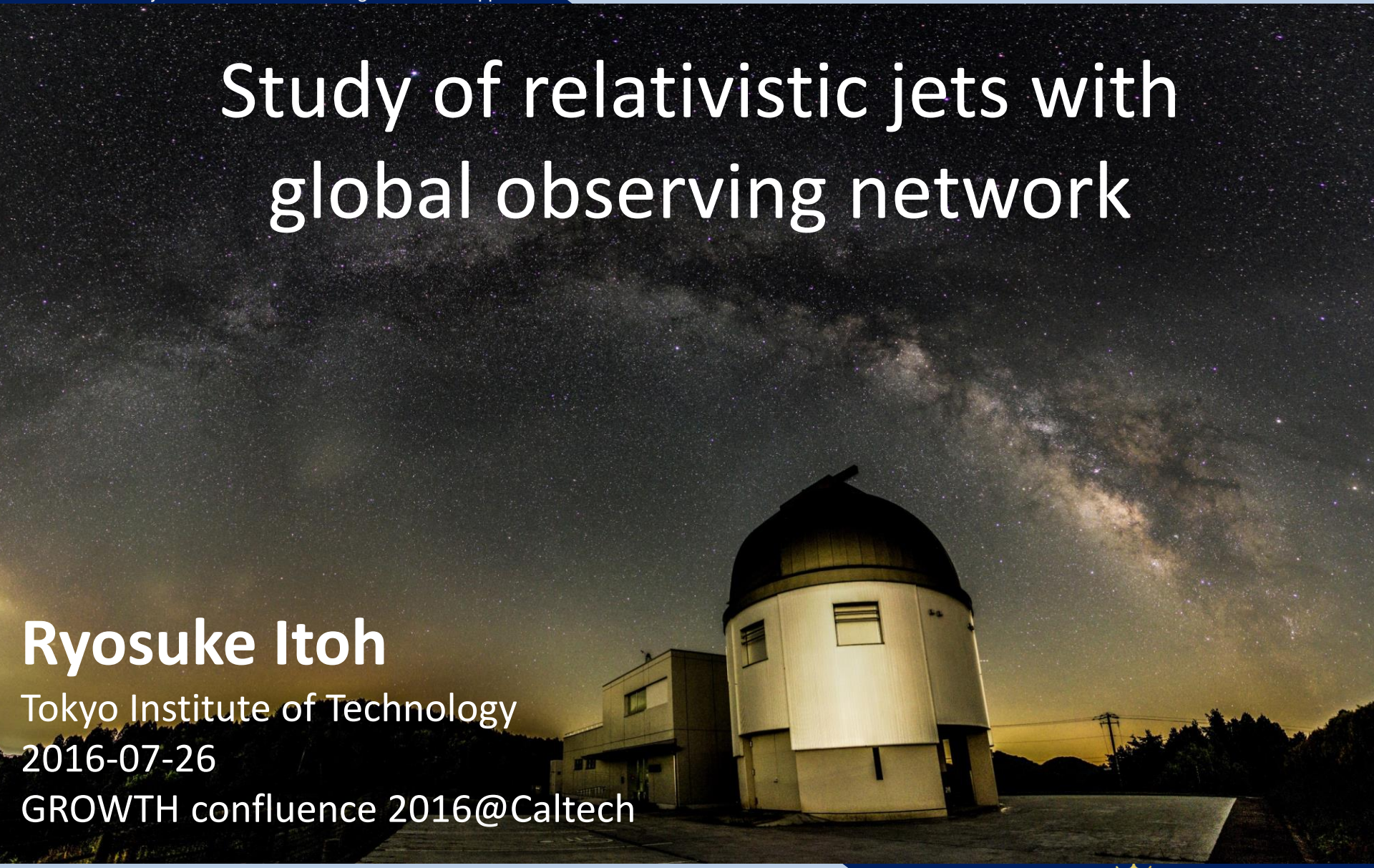
GROWTH
Global Relay of Observatories Watching Transients Happen

Study of relativistic jets with global observing network



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GROWTH confluence 2016@Caltech

