Picture Courtesy: Janus Brink

Slit Mask Integral Field Units for Southern African Large Telescope

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Plan of presentation

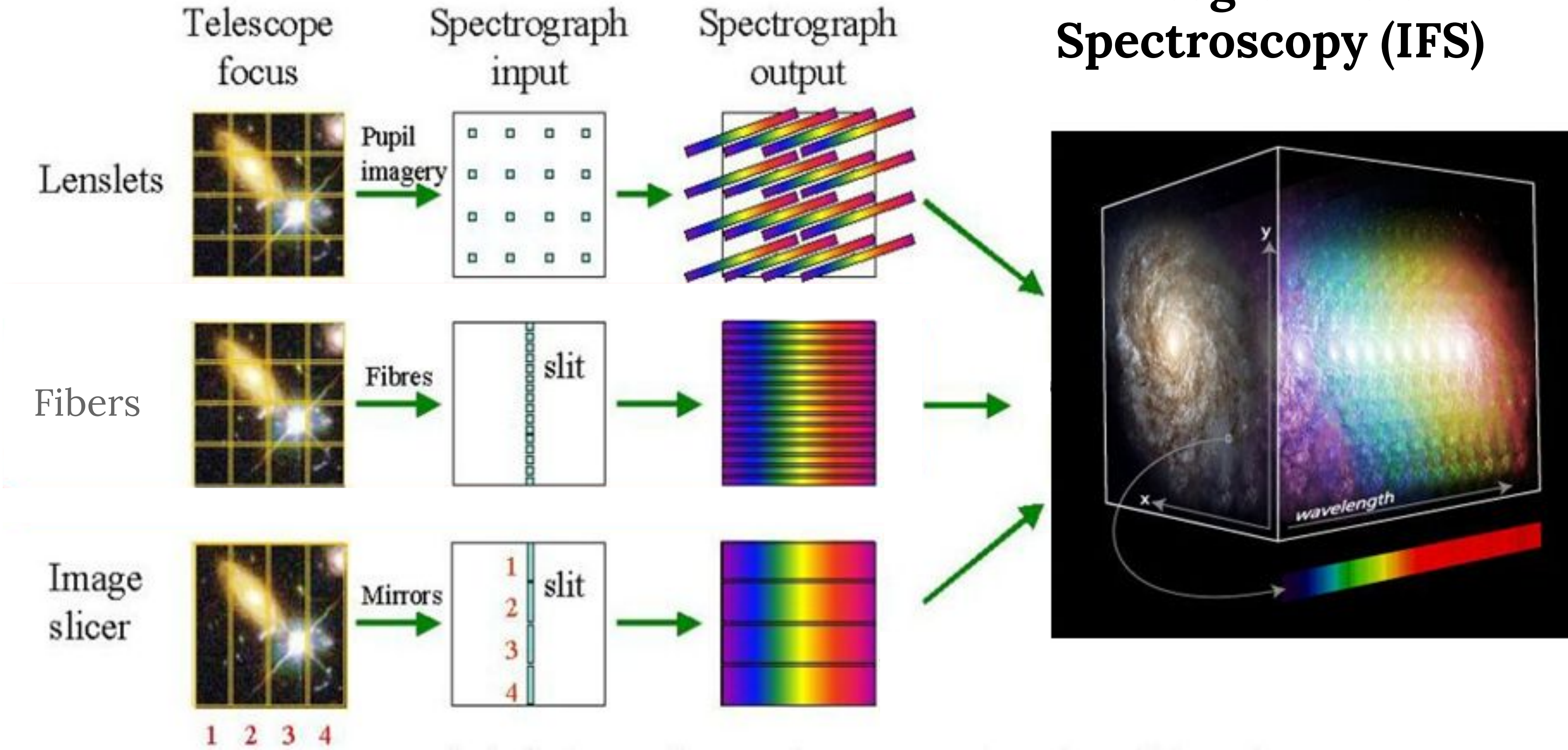
- Observational advantages of fiber spectroscopy

- Slit Mask IFUs for Southern African Large Telescope
  - Design
  - Current Status

- Future possible fiber instrumentation at SALT

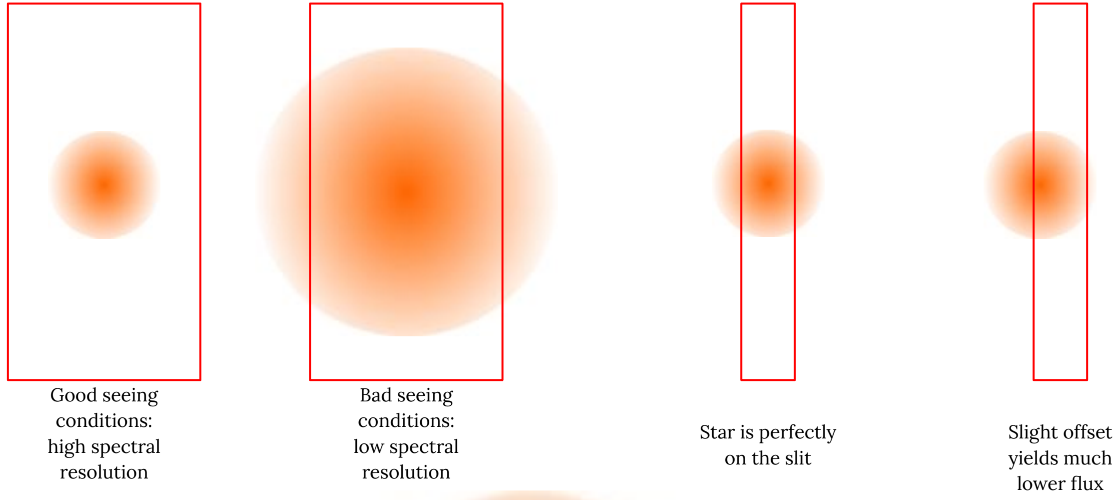
Observational advantages of fiber spectroscopy

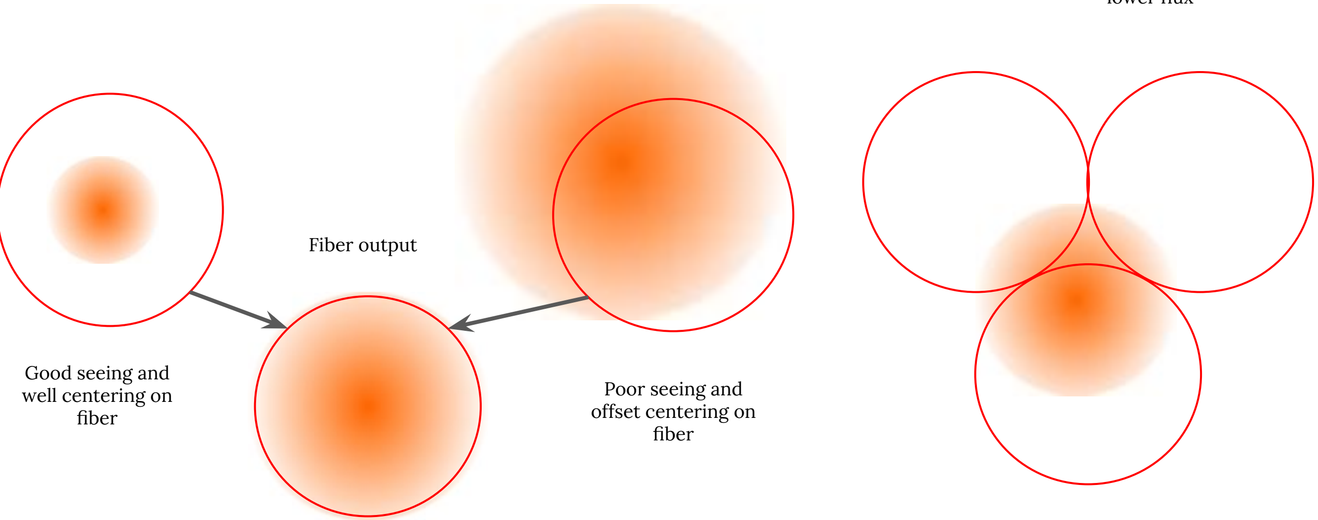
Integral Field Spectroscopy (IFS)



