HETDEX LOFAR Spectroscopic Redshift Catalog

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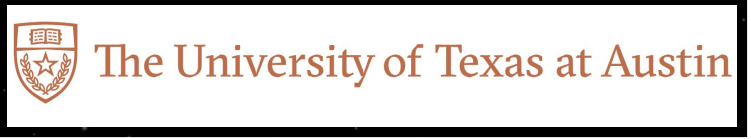


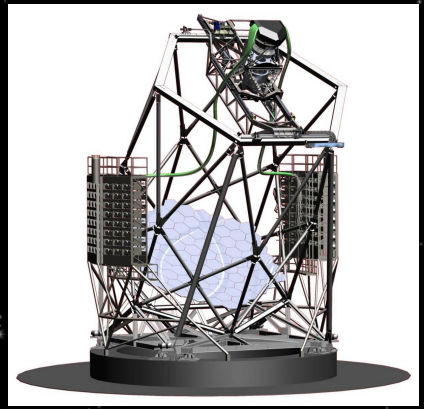
LOFAR Family Meeting 2024

01

HETDEX

HETDEX

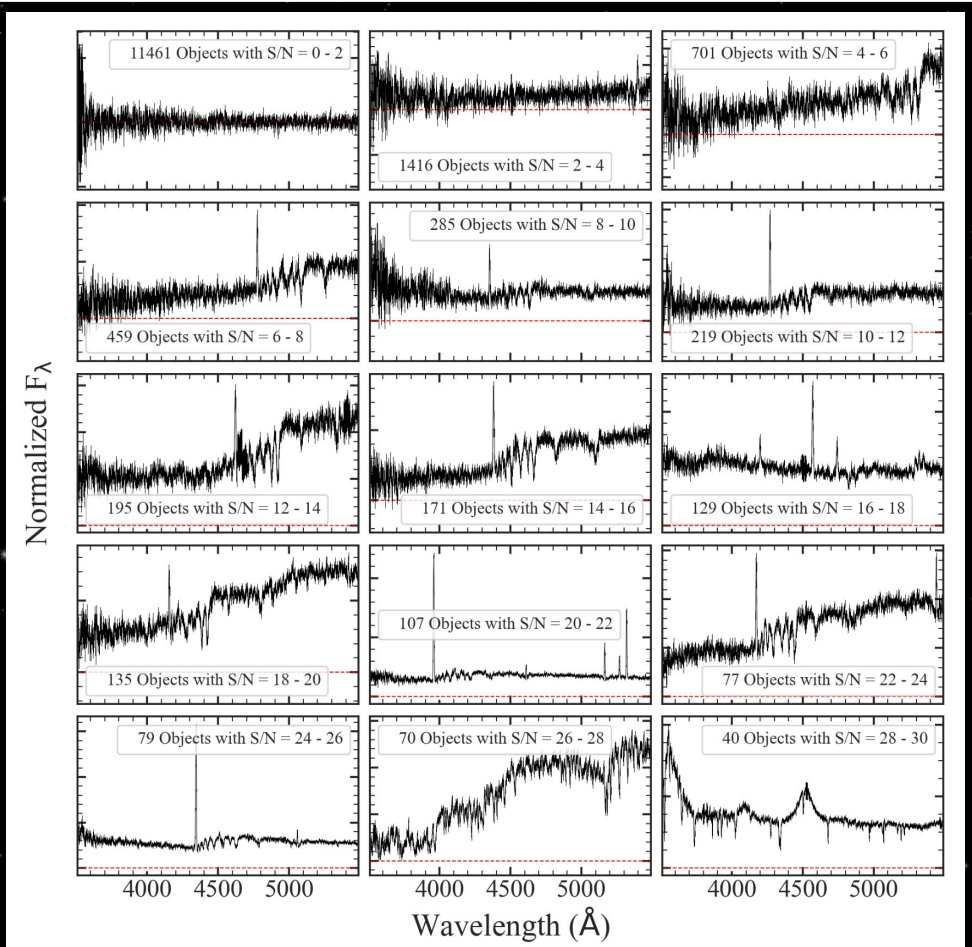
- **H**obby **E**berly **T**elescope **D**ark **E**nergy E**X**periment
- 10 m class optical telescope
- R ~ 800
- Spectroscopically studies galaxies and stars
- Joint collaboration betweenUT Austin, Penn State University, Ludwig-Maximilians-Universität München, and Georg-AugustUniversität Göttingen



Combining the LOFAR photometric radio survey and the optical spectroscopy of HETDEX/VIRUS offers characterization of key physical parameters such as spectroscopic redshift, SFR, and stellar mass.

LoTSS targeted the HETDEX Spring field due to the synergy of their key objectives

HETDEX	LoTSS
Ability to obtain [OII] redshifts up to z ~ 0.5 →	Tracking the star formation rate density using radio continuum observations
Goal to obtain emission line redshifts using Lyα at 1.9 < z < 3.5 →	Around the peak in the space density of powerful AGN Around the peak of the star formation rate and merger rate of galaxies



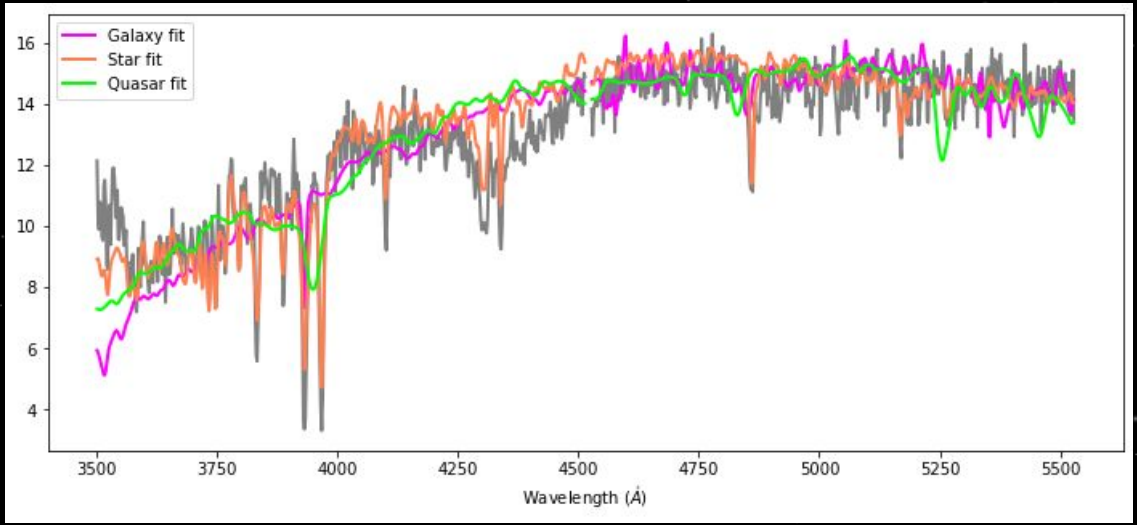
From the 325,694 sources in the first value-added LoTSS catalog, **28,705 sources** had fiber coverage in HETDEX DR4

