2018 SPIE ASTRONOMICAL INSTRUMENTATION+TELESCOPE @Austin, June 10 - 15

DOTIFS: Fore-optics and calibration unit design

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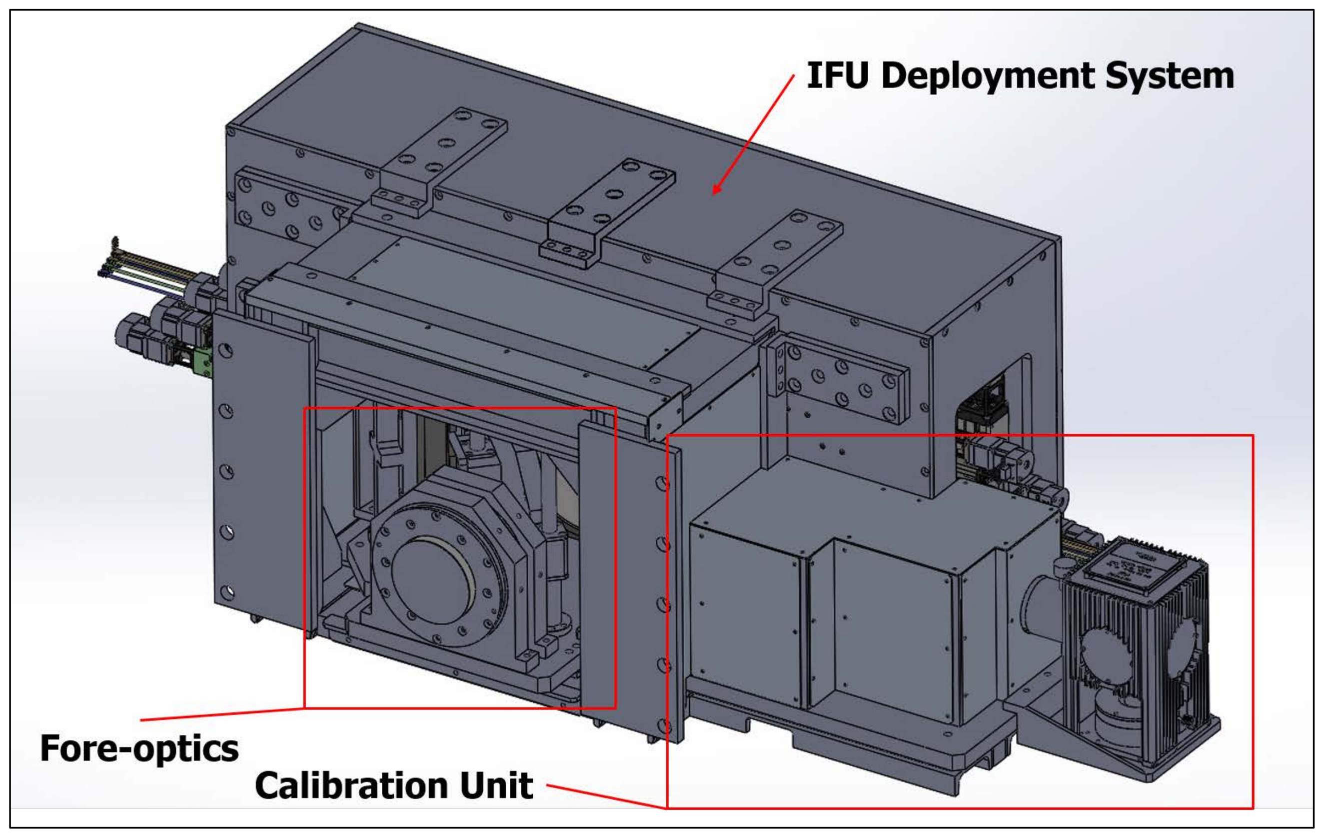
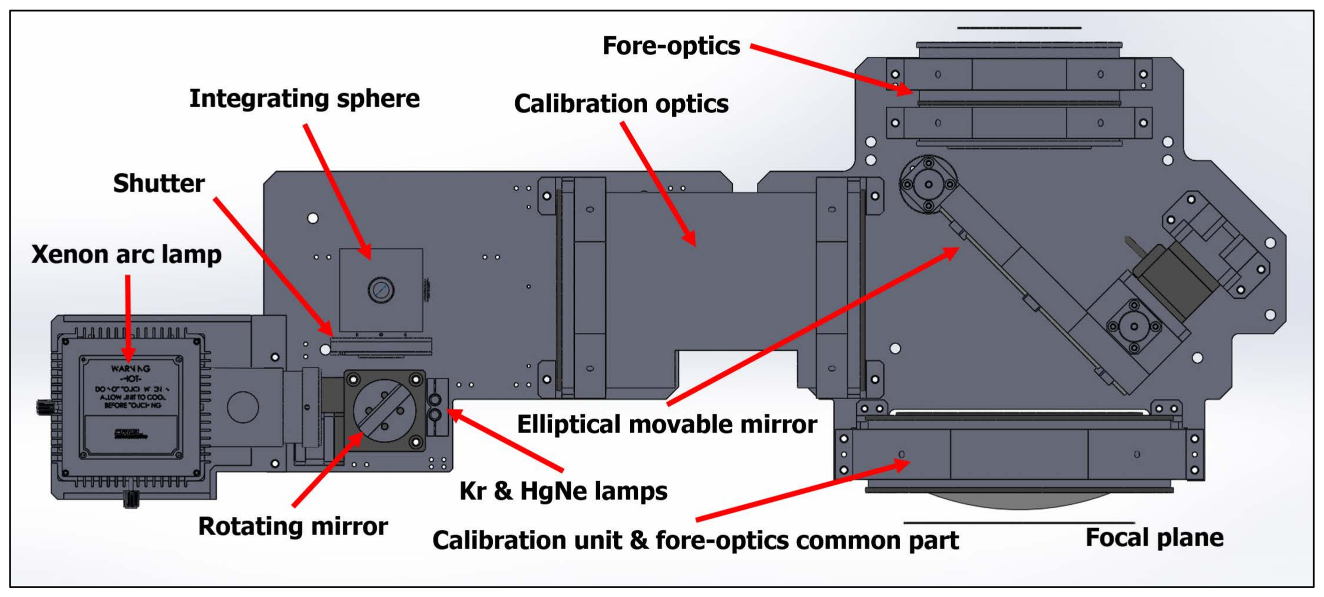
Introduction

