

FEASIBILITY STUDY FOR THE NEXT-GENERATION SPECTROSCOPIC SURVEY WITH DEDICATED LARGE TELESCOPES

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SURVEY SCIENCE GROUP WORKSHOP 2024 @ HIGH1 RESORT, JANUARY 30TH, 2024

SPECTROSCOPIC SURVEY: CURRENT AND NEAR-FUTURE STATUS

- ▶ Korean community has participated in several international spectroscopy programs (SDSS & DESI).
- ▶ We also have access to spectrographs in current and future large & extremely large telescopes such as Gemini (8.1m) and GMT (24.5m).
- ▶ **We have been involved with various large programs, maybe its time to lead!**

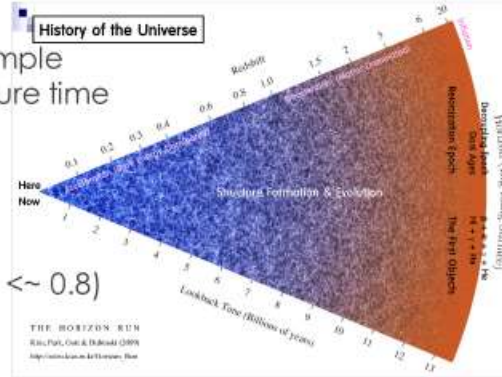
6.5M-CLASS SPECTROSCOPIC SURVEY?

► Why 6.5m-class?

- To get scientifically meaningful spectrum sample at Hubble distance ($z \sim 1$) with 1-hour exposure time

► Why Flux-limited Survey?

- To maximize the sample density at the limited dark energy-dominated era ($z \ll 0.8$)
- To study various astrophysical phenomena other than just dark energy



In 2006/2007...

@ SSG 2023

SPM-TWIN TELESCOPES: PROJECT OVERVIEW

J. Jesús González¹ and The SPM-Twin Project Team



GENERAL SPM-TWIN INSTRUMENT CONCEPT	
Wide-Field Telescope (WFT) (Modified Magellan/MMT)	Standard Field Telescope (SFT) (Updated Magellan/MMT)
Optimized for: Wide-coverage/Field Spectroscopy	Multi-purpose Survey-based/Visible-IR Astronomy and AO research
Field of view: $\theta \geq \sim 1.5^\circ$	$\theta \sim 1.5^\circ$ (seeing limited) $\theta \sim 1^\circ$ (AO)
Operation Range: Visible to NIR (0.3-1.6 μ m)	Visible to MIR (0.4 - 8 μ m) (Short)
Spatial Resolution: Seeing-limited (Narrow-band imaging) $\sim 2'' - 3''$ (Spatially limited sampling) (Integral-Field Spectroscopy)	Seeing-limited (current mode) Diffraction limited (AO mode)
Spectral Resolution: ~ 4000 (IF Spectroscopy) $\leq \sim 1000$ (Visible-NIR Imaging)	Wide range (active instrumented mode)
1 st Generation Instrumentation: <ul style="list-style-type: none"> a) Wide-Field & Atmospheric Dispersion Corrector system b) Deployable equipment and integral Field units, coupled to a set of spectrographs, for simultaneous 3rd-range spectra of thousands of objects c) Wide-Field Imager (Visible-Narrow Band) 	<ul style="list-style-type: none"> a) Secondary set (Star/Cam/AO) b) High-Resolution Visible & Near-Infrared Spectrographs c) NIR/AD Science Instrument d) M4 IR Non-Generation Instrument Ready to accommodate: <ul style="list-style-type: none"> (1) Artificial Star System & Adaptive secondary mirror (2) Giant & Redclad Instruments

