(Pre-)Pre-Study for Korean Large Spectroscopy Telescope

Sungwook E. Hong, Arman Shafieloo, Jae-Woo Kim (KASI),
Ho Seong Hwang (SNU) & Changbom Park (KIAS)

Survey Science Group Workshop 2023, January 18th, 2023

Astronomy & Astrophysics in 2020s

- Arrival of 4th generation of telescopes and surveys including large telescopes (DESI, LSST, GMT, WFIRST, TMT, etc.)
- Going high resolution: Shifting from imaging to spectroscopy

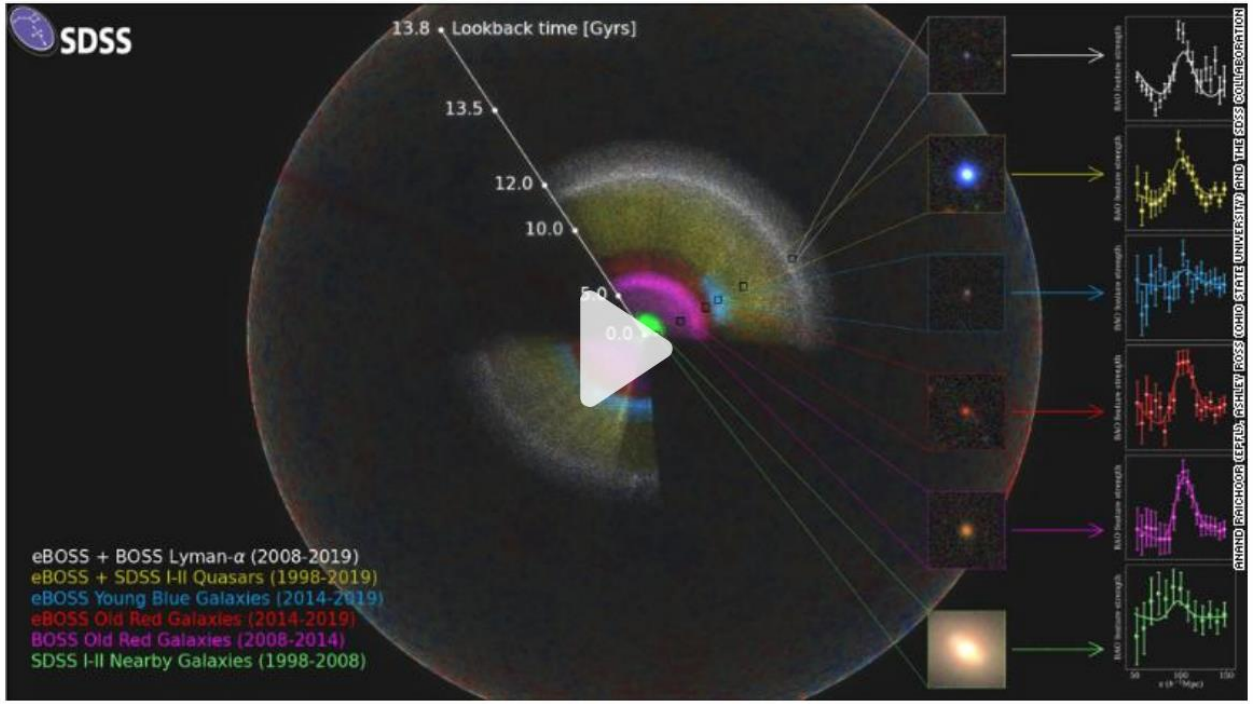
Seeking an opportunity to lead in wide-deep field multi-object spectroscopy (5th generation)

Current and Near-Future Status

- 2000s-2010s
  - Multi-object spectroscopy on the 2m-class telescopes
  - Example: SDSS with a 2.5 meter size telescope
- 2020s
  - Large-scale spectral surveys with the 3~4m-level telescopes
  - Example: DESI with a 4 meter telescope and 5000 fibers

11 billion years of history in one map: Astrophysicists reveal largest 3D model of the universe ever created


By Joshua Berlinger and Jessie Yeung, CNN
Updated 1748 GMT (0148 HKT) July 22, 2020



See a 3D model of the universe 01:17

(CNN) — A global consortium of astrophysicists have created the world's largest three-dimensional map of the universe, a project 20 years in the making that researchers say helps better explain the history of the cosmos.

