Fantastic fits of AGN spectra with FANTASY

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

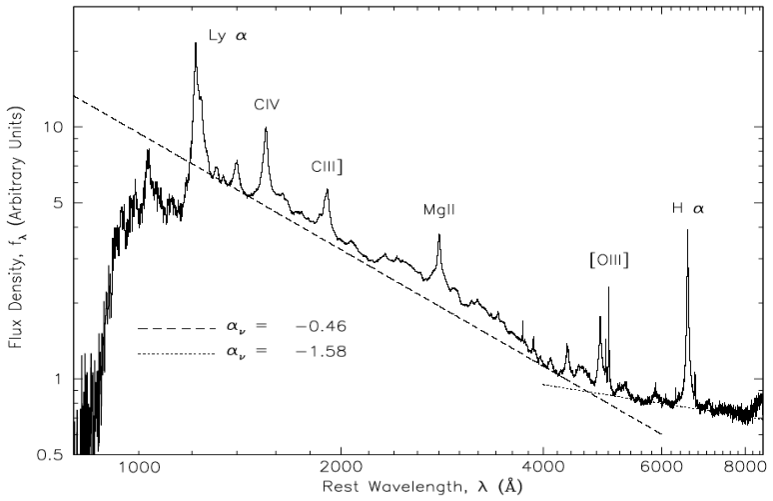
Rakić 2022, MNRAS, 516, 1624R
Ilić, Rakić, Popović 2023, ApJS, accepted

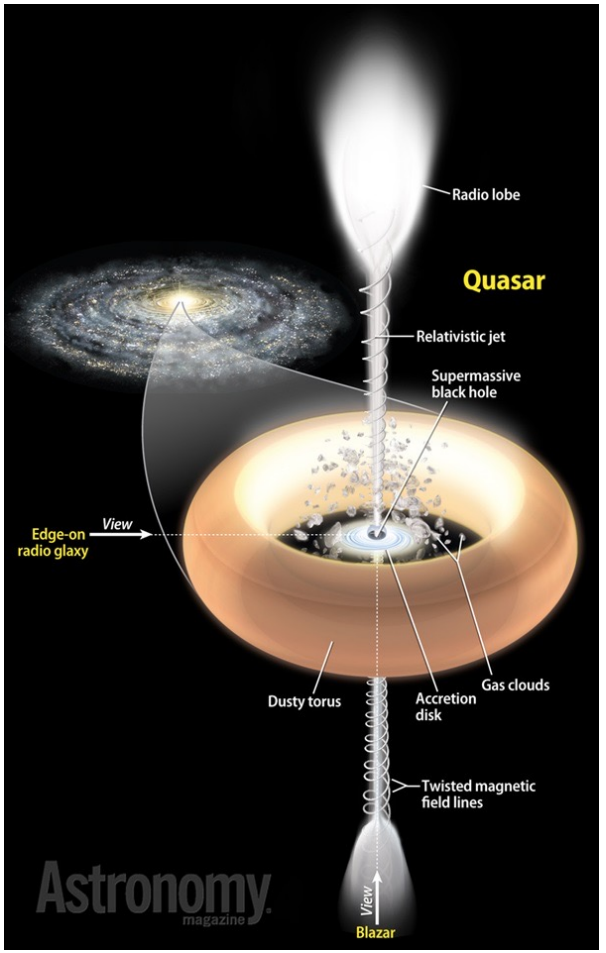
AGN Broad Emission Lines

- 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

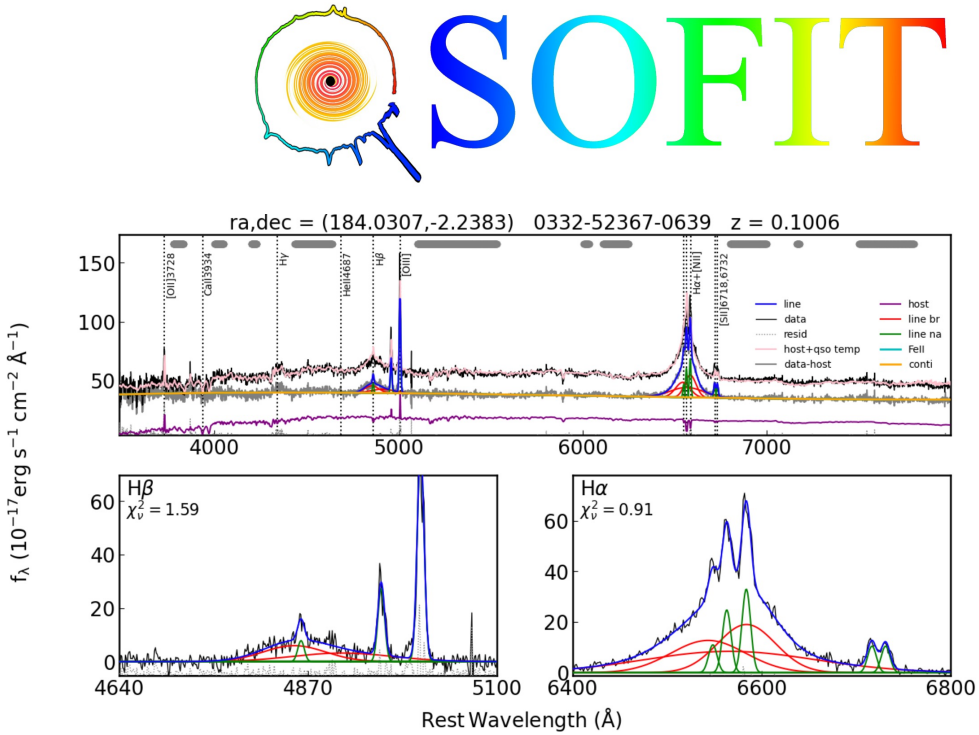
→ era of massive surveys and data collecting





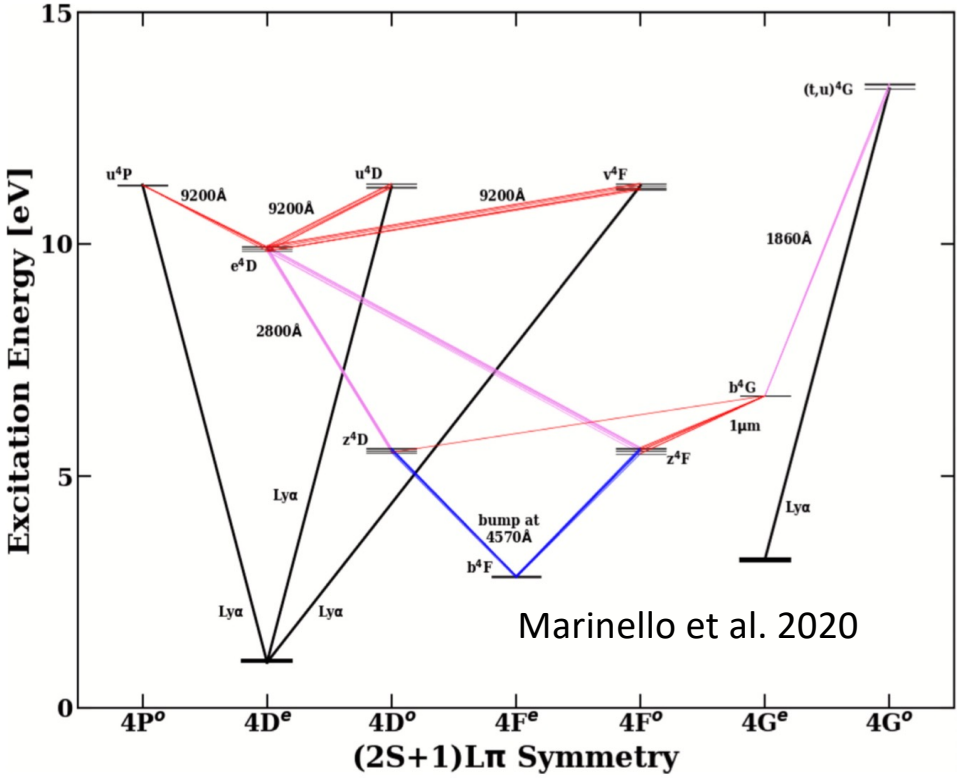
Examples of fitting tools specialized for AGN

