Kiso Supernova Survey (KISS):

短時間変動するextremely radio-loud AGNの発見

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MT, T. Morokuma, R. Itoh, H. Akitaya, N. Tominaga, Y. Saito, and KISS collaboration, 2014, submitted to ApJL

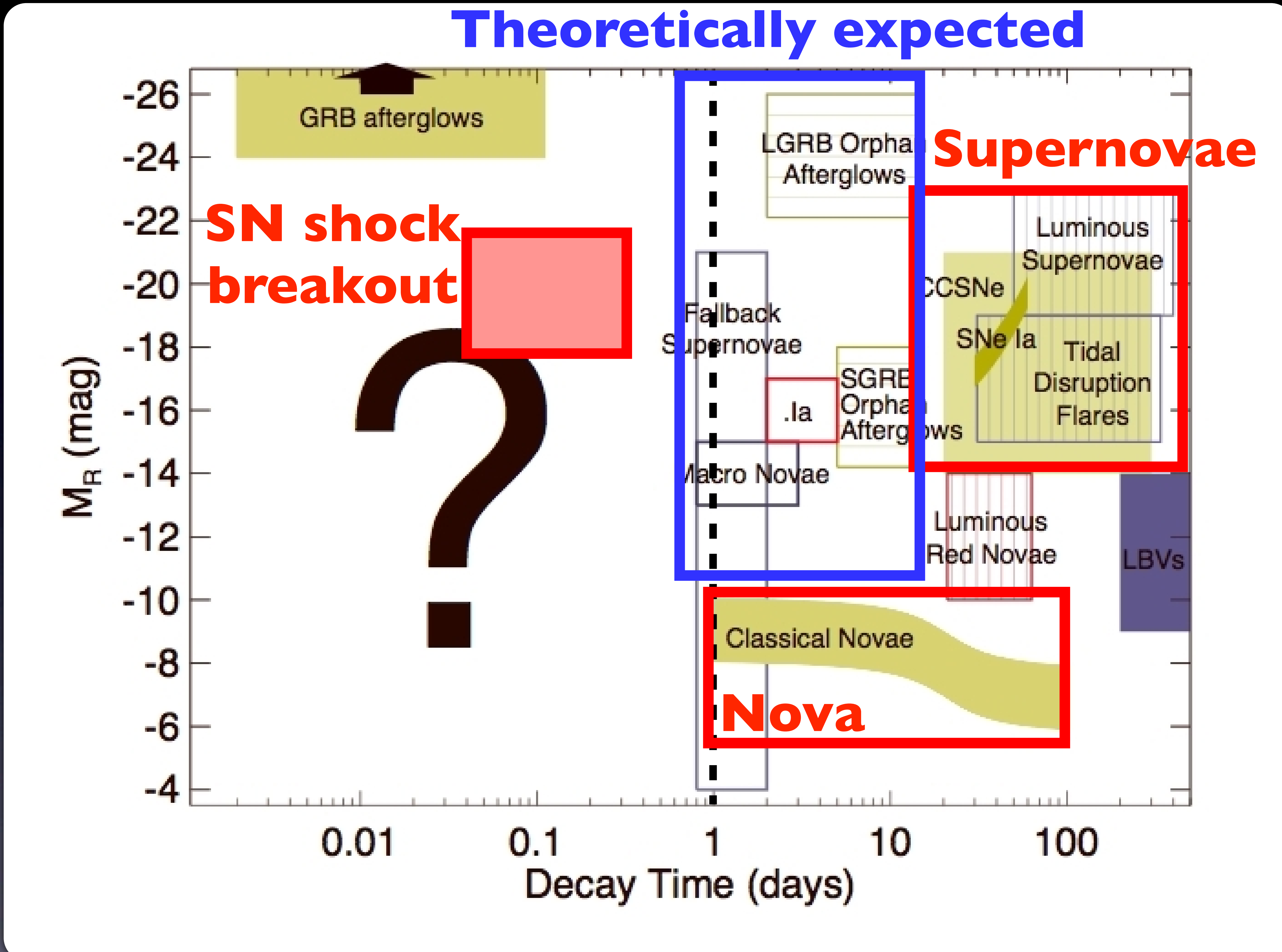
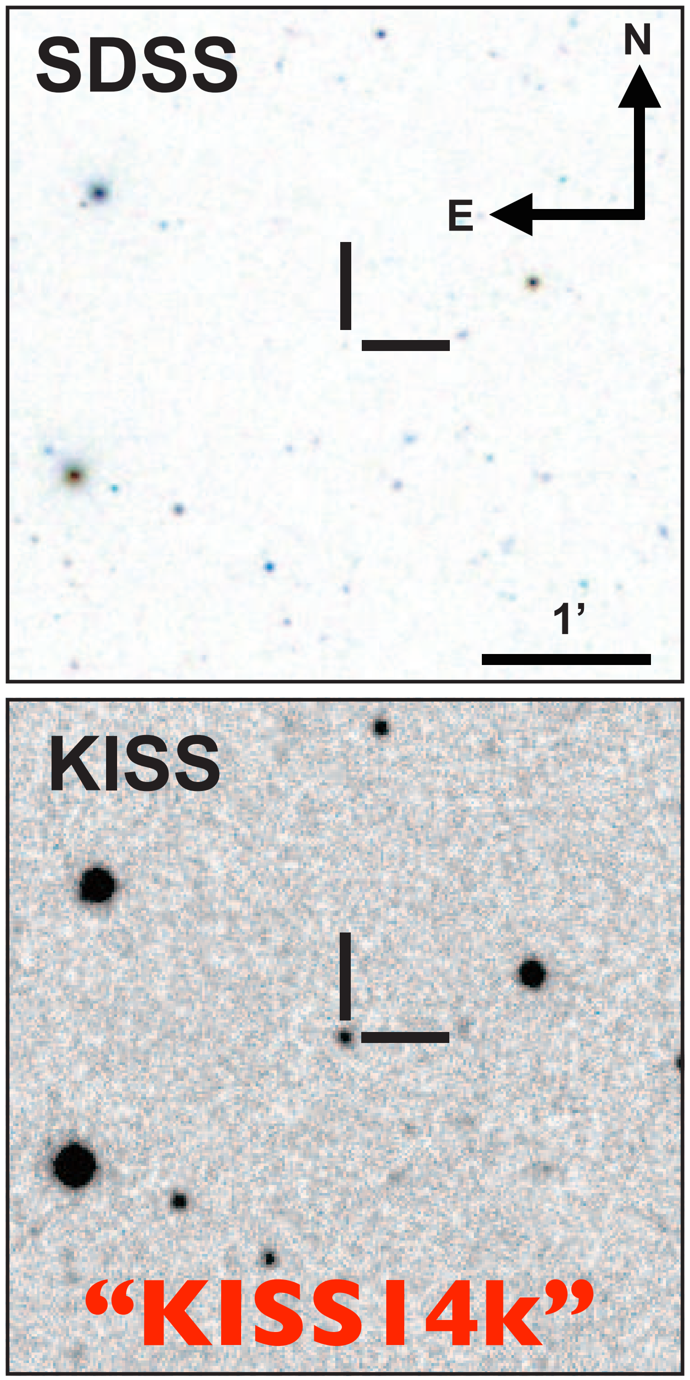
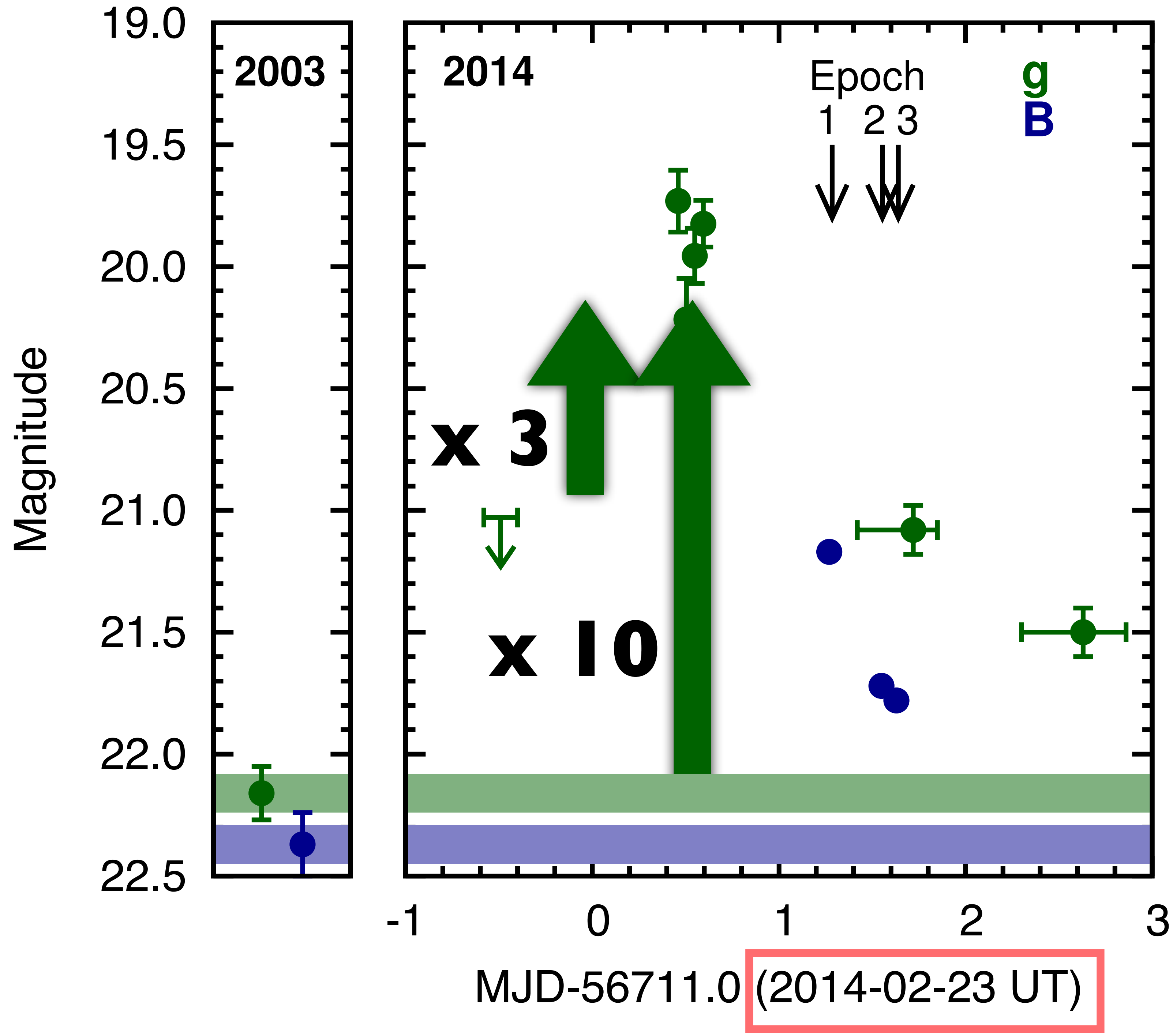
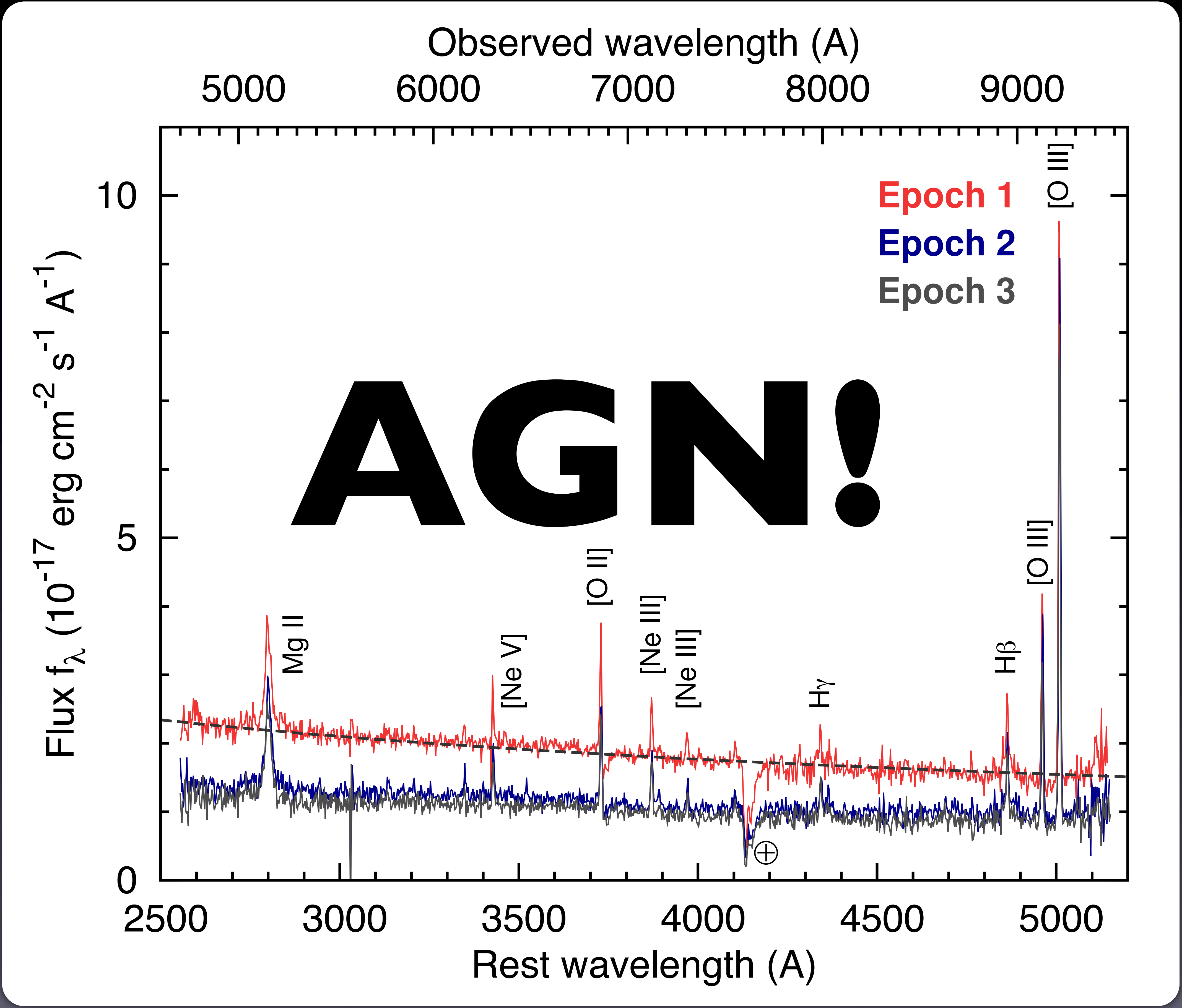


