Development and testing of new CMOS

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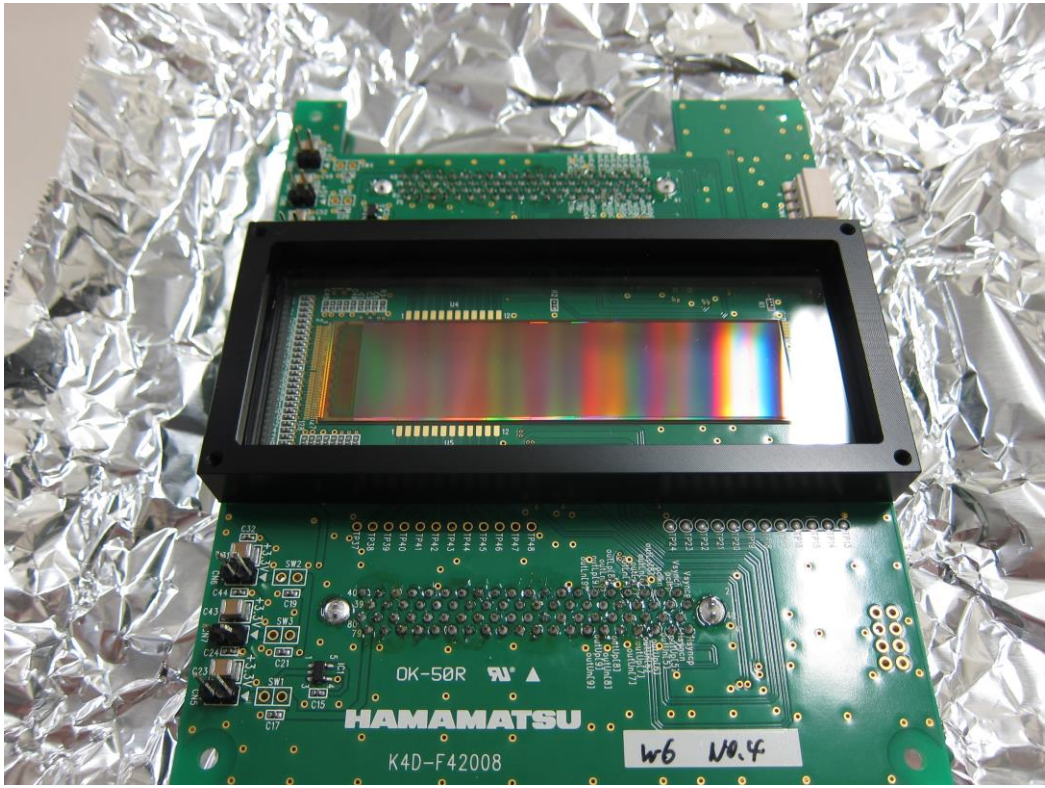
(NAOJ)
For CMOS Development Team

CMOS Sensor Prototyping

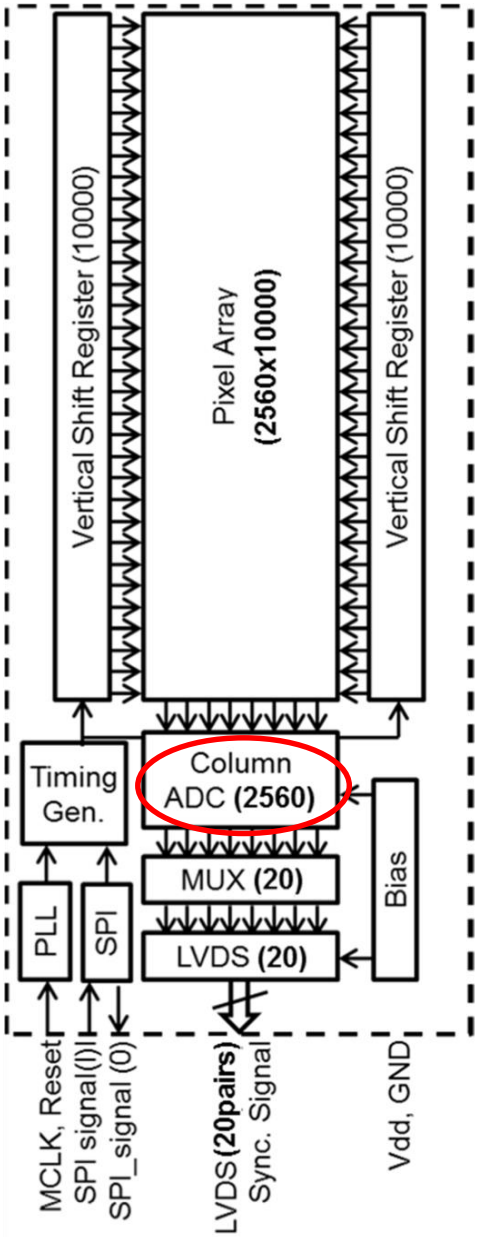
- Hamamatsu Photonics
- F.I. and B.I.
- 2,560 x 10,000 pixels
- 7.5 µm square pixel
- Full well ~ 30,000 e
- R.N. ~ 2 e
- Dark: 90 e/s/pix @ 300 K



- 10 Hz (-> 6.5 Hz, design flaw found, fixed now)

