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Development Status of the DOTIFS Project: a new multi-IFU optical spectrograph for the 3.6m Devasthal Optical Telescope

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January, 27, High 1**

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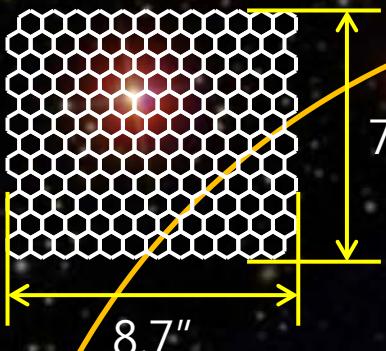
- DOTIFS Overview
- Science Drivers
- Telescope & Instrument Subsystem
- Data Simulator
- Current Status & Future Plan
- Summary



DOTIFS Overview

- DOTIFS: Devasthal Optical Telescope Integral Field Spectrograph
- Multi-Integral Field Unit
- # of IFUs: 16
- IFU field of view: 8.7 x 7.4 arcsec (12x12=144)
- Spatial resolution: 0.8 arcsec (vertex to vertex, hexagonal)
- Spatial elements per IFU: 144 (12x12)
- Total # of spatial elements (# of fibers) : 2304
- Focal plane field of view: 8 arcmin (diameter)
- 8 Identical spectrographs
- Wavelength range: 370 – 740 nm
- Resolving power: R~1800 @555nm ($\Delta\lambda = 3.08\text{\AA}$)

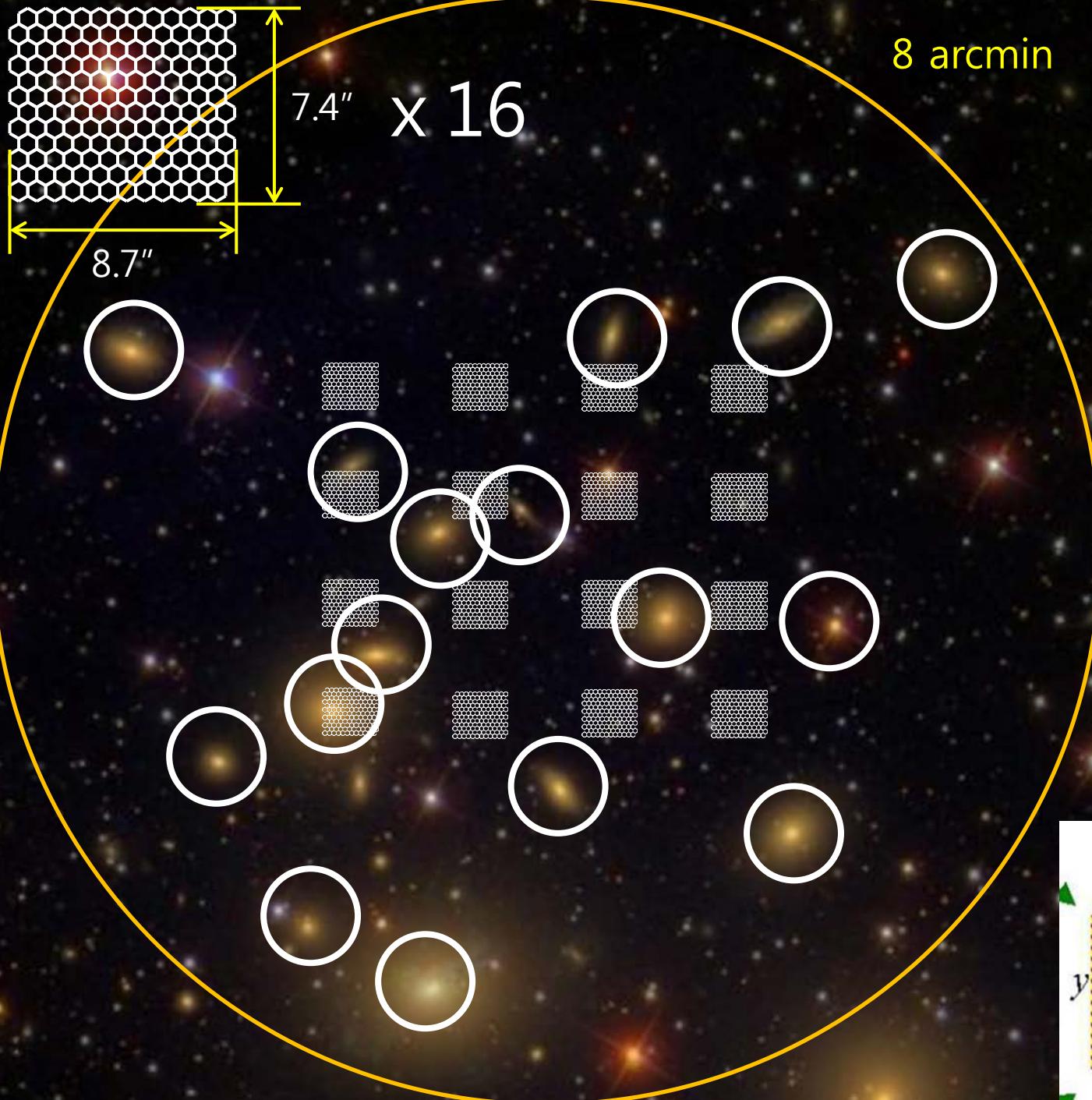
IFU:
(12x12)
(hexagonal
microlens
array)



7.4" x 16

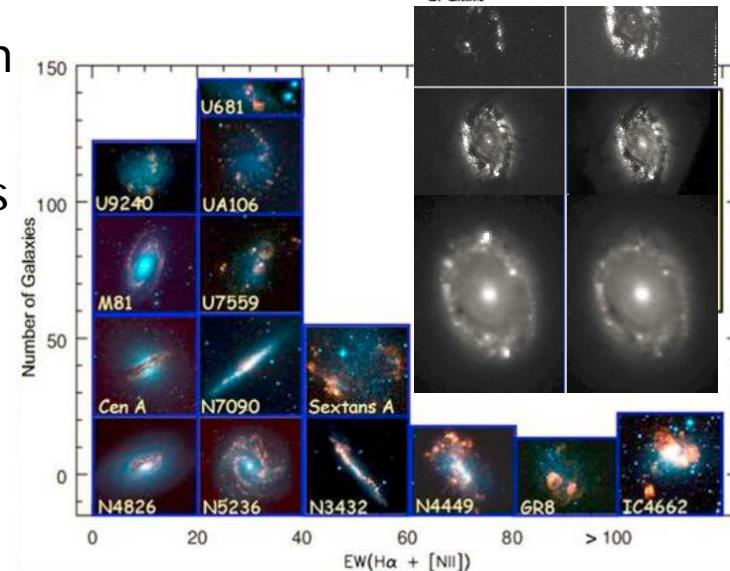
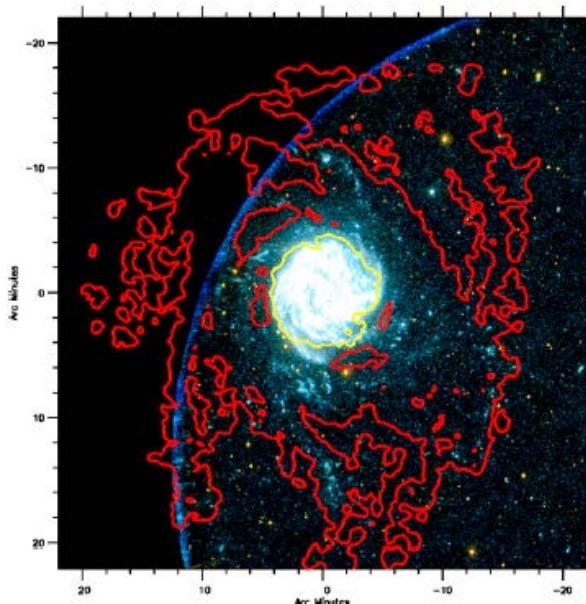
8 arcmin

