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9881-26

Proto Flight Model (**PFM**) development status of Visible and Near-Infrared Radiometer (**VNR**) on the Second-Generation Global Imager (**SGLI**)

6 April 2016

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10th SPIE Asia-Pacific Remote Sensing Symposium

Earth Observing Missions and Sensors: Development, Implementation, and Characterization IV

New Delhi, India, 4-7 April 2016

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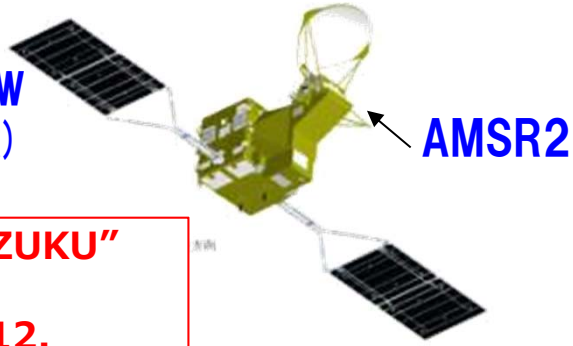
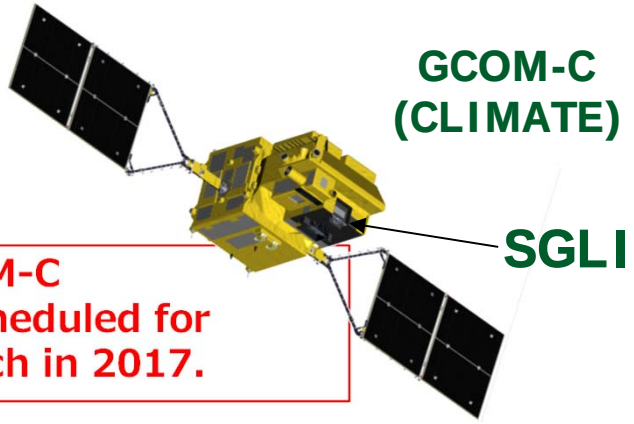
Global Change Observation Mission (GCOM)

- 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)



GCOM-W "SHIZUKU" was launched on May 18, 2012.

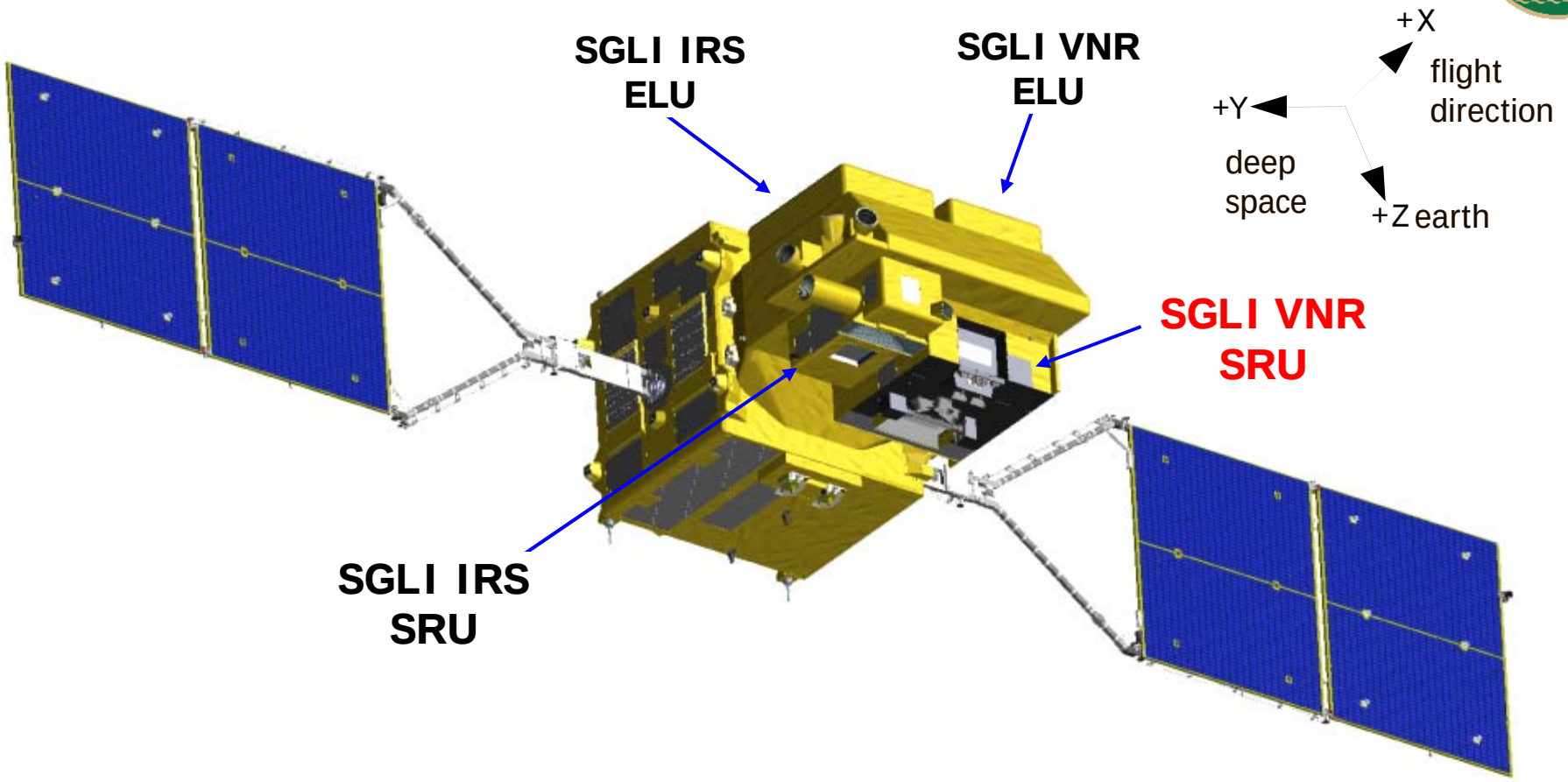
Sensor	Advanced Microwave Radiometer 2 (AMSR2) Passive Microwave Observation Water vapor, soil moisture etc



GCOM-C is scheduled for launch in 2017.