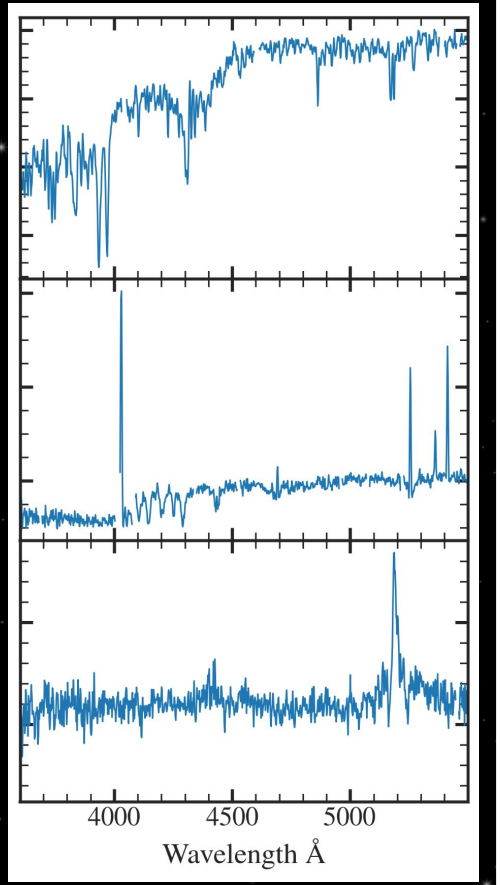
02
Classification and Redshift Assignment

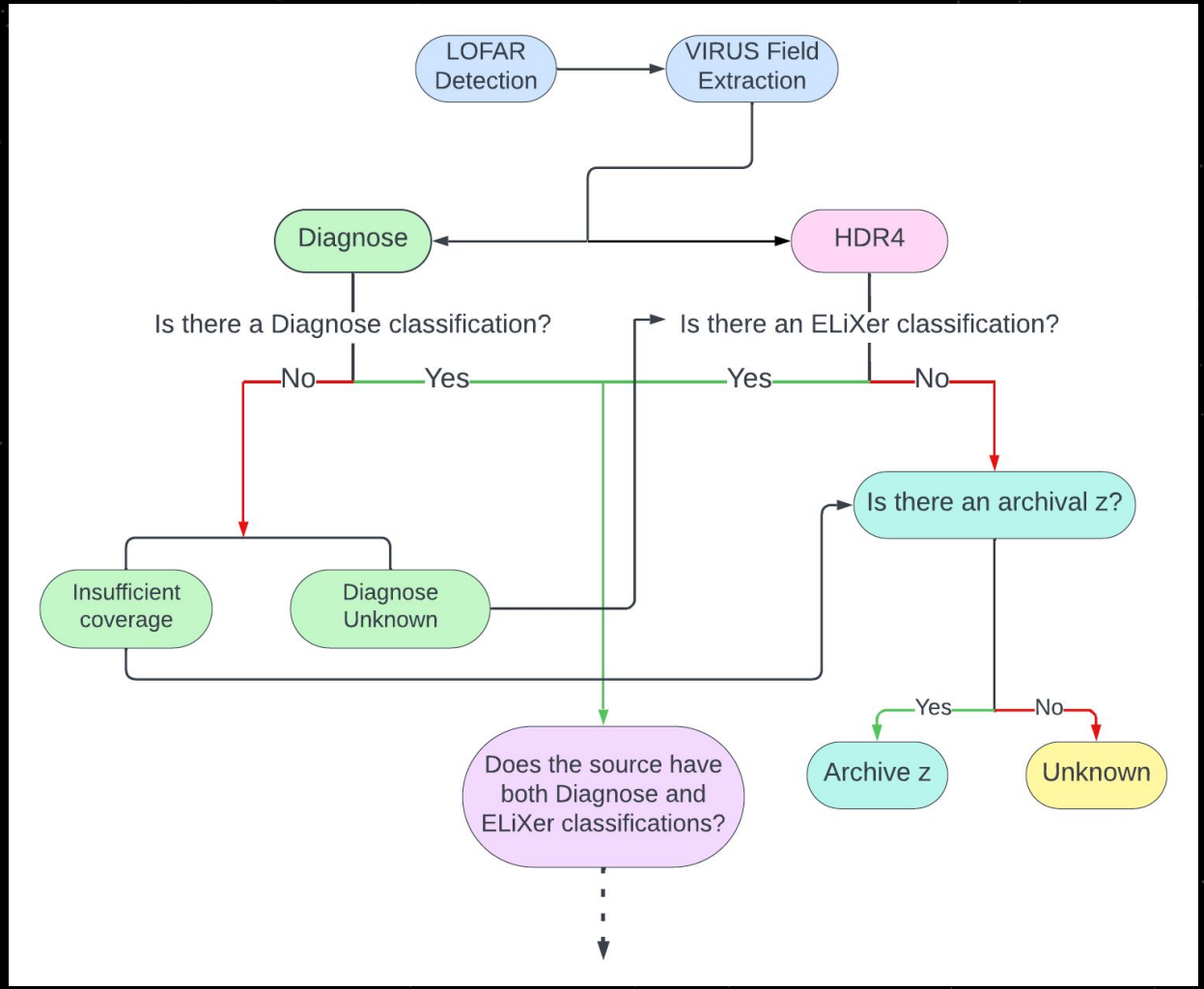
ELiXer (Davis et al. 2023)

