VCST Internal Memo

Title: Assessment of FP-11 Polarization Sensitivity for the VIIRS F2 DNB LGS
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References

[1] TP1544640-2222 Rev A, 'Polarization Sensitivity FP-11 Test Procedure,' Raytheon.
[2] VCST_TECH_REPORT_14_001, 'Preliminary Analysis of FP-11 Polarization Sensitivity DNB Data,' Jeff McIntire, January 1, 2014.
[3] VCST_TECH_REPORT_14_012, 'Summary of Preliminary Analysis of FP-11 Polarization Sensitivity Data,' Jeff McIntire, January 28, 2014.
[4] 'JPSS J1: Results from FP-11 Polarization Ambient,' Raytheon, January 9, 2014.
[5] VIIRS.10.15.036, 'Polarization Test Source Assembly (PTSA) Calibration and Performance Verification,' Josh Cohen, Dan Tiffany, Eslim Monroy, and Tung Wang, November 13, 2013.
[6] VCST_TECH_MEMO_14_002, 'Assessment of FP-11 Polarization Sensitivity for the VIIRS F2 VisNIR Bands,' Jeff McIntire, March 15, 2014.

1. Introduction

VIIRS F2 sensor polarization sensitivity was measured for the DNB LGS during FP-11 in ambient phase II testing [1]. Preliminary Analysis was reported in [2-4]. This work will provide an overview of the test setup and objectives, analysis methodology, and results (both baseline testing and additional special testing performed after the nominal FP-11 was completed).

The test setup, equipment, and configurations were described in [5,6] and the methodology for determining the polarization sensitivity and phase were outlined in [6]. Note that, unlike the VisNIR bands, no requirement specifies the maximum DNB sensitivity to input polarized light.

2. Analysis

The data analyzed during the nominal FP-11 testing is listed in Tables 1 and 2 (including the type of test, number of collects, scan angle, and samples used). Note that only the test configurations using the BVONIR polarizer were used; the DoLP for the BVO777 is known to fall off significantly in the longer wavelength side of the DNB bandpass, whereas the BVONIR is more consistent throughout the entire DNB spectral range (see [6]). In this work, 10 EV LGS samples were used in the processing. The OBC BB view data was used as a dark reference, averaged per scan, and subtracted from each EV pixel of the corresponding scan. Then all EV pixels were first averaged over a particular scan and then all scans were averaged in each collect (a 3-sigma outlier rejection was used in each average). Note that the BB data was first truncated from 14 to 13 bits in order to remove any bias between the EV and BB data.

Note that, as the DNB was operated in auto gain, only data that was in LGS was used in this analysis. All of the stray light data was not in LGS, so no stray light investigation was conducted. In addition, for a small number of polarizer angles, the efficiency data was not in LGS; however, sufficient data was in LGS to allow the polarizer DoLP to be determined.

Each collect corresponded to a measurement at a discrete polarizer sheet angle. The angle was cycled from 0 to 360 degrees in 15 degree increments. This set of 25 measurements was then used to determine the Fourier coefficients defined in [6], and finally the linear polarization sensitivity and phase. First the cross polarizer efficiency test was analyzed; then the efficiency correction was used in the final polarization sensitivity calculation.

A series of special tests were run after the conclusion of the nominal testing, the data collected from which is listed in Table 3. The tests were conducted to provide additional information regarding the baseline testing and improve the Raytheon modeling of the transmittance of polarized light.

3. Results

Cross polarizer test data was analyzed for both configurations and the DoLP of the polarizer in each configuration was determined. The efficiency was calculated for each detector and HAM side; the results for the BVONIR with and without the Sonoma filter are shown in Figure 1. The DoLP is about 95 % with the Sonoma filter and about 97 % without the Sonoma filter. Note that the Sonoma filter cuts off at about 650 nm and the DNB bandpass covers ~500 – 900 nm; as a result, the different calculated BVONIR efficiencies may reflect spectral variation in the DoLP. Also, some data for the Sonoma filter case was not in LGS, which may result in a slightly lower calculated efficiency.

