The Completion of HETDEX



(Hobby-Eberly Telescope Dark Energy eXperiment)

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on behalf of the HETDEX collaboration

1 November 2024

What is HETDEX?

- Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) is a galaxy survey with unique properties:
  - The ***first*** **blind** spectroscopic large-scale structure survey
    - **Blind** = no pre-selection; huge discovery potential!
  - The **first** 11 Gpc^3-class survey at high-z [**1.9<z<3.5**] with sufficient number density (nP(k)=1 at k~0.25 h/Mpc).
  - The previous big surveys (2dF, SDSS, WiggleZ, etc) were done at z<1, and BOSS QSOs are quite sparse.

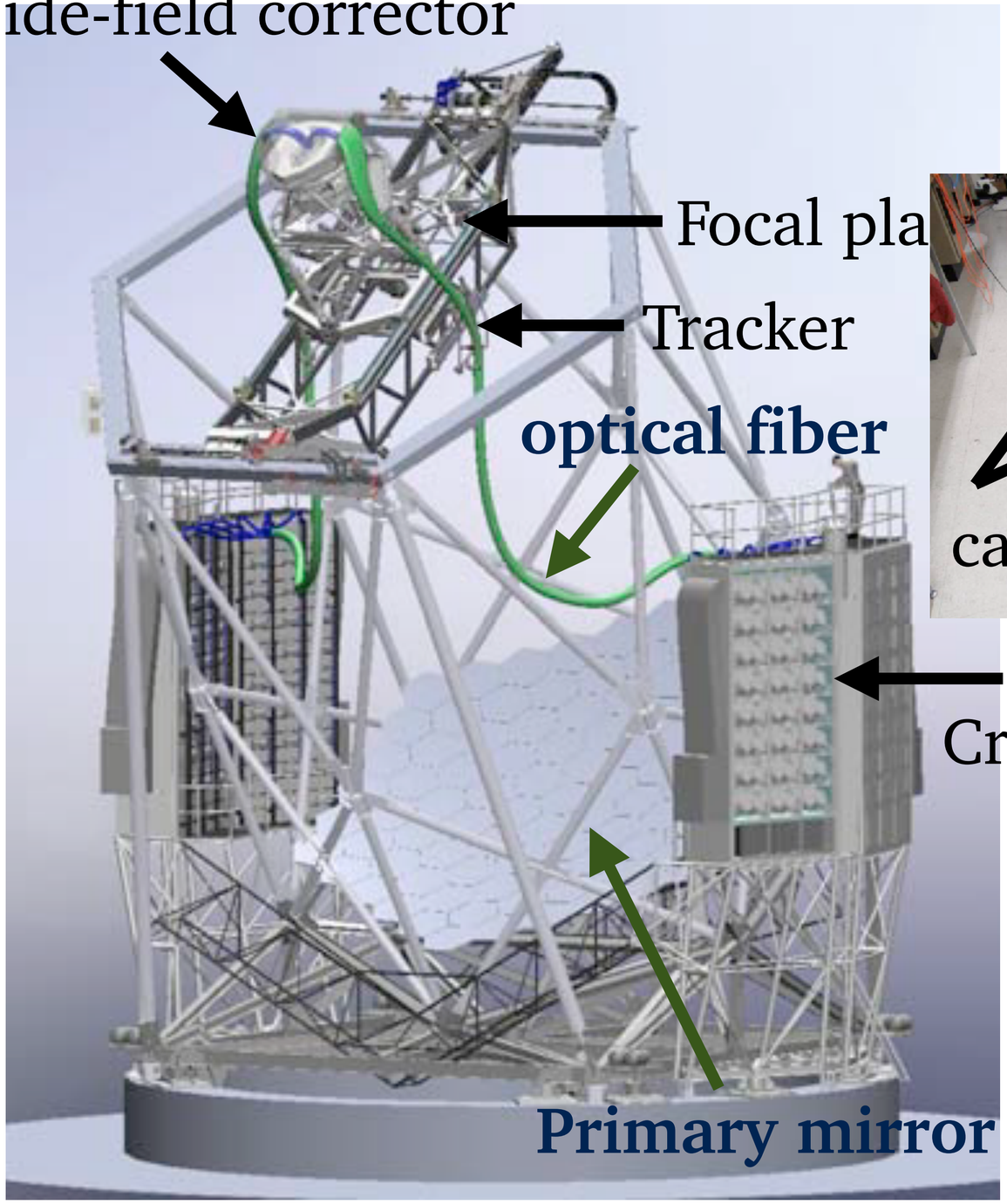
35k spectra in every 6 mins

- HETDEX will use the newly-built integral field unit (IFU) spectrographs called “VIRUS*” (Hill et al.)
  - We have 78 IFUs on the focal plane
  - Each IFU has 448 fibers
  - Each IFU feeds two VIRUS spectrographs
  - **Therefore, we will have 35K (34,944) fibers in the sky at once (every 6 minutes, $\sigma_F = (1\sim5)\times10^{-17}$ erg/s/cm^2)!**

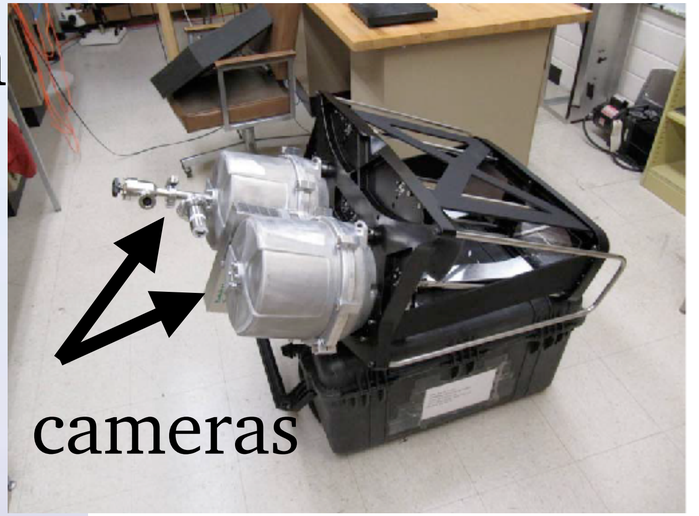
*VIRUS = Visible Integral-field Replicable Unit Spectrograph