NSF PIRE

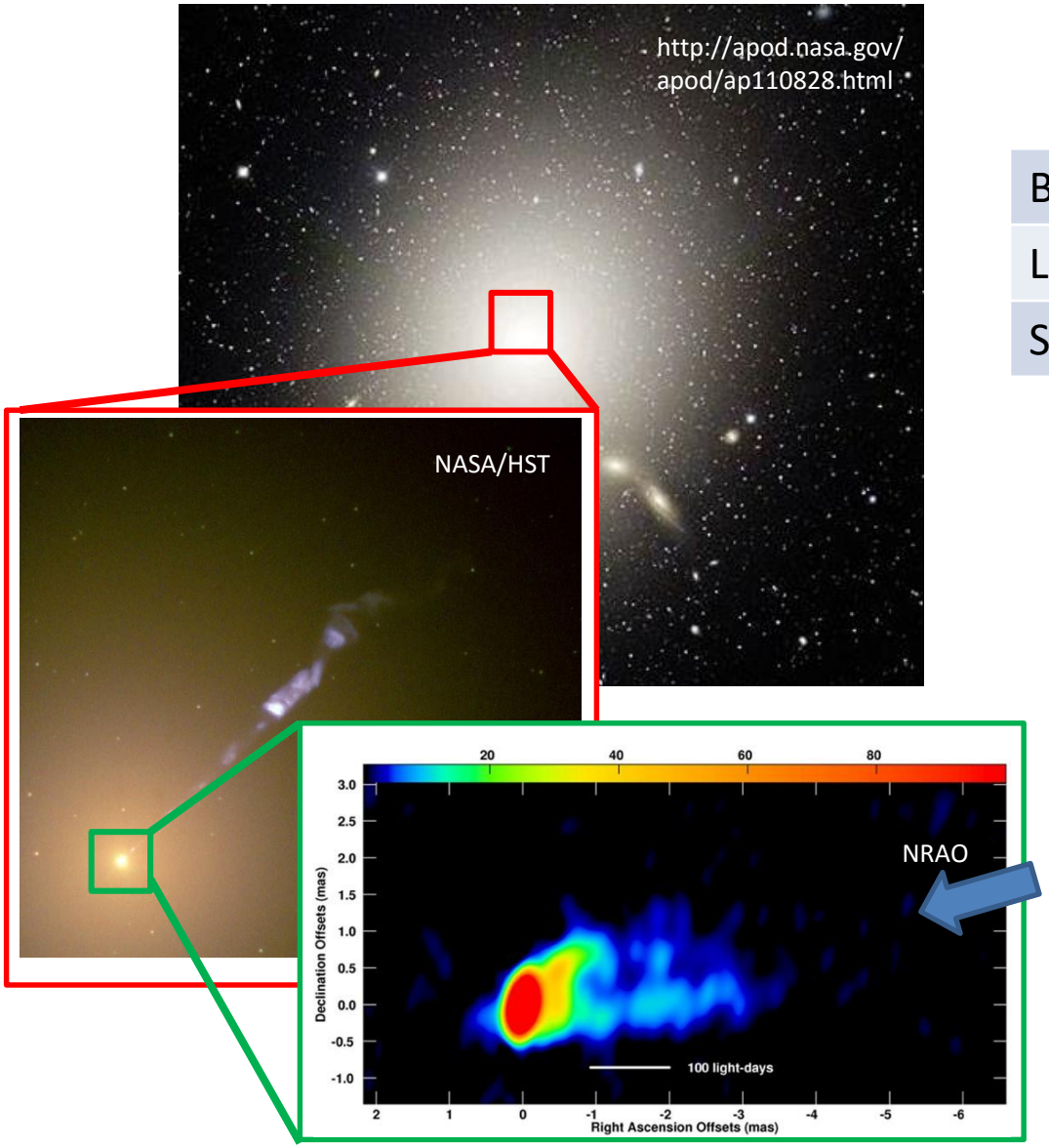
Outline

(I suspect that some people might think AGNs are just **NOISE** when searching for new optical transients)

Presentation of **AGN jet** study with global observing network

1. Introduction of relativistic jet
2. Observatories
3. Results
   - Blazar CTA102
   - Narrow Line Seyfert I
4. Summary

Relativistic jets



Relativistic jets in the AGNs

BH Mass	$10^6 - 10^9 M_\odot$
Length	~10^6 pc
Speed	Γ ~ 10 (v=0.99c)