The polarization sensitivity was derived for all DNB LGS detectors, HAM sides, and scan angles. Figure 2 plots the measured dn for HAM side A using the BVONIR polarizer without the Sonoma filter at a scan angle of -8 degrees (UAID 4301893). The lines indicate the calculated Fourier series using the zeroth through fourth order terms; the Fourier series reproduces the observed behavior very well. Note that the amplitude and phase of the Fourier series varies with detector. Figure 3 shows the zeroth through fourth order Fourier coefficients for HAM side A versus scan angle for all detectors. Only the zeroth and second order terms show non-negligible results. Figure 4 compares the second order term a_2 across test configurations and repeated measurements at a scan angle of -8 degrees (HAM side A). The repeated measurements generally agree well for each BVONIR configuration; between the two BVONIR configurations, the agreement is also good at -8 degrees scan angle, but not as good at other scan angles. Again, note that the Sonoma filter excludes part of the DNB bandpass; the differences between the two configurations indicate that the spectral dependence of the polarization sensitivity changes over the bandpass.

The final polarization factors (a_2) are shown for all detectors and scan angles in Figure 5 (6) for HAM side A (B). The maximum values per HAM side and scan angle are shown in Table 4; the final polarization results were derived using the BVONIR without the Sonoma filter. For some scan angle – detector combinations, the final DNB LGS polarization factors are as high as ~1.7 %. There is also noticeable HAM side dependence with up to about 0.3 % difference, where the HAM side B results are generally larger in the Sonoma filter results. Also, note that there is noticeable variation both with detector (~0.5 %) and with scan angle (~1.0 % for the Sonoma filter data, but considerably smaller without the Sonoma filter). The differences between test configurations also vary considerably with scan angle. The corresponding final polarization phases (δ_2) are shown for all detectors and scan angles in Figure 7 (8) for HAM side A (B).

The resulting a_2 derived from special testing are shown in Figure 9 in comparison to the nominal testing results measured at -8 degrees scan angle. Note that differences between the nominal results and testing in which the cross hairs and baffling were removed are very small. As expected, blocking the upper or lower half of the telescope aperture showed some differences; this results from different portions of the mirrors being illuminated and different angles of incidence on the dichroic and the filter assembly. The differences between the nominal testing and the special testing with the Hoya shaping filter are shown in Figure 10. All detectors showed less than 0.1 % difference from the two different spectra (see [6]).

4. Summary

FP-11 polarization sensitivity testing was performed under ambient conditions for the VIIRS F2 sensor. Analysis showed the following:

- Linear polarization sensitivity for the DNB LGS was observed to be as high as ~1.7 %.
- Differences in linear polarization sensitivity with HAM side are as high as ~0.3 %.
- Large detector to detector and scan angle differences were observed (up to ~1.0 %). This is likely the result of angle of incidence changes on the filter assembly.
- Special testing conducted after nominal testing and the multiple test configurations in nominal testing indicated that the polarization sensitivities observed likely reflected the true performance of the sensor, and not the test configuration.
- Results presented here were derived using only DNB LGS data; the polarization sensitivity may be different for the MGS and HGS as the angles of incidence on the filter assembly are different.

Table 1: Data used in the nominal FP-11 test analysis using the BVONIR polarizer without the Sonoma filter

Test type	UAID	Collects	Scan angle	Samples
Efficiency	4301889	1 – 25	-8	804 – 815
Polarization Sensitivity	4301893	1 – 25	-8	804 – 815
	4301896	1 – 25	55	2033 – 2042
	4301900	1 – 25	-55	30 – 39
	4301904	1 – 25	-45	220 – 229
	4301906	1 – 25	-20	570 – 579
	4301908	1 – 25	-8	805 – 814
	4301910	1 – 25	22	1390 – 1399
	4301914	1 – 25	45	1845 – 1854
	4301917	1 – 25	-8	805 – 814

Table 2: Data used in the nominal FP-11 test analysis using the BVONIR polarizer with the Sonoma filter

Test type	UAID	Collects	Scan angle	Samples
Efficiency	4301885	1 – 25	-8	804 – 815
Polarization Sensitivity	4301894	1 – 25	-8	804 – 815
	4301895	1 – 25	55	2033 – 2042
	4301899	1 – 25	-55	30 – 39
	4301901	1 – 25	-45	220 – 229
	4301905	1 – 25	-20	570 – 579
	4301907	1 – 25	-8	805 – 814
	4301909	1 – 25	22	1390 – 1399
	4301911	1 – 25	45	1845 – 1854
	4301916	1 – 25	-8	805 – 814

