

(Hobby-Eberly Telescope Dark Energy eXperiment)

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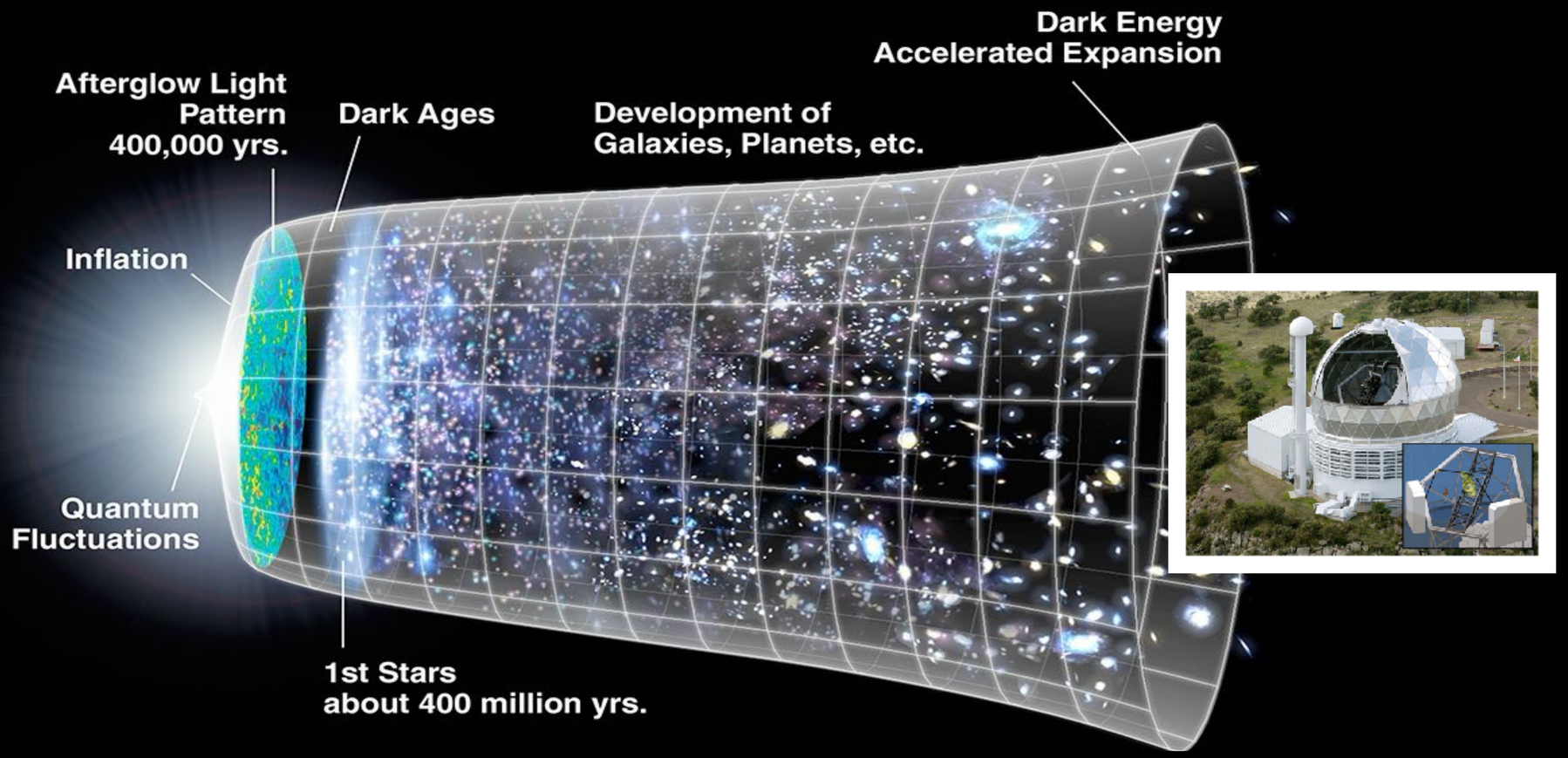
30 January 2024 @ SSG workshop

HETDEX



Use 10m HET to map the universe using 1.2M Lyman-alpha emitting galaxies (LAEs) in z=1.9–3.5 (540 □°)

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.

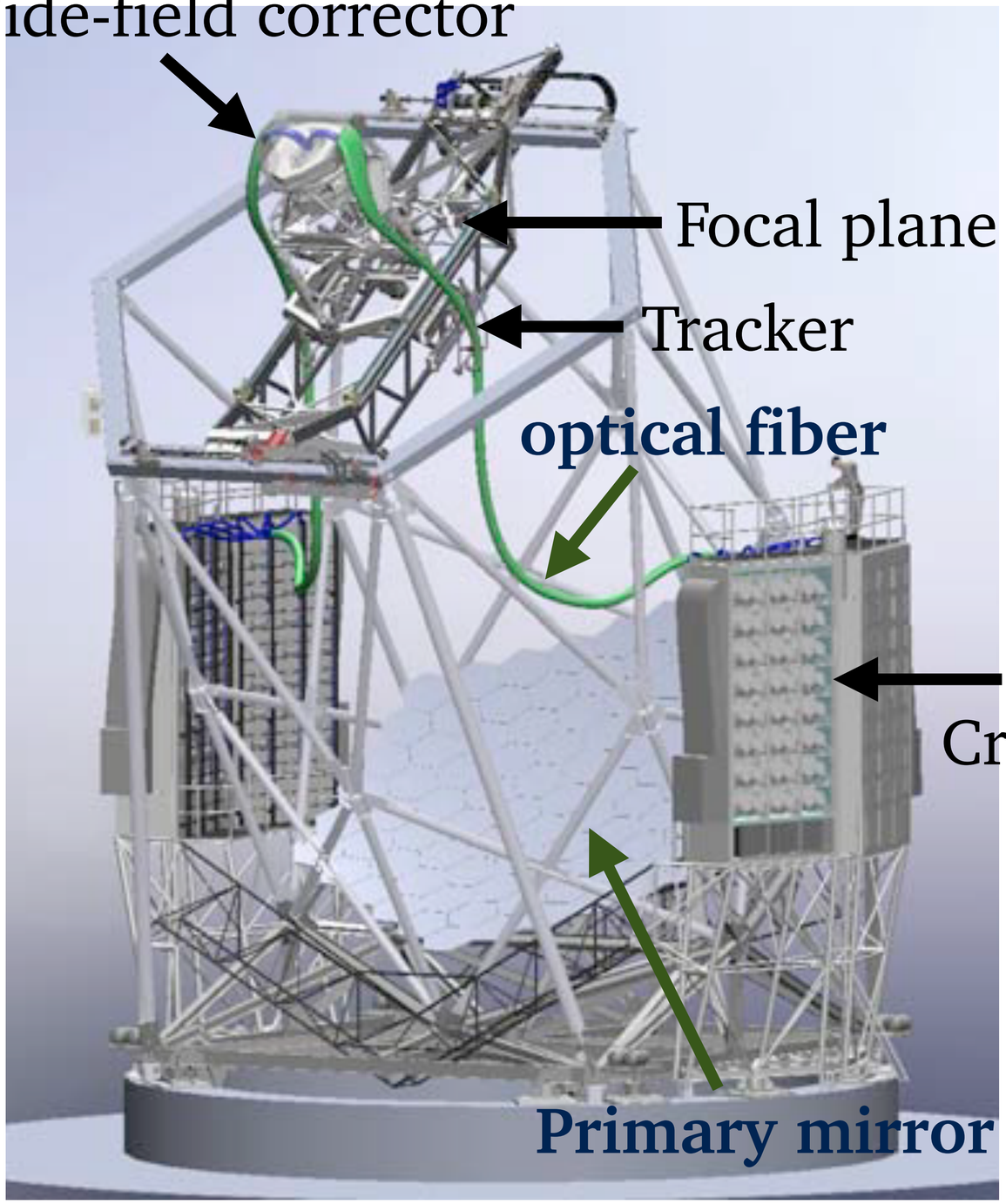
35k spectra in every 6 mins

- 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)!**

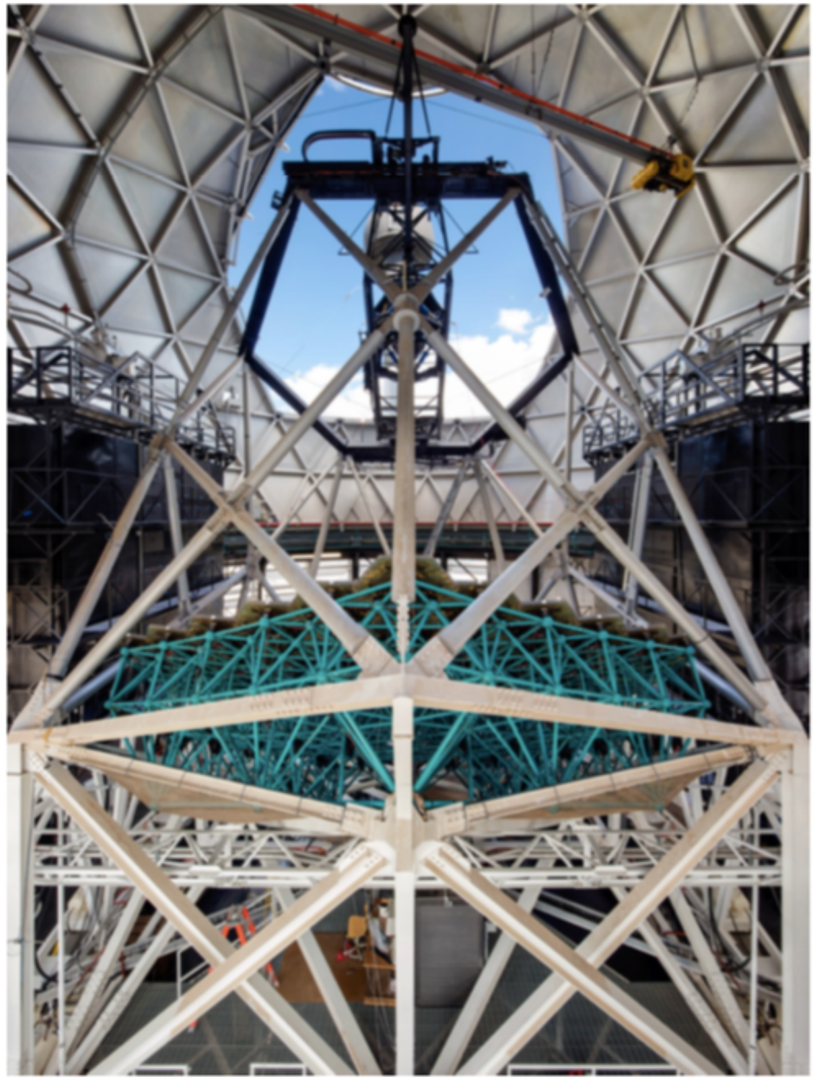
*VIRUS = Visible Integral-field Replicable Unit Spectrograph

