Complete 3D Mapping of the Local Accelerating Universe (+Metal-poor Star Search)

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KASI 한국천문연구원
Korea Astronomy & Space Science Institute

Main

우주 탐사 연구회 (Survey Science Group)가 제 8 회 워크샵을 개최합니다.

우주 탐사 연구회는 그간 정기 모임을 통해서 국내외의 우주관측사업과 이와 관련된 경쟁력 있는 과학적 연구들을 검토하고 참여 방안을 논의하였습니다.

본 워크샵을 통해서 한국 천문학계에서 진행 및 계획되고 있는 여러 사업들에 대한 집중적이고 구체적인 논의와 검토가 이루어지는 자리를 마련하고자 합니다.

* 일시: 2019년 2월 20일(수)부터 22일(금)까지
* 장소: 하이원 리조트 (세미나: 마운틴 프라자, 객실: 마운틴 콘도)

Thursday (21st)

Time	Details
07:30 - 09:30	Breakfast
	Session II. Development of Optical Instruments (Chair: Hong Bae Ann)
09:30 - 09:45	YoonKyung Shin (KASI): Current status of MOS facilities in the World
09:45 - 10:00	Changbom Park(KIAS): MOS (TBD)
10:00 - 10:15	Jong Chul Lee (KASI): External Galaxy researches using IFS in Korea
10:15 - 10:45	Ho Seong Hwang (KASI): 중대형 망원경 기기개발 관련 토의
10:45 - 11:05	Coffee Break
	Session III. Surveys with Optical Telescopes (Chair: Hong Bae Ann)
11:05 - 11:20	Jongwan Ko (KASI): A pathfinder telescope: probing the Universe down to hitherto unexplored SB levels
11:20 - 11:35	Hong Soo Park (KASI): Current Status of the KMTNet Supernova Program (KSP)
11:35 - 11:50	Narae Hwang (KASI): Korean 8m Class Optical Facility: Gemini
11:50 - 12:20	Ho Seong Hwang (KASI): East Asian Observatory and Subaru 관련 토의
12:20 - 14:00	Photo / Lunch
	Banquet (18:00 ~)

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:	$\Phi \geq \sim 1.5^{\circ}$	$\Phi \sim 1.5'$ (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

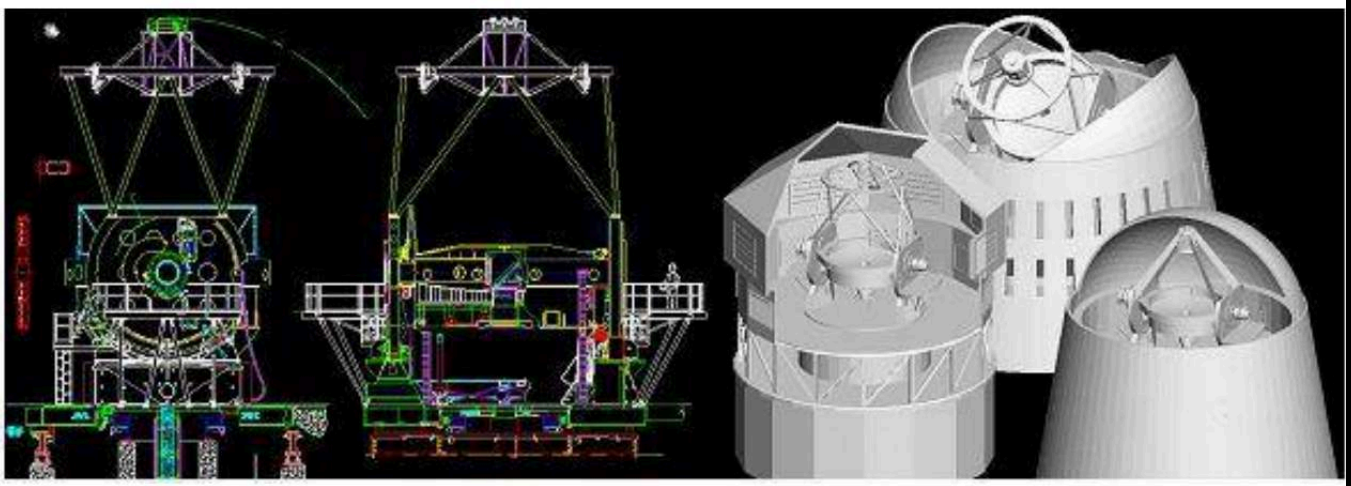
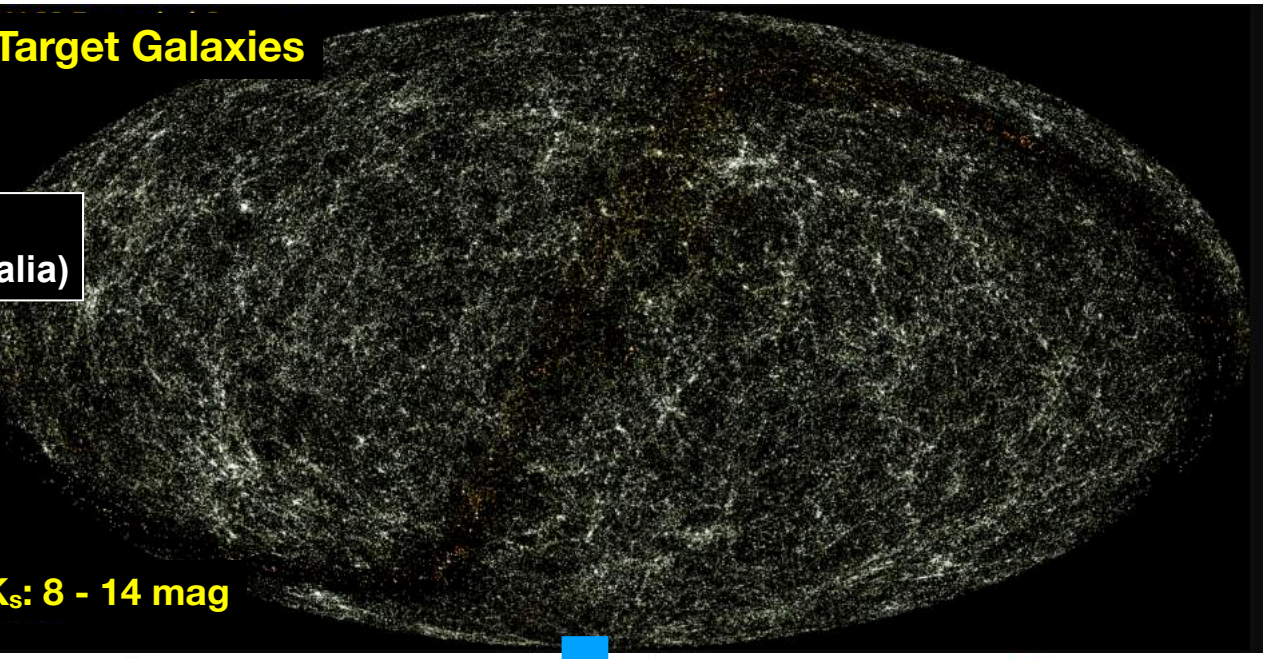


Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

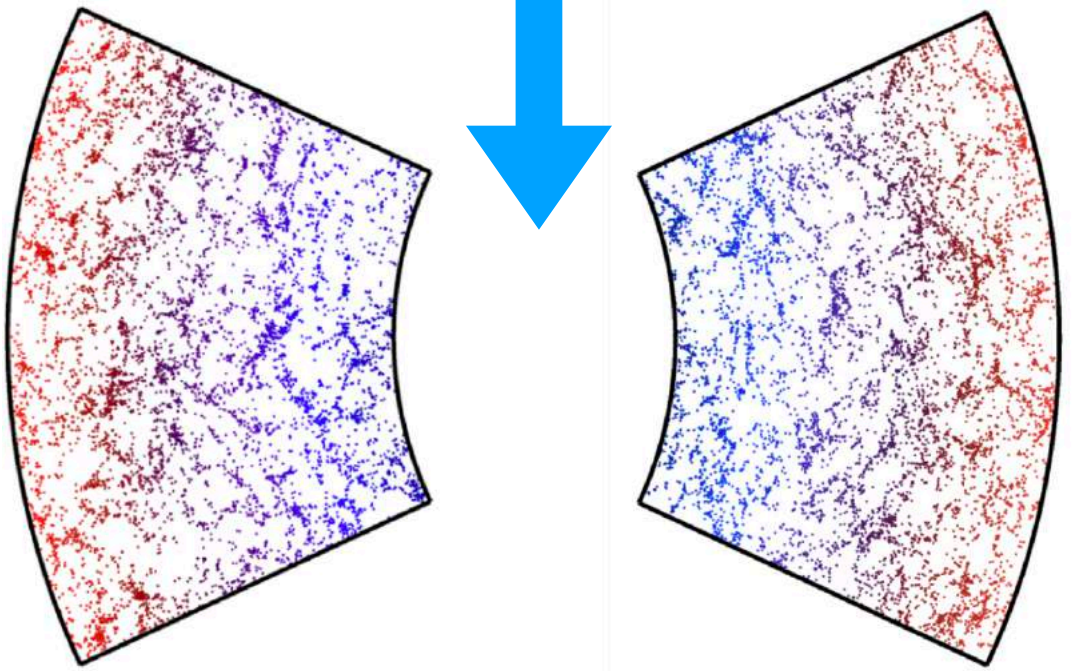
Multi-Object Spectroscopy Development + Spectroscopic Survey: 1 page Summary

2. [2023-25] All-sky Spectroscopic Survey

Northern Hemi.: McDonald 2.7m Tel.
Southern Hemi.: KMTNet 1.6m Tel. (Australia)



1. [2021-22] Development of MOS



3. [2026] Test of Cosmological Models on Galaxy Formation by comparing Observations (Left) and Simulations (Right)

Q: Why do we want this new survey?

Let's
1. make MOS by ourselves, and
2. do a lot of interesting research with an all-sky redshift data.

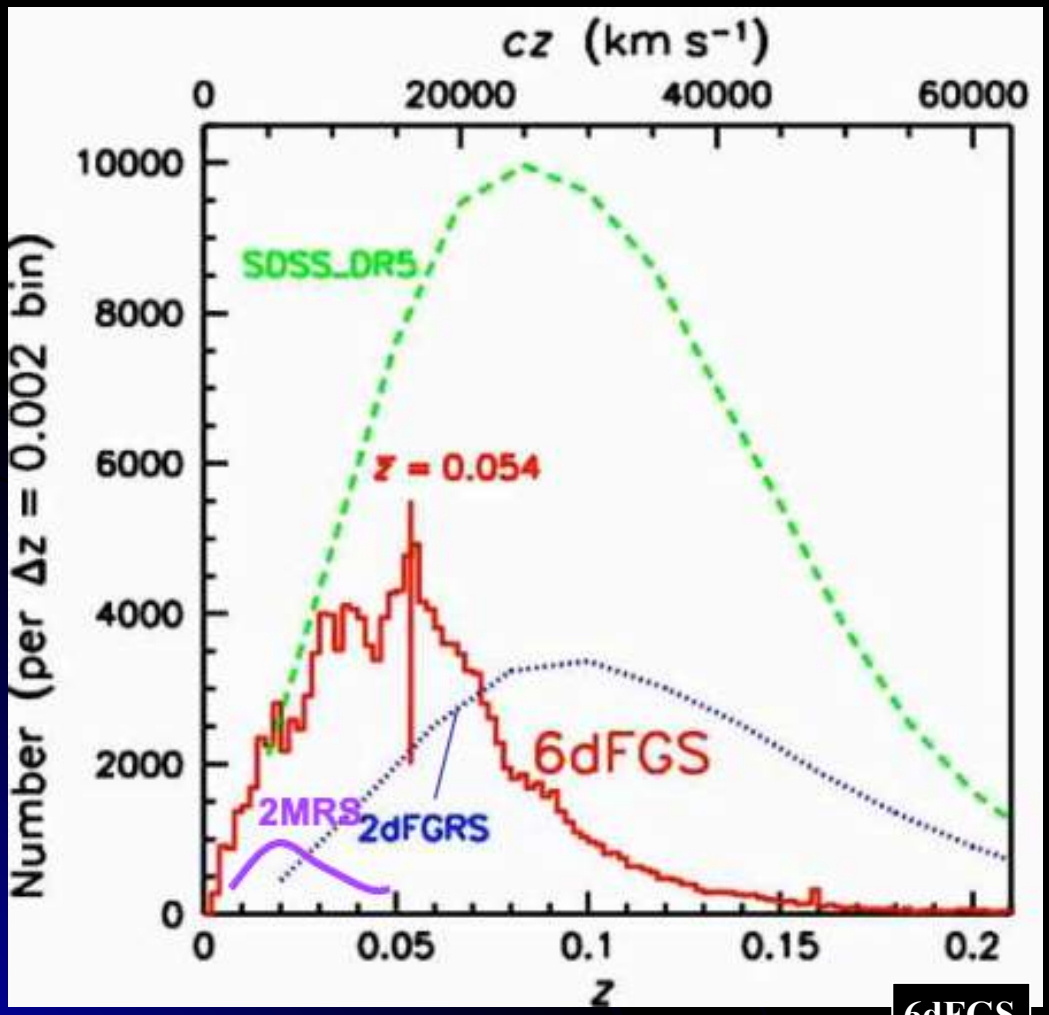
Q: Why do we want this new survey?

➢ **Immediate Goals: Construction of a complete sample of galaxies at z<0.05**

- ➢ Galaxy Formation/Evolution Related…
  - ➢ Construction of complete sample of nearby galaxy clusters/groups (Song, H.)
  - ➢ Study of Galaxies with Bars (Yoon, Y.)
  - ➢ Study of Brightest Cluster Galaxies (Lee, J. C.)
  - ➢ Combination with the data including SDSS:
    - ➢ Make a complete sample of galaxies at r<17.77
      by including bright galaxies not observed in previous surveys
    - ➢ Very useful for studying the galaxies in high-density regions
      (e.g. galaxy clusters) that were incomplete in previous surveys
- ➢ Cosmology related…
  - ➢ Test of the cosmological models
    through statistical comparisons with cosmological simulations
  - ➢ Study of galaxy clustering by combining the data at z>0.05 (e.g. 2pCF, AP test):
    Trace the evolution of dark energy effects on galaxy clustering (Park, C.)
  - ➢ Measurement of density contrast of nearby universe:
    Contribute to resolve the Hubble parameter discrepancy (Hwang, H. S.)
  - ➢ Study of growth rate of the universe
    using density/momentum field of early-type galaxies (Shim, J.)
  - ➢ Study of isotropy of the universe (Shim, J.)

Q: Why do we need a new survey?