Advantages of IFU spectroscopy

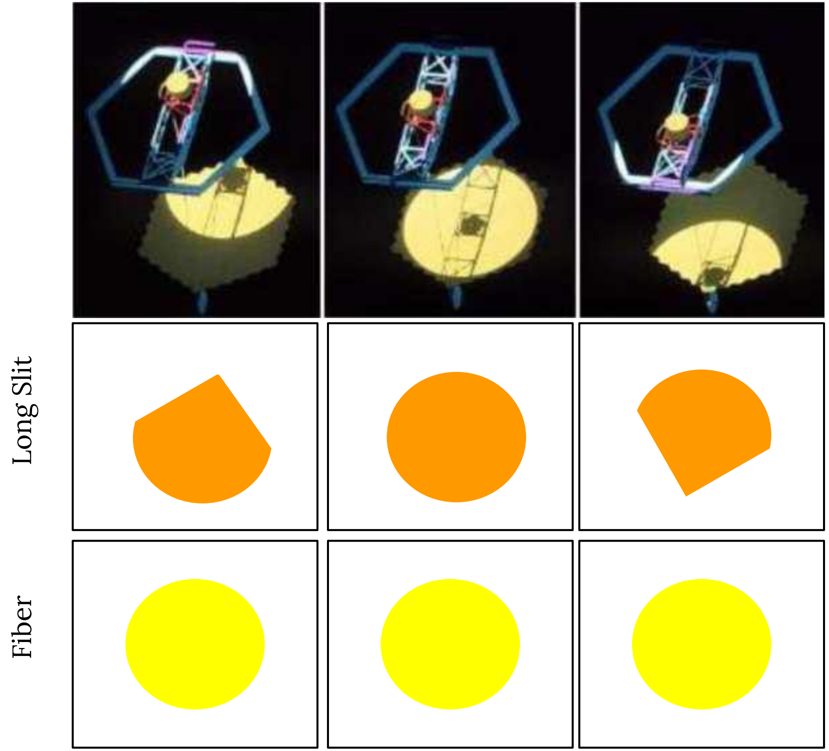
If the slit is wide, then it is the seeing that determines the spectral resolution.





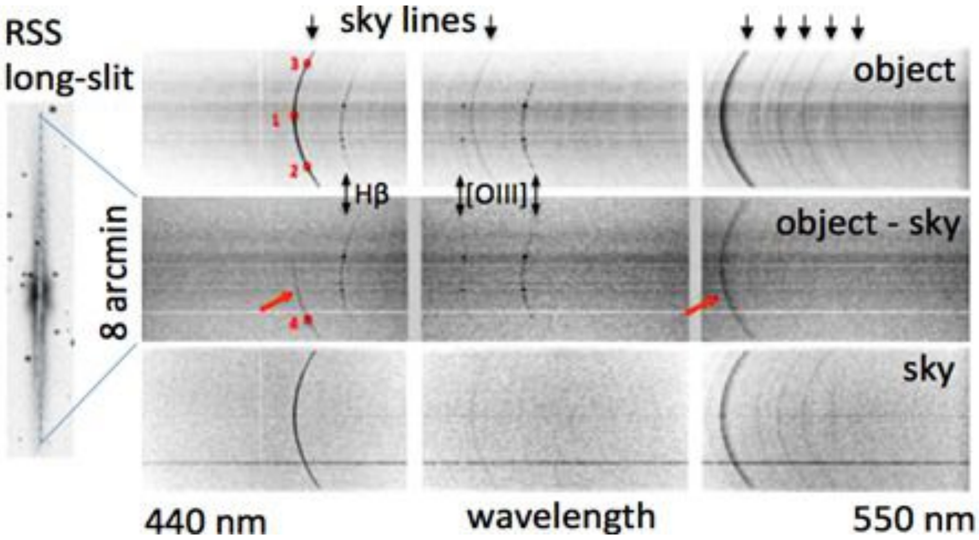
1. Slit width dependent resolution
2. Pointing dependent flux variation

Advantages of IFU spectroscopy for SALT

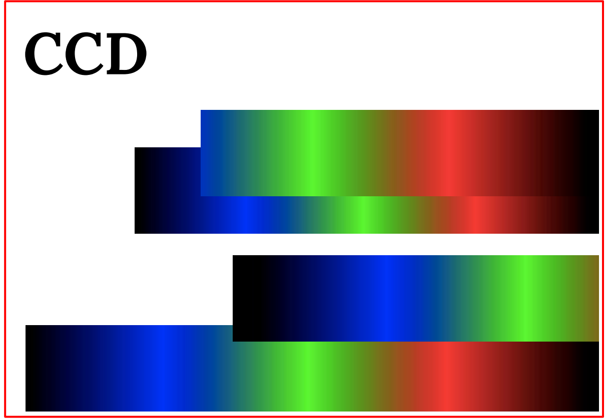


Far field projected on the grating

1. Slit width dependent resolution
2. Pointing dependent flux variation
3. Non-uniform grating illumination for fixed elevation telescope like SALT

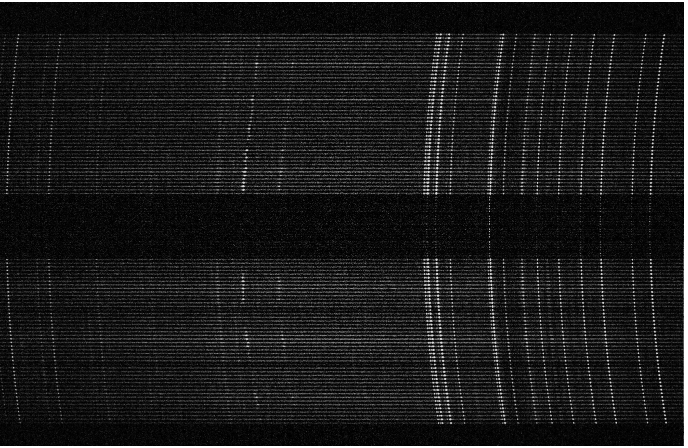


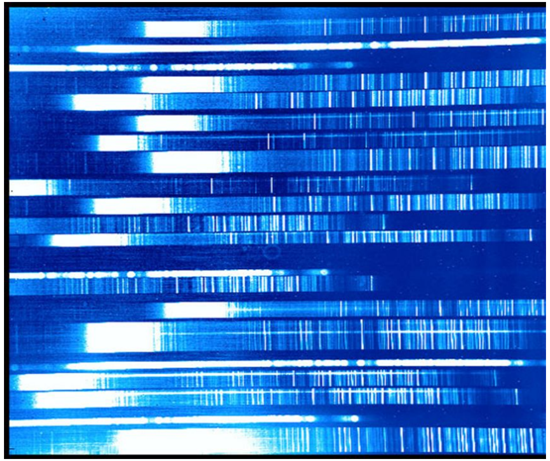
Advantages of IFU spectroscopy



Near infrared multiple-object spectroscopy with SUBARU/MOIRCS

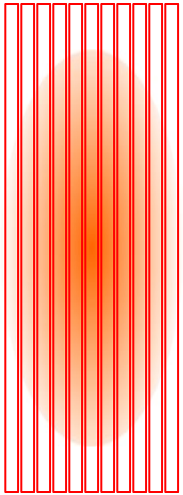
Optical integral field spectra from HexPak-WIYN





1. Slit width dependent resolution
2. Pointing dependent flux variation
3. Non-uniform grating illumination for fixed elevation telescope like SALT
4. Wastage detector real estate
5. Inconsistent wavelength coverage
6. Overlapping spectra/inconsistent spatial coverage

