Focal Plane Hardware, Metrology System and Fiber Assignment Algorithm

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in S.N.U. Astronomy

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In 2006/2007…

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SPM-TWIN TELESCOPES: PROJECT OVERVIEW

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

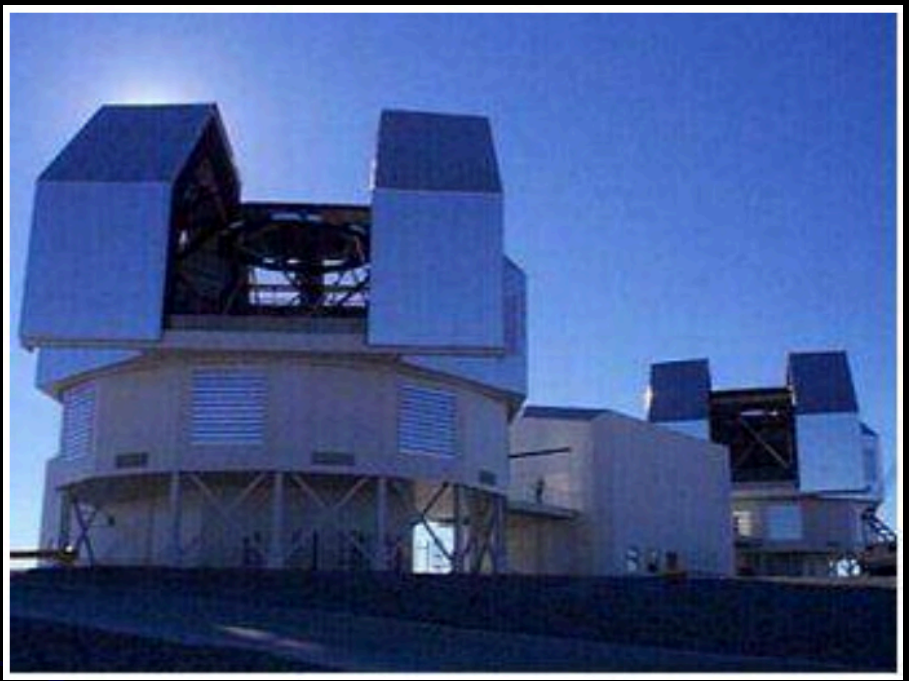


TABLE 1

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

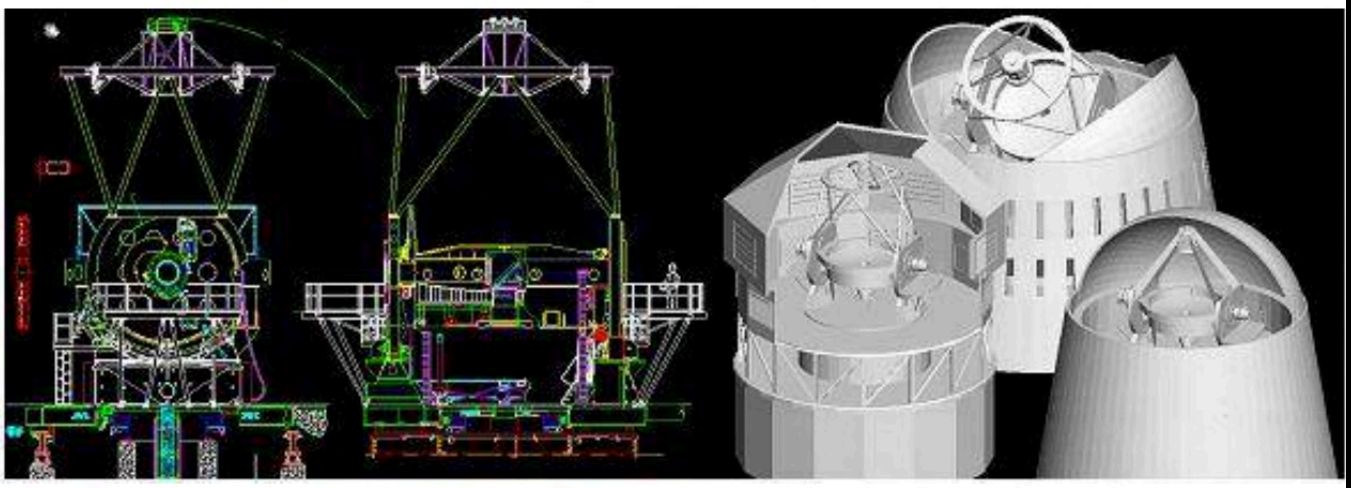


Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

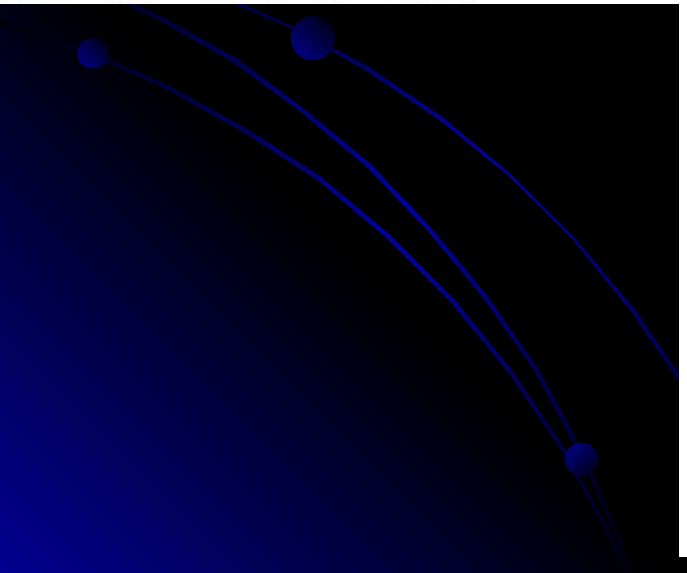
Main

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)



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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 ~)

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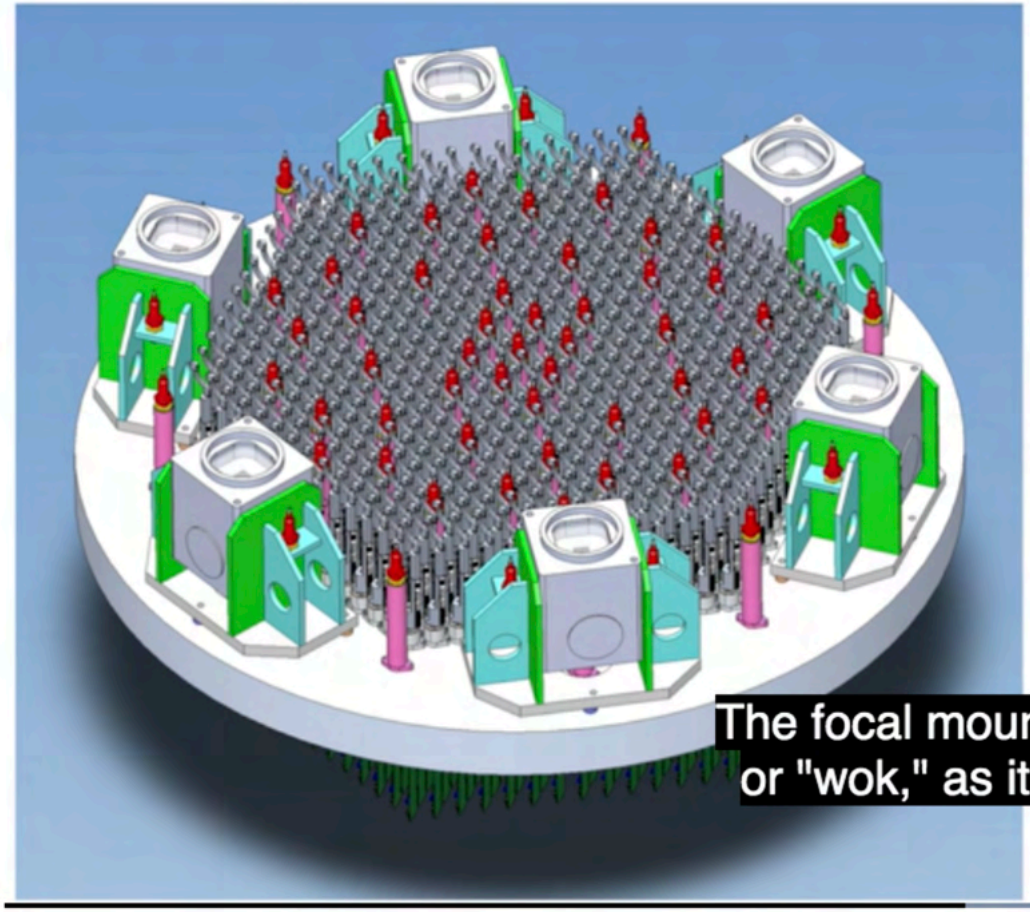
Session VII. Local and Nearby Universe (*Chair: Hong Bae Ann*)	
10:45 – 11:00	Sungsoo S. Kim (KHU): ^{3}He Distribution on the Lunar Surface
11:00 – 11:15	Ho Seong Hwang (KASI): Complete 3D Mapping of the Local Accelerating Universe
11:15 – 11:25	Ho-Gyu Lee (KASI): MOS Stellar Survey
11:25 – 11:40	Jongwan Ko (KASI): CLEVOR's Activities to Explore the Low Surface Brightness Universe
11:40 – 11:50	Yun Hee Lee (KNU): Bar Classification based on the Potential Map
11:50 – 12:05	Chunglee Kim (EWU): What we have been learned about NS/BH populations via GW observations?
12:05 – 12:25	Discussion
12:25 - 14:00	Lunch

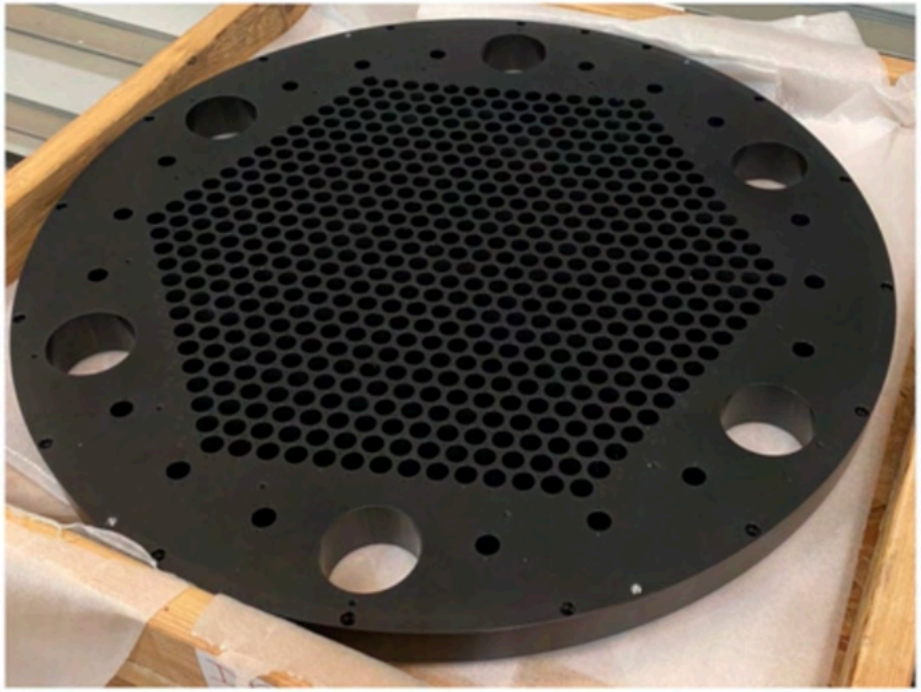
1. Focal Plance Hardware (Oh, heeyoung; Lee, Yongseok)
    1. Mounting Plate
    2. Cage for the Fiber Positioner System
2. Metrology System (Kim, Dongkok)
3. Fiber Assignment Algorithm (Kwon, Min Sung; Lee, Jong Chul)

1-1. Mounting Plate

Reference example: SDSS-V

Focal Plane Mounting Plate ("wok")





The focal mounting plate, or "wok," as it's known, aspheric surface figured to ±18μm

Fabricated by Tapemation Large Precision

준비: 오희영 (천문연)

