MERIS US Workshop

Instrument Characterization Overview

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Presentation Overview

On-Ground Characterisation

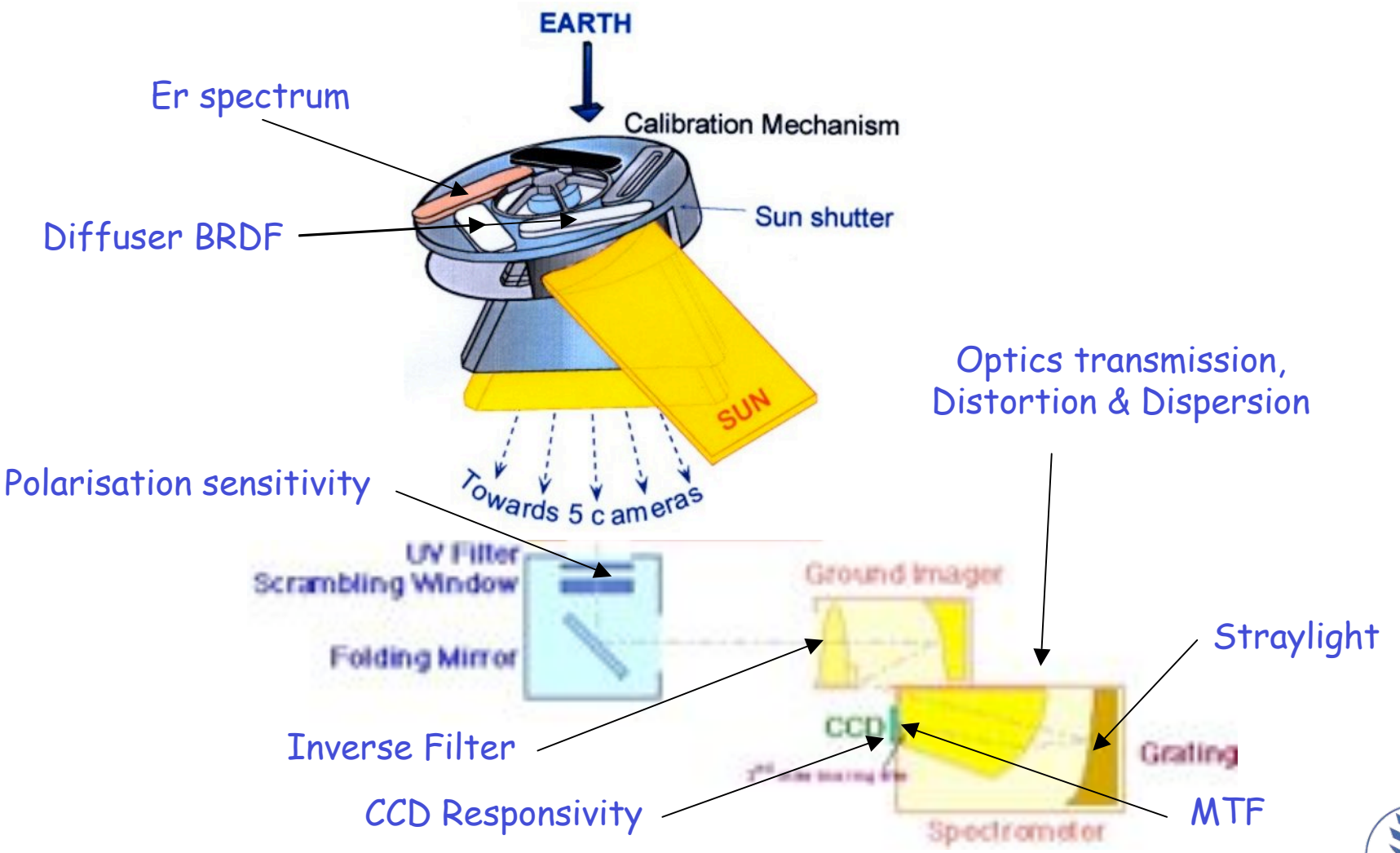
1. Diffuser characterisation
2. Polarization sensitivity
3. Optical Transmission
4. Optical Distortion & Dispersion
5. Straylight
6. CCD Responsivity
7. MTF
8. Spectral Smile & Frown
9. Pointing

On-Orbit Characterisation

1. Offset stability
2. CCD Sensitivity to SAA
3. NEDL

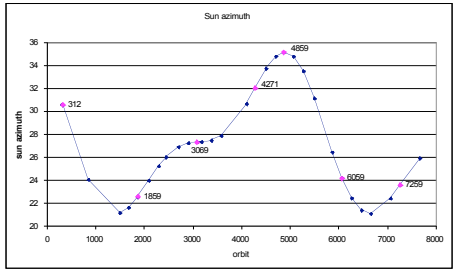
Unit Level characterisation

Overview



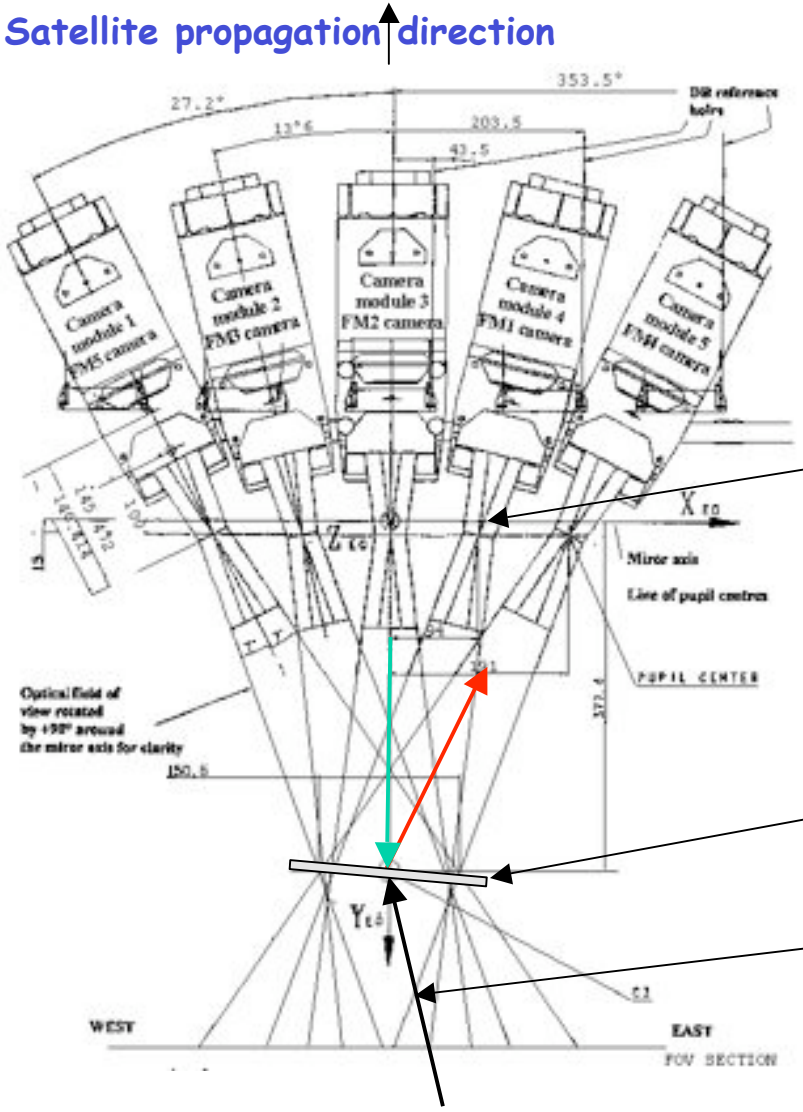
Diffuser Geometry

Illumination angle on diffuser maintained at 65.35 deg.

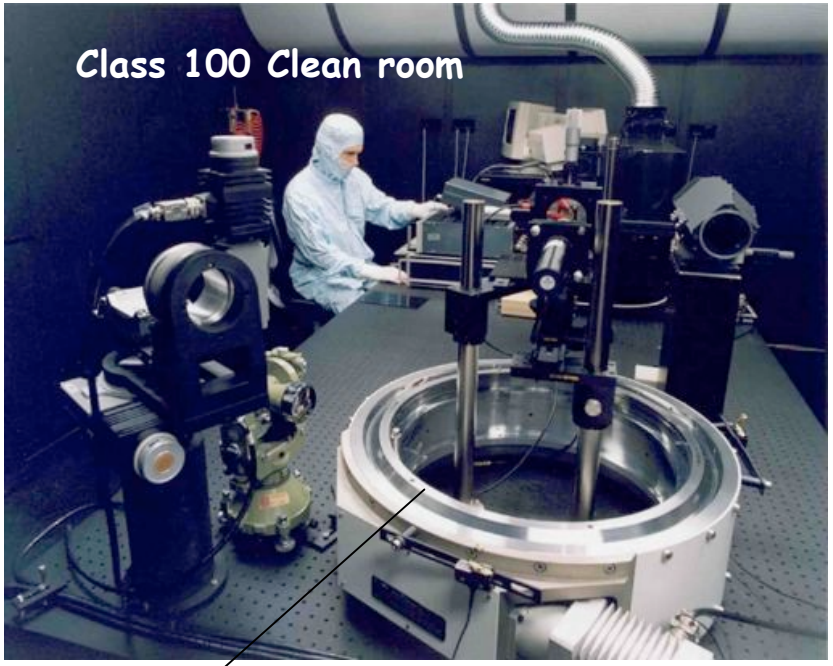


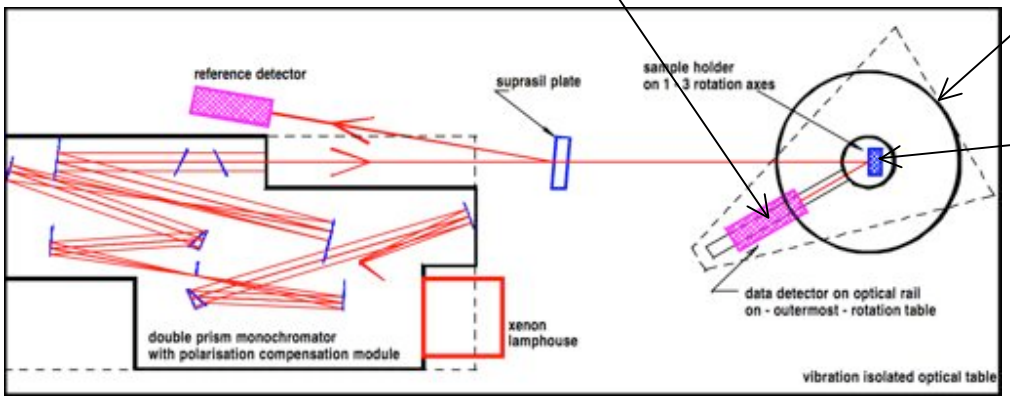
Azimuth angle varies along the year (21-35 deg)

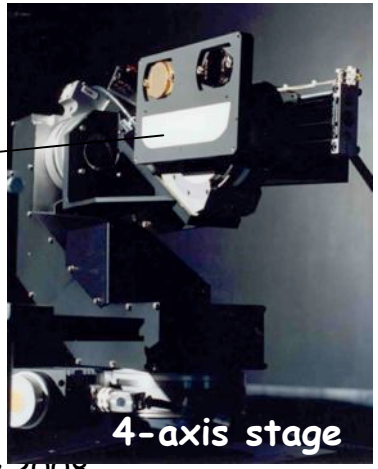
The normal to the diffuser, the nadir pointing direction and the solar illumination direction for the nominal azimuth angle (27.5 deg) are in the same plane.



Characterisation Bench



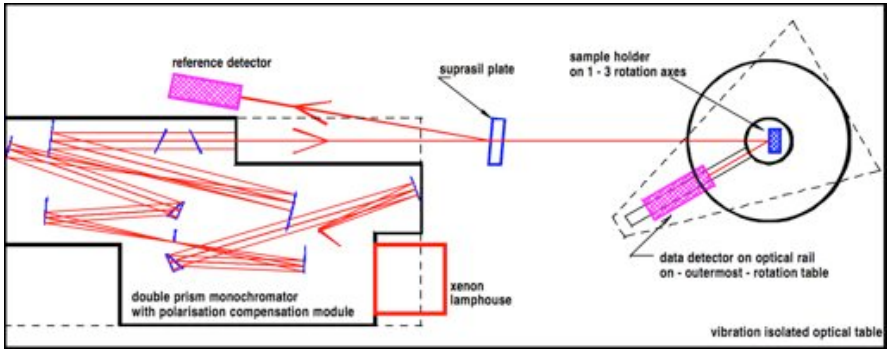




Diffuser Characterisation

Method

- Monochmator overfills the detector's pupil - irradiance measurement
- Monochmator overfills measured area on the diffuser - radiance measurement.
- Reference detector monitors monochomator output during measurements



Double Prism Monochomator

Beam divergence = 32arcmin
Beam diameter = 50mm
Source = Xenon arc
Polarisation < 0.5%
Adjustable spectral bandwidth
(Blue=3nm NIR=20nm)

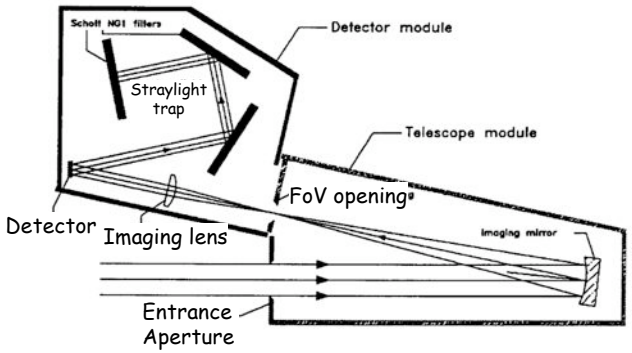
Detector

FoV = 1.2 deg
Pupil = 14mm x 18mm
Distance to diffuser = 350mm
Polarisation < 1-4% (λ)

