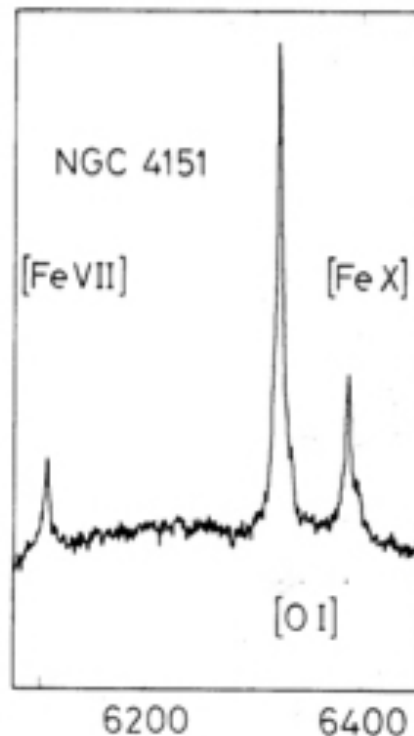
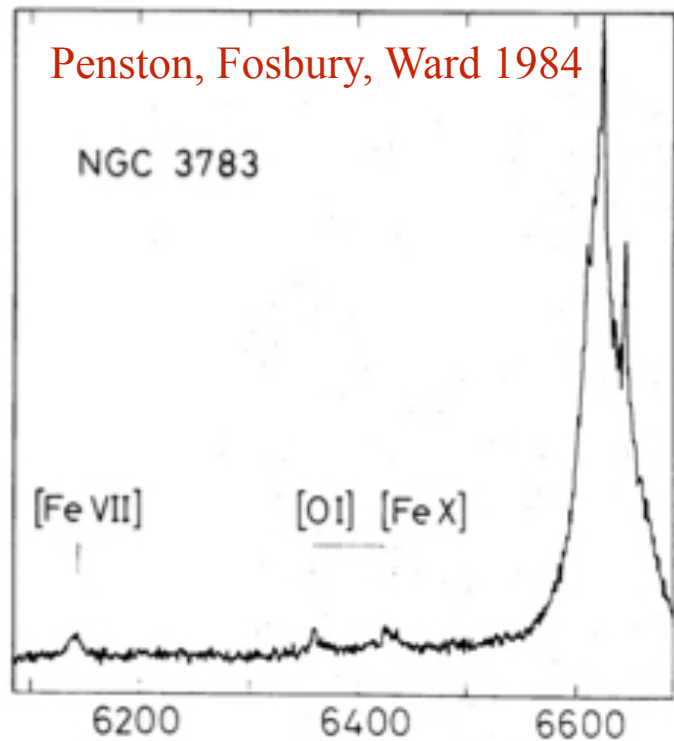


# Coronal reverberation

Andy Lawrence  
Torus 2022 Leiden  
Dec 13-15 2022

with Charles Yin, Phil Short, Matt Micholl, Martin Ward, and others

Penston, Fosbury, Ward 1984



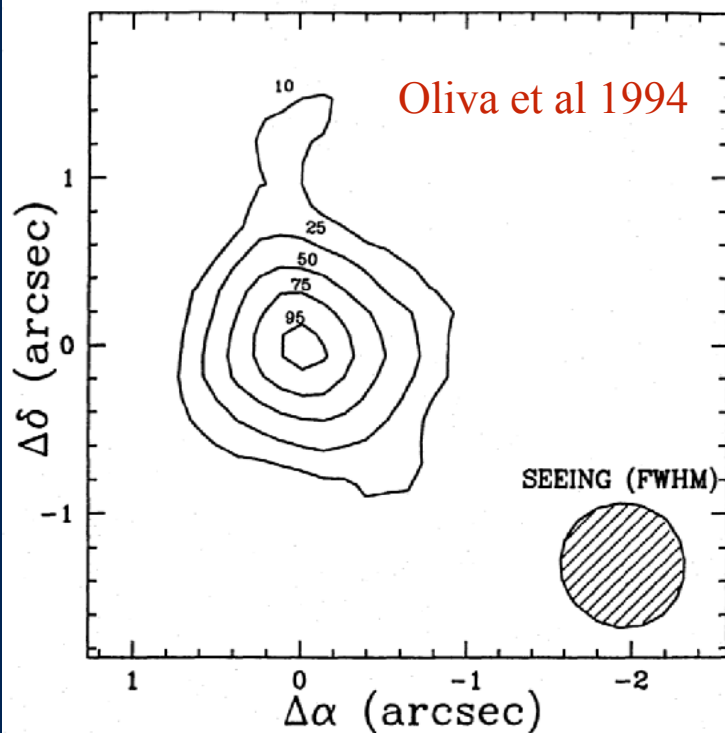
## Coronal lines in AGN

photo-ionised

potentials 100-400eV

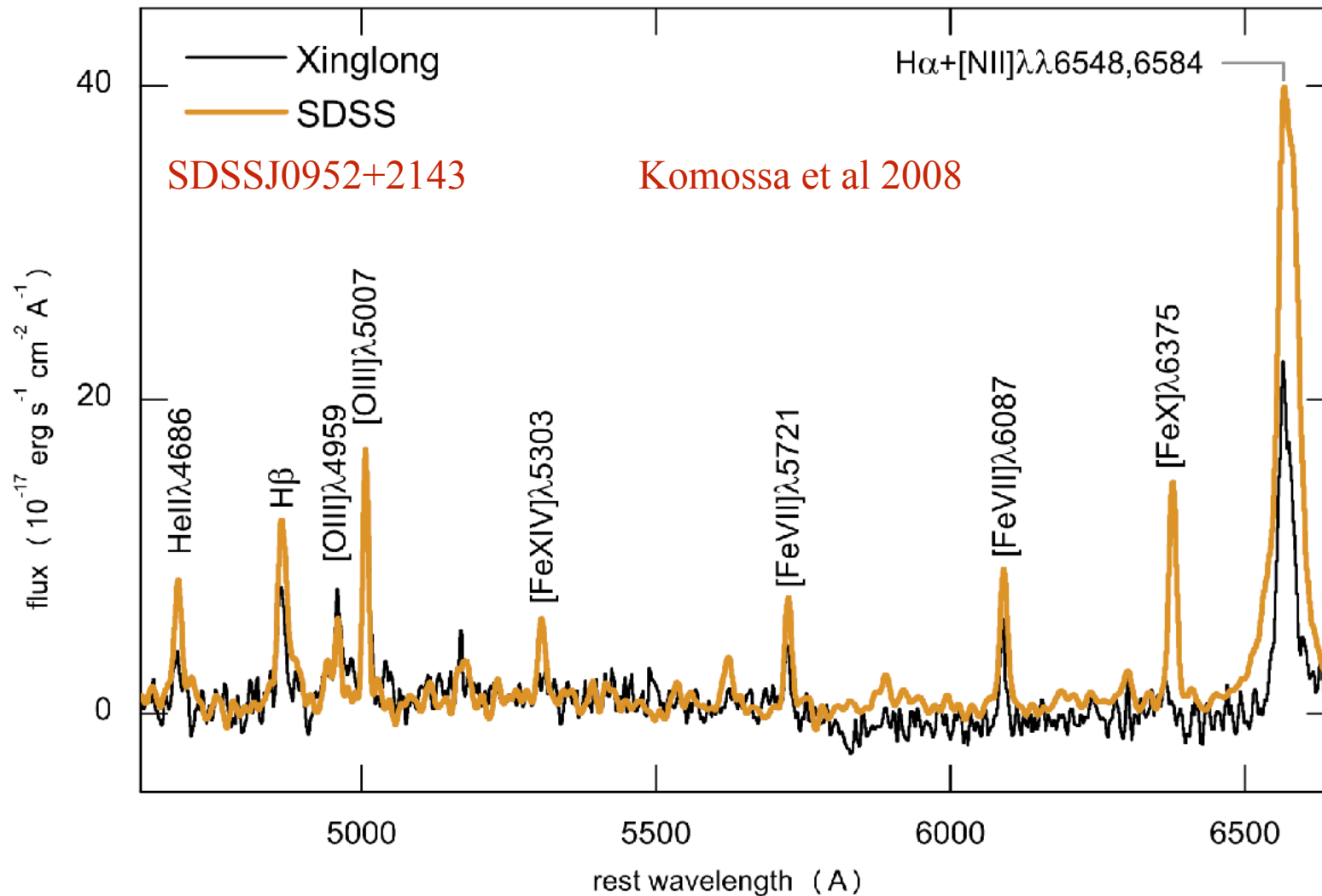
intermediate line width  
==> intermediate distance?