1-1. Mounting Plate

Design Concept

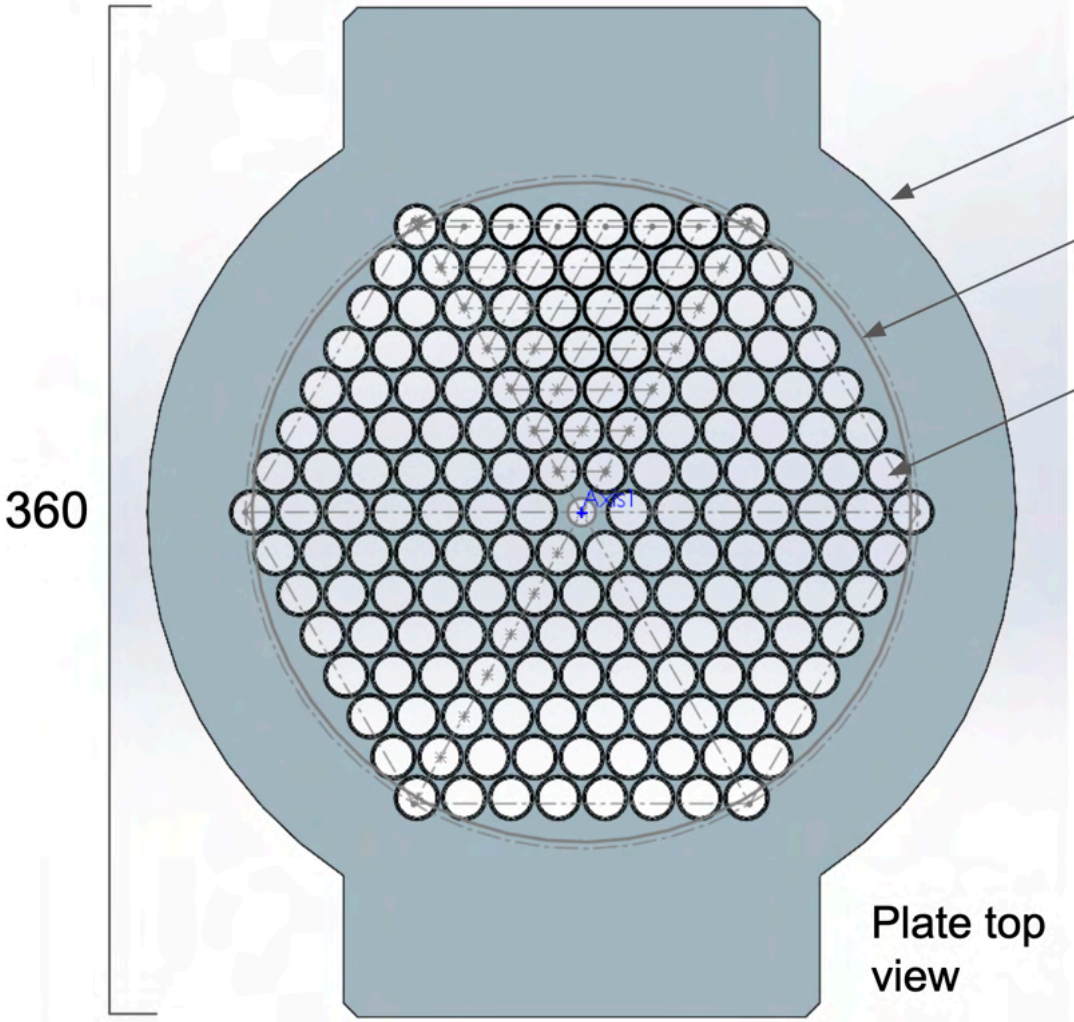


Plate top view

- 169 holes for fiber positioner + fiducials
- Central hole: possible use of guide cam?

1-1. Mounting Plate

Design Concept

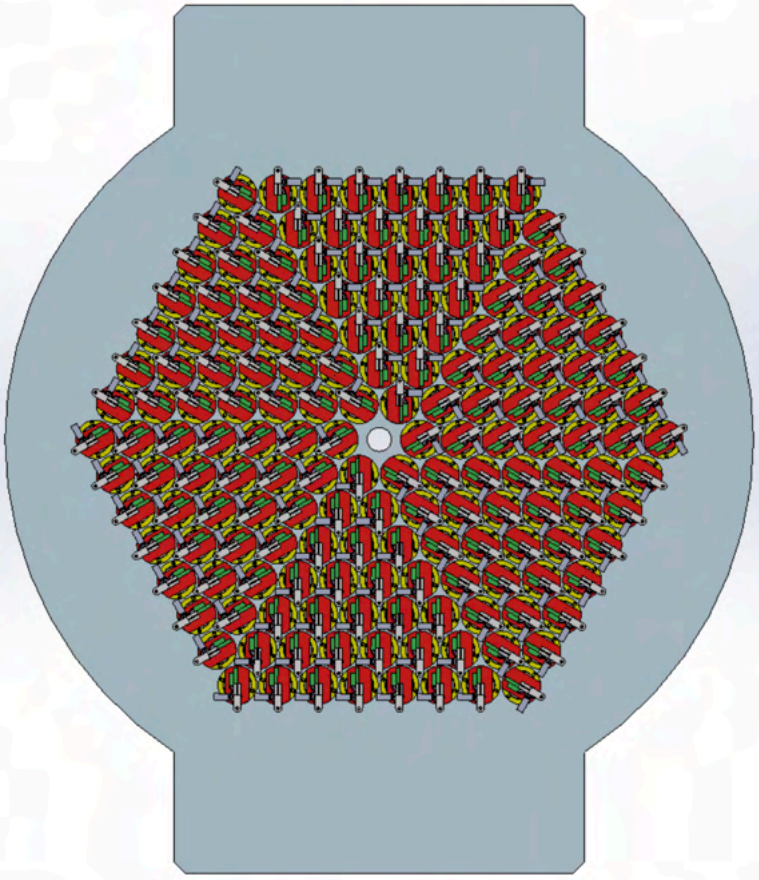
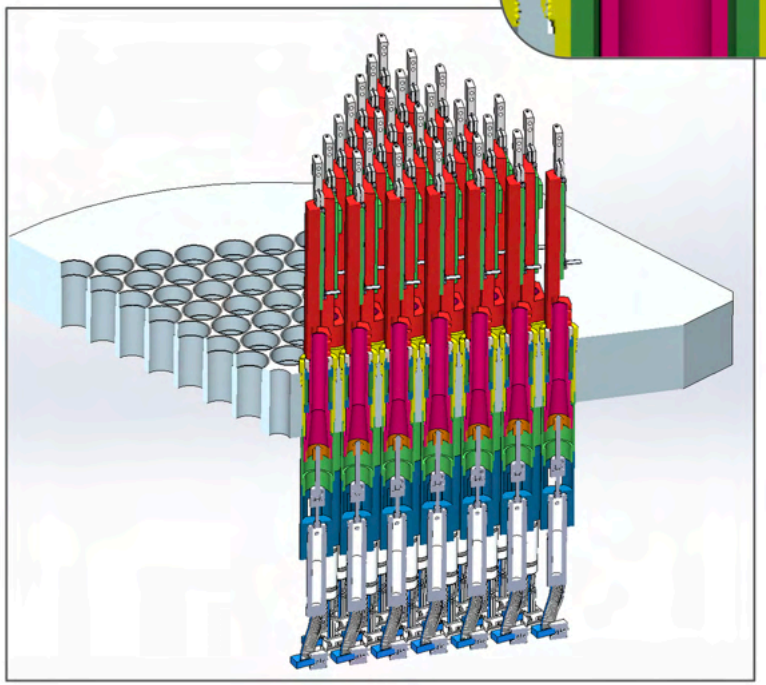
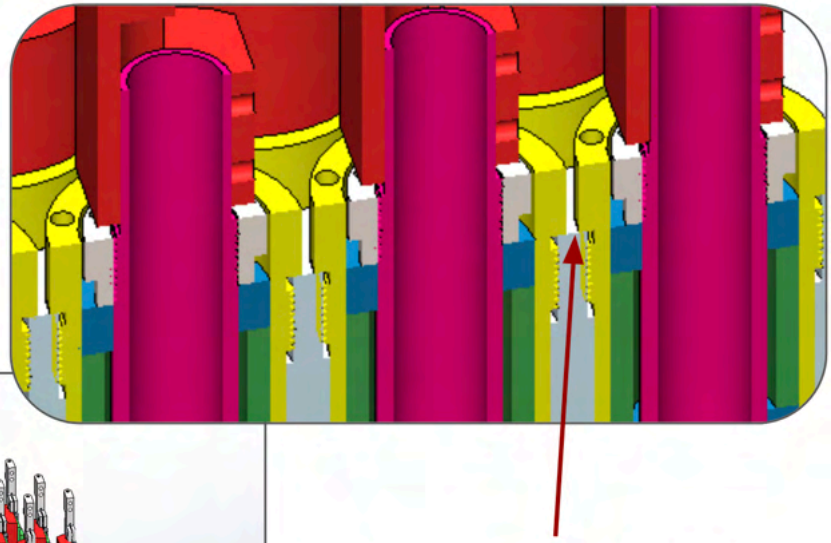


Plate + Fibers



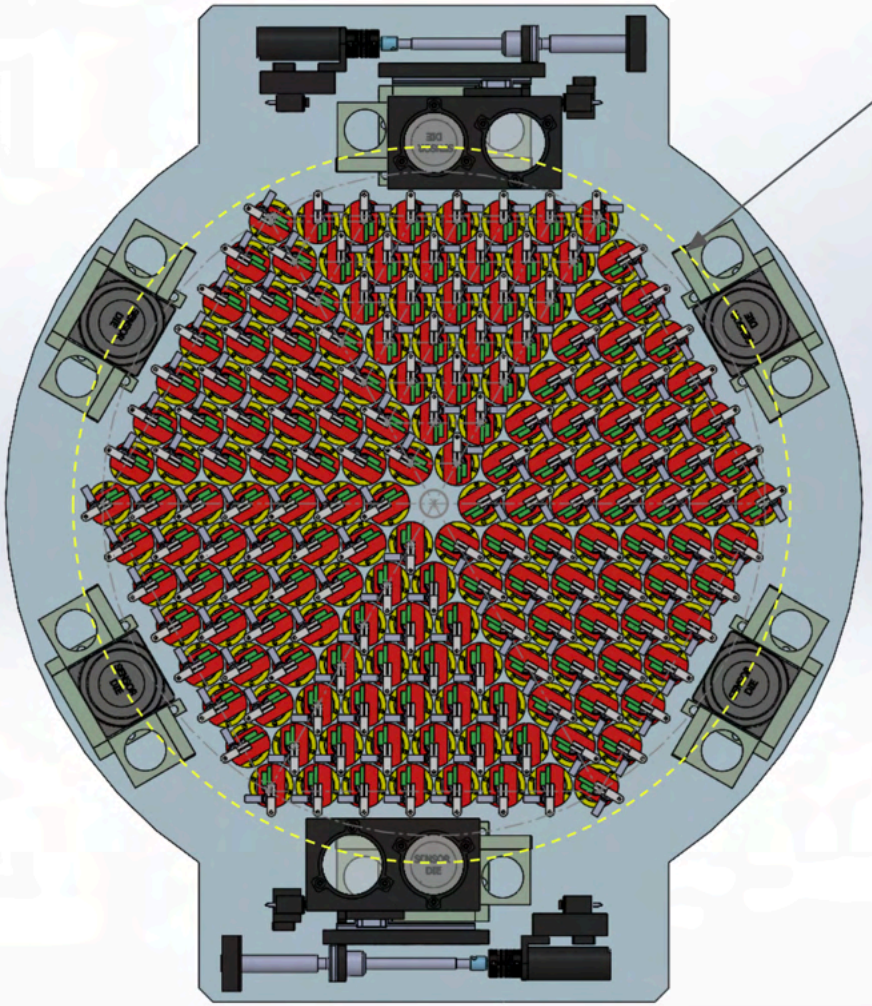


0.8mm gap between positioners

준비: 오희영 (천문연)

