Multi-color optical observation of V404 Cygni

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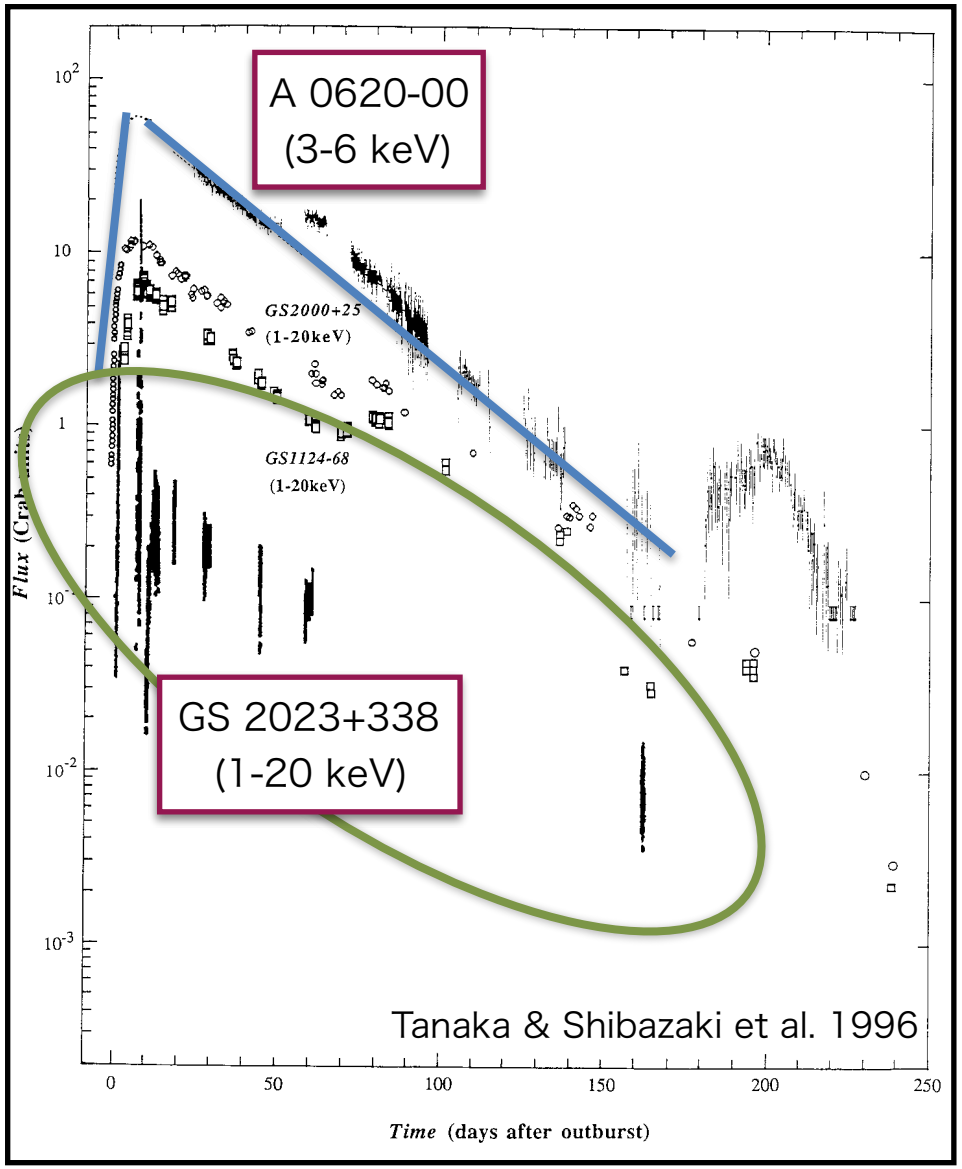
V404 Cyg (=GS 2023+338)

- Discovered by GINGA satellite
  (Makino 1989, Kitamoto et al. 1989)
  ➡ Low-mass black hole binary
- Physical parameters of binary system are well determined
  - M_{BH} : $9^{+0.2}_{-0.6}$ $M_\odot$
  - M_{star} : $0.7^{+0.3}_{-0.2}$ $M_\odot$
    (Khargharia et al. 2010)
  - P_{orb} : 6.4714 d …

