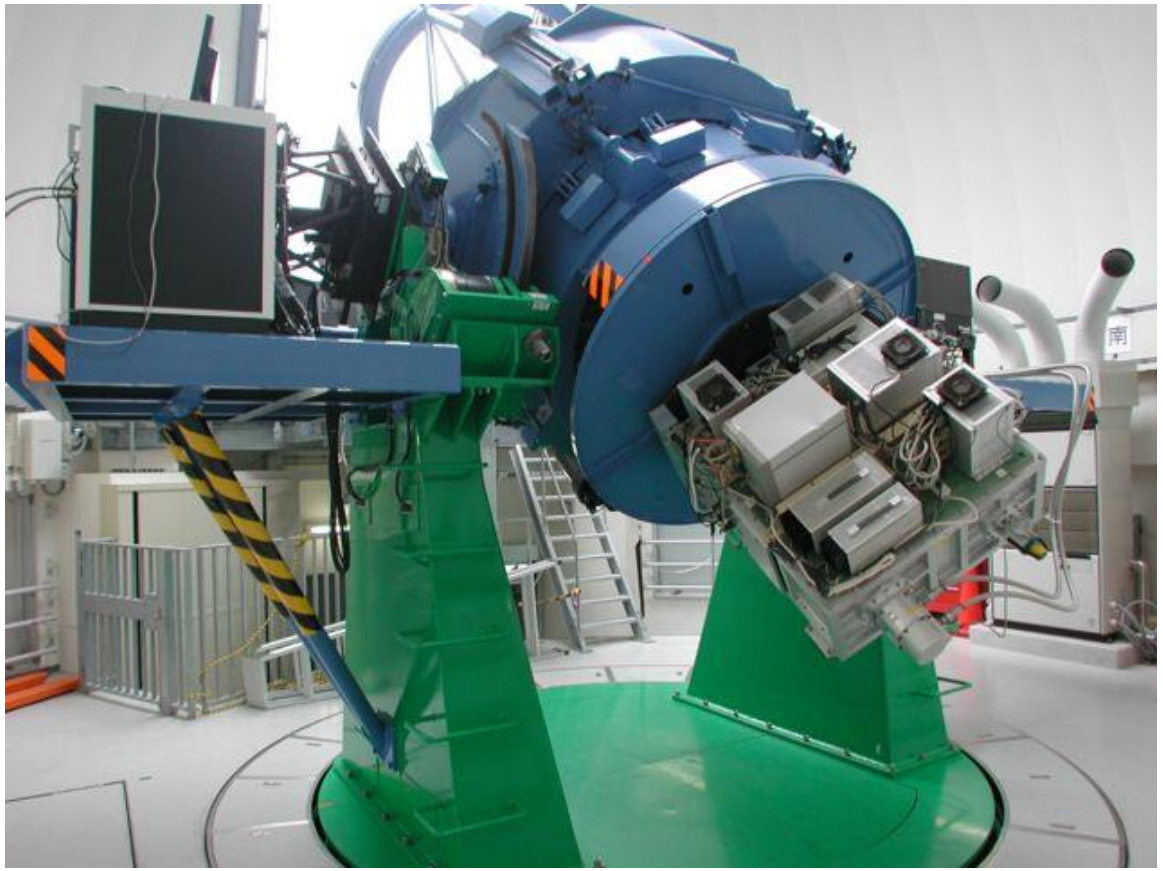
Current status and results of the Kanata telescope

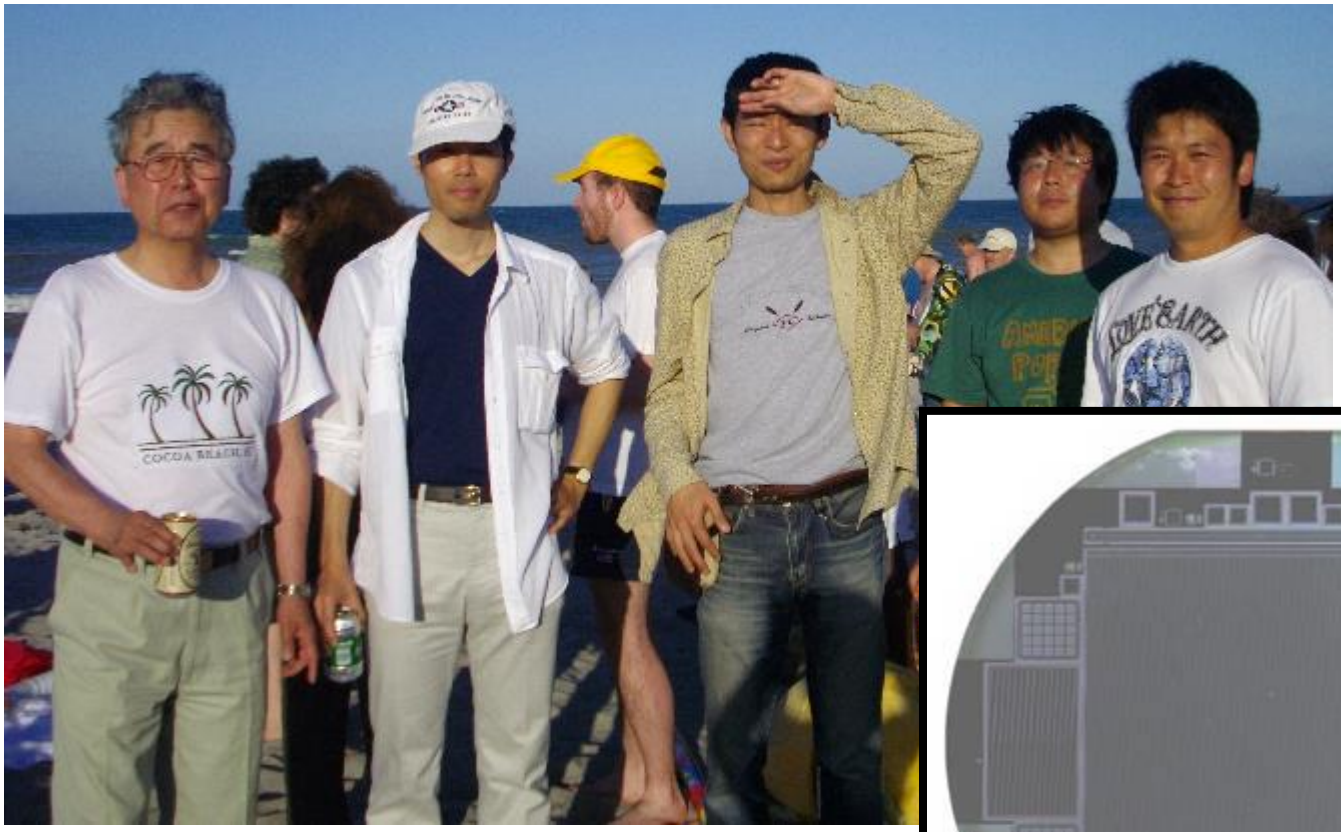
Makoto Uemura
(Hiroshima University)
on behalf of the “Kanata” team

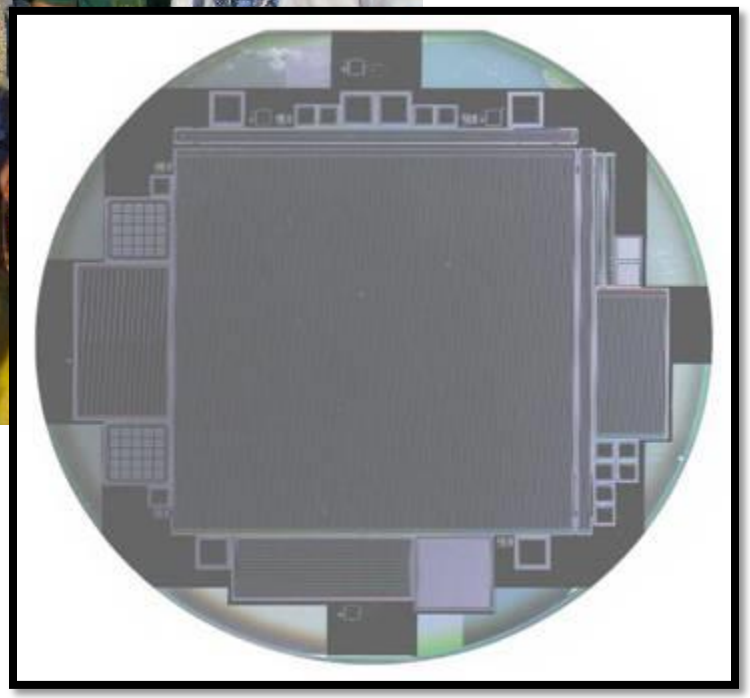


Outline

- Introduction of the “Kanata” group
- Blazar monitoring with “Kanata”
- Future plan