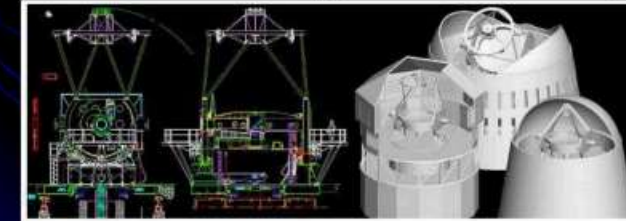


Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

PAST, PRESENT, AND NEAR-FUTURE

Dec 2019	<ul style="list-style-type: none"> Initial discussion started
Jan-Sep 2020	<ul style="list-style-type: none"> Discuss on main survey Start writing a brief white paper
Aug-Oct 2020	<ul style="list-style-type: none"> KASI preliminary study proposal: <i>Pre-Study for a Large Korean Spectroscopic Telescope</i> (PI: Arman Shafieloo)
Jul 2022 - Now	<ul style="list-style-type: none"> Discussion resumed



중립적이며 사색적

Pre-Study for Large Korean Spectroscopic Telescope

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

PAST, PRESENT, AND NEAR-FUTURE

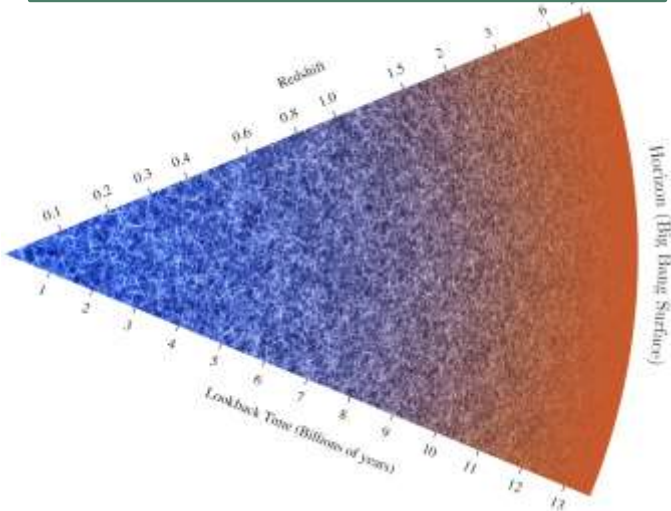
Mar-May 2023	<ul style="list-style-type: none"> Apply for KASI Qrontier
Jul-Dec 2023 (If Qrontier selected)	<ul style="list-style-type: none"> Write Qrontier Preliminary Report Form domestic/international committee
2024-2026 (If Qrontier selected)	<ul style="list-style-type: none"> Detailed study with committee Surveys to collect community requests from KAS (& KSSS) Write the Qrontier Final Report as an input for the next step Consider joining other next-gen international survey projects



WHAT KOREAN COMMUNITY WANTS:

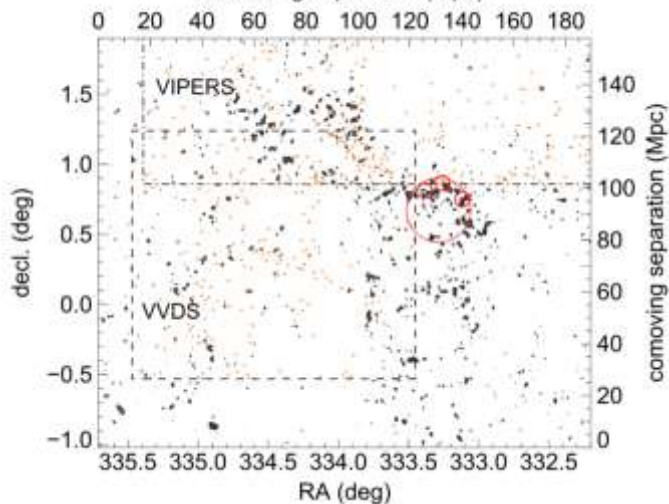
1. UNDERSTANDING 8GYR HISTORY OF THE UNIVERSE

Spectroscopic Survey up to $z \sim 1$



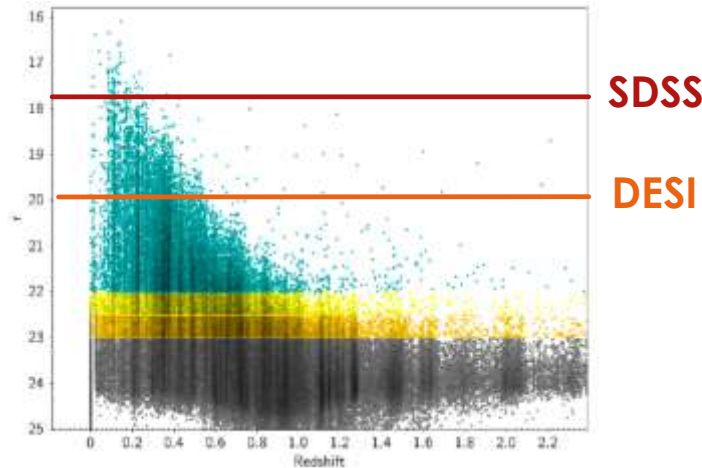
- First complete spectroscopic survey of the Universe of 8Gyr
- Solving the problems of dark matter/energy
- Measuring galaxy clustering without bias
- Studying early universe using quasars at $z > 6$

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

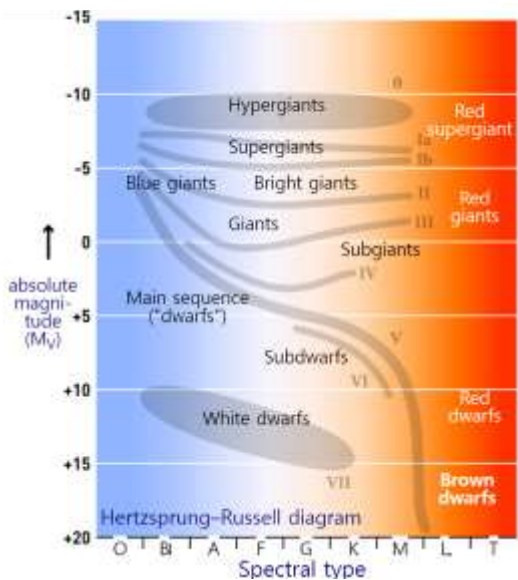


- Limits on telescopes & technology
- Bias due to the color/type selection
- Insufficient for coherent understanding of the Universe
- Needs large optical/NIR spec. survey with large telescopes
- Needs spec. data @ $r=22-23$ ($J \sim 22$)
- 10-23k galaxies per deg^2

WHAT KOREAN COMMUNITY WANTS:

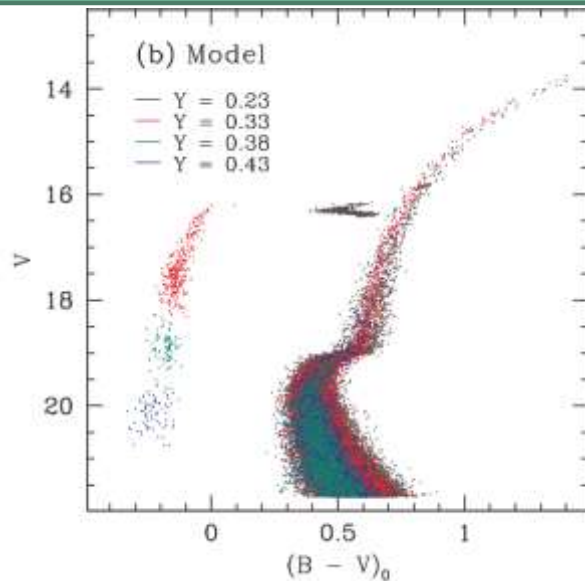
2. UNDERSTANDING OUR GALAXY

M/L Dwarfs



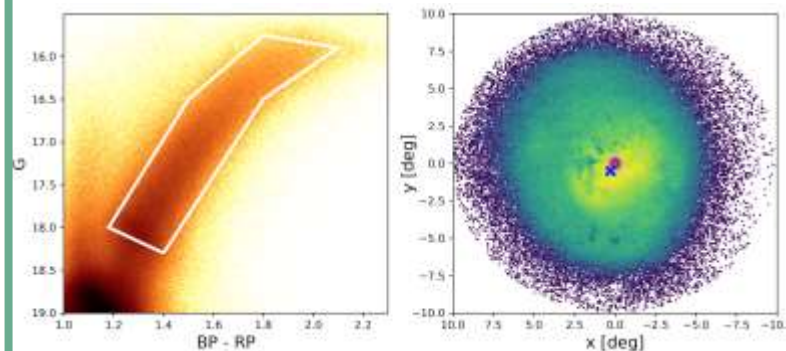
- Age of Universe & early element abundance
- Formation time of disks & halos
- Low-mass tail of stellar IMF
- Host stars of habitable exoplanets
- Aims M-dwarfs with $r < 22$ within 2.5-15 kpc (c.f. LAMOST: $r < 19-20$)

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

Large Telescope

Wide-field MOS

Optical/NIR

Flux-limited

Southern Hemisphere

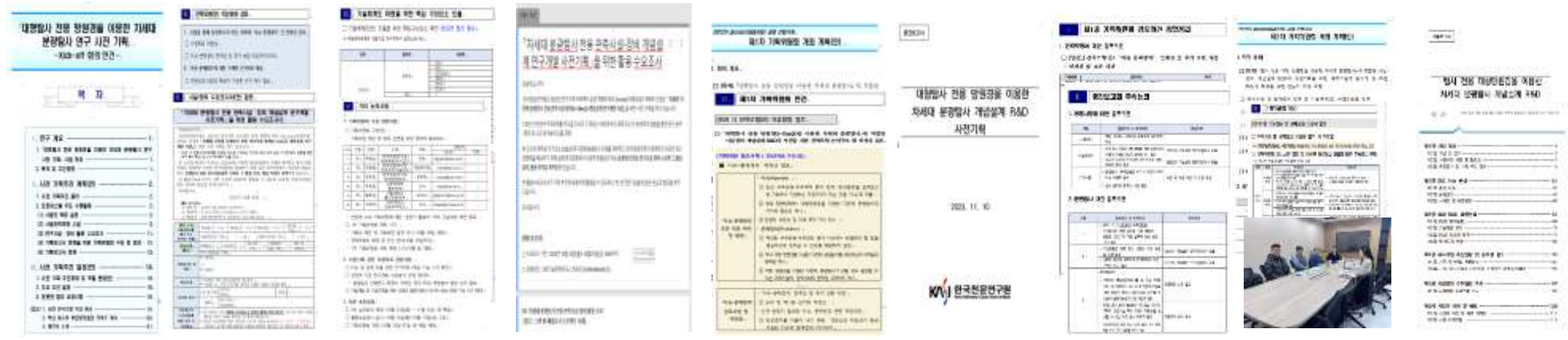
Surveying objects with $r \sim 22$ without bias
(1hr-exposure, $R \sim 2,000$)

1. Measuring spectra of stars within Milky Way up to $r \sim 22$
2. 3D mapping of $\sim 100M$ extragalaxies up to past 8Gyr
3. Unexpected discoveries!!!

- Originality compared to other planned surveys
- Synergies with Korean community-associated facilities (GMT, Gemini, VRO)

1. 추진 경과

기획위원회 3회, 실무회의 4회, KASI 연구진 중간점검 1회
 총 8회 전문가 회의와 시설장비 활용 수요조사를 실시하여
 「탐사 전용 대형 망원경을 이용한 차세대 분광탐사 개념설계 R&D」 사전기획 보고서를 마련



「차세대 분광탐사 전용 관측시설·장비 개념설계 연구개발 사전기획」을 위한 활용 수요조사

안녕하십니까?

한국천문연구원은 2023년 연구기획 프로젝트 운영 계획에 따라 Qrontier(미래유망)* 과제로 선정된 「차세대 다천체 분광탐사 전용 관측시설·장비(6~15m급) 개념설계 연구개발 사업」을 위한 사전 기획을 하고 있습니다.

