

# Polarimetric monitoring of jets with Kanata Telescope

**Ryosuke Itoh**

Tokyo Institute of technology

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@lerapetra







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# Kanata & Instruments



**HOWPoI** (1<sup>st</sup> Nasmyth, 2009-)

Optical Polarimeter (450 – 900 nm)  
One-shot polarimetry (double-WP)  
Wide Field (8'x8')

For **fast** polarimetry  
(time scale ~a few min.)

**TRISPEC** (Cassegrain, 2006-2011)

**HONIR** (Cassegrain, 2014-)

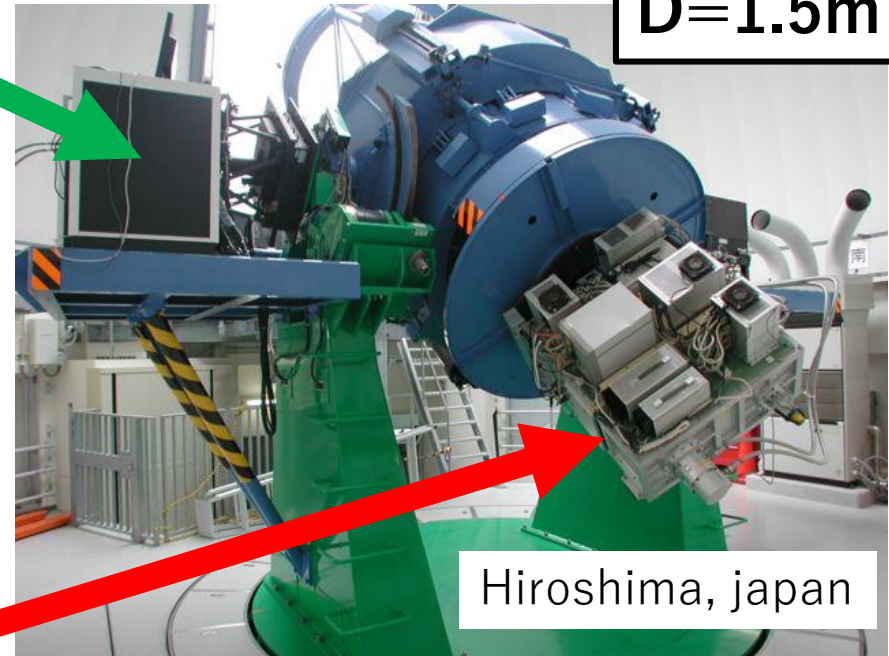
**Simultaneous** Optical/NIR band polarimeter (450—2,400 nm)

**Imaging polarimetry** and **spectropolarimetry**

(Now they are developing the one-shot polarimetry mode)

Since Fermi launched (2008-), we performed

- Daily polarimetric monitor of ~40 AGNs
- Follow-up observation of GeV flare targets





# Target List



Red; GeV bright source

FSRQ	LSP	ISP	HSP	RL-NLSy1
<b>3C 454.3</b> (498)	<b>BL Lac</b> (539)	<b>S5 0716+714</b> (628)	<b>Mrk 501</b> (244)	1H 0323+342
<b>3C 273</b> (332)	OJ 287 (413)	<b>3C 66A</b> (487)	<b>PG 1553+113</b> (225)	PMN J0948+0022
<b>3C 279</b> (177)	AO 0235+164 (93)	<b>1ES 1959+650</b> (202)	<b>PKS 2155-304</b> (161)	
PKS 1749+096 (163)	OJ 49 (70)	S2 0109+22 (102)	<b>Mrk 421</b> (74)	
3C 371 (124)	S4 0954+658 (5)	PKS 0048-097 (63)	<b>ON 325</b> (56)	
RX J1542.8+612 (113)	1ES 1218+304 (3)	ON 231 (48)	1ES 0806+524 (54)	
<b>PKS 1510-089</b> (110)		OQ 530 (19)	H 1722+119 (66)	
Mis V1436 (106)			PKS 0422+004 (42)	
<b>CTA 102</b> (92)			1ES 2344+514 (33)	
PKS 1502+106 (76)			1ES 0647+250 (24)	
<b>QSO 0454-234</b> (28)			1ES 0323+022 (21)	
S5 1803+784 (35)				
PKS 0754+100 (28)				
PKS 0215+015 (5)				
<b>GB6 J1239+0443</b> (5)				



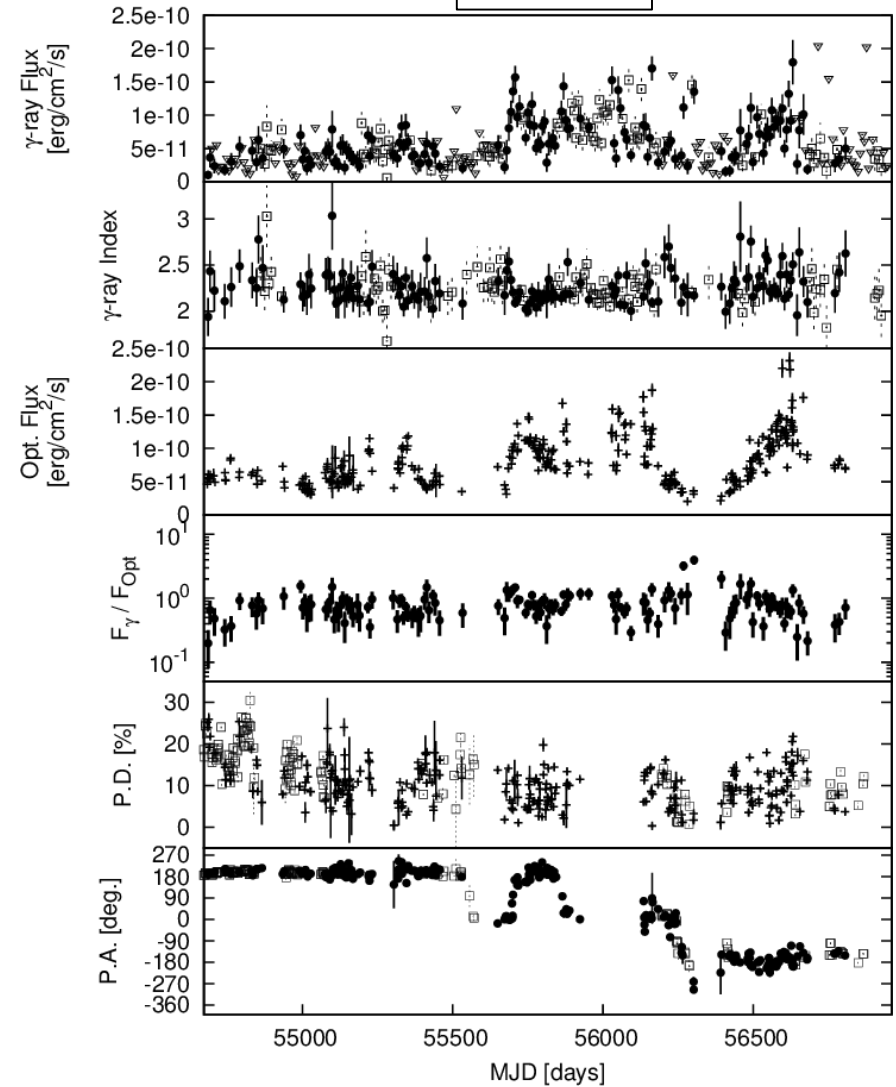
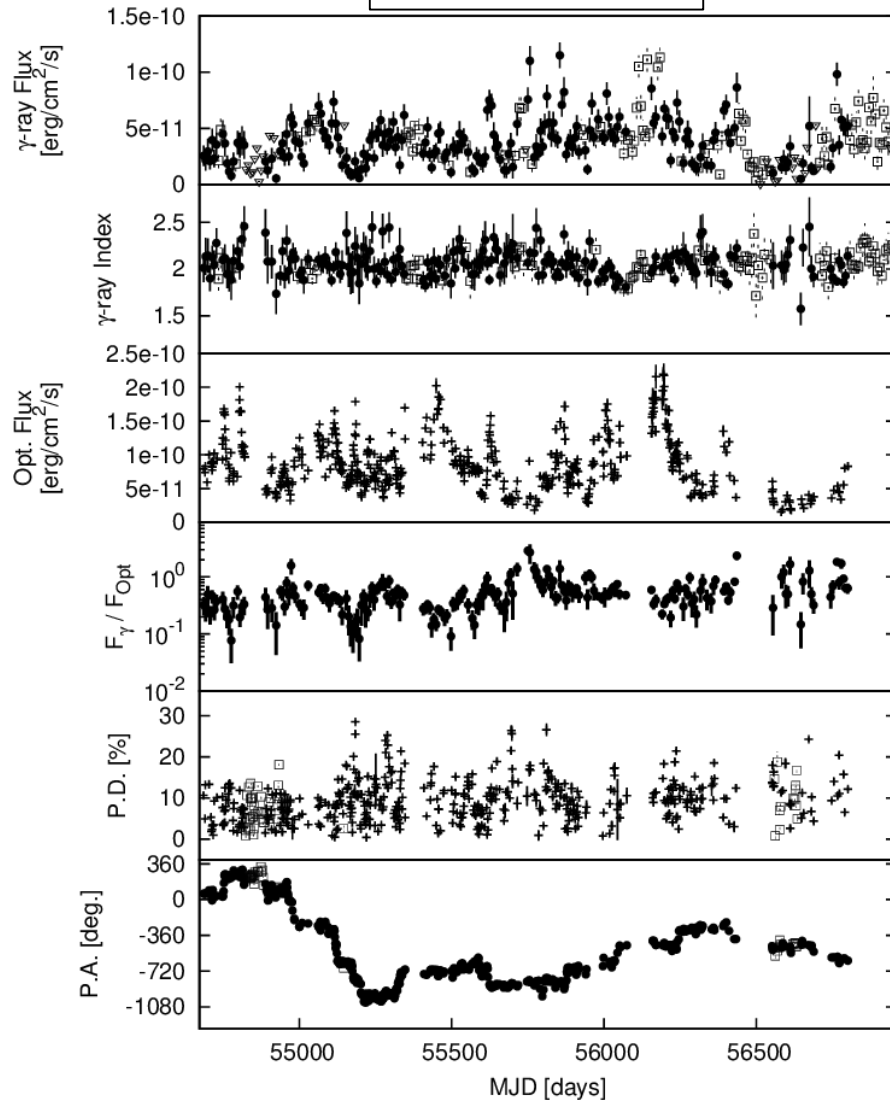
# Light curves