➢ **A simple answer is that there are no surveys good for our scientific goals.**



6dFGS

- Previous Redshift Surveys
  - Some very nearby, bright galaxies (z<0.05) were excluded because of various observational selection effects (e.g. saturation; not in the phot. cat.)
  - Few all-sky surveys
- New Redshift Surveys
  - Need a complete sample of nearly galaxies for the study of dark energy
  - All-sky Survey: Need a Sufficient Volume for the study of z=0 Universe
- Need a MOS on a wide-field telescope for this new redshift survey!

Q: How good is this survey compared to other surveys?

➢ It is an all-sky survey with a simple magnitude limit

Q: Why do we need an all-sky survey?

1. Not only to decrease the uncertainties of physical parameters we would like to measure
   1. Need a Sufficient Volume for the study of z=0 Universe (larger is better)

2. But also to secure scientific competitive power (cf. SDSS/Taipan/4MOST): Blue Ocean Strategy!
   ➢ Science Cases that can be done only with all-sky data
   ➢ Combination with all-sky survey data (e.g. SPHEREx/Planck/eROSITA/WISE++)

Q: Why KMTNet?

➢ Thanks to Narae's Suggestion last year

1. Right telescope for this survey!
   1. Wide-Field of View: survey efficiency
   2. Southern Hemisphere: LSST follow-up, GMT preparation
   3. KASI Facility: our own experience
      - ➢ Good for training young people
      - ➢ Good for planning future surveys with larger telescopes (e.g. SPHEREx follow-up)

2. Should we give up the uniqueness of KMTNet? (monitoring a target continuously for 24 hours)
   1. We can use non-bulge time for our survey (with 1 telescope)
   2. Eventually, we can think about spectroscopic monitoring with 3 telescopes! (e.g. any bright variables from LSST?, AGN)

New Redshift Survey: Instrument Requirement

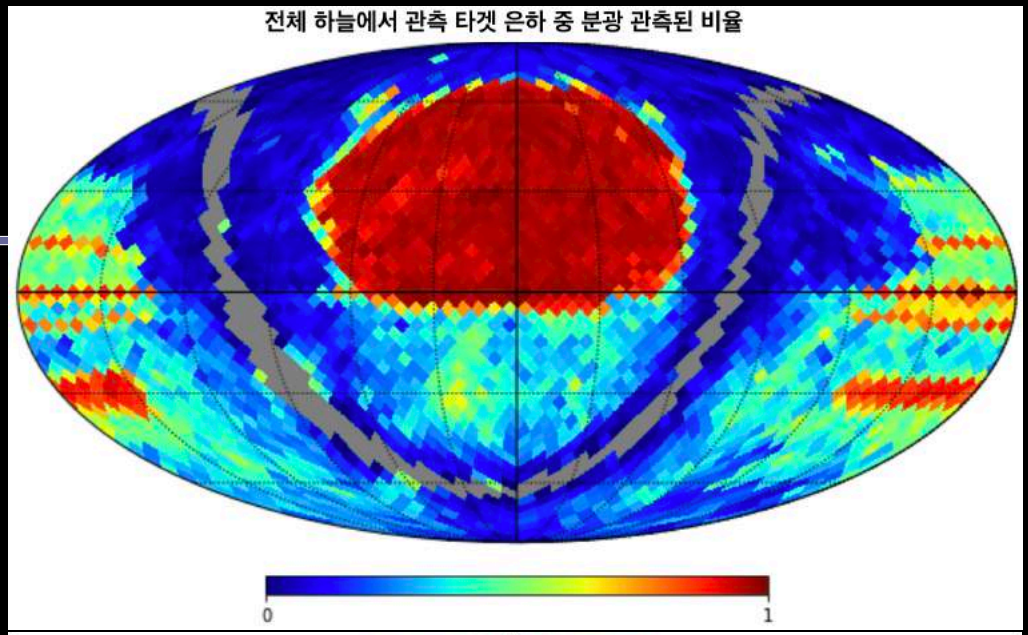
Specification	Requirement (Spec…) - KMTNet	Requirement (Spec…)-MDO
Field of View	> 6 deg^2	1.5 deg^2 (with AWACS/WFC)
Number of Fibers per field	> 140 (~114 targets (max. 228)+26 skies)	
Fiber FoV (Diameter)	~3”	~4.2”
Spectral Resolution	1000-2000 (=> 30-50 km s^{-1})	Current: VIRUS-P (R~3000)/VIRUS-W (R~9000) Future (2021): VIRUS-2 (R~2000)
Wavelength Coverage	3700 - 7500 Å	VIRUS-P (3400-6500 A) VIRUS-W (4900-5450 A) VIRUS-2 (3700-9300 A)
Exposure per field	<15 min (10 min on source + 5 min overhead)	<10 min (5 min on source + 5 min overhead)