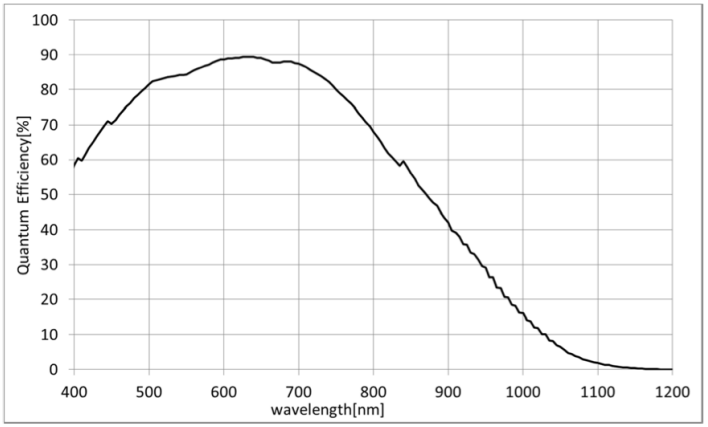
CMOS Sensor Prototyping

■ ブロック図



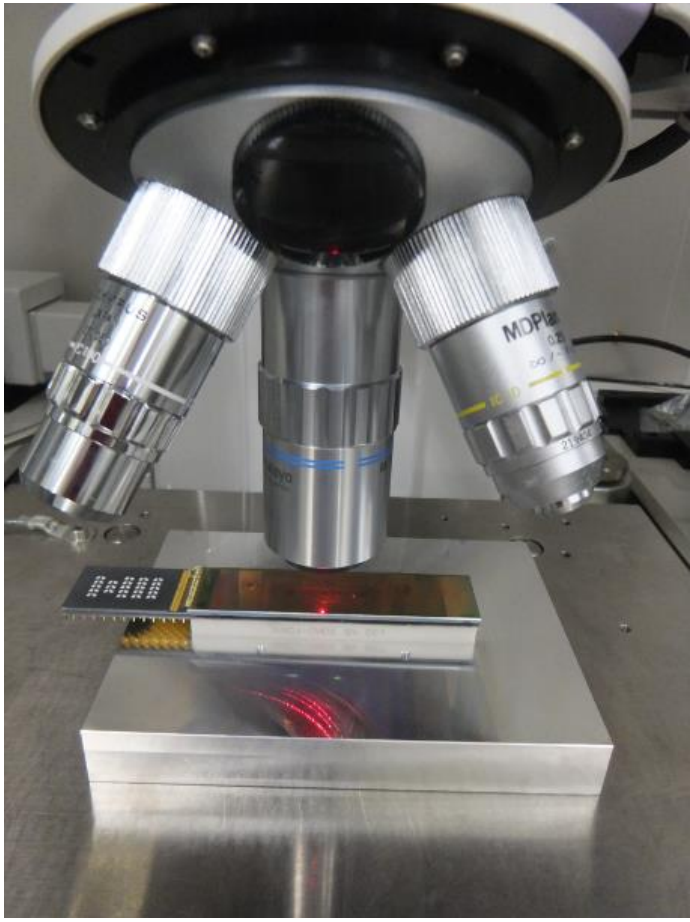
Item	Unit	Back Illuminated	Front Illuminated
Image Size	mm	19.20 x 75.00	
Pixel Size	μm	7.5	
Format	pixel	2560 x 10000	
Fastest Frame Rate	fps	6	10
Quantum Efficiency	%	>= 48 (400 nm) >= 60 (800 nm)	>= 5 (400 nm) >= 11 (800 nm)
Ratio of defect pixels	%	<= 5	
Resolution (*1)	μm	<= 5	<= 5
Dark Current	e / pixel / sec	<= 1000 (Room Temperature)	<= 200 (Room Temperature)
Read Noise (High Gain) (Low Gain)	e rms	<= 5 <= 30	<= 3 <= 25
Full Well (High Gain) (Low Gain)	e	>= 2000 >= 20000	>= 2000 >= 30000
Responsivity (High Gain) (Low Gain)	μV/e	640 40	
ADC Resolution	bit	10 (*2)	

