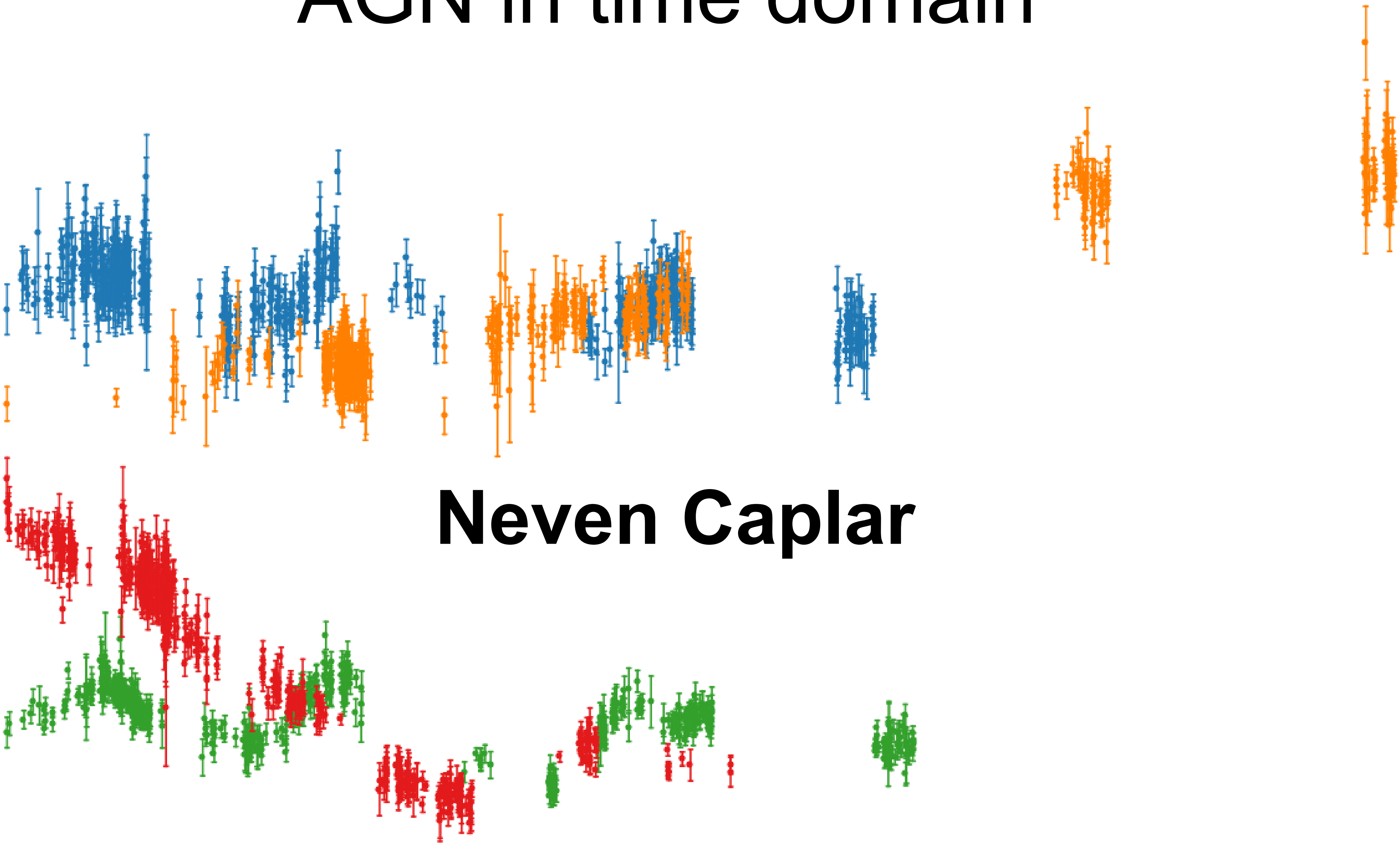
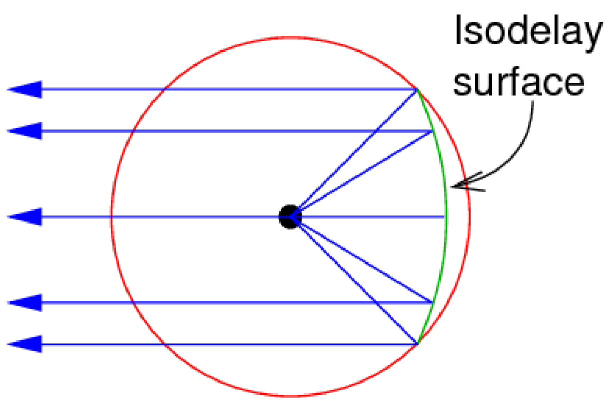
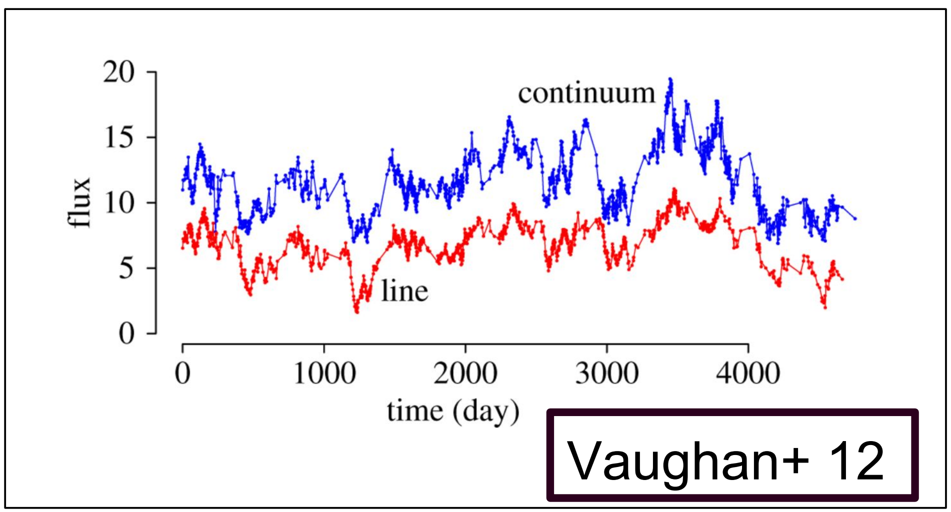
Stochastic variability of AGN in time domain



