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Shot Analysis of Kepler Blazar W2R 1926+42

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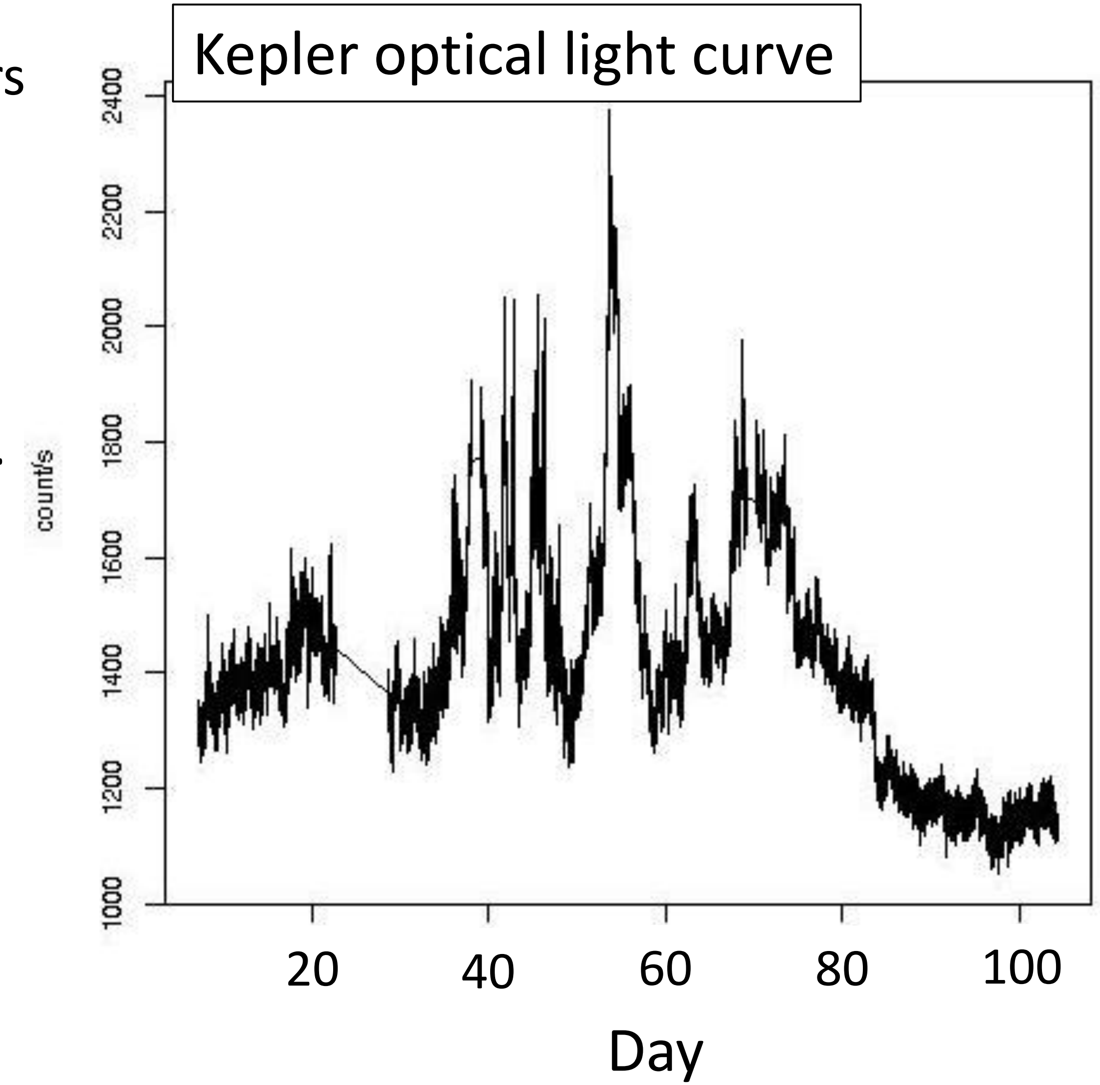
Rapid Variation in Blazars and W2R 1926+42

- Blazars show violent variations with minutes to years timescales.
- Long-term variations are apparently composed numerous components with a variety of timescales.
- Rapid variations (with timescales less than a day) seem to be superposed on the long-term variations.
- The origin of variations is poorly understood.