Hobby-Eberly Telescope with VIRUS





Real Prime Focus Instrument





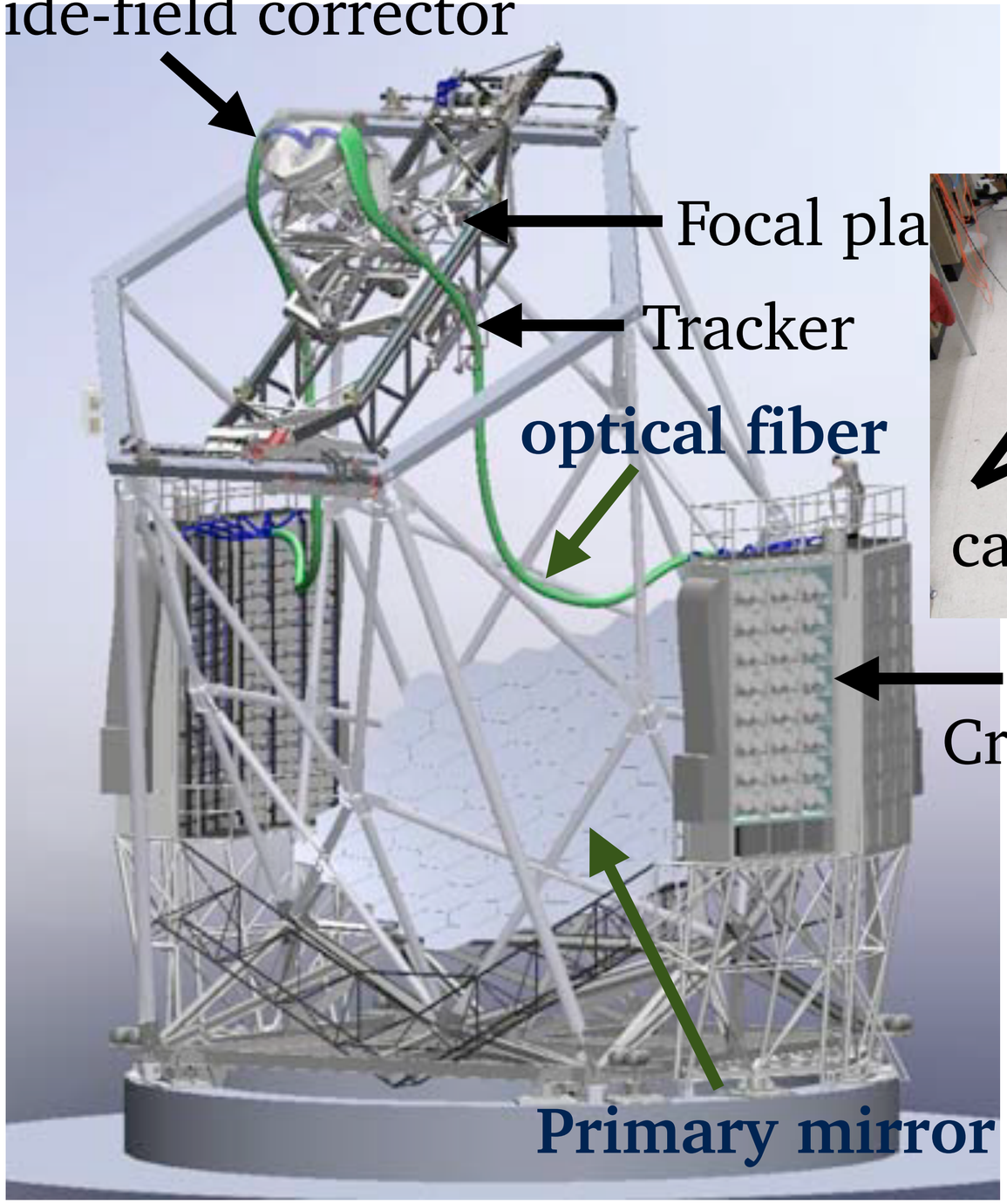
VIRUS enclosures



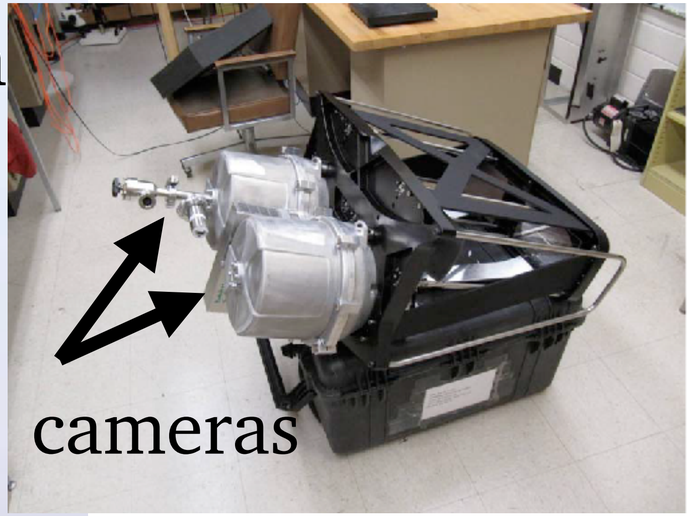
VIRUS enclosures built by TAMU

Hobby-Eberly Telescope with VIRUS





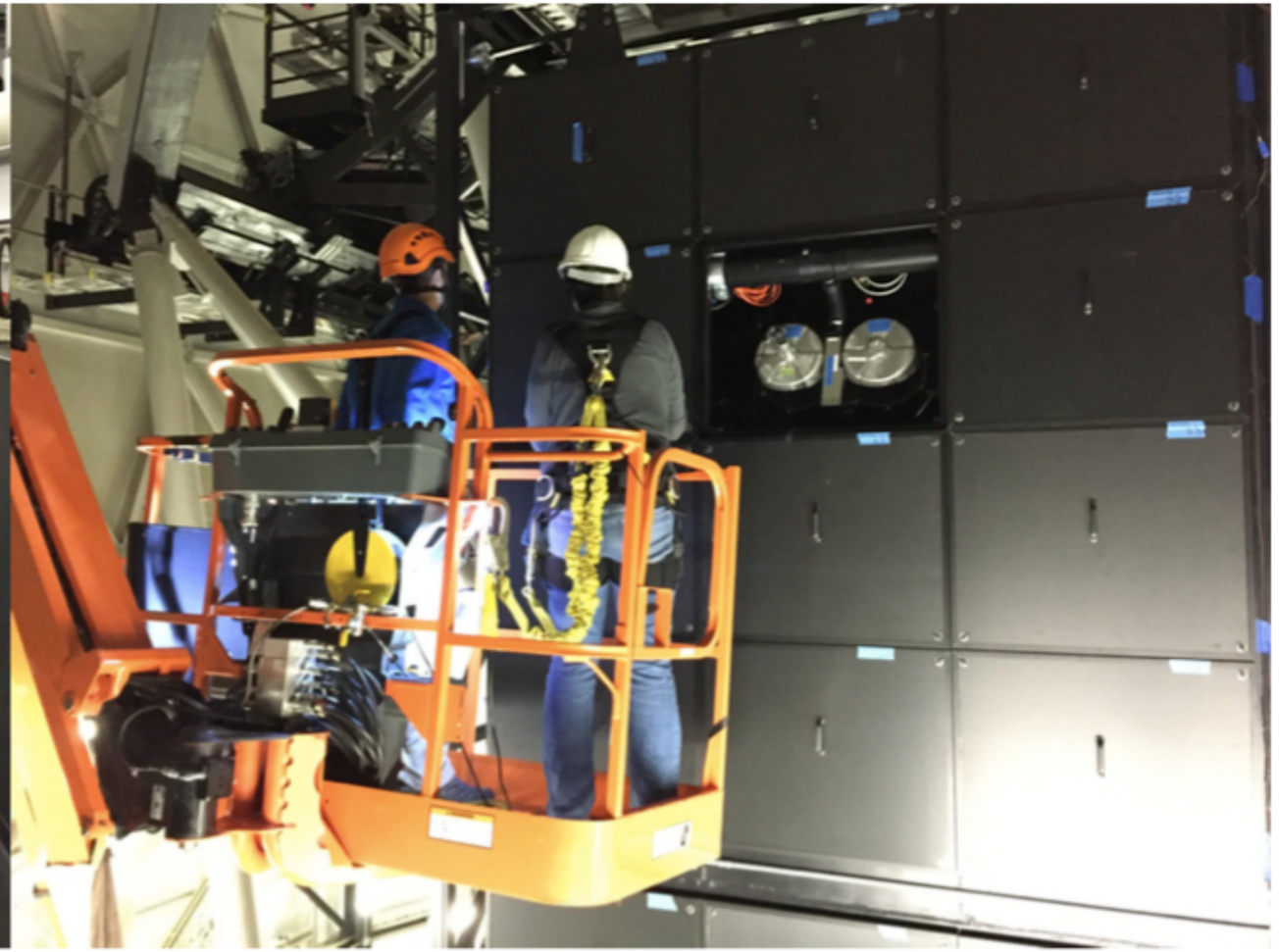
*One **VIRUS** Detector Unit*



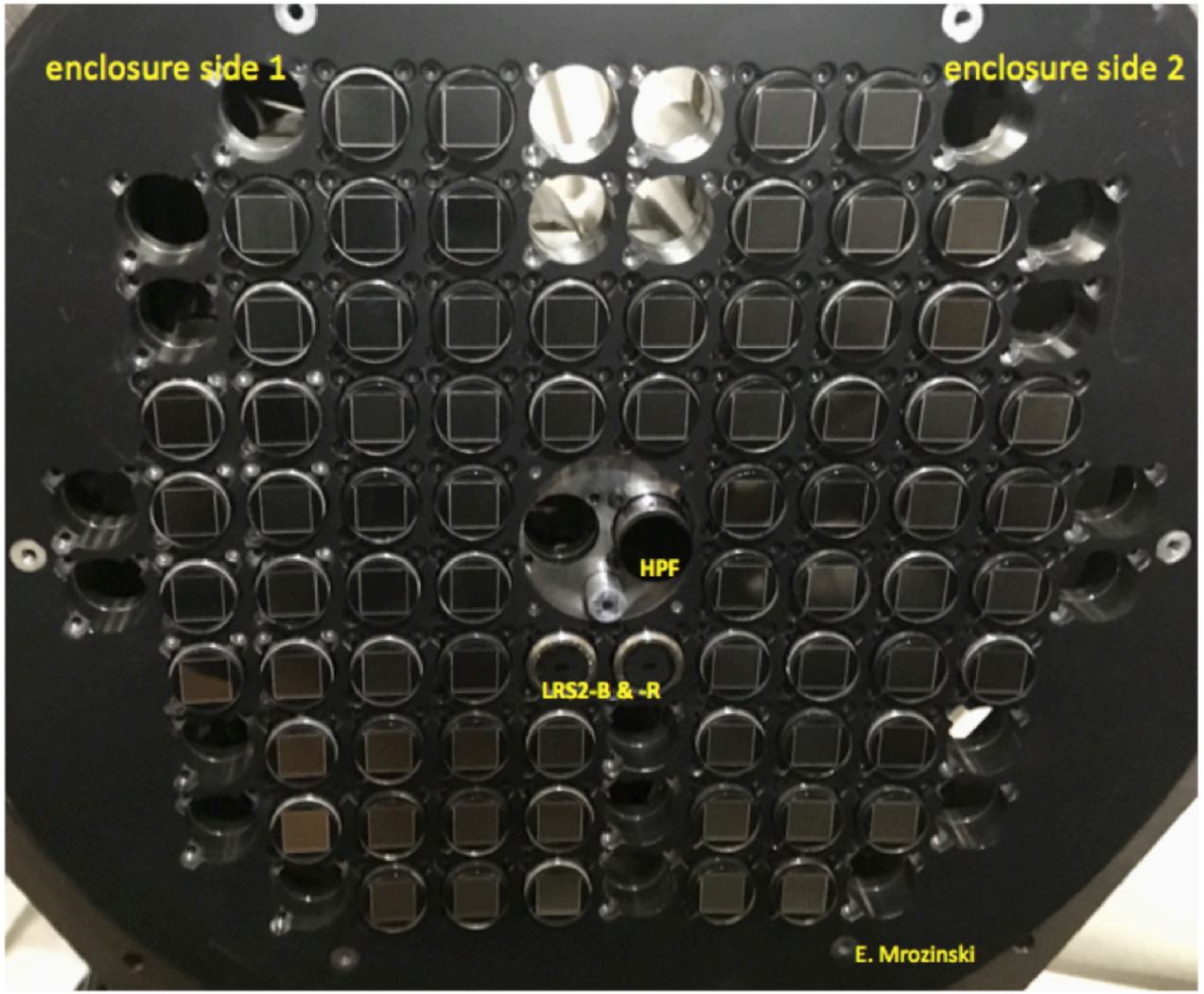
Detectors /
Cryogenic system

Deploying VIRUS units

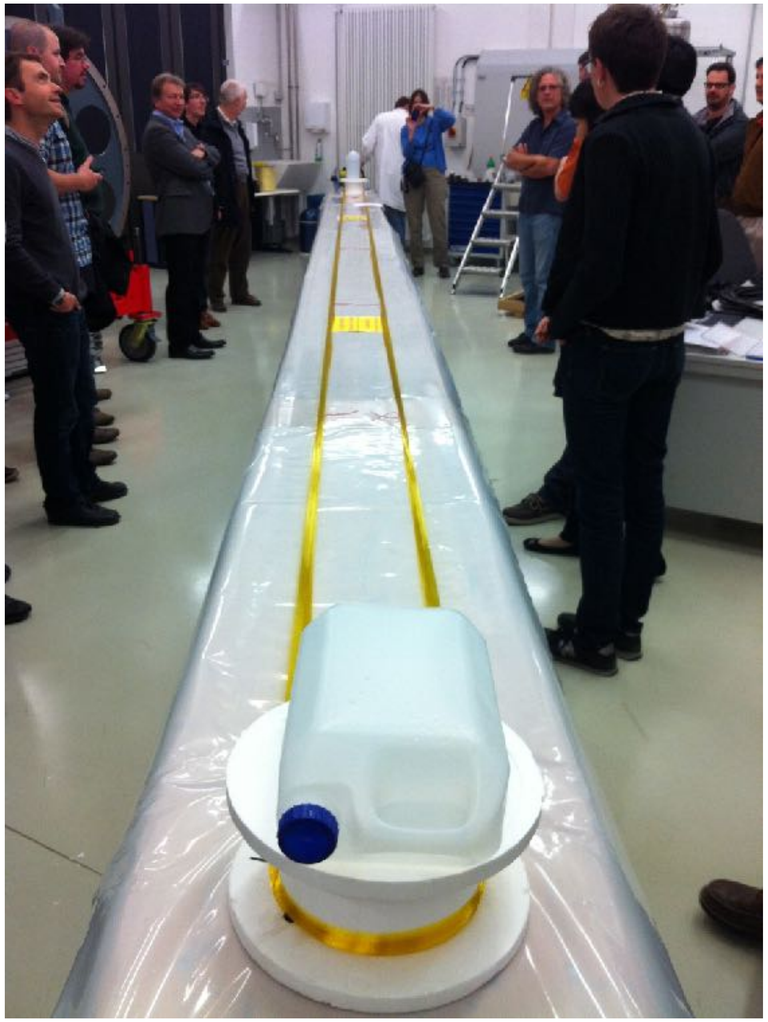




IFUs on the focal plane



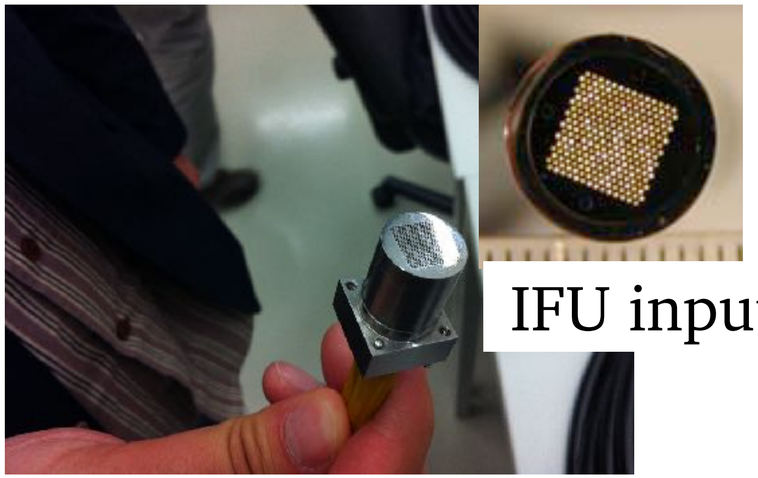
Fibers fabricated at AIP



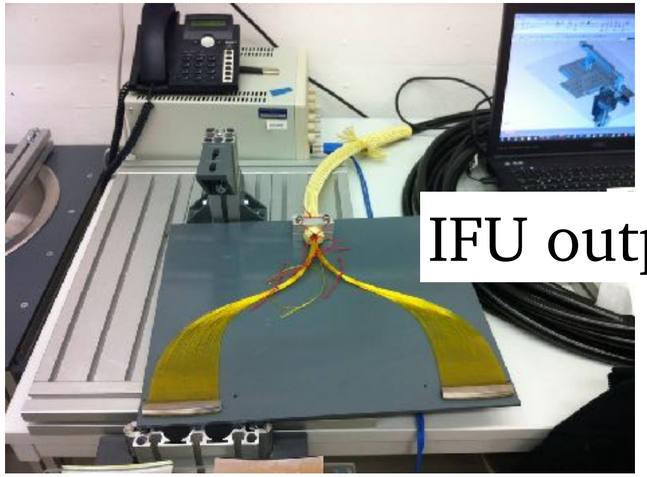
a Lo~ong fiber!