Error budget

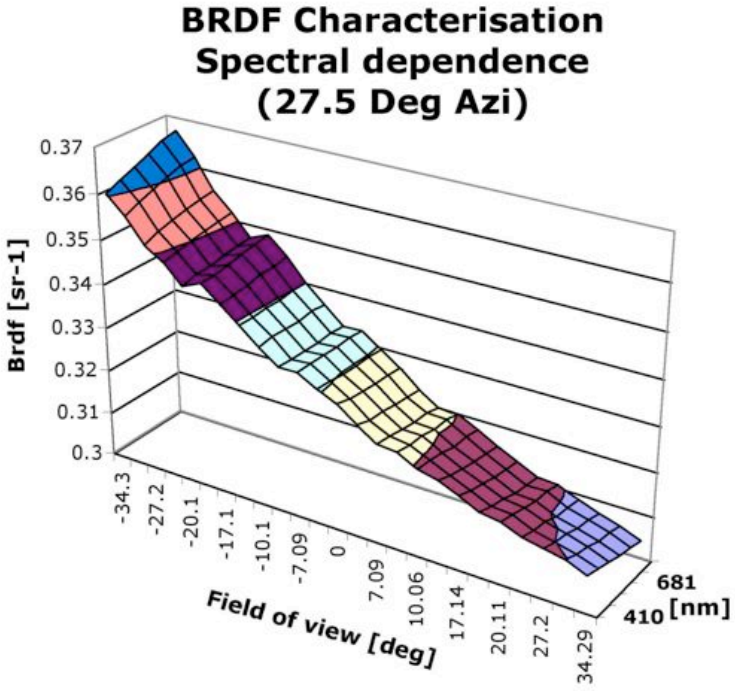
Error sources	Error Type	BRDF	Inter-Pixel	Inter-Band
Field of View	Bias	<0.2 %	-	-
Angular precision	Random	0.10%	0.10%	-
Detector linearity	Random	0.30%	-	0.30%
Beam Uniformity	Signed Bias	-0.15%	-	-
	Bias	0.35%	0.20%	0.20%
Noise	Random	0.20%	0.20%	0.20%
Polarisation	Bias	<0.05%	<0.01%	<0.01%
Straylight	Signed bias	0.10%	-	-
	Bias	0.10%	0.10%	0.10%
Total	-	**0.49%**	**0.26%**	**0.38%**

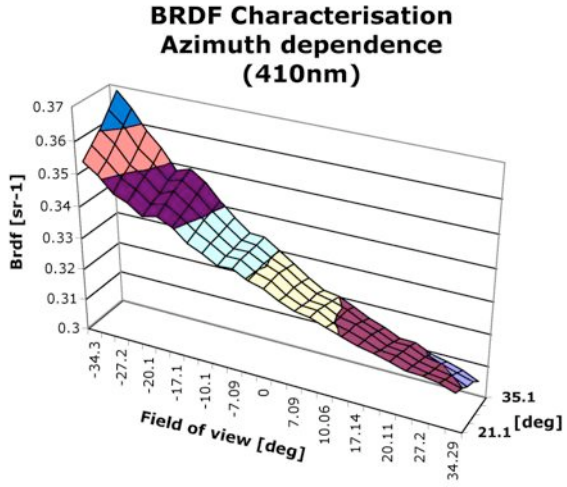
Total error (1σ) = $|\Sigma Sb_i| + sqr[\Sigma B_i^{2/3} + \Sigma \sigma_k^2]$

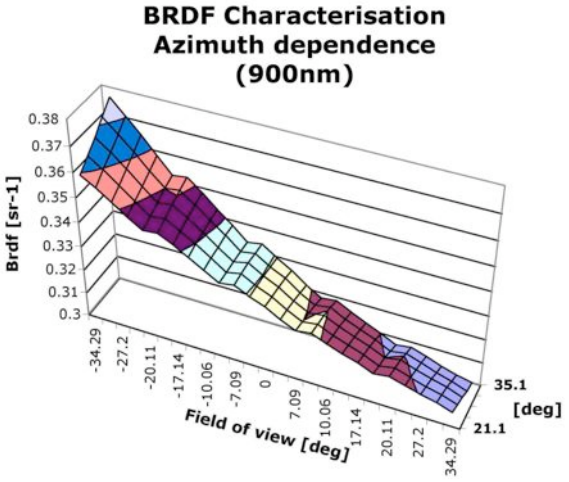


Diffuser Characterization

Results





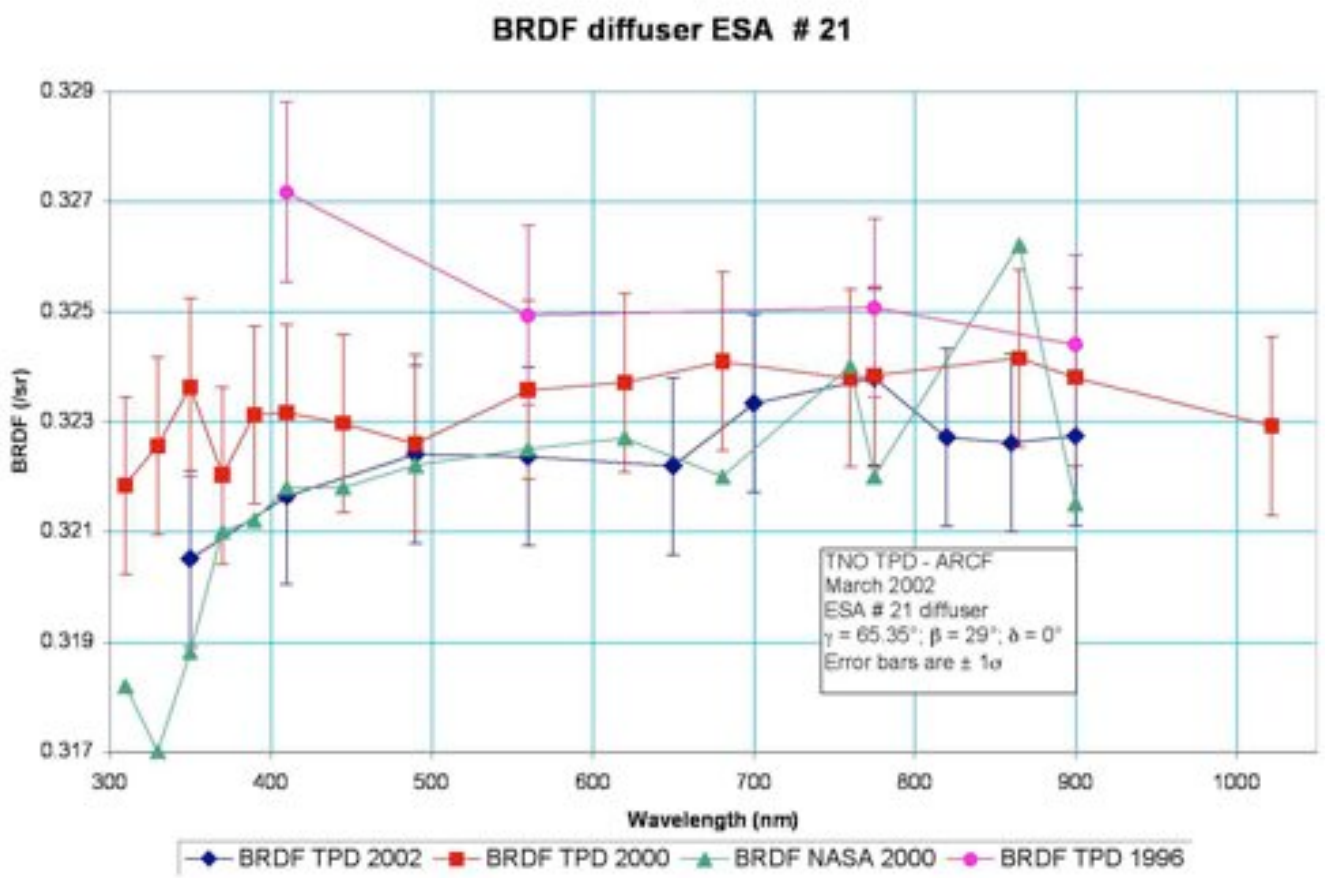


Spectral dependence

BRDF Increases more toward forward scattering for longer wavelengths

Comparison with Nasa

and long term monitoring

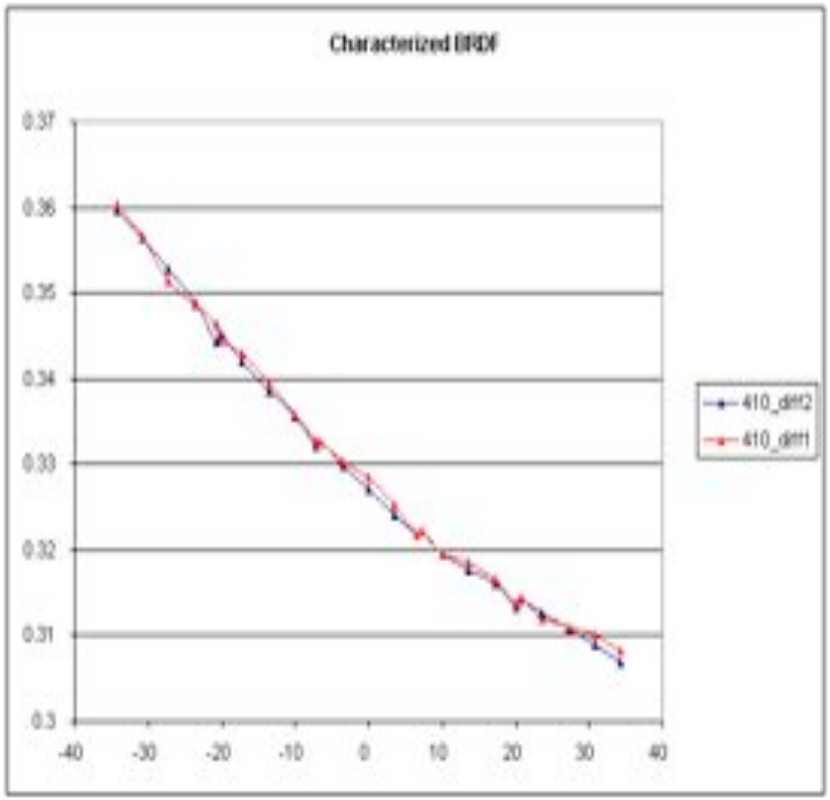


Inter-comparison with NASA (2000), agreement within measurement accuracy (1%)

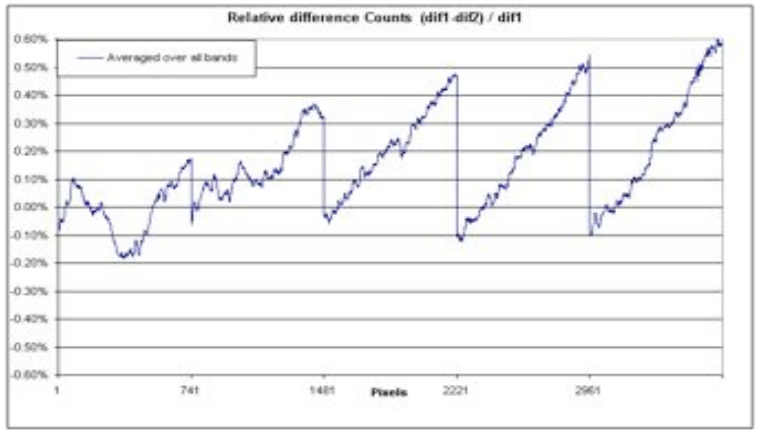
MERIS diffuser characterisation data = TPD 1996

Monochromator and Detector head upgraded in 2000 at TPD.