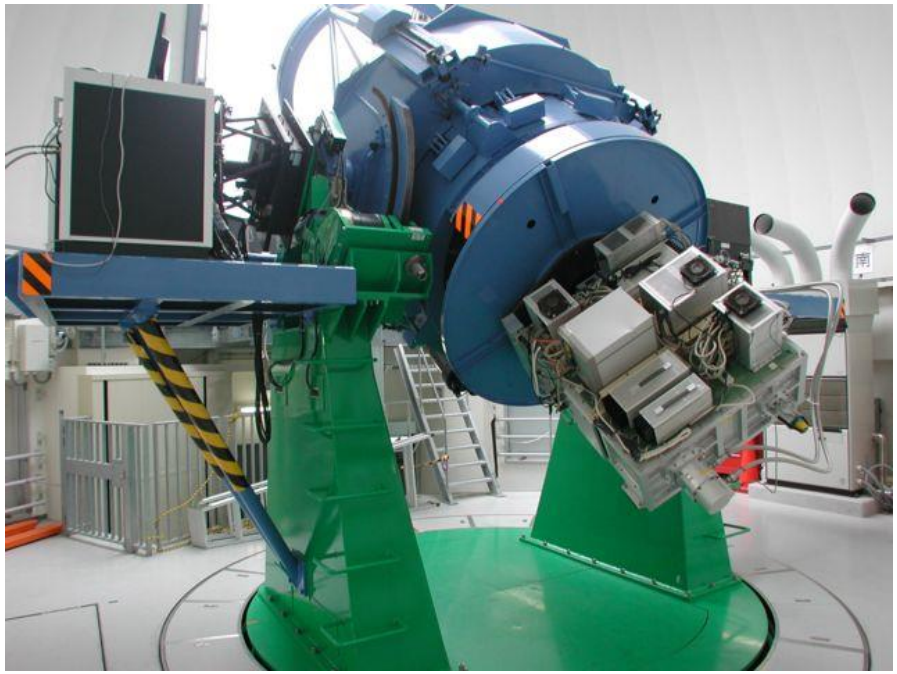
Fermi and our group





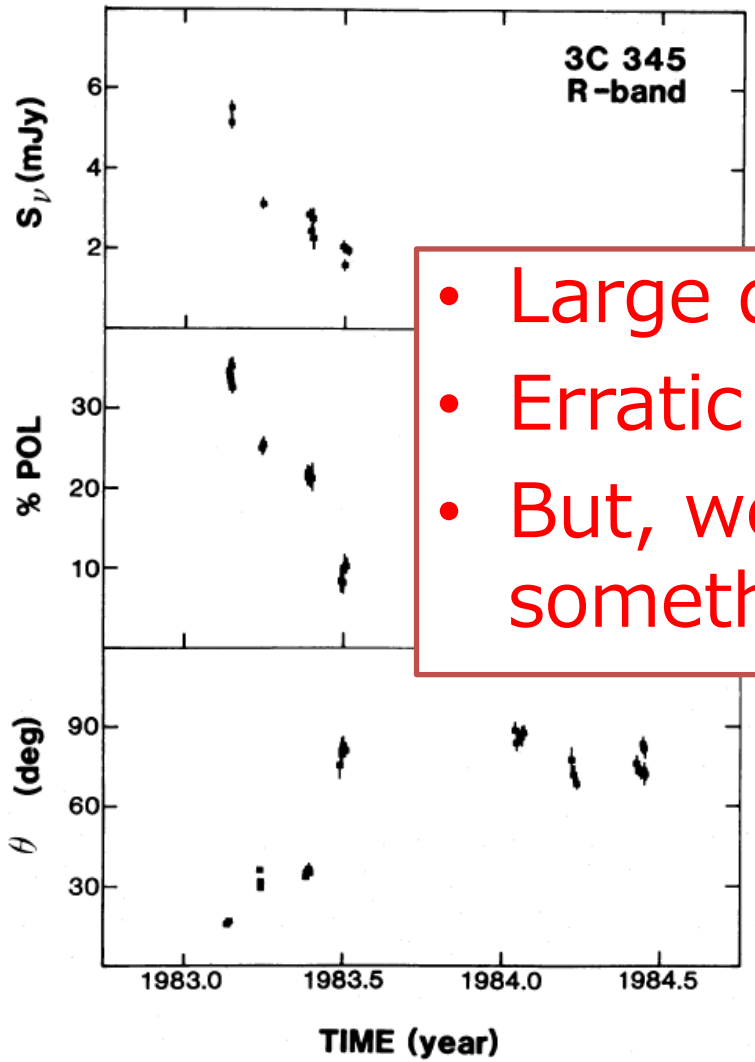
“Kanata” telescope

- Since 2006
- 1.5-m
- Observatory
  - 20 min by car from here
- Polarimetry
- Simultaneous optical and NIR observations
- Follow-up observations of Fermi blazars
- Dedicated for astronomical transients
  - GRB
  - Supernovae
  - Cataclysmic variables
  - X-ray transients

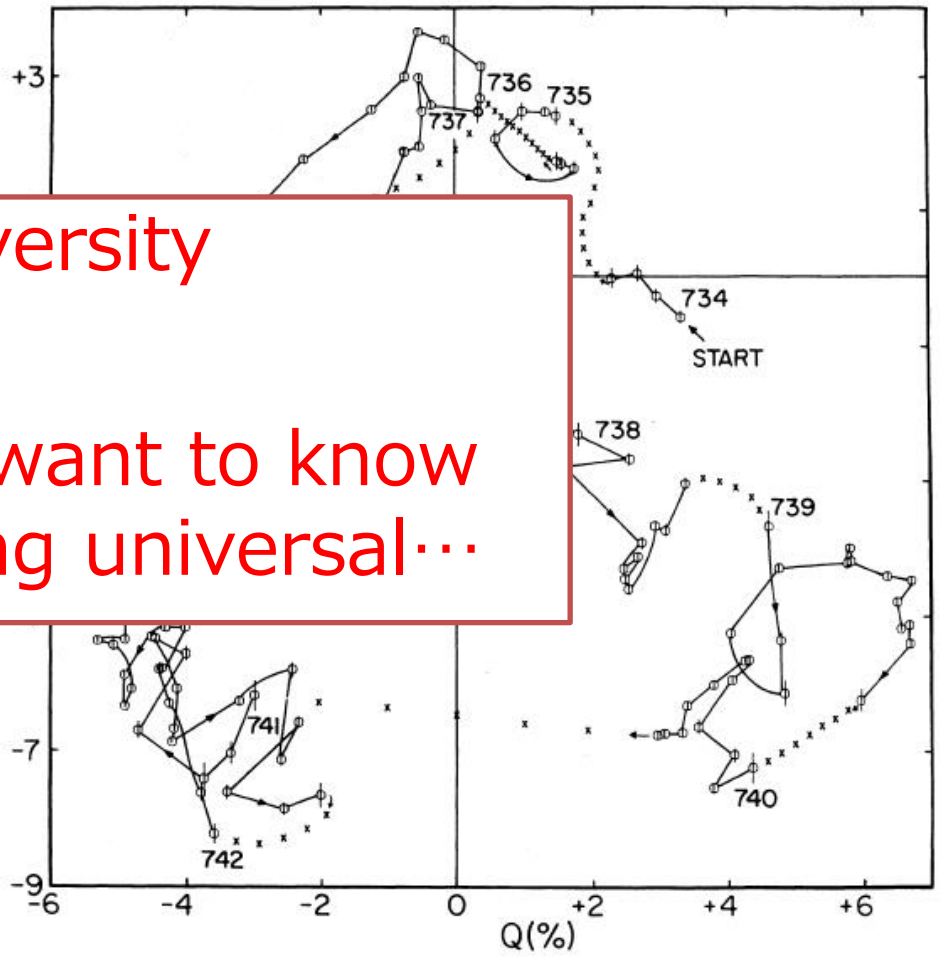


Past studies of blazar polarization

Example of systematic variation in 3C 345 (Smith et al. 1986)