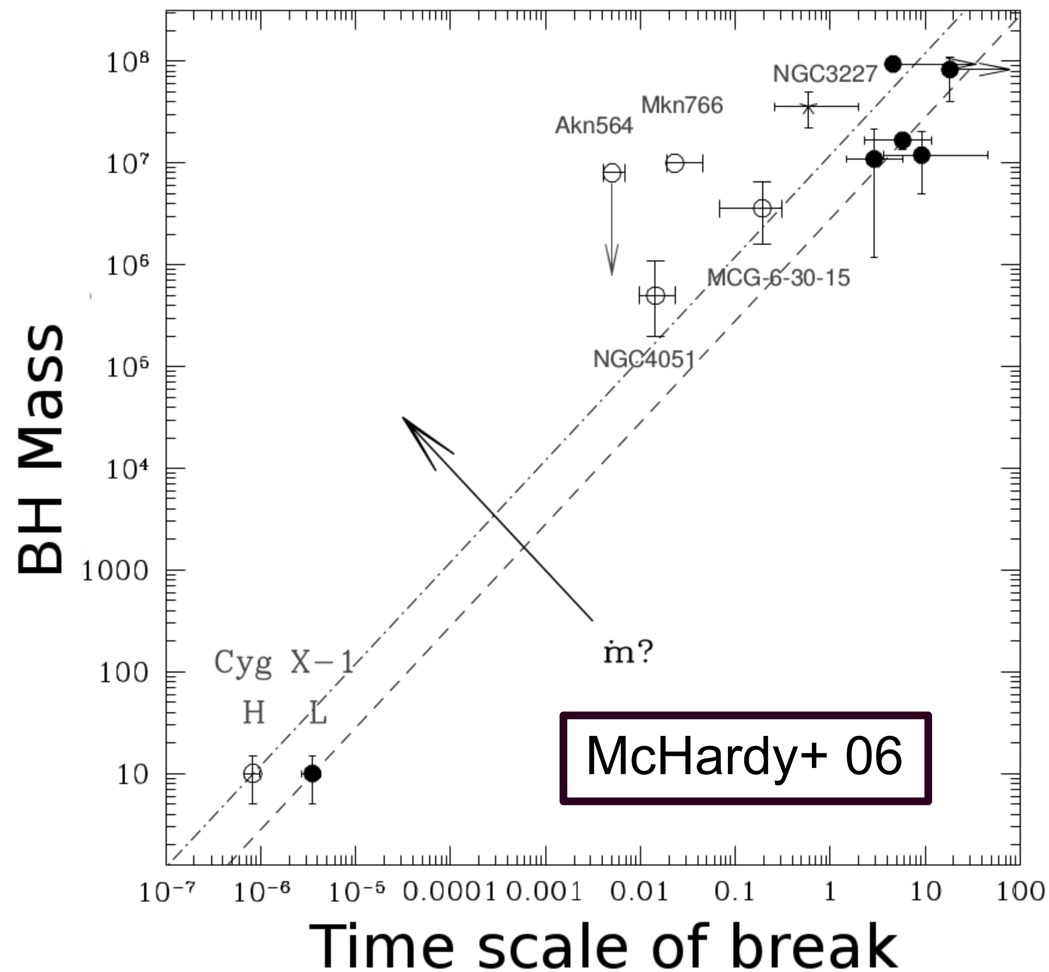
Neven Caplar

Why quasar variability?



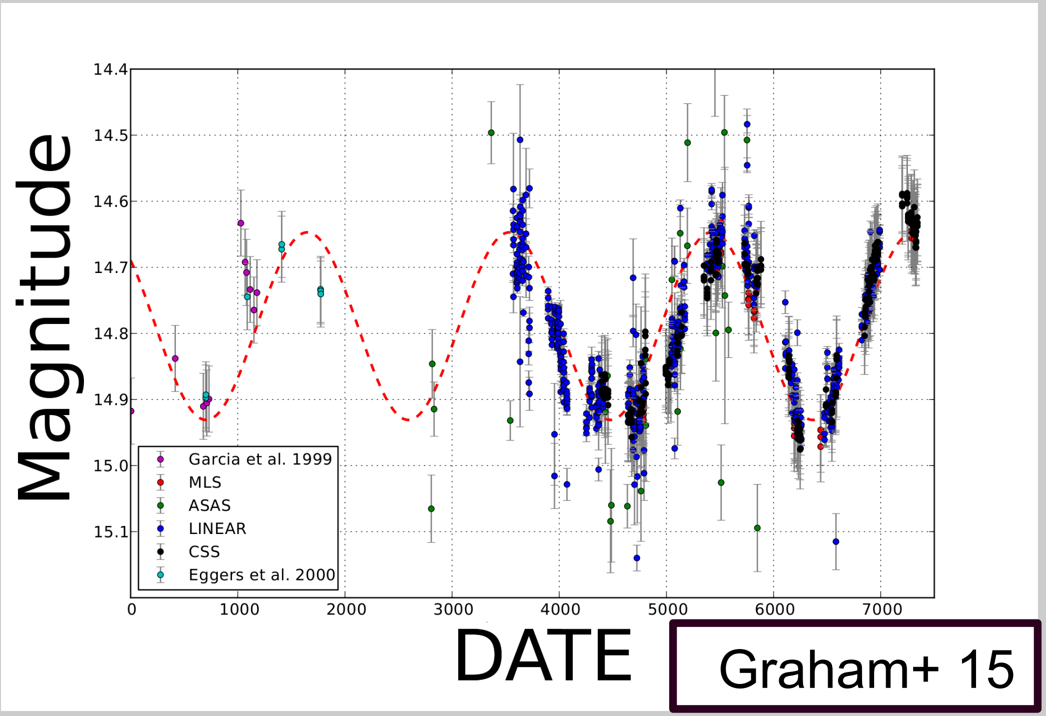


- Reverberation mapping
- Probes structure of broad-line region
- Method to measure BH mass

