

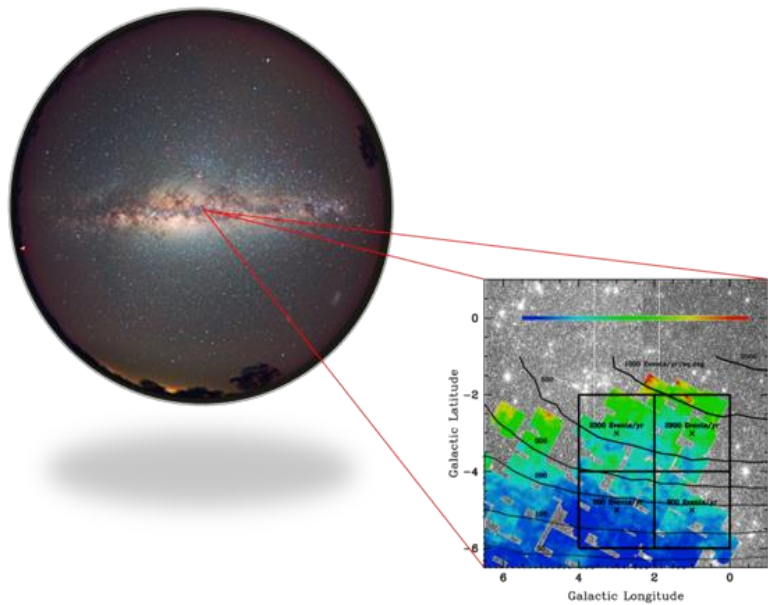
Korea Microlensing Telescope Network KMTNet Supernova Program (KSP)



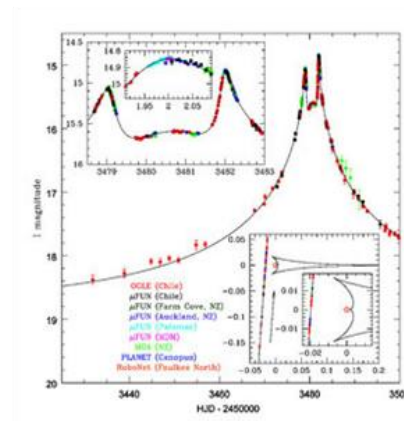
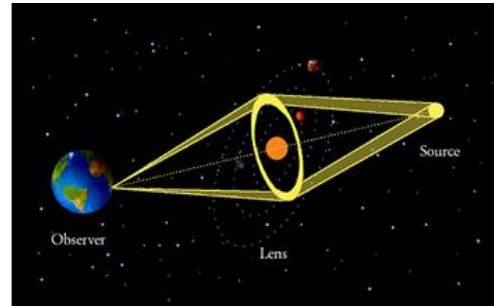
Hong Soo Park (KASI), Dae-Sik Moon(PI, U. Toronto), Sang Chul Kim,
Youngdae Lee, (Jae-Joon Lee, Chung-Uk Lee, Seung-Lee Kim)

2019.2.20.-22. Survey Science Group Workshop

Main Science of KMTNet



Monitoring the Galactic Bulge



Detection of micro-Gravitational Lensing events



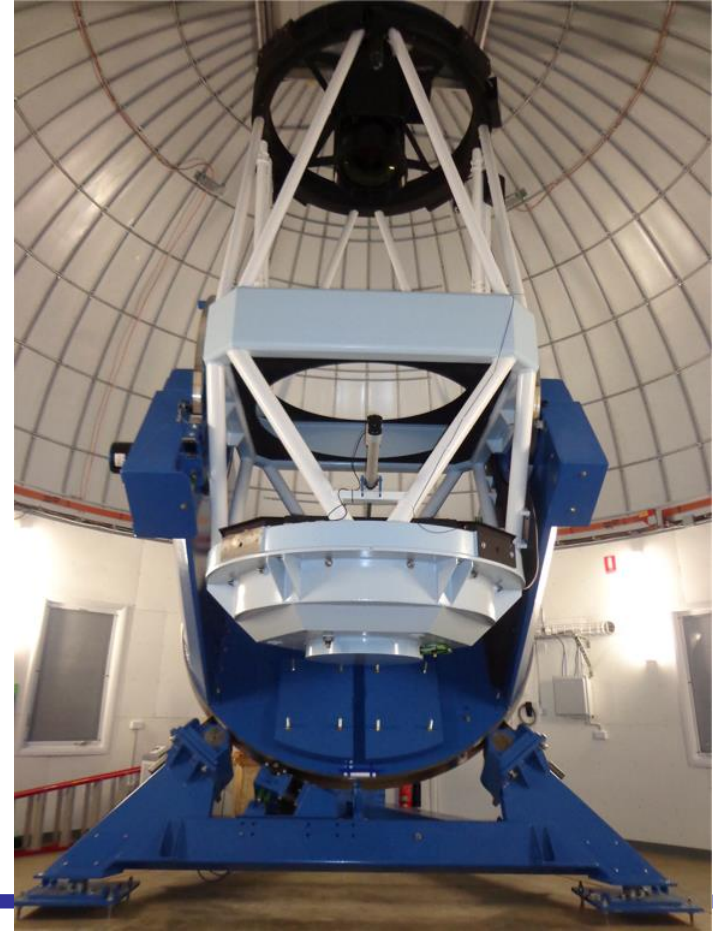
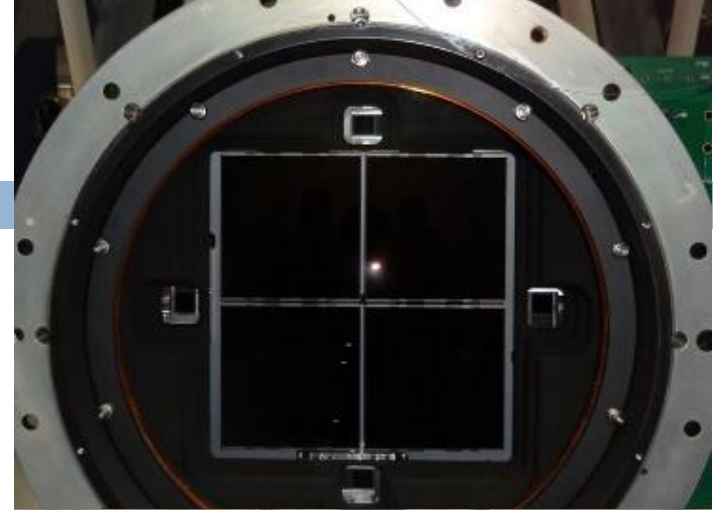
Discovery of **extra-solar planets**



KMTNet Observation System

3

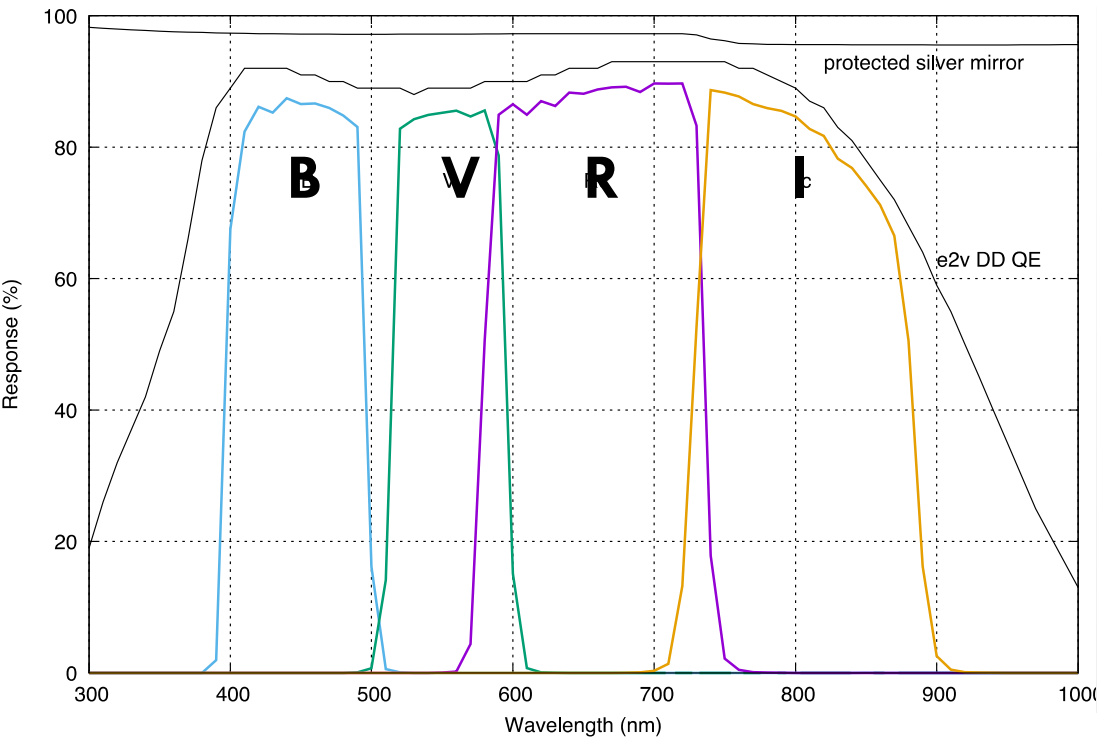
- ❑ **K**orea **M**icrolensing **T**elescope **N**etwork
- ❑ Three Identical Observing Systems:
CTIO in Chile, SAAO in South Africa,
SSO in Australia
- ❑ **24-hours Monitoring** of night sky at
Southern Hemisphere
- ❑ Primary Mirror with 1.6m Diameter
- ❑ 4 Chips with 9K x 9K pixels
- ❑ 0.4 arcsec/pixel,
- ❑ **2°x2° wide-field of view** (FOV)