Advantages of IFU spectroscopy



Long slit

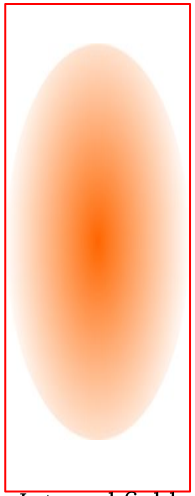
Total throughput

=

Instrument throughput

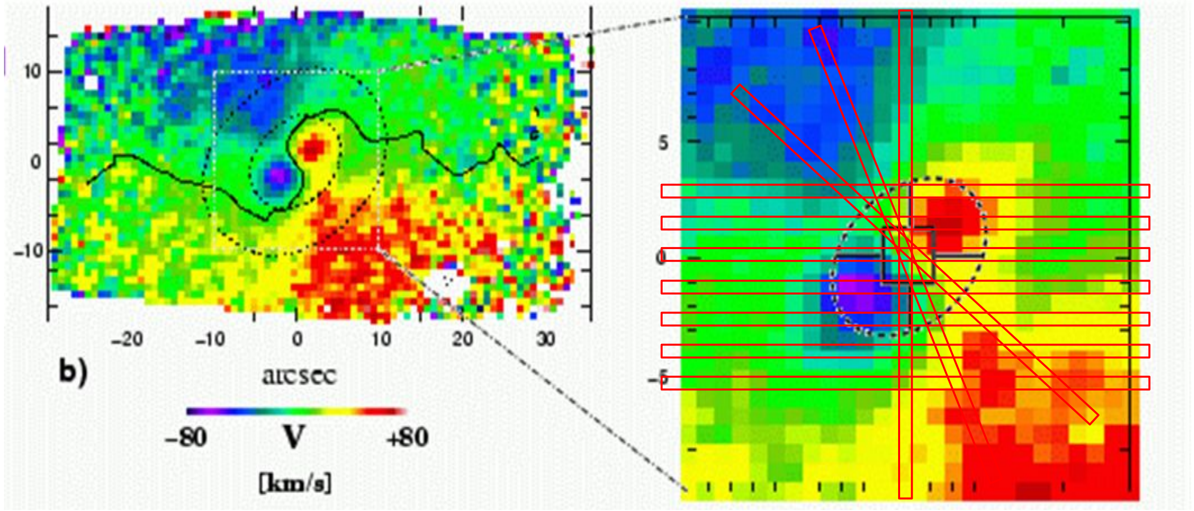
x

number of exposures



Integral field spectroscopy

1. Slit width dependent resolution
2. Pointing dependent flux calibration
3. Non-uniform grating illumination for fixed elevation telescope like SALT
4. Wastage detector real estate
5. In-consistent wavelength coverage
6. Overlapping spectra/inconsistent spatial coverage
7. Inefficient 1D coverage and ultimately lower throughput.

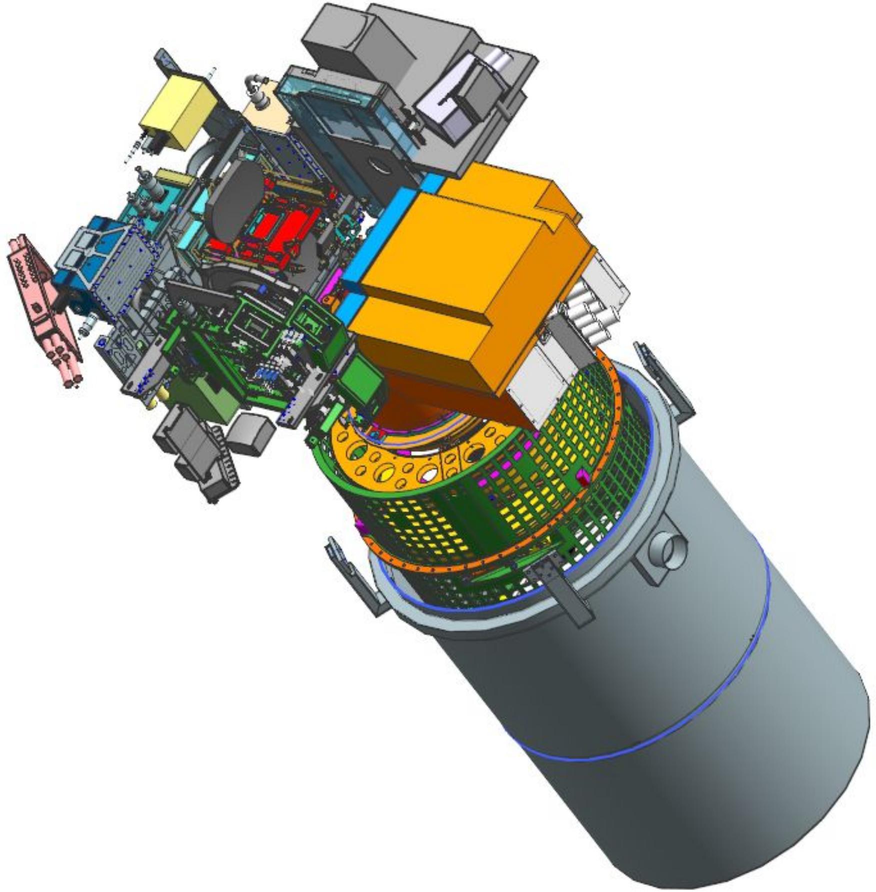


Development of Slit Mask IFU for Southern African Large Telescope

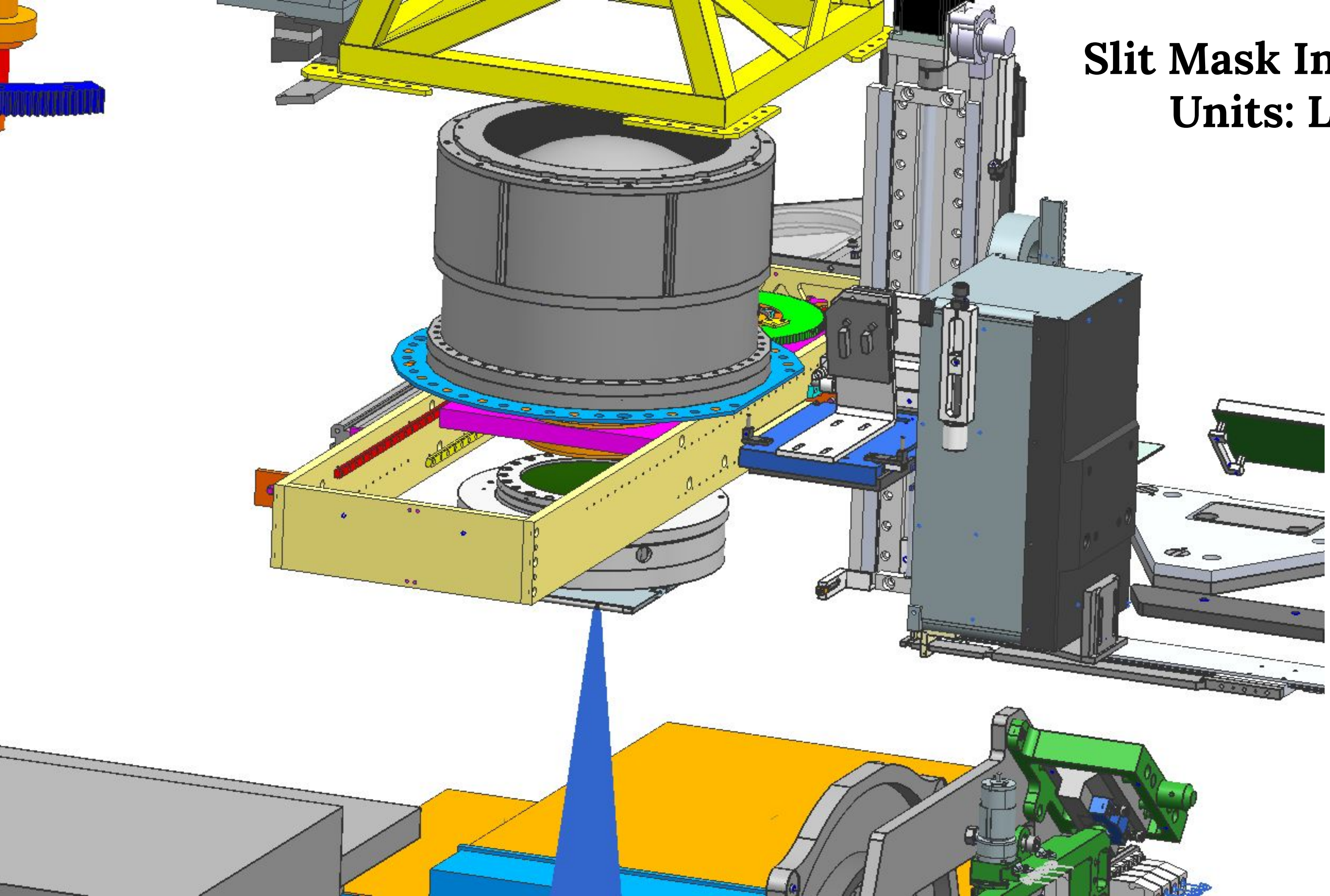
Slit Mask Integral Field Units for spectroscopy with RSS

