

Suzaku Observation of Compton-thick Active Galactic Nuclei Selected by Swift/BAT

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Introduction : Active Galactic Nucleus

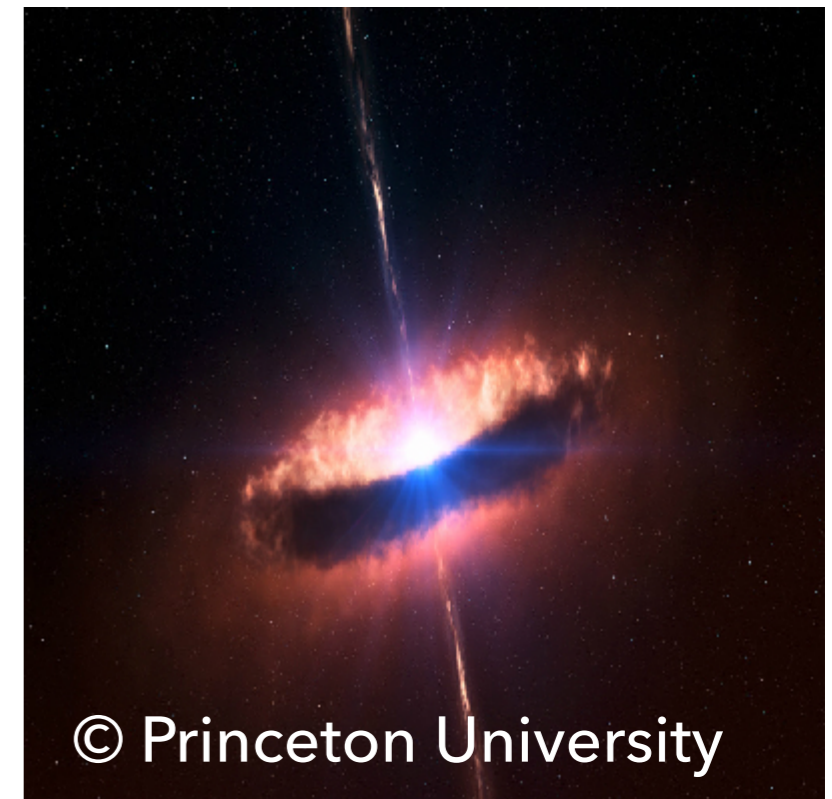
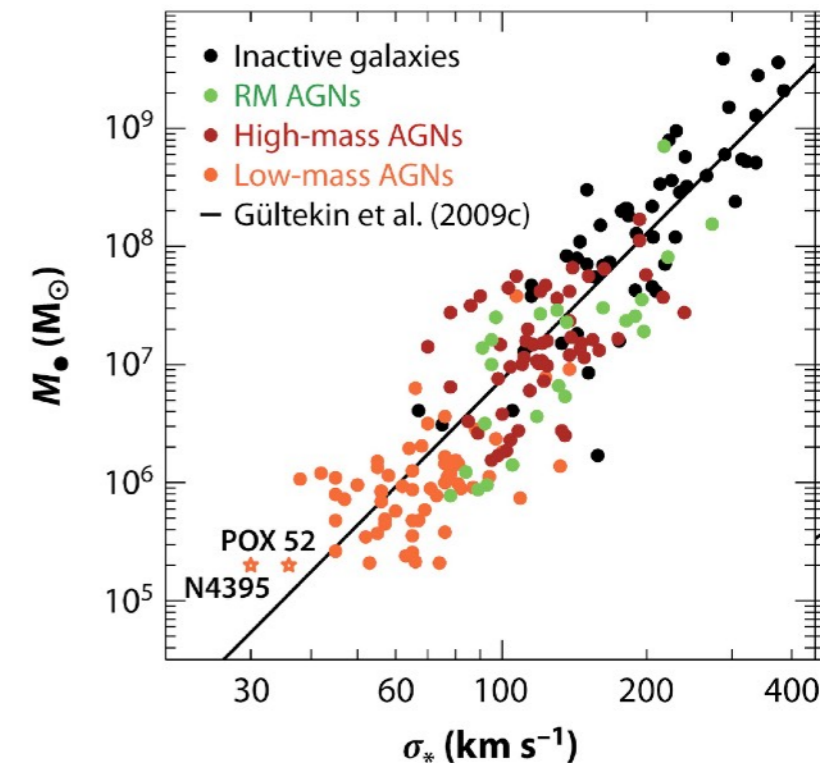
Super Massive Black Hole (SMBH)

- * Universally exists in galactic center
- * $M_{\text{BH}} = 10^6 - 10^{10} M_{\text{SUN}}$
- * Coevolution between SMBH and galaxy

Active Galactic Nucleus (AGN)

- * Emits from radio to gamma-ray
- * Mass accretion onto the SMBH
- * Enable to investigate the growth history

