Development status of the Second-generation Global Imager (SGLI) on GCOM-C1

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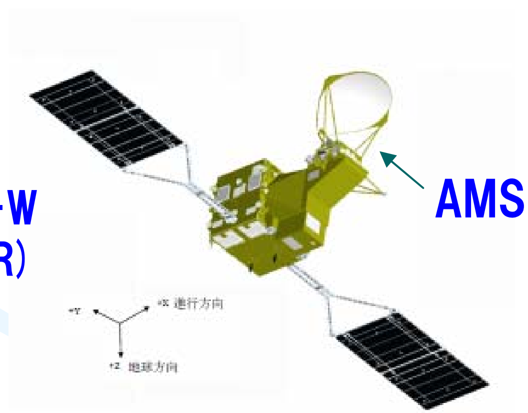
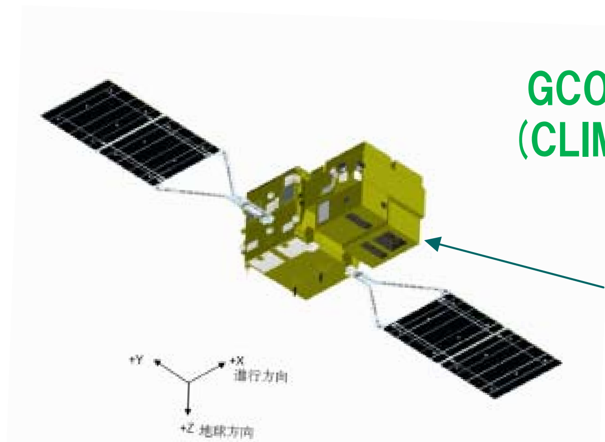
Contents

- Global Change Observation Mission (GCOM)
- SGLI on GCOM-C1 Satellite
- BBM Test Result of SGLI VNR
- BBM Test Result of SGLI IRS
- Current Status
- Conclusion

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

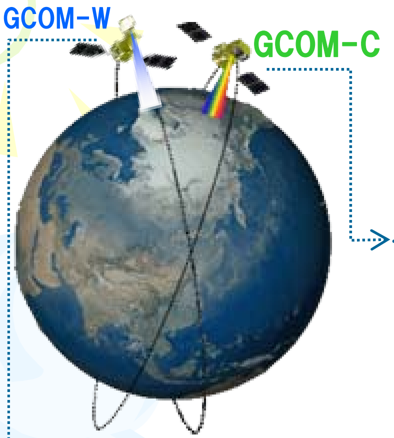
Sensor	**Second Generation Global Imager (SGLI)** Optical Observation 380nm – 12 micron Cloud, Aerosol, Vegetation, Chrolophl etc

GCOM Mission

GCOM observation

GCOM-W

GCOM-C



Frequent and long term (>10yer) global observation system

GCOM observation

Radiation budget
- Surface albedo
- Snow ice
- Cloud/ aerosol
- SST/ LST

Carbon cycle
- Vegetation cover
- Primary production
- Coastal environment

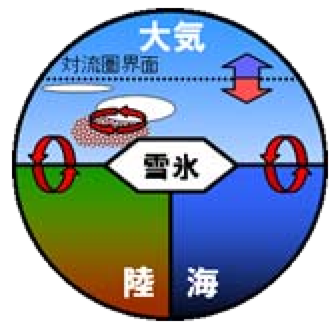
Water cycle
- Water vapor, cloud, precipitation
- Soil moisture
- Sea ice, snow
- SST, wind

Input

Comparison

Model prediction

Climate system model



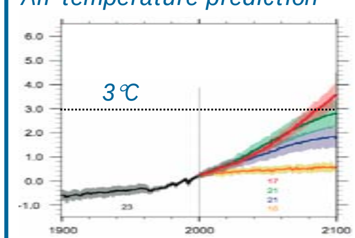
Improve accuracy

- Improvement of parameterization about radiation budget and carbon cycle, etc. in climate prediction model.
- Verification and improvement of prediction of the earth environment change including the water cycle by comparison with the satellite observation.

Prediction results

- Surface temperature
- Sea level
- Snow and sea ice area
- Environmental change
- Rain/drought distribution
- Extreme weather frequency
- Land cover

Air temperature prediction



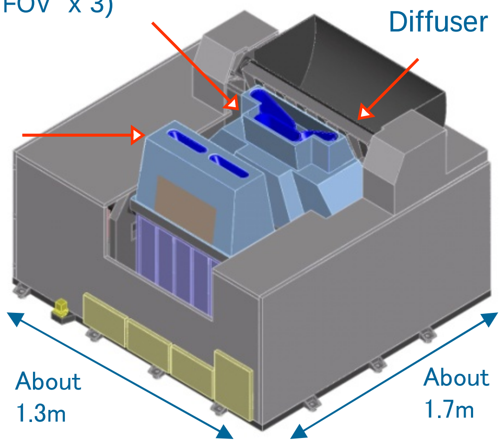
Data application → **Operational use for fishery, sea route, weather forecast, etc.**

Knowledge → **monitoring and understanding of the earth environment change**

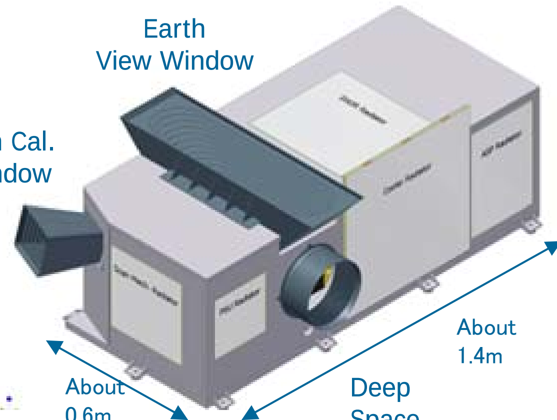
Future prediction → **Policy design through prediction improvement**

