Suzaku X-Ray Monitoring of Gamma-Ray-Emitting Radio Galaxy, NGC 1275

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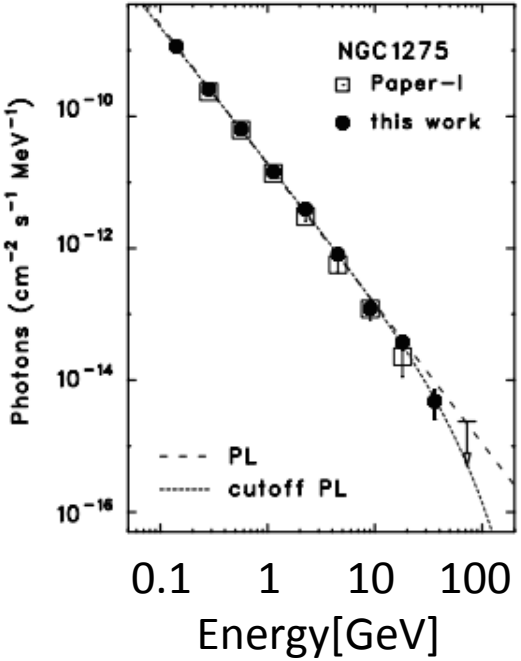
Introduction

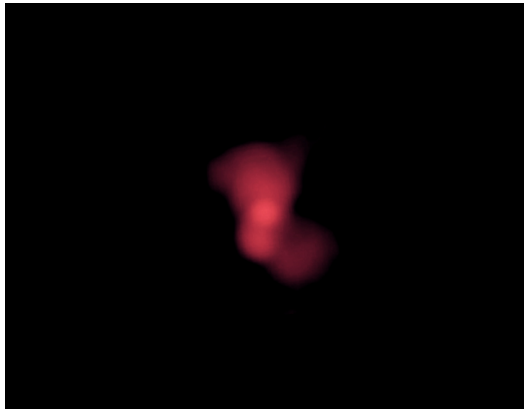
☆NGC 1275

・An elliptical galaxy, locating at the center of the Perseus cluster (z=0.0179)
・It is known as an AGN and classified as a radio-loud Seyfert galaxy or a radio galaxy.
・A viewing angle of apparent jet is about 30-55 deg (Walker+94).
・Fermi detected **GeV gamma-ray emission** for the first time (Abdo+09), and NGC 1275 is **the brightest in gamma-ray among radio galaxies**.

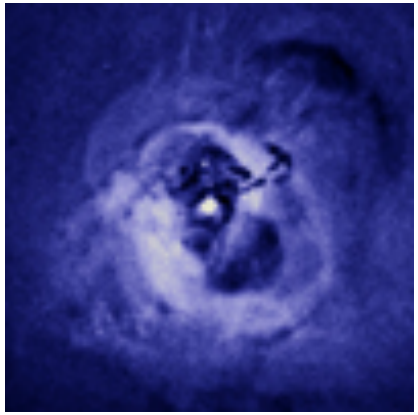
GeV Gamma-ray Spectrum
Kataoka+10



Optical (Hubble)



Radio (VLA)



X-ray (Chandra)

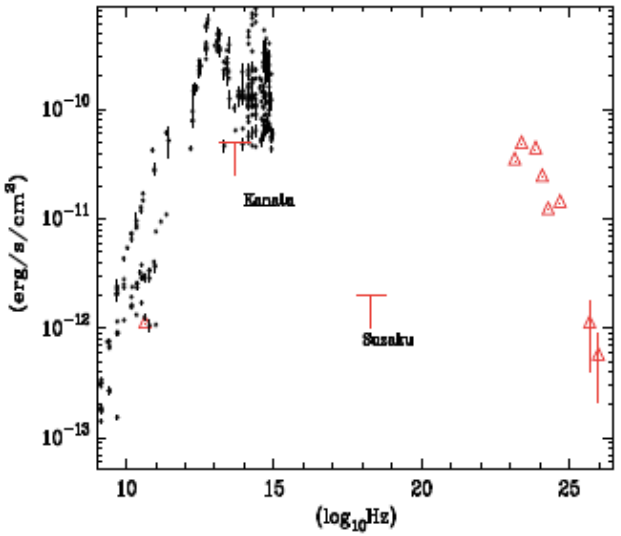
Past Observations

- Fermi observation showed **the time variation of GeV gamma-ray flux** with several months scale (Kataoka+10, Donato+10, Brown+11) and **TeV gamma-ray were detected** with MAGIC (Aleksic+10).
- The SED of NGC 1275 is reported to be explained by **the synchrotron self-Compton (SSC) model** (Abdo+09).

