150 година МАТФ Универзитет у Београду Математички факултет

МАТФ University of Belgrade Faculty of Mathematics

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Nemanja →

Fantastic fits of AGN spectra with FANTASY

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FANTASY

Fully Automated pythoN Tool for AGN Spectra anaIYsis

https://fantasy-agn.readthedocs.io/en/latest/

go to code

Rakić 2022, MNRAS, 516, 1624R
Ilić, Rakić, Popović 2023, ApJS, accepted

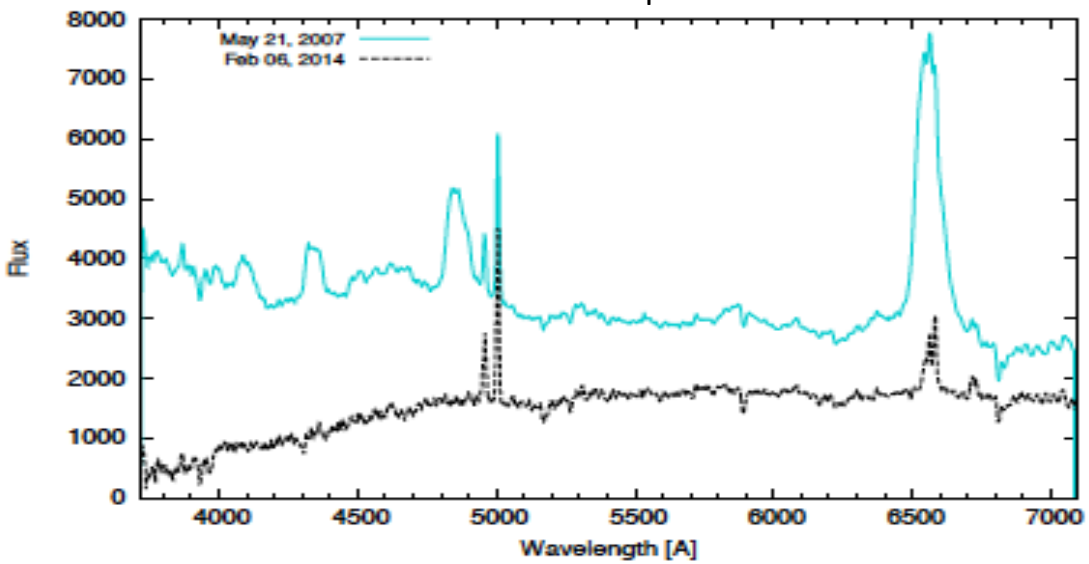
Complex AGN Broad Emission Lines

- type 1 AGN - broad emission lines → Broad Line Region
  - → not specially resolved (except GRAVITY)
  - → important to understand the power of AGN and measure BH mass
  - → **we still need spectroscopy**

→ **AGN spectra are complex**

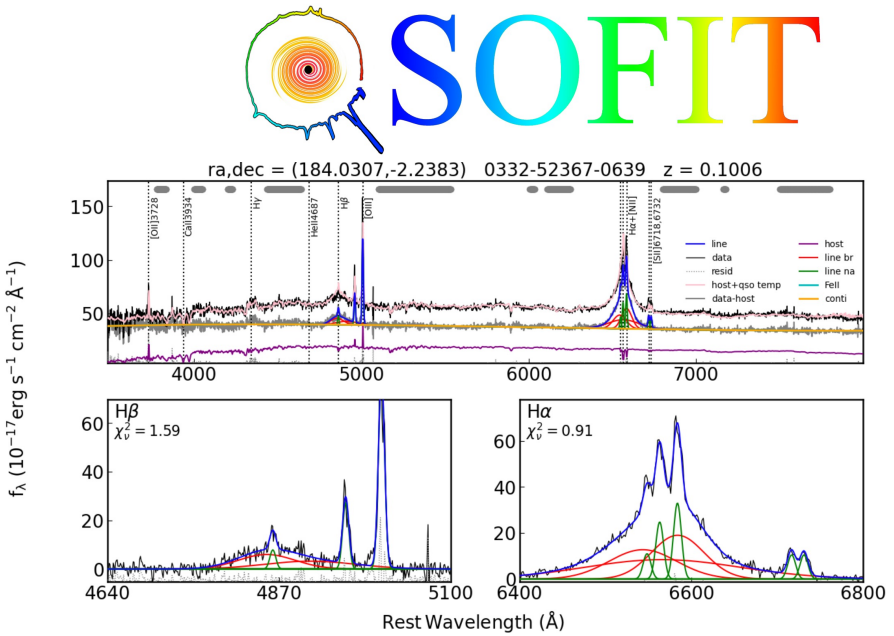
→ era of massive surveys and data collecting

Shapovalova+ 2019



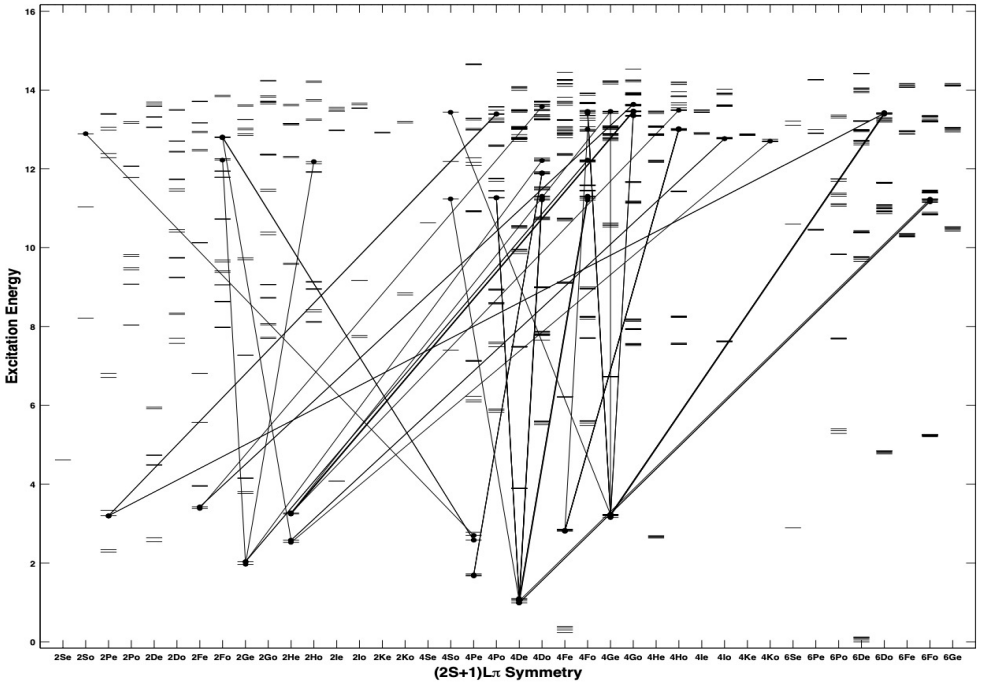
Examples of fitting tools specialized for AGN

- Quasar Spectral Fitting package (QSFIT; Calderone et al. 2017)
- Python QSO fitting code (PyQSOFit; Guo et al. 2018, 2019)
- Sculptor (Schindler 2022)
- pPXF (Cappellari 2017)
- and more…