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

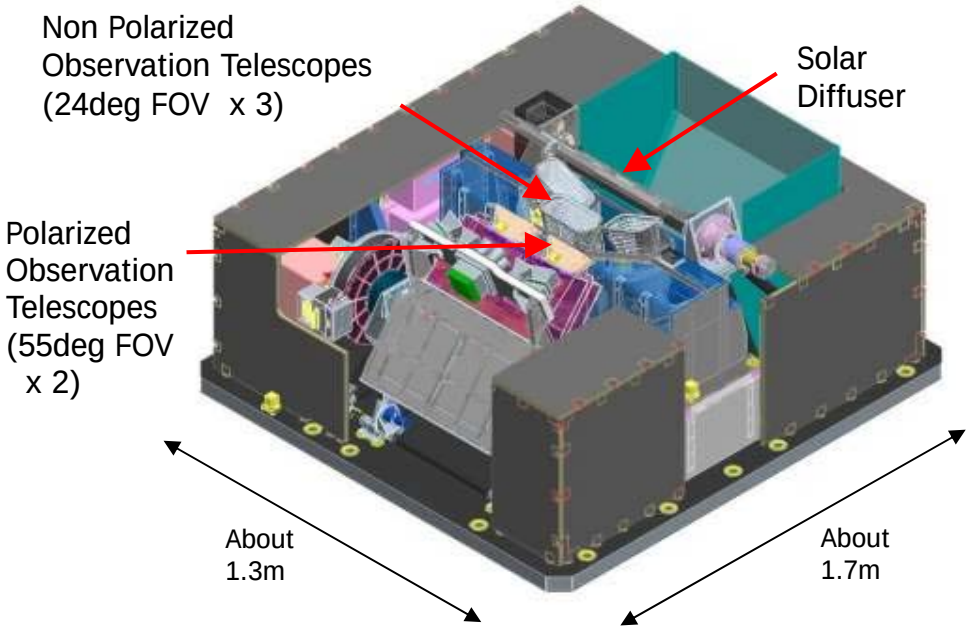
SGLI on GCOM-C1 satellite

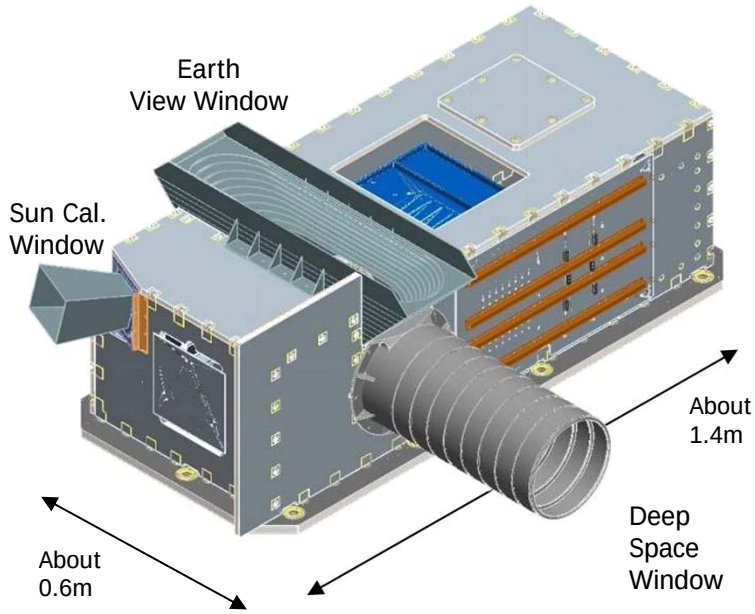


Mission Life	> 5 years
Solar Paddle	> 4000w（End of Life）
Mass	about 2,000kg

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)





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 Specification

- 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.

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 673.5nm and 868.5nm

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

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

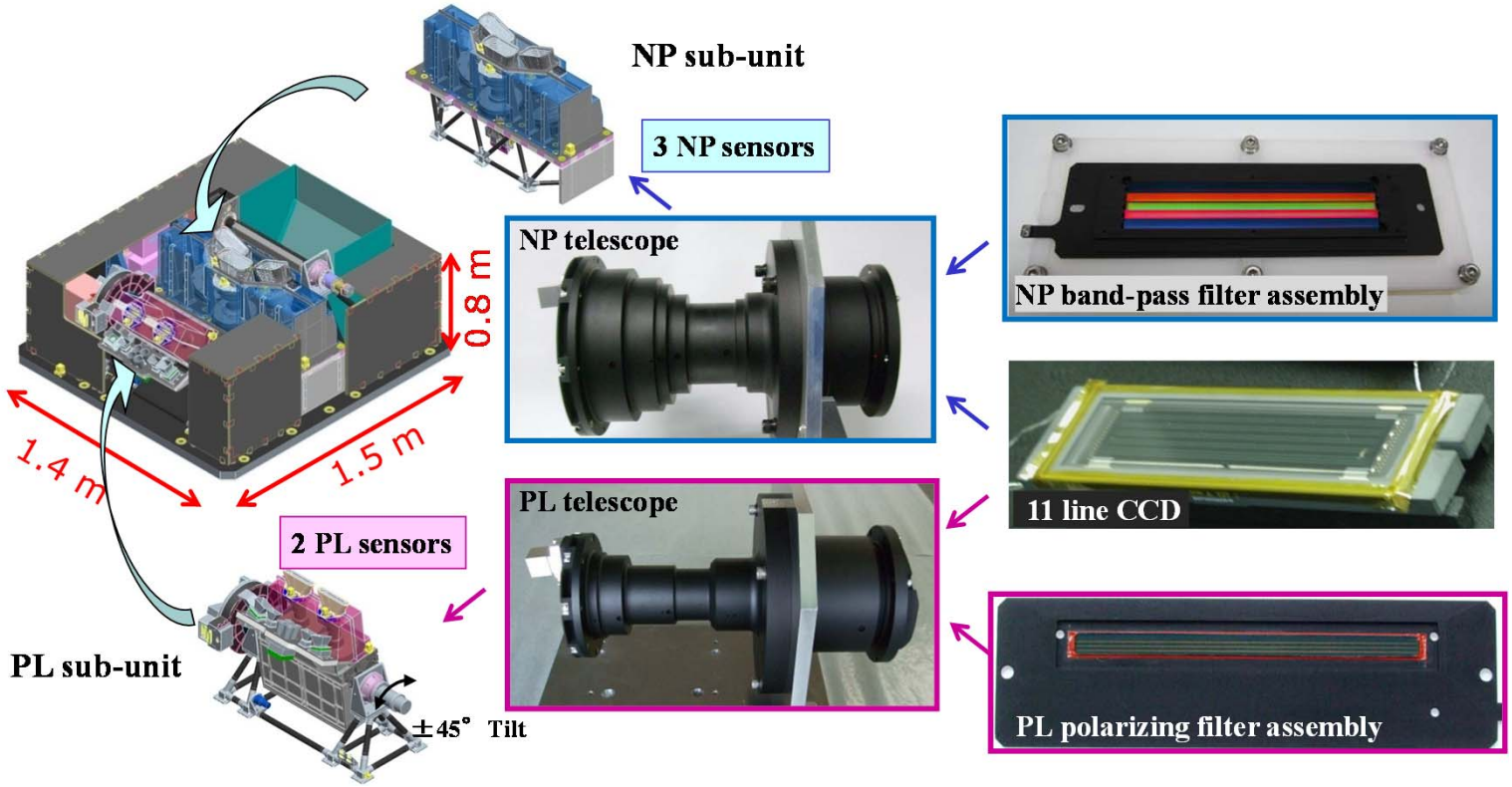
Visible and Near Infrared Radiometer (VNR)