Kormendy & Ho 2013

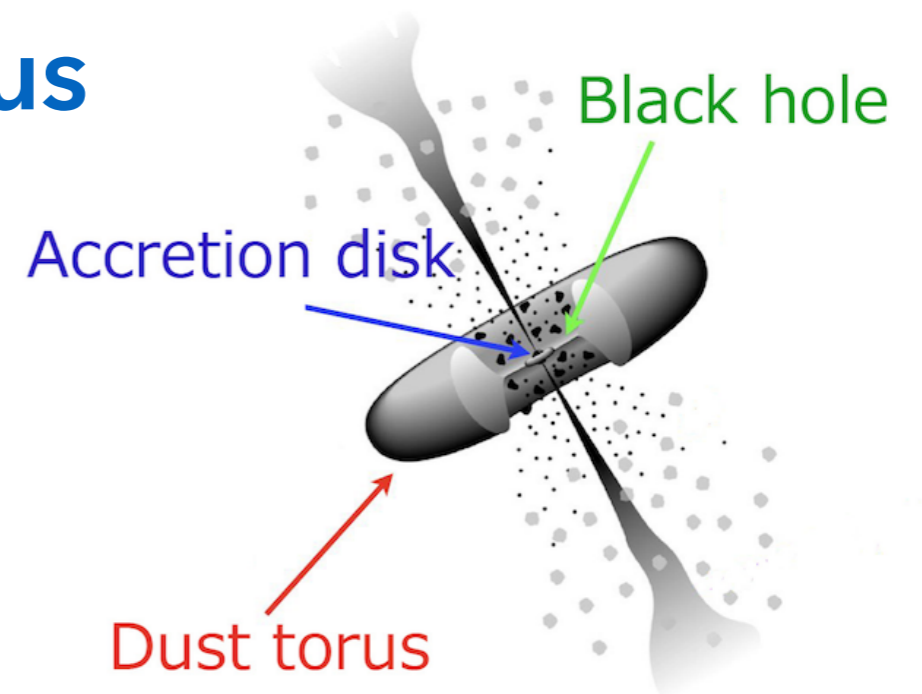


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Introduction : Structure of AGN

Structure of Active Galactic Nucleus

- * Super Massive Black Hole
- * and Accretion Disk at the center
- * Torus surrounds them (Antonucci 1993)



Role of Torus

- * Torus (1 pc) feed mass onto SMBH (10^{-6} pc) from galaxy (10^3 pc)
- * Key structure to understand coevolution
- * However, Torus structure is poorly understood

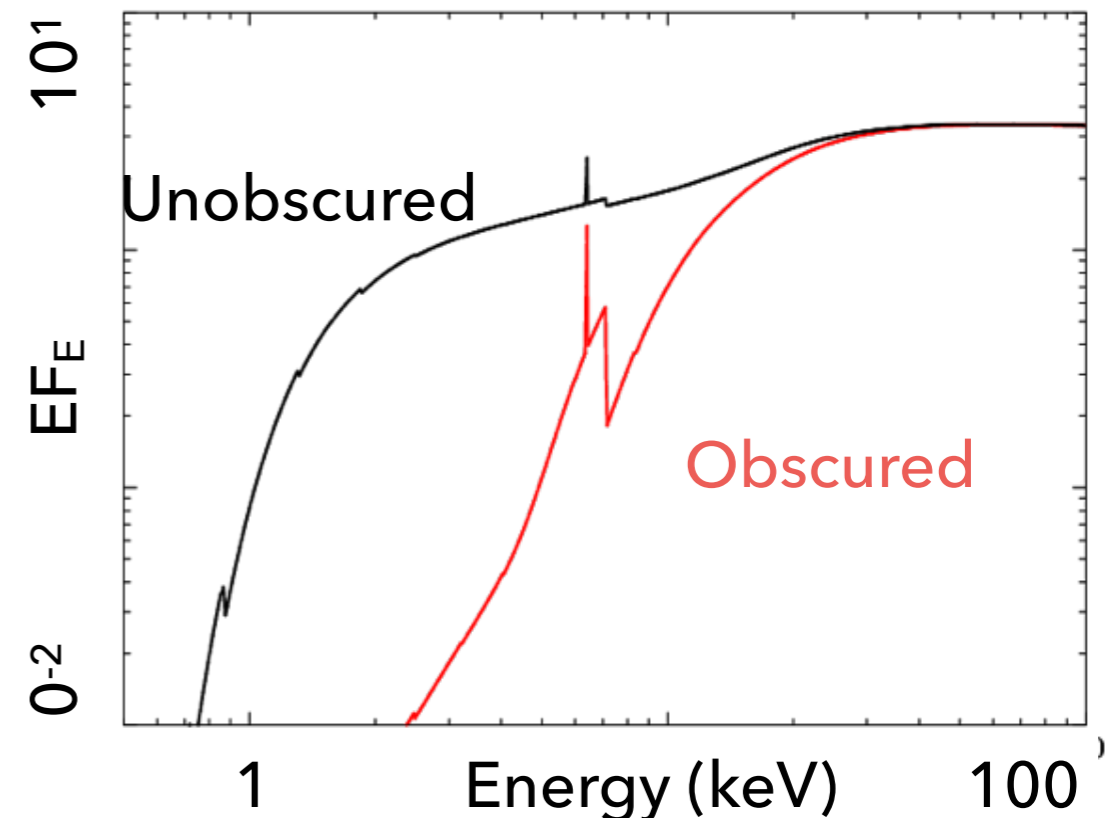
Introduction : Compton-thick AGN

Compton-thick AGN (CTAGN)