SGLI

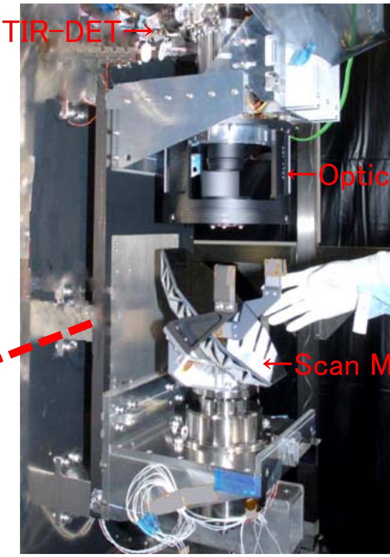
Second Generation Global Imager



Visible and Near Infrared Radiometer
(SGLI-VNR)



Infrared Scanning Radiometer
(SGLI-IRS)



SGLI IRS
Bread Board Model

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 (VNI) and 500m (T) spatial resolution and polarization/along-track slant view channels (P), 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 674nm and 869nm

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

SGLI channels

CH	λ	$\Delta\lambda$	L_{std}	L_{max}	SNR at Lstd	IFOV
	VN, P, SW: nm T: μm		VN, P: $W/m^2/sr/\mu m$ 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	8	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

Bread Board Model (BBM) Activity
Visible and Near infrared radiometer (VNR)

NEC/TOSHIBA
NEC東芝スペースシステム

Critical Technologies

- To Validate feasibility of the critical components

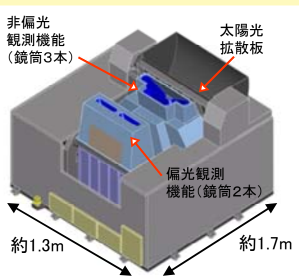
・Bandpass filters

・CCD

Complete

BBM System Design

-To establish SGLI system design to achieve observation requirement



Complete

BBM Component Tests

- To assess and demonstrate the observation performances by component level

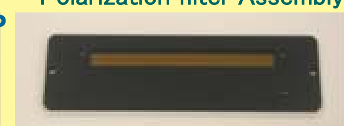
<Major BBM component>

・11line CCD

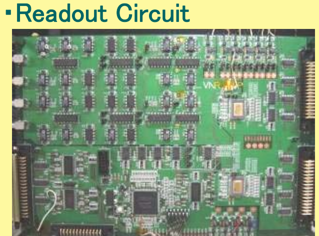
・Bandpass filter Assembly

・Optics

・Polarization filter Assembly



・Readout Circuit

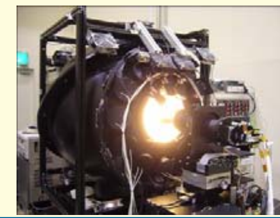


Complete

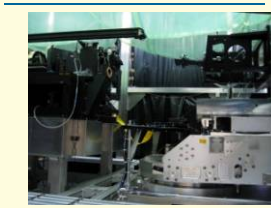
BBM System Tests

- To assess and demonstrate the observation performances by system level

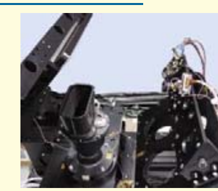
Radiometric Tests



Geometric Tests



Tests with onboard calibrators



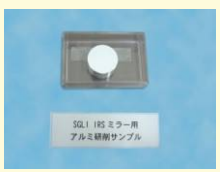
Complete

Bread Board Model (BBM) Activity
Infrared Scanning radiometer (IRS)

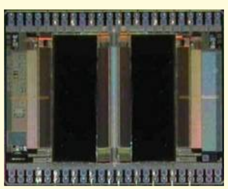
NEC/TOSHIBA
NEC東芝スペースシステム
Global Change Observation Mission

Critical Technologies

- To Validate feasibility of the critical components



・Mirror Sample

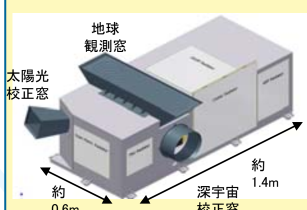


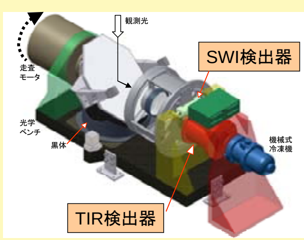
・TIR detector

Complete

BBM System Design

-To establish SGLI system design to achieve observation requirement





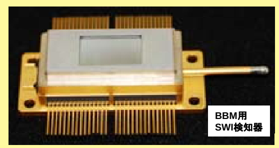
Complete

BBM Component Tests

- To assess and demonstrate the observation performances by component level

〈Major BBM component〉

・SWIR Detector

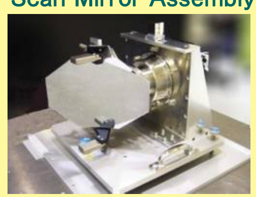


・TIR Detector

・Optics

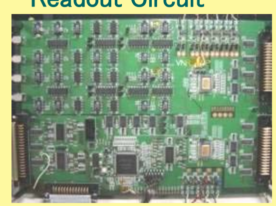
・Mechanical Cooler

・Scan Mirror Assembly



・Blackbody

・Readout Circuit

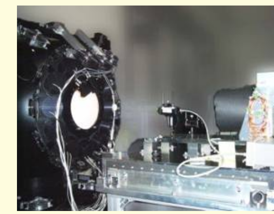


Complete

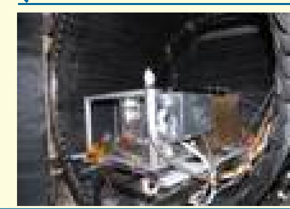
BBM System Tests

- To assess and demonstrate the observation performances by system level

SWIR Radiometric Tests



TIR Radiometric Tests (Vacuum condition)