8.7"

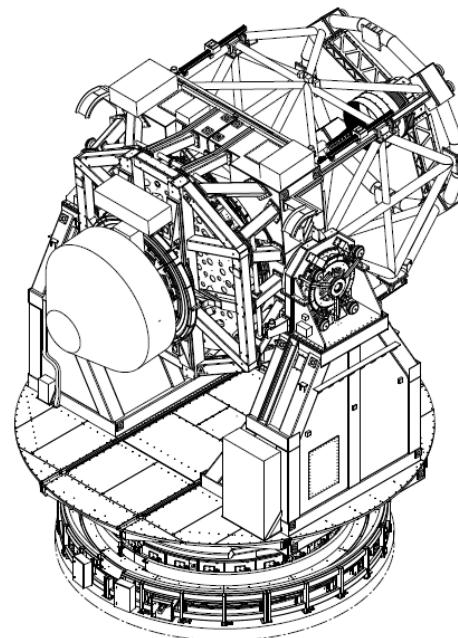


Science Drivers

- Science Reference Document
 - *Swara Ravindranath, Amitesh Omar, A. N. Ramaprakash, 2011*
 - Circumnuclear rings in barred galaxies
 - H-alpha emissions from Lyman-alpha clouds
 - Rotation curves of nearby galaxies
 - AGN outflows, Dual AGNs or pairs
 - Galactic HII regions
 - Merging, and Interacting galaxies, ULIRGS
 - Galaxies in clusters and Groups: Star formation
 - Outer regions of star-forming galaxies
 - Emission-line galaxies at intermediate redshifts



3.6m Telescope

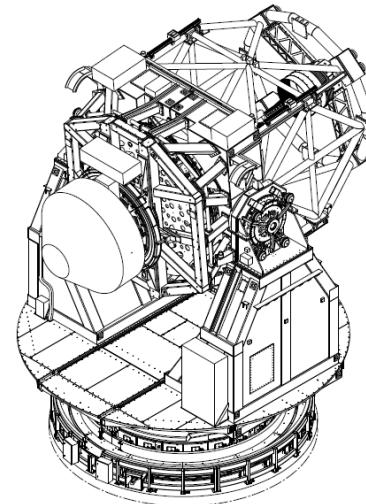


Sagar et al. 2012

- Devasthal Optical Telescope
- Manufactured by AMOS @Belgium
- Effective focal ratio: F/9 ($f=32400\text{mm}$)
- Field of view: 30' for axial port, 10' for side ports
- Alt. 2450m
- Seeing: 1.1" (median), 0.7" (best)