Oliva et al 1994



Circinus: 4Mpc

resolved?  $\sim 10$ pc



super strong  
coronal lines  
in non-AGN

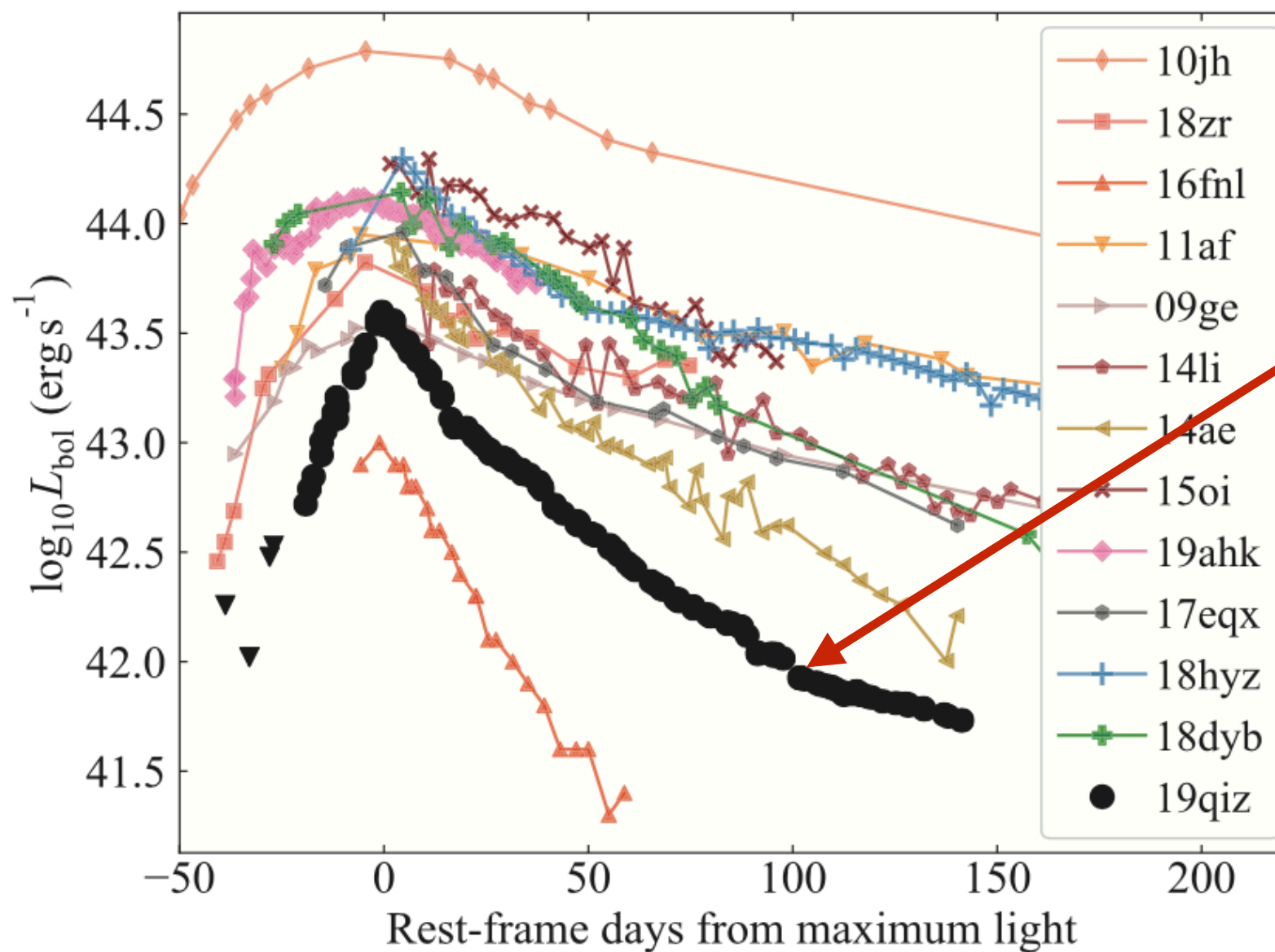
“ECLE”

orange  
Dec 2005

black  
Dec 2007

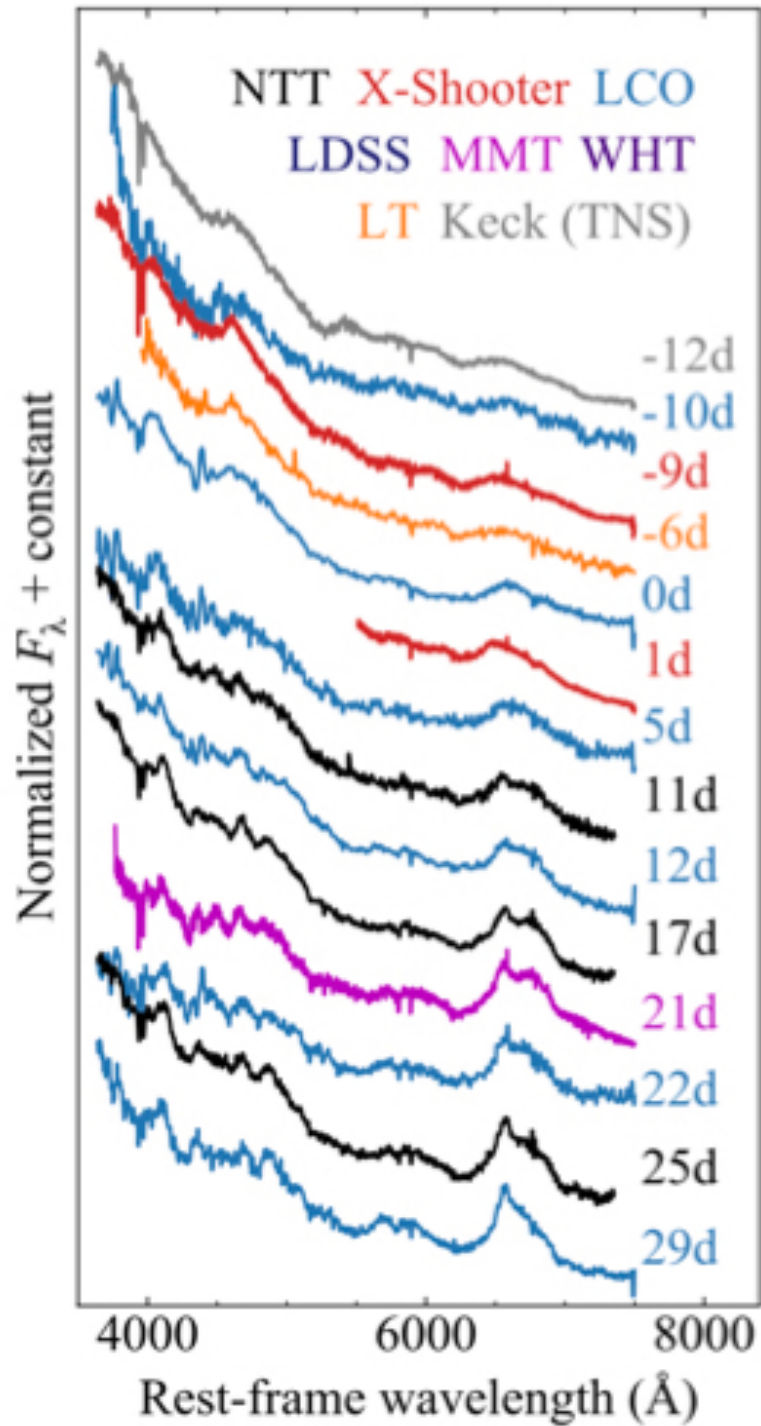
fading with time!  
echo of past event?

