K-DRIFT: KASI Deep Rolling Imaging Fast Telescope

K-DRIFT update: 2024 project status report

고종완(Jongwan Ko) & K-DRIFT Team

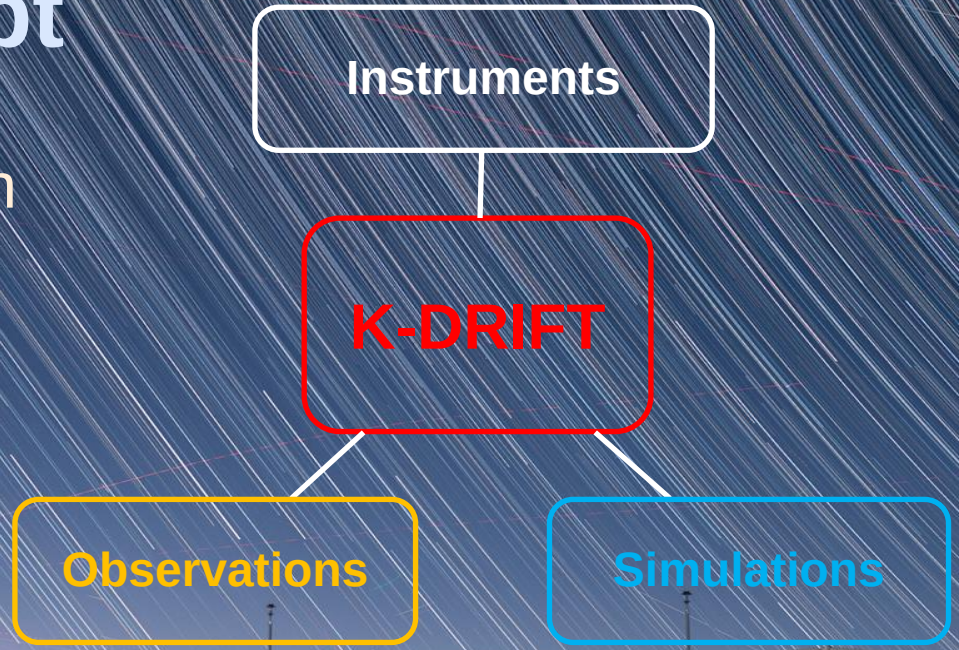
Korea Astronomy and Space Science Institute

BOAO, 2021.6.13, 04:59

12th SSG Workshop, 2024.01.30

Basic Concept

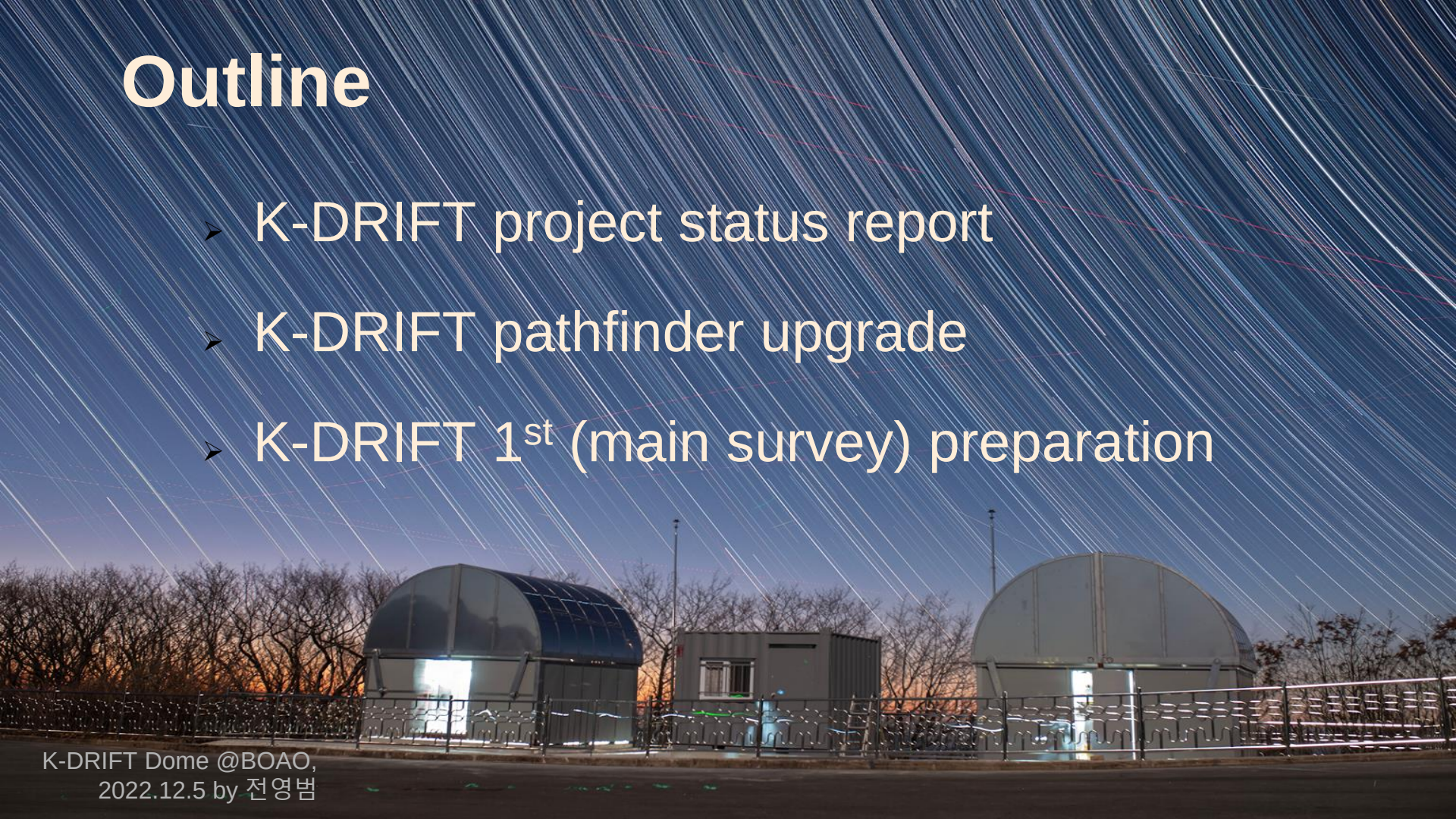
Exploring the LSB universe with our own cutting-edge telescopes



K-DRIFT Dome @BOAO, 2022.12.5 by 전영범

Outline

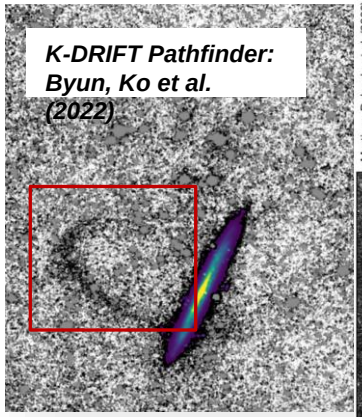
- K-DRIFT project status report
- K-DRIFT pathfinder upgrade
- K-DRIFT 1st (main survey) preparation