Hobby-Eberly Telescope with VIRUS





*One **VIRUS** Detector Unit*



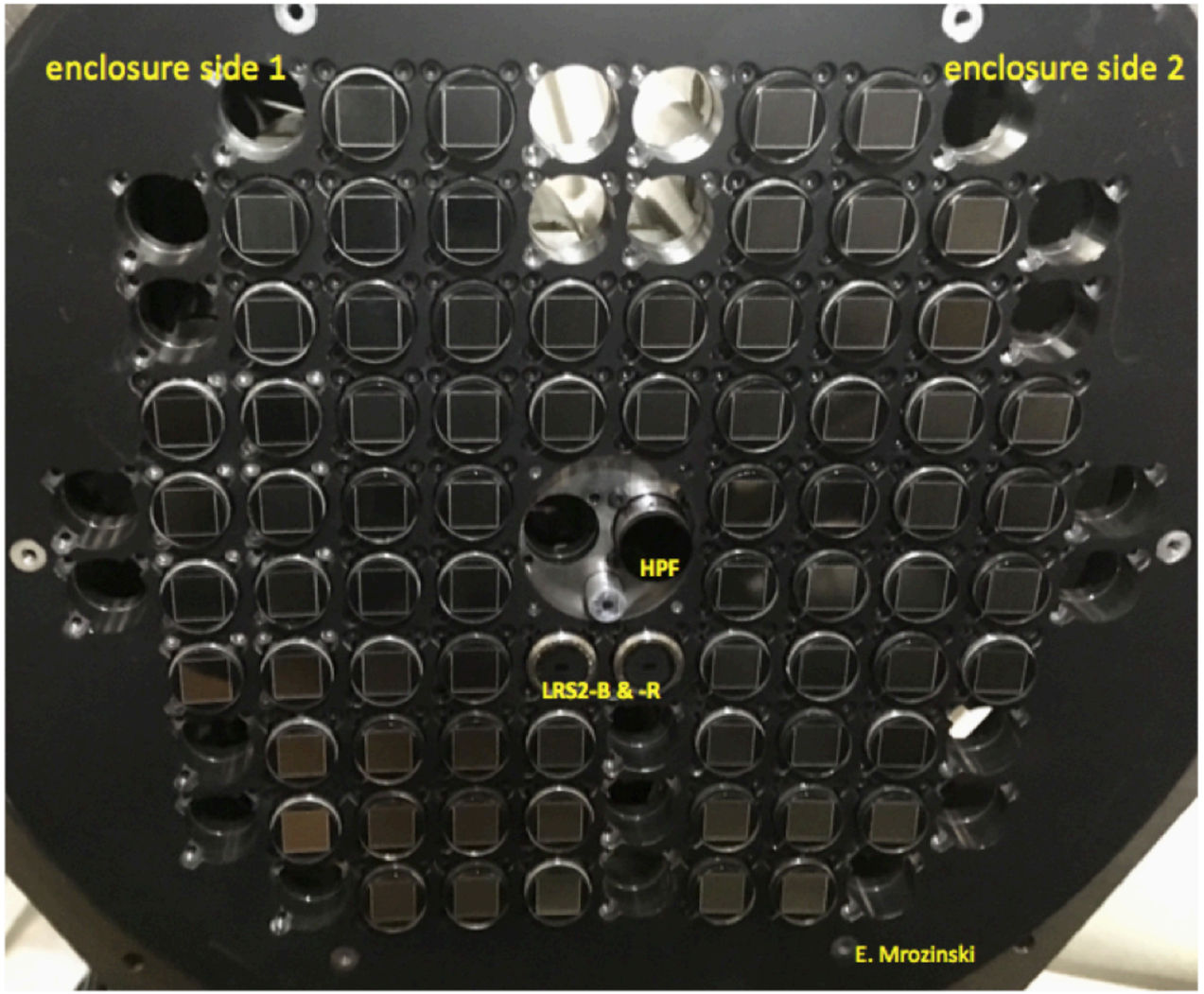
Detectors /
Cryogenic system

VIRUS enclosures

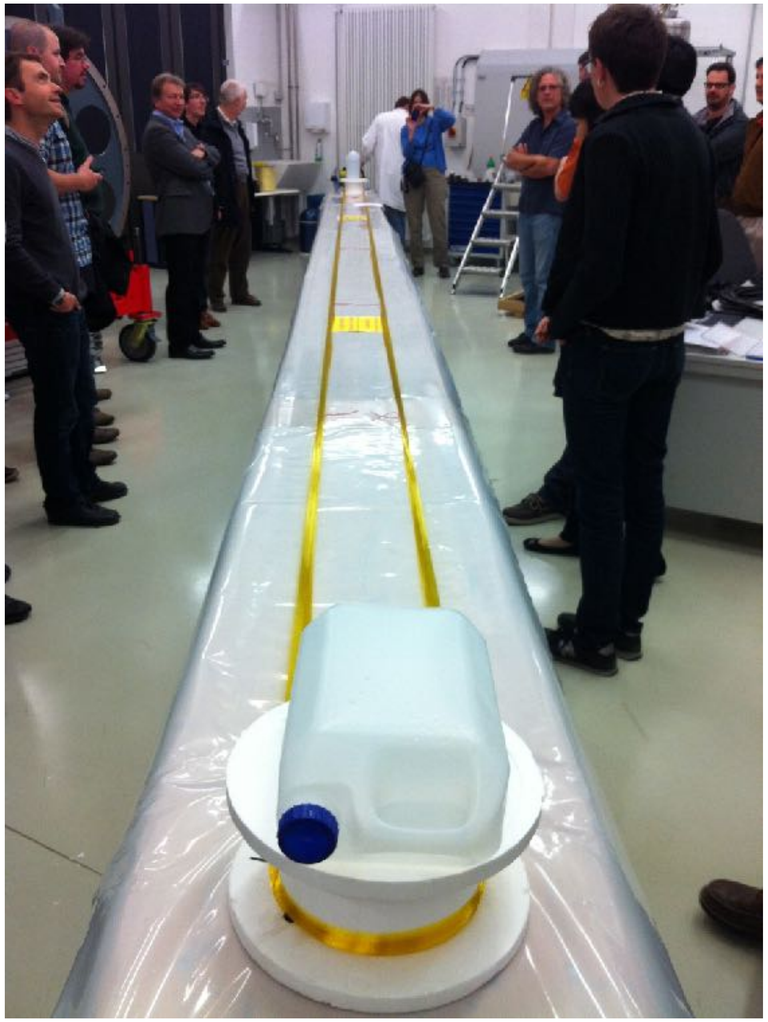


VIRUS enclosures built by TAMU

IFUs on the focal plane



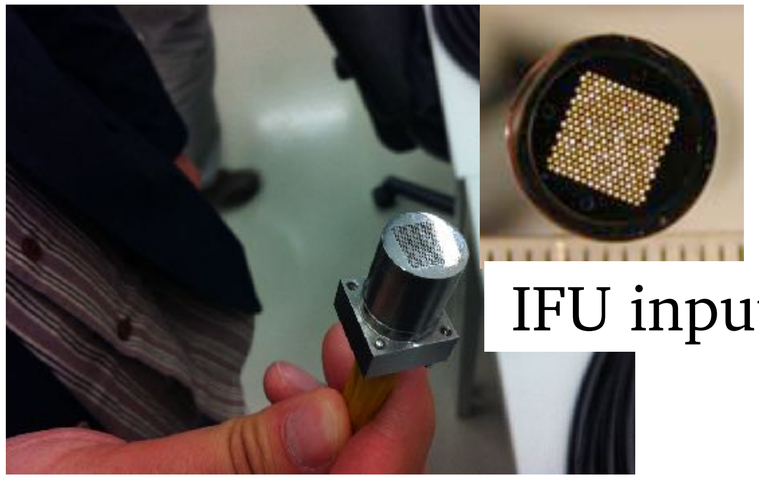
Fibers fabricated at AIP (picture in 2013)



a Lo~ong fiber!

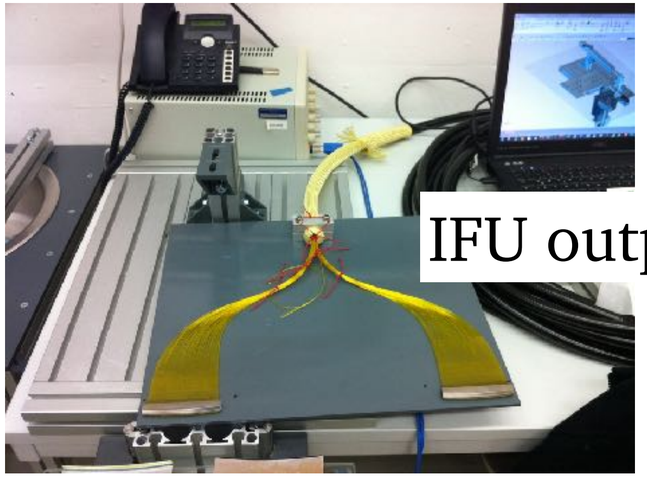


Put into cables...



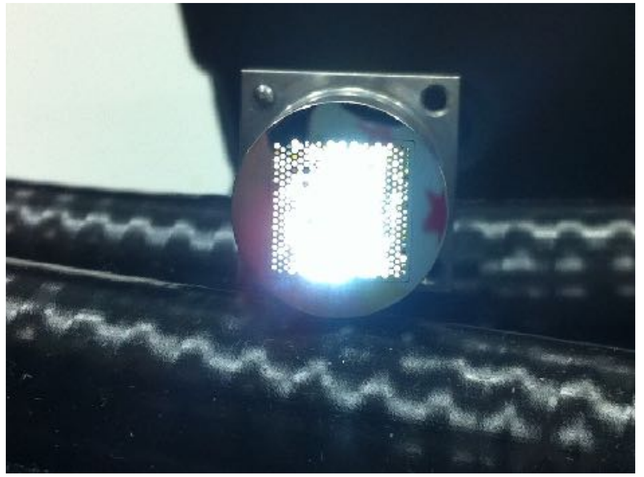
IFU input

448 fibers per IFU



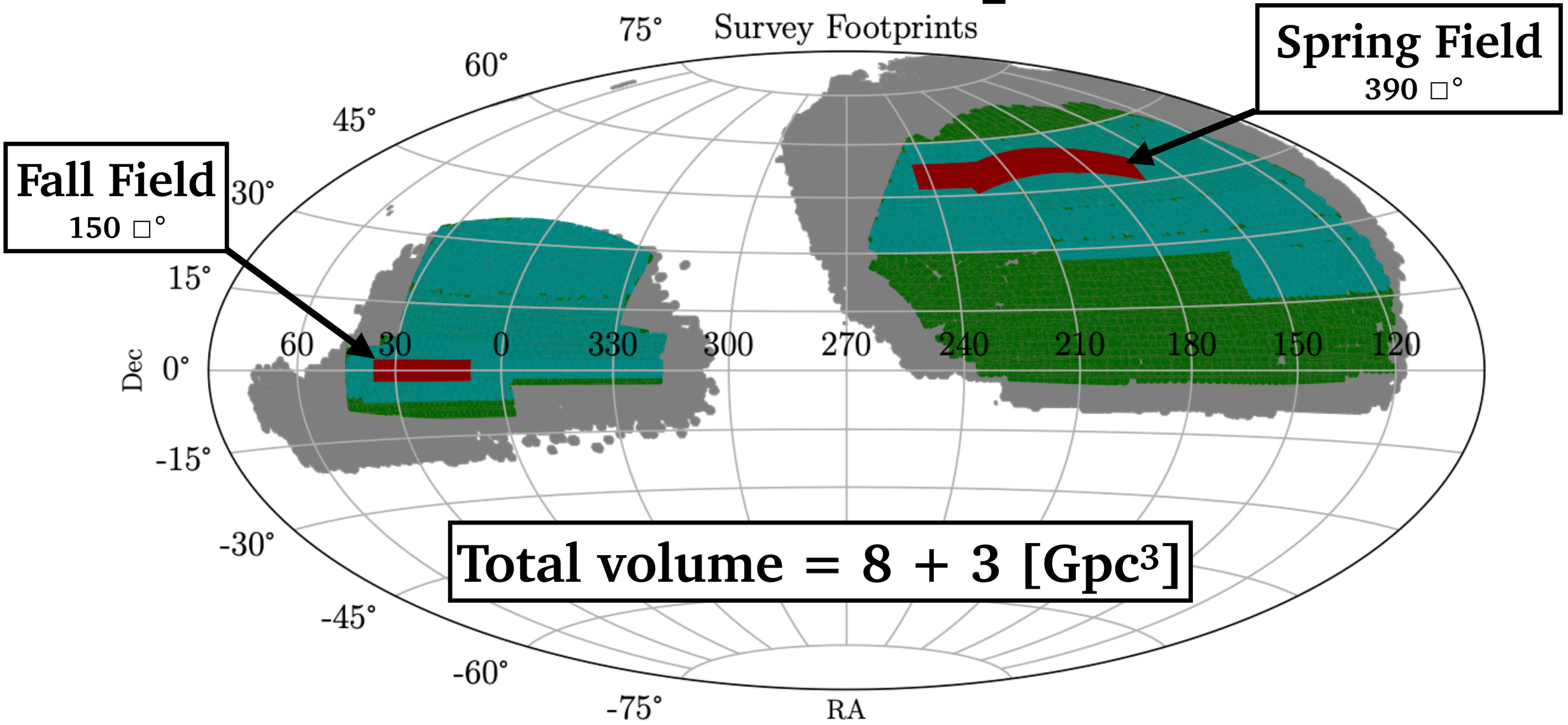
IFU output

One IFU feeds two spec.



