X-Ray Observations of Active Galactic Nuclei with Relativistic Jets

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Co-Evolution of Galaxy & Central Black Hole

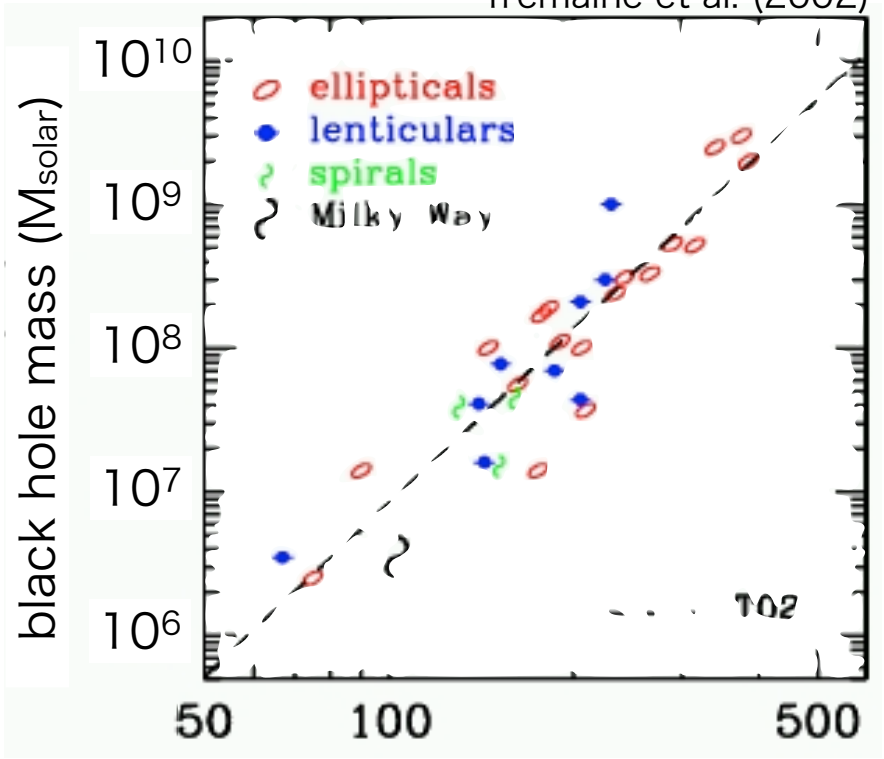
Almost all galaxies have supermassive black hole.

$M_{BH} = 10^6 - 10^9\ M_{solar}$ ($M_{solar} = 2 \times 10^{33}$ g)

Correlation of black hole mass and galaxy mass

→ **Black hole growth = galaxy evolution**

Tremaine et al. (2002)



Active Galactic Nuclei (AGN)

