VIIRS F1 Pre-Launch Calibration and Characterization:

Polarization Insensitivity for VisNIR Bands

NPP Instrument Calibration and Support Team (NICST)

Presented by

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Objectives, Specifications, and Tests

- **Test Objectives**
  - Examine the insensitivity of the sensor to input polarized light
  - Measure polarization insensitivity for every VISNIR band and detector at discrete scan positions

Table 1. Polarization sensitivity requirements

Band	Center Wavelength (mm)	Maximum Polarization Sensitivity
M1	0.412	3%
M2	0.445	2.5%
M3	0.488	2.5%
M4	0.555	2.5%
I1	0.640	2.5%
M5	0.672	2.5%
M6	0.746	2.5%
I2	0.865	3%
M7	0.865	3%

- **Specifications**
  - **SRV0060** The VIIRS Sensor linear polarization sensitivity of the VIS and NIR bands shall be less than or equal to the values indicated in TABLE 1 for scan angles less than 45 degrees off Nadir.
  - **SRV0469** The VIIRS sensor linear polarization sensitivity shall be measured within a characterization uncertainty of 0.5% (one sigma) for scan angles less than 55.84 degrees off nadir
- **Tests**
  - FP-11: Strong non-uniformity of light source
  - STR-545 and STR-554: Non-perfect polarized input light
  - EPT-679: Post TV test

Data Analysis Status

- Two polarization sheets and one blocking filter were used
  - Filter 1 with blocking filter provides full polarized light for M1-M3 (Saturated for M4)
  - Filter 2 without blocking filter provides well polarized light for other bands (less than 2% non-polarized light)
  - Filter 1 without blocking filter can also provide well polarized light for M4-M6 and I1. However, the light is not fully polarized for M7 and I2 and a correction factor of 0.5930 and 0.5966 should be applied, respectively.
- All data are analyzed and polarization parameters are derived for all VISNIR bands and for all selected scan angles: -55, -45, -22, -8, 20, 45, and 55 degree
- The derived polarization factors satisfy the VIIRS specification for the polarization factor (3% for M1 and M7; 2.5% for all other VisNIR bands)
- Uncertainty (less than 0.5%)
  - Non-uniformity of the light source: One-cycle oscillation amplitudes are all smaller than 0.2%
  - Repeatability: better than 0.15%
  - Others: less than 0.3%

Algorithms for Data Analysis

- Fourier Analysis

$$dn(\alpha) = c_0 + \sum_{i=1}^{4} \left[c_i \cos(i\alpha) + d_i \sin(i\alpha) \right]$$

$$c_i = \frac{1}{\pi} \int_{-\pi}^{\pi} dn(\alpha) \cos(i\alpha) d\alpha$$

$$d_i = \frac{1}{\pi} \int_{-\pi}^{\pi} dn(\alpha) \sin(i\alpha) d\alpha$$

- Only second order oscillation has information for the polarization effect
- Other order oscillations due to light source and other noise