■ 分光感度特性（代表例）



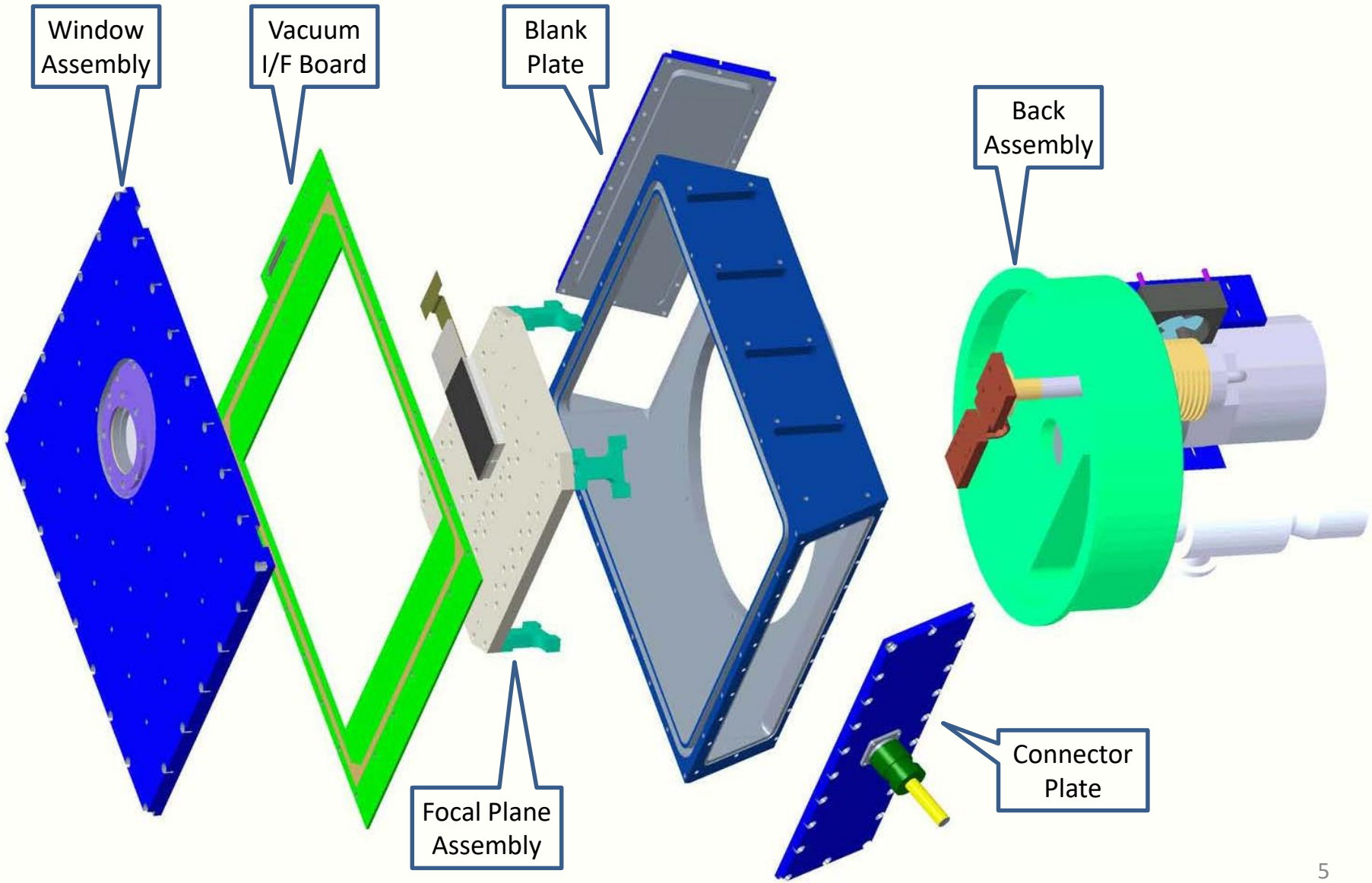
Our Recent Activity

- Aluminum Nitrite blocks with accurate dimension, which are worked as fiducial for the focal plane mosaicking, are manufactured and measured (Y.Kamata)
- CMOS Sensors are extensively tested in NAOJ (Y. Kamata)
  - Readout test (dark, full-well, linearity, etc.)
  - Height (flatness) measurement
- Custom-made readout electronics are made and tested in NAOJ (S.Miyazaki)
- Mechanical design of CMOS Camera and interface to telescopes are carried out (Y.Komiyama)
- Optical calculation, data analysis, etc. (S.Kawanomoto)
- The CMOS Camera was assembled and tested in this summer with 2 summer students