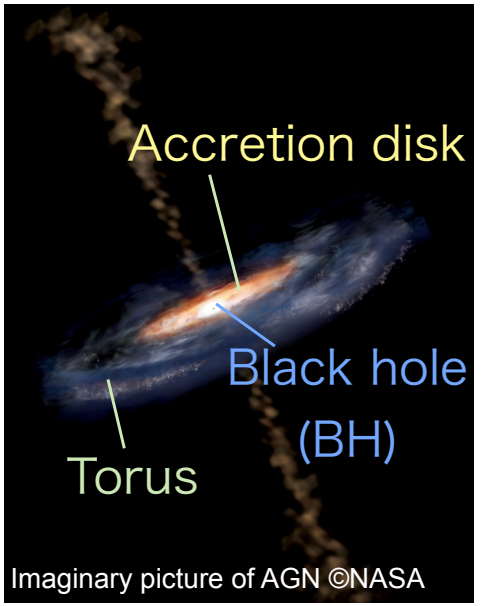
Active gas accretion

↓

Growing state of BH

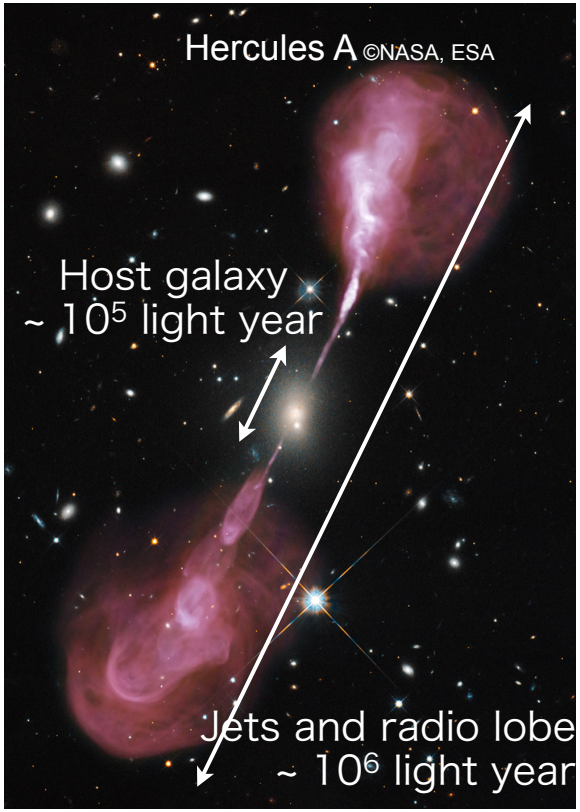
↓

Key of galaxy evolution



AGN Feedback to the galaxy

Galaxy
- AGN
  - with Jet (~10% of AGNs)
  - without Jet
- no-AGN



AGN jets stop the star formation in the host galaxy(?).

⬇

AGN with jets: key object to understand the AGN feedback to galaxy evolution.

⬇ BUT...

Structure of the central engine in AGNs with jets is not known well.

