# KWFC: four square degrees camera for the Kiso Schmidt telescope

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**ABSTRACT**

The Kiso Wide Field Camera (KWFC) is a facility instrument for the 105-cm Schmidt telescope being operated by the Kiso Observatory of the University of Tokyo. This camera has been designed for wide-field observations by taking advantages of a large focal-plane area of the Schmidt telescope. Eight CCD chips with a total of 8k x 8k pixels cover a field-of-view of 2.2 degrees x 2.2 degrees on the sky. The dewar window works as a field flattener lens minimizing an image distortion across the field of view. Two shutter plates moving in parallel achieve uniform exposures on all the CCD pixels. The KWFC is equipped with a filter exchanger composed of an industrial robotic arm, a filter magazine capable of storing 12 filters, and a filter holder at the focal plane. Both the arm and the magazine are installed inside the tube framework of the telescope but without vignetting the beam. Wide-field survey programs searching for supernovae and late-type variable stars have begun in April 2012. The survey observations are performed with a management software system for facility instruments including the telescope and the KWFC. This system automatically carries out observations based on target lists registered in advance and makes appropriate decisions for implementation of observations by referring to weather conditions and status of the instruments. Image data obtained in the surveys are processed with pipeline software in real time to search for candidates of time-variable sources.

**Keywords:** wide field camera, Kiso Observatory, Schmidt telescope, CCD, optical, survey observation, robotic arm, real-time reduction

## 1. INTRODUCTION

In the last decade, wide-field observations with large format arrays have achieved remarkable results in many astronomical fields from exoplanets to cosmology, and particularly a combination of a mosaic CCD camera and a wide-field large telescope has enabled statistical discussion on rare objects, e.g., Subaru/Suprime-Cam (Miyazaki et al. 2002[1]); SDSS telescope and camera system (Gunn et al. 1998[2]). Now, in response to further demands on larger statistical researches on rare objects, larger instruments and telescopes optimized for wide-field observations are being developed, e.g., Subaru/Hyper Suprime-Cam (Miyazaki et al. 2006[3]); VISTA telescope and camera system (Dalton et al. 2006[4]). Meanwhile, rare events of variable objects, such as nearby supernovae, flare phenomena of dwarf novae, near-earth objects, and transit phenomena of exoplanets, found in high-cadence observations with smaller telescopes recently attract much attention (e.g., Law et al. 2009[5]; Rau et al. 2009[6]; Soszynski et al. 2008[7]). To search for the rare events effectively, a field-of-view beyond one square degree is crucial as well as acquiring sufficient machine time.

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The Kiso Wide Field Camera (KWFC) is a wide-field camera mounted on the Kiso 105-cm Schmidt telescope (f/3.1) being operated by the Kiso Observatory of the University of Tokyo. This camera has eight CCD chips with a total of 8k x 8k pixels achieving a field-of-view of 2.2 degrees x 2.2 degrees owing to the large focal-plane area of the Schmidt telescope (Figure 1). The CCDs are cooled down to 168 K in a cryogenic dewar and controlled by the Kiso Array Controller (KAC) which is a data acquisition system designed for the KWFC. The entrance window of the dewar works as a field flattener lens to correct an image distortion. The KWFC is equipped with a shutter unit with two moving shutter plates achieving uniform exposures on all the CCD pixels. The filter exchanger of the KWFC is composed of an industrial robotic arm, a magazine unit capable of storing 12 filters, and a focal-plane unit. The Kiso Observatory has begun monitoring survey programs for the rare events of the variables with the KWFC in April 2012. The survey observations are performed with a management software system for facility instruments including the telescope and the KWFC. This system automatically carries out observations based on target lists registered in advance and makes appropriate decisions for implementation of observations by referring to weather conditions and status of the instruments. Image data obtained in the surveys are processed with pipeline software in real time to search for candidates of time-variable sources.

The CCDs and the KAC are described in section 2. The cryogenic dewar and the optical design are described in sections 3 and 4, respectively. The shutter unit, the filters, and the filter exchanger are described in section 5. Results of performance evaluations for the KWFC are summarized in section 6. The automatic observation system and the survey plans are described in sections 7 and 8, respectively.

