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

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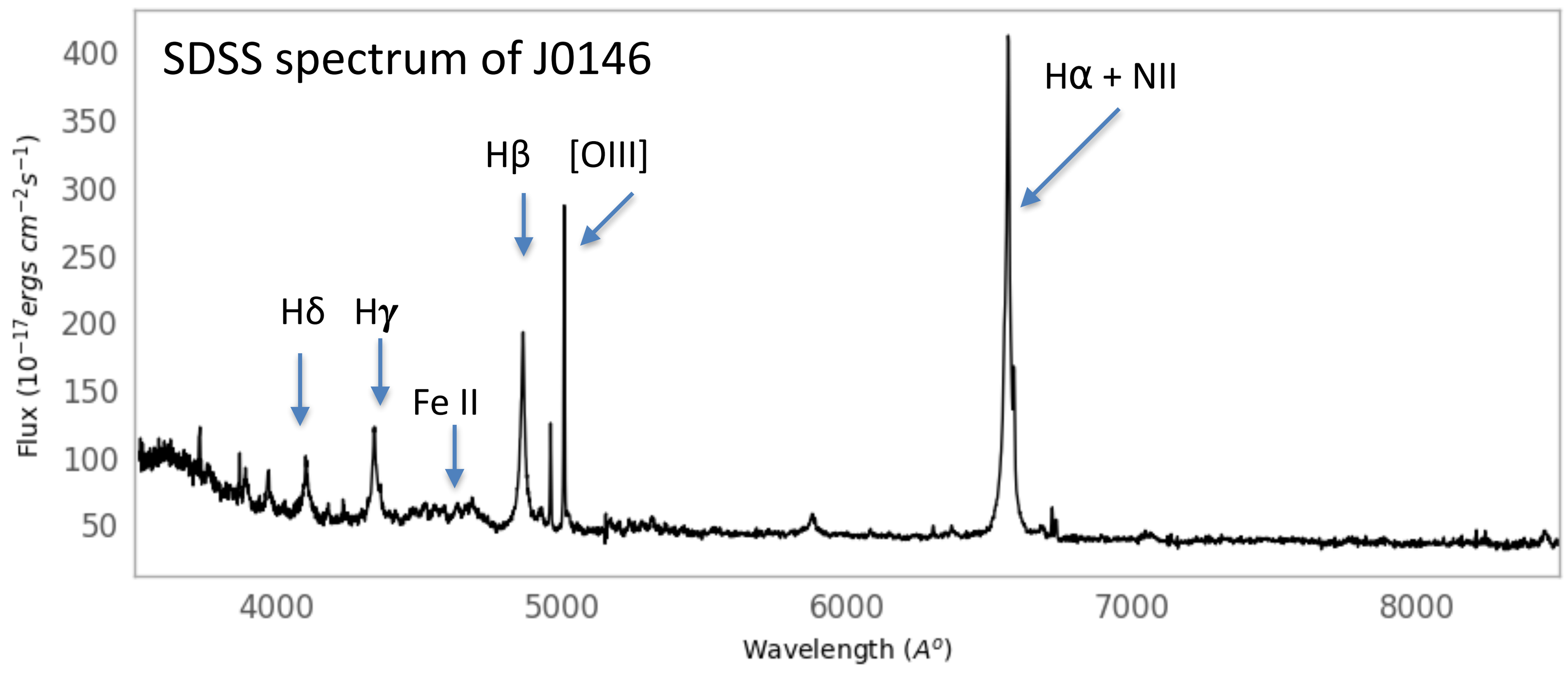
INTRODUCTION

Narrow Line Seyfert 1 (NLS1) Galaxy is a class of Active Galactic Nuclei (AGN) with:

- ✦ FWHM of broad Hβ < 2000 km/s (Osterbrock and Pogge, 1985)
- ✦ Flux ratio [O III] / Hβ < 3
- ✦ Optical properties are often accompanied by strong Fe II multiplets (Goodrich, 1989)
- ✦ Low black hole masses (< $10^8 M_\odot$, Komossa et al., 2008)
- ✦ NLS1s commonly show high Eddington ratios, even exceeding unity



NEED FOR A PURE SAMPLE

- ✦ 2017: Rakshit et al., 2017 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.
- ✦ 2018-2019: Irene Varglund née Björklund (Master thesis) studied these sources individually and found contamination of at least 64% leaving ∼ 4000 NLS1 candidates (4k sample).
- ✦ 2019-2020: Berton et al., 2020, studied line profiles of the 4k sample and found that line profiles separate properties of NLS1. But better data quality is needed to confirm.

