

# The Origins of Strong HeII in Extremely Metal Poor Galaxies

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Edited for pdf version

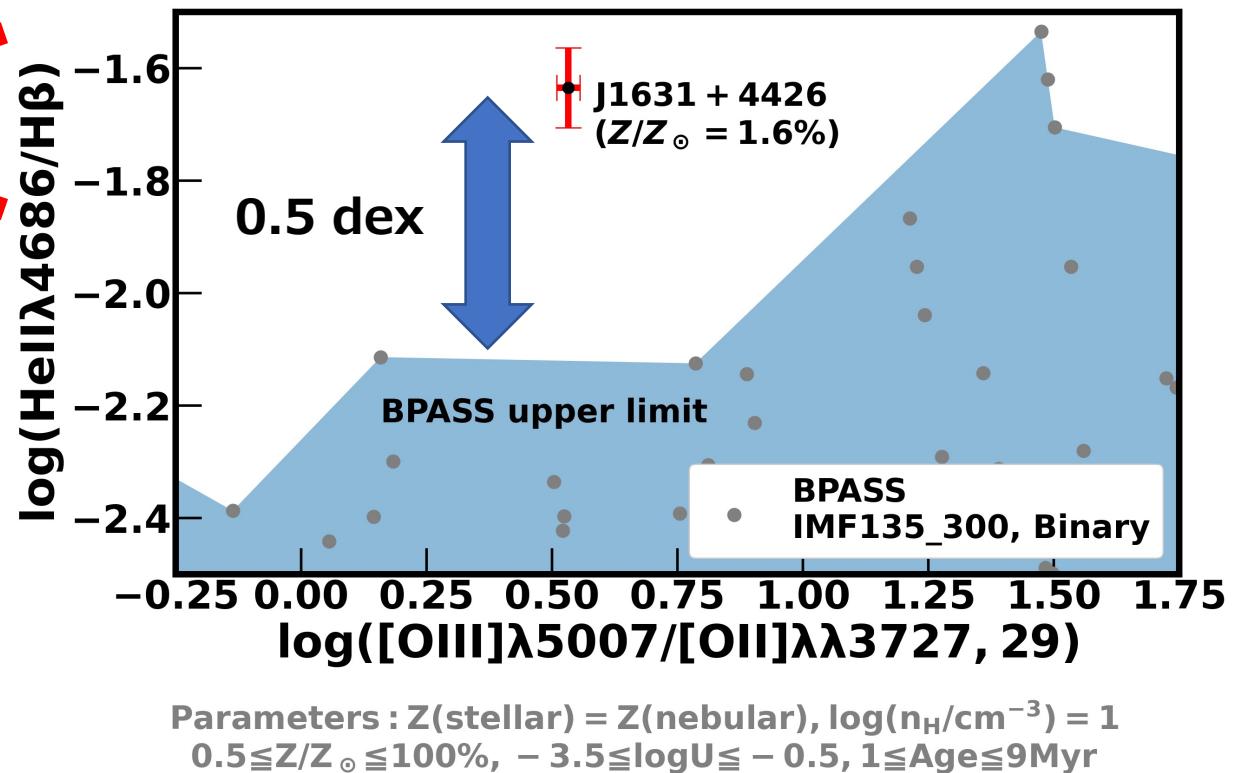
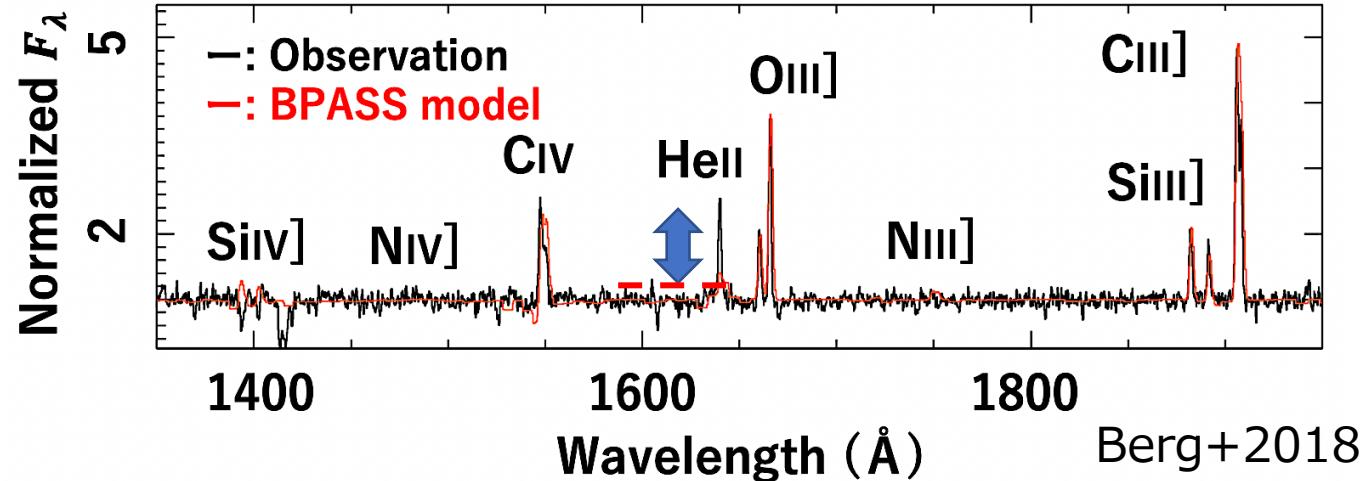
# Extremely Metal Poor Galaxies (EMPGs) Remaining Problem

Too strong HeII  
(Berg+18,  
Nakajima+18)

Stellar synthesis  
models (e.g., BPASS)  
**Need Harder  
Radiation**

High Mass X-ray  
Binary? (Schaerer+19)

Metal poor AGN?  
(Nakajima+18)



# Objective

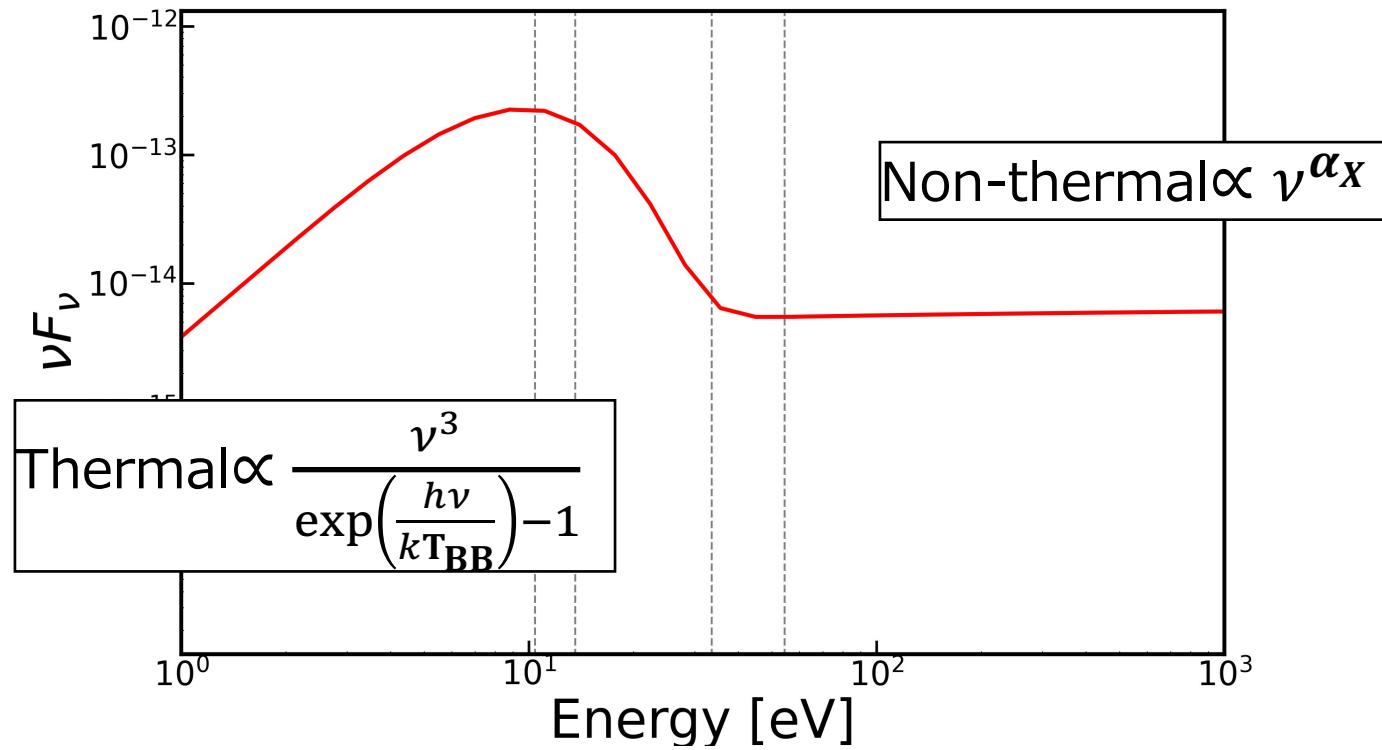
- Find spectral shape that reproduce emission lines!

