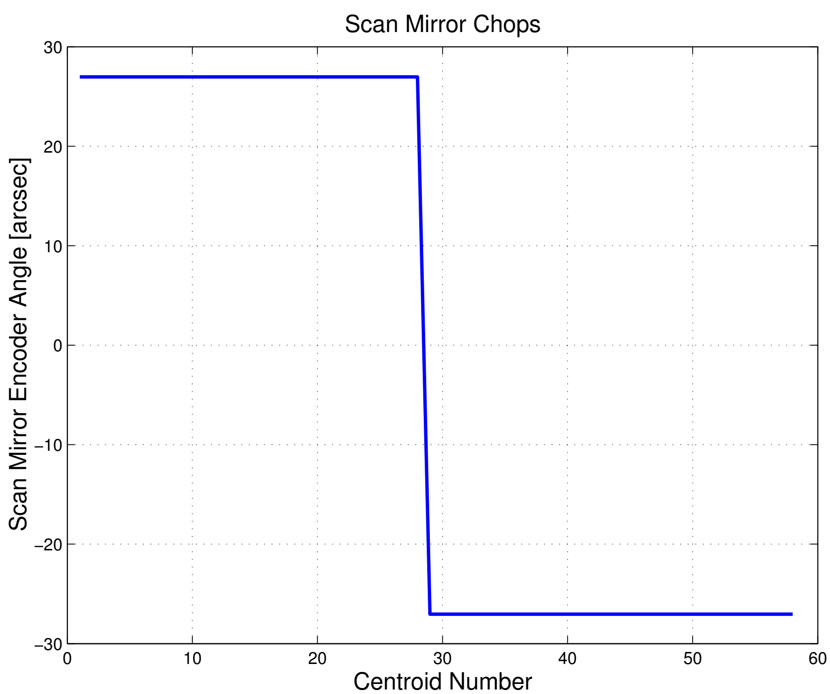

Figure 3.36: Scan Mirror Chops

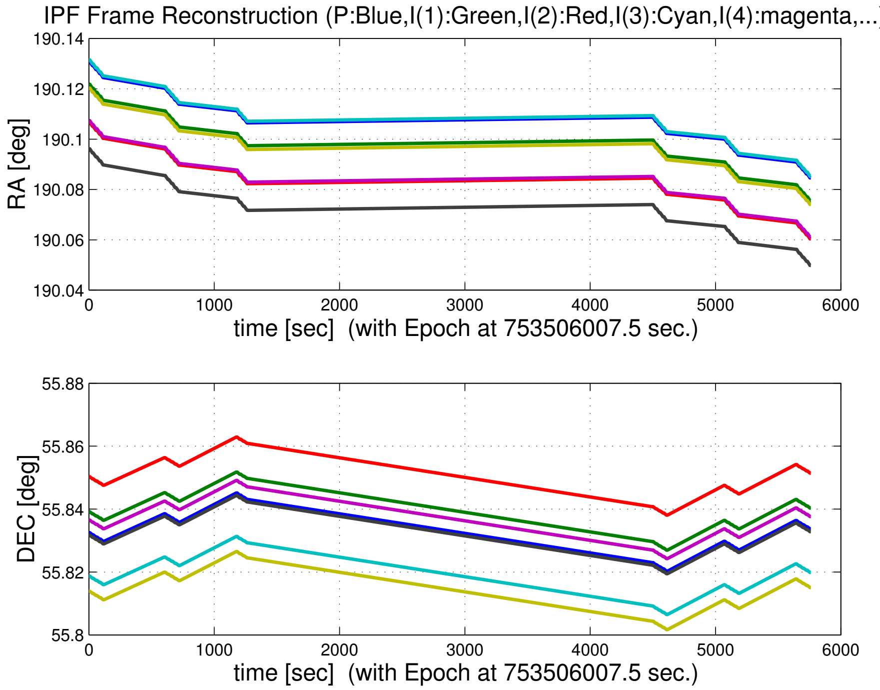

Figure 3.37: IPF Frame Reconstruction

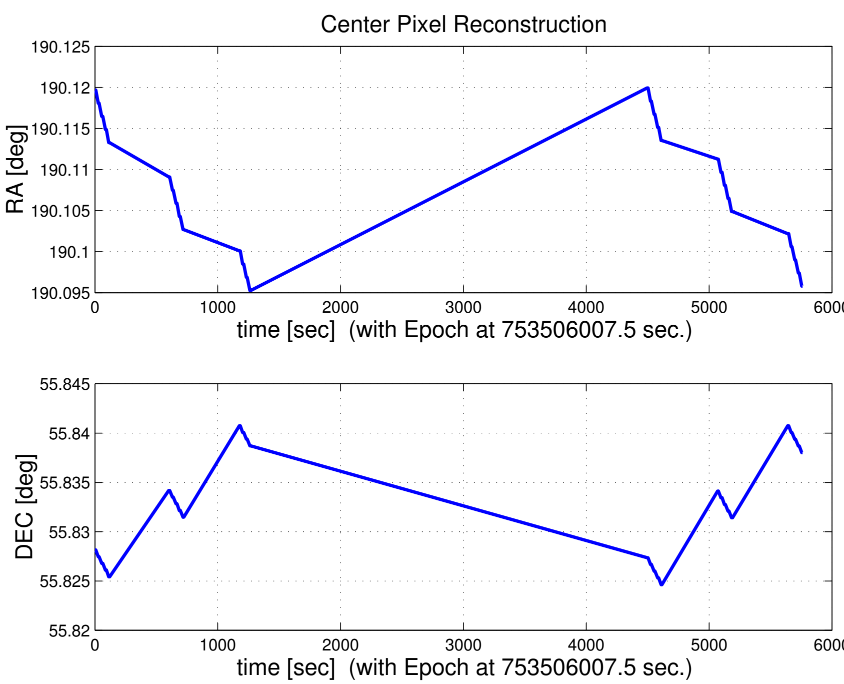

Figure 3.38: Center Pixel Reconstruction

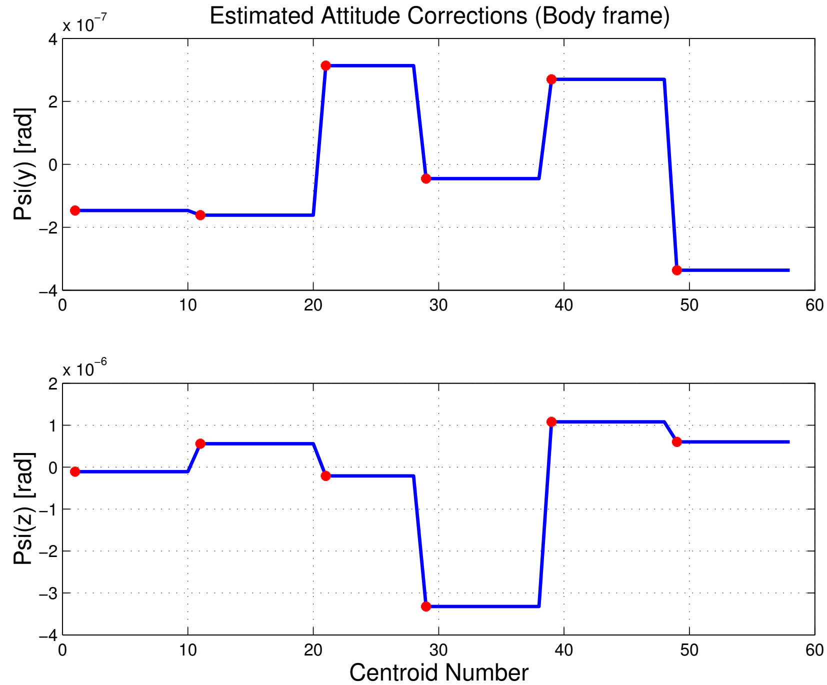

Figure 3.39: Estimated attitude corrections (Body frame)

