



SHERLOCK HOLMES IN
SHERLOCK BBC SERIES

Seeking out the non-CIE process in hot gas of M31



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(*Purple Mountain Obs.*)

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Zhang (NfU)*

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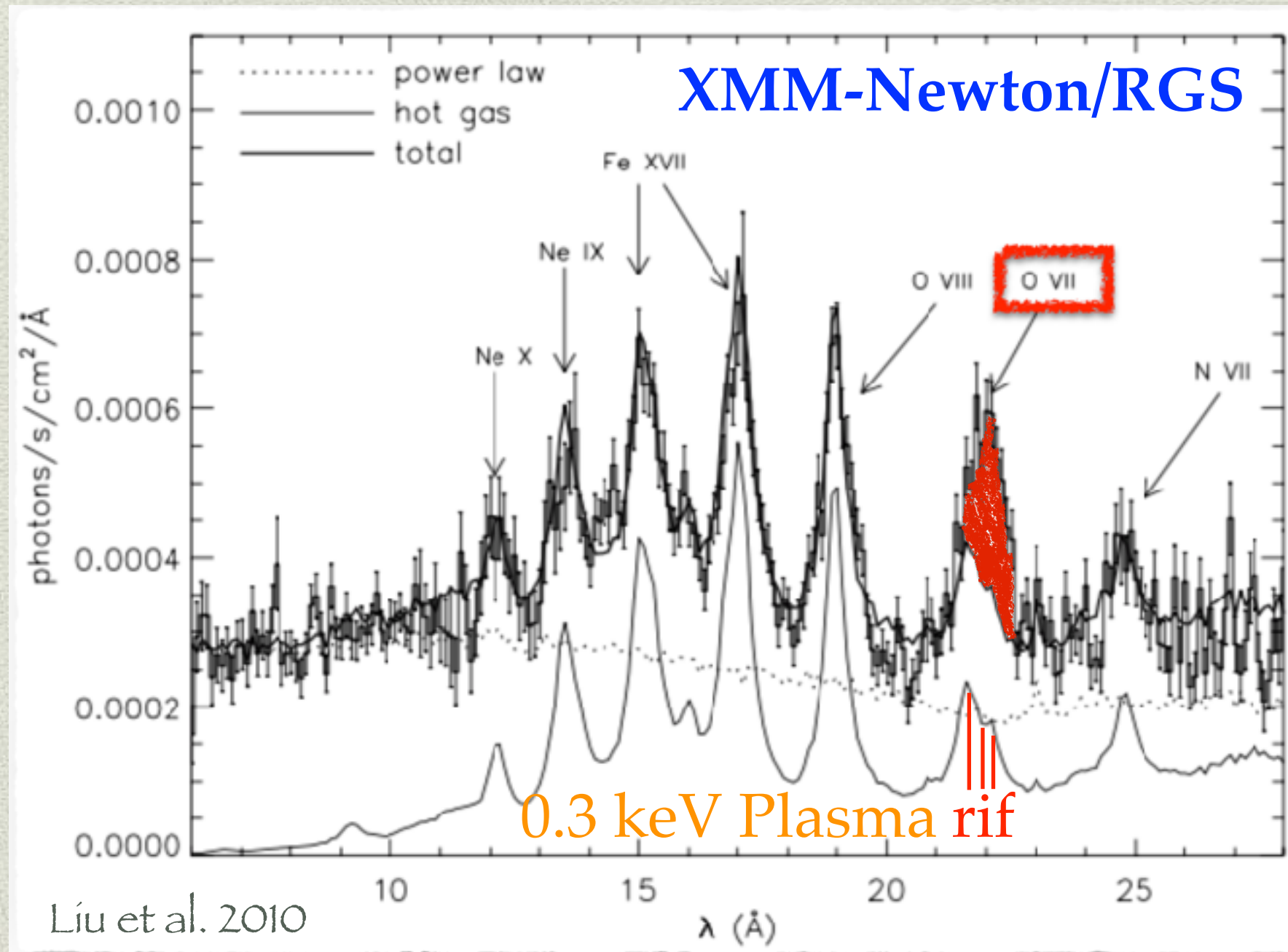
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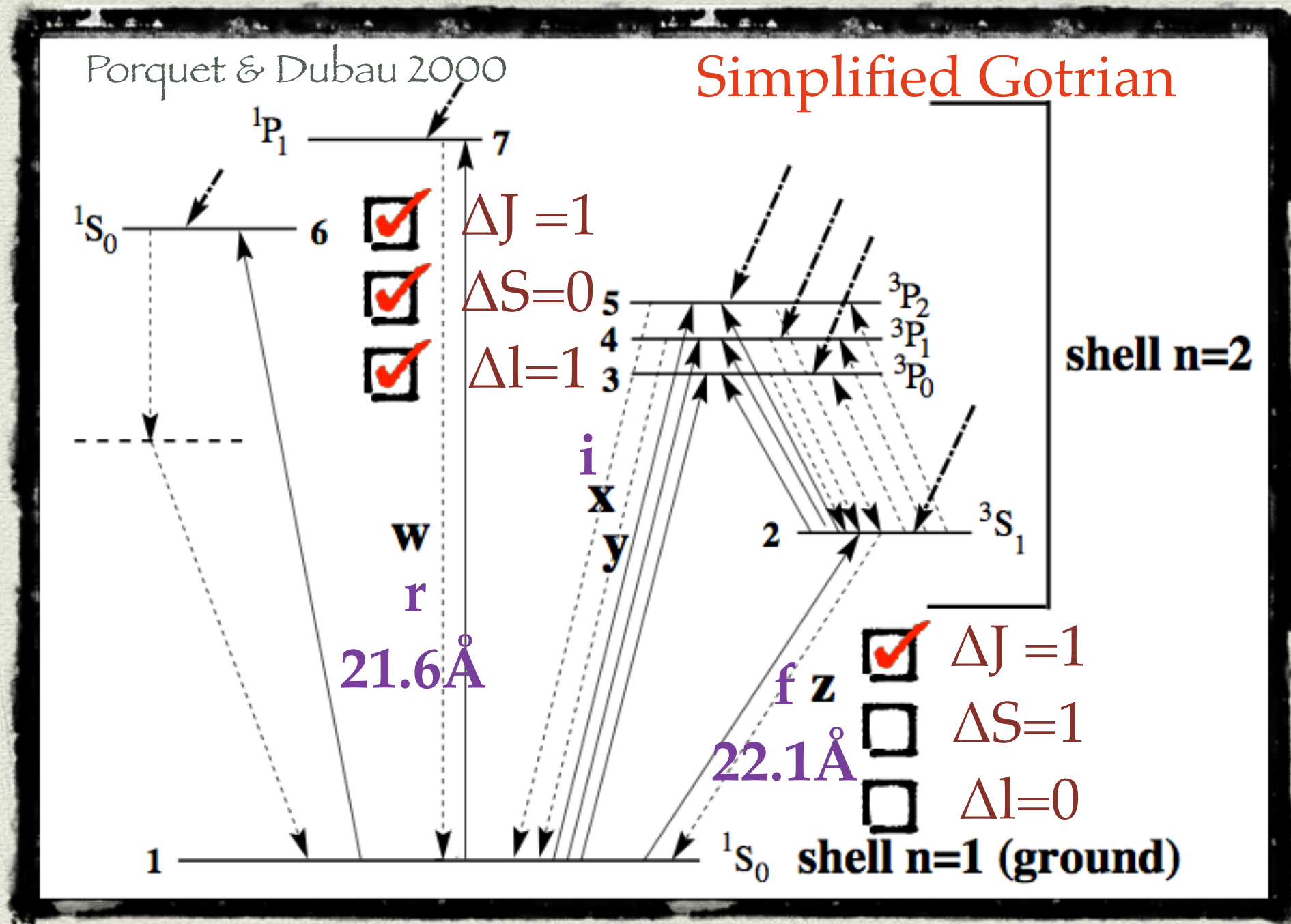
Non-CIE: strong OVII f line



◆ In a CIE plasma,
r > **f** line

◆ In M31,
f > **r** line

Non-CIE: strong OVII f line



◆ In a CIE plasma,
 $r > f$ line

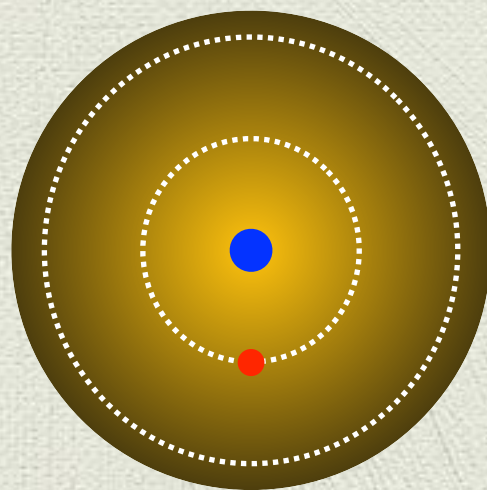
◆ In M31,
 $f > r$ line

Two Scenarios (~~Suspects~~)

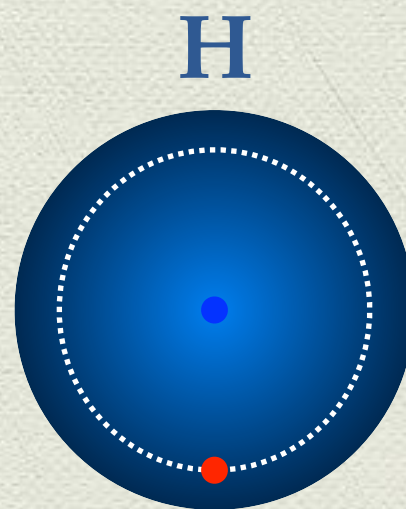


Name: charge exchange (CX)

Hot ions rob electrons from neutral atoms, and produce stronger f line.



O^{7+}



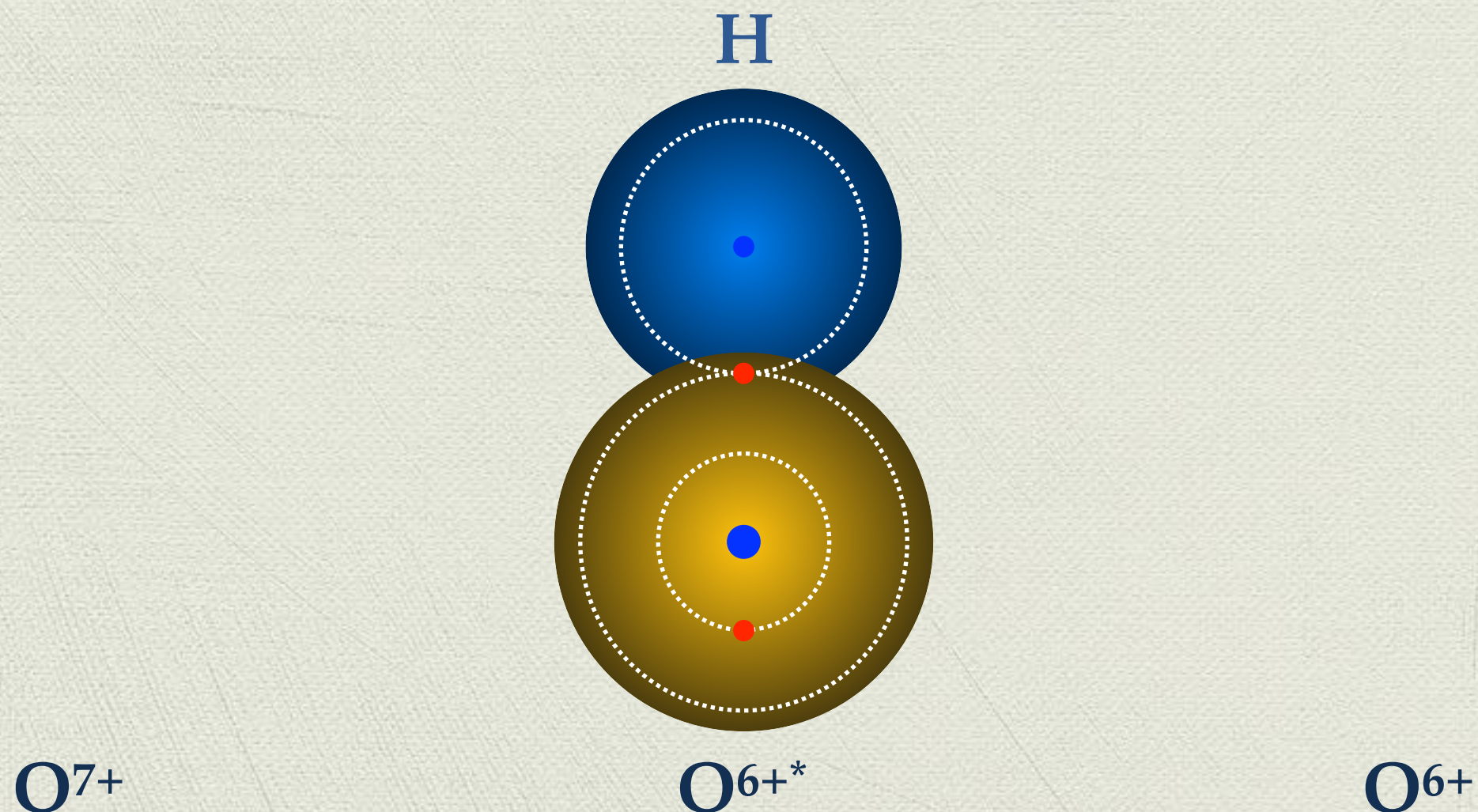
O^{6+*}

O^{6+}



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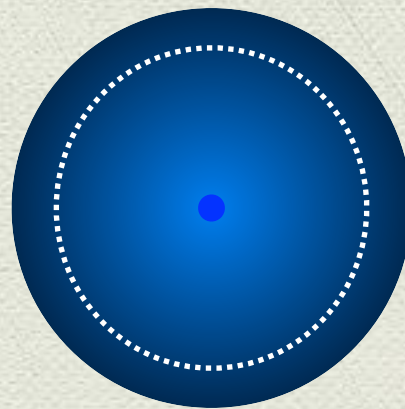