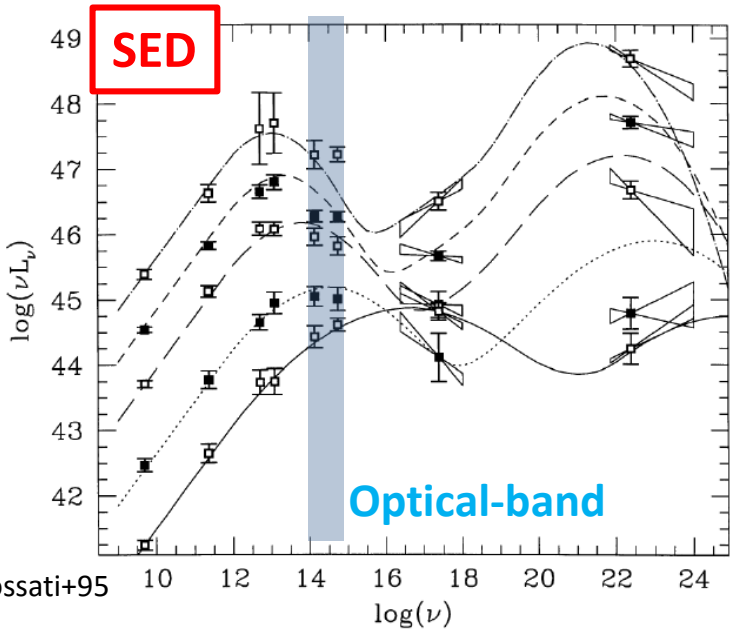
How are jets formed and powered ?

Blazar;

It have strong relativistic jets aligned with the **observer's line of sight** and are apparently bright due to **relativistic beaming**

One of most suitable objects to study the jets

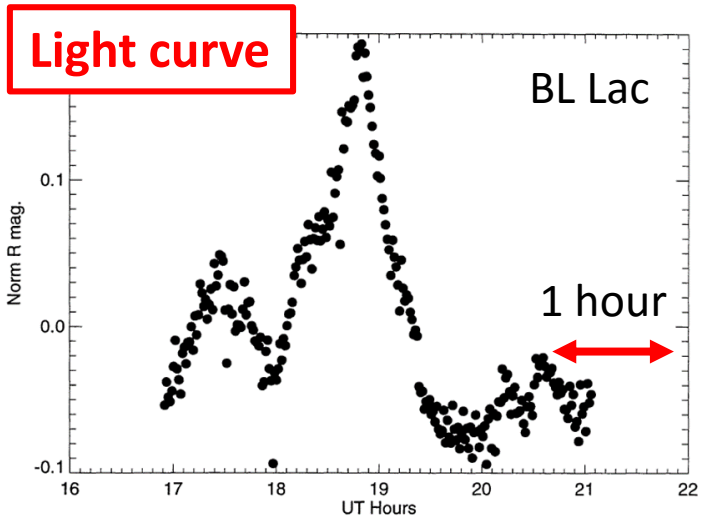
SED & variability



Fossati+95

- Two-peak SED from radio to gamma-ray
- Polarized emission in low-energy band
- Rapid & large variability

Synchrotron radiation (Radio to UV band)
Inverse Compton scattering (X-ray to gamma-ray)



Miller+01

Such rapid flares may be directly linked to the injection and acceleration processes

