UPGRADE OF THE DETECTOR IN THE INTEGRAL FIELD SPECTROGRAPH OSIRIS

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AstroTechTalk
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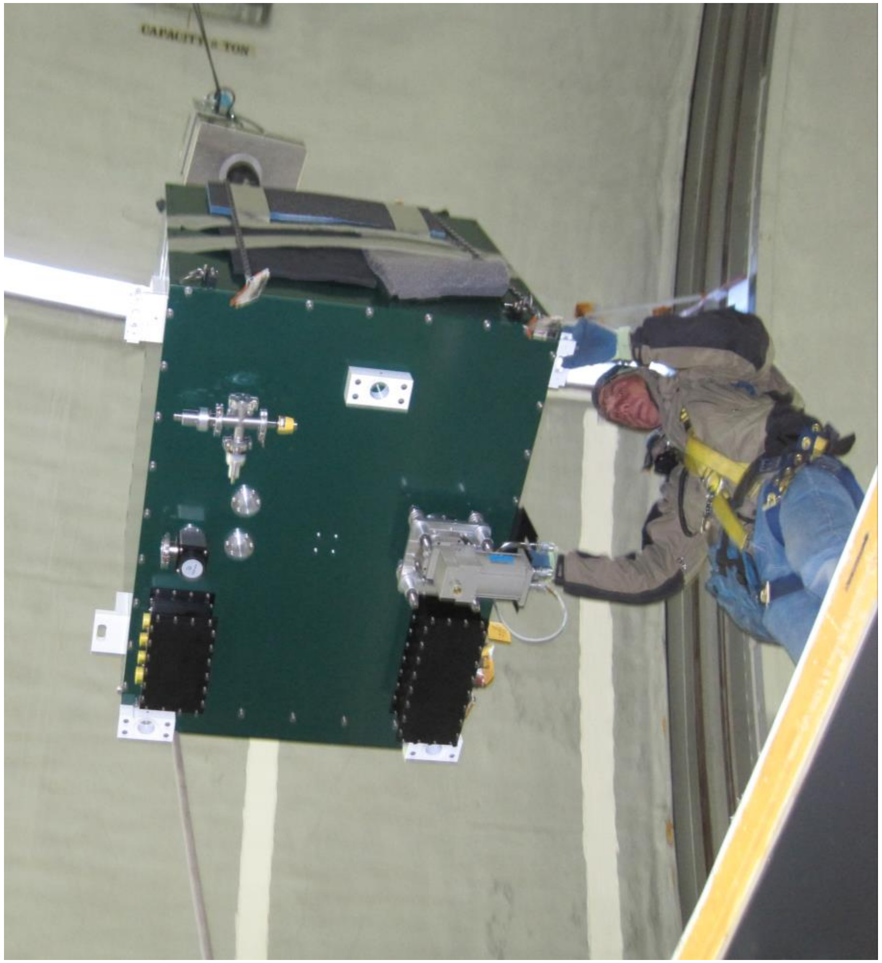
Integral Field Spectrograph (IFS): OSIRIS @ Keck Observatory



OSIRIS

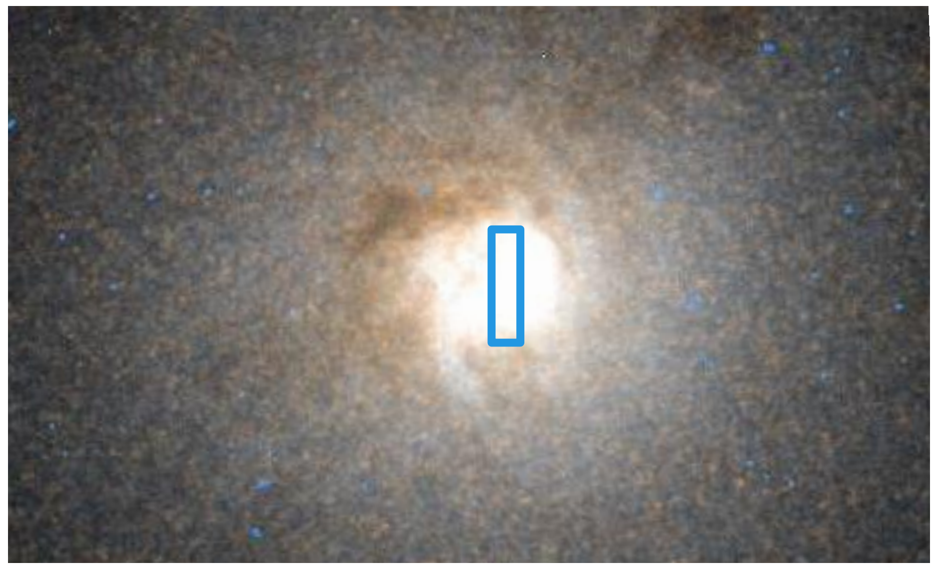
- First light in 2005
- Near-infrared instrument: 1 – 2.5 microns
- Spectral resolution: ~3,800
- Spatial resolution: diffraction limited (thanks to adaptive optics)
- Spatial pixel plate scales: 0.020 – 0.100 arcseconds/pixel
- Observe up to 3,000 spectra **simultaneously**

Outline

- Introduction: Integral Field Spectroscopy
  - One example science case: nearby active galaxies
- Overview of OSIRIS spectrograph
- Details of the upgrade of the OSIRIS detector

Spectra are often measured using light coming from a single aperture.

15 arcsec

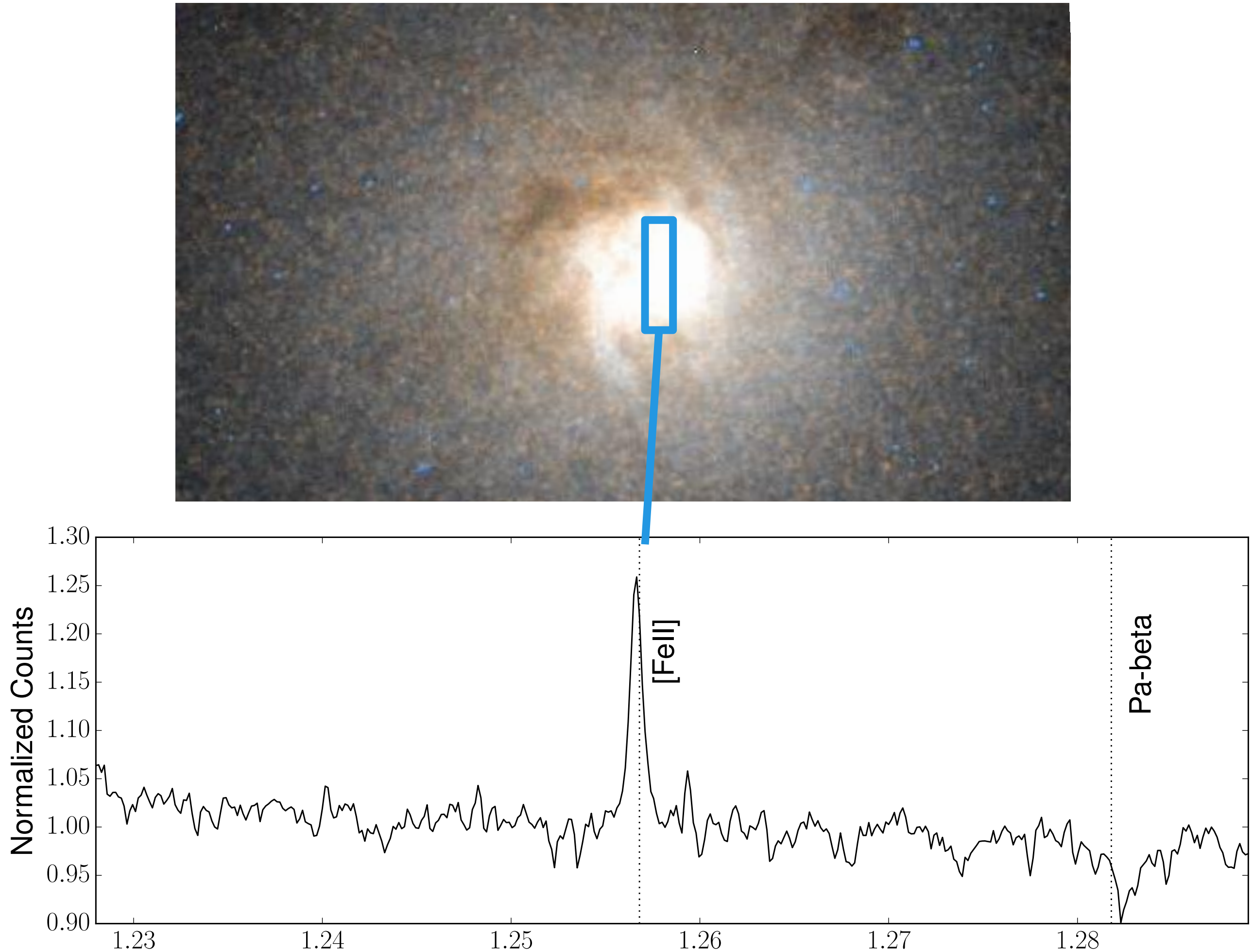


Nearby galaxy NGC 404

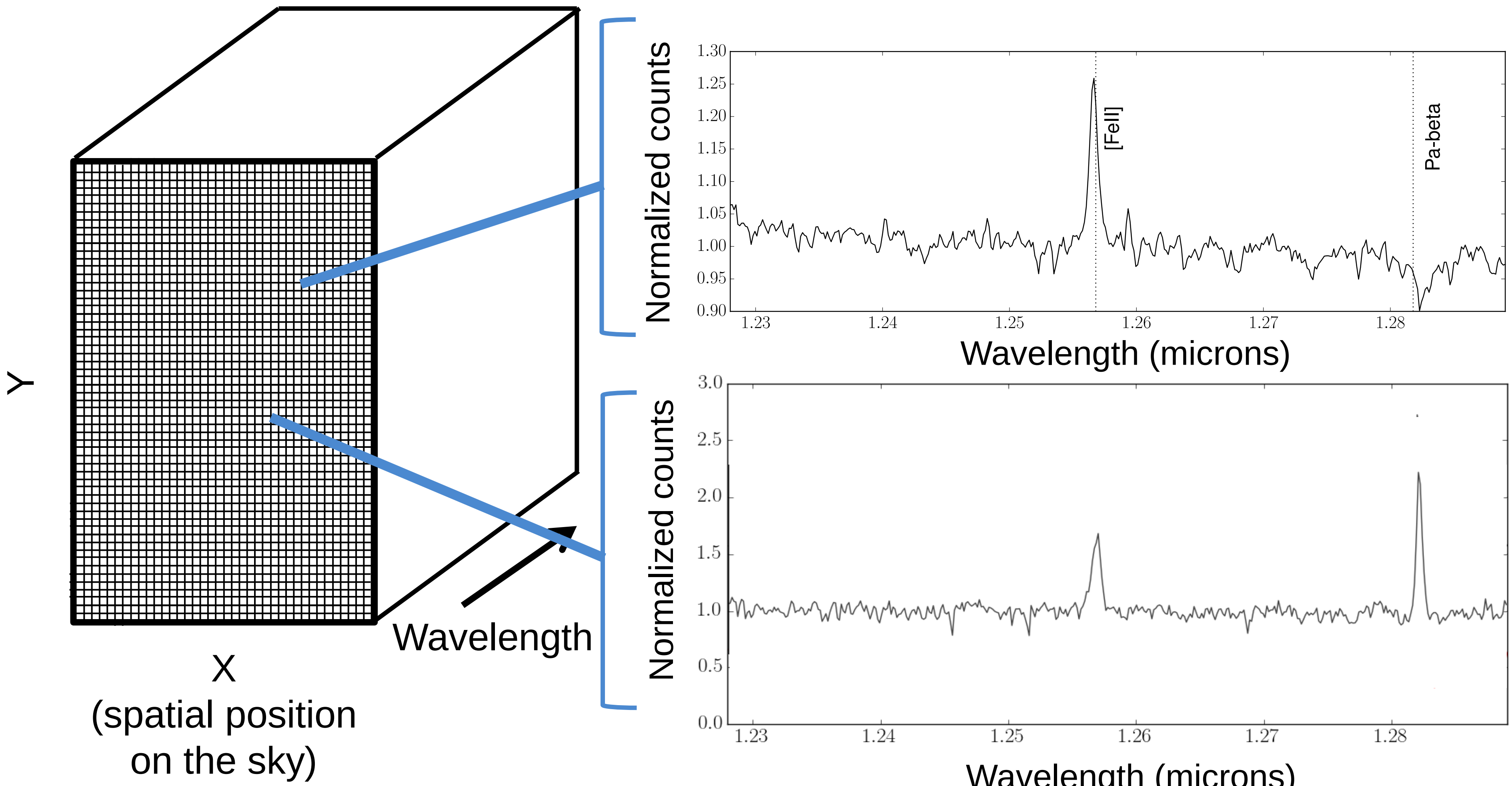
slit aperture: **0.75 x 3 arcseconds**

Image Source: HST Legacy Archive

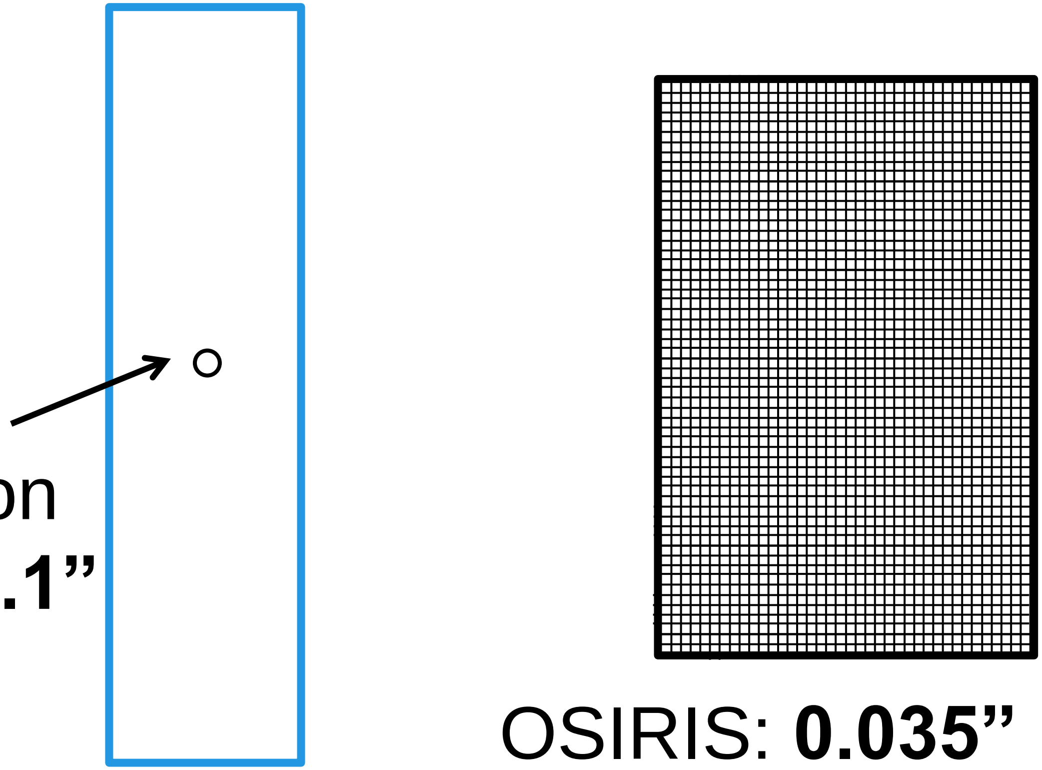
Emission and absorption lines in a single spectrum give information about physical conditions in the source.



