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

SUNGWOOK E. HONG (KASI) ON BEHALF OF KLST TEAM

11TH KIAS WORKSHOP @ GYEONGJU, NOVEMBER 1ST, 2024

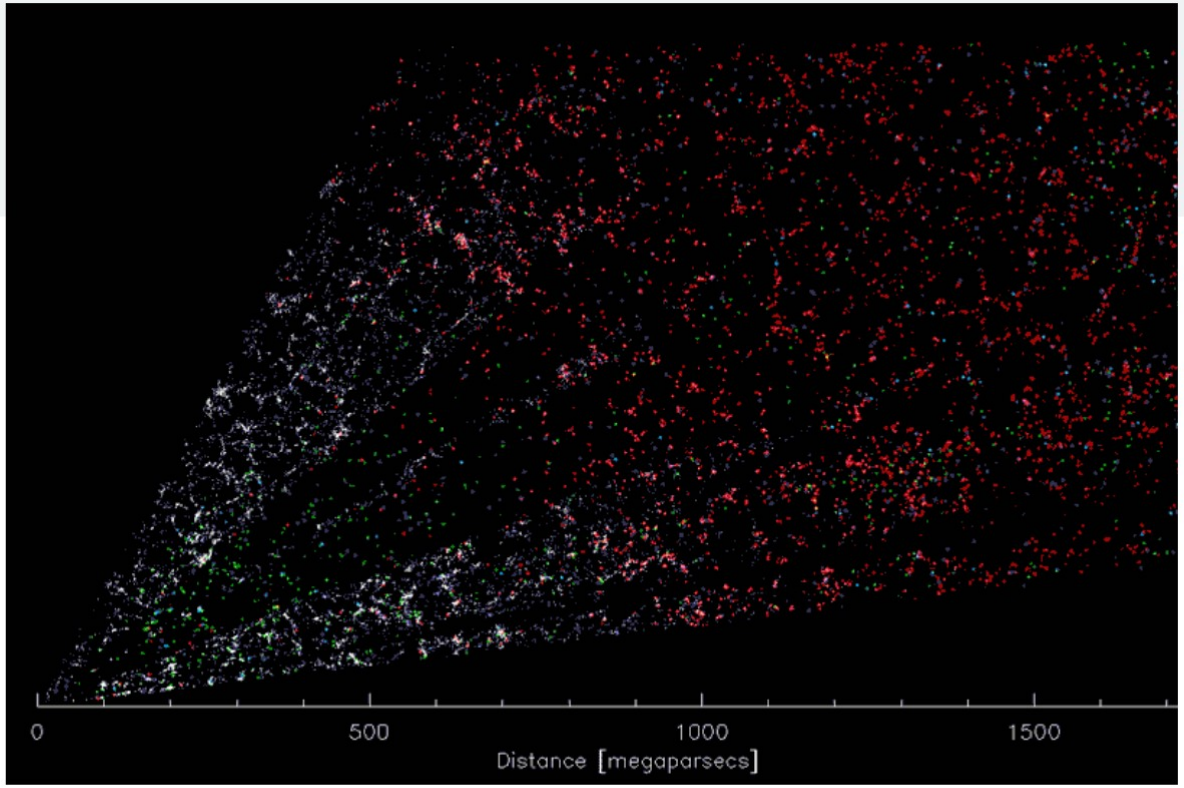
ARTICLE • COSMIC FRONTIERS

Dark Energy Spectroscopic Instrument (DESI) Creates Largest 3D Map of the Cosmos

By **Adam Becker**
January 13, 2022

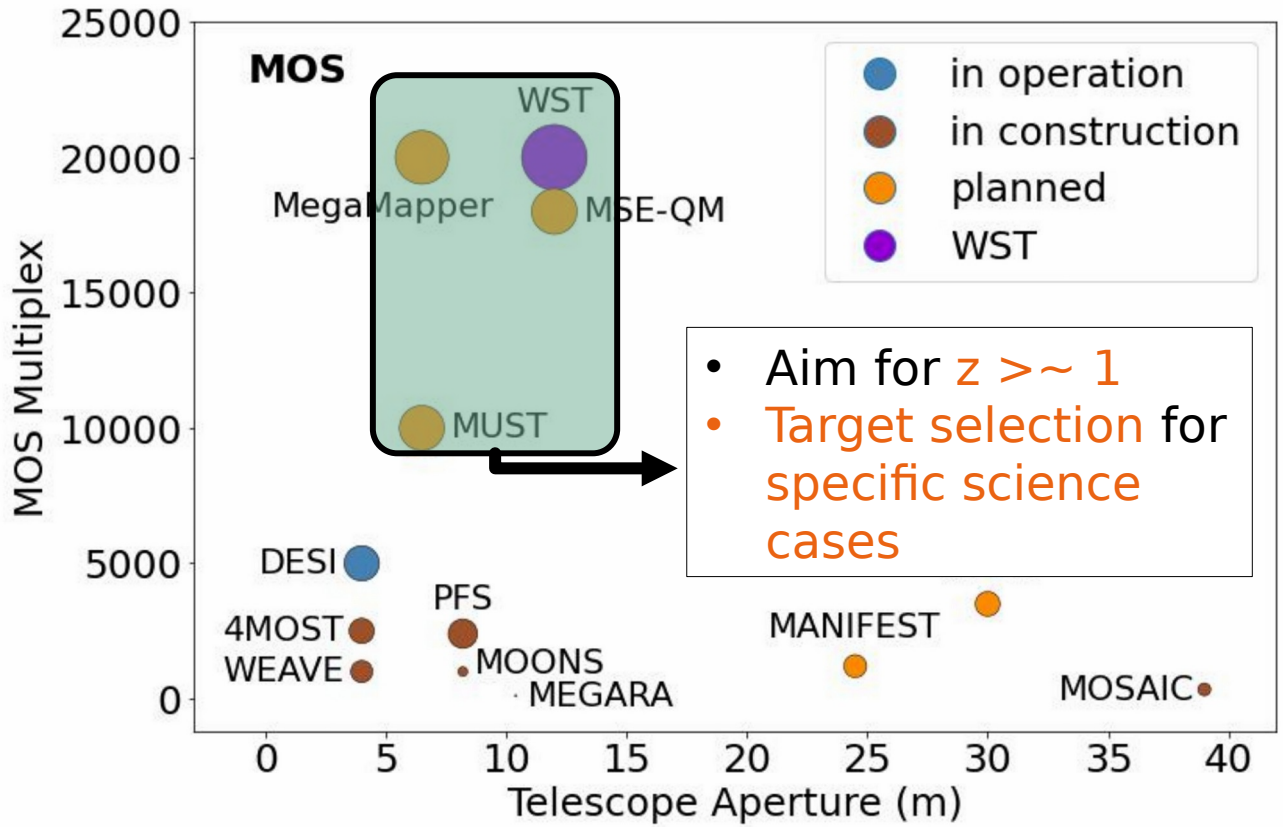
DESI has already mapped out more galaxies than all previous 3D surveys combined — and it's just getting started

MEDIA CONTACT



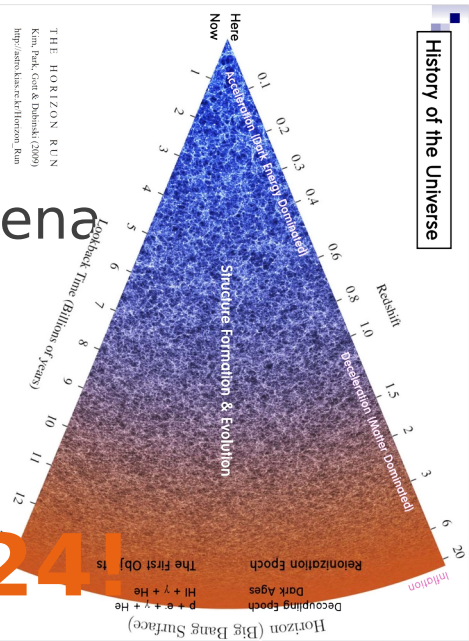
DESI's three-dimensional "CT scan" of the Universe. (Credit: D. Schlegel/Berkeley Lab using data from DESI) D. Schlegel/Berkeley Lab using data from DESI

NEXT-GEN SPECTRO-SCOPIC SURVEYS



Flux-limited Surveys?

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



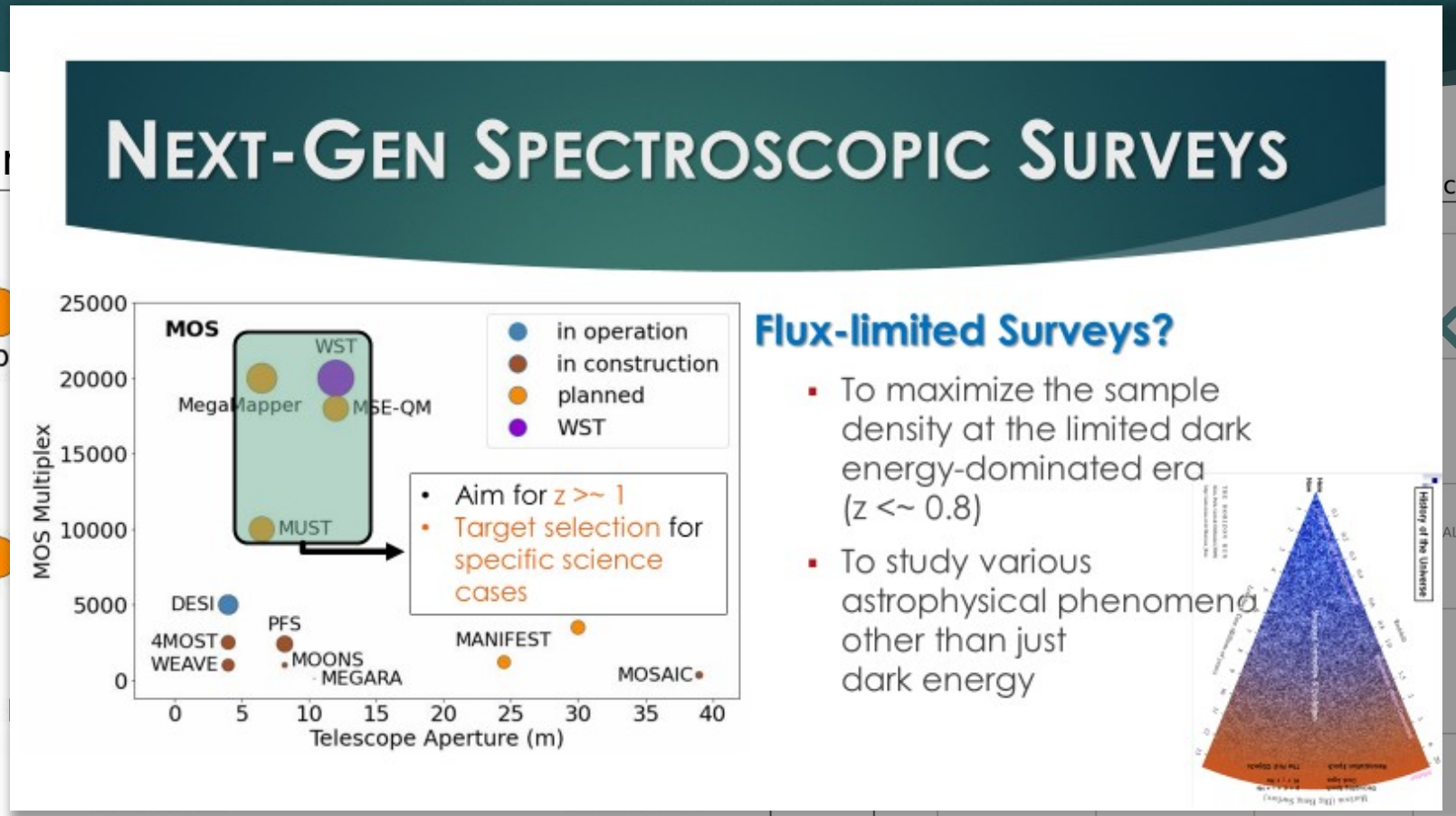
KASI started feasibility study from '24!