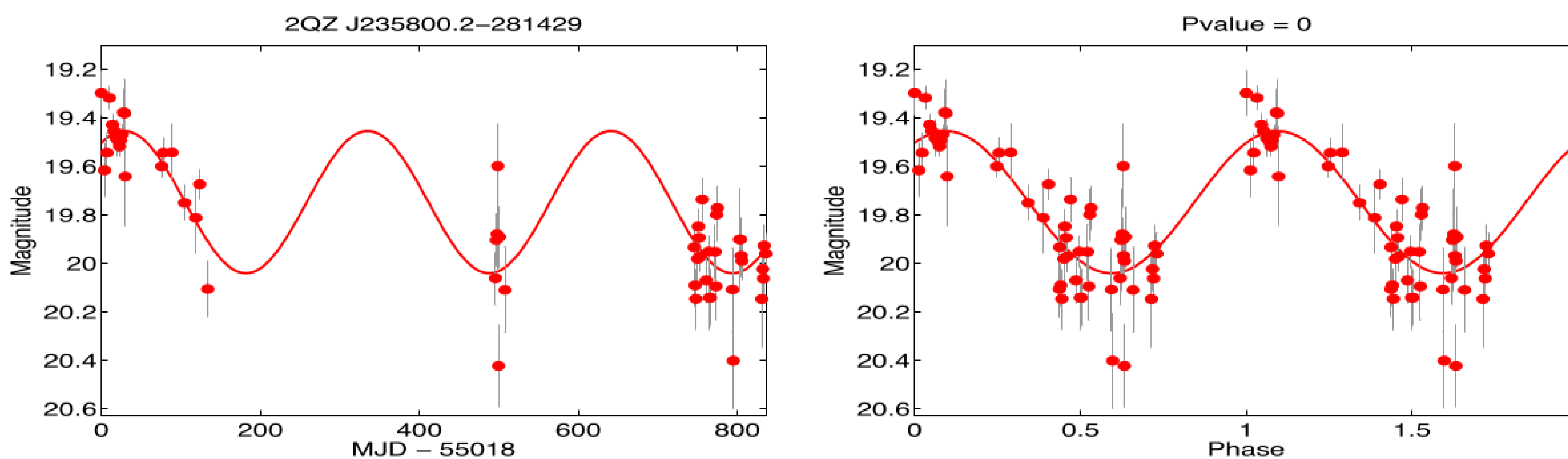


- BH mass correlated with with break in the X-ray power spectrum density

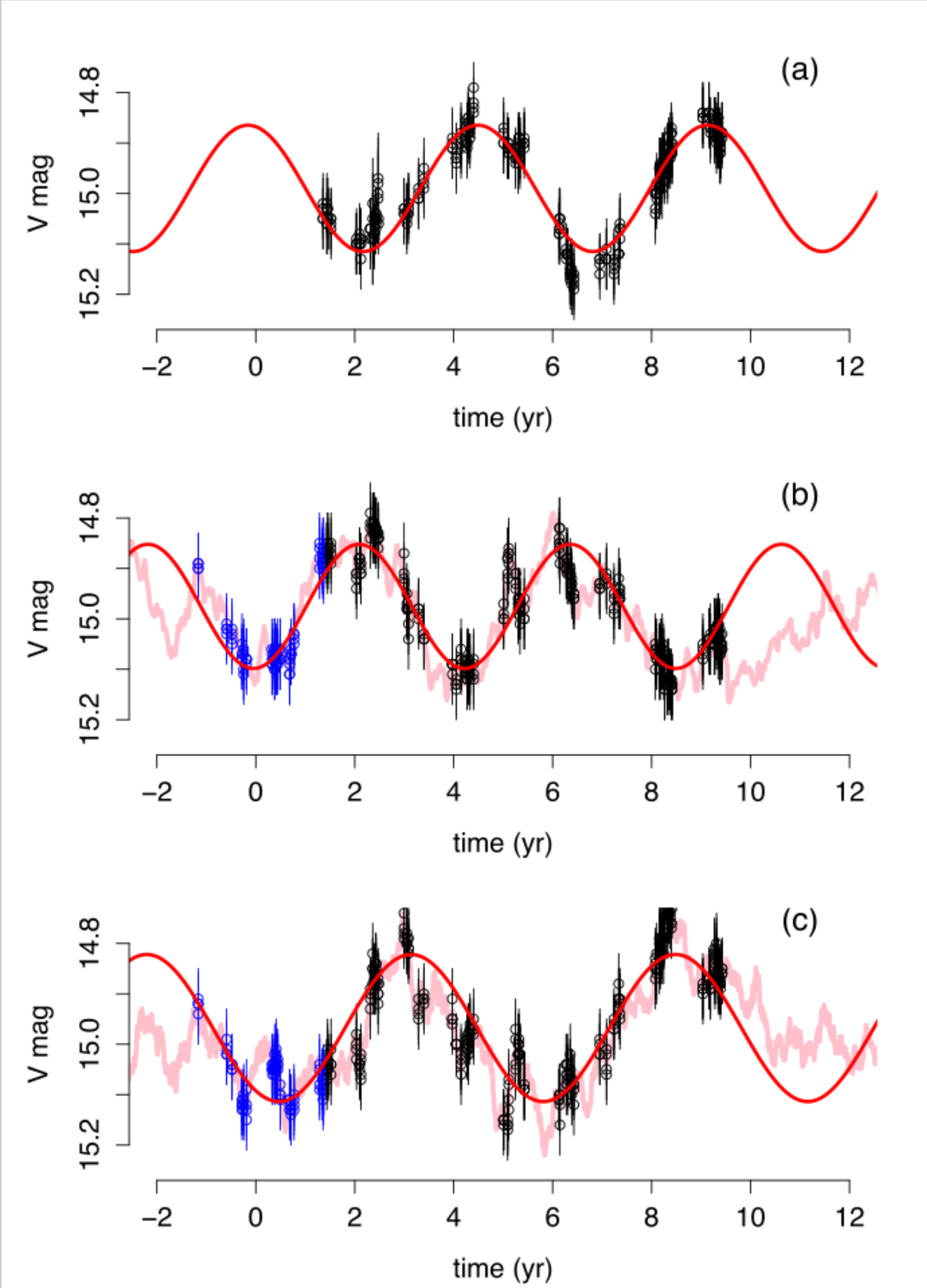
- Search for binaries of supermassive black holes with a sub-parsec separation
- Expected as a consequence of galaxy mergers



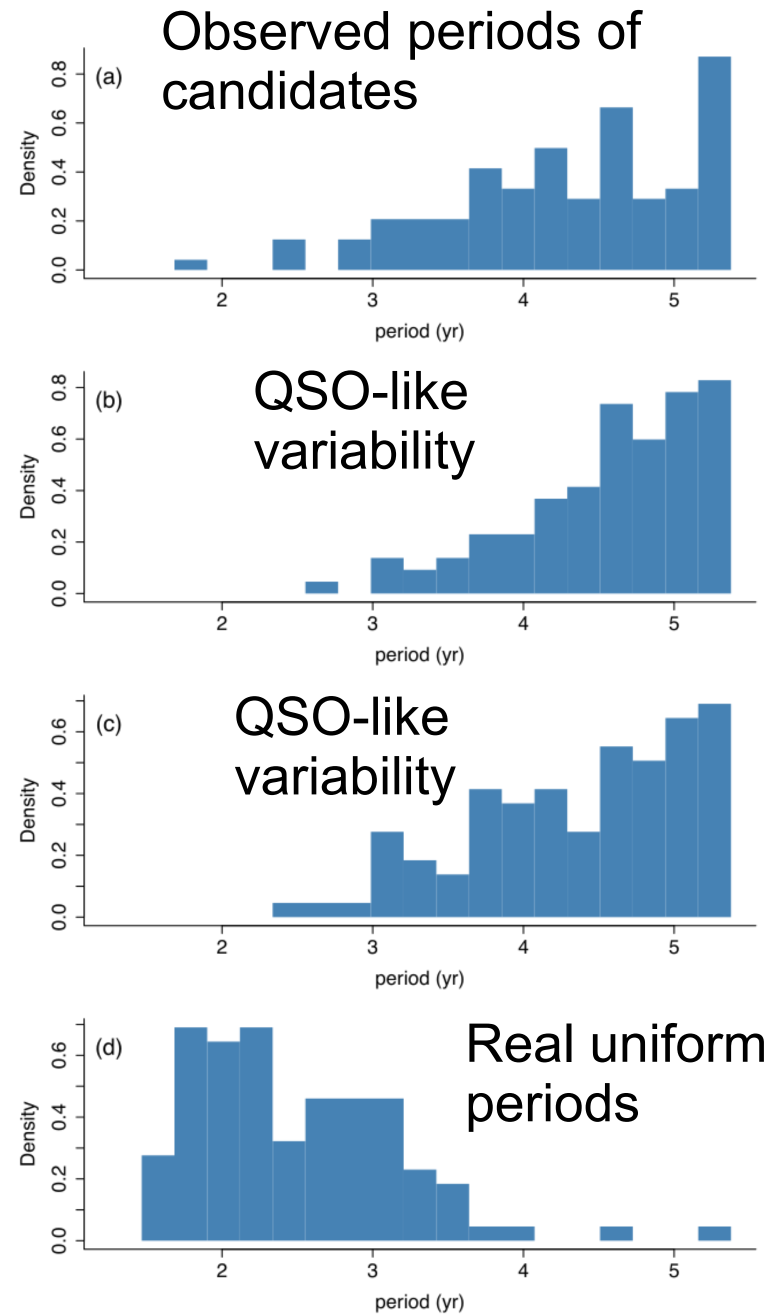
Graham+ 15



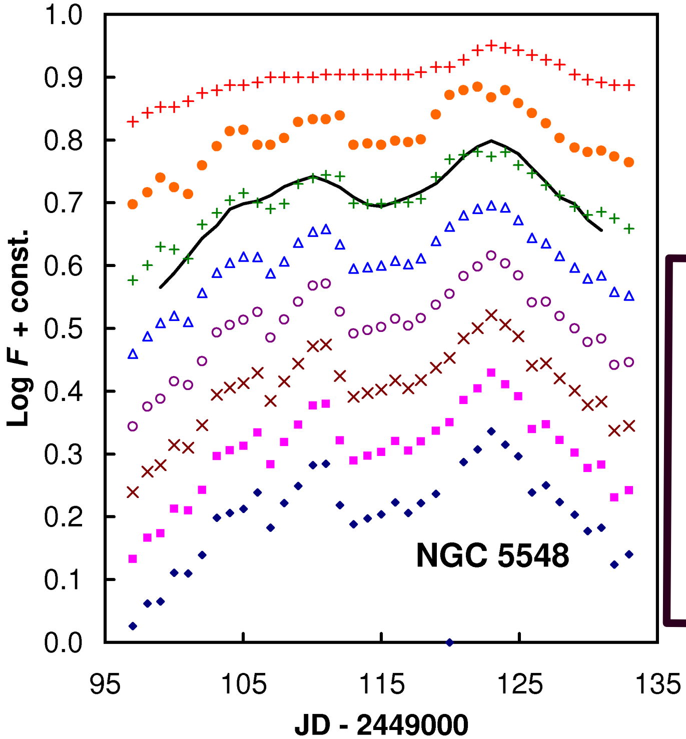
Charisi+ 16



- But stochastic process can also mimic periodicity!