→However, optical and X-ray emission from jet has not been clear.

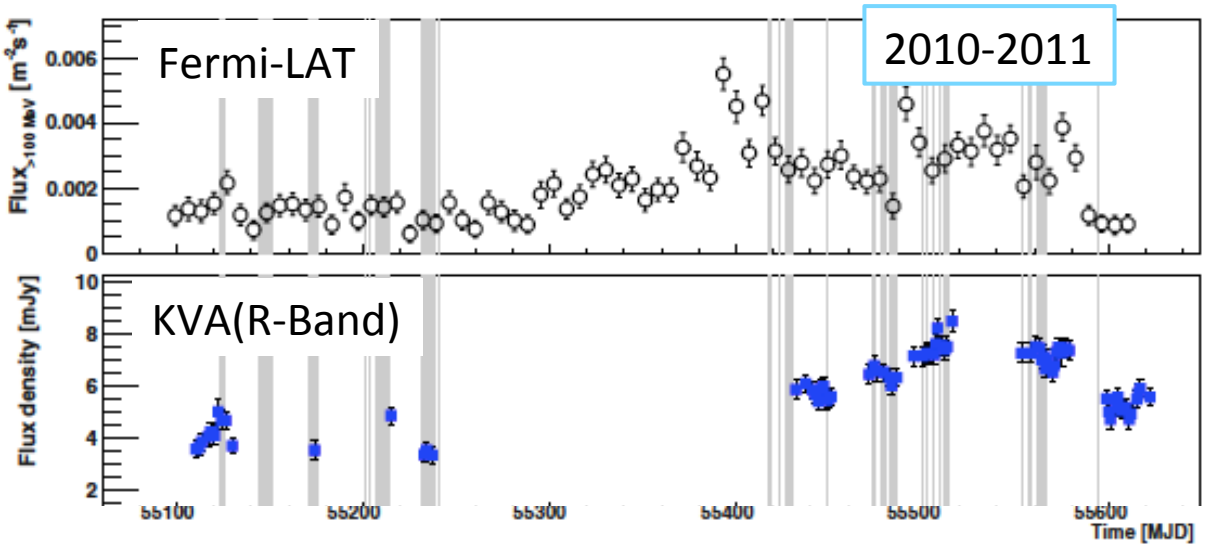
- Recently, **variability correlation between GeV and optical** was found. (Aleksic+14)

SED of the NGC 1275 nucleus



Yamazaki et al. 2013

Multifrequency Light Curve

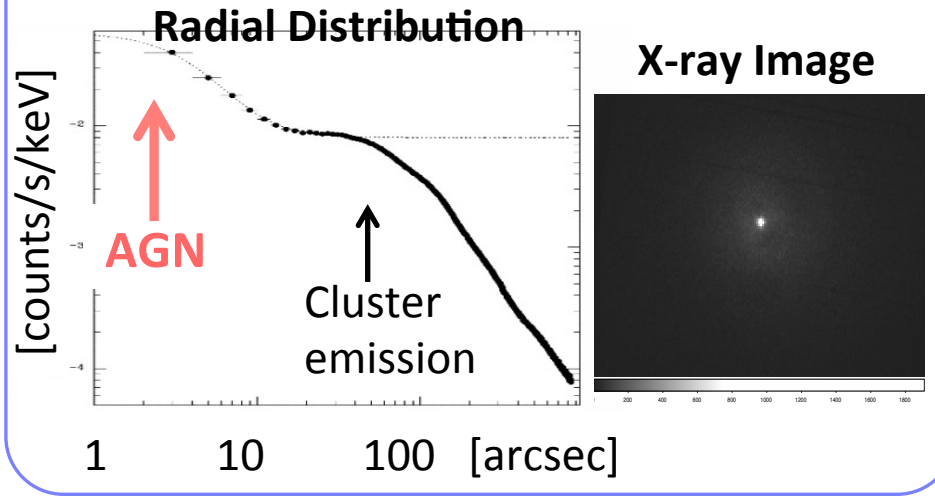


Aleksic et al. 2014

Past X-ray Observations

XMM-Newton

Flux $(1.43\pm0.29)\times10^{-11}$,
Γ 1.63 (0.5-8keV) (Churazov+03)



