

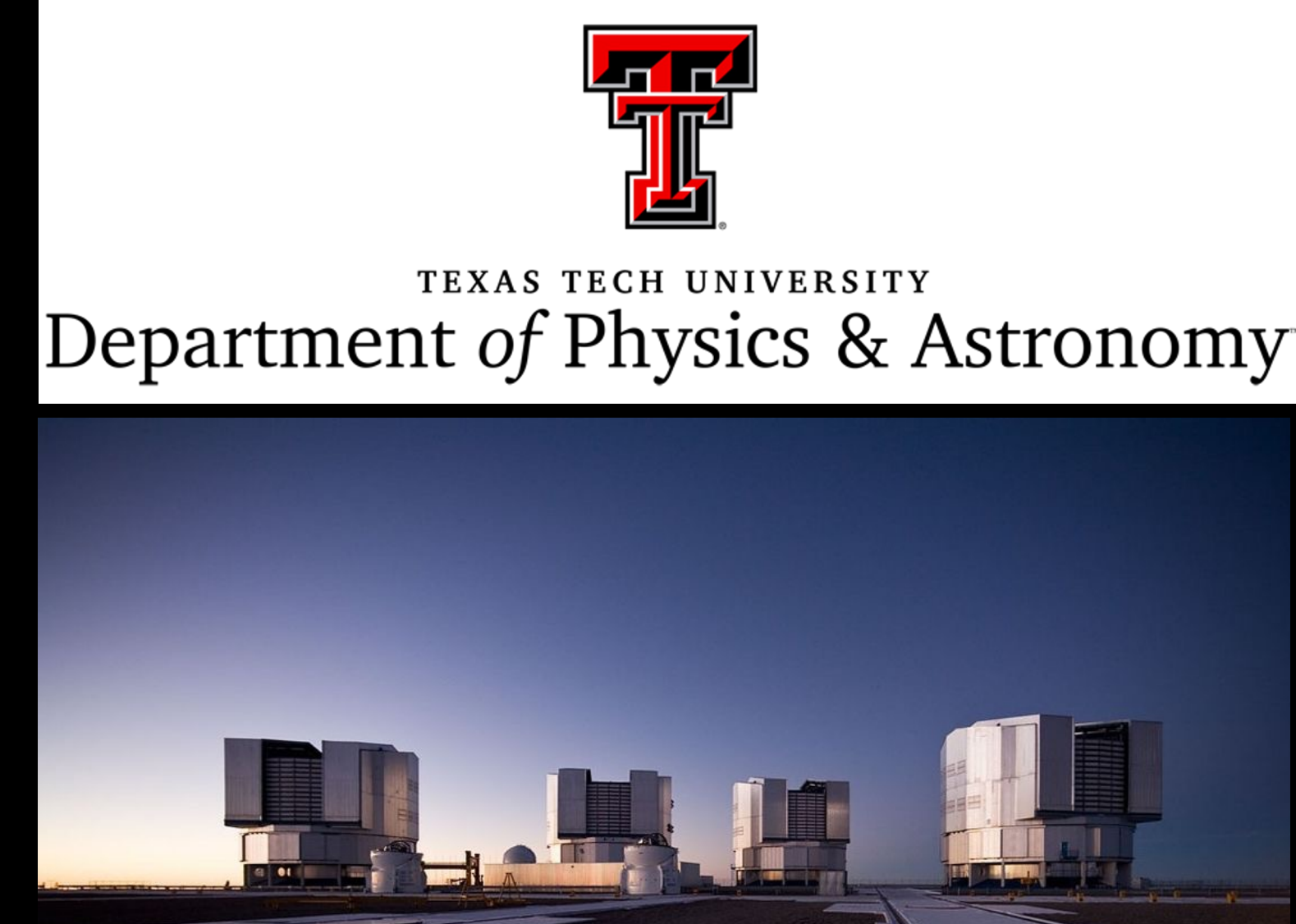


# Building a Pure Sample of Narrow-Line Seyfert 1 Galaxies Using FORS2 Spectroscopy

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