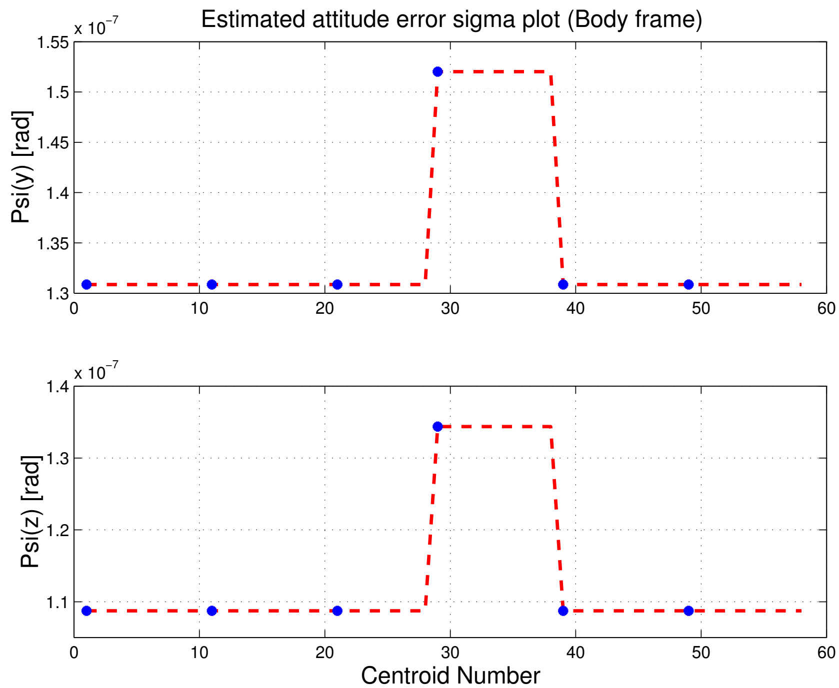

Figure 3.40: Estimated attitude error sigma plot (Body frame)

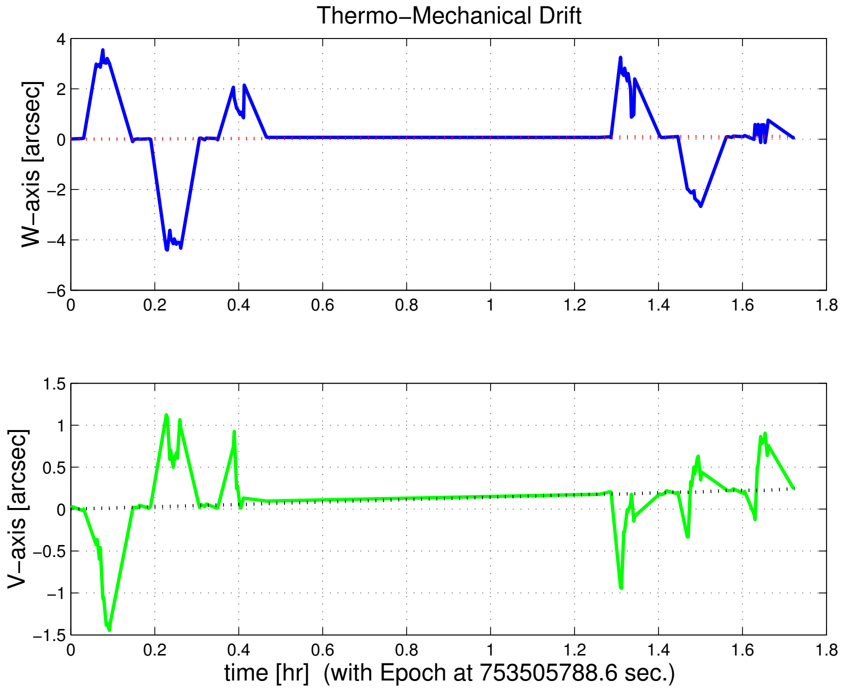

Figure 3.41: Thermo-mechanical boresight drift (equiv. angle in (W,V) coords)

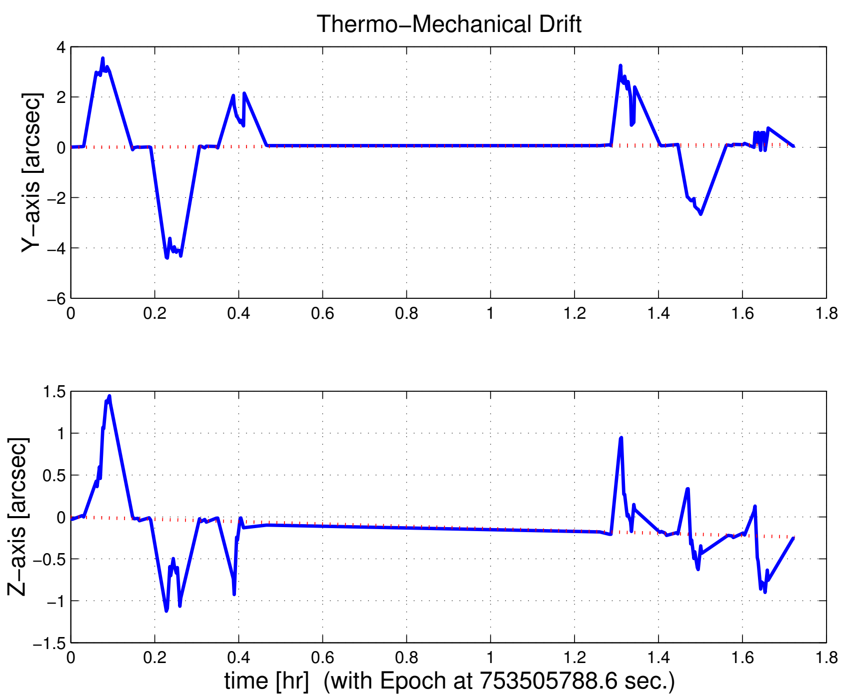

Figure 3.42: Thermo-mechanical boresight drift (equiv. angle in Body frame)