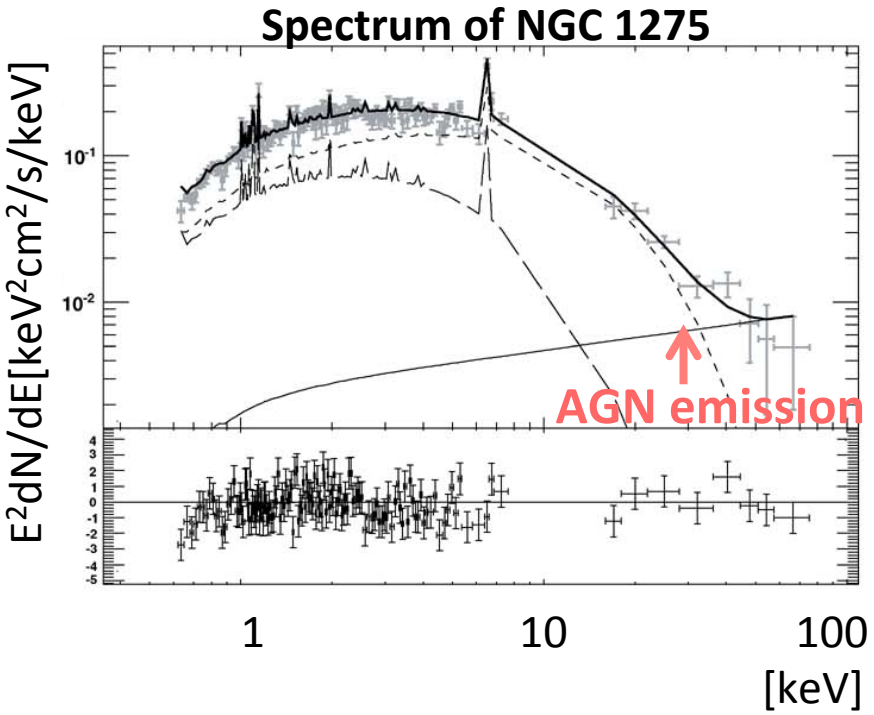
Chandra

Flux 6.1×10^{-12} , Γ 1.6±0.1 (0.5-5keV) (Balmaverde+06)

Chandra data suffer from pile-up for the nucleus.

Swift/BAT

Flux 1×10^{-11},
Γ 1.7(+0.3,-0.7) (15-55keV) (Ajello+09)



Swift/BAT could not resolve the nucleus spatially.

