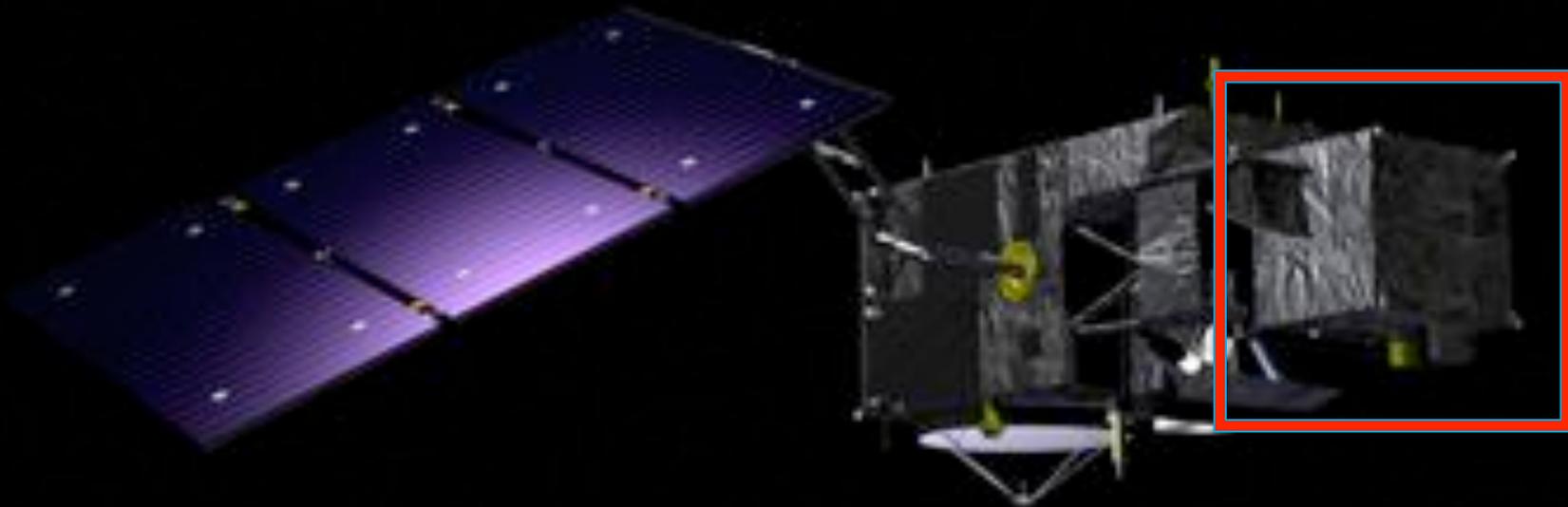


# Sentinel-3 OLCI: Status

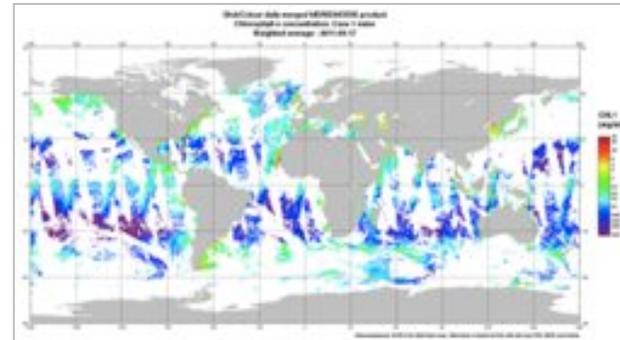


Jens Nieke, F. Borde, C. Mavrocordatos

# Outline



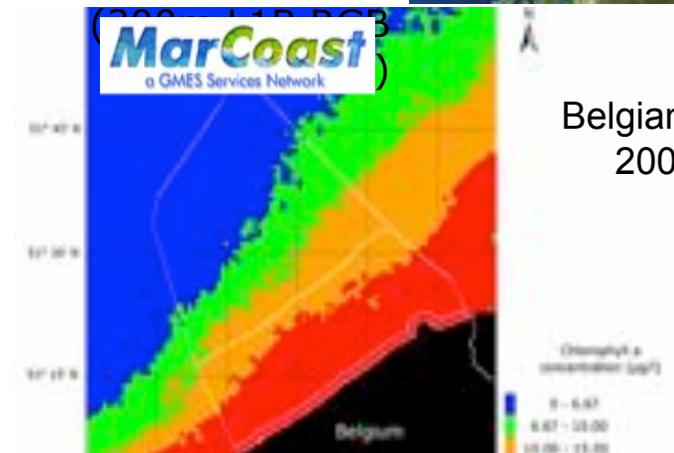
Chl-a ENVISAT  
MERIS, 17-18  
March 2011



- **Background**
- **OLCI development status**
- **Assembly, Testing & Integration (AIT)**
- **Camera EM and FM test results**
- **OLCI core products**
- **Summary**

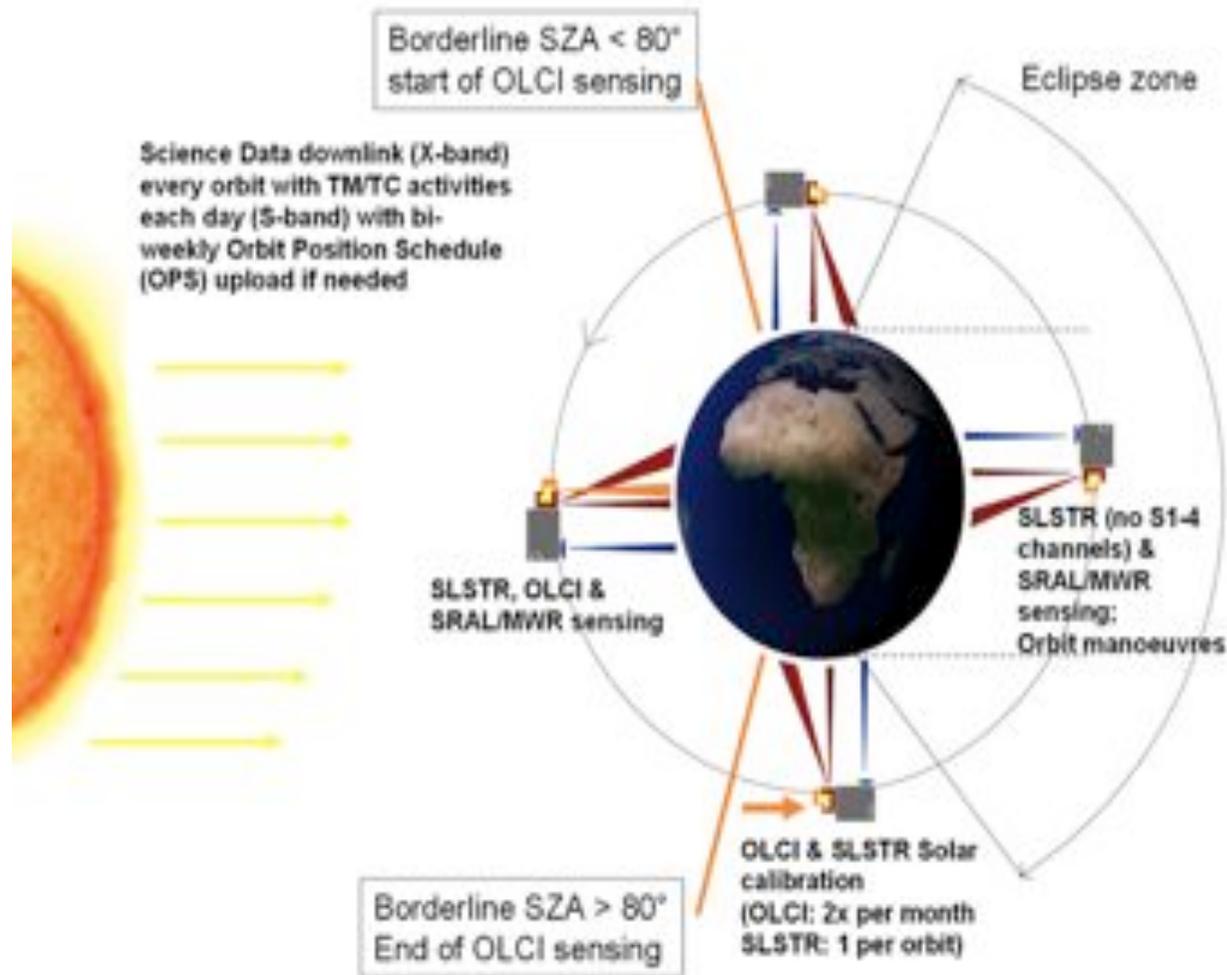


ENVISAT MERIS Algae  
Bloom



L3 products:  
Belgian CHLa 90% Mar-Oct  
2005-2010 (Ruddick)

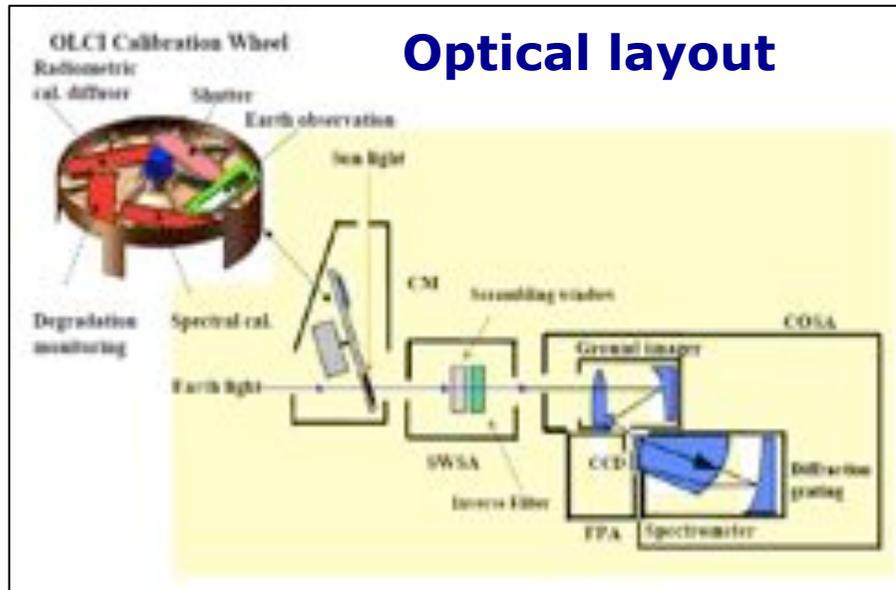
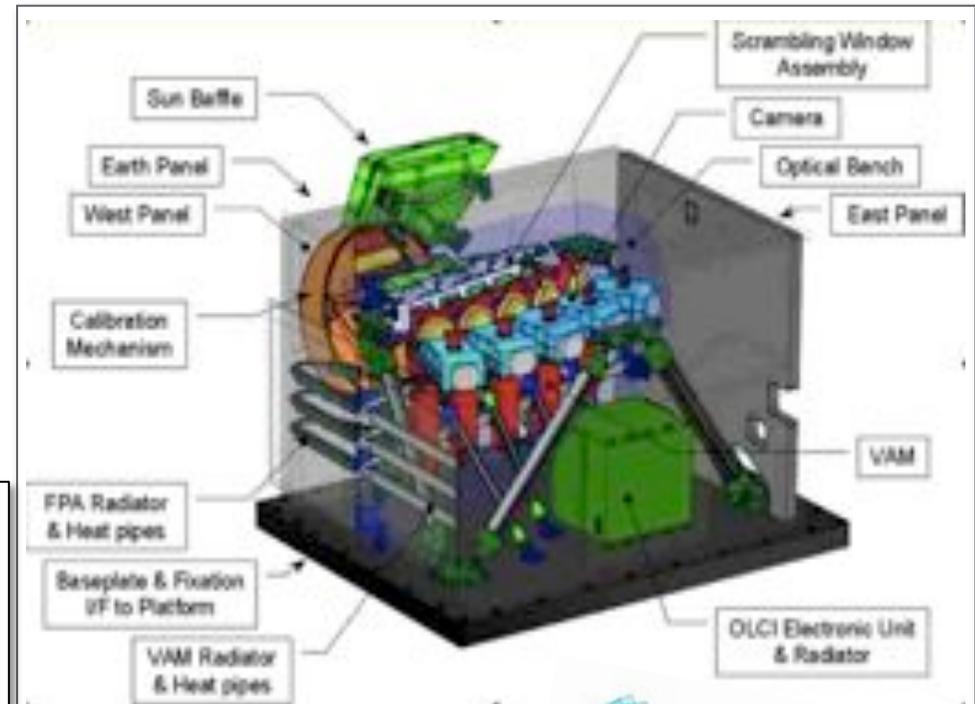
# Sentinel-3 operations and acquisitions for each orbit