- * $\log N_{\text{H}}/\text{cm}^{-2} > 24$
- * Radiation strongly interact with Torus
- * Suitable to investigate the structure

To observe CTAGN

- * Photon are strongly absorbed
- * Need high penetration power
- * Useful approach is Hard X-ray

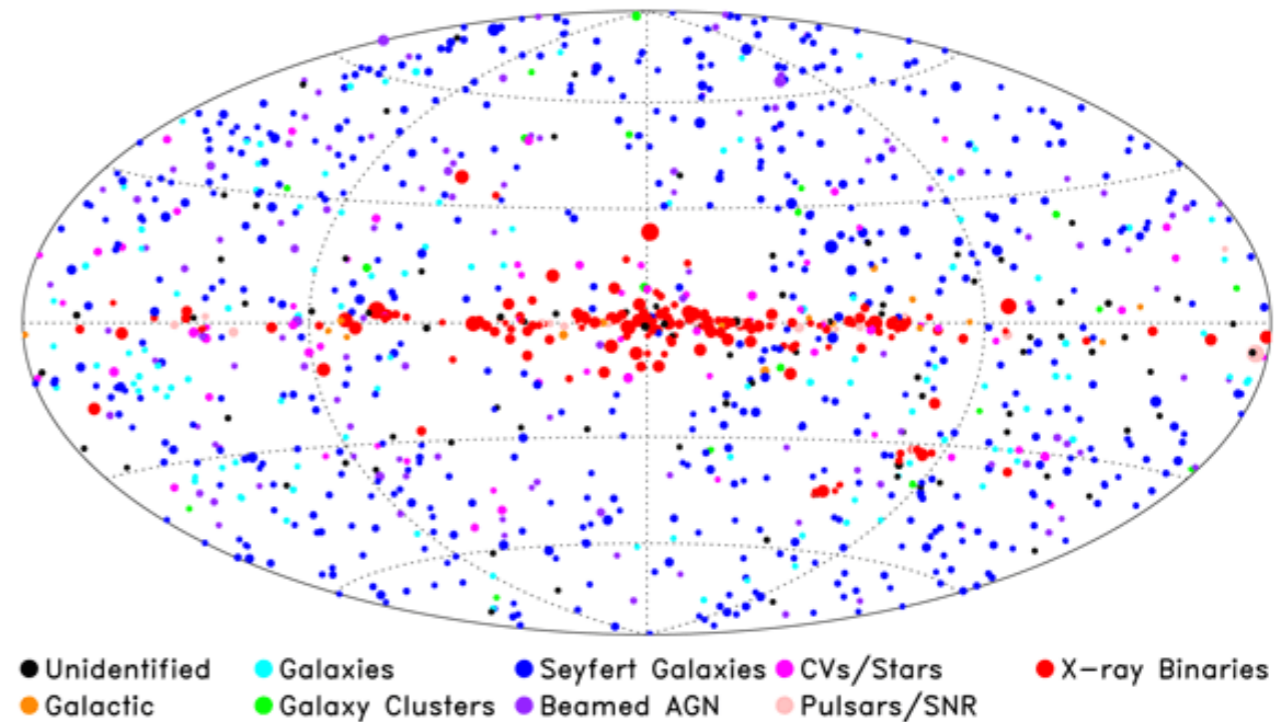


Introduction : Swift/BAT Hard X-ray Survey

Swift/Burst Alert Telescope

- * Hard X-ray survey (14-100 keV)
- * Swift/BAT 70 month catalog
- * (Baumgartner+13)