Table 3: Data used in the special FP-11 test analysis using the BVONIR polarizer

Test type	UAID	Collects	Scan angle	Samples	Filter	Notes
Polarization Sensitivity	4301918	1 – 25	-8	805 – 814	Sonoma	Cross hairs removed
	4301920	1 – 25	-8	805 – 814		
	4301921	1 – 25	-8	805 – 814	Sonoma	Lower half blocked
	4301922	1 – 25	-8	805 – 814		
	4301923	1 – 25	-8	805 – 814	Sonoma	Upper half blocked
	4301924	1 – 25	-8	805 – 814		
	4301927	1 – 20	-8	805 – 814	Hoya	
	4301928	1 – 5	-8	805 – 814	Hoya	
	4301929	1 – 25	-8	805 – 814	Sonoma	Baffling removed
	4301930	1 – 25	-8	805 – 814	Sonoma	
	4301931	1 – 25	-8	805 – 814	Sonoma	

Table 4: Maximum polarization factors (a_2)

Band	HAM	Scan Angle						
		-55	-45	-20	-8	22	45	55
DNB	A	1.66	1.60	1.41	1.35	1.36	1.38	1.37
	B	1.44	1.42	1.39	1.39	1.51	1.57	1.59

Figure 1: BVONIR polarizer efficiency determined with (black/red) and without (blue/green) the Sonoma filter

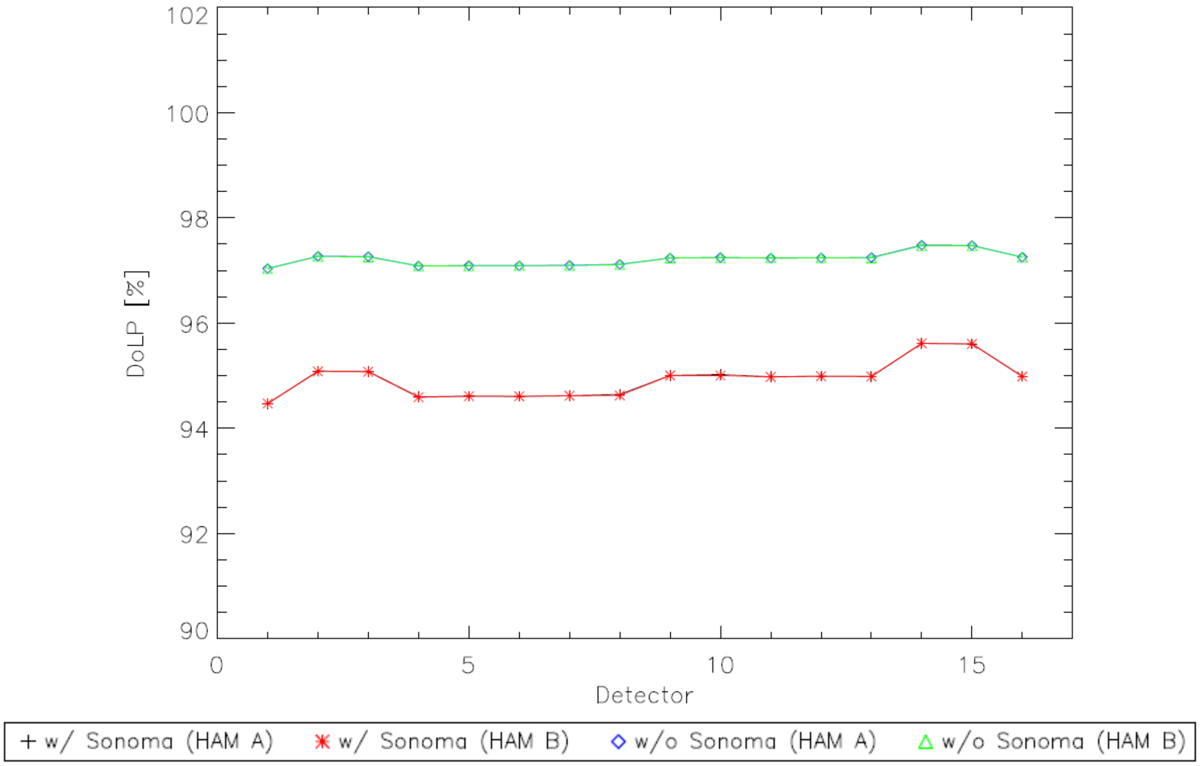

Figure 2: dn as a function of polarizer angle for DNB LGS, HAM A using BVONIR without the Sonoma filter