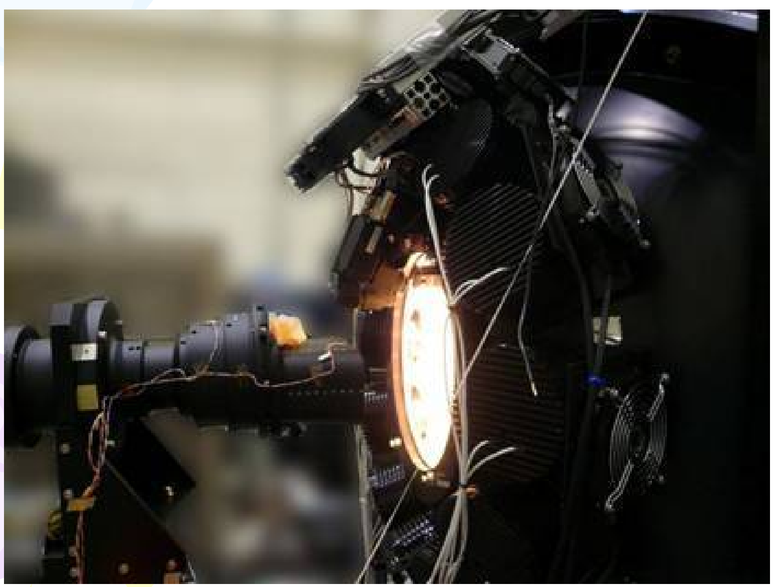
Geometric Tests

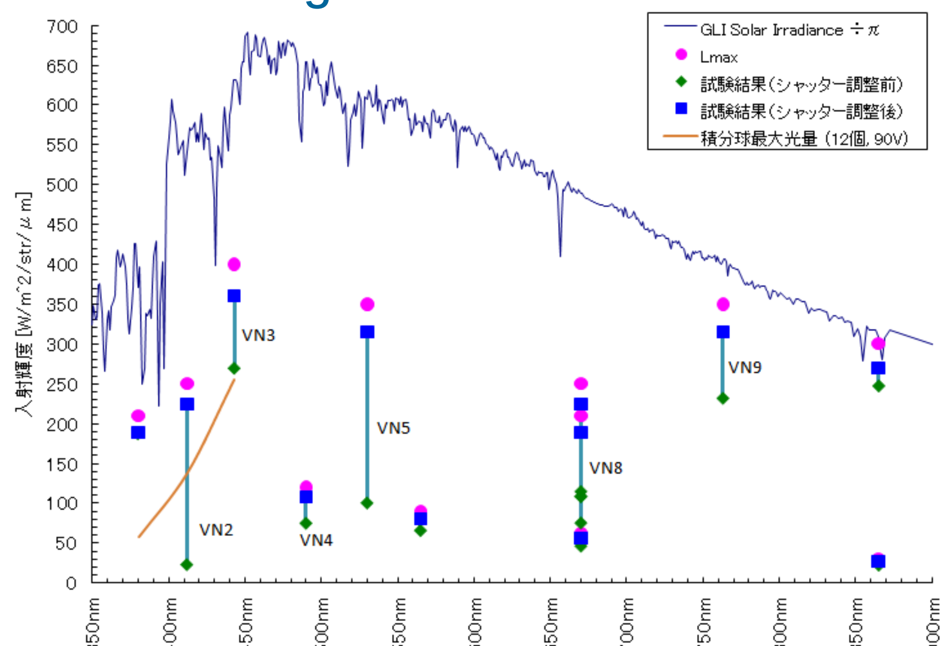
Tests with onboard calibrators

Complete

BBM test results of VNR Dynamic Range

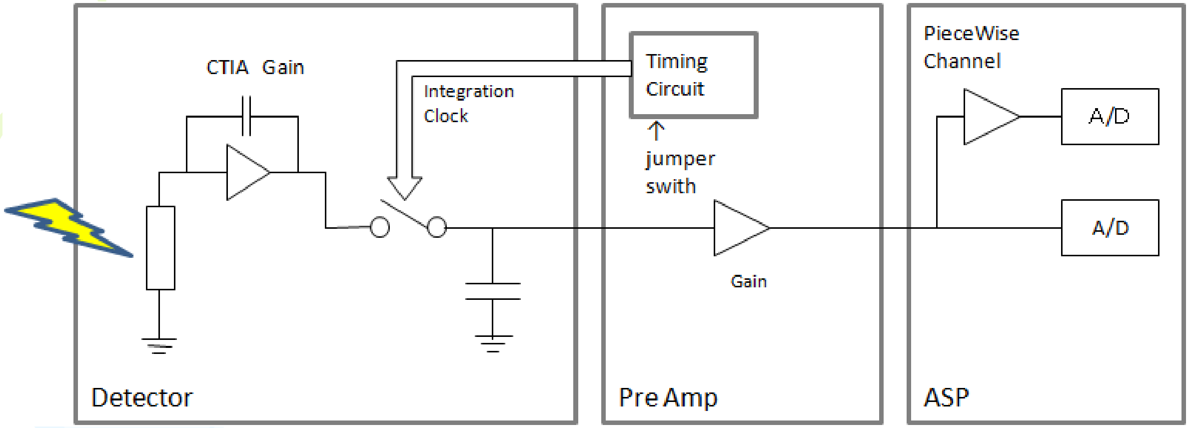
- VNR dynamic range requirement is set based on careful study of target characteristics.
- VNR uses CCD. Integration time can be easily changed by command.
- This means dynamic range adjustment is possible.
  - ✓ Difference between design and manufacturing results such as transmittance of optics can be adjusted
  - ✓ Dynamic range modification can be changed even after launch
  - ✓ Calibration technique using different integration time.