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!**

In 2006/2007…

RevMexAA (Serie de Conferencias), **28**, 39–48 (2007)

SPM-TWIN TELESCOPES: PROJECT OVERVIEW

J. Jesús González[1] and The SPM-Twin Project Team

TABLE 1

GENERAL SPM-TWIN INSTRUMENT CONCEPT

	Wide-Field Telescope (WFT) (Modified Magellan/MMT)	Standard Field Telescope (SFT) (Updated Magellan/MMT)
Optimized for:	Wide-Integral-Field Spectroscopy	Multi-purpose Seeing-limited Visible-IR Astronomy and AO prepared
Field of view:	$\Phi \geq \sim 1.5°$	$\Phi \sim 1.5'$ (seeing limited) $\Phi \sim 1'$ (with AO)
Operation Range:	Visible to NIR (0.32–1.8μm)	Visible to Mid-IR ($\sim 0.4 - 28\mu$m)
Spatial Resolutions	Seeing-limited (Narrow-Band imaging) $\sim 1'' - 3''$ Spaxel-limited sampling (Integral-Field Spectroscopy)	Seeing-limited (normal mode) Diffraction limited (AO mode)
Spectral Resolutions	$\sim$ 4000 (IF Spectroscopy) $\leq \sim$ 1000 (Tunable N-B imaging)	Wide range (science instrument suite)
1st Generation Instrumentation	a) Wide-Field & Atmospheric Dispersion Corrector system b) Deployable single-spaxel and Integral-Field units, coupled to a suit of spectro-graphs, for simultaneous full-range spectra spectra of thousands of objects c) Wide-Field Imager (Tunable Narrow-Band)	a) Secondary set (Nass/Cass/AO) b) High-Resolution Visible & Near-Infrared Spectrographs c) NIR/AO Science Instrument d) Mid-IR New-Generation Instrument Ready to accommodate: (i) Artificial-Star System & Adaptive secondary mirror (ii) Guest & Replicated Instruments