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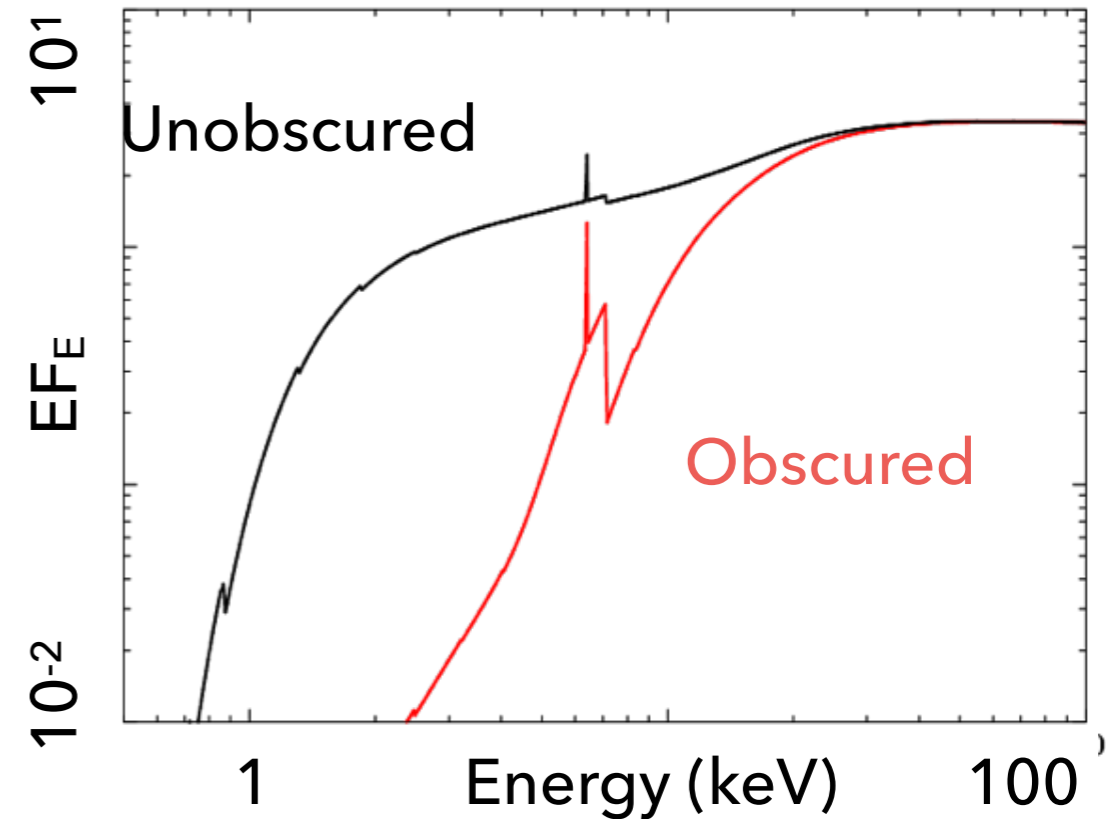
Catalog of Compton-thick AGN

- * 55 Compton-thick AGNs (Ricci+15)
- * They analyzed AGN data of Swift/BAT 70 month catalog
- * However, using data mainly from the Swift/XRT below 10 keV

Method : Broadband X-ray Observation

Broadband X-ray Spectrum

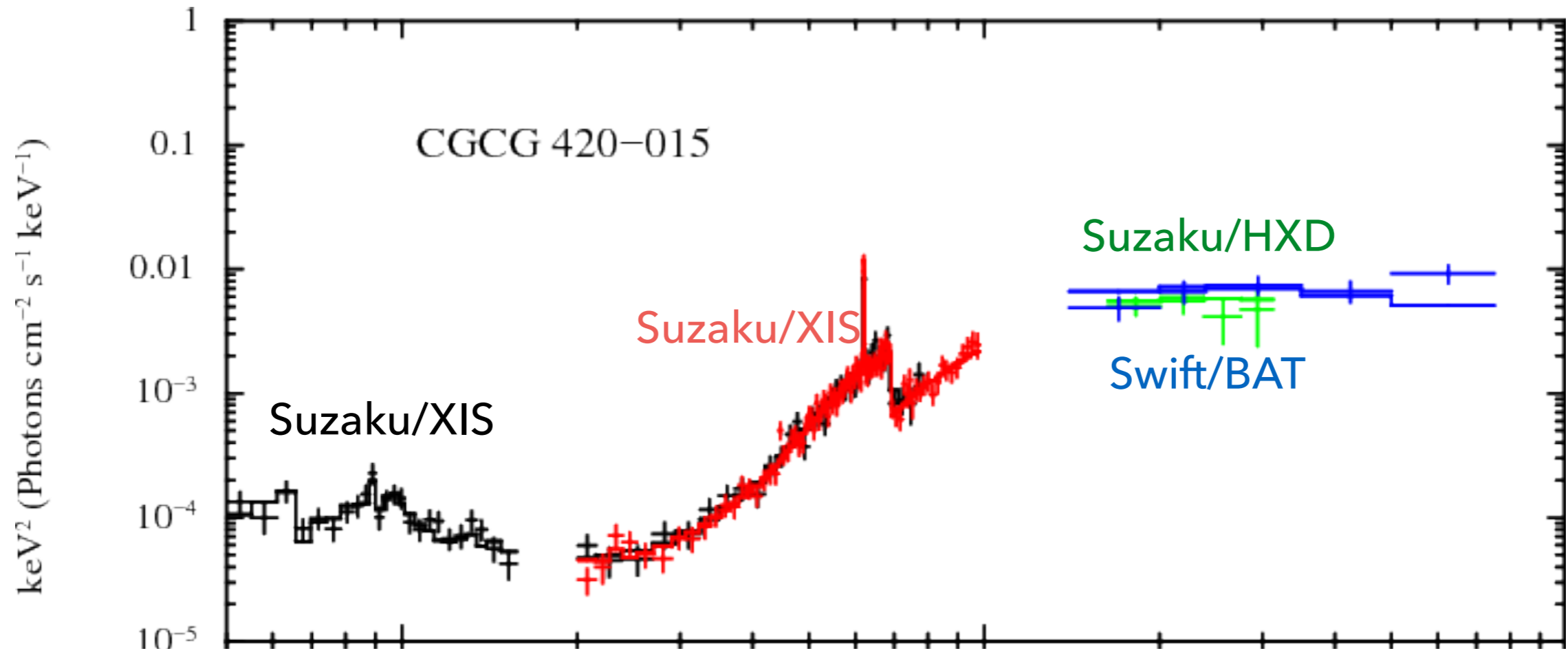
- * To constrain the Torus Parameters
- * Need broadband X-ray spectrum
- * Focused on X-ray satellite Suzaku