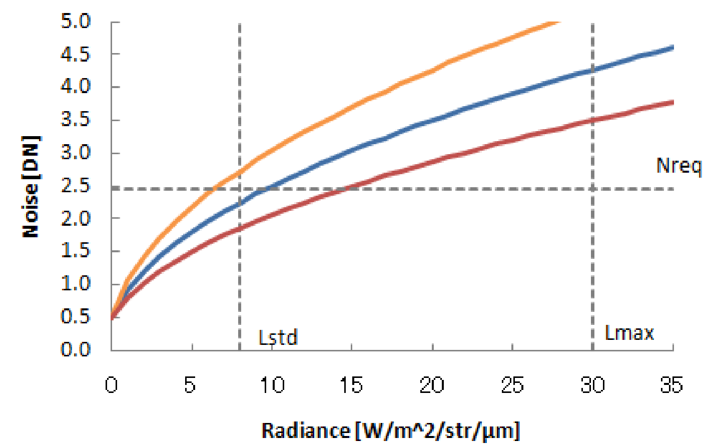




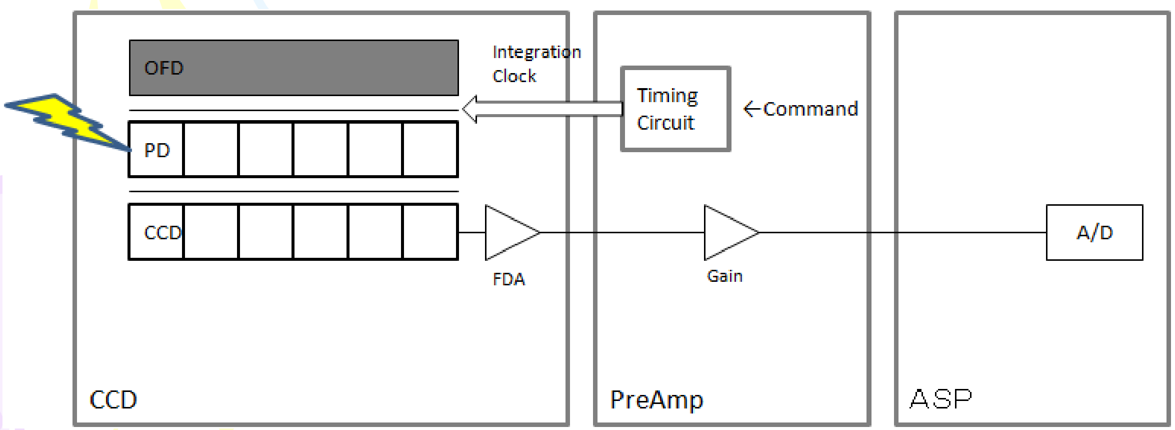
BBM test results of VNR CCD Integration Time