■VNR Non-Polarized (NP) sensor

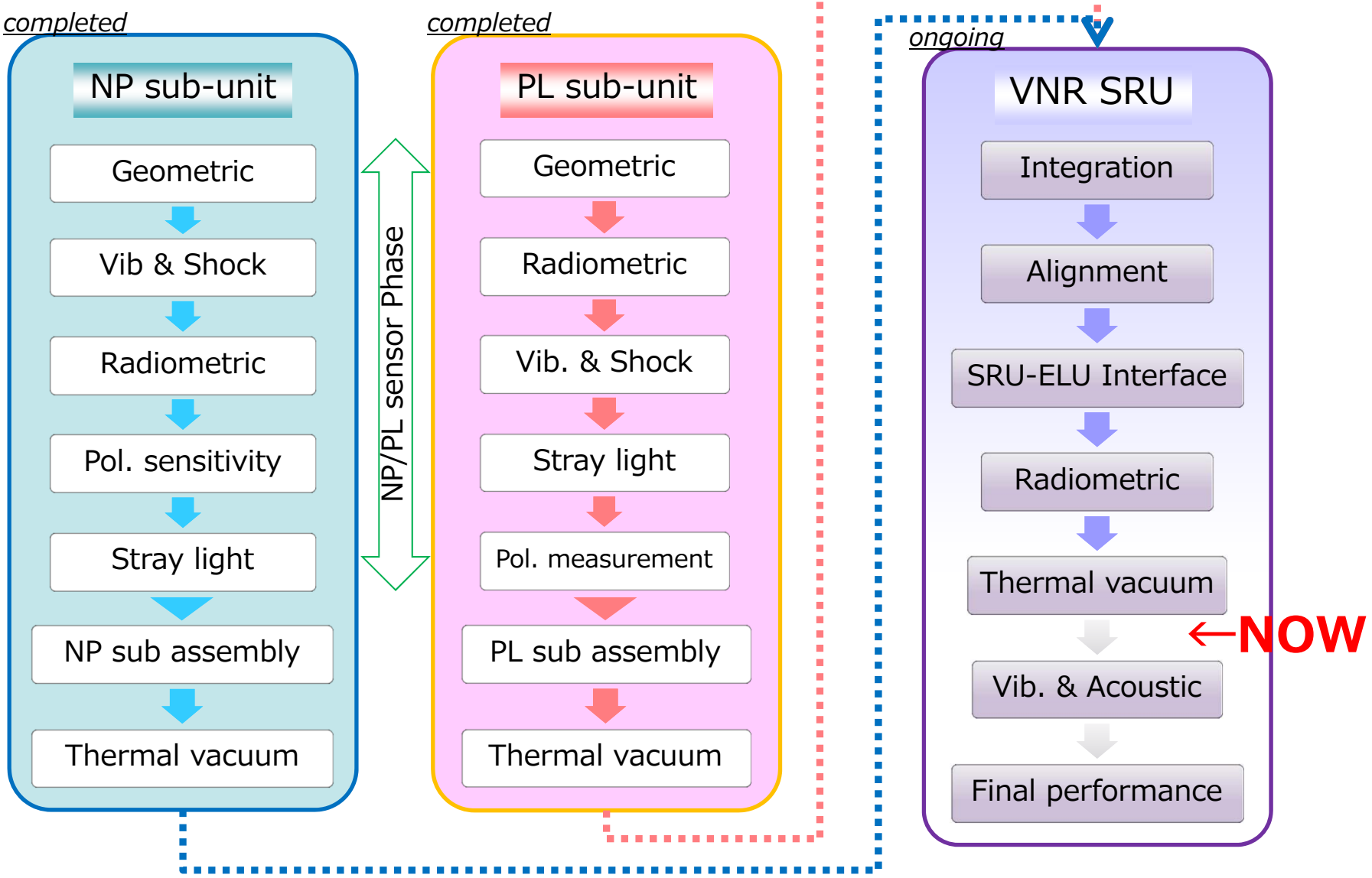
- ✓ 24deg FOV each for 3 NP sensors. (total 70deg, nadir looking)
- ✓ 11 lines Band pass filter(BPF) on the 11 line 6000pix CCD

■VNR Polarized (PL) sensor

- ✓ 55dev FOV with +/-45deg tilting mechanism. (forward, backward and nadir looking)
- ✓ 3 polarization filter on the same design CCD with NP sensor for 3 pol. directions



