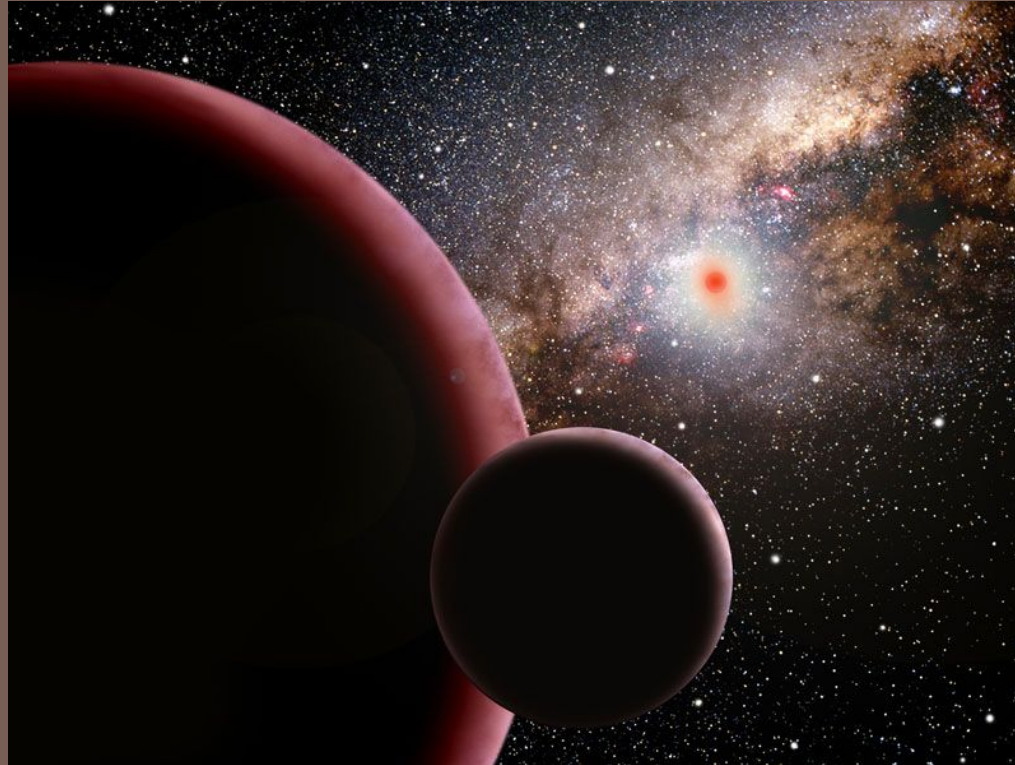


Korea Microlensing Telescope Network (KMTNet) : Wide-field Photometric System



Sang Chul KIM¹, Chung-Uk Lee¹, Seung-Lee Kim¹, Dae-Sik Moon²

TDA-MMS 2019

2019 Feb 9-10, Nikko, Japan

1 Korea Astronomy and Space Science Institute (KASI), Korea

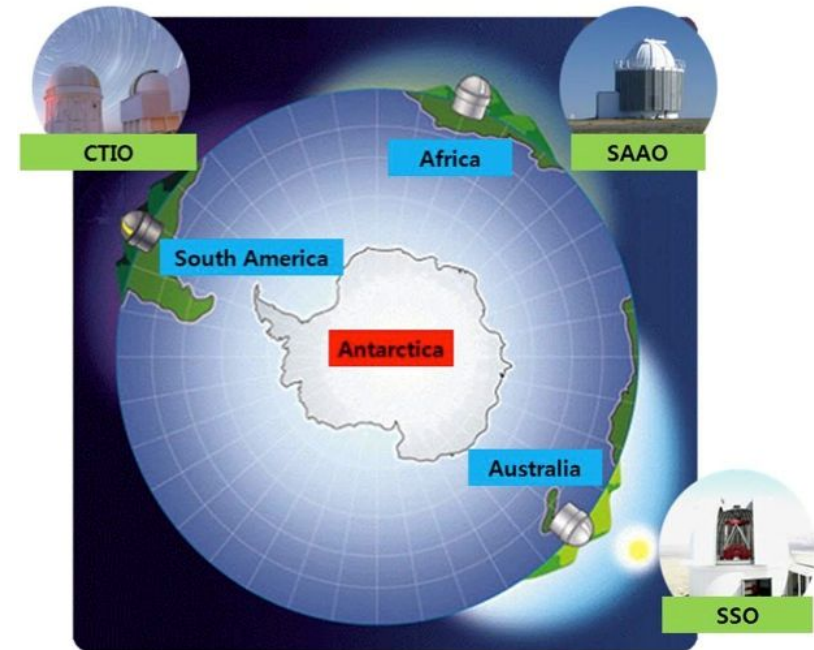
2 University of Toronto, Canada

Project Overview



- Development of the **KMTNet** System
 - **Korea Microlensing Telescope Network**
 - Three Identical Observing Systems
 - 24-hours uninterrupted Monitoring of night sky at Southern Hemisphere
 - It has been installed at CTIO in Chile, SAAO in South Africa, SSO in Australia

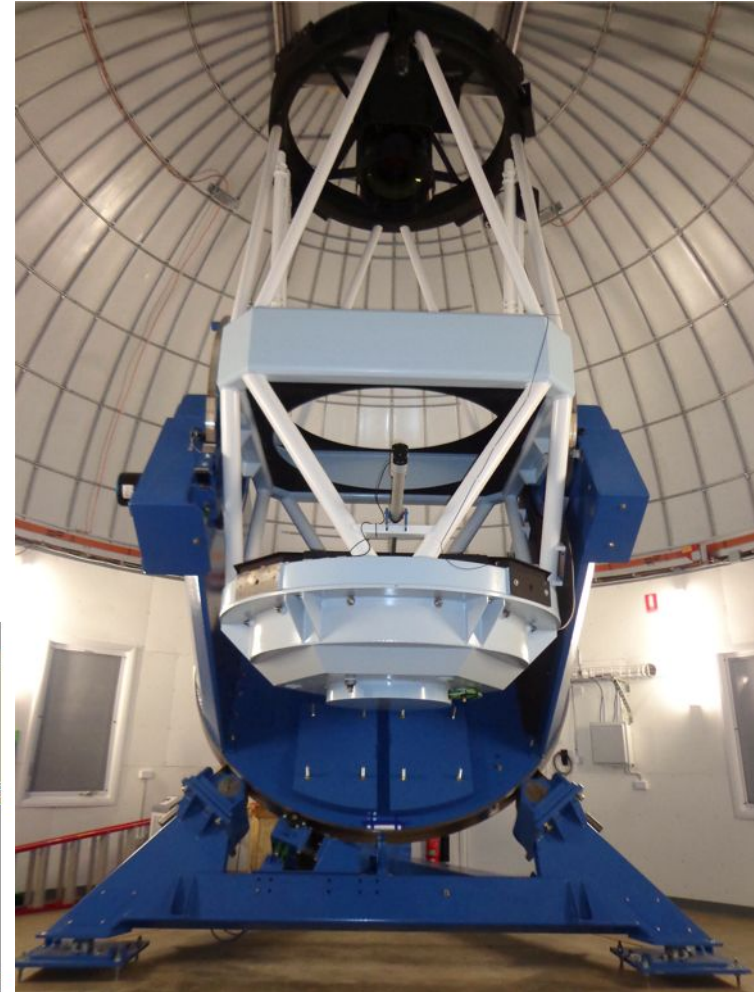
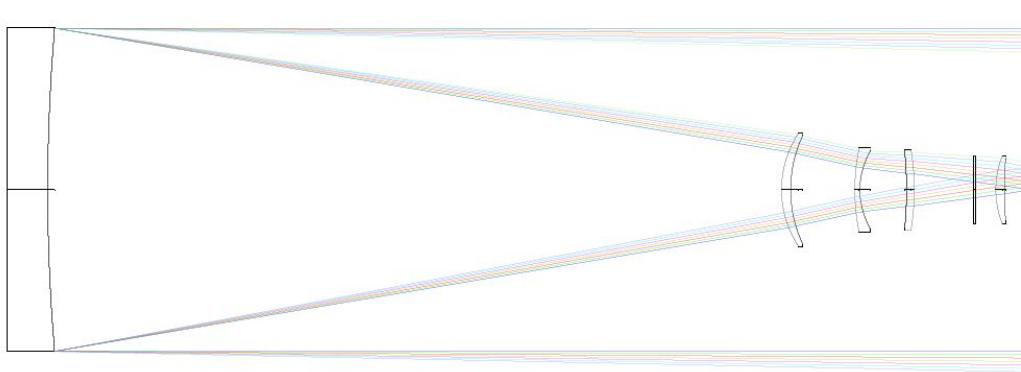
- Budget
 - Development : ~20M\$ for 6 years from 2009 to 2014
 - Operation : ~2M\$ per year from 2015