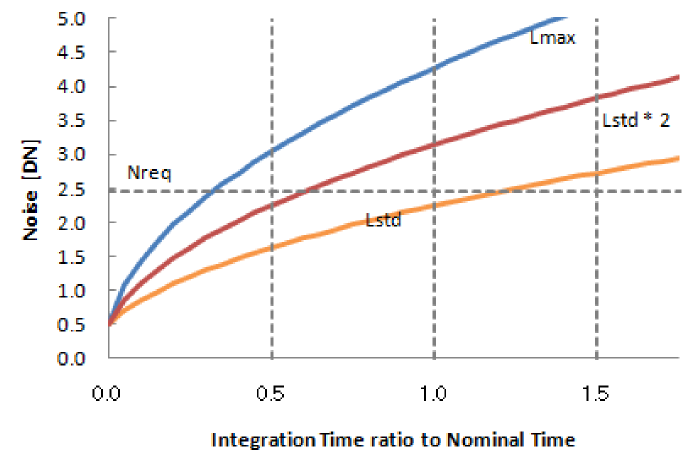
Previous GLI design





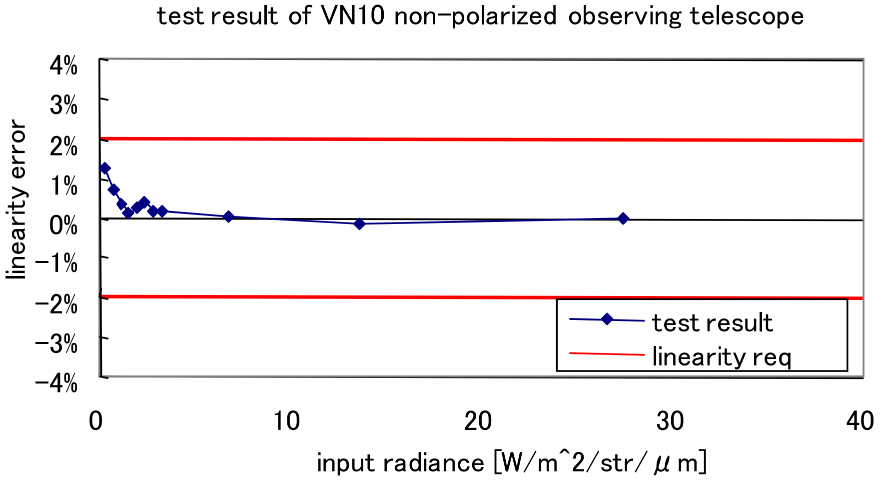
SGLI VNR design

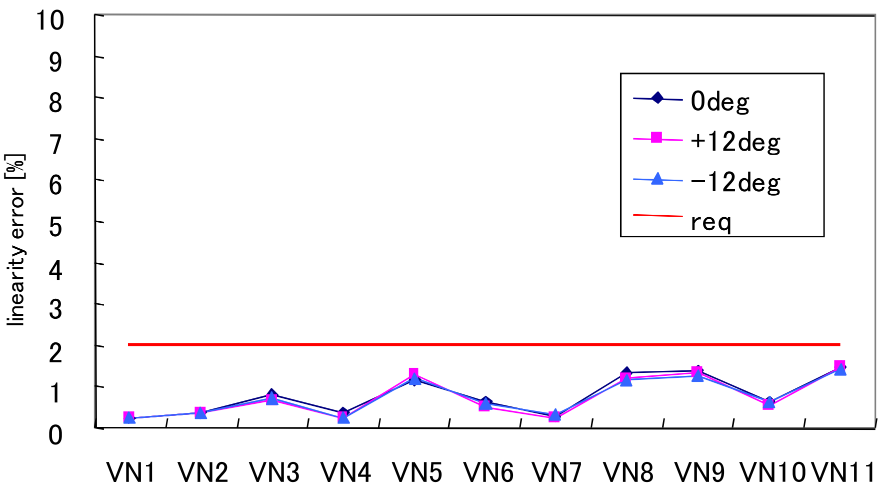




BBM test results of VNR Linearity

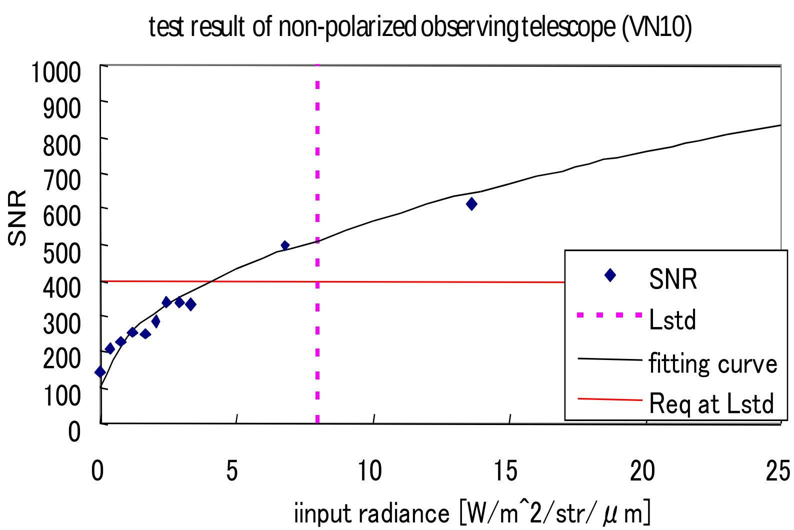
- Linearity is very important for radiometer because it leads to accuracy dependencies to input radiance level.
- Also, the test methodology using integration time above mentioned uses the assumption that sensor is very linear.
- VNR BBM linearity is checked for both input radiance dependencies and integration time dependencies.
- Test result is very good and further detailed analysis is conducted to find the major non-linear element to improve.





