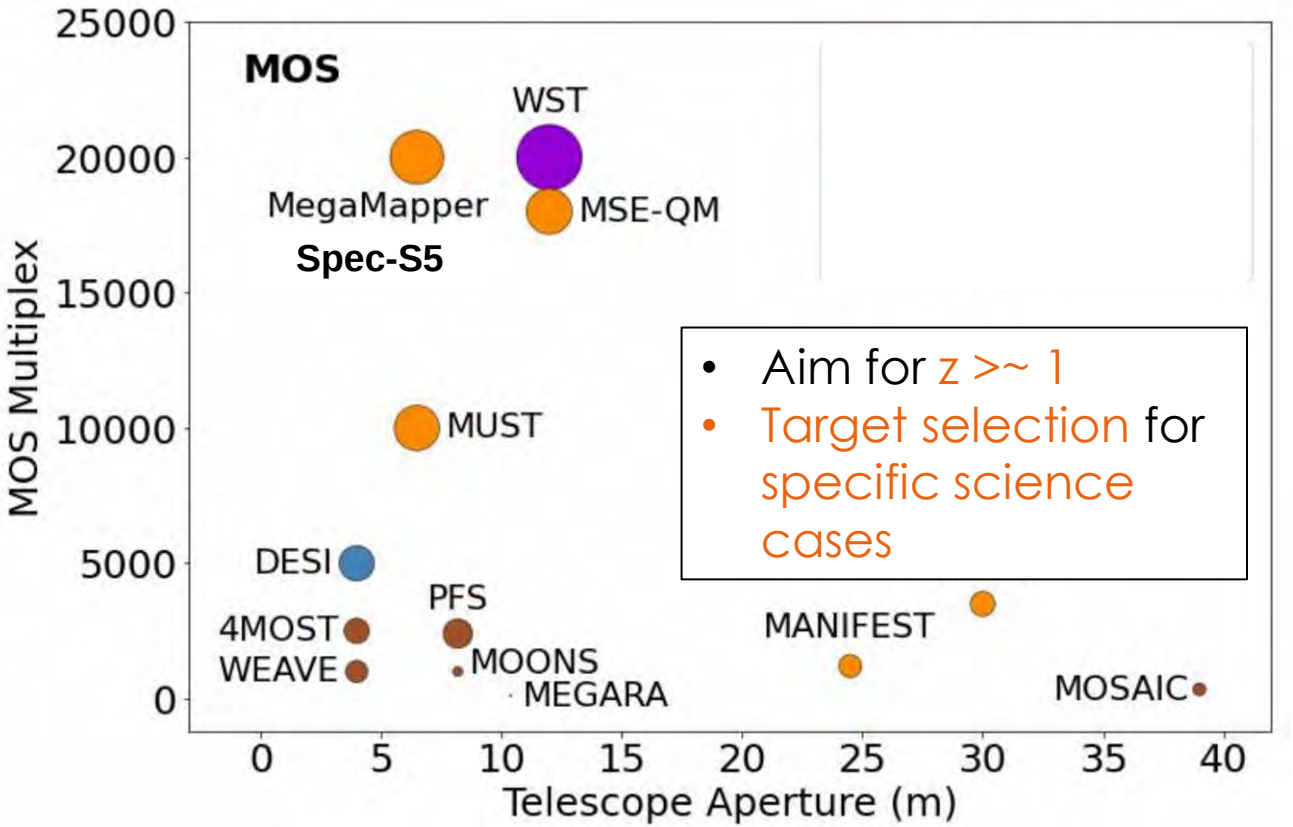
한국천문연구원
Korea Astronomy & Space Science Institute

KLST: Feasibility Study for the Next-Generation Spectroscopic Survey with Dedicated Large Telescopes

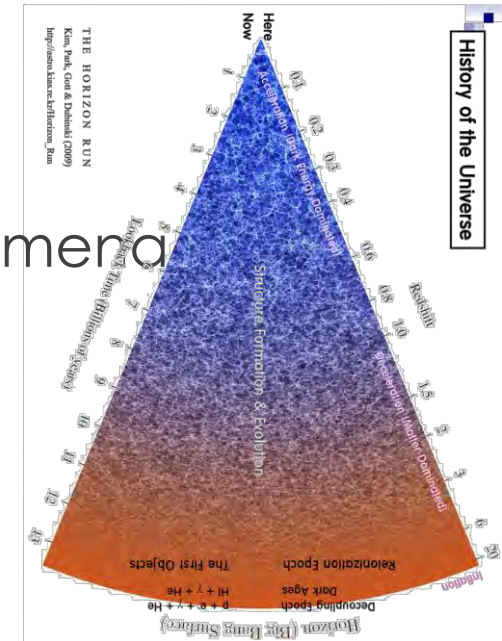


Current & Next-Gen Spectroscopic Surveys



Flux-limited Surveys?

- To maximize the sample density at the dark energy-dominated era (z <~ 0.8)
- To study various astrophysical phenomena other than just dark energy



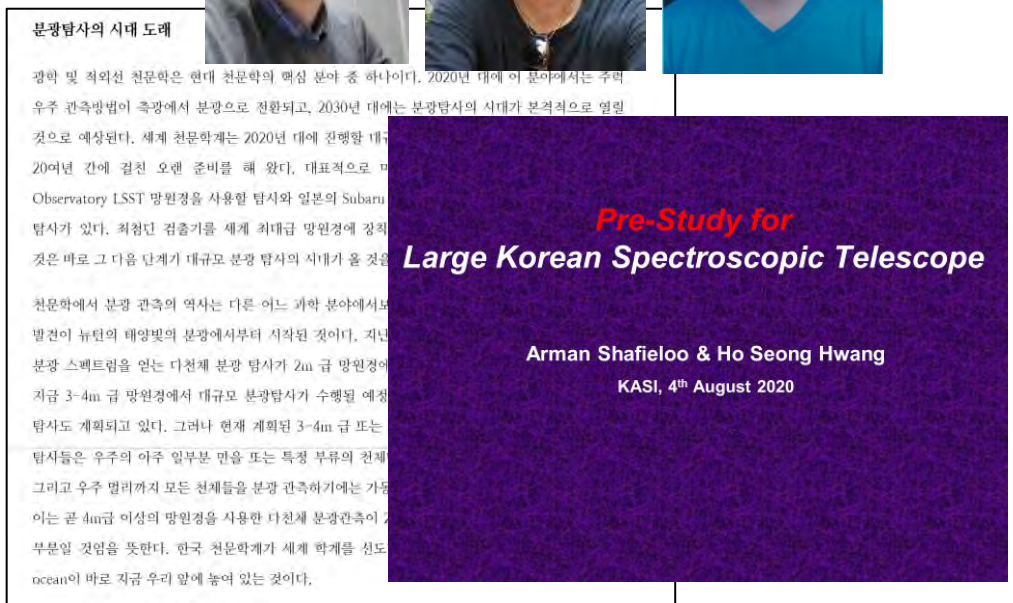
KOREAN LARGE SPECTROSCOPIC TELESCOPES (KLST)







