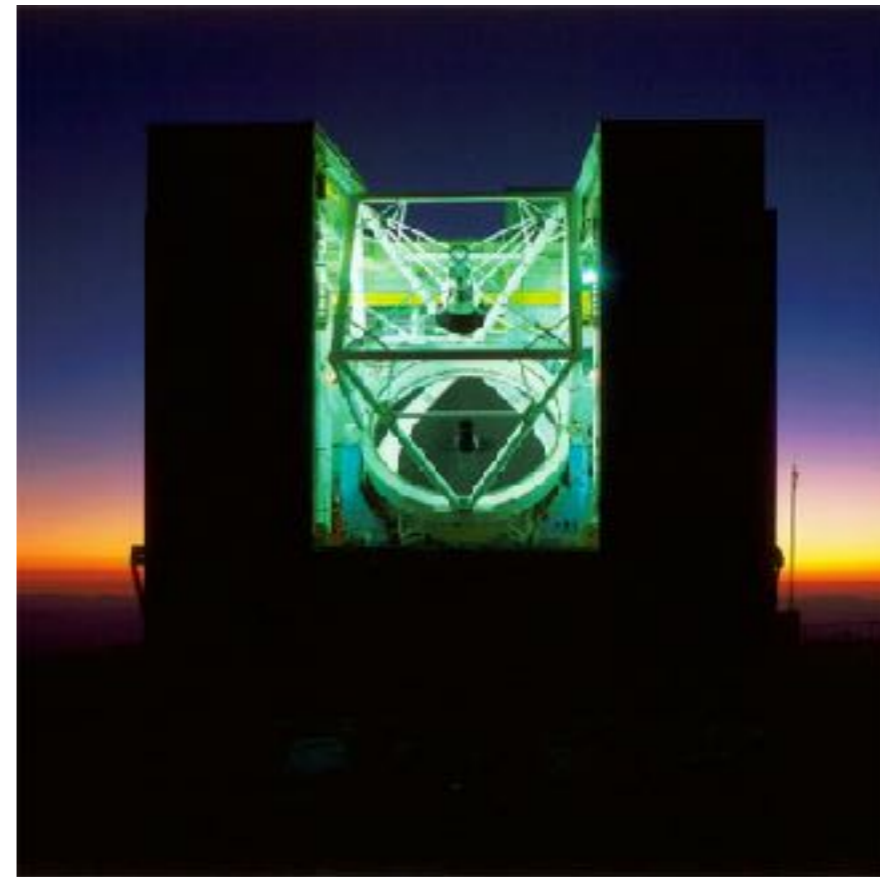


# Wide field optical spectroscopy at the MMT

6.5-m telescope at Mt. Hopkins  
(2 hours south of Tucson)

Benjamin Weiner (MMTO)  
EURECA, March 15, 2024



**Binospec**



**Hectospec**

# MMT has two large optical spectrographs, both queue scheduled

## Binospec: multi-slit, high throughput

- 2-side multislit spectrograph + imager, PI Dan Fabricant, SAO. Commissioned 2018.
- **Two 8x15' fields**, each with identical spectrograph.
- Up to ~100 slitlets per side.
- Three gratings for resolution  $R \sim 1300-4400$ .
- Coverage up to 3900-9200 Å at once, approx 3500 - 10,000 Å is accessible.
- New Integral Field Unit samples a 12x22" area with 0.7" spaxels.
- **Excellent throughput and sky subtraction.**
- User-friendly slitmask design written by Sean Moran at SAO.
- Pipeline data reduction by SAO TDC.
- "Binospec is the first of the ELT instruments" [in its complexity and capability] - Steve Shectman

