VIRGINIA TECH

Active Galactic Nuclei: Monsters to Scale or Puzzles to Solve?

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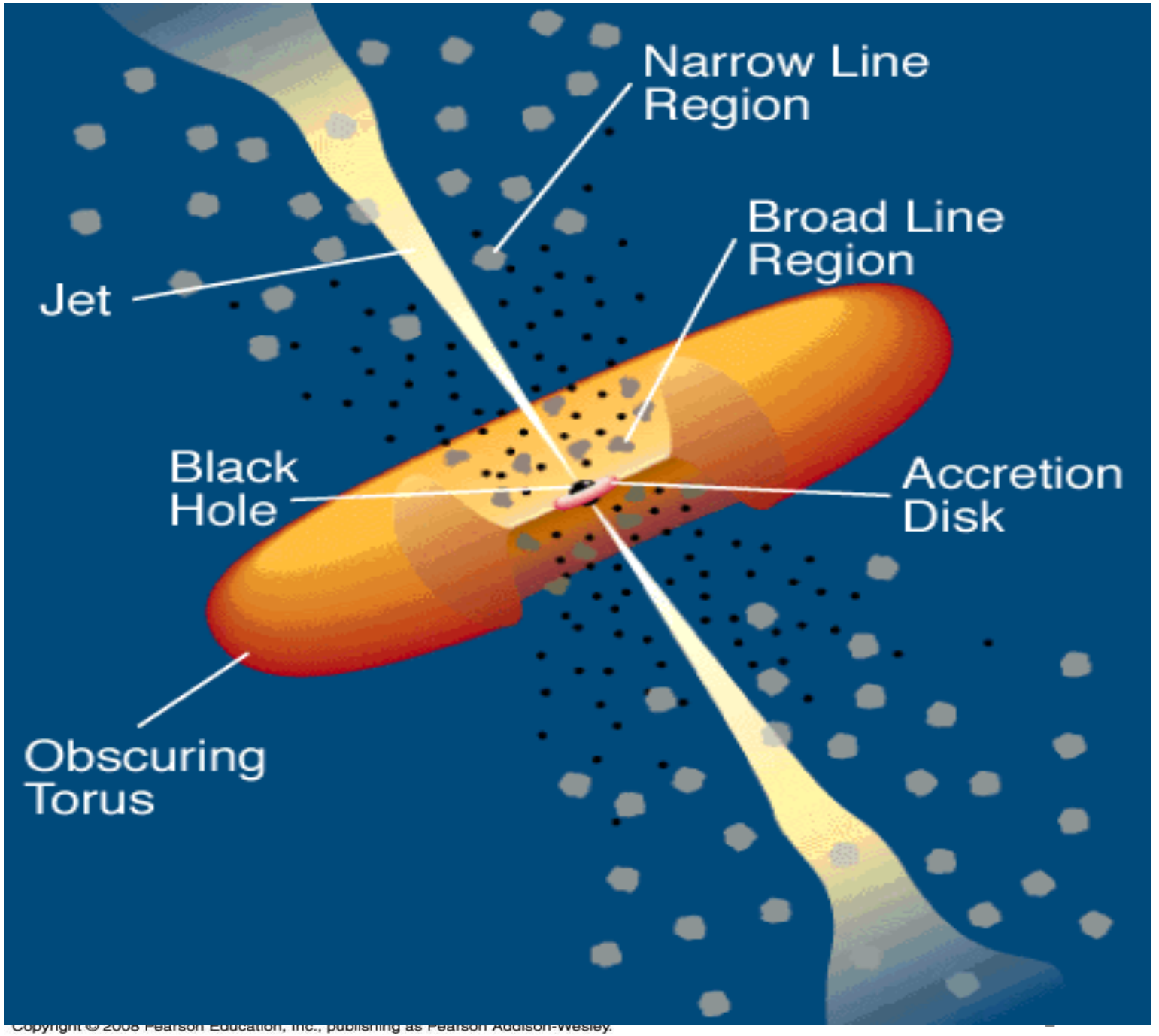
March, 2023

Credit: ESA/Hubble, L. Calçada (ESO)

AGN:
Active Galactic nucleus

- A compact region at the center of a massive galaxy
- Luminosity is much higher than normal
- This excess luminosity is not produced by stars



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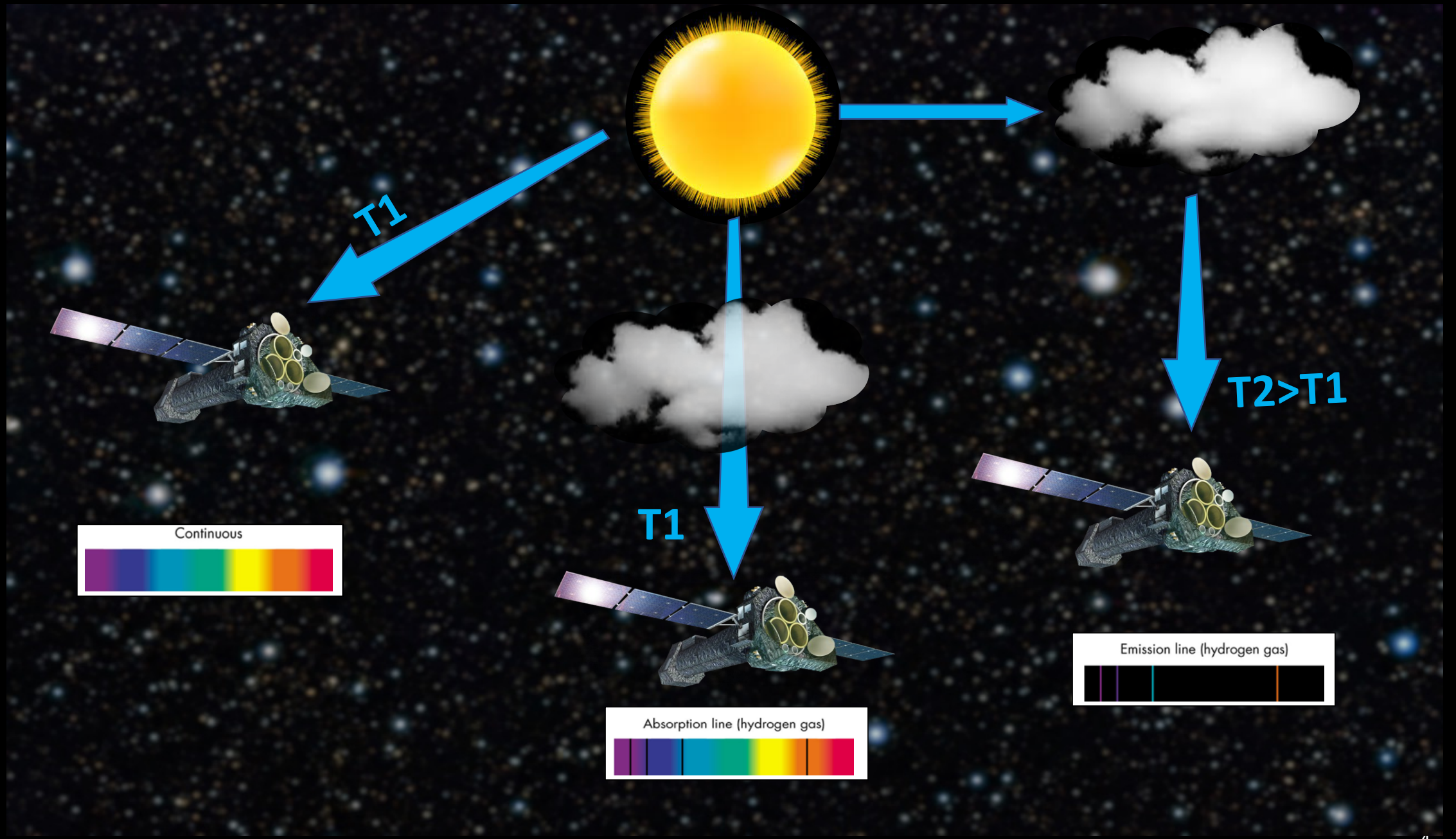
Why do we care about them?
Because of the supermassive black holes!

Correlation with galaxy properties

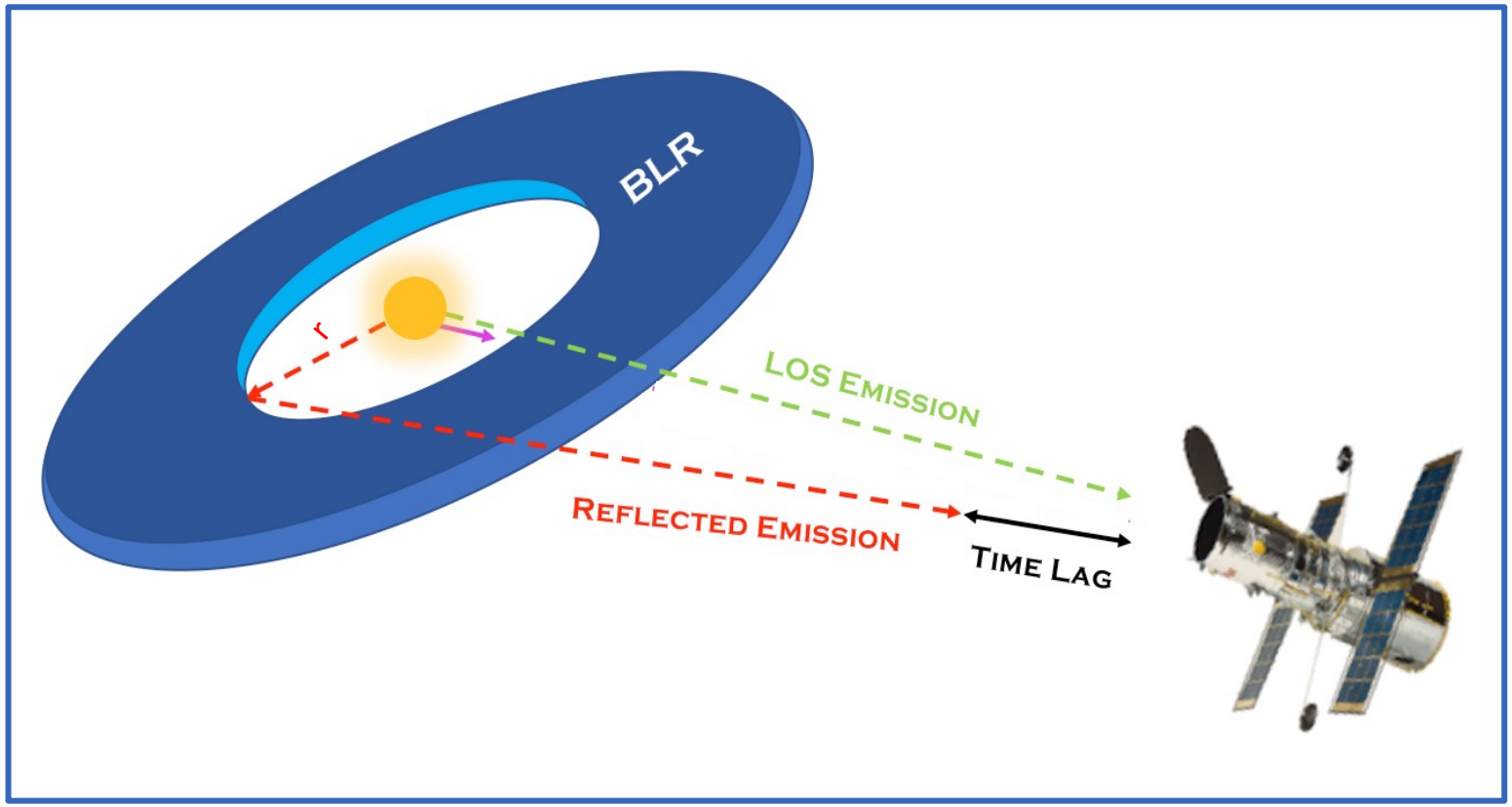
Connection to galaxy mergers

Constraints on accretion models

Probes of the distant Universe


T1
T1
T2>T1
Continuous
Absorption line (hydrogen gas)
Emission line (hydrogen gas)

Reverberation Mapping



Estimation of AGN's Mass

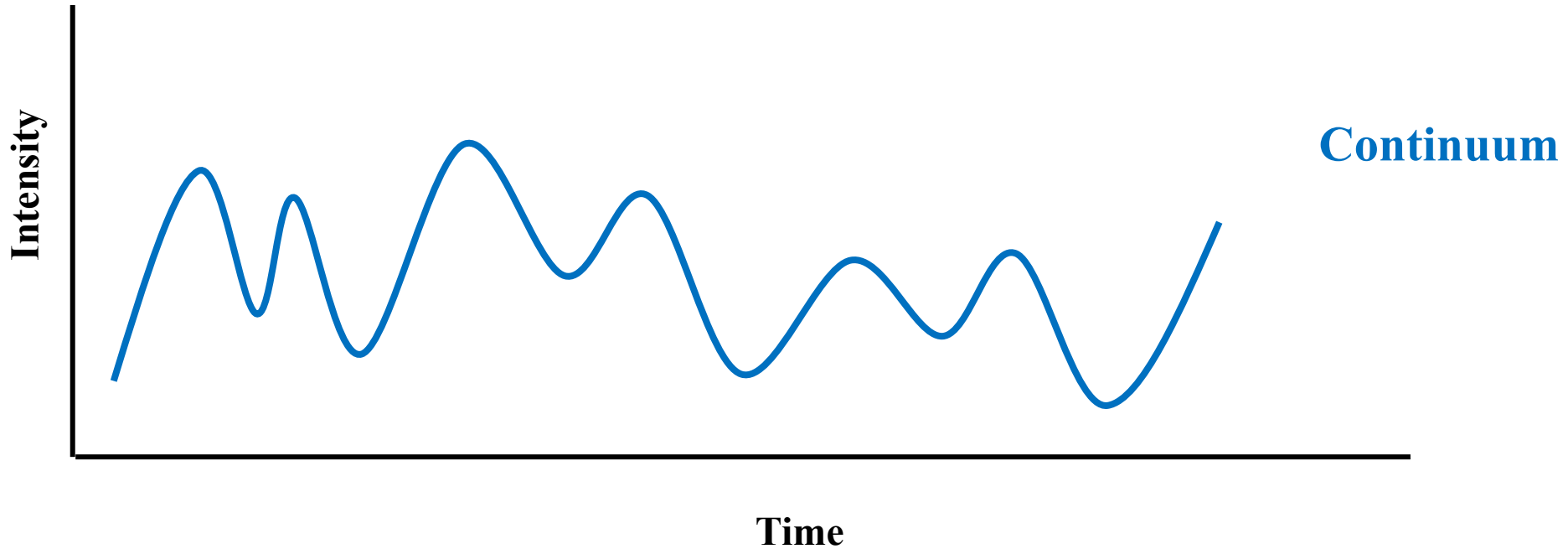
$$M = \frac{r v^2}{G}$$

Two parameters needed:

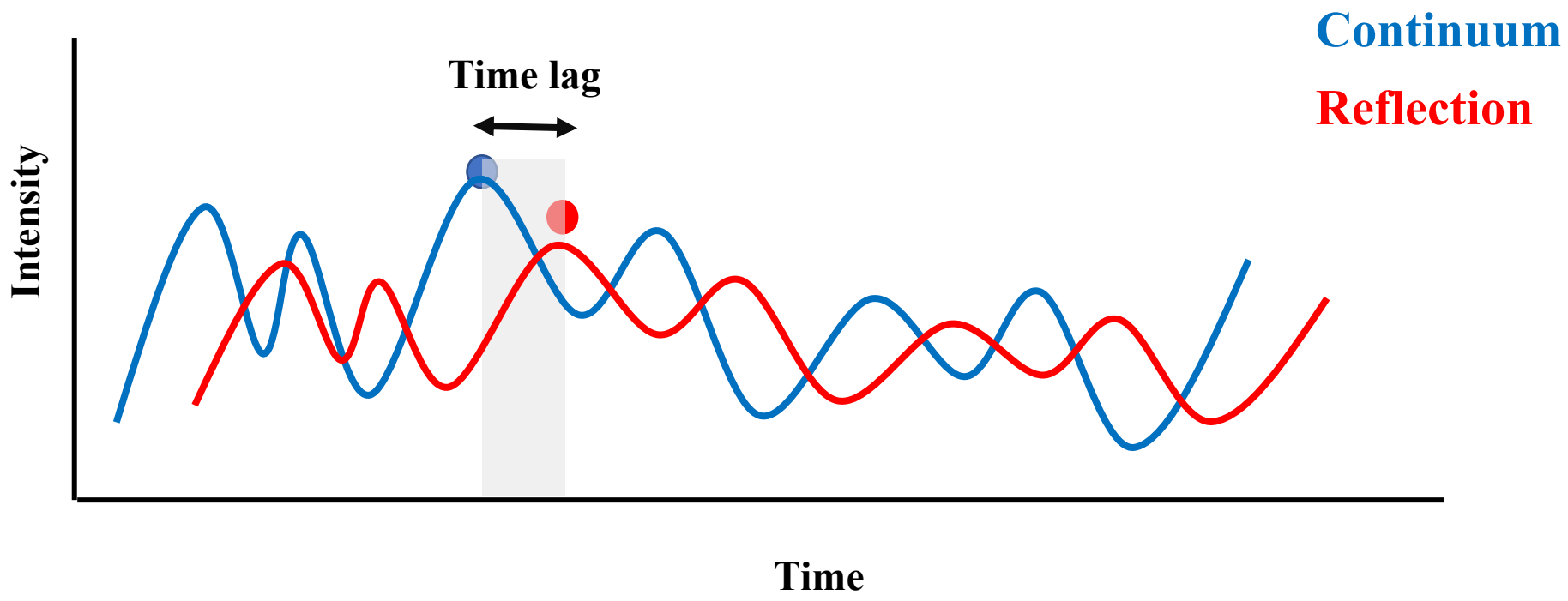
1-**velocity** → from Doppler line broadening!