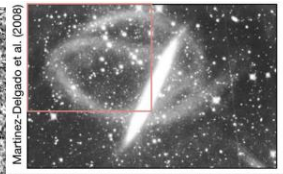


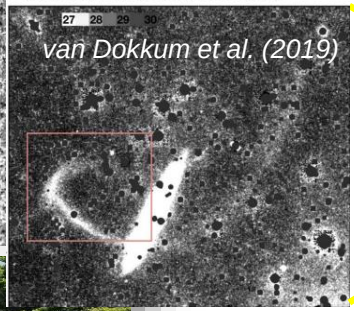
K-DRIFT Dome @BOAO,
2022.12.5 by 전영범

Motivation: why exploring the LSB Universe

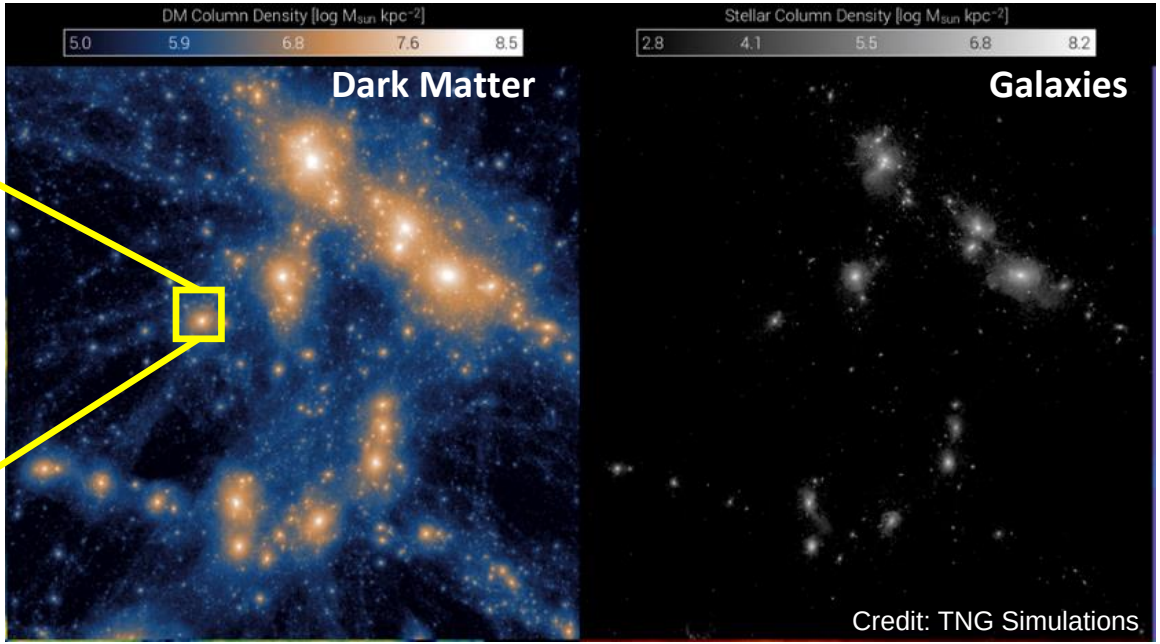
Observations







Simulations



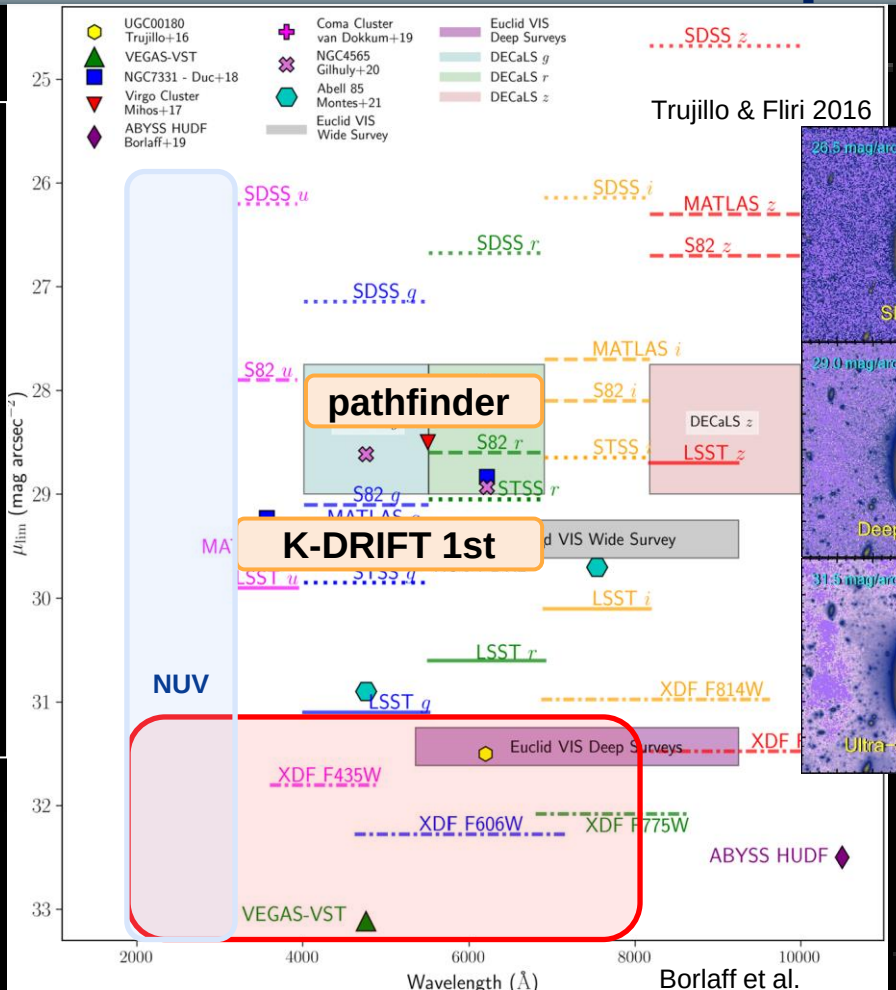
LCDM ⇒ all galaxies are surrounded by vast and complex network of LSB filaments

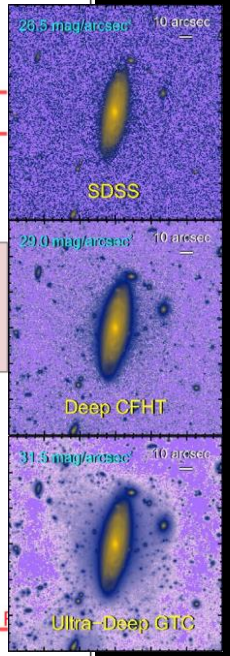
But, LSB regime (*generally, <0.1 % of the night sky level*) that is undetectable in past wide-area surveys

Science & technical challenges ⇒ ***A step change in our understanding of the Universe!***

K-DRIFT to Space: why space?

SB limit (3σ, 10x10 arcsec²)





night sky level ~ 22.0 mag arcsec^{-2}

(~27.0 mag arcsec^{-2})

(~29.0 mag arcsec^{-2})

LSB universe will be explored with Rubin Obs., Euclid, … K-DRIFT

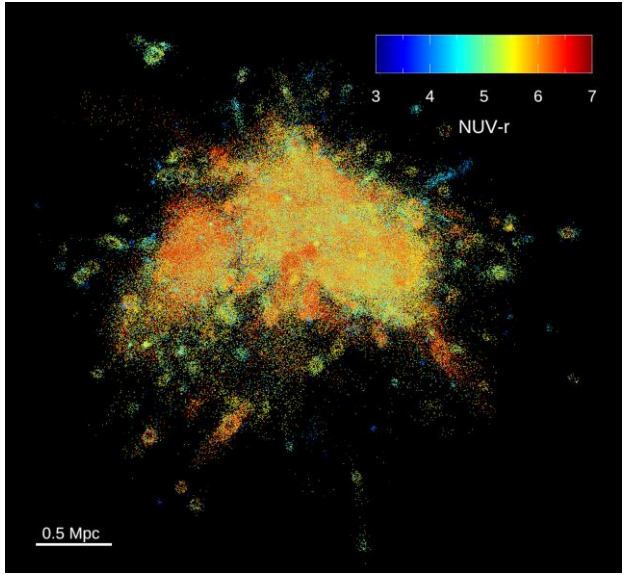
(>31.0 mag arcsec^{-2})

Ultra-LSB universe is almost unexplored!