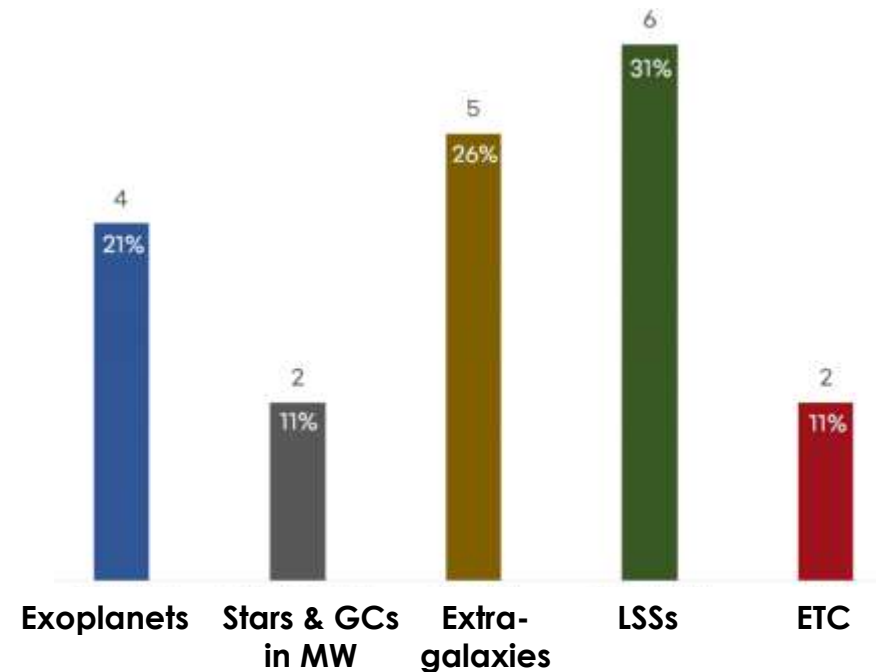
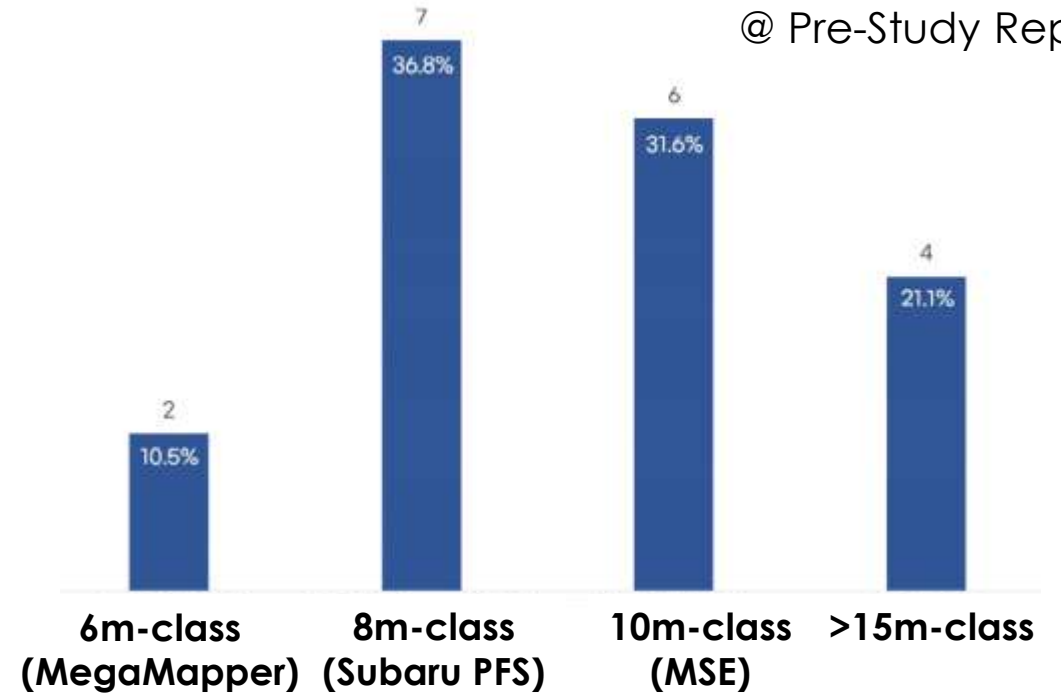
* 30년 내 천문우주과학계를 주도할 것으로 기대되는 차세대 유망 과제 또는 타 분야와의 융합을 통한 연구 분야 확장 및 신규 연구분야 도출 과제

본 조사의 목적은 다가오는 2030년대 다천체 분광탐사 시대를 대비하고 한국 천문학계가 세계적인 수준의 연구경쟁력을 확보하기 위해 실제 연구현장에서 시급하게 필요로 하는 분광탐사 전용 연구시설·장비 수요와 그 활용 분야, 활용 목적을 파악함에 있습니다.

