

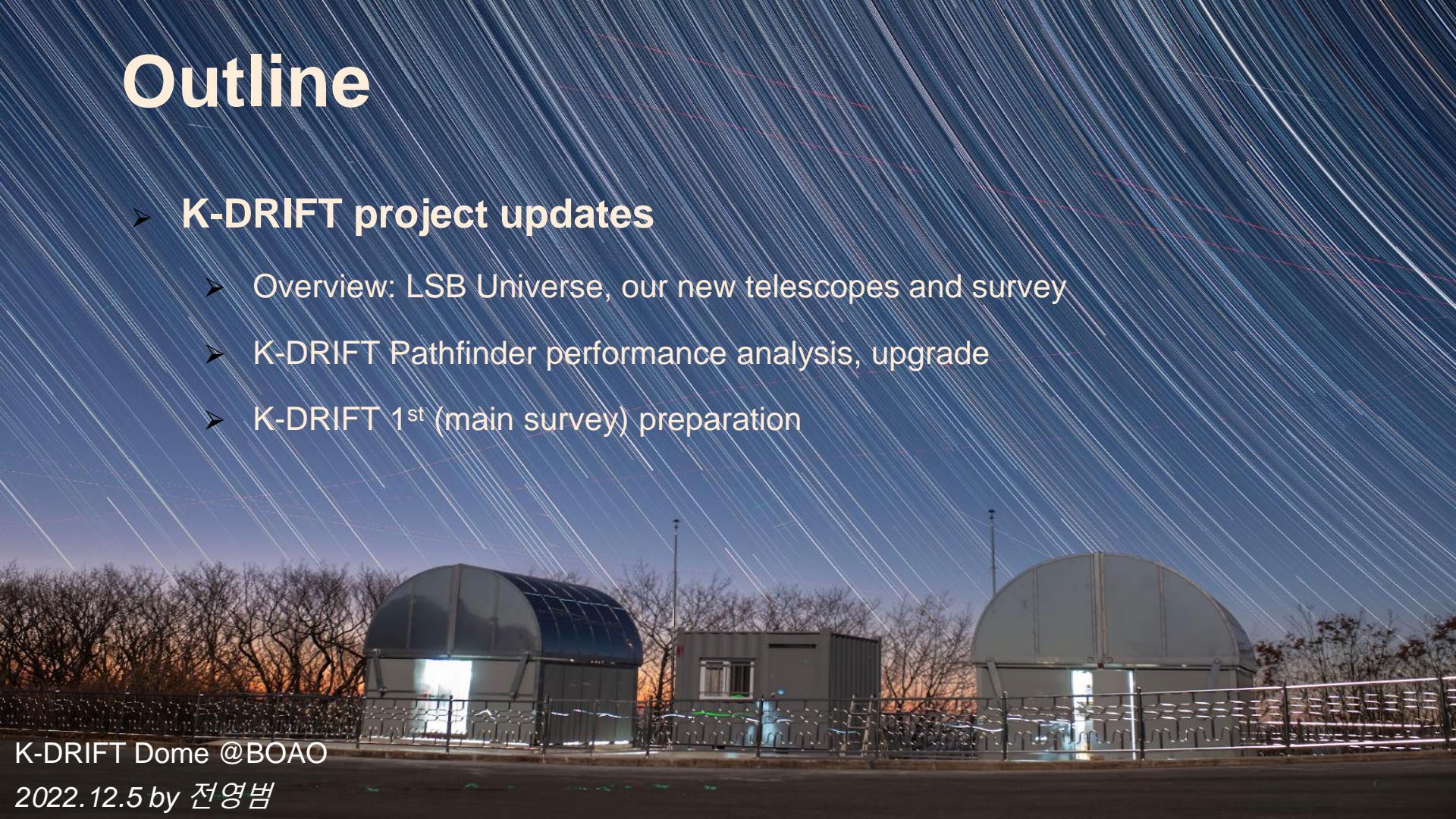
K-DRIFT Project Updates

K-DRIFT Team: 고종완, 김윤종, 김재우, 김지현, 박홍수, 변우원, 선광일, 성언창, 신지혜, 윤용민, 이용석, 전영범, 천경원, 천상현, 최창수(한국천문연구원), 장승혁(스마트 IT 융합 시스템 연구단), 김도훈(그린광학), 유재원(고등과학원), 이가영(한국천문연구원/경북대학교), 지명국(연세대학교), 김대욱(애리조나대학교), 문일권(한국표준과학연구원), 권혁선(에이디솔루션)

Outline

➤ K-DRIFT project updates

- Overview: LSB Universe, our new telescopes and survey
- K-DRIFT Pathfinder performance analysis, upgrade
- K-DRIFT 1st (main survey) preparation



K-DRIFT Dome @BOAO

2022.12.5 by 전영범

K-DRIFT overview: K-DRIFT will unveil the LSB Universe

Key words for K-DRIFT:

(Science)

LSB Universe

(Instrument: LSB-optimized)

Off-axis freeform three-mirror system

Fast-optics arrays

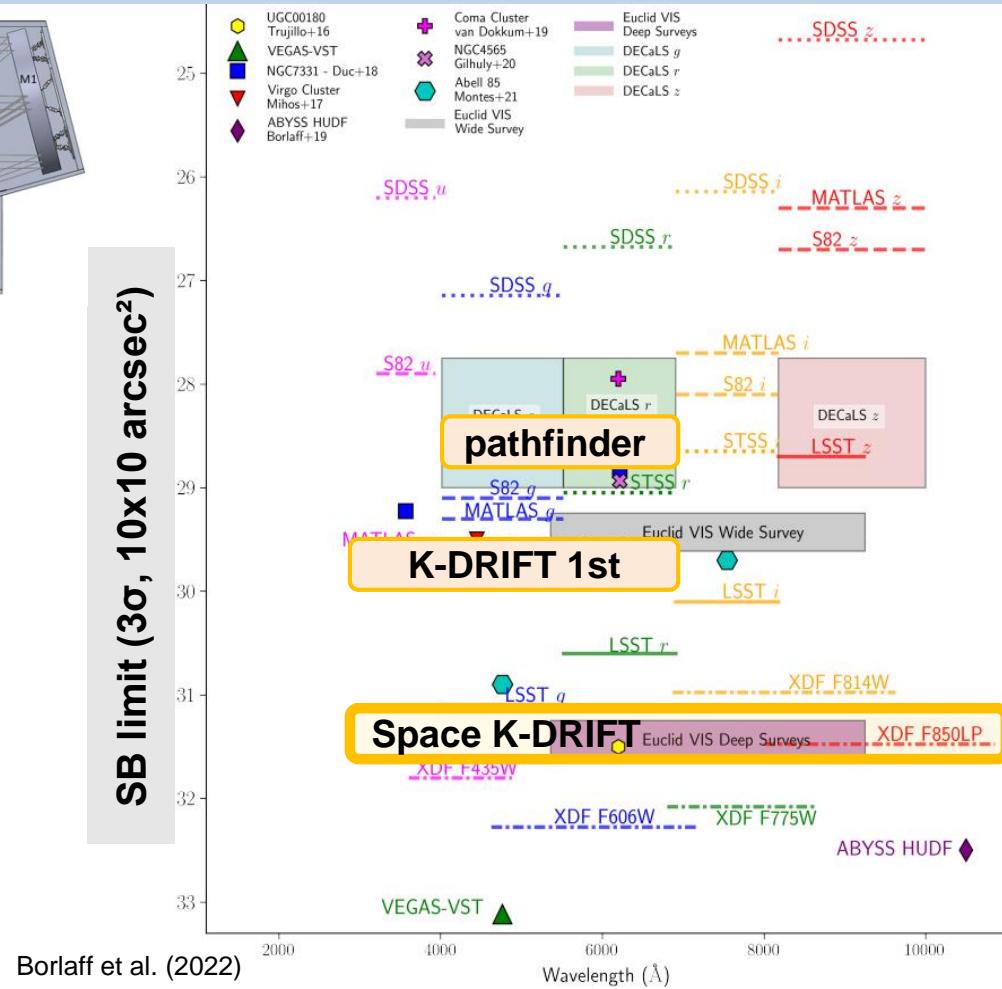
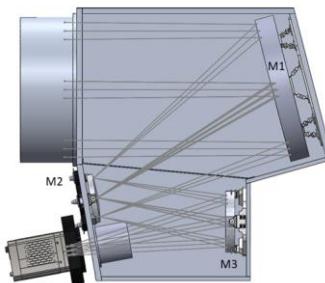
Single CMOS detector with large FoV