Figure from LSST Science Book
(after PTF collaboration, Rau+09, Kasliwal+,Kulkarni+)

Discovery of a short-timescale transient






Observed wavelength (A)
5000
6000
7000
8000
9000
Flux f_λ (10^-17 erg cm^-2 s^-1 A^-1)
10
5
0
Epoch 1
Epoch 2
Epoch 3
AGN!
Mg II
[Ne V]
[O II]
[Ne III]
[Ne III]
Hγ
Hβ
[O III]
[O III]
2500
3000
3500
4000
4500
5000
Rest wavelength (A)

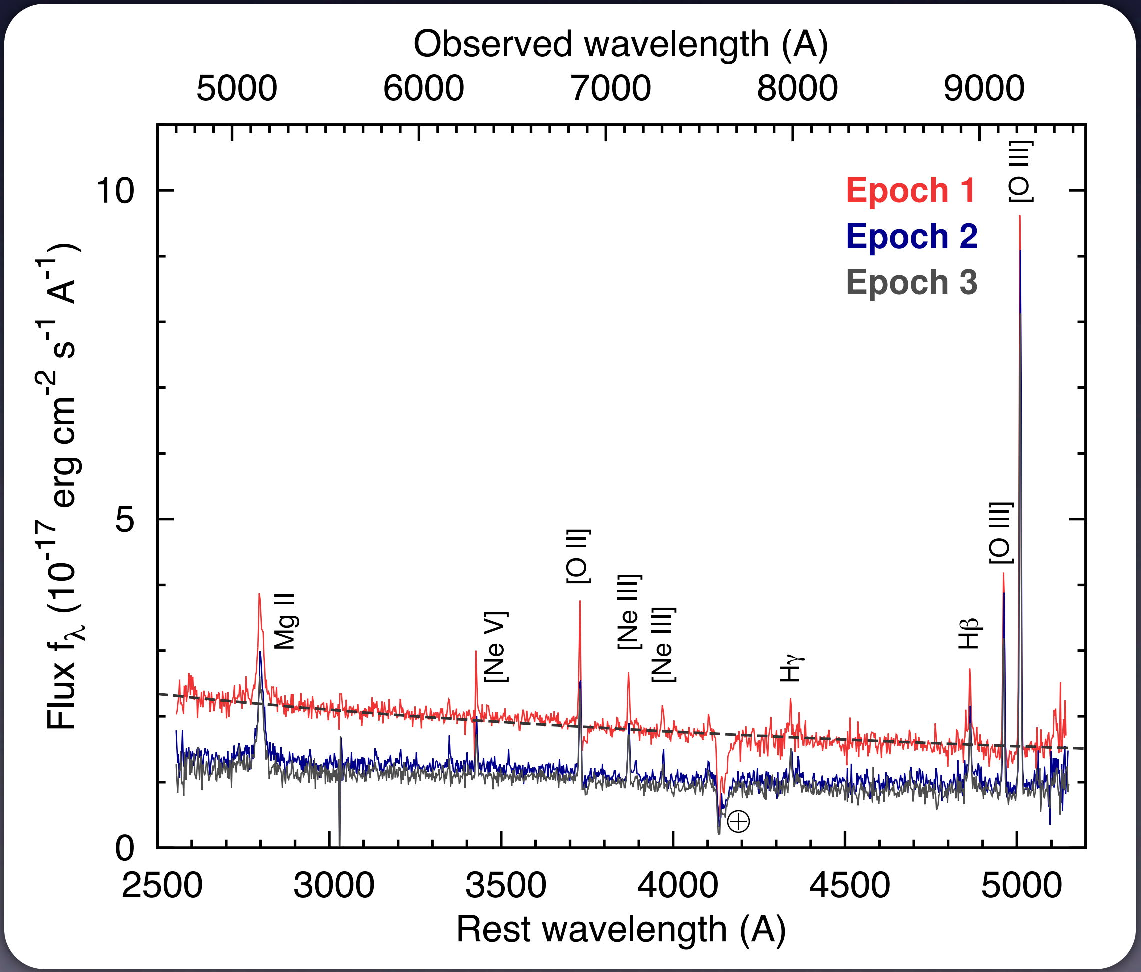
AGN variability within a day?