Data from IFS is a cube in which every spatial pixel has a spectrum.



Combining integral field spectroscopy with adaptive optics gives **high spatial resolution** + **spectral** information.

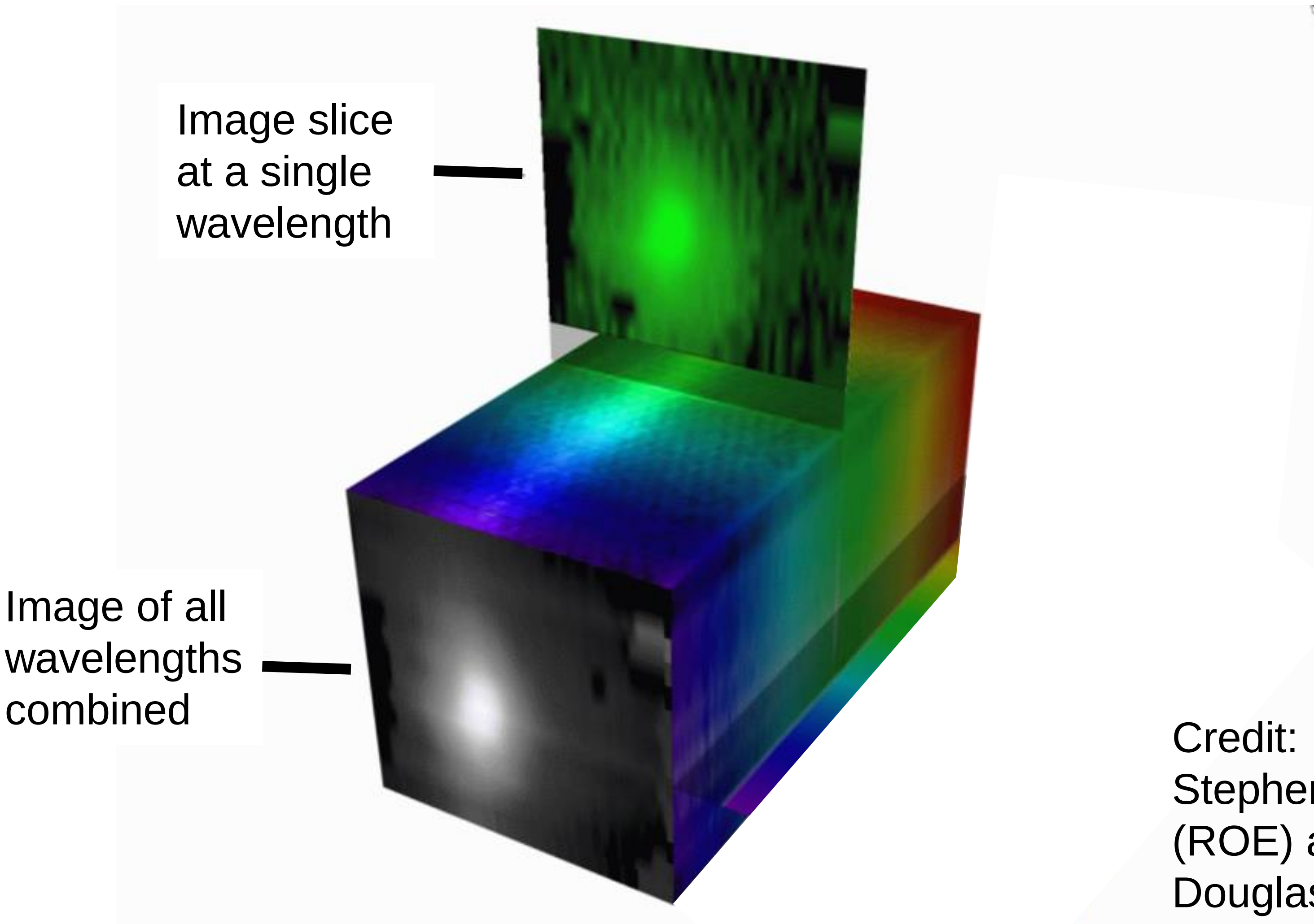


AO resolution element: ~**0.1”**

OSIRIS: **0.035” pixels**

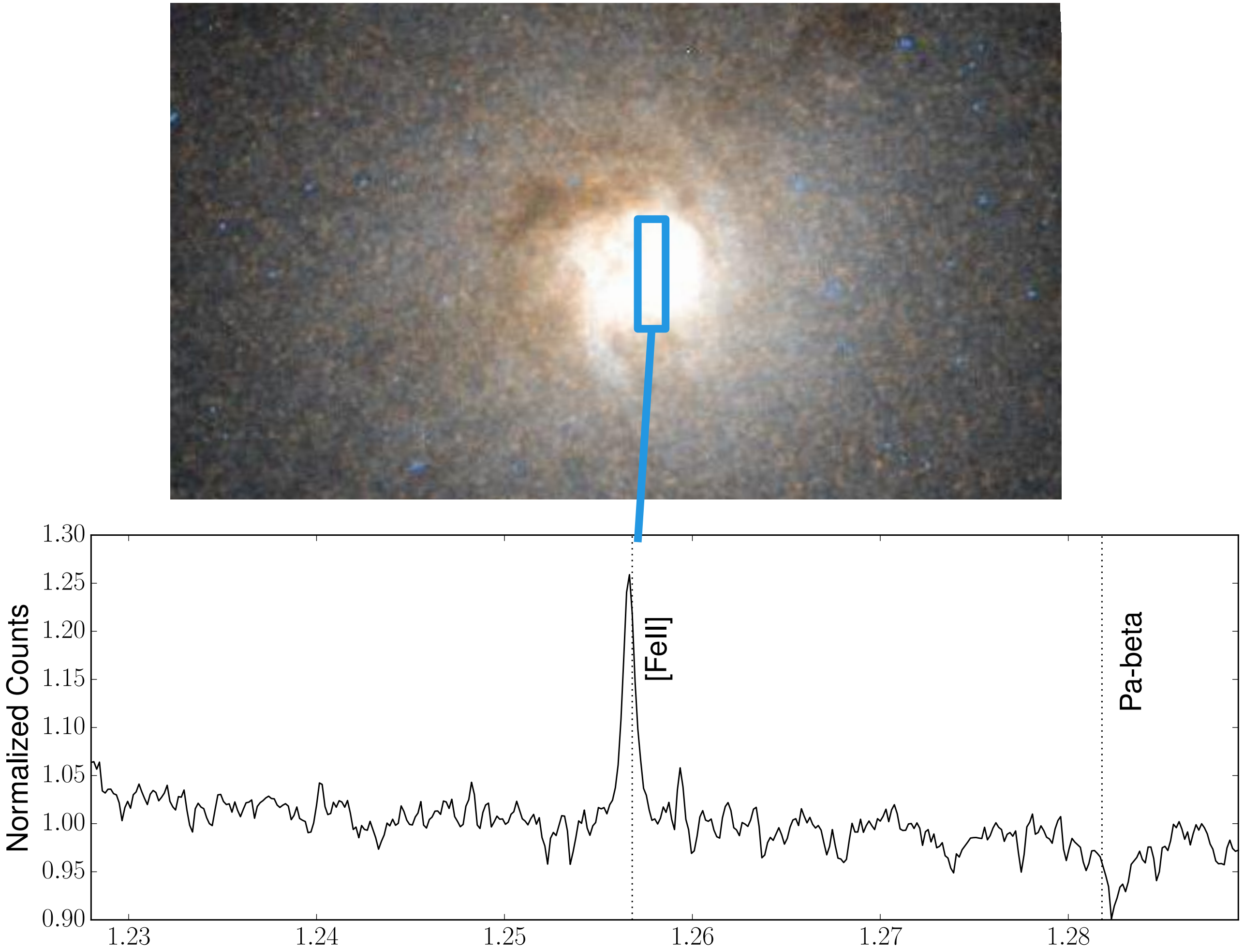
slit aperture: **0.75” x 3”**

Data cube contains an image for every wavelength sampled by the instrument.

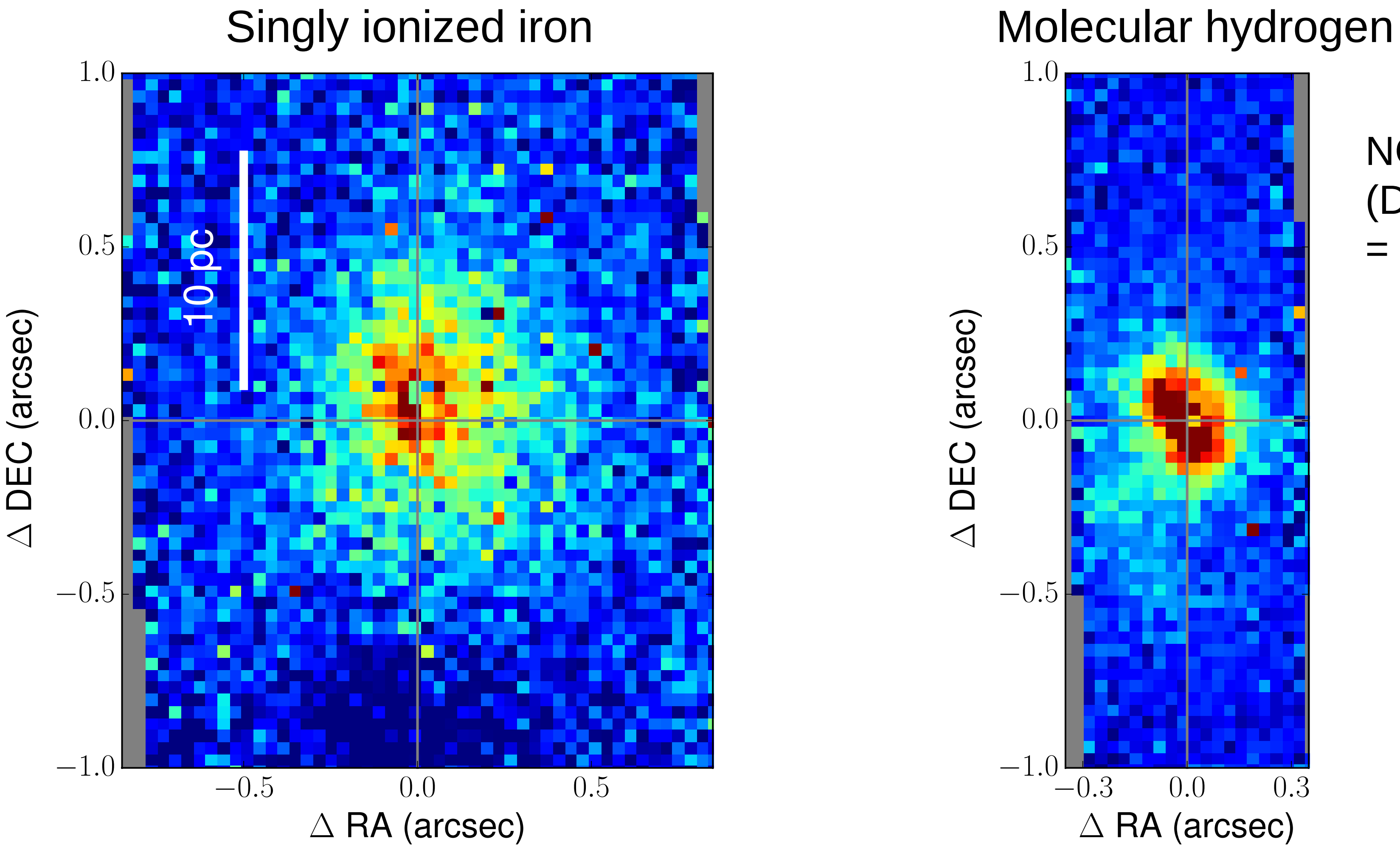


Credit: Stephen Todd (ROE) and Douglas Pierce-Price (JAC)

Emission and absorption lines in a single spectrum give information about physical conditions in the source.