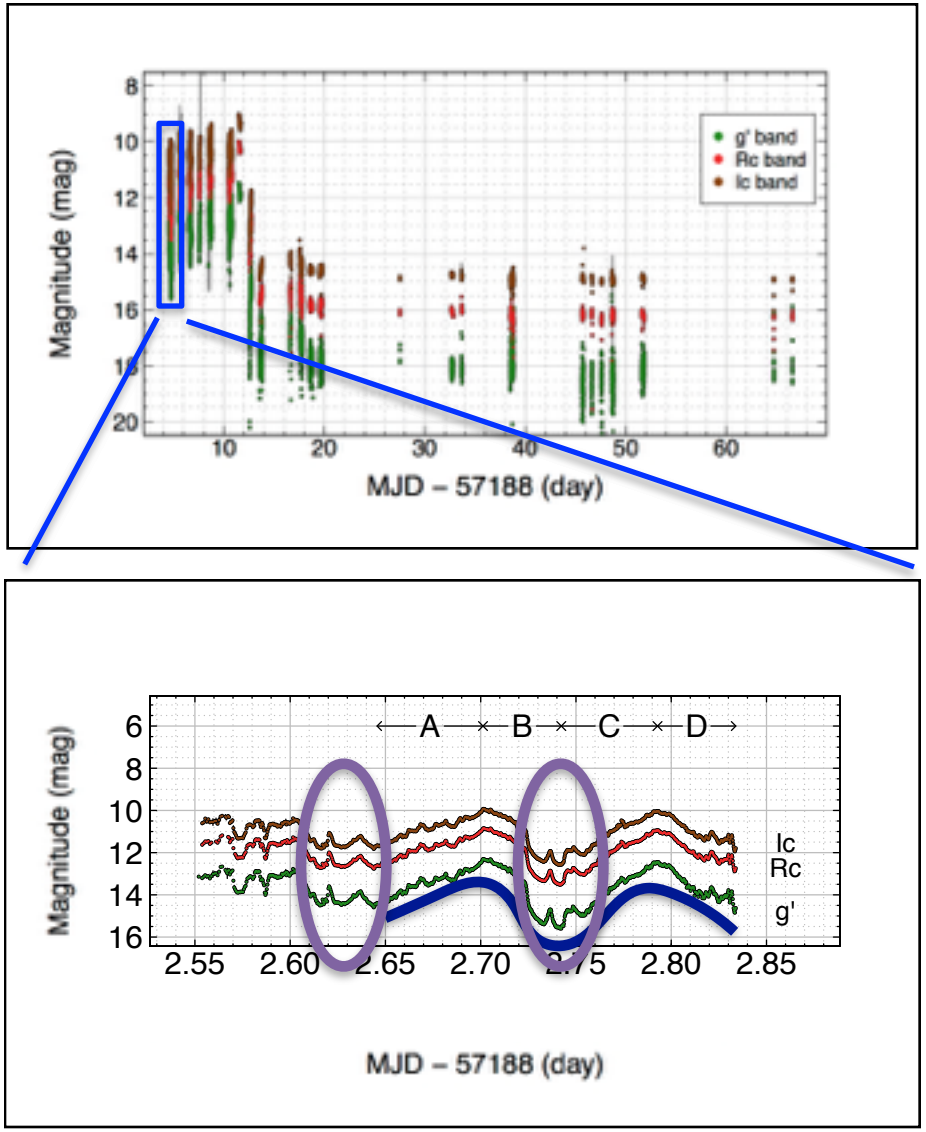
The variability of V404 Cygni during a outburst is different from the typical BHB's one.



