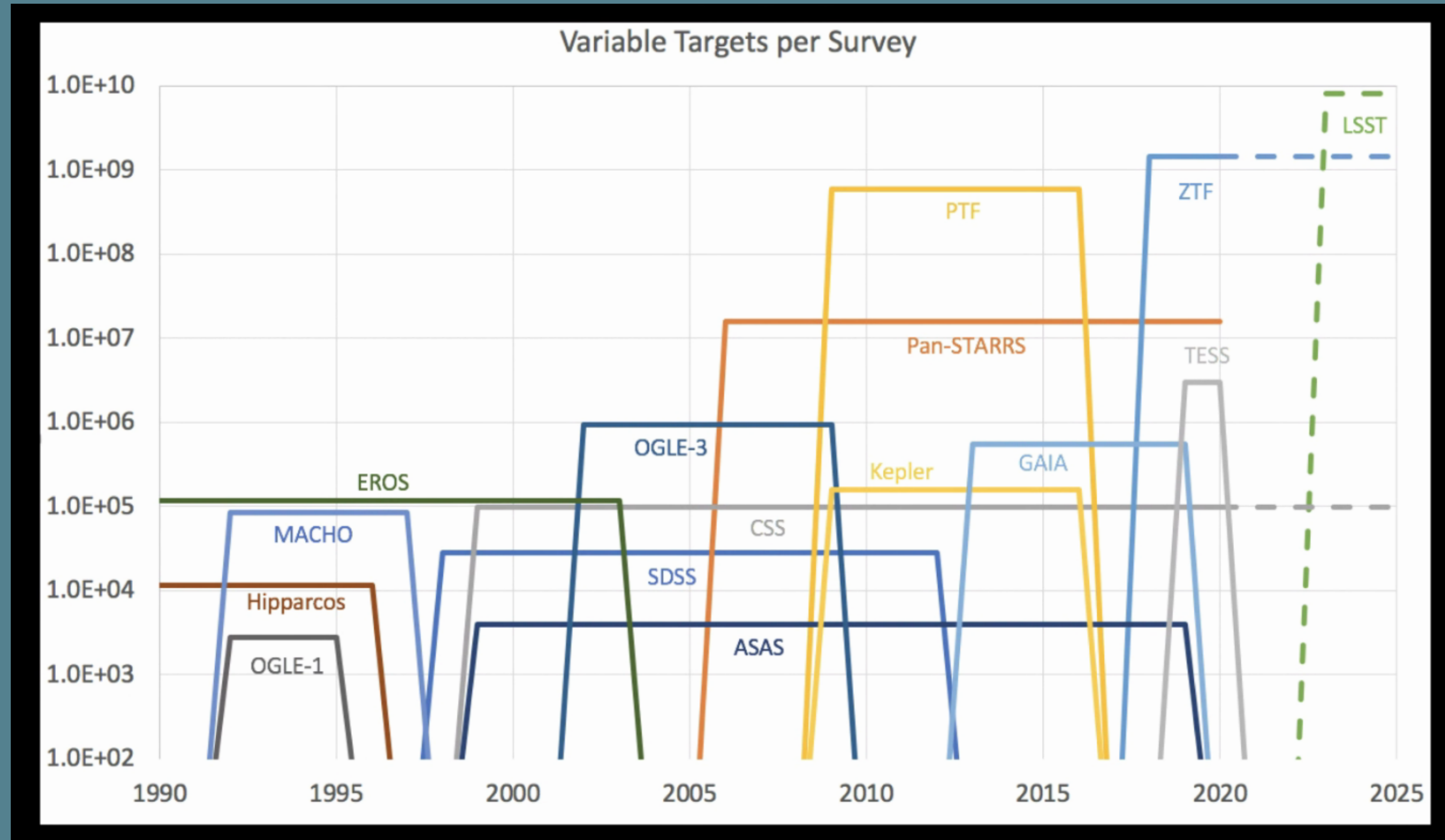


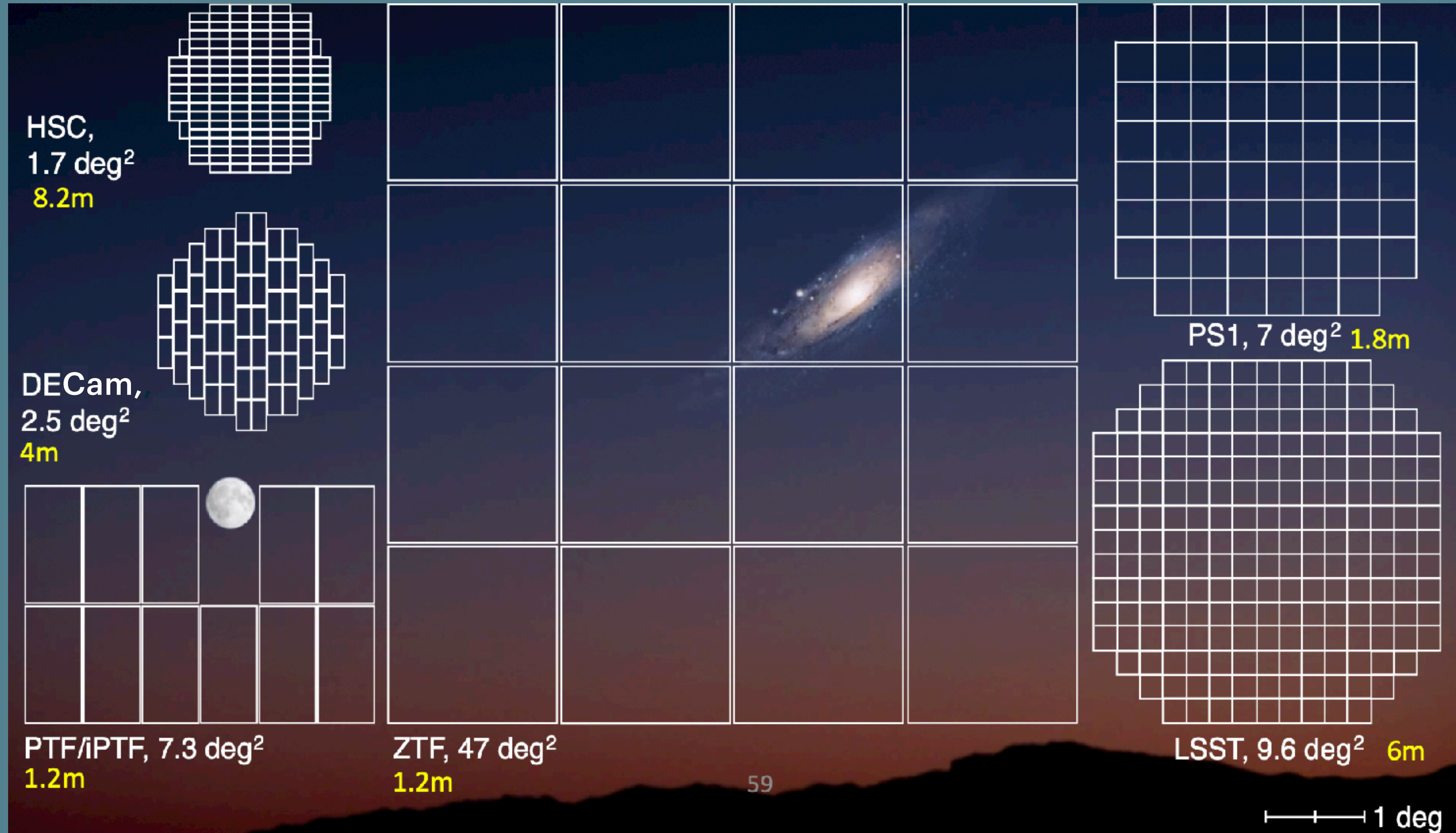
The Restless Nature of AGN: 10 years later

SPECTROSCOPIC SURVEYS FOR TIME-DOMAIN SCIENCE

VARIABILITY SURVEYS



VARIABILITY SURVEYS



VARIABILITY SURVEYS

Dedicated facilities:

Zwicky Transient Factory: 1.2m, *gri* ~ 20.5

ATLAS: 50cm Schmidt telescope

ASAS-SN: 24 x 14cm telescopes

QUEST-La Silla: 1m Schmidt -> LS4

Vera Rubin LSST: 6.5m, 10 years, *ugrizy* ~ 25-27 over 18,000 deg²
ugrizy ~ 27-29 over 38 deg² (deep drilling fields)

PS1: 1.8m

Kiso Schmidt: 1m

SkyMapper: 1.35m

BlackGem: 65cm telescopes

Time-resolved Large Imaging Surveys:

SDSS/S82: 2.5m APO, 3 deg²

DES: 4m Blanco, 2.5 deg²

HSC-SSP: 8m Subaru, 1.7 deg²



Vera Rubin Observatory

Alert stream brokers will help with the classification bottleneck of transient events

See alerce.online

ALeRCE ZTF Explorer

Object: ZTF21abaxaqq

Corrected: yes

Stellar: no

Detections: 191

Discovery date: Tue, 11 May 2021 11:36:49 UTC

Last detection: Tue, 30 May 2023 10:42:46 UTC

Non Detections: 0

RA(J2000): 4.928706656544503

Dec(J2000): 29.3168791078534

FINDING CHART OTHER ARCHIVES

Type	Name	Redshift
TDE	2021mhg	0.073

Discovered by ZTF Provided by TNS

Light Curve

Magnitude vs Modified Julian Dates

Legend: g (green), r (red), g DR5, r DR5, DR5

Options: Difference Magnitude, Apparent Magnitude, Folded

Buttons: DISPLAY DR, DOWNLOAD

Magnitude Statistics

stat	g	r
stellar	false	false
corrected	true	true
ndet	39	152
ndubious	0	0
magmean	19.701	19.300

Rows per page: 5

1-5 of 14

Lc Classifier

AVRO

date: Tue, 11 May 2021 11:3...

Science Template Difference

DOWNLOAD DOWNLOAD DOWNLOAD

Crossmatch

Max. distance: 10 arcsec

Source	Distance (arcsec)
DECaLS (27 attributes)	0.099
GAIA/DR2 (28 attributes)	0.035
GALEX (10 attributes)	1.919

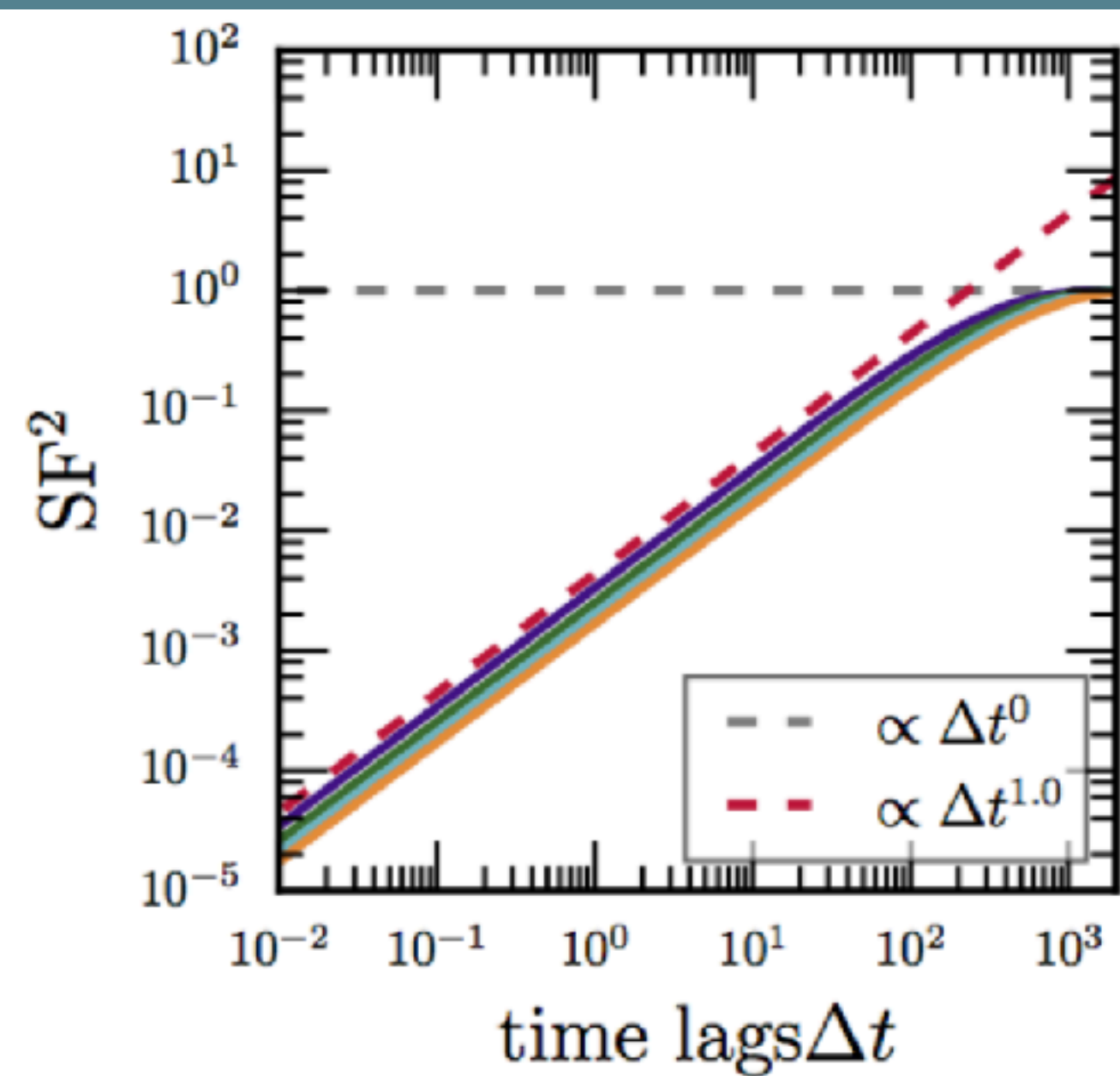
BUT.....