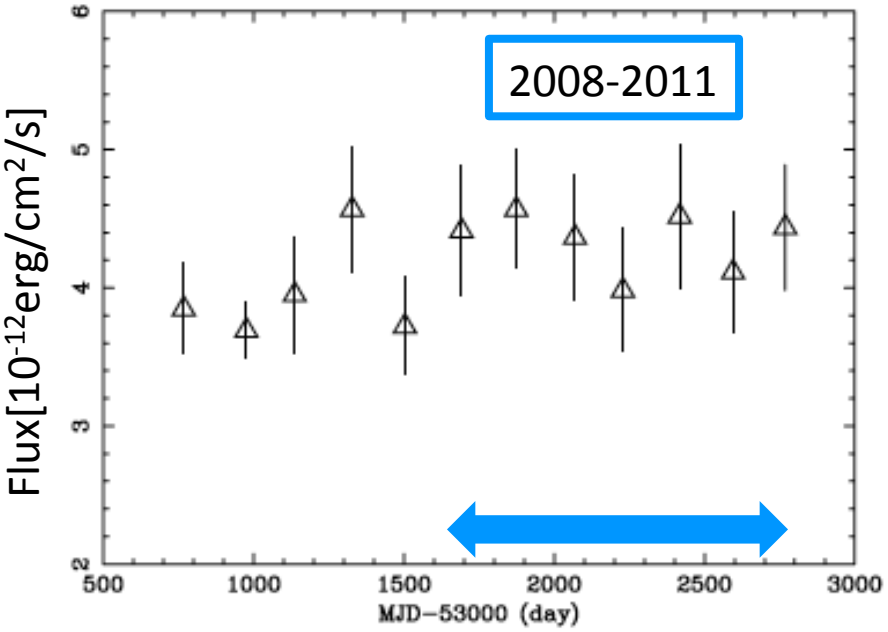
XMM-Newton and Chandra…

- can resolve **the nucleus emission**
- the number of observations are small

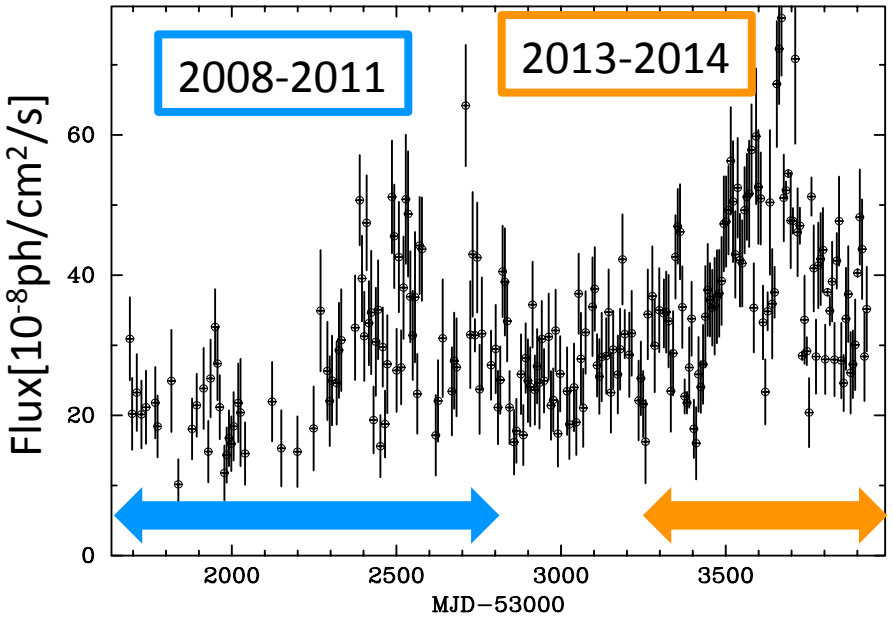
Past X-ray Observations

Past Study of Variability Correlation between X-ray (Suzaku) and GeV Gamma-ray
→There are no correlation **in 2008-2011** (Yamazaki+13).

2006-2011 Suzaku X-ray Light Curve



2008-2014 GeV Gamma-ray Light Curve
(archival light curve supplied by GSFC)