*RI+16*

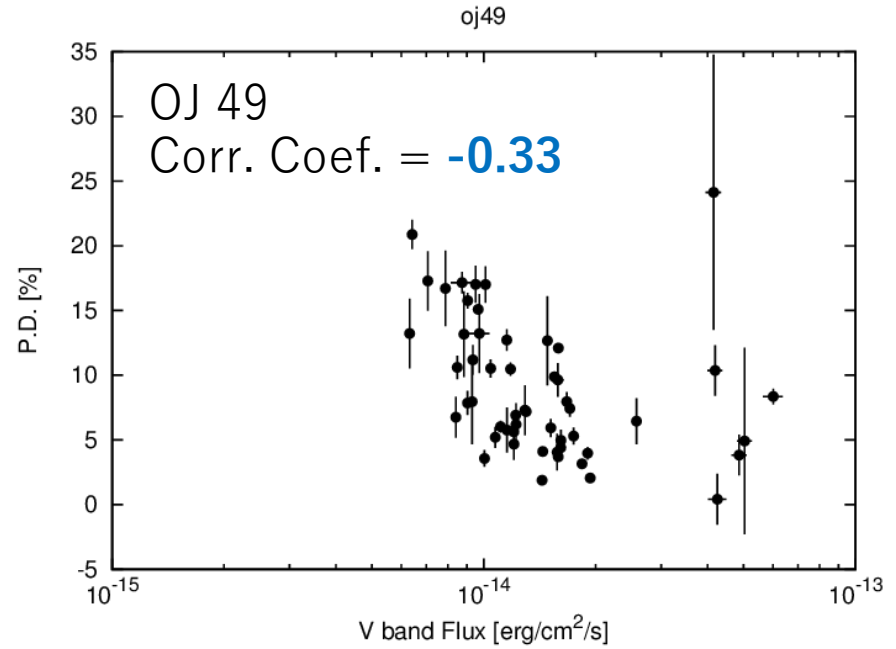
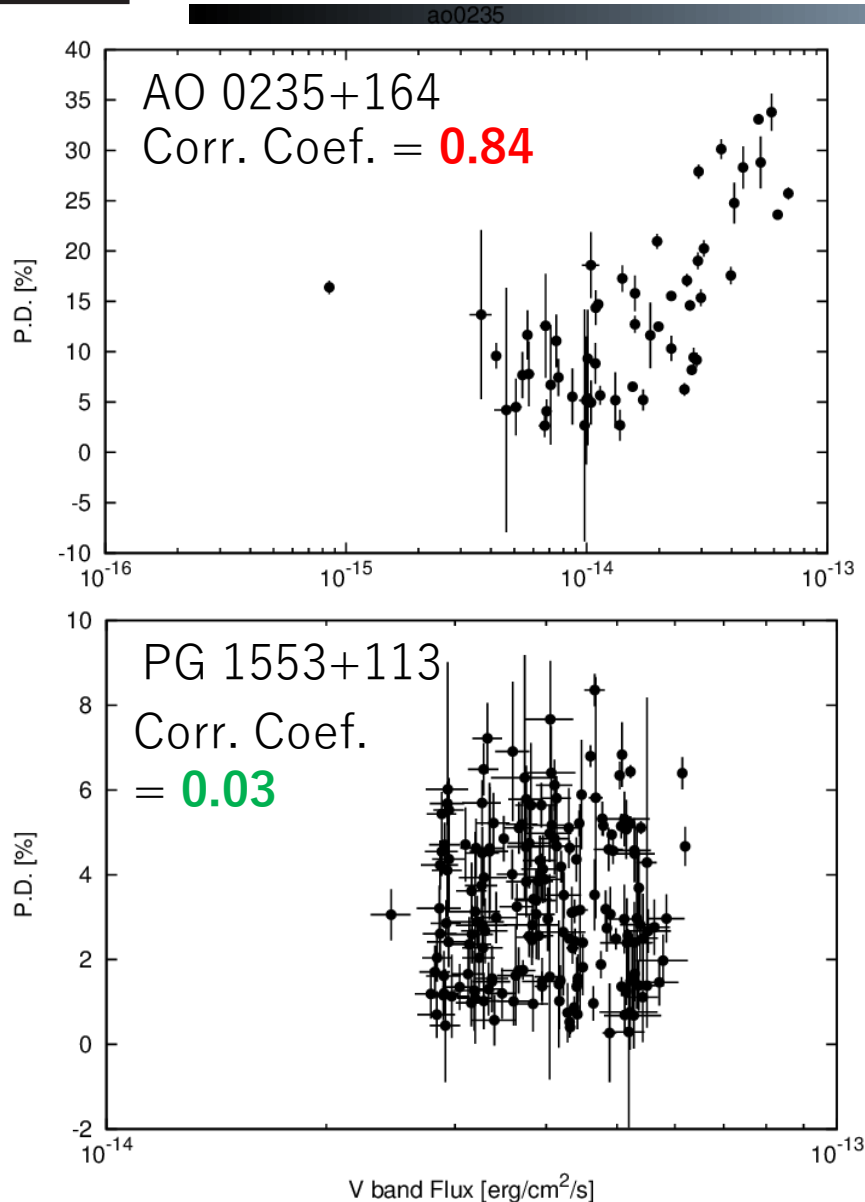
S5 0716+714