## 1. Generalized Spectrum

- Blackbody + Power-law Radiation

## 2. Efficient Parameter Search

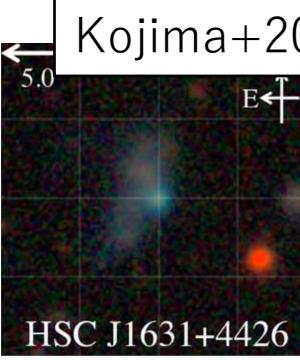
- Markov Chain Monte Carlo (MCMC) technique



# Samples

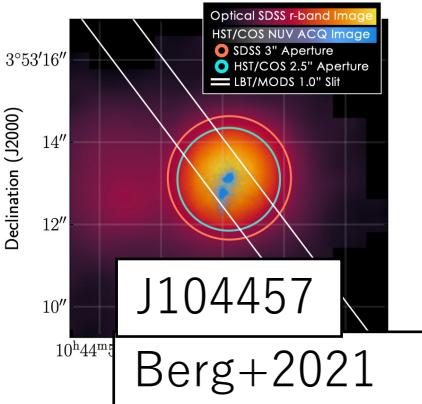
Galaxy	Metallicity ( $z/z_{\odot}$ )	Comments
J1631+4426	1.6%	The lowest metallicity
J104457	5.8%	Previously studied to reproduce HeII
I Zw 18 NW	3.0%	Well Studied EMPGs

**Kojima+2020**



HSC J1631+4426

**Berg+2021**



J104457

**Heap+2015**



I Zw 18

# Data: Line Fluxes

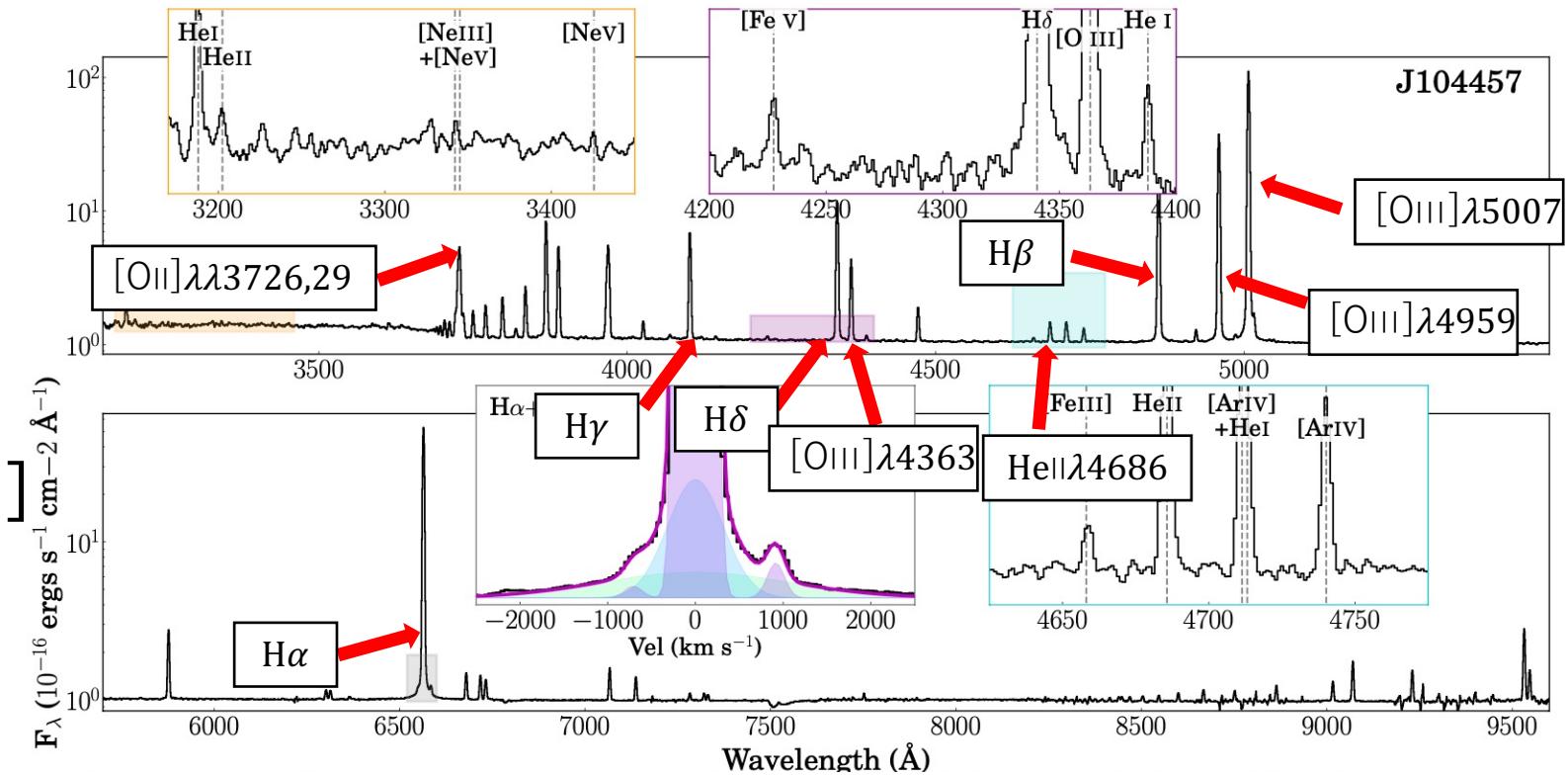
Emission lines used

$H^+$ :  $H\beta$ ,  $H\gamma$ ,  $H\delta$ , ( $H\alpha$ )