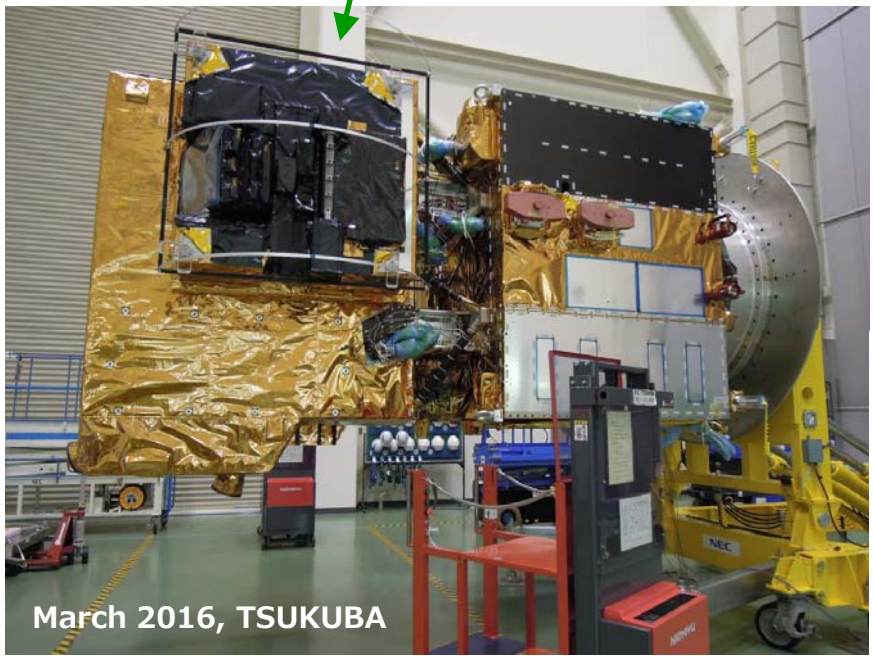
SGLI VNR Current Status

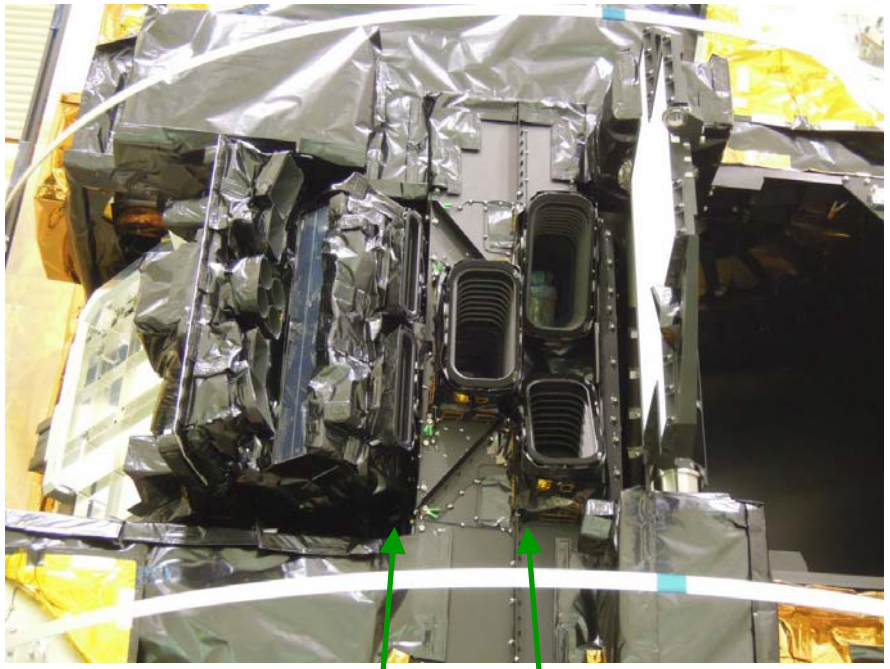


Current Status

VNR SRU Onboard Configuration

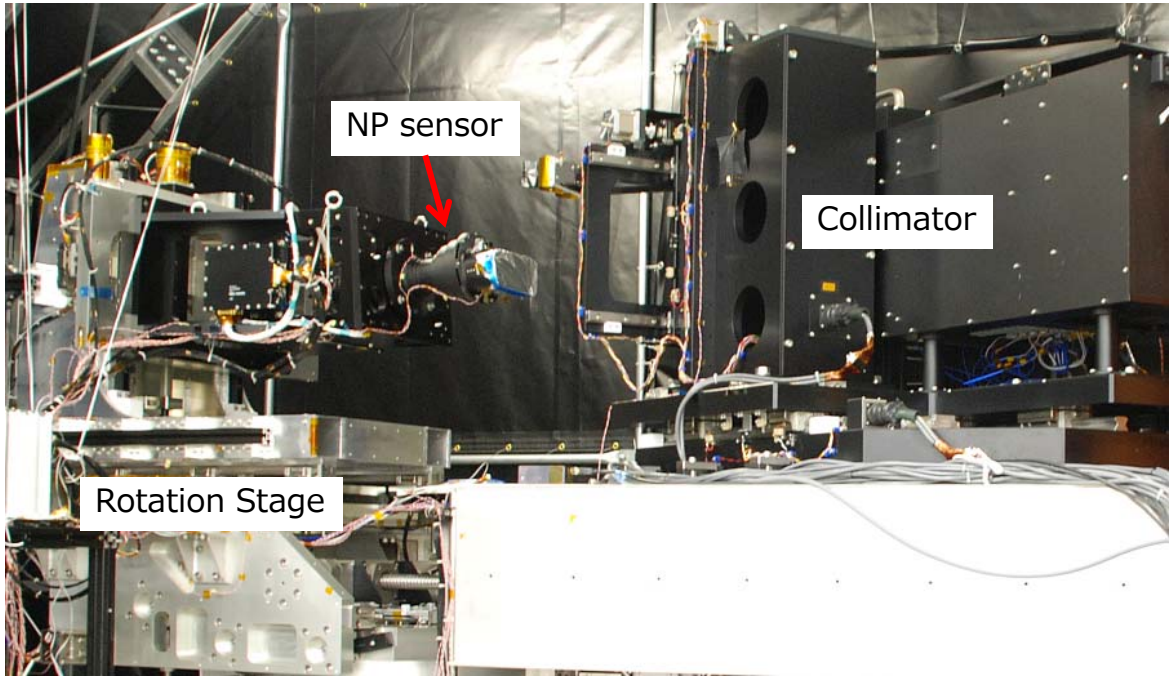
VNR SRU





Geometric Test

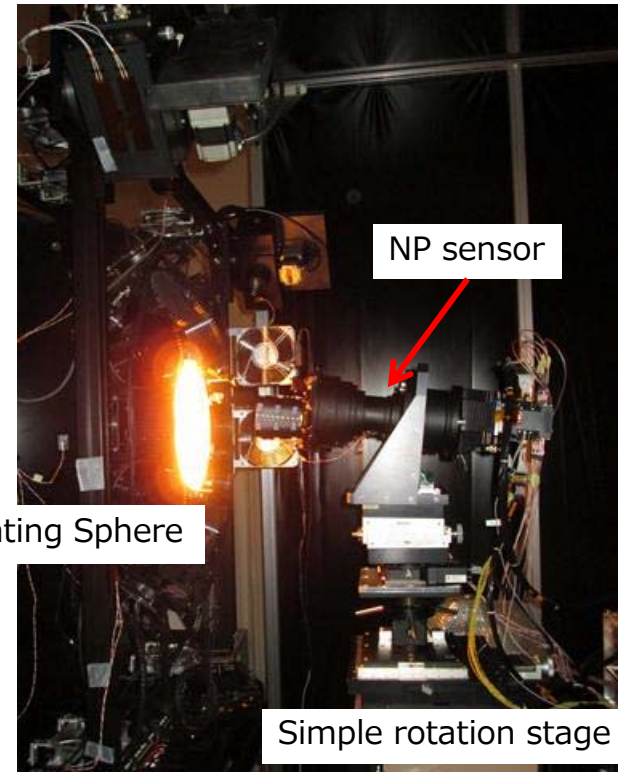
- NP/PL sensor Performance Test by Collimator
  - Geometric test
  - Polarization sensitivity of NP sensor
  - Muller Matrix for PL sensor
  - Stray light test / Stray light correction model

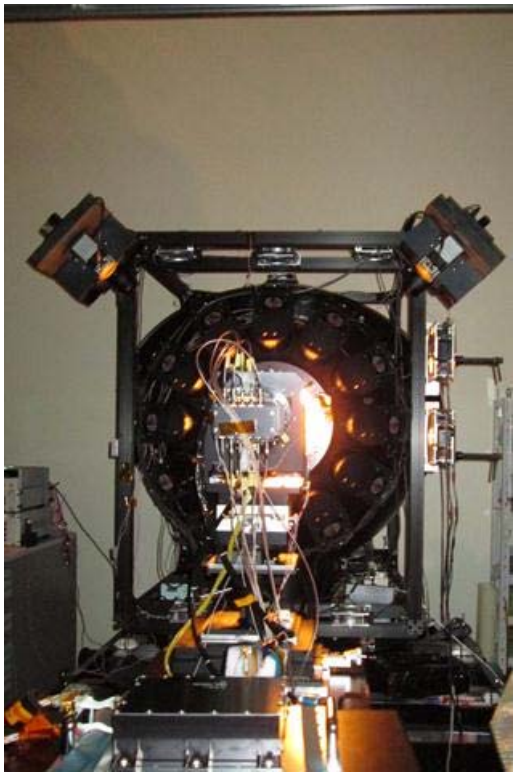


Rotation Stage : 6-axis (3-linear, 3-rotation)

Radiometric Test (Integrating Sphere)

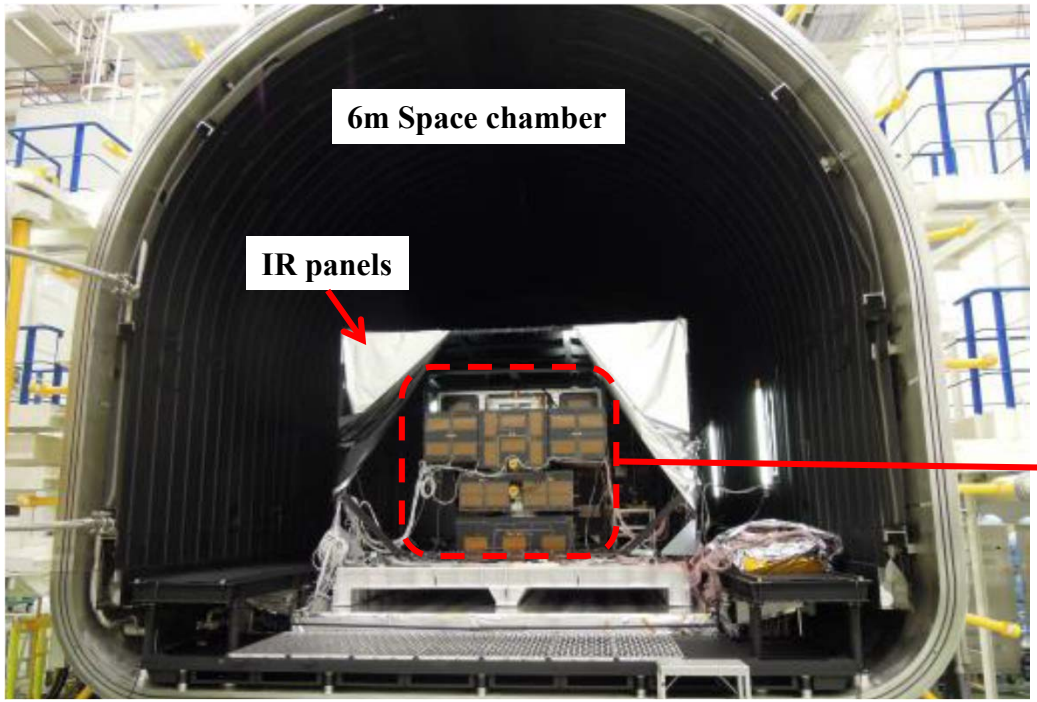
- Radiometric Performance Test by Integrating Sphere ; BaSO4, Spectralon(option)
  - Radiometric test for NP/PL sensor
  - Radiometric test for SRU

