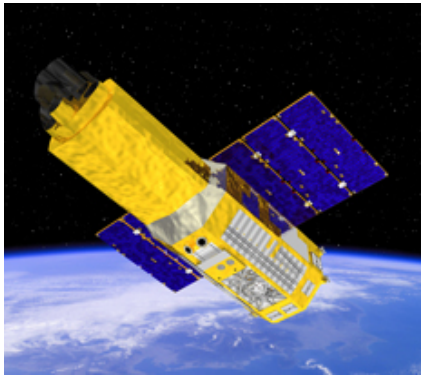


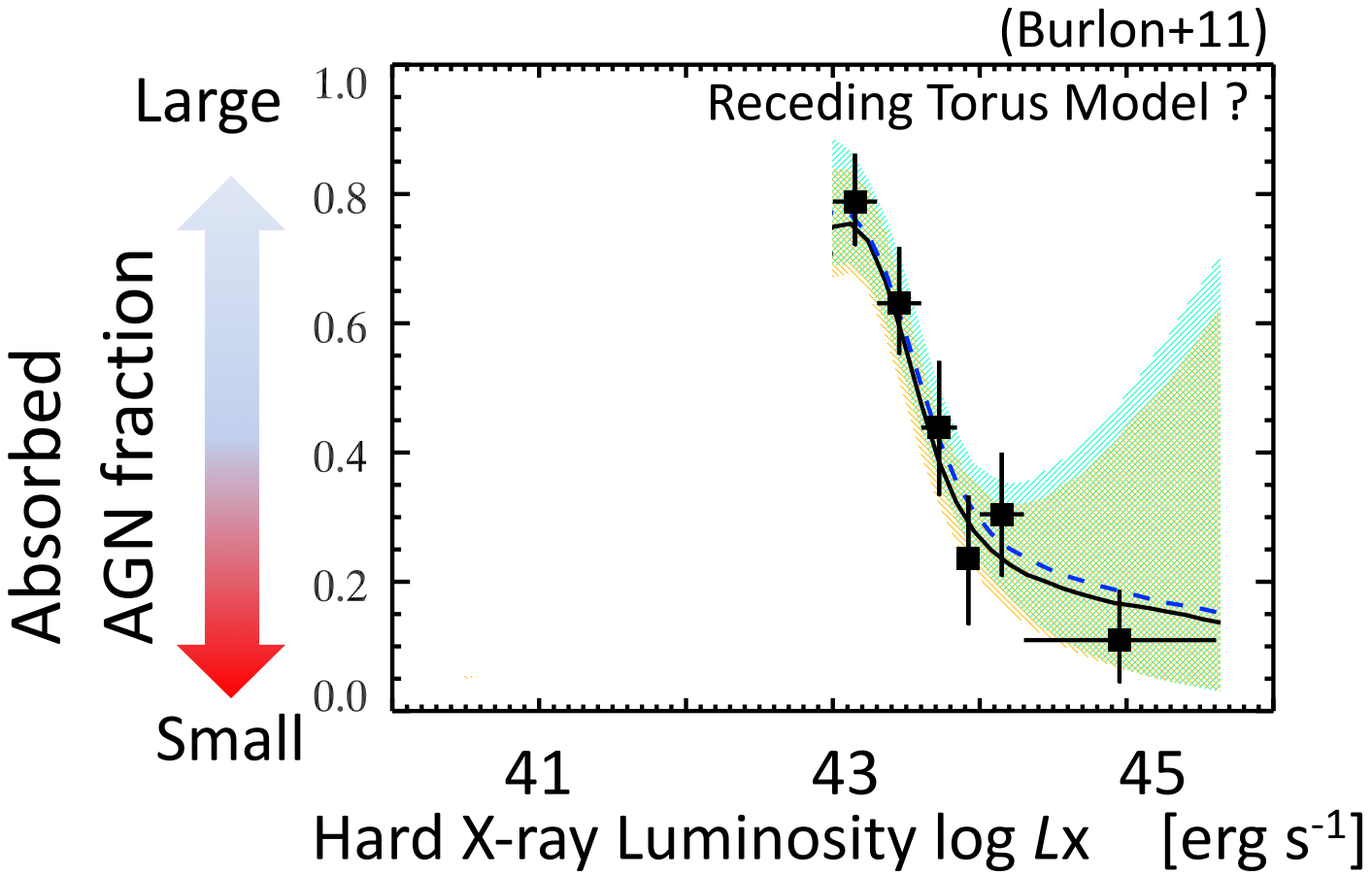
(NASA)

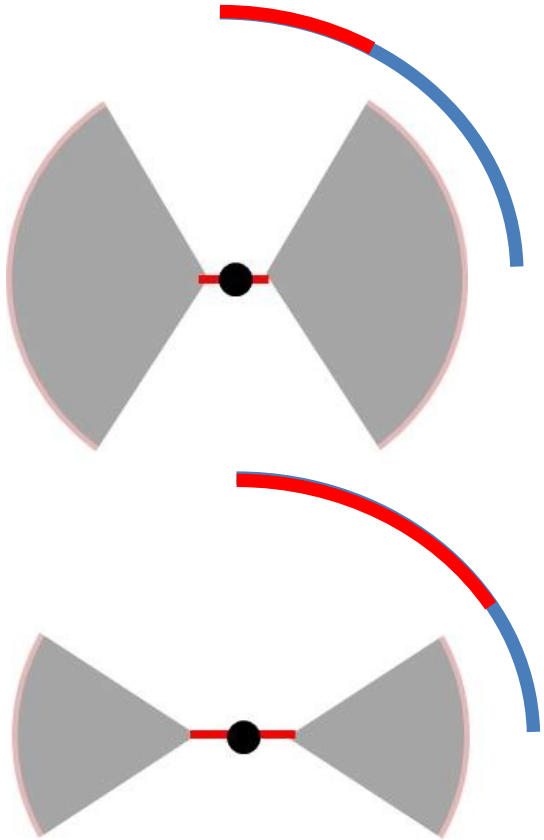
# Study of torus structure of low-luminosity AGN with *Suzaku*

(Kawamuro et al. 2013, Kawamuro et al. 2015 in prep)