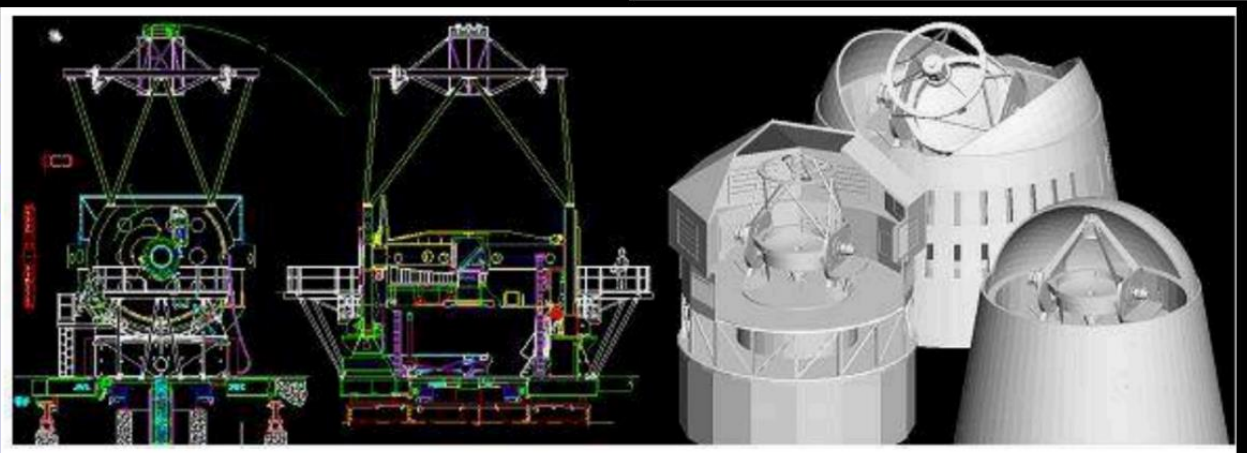
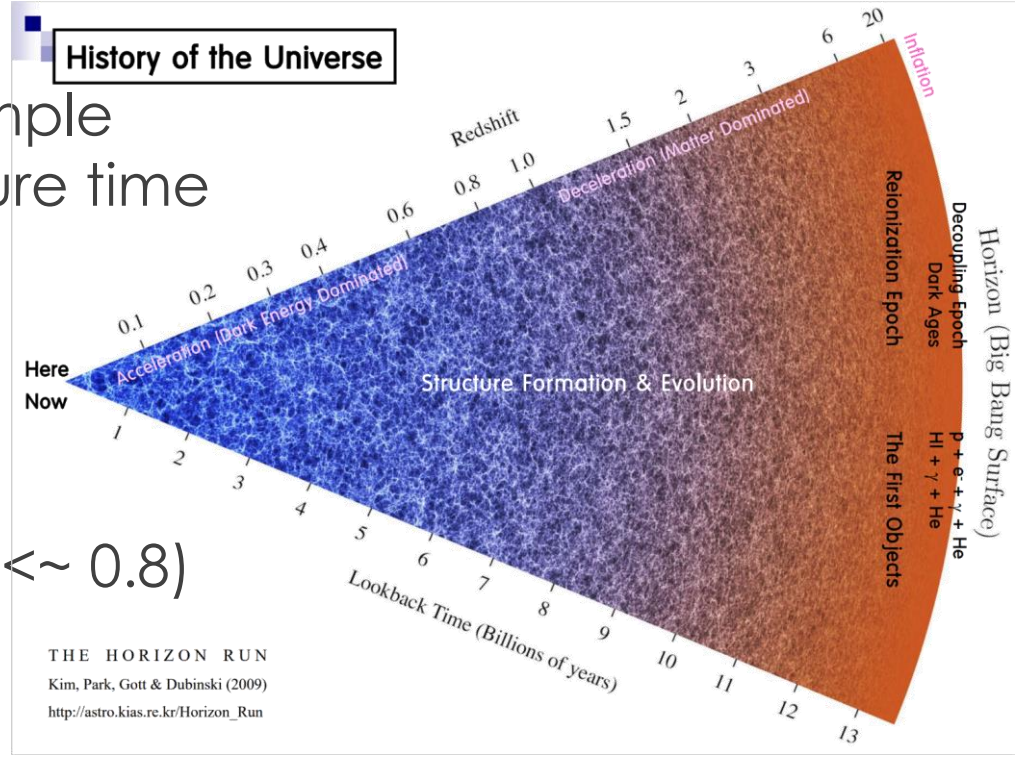


Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

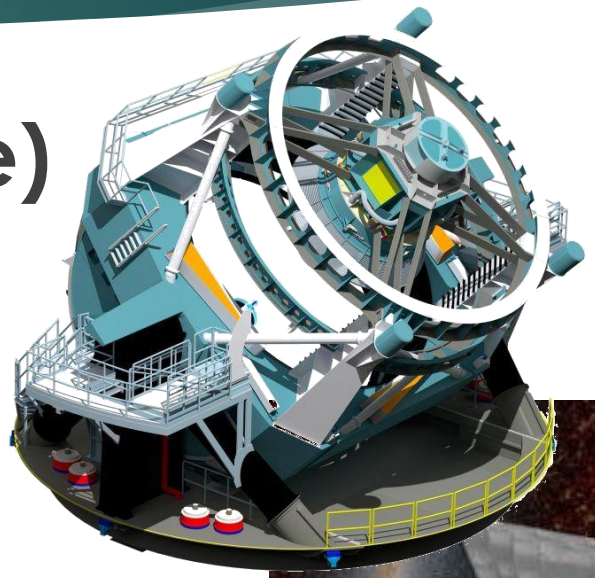
6.5m-class Spectroscopic Survey?