Telescope



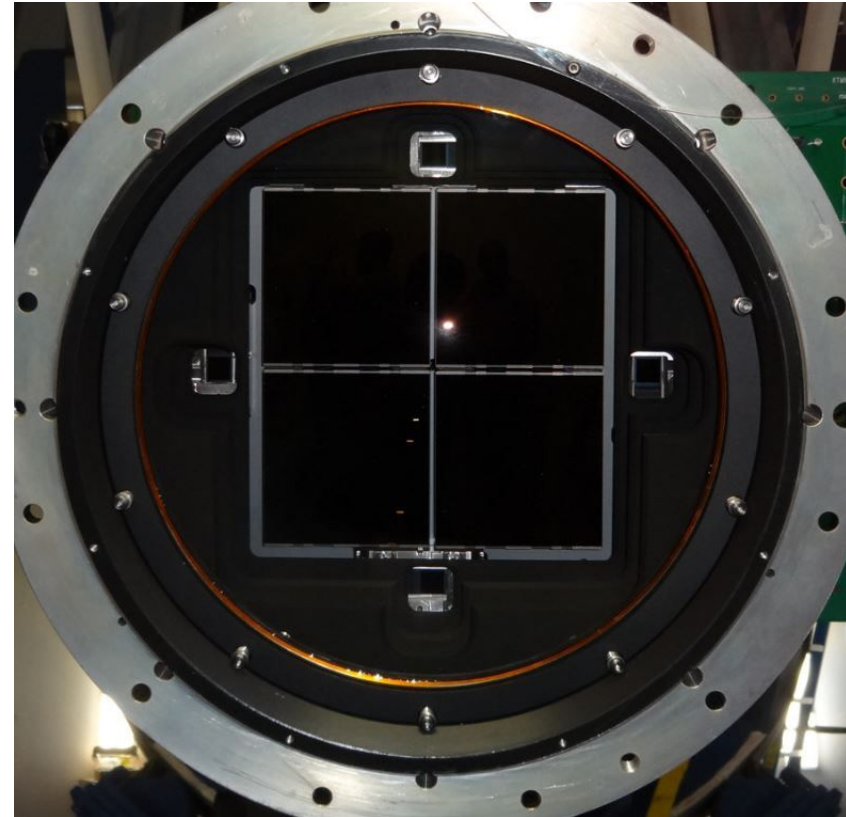
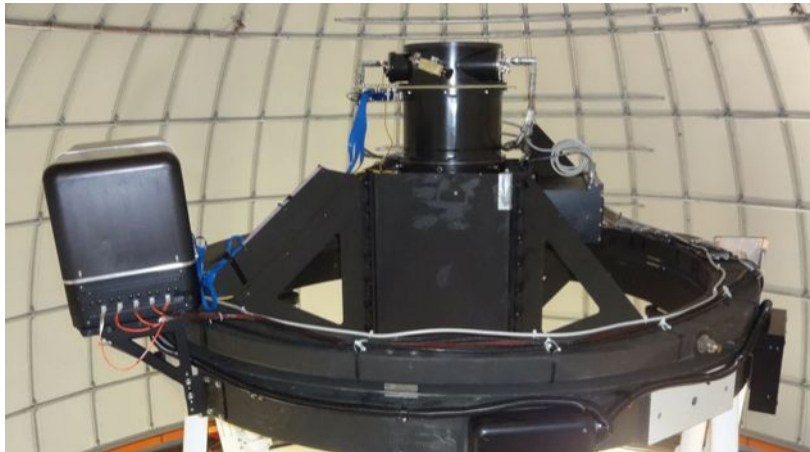
- Wide Field Optical Telescope
 - ▣ Primary Mirror with 1.6m Diameter
 - ▣ Prime Focus type Reflector
 - ▣ Equatorial Mount
 - ▣ Effective Focal Length of 5160mm
 - ▣ Four Field Corrector Lenses
 - ▣ Delivered Image Quality of 1.0 arcsec FWHM under 0.75 arcsec seeing