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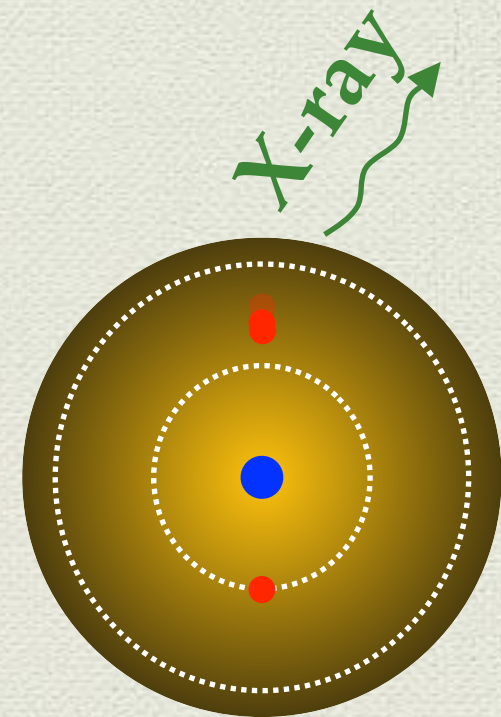
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H



O⁷⁺

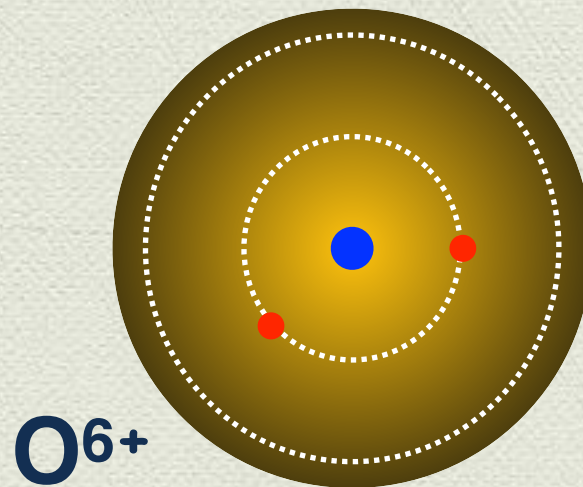
O^{6+*}



O⁶⁺

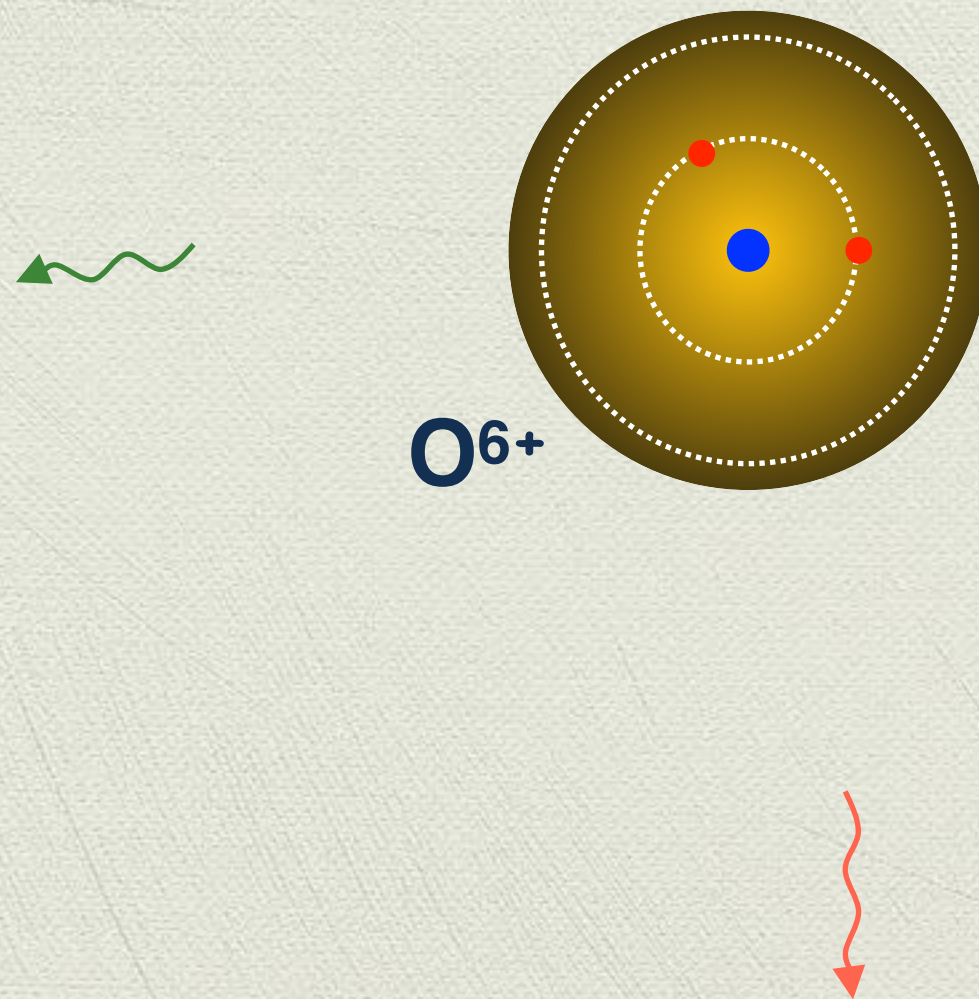
Name: resonance scattering (RS)

Photons of resonance line are scattered,
thus r line is reduced.



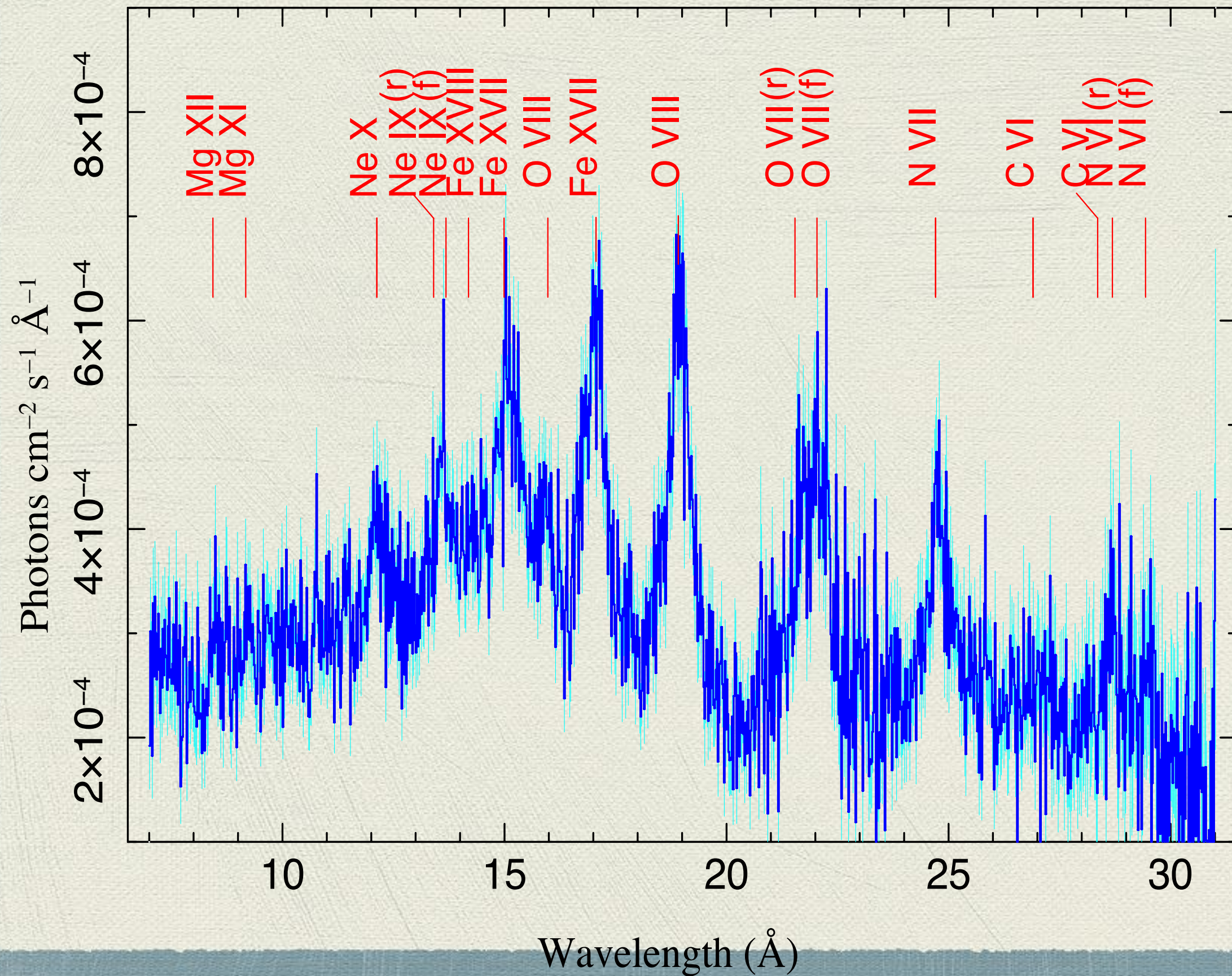
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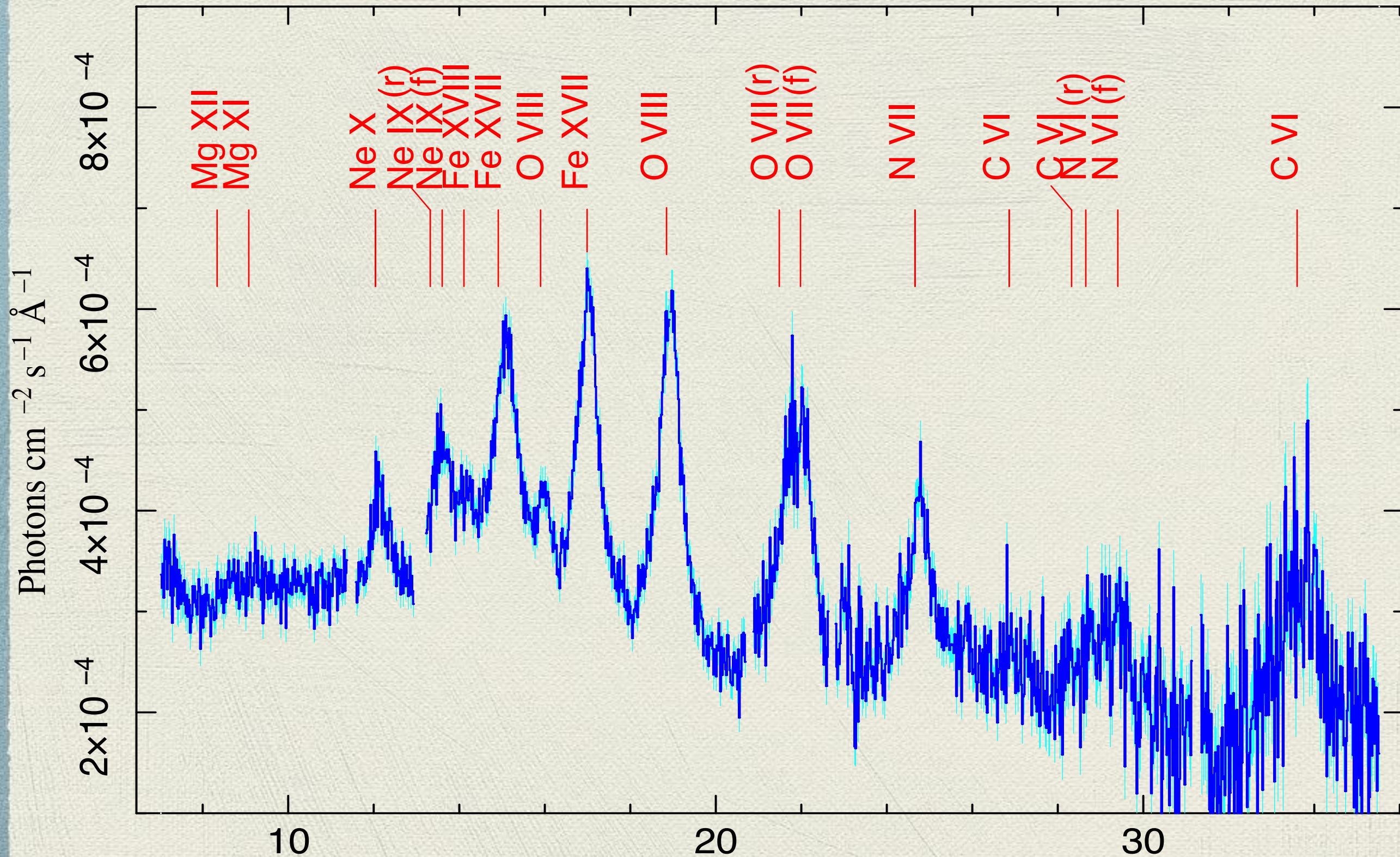