1-1. Mounting Plate

Design Concept



Φ 260 -- diameter of guide camera center

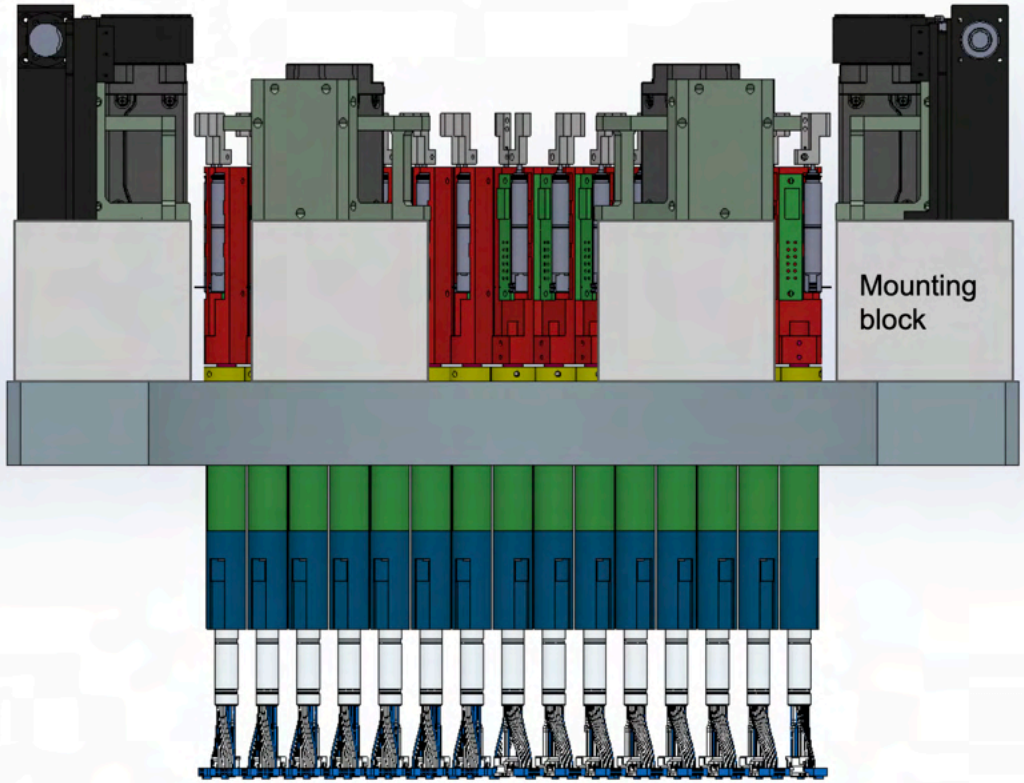
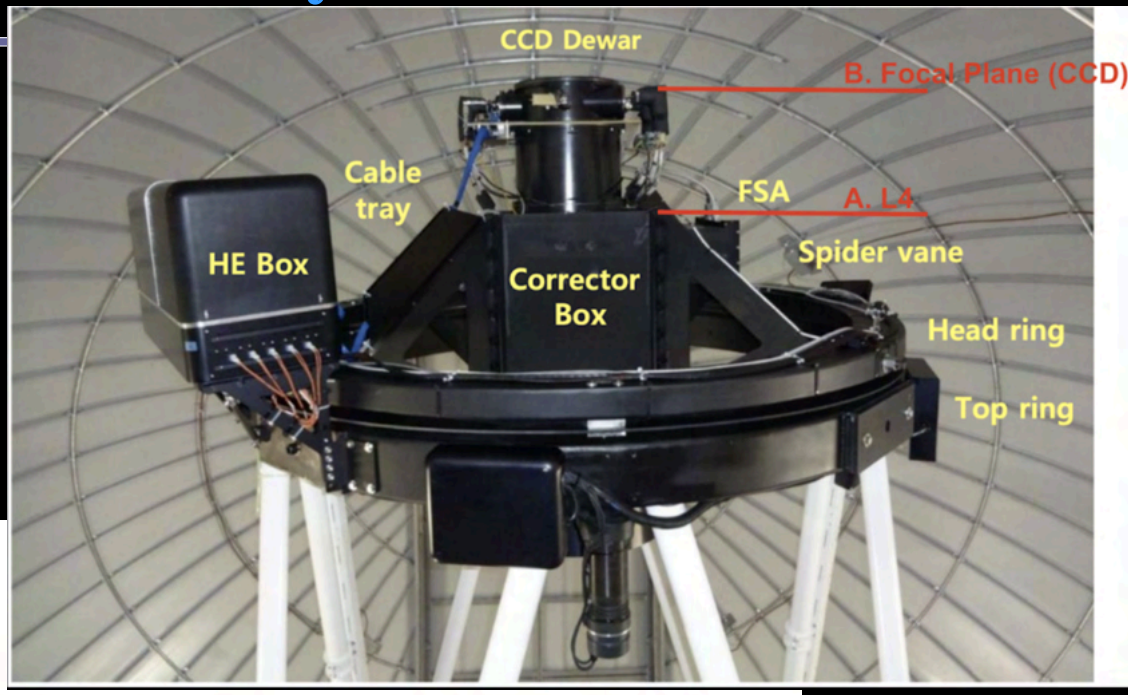


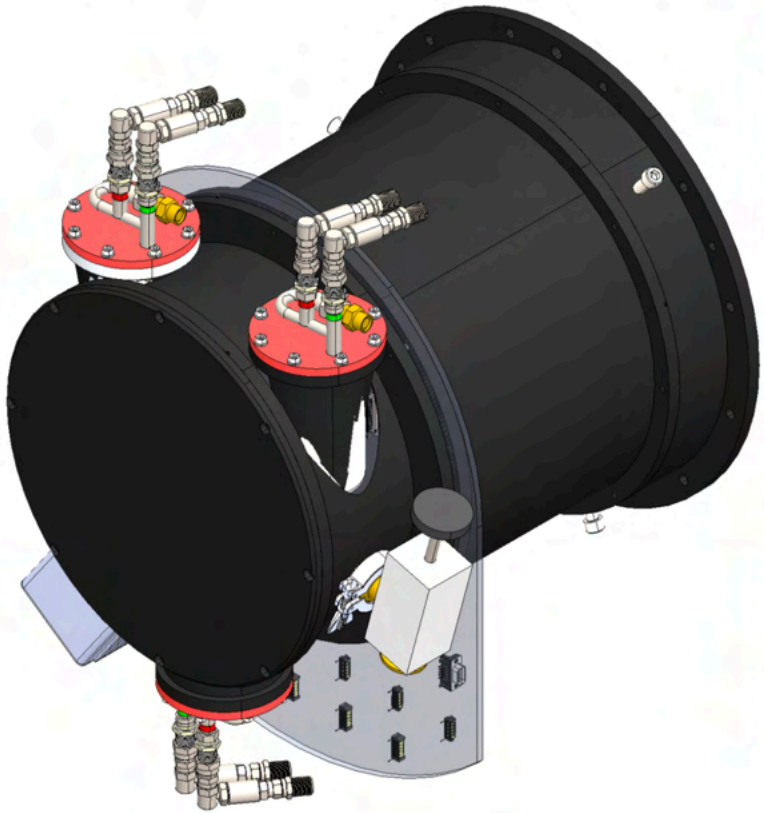
Plate + Fibers + Guide Cameras

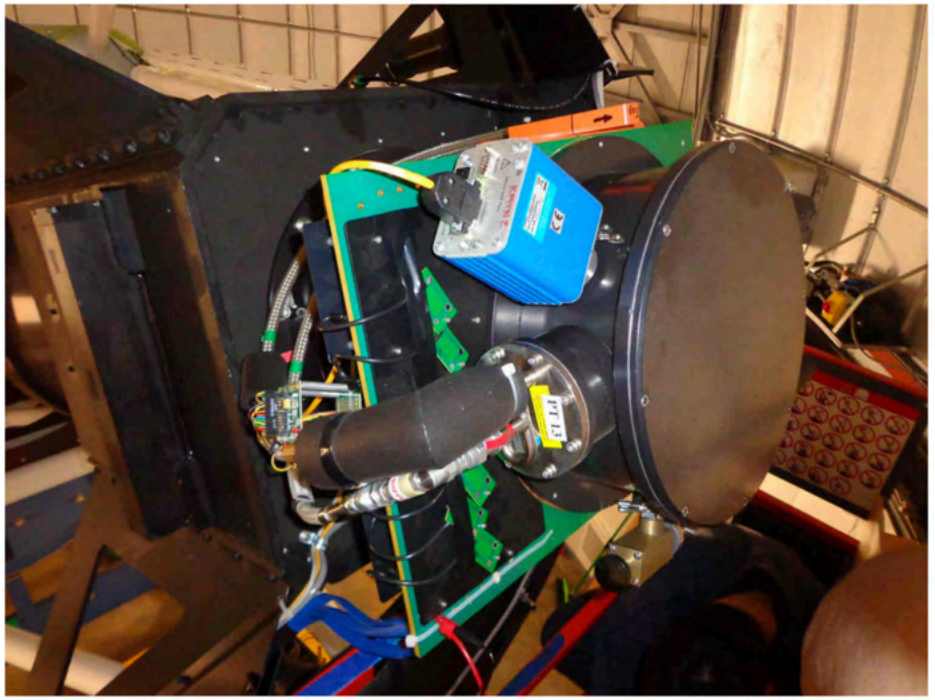
준비: 오희영 (천문연)

1-2. Cage for the Fiber Positioner System



KMTNet Science Camera



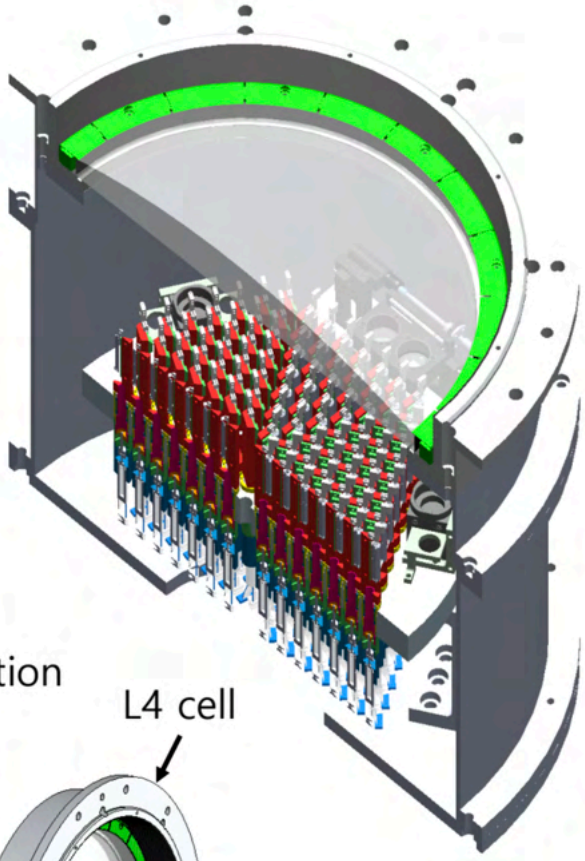


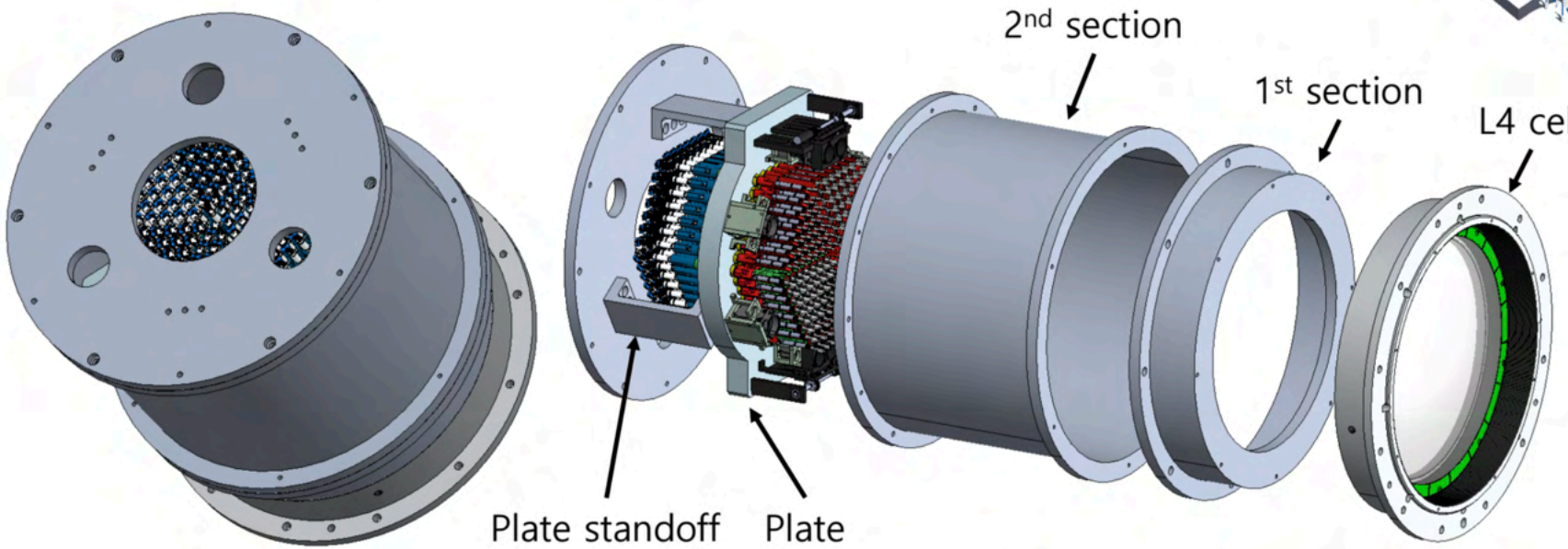
준비: 이용석 (천문연)

1-2. Cage for the Fiber Positioner System

Preliminary design

- 유지보수 편의를 위해 3개의 단으로 나누어 조립
- 후단부 plate를 통과해야 되는 fiber, power, 통신 케이블 다발의 size에 따라 hole size 변경 필요
- 내부 냉각용 열교환기가 장착될 후단부 추가 필요





2. Fiber View Camera (Metrology System)

Metrology system?