Sample Selection

- * Suzaku/XIS (0.5-10.0 keV) & Suzaku/HXD (16.0-40.0 keV)
- * There are both observation data of Suzaku/XIS and Suzaku/HXD
- * Our sample is 12 Compton-thick AGN candidates

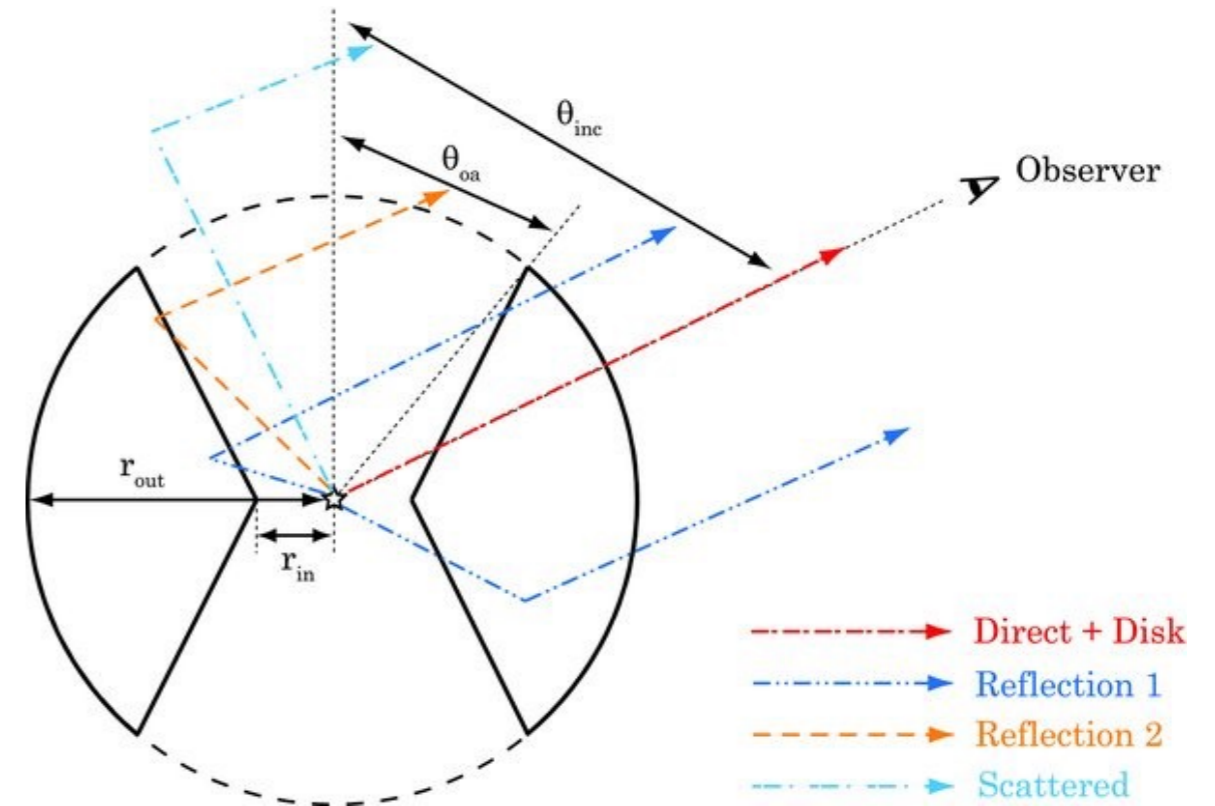
Results : Broadband X-ray Spectrum



Model : Ikeda Torus Model