1. Facility class instrument
2. In varying spatial and spectral resolution
3. Possible to be used interchangeably with long slits

Slit Mask Integral Field Units: Location

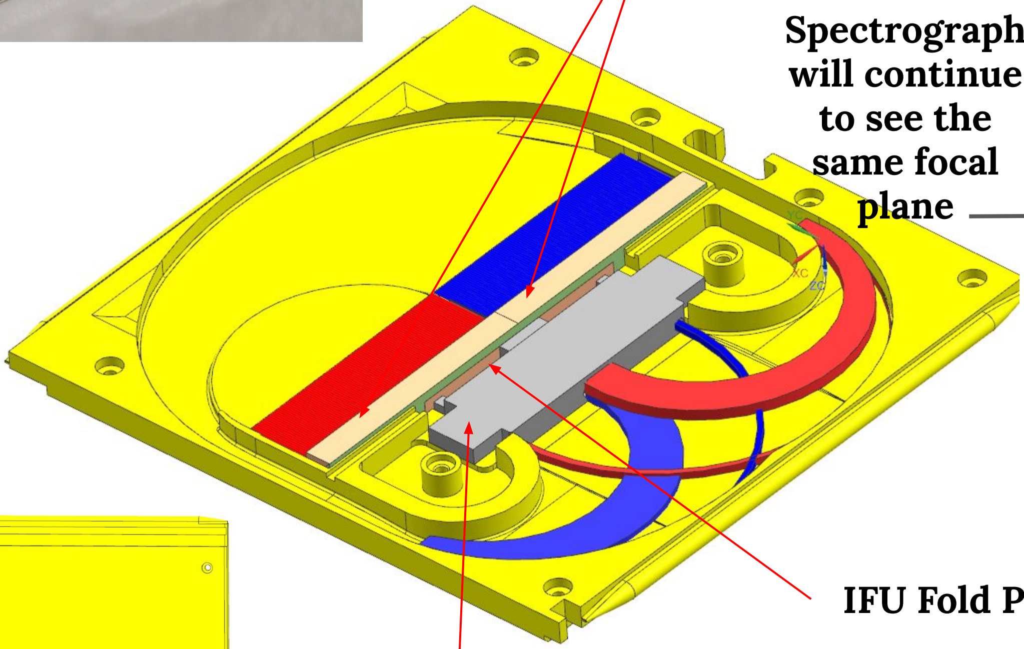


Slit Mask Integral Field Units: Location

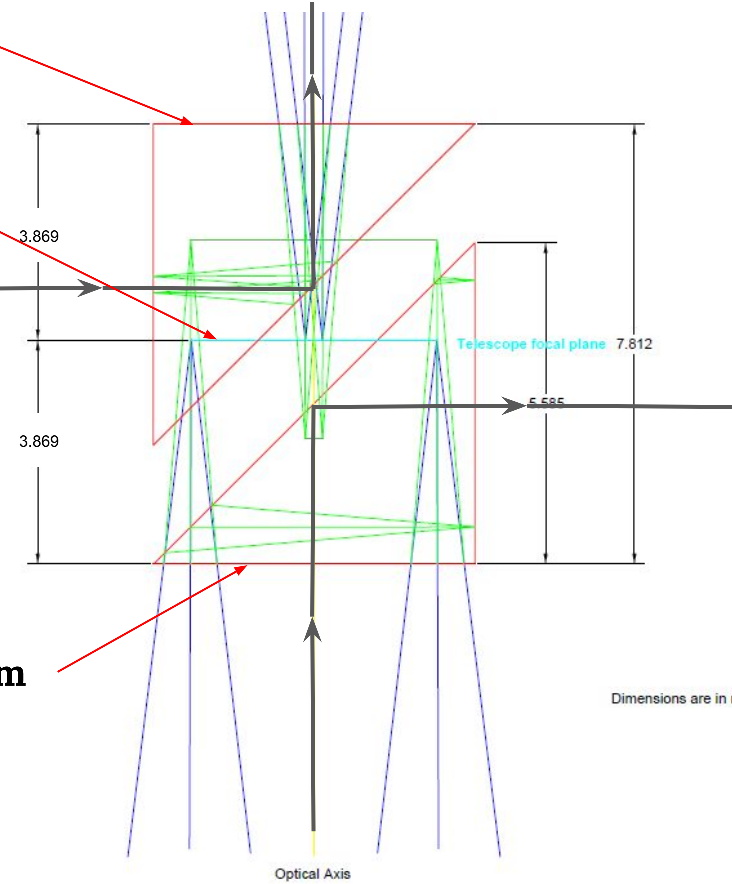


Photon routing inside Slit Mask IFU

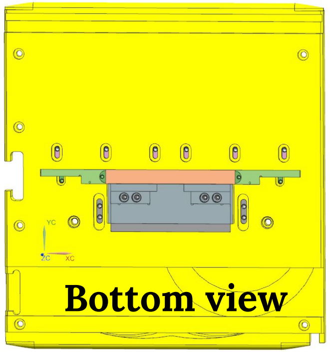
Slit Fold Prism



Spectrograph will continue to see the same focal plane



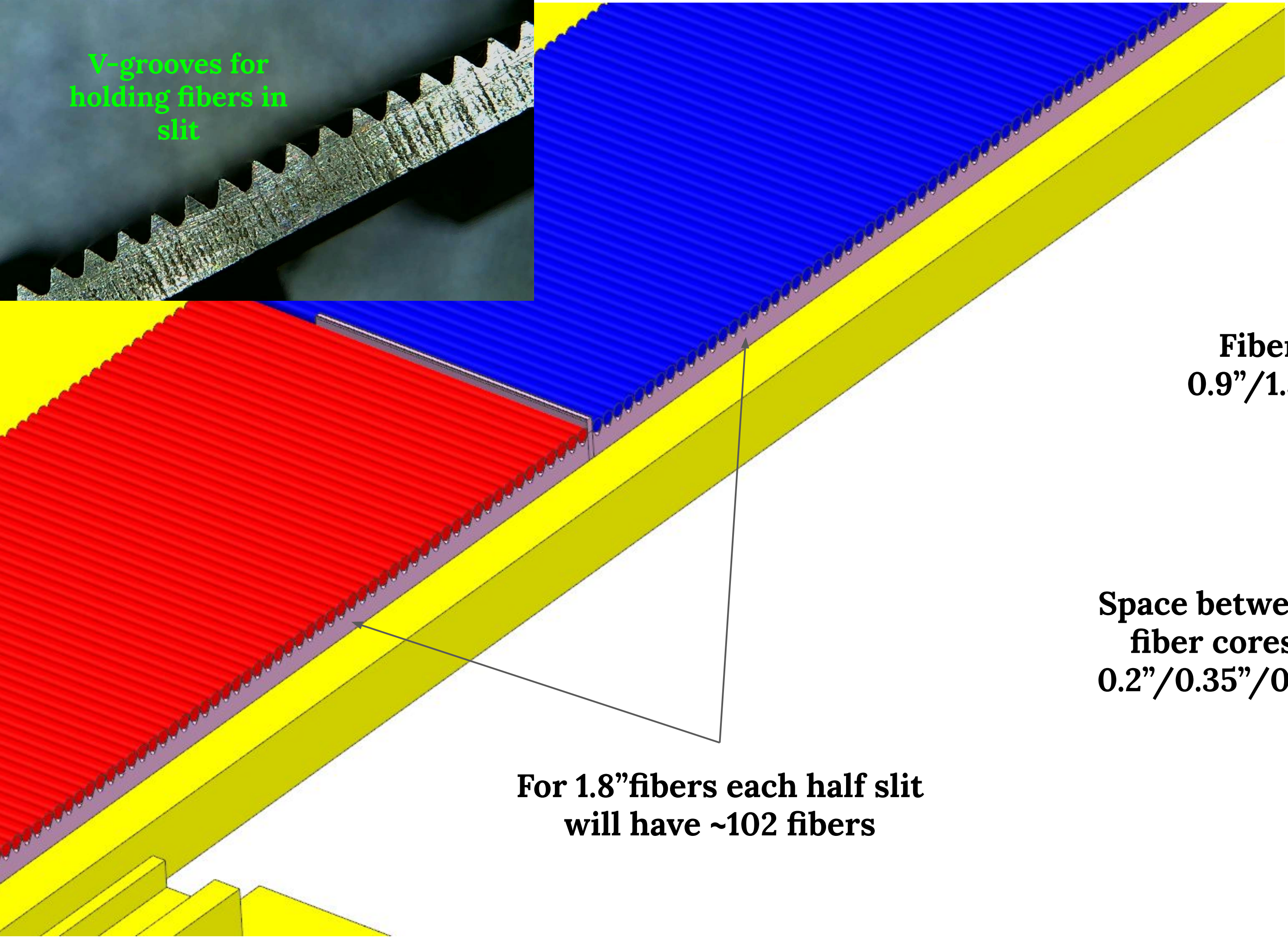
IFU Fold Prism

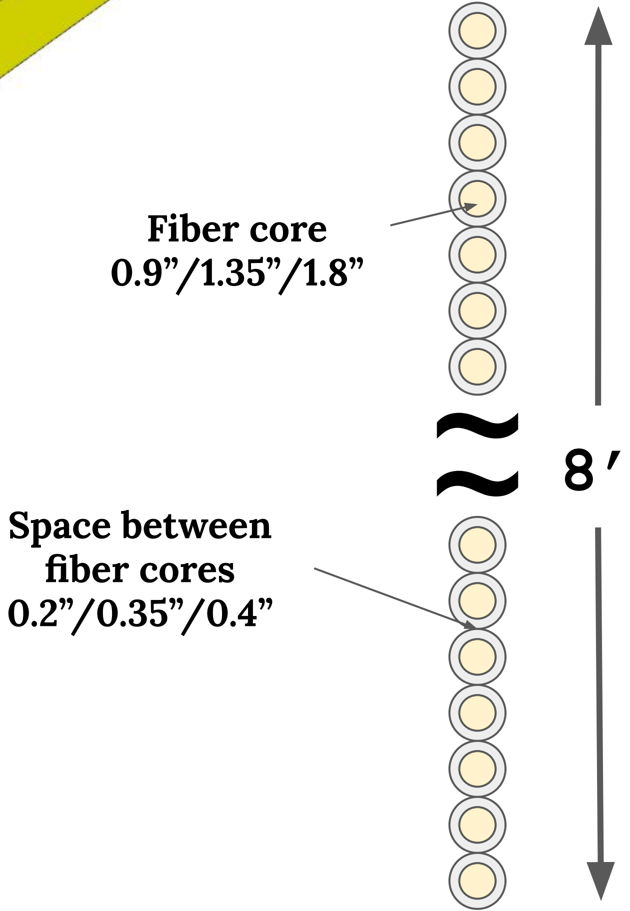


Integral Field Unit

Telescope