(Technique: LSB-optimized)

Optimized observing techniques

Dedicated calibration procedures

Optimized simulation techniques



Motivation: why exploring the LSB Universe

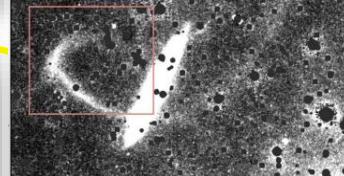
Observations

K-DRIFT 퍼스파인더:
Byun, Ko et al. (2022)

Marinelli-Delgado et al. (2008)



van Dokkum et al. (2019)



Duc et al. 2015



Simulations

DM Column Density [$\log M_{\odot} \text{ kpc}^{-2}$]

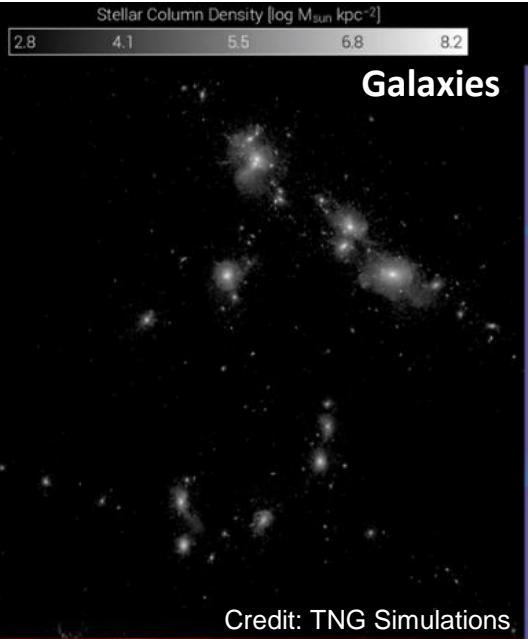
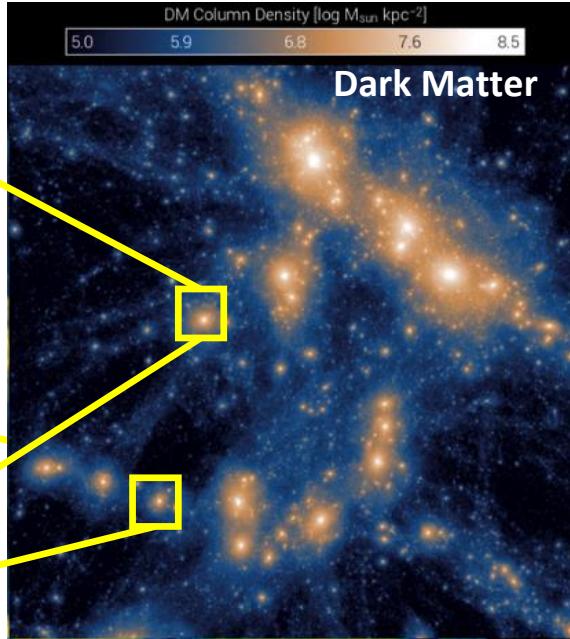
5.0 5.9 6.8 7.6 8.5

Dark Matter

Stellar Column Density [$\log M_{\odot} \text{ kpc}^{-2}$]

2.8 4.1 5.5 6.8 8.2

Galaxies



Credit: TNG Simulations.

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

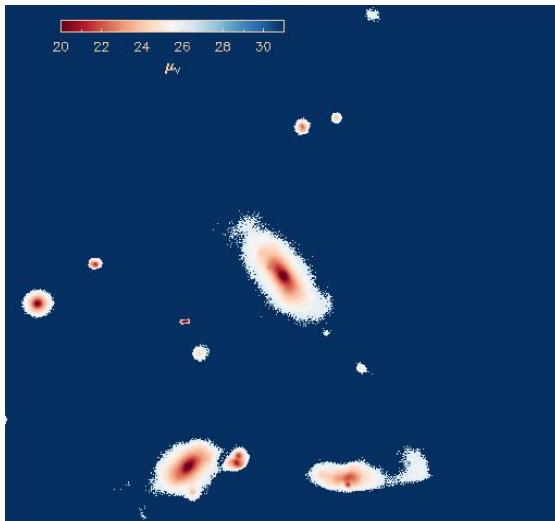
But, LSB regime (*generally, <0.1 % of the night sky level*) that is undetectable in past wide-area surveys

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

Motivation: why exploring the LSB Universe

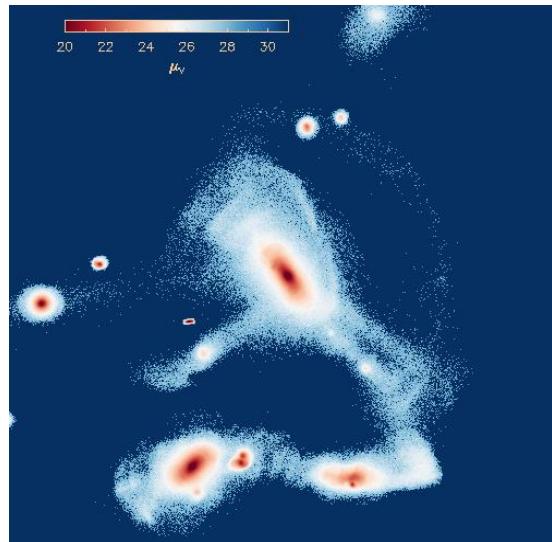
LSB/ultra-LSB universe (~0.1/0.01% of night sky): 밤하늘의 배경밝기보다 수천/만 배 이상 어두운 표면 밝기로, 초극미광 우주는 인류가 현재까지 수행해온 대규모 광학 탐사에서 밝혀지지 않은 미지의 영역

< 27 mag/arcsec²



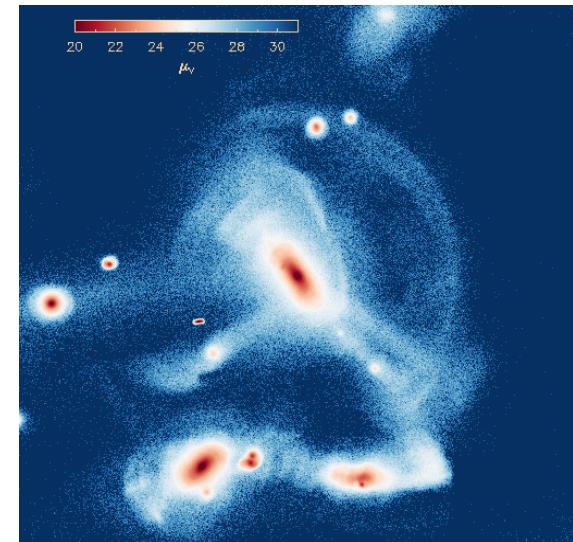
Yesterday (e.g., SDSS, CFHTLS)
2~4m Ground-based