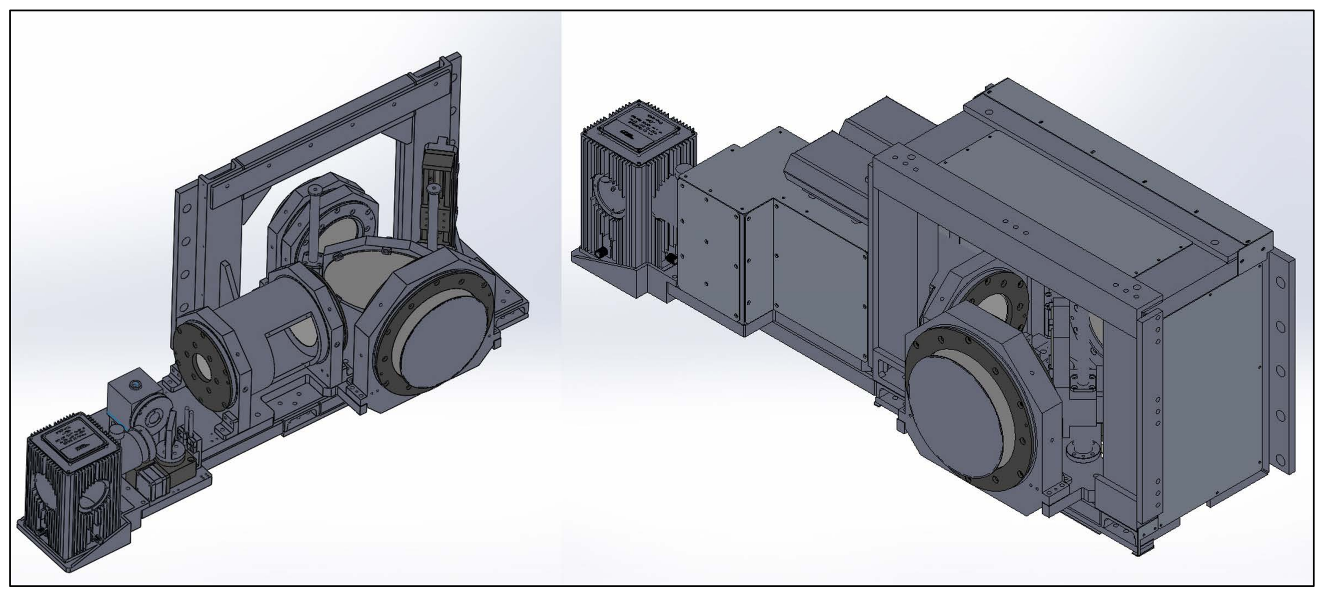
We present fore-optics and calibration unit design of Devasthal Optical Telescope Integral Field Spectrograph (DOTIFS)[1]. DOTIFS fore-optics is designed to modify the focal ratio of the light and to match its plate scale to the physical size of Integral Field Units (IFUs). The fore-optics also delivers a **F/21.486 telecentric beam** to the IFUs on the telescope focal plane. There is a calibration unit part of which is combined with the fore-optics to have a light and compact system. We use **Xenon arc lamp** as a continuum source and **Krypton/Mercury-Neon** lamps as wavelength calibration sources. Fore-optics and calibration unit shares two optical lenses to maintain compactness of the overall subsystem. Here we present optical and opto-mechanical design of the calibration unit and fore-optics as well as calibration scheme of DOTIFS.