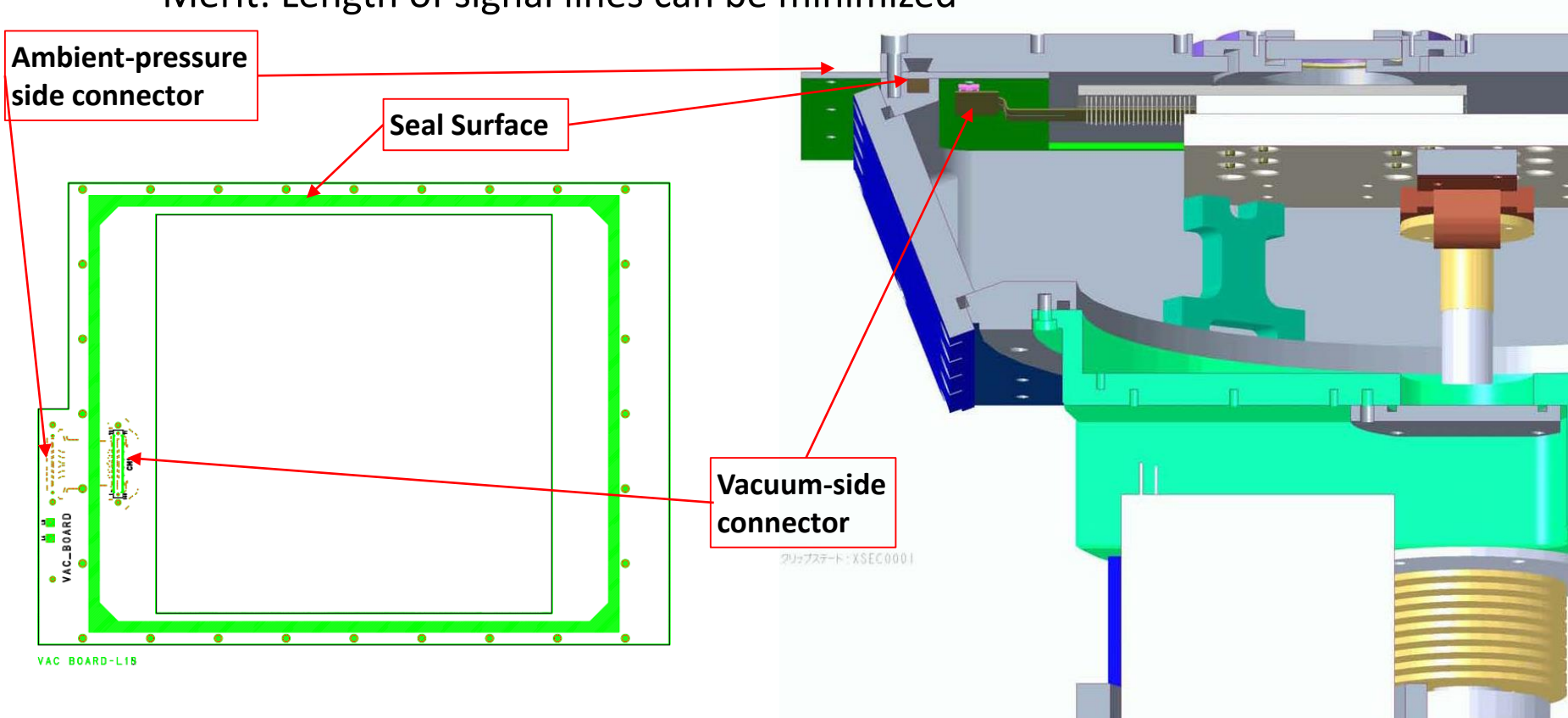
Flatness measurement of CMOS sensor

CMOS Camera Design

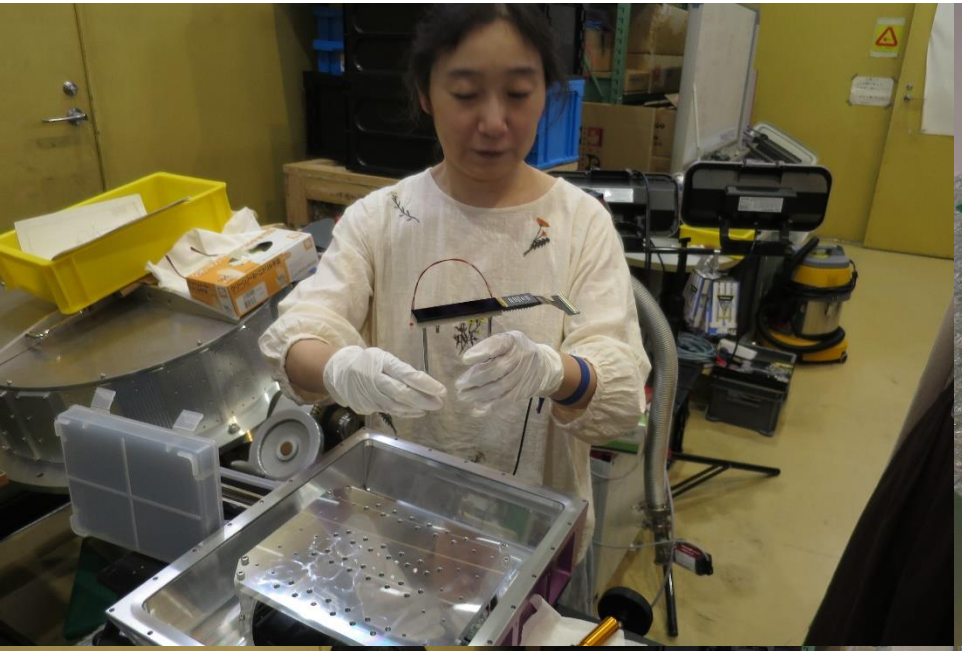


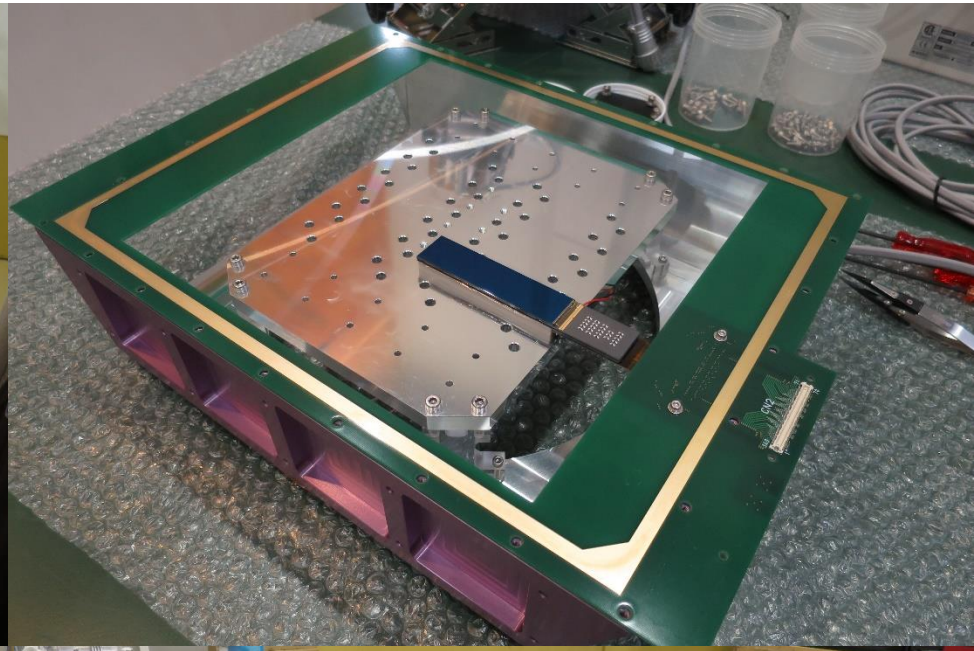
CMOS Camera: Vacuum I/F Board

- In general, hermetic connectors have been used for a vacuum feed-through
  - Expensive, number of pins are limited (1 CMOS requires >100 signal lines)
- Instead, we use PC Board as a vacuum feed-through
  - The PC board is sandwiched by O-ring seals from both side
  - Signal lines are embedded in the inner layers
  - Merit: Length of signal lines can be minimized



CMOS Camera Assembly (2019 Aug)