➢ We investigate a mechanism of rapid variation.

- Monitored by *Kepler spacecraft* with 1-minute time resolution.



Why Shot Analysis?

- Frequency-domain analyses (e.g. PSD) are limited use, since it is difficult to relate with physical mechanisms.
- Time-domain analyses could be useful, however, photon statistics is rather poor.

➡ Stacking analysis (superposition of many shots to produce “mean shot profile”)

☐ *Problem with rapid variations*

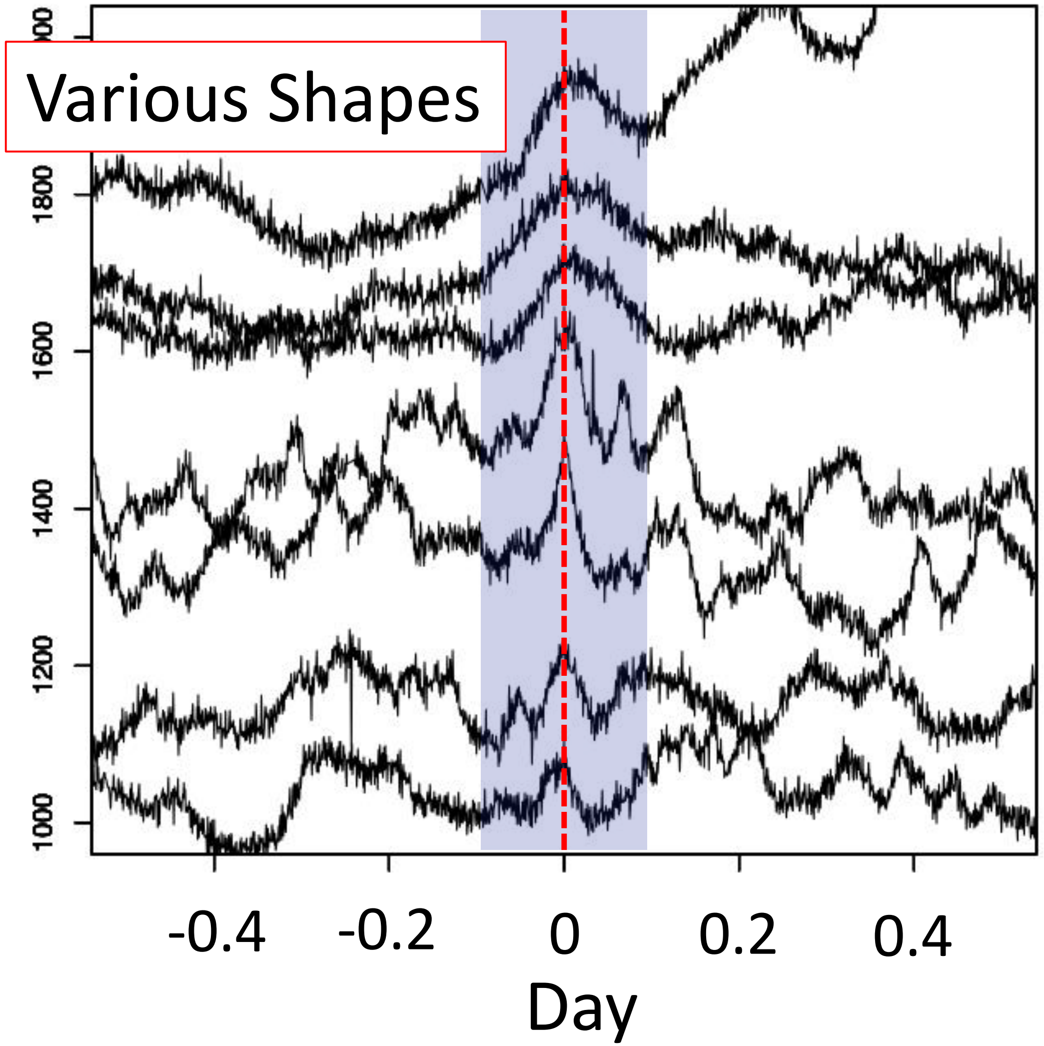
- Various shapes (amplitude and acuteness)

☐ *Advantage of Shot Analysis*

- Local features are cancelled in the mean profile.