AGN rarely trigger transient-like events.....

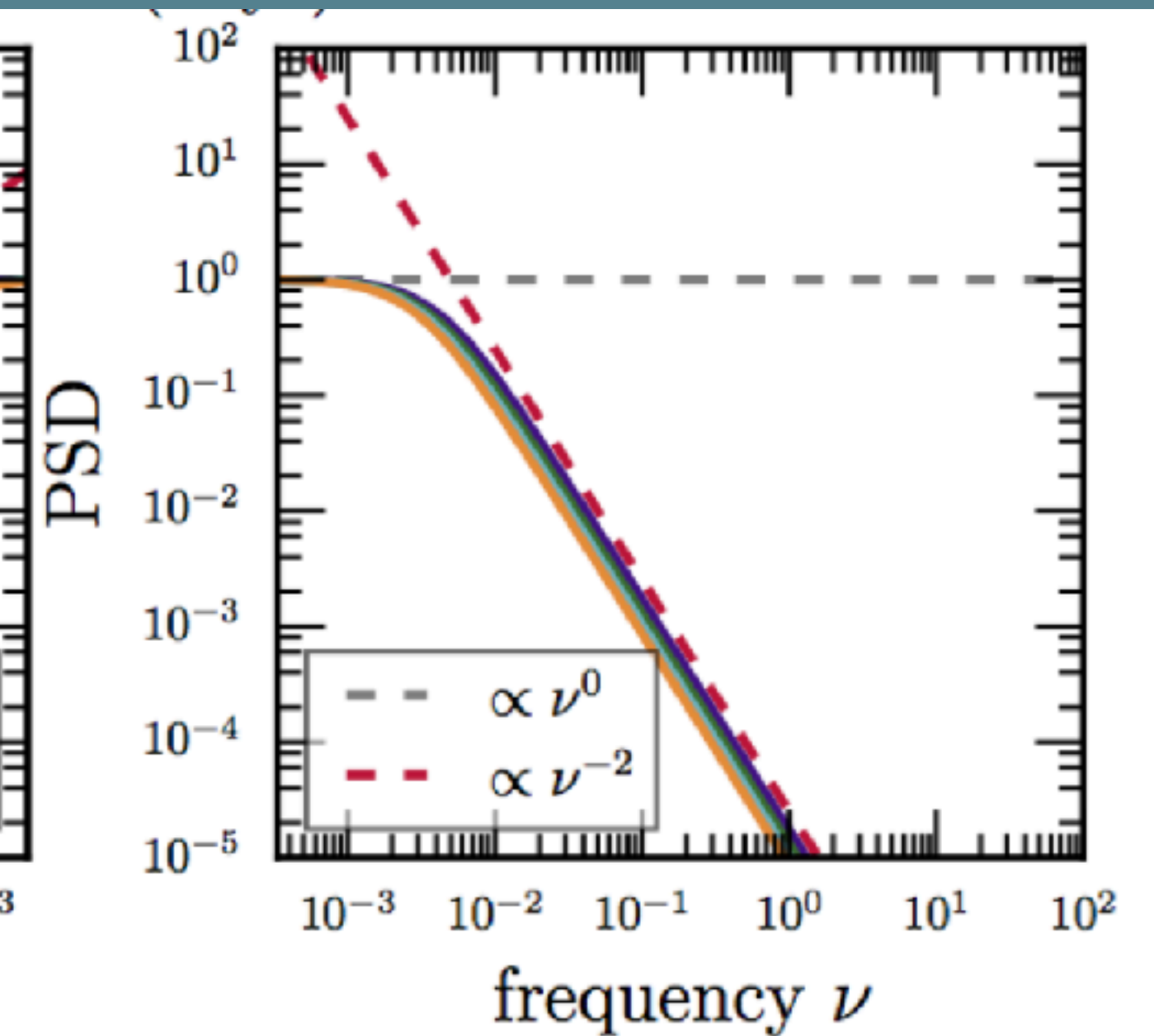
The bread and butter of AGN variability studies: Data Releases

With the exception of CL AGN and TDEs

Structure Function



Power Spectrum



Moreno et al. 2019

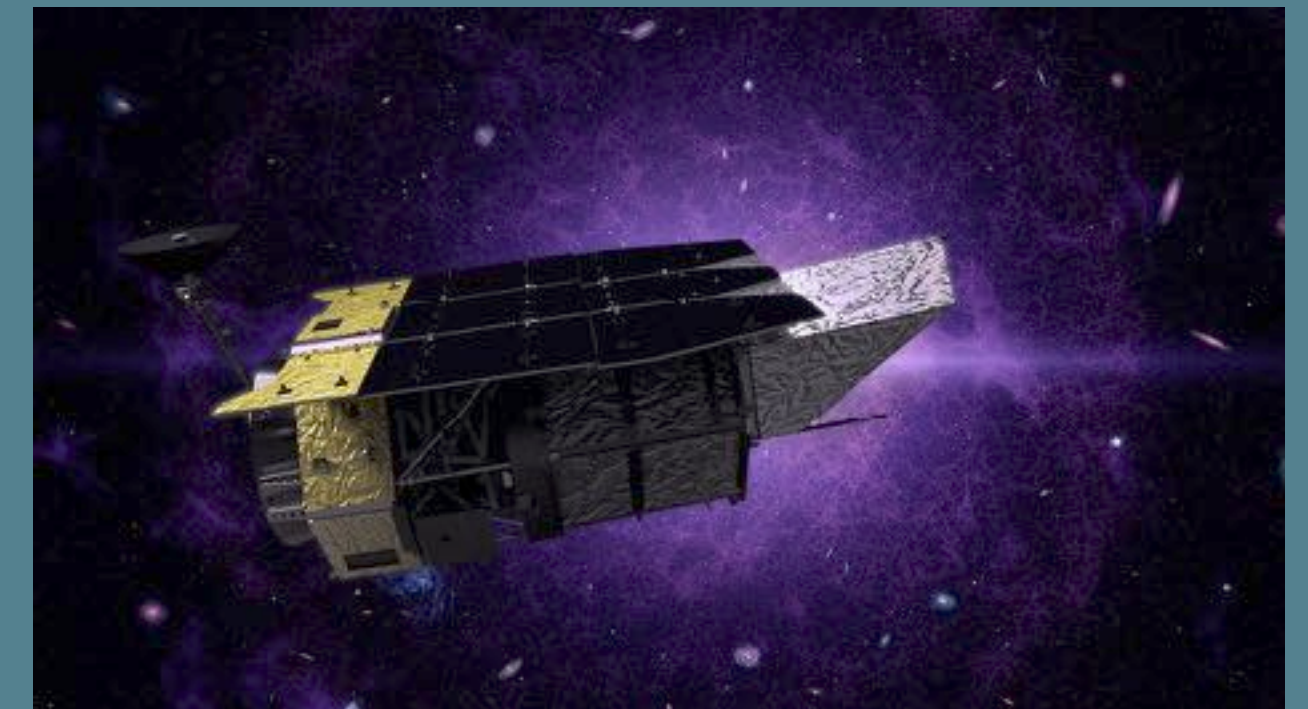
MULTI-WAVELENGTH SYNERGY

Other massive DEEP-WIDE field imaging surveys coming online in the next years

Vera Rubin LSST (NOIRLab): 6.5m, 10 years, *ugrizy* ~ 25-27 over 18,000 deg²
ugrizy ~ 27-29 over 38 deg² (deep drilling fields)

Euclid Space Telescope (ESA): 1.2m, 6 year mission, *riz+YJH* ~ 24 over 15,000 deg², **also spectra!**
~ 26 over 40 deg²

Nancy Roman Space Telescope (NASA / ex WFIRST): 2.4m, *YJH* ~ 26-27 over 2,000 deg²



Natural symbiotic relation between time-domain astronomy and massively multiplexed spectrographs

Desired Measurables:

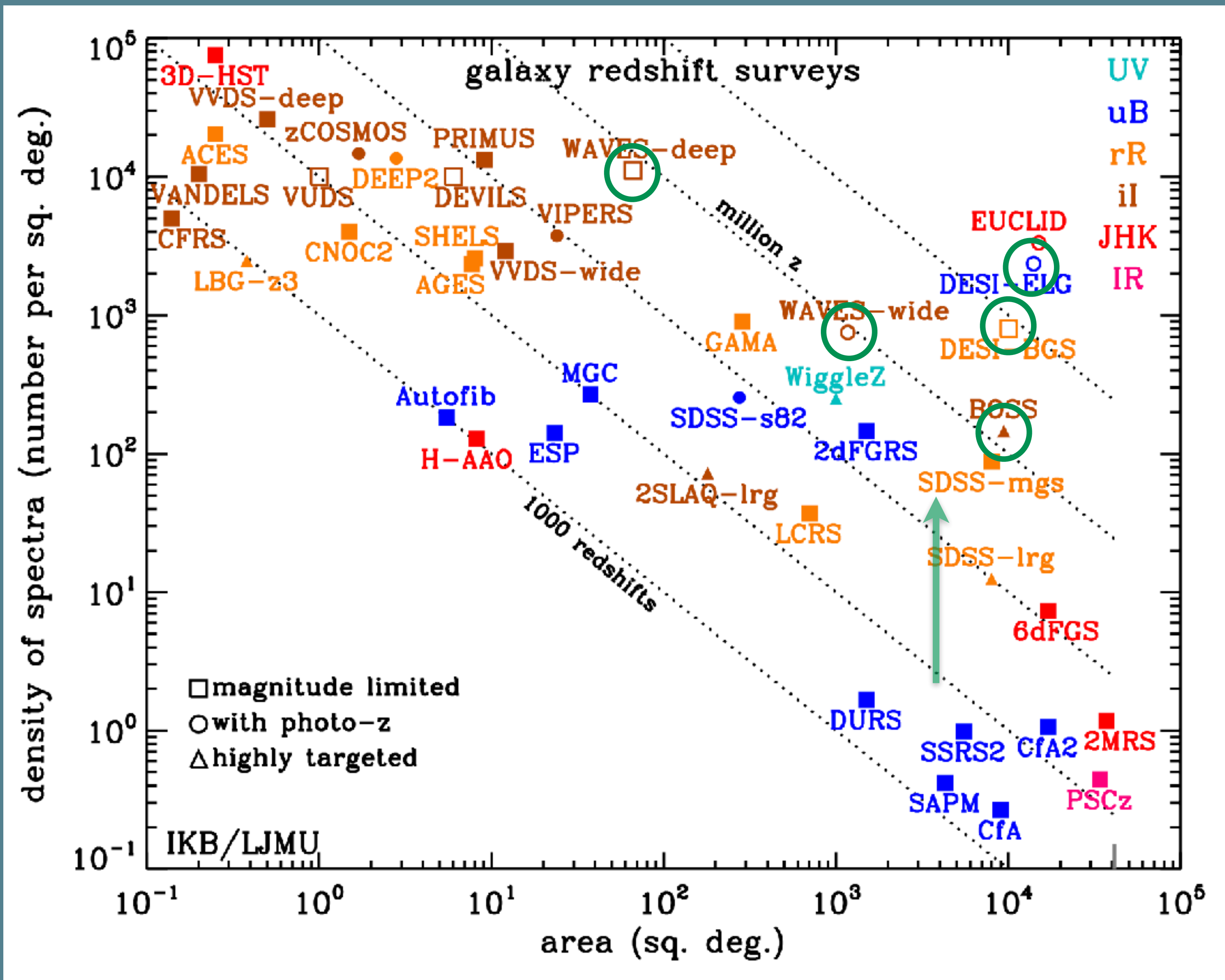
- Redshifts
 - Emission line fluxes / continuum
 - Detection of broad components
 - Host Galaxy characterization
 - Variations in continuum / line emission profiles from repeated observations
-

GROUND BASED SPECTROSCOPY

	Instrument/Telescope	Collecting Area m ²	Field of view deg ²	Multiplex	R _{opt} / NIR / both
SDSS-V BOSS Spec APOGEE Spec	APO / du Pont ✓	4.9	3.0 / 2.1	500	> 1500
				300	22000
4m class funded	4MOST	10.7	4.00	1400	6500 20000
	Mayall 4m / DESI ✓	11.4	7.08	5000	> 2000
	WHT / Weave	13.0	3.14	1000	5000 20000
8-10m class funded	Subaru / PFS	52.8	1.25	2400	> 3000
	VLT / MOONS	52.8	0.14	500	> 4000
					9000 20000
Proposed & unfunded	Megamapper @ GMT	28.0	7.06	> 20,000	> 2000
	Keck / FOBOS	76.0	0.087	1800	3500
	MSE @ CFHT	78.5	1.52	4000	> 1000 > 20000
	ESO Spectel	113.1	4.90	15000	3000
	ESO wST	78.5	5.00	20000	> 2000 > 20000