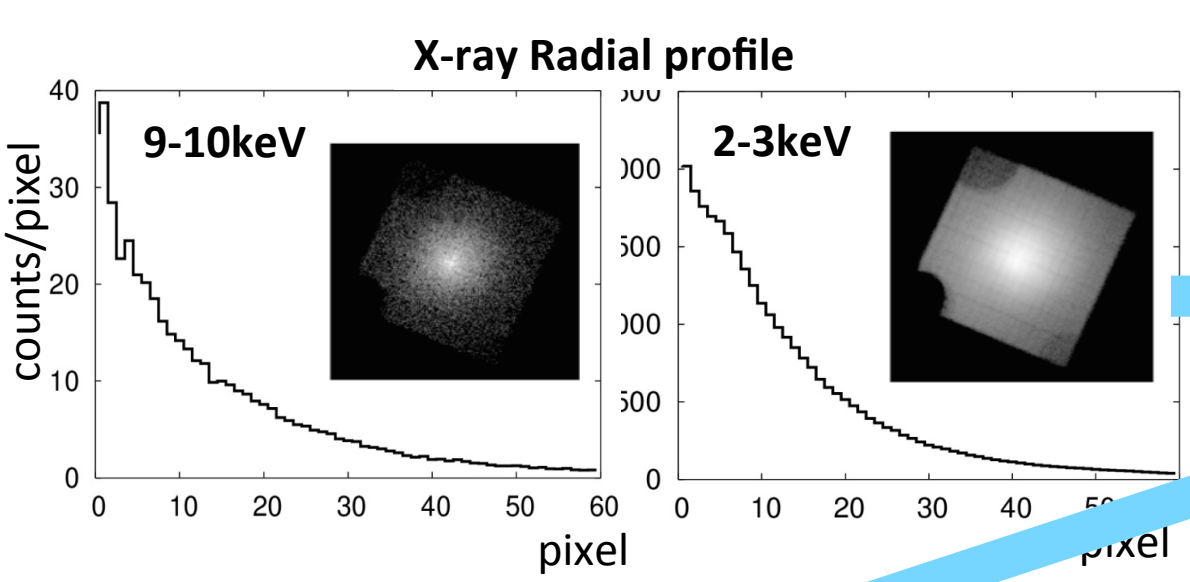
☆Purpose of This Study

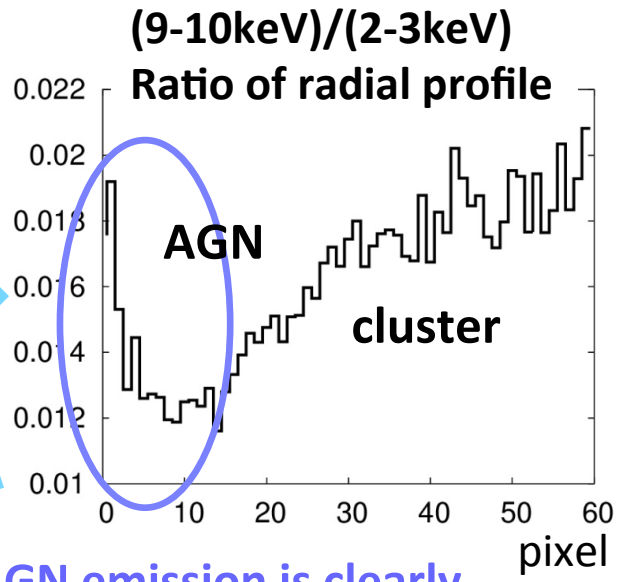
Extend the analysis of Suzaku/XIS observation data to 2014 to study the variability correlation with a big GeV Gamma-ray flare **in 2013-2014**.
(Suzaku/XIS has observed the Perseus Cluster every half year with 40 ks.)

Analysis of Suzaku/XIS data of NGC 1275

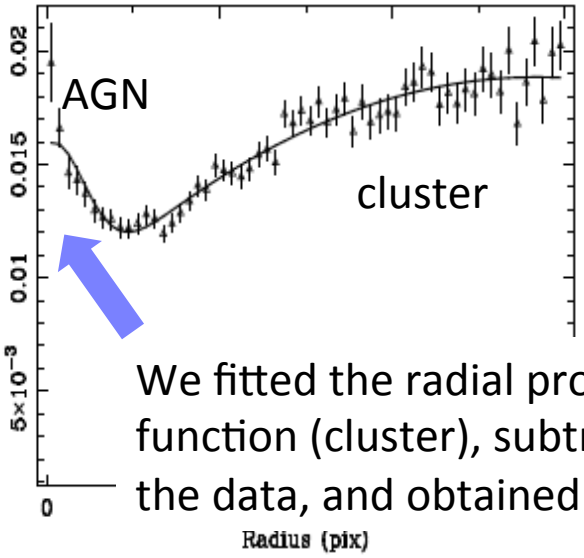
Suzaku PSF cannot resolve NGC 1275 nucleus well.

→We extracted the AGN emission by imaging spectroscopy.





AGN emission is clearly seen at the center region.