**Taiki KAWAMURO**, Yoshihiro UEDA, Fumie TAZAKI (Kyoto Univ.),
Yuichi TERASHIMA (Ehime Univ.), Richard MUSHOTZKY (UMD)

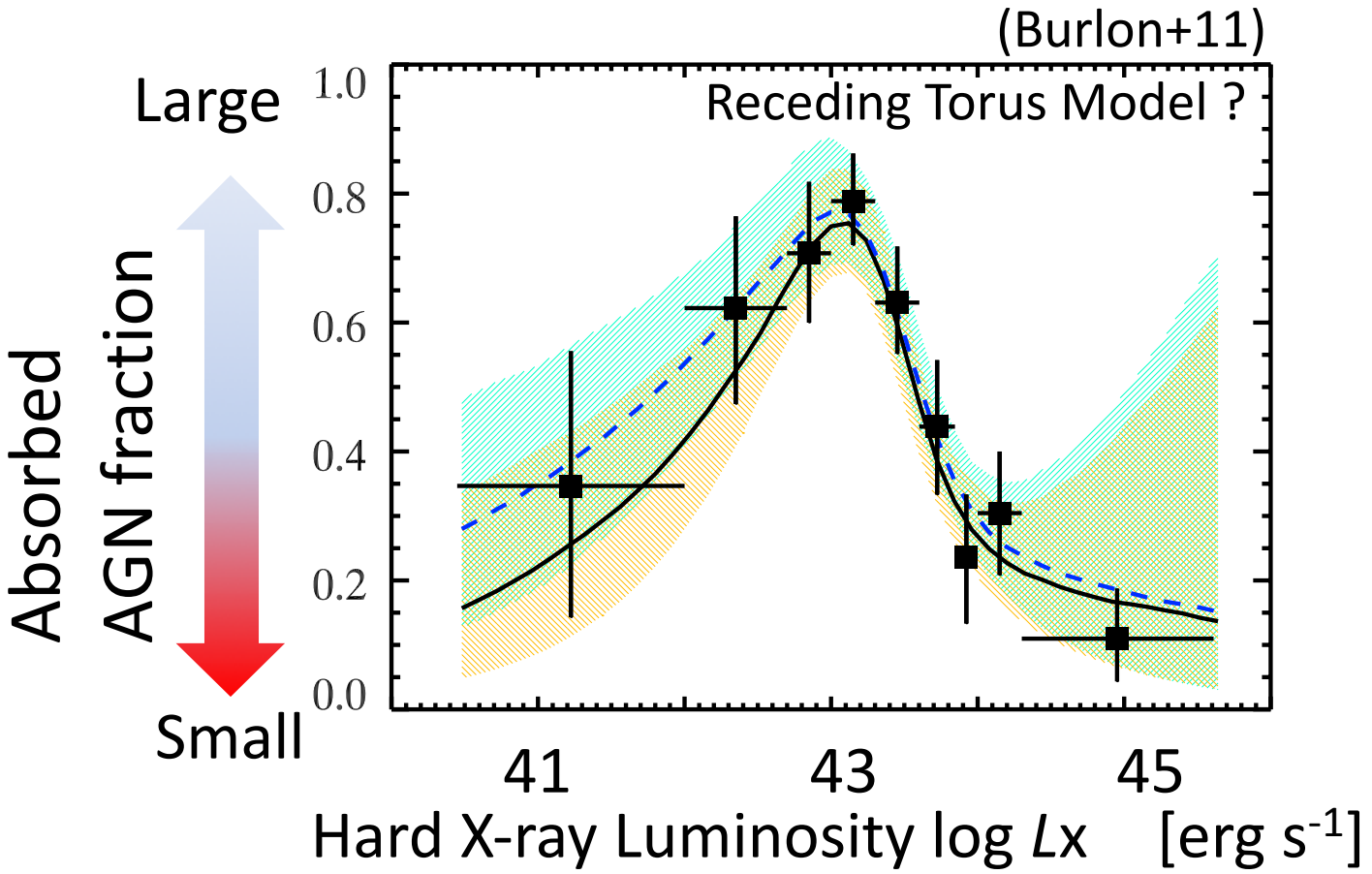
# Luminosity Dependence of Torus Structures

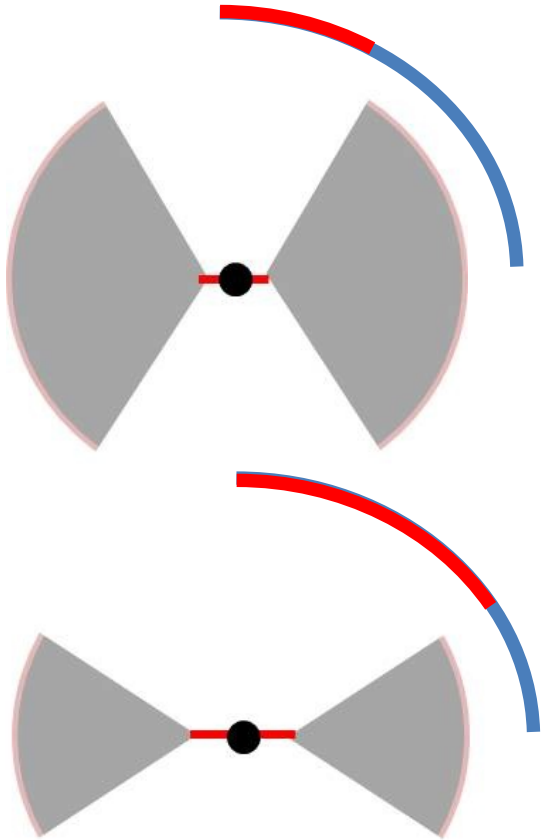


- Absorbed AGN fraction ↔ Averaged solid angle of dust tori.
- Negative correlation (log Lx > 43) → Receding torus model.
- Positive correlation (log Lx < 43) → **Our work.**