# S3 OLCI: Technical details

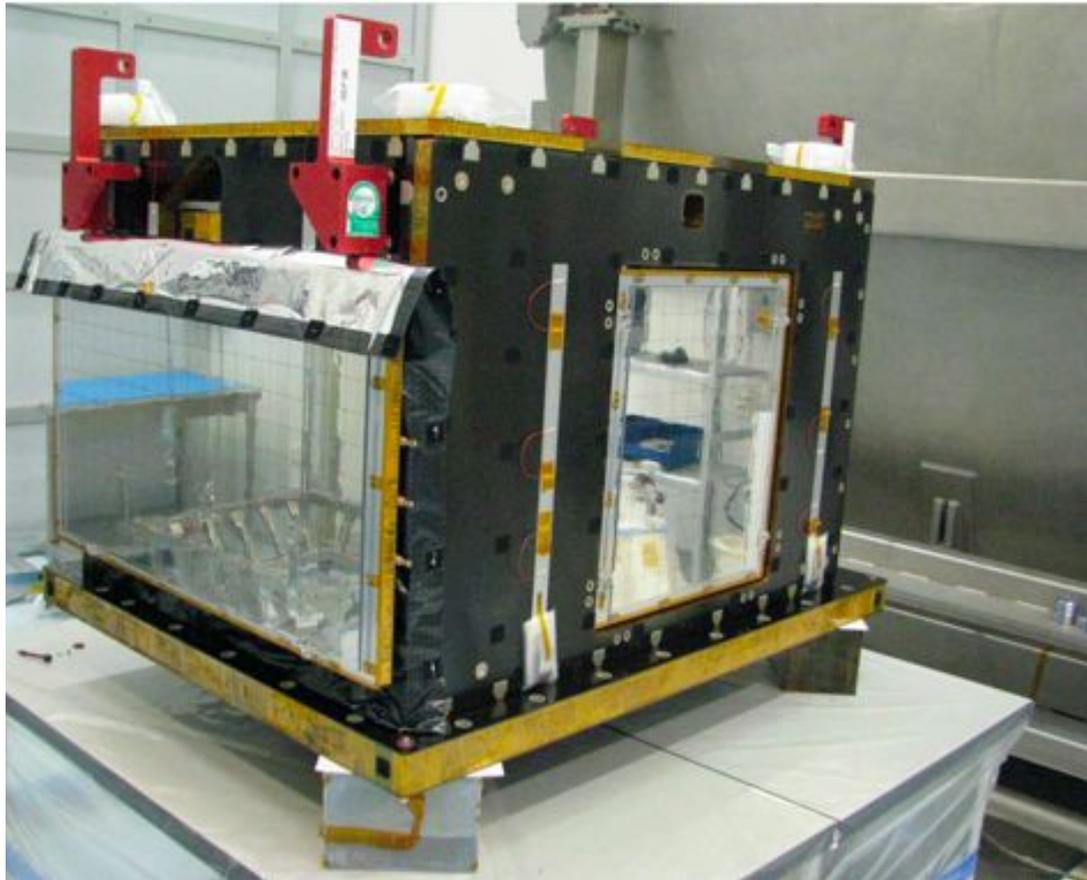
## Basic configuration similar to MERIS:

- 5 Camera Optical Sub Assemblies (COSA),
  - 5 Focal Plane Assemblies (FPA),
  - 5 Video Acquisition Modules (VAM),
- 1 Scrambling Window Assembly (SWA),
- 1 OLCI Electronic Unit (OEU) managing all the instrument functions,
- 1 calibration assembly allowing radiometric and spectral calibration.