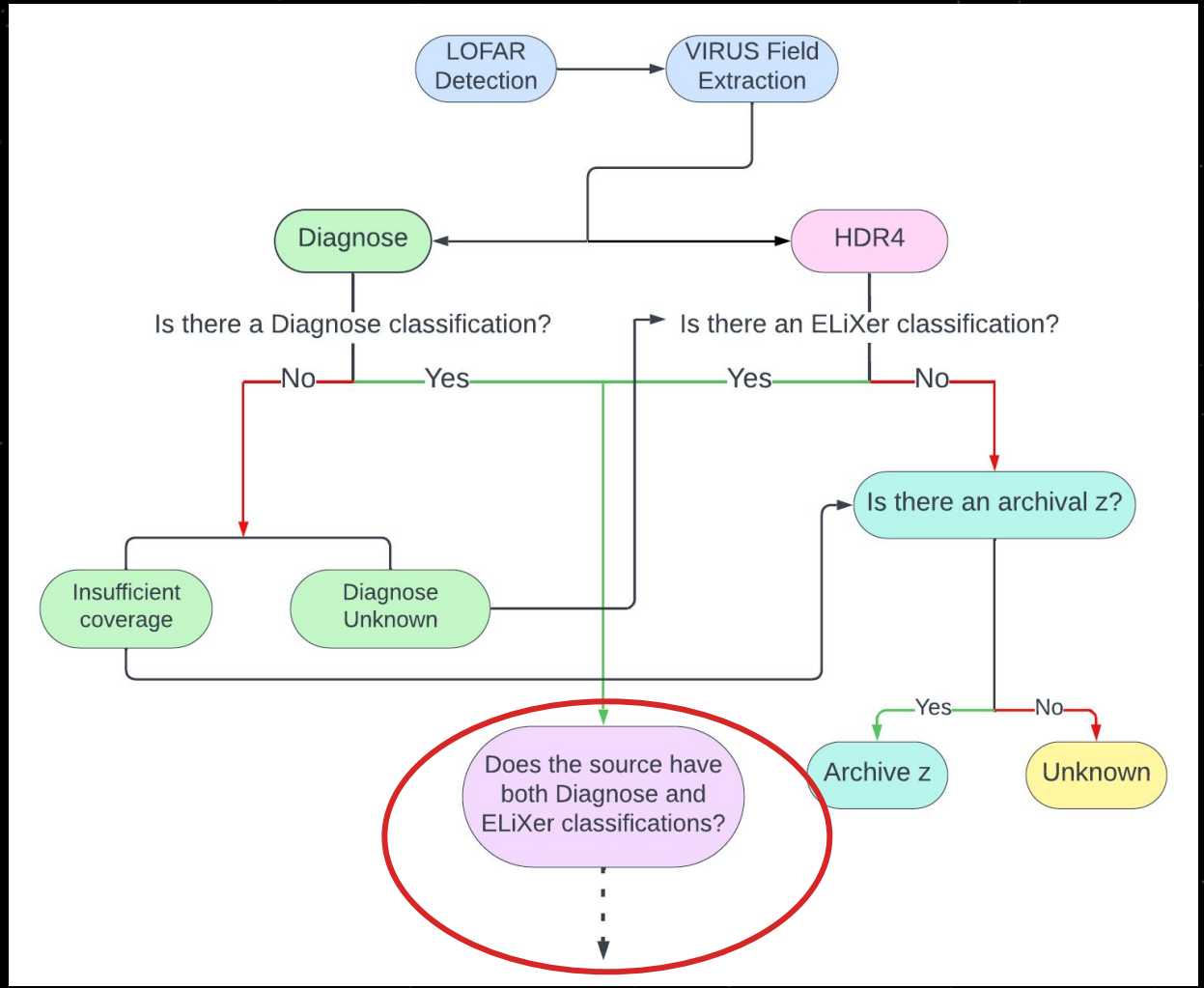
- **E**mission **L**ine e**X**plorer
- Main classifying tool for HETDEX
- Pulls out a single emission line → identifies → derives redshift
- Specifically built to distinguish LAEs (98.1% accuracy)

Diagnose assigns a classification of star, galaxy, or quasar and provides a redshift estimate