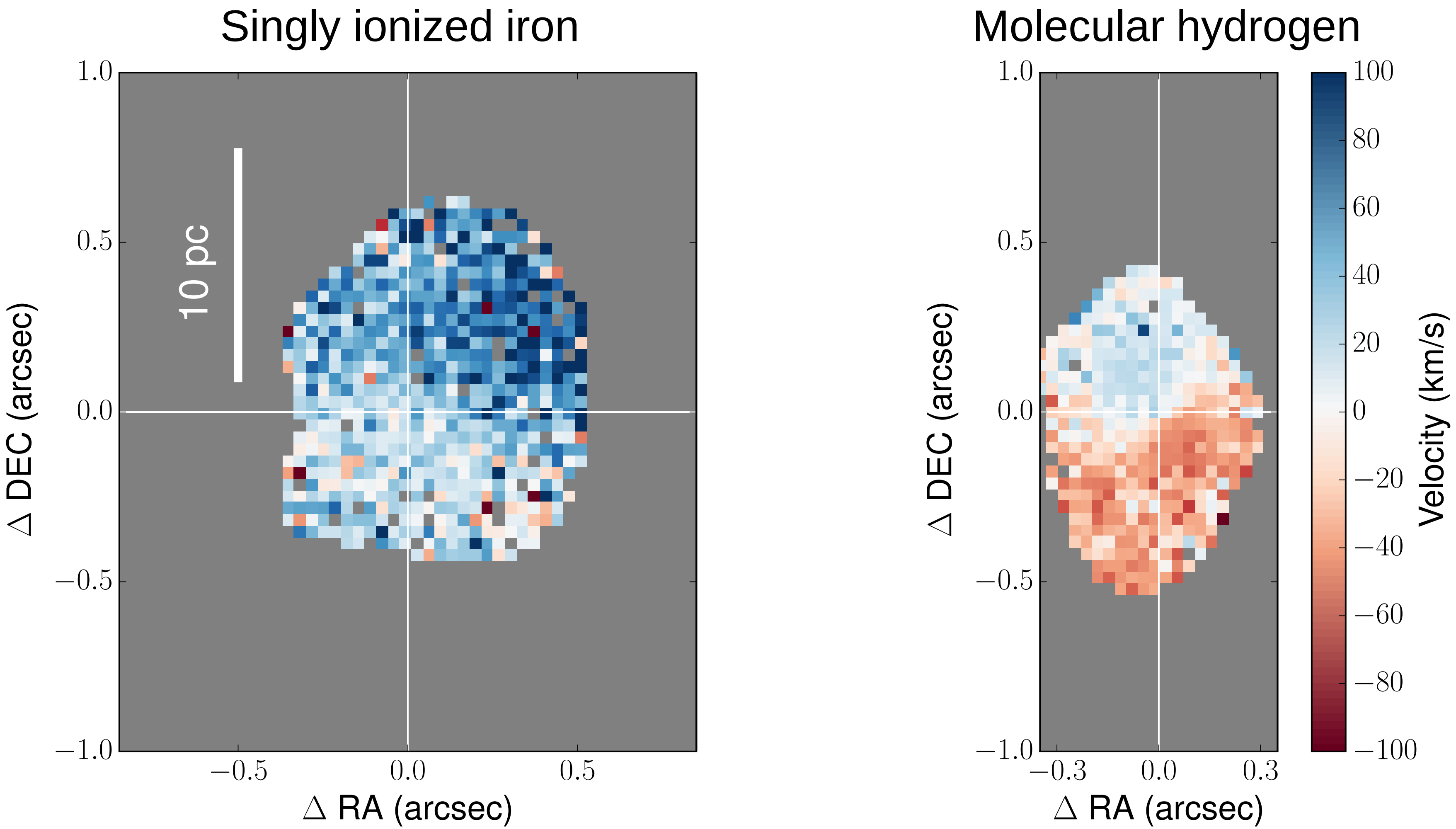


IFS can be used to map the emission from ionized and molecular gas at the centers of galaxies.



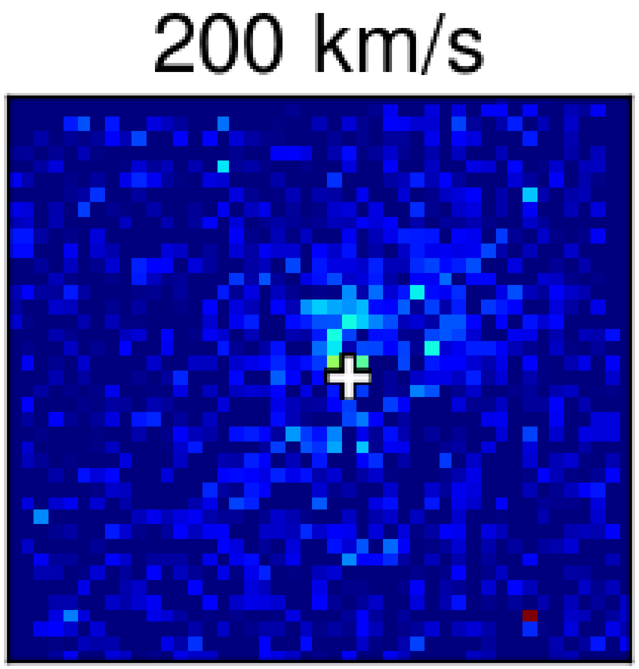
NGC 404
(Distance
= 3 Mpc)

Single ionized iron and molecular hydrogen lines show different velocity structures with perpendicular gradients.



IFS can additionally track gas emission as a function of velocity.

