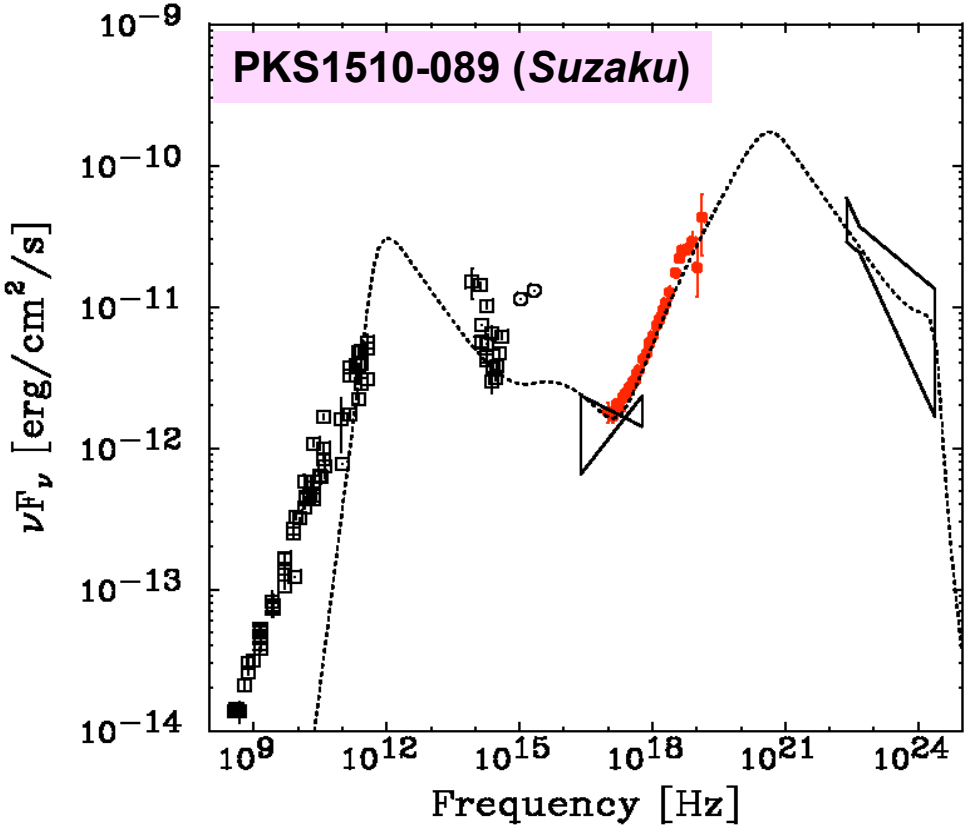
Suzaku observations of AGN and synergy with GLAST

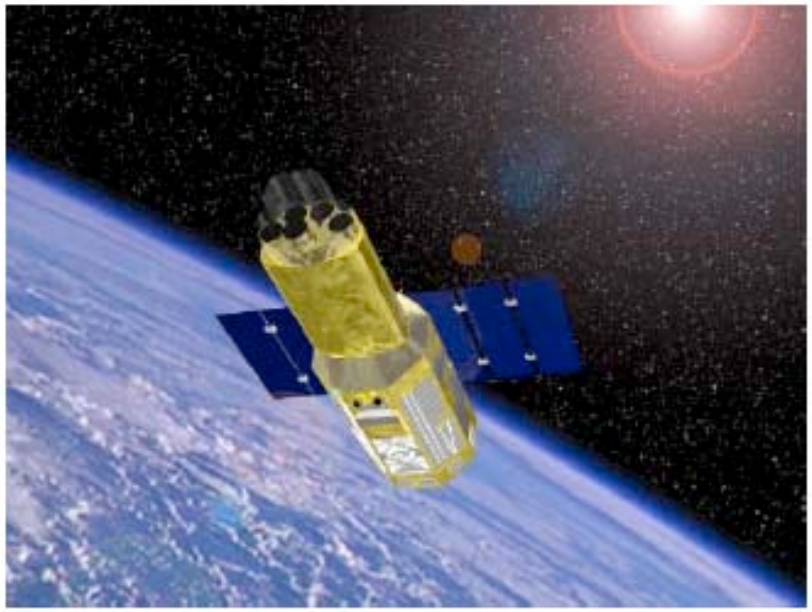


Jun Kataoka (Tokyo Tech)

in collaboration with T.Takahashi ,G.Madejski, T.Kamae, S.Watanabe, M.Ushio, T.Kohmura and ***Suzaku team***

Outline

- **About *Suzaku***
  - Mission status
  - Payloads & advantages
- **Highlights from *Suzaku***
  - TeV blazars
  - GeV blazars
  - ToO by *GLAST* trg
- **New GeV source**
  - Nearby FR-I/II
  - BLRG
- **Summary**



Suzaku – overview

- 5th Japanese X-ray astronomy satellite to study
  - structure formation of the universe
  - environment very close to black holes

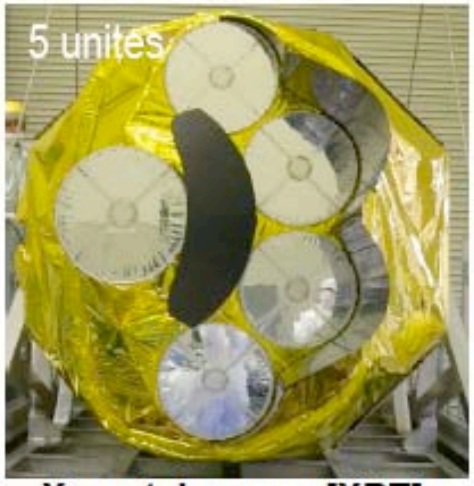
  by using
  - high-resolution X-ray spectroscopy
  - wide-band X-ray spectroscopy

Highly complementary to Chandra & XMM

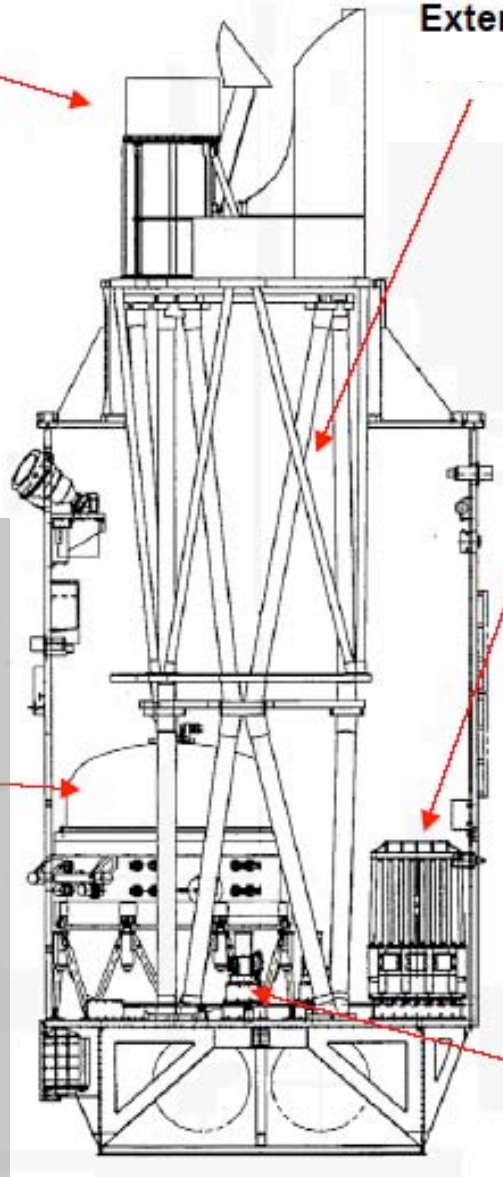
- Successfully launched on July 10, 2005 with JAXA's M-V rocket
- > 300 sources have been observed by the end of Jan 2007

Suzaku in the final ground test

Science payloads of Suzaku



X-ray telescope [XRT]



Extensible optical bench

Hard X-ray detedtor
(HXD: 10-600 keV)