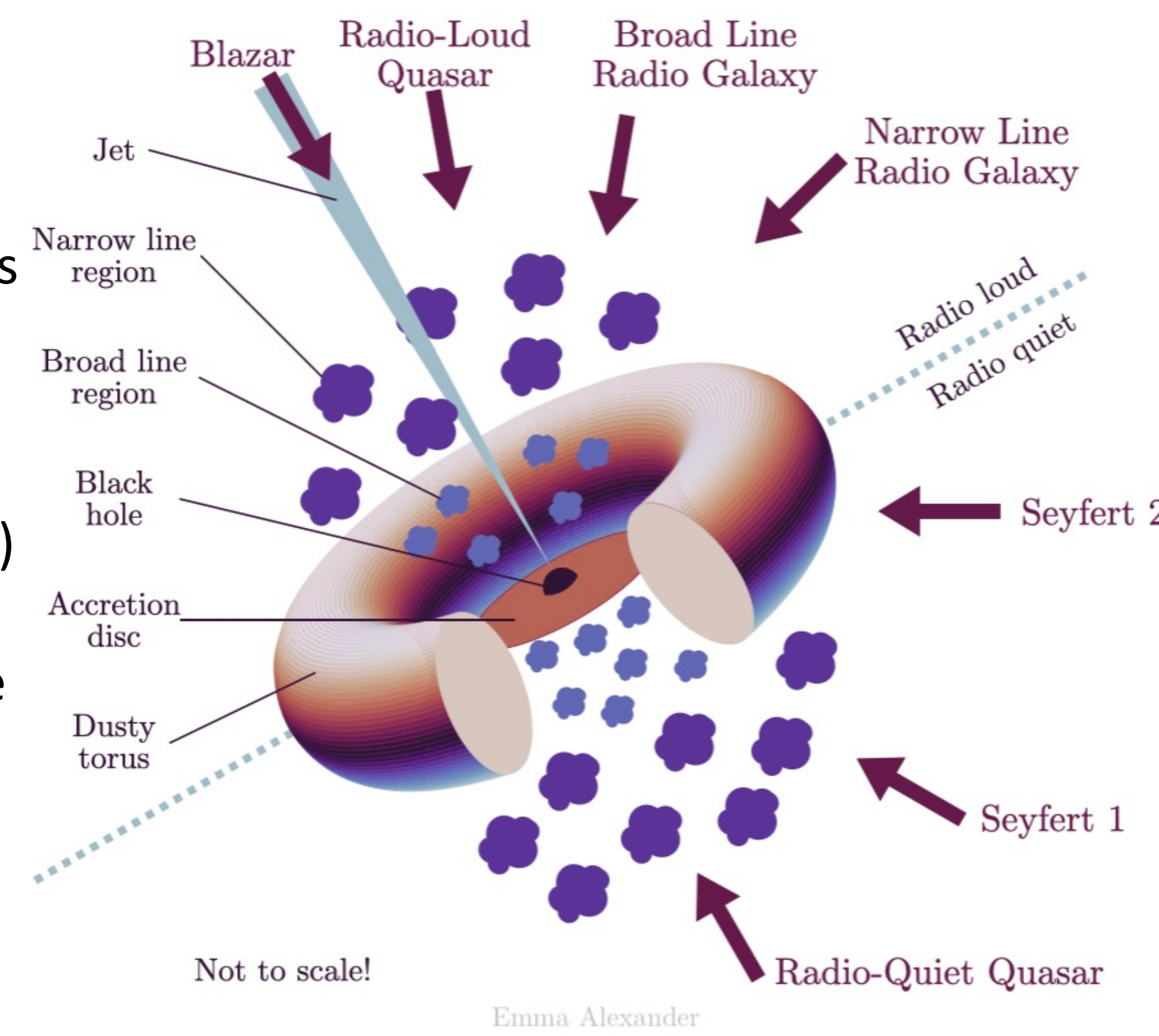


## Introduction

➤ Active Galactic Nuclei (AGN) are powered by accretion of matter onto supermassive Black Holes (SMBHs) at the center of galaxies.