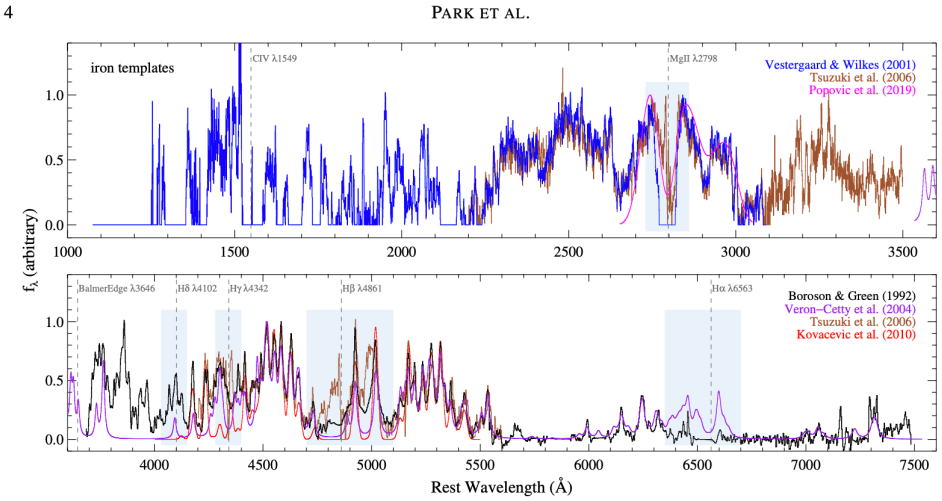
Richness of AGN Emission lines

827 Fe II energy levels and Lya transitions
out of 23,000 (Sigut & Pradhan 2003)



- Broad Lines – H, HeI, HeII, CIV, MgII, etc.
- Narrow lines– OIII, NII, SII, OI, etc.
- Coronal lines
- Fe II lines

- Great need for FeII templates (latest review in Park et al. 2022)



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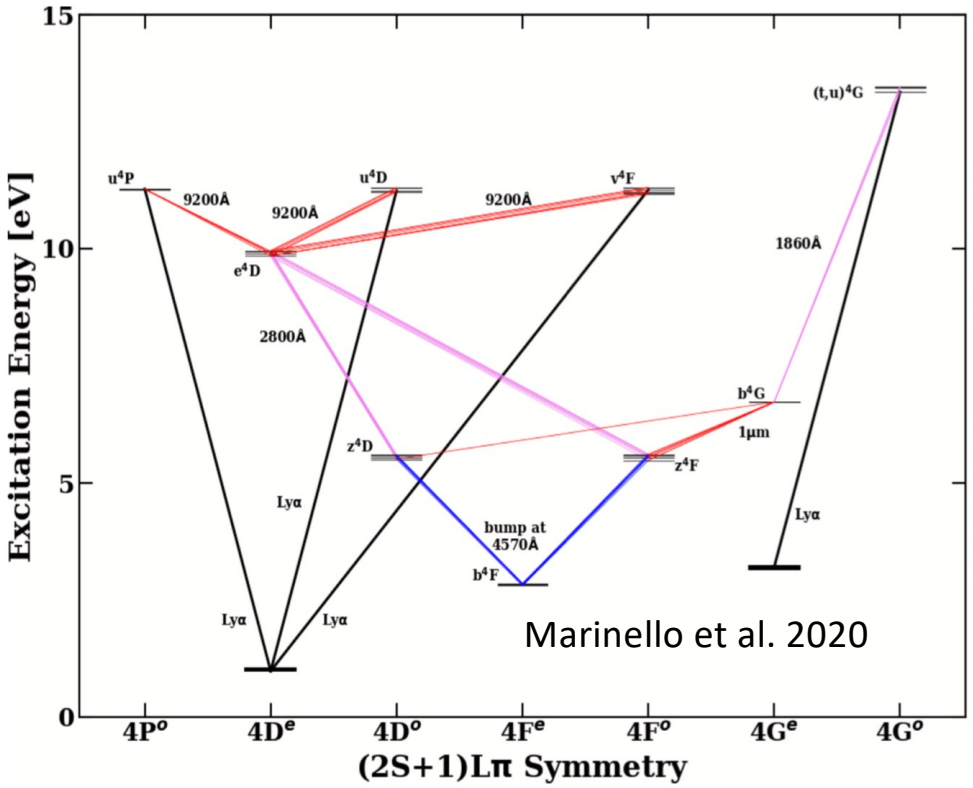

Marinello et al. 2020

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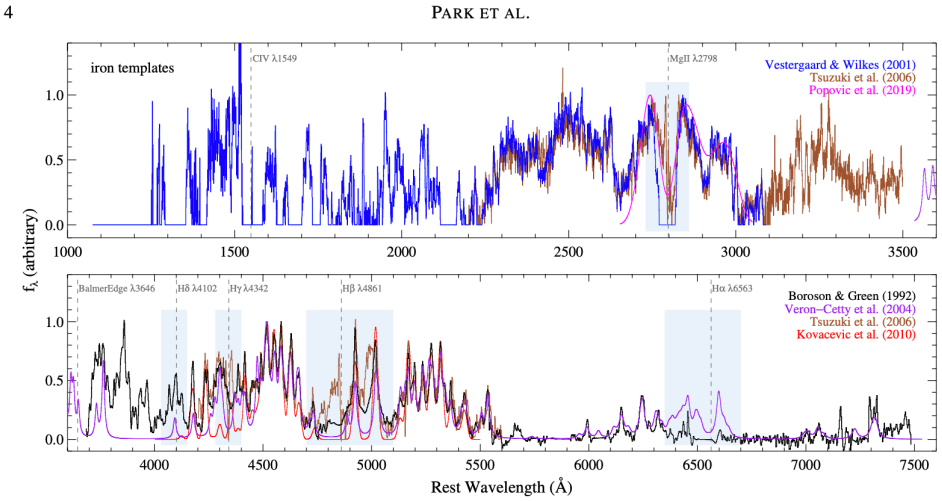
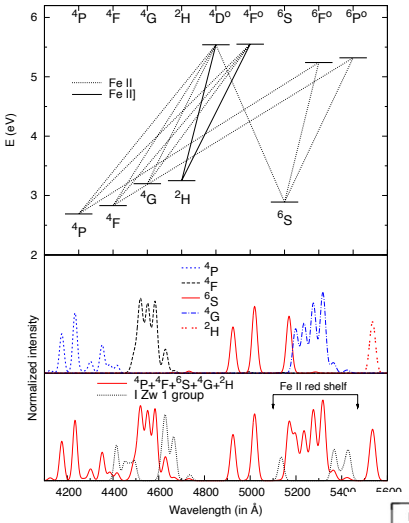
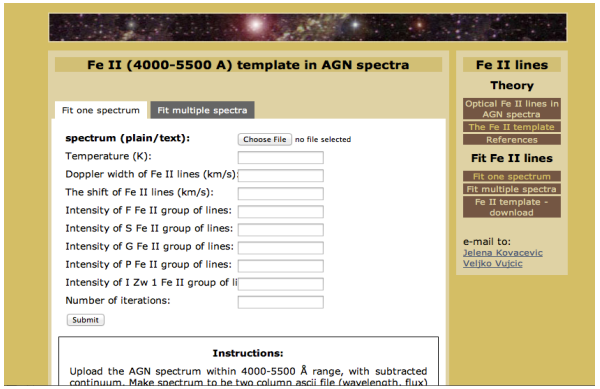


FeII line model

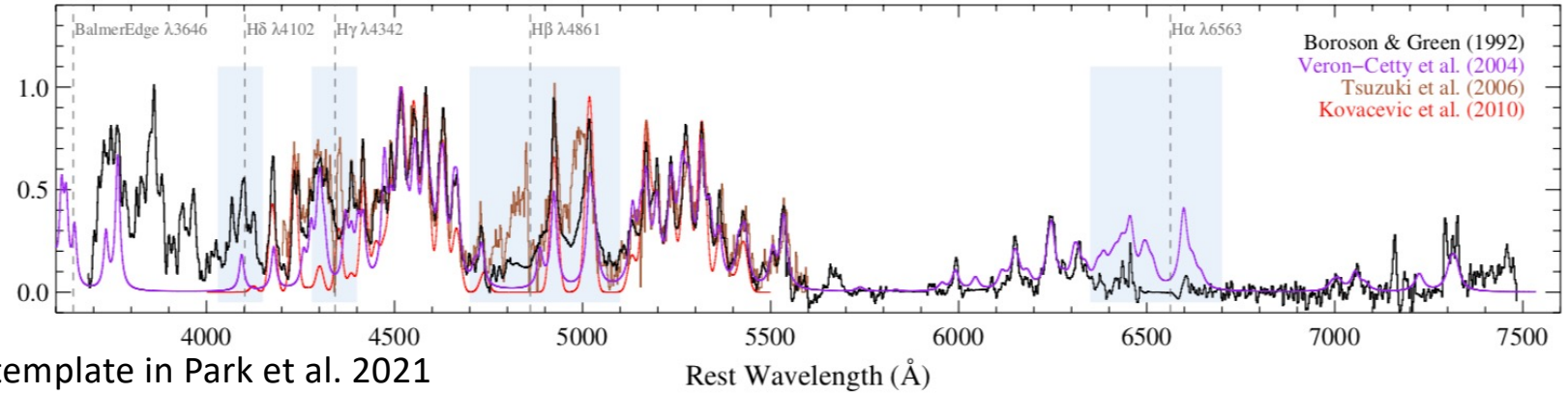


- **optical Fe II semi-analytical model** - gives one of the best fit of the Fe II lines (Kovačević+ 2010, Shapovalova+2012)