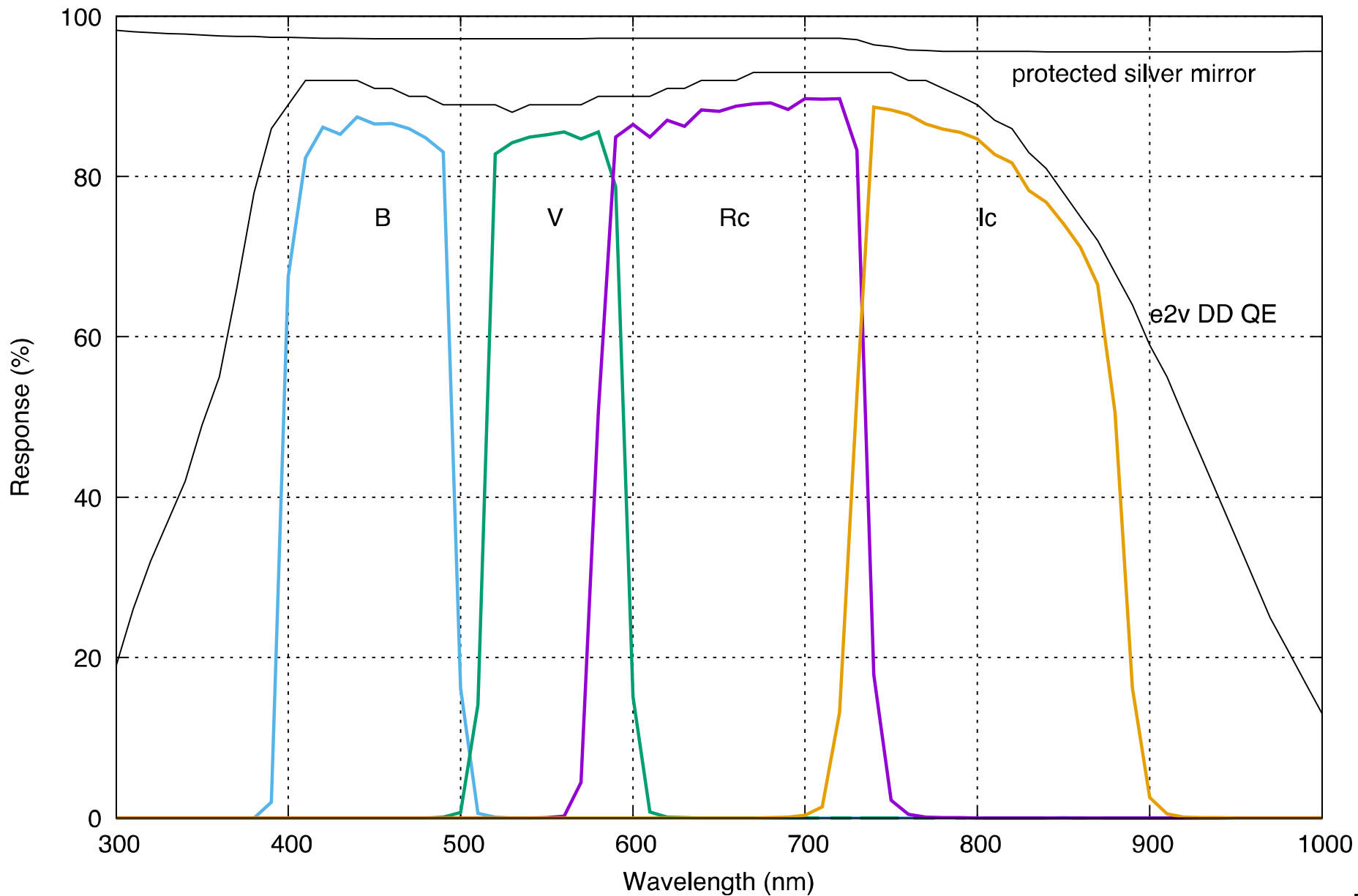
Camera



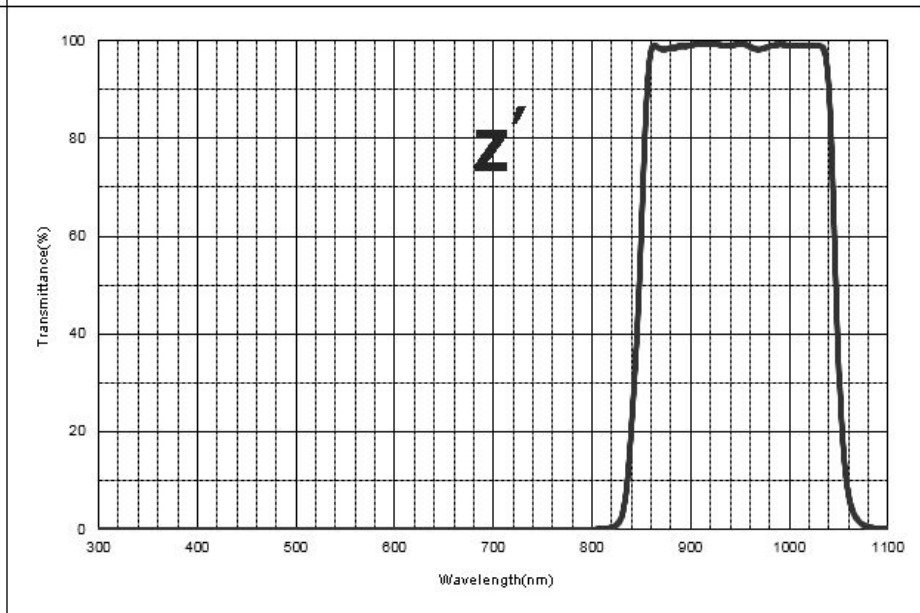
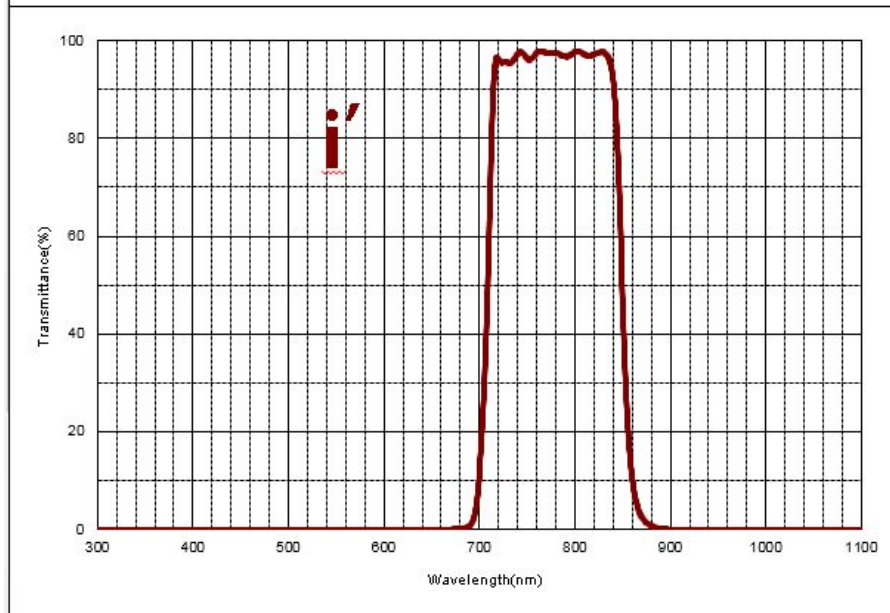
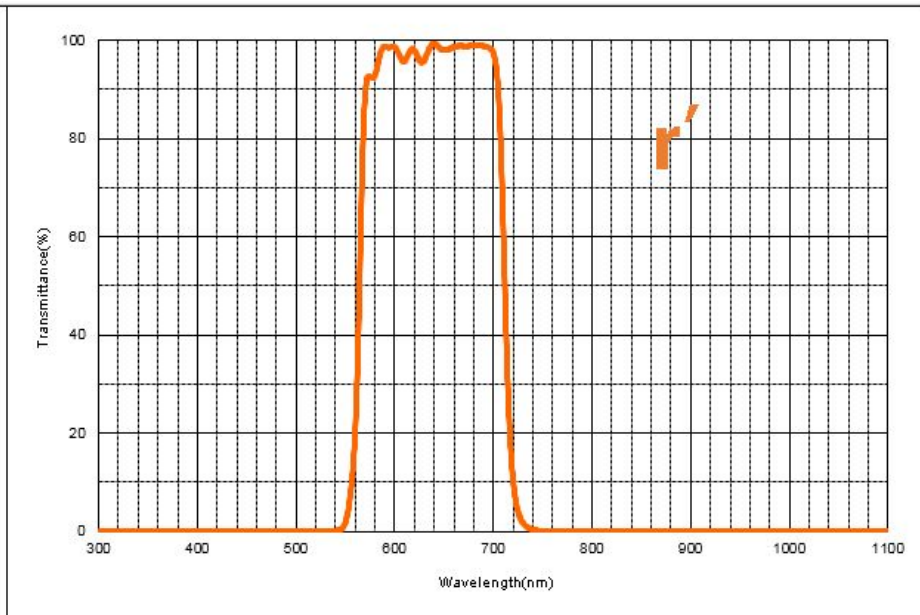
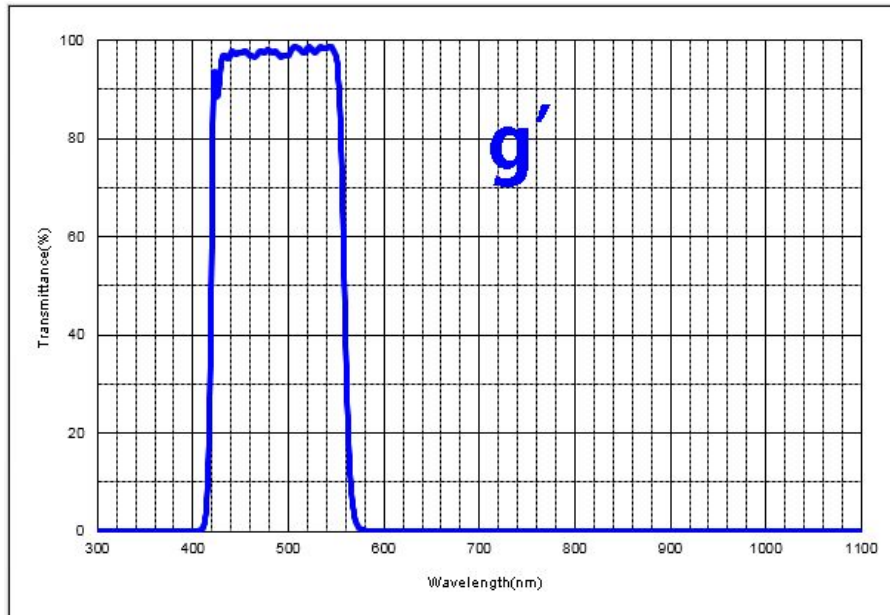
- Large-Format Mosaic CCD camera
 - ▣ Four e2v Chips with $9k \times 9k$ pixels
 - ▣ $10 \mu\text{m} \times 10 \mu\text{m}$ pixel
 - ▣ 0.4 arcsec/pixel, $2^\circ \times 2^\circ$ Field Of View (FOV)
 - ▣ High Quantum Efficiency of $\sim 90\%$
 - ▣ Cryogenic Cooling System