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



Richness of AGN Emission lines

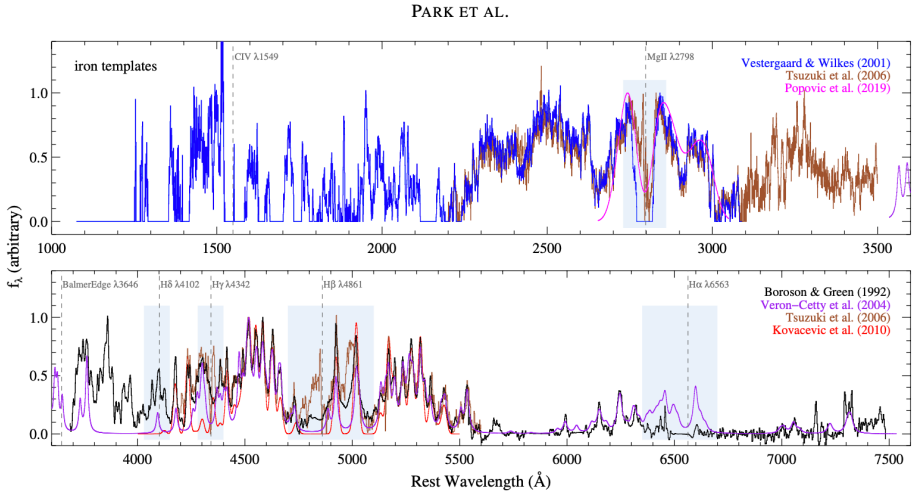
827 Fe II energy levels and Lya transitions
out of 23,000 (Sigut & Pradhan 2003)



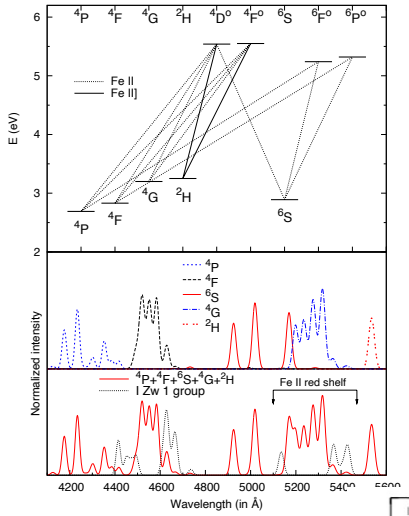
Marinello et al. 2020

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

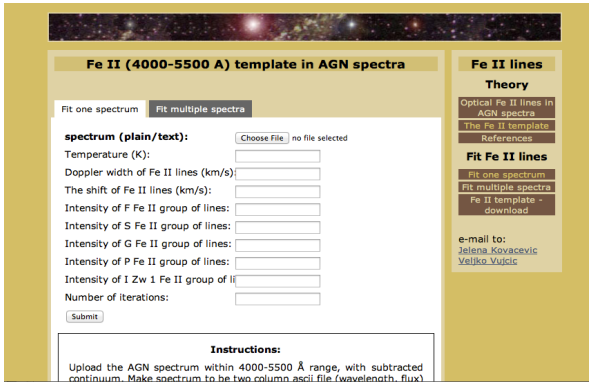
- Great need for FeII templates (latest review in Park et al. 2022)



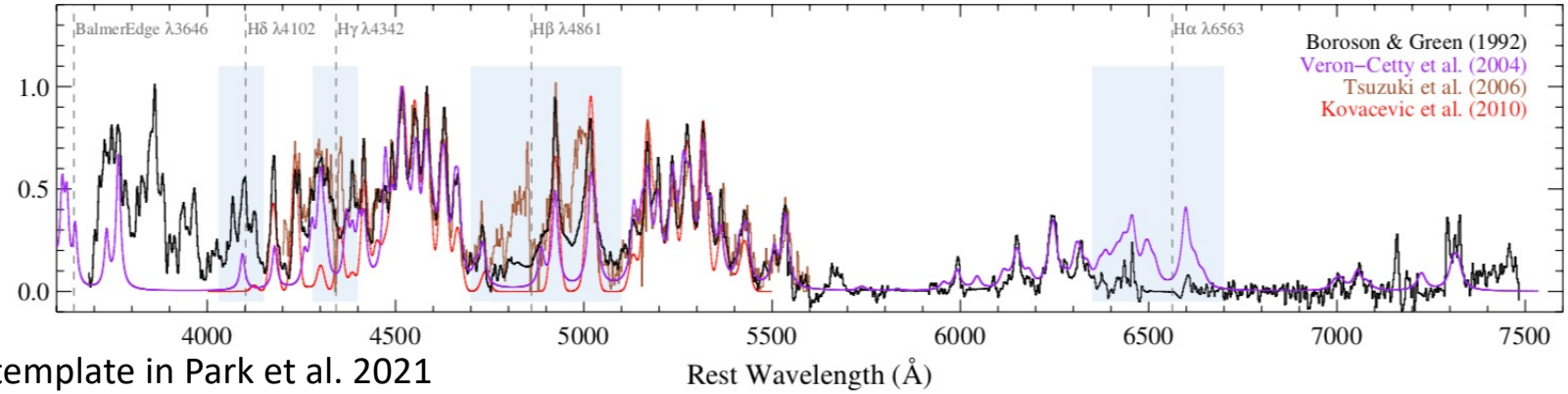
FeII line model



- **optical Fe II semi-analytical model** - gives one of the best fit of the Fe II lines (Kovačević+ 2010, Shapovalova+2012)
- But, does not extend to red part
- Some line ratios empirical