DOTIFS Optics Trail

Telescope
Side port



Magnifier

F/9

F/21.486

IFUs

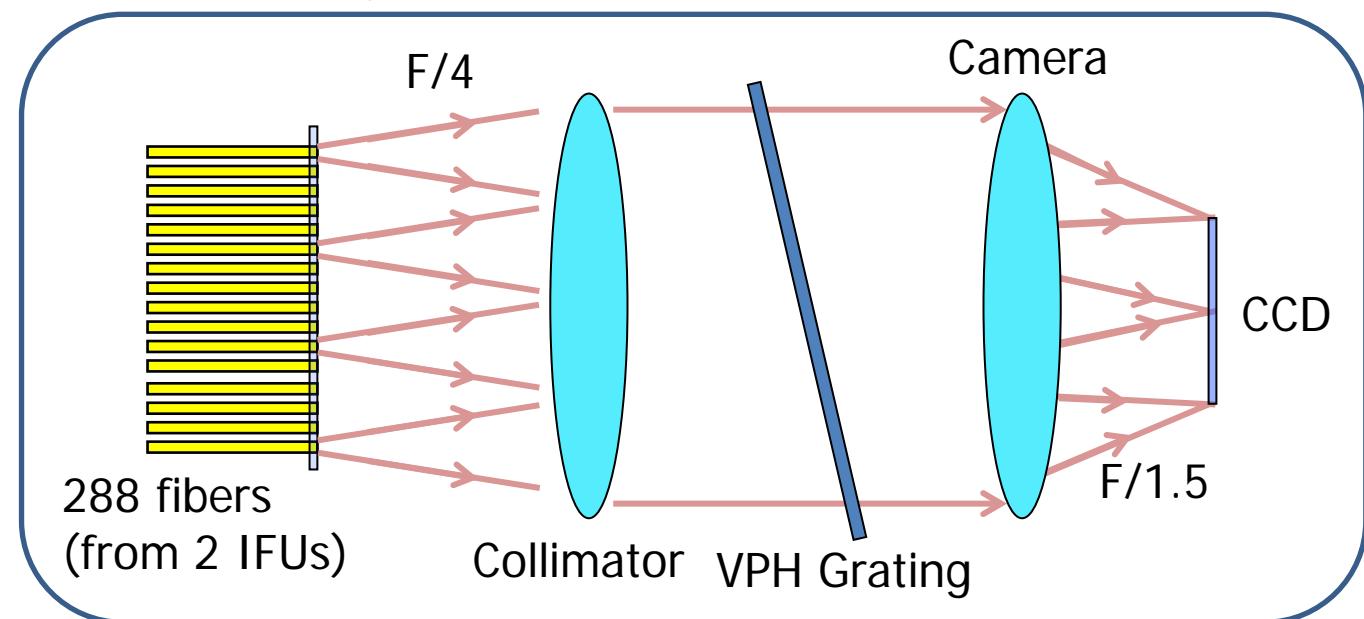
F/4.5

8 arcmin
Focal Plane

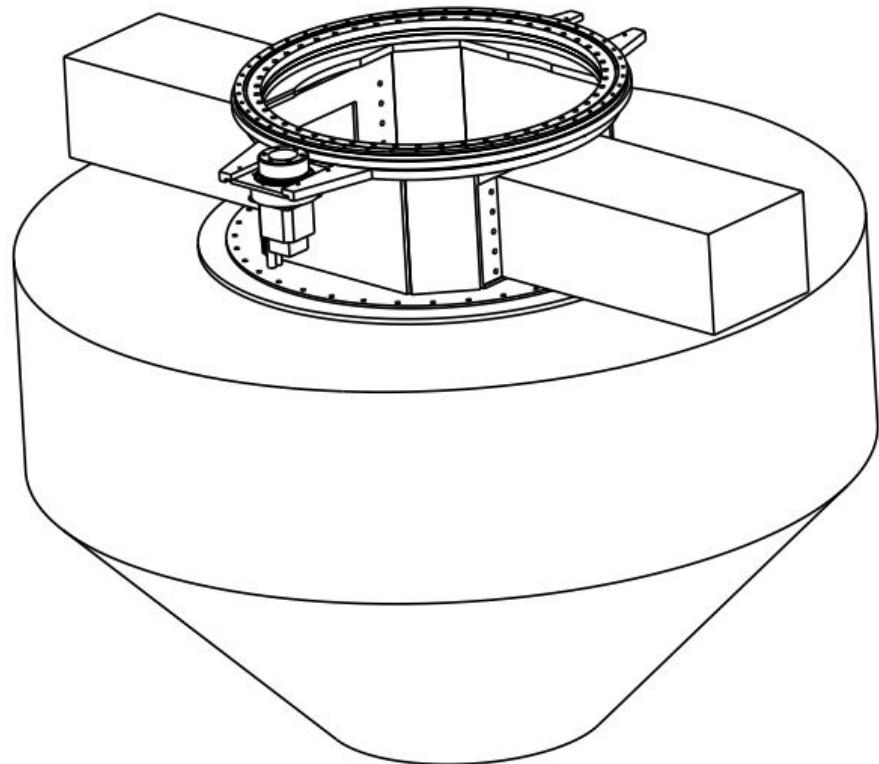
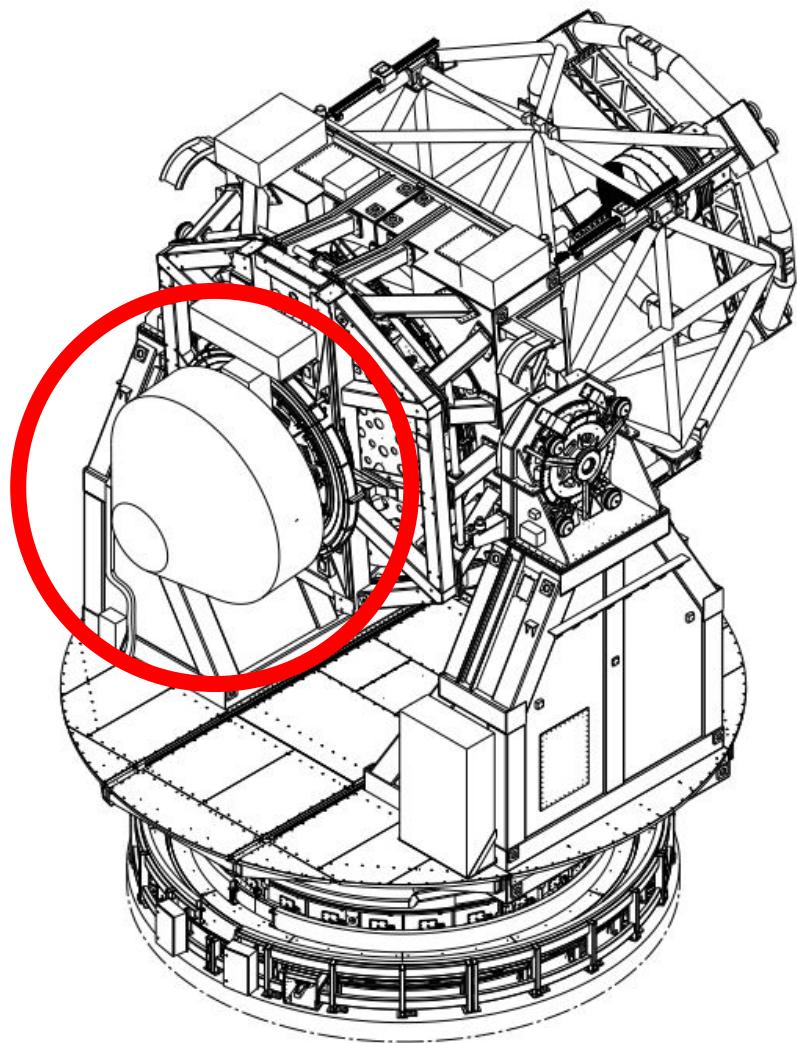
x 16 IFUs.
144 fibers / 1 IFU

8 x
Spectrographs

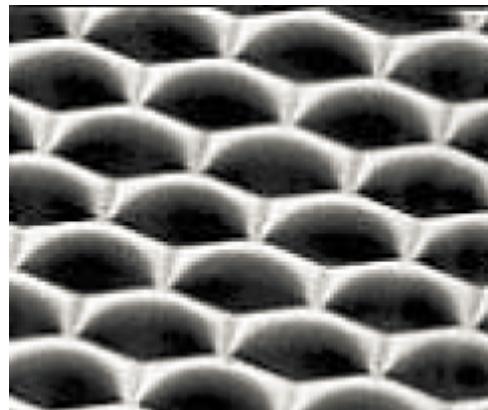
2304
Optical fibers
(~2m)