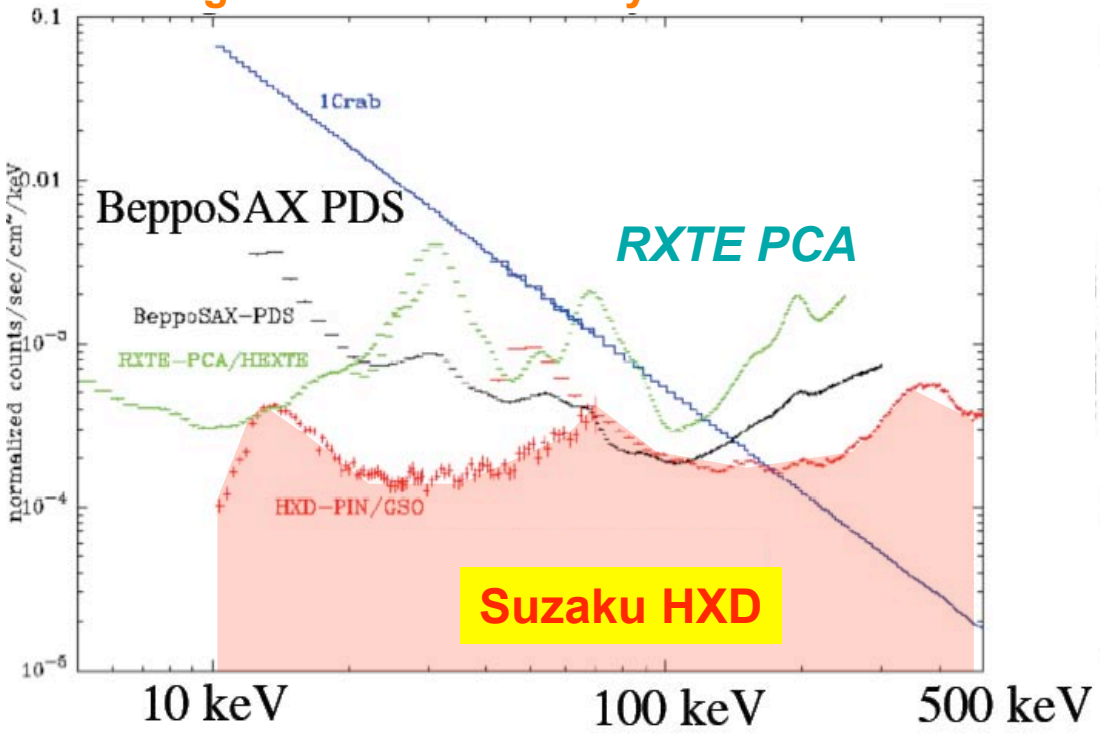
X-ray spectrometer
(XRS: 0.3-10 keV)

X-ray imaging spectrometer
(XIS:0.3-10 keV)

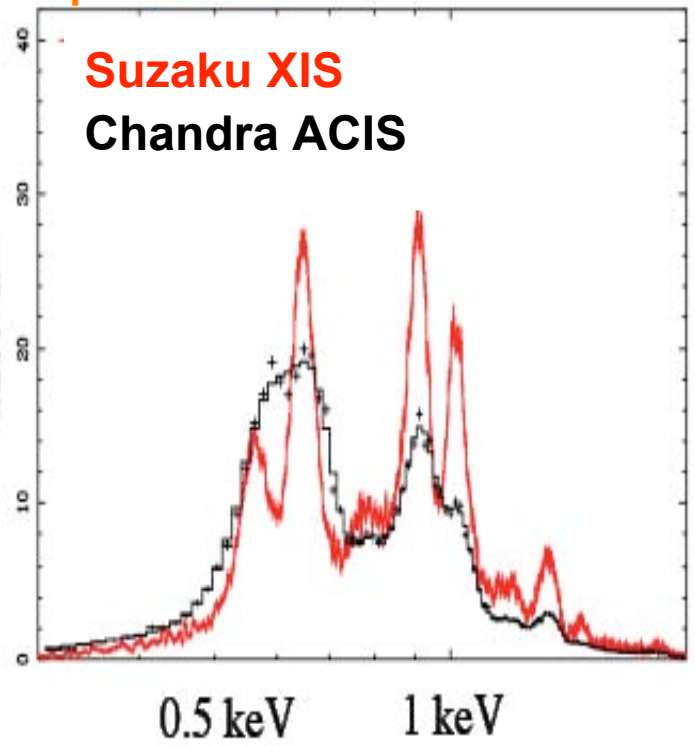
Advantages of Suzaku

- High S/N ratio between 0.3 and ~ 300 keV.
  - ~1000 cm^2 effective area for the XIS (comparable to XMM at >5keV)
  - Extremely low background for both the XIS and HXD
- excellent spectral resolution especially below 1 keV.

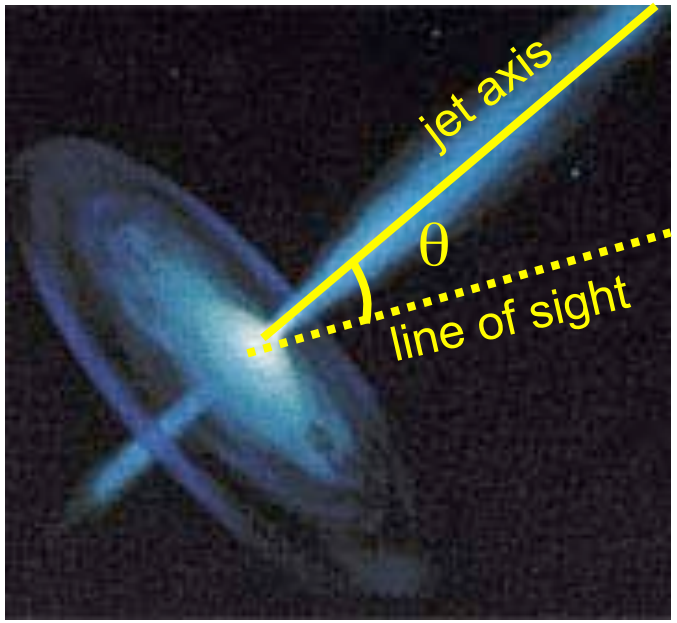
Background normalized by effective area

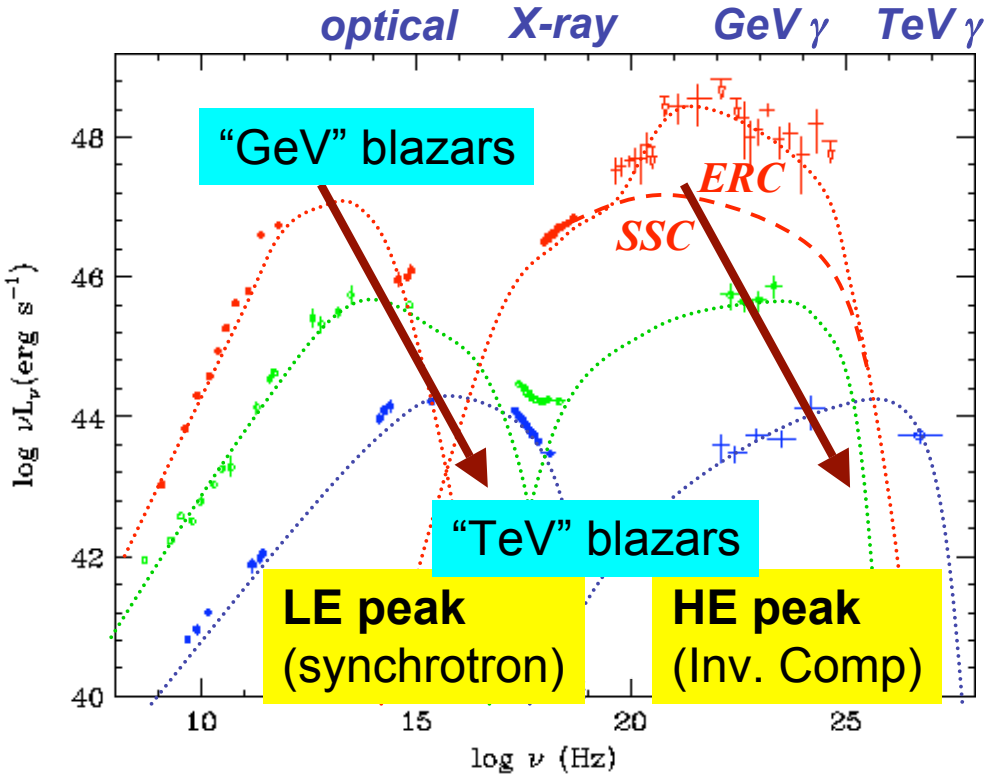


Spectrum of SNR E0102.2-729



Why Blazars with Suzaku?