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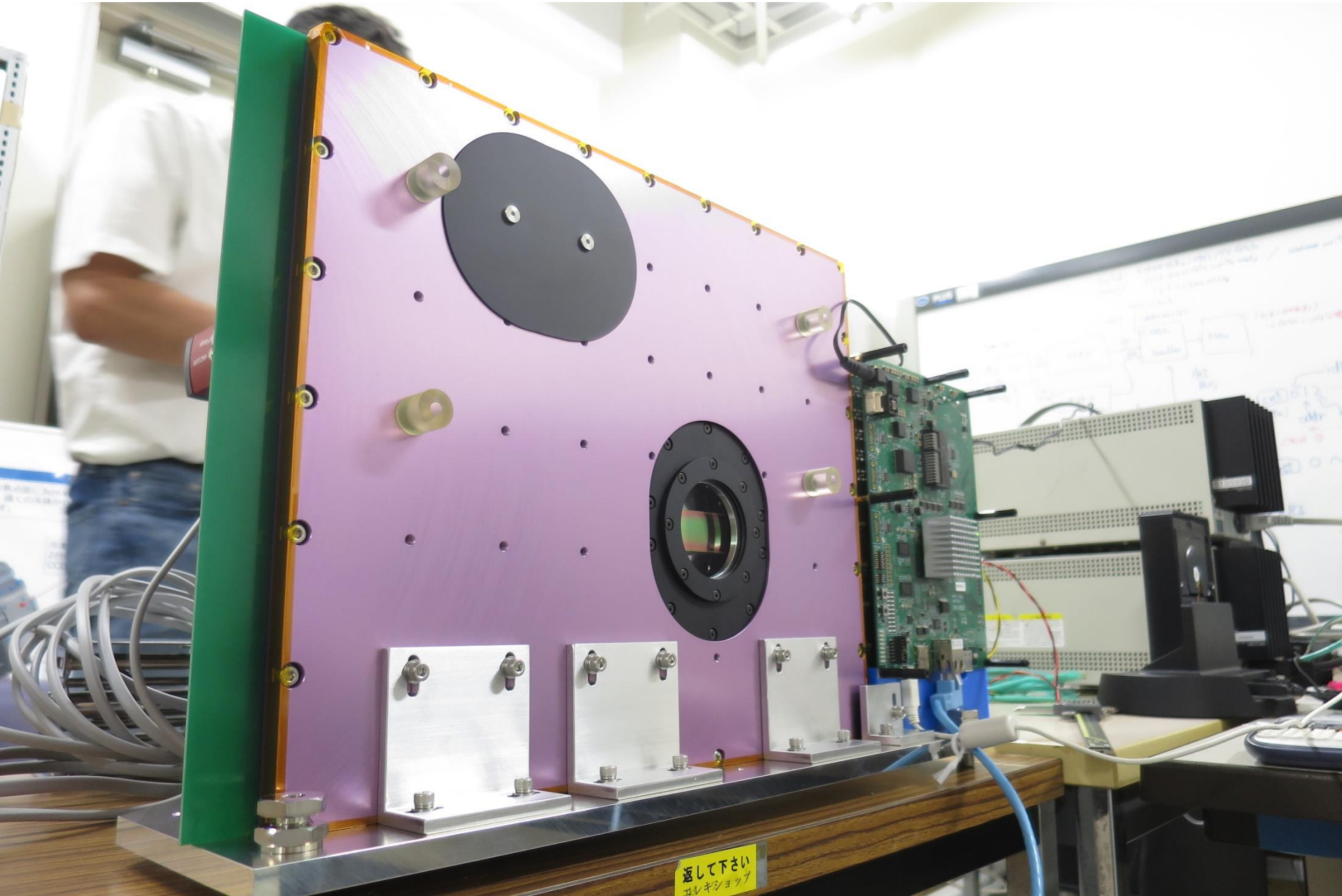