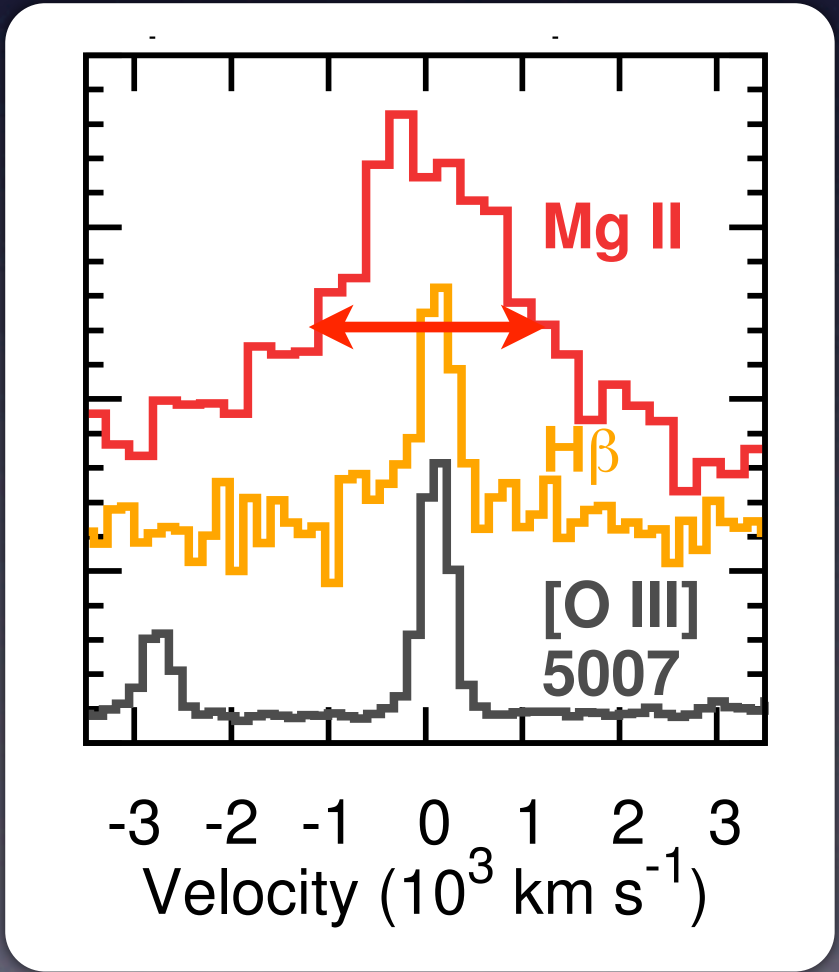
~ 100 days for typical AGNs

Similar to Blazars (AGNs w/o emission lines)