2-**distance** → through "Reverberation Mapping"

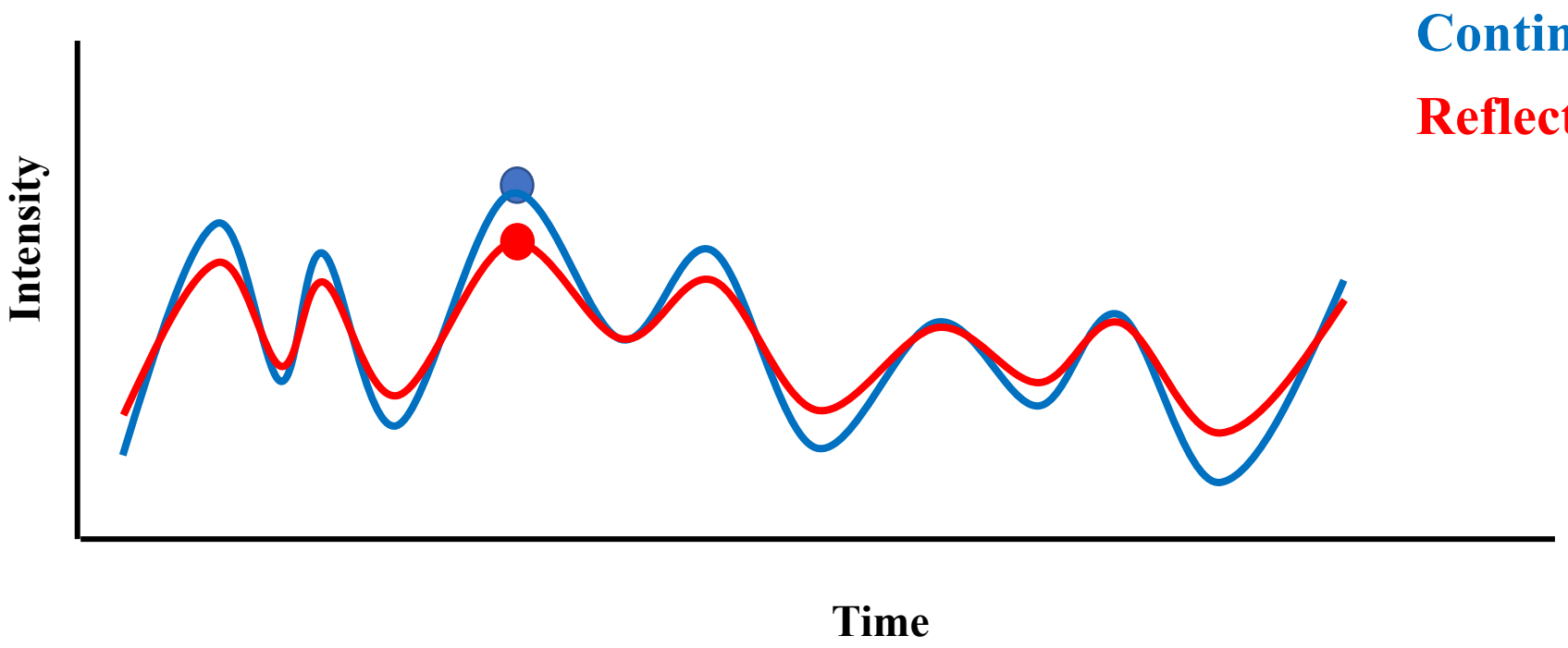
The Time Lag



The Time Lag



The Time Lag



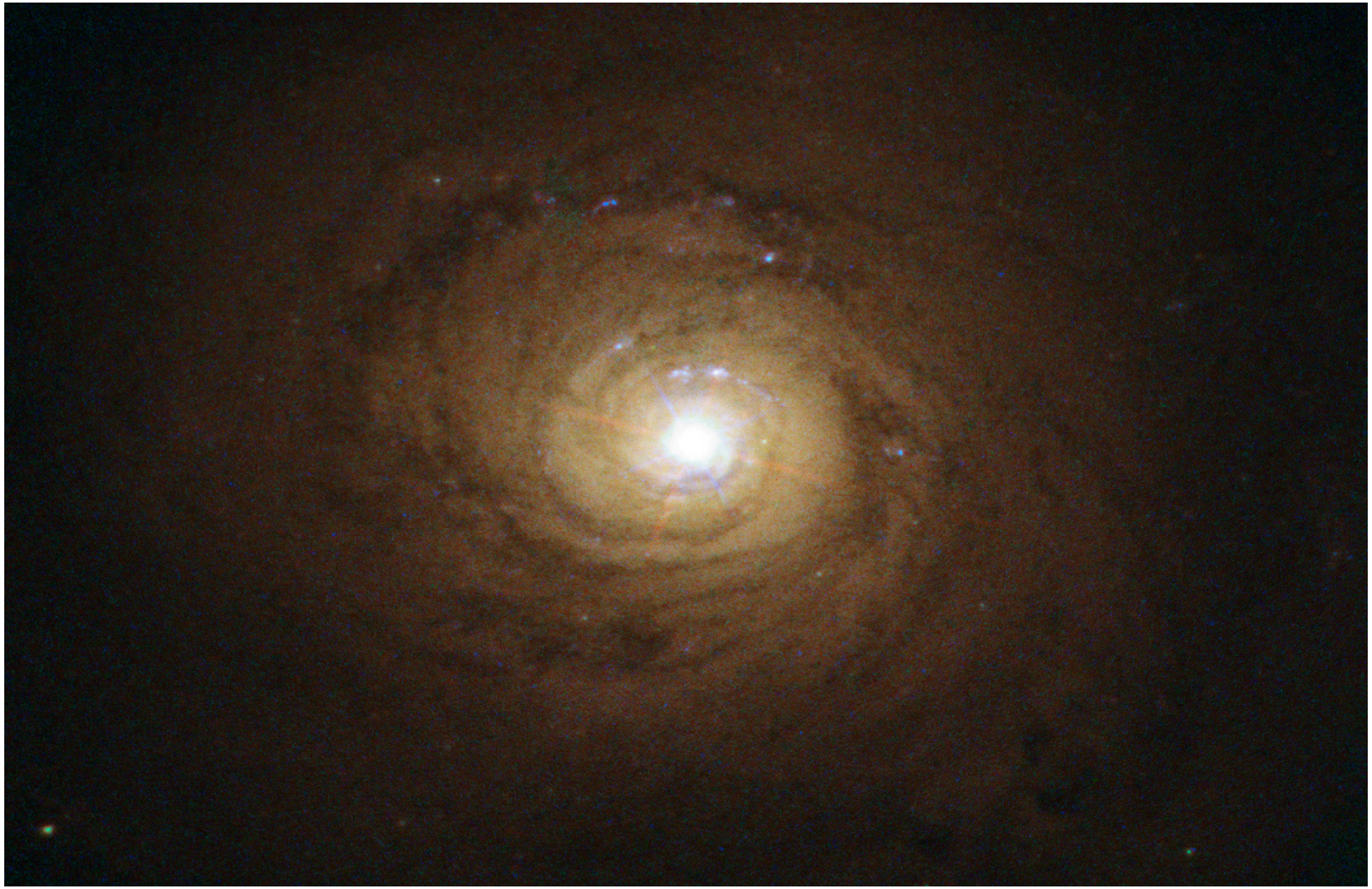
Continuum

Reflection [Shifted]

AGN NGC 5548

Distance: 245 million LY

Mass of BH: $7\times10^7\ M_\odot$



Credit: Hubble Space Telescope

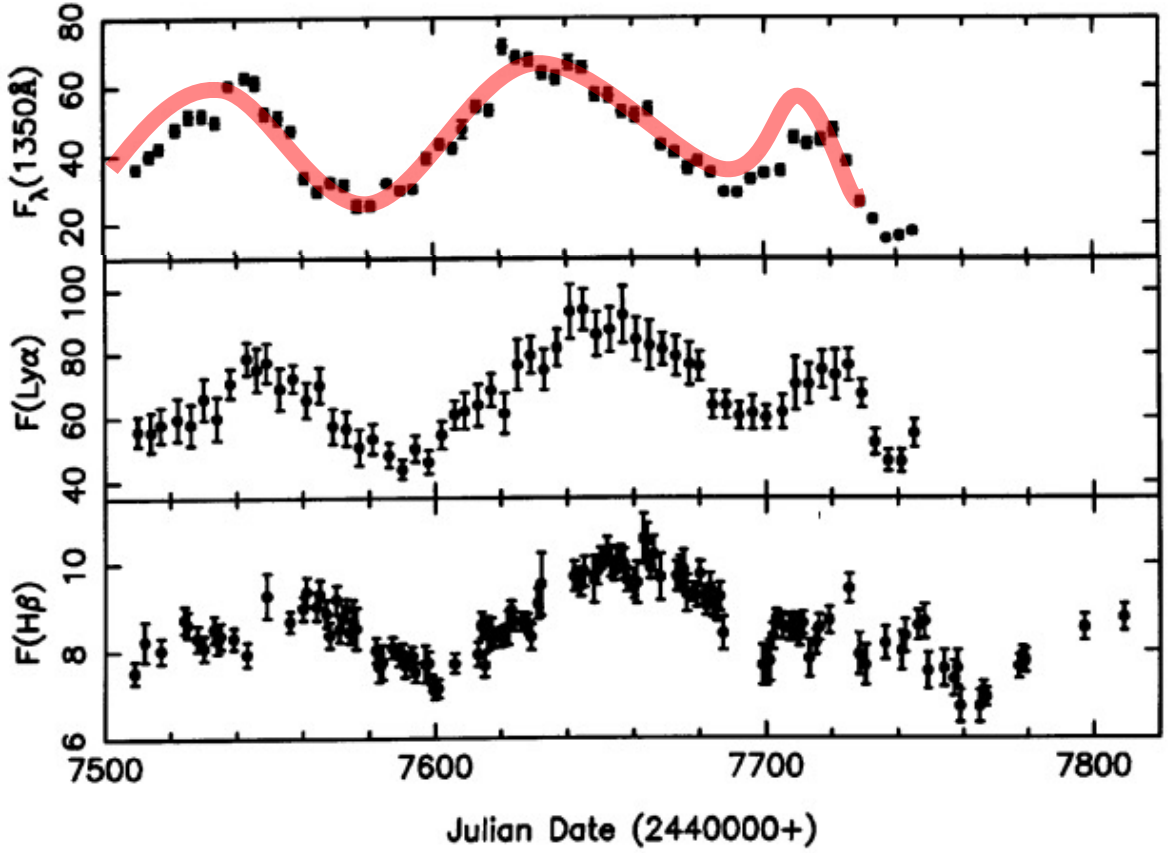
AGN STORM Project

Space Telescope and Optical Reverberation Mapping

- They started the observations in 2014
- 6 space-based telescopes
- 181 orbits of Hubble
- 21 ground-based telescopes
- More than 100 astronomers from US and Europe
- The “Anatomy” campaign (2013)

What they expect to see:

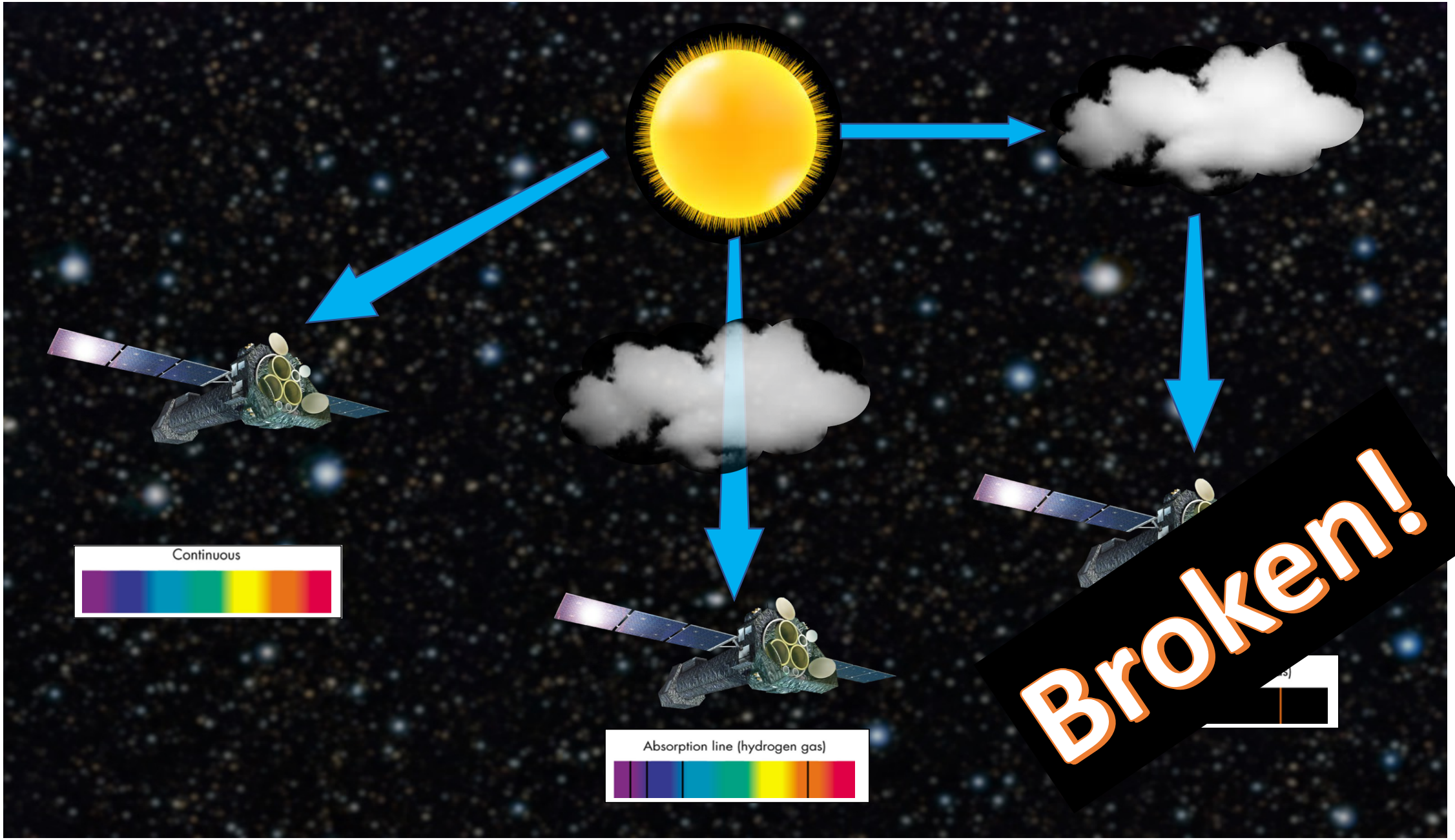
Sample light curves for NGC 5548 from 1988-1989



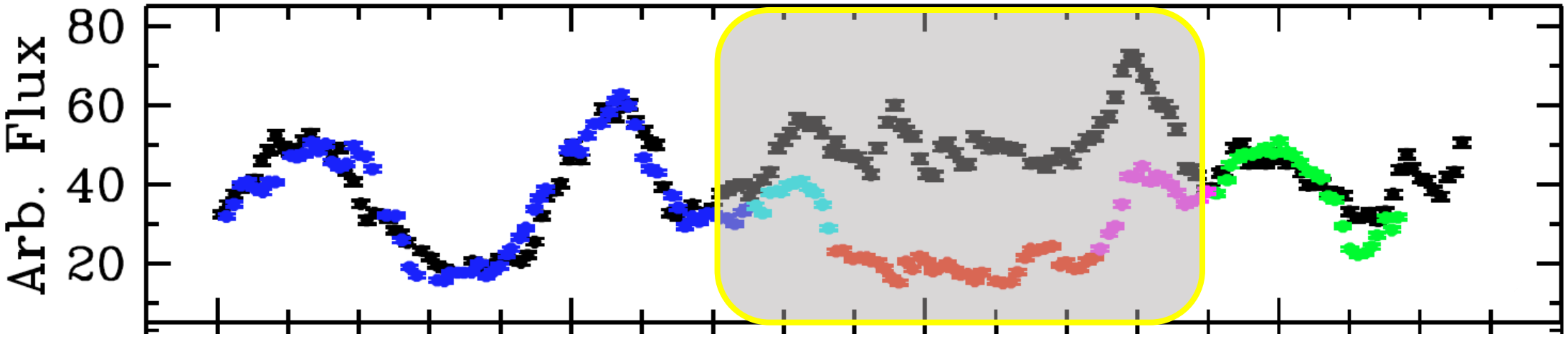
The Continuum

The emission lines

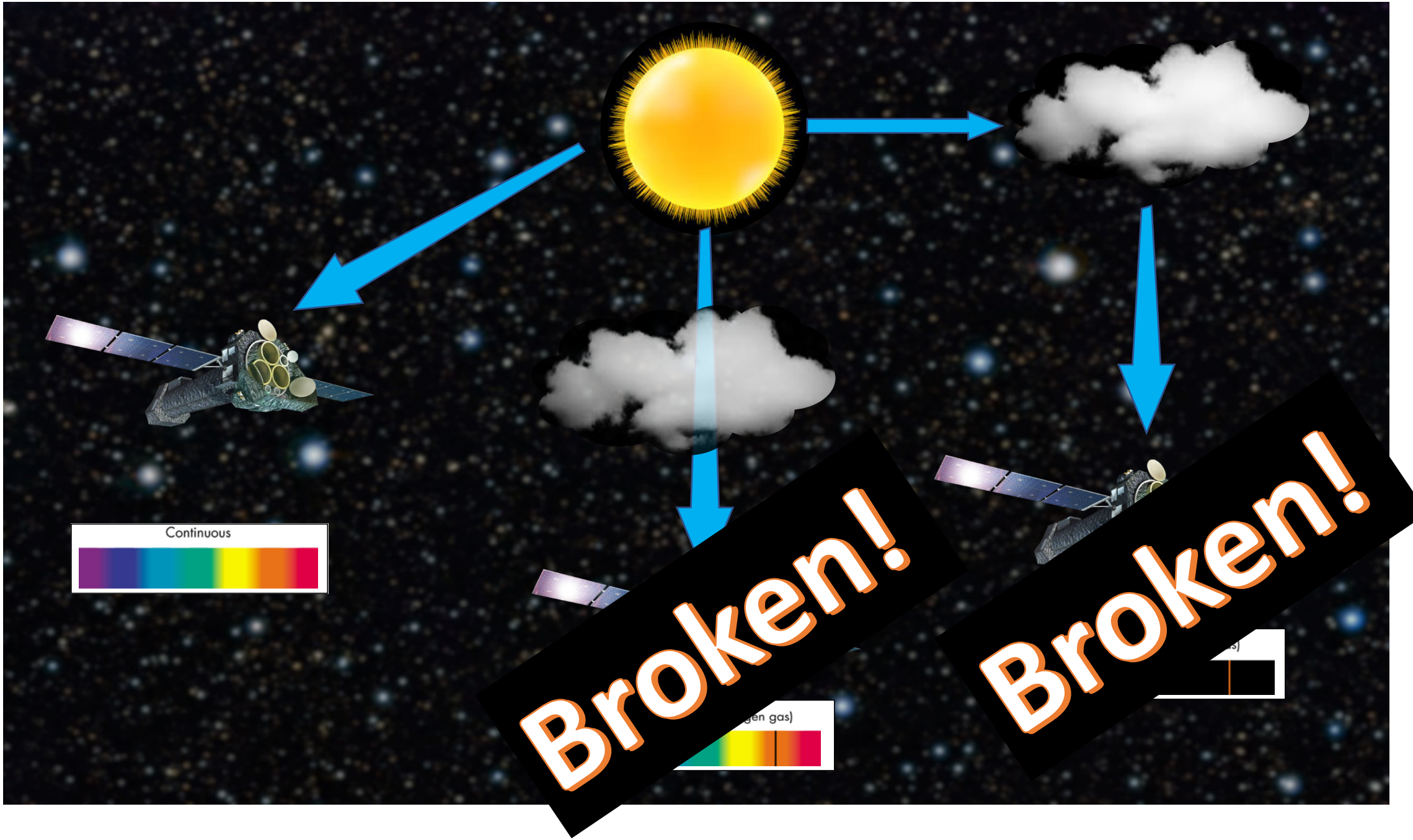
Peterson(1993)


Continuous
Absorption line (hydrogen gas)
Broken!

Emission Line Holiday!!