➢ *Calculate a mean profile of rapid variations.*

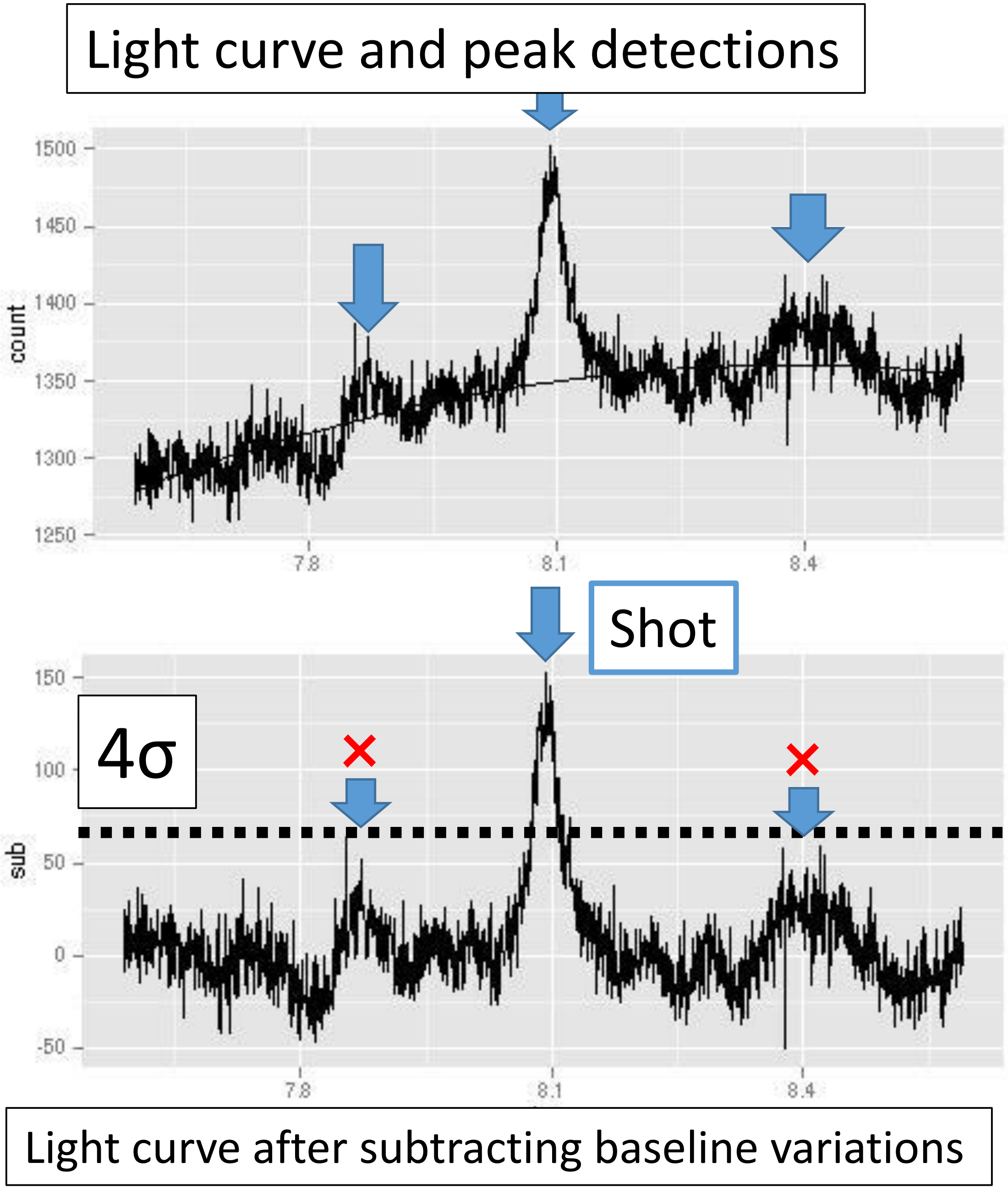
Examples of rapid variations



Detection of Shots

- We define a detection procedure and choice variations as shots.
- Select candidates of rapid variations
    1. Approximate a baseline variation by polynomial function, and subtract.
    2. Estimate an amplitude of the rapid variation.
    3. If the amplitude is larger than 4σ of Poisson noise level, we define the rapid variation as a shot.