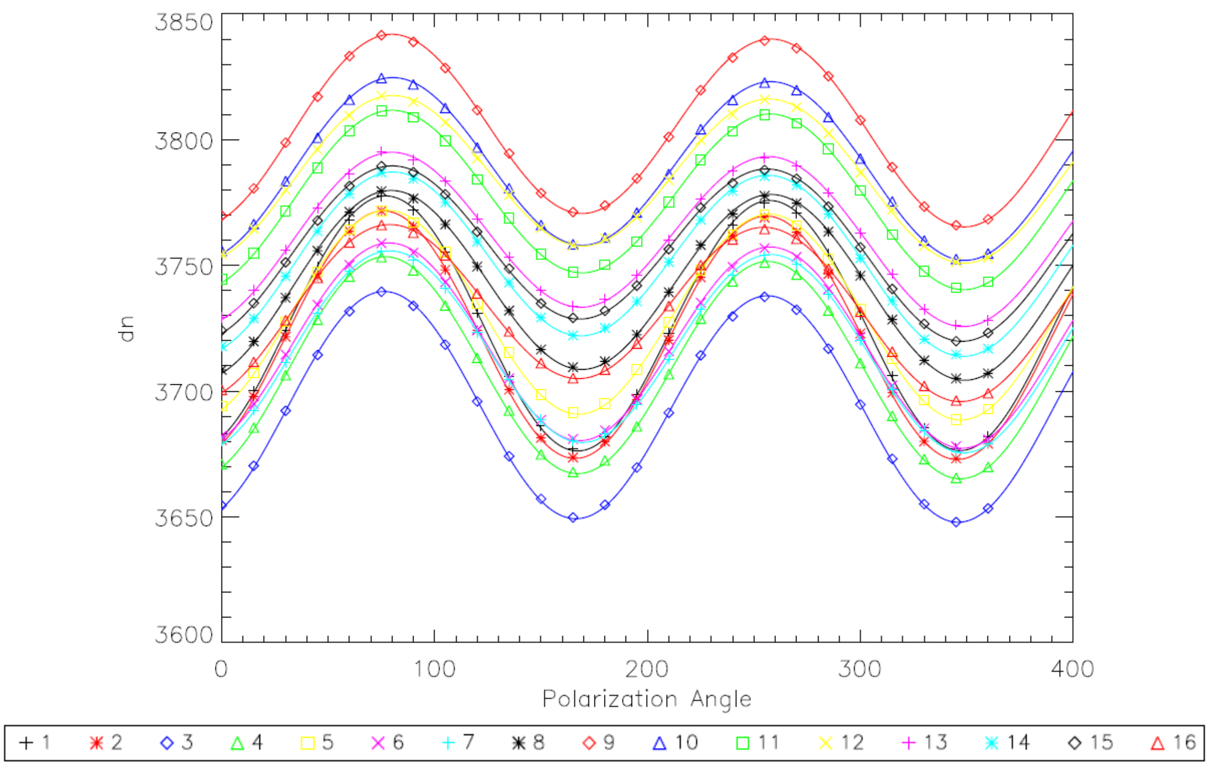

Figure 3: Fourier coefficients for DNB LGS HAM A using BVONIR without the Sonoma filter