Optical Light Curves

- All of the optical bands (g', Rc, and Ic) seems to be **perfectly correlated**

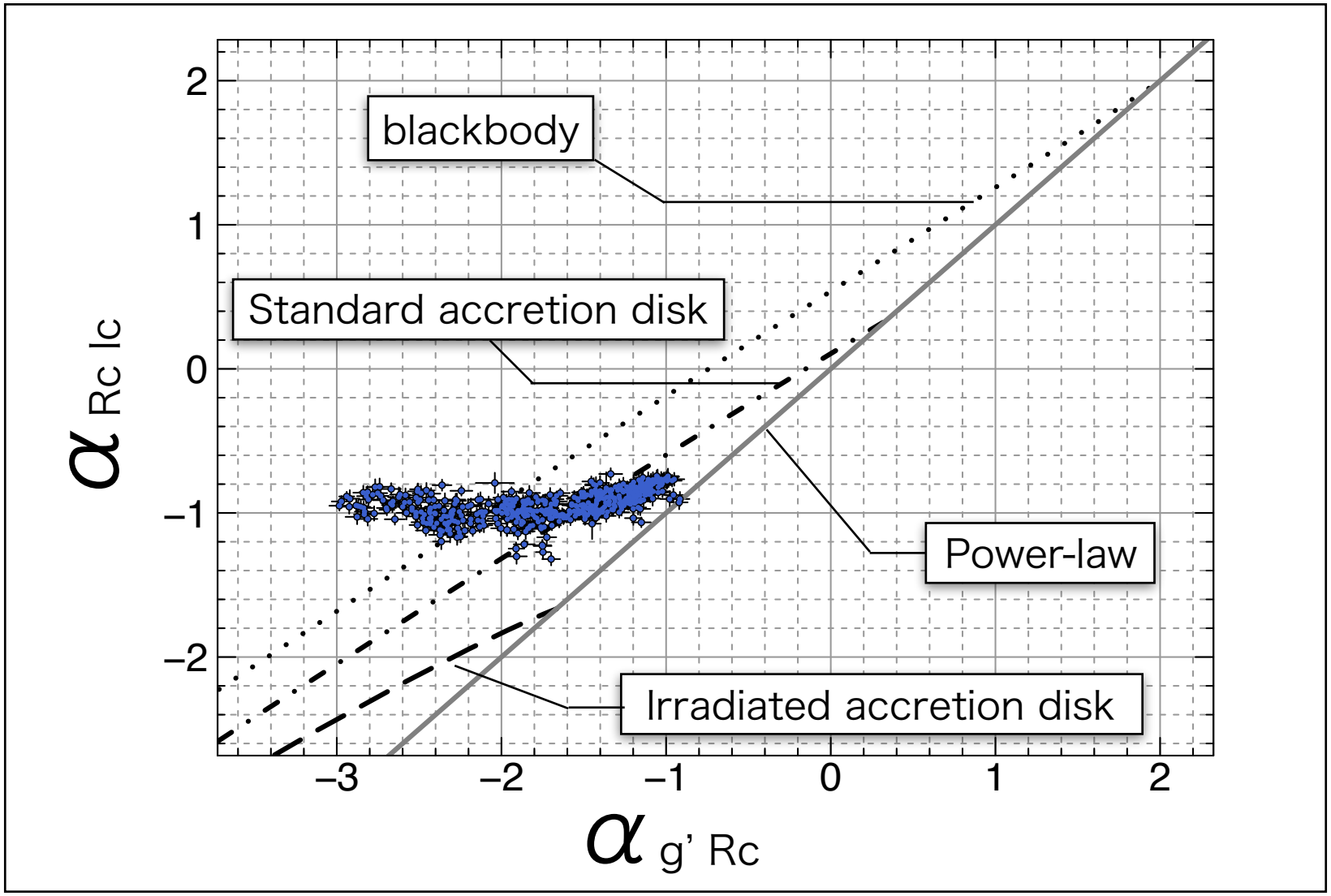
- Composing two distinct variations; **slow-big swings** & **small wiggles**
  - Slow-big swinging component show very large variations (~ 3 mag) on a timescale shorter than an hour
  - Fast-small wiggling component have variations smaller than 1 mag on a timescale about some minutes