BL Lac





# Correlation betw. flux and P.D.



Even same type source does not shows same trends

**Chaotic!!**

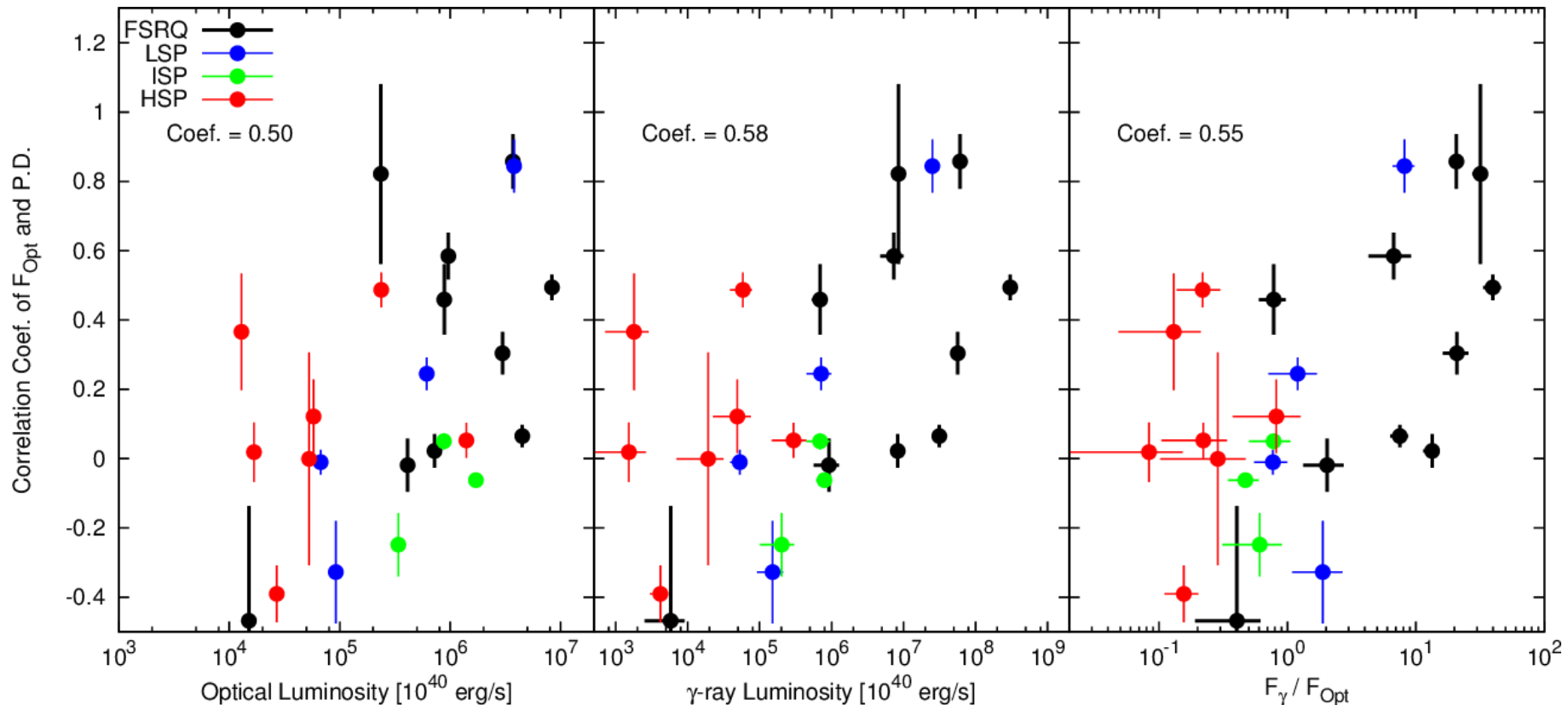
What's major parameter for Blazars?



# Correlation between Lum. & Correlation coef.



RI+16



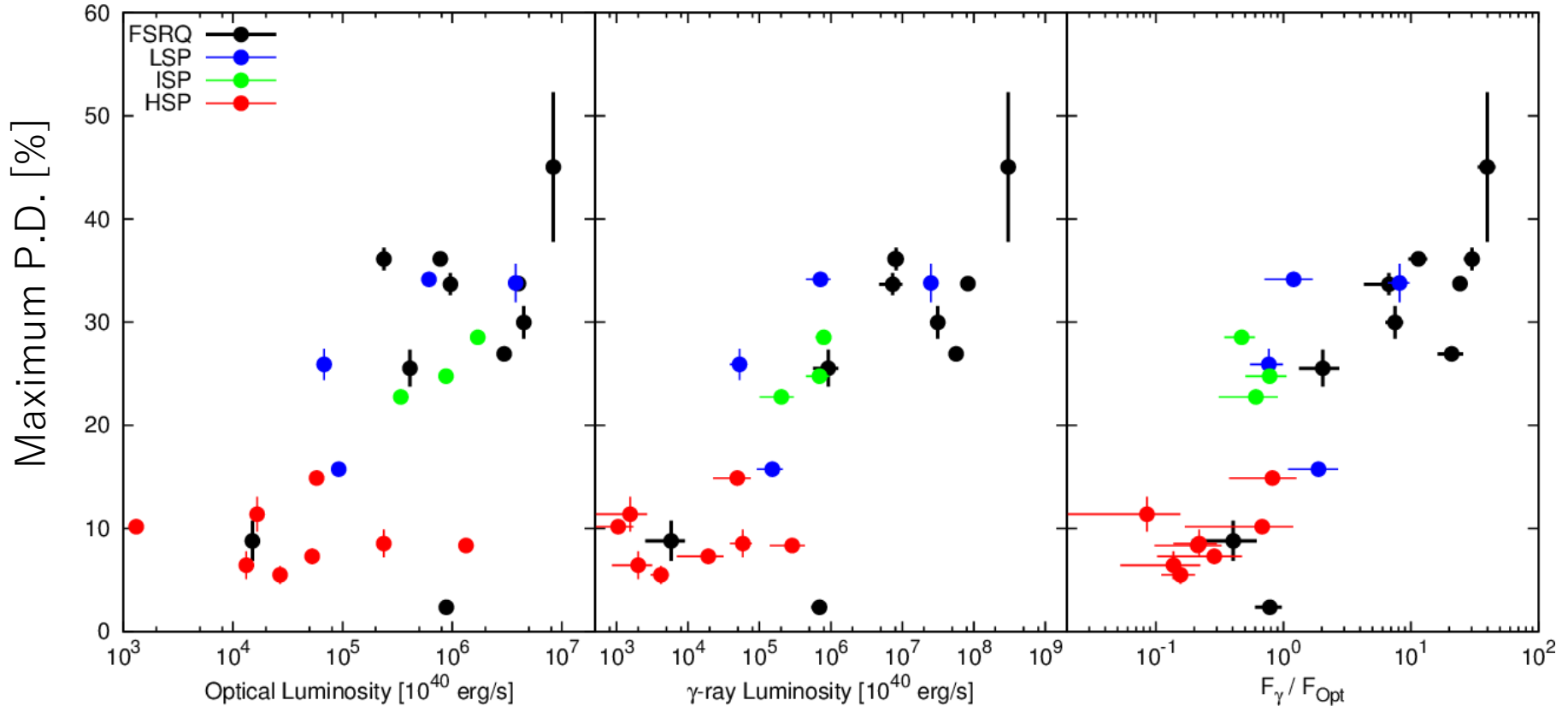
**Gamma-ray luminous blazars tend to show correlation between optical flux and P.D.**