More Evidences

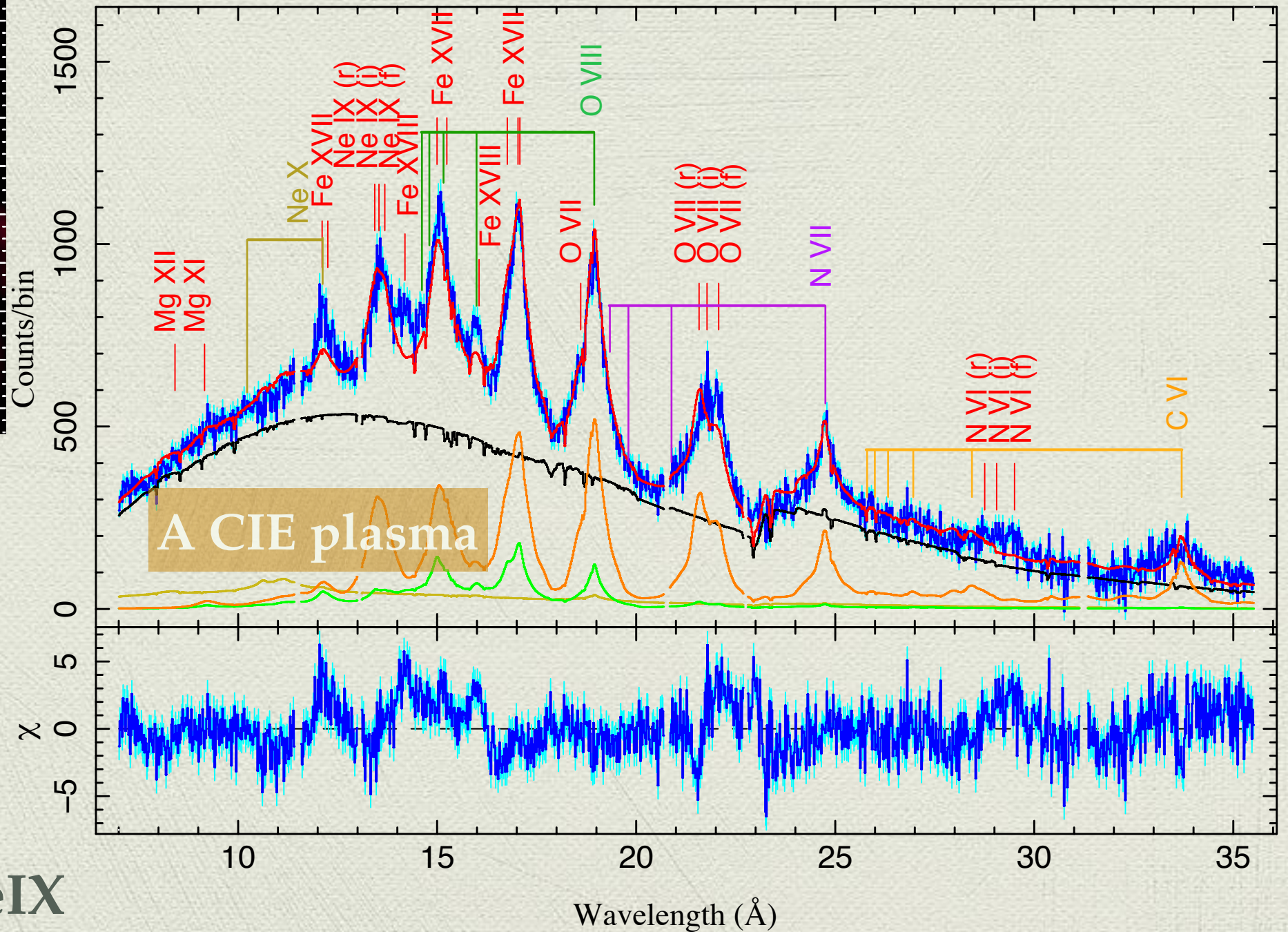
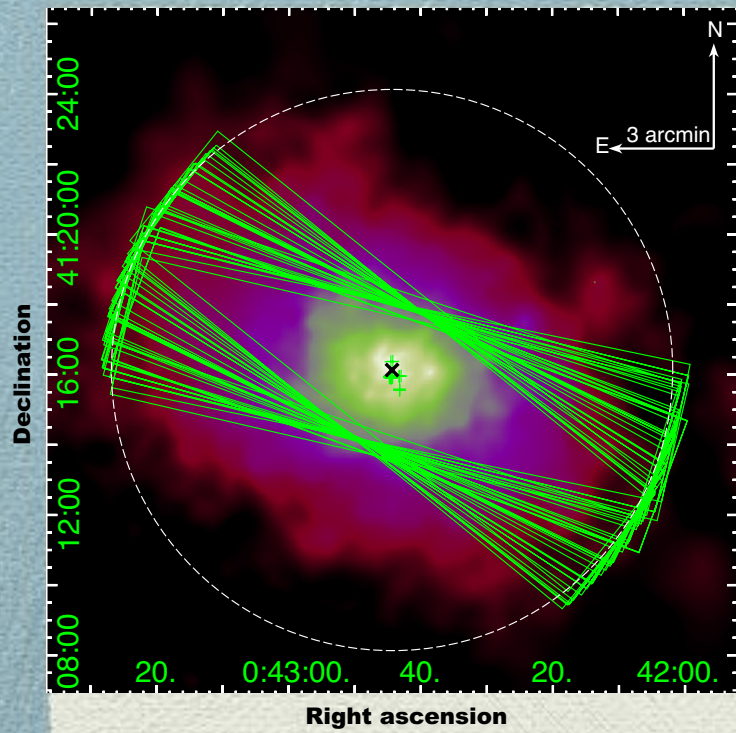
3=>36 observations



3=>36 observations

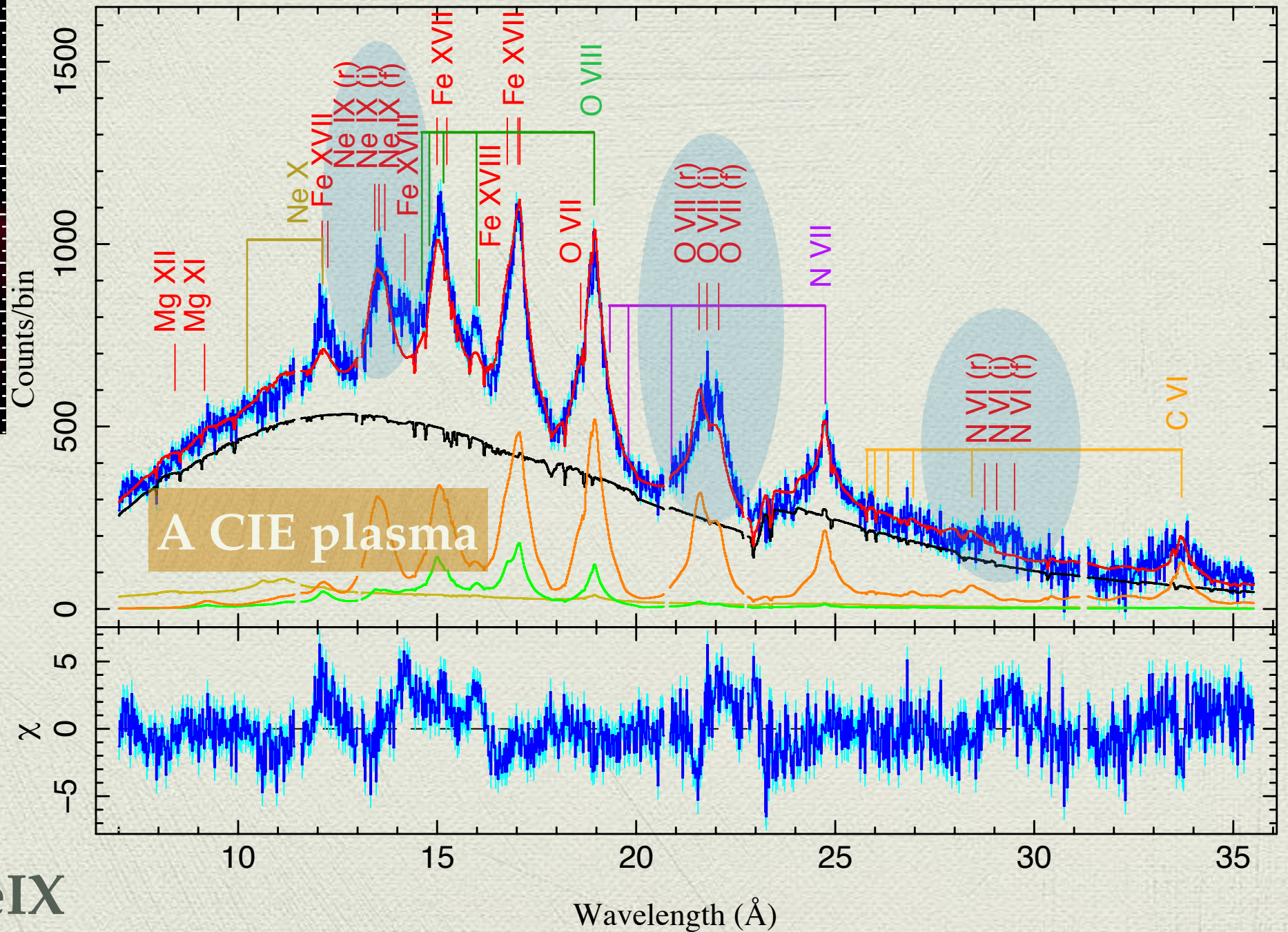
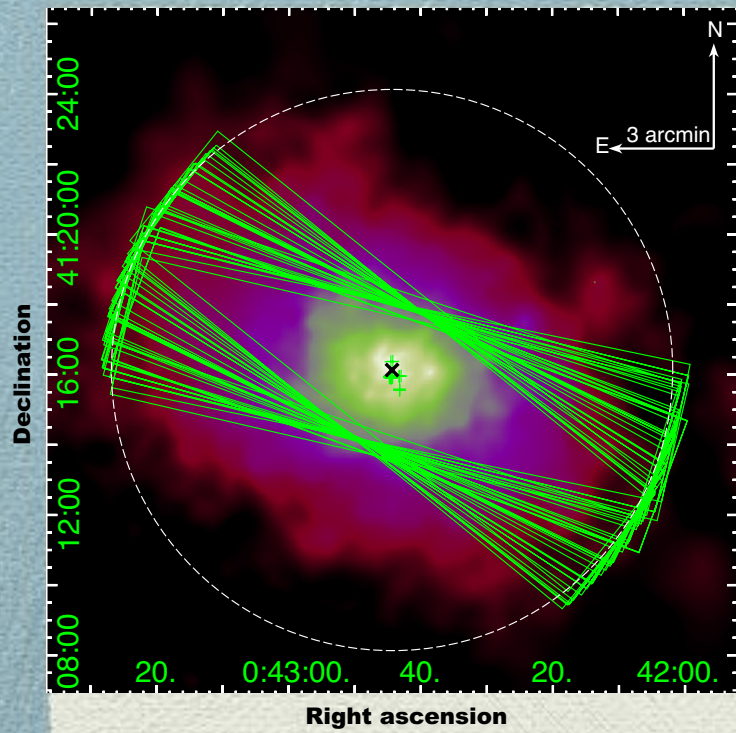