Vaughan+ 16



Korista+ 95

- Quasar variability as a test of accretion disk physics

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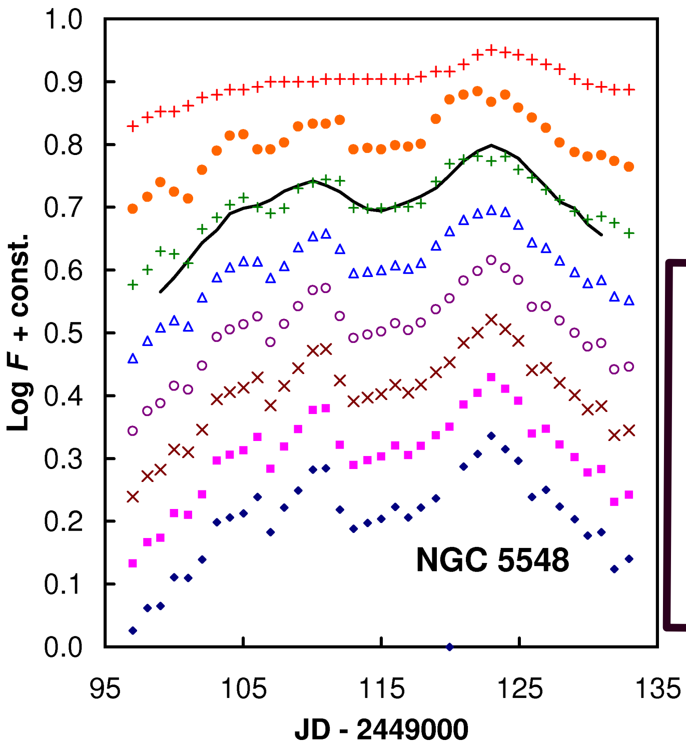
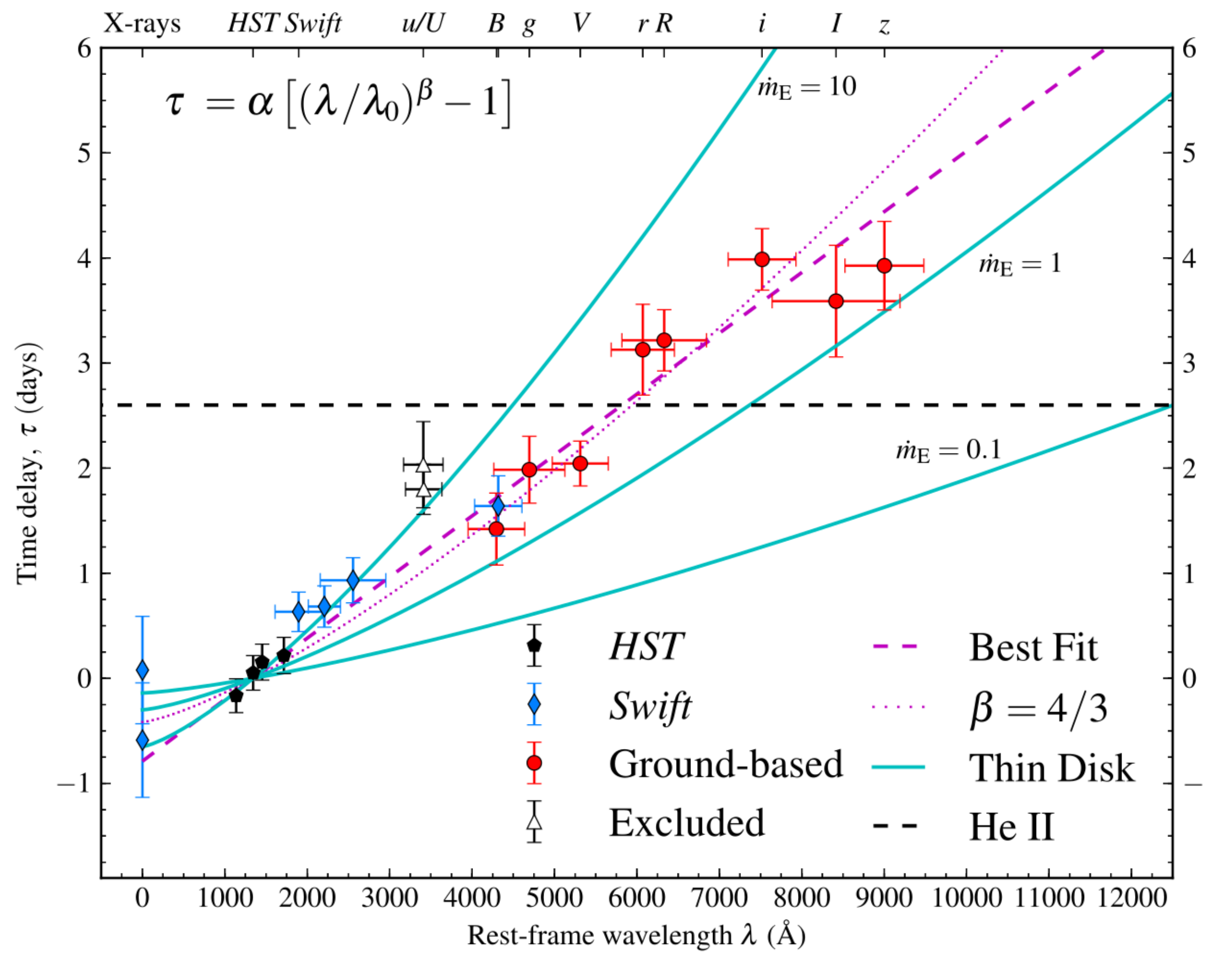