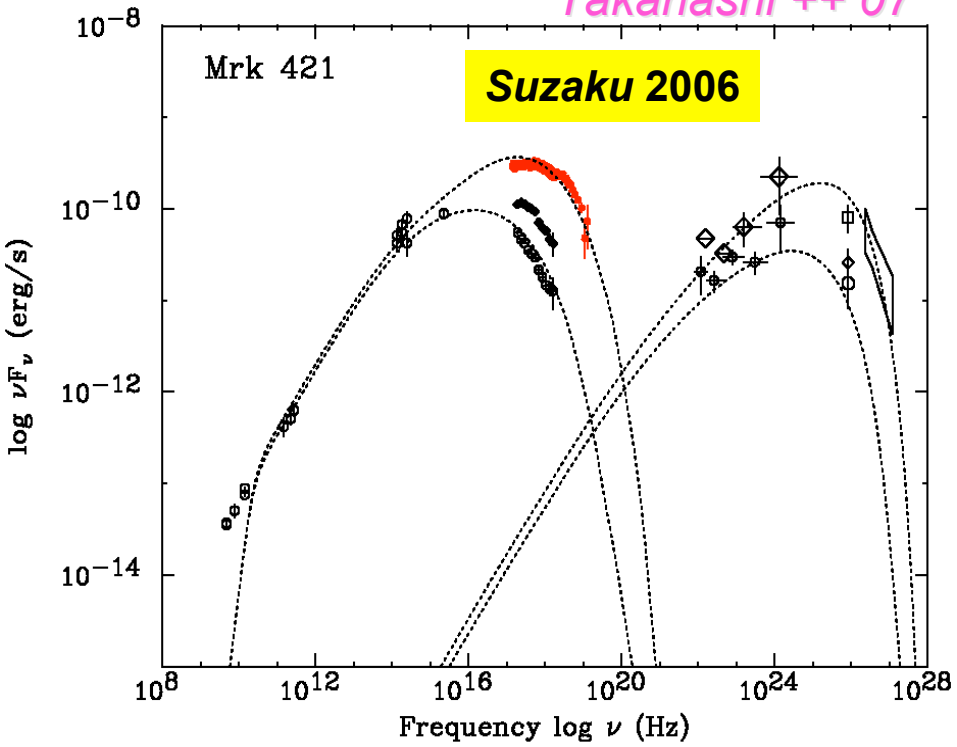


- Jet is pointing close to our line of sight (θ ~ a few deg).
  - brightness & rapid variability caused by relativistic beaming.
- Two distinct peak structures in the SED
  - Sync + inv. Copmton, but wide variety (blazar sequence).
  - Need wide coverage ; hard-X-ray properties are still poorly known!

Suzaku view of Mrk421 (spectra)

Takahashi ++ 07

Sorry, preliminary
- this figure is published very soon.



$F_{2\text{-}10\ keV}$ ~ 18mCrab

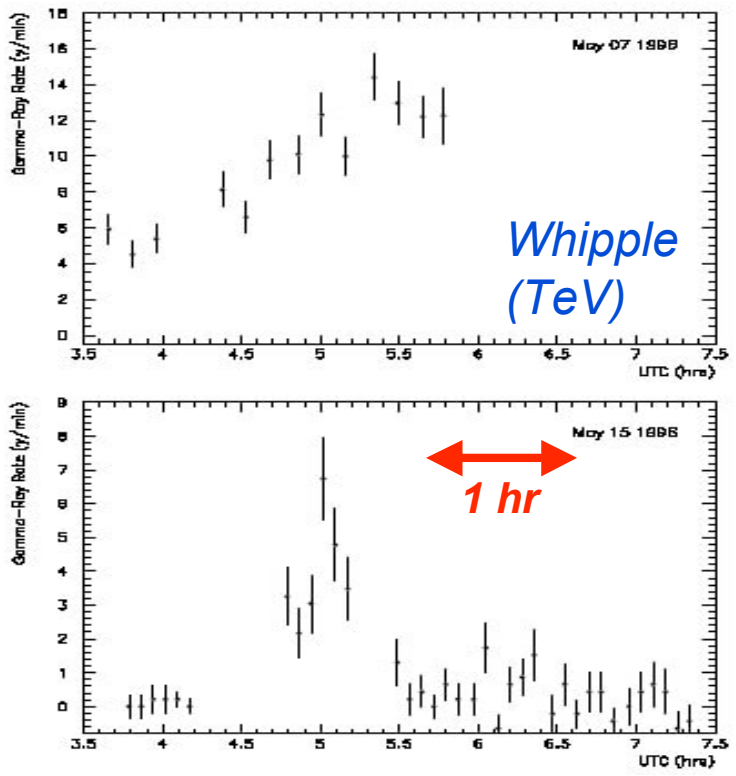
- Mrk 421 was observed in Apr 2006 for a 40 ksec by Suzaku.
  - very bright phase, 1/3 of historical flare in 2001-02 (e.g., Cui 2004).
- X-ray spectrum gradually curves toward high energies:
  - **Γ_1 ~ 1.9** (E<3 keV), **Γ_2 ~ 2.2** (3<E<18 keV), **Γ_3 ~ 3.0** (E>18 keV)

➡ ***from "peak" to "real end" of the Sync emission !***

Suzaku view of Mrk421 (variability)

Gaidos++ 96

Sorry, preliminary
- this figure is published very soon.

