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Integrating Kyoto3DII with Subaru/AO188 for improved image-quality observation in optical

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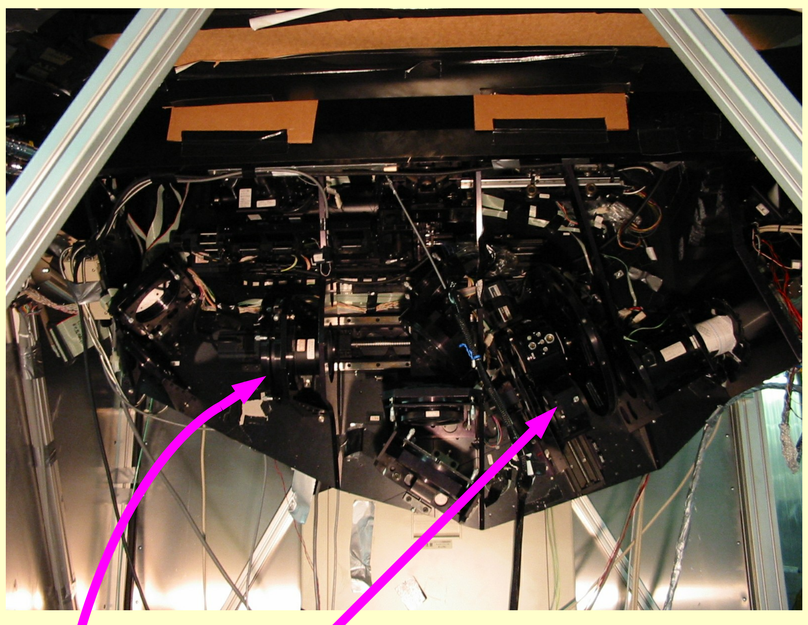
Abstract

The Kyoto Tri-dimensional Spectrograph II (Kyoto3DII) is a multimode optical spectrograph with four observation modes: Fabry-Perot (FP) imager; Integral Field Spectrograph (IFS) with a lenslet array; long-slit spectrograph; and filter imaging modes. This instrument is operated at Subaru Cassegrain focus.
The aim of integrating Kyoto3DII with Subaru/AO188 is to valuate the performance of the AO188 system in optical wavelength and to retrieve 3D data cubes with improved image quality.
According to model simulations by the AO188 team, the AO188 system will reduce image sizes by about one third or so even in the optical wavelength such as R band. Our ~ 0.1 arcsec sampling well samples E50.

To connect the two instruments, we need a beam splitter between the Kyoto3DII and the AO188. Because major targets of this instrument are extragalactic objects, which we can rarely find suitable natural guide stars, our beam splitter must reflect shorter wavelengths including that of the laser guide star (589 nm) to the AO188. We designed our multilayer coated beam splitter to pass the wavelength region longer than 640 nm to the Kyoto3DII including Hα wavelength at the rest frame.
To adjust the Kyoto3DII with the beam of the AO188, we need a new mount and designed it to well fit to the mechanical limitations of the Nasmyth floor.
In this poster, we'll show the simulations of the expected images, and the current status of developments and commissioning.

About Kyoto3DII

Observing parameters (at Subaru Cassegrain focus)
* FP mode - 0".056 per pixel, 1'.9 FoV, R ~ 300 - 600 (4000 - 7000 A)
* IFS mode - 0".096 per lenslet, 3".4 FoV (~1000 spectrum for object, ~200 for sky at ~30")
  R ~1200 (3600 - 9100 A, covered with 5 wavelength range)
  R ~4000 (covers [OIII]+Hβ and Hα at z=0)

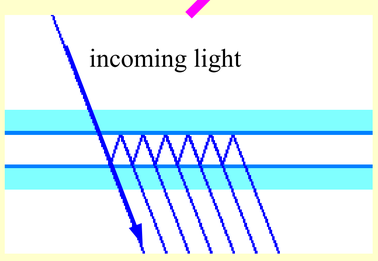


Main charactaristics
* Compact and portable
* Multi-mode 3D spectroscopy

Kyoto3DII has 4 modes
* filter imaging
* long-slit spectroscopy
* IFS with a lenslet array
* Fabry-Perot Imaging

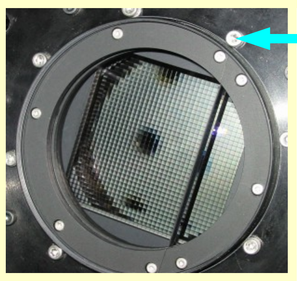
Can observe with multi-mode in one run
* one FP and one grism mode
* five grisms mode
(Long-slit spectroscopy and filter imaging could be used in any configuration)