Singly ionized iron

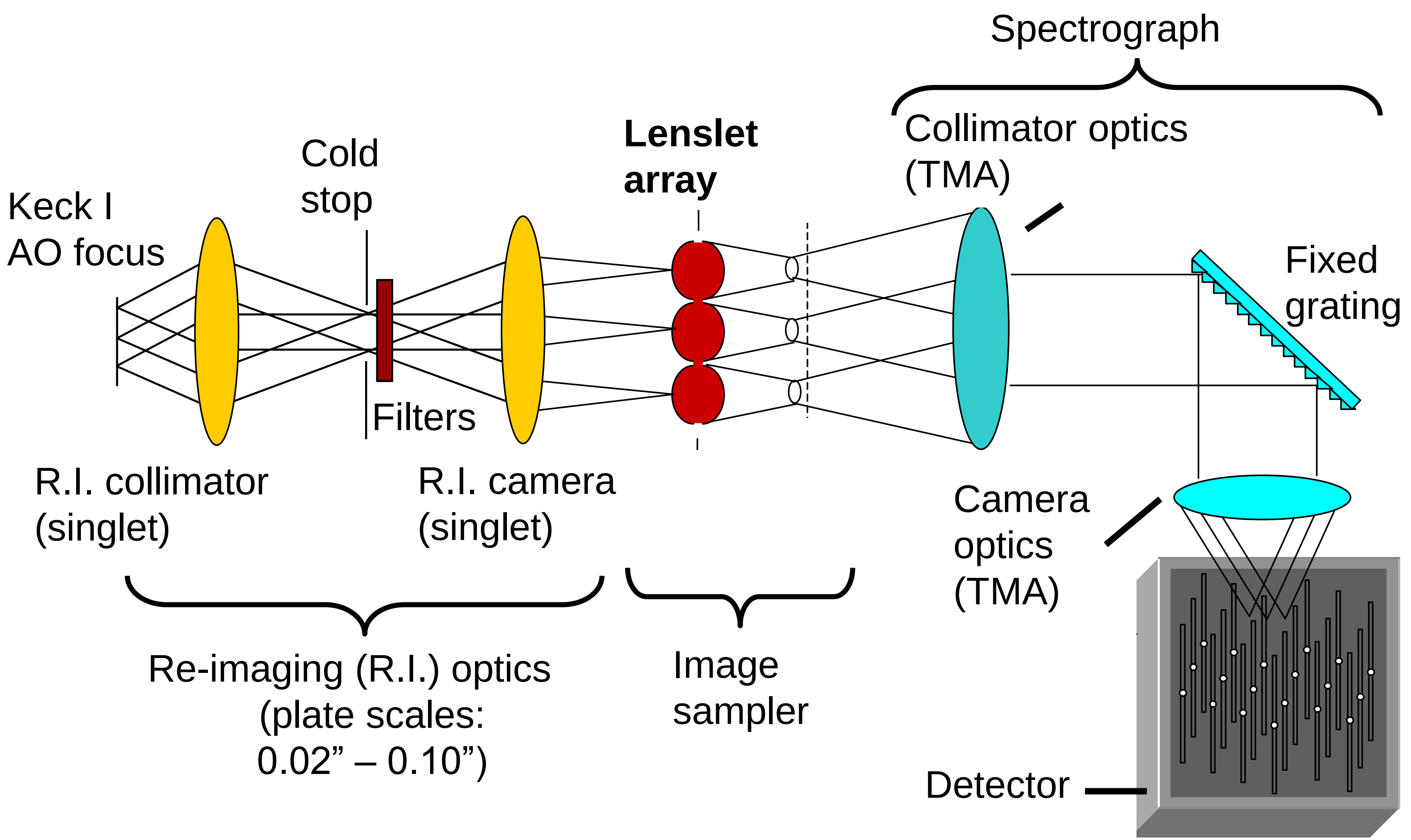


Singly ionized iron

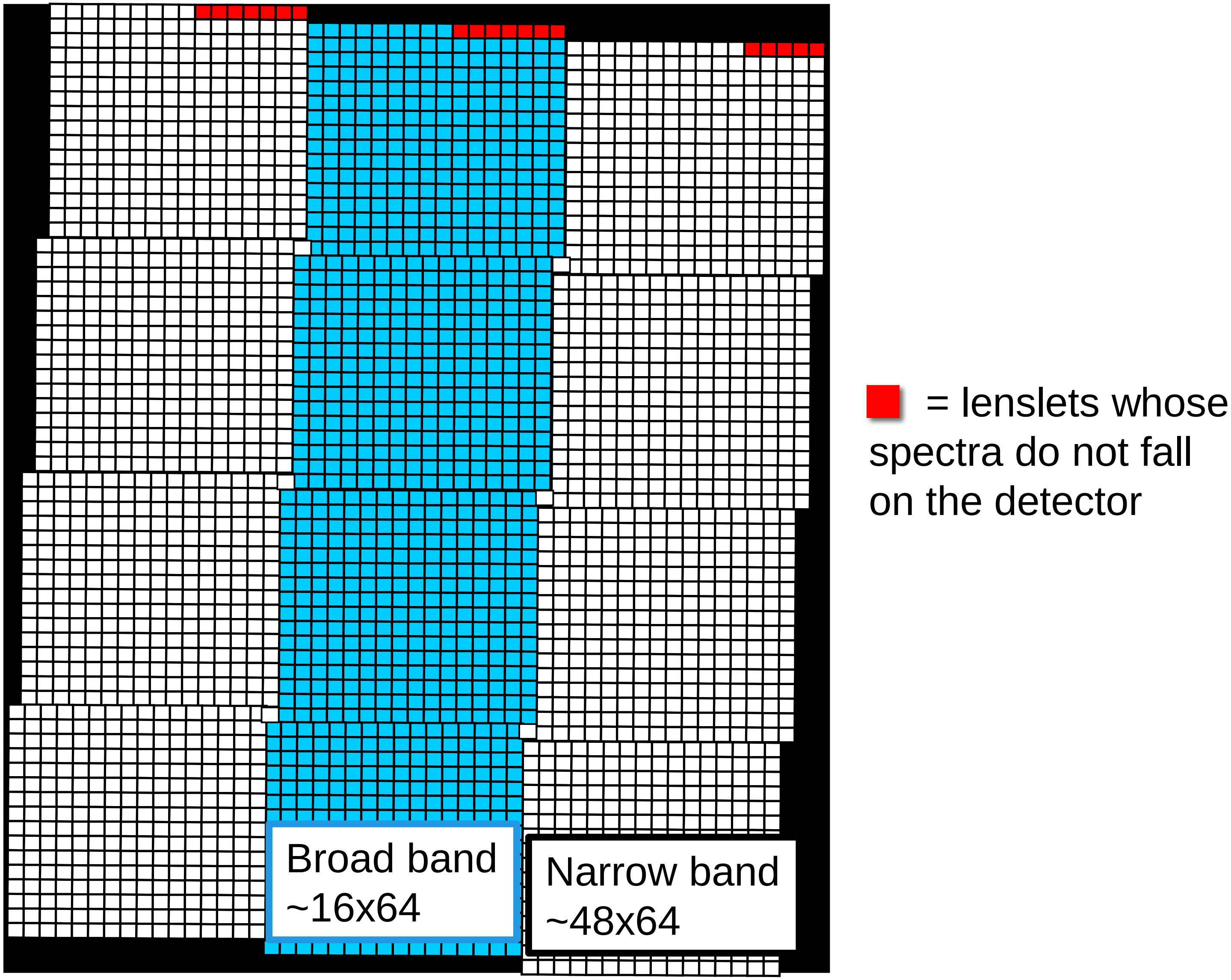
1” (15 pc) on a side

✚ = center of continuum emission

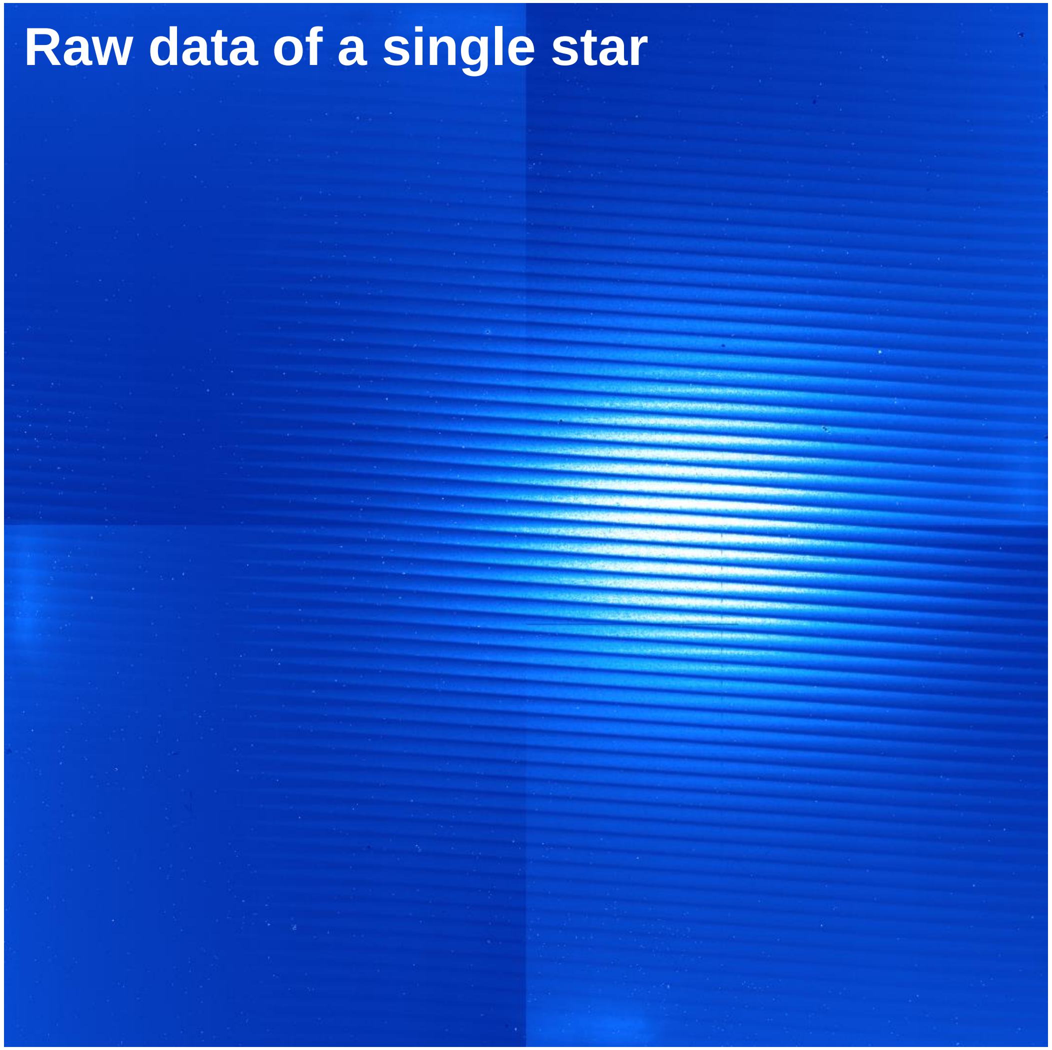
OSIRIS: a lenslet IFS



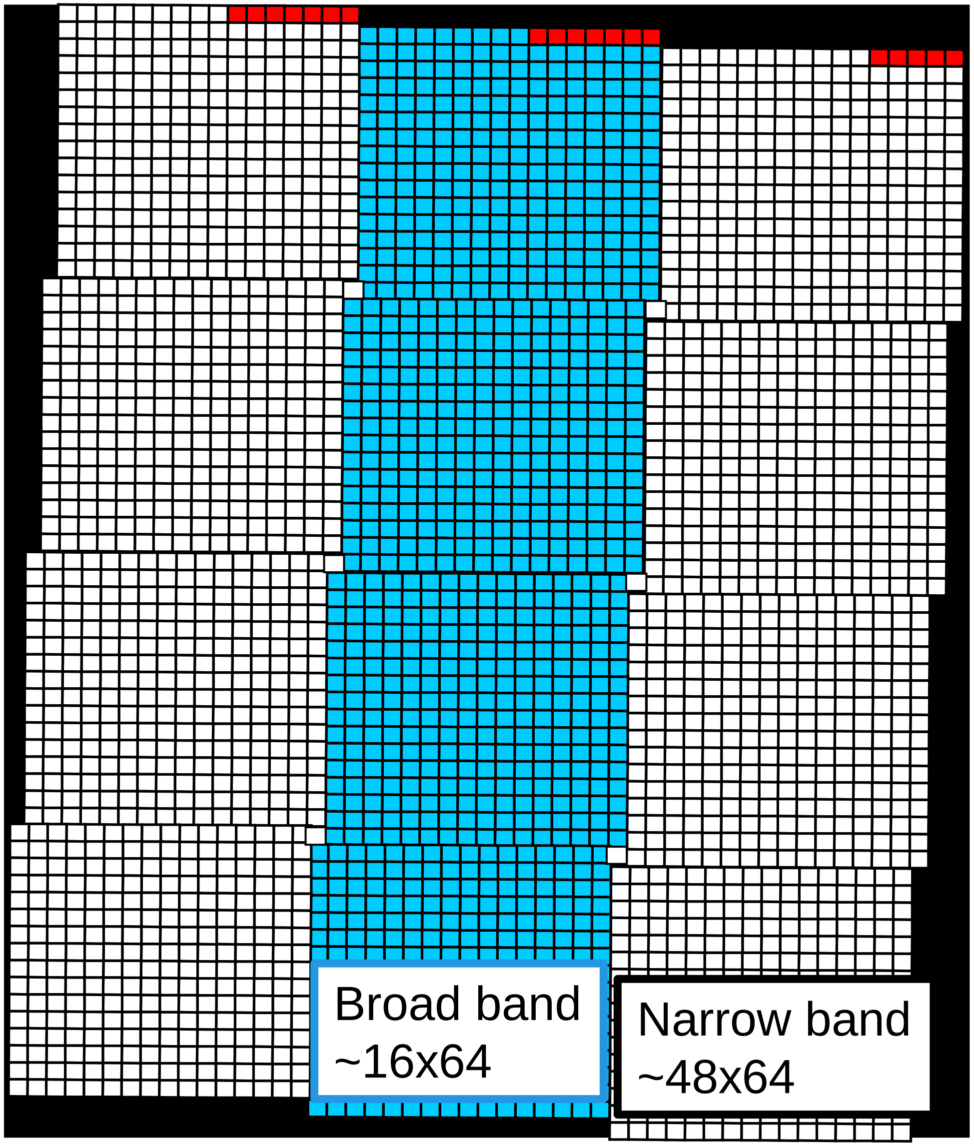
Grid of lenslets is rotated relative to dispersion of direction so spectra are interleaved on the detector.



The point spread function (PSF) of each lenslet must be measured to convert raw data to a data cube.

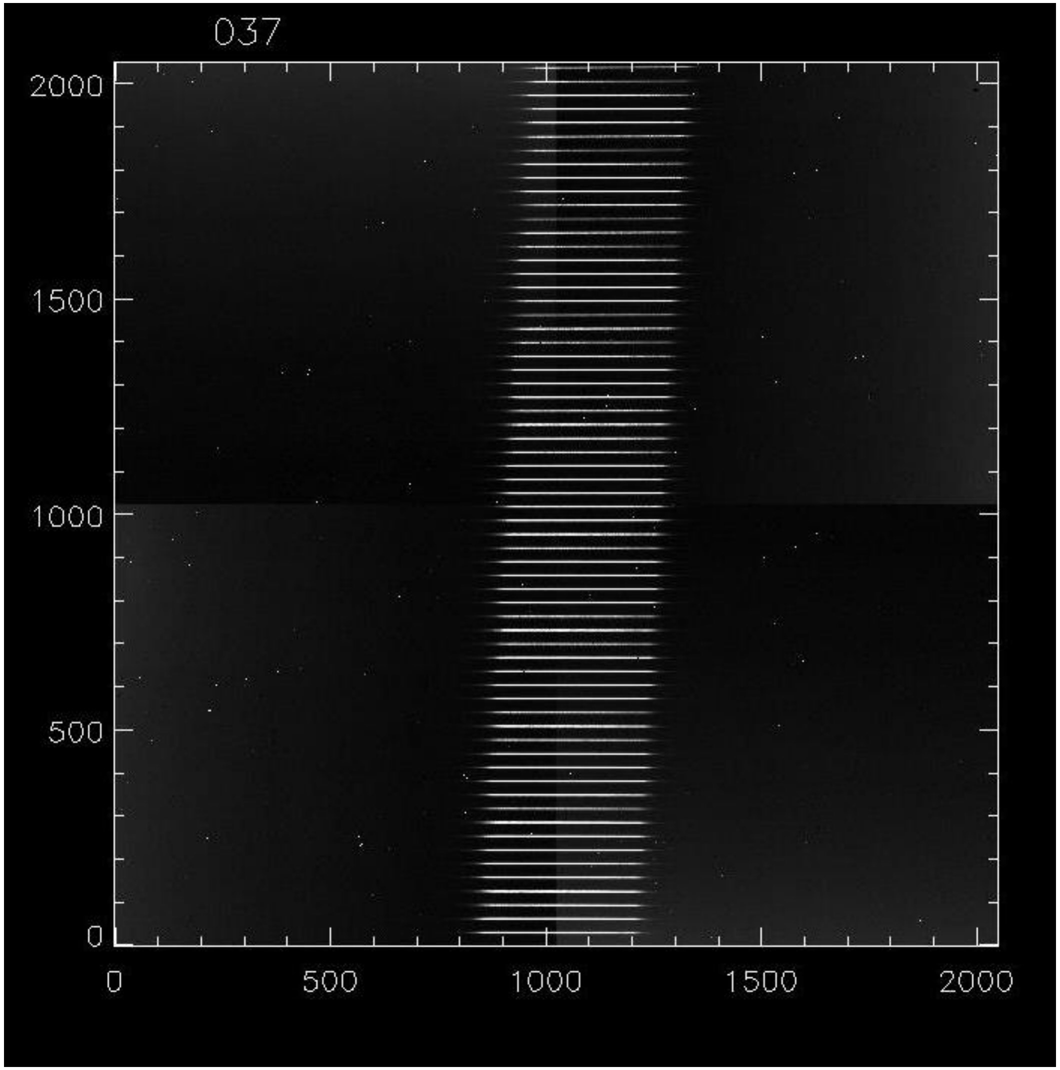


Data to measure lenslet PSFs are taken by illuminating one column at a time.



= lenslets whose spectra do not fall on the detector

When single column of lenslets is illuminated, the spectra are 32 pixels apart.



Detector in OSIRIS spectrograph was upgraded in January 2016.

- Motivations to upgrade:
  - Increased quantum efficiency of new Hawaii-2RG detector

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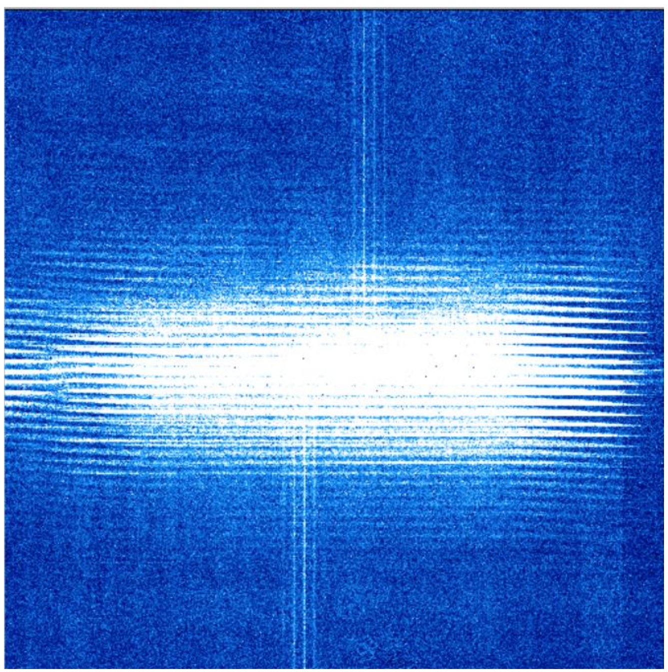
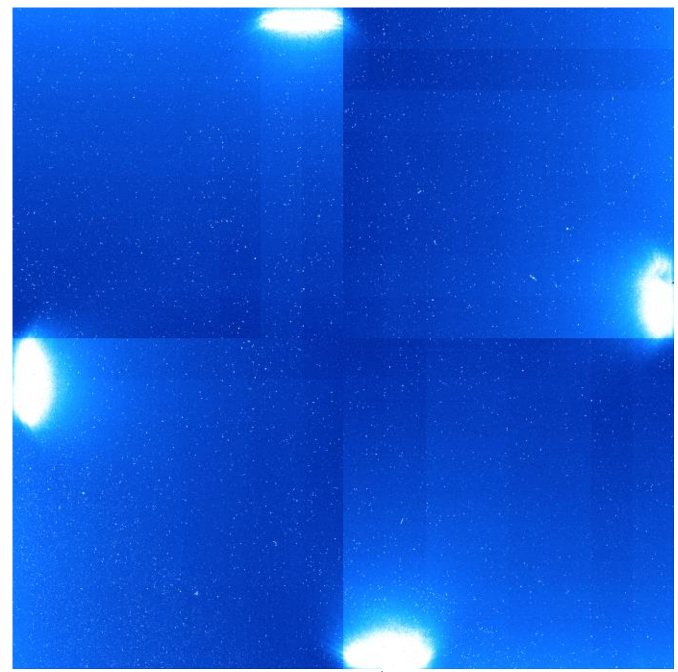


Crosstalk

Channel-to-channel baseline variation



Shift register glow

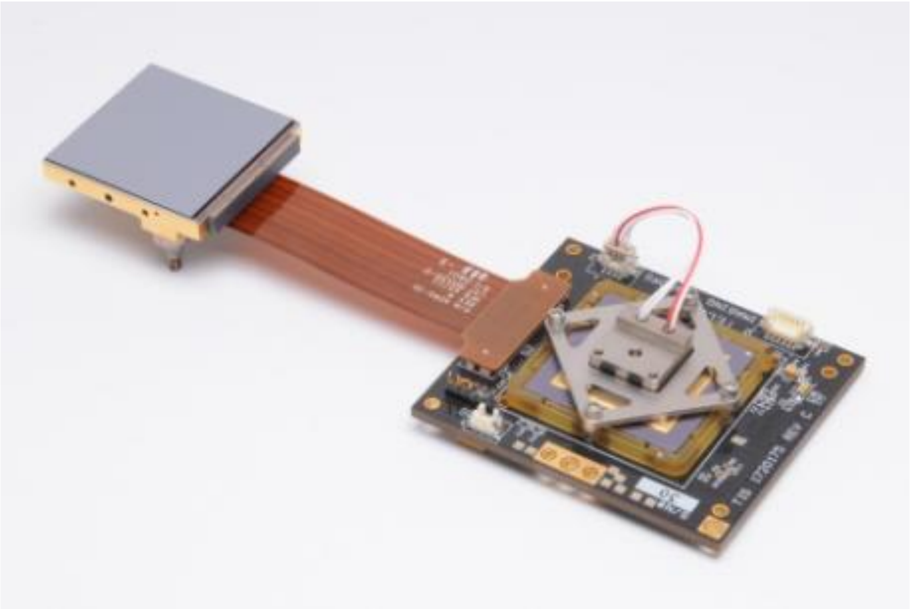
Detector in OSIRIS spectrograph was upgraded in January 2016.