36 Observations & RGS spectrum

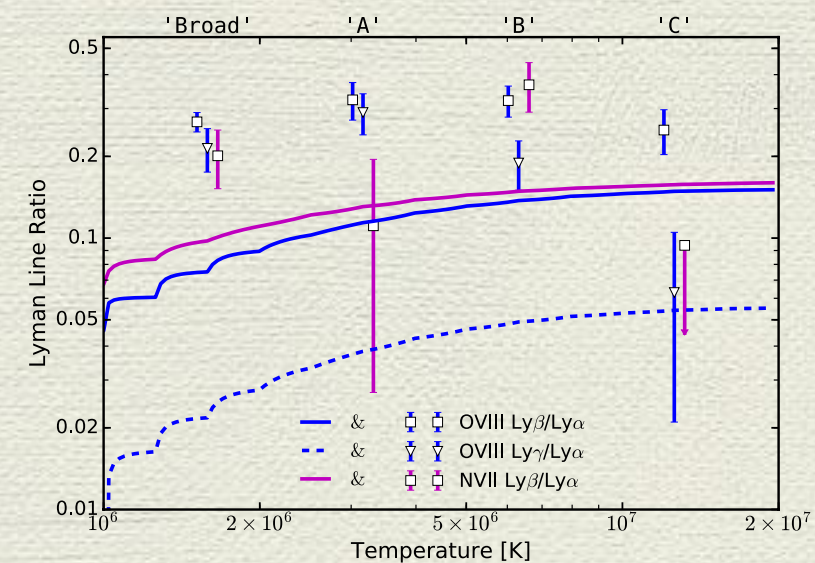
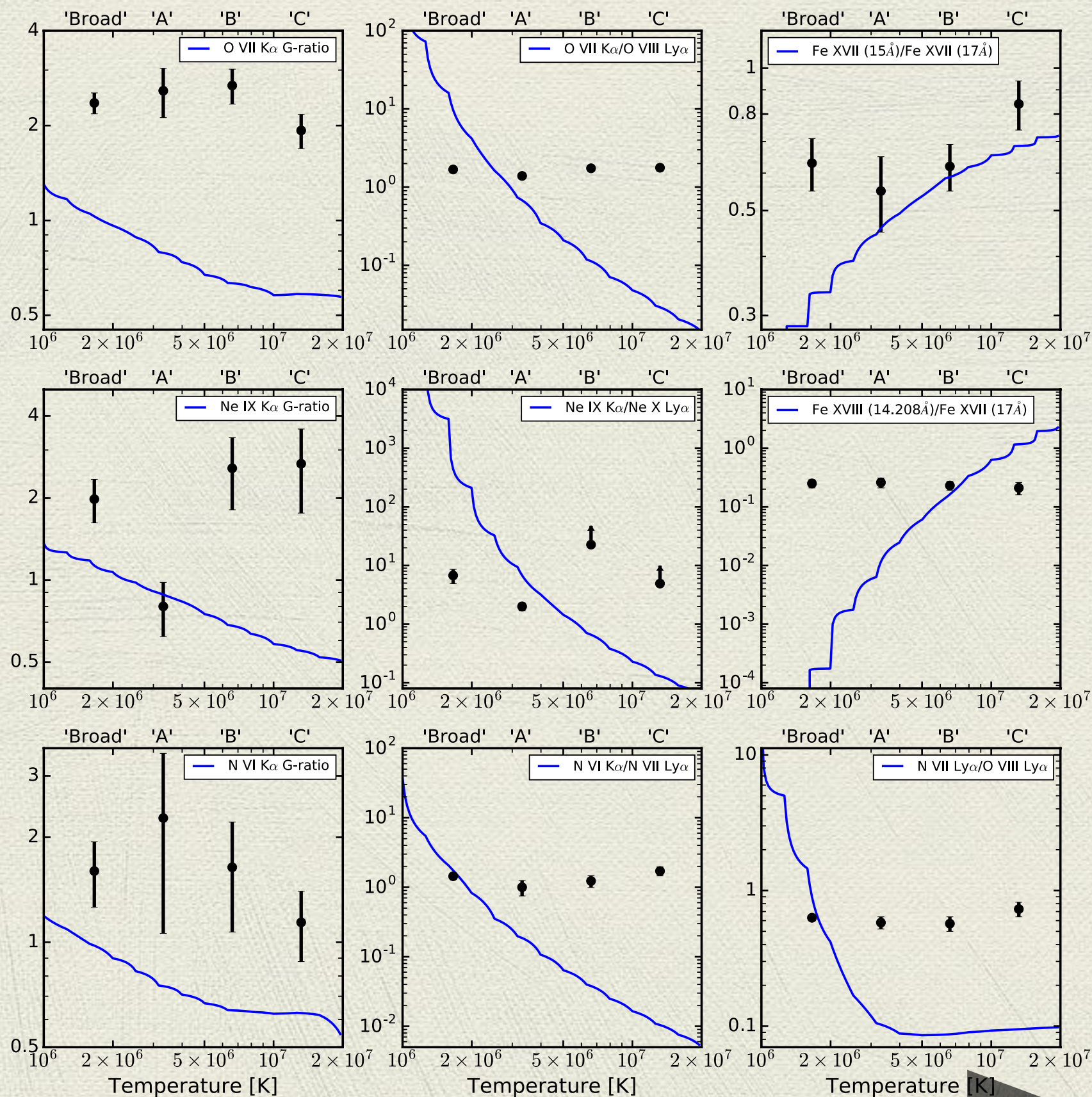


- 0.8 Ms
- Strong f lines from He-like OVII, NVI, NeIX

36 Observations & RGS spectrum



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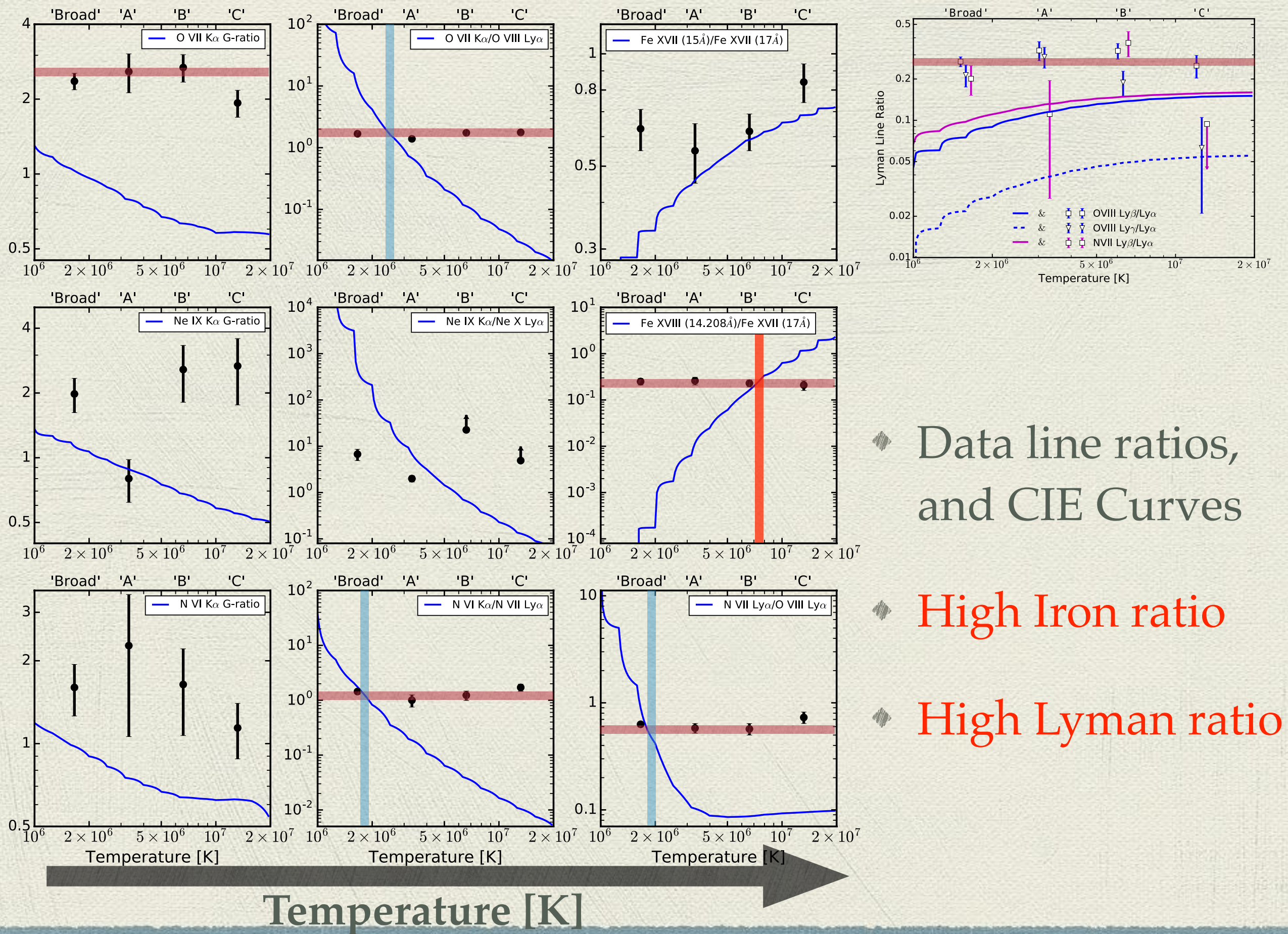


◆ Data line ratios,
and CIE Curves

◆ High Iron ratio

◆ High Lyman ratio

Temperature [K]