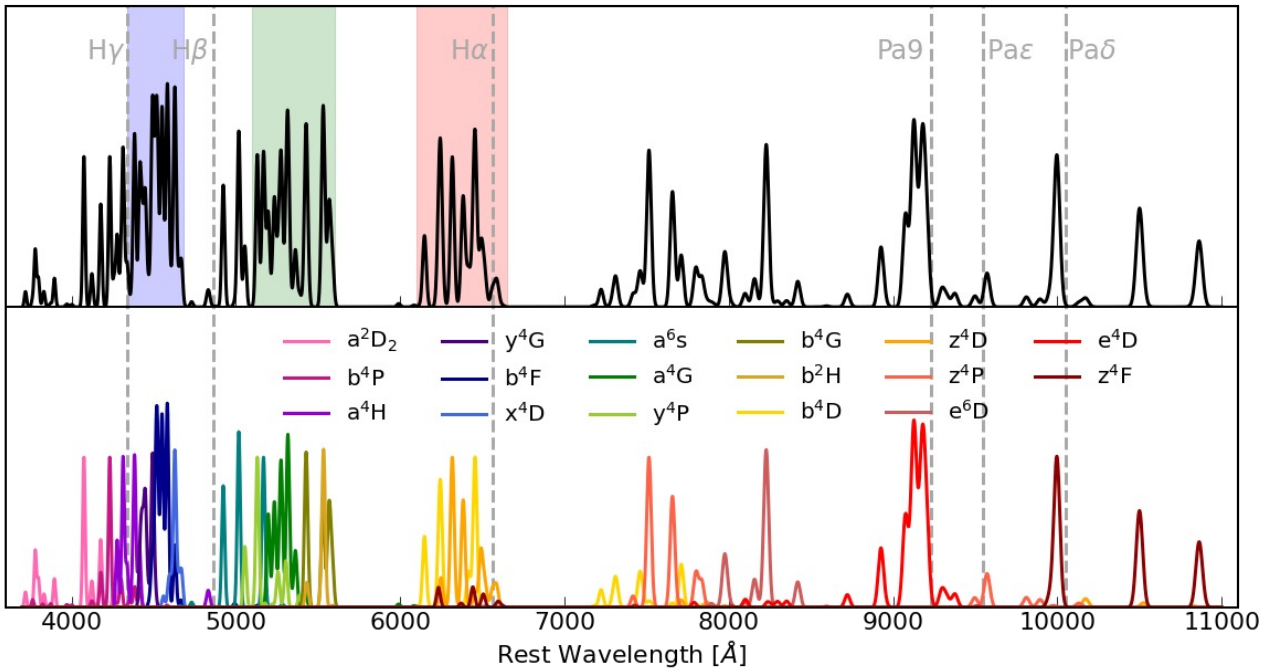
online tool at Serbian VO:
http://servo.aob.rs/FeII_AGN/



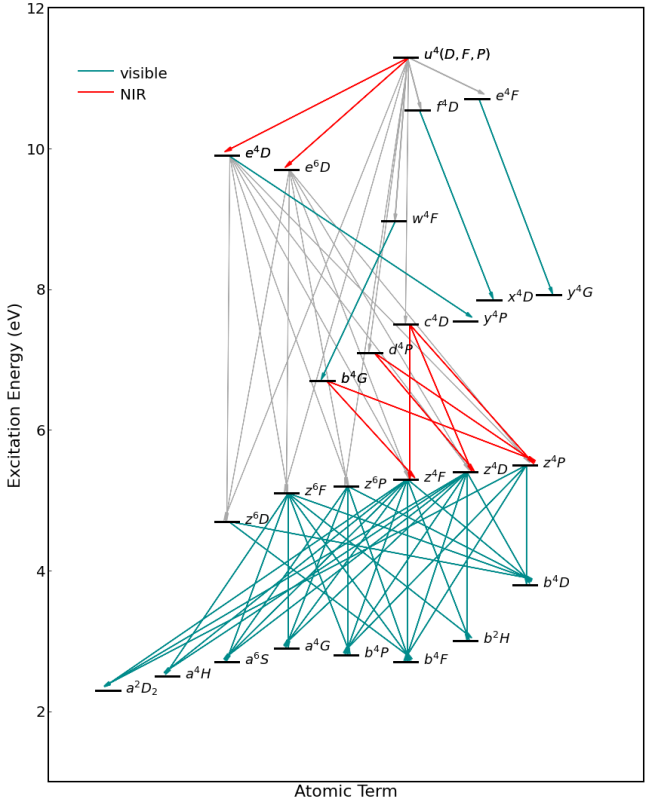
Latest template in Park et al. 2021

FeII emission in AGN

- 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

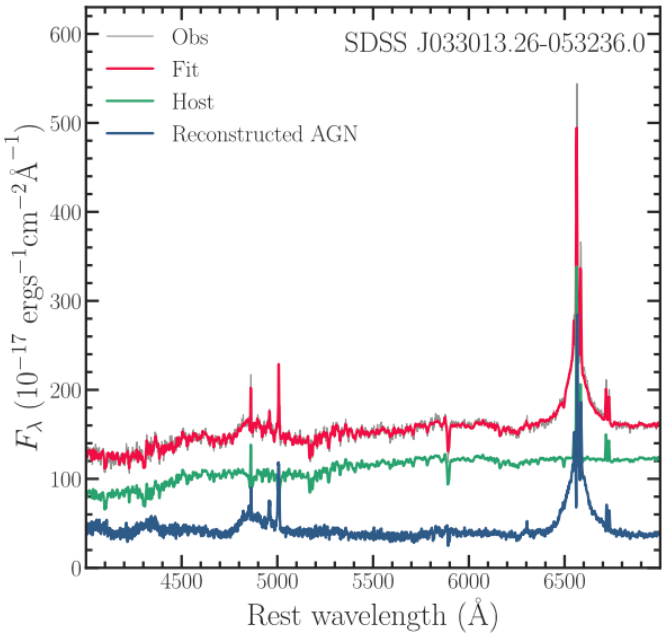
- **F**ully **A**utomated pytho**N** **T**ool for **A**GN **S**pectra anal**Y**sis → **FANTASY**
- optimized for AGN optical &NIR spectra (3000-11,000A), but also UV
- atonomous & flexible
- variety of data-produces
- open-source: github
- features:
  - Different reading classes
  - Preparation of spectra (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)

```
from spectra import read_gama_fit # reading GAMA survey fit files

s=read_gama_fit('foo.fit')
s.automatic_fit()
```