- Does not extend to red part, near Ha line
- Some line ratios empirical



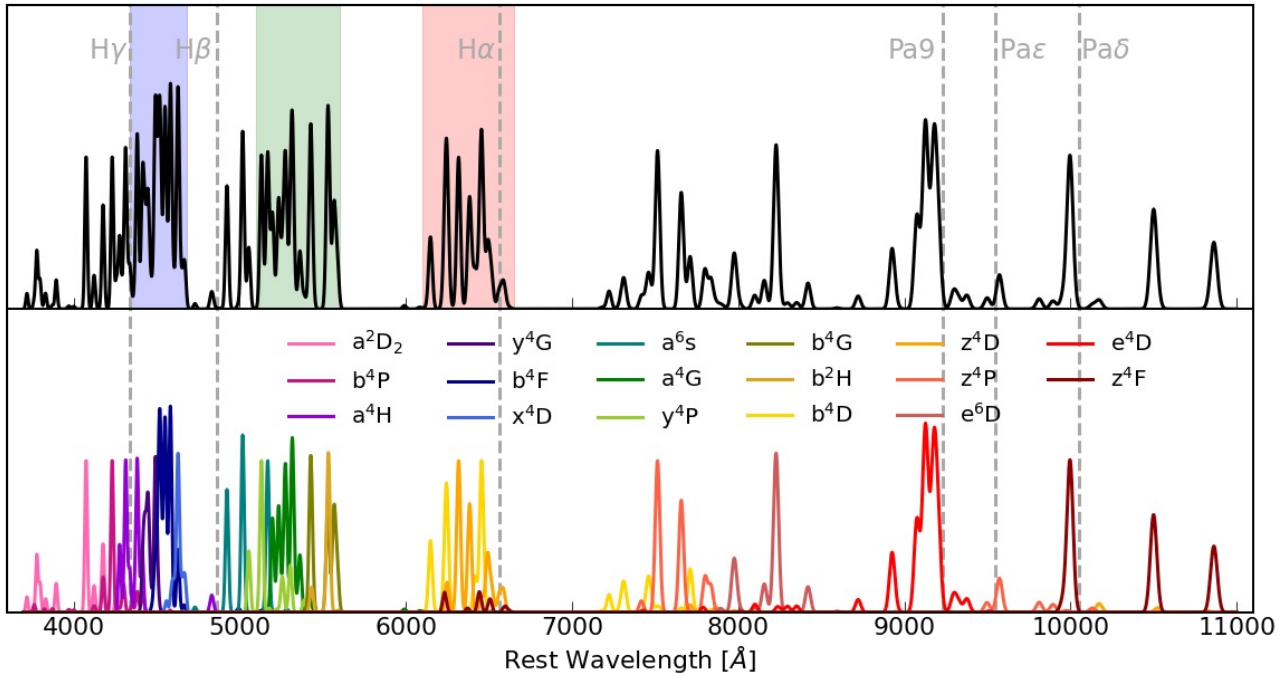
online tool at Serbian VO:
http://servo.aob.rs/FeII_AGN/



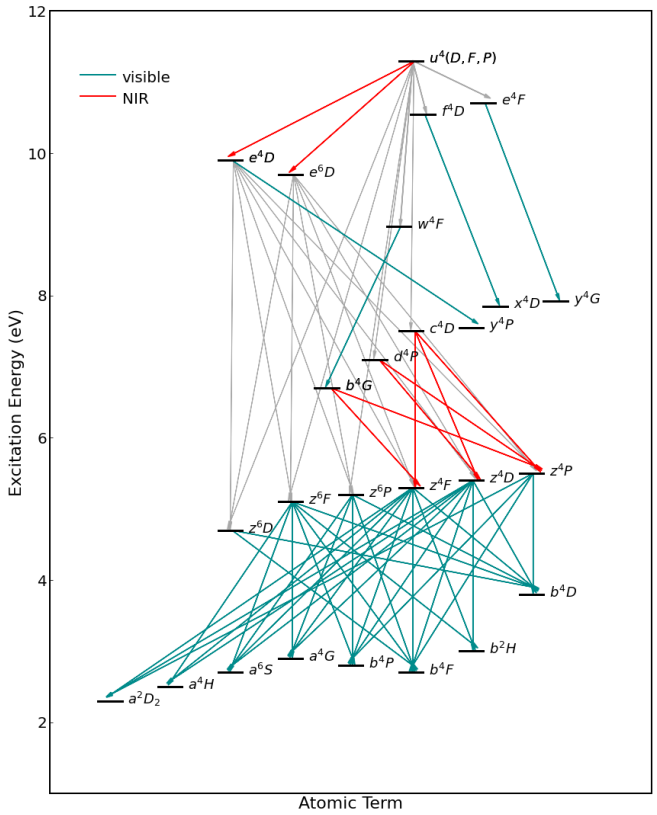
Latest template in Park et al. 2021

FeII modell for AGN (not template)

- Model of FeII emission **(3,700-11,000A)** using atomic data (based on Popovic et al. 2002, Kovacevic et al. 2010)



3,700-11,000A



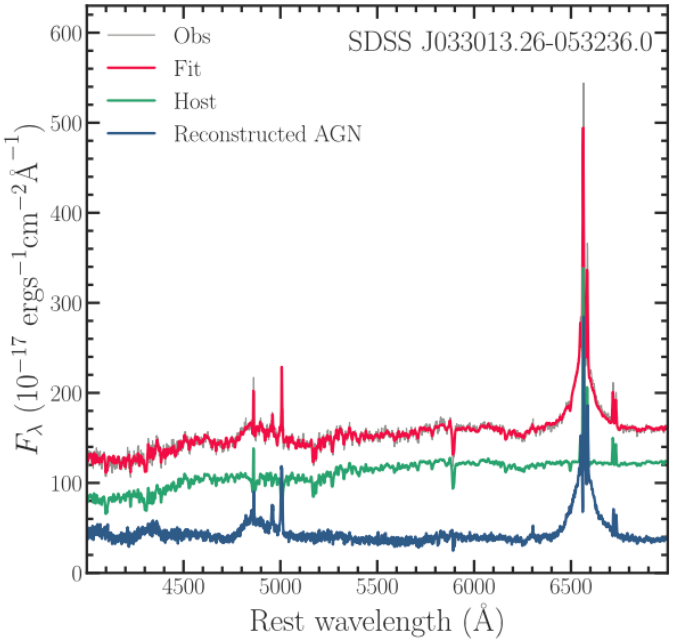
Ilić, Rakić, Popović 2023, ApJS, in press

FANTASY tool

- **F**ully **A**utomated pytho**N** **T**ool for **A**GN **S**pectra anal**Y**sis → **FANTASY**
- optimized for AGN optical &NIR spectra (3000-11,000A), but also UV
- atonomous & flexible
- variety of data-produces
- open-source: github
- features:
  - Different reading classes
  - Preparation of spectra (e.g. reddening, redshift, NaN values)
  - Host galaxy removal – using eigenvector
  - Libraries of significant emission lines
  - FeII lines model
  - Fitting uncertainties (Monte Carlo bootstrap method)