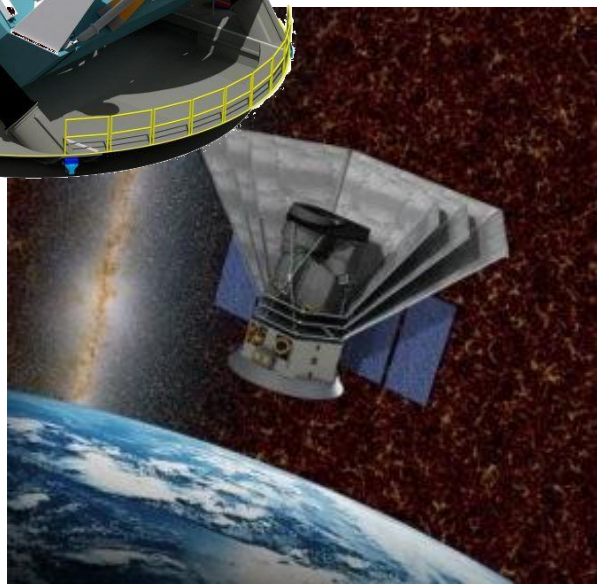
- **Why 6.5m-class?**
  - To get scientifically meaningful spectrum sample at Hubble distance (z ~ 1) with 1-hour exposure time
- **Why Flux-limited Survey?**
  - To maximize the sample density at the limited dark energy-dominated era (z <~ 0.8)
  - To study various astrophysical phenomena other than just dark energy



6.5m-class Spectroscopic Survey?

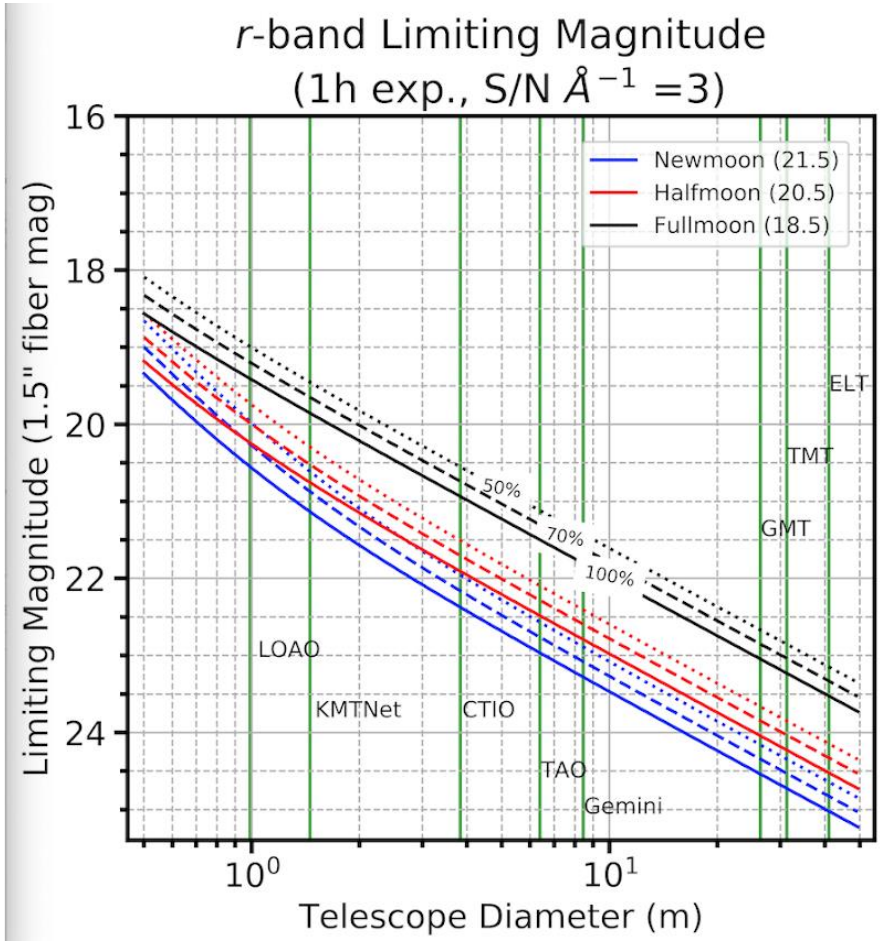
- **Synergy with other surveys (example)**
  - Full follow-up spectroscopic observations of LSST
  - Complementary of SPHEREx with higher spatial/spectral resolutions & different wavelength