$O^+$ :  $[OII]\lambda\lambda 3726,29$

$O^{++}$ :  $[OIII]\lambda 4363$ ,  $[OIII]\lambda 4959$ ,  $[OIII]\lambda 5007$

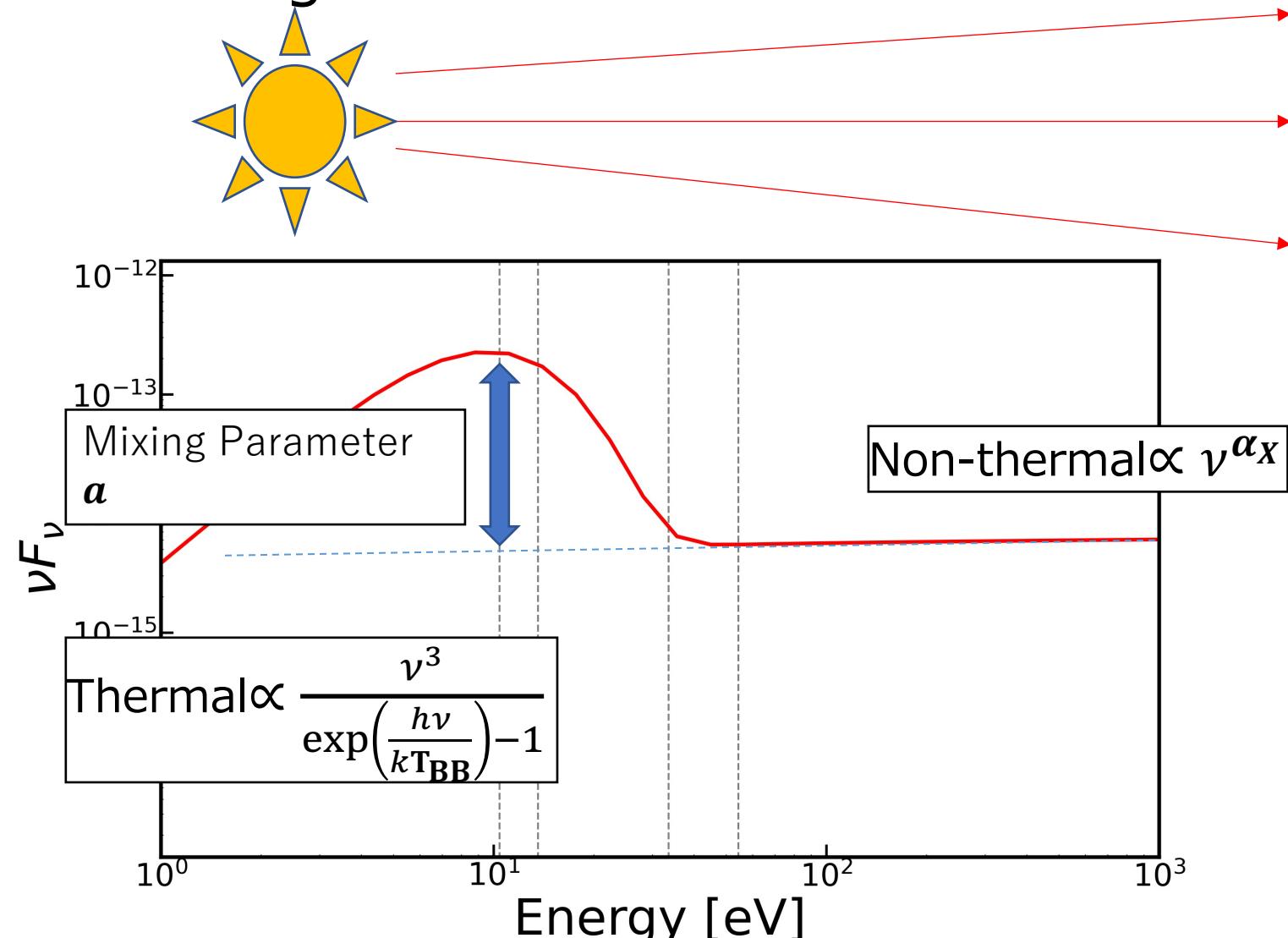
$He^{++}$ :  $HeII\lambda 4686$



Berg+2021

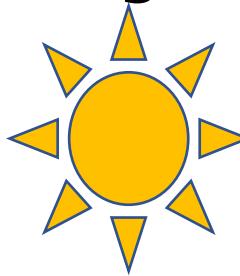
# ① Photoionization Model

Ionizing Source

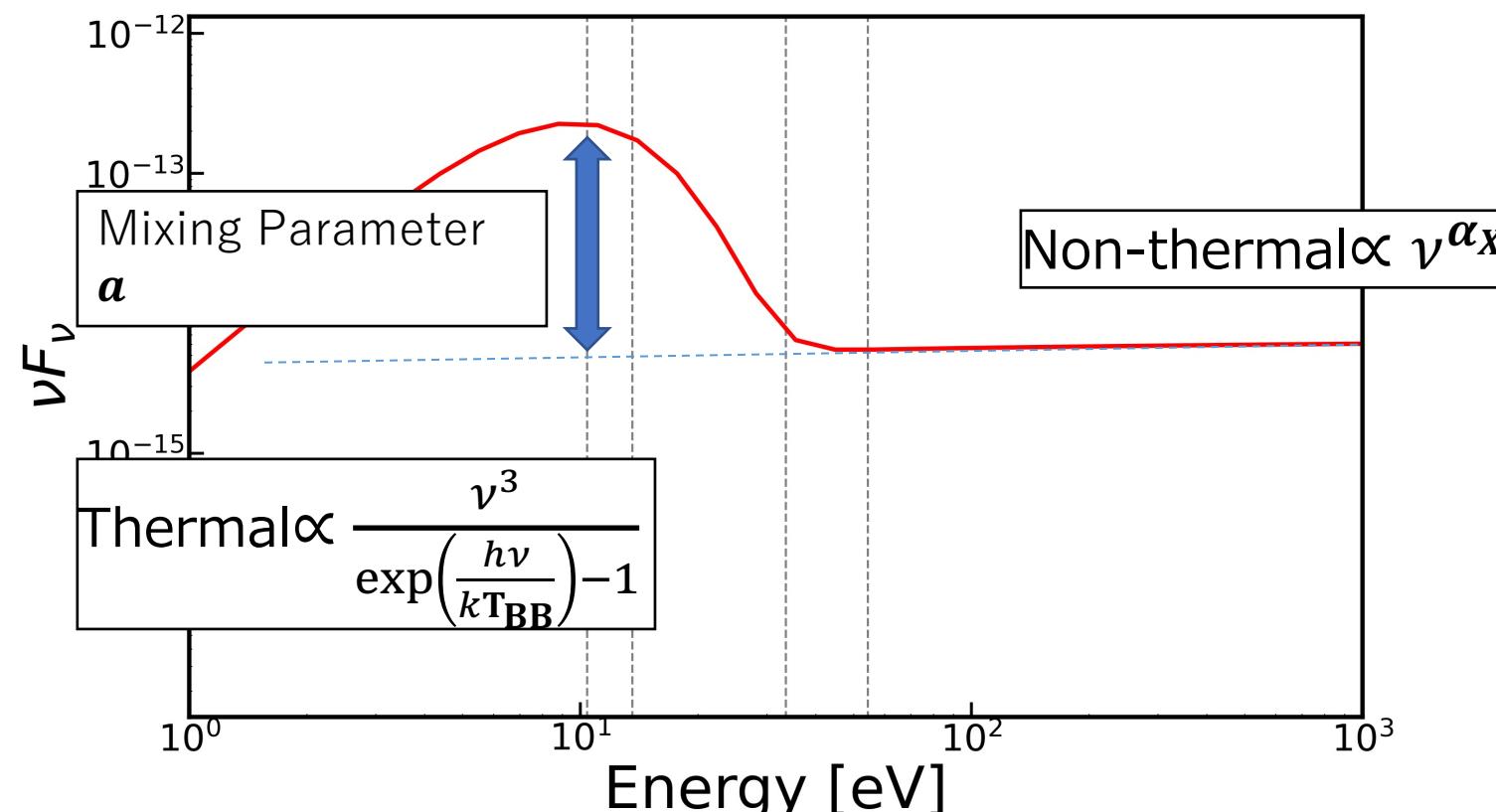