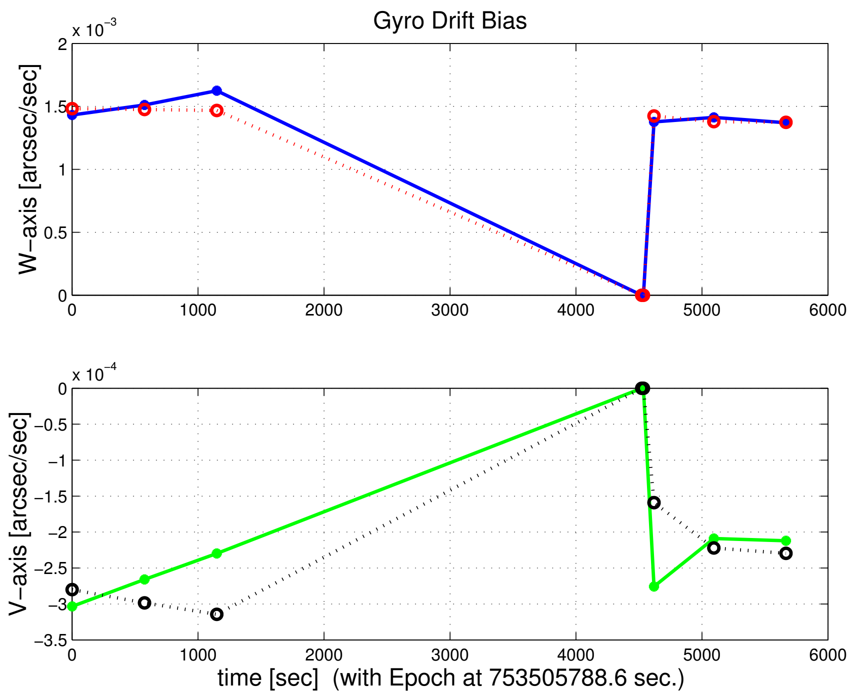

Figure 3.43: Gyro drift bias contribution (equiv. rate in (W,V) coords)

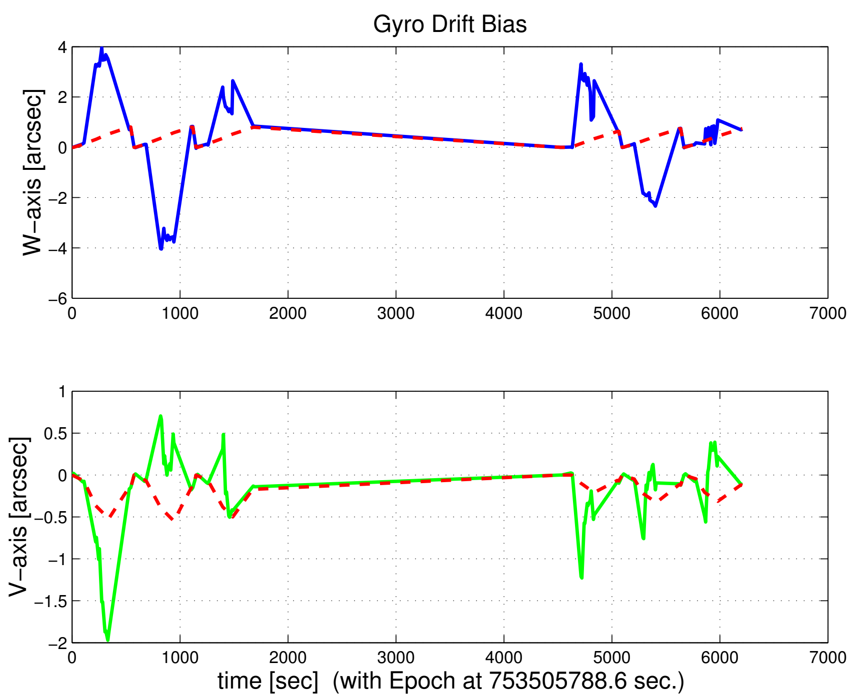

Figure 3.44: Gyro drift bias contribution (equiv. angle in (W,V) coords)

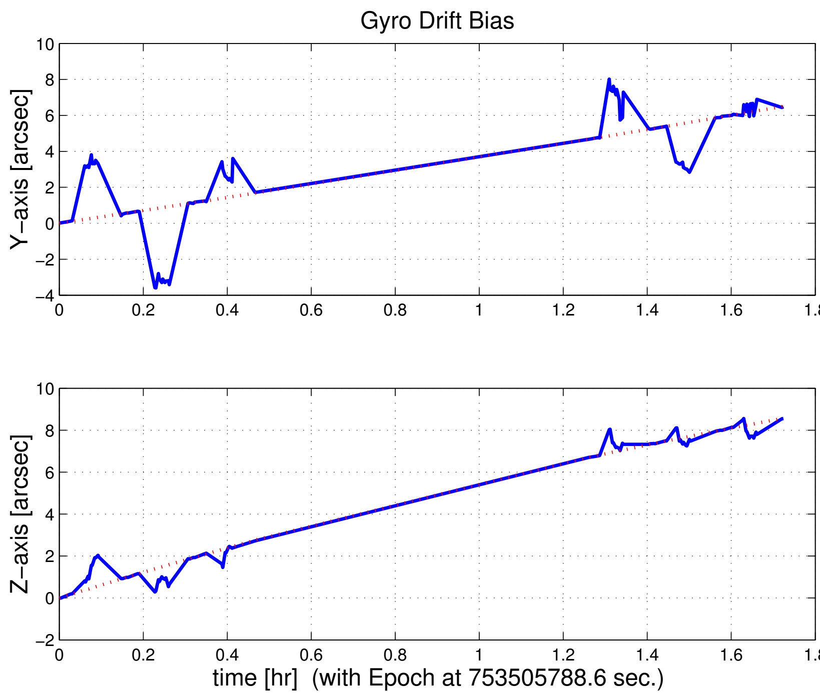

Figure 3.45: Gyro drift bias contribution (equiv. angle in Body frame)