A test fibers being lit

HETDEX Footprint

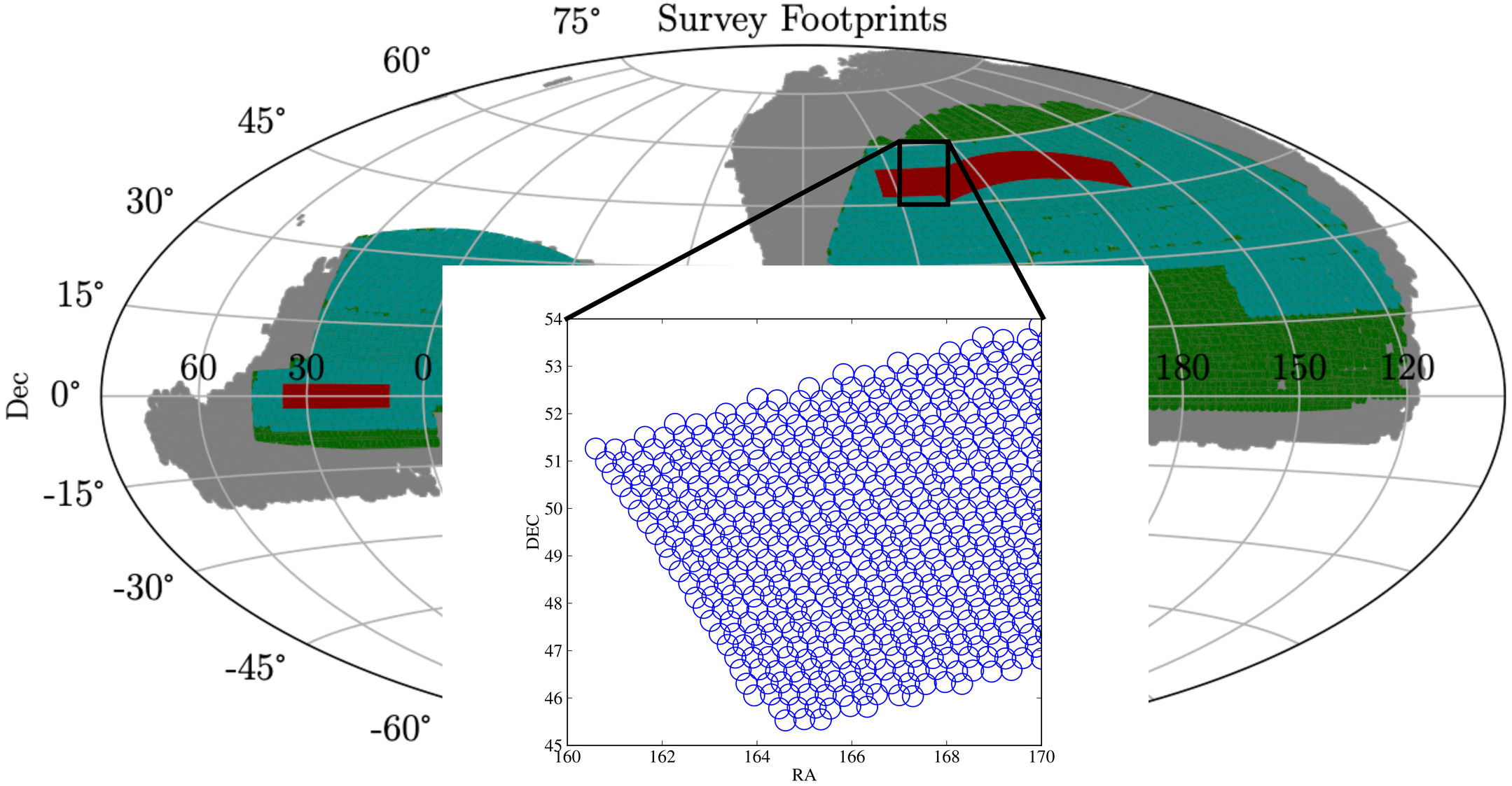


Spring Field
390 □°

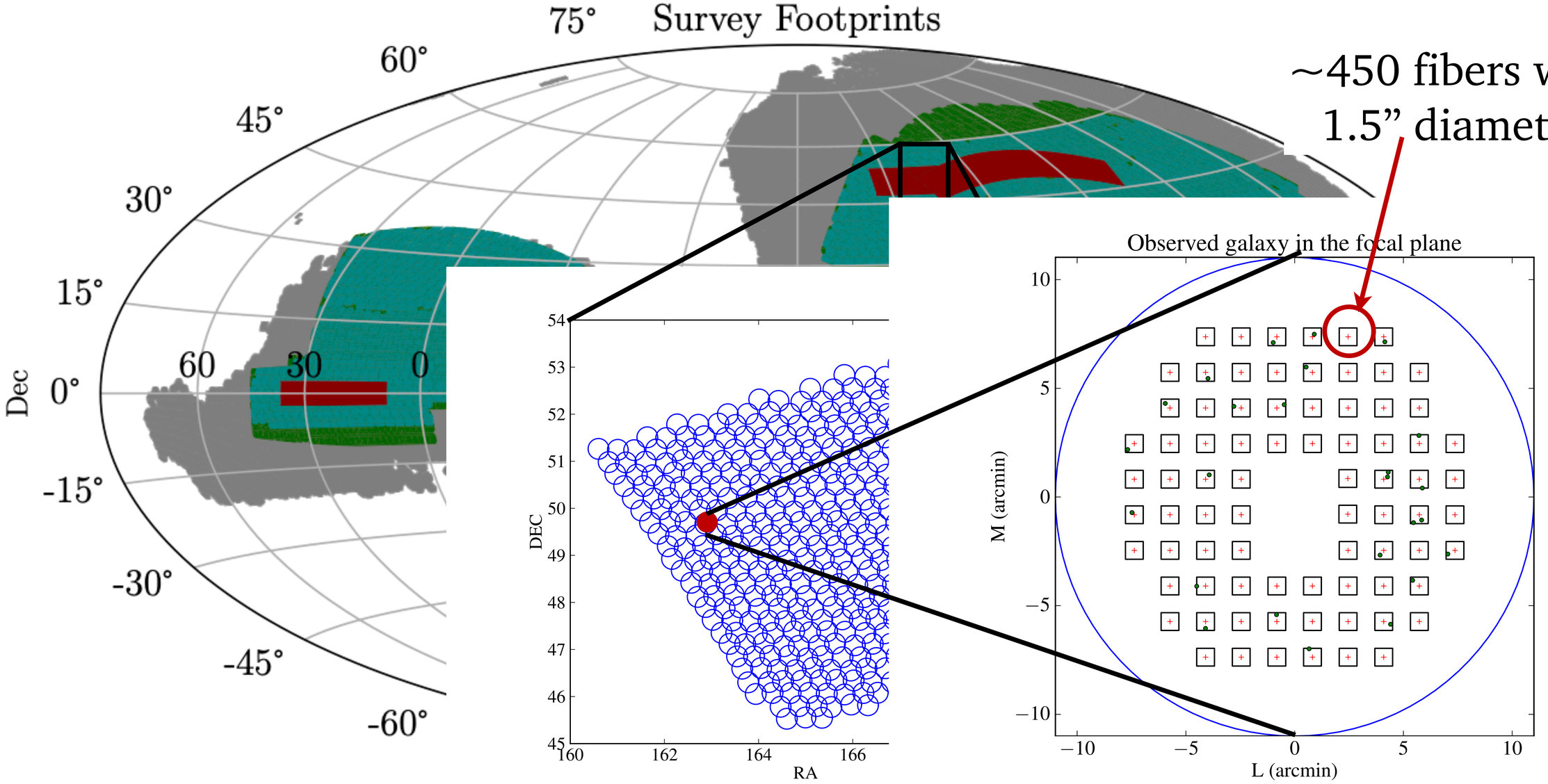
Fall Field
150 □°

Total volume = 8 + 3 [Gpc³]

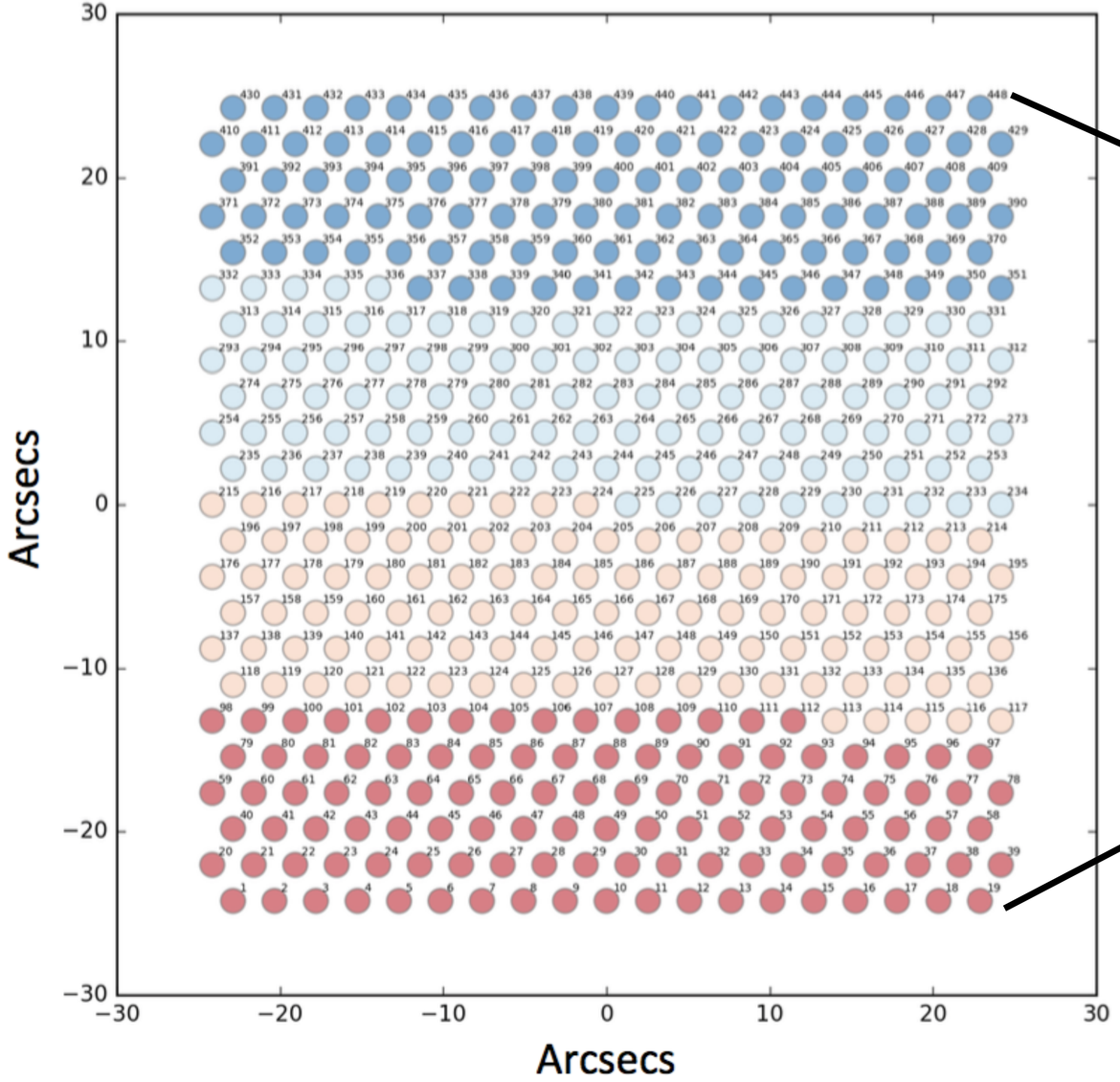
About 4000 shots (22’ FoV)

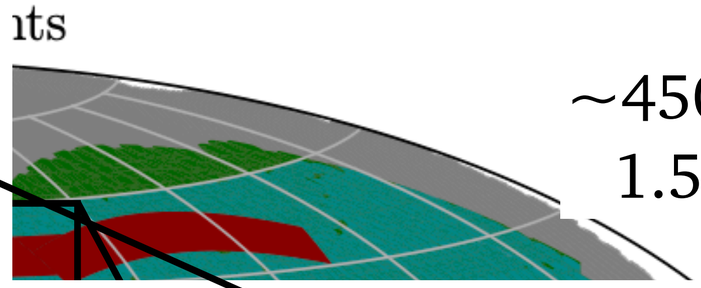


A shot with 78 IFUs (50”×50”)

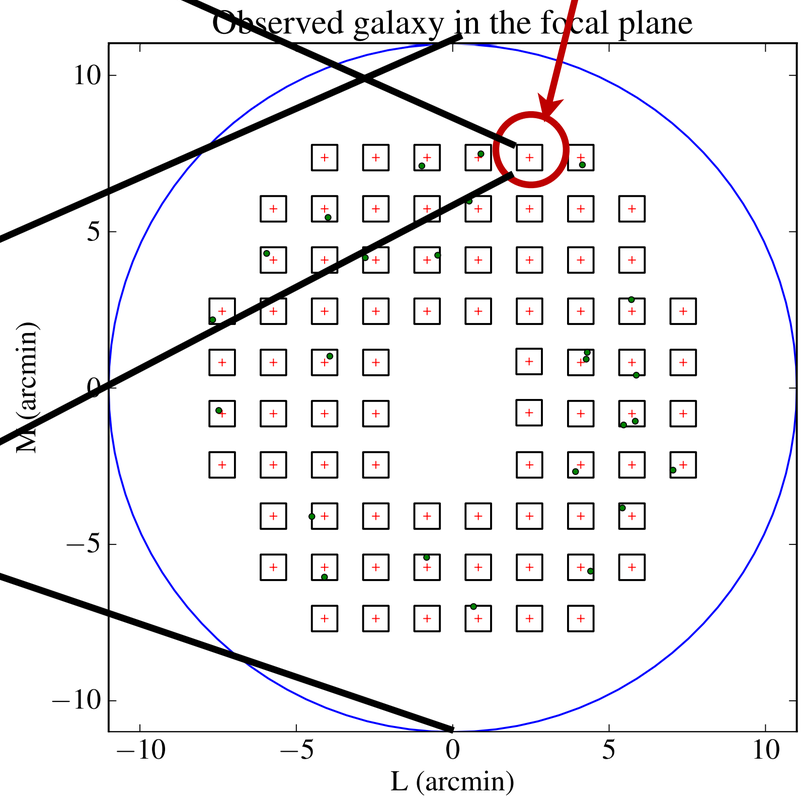


448 fibers (1.5”-diameter)