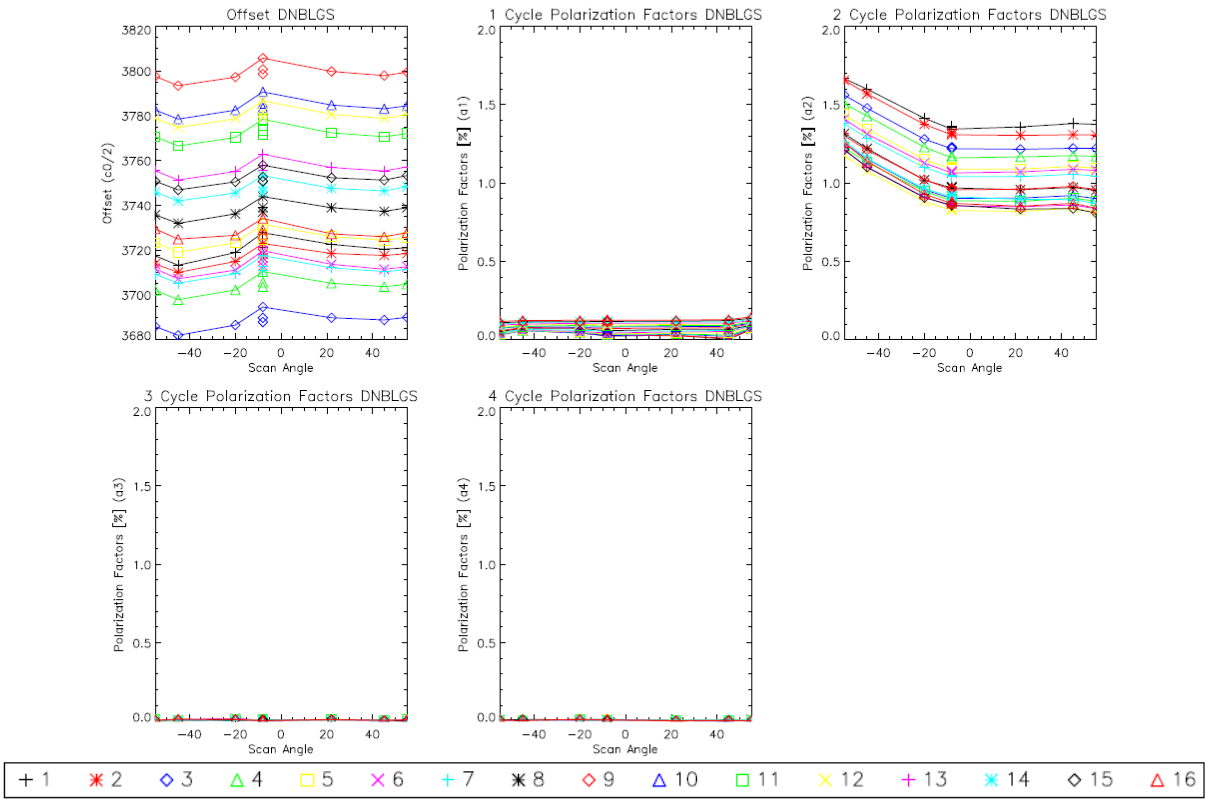

Figure 4: Polarization factor a_2 for DNB LGS, HAM side A in [%] across test configurations and repeated measurements