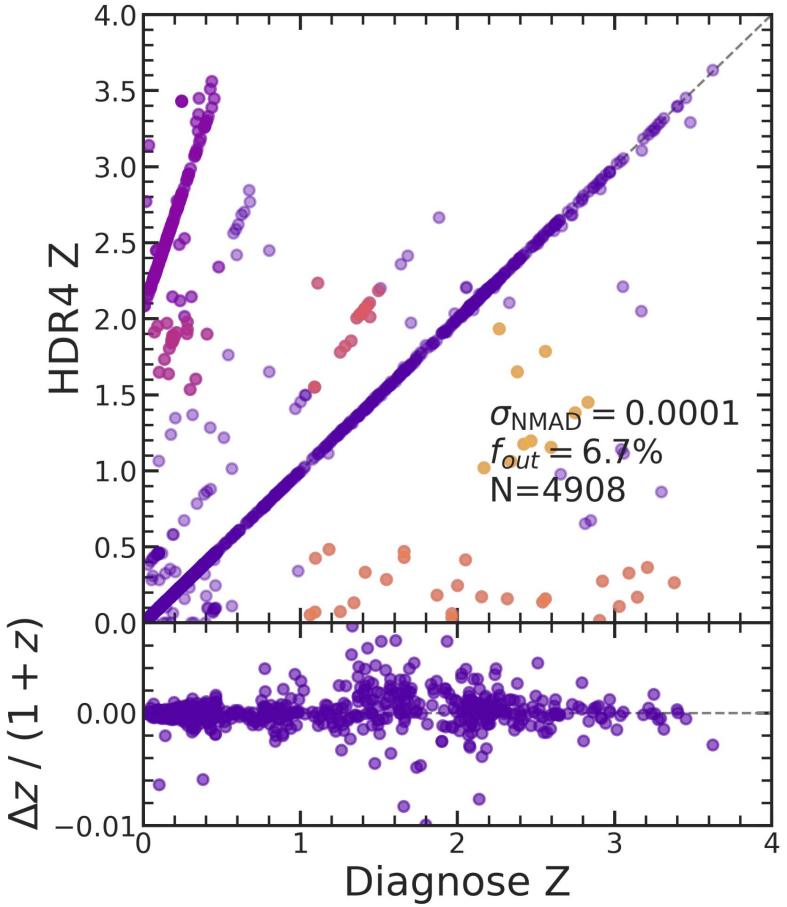


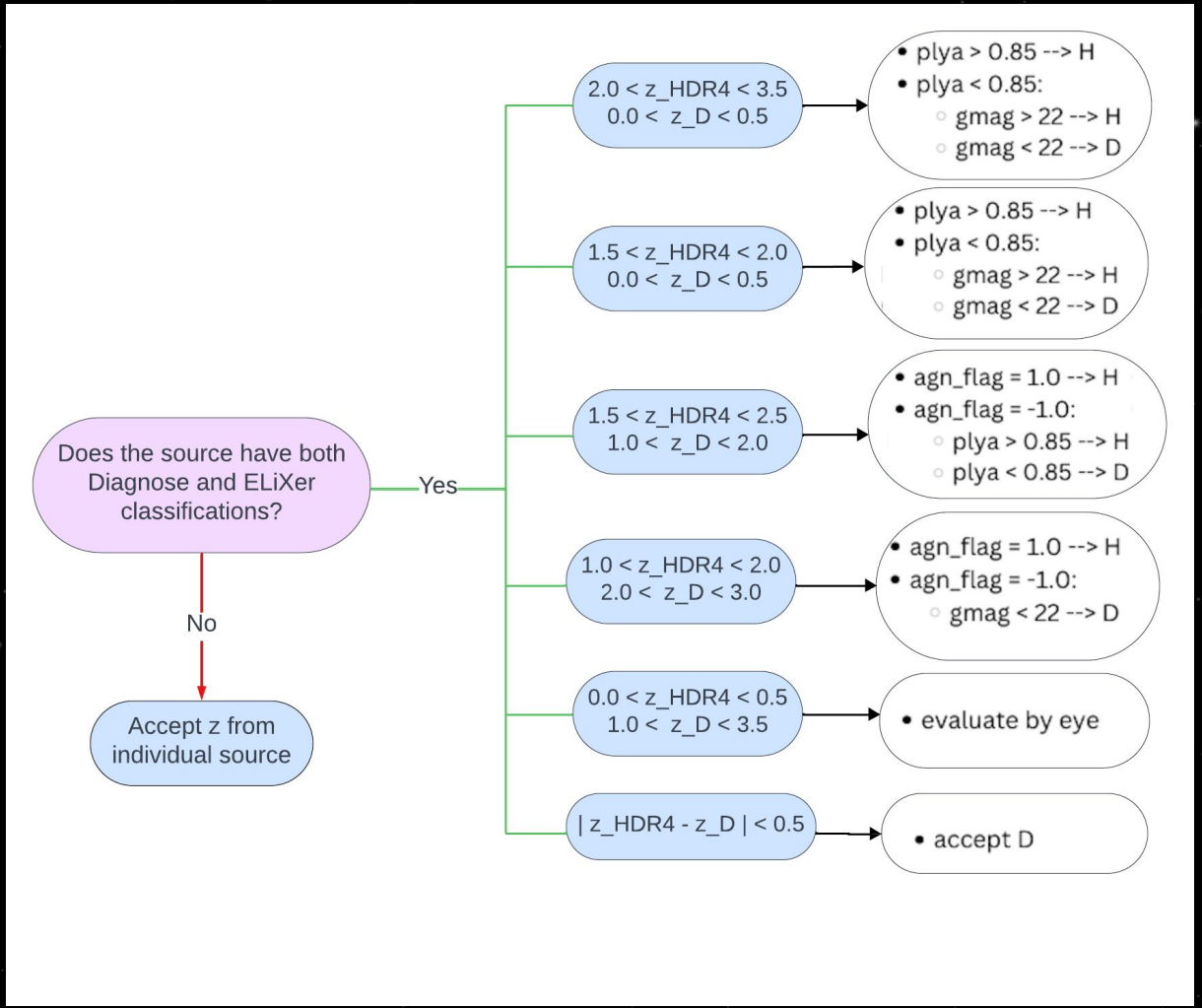



LOFAR Detection
VIRUS Field Extraction
Diagnose
HDR4
Is there a Diagnose classification?
Is there an ELiXer classification?
No
Yes
Yes
No
Insufficient coverage
Diagnose Unknown
Is there an archival z?
Yes
No
Does the source have both Diagnose and ELiXer classifications?
Archive z
Unknown


LOFAR Detection
VIRUS Field Extraction
Diagnose
HDR4
Is there a Diagnose classification?
Is there an ELiXer classification?
No
Yes
Yes
No
Is there an archival z?
Insufficient coverage
Diagnose Unknown
Yes
No
Does the source have both Diagnose and ELiXer classifications?
Archive z
Unknown

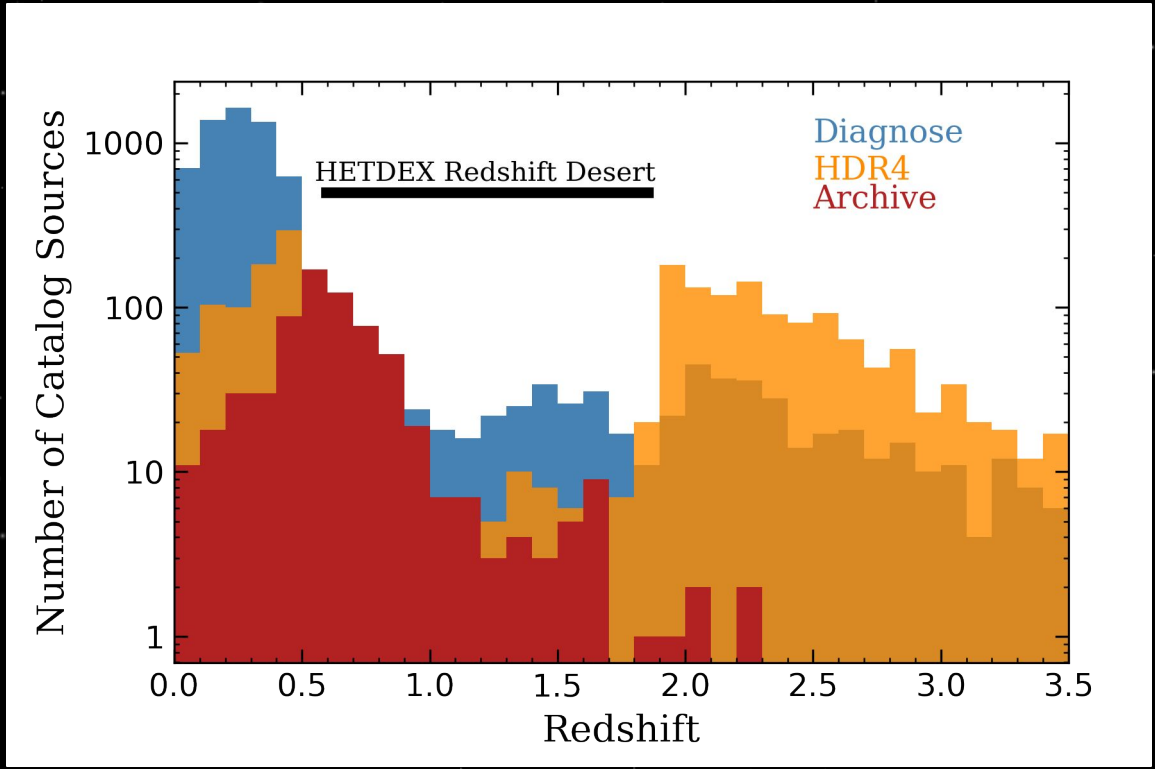
Of the 4,908 sources with both Diagnose and HDR4 redshifts, **92.3%** agree within $\Delta z < 0.05$