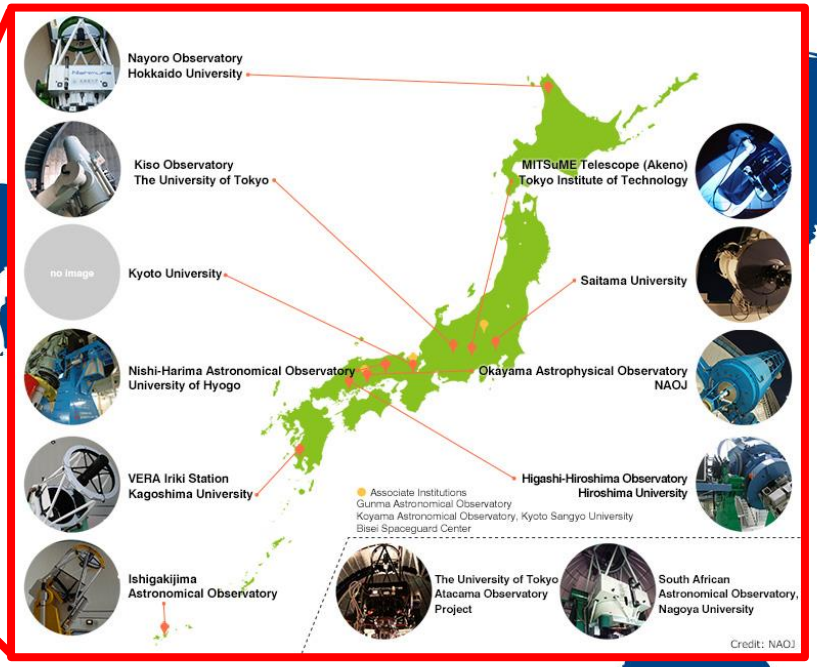
Requirement;
immediate, continuous (< day) and multi-band obs.

Global observing network

OISTER; Japanese observing network

12 telescopes in Japan
1 telescope in South Africa
1 telescope in Chili

0.5—2.0m telescopes



http://www.imageba rld%20Map%20Dark.jpg?m=1300155390
http://www.nao.ac.jp/en/contents/news/science/2016/20160607-oister-fig02-en.jpg
http://www.ioa.s.u-tokyo.ac.jp/TAO/intro/intro4.html
http://oister.oao.nao.ac.jp/wordpress/wp-content/uploads/2012/04/irsf_tel.jpg

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Blazar CTA102

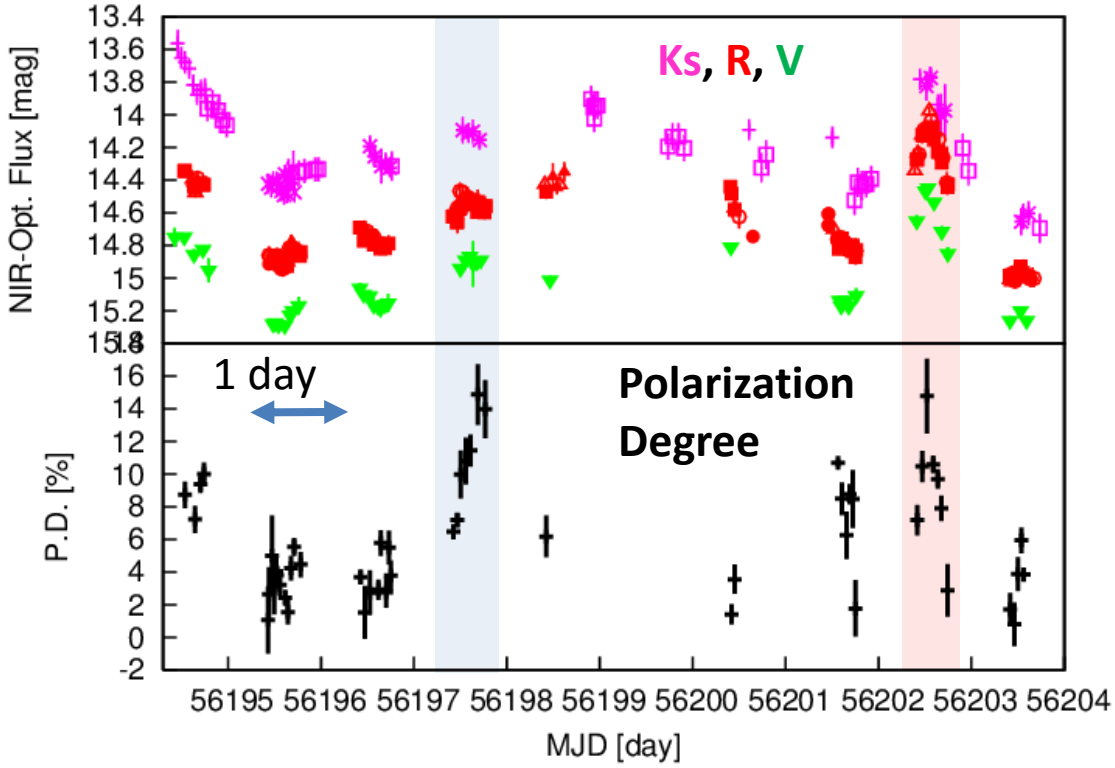
Luminous blazar, showed large outburst in Sep. 2012
We trigged ToO Observation of this outburst with Japanese global observing network