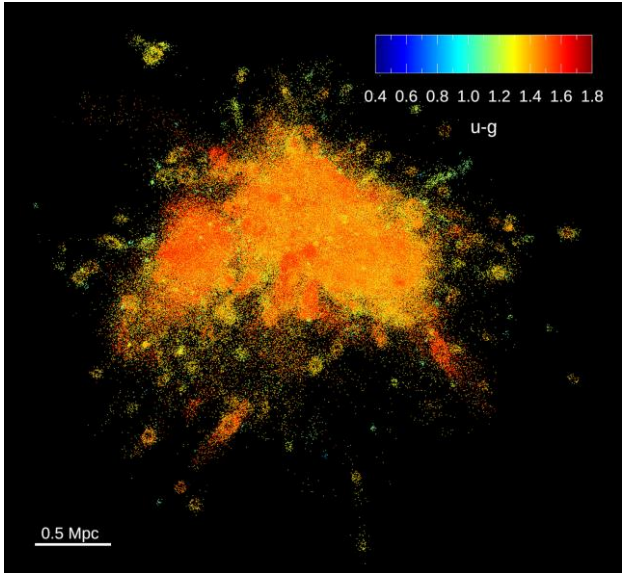
Space telescope!

Case 1: ICL

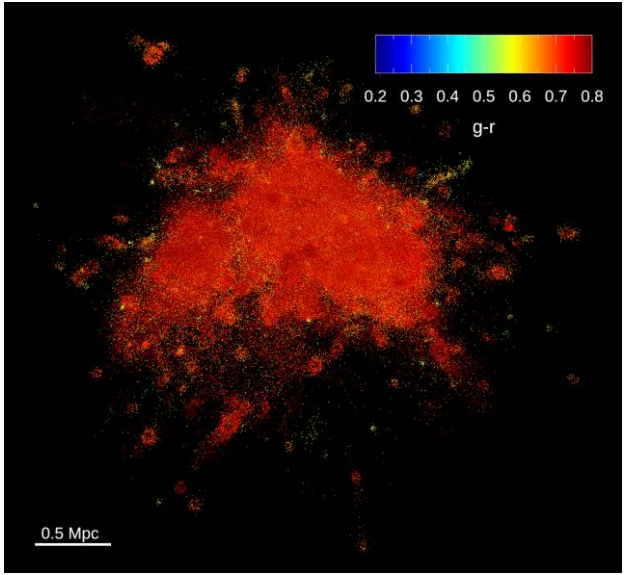
NUV-r



u-g

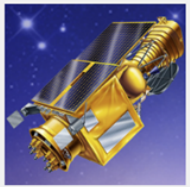
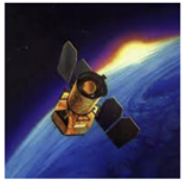
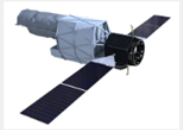


g-r

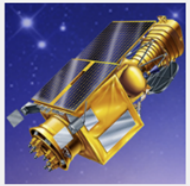
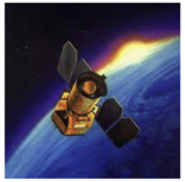
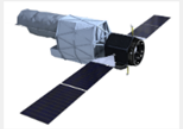


Color gradient + recent SFA ➔ ICL origin

UV Mission Comparison

	MISSION	UV INSTRUMENT APERTURE DIAMETER	BANDPASS IN THE UV REGION	POINT SPREAD FUNCTION	DETECTOR	FIELD OF VIEW	LAUNCH DATE
	ULTRASAT Ultraviolet Transient Astronomy Satellite	0.33 m	230-290 nm	8.3 arcseconds	CMOS	204 degrees^2	2026 (planned)
	GALEX Galaxy Evolution Explorer	0.5 m	170-280 nm 135-175 nm	5.5 arcseconds	MCP	1.13 degrees^2	Launched April 28, 2003 (Decommissioned June 28, 2013)
	UVEX The Ultraviolet Explorer	0.75 m	139-190 nm and 203-270 nm	2.25 arcseconds	CMOS	12.25 degrees^2	2028 (pending downselect)
	STAR-X Survey and Time-domain Astrophysical Research eXplorer	0.3 m	160-200 nm and 250-300nm	4.0 arcseconds	MCP	1.0 degrees^2	2028 (pending downselect)

UV Missio

	MISSION	UV INSTRUMENT APERTURE DIAMETER	BANDPAS THE UV REGION				
	ULTRASAT Ultraviolet Transient Astronomy Satellite	0.33 m	230-290 r				
	GALEX Galaxy Evolution Explorer	0.5 m	170-280 nm 135-175 nm				
	UVEX The Ultraviolet Explorer	0.75 m	139-190 nm and 203-270 nm	2.25 arcseconds	CMOS	12.25 degrees^2	2028 (pending downselect)
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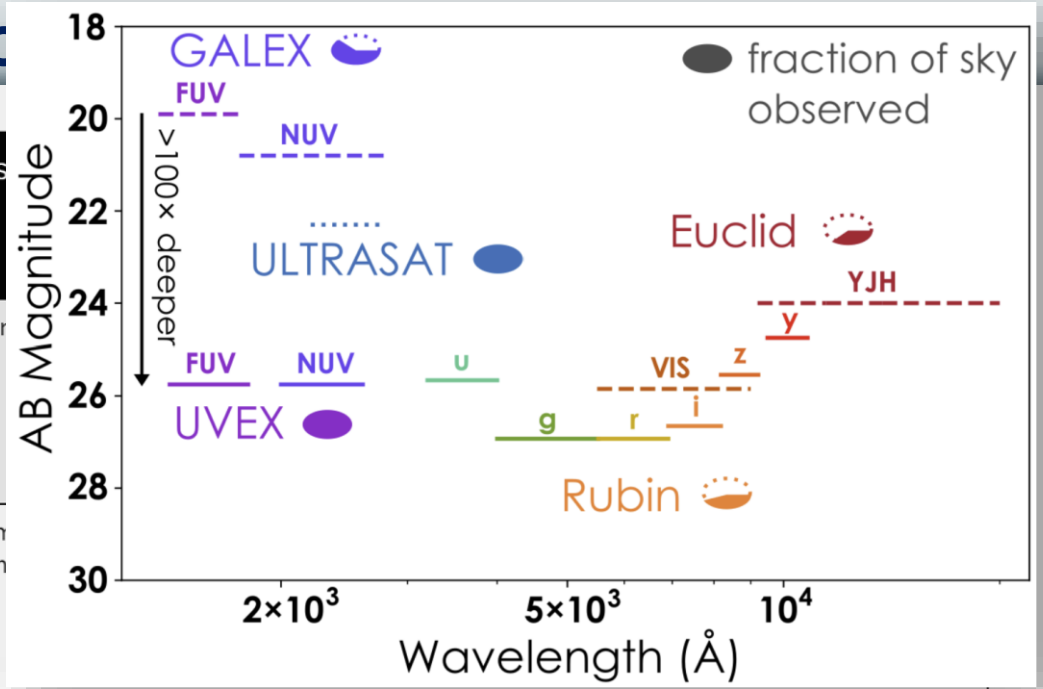