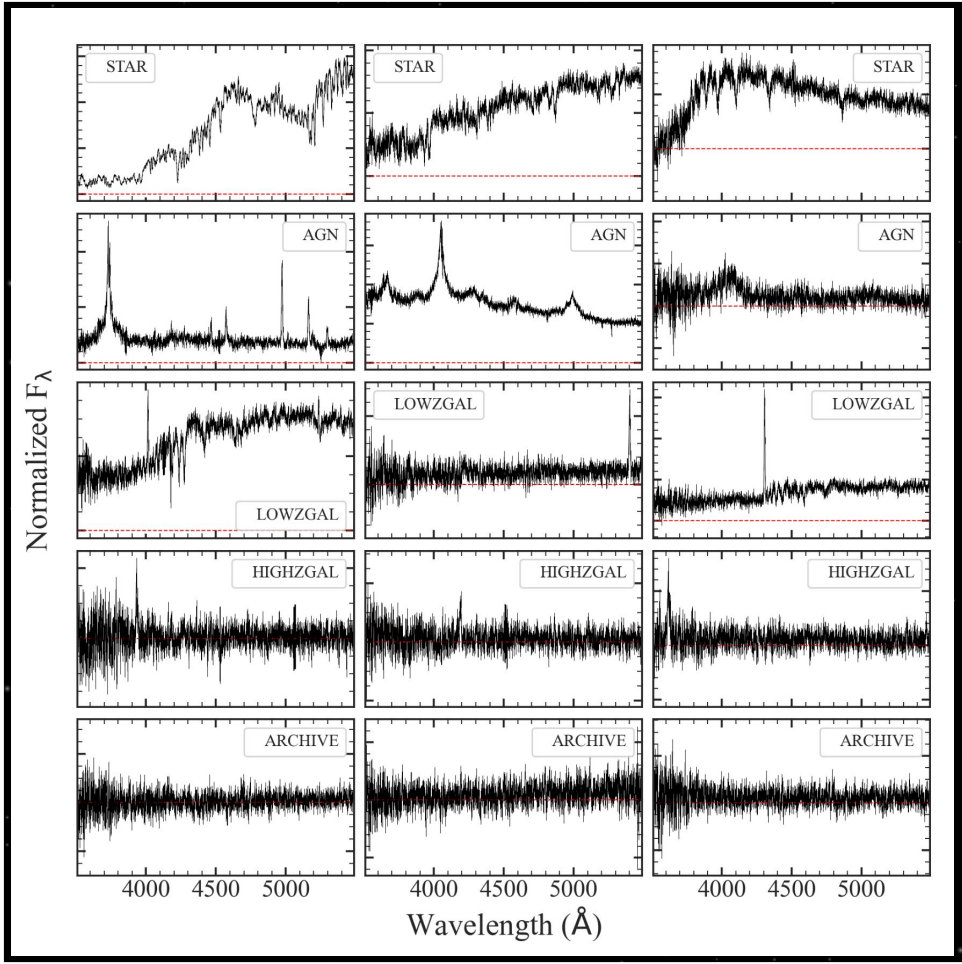



Does the source have both Diagnose and ELiXer classifications?
Yes
No
Accept z from individual source
2.0 < z_HDR4 < 3.5
0.0 < z_D < 0.5
• plya > 0.85 --> H
• plya < 0.85:
◦ gmag > 22 --> H
◦ gmag < 22 --> D
1.5 < z_HDR4 < 2.0
0.0 < z_D < 0.5
• plya > 0.85 --> H
• plya < 0.85:
◦ gmag > 22 --> H
◦ gmag < 22 --> D
1.5 < z_HDR4 < 2.5
1.0 < z_D < 2.0
• agn_flag = 1.0 --> H
• agn_flag = -1.0:
◦ plya > 0.85 --> H
◦ plya < 0.85 --> D
1.0 < z_HDR4 < 2.0
2.0 < z_D < 3.0
• agn_flag = 1.0 --> H
• agn_flag = -1.0:
◦ gmag < 22 --> D
0.0 < z_HDR4 < 0.5
1.0 < z_D < 3.5
• evaluate by eye
| z_HDR4 - z_D | < 0.5
• accept D

03
Redshift Results

9,227 redshifts for 28,705 Sources



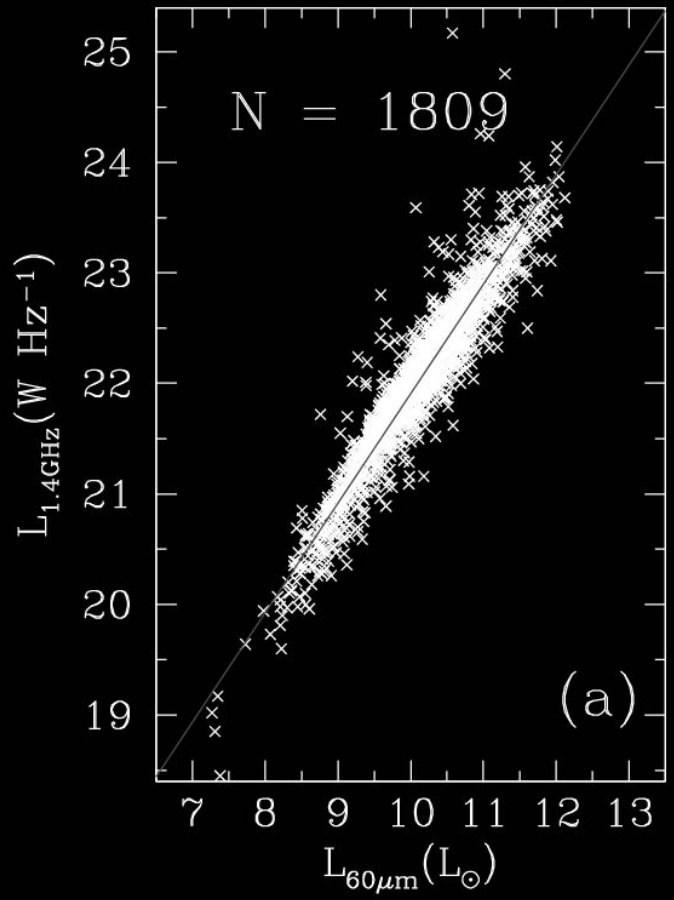


HETDEX LOFAR Classifications

- ★ STAR - 197
- ★ AGN - 804
- ★ **LOWZGAL - 6,394**
  - ○ 0.0 < z < 0.5
- ★ HIGHZGAL - 1,075
  - ○ 1.9 < z < 3.5
- ★ ARCHIVE - 757