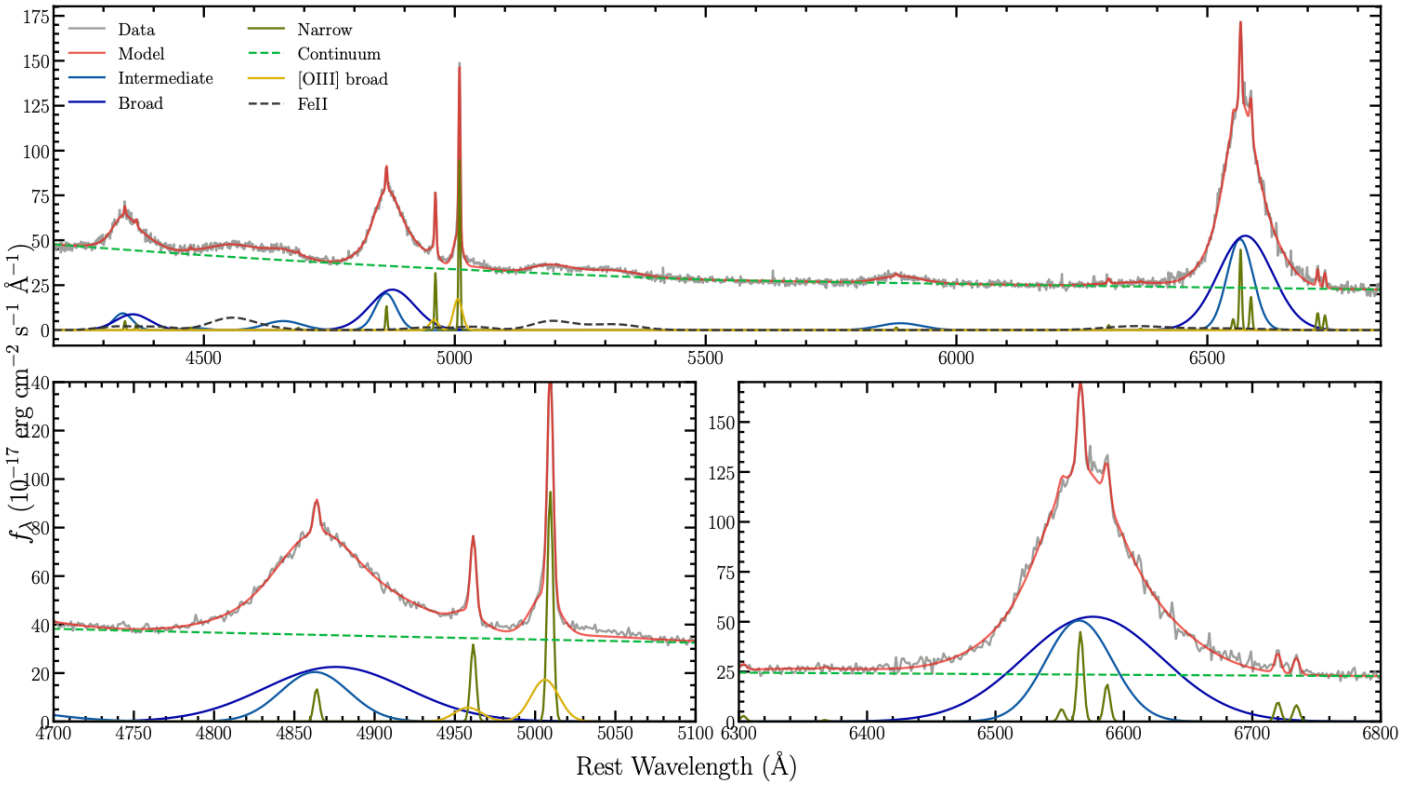
Rakić 2022, Ilic+2023

Example of SDSS spectra



host-galaxy removal

simultaneous fitting of all AGN components



Rakić 2022, MNRAS, 516, 1624R

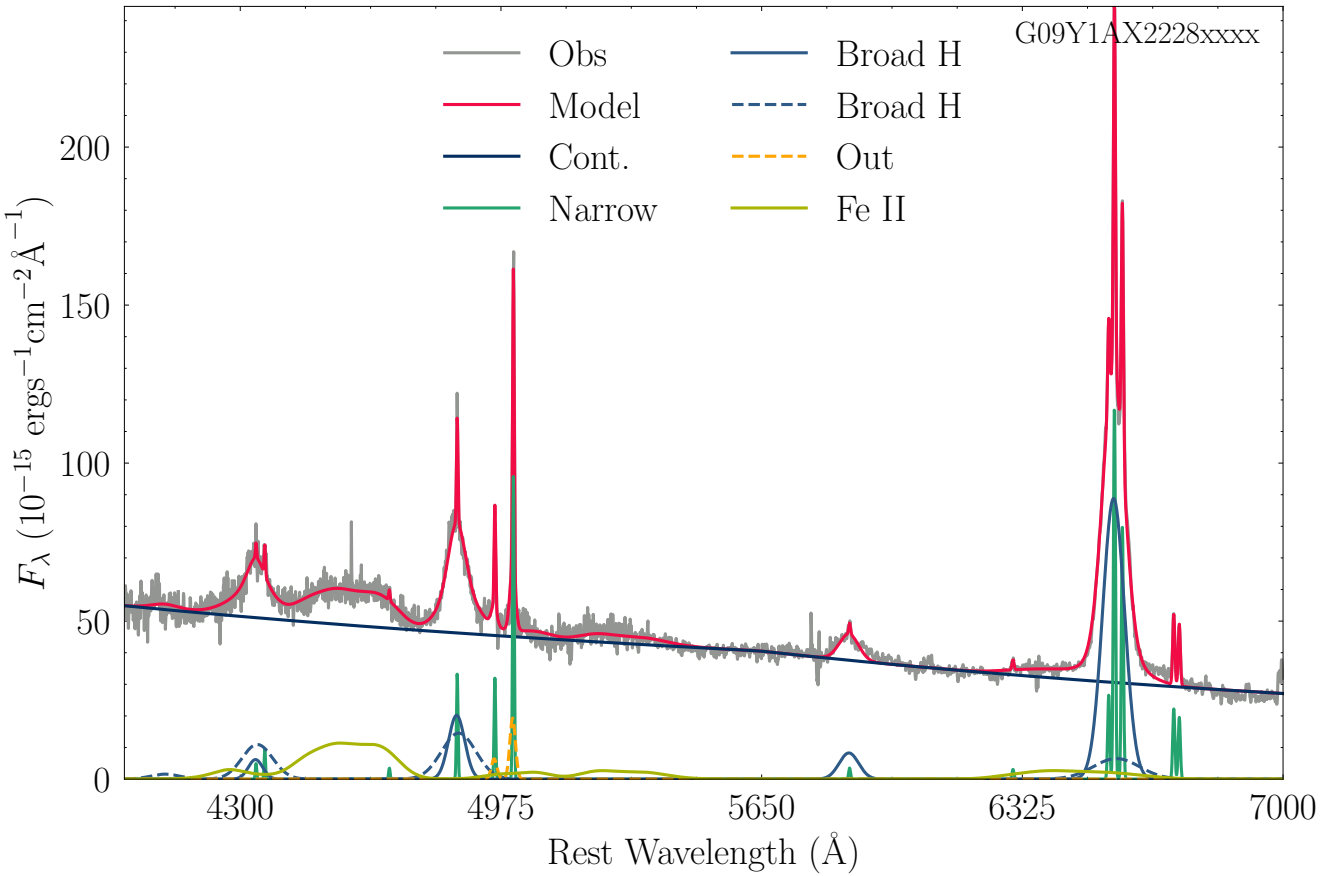
Example of GAMA spectra

Predifined line lists:

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

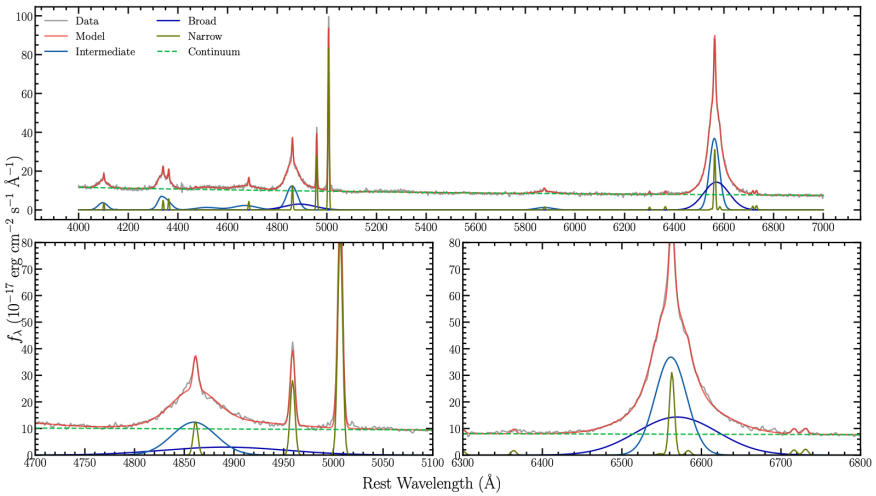
Different Line Models:

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



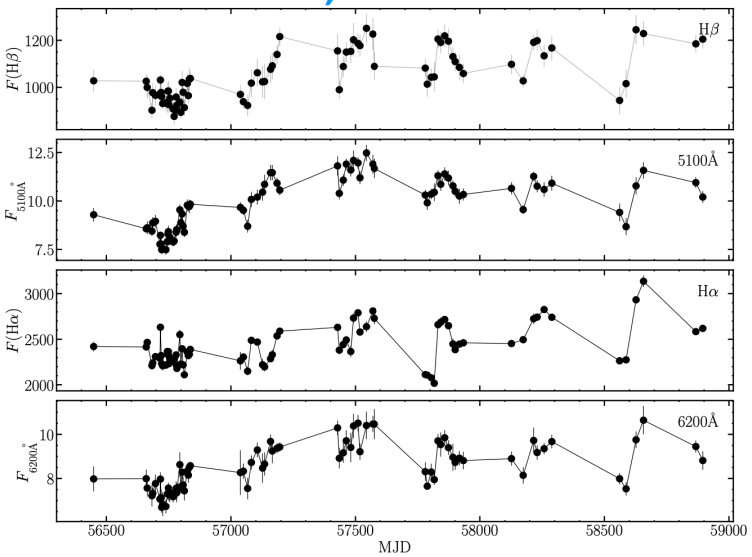
Ilić, Casura et al., in prep

Intrinsic Baldwin effect



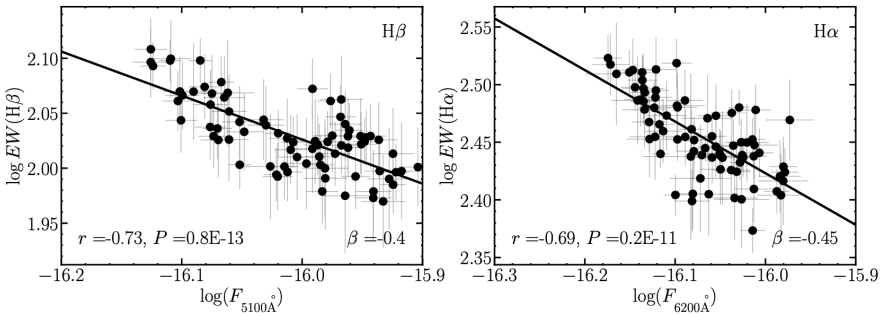
- SDSS-RM (Shen et al. 2015) – monitoring of ~850 objects
- We selected only spectra with S/N>20, z<0.5 → 8 objects

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)