Basic System Requirements

Telescope Preference	1 × 10 m or 2 × 6.5 m
Magnitude Limit	m_r = 21~22
Survey Area	Southern Sky
Field of View	2.5 deg^2 = Φ 1.8 degree
Multiplex	10,000 ~ 13,000 for low-resolution 2,500~3,000 for high-resolution
Spectral Range	370 ~ 1200 (or 1800) nm
Spectral Resolution	40,000 for high-resoultion, 6,000 for low-resolution
Plate scale	0.1 ~ 0.15 mm/arcsec (650 ~ 980 mm for 1.8 degree)
Others	theta-phi, spine, theta-r type fiber positioner Fiber or Image Slicer

From Yunjong Kim's slide

BASIC REQUIREMENTS



From David Parkinson's slide

Spectroscopic survey proposal I: Hubble Depth Survey

Photometric catalogs from LSST

- galaxies with i_{limit} = 20.5 or r_{limit} = 21 (z_{max} ~1)

→ n_{sky} = 6,000 gal/deg^2, $n_{spatial}$ (z~1)~ 2x10^{-4}(h^$^{-1}$Mpc)$^{-3}$

Spectroscopic survey

- 300/2 nights using 9.2m (effective) telescope system, with ~0.3hr exposures, multiplexing of 20,000, spectral R=6000 → a flux-limited sample of ~140M galaxies covering ~24,000 deg^2

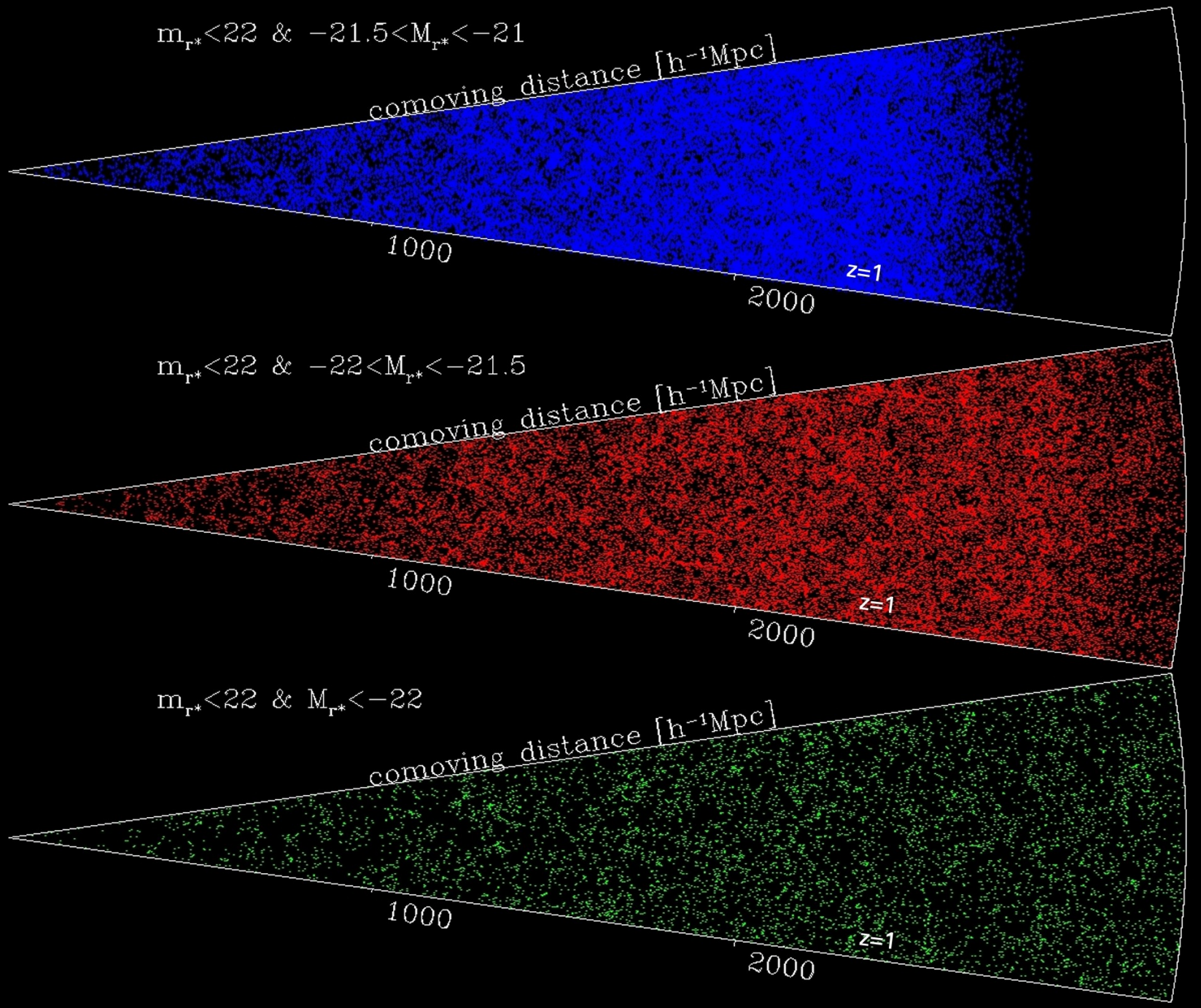
Uniqueness of the wide & dense HDS

- Relatively easier survey with immense scientific returns on low-z astrophysics
- Other future competing surveys will not much focus on this region of the universe.
- The best period of the universe to examine the various effects of the dark energy.

From David Parkinson's slide

Survey predictions: HDS

HDS in a flat ΛCDM universe [Park & Kim, RevMexAA, 28, 93 (2007)]



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Actual survey will be wider

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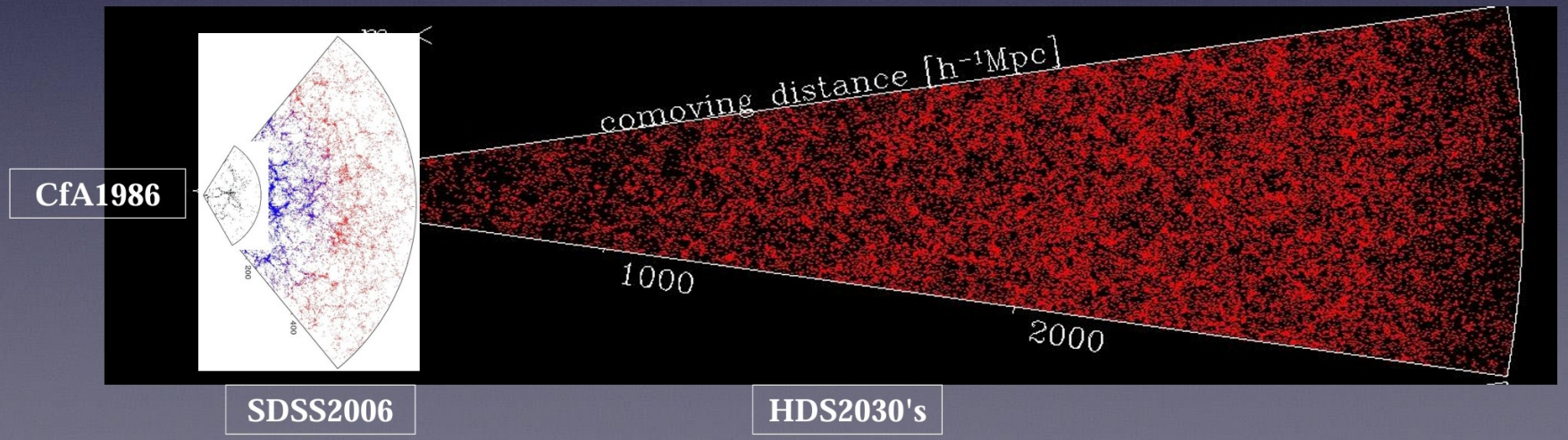
r_{lim}=21 will be ~1.6x shallower

From David Parkinson's slide

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 …)



From David Parkinson's slide

Spectroscopic survey proposal II: Redshift Desert Survey

Photometric catalog

- galaxies with i_{limit}=24 (z_{max} ~1.7)