< 29 mag/arcsec²



Today (e.g., DECaLS, SSPs)
4~8m Ground-based
K-DRIFT 1st
1 year LSST depth

< 31 mag/arcsec²



Tomorrow (e.g., Euclid, LSST)
10 year LSST depth
Space K-DRIFT

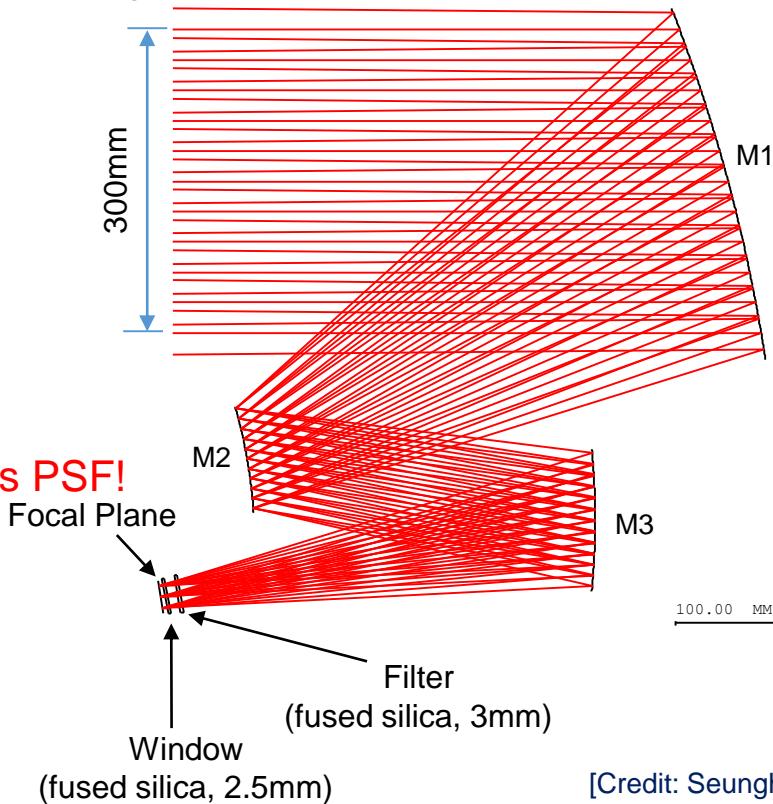
Strategies: fast off-axis TMA

Specification

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

large FoV,

homogeneous PSF!

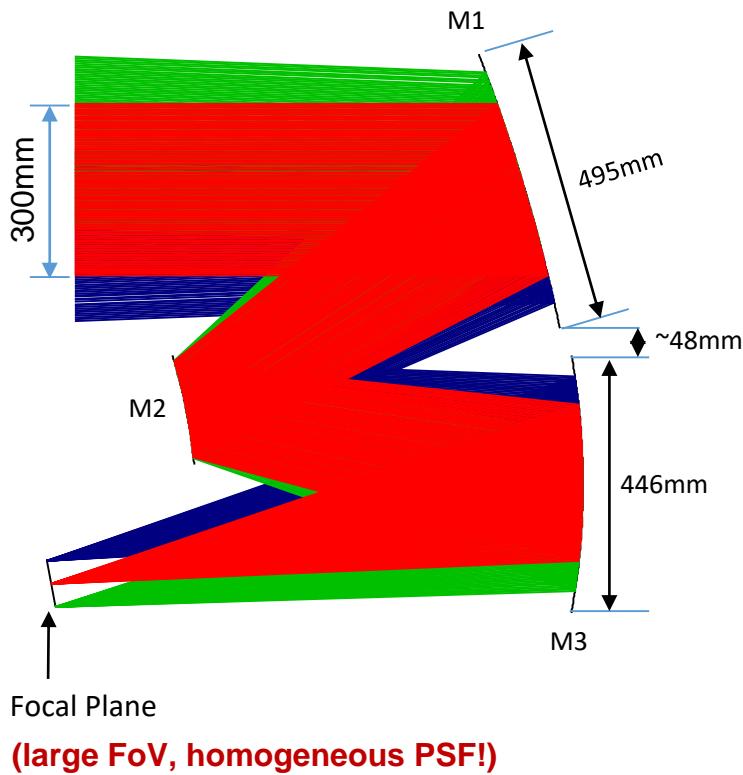


[Credit: Seunghyuk Chang]

Parameter	Measurement
Aperture Diameter	300mm
Focal Length	1200mm
Focal Ratio	4
Field of View	1.07°(H) x 1.07°(V)
Image Area	22.5mm x 22.5mm
Resolution	1.89 '' / 11um
M1-M2 Distance	550mm
M2-M3 Distance	350mm
M3-PF Distance	435.2231mm
M1 Tilt Angle	-15°
M2 Tilt Angle	20°
M3 Tilt Angle	-10°

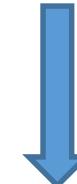
K-DRIFT 1st optical design

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



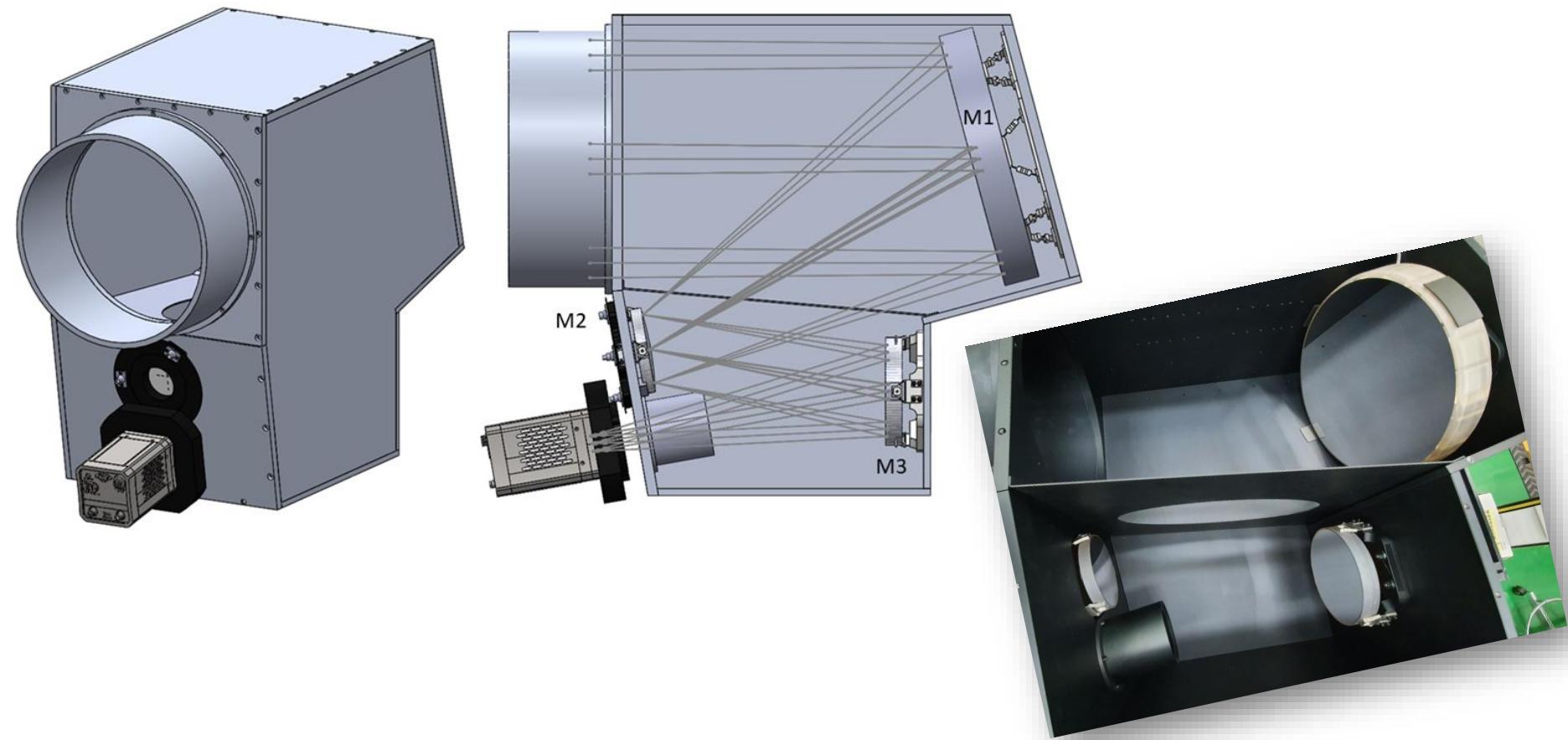
Parameter	Measurement
Aperture Diameter	300mm
Focal Length	1050mm
Focal Ratio	3.5
Field of View	$4.43^\circ \times 4.43^\circ$
Image Area	81.2mm x 81.2mm
Pixel Scale	1.96 " / 10um

19.6 deg² vs 9.6 deg² (Rubin Obs.)
보통 달 ~81개 크기!