Conclusion

- Fast-small wiggling component is the standard accretion disk
- Slow-big swinging component exhibits a power-law spectrum
- The optical variation is the mixture of these components

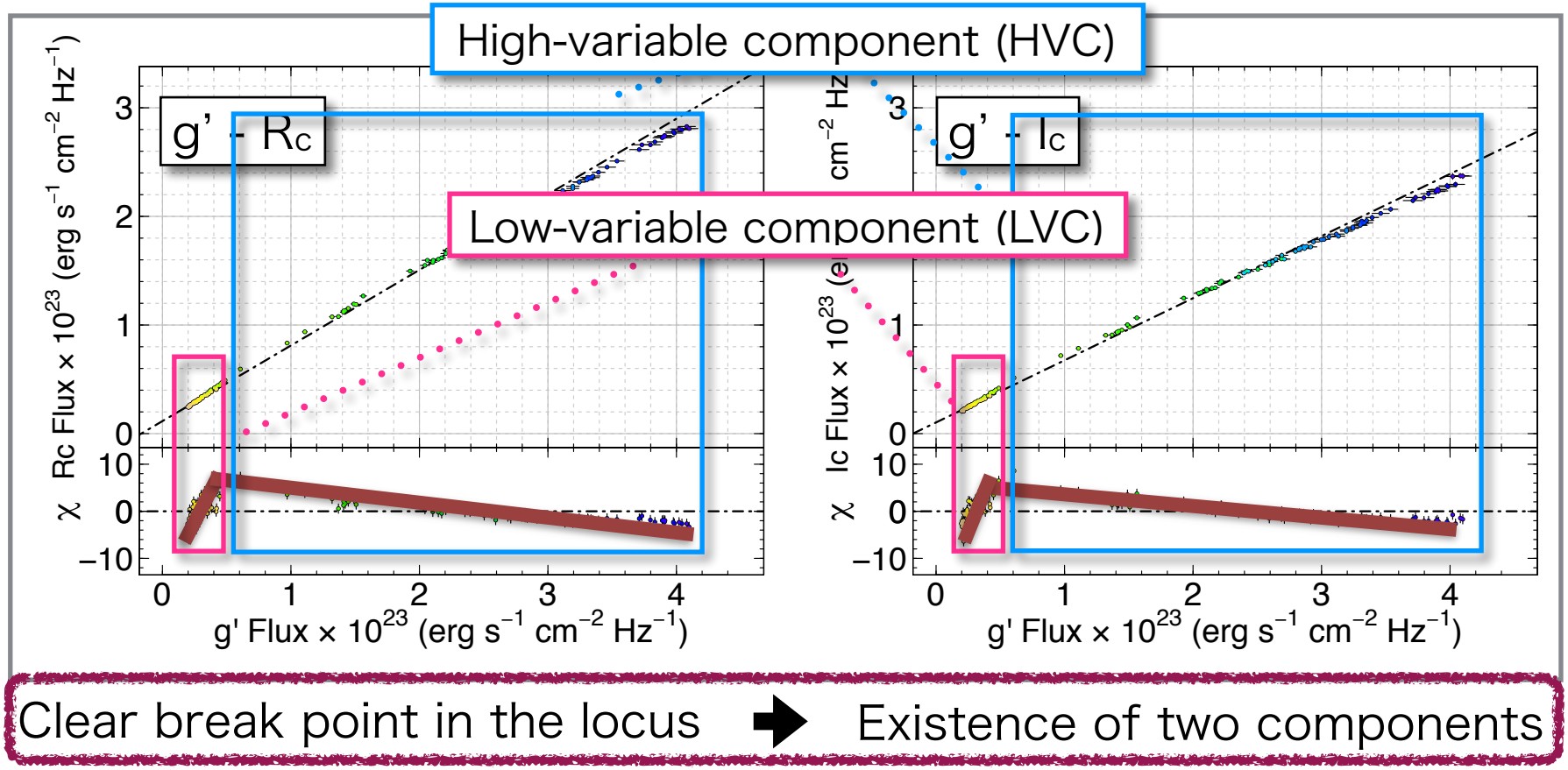
Spectral Variability



Correlation Analysis

Flux-Flux plot : Correlation diagram between different energy bands

The slope of the locus (k) is proportional to the spectral index(α): $\log(k) \propto \alpha$