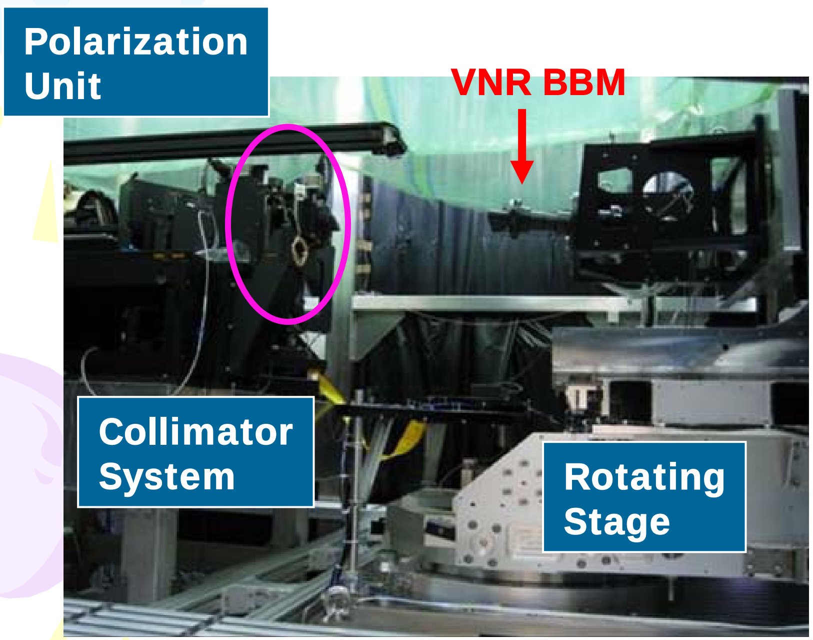
BBM test results of VNR Noise

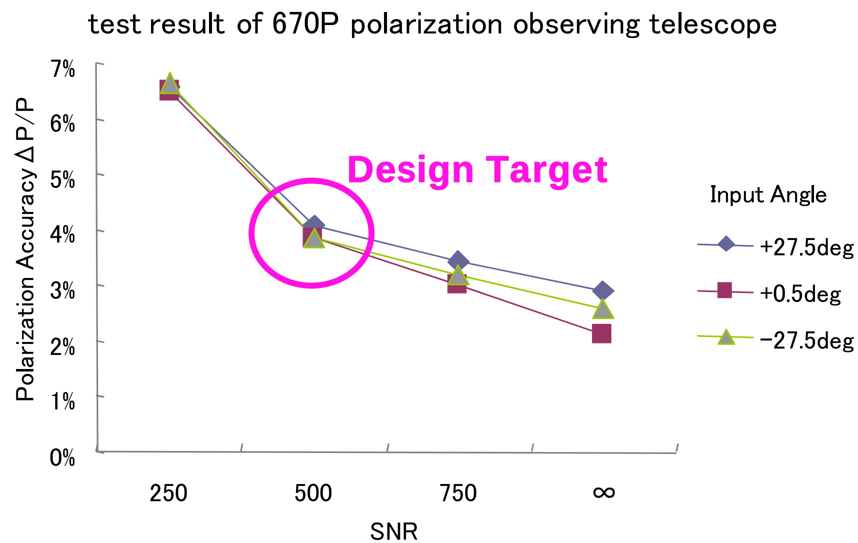
- SGLI noise performance is required as Signal to Noise Ratio (SNR) at standard signal observation radiance (Lstd) for each observation channel.
- Both integration time dependence and input radiance for SNR was checked.
- The all channels noise level met the sensor specification.



BBM test results of VNR Polarized Light Observation

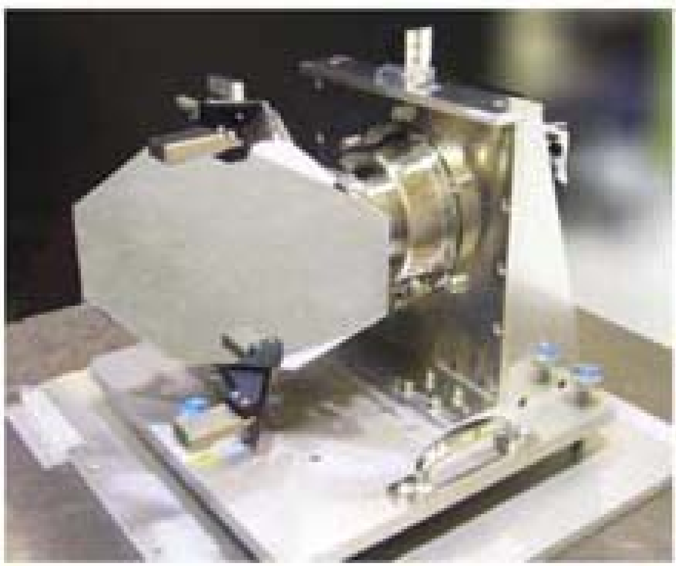
- The special polarization unit is set to the collimator light source. The collimator polarization characteristic is canceled with de-polarizer filter and polarized unit can be rotated around the optical axis to realize the desired polarized direction for both linear and partially polarized light.
- As the result of BBM test, approximately 4% polarization observation accuracy (ΔP/Pstd) and 1.3deg polarization direction error is confirmed for the 670nm polarization observing telescope with standard 5% polarized light (Pstd).