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

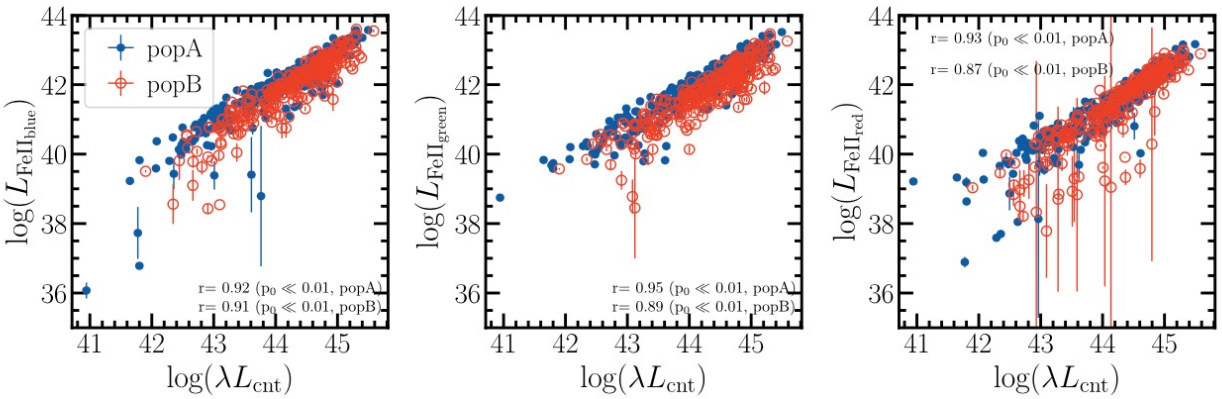


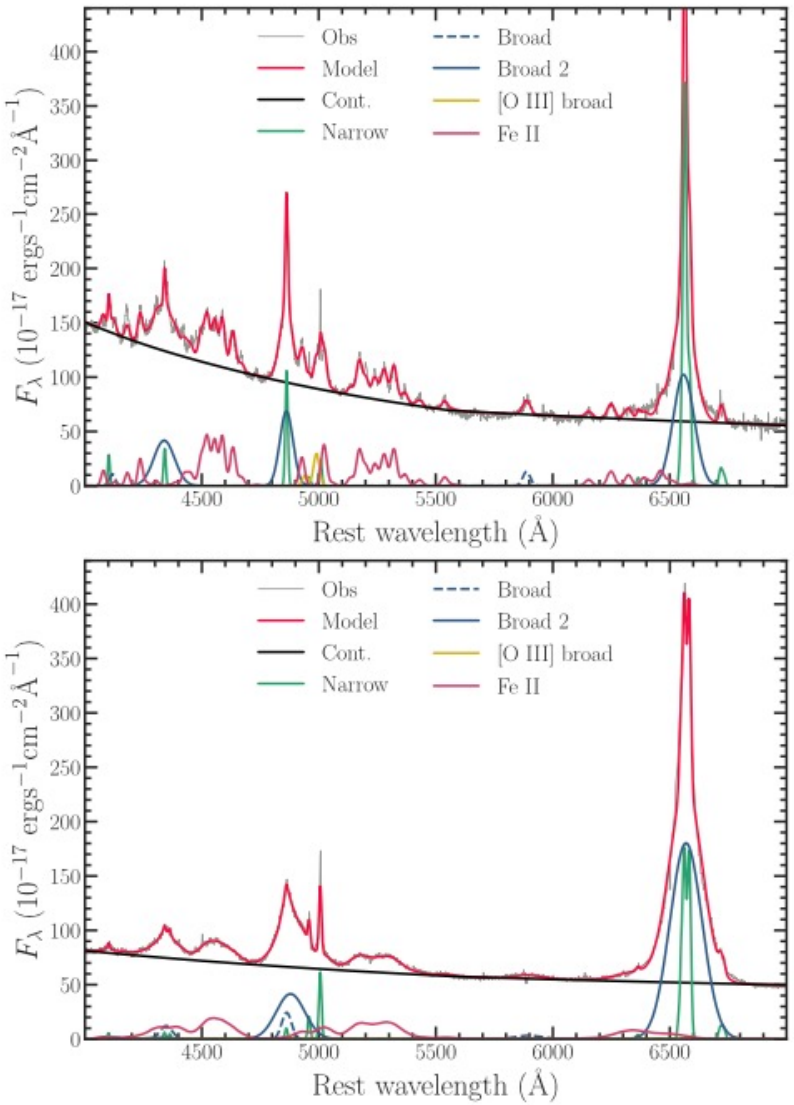
Rakić 2022, PhD thesis

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

FANTASY for extreme TDE

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

- Tidal Distruption Event **PS16dtm** in Narrow-line Seyfert 1 galaxy

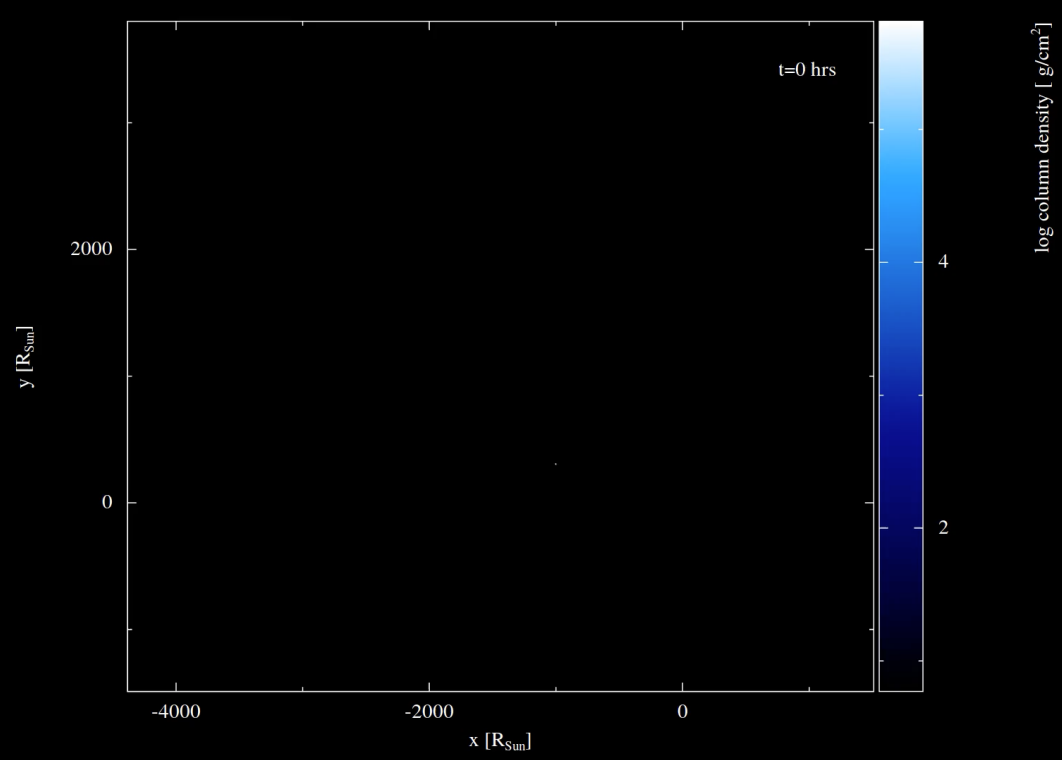
- Petrushevska, Leloudas, Ilić…Rakić et al. 2023, A&A, 669, A140

Credits:
NASA/JPL-Caltech

Tidal disruption events

- First suggested by theorists in the 1970s, that stars that pass close enough to the SMBH, tidal forces can rip the star apart

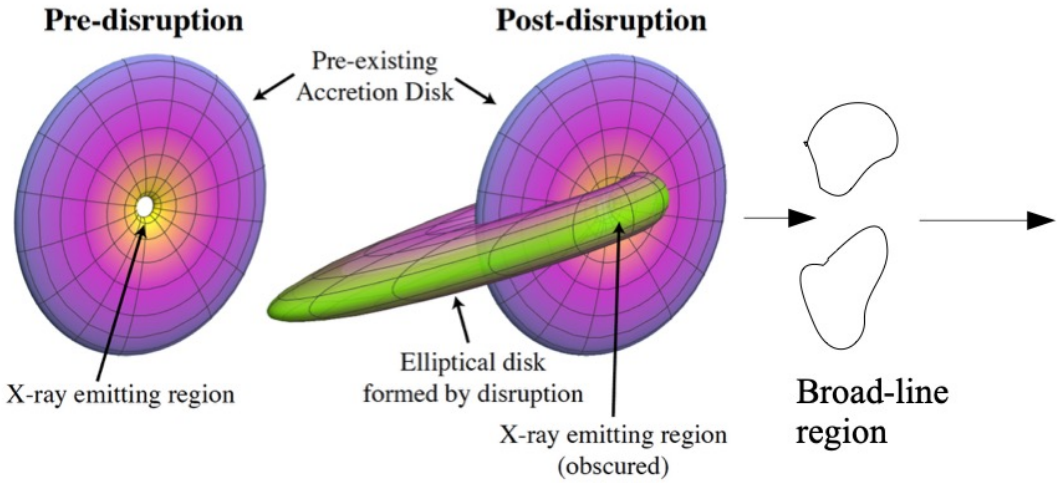
- Classical picture (Rees 1988): roughly half of the gaseous stellar debris remains gravitationally bound in a range of highly eccentric elliptical orbits,
- Accretion disk is formed
- Light should peak in the X-ray domain