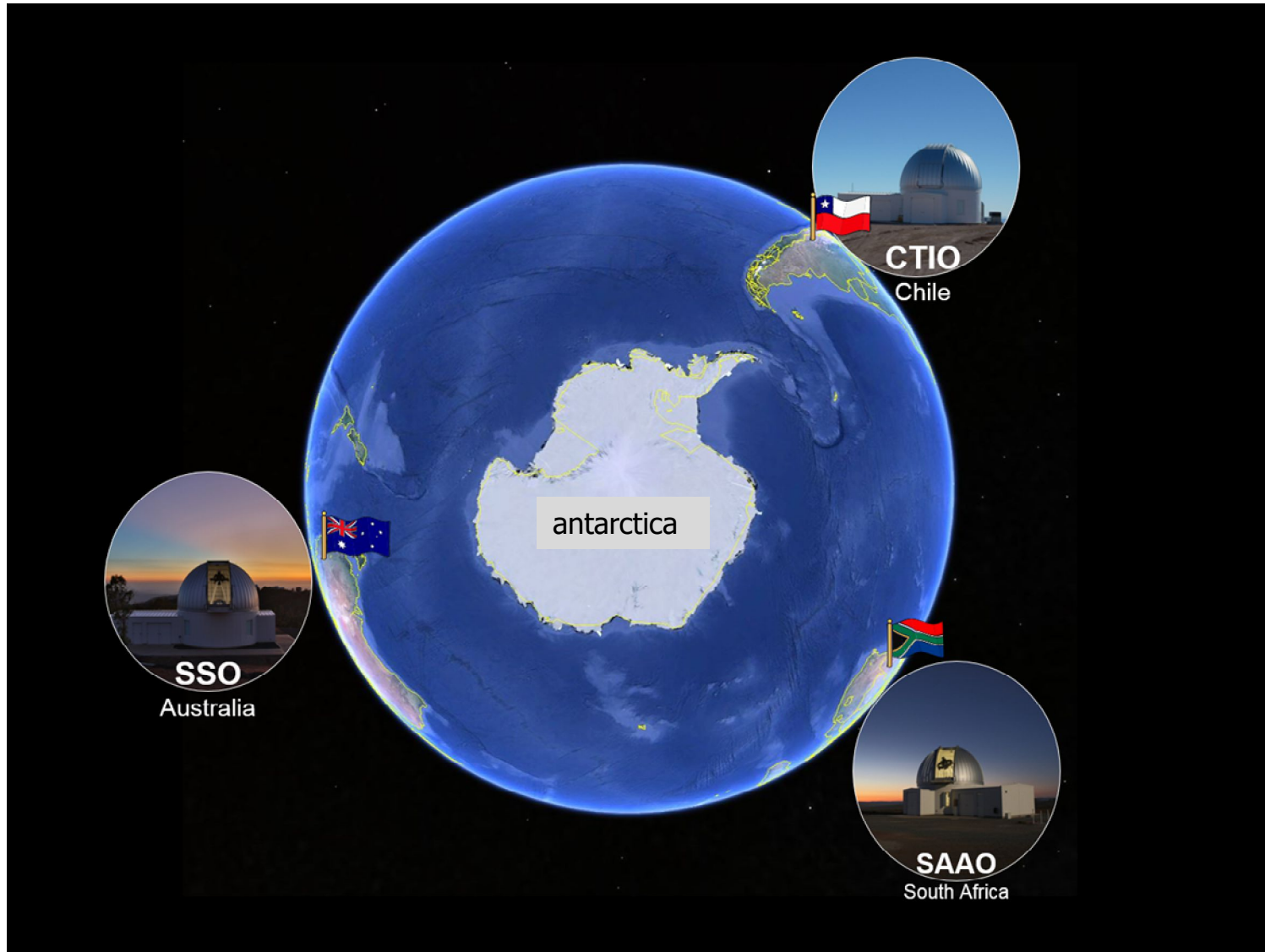
BVRI Filters (3 sites) : Grade 1, Deep depletion, Astro multi-2



SDSS band pass filters at CTIO



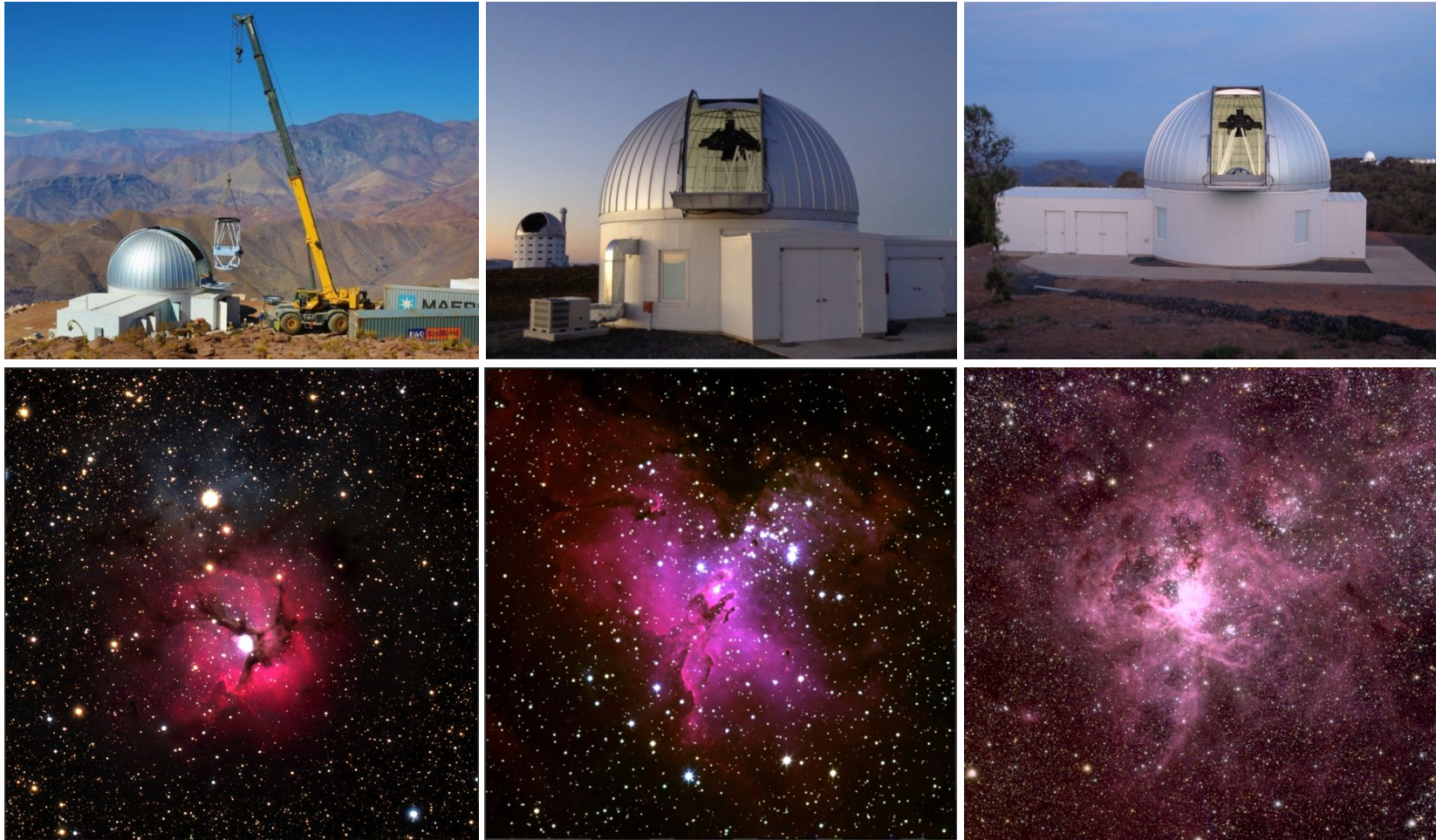
Observation Sites



Installation



- Installation of the Three Telescopes in 2014 and Test Observation with a 4K CCD Camera