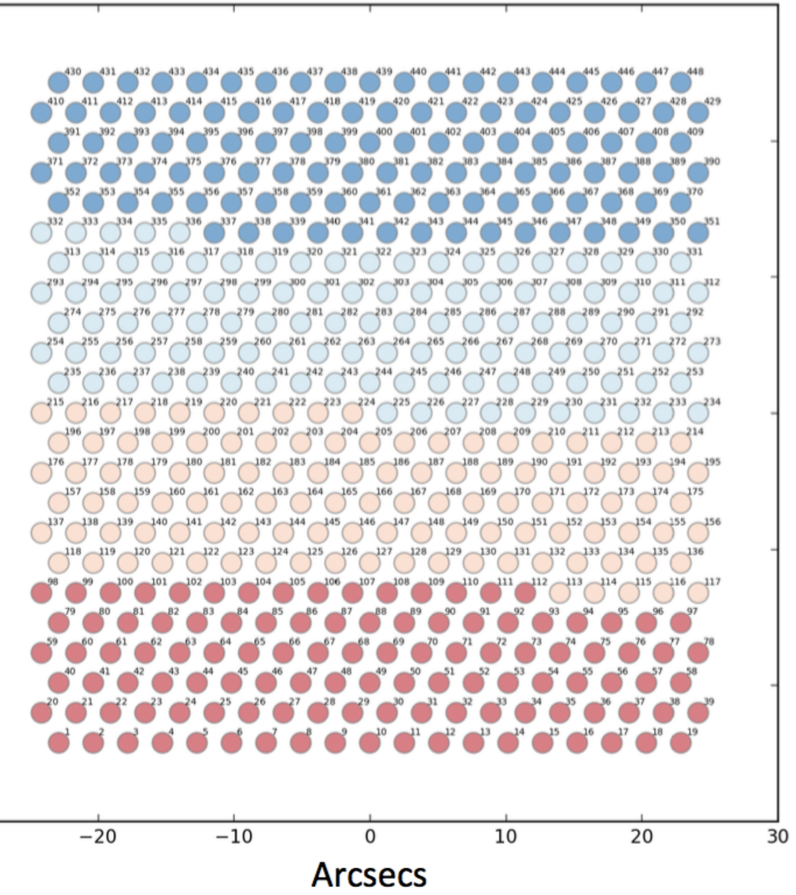


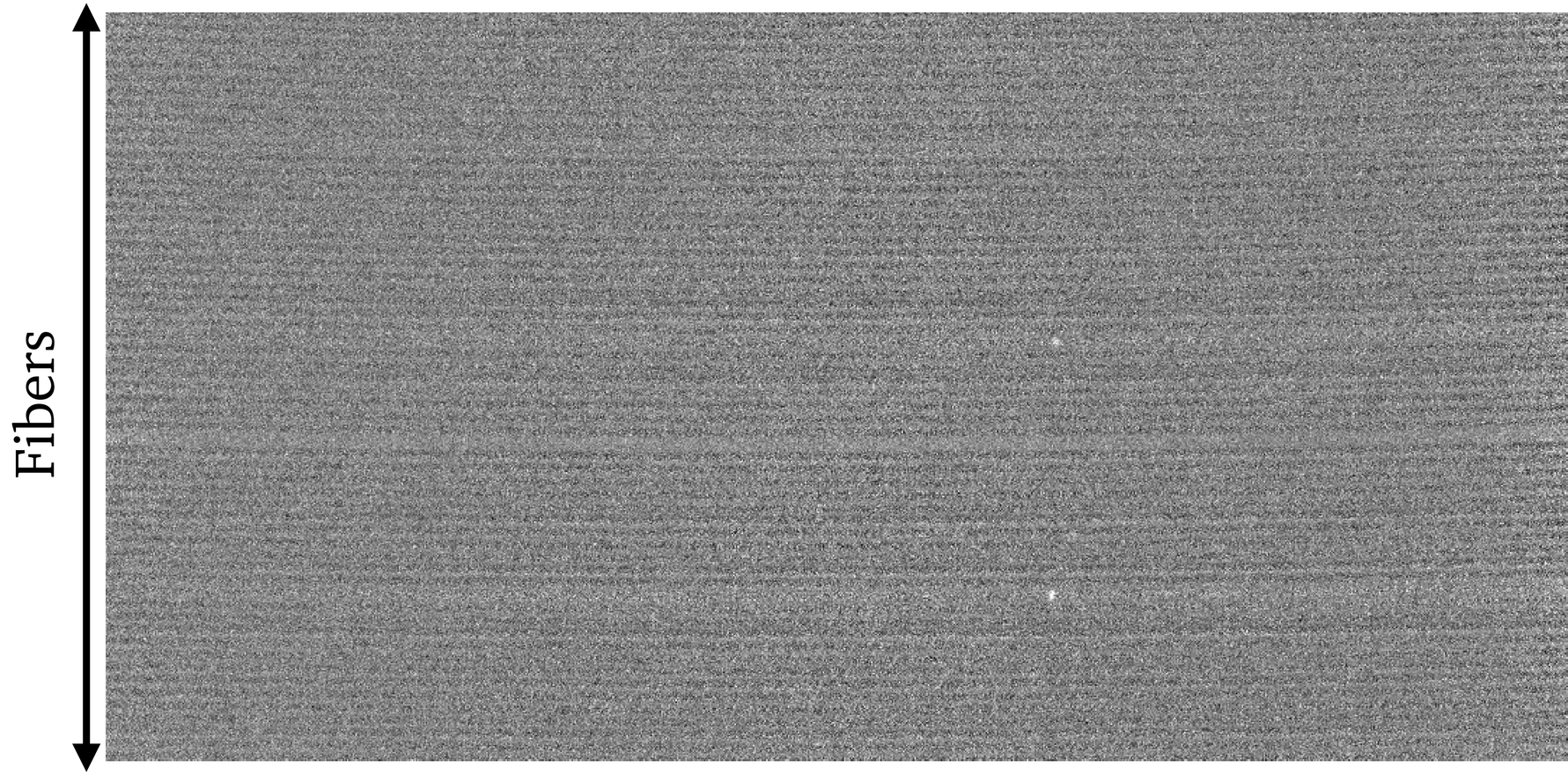


~450 fibers with 1.5” diameter

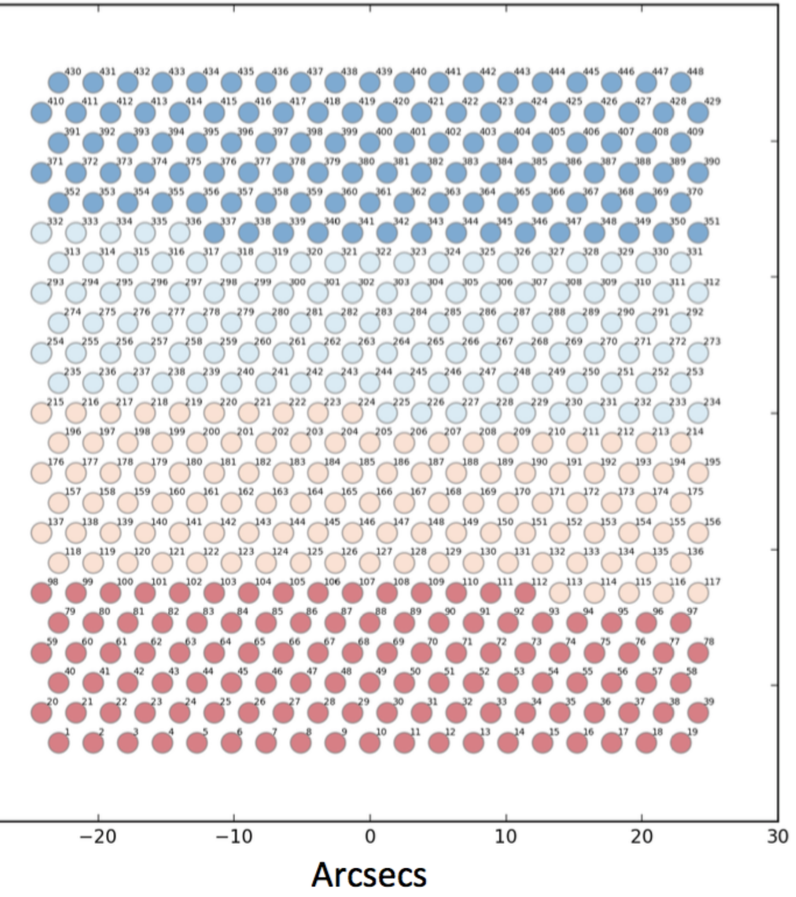


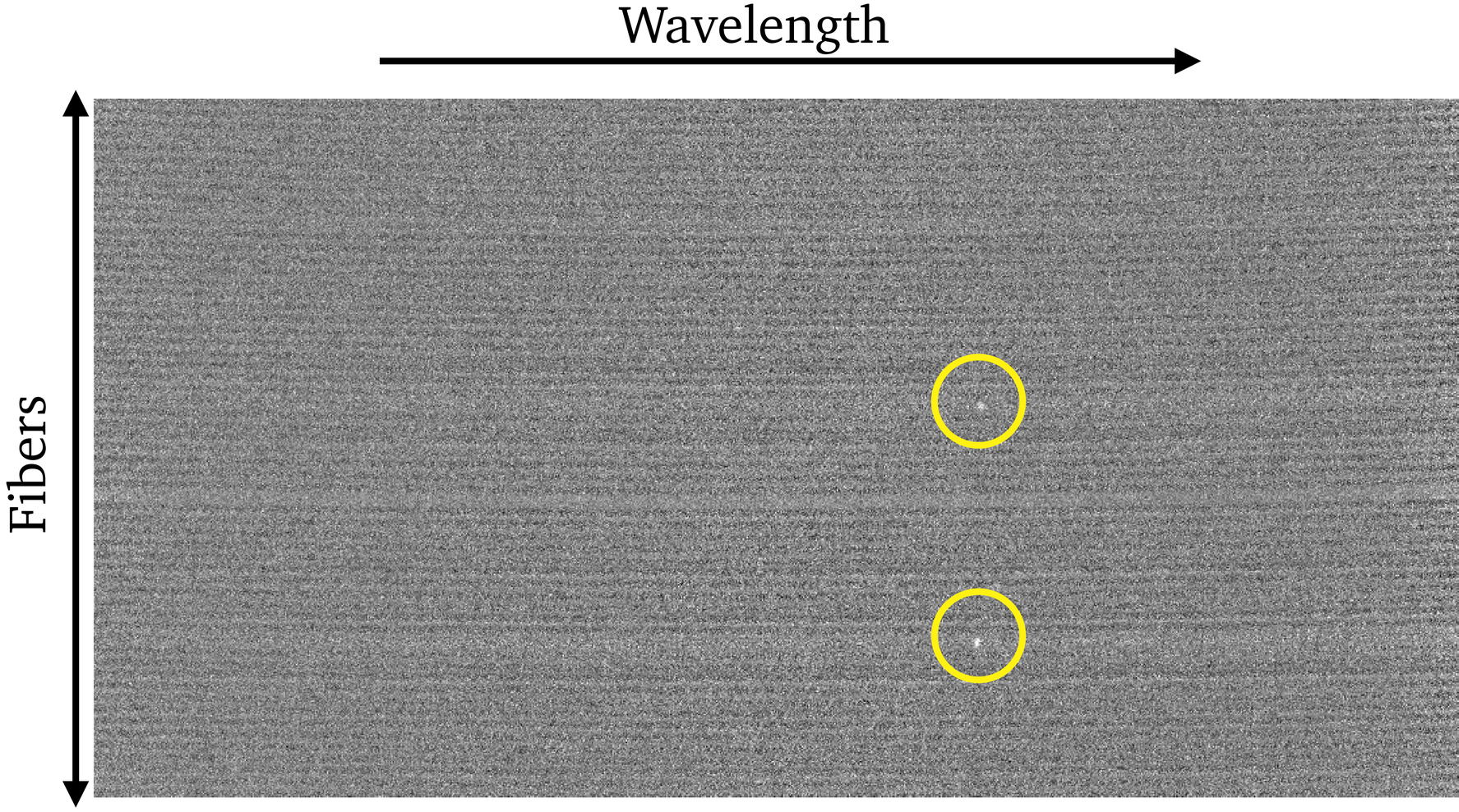
Example data frame





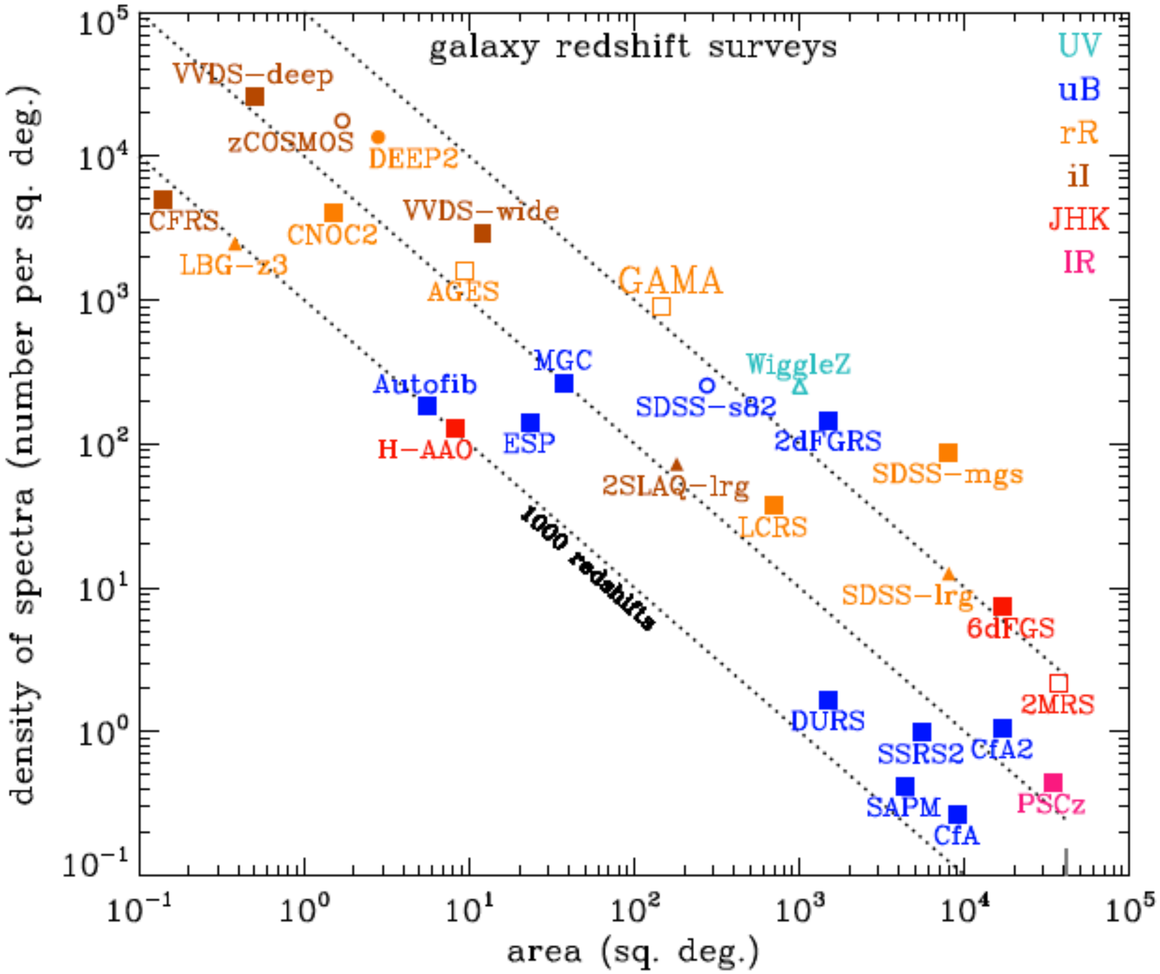
Example data frame (two LAE!)





Density of spectra

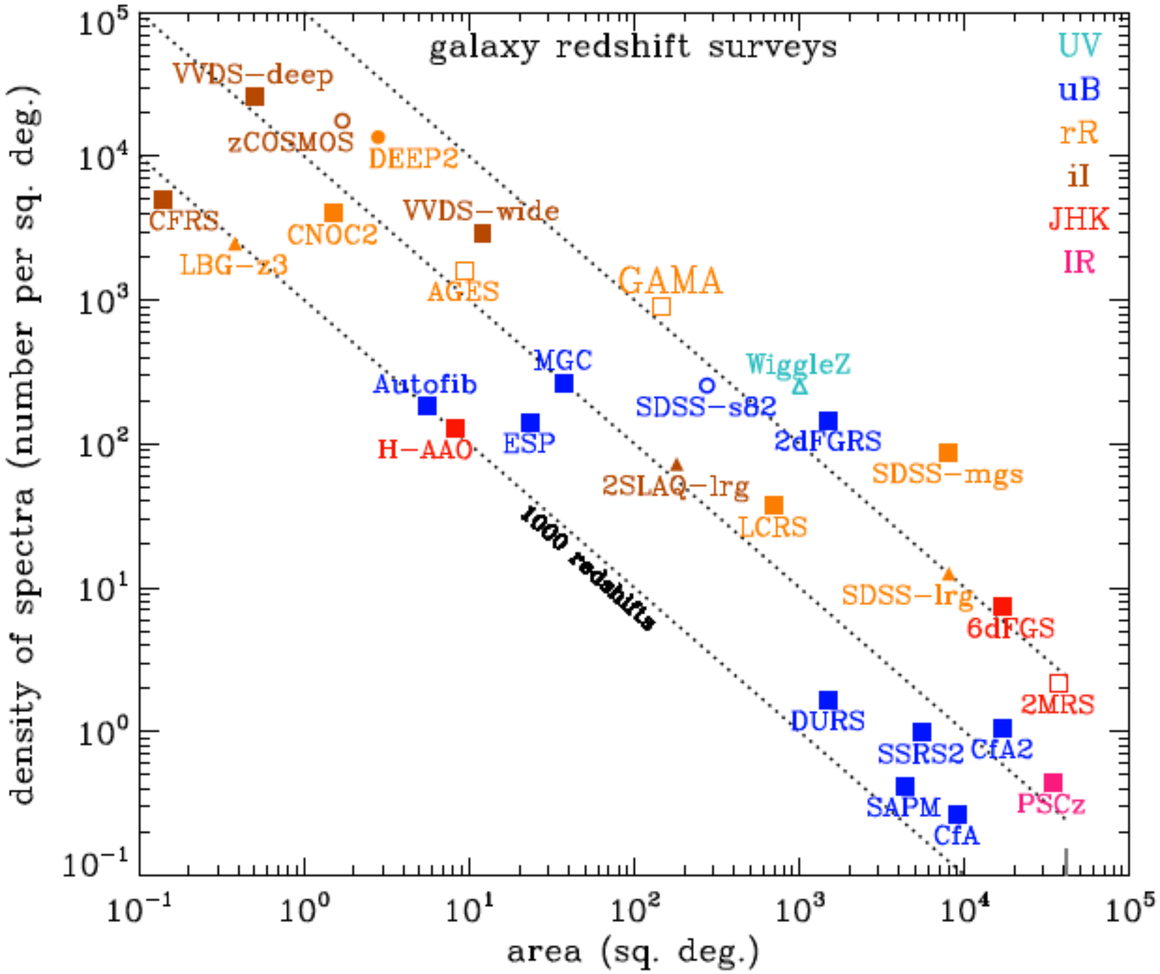