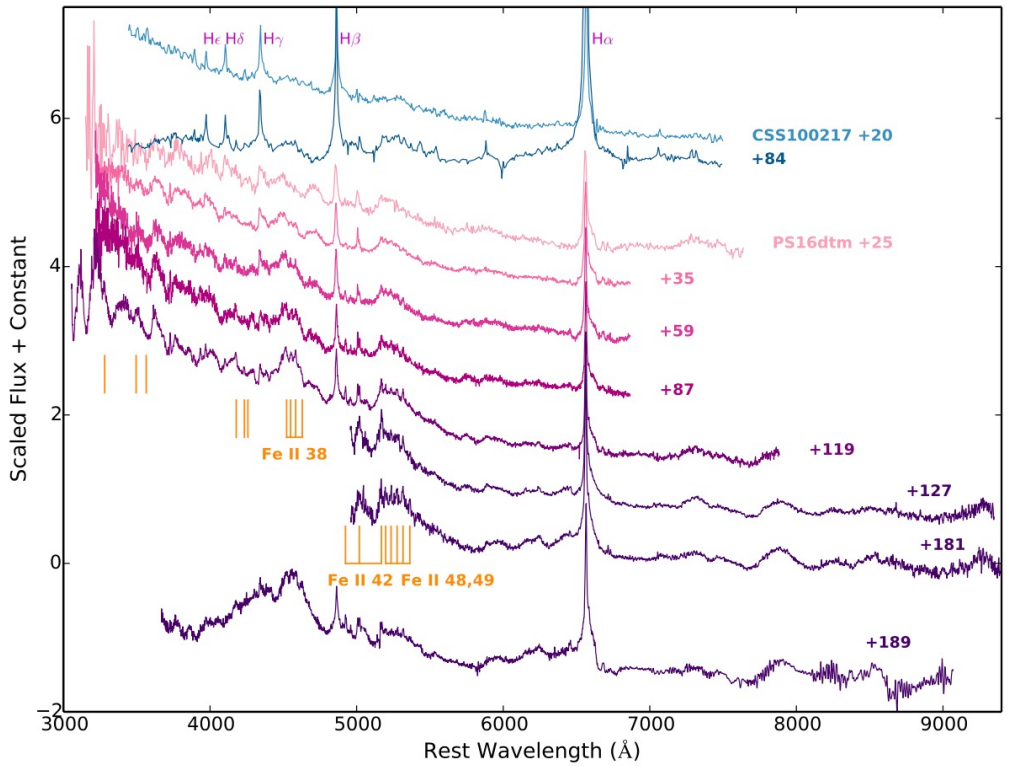


A hydrodynamic simulation of a tidal disruption event. Credit: Taj Jankovič

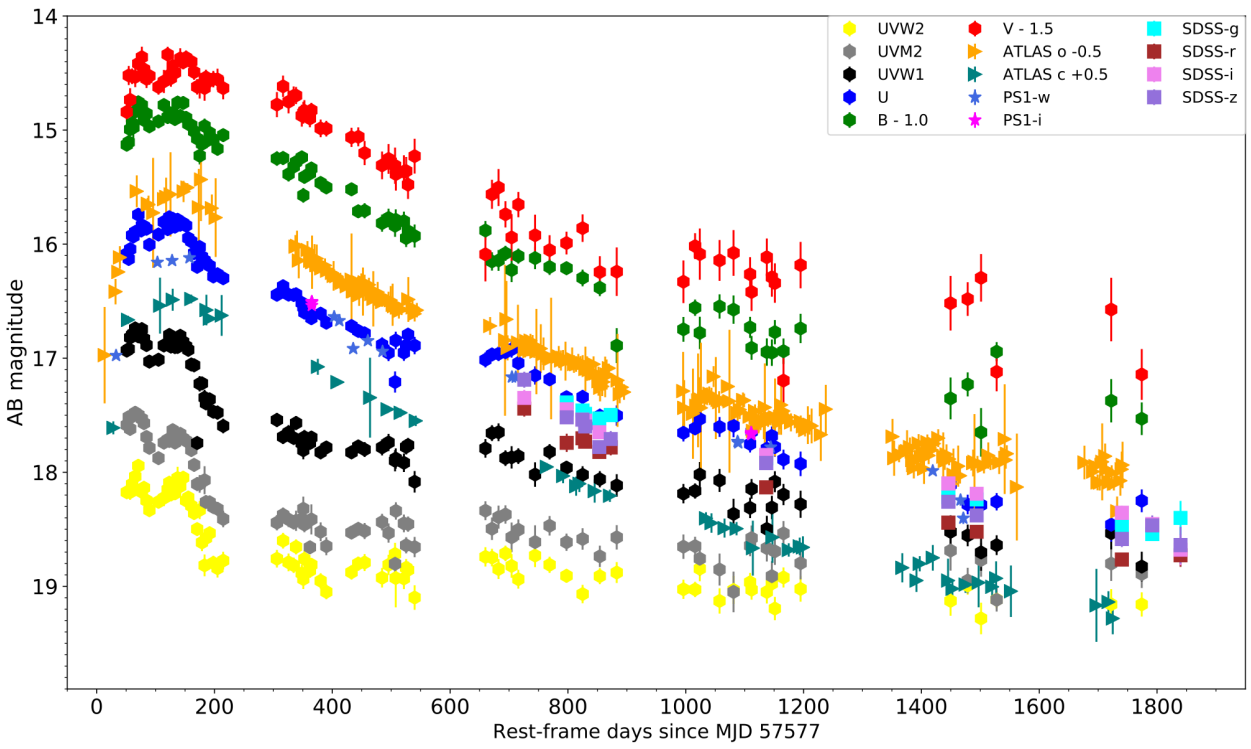
Results from Blanchard+2017

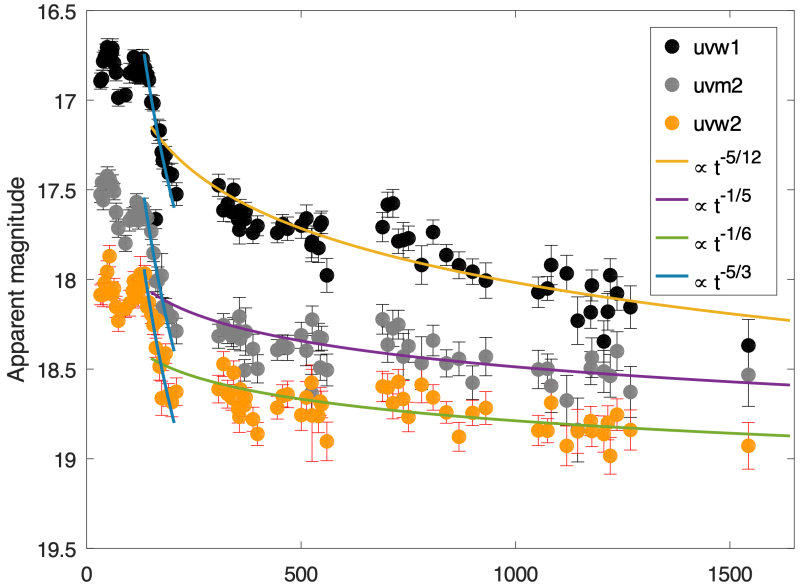
- PS16dtm is blocking the pre-existing X-rays from the AGN host → Blanchard+ 2017 predicted that X-rays will reappear as the accretion rate decreases
- Strong increase of broad emission lines, especially FeII





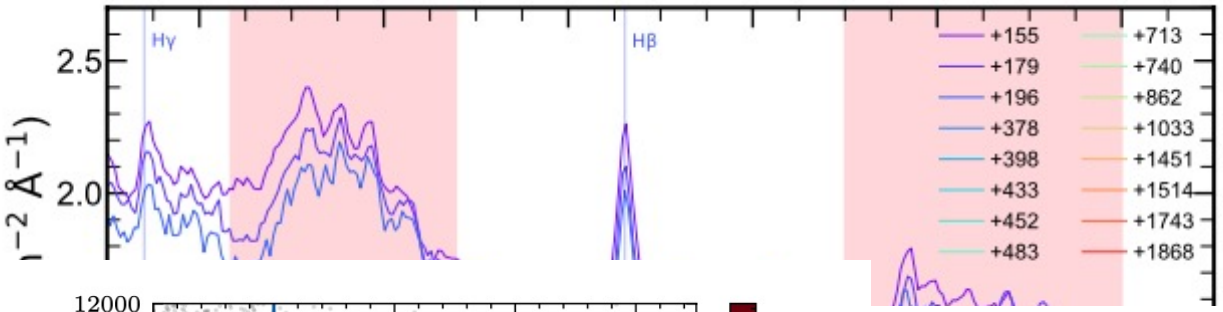
Our study - 2000 days of photometric and spectroscopic monitoring