TDE??

TDE  
AT2019qiz

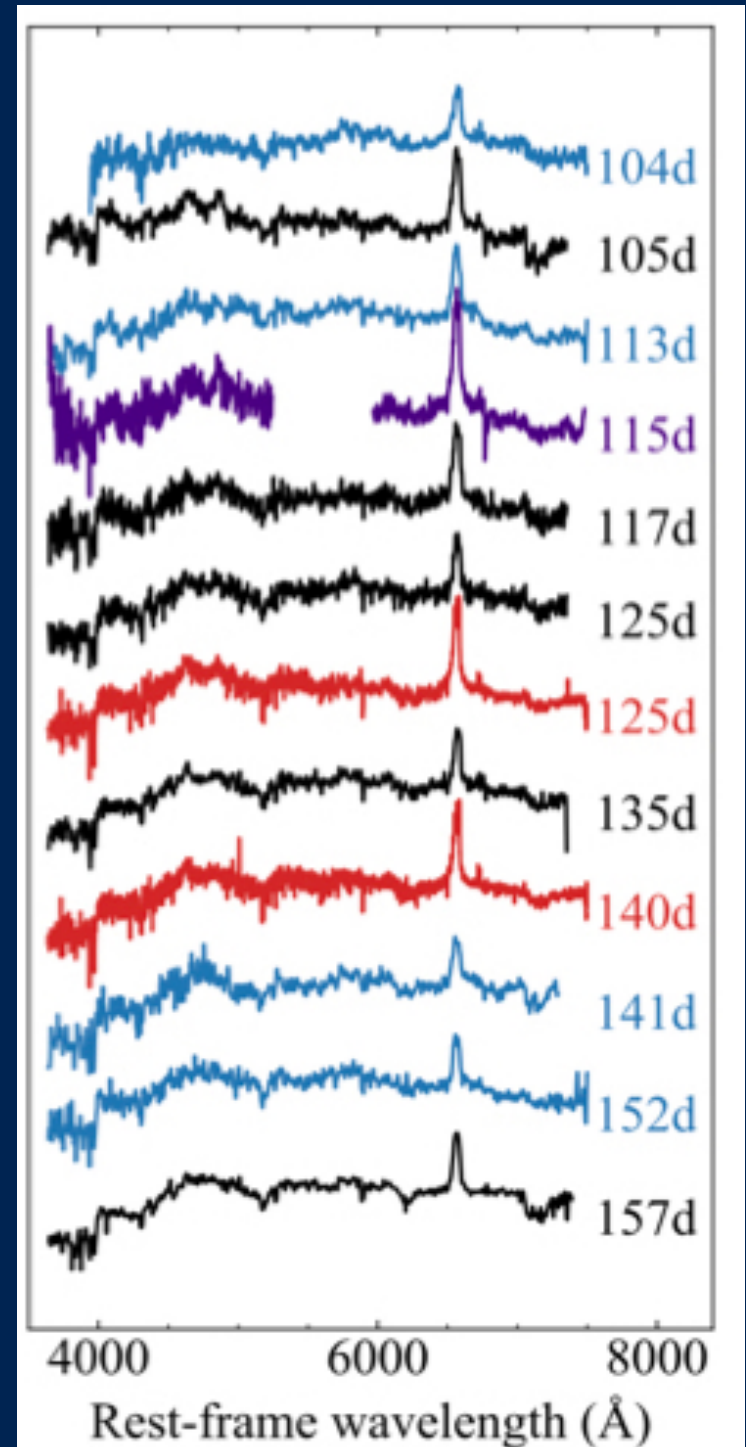
# TDE AT2019qiz

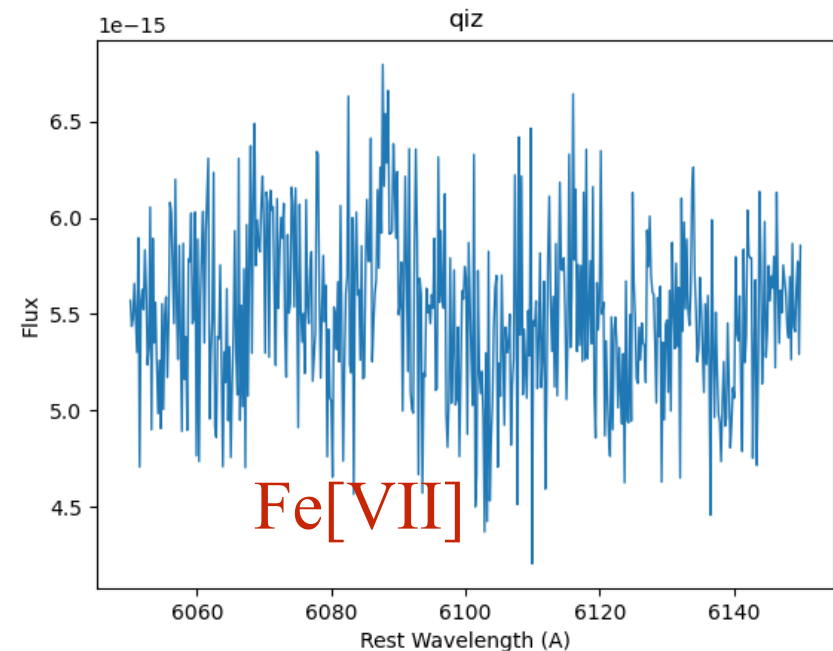
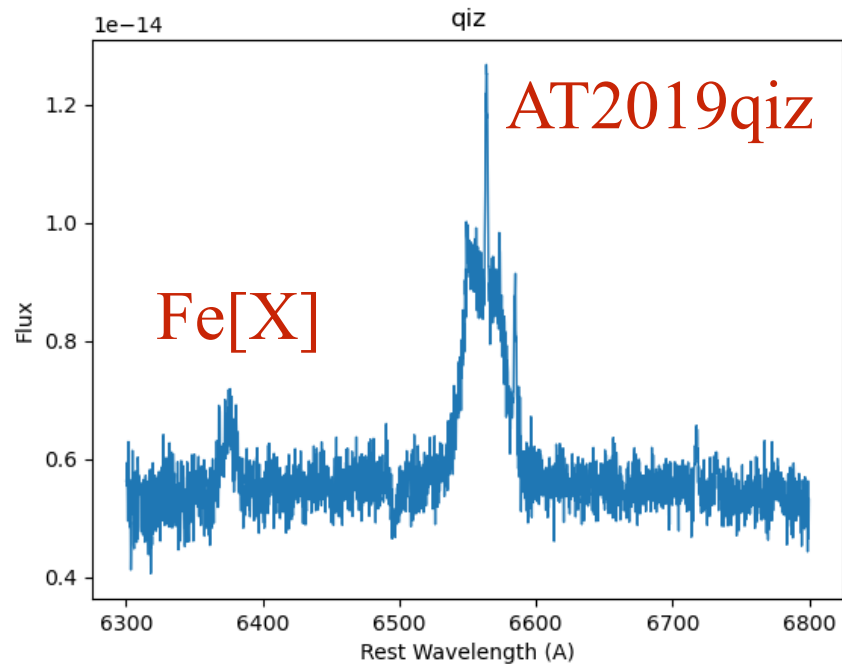
Nicholl et al 2020