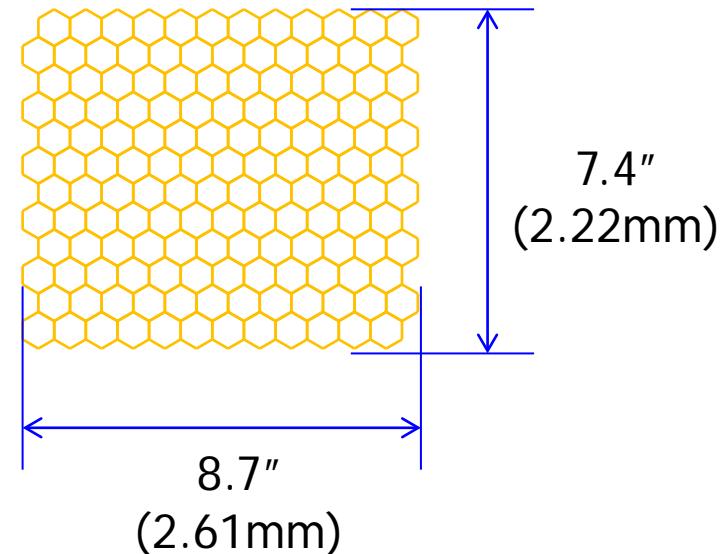
DOTIFS Optics



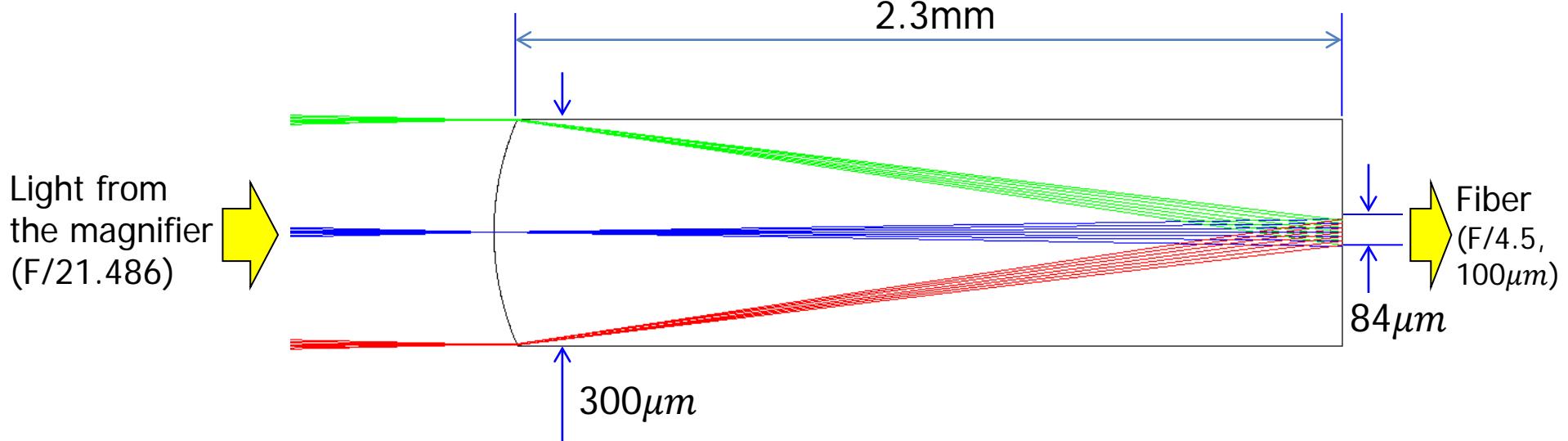
Integral Field Unit



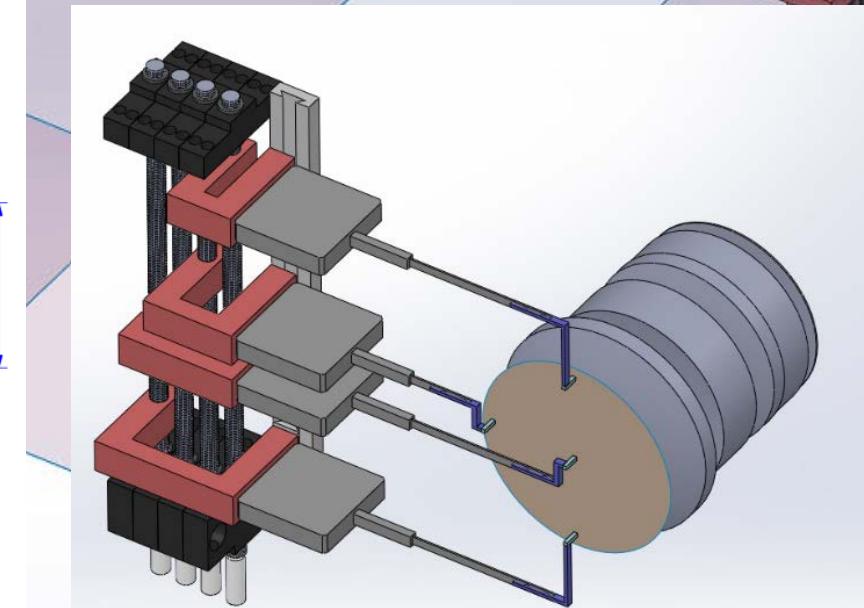
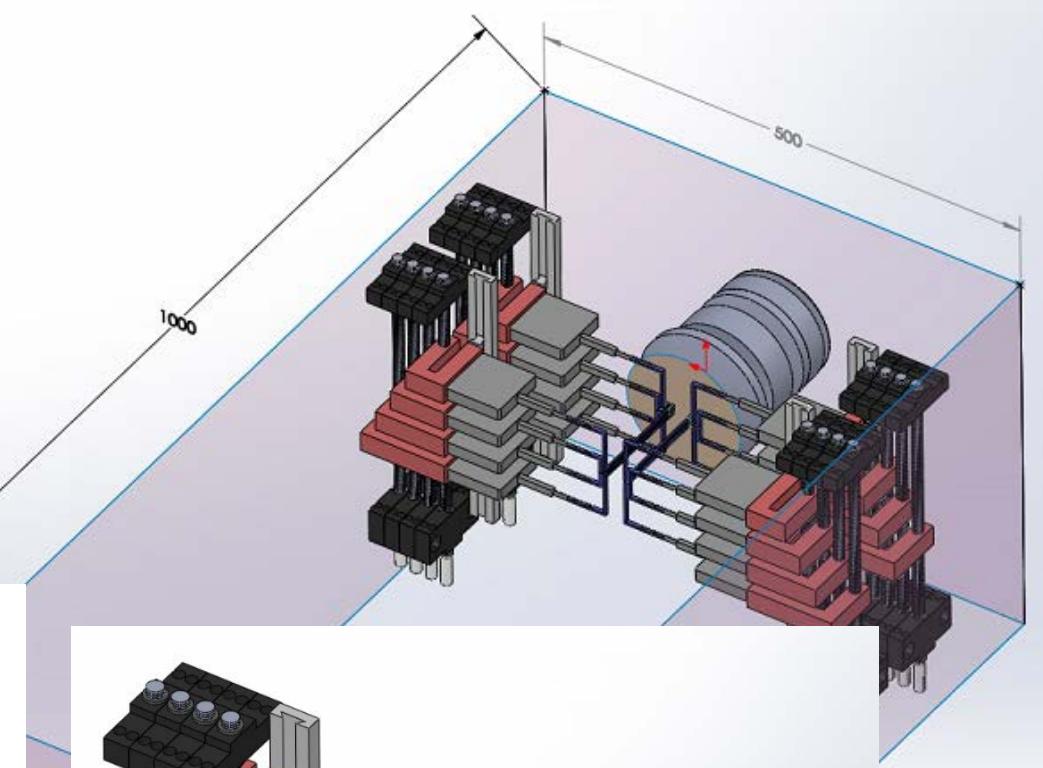
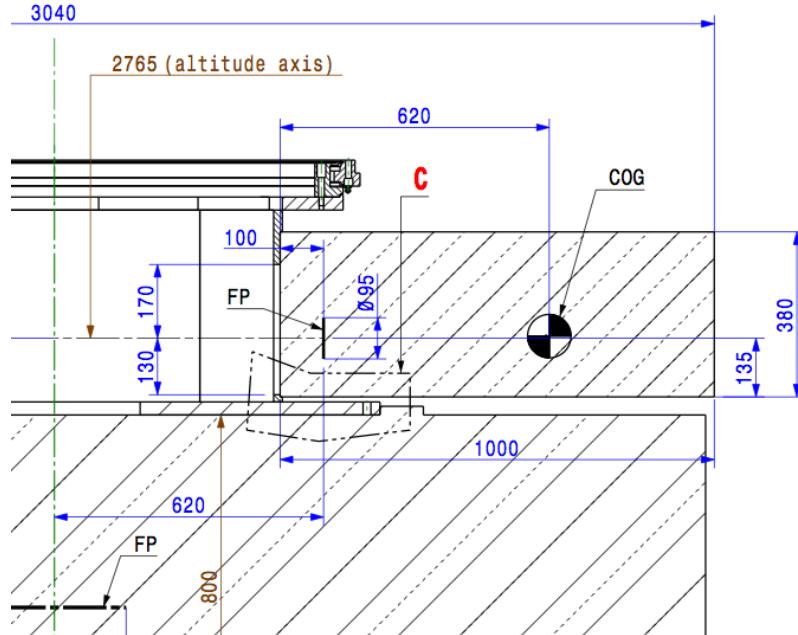
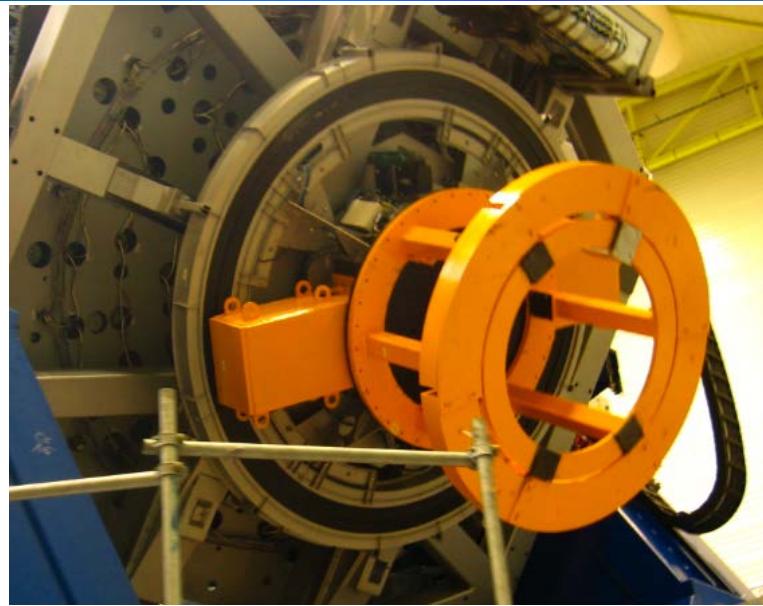
Hexagonal shape
microlens array