  → n_{sky} = 80,000 gal/deg^2

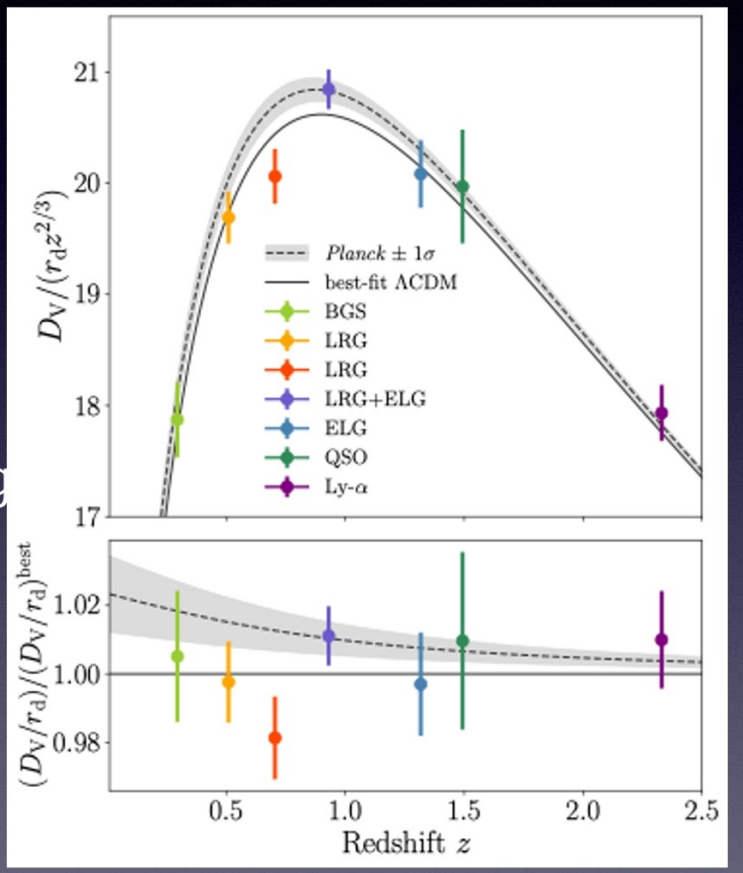
Spectroscopic survey

- 200 nights with ~8 hr exposures, multiplexing of 20,000

→ a flux-limited sample of ~4M redshift desert galaxies covering ~50 deg

Applications of the RDS data

- Missing measurements in redshift desert, where $\Omega_{DE} \rightarrow 0$
- BAO measurements trace optical galaxies with easy to detect lines: most at z<1.5 (LRG and ELG) or z>2.3 (QSO and Ly-α)

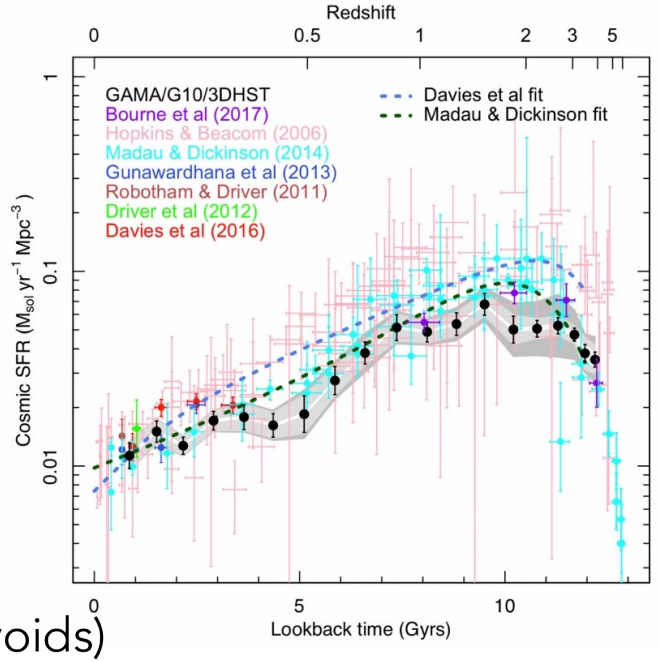


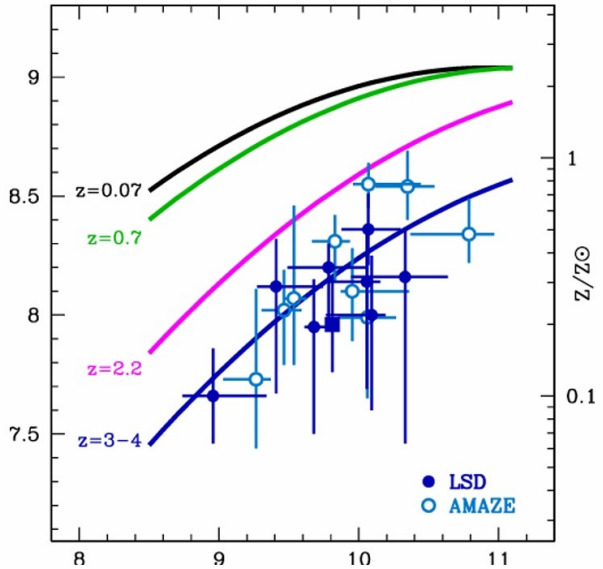
- **Tracing evolution of Galaxies at z < 1-2**
  - ⋆ Star formation activity
  - ⋆ Gas-phase metallicity
  - ⋆ Stellar populations : mass, velocity dispersion, age, stellar metallicity

- **Active Galactic Nuclei at z < 1**
  - ⋆ Higher resolution spectroscopy (R > 4000?)
  - ⋆ Time-series spectroscopy?
    - → Require some additional survey strategies

- **Dwarf Galaxies**
  - ⋆ Faint dwarf galaxy confirmation (z ~ 0.02, R ~ 3000)
  - ⋆ Local volume dwarfs (Virgo, Coma, Fornax, groups, voids)
  - ⋆ Their globular clusters?

- **Galaxy Clusters (z < 1.5, R ~ 1500-3000)**
  - ⋆ Identification, membership
  - ⋆ Infall region - mass evolution of clusters





From Jubee Sohn's slide

Stellar & Exoplanet Science

- Key Science 1. Rubin/LSST & future facilities follow-up in the context of stellar populations
  - Spectroscopic observation for isolated/newly discovered dwarf galaxies
  - Newly discovered transients/peculiar transients
- Key Science 2. Stellar populations in the Milky Way and Local Universe
  - The origin of the elements
  - Star formation and stellar evolution
  - Assembly history of the Milky Way : Galactic Archaeology
- Key Science 3. Exoplanet hosting stars and nearby exoplanet
  - High-resolution spectroscopic survey for nearby stars (M-dwarf) with planets
  - Transmission spectroscopy for exoplanet hosting stars
  - Search for Jupiter mass exoplanet with radial velocity

From Sang-Hyun Chun's slide

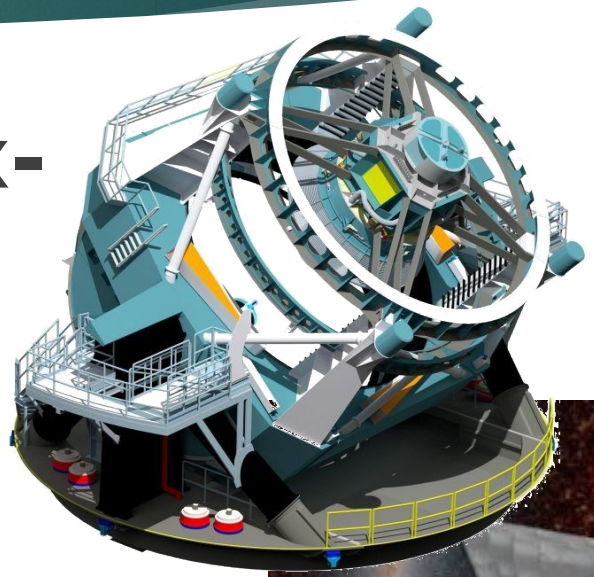
PLAN FOR FEASIBILITY STUDY (‘24-26)

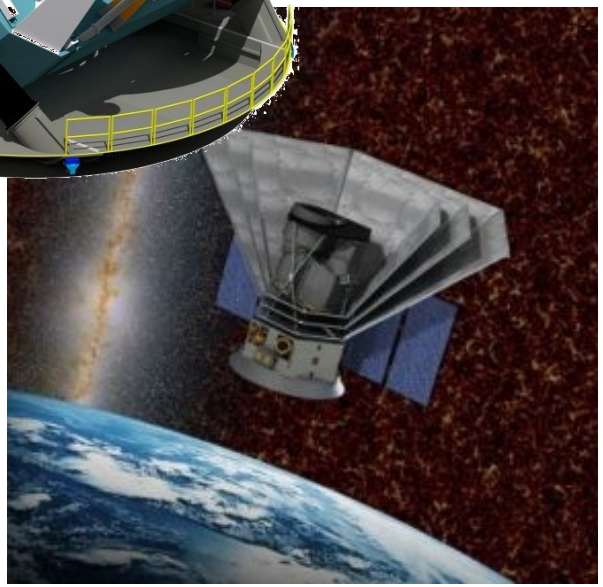
- Scientific topics
  - **Key topics (‘24)**
  - **Detailed studies (late ‘24-early ‘25)**
- Concept on instruments & facilities
  - **Key requirements & concept (‘24)**
  - **Detailed studies (late ‘24-early ‘25)**
  - Technology system diagram/planning (‘25)
  - Observatory candidates studies (‘25)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



>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





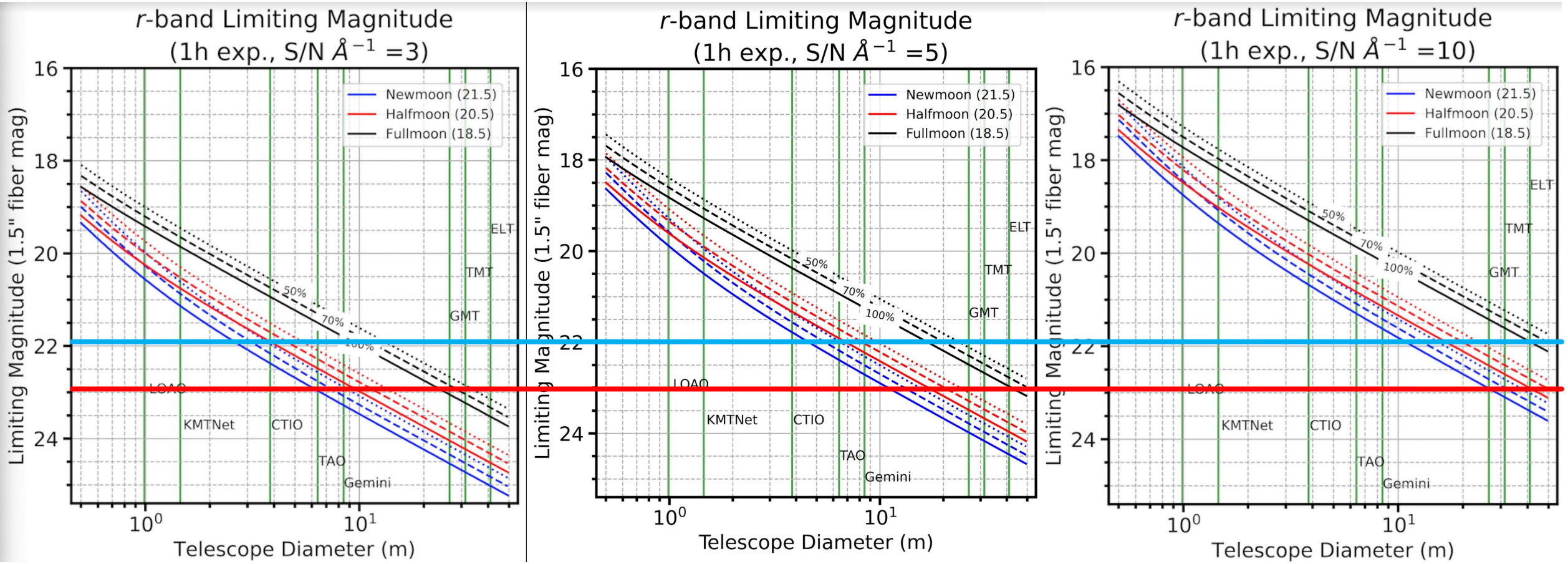

r-band Limiting Magnitude
(1h exp., S/N Å^{-1} =3)
r-band Limiting Magnitude
(1h exp., S/N Å^{-1} =5)
r-band Limiting Magnitude
(1h exp., S/N Å^{-1} =10)
Limiting Magnitude (1.5" fiber mag)
Telescope Diameter (m)
Newmoon (21.5)
Halfmoon (20.5)
Fullmoon (18.5)
50%
70%
100%
LOAO
KMTNet
CTIO
TAO
Gemini
TMT
GMT
ELT