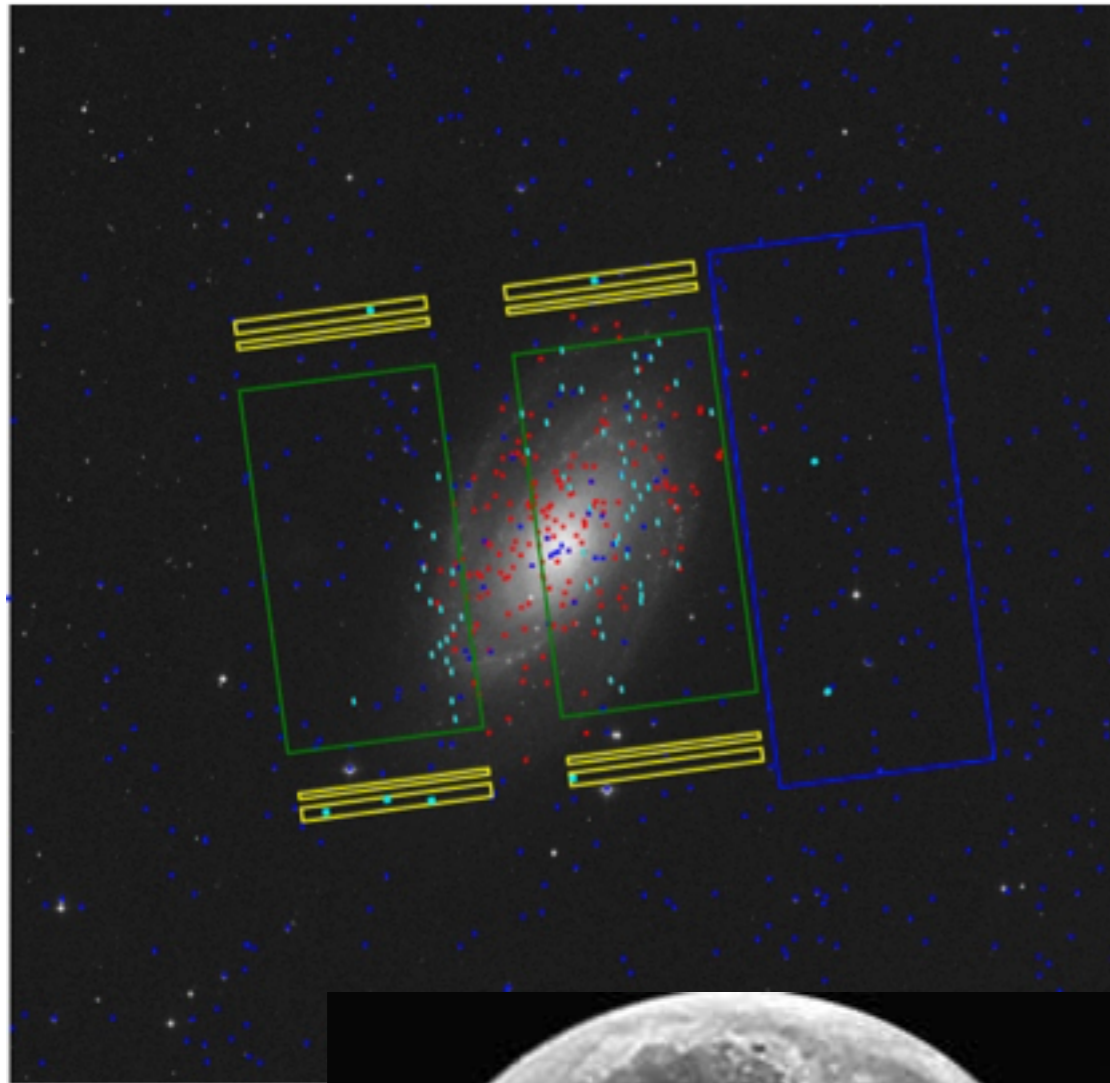
## Hectospec: multi-fiber, very wide area

- Multi-fiber wide field spectrograph, PI Dan Fabricant, SAO. Commissioned 2004.
- **300 x 1.5" fibers within a 1 degree diameter**, robotic fiber positioner.
- Resolution  $R \sim 1100$ , coverage ~ 3800-9000 Å at once.
- Throughput is adequate but not as good as Binospec. Sky subtraction in red is not as good.
- **Hectochelle**: same fibers, single-order hi-res echelle spectra, different data reduction.