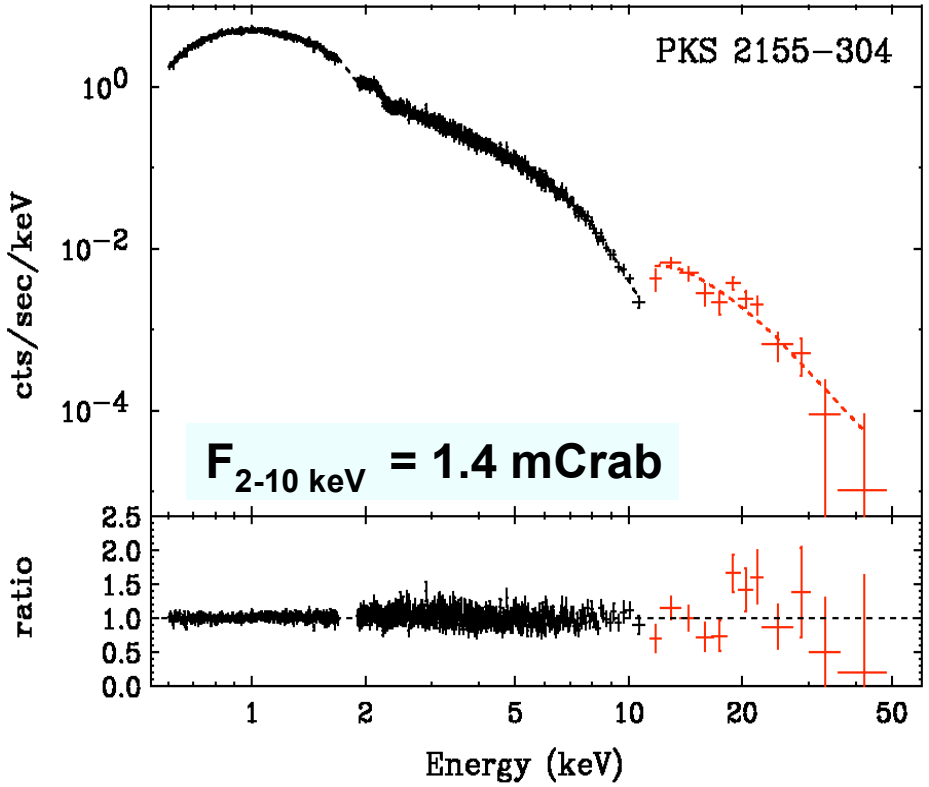


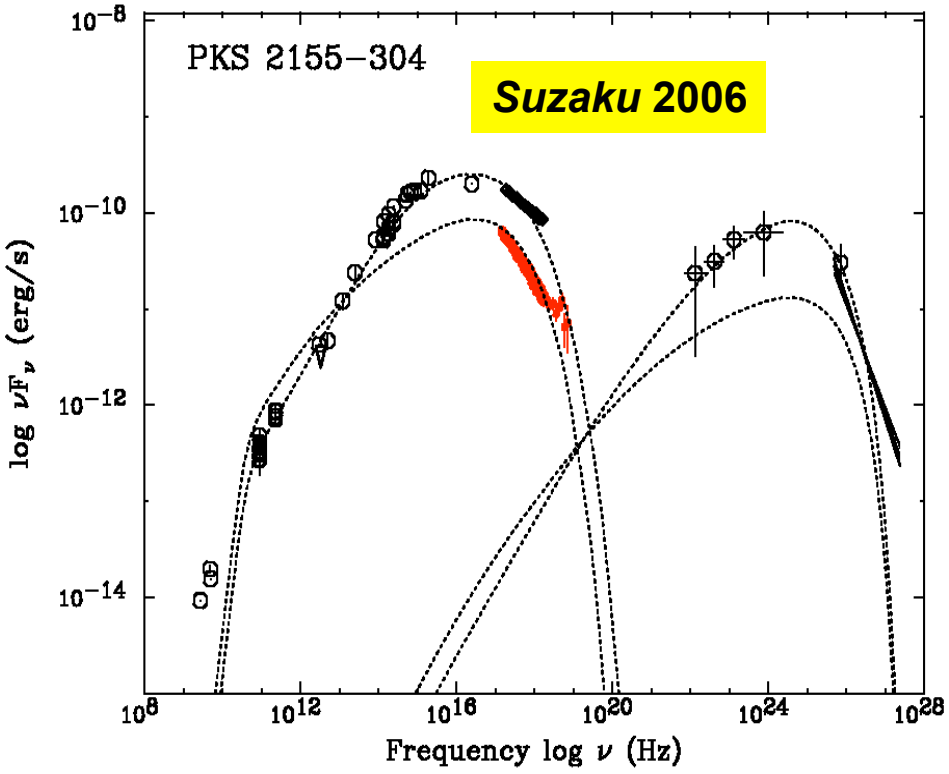
- Clear detection of "intra-day variability" at >10 keV !
  - note excellent S/N, even above 10 keV – error bars are "invisible"…

Variability correlation, spectral evolution on **hour-scale** possible with *GLAST*, *VERITAS* and *H.E.S.S* ++.

Suzaku view of PKS2155-304 (spectra)

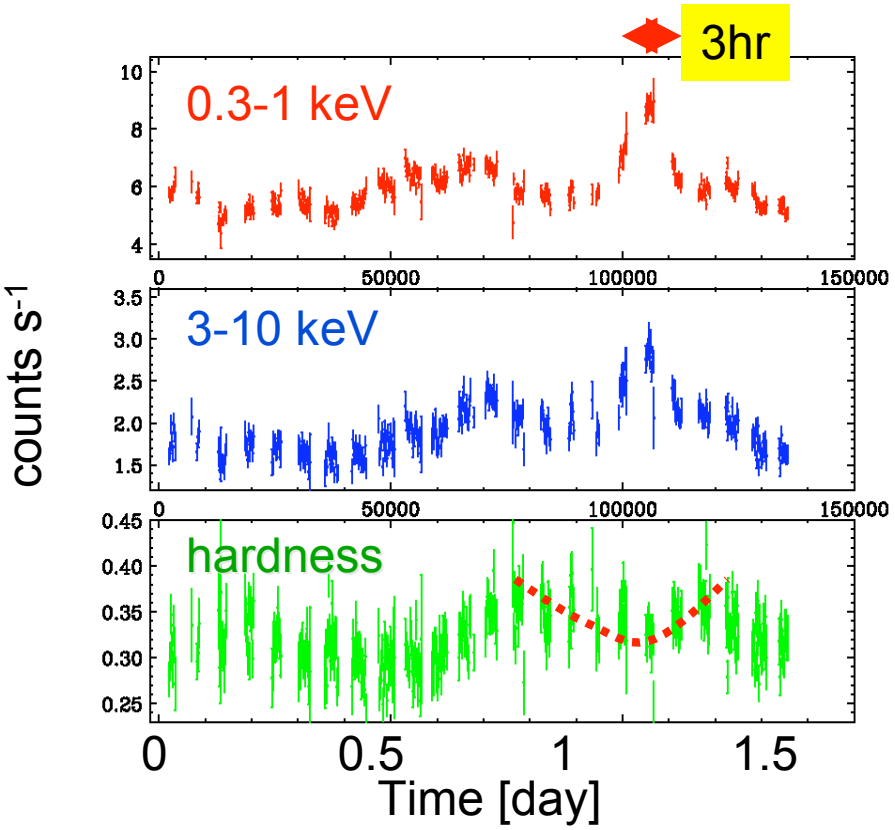
Kohmura++ 07

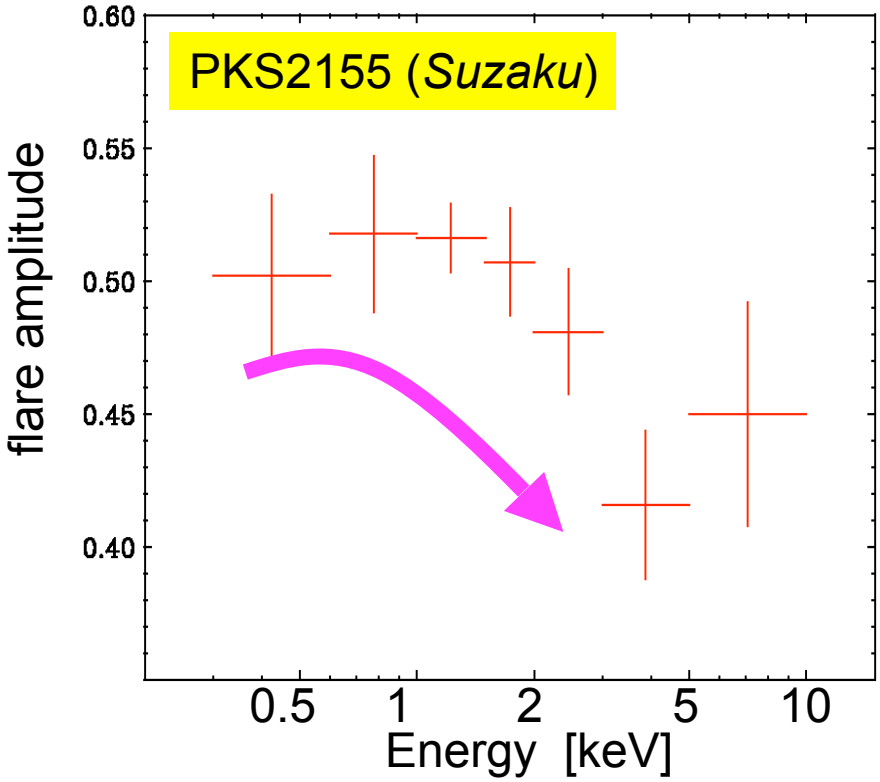




- PKS2155 was observed for 65 ksec as a calibration target in 2005.
  - simultaneous with H.E.S.S: data processing by S.Wagner++
- Unfortunately, it was in a historically low state (1/10 of flare state…), but we could determine the energy spectrum up to 50 keV.
  - a single steep PL of $\Gamma \sim 2.6$ well fit the data.