# OLCI Structure

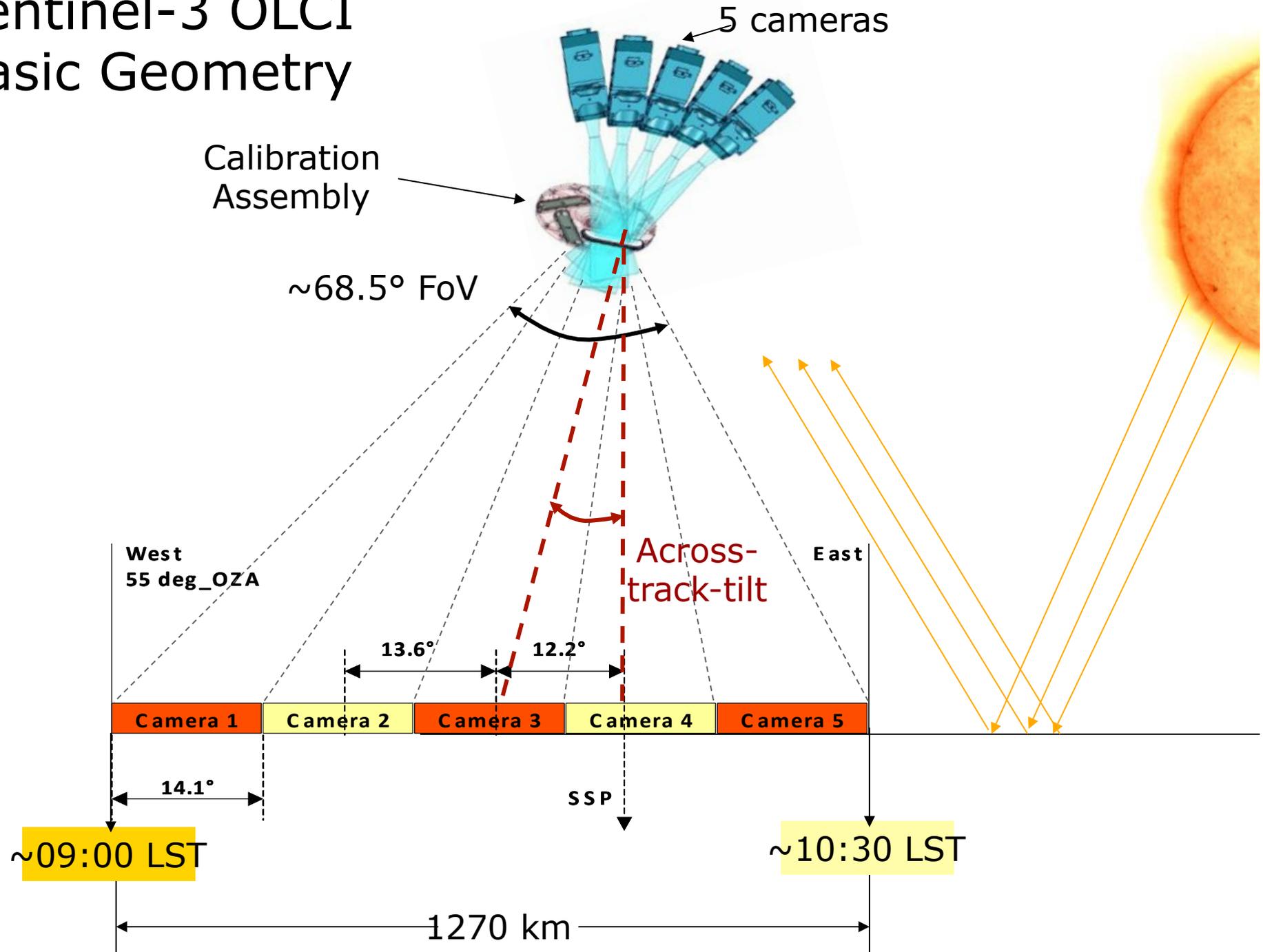
OLCI structure: side panels fit check



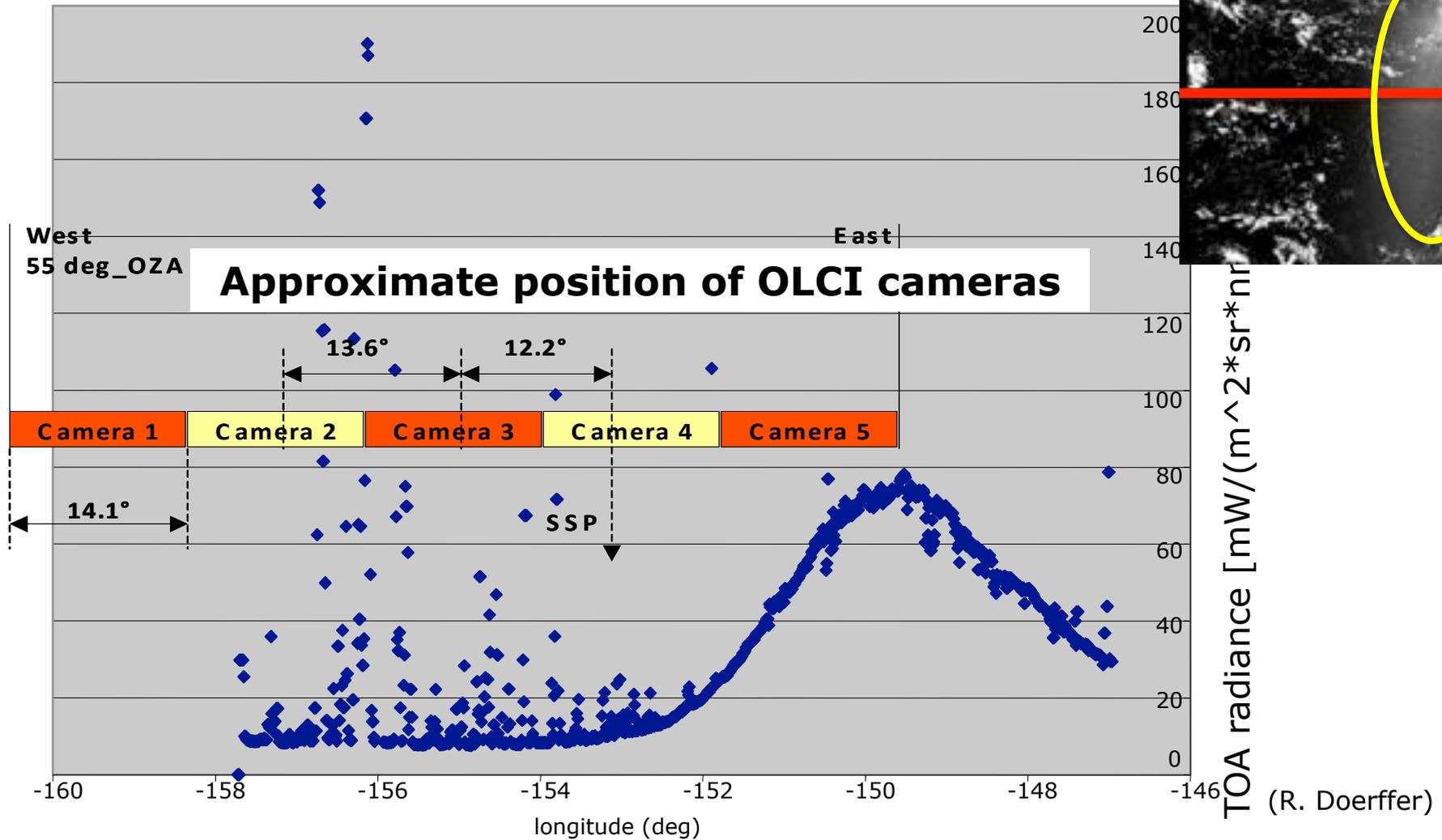
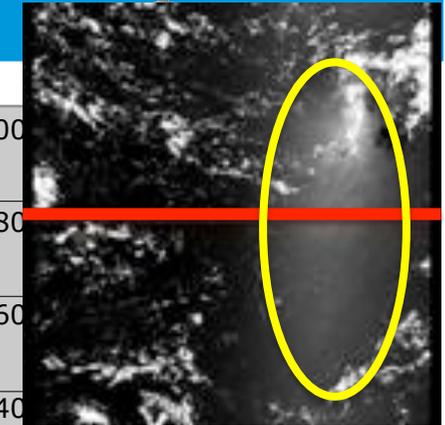
OLCI structure: Camera bench (top), baseplate (bottom) and VAM bench (vertical)



# Sentinel-3 OLCI Basic Geometry



# Transect showing MERIS sunglint MERIS band 9 (708 nm) Hawaii



# OLCI: Ocean and Land Colour Instrument comparison to MERIS



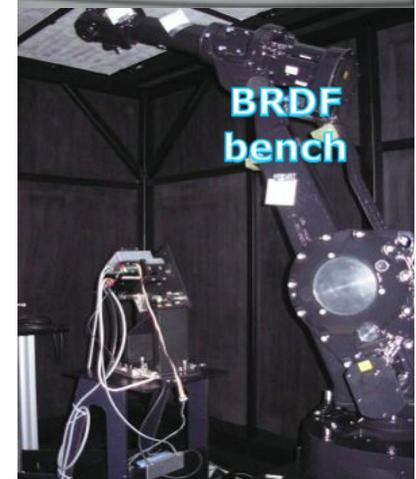
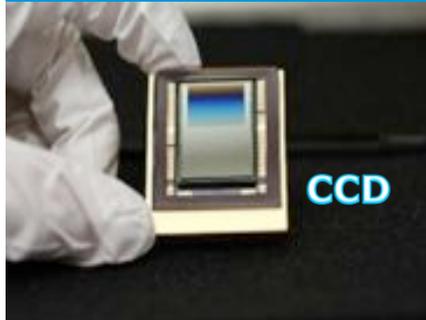
Pushbroom Imaging Spectrometer (VIS-NIR) – similar to MERIS

## Key Improvements/Features:

- More spectral bands (from 15 to 21): 400-1020 nm
- Broader swath: 1270 km
- Reduced sun glint by camera tilt in west direction (12.20°)
- Absolute (relative) accuracy of 2% ( relative 0.5%)
- Polarisation sensitivity < 1%
- Full res. 300m acquired systematically for land & ocean
- Reduced res. 1200m binned on ground (L1b)
- Improved characterization, e.g. straylight, camera boundary characterization
- Ocean coverage < 4 days, (< 2 days, 2 satellites)
- Timeliness: 3 hours NRT Level 2 product
- 100% overlap with SLSTR

MERIS Bands	$\lambda$ center	Width
Yellow substance/detrital pigments	412.5	10
Chl.. Abs. Max	442.5	10
Chl & other pigments	490	10
Susp. Sediments, red tide	510	10
Chl. Abs. Min	560	10
Suspended sediment	620	10
Chl. Abs, Chl. fluorescence	665	10
Chl. fluorescence peak	681.25	7.5
Chl. fluorescence ref., Atm. Corr.	708.75	10
Vegetation, clouds	753.75	7.5
O <sub>2</sub> R-branch abs.	761.25	2.5
O <sub>2</sub> P-branch abs.	778.75	15
Atm corr	865	20
Vegetation, H <sub>2</sub> O vap. Ref.	885	10
<b>New OLCI bands</b>	<b><math>\lambda</math> center</b>	<b>Width</b>
Aerosol, in-water property	400	15
Fluorescence retrieval	673.75	7.5
Atmospheric parameter	764.375	3.75
Cloud top pressure	767.5	2.5
Atmos./aerosol correction	940	20
Atmos./aerosol correction	1020	40

# S3A OLCI development status (Sep-2013)



## Instrument CDR: Nov-2011.

For the OLCI subsystems, all CDR are closed, EM tested and most of PFM HW is delivered:

- **Camera Optical Sub-Assembly (COSA):** all FM Cameras successfully delivered.
  - **Calibration Mechanism (CM):** PFM with characterized FM diffusers delivered.
  - **Scrambling Window Assembly (SWA):** SWU GSE and PFM delivered.
- **Charge Coupled Devices (CCDs):** all CCDs for S3A and S3B delivered.
  - **Video Acquisition Module (VAM) and Focal Plane Assembly (FPA):** FPA PFM/FM2/3/4/5 and VAM PFM and FM2 delivered and integrated in cameras.
  - **OLCI Electronics Unit (OEU):** EM integrated in the OLCI EM instrument, PFM delivery in preparation.
- **PFM Instrument** Integration has started

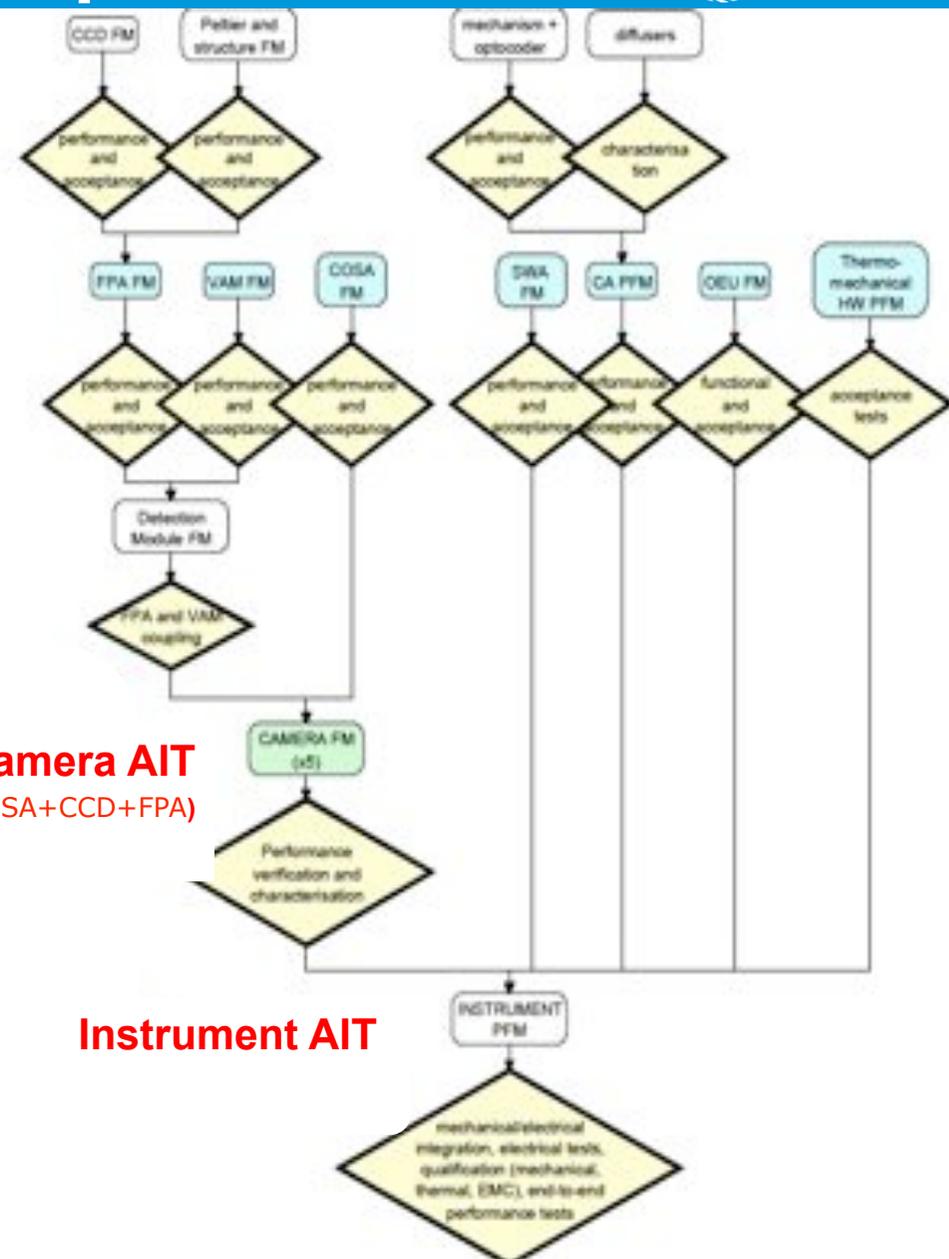
OLCI Status

26 Nov 2013 | ESRIN

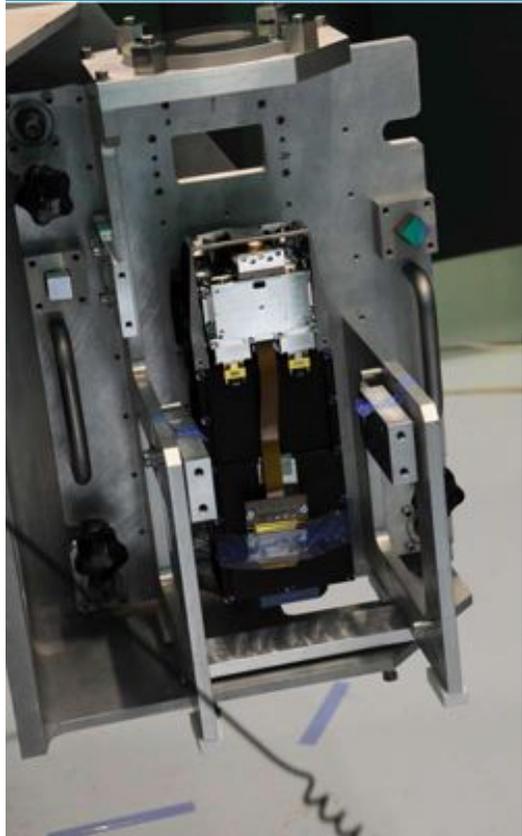
# Assembly, Testing and Integration (AIT) Sequence