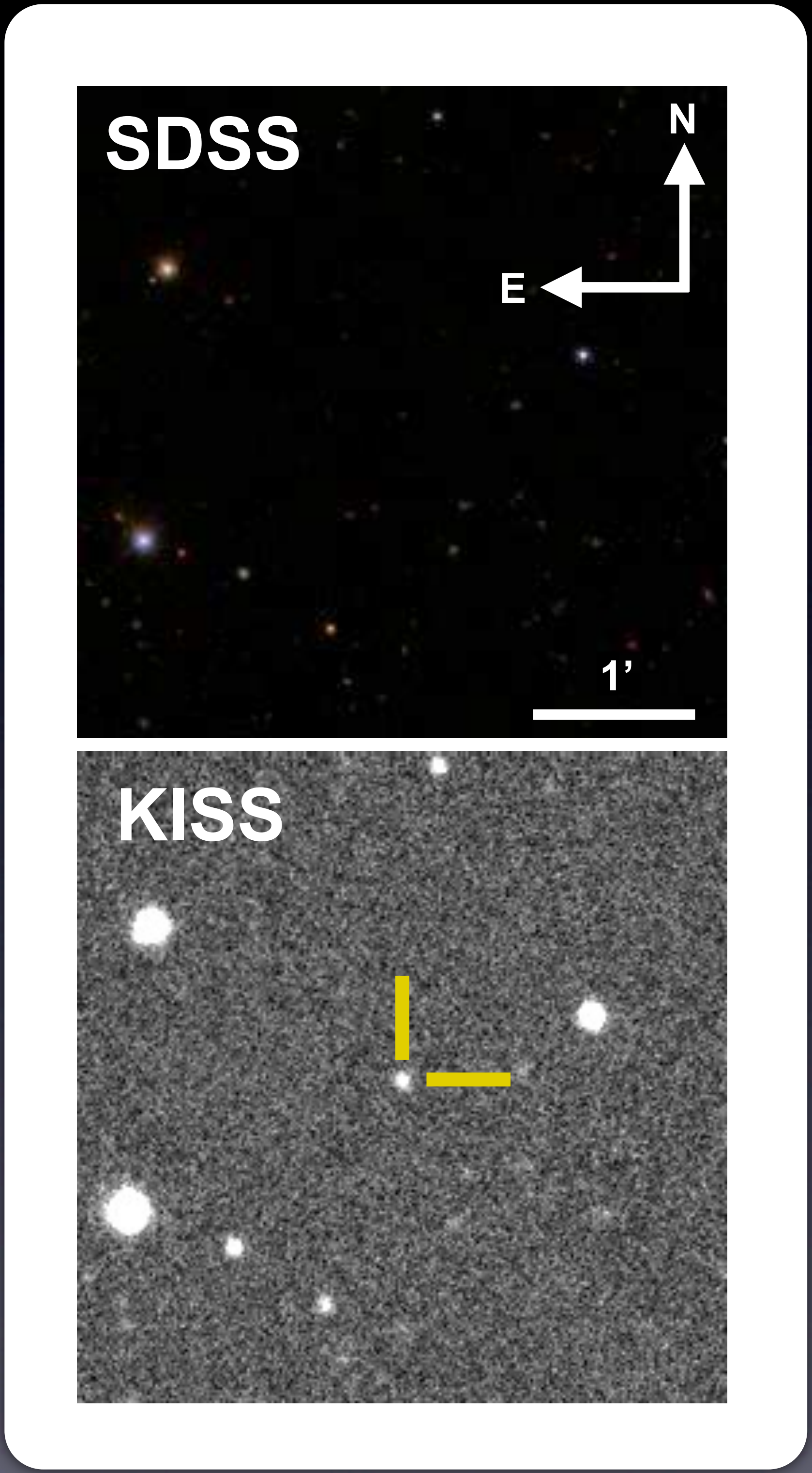
Closer look (1): Optical spectra

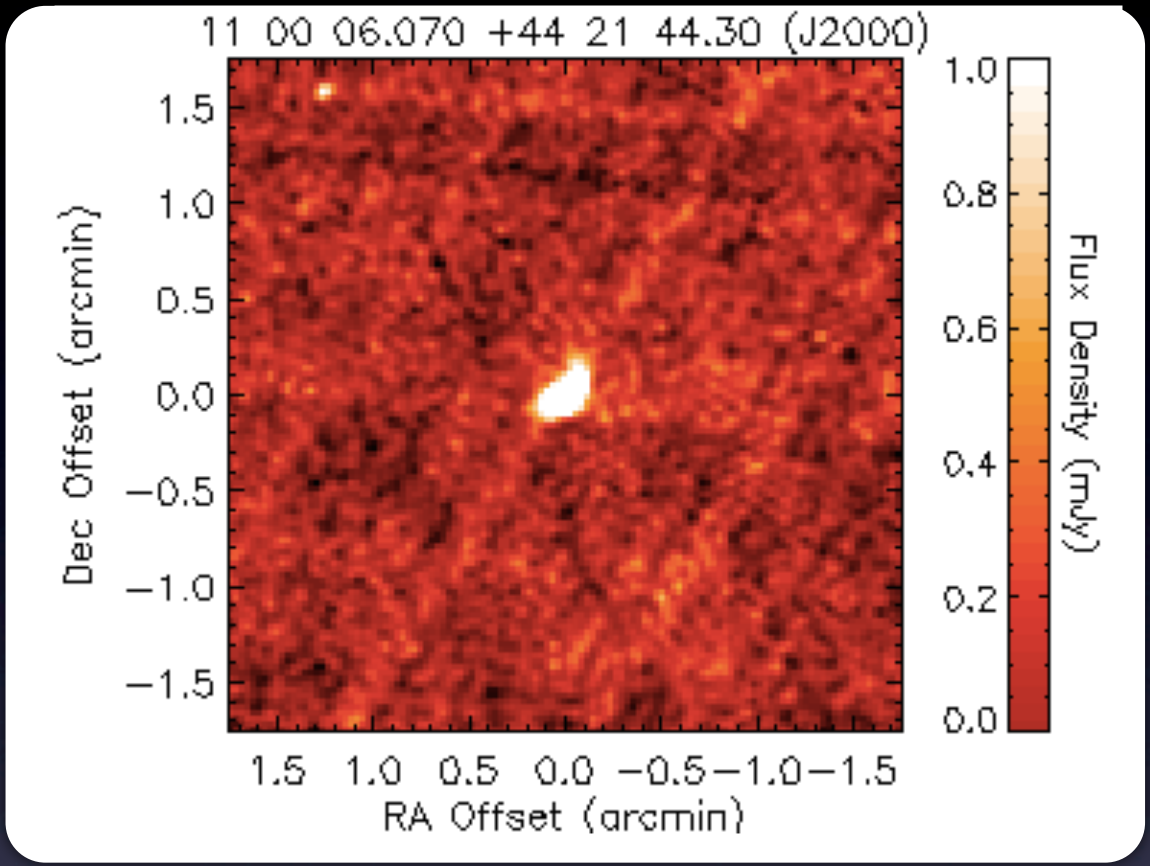
- **Line width of ~ 2000 km/s**
  - **Broader than narrow line region**
  - **Narrower than typical AGNs**
    ==> "narrow-line" Seyfert 1 galaxy
    (M_{BH} ~ 1.5 x 10^7 Msun)





Closer look (2): Archival radio data





~ 20 mJy @1.4 GHz

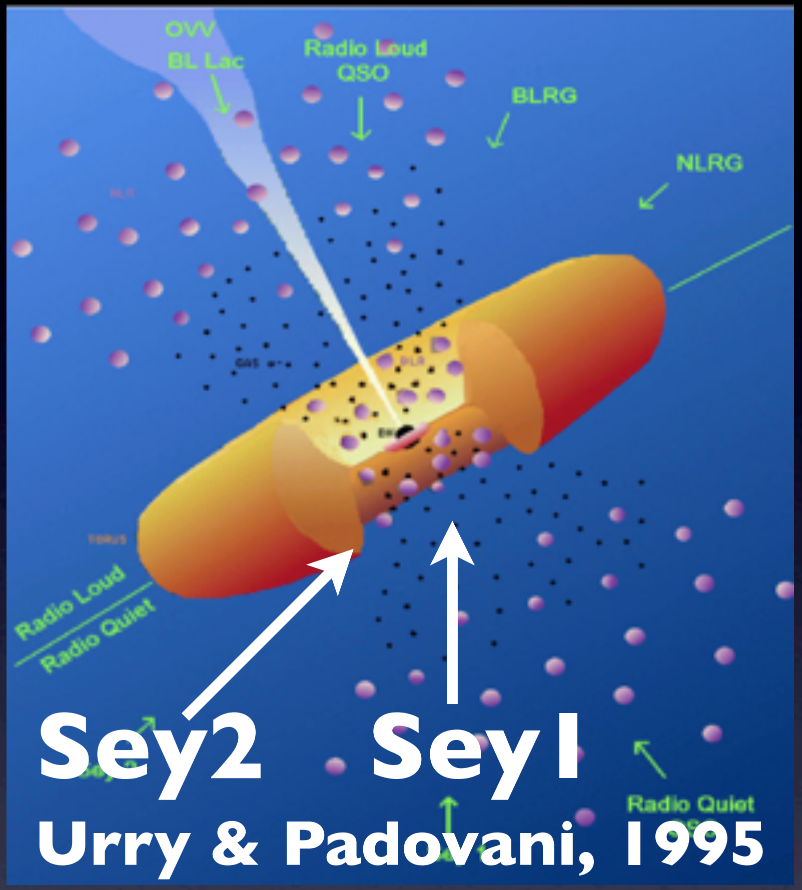
Radio loudness

$R = f_\nu$ (radio) / f_ν (opt)

~ 3000 !

“Narrow-line” Seyfert 1 galaxies

(e.g., Osterbrock & Pogge 1985, Pogge 2000, Komossa 2008, Zhou+2006)



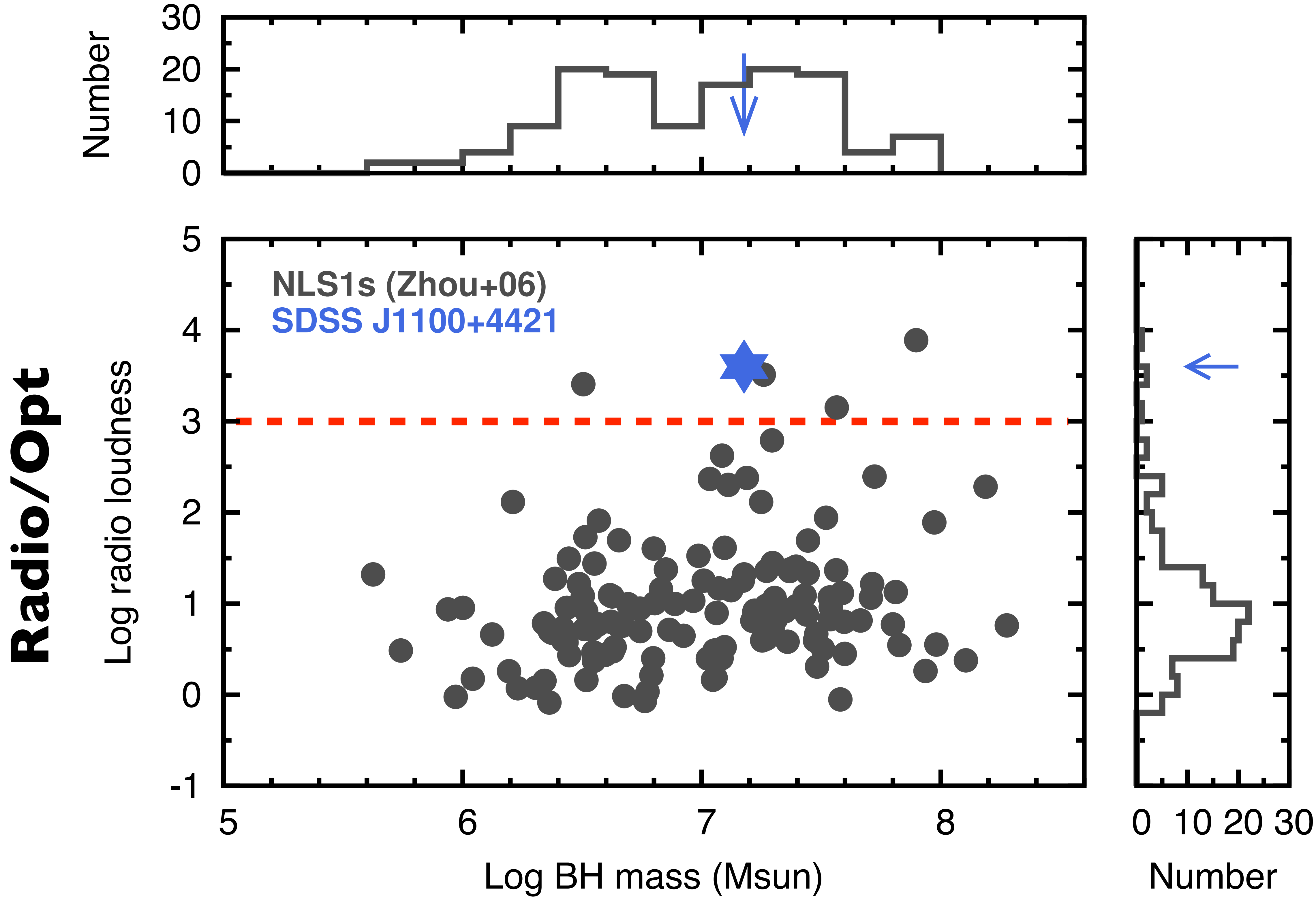
Urry & Padovani, 1995

- ~15 % of broad-line AGNs (~2000 objects in SDSS)
- Relatively “narrow” broad lines (v < 2000 km/s)
- Smaller black hole mass ($M_{BH} \sim 10^6 - 10^8$ Msun)
- High Eddington ratio ($L_{bol}/L_{Edd} \sim 0.1 - 1$)