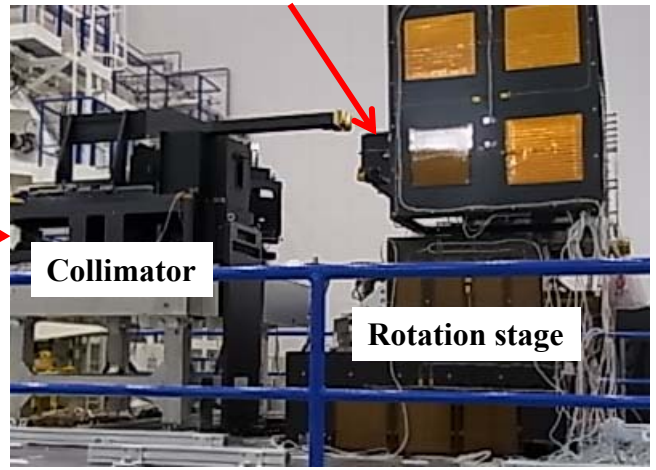




Thermal Vacuum Test

- Thermal Vacuum Test
  - Geometric test for NP/PL sub-unit
  - Radiometric test for NP/PL sub-unit



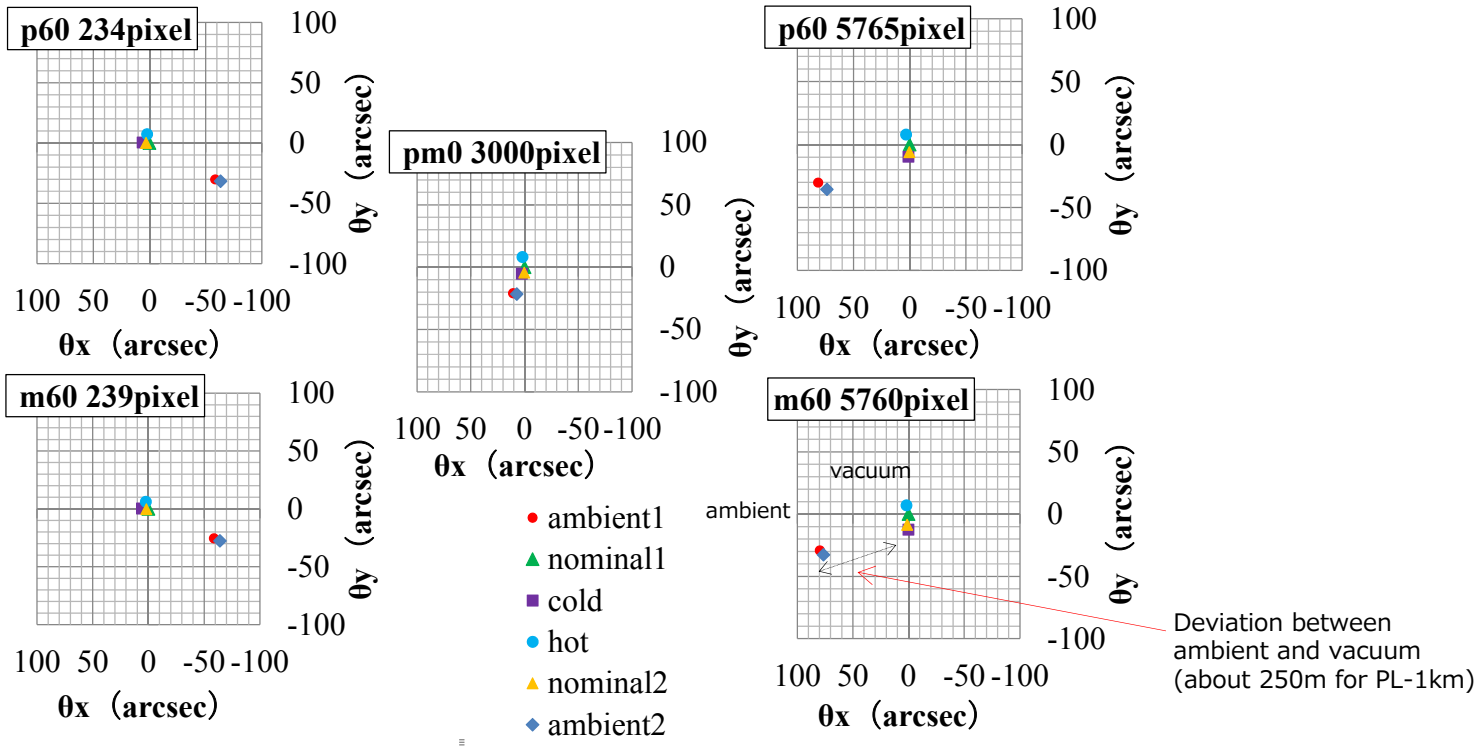


Collimator and Rotation stage are setting in the 6mφ Space chamber in TSUKUBA
Test condition : 6 (2-ambient, 4-vacuum)

Geometric Performance (Alignment)

■ CCD view angle measurements and verification

✓ Ambient and Thermal Vacuum environment



◆ Note

View angles are stable in thermal vacuum condition. (20~30℃)

The deviation between ambient and vacuum is due to the change of focal length.

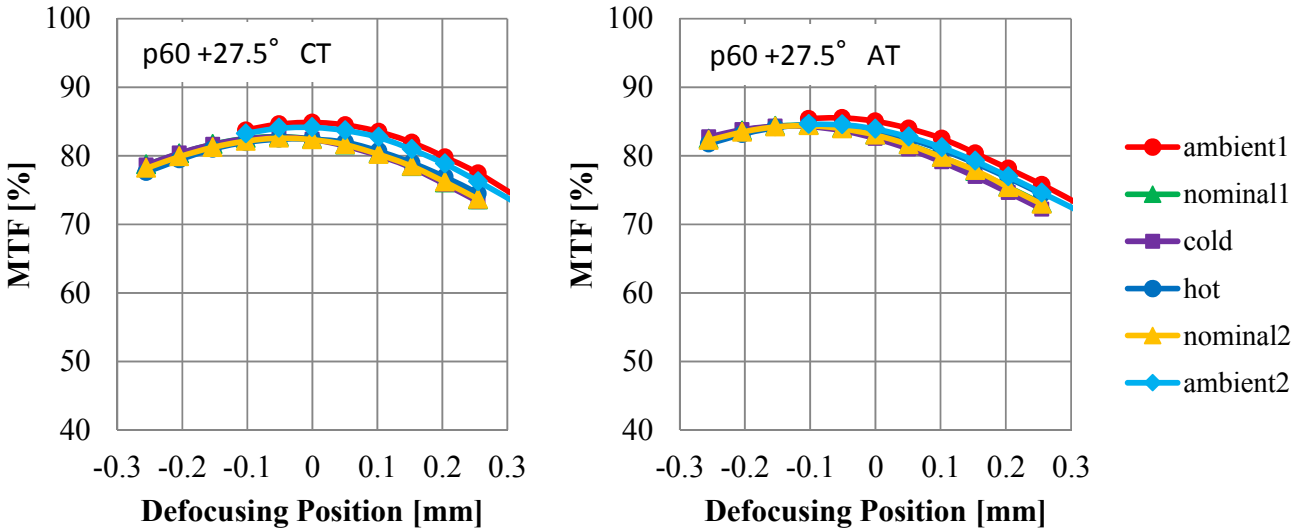
The data for geometric model are acquired.

Geometric Performance (MTF)

■ MTF defocus

Following figures show the MTF defocus trend data.

Data point : PL2 sensor, +60° of pol. angle, +27.5° of view angle



The ambient data are the corrected value due to the vacuum shift of focal length

◆NOTE

MTF defocus is stable in thermal vacuum condition. (20~30℃)

MTF peak is almost 0 defocusing position, it means CCD position is suitable.