Southern sky survey (in ~3Y):
> 29 mag/arcsec² in u, g & r

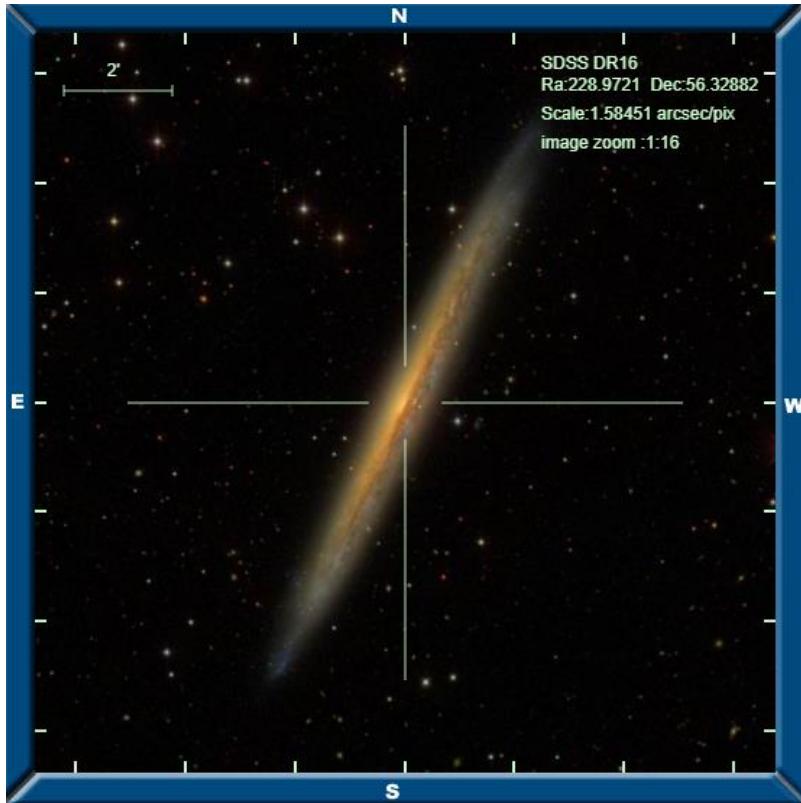
K-DRIFT Pathfinder optomechanical design



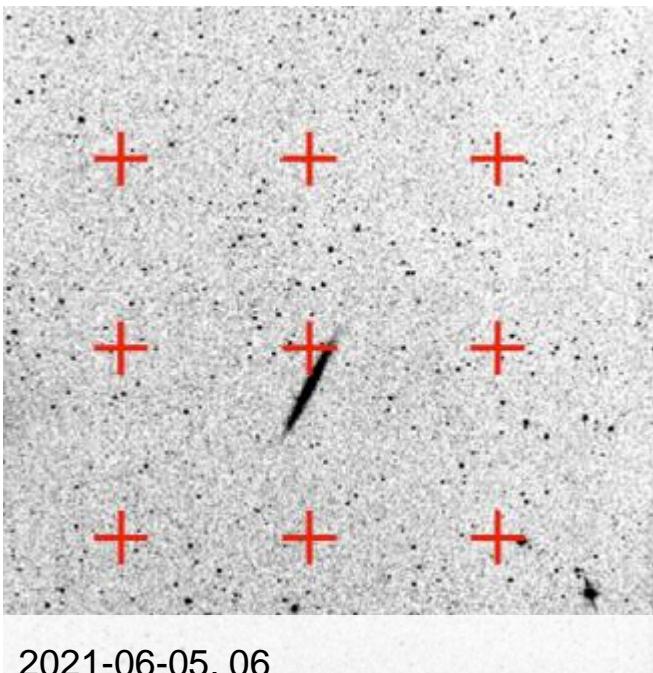
K-DRIFT Pathfinder test obs.: NGC 5907

(edge-on galaxy, ~ 17 Mpc, $\sim 8 \times 10^{10} \odot$)

SDSS(2.5m, 53.9s exp.) vs Martinez-Delgado et al.(2008; 0.5m, 11.35h exp.)



K-DRIFT Pathfinder test obs.: NGC 5907



15-arcmin shifted dithering, 30sX10

Tracking & focusing uncertainty

Sky quality: SQM 20.3~20.8

Humidity: 52~86%(mirror)/73~92%(dome)

Byun, Ko et al. (2022)

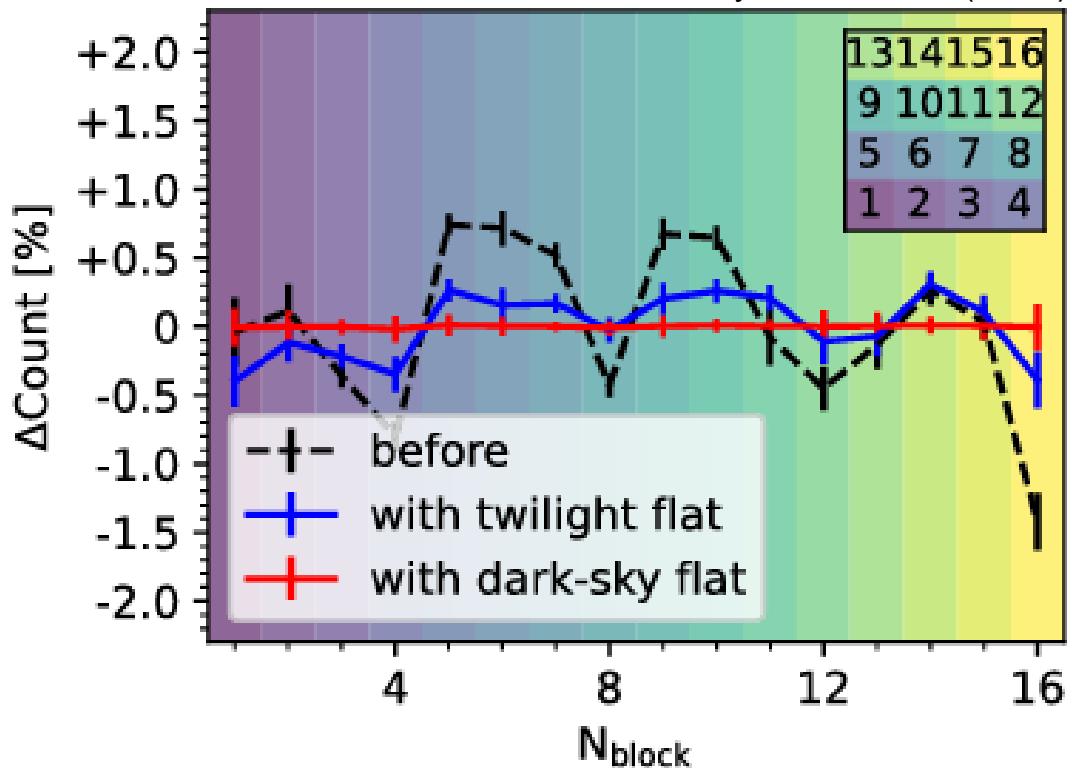
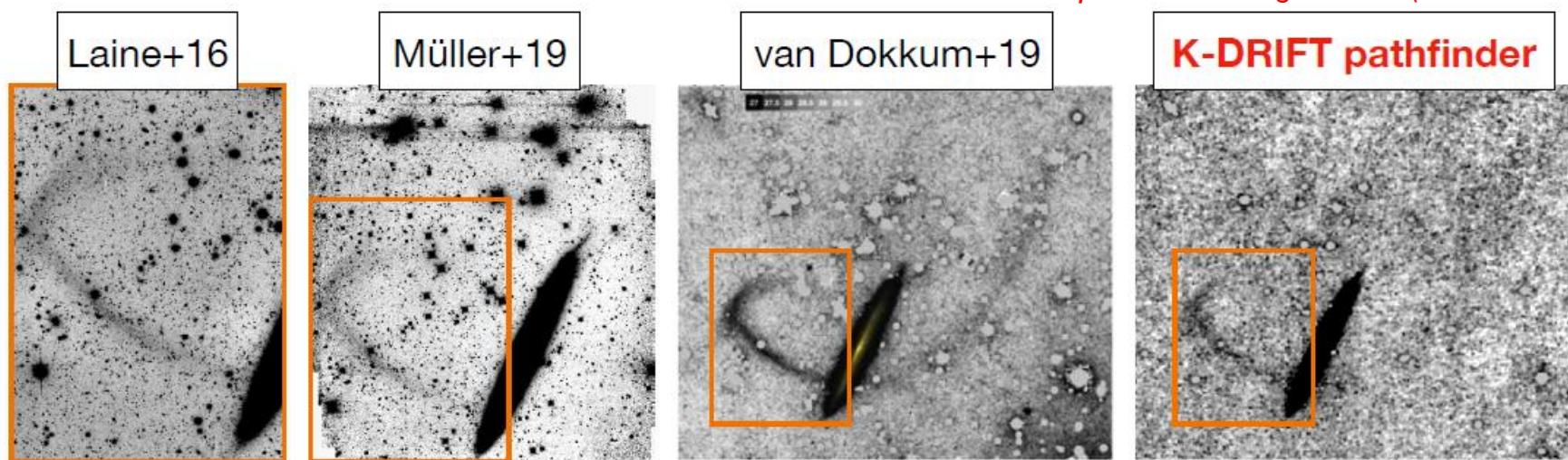