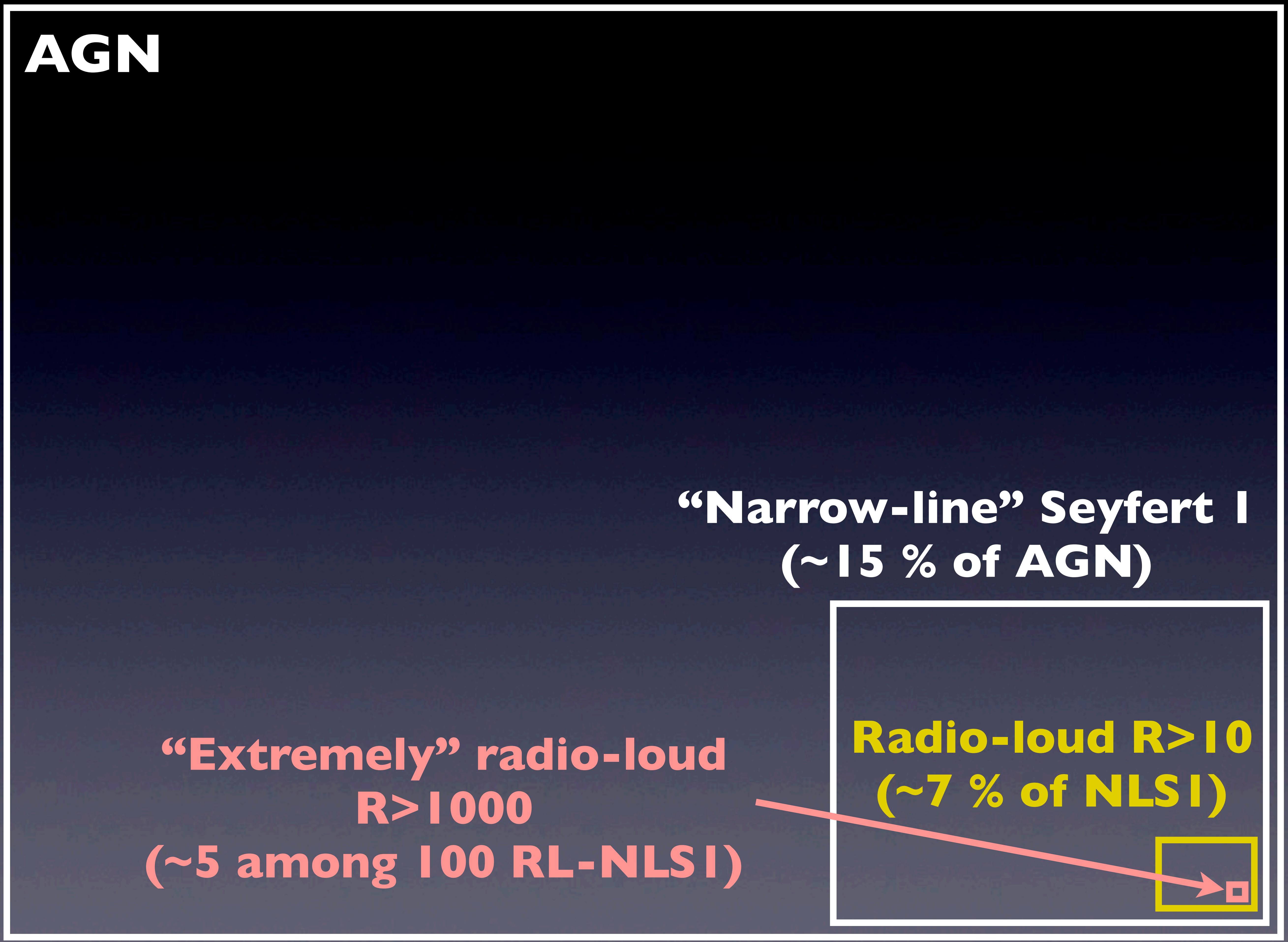
==> “Growing” supermassive black hole

- Only ~7 % of NLS1s are radio-loud (R > 10)

Only 5 objects with R > 1000

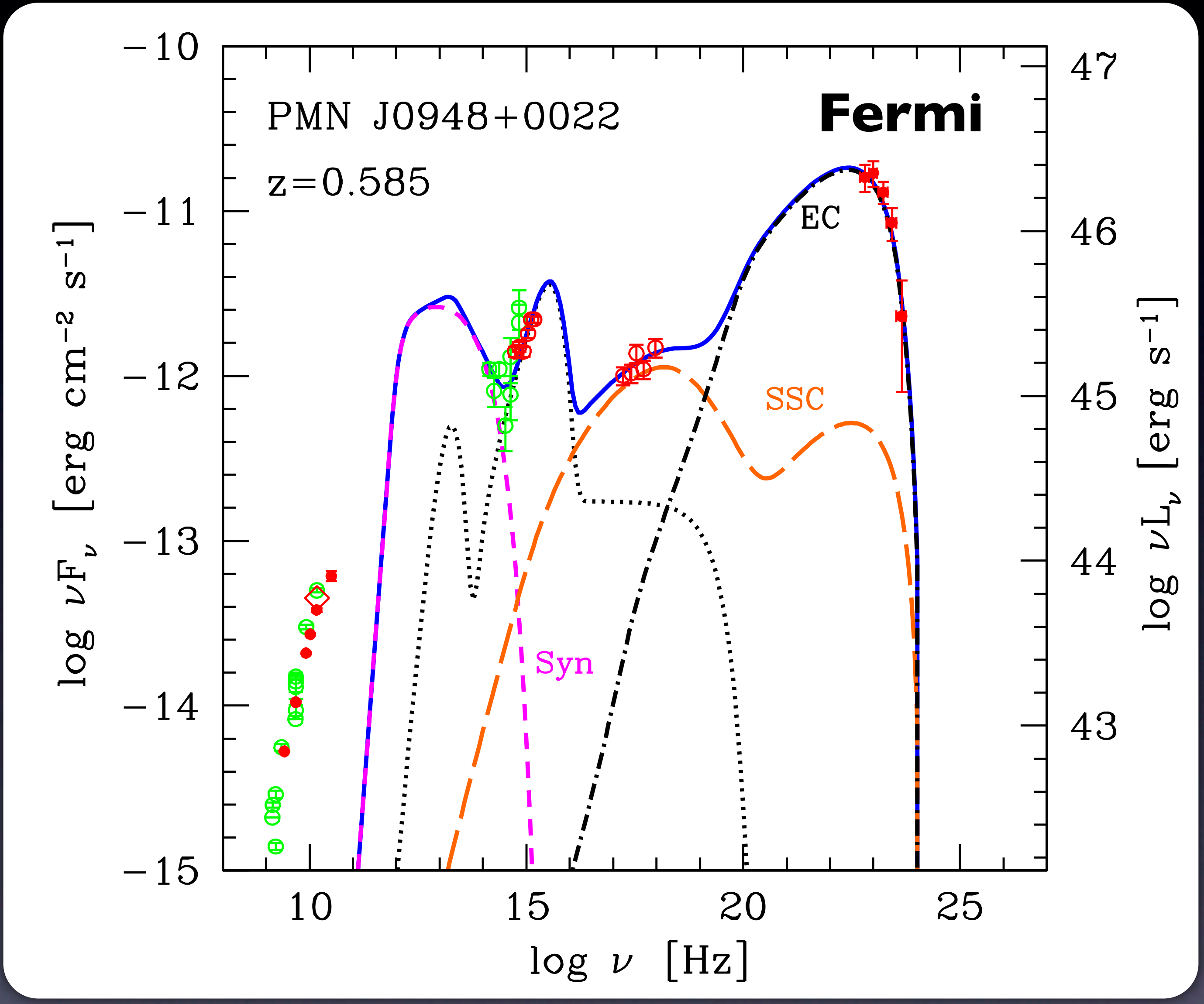


Zhou+06, MT+14


AGN
“Narrow-line” Seyfert 1
(~15 % of AGN)
Radio-loud R>10
(~7 % of NLS1)
“Extremely” radio-loud
R>1000
(~5 among 100 RL-NLS1)