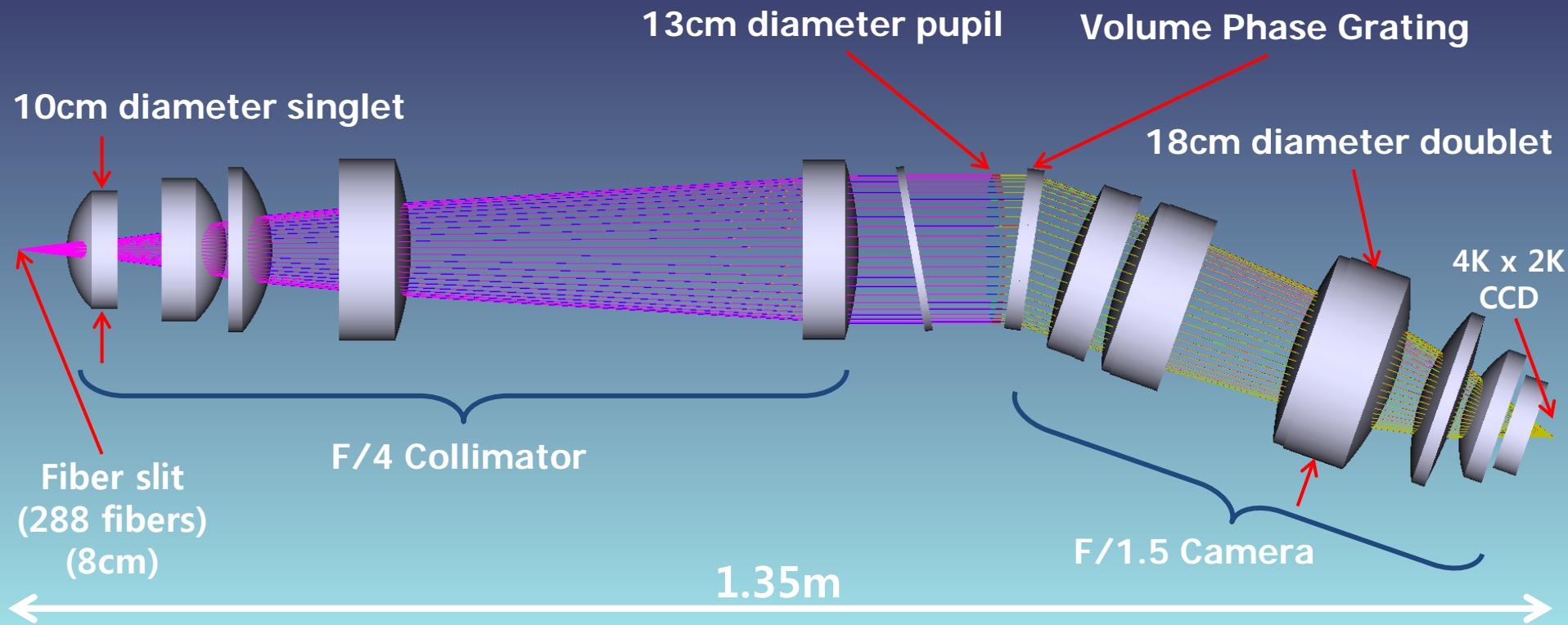
Example of one microlens (F/4.5, ~99% Fill factor)