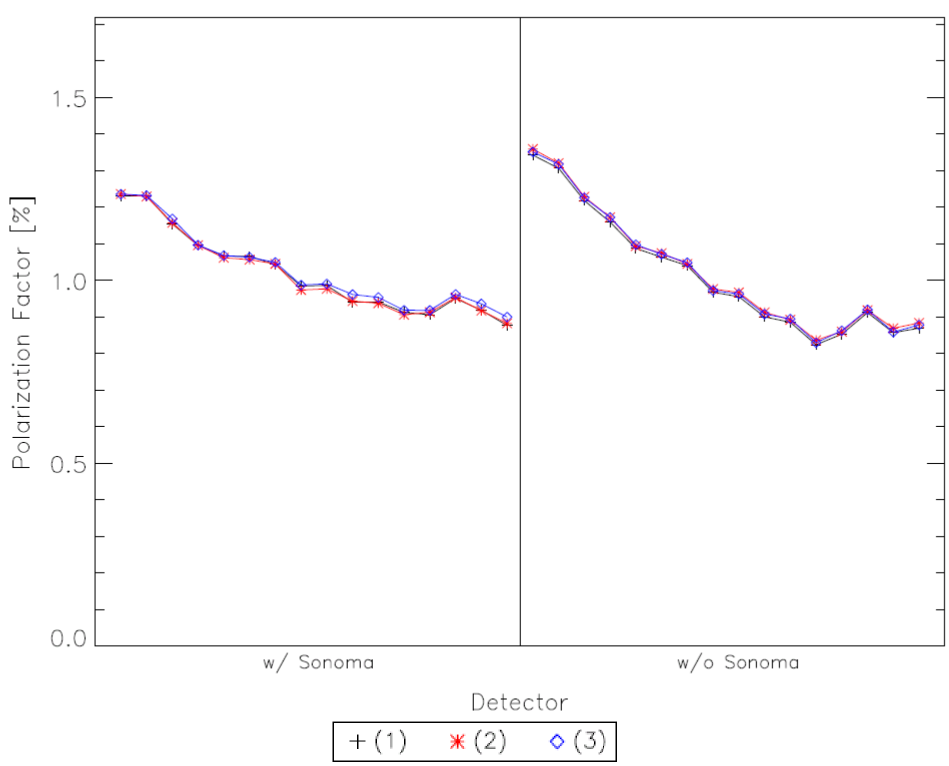

Figure 5: Polarization factor a_2 for HAM side A in [%] across scan angles

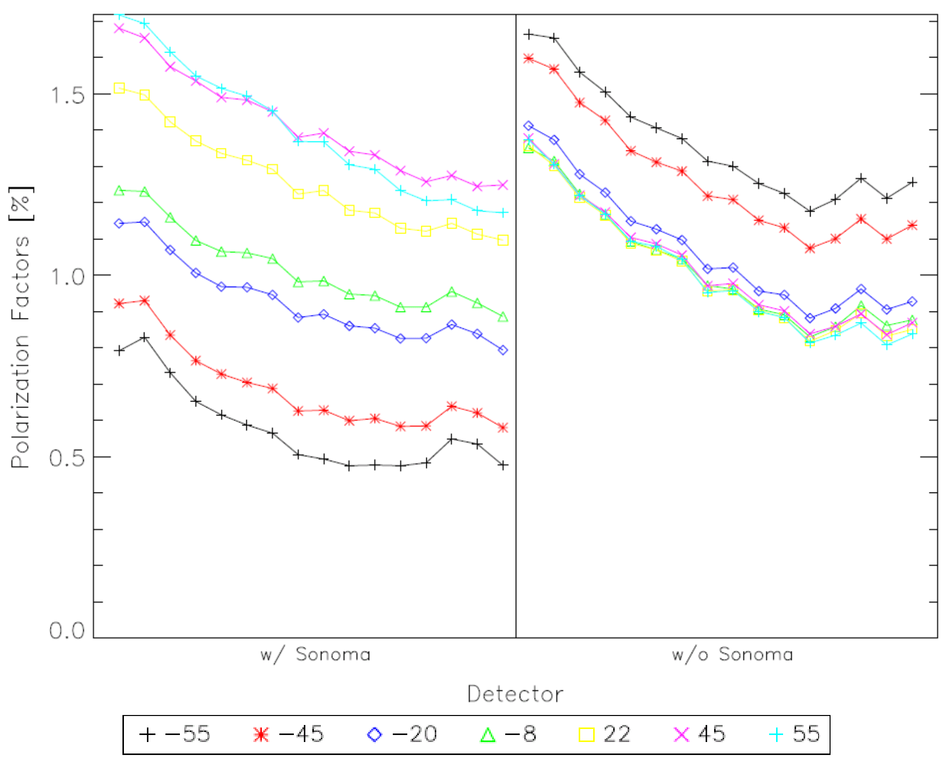

Figure 6: Polarization factor a_2 for HAM side B in [%] across scan angles

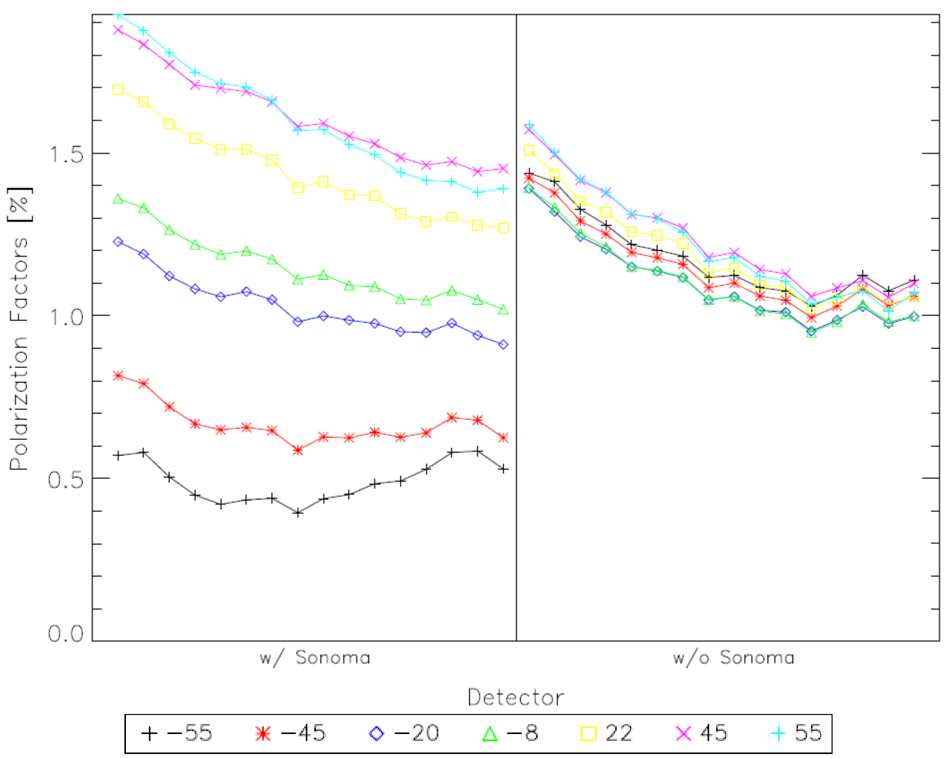