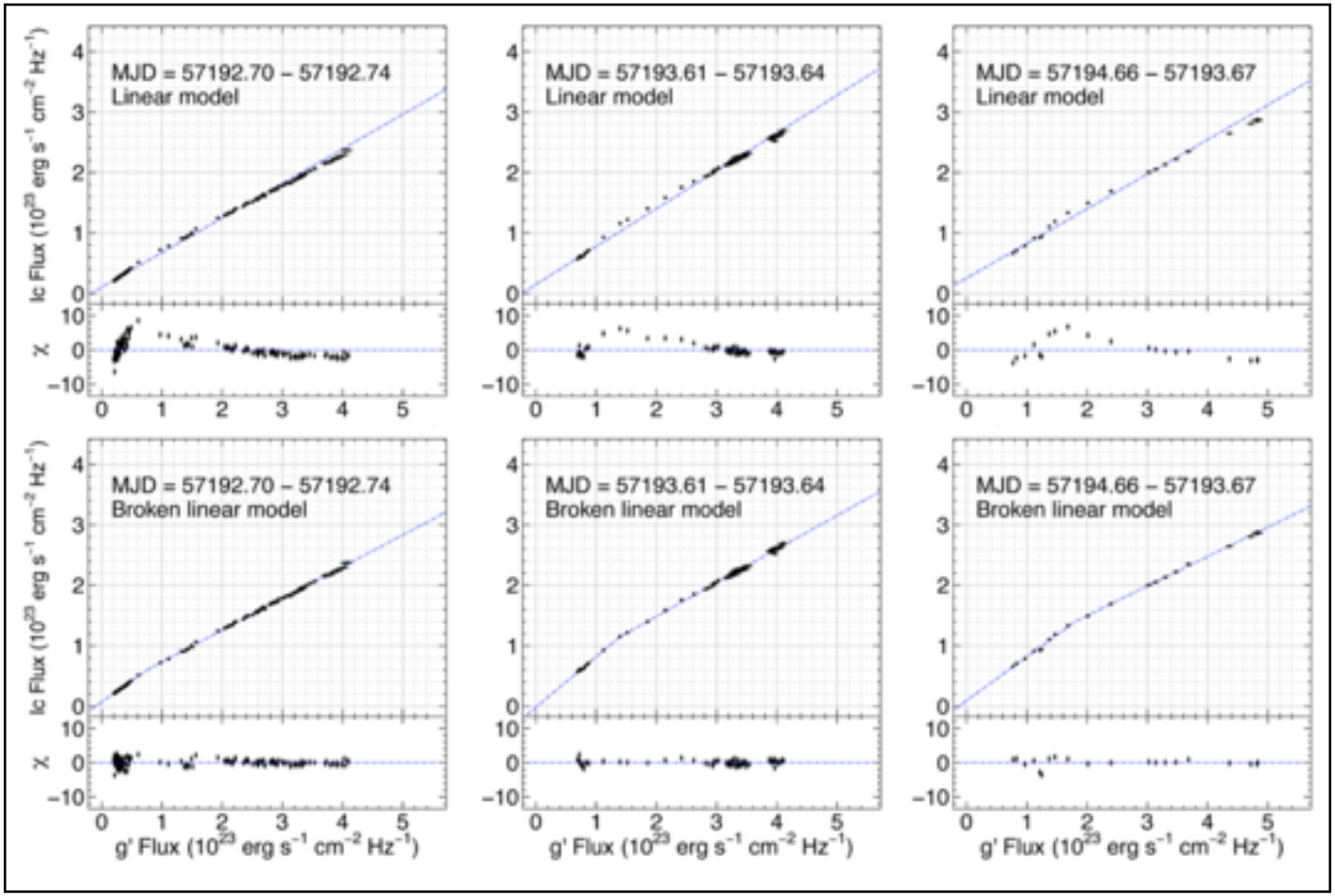
Clear break point in the locus ➡ Existence of two components