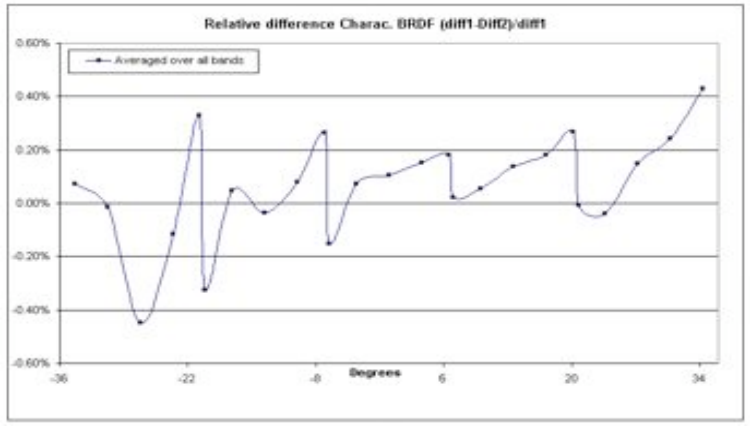
Comparison Diffuser 1&2



BRDF of Diffusers-1&2 at 410 nm

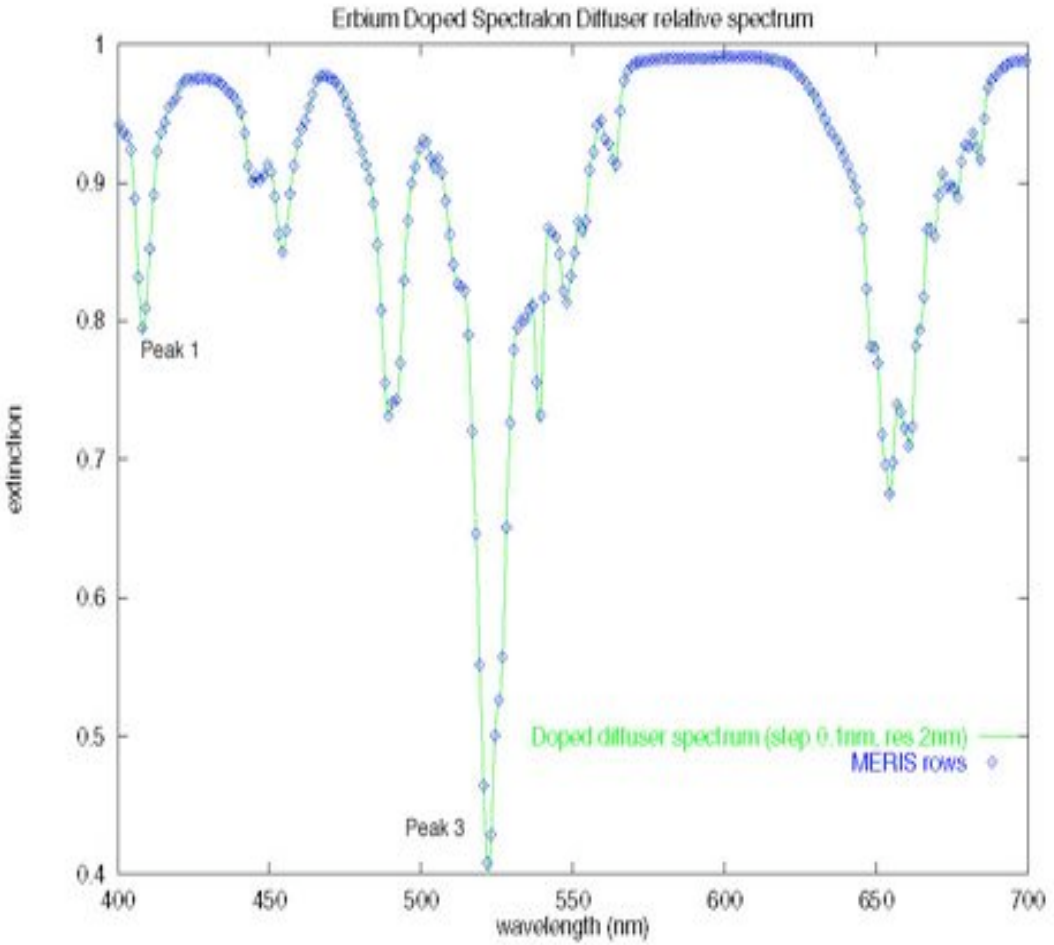


Ratio Diffusers-1&2 BRDF on-orbit



Ratio Diffusers-1&2 BRDF on-ground

Erbium Spectral Absorption



Absorption Spectrum of Erbium doped Spectralon™ diffuser

5 Positions Mechanism:

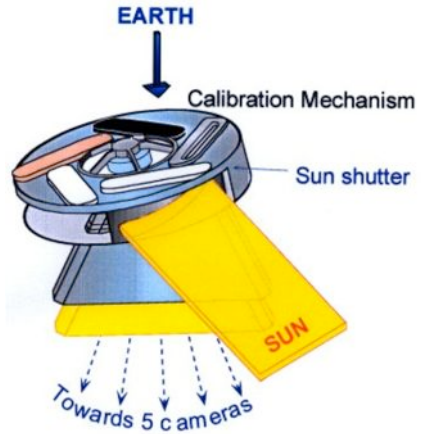
Shutter

Aperture

Diff-1

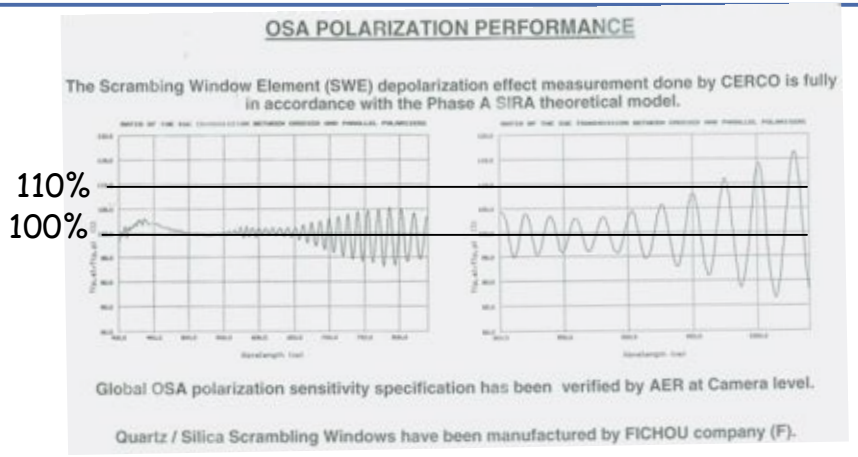
Diff-2

Diff-Er

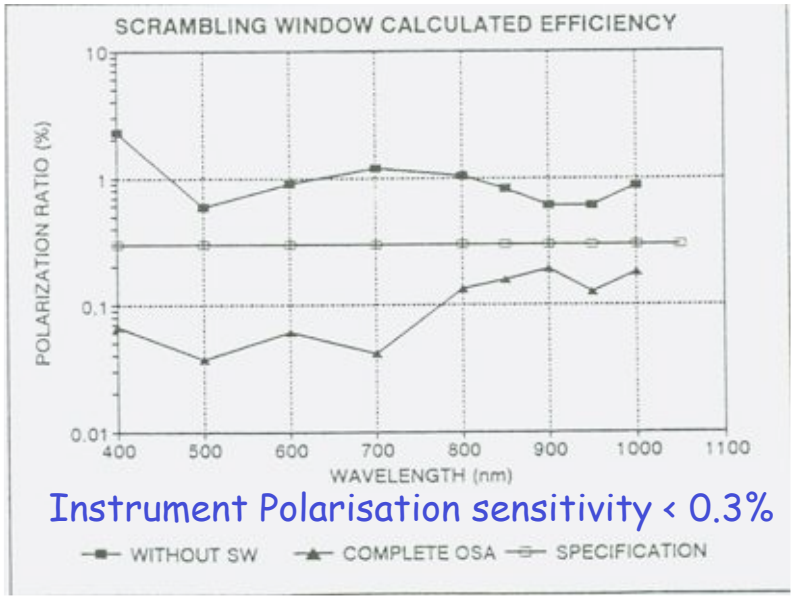


Polarisation sensitivity

Scrambling Window Sub-Assembly (SWSA)
(In front: UV-filter & Scrambler assembly)

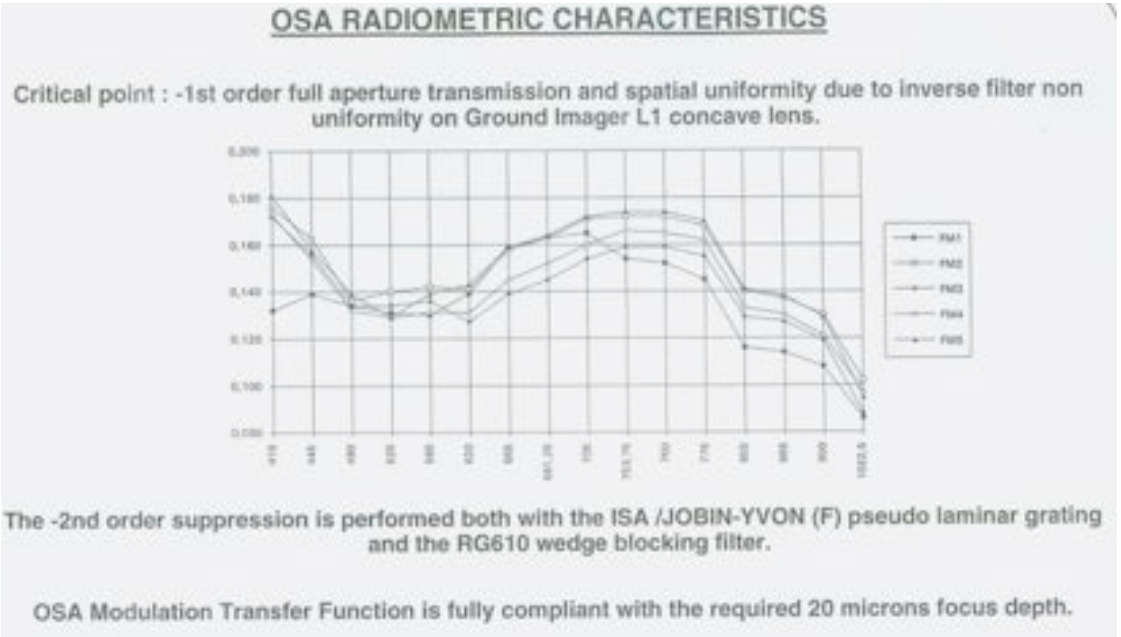


Scrambler residual monochromatic polarisation sensitivity [s/p]



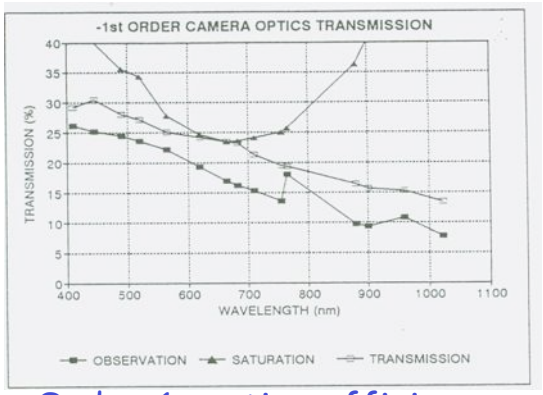
Instrument Polarisation sensitivity < 0.3%

Optics Transmission

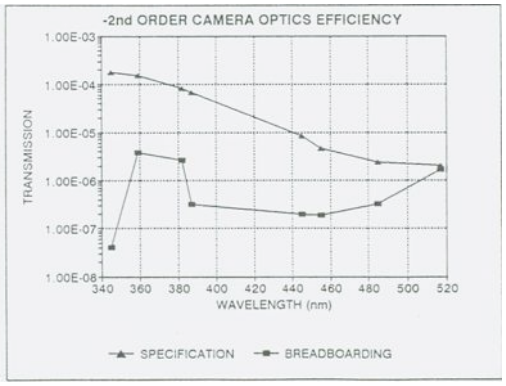


Optics transmission

The strong attenuation in the region 480nm to 620nm is due to the "inverse filter" whose purpose is to "flattens" spectrally the MERIS system response