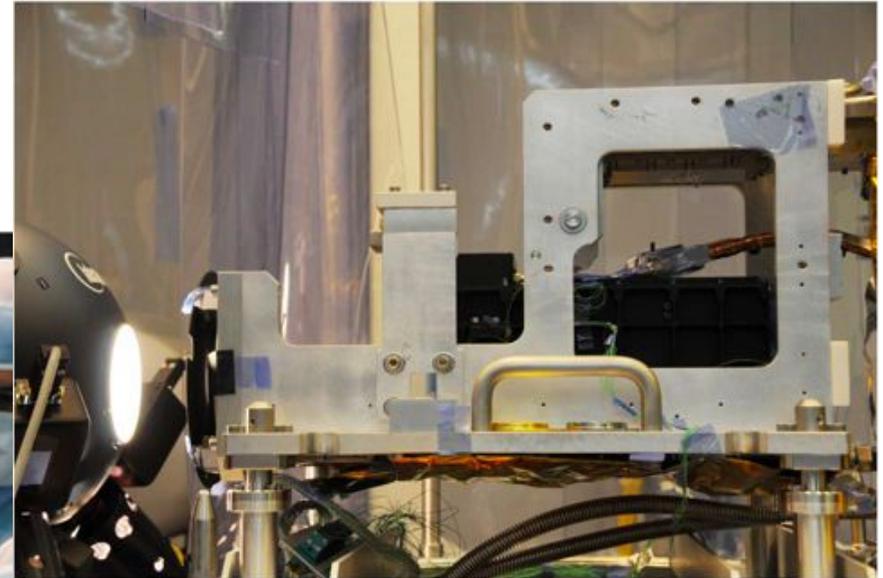
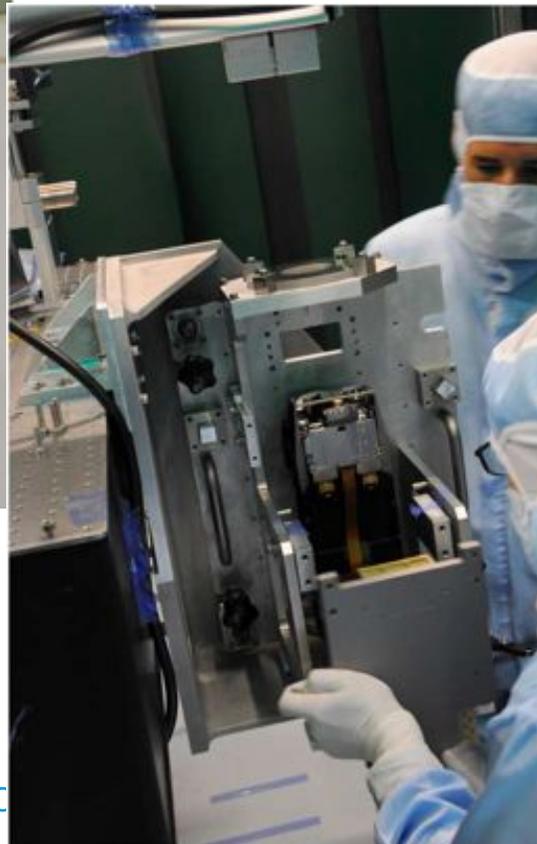
- AIT for 5 cameras completed
  - Camera Integration in OLCI-A structure started,
  - Calibration mechanism has been characterised and delivered, ready for integration,
  - Instrument delivery to satellite level planned end of this year.
- The integration of 5 cameras in the PFM instrument has started.



# OLCI Camera AIT

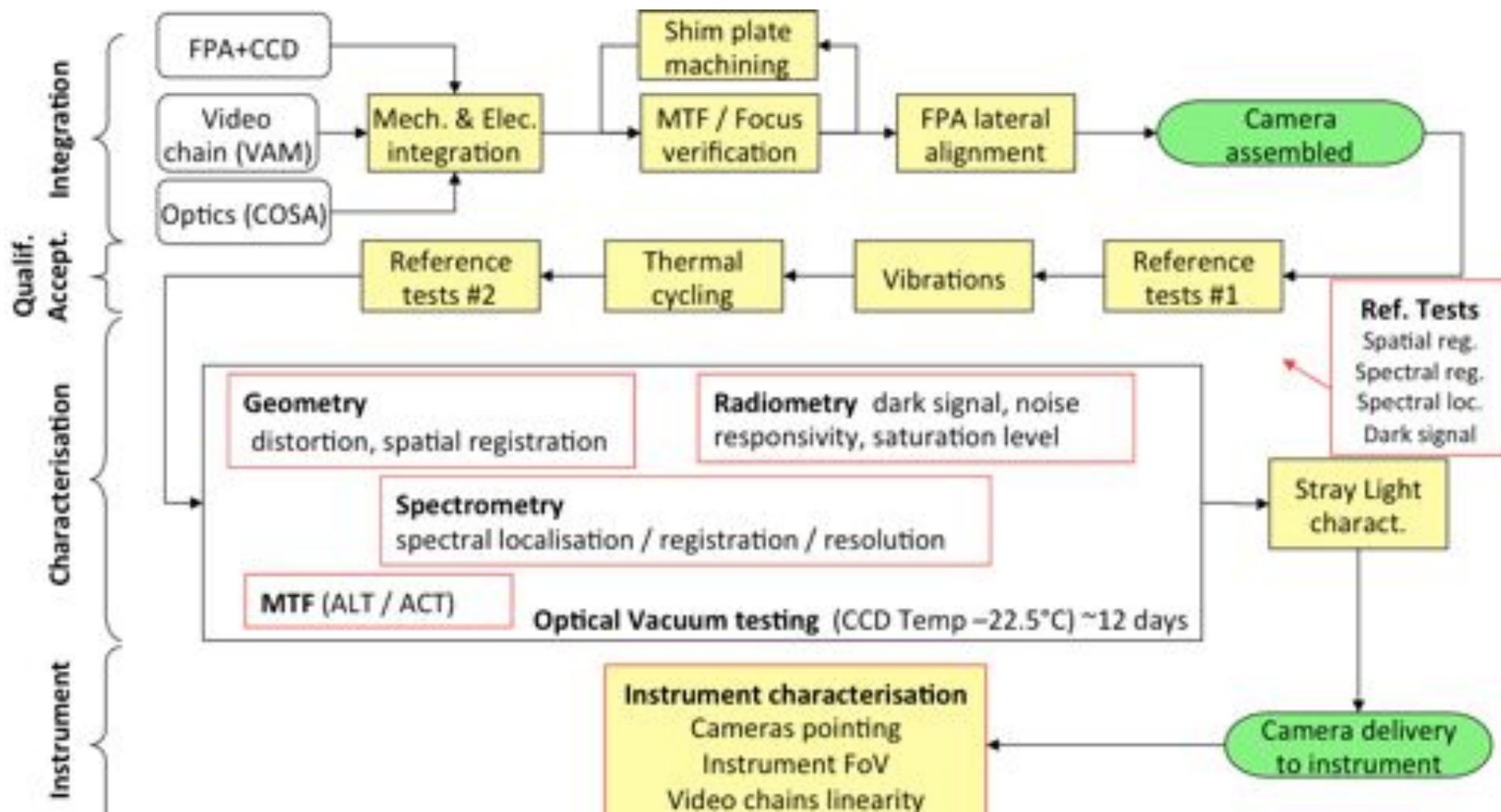


Camera mounted on the test bench (top) and with VAM (left)



Camera under test

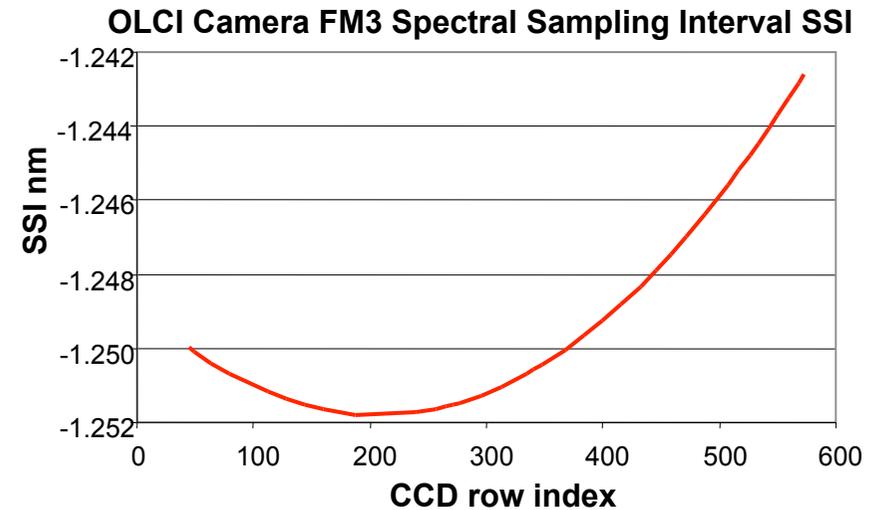
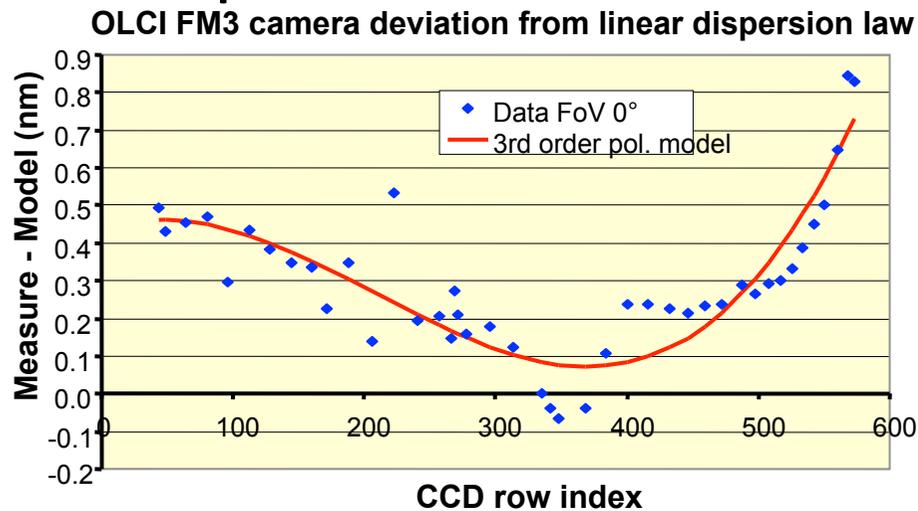
# Camera test & characterisation sequence