Table. Summary of major surveys relevant to this proposal - Science

Name	Galaxy sample with limiting mag.	Area Coverage (deg^2)	Status
SDSS (2.5m) Main BOSS eBOSS	r_Pet=17.77 (no color sel.) i<19.9 (BOSS, color sel.) i<21.8 (eBOSS, color sel.)	~7500 deg^2	Finished
DESI/BGS (4m)	r_(Mod)=19.5 (no color sel.)	~14,000 deg^2	On-going (until 2025)
MegaMapper (6.5m)	Not fixed, but color-selection.	Not fixed	Under discussion (First light in early 2030's)
Subaru/PFS (8m)	J<23.4 (with color selection)	~16 deg^2	Under construction (First light in 2023?)
MSE (10m)	i<23 (with color selection)	~10,000 deg^2	Under discussion (First light in late 2030's)
This Study	r<~22 - 23 (NO color selection)	~3,000 deg^2	

Name	Sample Properties	No. Targets	Key Science
Subaru/PFS	with color selection (ELGs @ within 1,400 deg^2)	~ 4 million	Cosmology (BAO, growth rate)
	with color selection (galaxies @ within 16 deg^2) (quasars @ within 1,400 deg^2)	~ 1 million	Galaxy/Cluster Evolution
	(for limited fields) (Stars at MW, dSph, M31, M33)	~ 1 million	Galactic Archaeology (kinematics, chemical evolu-tion)
Our Study	without color selection (galaxies within ~3,000 deg^2) (stars at MW, dSph)	~ 100 million	Exoplanets, Low-mass Stars, Galactic Archaeology, Galaxy/Cluster Evolution, Cosmology

WG1: Stellar/(Exo)Planetary Science

(양성철 , 천상현 , 안덕근 , 이영선 , 임범두 , 정선주 , 홍경수)

Telescope Preference	1 x 10m
Magnitude Limit	-
Survey Area	Southern Sky
Field of View	3 deg x 3 deg (MOS) 5 arcmin x 5 arcmin (IFU)
Multiplex	10,000 (0.31 / arcmin^2)
Spectral Range	3,400-8,000 A, 11,000-16,500 A
Spectral Resolution	40,000-50,000
Signal-to-Noise Ratio	30, 100
Others	Commissioning camera for imaging MOS (main) + IFU (switchable)

WG2: Extragalaxy/Cluster Science

(손주비, 황호성, 박홍수, 신윤경, 오규석, 이성국, 이종철, 이준협)

Telescope Preference	-
Magnitude Limit	-
Survey Area	-
Field of View	19 arcmin x 19 arcmin
Multiplex	500 (1.4 / arcmin^2)
Spectral Range	7,400-25,000 A
Spectral Resolution	4,000
Signal-to-Noise Ratio	30 @ 1.2 um
Others	IFS option

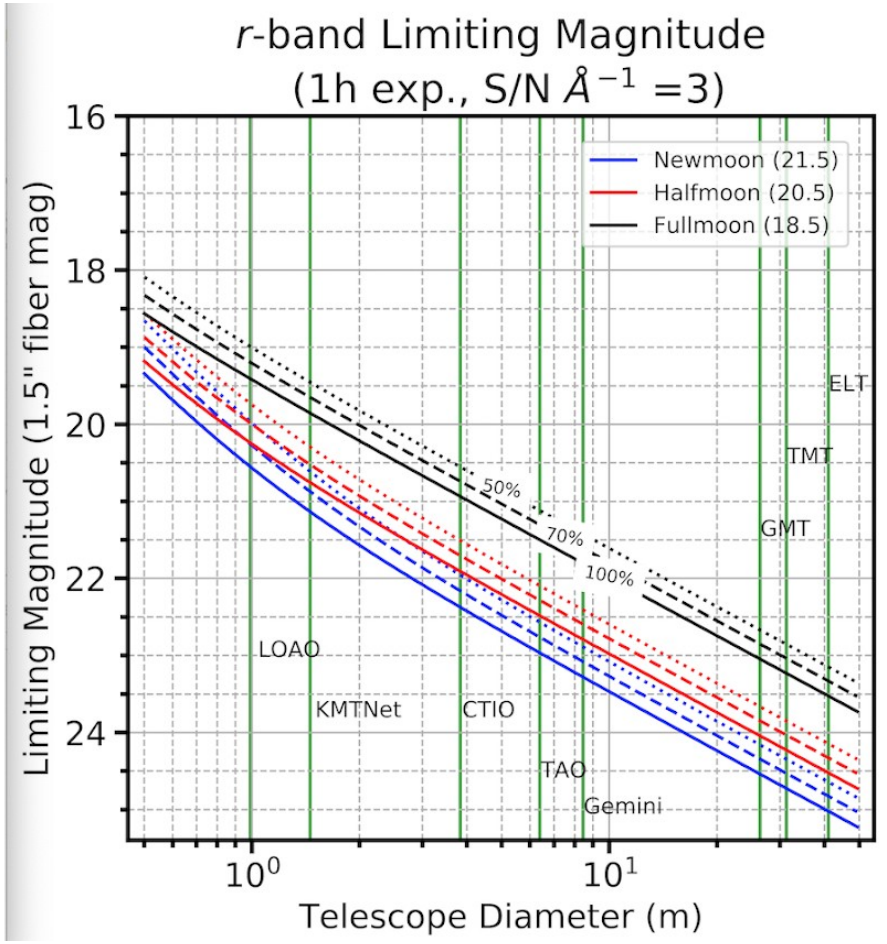
WG3: Large-scale Structure/ Cosmology

(Parkinson, 박창범 , Carr, L'Huillier, Sabiu, Shafieloo, Qin, 김주한 , 김준한 , 유재원 , 정동희)

Telescope Preference	2 x 6.5m
Magnitude Limit	m_r = 21-22
Survey Area	27,000 deg^2 (HDS-WIDE), 5,000 deg^2 (HDS-DEEP), 250 deg^2 (RDS)
Field of View	0.5 deg^2 (HDS-DEEP), 2.5 deg^2 (HDS-WIDE), 0.13 deg^2 (RDS)
Multiplex	10,000 (2.78 / arcmin^2; HDS-DEEP) 10,000 (1.11 / arcmin^2; HDS-WIDE) 10,000 (22.2 / arcmin^2; RDS)
Spectral Range	3,800-11,000 A
Spectral Resolution	2,500? 6,000?
Signal-to-Noise Ratio	-
Others	Wedding-cake strategy with twin telescopes

SURVEY SPECIFICATION (SAMPLE)

Name	Limiting mag.	Exposure	Goal (S/N)	Fiber Size	Spectral Resolu-tion
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 (SAMPLE)

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)

TELESCOPE (SAMPLE)

Option 1. Two 6.5m-telescopes

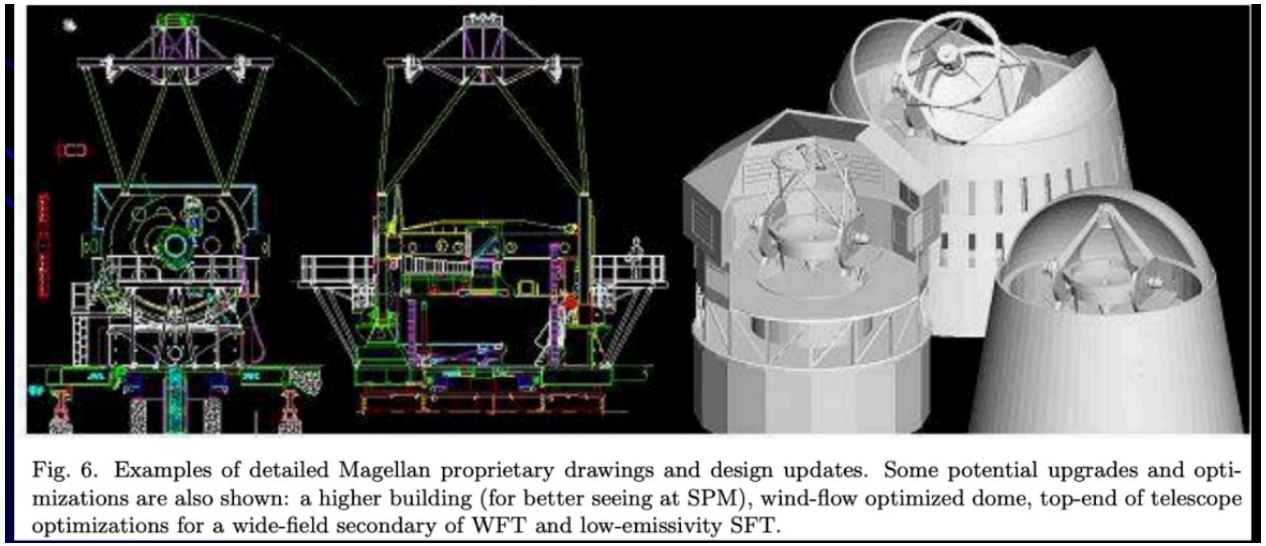
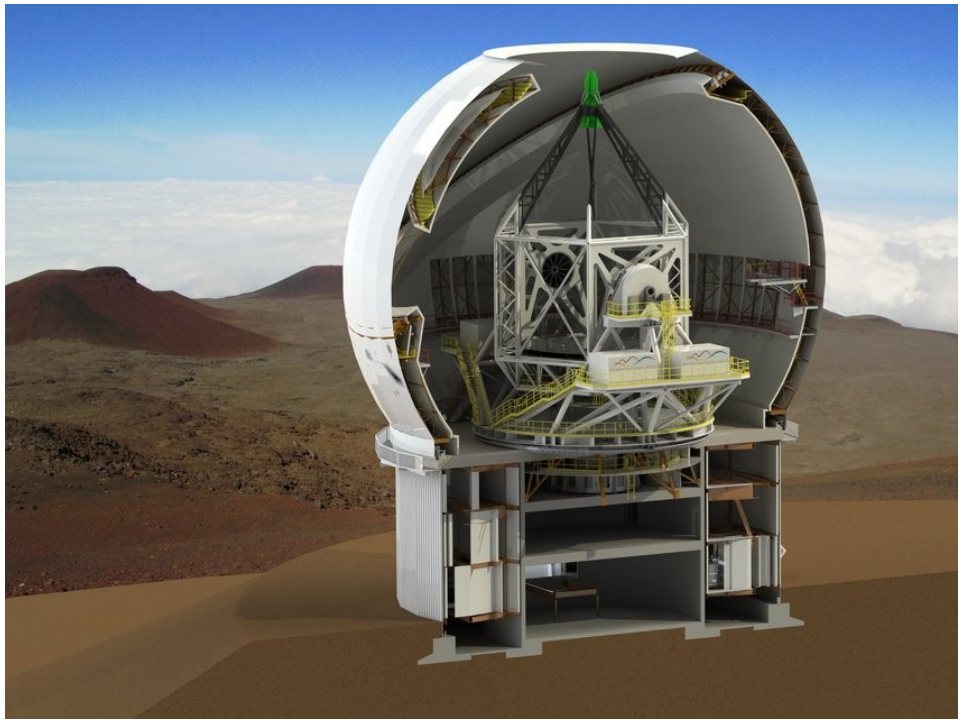
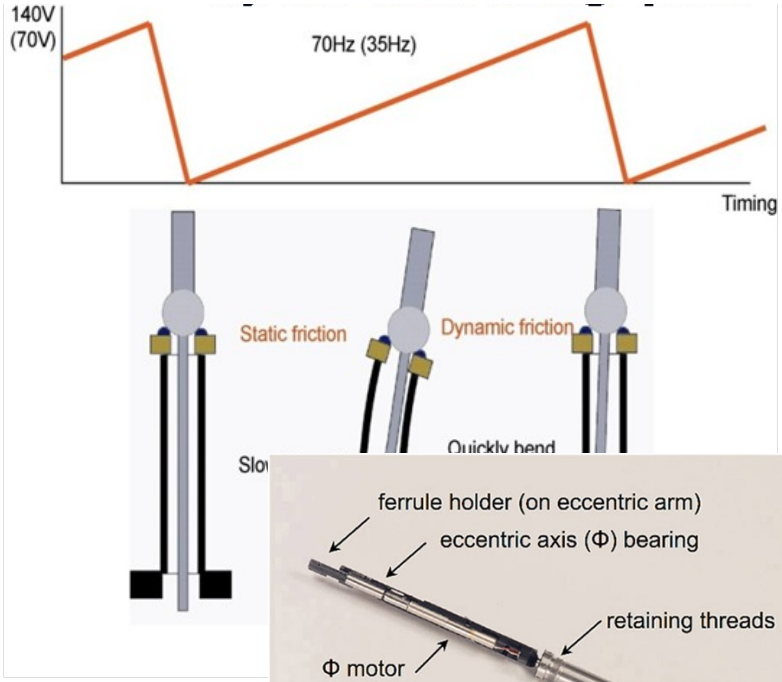