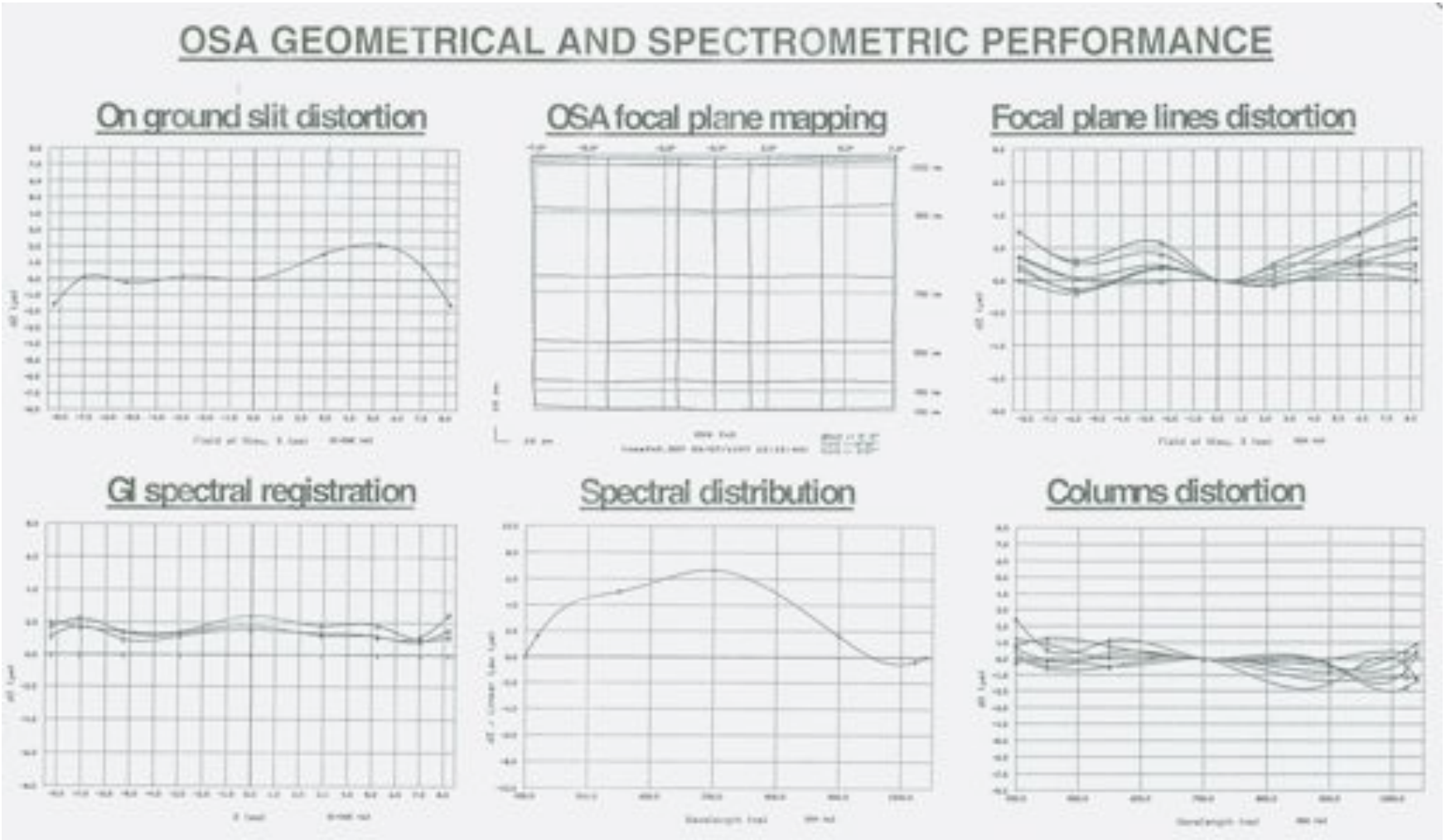
Order-1 grating efficiency



Order-2 grating efficiency

Orders +1, +2 and 0 are caught by light traps in the corrector block

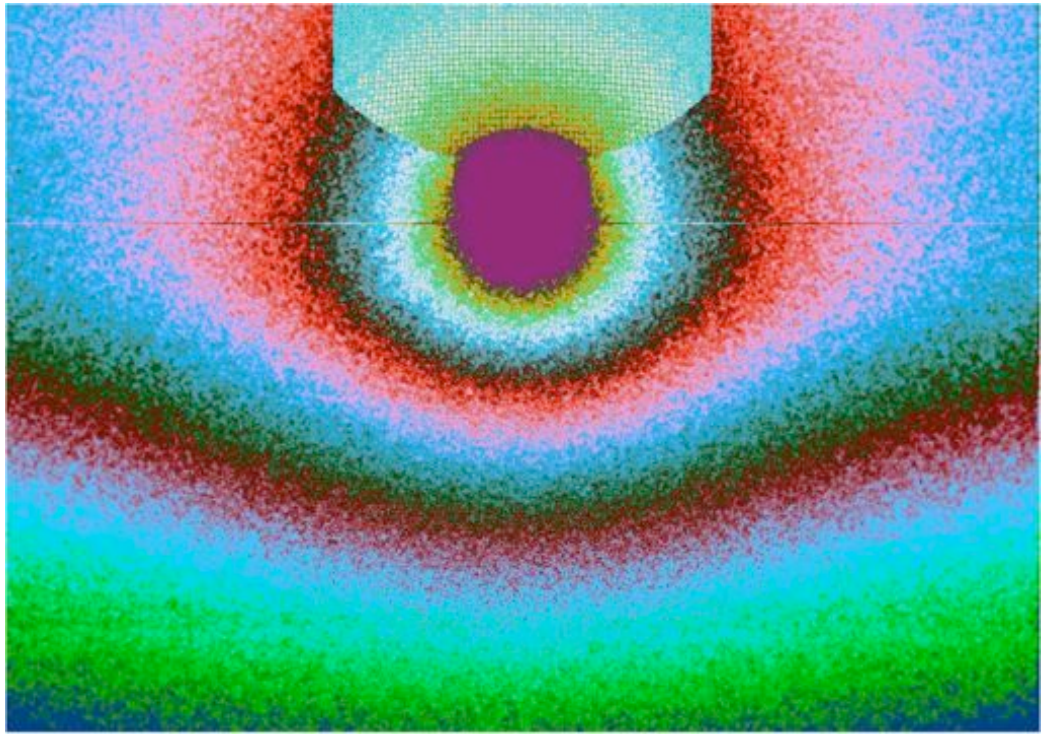
Optical Performances



X axis = field of view {-8, 8} mm Y-axis = range {-8, 8}μm

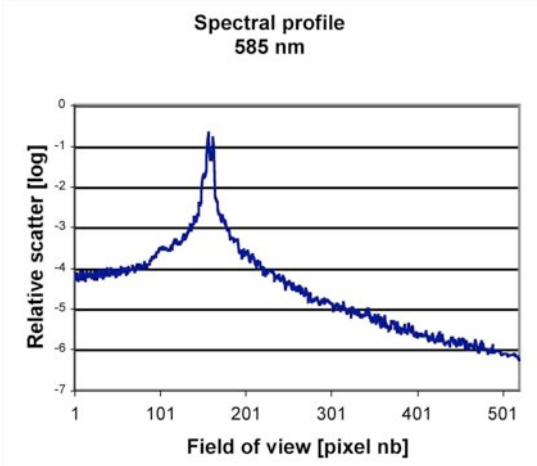
(pixel=22 μm / 1.25nm, FoV = 740 pix)

Straylight Characterisation

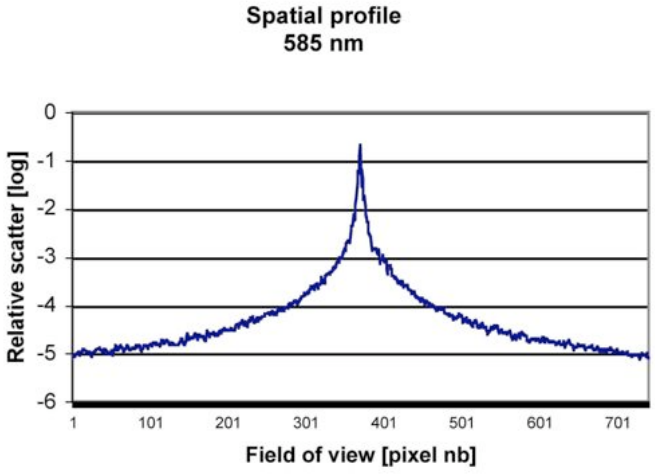


ASAP model result on axis for 585nm

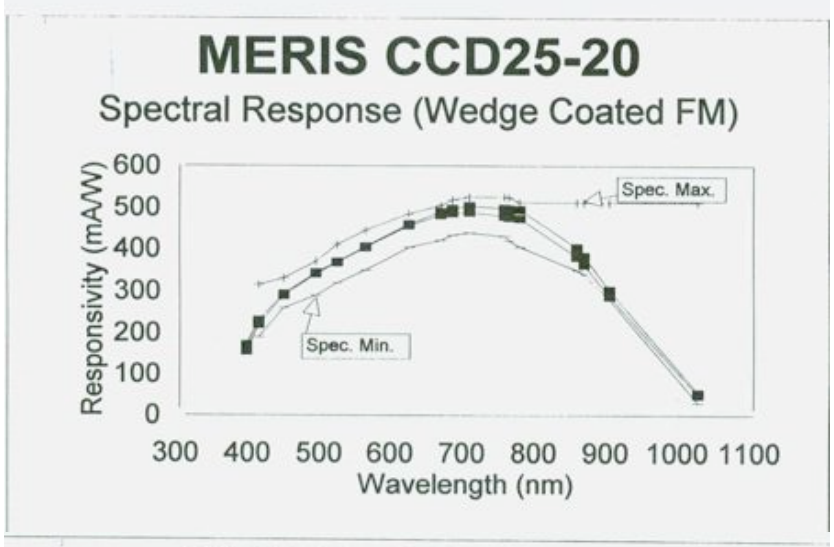
Total Integrated Scatter (TIS) measurements performed on all optical surfaces (and coatings) using "as built" witnesses.

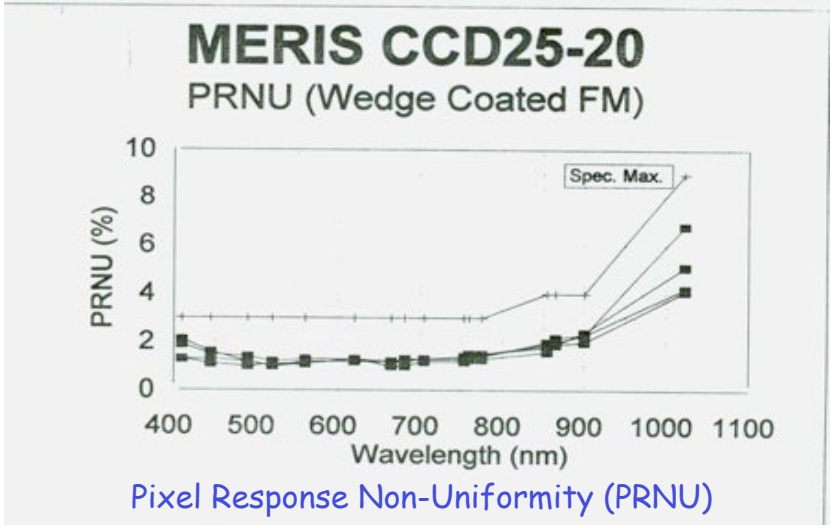


Centred Profiles

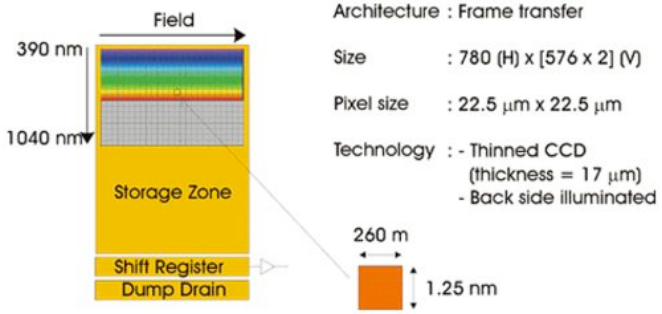


CCD Characteristics

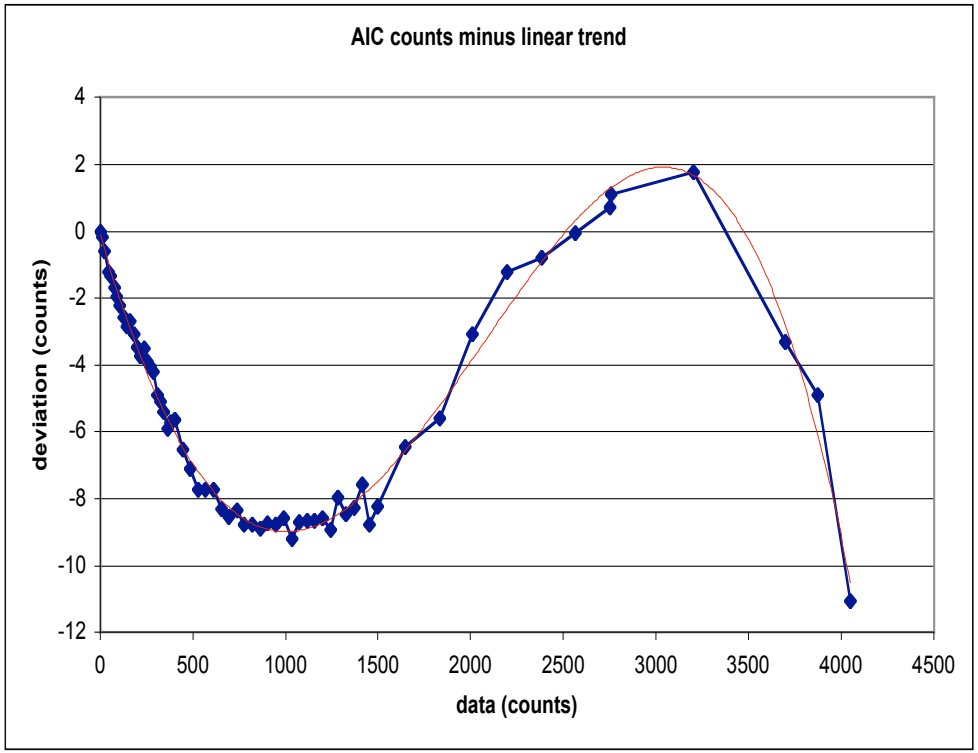




Pixel Response Non-Uniformity (PRNU)



Non-linearity

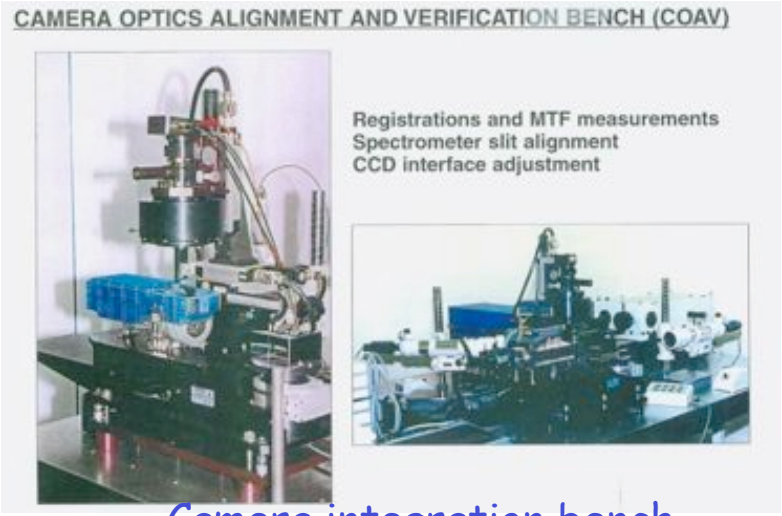


Non-linearity measured performed at:
•CCD level by varying integration time
•Analogue Imaging Chain level (above)
by varying distance to the light source

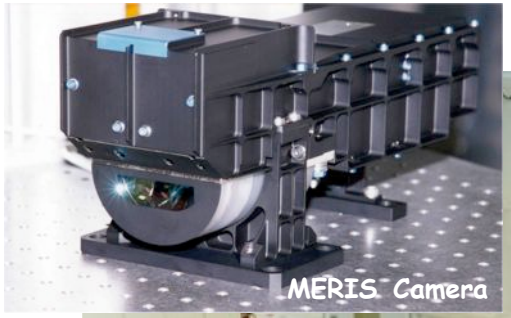
- Rms non-linearity < 0.1% of full range, increases to > 1% at low signal levels.
- Non-linearity primarily due to CCD output trans-impedance amplifier.
- Very low integral and differential non-linearity of the ADC
- Plot represents NL at CCD output (4096 counts = 1.5V full range.)