weak  
broad  
lines

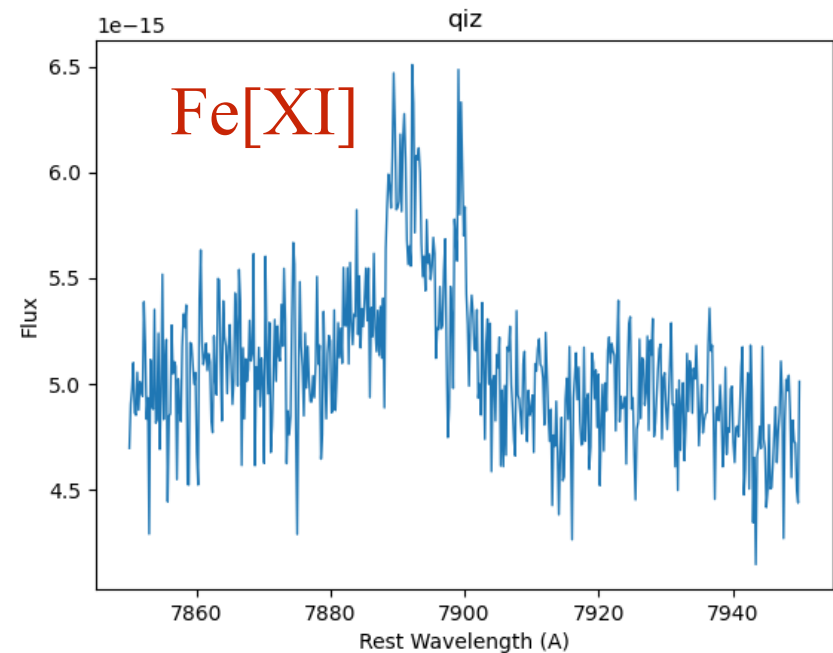
starlight  
plus some  
H $\alpha$

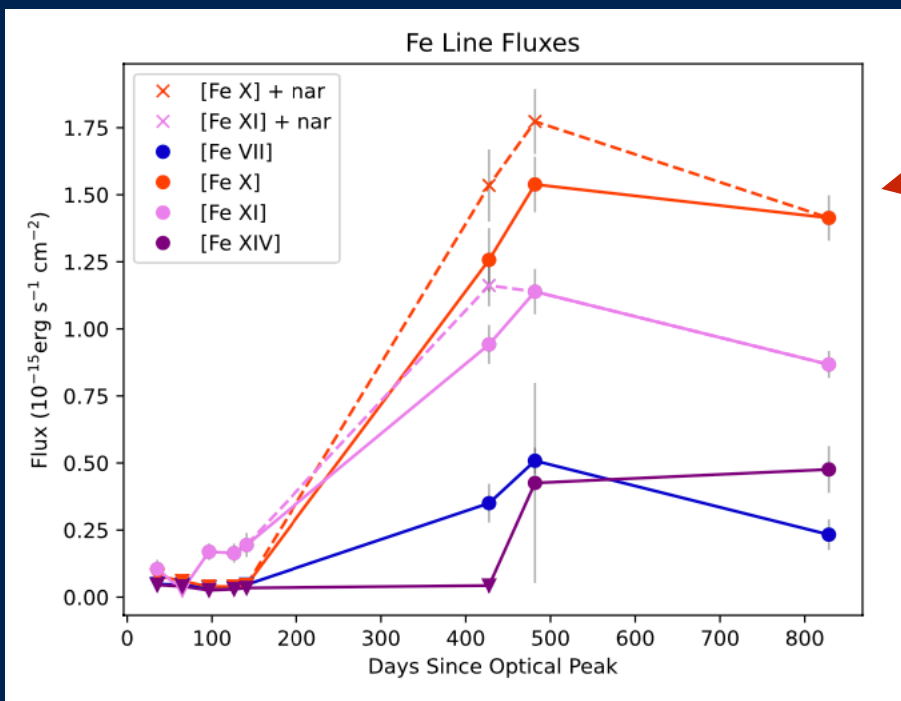




Short et al 2022

Coronal lines appear  
after  $\sim 2$  years



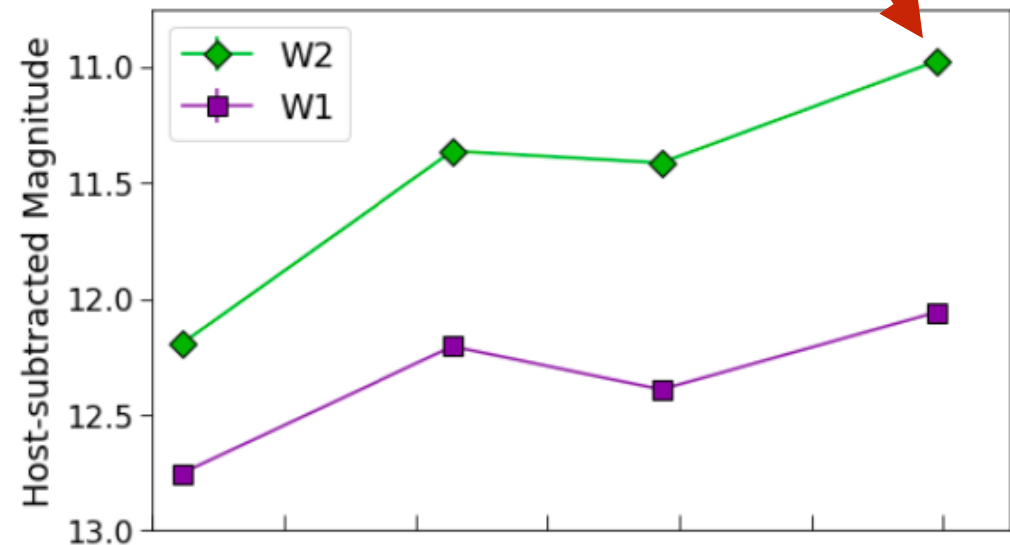
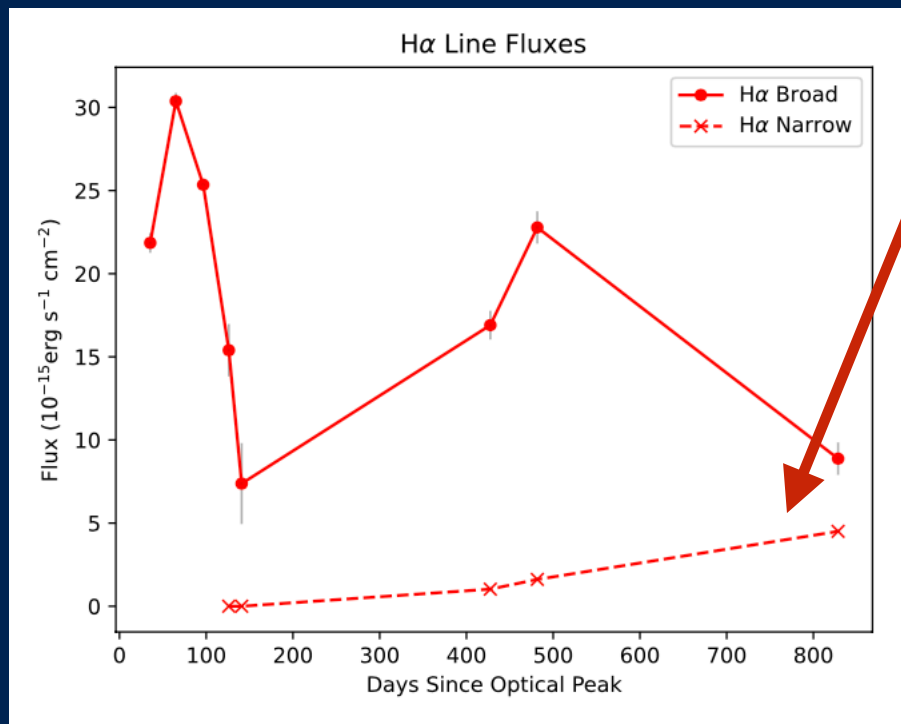