Fiber가 원하는 위치(타겟)에 잘 도달했는지 측정, 보정

① back illuminated fiber/fiducial 카메라로 촬영

② (카메라 좌표 → focal plane 좌표) 변환

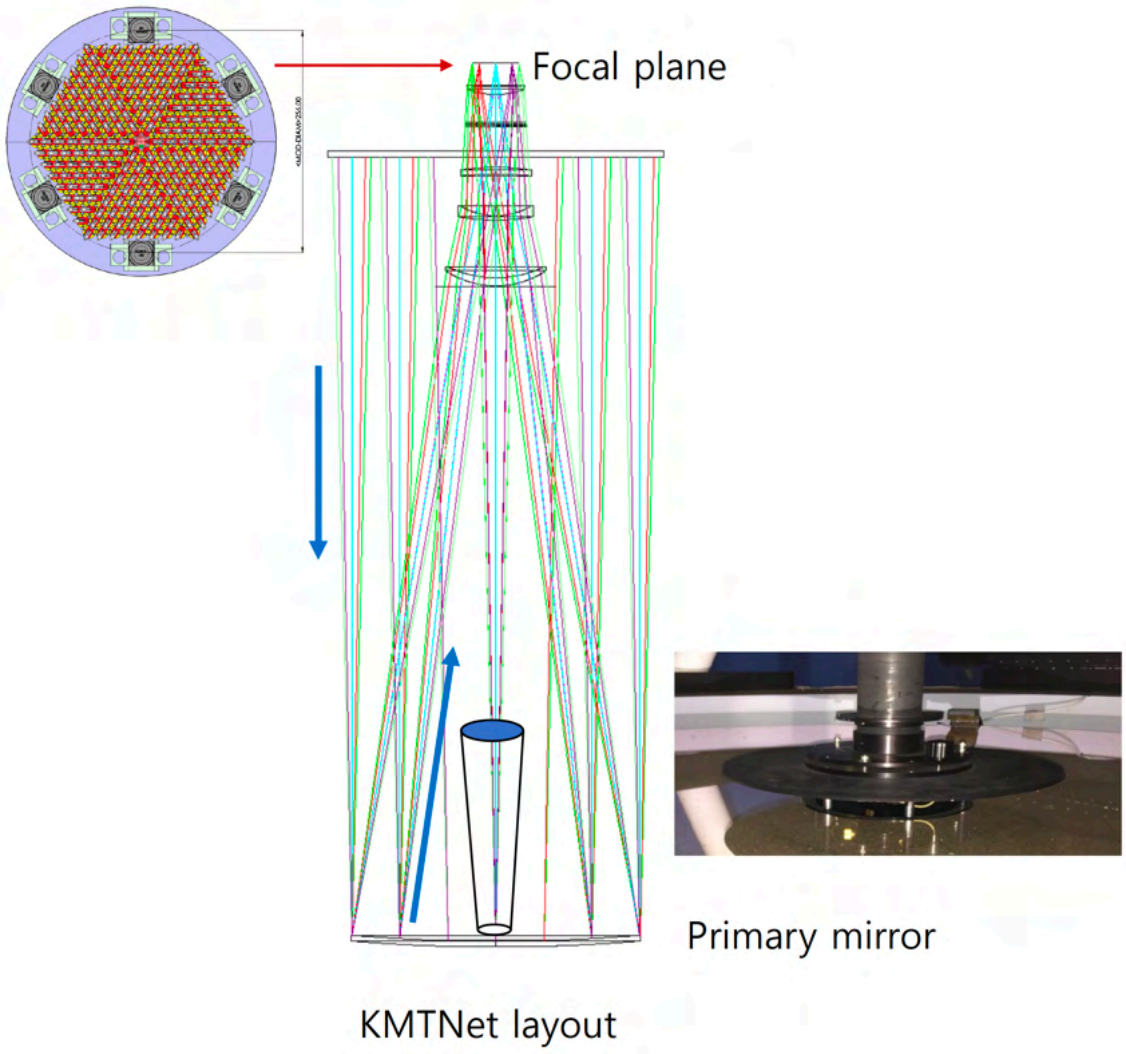
③ 위치 보정

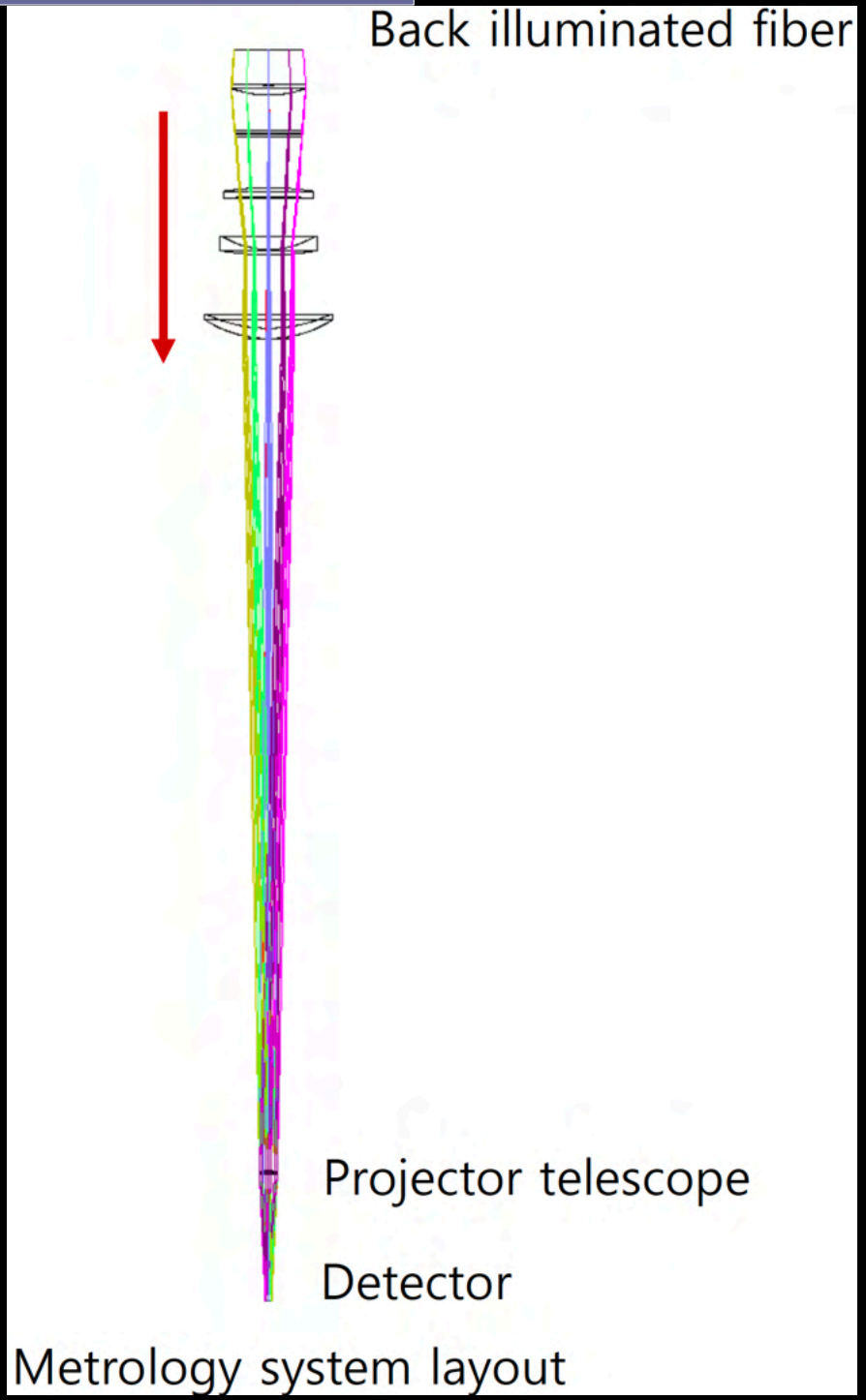
- Requirements

1. (< ~5 μm) 위치 정밀도
2. 촬영 후 위치 보정까지의 시간

준비: 김동국 (서울대)

2. Fiber View Camera (Metrology System)

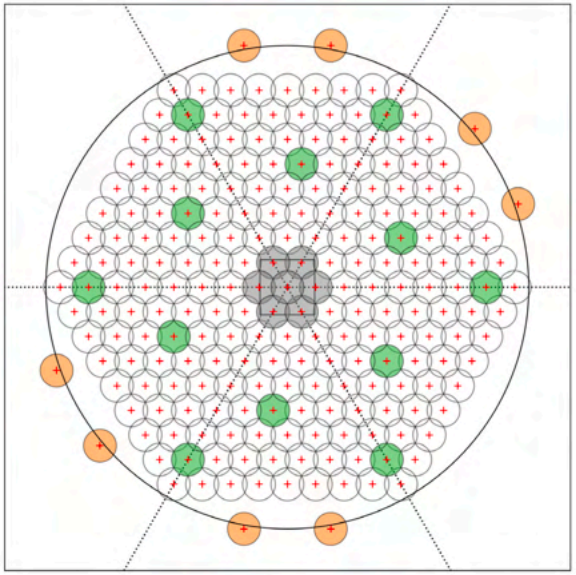




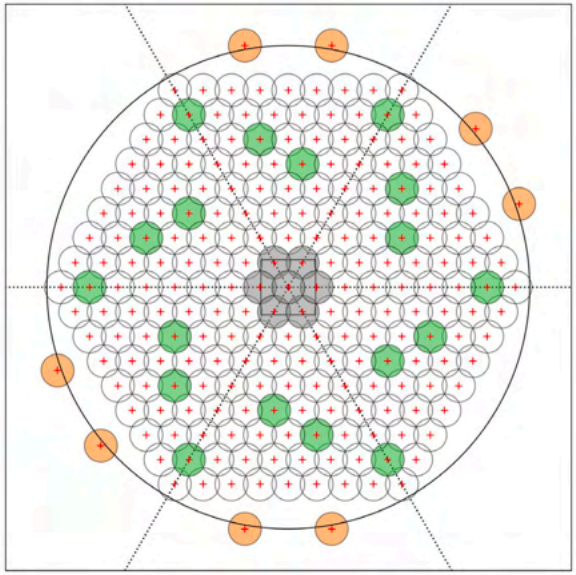
준비: 김동국 (서울대)