Camera Level Characterisation

Overview



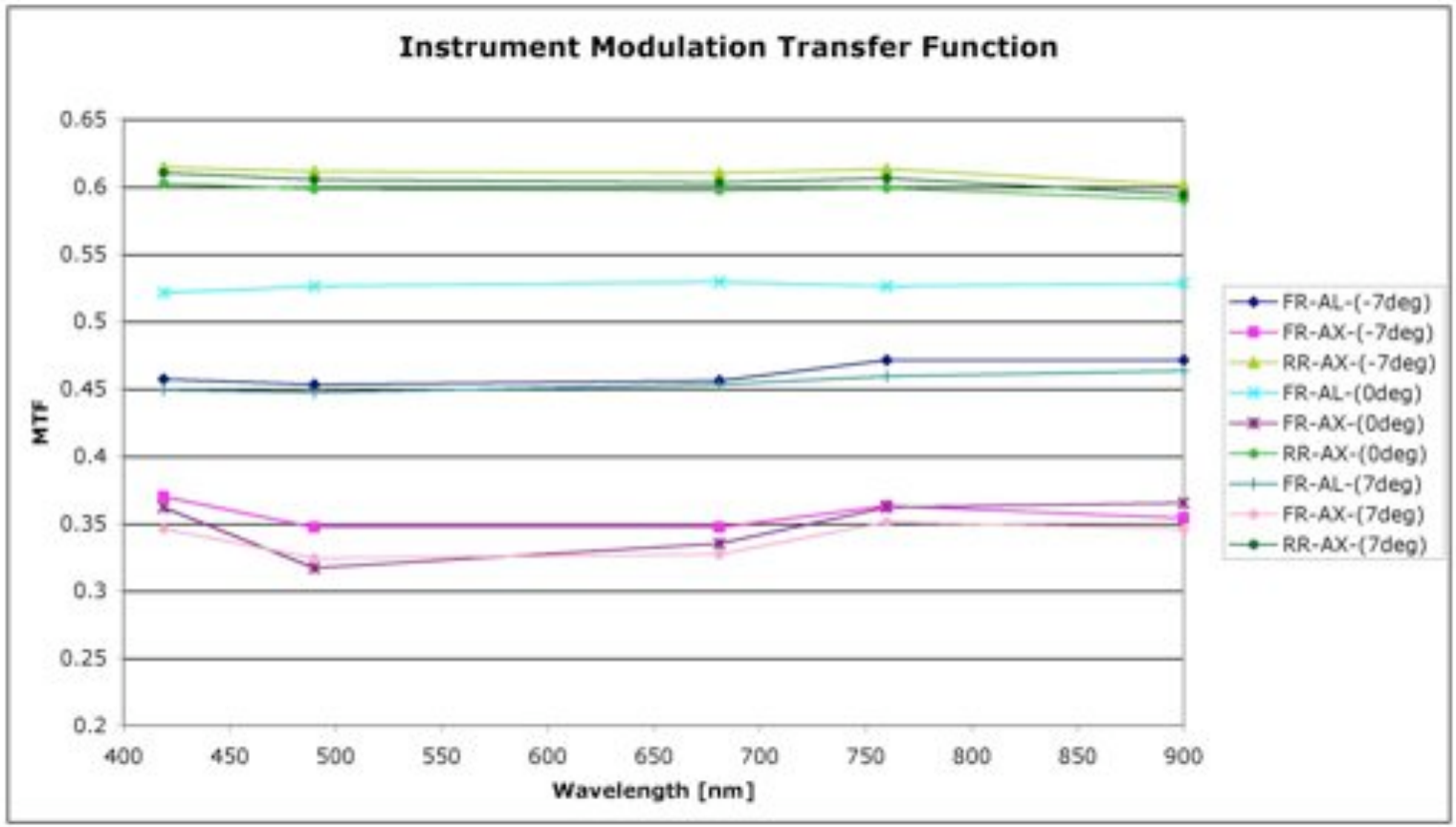
Camera integration bench



Camera performance test bench

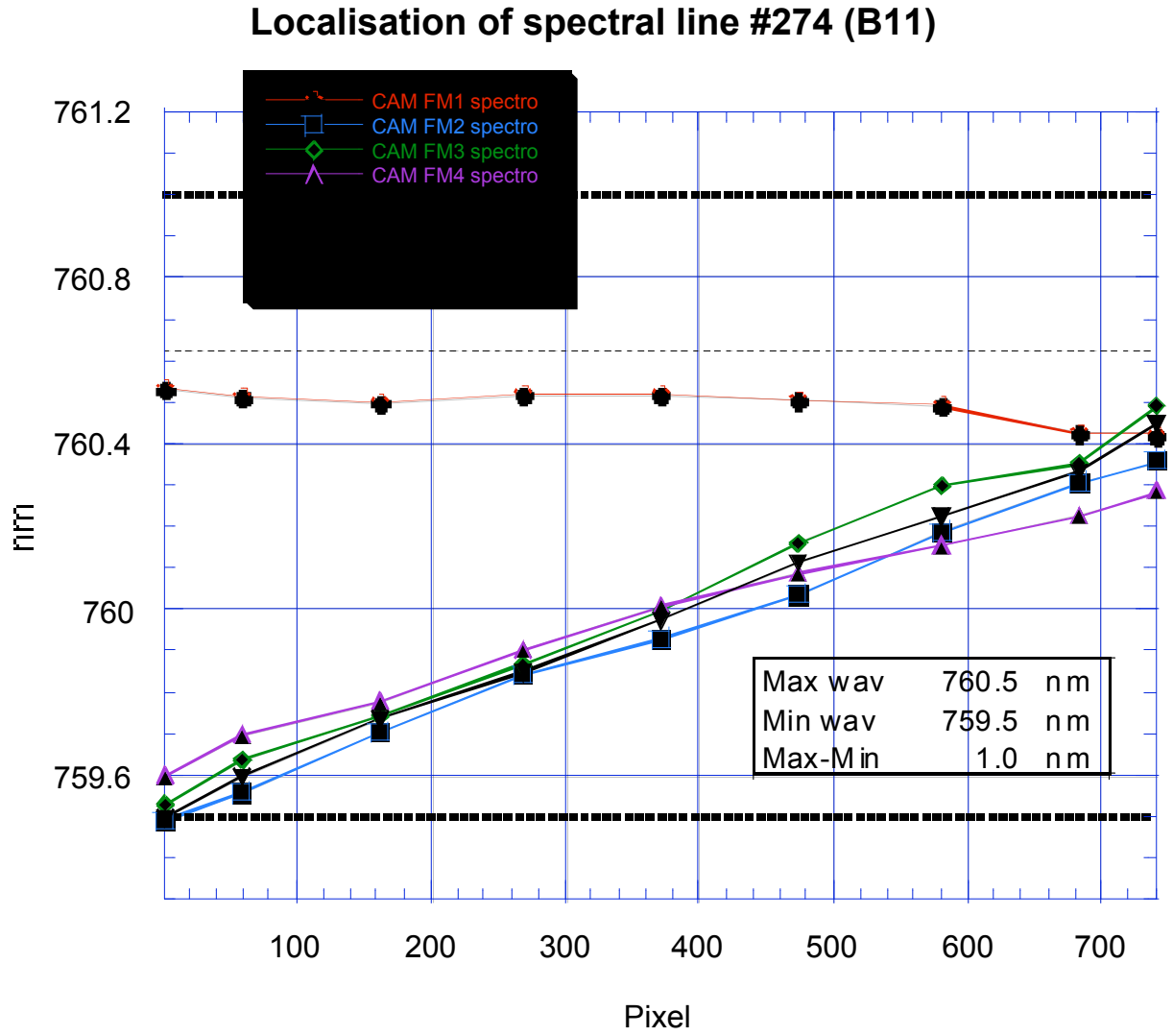
Camera Level Characterisation
(Thermal Vacuum)
- MTF
- Spectral Smile
- Spectral Frown

Modulation Transfer Function



MTF (22lp/mm) as a function of wavelength for:
Full resolution (FR=300m) Along track (AL) FoV [deg] [Fnyquist=1.542]
Full resolution (FR) Across track (AC) FoV [deg] [Fnyquist=1.496]
Reduced resolution (RR=1200m) Across track (AC) FoV [deg] [Fnyquist=0.374]

Spectral Smile @ O2A



Spectral Characteristics

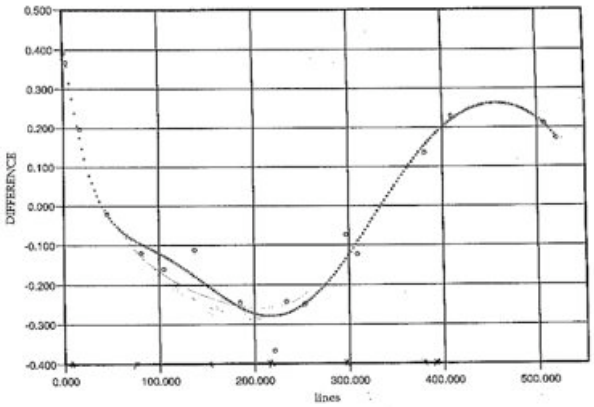


Figure 5 a : Camera 1. The mean difference between the central wavelength and the linear law is fitted as a function of line number.

Deviation from linear dispersion

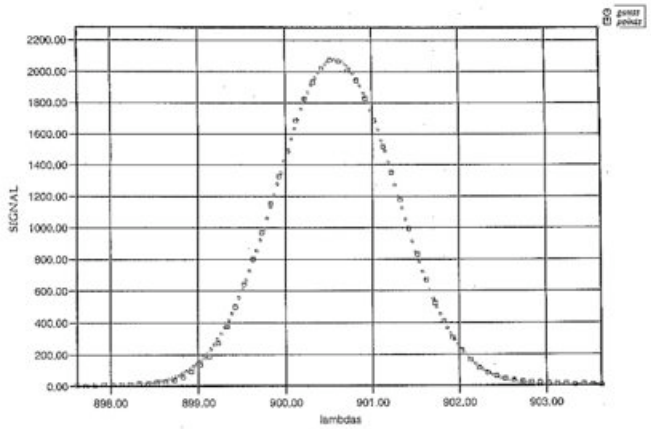
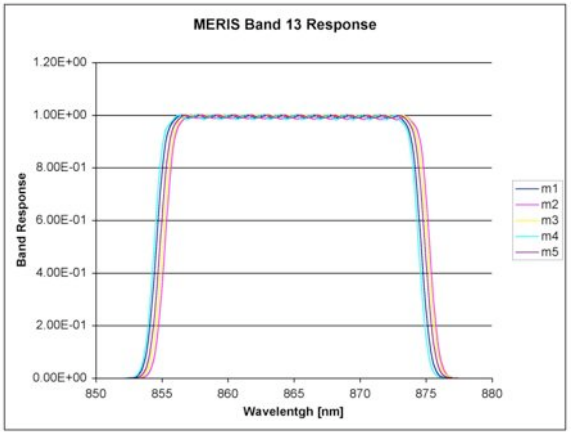
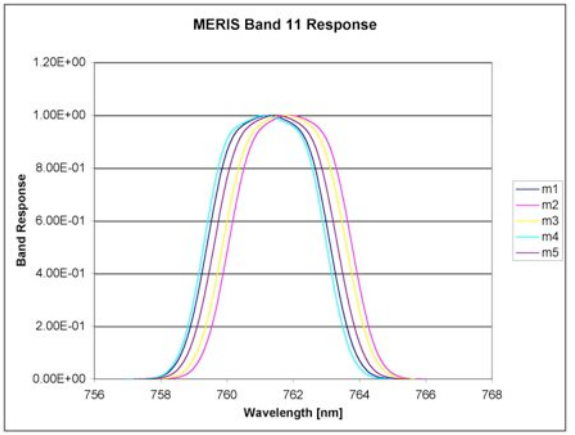


Figure 1a : Comparison between raw data and fit of instrument spectral response : An example of measurements without significant noise (camera 5, line 409, column 1).