04
Star Formation at Radio Wavelengths

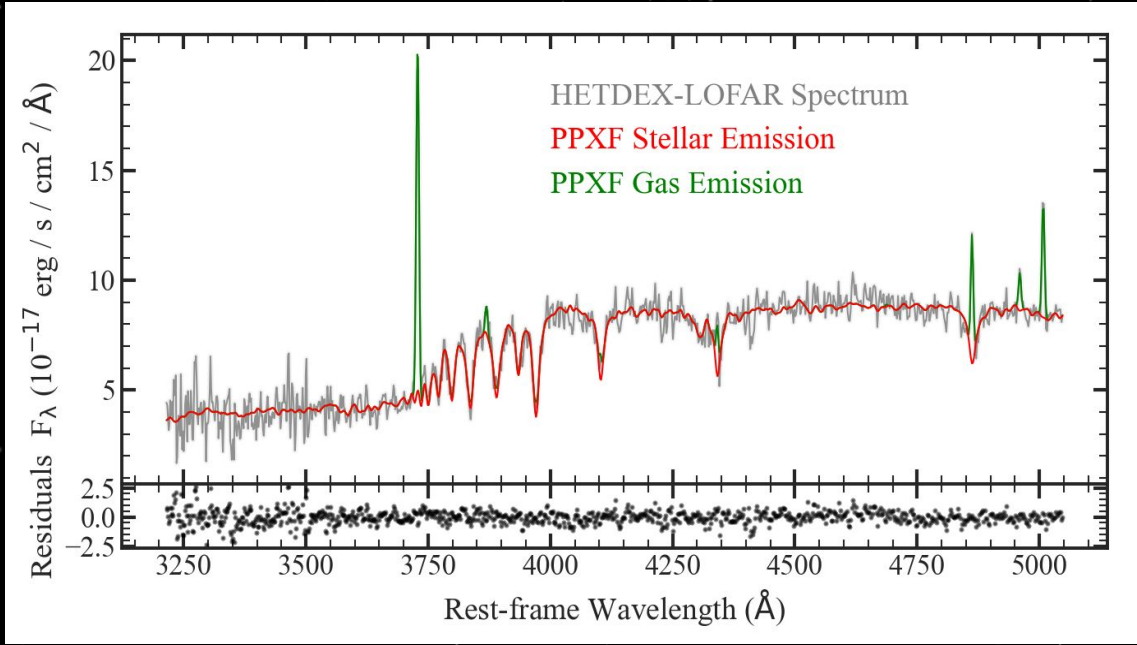
Increasing sensitivity has provided the framework for radio surveys to become the primary means of identifying star-forming galaxies

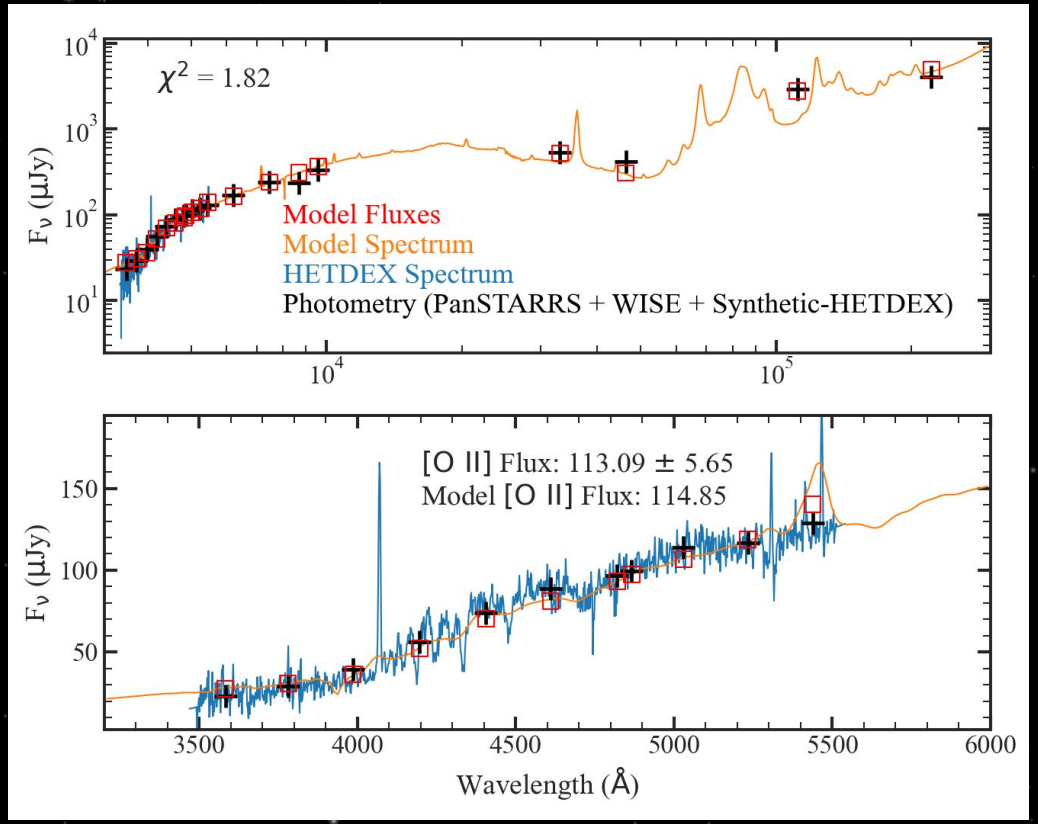


Yun et al. 2001

HETDEX LOFAR can explore the relationship between 150 MHz with SFR/M and [O II] with ~5,900 $z < 0.5$ galaxies

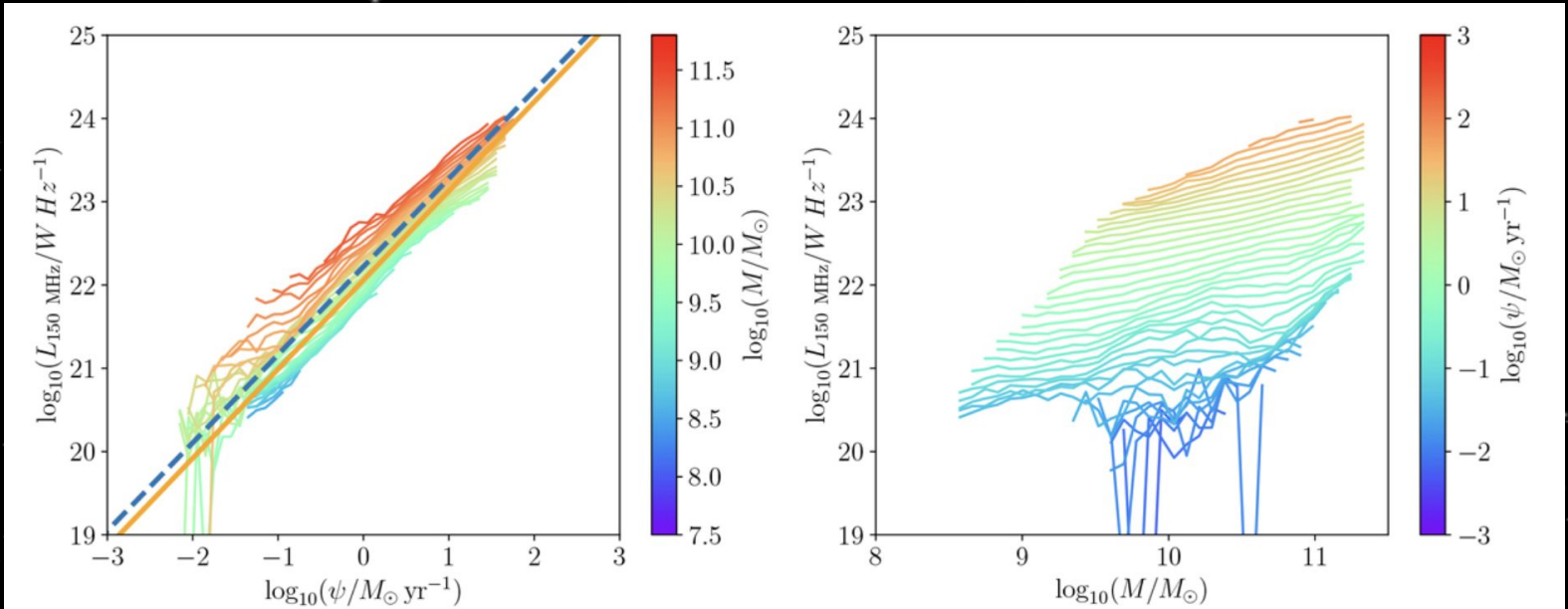
Penalized PiXel Fitting succeeds in extracting [O II] emission but is insufficient for SED fitting