2. Fiber View Camera (Metrology System)

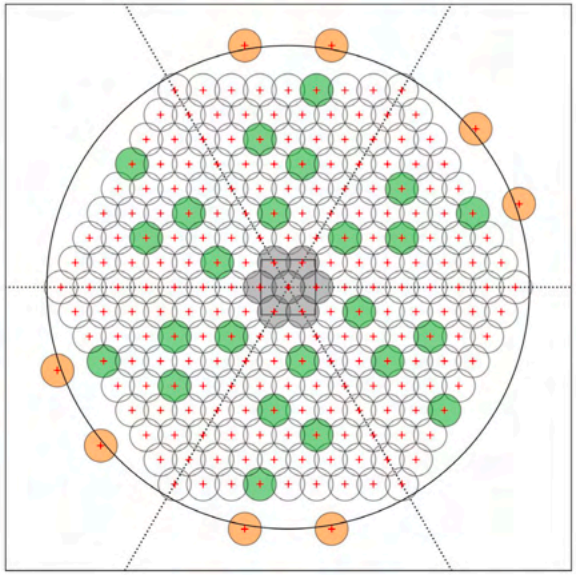
3. Fiducial configuration



(12+8)=20개



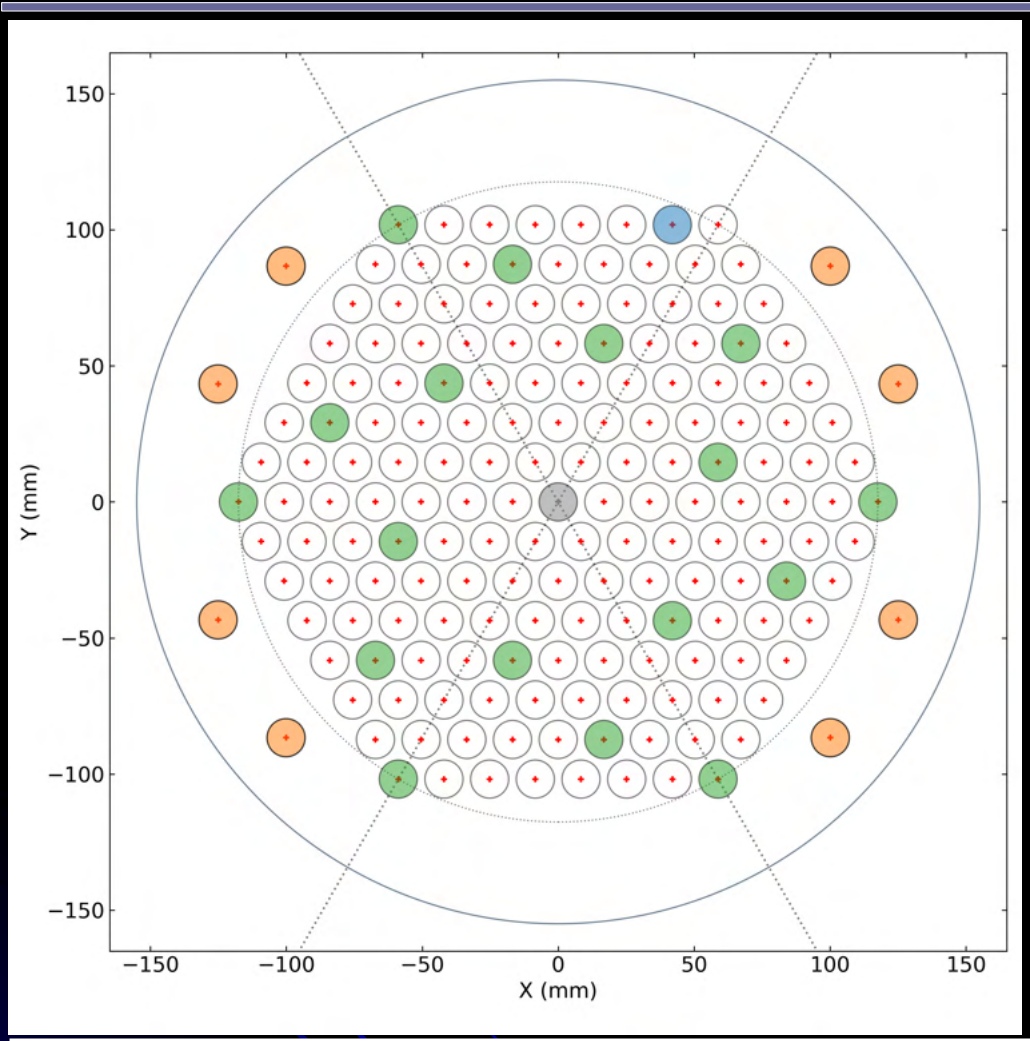
(18+8)=26개

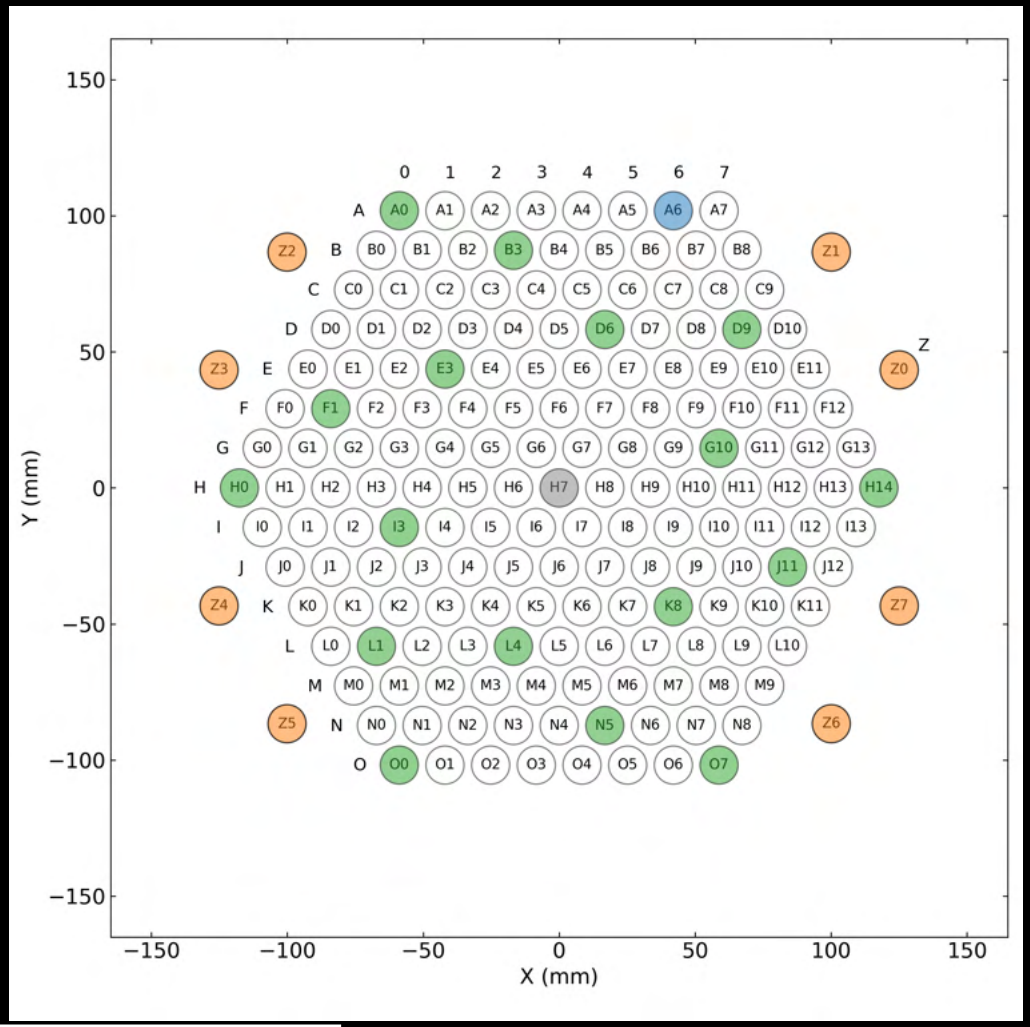


(24+8)=32개

- 정확한 위치를 알고 있는 fiducial을 이용해 distortion 측정
- Target, sky에 최대한 많은 fiber를 할당하기 위해 개수를 최소화하는 것이 목표

2. Fiber View Camera (Metrology System)



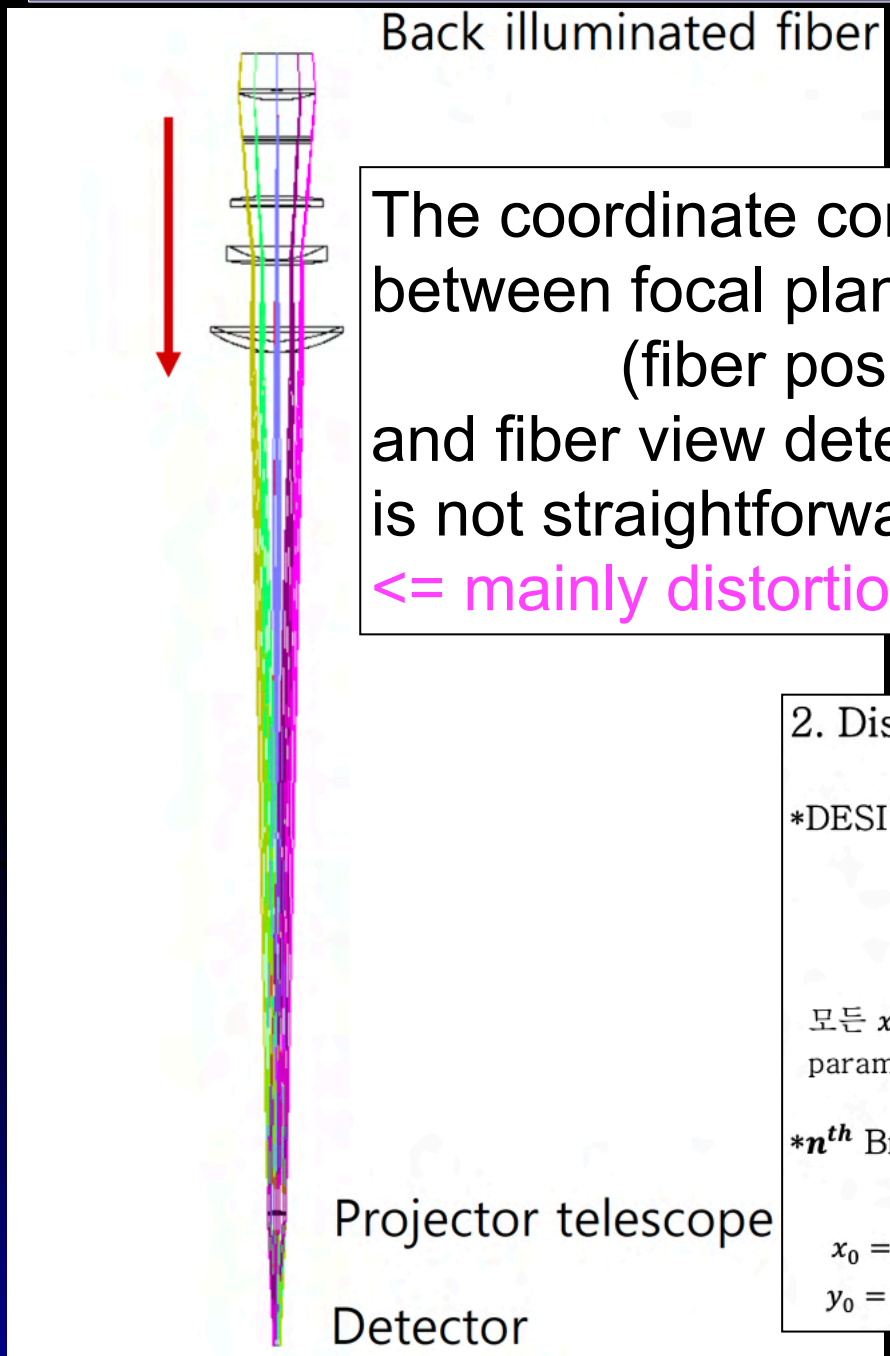


* Total number of holes: 177 (= 169 + 8)
  * Number of Fiducials: 26 (= 8 orange + 18 green/blue)
  * Number of hole used for guiding camera: 1 (gray)
  * Number of fibers for scientific observation: 150
    * For Targets: ~130
    * For Skys: ~20

준비: 김동국 (서울대)

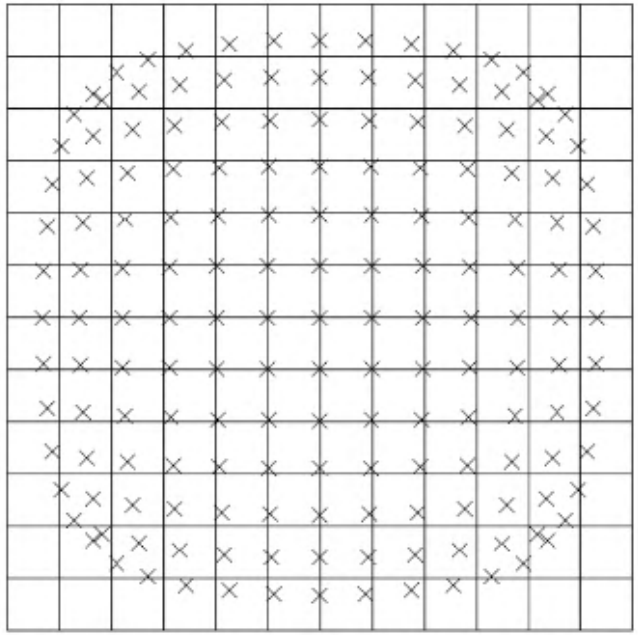
2. Fiber View Camera

준비: 김동국 (서울대)



The coordinate conversion between focal plane (fiber positioner) and fiber view detector plane is not straightforward
<= mainly distortion!

Distortion fitting



2. Distortion fitting

*DESI distortion model (cross term 모두 고려)

$$x_0 = a_{00} + (a_{10}x + a_{01}y) + (a_{20}x^2 + a_{11}xy + a_{02}y^2) + \cdots$$
$$y_0 = a_{00} + (b_{10}x + b_{01}y) + (b_{20}x^2 + b_{11}xy + b_{02}y^2) + \cdots$$