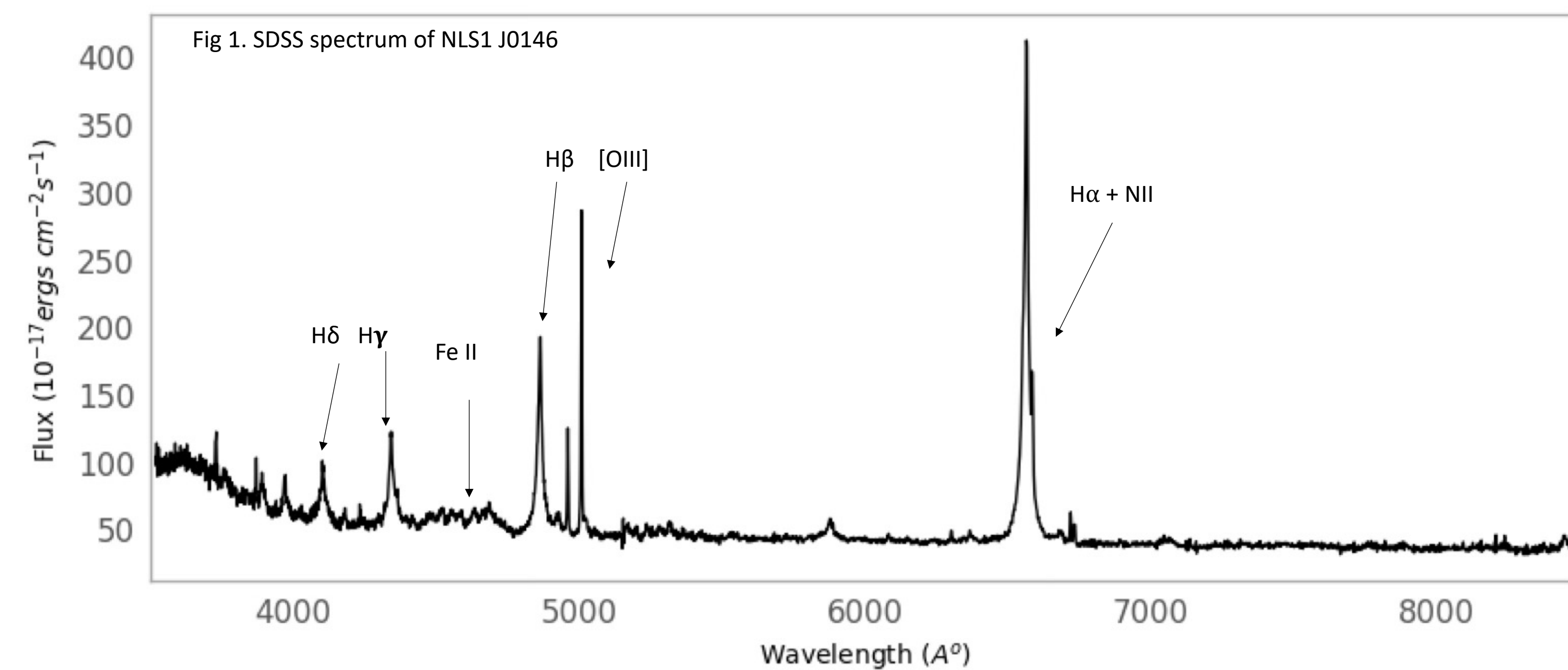
➤ The Unified Model of AGN [1]:

- Type 1 (broad and narrow emission lines visible)
- Type 2 (only narrow emission lines visible)
- Due to the difference in viewing angle.



➤ Narrow Line Seyfert 1 (NLS1) Galaxy is a class of AGN with:

- Full Width Half Maximum (FWHM) of broad H $\beta$  < 2000 km/s [2]
- Flux ratio [O III] / H $\beta$  < 3
- Optical properties are often accompanied by strong Fe II multiplets [3]
- Low BH masses (< 10<sup>8</sup>M $_{\odot}$ ) [4]
- NLS1s commonly show high Eddington ratios, even exceeding unity