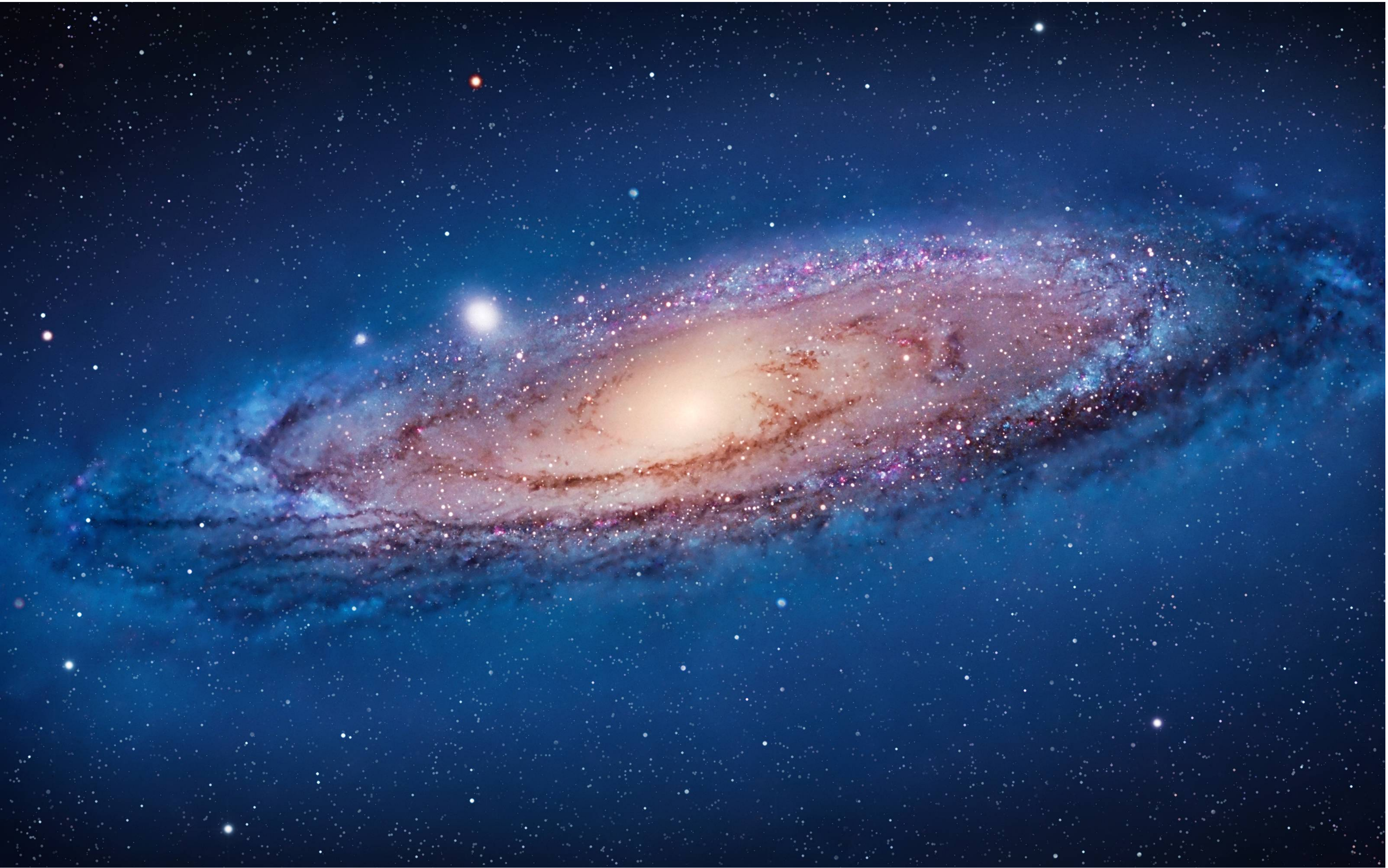
Korista+ 95



Fausnaugh+ 16

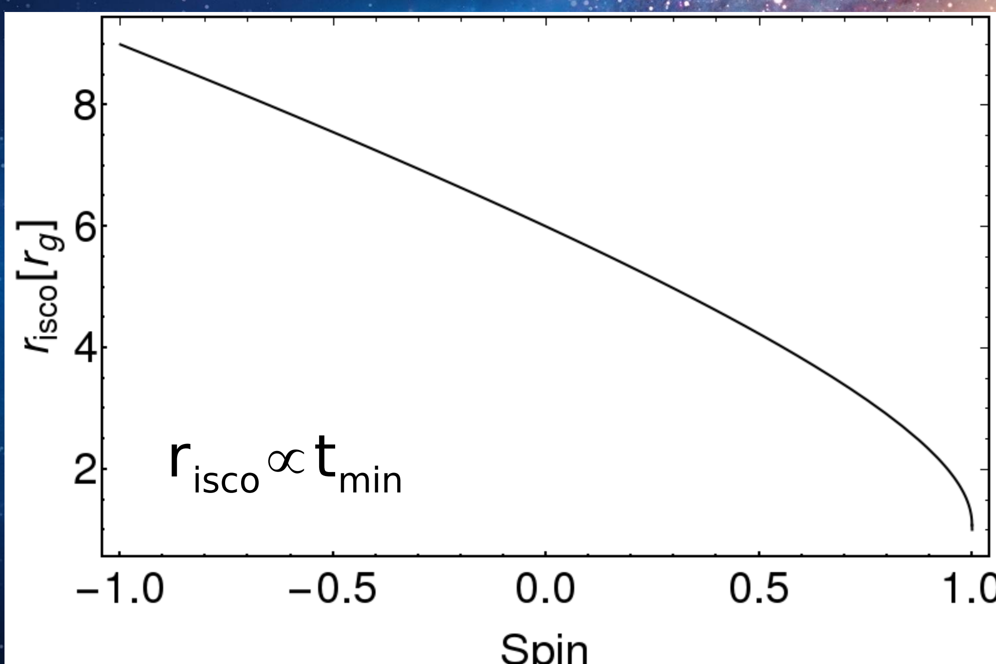
- Different wavebands are correlated
- Time delays of serveral days
- Comparable to light-travel time?

- Quasar variability as a method to measure spin



- Quasar variability as a method to measure spin

Measure the shortest time-scale of variability; connected with radius of last stable orbit



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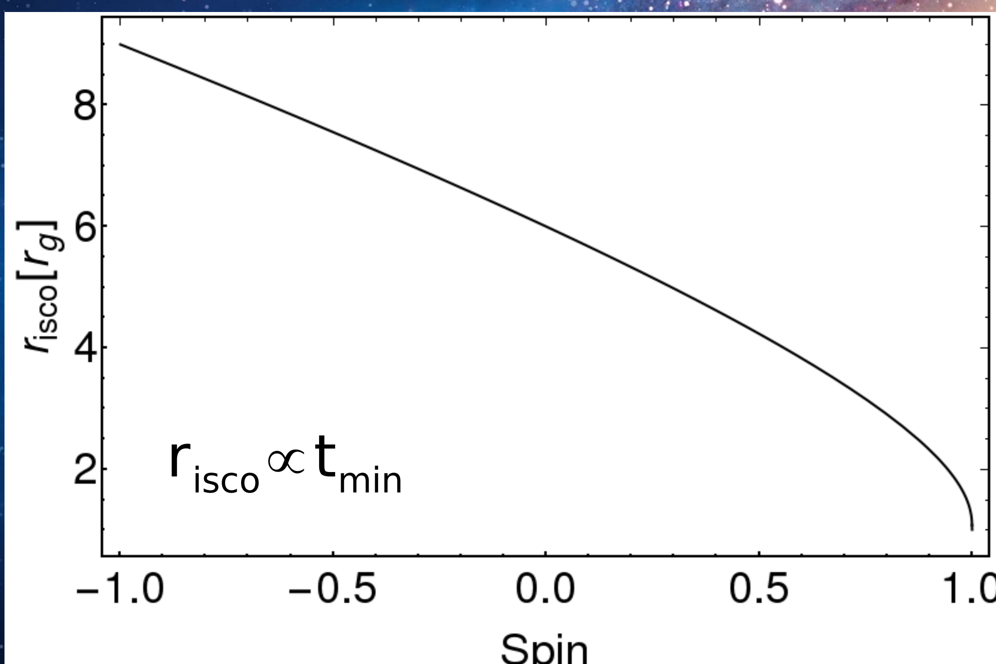
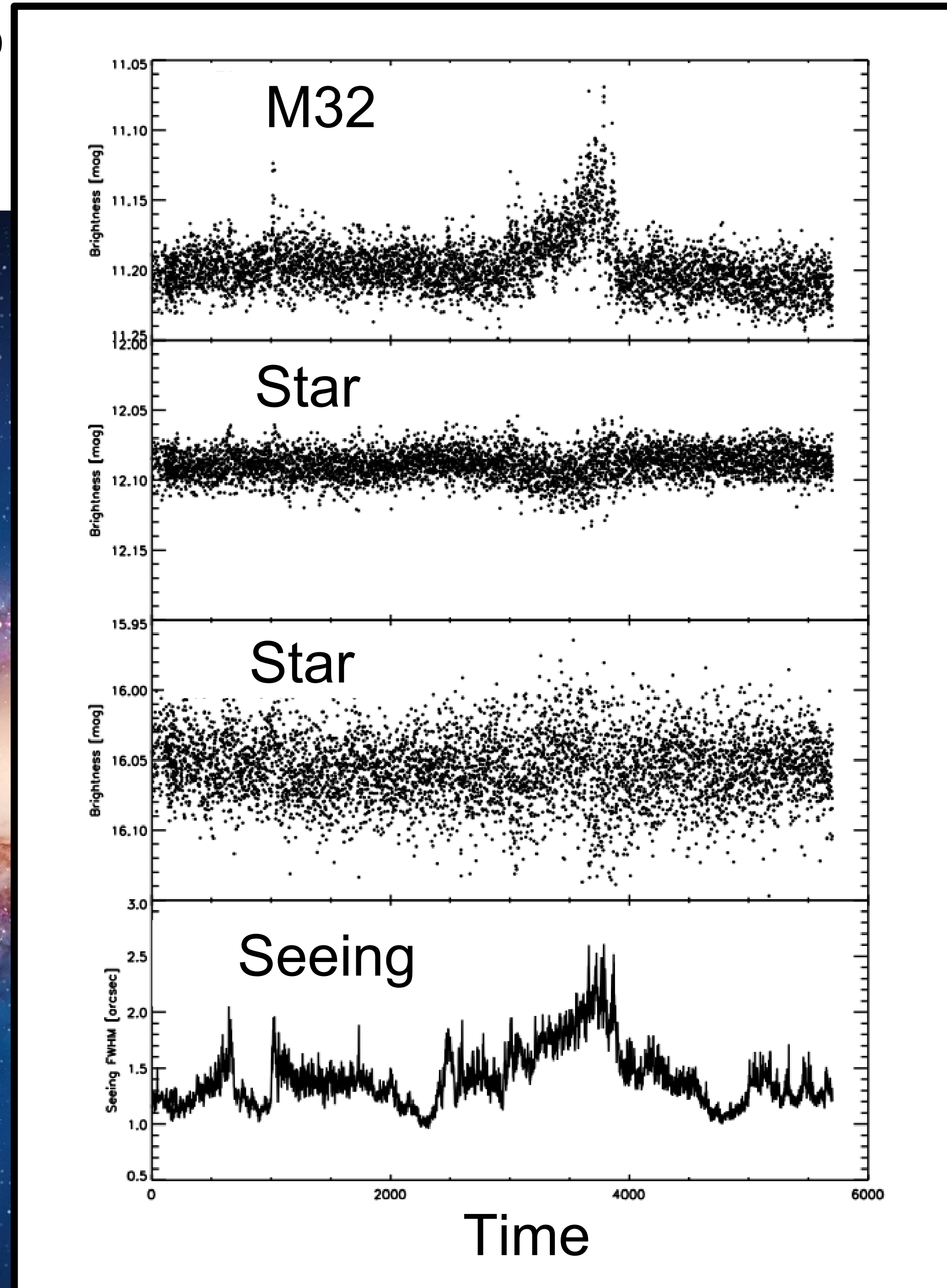
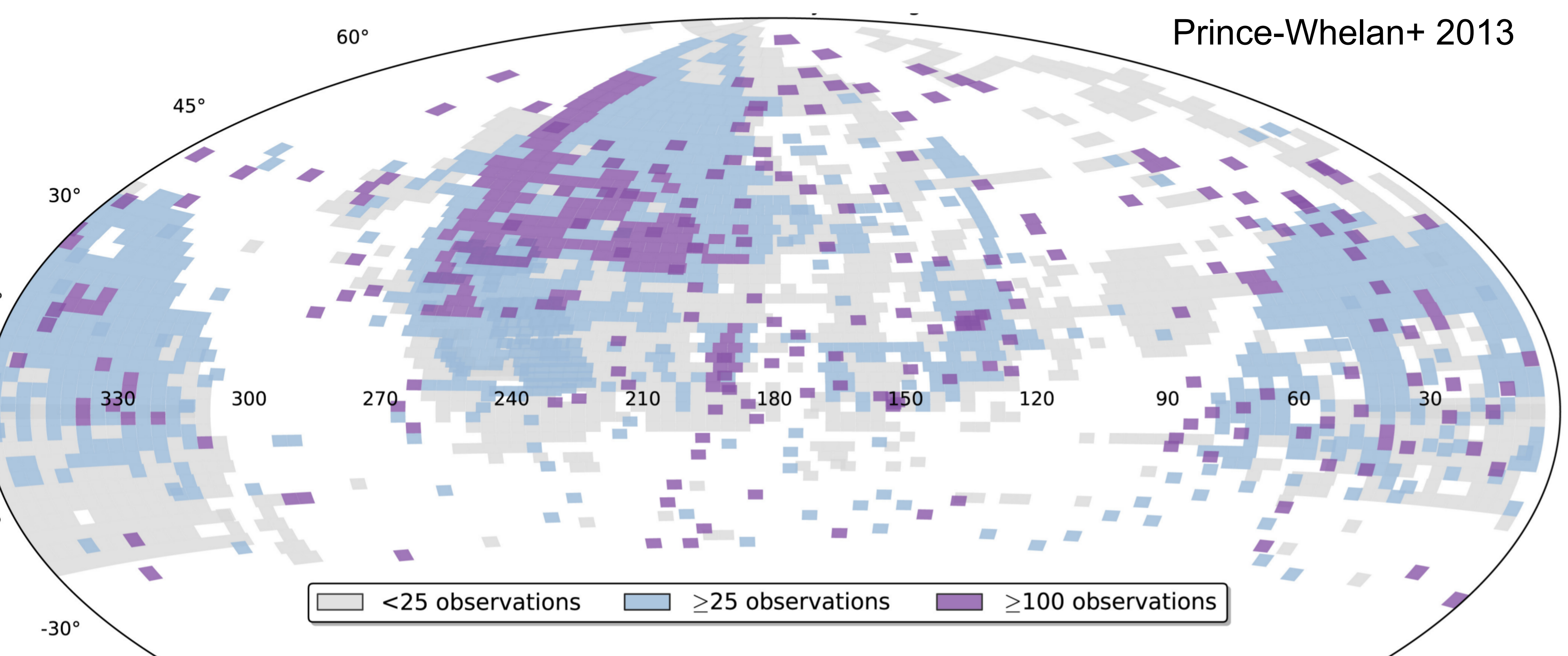