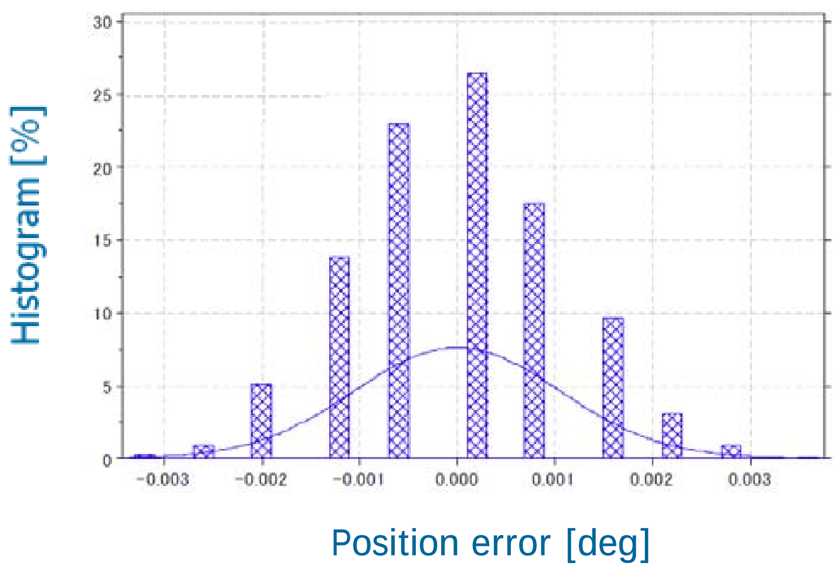




BBM test results of IRS Scanning Performance

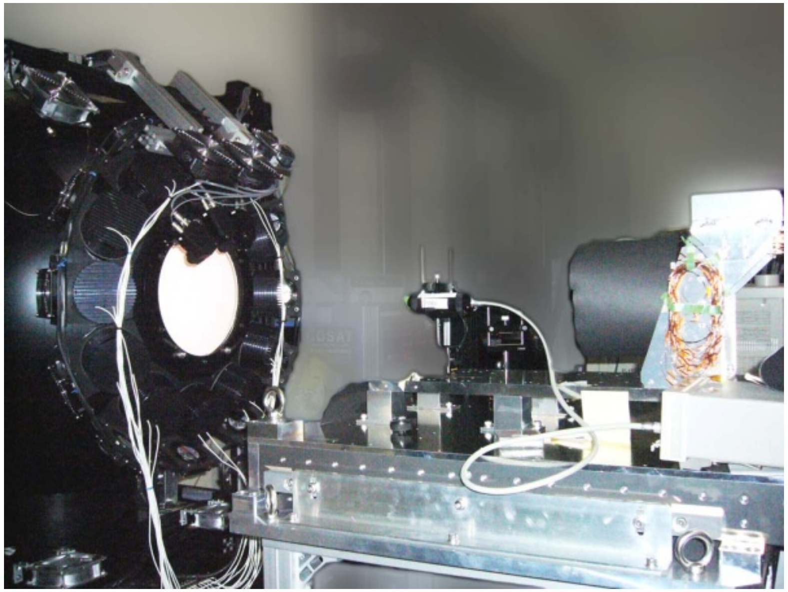
- Because very stable rotating speed is important for sensor observation geometry, the centroid position error and product of inertia should be minimized.
- Manufacturing error and assembly process were carefully studied and confirmed. The friction learning technique in the rotation speed control loop is also applied.
- The selection of the bearing unit is another key issue for the IRS 5years operation requirement. The bearing lifetime test under the vacuum condition was successfully completed for required 2.7 x 10^8 revolution operation and still under the test for the further design margin.

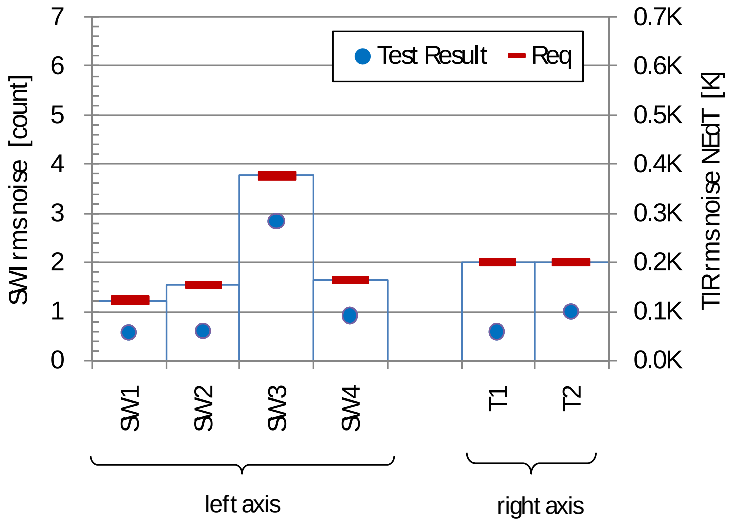




BBM test results of IRS SWI Radiometric Performance

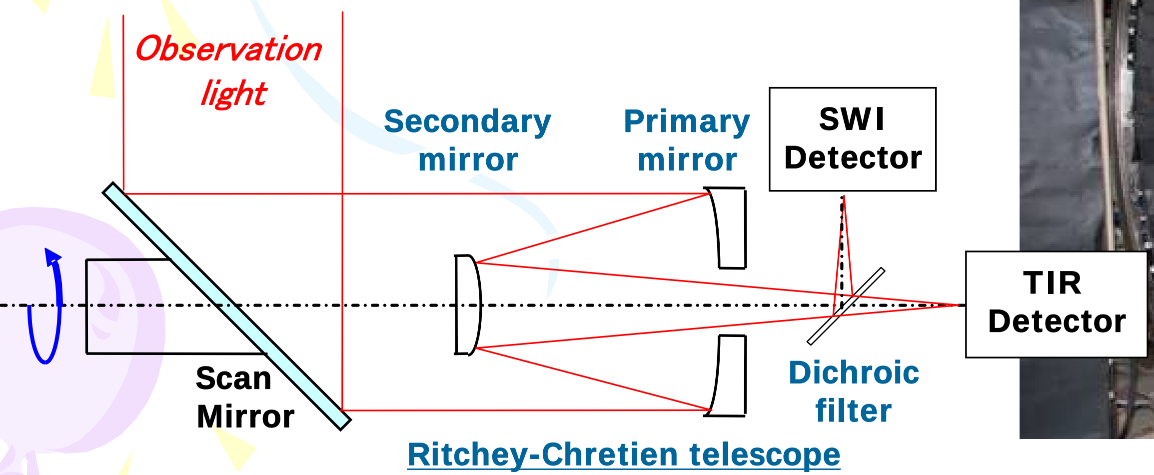
- SNR performance
  - ✓ high transmittance of telescope and filters
  - ✓ detector sensitivity
  - ✓ dark current of 2.2μm channel at operating -30deg C
  - ✓ System SNR performance
- Dynamic Range
  - ✓ adjustment at analog signal processor (ASP)
- EMC allowance limit
  - ✓ Trans Impedance Amplifier (TIA) for detector readout.
  - ✓ EMC test in the shield room for both RF radiation and conductive noise allowance