3.2 IPF OUTPUT DATA (IF MINI FILE)

```
OUTPUT FILE NAME: IFmini504121.dat   DATE: 04-Dec-2003   TIME: 15:51
INSTRUMENT NAME:  MIPS_SED_center   NF: 121
IPF FILTER VERSION: IPF.V3.0.0B       SW RELEASE DATE: November 3, 2003
FRAME TABLE USED: BodyFrames_FTU_14a
--------------------------------------------------------------------------------
---------------------------- IPF BROWN ANGLE SUMMARY ----------------------------
--------------------------------------------------------------------------------
         ------------ WAS ------------           ------------ IS -------------
Frame    theta_Y     theta_Z     angle           theta_Y     theta_Z     angle
Number   (arcmin)    (arcmin)    (deg)           (arcmin)    (arcmin)    (deg)
------  ---------------------------------       ---------------------------------
 121     +6.055286  -9.441871   +0.000049        +6.090493  -9.446430   +0.000049
 105     +5.561100  -9.441900   -0.000000        +5.587058  -9.446430   +0.000049
 106     +4.737300  -9.441900   +0.000000        +4.747999  -9.446431   +0.000049
 122     +6.714265  -9.923538   +0.000049        +6.761740  -9.931406   +0.000049
 123     +5.396308  -9.923538   +0.000049        +5.419246  -9.931406   +0.000049
 125     +6.714265 -10.395205   +0.000049        +6.761740 -10.406314   +0.000049
 126     +5.396308 -10.395205   +0.000049        +5.419247 -10.406314   +0.000049
--------------------------------------------------------------------------------
OFFSET          NF          Delta_CW          Delta_CV
  0            121           +0.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_SED_center
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.055286        -9.441871       +0.000049
IS (EST)            +6.090493        -9.446430       +0.000049
dT_EST              +0.035207        -0.004558       -0.000000
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA     +7.824947        -0.974117     +999.999999
--------------------------------------------------------------------
OFFSET          NF          Delta_CW          Delta_CV
  1            105           -3.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_SED_9
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +5.561100        -9.441900       -0.000000
IS (EST)            +5.587058        -9.446430       +0.000049
dT_EST              +0.025958        -0.004530       +0.000049
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA     +5.769286        -0.968026     +999.999999
--------------------------------------------------------------------
OFFSET          NF          Delta_CW          Delta_CV
  2            106           -8.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_SED_10
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +4.737300        -9.441900       +0.000000
IS (EST)            +4.747999        -9.446431       +0.000049
dT_EST              +0.010699        -0.004531       +0.000049
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA     +2.378030        -0.968179     +999.999999
--------------------------------------------------------------------
OFFSET          NF          Delta_CW          Delta_CV
  3            122           +4.000            +2.890     pixels
OFFSET FRAME NAME: MIPS_SED_1
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.714265        -9.923538       +0.000049
IS (EST)            +6.761740        -9.931406       +0.000049
dT_EST              +0.047475        -0.007868       -0.000000
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA    +10.551639        -1.681345     +999.999999
--------------------------------------------------------------------
OFFSET          NF          Delta_CW          Delta_CV
  4            123           -4.000            +2.890     pixels
OFFSET FRAME NAME: MIPS_SED_2
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +5.396308        -9.923538       +0.000049
```

```
IS (EST)            +5.419246        -9.931406       +0.000049
dT_EST              +0.022939        -0.007868       -0.000000
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA     +5.098255        -1.681347     +999.999999
-----------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  5             125           +4.000            +5.720     pixels
OFFSET FRAME NAME: MIPS_SED_3
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +6.714265       -10.395205       +0.000049
IS (EST)            +6.761740       -10.406314       +0.000049
dT_EST              +0.047475        -0.011109       -0.000000
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA    +10.551639        -2.373893     +999.999999
-----------------------------------------------------------------
OFFSET           NF          Delta_CW          Delta_CV
  6             126           -4.000            +5.720     pixels
OFFSET FRAME NAME: MIPS_SED_4
Brown Angle       theta_Y(arcmin)  theta_Z(arcmin)  angle(deg)
WAS(FTB)            +5.396308       -10.395205       +0.000049
IS (EST)            +5.419247       -10.406314       +0.000049
dT_EST              +0.022939        -0.011109       -0.000000
T_sSIGMA            +0.004499        +0.004680     +999.999999
dT_EST/T_sSIGMA     +5.098255        -2.373893     +999.999999
-----------------------------------------------------------------
-----------------------------------------------------------------------------------
-----------------------------------------------------------------------------------
VARNAME             MEAN                    SIGMA                SCALED_SIGMA
del_alpha  -4.2618577937580948E-013 +2.3704109706542190E-002 +9.6669762503611839E-003
beta       +1.0205597599999976E+000 +3.4208415833185450E-002 +1.3950827409924376E-002
del_theta2 +1.8625248658497200E-017 +3.2092553969191077E-006 +1.3087939638921807E-006
del_theta3 +3.9193273260640545E-017 +3.3378311730198269E-006 +1.3612295537255491E-006
del_arx    +2.9173940756135712E-015 +3.7965905135394688E-005 +1.5483201344028209E-005
del_ary    +4.8126777554098940E-017 +3.1015403426584774E-006 +1.2648657639203214E-006
del_arz    -7.7981294195579110E-019 +3.1005334511492092E-006 +1.2644551348594839E-006
brx        -2.6312067534387551E-009 +1.0237464850256599E-008 +4.1750283303837452E-009
bry        +8.4479762863962511E-011 +7.9723303369417579E-010 +3.2512644001972180E-010
brz        -1.8788444088344033E-010 +7.9701516999722656E-010 +3.2503759115721240E-010
bgx        -1.6227520780916517E-006 +1.4088476677858265E-006 +5.7455424875558539E-007
bgy        +4.7434105006395976E-009 +2.4836466839700503E-009 +1.0128772523188394E-009
bgz        +8.4541222852548621E-009 +6.1992941152941932E-009 +2.5281872942485132E-009
cgx        +1.1376429721597852E-010 +3.8226567517402503E-010 +1.5589504305304863E-010
cgy        +1.0706554255684389E-013 +5.9662786170070546E-013 +2.4331592457035741E-013
cgz        -5.6727939267087830E-013 +1.6687819642974055E-012 +6.8056028324243499E-013
-----------------------------------------------------------------------------------
LSQF RESIDUAL SIGMA SCALE =         +4.0781857534574090E-001
-----------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------
                    a_mirror(1)               a_mirror(2)               a_mirror(3)
a_mirror_ipf   +0.0000000000000000E+000  +4.6621805907424277E-002  +9.9891261240106988E-001
a_mirror_tpf   -1.8978259856101552E-003  +4.6615917409626666E-002  +9.9891108438168152E-001
beta                beta_0                    beta                      beta_total
               +2.8047410000000001E-006  +1.0205597599999976E+000  +2.8624058018221531E-006
---------------------------------------------------------------------------------------------------------
qT                 qT(1)                    qT(2)                    qT(3)                    qT(4)
FrmTbl:    +1.6358468638933700E-006 -8.8070411393688104E-004 +1.3732638926728399E-003 +9.9999866925104897E-001
Estim:     +1.6422949584308086E-006 -8.8582472911310649E-004 +1.3739268848761707E-003 +9.9999866381749092E-001
DelTheta         deltheta(1)              deltheta(2)              deltheta(3)
           -6.7122058772485675E-012 -1.0241241835464063E-005 +1.3260029609367060E-006        [rad]
EulAngT          theta(1)                 theta(2)                 theta(3)                 [rad]
Mean       +8.5047004152404309E-007 -1.7716525305619660E-003 +2.7478549589991558E-003
SigmaT     +9.9990000000000000E+004 +3.2092553969191077E-006 +3.3378311730198269E-006
---------------------------------------------------------------------------------------------------------
qR                 qR(1)                    qR(2)                    qR(3)                    qR(4)
ASFILE:    +7.0925685577094555E-004 +1.2694769538938999E-003 -1.6279894043691456E-004 +9.9999892711639404E-001
Estim:     +6.8664624809965222E-004 +1.2689065212083794E-003 -1.6179975953873436E-004 +9.9999894610644879E-001
DelThetaR        delthetaR(1)             delthetaR(2)             delthetaR(3)
```

```
         -4.5223546128075194E-005 -1.1468130715980737E-006 +1.9417936478380761E-006         [rad]
EulAngR        angR(1)                  angR(2)                  angR(3)                    [rad]
Mean     +1.3728852844284204E-003 +2.5380352910712193E-003 -3.2185764043330393E-004