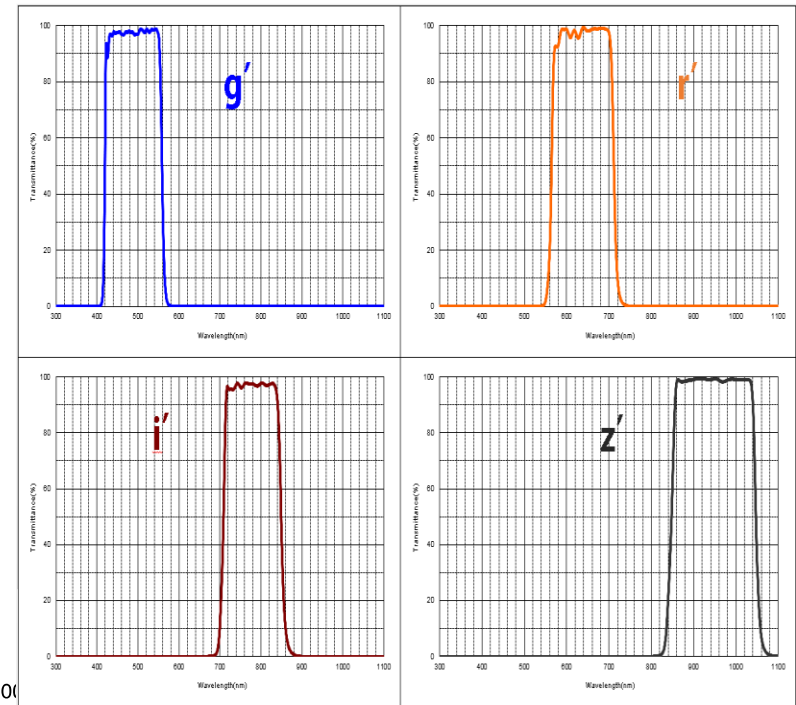
KMTNet Filter System



CTIO, SAAO, SSO: BVRI filters



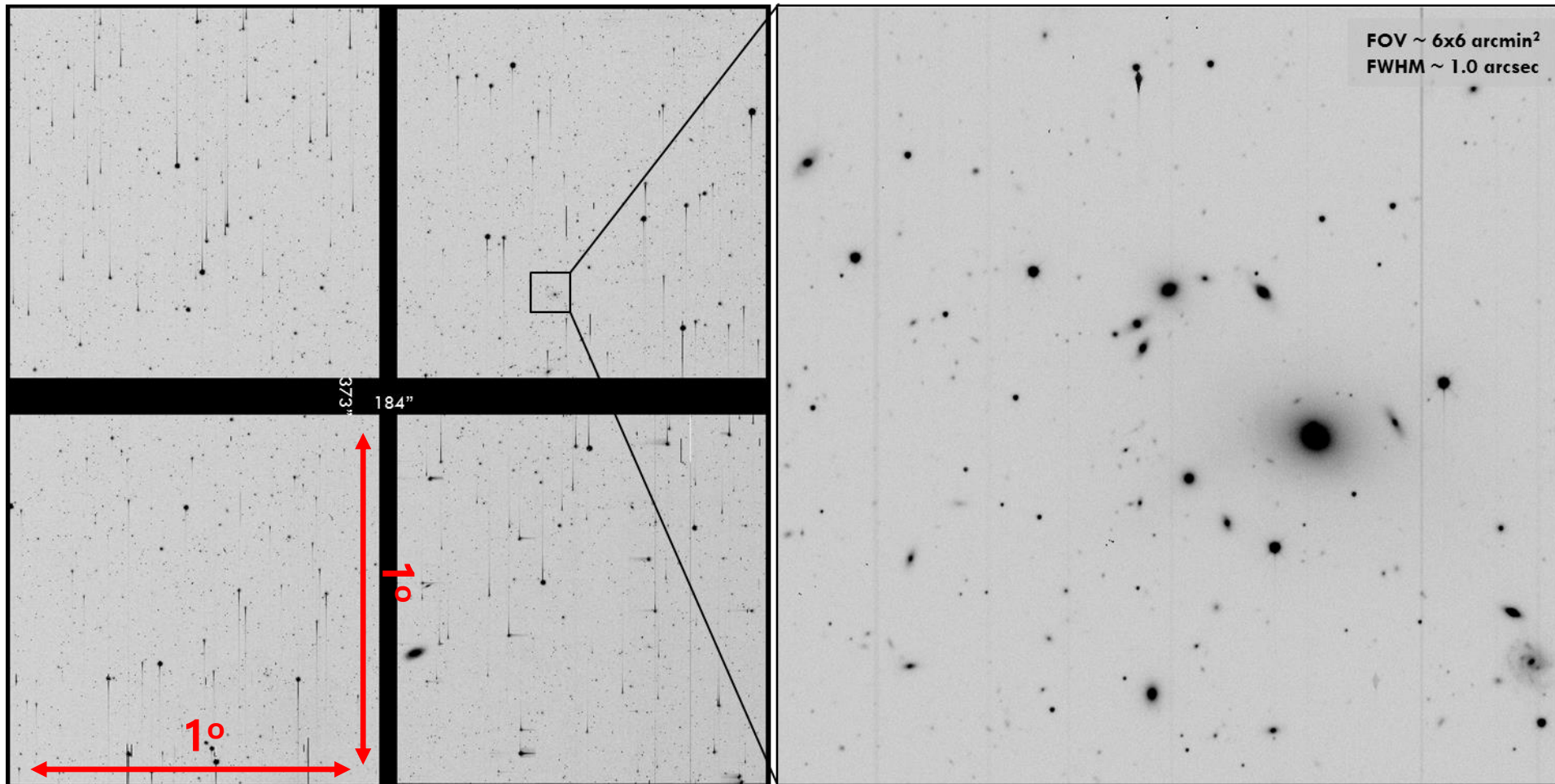
CTIO: SDSS (griz) filters



Sample Image

5

Galaxy Cluster 2015.02, CTIO. 120 sec, R filter

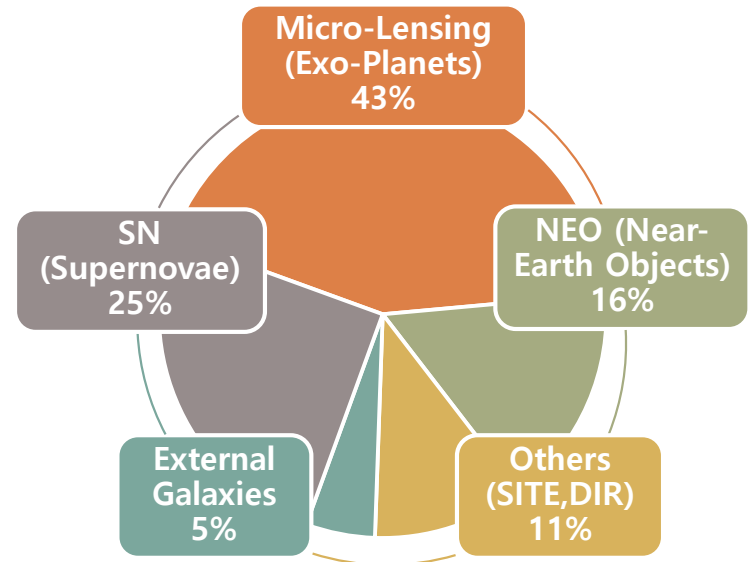
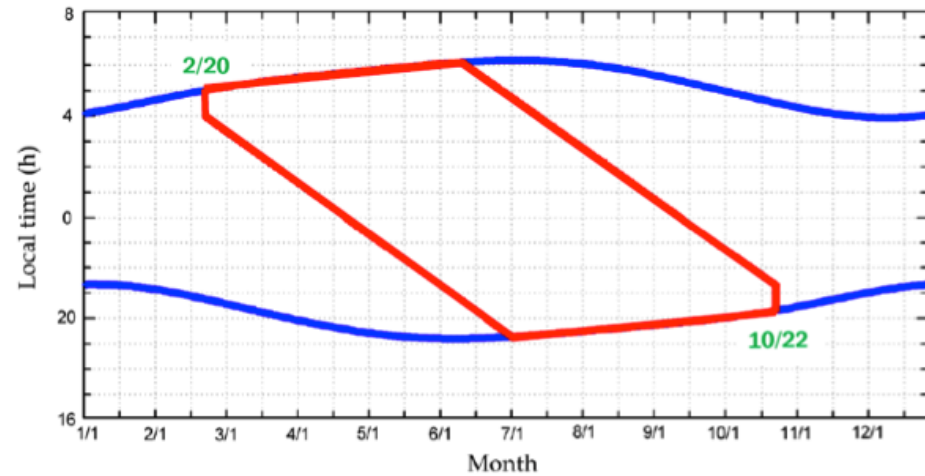