Arrangement of fibers in slit



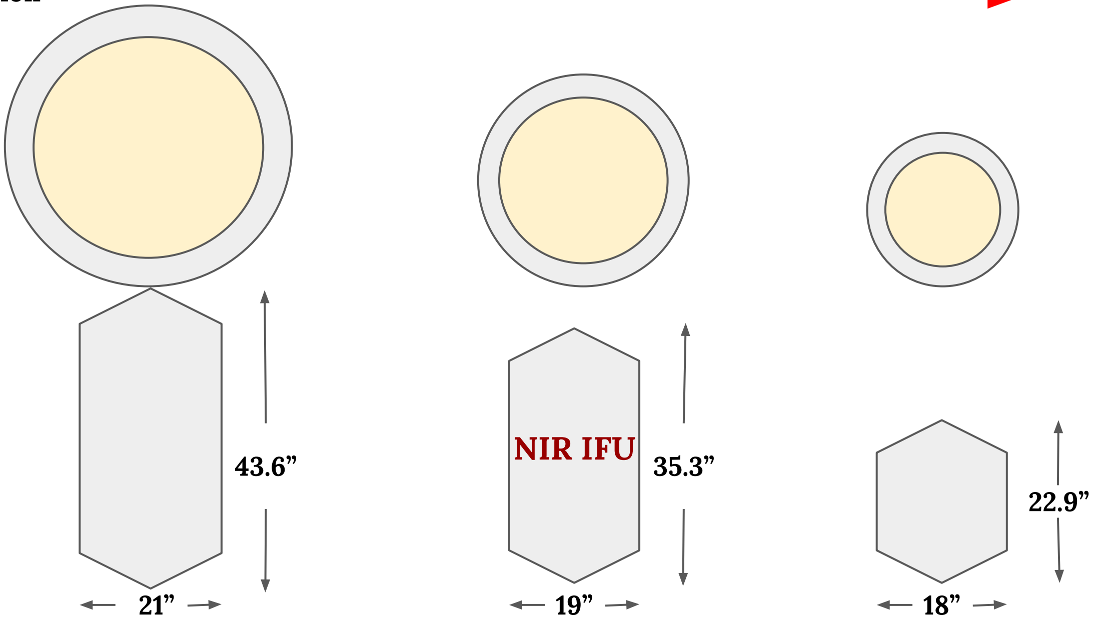


Integral Field Unit: Variants

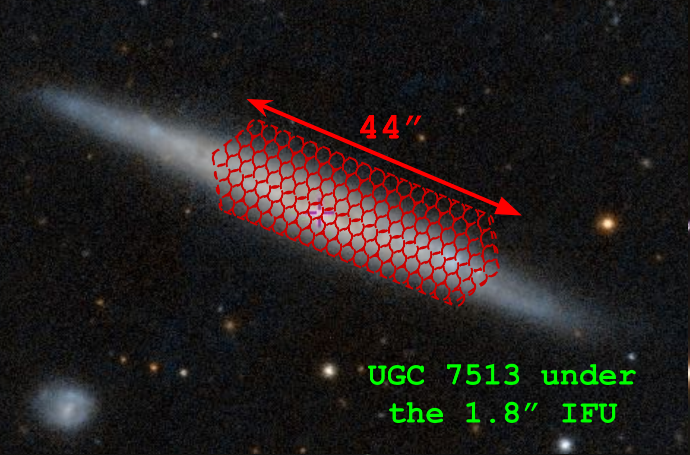
Area on sky

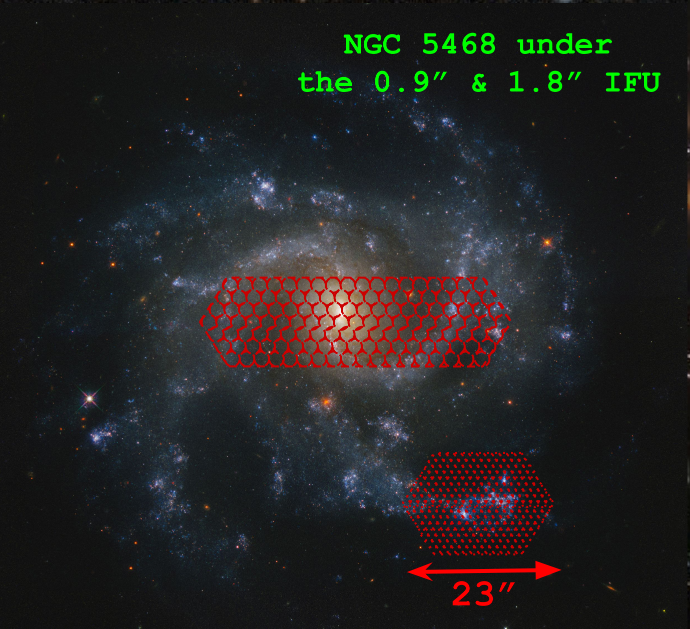
Gap between spaxels

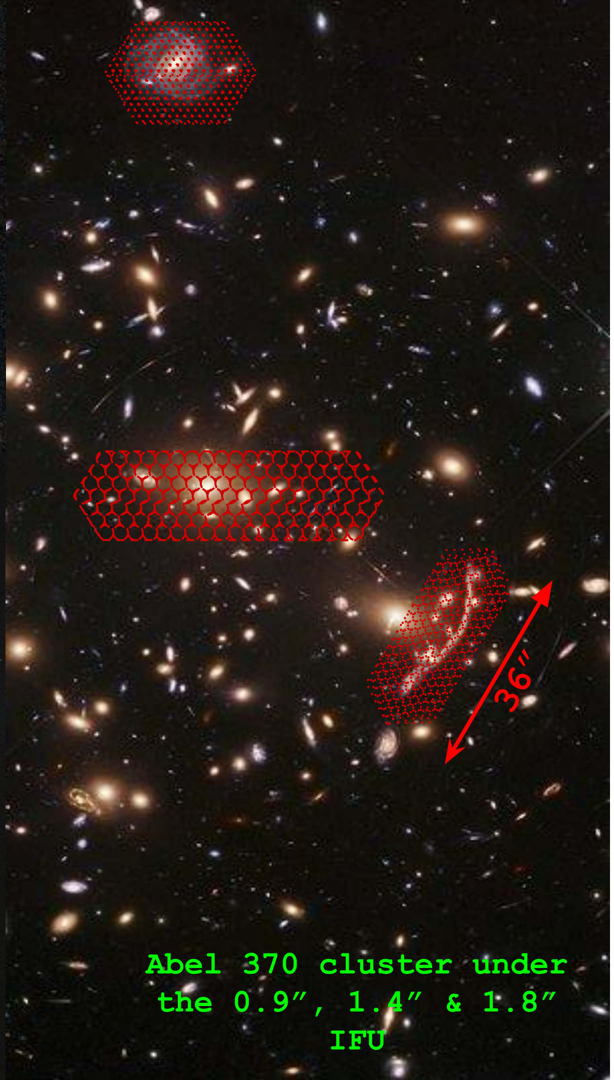
Spectral Resolution



Fiber core	400um	300um	200um
On Sky	1.8”	1.35”	0.9”
# of fibers	204	246	336
Object	179	214	309
Sky	25	32	27

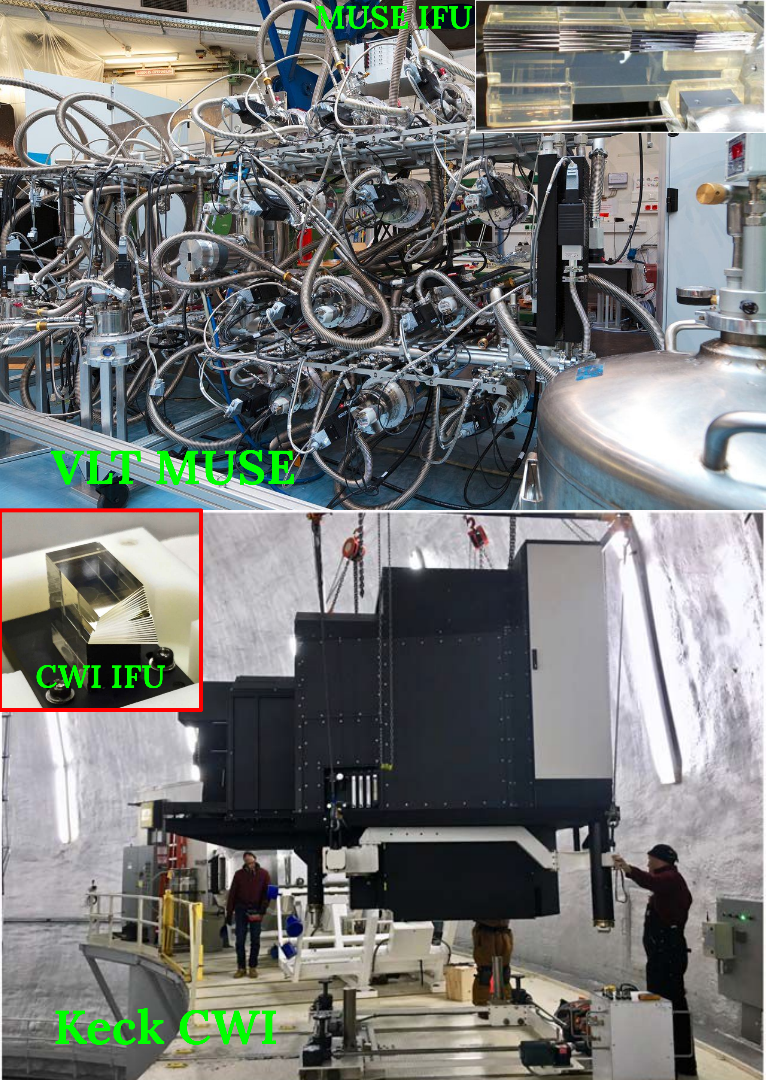






Slit Mask IFUs enable …

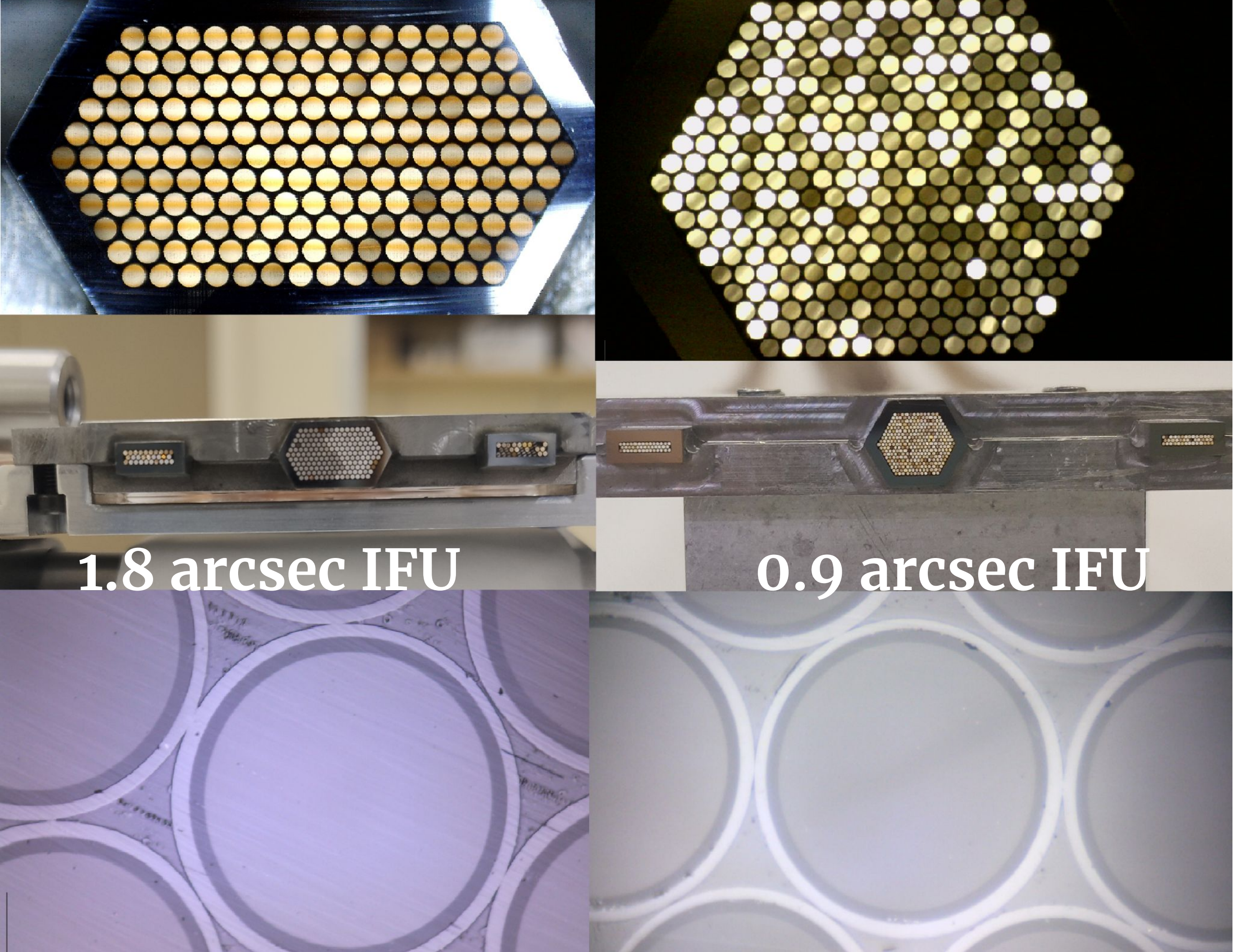
- Optimum coverage of edge on galaxies due to the elongated hexagonal shape.
  - Stellar/gas dynamics, chemical composition, star formation of thin and thick disks, halo, disk-halo interface are achievable.
- Efficient mapping of less-inclined and face on galaxies can be done as well.
  - Detailed observations of star forming sites like circumnuclear rings in NGC 1097.
  - Observation of counter-rotating core kinematic structure.
- In cluster environments, observations of multiple, closely spaced galaxies in a single exposure are achievable.
  - Mergers and interacting galaxies can be observed together.
  - Extremely lensed galaxy arcs such as in Abel 370 cluster.