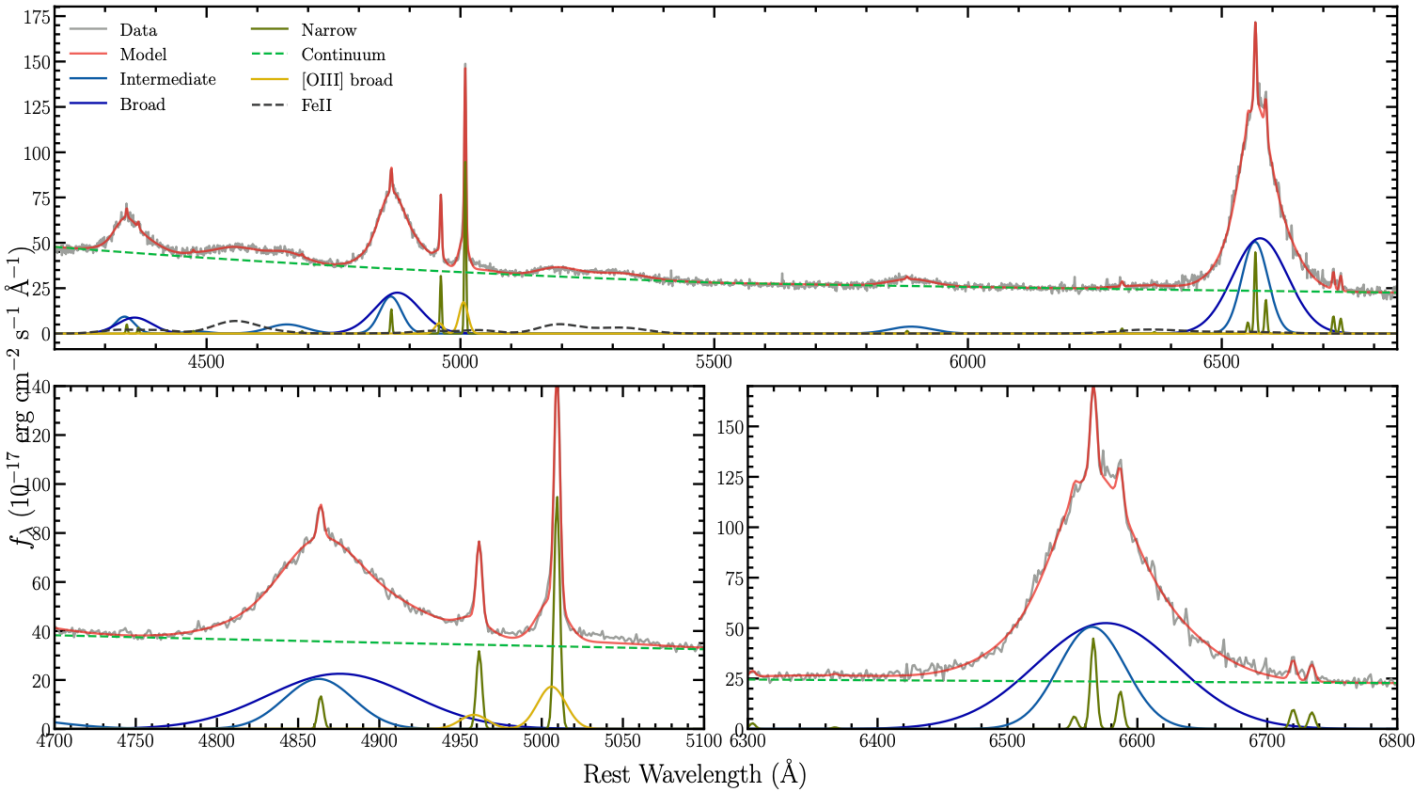
Rakić 2022, Ilic+2023

Example of SDSS spectra



host-galaxy removal

simultaneous fitting of all AGN components



Rakić 2022, MNRAS, 516, 1624R

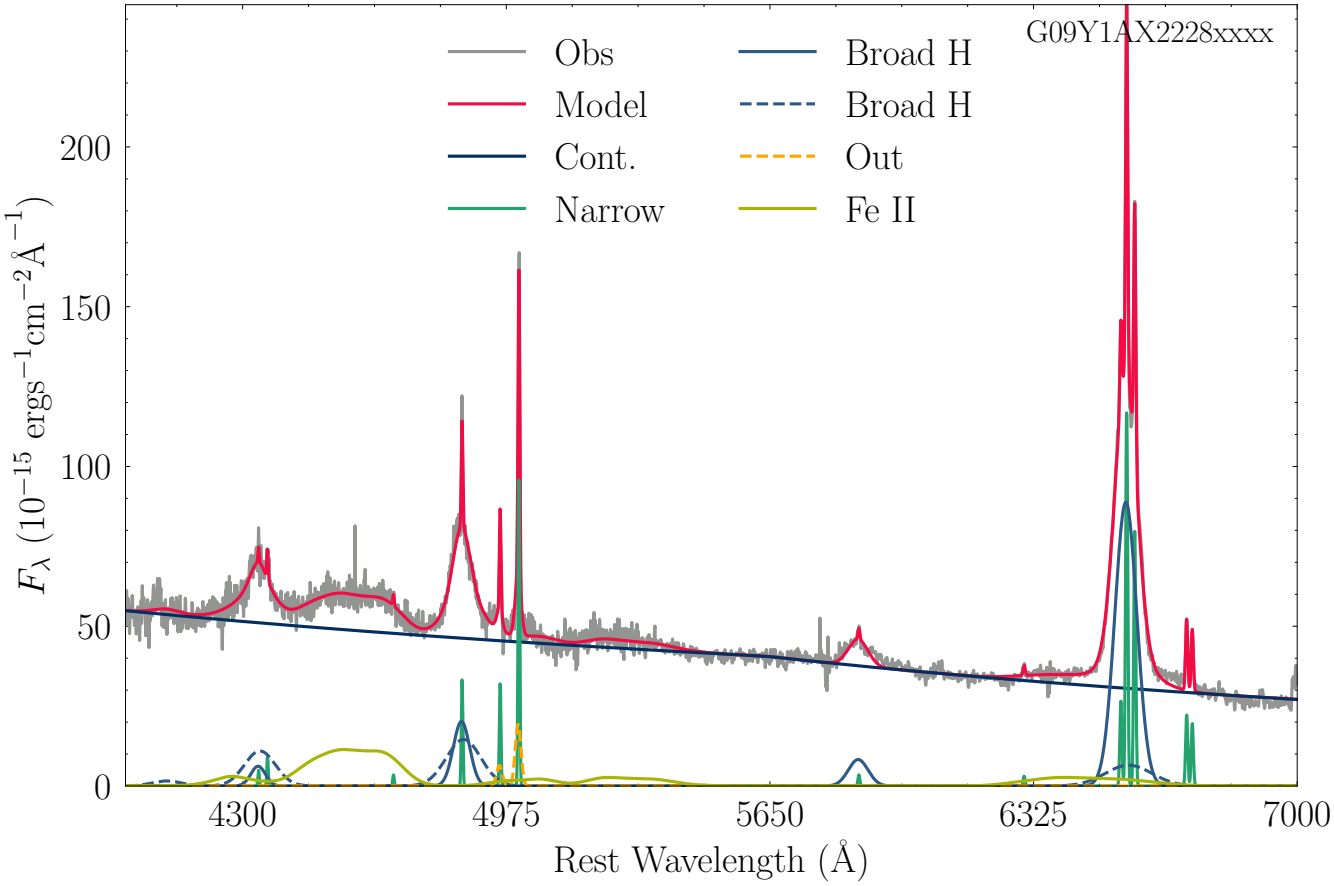
Example of GAMA spectra

Predifined line lists:

- Broad H
- Narrow – standard
- Narrow – extended
- FeII
- Coronal lines
- Customized lists

Different Line Models:

- Easy to add model components
- Set initial parameters, but code can also try to guess