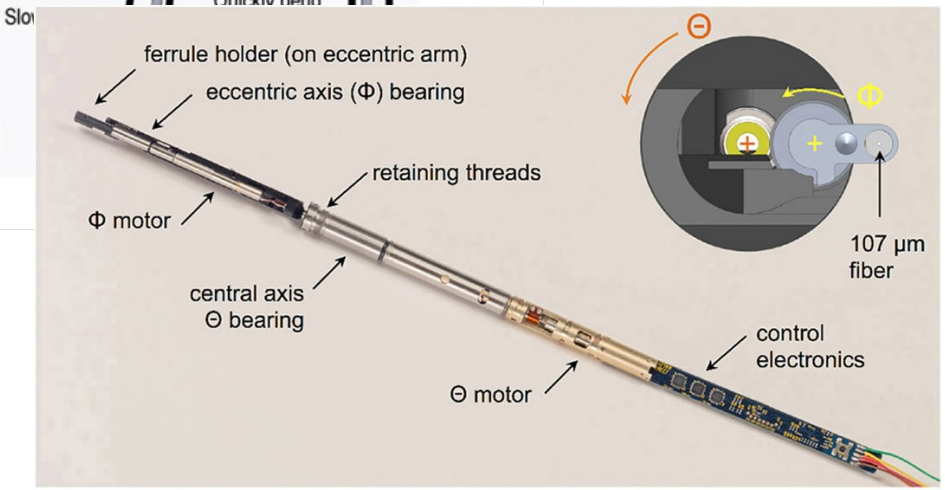
Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

Option 2. 10m-telescope



MULTIPLEX SPECIFICATION (SAMPLE)





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

FOV & Multiflexing

- **VLT MOONS (650-1800nm)**
  - ~1m diameter focal plane = 25 arcmin diameter FOV
  - ~1,000 theta-phi fiber positioners
- **MegaMapper (360-980nm)**
  - 1.2m diameter focal plane = 3 degree diameter FOV (0.113mm/“)
  - 26,100 theta-phi fiber positioners (6.1mm pitch)
- **Subaru PFS (380-1260nm)**
  - 1.3 degree diameter FOV
  - 2,394 fiber positioners incl. piezo actuator with 2 rotational axes (8mm pitch)
- **WST (350-1600nm for telescope, 370-970 for 1st instruments)**
  - 1.4m diameter focal plane = 2 degree diameter FOV
  - 22,000 positioners : theta-phi, phi-r or three actuators
- **MSE (360-1800nm)**
  - 1.4 degree diameter FOV
  - >3,200 spine type fiber positioners (Sphinx)
- **DESI (360-980nm)**
  - 0.8m diameter focal plane = 3.2 degree diameter FOV
  - 5,000 theta-phi fiber positioners (10.4mm pitch)
- **4MOST (390-950nm)**
  - 0.55m(?) diameter focal plane = 2.5 degree diameter FOV
  - 2,436 spine type fiber positioners (AESOP)

중점추진내용	1단계			2단계									
	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36
1. 개념설계 R&D													
1) 분광탐사 사업설계 - 중점연구분야 및 연구주제 도출 - 관측 시설장비 성능 목표 및 컨셉 수립	■	■	■										
2) 분광탐사 추진내용 정립 - 시설장비 구축계획 수립 및 추진 - 연구주제별 세부내용 도출			■										
3) 분광탐사 추진전략 수립 - 단계별 구축로드맵 수립 - 추진체계(국제 컨소시엄) 구성(안) 마련 - 사업예산(안) 마련	■	■	■										
4) 분광탐사 운영계획 수립			■										
2. 예타 기획													
1) 사업 추진 타당성 분석 - 과학기술적, 정책적, 경제적 타당성 분석													
3. 시설장비 구축 및 R&D 수행													
1) 관측소 건설 - 관측소 설계 및 제작				■	■	■	■	■	■	■	■	■	
2) 분광탐사용 대형 망원경 광학/광기계부 개발 및 제작					■	■	■	■	■	■	■	■	
- 망원경 광학계 설계 및 제작(8년)					■	■	■	■	■	■	■	■	
- 광기계부 설계 및 제작(6년)					■	■	■	■	■	■			
- 조립 및 성능평가											■	■	
- 관측 프로그램 설계 및 제작(4~5년)							■	■	■	■	■	■	
3) 분광탐사용 관측기기 개발 및 제작				■	■	■	■	■	■	■	■		
- 다천체 분광관측 시스템 개발 (관측방식 결정 포함)				■	■								
- 분광기 광학계 설계 및 제작					■	■	■	■	■	■			
- 가시광·적외선 검출기 설계 및 제작					■	■	■	■	■	■			
- 기기 제어 소프트웨어 개발				■	■	■	■	■	■	■			
4) 자료 보관 및 처리 기술 개발												■	■
5) 시험관측												■	■
4. 다천체 분광탐사 미션 수행													
1) 다천체 분광탐사 미션수행												■	■

분류	중분류	세분류	세부구성요소
		마운트 가공 기술	- 기계적 공차 범위 내 가공 및 측정 기술 - 기계부 공차 범위 내 구조, 열, 안전성 해석 기술 - 마운트 치구 설계 및 제작 기술 - 대형 망원경 피어 제작 기술
		마운트 조립 기술	- 조립 절차, 평가 및 시험 기술
		안전장치 설계 및 제작 기술	- 거대 구조물의 구동에 따른 안전장치 설계 및 제작 기술
		구동 장치 설계 및 해석 기술	- 대형 망원경 구동장치 설계 및 해석기술
	돔	돔설계	- 지면 기류 보정용 유체 역학계산 기술 - 지면 기류 정밀 측정 기술
	관측영향 요소 분석기술 (관측부지)	관측영향 요소 분석기술	- 풍향 및 풍속의 실시간 측정 기술 - 상층대기 상태 측정 기술 - 천체 시상 측정 기술 - 대기의 수치모델 기술
	소프트웨어	망원경 제어 프로그램	- 망원경 제어 프로그램 개발 기술
가시광 분광기	요구조건	요구조건 분석 기술	- 가시광 분광기 시스템 요구조건 분석 기술 - 분광기 광학계 요구 조건 분석 기술 - 분광기 광기계 요구 조건 분석 기술
	광학설계	광학설계 및 해석 기술	- 분광광학계 설계 및 해석 기술 - 비구면 및 회절격자의 사용에 따른 설계, 조립, 평가 기술
		산란광 해석 기술	- 광선 추적 및 배플 설계 기술
	광학제작	광학가공 기술	- 렌즈 재료 생산 기술 - 렌즈 초기 형상 공정 기술 - 광학면 초기 형상 가공 기술 - 광학면 미세 형상 가공 기술 - 비구면 광학면 연마 및 측정 기술
		증착 및 측정	- 렌즈 증착 기술 - 렌즈 반사율/투과율 측정 - 회절격자 성능 측정 - beam splitter 성능 측정
		광기계 가공 기술	- 분광기 광기계 및 마운트 구조 가공 기술
		광학시험	- 광학면의 정밀 형상 측정 기술 - 광학 요소 및 시스템의 파면 수차 측정 기술