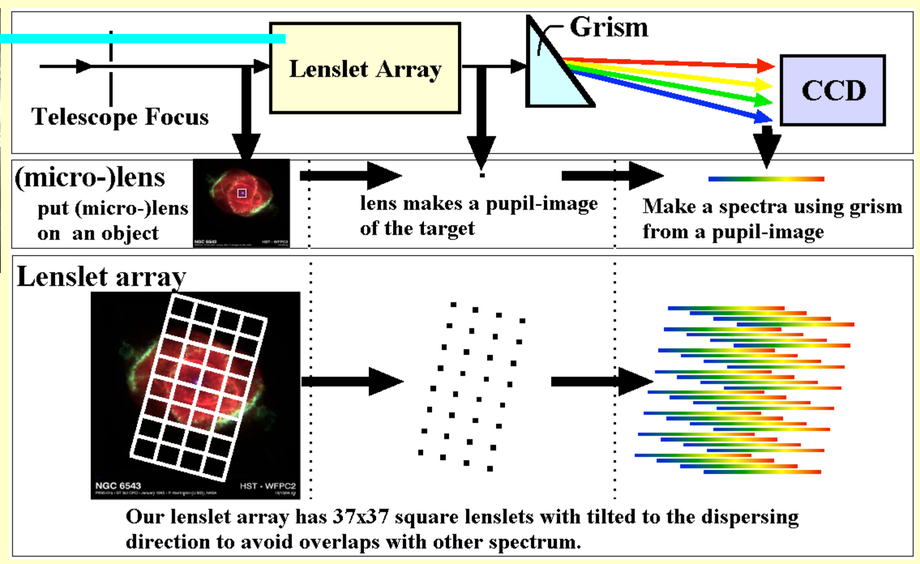
Fabry-Perot imaging mode



Fabry-Perot etalon is made of coated reflecting mirrors in parallel, and interference occurs between the multiple reflections between the two surfaces.
If the transmitted beams are in phase, constructive interference occurs and output beam has a high-transmission peak, which depends on the wavelength of beams and the separation of two surfaces.

Lenslet array spectroscopy mode



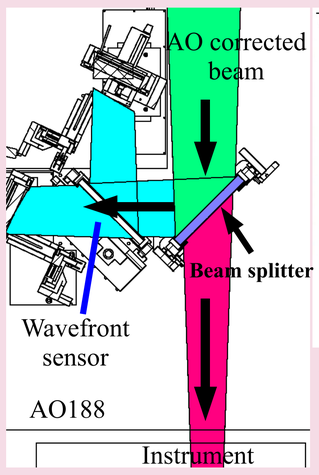


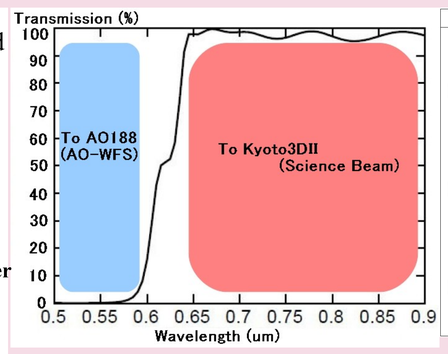
Our lenslet array has 37x37 square lenslets with tilted to the dispersing direction to avoid overlaps with other spectrum.

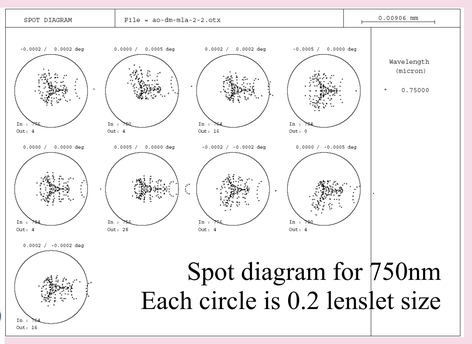
Developments for the Integration

1. Beamsplitter for Kyoto3DII

Other instruments only use an infrared wavelength region for the instrument, and pass an optical wavelength region to the wavefront sensor of the AO188 system. Because the target wavelength of Kyoto3DII is optical, we designed a new beam splitter which transmits some optical wavelength region to the Kyoto3DII.







Spot diagram for 750nm
Each circle is 0.2 lenslet size

Required specifications from science
* Reflection (to AO wavefront sensor) - Reflect 589nm (LGS) and below
* Transmission (to Kyoto3DII) - Transmit Hα with wing (to 644nm)

Design outlines
* Size, Material and Coatings
  - Size is the same as the outline size of other beam-splitters except for the angle of wedge
  - Substrate material is SiO2, and coating materials are Al2O3, TiO2, SiO2, and MgF2.
* Image quality (aberration)
  - Only modified the angle of wedge, no compensator
  - For astigmatism, almost all light are in 0.2 lenslet
  - For transverse chromatic shift, <0.25 lenslet in a specrtal band and will be corrected with software
* Reflection and Transmission
  - Reflect ~96% at 589nm. Transmit 97% at 644nm, 97% at 656nm and keep >95% at >644nm

2. New mount for Kyoto3DII at nasmyth floor

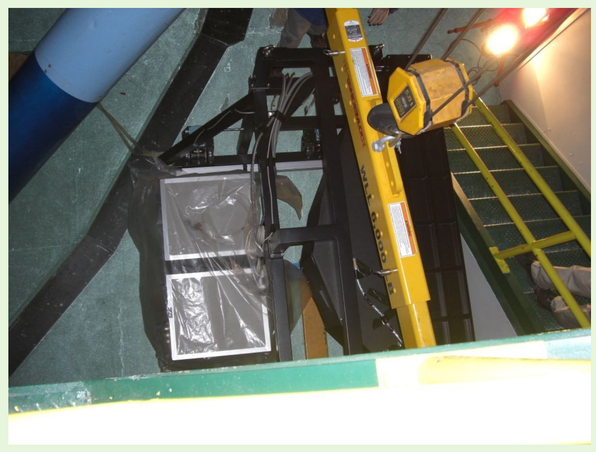
The Kyoto3DII is now operated at the Cassegrain focus of the Subaru telescope and will be operated both at Cassegrain focus and at Nasmyth focus with the AO188.