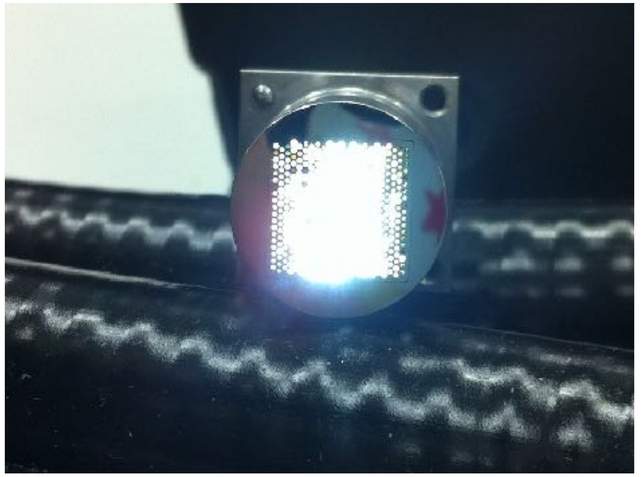
Put into cables...



448 fibers per IFU

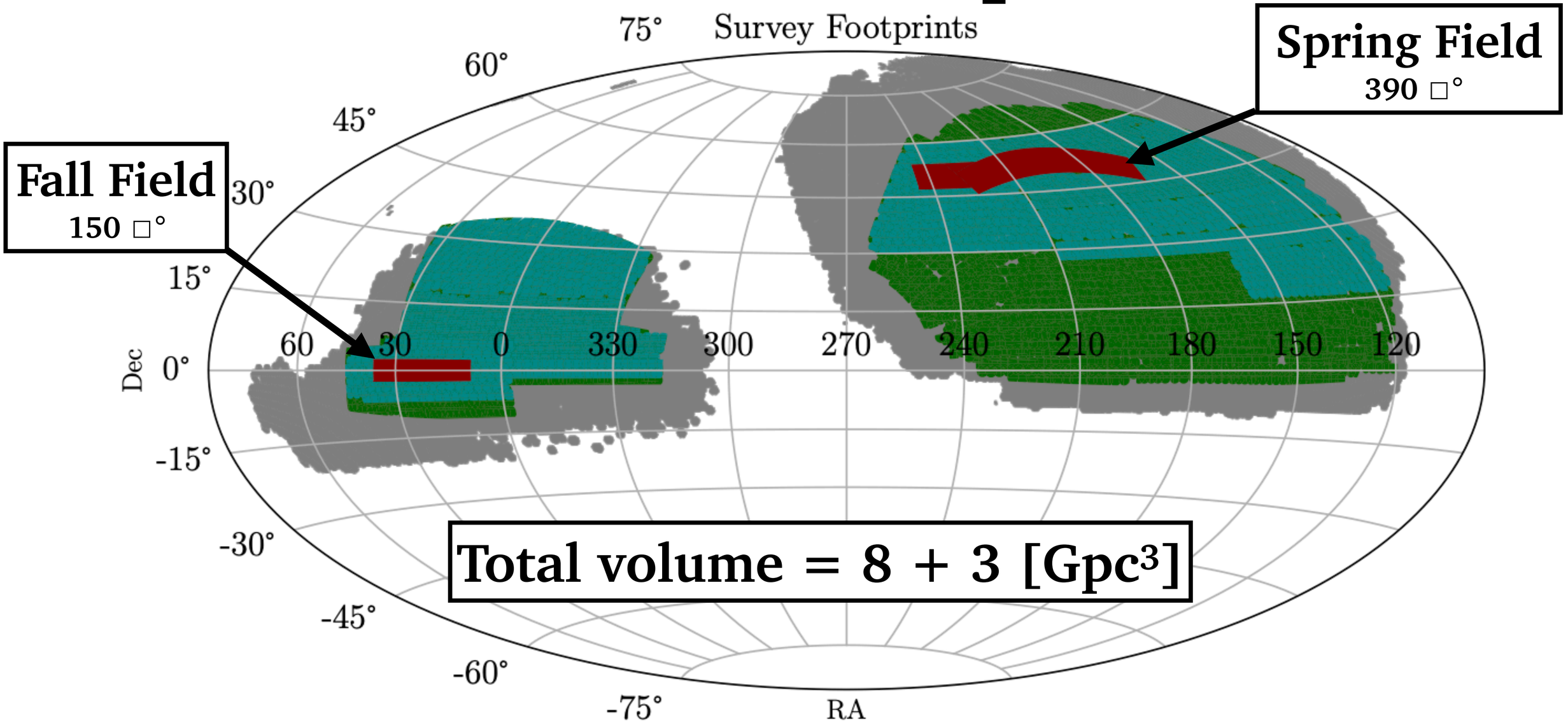


One IFU feeds two spec.



A test fibers being lit

HETDEX Footprint

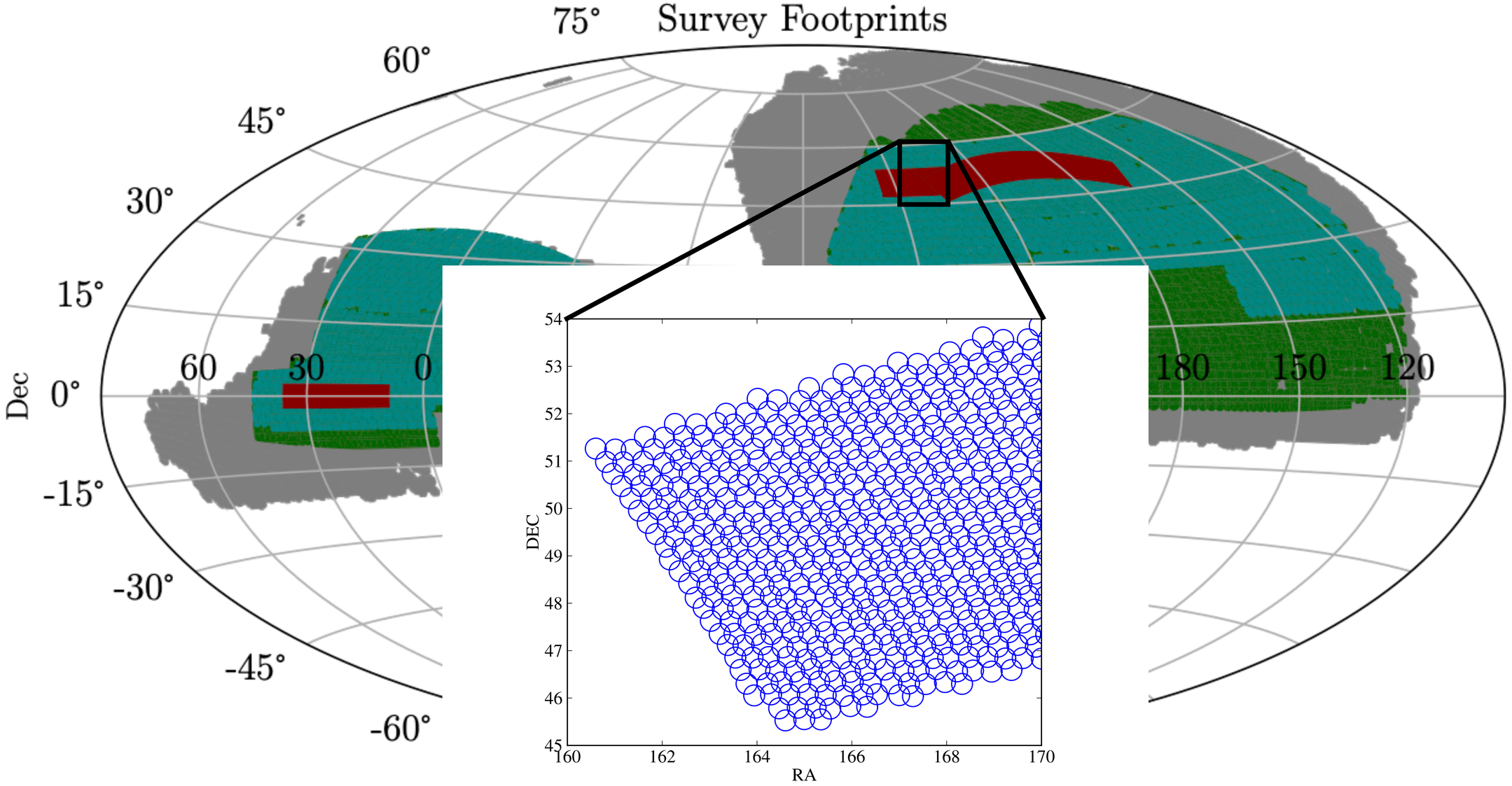


Spring Field
390 □°

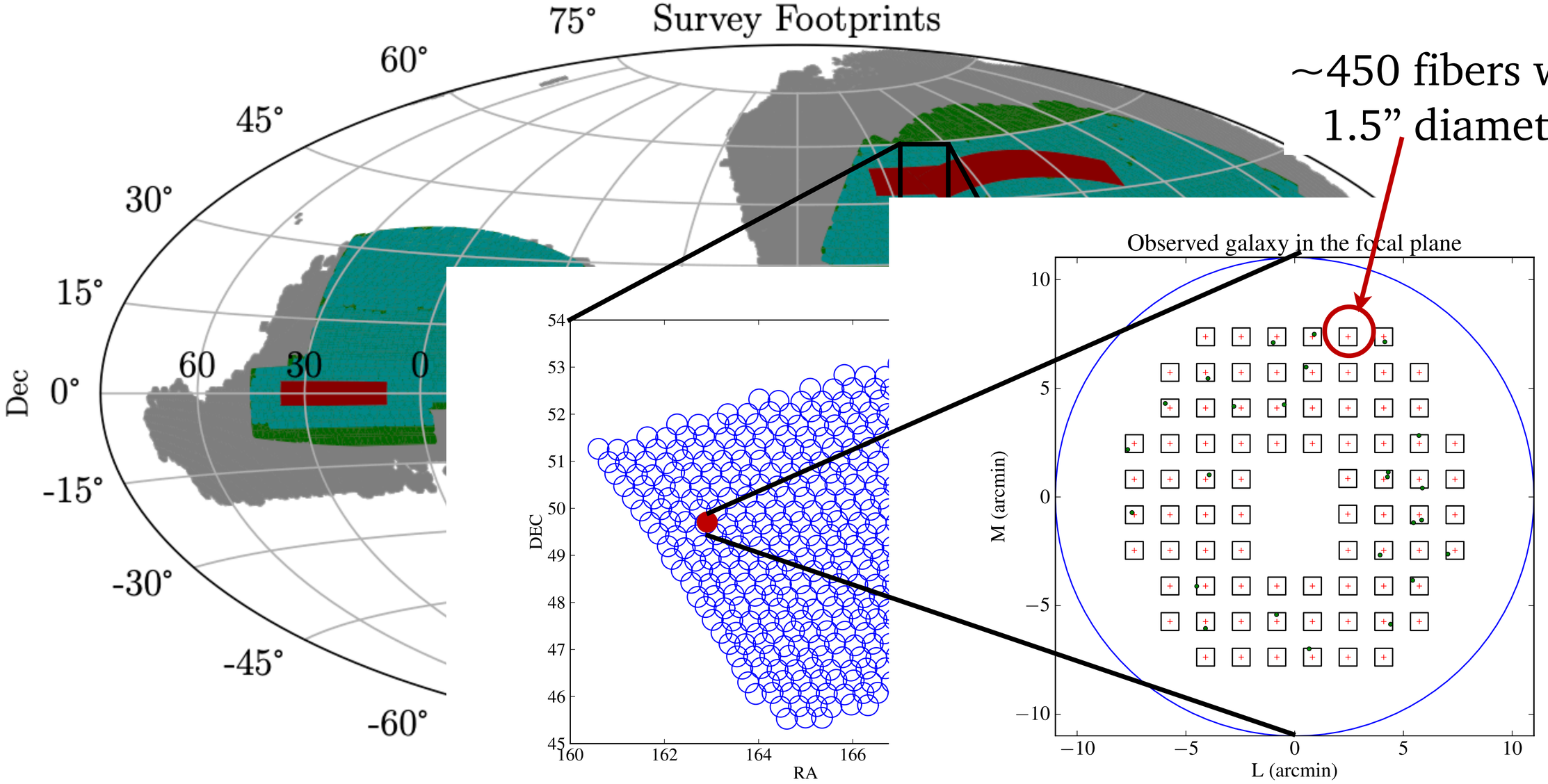
Fall Field
150 □°

Total volume = 8 + 3 [Gpc³]