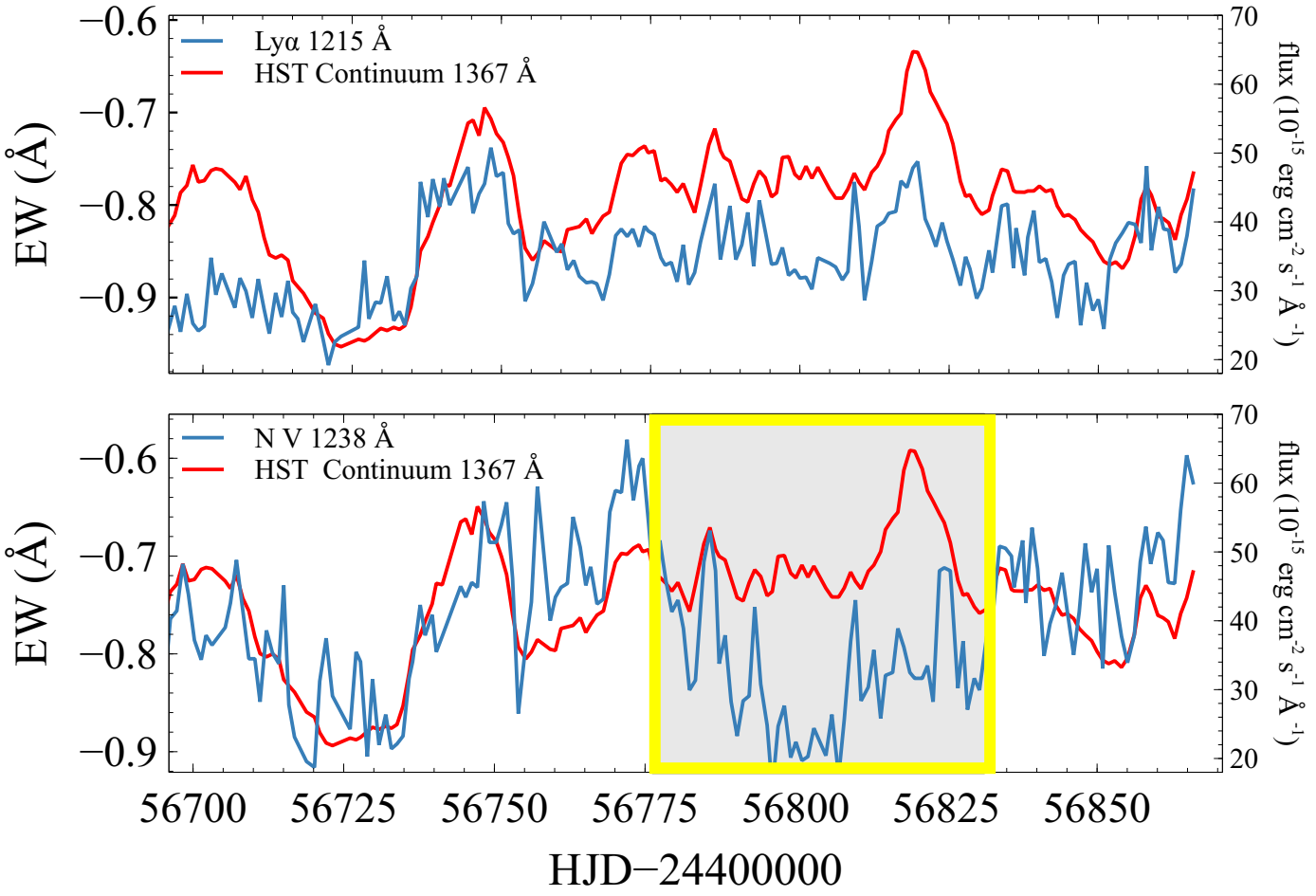
The Continuum **Emission Line**

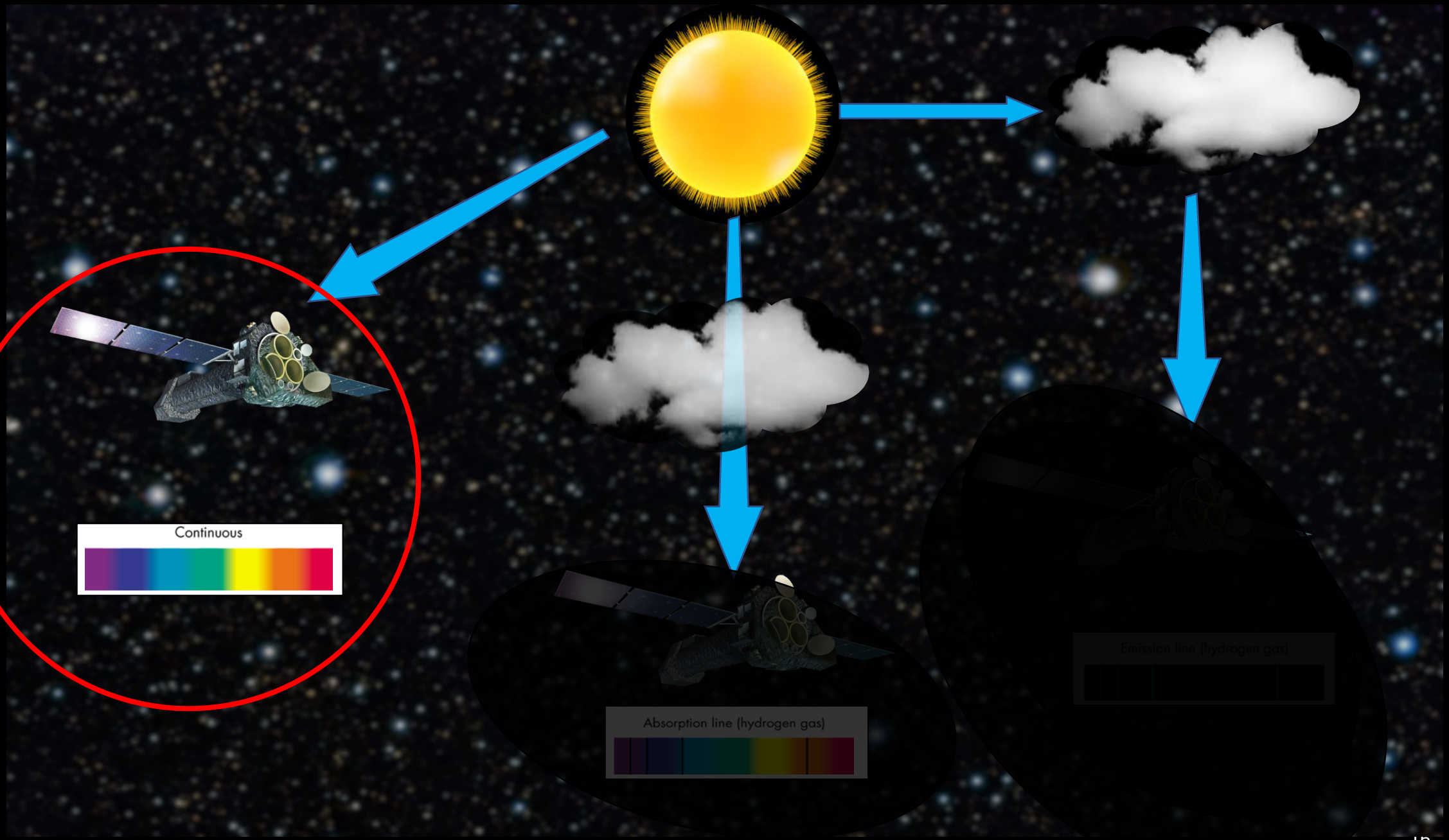

Continuous
Broken!
Broken!

2- Absorption Line Holiday (STORM)

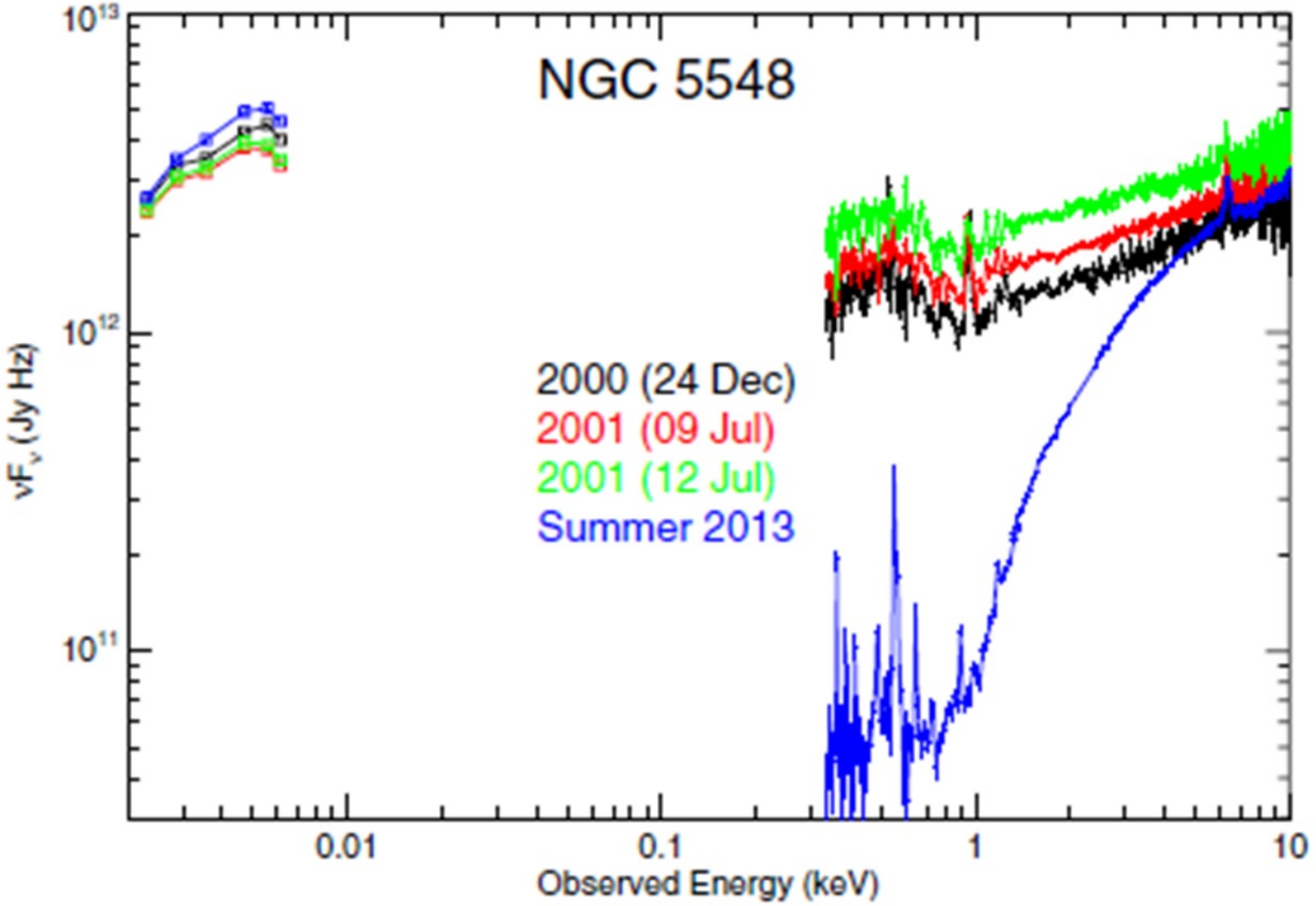
a correlated element

A decorrelated element

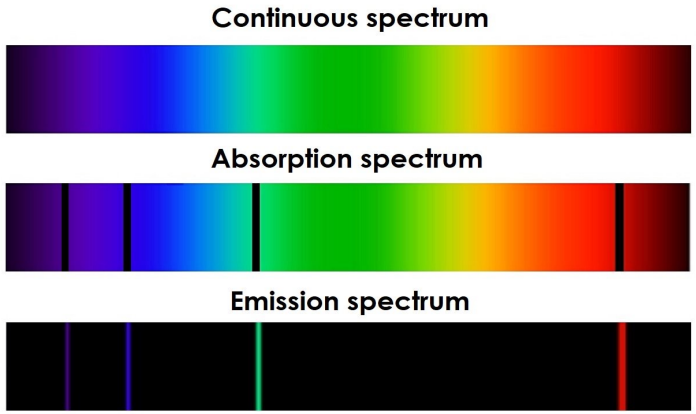



Continuous
Absorption line (hydrogen gas)
Emission line (hydrogen gas)

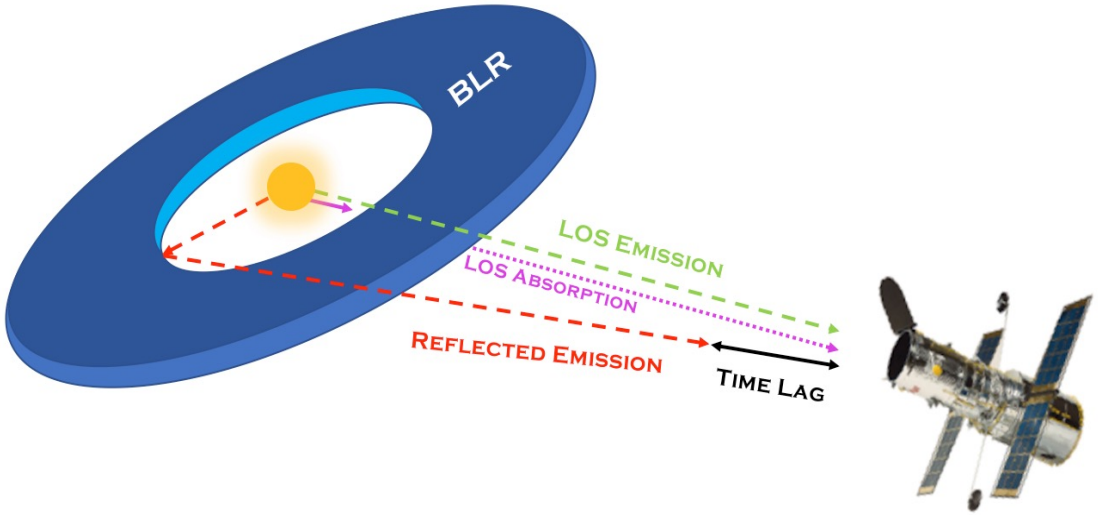
3- Heavy Absorption in X-ray (Anatomy)



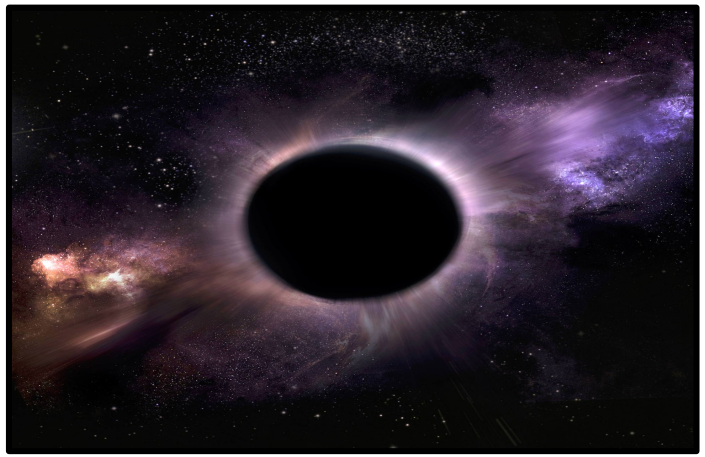
Why are these results so important?



The correlation between the continuum and the emission lines is the basic requirement for the RM method



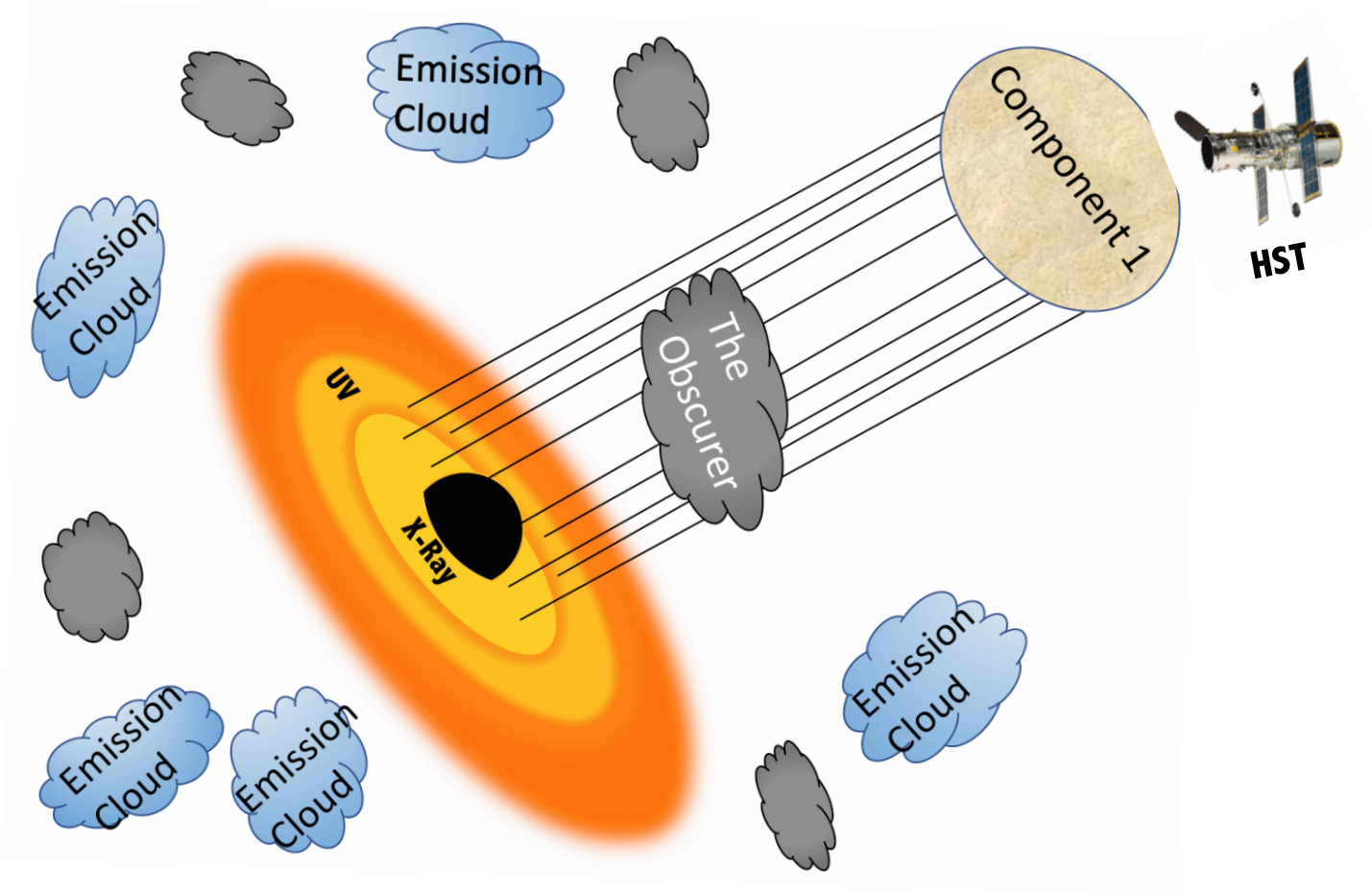
RM method is the only direct way to measure the mass of black holes



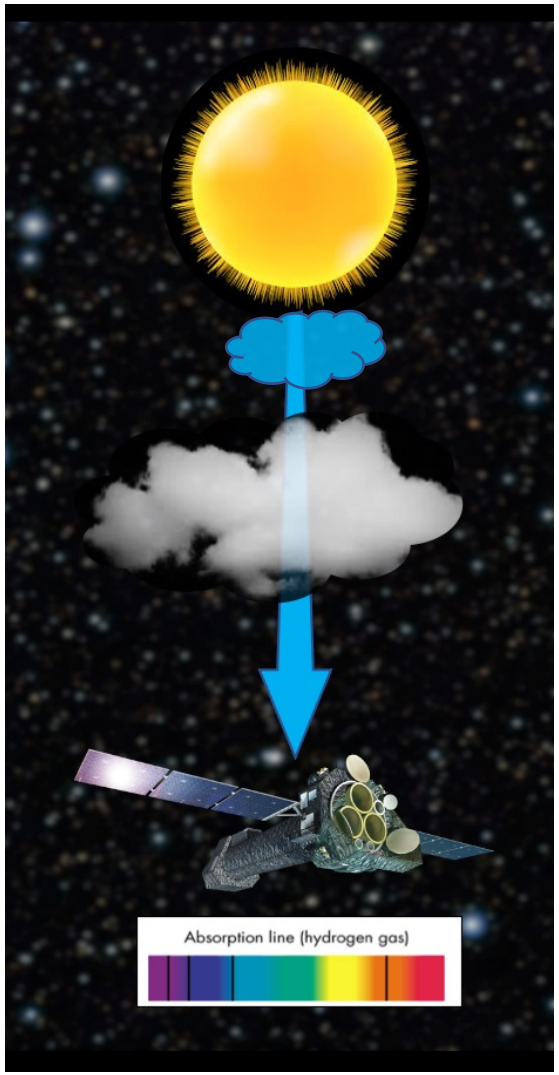
Mass of BH is what everybody wants to know. It controls the galaxy and it teaches us about the evolution of the galaxies.