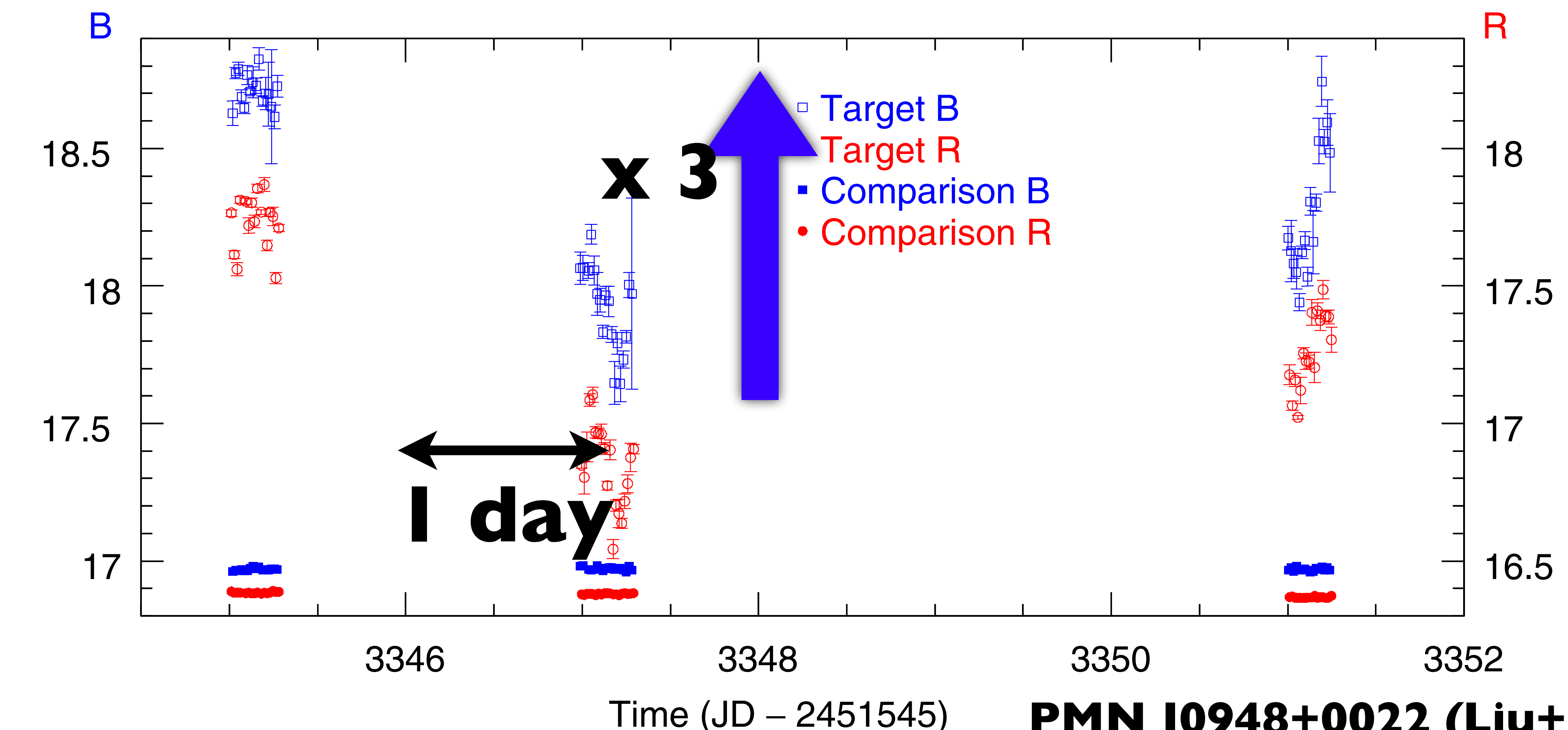
A new class: "γ-loud" narrow-line Seyfert 1

- **4 radio-loud objects detected by Fermi (100 MeV - 100 GeV)**
  => "γ-loud" NLS1
  - **Relativistic jets pointing to us (~ blazars)**
  - **Extreme variability (~ blazars)**



PMN J0948+0022 (Abdo+09)

Extreme variability of γ-loud objects



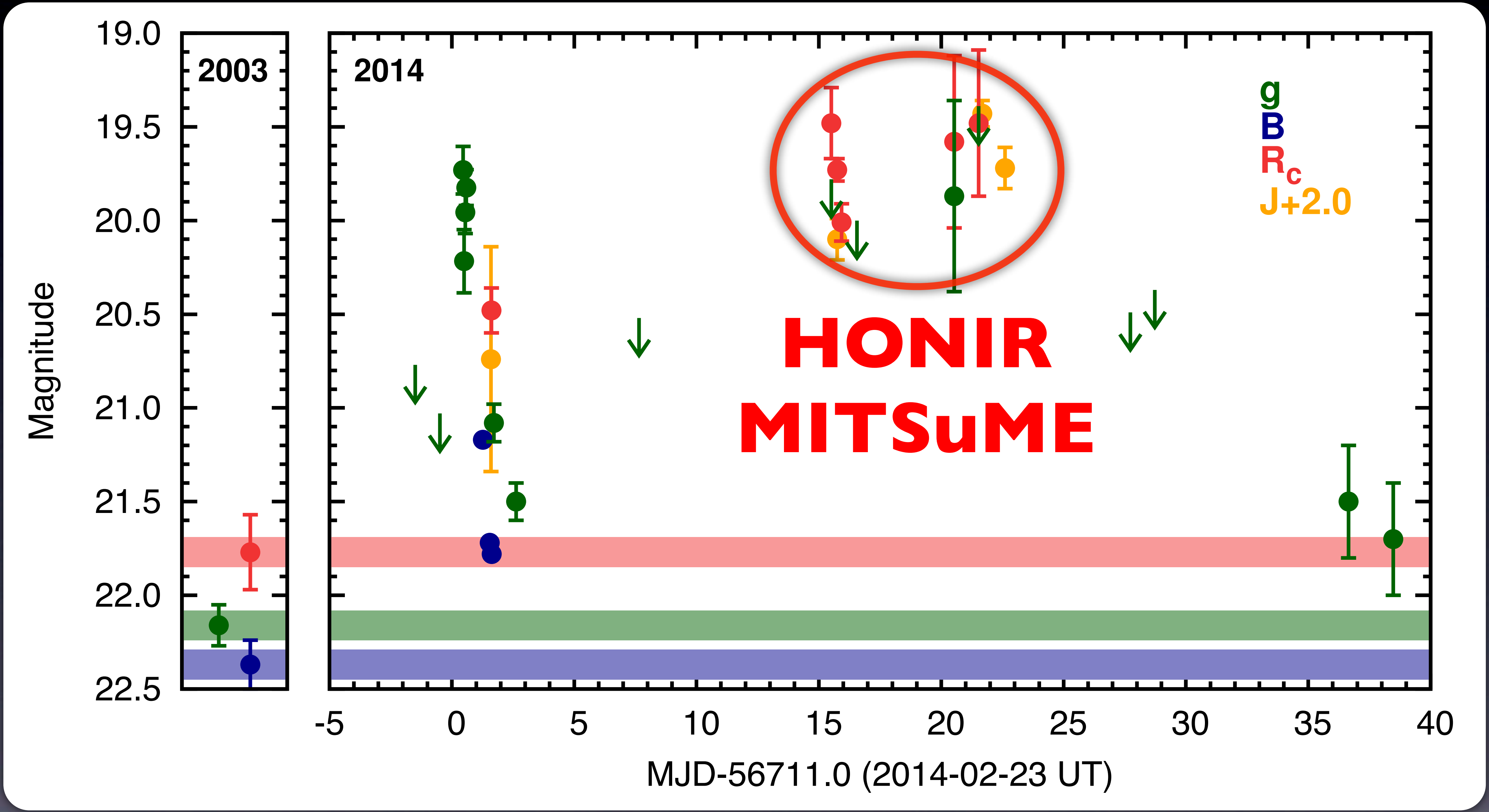
PMN J0948+0022 (Liu+10)

Synchrotron emission from jets

Detection of polarization (Eggen+13, Itoh+13)