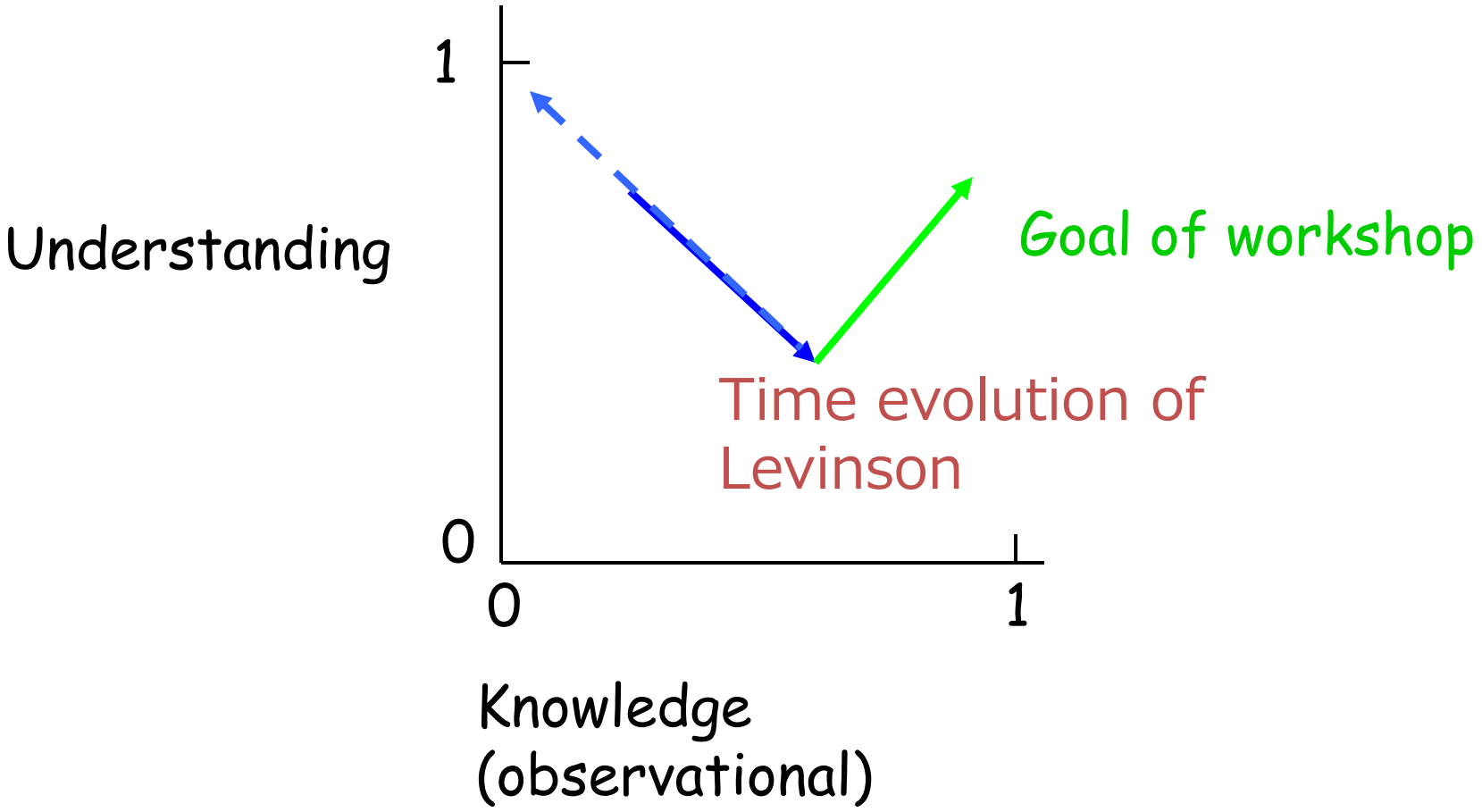
Example of random motion in the QU plane of BL Lac (Moore et al. 1982)



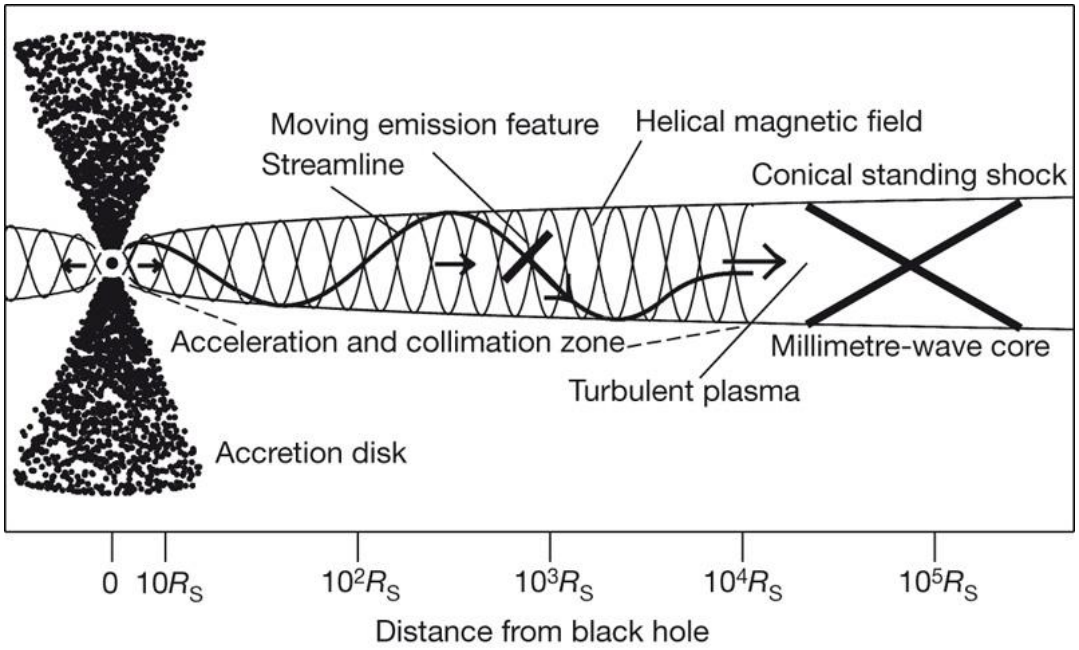
- Large diversity
- Erratic
- But, we want to know something universal…