We detect 195 shots. We calculate a mean profile of these detected shots.

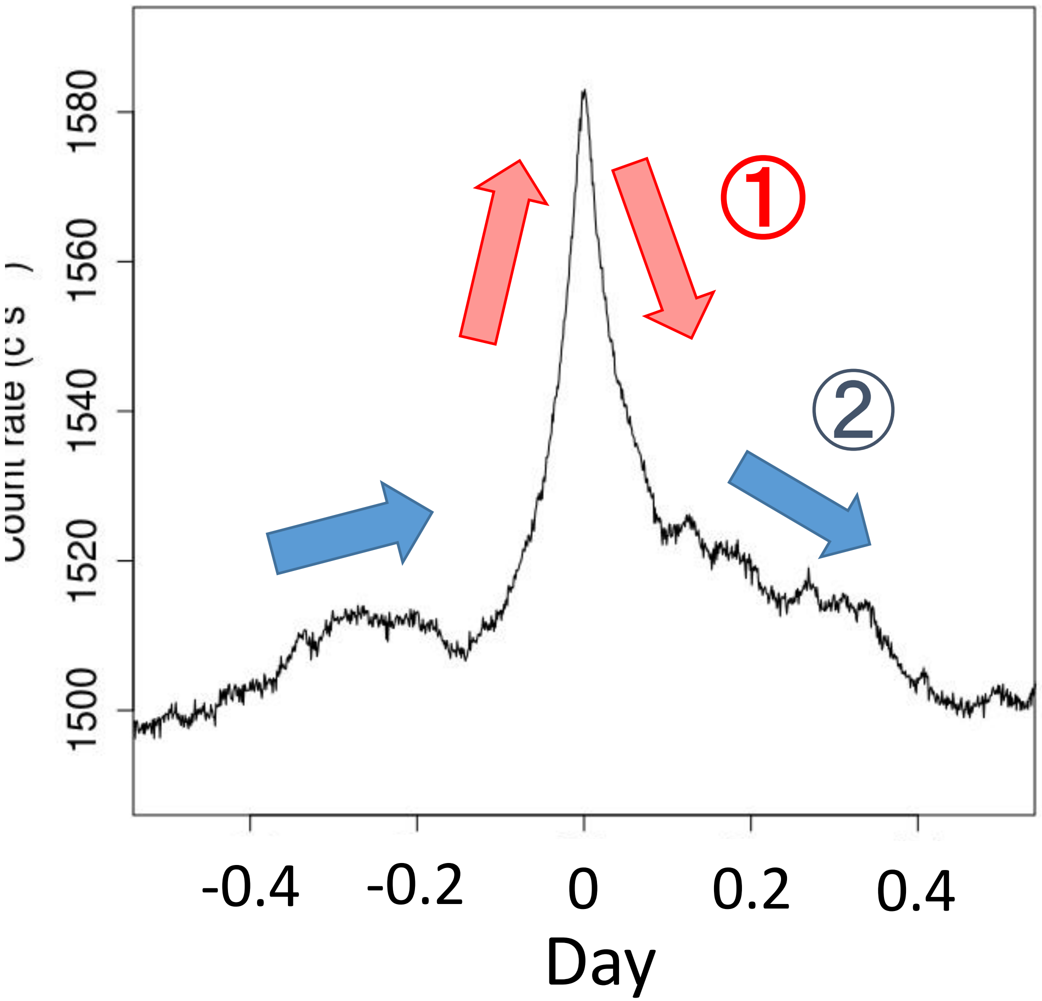


Mean Profile of Detected Shots

- Two components
  1. Spiky component with rapid rise and decay
  2. Slowly varying baseline component
- Rising and decaying of component 1 are exponential shapes.
- The peak of the component 1 is smoothly connected from rising to decaying.

◆ Estimate the rising and decaying timescales of component 1.