$2^\circ \times 2^\circ$ FOV

Science Case

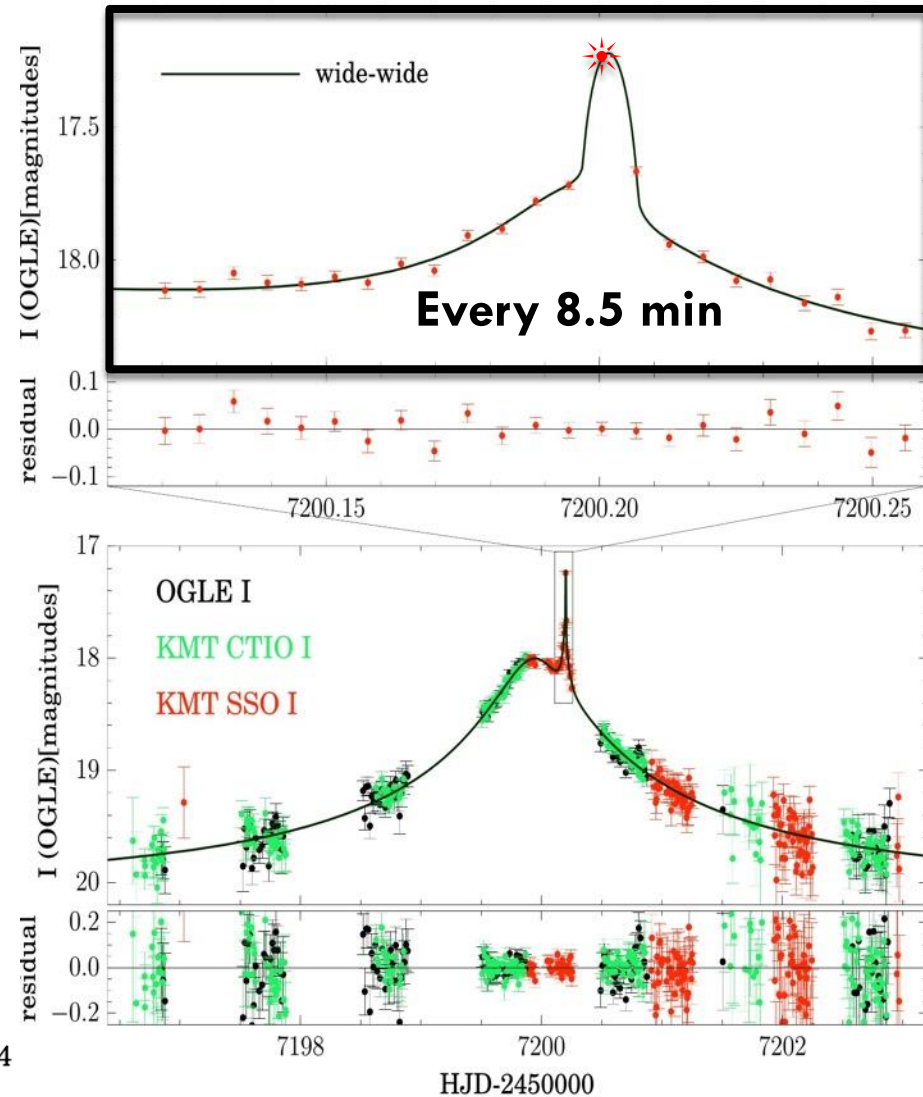
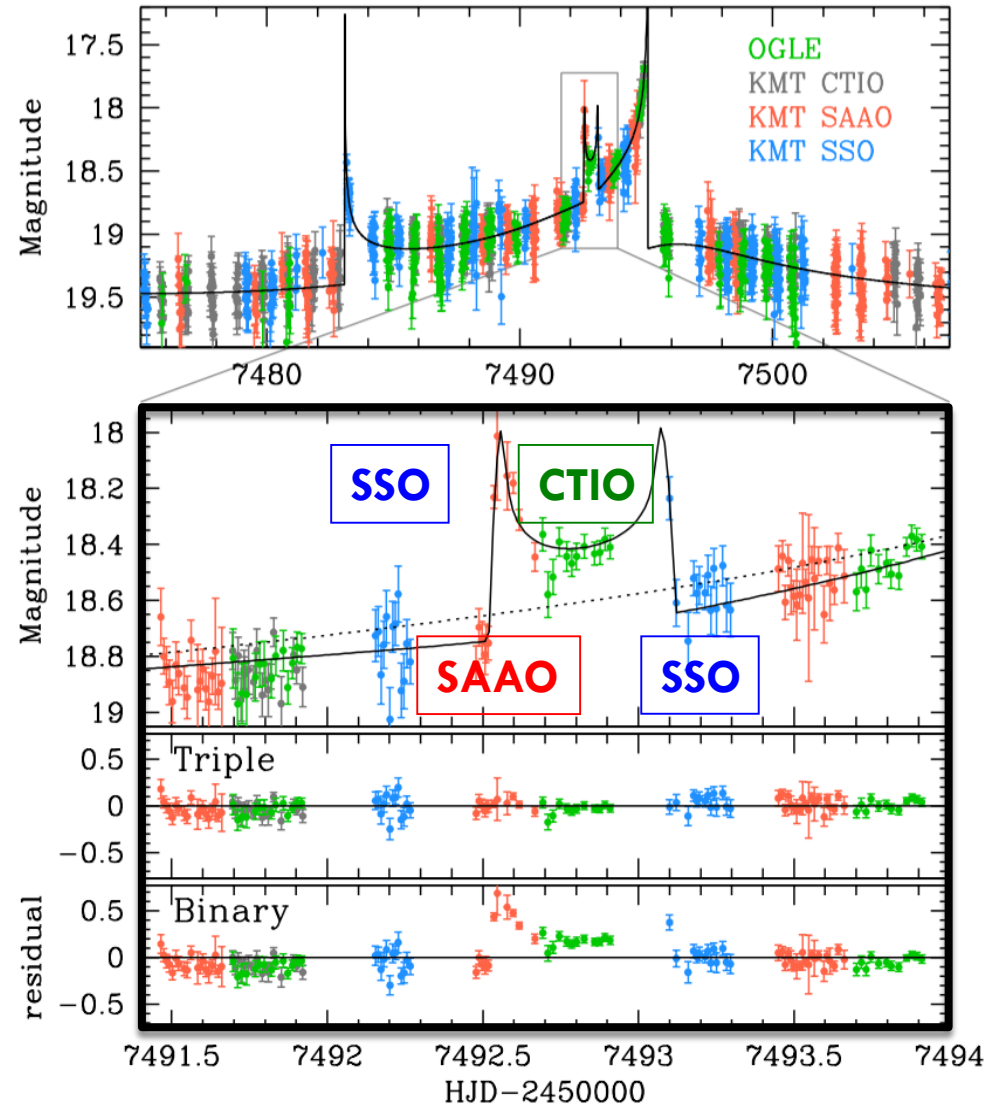


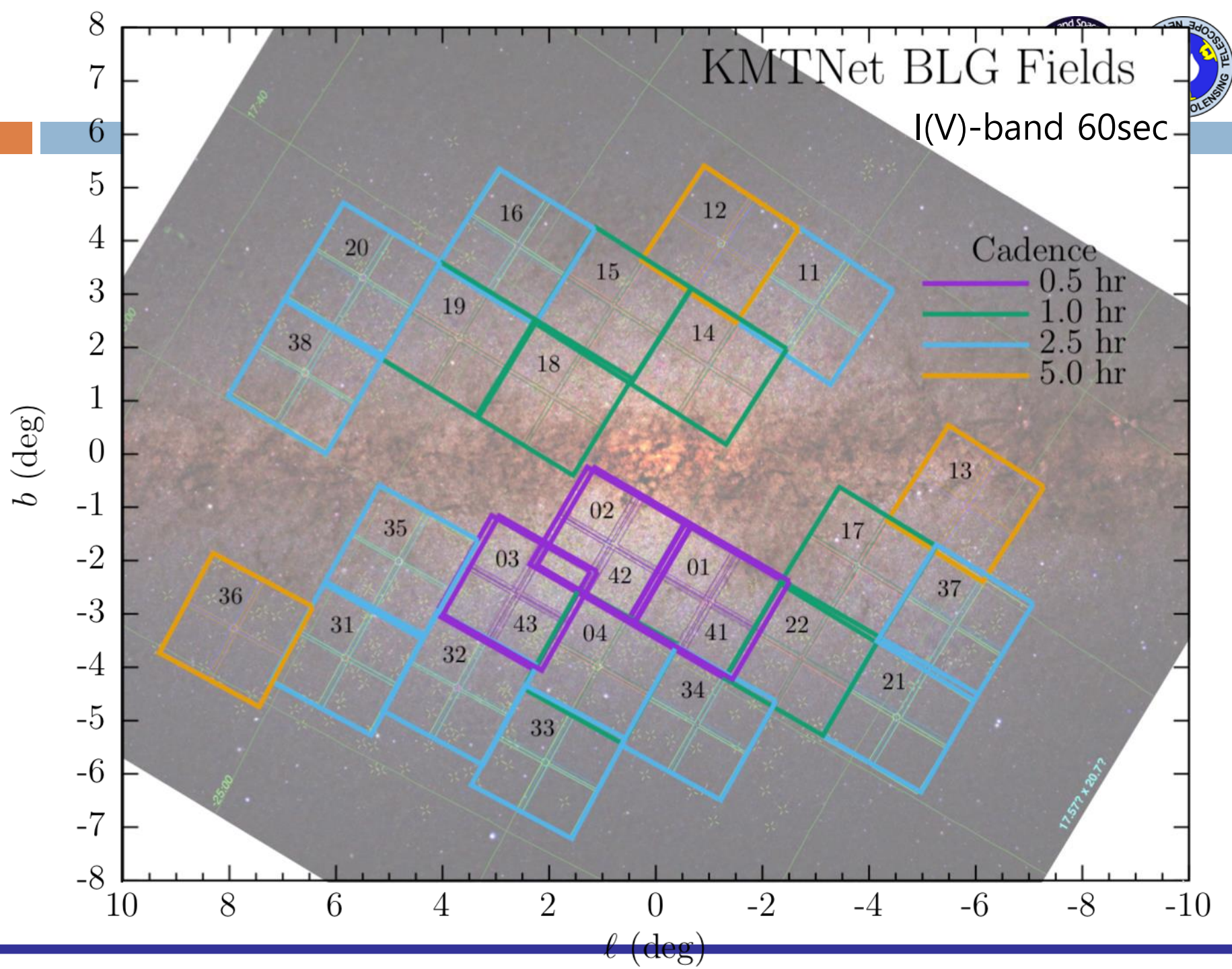
- Be performed for 5 years from 2015
- Galactic Bulge Season (Red)
 - Search for Extra-solar Planets with the **micro-gravitational lensing** technique, especially, **Earth-mass Planets in the Habitable Zone**
 - Search for Variable Objects
- Non-Bulge Season (Blue)
 - **Survey of Supernovae (~20%/17%)**
 - Survey of Asteroids and Comets, especially, **Near-Earth Objects**
 - Multiband Photometry of External Galaxies
 - Others (e.g. Collaboration with Host Countries, Director/Maintenance Time)



2017

Example of Light Curve





KMTNet Supernova Program (KSP)



▣ Members:

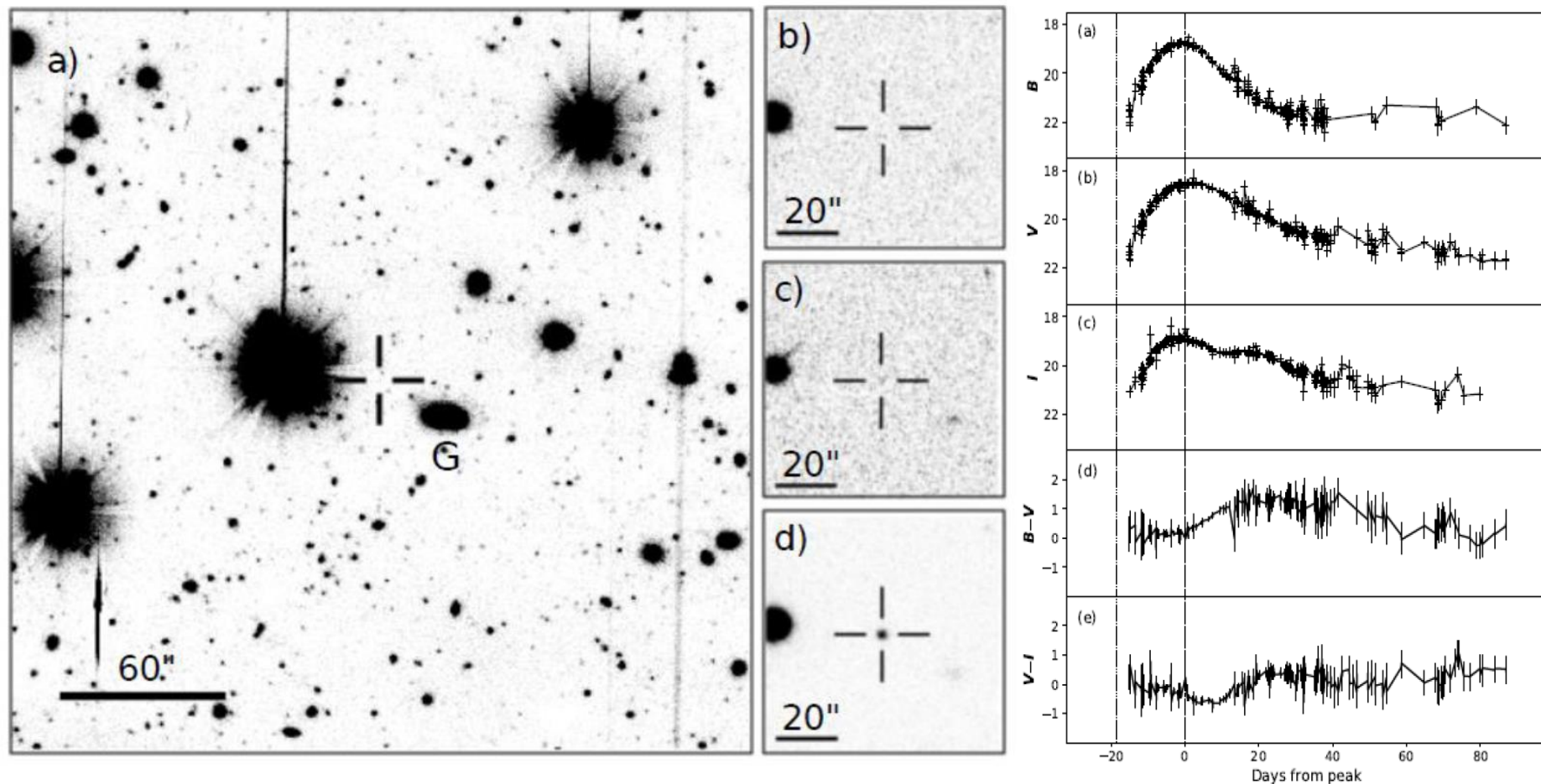
- KASI: Sang Chul Kim, Hong Soo Park, YoungDae Lee, (Jae-Joon Lee)
- U. Toronto: Dae-Sik Moon (PI), M. Drout, C. Y. Ni, N. Afasari, et al.

▣ Scientific Projects

- **Infant/Early explosions (Supernova)**
 - Fast, rare optical transients
 - Variable objects (star, AGN)
 - **Low surface brightness objects (dwarf galaxies, star clusters)**
- ▣ Target fields: >10 galaxy groups/semester, nearby fields ($D < 20 \text{ Mpc}$)
 - ▣ 3 sites, BVI, 60sec exposure time

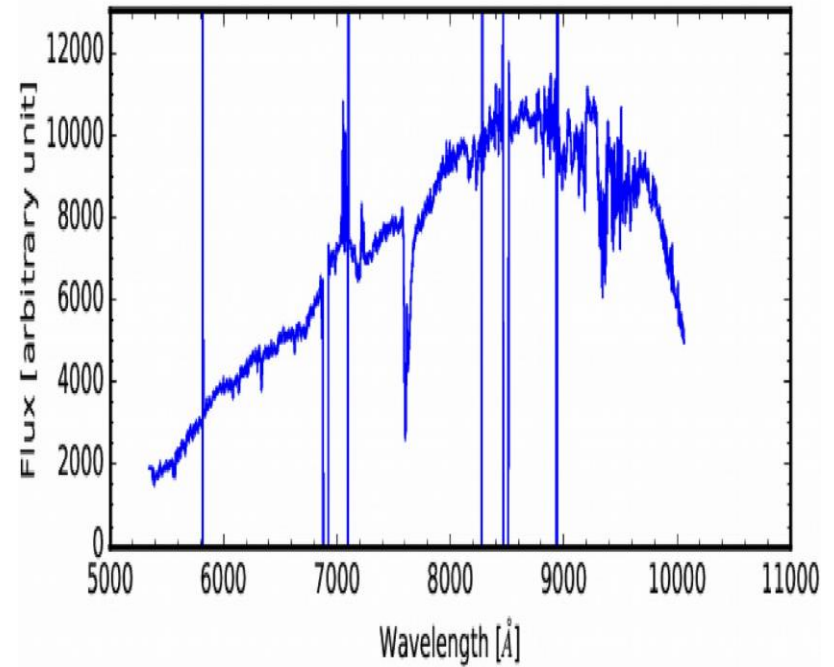
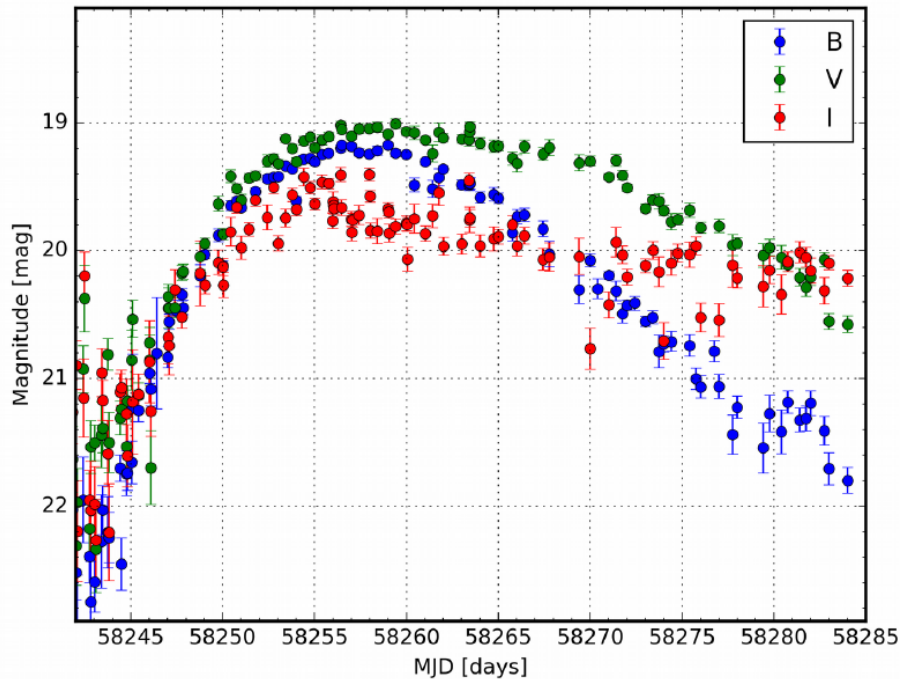
➔ **~20 KMTNet discovered early supernovae** – unique data set with BVI information and Gemini spectra → individual study + statistical analyses

Examples of KSP-discovered Supernovae



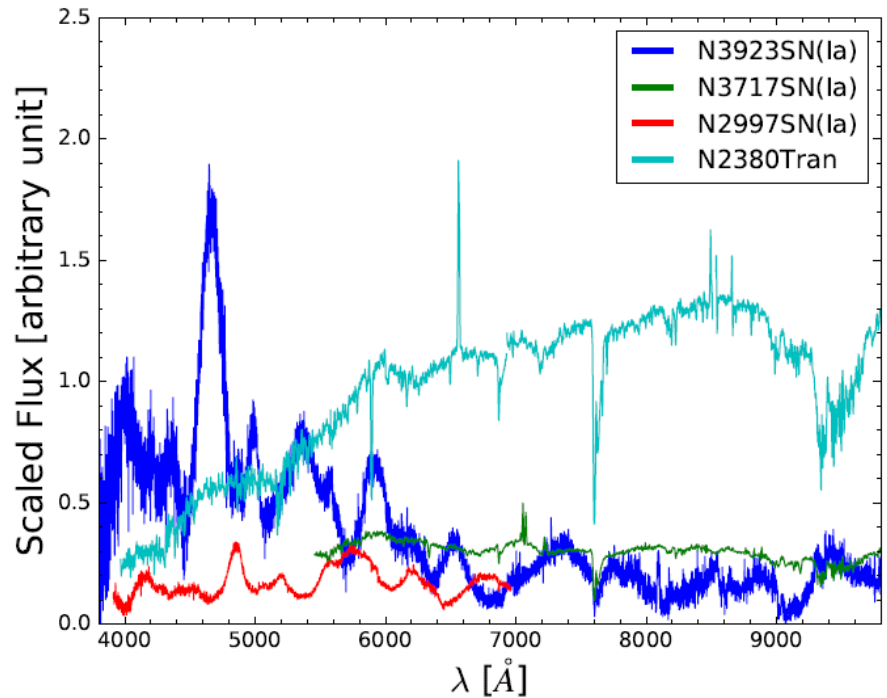
KSP-OT-201509a (Moon et al. 2019 in circulation)
Rapidly-declining **Normal Hostless** ($B > 26 \text{ mag/''}^2$) Type Ia Supernova

Examples of KSP-discovered Supernovae



KSP-OT-2018ng (Lee YD et al. 2019 in preparation)
Type Ia SN Light Curve, Gemini ToO observation