- HETDEX will obtain ***104,832 spectra*** (with three 0.5” dithers to fill the fiber gaps) in every 20 minutes. That’s a lot of spectra!
- As a blind survey, most fibers will fall on **blank sky**. But, still the density of spectroscopic target is still off-scale!



From Sarah Brough

Density of spectra

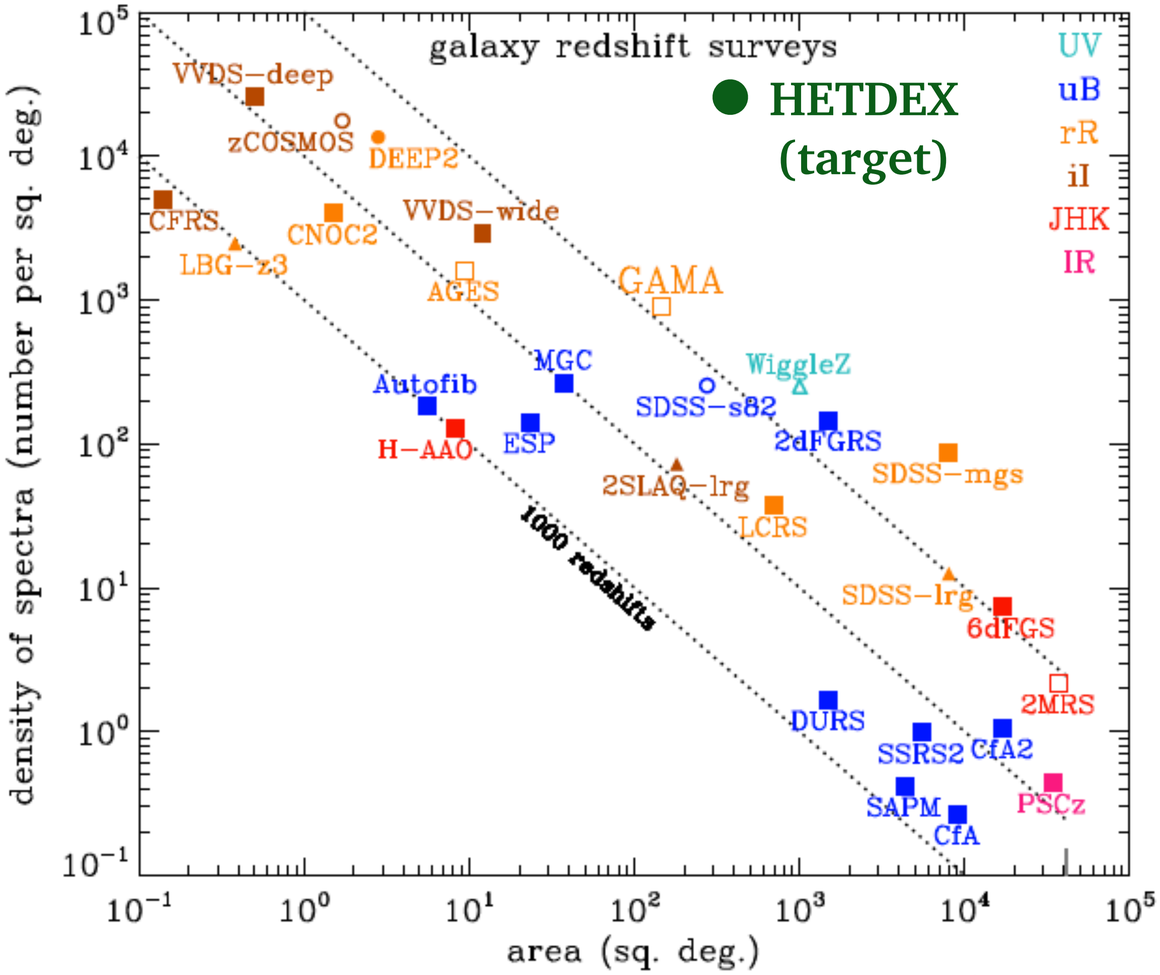
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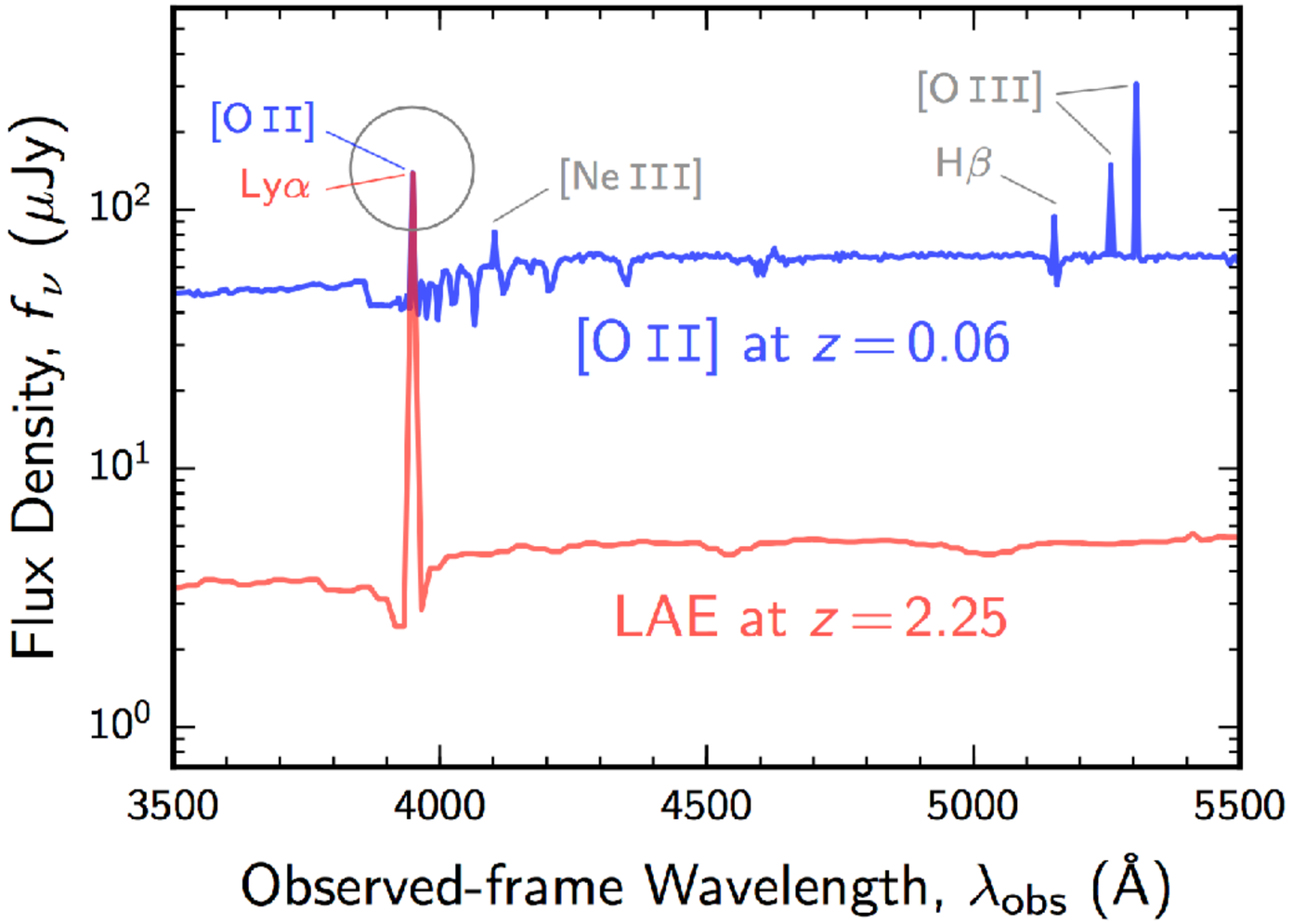
What do we detect?