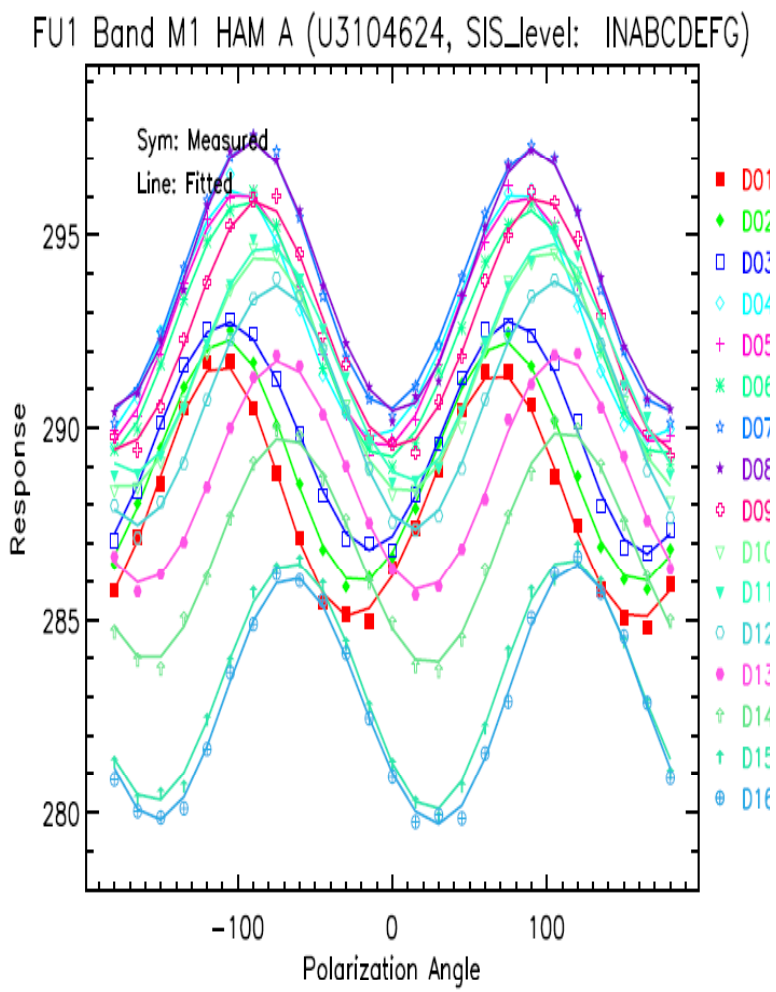
  - α is the polarization angle

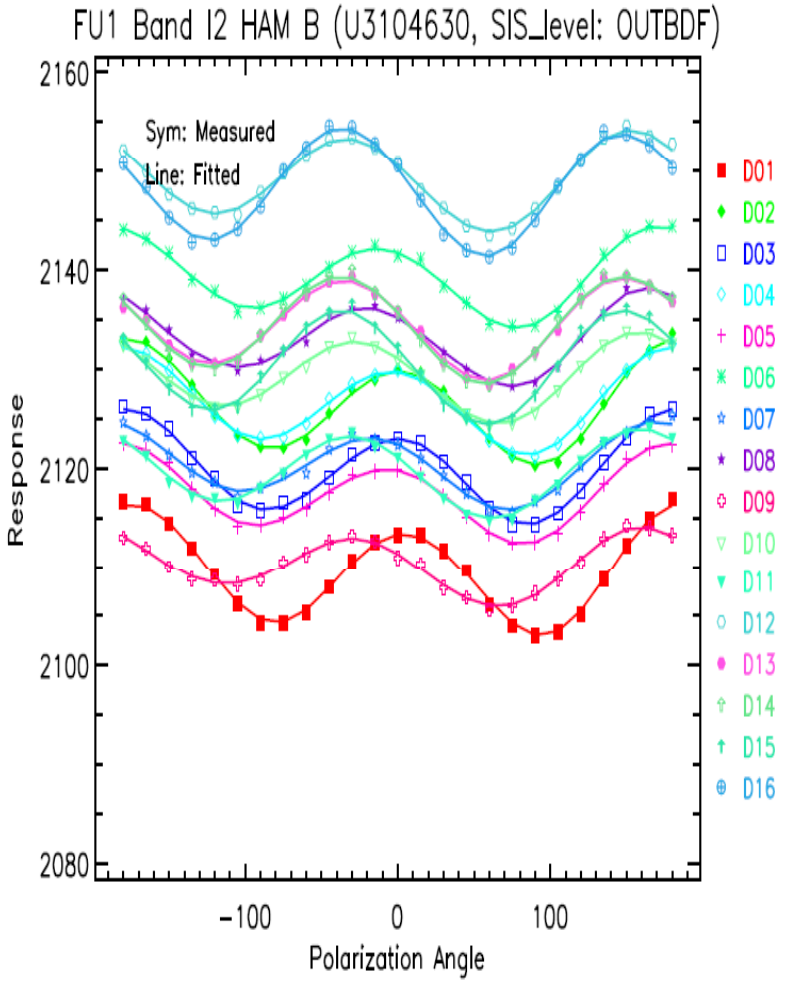
- Oscillation

$$dn(\alpha) = c_0 \left[1 + \sum_{i=1}^{4} a_i \cos(i\alpha + \beta_i) \right]$$