SigmaR   +3.7965905135394688E-005 +3.1015403426584774E-006 +3.1005334511492092E-006
------------------------------------------------------------------------------------------------
Initial Gyro Bias       Bg0(1)                   Bg0(2)                   Bg0(3)
                 -4.1176156173605705E-007 -2.0741615003316838E-007 +3.6428332350624260E-007
Gyro Bias Correction    Bg(1)                    Bg(2)                    Bg(3)
                 -1.6227520780916517E-006 +4.7434105006395976E-009 +8.4541222852548621E-009
Total Gyro Bias         BgT(1)                   BgT(2)                   BgT(3)
                 -2.0345136398277085E-006 -2.0267273953252878E-007 +3.7273744579149748E-007

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)
                 +1.1376429721597852E-010 +1.0706554255684389E-013 -5.6727939267087830E-013
Total Gyro Bias Rate     CgT(1)                   CgT(2)                   CgT(3)
                 +1.1376429721597852E-010 +1.0706554255684389E-013 -5.6727939267087830E-013
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
OFFSET         NF         Delta_CW          Delta_CV
  1           105          -3.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_SED_9
qT             qT(1)                    qT(2)                    qT(3)                    qT(4)
WAS(FTB) +1.1107393564578807E-006 -8.0882835774358946E-004 +1.3732678078675808E-003 +9.9999872996468453E-001
IS (EST) +1.5416938615970763E-006 -8.1260317114967610E-004 +1.3739270014447159E-003 +9.9999872599834050E-001

DelTheta       deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
         +8.5260163902982997E-007 -7.5508063693348257E-006 +1.3177044038899031E-006
EulAngT        theta(1)                 theta(2)                 theta(3)                   [rad]
Mean     +8.5047004152404309E-007 -1.6252092235788762E-003 +2.7478550835449652E-003
sSigmaT  +1.9934295669825048E-010 +1.3087939638921831E-006 +1.3612295391293257E-006
SigmaT   +4.8880303338132964E-010 +3.2092553969191132E-006 +3.3378311372288550E-006
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
OFFSET         NF         Delta_CW          Delta_CV
  2           106          -8.000            +0.000     pixels
OFFSET FRAME NAME: MIPS_SED_10
qT             qT(1)                    qT(2)                    qT(3)                    qT(4)
WAS(FTB) +9.4619872160855978E-007 -6.8901165124669384E-004 +1.3732679310954998E-003 +9.9999881969792281E-001
IS (EST) +1.3740253402264700E-006 -6.9056724025289560E-004 +1.3739271793562608E-003 +9.9999881771885346E-001

DelTheta       deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
         +8.5228615862268436E-007 -3.1123514226899814E-006 +1.3179124633201674E-006
EulAngT        theta(1)                 theta(2)                 theta(3)                   [rad]
Mean     +8.5047004152404309E-007 -1.3811370623336152E-003 +2.7478552911211710E-003
sSigmaT  +5.3158118302836563E-010 +1.3087939638921860E-006 +1.3612294499302052E-006
SigmaT   +1.3034746702690065E-009 +3.2092553969191209E-006 +3.3378309185063006E-006
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
OFFSET         NF         Delta_CW          Delta_CV
  3           122          +4.000            +2.890     pixels
OFFSET FRAME NAME: MIPS_SED_1
qT             qT(1)                    qT(2)                    qT(3)                    qT(4)
WAS(FTB) +1.8358793410083503E-006 -9.7654843776767111E-004 +1.4433192696752502E-003 +9.9999848158847915E-001
IS (EST) +1.8457996453474123E-006 -9.8345338751852076E-004 +1.4444636084960829E-003 +9.9999847316929014E-001

DelTheta       deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
         +2.1277165657483715E-009 -1.3809919413231266E-005 +2.2887044330232198E-006
EulAngT        theta(1)                 theta(2)                 theta(3)                   [rad]
Mean     +8.5047004152404299E-007 -1.9669103725269235E-003 +2.8889287822706465E-003
sSigmaT  +3.2476350680240828E-010 +1.3087939534199914E-006 +1.3612295250531406E-006
SigmaT   +7.9634309576771945E-010 +3.2092553712405585E-006 +3.3378311027130527E-006
------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------
```

```
OFFSET           NF         Delta_CW          Delta_CV
  4             123           -4.000            +2.890     pixels
OFFSET FRAME NAME: MIPS_SED_2
qT              qT(1)                   qT(2)                   qT(3)                   qT(4)
WAS(FTB)  +1.5592110437274310E-006 -7.8485965069199654E-004 +1.4433195477687509E-003 +9.9999865040987967E-001
IS (EST)  +1.5637571685383335E-006 -7.8819592852142739E-004 +1.4444638925659938E-003 +9.9999864613348155E-001

DelTheta        deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
          +1.2502850318446810E-009 -6.6725629223103159E-006 +2.2887021137357364E-006
EulAngT         theta(1)                theta(2)                theta(3)                [rad]
Mean      +8.5047004152404309E-007 -1.5763948932958505E-003 +2.8889290167896839E-003
sSigmaT   +3.2248903254582319E-010 +1.3087939534200136E-006 +1.3612295255938652E-006
SigmaT    +7.9076592397102826E-010 +3.2092553712406132E-006 +3.3378311040389481E-006
----------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------
OFFSET           NF         Delta_CW          Delta_CV
  5             125           +4.000            +5.720     pixels
OFFSET FRAME NAME: MIPS_SED_3
qT              qT(1)                   qT(2)                   qT(3)                   qT(4)
WAS(FTB)  +1.9028717754709402E-006 -9.7654834006580314E-004 +1.5119203599843502E-003 +9.9999838022196008E-001
IS (EST)  +1.9137293258597253E-006 -9.8345328787204588E-004 +1.5135360556222102E-003 +9.9999837101096145E-001

DelTheta        deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
          +3.9689352841947994E-009 -1.3809917922610649E-005 +3.2314189394642934E-006
EulAngT         theta(1)                theta(2)                theta(3)                [rad]
Mean      +8.5047004152404309E-007 -1.9669104329143460E-003 +3.0270738944485755E-003
sSigmaT   +4.5348383934961644E-010 +1.3087939179234132E-006 +1.3612295223861235E-006
SigmaT    +1.1119744581647890E-009 +3.2092552842004376E-006 +3.3378310961733383E-006
----------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------
OFFSET           NF         Delta_CW          Delta_CV
  6             126           -4.000            +5.720     pixels
OFFSET FRAME NAME: MIPS_SED_4
qT              qT(1)                   qT(2)                   qT(3)                   qT(4)
WAS(FTB)  +1.6130533703694909E-006 -7.8485957791016943E-004 +1.5119206033337609E-003 +9.9999854904341257E-001
IS (EST)  +1.6181998888585660E-006 -7.8819585449063808E-004 +1.5135363038508516E-003 +9.9999854397520660E-001

DelTheta        deltheta(1)              deltheta(2)              deltheta(3)
Units             rad                      rad                      rad
          +2.7300829389305527E-009 -6.6725617892765423E-006 +3.2314143465153885E-006
EulAngT         theta(1)                theta(2)                theta(3)                [rad]
Mean      +8.5047004152404299E-007 -1.5763949650201279E-003 +3.0270740333907687E-003
sSigmaT   +4.5025974515111810E-010 +1.3087939179234863E-006 +1.3612295234563189E-006
SigmaT    +1.1040687510847106E-009 +3.2092552842006167E-006 +3.3378310987975332E-006
----------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------
               q(1)                    q(2)                    q(3)                    q(4)
PCRS1A: +5.3371888965461637E-007 +3.7444233778550031E-004 -1.4253684912431913E-003 +9.9999891405806784E-001
PCRS2A: -5.2779261998836216E-007 +3.8462959425181312E-004 +1.3722087221825403E-003 +9.9999898455099423E-001
------------------------------------------------------------------------------------------
**********  CS-FILE PARAMETERS:  **********  **********  AS-FILE PARAMETERS:  **********
Row (01) PIX2RADX: +4.8814436010000000E-005  Row (1) TASTART:   +7.5350500009072876E+008
Row (02) PIX2RADY: +4.8814436010000000E-005  Row (2) TASTOP:    +7.5351249999077451E+008
Row (03) CX0:      +1.2500000000000000E+001  Row (3) S/C TIME:  +7.5348302409075928E+008
Row (04) CY0:      +1.5000000000000000E+000  Row (4) QR1:       +7.0925685577094555E-004
Row (05) BETA0:    +2.8047410000000001E-006  Row (5) QR2:       +1.2694769538938999E-003
Row (06) GAMMA_E0: +3.2200000000000000E+003  Row (6) QR3:       -1.6279894043691456E-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)
```

```
5.07899146E+000  3.91495030E-001  3.91762700E-001  [arcsec]
-----------------------------------------------------------
PIX2RADX = 4.881443601000E-005[rad/pixel]
XPIXSIZE = 10.0687[arcsec]
PIX2RADY = 4.881443601000E-005[rad/pixel]
YPIXSIZE = 10.0687[arcsec]
CX0 = 12.5[pixel] = 125.86[arcsec]
CY0 = 1.5[pixel] = 15.10[arcsec]
-----------------------------------------------------------
NOMINAL BETA0 = 2.804741000000E-006[rad/encoder unit]
ENCODER UNIT SIZE = 0.58[arcsec]
GAMMA_E0 = 3220.00[encoder unit] = 1862.83[arcsec]
-----------------------------------------------------------
                | +1 | +0 |
FLIP MATRIX D = |----|----|   and   DG = -1
                | +0 | -1 |
-----------------------------------------------------------
```