Survey Specification (Tentative)

Name	Limiting mag.	Exposure	Goal (S/N)	Fiber Size	Spectral Resolution
SDSS/Main SDSS/BOSS (2.5m)	r_Pet=17.77 r_cModel<19.5 (LOWZ) i_cModel<19.9 (CMASS)	45 min 90 min	10 per Ang. S/N_i^2>20	3" 2"	~1800 ~1500-2200
DESI/BGS (4m)	r_(Mod)=19.5	10 min	- minimum S/N(~3?)	1.5"	2000-5000
MSE (10m)	i<23 (where r-i=0-1)	60 min	Not yet?	1"	2000-3500, 6000, 40000
This Study (6.5m)	r_Petro~21.5 => ~22 (if S/N~3 per spectral resolution) **Fully flux-limited data**	60 min	S/N~3 per Ang.	1.5"	1000-2000?



Survey Specification (Tentative)

Telescope (Project name)	Primary Mirror Diameter	Maximum Instrumental FoV	Etendue (AΩ [m^2 deg^2])
Mayall (DESI)	4m	3.2 deg.	101
Blanco	4m	2.2 deg.	47.8
VISTA (4MOST)	4.1m	2.6 deg.	70.1
WHT (WEAVE)	4.2m	2 deg.	43.5
MMT	6.5m	1 deg.	26.1
MegaMapper	6.5m	3 deg.	235
Subaru (HSC)	8.2m	1.5 deg.	93.3
Rubin Obs. (LSST)	8.4m	3.5 deg.	533
MSE	11.3m	1.5 deg.	177

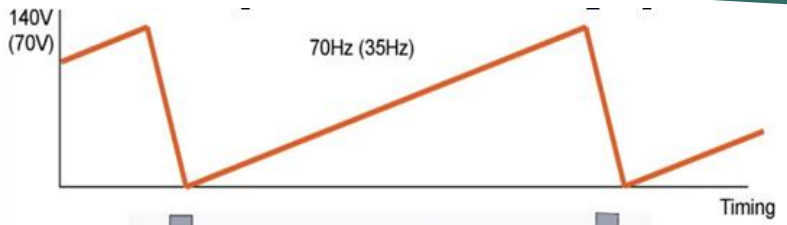
Survey Coverage (deg^2)
3,000 (shallow) + 300 (deep)

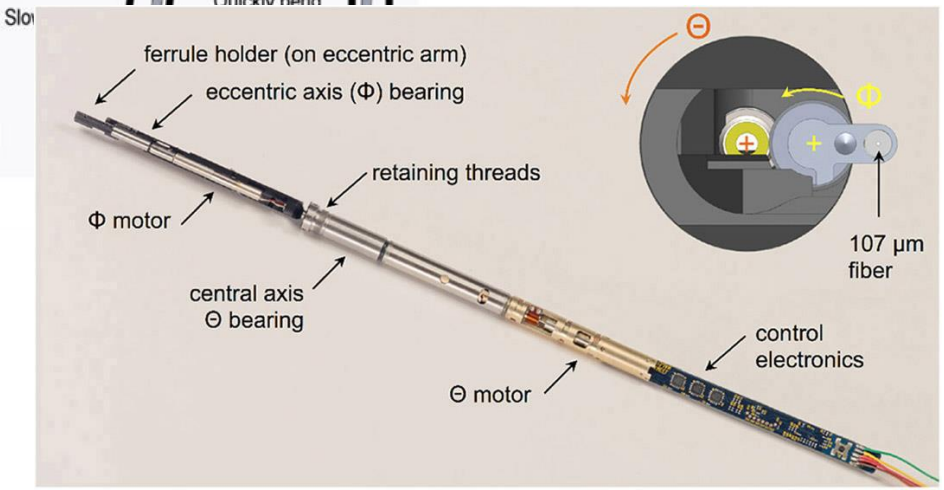
FoV Diameter (deg.)
~2 (min.) / ~3 (goal)