# Correlation between Lum. & Maximum PD



RI+16



**Maximum PD shows good correlation with gamma-ray Luminosity or ratio of gamma-ray flux and optical flux (not optical luminosity)**





# Discussion; Multi emission region



Compton Dominance (for external Compton)

$$\frac{L_{\text{EC}}}{L_{\text{sync}}} \sim \Gamma^2 \frac{u_{\text{ext}}}{u_B} \quad \text{Sikora+08}$$

	High PD	Low PD
Bulk Lorentz factor	High	Low
Number of emission region	Few	Many
Compton dominance	High	Low

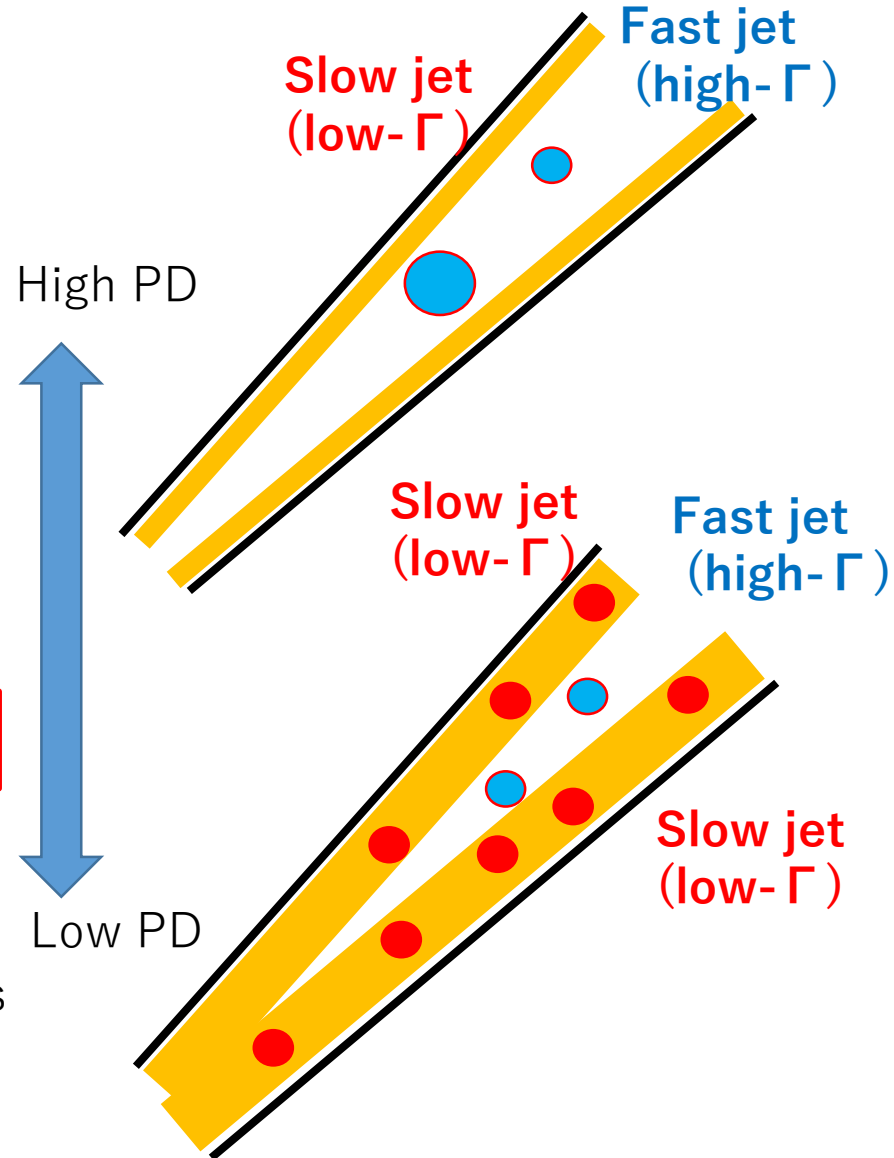
Spine-sheath model

+

Multi-Emission region model

**Spine: aligned magnetic field**  
**sheath: chaotic magnetic field**

Superposition of several emission regions with various magnetic field directions will result in low degree of total polarization.





# Summary for systematic study of blazar

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- We performed long-term optical polarimetric observation of  $\sim 40$  blazars with Kanata and *Fermi/LAT*. And we found Compton dominance might be good indicator of polarization properties
- It imply a systematic difference in the intrinsic alignment of magnetic fields in pc-scale relativistic jets between different types blazars
- A measurement of “Flare cadence” will be helpful to test the assumption of “multi-emission region” model.



# Light curves on CDS/VizieR



All of our data  
(flux & polarization in optical  
& NIR) are available from  
**CDS/VizieR** web page

<http://vizier.u-strasbg.fr/viz-bin/VizieR>

The screenshot shows the VizieR Search Page interface. The search criteria are set to 'J/ApJ/833/77' and 'ident'. The search results show a list of studied stars (45 rows) for the object 'J/ApJ/833/77'. The table below shows the columns available for the search, with checkboxes for 'Show' and 'Sort', and a 'Constraint' column for filtering results.

Show	Sort	Column	Clear	Constraint	Explain (UCD)
<input type="checkbox"/>	<input type="radio"/>	reco			Record number assigned by the VizieR team. Should Not be used for identificat
<input checked="" type="checkbox"/>	<input type="radio"/>	Name		(char)	Blazar ID in the form Kanata-BL-NN ( <a href="#">meta.id</a> / <a href="#">meta.main</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	3FGL		(char)	Fermi-LAT 3FGL name (3FGL JHHMM+DDMM) ( <a href="#">meta.id</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	CptName		(char)	Counterpart name ( <a href="#">meta.id</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	RAJ2000		<a href="#">"h.m.s"</a>	Right ascension (J2000.0) ( <a href="#">pos.eq.ra</a> / <a href="#">meta.main</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	DEJ2000		<a href="#">"d.m.s"</a>	Declination (J2000.0) ( <a href="#">pos.eq.dec</a> / <a href="#">meta.main</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	lc			<a href="#">VRJKs light curves</a> ( <a href="#">meta.ref.uri</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	pd			<a href="#">polarisation degree curves</a> ( <a href="#">meta.ref.uri</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	pa			<a href="#">polarisation angle curves</a> ( <a href="#">meta.ref.uri</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	photV		(char)	phot/V when Johnson V photometry ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	photR		(char)	phot/R when R Cousins photometry ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	photJ		(char)	phot/J when J Johnson photometry ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
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<input checked="" type="checkbox"/>	<input type="radio"/>	PDV		(char)	PD/V when V polarisation degree ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	PDR		(char)	PD/R when R polarisation degree ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	PAV		(char)	PA/V when V polarisation angle ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	PAR		(char)	PA/R when R polarisation angle ( <a href="#">Note 1</a> ) ( <a href="#">meta.code</a> )
<input checked="" type="checkbox"/>	<input type="radio"/>	Simbad	Simbad		<a href="#">ask the Simbad data-base about this object</a> ( <a href="#">meta.ref.uri</a> )