Fe lines peak at  $\sim 500$  days

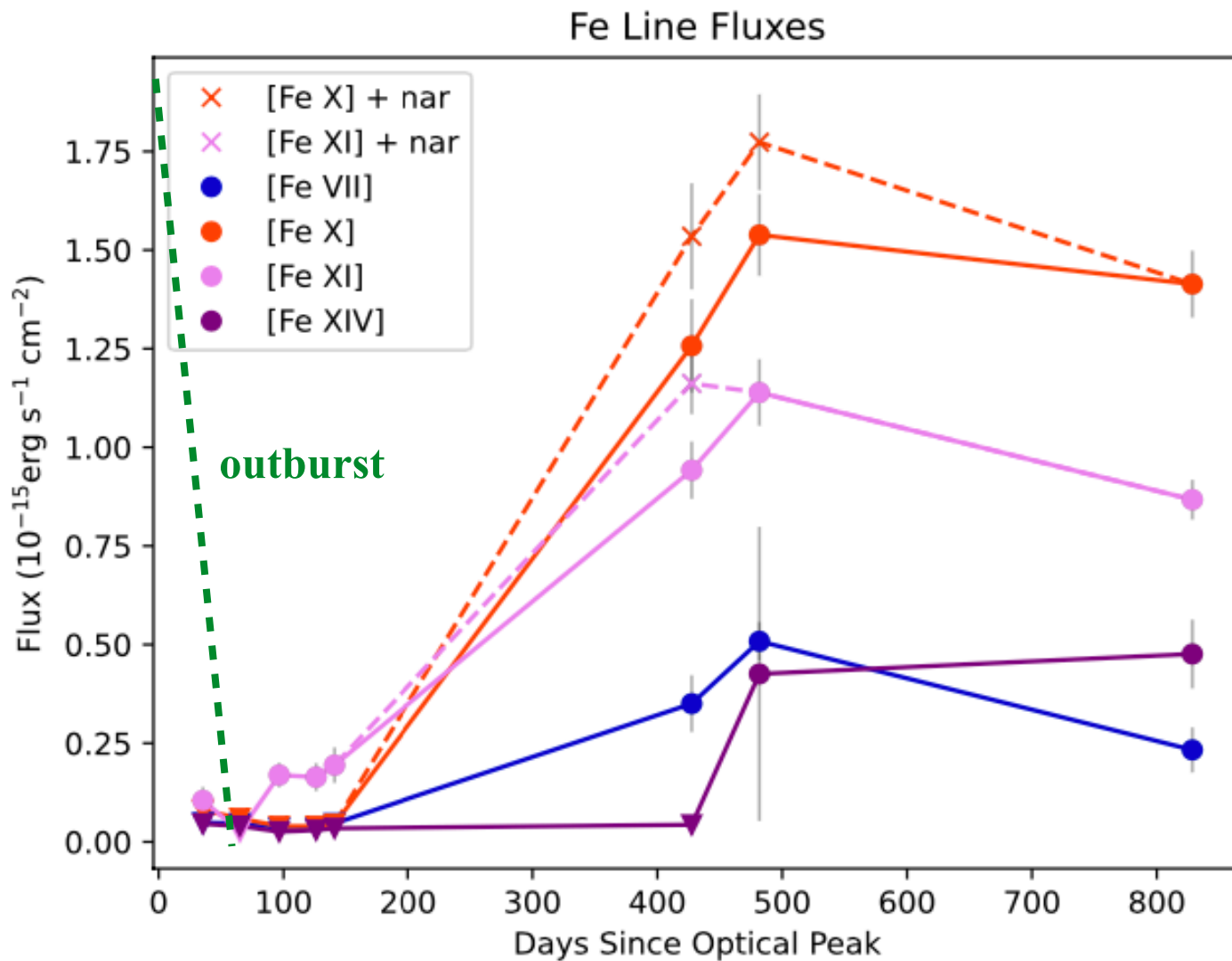
Narrow H $\alpha$  and H $\beta$  still climbing at 800 days

MIR still climbing at 800 days

Short et al 2022



mean delay



material at  
wide range of  
angles / distances

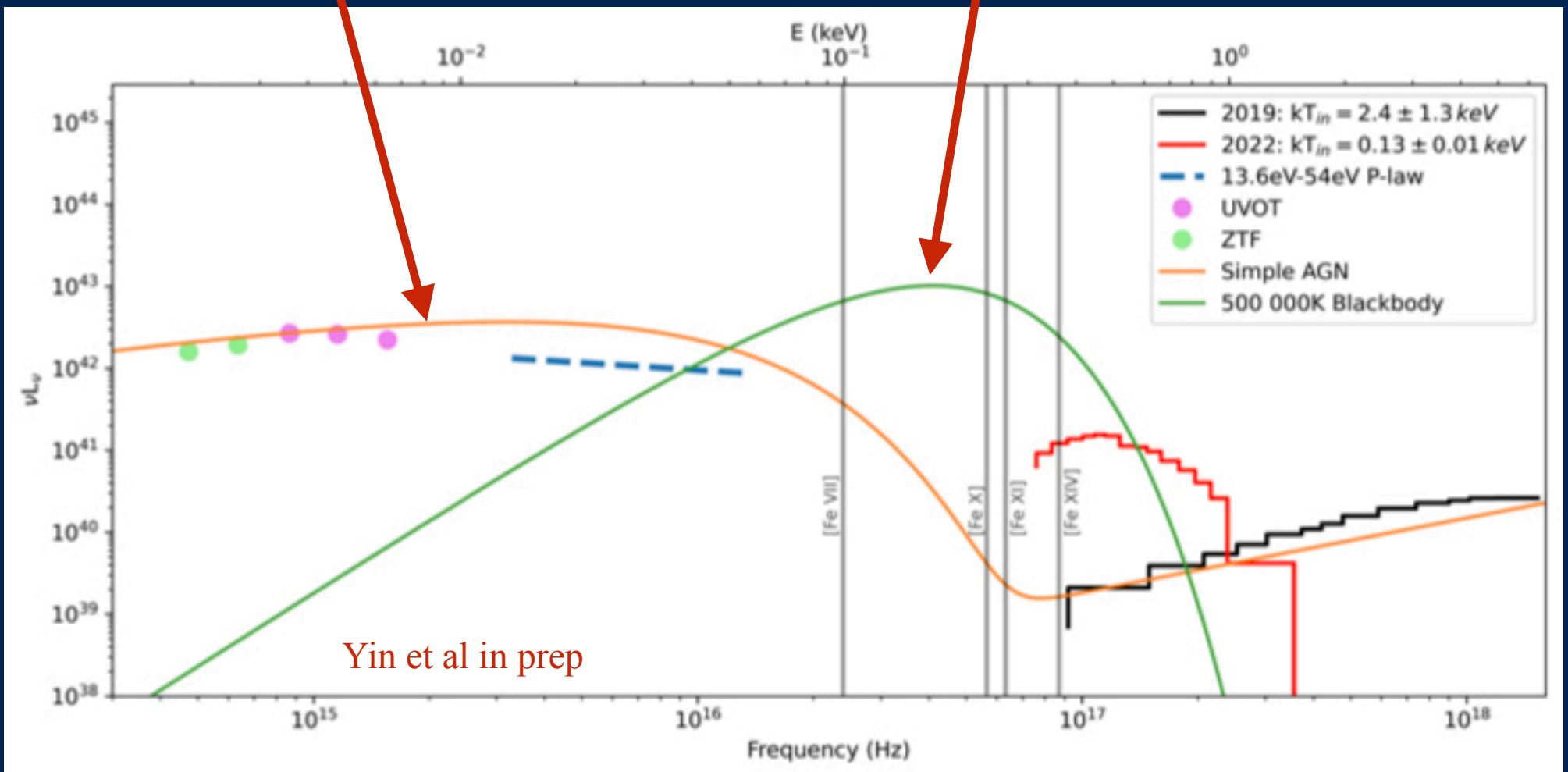
not made in this  
outburst ... outflow  
time  $\sim 5000$  years