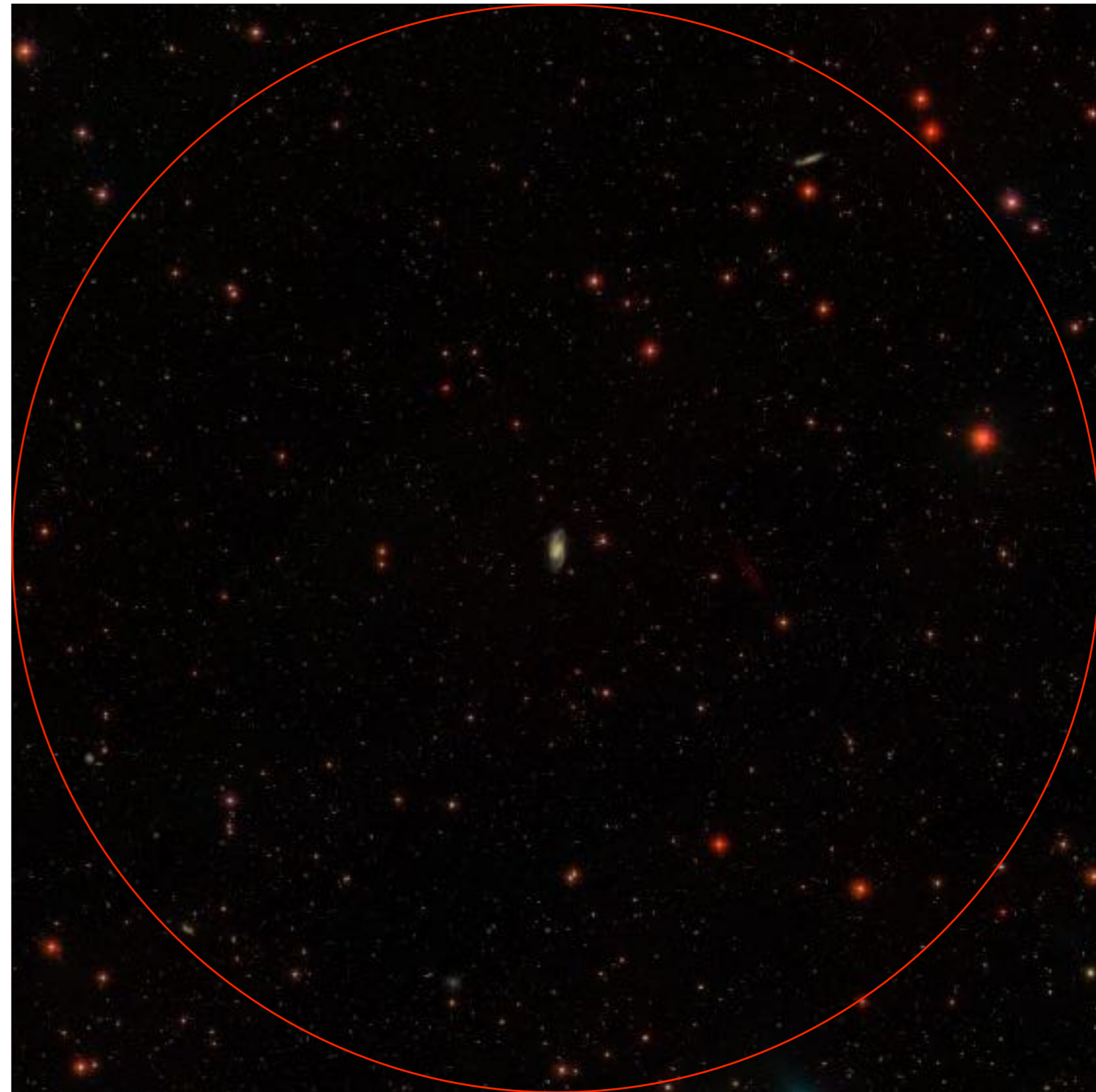
**Visit [www.mmt.org](http://www.mmt.org) > Observing > Instrument Suite for detailed information.**