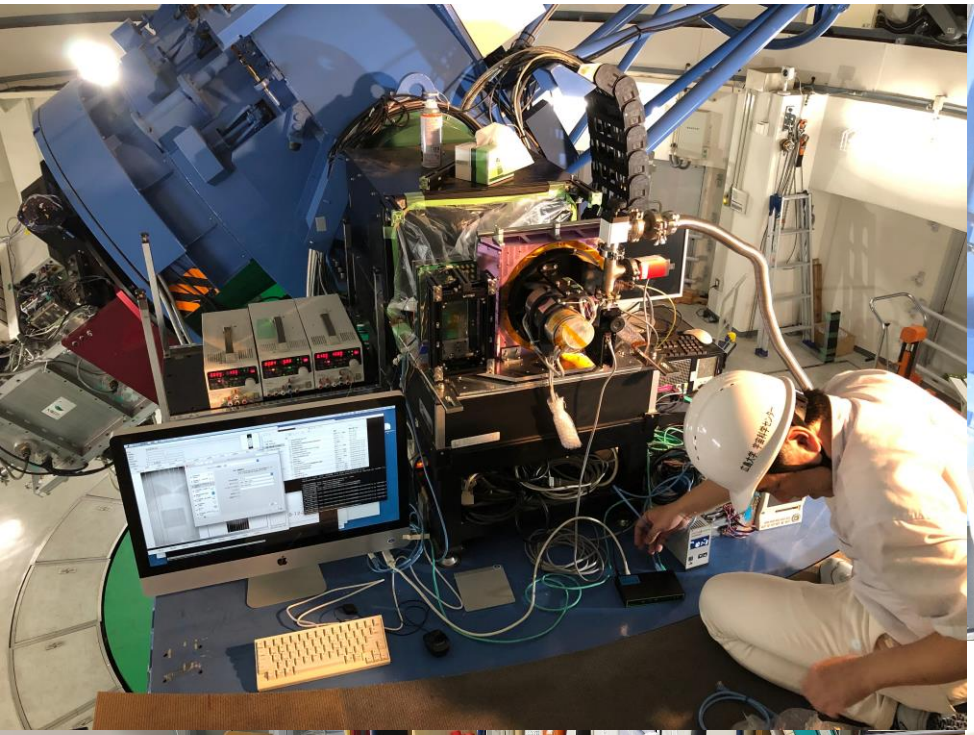
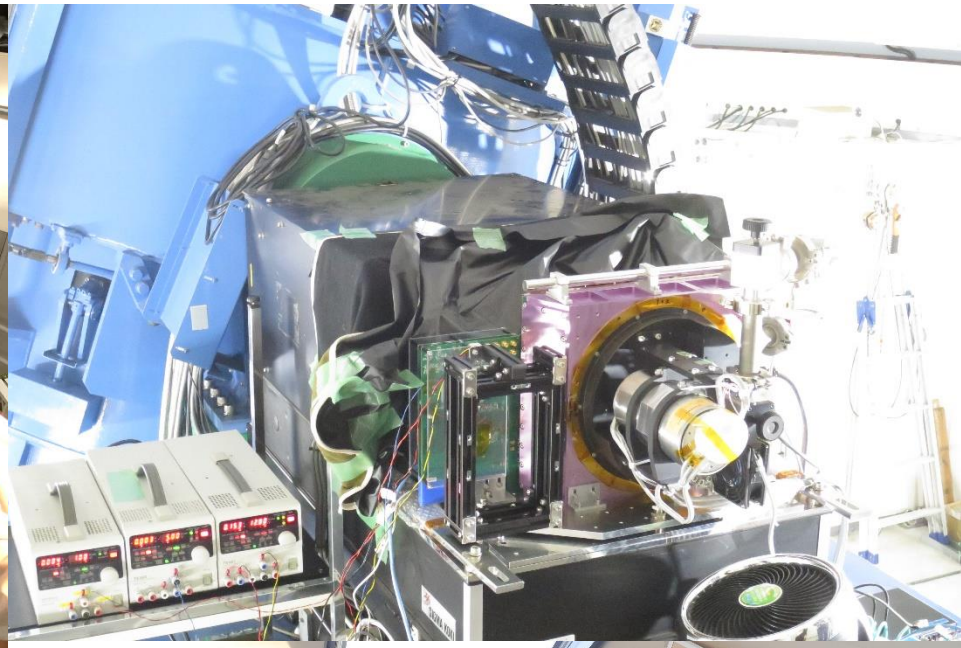
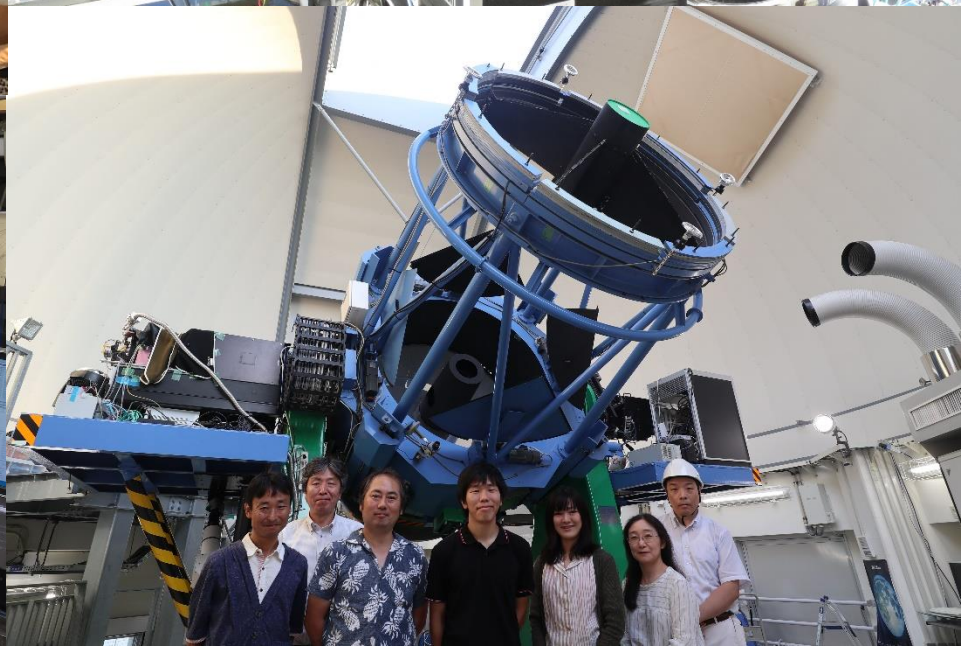