Opto-Mechanics

We present opto-mechanical structure of the fore-optics and calibration unit. The design has two moving components, a round shape rotating mirror which selects the type of calibration light source and a movable elliptical mirror which can direct light from calibration sources to the focal plane. Light from calibration source falls on focal plane when elliptical mirror blocks the light from the telescope side. There are baffles to separate the space before and after the integrating sphere physically. An electronic shutter is placed at the input port of the integrating sphere so calibration sources can be turned on and warmed up while target observation is ongoing.

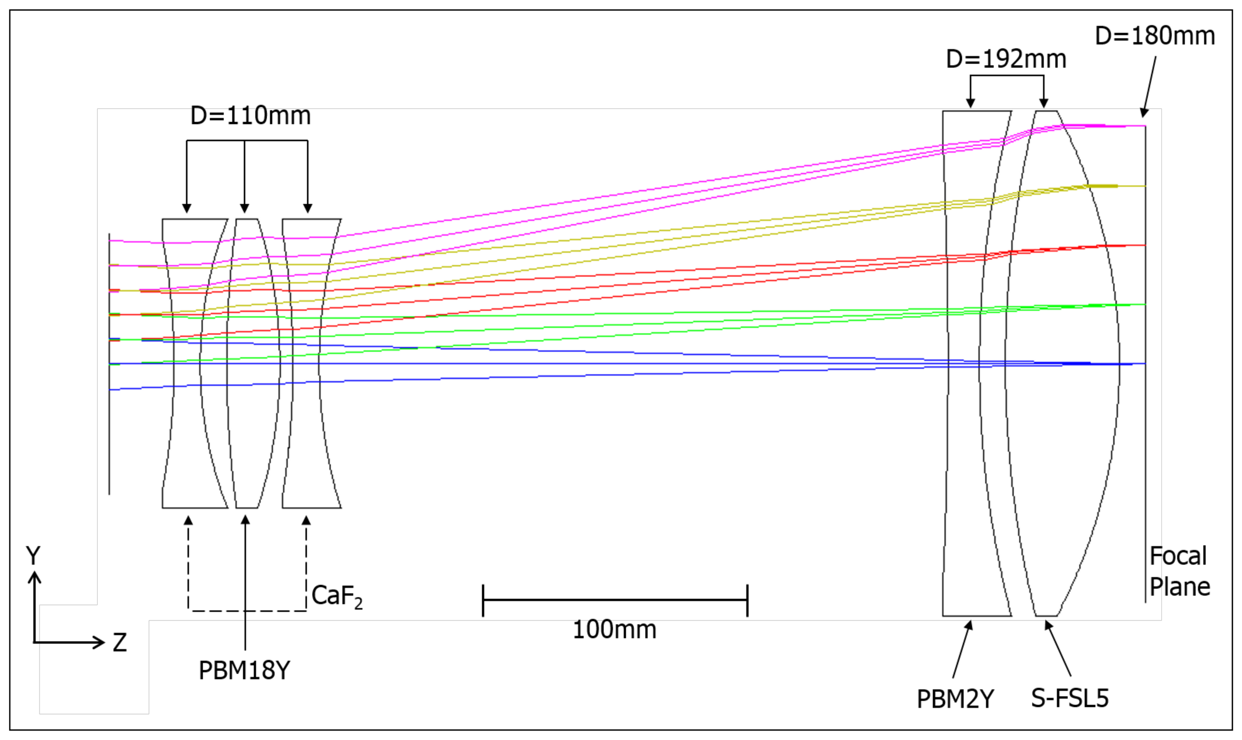


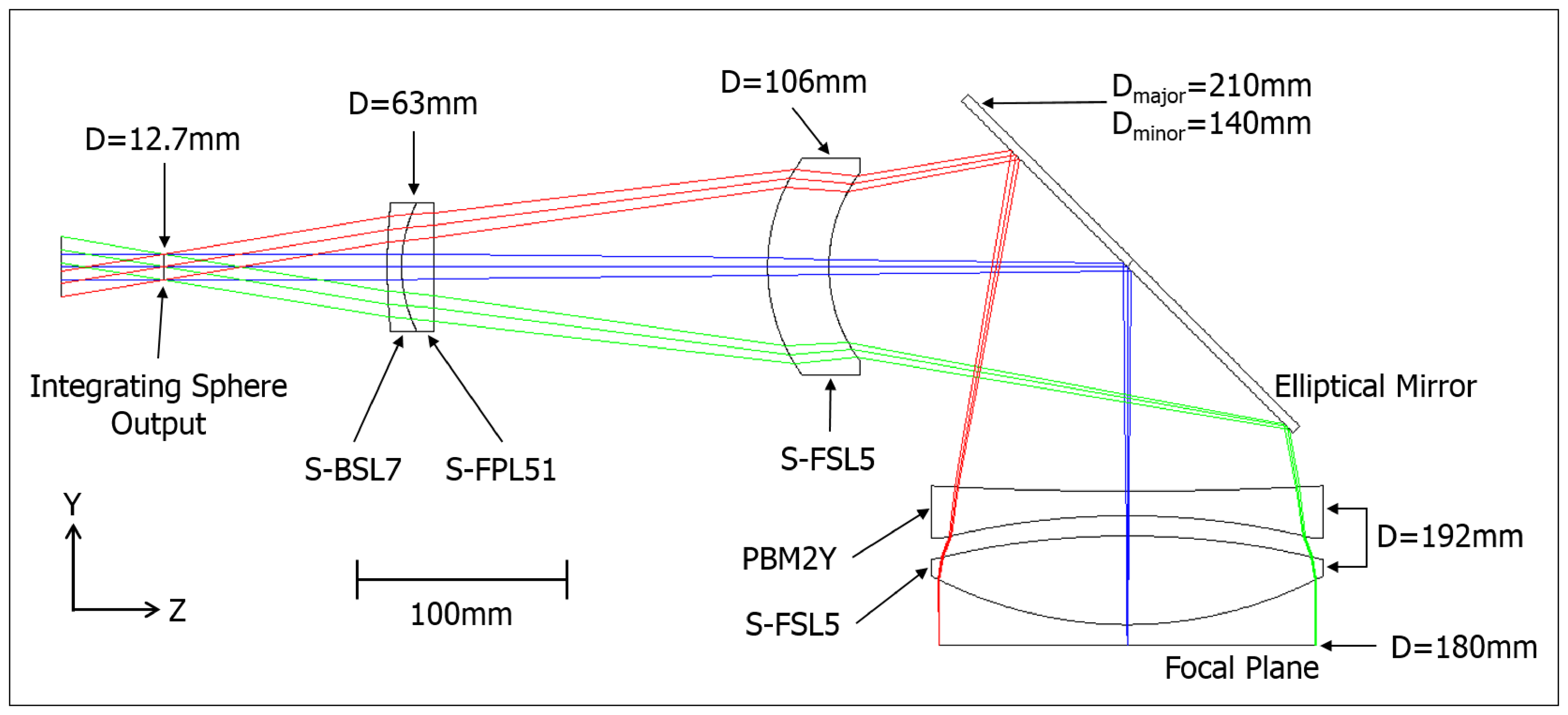




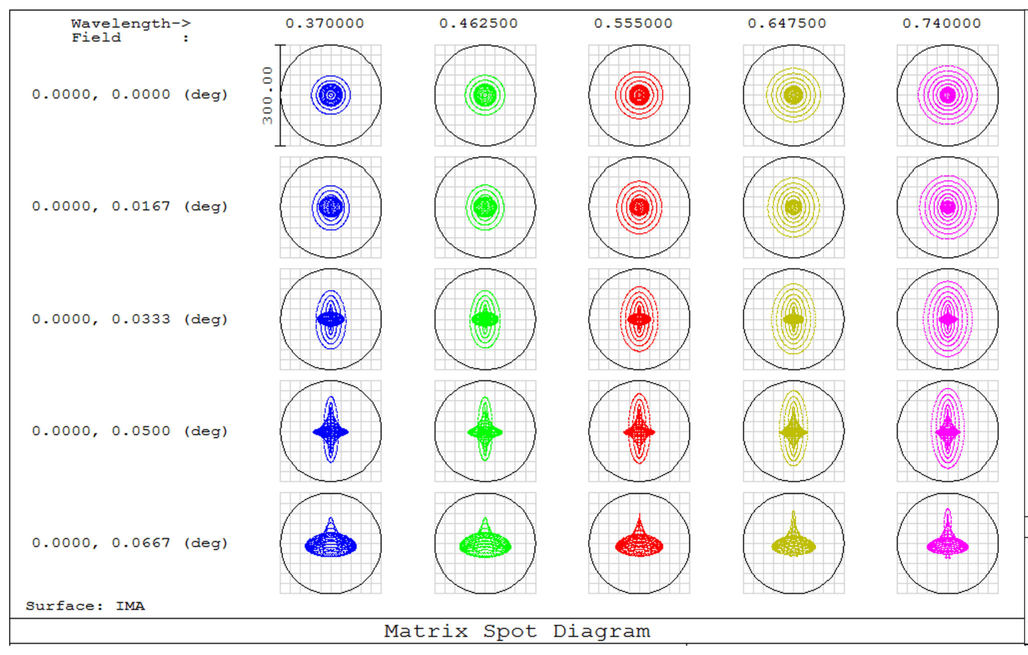
(Top) Overall mechanical rendering of DOTIFS subsystems which is positioned at the telescope Cassegrain side port. **(Middle)** Top-view of DOTIFS fore-optics and calibration unit opto-mechanical structure. Covers are removed to show internal components. Elliptical movable mirror can be retracted to the out of paper direction by linear guideway stage. **(Bottom)** Fore-optics and calibration unit at different viewing angles.