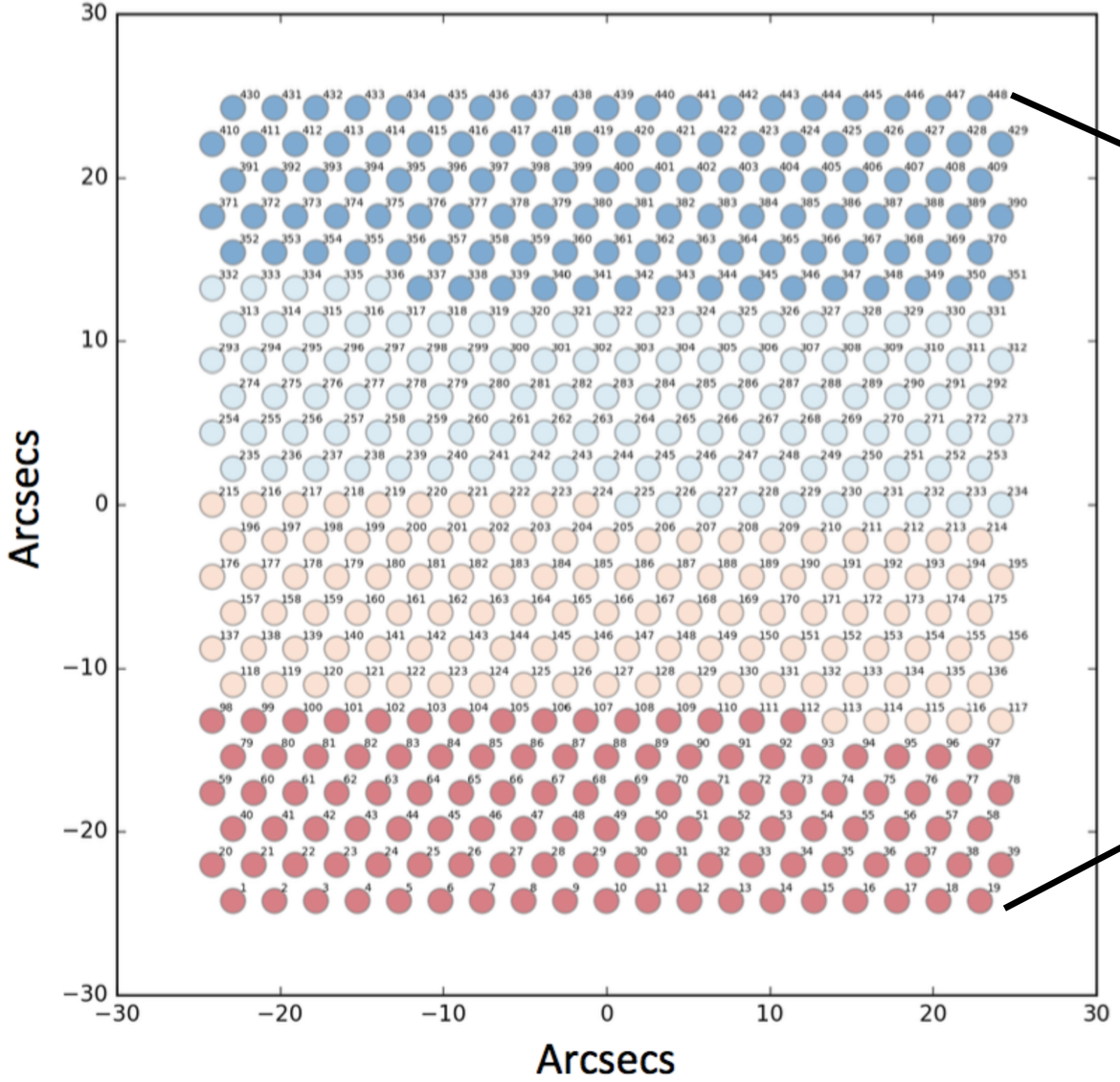
About 4000 shots (22’ FoV)

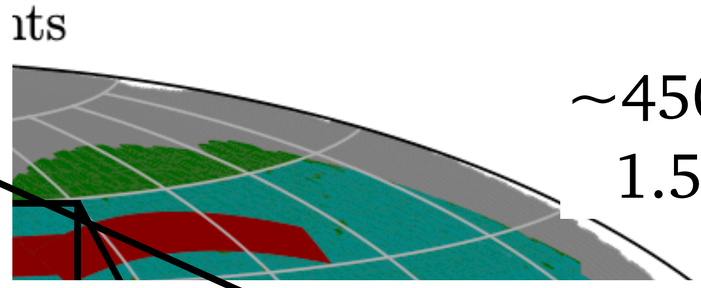


A shot with 78 IFUs (50”×50”)

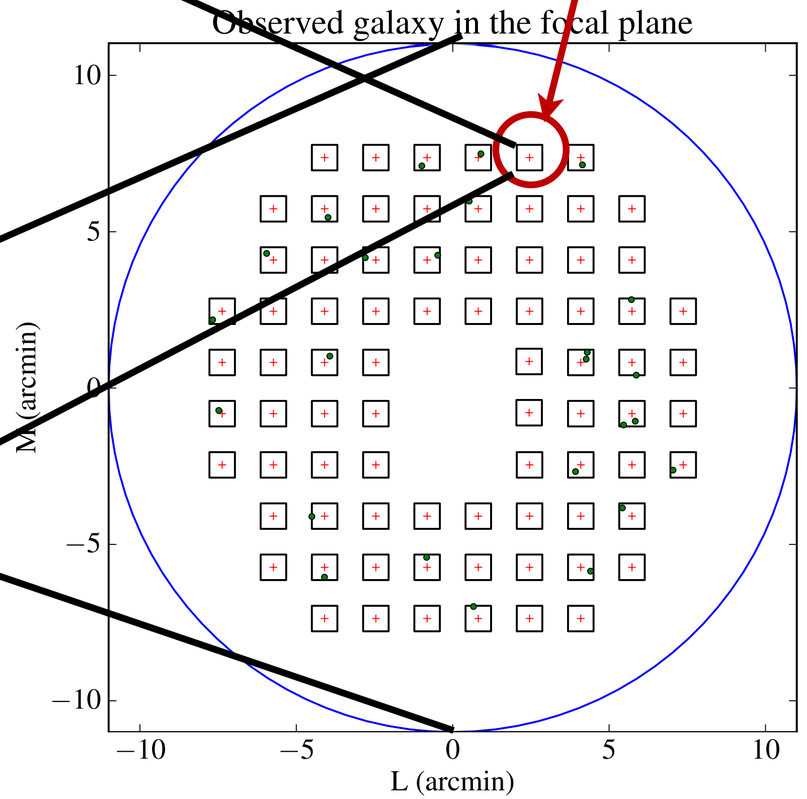


448 fibers (1.5”-diameter)

