Optical Design of Multi-field Integral Field Unit Spectrograph for the ORCAS Keck Instrument Development II (ORKID II) Instrument

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INTRODUCTION

We have designed an Integral Field Unit for the ORCAS Keck Instrument Development II (ORKID II) Instrument. Building on the success of the ORKID camera which achieved 15.2 masec PSF FWHM visible light imaging, ORKID II will add Integral Field Spectroscopy to analyze Active Galactic Nuclei (AGN), supernovae redshift and brightness, and other observations. Several design options have been explored based on image slicers manufactured by the Canon Corporation's machining process. Field layouts can include up to three disparate spatial sampling, with a lower limit of 6.7 masec. Spectral resolutions are considered from R 100 to R 10,000.

The design shown in Figure 1 demonstrates the concept for a stand-alone instrument concept for the W.M. Keck Observatory. With a 10-m aperture, ORKID II could provide wide-field spectrographic imaging with spatial sampling from 6.7 mas to 26 mas. The design can be adapted to other systems, such as the Habitable Worlds Observatory (HWO).

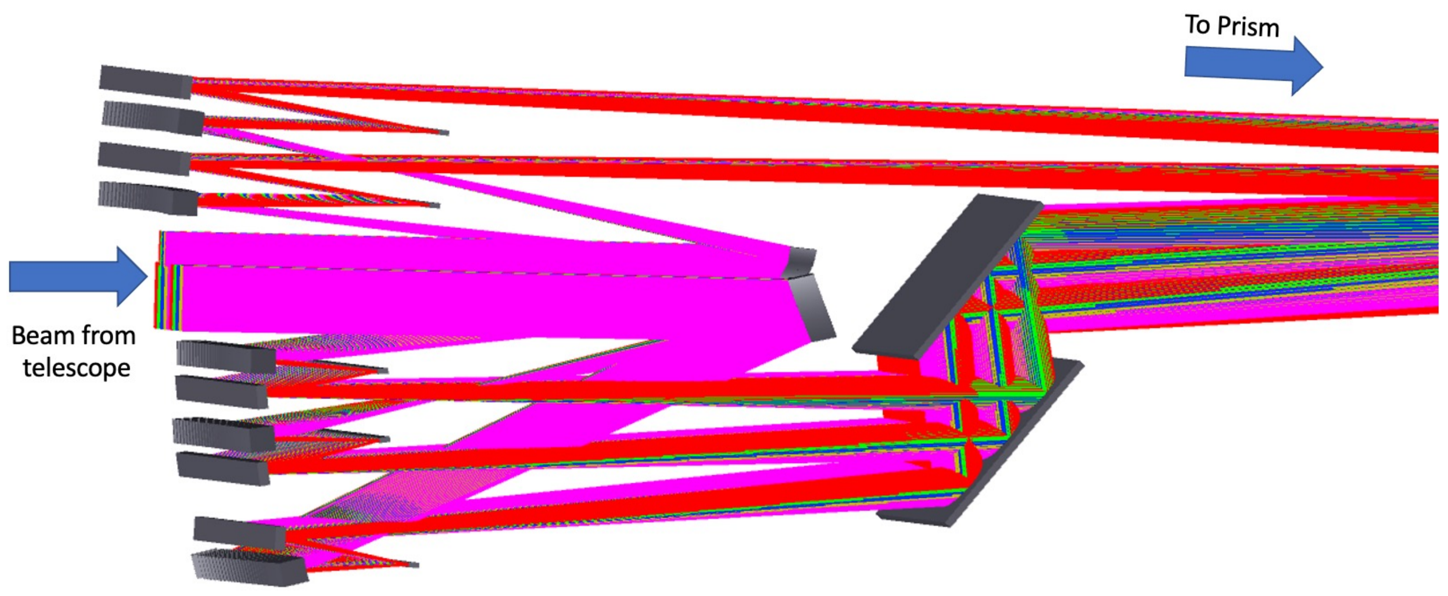

Fig. 1 Optical Layout of the Image Slicer Assembly

Designing the layout for machined optical components allows for close-cut multiple mirror surfaces on a single substrate.

Integral to the design concept is the capabilities of Canon Corporation's 5-axis machining process. Using diamond cutting tools, they are able to machine multiple optical surfaces with 2 nm RMS surface figure and roughness.