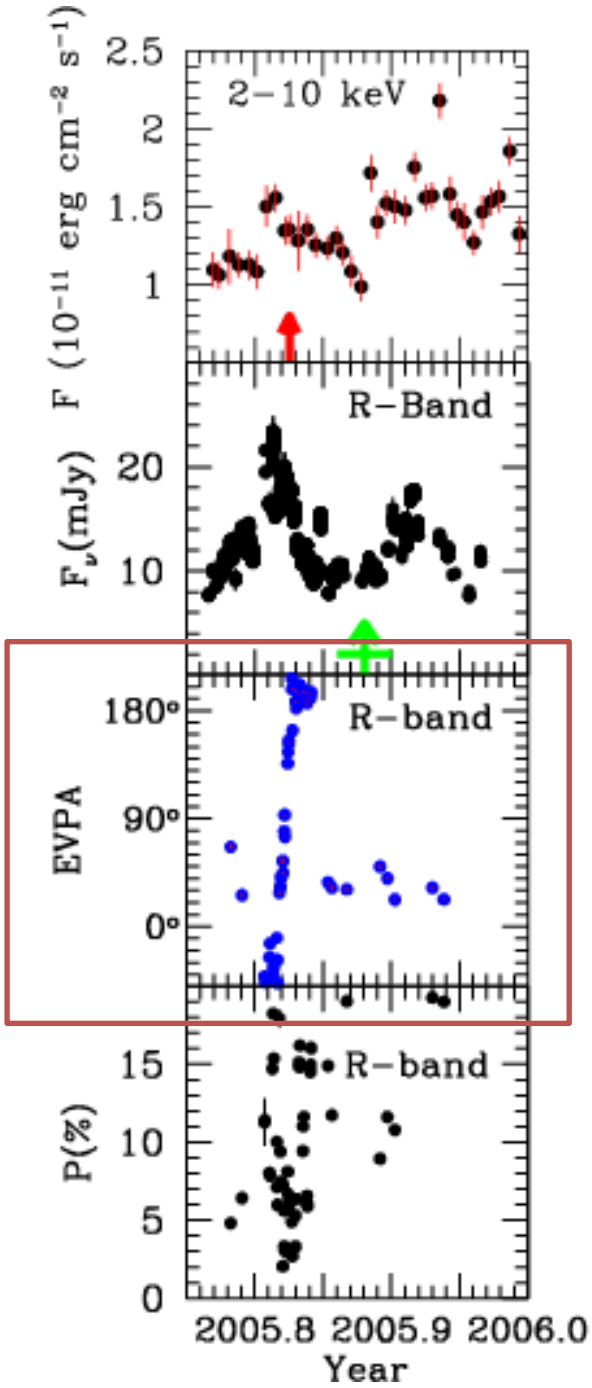
Summary talk in "Workshop on Blazar Variability across the Electromagnetic Spectrum" on 22-25 Apr 2008 in Ecole Polytechnique (France), by Dr. P. Kaaret.

Amir: "The more I know about these objects, the less I understand them".



Rotation of polarization



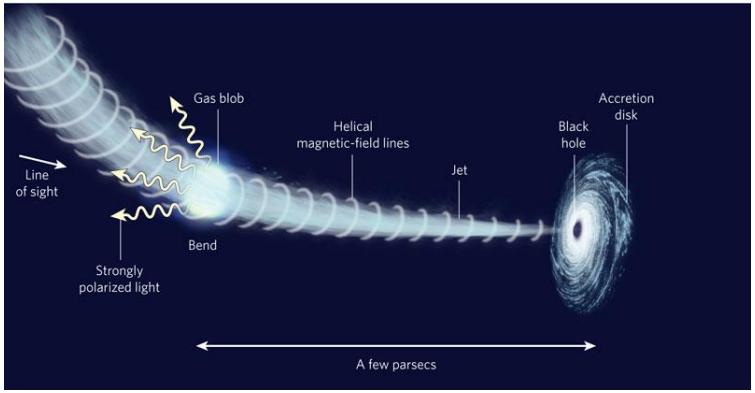


- BL Lac
- Rotation of Polarization → TeV flare
  - Marscher+

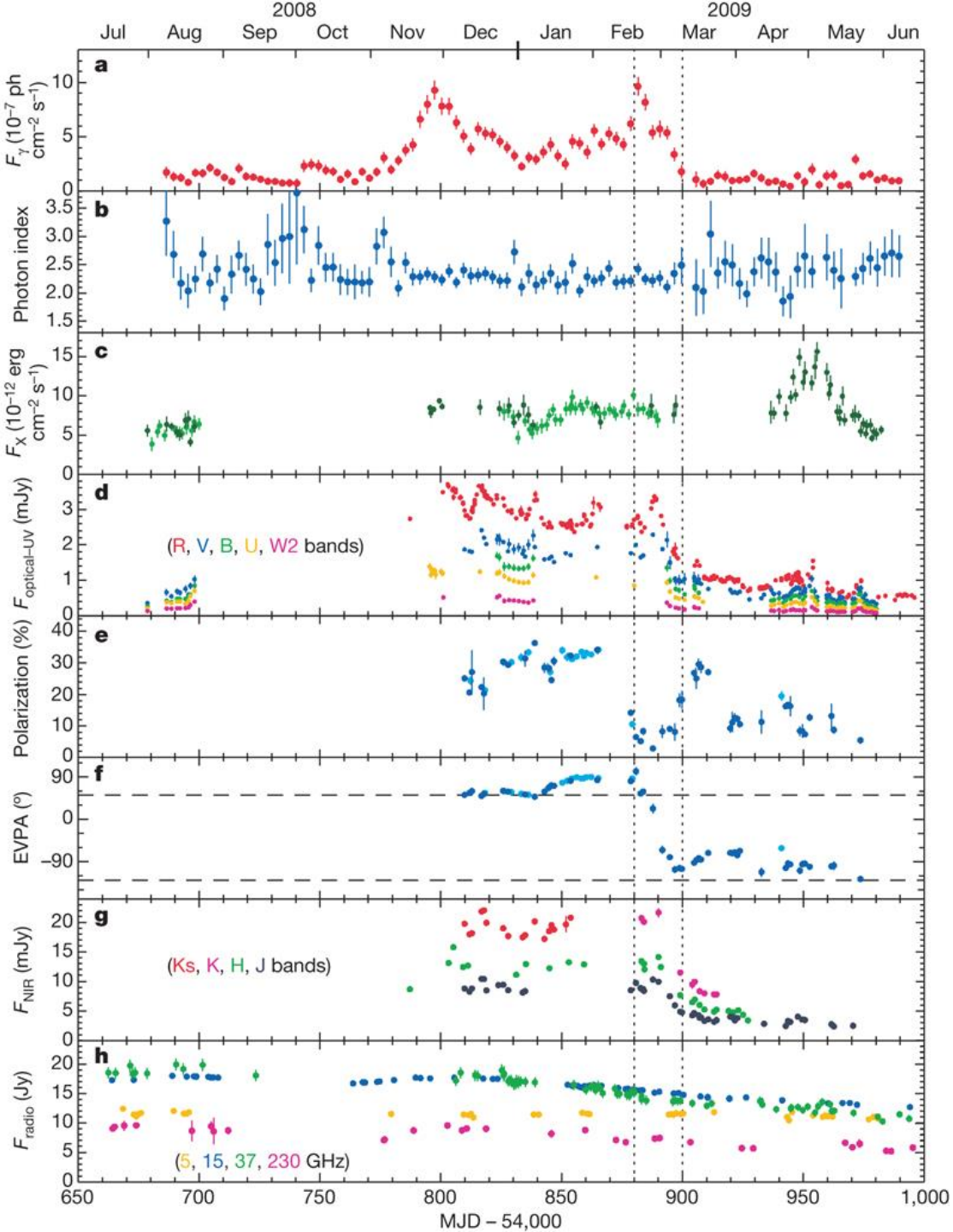
Blazar monitoring project with “Kanata”

- Goal: to establish properties of polarization variations in blazars
- Method: polarization monitoring with short cadence (once a few days) and a long monitoring period (a few years)
- Instrument
  - “Kanata” 1.5-m telescope
  - TRISPEC: simultaneous optical and NIR images with the polarimetric mode
- Targets: 42 blazars
  - 13 FSRQs, 8 LBLs, 9 IBLs, and 12 HBLs
- Observation period
  - 2008 --- 2010 with TRISPEC (Ikejiri, et al. 2011)
  - Continuing with HOWPol up to now