- Motivations to upgrade:
  - Increased quantum efficiency of new Hawaii-2RG detector
  - Artifacts in original Hawaii-2 detector
  - Eventual failure via delamination!

New H2RG operated with Teledyne Sidecar ASIC and SAM electronics.

__Inside dewar__
H2RG + ASIC
(Application Specific Integrated Circuit)

__Outside dewar__
SAM (Sidecar Acquisition Module)

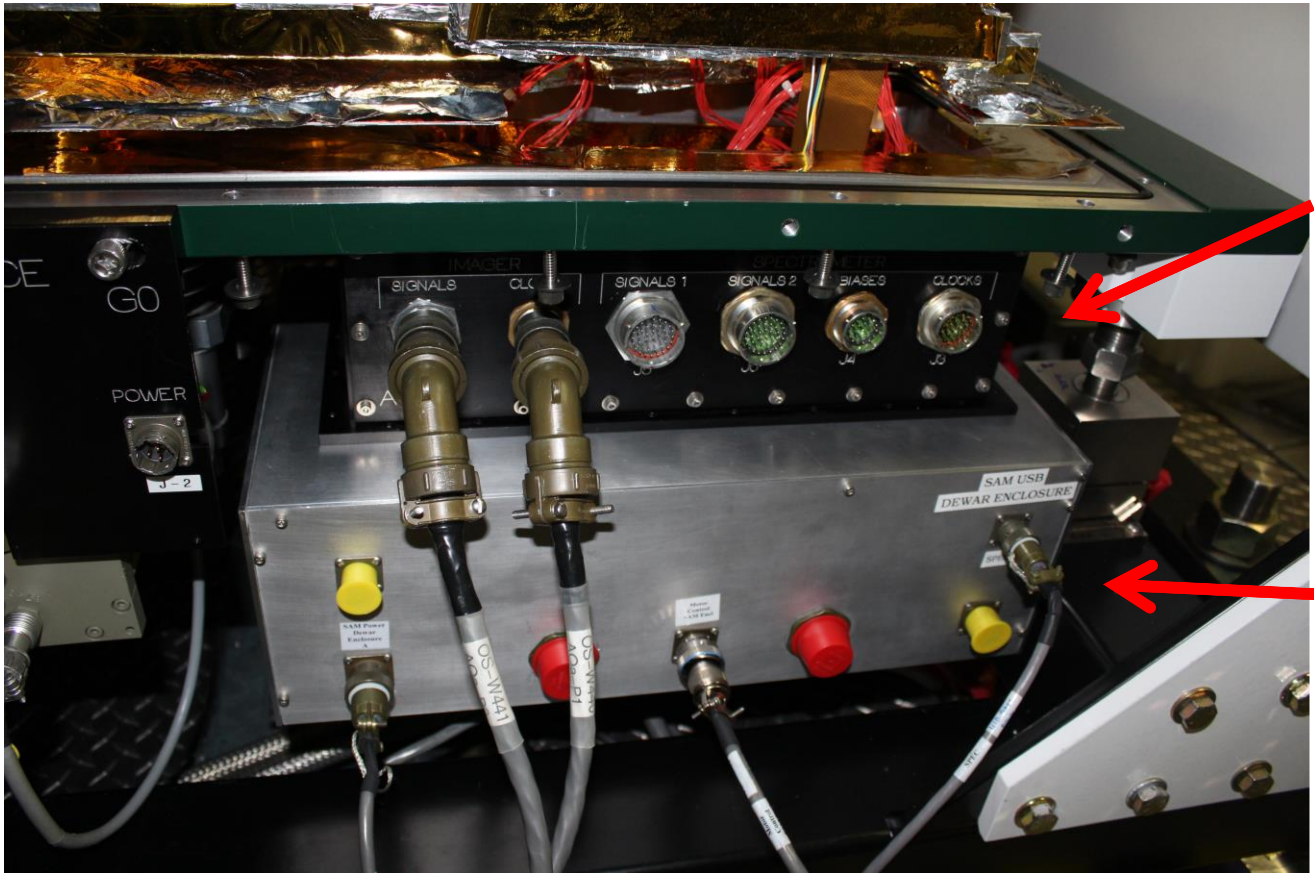


John Auyeung, Teledyne

New SAM card mount and enclosure designed to maintain function of OSIRIS imager detector.

Original electronics feedthrough box:

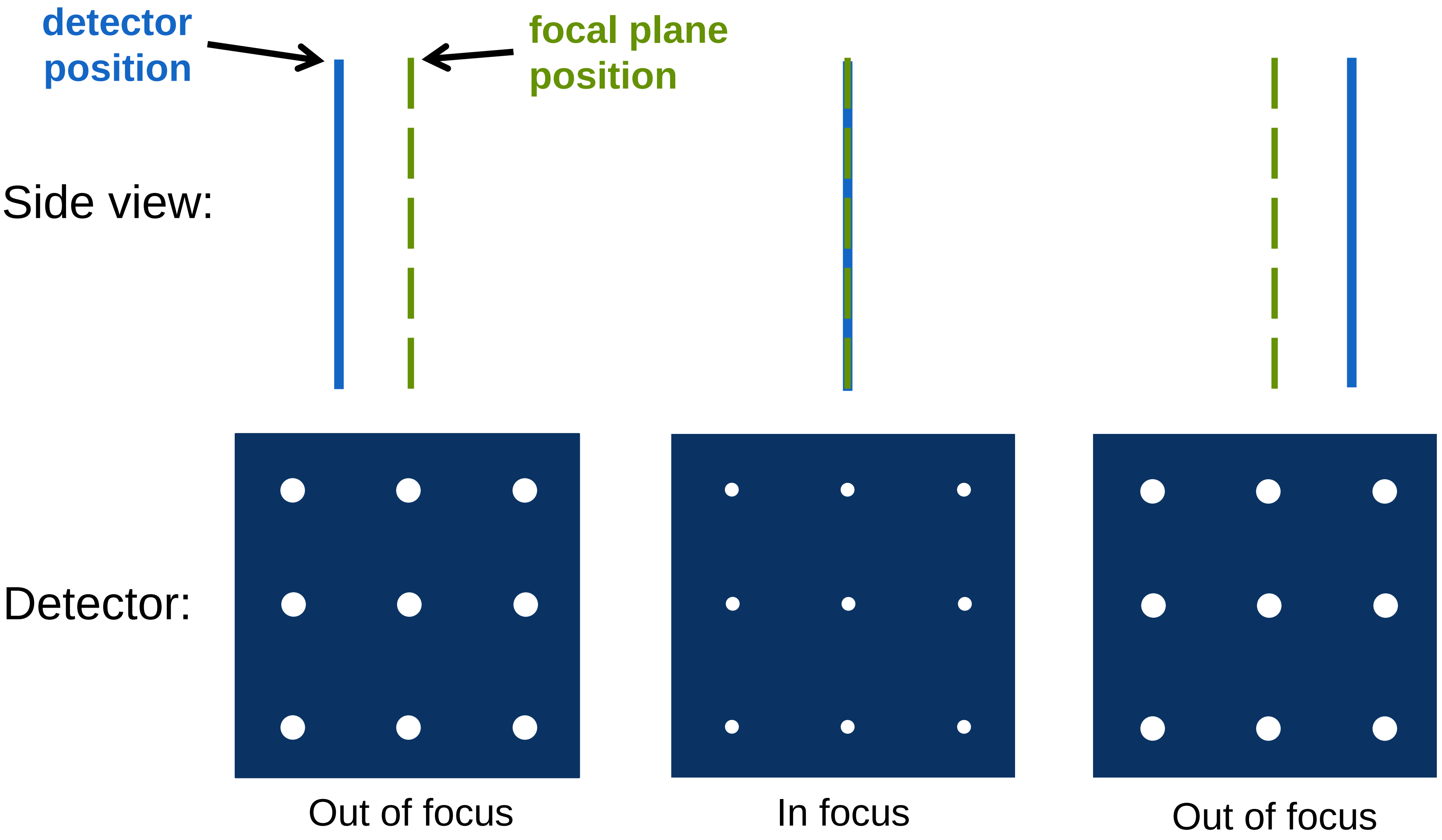
New SAM card mount and enclosure designed to maintain function of OSIRIS imager detector.



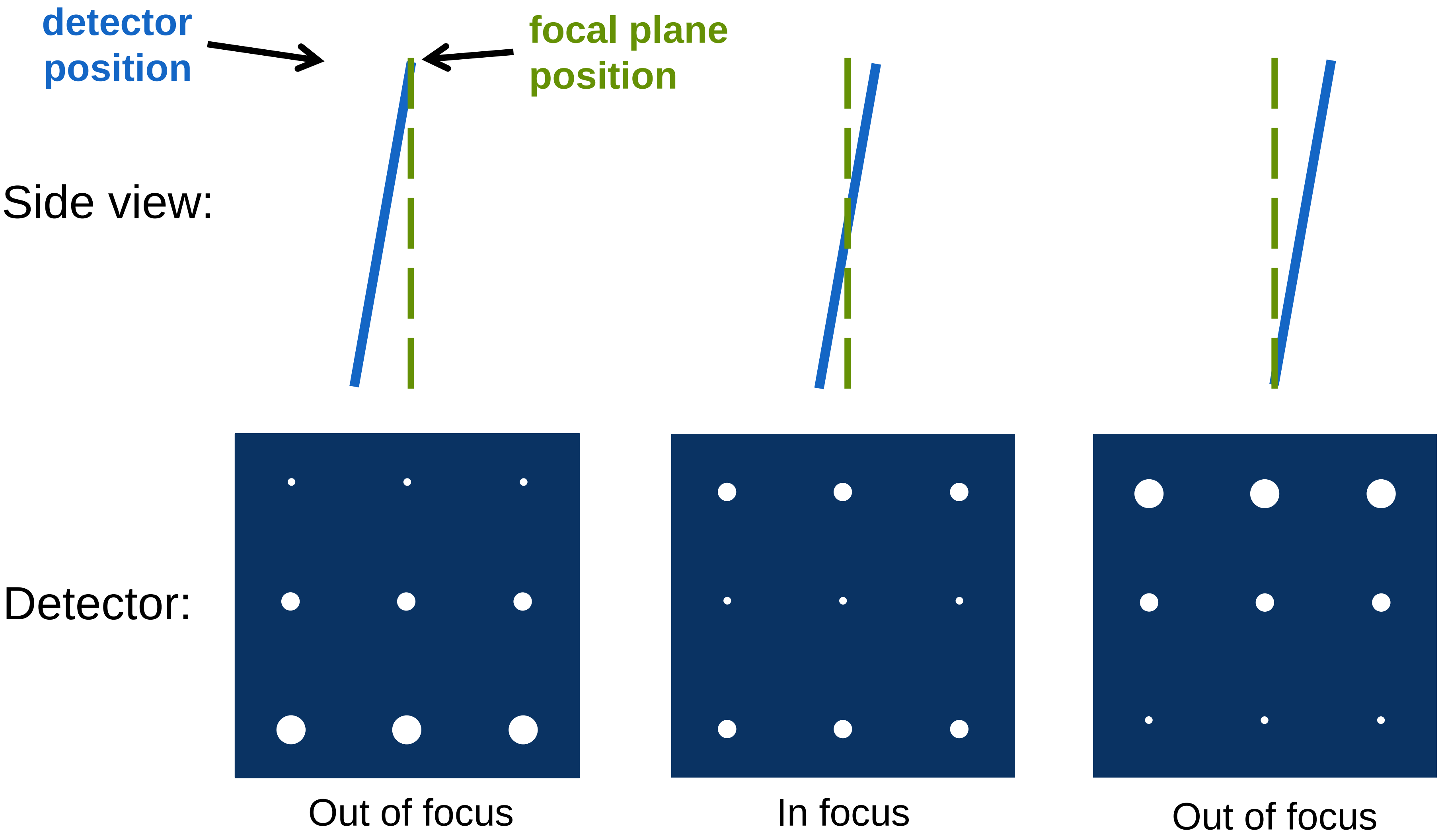
Original feedthrough

SAM enclosure

New H2RG detector was mounted on focus mechanism to reduce time OSIRIS was off the telescope.

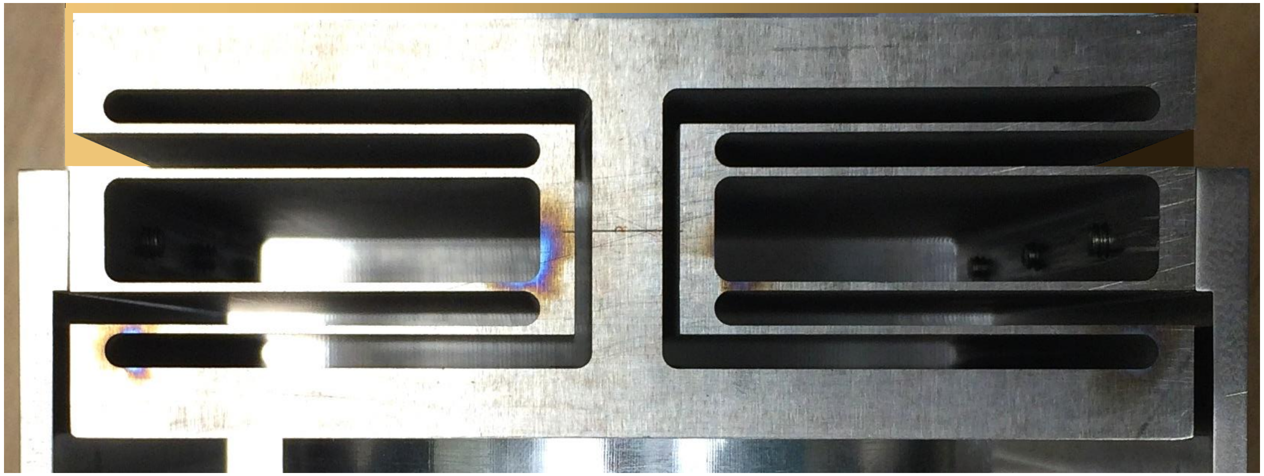


Focus mechanism allowed us to determine direction of offset and the tip/tilt of the detector in a single cool down.