Suzaku view of PKS2155-304 (variability)



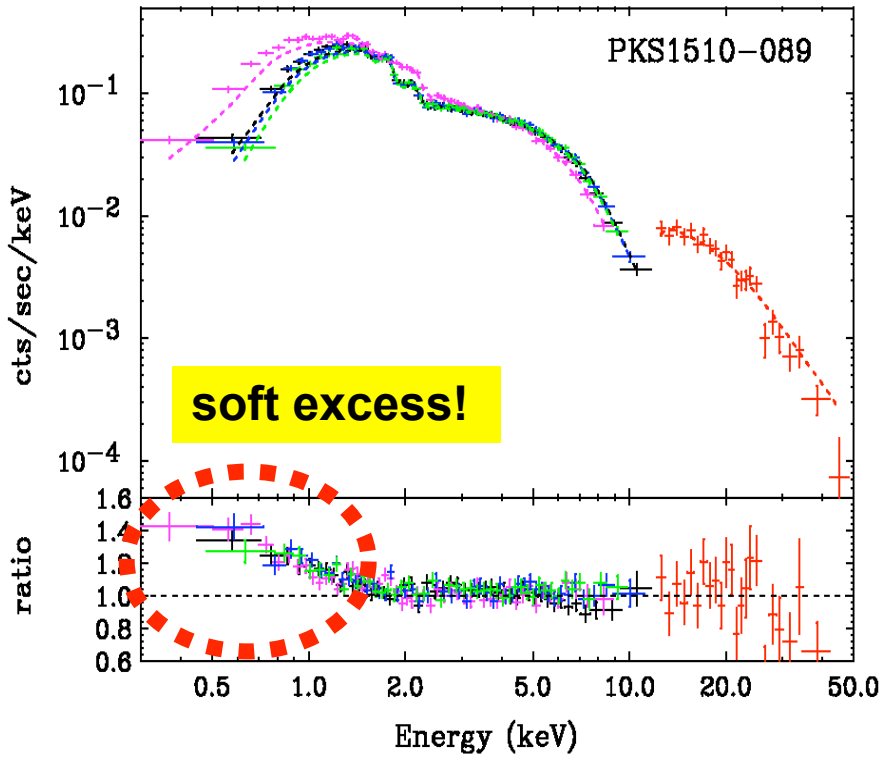


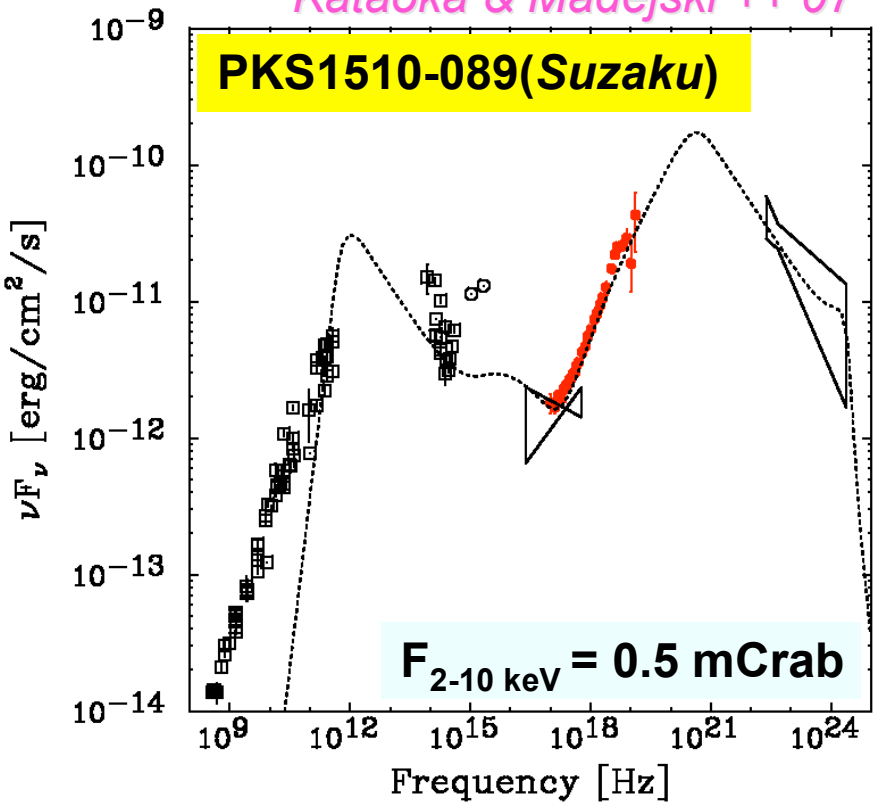
- Rapid, large amplitude flare on ~hr scale.
- A curious flare – the spectrum get ***"steeper"*** when brighter.

- smaller variability at higher energy – completely opposite trend.
- a new challenge to shock acceleration theory ?

Suzaku view of PKS1510-089 (spectra)

Kataoka & Madejski ++ 07

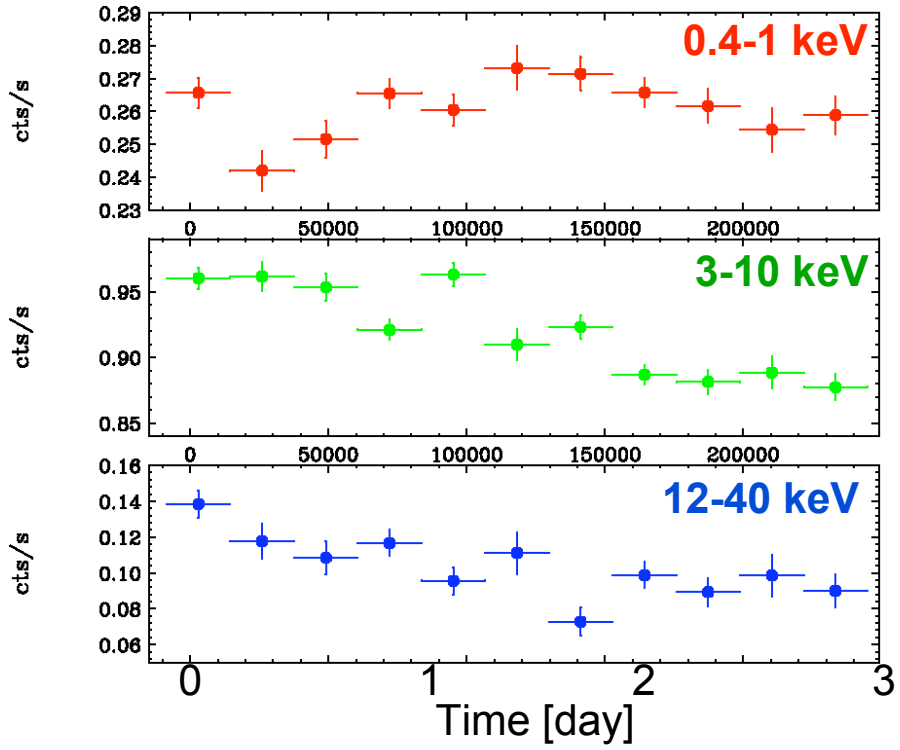


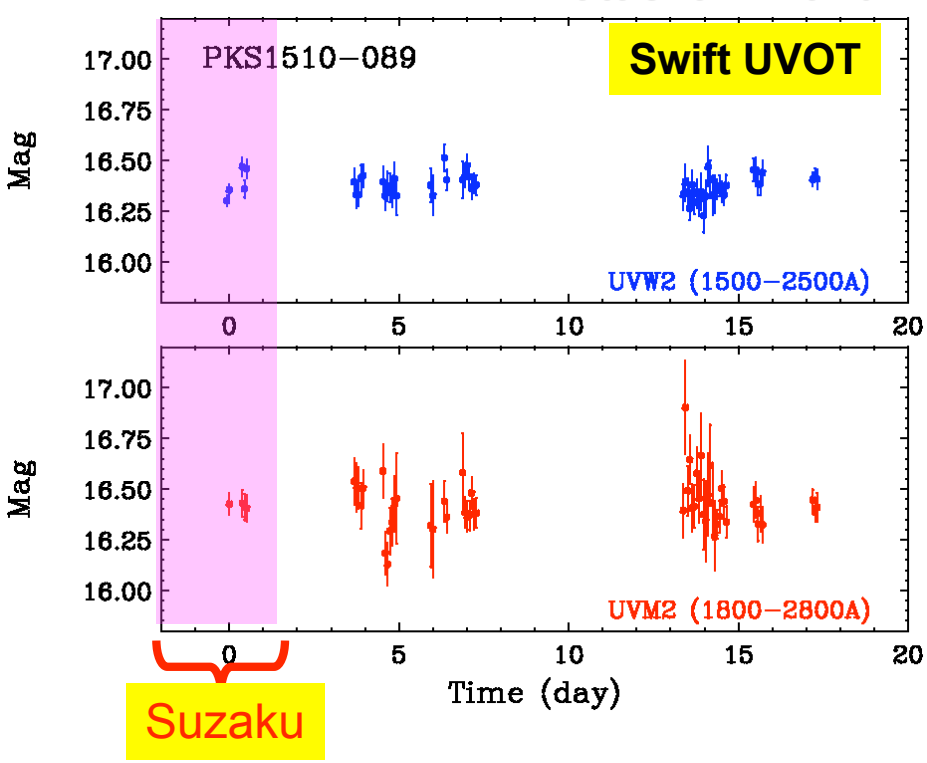


- Intensive monitoring over 3 days (120 ksec chunk of data).
- Hard spectrum (Γ = **1.2**) up to 60 keV with a soft excess.
  - unordinary flat electron population; **$N(\gamma) \propto \gamma^{-1.4}$**
  - soft excess is fitted either by **disk-BB (~0.2keV)** or steep PL (Γ ~ 3.0).