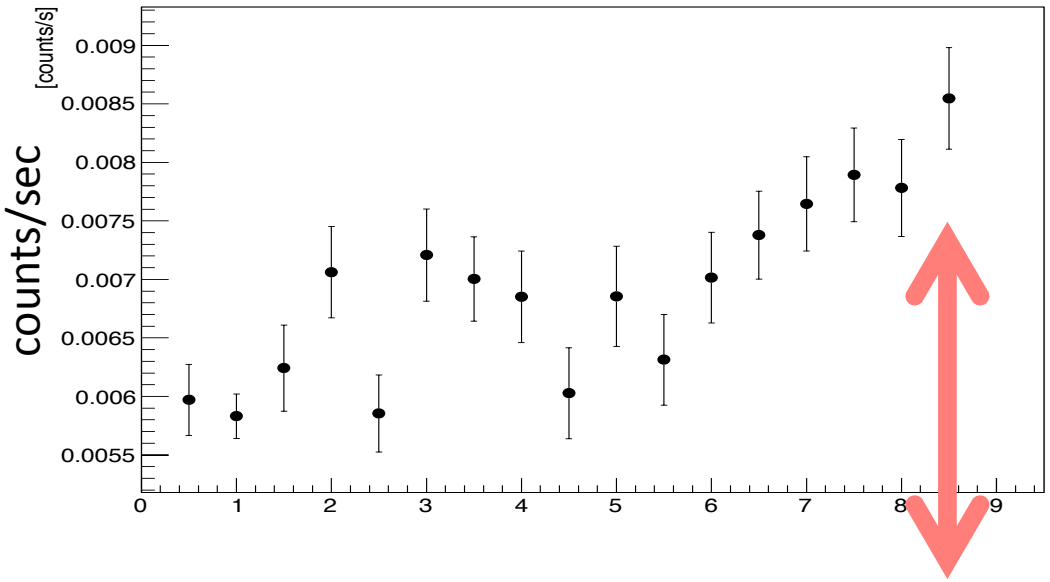


We analyzed the data from 2006 to 2014 and derived an X-ray light curve.

We fitted the radial profile with Gaussian (AGN) and quadratic function (cluster), subtracted the model-cluster component from the data, and obtained the AGN photon counts.

Results : Suzaku/XIS X-ray Light Curve of NGC 1275

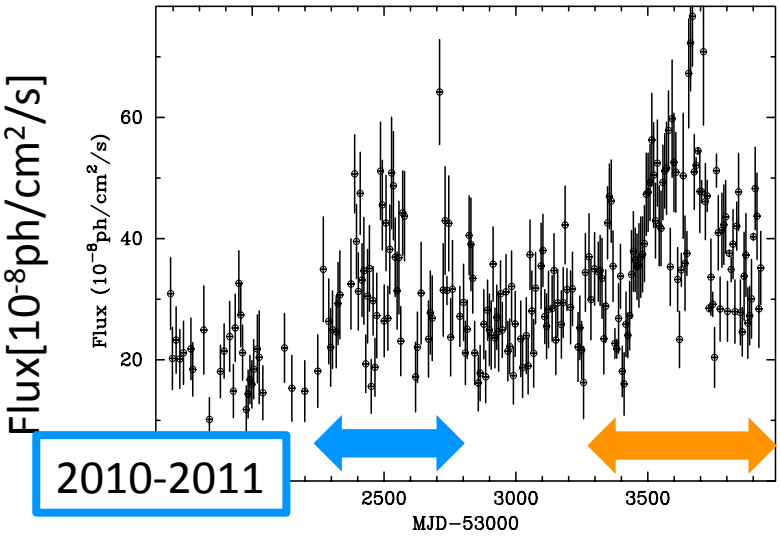
2006-2014 X-ray Light Curve



Brightening of the nucleus in the X-ray band was found in 2013-2014, correlating with GeV gamma-ray flare.

This is the first evidence of X-ray variability of NGC 1275.