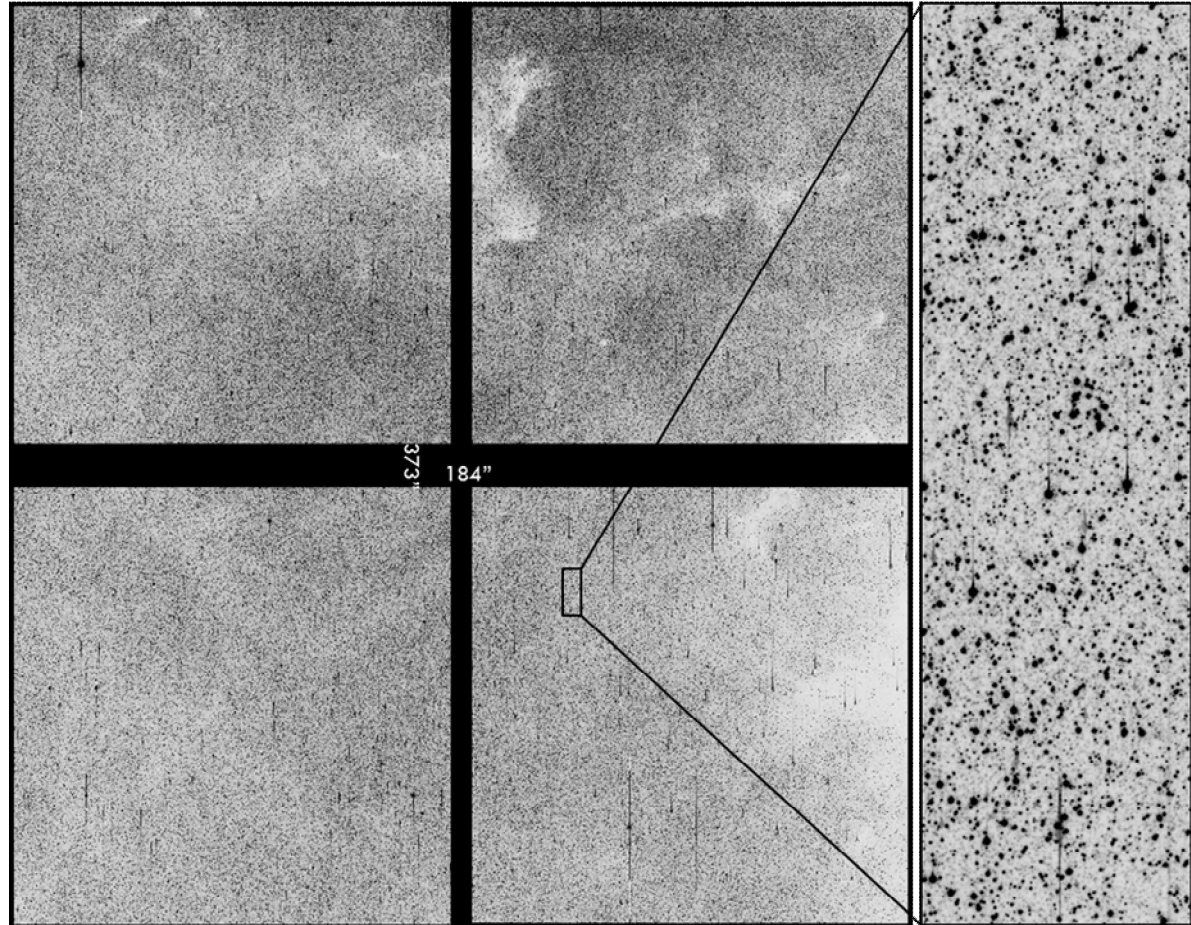
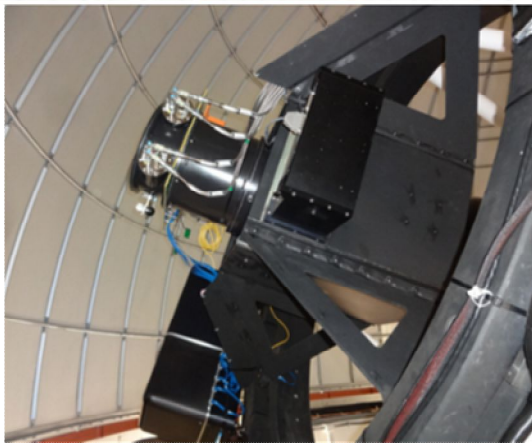
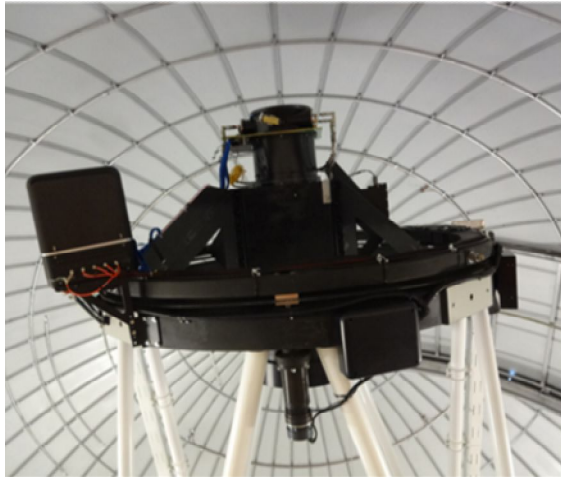
Upper) From left to right, CTIO in Chile on March 2014, SAAO in South Africa on July 2014, and SSO in Australia on November 2014

Lower) From left to right, Trifid nebula taken at CTIO, Eagle nebula at SAAO, and Tarantula nebula at SSO. 900sec in B, 600sec in V, and 300sec in I-band

Installation



- Installation of the Three Cameras by the end of June 2015



Left) Mosaic 18k CCD camera attached to the 1.6m telescope at CTIO in Chile

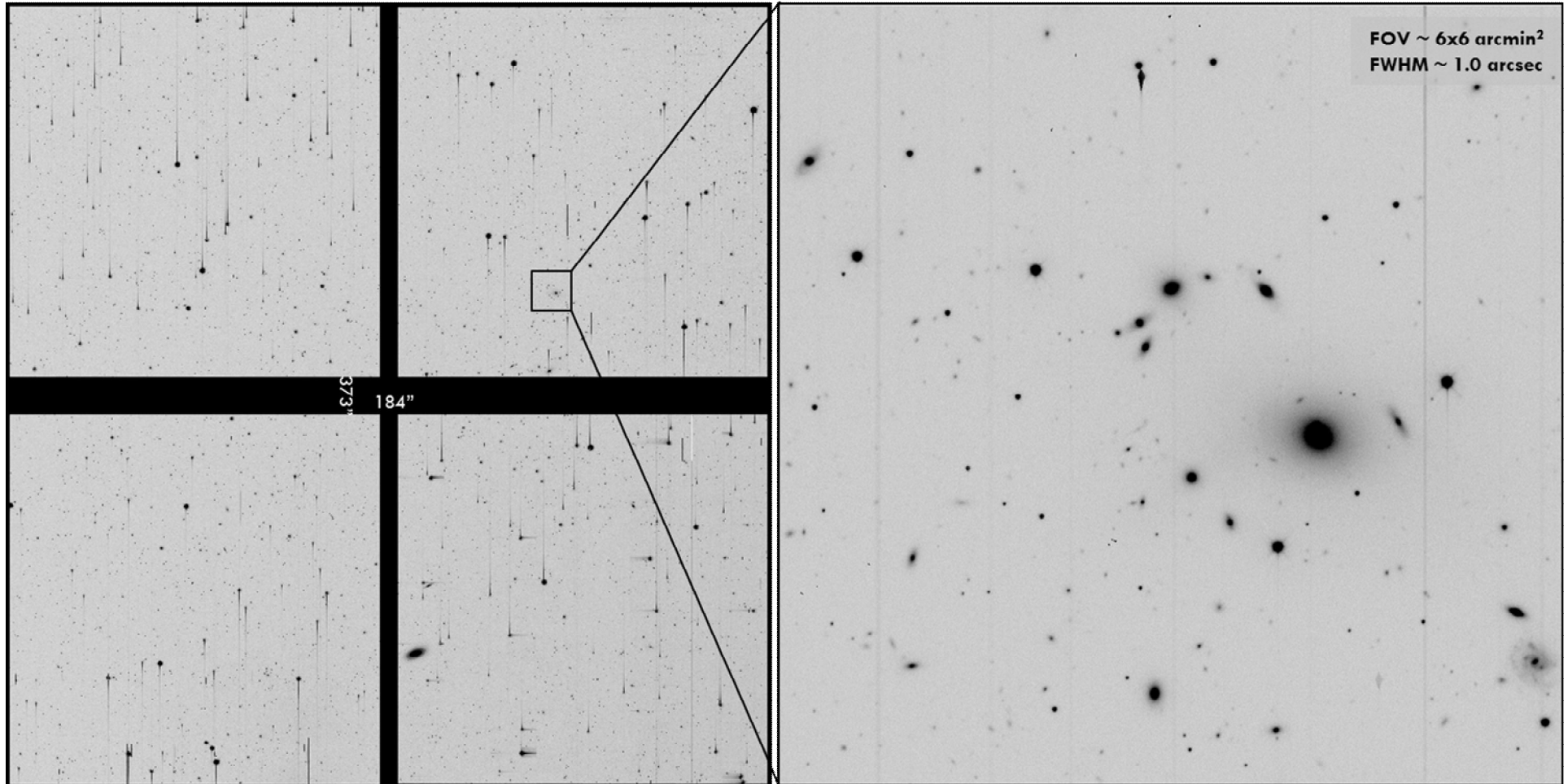
Center) Mosaic CCD image sample of the Galactic Bulge taken at SAAO on March 2015