range of delays



standard AGN SED

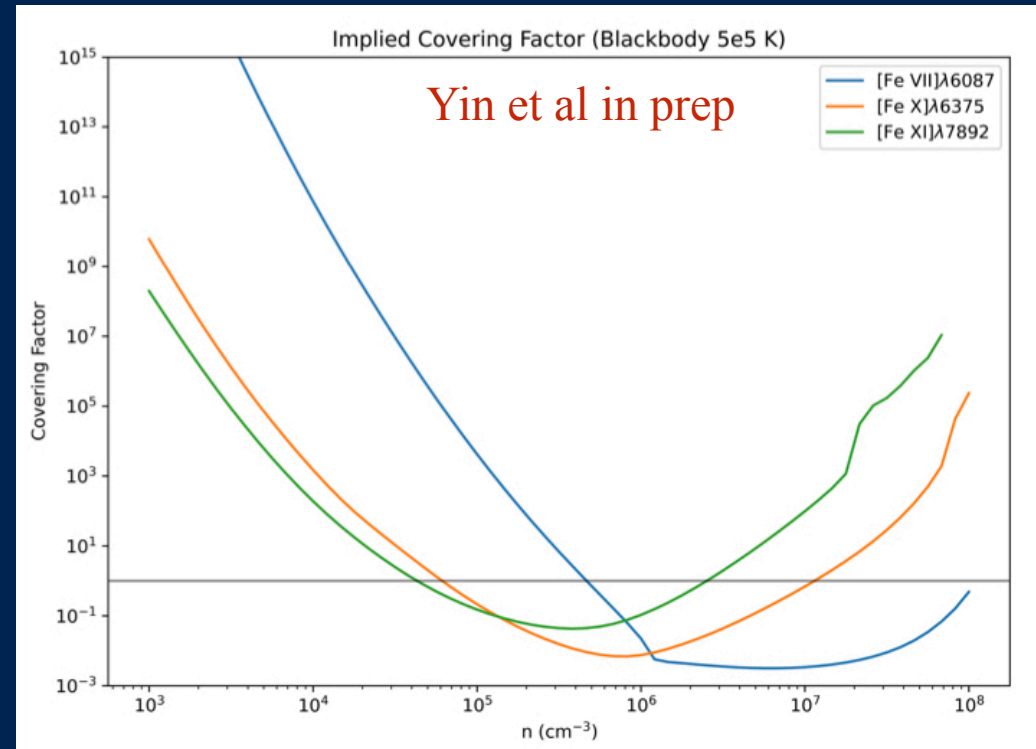
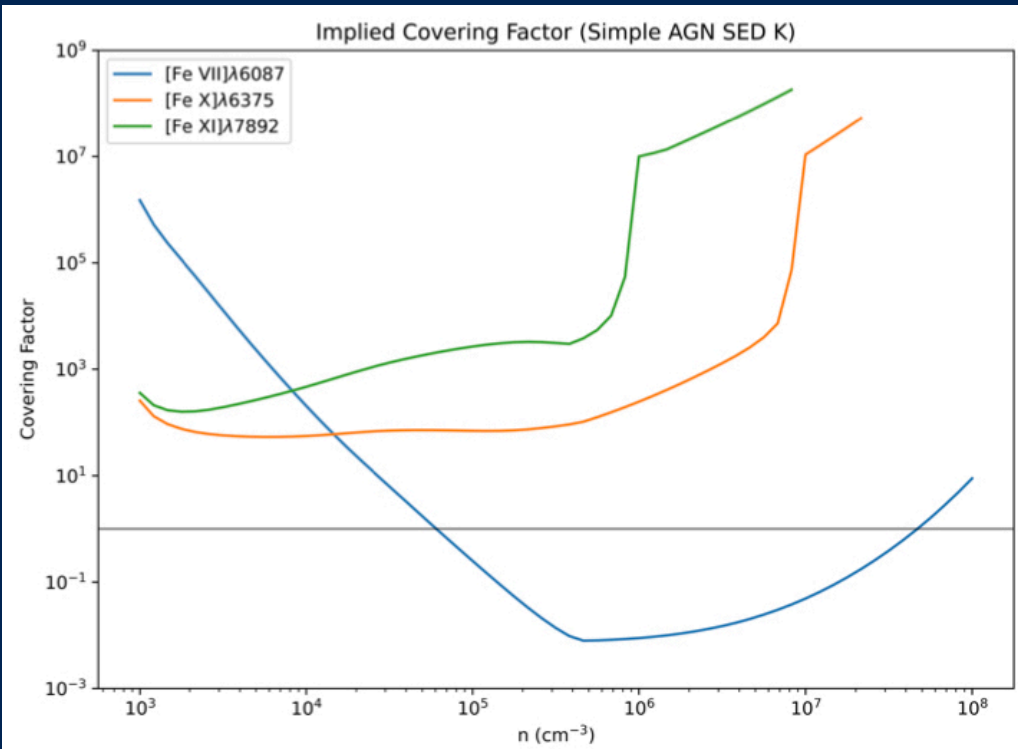
$T \sim 500\text{K}$  for  $M_{\text{H}} \sim 10^6$



can we explain line strengths?

standard SED: hopeless

500K BB: much better



- [FeXI]/[FeVII] requires very hard continuum
- $n \sim 10^5$ - $10^6$  intermediate between BLR and NLR
- covers about 1% of sky
- mass  $\sim 1$ -5  $M_{\text{sun}}$

not random ISM  
needs previous AGN activity  
(or previous TDE??)

# WHY THIS ONE??

we observed ten more TDEs  
two years after outburst...

and saw no more coronal lines...