$$a_i = \sqrt{c_i^2 + d_i^2} / c_0, \quad \beta_i = a \tan(d_i, c_i)$$

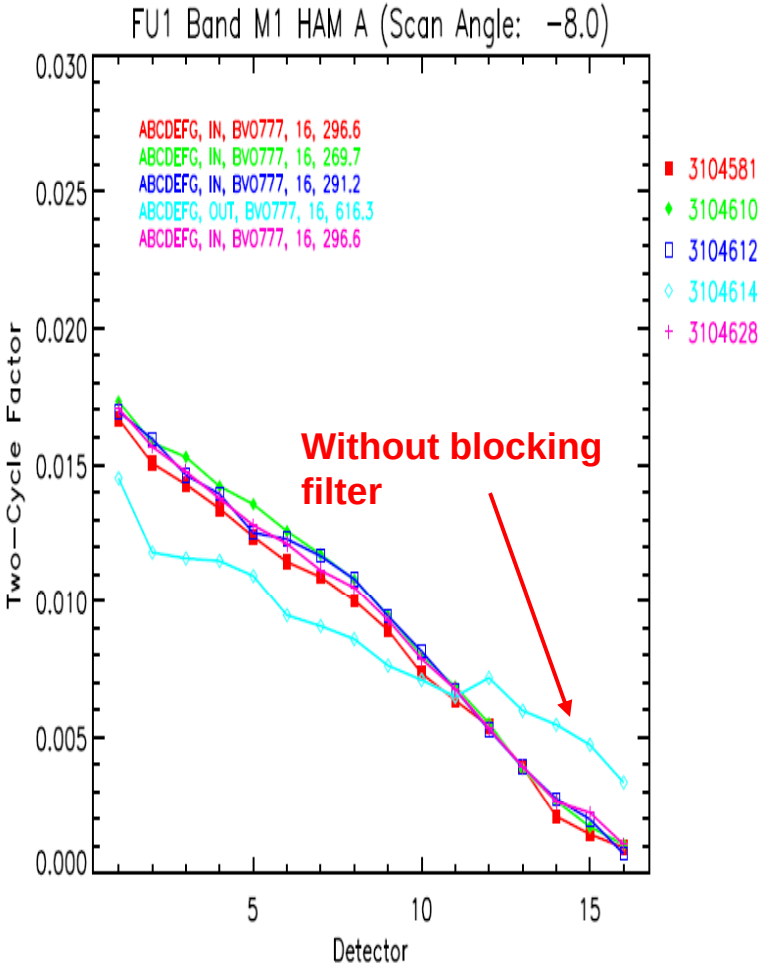
Response

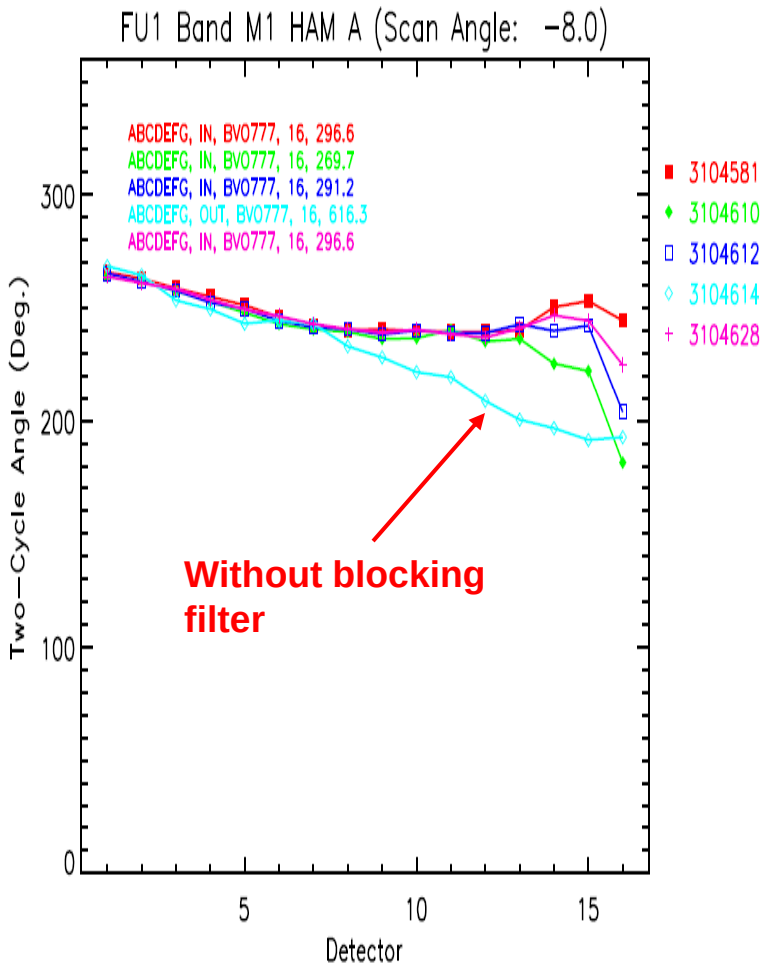




No obvious non-uniformity of the light source or other noises are observed.