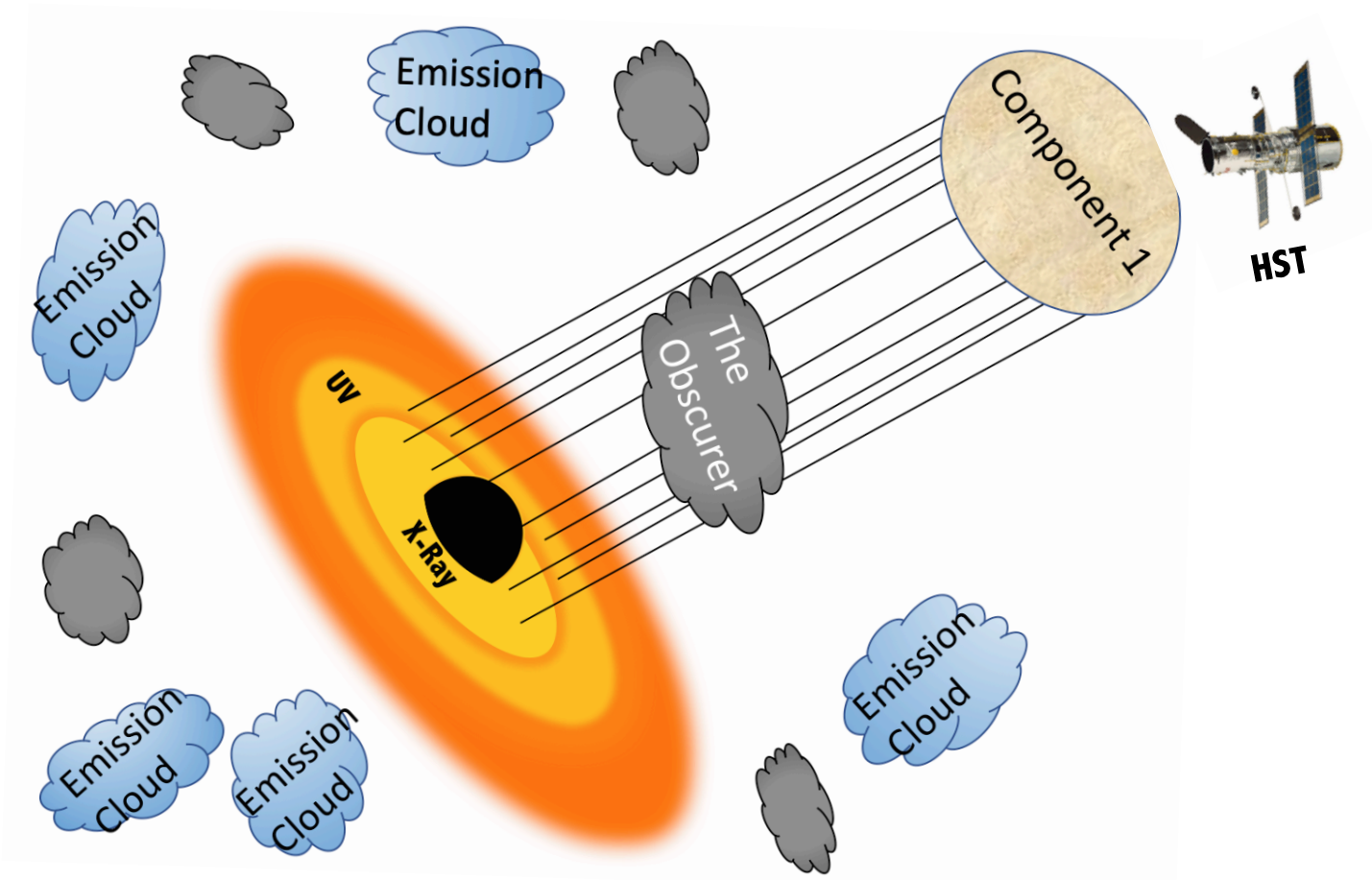
First step:
The Absorption-Line Holiday

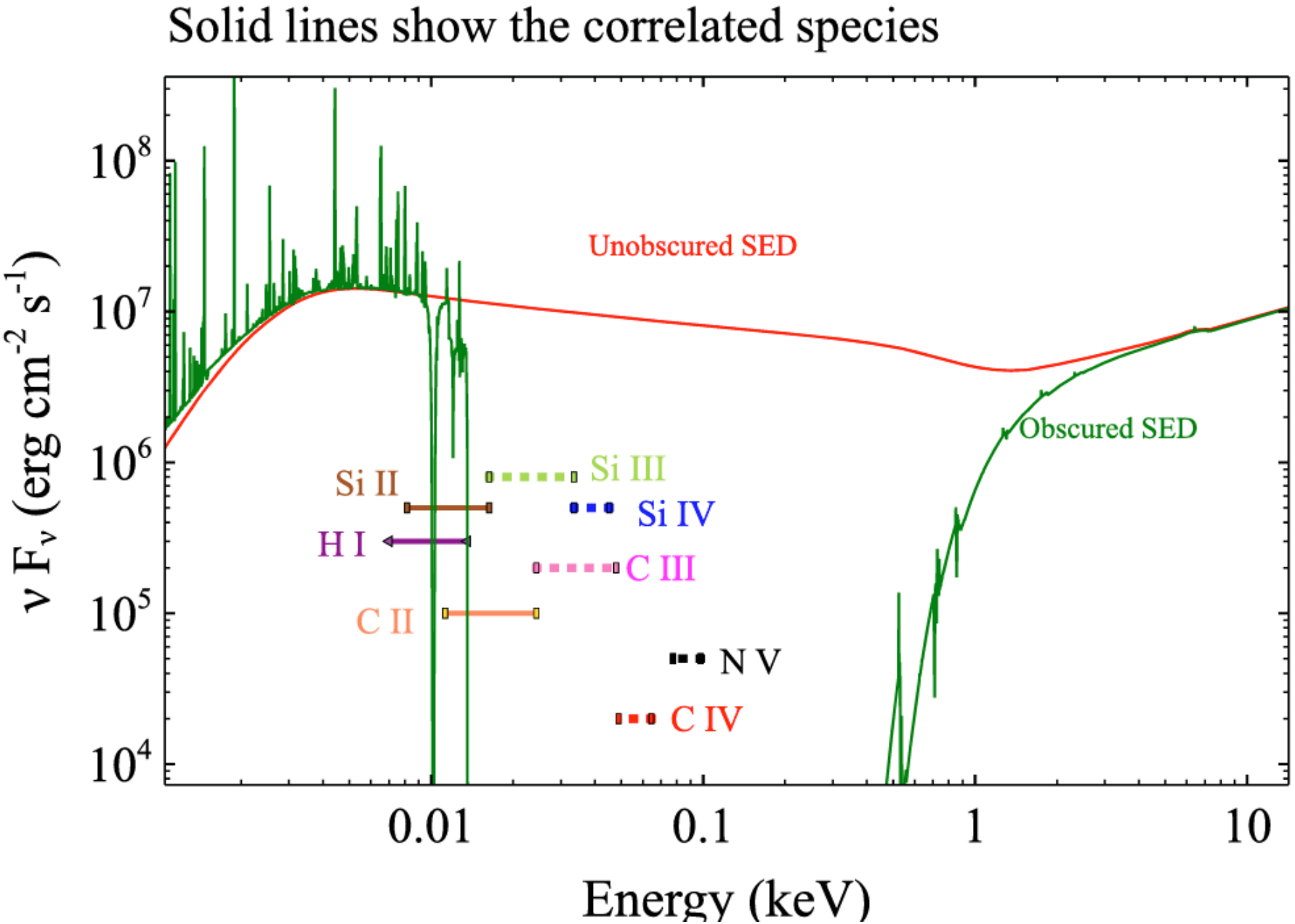
The Absorption-Line Holiday



The Absorption-Line Holiday






Solid lines show the correlated species
Unobscured SED
Obscured SED
Si II
Si III
Si IV
H I
C III
C II
N V
C IV
10^8
10^7
10^6
10^5
10^4
νF_ν (erg cm^{-2} s^{-1})
0.01
0.1
1
10
Energy (keV)

There are two possibilities

1- Abs. Holiday is a result of variable luminosity

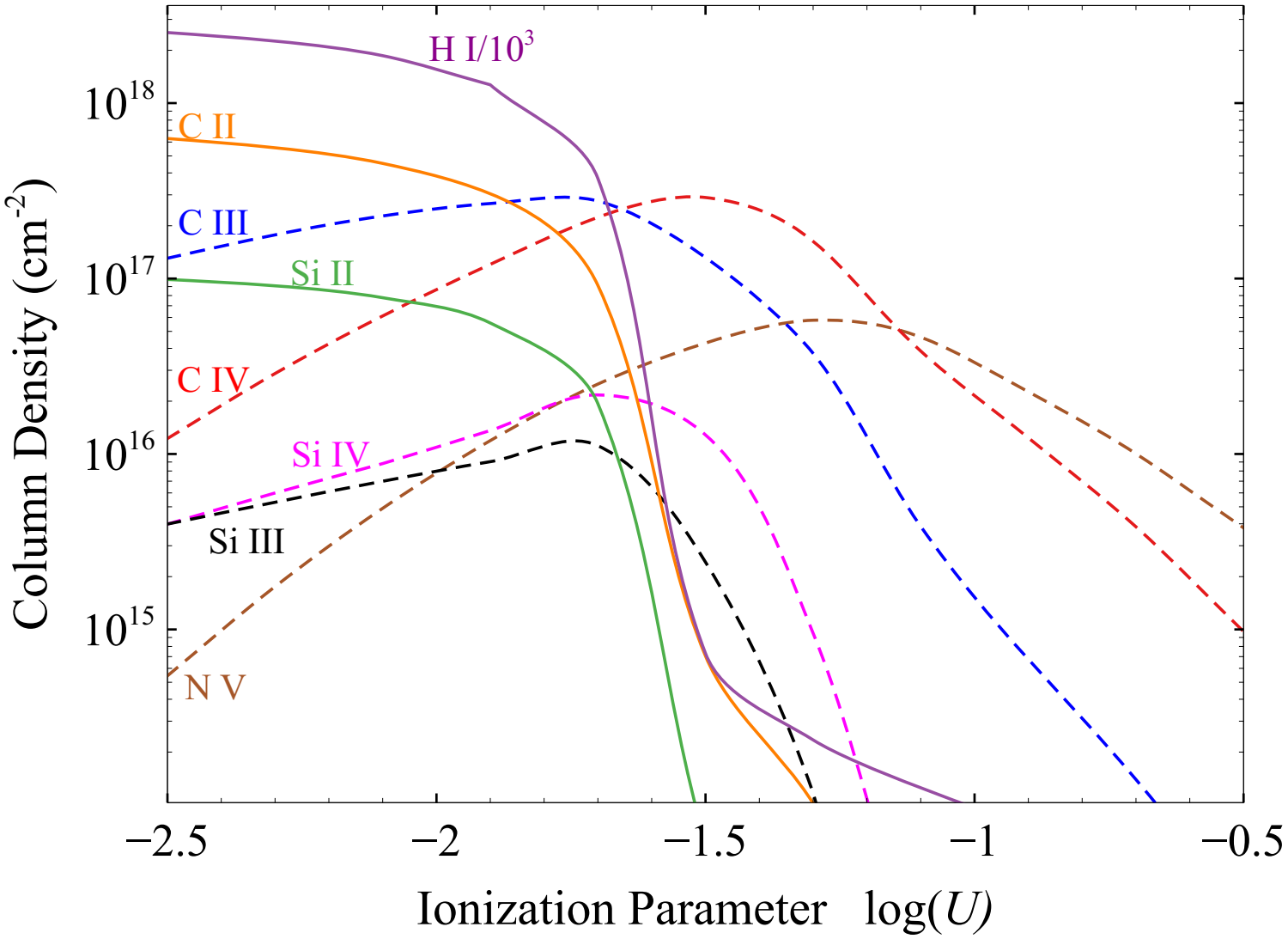
2- Abs. Holiday is a result of variable shape of SED

There are two possibilities

1- Abs. Holiday is a result of variable luminosity

2- Abs. Holiday is a result of variable shape

The effects of variable luminosity on the absorption lines

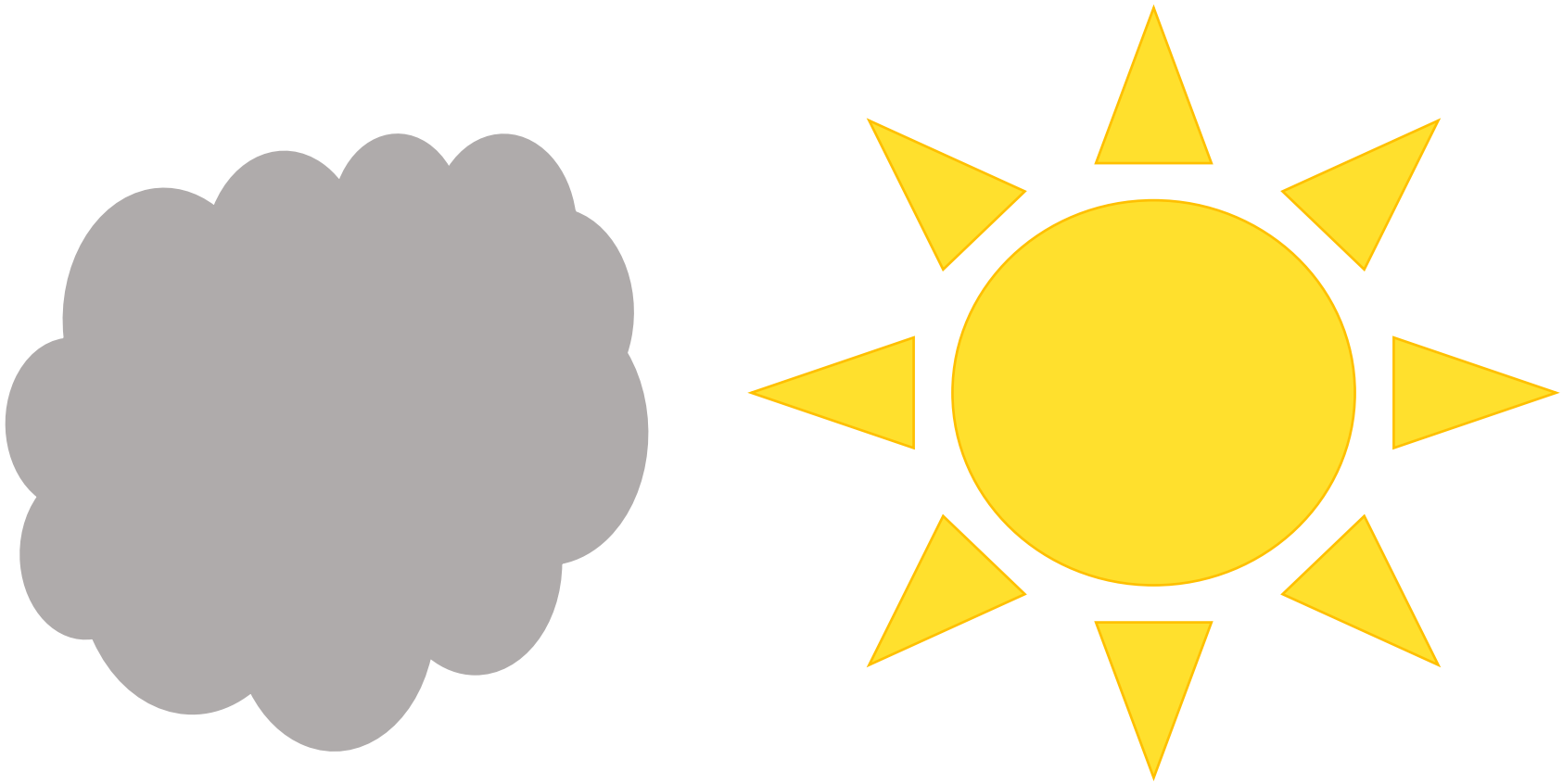


There are two possibilities

~~1- Abs. Holiday is a result of variable luminosity~~

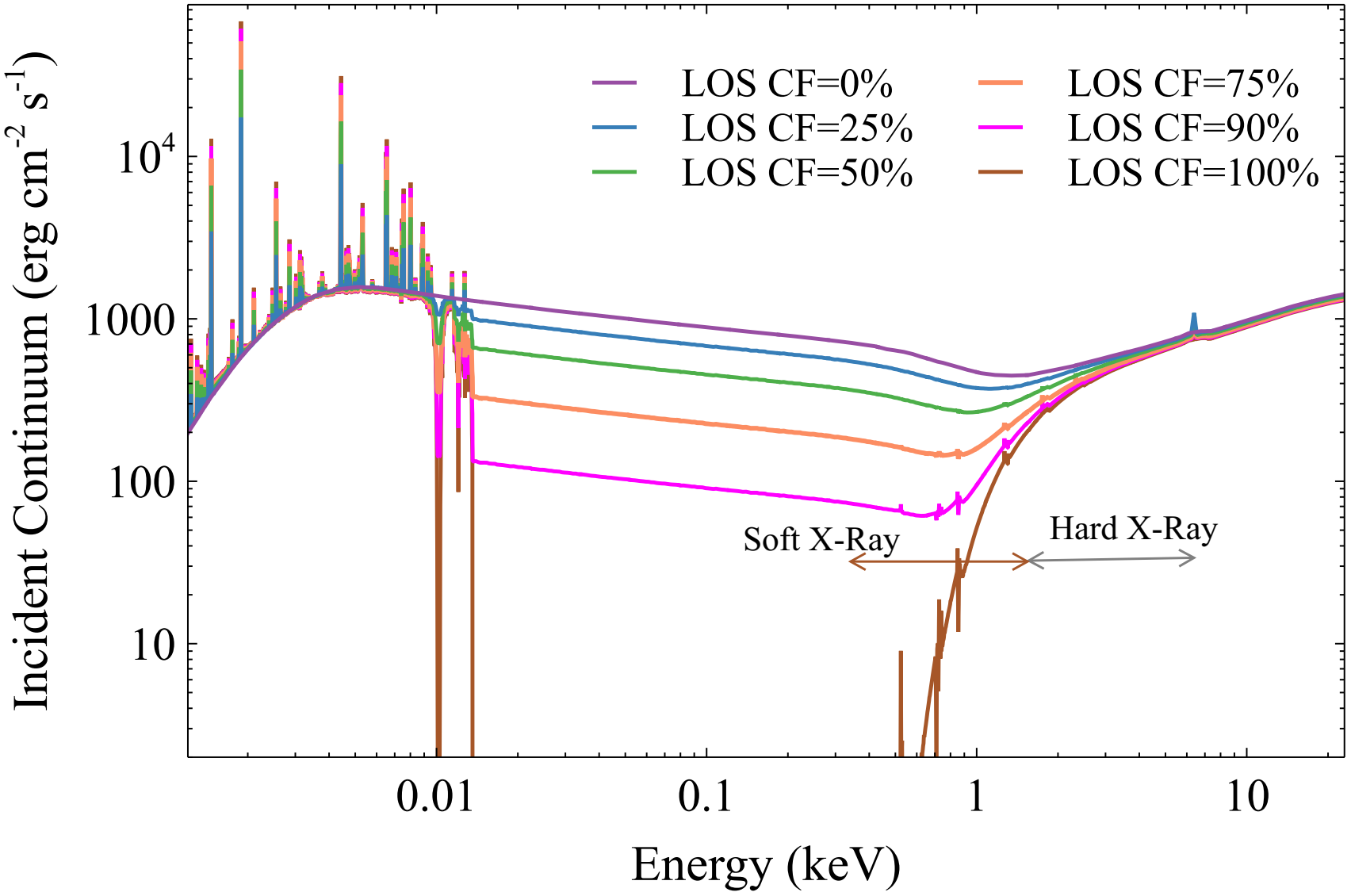
2- Abs. Holiday is a result of variable shape of SED