Test Observation @ Hiroshima (2019 Sep)







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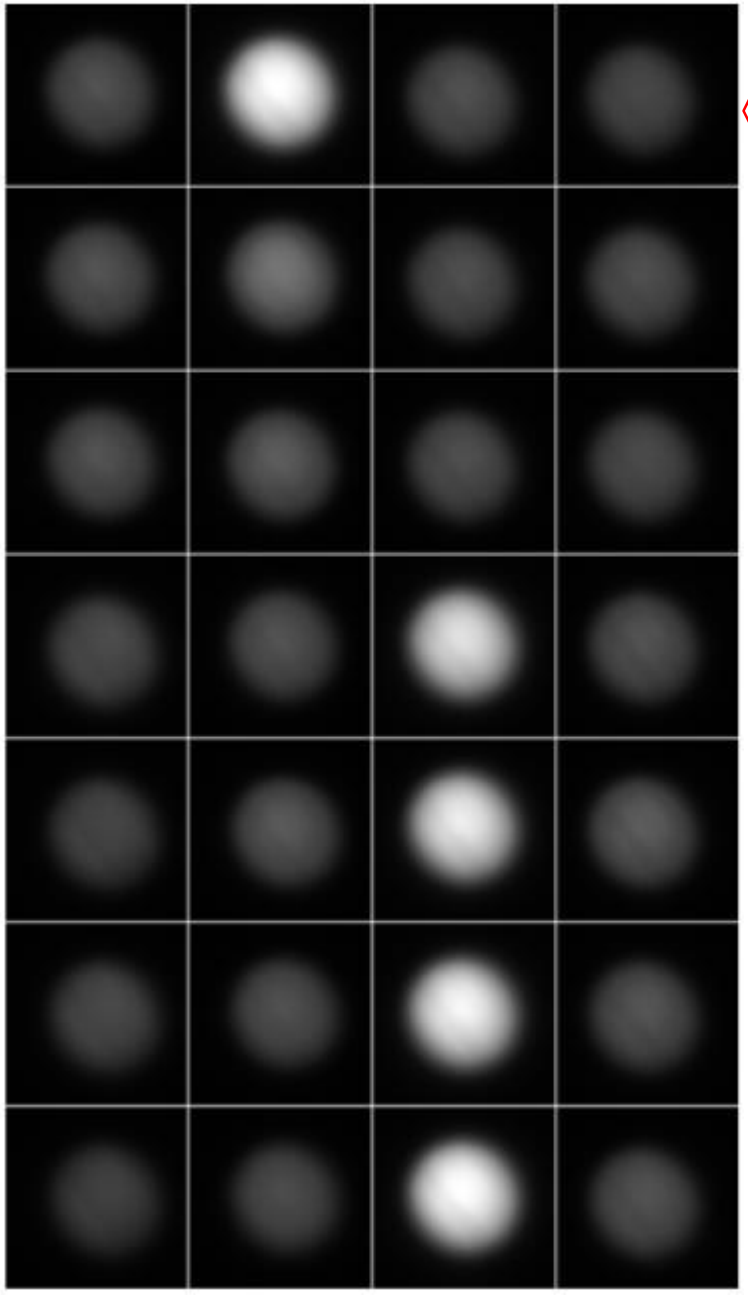
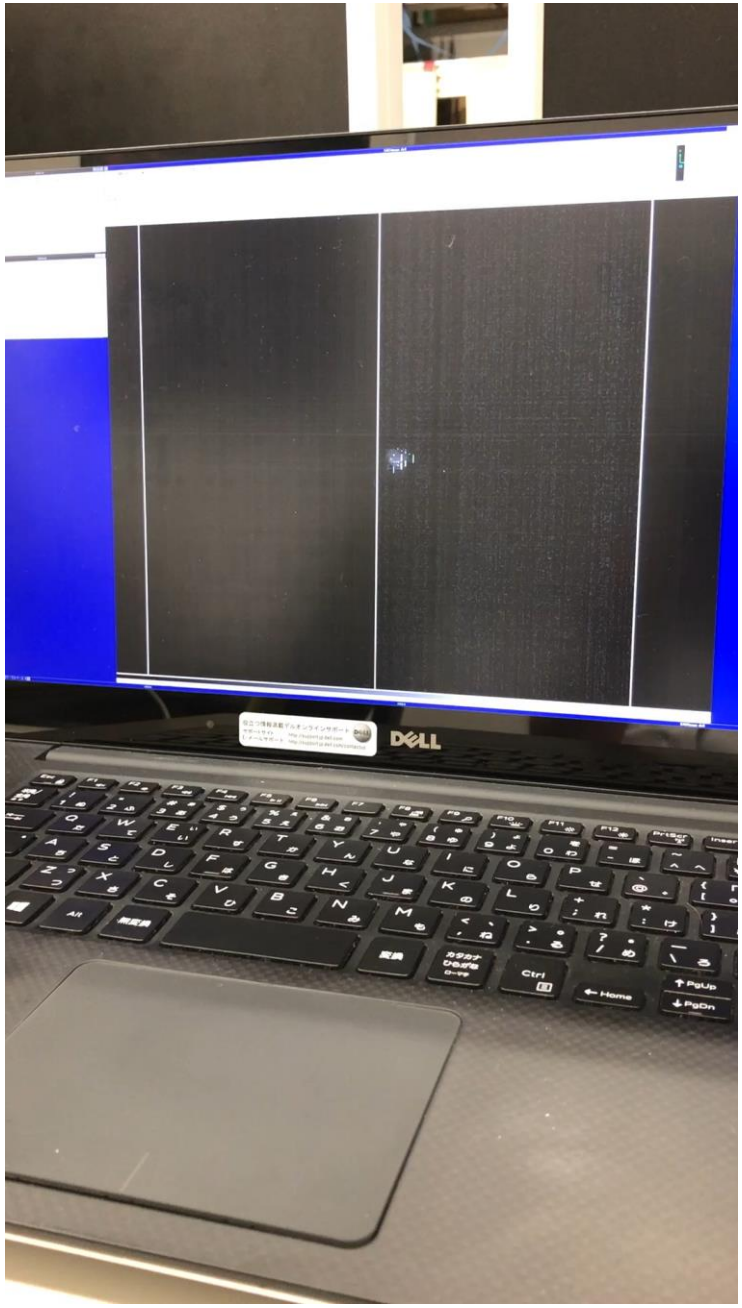