Polarization rotation in 3C 279

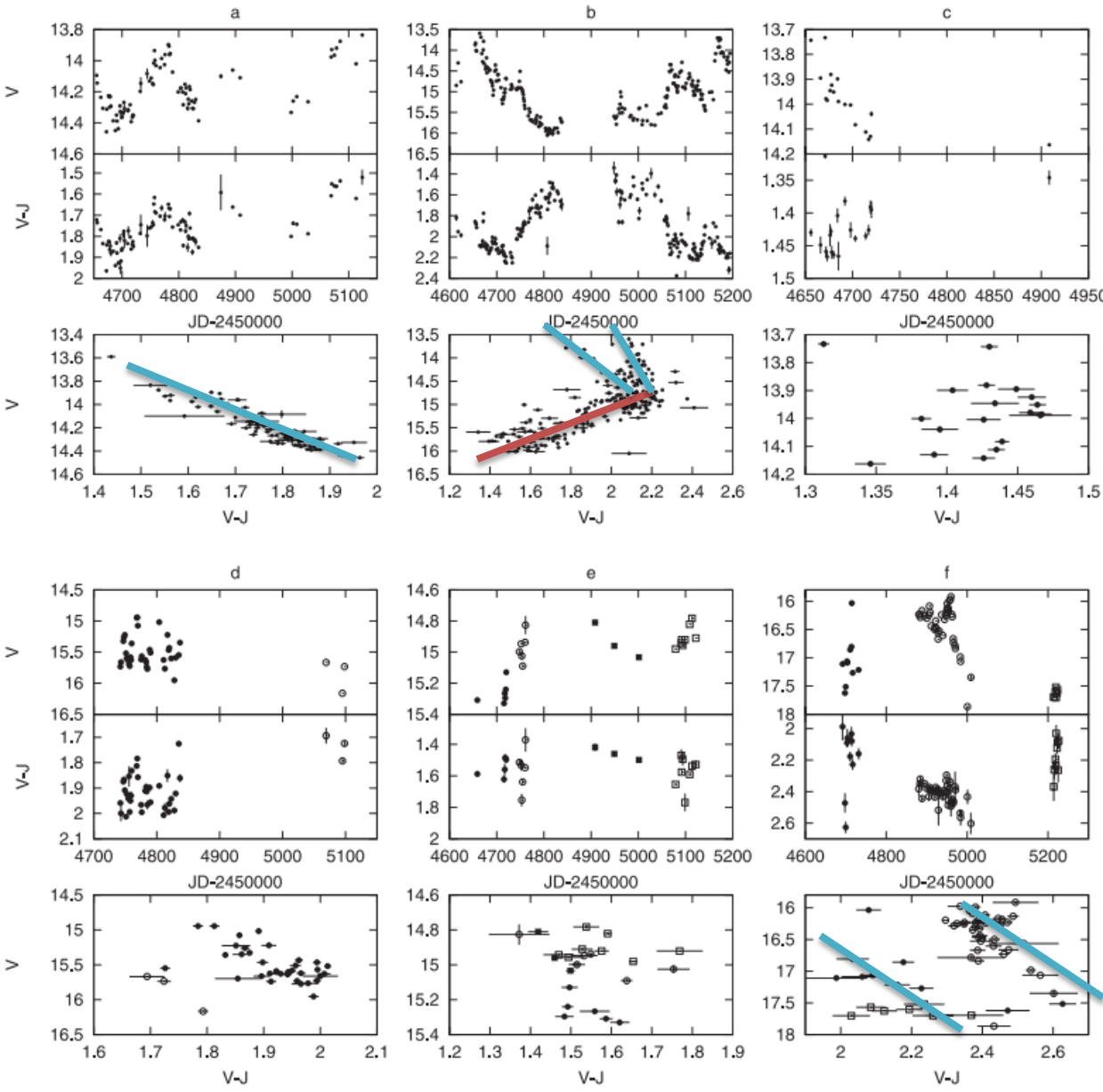


- Abdo+10, *Nature*
- Optical and gamma-ray flares
- Polarization rotation
- Bending jet scenario

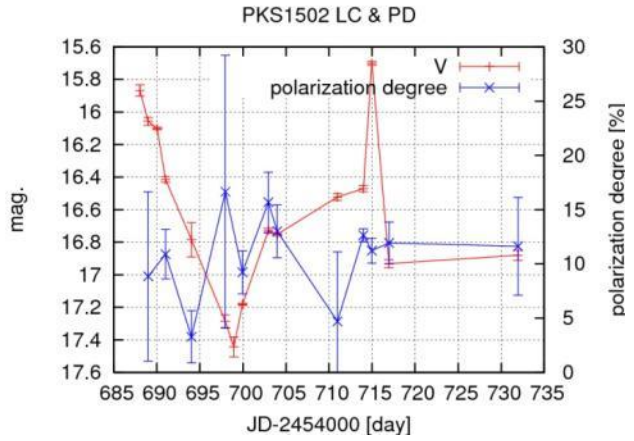


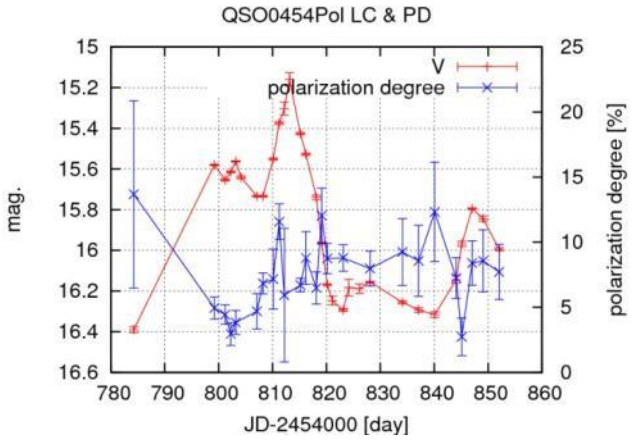
Universal correlation between the flux and color

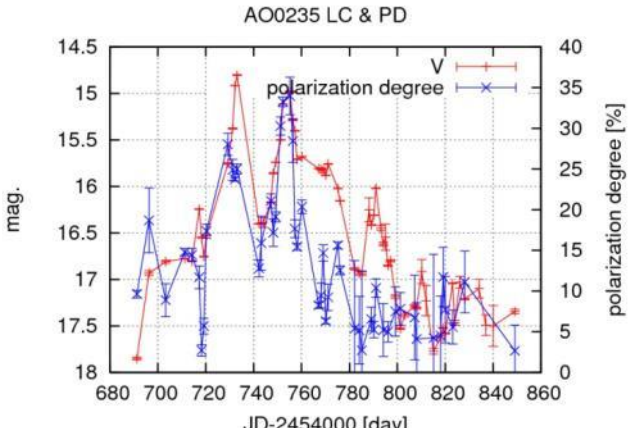
- Ikejiri+11
- Bluer-when-brighter = universal law in blazars
- Flare = increase of high energy electrons