METHODS

The input field can be as fast as f/160, with the X-axis up to f/80. The Image slicer mirrors vary from 100 to 400 μm across three fields: Fine, Coarse and Very Coarse. (Figure 2) The slices are re-images to five output Pseudo-Slits. These slits can be projected to a common exit pupil for spectrographic dispersion. In our example shown here, (Fig 3) they are dispersed by R_{min}100 prisms onto a single 4k x 4k sensor with an 80% fill factor. The overall design can be used for Ground or Space-based telescopes, matching to the angular resolution of the system.

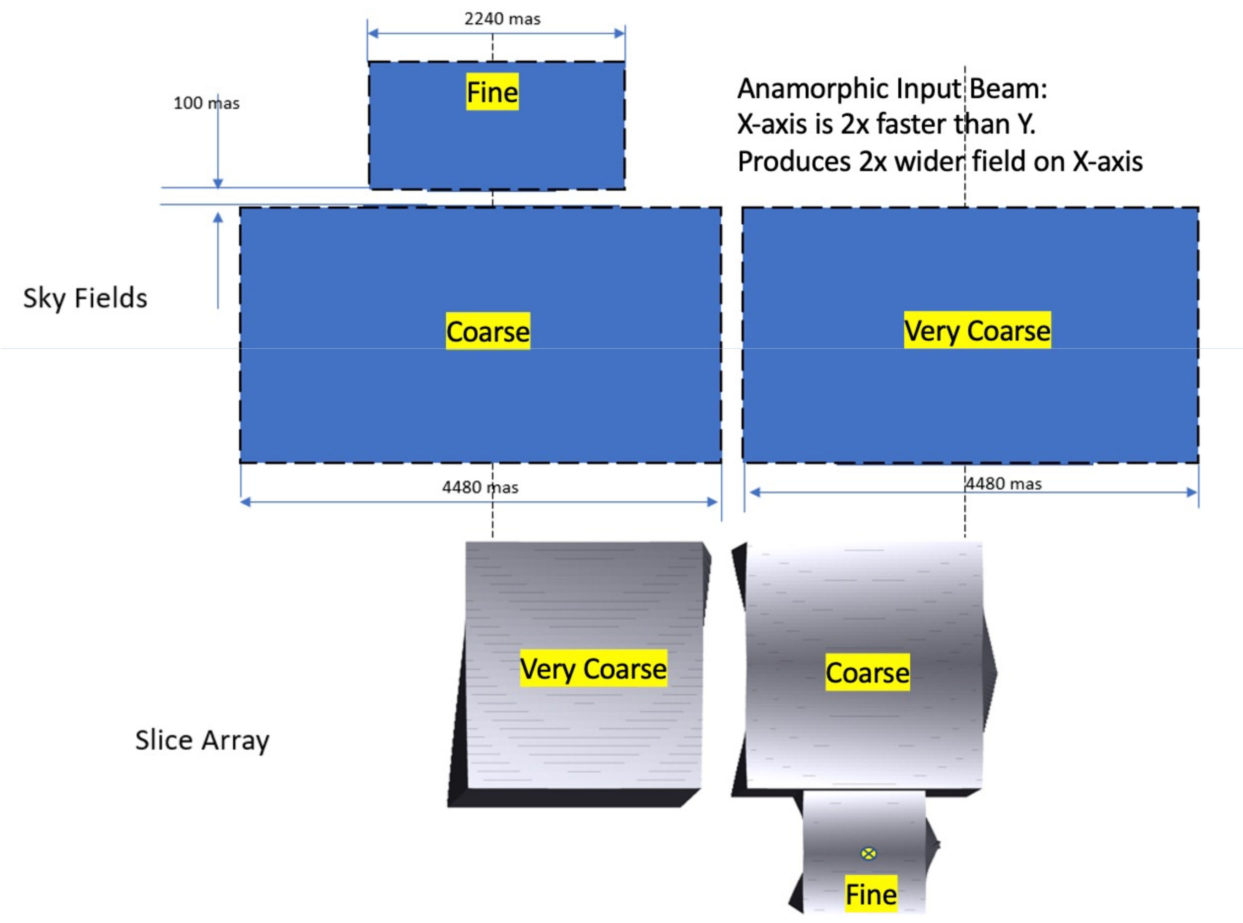

Fig. 2 Image Slicer and Field Layout

The modular design of the concept allows for updating the instrument for various observing campaigns.