# Spectral Dispersion

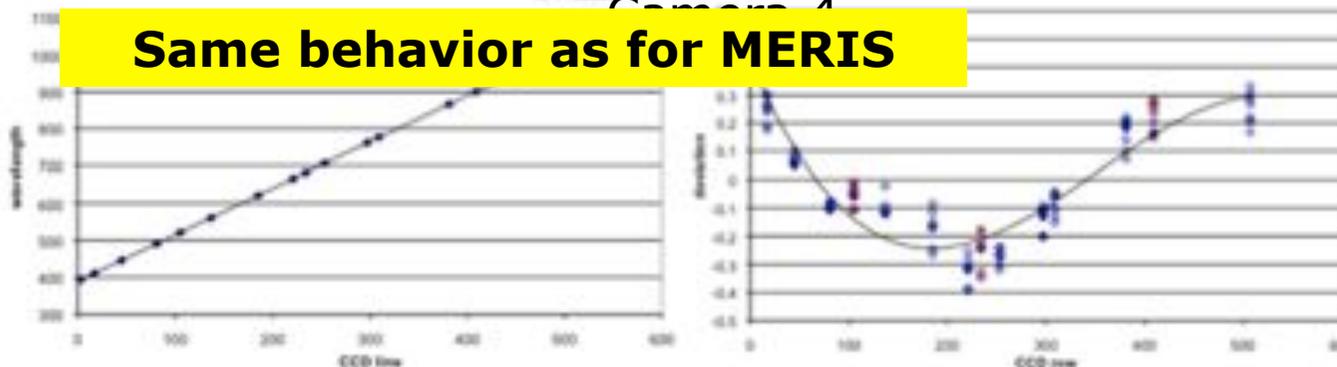
- Spectral (theoretical) linear dispersion model:  $\lambda = 1.25x + C$
- Deviation from linear model is characterised for central column →

## dispersion law model



Characterized central wavelength for MERIS

Same behavior as for MERIS



# Spectral registration

MERIS all cameras @ 681nm

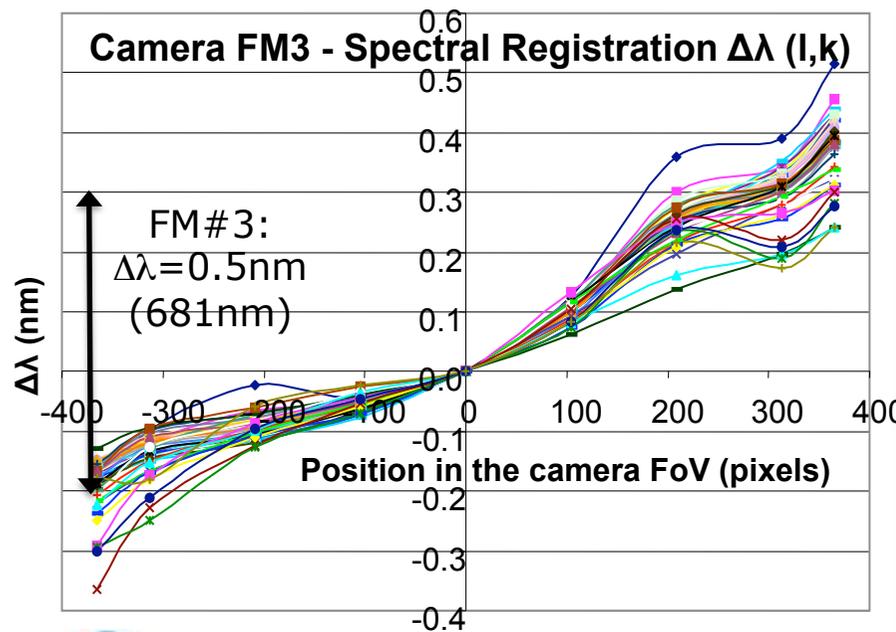


**OL-DE-020:** The spectral misregistration shall be less than 0.0014  $\mu\text{m}$  (goal: 0.001  $\mu\text{m}$ )

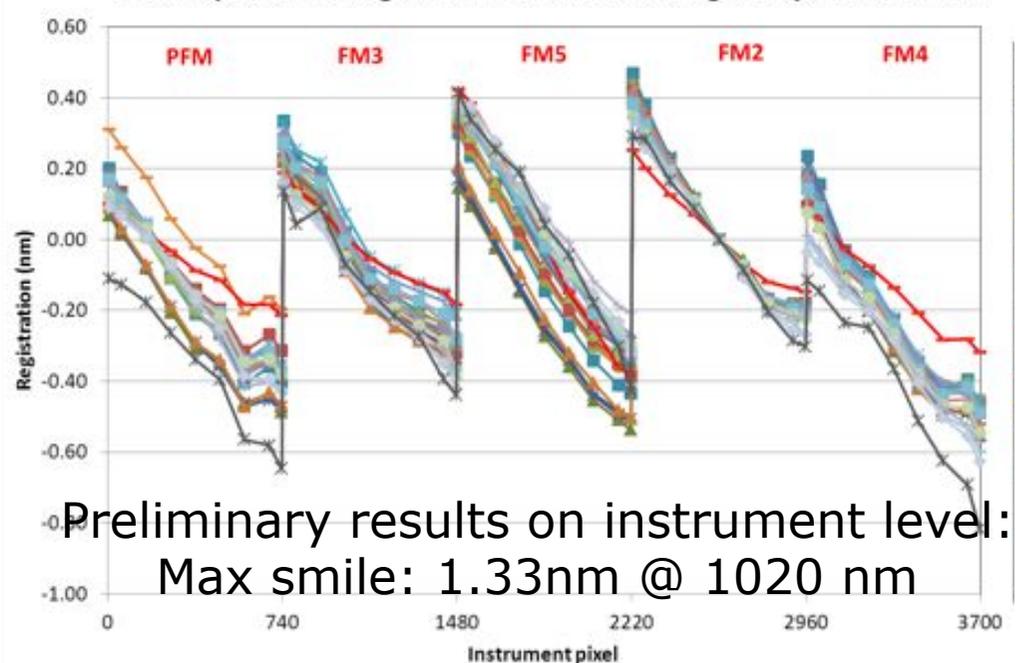
OLCI Results:

- FM#3 is compliant with goal,
- All cameras will have similar shape
- Preliminary Results on Instrument level very promising

Camera FM3 - Spectral Registration  $\Delta\lambda$  (l,k)

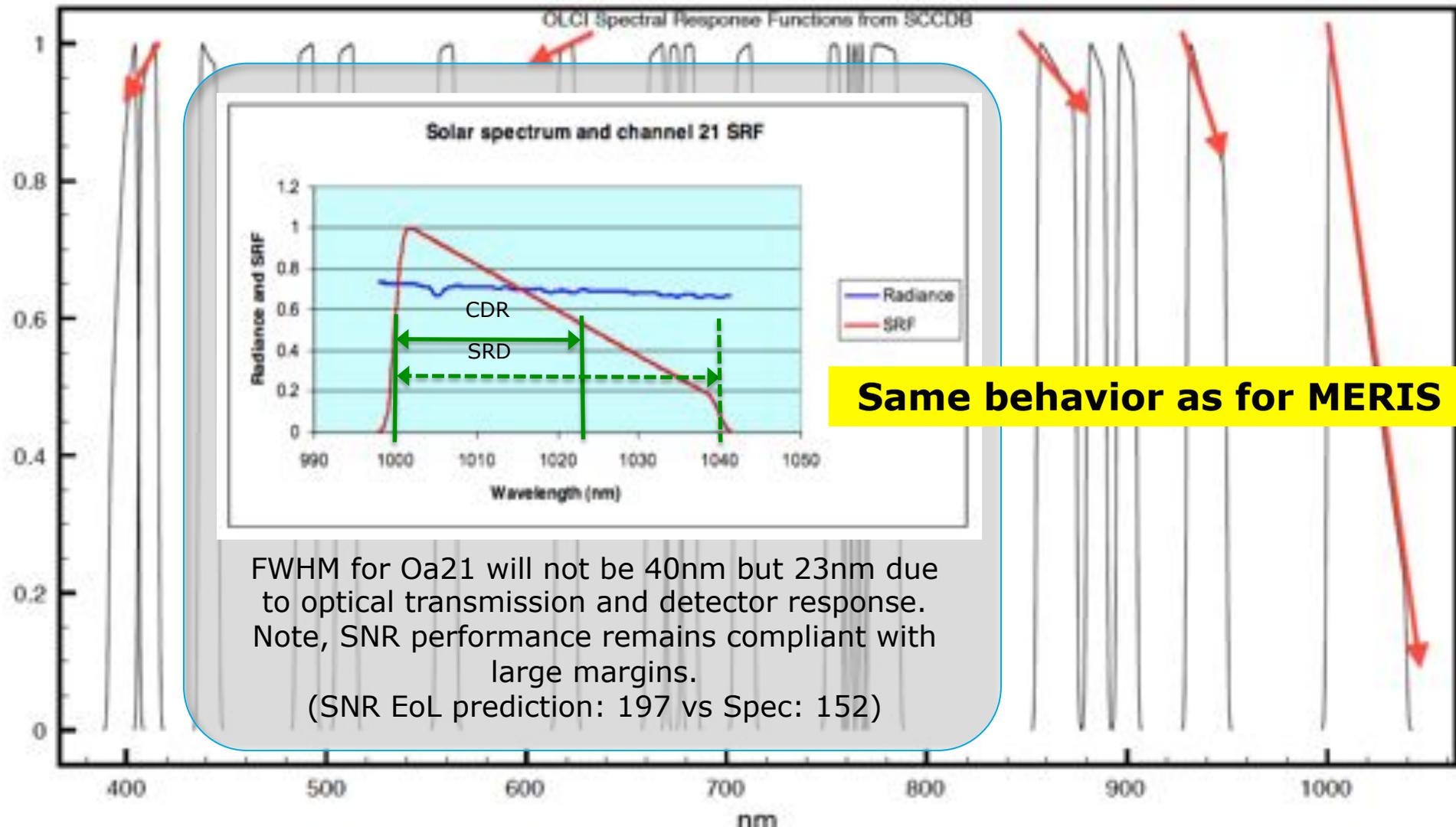


OLCI-A spectral mis-registration at center wavelength of spectral channels



Preliminary results on instrument level:  
Max smile: 1.33nm @ 1020 nm

# Normalized Spectral Response Functions



**Same behavior as for MERIS**

FWHM for Oa21 will not be 40nm but 23nm due to optical transmission and detector response. Note, SNR performance remains compliant with large margins. (SNR EoL prediction: 197 vs Spec: 152)

# Spatial (mis-)registration



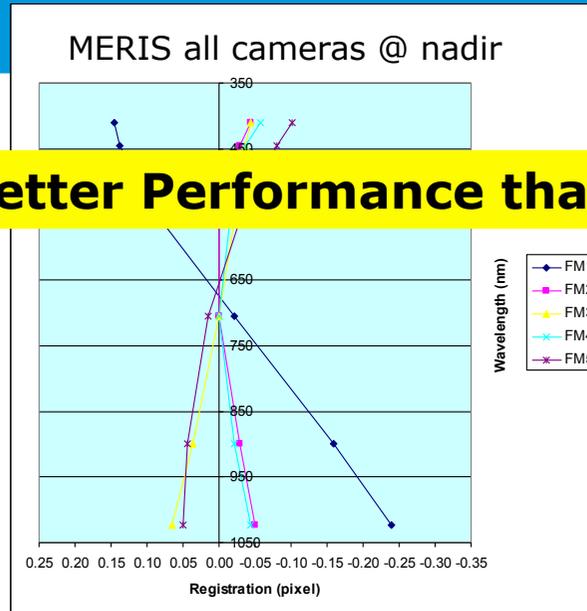
## OL-DE-160:

The inter-channel spatial co-registration shall be less than 0.4 FR SSD in the spectral range from 400 to 900 nm (goal 0.3 FR SSD).