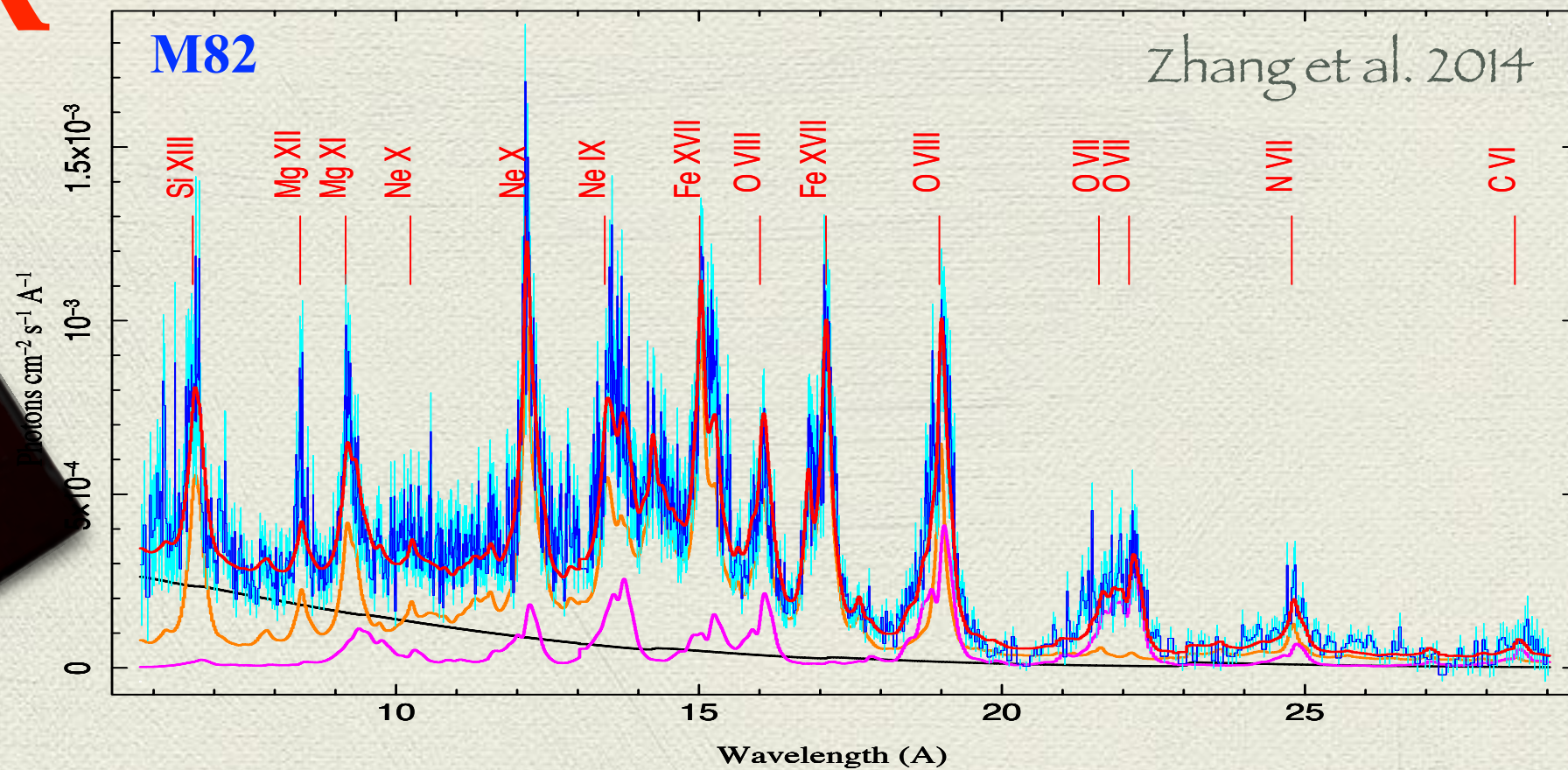
Credit: NASA

CX

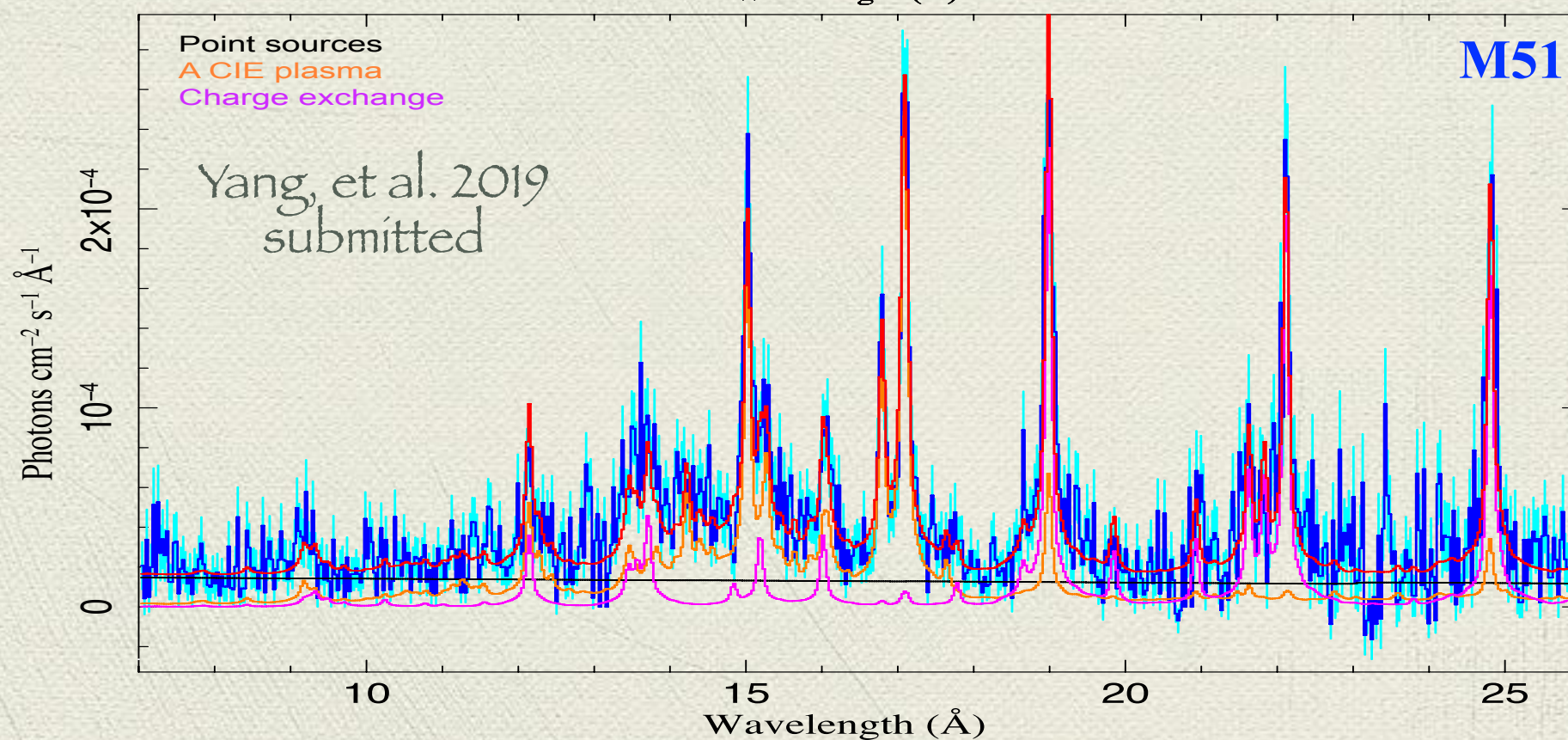


M82

Zhang et al. 2014



M51



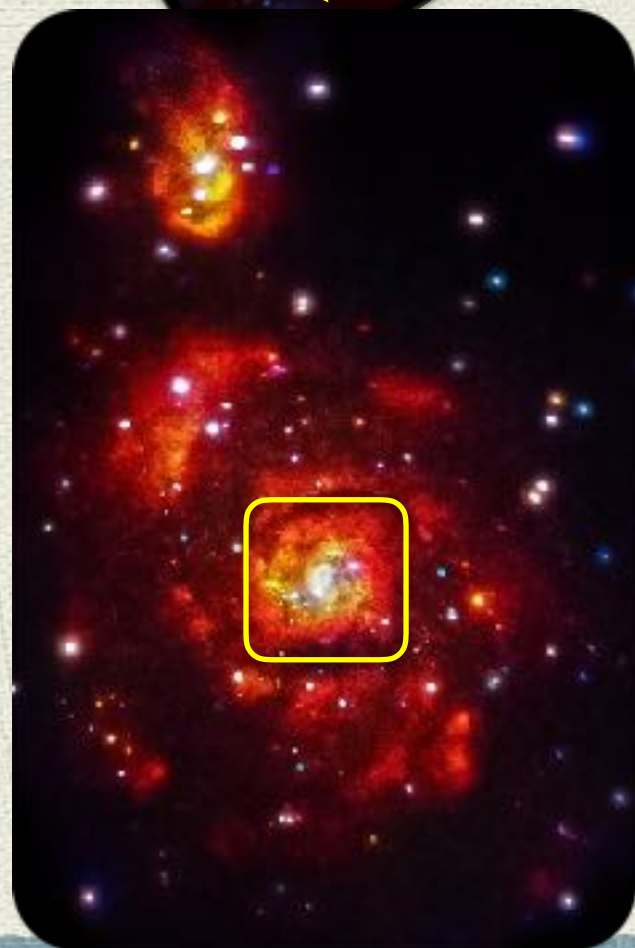
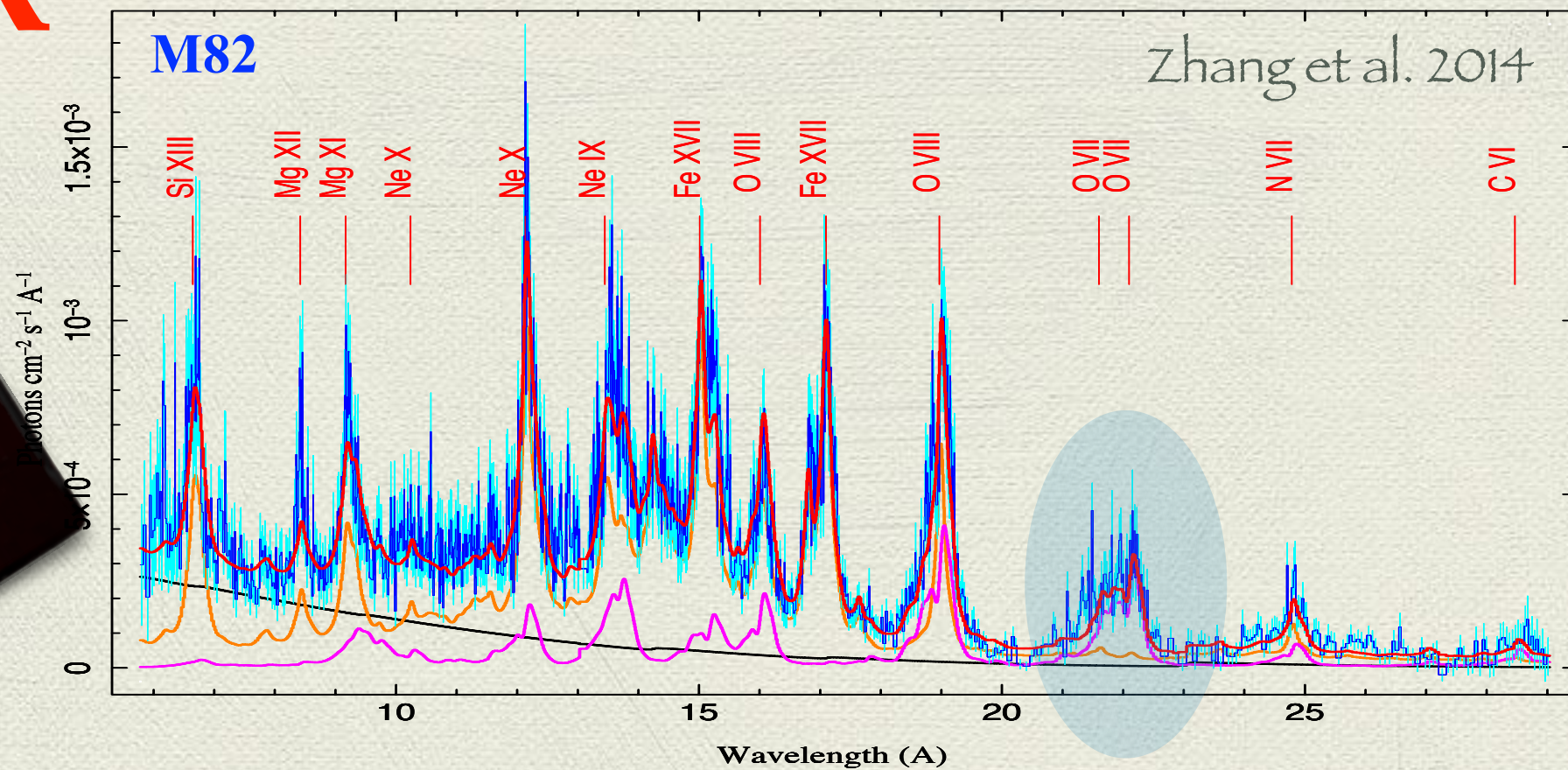
Credit: NASA