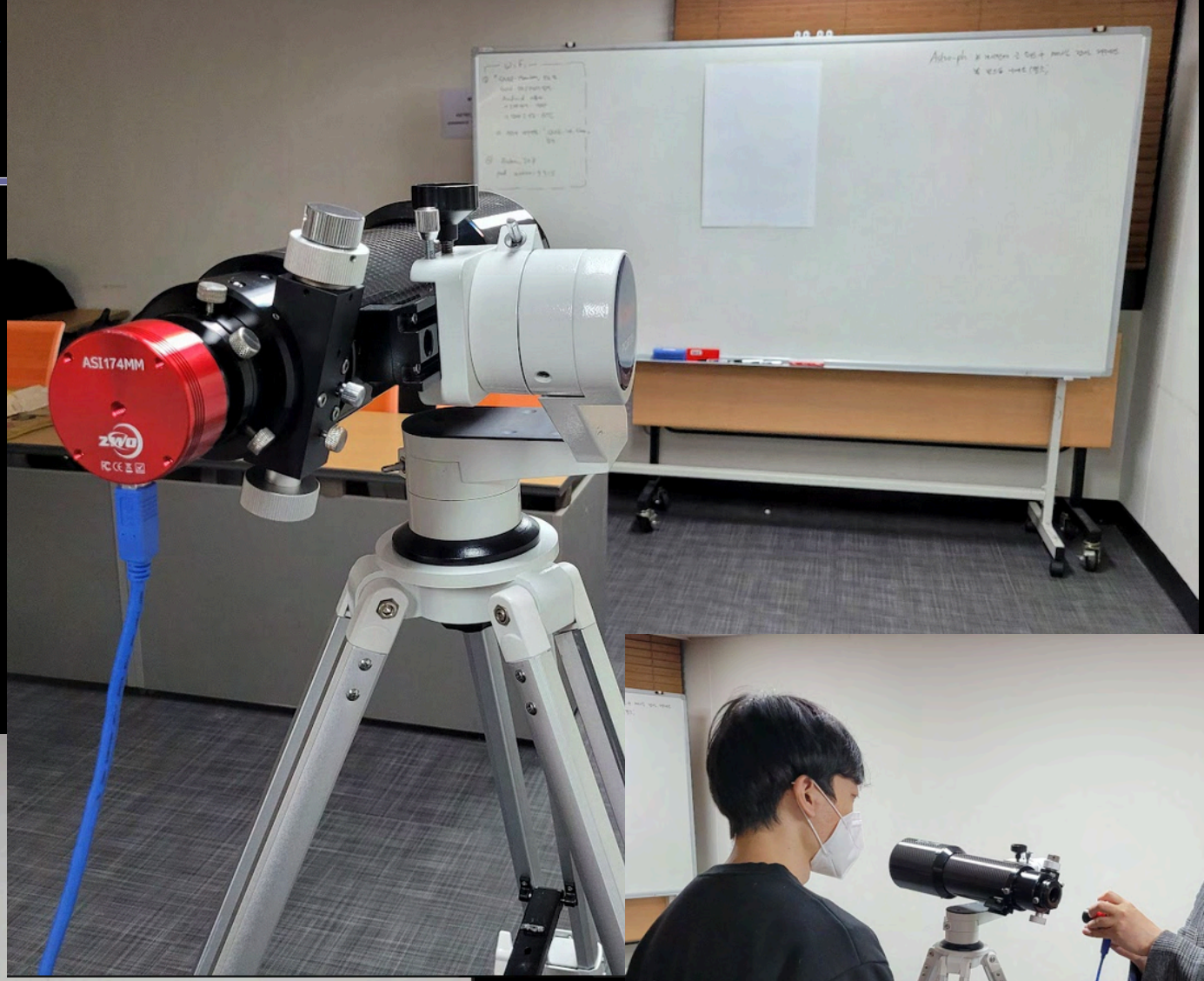
모든 $x^i y^{n-i}$ 항이 고려되지만 같은 차수 다항식일때 Brown–Conrady model에 비해 parameter 개수가 더 많음.

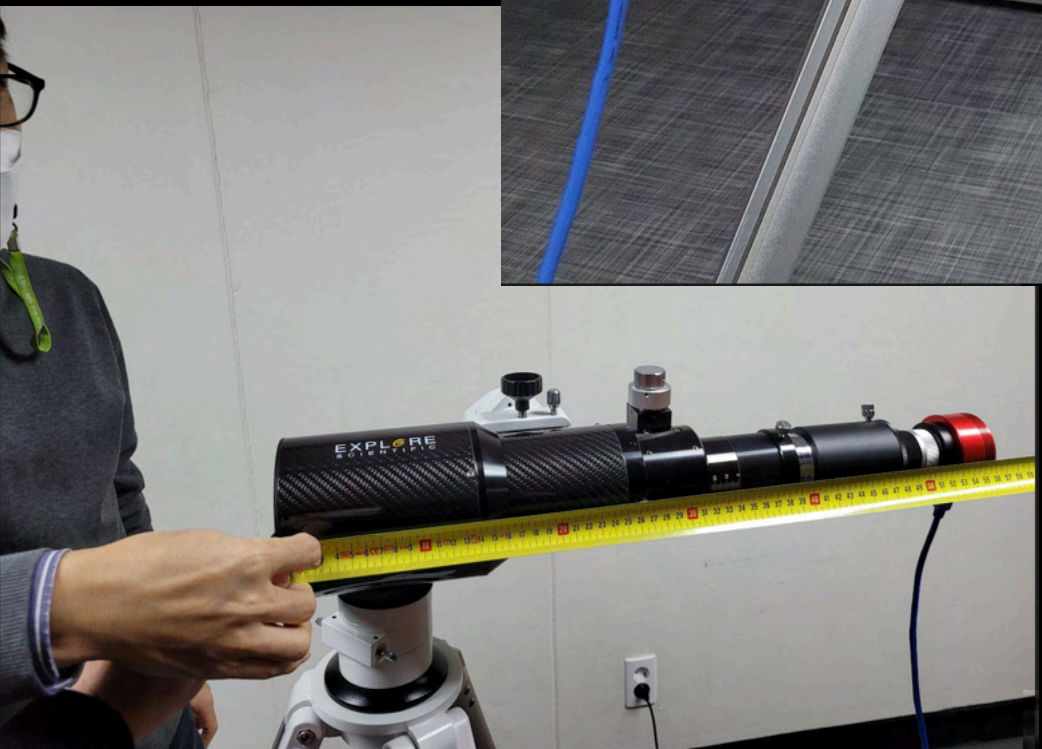
*n^{th} Brown–Conrady model

$$x_0 = x + x \cdot (k_{1x} \cdot r^2 + k_{2x} \cdot r^4 + \cdots) + [p_{1x} \cdot (r^2 + 2x^2) + 2p_{2x}xy] \cdot (1 + p_{3x} \cdot r^2 + p_{4x} \cdot r^4 + \cdots)$$
$$y_0 = y + y \cdot (k_{1y} \cdot r^2 + k_{2y} \cdot r^4 + \cdots) + [p_{1y} \cdot (r^2 + 2y^2) + 2p_{2y}xy] \cdot (1 + p_{3y} \cdot r^2 + p_{4y} \cdot r^4 + \cdots)$$

2. Fiber View Camera

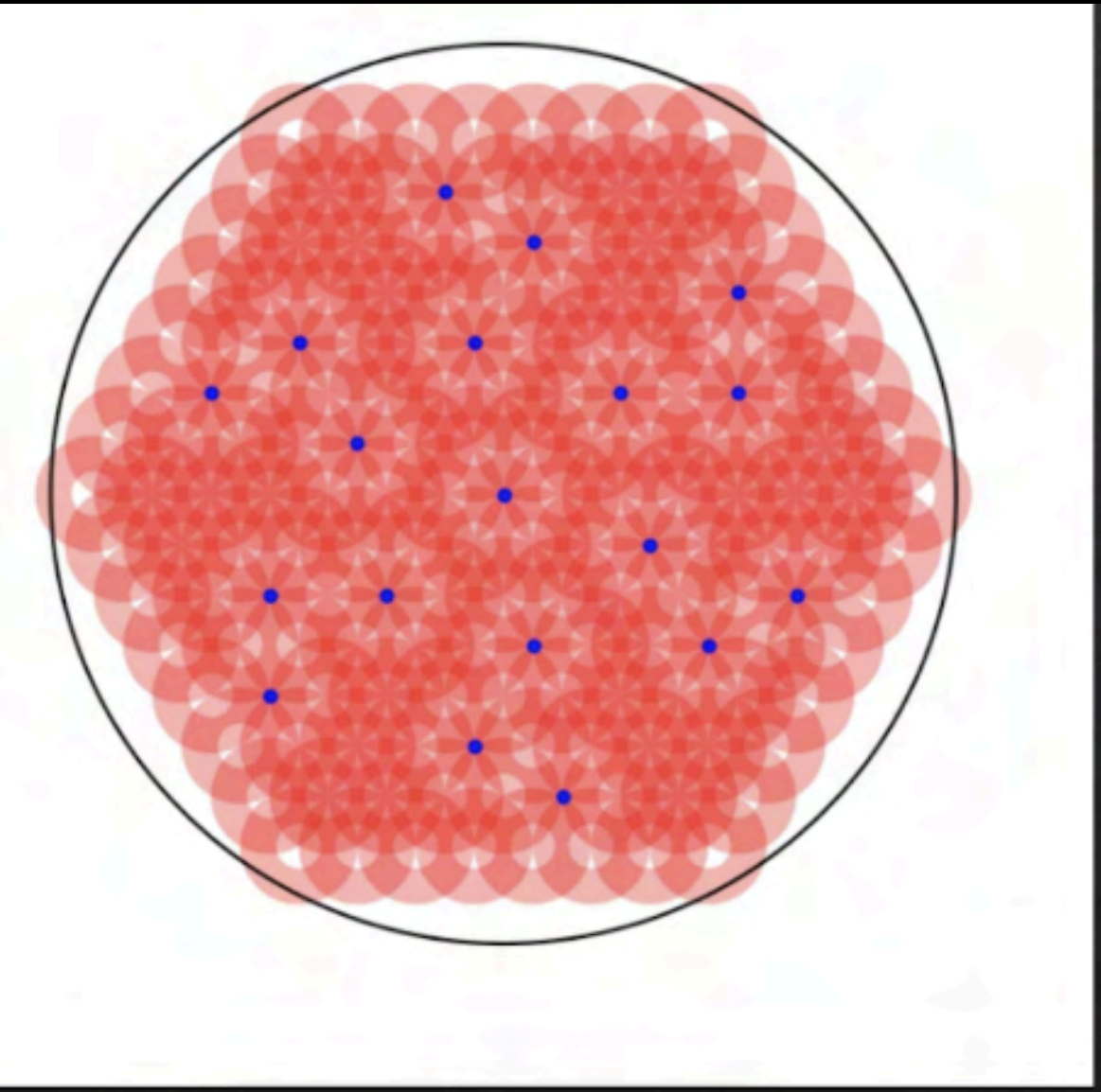
준비: 김동국 (서울대)





3. Fiber Assignment Algorithm

준비: 권민성 (서울대)

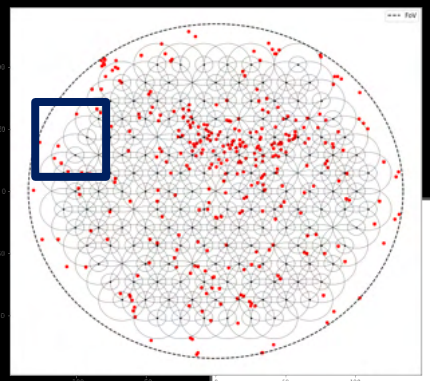


	extn
FoV diameter	260 mm
pitch	16.8
α arm	5.2
β arm	11.6
patrol radius	6.4-16.8

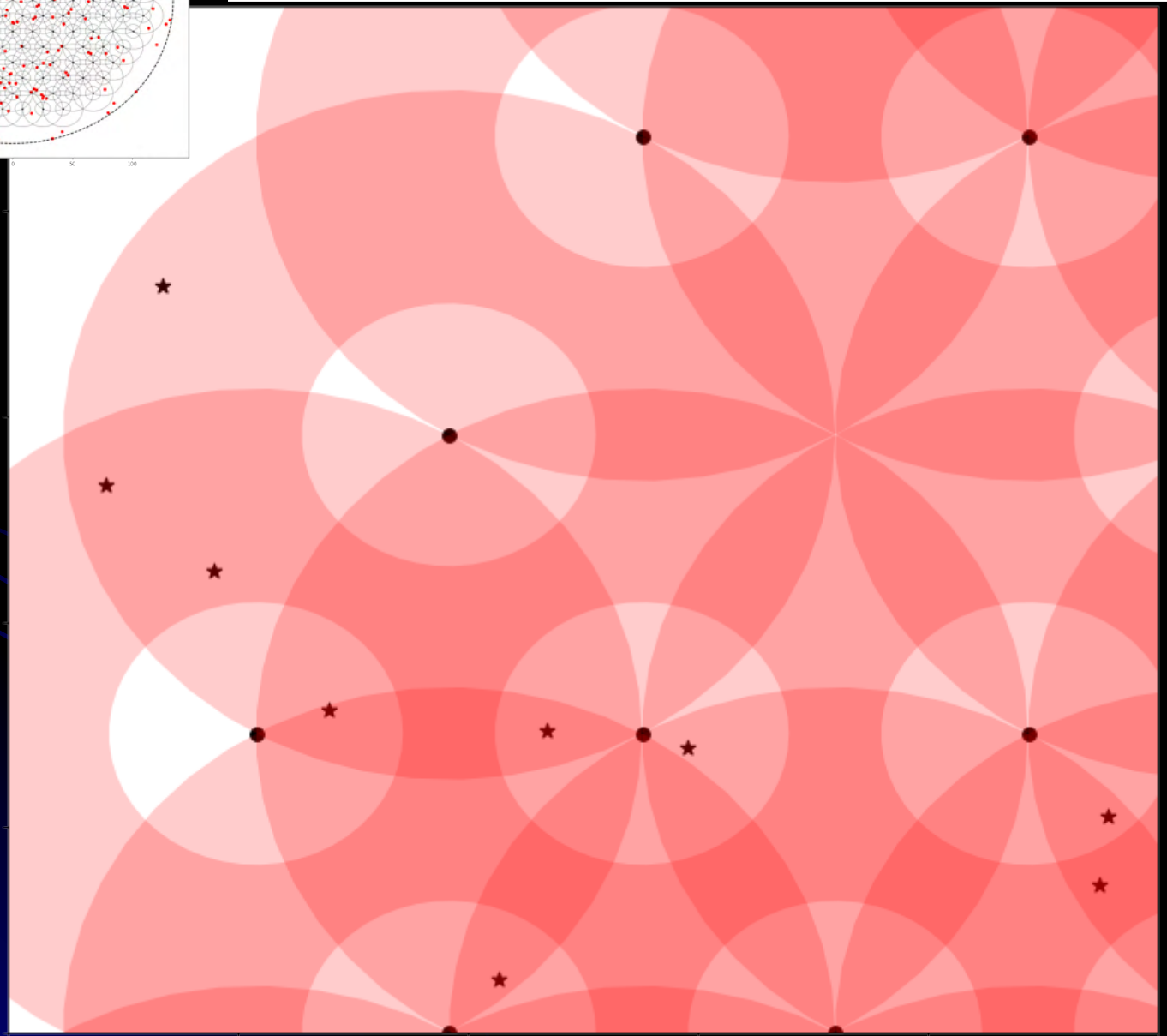
- 19 fiducial
- 20 Sky fiber
- Minimum distance (3mm)