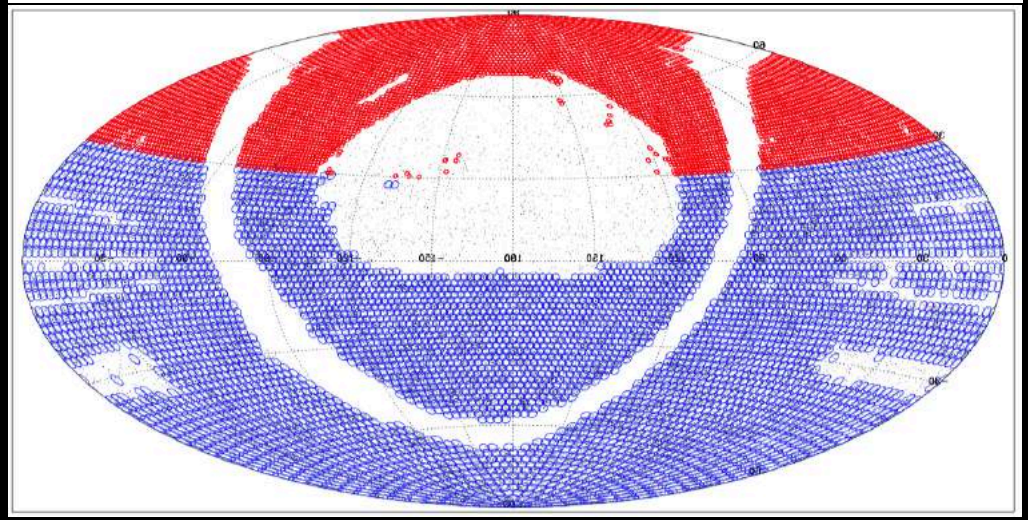
Timeline

첨단 관측기술 개발을 통한 은하기원 규명

	2021	2022	2023	2024	2025	2026	예상 대표 성과
측광 기술 개발	극미광 우주 탐사용 망원경 개발 - 비축 자유곡면 광학계 - 신소재 특성 해석 및 가공 - 산란광 제어 기술 - 초고속 검출기 사용기술 - 망원경 성능 평가 최적화 - 고효율의 탐사관측 전략		시험관측 (국내) - 요구사항 도출	측광 탐사 관측 (국외: 남아공, 칠레, 뉴질랜드, 호주) - 천구 적도 영역 (~360 deg^2) - 가까운 우주의 은하 위성 은하 탐사 - LSST와의 시너지 활용			기대효과1: 표준우주모형의 여러 천문학적 난제 해결 가능성 제시
			기술 최적화 및 국산화 (국산 소재 개선)				
			극미광 우주 탐사용 우주망원경 개발 준비				
	극미광 천체 관측 자료와 시뮬레이션 자료 비교분석을 통한 은하기원 규명 연구						
분광 기술 개발	다천체 분광기 개발 - 광시야 조절기 설계 및 제작 - 광섬유 위치기/분광기 구입 및 조립 - 구동 소프트웨어 개발		북반구 시험관측 (맥도날드 2.7m 망원경)	북반구 분광 탐사 관측 (맥도날드 2.7m 망원경) 남반구 시험관측 (호주 KMTNet 1.6m 망원경) 남반구 분광 탐사 관측 (호주 KMTNet 1.6m 망원경)	북/남반구 자료 분석	북/남반구 자료 결합 및 과학 연구	기대효과2: 첨단 관측기술의 국내 다양한 분야 적용 - 첨단관측 망원경 개발 기술 - 신소재 가공 및 분광기 개발 기술
	- 기존 3차원 분광 관측 자료를 토대로 한 연구 성과 창출 - Hector 본격 참여 및 초기 자료 활용 연구 수행 - 3차원 분광 관측 연구를 위한 신규 인력 확보			- Hector 프로젝트 팀과의 적극적인 국제 교류를 통해 3차원 분광 기술 습득 및 신규 연구인력 훈련 - Hector 관측 자료를 활용한 과학연구 성과 창출			
	1-3차원 분광 관측 자료와 시뮬레이션 자료 비교분석을 통한 은하기원 규명 연구						
수치 모의 실험	고성능 컴퓨팅 시스템 구축			고성능 컴퓨팅 시스템 업그레이드 및 유지 보수			기대효과3: 세계 최대 규모의 모의수치실험 수행
	세계 최대규모 시뮬레이션 (HR5) 데이터를 활용한 다양한 분석연구			관측 데이터의 한계를 보완/극복하기 위한 전략적인 시뮬레이션 수행 - 통계학적으로 우수한 빅 사이즈의 데이터 생성 - 관측된 천체 현상 및 특성을 재현하는 메커니즘 추적 - 최신의 이론연구를 기반으로 한 정밀한 수치모형 구현			
	차세대의 세계 최대규모 유체역학 시뮬레이션 기획 및 준비 (KASI Run)			차세대의 세계 최대규모 유체역학 시뮬레이션 (KASI Run) 수행 및 분석			
	우주론적 유체역학/중력진화 시뮬레이션 데이터와 다양한 관측 데이터의 비교분석을 통한 은하기원 규명 연구						
예산	27.3억	35.7억	11.9억	10.0억	7.8억	7.3억	

Survey Simulation (by Lee, Jong Chul)





	KMTNet tiles	KMTNet nights	MDO tiles	MDO nights
dec=30	6287	197	8389	175
dec=20	5629	176	11021	230
dec=15	5281	166	12413	259
dec=30 & den >5	4567	143	4808	101
dec=20 & den >5	**4198**	**132**	**6158**	**129**
dec=15 & den >5	**4016**	**126**	**6911**	**144**

KMTNet: FoV = 6, exp = 10+5

MDO: FoV = 2.27, exp = 5+5

1 night = 8 hours

SDSS (main) = 7000 (KMTNet 3700 / MDO 3300)

plane (+/-5 region) = 3600 (KMTNet 2750 / MDO 840)

tiling factor = ~1.35

weather factor = ~1.4

additional tiling factor = ~1.1

bright time factor = ~1.2

244 nights! ~ 8 months for 2 years

Including bright time

199 nights! ~ 6.6 months for 2 years

Excluding bright time

+ Metal-poor search during bright time (Lee, Ho-Gyu)

MOS: Research Budget + ManPower

- Total Budget: ~34억
  - Design+Manufacture: ~26.7 억
    - Spectrograph, Wide-field Corrector, Fiber positioner, Assembly, etc.
    - KMTNet: ~16.3억, MDO: ~10.4억
  - Labor cost (1 Postdoc + 1 Student every year): ~4억
  - Test Obs., Maintenance & Data reduction system: ~3.3억

- Man Power
  - KASI (Project management: Planning, Manufacture, Science)
    - Galaxy Evolution Group (Jongwan Ko, Jong Chul Lee, Jae-Woo Kim)
    - GMT Science/Instrumentation Group (Sungho Lee, Chan Park, Ho-Gyu Lee)
    - In addition, new staff/postdoc/student
    - Of course, you're very welcome to join!!
  - Domestic
    - KIAS (Planning, Science: Changbom Park, Junsup Shim, Yongmin Yoon)
    - Univ. Of Seoul (MOS design/manufacture: Sungwook Hong)
    - SNU (Manufacture: Dongguk Kim)
    - Yonsei (Science: Hyunmi Song)
  - International
    - University of Arizona (MOS design: Haeun Chung)
    - Univ. of Texas at Austin (WFC design: Hanshin Lee)
    - Penn State University (Science: Donghui Jeong)