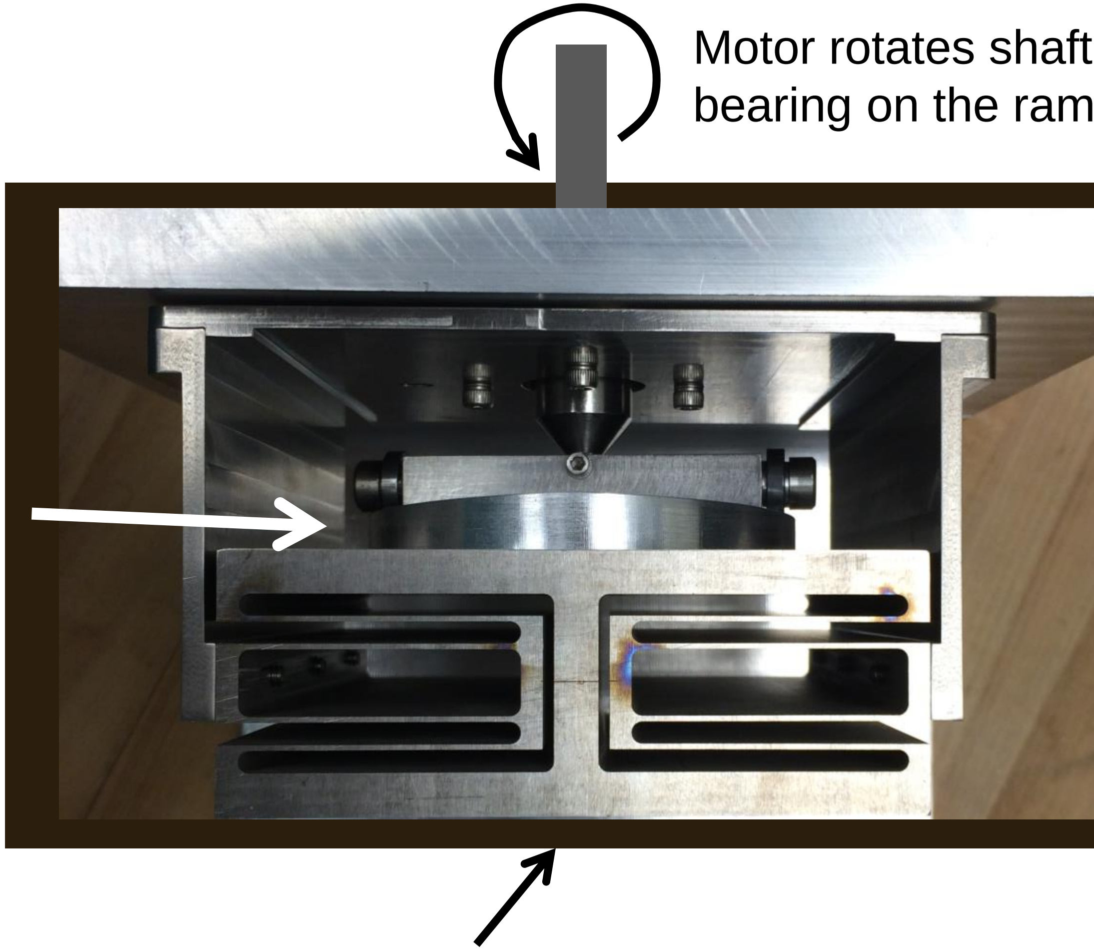


Original focus mechanism design was based on MOSFIRE (Keck) and GPI (Gemini South).

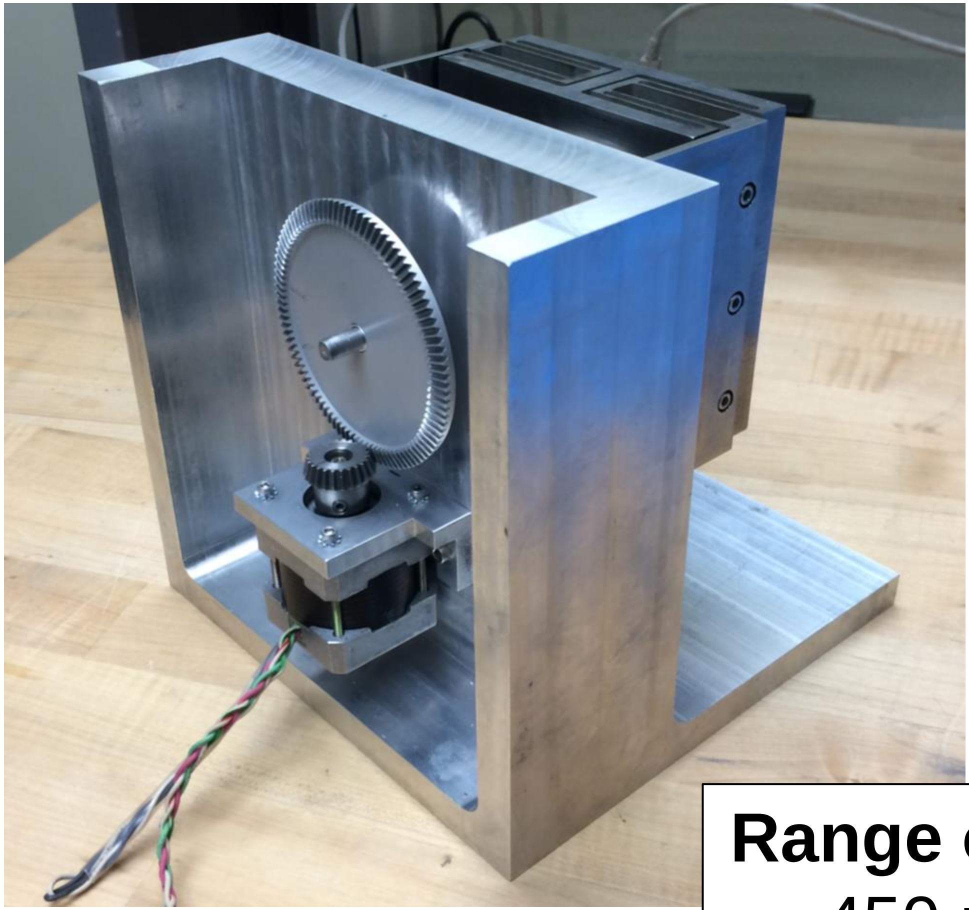
Based on a titanium flexure:

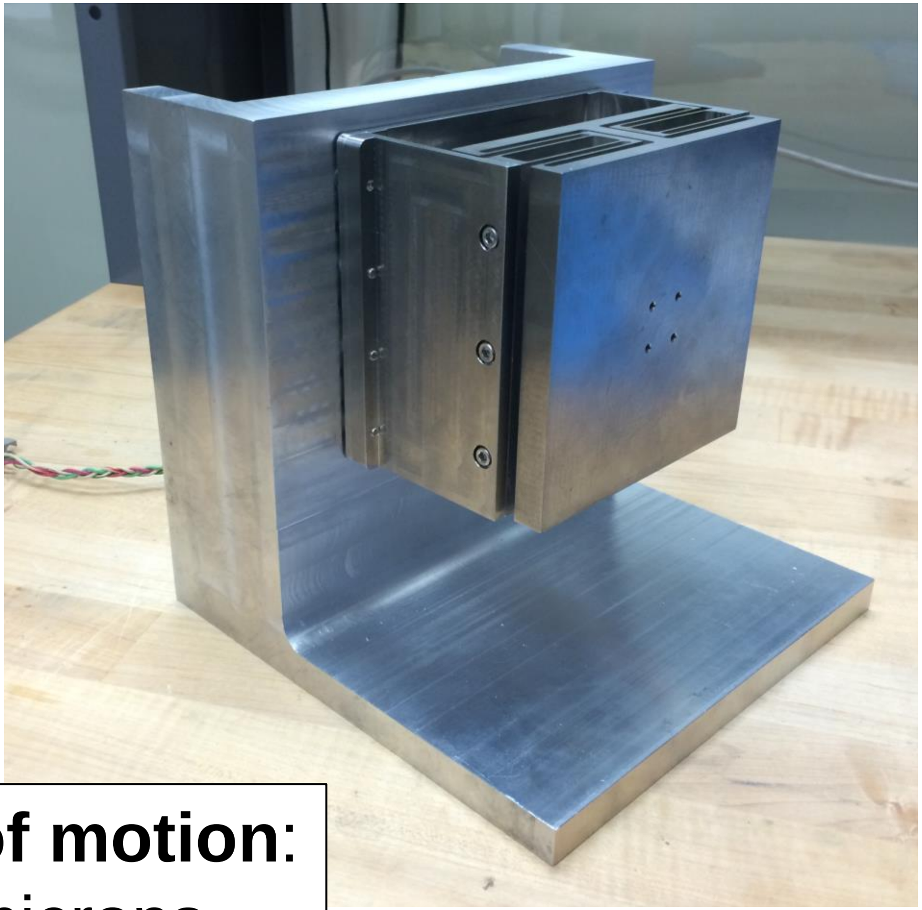


Two roller bearings push on the back of the flexure and drive the detector forward/backward.



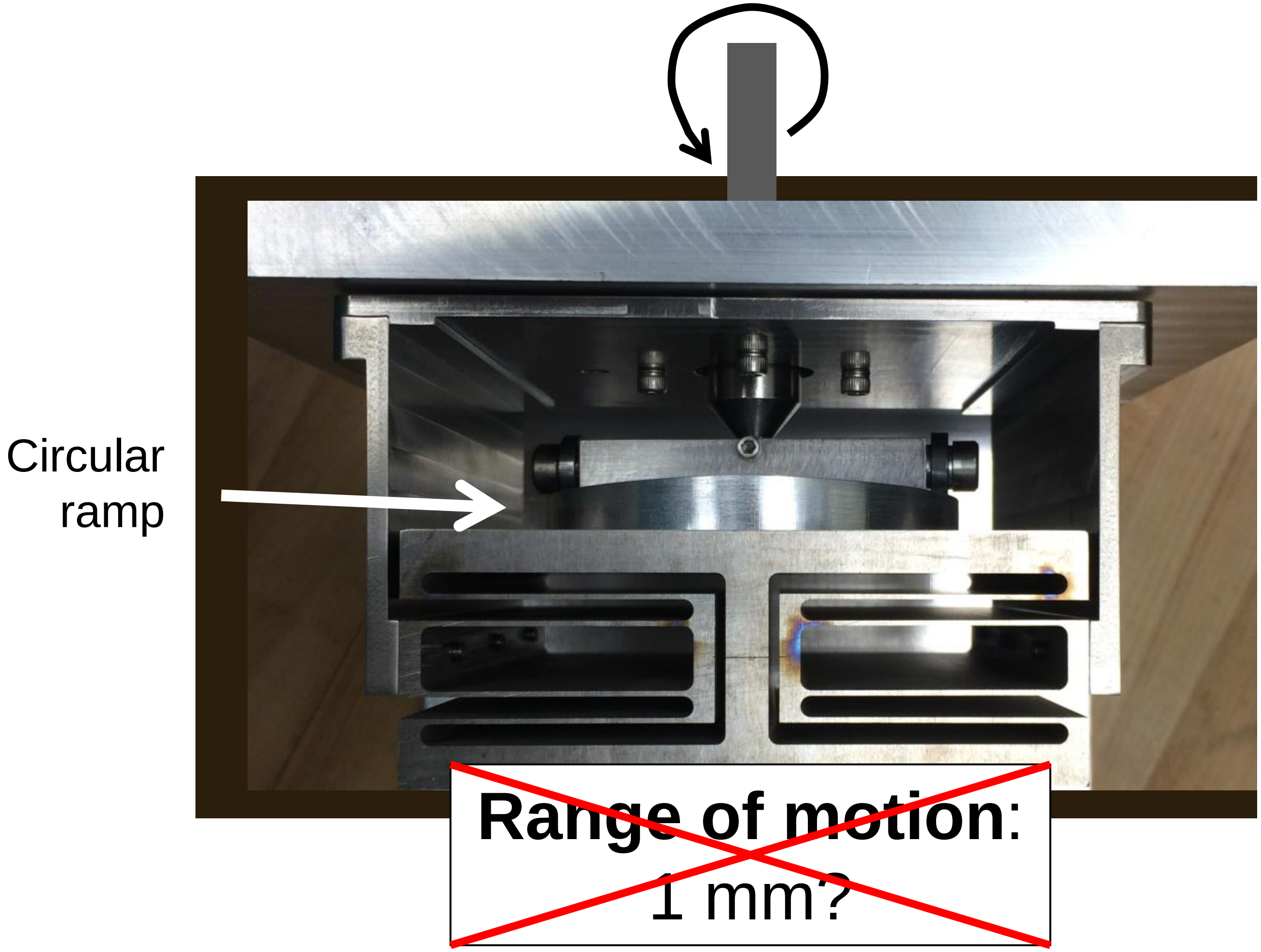
Tests of the range of motion found that it was ~1/2 of the required 1 mm range.