3.3 IPF EXECUTION LOG

```
***********************************************************************
IPF EXECUTION-LOG FILE NAME:  LG504121.dat
INSTRUMENT TYPE:              MIPS_SED_center
IPF FILTER EXECUTION DATE:    04-Dec-2003    TIME: 15:49
IPF FILTER VERSION USED:      IPF.V3.0.0B
***********************************************************************

**************************************
SLIT FLAG ENABLED! ENTERING SLIT MODE.
**************************************


------------------- Loading & Preparing Input Files -------------------
AAFILE:  AA501121 Loaded!        AAFILE dimension = 75000 X 21
ASFILE:  AS501121 Loaded!
CAFILE:  CA502121 Loaded!        CAFILE dimension = 58 X 15
CBFILE:  CB501121 Loaded!        CBFILE dimension = 36 X 15
CCFILE:  CC504121 Created!       CCFILE dimension = 94 X 19
CSFILE:  CS502121 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 ]
mask2 = [ 1  1  0  1  1  1  1  1  1  1  1  0  0  0  1  1  1  1  1  1 ]
-----------------------------------------------------------------------

---------------  Selected Initial Gyro Bias Parameters  ---------------
User Entered 1 : Use AFILE database - from S/C filter
IPF Linearized Using Following Nominal Gyro Bias Estimates
bg0 = [-4.1176156173605705E-007 -2.0741615003316838E-007 +3.6428332350624260E-007 ]
cg0 = [+0.0000000000000000E+000 +0.0000000000000000E+000 +0.0000000000000000E+000 ]
-----------------------------------------------------------------------

---------------  Gyro Pre-Processor Run Completed  --------------------
     AGFILE CREATED:  AG504121.m     ACFILE CREATED:  AC504121.m
-----------------------------------------------------------------------
Total Gyro Preprocessor Execution Time: 24 seconds
```

```
FRAME TABLE ENTRIES FOR PCRS LOADED TO TPCRS
q_PCRS4 = [ +5.3371888965461637E-007     q_PCRS5 = [ +7.3379987833742897E-007
            +3.7444233778550031E-004                 +5.2236196154513707E-004
            -1.4253684912431913E-003                 -1.4047712280184723E-003
            +9.9999891405806784E-001 ];              +9.9999887687698918E-001 ];
q_PCRS8 = [ -5.2779261998836216E-007     q_PCRS9 = [ -7.1963421681856818E-007
            +3.8462959425181312E-004                 +5.3239763239987400E-004
            +1.3722087221825403E-003                 +1.3516841804518383E-003
            +9.9999898455099423E-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) = 1.0000000000000001E-001
p2f(03) = am3   = +1.0000000000000000E+000
p2f(04) = beta  = +1.0000000000000000E+000  Sigma_initial(19,19) = 1.0000000000000001E-001
p2f(05) = qT1   = +1.6358468638933702E-006  Sigma_initial(20,20) = 9.9999000000000000E+004
p2f(06) = qT2   = -8.8070411393688115E-004  Sigma_initial(21,21) = 1.0000000000000000E-002
p2f(07) = aT3   = +1.3732638926728402E-003  Sigma_initial(22,22) = 1.0000000000000000E-002
p2f(08) = qT4   = +9.9999866925104908E-001
p2f(09) = qR1   = +7.0925685577094555E-004  Sigma_initial(23,23) = 2.4623645462849353E-004
p2f(10) = qR2   = +1.2694769538938999E-003  Sigma_initial(24,24) = 1.8980214668701687E-005
p2f(11) = qR3   = -1.6279894043691456E-004  Sigma_initial(25,25) = 1.8993191646840778E-005
p2f(12) = qR4   = +9.9999892711639404E-001
p2f(13) = brx   = +0.0000000000000000E+000  Sigma_initial(26,26) = 1.6110323582422487E-004
p2f(14) = bry   = +0.0000000000000000E+000  Sigma_initial(27,27) = 1.6110323582422487E-004
p2f(15) = brz   = +0.0000000000000000E+000  Sigma_initial(28,28) = 1.6110323582422487E-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) = 1.6110323582422487E-004
p2f(20) = bgy   = +0.0000000000000000E+000  Sigma_initial(33,33) = 1.6110323582422487E-004
p2f(21) = bgz   = +0.0000000000000000E+000  Sigma_initial(34,34) = 1.6110323582422487E-004
p2f(22) = cgx   = +0.0000000000000000E+000  Sigma_initial(35,35) = 2.5954252593035814E-008
p2f(23) = cgy   = +0.0000000000000000E+000  Sigma_initial(36,36) = 2.5954252593035814E-008
p2f(24) = cgz   = +0.0000000000000000E+000  Sigma_initial(37,37) = 2.5954252593035814E-008
-----------------------------------------------------------------------------------------

--------------------   IPF KALMAN FILTER STARTED  ---------------------
Iteration#001: |dp|= +4.847487071691E-002   RMS(|Res|)=+1.795700937869E-005
Iteration#002: |dp|= +3.099680731235E-002   RMS(|Res|)=+1.423779755143E-005
Iteration#003: |dp|= +2.061470307326E-002   RMS(|Res|)=+1.309670583524E-005
Iteration#004: |dp|= +3.758910760802E-003   RMS(|Res|)=+1.292376372170E-005
Iteration#005: |dp|= +5.168955031442E-003   RMS(|Res|)=+1.291491444801E-005
Iteration#006: |dp|= +7.902366506198E-004   RMS(|Res|)=+1.292554029735E-005
Iteration#007: |dp|= +1.357006254020E-003   RMS(|Res|)=+1.292406930124E-005
Iteration#008: |dp|= +2.312840009871E-004   RMS(|Res|)=+1.291812303752E-005
Iteration#009: |dp|= +3.312716547686E-004   RMS(|Res|)=+1.291774470536E-005
Iteration#010: |dp|= +8.594918126926E-005   RMS(|Res|)=+1.291893253203E-005
Iteration#011: |dp|= +7.665262456096E-005   RMS(|Res|)=+1.291918751001E-005
```

```
Iteration#012: |dp|= +2.953387561330E-005   RMS(|Res|)=+1.291889354226E-005
Iteration#013: |dp|= +1.657527292955E-005   RMS(|Res|)=+1.291879418336E-005
Iteration#014: |dp|= +9.245333296983E-006   RMS(|Res|)=+1.291885590369E-005
Iteration#015: |dp|= +3.296529009178E-006   RMS(|Res|)=+1.291888881025E-005
Iteration#016: |dp|= +2.688194635272E-006   RMS(|Res|)=+1.291887694084E-005
Iteration#017: |dp|= +5.948638961849E-007   RMS(|Res|)=+1.291886709763E-005
Iteration#018: |dp|= +7.353897163651E-007   RMS(|Res|)=+1.291886893701E-005
Iteration#019: |dp|= +1.097284690644E-007   RMS(|Res|)=+1.291887167386E-005
Iteration#020: |dp|= +1.904957908986E-007   RMS(|Res|)=+1.291887153458E-005
Iteration#021: |dp|= +3.193854557193E-008   RMS(|Res|)=+1.291887081841E-005
Iteration#022: |dp|= +4.678164936466E-008   RMS(|Res|)=+1.291887076743E-005
Iteration#023: |dp|= +1.186841202294E-008   RMS(|Res|)=+1.291887094425E-005
Iteration#024: |dp|= +1.085512918869E-008   RMS(|Res|)=+1.291887097864E-005
Iteration#025: |dp|= +4.097611833839E-009   RMS(|Res|)=+1.291887093761E-005
Iteration#026: |dp|= +2.355824629151E-009   RMS(|Res|)=+1.291887092385E-005
Iteration#027: |dp|= +1.290900873022E-009   RMS(|Res|)=+1.291887093269E-005
Iteration#028: |dp|= +4.717772504469E-010   RMS(|Res|)=+1.291887093727E-005
Iteration#029: |dp|= +3.772583429463E-010   RMS(|Res|)=+1.291887093557E-005
Iteration#030: |dp|= +8.429020435882E-011   RMS(|Res|)=+1.291887093420E-005
Iteration#031: |dp|= +1.045336131849E-010   RMS(|Res|)=+1.291887093447E-005
Iteration#032: |dp|= +1.700171711488E-011   RMS(|Res|)=+1.291887093485E-005