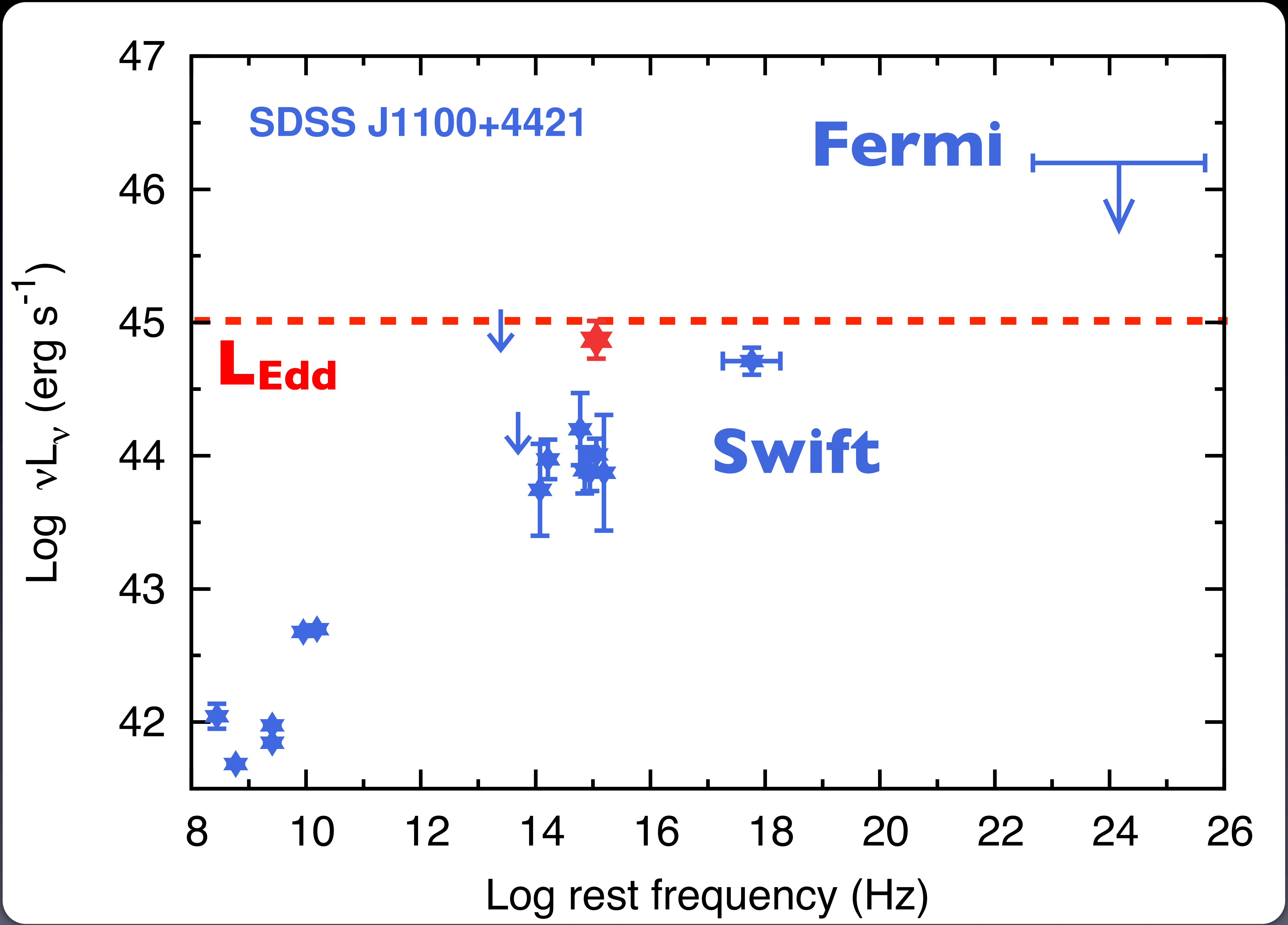
Follow-up observations

(Subaru/FOCAS, Kanata/HONIR, MITSuME, Kottamia, and Okayama/KOOLS)

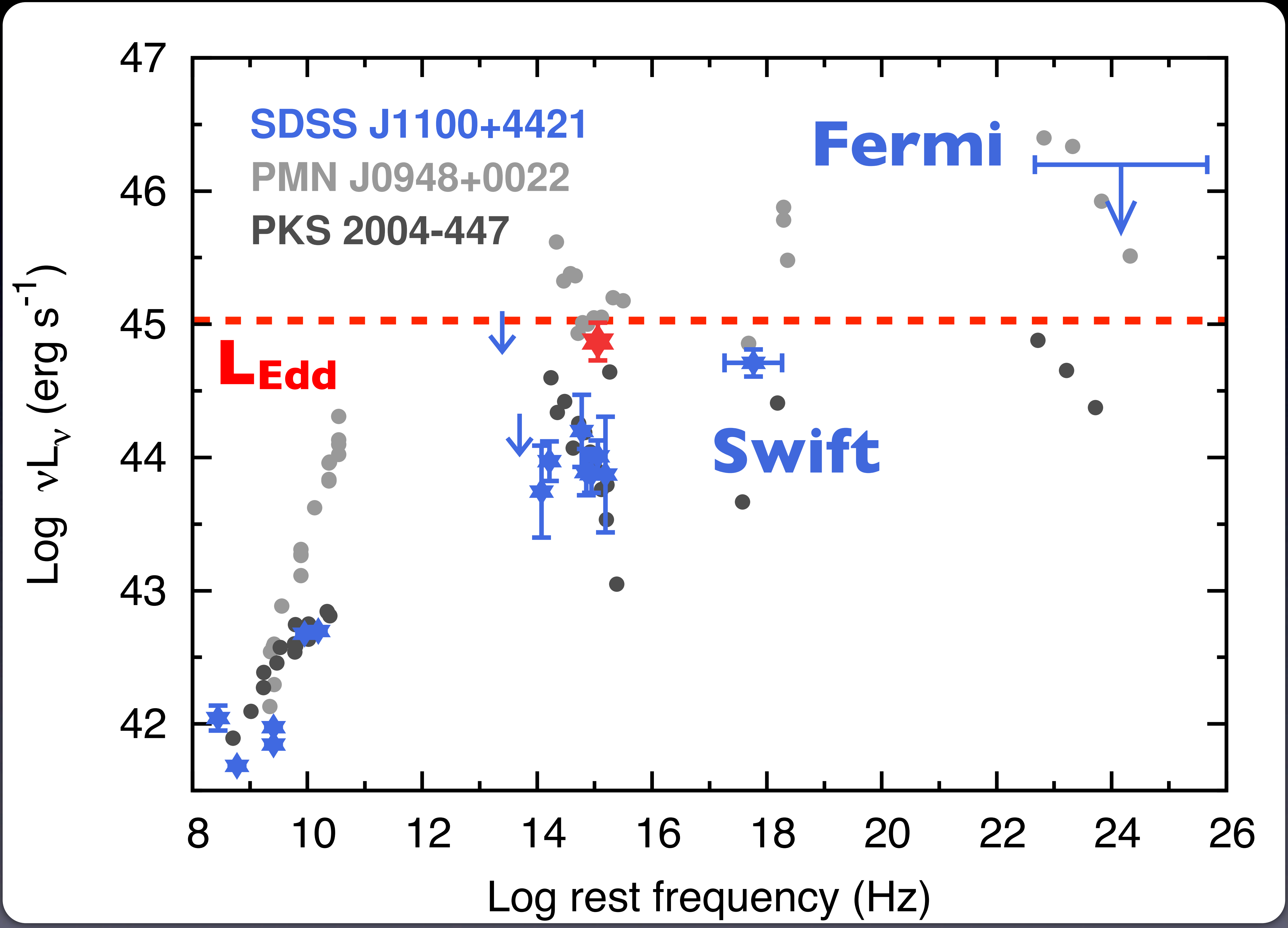


Variable even after the "flare"

Spectral Energy Distribution



Spectral Energy Distribution



Nature of the transient

- Narrow-line Seyfert 1 (v ~ 2000 km/s)
  - ~10^7 Msun of BH
- Extreme radio loud (R ~ 3000)
- Short timescale, blazar-like variability
- High Eddington ratio
  - L_{bol}/L_{Edd} ~ 0.3 ==> L_{acc}/L_{Edd} ~ 3 (Super-)critical accretion

⇒ An object similar to γ-loud NLS1s

Origin of the “flare”

1
Tidal disruption

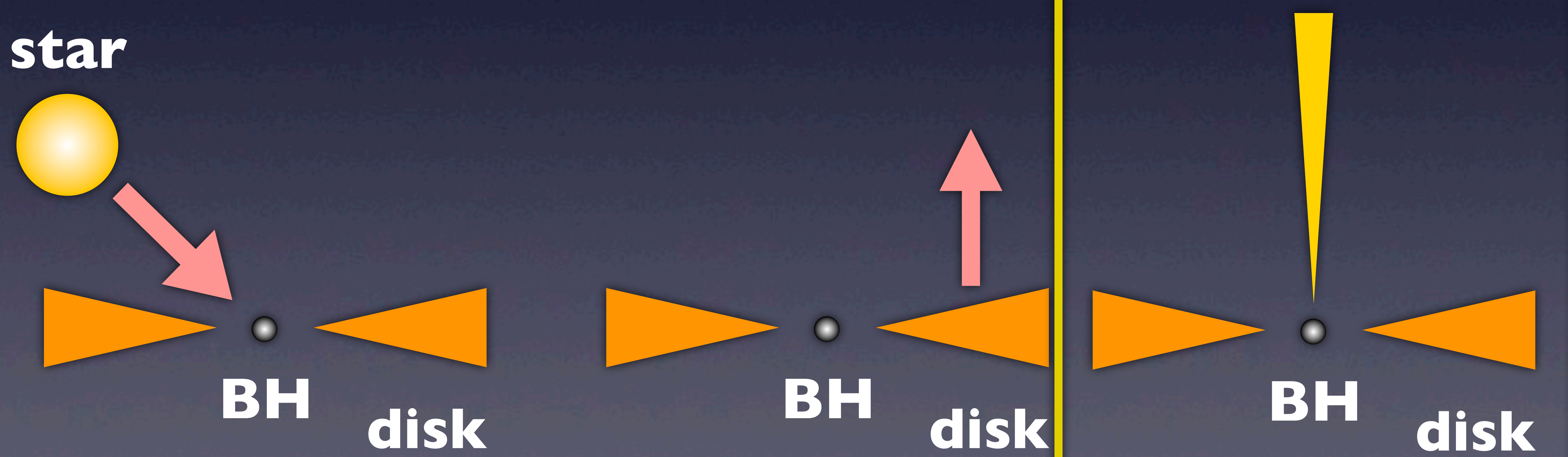
Emission only once...

2
Accretion disk

$r \sim 10^{15}$ cm
$\tau \sim 30$ days...

3
Relativistic jet

τ can be < 1 day



AGN

What is the role of jets in growing SMBH...??