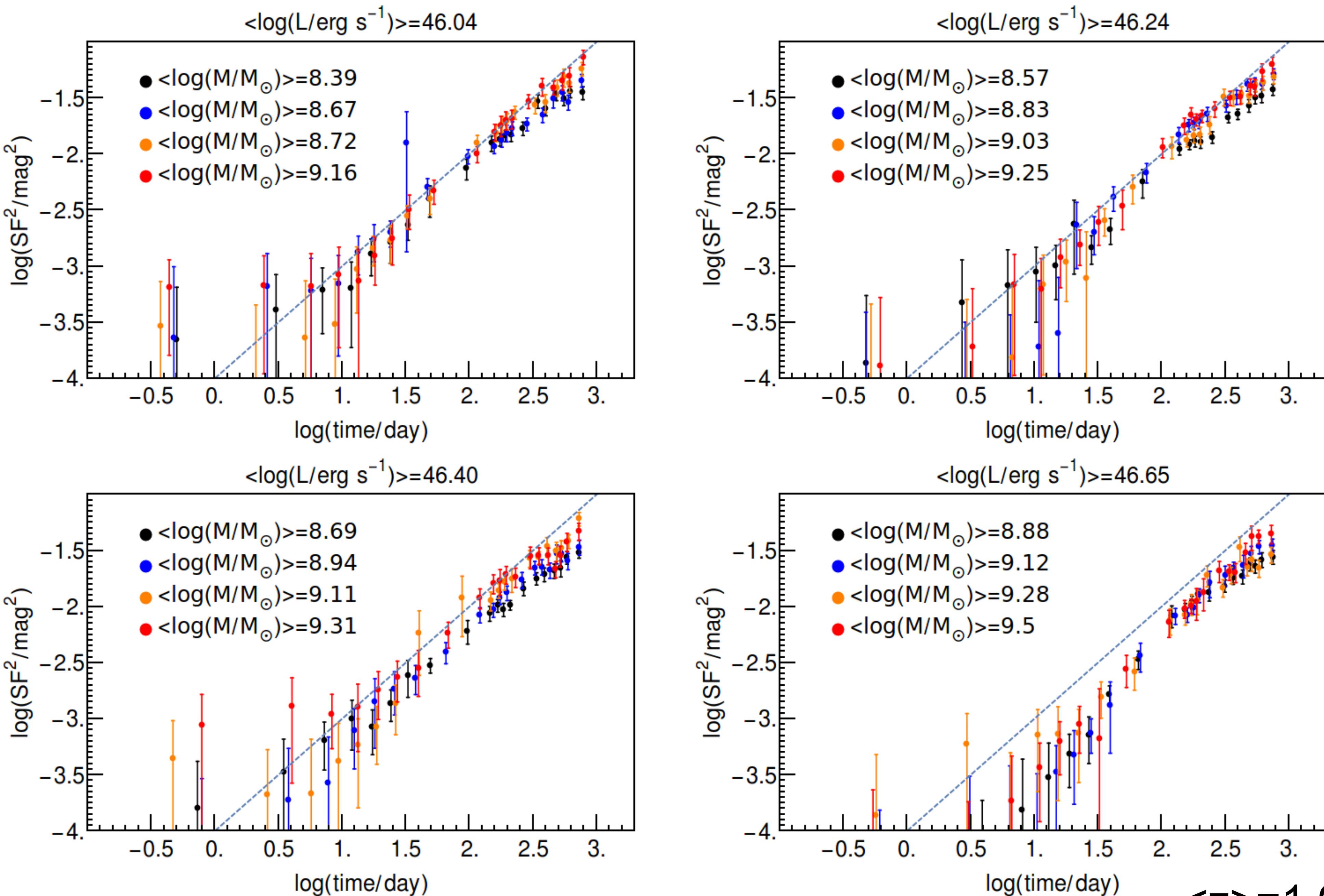
Chary+ 17

- 1.5 m telesope on Mount Palomar in south California
- Transient sky survey started in March 2009
- Data mostly in r band (centered at 6580 Å)