Dec 2019	• Initial discussion started
Jan-Sep 2020	• Discuss on main survey • Start writing a brief white paper
Aug-Oct 2020	• KASI preliminary study proposal: *Pre-Study for a Large Korean Spectroscopic Telescope* (PI: Arman Shafieloo)
Jul 2022 - 2023	• Discussion resumed • **KASI Qrontier selected**

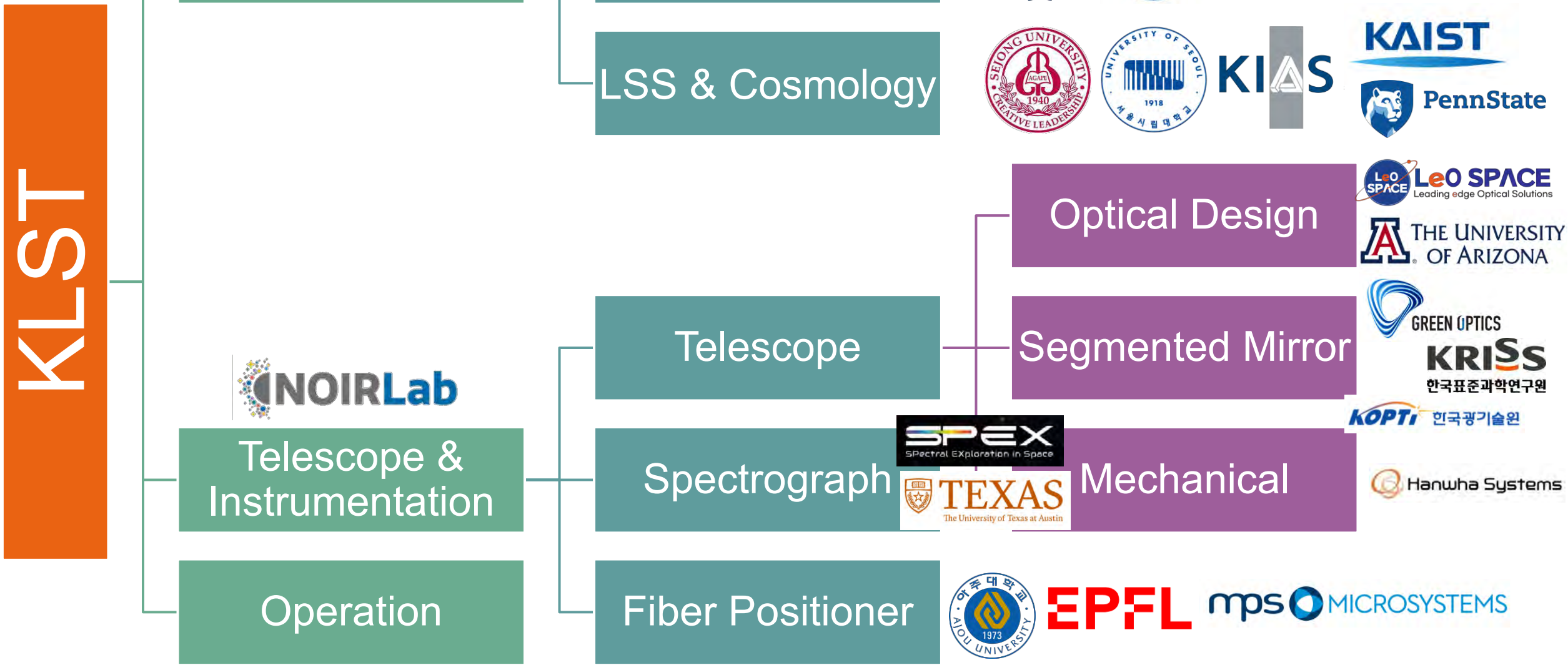

분광탐사의 시대 도래

광학 및 적외선 천문학은 현대 천문학의 핵심 분야 중 하나이다. 2020년 대에 이 분야에서는 주력
우주 관측방법이 측광에서 분광으로 전환되고, 2030년 대에는 분광탐사의 시대가 본격적으로 열릴
것으로 예상된다. 세계 천문학계는 2020년 대에 진행할 대
20여년 간에 걸친 오랜 준비를 해 왔다. 대표적으로
Observatory LSST 망원경을 사용할 탐시와 일본의 Subaru
탐사가 있다. 최첨단 검출기를 세계 최대급 망원경에 장착
것은 바로 그 다음 단계가 대규모 분광 탐사의 시대가 올 것을

천문학에서 분광 관측의 역사는 다른 어느 과학 분야에서보
발견이 뉴턴의 태양빛의 분광에서부터 시작된 것이다. 지
분광 스펙트럼을 얻는 다천체 분광 탐사가 2m 급 망원경에
지금 3~4m 급 망원경에서 대규모 분광탐사가 수행될 예정
탐사도 계획되고 있다. 그러나 현재 계획된 3~4m 급 또는
탐사들은 우주의 아주 일부분 면을 또는 특정 부류의 천체
그리고 우주 멀리까지 모든 천체들을 분광 관측하기에는 가
이는 곧 4m급 이상의 망원경을 사용한 다천체 분광관측이
부분일 것임을 뜻한다. 한국 천문학계가 세계 학계를 선도
ocean이 바로 지금 우리 앞에 놓여 있는 것이다.

Pre-Study for
Large Korean Spectroscopic Telescope

Arman Shafieloo & Ho Seong Hwang
KASI, 4th August 2020


KLST
Science
Stellar
Galaxies & Clusters
LSS & Cosmology
Telescope & Instrumentation
Telescope
Spectrograph
Fiber Positioner
Optical Design
Segmented Mirror
Mechanical
Operation
NOIRLab
SPEX
SPectral EXploration in Space
TEXAS
The University of Texas at Austin
KIAS
KAIST
PennState
LeO SPACE
Leading edge Optical Solutions
THE UNIVERSITY OF ARIZONA
GREEN OPTICS
KRISS
한국표준과학연구원
KOPTI
한국광기술원
Hanwha Systems
EPFL
mps MICROSYSTEMS

