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Proto Flight Model (PFM) performance and development status of Visible and Near Infrared Radiometer (VNR) on the Second-generation Global Imager (SGLI)
9264-27

October 14, 2014
SPIE Asia-Pacific Remote Sensing in Beijing

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- GCOM mission and GCOM-C1 satellite
- SGLI performance
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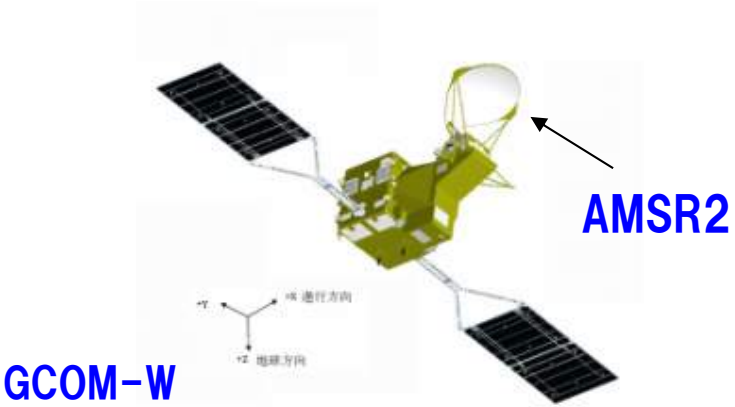
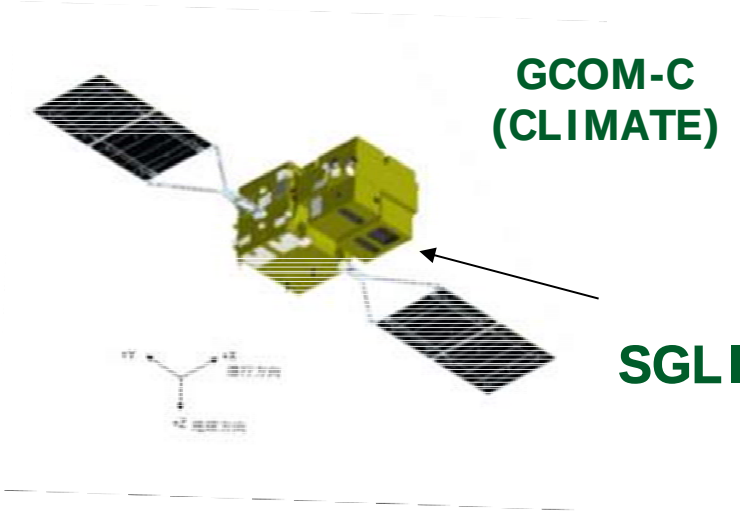
Global Change Observation Mission (GCOM)

- Global observation satellite system as JAXA's GEOSS contribution.
- 2 satellite series for 5 years, total 13 years observation.
  - ✓ **GCOM-W** Microwave radiometer observation for **WATER CYCLE** using AMSR2 (AMSR-E follow on)
  - ✓ **GCOM-C** Optical multi-channel observation for **RADIATION BUDGET** and **CARBON CYCLE** using SGLI (GLI follow on)