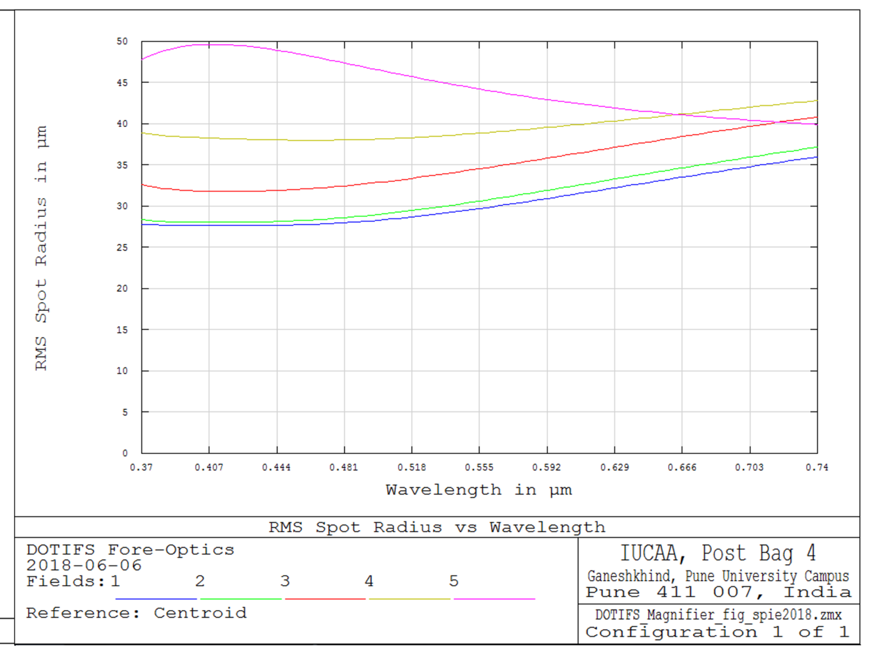
Optical Design & Performance

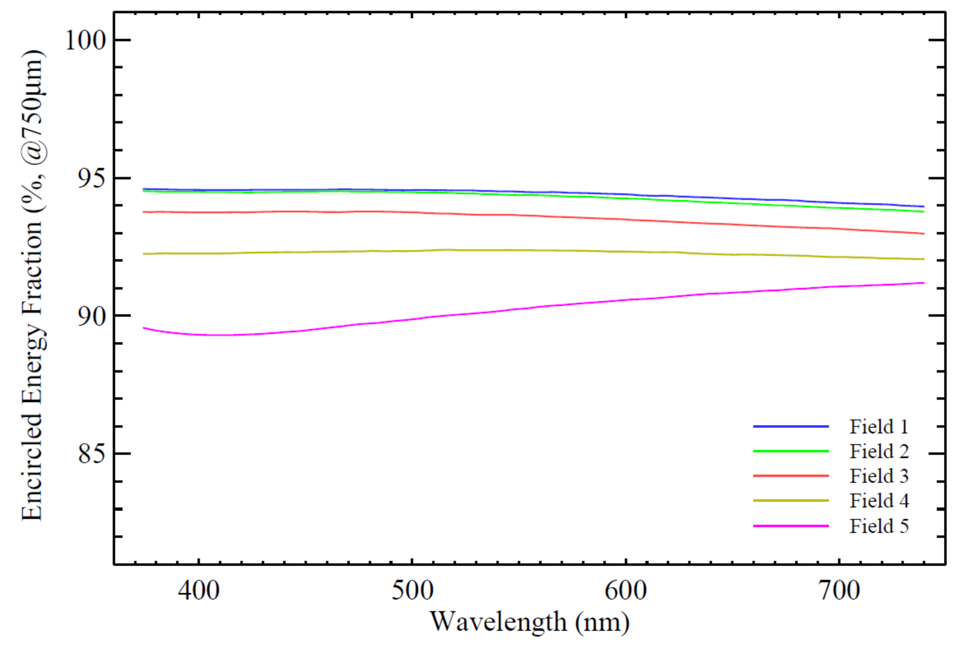




(Left) Fore-optics layout. We design fore-optics to refract telescope F/9 beam to F/21.486 telecentric beam. It changes plate scale on the focal plane from 157 μm / arcsec to 300 μm / 0.8 arcsec. the output beam is telecentric so incidence angle of the light to each IFU would be perpendicular to the focal plane. **(Right)** Calibration unit optics layout. Elements from the integrating sphere output to the focal plane is shown. The output light from the sphere is considered as a uniform light source and used as the object of calibration optics. We design calibration optics and fore-optics to use two lenses in common to fully utilize the limited space around the Cassegrain side port. The last two lenses in this diagram are identical to the last two lenses in the fore-optics layout. The movable large elliptical mirror is placed between the third and fourth lenses of the fore-optics lens and acting as calibration source selector.