- λ=350–550nm with the resolving power of R~700 down to a flux sensitivity of (a few)$\times 10^{-17}$ erg/cm^2/s (m_{AB}~22) gives us:
  - ~1.2 M Lyman-alpha emitting galaxies at 1.9<z<3.5
    - We will observe **~200 LAEs in 20 minutes!!**

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  - ~1.2 M Lyman-alpha emitting galaxies at 1.9<z<3.5
    - We will observe **~200 LAEs in 20 minutes!!**
  - ~1M [OII] λ3727 emitting galaxies
  - ~0.4 M other galaxies
  - ~0.25 M Milky way stars
  - 25k AGNs (z<3.5) + etc (~2000 clusters, Astroids, SN, PN, …)

LAE vs. [OII] λ3727



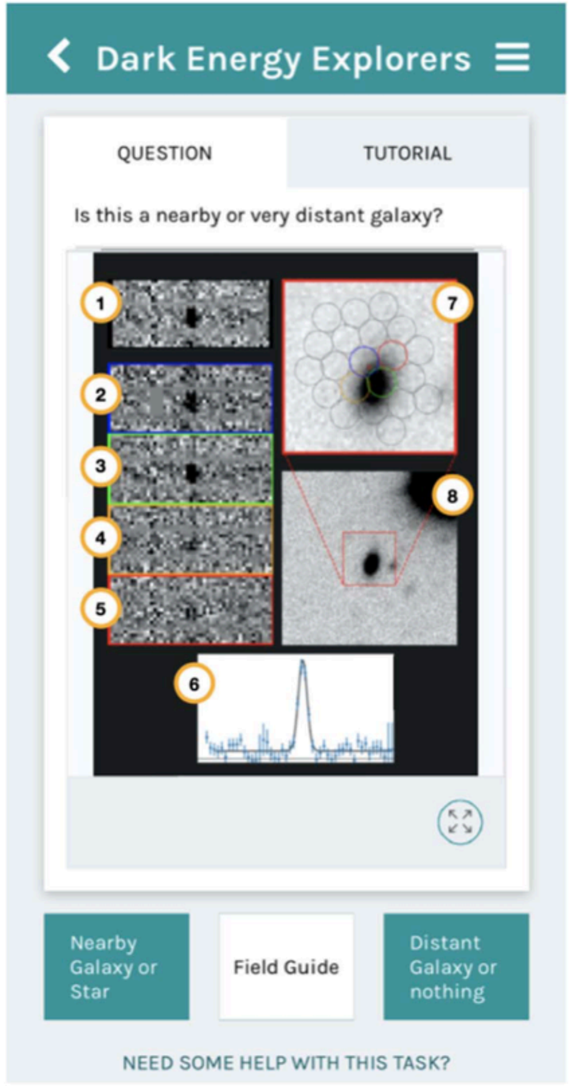
- Because [OII] λ3727 is a fairly *isolated* line.
- [OII] λ3727 from low-redshift galaxies can be confused as LAEs.
- Key to distinguish them:
  - Equivalence width
  - Continuum flux
- Citizen science!!

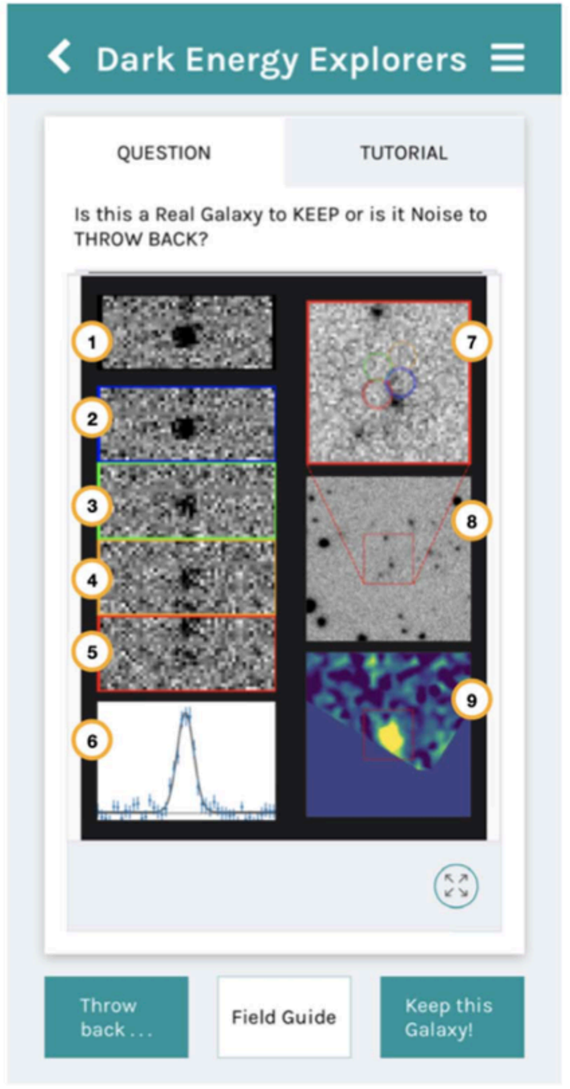
House et al. (2023)

Dark Energy Explorer



- ~0.5 Million classification by 11,000 volunteers in 85 countries
- 209k, 60k cases for, respectively, OII/LAE, real/false classifications





APS NEWS | CAREERS AND EDUCATION

To Hunt for Dark Energy, Swipe Left or Swipe Right

A citizen science initiative, Dark Energy Explorers, has recruited 17,000 people to identify galaxies.



By Sophia Chen

May 15, 2024

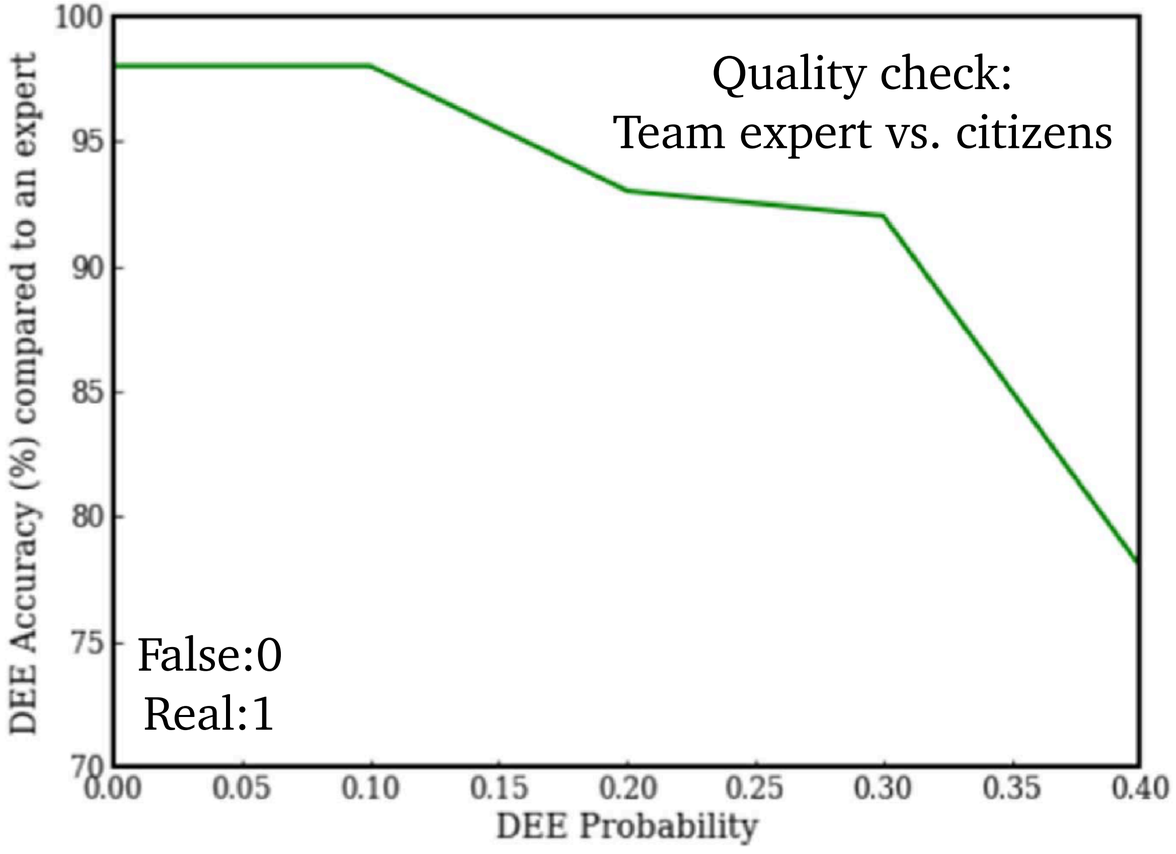


The night sky above the McDonald Observatory's Hobby-Eberly Telescope in western Texas. Since 2021, citizen scientists have searched for galaxies in the telescope's images.
McEthan Tweedie Photography