OBJECTIVE

- ✦ Classifying L and G sources.
- ✦ Calculate accurate physical parameters: BH mass, Eddington ratio, R4570.
- ✦ Explore intra-class evolution of NLS1 by finding correlation between:
  - BH mass correlated to line properties
  - Properties evolve as the BH evolves
  - Constrains on evolution
- ✦ Find similarity to high z AGN because large number of AGN in early universe are NLS1s. Maybe all AGN go through NLS1 phase characterized by rapid accretion onto a under-massive SMBH. Studying these NLS1s in the local universe can help us study AGN at high redshifts.

RATIONAL

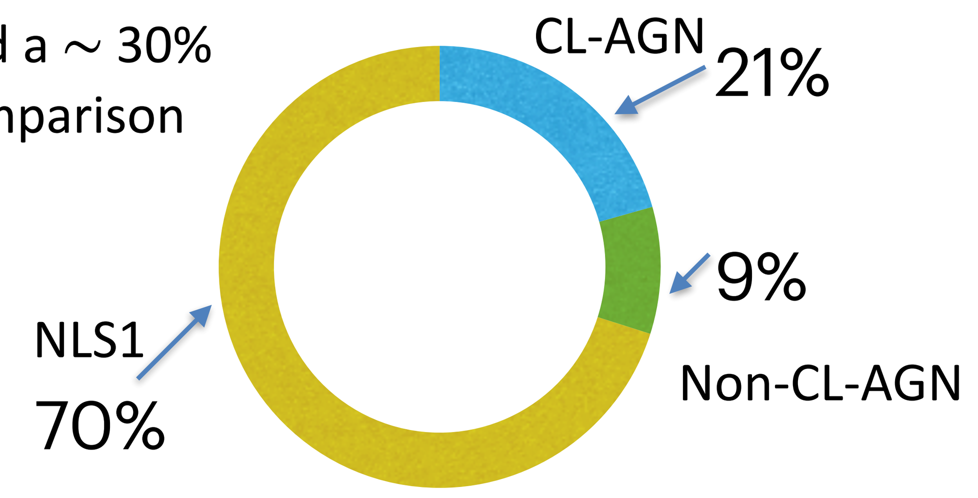
- ✦ We want to re-observe the 4k sample with S/N ∼ 30 (Järvelä et al., 2018) to reliably identify true NLS1 sources.
- ✦ We also need to model the Hβ line and see if the emission lines are better estimated using a Gaussian or Lorentzian profile because when Berton et al., 2020 studied the 4k candidate NLS1s they found that going from **Lorentzian to Gaussian:**
  - Black hole mass increases
  - Eddington ratio decreases
  - Fe II strength decreases
  - [O III] luminosity increases

DATA

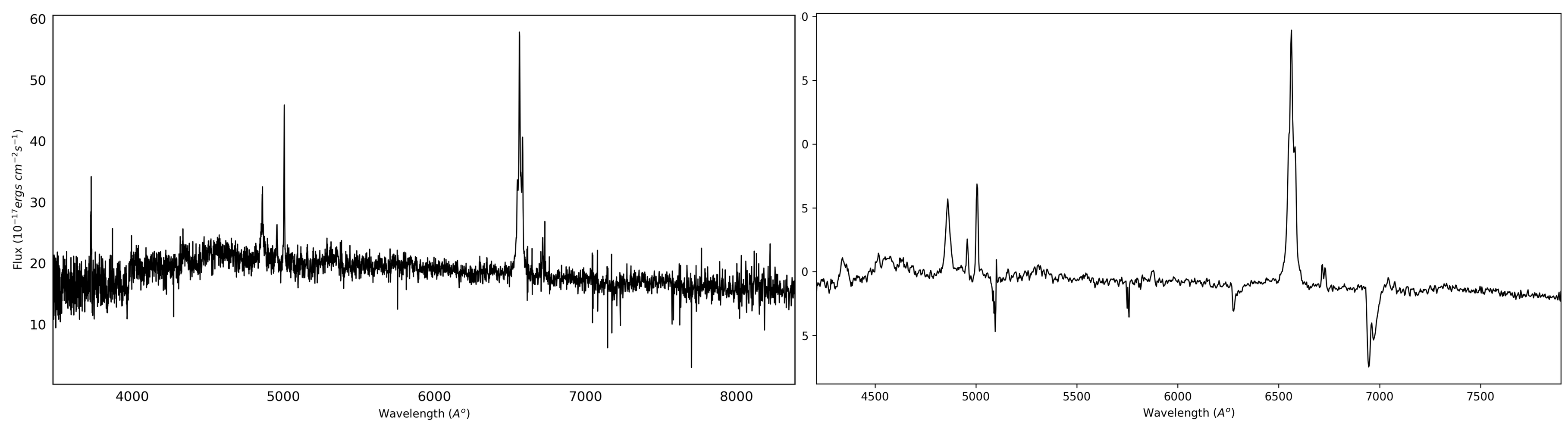
ESO, VLT, FOcal Reducer/low dispersion Spectrograph 2 (FORS2) instrument + Gemini Multi-Object Spectrograph (GMOS) (Future)