Ikeda Torus Model

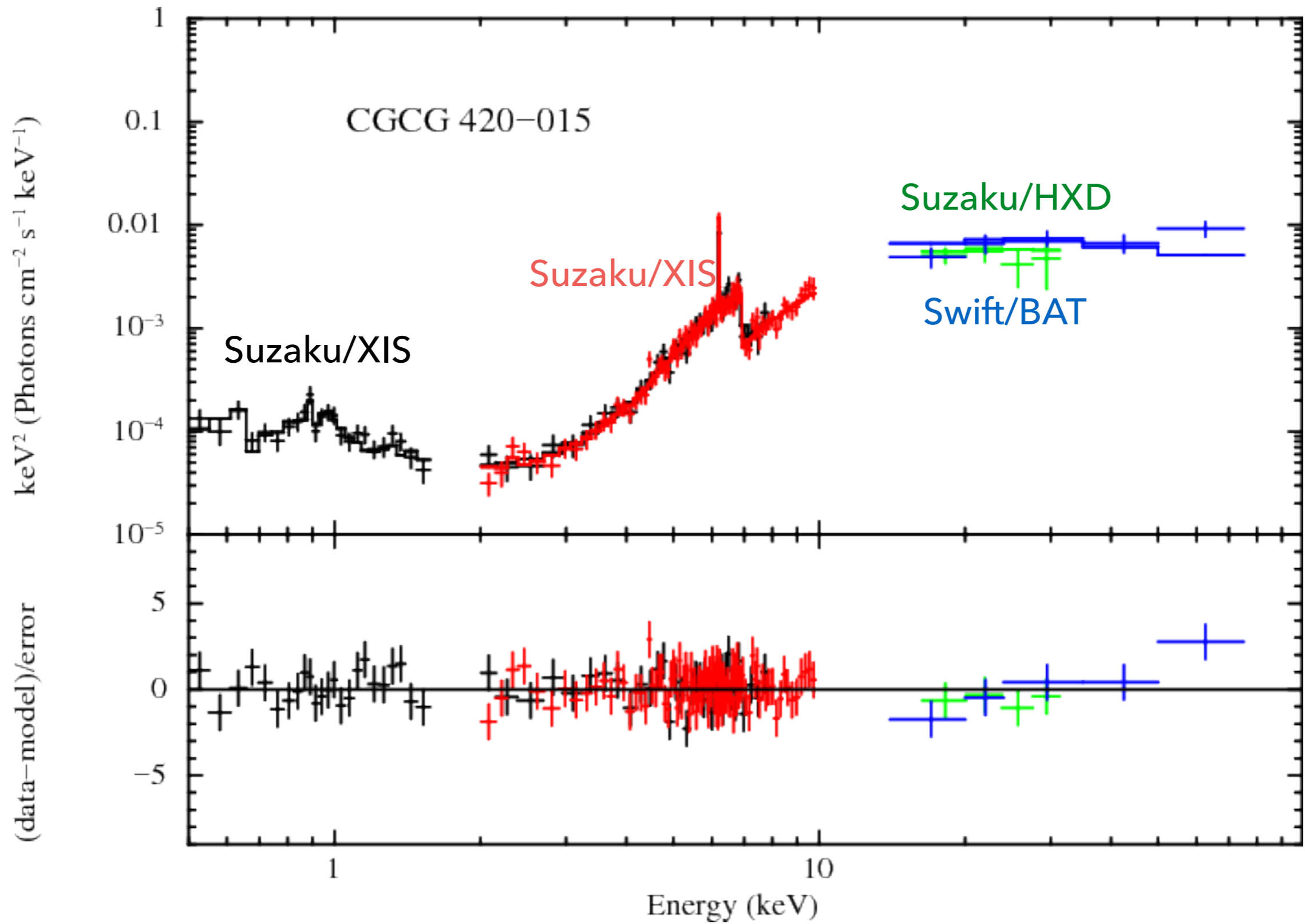
- * Torus model : Ikeda+09
- * Geometry : Partial spherical
- * Distribution : Smooth



Free Parameters

- * N_H : Hydrogen column density
- * θ_{incl} : Inclination angle
- * θ_{open} : Opening angle of the torus