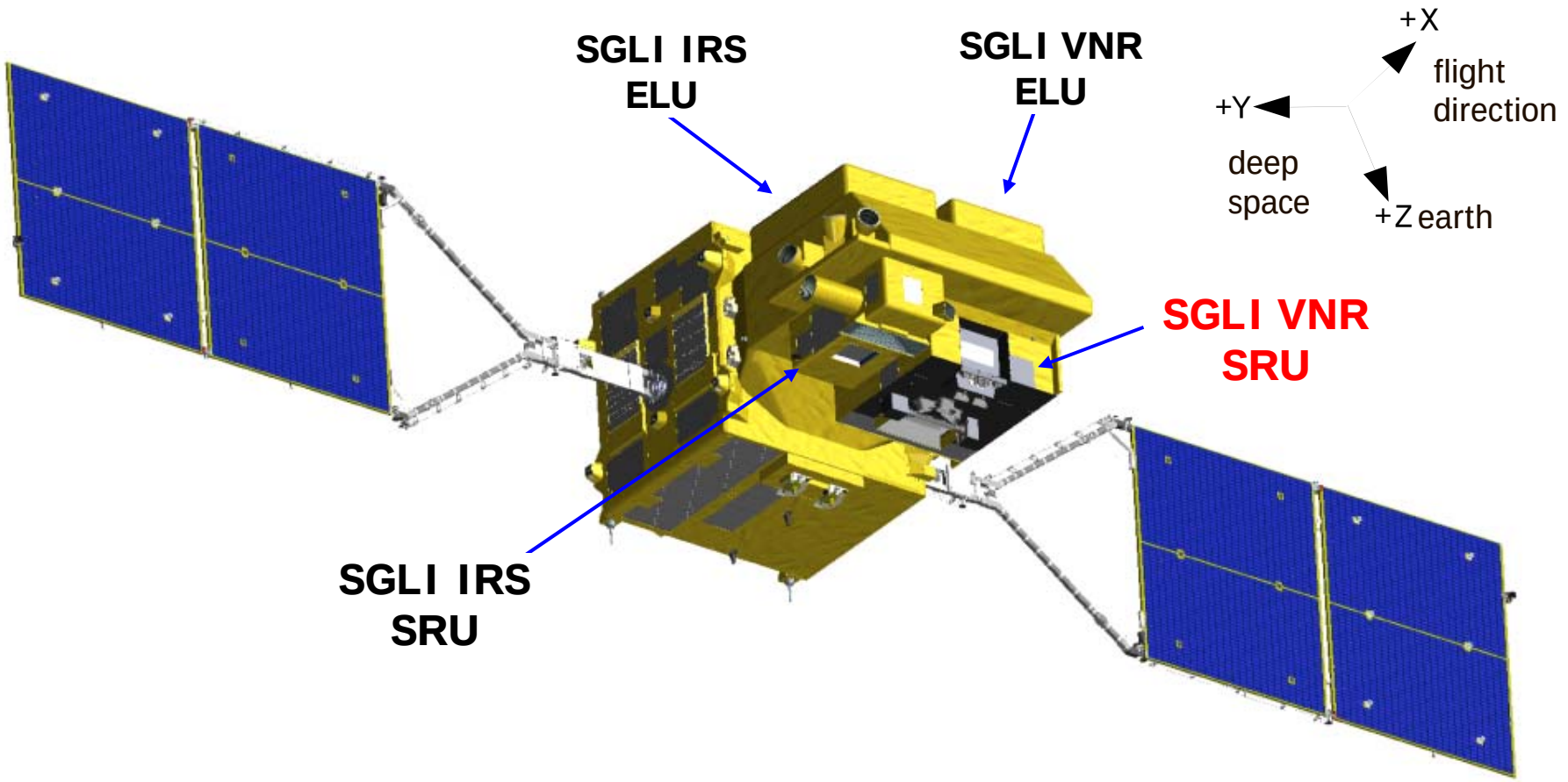




Sensor	**Advanced Microwave Radiometer 2 (AMSR2)** Passive Microwave Observation Water vapor, soil moisture etc

Sensor	**Second Generation Global Imager (SGLI)** Optical Observation 380nm – 12 micron Cloud, Aerosol, Vegetation, Chrolophl etc