3. Fiber Assignment Algorithm

준비: 권민성 (서울대)

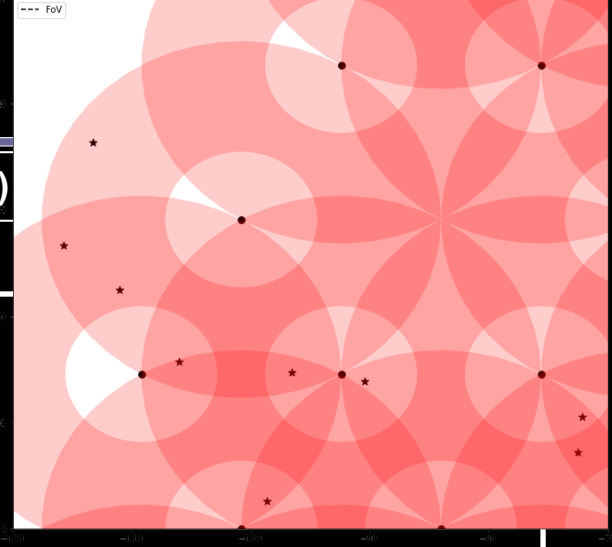


How to maximize the number of fibers with targets for a given field?



3. Fiber Assignment Algorithm

준비: 권민성 (서울대)



1. Simple Algorithm:
   Assign a fiber to a target with a lower rank

2. Algorithm I
   1. When there is only one target within a region covered by a fiber, assign the fiber to that target first
   2. Assign other fibers to minimize the cost function

the minimization of which simultaneously satisfies the both optimal criteria,

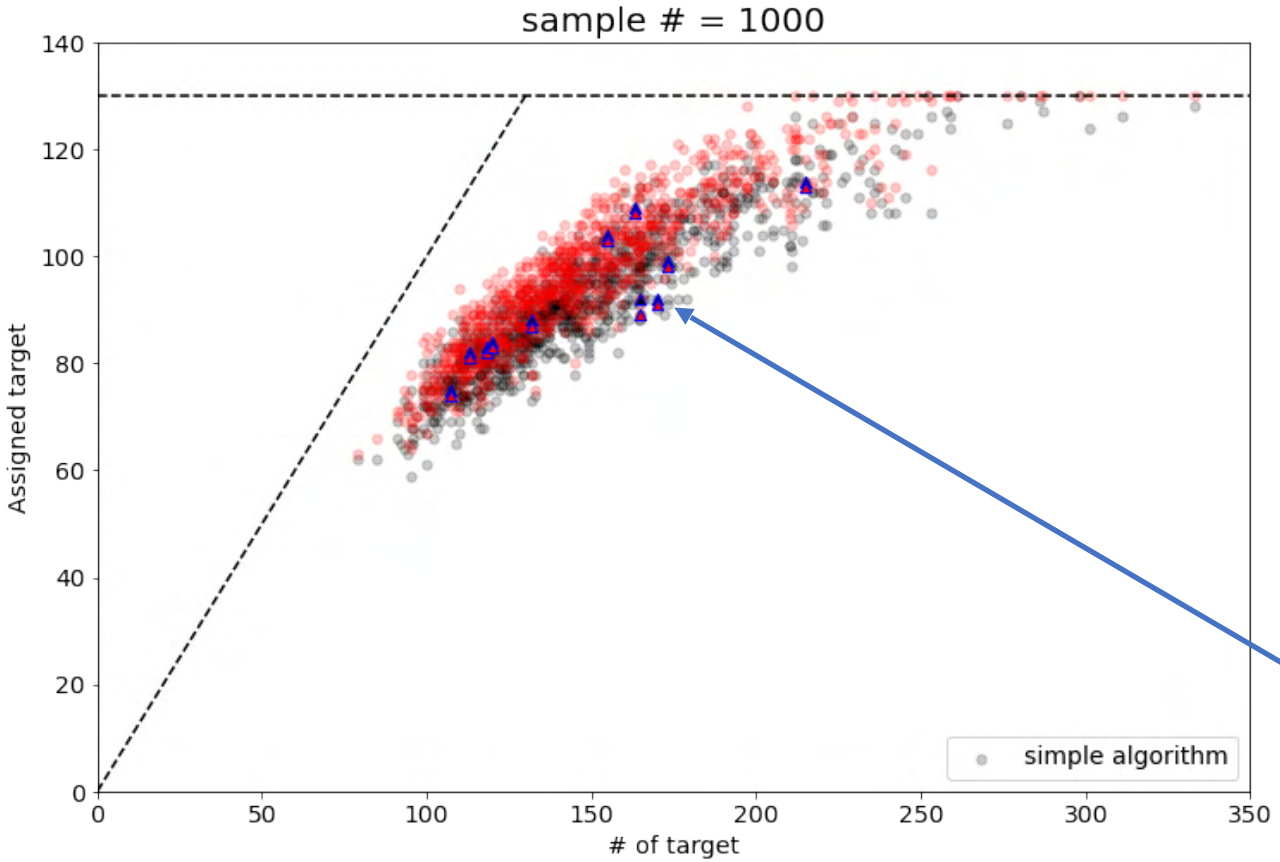
$$\frac{\|q_i - q_t\|_2}{\|q_i - \overline{\mathcal{Q}}\|_2} \quad (\forall i : 1 \leq i \leq \|\Gamma_t^{\mathcal{P}}\|) \tag{8}$$

3. Algorithm II
   1. Assign a fiber to a target covered by a smaller number of fibers first
   2. Apply the 3mm separation condition to reassign the fibers

준비: 권민성 (서울대)