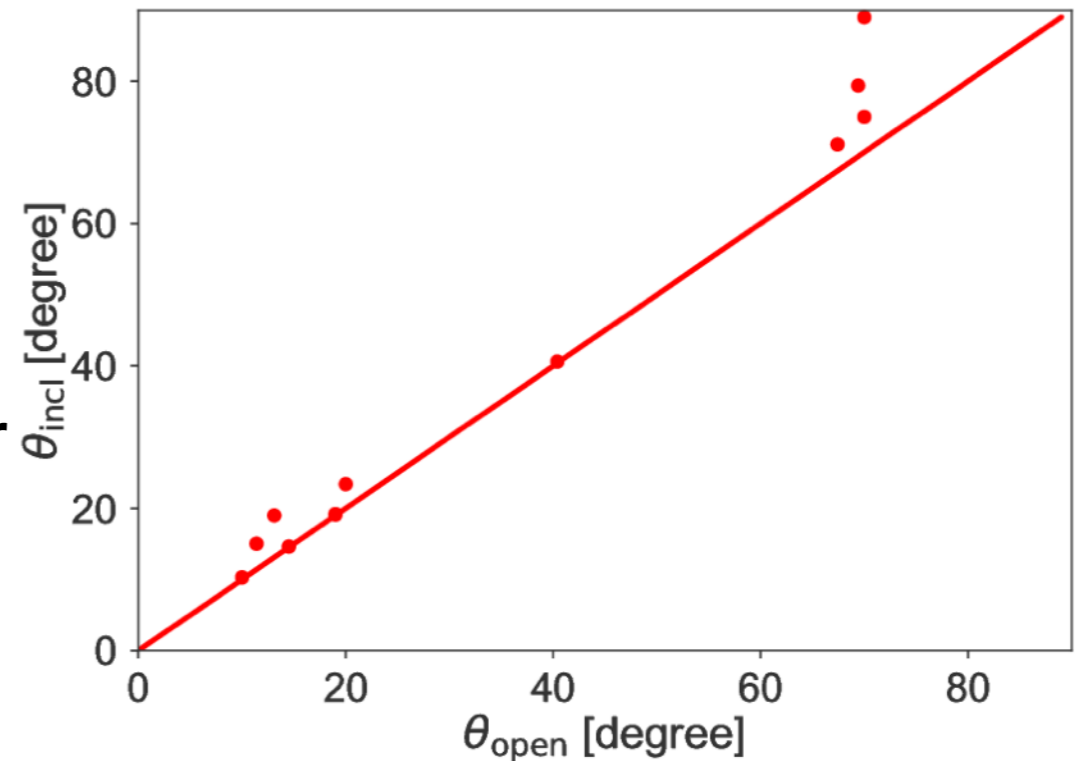
Results : Spectral Fitting



Discussion : Torus Structure

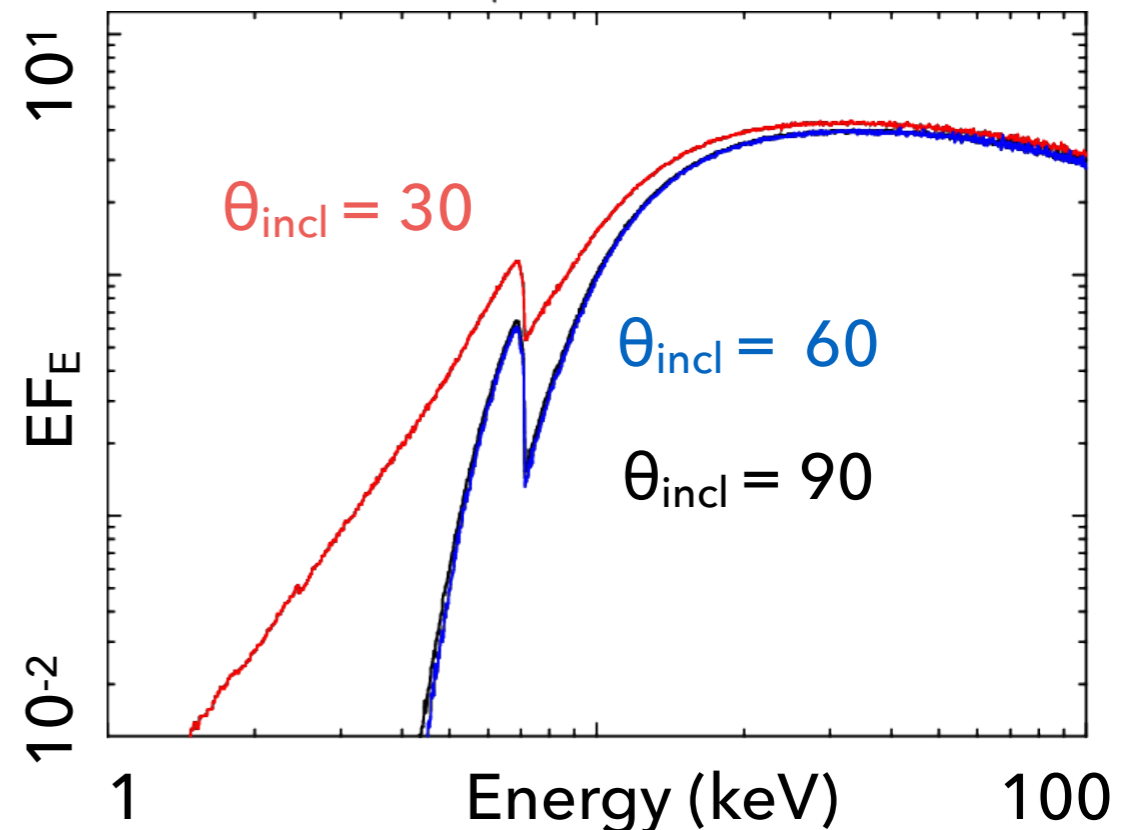
Torus Structure

- * Tight correlation?
- * These are independent parameter
- * Why?