LVC = small wiggles & HVC = Large swings

Correlation Analysis

Flux-Flux plot : Correlation diagram between different energy bands

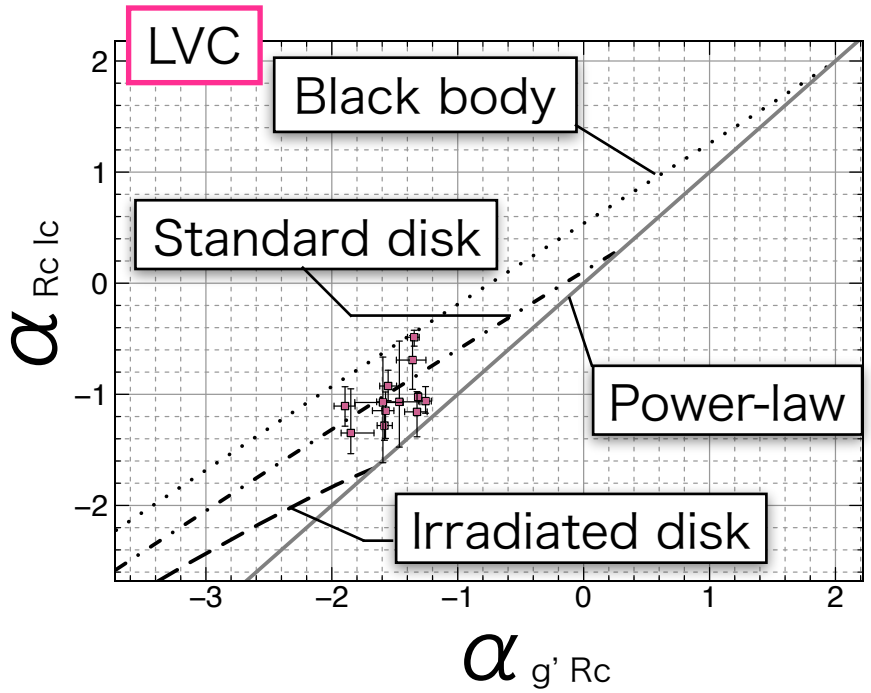
The slope of the locus (k) is proportional to the spectral index(α): $\log(k) \propto \alpha$