분류	중분류	세분류	세부구성요소
			- 광학 시스템의 분해능 측정 기술
		광학계 및 기계부 조립 기술	- 정밀 광학계의 조립 절차, 평가 및 시험 기술 - 광학계 및 기계부 정렬 기술 - 분광기 구동 및 운용에서 광학 성능을 유지할 수 있는 광학 요소 및 시스템 체결 기술
	기계부	광기계 설계	- 광학 성능 유지를 위한 기계 구조의 설계 및 해석 기술 - 분광기 및 기계 구조의 경량화 설계 및 해석 기술
		광기계 해석 기술	- 광학계, 요소별 마운트 및 제어 과정에서 발생할 수 있는 불안정 요인 해석 및 제어 기술 - 온도 변화 및 온도 구배에 따른 응력 해석 기술 - 분광기 제어에 따른 동적 응력 해석 기술
	검출기	검출기	- 검출기 선정 - 검출기 성능검증 - 쿨러
	소프트웨어	분광기 제어 프로그램	- 분광기 제어 프로그램 개발 기술
적외선 분광기	요구조건	요구조건 분석 기술	- 적외선 분광기 시스템 요구조건 분석 기술 - 분광기 광학계 요구 조건 분석 기술 - 분광기 광기계 요구 조건 분석 기술
	광학설계	광학설계 및 해석 기술	- 분광광학계 설계 및 해석 기술 - 비구면 및 회절격자의 사용에 따른 설계, 조립, 평가 기술
		산란광 해석 기술	- 광선 추적 및 배플 설계 기술
	광학제작	광학가공 기술	- 렌즈 재료 생산 기술 - 렌즈 재질 초기 형상 공정 기술 - 광학면 초기 형상 가공 기술 - 광학면 미세 형상 가공 기술 - 비구면 광학면 연마 및 측정 기술
		증착 및 측정	- 렌즈 증착 기술 - 렌즈 반사율 측정 - 회절격자 성능 측정 - beam splitter 성능 측정

In 2006/2007…

@ SSG 2023

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

SPM-TWIN TELESCOPES: PROJECT OVERVIEW

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

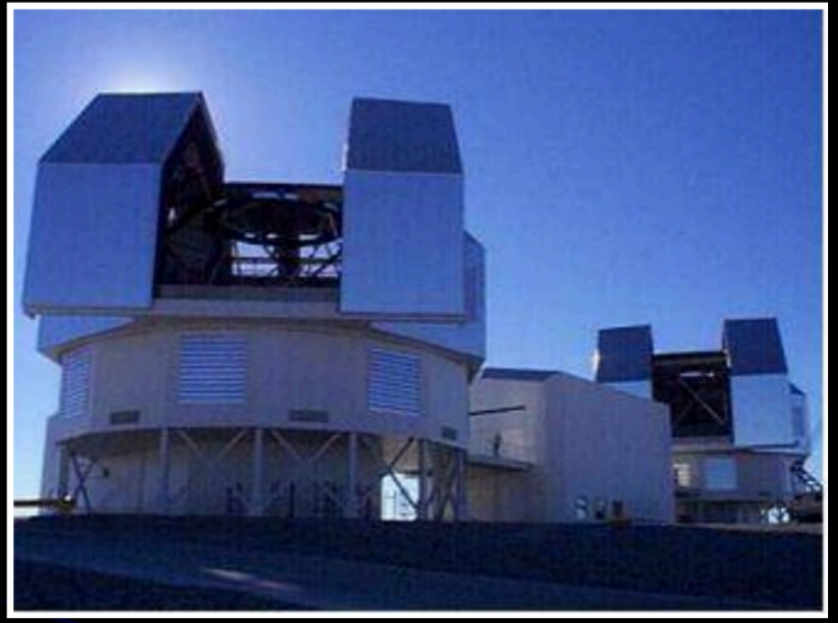


TABLE 1

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

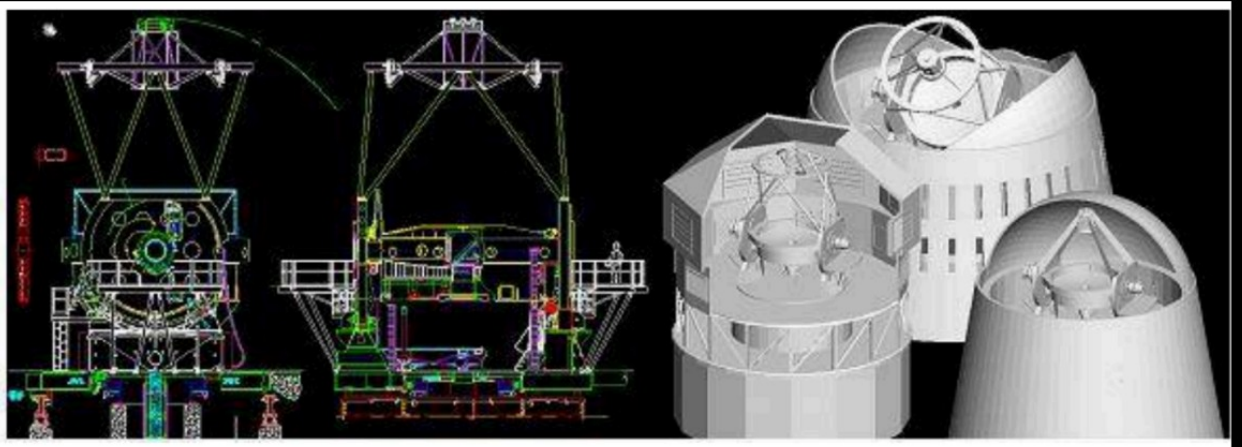
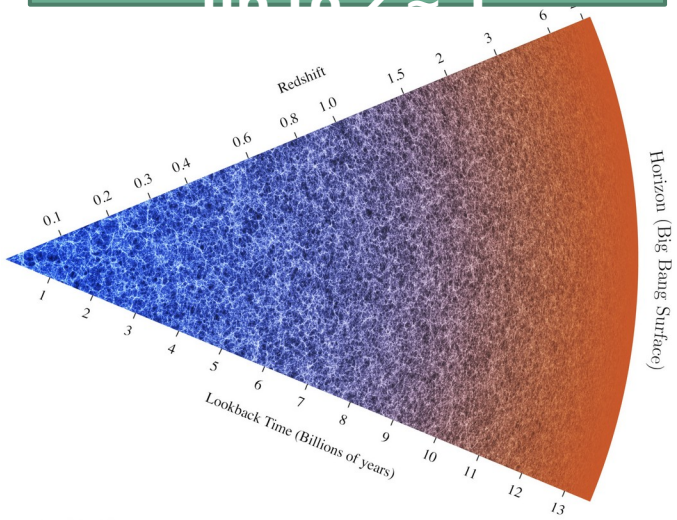


Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

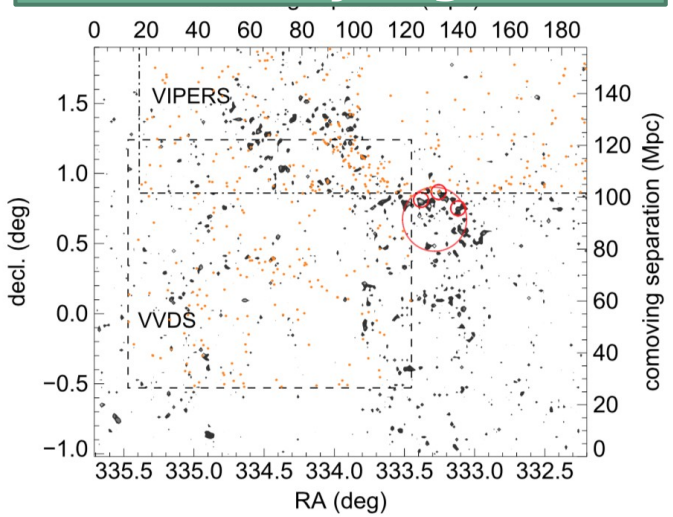
WHAT KOREAN COMMU-NITY WANTS: UNDERSTANDING 8GYR HISTORY OF THE UNIVERSE

Spectroscopic Survey up to z ~ 1



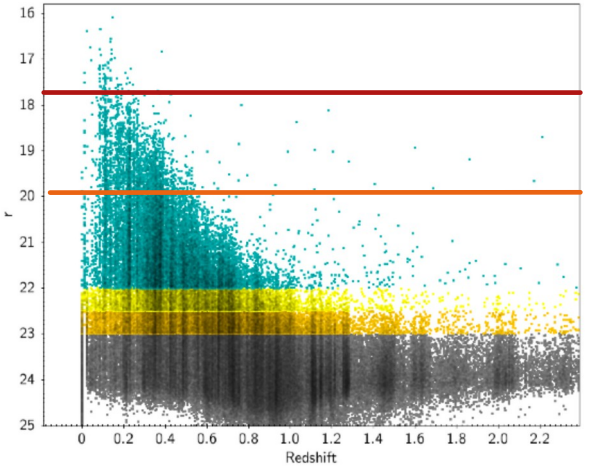
- First complete spectroscopic survey of the Universe of 8Gyr
- Solving the problems of dark matter/energy
- Measuring galaxy clustering without bias
- Studying early universe using quasars at z > 6

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

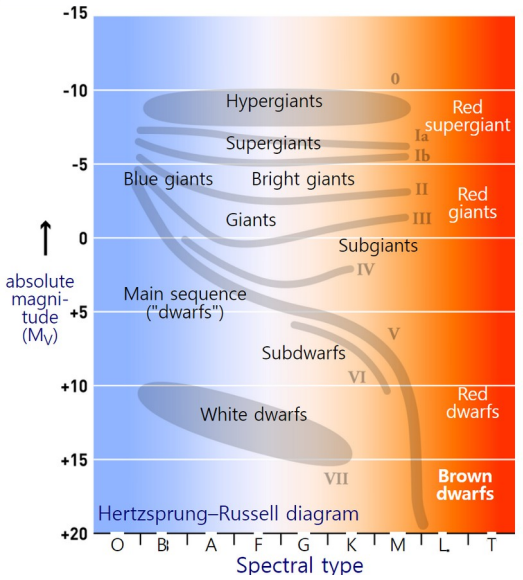


- Limits on telescopes & technology
- Bias due to the color/type selection
- Insufficient for coherent understanding of the Universe

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

WHAT KOREAN COMMUNITY WANTS: 2. UNDERSTANDING OUR GALAXY

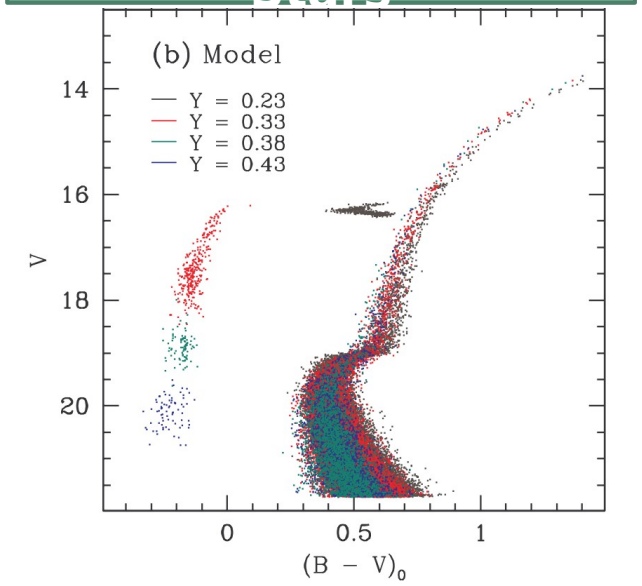
M/L Dwarfs



- 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)