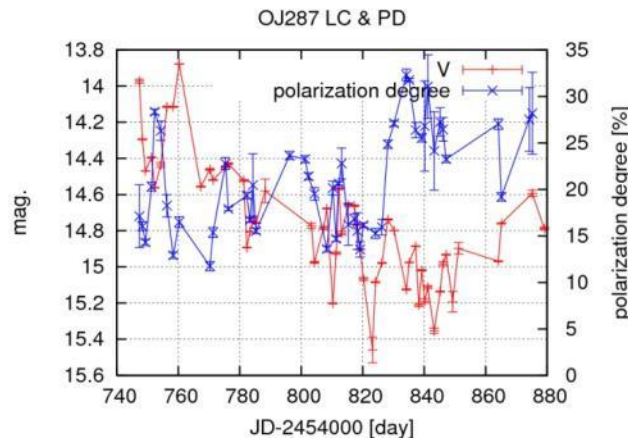


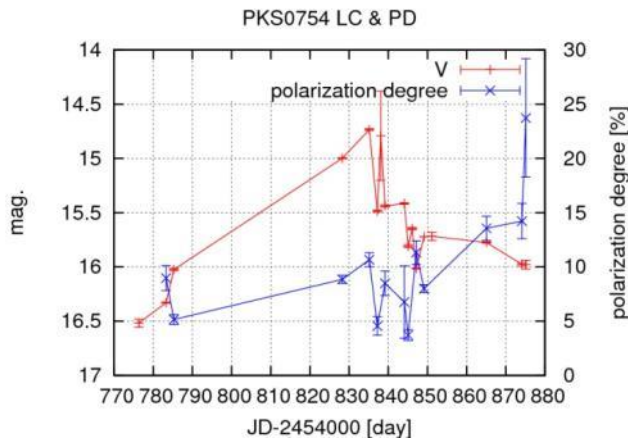
Examples of Polarimetric observations

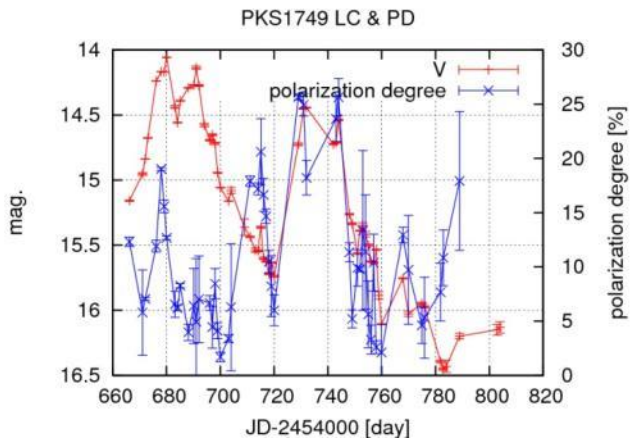












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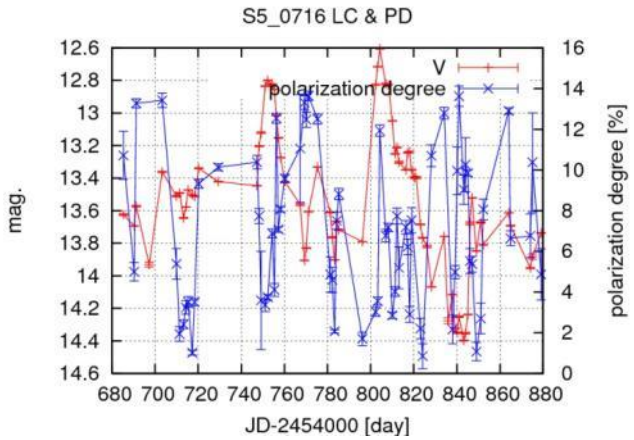
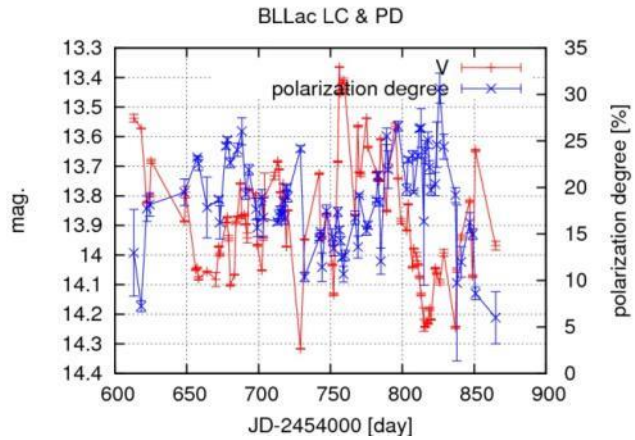
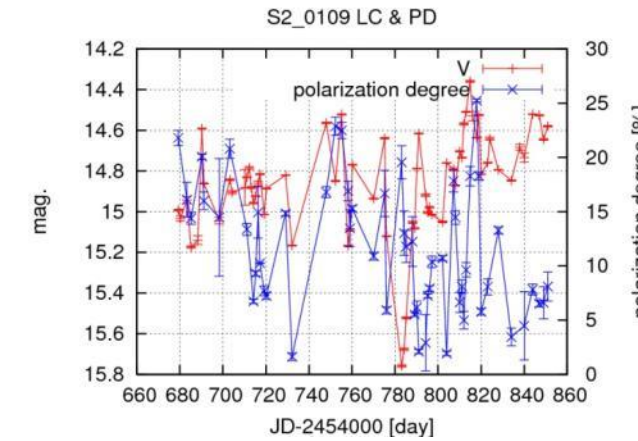
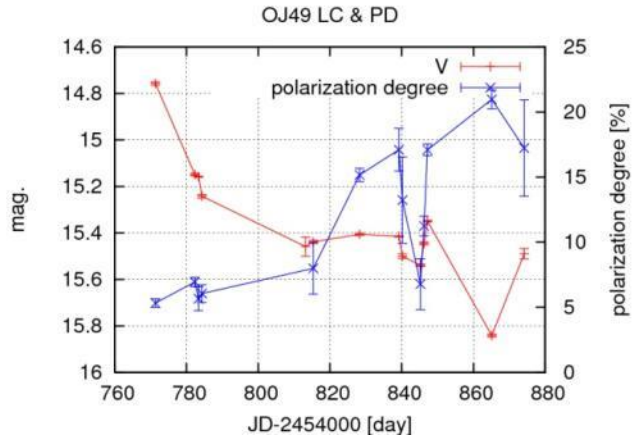
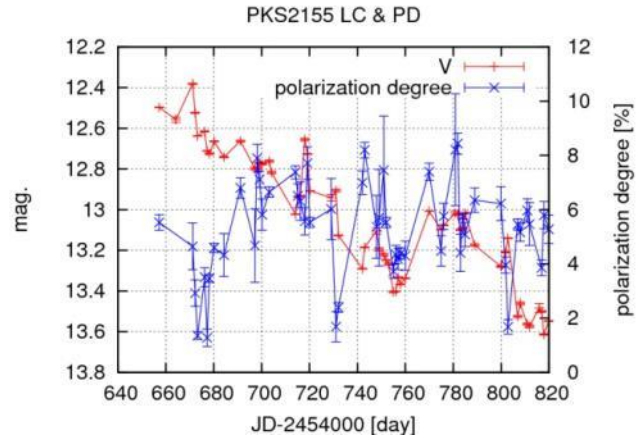
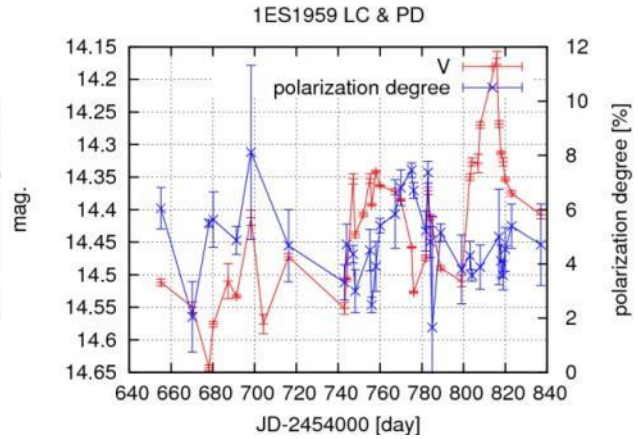