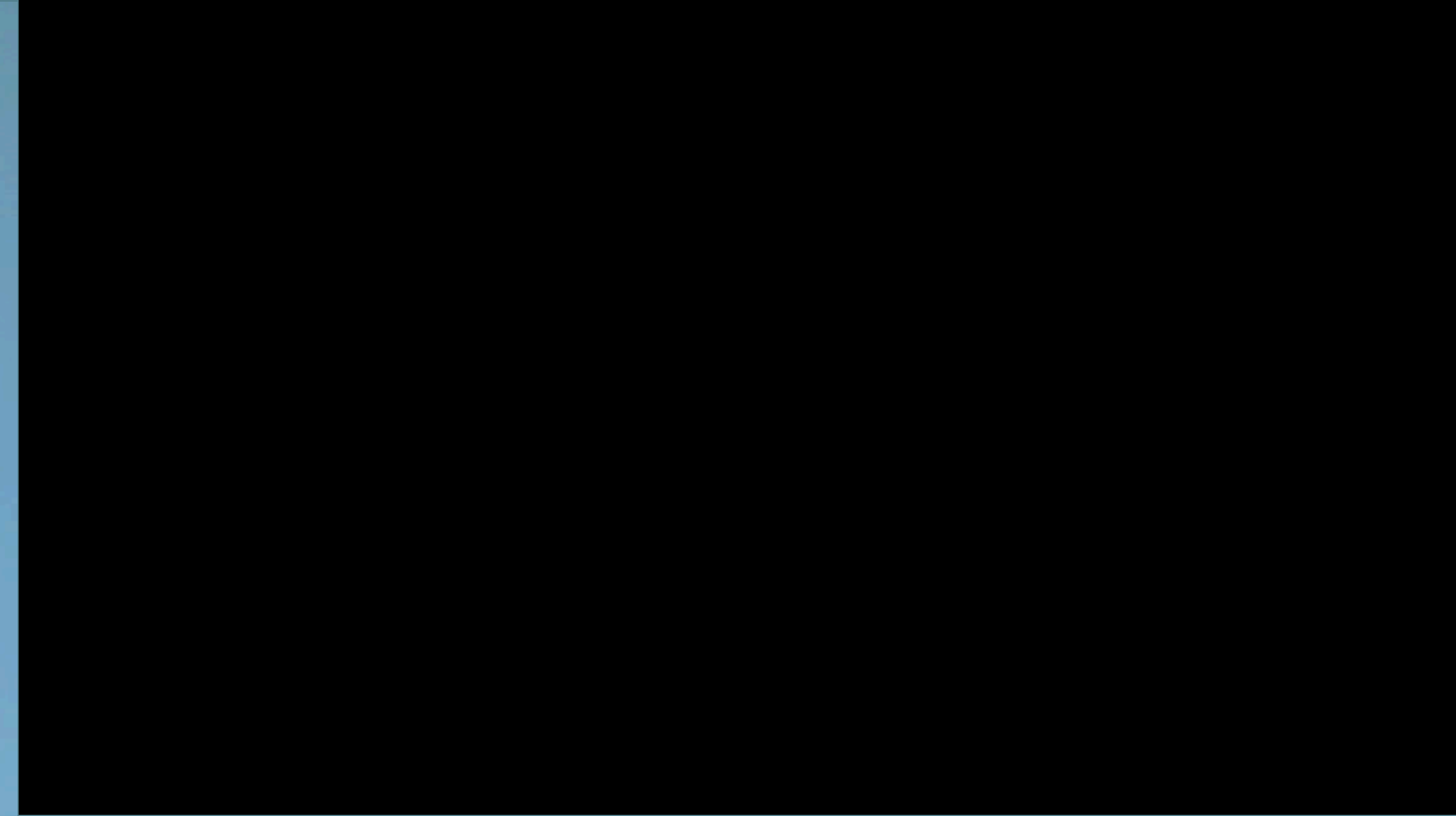
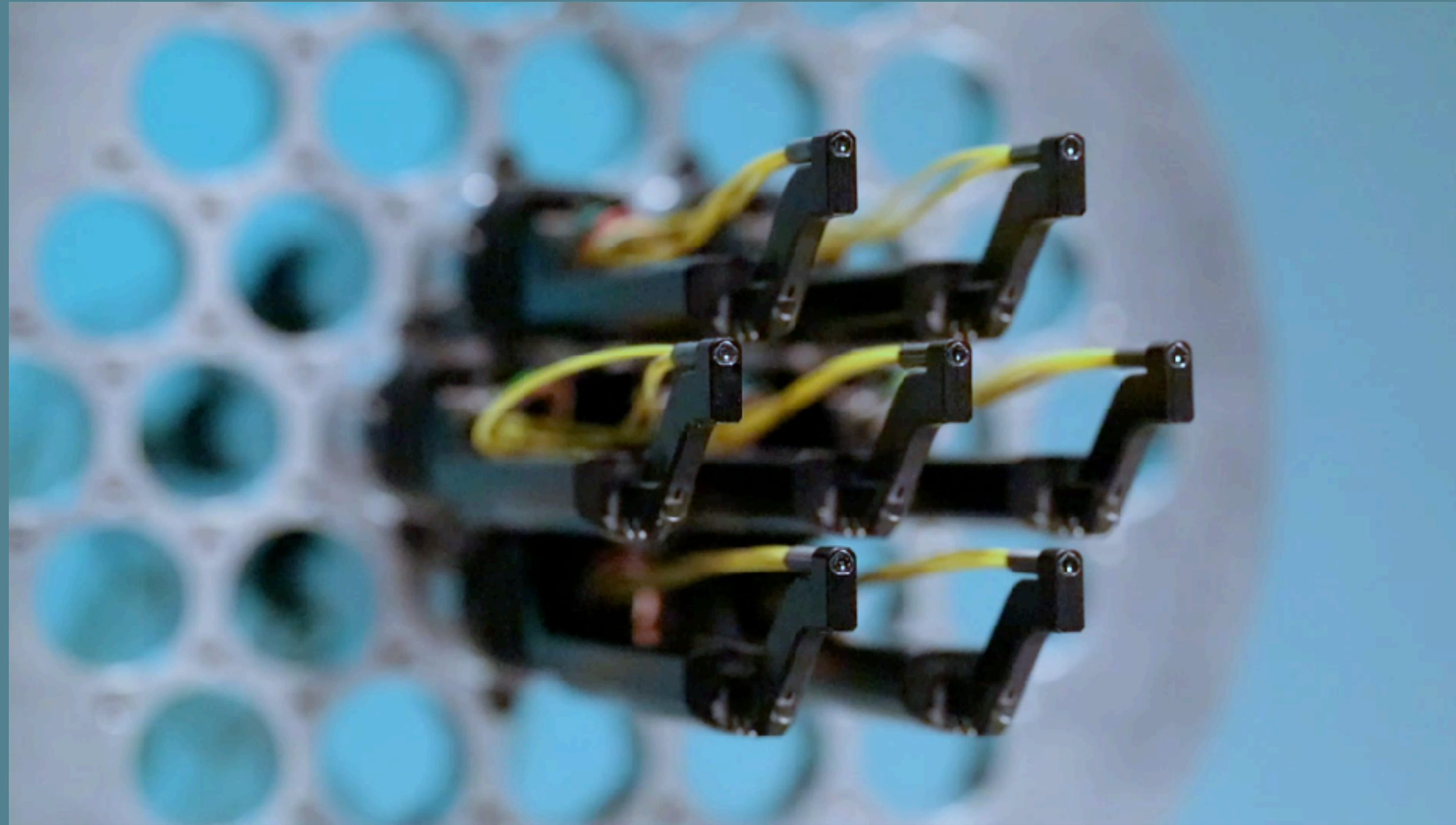
Adapted from Ellis 2021

SPECTROSCOPIC SURVEYS



I. K. Baldry

SDSS-V APOGEE-2 / WEAVE

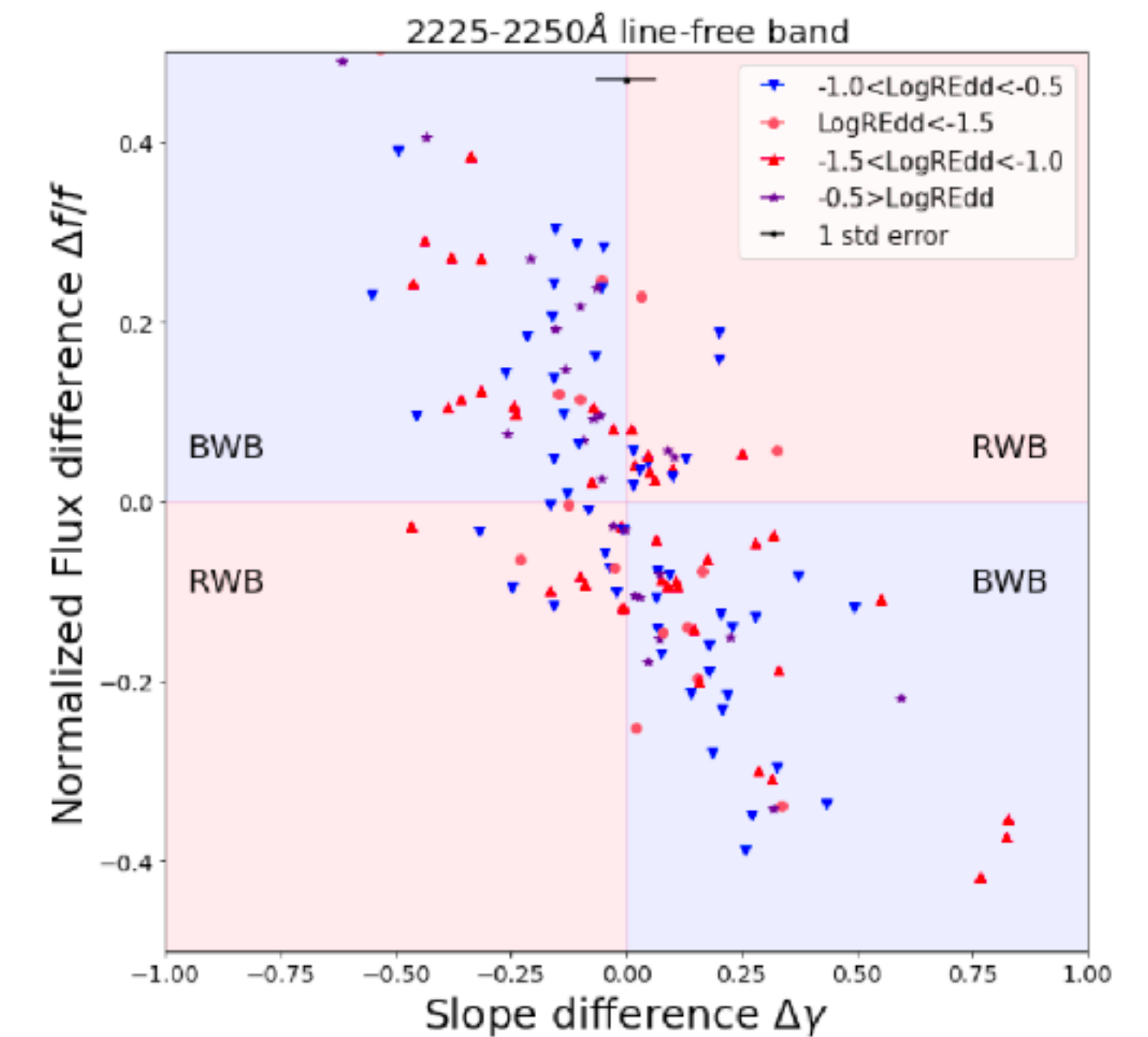
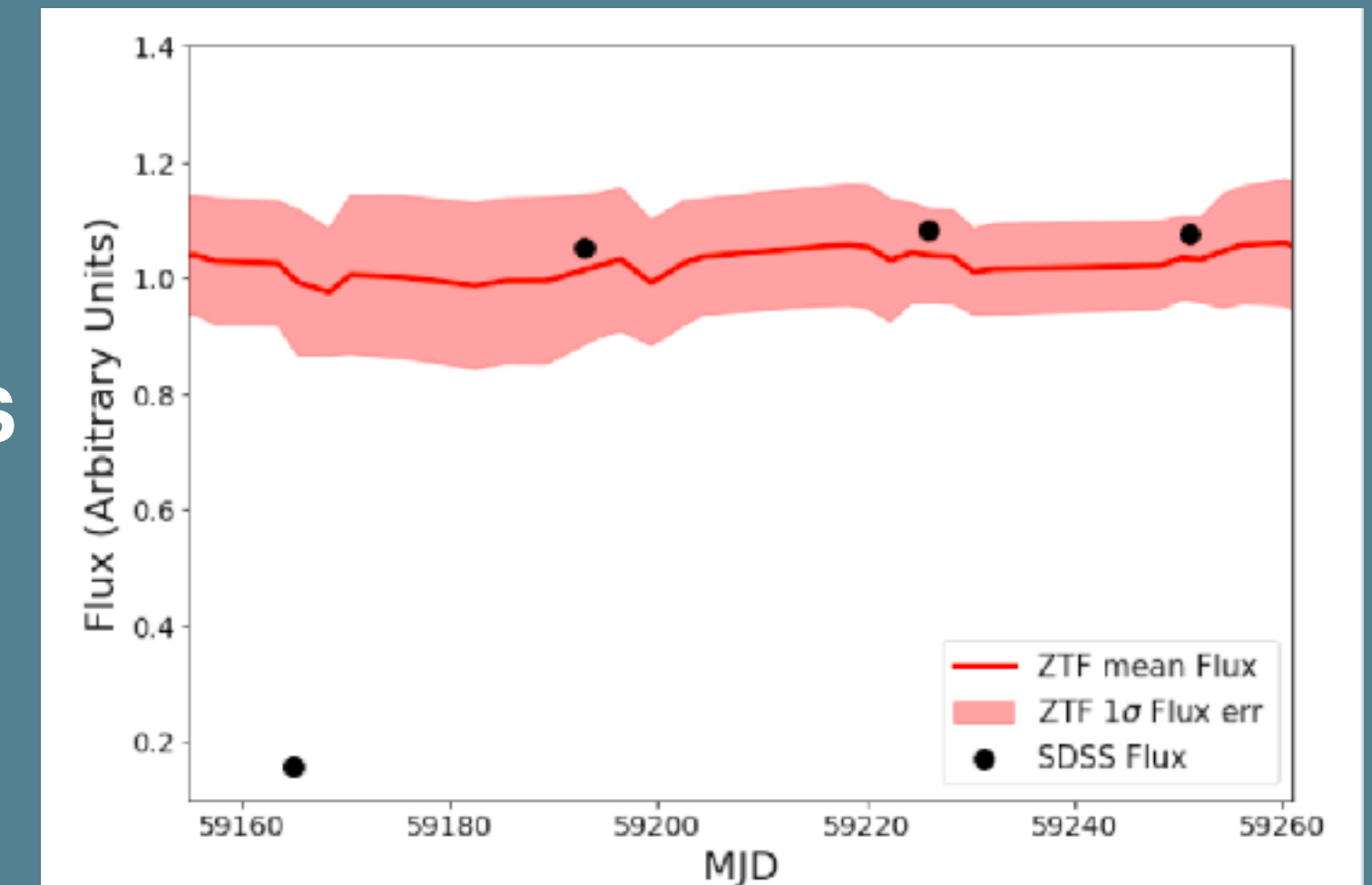
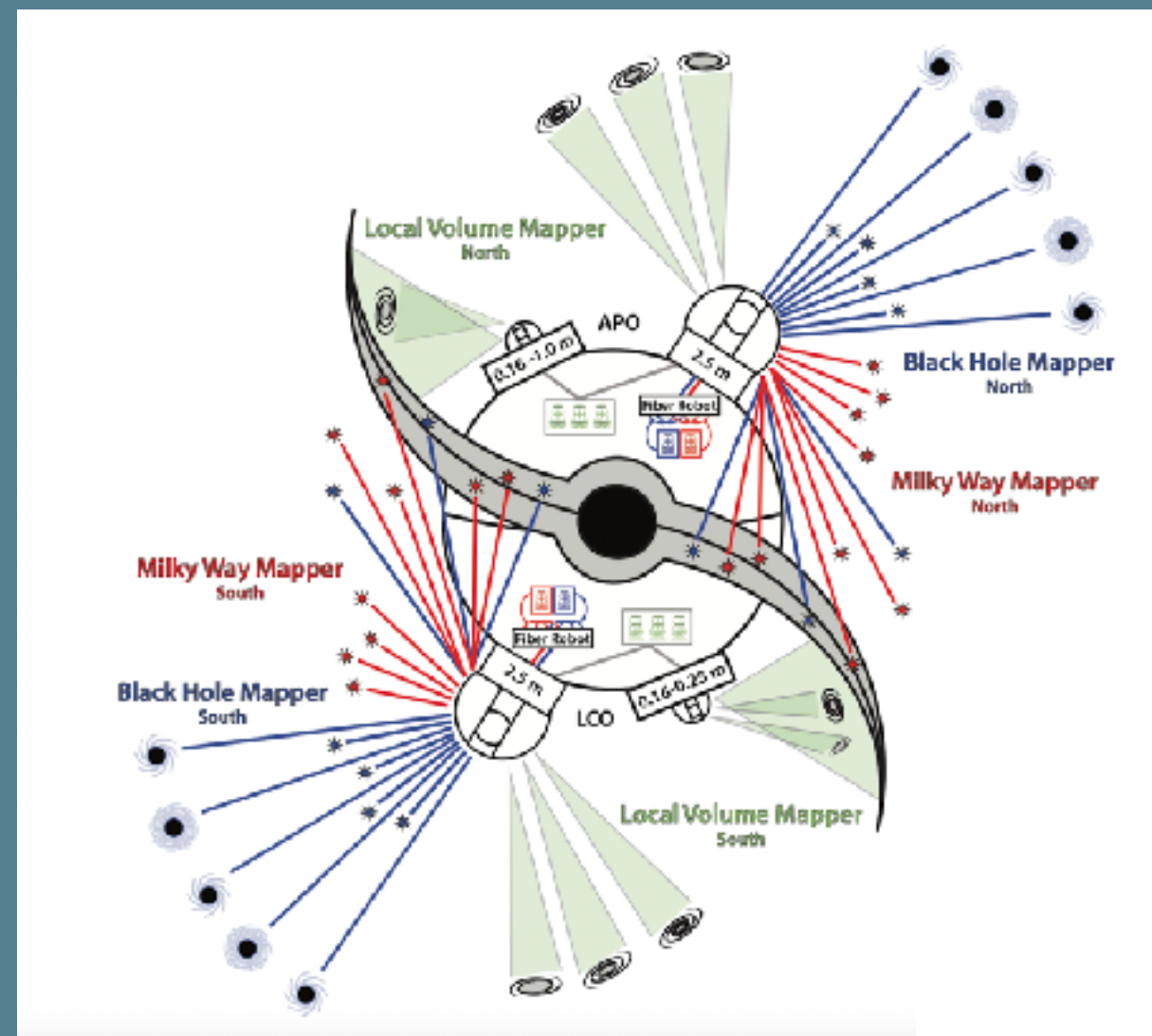