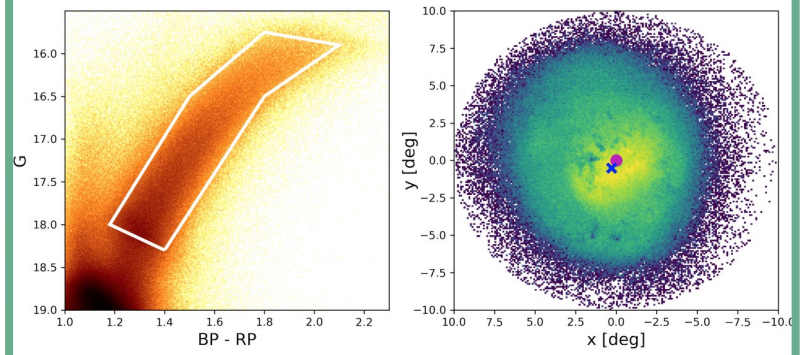
Chemically Peculiar Stars



- 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

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 - 2023	• 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 것

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 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 WORKING GROUPS

Stellar/(Exo)Planetary Science	**양성철 , 천상현** , 정선주 , 주석주 , 홍경수 (천문연), 안덕근 (이화여대), 이영선 (충남대), 임범두 (공주교대)
Extragalaxy/Cluster Science	**손주비 , 황호성** , 이성국 (서울대), 박홍수 , 신윤경 , 오규석 , 이종철 , 이준협 (천문연)
Large-scale Structure/Cosmology	**David Parkinson**(천문연), **박창범** (고등과학원), Arman Shafieloo, Anthony Carr(천문연), Benjamin L'Huillier(세종대), Cristiano Sabiu(서울시립대), 김주한 , 유재원 (고등과학원), Motonari Tonegawa, Stephen Appleby(APTCP), 김준한 (KAIST), 정동희 (PSU)
Telescope/Observatory/Instrumentation	**김윤종 , 이충욱 , 한정열 ,** 박병곤 , 이동주 , 이지우 (천문연), 경재현 , 이형권 (레오스페이스), 김영수 , 박상영 (한화시스템), 문일권 (표준연구원), 유정훈 (그린광학), 인정환 (한국광기술원), 정하은

Large Telescope

Wide-field MOS

Optical/NIR

Flux-limited

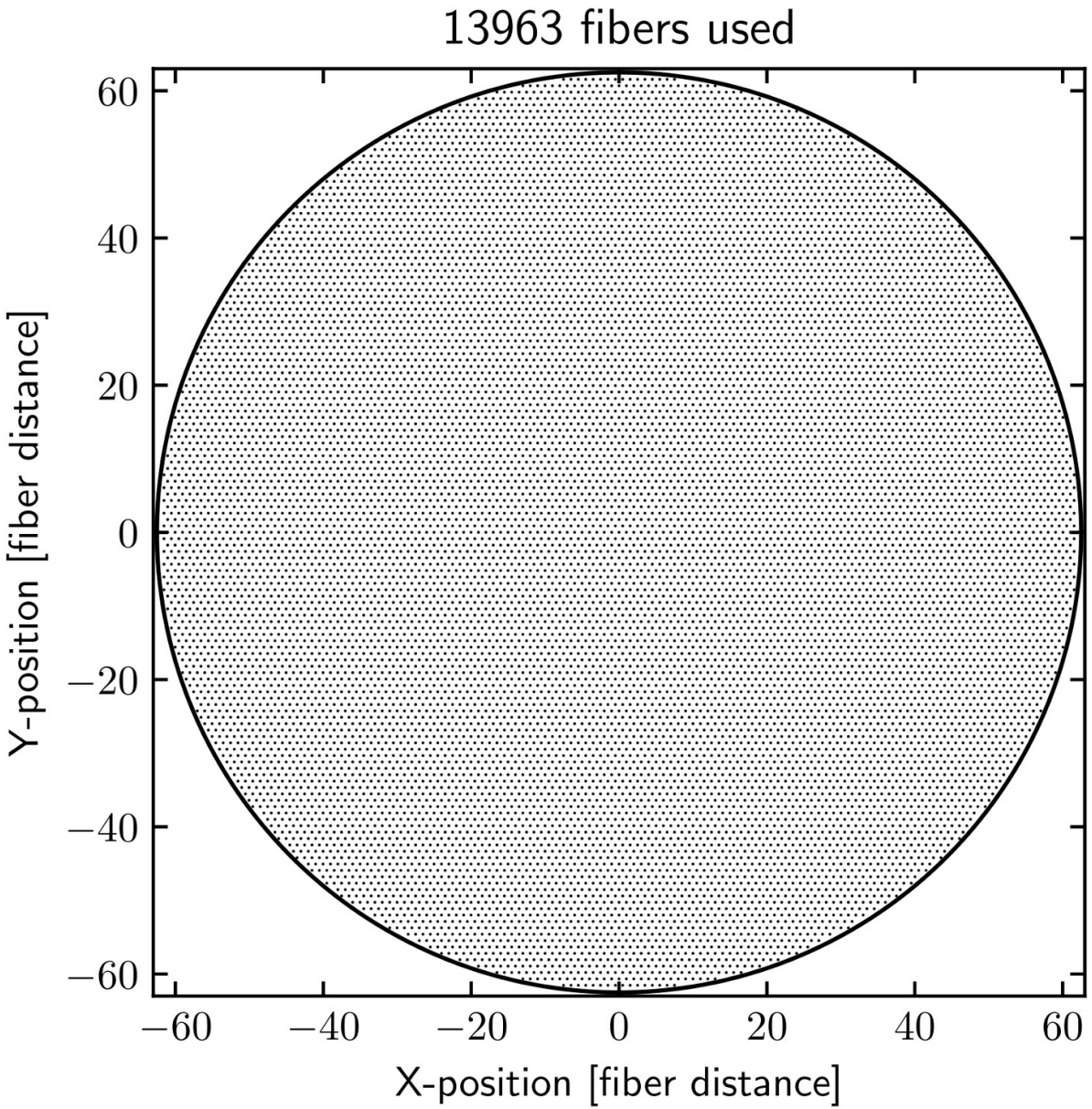
Southern Hemisphe

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

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

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

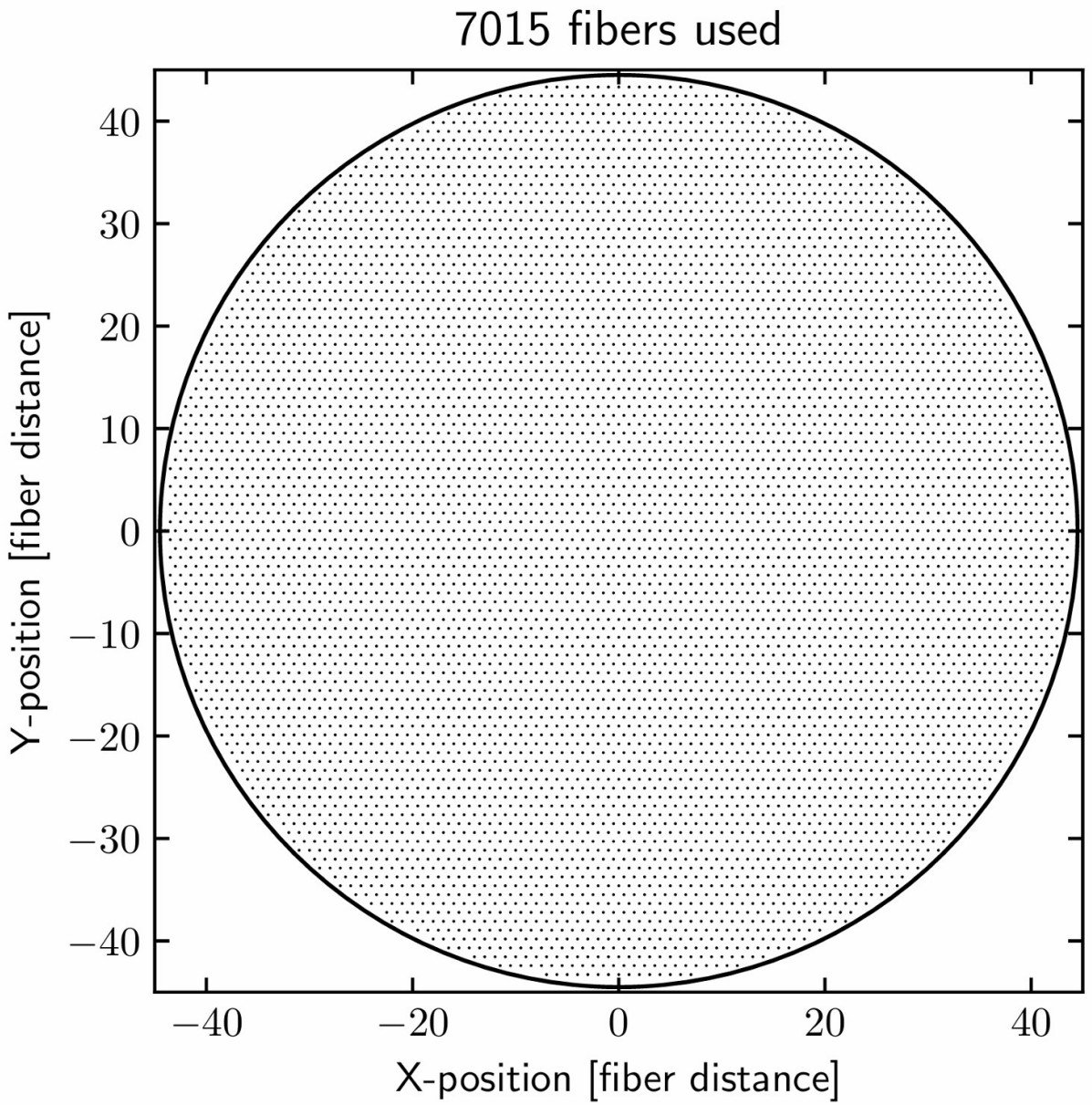
Focal Plane Scenario for 1 × 10 m



Low-/High-res at Once 1.