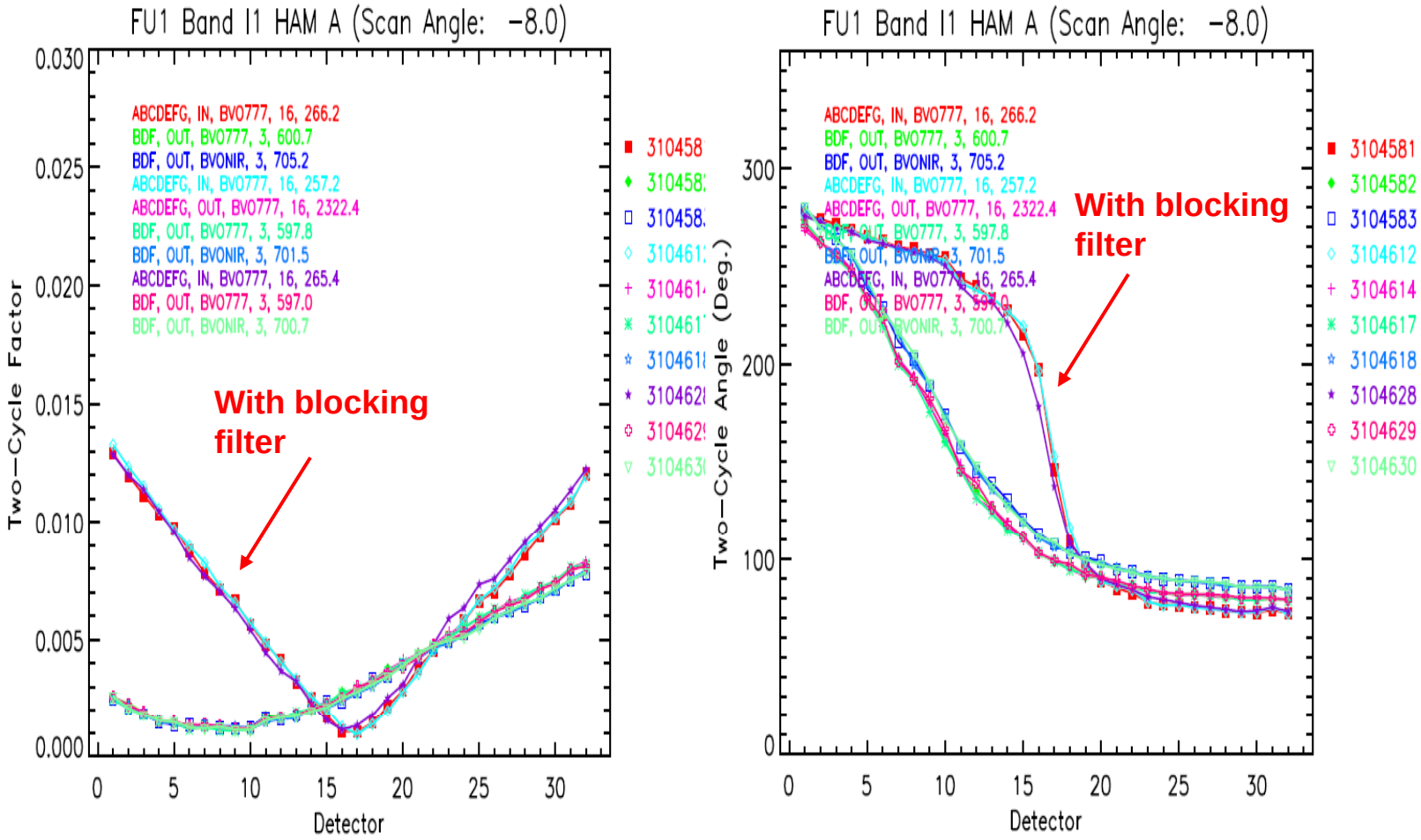
Dependence on Blocking Filter





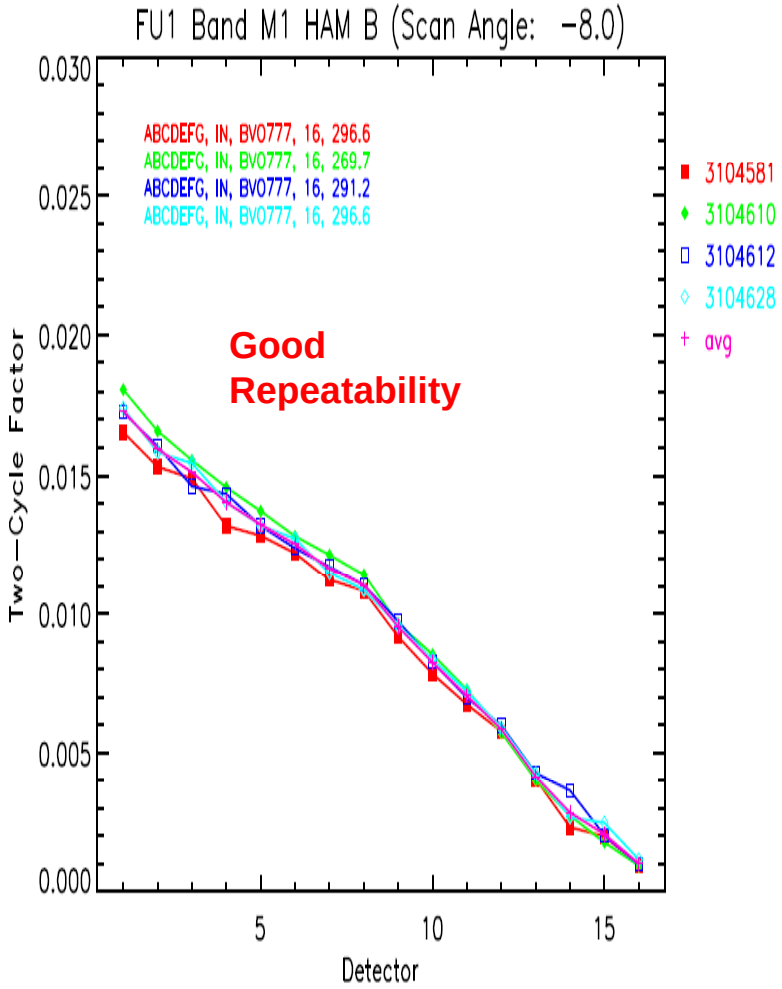
The Blocking filter reduces the noise due to the crosstalk from long wavelength bands.

Dependence on Blocking Filter

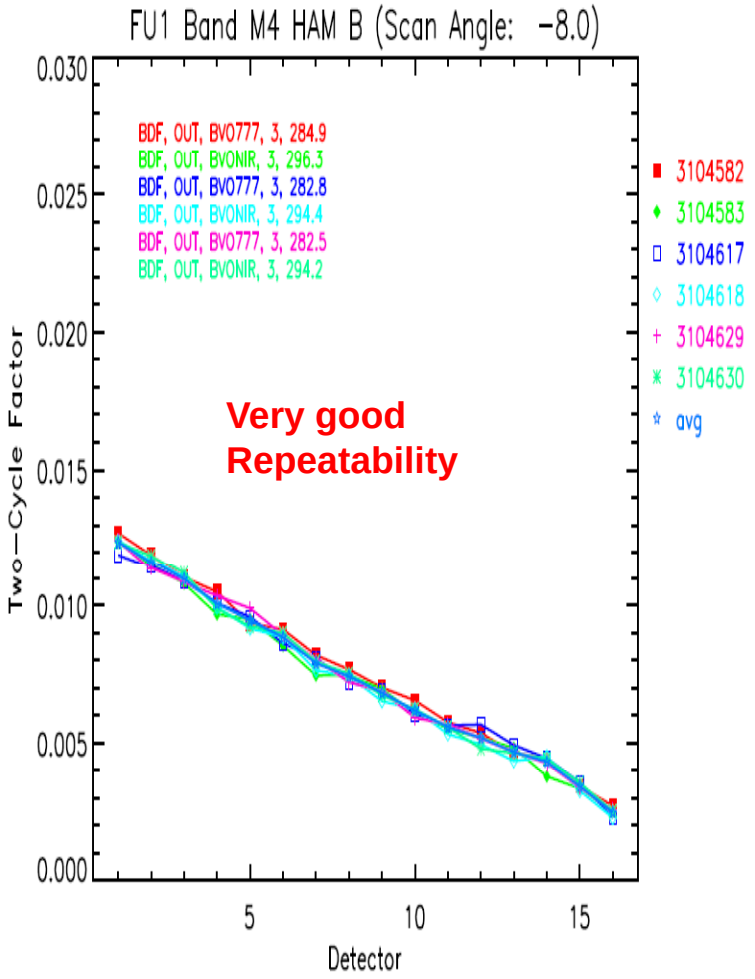


The blocking filter reduces the incident radiance for band I1 and relatively increases noise due to the crosstalk from short wavelength bands