SPECTROSCOPIC SURVEY HIGHLIGHTS: SDSS-V BHM

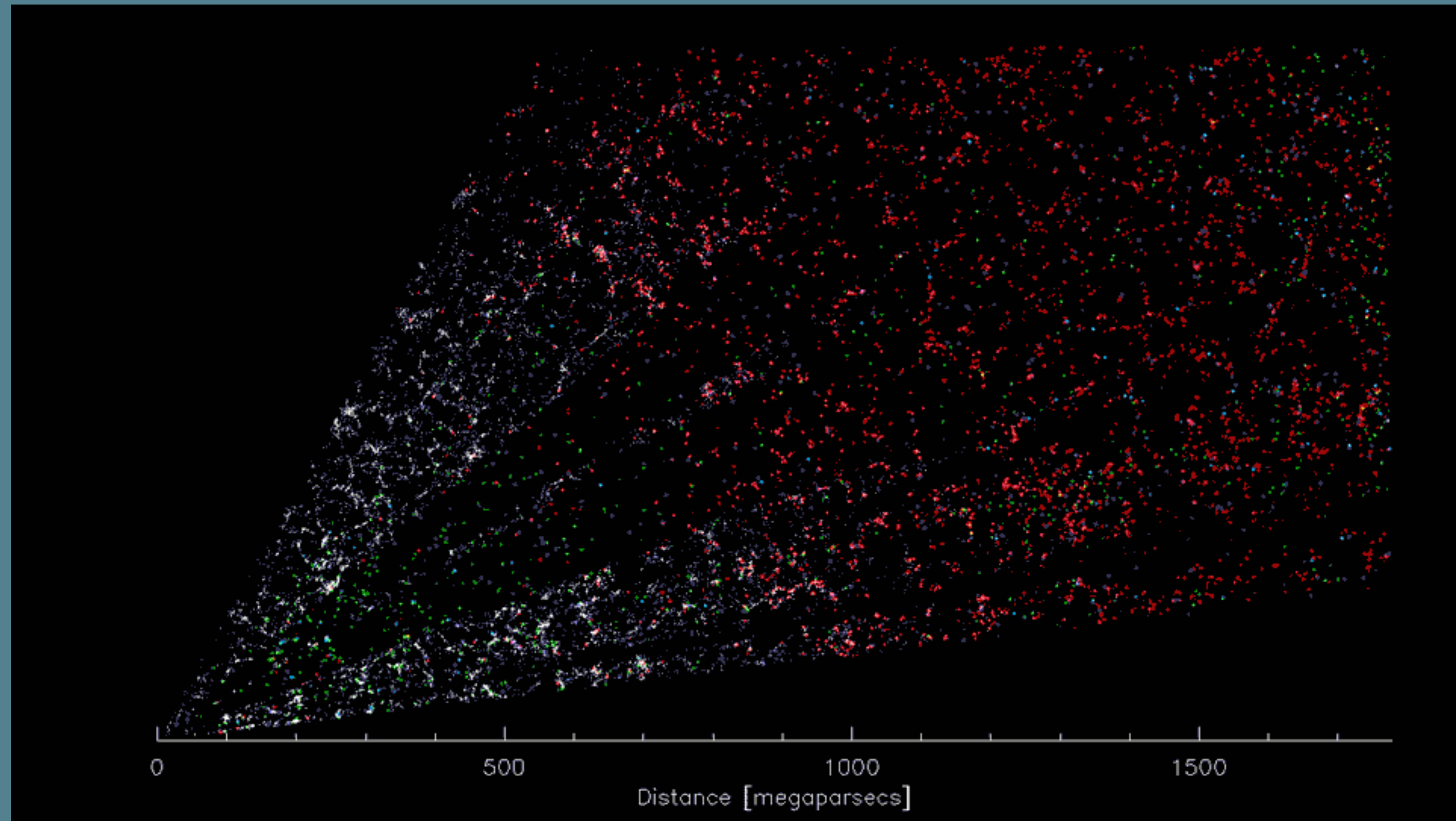
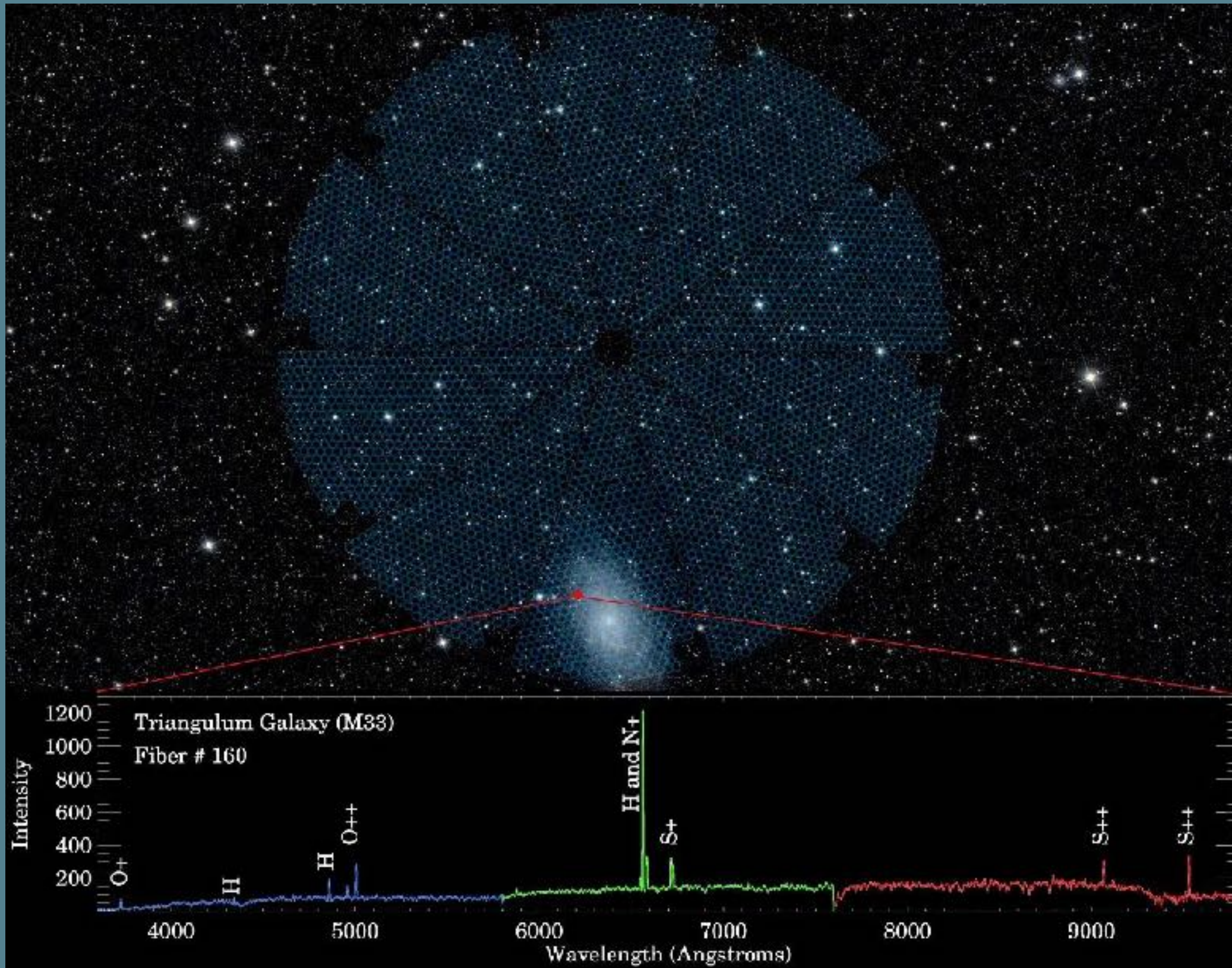
- AQMES: All-Quasar Multi-Epoch Spectroscopy
- Reverberation Mapping (\neq SDSS-III RM Project)
- Spiders: SPECTroscopic IDentification of ERosita Sources
- SCS: Chandra Source Catalog