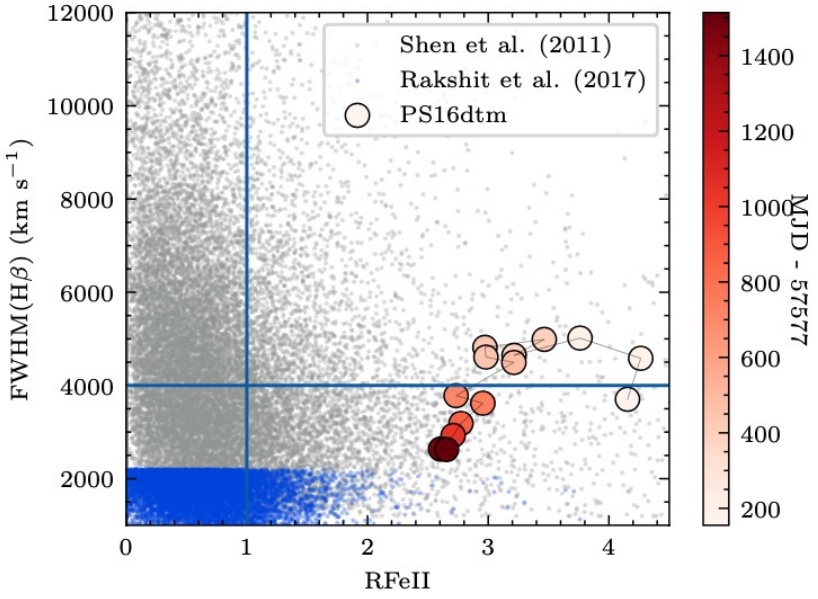




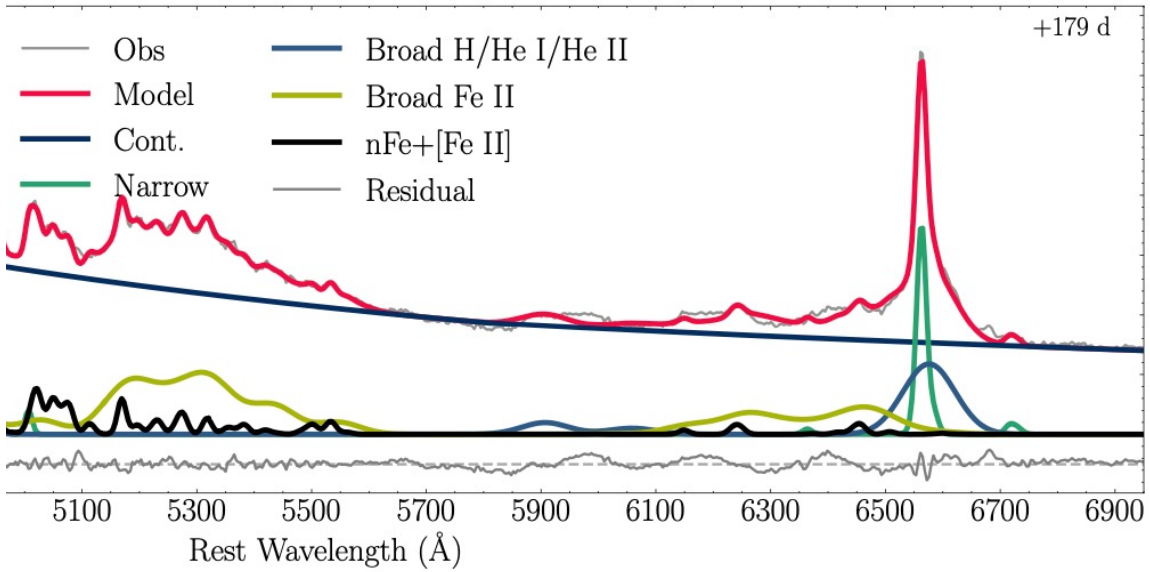
Petrushevska, Leloudas, Ilić …Rakić et al. 2023, A&A, 669, A140

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

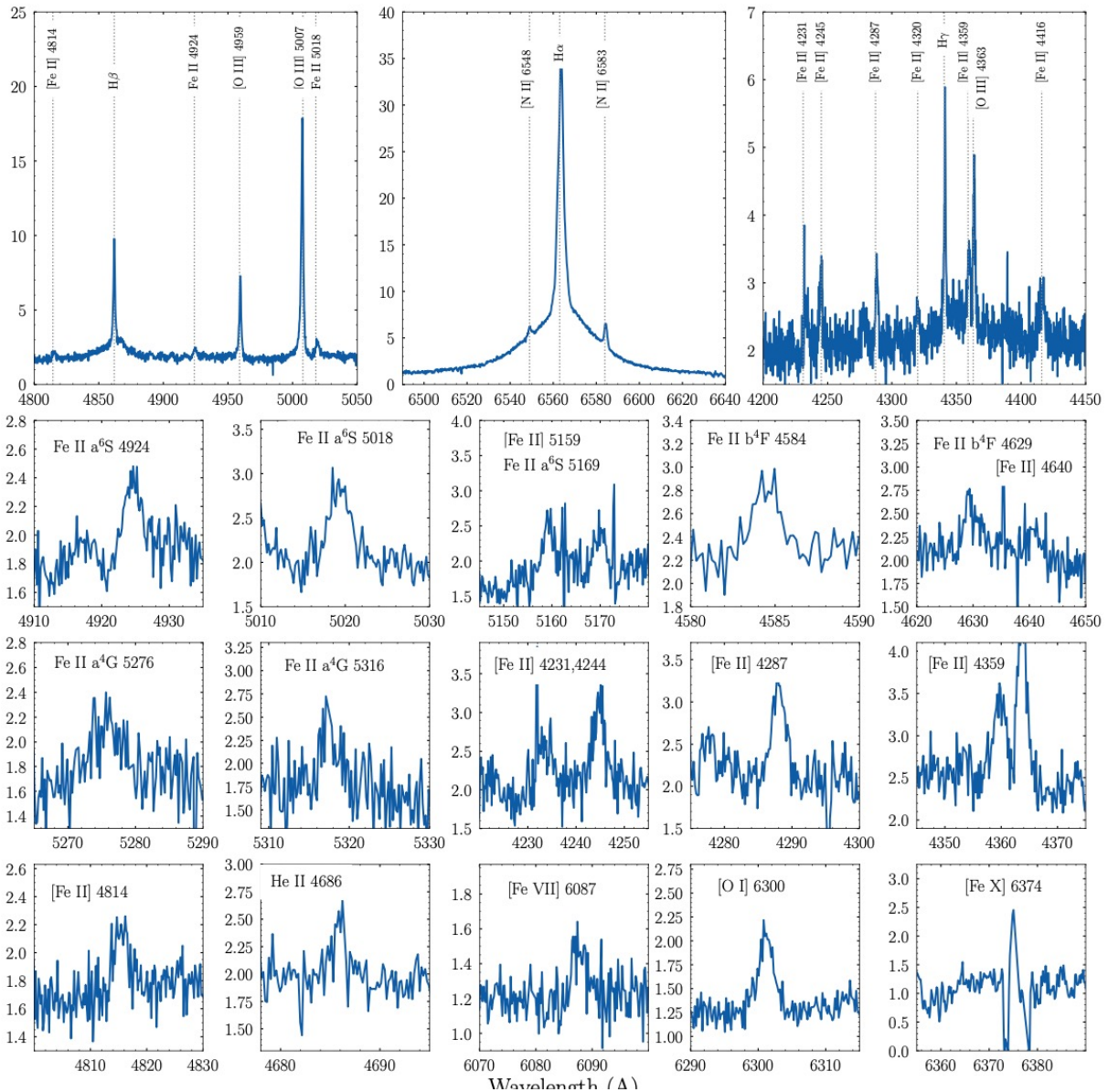


~2000 day after the event

XShooter, VLT spectrum

- FeII almost completely disappeared

- X-ray has not returned to pre-outburst levels despite that in optical returning to the pre-outburst level

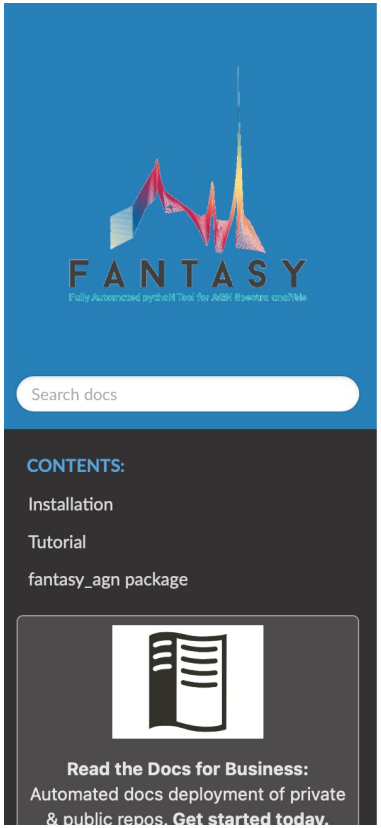


Fantasy: Open Source Publicly Avilable

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

- **pip install fantasy_agn**
- Tutorials available
- Plan for online workshop

…and growing



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