Mean profile of shots



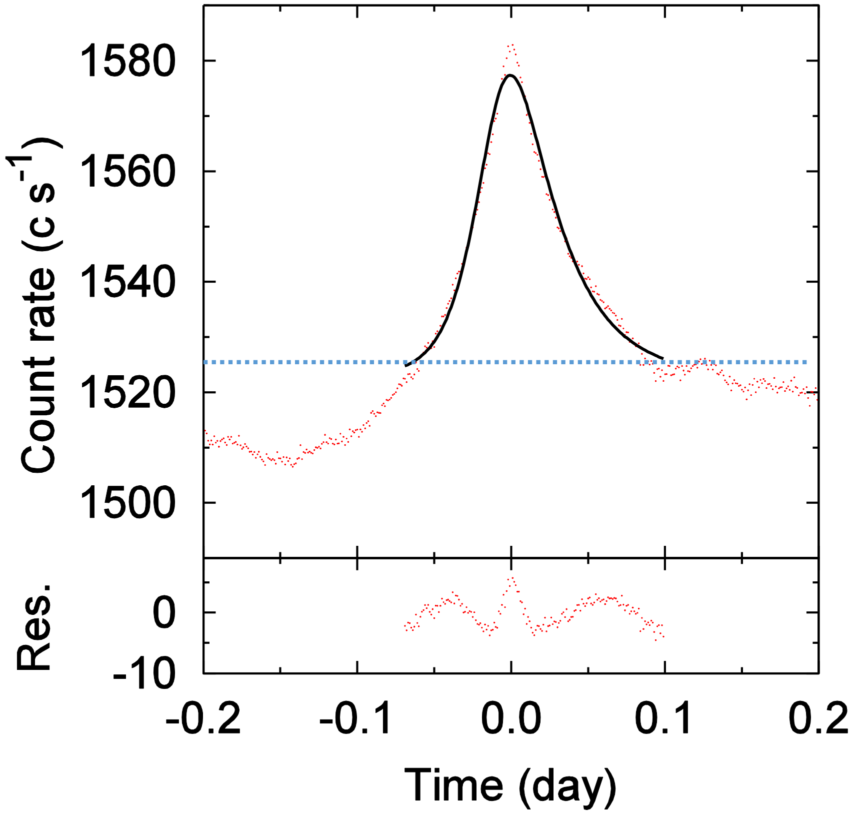
Rising and Decaying Timescales

- Fitted with exponential function to component 1

$$F(t) = \frac{F_0}{e^{-t/T_r} + e^{t/T_d}} + F_c$$

Abdo+ 2010

e-folding time	Best Fitted Value	95% confidence level
Rising time; T_r	0.0189 (day)	[0.0147, 0.0217]
Decaying time; T_d	0.0240 (day)	[0.0180, 0.0284]