Mar. 21-22, 2024
1st Workshop











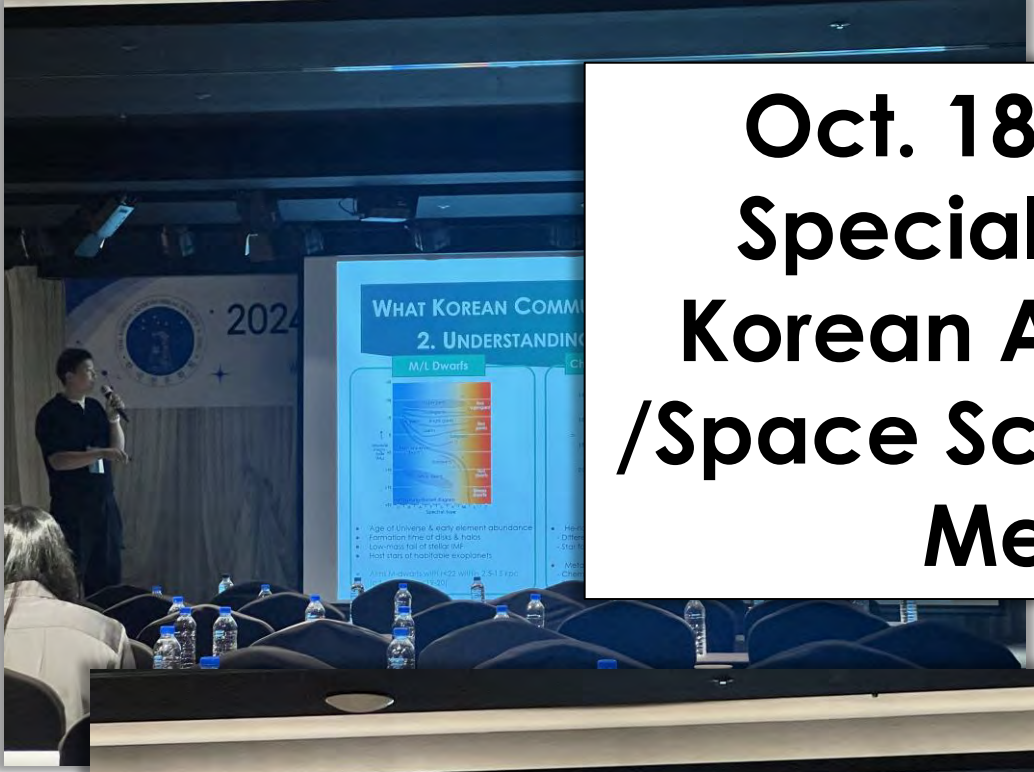


회의 일시 / 장소	2024년 06월 19일 (13:00 ~ 17:00) / Pacifico Yokohama, 일본 요코하마
회의 제목(내용)	제목 : 2024 SPIE 기술교류회 - "2024 SPIE Astronomical Telescopes + Instrumentation" 학회에 참여하는 전세계의 한국인 천문학자 및 관측기기개발자 간 교류 - "대형 전용 망원경을 활용한 차세대 분광탐사 기획연구" 소개 및 관련 전세계 한인 연구자의 조언 청취 및 공동협력 모색
참석자 정보 (총 35명)	내부 참석자 (총 10명): 홍성욱, 김재우, 김윤종, 이충욱, 한정열, 김우진, 문봉곤, 안교훈, 이용석, 이지우
	외부 참석자 (총 25명) : 김건희(한밭대), 김대욱/오창진/이선우/정하은(Arizona), 김성희/김현배/원동식(텔레픽스), 김준한(KAI 김지훈(서울대), 맹환호(한밭대), 박준규(연서 송인웅/양호순/이윤우/이재협(표준연), 양태석/장승원/전유라(레오스페이스), 유정훈/이창희/조재영(그린광학), 이한신(UT A 장승혁(스마트IT연구단), 최종국(항우연)

Jun. 19, 2024
Korean Instrumentation Scientist Meeting @ SPIE



Oct. 18 & 29, 2024 Special sessions @ Korean Astronomical /Space Science Society Meetings









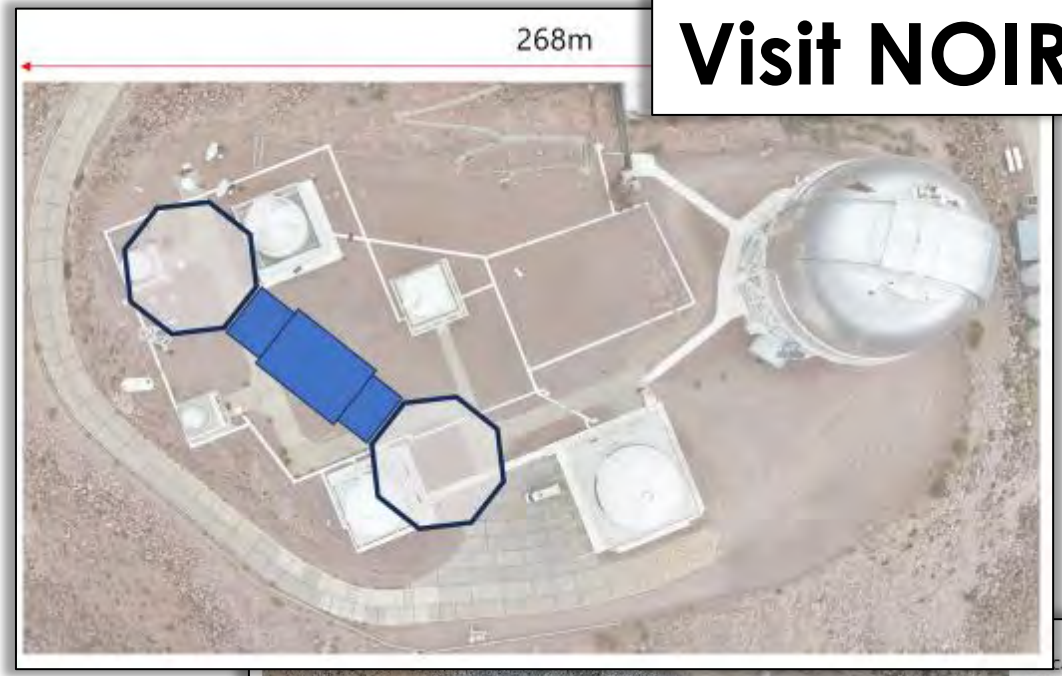
Nov. 27-29, 2024
2nd Workshop







Jan. 11-19, 2025
Visit NOIRLab/CTIO & LCO







Korea Astronomy and Space Science Institute

NOIRLab

Letter of Intent

Between

Korea Astronomy and Space Science Institute (KASI)
Republic of Korea

and

NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab)
United States of America