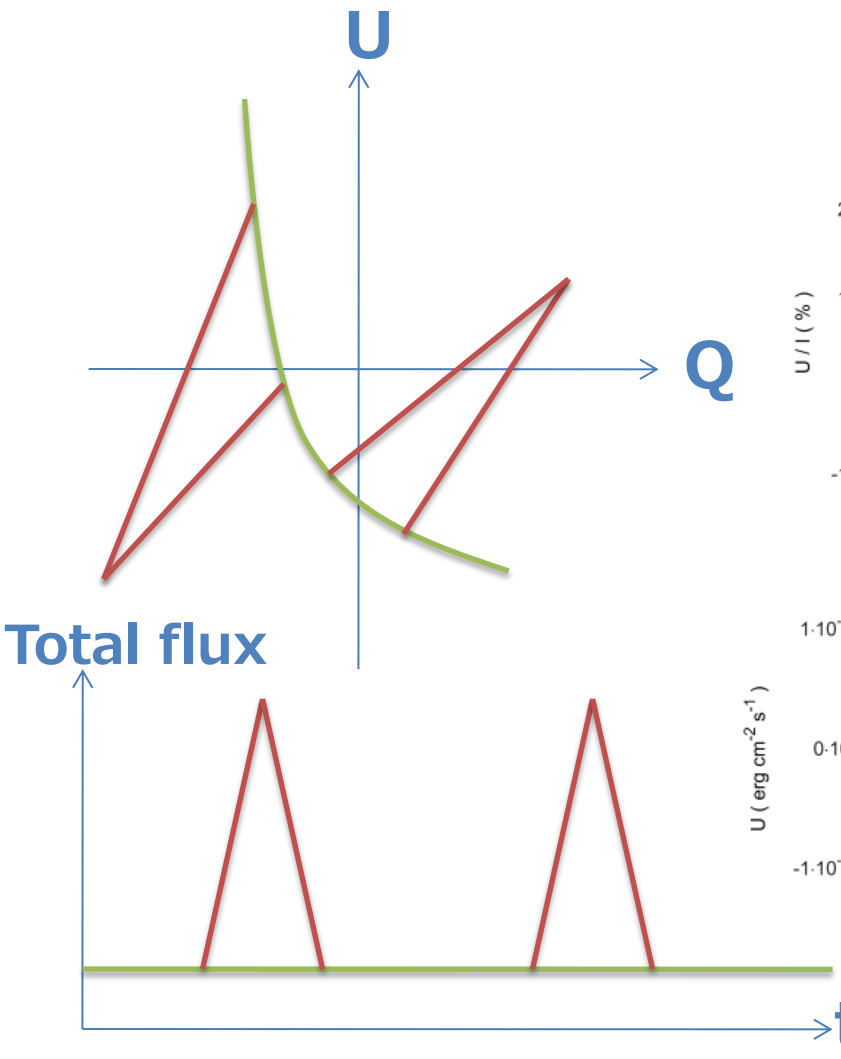


Universal Characteristics of Polarization Variations

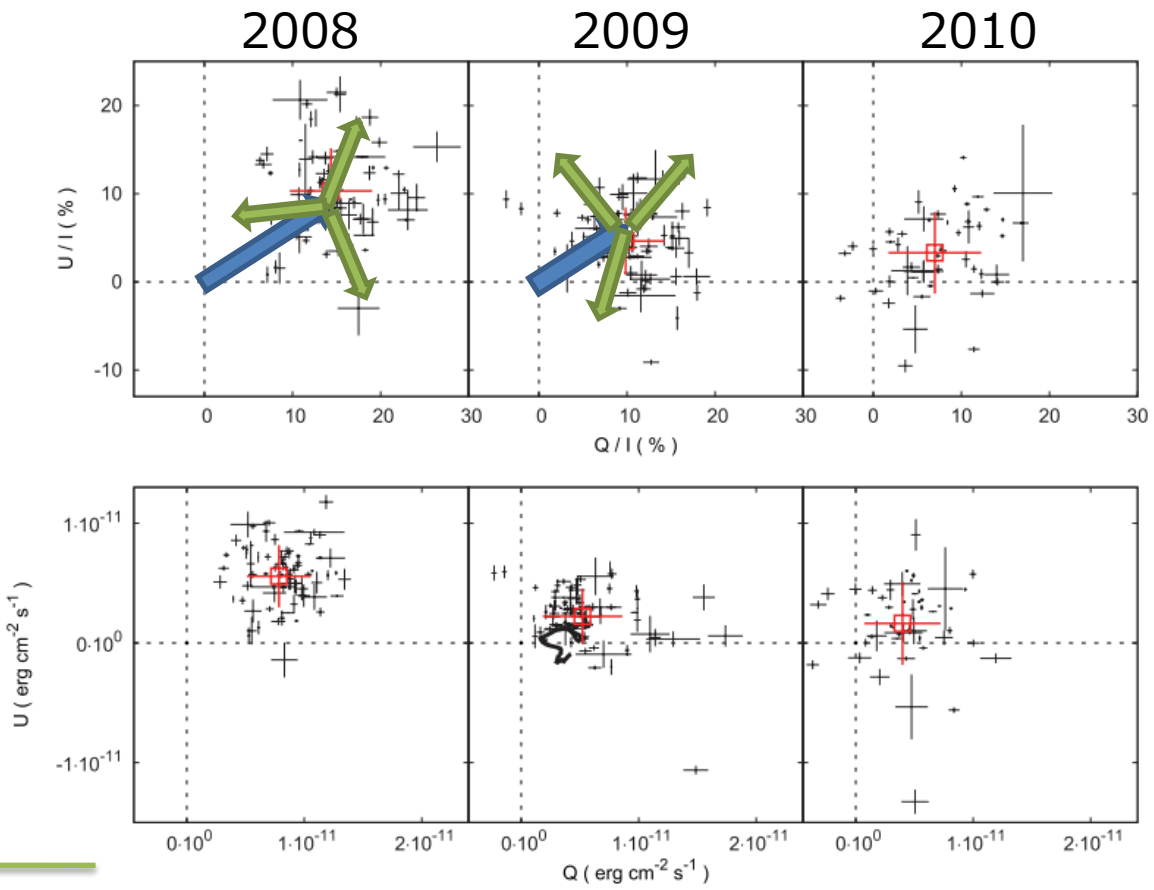
Erratic

(Yes, we know it, already)

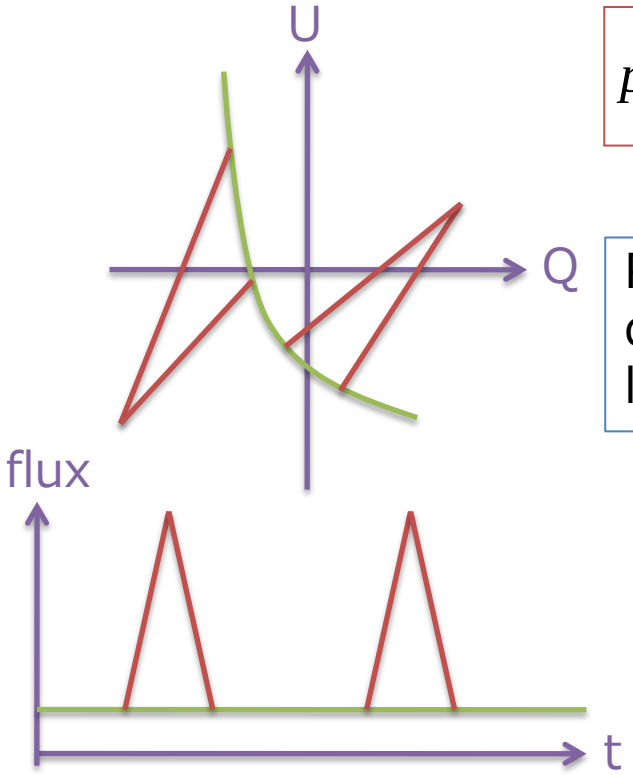
Variations in the Stokes QU plane



BL Lac (Sakimoto et all., 2013)



Bayesian separation: Model (Uemura+10)



$$p(Q_0, U_0 \mid f, Q_{\rm obs}, U_{\rm obs}) = \frac{L(f, Q_{\rm obs}, U_{\rm obs} \mid Q_0, U_0) \times \pi(Q_0, U_0)}{C}$$

Posterior distribution of the long-term trend

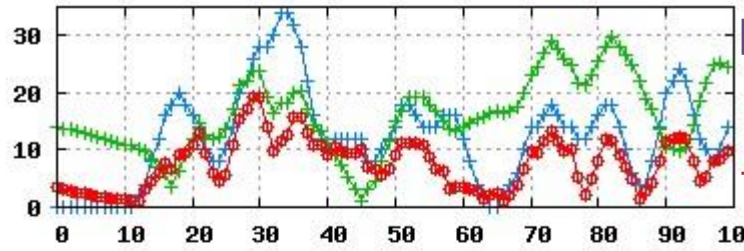
Likelihood function, maximized when the total flux and polarized flux completely correlate.