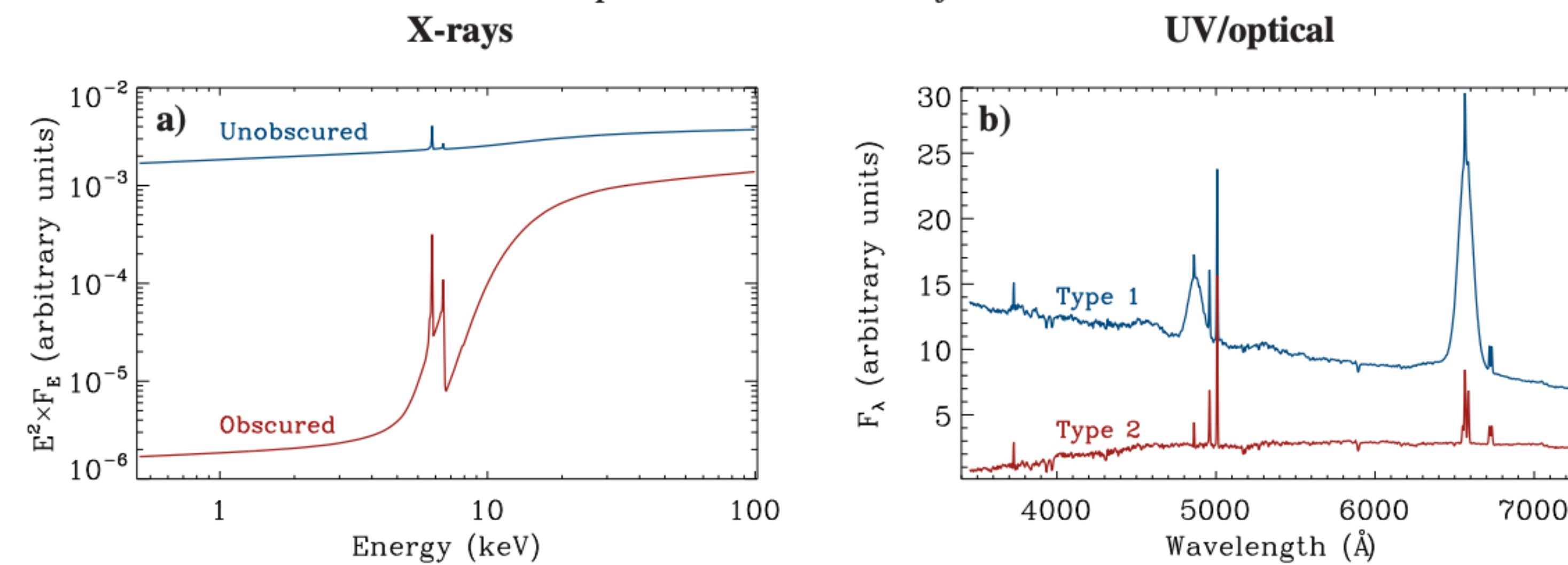


- Rakshit et al., 2017 [5] created a sample of NLS1s using SDSS DR12 which had 11,101 sources but SDSS data is noisy and their S/N threshold was low.
- 2019: Irene Varglund née Björklund (Master thesis) studied these sources individually and found contamination of at least 64% leaving 4000 NLS1 candidates (4k sample).
- Berton et al., 2020 [6], studied line profiles of the 4k sample and found that line profiles separate properties of NLS1. But better data quality is needed to confirm.
- We want to re-observe the 4k sample with S/N 30 [7] to reliably identify true NLS1 sources.

➤ Changing look AGN (CLAGN):

- Undergoes dramatic flux and spectral shifts over months to decades.
- Broad emission lines and continuum emissions appear or disappear, effectively changing the galaxy's classification between Type 1 and Type 2.