Changes in the obscurer affects the shape of the SED

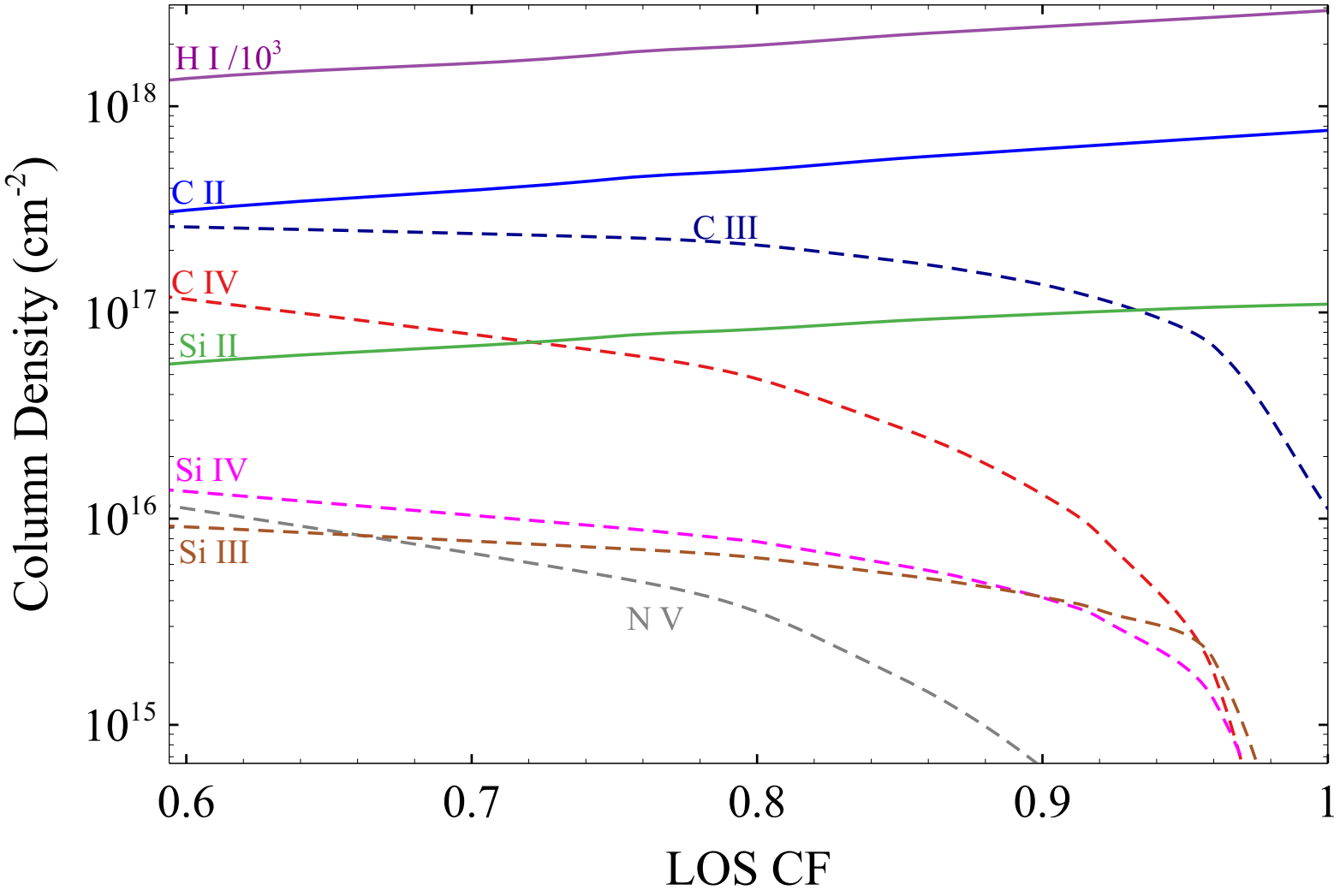


Line of Sight Covering Factor 100 %

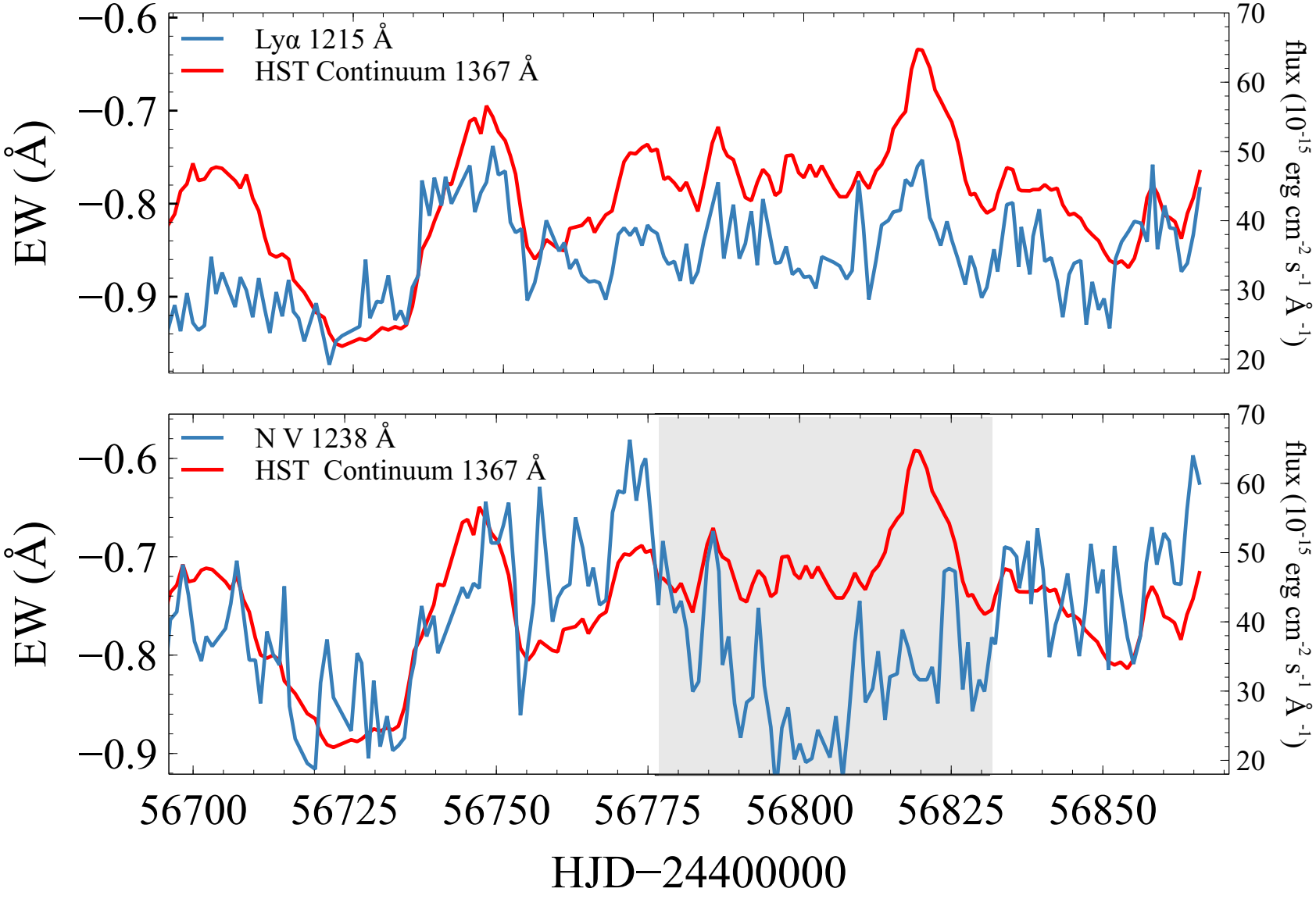
The effects of variable covering factor on the shape of the SED



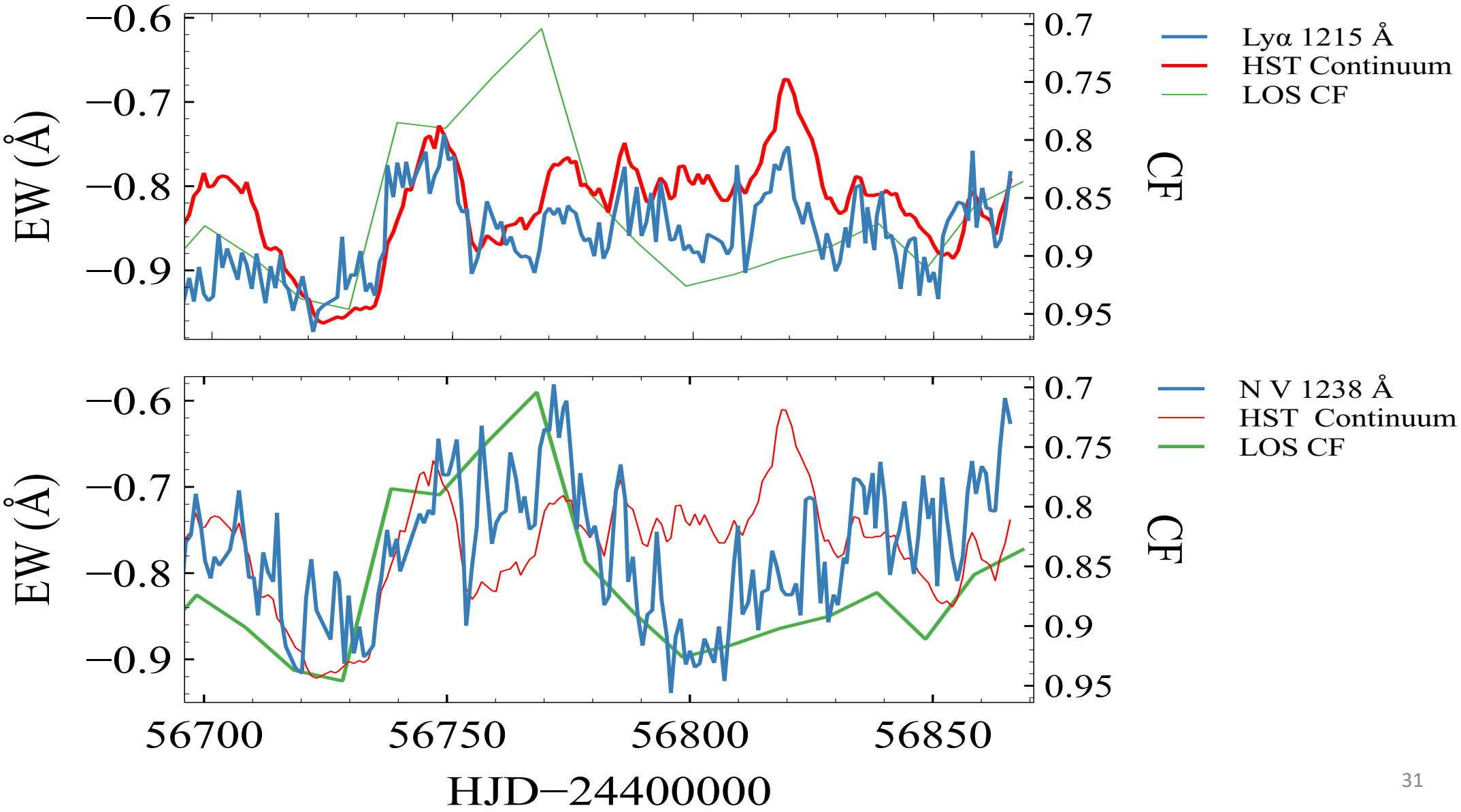
The effects of variable CF on the absorption lines



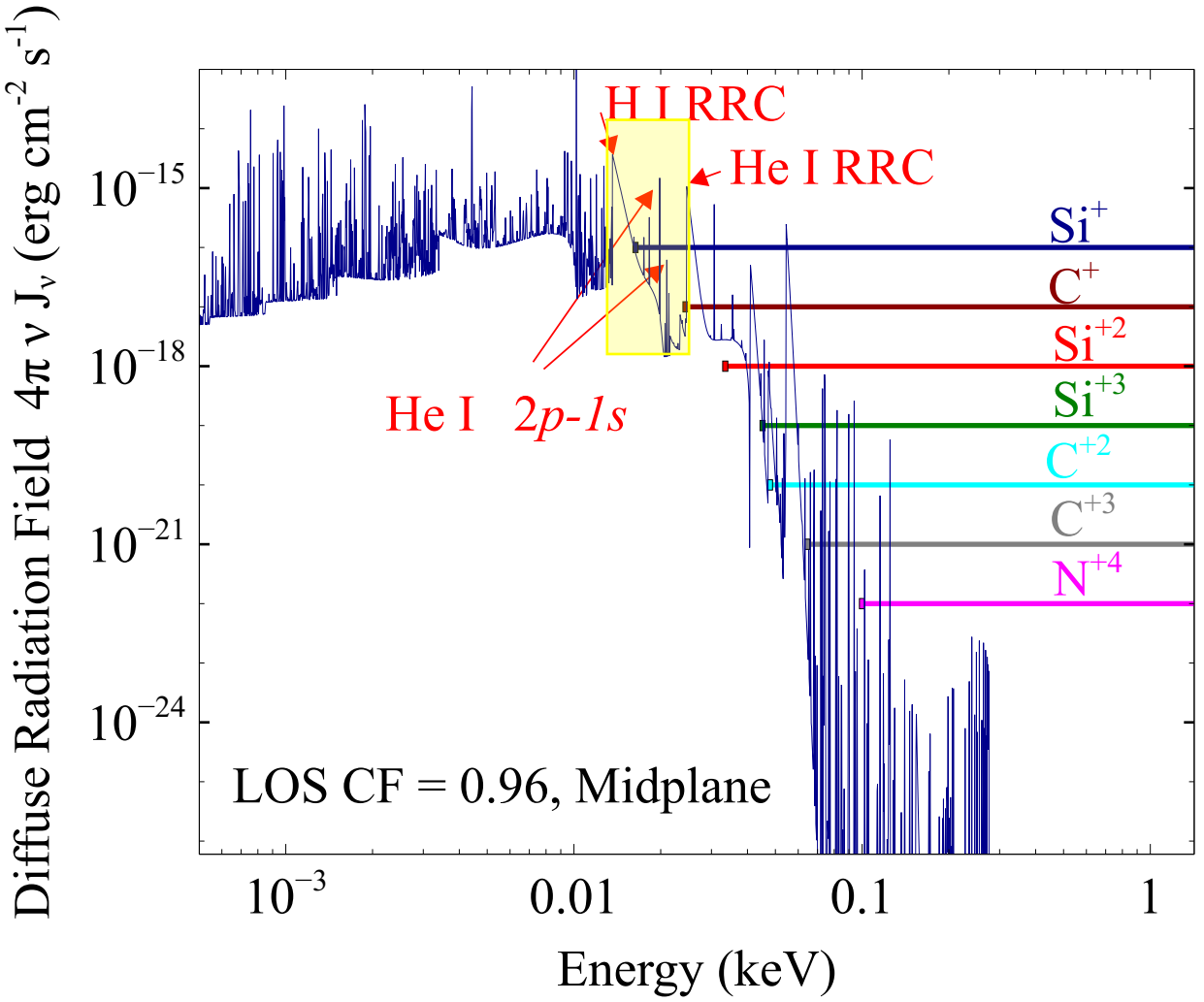
Comparing the results with the observations



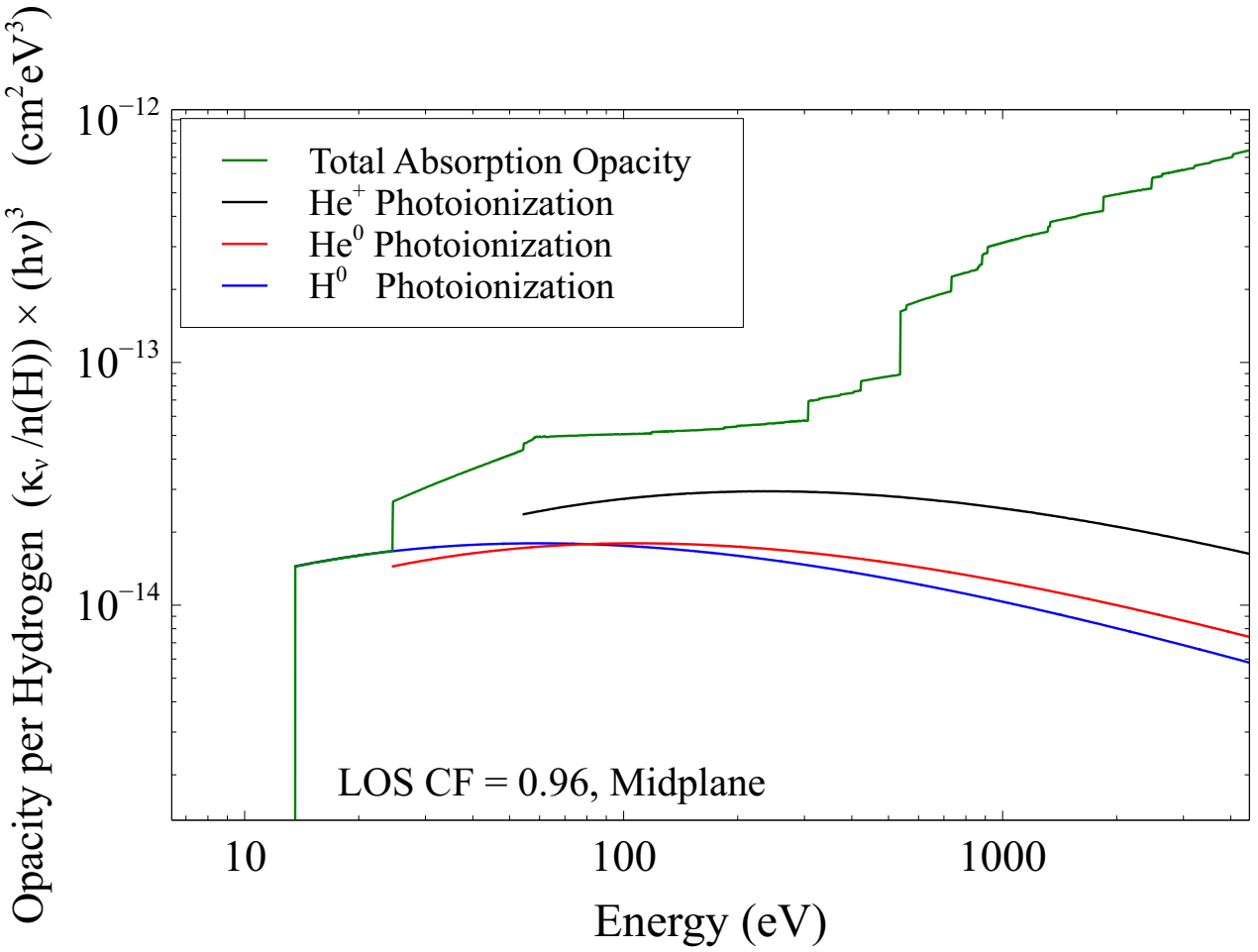
Comparing the results with the observations