SGLI on GCOM-C1 satellite

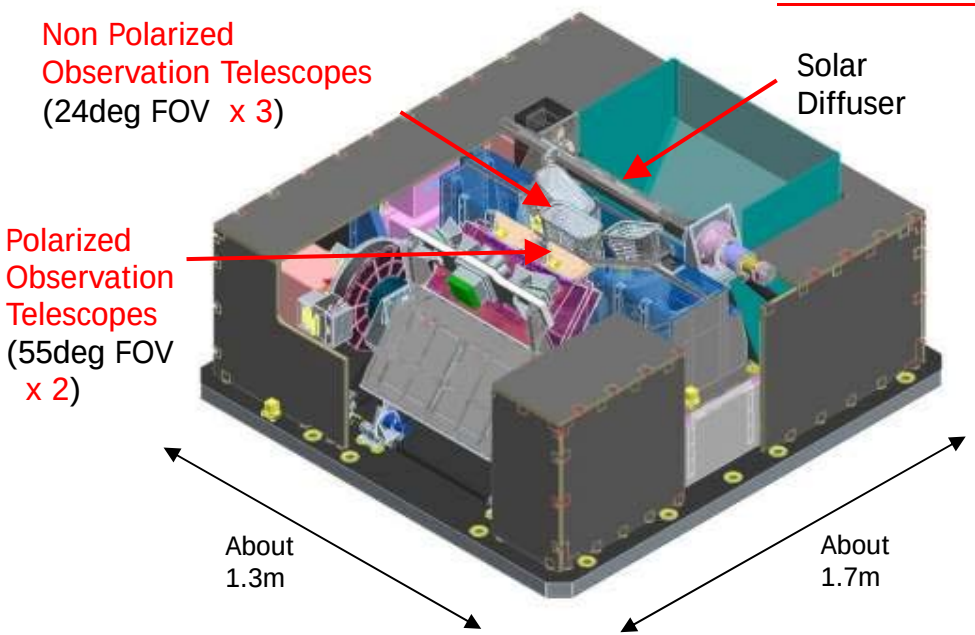


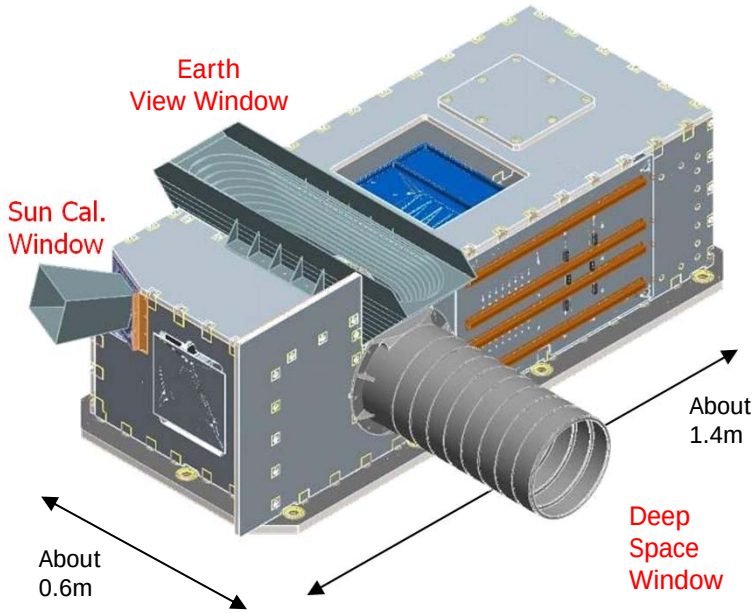
Mission Life	> 5 years
Solar Paddle	> 4000w（End of Life）
Mass	about 2,000kg

SGLI **Second Generation Global Imager**
VNR **Visible and Near Infrared Radiometer**
IRS **Infrared Scanning Radiometer**
SRU **Scanning Radiometer Unit**
ELU **Electronic Unit**

SGLI (*Second Generation Global Imager*)

External View





Visible and Near Infrared Radiometer
(SGLI-VNR)

Infrared Scanning Radiometer
(SGLI-IRS)

Sensor Unit	Features
SGLI VNR	Non Polarized Observation（11ch）, IFOV 250m, Swath 1150km Polarized Observation（2ch）, IFOV 1km, Swath 1150km
SGLI IRS	Shortwave Infrared（SWI 4ch）, IFOV 250m/1km, Swath 1400km Thermal Infrared（TIR:2ch）, IFOV 500m, Swath 1400km

SGLI Performance

- The SGLI features are **250m (VNR-NP & SW3) and 500m (TIR) spatial resolution** and **polarization/along-track slant view** channels (VNR-PL), which will improve land, coastal, and aerosol observations.

250m over the Land or coastal area, and 1km over offshore

GCOM-C SGLI characteristics	
Orbit	Sun-synchronous (descending local time: 10:30) Altitude 798km, Inclination 98.6deg
Mission Life	5 years (3 satellites; total 13 years)
Scan	Push-broom electric scan (VNR) Wisk-broom mechanical scan (IRS)
Scan width	1150km cross track (VNR: VN & P) 1400km cross track (IRS: SW & T)
Digitalization	12bit
Polarization	3 polarization angles for P
Along track direction	Nadir for VN, SW and T, +45 deg and -45 deg for P
On-board calibration	VN: Solar diffuser, LED, Lunar cal maneuvers, and dark current by masked pixels and nighttime obs. SW: Solar diffuser, LED, Lunar, and dark current by deep space window T: Black body and dark current by deep space window

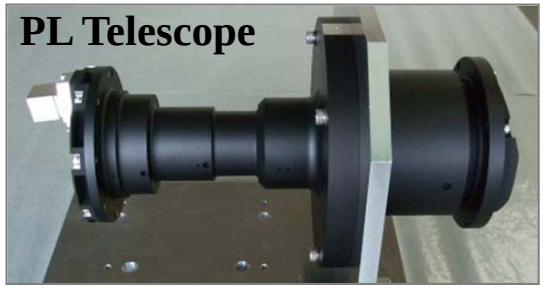
Multi-angle obs. for 674nm and 869nm

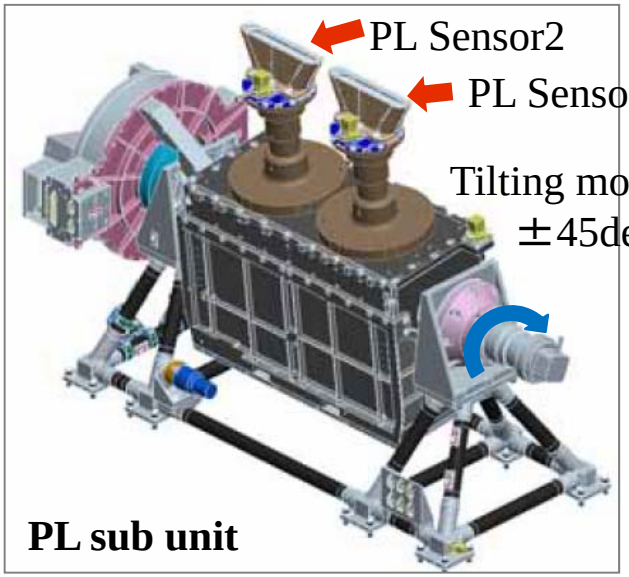
SGLI channels						
CH	λ	Δλ	L_{std}	L_{max}	SNR at Lstd	IFOV
	VN, P, SW: nm T: μm		VN, P: W/m²/sr/μm T: Kelvin		VN, P, SW: SNR T: NEΔT	m
VN1	380	10	60	210	250	250
VN2	412	10	75	250	400	250
VN3	443	10	64	400	300	250
VN4	490	10	53	120	400	250
VN5	530	20	41	350	250	250
VN6	565	20	33	90	400	250
VN7	*673.5*	*20*	23	62	400	250
VN8	*673.5*	20	25	210	250	250
VN9	763	12	40	350	1200	250/1000
VN10	*868.5*	20	8	30	400	250
VN11	*868.5*	20	30	300	200	250
P1	*673.5*	20	25	250	250	1000
P2	*868.5*	20	30	300	250	1000
SW1	1050	20	57	248	500	1000
SW2	1380	20	8	103	150	1000
SW3	*1630*	200	3	50	57	250
SW4	2210	50	1.9	20	211	1000
T1	10.8	0.7	300	340	0.2	250/500
T2	12.0	0.7	300	340	0.2	250/500