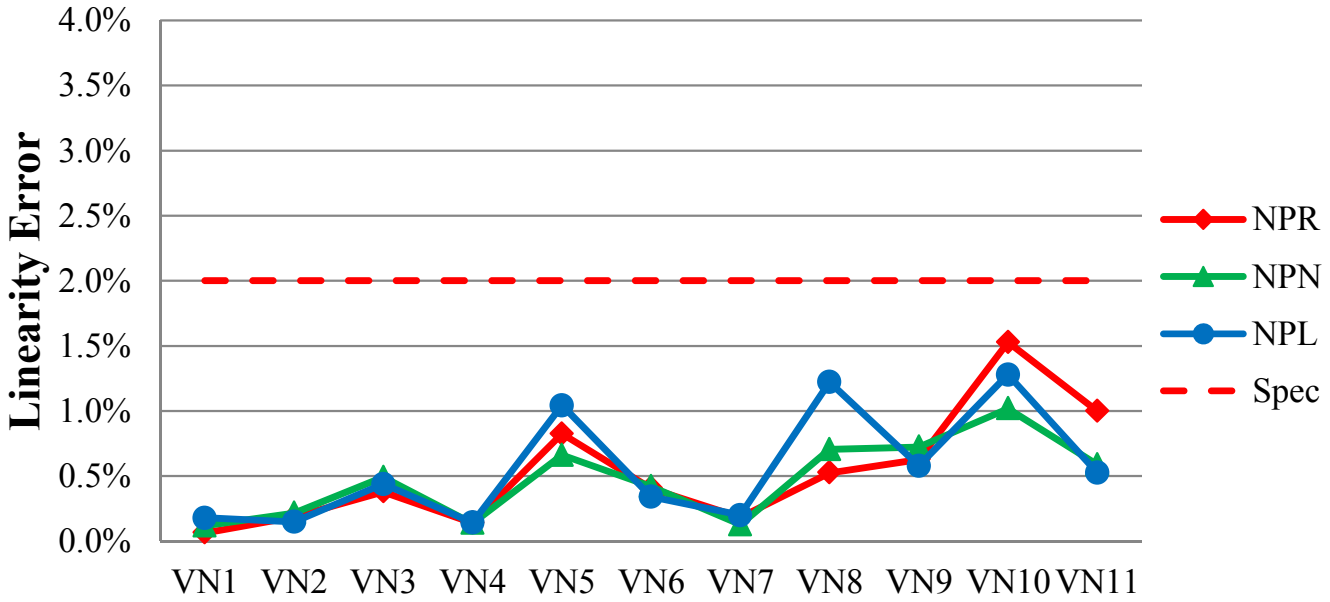
MTF value attains high resolution of >80%.

Radiometric Performance (Linearity)

■ Linearity error

Test condition : TVT nominal2 data, 0.3L_{std} ~ L_{max} of radiance

Plot data : worst deviation values



◆Comment

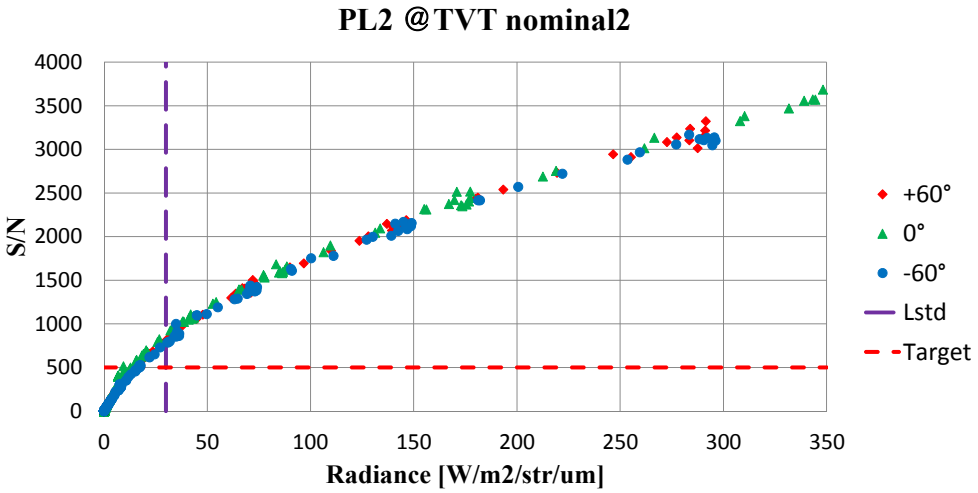
The data satisfies within 2%. (requirement)

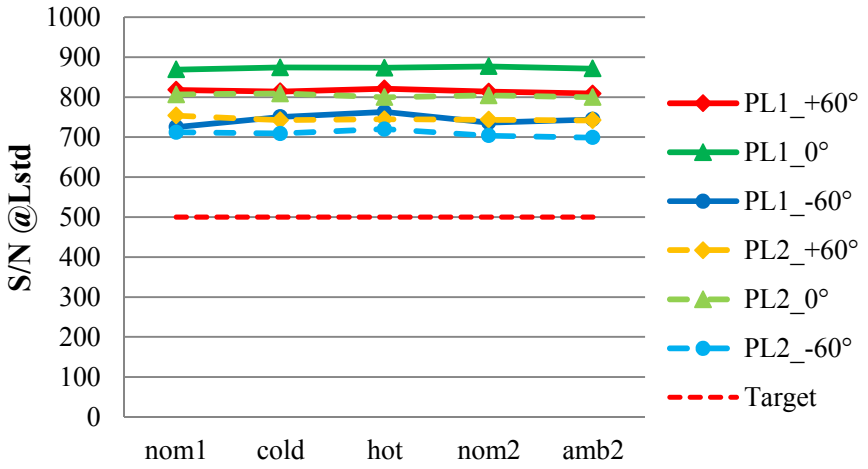
The final data will acquire at the final performance test of SRU PFT.

Radiometric Performance (SNR)

■ SNR

PL sub-unit TVT results in TVT tests.





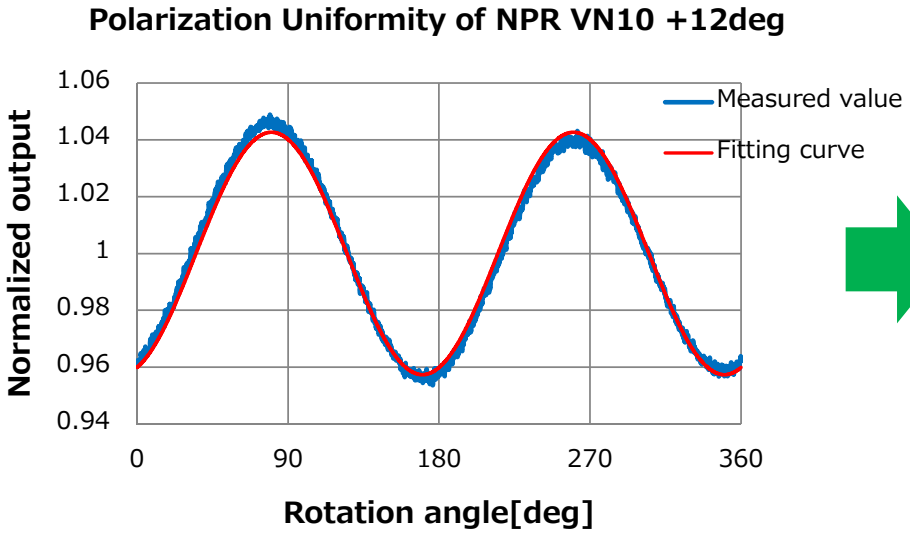
◆Comment

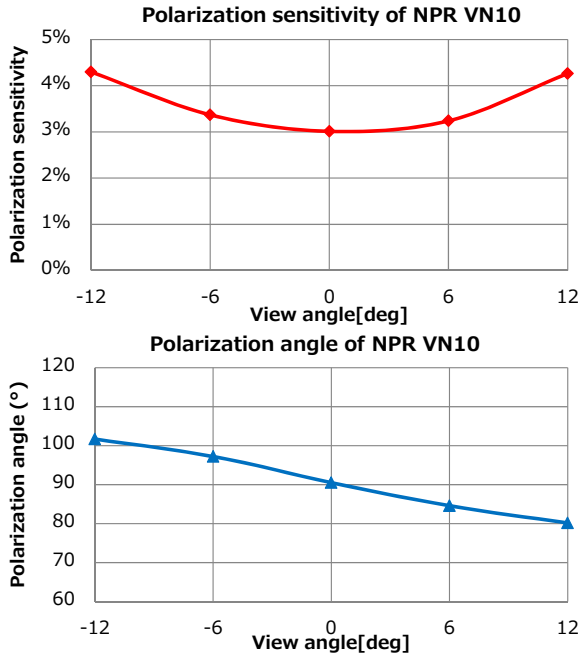
The SNR data satisfies >500.
(SNR 500 comes form polarization accuracy requirements)