Right) A zoomed image to show a dense stellar field of the Galactic Bulge

Sample of Test Images



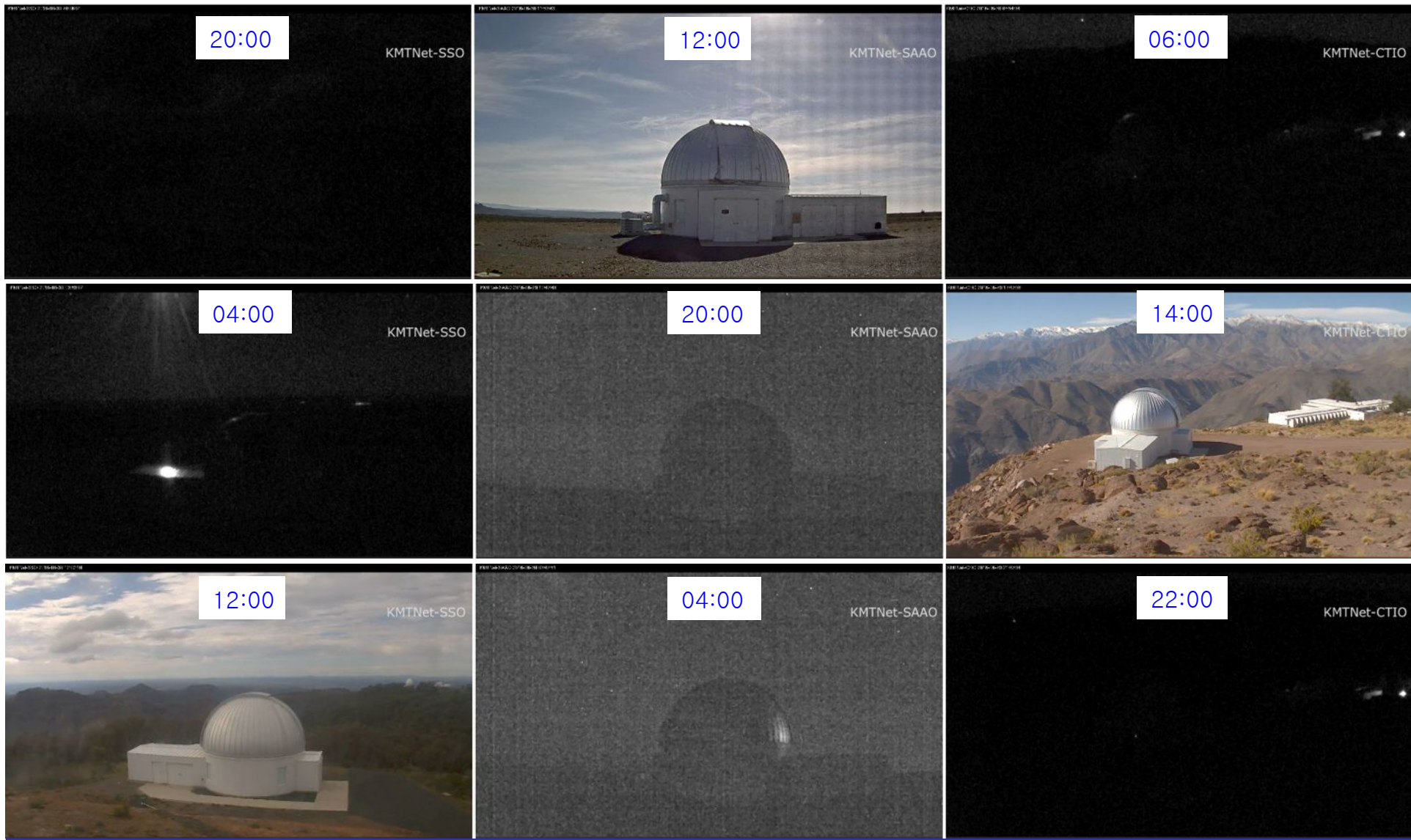
- Test run of an external galaxy on February, 2015 at CTIO. 120 sec exposure with R filter



Left) Mosaic CCD image sample

Right) A zoomed image to represent a cluster of galaxies

KMTNet – 24-hour continuous observation



Observing Room



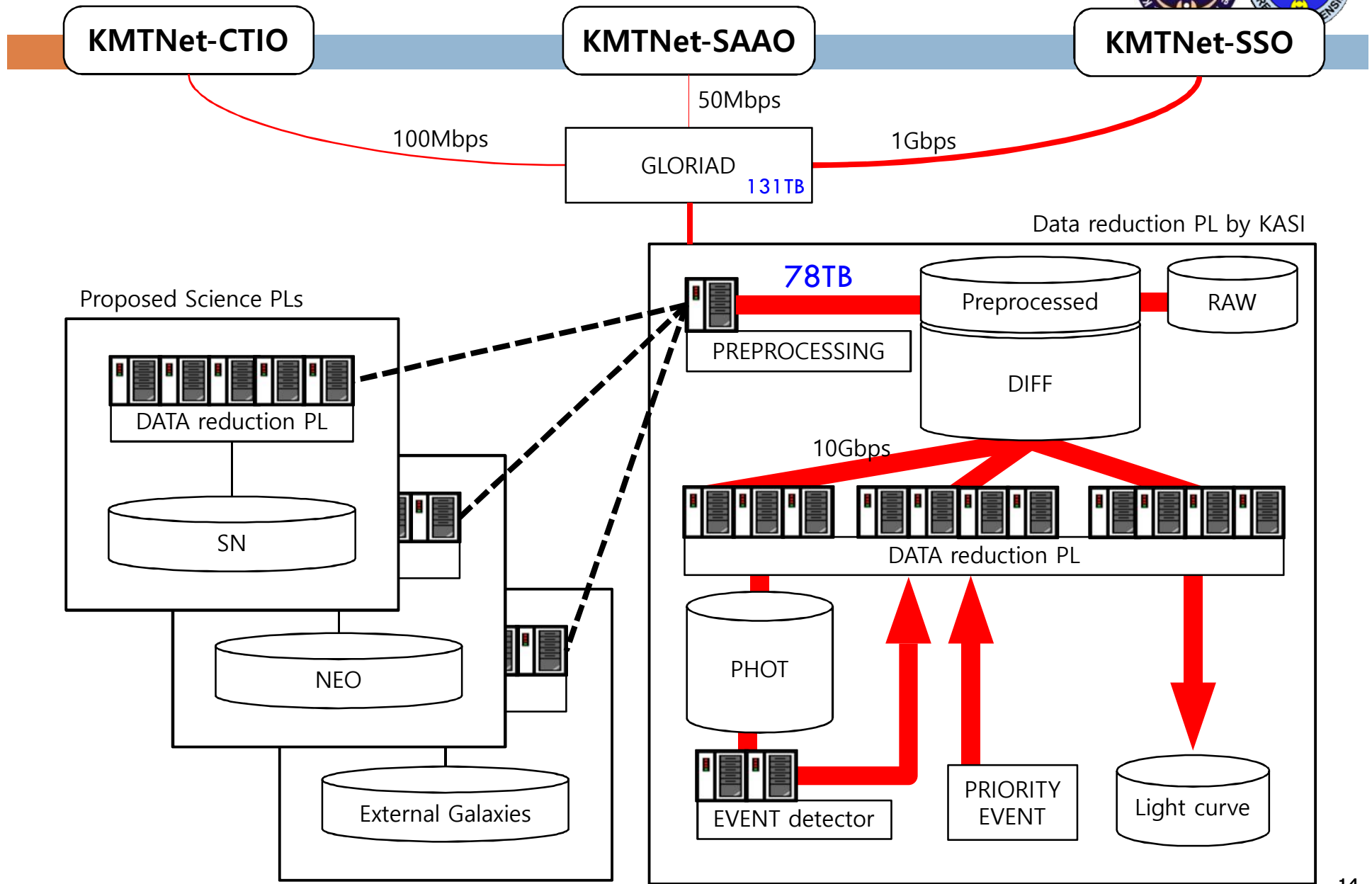
Data Handling



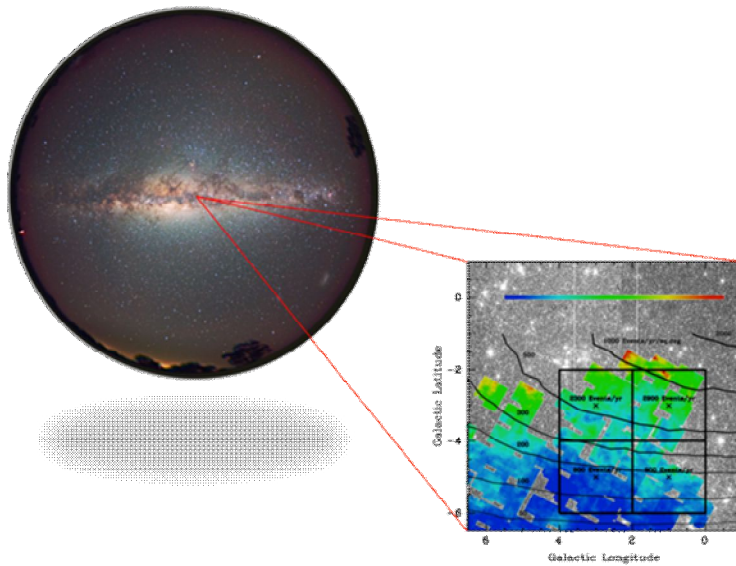
- Data Acquisition
 - Two residence observers (+ visiting observers) perform the observation at each site.
- Data transfer
 - A mosaic $18k \times 18k$ CCD image with **680 MByte** can be transferred from CTIO, SAAO, and SSO to KASI in 2 minutes after the observation with a rate of higher than **45 Mbps**.
- Image Processing
 - All the CCD images are pre-processed with the pipeline which was developed at KASI.
 - Project P.I.(s) can download the pre-processed images within 1~2 days after the observation.
 - Difference Image Analysis (DIA) is applied to the Bulge data to search for variable objects.