Figure 7: Polarization phase δ_2 for HAM side A in [%] across scan angles

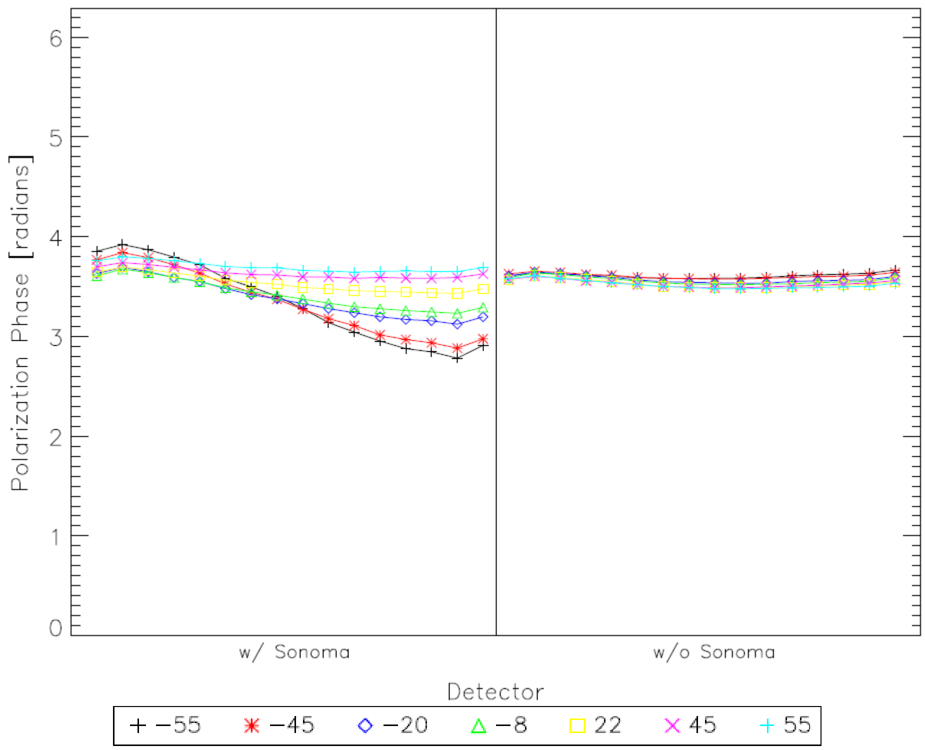

Figure 8: Polarization phase δ_2 for HAM side B in [%] across scan angles

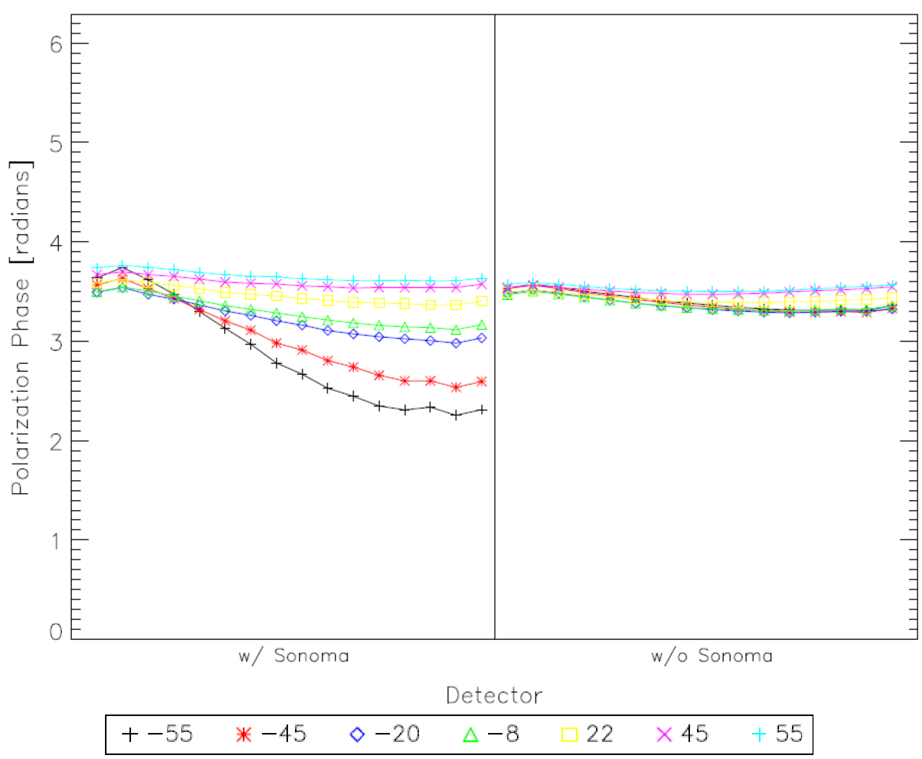