on

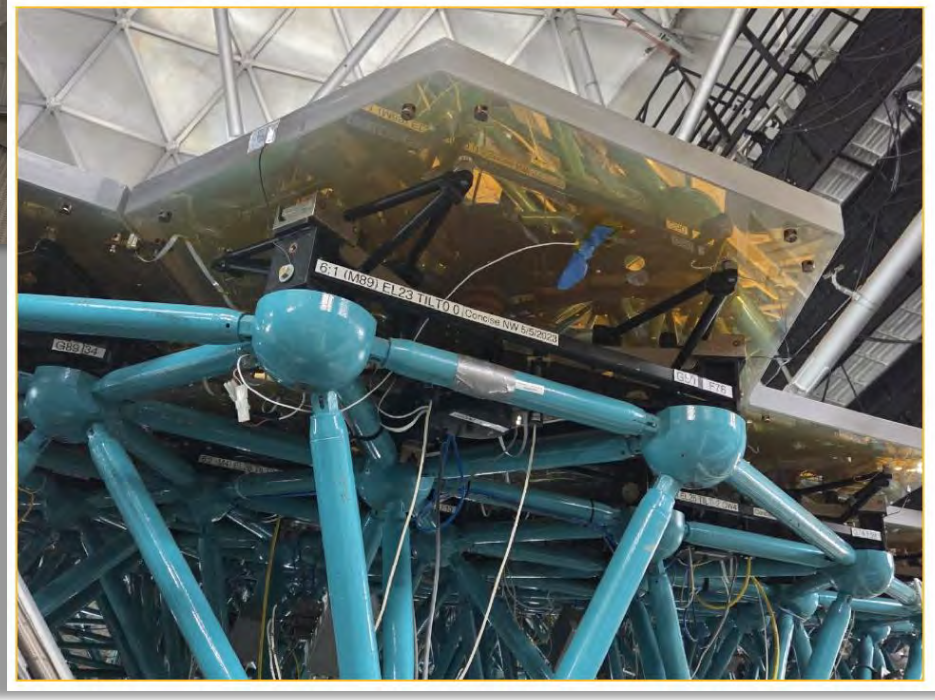
Cooperation in Scientific Research and Telescope Development for Wide-Field Spectroscopic Surveys

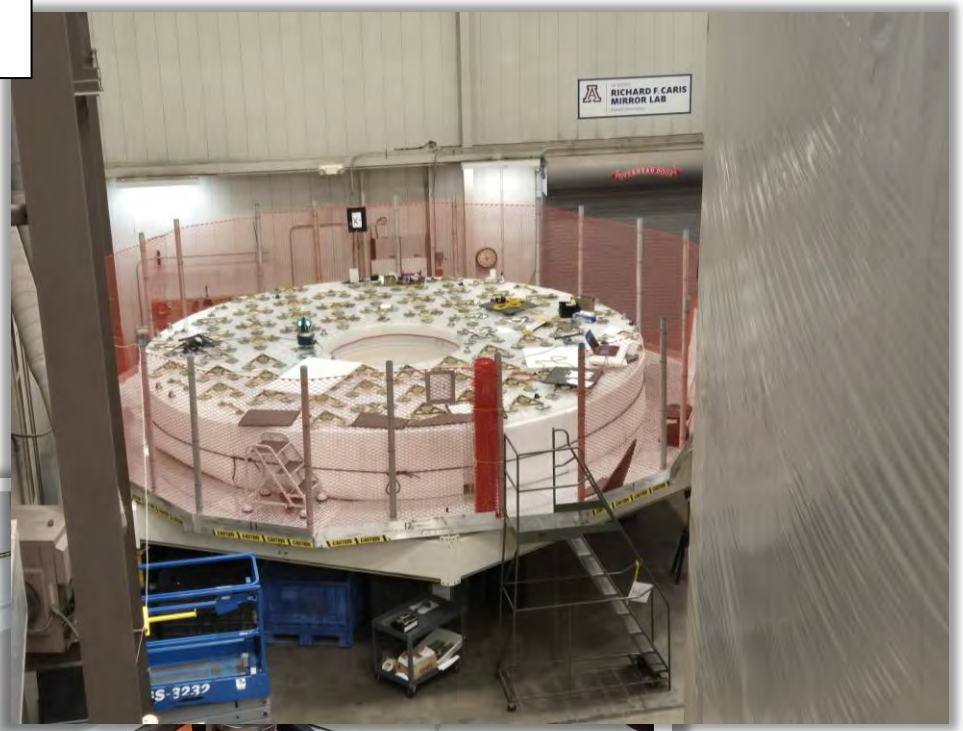
Preamble

Recognizing the mutual interest in advancing astronomical research and contributing to the global understanding of the universe, Both Parties, KASI and NSF's NOIRLab, have expressed their intent to collaborate on scientific research and the development of telescopes related to KASI's "Feasibility Study for the Next-Generation Spectroscopic Survey with Dedicated Large Telescopes" (KLST). This partnership aims to explore scientific research, technology development, and site surveys through joint efforts.