MOS: Subaru/PFS

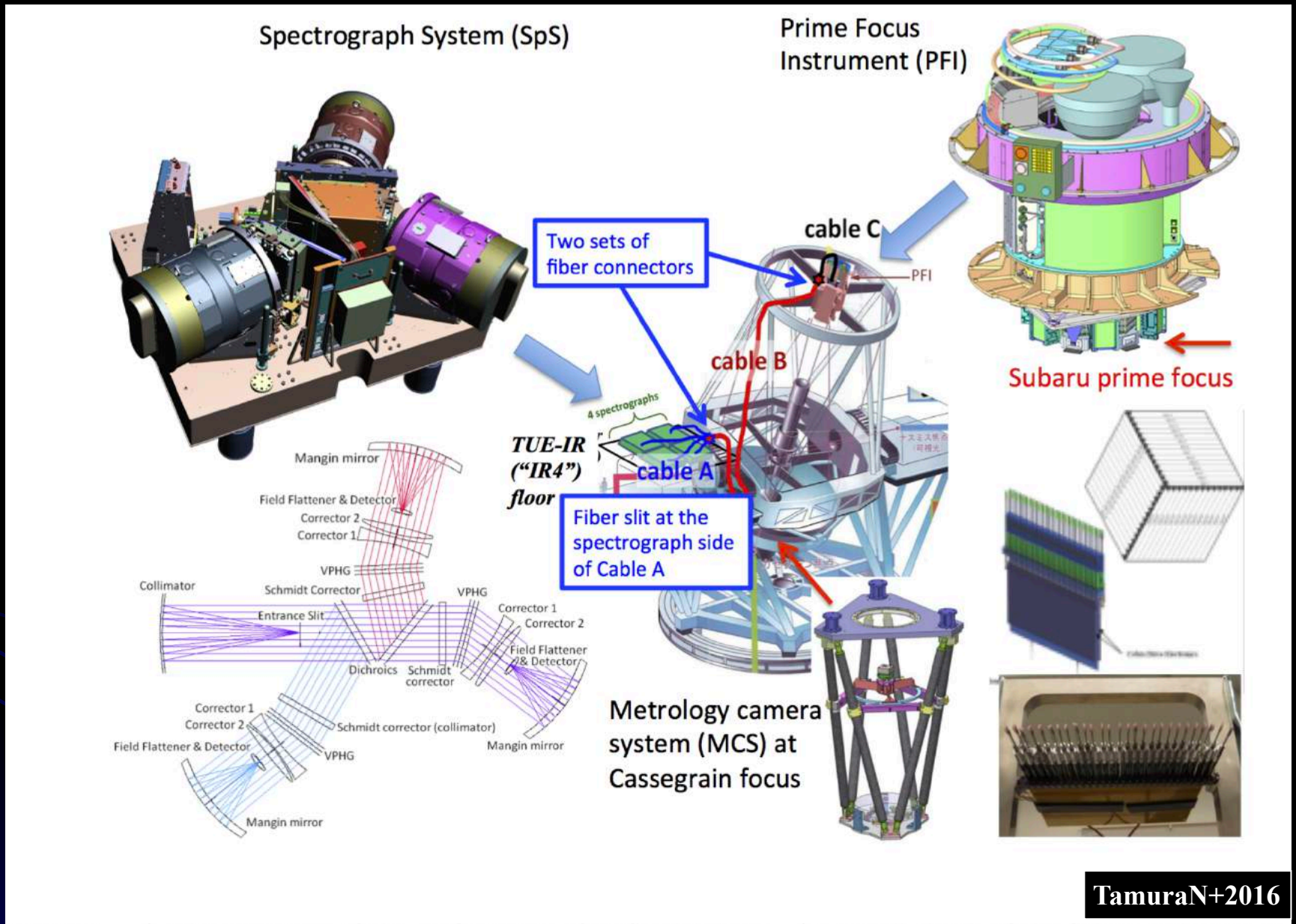
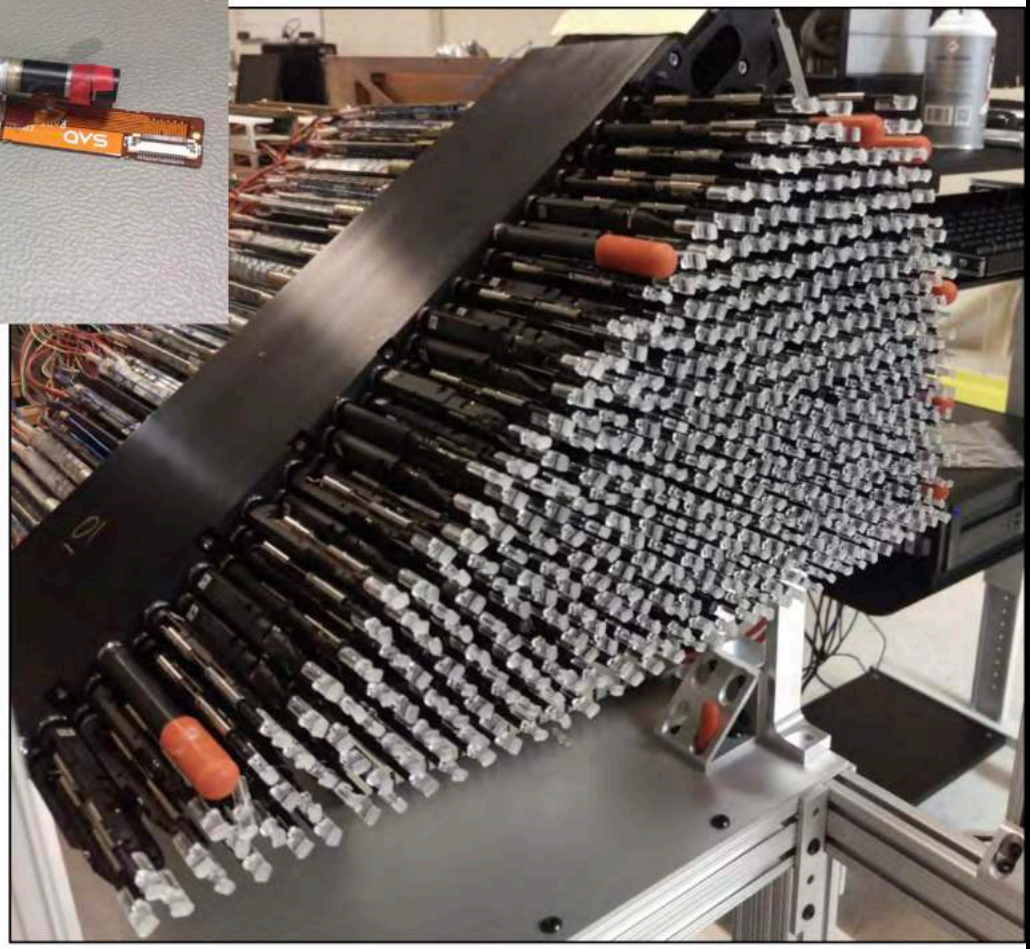
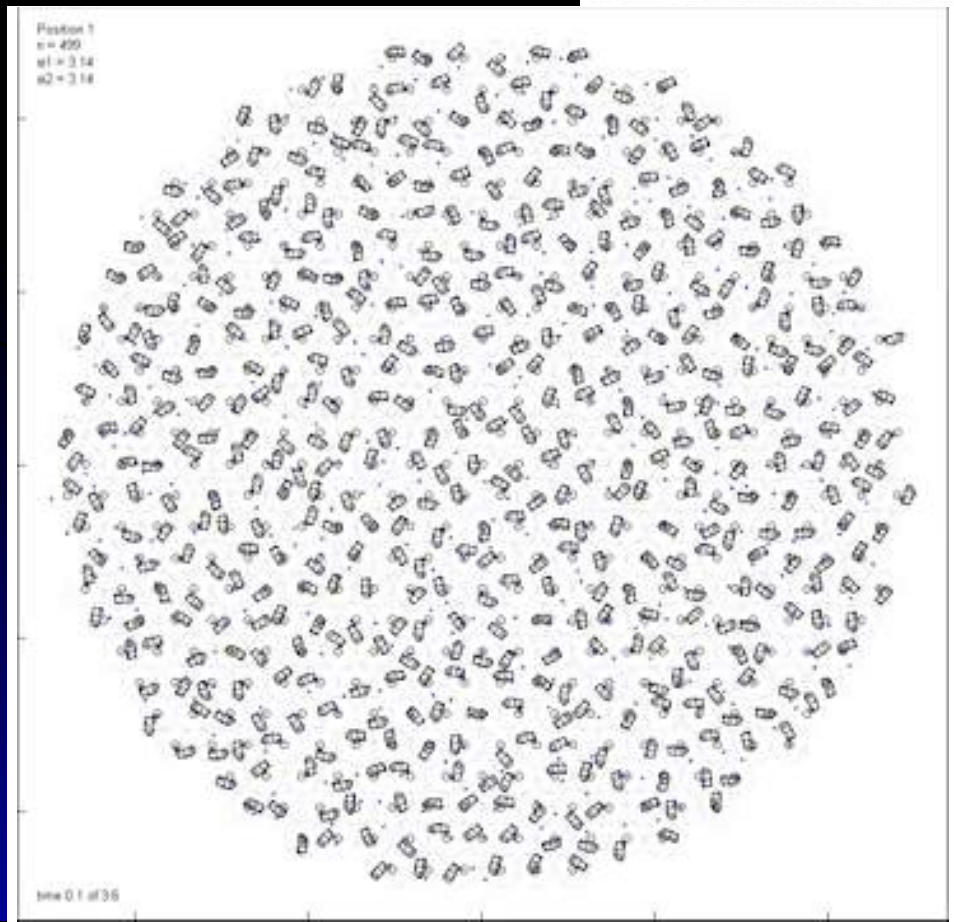


Figure 3. A schematic view of the configuration of PFS subsystems. An overall sketch of the Subaru Telescope is presented in the middle with the PFS fiber cable routed from the prime focus to the spectrograph system. On the right, a solid model of PFI (top), a schematic view of the focal plane (middle), and a photo of the Cobra engineering model fiber positioners module are presented. On the left, a solid model of one spectrograph module (top) and a ray-trace view of it (bottom) are shown.