Max. Multiplex
~10,000 (min.) / ~70,000 (goal)

Spectral Resolution
R ~ 2,000 (Δv ~ 30-40 km/s)

Multiplex Specification (Tentative)





Robotic Fiber Positioner

- Mean separation: ~4.6 mm
- Positional accuracy: <~ 10 um
- Possible options
  - Echidna (FMOS)
  - Theta-phi (DESI, A-SPEC)

Fiber Core Diameter: 75 um

Budget (Initial Guess)

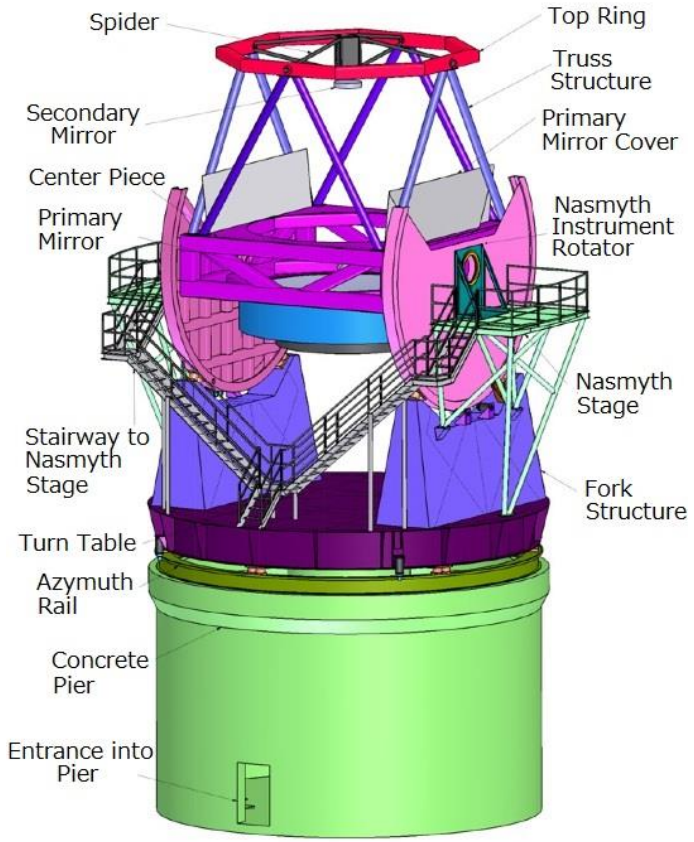
Item	Budget (USD)
Telescope	>> 70M
Secondary Mirror	> 10M
Wide-field Corrector	> 20M
Focal Plate	> 20M
Fiber Positioner System	> 5M
Spectrograph	> 20-50M