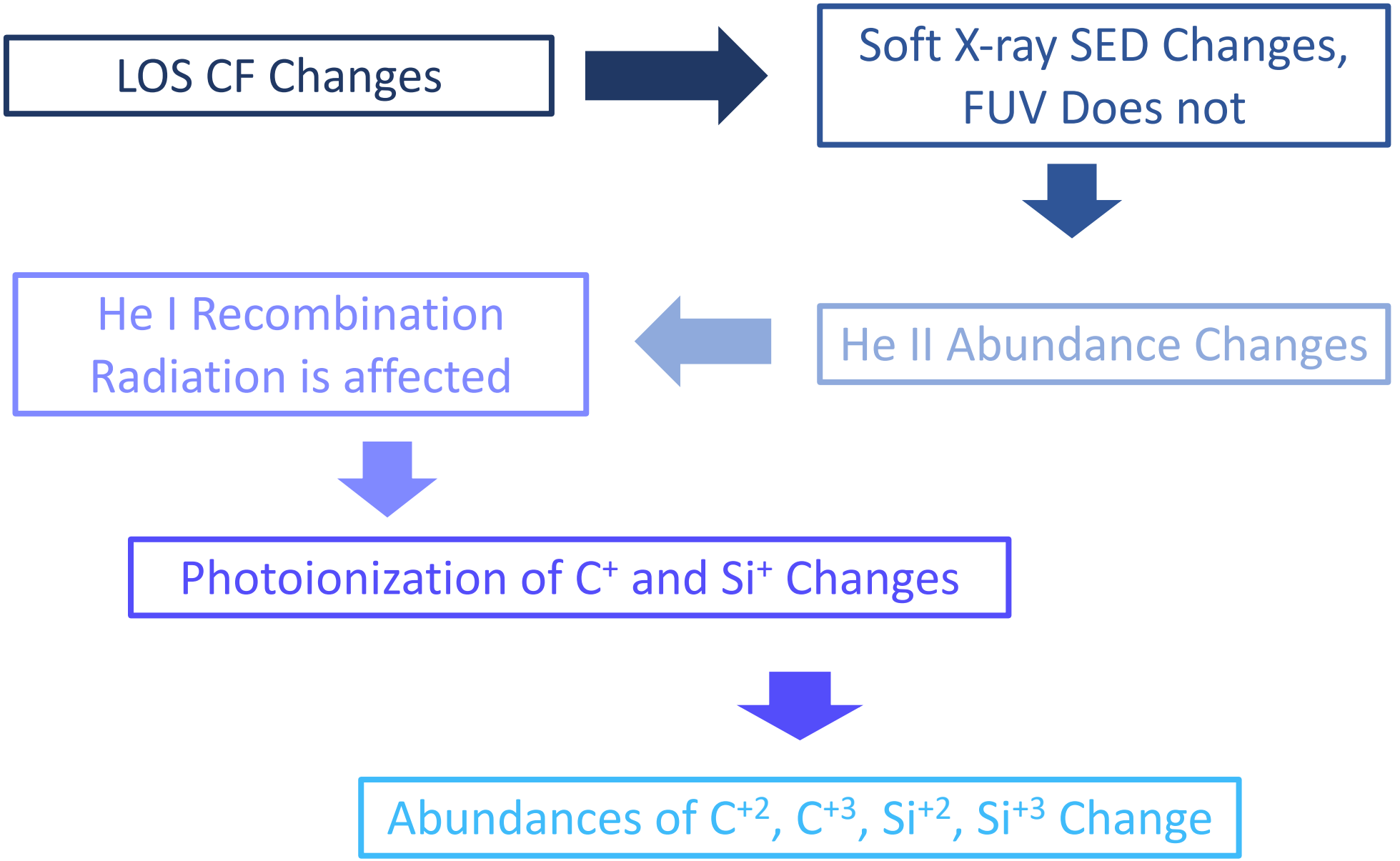


The Absorption-Line Holiday



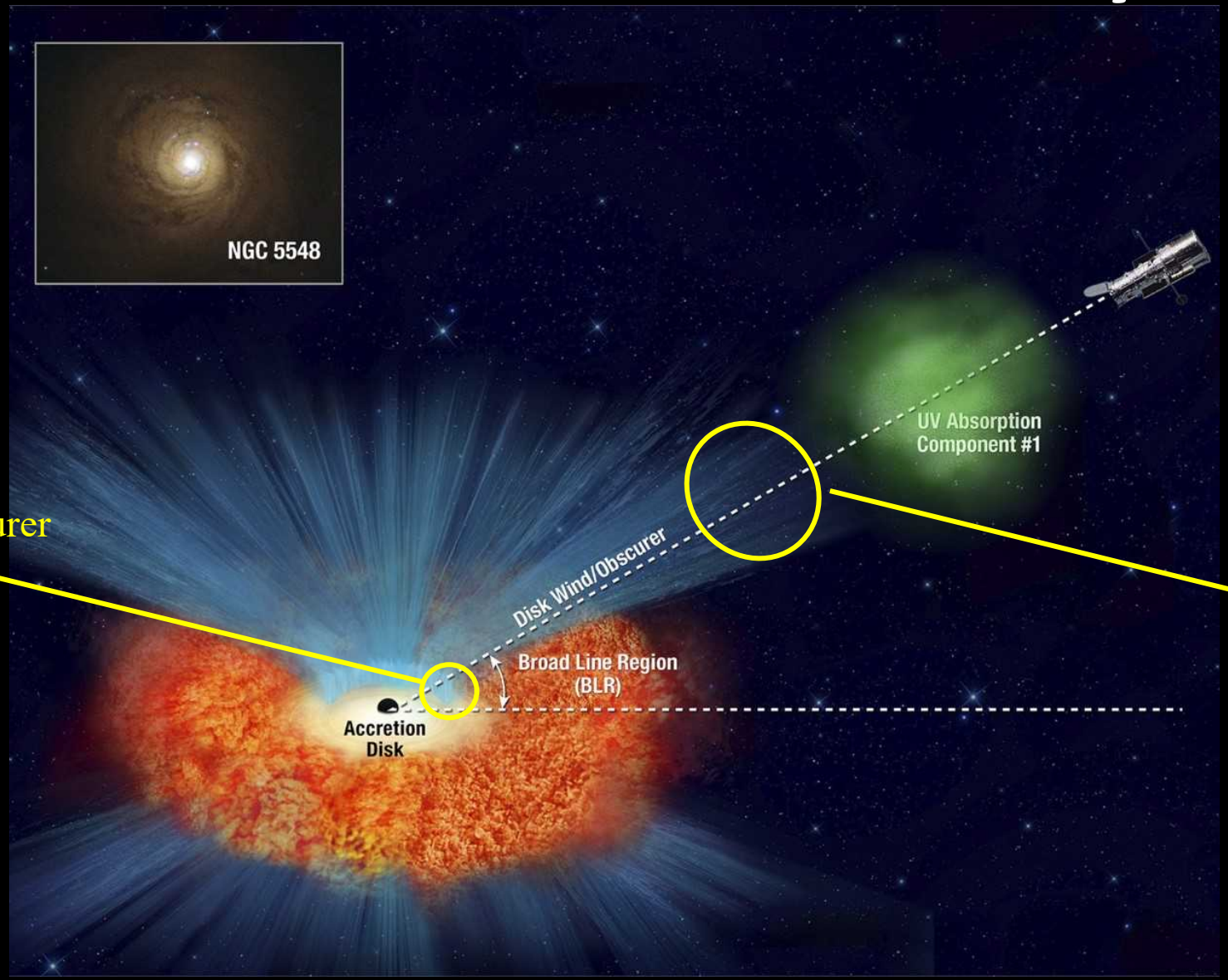
The Absorption-Line Holiday




LOS CF Changes
Soft X-ray SED Changes, FUV Does not
He II Abundance Changes
He I Recombination Radiation is affected
Photoionization of C^{+} and Si^{+} Changes
Abundances of C^{+2}, C^{+3}, Si^{+2}, Si^{+3} Change

Second Step:
The Emission-Line Holiday

The Emission-Line Holiday



The equatorial obscurer

The LOS obscurer

There are two possibilities

1- Emis. Holiday is a result of variable luminosity

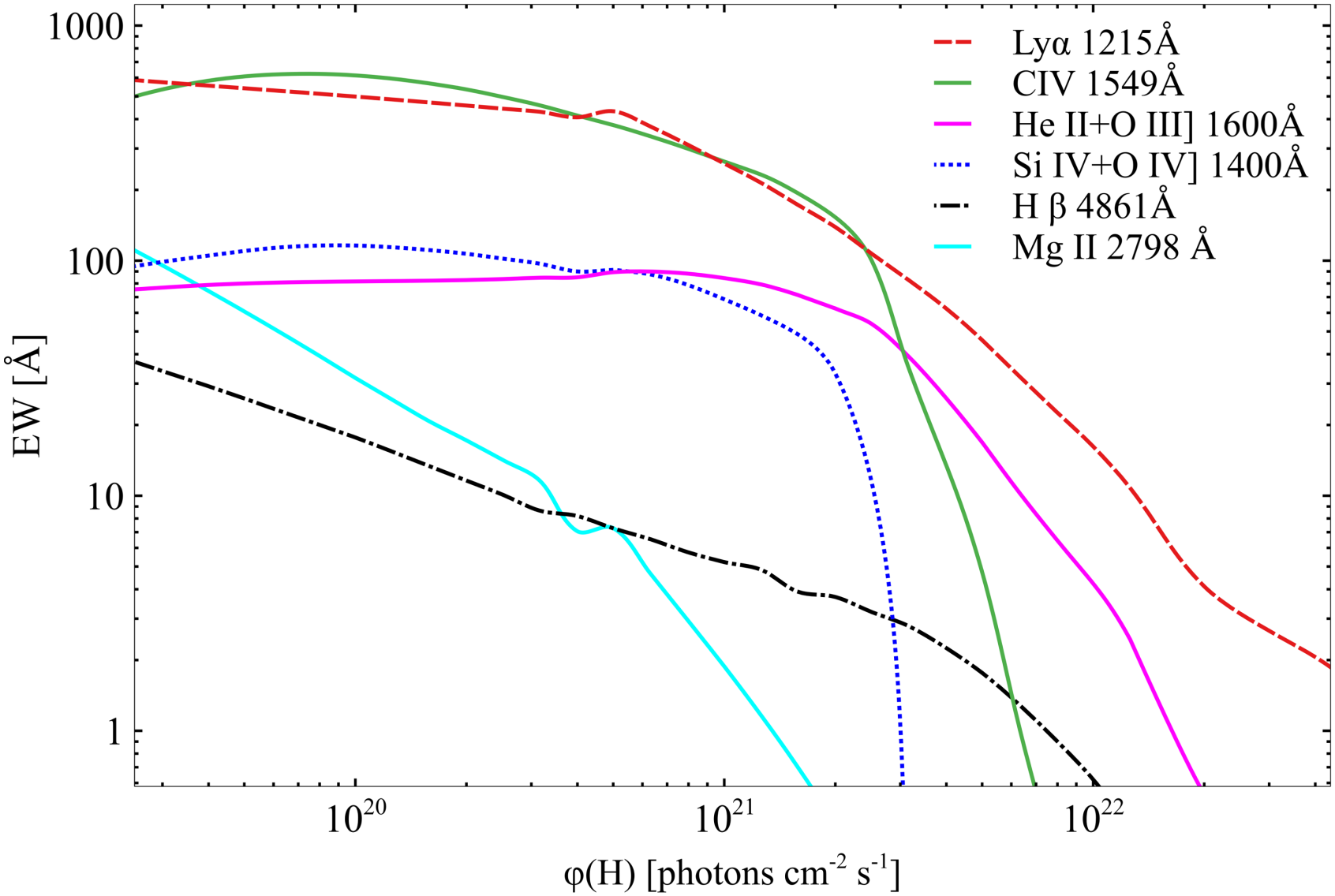
2- Emis. Holiday is a result of variable wind

There are two possibilities

1- Emis. Holiday is a result of variable luminosity

2- Emis. Holiday is a result of variable wind

Changes in the BLR- no equatorial obscurer

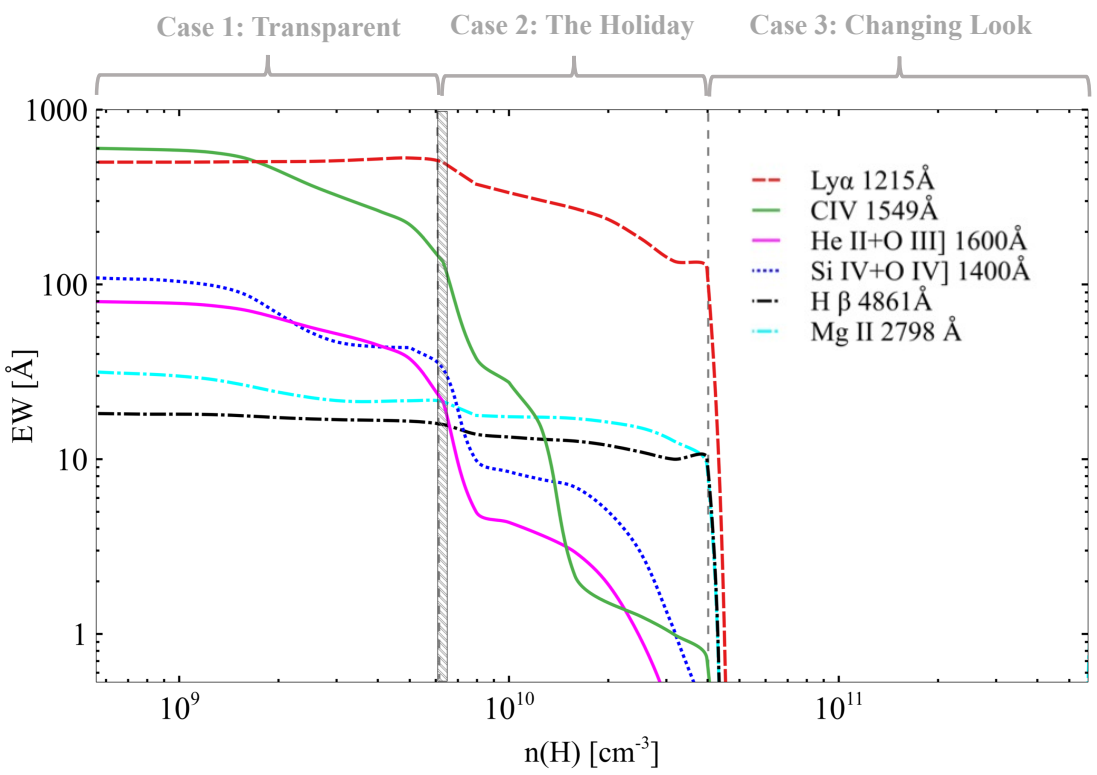


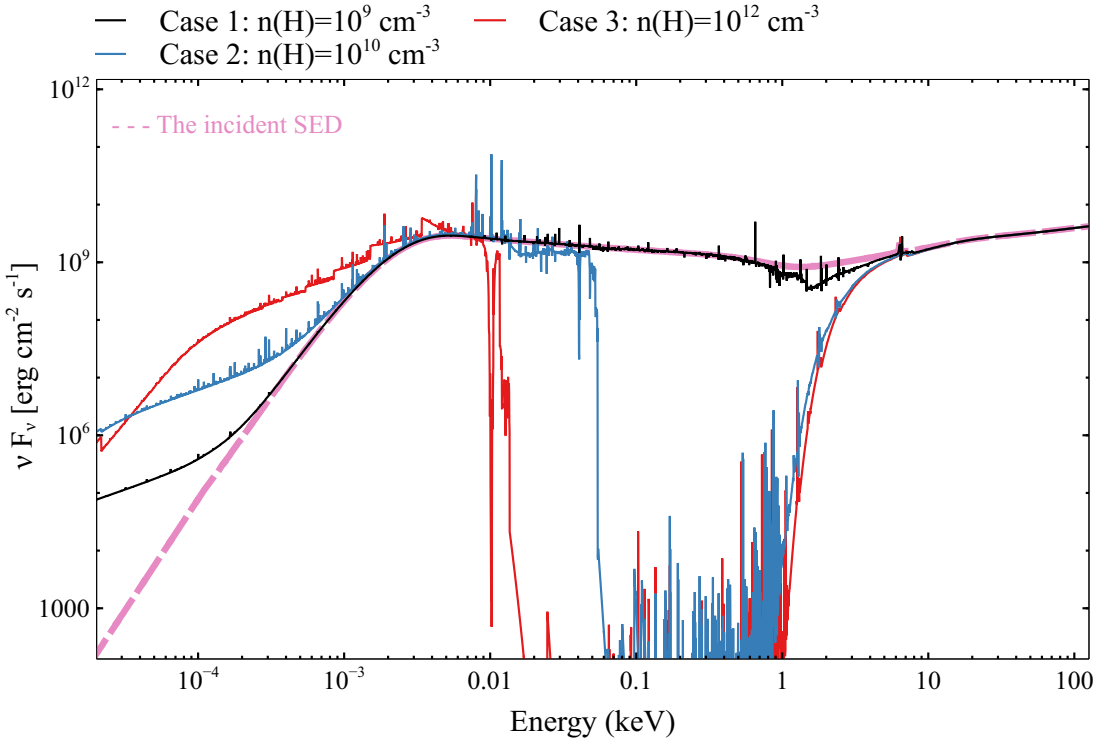
There are two possibilities

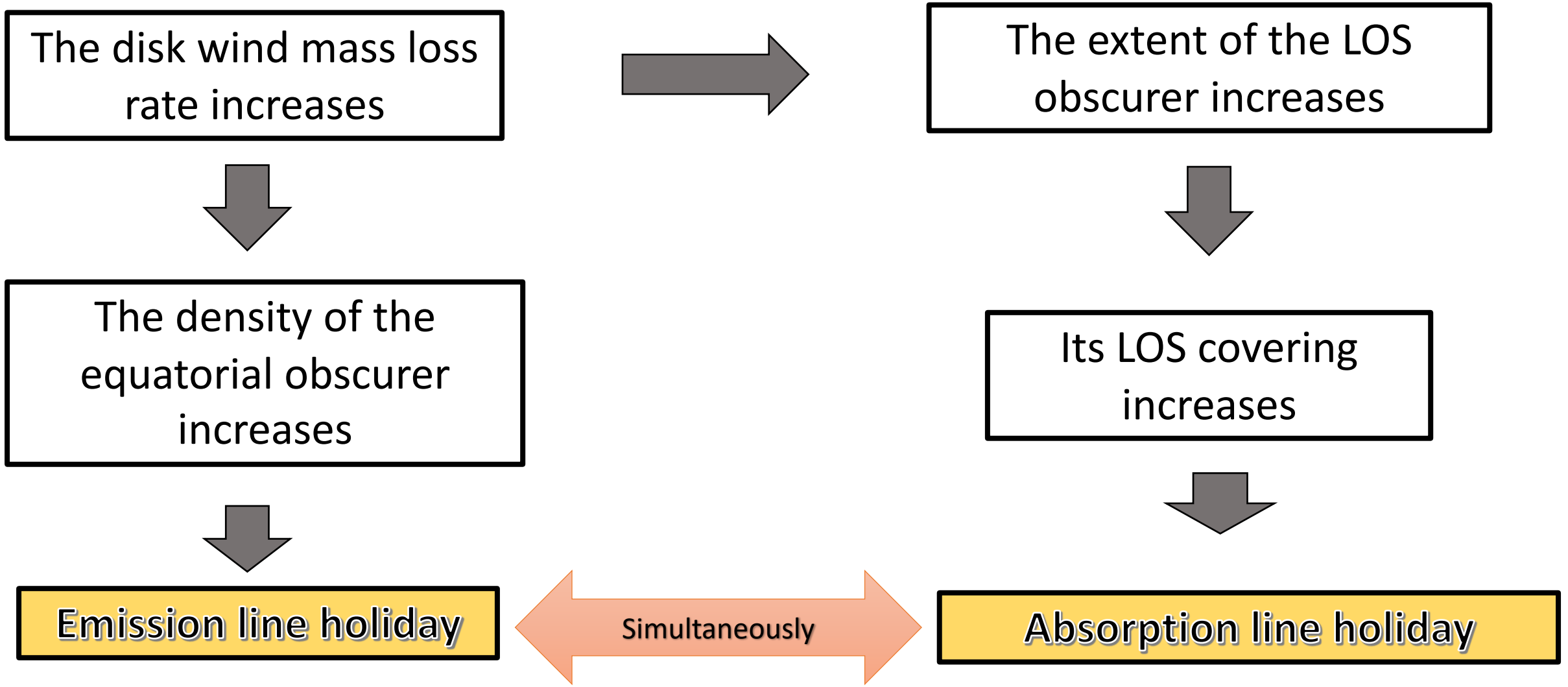
~~1- Emis. Holiday is a result of variable luminosity~~