18th DRs contains SDSS-V spectra

First results: Grisha Zeltyn (see talk tomorrow)
Santiago Bernal (see poster)



SPECTROSCOPIC SURVEY HIGHLIGHTS: DESI



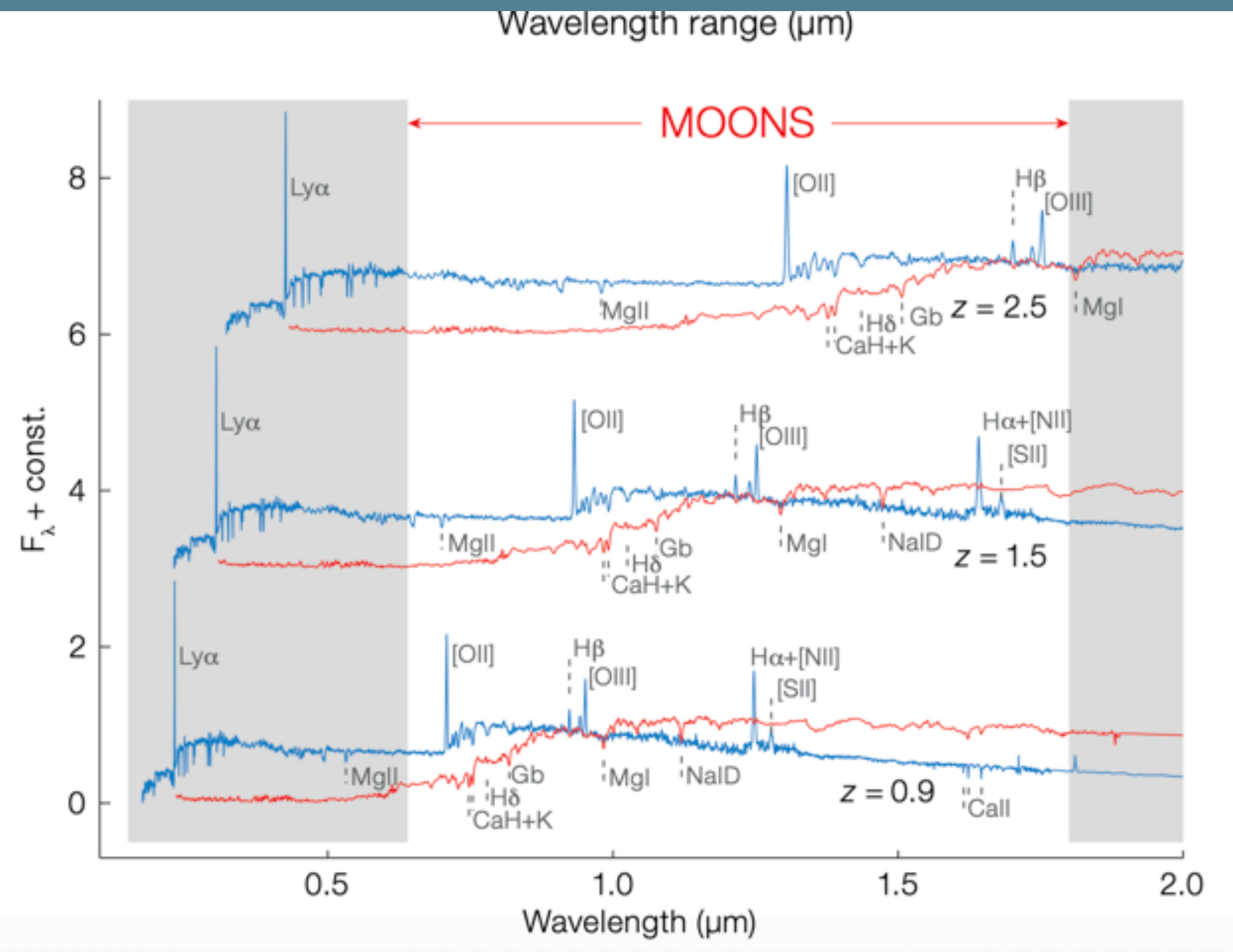
DESI Early Data Release contains 2M spectra from the Survey Validation phase of galaxies, quasars and stars

DESI Press Release 2022

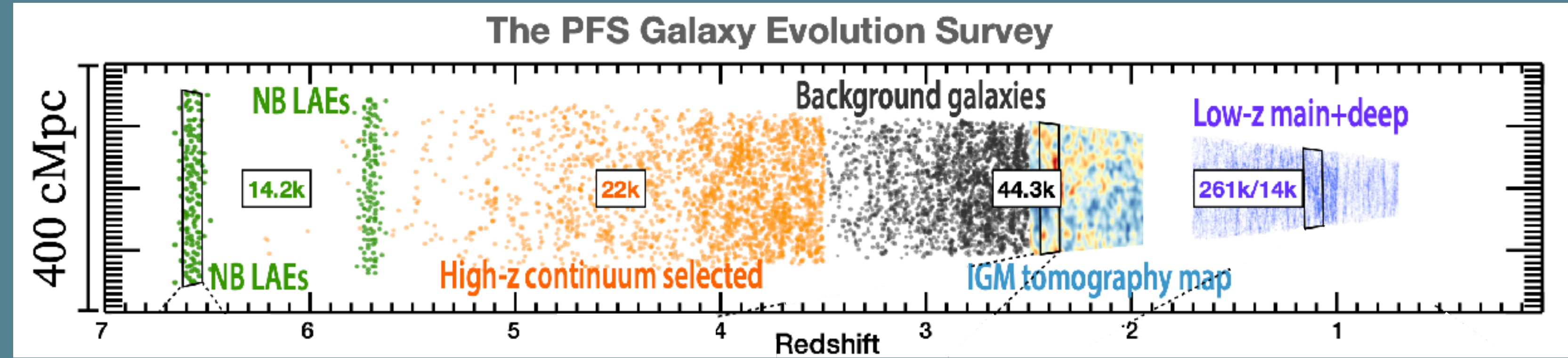
DESI targets have been selected from the Legacy Surveys (DECaLS, BASS and MzLS)

SPECTROSCOPIC SURVEY HIGHLIGHTS: MOONS & PFS

8m-class: MOONS (VLT) / PFS (Subaru)