## Binospec field - 2 x 8x15'

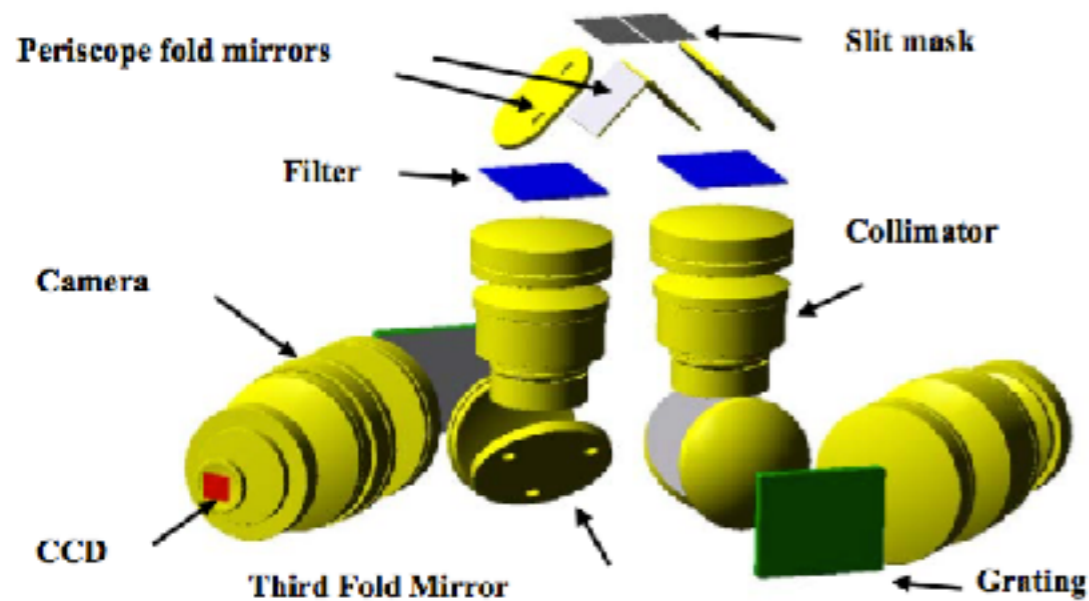


## Hectospec field - 1 deg diam



To scale - Moon ~ 30 arcmin

# Binospec and its Integral Field Unit at the MMT



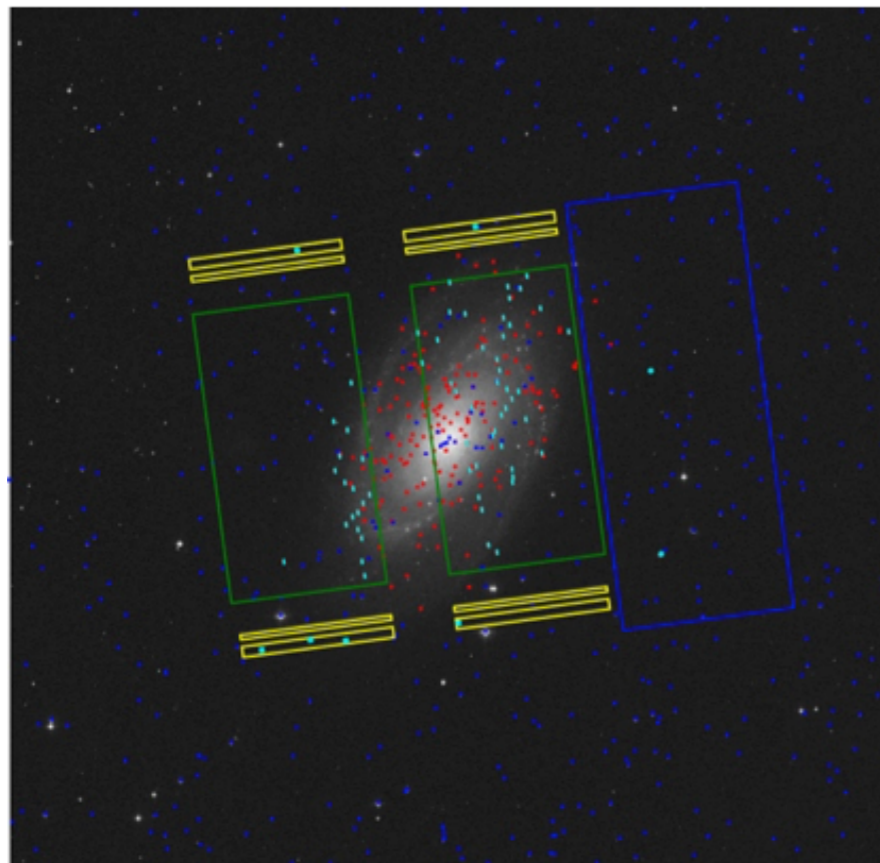
Binospec is a general purpose wide field multi-object spectrograph, constructed by SAO, in use at the MMT since 2018. It has two 8' x 15' fields of view, feeding two spectrographs.

Three selectable gratings give a choice of  $R \sim 1300-4000$  in a 1" slit, with broad optical wavelength coverage 3800-9000 Å at the lowest resolution.

For typical multi-slit observations one can observe ~75-100 objects per field of view, ~150-200 total, using machined metal slitmasks. Longslit and imaging are also available. Binospec's advantages include a wide field of view, and a high throughput from ~3900-9500 Å.