Problem of Smooth Torus

- * Ikeda model : Smooth Torus
- * Dependence on the Inclination
- * Soft X-ray flux increase



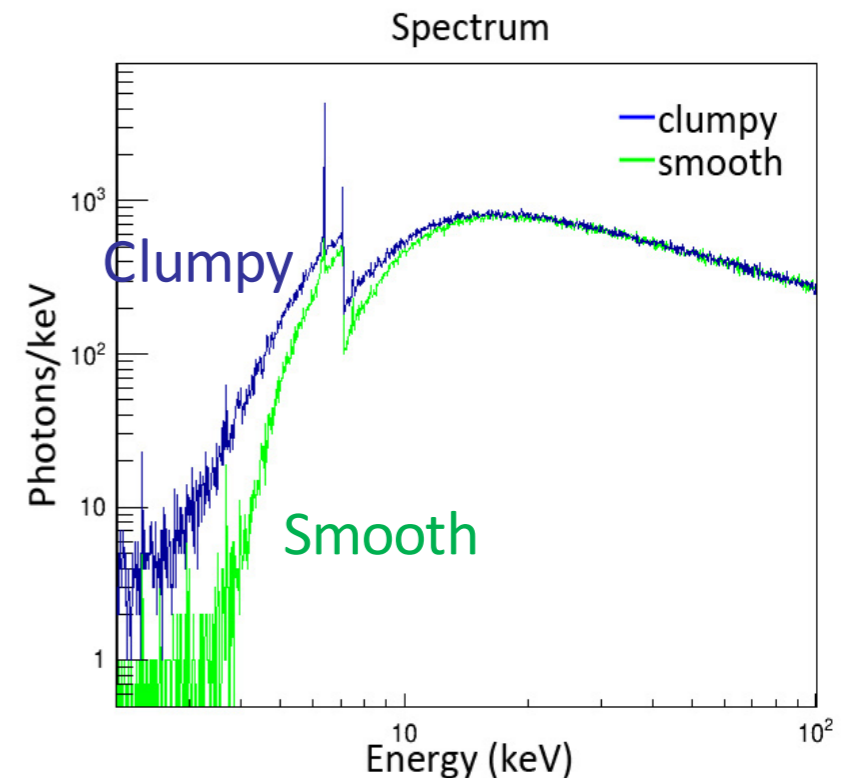
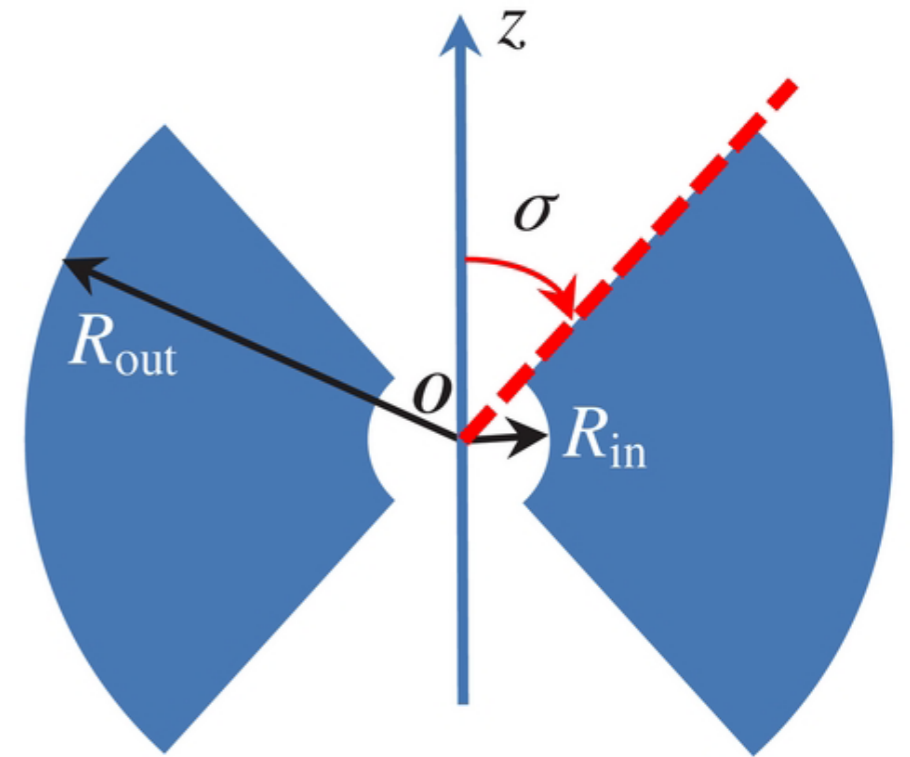
Discussion : Smooth Torus → Clumpy Torus

Smooth → Clumpy

- * Ikeda Torus : Smooth Torus
- * Smooth is not realistic (Nenkova+08)
- * Clumpy Torus is needed (Furui+16)

Clumpy Torus Model

- * Monte Carlo Simulation
- * Framework : MONACO (Odaka+11)
- * Reproducing the observed spectrum



Summary

- * Dust Torus is key structure to understand the coevolution.
- * Analyzed broadband X-ray spectra of 12 Compton-thick AGNs.
- * Found that the structure of the torus is clumpy.
- * It is necessary to make X-ray spectral model from clumpy torus.