# Luminosity Dependence of Torus Structures



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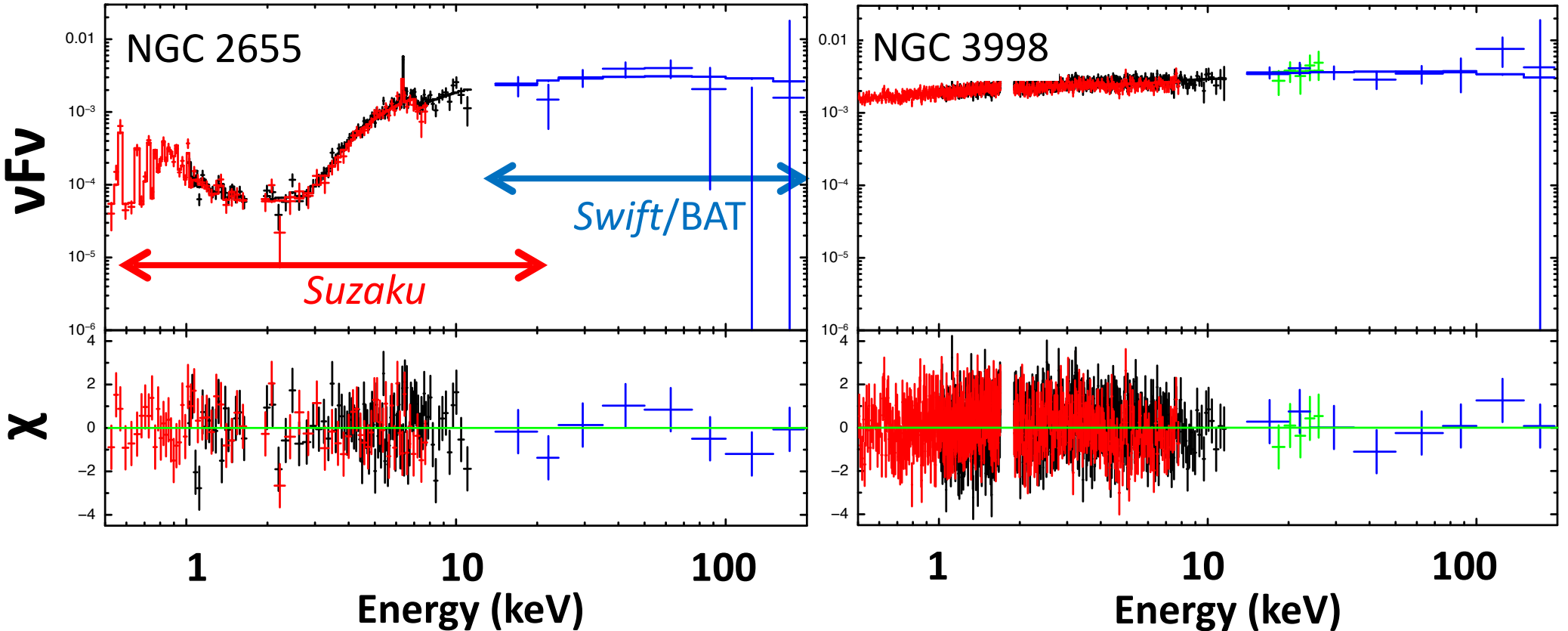
# X-ray View of Dust Torus

- From Swift/BAT 70-month catalog, 8 LLAGNs (Lx < $10^{42}$).
- Suzaku & Swift/BAT → Broadband Spectra (0.5-200 keV)

Indicators of dust torus:

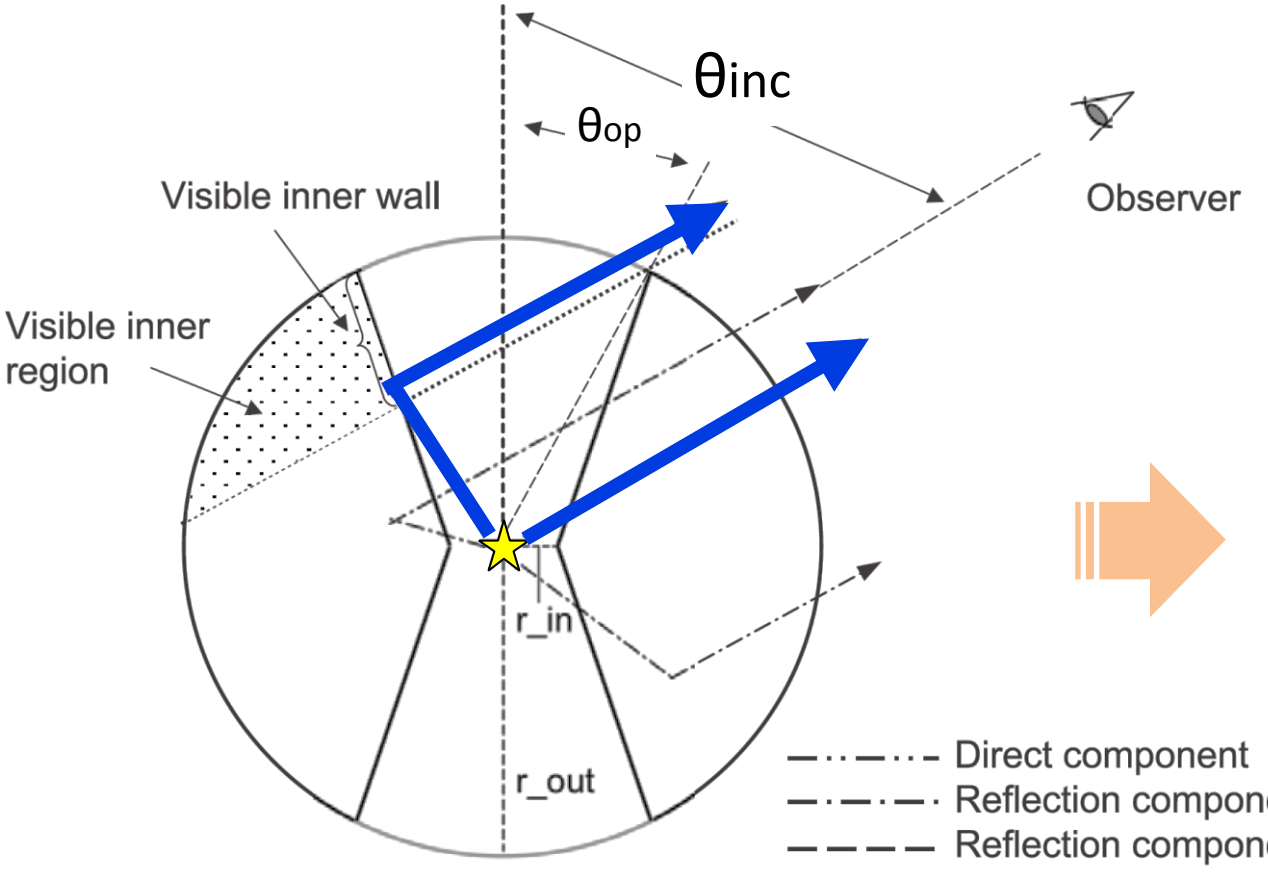
(1) Absorption feature

(2) Narrow Iron-Kα line

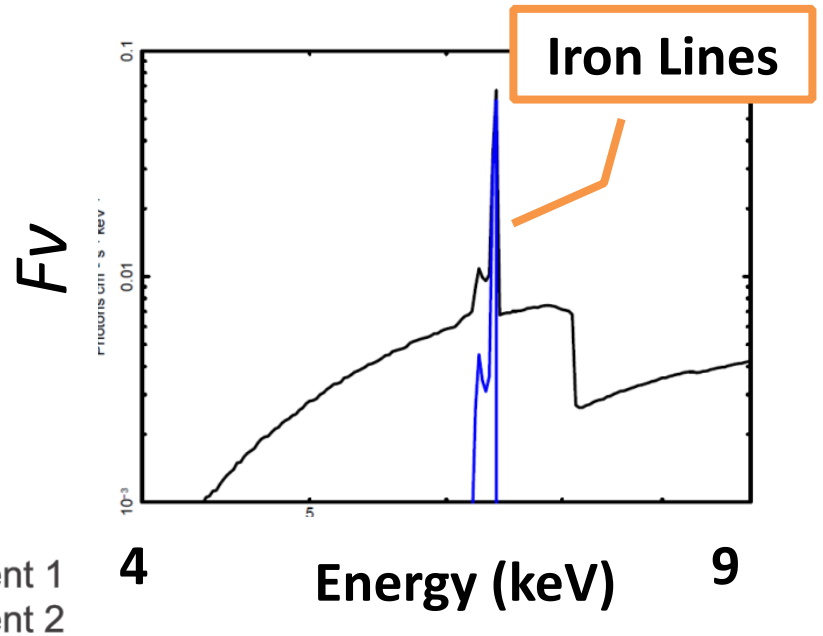


# Monte Carlo Simulation of Dust Torus Spectra

- We calculate the equivalent width (EW) of Iron-Kα line predicted from the assumed torus model (Ikeda et al. 2009).
  - (1) Opening angle (θop)
  - (2) Inclination angle (θinc)
  - (3) Column dens. ($N_H^{eq}$)