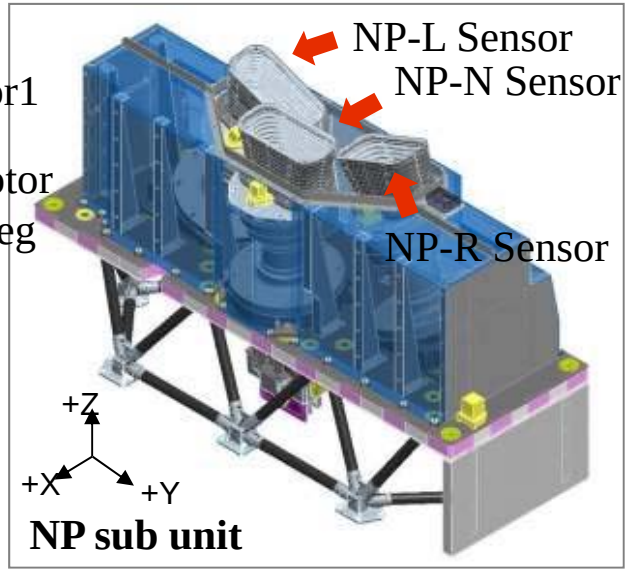
Option

VNR Optics

- 24deg (total 70deg) FOV for three NP sensors.
- 55dev FOV and +/-45deg tilting mechanism for two PL sensors.
- Three NP sensors and two PL sensors have been assembled already.
- Optical test such as integrating sphere test or parallel light test is ongoing.

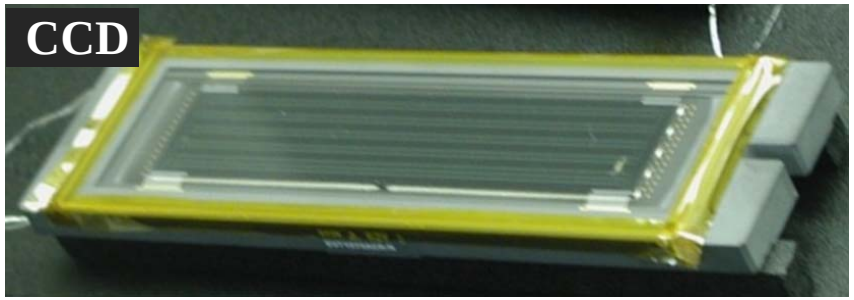




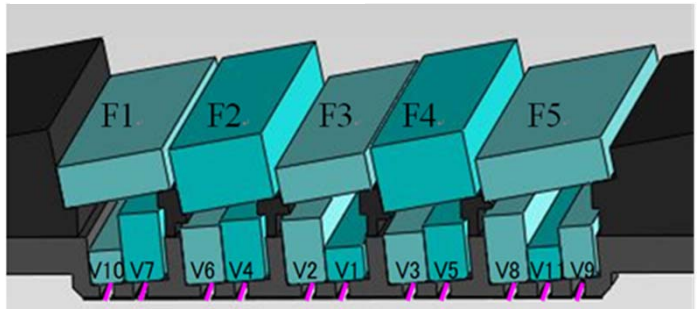


VNR focal plane assembly (FPA)

- 11 lines Band pass filter(BPF) is equipped on the 11 line 6000pix CCD for NP sensor.
- Polarization filter is equipped on the same kind of CCD for PL sensor. 3 of 11 lines are used for polarization outputs(+60deg, 0deg, -60deg).