Table 1. Key characteristics of the studies that observed the stellar stream of NGC 5907

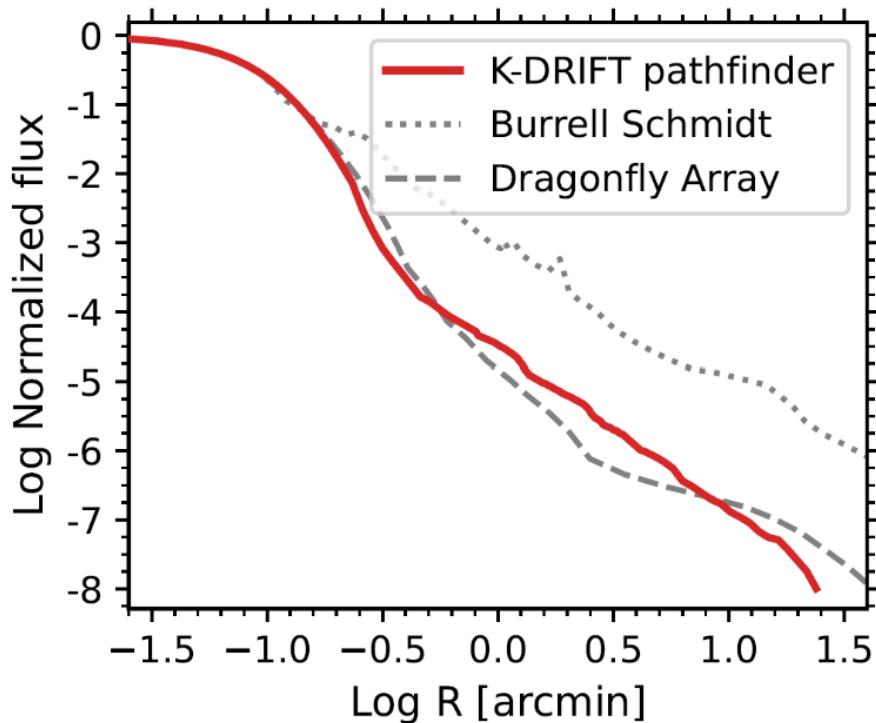
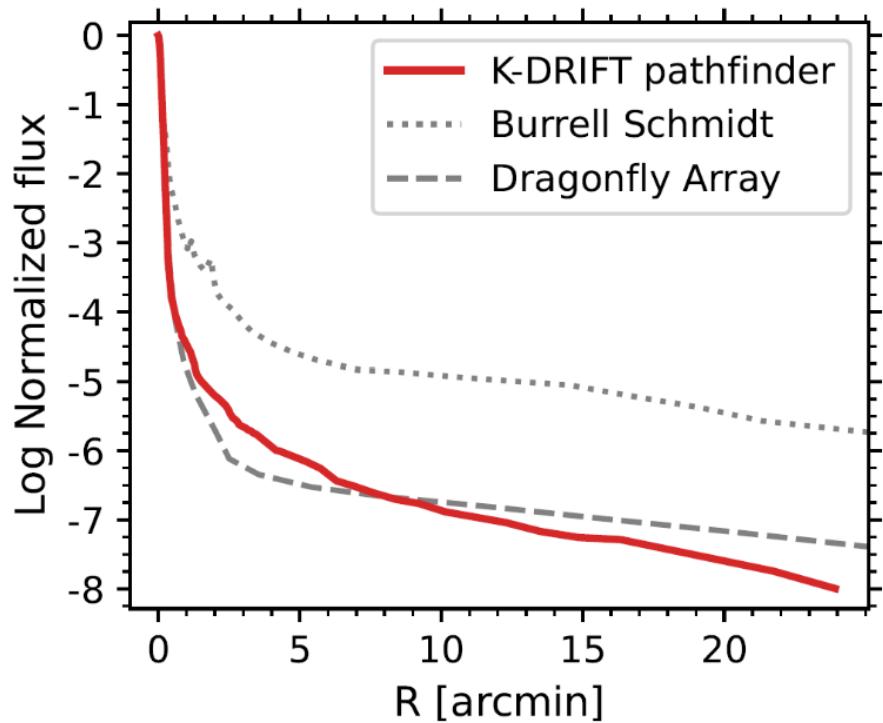
Reference	Diameter (m)	Total Exposure (hr)	filters	Telescope
Shang et al. (1998)	0.6/0.9	26.17	m_{6660}, m_{8020}	Schmidt telescope
Martínez-Delgado et al. (2008)	0.5	11.4	L	Ritchey–Chrétien telescope
Laine et al. (2016)	8.2	0.2	g, r, i	Subaru telescope
Müller et al. (2019)	1.4	7.2	L	Milanković telescope
van Dokkum et al. (2019)	0.143 (1)	115 (4.8)	g, r	Dragonfly Telephoto Array
This study Byun, Ko et al. (2022)	0.3	2.0	L	K-DRIFT pathfinder

NOTE—The values presented here are only for a single aperture with a single filter. Therefore, the Dragonfly Telephoto Array can practically be regarded as a 1 m telescope with a total exposure time of 4.8 hr.

$$\mu_r, 1\sigma \sim 28.5 \text{ mag arcsec}^{-2} (10'' \times 10'' \text{ boxes})$$