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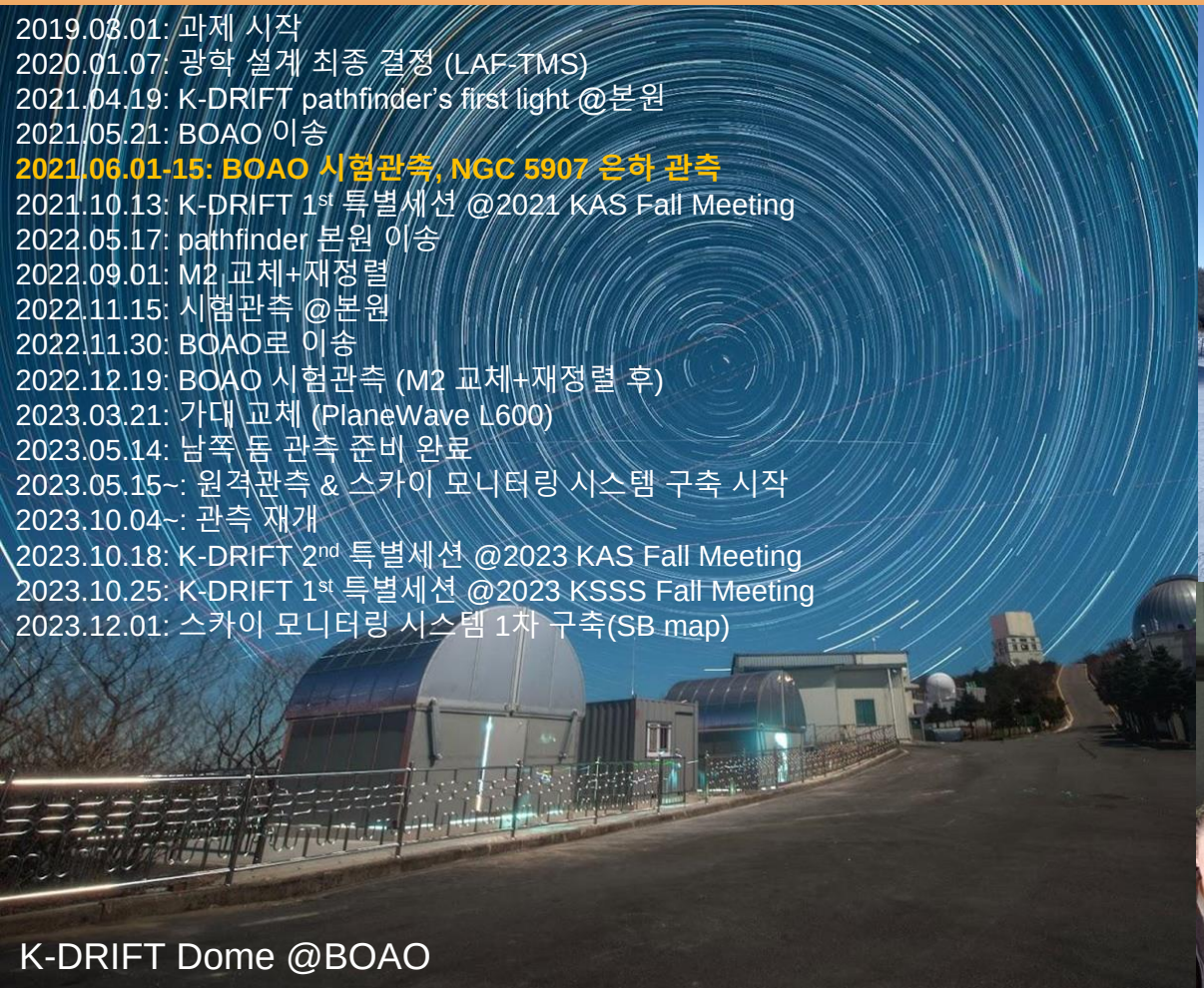
K-DRIFT Dome @BOAO,
2022.12.5 by 전영범

K-DRIFT from 2019 to Present

2019.03.01: 과제 시작
2020.01.07: 광학 설계 최종 결정 (LAF-TMS)
2021.04.19: K-DRIFT pathfinder's first light @본원
2021.05.21: BOAO 이송
2021.06.01-15: BOAO 시험관측, NGC 5907 은하 관측
2021.10.13: K-DRIFT 1st 특별세션 @2021 KAS Fall Meeting
2022.05.17: pathfinder 본원 이송
2022.09.01: M2 교체+재정렬
2022.11.15: 시험관측 @본원
2022.11.30: BOAO로 이송
2022.12.19: BOAO 시험관측 (M2 교체+재정렬 후)
2023.03.21: 가대 교체 (PlaneWave L600)
2023.05.14: 남쪽 돔 관측 준비 완료
2023.05.15~: 원격관측 & 스카이 모니터링 시스템 구축 시작
2023.10.04~: 관측 재개
2023.10.18: K-DRIFT 2nd 특별세션 @2023 KAS Fall Meeting
2023.10.25: K-DRIFT 1st 특별세션 @2023 KSSS Fall Meeting
2023.12.01: 스카이 모니터링 시스템 1차 구축(SB map)