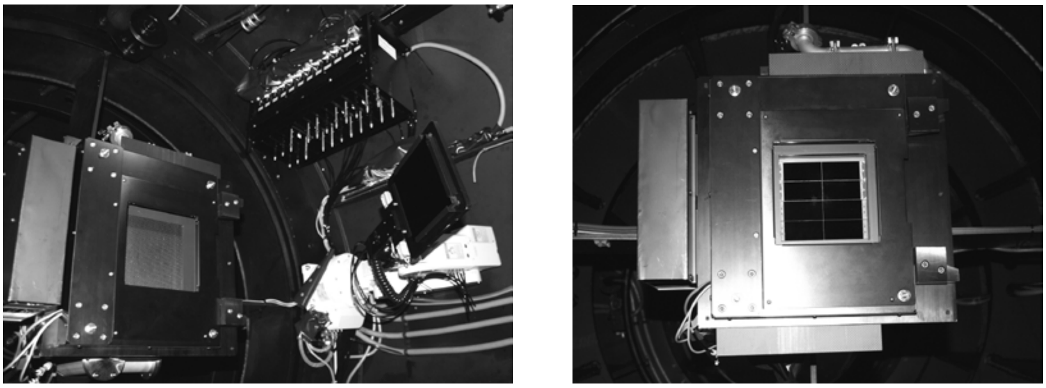

Figure 1. Left: Overview of the KWFC system mounted on the prime focal plane of the Kiso Schmidt telescope. The cryostat dewar is at the bottom left. The robot arm carrying a filter cassette is at the bottom right. The filter magazine is at the top right. Right: Top view of the cryostat dewar when the shutter is opened. The shutter unit and the focal plane unit of the filter exchanger are attached on the flattener lens side of the dewar. The rack including analog boards of the KAC is mounted on the left side of the dewar on the picture.

## 2. CCDS

### 2.1 CCDs

The KWFC has eight CCD chips composed of four CCDs with 2k x 4k pixels manufactured by Lincoln Laboratory, Massachusetts Institute of Technology (MIT) and four ST-002A CCDs with 2k x 4k pixels manufactured by Scientific Imaging Technologies, Inc. (SITe). The pixel size of these CCDs is 15 μm x 15 μm. Two out of the four MIT CCDs are test chips developed for instruments of the Subaru telescope (Miyazaki et al. 2002[1]) and the others are chips which had been stored as backups for the Subaru instruments. Three out of the four SITe CCDs are also backup chips for the Subaru instruments. Another chip is from the first CCD camera used for the TSPS survey conducted on the UK Schmidt telescope (Matsuoka et al. 2008[8]). The MIT and the SITe CCDs are mounted in a 2 x 4 arrangement covering a field-of-view of 2.2 degrees x 2.2 degrees on the sky as shown in Figure 2. Each of the CCDs is bonded on a spacer plate of aluminum nitride (AlN) in the same manner as Nakata et al (2000)[9] to adjust a height of the chip to each other. The dispersion of the thickness between the thickness-adjusted chips is measured to be 15 μm p-p, which does not affect image quality in the best seeing case of 2.5 arcsec. The CCDs with the spacers are mounted on an AlN cold plate of 8 mm thickness with leaving about 0.75 mm space.


Figure 2. Left: AIN cold plate installed in the cryogenic dewar. The cold plate is supported by fiber reinforced plastics (FRP) plates at the four corners. Right: Top view of the cryogenic dewar with the CCDs and the flattener lens. The MIT and the SITe CCDs are placed in the south and the north sides on the image area, respectively.

### 2.2 Kiso Array Controller

The Kiso Array Controller (KAC) is a data acquisition system newly developed based on the TAC system (Sako et al. 2008[10]) of the University of Tokyo Atacama Observatory (TAO) project (Yoshii et al. 2010[11]). The analog part of the KAC consists of two boards, the ADC main-board and the DRV main-board, connected each other by a backplane board. No cryogenic circuits are inside the cryogenic dewar. The ADC main-board is connected to four pieces of the ADC daughter-boards as shown in Figure 3. The ADC daughter-board has functions of clamp circuits, pre-amplifiers, fully-differential converters, 3rd order low-pass filters, and 16-bit A/D converters for four-channel inputs. When operating the CCDs in the dual-cannel mode, the ADC-daughter board is capable to digitize frame signals from two pieces of the MIT or SITe CCD chips. The frame signals from the CCDs are sampled at the reset level and the signal level, so called the correlated double sampling method. The CDS subtraction is processed by software in a control PC. The DRV main-board is connected to four pieces of the DRV daughter-boards and the IF board as shown in Figure 4. The DRV daughter-board generates bias voltages and clocking voltages which are synchronized with clock-timing-signals received from the digital part of the KAC. Each of the DRV daughter-boards is capable to drive the two MIT or the two SITe CCDs. The output gates for the bias and the clocking voltages are automatically opened after verifying that the generated voltages are valid. The IF board mediates communication between the analog and the digital parts. The digital data is transported with the LVDS protocol via a CAT-5 Ethernet cable. All the boards in the analog part are installed in a Eurocard-size rack mounted outside the cryogenic dewar. Power supply units are placed in a rack outside the tube framework at 6 m away from the prime focal plane.