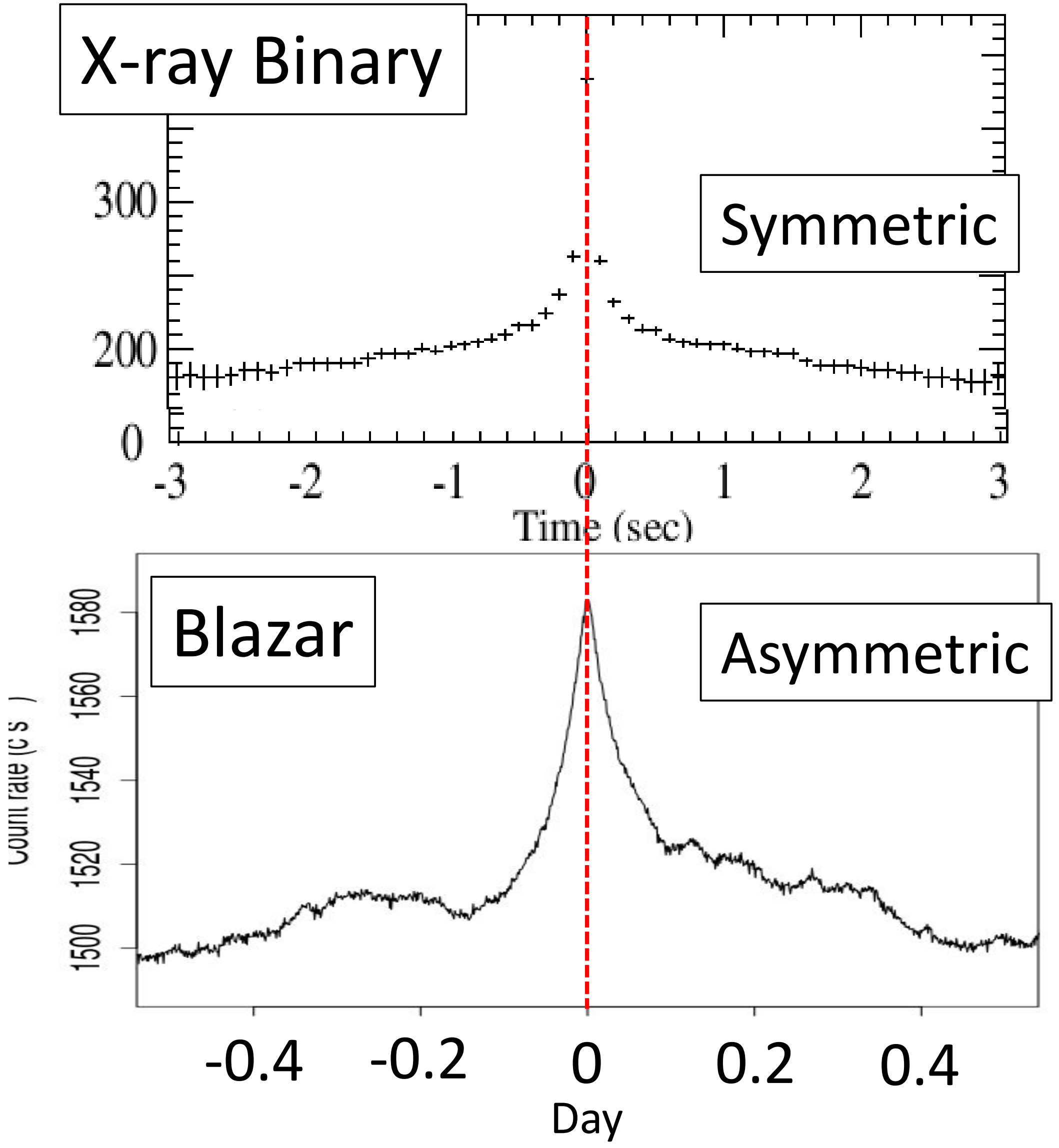


There is a difference between rising and decaying timescales.

Comparison with Profile of X-ray Binary

- Cygnus X-1, which is one of the most famous X-ray binaries, shows rapid variations with less than 1-sec timescale.
- The mean profile of shots in Cyg X-1 is almost symmetric, but depends on energy bands.
- Profiles between the blazar and Cyg X-1 are different.
- Future work; Spectral study to the mean profile of shots

Yamada+ 2013



Origin of Rapid Variations

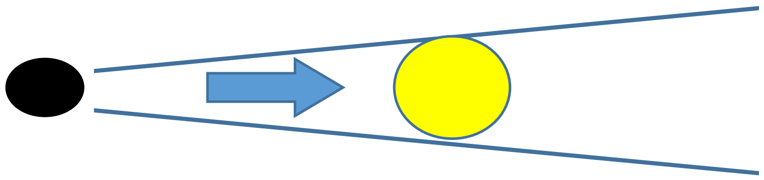
- If shots are caused by a variation of viewing angle, the shot profile should be symmetric.
  - ➢ A model in which the shot is caused by the symmetric variation of Doppler factor (e.g. precession of jet axis) is RULED OUT.

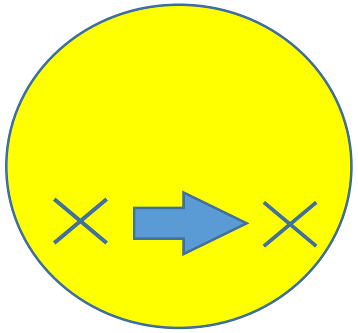
➢ Rapid variations are likely to be intrinsic phenomena.

- Particle acceleration in rapid variations

● Rising phase; an increase of the number of high-energy electrons in the jet.

● Decaying phase; In the case of synchrotron cooling, the Doppler factor can be estimated as 18 from its timescale (=2074 sec), assuming B=0.5 Gauss.





Observing point moves

✕ Symmetric profile

⇩

Particle acceleration

Summary

- Rapid variations with hours timescale always exist in W2R 1926+42.
- A mean profile of the rapid variations calculated from 195 shots shows an asymmetric profile.
- The mean profile of blazar is different from that of X-ray binary.
- Rising and decaying timescales of the mean profile are different.
  - ➢The rapid variations can be occurred by an increase of accelerated particles.

Thank you for your attention.