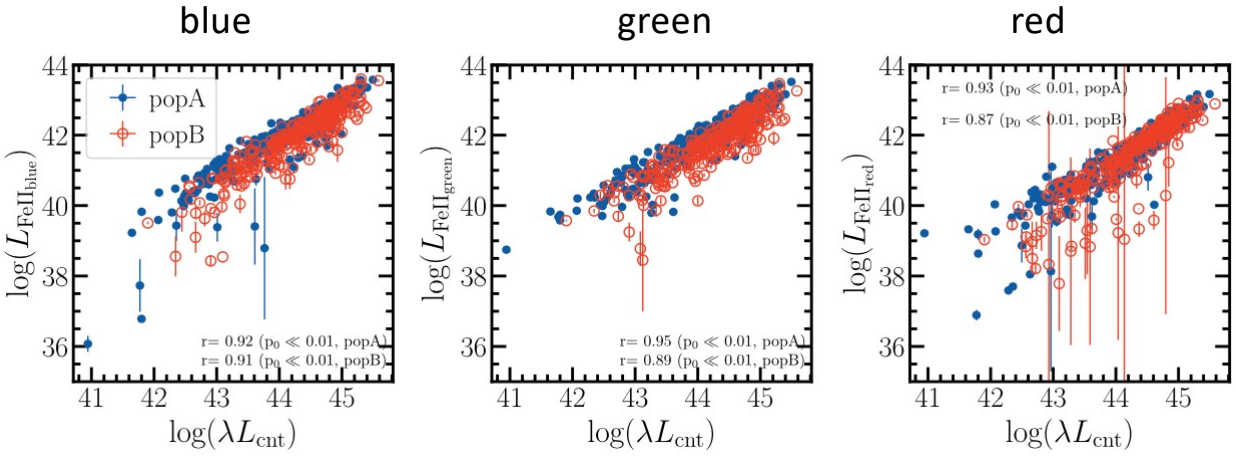


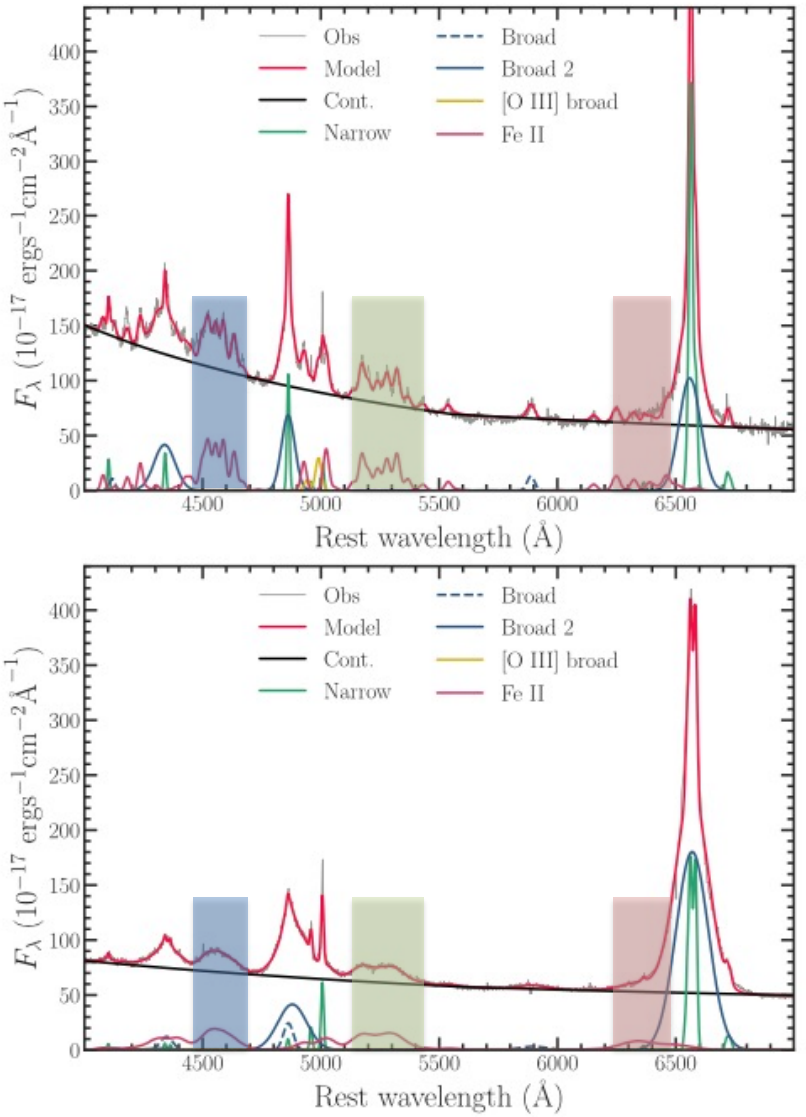
Ilić, Casura et al., in prep

FeII in the vicinity of Ha

- tested on ~650 SDSS spectra w S/N>30
- fitted with FANTASY using a single model

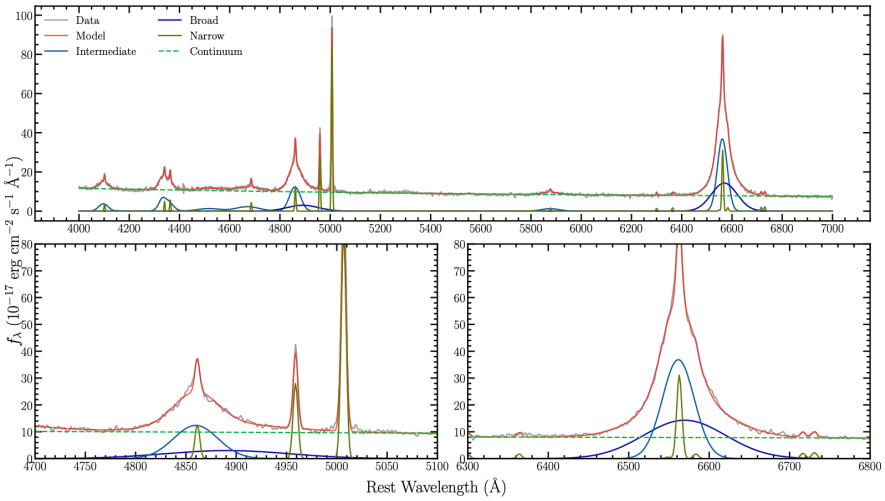
- when FeII emission seen near Hb line, always present near Ha (but weaker), especially in NLSy1





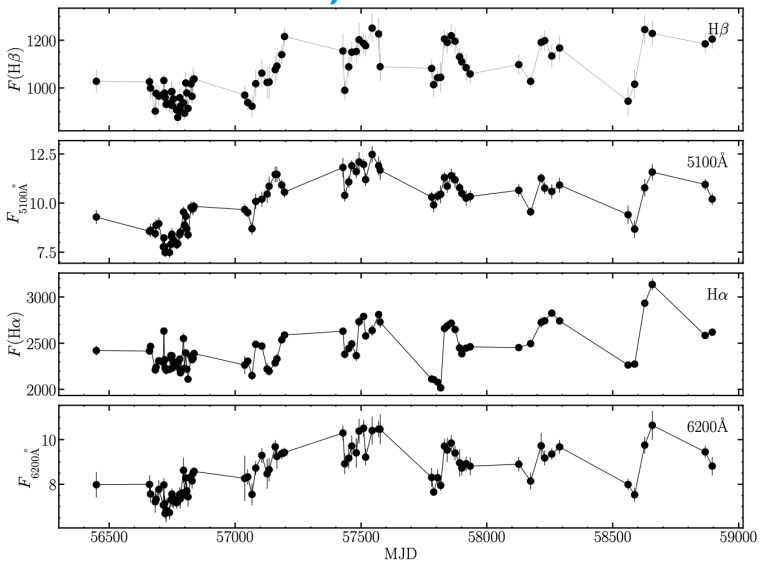
Ilić, Rakić, Popović 2023, ApJS, in press