Iteration#033: |dp|= +2.633760313346E-011   RMS(|Res|)=+1.291887093484E-005
Iteration#034: |dp|= +3.986471415140E-012   RMS(|Res|)=+1.291887093473E-005
Iteration#035: |dp|= +6.372604002746E-012   RMS(|Res|)=+1.291887093472E-005
Iteration#036: |dp|= +2.256835932084E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#037: |dp|= +1.506245018238E-012   RMS(|Res|)=+1.291887093475E-005
Iteration#038: |dp|= +6.198572197696E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#039: |dp|= +5.759631823021E-013   RMS(|Res|)=+1.291887093473E-005
Iteration#040: |dp|= +5.280722442874E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#041: |dp|= +5.752314058241E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#042: |dp|= +1.673184262428E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#043: |dp|= +2.899915949843E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#044: |dp|= +4.859431124521E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#045: |dp|= +9.128692767688E-013   RMS(|Res|)=+1.291887093473E-005
Iteration#046: |dp|= +8.437345787518E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#047: |dp|= +3.520765244898E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#048: |dp|= +9.577585363077E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#049: |dp|= +2.274920594604E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#050: |dp|= +6.039632374672E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#051: |dp|= +3.753220433953E-012   RMS(|Res|)=+1.291887093473E-005
Iteration#052: |dp|= +2.644056617209E-013   RMS(|Res|)=+1.291887093473E-005
Iteration#053: |dp|= +2.846519428539E-012   RMS(|Res|)=+1.291887093473E-005
Iteration#054: |dp|= +1.754706610931E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#055: |dp|= +4.895373195295E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#056: |dp|= +1.755978928531E-012   RMS(|Res|)=+1.291887093475E-005
Iteration#057: |dp|= +1.979733837828E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#058: |dp|= +3.930265107538E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#059: |dp|= +3.187807352602E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#060: |dp|= +2.698827832482E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#061: |dp|= +4.562371385977E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#062: |dp|= +4.796802102229E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#063: |dp|= +8.759225973426E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#064: |dp|= +3.055758463932E-013   RMS(|Res|)=+1.291887093473E-005
Iteration#065: |dp|= +2.639043078896E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#066: |dp|= +3.004596353211E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#067: |dp|= +1.065970616293E-012   RMS(|Res|)=+1.291887093473E-005
Iteration#068: |dp|= +4.352795731519E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#069: |dp|= +9.864191030606E-013   RMS(|Res|)=+1.291887093475E-005
Iteration#070: |dp|= +1.305715578819E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#071: |dp|= +1.615852635508E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#072: |dp|= +1.143177089059E-012   RMS(|Res|)=+1.291887093475E-005
Iteration#073: |dp|= +3.707142702680E-013   RMS(|Res|)=+1.291887093474E-005
Iteration#074: |dp|= +1.452619705476E-012   RMS(|Res|)=+1.291887093474E-005
Iteration#075: |dp|= +4.269086501290E-013   RMS(|Res|)=+1.291887093475E-005
IPF Kalman Filter Completed with Error |dp1| + |dp2| = +4.2690865012897674E-013
----------------------------------------------------------------------

----------------  IPF LEAST SQUARES FILTER STARTED  -----------------
```

```
Iteration#001   COND#=+2.264924949037E+008,    |dp|=+5.445206256802E-002
Iteration#002   COND#=+2.417746911359E+008,    |dp|=+4.925352043451E-002
Iteration#003   COND#=+2.382231729588E+008,    |dp|=+1.134567881983E-003
Iteration#004   COND#=+2.383216504746E+008,    |dp|=+1.103240163958E-004
Iteration#005   COND#=+2.383134906948E+008,    |dp|=+5.349005814312E-006
Iteration#006   COND#=+2.383138855510E+008,    |dp|=+2.657616829083E-007
Iteration#007   COND#=+2.383138633256E+008,    |dp|=+1.317346993243E-008
Iteration#008   COND#=+2.383138666515E+008,    |dp|=+6.518619266706E-010
Iteration#009   COND#=+2.383138664241E+008,    |dp|=+3.225153204677E-011
Iteration#010   COND#=+2.383138692006E+008,    |dp|=+2.952254522695E-012
Iteration#011   COND#=+2.383138705927E+008,    |dp|=+1.945745230500E-012
Iteration#012   COND#=+2.383138662934E+008,    |dp|=+8.858710035279E-013
Iteration#013   COND#=+2.383138664292E+008,    |dp|=+1.863688432644E-012
Iteration#014   COND#=+2.383138696426E+008,    |dp|=+2.837876101885E-012
Iteration#015   COND#=+2.383138680435E+008,    |dp|=+5.325436540000E-013
Iteration#016   COND#=+2.383138681405E+008,    |dp|=+1.280379017999E-012
Iteration#017   COND#=+2.383138689119E+008,    |dp|=+3.206553784444E-013
Iteration#018   COND#=+2.383138707735E+008,    |dp|=+1.337185223740E-012
Iteration#019   COND#=+2.383138700620E+008,    |dp|=+3.470867307882E-012
Iteration#020   COND#=+2.383138655849E+008,    |dp|=+1.392909609748E-013
Iteration#021   COND#=+2.383138664498E+008,    |dp|=+1.659441990681E-012
Iteration#022   COND#=+2.383138667365E+008,    |dp|=+1.176524579899E-012
Iteration#023   COND#=+2.383138671221E+008,    |dp|=+1.908573716409E-013
Iteration#024   COND#=+2.383138673208E+008,    |dp|=+1.111326918943E-012
Iteration#025   COND#=+2.383138667311E+008,    |dp|=+8.808424202816E-013
Iteration#026   COND#=+2.383138684621E+008,    |dp|=+7.681236589491E-013
Iteration#027   COND#=+2.383138684911E+008,    |dp|=+1.125223712903E-012
Iteration#028   COND#=+2.383138670090E+008,    |dp|=+1.137128707268E-012
Iteration#029   COND#=+2.383138686443E+008,    |dp|=+6.300206051950E-013
Iteration#030   COND#=+2.383138685117E+008,    |dp|=+3.448500209862E-013
Iteration#031   COND#=+2.383138705312E+008,    |dp|=+4.531624603752E-013
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Iteration#068   COND#=+2.383138700467E+008,    |dp|=+1.615600428798E-012
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Iteration#070   COND#=+2.383138678410E+008,   |dp|=+3.159824135739E-013
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Iteration#072   COND#=+2.383138695855E+008,   |dp|=+1.871998786304E-012
Iteration#073   COND#=+2.383138666396E+008,   |dp|=+1.671503100328E-012
Iteration#074   COND#=+2.383138701660E+008,   |dp|=+6.070420024042E-013
Iteration#075   COND#=+2.383138669135E+008,   |dp|=+1.465452972230E-012
IPF Least Squares Filter Completed with Error |dp1| + |dp2| = +1.4654529722299584E-012
-----------------------------------------------------------------------
Total Execution Time: 125 seconds
```