# ① Photoionization Model

Ionizing Source



Ionization Parameter  $U$



$F(\text{H}\beta)$

$F(\text{HeII})$

$F([\text{OIII}]), \text{etc...}$

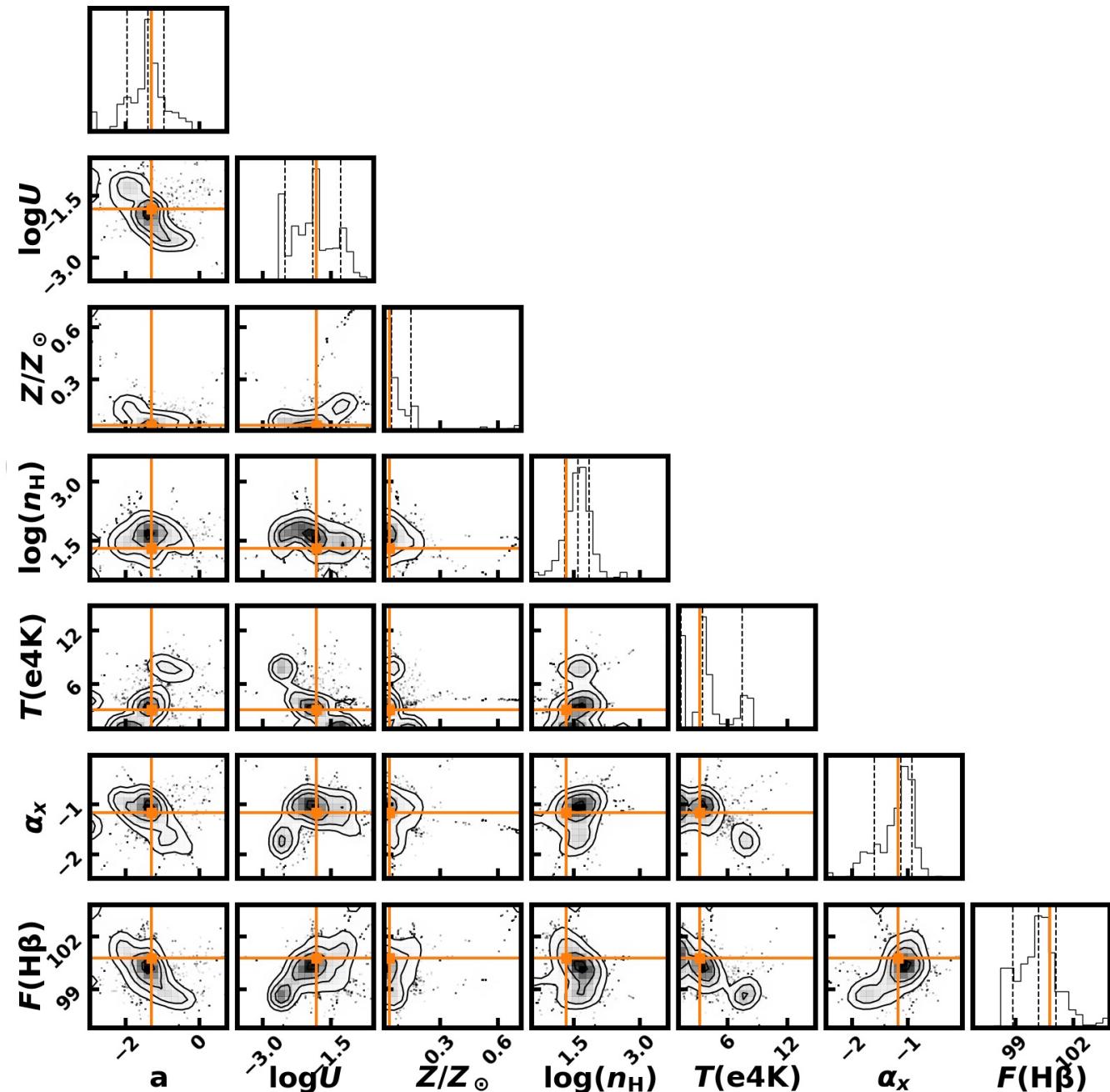
CLOUDY's output

7 free parameters:  
 $a, \alpha_X, T_{\text{BB}}, U, Z, n_{\text{H}}, F(\text{H}\beta)$