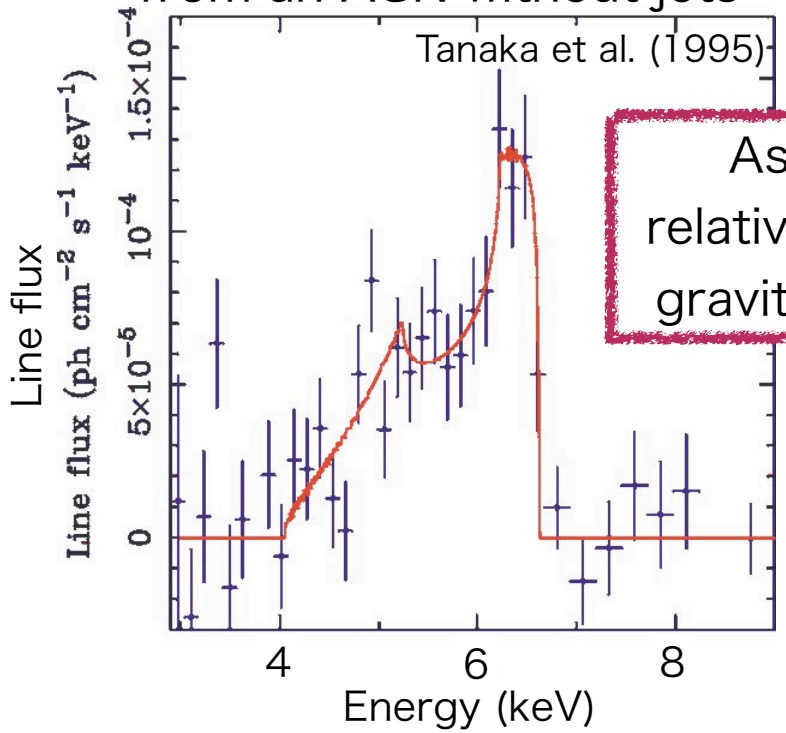
X-Ray Study of Central Part in AGN

Around black hole: high energetic space

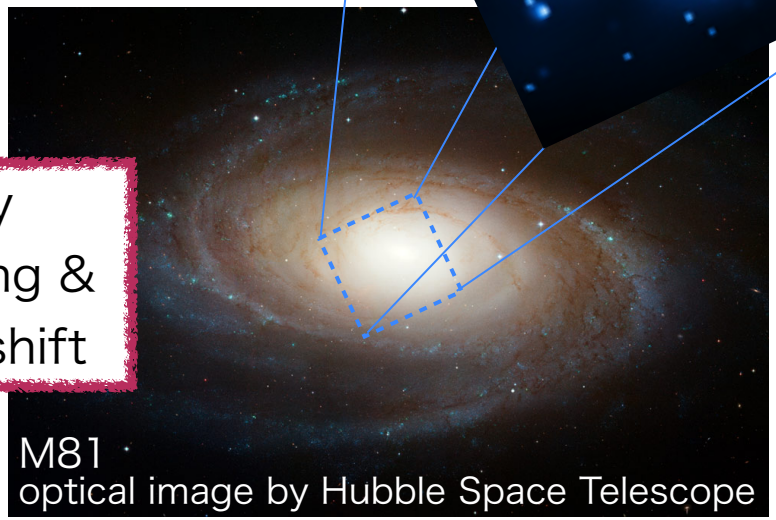
(Gravitational potential energy ~ GeV @ ~ 1 R_s)

(Schwaltzschild radius R_s; gas velocity ~ speed of light)

Fluorescence line of Fe-Kα @ 6.4 keV
from an AGN without jets



Asymmetry by
relativistic beaming &
gravitational redshift



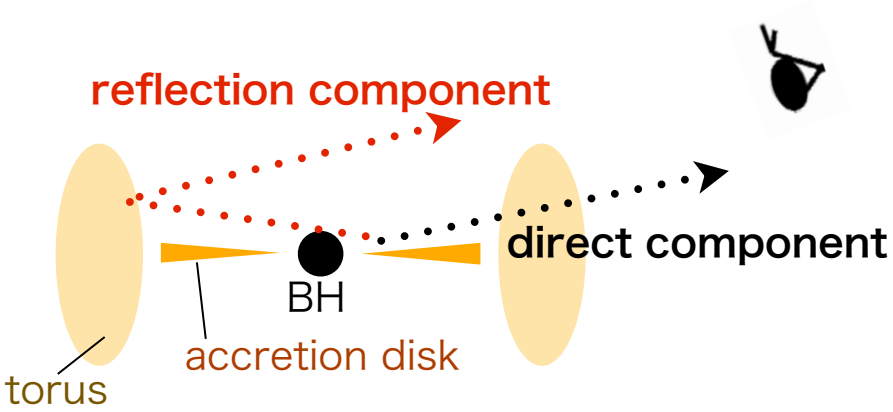
Difference of inner part of accretion disk between AGNs with jets and without jets?

Line emission from inner part of cold accretion disk in AGN without jets.

➡

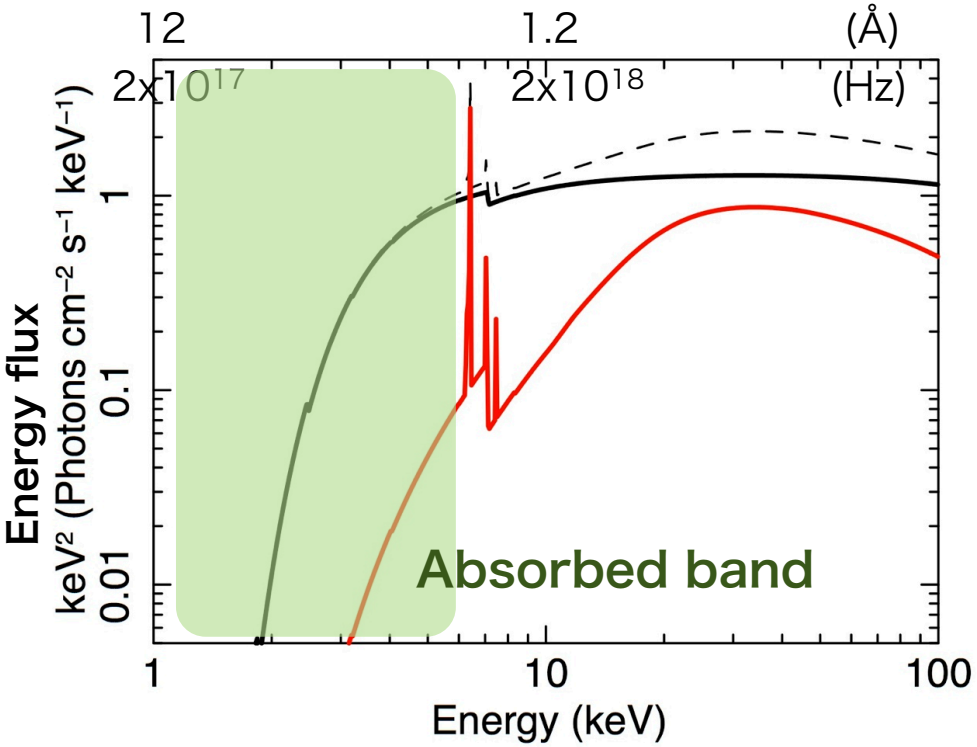
X-ray emission line has the information on relativistic field.