Deployment System

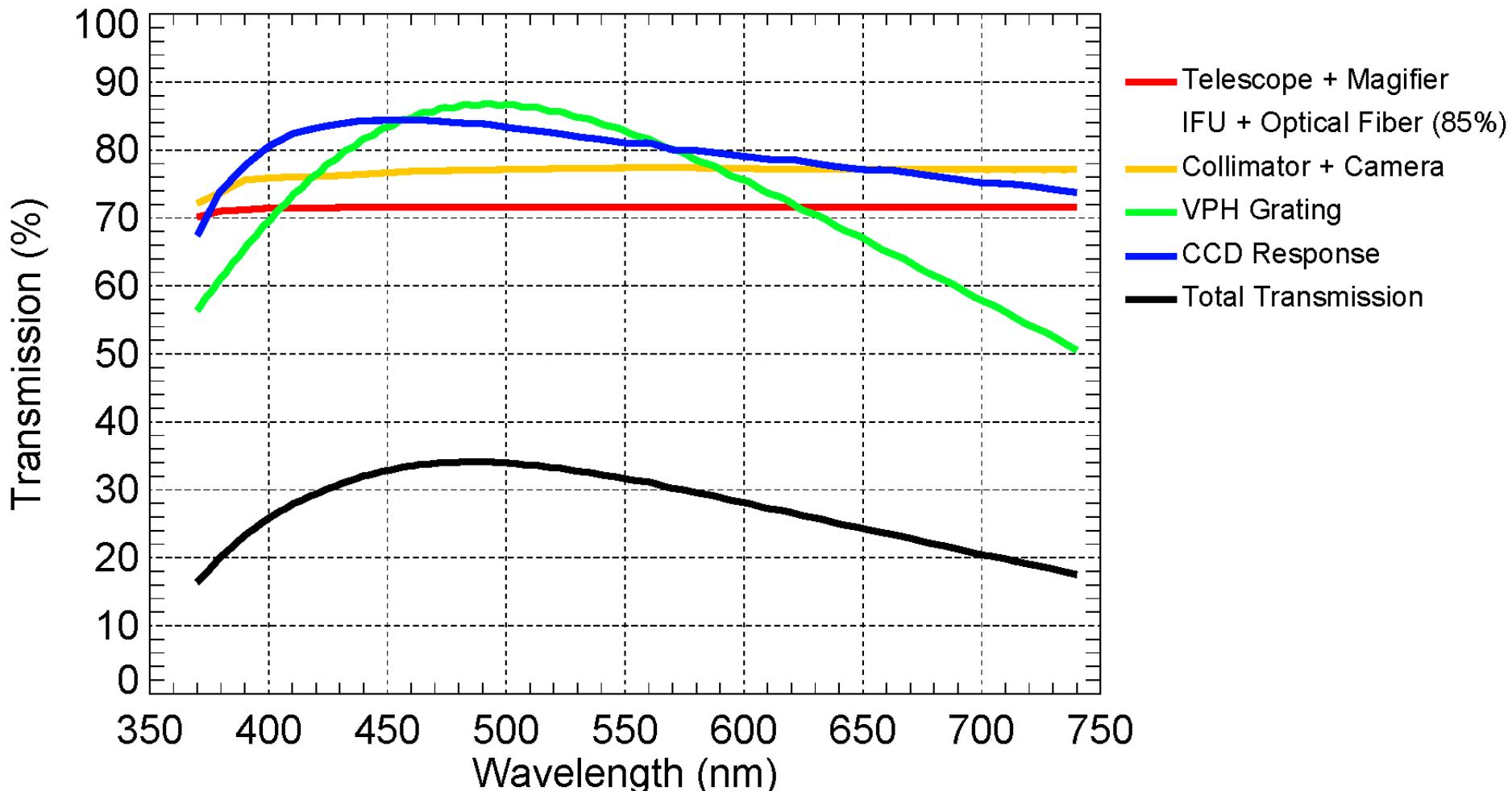


Spectrograph Optics



- Collimator: 3 singlets, 2 doublets
- Camera: 3 singlets, 3 doublets
- 8~16cm diameter, All Spherical
- VPH grating (615 lines/mm, 8.49 degrees, peak@480nm)

Throughput



- From telescope to CCD (Sky is not included)
- 27.5% on average
- 34.2% at peak, 16.4% and 17.5% at the blue and red end

DOTIFS Strength

- High throughput
 - Expect 27.5% on average, 16.4%@370nm, 31.3%@555nm and 17.5%@740nm
- IFU deployment system
 - Short IFU reconfiguration time (minimize overhead)
 - Fast x-y actuator system with proper deployment algorithm (avoid collision)
 - Target: < 30sec to reconfigure 16 IFUs.
- Multiplexity
 - 16 IFUs. FoV per IFU: 8.7" x 7.4"
- Spatial sampling
 - 0.8" vertex to vertex hexagonal shape.

DOTIFS Data Simulator

DDS input parameters

```
Seeing - 1.0
Moon_Phase(0~180) 90
Moon_Altitude(0-180) 135
Moon_Target_Separation(0~180) 45
Target_Altitude(20-90) 90.0
Exposure_time 900
PSF_grid_file psf_ext_32x22.psf
Fiber_field_map_file polycoeff.dat
Obs_mode(0:single,1:IFU) 1
Object_file_prefix hexa
ID_IFU1 1
ID_IFU2 2
Noise_apply_flag 0
Sky_background_file_prefix esosky
Sky_transmission_file_prefix esosky
Telescope_trans_file Tel.trans
```