Design requirements
- Use wheels to move the mount at cassegrain floor (not using cranes)
- Make the mount as light as possible
- Can hang by crane with mounting the Kyoto3DII and its whole electronics
- Movable mount and can adjust the Kyoto3DII with the beam of the AO188.

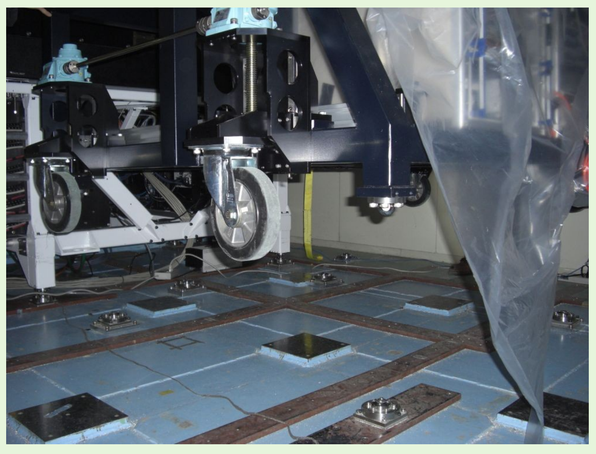
We decided to use welded steel frames.

Current Status and Future Works

The new mount is already deliverd to the Subaru.
The Kyoto3DII mounted on the Nasmyth mount.



Test to move the mount with a crane between the Cassegrain floor (stanby) and the Nasmyth floor.



Down the Kyoto3DII mount on the Nasmyth floor and move with wheels to the observing position.

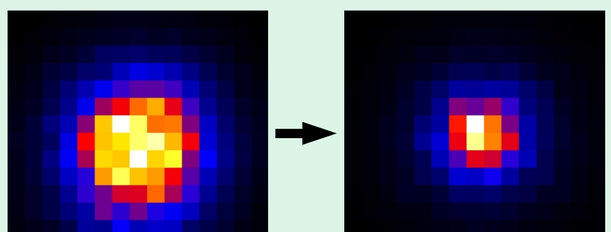
Measured the relative position to the output light axis of the AO188 and positioned our fixed point mount.

Future works

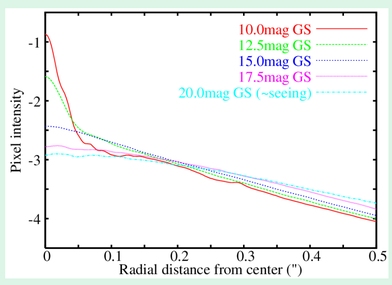
* Fine adjustment between the Kyoto3DII mount and the beam of the AO188, after screwing the fixed point mount onto the Nasmyth floor.
* Checking the whole electronics to be work fine at the Nasmyth floor.

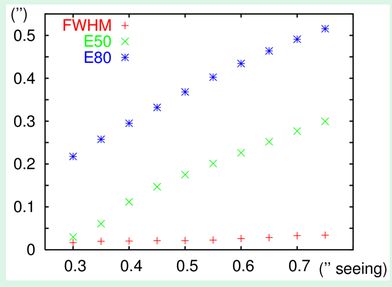
Expected Image Quality by Kyoto3DII with AO188

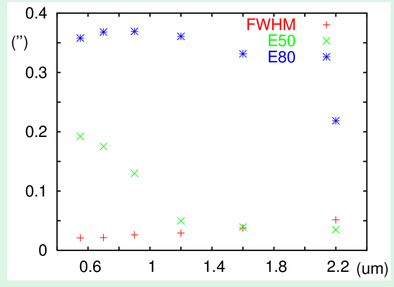
The main target wavelength of AO188 is infrared region, but AO188 is expected to reduce image sizes by about one third or so even in the optical wavelength such as R band according to the model simulations. Because the element number (188) of the AO system is not enough for the environment in the optical wavelength, such as the fried parameter, resultant images show a small core with strehl ratio < 0.1 and a wide spread halo.



Simulated images of a point like target for Kyoto3DII lenslet spectrograph mode in R band (7000A) and 0".5 seeing. Sampling is 0".088 per lenslet. The image without AO (left) and with AO (right) are shown. The guide star for the AO system is a natural guide star of 10 mag. The size of encircled energy 50% is 0".30 and 0".18.







Graphs for radial profiles of the point like target for various guide star brightness (left), FWHM and size of encircled energy for various natural seeing sizes (center), and FWHM and size of encircled energy for various wavelengths (right). Other simulation conditions are fixed at 0".50 seeing, R band (7000A), and a natural guide star of 10 mag.