MOS: Fiber Positioner





DESI

KMTNet

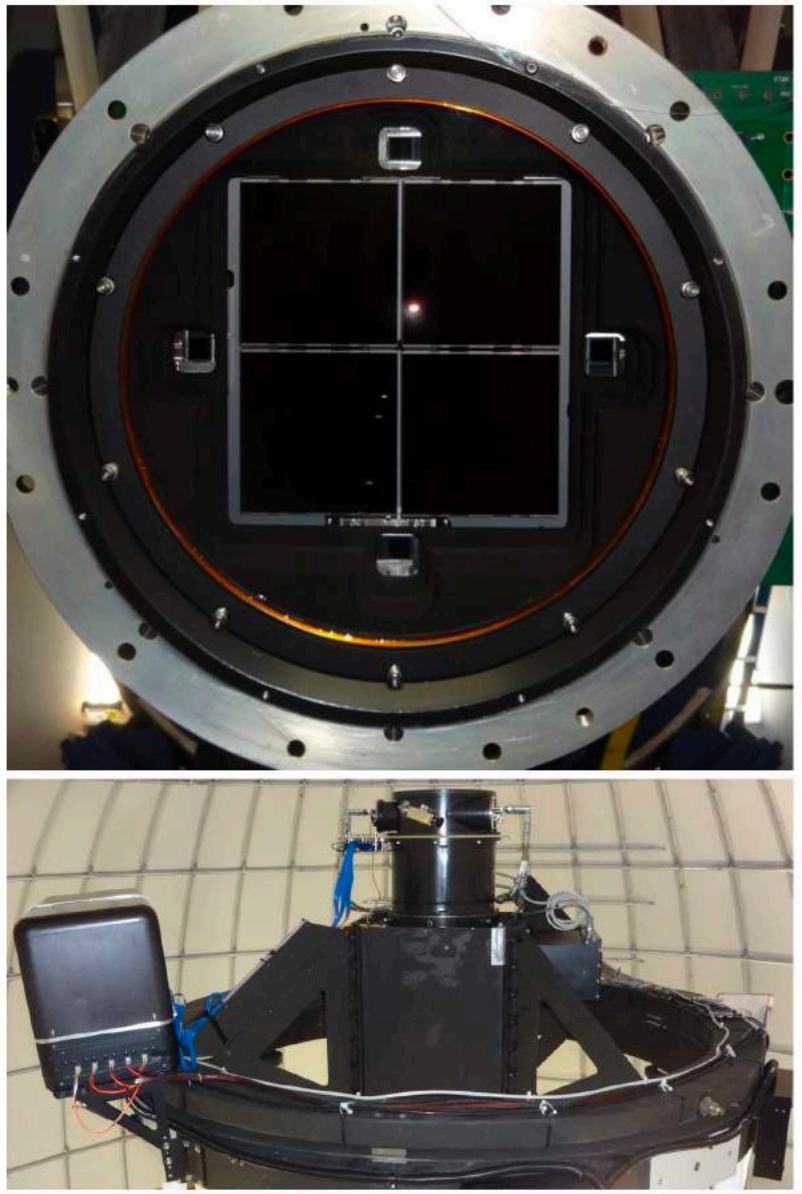


Figure 4. (Top) The camera's focal plane assembly mounted with four mosaic science CCDs and four small guide CCDs. (Bottom) The camera attached to the KMTNet telescope at CTIO. The head electronic box is mounted on the telescope top ring, shown at the left.

What should be added to the KMTNet 1.6m telescope?

- Upring (WFC+Fiber Positioner)
  - Constraints
    - Weight: <50 kg (camera only)
    - Distance between L4 and dome: <101 cm
  - WFC (~4 억): Optical Design + Manufacture
  - Fiber Positioner: ~3.5억 (~150 fibers)
  - Fiber (50 micron = 1.6 arcsec diameter): ~45 백만원

- Spectrograph system
  - IsoPlane 160 (F/3.9, $32,300) spectrograph
  - 300 grooves grating ($1,475)
  - PIXIS-1300B detector ($74,600)
  - 2 Spectrographs (to cover Halpha)
    - 347-552nm, R=1170@450nm
    - 538-740nm, R=1700@640nm

What should be added to the KMTNet 1.6m telescope?

- Guiding system (~20 백만원)
  - Exposure: 3.3m x 3
  - 1k CCD +
    Structure (design + process (aluminum) + black anodizing)

- Metrology system (~ 30 백만원)
  - Fiber Position Monitoring system near Primary mirror

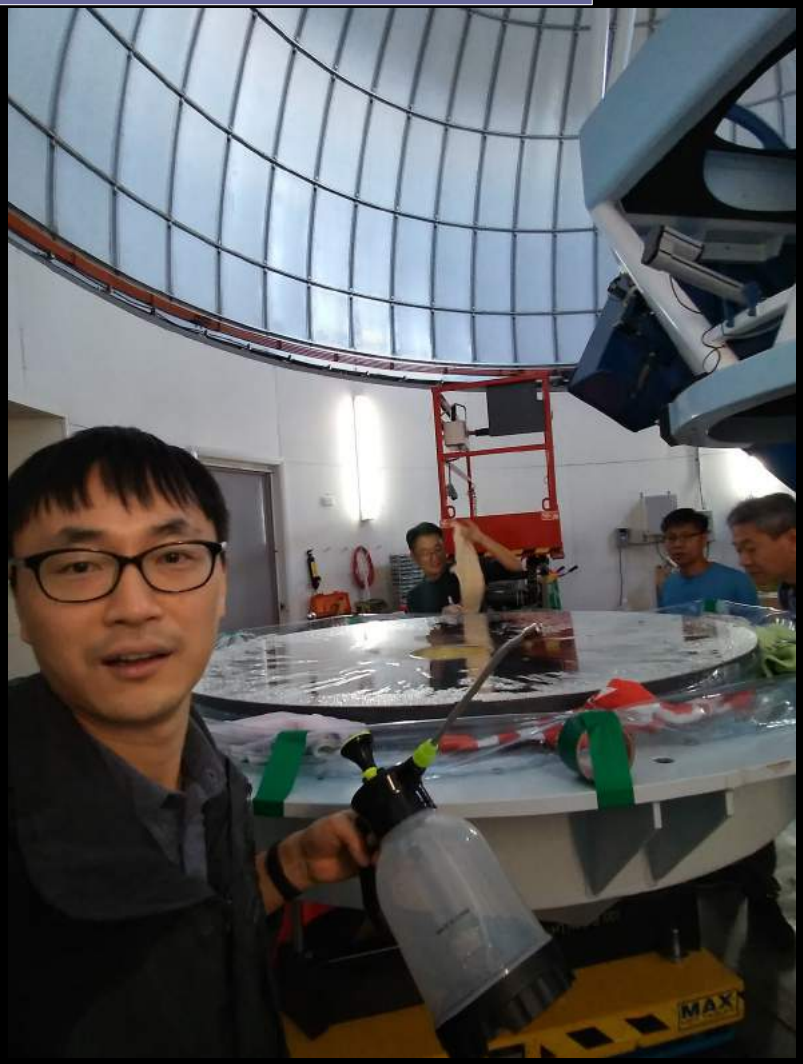
- Fiber beam splitter (for two spectrographs)

- And More….