CX



M82

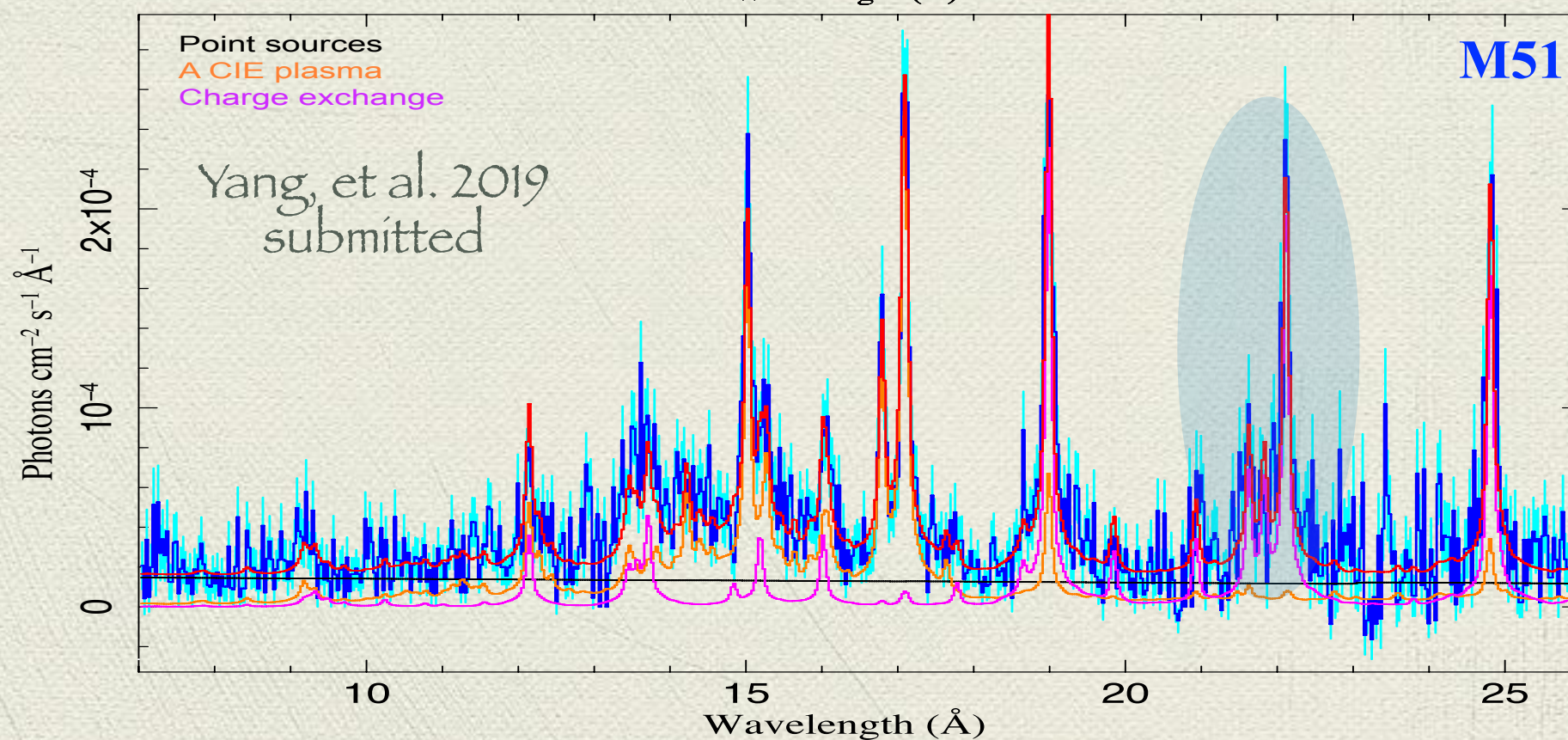
Zhang et al. 2014

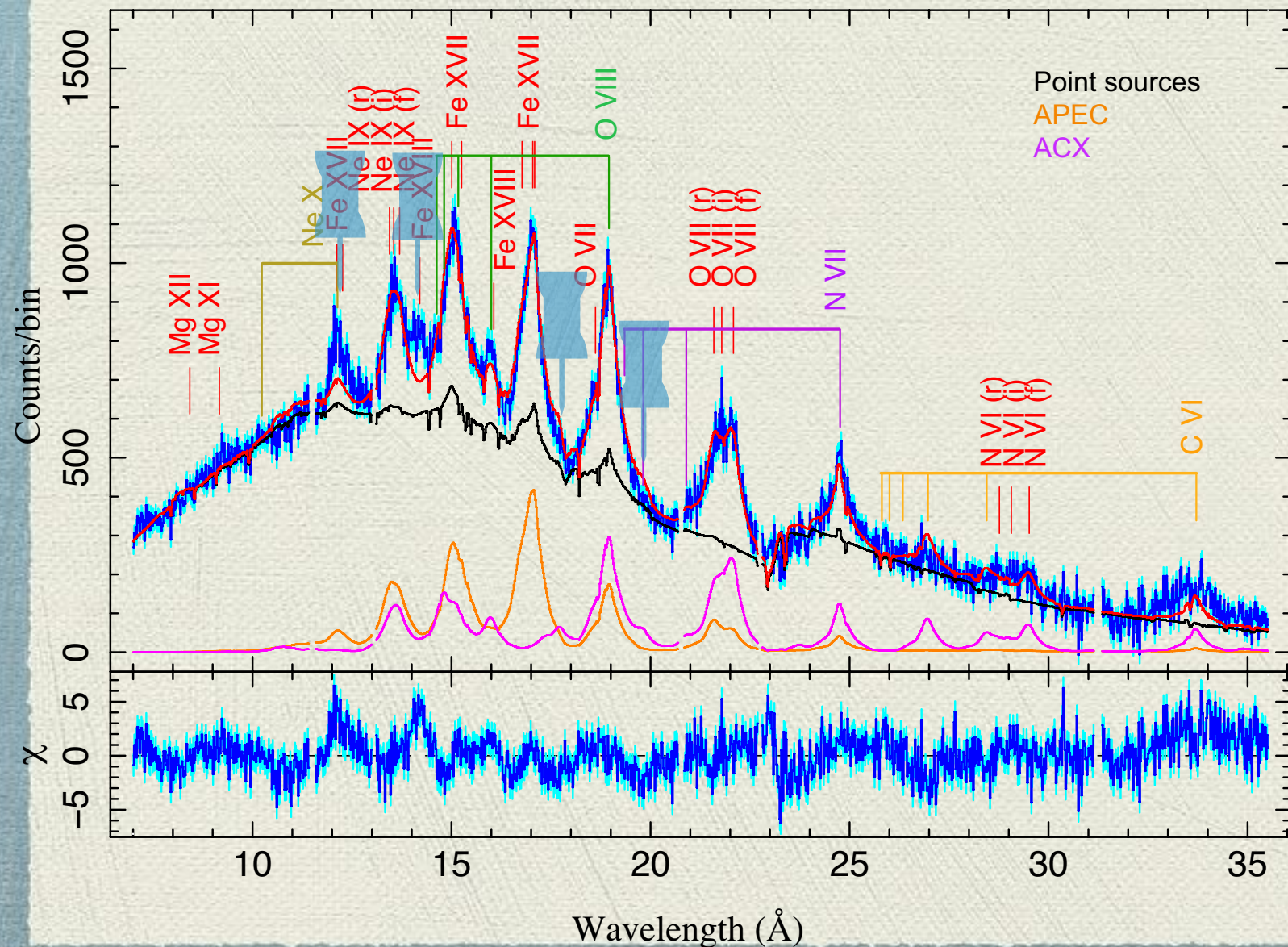
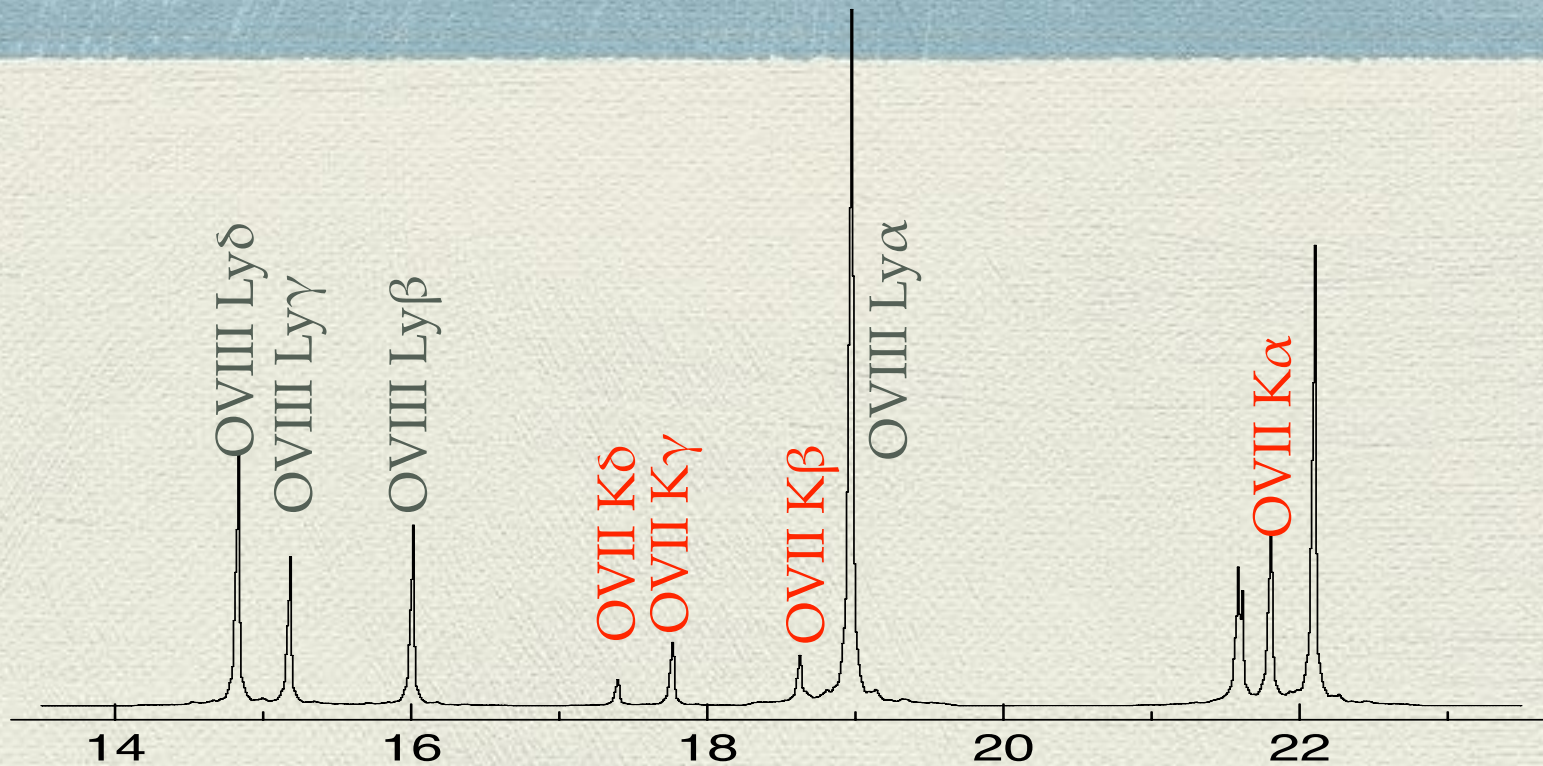


M51

Point sources
A CIE plasma
Charge exchange

Yang, et al. 2019
submitted





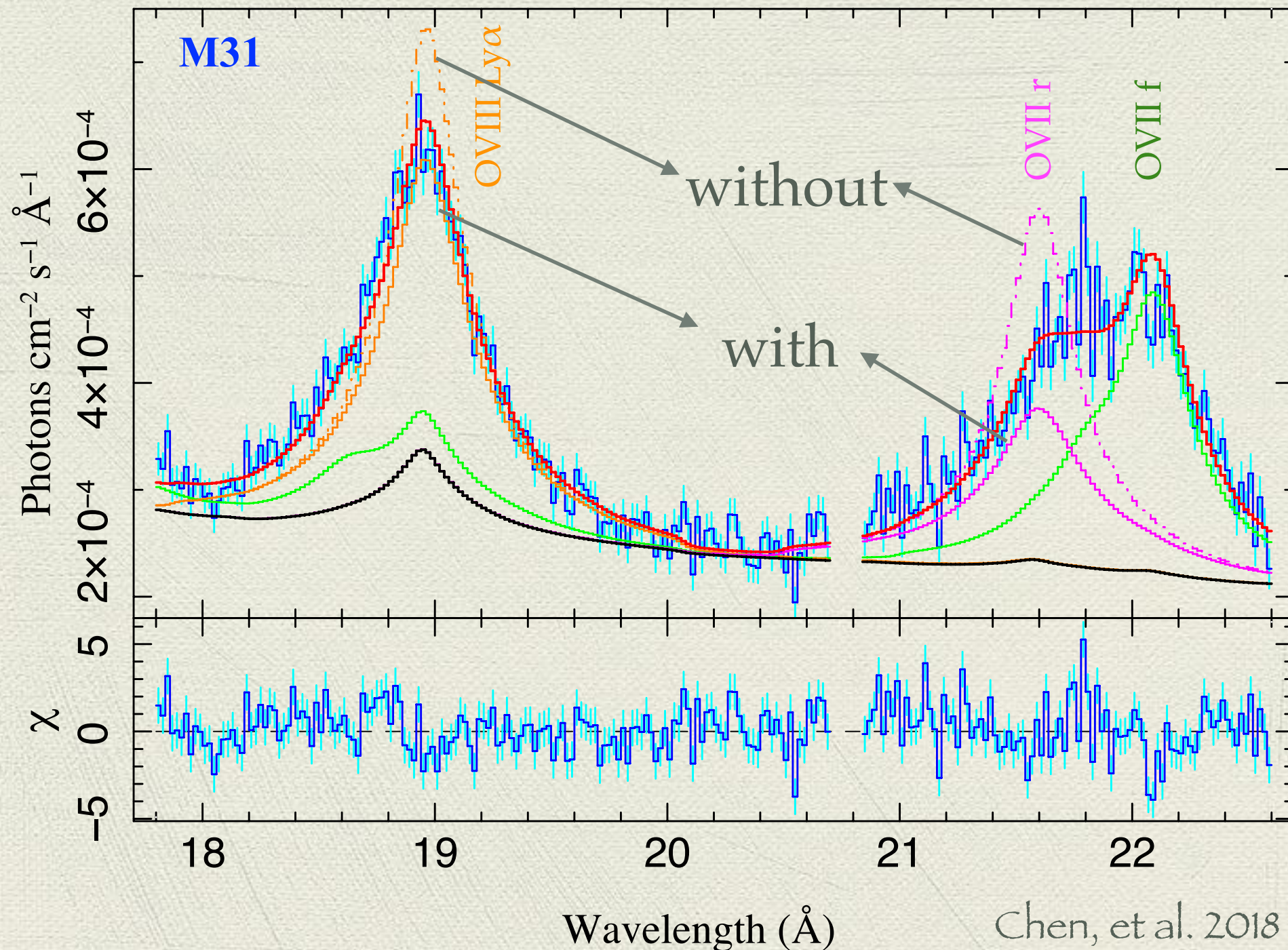
CX



- ◆ Good for β/α
- ◆ **Not** for γ/α or δ/α
- ◆ **Not** good for iron ratios
- ◆ Interface area is $\sim 5 \text{ kpc}^2$!!

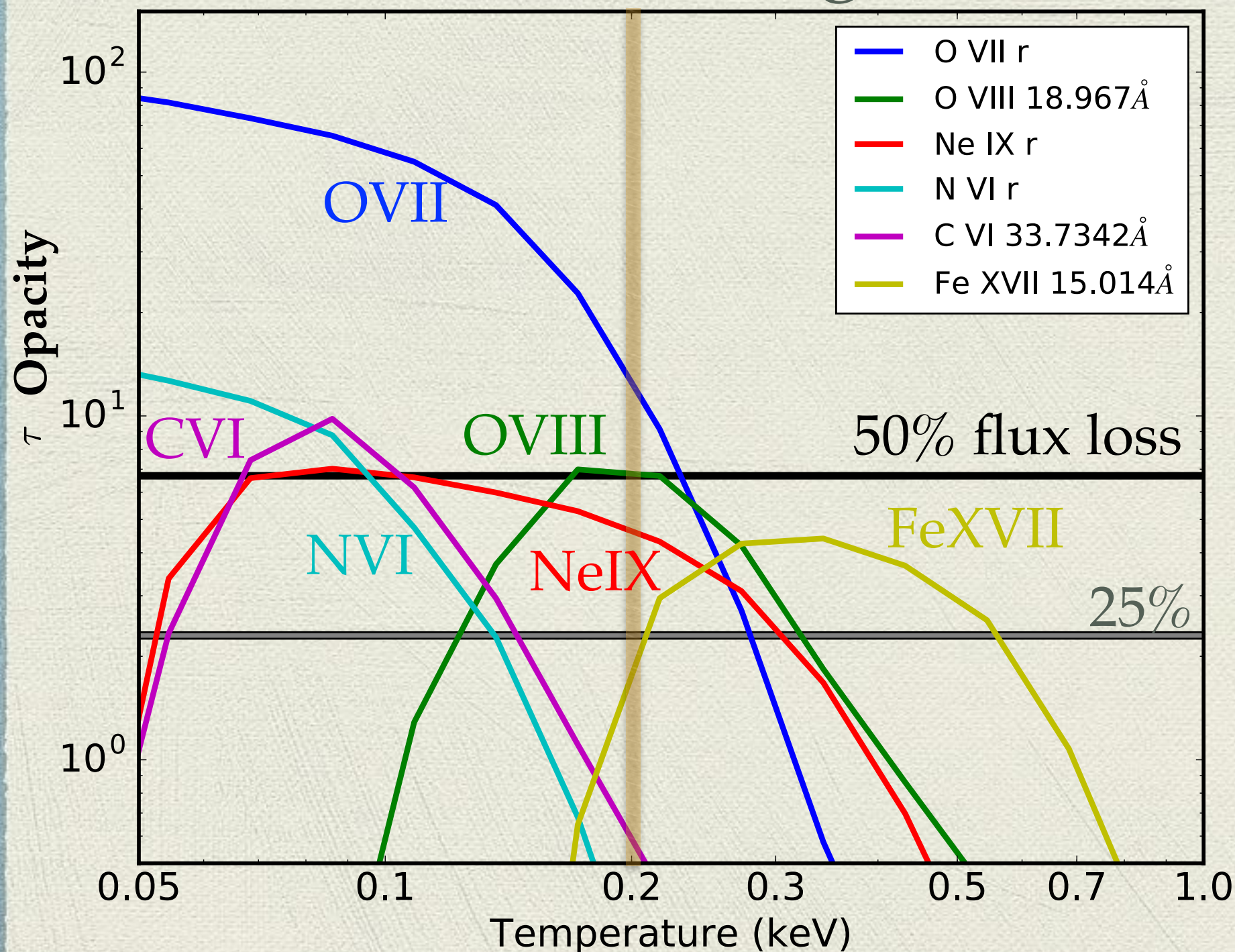
RS

- Explains Oxygen line ratios and shapes
- 0.2 keV & Turbulence: 40km s⁻¹



Lines suffering RS

RS



- ◆ Good for Lyman ratios
- ◆ **Not** for Iron ratios
- ◆ **Not** good for NVI f line

A single mechanism

on second thought

A single mechanism
A single event

on second thought

IC2497

[OIII]