Repeatability

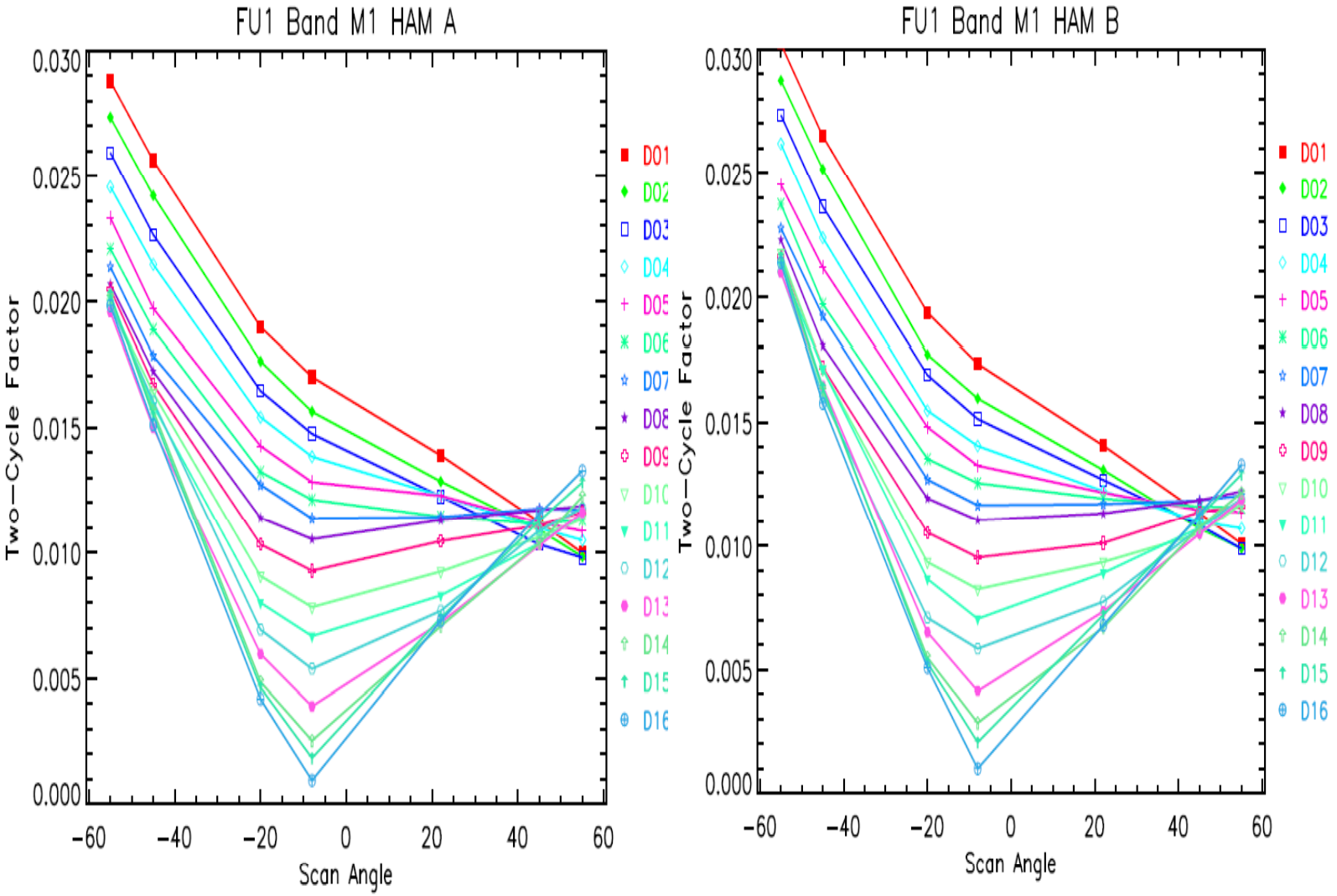


M1, M2, M3: IN, BVO777



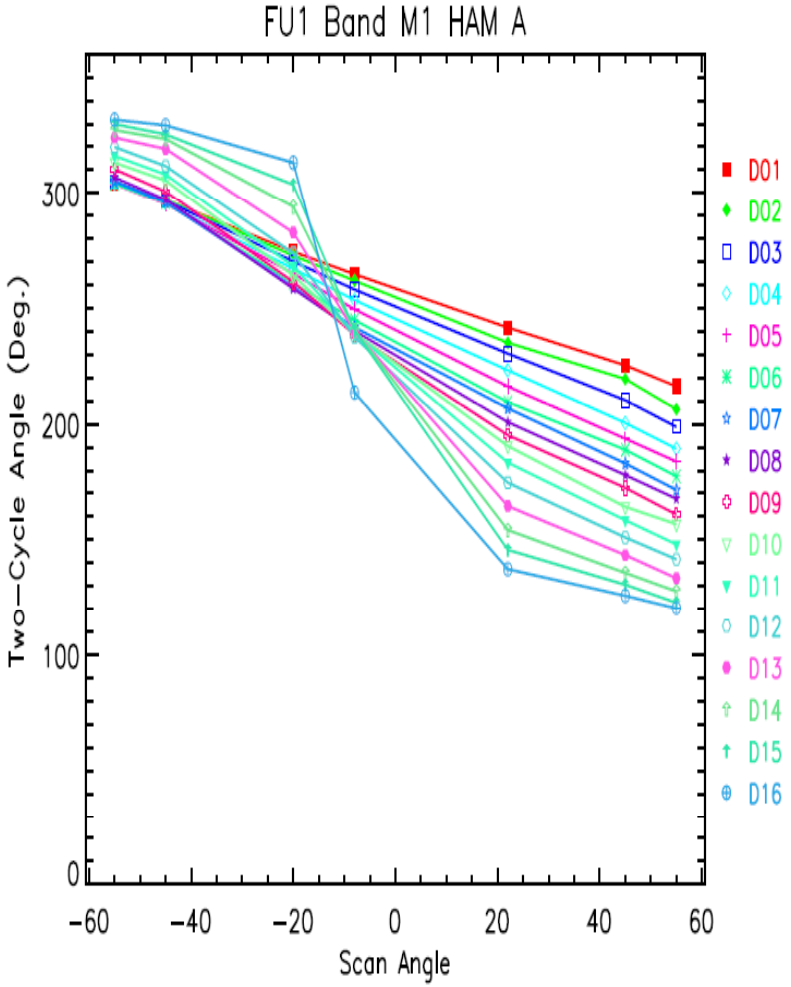
M4-M7, I1, I2: OUT, Both sheets