K-DRIFT Dome @BOAO

K-DRIFT Pathfinder 0.3m

Subaru 8.2m

K-DRIFT Pathfinder

Diameter: 0.3m

Exp. Time: 6000s

Subaru

Diameter: 8.2m

Exp. time: 1000s

K-DRIFT from 2019 to Present

2019.03.01: 과제 시작
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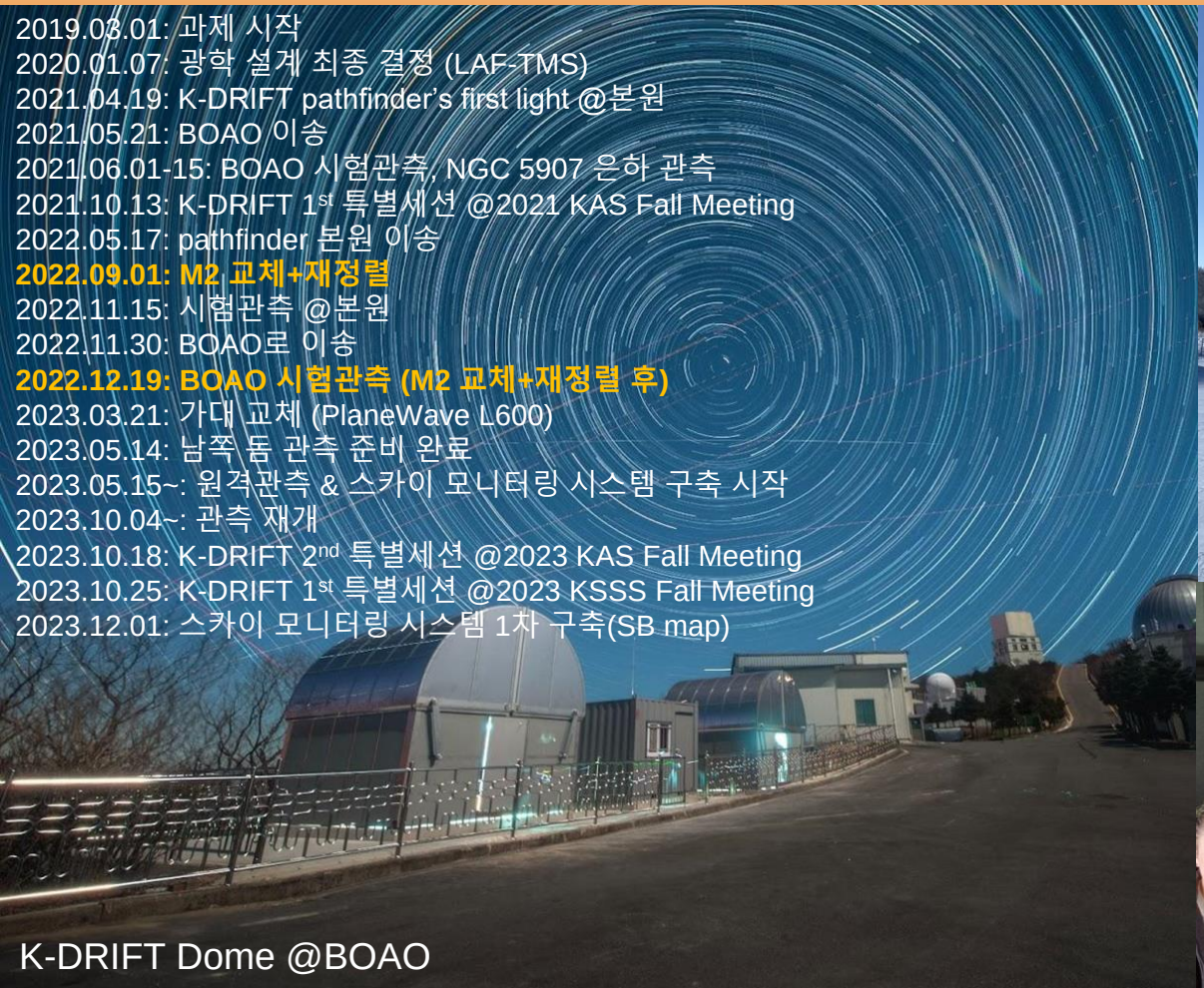
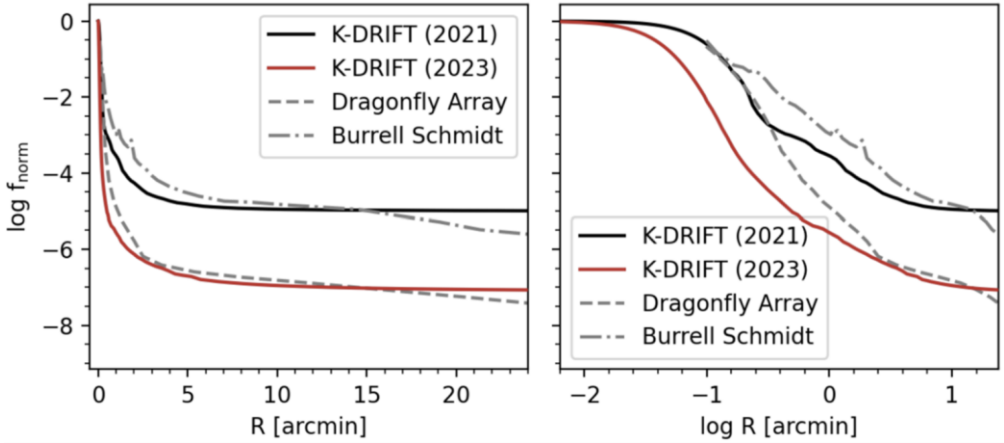
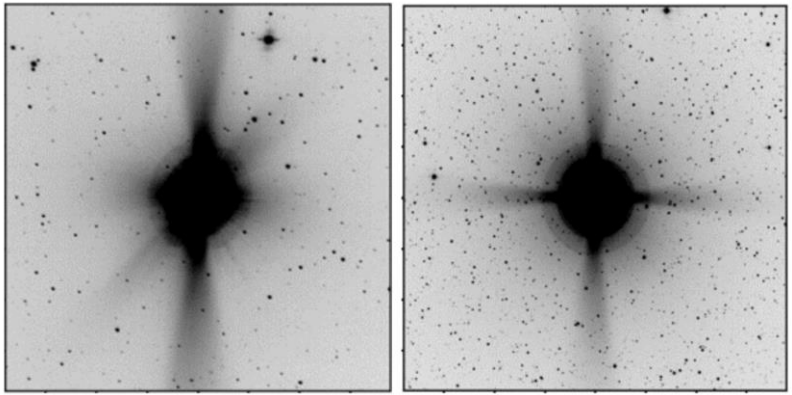

K-DRIFT Dome @BOAO

K-DRIFT pathfinder upgrade:
error control for off-axis freeform three-mirror system

PSF profiles



Observed bright stars in 2021 vs 2023

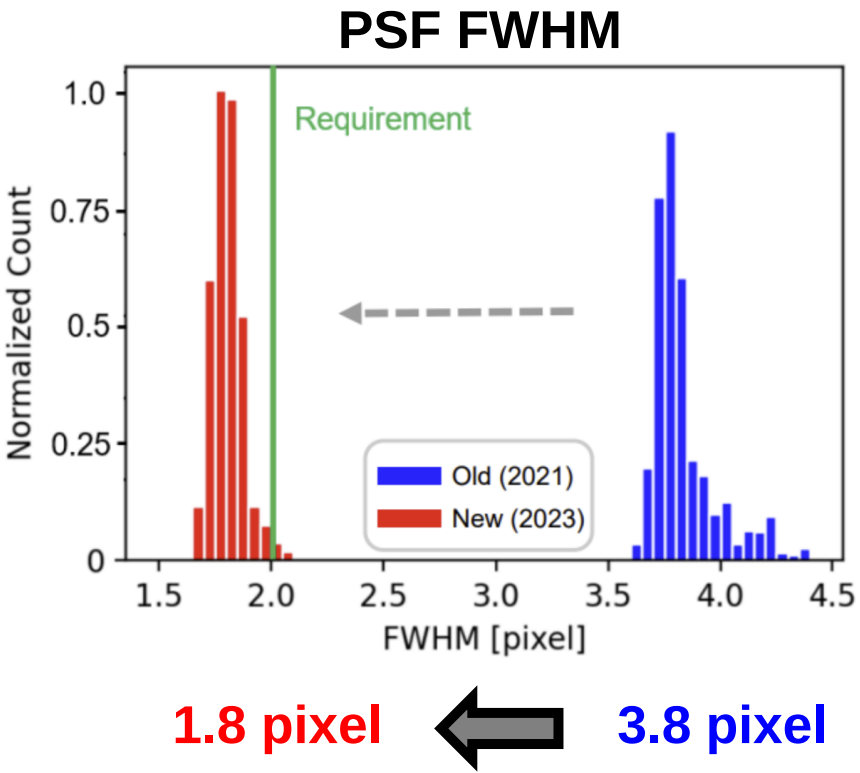


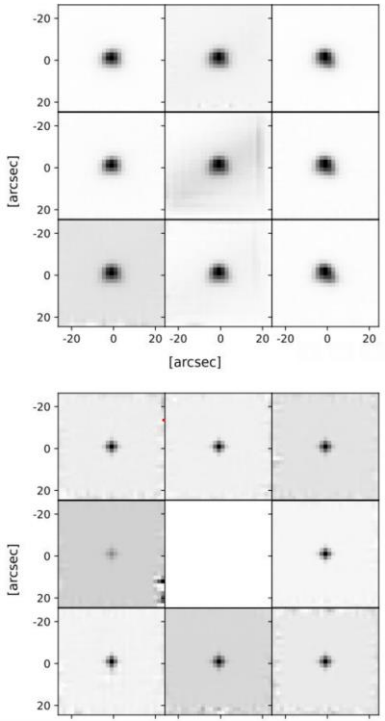
We have developed K-DRIFT's optical performance analysis algorithm!