Outdated
Not Fully Studied
(Probably Highly)
Underestimated

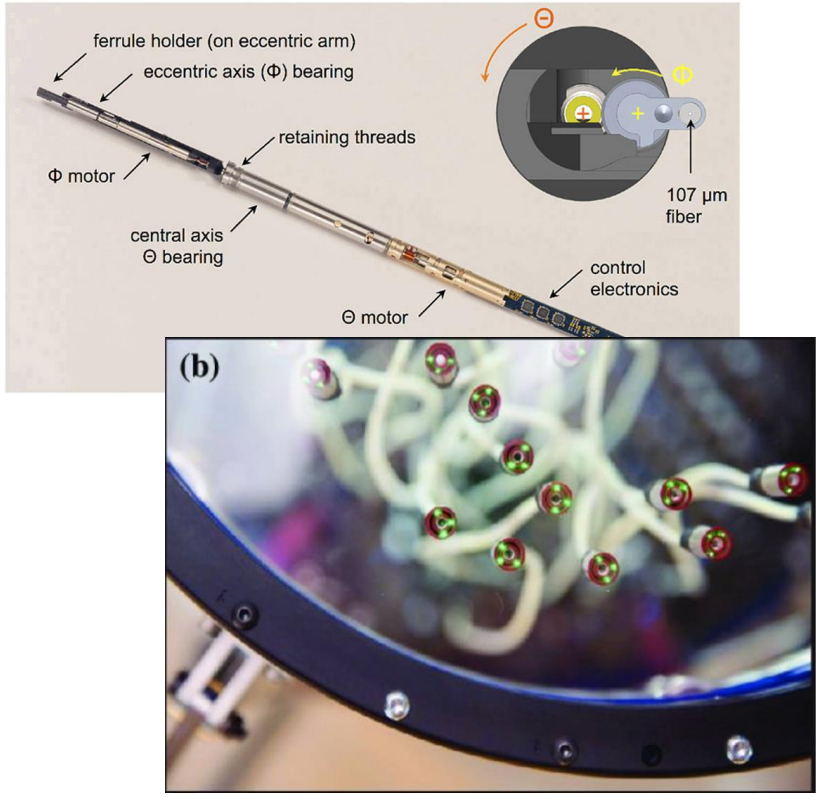
No single ordinary project can afford this!

- Need to convince **government**
- Need **community** input & support

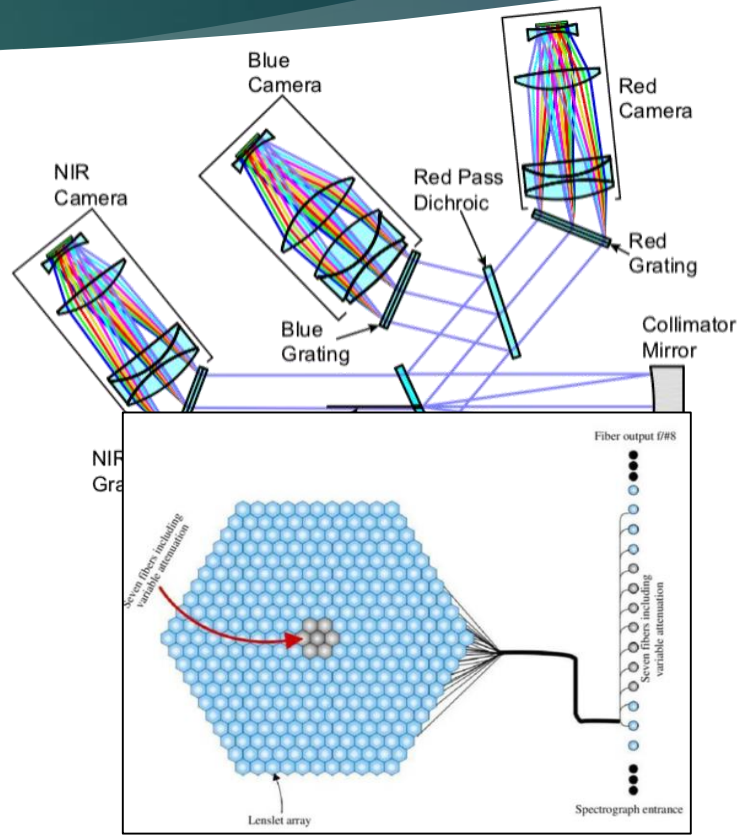
What to Determine?



Telescopes & Optics?



Robotic Positioner?



Spectroscopy Mode? (Visiting Instruments?)

Past, Present, and *Near*-Future

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 - Now	• Discussion resumed





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 탐사와 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. 지난
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 만을 또는 특정 부류의 천체
그리고 우주 멀리까지 모든 천체들을 분광 관측하기에는 가동
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

PAST, PRESENT, AND *NEAR*-FUTURE

Mar-May 2023	• Apply for KASI Qrontier
Jul-Dec 2023 *(If Qrontier selected)*	• *Write Qrontier Preliminary Report* • *Form domestic/international committee*
2024-2026 *(If Qrontier selected)*	• *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