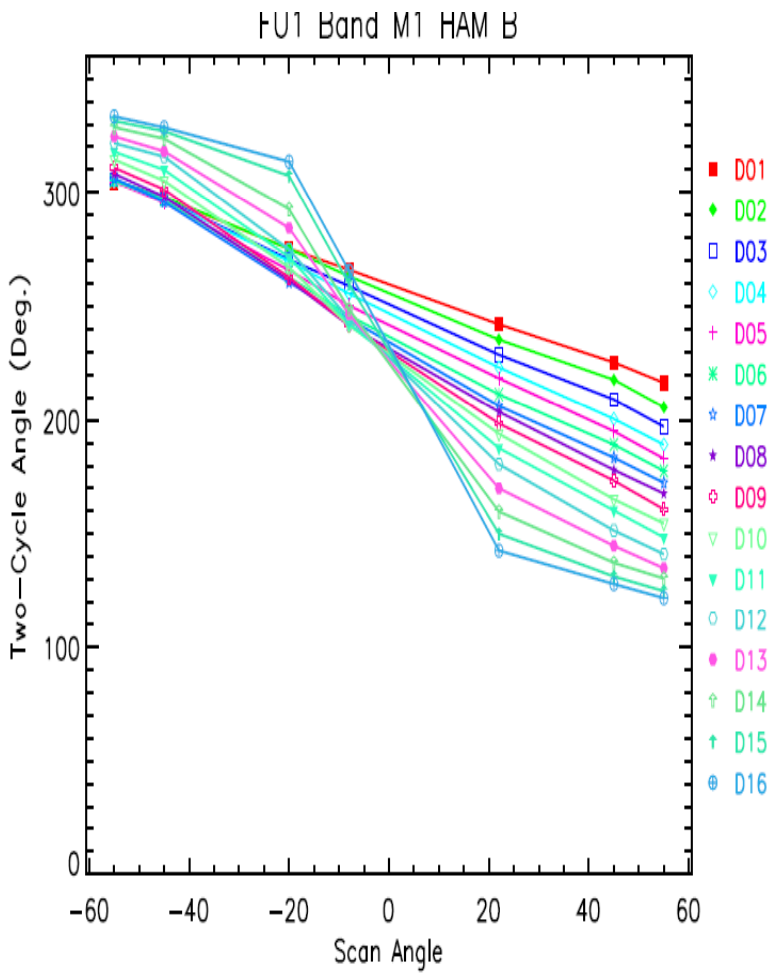
Polarization factor: M1



Strong detector and scan angle dependence but weak mirror side dependence for band M1