4 COMMENTS

Overall the data looked clean, and the filter converged nicely.

1. In the original CA-file (CA501121), half of the scan mirror angle data (i.e., column 12) were bad and did not indicate the correct mirror position value. A new CA file (CA502121.m) was re-delivered which fixed the problem.
2. A polarity error in the V direction was then detected when using the CS501121.m file. A new CS file (CS502121.m) was re-delivered which fixed the problem.
3. The IPF filter was run in Normal Mode. We estimated 16 parameters consisting of: 2 Brown angles, the mirror parameters (alpha and beta), 3 STA-to-PCRS alignment angles, 3 STA-to-PCRS thermomechanical drift parameters, and 3 gyro bias and 3 gyro bias-drift parameters. we estimated only 2 Brown angles (no Twist) because of the large uncertainty in the science centroids.
4. Unofficially we ran the IPF filter WITH plate scales and WITHOUT plate scales. Unfortunately, these two unofficial runs gave different Brown angle recommendations (4.8" and 2", respectively) in the W direction. We think this is because the centroids all lie on one side of the center in the W direction, and the plate-scale fit becomes correlated with the Brown angle estimate in that direction. Since the requirement is 1.1", this represents a substantial difference. We have decided NOT to use plate scales because we don't have sufficient data to resolve the extra parameters reliably. Also, the current Brown angles for SED seem to work very well and they were estimated in the earlier IPF run without estimating plate scales.

Recommendations for correcting frames 121, 105, 106, 122, 123, 125 and 126 are given in the IF file IF504121.dat. The recommended corrections are on the order of 0.3" in the V direction and 2" in the W direction. If the plate scales can be assumed negligible, this fine survey should be accurate to 0.4" which satisfies its fine survey requirement of 1.1" by a good margin. However, because of the one-sided nature of the centroid pattern, this assumption about plates scales could not be adequately tested. Hence the adequacy of the recommended updates remains as an open question pending analysis on future data sets.

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References

[1] D.S. Bayard, B.H. Kang, *SIRTF Instrument Pointing Frame Kalman Filter Algorithm*, JPL D-Document D-24809, September 30, 2003.

[2] B.H. Kang, D.S. Bayard, *SIRTF Instrument Pointing Frame (IPF) Software Description Document and User's Guide*, JPL D-Document D-24808, September 30, 2003.

[3] D.S. Bayard, B.H. Kang, *SIRTF Instrument Pointing Frame (IPF) Kalman Filter Unit Test Report*, JPL D-Document D-24810, September 30, 2003.

[4] *Space Infrared Telescope Facility In-Orbit Checkout and Science Verification Mission Plan*, JPL D-Document D-22622, 674-FE-301 Version 1.4, February 8, 2002.

[5] *Space Infrared Telescope Facility Observatory Description Document*, Lockheed Martin LMMS/P458569, 674-SEIT-300 Version 1.2, November 1, 2002.

[6] *SIRTF Software Interface Specification for Science Centroid INPUT Files (CAFILE, CS-FILE)*, JPL SOS-SIS-2002, November 18, 2002.

[7] *SIRTF Software Interface Specification for Inferred Frames Offset INPUT Files (OFILE)*, JPL SOS-SIS-2003, November 18, 2002.

[8] *SIRTF Software Interface Specification for PCRS Centroid INPUT Files (CBFILE)*, JPL SIS-FES-015, November 18, 2002.

[9] *SIRTF Software Interface Specification for Attitude INPUT Files (AFILE, ASFILE)*, JPL SIS-FES-014, January 7, 2002.

[10] *SIRTF Software Interface Specification for IPF Filter Output Files (IFFILE, LGFILE, TARFILE)*, JPL SOS-SIS-2005, November 18, 2002.

[11] R.J. Brown, *Focal Surface to Object Space Field of View Conversion.* Systems Engineering Report SER No. S20447-OPT-051, Ball Aerospace & Technologies Corp., November 23, 1999.