## ② MCMC Technique

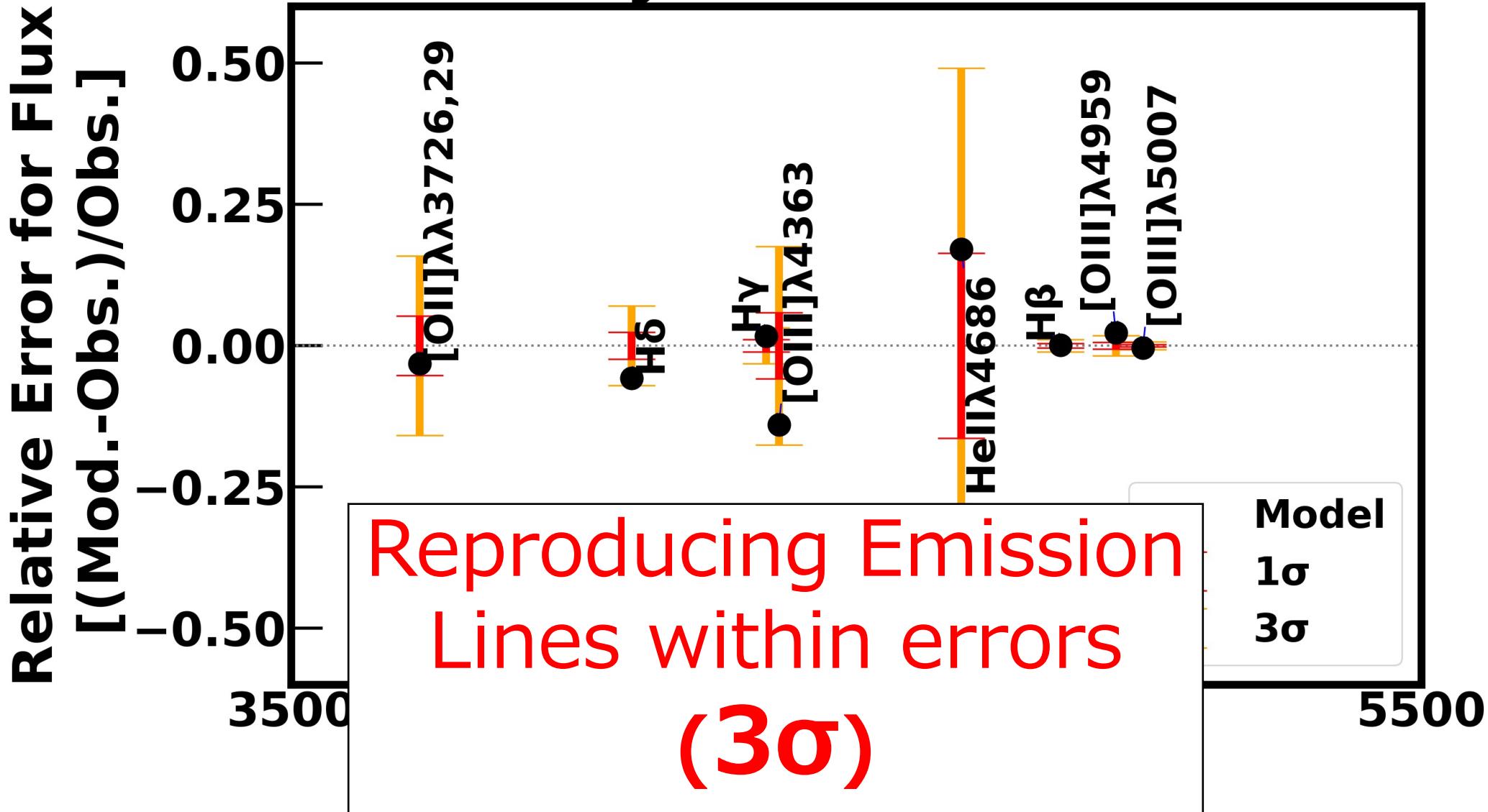
Best-Fit Parameter Set

→ Maximizes the Likelihood



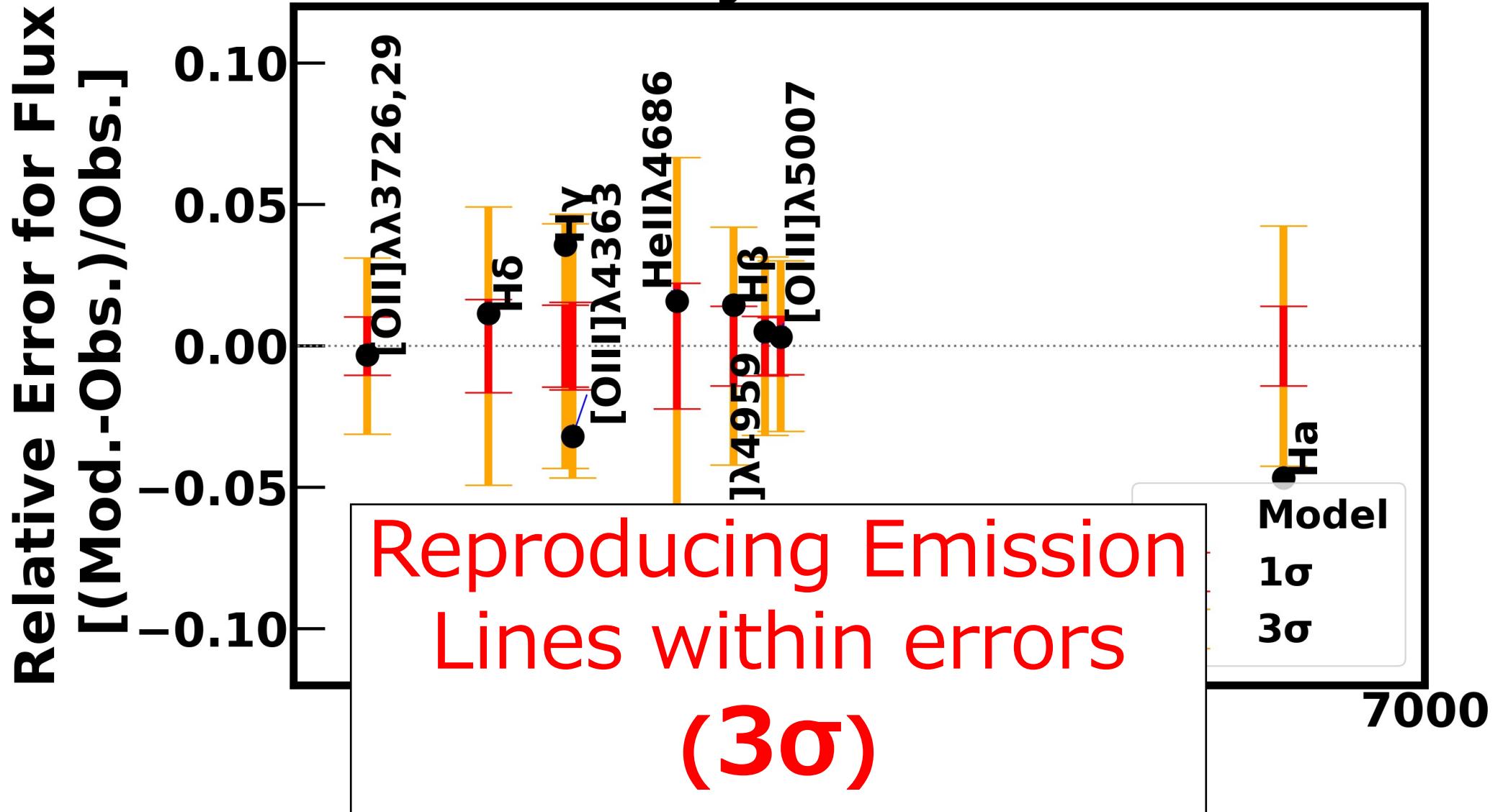
# Results: Emission Lines

J1631 + 4426



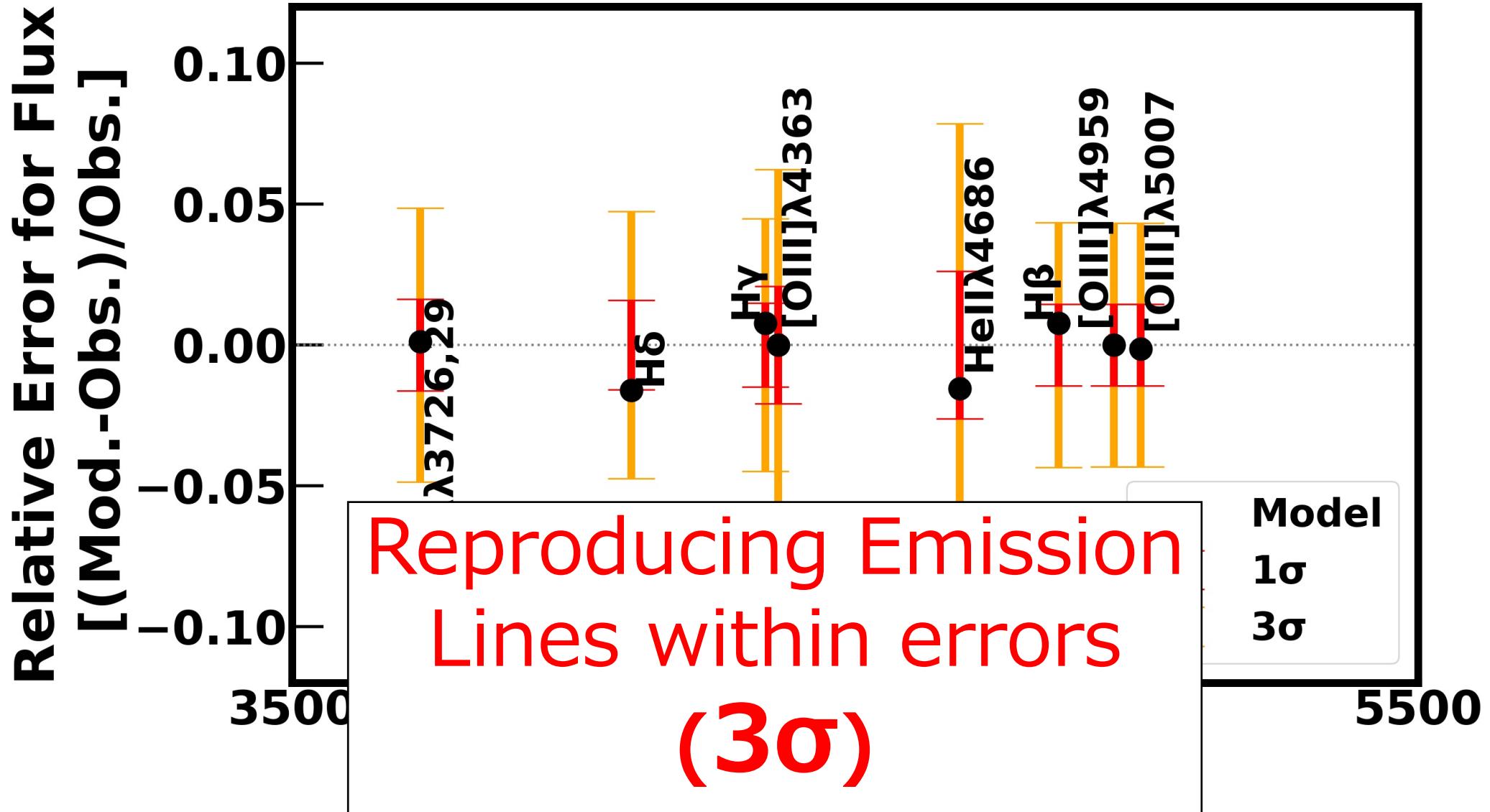
# Results: Emission Lines

J104457