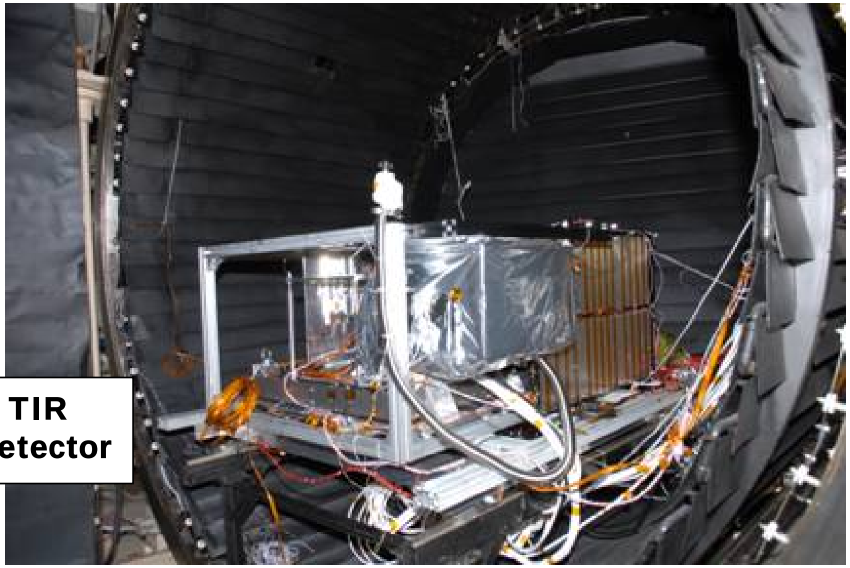




BBM test results of IRS TIR Radiometric Performance

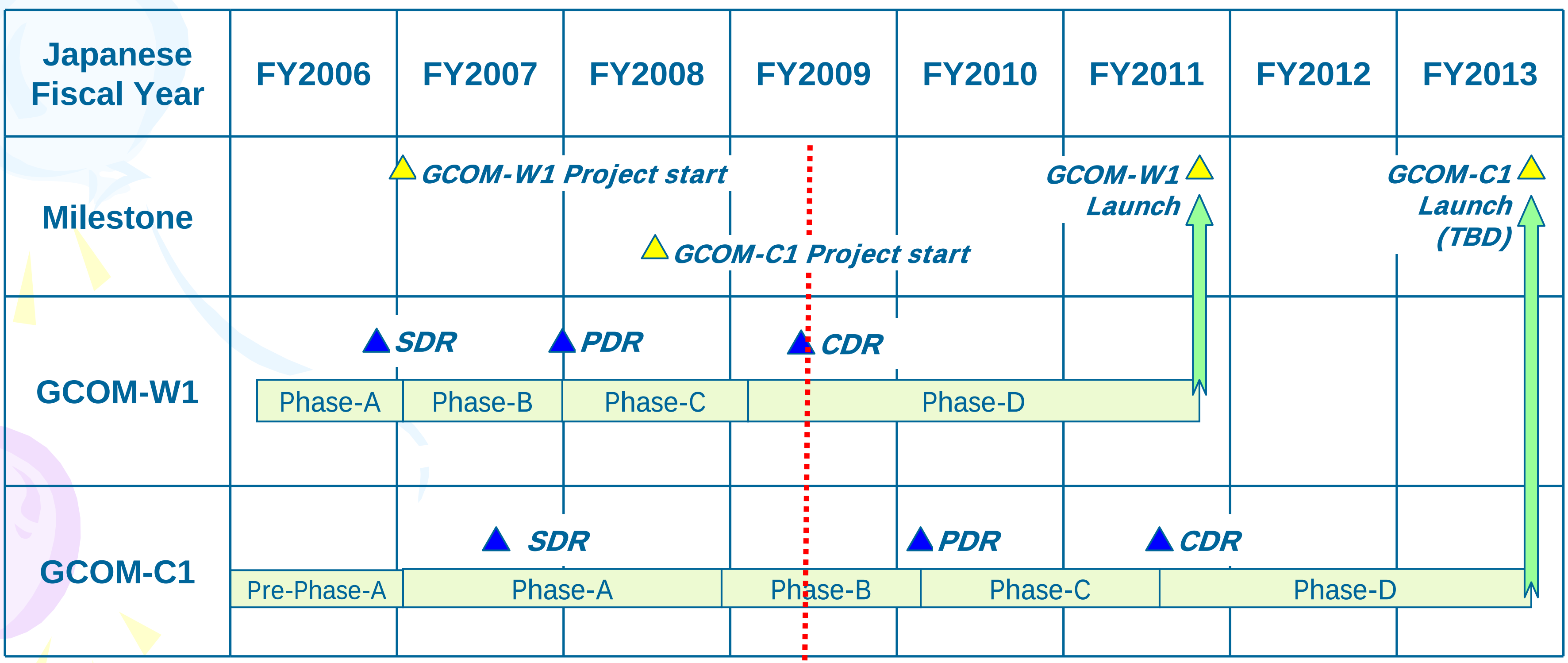
- Detector temperature & performance
  → special dewar for 55K
  → spectral characteristics at 55K
  → detector linearity
- Effects of sensor temperature around optical path
  → dynamic range design considering sensor temperature range
  → Thermal vacuum test to confirm the design.
- Dynamic range adjustment methodology
  → integrating capacity at ROIC
  → integration time
  → post amplifier gain (fixed)
- TIR system level test meets the noise requirement (NEdT). (previous page)





SGLI Current Status

- Based on the BBM successful test result the sensor Engineering Model (EM) design is on going.
- The manufacturing of EM starts soon. EM test will be conducted in next year, and sensor PFM manufacturing starts.
- The target launch of GCOM-C1 is JAN 2014.



Conclusion

- GCOM is JAXA's GEOSS contribution of global observation for water cycle, radiation budget and carbon cycle.
- SGLI is the optical sensor on GCOM-C1 satellite.
- Bread Board Model (BBM) design and test activity has successfully completed last year.
- The Engineering Model (EM) design is currently conducted.
- The EM testing including environmental test and I/F test with satellite system is planned in next year.