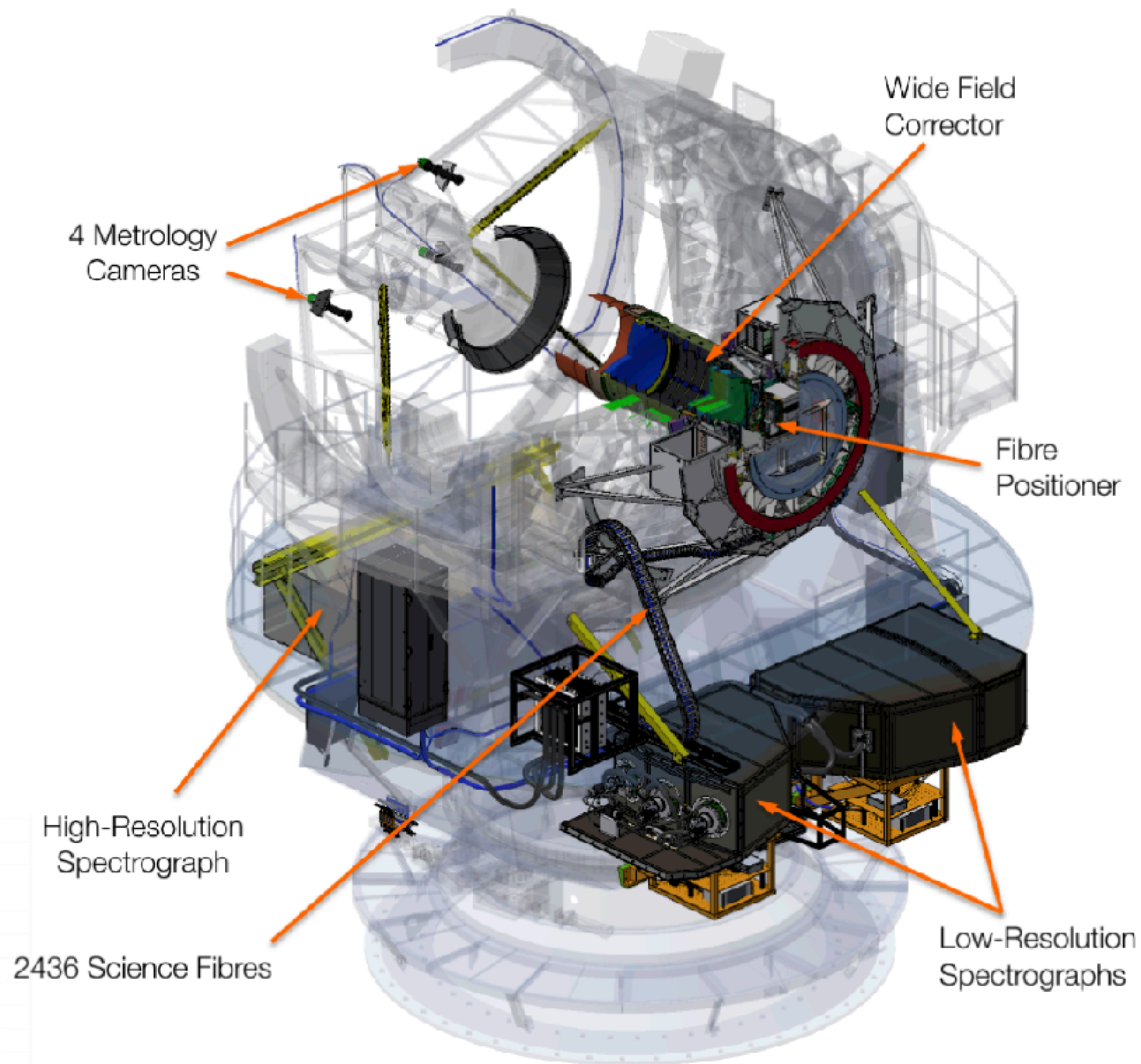


Maiolino+2020



Greene+2022

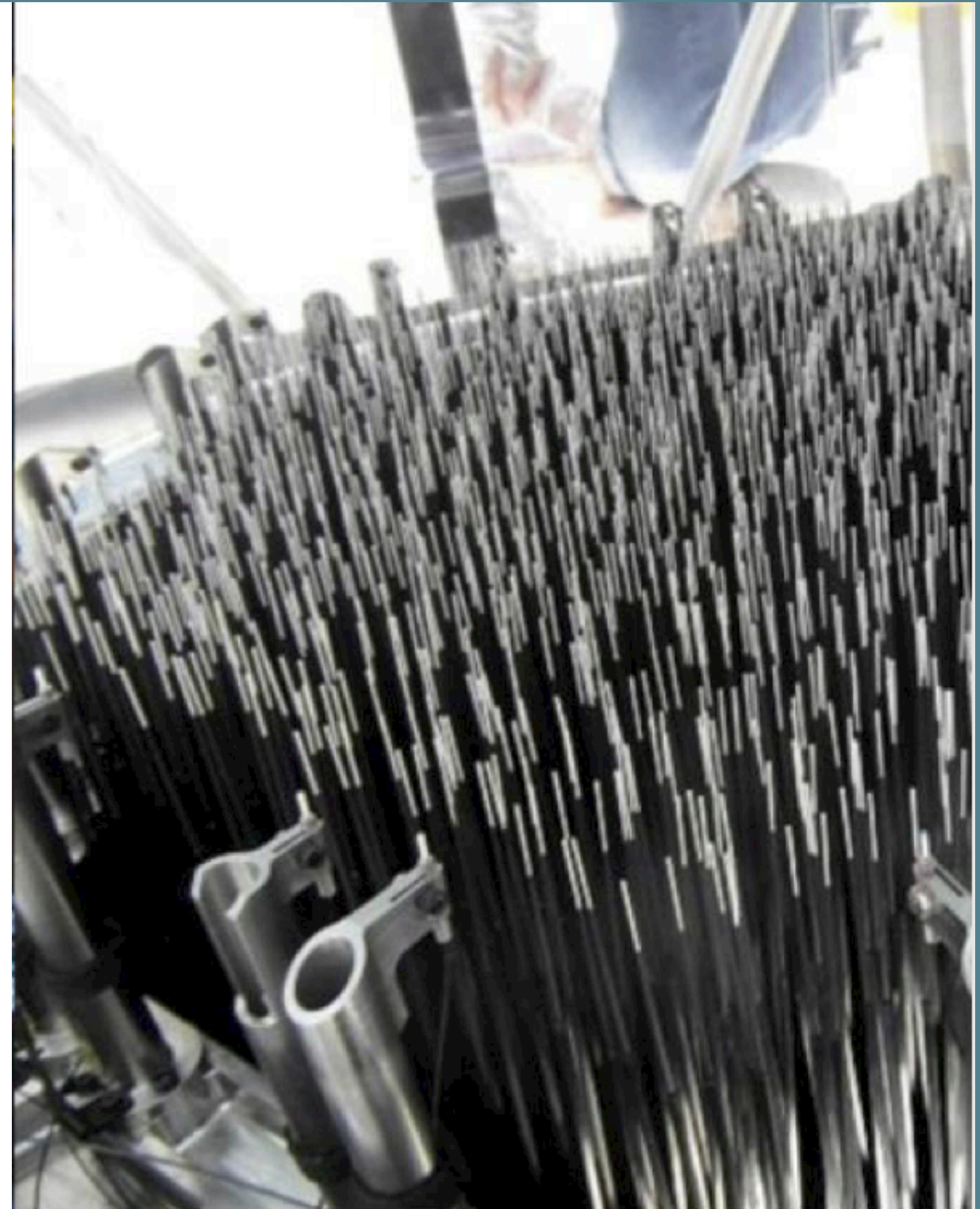
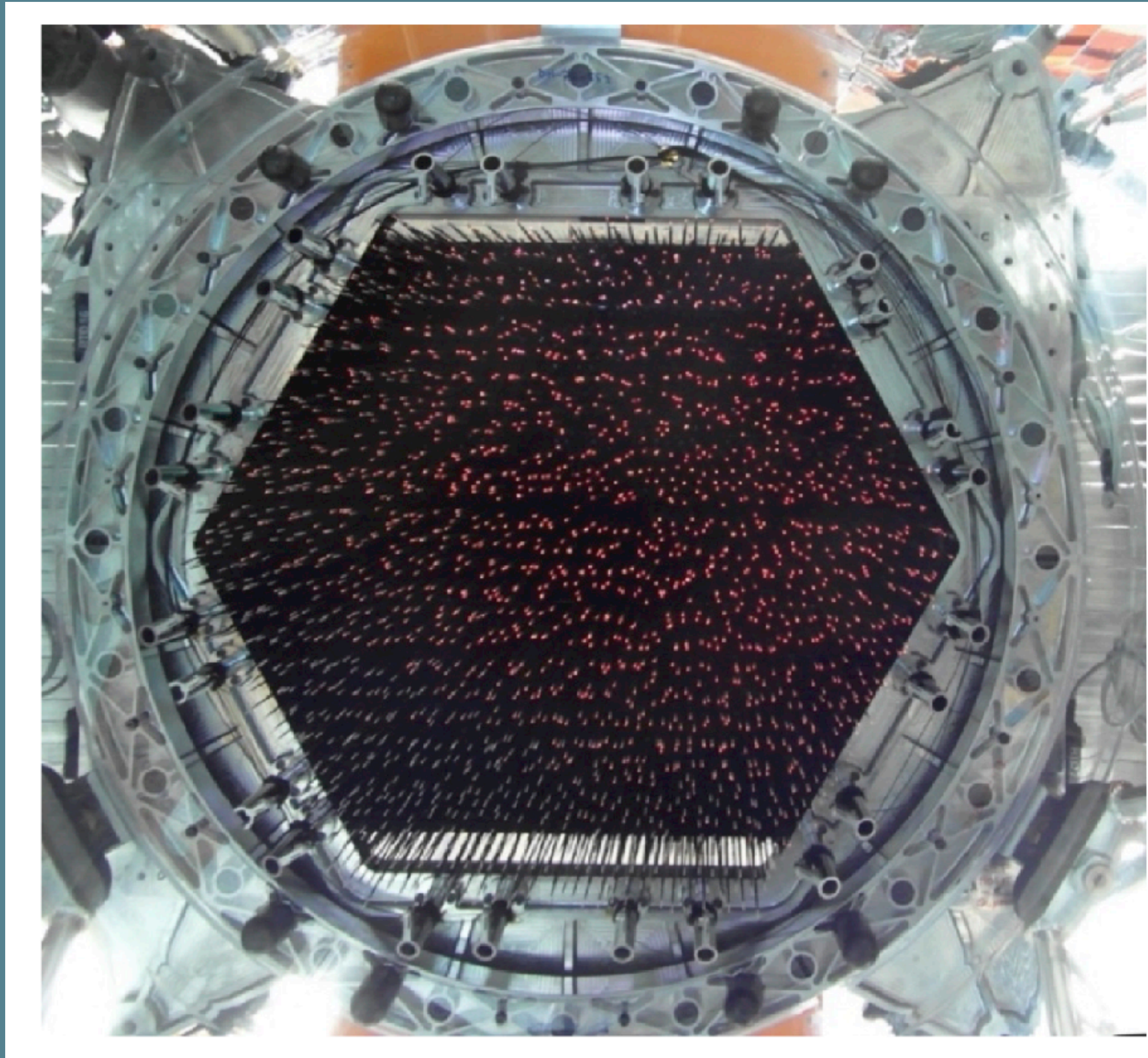
THE 4M MULTI-OBJECT-SPECTROSCOPIC-TELESCOPE (4MOST)



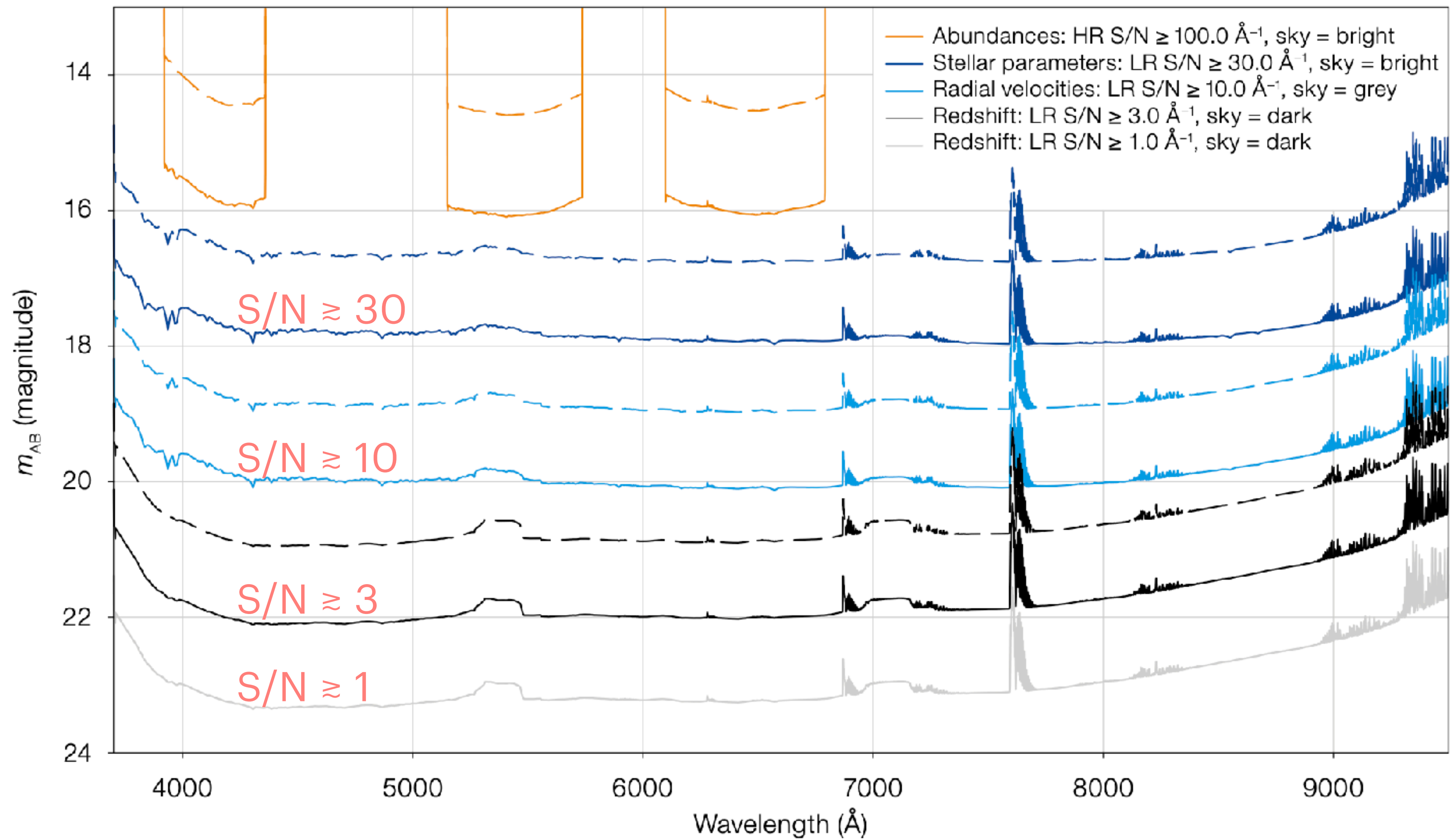
Low Resolution Spectrographs (2x)	Passband: 370-950nm $R > \lambda \times 10$ for $400\text{nm} < 500\text{nm}$ $R > 6000$ for $500\text{nm} < 885\text{nm}$ Velocity Accuracy < 1 km/s 1624 fibres in total
High Resolution Spectrograph	Passbands: 392.6-435.5, 516-573, 610-679 nm $R > 18,500$ Velocity Accuracy < 1 km/s 812 fibres

- In a 5-year survey 4MOST **observations will:**
- Cover at least twice an area of $\approx 16,000$ degree² (goal $> 20,000$) ($\sim 4\pi/2$)
 - Obtain > 15 million (goal > 25 million) spectra at resolution $R \sim 5000$
 - Obtain > 1 million (goal > 2 million) spectra at resolution $R \sim 20,000$.

4MOST



4MOST



4MOST

Consortium Surveys (70%)

- Milky Way Halo LR Survey
 - Milky Way Halo HR Survey
 - Milky Way Disk and Bulge LR Survey
 - Milky Way Disk and Bulge HR Survey
 - Galaxy Clusters Survey
 - AGN Survey
 - Galaxy Evolution Survey (WAVES)
 - Cosmology Redshift Survey
 - Magellanic Clouds Survey
 - Time-Domain Extragalactic Survey (TIDES)
- Irwin (IoA) , Helmi (RuG)
Christlieb (ZAH)
Chiappini, Minchev, Starkenburg (AIP)
Bensby (LU), Bergemann (MPIA)
Finoguenov (MPE)
Merloni (MPE)
Driver (UWA), Liske (UHH)
Kitaura (AIP), Richard (CRAL), Kneib (EPFL)
Cioni (AIP)
Sullivan (Southampton)

Community Surveys (30%)

- 1 Toloza, O. et al. – The White Dwarf Binary Survey (WDB)
- 2 Sacco, G. G. et al. – The 4MOST Survey of Young Stars (4SYS)
- 3 Ibata, R. et al. – 4MOST Gaia RR Lyrae Survey (4GRoundS)
- 4 Lucatello, S. et al. – Stellar Clusters in 4MOST
- 5 Pawlak, M. et al. – Spectroscopic Discovery of Binaries with Dormant Black Holes
- 6 Skúladóttir, Á. et al. – The 4MOST Survey of Dwarf Galaxies and their Stellar Streams (4DWARFS)
- 7 Iovino, A. et al. – Stellar Population Survey Using 4MOST (4MOST-StePS)
- 8 Duncan, K. et al. – Optical, Radio Continuum and HI Deep Spectroscopic Survey (ORCHIDSS)
- 9 Gruen, D. et al. – 4MOST Complete Calibration of the Colour-Redshift Relation (4C3R2)
- 10 Haines, C. et al. – CHANCES: A CHileAN Cluster galaxy Evolution Survey
- 11 Bauer, F. E. et al. – Chilean AGN/Galaxy Extragalactic Survey (ChANGES)
- 12 Krogager, J.-K. et al. – The 4MOST–Gaia Purely Astrometric Quasar Survey (4G-PAQS)
- 13 Peroux, C. et al. – Transform our Understanding of the Baryon Cycle with High-Resolution Quasar Spectroscopy (ByCycle)
- 14 Taylor, E. N. et al. – The 4MOST Hemisphere Survey of the Nearby Universe (4HS)
- 15 Collett, E. T. et al. – The 4MOST Strong Lensing Spectroscopic Legacy Survey (4SLSLS)

CHILEAN AGN / GALAXIES EXTRAGALACTIC SURVEY (CHANGES)

4MOST Community Survey time: ~ 2 Mhrs of low-resolution spectroscopy for a representative sample of **variability and SED selected AGN**

Variability selection:

Currently ZTF + La Silla-Quest (LS4)