Spectral pixel Line shape example and associated Gaussian model



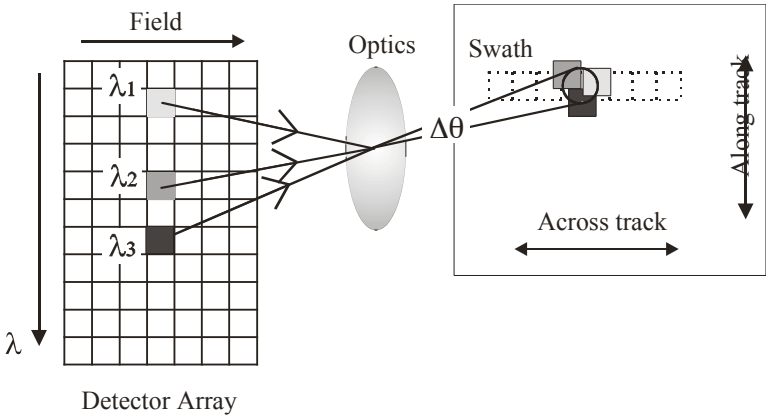
Modelled Band 13 Line shape
(16 spectral pixels)

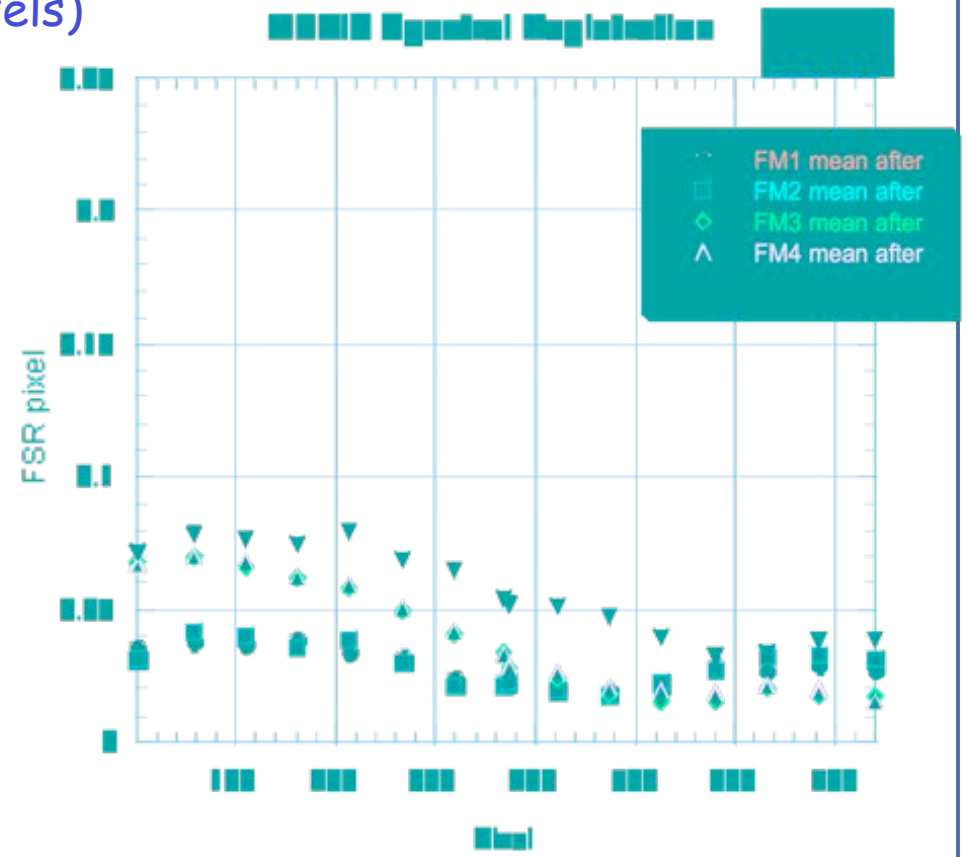


Modelled Band 11 Line shape
(2 spectral pixels)

Spectral Frown

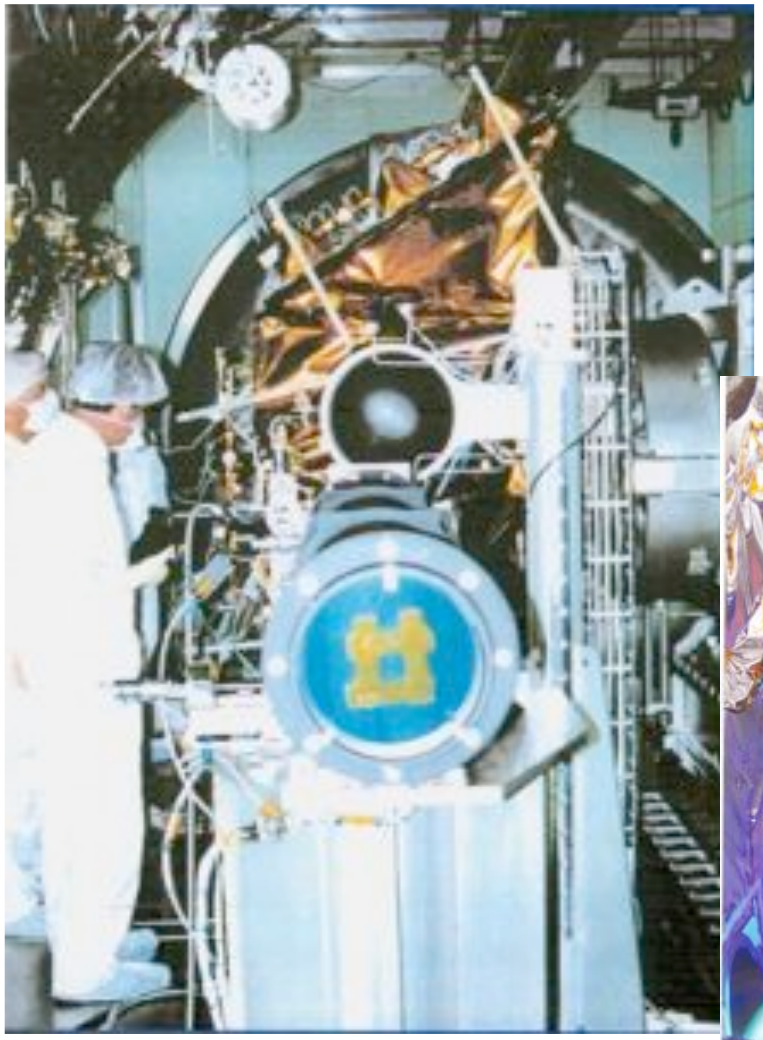
Spectral pixel band to band registration (in terms of 300m resolution pixels)



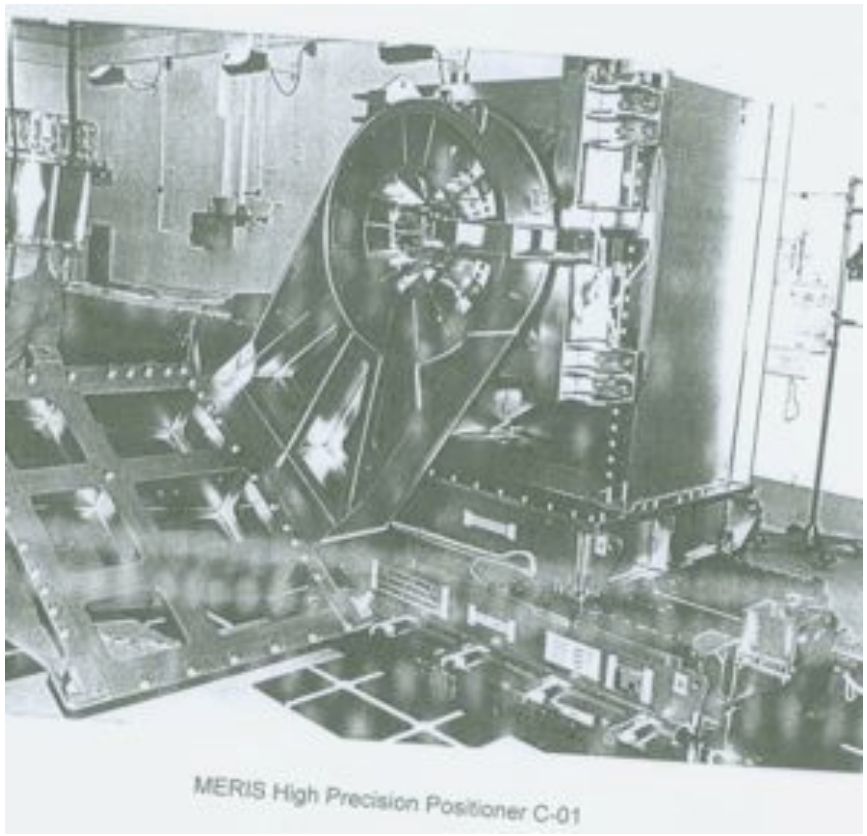


(*) average over all possible pairs of spectral bands

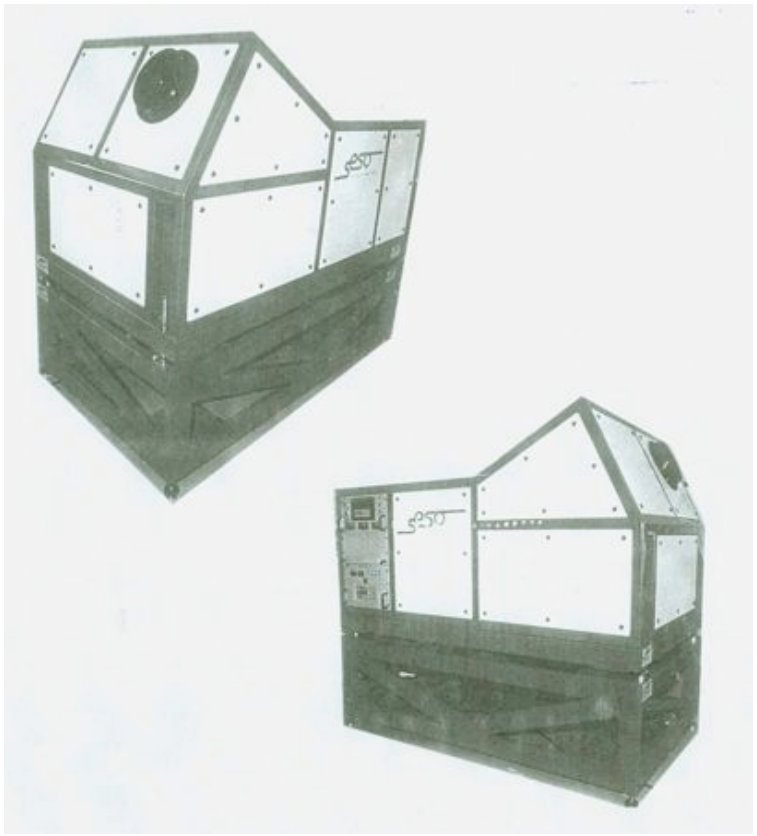
MERIS Level Characterisation



Ground Support Equipment

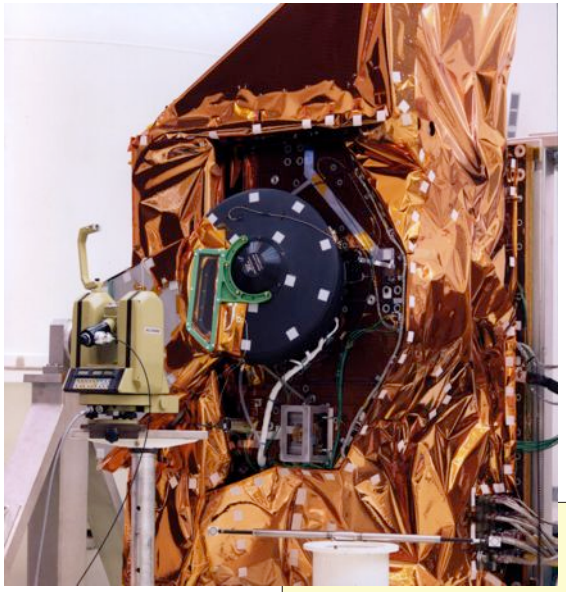


Precision Manipulator

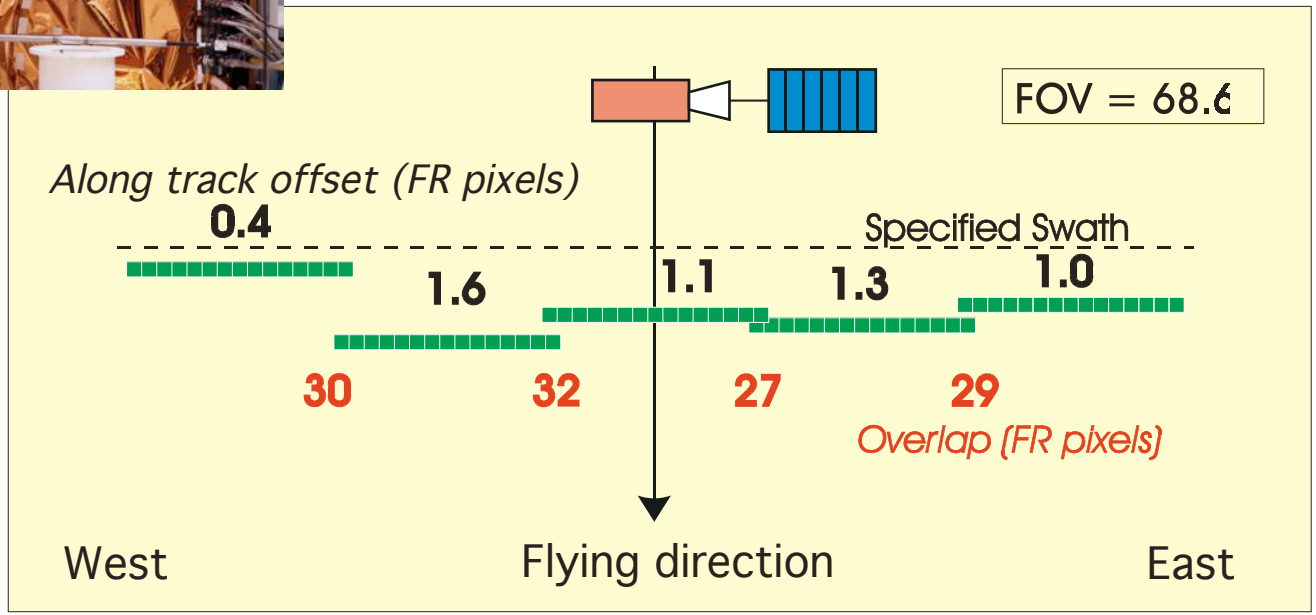


Solar Simulator

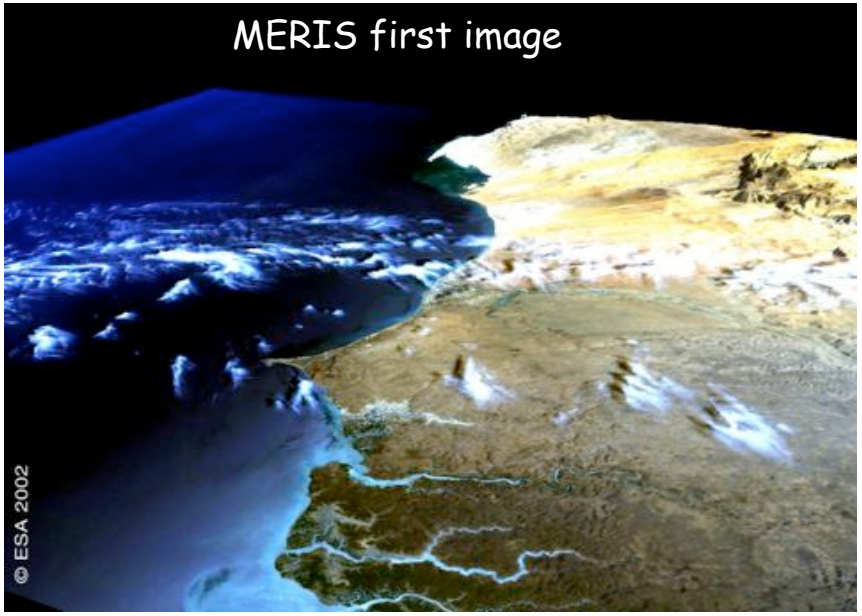
Pointing Characterisation



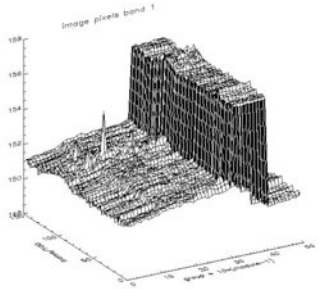
- Pointing Characterisation with Laser Theodolite