Gemini ToO Triggers of KSP Transients

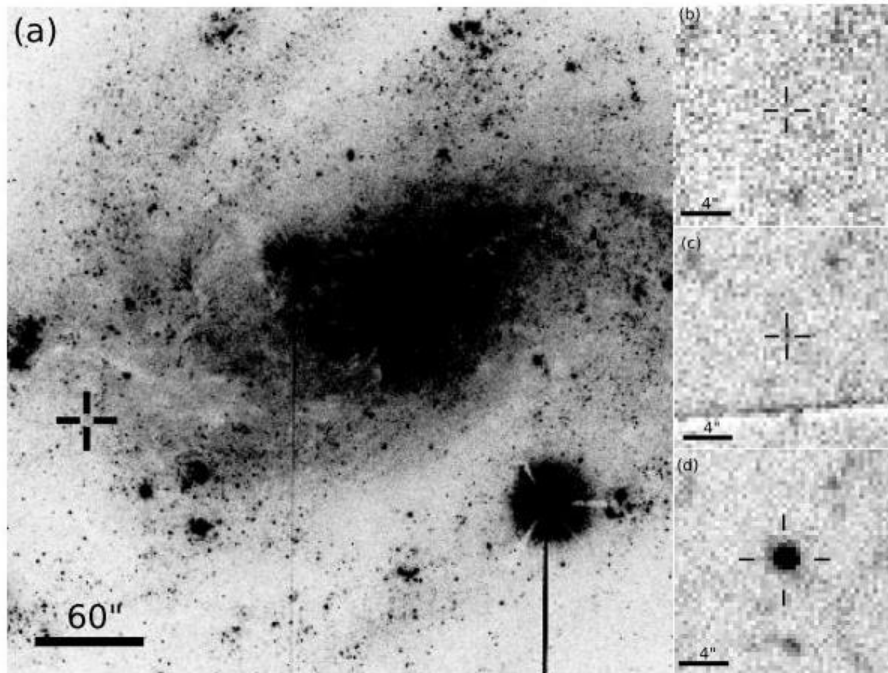


The first KSP detection: ~5 hours
after the explosion

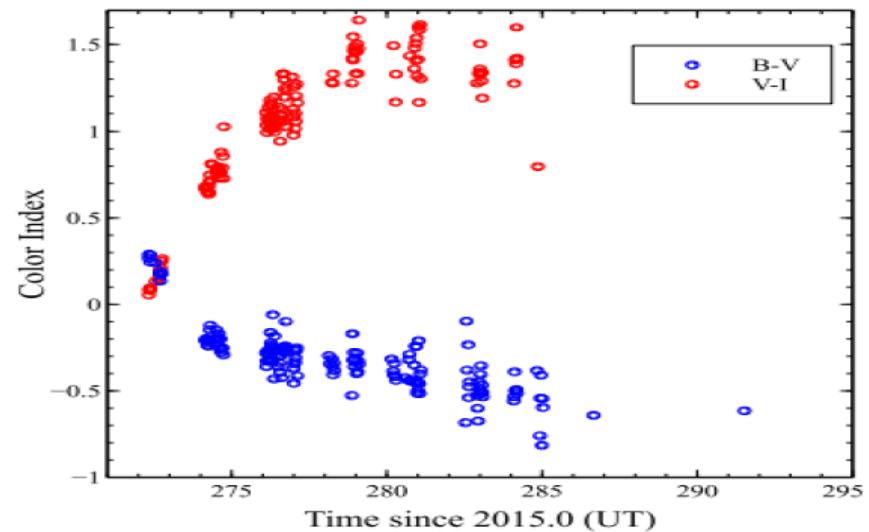
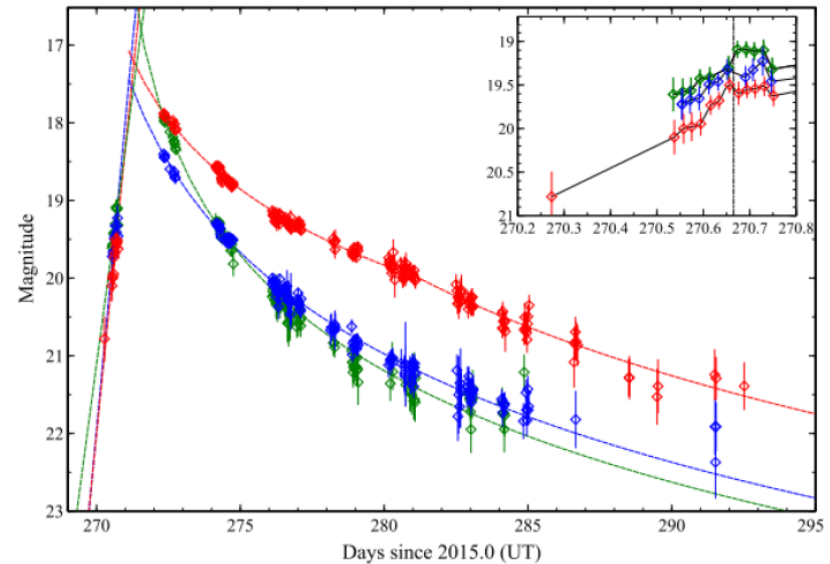
KSP real-time search: < 1.5 days

The first spectrum: < 4 days

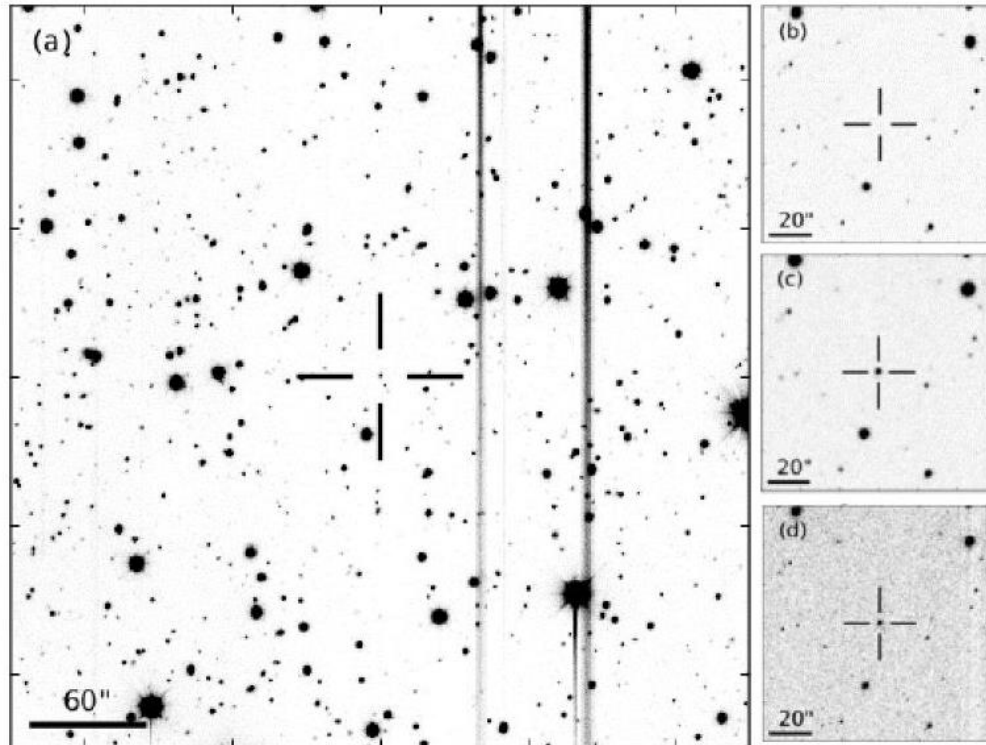
KSP- discovered Novae



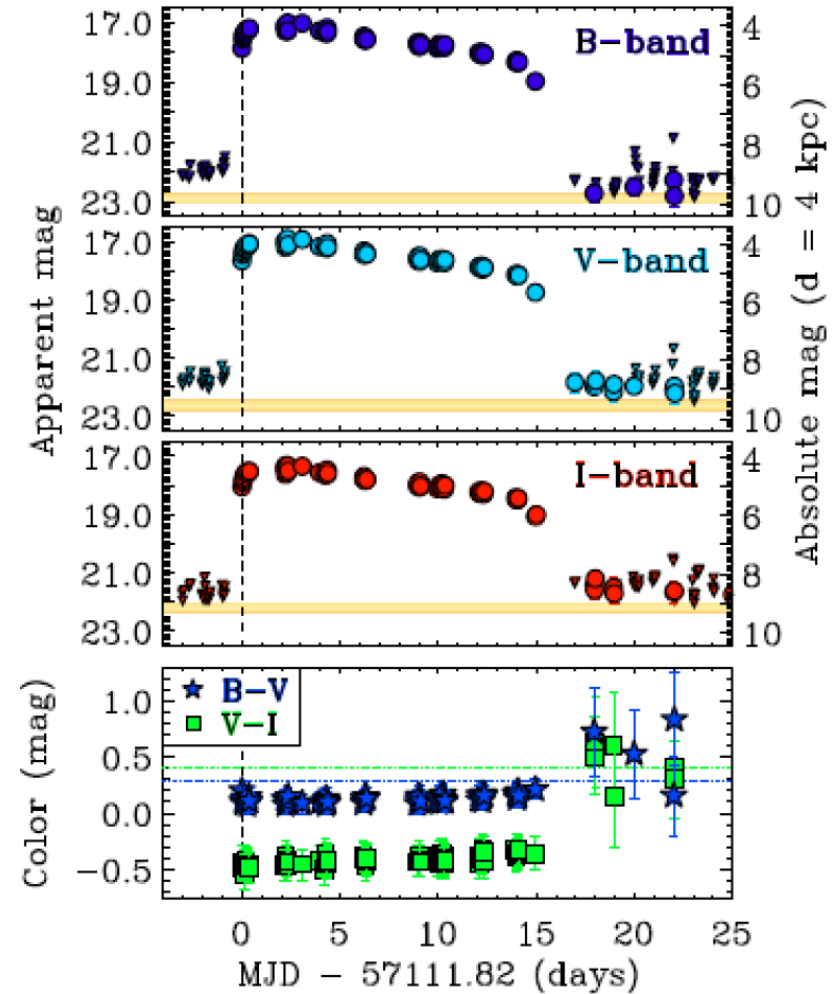
KSP-OT-201509a:
Antoniadis et al. (2017)
Rapidly Evolving Classical Nova