Suzaku view of PKS1510-089 (variability)

Kataoka ++ 07b

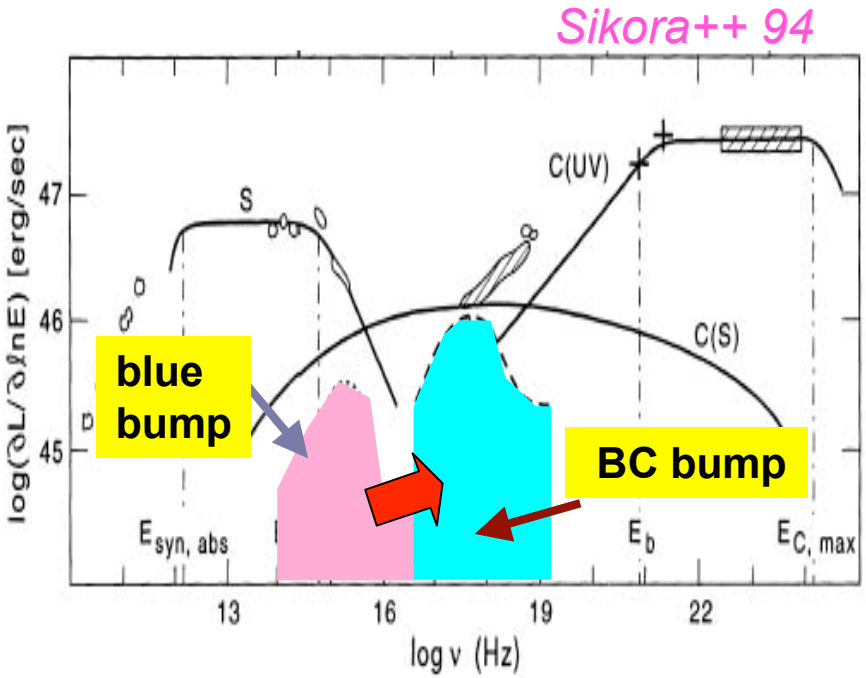


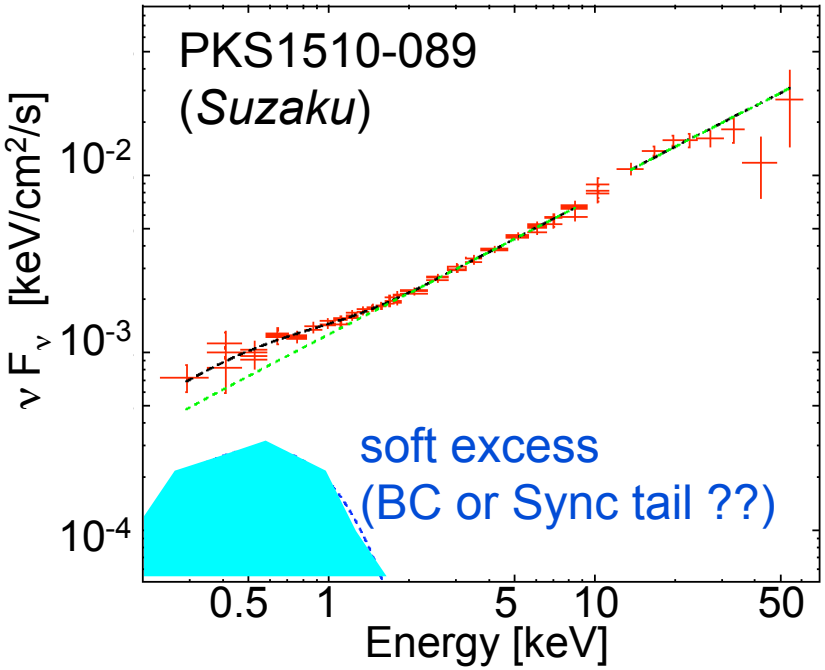


- **Variability pattern is different** only below 1 keV !
  - again, suggesting completely different origin for the soft excess!
- MW analysis are still on going - thanks for all collaborators!

Swift UVOT/XRT … **P.Roming**, **optical** … **G.Tosti ++.**
RATAN 600 … **Y.Kovalev**, **ATCA** … **P.Edwards**
Theory … **M.Sikora, L.Stawarz, R.Moderski ++**

More close look at "soft excess"

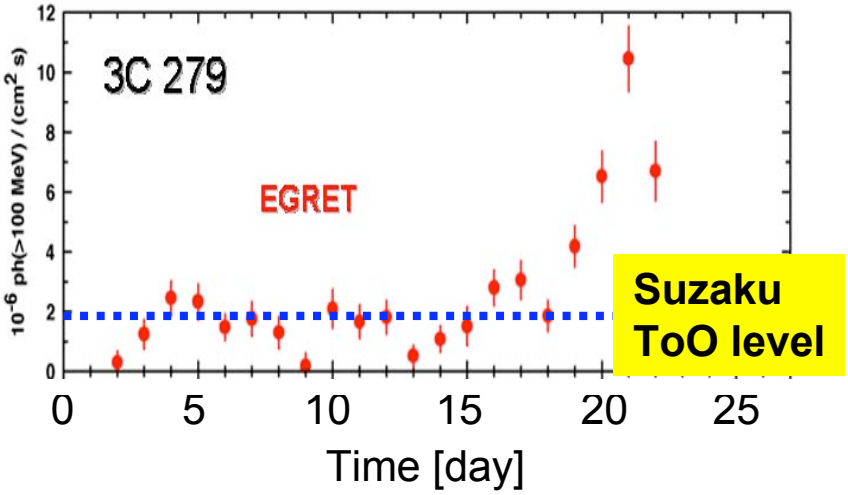




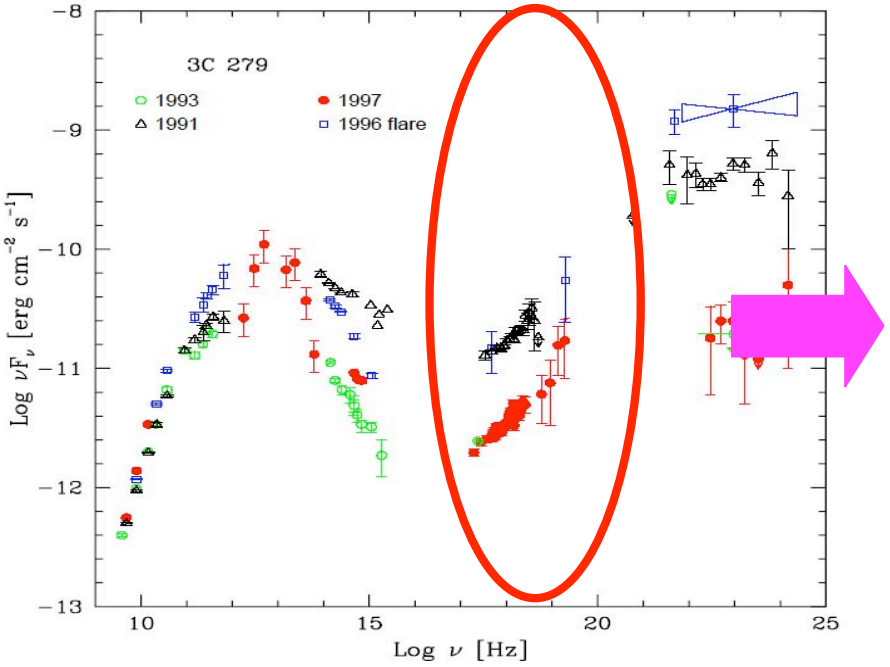
- Cold pair plasma *should* upscatter UV photons ("blue bump") via the Bulk-Comptonization (BC) to $E_{BC} \sim \Gamma_{BLK}^2 E_{diff} \sim 1$ keV.
- A clue to **"matter content of jet" : $L_{BC,46} \propto (n_e/n_p)\, L_{jet,46}$**