PRELIMINARY RESULTS

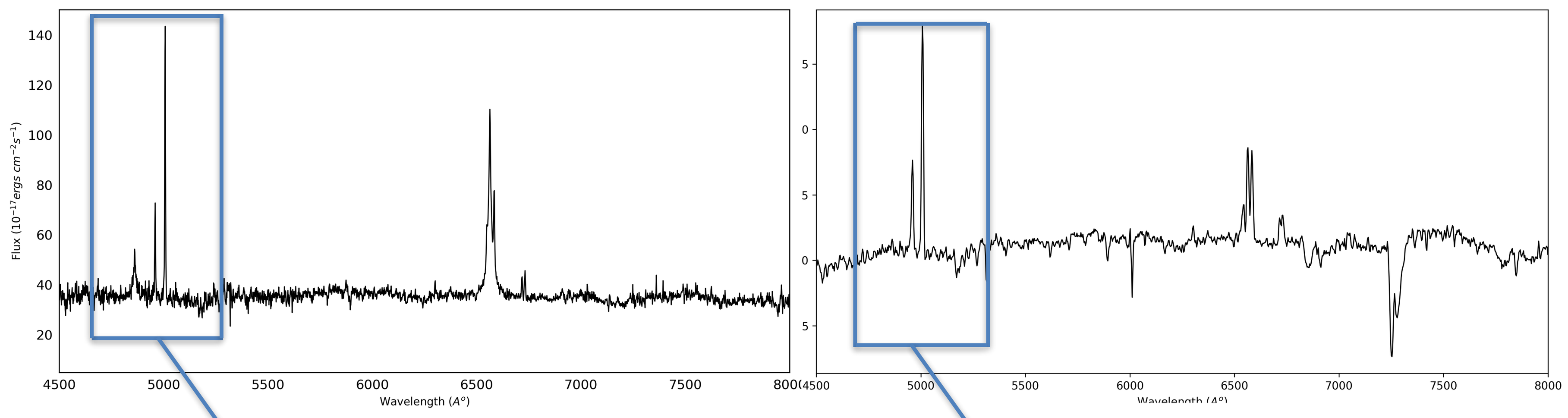
We analyzed 100 spectra and found a ∼ 30% contamination through a visual comparison of FORS2 and SDSS data.



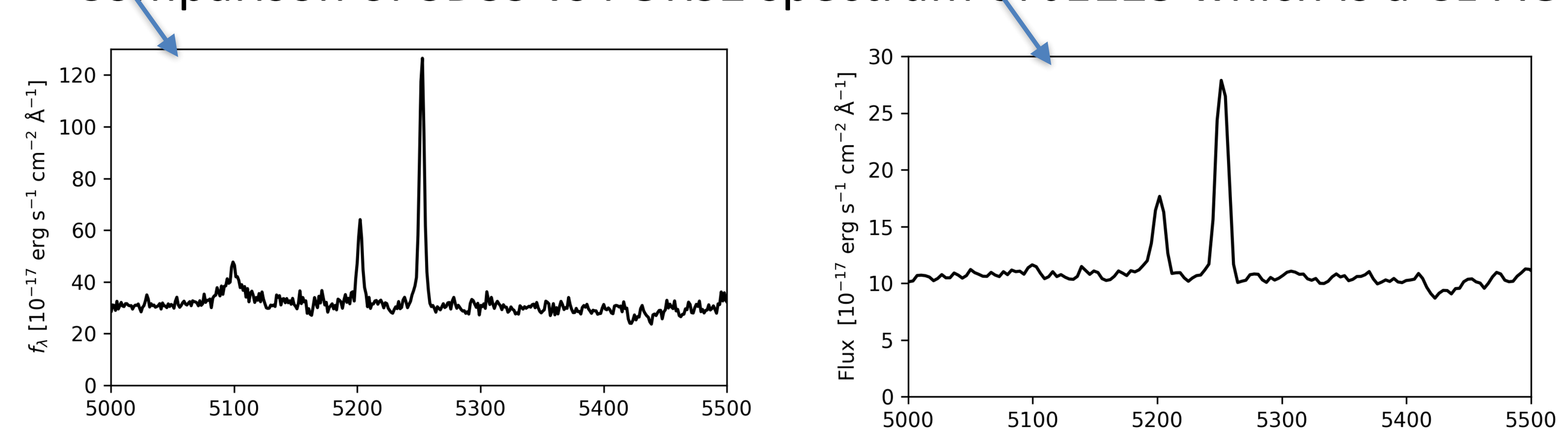
Spectral modeling is performed using FANTASY which is a Python-based open source code for simultaneous multi-component fitting of AGN spectra, optimized for the optical rest-frame band (3600-8000 Å) by N. Rakic, D. Ilic and L. C. Popovic.