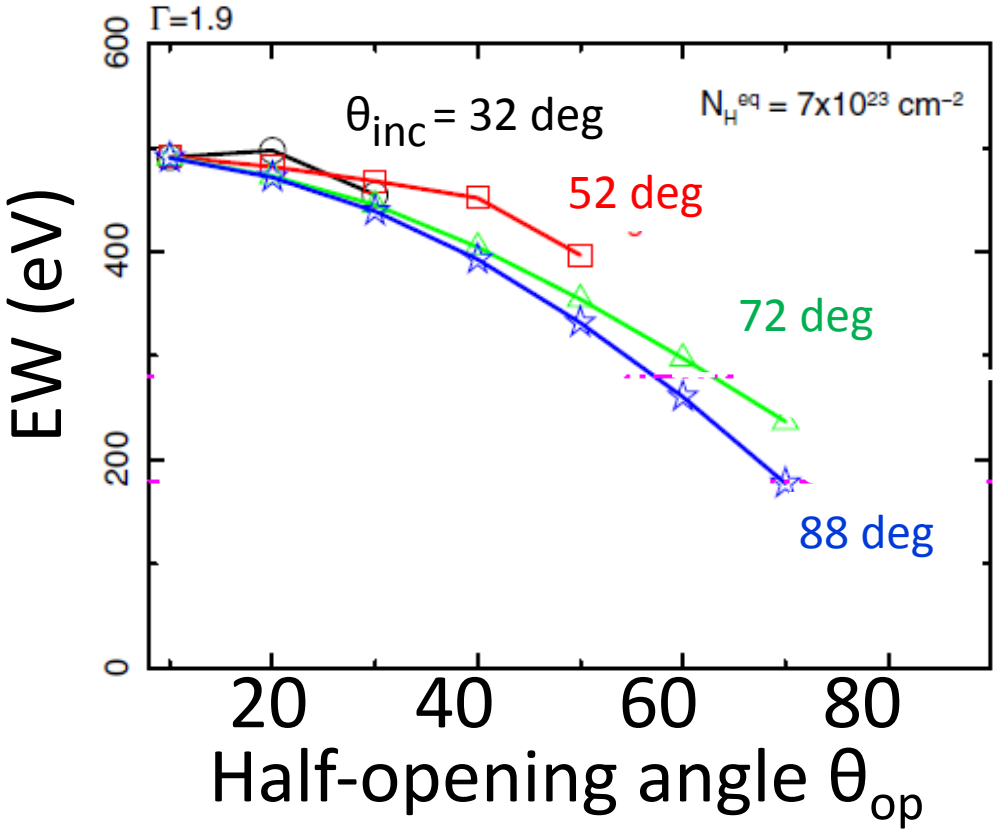



Simulated Spectra

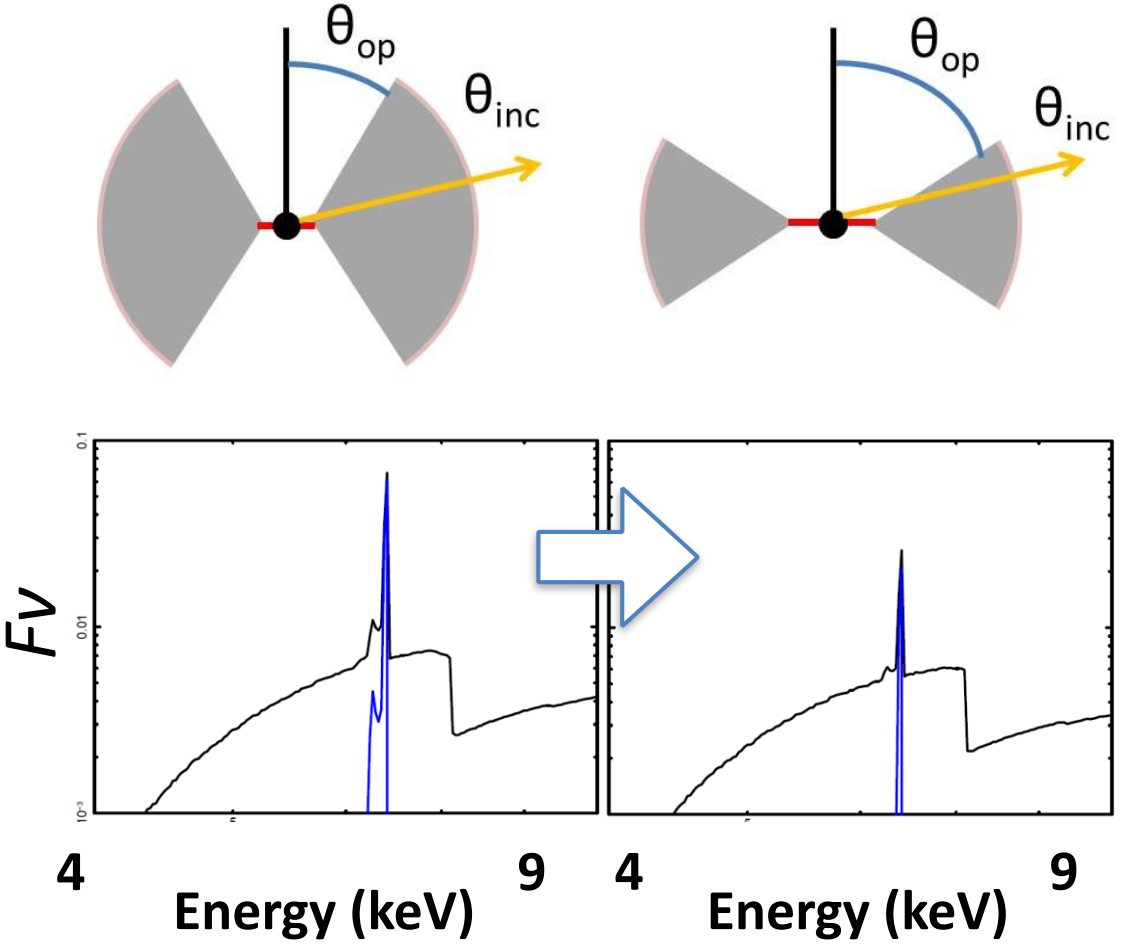


# Monte Carlo Simulation of Dust Torus Spectra

- We compare the simulated EW with the observed one, and constrain the half-opening angle $\theta_{op}$.