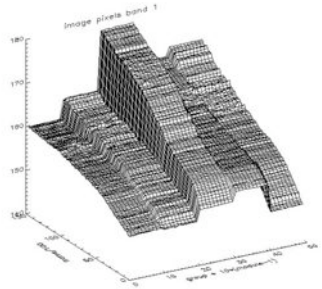
On-Orbit Characterisation



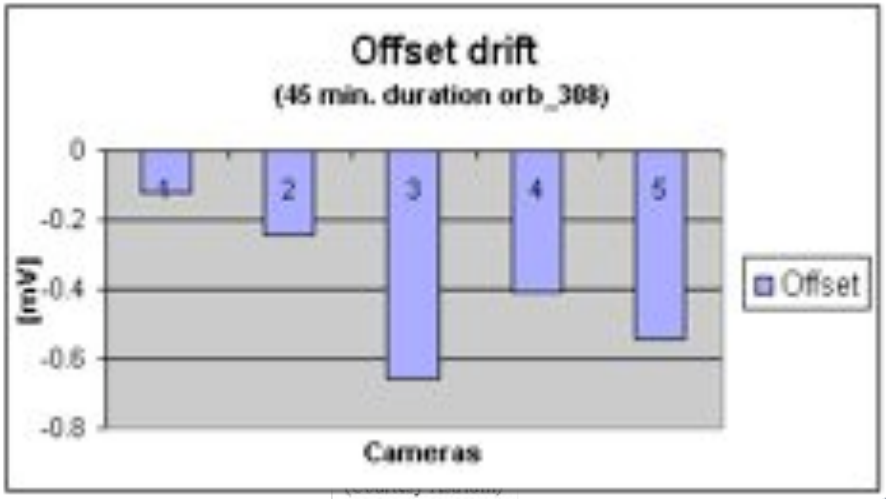
Dark Current characterisation, complete orbits with the shutter closed in Observation mode.



Orbit 292 Dark Current OCL ON



Orbit 293 Dark Current OCL OFF

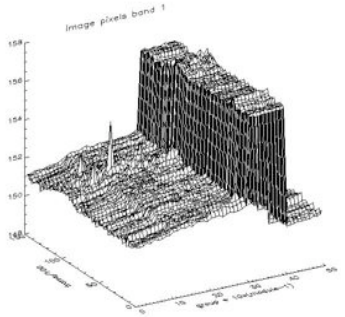


- CCD Temperature very stable
- VEU temperature drift 6 degrees

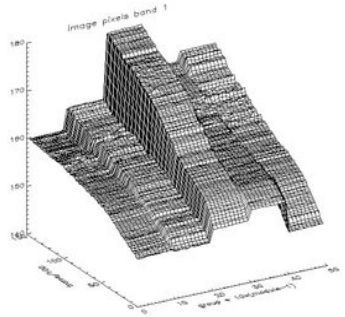
- Offset Control Loop converges well
- 0.6mV / 1.5 V Dynamic range

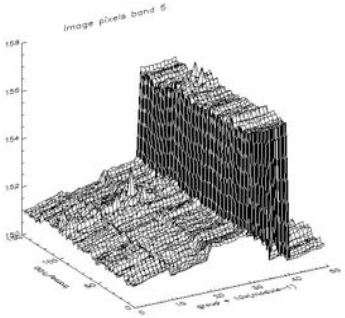
Dark Current characteristics

South Atlantic Anomaly

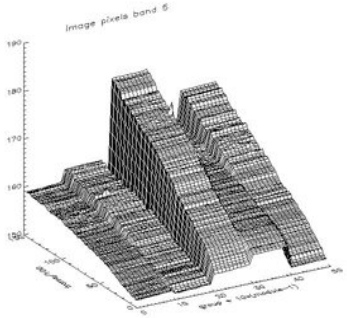


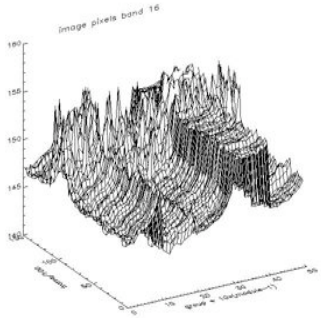
Band 1



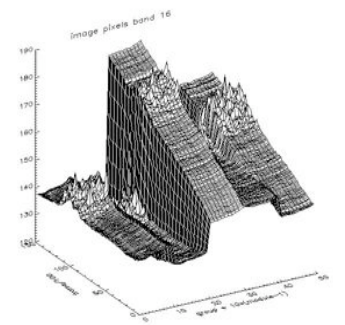


Band 5

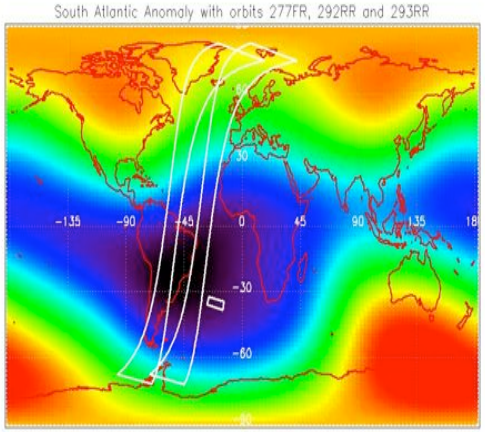




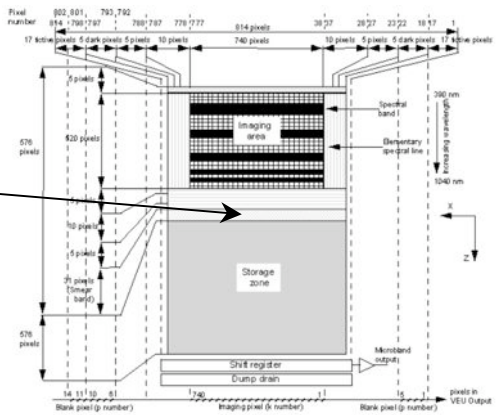
Smear Band



Spikes in the dark current when flying through the SAA, more important for the smear band.



Probably due to the secondary emission from the Alumium mask on the CCD, and the Gold coating on the window.

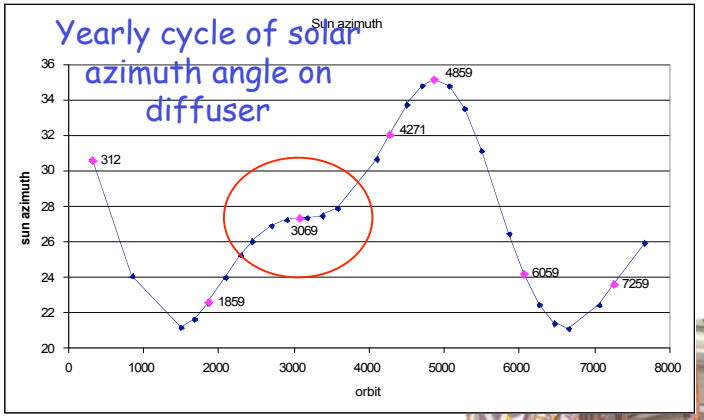


Orbit 292 Dark Current OCL ON

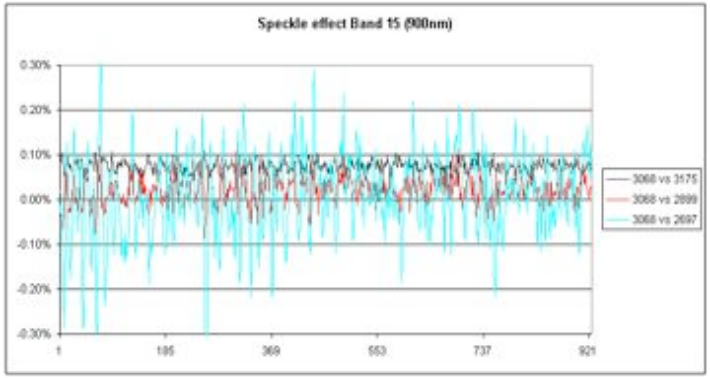
Orbit 293 Dark Current OCL OFF

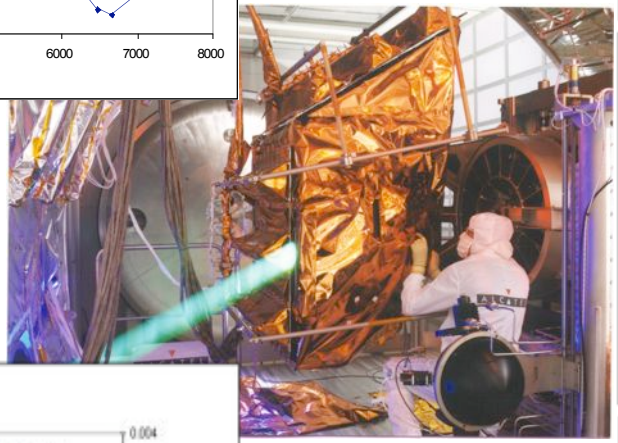
Diffuser "Speckle"