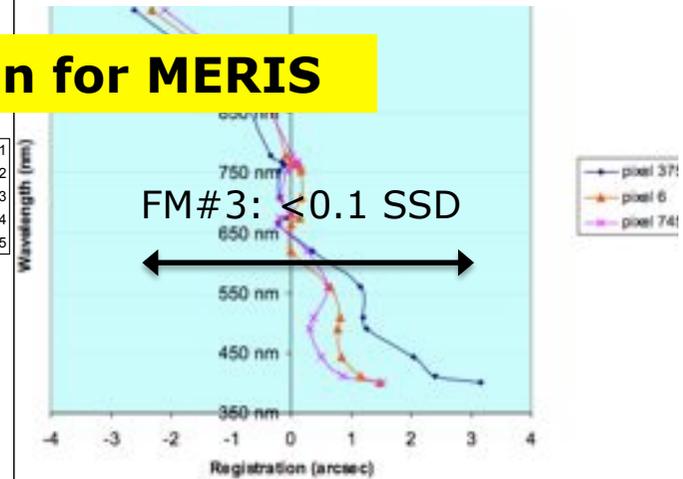
## OLCI Results:

- FM#3 is compliant with goal,
- All cameras will have similar shape,
- Preliminary Results on Instrument level very promising.

**Better Performance than for MERIS**



Measured ALT spatial registration at FoV center. Registration is very low: 6 arcsec at maximum, i.e., <0.1 SSD



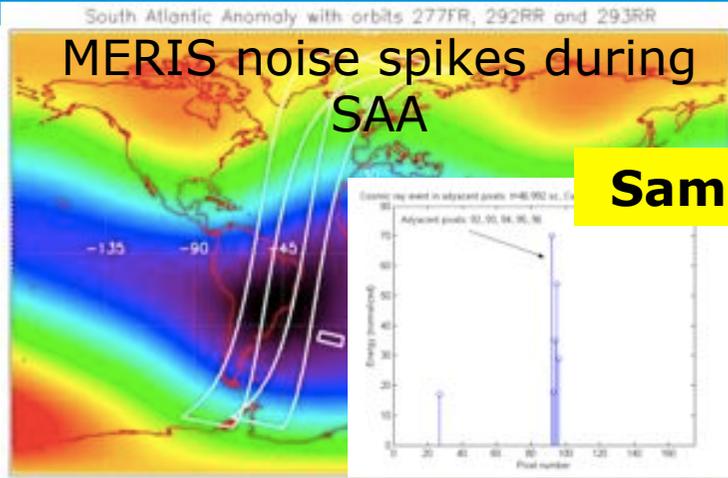
3-Sigma budget Full range			ACT Spatial registration			ALT Spatial registration		
	Signed Bias	Non Signed Bias	Random		Signed Bias	Non Signed Bias	Random	
CCD								
Max pixel deviation		1	µm peak			0.044		
CAMERA								
Max measured registration ACT		0.07	SSD			0.070		

	PFM	FM2	FM3	FM4	FM5
400-900 nm	0.12	0.17	0.13	0.15	0.18
390-1040 nm	0.18	0.22	0.14	0.20	0.19

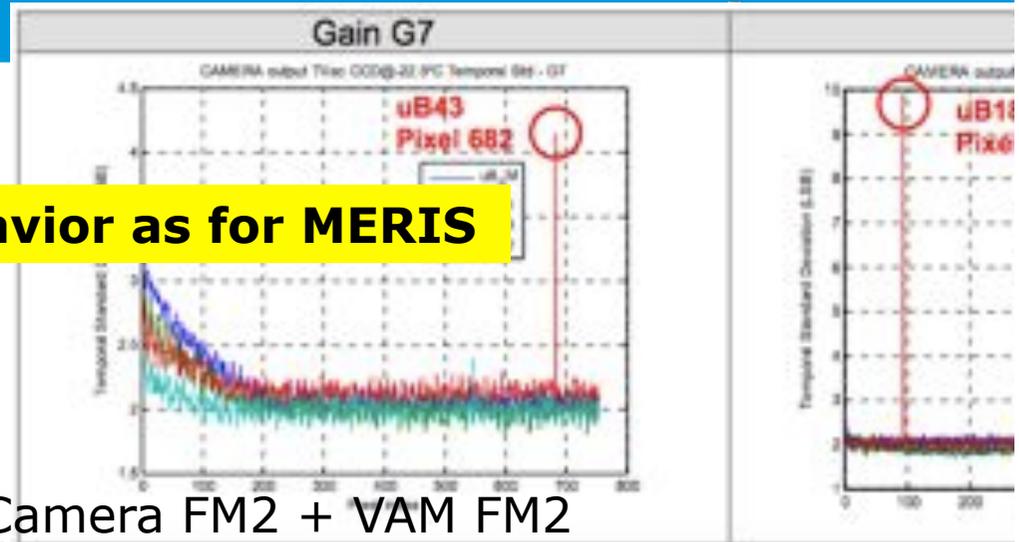
**Instrument level Preliminary Results: Overall spatial mis-registration worse measured performance (in SSD)**



# Radiometric Performance: dark (1)

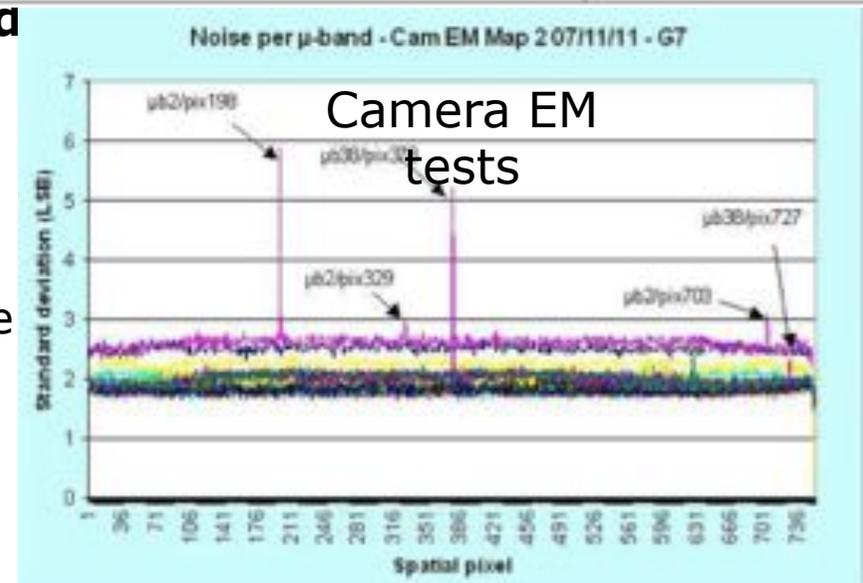


Same behavior as for MERIS



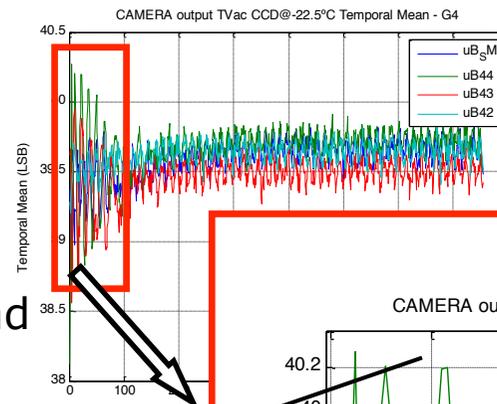
**During OLCI ground campaign (EM and FM2) Noise Spikes were detected. Most likely related to cosmic rays hitting the CCD.**

- Next Steps:
- During Phase E1: Investigation on occurrence
  - Mitigation via ground processing (TBD):
    - comparison of pixels with unexpected high levels with surrounding pixels, or
    - the comparison of these pixels with unexpected high levels with themselves in different temporal acquisitions.