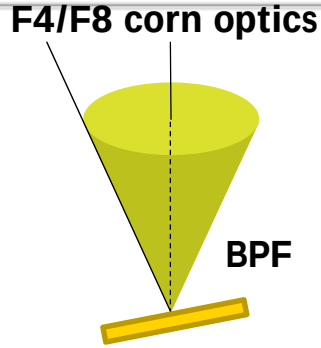
Structure of BPF

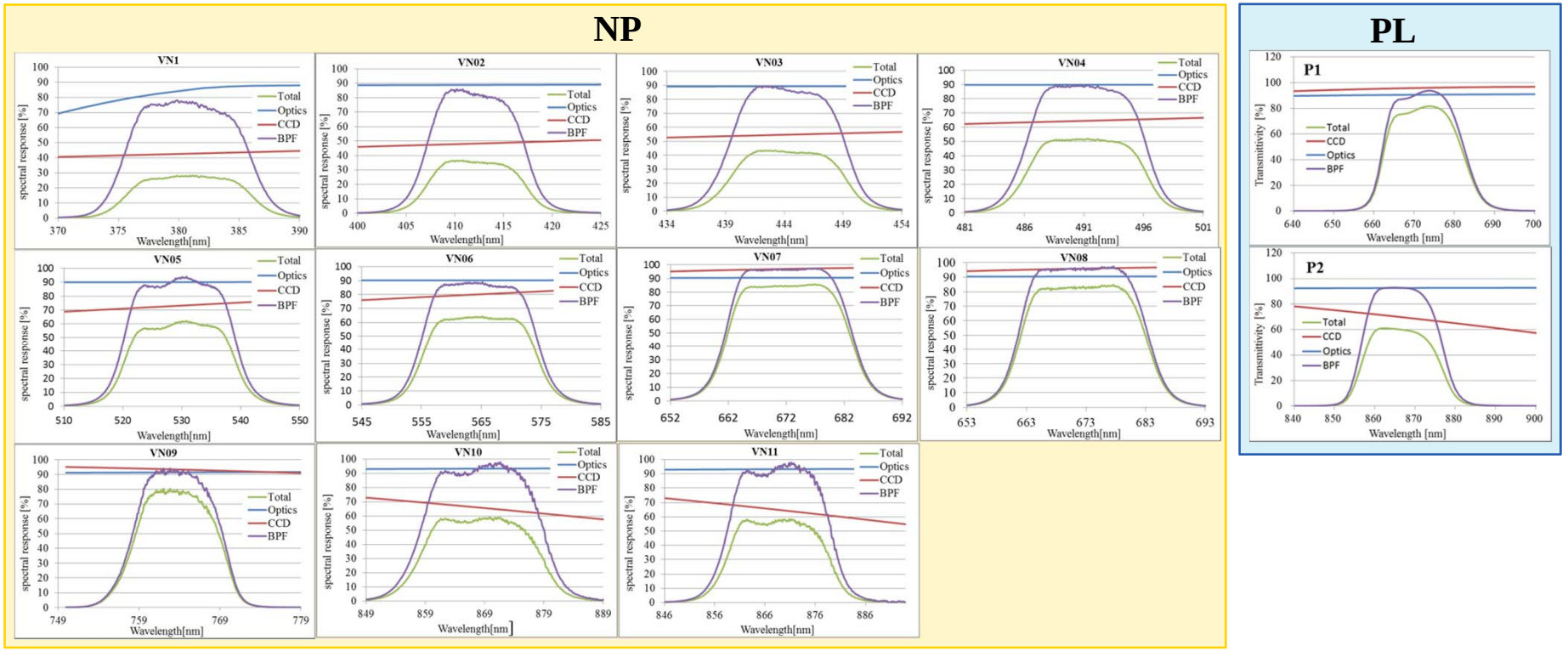


A. Kurokawa et al, “High-precision narrow-band optical filters for global observation”, ICSOS, Oct. 2012

VNR spectral performance

- Wavelength characteristics are total characteristics of telescope, CCD sensitivity and BPF.
- F4/F8 corn optics and filter slope is considered for NP/PL in this characteristics.
- BPF locality is considered by shifting the center wavelength.





Measurement accuracy of polarization

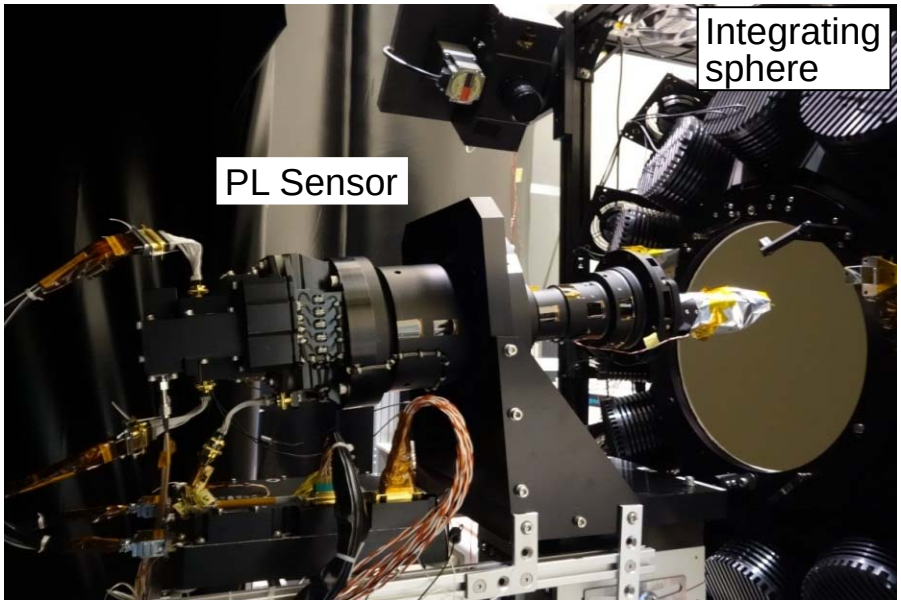
- Measurement error caused by SNR is calculated by considering SNR as 500 which is achieved with enough margin in the PFM test.
- Relative difference of three detectors depends on compensation error of sensitivity non-uniformity. PFM test has finished and it's under evaluation now.
- Mueller matrix compensation is used to realize the polarization target spec. So its measurement error is important.