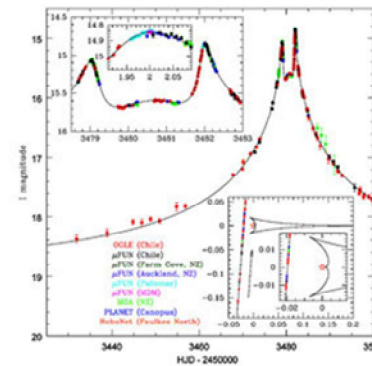
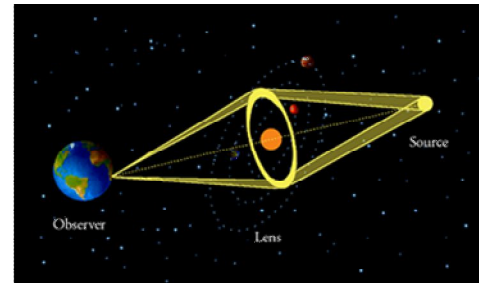
Data reduction pipeline



Main Science



Monitoring the Galactic Bulge



Detection of micro-Gravitational Lensing events

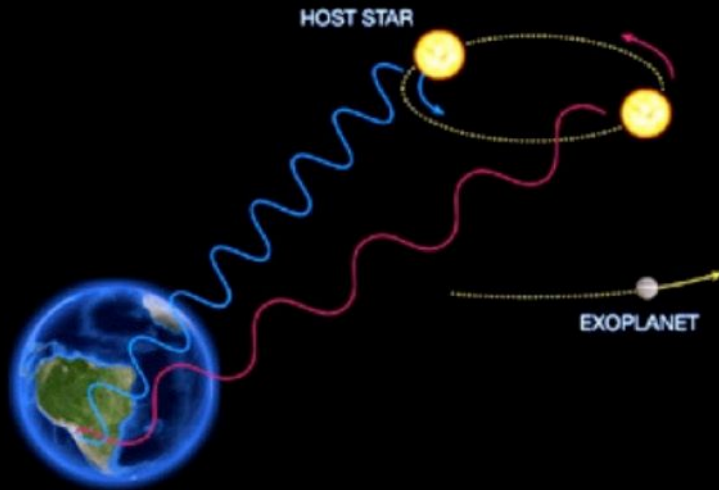


Discovery of **extra-solar planets**

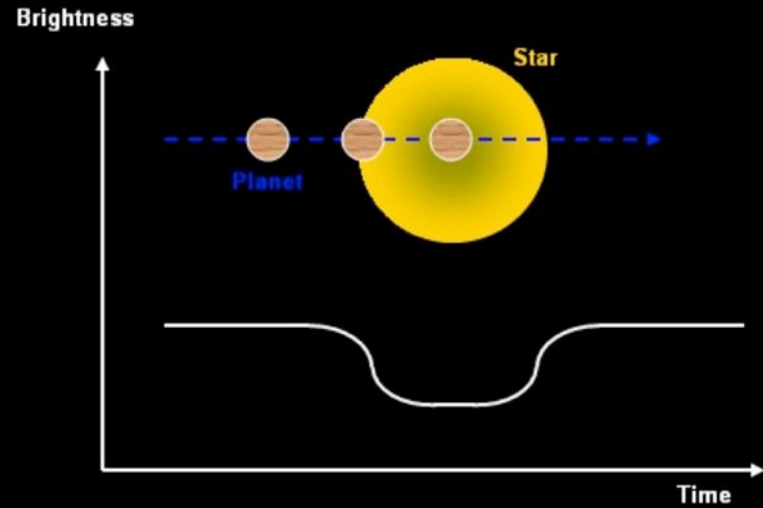


Big four

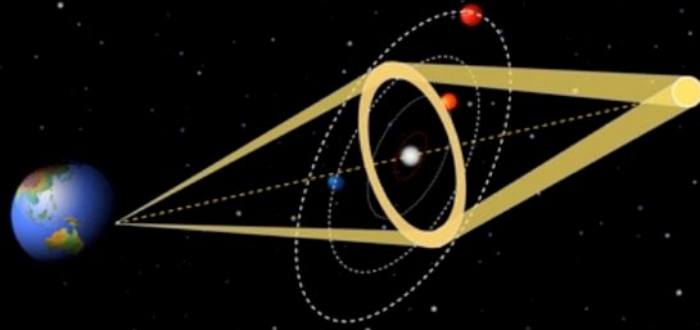
Radial Velocity



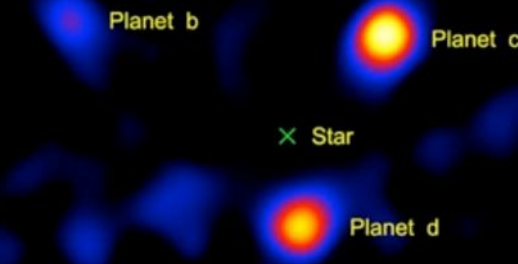
Transit Photometry



Microlensing



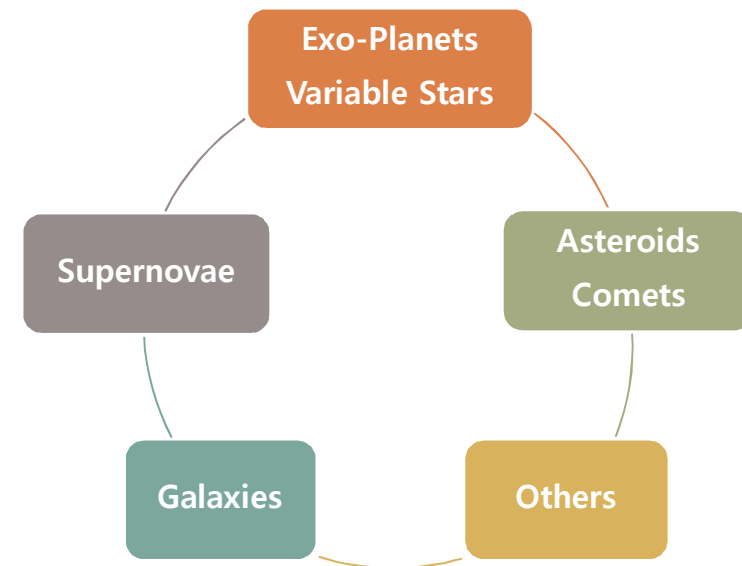
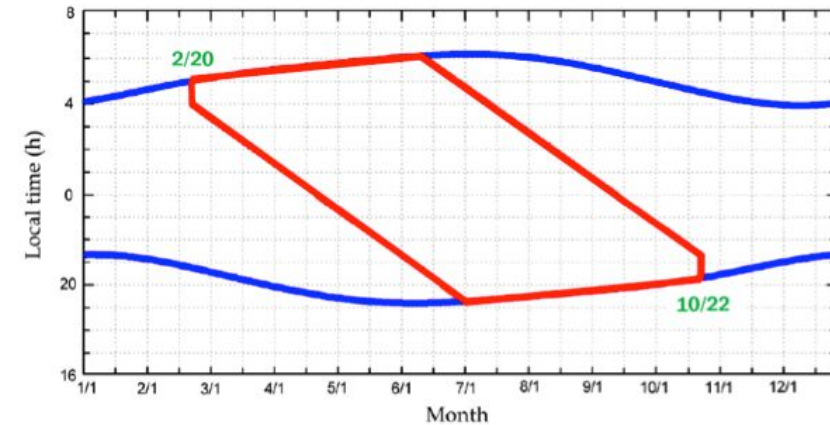
Direct Imaging