We obtained g', V, R, I, z', J, H and Ks-band photometric data and R-band polarimetric data with *OISTER* for 10 days

Itoh+13

2 types of intra-night variability are observed.

1. PD orphan flare.
2. Prominent flare with PD and total flux.



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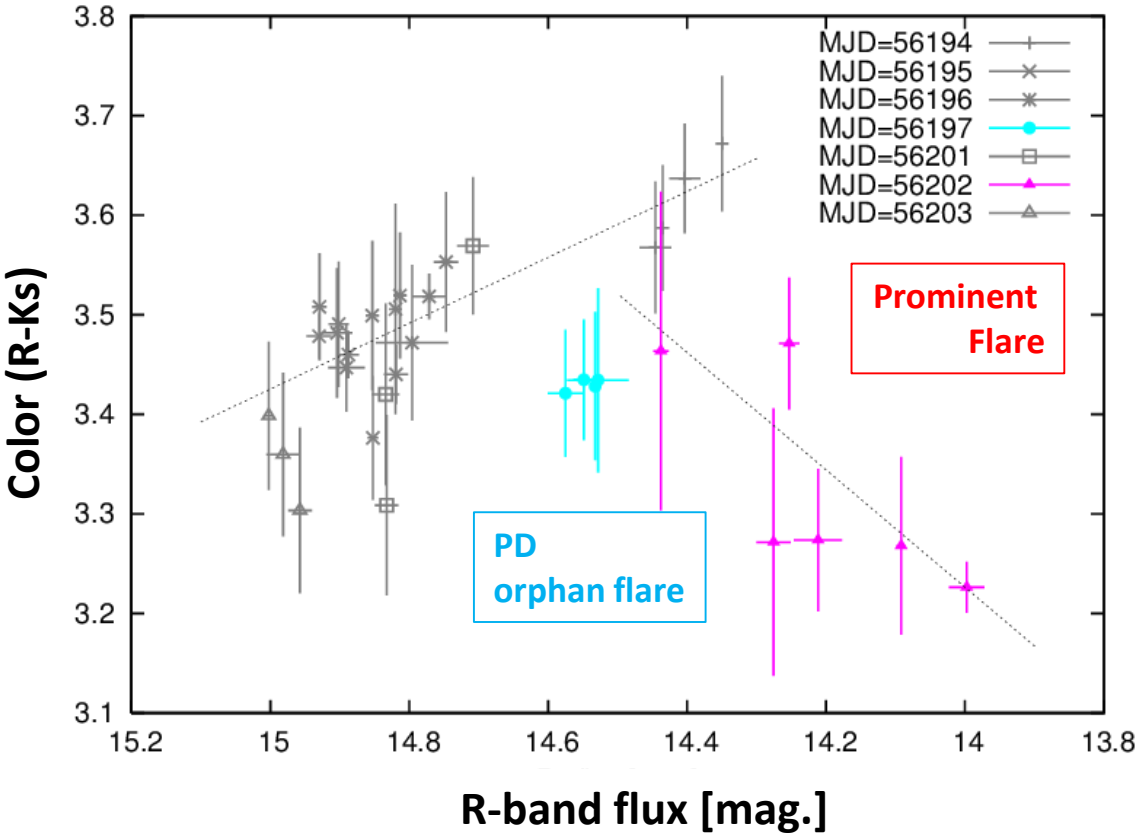
Flux vs color

Redder (softer)

Itoh+13

Long term variability :
"Redder when Brighter"
Prominent Flare:
"Bluer when Brighter"