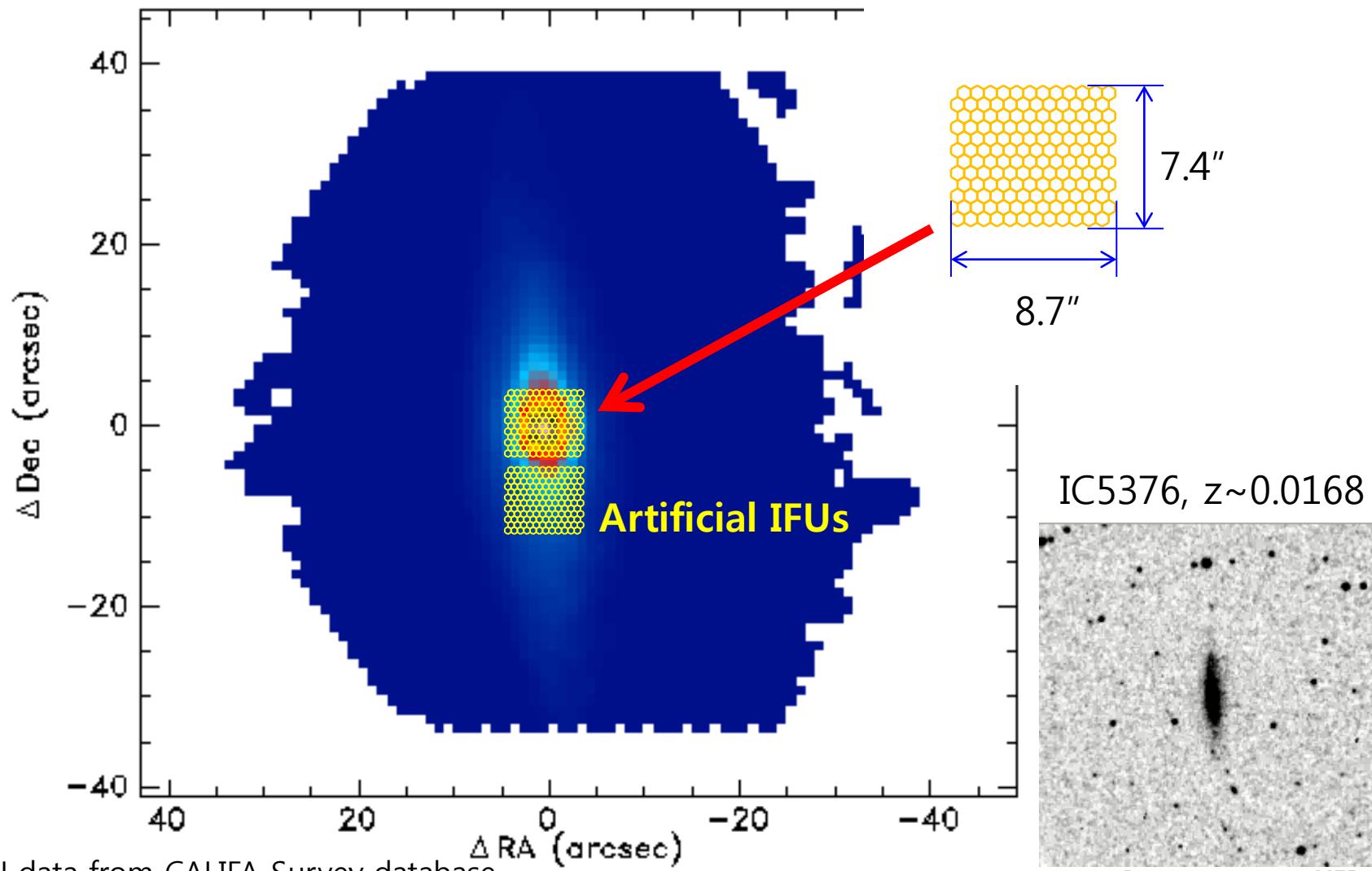
DDS execution

```
hchung@ubuntu:~/data_simulation$ ./DDS check3.dat
*****DOTIFS DATA SIMULATOR*****
Reading simulation parameters...
ifu file names: hexa01.fits hexa02.fits
Allocating memory...
Reading probability distribution files...
Reading PSF grid file...
Reading flux data files...
Sky background file: esoskyMP000MA000MT000.flux
Sky transmission file: esoskyTA090.trans
Reading transmission data files...
Littrow ghost case1 sum: 0.008788
Littrow ghost case2 sum: 0.212856
*****Simulation Parameters*****
Object name prefix: hexa
Number of fibers: 300
Wavelength range(nm): 370.0 to 740.0
Exposure time: 9.00e+02
Simulation wavelength dispersion(nm): 0.037000
Detector size(spectral * spatial): 3150 * 2100
PSF grid size(spectral * spatial): 32 * 22
Output file: Test.fits
*****
Expected execution time: 12.20 second
Running.....
Noise flag: OFF
Done!
Execution time: 12.00 second
*****
```

- It simulate a spectrograph CCD image.
- It is required to develop the data reduction software.
- It includes various instrument effects and observing conditions
 - Atmosphere, sky background, transmission, spectrograph optics effects, detector noise, moon phase, moon altitude, moon-target separation...