Intrinsic Baldwin effect



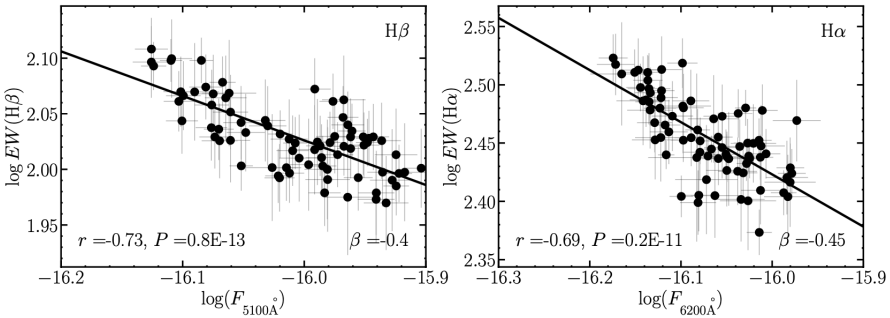
- SDSS-RM (Shen et al. 2015) – monitoring of ~850 objects
- We selected only spectra with S/N>20, z<0.5 → **8 objects**

SDSS RM 272, z=0.2628



- **Intrinsic Baldwin effect** seen in all objects
- **Why**: presence of non-ionizing optical continuum (also in Rakić et al. 2017)

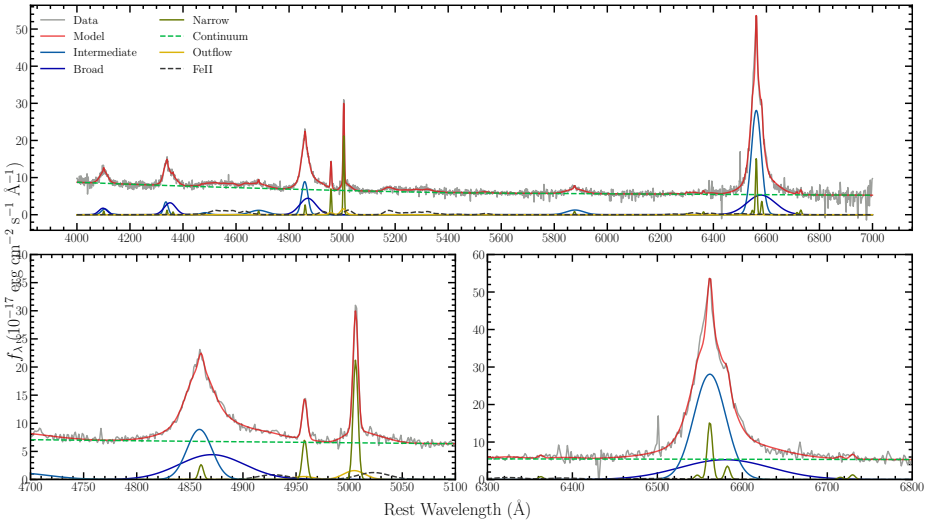
$$\log \mathrm{EW}_\lambda = A + \beta \log F_{\mathrm{cnt}},$$

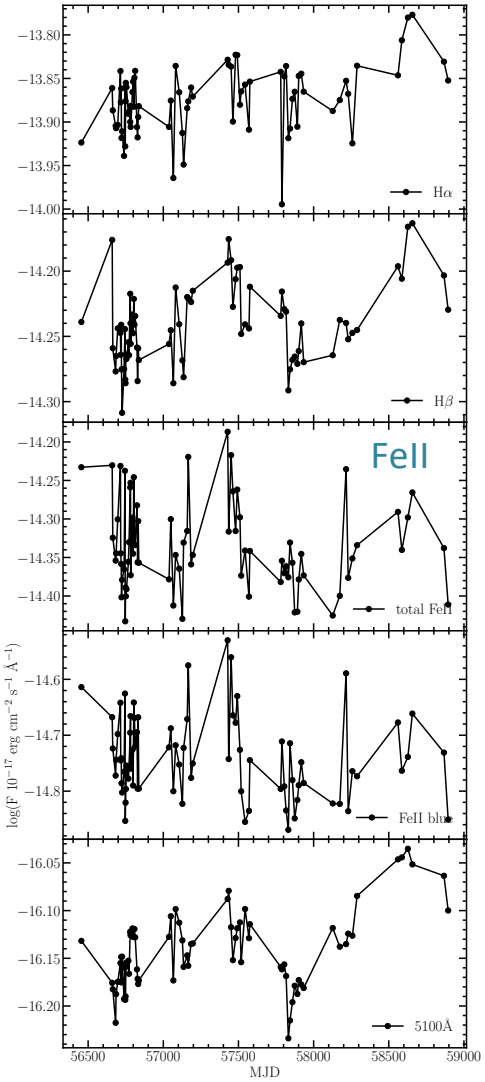


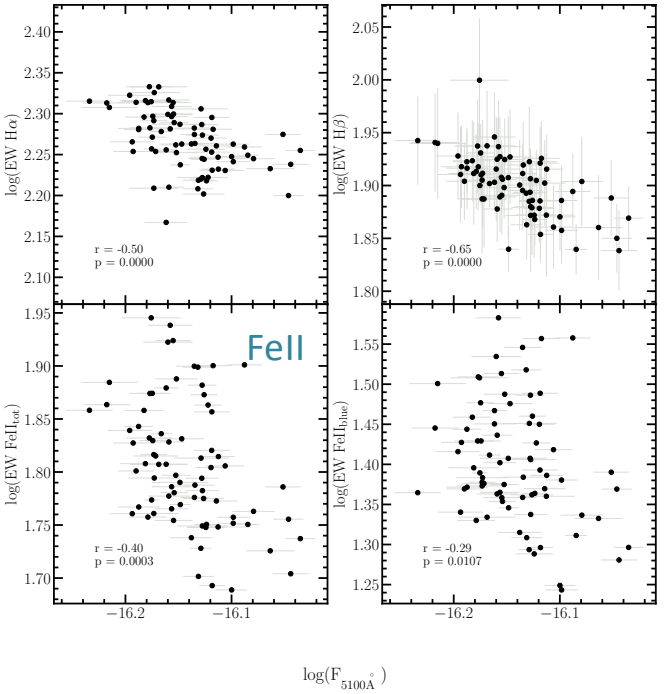
Rakić 2022, PhD thesis

SDSS RM 101

- Intrinsic Baldwin effect seen in Ha and Hb, also in FeII, but weaker
- challenge to measure FeII in survey data