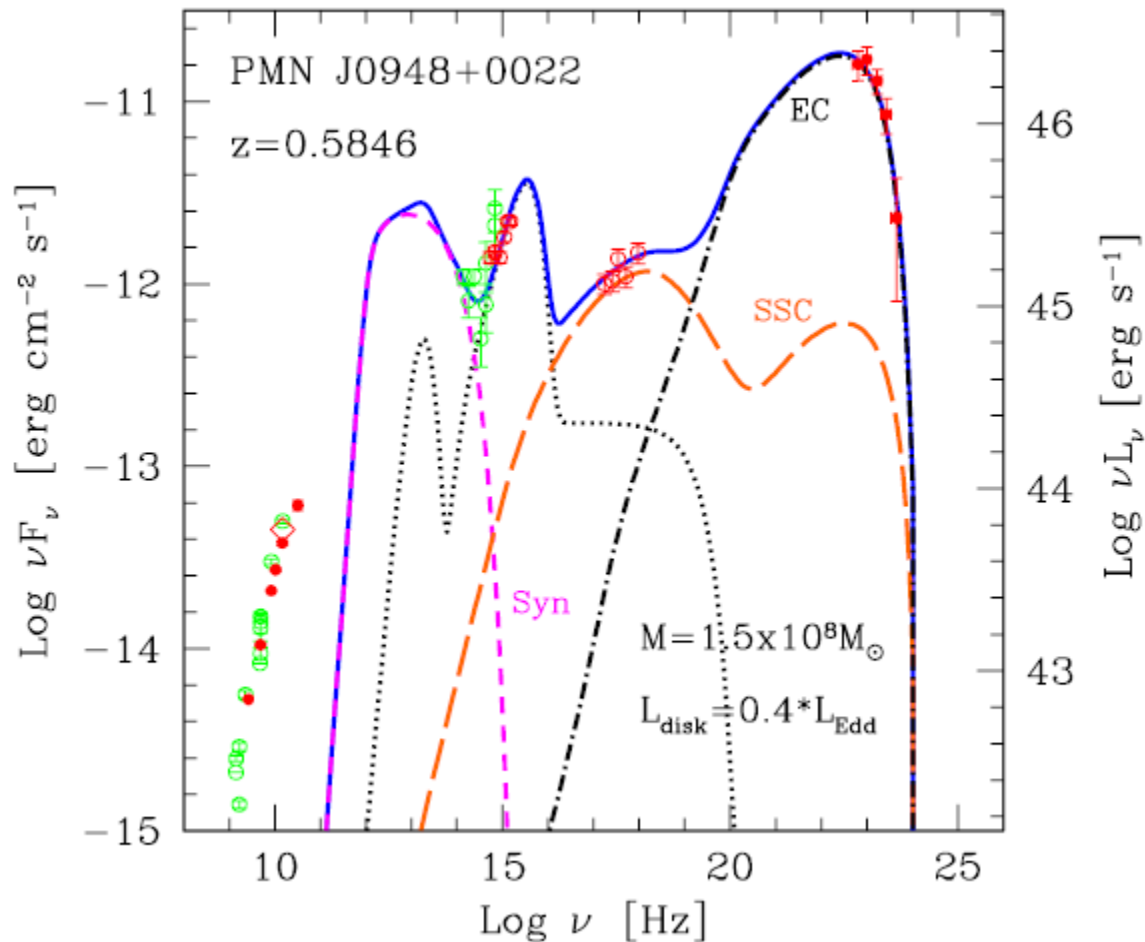
# PMN J0948+0022



GeV detected

Radio Loud Narrow Line Seyfert 1

Abdo+09



Host: spiral galaxy

Relatively light BH mass

( $10^6 - 10^7 M$ )

2012-12-18

NIR flare (ATel #4659)

2012-12-31

GeV flare (ATel #4964)





# blazar-like NLSy1s



Several Narrow Line Seyfert I galaxies (NLSy1s) also have relativistic jets

	NLSy1	Blazar
BH mass	$10^{5-7} M_{\odot}$	$10^{6-9} M_{\odot}$
Host galaxy	Spiral	elliptical
Accretion rate	$\sim$ Eddington limit	Low