X-Ray Study of Torus, Surrounding Central Engine



Hard X-ray transmits the torus.

→ **Signal detection of obscured AGN**



Information from X-ray spectrum

- **torus absorption**
- **torus reflection**

➡ **Suggest the torus structure**

Torus: gas supply to black hole

Important factor to clear the galaxy evolution

X-ray Study of AGN with Relativistic Jets

- What is the difference between AGNs with jets and without jets?

Inner part of accretion disk

Relativistic space close to black hole

Surrounding torus structure

Key of black hole growth and galaxy evolution

Study of AGN with Jets

Targets of AGNs with Jets

4C 50.55 (type 1); bright source
Tazaki et al. (2010), ApJ, 721, 1340

Physical properties of hot corona.
Accretion disk geometry.

3C 403 & IC 5063 (type 2)
Tazaki et al. (2011), ApJ, 738, 70

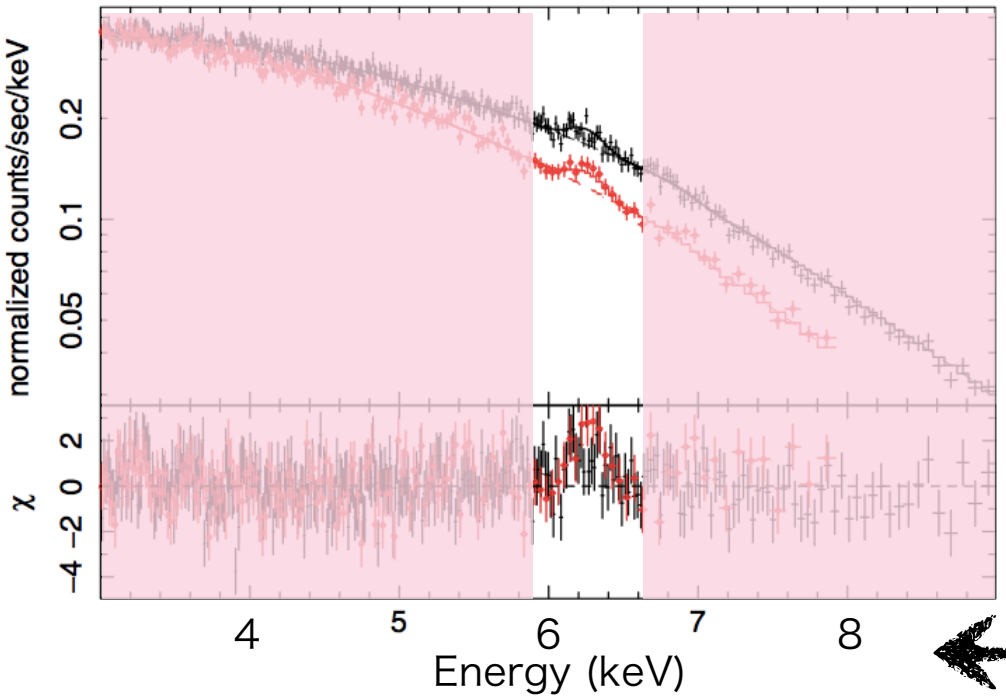
Torus geometry and
amount of scattering gas.