Time-domain survey as a new method to search for radio-loud objects w/o spectroscopy

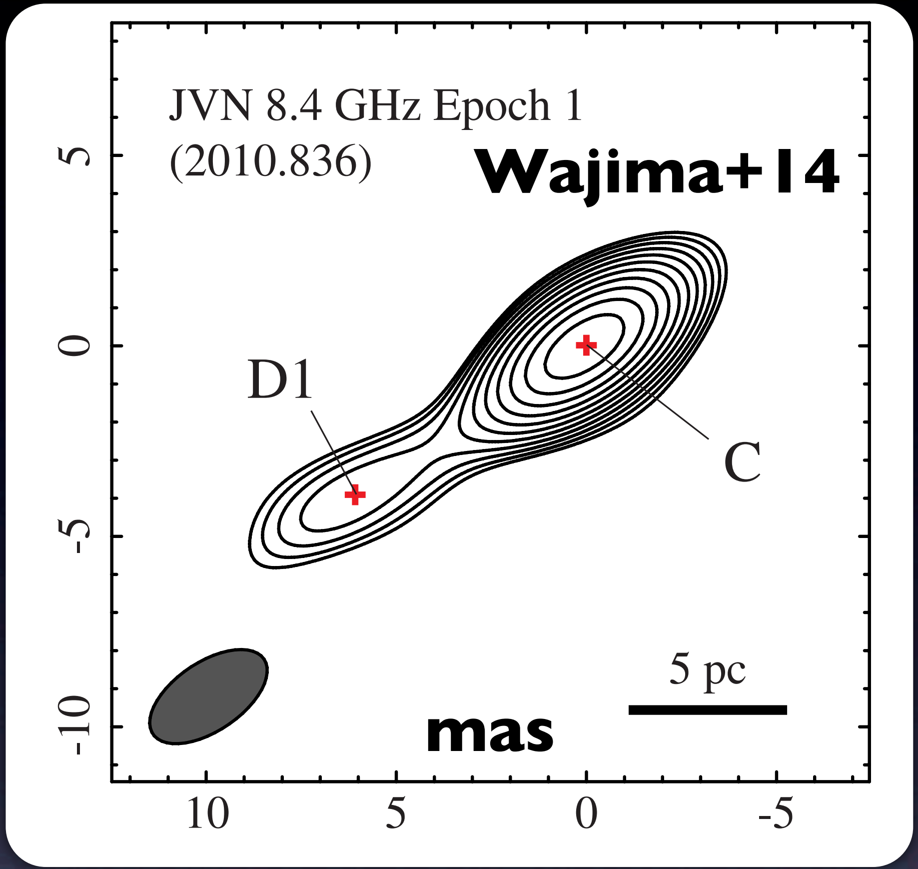
"Narrow-line" Seyfert 1 (~15 % of AGN)

Radio-loud R>10 (~7 % of NLS1)

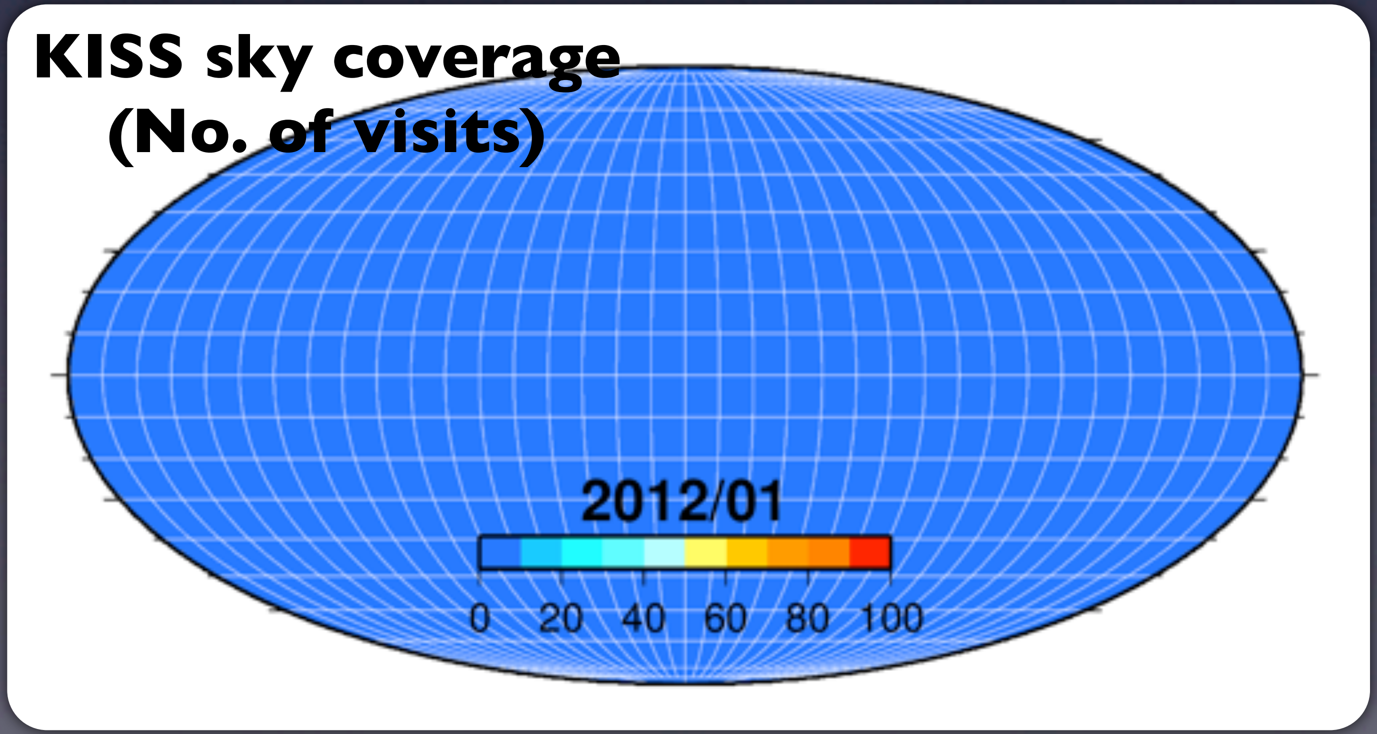
"Extremely" radio-loud R>1000 (~5 among 100 RL-NLS1)

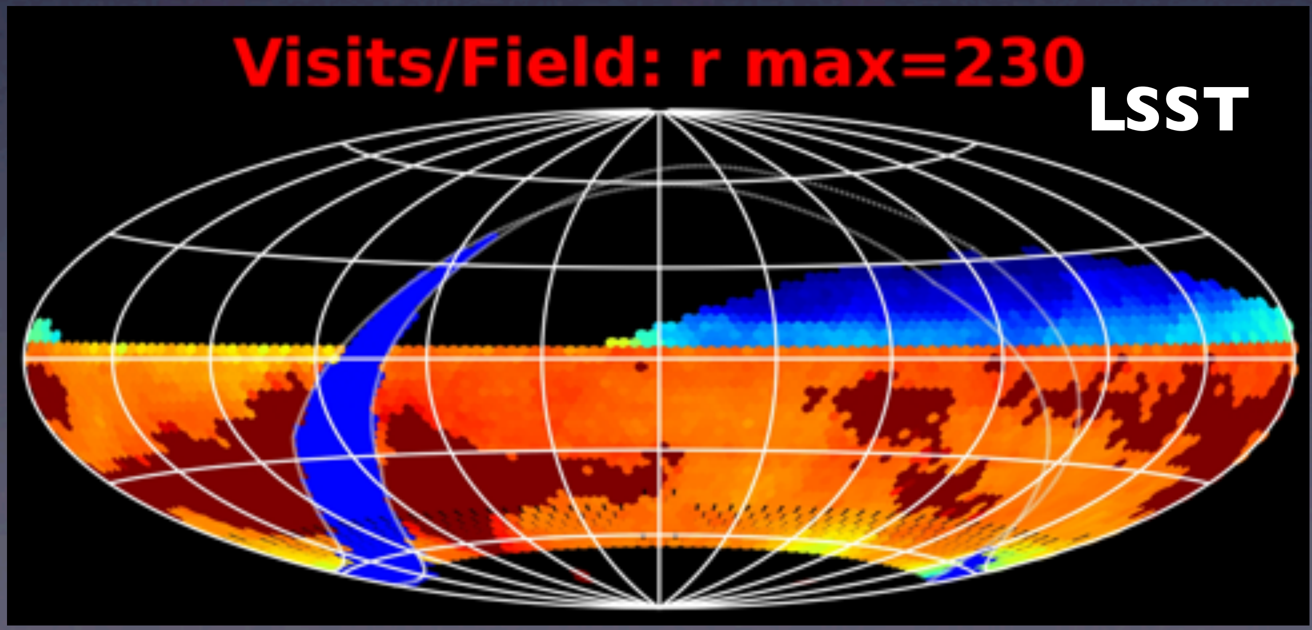
Ongoing works

- **Follow-up observations w/ Japanese VLBI network (JVN) => imaging of jets (1mas ~ 7pc)**
  Morokuma et al.



- **Search for short timescale variability**





Summary

- Discovery of rapid "flare" from an AGN
  - Narrow-line Seyfert 1 (~10^7 Msun of BH)
  - High Eddington ratio (L_{acc}/L_{Edd} ~ 1)
  - Among the most radio-loud objects (R>1000)
  - Blazar-like (γ-loud NLS1-like) variability
  - Emission from the jet
- Toward understanding origin/role of AGN jets
  - Time-domain survey as a new method
  - Multi-frequency simultaneous observations
- More interesting science in KISS data