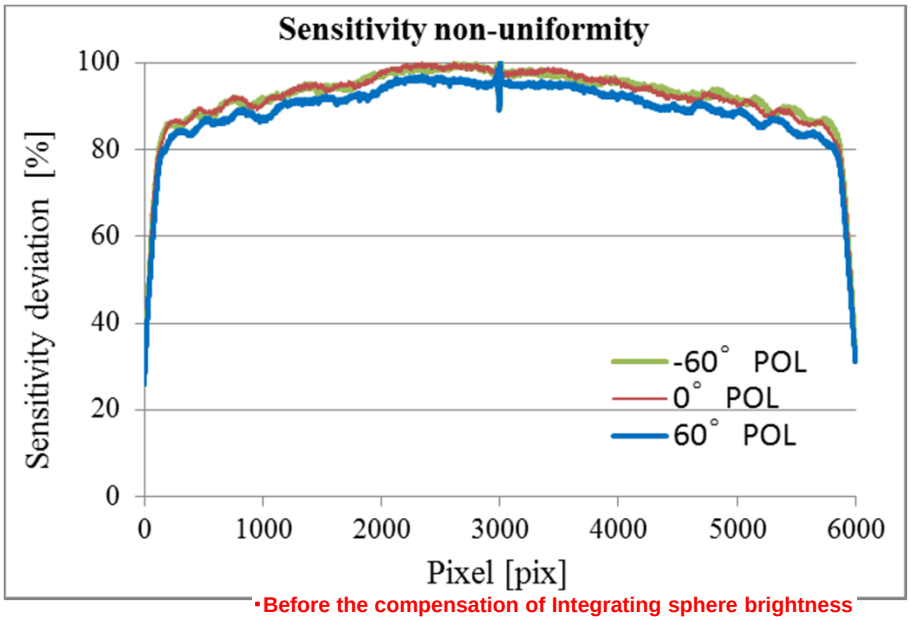
Measurement error cause of polarization	Measurement accuracy	
	Polarization Rate	Polarization Direction
Measurement error caused by SNR	3.27%	0.94°
Relative difference three detectors	≦1.9%	≦0.51°
Stability of the satellite attitude	—	≦0.009°
Mueller matrix error	≦1.3%	≦0.7°
Total (RSS)	≦4.00%	≦1.28°

Target spec. for measurement accuracy of polarization

Sensitivity non-uniformity for PL sensor

- Integrating sphere test for two PL sensors have finished.
- Sensitivity non-uniformity, S/N, linearity, dynamic range have just been measured.
- Sensitivity non-uniformity between pixels and between each polarized output(+60deg, 0deg, -60deg) will be compensated to meet distributed specification for relative difference of three detectors.