Abdo+09

## Optical emission; Disk or Jet

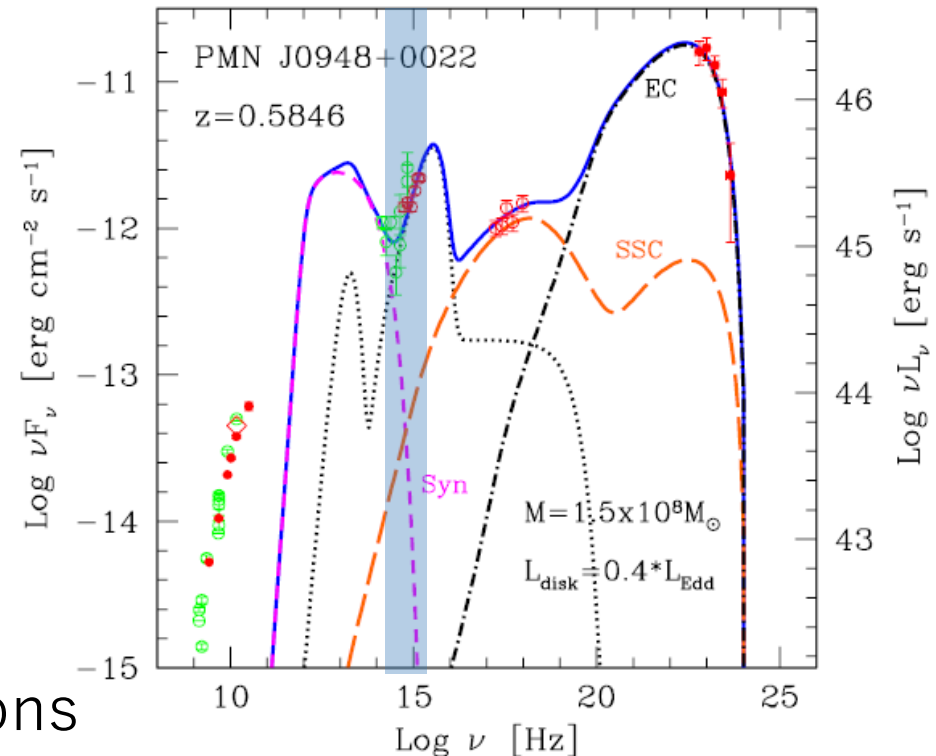
PMN J0948+0022

GeV flare in Dec. 2012

1H 0323+3.42

GeV flare in Jun. 2013

Triggered ToO observations





# PMN J0948+0022

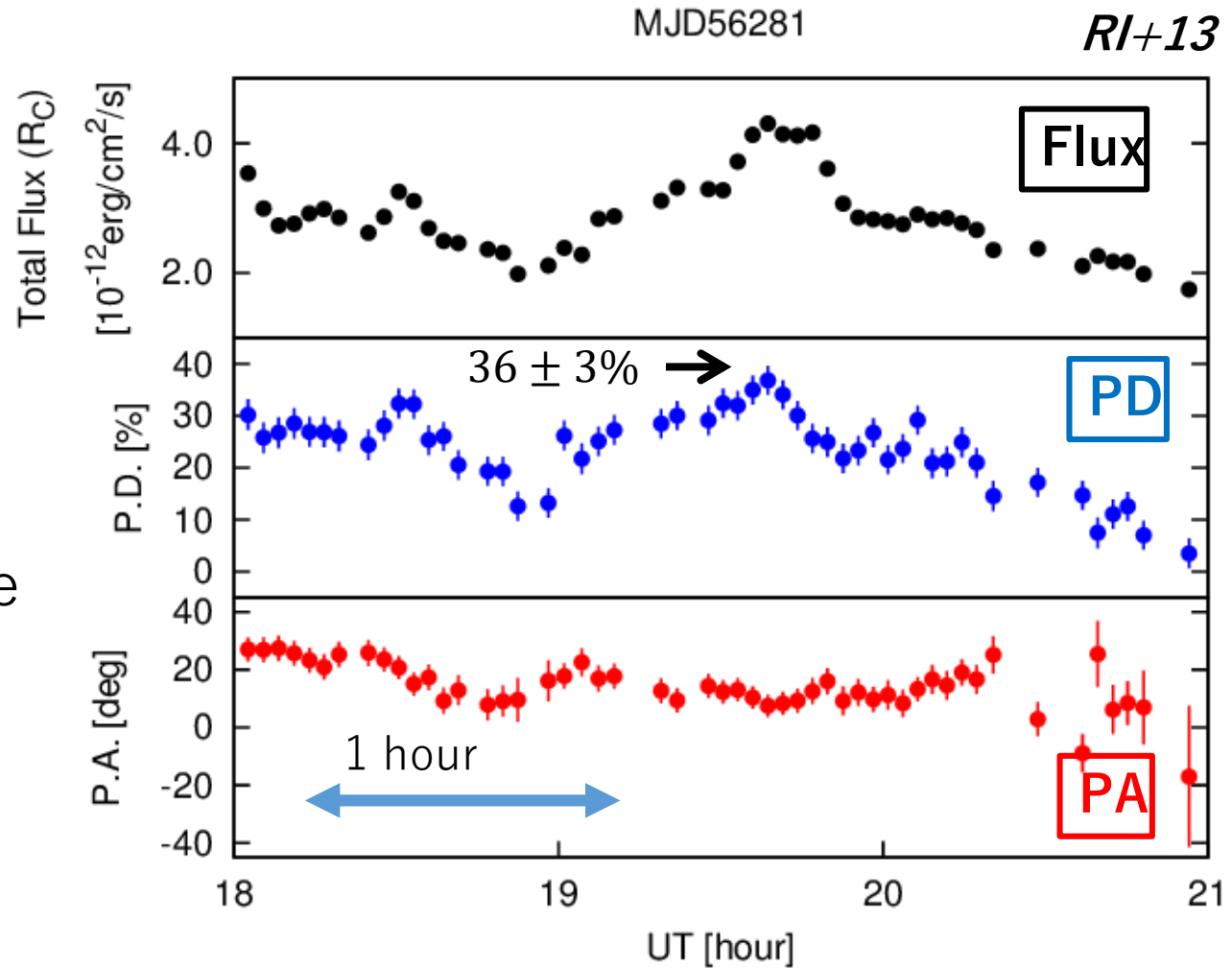


Good correlation  
between flux and  
PD

A few minute  
variability

No significant time  
lag ( $< 10$  min.)

Constant PA  
during flare

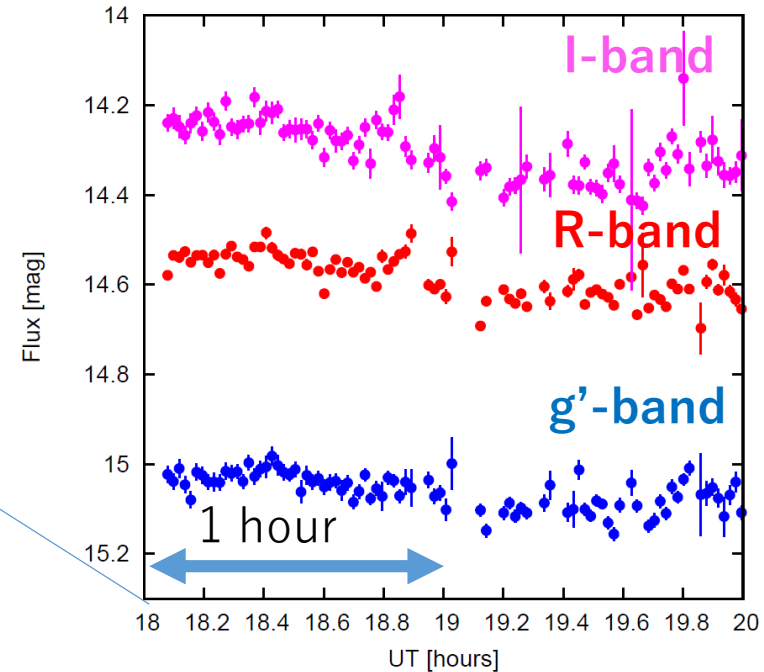
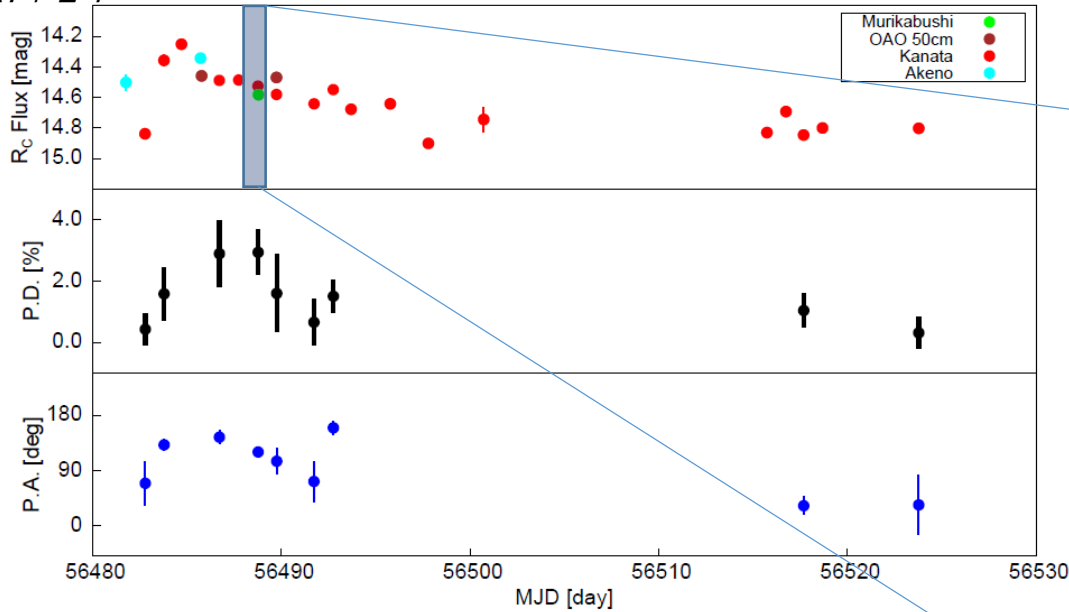




# 1H 0323+342



*RI+14*



**Gradual increasing of PD ( $\sim 3\%$ )**

Variable synchrotron component is more contaminated by disk emission in high frequency