Mar 17-25, 2025
Visit UT Austin & UA







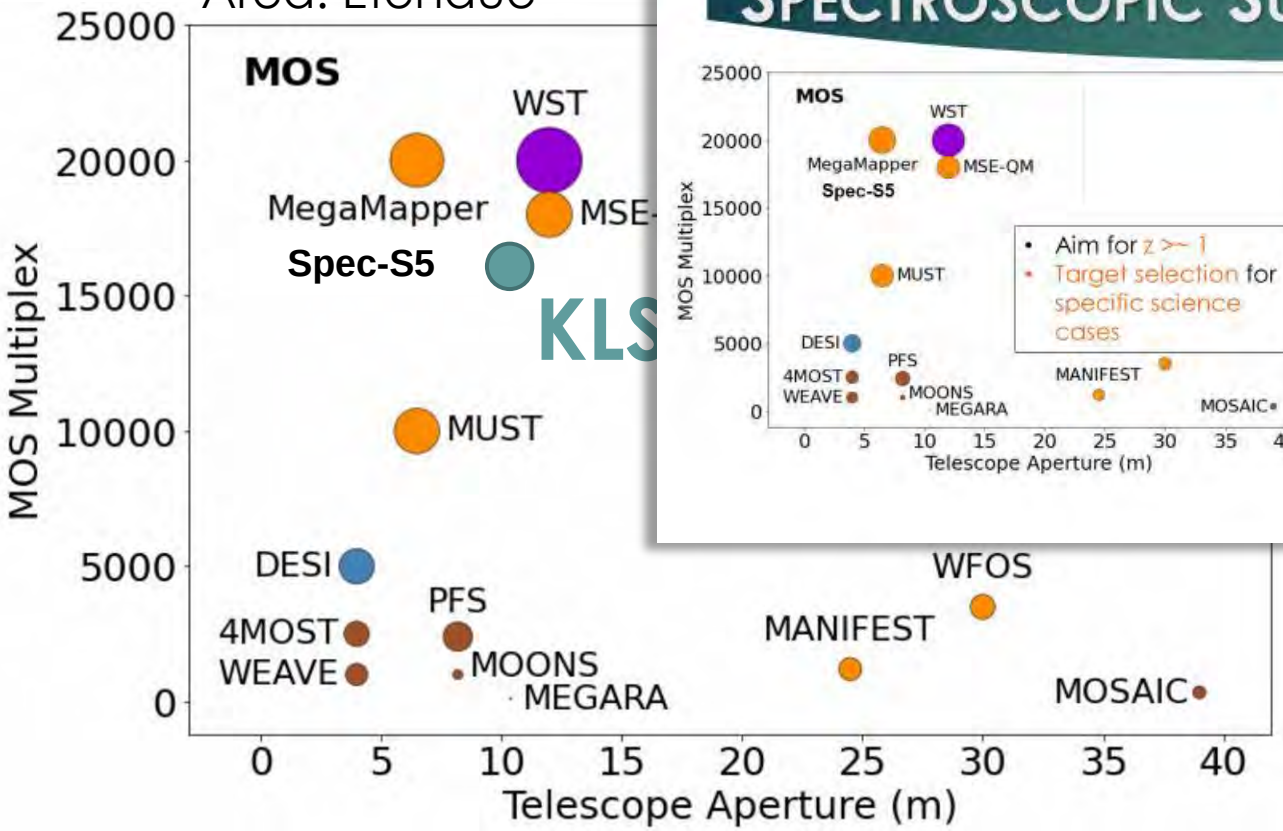


Basic Requirements

Telescopes	Two 6.5m @ Southern hemisphere (effectively ~9.2m when aiming the same targets)
Survey Magnitude Limit	r=21-22
Wavelength Range	VIS + NIR
Field of View	1.8deg / 2.5deg^2
Spectral Resolution	6,000(low-res), 45,000(high-res)
Multiplexing	13,000(low-res), 3,000(high-res)

Basic Requirements

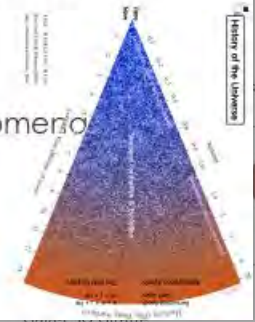
Area: Etendue



Current & Next-Gen Spectroscopic Surveys

Flux-limited Surveys?

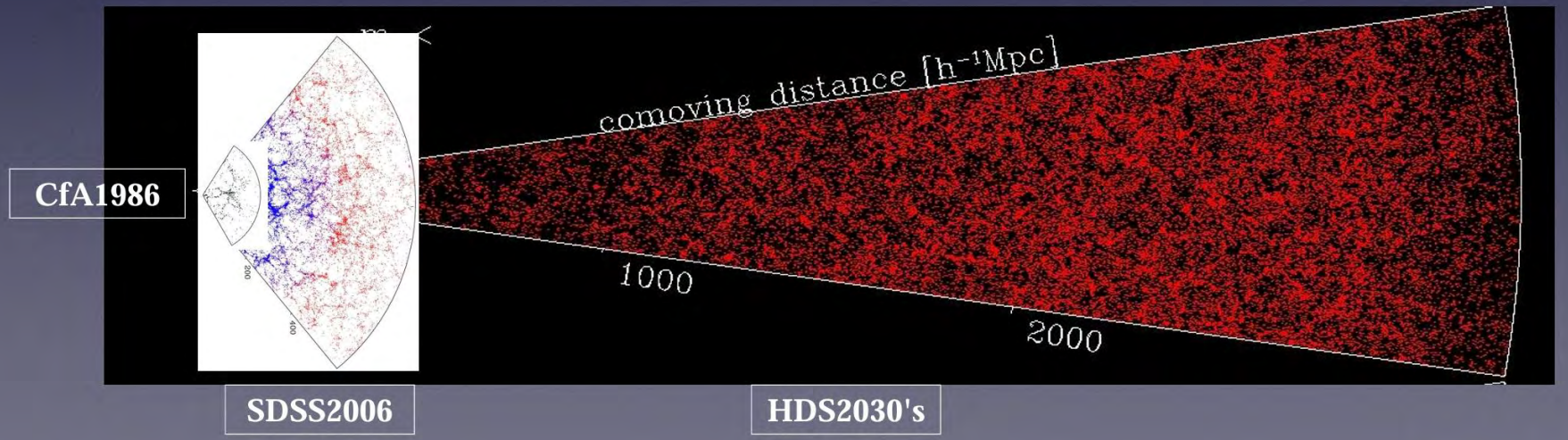
- To maximize the sample density at the dark energy-dominated era (z <~ 0.8)
- To study various astrophysical phenomena other than just dark energy



Hubble Depth Survey

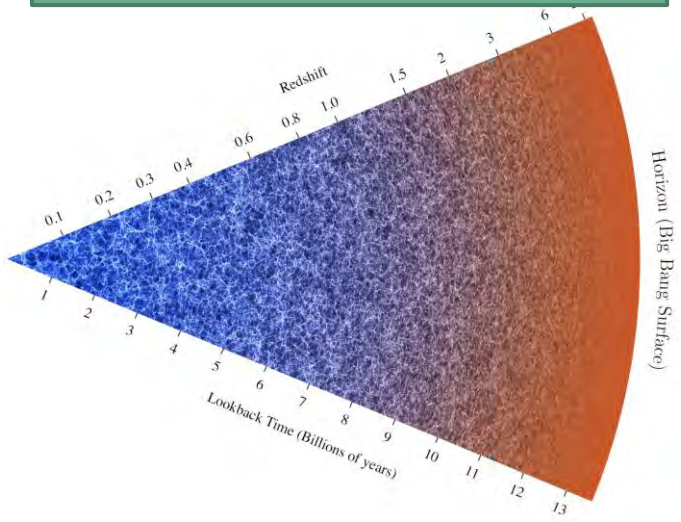
- A complete spectroscopic survey of the local universe

1. **Deep** (z ~ 1) → evolution of universe (DE science) & tracers
2. **Wide** (area >> 1000 deg^2) → large scale structure sciences (initial conditions)
3. **Dense** (mean d ~< 5 h^{-1}Mpc) → physics of galaxy formation. high-order statistics
4. **Complete** → no sampling biases. unexpected findings. satellite system survey / dark halo survey
5. **Compatible** with parallel surveys →sparse & deeper rare object surveys (LRGs, ELGs, QSOs …)