The EUV continuum is really there

Material already out there

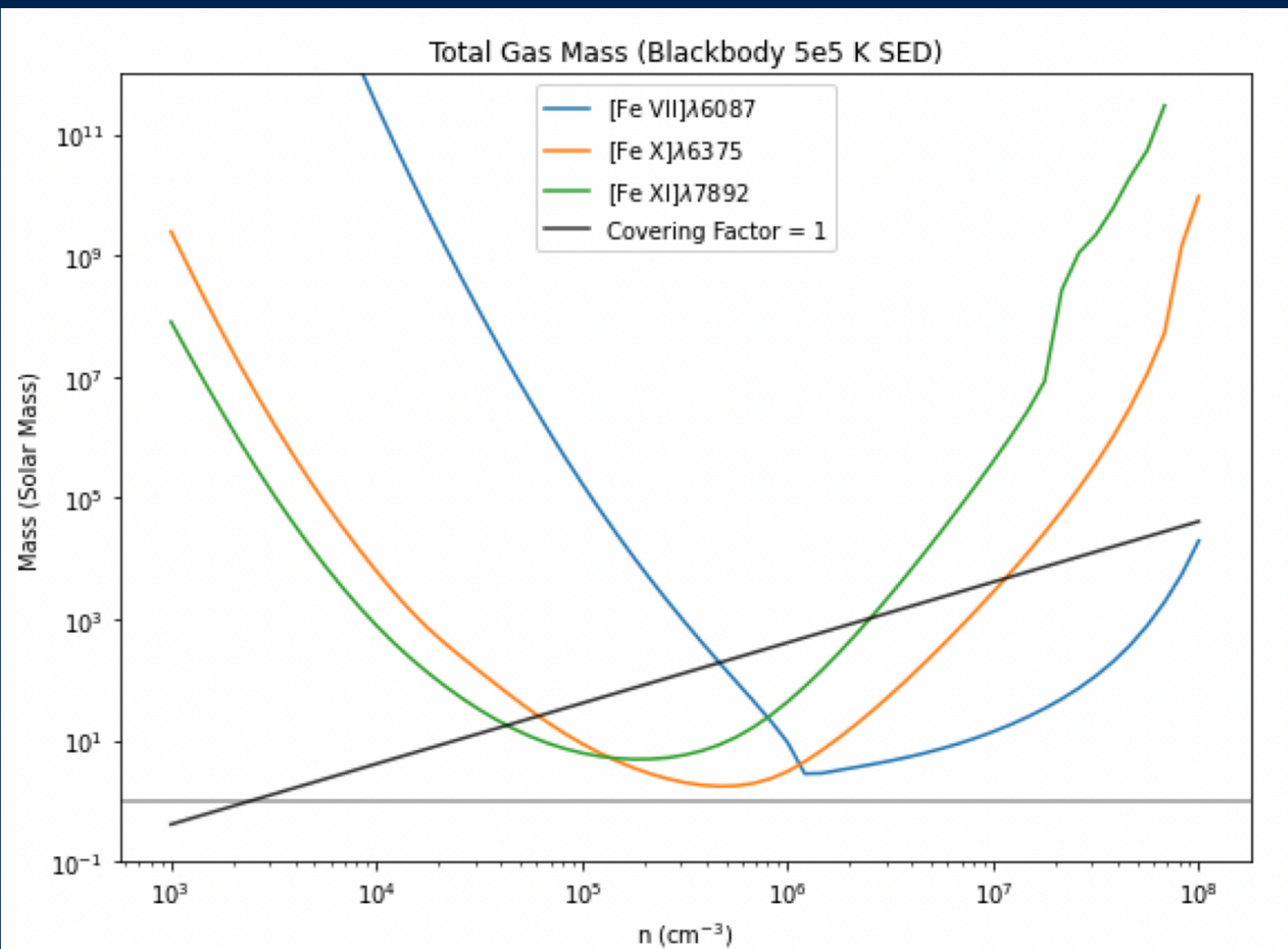
Made by previous activity

Between BLR and NLR  
in both distance and density

FIN

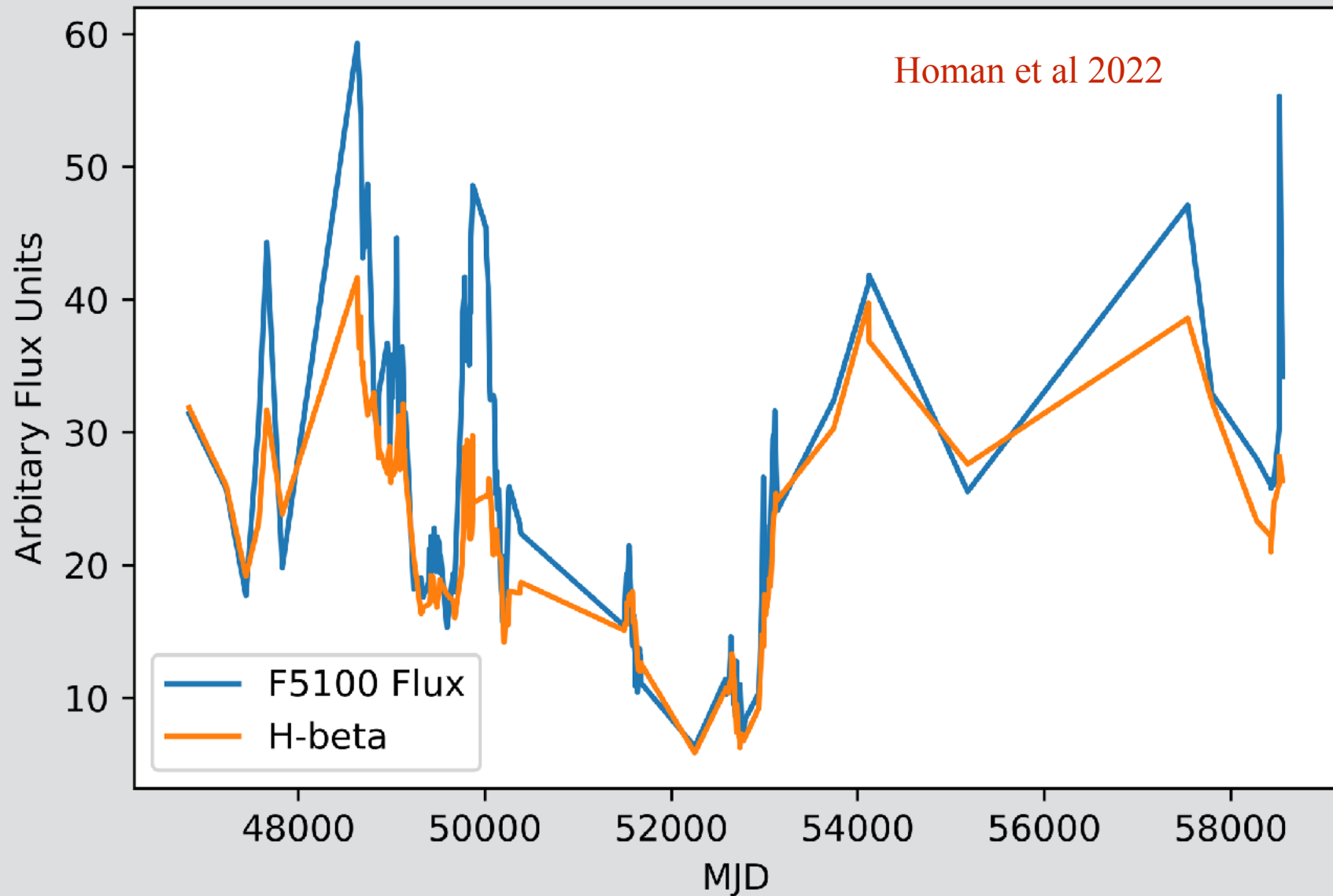


Bonus material



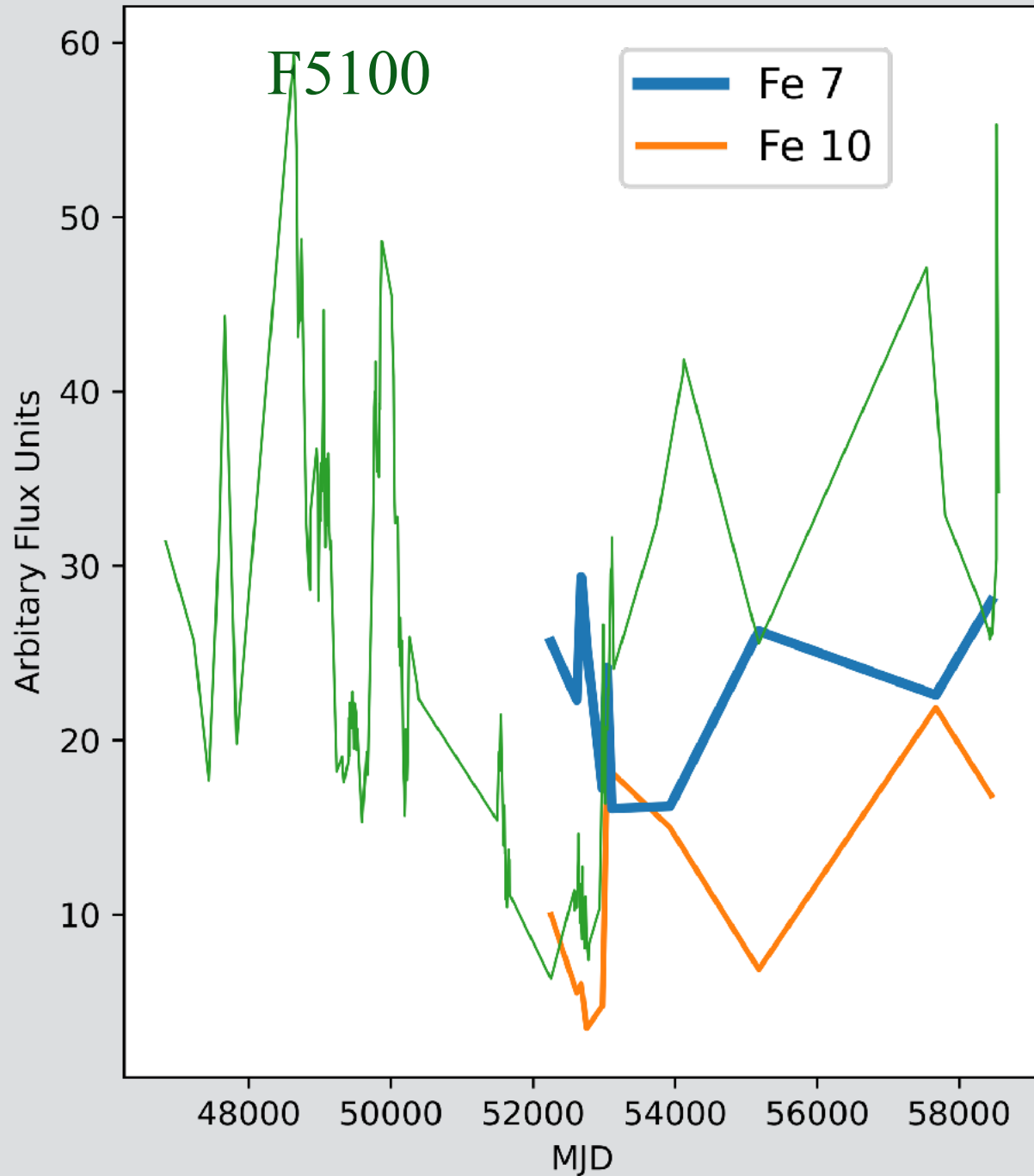