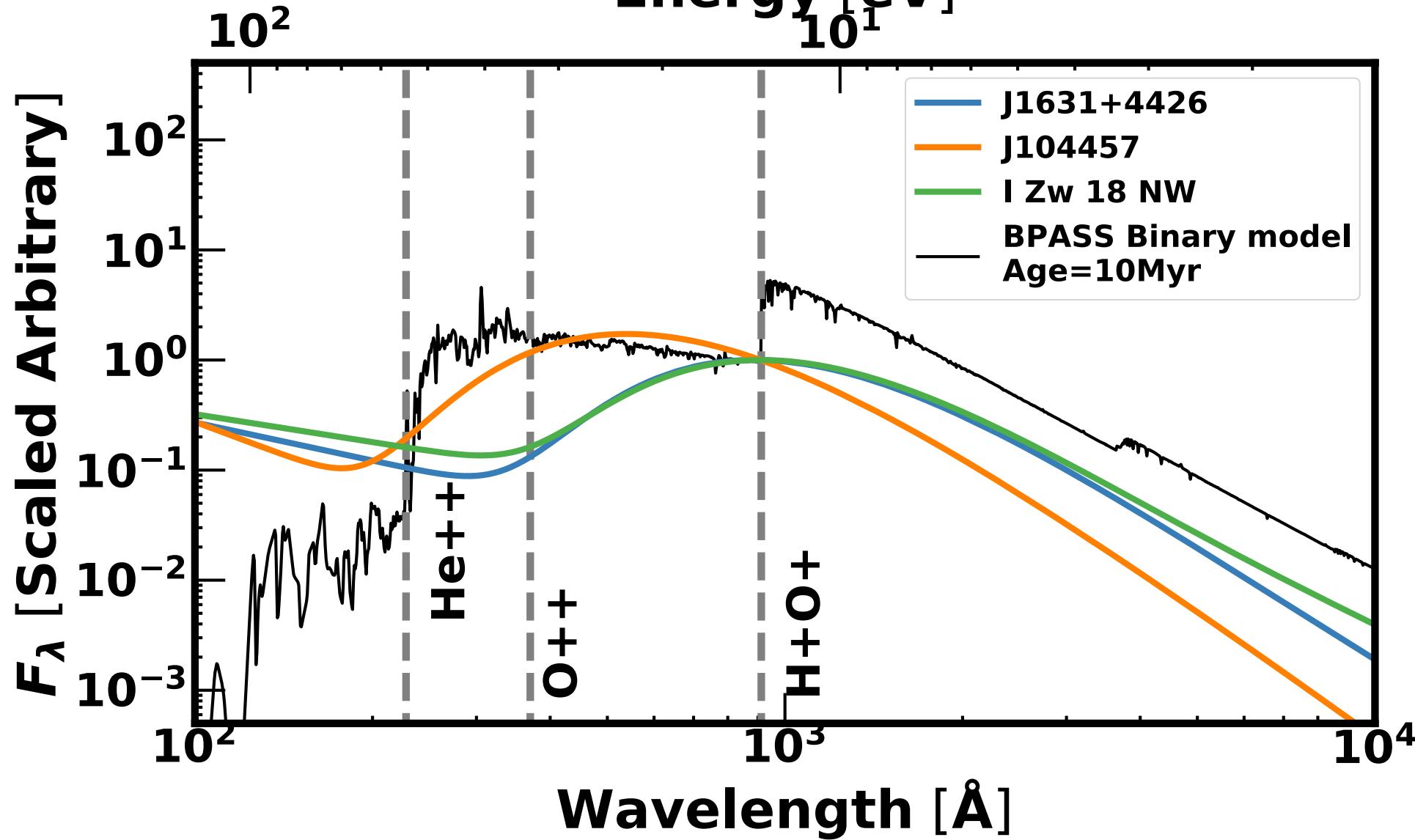
# Results: Emission Lines

I Zw 18 NW

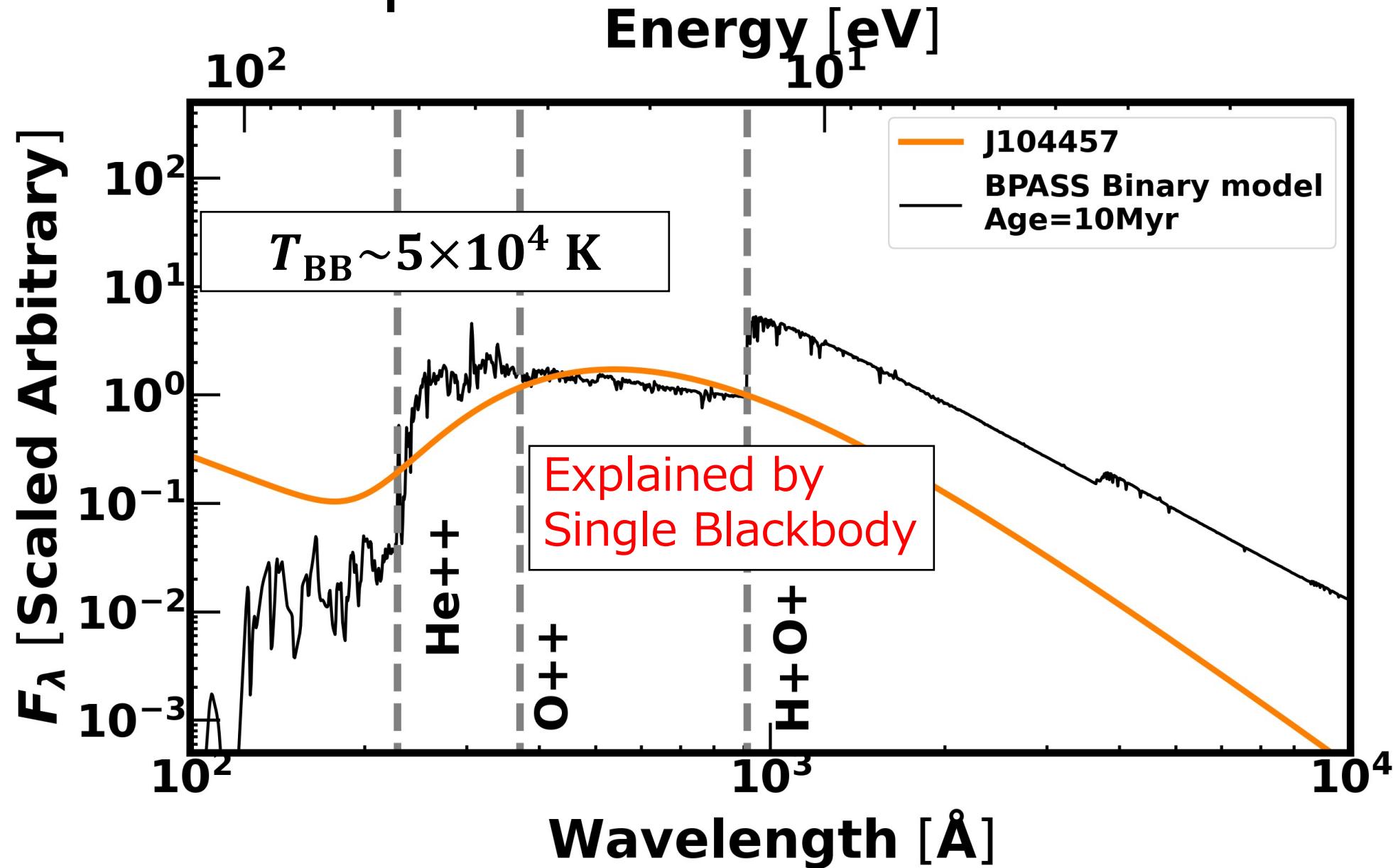


# Results: Spectral Shapes

Energy [eV]



# Spectral Shape Features



# Ionizing Sources?

SED of HMXB  
(Paredes+2006)