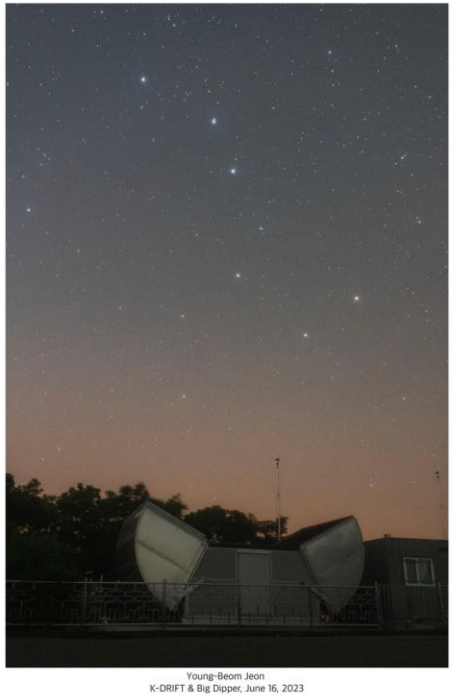
K-DRIFT pathfinder upgrade

M2 replacing + Realigning + Mount replacing

On-sky test observations: 2022.11.15 @KASI & 2022.12.14, **2023.03.21 @BOAO**

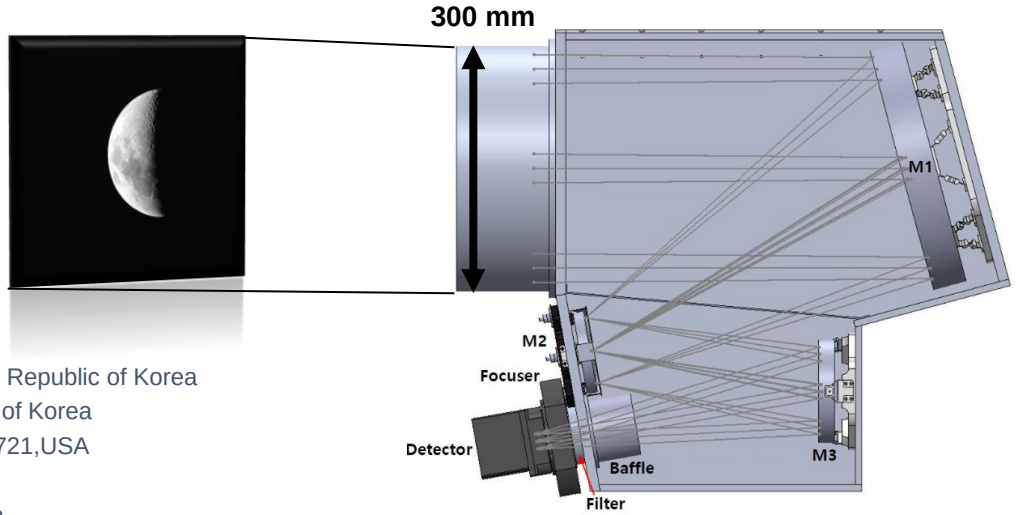






On-sky Point Spread Function Analysis for the Off-axis Freeform Three-mirror Telescope

Gayoung Lee[1,2] , Yunjong Kim[2], Daewook Kim[3], Woowon Byun[2], Seunghyuk Chang[4] and Jongwan Ko[2,5]

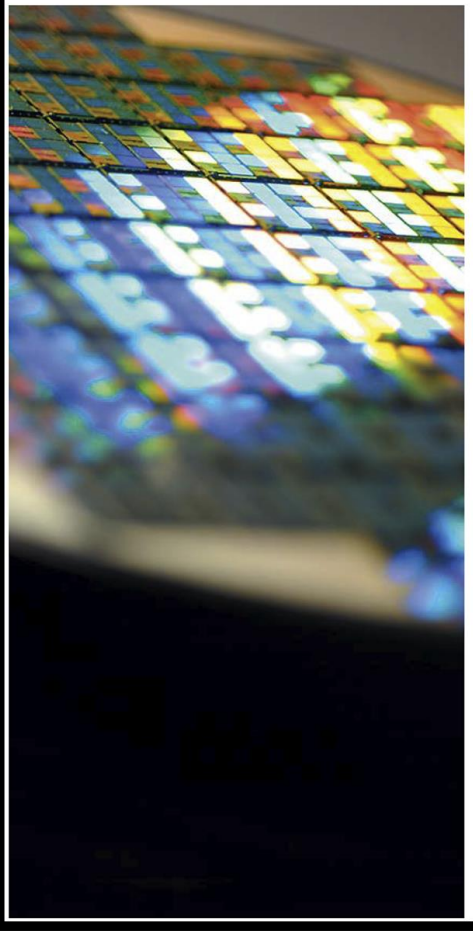


[1] Department of Astronomy, Kyungpook National University, Daegu 41566, Republic of Korea
[2] Korea Astronomy and Space Science Institute, Daejeon 34055, Republic of Korea
[3] Wyant College of Optical Sciences, University of Arizona, Tucson, AZ 85721,USA
[4] Center for Integrated Smart Sensors, Daejeon 34141, Republic of Korea
[5] University of Science and Technology, Daejeon 34055, Republic of Korea

On-sky
for the scope

Gayoung Lee[1,2],
and Jongwan Ko

[1] Department of Astr
[2] Korea Astronomy a
[3] Wyant College of O
[4] Center for Integrate
[5] University of Scien



Student Paper Award

Optical Fabrication and Testing (OF&T)

Presented to

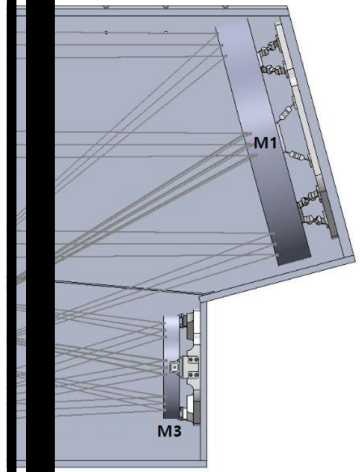
Gayoung Lee
Kyungpook National University, Korea
Astronomy and Space Science Institute, Republic of Korea

For the paper

On-Sky Point Spread Function Analysis for the Off-Axis Freeform Three-Mirror Telescope

Optica Design and Fabrication Congress
04 – 08 June 2023
Québec City, Québec, Canada

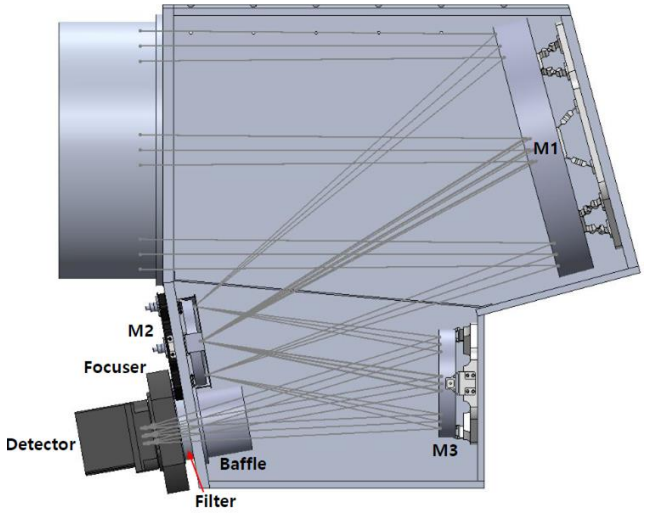
OPTICA | Formerly OSA



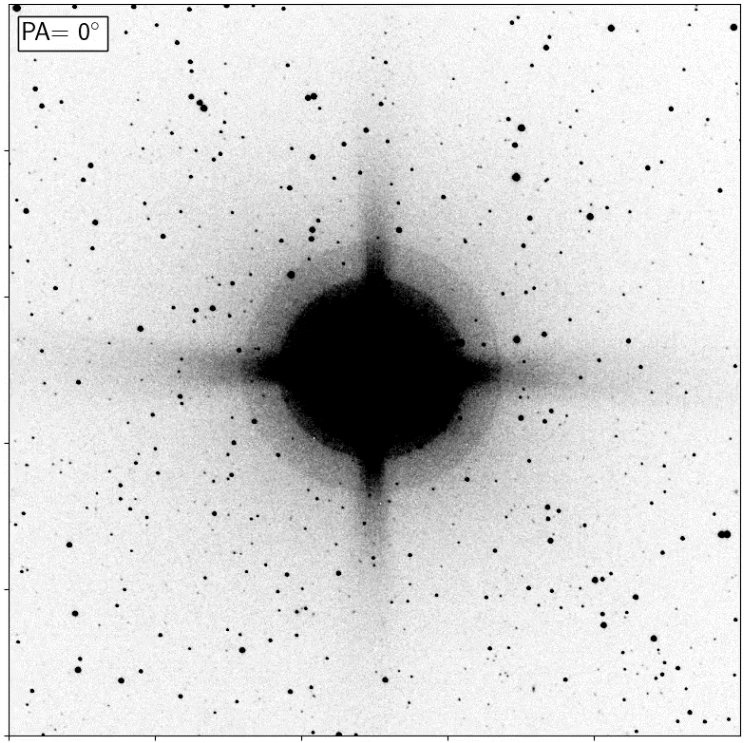
K-DRIFT pathfinder upgrade:
stray light control for off-axis freeform three-mirror system

Camera rotation test:

position angle is rotating by ~30°



Observed bright star



We have developed K-DRIFT's stray light analysis algorithm!