Similar Instruments on 10m class telescopes

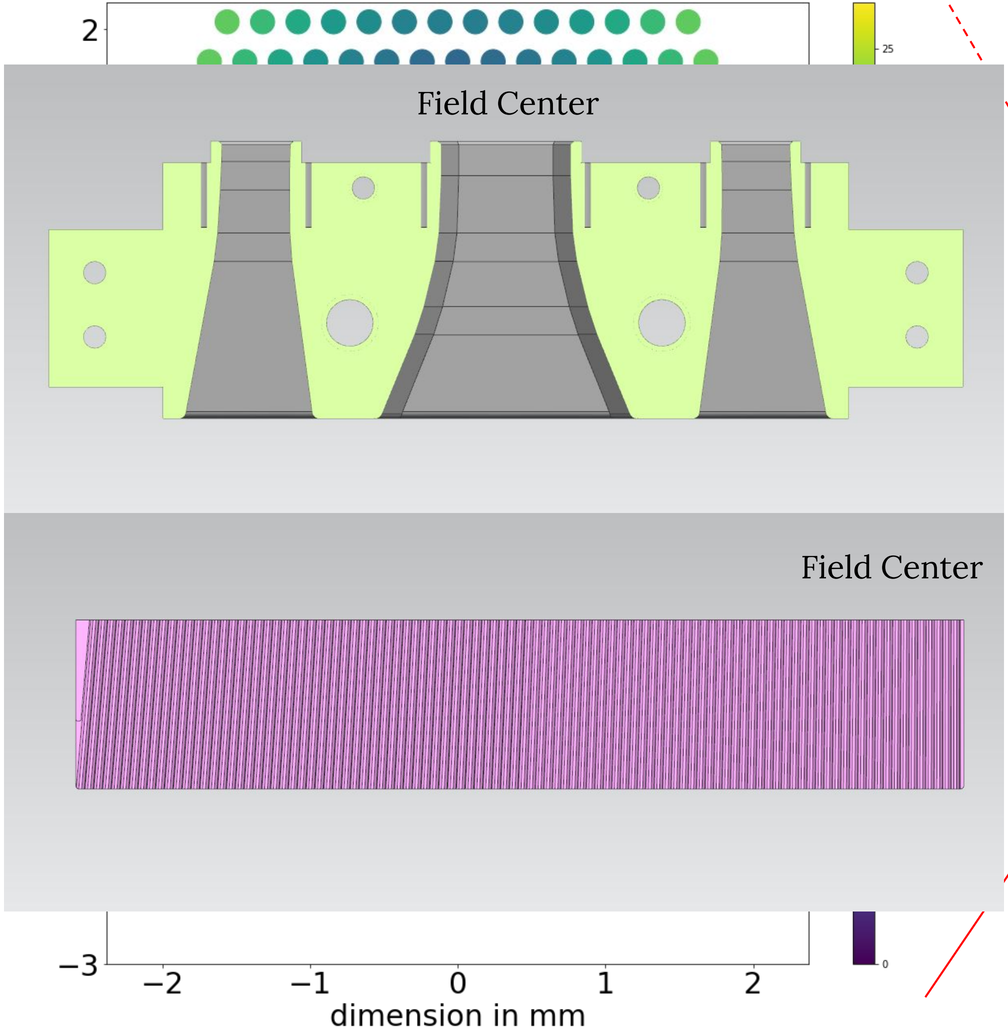
	VLT MUSE	Keck Cosmic Web Imager	SALT Slit Mask IFU
Primary Mirror diameter	8.2 m	10 m	9.2 m
Wavelength range	465-930 nm	350-560 nm	360-900 nm
Field of view	3600 sq arcsec	165-660 sq arcsec	412-1354 sq arcsec
Spectral Resolution	1750-3750	1000-20000	1400-6000
Spatial resolution	0.2"	0.35”-1.4”	0.9”-1.8”
Multiplexing	9000	343	204-340

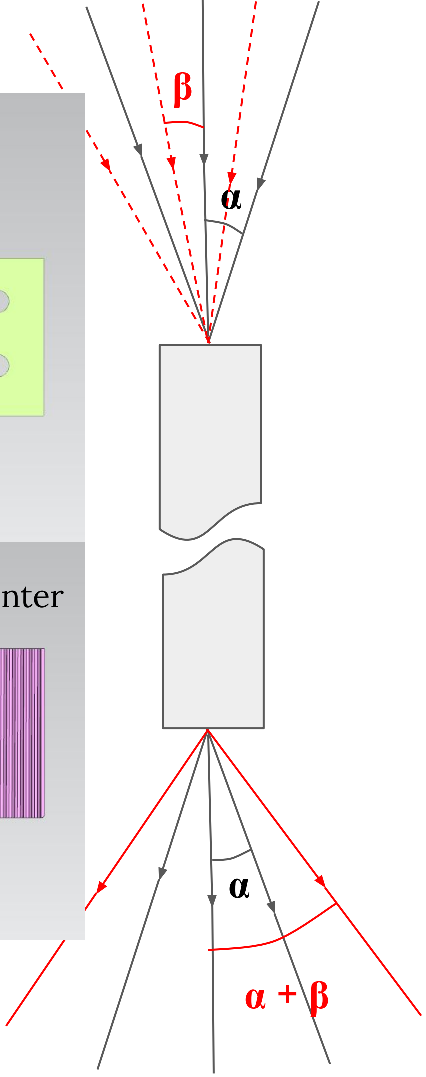
Slit Mask IFU Current Status- Fiber Polishing