2- Emis. Holiday is a result of variable wind

Changes in the BLR- considering the equatorial obscurer

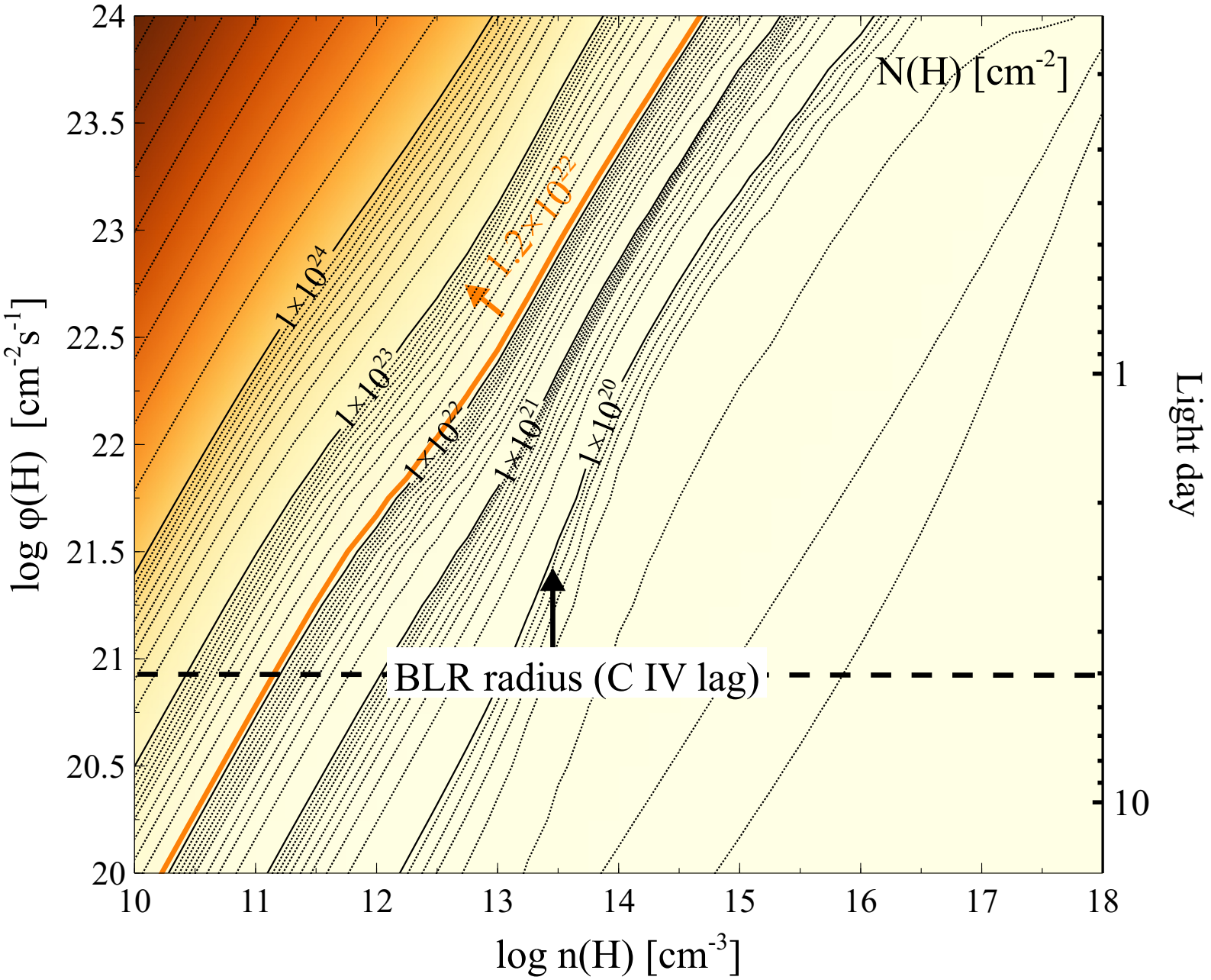




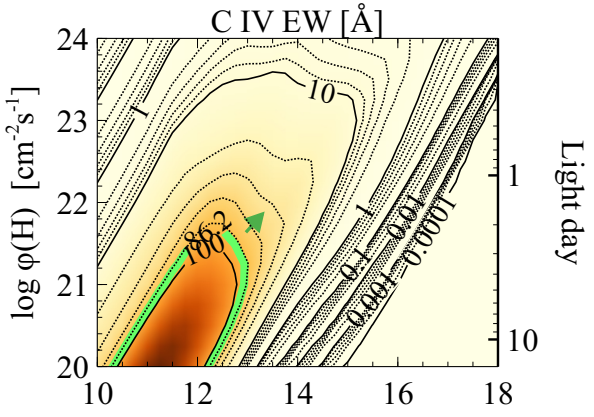

The disk wind mass loss rate increases
The extent of the LOS obscurer increases
The density of the equatorial obscurer increases
Its LOS covering increases
Emission line holiday
Simultaneously
Absorption line holiday

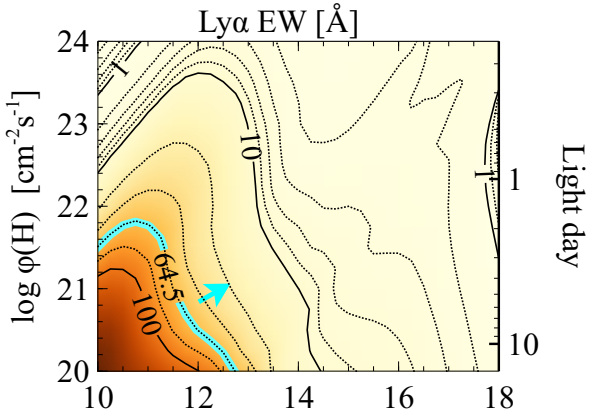
Third Step:
Determine what is thee wind!

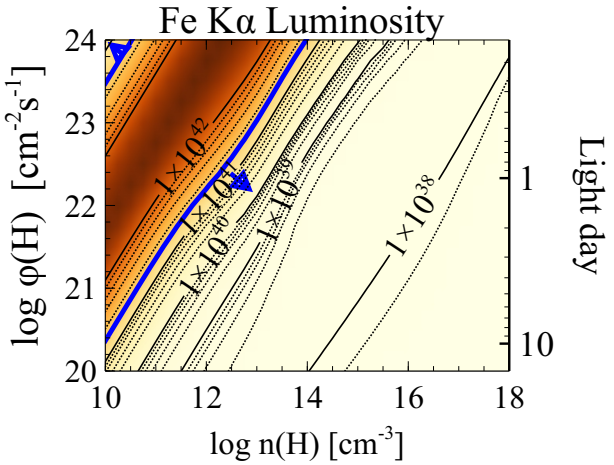
A Novel Approach to Trace the Disk Wind

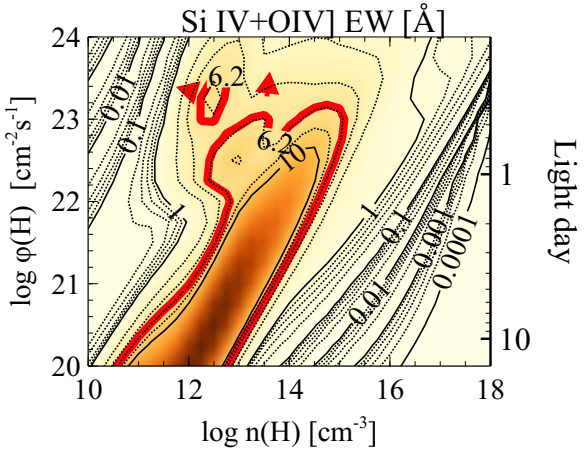


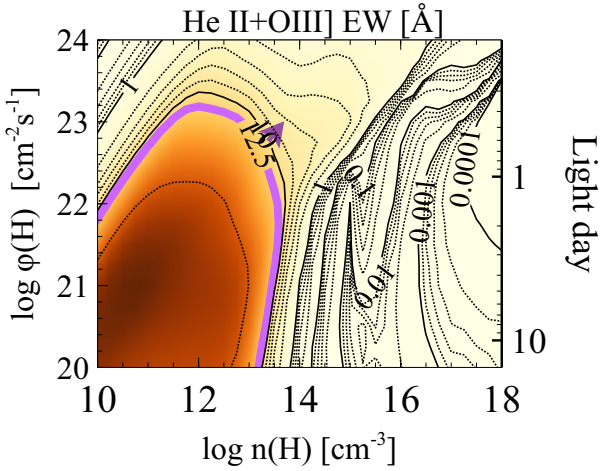
Emission from the disk wind

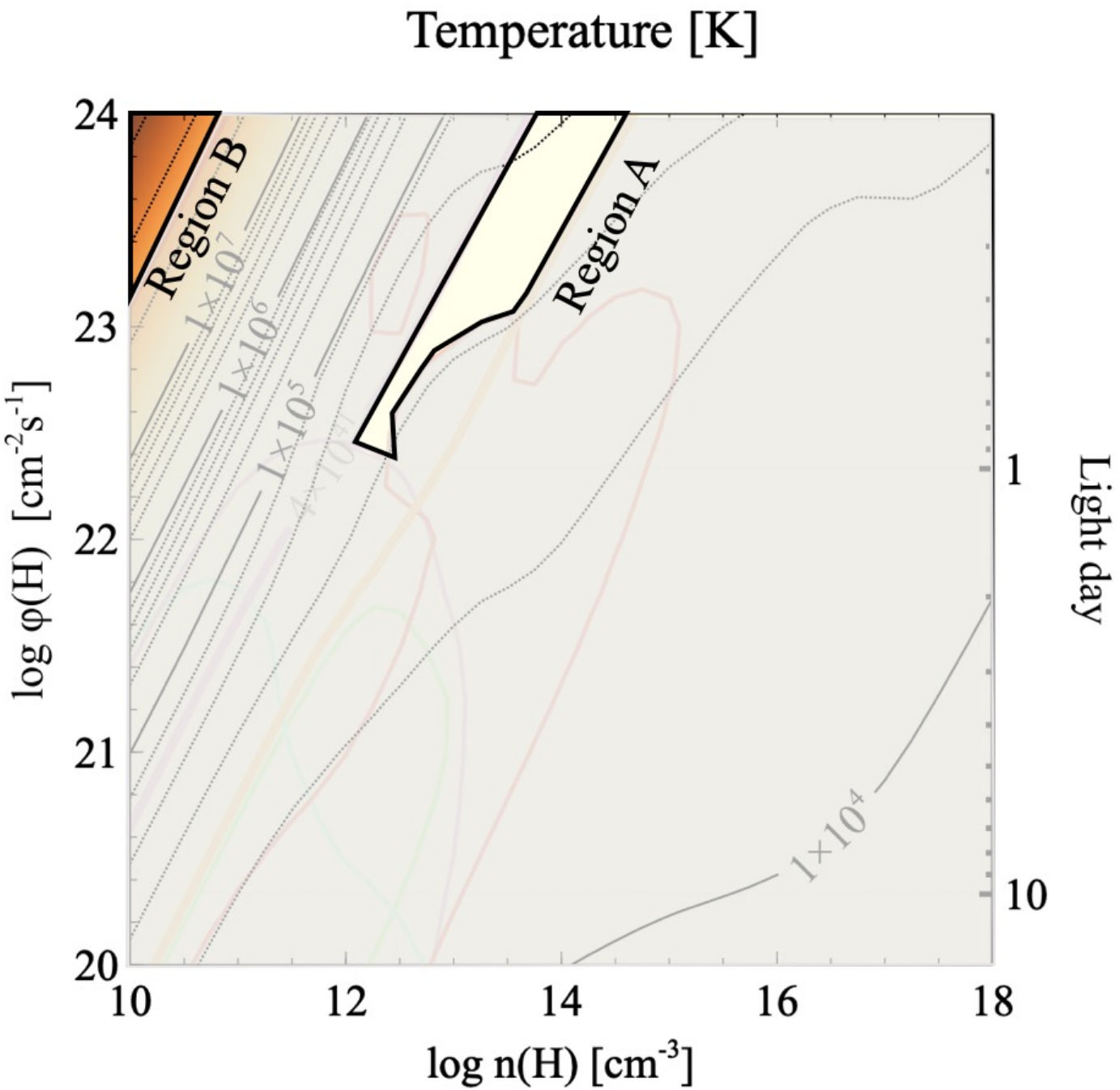


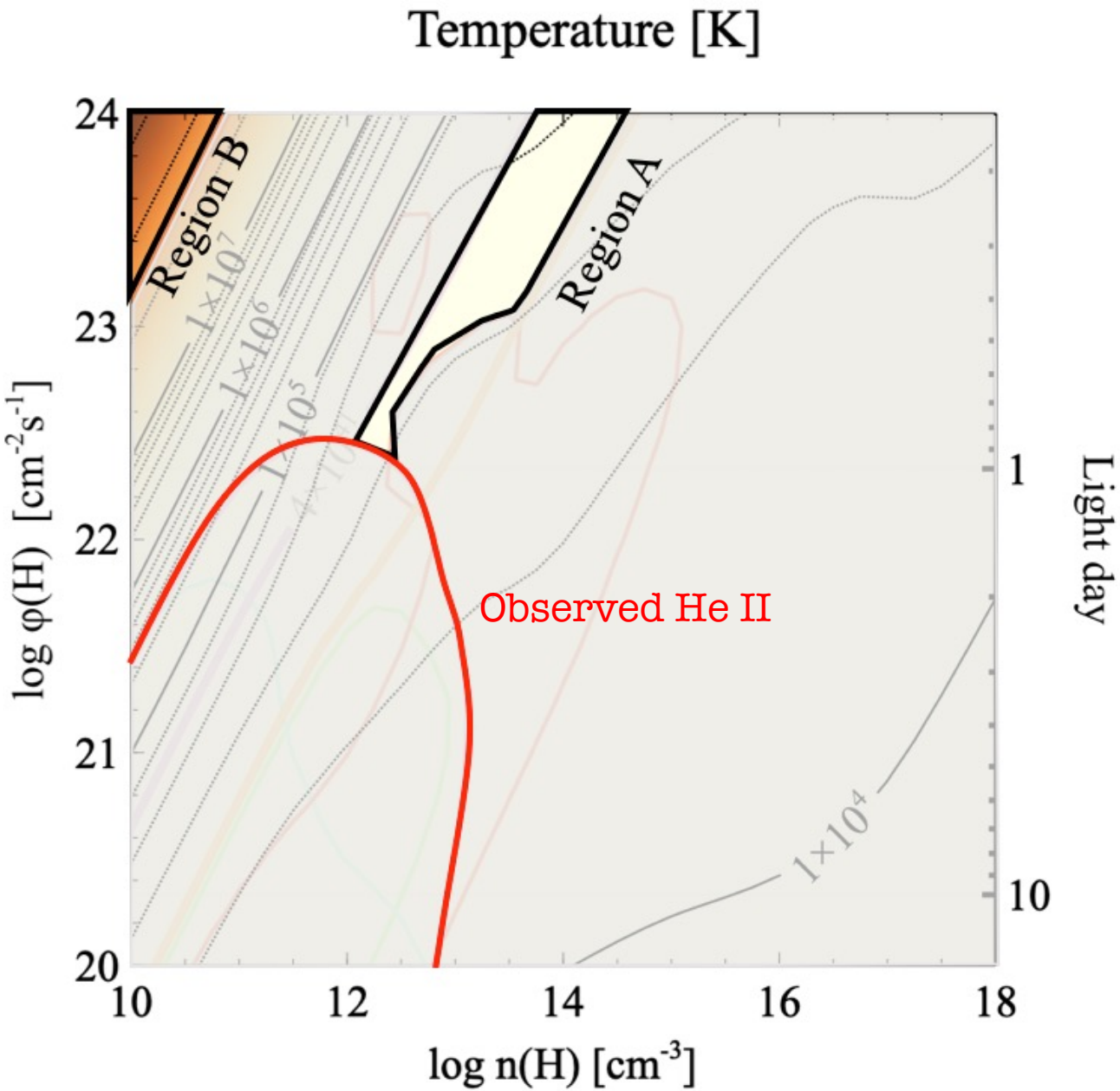


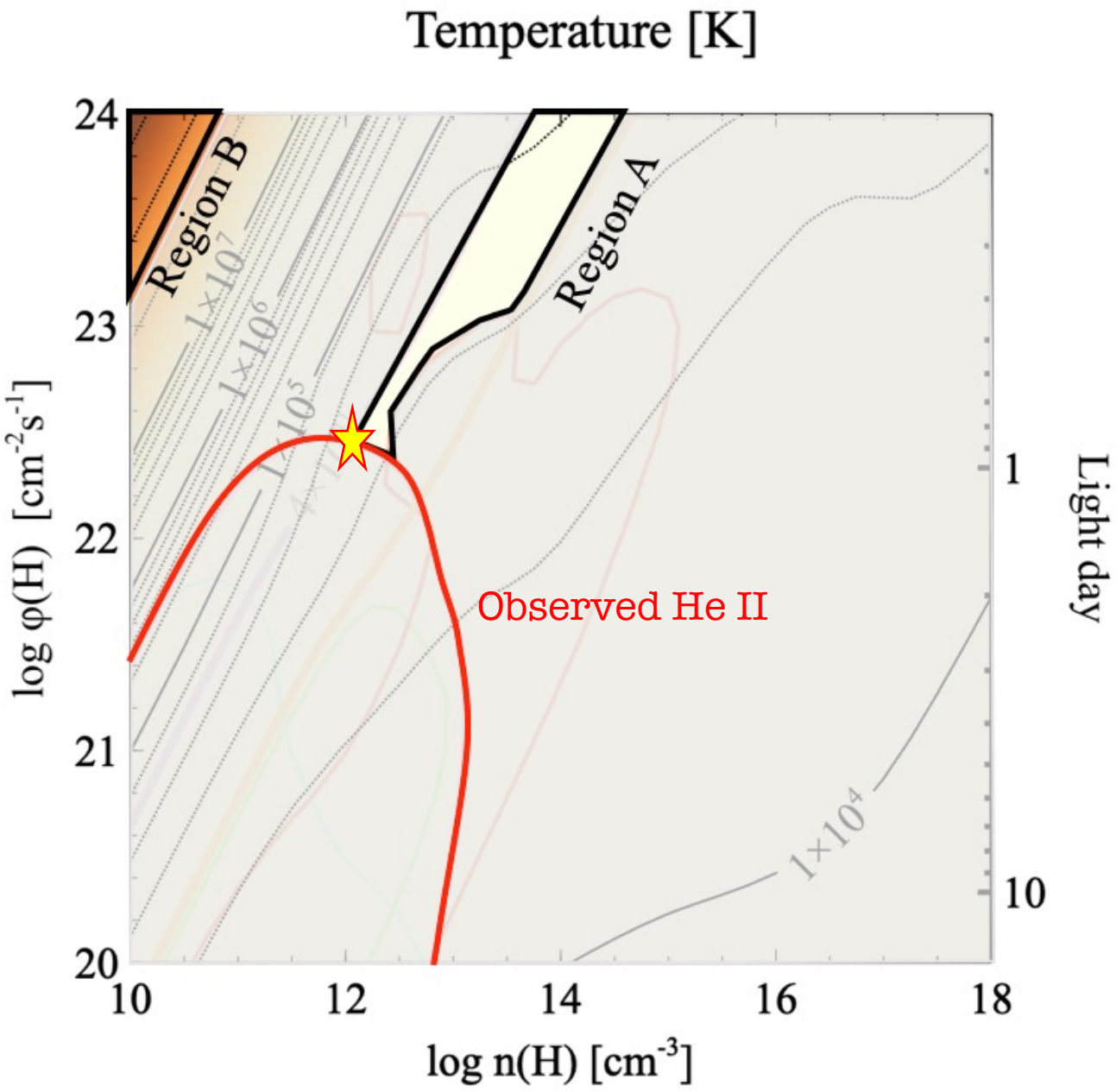







Temperature [K]
Region B
Region A
1×10^7
1×10^6
1×10^5
4×10^4
1×10^4
log φ(H) [cm^-2 s^-1]
log n(H) [cm^-3]
Light day
24
23
22
21
20
10
12
14
16
18
1
10


Temperature [K]
Region B
Region A
1×10^7
1×10^6
1×10^5
1×10^4
Observed He II
log φ(H) [cm^{-2}s^{-1}]
log n(H) [cm^{-3}]
Light day
24
23
22
21
20
10
12
14
16
18
1
10