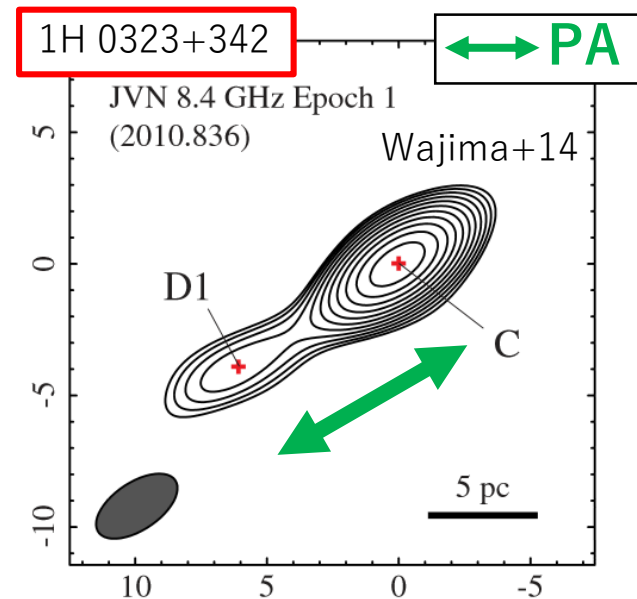
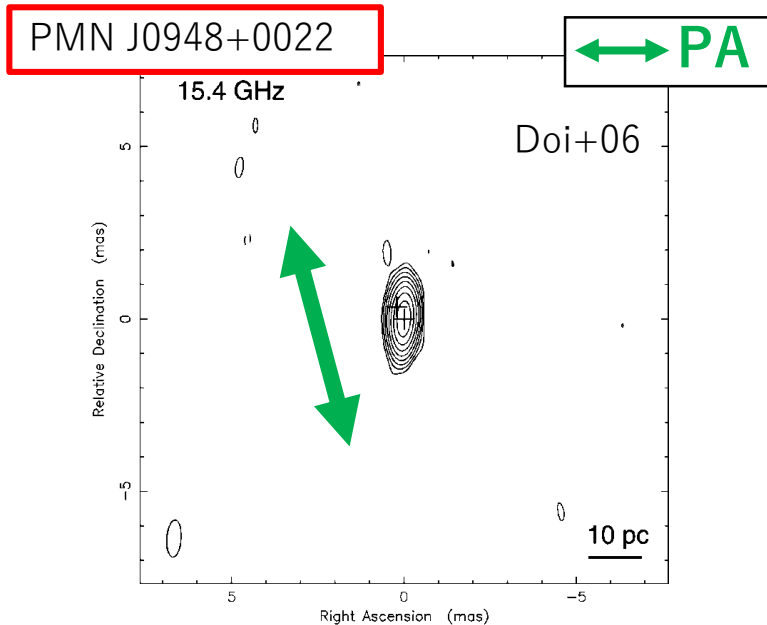


# Discussion



Suggests light mass BH

$$t_{lc} \sim r_g/c \sim 3.2 \times 10^2 (M/10^{7.5} M_{\odot}) \text{ s}$$



Directions of PA Supports Shock-in-Jet scenario -> similar to blazar's jet





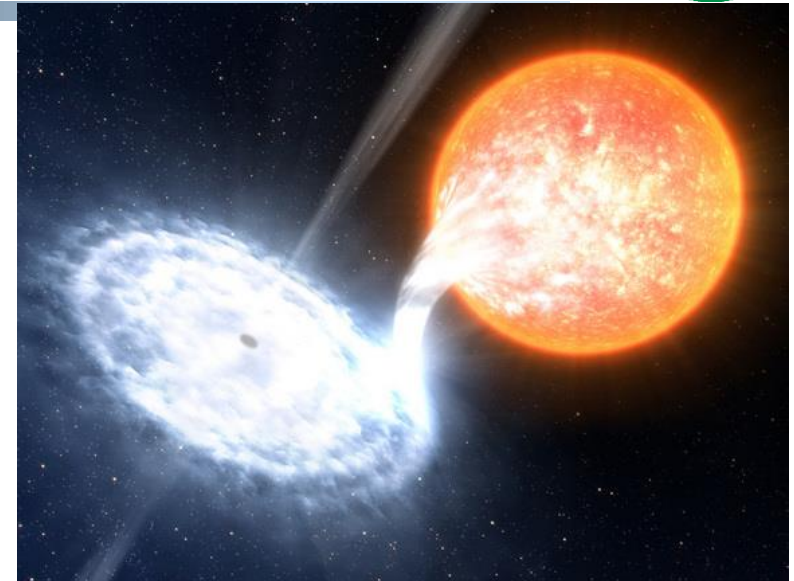
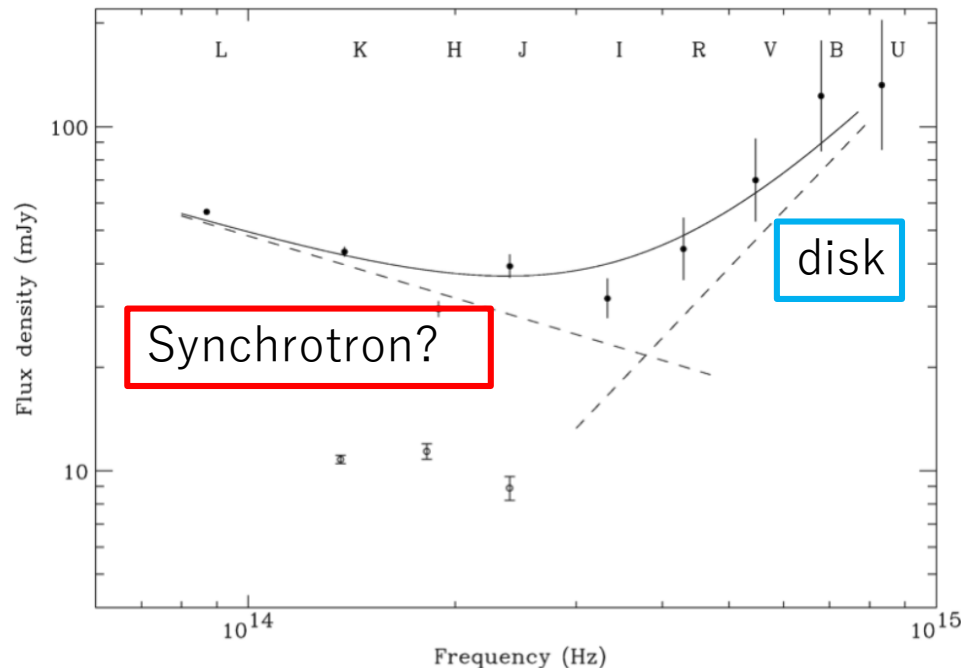
# micro-quasars



Relativistic jets with stellar mass BH ( $\sim 10M_{\odot}$ )

Polarimetry in the optical band is a powerful method to unveil the emission mechanism

SED of XTE J1118+480 (Corbel & Fender 2002)



<http://www.space.com/19029-a-binary-black-hole.html>

If the emission is due to optically-thin synchrotron emission, high PD in near-infrared band is expected