본 활용수요조사서가 기획 추진에 유용하게 활용될 수 있도록 산,학,연 전문가님들의 많은 관심과 협조를 부탁드립니다.

감사합니다.

@ Pre-Study Report



Initial survey to KAS members

- Oct. 18-31, 2023 (after KAS fall meeting)
- 19 answers

→ Will be renewed early 2024!



분류	중분류	세분류
망원경	요구조건 분석기술	요구조건 분석 기술
	광학설계 및 해석기술	광학설계 및 해석 기술
		산란광 해석 기술
		적응과학 측정 및 제작
		농동과학 측정 및 제작
	광학제작 기술	광학가공 기술
		증착 및 측정 기술
		광기계 가공 기술
		광학시험
	기계부 설계 및 제작 기술	광학계 및 기계부 조립
		광기계 설계
		광기계 해석
		마운트 설계
		광기계 조립
		치구제작
		마운트 가공
		마운트 조립
		안전장치 설계 및 제작
구동 장치 설계 및 해석		
돔	돔설계	
관측영향 요소 분석기술 (관측부지)	관측영향 요소 분석기술	
소프트웨어	망원경 제어 프로그램	

분류	중분류	세분류
가시광/적외선 분광기	요구조건 분석기술	요구조건 분석
	광학설계 및 해석 기술	광학설계 및 해석
		산란광 해석
	광학제작기술	광학가공
		증착 및 측정
		광기계 가공
		광학시험
	기계부	광학계 및 기계부 조립
		광기계 설계
	검출기	검출기
소프트웨어		분광기 제어 프로그램
다천체 분광관측 시스템	요구조건	요구조건 분석
	다천체 분광관측 기술	초점면 기기
		초점면 모니터링 시스템
	광섬유 케이블	광섬유 케이블
		전단 광학계
	기계부	구동부 설계
마운트 설계		
소프트웨어	광섬유 위치기 제어 프로그램	
	자료 보관 및 처리	자료 보관 및 처리

- ### Science WG

 - 핵심 과학연구 주제 논의
 - 각 연구주제에 대한 연구목표 논의
 - 학계 의견 수렴을 통한 연구목표 구체화
 - 다른 거대탐사 프로젝트와의 시너지 연구
 - 연구 목표 달성을 위한 요구사항 도출

Instrument WG

 - 기기 디자인 조사
 - 국내외 연구기관/업체의 기술개발/협력 가능성 조사
 - 개념설계 및 예산 규모 산출

Telescope WG

 - 망원경 디자인 조사
 - 국내외 연구기관/업체의 기술개발/협력 가능성 조사
 - 망원경 건설 후보지 및 협력 가능 기관 조사
 - 개념설계 및 예산 규모 산출

PLAN FOR FEASIBILITY STUDY ('24-26)

- ▶ Scientific topics
 - ▶ **Key topics confirmation (early '24)**
 - ▶ **Detailed studies on key(+alpha) topics (late '24-early '25)**
- ▶ Concept on instruments & facilities
 - ▶ **Requirements & concept confirmation ('24)**
 - ▶ Technology system diagram & planning ('25)
 - ▶ Observatory candidates studies ('25)
- ▶ Planning
 - ▶ **Relation with other planned international surveys ('24-early '25)**
 - ▶ Risks & resolutions ('25)
 - ▶ Roadmap, budget & operation strategy ('25-early '26)
- ▶ Writing reports for the next step ('26)

**Kick-off Meeting
2:30 PM Today!**