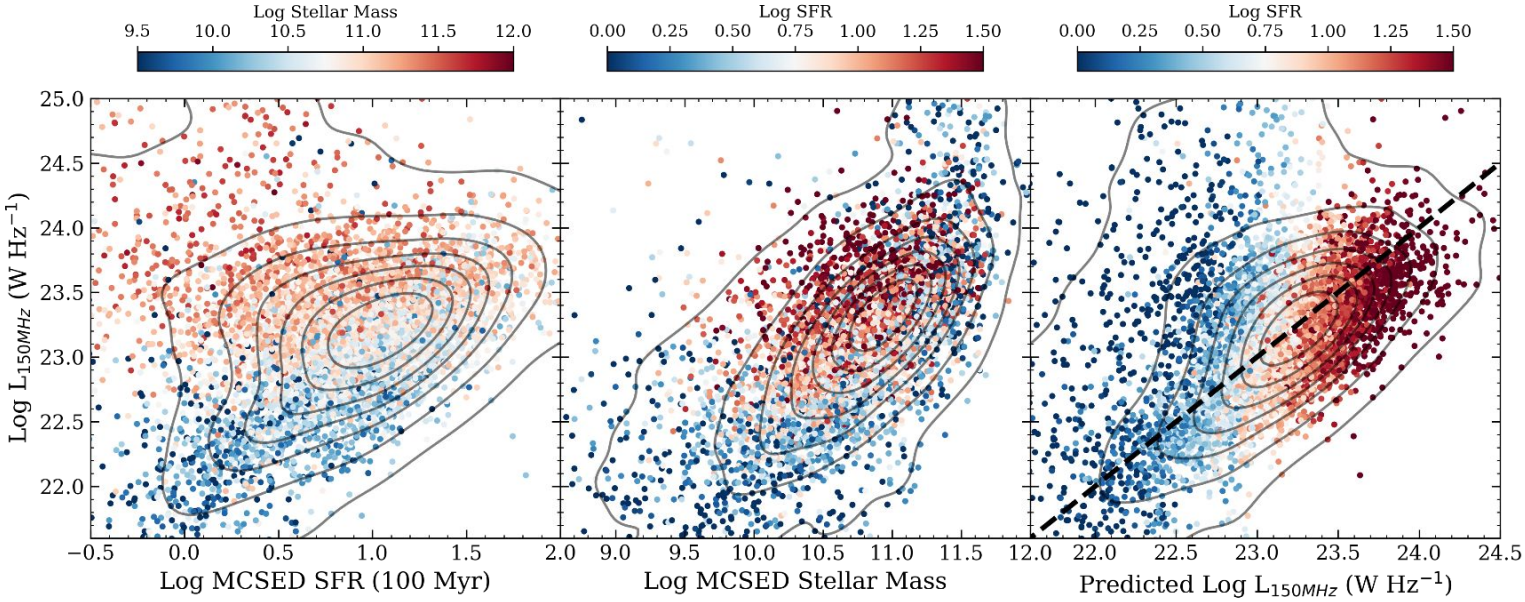
MCSED is **flexible** in its fitting approach using FSPS models and MCMC parameter estimation

Previous studies found strong correlation between SFR and 150 MHz but a secondary mass dependence