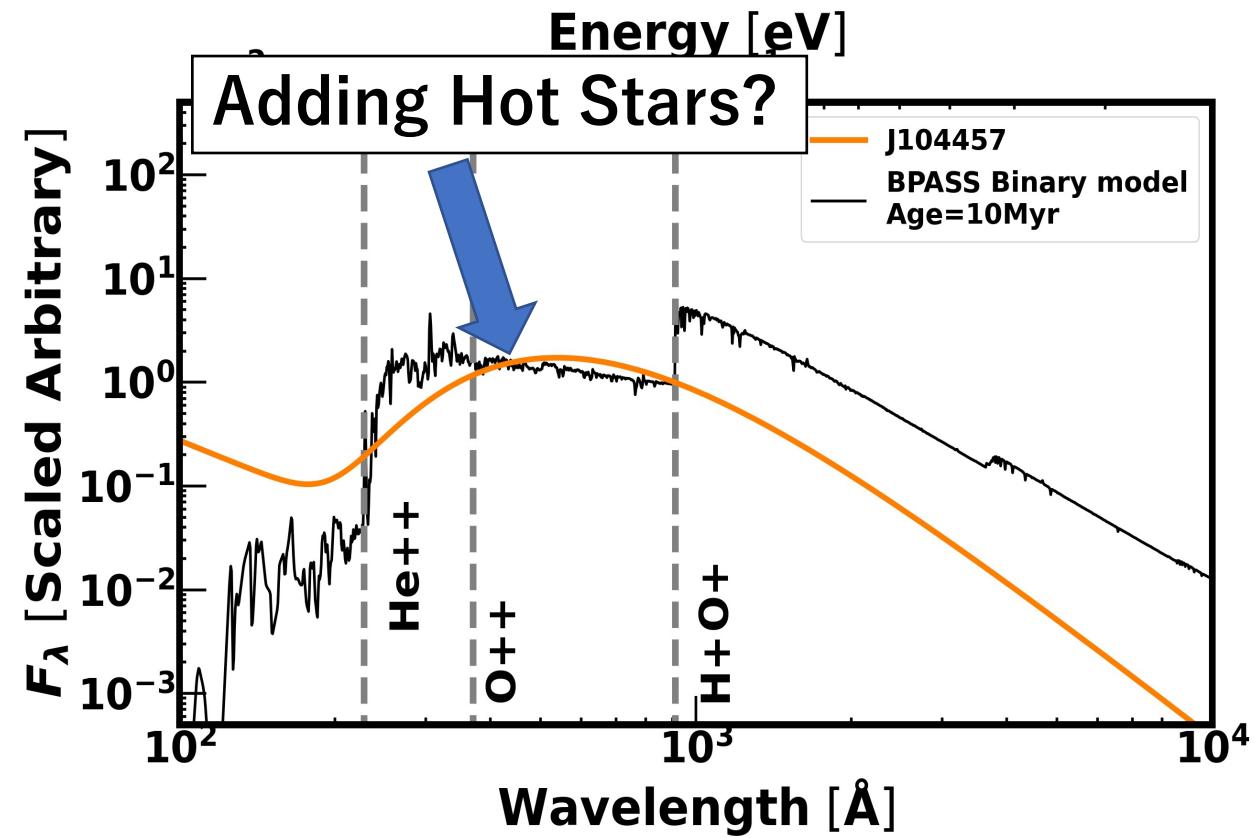
## 1. Stellar Contributions

- Fast Rotating Stars
- First Stars

## 2. Compact Objects?

- AGN
- Ultra-Luminous X-ray source

## 3. Others?



# Ionizing Sources?

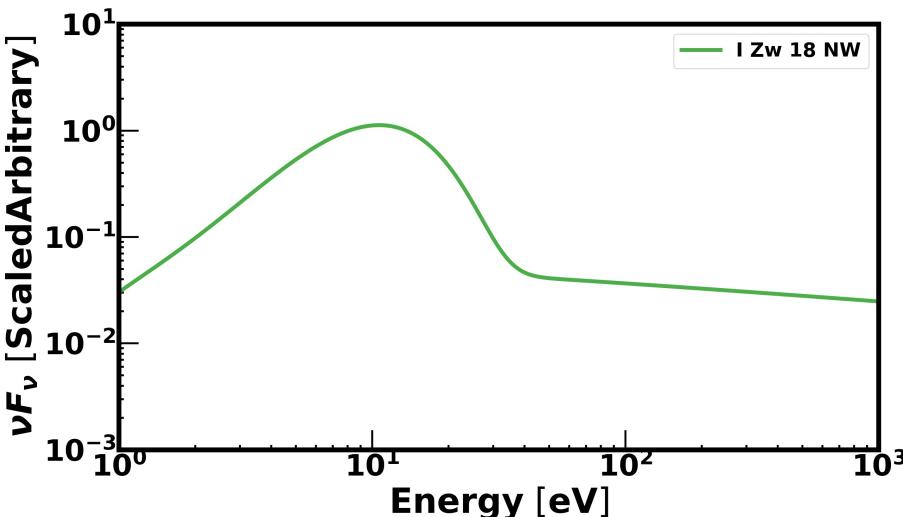
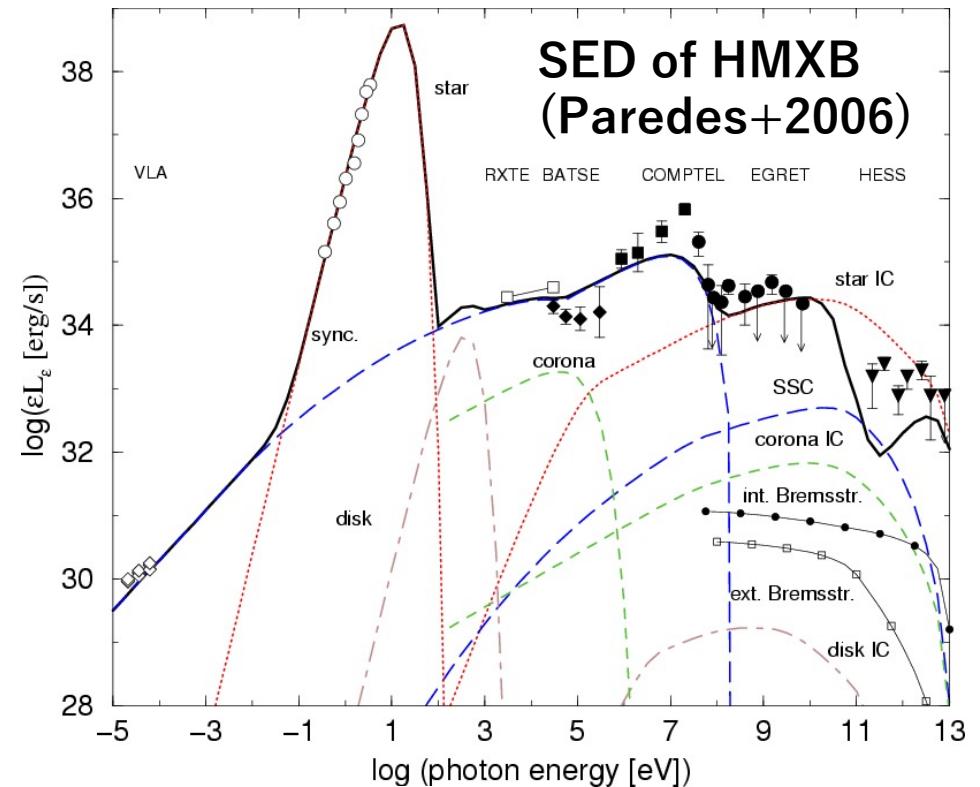
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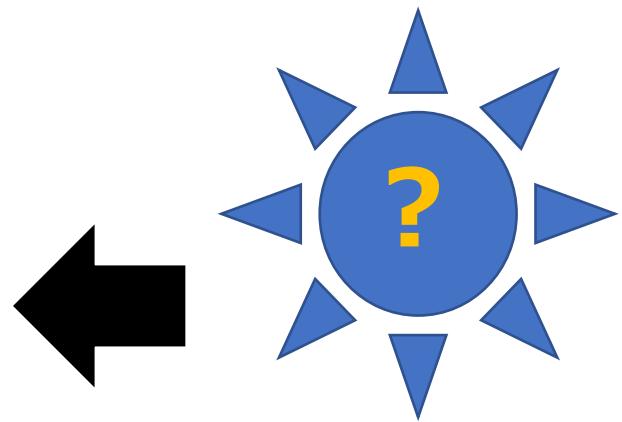
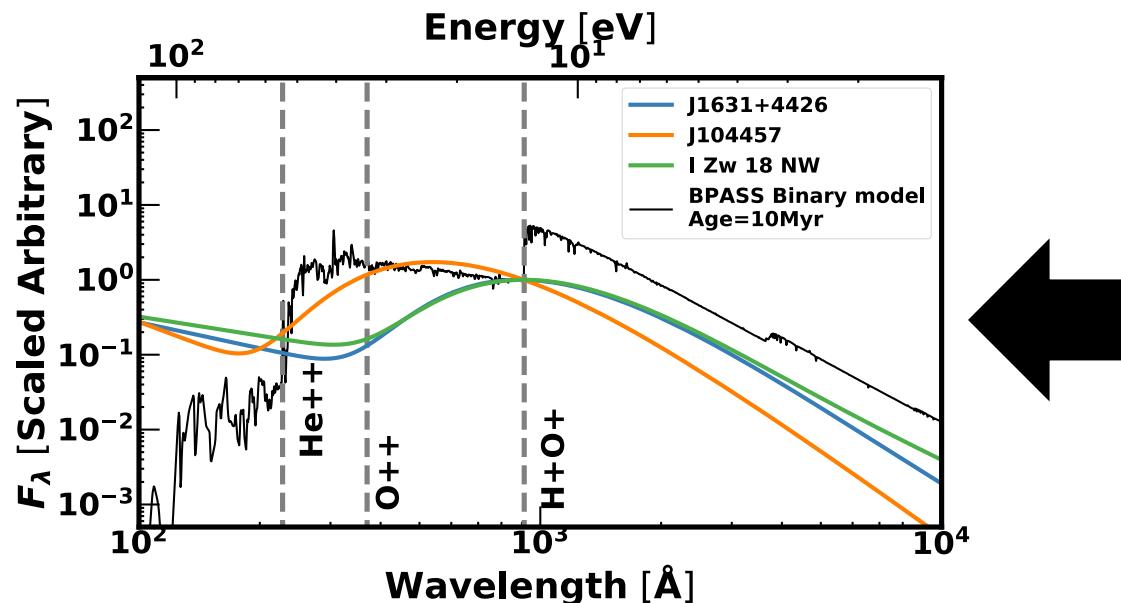