Figure 9: Comparison of polarization factors a_2 for HAM side A in [%] from nominal and special testing

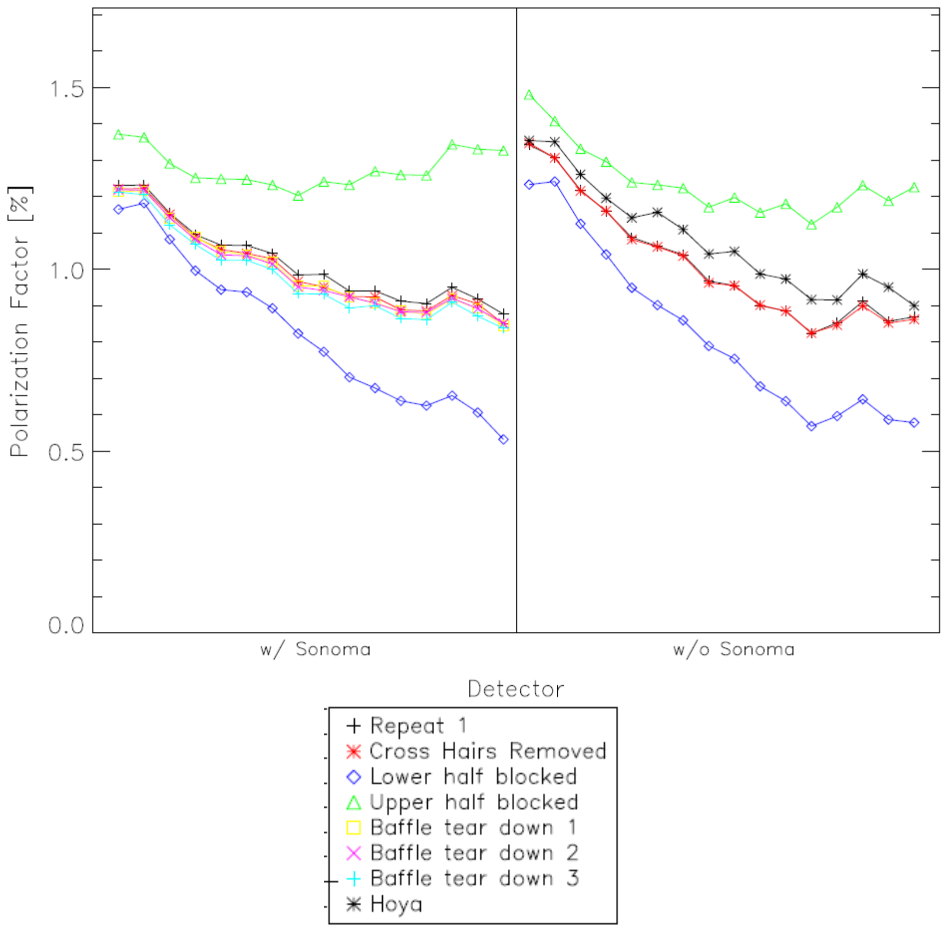

Figure 10: Difference between polarization factors a_2 for HAM side A in [%] between nominal testing and testing using the Hoya filter