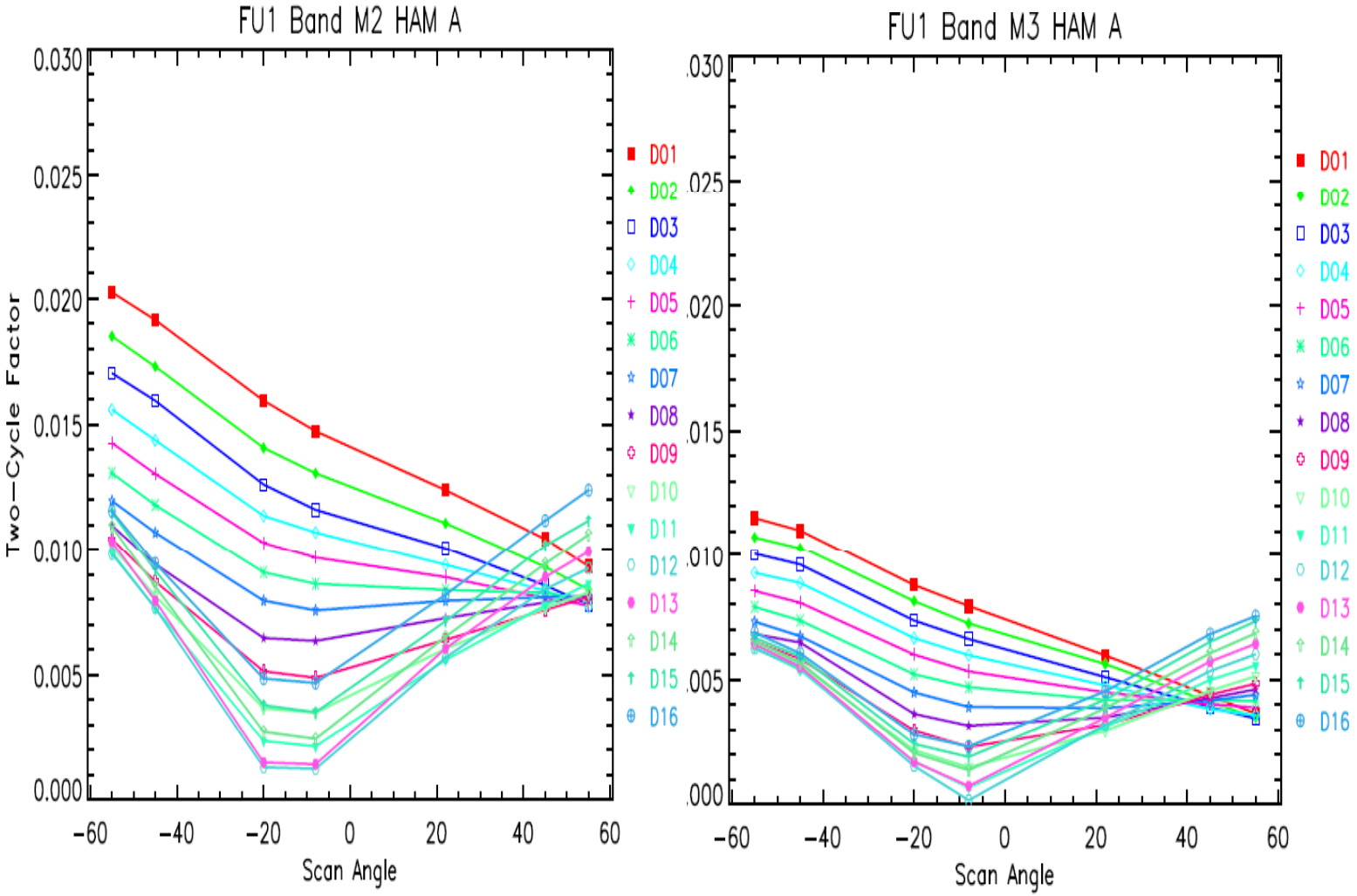
Polarization Phase Angle: M1





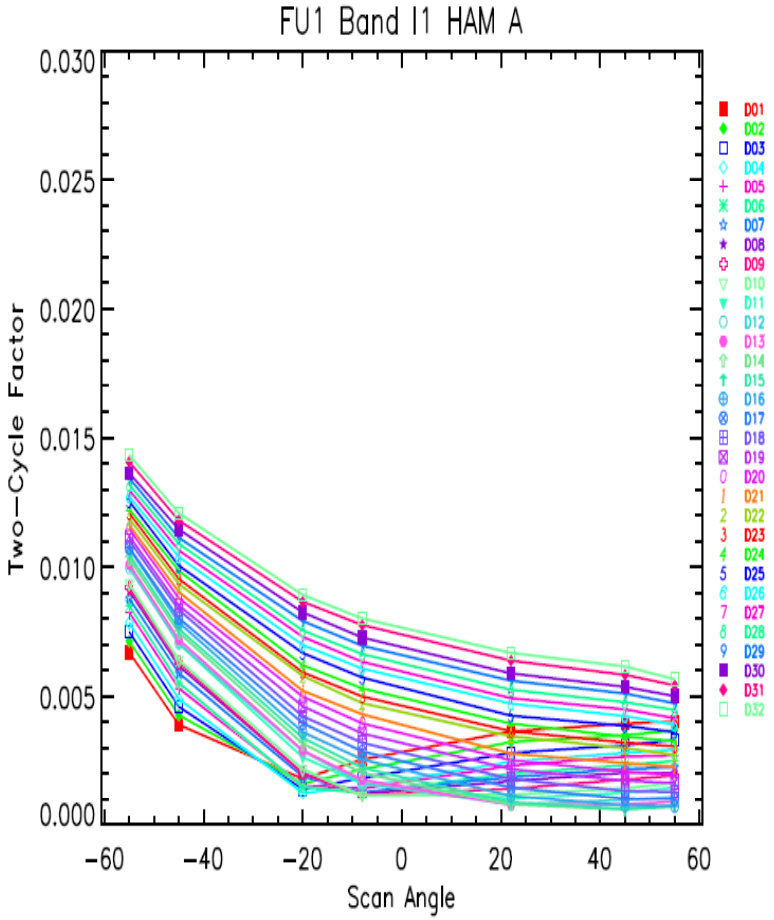
Strong detector and scan angle dependence but weak mirror side dependence for band M1

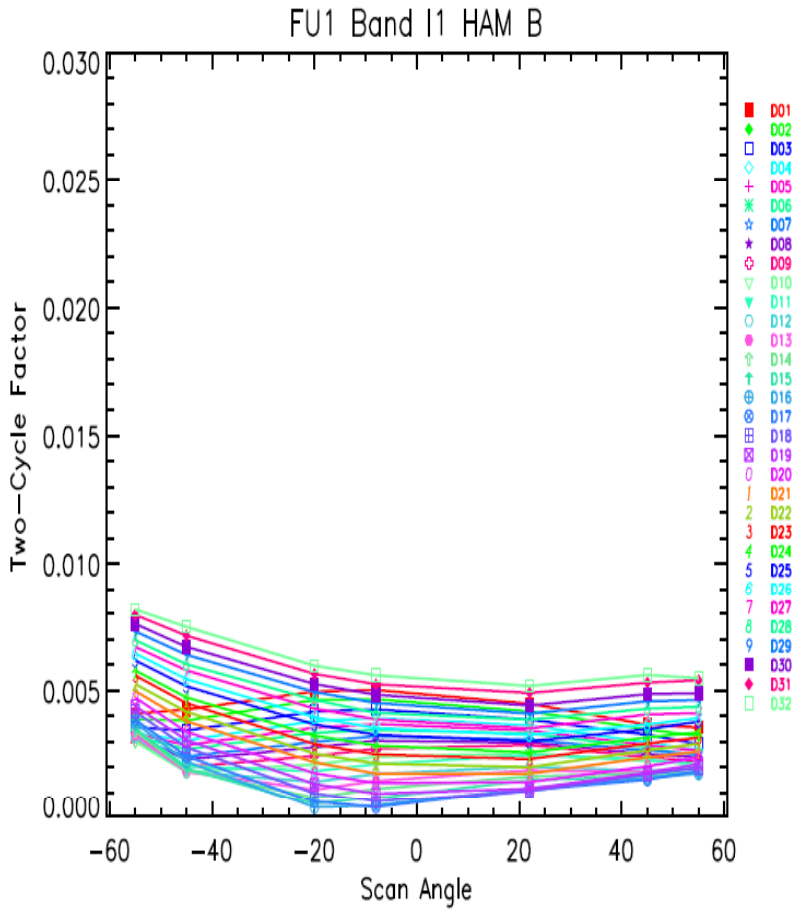
Polarization Factor: M2 and M3



Polarization factors of different detectors in a given band cross and the cross point moves to smaller scan angle with increasing wavelength