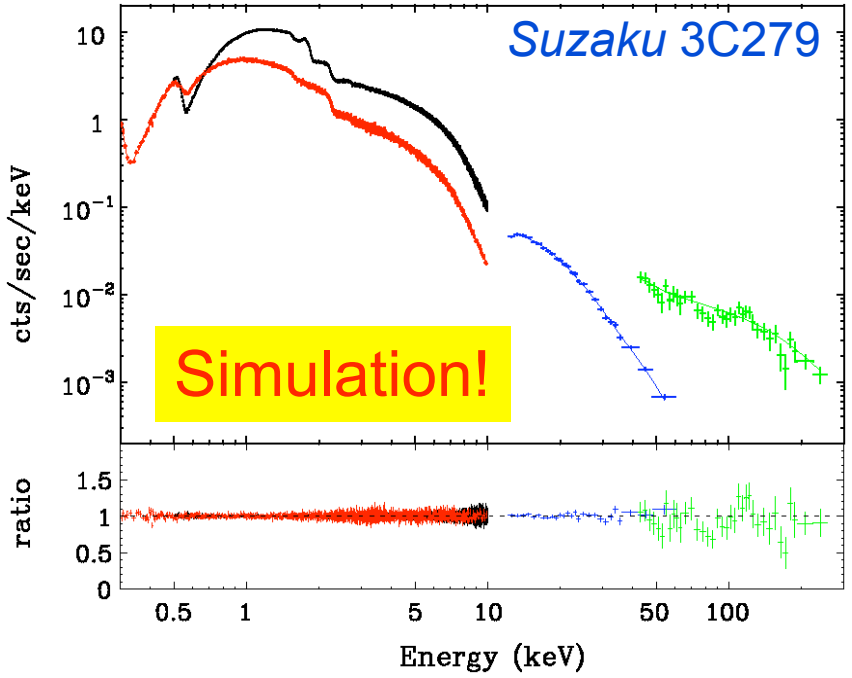
  - but can we safely reject contamination from the Sync tail ?
    → **optical/UV data important**
  - X-ray precursor before the γ-ray (GeV) flare ?
    (Moderski ++ 04, Celloti++07) → **GLAST strongly awaited !**

Suzaku ToO by GLAST trigger

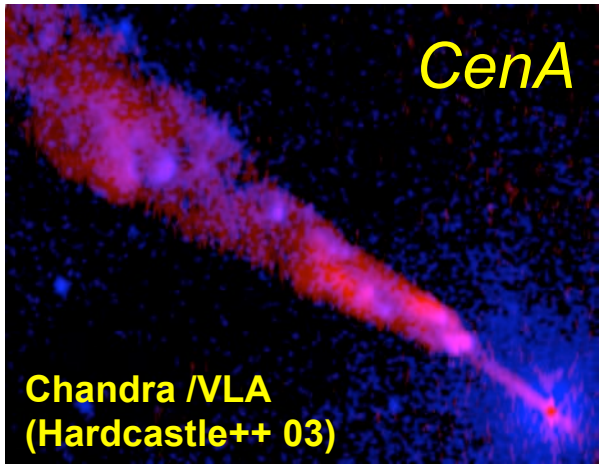


- We are proposing ToO monitoring of GeV flare with *Suzaku* (PI:JK) as well as persistent obs. (PI: GM).
  - F > 2×10^{-6} ph/cm^2/s
  - 200 ksec for 1 of 5 src
- *If accepted*, data will be open to all *GLAST* team without delay.



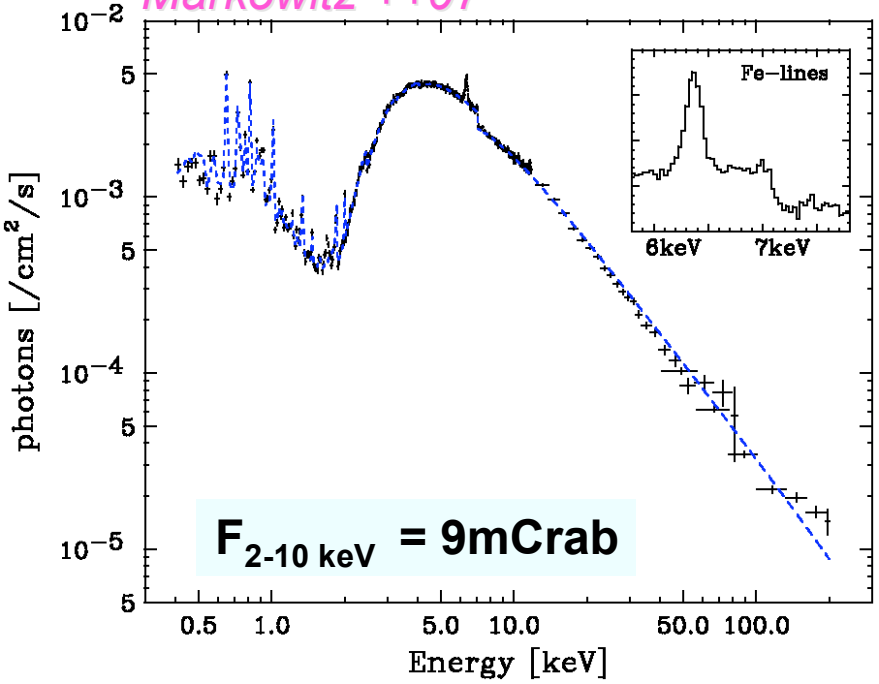


New GeV Sources? : mis-aligned blazars

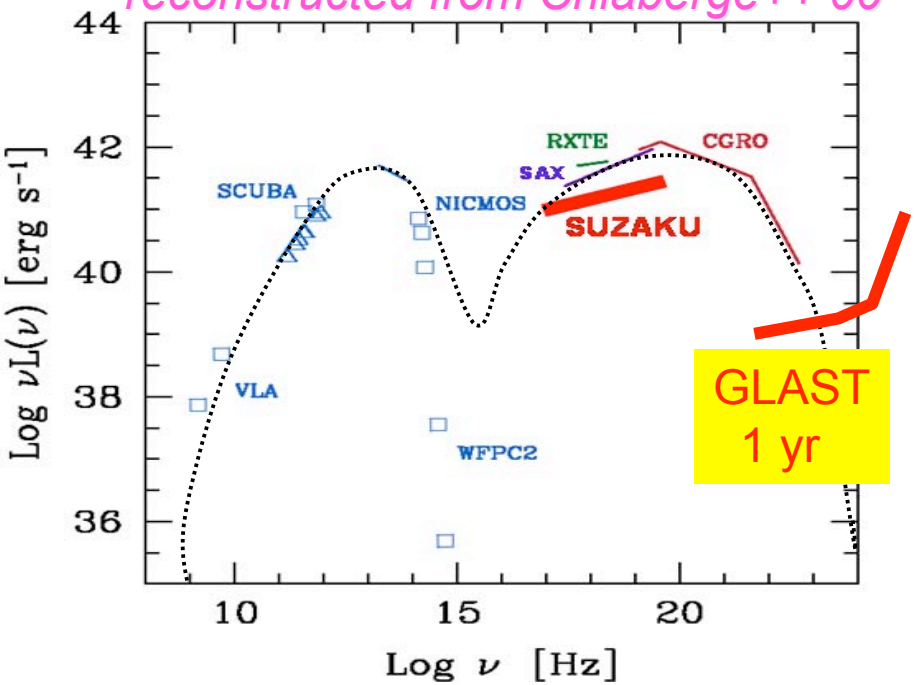


- Not many, but nearby FR-I/ II galaxies can be detected as "mis-aligned" blazars. (e.g., **Cen A**, M87 etc…)
- "unification scheme" of blazars & RG.
  - low power FR I ⟺ TeV blazars
  - high power FR II ⟺ GeV blazars