The digital part of the KAC is composed of the LVDS interface-board as shown in Figure 5, left and a commonly-used PC running a non-real-time Linux-OS with two digital I/O cards, PEX-292144s manufactured by Interface Corporation. The LVDS board mediates communication between the digital I/O cards and the analog part. Since the PEX-292144 is a PCI Express bus card with a bus-master DMA function, it is capable to input and output parallel signals with minimum loads of CPUs in synchronization with a timing clock generated by an onboard oscillator. The two I/O cards are used for data input and output. The clock-timing-signals for the CCDs are generated in real-time by software in a manner similar to the TAC system (Sako et al. 2008[10]). The frame data received from the analog part via the LVDS interface-board is transferred to an allocated memory space in the PC and then written (appended) at the end of a raw-data file on a hard drive every 10 MB transferred.

The KAC software controls the digital I/O cards and the shutter unit. The generated raw-data file is converted to FITS-image files for each of the CCDs with subtracting the correlated double sampling data. The format of the FITS image for each CCD is 16 bit data of 4146 x 2100 pixels including data in the extended regions and the overscan regions on the chip. Since the charge-transfer speed of the SITe-CCDs is relatively slower, the KAC software has two different modes of readout speed. In the all-CCD readout (slow) mode, FITS-image files of the eight CCDs are produced in 120 sec. In the MIT-only readout (fast) mode, image files of the four MIT-CCDs are produced in 60 sec. The 2 x 2 pixels binning readout is also available for the two readout modes. All the FITS images is north-up. The tiled image combined from the one-exposure images is automatically generated for a quick look during observations.

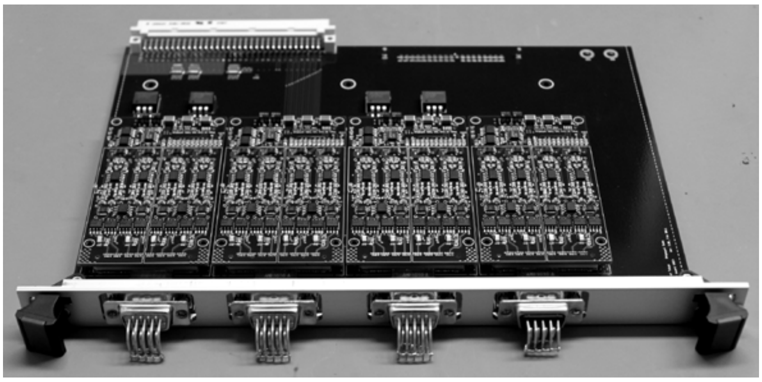

Figure 3. Overview of the ADC main-board with four pieces of the ADC daughter-boards. The outside dimension of the ADC main-board is 233.4 mm x 160 mm.

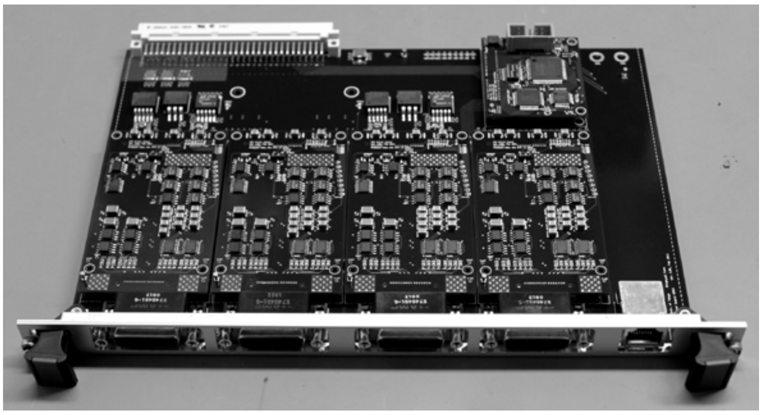

Figure 4. Overview of the DRV main-board with four pieces of the DRV daughter-boards and the IF board. The outside dimension of the DRV main-board is 233.4 mm x 160 mm.