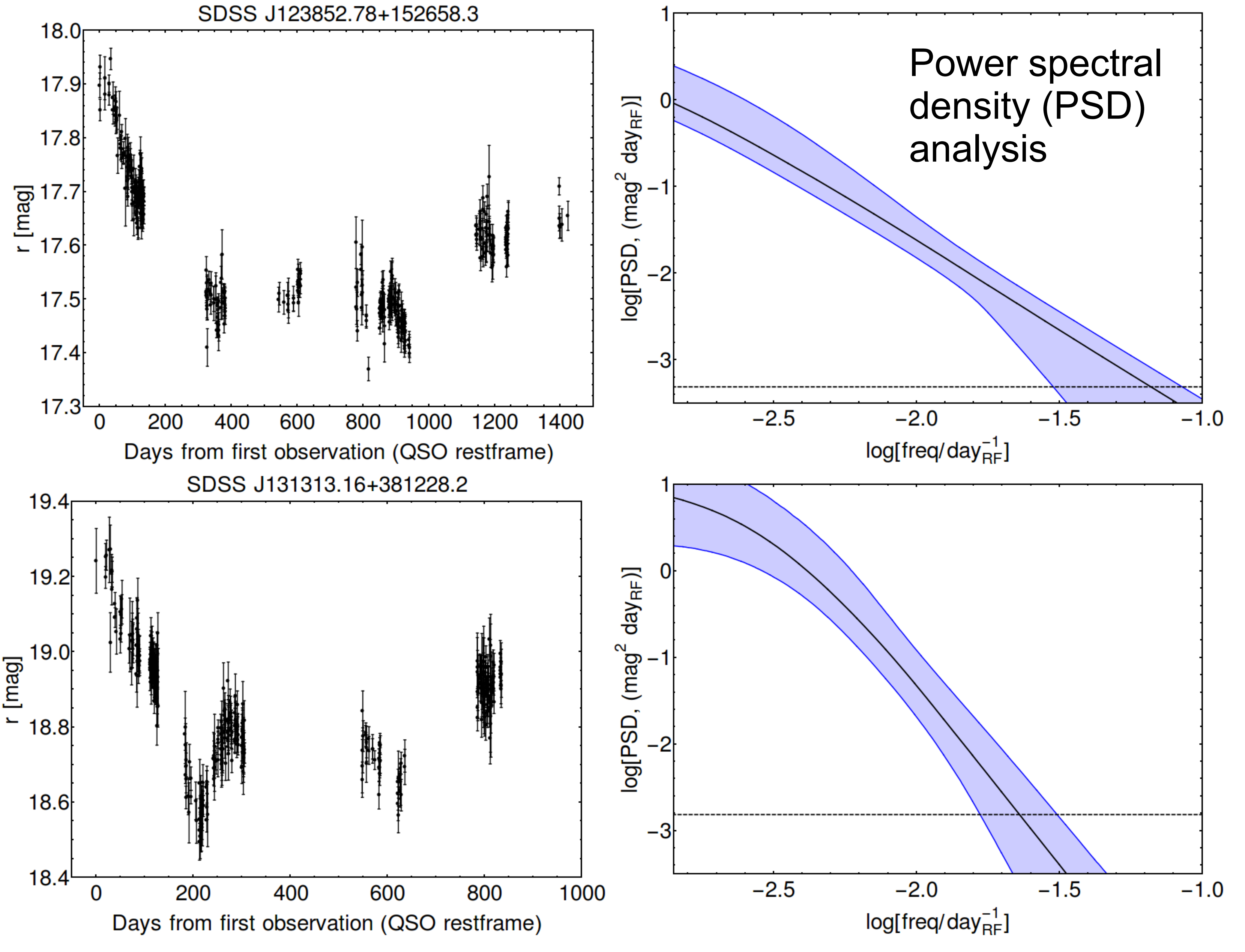
- 28000 AGNs brighter than r=19.1
- 2.4 million data points = largest calibrated single band dataset!