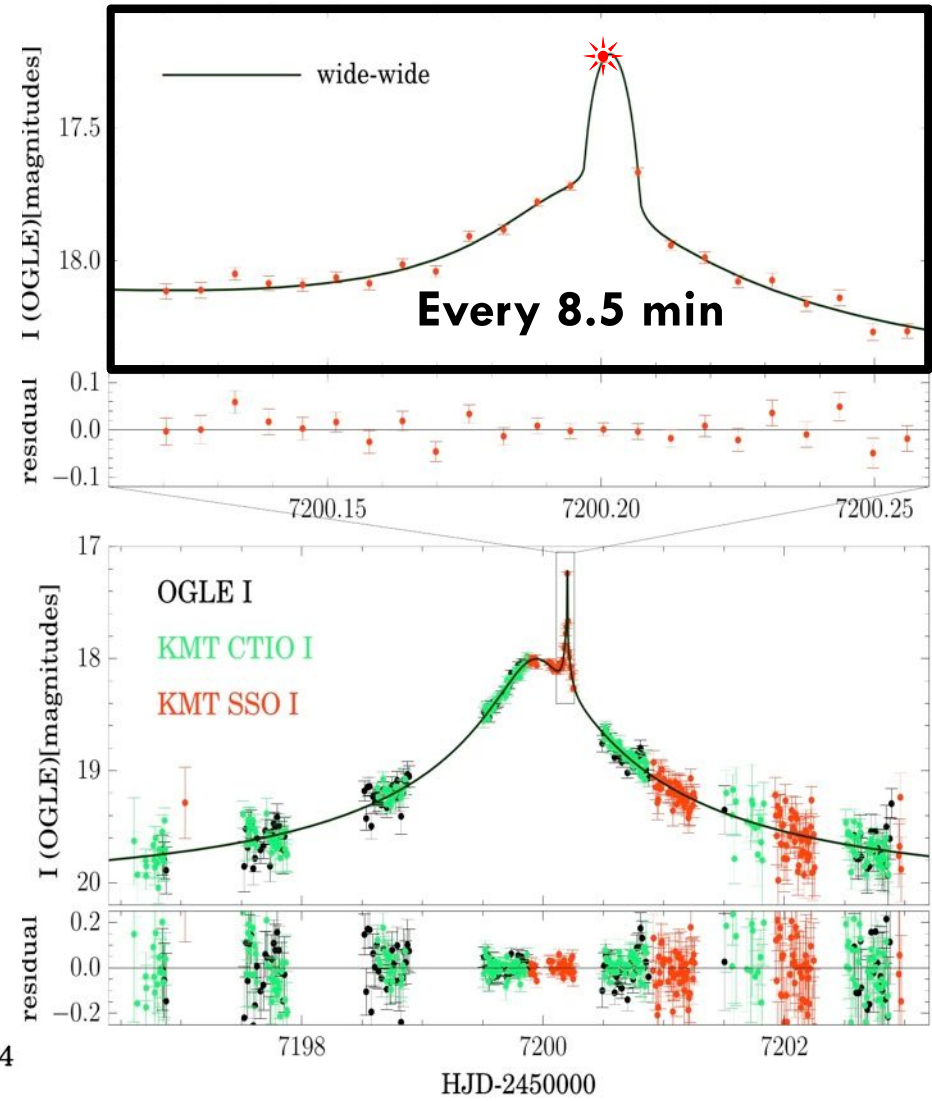
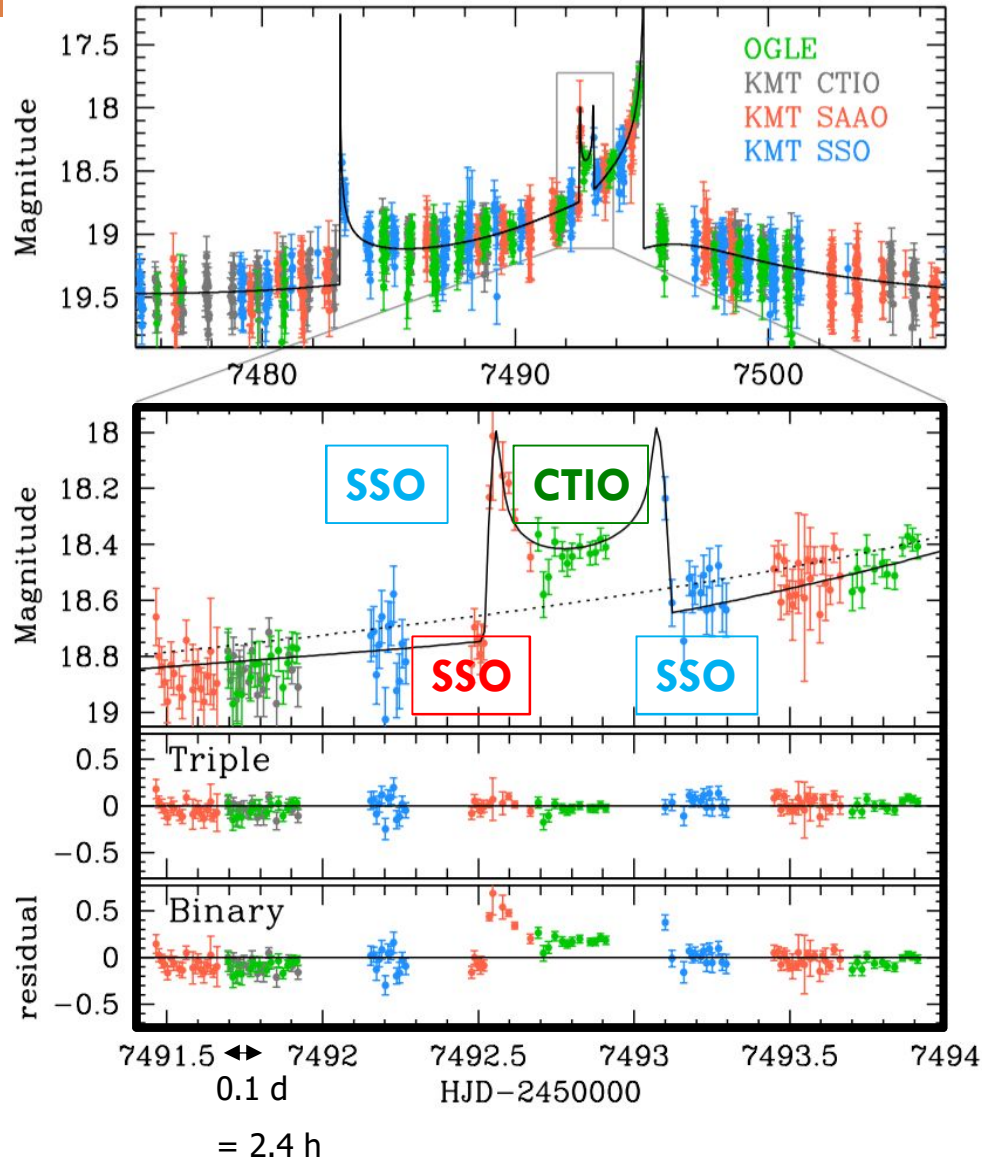
Sciences



- Galactic Bulge Season (Red)
 - Search for Extra-solar Planets with the micro-gravitational lensing technique, especially, Earth-mass Planets in the Habitable Zones
 - Search for Variable Objects (e.g. eclipsing binaries, pulsating stars, planetary transits, stellar flares, novae, other transient events)
- Non-Bulge Season (Blue)
 - Seven observation programs selected on 2012 will be performed for 5 years from 2015
 - Survey of Supernovae
 - Survey of Asteroids and Comets, especially, Near-Earth Objects
 - Multiband Photometry of External Galaxies
 - Others (e.g. Collaboration with the Host Countries, Director/Maintenance Time)



KMTNet – high cadence of 8.5 min



KMTNet (Unique) Advantages



▶ (Highly) Competitive Etendue ($A \times \Omega$)

KMTNet: $1.6^2 \times 2^2 \approx 10.2$ (m² sqd)

▶ Excellent Pixel Sampling & Filter Sets

KMTNet: 0.4"/pixel, BVRI ($g'r'i'z$) H α

▶ (Unique) 24-hr Continuous Sky Coverage

(Supernovae: Early, rare, and high-cadence monitoring)