Feb. 1-2) Seoul - Sydney - Dubbo - Coonabarabran - Siding Spring Observatory

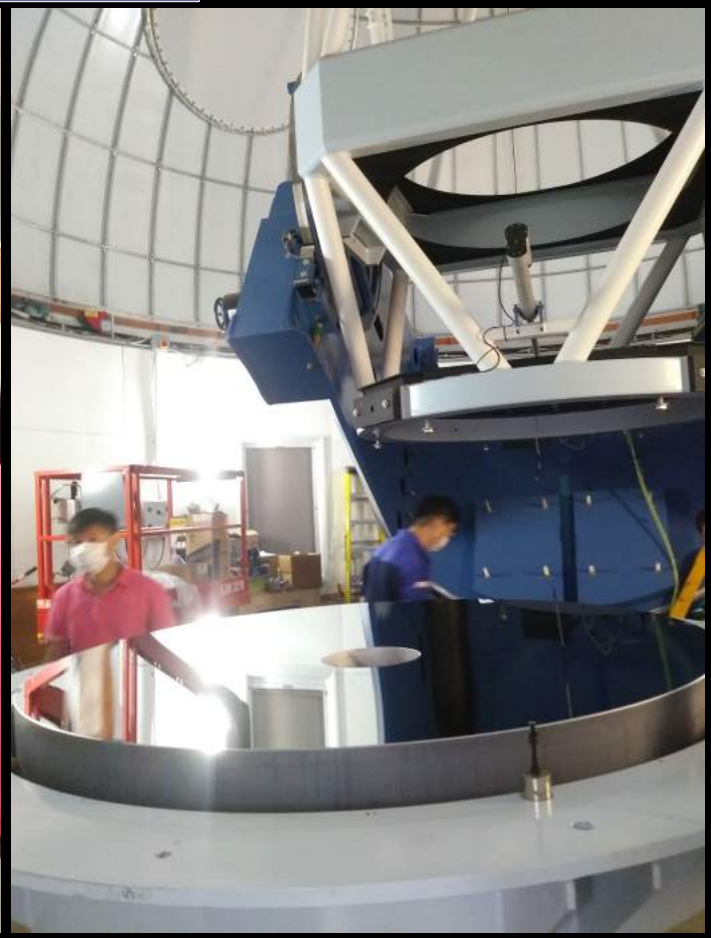
- Dubbo 공항 도착 - Hertz 렌터카
- Fortune Restaurant 에서 점심 (Yummy Hot box 굿!)

Feb. 3) KMTNet-SSO 주경 분리 및 세척 작업 테스트



- 주경 카세그레인 초점 구멍으로 배수호수 설치중
- 물 분무기로 1차 세척 중

Feb. 5) 주경 코팅 확인 및 설치, 분광기 설치를 위한 측정



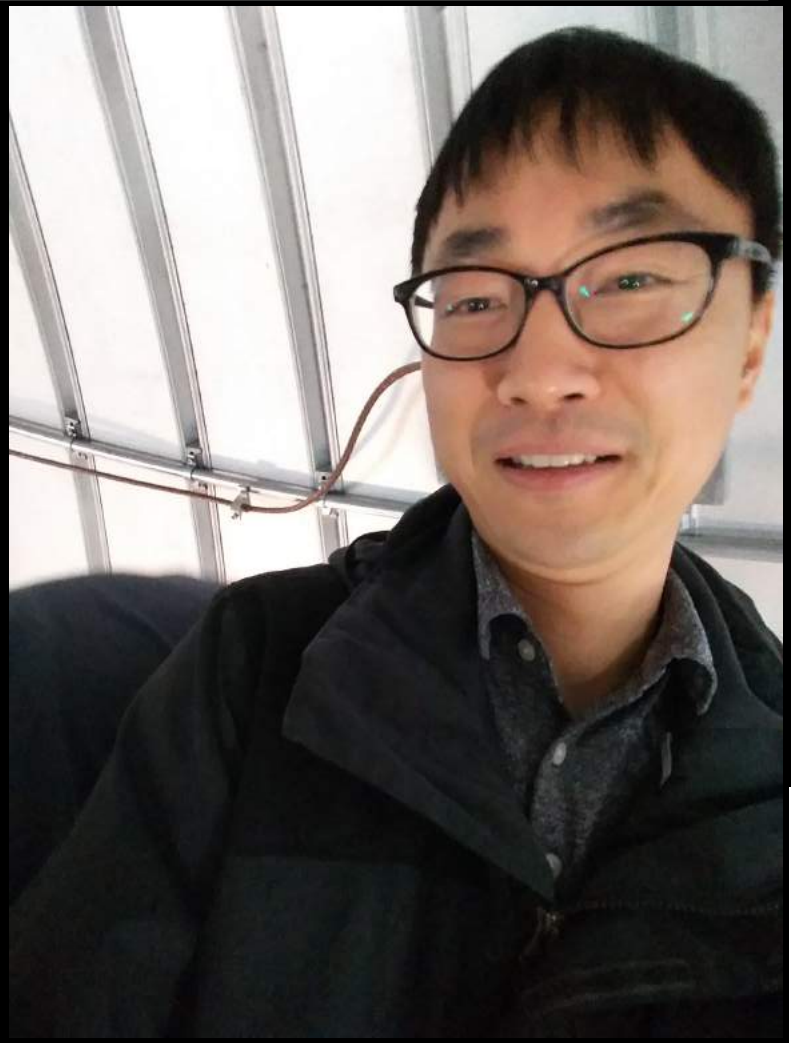
- 코팅 완료 후 반사율 측정하는 Shane (84-85% 나옴)
- 주경 눕혀 놓고, 예전에 생긴 crack 퍼지지 않도록 Sandpaper로 둥글게 갈아줌
- KMTNet 돔으로 돌아온 주경