⇨ $\theta_{op}$ ~ 60-70 degree.



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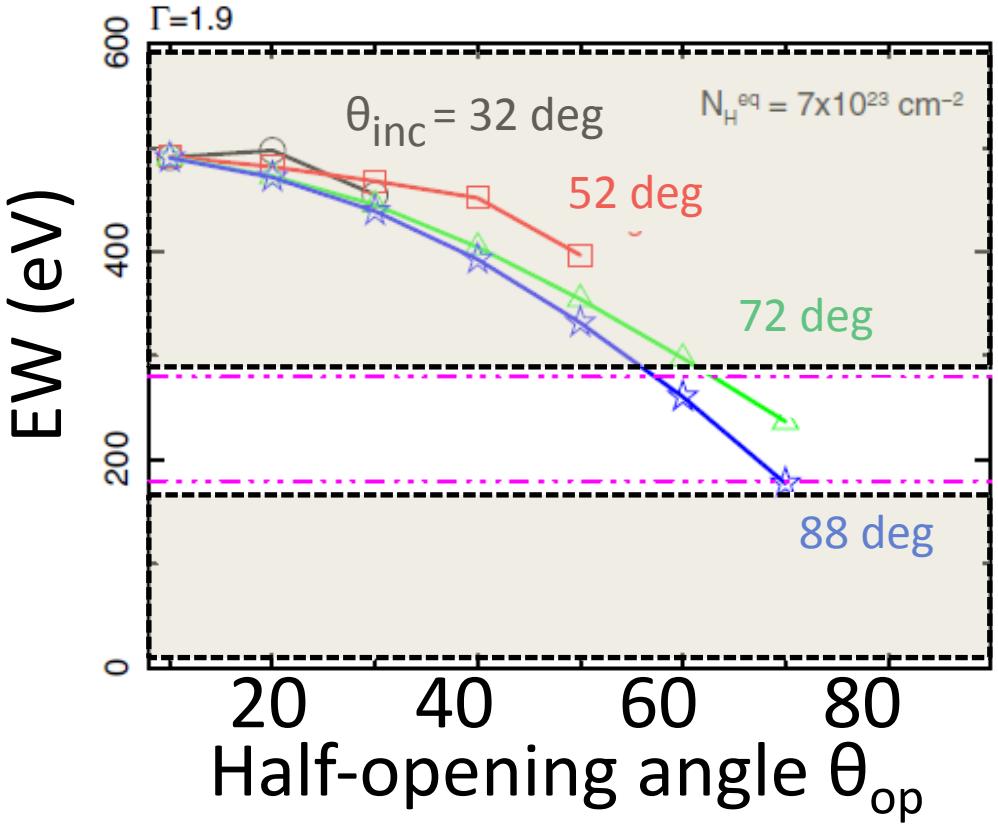


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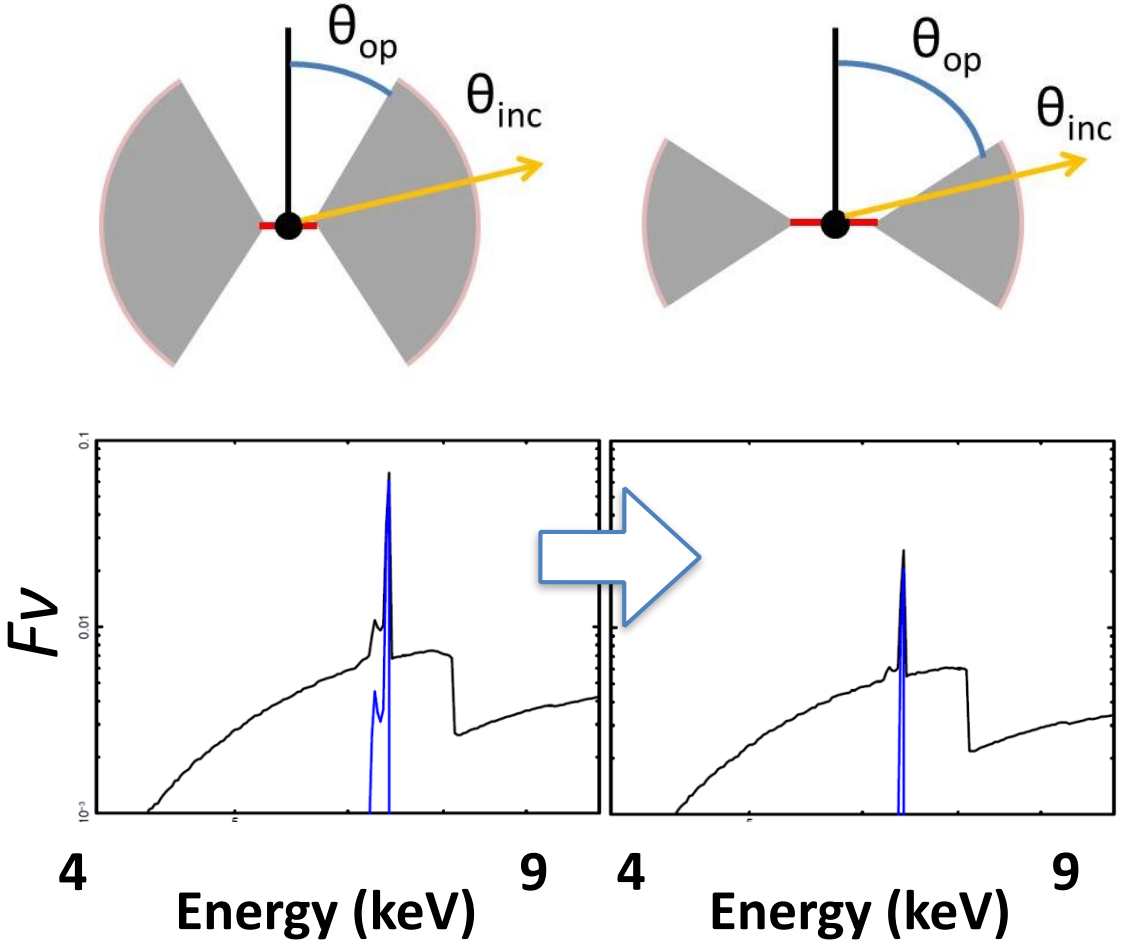