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## 3. Others?



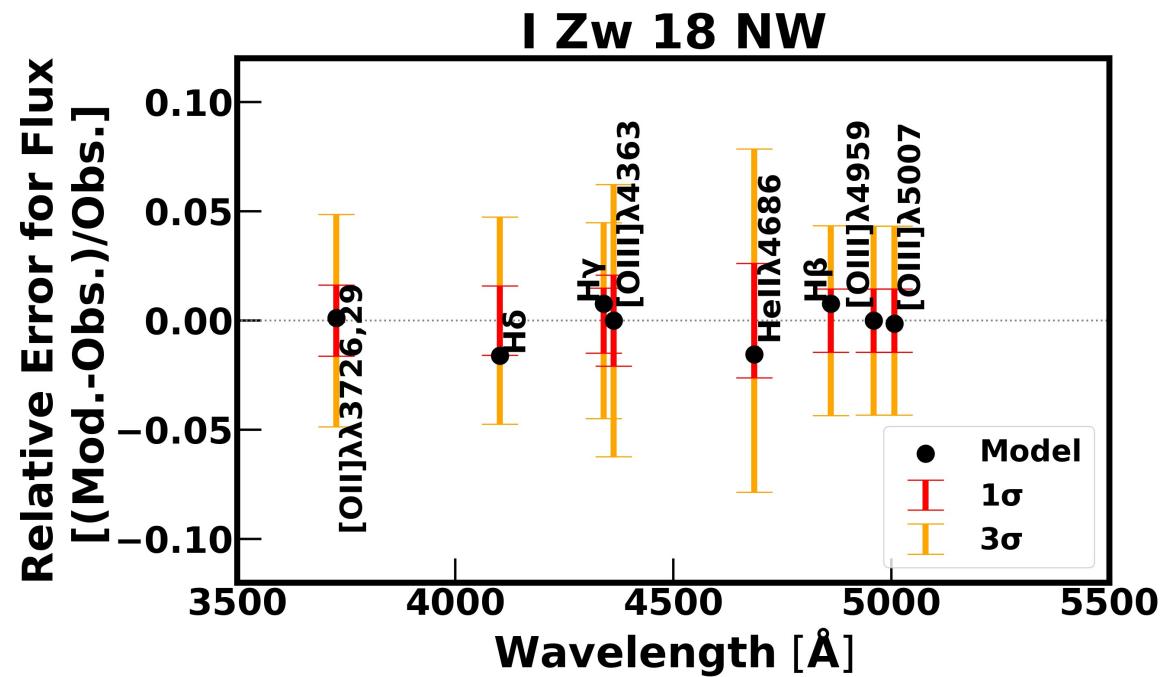
# Future Improvements

- Evaluate Ionizing Radiation Sources
  - Rotating Stars
  - AGN
- Longer Sampling



# Summary

- Generalized Spectrum + MCMC
- Reproduced Emission lines within errors
- More evaluations on ionization sources
  - (Rotating Stars, AGN, etc⋯)



Thank You!

ご清聴  
ありがとうございました