The final data will acquire at the final performance test of SRU PFT.

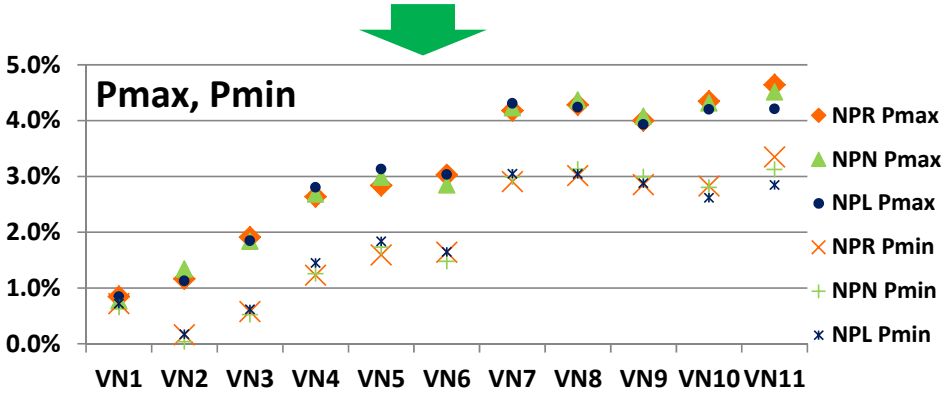
Polarization Sensitivity for NP sensor

◆Polarization measurements using the linear polarizer.
  a) Polarization sensitivity
  b) Polarization direction





◆Polarization sensitivity exceeds 3% target in RED and NIR channels as predicted from EM test results.
  → Sensitivity Model req. in the retrieval algorithm.



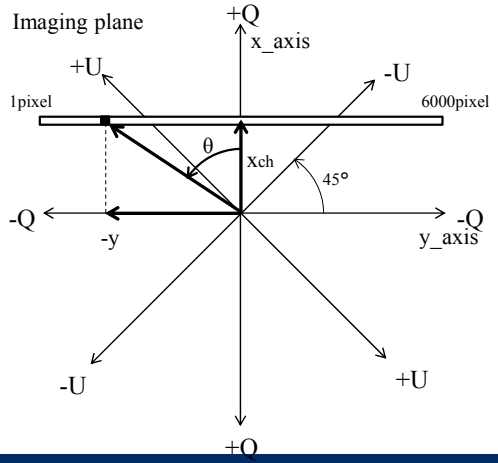
Polarization Sensitivity for NP sensor (Model)

Model parameter ρ_c, ρ_{max} for Stokes Q and U componets

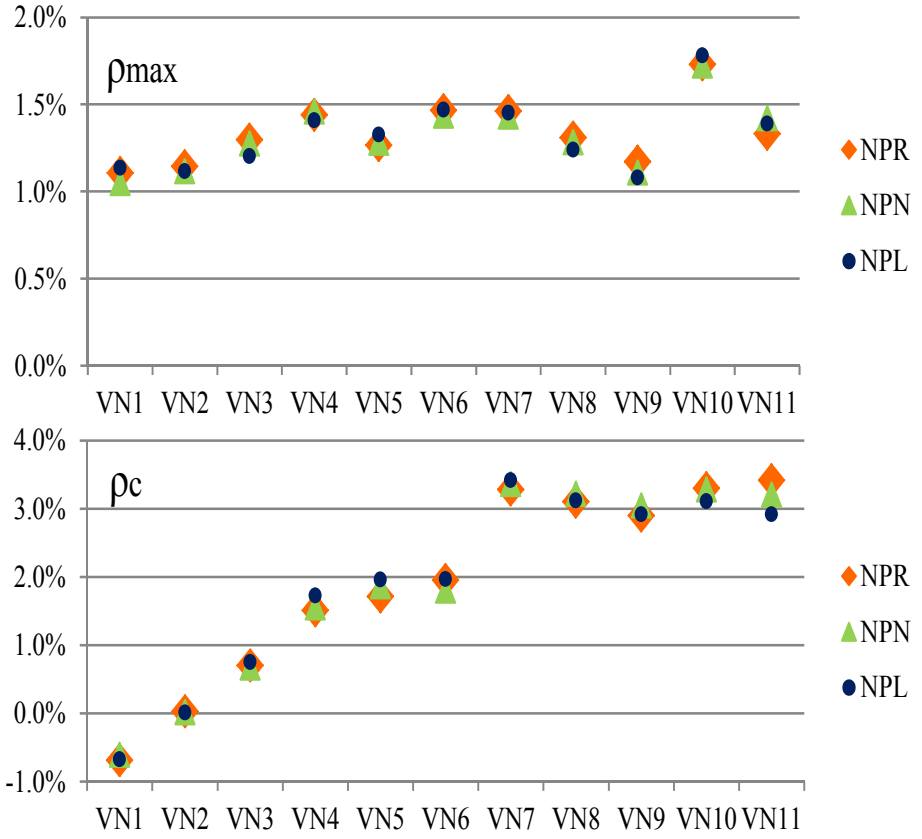
$$Q = \frac{-\rho_c + \rho_l \cos 2\theta}{1 - \rho_c \rho_l \cos 2\theta} \qquad U = \frac{(1-\rho_c)\rho_l \sin 2\theta}{1 - \rho_c \rho_l \cos 2\theta}$$

$$\theta = \tan^{-1}\left(-\frac{y}{x_{ch}}\right) \qquad \rho_l = \frac{x_{ch}^2 + y^2}{x_{ch}^2 + y_{max}^2}\rho_{max}$$

ρ_c : Pol. sensitivity of CCD+BPF
ρ_l : Pol. sensitivity of telescope
ρ_{max} : Pol. sensitivity of telescope (maximum)
x_{ch} : channel (pixel) location for AT direction
y : pixel location for CT direction
y_{max} : pixel location for CT direction (maximum)