"PD orphan flare" also shows slightly blue color compare with long-term trend



Implying injection of high-energy electron in short time variability

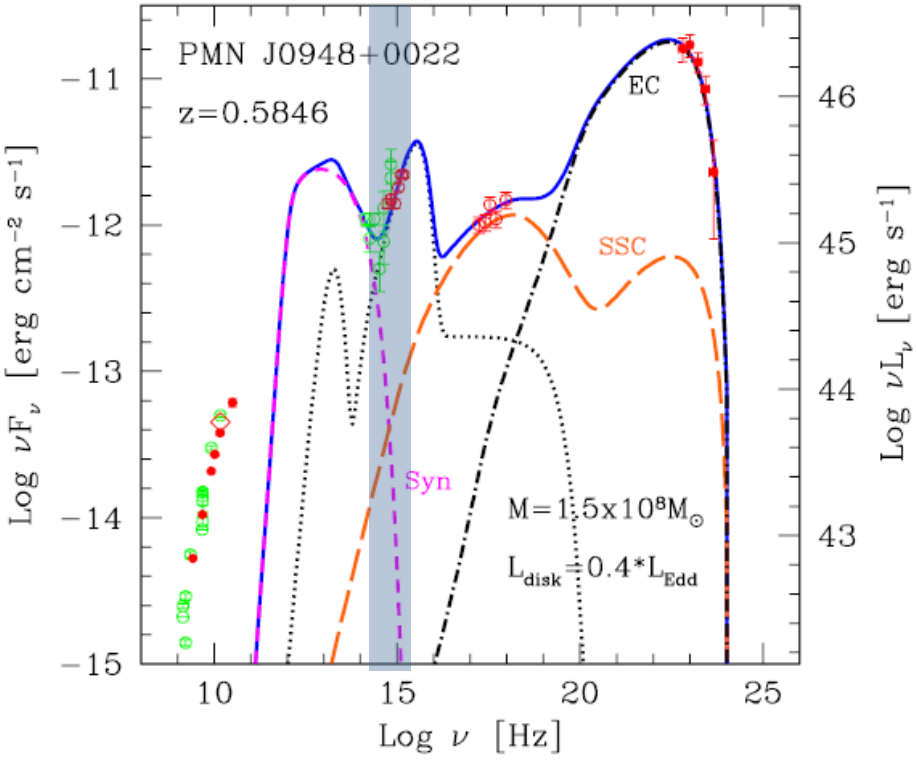
A high PD indicates a presence of highly ordered magnetic field within the compact emission zone

blazar-like NLSy1s

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

	NLSy1	Blaszar
BH mass	$10^{5-7} M_{\odot}$	$10^{6-9} M_{\odot}$
Host galaxy	Spiral	elliptical
Accretion rate	~ 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