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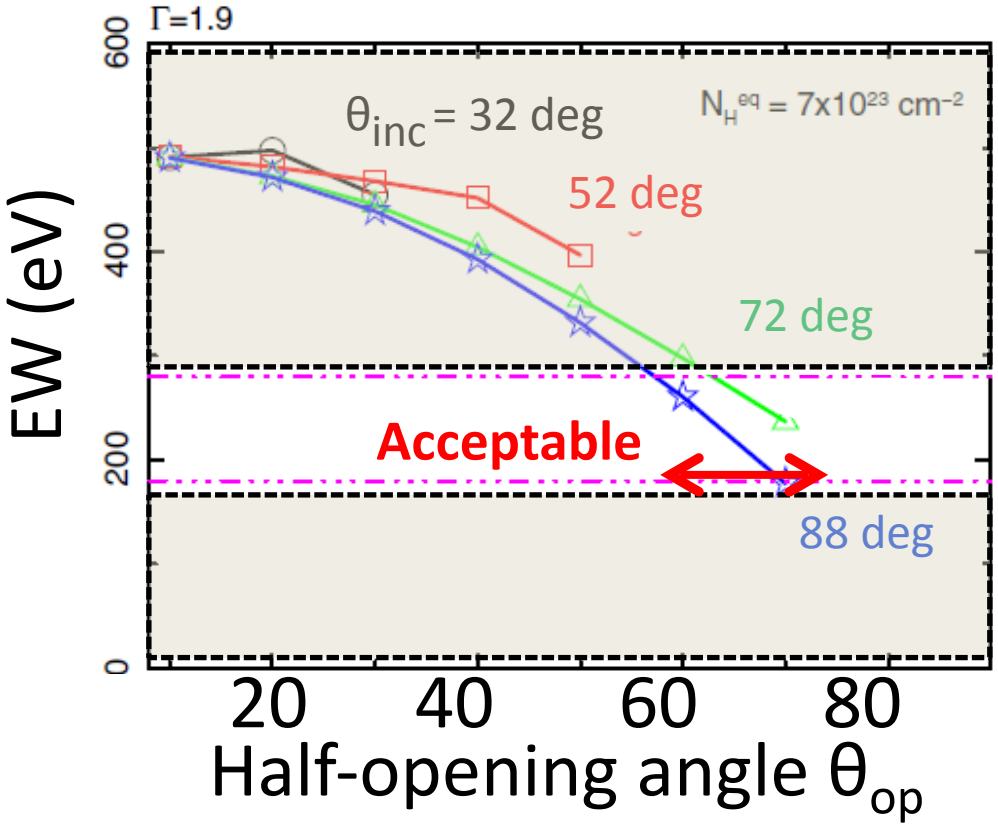


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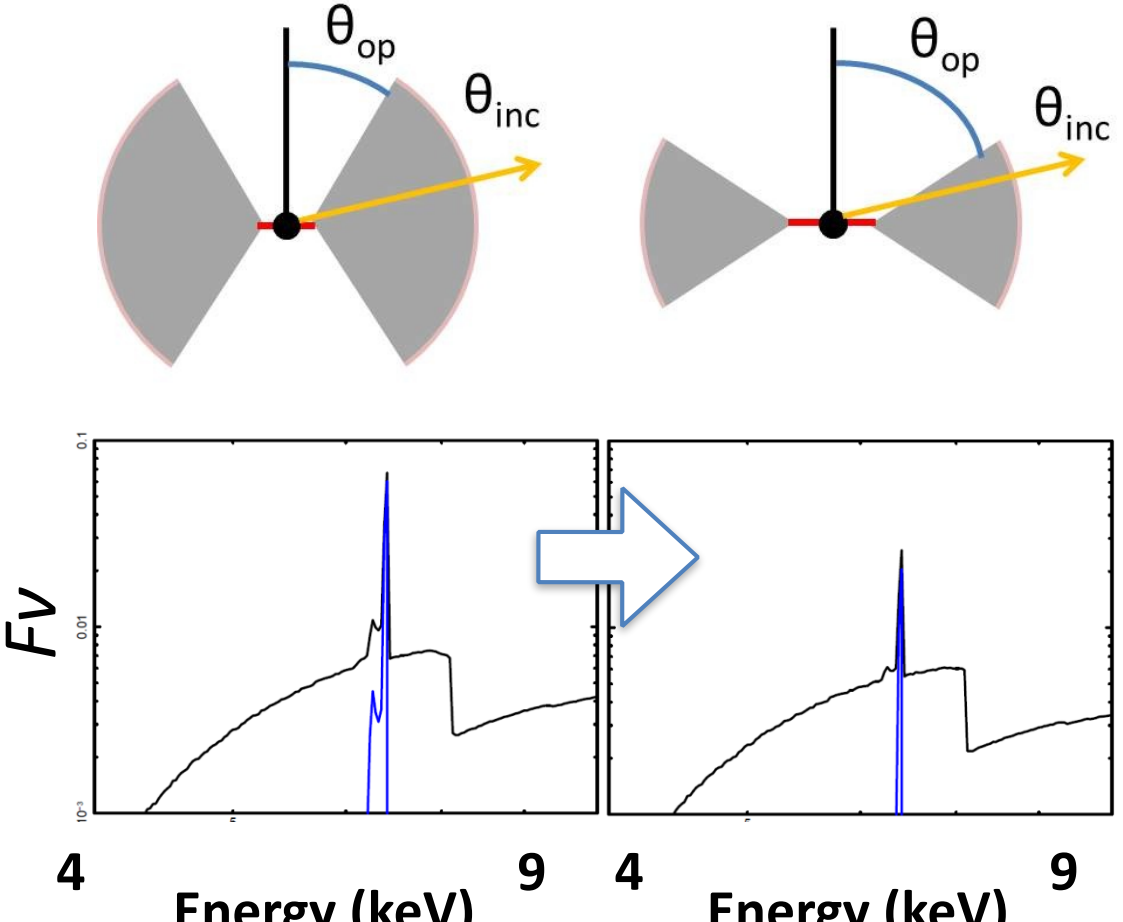
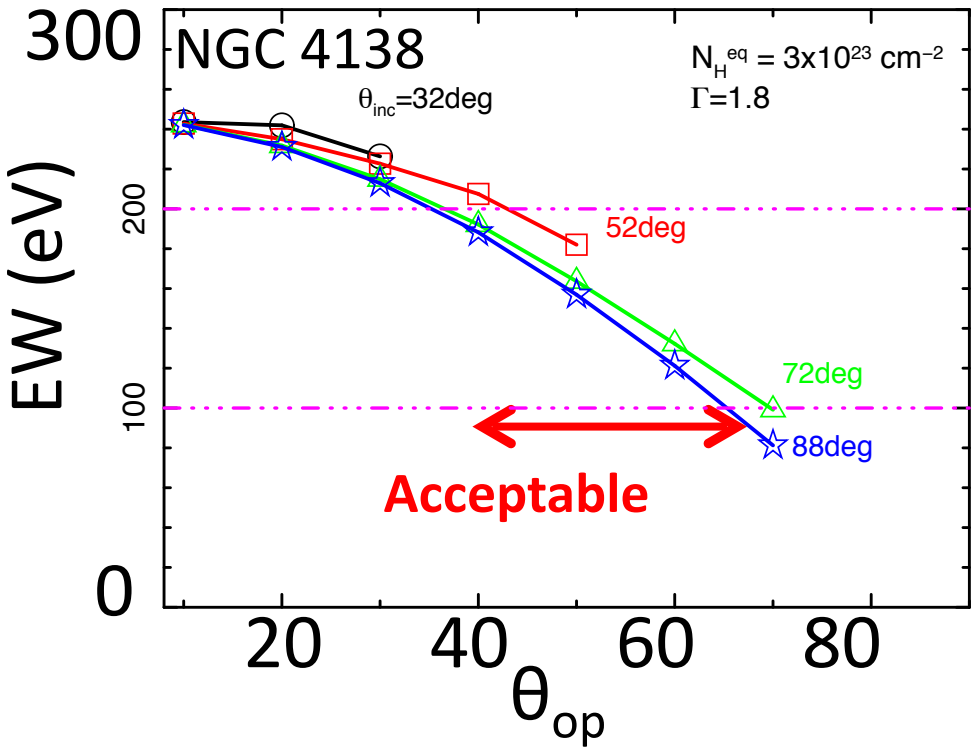
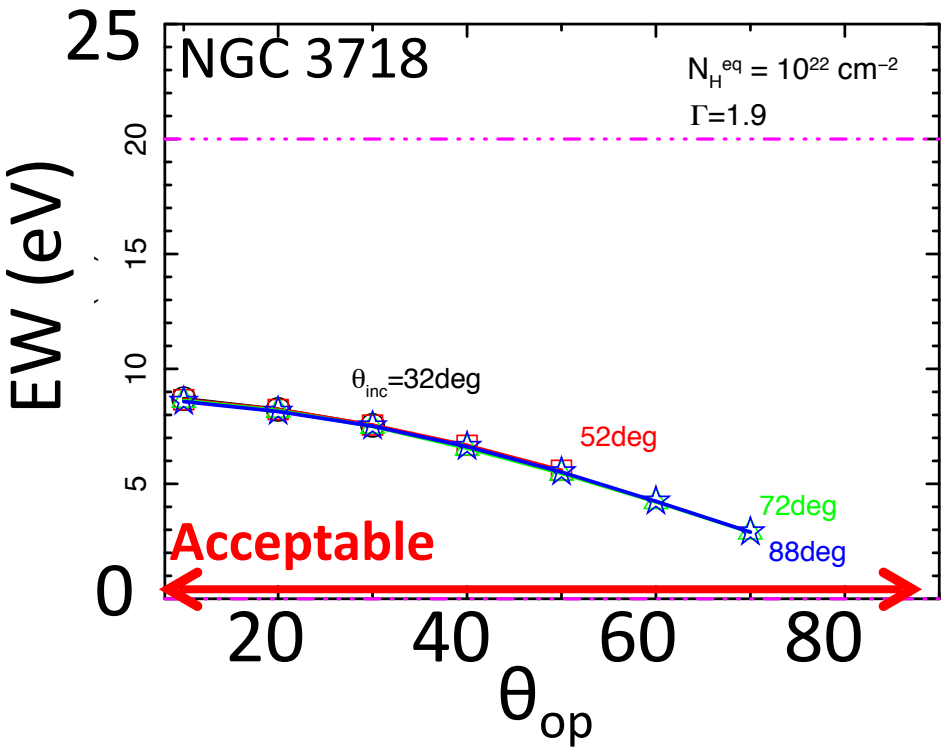