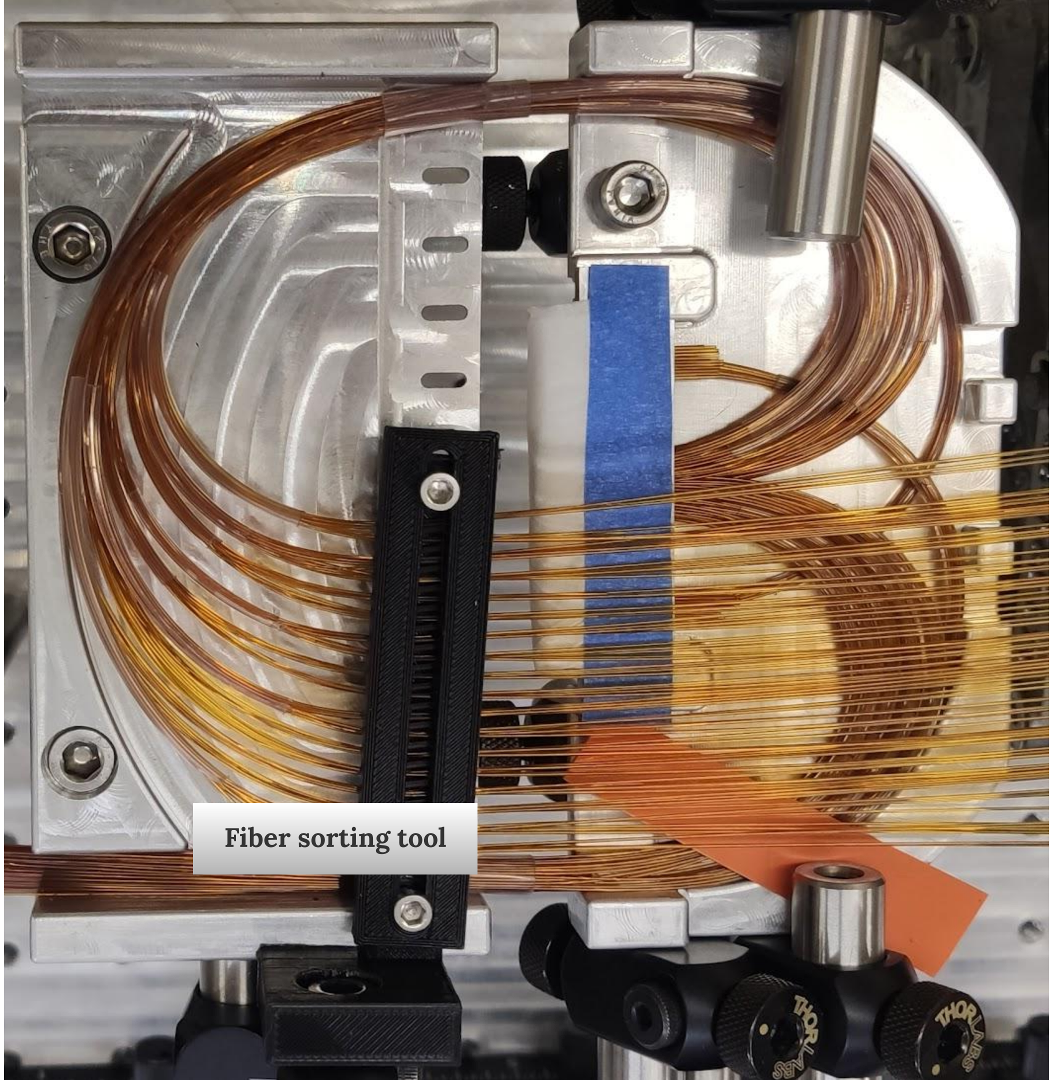
- Controlled force on fiber face during polishing minimizes physical focal ratio degradation.
- Optical grade surface finish up to ~0.3 um.
- Polish and inspect scheme to minimize geometric focal ratio degradation.
- Speed control to optimize finish.
- High power inspection microscope to verify polish.

Slit Mask IFU Current Status- Fiber Routing





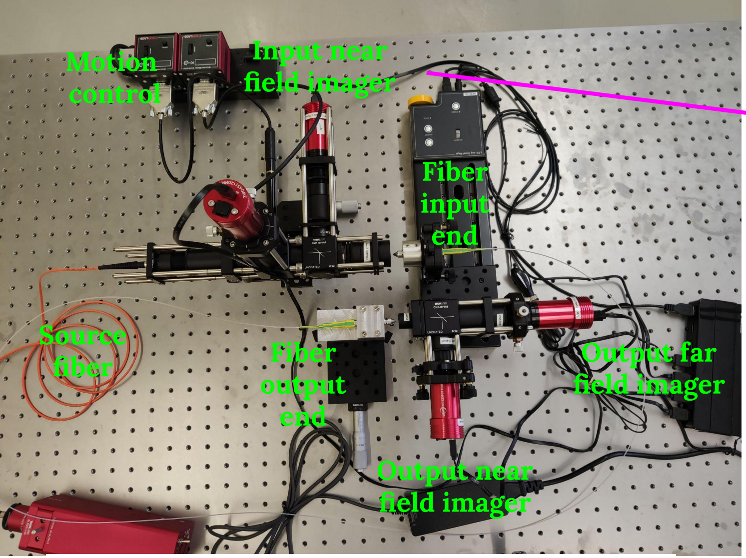
- SALT has field dependent non-telecentricity of 76 arcsec for every arcsec of radial shift from the center of the field.
- Non-telecentricity acts as an additional input angle into the fiber leading to geometric focal ratio degradation.
- Sky fibers are tilted to match the non-telecentricity distribution of the object fibers.
- Similar non-telecentricity sky and object fibers are grouped together and placed at a similar location in the slit in order to go through similar part of the spectrograph optics.

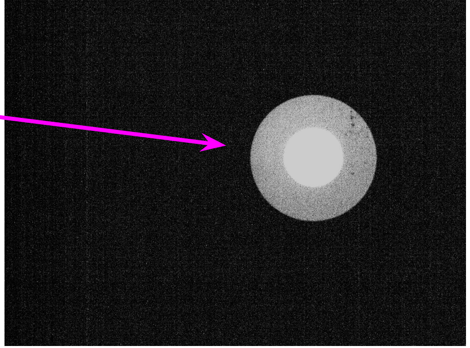


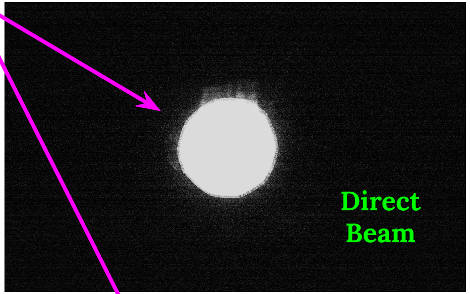
Slit Mask IFU Current Status- Fiber Integration Setup

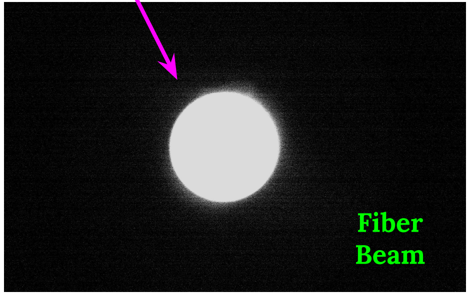
- Need to polish fibers on the slit end while keeping the bend radius intact.
- Fibers having coherent non-telecentricity is being grouped together at the slit.
- Fibres are currently being routed from sky to spectrograph end.
- Further encapsulation provided to avoid relative motion along the fiber length that results in breakage.

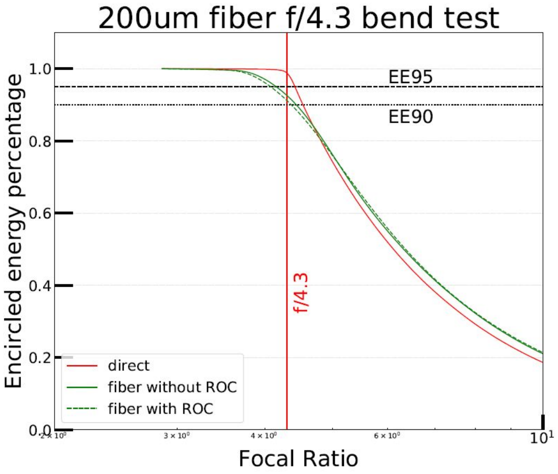
Slit Mask IFU Current Status- Fiber Performance Measurement











- Measurement of focal ratio degradation by the fiber with and without a bending radius.
- Ensures input beam at the center of the fiber with correct input beam speed.
- Measures relative and absolute throughput by comparing direct beam against the fiber beam.
- Produce telecentric beam and avoid artificial FRD.

Future possible fiber instrumentation at SALT

Future Possible Fiber Instruments at SALT

2yrs

1. **Fibre Spectropolarimetery: HRS, Integral field and MOS**
    a. Proof of concept demonstration planned for SpUpNIC on SAAO 1.9m telescope.
    b. Pre-focus, insertable polarimeter enables multi-purpose spectrometer use, small waveplates and beam-splitters, and eliminates instrumental polarization calibration requirements that currently hamstring RSS spectropolarimetry.
    c. Additional fiber-scrambling improves calibration and sky-subtraction on SALT moving-pupil telescope and provides options for fiber-based IFU and MOS with spectropolarimetric capability without perturbing spectrograph.

3-4yrs

2. **Fibre-fed Robert Stobie Spectrograph in the spectrograph room**
    a. Stable, no-flexure, temperature controlled, clean environment with easy servicing.
    b. Option for deployable MOS and mini-IFUs suited for stellar and extragalactic science.
    c. Dramatically simplify top-end operations; *open up payload for redesign for simultaneous feed of NIRWALS*
    d. Fabry-Perot incorporated in new reimaging camera also replacing SALTICAM.

5-7yrs

3. **Large-format integral field unit:** 2 arcmin diameter feeding 10 spectrographs
    a. Unmatched mapping and low-surface-brightness capabilities.
    b. Texas saddle-bag configuration to maximize fibre performance <400nm and reduce cost.

Questions/Comments/ Suggestions