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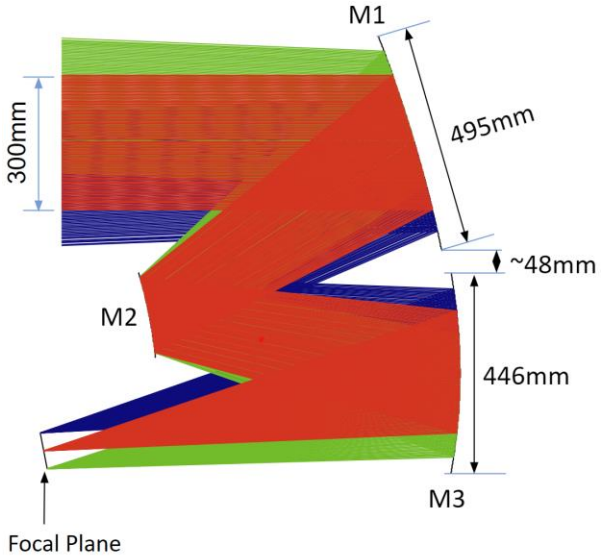
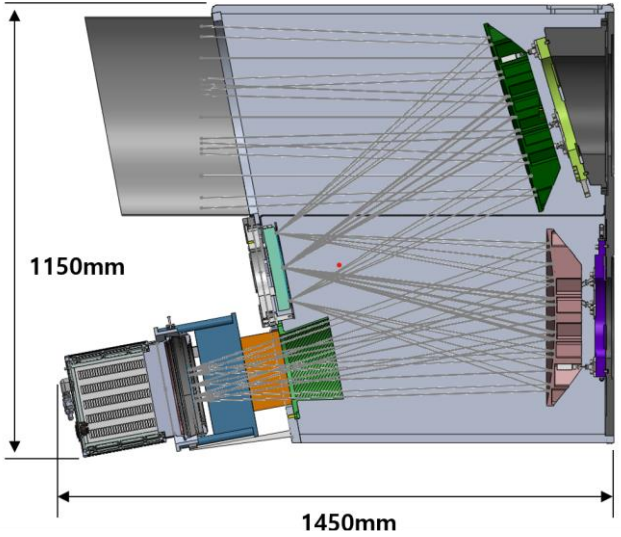
K-DRIFT Dome @BOAO,
2022.12.5 by 전영범

K-DRIFT 1st (G1) Optical Design

LAF-TMS (Linear-Astigmatism-Free Three-Mirror System)





Parameter	Measurement
Aperture/ Entrance pupil diameter	300/500mm
Focal Length	1050mm
Focal Ratio	3.5
Field of View	4.43°(H) x 4.43°(V)
Image Area	81.2mm x 81.2mm
Pixel Scale	1.96″ / 10um

(large FoV, homogeneous PSF!)

Optical design:
Seunghyuk Chang

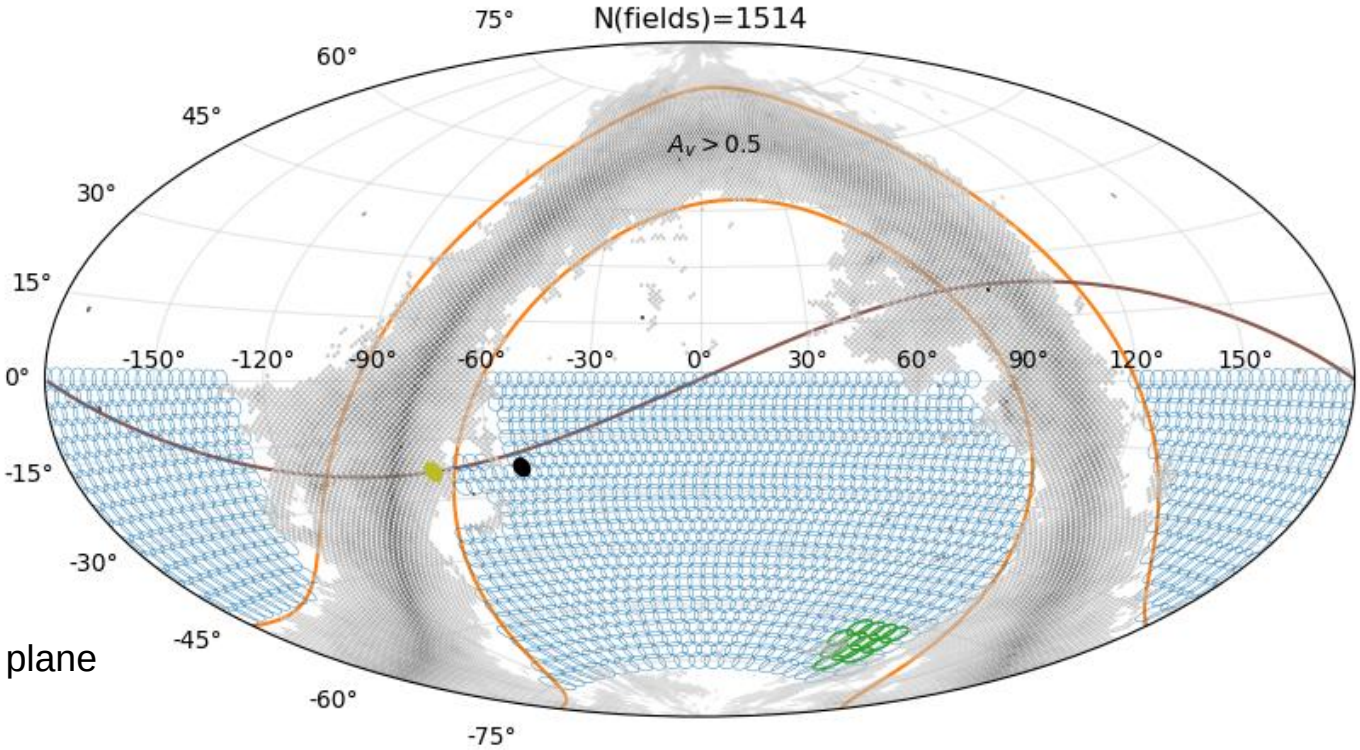
19.6 deg² vs 9.6 deg² (Rubin Obs.)

보름달 ~81개 크기!