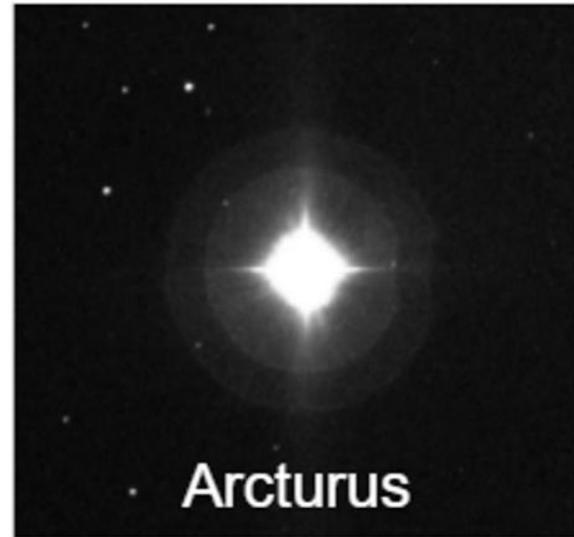
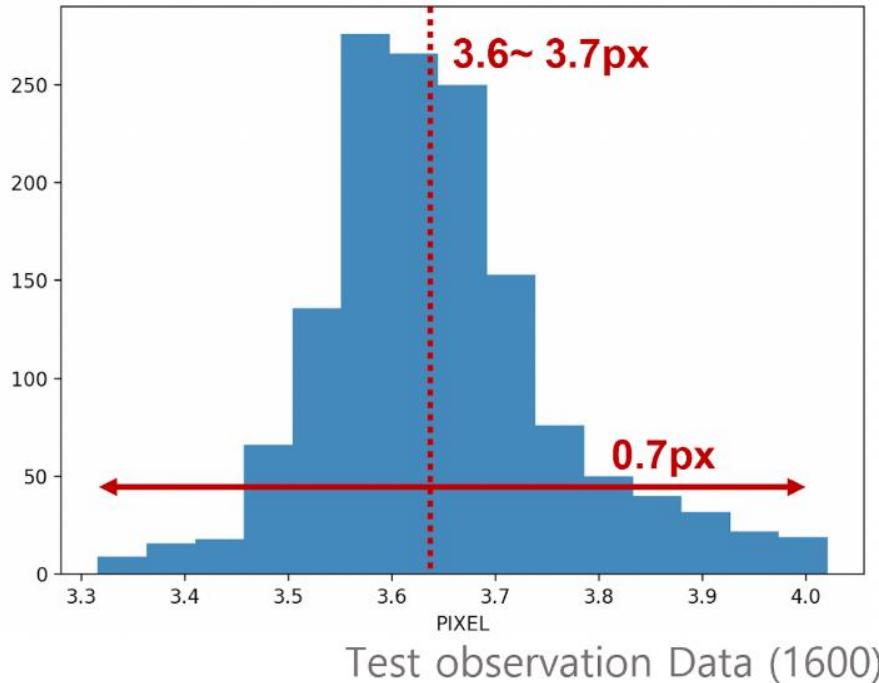


Pathfinder performance: PSF



Pathfinder performance: PSF

PSF FWHM

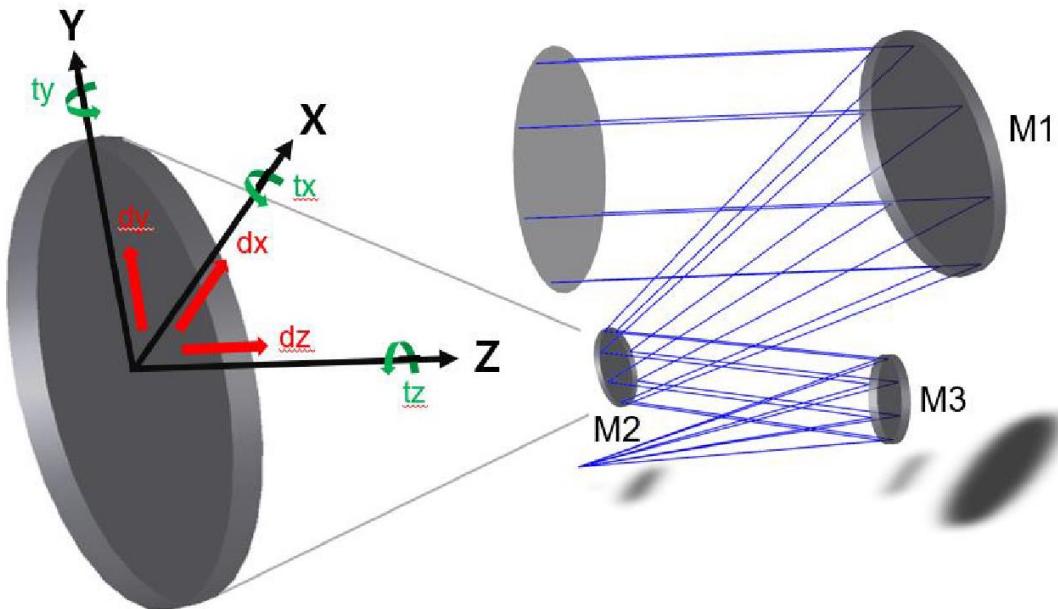


Requirement : 3.8 arcsec (2px)

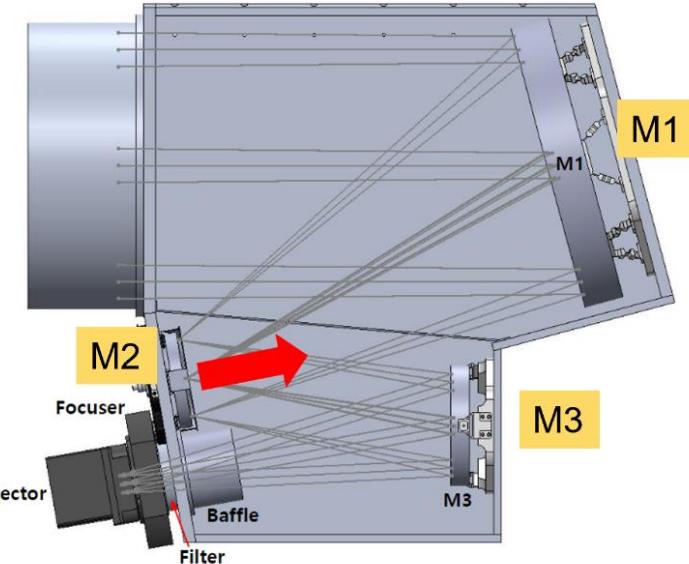
Observation : 6.7 arcsec (3.5px)

→ What degrades the performance of the K-DRIFT pathfinder?

Pathfinder upgrade: performance analysis



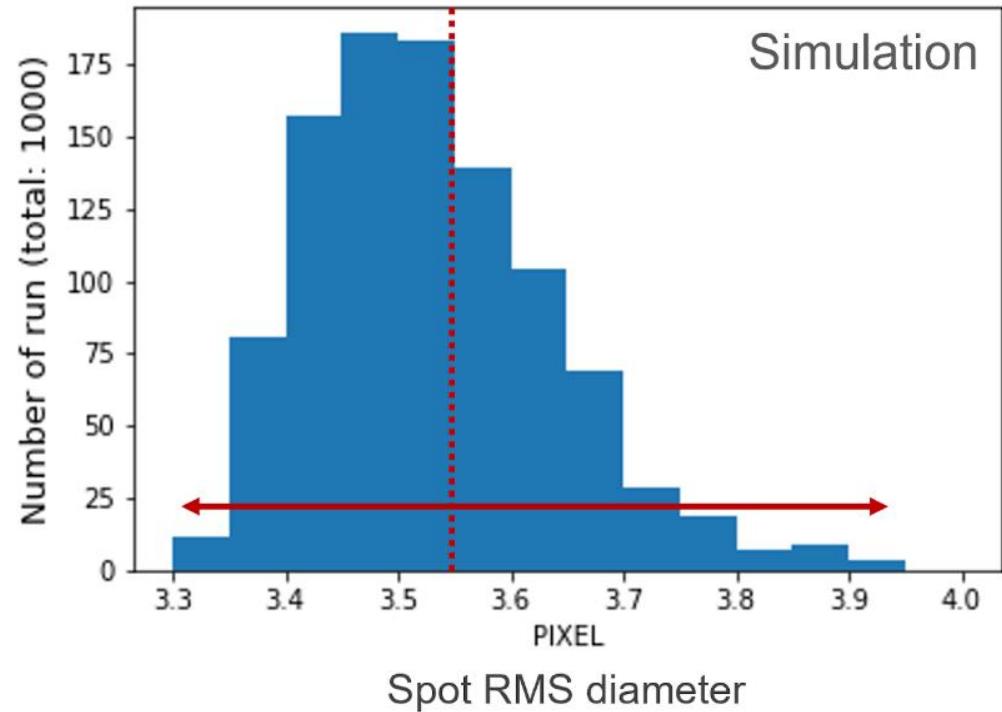
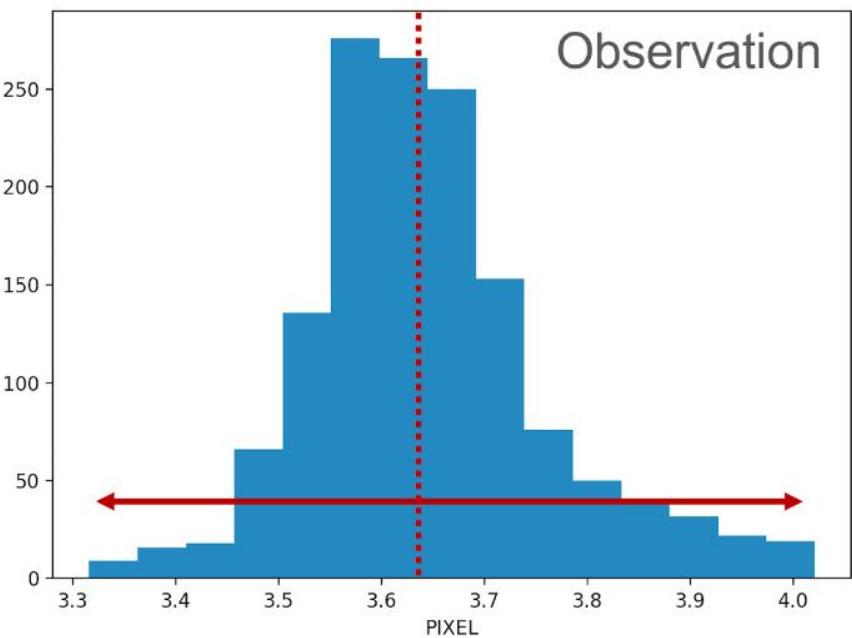
6 degrees of freedom of M2