Fig 2: Spectral classes identified in: [8]



Spectral transitions usually driven by:

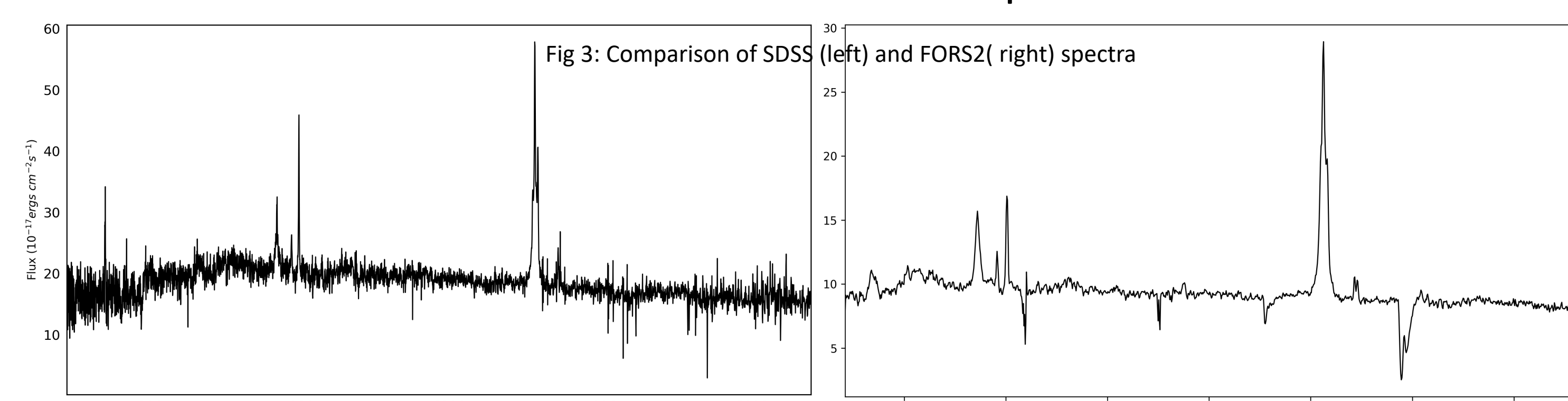
Changing obscuration (CO-AGN)

Changing accretion state (CS-AGN)