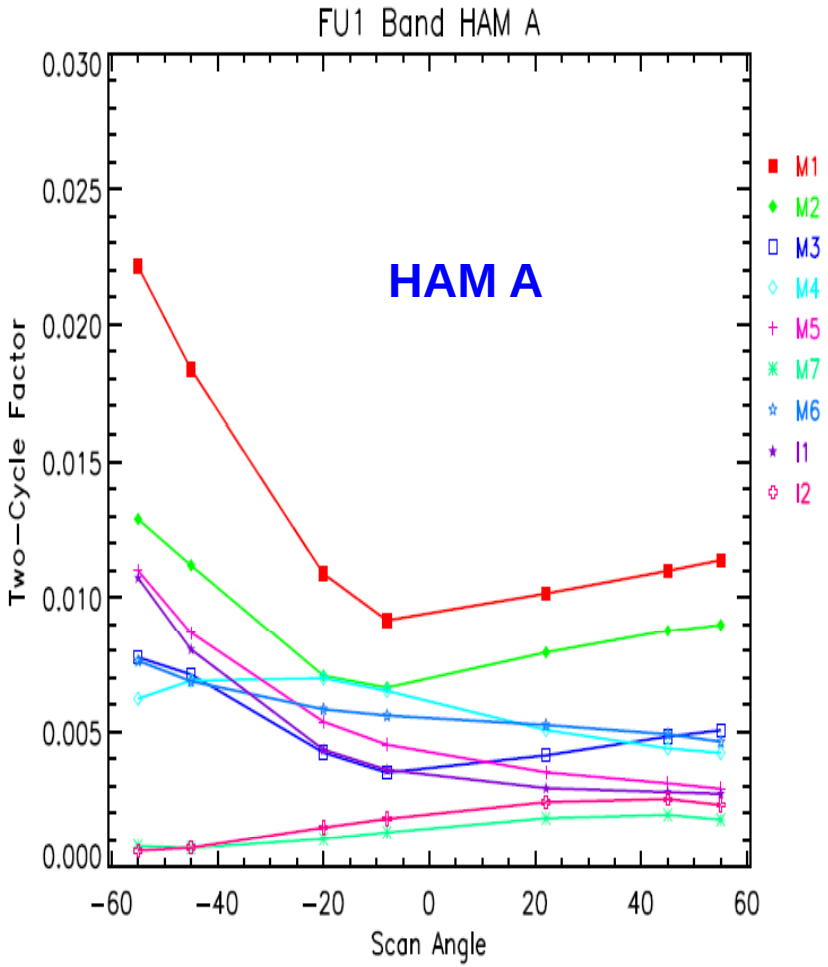
HAM Side Difference

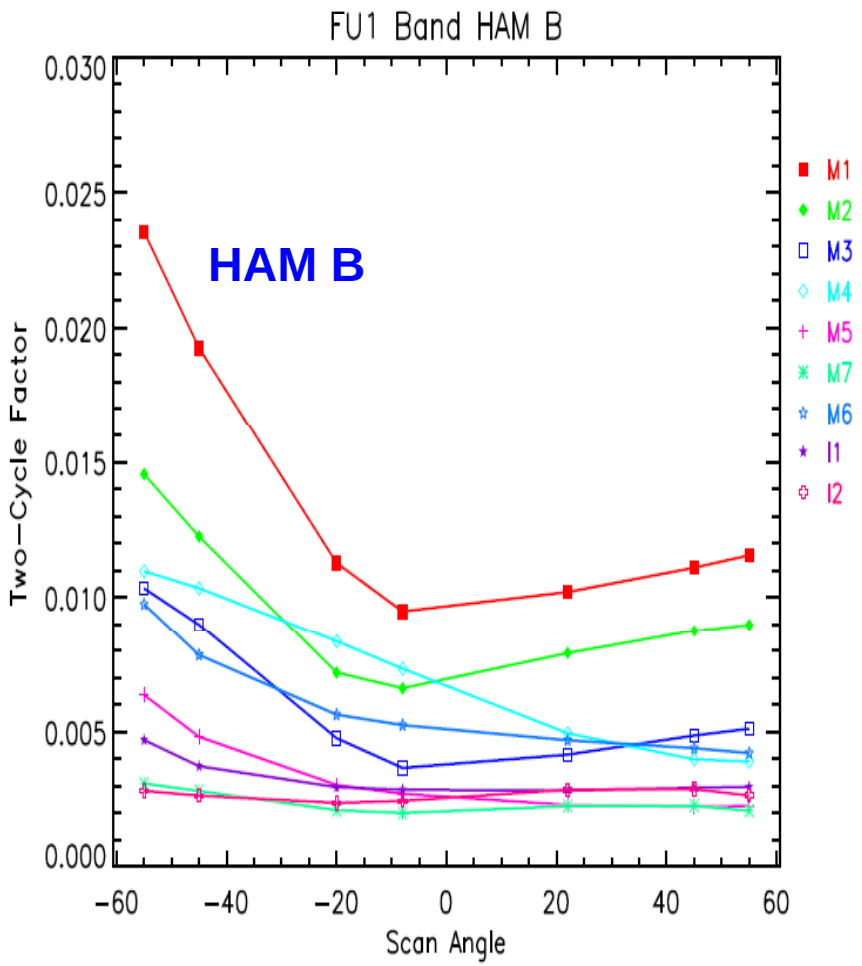




For band I1 (640 nm), the polarization factors are quite different for the two mirror sides at small AOI. The difference between the two mirror sides is also observed for polarization factors of bands M4 (555 nm) and M5 (670 nm). These phenomena were also observed in the polarization factors derived from the tests using the PSA (FP-11).

Detector Averaged Polarization Factor





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Summary

- The polarization parameters are derived from ETP-679 test in which SIS100 with a polarizer sheet was used as light source for all VISNIR bands and for all selected scan angles
  - Non-uniformity of the light source is small
  - The incident light is either well polarized or correctable for its non-perfect polarization
  - The repeatability of the test is very high
- The derived polarization factors satisfy the specifications for both their values and uncertainty.
- The derived polarization factors vary strongly with detector and the variability depends on the scan angle. For bands I1, M4, and M5, they also vary significantly with HMA mirror side.
- Neither the variability itself nor its dependence on scan angle could be verified by a ray-tracing model.