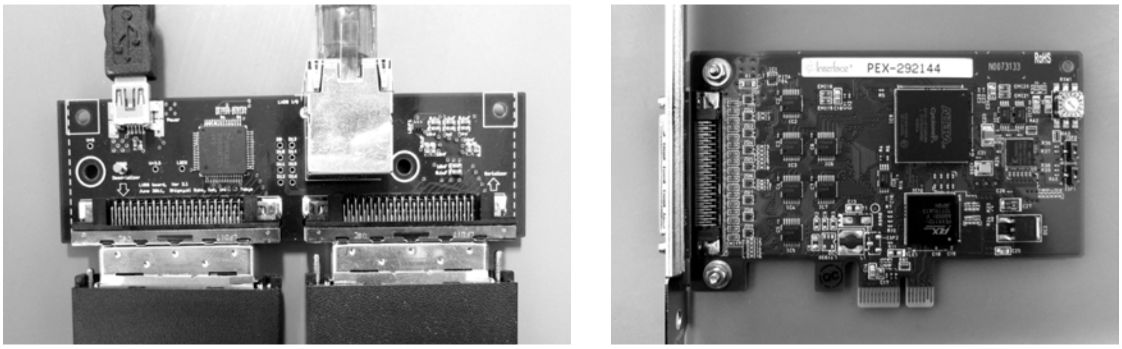


Figure 5. Left: Top view of the LVDS interface-board. The outside dimension is 100 mm x 30 mm. Main power is supplied via an USB cable. This board should be placed at less than 1 m away from the I/O cards to reduce communication errors. Right: Top view of the digital I/O card PEX-292144 supporting the bus-master DMA function.

## 3. CRYOGENIC DEWAR

### 3.1 Dewar

The cryogenic dewar has a box-shaped structure made of A5052P aluminum and is equipped with an optical window, two vacuum ports, and five hermetic connectors as shown in Figure 6. One out of the five connectors is used for temperature control and the others are for control and readout of the CCDs. The AIN cold plate is supported by fiber reinforced plastics (FRP) plates and cooled down below 168 K by the PDC-08 pulse tube refrigerator of Iwatani Industrial Gases Co. Ltd. To make easier to access inside the dewar, walls at the bottom and two of the side are able to be opened as well as the window (top) side. The dewar is attached on the prime focal plane through a polyimide sheet of 75 μm thickness to provide electrical insulation against the telescope.

### 3.2 Cryogenic and Vacuum System

The pulse tube refrigerator is connected to a compressor on the dome floor via two flexible helium hoses of 20 m length. Electrical insulating couplers are inserted between the refrigerator and the hoses. While the refrigerator obtains a performance of 8 W at 77 K when the cold head faces upward against gravity, it is drastically degraded when facing below the horizontal. To reduce the performance degradation, the refrigerator is mounted on the dewar as the cold head faces to the corrector lens of the telescope, which faces above the horizontal at any time. The temperature of the AIN cold plate is stabilized at 168.0 K with an error of 0.03 K by the Model 325 temperature controller of Lake Shore Cryotronics, Inc. with an aluminum-housed resistor and a Pt100 temperature sensor installed on a heat path.

The molecular sieve 13X 1/16 of Nacalai Tesque, Inc. is adopted in the dewar. The molecular sieves are bonded on surfaces of copper plates of 1 mm thickness with the Stycast 2850 FT epoxy as shown in Figure 7. The six copper plates are stacked and mounted on a heat path between the cold head and the AIN cold plate. The KWFC will be equipped with the VacIon Plus-20 ion pump of Varian Inc. to keep high-vacuums during a single season without additional vacuuming.

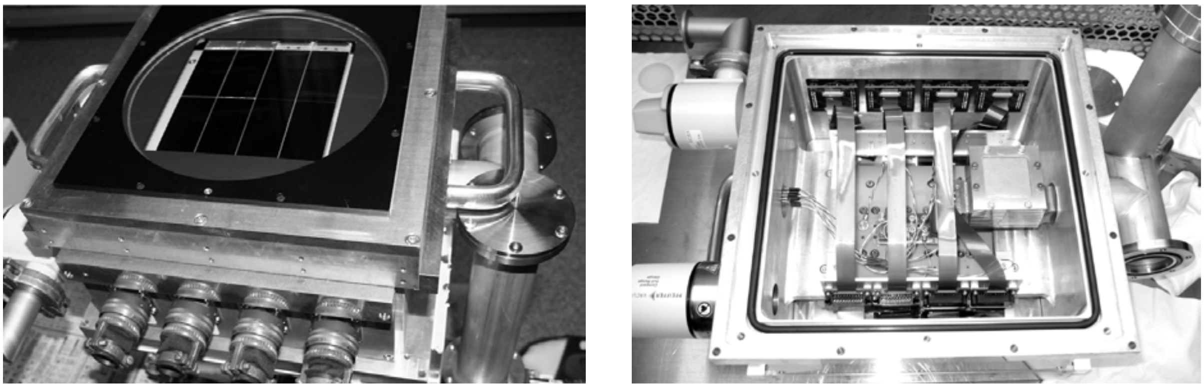

Figure 6. Left: Overview of the cryogenic dewar. The cold head is installed in the vacuum pipes at the right with facing to the bottom corresponding to the direction of the corrector lens of the telescope. The outside dimension of the box shaped part is 300 mm x 300 mm x 160 mm. Right: Bottom view of the dewar. The bottom-side wall is removed in the picture. The signals from the eight CCDs are transferred to outside the dewar via eight pieces of the interface boards and four pieces of the hermetic boards. Flexible printed circuit (FPC) cables with 30 copper lines of 18 μm thickness and 0.5 mm pitch are used. The storage for the molecular sieves is installed onto the heat path between the cold head and the cold plate.