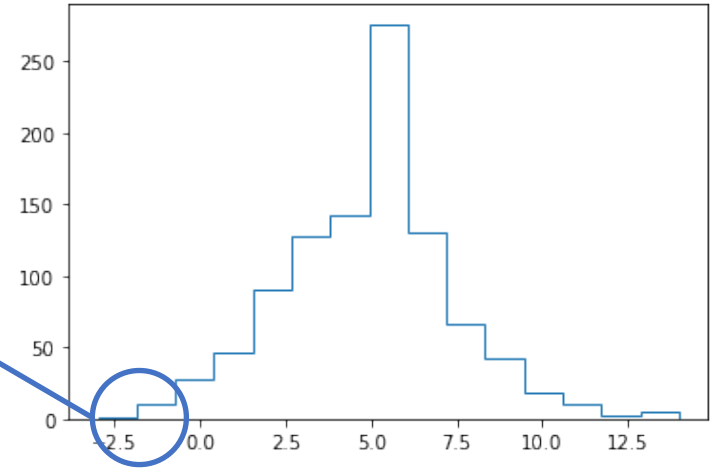
Fiber Assignment Algorithm

Simple algorithm과 비교



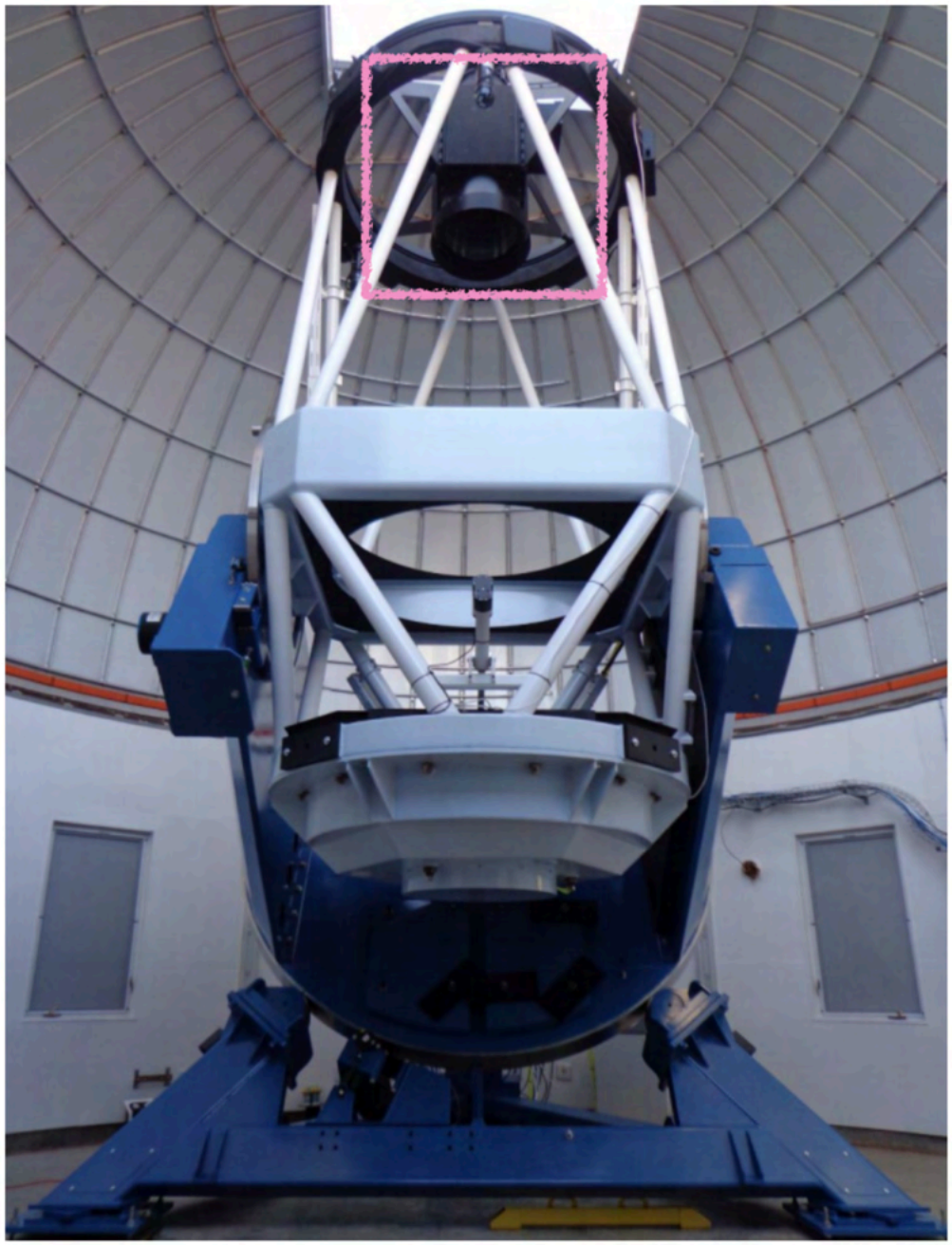
추가로 assigned된 target 4.92 ± 2.58

+5.4%



There are still many things to improve…

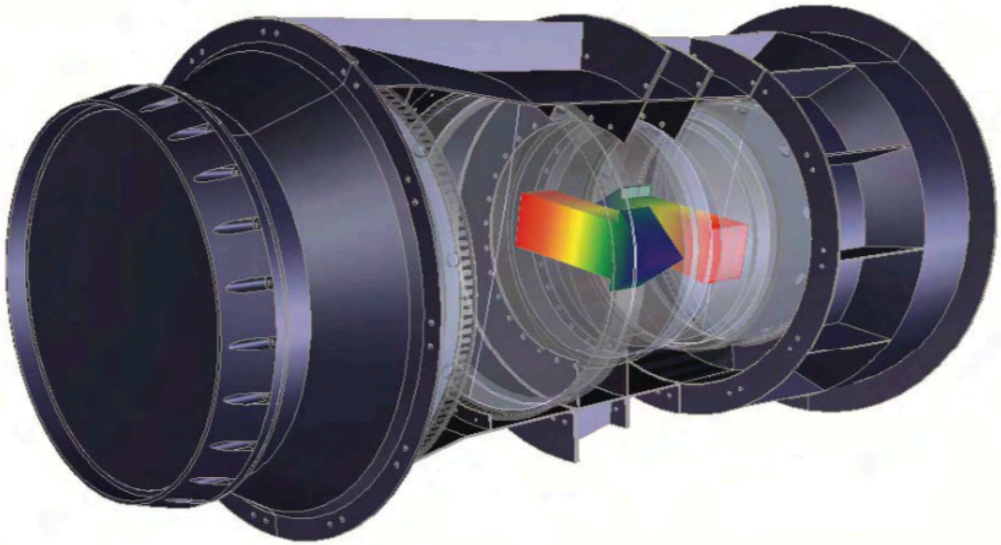
4. Wide-Field Corrector

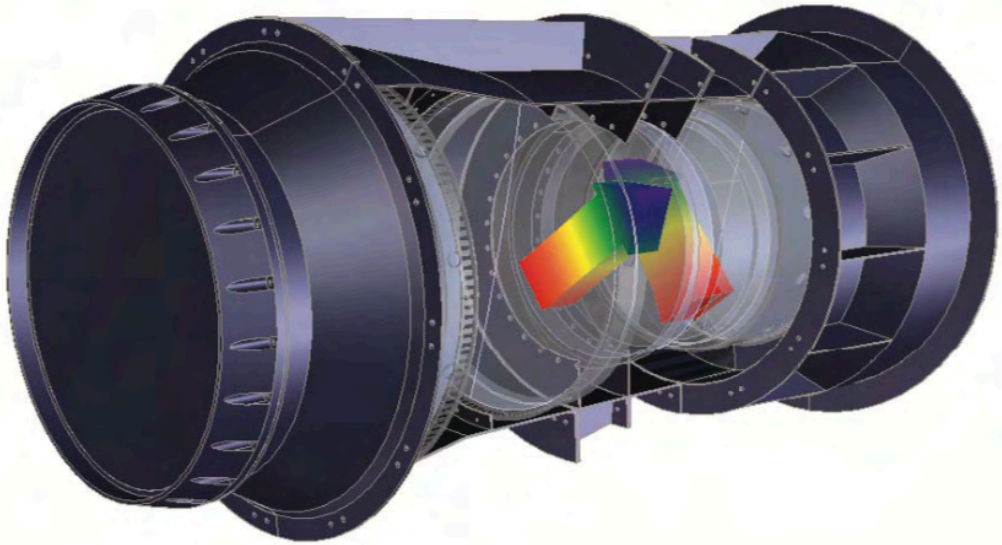


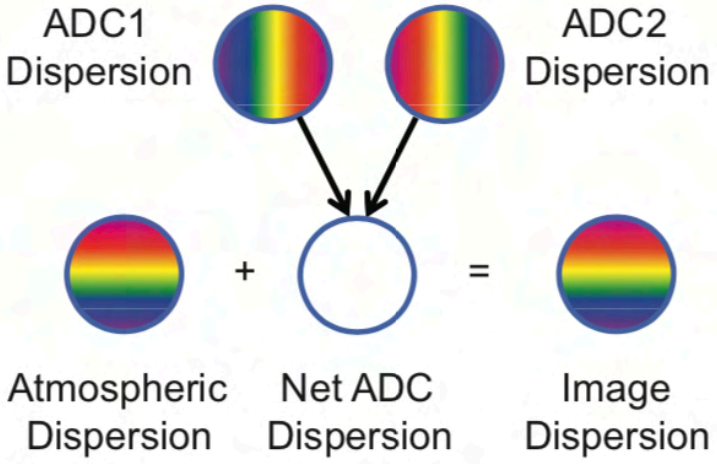
KMTNet WFC + new ADC

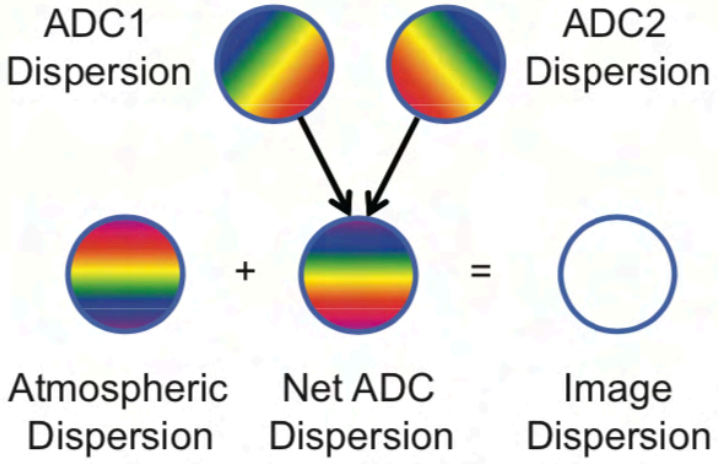
- Current KMTNet WFC with 4 lenses
- Filter shutter assembly (FSA)
- Adding new ADCs instead of FSA
- Rotating ADC

4. Wide-Field Corrector (e.g. DESI)









4. Wide-Field Corrector

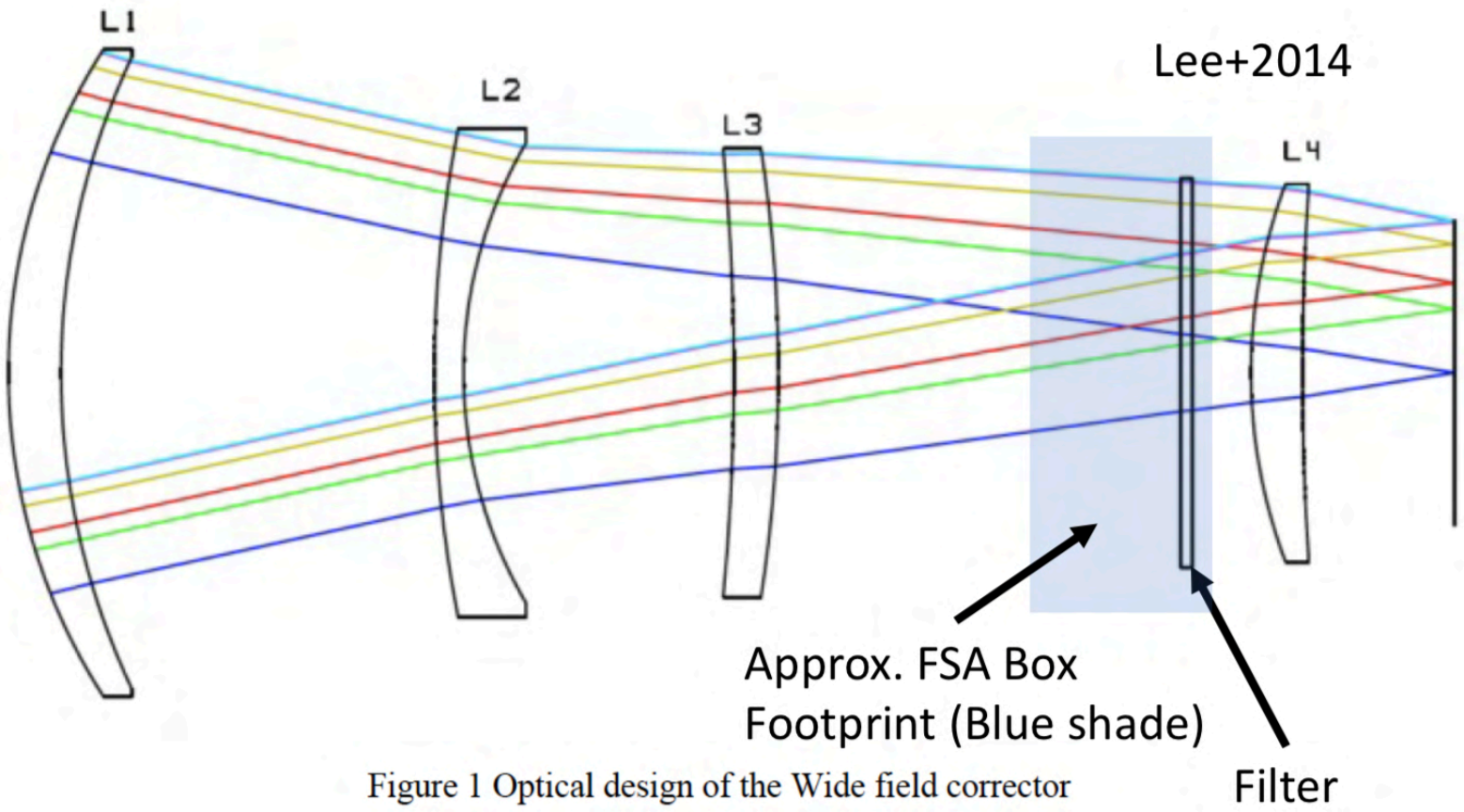


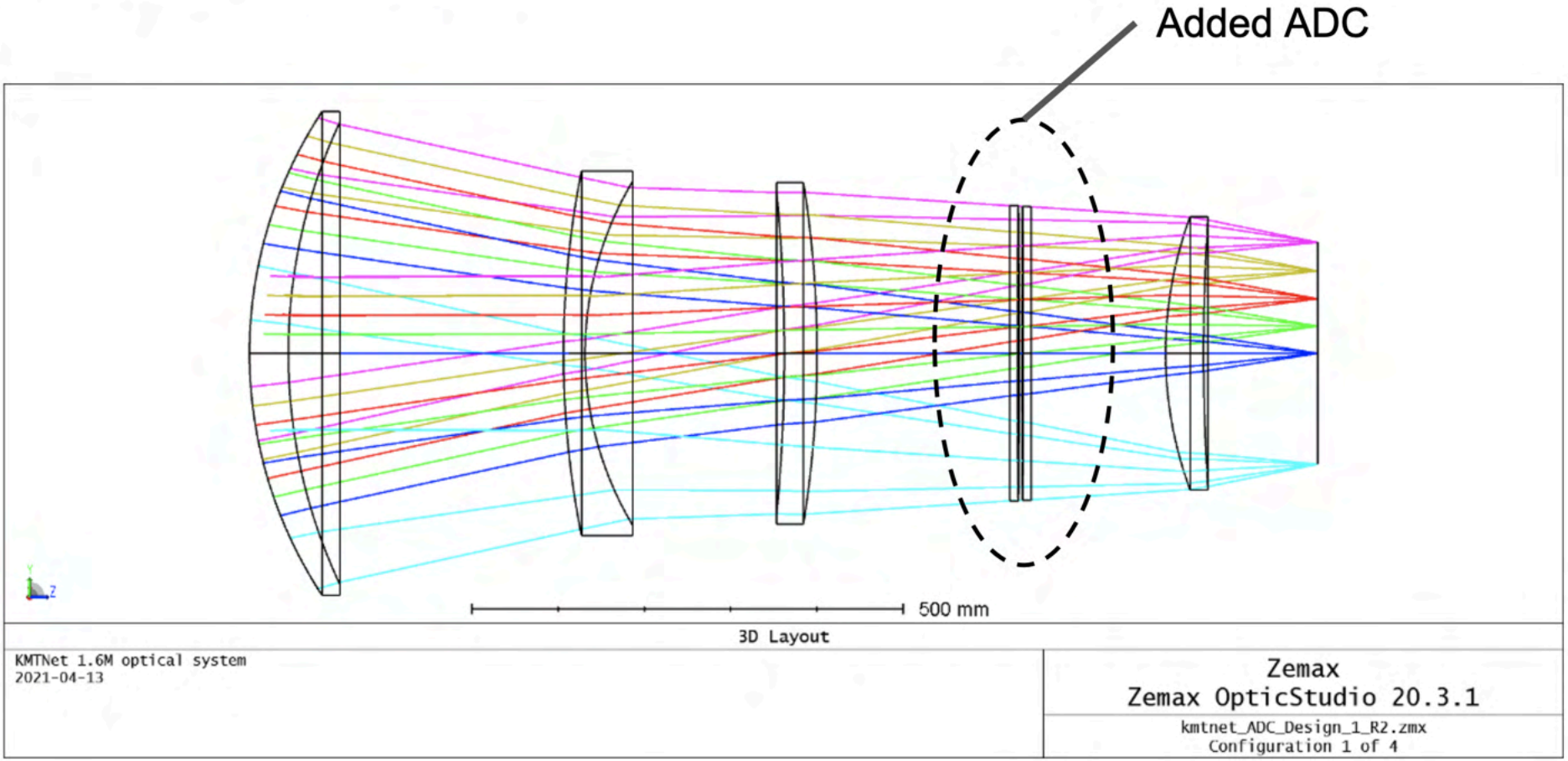
Figure 1 Optical design of the Wide field corrector

Table 1 Wide field corrector lenses specifications

Lens number	Edge diameter	Clear aperture	Thickness	Material
L1	552 mm	546 mm	45 mm	BK7
L2	416 mm	410 mm	25 mm	BK7
L3	382 mm	374 mm	38 mm	BK7
L4	322 mm	316 mm	44 mm	Fused Silica

4. Wide-Field Corrector

ADC Design -- Layout



Φ341, 10T

Add ADC_F-Silica

In Summary

1. Focal Plance Hardware (Oh, heeyoung; Lee, Yongseok)
    1. Mounting Plate
    2. Cage for the Fiber Positioner System
2. Metrology System (Kim, Dongkok)
3. Fiber Assignment Algorithm (Kwon, Min Sung; Lee, Jong Chul)