In the future: Rubin LSST survey

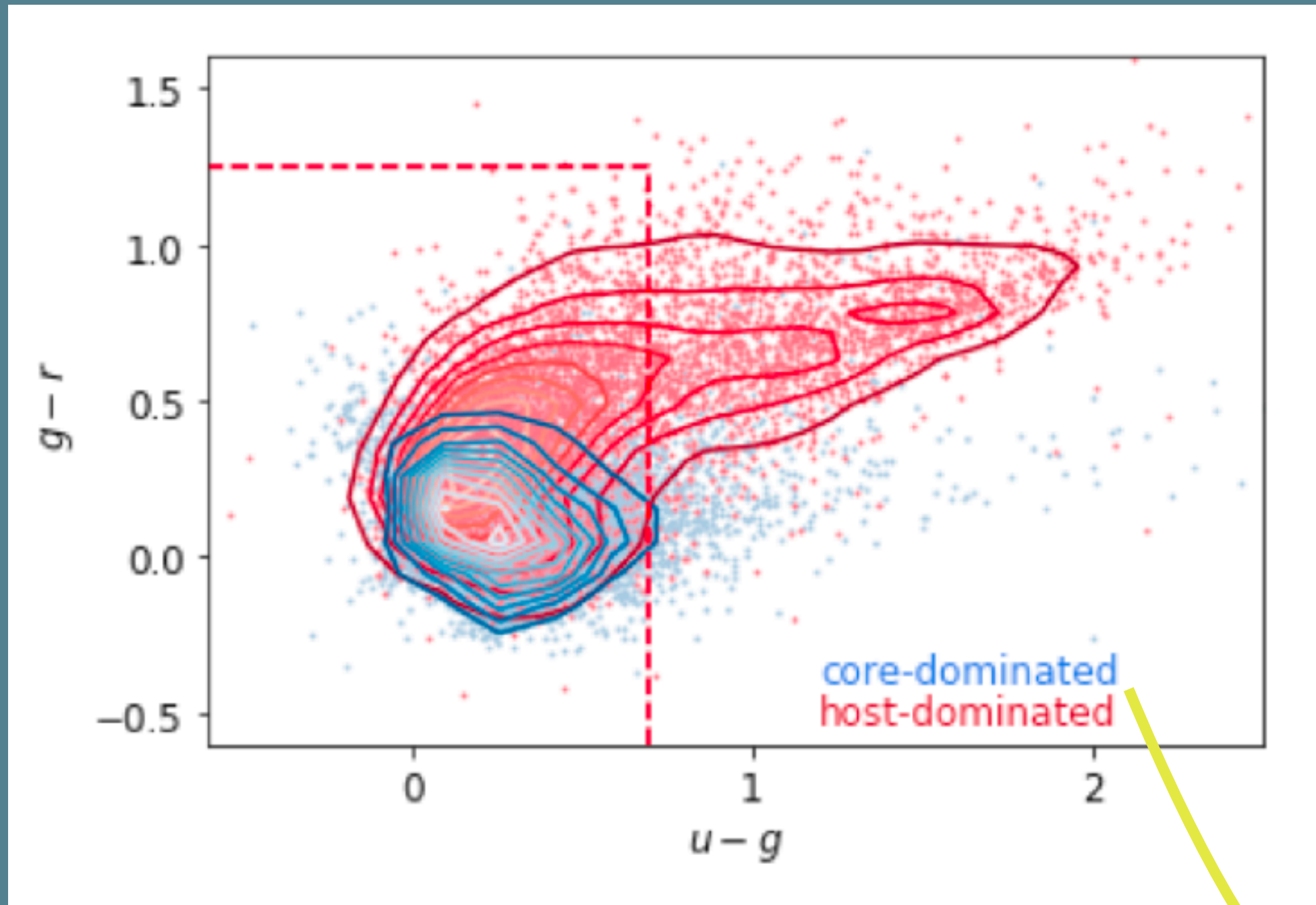
SED selection:

Optical-NIR-MIR SED modeling to look for warm dust

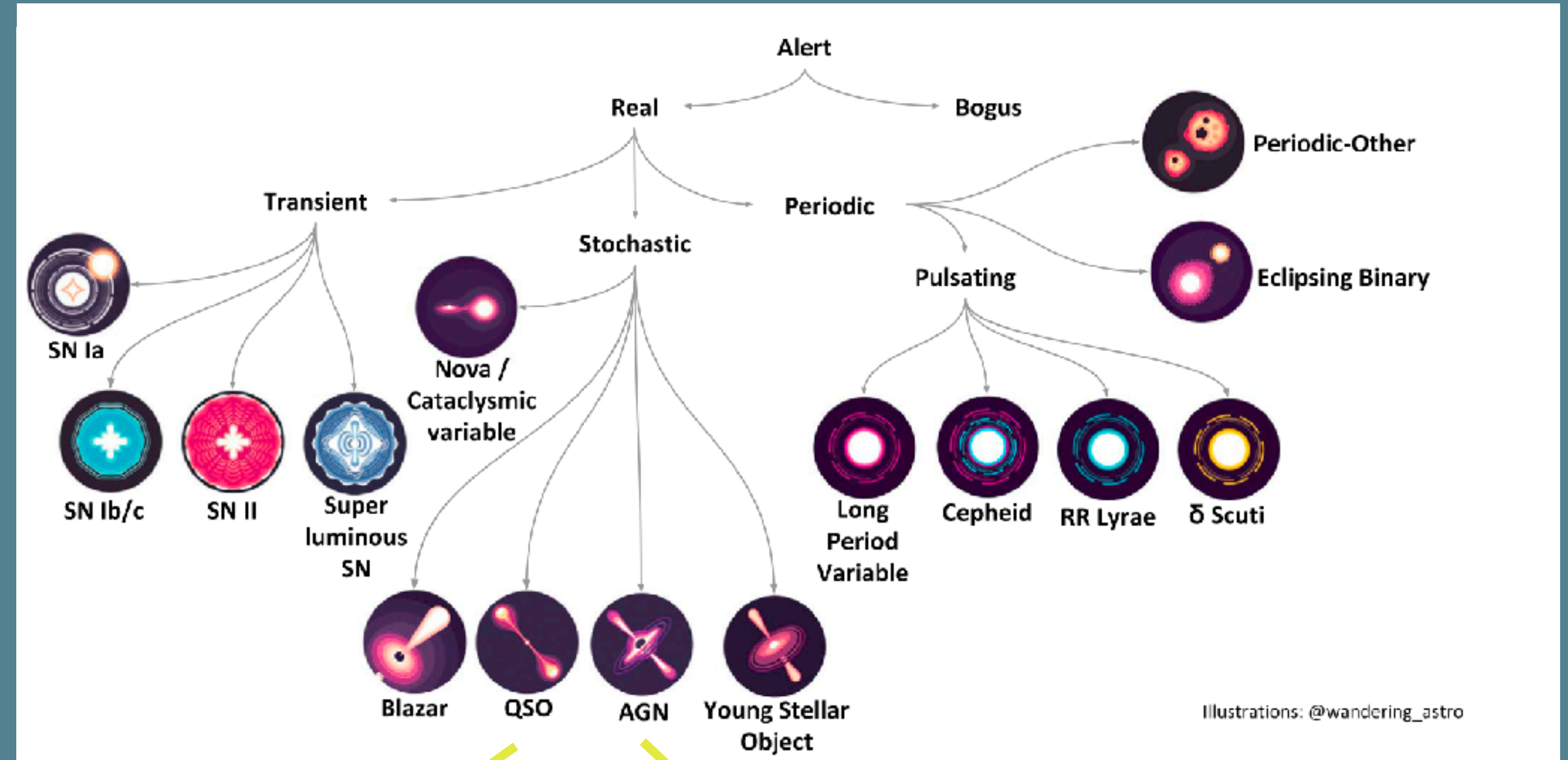
+ Changing Look / State AGN, TDEs, Lensing, Intervening QALs + **Repeat Visits**

CHILEAN AGN / GALAXIES EXTRAGALACTIC SURVEY (CHANGES)

Variability selection:



Random forest algorithm to classify light curves



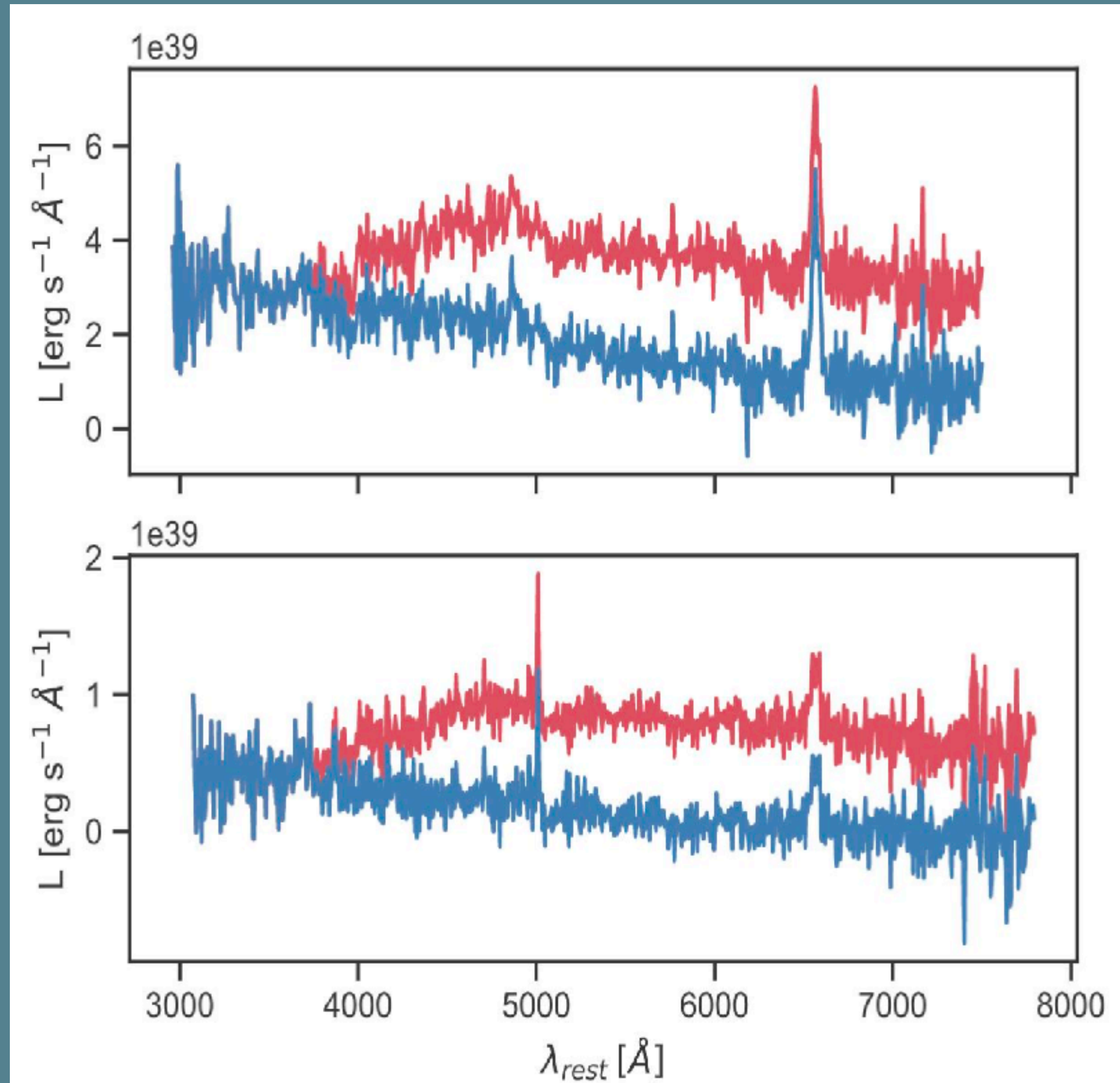
core-dominated

host-dominated

Sánchez-Sáez+2021

CHILEAN AGN / GALAXIES EXTRAGALACTIC SURVEY (CHANGES)