# Thirty year light curve of MKN 110

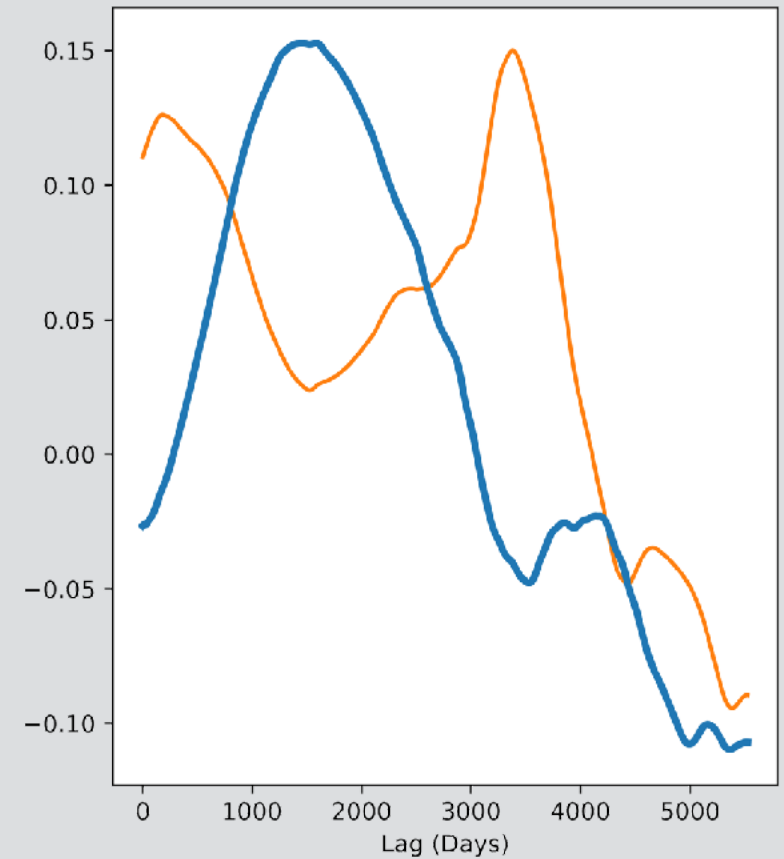


Hbeta tracks historic dip

## Fluxes Over Time



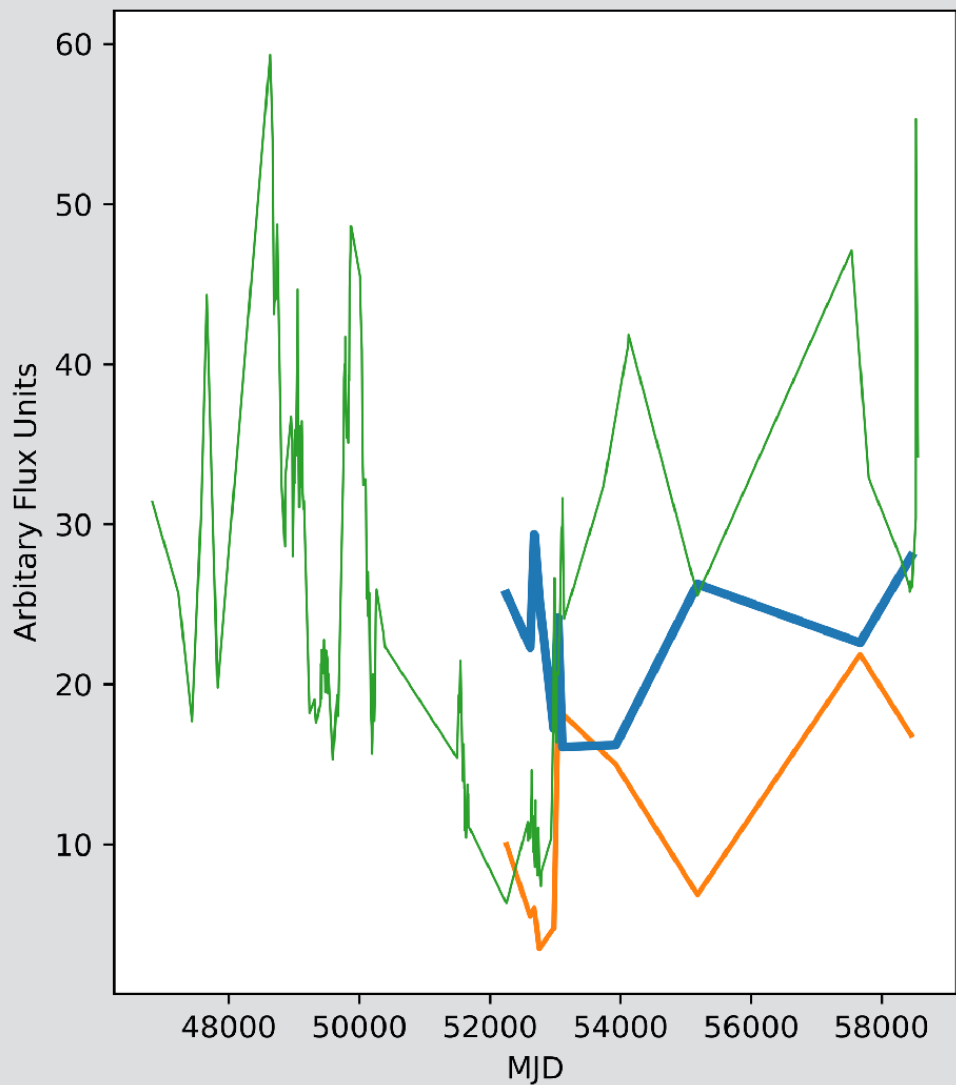
## Fe 7 and 10 Cross-correlated with F5100



[FeVII] lags  
by 1600 days?

cf broad Hbeta  
lag 24 days

Fluxes Over Time



original

shifted