- 14,000 fibers
(11,500 low-res + 2,500 high-res)
- 125 x pitch diameter
- 8 mm pitch → 1.000 m diameter
- 1.8 deg diameter → 0.154mm/"
- 0.8" seeing → 123um core fiber

Focal Plane Scenario for 2×6.5 m

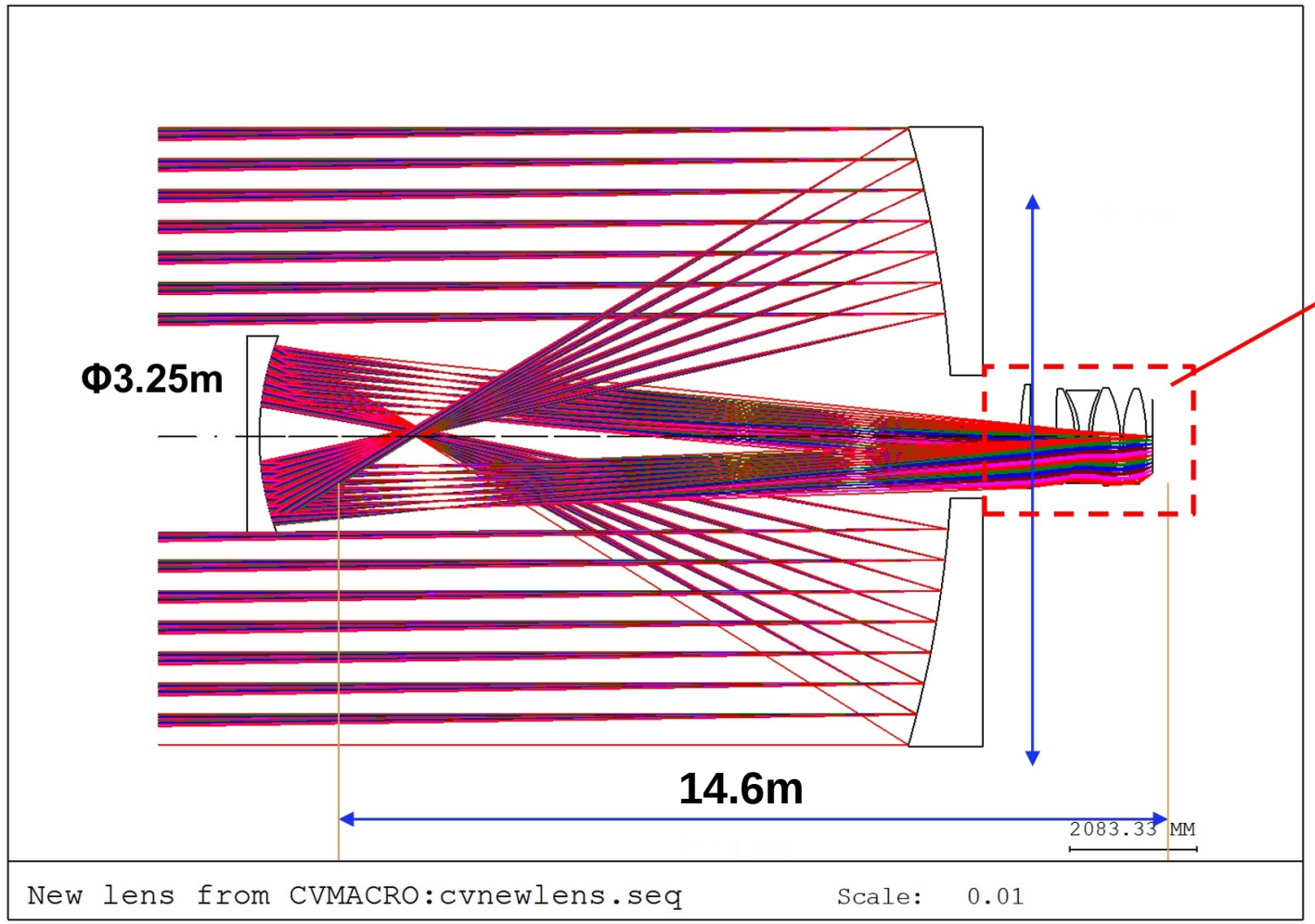


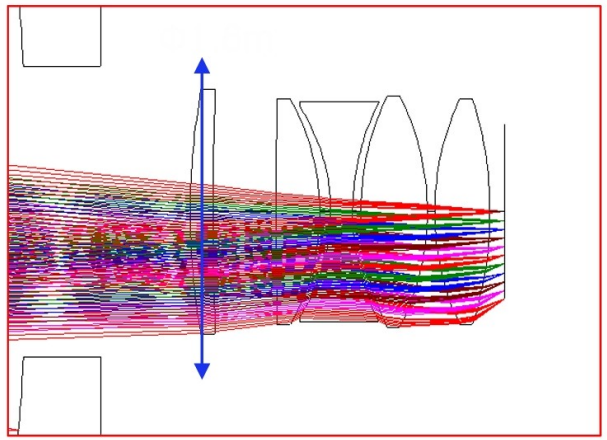
Low-/High-res at Once 1.

- 7,000 fibers per telescope
(5,750 low-res + 1,250 high-res)
- 89 x pitch diameter
- 8 mm pitch → 0.712 m diameter
- 1.8 deg diameter → 0.110mm/"
- 0.8" seeing → 88um core fiber

Concept study for the telescope

Gregorian - M1 10 m



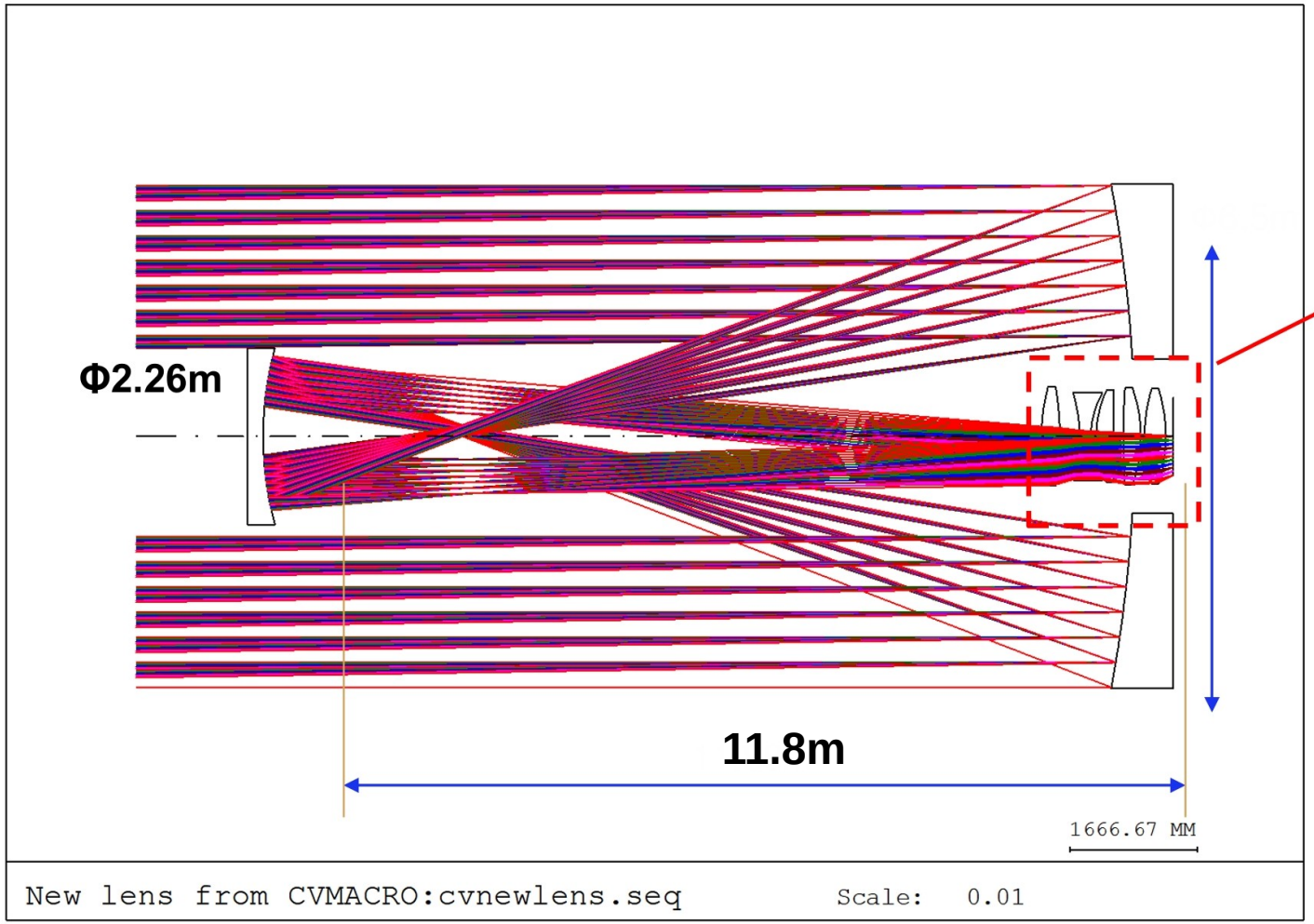


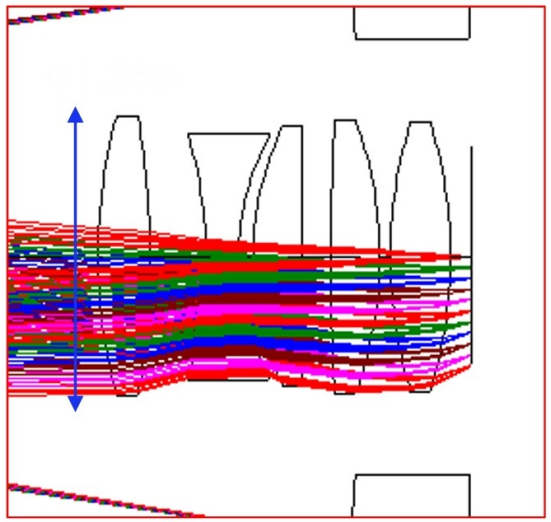
INFINITE CONJUGATES	
EFL	-39062.2281
BFL	99.9969
FFL	0.1056E+07
FNO	-3.9062
IMG DIS	100.0000
OAL	14675.0004
PARAXIAL IMAGE	
HT	599.9999
ANG	0.8800
ENTRANCE PUPIL	
DIA	10000.0000
THI	11500.0000
EXIT PUPIL	
DIA	374.0915
THI	1561.2814

LeO SPACE Leading edge Optical Solutions

Concept study for the telescope

Gregorian - M1 6.5 m





INFINITE CONJUGATES

EFL	-32551.8608
BFL	99.9992
FFL	0.7232E+06
FNO	-5.0080
IMG DIS	100.0000
OAL	12208.2348
PARAXIAL IMAGE	
HT	500.0000
ANG	0.8800
ENTRANCE PUPIL	
DIA	6500.0000
THI	11800.0000
EXIT PUPIL	
DIA	297.4354
THI	1589.5495

LeO SPACE Leading edge Optical Solutions