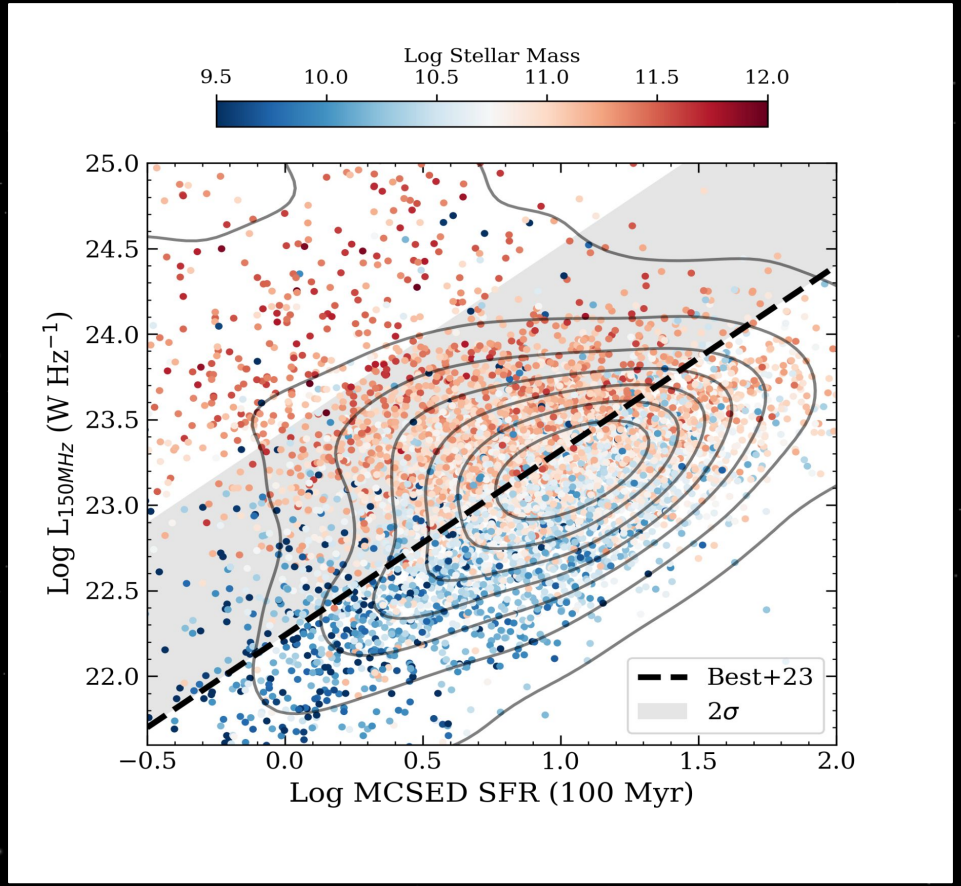


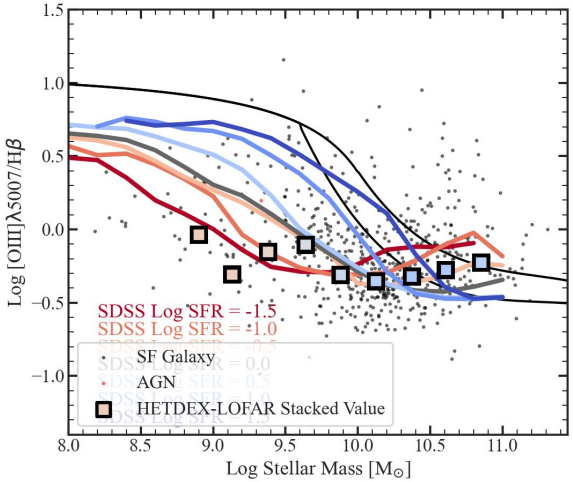
Smith et al. 2021

We find a strong correlation between radio luminosity and SFR

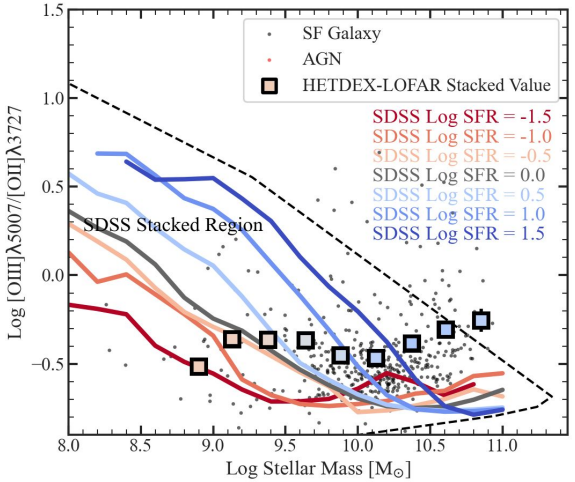


Best et al. 2023

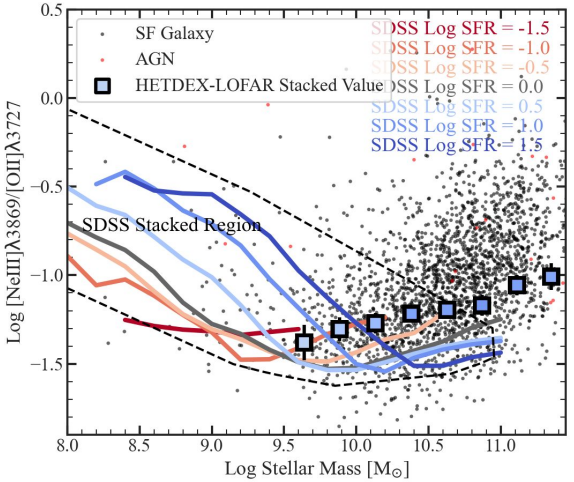



Log [OIII]λ5007/Hβ
Log Stellar Mass [M⊙]
SDSS Log SFR = -1.5
SDSS Log SFR = -1.0
SF Galaxy
AGN
HETDEX-LOFAR Stacked Value

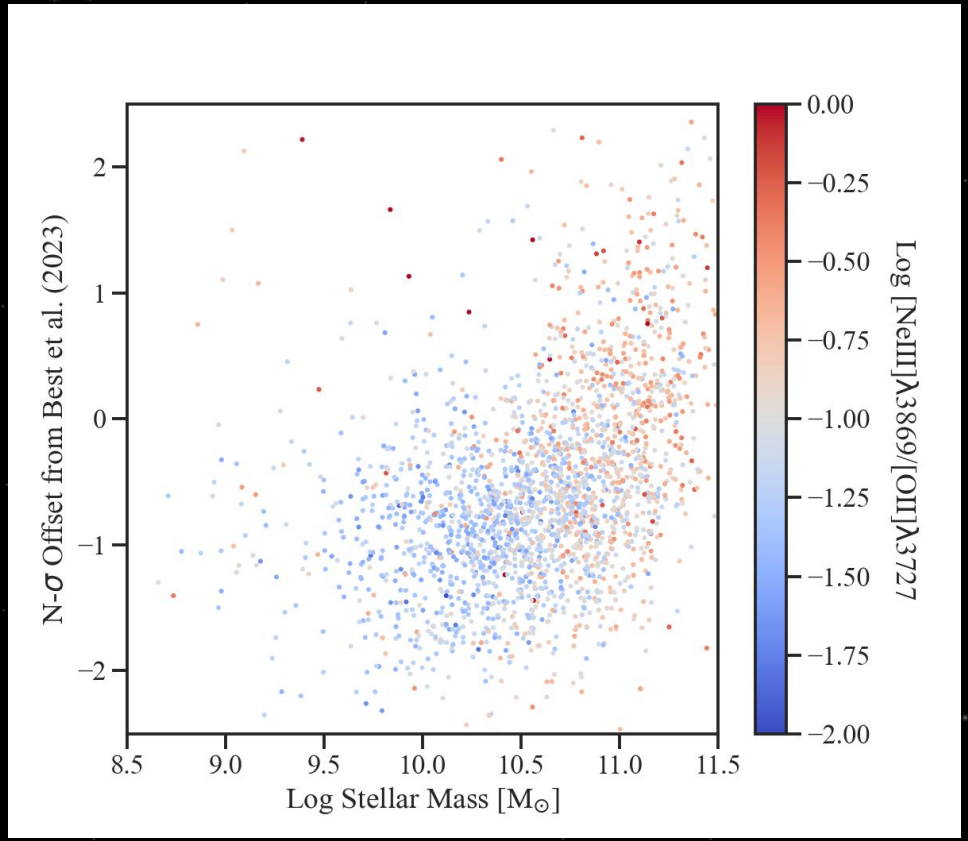
z < 0.1


Log [OIII]λ5007/[OII]λ3727
Log Stellar Mass [M⊙]
SF Galaxy
AGN
HETDEX-LOFAR Stacked Value
SDSS Log SFR = -1.5
SDSS Log SFR = -1.0
SDSS Log SFR = -0.5
SDSS Log SFR = 0.0
SDSS Log SFR = 0.5
SDSS Log SFR = 1.0
SDSS Log SFR = 1.5
SDSS Stacked Region

z < 0.1


Log [NeIII]λ3869/[OII]λ3727
Log Stellar Mass [M⊙]
SF Galaxy
AGN
HETDEX-LOFAR Stacked Value
SDSS Log SFR = -1.5
SDSS Log SFR = -1.0
SDSS Log SFR = -0.5
SDSS Log SFR = 0.0
SDSS Log SFR = 0.5
SDSS Log SFR = 1.0
SDSS Log SFR = 1.5
SDSS Stacked Region

z < 0.4



- AGN have harder ionization fields
  - Ne3O2 > 1
- No galaxies in our sample have Ne3O2 > 1

- As galaxies reach Log Stellar Mass >10.5 → Ne3O2 increases
  - Suggests possible AGN contribution

HETDEX LOFAR enables many different galaxy/AGN projects!

Thank you!

Contact me:
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