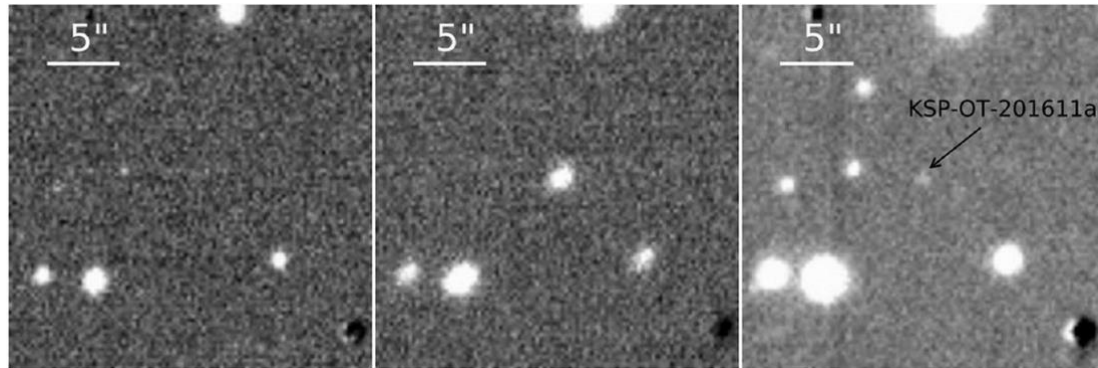
KSP- discovered Novae



KSP-OT-201503a:
Brown et al. (2018)
Peculiar Dwarf Nova



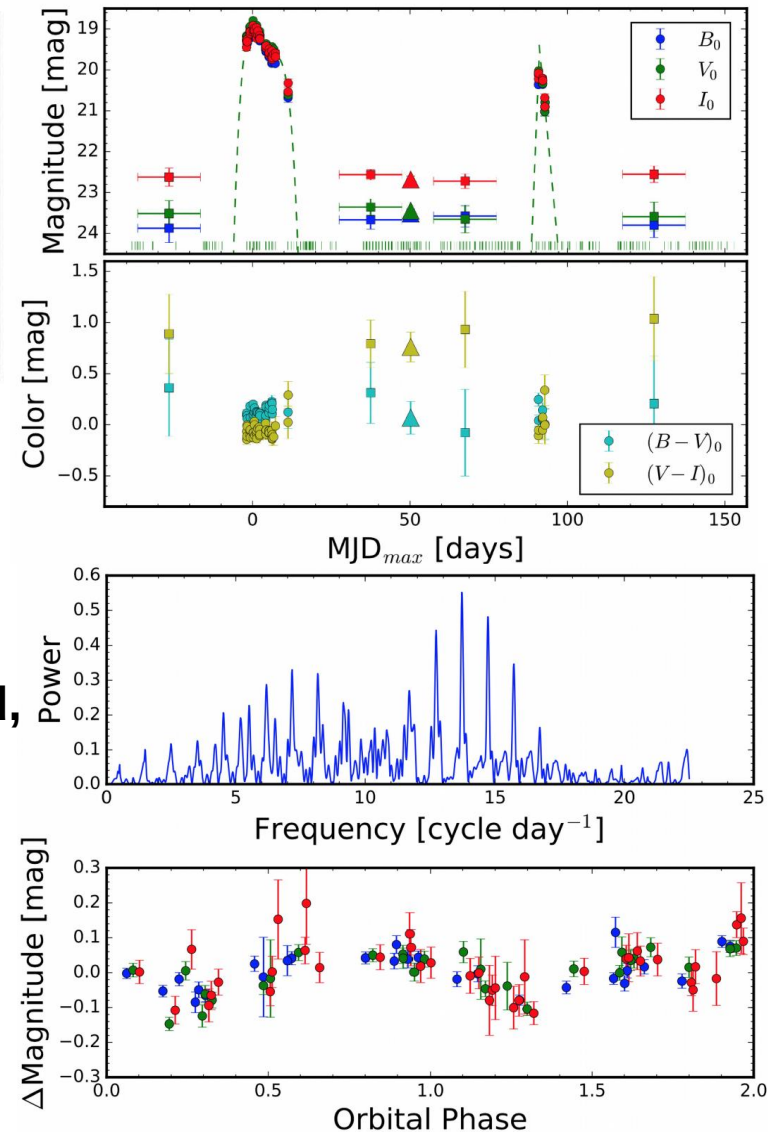
KSP- discovered Novae



KSP-OT-201611a:

Lee YD et al. (2019, in circulation)

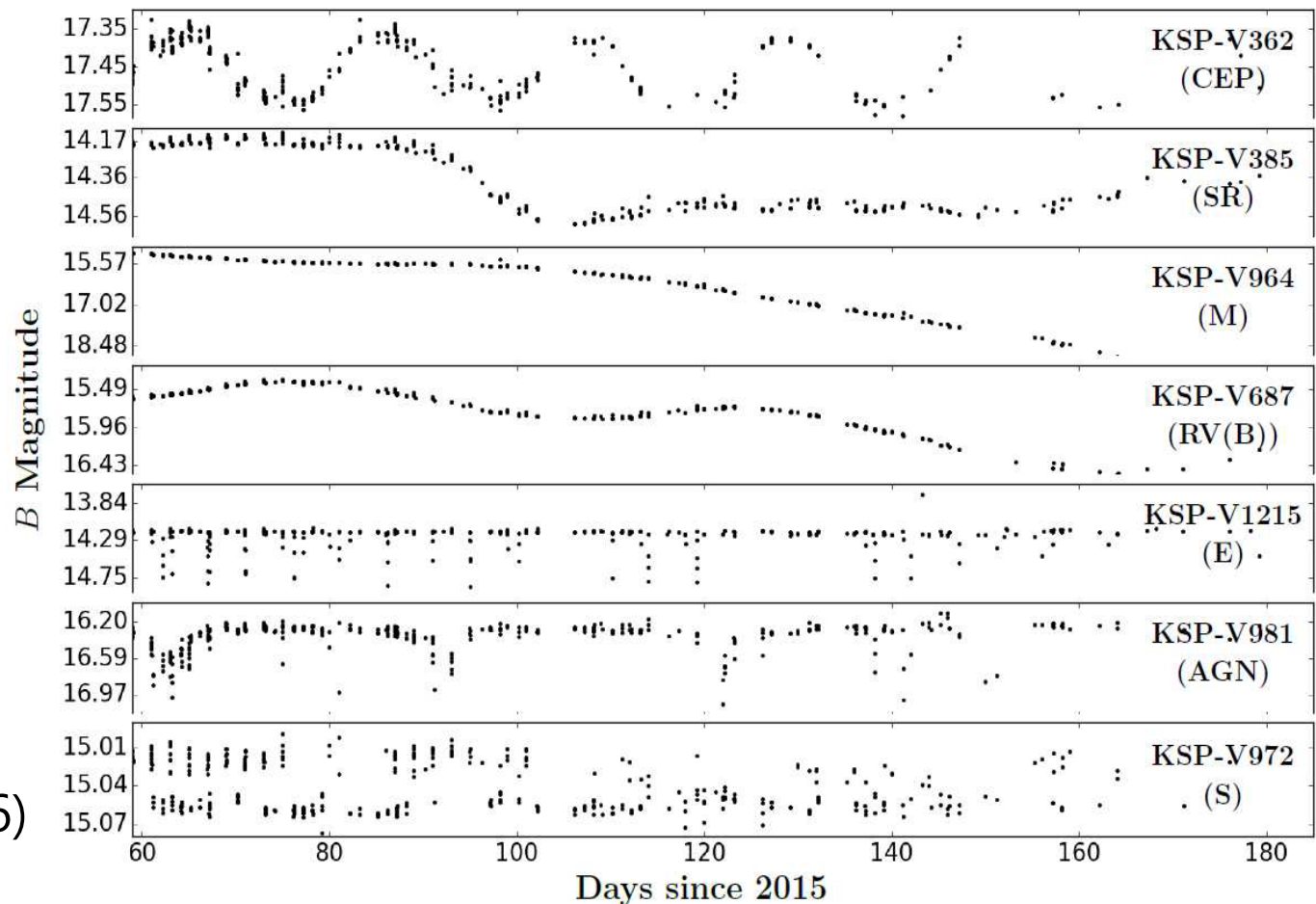
**Most distant (~7kpc) Dwarf Nova ever detected,
CV binary system in the outer galaxy**