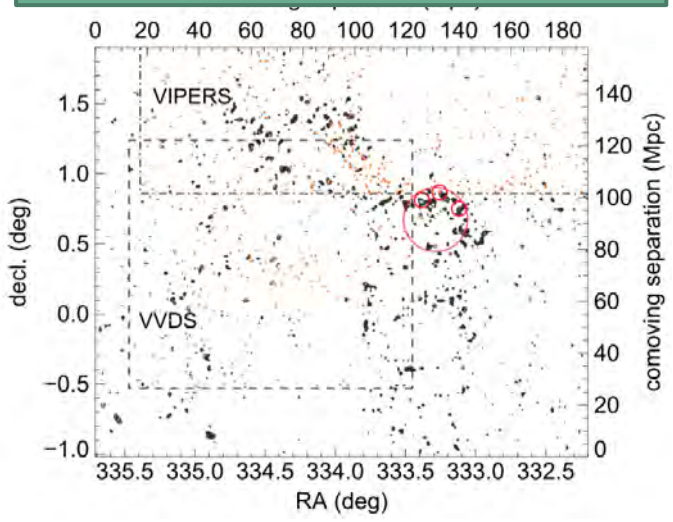
UNDERSTANDING 8GYR HISTORY OF UNIVERSE

Spectroscopic Survey up to z ~ 1



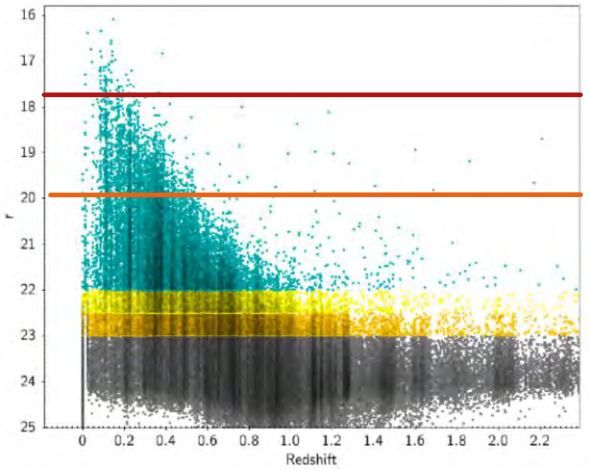
- First complete spectroscopic survey of the Universe of 8Gyr
- Solving the problems of dark matter/energy
- Measuring galaxy clustering without bias
- Studying early universe using quasars at z > 6

Mapping the Universe at 8Gyr ago



- Making the galaxy map at 8Gyr ago
- Discovering new galaxy clusters & large-scale structures
- Studying their evolution during 8Gyr
- Testing cosmic inflation using density field

Current Limitation

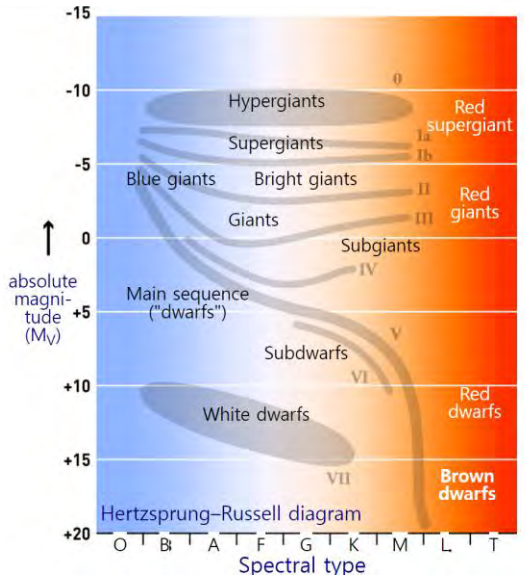


- Limits on telescopes & technology
- Bias due to the color/type selection
- Insufficient for coherent understanding of the Universe

- Needs large optical/NIR spec. survey with large telescopes
- Needs spec. data @ *r*=22-23 (*J*~22)
- 10-23k galaxies per deg^2

Understanding Our Galaxy

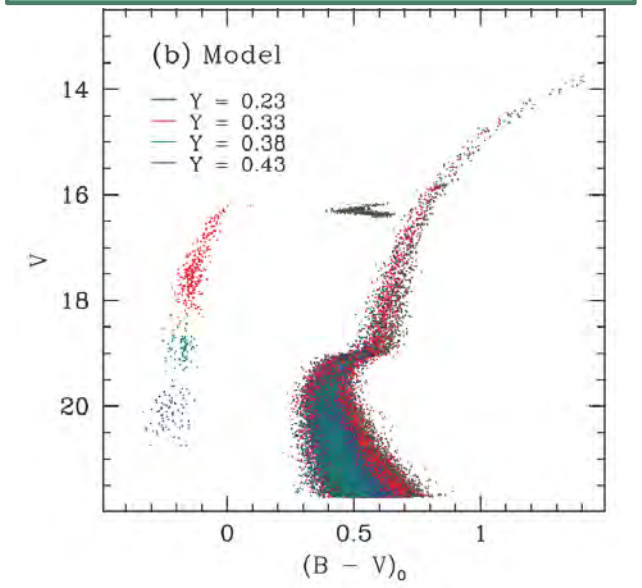
M/L Dwarfs



- Age of Universe & early element abundance
- Formation time of disks & halos
- Low-mass tail of stellar IMF
- Host stars of habitable exoplanets

- Aims M-dwarfs with *r*<22 within 2.5-15 kpc (c.f. LAMOST: *r*<19-20)

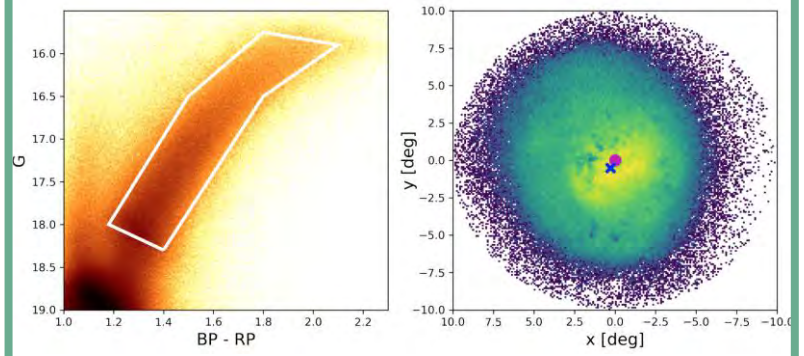
Chemically Peculiar Stars



- He-rich stars
  - Differences on Helium abundance
  - Star formation & chemical abundance

- Metal-poor stars
  - Chemical abundance due to the SNs
  - Stars formed at the early Milky Way

Red Giants at Nearby Galaxies



- Giants at nearby galaxies
  - Kinematic mapping of galaxies
  - Metallicity mapping of galaxies

- Galaxy formation study from galactic structures

- Understanding the formation of Milky Way using the comparison

KLST White Paper: Structure

Main Paper
(authors:
management group/WG leaders/everyone)

I. Introduction
II. Science Cases
  I. Stellar/planetary
  II. Galaxies/clusters
  III. LSS/cosmology
III. Survey Design
  I. Area
  II. Targets
  III. Plan/operation/data processing
IV. Instrument Design
  I. Site
  II. Telescope
  III. Spectrograph
  IV. Positioner
V. Synergies with other facilities
VI. Conclusions

Science WG Main Papers
(authors: WG leader/WG members)

I. Introduction
II. Case I: ##########
III. Case 2: ###########
IV. ...
V. Survey Design
  I. Area
  II. Targets
VI. Synergies with other facilities
VII. Conclusions

Auxiliary Papers/Proposals
(authors: corresponding researchers)

I. Introduction
II. Scientific Justification
III. Method
IV. Expectation

Instrumentation Part Paper
(authors: corresponding researchers)

Similar to SPIE proceedings?