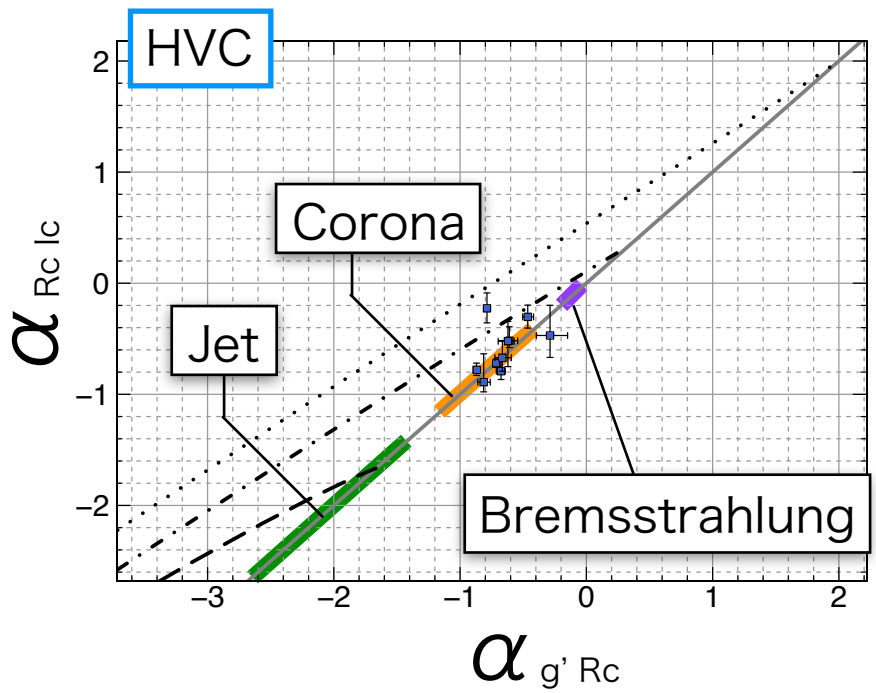


Spectral Variability

Estimating the origins of LVC and HVC from derived spectral indices

➡ Color-color diagram





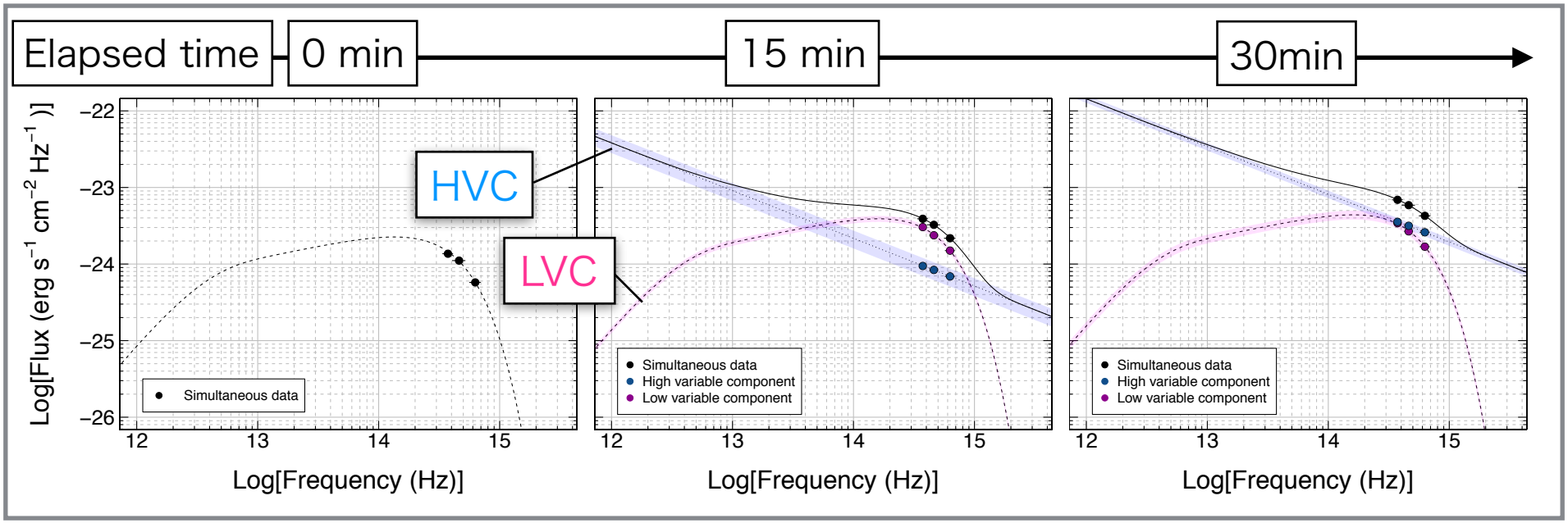
LVC : Emission from the standard accretion disk?

HVC : power-law spectrum ➡ Corona locating nearby the disk?