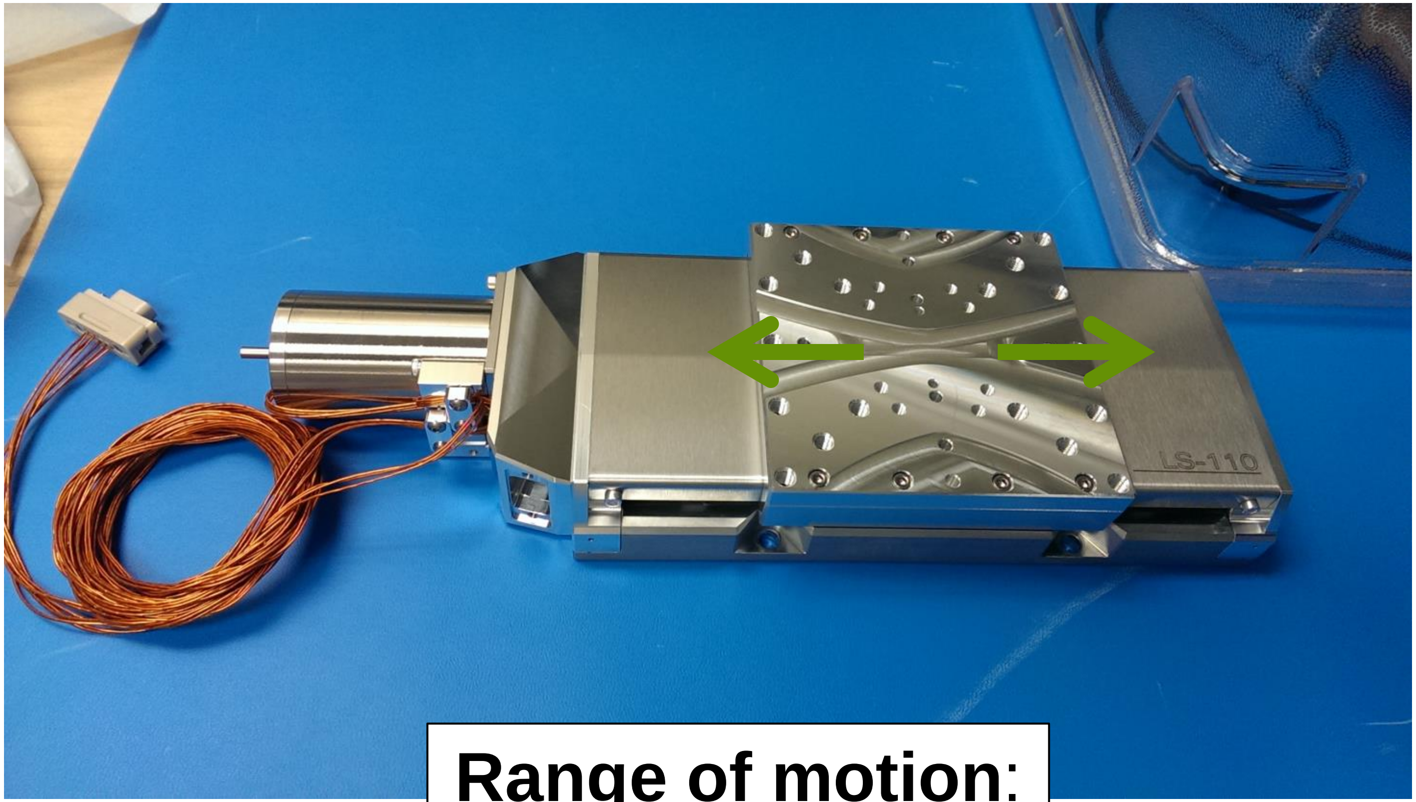


Range of motion:
450 microns

Tested new ramp with 1 mm range of motion and found 1 mm was unfeasible with this design.



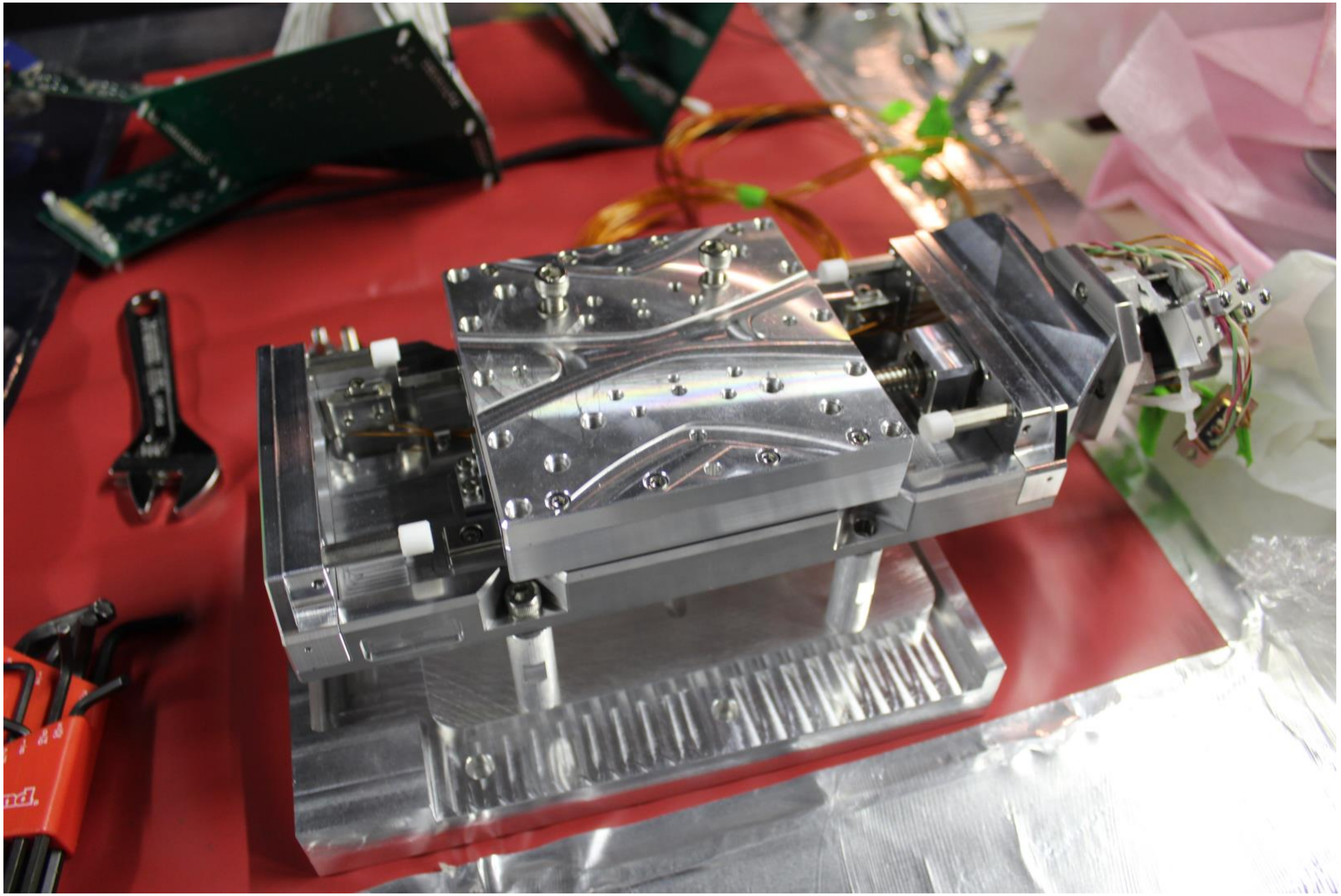
New design for focus mechanism based around a linear stage.



Range of motion:
25 mm

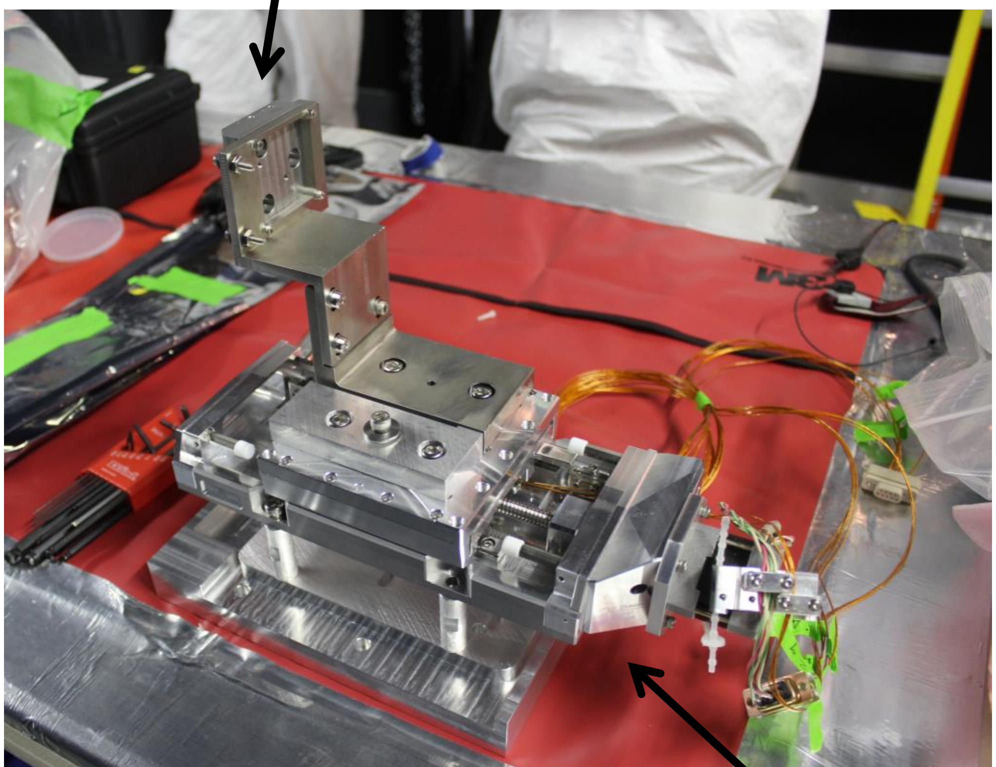
Physik Instrumente (LS-110)

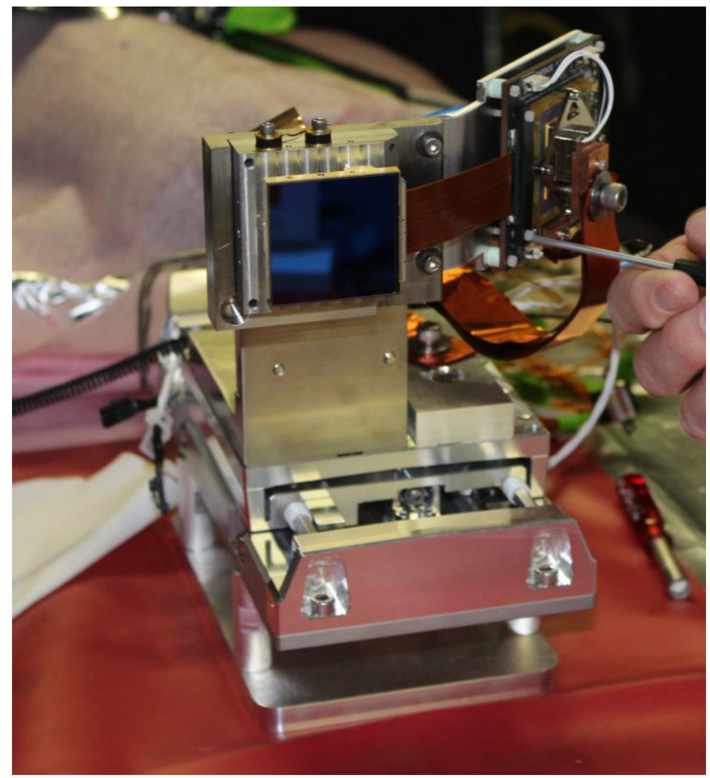
After laboratory tests of linear stage, replaced with high-torque stepper motor.



Detector mounting structure designed with adjustable shims to change position and tip/tilt.

Detector mounting location

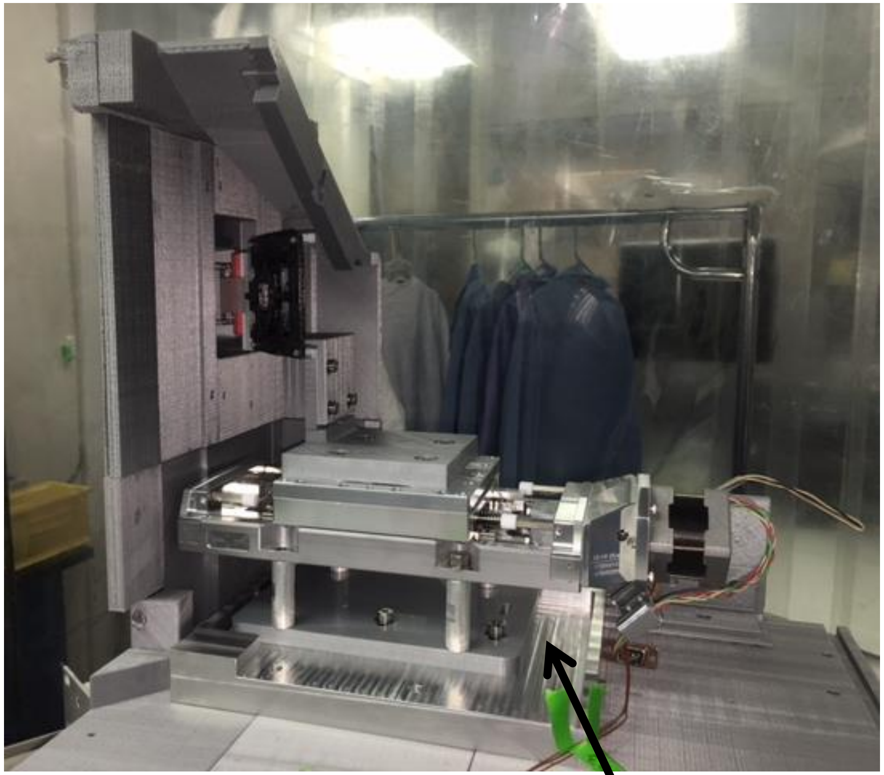




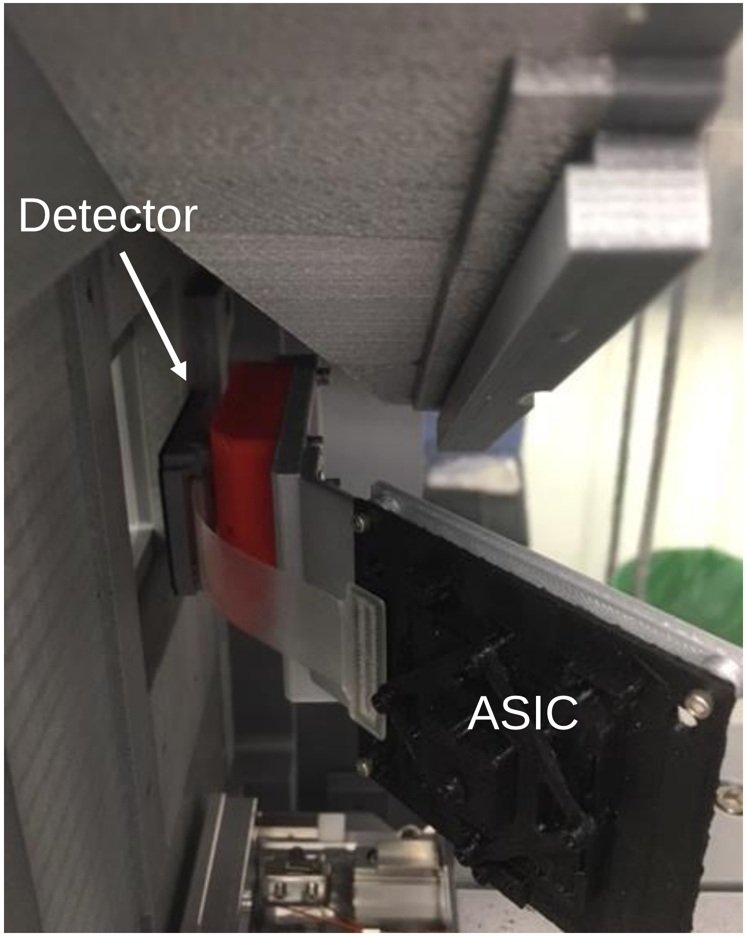
Physik Instrumente
linear stage

Used a 3D-printed model of OSIRIS interior to verify installation procedure.