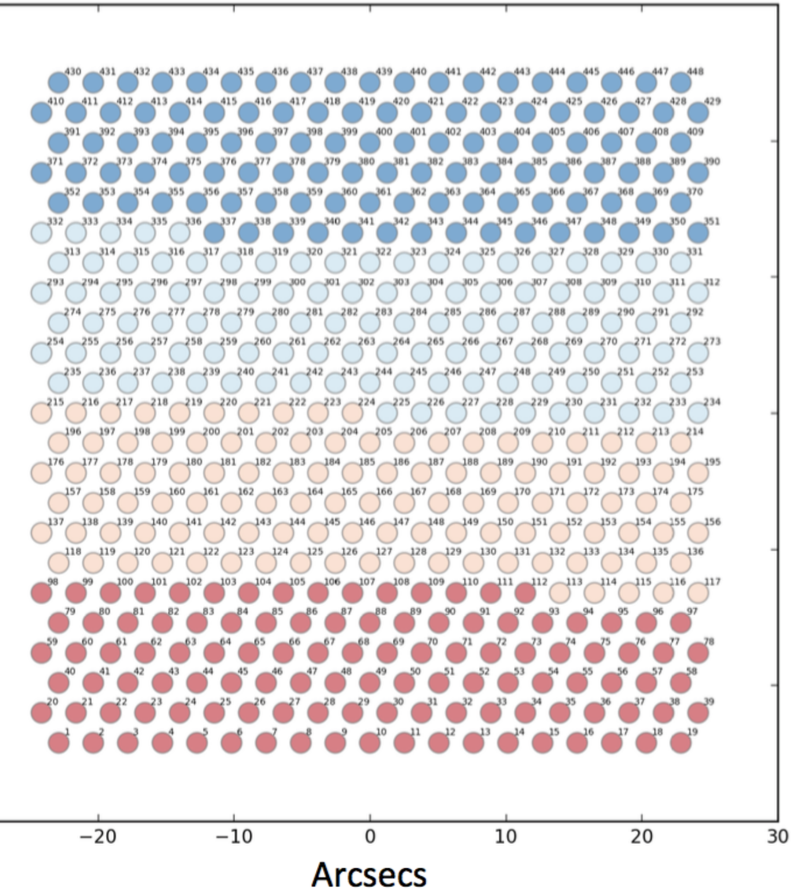


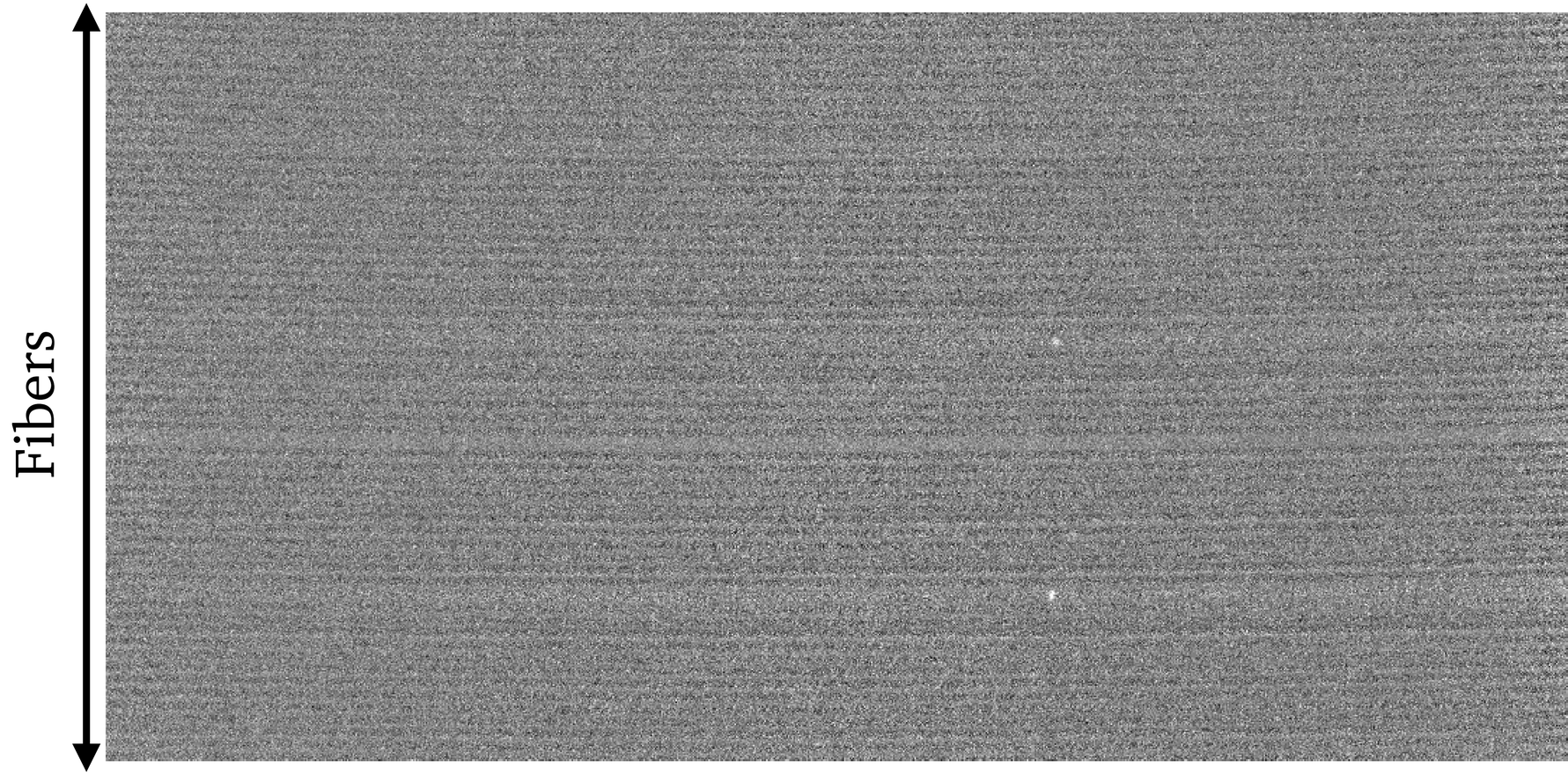


~450 fibers with 1.5” diameter

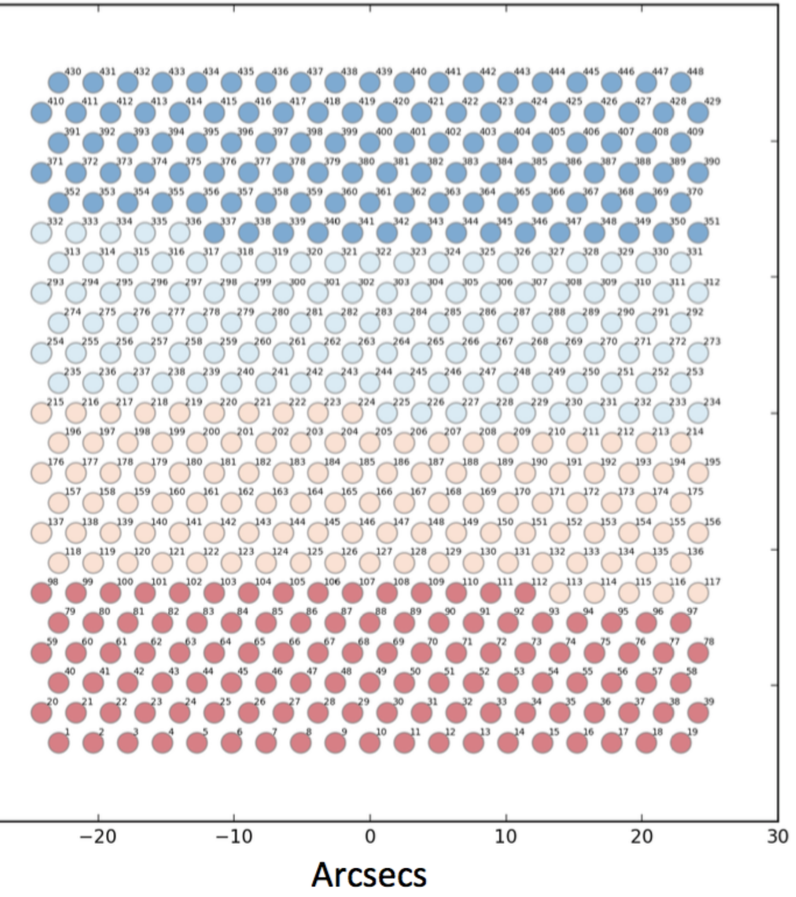


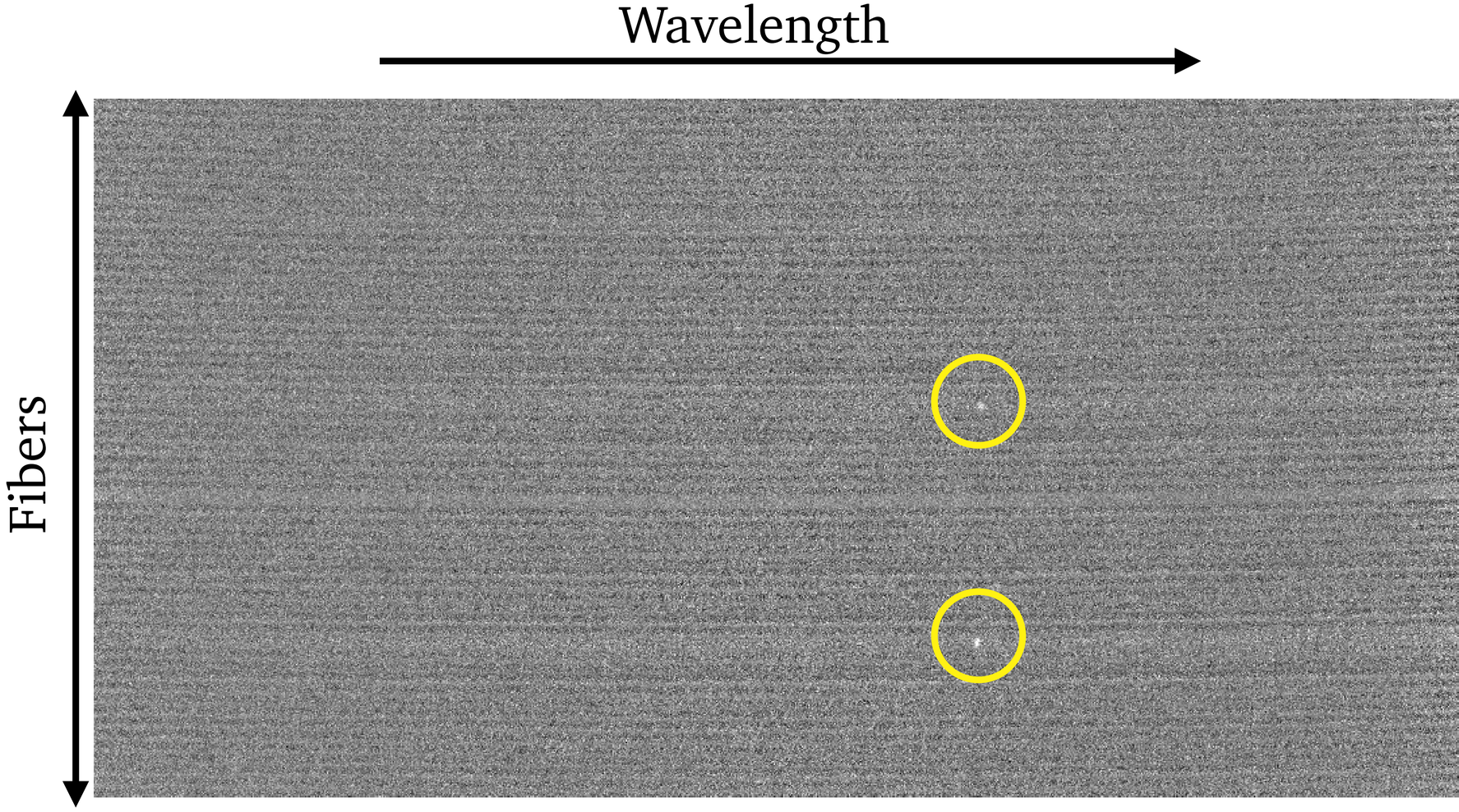
Example data frame





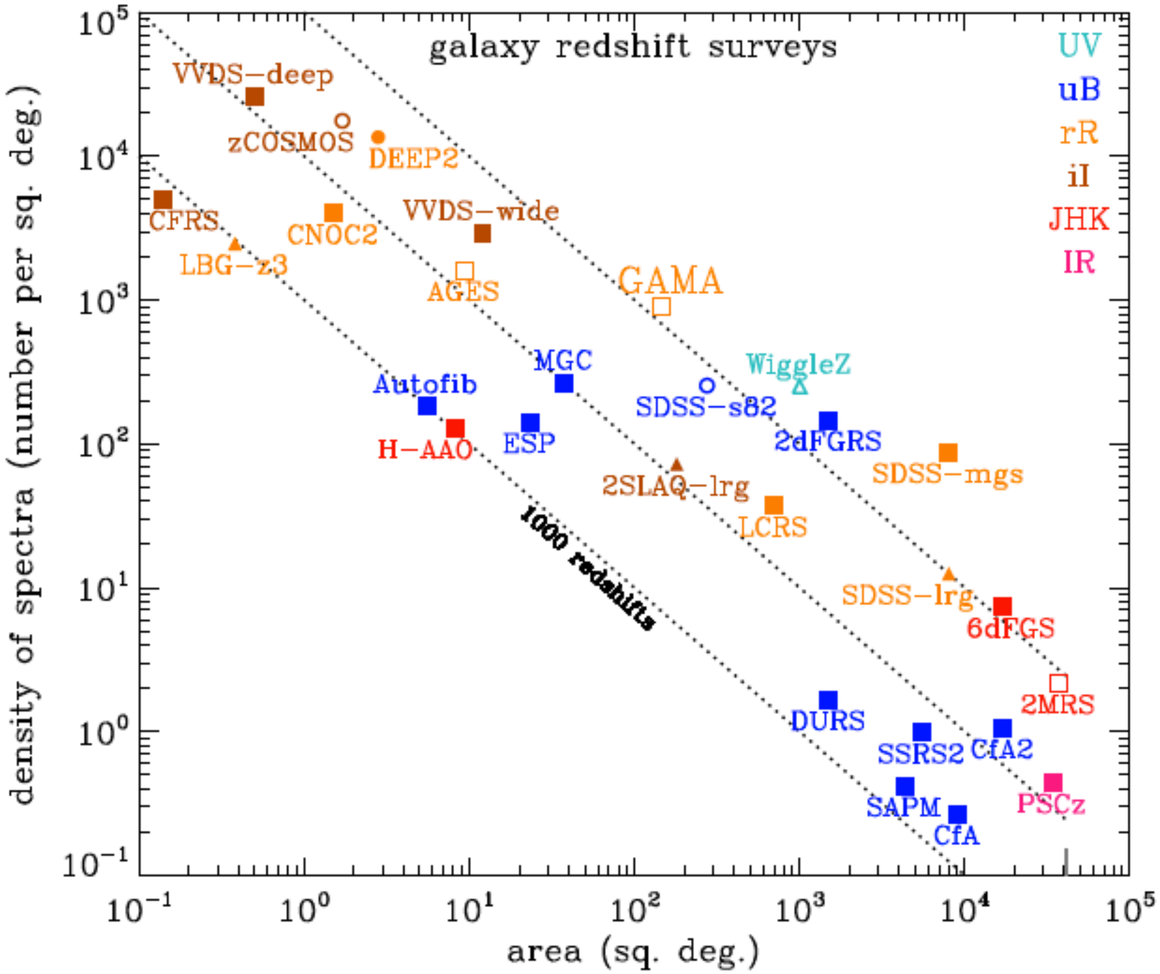
Example data frame (two LAE!)





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

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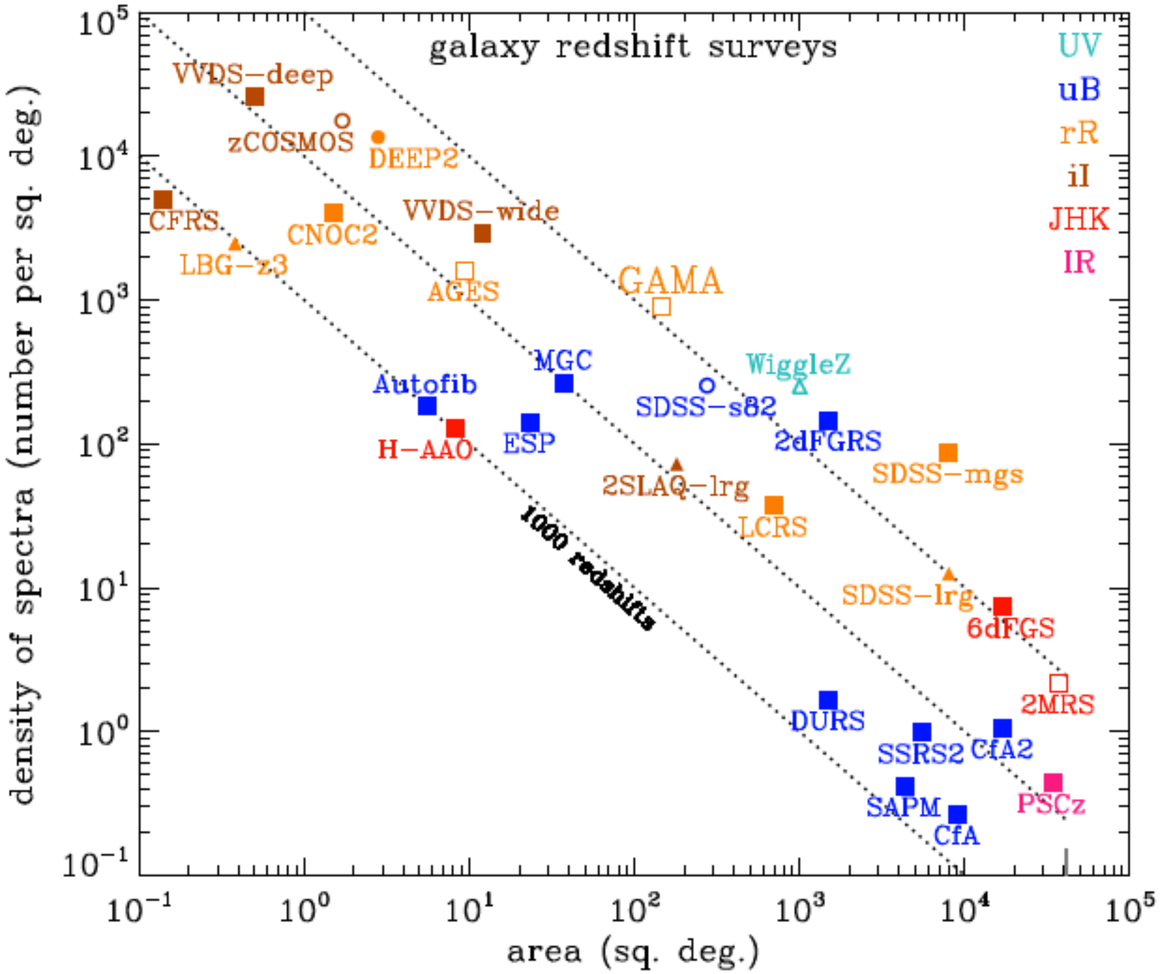