K-DRIFT Pathfinder

Pathfinder upgrade: performance analysis

Monte Carlo simulation that randomly moves M2 for 6 degrees of freedom.

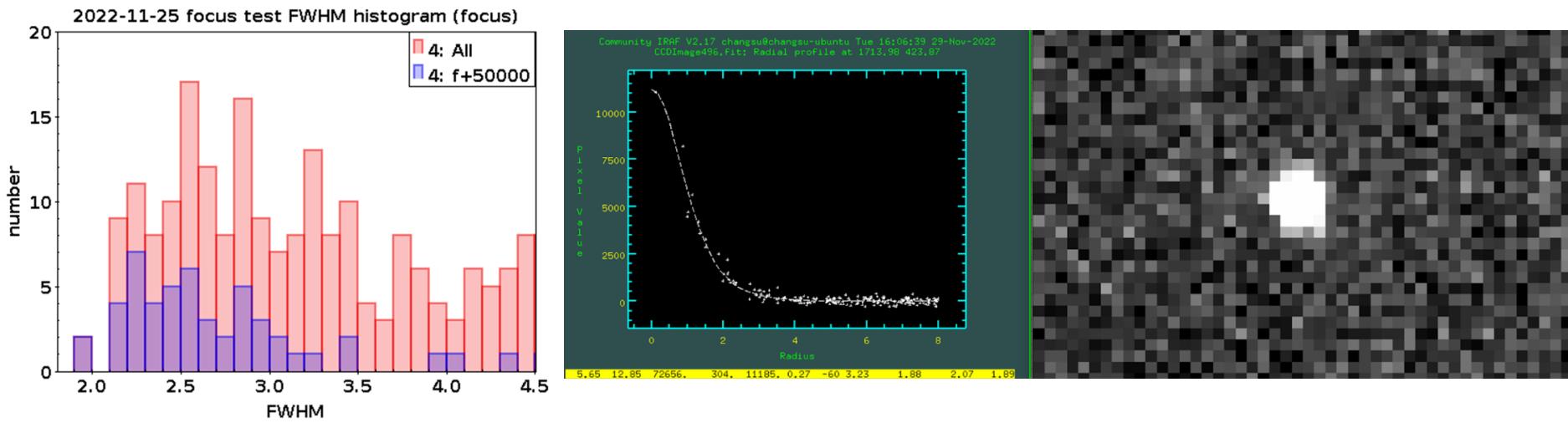


Pathfinder upgrade: M2 replacement

M2 replacement: to minimize MSF error

Test observations: 2022.11.15 @KASI & 2022.12.14 @BOAO

Improved: ~3.7px ~2.5px



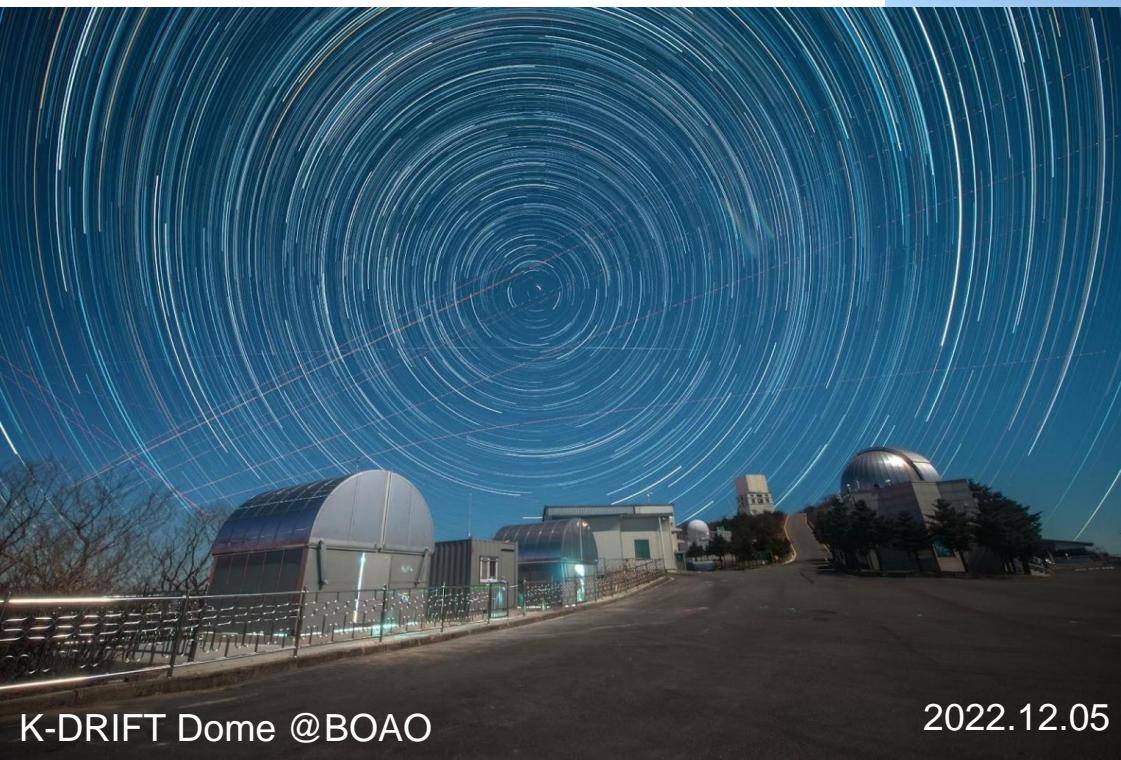
K-DRIFT/Pathfinder Dome @BOAO



콘크리트 패드 19 m x 5 m



K-DRIFT/Pathfinder Dome @BOAO



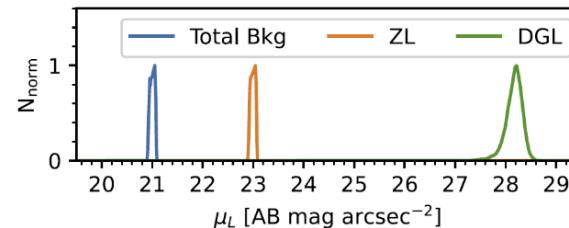
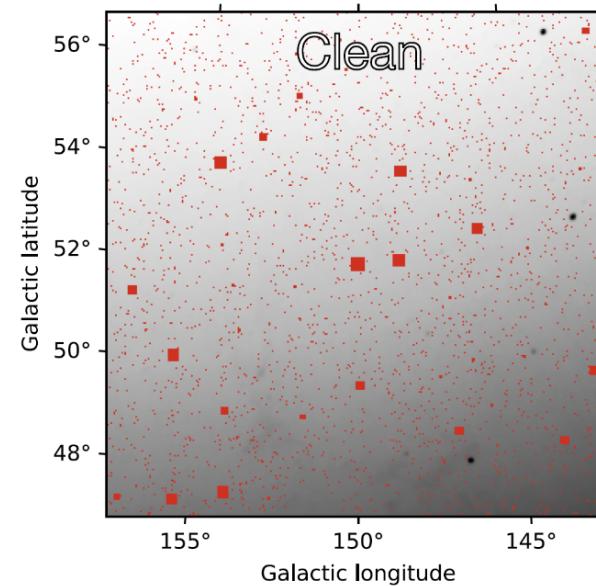
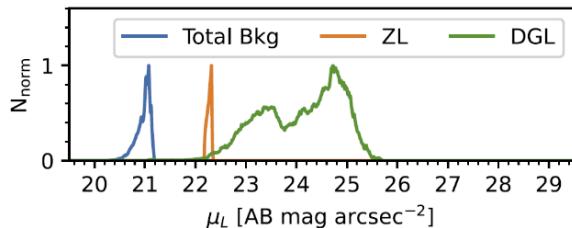
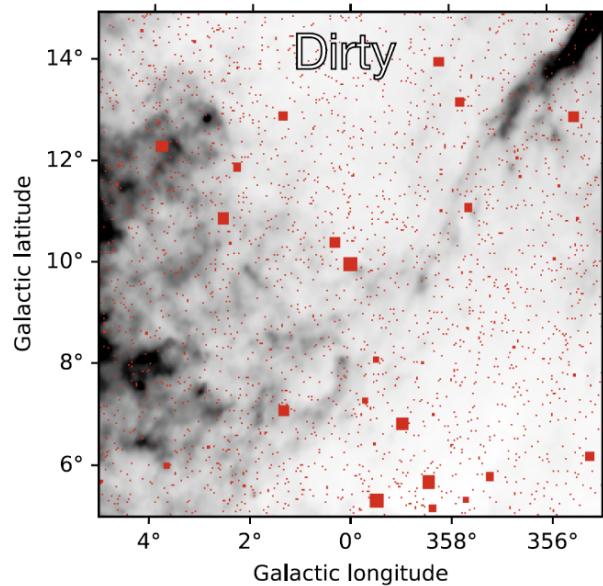
Pathfinder

K-DRIFT 1st backup



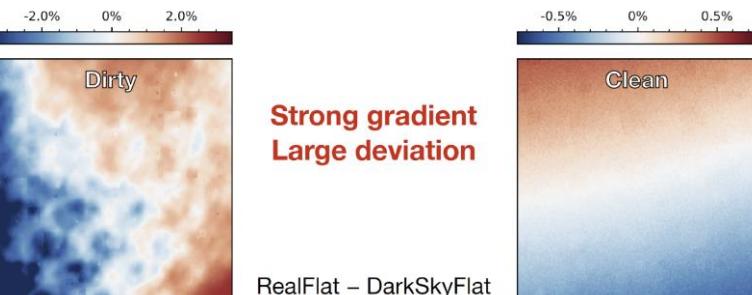
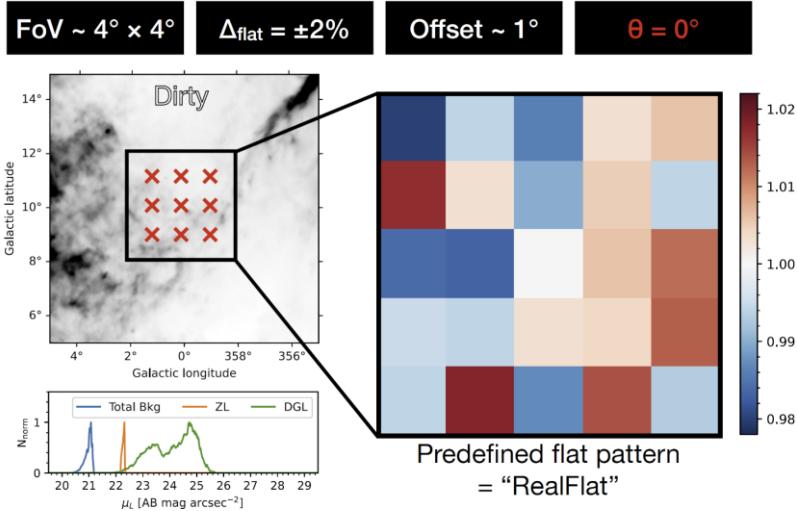
K-DRIFT preparation: sky simulation