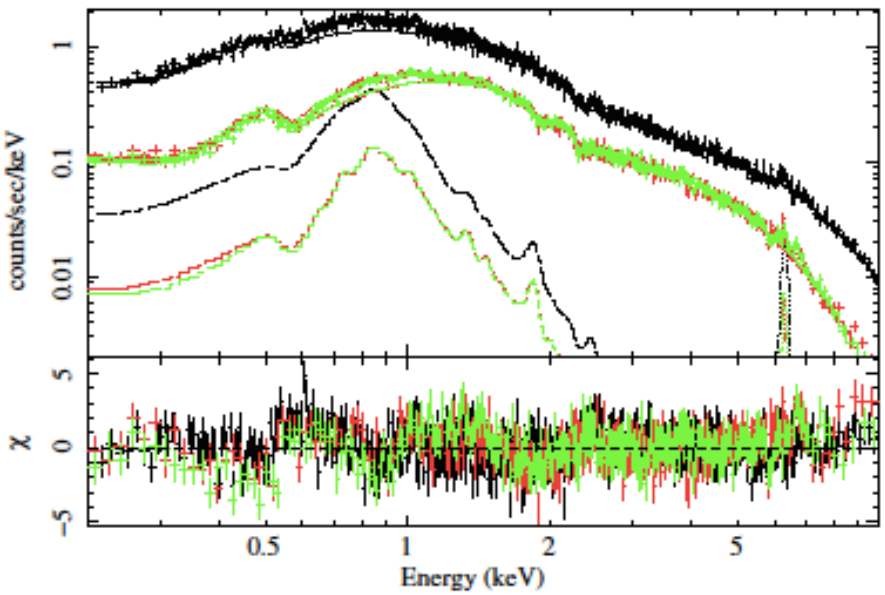
2008-2014 Gamma-ray Light Curve



X-ray spectrum is consistent with the XMM-Newton results. However, it is not clear how the X-ray spectrum varied, because of worse Suzaku/XIS PSF.

Origin of X-ray variability

XMM-Newton X-ray spectrum (2006)



XMM-Newton spectrum

- Fe-K line (equivalent width ~70 eV)
- Photon index ~1.73

Spectrum is similar to that of Seyfert galaxy.

Weak correlation between X and Gamma in 2008-2011.

Disk/corona emission seems to be dominant in the X-ray band.

What is the origin of X-ray variability correlating with Gamma-ray ?

Jet emission or disk/corona emission ?

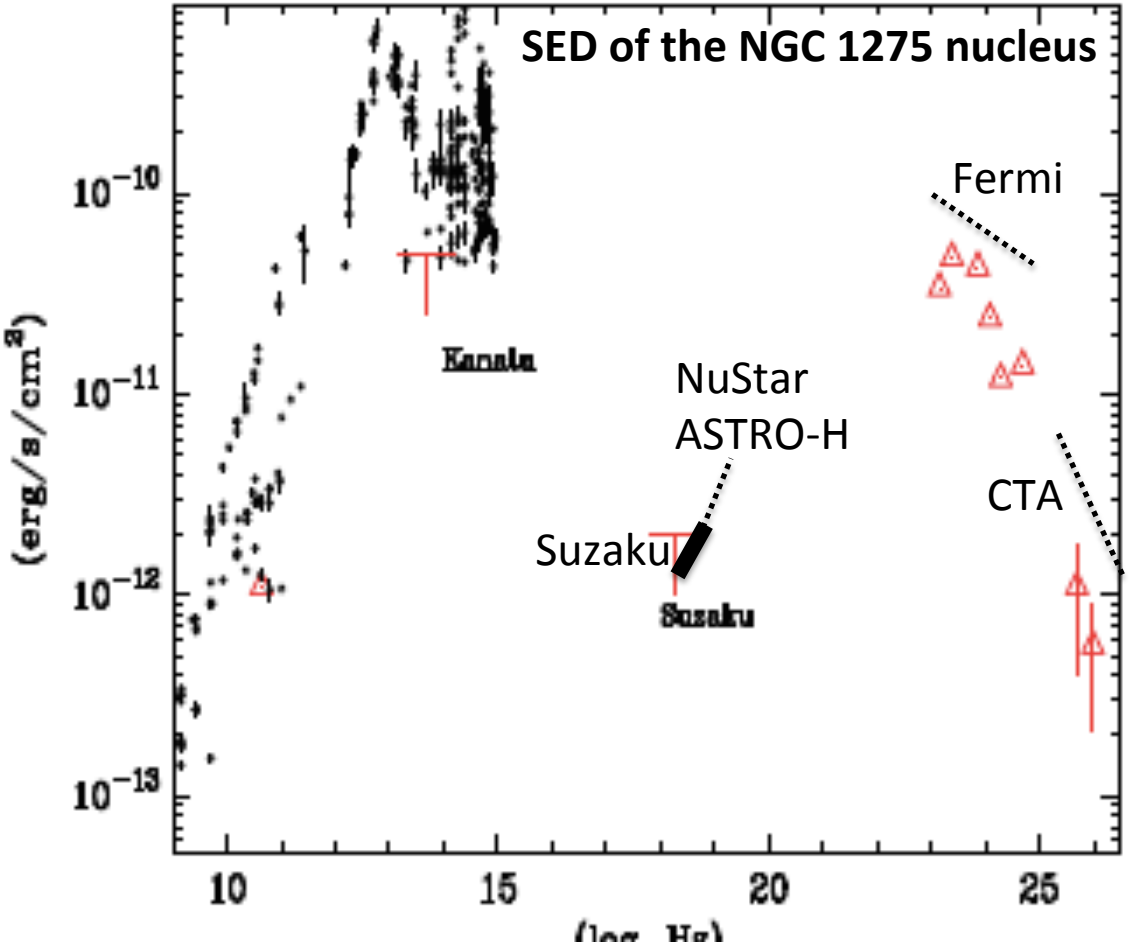
If disk/corona emission, NGC1275 would become a rare and important object from which both disk/corona emission and jet emission from X-ray to gamma-ray band. We can study the **disk/jet connection** from the X-ray and gamma-ray correlation. Note that optical lines are reprocess of disk/corona emission, while X-ray traces the disk/corona emission directly.