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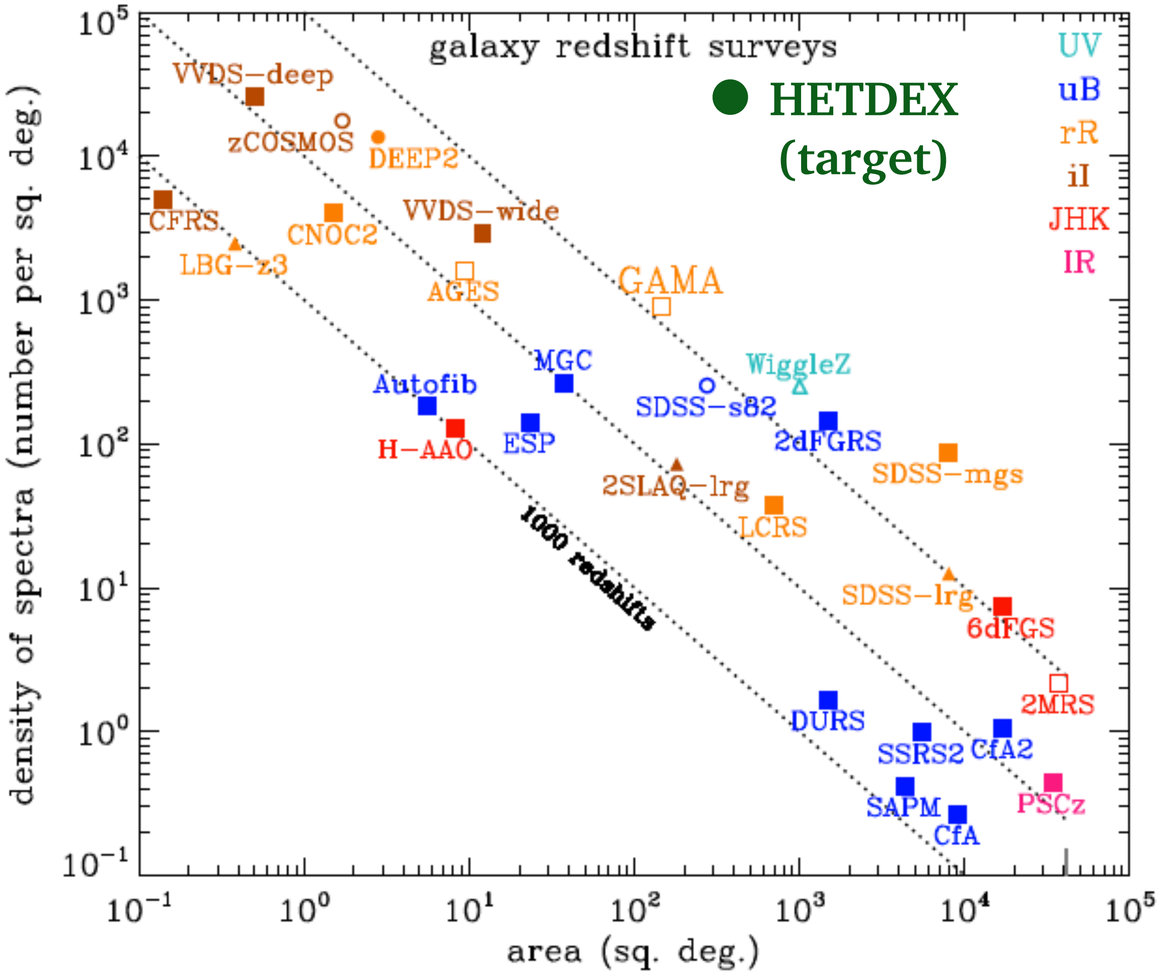

From Sarah Brough

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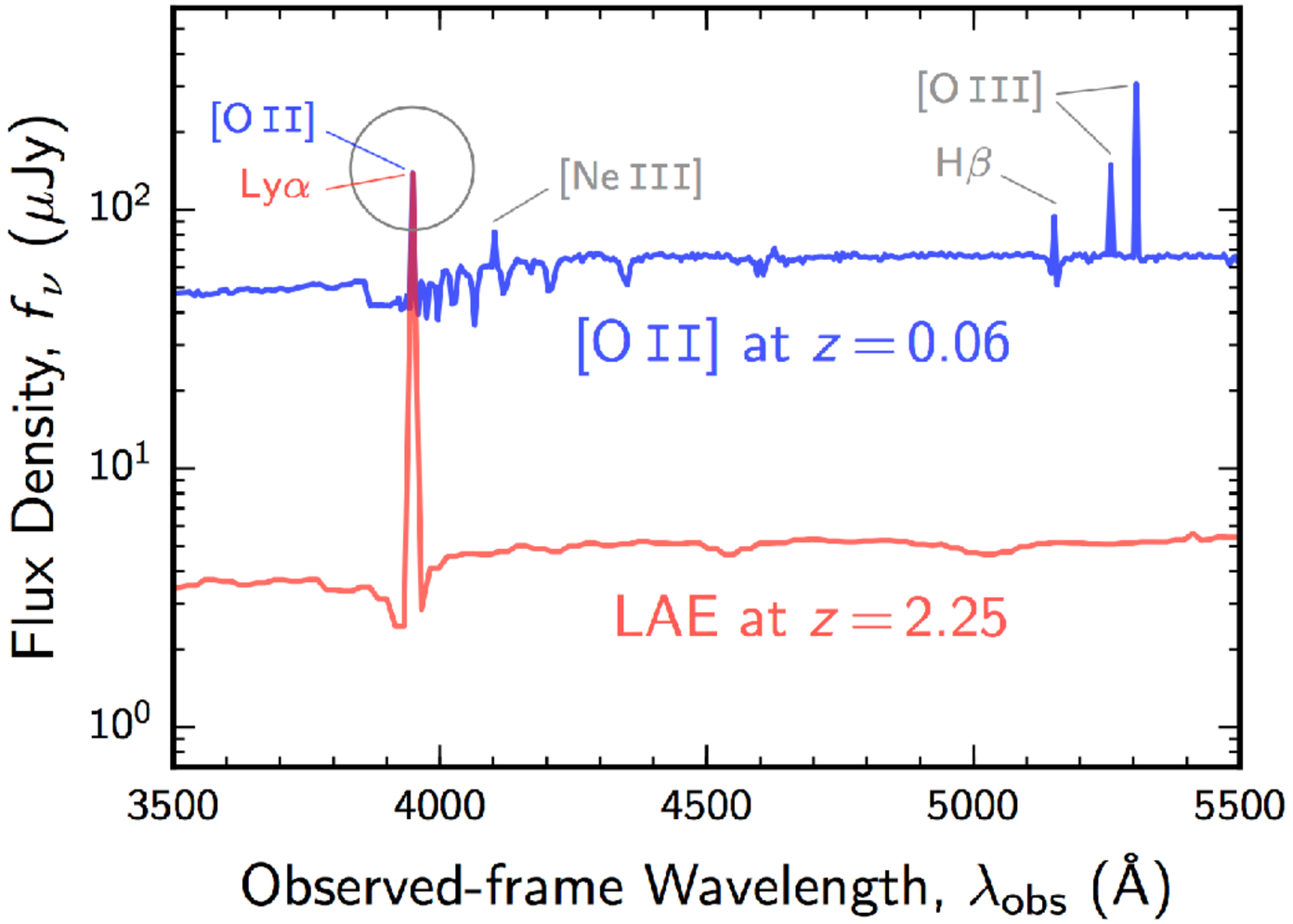
  - ~1.2 M Lyman-alpha emitting galaxies at 1.9<z<3.5
    - We will observe **~200 LAEs in 20 minutes!!**
  - ~1M [OII] λ3727 emitting galaxies
  - ~0.4 M other galaxies
  - ~0.25 M Milky way stars
  - 25k AGNs (z<3.5) + etc (~2000 clusters, Astroids, SN, PN, …)

LAE vs. [OII] λ3727



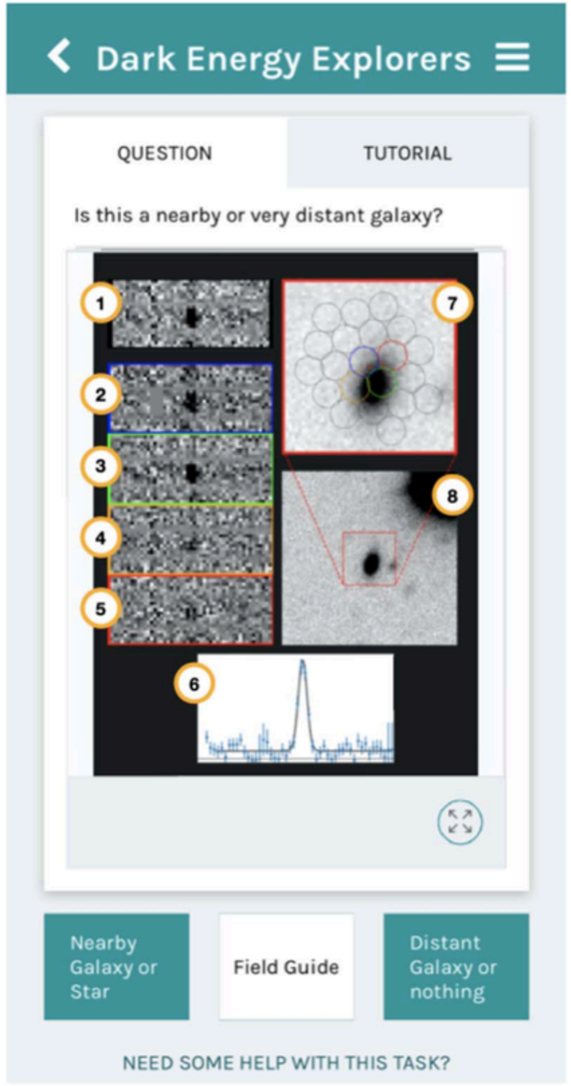
- Because [OII] λ3727 is a fairly *isolated* line.
- [OII] λ3727 from low-redshift galaxies can be confused as LAEs.
- Key to distinguish them:
  - Equivalence width
  - Continuum flux
- Citizen science!!

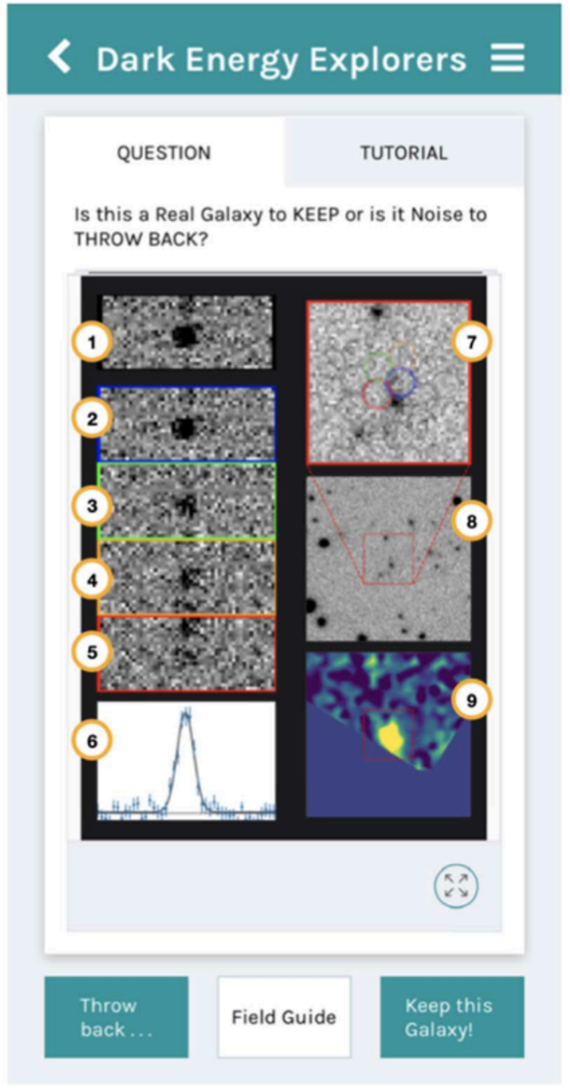
House et al. (2023)