Optical SED

Verifying the interpretation : Optical SED = standard disk + power-law

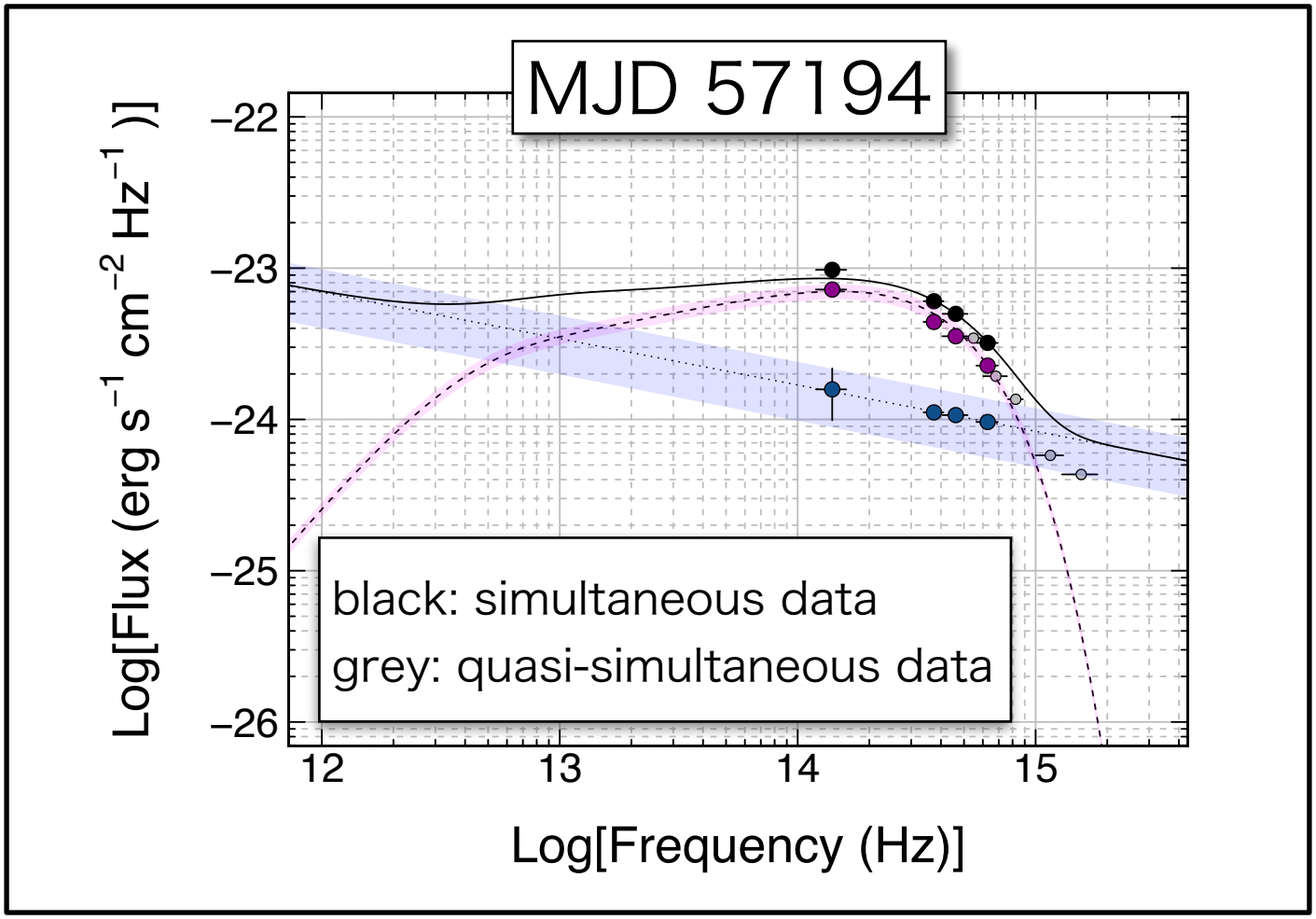
1. Determining the inner most temperature from spectral indices of LVC
2. Determining the power-law index from spectral indices of HVC
3. Fitting these models to the original data



Variation of HVC is always dominant without any assumption of normalization

NIR-UV SED

NIR-UV SED for V404 Cyg can be reconstructed with our model



Summary

We performed time domain analysis of the optical variation in V404 Cyg

- **Decomposed the optical variation** to two distinct components:

  low-variable component (LVC) and high-variable component (HVC)

- Derived characteristics of these components
  - LVC : its spectrum is similar with that of **standard disk model**
  - HVC : its spectrum follows **the power-law model**

We performed spectral energy distribution (SED) analysis from NIR to UV

- The SED can be interpreted as **the sum of LVC and HVC**
- Optical variations are able to reproduced by almost **only the changes of HVC** (consistent with the result of the time domain analysis)