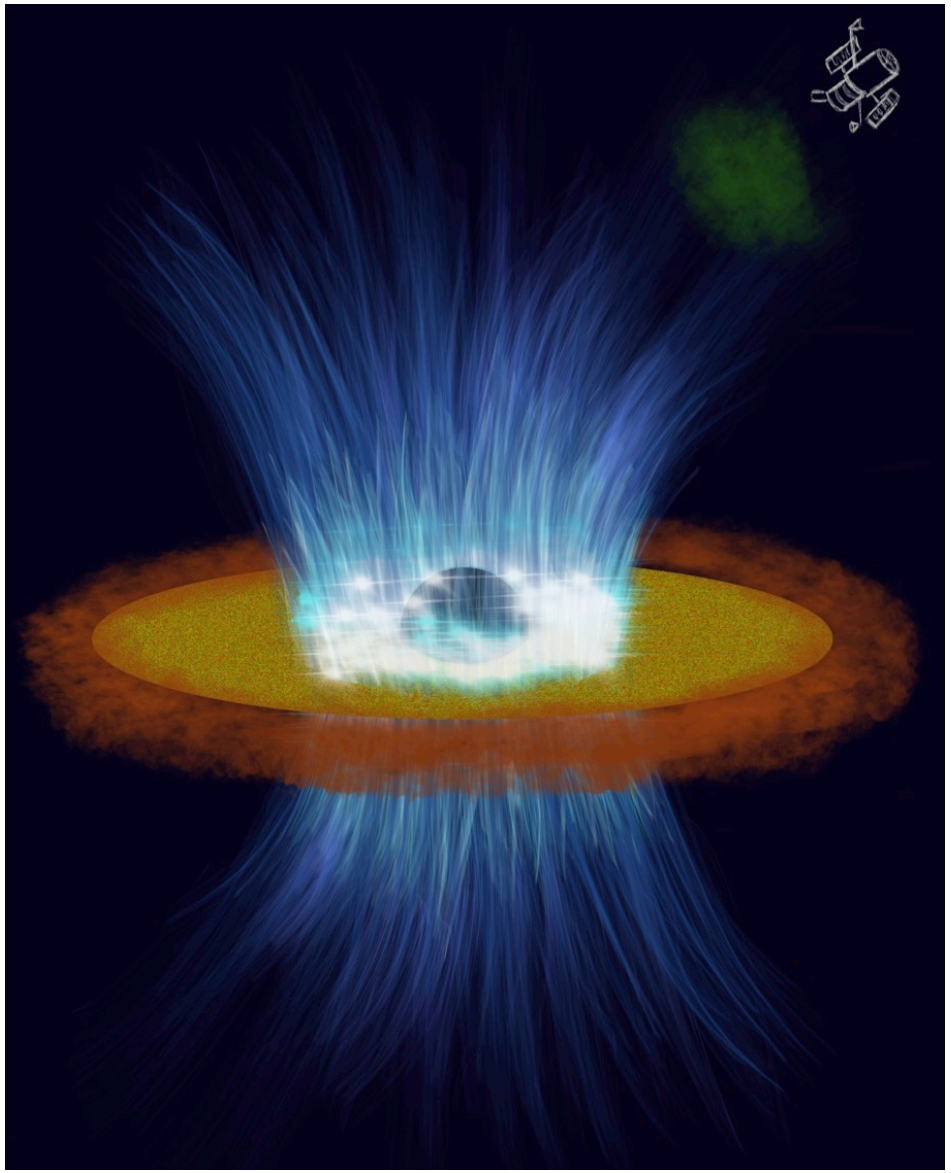
n(H)=12 cm^{-3}

N(H)=$10^{23} cm^{-2}$

R= 1 Light Day

T=5 x 10^4 K

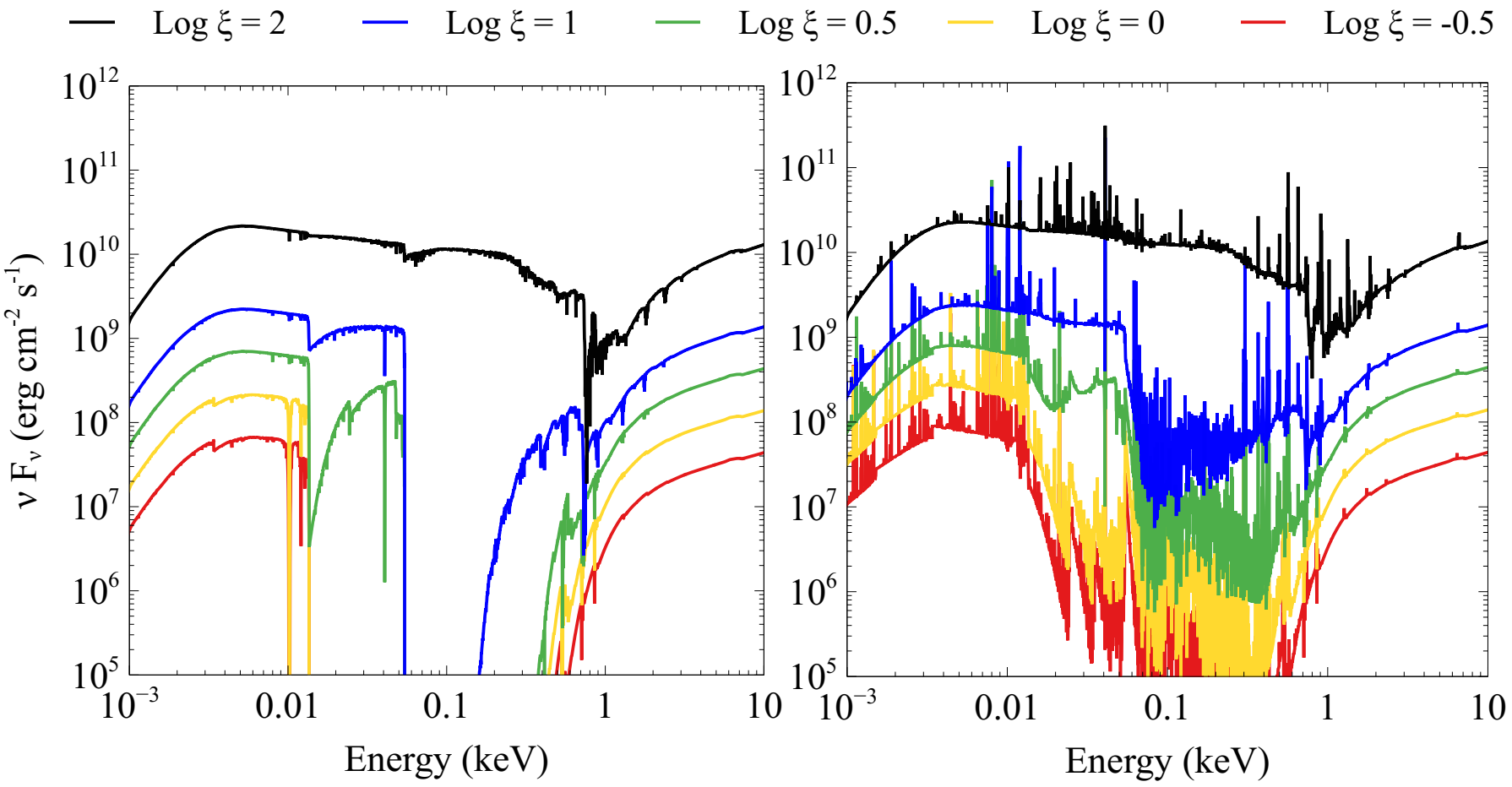
ξ= 1 erg cm s^{-1}



Effects on the field?

An Atlas of UV and X-ray Signature of the Wind

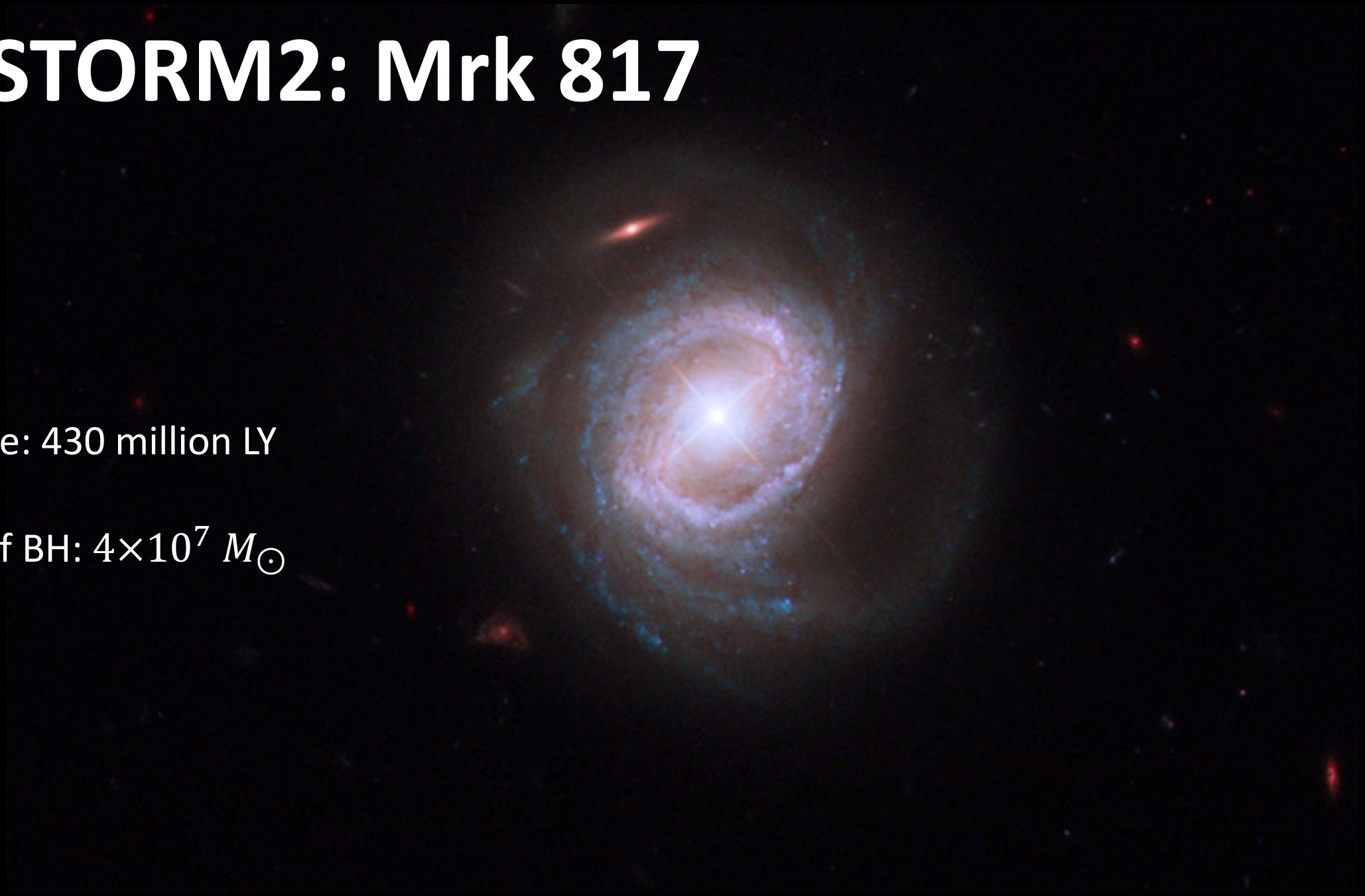
Variable ionization parameter



Conclusions

- ✓ A new geometry for the NGC 5548 : Disk Wind
- ✓ The wind can alter the normal behavior: holidays
- ✓ The wind can be a source of emission: very broad lines
- ✓ It is possible to detect and trace the wind: my novel tool
- ✓ Winds can affect the observations in many ways: the atlas
- ✓ All AGN studies must consider the the winds: cloud shadowing

STORM2: Mrk 817



Distance: 430 million LY

Mass of BH: $4\times10^{7}\ M_{\odot}$

- Carefully selected because it showed no history of strong UV absorption and/or X-ray obscuration.

- Observations reveal the presence of new broad and narrow absorption lines

- X-rays are significantly obscured compared to earlier observations

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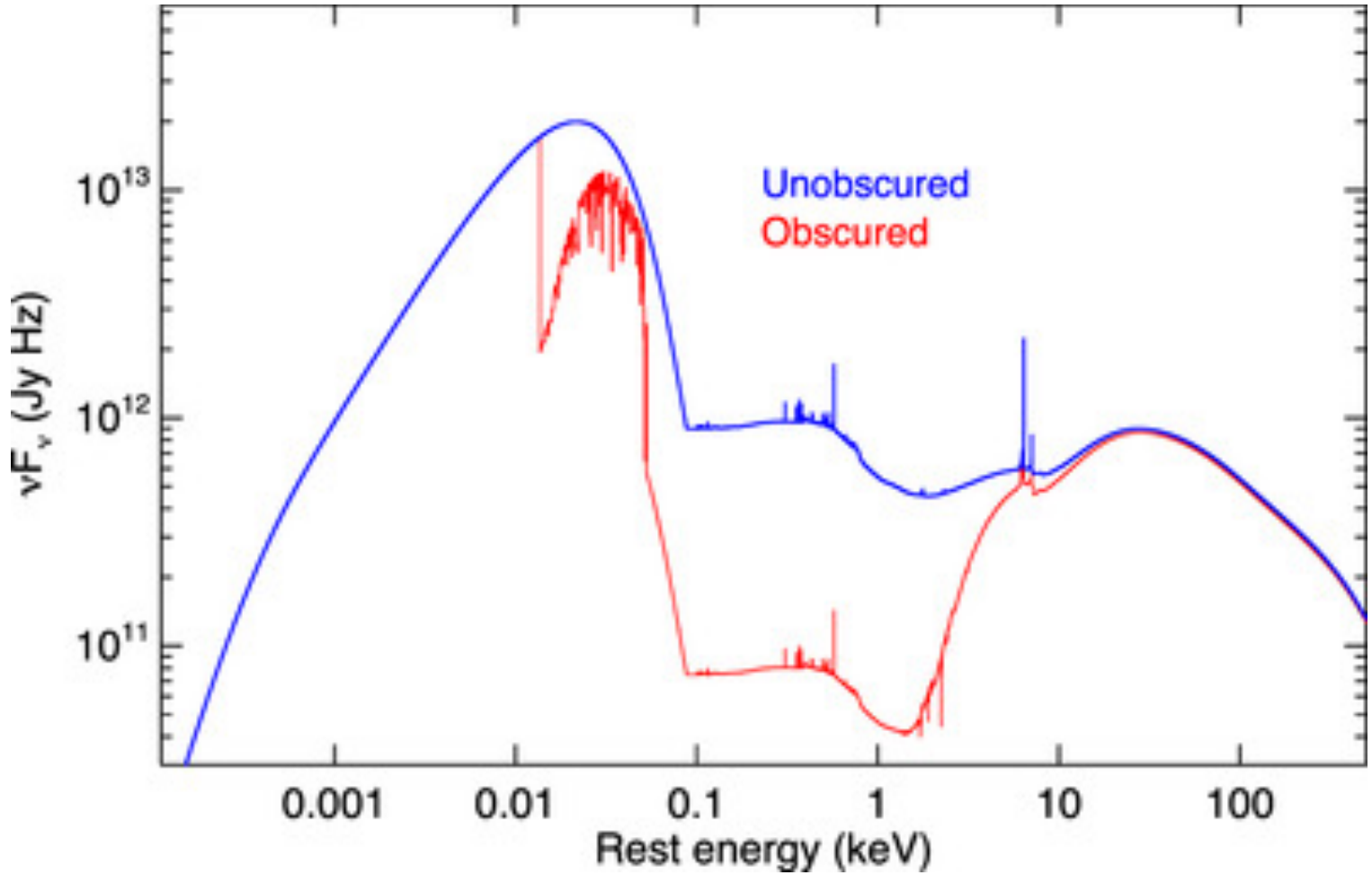
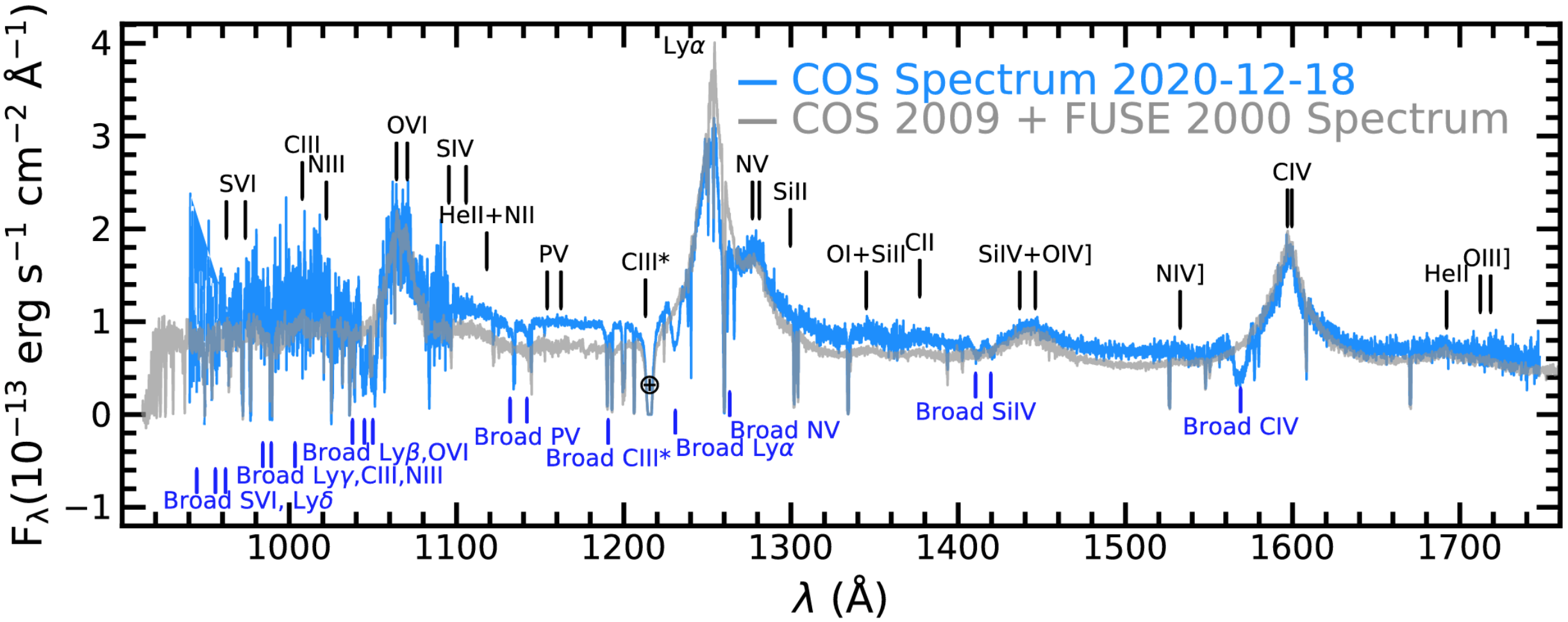
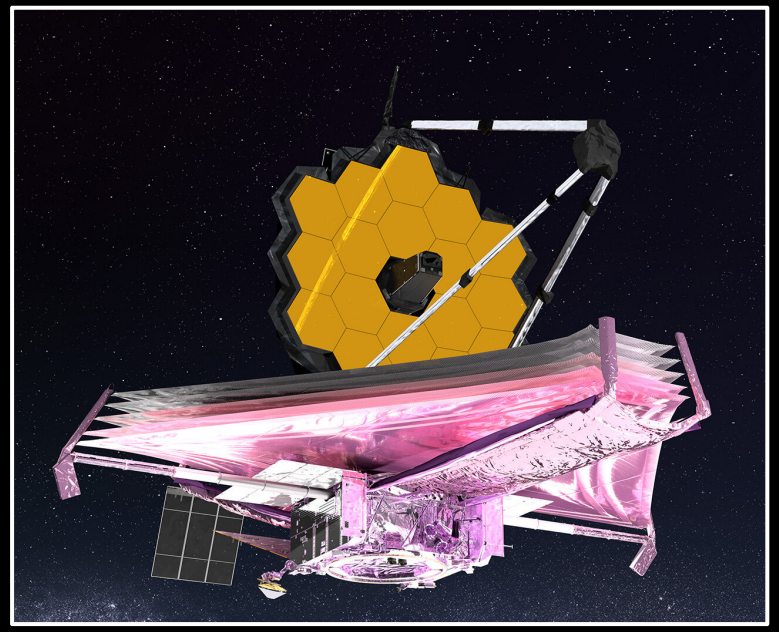
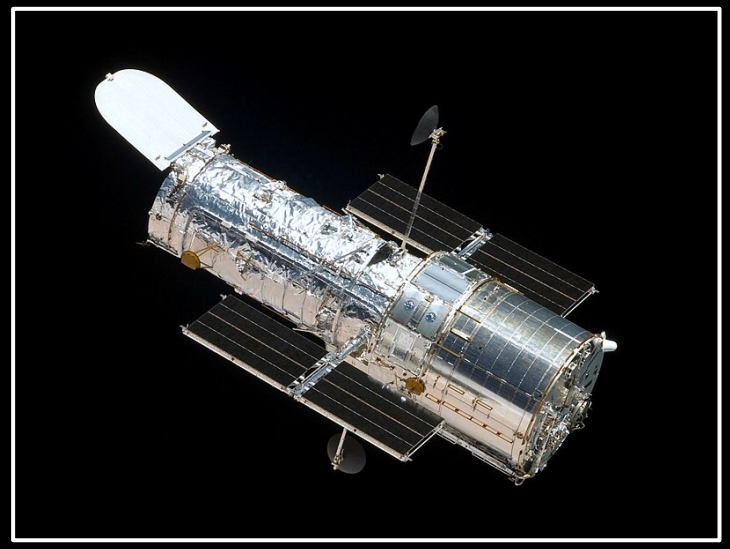
AGN STORM 2. I. First results: A Change in the Weather of Mrk 817





Kara et al. 2021






danke
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mochchakkeram
dziękuję
go raibh maith agat
obrigado
sukriya
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