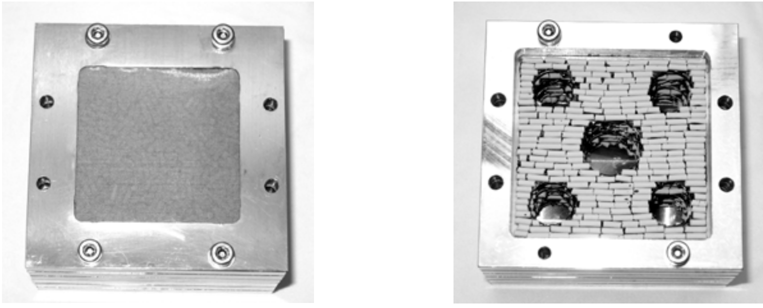

Figure 7. Left: Top view of the storage for the molecular sieves. Right: Picture of the storage when the meshed top cover is removed. The molecular sieves with cylindrical shapes are bonded on the copper plates of 1 mm thickness with five holes. The storage is composed by stacking the six copper plates. The outside dimension of the storage is 60 mm x 60 mm x 37 mm.

# 4. OPTICS

The entrance window of the cryogenic dewar works as a field flattener lens to correct an image focused on a spherical surface. The lens substrate is made of BK7 glass with a biconvex shape of 220 mm diameter and 16.5 mm maximum and 11.3 mm minimum thicknesses. The curvature radii of the first and the second surfaces are 1566 mm and 4367 mm, respectively. The inner surface of the flattener lens is apart from the CCD surface by 9.5 mm at the optical center.

Spot diagrams calculated for the KWFC mounted on the Kiso Schmidt telescope including a filter of 15 mm thickness are shown in Figure 8. Most energy of a PSF is focused inside a CCD pixel with a size of 15 μm square at the outermost edge of the CCDs. The safety factor of the flattener lens when vacuumed is calculated to be 4.6 assuming the breaking strength of the BK7 glass is 5 x $10^7$ Pa and a flat shape of 11.3 mm thickness. The physical distortion produced when vacuumed is estimated to be 110 μm at the optical center, which does not affect the image quality.


Figure 8. Spot diagrams for the KWFC mounted on the Kiso Schmidt telescope at 0.55 μm wavelength. The distances along the x- and y- axes of the image file from the optical center are indicated at the top of each image in degrees. The physical distances are also indicated at the bottom of each image in mm. Solid bar indicates a physical size of the CCD pixel in microns. Most energy of a PSF is focused inside a CCD pixel with a size of 15 μm.

# 5. SHUTTER AND FILTER SYSTEM

## 5.1 Shutter Unit

The shutter unit is equipped with two linear actuators, KUMISA-160-PB-R of KSS Co. Ltd., to drive two shutter plates as shown in Figure 9. The shutter plates are moved in parallel to the same direction with a time interval corresponding to a specified exposure time. This method achieves uniform exposures on all the CCD pixels. In a short time exposure below around 0.5 sec, the shutter plates are moved together with keeping a spatial interval which achieves a specified exposure time. The accuracy of an open time is approximately 3 msec. The linear actuators are synchronized by a controller with an internal timer. The controller communicates with a PC via RS-232C connection. Air tubes with several dozen holes on the surface are installed along an inner rim of the shutter unit. The tubes with holes work as exhaust nozzles of dry air supplied from an air-compressor and prevent the flattener lens from fogging when the dewar is cooled down. The shutter unit is attached on the dewar frame.