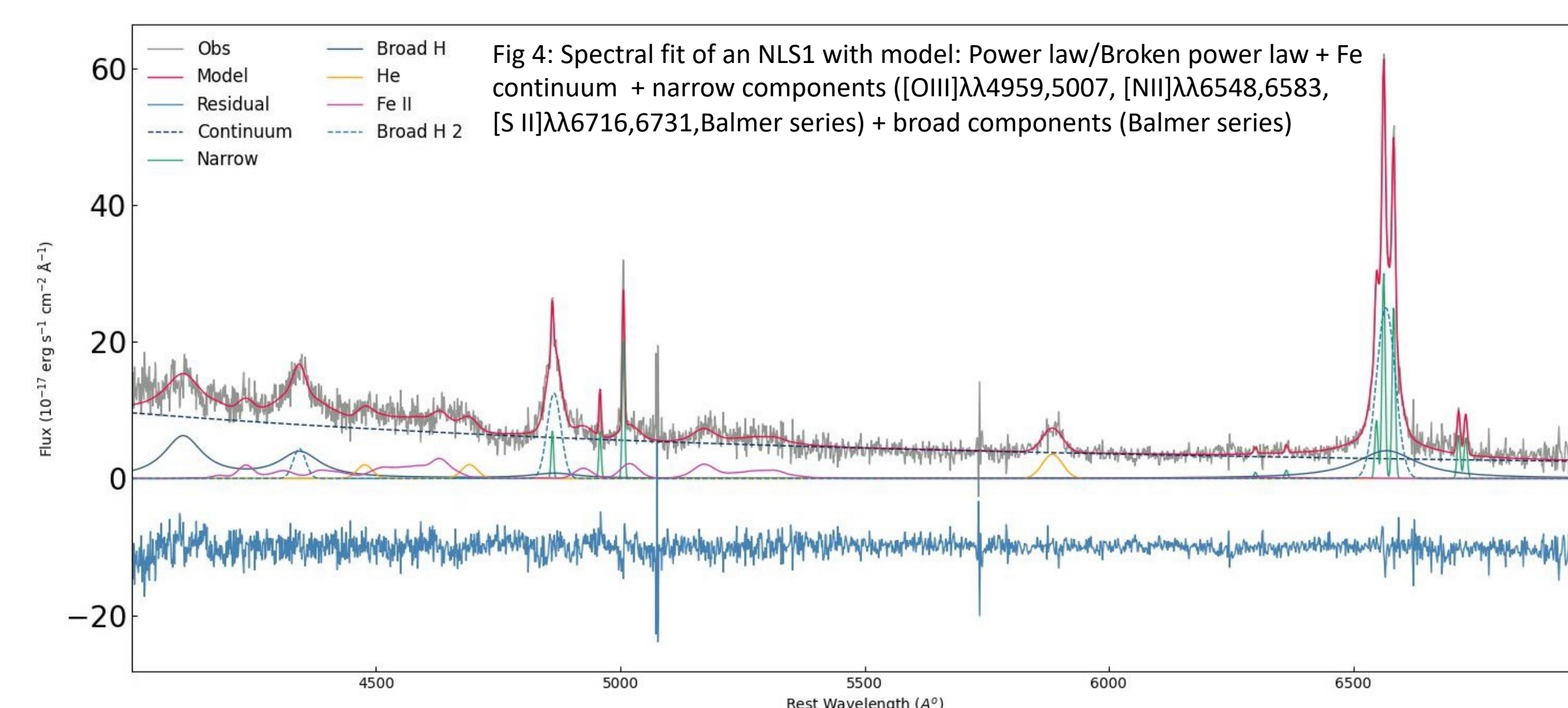
## Data and Analysis

➤ Instruments: **FORS2**, **DESI** & **SDSS**.

➤ Visual crossmatch of 100 SDSS and FORS2 spectra to find contaminants.



➤ Spectral fitting using FANTASY [9],[10],[11] - a Python-based open source code for simultaneous multi-component fitting of AGN spectra, optimized for the optical rest-frame band (3600-8000 Å).