Korean book

Korea Astronomy and Space Science Institute

Science Topics in LSS & Cosmology

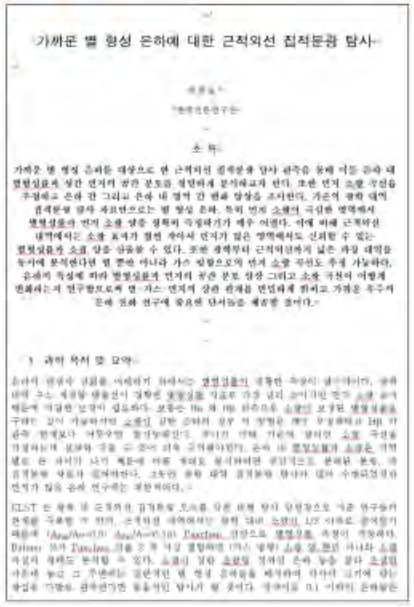

The Hubble Deep Survey and Estimating Summary Statistics for KLST


연결계이론 기반의 우주 구조 분석: KLST를 이용한 초기우주 은하(G선택)연구


Observing the distribution of galaxies in the Redshift Desert with KLST

Korea Astronomy and Space Science Institute

Science Topics in Galaxies & Clusters


가까운 별 형성 은하에 대한 근적외선 집적분광 탐사

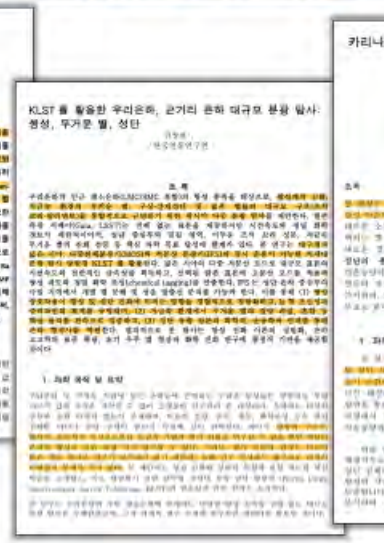

KLST 분광사베이를 통한 은하단내광(ICL)과 은하단 진화 연구

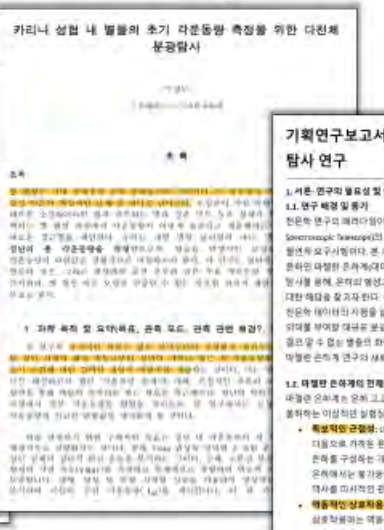

The KLST/IFU Survey of Merging Clusters

Korea Astronomy and Space Science Institute

Science Topics in Stellar Science


은하문라의 천체적 표현 및 로프팅 방법 역사 탐구


KLST를 활용한 우리은하, 근기리 은하 대규모 분광 탐사: 형성, 두꺼운 별, 성단


카리나 성협 내 별들의 초기 각운동량 측정을 위한 다천체 분광탐사

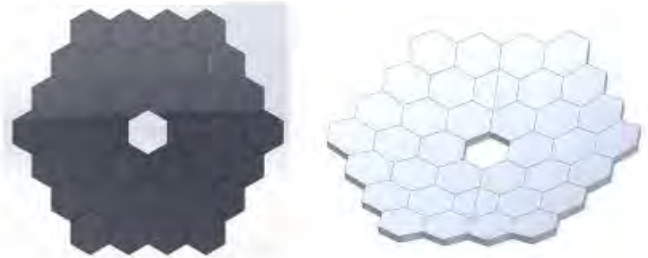

기획연구보고서: KLST 를 활용한 마젤란 은하계 분광 탐사 연구

- Segment diameter 1.8 m ; thickness 75 mm (similar to Keck M1)
  edge gap 2 mm (Keck 3 mm)



Zerodur segment

Drawing of 10 m Segmented Mirror
– Segment e2e: 1.8 m

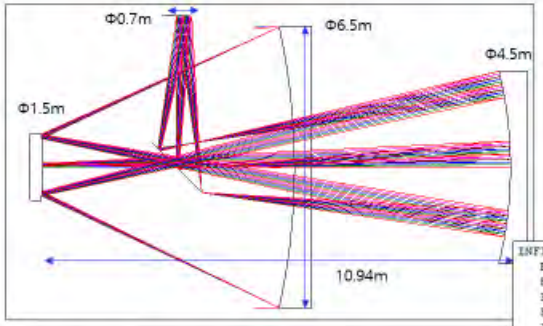


KRISS
한국표준과학연구원

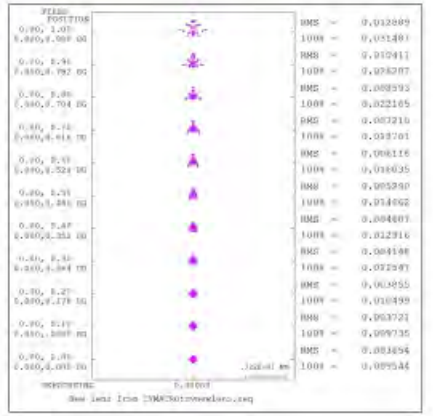
[Concept Design] 광학계 구성안

LeO SPACE Leading edge Optical Solutions

- Korsch type (PM 6.5m)



INFINITE CONJUGATES
EFL -22781.2786
BFL 10.0385
FFL -0.1254E+06
FNO -3.5048
IMG DIS 10.0000
OAL 742.4967
PARAXIAL IMAGE
HT 349.9228
ANG 0.8800
ENTRANCE PUPIL
DIA 6500.0000
THI 0.0000
EXIT PUPIL
DIA 1180.3857
THI -4126.9915



•볼록형상 부경 제작의 어려움
•렌즈 없는 구성으로 가장 좋은 광학 성능 구현

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Domestic Status of Mirror Materials (ZERODUR, SiC)

KOPTI

◆ Zerodur Materials

- Name: Development of **LAS-based extremely low expansion glass-ceramic** for extreme ultraviolet mirrors (Project of the Ministry of Commerce and Industry)
- Period: July 2024 to December 2028 (4 years and 6 months)
- Organization: **HASS**

	2024	2025	2026	2027	2028
Purpose	Basic Experiment	Φ100mm x 60T	Φ300mm x 60T	Φ500mm x 60T	Φ500mm x 110T