Dark Energy Explorer



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

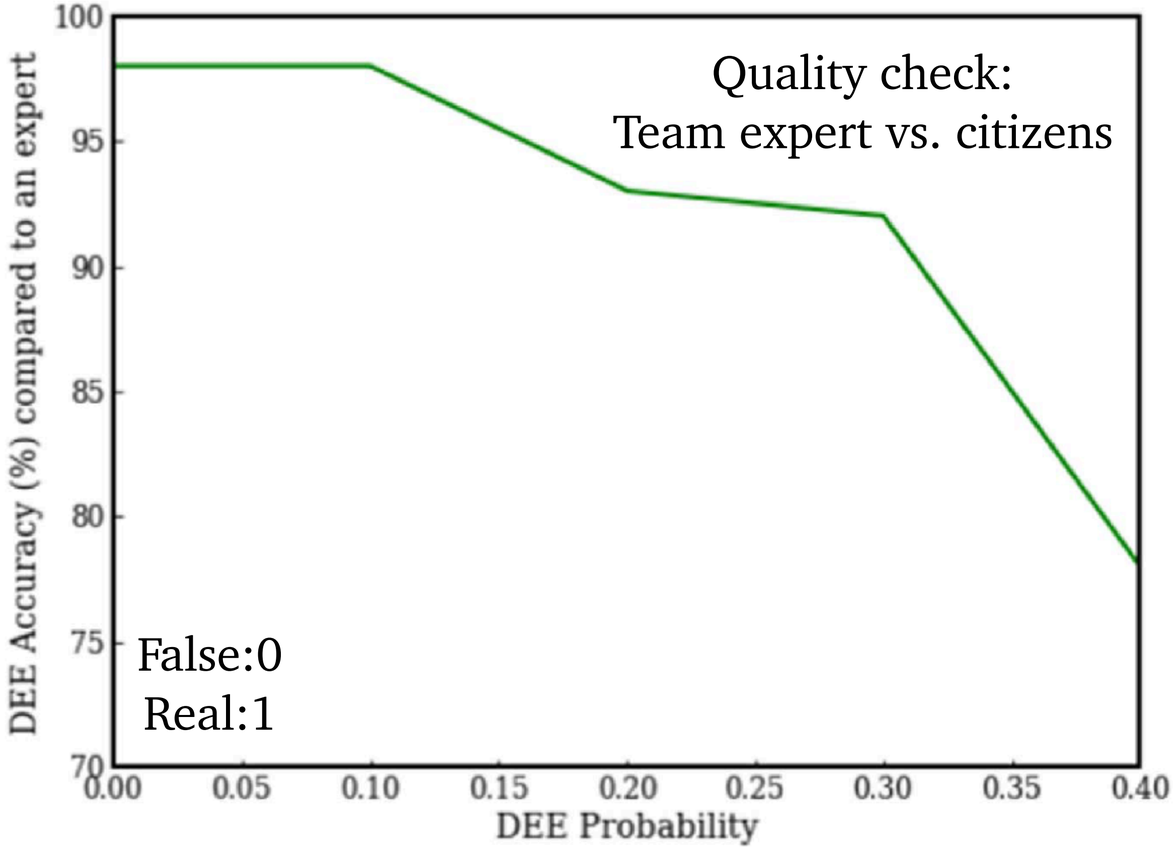




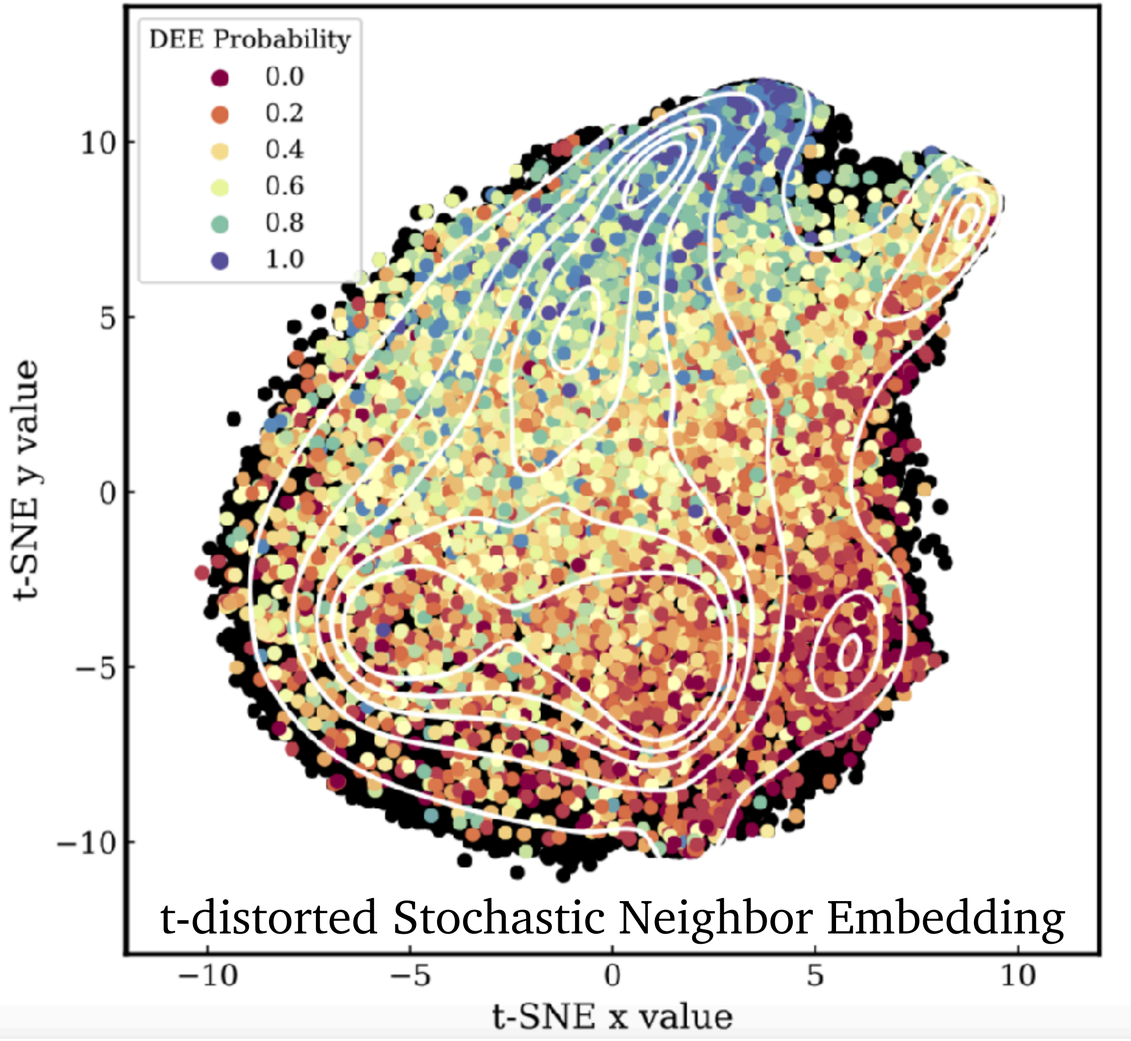
House et al. (2023)

ML classification of the real/false

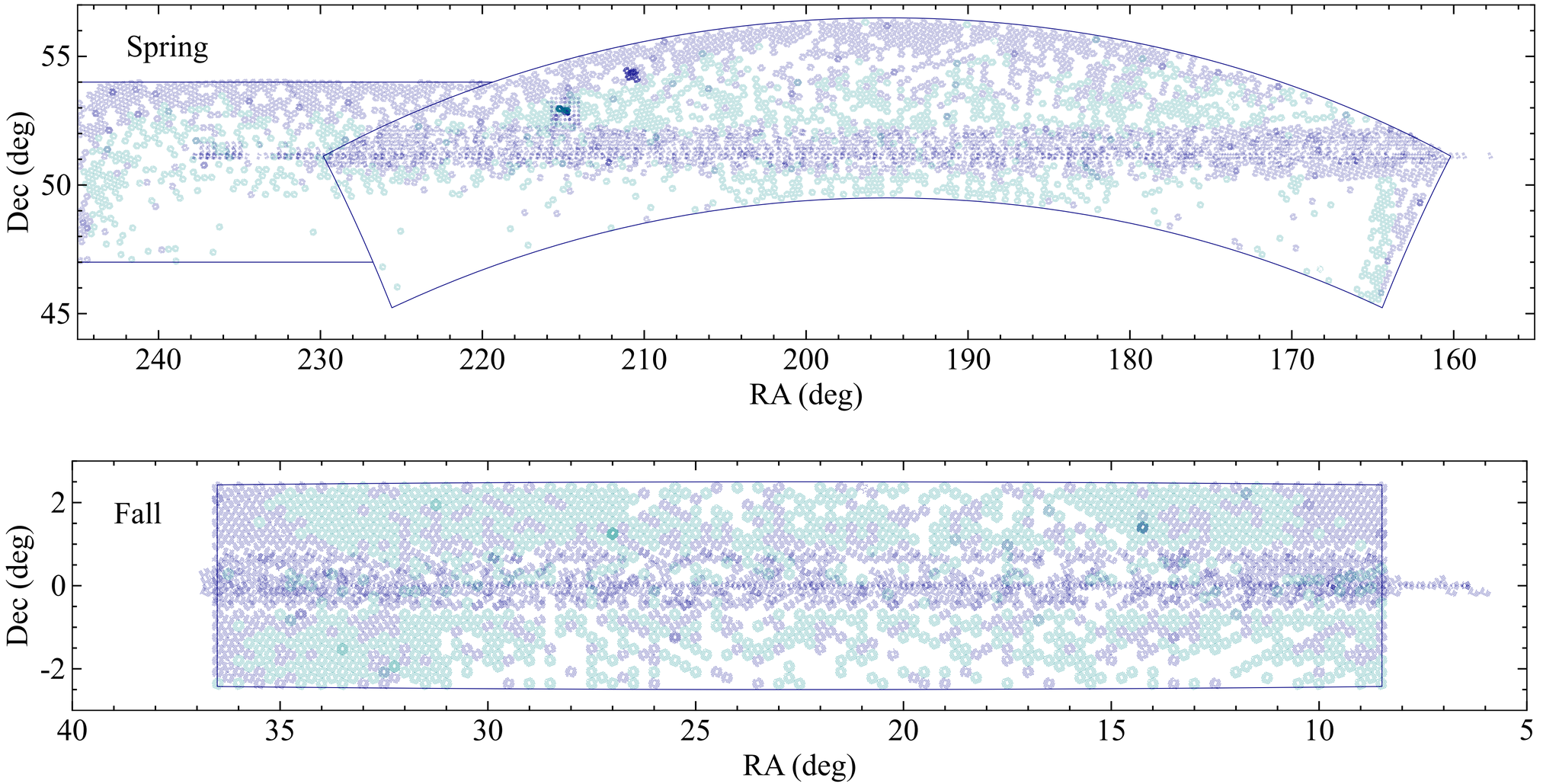
Charge trap, hot pixels, time-variable changes in calibration, …



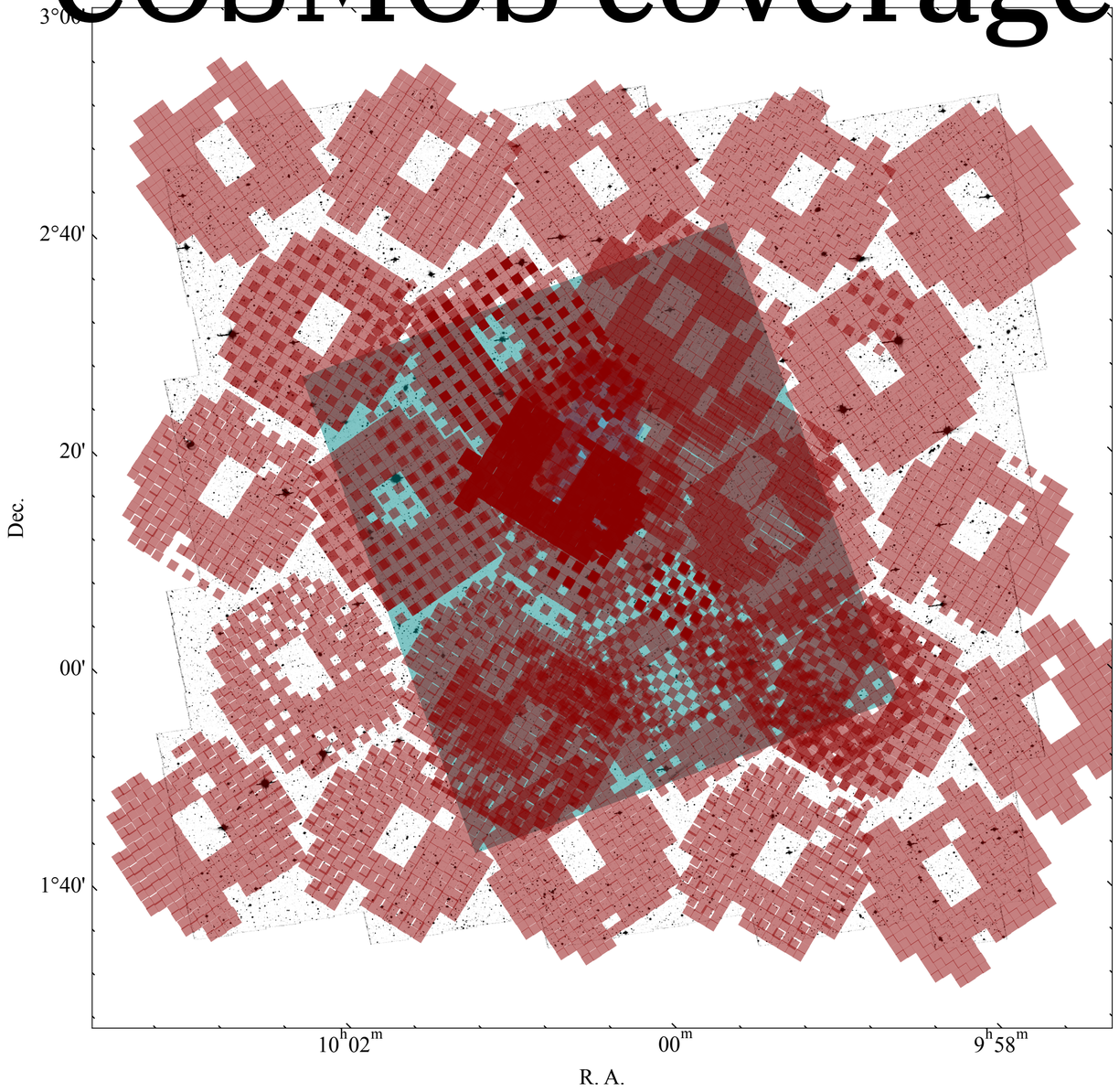
Average over 10 classification of each source



Survey status: >75% complete!