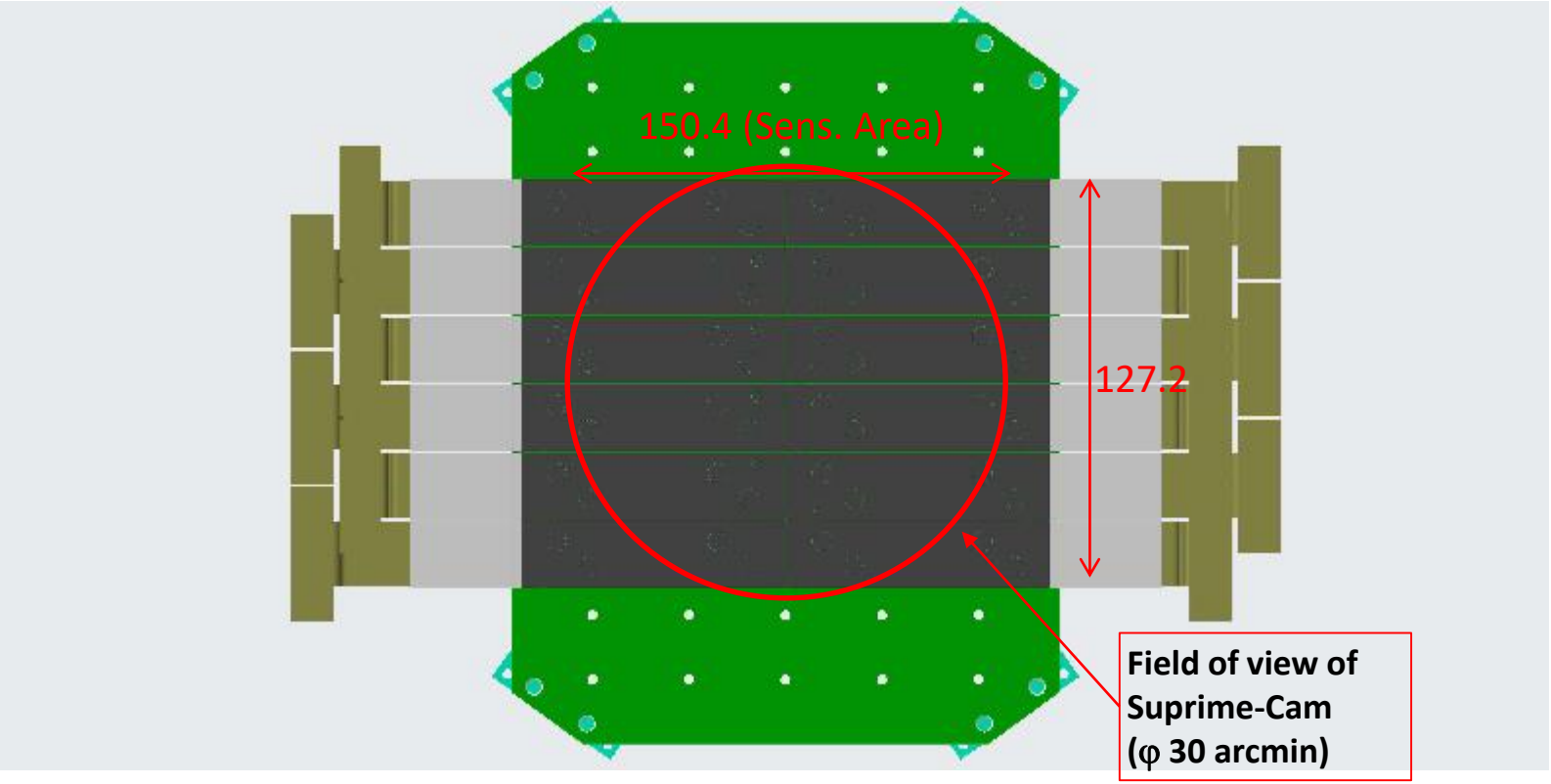
Consecutive images of Jupiter



Speckle image of Denebu (10ms integ.)

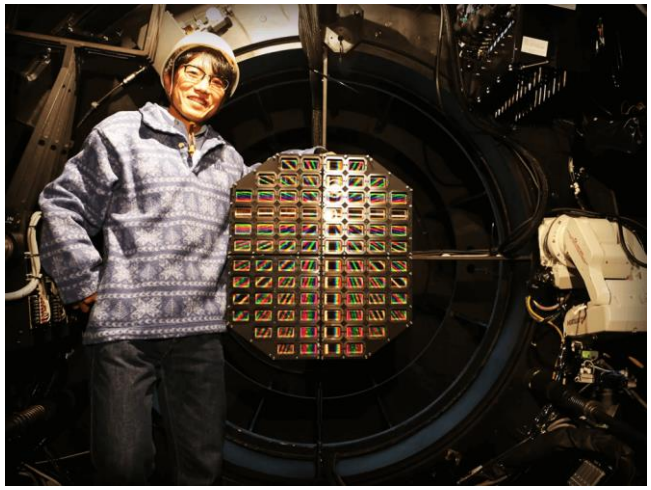
Future Plan

- 2nd test observation at Hiroshima with B.I. device in Feb. 2020
- Development of sensor (higher sensitivity) and readout electronics (multi-channel readout)
- Development for installation to Subaru Telescope
  - Replacing Suprime-Cam with CMOS Camera
  - Interface, function test of (old) prime focus unit, etc.

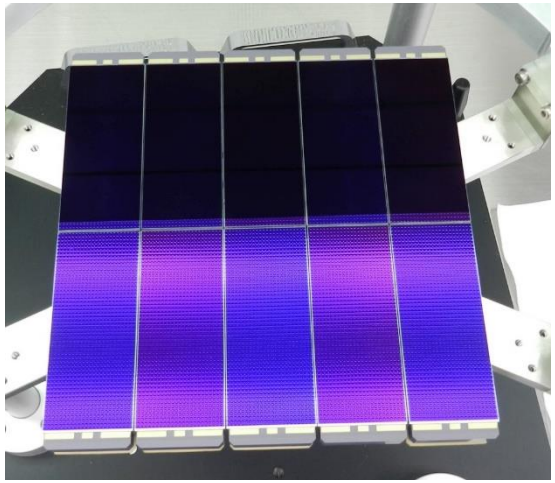


CMOS Comparison

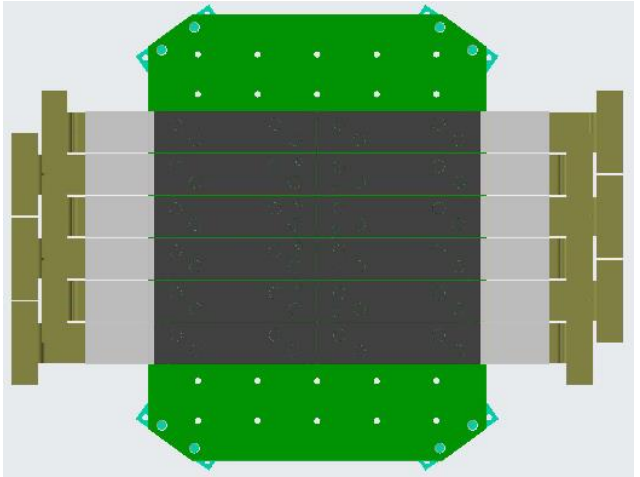
	Tomo-e Gozen	TAOS II	Subaru CMOS
Tel. Aperture	1.05 m	1.3 m	**8.2 m**
Field of View	20 deg^2	2.3 deg^2	0.25 deg^2
Frame Rate	2 sec^{-1} (20 for part)	20 sec^{-1}	**10 sec^{-1}**
Limiting Mag.	~17 mag	~18 mag	~21 mag
Sensor Format	2000x1128 (19um/pix)	1920x4608 (16um/pix)	2560x10000 (7.5um/pix)
# of Sensors	84	10	12
Vendor	Canon	e2v	Hamamatsu
Site	Kiso	Mexico	**Maunakea**



Tomo-e Gozen



TAOSII Focal Plane



Subaru CMOS Camera

Summary

- CMOS sensors with 2,560 x 10,000 pixels which can be read with 10Hz have been developed.
- CMOS Camera has been designed and assembled. It has been attached to Hiroshima Kanata Telescope and test observation was carried out (and another one will be in the next week).
- The CMOS Camera with 12 CMOS sensors will be assembled. It is proposed to be installed at the prime focus of Subaru Telescope, opening new area: wide-field and high-speed astronomy.