◆ SiC materials

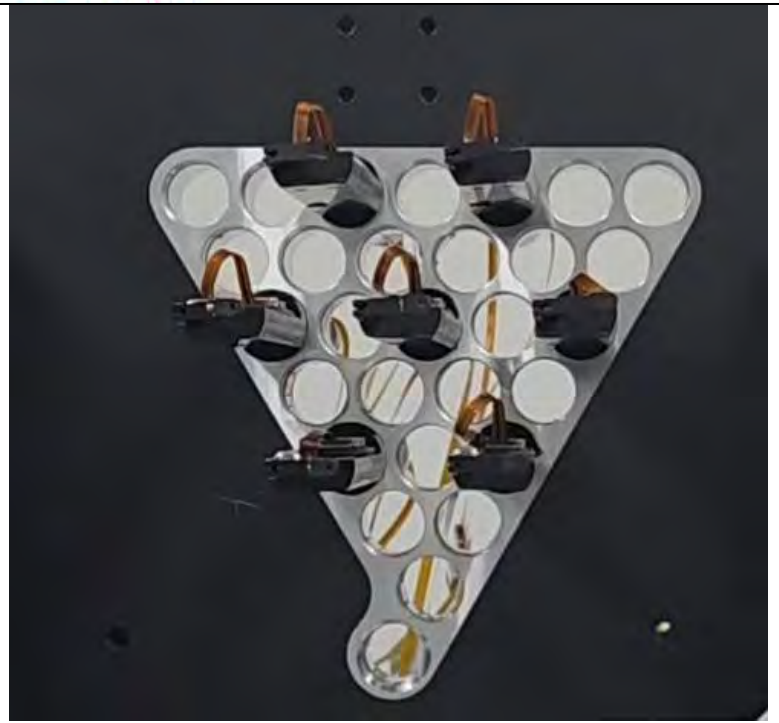
- Company Name: **Orange Materials Co., Ltd**
- Possessing Technology: **Reaction sintering SiC mirror and structure** fabrication technology, **SiC welding** technology



[Orange Materials]

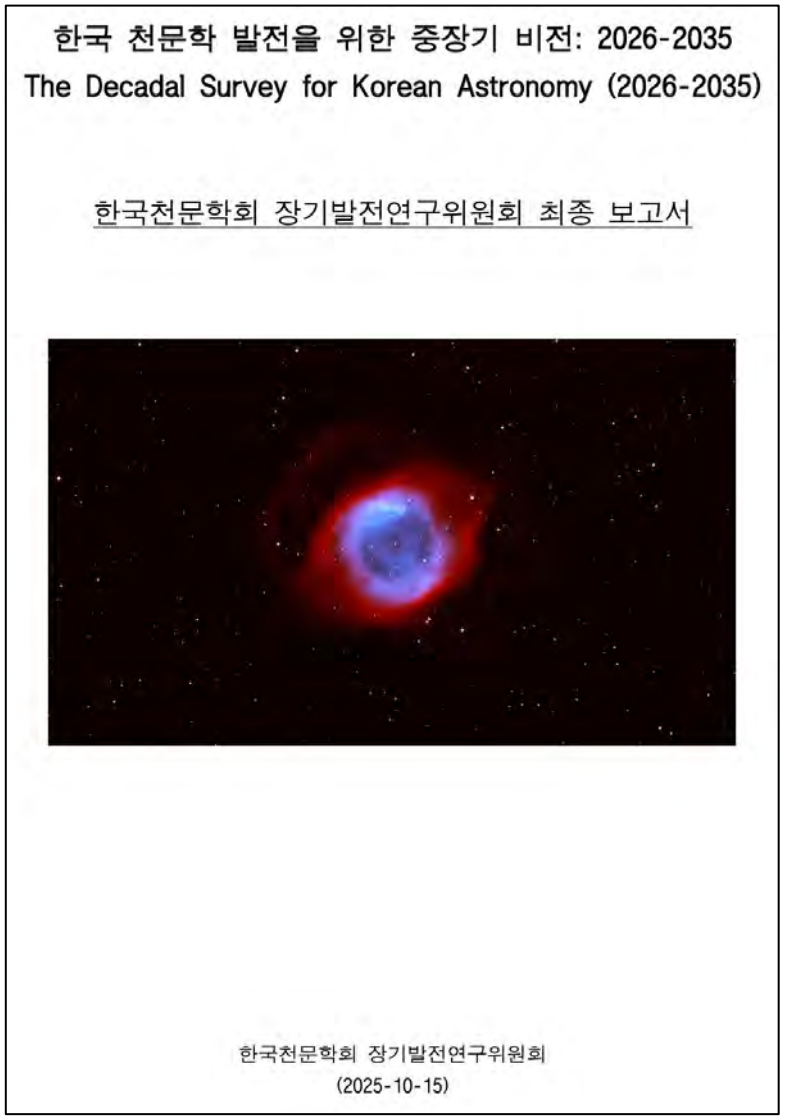
- **Up to 1,200mm, weldable into larger mirror**
- 300mm diameter : Manufacturing for Defense

Optical Lens Material Research Center



아주대학교 AJOU UNIVERSITY 1973

Top Priority: The Decadal Survey for Korean Astronomy 2026-2035



7.2. P1 (Top Priority)

Selection Criteria:
A research facility capable of conducting innovative scientific missions that lead global advancements in technology. It must have full support from the academic community and be expected to generate significant ripple effects and high utility.

A. Future Facility

1. 6.5m-Class Optical Spectroscopic Telescope:
This project envisions either two 6.5-meter-class telescopes or a spectroscopic-dedicated telescope with equivalent light-gathering power, aimed at conducting spectroscopic research of the southern sky. It is a versatile instrument applicable across all fields of astronomy, including extragalactic and cosmological studies. With a target operational date of 2035, the facility is expected to lead spectroscopic research of the southern sky.
Backed by a strong domestic research community focused on galaxies and galaxy clusters, this ambitious project aims to cover all stages of research: telescope construction, spectrograph development, data acquisition, and scientific analysis. It is anticipated to yield diverse ripple effects, including the acquisition of technical expertise, training of research personnel, and enhancement of research competitiveness.

Plan for Feasibility Study ('24-26)

- Scientific topics
  - **Key topics ('24)**
  - **Detailed studies (late '24-early '25)**
  - White papers & international workshops (~ mid '26)
- Concept on instruments & facilities
  - **Key requirements & concept ('24)**
  - **Detailed studies (late '24-early '25)**
  - **Observatory candidates studies ('25)**
  - Technology system diagram/planning ('25)
- Planning
  - Risks & resolutions ('25)
  - Roadmap, budget, operation strategy ('25)
- Writing reports for the next step (late '25)

→ **Apply for funding from the Korea Aerospace Administration**