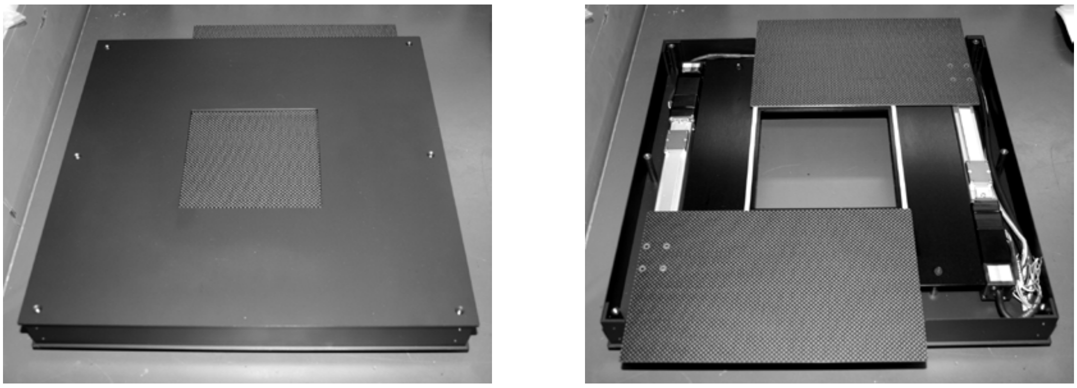

Figure 9. Left: Top view of the shutter unit. Right: Same view, but the upper cover is removed and the shutter plate is opened. The outer dimension of the shutter unit excepting the shutter plates is 400 mm x 400 mm x 47 mm. The shutter plate has a size of 255 mm x 160 mm x 1.5 mm and is made of carbon fiber reinforced plastics (CFRP) to reduce weight. Built-in mechanical switches are used as position limit sensors in the linear actuators.

### 5.2 Filters

Available filters for the KWFC are listed in Table 1. The size and the weight of the filters are 158 mm x 158 mm x 15 mm and 0.97 kg, respectively. The Kiso observatory possesses several kinds of narrow-band filters with a size of 100 mm x 100 mm developed for the previous open-use camera, 2kCCD (Itoh et al. 2001[12]). The narrow-band filters are also available for the KWFC, although the field-of-view is limited to be 50 arcmin square.

Table 1. Available filters for the KWFC. The center wavelengths, $\lambda_c$, and the bandwidths, $\Delta\lambda$, are measured in parallel light, while for the SDSS-r and the SDSS-i band filters design values for a beam of f/3.1 are described. The SDSS-z band filter has a long-wavelength-pass characteristic of 826 nm cut-off. The effective bandwidths of the SDSS-z band depend on spectral responses of quantum efficiencies of the CCDs.

| **Name** | $\lambda_c$ nm | $\Delta\lambda$ nm | **Name** | $\lambda_c$ nm | $\Delta\lambda$ nm |
|---|---|---|---|---|---|
| B | 445 | 122 | SDSS-u | 353 | 56 |
| V | 551 | 109 | SDSS-g | 467 | 131 |
| R | 659 | 125 | SDSS-r | *613* | *123* |
| I | 809 | 153 | SDSS-i | *756* | *120* |
| | | | SDSS-z | - | - |

### 5.3 Filter Exchanger

How to store and exchange large filters is a common problem for a wide-field camera mounted on a prime focal plane. In order to storage a dozen of filters, complicated electro-mechanical system is needed to be installed on the focal plane, which has less space and less load capacity, e.g., Subaru/Suprime-Cam (Miyazaki et al. 2002[1]). In the KWFC, these problems are solved by using an industrial robotic arm.

The filter exchanger is composed of the robotic arm, a magazine unit, and a focal plane unit as shown in Figure 10. The MELFA RV-2SQ industrial 6-axis robotic arm with a payload of 2 kg manufactured by Mitsubishi Electric Corporation is adopted. The robotic arm and the magazine unit are placed on the tube framework of the telescope with mechanical strength. Each filter is installed into a frame cassette with handling bars as shown in Figure 11, right. The magazine unit is equipped with storage slots for the 12 filter cassettes. The focal plane unit with lightweight is attached on the shutter unit. The robotic arm transports one of the filter cassettes between the magazine and the focal plane units. It takes for about 45 sec to exchange a filter to another. The robotic arm does not affect the optical performance since the arm is evacuated to a position outside the telescope beam during exposure. Air cylinders with electromagnetic air valves are installed in a hand part of the robotic arm, each of the storage slots of the magazine, and a filter holder of the focal plane unit. These air cylinders are collectively managed by a control unit of the robotic arm to prevent accidentally dropping the filter cassette during transportation. Taper-shaped guide rails are provided on the storage slots and the filter holder. Meanwhile, the RV-2SQ robotic arm has a compliance control function for interactive response to opposing forces, which is capable to compensate for workpiece tolerances. Therefore, even if relative positions between the three units are changed by gravity with changing attitude of the telescope, the filter cassette is smoothly carried into the storage slots and the filter holder along the guide rails. The RV-2SQ robotic arm also has a collision detection function. This prevents damage to the telescope and the camera part of the KWFC as well as the filter exchanger system itself in collision accident. The air cylinders are locked safety and the filters never drop when either the power supply or the air supply is accidentally turned off. At present, for safety reasons, the cover of the primary mirror is temporary closed during exchanging filters.