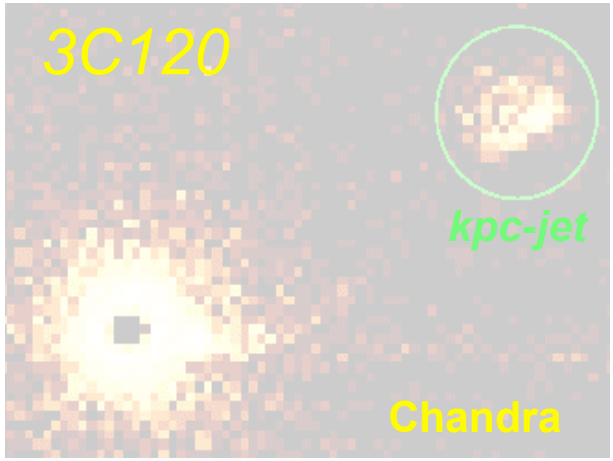
Markowitz ++07



reconstructed from Chiaberge++ 00

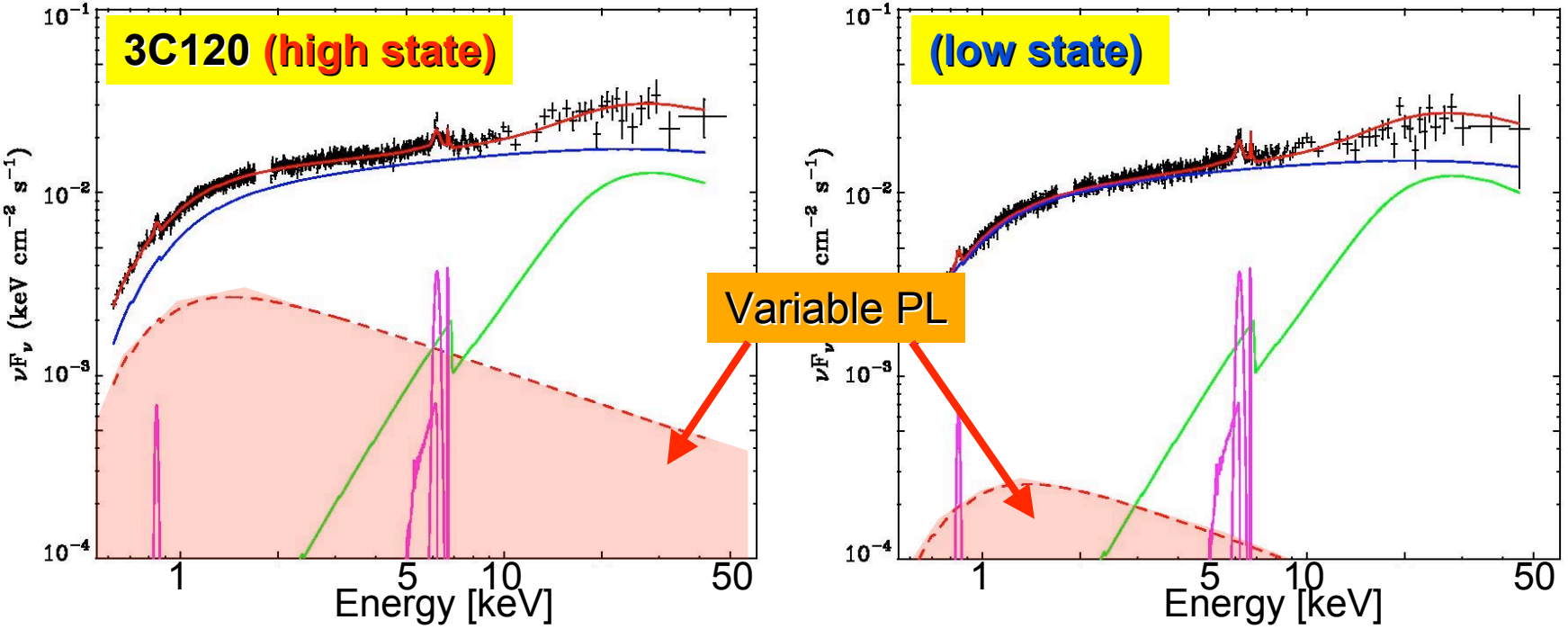


New GeV Sources? : Broad Line Radio Glaxies (1)

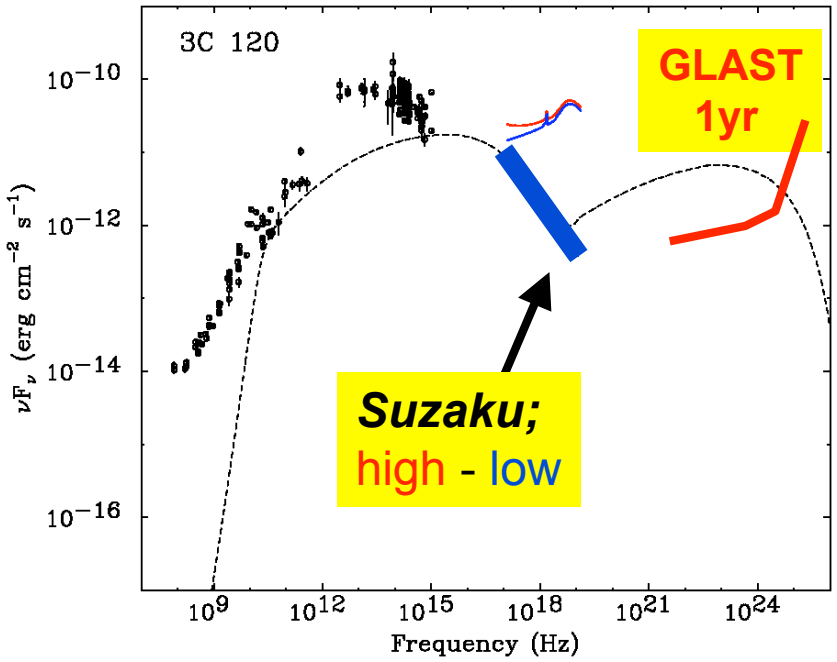


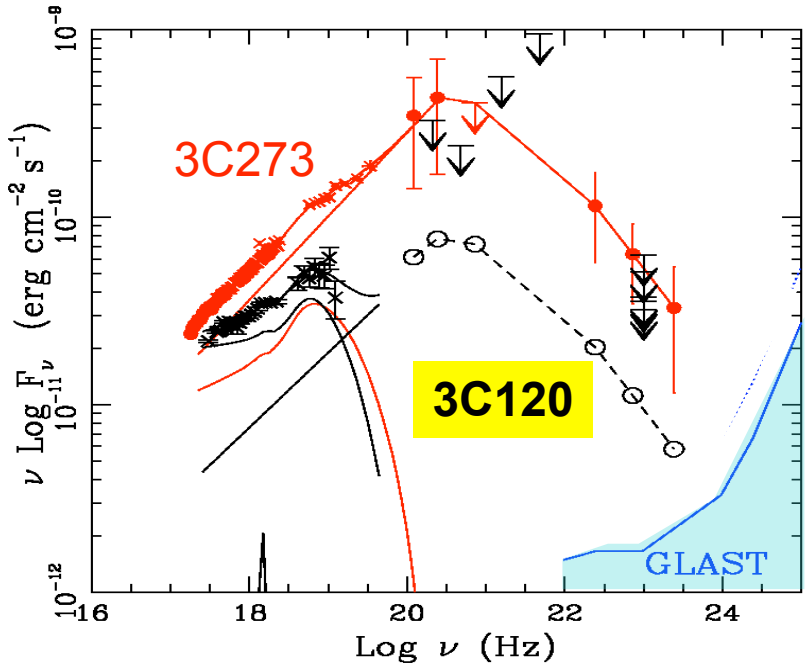
- Broad emission lines, but also has extended jet emission (**"composite"of Sy + RG.)**
- **3C120:** 40ksec x 4 observations in 2006.
- *Suzaku* discovered that the variability is mainly caused by a steep PL of **$\Gamma \sim 2.7$.**

Kataoka ++07a



New GeV Sources? : Broad Line Radio Glaxies (2)





- If variable component originates from the Sync emission of ***"hidden jet",*** IC emission can be detectable with GLAST.
- Similar conclusion was made by direct fitting the SED with a "composite" disk and jet model *(Grandi++ 07; P12.8 this meeting)*

Other GLAST candidates : 3C390.3, 3C382, 3C111, 3C445 ++

Summary

I have reviewed recent observational highlights from *Suzaku* and synergy with *GLAST*.

- ✓ Deep & wide MW monitoring will provide "new" blazar physics even for well-known sources;
  - ➢ TeV blazars … acceleration limit, hr-scale evolution…
  - ➢ GeV blazars … Bulk Compton, jet content… **/ToO!**
- ✓ A number of non-blazar type AGN will be also detected for the first time in GeV band
  - ➢ nearby FR-I … "mis-aligned" blazars?
  - ➢ BLRG … evidence for hidden jet ?
    unification of RL & RQ AGN