# Results Based on Torus Model

1) Six LLAGNs showing the iron line.
   → Torus is developed (θop < 70° or log $N_H^{eq} \gtrsim 23$).

2) NGC 3718 and NGC 3998
   → No significant iron line is detected.



# Results Based on Torus Model

1) Six LLAGNs showing the iron line.

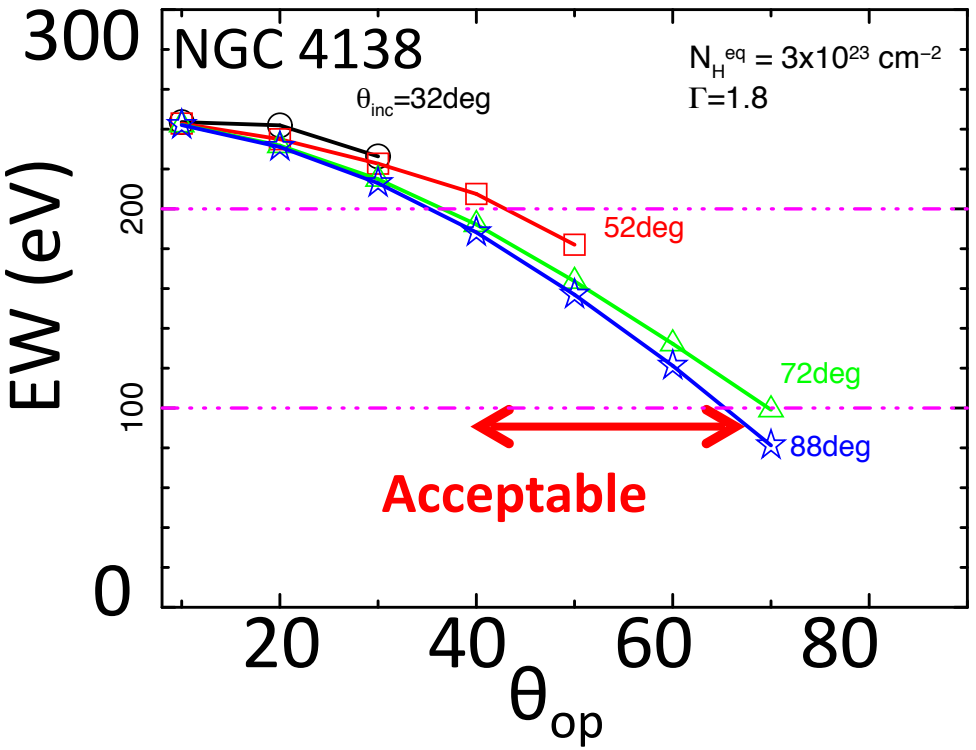
→ Torus is developed (θop < 70° or log $N_H^{eq}$ ≳ 23).