(Airglow) + Zodiacal light + Diffuse Galactic light + Object(mask)

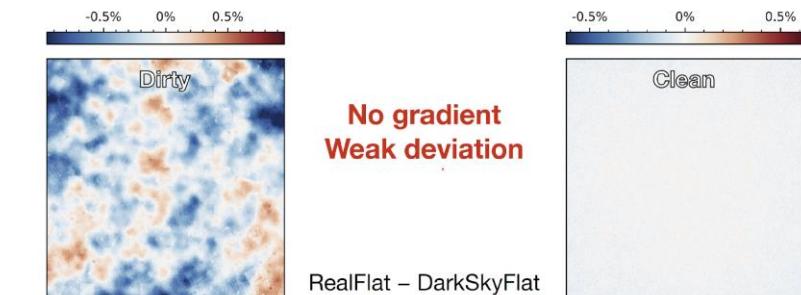
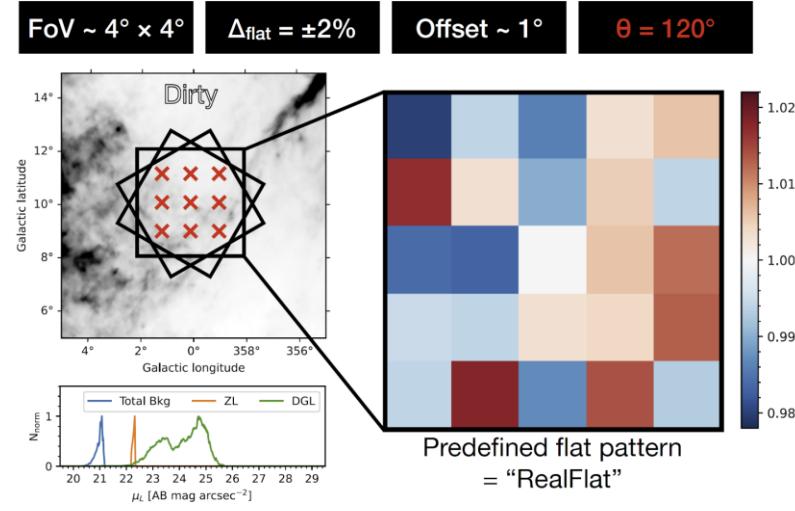


K-DRIFT preparation: sky simulation

Case study: nine-point dithering



Case study: rolling dithering



Roadmap: K-DRIFT Project in the 1st stage

자체연구개발사업 →

주요사업 →

2019-2020

K-DRIFT
pathfinder 개발
(30cm)

2021-2024

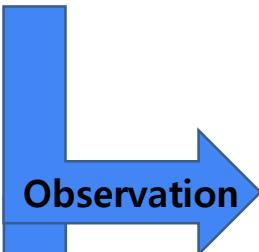
K-DRIFT 1st 개발
(2, 30cm급)

2025-2027

K-DRIFT 2nd 개발
(3, 30-50cm급)

2028-2029

K-DRIFT 3rd 개발
(우주망원경
pathfinder)



- K-DRIFT 시제품 제작 마무리, 보현산천문대 설치 및 운영
- 천문대 시험운영을 통한 망원경 성능 시험
 - K-DRIFT 1st 설계 피드백
- 동 설치를 통한 원격 탐사관측 시스템 개발
- LSB 전체 분석에 최적화된 자료처리 파이프라인 개발

1차 LSB 탐사관측 수행:
~30 mag/arcsec²
LSB optical colors

2차 LSB 탐사관측 수행:
>30 mag/arcsec²
LSB optical SEDs

관측기술 업그레이드:
LSB 우주 탐사관측용
지상망원경 개발

관측기술 업그레이드:
LSB 우주 탐사관측용
우주망원경 개발 준비