3D model of OSIRIS and detector mounting structure:

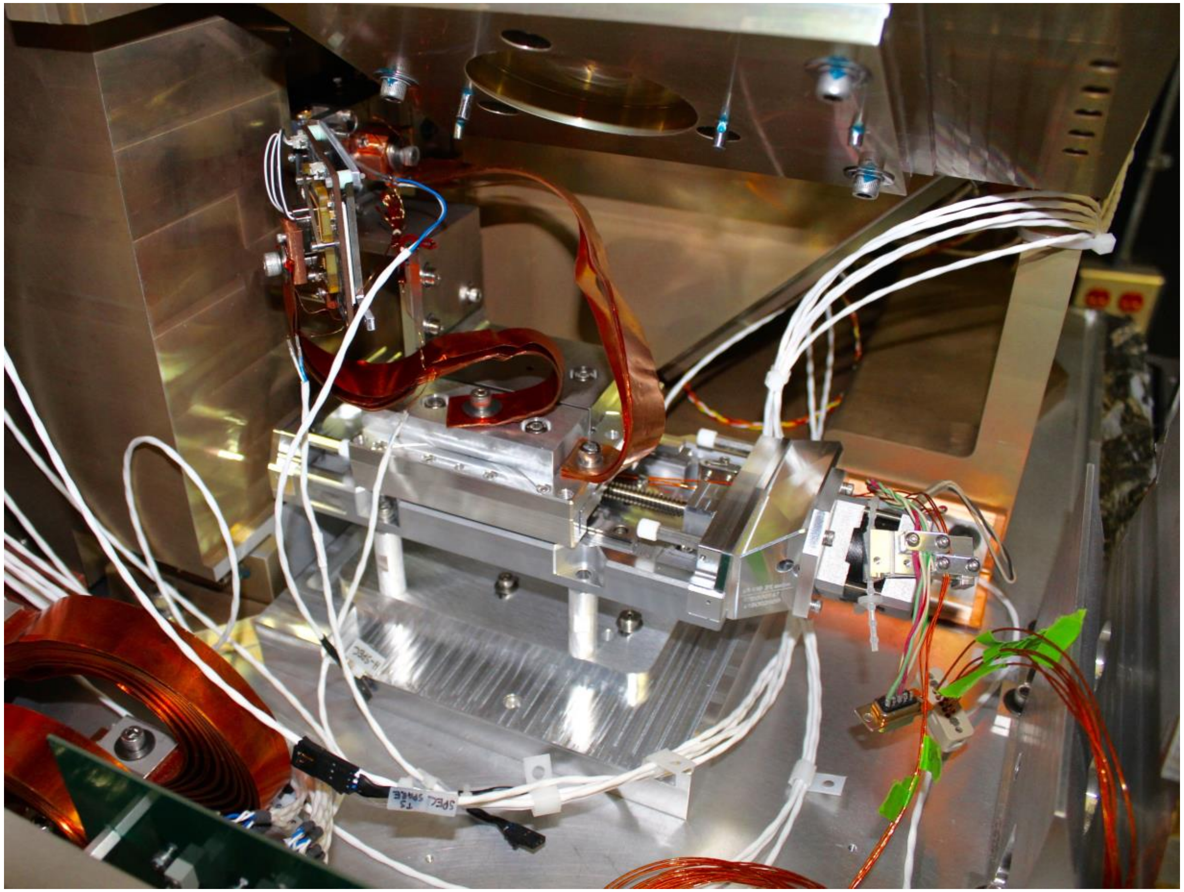


Focus mechanism

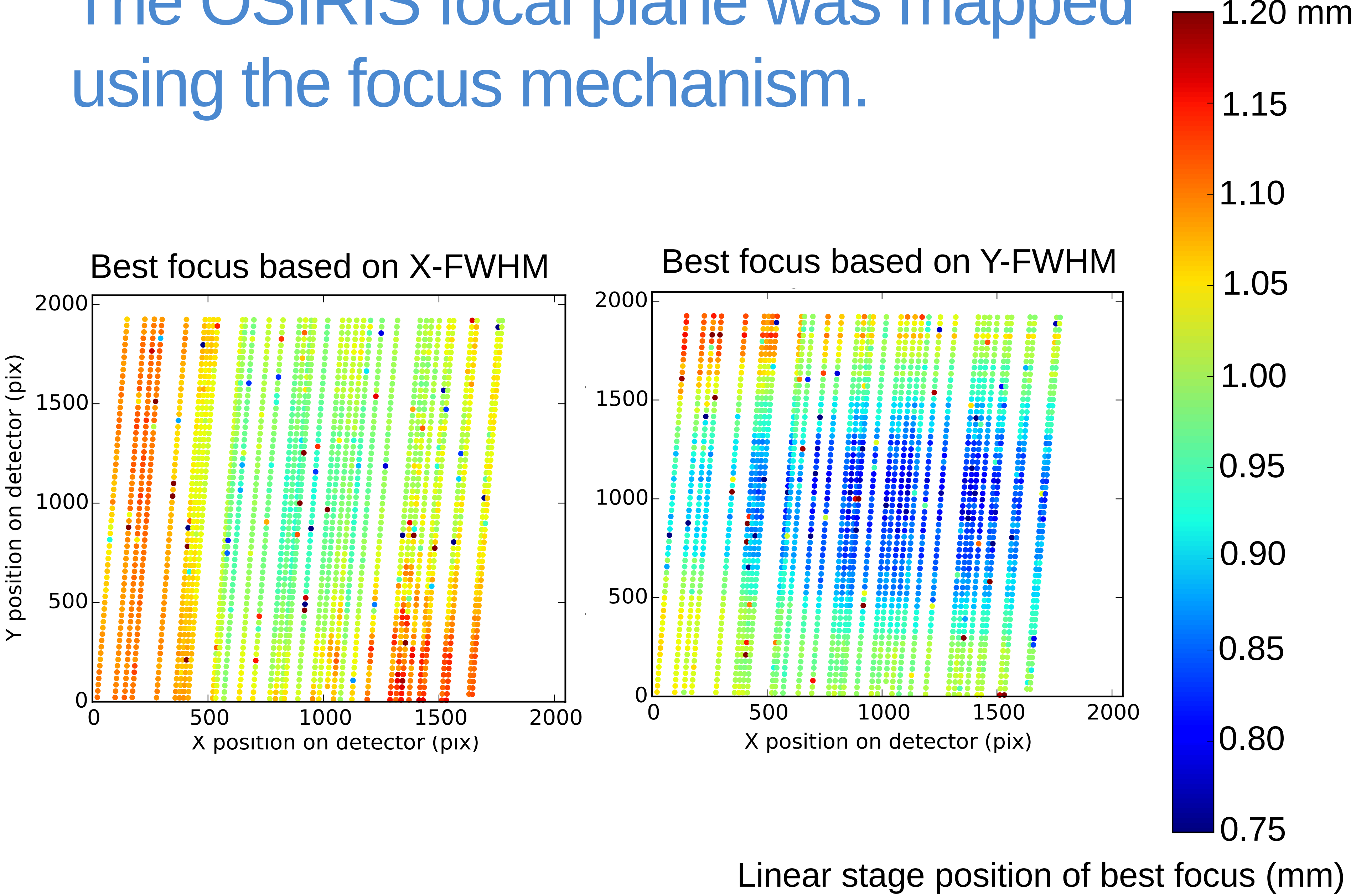


Interior of OSIRIS dewar with new detector and focus mechanism.

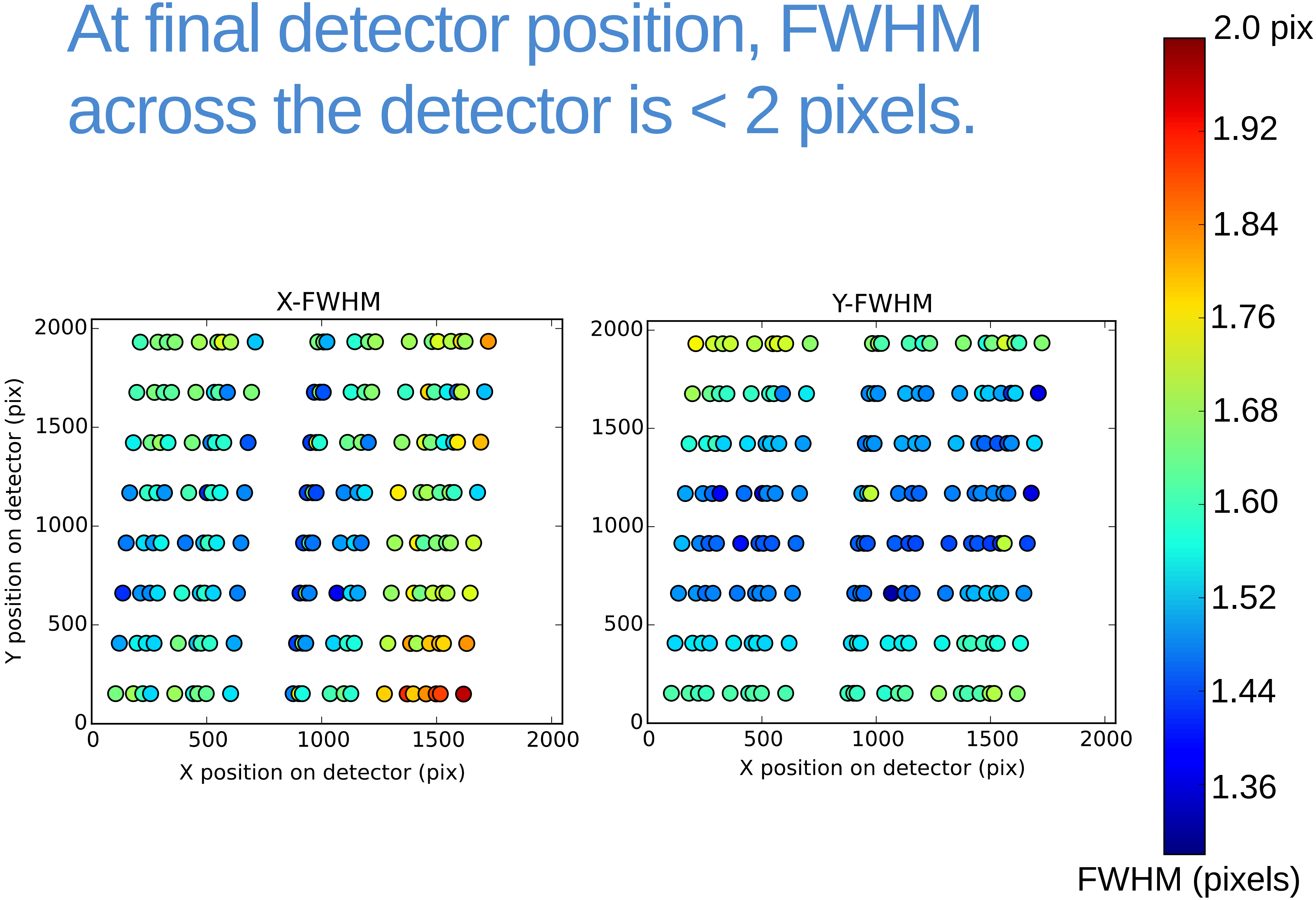
New detector and focus mechanism installed in OSIRIS:



The OSIRIS focal plane was mapped using the focus mechanism.

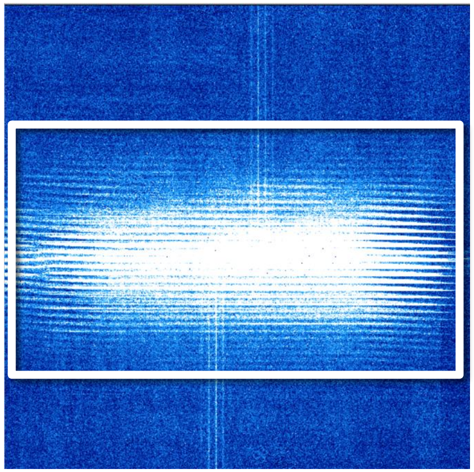


At final detector position, FWHM across the detector is < 2 pixels.



Raw sensitivity of OSIRIS has increased by a factor of 1.6 – 2.

Filter	Plate Scale (mas)	New/Old Detector Raw Flux
Jn1 (1.20 μm)	100	**2.04**
Jn2 (1.26 μm)	35	**2.09**
Hn2 (1.57 μm)	100	**1.68**
Kn3 (2.17 μm)	35	**1.63**



Aperture used for measuring electrons/sec.

Summary

- The upgrade of the OSIRIS spectrograph detector to an H2RG has **roughly doubled the sensitivity of the instrument**.

- The new detector removes the artifacts of the old H2 detector and is not in danger of catastrophically failing via delamination.

- The upgraded OSIRIS spectrograph was commissioned in March 2016 and is in use by science observers.