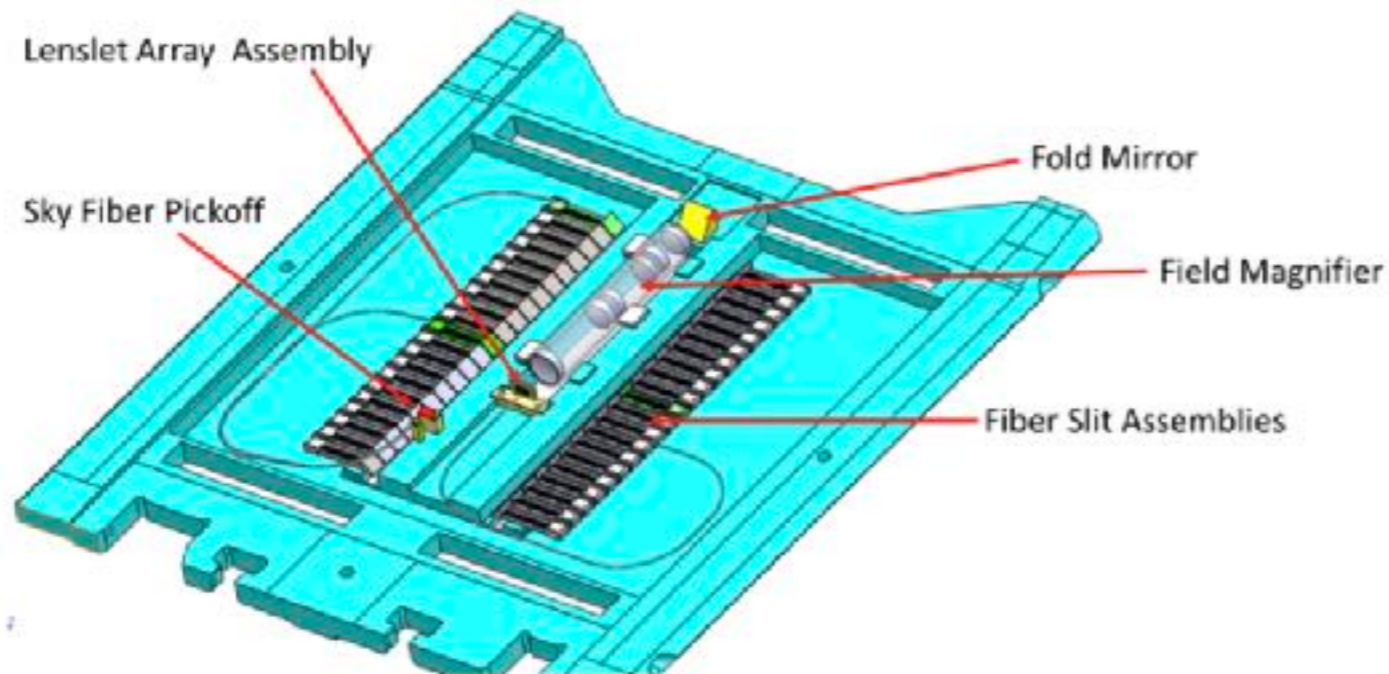
High-z projects with Binospec have included:

- $z = 6-7$  quasars and Ly-alpha emitters at 8000-10000 Å observed.
- restframe-UV spectra of  $z=2-3$  analogs of reionization-era galaxies
- Ly-a spectra of  $z=2-4$  LBGs in JWST fields
- *your idea here*