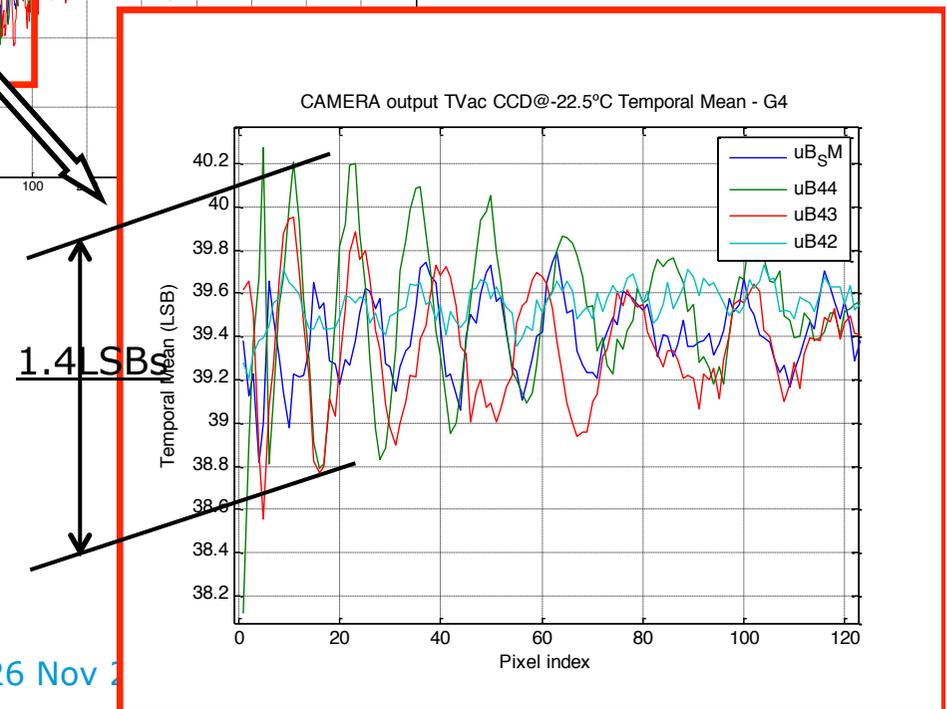


## Oscillation anomaly.

- Dark signal with frequency around 70KHz at the beginning (around 150pixels) of some micro-bands.
- Phenomenon especially after dumping/binning many lines.
- On FPA, CCD or VAM level no oscillations.
- Impact: on radiometric stability and absolute accuracy for Oa13,14,15 and Oa19,20.
- Investigations on all levels and models (e.g., EGSE, grounding, EMC) ongoing.
- Potential mitigation:
  - Full characterisation (vacuum vs ambient) on instrument level (TBC)
  - Ground correction (for the stable portion of the oscillation) (TBC)



**G4**



# Radiometric Performance

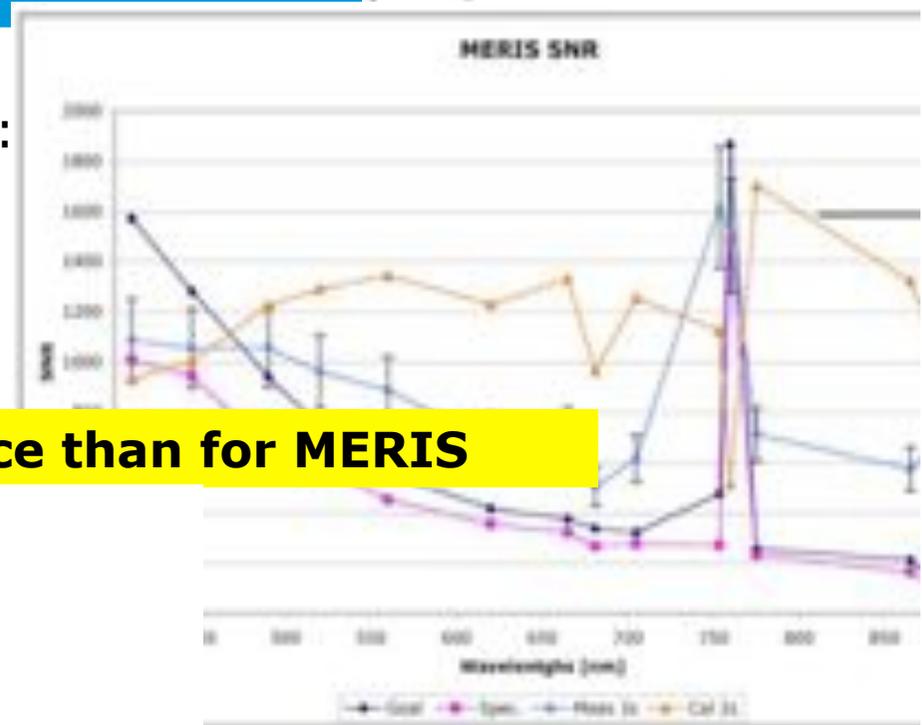
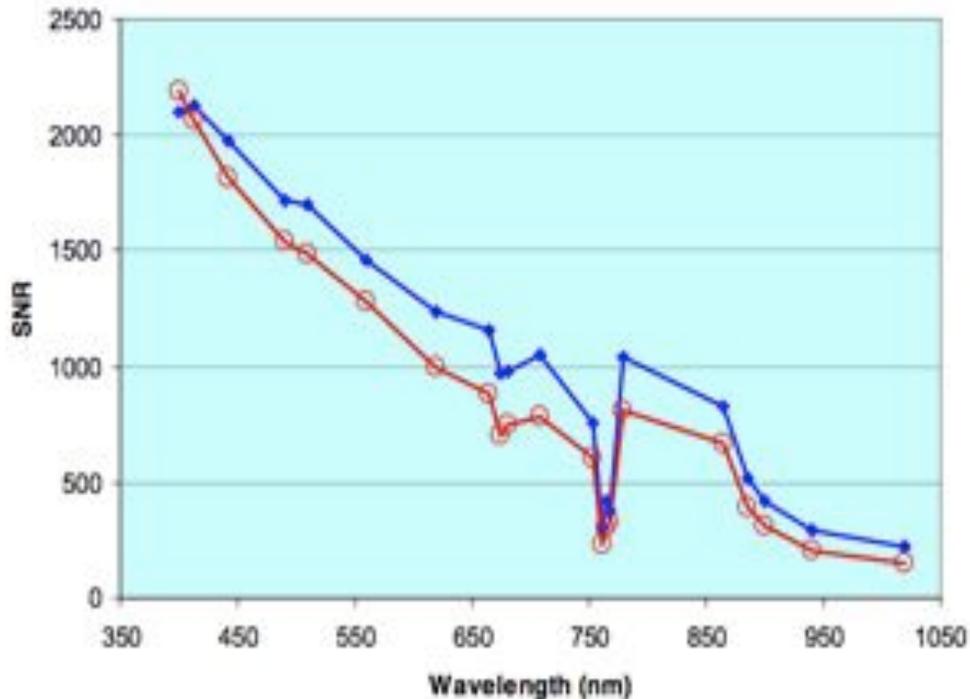
MERIS SNR for different signal

## OLCI Results:

Measured RR SNR is close to predictions:

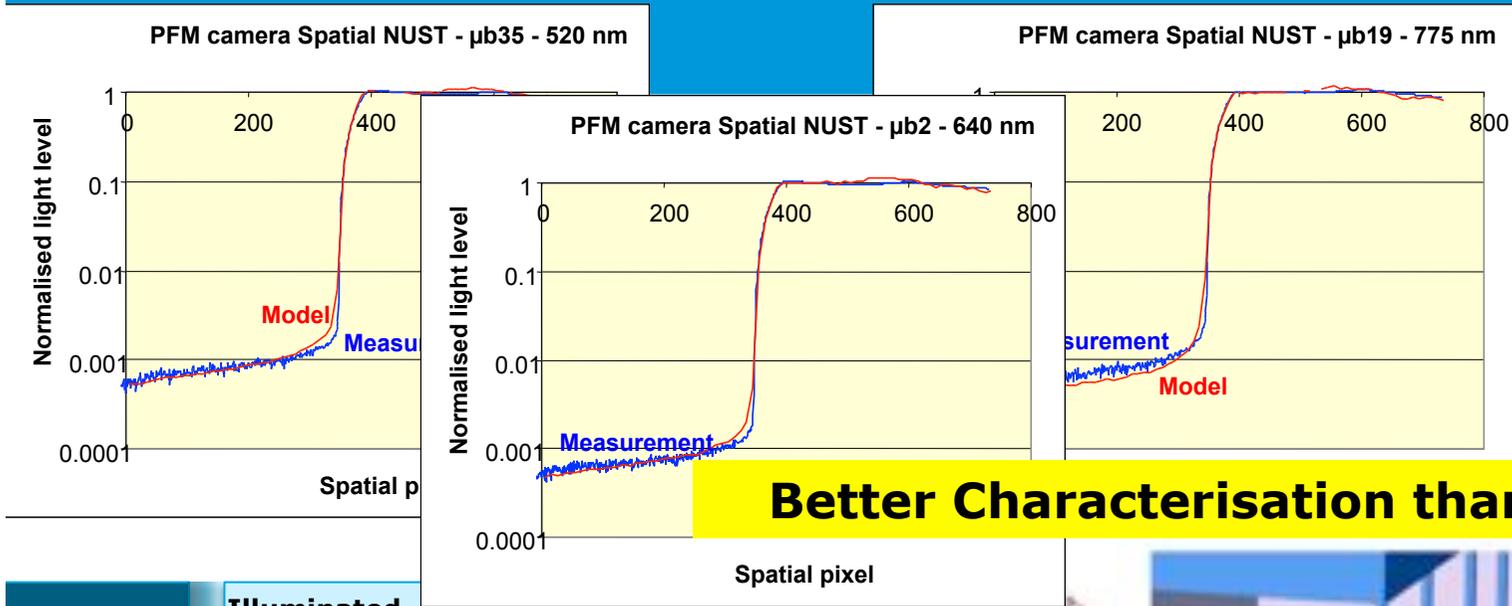
- Predicted SNR in flight.
- Requirement is met except marginally for extreme blue channels.

**Similar/better Performance than for MERIS**

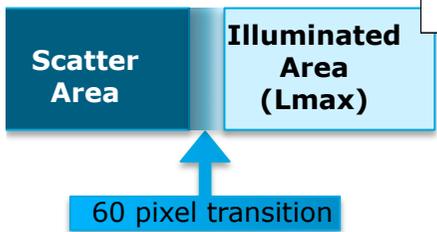


Note, SNR is difficult to measure and to compare directly with SRD Req. (dependence on signal level). **Instrument test will provide confirmation.**

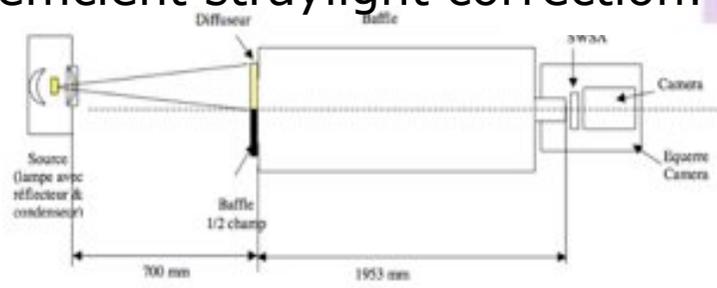
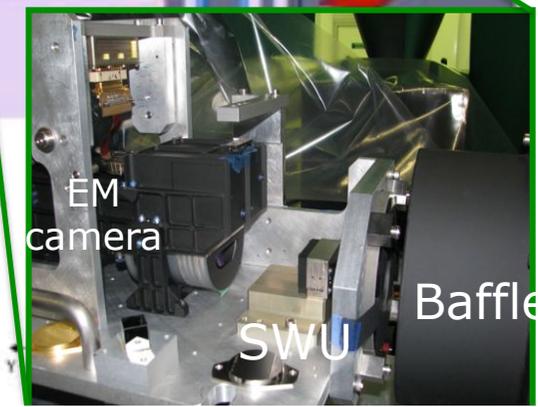
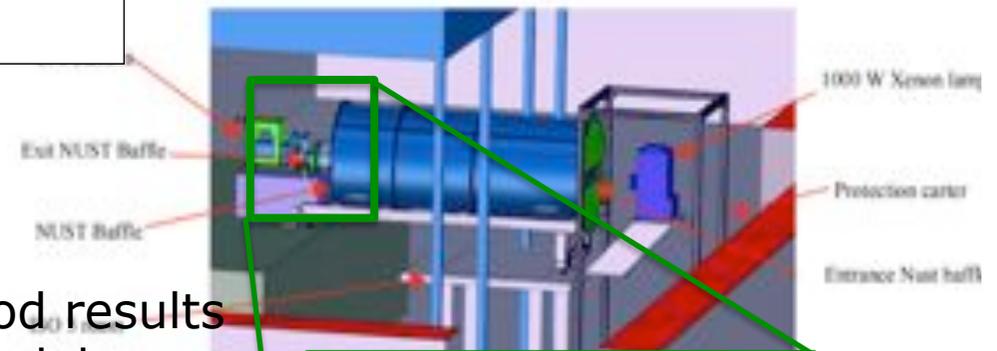
# Radiom. Performance: Straylight