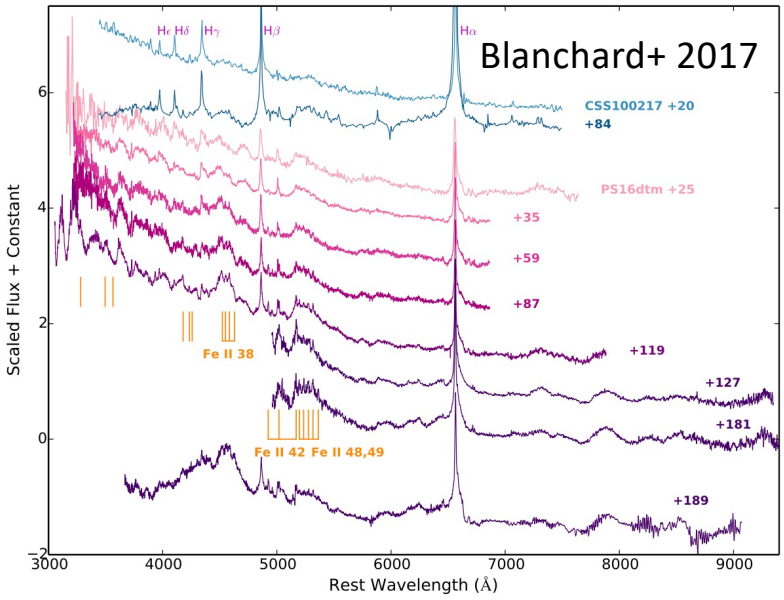
FANTASY for extreme TDE

The rise and fall of the iron-strong nuclear transient PS16dtm

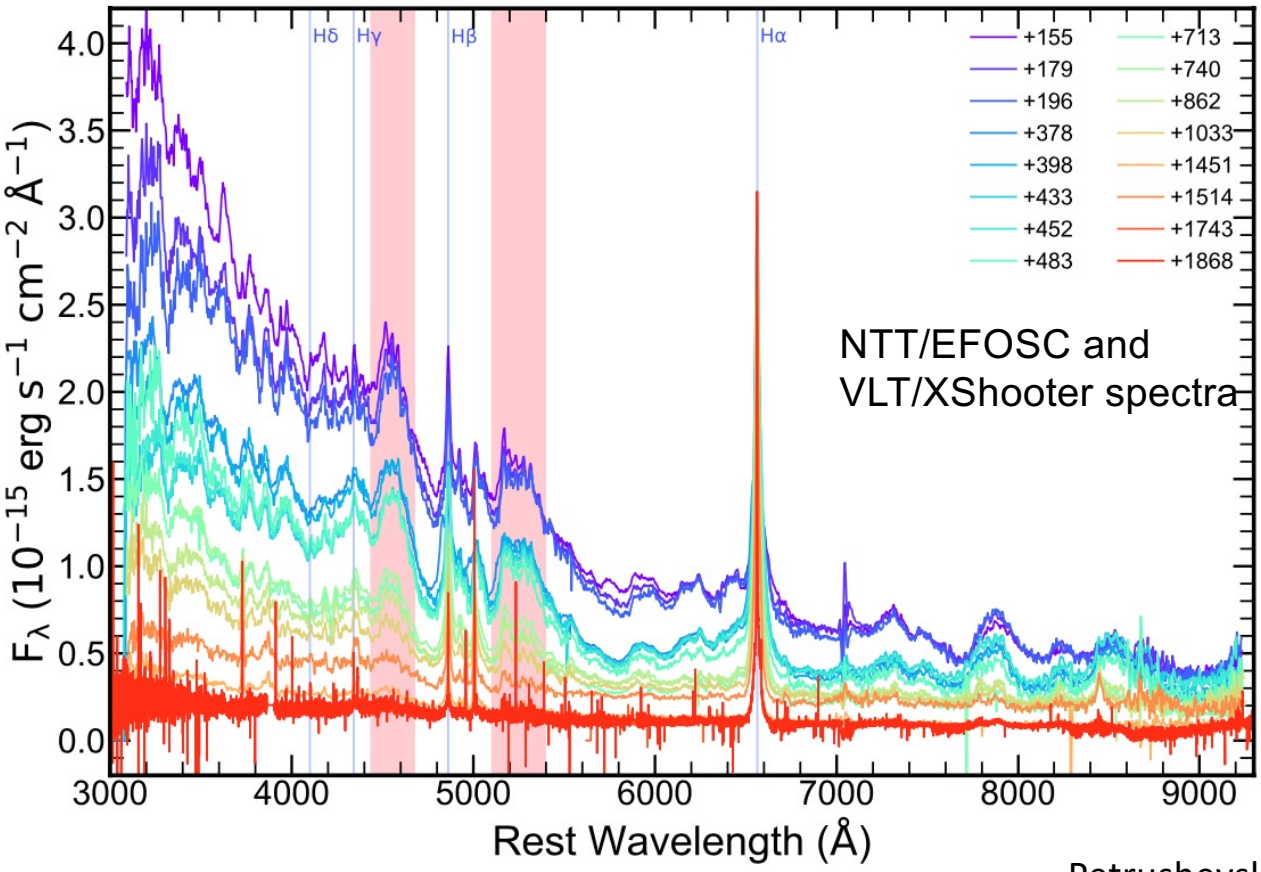
- TDE **PS16dtm** in Narrow-line Seyfert 1 galaxy
- Strong increase of broad emission lines, especially FeII
- PS16dtm is blocking the pre-existing X-rays from the AGN host (Blanchard+ 2017)
- Our study - 2000 days of photometric and spectroscopic monitoring

(Petrushevska, Leloudas, Ilić et al. 2023, A&A, 669, A140)

→ See poster no 20. by Tanja Petrushevska



PS16dtm spectra - strongest iron emission in a nuclear transient



- Hydrogen Balmer lines (narrow, intermediate and broad components)
- **broad Fe II emission is transient**: not present in the pre-outburst spectrum and completely disappeared in our last spectrum at +1868 days
- super-Eddington accretion

Petrushevska, Leloudas, Ilić, et al. 2023, A&A, 669, A140

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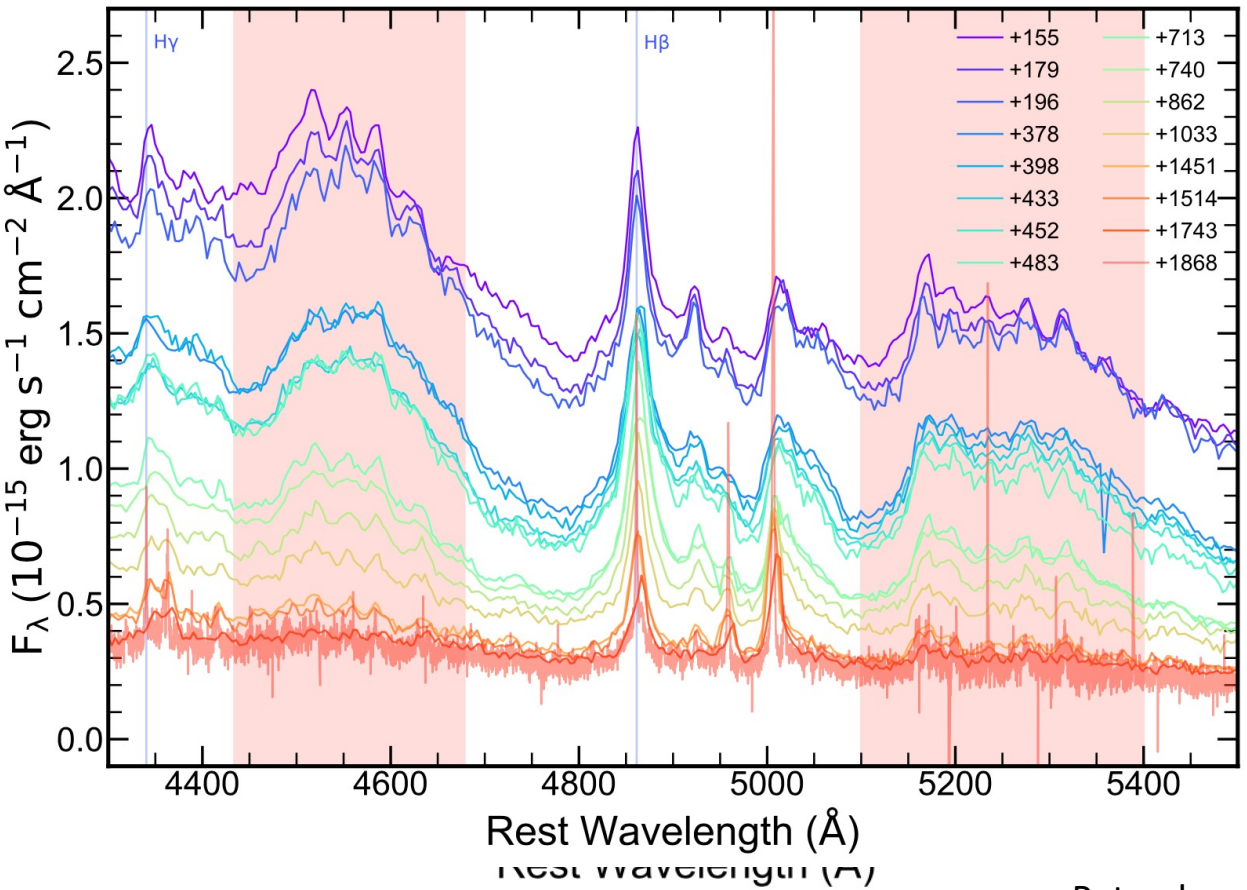