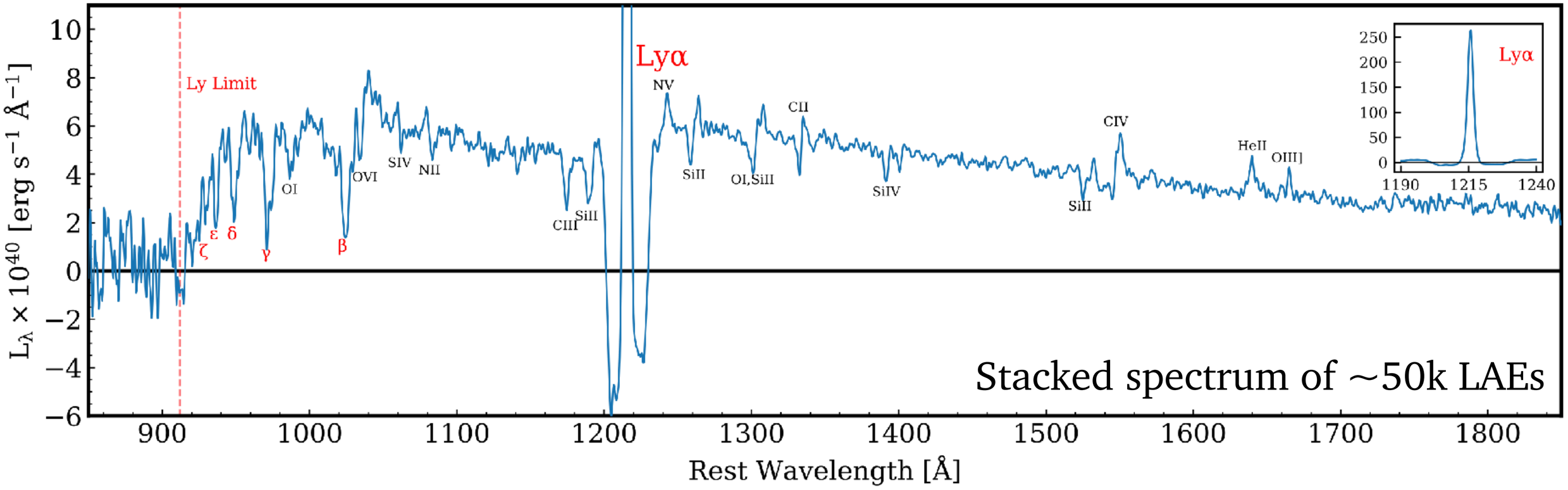


COSMOS coverage

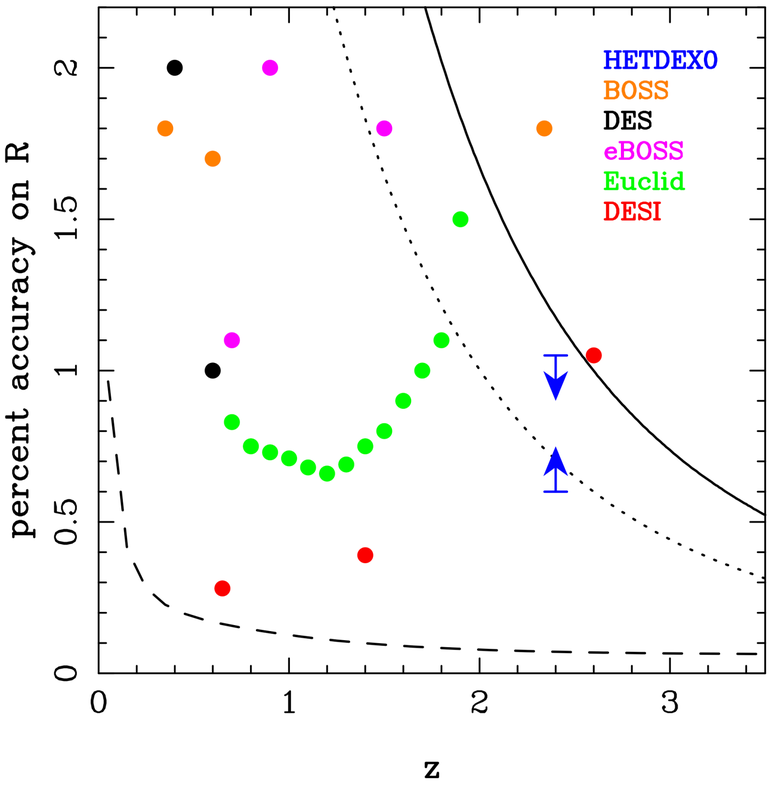


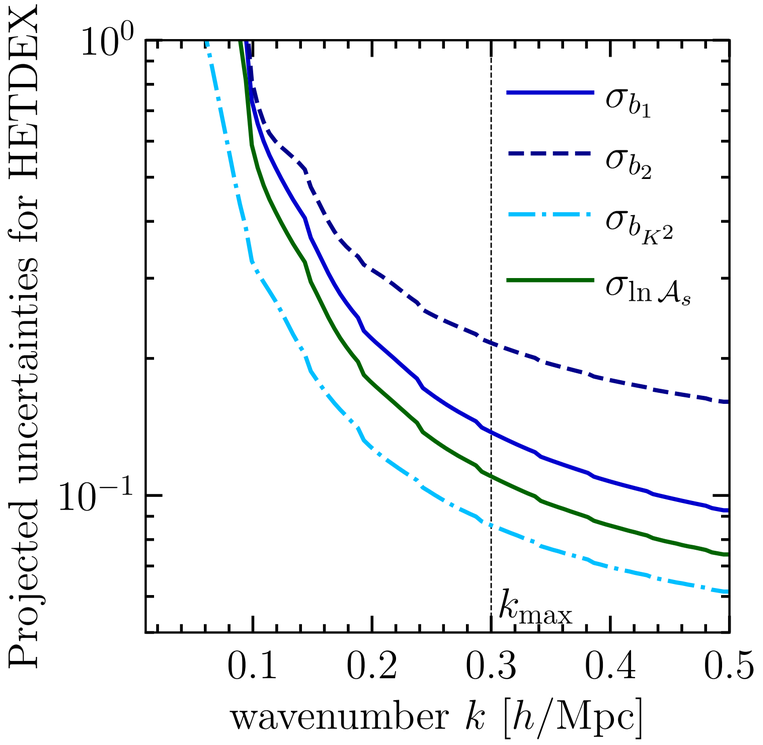
Davis et al. (2023)
Cooper et al. (2023)

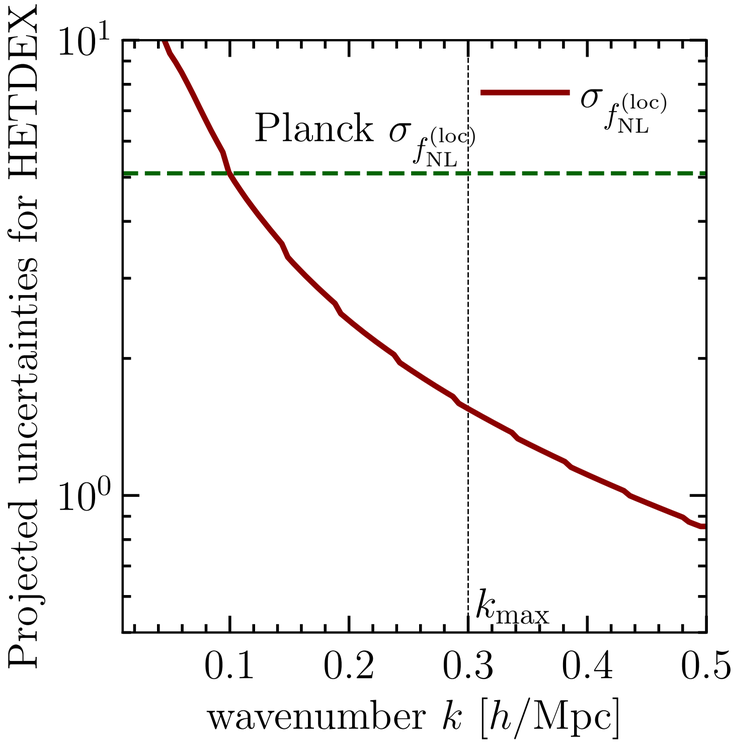
HETDEX Public Source Catalog

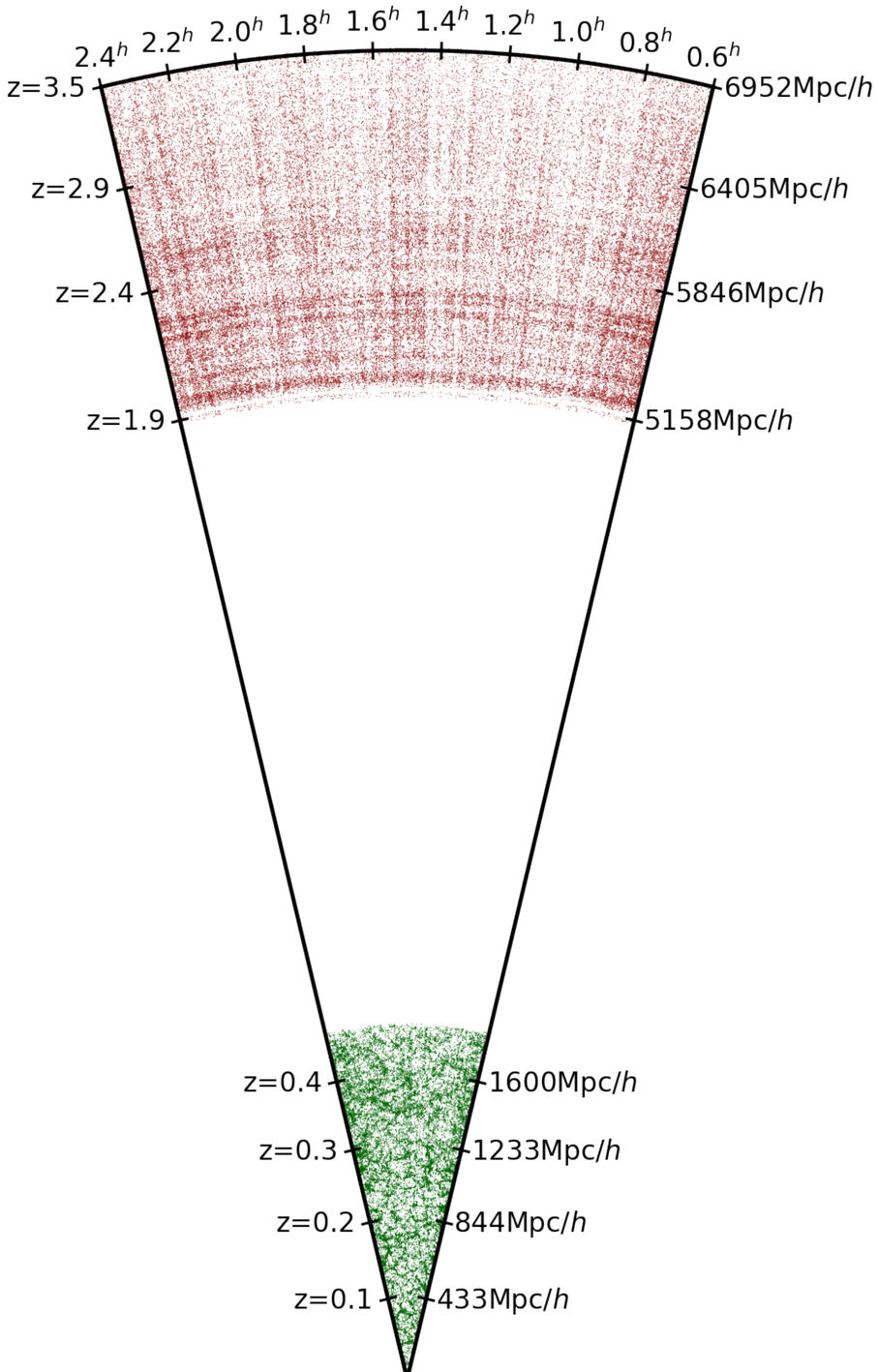


Cosmology with HETDEX

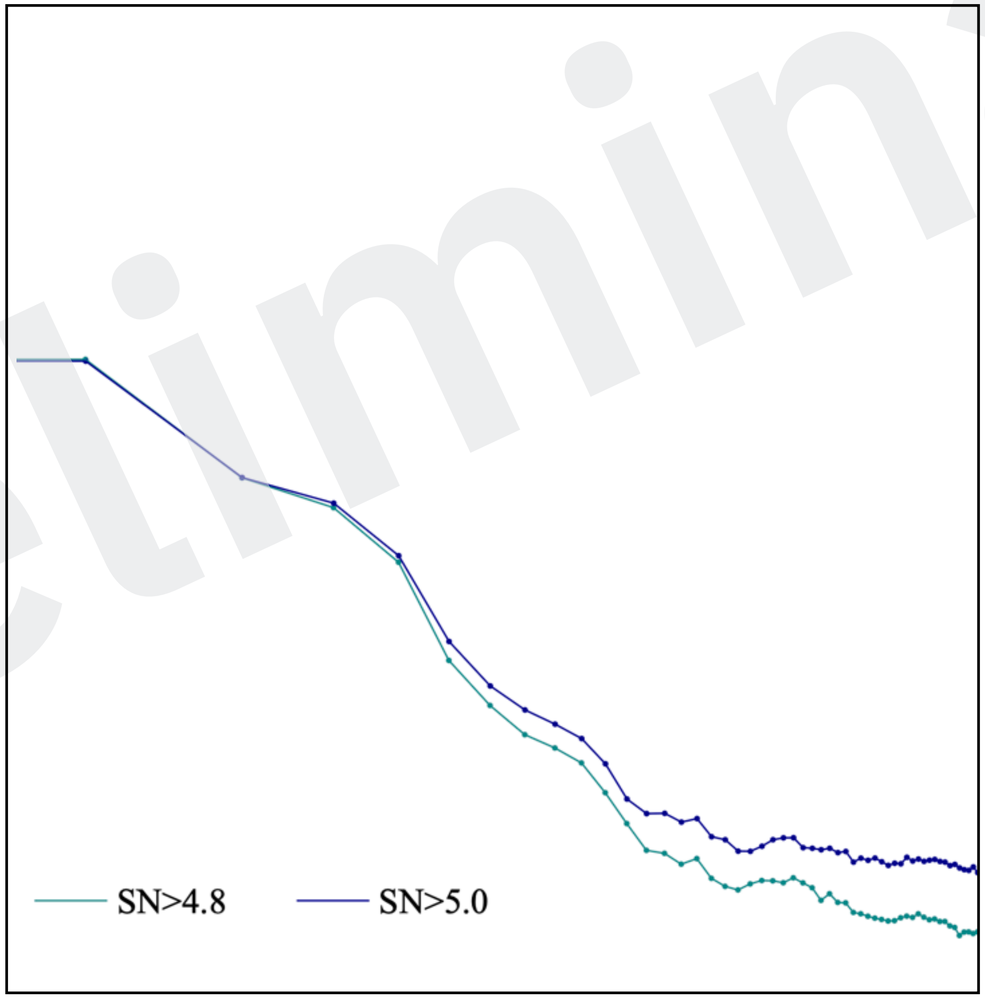







2.4^h
2.2^h
2.0^h
1.8^h
1.6^h
1.4^h
1.2^h
1.0^h
0.8^h
0.6^h
z=3.5
6952Mpc/h
z=2.9
6405Mpc/h
z=2.4
5846Mpc/h
z=1.9
5158Mpc/h
z=0.4
1600Mpc/h
z=0.3
1233Mpc/h
z=0.2
844Mpc/h
z=0.1
433Mpc/h

Baryon Acoustic Oscillations!!



preliminary

Conclusion

- HETDEX is the first **blind** spectroscopic survey with a large (~11 Gpc^3) volume (***Main survey: 2017-2024***)
- We are detecting toward ~1.5 Million Lyman-alpha emitting galaxies to map the large-scale structure in a relatively unexplored territory of ***z=1.9–3.5.***
- Detection of dark energy (even if it is a cosmological constant) at 1.9<z<3.5, plus neutrino mass; curvature; primordial power spectrum, primordial non-Gaussianities, etc.