Acquisition System of Nobeyama MKID Camera

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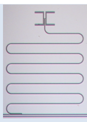
ABSTRACT: We are developing a superconducting camera based on microwave kinetic inductance detectors (MKIDs) to observe 100/150-GHz bands with the Nobeyama 45 m telescope. An acquisition system for the camera has been designed to operate the MKIDs with the telescope. This system is required to connect the telescope control system (COSMOS) to the readout system of the MKIDs (MKID DAQ) which employs the frequency-sweeping probe scheme. The acquisition system is also required to record the reference signal of the beam switching for the demodulation by the analysis pipeline in order to suppress the sky fluctuation. The system has to be able to merge and save all data acquired both by the camera and by the telescope, including the cryostat temperature and pressure and the telescope pointing. In addition, the system is desired to provide quick-look data that observers would check. A collection of software which implements these functions and works as a TCP/IP server on a workstation was developed. The server accepts commands and observation scripts from COSMOS, and then issue commands to MKID DAQ to configure and start data acquisition. We checked the demodulation algorithm of beam switching by observing celestial continuum sources with a receiver of the Nobeyama 45 m telescope. We also made a test operation of the MKID camera on the Nobeyama 45 m telescope and obtained successful scan signals of the atmosphere and of the Moon.

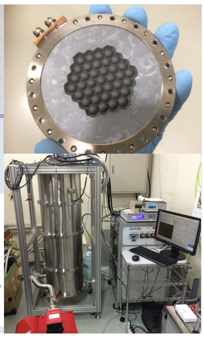
INTRODUCTION

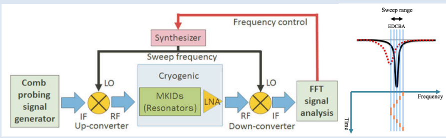
MKID Camera

Detector array for continuum observation > 90 GHz, fabricated at Advanced Technology Center (ATC), NAOJ

- Si lens + slot antenna + Al MKID
- Up to ~ 10^3 beams
- Readout system: FFTS w/ frequency sweeping







NRO 45-m Telescope

Radio telescope for single-dish and VLBI observations at Nobeyama Radio Observatory (NRO).

- Cassegrain reflector
- Alt-azimuth mount
- Nasmyth focus w/ reimaging optics
- RF: 20 – 230 GHz
- FoV ~3′
- Control software: COSMOS
- On-the-Fly (OTF) mode, 10 S/s
- Beam switch for continuum observation ~10 Hz

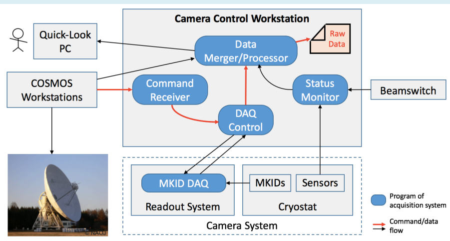
Camera on Telescope

Requirements for Camera DAQ

- Placed at the lower cabin
- Data acquisition:
  - Synchronized to the telescope
  - Modes for calibration/observation
- Quick-look for observers
- w/o field rotator
  → field rotation treatment in data analysis
- beam-switched signals
  → demodulation in data analysis

DESIGN OF ACQUISITION SYSTEM

Concept: one workstation can connect the camera system and telescope system.



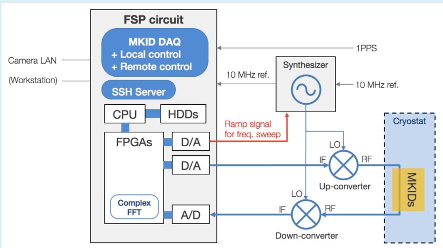
Synchronization

- Clock pulse 1PPS and 10-MHz reference signal are provided from the telescope.
- Computer system clocks are synchronized with NTP servers of the observatory.

MKID Readout System

Key component: prototype frequency-sweeping probe (FSP) w/ 4096-MS/s A/D & D/A

- Simple interface of remote control via TCP/IP is added to MKID DAQ: start query with specified time, stop query, and status query.
- DAQ settings can be configured before the operation.
- File transfer and other remote operations via SSH.



Data Flow

Data source

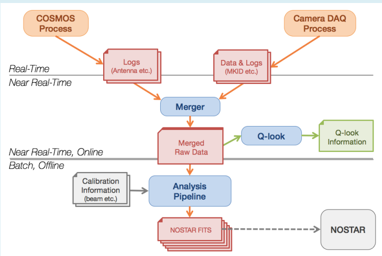
- Telescope logs (antenna position, etc.) from COSMOS
- MKID spectra and camera logs form Camera DAQ

Output

- OTF data in Flexible Image Transport System (FITS) file format, suitable for Nobeyama OTF Software Tools for Analysis and Reduction (NOSTAR)

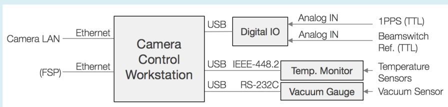
Processing

- Three types: Real-time, near real-time, & batch



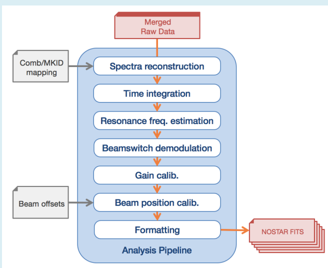
Camera Control Workstation

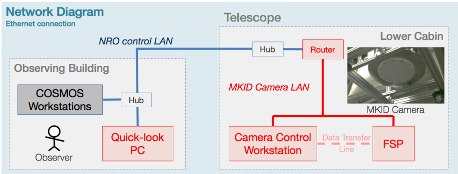
- Receives commands from COSMOS as TCP/IP server.
- Sends commands to readout system.
- Runs processes for DAQ, stores all data, and runs the analysis pipeline.



Analysis Pipeline

The pipeline does all process to obtain NOSTAR files of radiation temperature.





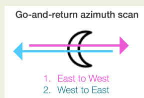
TEST MEASUREMENTS

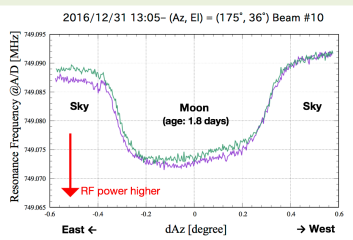
First test of MKID camera on 45-m Telescope

- Commissioning during 2016/12/28 – 2017/01/05
- 19 MKIDs (19 beams) were used.
- Basic functionality of DAQ system was checked.

Moon Scan

Signals of the Moon were obtained successfully. No time difference btw the telescope and the camera was found using go-and-return scan.





Future Prospects:

- Improve effective data rate
- Scalability demonstration

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