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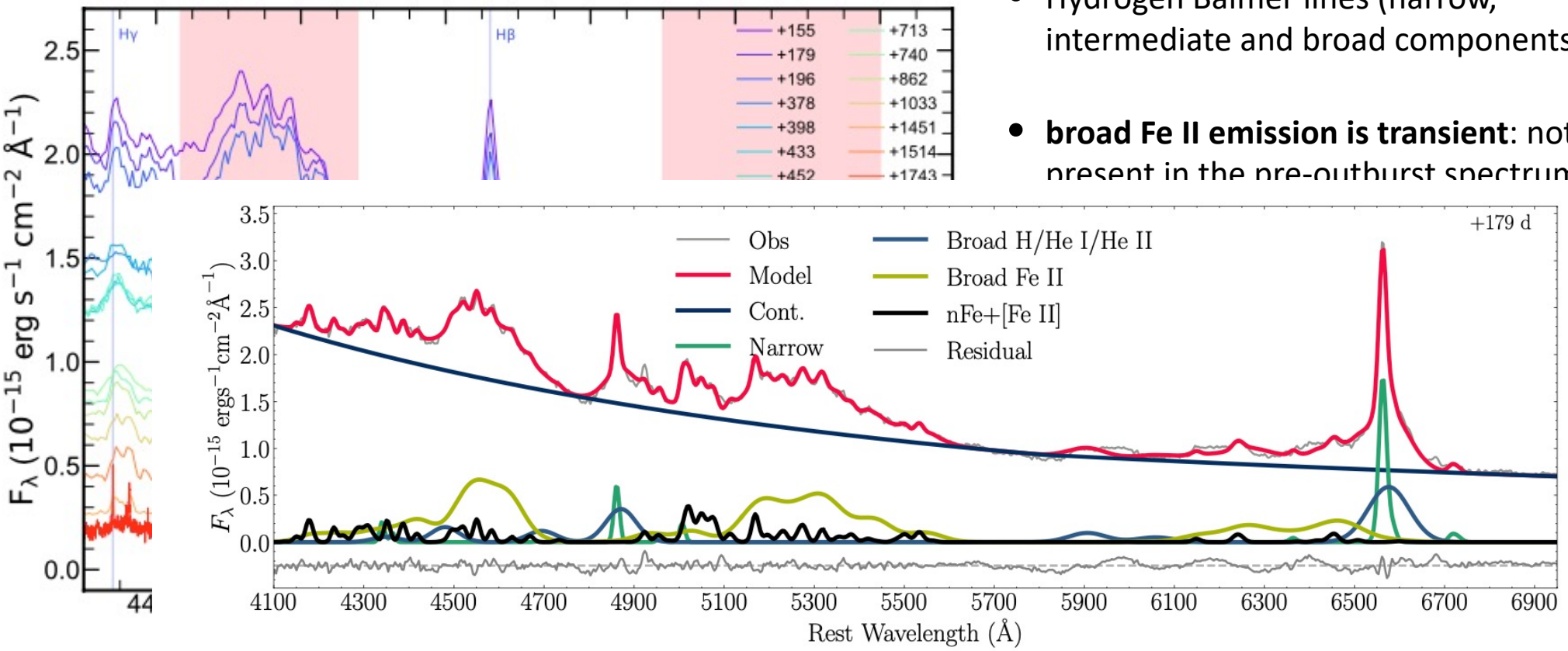

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Petrushevska, Leloudas, Ilić, et al. 2023, A&A, 669, A140

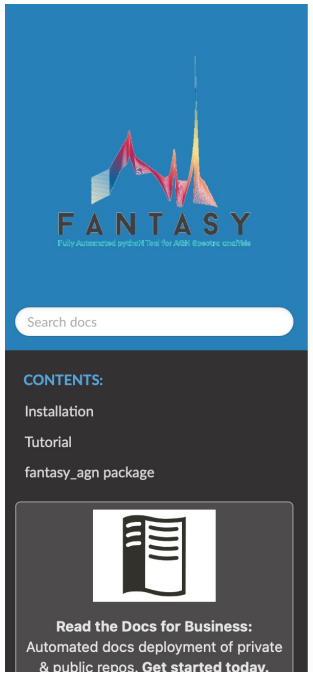
Fantasy: Open Source

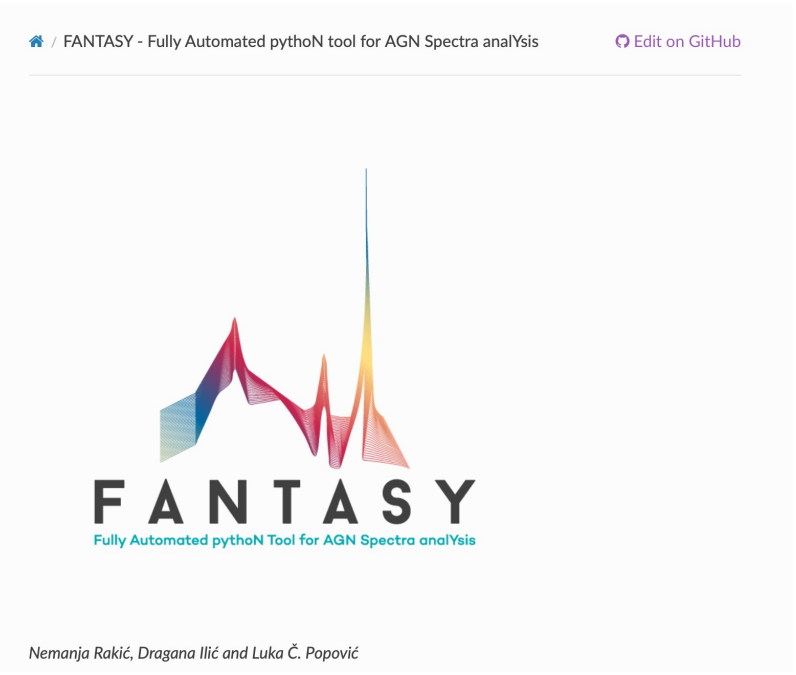
- https://fantasy-agn.readthedocs.io/en/latest/

go to code

- **pip install fantasy_agn**
- Tutorials available
- Plan for online workshop
  (dragana.ilic@matf.bg.ac.rs)

…and growing……



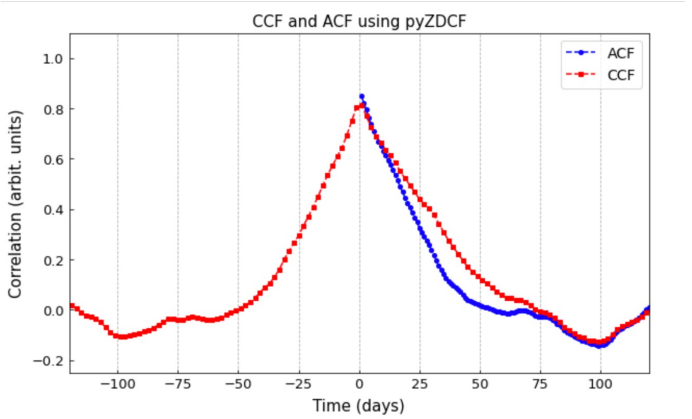


Rakić 2022, MNRAS, 516, 1624R
Ilić, Rakić, Popović 2023, ApJS, in press

pyZDCF – ZDCF in python

part of SER-SAG-S1 *In-kind* contribution to the LSST
https://github.com/LSST-sersag/dle

- Python module of a Fortran program ZDCF
  (Z-transformed Discrete Correlation Function, Alexander 199
  - pyZDCF is based on the original Fortran code fully developed by Prof. Tal Alexander from Weizmann Institute of Science, Israel
  - Jankov, I., Kovačević A. B., Ilić, D., et al. 2022, AN, 343, e210090
  - https://pyzdcf.readthedocs.io/en/latest/index.html



- "Photometric reverberation mapping of AGNs
  → Notebook on NOIRLab Astro Datalab

https://datalab.noirlab.edu