Feb. 6) 다른 망원경 견학 및 분광기 설치(길이) 테스트

➢ CCD 끝단에서 돔까지의 거리 (망원경 30도 정도 눕혔을때): 돔 올라가는 프레임까지: 59 cm, 돔 끝단까지는 69 cm

➢ 이 결과, L4부터 돔까지의 거리(망원경 30도 정도 눕혔을 때): 47 + 59 cm = 106 cm

Feb. 5) 주경 코팅 확인 및 설치, 분광기 설치를 위한 측정



➢ 측정을 위해 8m 높으로 Skyjack 타고 올라옴…

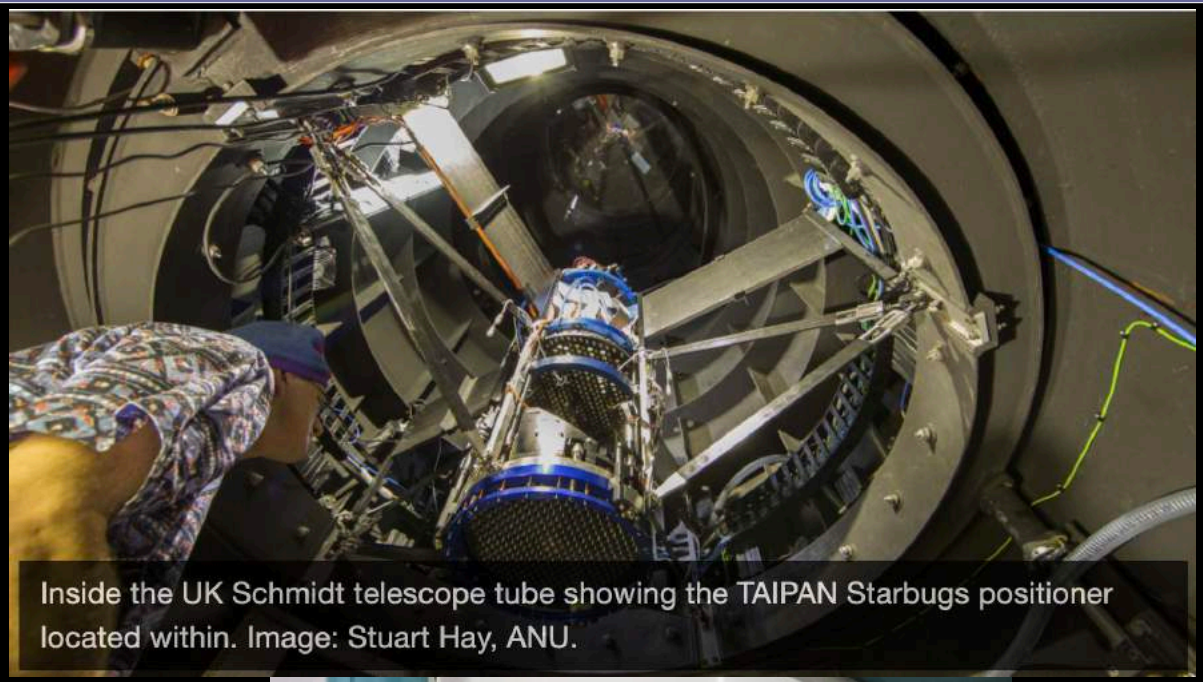
Feb. 6) 다른 망원경 견학 및 분광기 설치(길이) 테스트

➢ CCD 끝단에 길이 54cm 짜리 박스 만들어서 (즉 L4 부터 총 길이: 101 cm - 이게 최종!) 돔에 걸리는 지 테스트

Feb. 6) 분광기 설치(길이) 테스트

➢ CCD 끝단에 길이 54cm 짜리 박스 만들어서 (즉 L4 부터 총 길이: 101 cm - 이게 최종!) 돔에 걸리는 지 테스트: 안 걸림!

Feb. 6) 다른 망원경 견학 및 분광기 설치(길이) 테스트

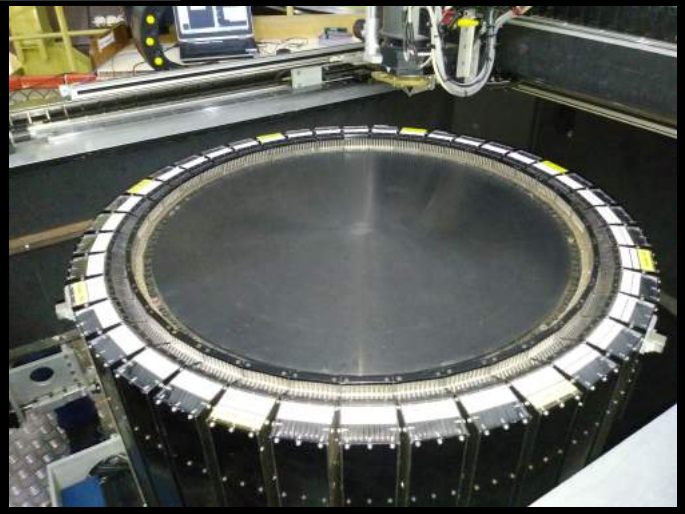


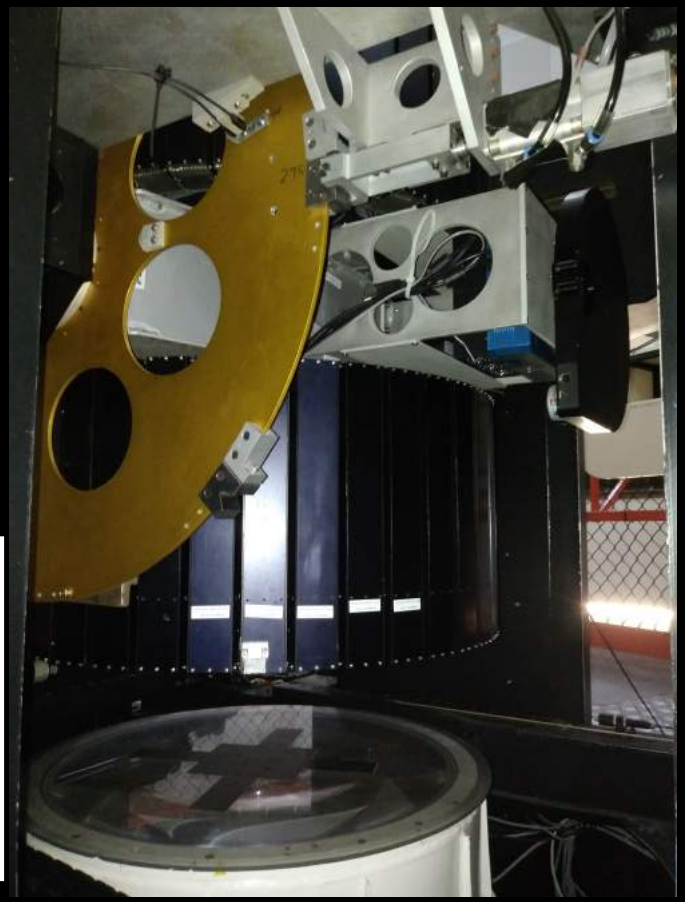
Inside the UK Schmidt telescope tube showing the TAIPAN Starbugs positioner located within. Image: Stuart Hay, ANU.

➢ TAIPAN survey 하고 있는 1.2m (위쪽 aperture 크기, 아래쪽 주경은 1.8m) UK Schmidt 망원경 (1973년 건설- DSS 남반구 유리건판 탐사, 6dFGS 등)

➢ 2020년 2월 현재까지 commissioning 단계, starbug가 유리면에 닿는 material에 문제가 있어서 새로운 material 테스트 중이라 함. 실제 탐사는 2020년 4월부터 시작할 예정이라 함.

Feb. 6) 다른 망원경 견학 및 분광기 설치(길이) 테스트





➢ 3.9m The Anglo-Australian Telescope 모습과 여러 부경의 모습

➢ 2dF fiber positioner: 황나래 박사 말대로 바로 아래 단에 fiber position system이 하나 더 있고, 그 아래 WFC가 있어서, fiber position system을 flip 하면서 관측 overhead time 줄임

For the Northern Hemisphere..

Complete 3D mapping of the Local Accelerating Universe

Korean Astronomy and Space Science Institute (KASI) Multi-Object Spectroscopic (MOS) Survey Collaboration Proposal

KASI MOS Survey Collaboration

excerpted, translated, and expanded by
Hanshin Lee (lee@astro.as.utexas.edu)
McDonald Observatory, University of Texas - Austin

N.B. This white paper contains a snapshot of some subsets of the original proposal (Dec. 2019) written by the KASI MOS survey collaboration. It is actively being updated in preparation for the final Korean government funding agency panel review sometime over the next several months. The main purpose of this white paper is, primarily, to inform the KASI's interest in engaging with the UT Astronomy and as a medium to foster collaborations in areas of wide-field MOS instrument development, survey design/execution on the Harlan J. Smith Telescope in west Texas, and development of science programs based on MOS survey data both from this particular survey as well as other existing/on-going/planned surveys. I hope that this would ultimately lead to interest, in both scientific and technical nature, among the members of the Department of Astronomy and the McDonald Observatory in participating in the collaboration at various capacities.

➢ **We need your help to make this project succeed!**

➢ **Thank you! Questions?!**