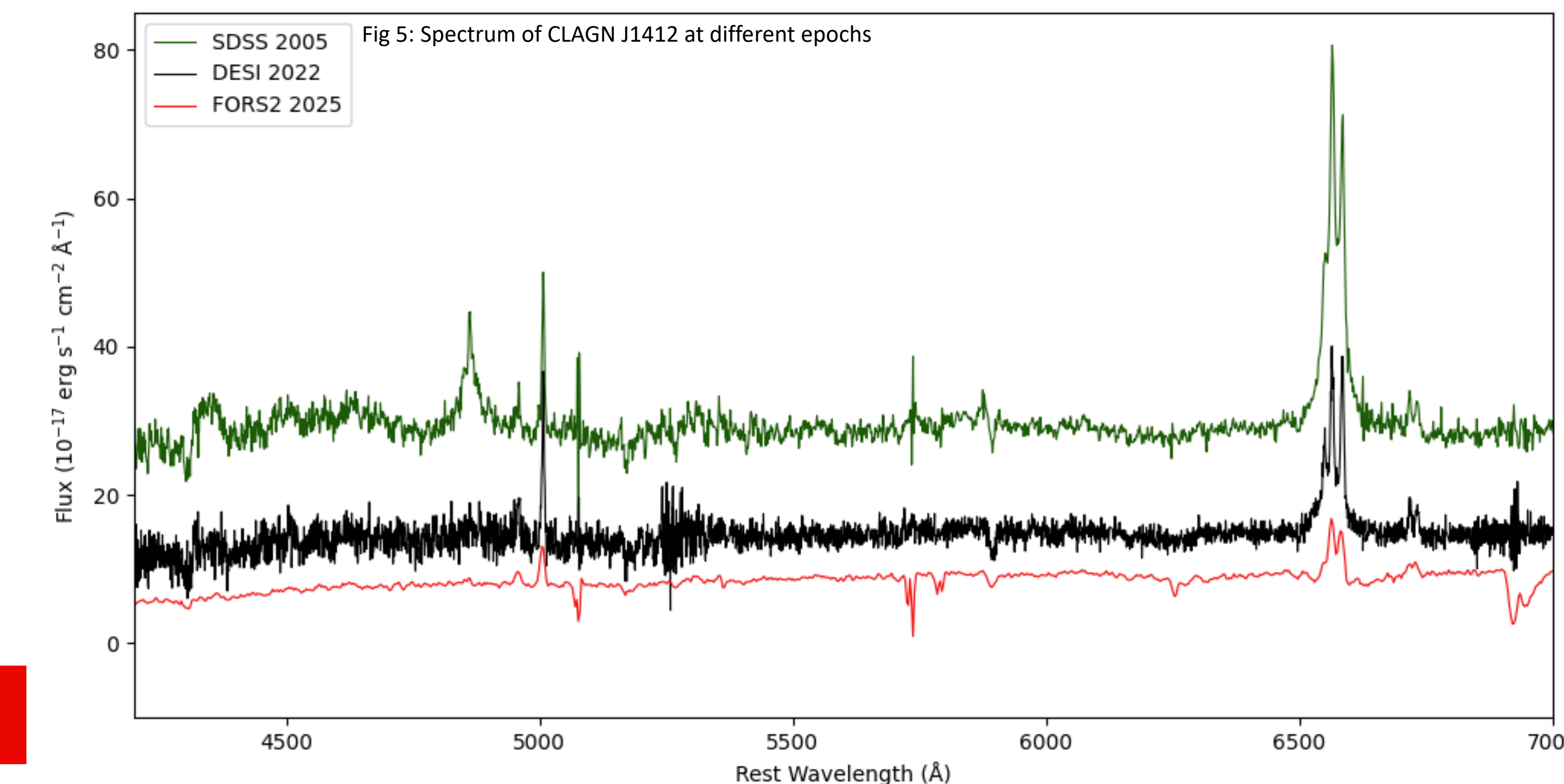


➤ Spectral fitting of these spectra can help us determine:

- NLS1 classification – Yay! or Nay
- BH mass
- Eddington ratio,  $\lambda_{\text{Edd}} = L_{\text{bol}}/L_{\text{Edd}}$
- Emission line properties – flux, luminosity, Equivalent Width, FWHM

## Results and Discussions

- Sample of 100 sources with  $z < 0.1$  and  $15 < \text{SDSS g-mag} < 18$ .
- 30% contamination in an already cleaned sample.
- 13 CLAGN in the sample of  $\approx 100$  sources previously classified as NLS1s.
- These are high Eddington sources  $\lambda_{\text{Edd}} \geq 0.1$  with BH mass  $10^6$  to  $10^7 M_{\odot}$



- Changes in Broad Line Regions: Narrow Line Regions stay constant due to the much longer light travel time-scales.
- CLAGN mechanism:
  - Variation in intrinsic accretion rate
  - Obscuration
  - Tidal Disruption Events (cannot explain repeating CLAGN)
- 7 out of 13 have disappearing H $\beta$  line going from SDSS to FORS2.
- Rest have changing width of the H $\beta$  line.
- Not enough observations in different epoch to constrain when exactly the change happened.
- Thin disk state is not stable. At high Eddington ratios, the disk can puff up due to high radiation pressure and push material into the BH as well as away from it. This puffed up disk can collapse at some point as the radiation pressure weakens and the disk goes back to being a thin disk [12]
- The changes in our source might be similar to flip-flop transitions in stellar mass BHs but on longer time scales due to higher BH mass of our sources. Accretion physics should be scale free and so the time-scales should scale roughly linearly with black hole mass [13].

## References

- [1]Urry, C. M., & Padovani, P. 1995, PASP, 107, 803; [2] Osterbrock & Pogge 1985, ApJ, 297:166; [3]Goodrich, R. W. 1989, ApJ, 342:224; [4]Komossa et al. 2018, MNRAS, 477:5115; [5]Rakshit et al. 2017, ApJ, 229:39; [6]Berton et al. 2020, CoSka, 50:270; [7]Järvelä et al. 2018, A&A, 619:69; [8]Ricci, C. and Trakhtenbrot, B., Nature Astronomy 7.11 (2023): 1282-1294; [9]Illic et al. 2020, A&A, 683:A13; [10]Illic et al. 2023, ApJ, 267:19; [11]Rakic 2022, MNRAS, 516:1624; [12]Szuszkiewicz, E. and Miller, J.C., MNRAS 328.1 (2001): 36-44; [13]Maccarone, T., et al. , PASA 43 (2026): e044.