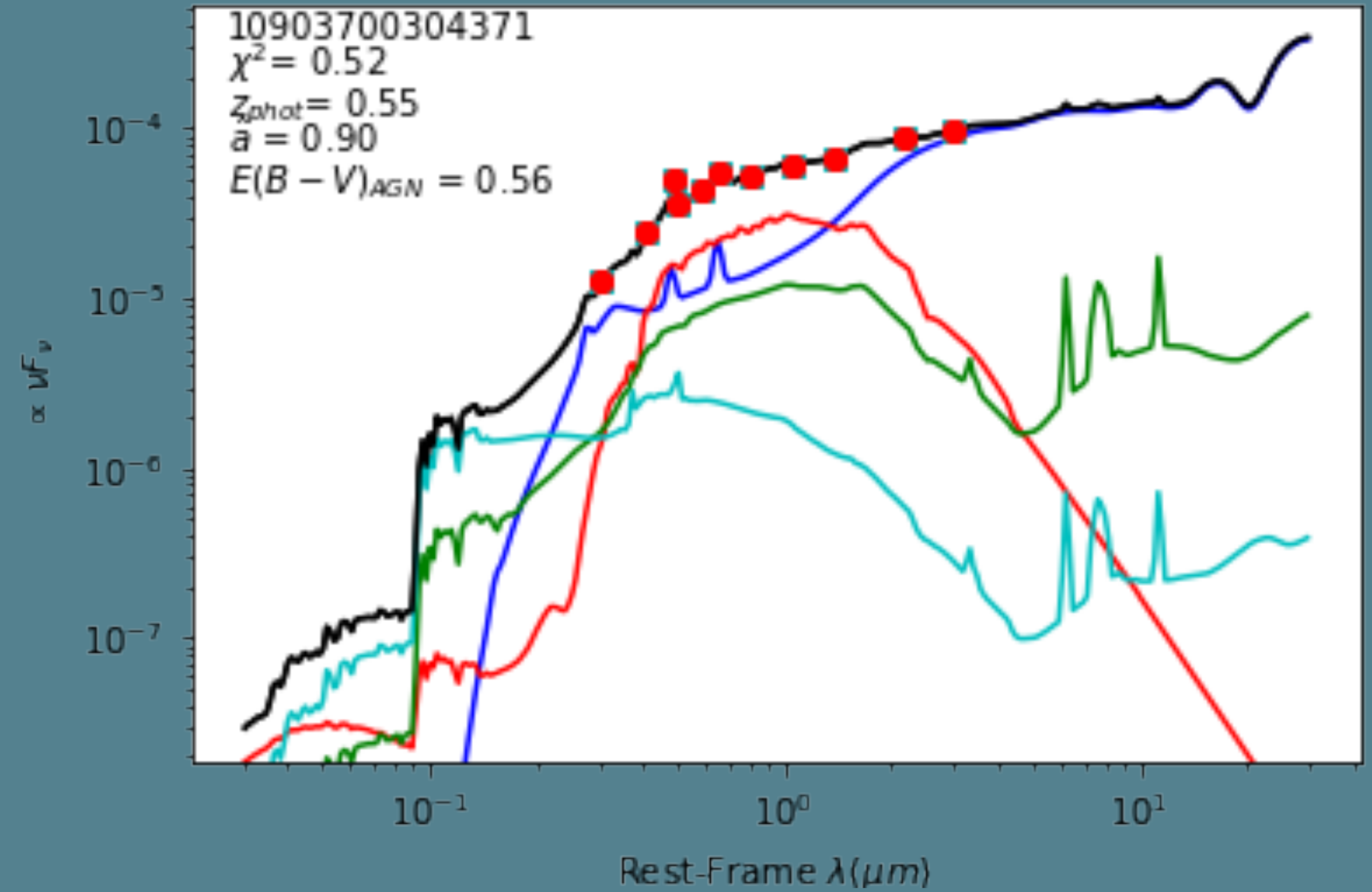
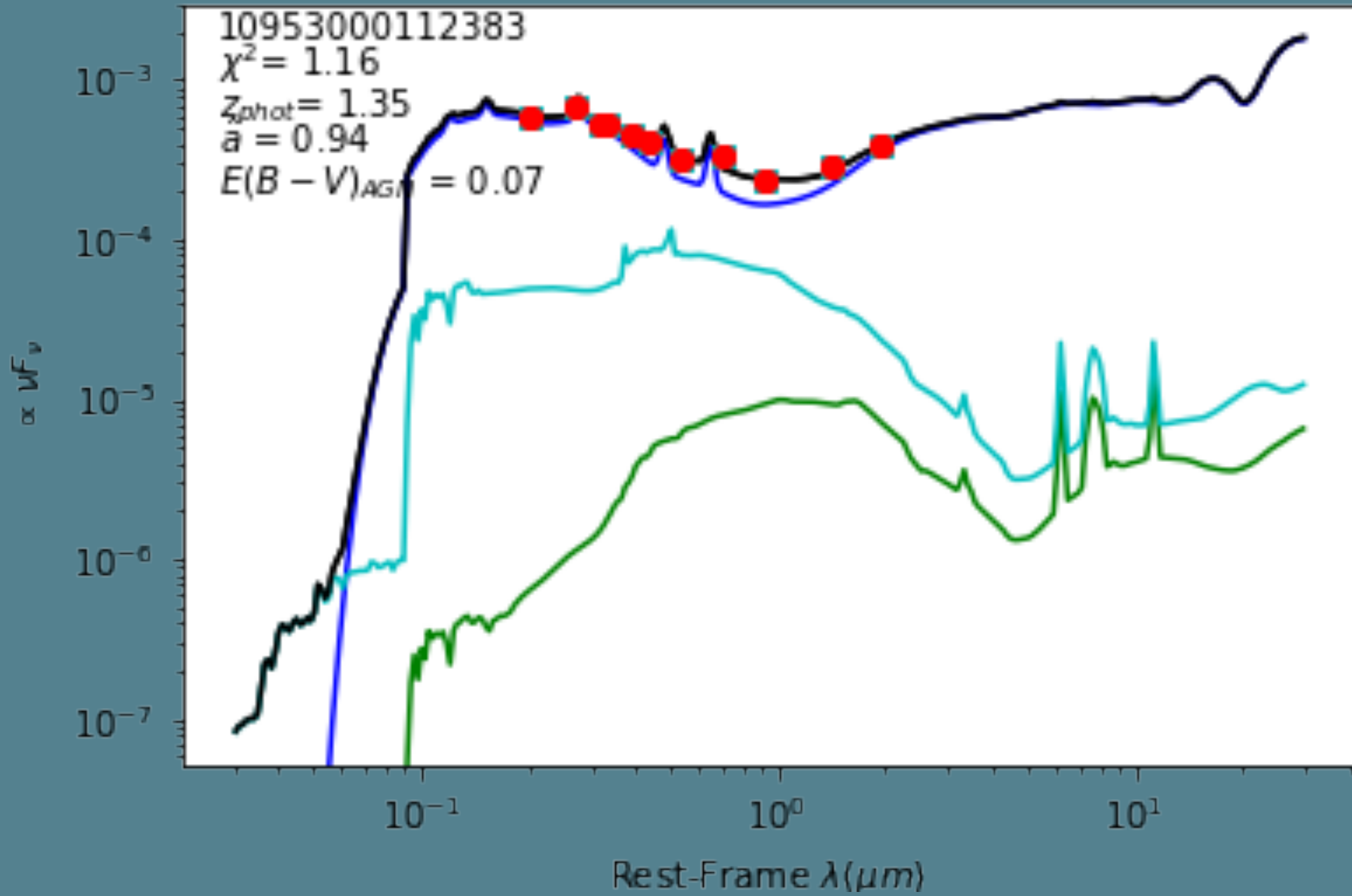
Variability selection:



Sánchez-Sáez+2019

CHILEAN AGN / GALAXIES EXTRAGALACTIC SURVEY (CHANGES)

SED selection:



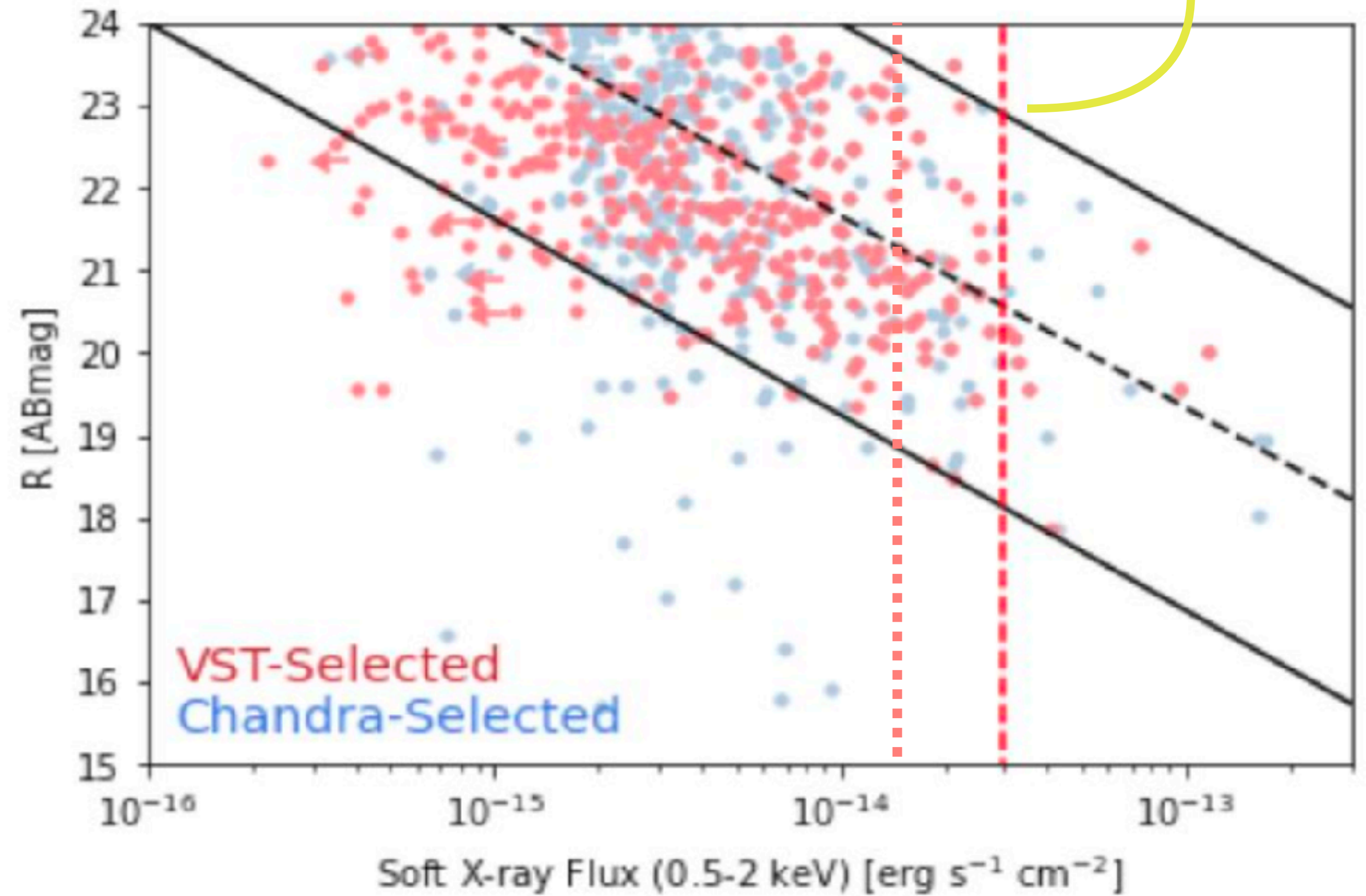
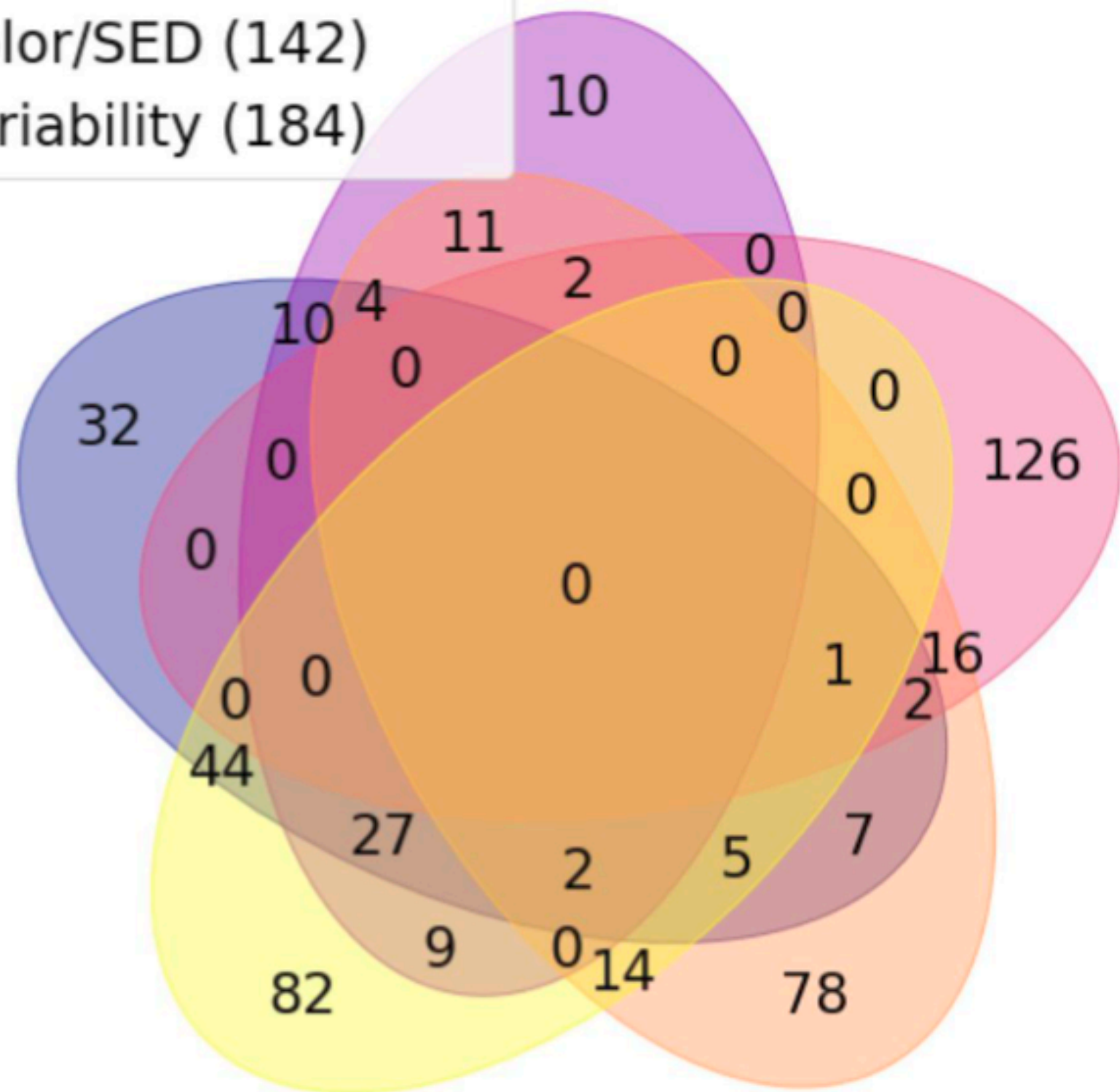
DATA: Delve (DECam grizy) - VHS/Viking (VISTA YJHKs) - catWISE (W1 W2)

CHILEAN AGN / GALAXIES EXTRAGALACTIC SURVEY (CHANGES)

Overlap with eROSITA GTO AGN Survey

eRosita

- eROSITA X-ray (134)
- WISE MIR (75)
- Radio (147)
- Color/SED (142)
- Variability (184)



WIDE AGN Distribution ($R < 22.5$) cut: 482 AGN/deg²

Adapted from De Cicco+2021

Main Deliverables:

BH accretion rate densities, evolution and host synergies for moderately accreting AGN ($10^{-4} < L/L_{\text{Edd}} < 10^{-1}$) that comprises ~ 50–80% of the estimated total mass accretion onto BHs in type 1 and mildly obscured AGN that strongly complements other 4MOST AGN samples.