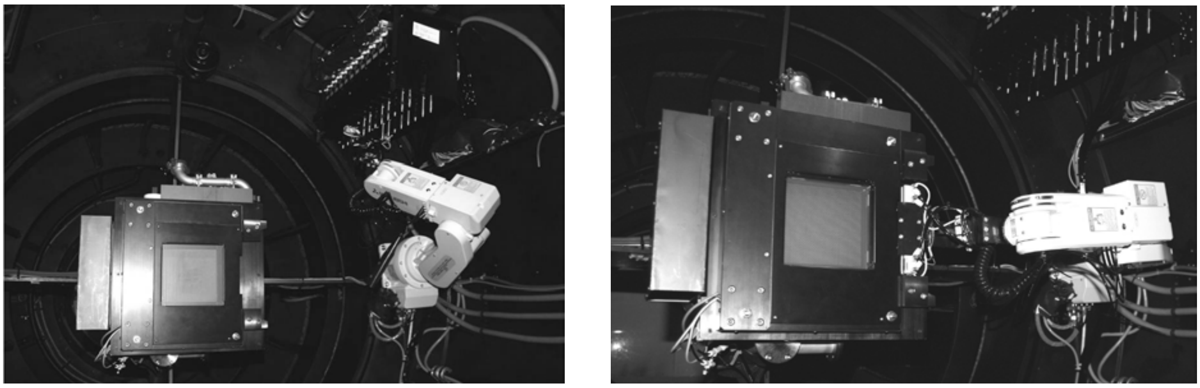

Figure 10. Left: Overview of the filter exchanger system. One of the filter cassettes is picked up by the hand of the robotic arm. Right: Picture of the focal plane unit when the V-band filter is set into the filter holder by the robotic arm.

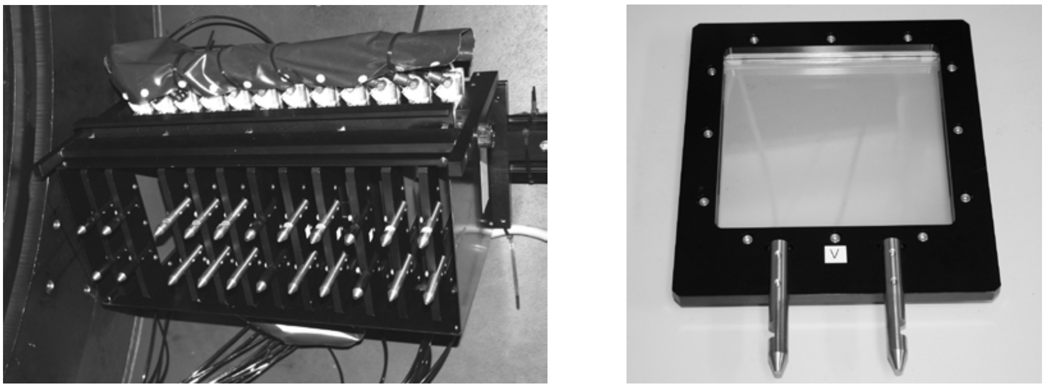


Figure 11. Left: Overview of the magazine unit with 12 slots for the filters. Right: Overview of the filter cassette with the V-band filter. The filter cassette has two bars which the hand of the robotic arm grabs. The total weight of the cassette including the filter is 1.8 kg.

# 6. PERFORMANCE SUMMARY

Results of performance evaluations of the KWFC system mounted on the Kiso Schmidt telescope are summarized below. The readout noises of the MIT and the SITe CCDs are 5 to 10 $e^-$ and about 20 $e^-$, respectively. The dark current of the both CCDs is below 5 $e^-$ $hour^{-1}$ $pixel^{-1}$ at an operation temperature of 168 K. The signal gain is set to approximately 2 $e^-$ $ADU^{-1}$ with adjusting gains of the pre-amplifiers on the ADC daughter-board. The saturation levels of the CCDs are in 8 to 10 x $10^4$ $e^-$. It is recommended to use those in a range below 6 x $10^4$ $e^-$ where all the CCDs have good linearity. The readout time including overhead for wiping and data conversion is 120 sec and 60 sec in the full-area and the MIT only readout-modes, respectively.

The pixel scale is 0.946 arcsec $pixel^{-1}$ and the field-of–view is 2.2 degrees x 2.2 degrees. The PSF size is confirmed to be limited by atmospheric seeing rather than intrinsic optical performance when the seeing size is around 2.5 arcsec corresponding to that in the best seeing. The image distortion across the field of view has been measured to be less than 0.2 arcsec. The interval spaces between the CCD chips are about 90 arcsec and about 60 arcsec on the sky in the north-south and the west-east directions, respectively.