**Better Characterisation than for MERIS**



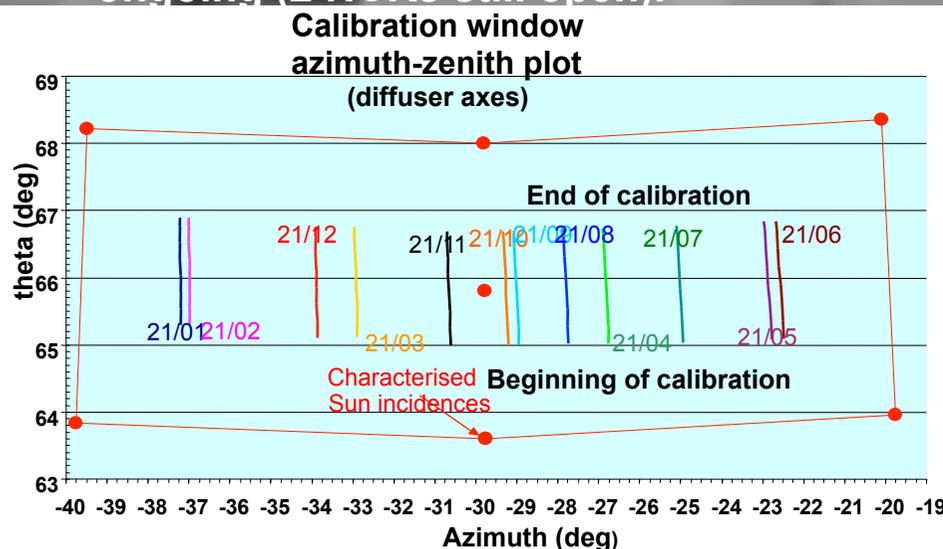
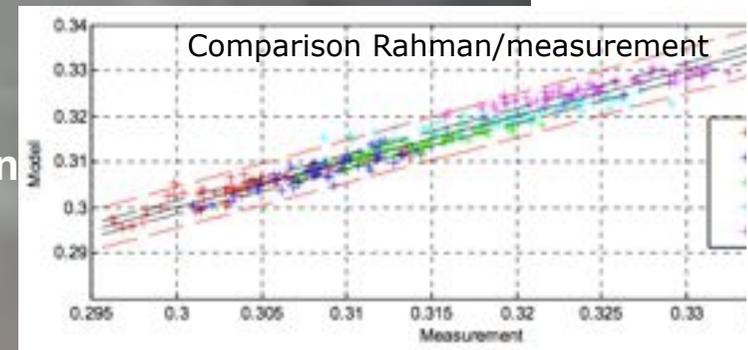
New spatial NUST set-up provides good results for the correlation with ASAP model  
 => Baseline for efficient straylight correction!



# Diffuser characterisation (1/2)

## Diffuser BRDF

- BRDF measurements (relative and absolute) for FMA and FMB for several set of wavelengths, incidence and observation angles covering the whole flight range.
- Mathematical BRDF model were tested to fit the absolute measurements, but only 2 models (based on Rahman) gave good results.
- Traceability to international standards by PTB/NPL.
- Final cross-validation between SLSTR and OLCI is ongoing (2 NCRs still open).

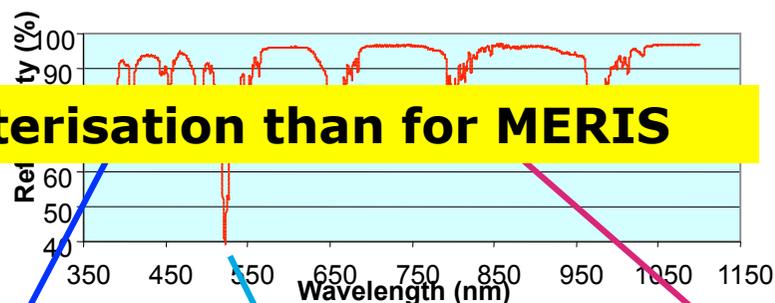


Accuracies in 1sigma	Absolute		Relative spatial	
	Perf	Req	Perf	Req
400 nm	0.338%	0.50%	0.301%	0.30%
490 nm	0.206%	0.50%	0.063%	0.30%
560 nm	0.226%	0.50%	0.134%	0.30%
681 nm	0.214%	0.50%	0.097%	0.30%
780 nm	0.252%	0.50%	0.171%	0.30%
900 nm	0.225%	0.50%	0.078%	0.30%
1020 nm	0.242%	0.50%	0.080%	0.30%

# Diffuser characterisation (2/2) spectral calibration

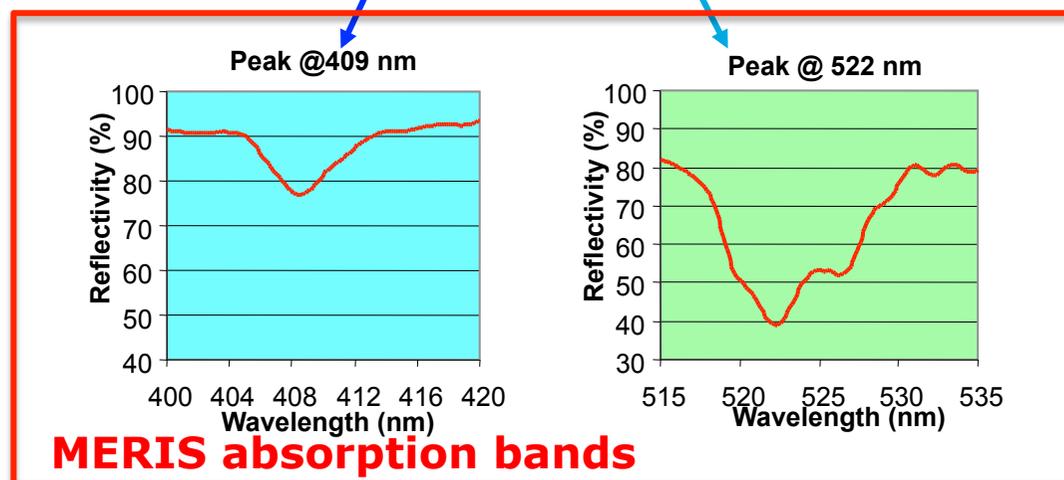
Within OLCI a maximum of 3 peaks each with 15 spectral lines can be used.

## Better Characterisation than for MERIS

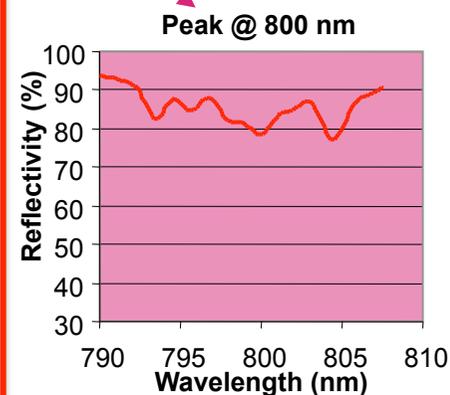


Erbium-doped  
Zenith 8%  
« pink diffuser »

3 absorption peaks are proposed for nominal spectral calibration



**MERIS absorption bands**

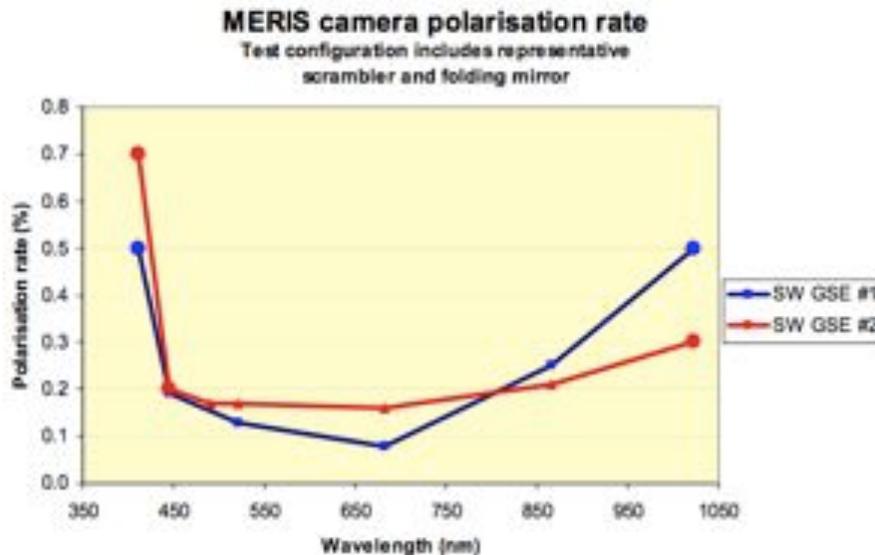


3 other peaks optional: 490 nm, 658 nm, 975 nm.

- Measurement performed on PFM camera

**Better Characterisation than for MERIS**

- Improvements with respect to MERIS testing: 3 dichroic polarisers instead of 1
- Characterisation of transmission uniformity for each polariser, main contributor to error budget



Channel	FoV	Polarisation ratio PR (%)		Compliance < 1% with S
		without SWU	with SWU	
Oa1	0°	0.81	0.2	OK
	7°	0.71	0.12	OK
Oa2	0°	/	/	?
	7°	0.23	/	OK
Oa3	0°	/	/	?
	7°	0.31	/	OK
Oa5	0°	0.48	/	OK
	7°	0.77	0.34	OK
Oa13	0°	1.16	0.21	OK
	7°	0.94	0.14	OK
Oa18	0°	1.16	0.21	OK
	7°	1.01	0.16	OK
Oa21	0°	0.8	0.23	OK
	7°	0.8	0.17	OK

# Conclusion



- **OLCI Development is built on MERIS heritage**
- **Maintain heritage:**
  - Camera design, calibration principle, spectral bands
- **Provides Improvement:**
  - More spectral bands, 300m FR over land and ocean, NRT, improved characterization...
- **OLCI A and B units are under development:**
  - a. OLCI PFM delivered end of 2013,
  - b. OLCI FM2 delivered Q3 2014.
- **OLCI camera test results and performance prediction demonstrate improved or similar performances as MERIS.**
- **OLCI will secure the continuity of ocean and land colour observation for the next decade.**

# Acknowledgements