KSP-discovered Variable Sources

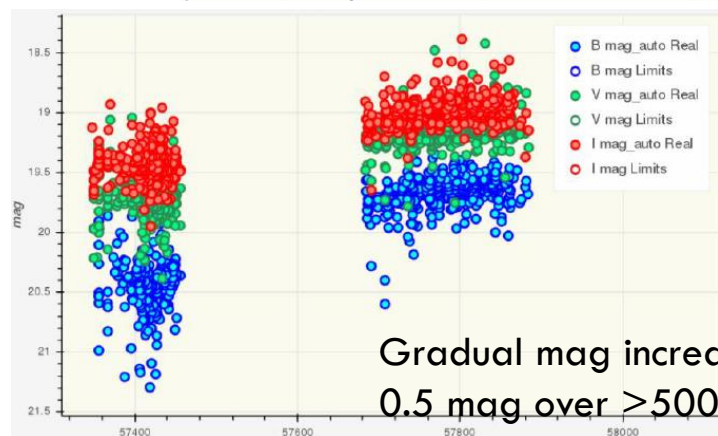
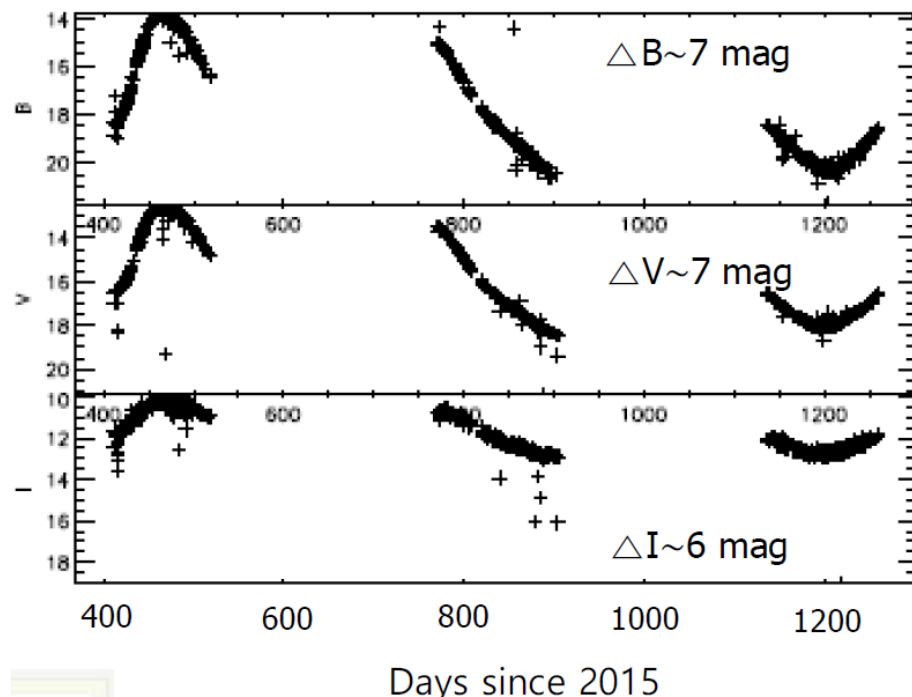
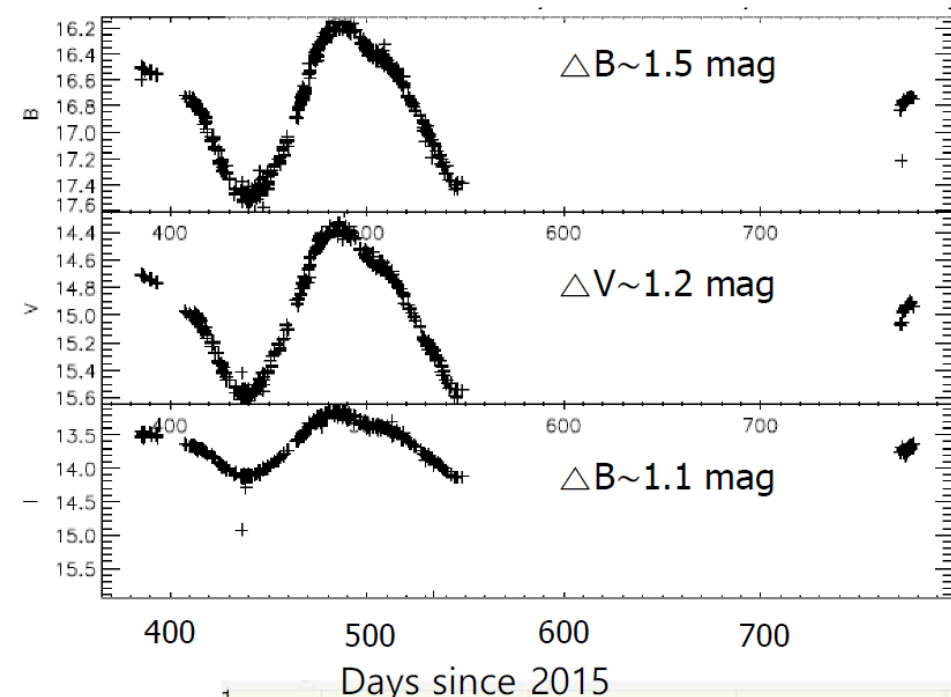


NGC 2784 field : 20 square degree field, 120 days monitoring, early 2015
~**1250 variables sources**: 51 Cepheids, 17 semi-regular variables, 3 Miras, 2 RV Tauri stars, 26 eclipsing binaries, 1 AGN, and many unstudied variables



He et al. (2016)

KSP-discovered Variable Sources



Gradual mag increase by
0.5 mag over >500 days

Long-Period red Variables Kim SC et al. 2019, in preparation

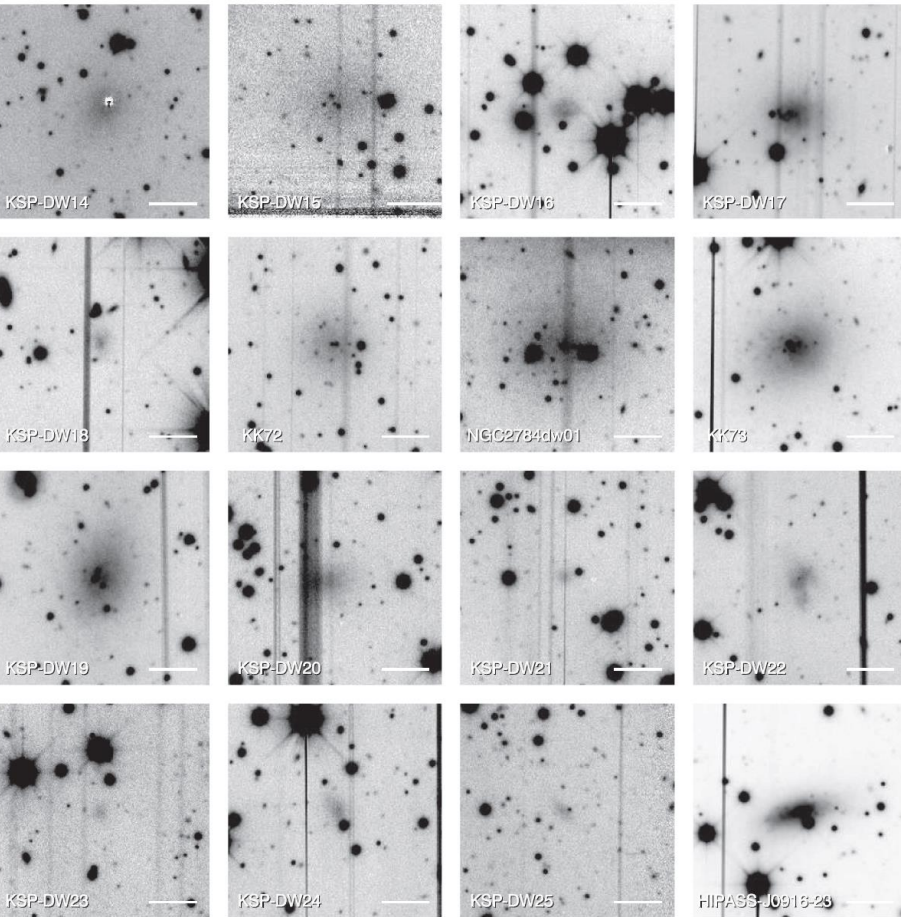
Pulsation **P=100-1000 days**, $T \sim 2000\text{K}$
>10 fields: K196, N3511×2, N3585×2,
N3621×2, N3717×2, N5026, N5028

KSP for discovering new Dwarf Galaxies

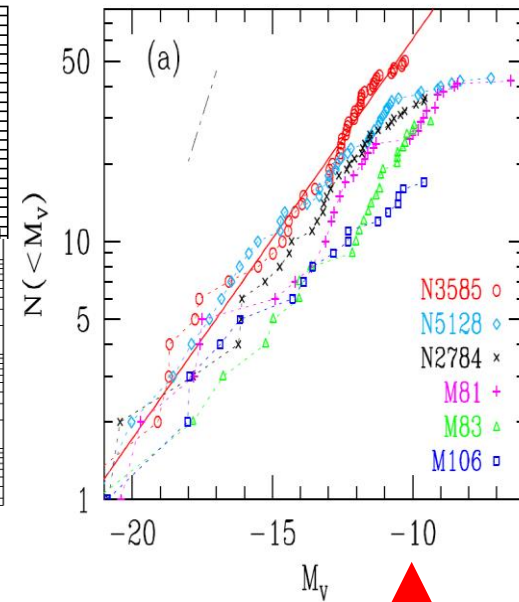
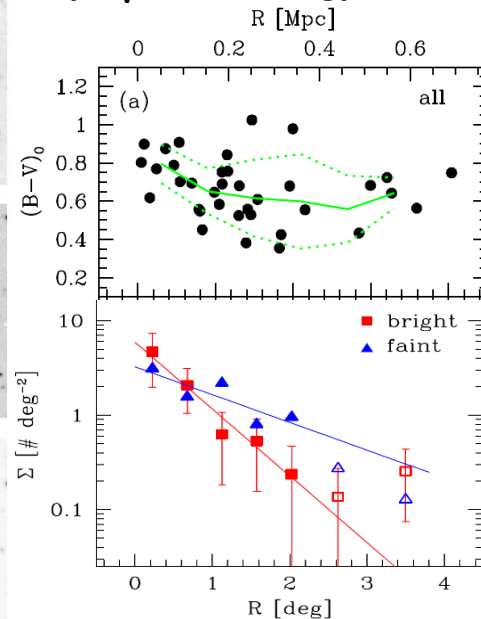


- ❑ Dwarf galaxy searching
- ❑ Homogeneous sample: **>20 galaxy groups**
- ❑ Deep imaging: Stack with **>300 images** (>5hours=300x60sec; ~25h)
- ❑ Multi-color information: **BVI**
- ❑ Wide-field of view: **>2 fields** x(2°x2°)=8 square degree
- ❑ **$\mu_V \sim 28 \text{ mag/arcsec}^2$** (extended sources), **$V \sim 24 \text{ mag}$** (point sources)
- ❑ Seeing <1.5 arcsec
- ❑ $D < 20 \text{ Mpc}$ (**$M_V < -10 \text{ mag}$** , $R > 0.5 \text{ Mpc}$)
- ❑ Topic: **Searching, Group Properties** using faint dwarfs (LFs, radial distributions, surface brightness profile of dwarfs, etc)
- ❑ Ultra-Diffuse Galaxies, Nucleated Dwarfs
- ❑ follow-up observation: Gemini-S/nucleated dwarfs (2019A)
- ❑ Additional study: Star clusters, especially Globular Cluster System