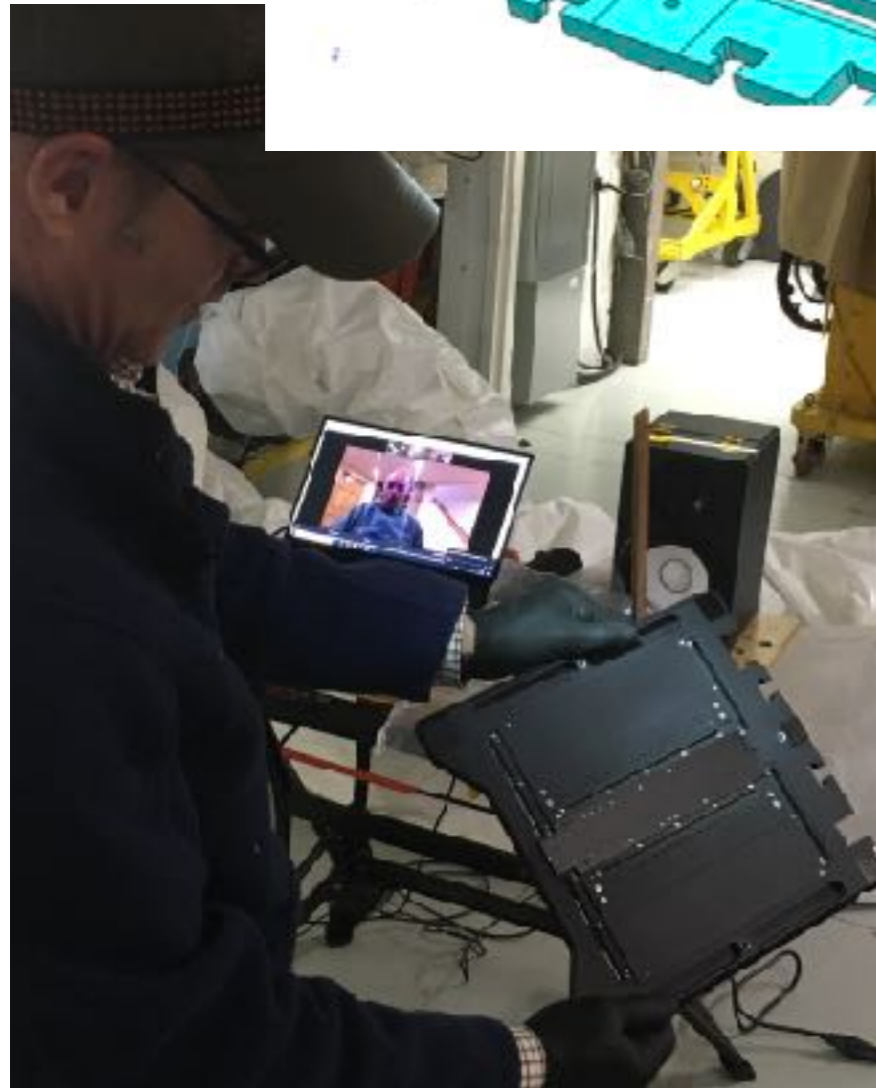




# Binospic and its Integral Field Unit at the MMT



SAO has constructed an Integral Field Unit (IFU) for Binospic. The IFU provides spatially 2-D spectroscopy over a single small field of view. The IFU is inserted into the instrument in place of a regular slitmask. It uses lenslets and fibers to remap the field of view onto two pseudo-longslits that are then dispersed by the usual Binospic spectrographs.