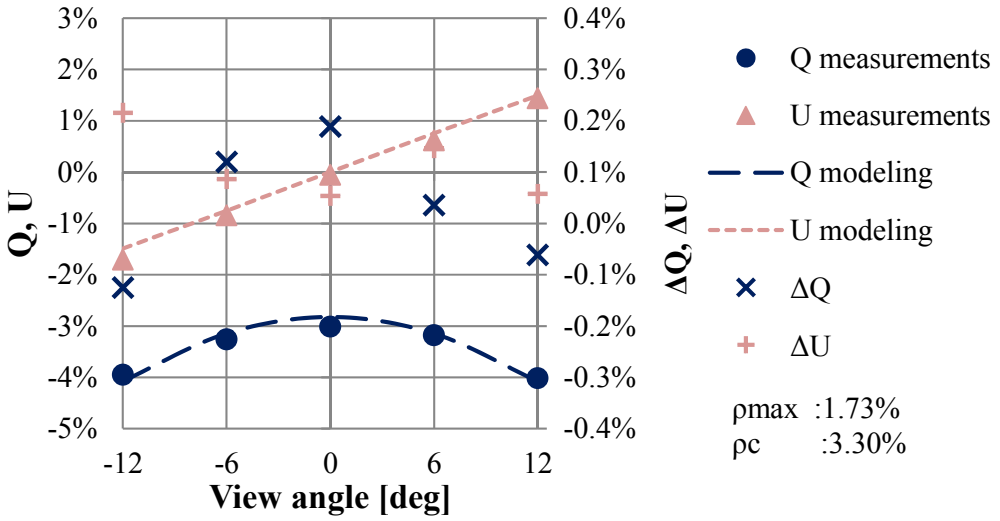
Coordinate definition

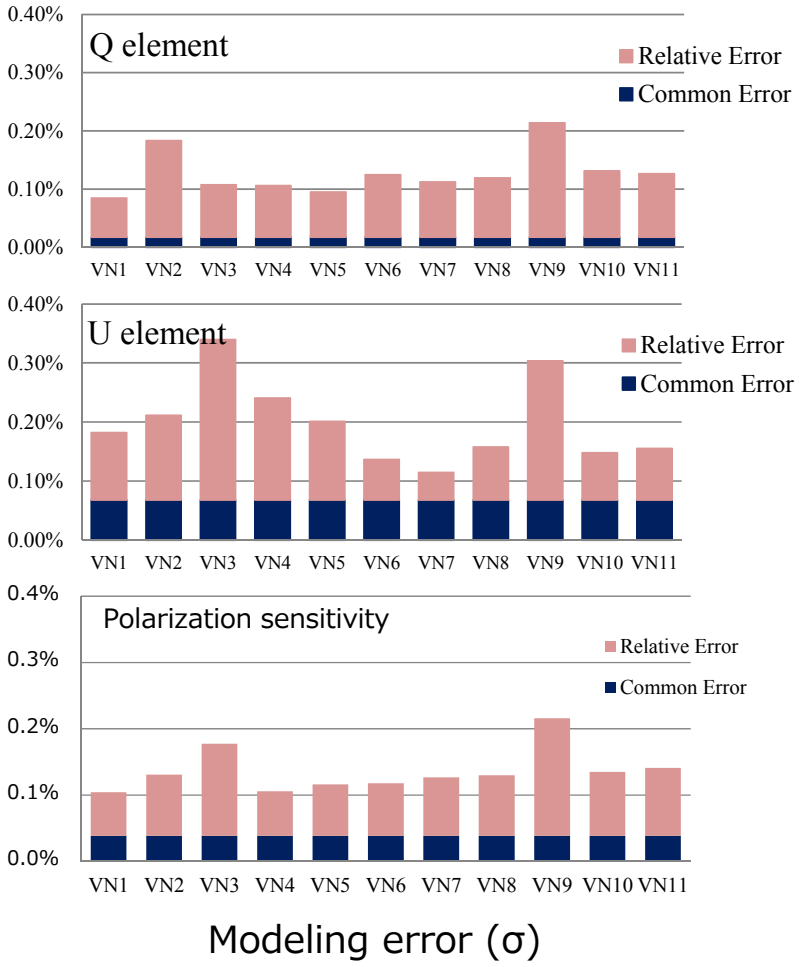


Polarization Sensitivity for NP sensor (Model Accuracy)

◆Modeling errors from 5 view angles data (3 for model, 2 for verification)

The model and the Modeling error of NPR VN10





Modeling error (σ)

◆Results

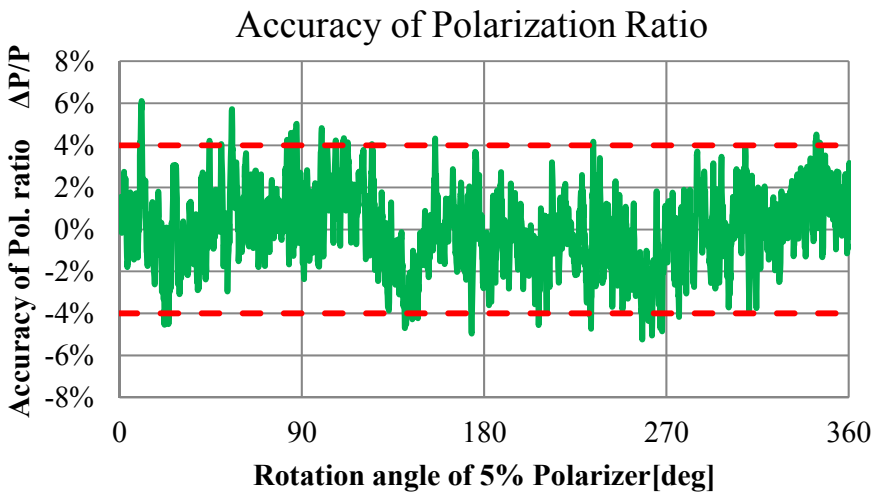
Q, U modeling are realized with sufficient accuracy comparing to the req.

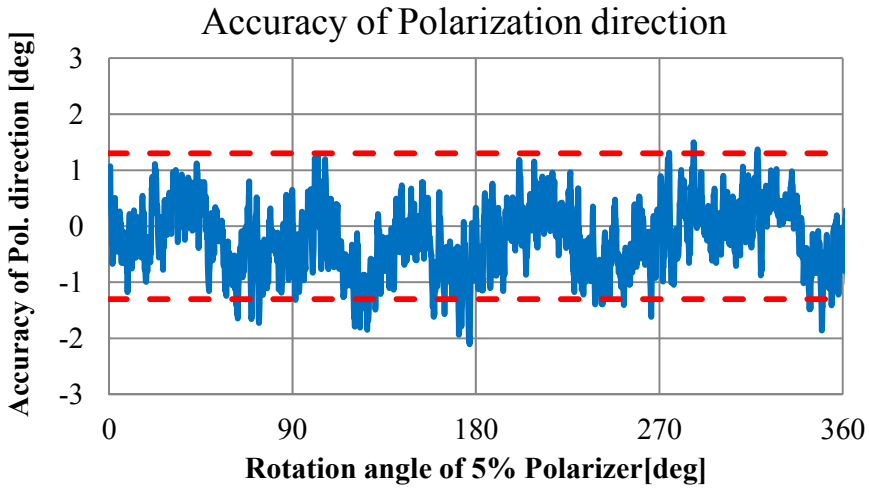
Relative errors between bands : <0.4%
Band-common errors : <0.6%

Polarization Observation Accuracy for PL sensor

◆Target Accuracy
Pol. ratio (ΔP/Pstd) : <4%
Pol. direction : <1.3˚
Incident light : standard radiance of Lstd, standard pol. ratio of 5% at any direction

◆ Results from the PL sensor test (PL2, view angle of +0.5˚ , at Lstd Input)





◆Comment
Measurement accuracy of pol. is realized within the target mostly. (initial analysis)
The final analysis of the accuracy will carry out applying the SRU radiometric data.

Conclusion

- Test results of VNR-SRU PFM met the requirement.
- Precise sensor models are analyzed for the data processing
  - ✓Geometric model
  - ✓Radiometric gain
  - ✓Polarization sensitivity model of NP sensor
  - ✓Mueller Matrix for PL sensor
- The final VNR test is now ongoing before the delivery to the satellite system.
  - ✓Mechanical Environmental Test (Vibration and Acoustic Excitation)
  - ✓Final Performance Test (Integrating Sphere, Calibration Test , … etc)
- Target launch in 2017