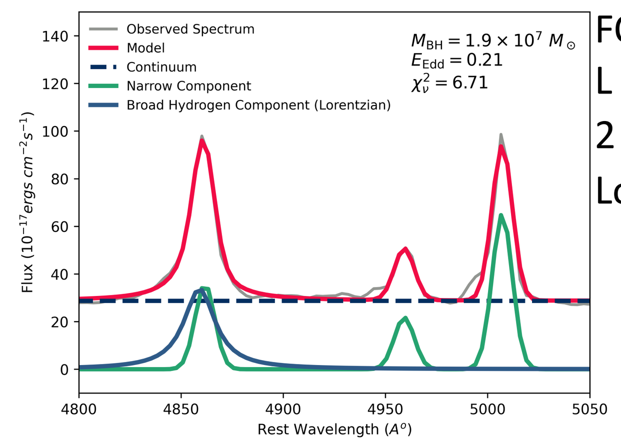
Comparison of SDSS vs FORS2 spectrum of J0928



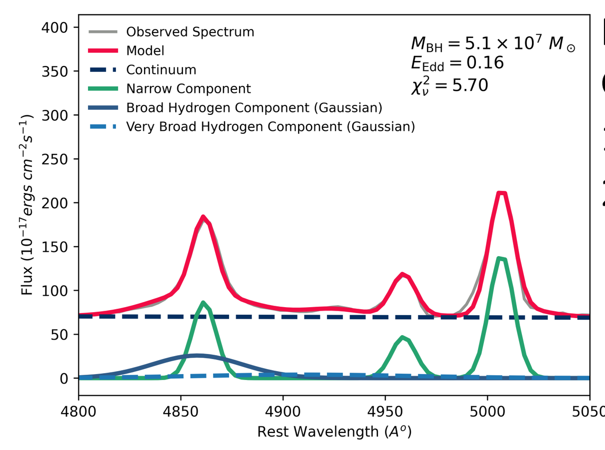
Comparison of SDSS vs FORS2 spectrum of J1125 which is a CL-AGN



Broad Balmer lines have disappeared from SDSS to FORS2.



FORS2 spectra - J0113
L type source.
2 Gaussian χ^2_ν = 17.49
Lorentzian χ^2_ν = 6.9.



FORS2 spectra - J1128
G type source.
1 Lorentzian χ^2_ν = 18.35
2 Gaussian χ^2_ν = 5.7.

Model used in FANTASY
Power law/Broken power law
+ Fe continuum
+narrow components ([O III]λλ4959,5007, [N II]λλ6548,6583, [S II]λλ6716,6731, Balmer series)
+ broad components (Balmer series)

FUTURE WORK

- ✦ For the CL-AGN we want to check archival data and see if the change is significant, the change in classification, time scale of change and the change in line properties.
- ✦ Detailed spectral fitting for the CL-AGN spectra of SDSS, FORS2, LAMOST, DESI, other archival data.
- ✦ Detailed modeling of the spectra, distinguishing between Lorentzian and Gaussian sources.
- ✦ Fit spectral lines using the Voigt profile check if sources that are better fit with a Lorentzian is dominated by a Lorentzian, and vice versa.

REFERENCES

• Berton et al. 2020, CoSka, 50:270 • Goodrich, R. W. 1989, ApJ, 342:224 • Ilic et al. 2020, A&A, 683:A13 • Ilic et al. 2023, ApJ, 267:19 • Järvelä et al. 2018, A&A, 619:69 • Komossa et al. 2018, MNRAS, 477:5115 • Osterbrock & Pogge 1985, ApJ, 297:166 • Rakic 2022, MNRAS, 516:1624 • Rakshit et al. 2017, ApJ, 229:39 •