Origin of X-ray variability

If jet emission, variable X-ray component would be a low energy tail of inverse Compton.

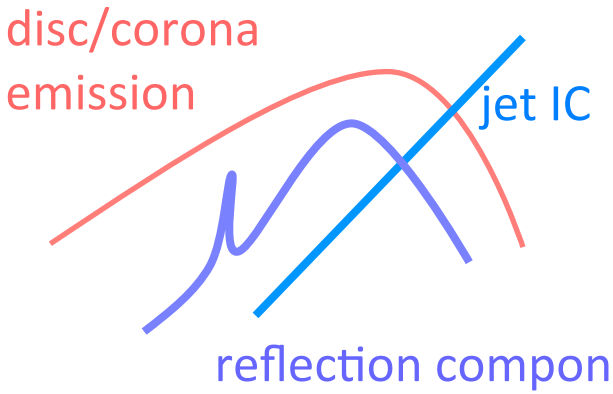
We can trace a precise SED variability from X-ray to gamma-ray to constrain the flare mechanism.

In the near future, we can trace the jet flare from X-ray to gamma-ray, with NuStar, ASTRO-H, Fermi, and CTA.



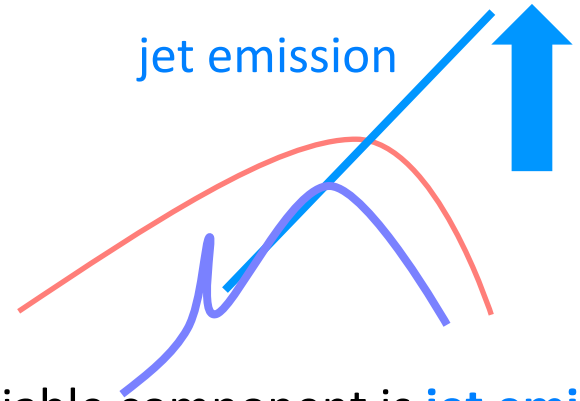
If we could obtain the X-ray spectral variability…

We infer the following X-ray spectral components for NGC 1275.



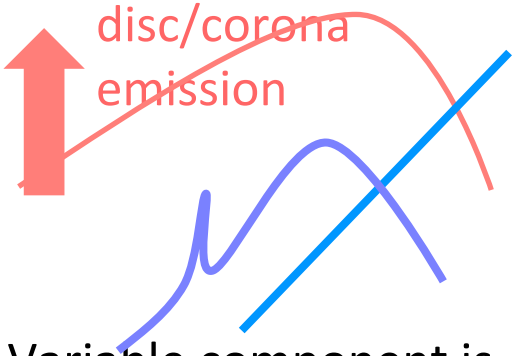
However, Suzaku cannot distinguish these two scenarios.

harder-when-brighter



Variable component is **jet emission**

softer-when-brighter



Variable component is
disc/corona emission

Further X-ray observations (XMM-Newton, NuStar, ASTRO-H) are important.

☆Summary

・We analyzed Suzaku/XIS observation data of NGC 1275.

・From 2013 to 2014, brightening of the nucleus in the X-ray band was found, correlating with GeV gamma-ray flare

(This is the first evidence of X-ray variability of NGC 1275.)

・However, we cannot find what the variability component is, disk/corona or jet ?

☆Future Prospects

・In addition to Fermi observation, it is important to observe NGC 1275 by using XMM-Newton, NuStar, ASTRO-H.

・CTA TeV gamma-ray observation is also important to understand the gamma-ray flare.

・We are also continuing to monitor NGC 1275 by Kanata optical telescope (see Kawaguchi's poster).