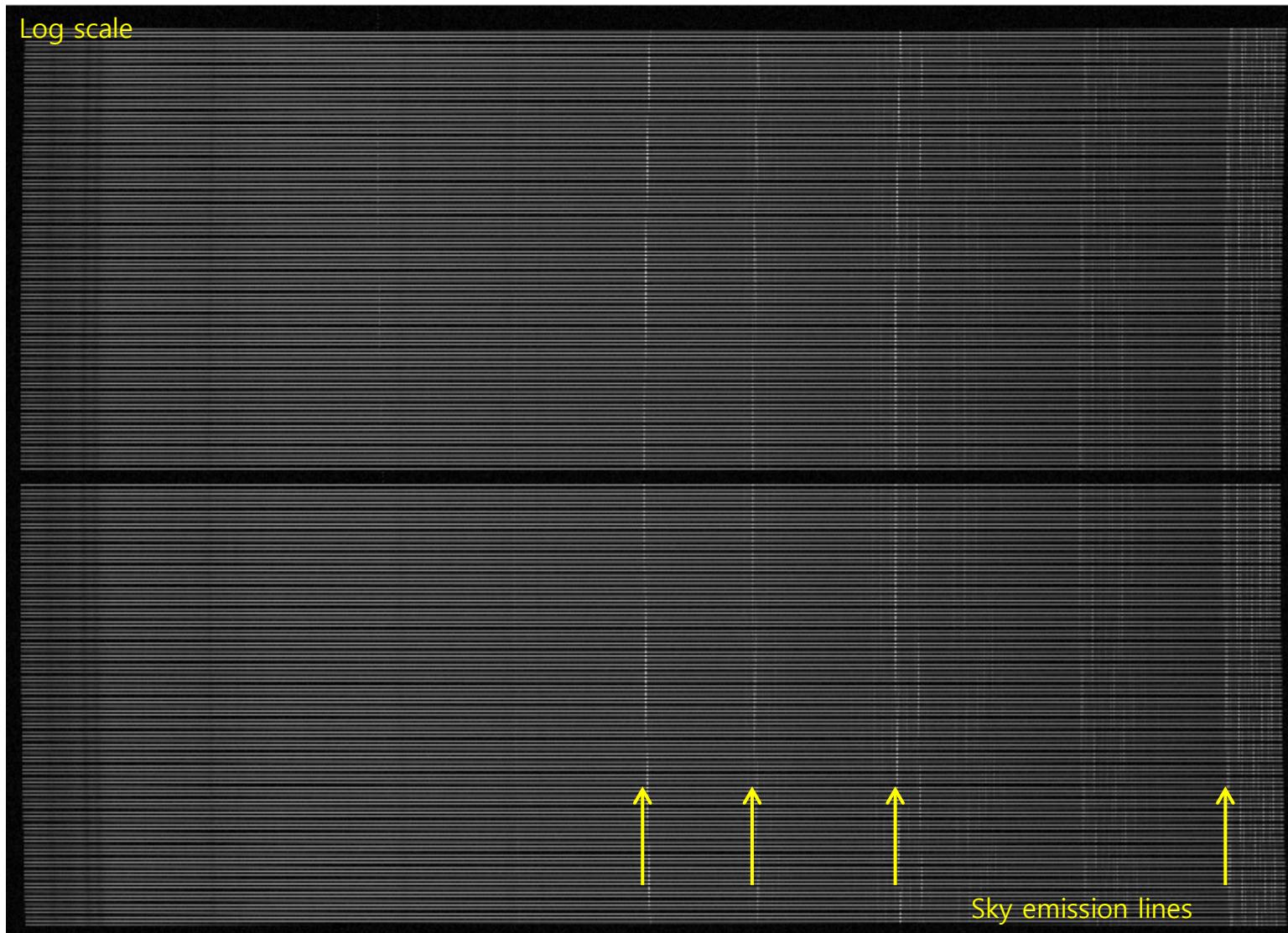
DOTIFS Data Simulator

- Virtual observation

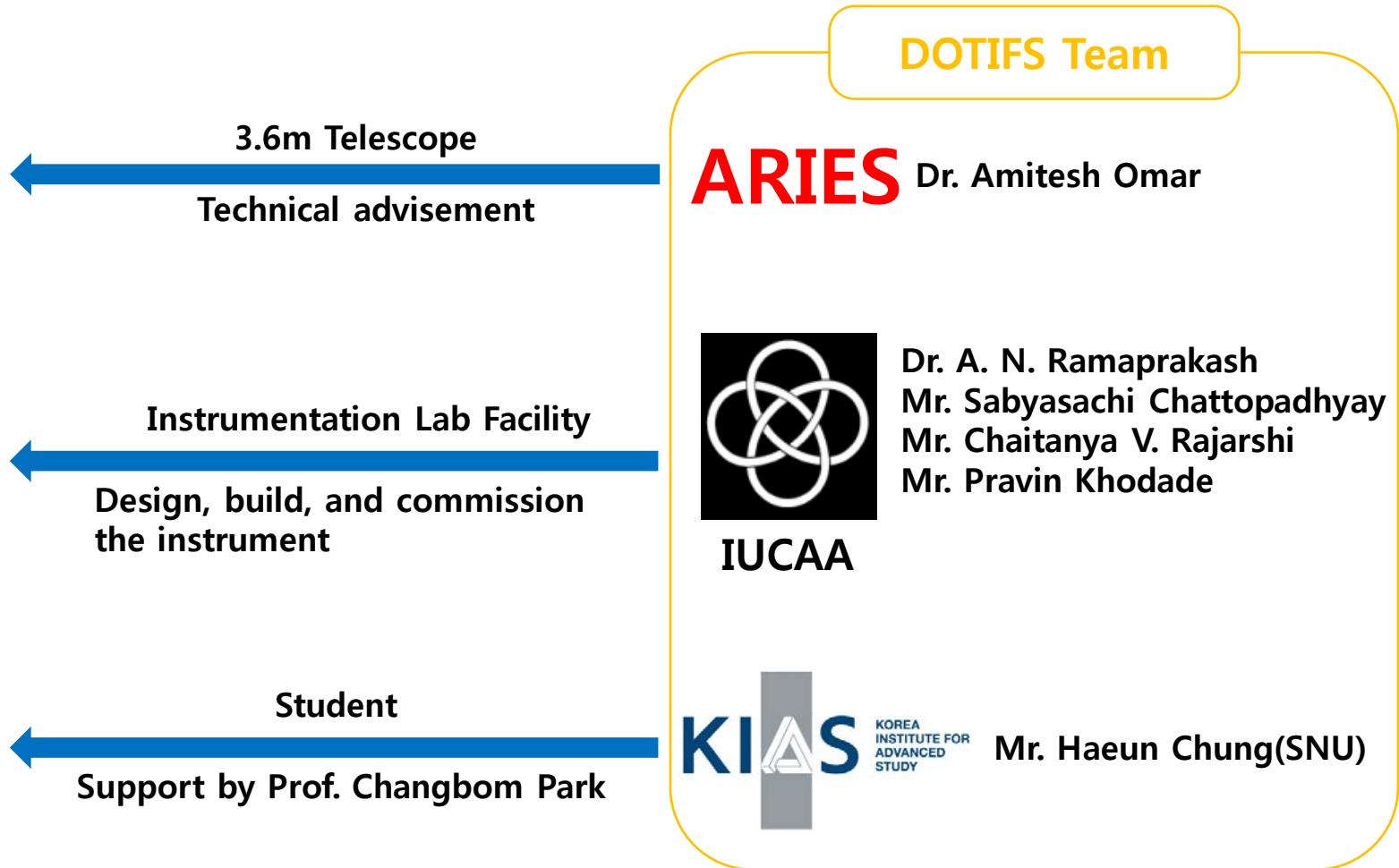


DOTIFS Data Simulator

- Simulation result



Project DOTIFS



History

- Aug 2011: MoU signed (IUCAA & ARIES)
- Sep 2011: Science Reference Document developed
- Aug 2012: Conceptual design ready
- Oct 2012: Conceptual Design Review (at ARIES)
- Dec 2012: Start ordering of test components
- Apr 2013: Baseline Design Review (at IUCAA)
- Nov 2013: Spectrograph optics design ready
- Jun 2014: MoU signed (between IUCAA & KIAS)
- Jun 2014: Optics Design Review (at IUCAA)
- Aug 2014: Magnifier optics design ready

History

- Jun 2014: Optics Design Review (at IUCAA)
 - Decided to develop proto model before full configuration
 - 4 IFUs with 2 spectrographs
- Aug 2014~
 - Revisions on spectrograph optics
 - Re-quote lens pricing to lens manufacturers
 - 2 spectrographs + 1 magnifier optics

Current Status

- Design
 - Spectrograph and magnifier optics design
 - IFU and deployment system design
 - Opto-mechanical design
- Hardware
 - Optics vendor identification
 - Ordering optical components
 - Ordering major/sample parts
 - Testing sample parts
- Software
 - Data simulator
 - Data reduction software
 - Deployment software

Future Plan

- Apr 2015: Order optics lenses
- Jul 2015: Opto-mechanical design ready
- Aug 2015: Deployment system design ready
- Jan 2016: Start spectrograph assemble
- Jan 2016: Data reduction software ready

Summary

- DOTIFS is a Multi-Integral Field Unit optical spectrograph for India's 3.6m Devasthal Telescope
 - International instrumentation project between KIAS, IUCAA and ARIES.
 - Focal plane field of view: 8 arcmin
 - # of IFUs: 16 (FoV per IFU=8.7 x 7.4 arcsec)
 - Spatial resolution: 0.8 arcsec (hexagonal)
 - Wavelength range: 370 – 740 nm (R~1800 @555nm)
- Current status:
 - Spectrograph optics / main parts design / data simulator are finalized.
 - Several opto-mechanical parts and optics have been ordered.
 - Reduction software is under development.
- SPIE Proceeding paper: [Chung et al, 2014](#)
- DOTIFS is planned to be commissioned around 2017.

Thank you !