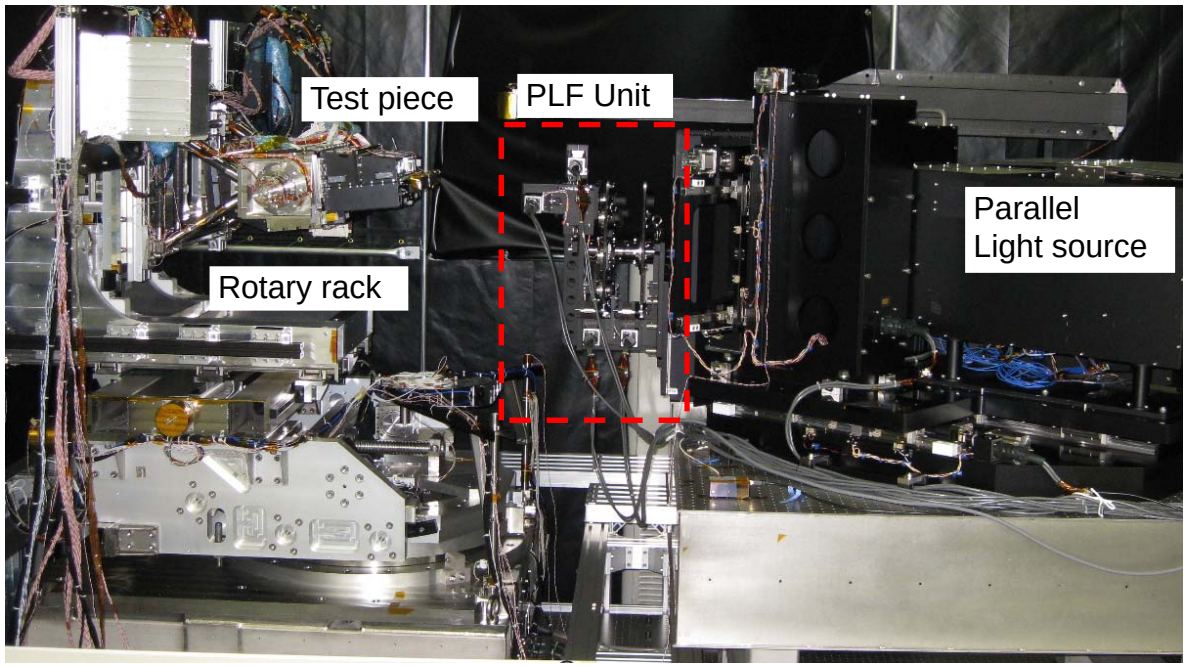


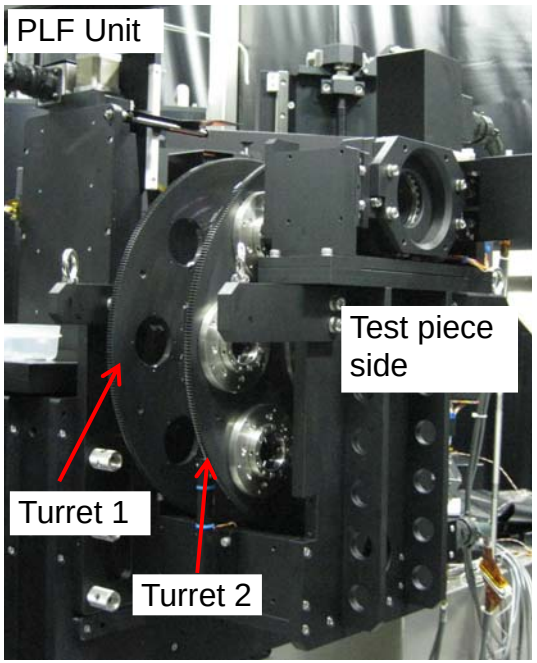
・Before the compensation of Integrating sphere brightness
・Pixel data will be integrated.

Polarization observation test

(a) Measure the three outputs of PL sensor $I_{(0^\circ)}(\theta)$, $I_{(+60^\circ)}(\theta)$ and $I_{(-60^\circ)}(\theta)$ while rotating the linear polarization plate on turret2 as shown in Figure below and calculate Mueller matrix.

(b) Change the linear polarization plate to 5% polarization plate on turret2 and measure the three outputs again.





Measurement accuracy of polarization rate and direction

(c) Calculate the polarization rate and direction by eq.(1),(2),(3)

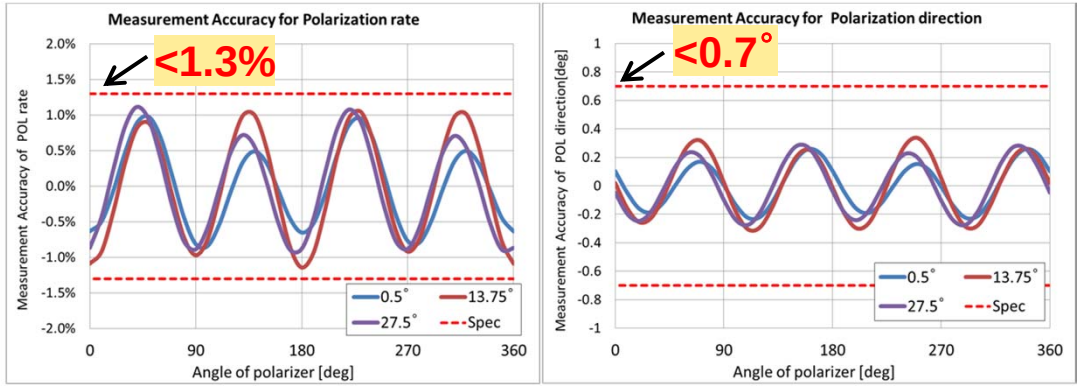
(d) Calculate the accuracy of polarization rate and direction.

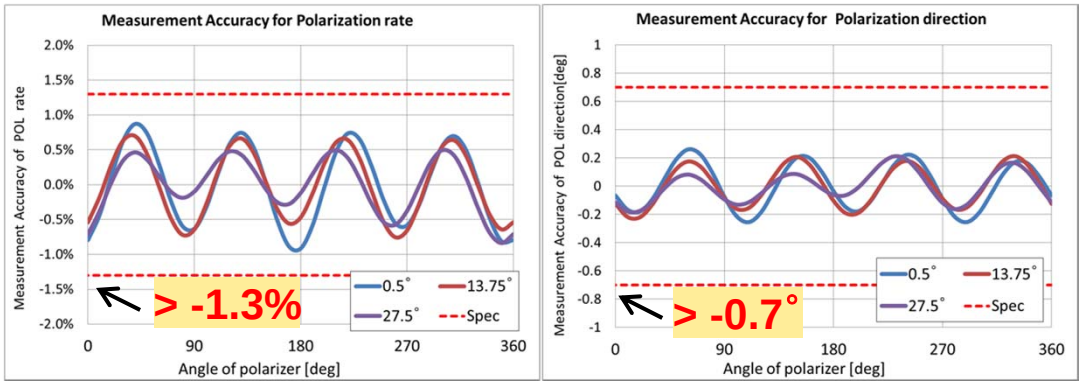
These are in the distributed specification as shown below.