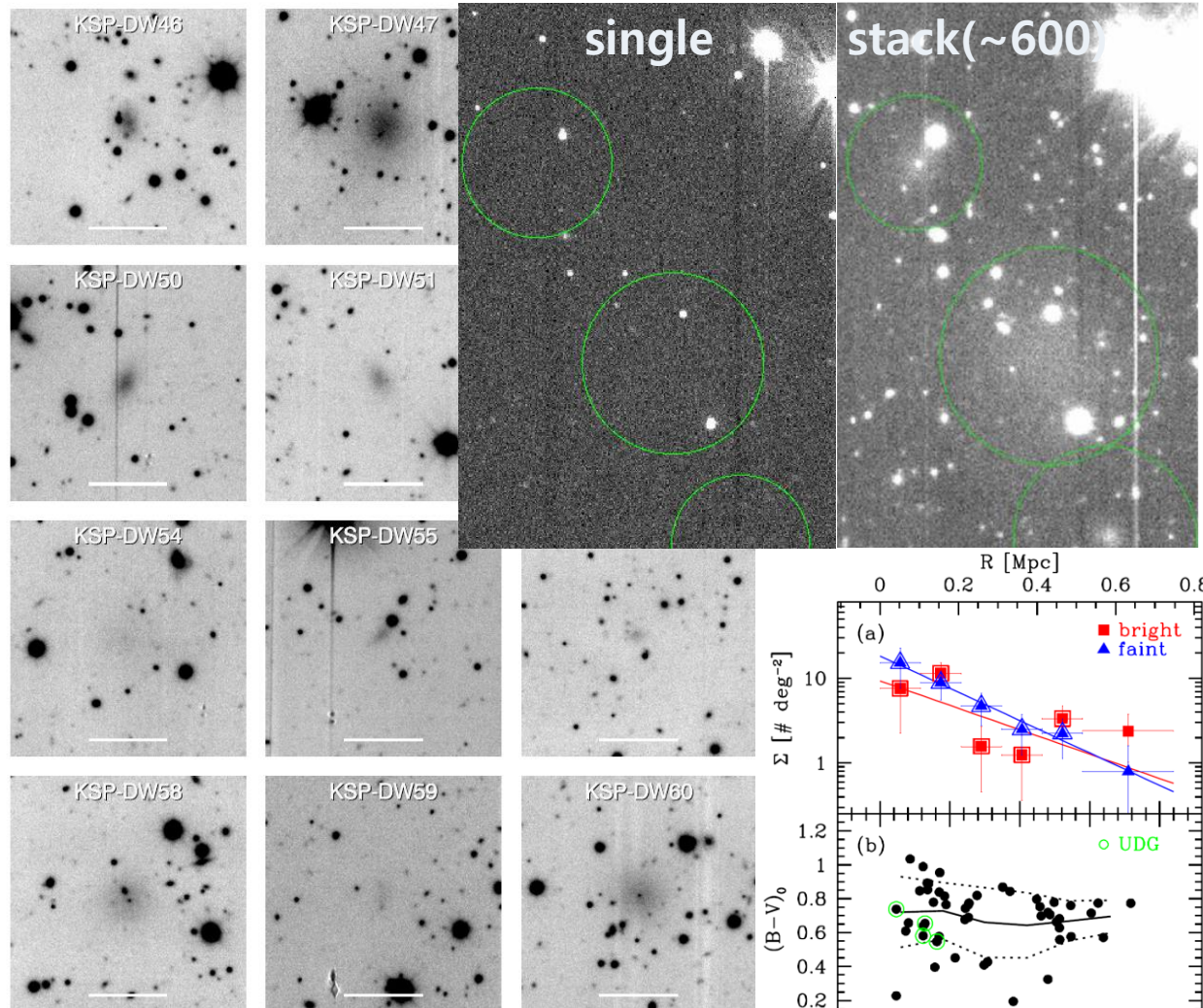
KSP for discovering new Dwarf Galaxies



NGC 2784 Group: Park et al. (2017)
38 dwarf galaxies at 30deg²
 Radial Distributions (# density, color)
 Luminosity Functions of Galaxy Groups
 ($M_V < -10$ mag)



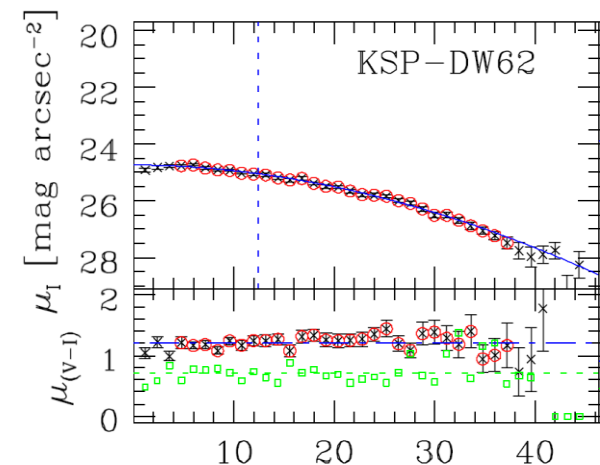
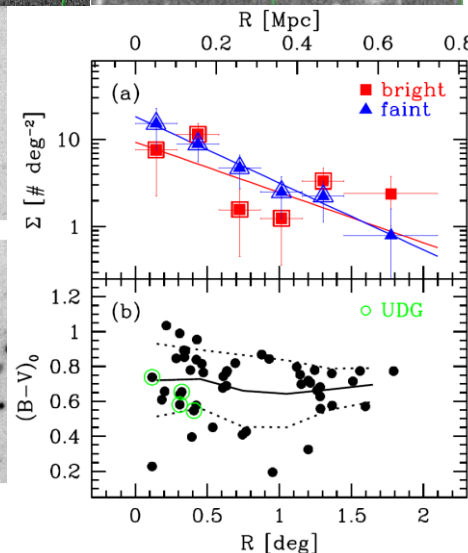
KSP for discovering new Dwarf Galaxies



NGC 3585 Group:
Park et al. (2019, submitted)
50 dwarf galaxies at 7deg^2

Nucleated Dwarfs:
8/50 (N3585), 3/38 (N2784)
→ Gemini/GMOS-S (2019A)

Ultra-Diffuse Galaxies(UDG):
 $R_{\text{eff}} > 1.5\text{kpc}$, $\mu_{0,g} > 24\text{ mag/''}^2$
 $N \sim 4/50$

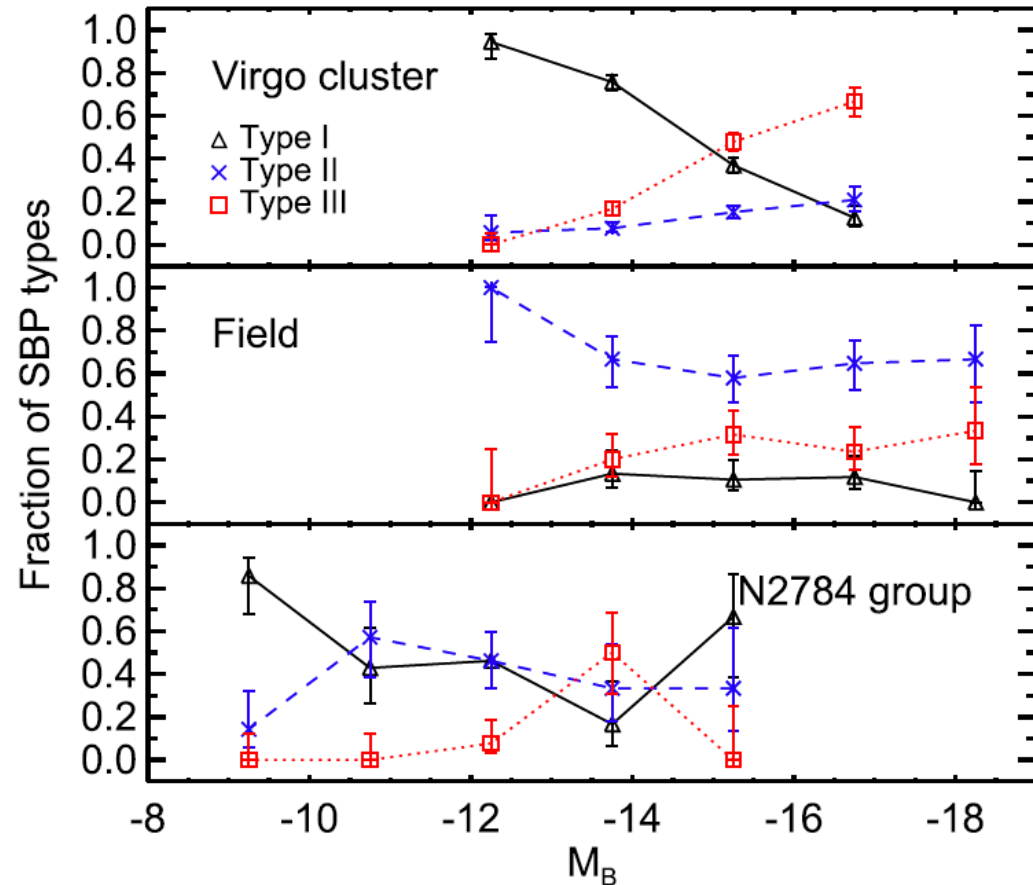


KSP for discovering new Dwarf Galaxies



NGC 2784 Group:
Lee YD et al. (2018)

**Surface Brightness Profiles of
dwarf galaxies**



Summary

- **Unique data set from KMTNet for studying early supernovae with color information – it's unrivalled**
- **Statistically significant sample size with interesting individual sources**
- **Already begun providing new insights into supernova explosion and progenitors**
- **Invaluable data for studying dwarf novae, variable sources and dwarf galaxies**

- KSP 자료 활용 연구: 적극 환영합니다!!!
 - KMTNet 관련 주요 일정
 - 연구기간: 1단계(2015.10.1.-2020.9.31.) → 2단계(2020.10.1. – 2025 ???)
 - 과제공모: 4-6월 (과제심사: 7-9월)
 - 선정발표: 9월
 - 2019 봄 천문학회: KMTNet 특별세션
 - 우수연구주제의 적극적인 참여를 기대합니다.
- 우수과제 예시: 중력렌즈 탐색연구(50% 관측시간x논문20편/년~5천만원/편)



- 재학생 전원 졸업시까지 연수장려금 지원 (매월 120~160만원)
- 등록금 별도 전액 지원, 기숙사 제공 가능, 해외 연수 기회
- 매 학기 신입생 모집 (박사과정, 통합과정)

입학 문의 모집공고 매년 3월 초 및 9월 초
김상철 sckim@kasi.re.kr 박홍수 hspark@kasi.re.kr