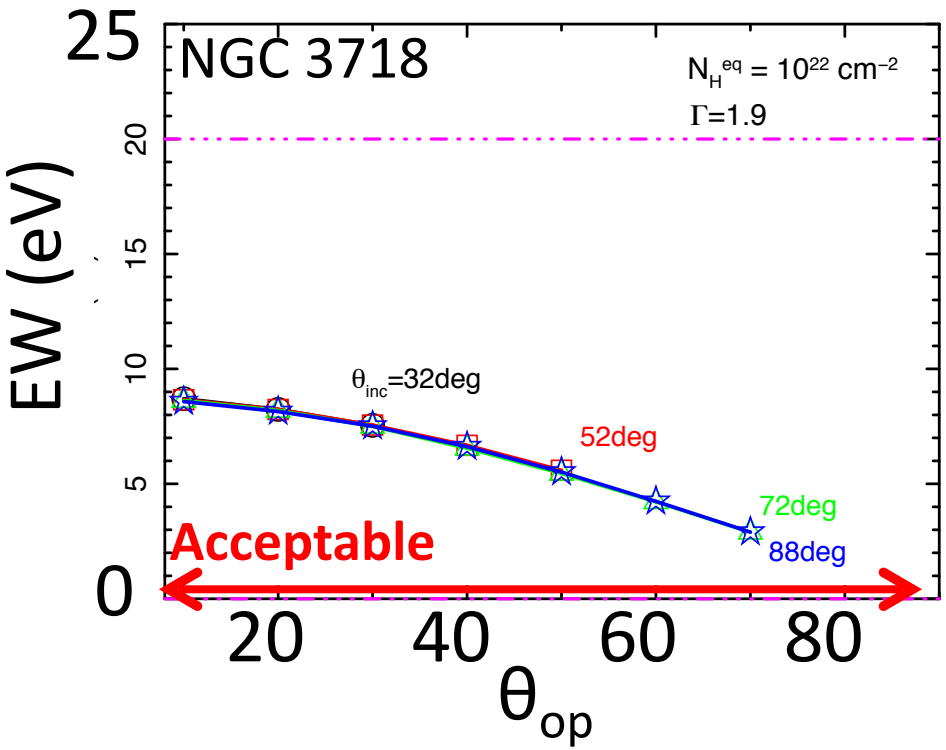
→ **Eddington ratio > 2x10$^{-4}$.**

2) NGC 3718 and NGC 3998

→ No significant iron line is detected.

→ **Eddington ratio < 2x10$^{-4}$.**



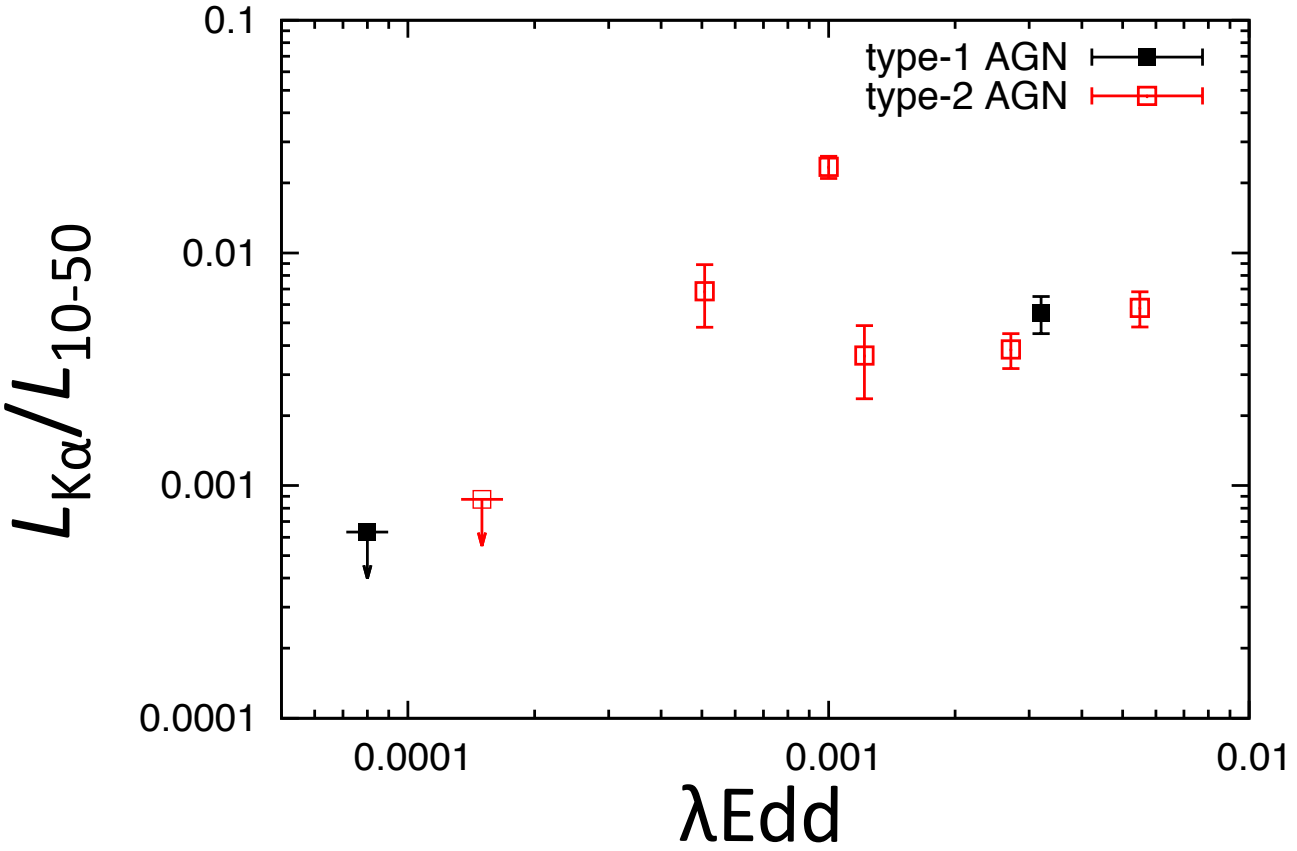



# Eddington ratio dependence

- **Eddington ratio** (**$2 \times 10^{-4}$**) can divide our LLAGNs into two types of AGNs:

(1) the torus is small and little mass accretion takes place

(2) the torus is moderately developed and a sufficient amount of gas is supplied to the black hole.



# Summary

- The good quality broadband spectra obtained with *Suzaku* and *Swift*/BAT constrain the half opening angle in six LLAGNs showing iron Kα line.

- For LLAGNs, the important parameter governing the torus is not luminosity, but **Eddington ratio**.

- Our result suggests the two types of AGNs in LLAGNs:
  (1) the torus is small and little mass accretion takes place
  (2) the torus is moderately developed and a sufficient amount of gas is supplied to the black hole.