Credit: WIKI

Hanny's Voorwerp

- ◆ [OIII] bright, found in 2007
- ◆ IC2497 was a quasar *~ 0.1 Myrs ago*
- ◆ Ionizing Luminosity was $>10^{45} \text{ erg s}^{-1}$ (Lintott+2009)

8 More Quenched AGNs

Hubble News Release, 2015

Extended Gas in Active Galaxies ■ *Hubble Space Telescope* ■ WFPC2 ■ ACS/WFC ■ WFC3/UVIS

SDSS 1430+13

NGC 5972

SDSS 1510+07

UGC 7342

NGC 5252

Mkn 1498

UGC 11185

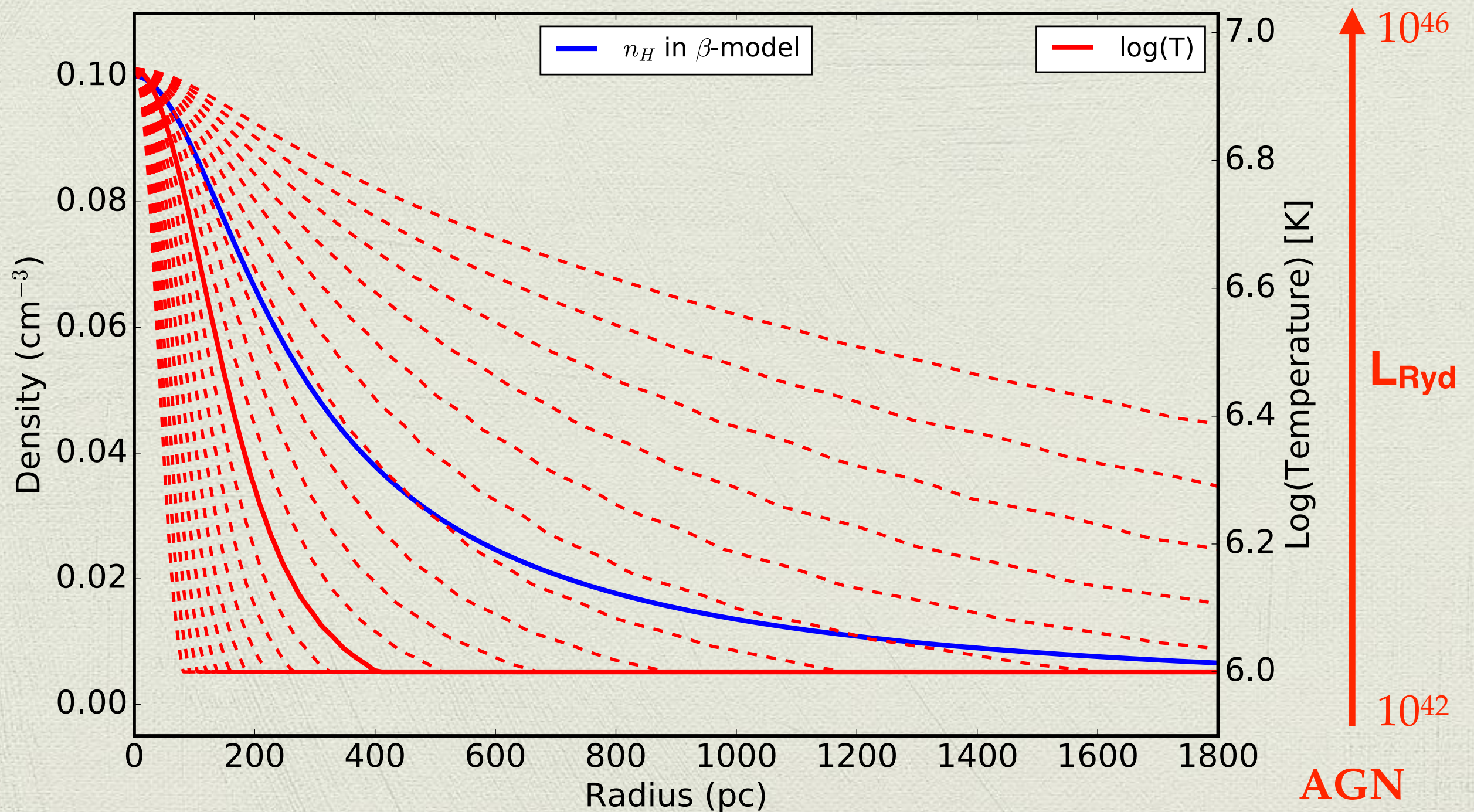
SDSS 2201+11

A quenched AGN in M31?

- ◆ The molecular gas in the center of M31 is **less than a tenth** of that in the Galactic center (Melchior & Combes 2017; Li et al. 2019): **exhausted by the past AGN activity?**
- ◆ Fermi Bubbles in M31? (Pshirkov et al. 2016)

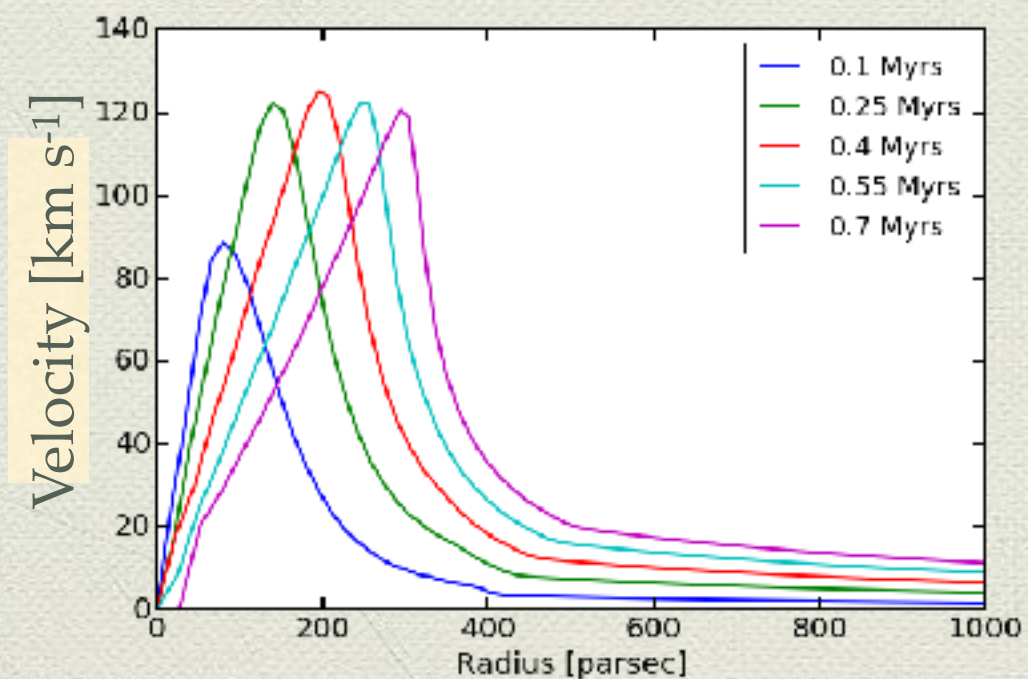
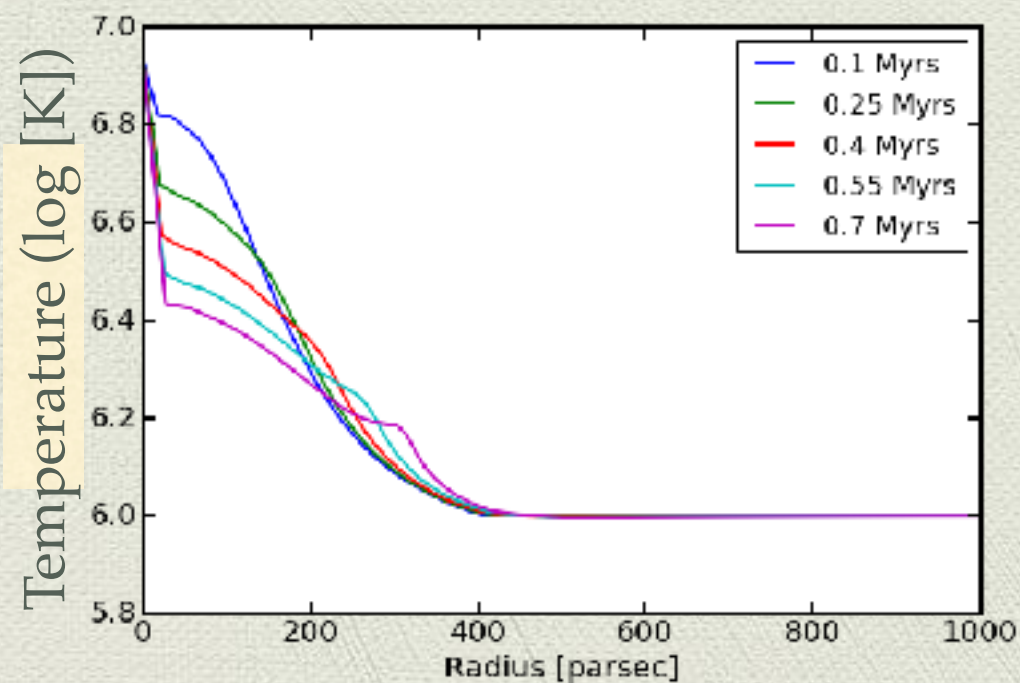
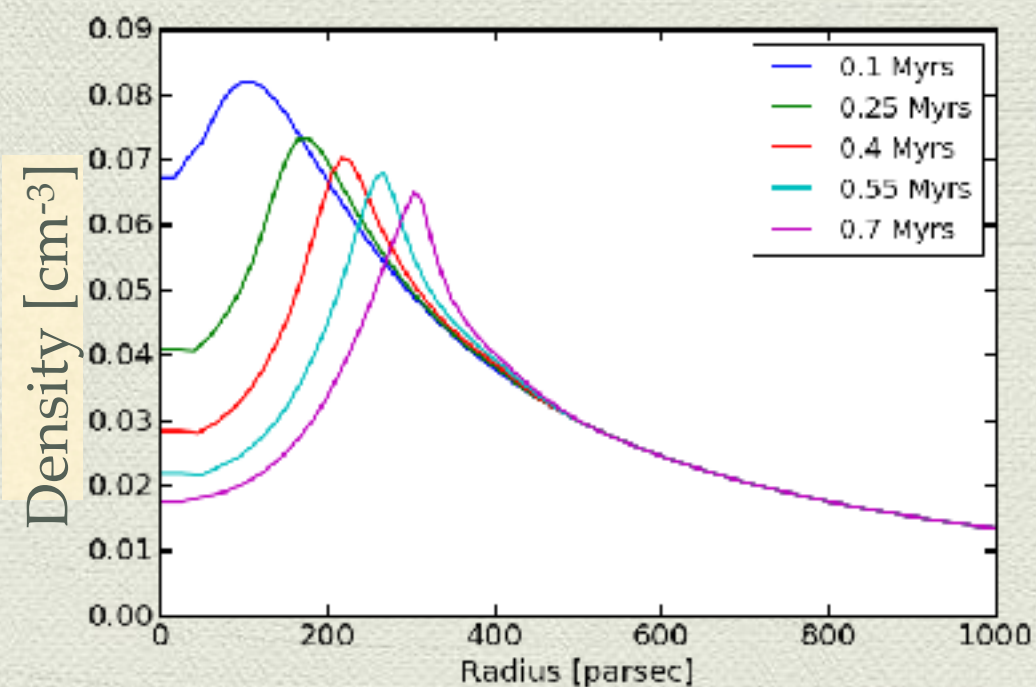
An AGN Relic Model:

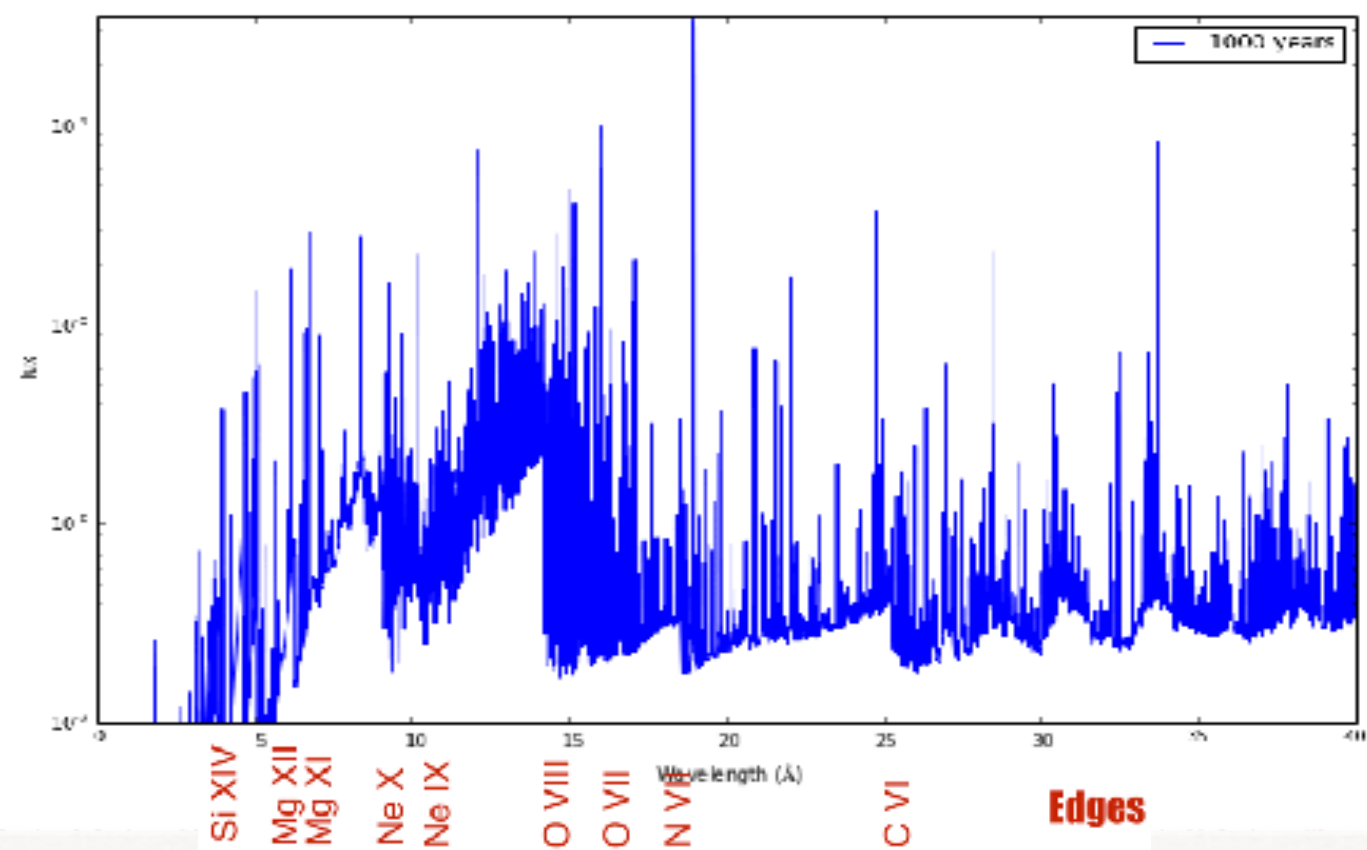
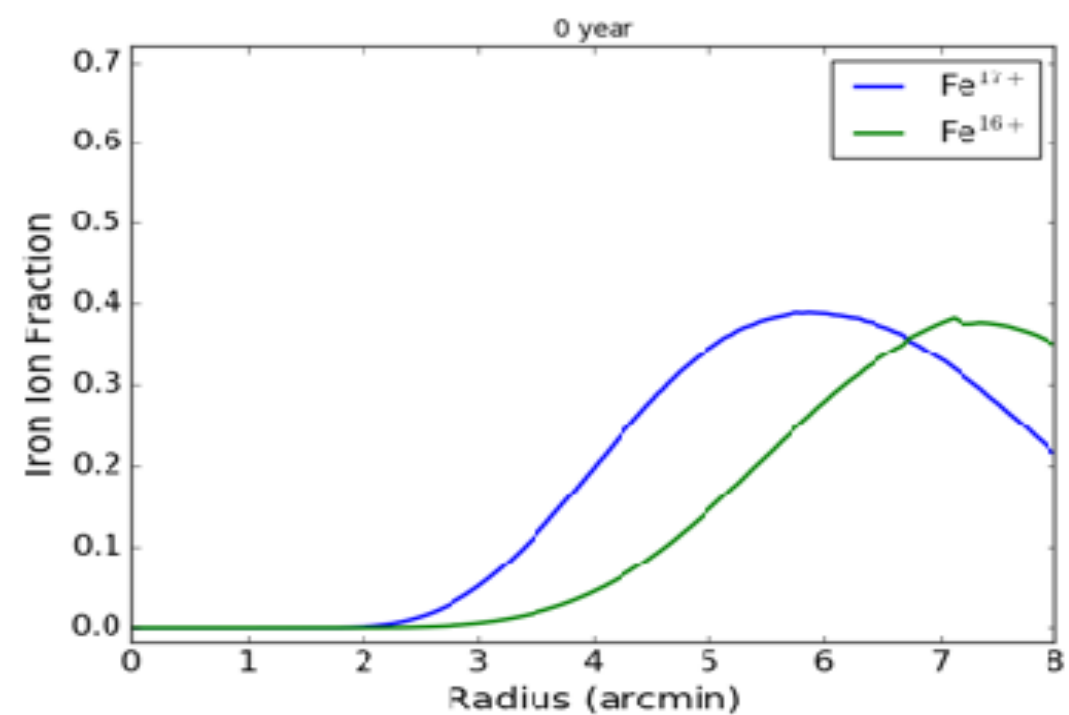
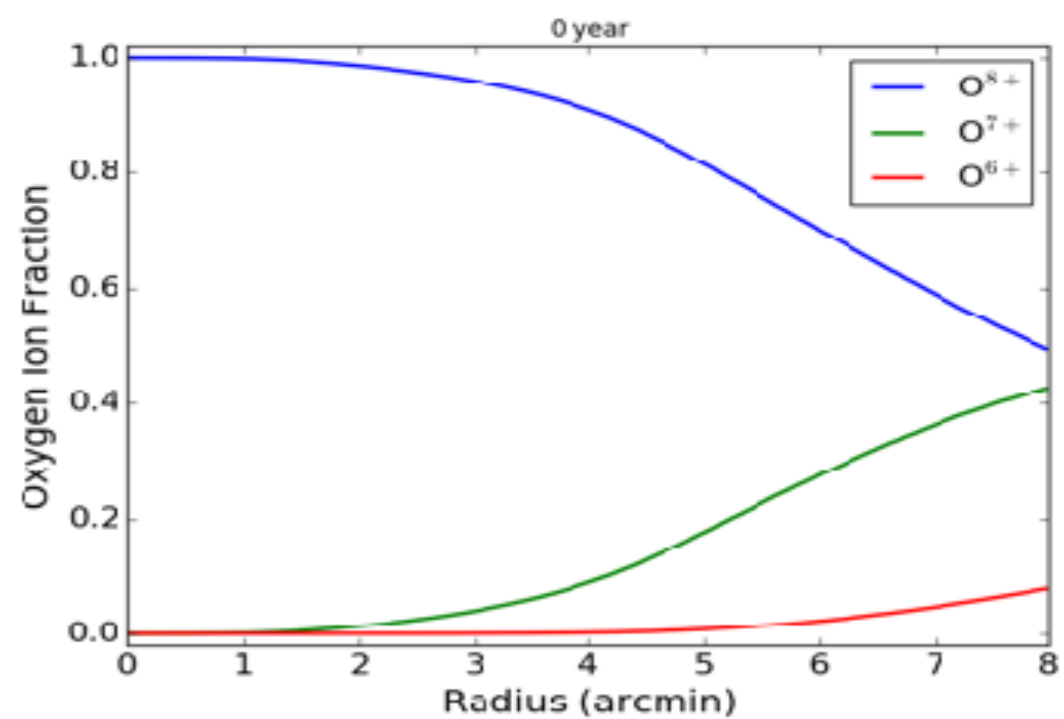
(Turn ON AGN give) **Luminosity**



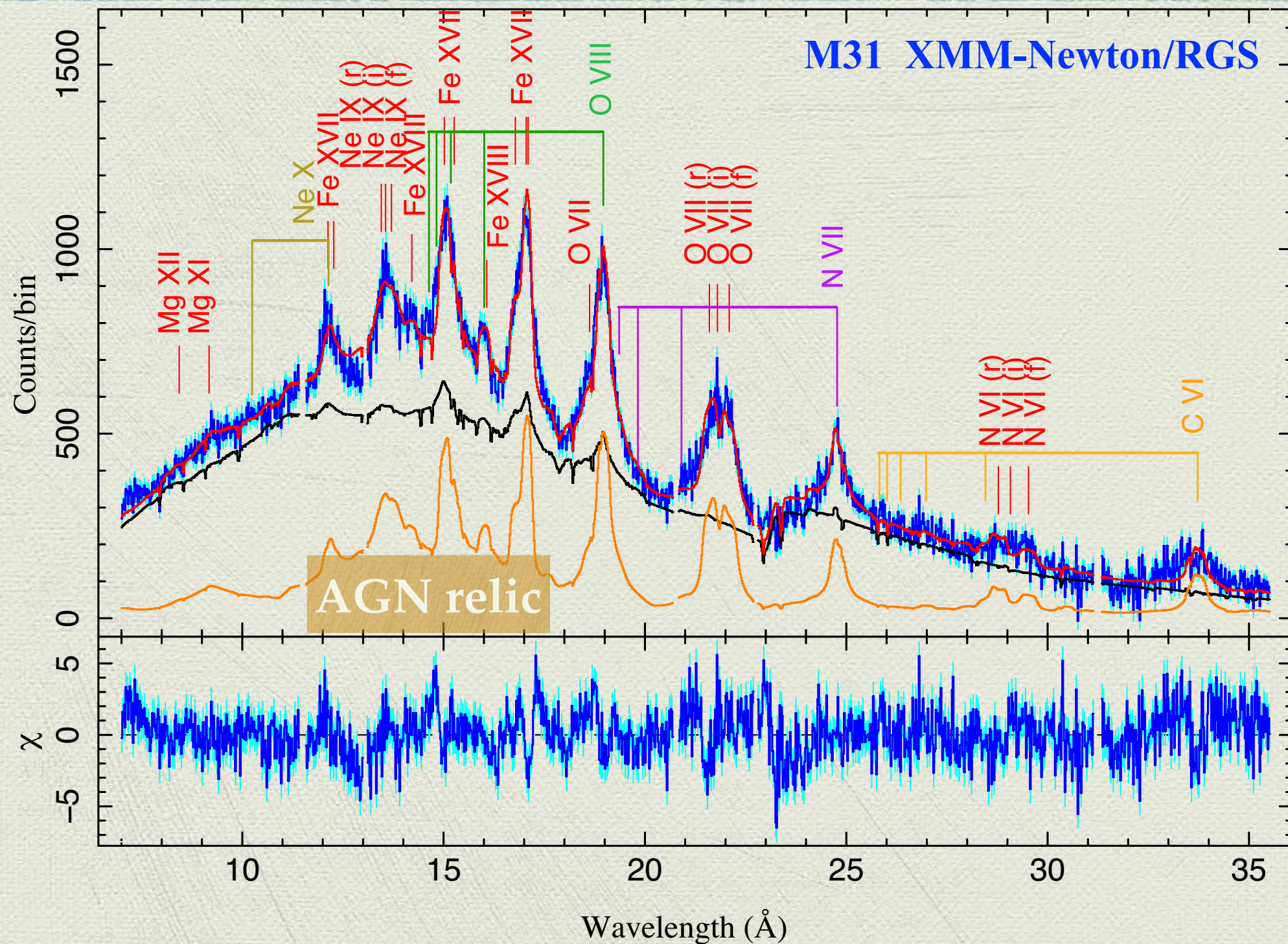
An AGN Relic Model:

(Turn OFF AGN give) **Time**



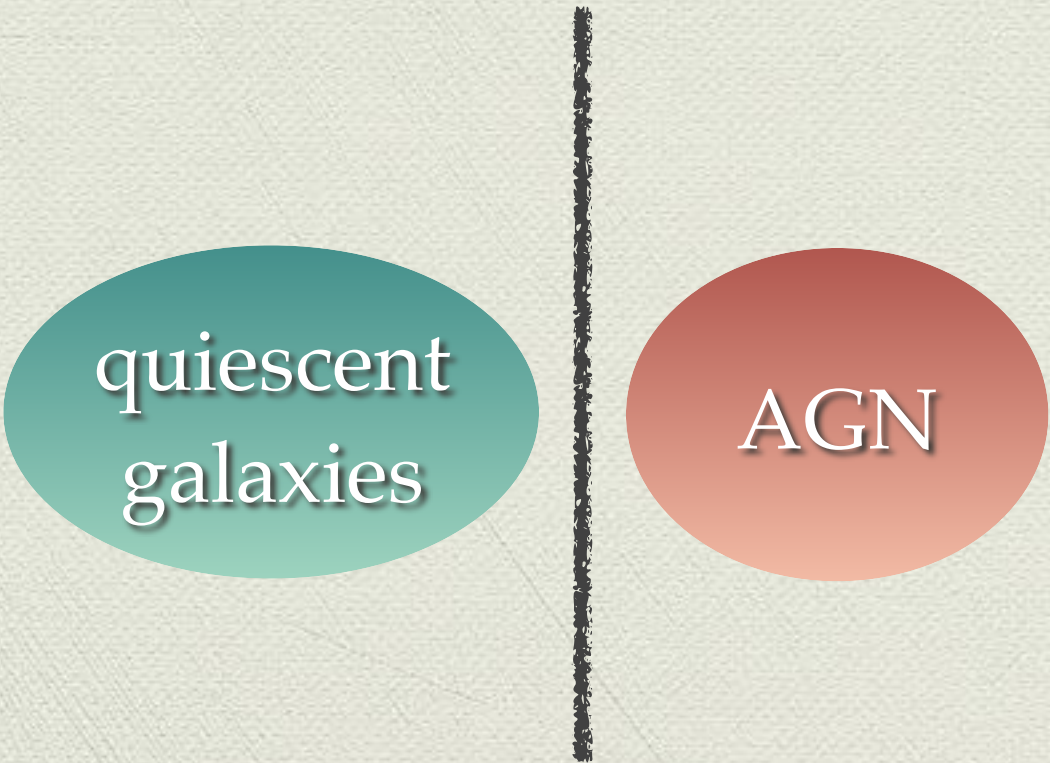


A past AGN



Summary

- ◆ M31 likely hosted a bright AGN about half a Myrs ago
- ◆ AGN 'daily life' (Eat and Rest) with future instruments



quiescent
galaxies

AGN

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Luminosity