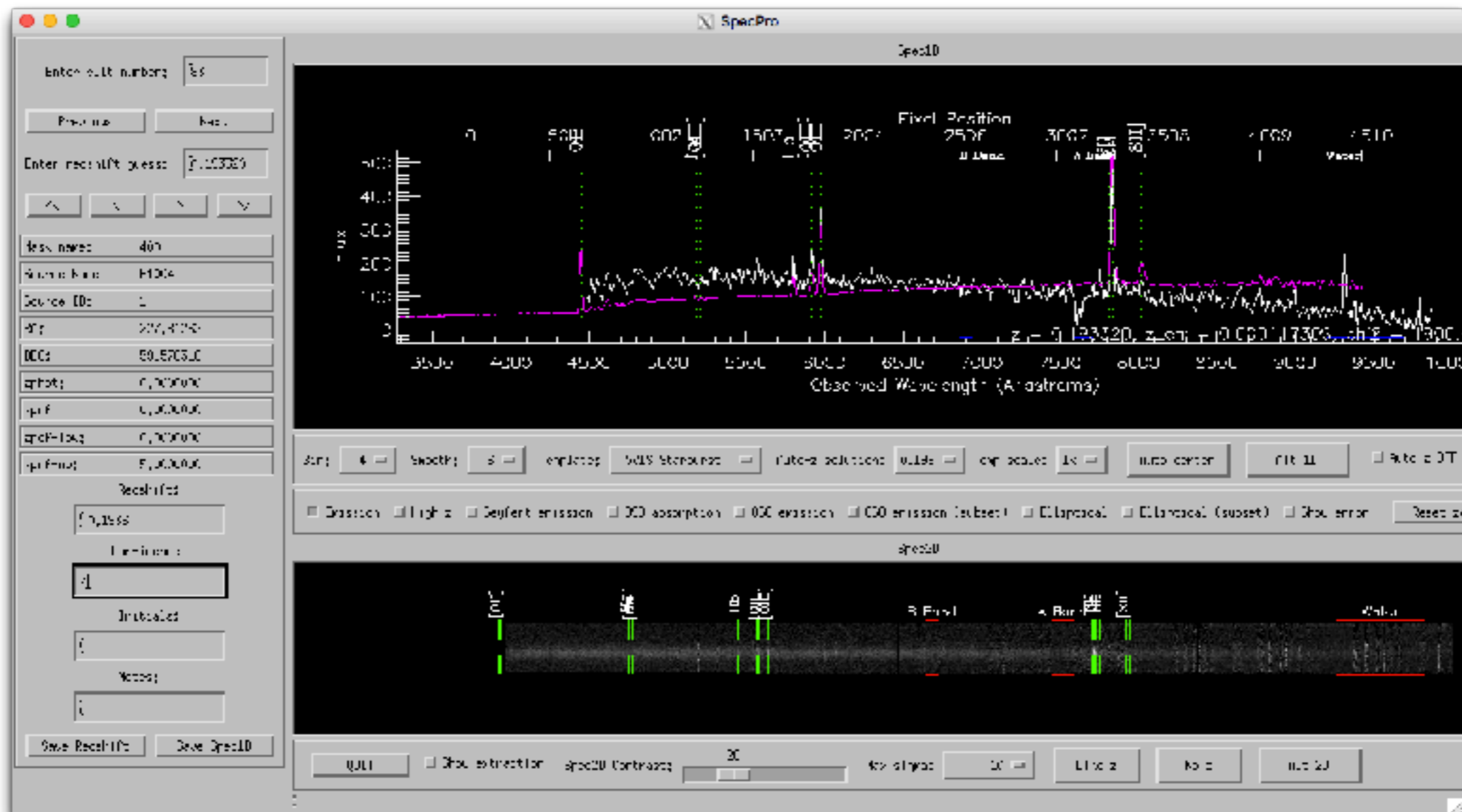
Key points for prospective users of the IFU:

- Commissioned in 2023B. Several programs are underway in 2024A, *shared-risk* observing.
- Single **22" x 12" science field**, fiber spaxel **spacing ~0.7" hexagonal**, fully sampled (no gaps).
- Smaller sky field, offset ~ 8 arcmin away.
- **750 fibers** counting both science and sky.
- Spectral resolution as if using a 0.7" slit, so **R ~ 1900-5000** depending on the grating.
- Wavelength coverage same as if using a slit.
- Queue scheduled, like all Binospic observations. Entering target details is similar to a longslit target.
- Data is reduced by an extension of the Binospic pipeline; some data has been reduced but still under development; the data is similar to reducing a slit exposure with a source every 2.4 arcsec.

<https://www.mmt.org/instrument-suite/binospic/binospic-ifu-information/>

# What can I do with my data?

- Hectospec data can be reduced by the user with HSRED; also fits galaxy redshifts.
- Use “qplot” to inspect the 1-d spectra and redshifts from HSRED, and record quality codes. <https://github.com/bjweiner/qplot>
- Binospec data are reduced with a SAO pipeline by SAO staff; code is public and can be run by users as well.
- Binospec reduced data can be post-processed to view 2-d and 1-d spectra and fit templates for redshifts, using Specpro GUI (by Dan Masters, adapted by BJW for Binospec). <http://www.mmt.org/instrument-suite/binospec/using-specpro-to-review-binospes-spectra/>





# How the Binospec and MMIRS queues run

- Users upload targets, design masks, set priorities; subdivided into max 2-hour observing blocks.
- Scheduler software ranks the OBs based on elevation, priority, program completion. Based on the astroplan package. Queue observer chooses among the high ranked OBs, with respect to conditions: moon, seeing, wind, clear/cirrus, etc.
- Instrument scientist manages queue, mask exchanges, relays between PIs and observers, advises PIs on observation setups.
- Issues: RA oversubscription at certain times; many programs need good conditions for deep integrations on a few extragalactic survey fields, for which the instrument is highly suited. We could use more programs that can cover less-popular RAs, or accept below-average weather.