$$\begin{pmatrix} I(\theta) \\ Q(\theta) \\ U(\theta) \end{pmatrix} = M^{-1} \cdot \begin{pmatrix} \frac{2}{3} & \frac{2}{3} & \frac{2}{3} \\ \frac{4}{3} & -\frac{2}{3} & -\frac{2}{3} \\ 0 & \frac{2}{\sqrt{3}} & -\frac{2}{\sqrt{3}} \end{pmatrix} \cdot \begin{pmatrix} \bar{I}_{(0°)}(\theta) \\ \bar{I}_{(+60°)}(\theta) \\ \bar{I}_{(-60°)}(\theta) \end{pmatrix} \quad \cdots (1)$$

$$\text{Polarization rate}: \quad \varphi(\theta) = \frac{1}{2}\tan^{-1}\left(\frac{U(\theta)}{Q(\theta)}\right) \quad \cdots (2)$$

$$\text{Polarization direction}: \quad \rho(\theta) = \frac{\sqrt{Q(\theta)^2 + U(\theta)^2}}{I(\theta)} \quad \cdots (3)$$

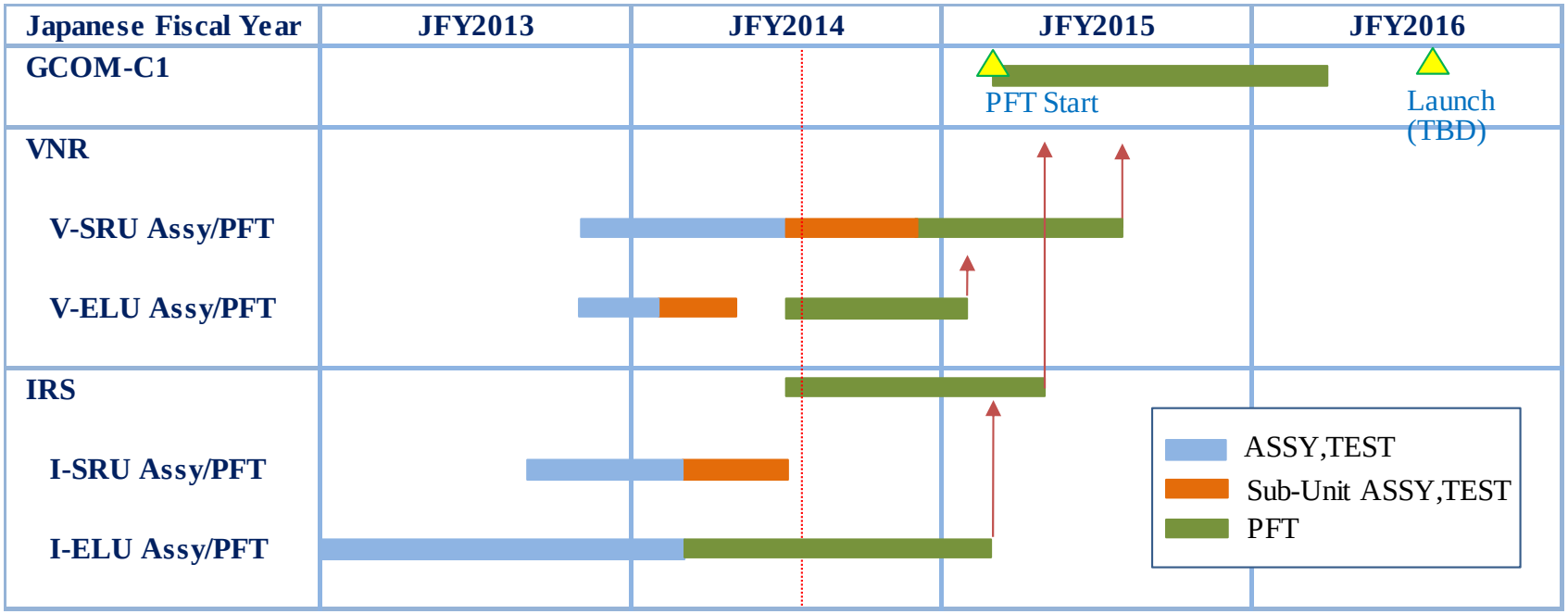




Accuracy of Pol rate **Accuracy of Pol direction**

Current status

- Three NP sensors have been assembled and parallel light test will start by the end of this year.
- Two PL sensors are assembled and integrating sphere test have been finished already. Parallel light test including polarization observation test will start from now.
- I-SRU Component assembly and PFT have been done and system test will start soon.



Conclusion

- GCOM is JAXA's GEOSS contribution and SGLI is the optical sensor on the GCOM-C1 satellite.
- VNR spectral performance is measured and calculated.
- VNR PL & NP sensor assembly has finished and optical test is ongoing. Polarization observation test will start within this year.
- Target launch of GCOM-C1 is JFY2016