3C 206 (type 1) & PKS 0707-35 (type 2);
luminous source
Tazaki et al. (2013), ApJ, submitted

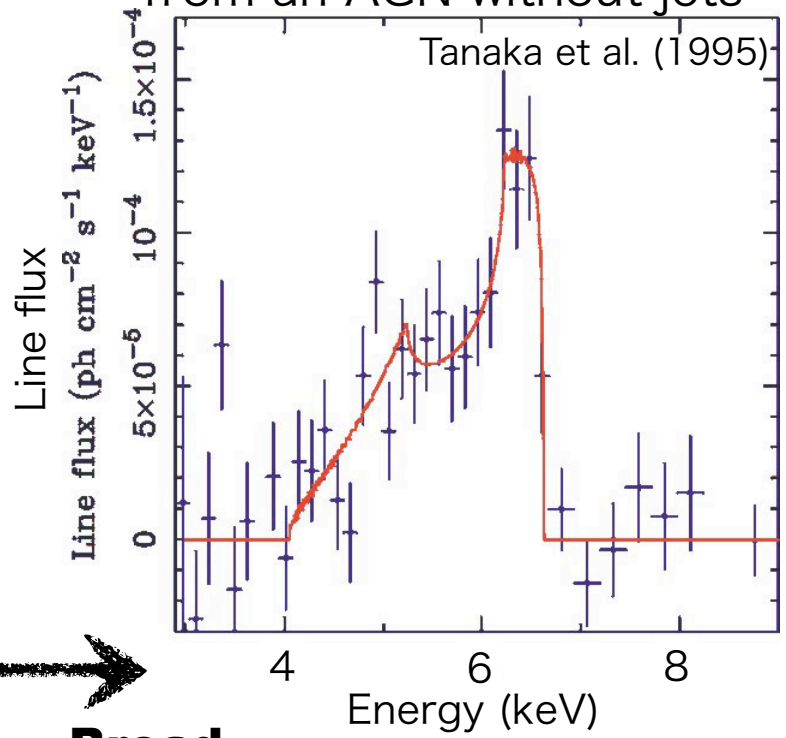
Detailed study of torus geometry
in the luminous AGN with Jets.
(Unknown relation between the AGN
structure and the central engine power.)

Inner Part of Accretion Disk

Suzaku/XIS spectrum



Fluorescence line of Fe-Kα @ 6.4 keV from an AGN without jets



Narrow **Broad**

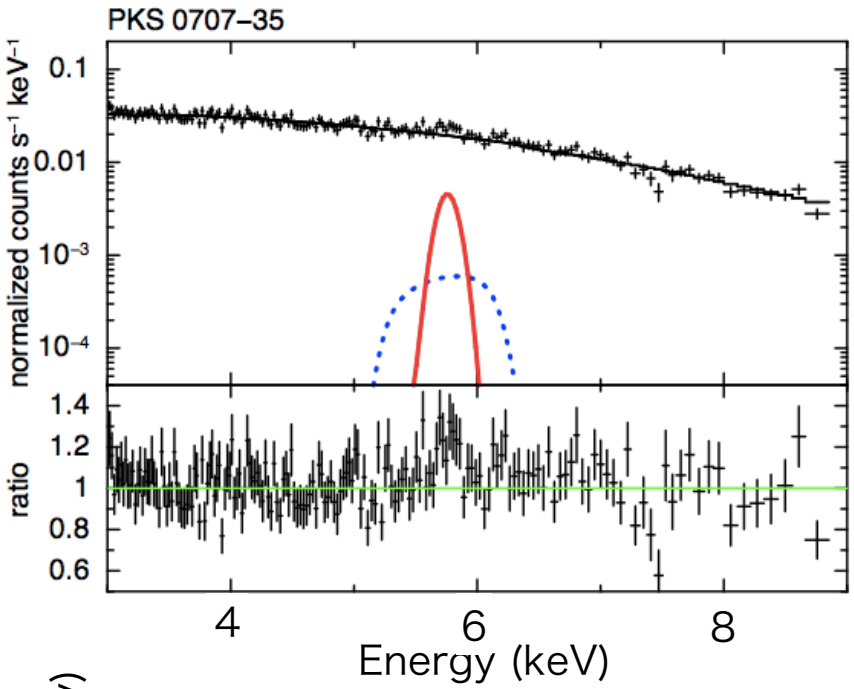
Inner radius of accretion disk

R_{in} > 100 R_s (R_s = 2GM/c^2)

Truncated disk
(R_{in} ~ 6 R_g; innermost stable orbit)

Cold accretion disk in AGN with jets is truncated, and does not expand close to the black hole.