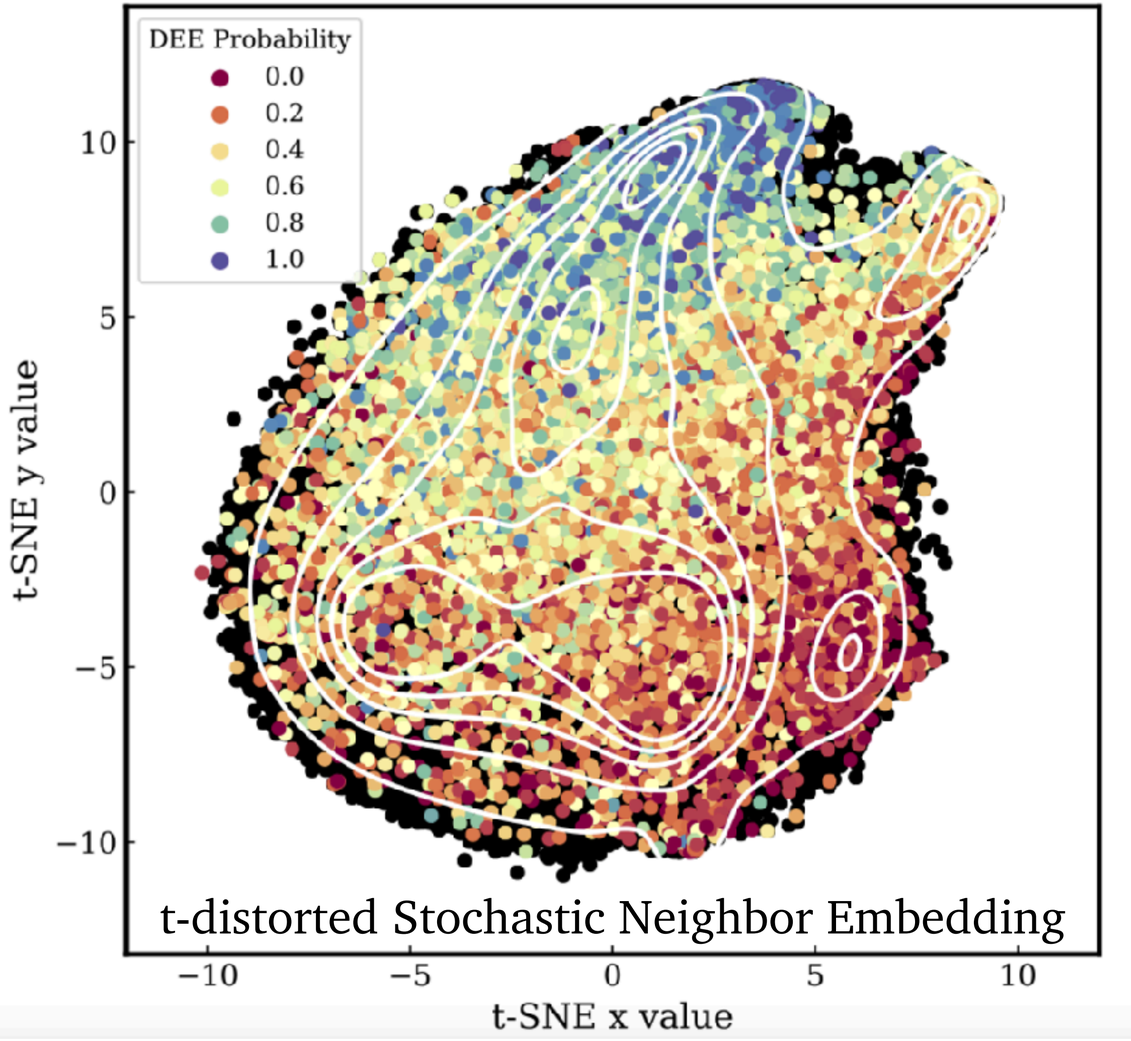
House et al. (2023)

ML classification of the real/false

Charge trap, hot pixels, time-variable changes in calibration, …

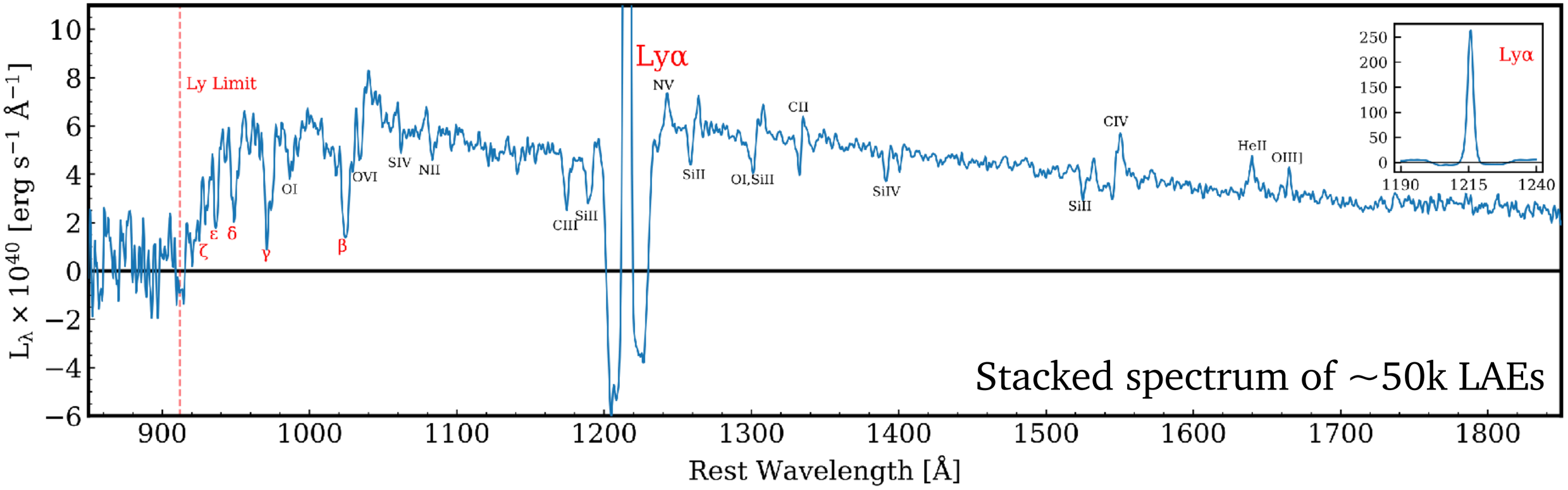


Average over 10 classification of each source

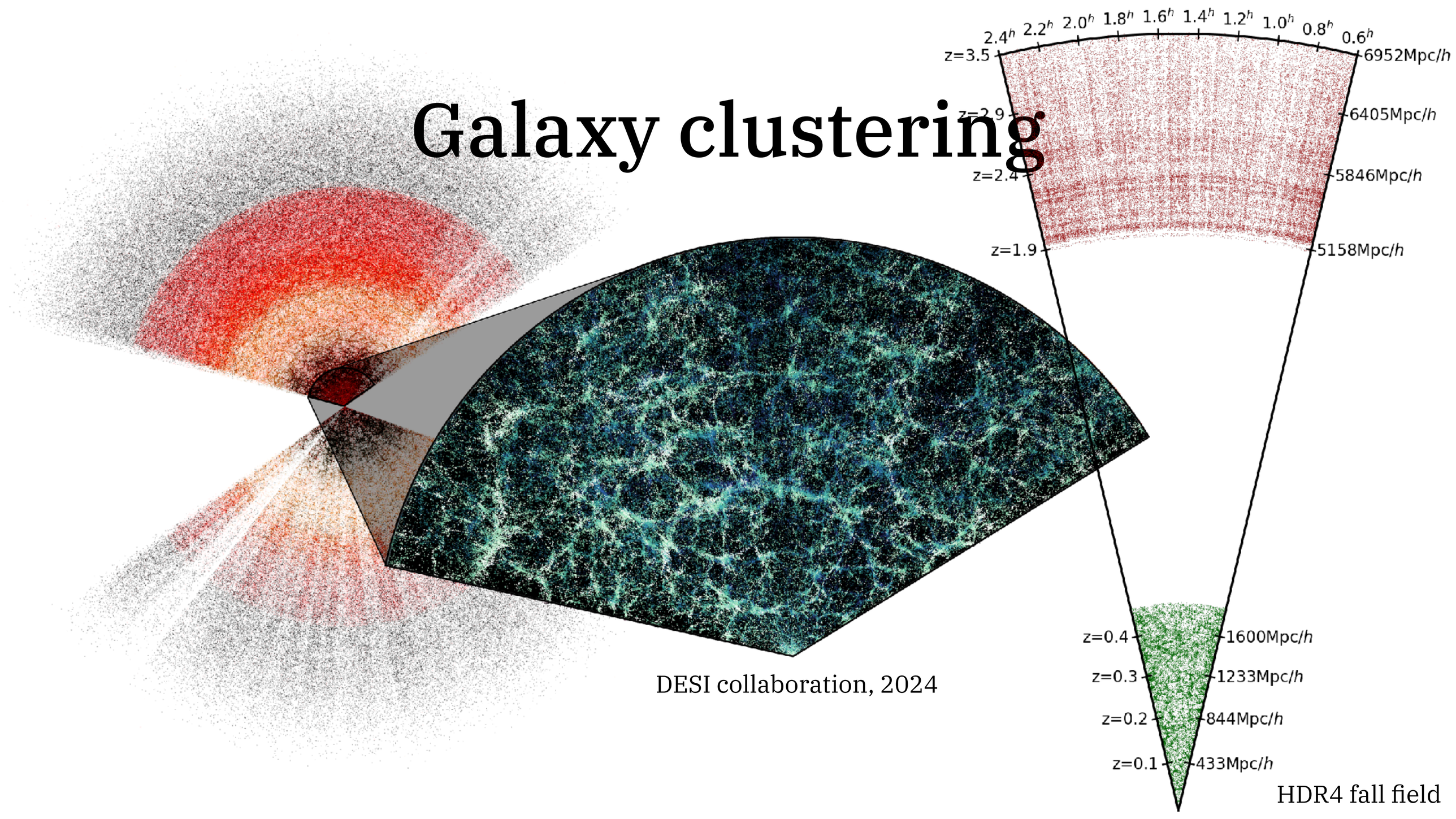


Davis et al. (2023)
Cooper et al. (2023)