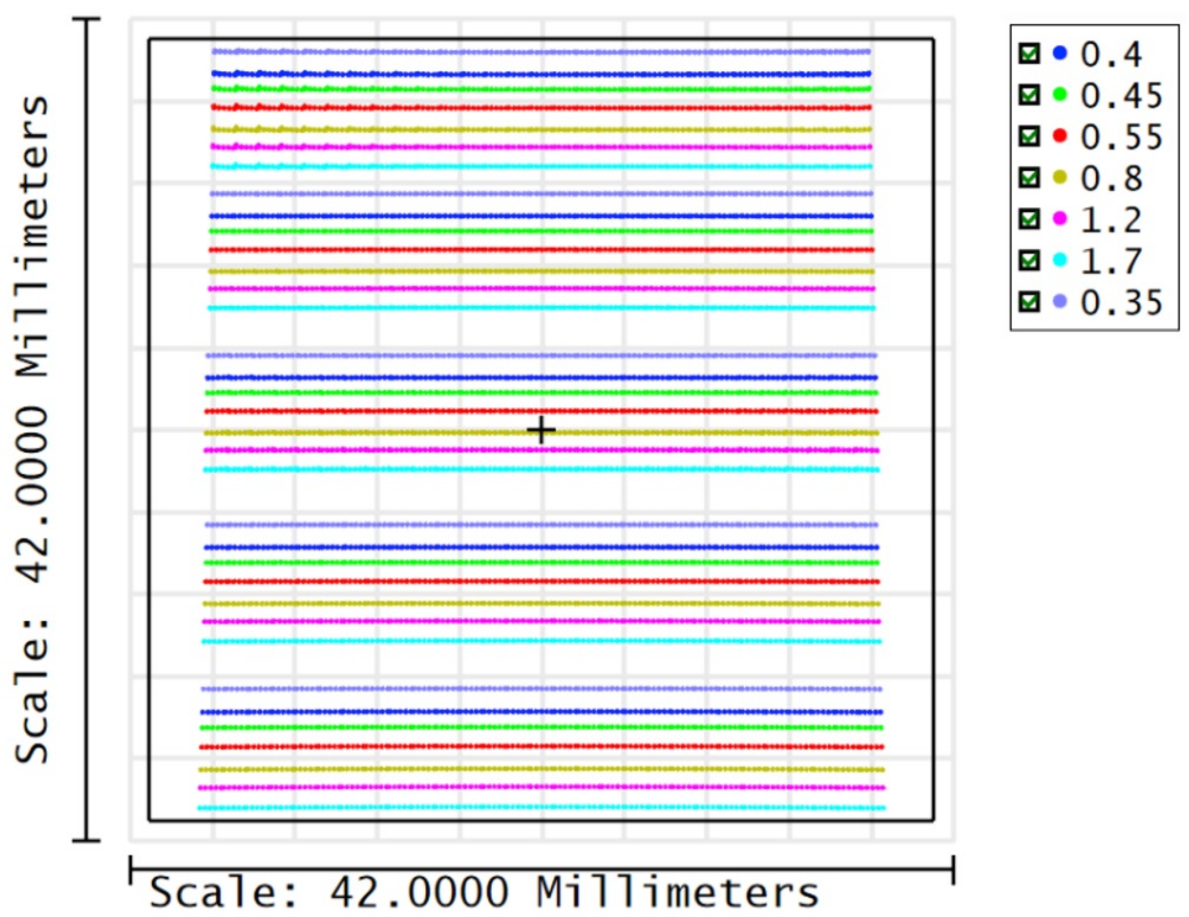

Fig. 3 Focal Plane Layout

RESULTS

The performance across all slicers are shown in Fig 4-6:

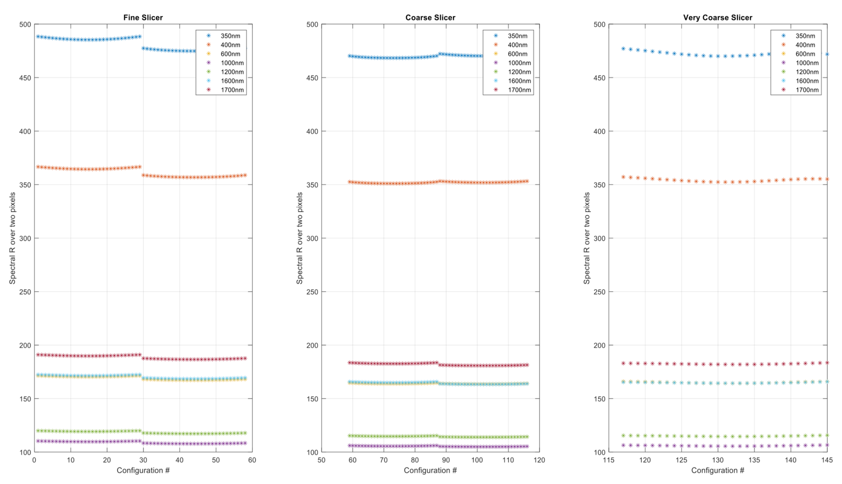

Fig. 4 Spectral Resolution (Pixel Pairs)

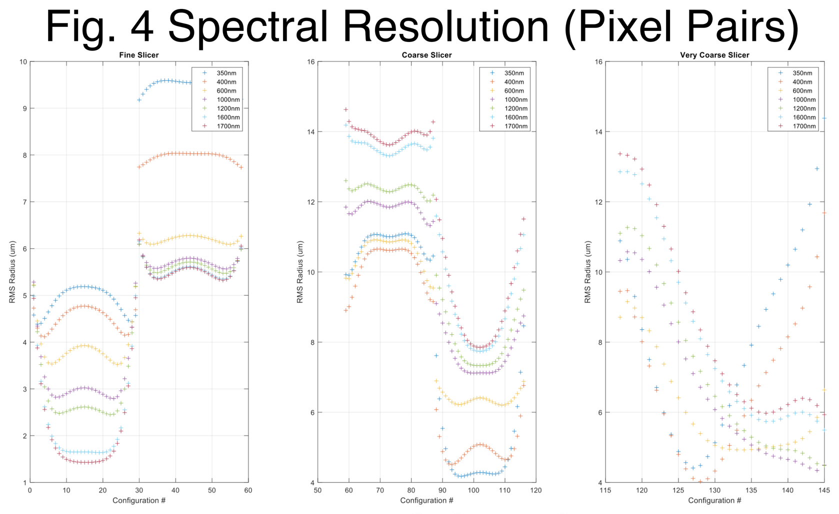

Fig. 5 RMS Spot Size

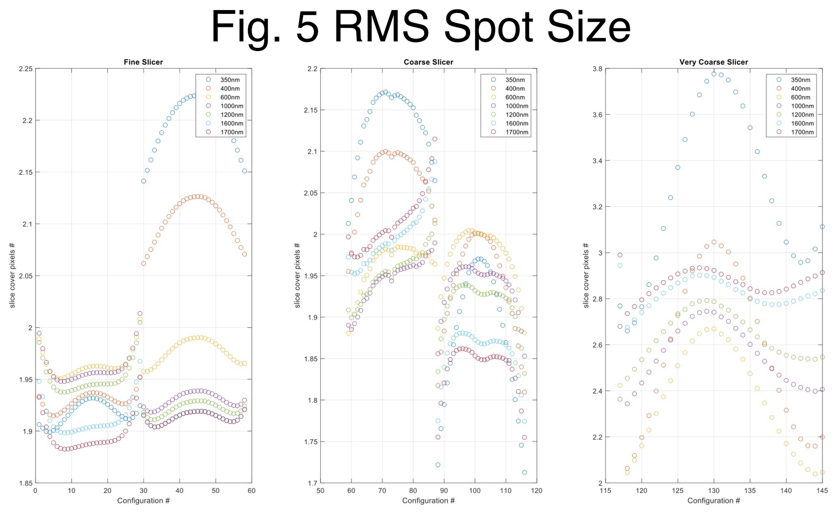

Fig. 6 Y-Axis slit magnification

CONCLUSIONS

We have a well-defined path forward to build and use a new class of Integral Field Spectrographs based on machined optical components. This will continue to be developed for ground- and space-based instrumentation.

The use of machined Image Slicer Assemblies is a proven technology that can be expanded on for use in all areas of spectrophotonic imaging.

REFERENCES

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This research is funded by NASA