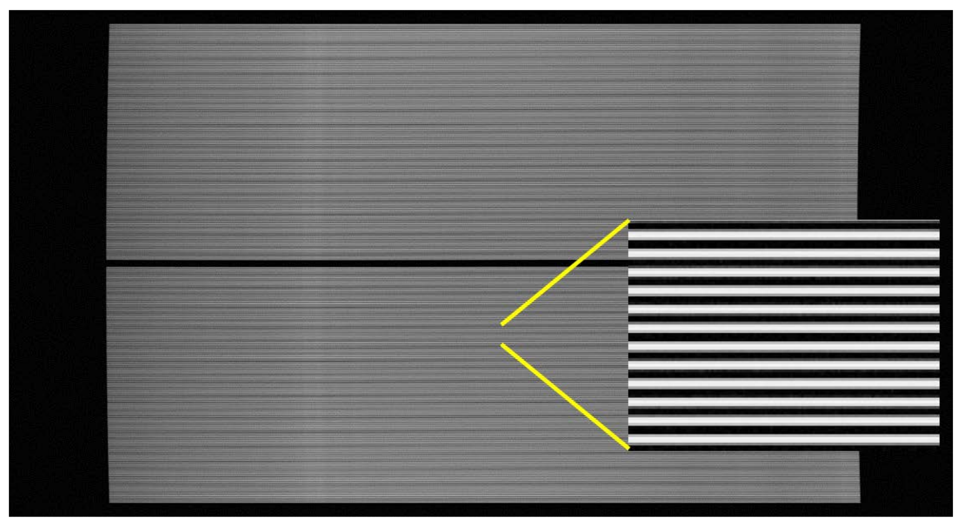


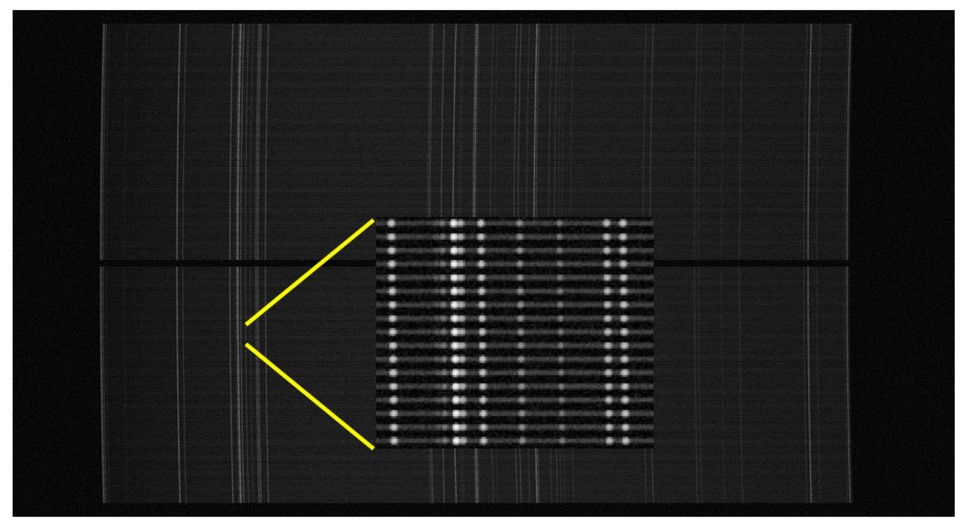




(Left) ZEMAX matrix spot diagram of the DOTIFS fore-optics. The diameter of a black circle around each spot is 300 μm, which represent a size of one microlens. **(Middle)** Wavelength versus RMS spot radius plot. **(Right)** Extended source encircled energy fraction of the fore-optics with 2 arcsec diameter uniform source. Sampling size is 750 μm in a circle, which correspond to approximately 2.5 times of the microlens sampling size.

Calibration Sources and Calibration Scheme





(Left) DOTIFS calibration light sources. DOTIFS uses Xenon arc lamp as a continuum source due to its relatively flat radiation curve within the DOTIFS working wavelength range. Krypton (Kr) and Mercury-Neon (HgNe) lamps are chosen as wavelength calibration sources, considering there emission line distribution. We also employ a integrating sphere to scramble the light from calibration source and provide uniform and collimated light to the calibration optics. Simulated **(Center)** Xenon arc lamp and **(Right)** Kr/HgNe lamp exposure images. They are produced by DOTIFS data simulator[2], which use known throughput of the instrument and radiation curve of continuum and emission line sources. Here we briefly describe fundamental calibration scheme of DOTIFS. In principle, DOTIFS take two sets of calibration source image for each science exposure. This is to have highest calibration accuracy as well as to trace possible flexure effect during the science exposure. At each calibration exposure, Xenon lamp will be turned on for few minutes ahead to be stabilized. A shutter near the integrating sphere input port will be closed during this warm-up phase. When Xenon lamp becomes stabilized, the shutter will be opened, and the elliptical mirror will be placed between the fore-optics lenses to block the light from the telescope. Continuum source image will be taken when everything is ready. After that, the arc lamp will be turned off, and wavelength calibration lamps will be turned on to take wavelength calibration source image. After taking two calibration images, the shutter will be closed, and the elliptical mirror is moved out so the next science exposure can be made.

Current Status

As of 2018 May, we ordered lens components to the to the lens fabricator and we expect to receive them by the end of July 2018. We ordered and received round mirror, elliptical mirrors, calibration light sources, integrating sphere, rotation stage and linear guideway stage from manufacturers. Opto-mechanical components are fabricated by local machines shops and ready to be assembled. Currently, we are working on verification of parts which are on our hands. We will start assembly of components once lens components arrive.

References

[1] Chung, H., Ramaprakash, A. N., Omar, A., Ravindranath, S., Chattopadhyay, S. et al. Proc. SPIE 9147, 91470V-70V-8 (2014)
[2] H. Chung, A. Ramaprakash, and C. Park, PKAS, 30(2), 675-677 (2015).