HETDEX Public Source Catalog



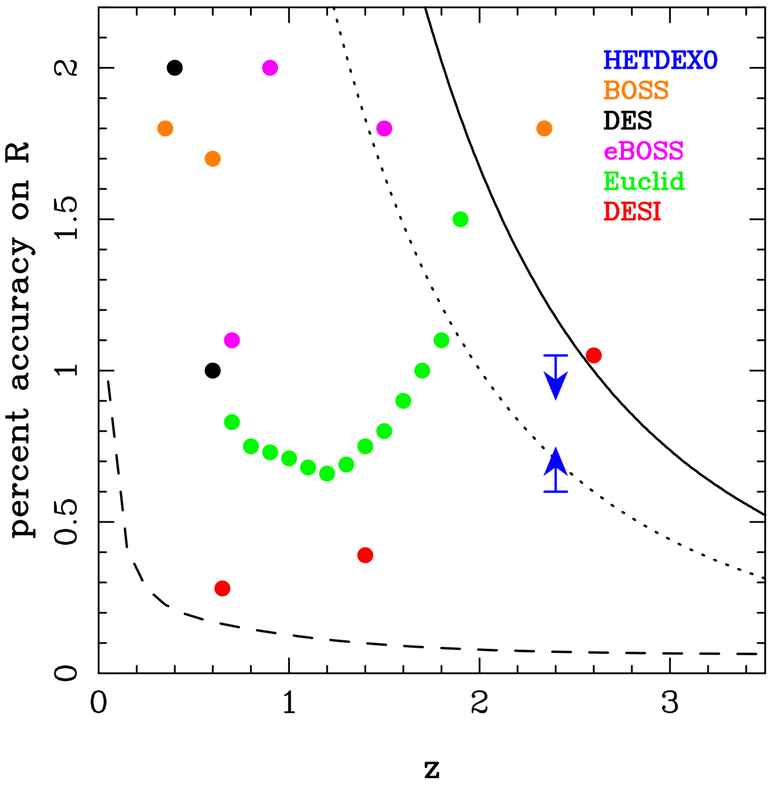
Galaxy clustering

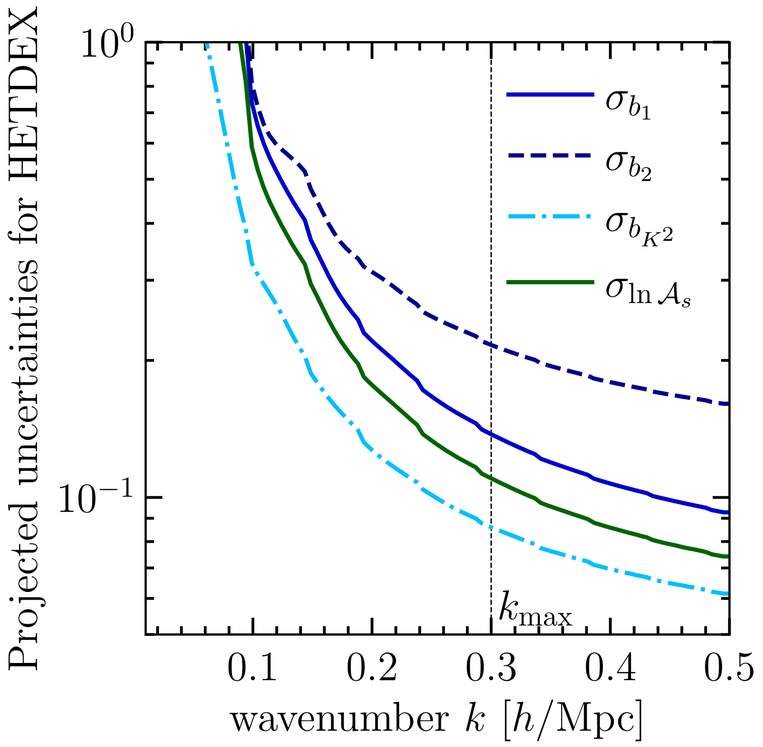


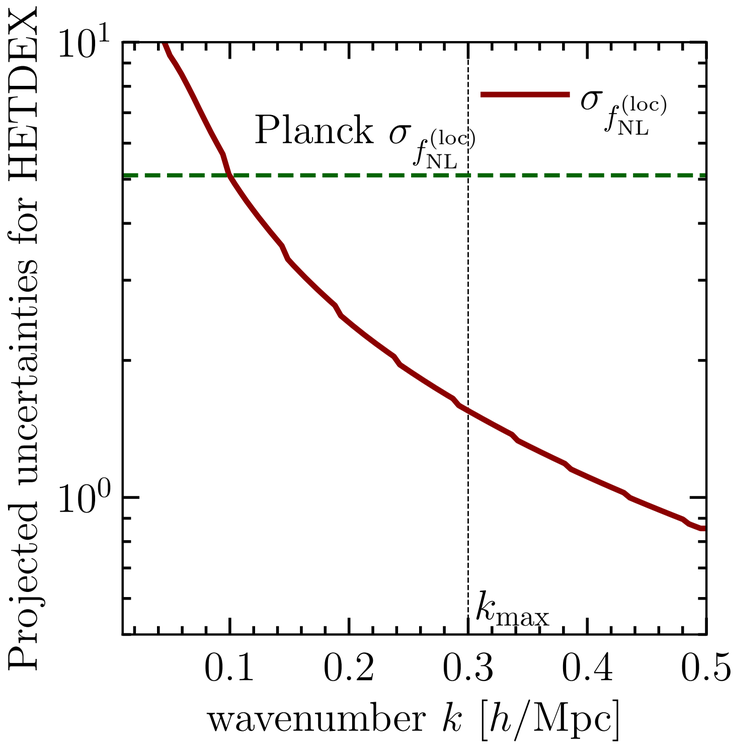
DESI collaboration, 2024

HDR4 fall field

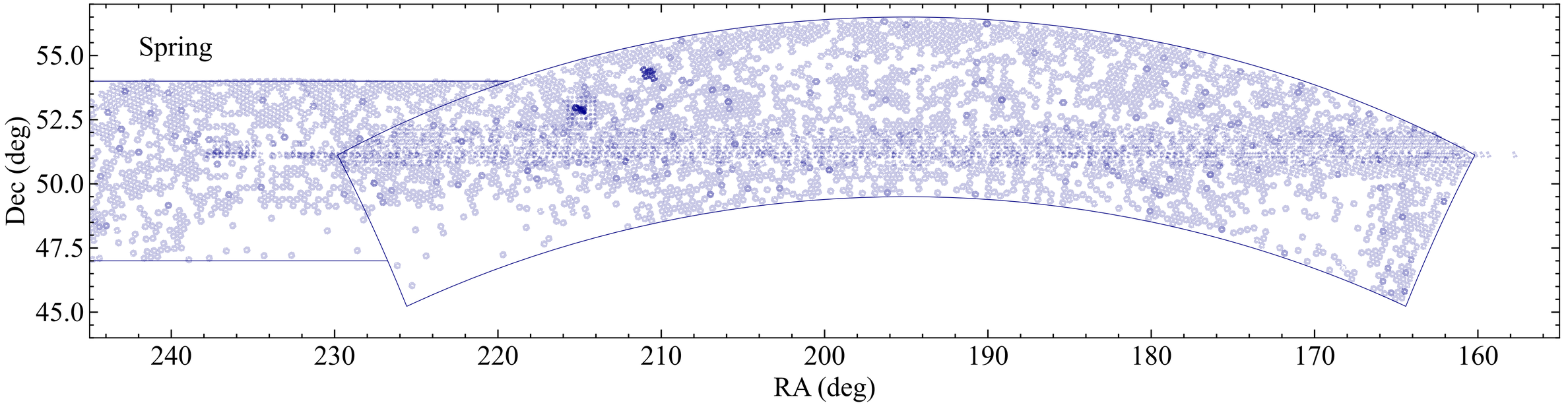
Statistical power of HETDEX



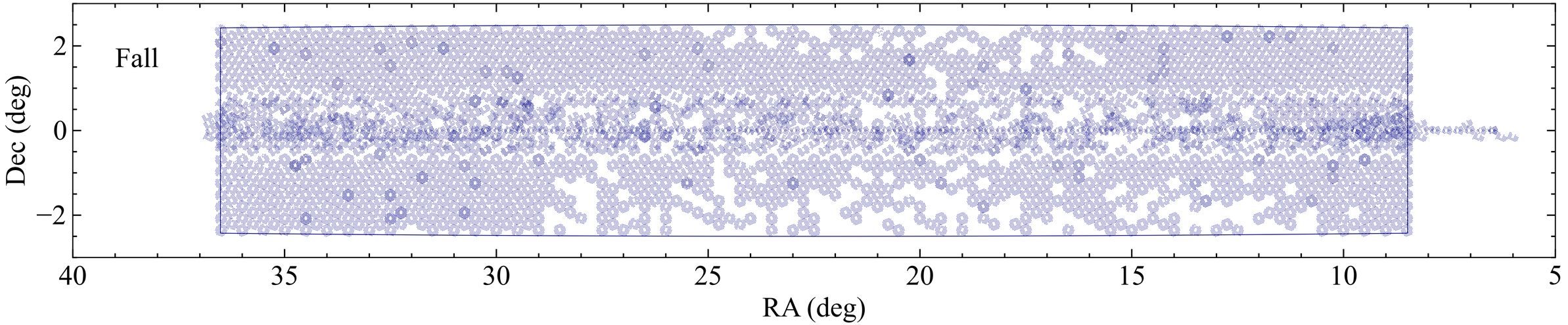




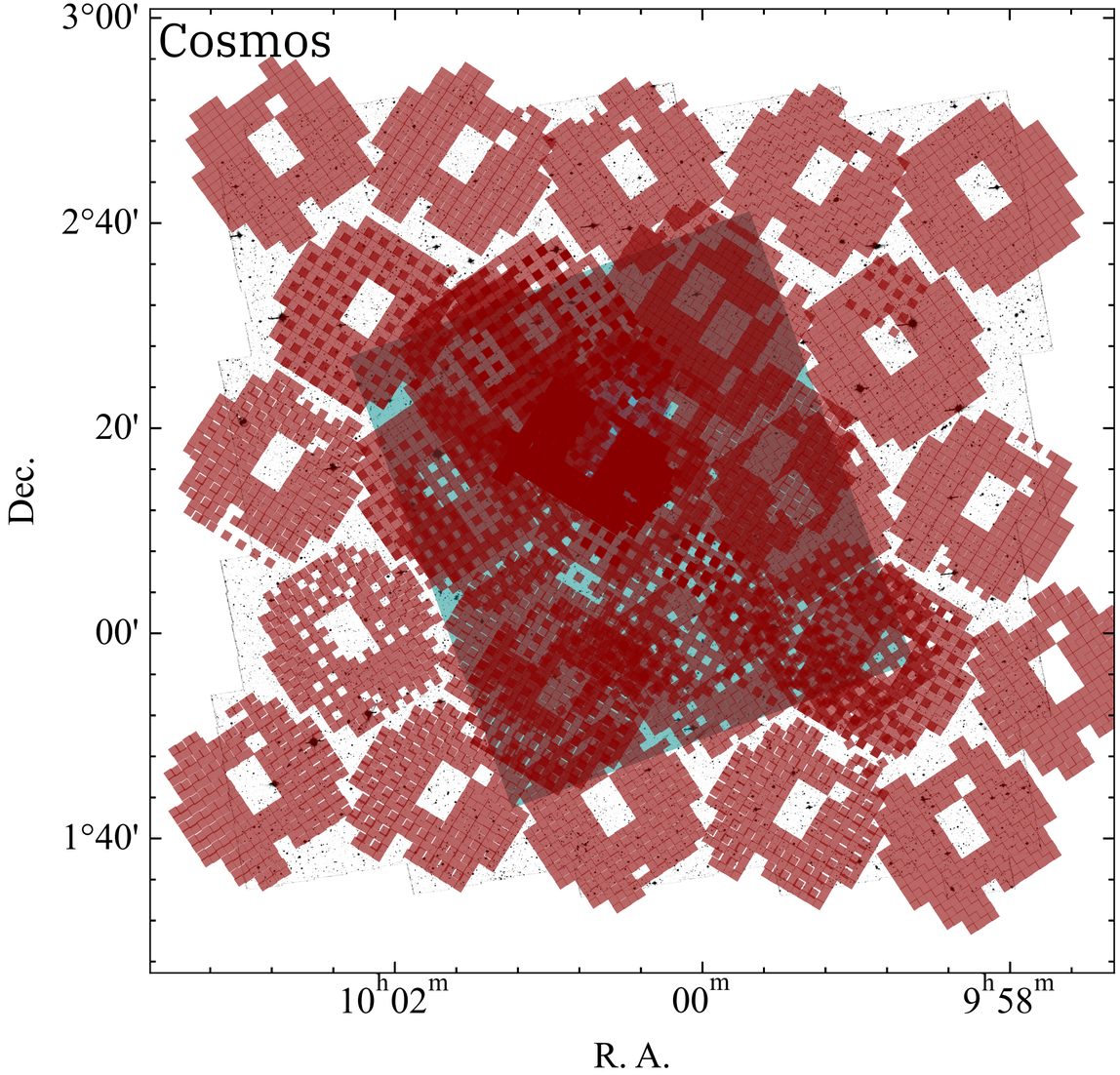
Final HETDEX footprint



Final HETDEX footprint



Final HETDEX footprint



Conclusion and outlook

- Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) survey completed the data collection in July 2024!
- A lesson from ongoing cosmology analysis:
  - To draw a synthetic catalog for a blind emission-line survey, we need to model every pixel, pointing by pointing.
- The Lyman-alpha (1215.67Å) is the farthest-reach optical emission line; HETDEX can be thought of as a pathfinder for future high-z emission-line surveys!