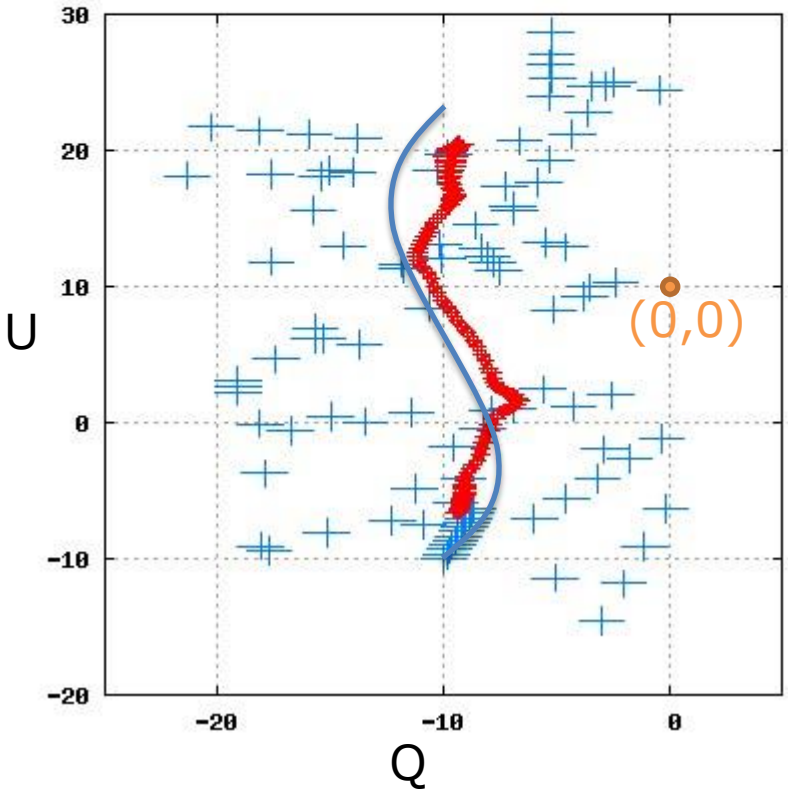
Prior distribution of the long-term trend (smoother curve is preferred).

$$\pi(Q_0) = \prod \frac{1}{\sqrt{2\pi w^2}} \exp\left\{ -\frac{(Q_{0,i} - Q_{0,i-1})^2}{2w^2} \right\}$$

- The estimation of the parameters is done with the Markov Chain Monte Carlo (MCMC) method.

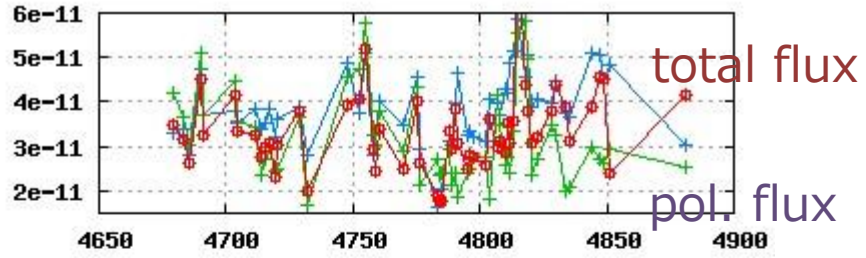
Bayesian separation: Demo

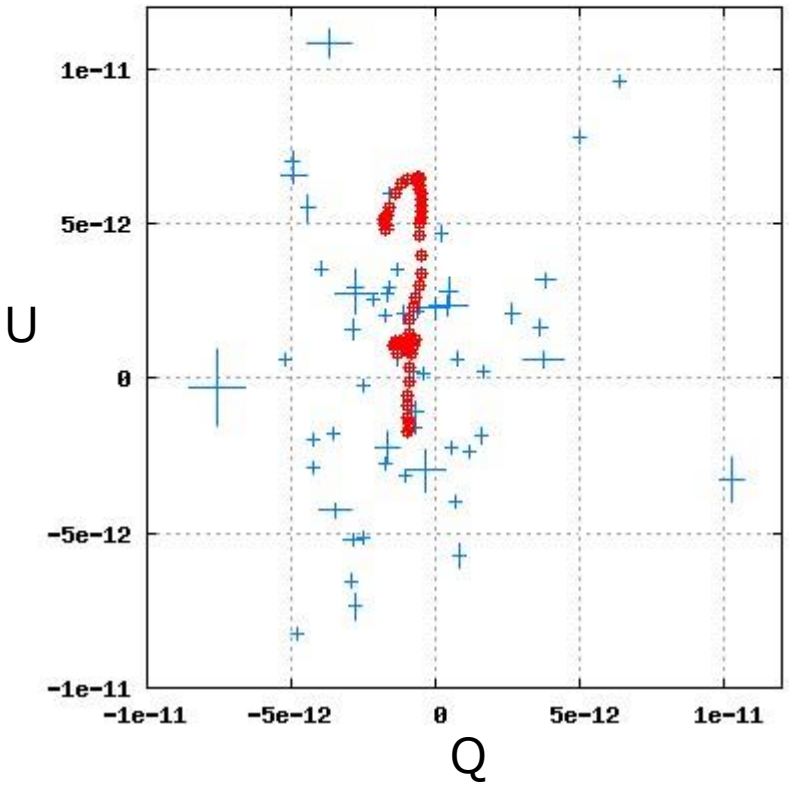




- The long-term trend is successfully estimated.
- This method can extract a long-term trend even if observed variations are apparently just erratic.

Bayesian separation: Example: S2 0109+224



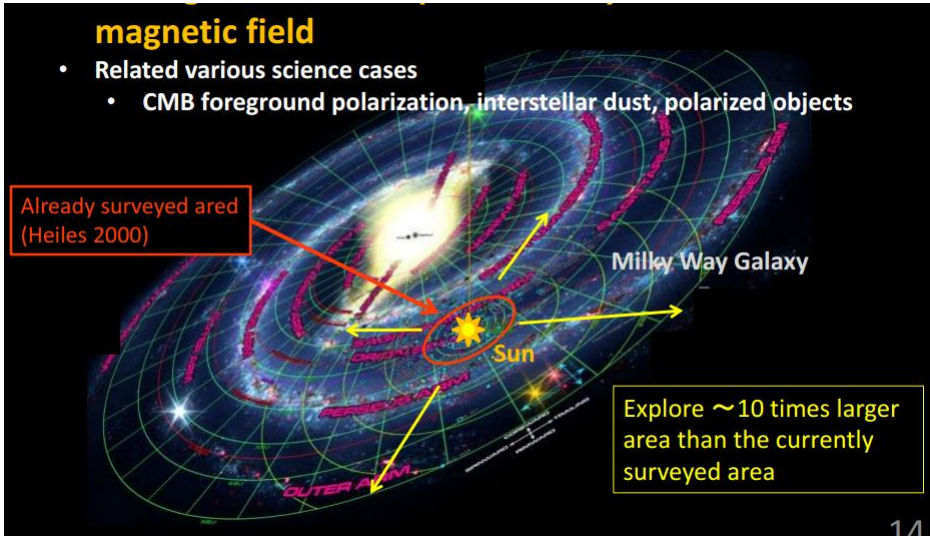


- Data: Aug.2008 – May 2009
- Our model works well, even if the observed Q,U apparently distribute around (Q,U)=(0,0).
- Growth and decay of long-term trends?
  - Another trend was born in the latter period?

My future plan

- Application of Bayesian and/or machine learning methods, in order to
  - identify base, long-term polarization components
  - select models of polarization rotation: random motion or real rotation
  - etc…
- Collaboration with machine learning people.

Future plan: the Kanata team



- 15:15-15:35 Koji Kawabata (Hiroshima University)
  "Future SGMAP project“
- 16:30-17:00 Ryosuke Itoh (Hiroshima University)
  "Study of Relativistic Jets with Optical Polarimetry in Various Timescales"

- X-ray & gamma-ray group in Hiroshima University (tomorrow)
  - 14:45-15:15 Yasushi Fukazawa (Hiroshima University)
    "Astro-H, and future CAST mission"
  - 15:15-15:35 Hiromitsu Takahashi (Hiroshima University)
    "High energy polarimetry missions: PoGO, SPHiNX, and Polaris missions“
  - 10:50-11:20 Yasuyuki Tanaka (Hiroshima University)
    "Fermi-LAT detection of VHE photons from z=1.1 blazar and synergy with Astro-H, Fermi and CTA"

Summary

- “Kanata” has monitored 42 blazars, and the monitoring of several famous objects still continues (also tonight).
- Strong correlation between the color and flux.
- Approaches with machine lerning/statistical methods may be important to establish a universal characteristics of polarization variation in blazars.