Southern sky survey (2025~)

- **>29.5 mag/arcsec² in u, g, r**
- **+ narrow bands (Hα, OIII, …)**

K-DRIFT 1st (G1) survey plan: rolling-dithering



Blue: the rolling-dithering fields

Orange: ±15° from the Galactic plane

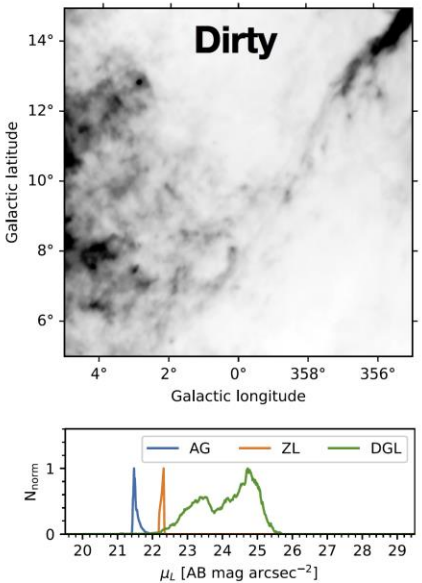
Brown: the ecliptic plane

Green: the SEP regions

Yellow (**black**): the sun (the moon)

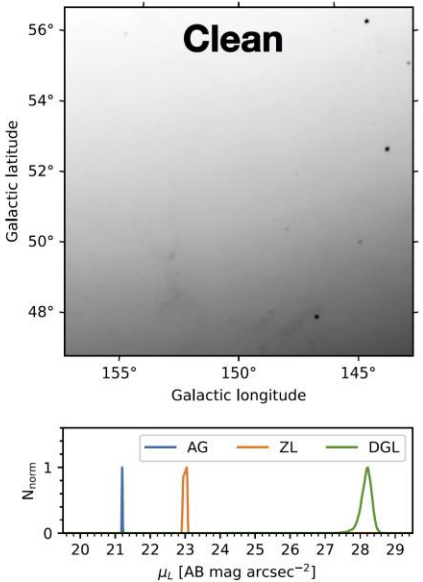
Grayscale: Galactic cirrus (A_v > 0.5)

Survey preparation: sky simulation & rolling dithering



"However, a dark-sky flat may not be perfect because it contains airglow, zodiacal light, and diffuse galactic light."

How can we remove these effects?



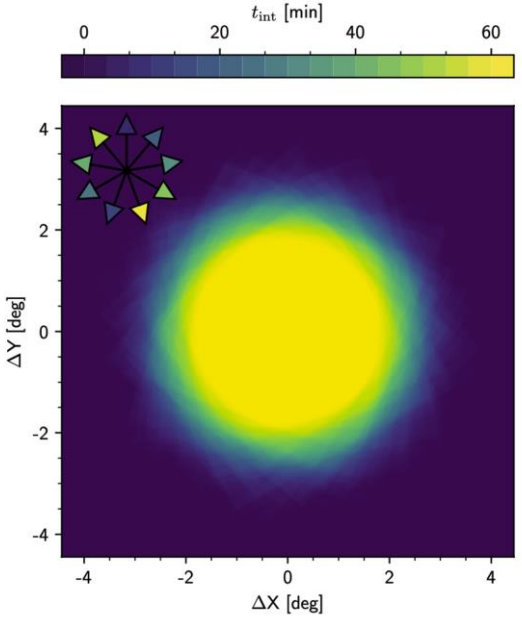
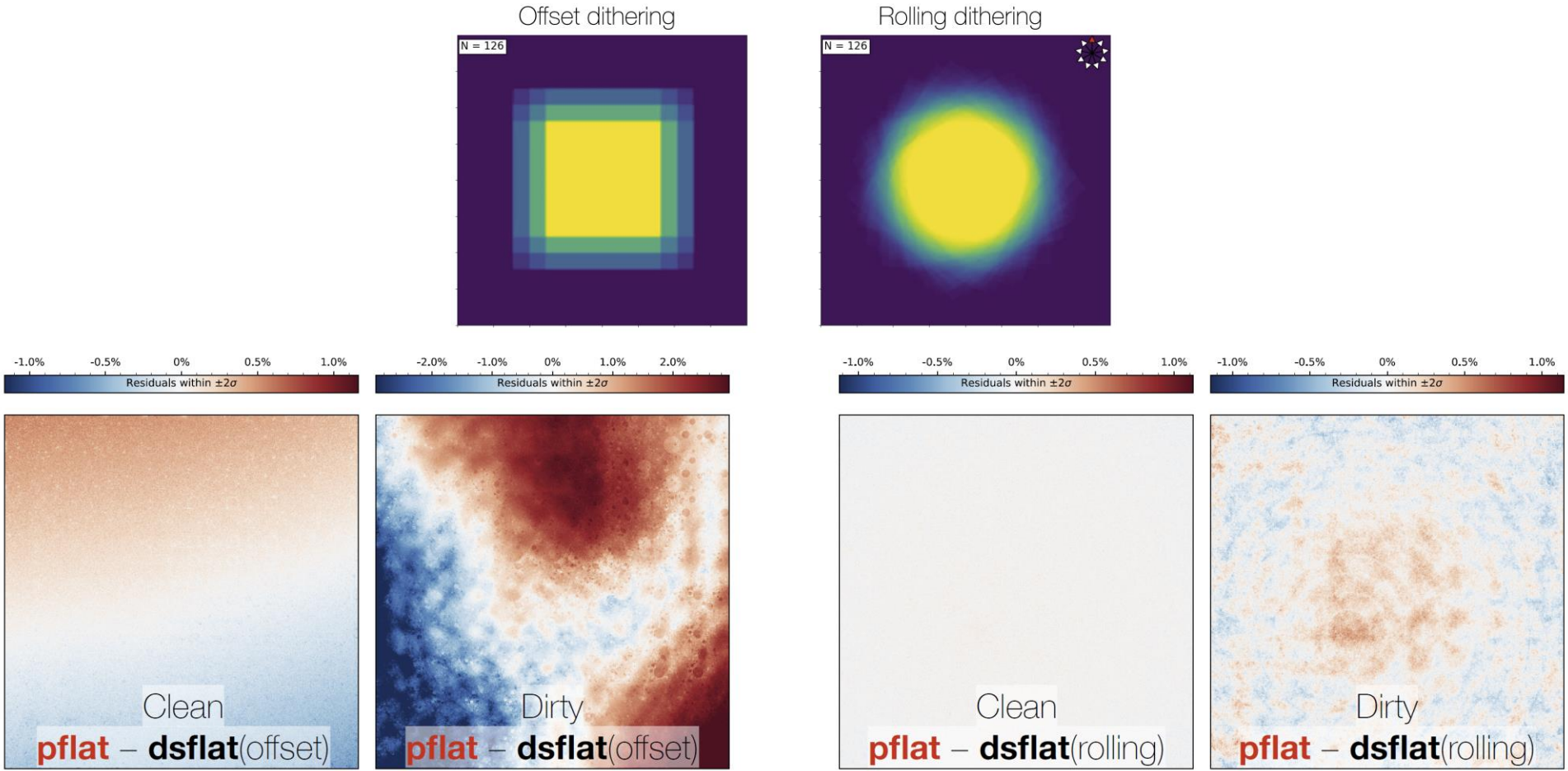


Figure 1. Coverage of a single observation sequence using the rolling dithering method. For each exposure, the offset is randomly determined within a $30' \times 30'$ box relative to the original coordinate. The camera's position angle rotates by 160° after several exposures, and the angular direction is displayed in the upper left of the panel. The effective area with the longest integration time is $\sim$12 deg^2.

Survey preparation: sky simulation & rolling dithering



Discussions: K-DRIFT space mission

KDRIFT
KASI DEEP ROLLING IMAGING FAST TELESCOPE

Key words for K-DRIFT:

(Science)

LSB Universe → **White Paper (soon!)**

(Instrument: LSB-optimized)

Off-axis freeform optical system

Fast & active optics

Single sCMOS detector with large FoV

(Technique: LSB-optimized)

Optimized observing techniques

Dedicated calibration procedures

Optimized simulation techniques