Trigged ToO observations

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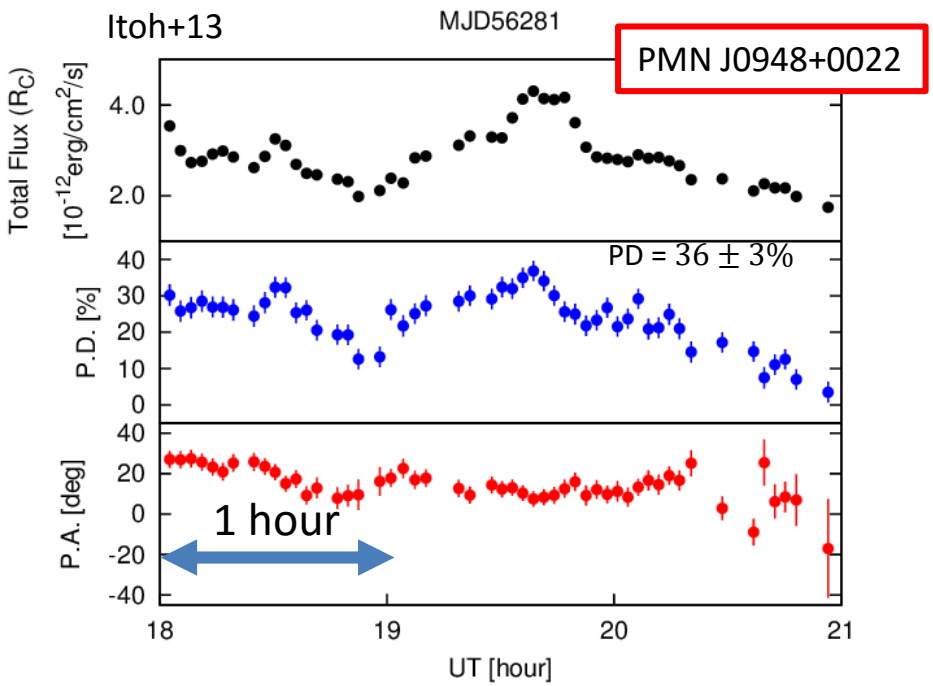
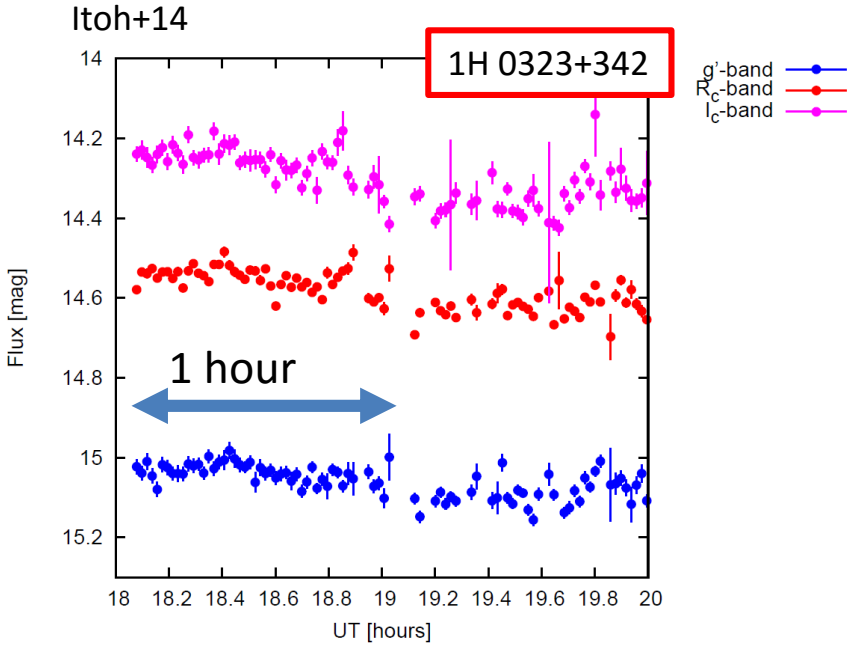
Minute-scale variability



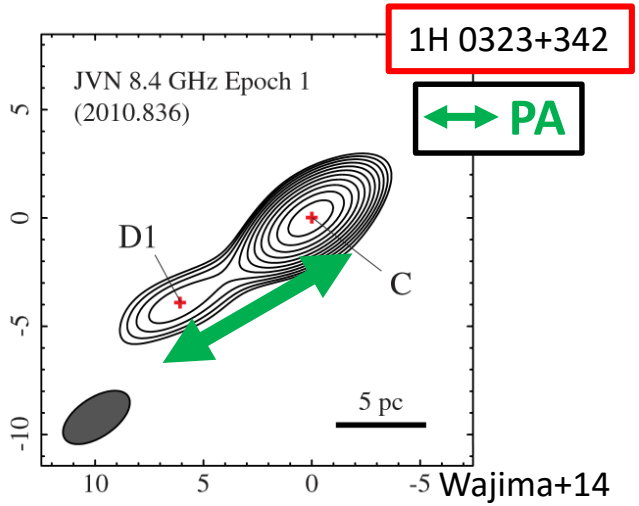


Evidence of synchrotron emission in the optical band

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

Suggests light mass BH

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



Summary

- We obtained **multi-mode** observational data for several relativistic jets during outbursts with timescale of minutes to days

- We found several new type of outbursts from several jets
- It enable us to study the injection and acceleration processes

- The global observing network system is valueable for studying the jet

- It is important to make flexible observation plan
  (e.g., photometry or spectroscopy? Filter selection and so on…)