The 5-sigma limiting magnitudes for point sources have been measured to be 20.9 and 20.3 mag in 3 minutes exposure in the SDSS-g and the SDSS-i bands, respectively. The limiting magnitudes estimated from the measured values of the previous open-use camera 2kCCD (Itoh et al. 2001[12]) are listed in Table 2.

The inaccuracy of the exposure time caused by the shutter unit is approximately 3 msec. The minimum exposure time is mechanically limited to 10 msec. The time exchanging the filters is 45 sec. Additional time of about 60 sec is needed to open and close the cover of the primary mirror for safety reasons. The cryogenic system is capable to keep the CCDs at 168.0 K with an error of 0.03 K for a few weeks without additional vacuuming. When the ion pump is installed, the maintenance free time will be extended to longer than a month.

Table 2. Limiting magnitudes estimated from the measured values of the previous open-used camera 2kCCD assuming a seeing size of 3 arcsec, an exposure time of 15 minutes, and 10 sigma detection.

| | **B** | **V** | **R** | **I** |
|---|---|---|---|---|
| | mag | mag | mag | mag |
| **MIT-CCDs** | 21.9 | 21.3 | 20.9 | 20.2 |
| **SITe-CCDs** | 22.2 | 21.2 | 20.9 | 20.1 |

# 7. AUTOMATIC OBSERVATION SYSTEM

The Kiso Schmidt telescope is conducting monitoring survey programs for the rare events of the variables with the KWFC. The survey observations are performed with a management software system for facility instruments including the telescope and the KWFC. This system mainly consists of observation management software and queue-observation software. The observation management software makes appropriate decisions for implementation of observations by referring to weather conditions and status of the instruments. The queue-observation software sequentially executes commands for the instruments which are registered in advance. Image data obtained in the surveys are processed with the pipeline software in real time to search for candidates of time-variable sources. Each component of the automatic observation system is described below.

## 7.1 Pipeline Software

The pipeline software performs standard bias and overscan subtractions, bad-pixels masking, and flat-fielding processes. After that, celestial coordinates are derived with reference to the USNO-B1.0 catalog (Monet et al. 2003[13]) and a rough zero-point magnitude is derived with reference to the SDSS DR7 catalog (Abazajian, et al. 2009[14]) or USNO-B1.0 catalog. Image stacking is also available with public software SWarp (Bertin et al. 2002[15]) for images obtained in dithering observations. In standard observations, the FITS-image files produced by the KAC are automatically transfer to an analysis PC and reduced by the pipeline software. This software will be distributed to users of the KWFC.

### 7.2 Management Software and Database

All information required for the automatic observations is collected into a database provided by MySQL. The database has tables for status of the instruments and weather conditions, information of observers, observation logs, and images taken by monitoring cameras. The information stored in the database is accessible from inside the Kiso Observatory with MySQL client programs and web browsers. The observation management software comprehensively evaluates implementation of observations by referring to the information on the database and closes the dome slit and temporary stops the telescope system when weather conditions worsen or any problems on the instruments are detected. The queue-observation software sequentially executes commands registered in a queue list. It is available to insert and remove the commands into/from the queue list as well as to stop the queue sequence. When the observation management software judges that execution of observations is inappropriate, the queue-observation software stops ongoing sequence as soon as possible and waits for lifting of the restriction. The automatic observation system is capable to be operated via SSL-VPN connection from outside the Kiso Observatory.

## 8. SURVEY PLANS

The Kiso Schmidt telescope has begun two monitoring survey programs, KIso Supernova Survey (KISS) and the KWFC Intensive Survey of the Galactic Plane (KISOGP), with the KWFC in April 2012.

KISS is a program searching for nearby supernovae in about 100 square degrees in each season. KISS monitors each survey field in the g-band with high cadences, every one hour (five times per night). The main purpose is to catch the earliest optical light of core-collapse supernovae just after explosions (shock breakouts; see Tominaga et al. 2009[16]) to reveal physical parameters of progenitor stars and also those of Type-Ia supernovae to understand the unknown progenitor systems. The first supernova discovery by KISS has been reported in CBET 3126[17], followed by two supernova discoveries (CBET 3139[18], 3145[19]).

KISOGP is a monitoring survey program for the northern Galactic plane. The survey field covers 300 square degrees of the Galactic plane between 60 degrees and 210 degrees in the galactic longitude. Our plan is to collect roughly 50 time-series images per each region during the three years from 2012. The main goal is to study structure and evolution of the Galaxy based on pulsating stars like Cepheids. Cepheids are good tracers of the Galaxy structure because it is possible to estimate their distances and ages accurately (see e.g., Matsunaga et al. 2011[20]). The KISOGP project is designed to discover the Cepheids hidden in the Galactic plane. With our survey data, we also search for transient objects in the Galactic plane like novae and dwarf novae.

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