Torus Structure of Luminous AGNs



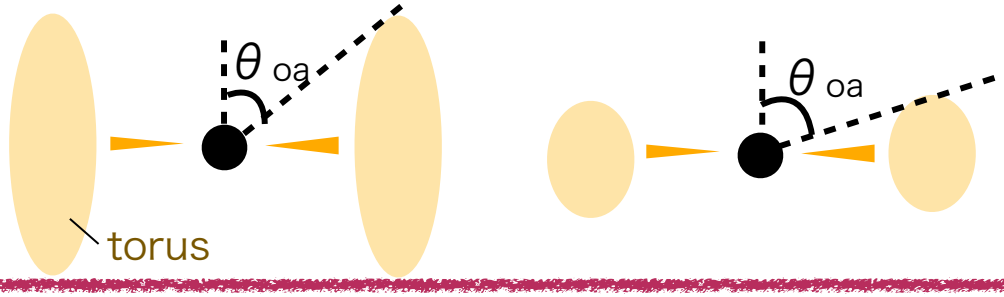
Reflectors:

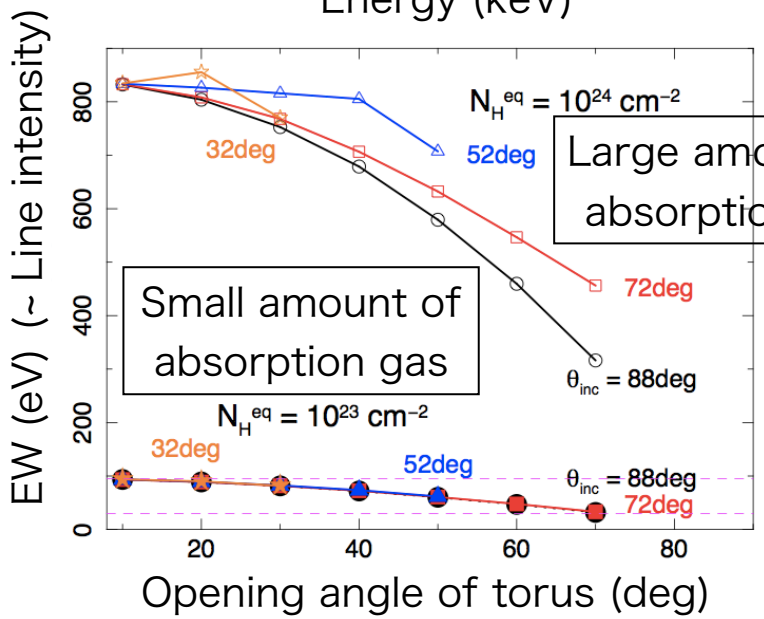
- **torus (narrow line)**
- **accretion disk (broad line)**.

EW (~ line intensity) of narrow line confines torus size

equivalent width (EW)

(line intensity normalized with continuum flux)





Large amount of absorption gas

Small amount of absorption gas

Small amount of absorption gas in torus and/or **small size torus**

Luminous AGNs evaporate the gas and dust in the torus?

Summary
~ X-Ray Study of AGN with Relativistic Jets ~

- Study of active galactic nuclei (AGN) spouting jets with X-ray satellite *Suzaku*.

- AGNs with jets (possibly):

  - have truncated accretion disk (bright AGN; 4C 50.55)
    Related to the mechanism of jet ejection (?)

  - have a trend that luminous AGNs have small torus (luminous AGNs with jets; 3C 206 and PKS 0707-35).
    Central source irradiation → Torus evaporation (?)

We need statistical study with larger sample!!