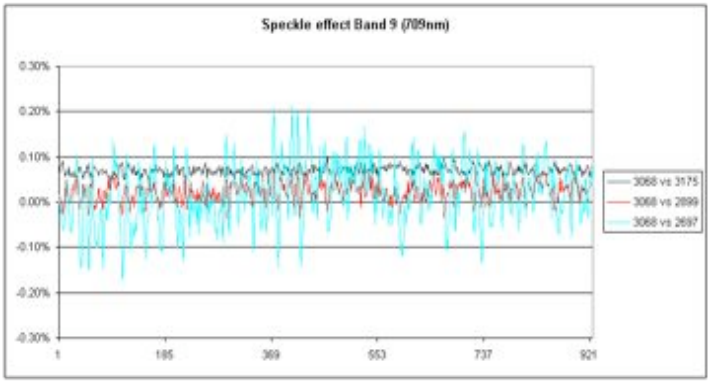
Across Track

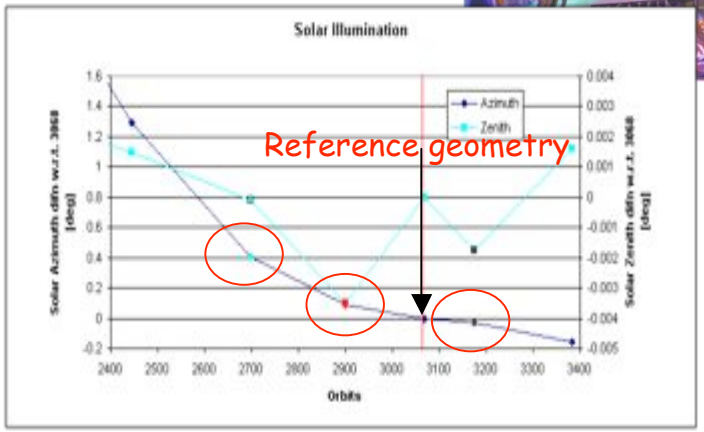


Speckle increases with increasing wavelength

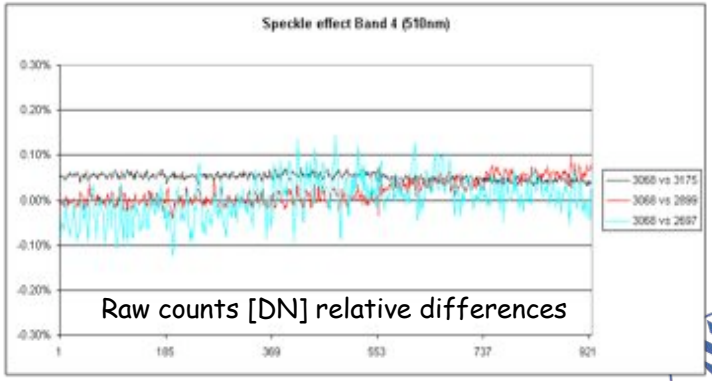






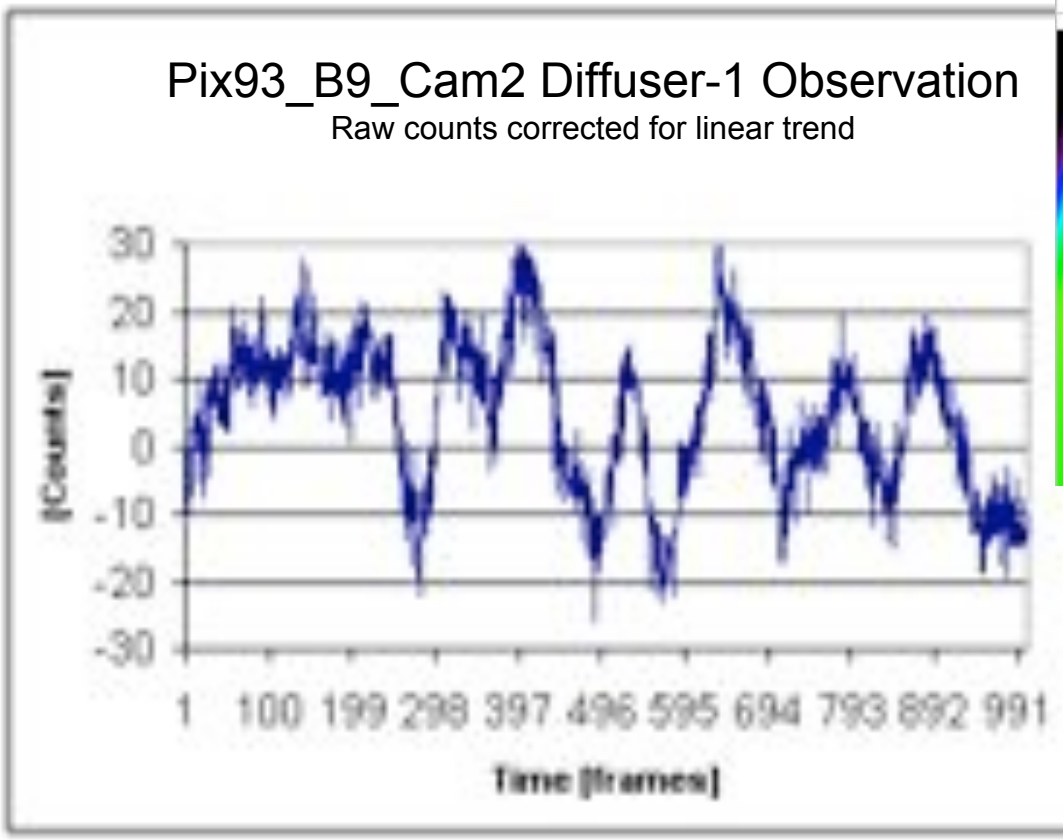


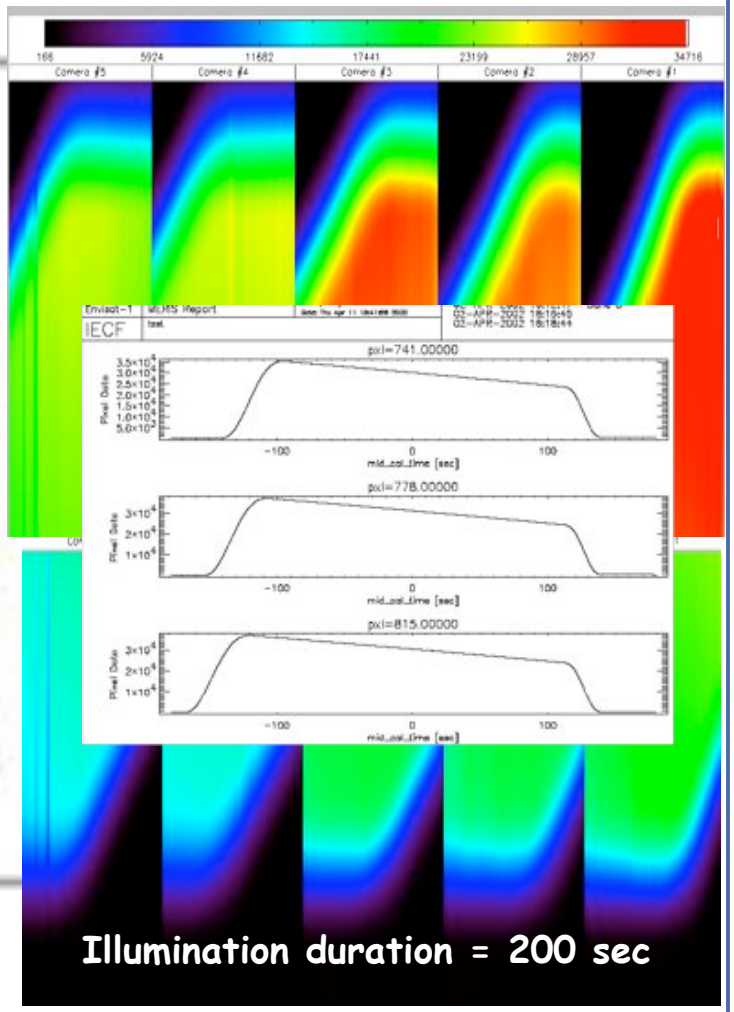
Speckle increases with increasing azimuth differences



Diffuser "Speckle"

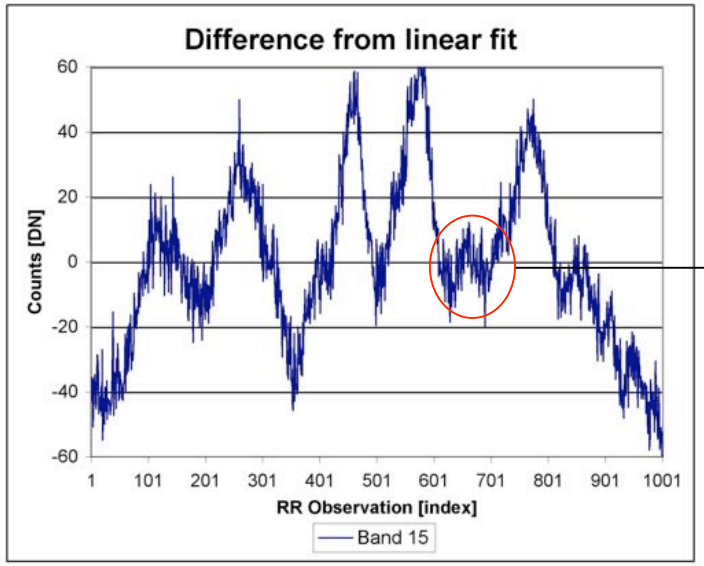
Along-Track

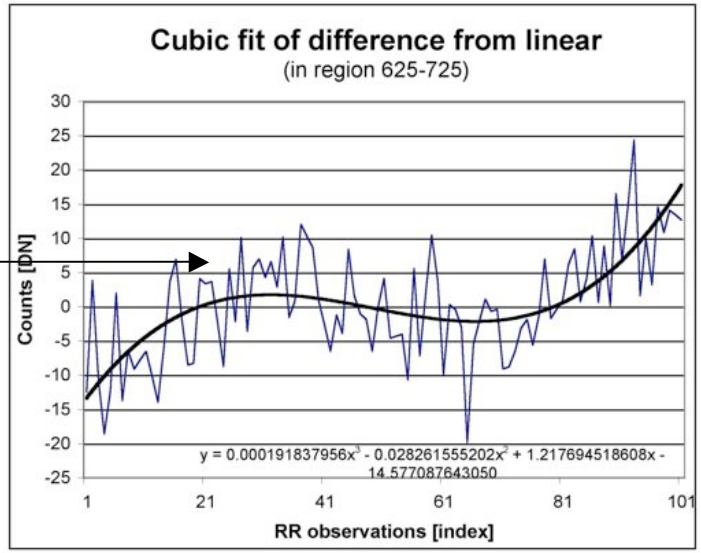


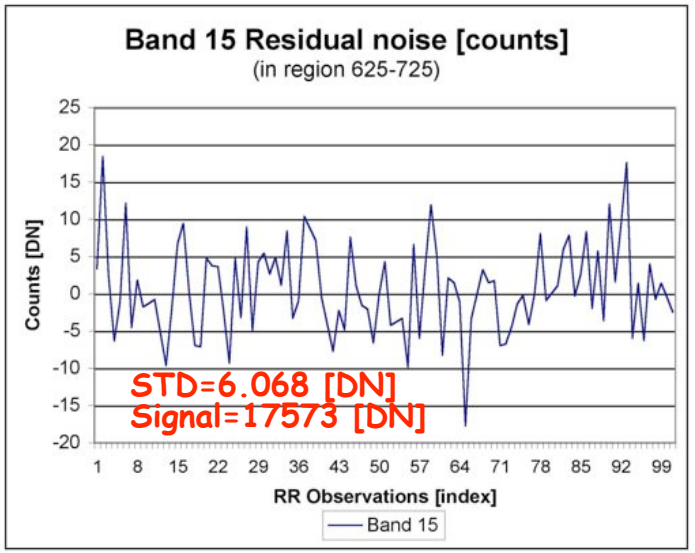


Diffuser "speckle" confirmed by TNO study
=> Present on all diffusers

SNR Computation







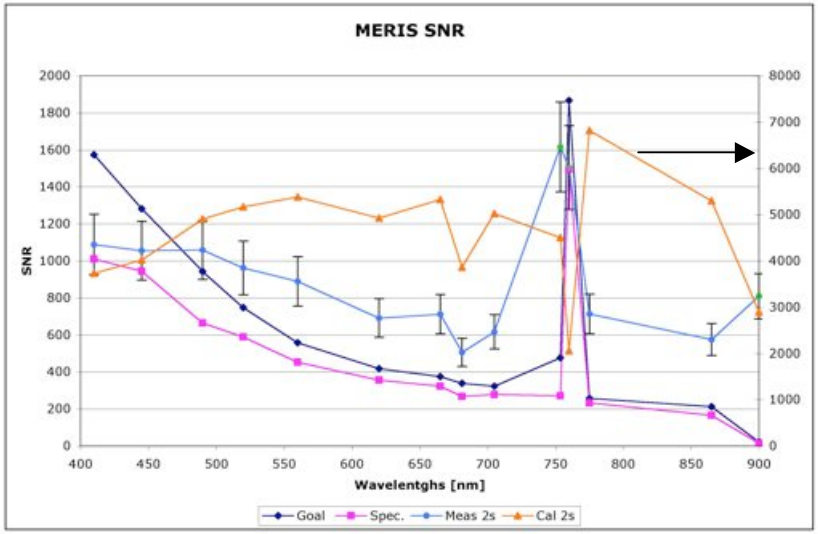
Methodology using diffuser observation :

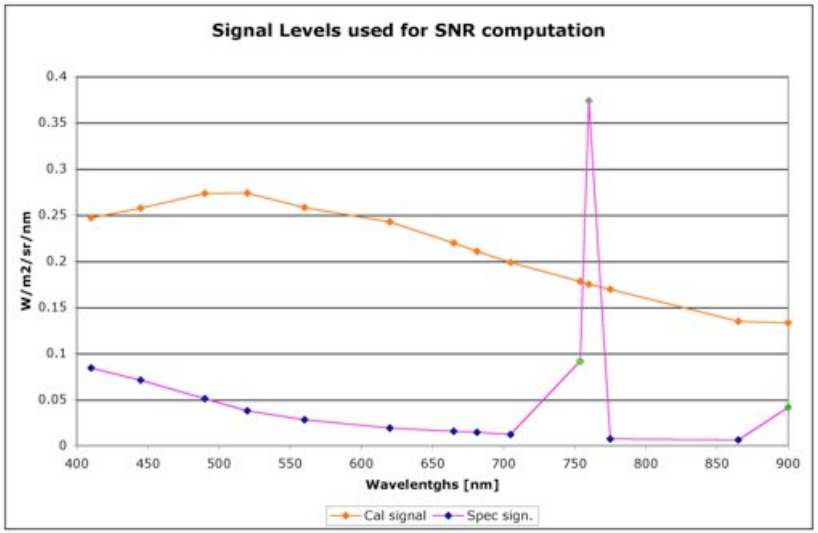
1. Difference from linear fit of Raw counts
2. Difference from cubic fit of selected region from 1.
3. Compute the standard deviation (1σ) of noise
4. Adjust the noise (2σ) to the specified signal level (Assuming shot noise limited)
5. Compute SNR

Assumptions:

The large modulations are "speckle" based only !

Signal to Noise Ratio





SNR	Goal	Spec.	Cal 2σ	Ocean 2σ	Meas 2σ	Cal signal	Ocean Sign.	Meas sign.
410	1574	1011	3730	1068	1089	0.2471	0.0810	0.0842
445	1282	945	4019	1048	1056	0.2573	0.0700	0.0710
490	943	664	4905	1080	1059	0.2731	0.0530	0.0509
520	748	589	5171	1051	962	0.2737	0.0453	0.0379
560	557	452	5378	938	889	0.2579	0.0314	0.0282
620	418	355	4927	714	692	0.2423	0.0204	0.0191
665	376	322	5325	708	712	0.2195	0.0155	0.0157
681.25	339	268	3859	500	506	0.2105	0.0141	0.0145
705	323	278	5021	616	617	0.1985	0.0119	0.0120
753.75	478	270	4507	522	1615	0.1778	0.0095	0.0914
760	1868	1494	2059	210	1504	0.1749	0.0073	0.3735
775	258	233	6820	766	713	0.1692	0.0085	0.0074
865	213	165	5296	524	575	0.1347	0.0053	0.0064
900	22	15	2896	259	316	0.1329	0.0042	0.0415

SNR Specifications (Goal, Spec), Estimated SNR at three signal levels (Cal, Ocean, Meas) [W/m2/sr/nm]. Note that the specifications include two "Land" bands and one "cloud" bands