# V404 Cyg flare in Jun. 2015

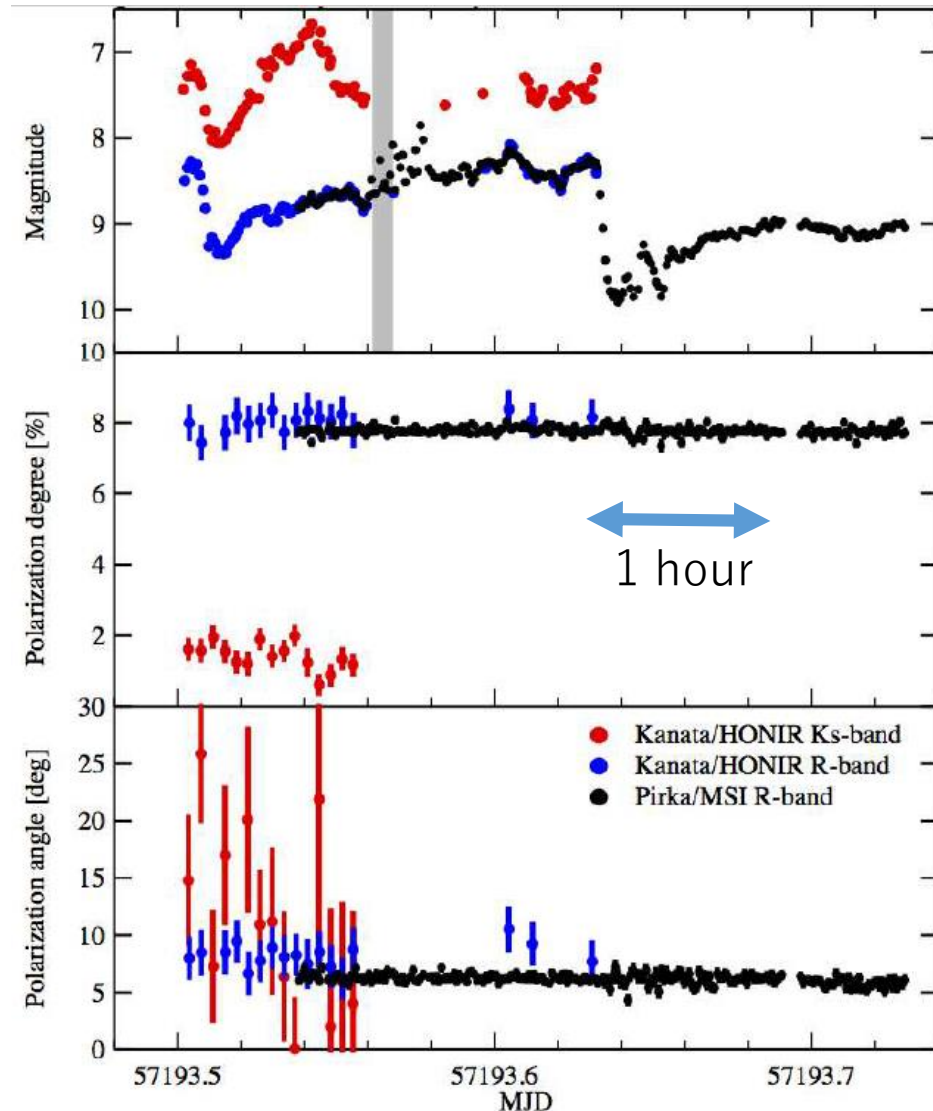


Tanaka, RI+16

Jun. 2015 outburst

No significant temporal variation of PD and PA in both R and Ks bands

‘The optical and NIR emissions are dominated by either disk or optically-thick synchrotron emission, or both.’





# Astrophysical jets



	Blazar	NLSy1	Microquasar
BH mass	$\sim 10^{7-9} M_{\odot}$	$\sim 10^7 M_{\odot}$	$\sim 10^{0-1} M_{\odot}$
Time scale	hours $\sim$	Min. $\sim$	--
Maximum PD	$> 40\%$ (FSRQ)	$\sim 35\%$	--
PA rotation	0	--	--

- Further observation of several type of jet (small mass BH, misaligned AGN etc..) will help us to investigate the jet



# Summary

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- **Kanata team continuously performed polarimetric monitoring of jets**
- **We now open the 6.5 years archival photopolarimetric data for ~ 40 blazars**
- **We are also interested in different type of relativistic jets (NLSy1s, micro quasars)**





# Back up slide

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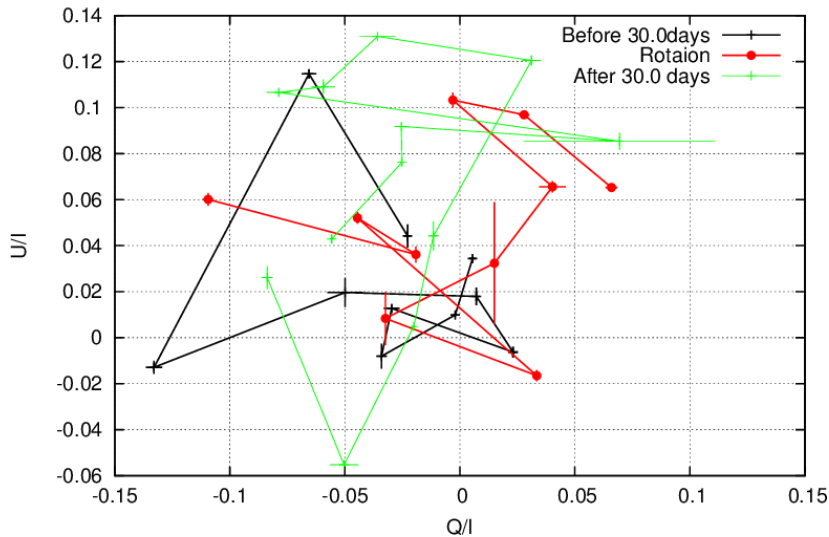




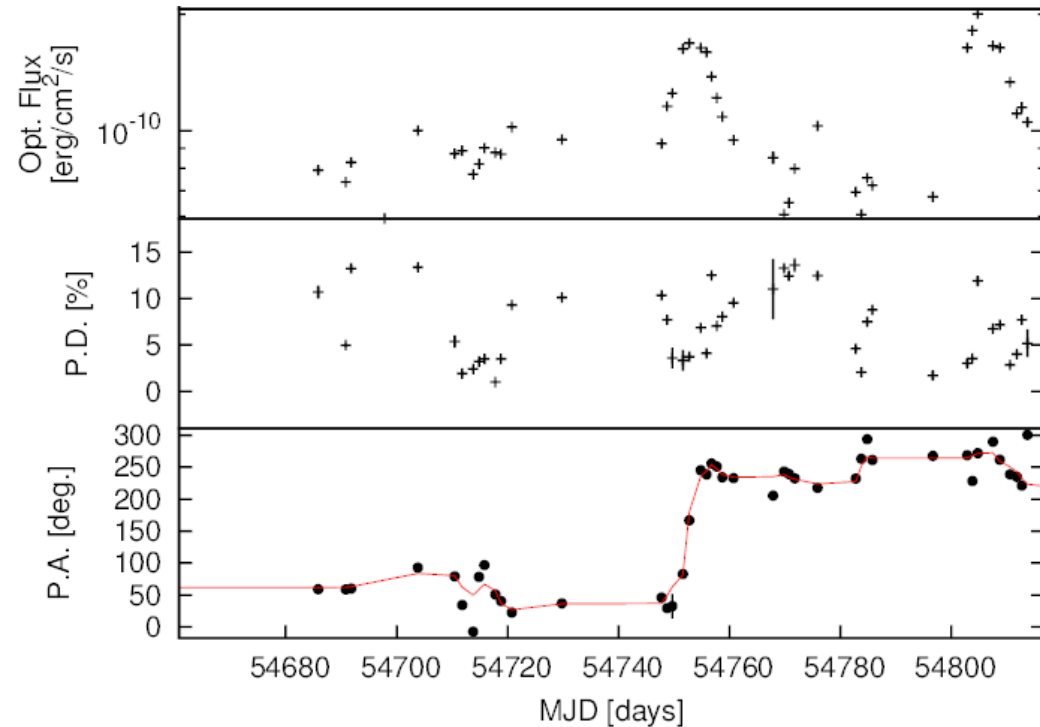
# PA rotation with Kanata data



Polarization variability on the Stokes QU plane for S5 0716+714



Light curve of S5 0716+714



We found 33 PA rotation events from 15 objects,  
But there are no clear relation between PA rotation and  
GeV/Optical flare