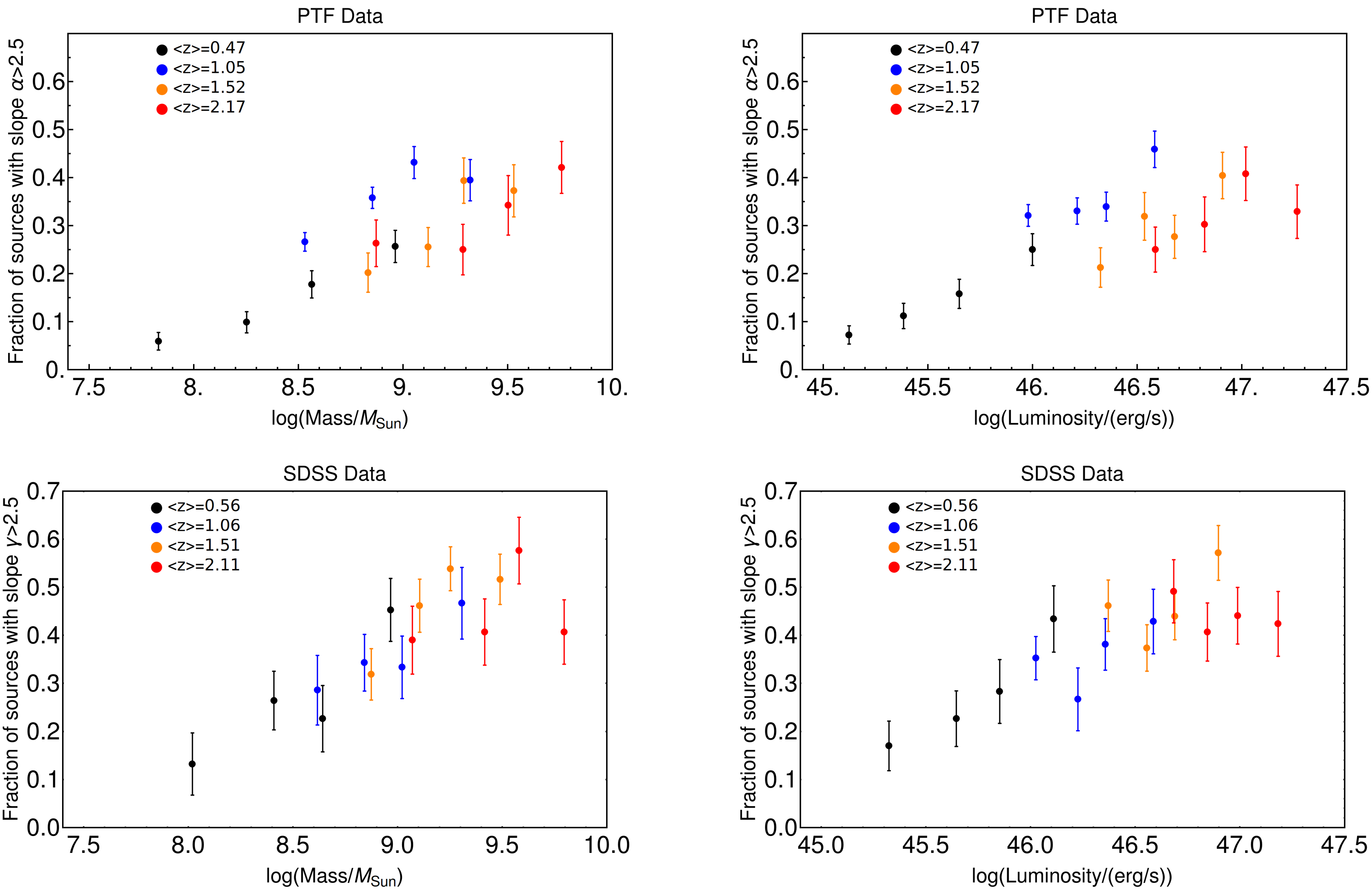


Variance of magnitude difference as a function of time lag between measurements

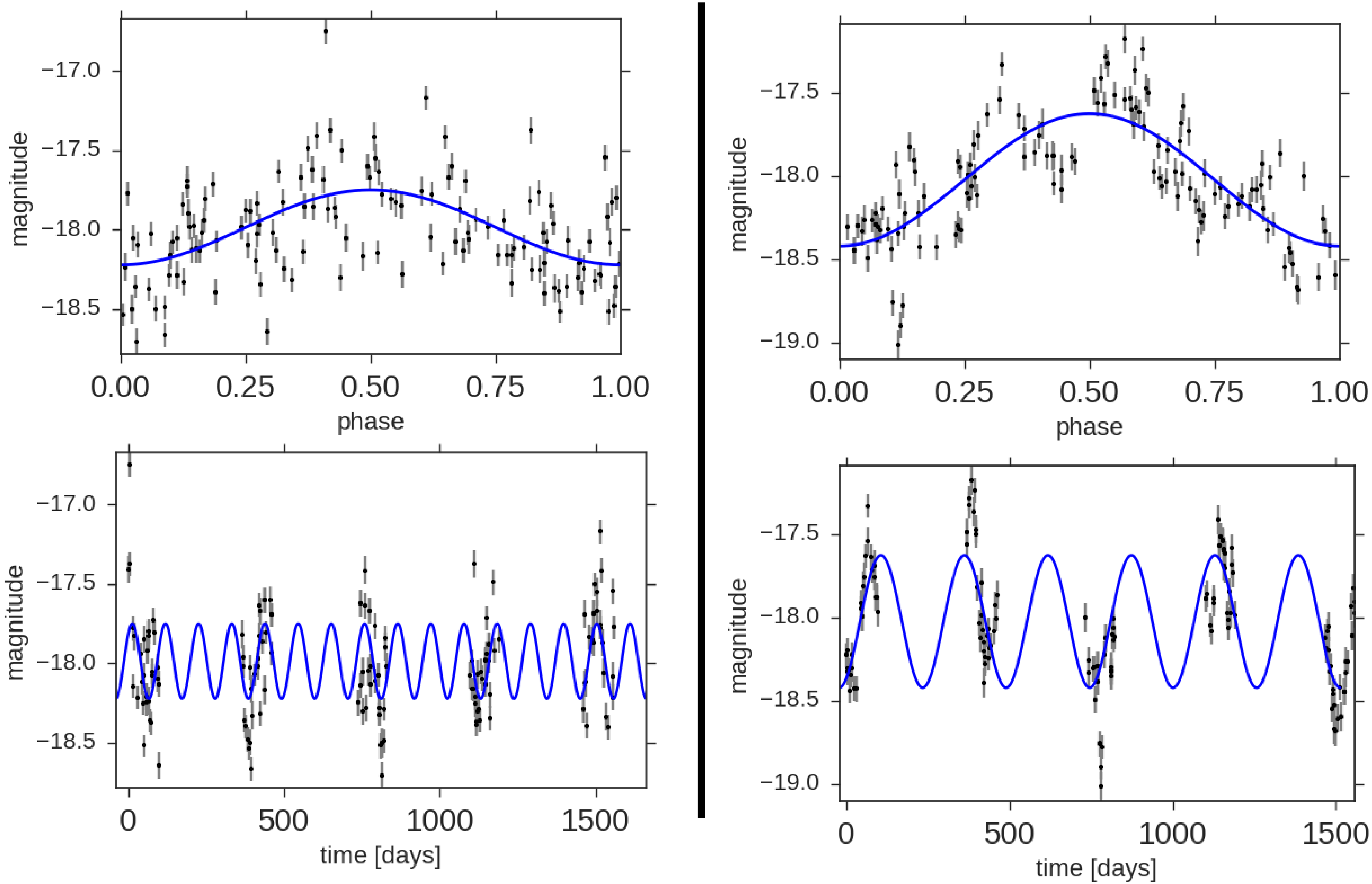


<z>=1.05


SDSS J123852.78+152658.3
r [mag]
Days from first observation (QSO restframe)
Power spectral density (PSD) analysis
log[PSD, (mag^2 day$_{RF}$)]
log[freq/day$_{RF}^{-1}$]
SDSS J131313.16+381228.2
r [mag]
Days from first observation (QSO restframe)
log[PSD, (mag^2 day$_{RF}$)]
log[freq/day$_{RF}^{-1}$]

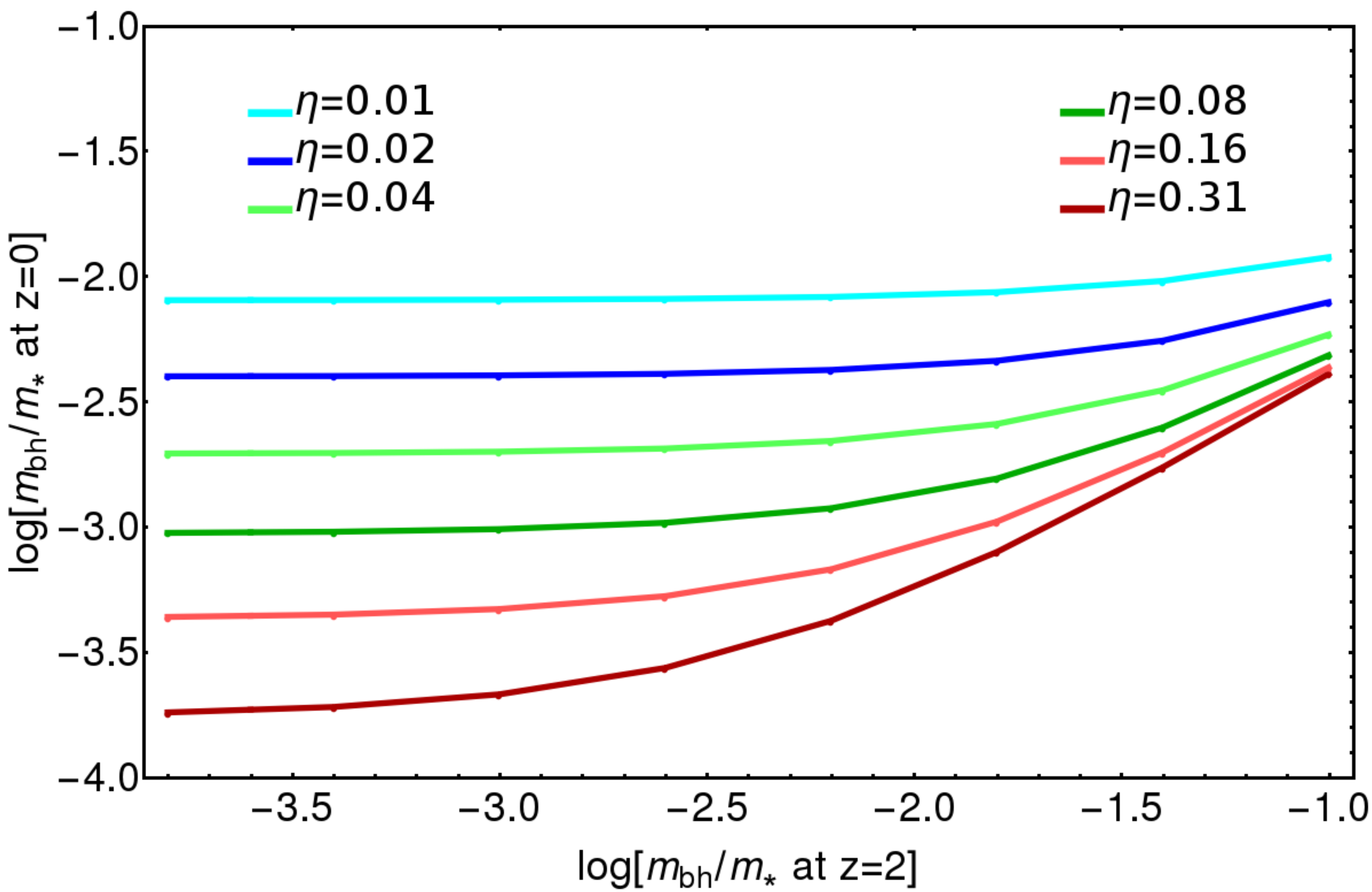

PTF Data
<z>=0.47
<z>=1.05
<z>=1.52
<z>=2.17
Fraction of sources with slope α>2.5
log(Mass/M_{Sun})
PTF Data
<z>=0.47
<z>=1.05
<z>=1.52
<z>=2.17
Fraction of sources with slope α>2.5
log(Luminosity/(erg/s))
SDSS Data
<z>=0.56
<z>=1.06
<z>=1.51
<z>=2.11
Fraction of sources with slope γ>2.5
log(Mass/M_{Sun})
SDSS Data
<z>=0.56
<z>=1.06
<z>=1.51
<z>=2.11
Fraction of sources with slope γ>2.5
log(Luminosity/(erg/s))

I. Quantify influence of the PSD effect on AGN periods



II. Constrain spin from variability

- Accretion efficiency is dependent on the AGN spin
  - Considerable effect on the black hole-galaxy co-evolution
- AGN spins are observationally poorly constrained



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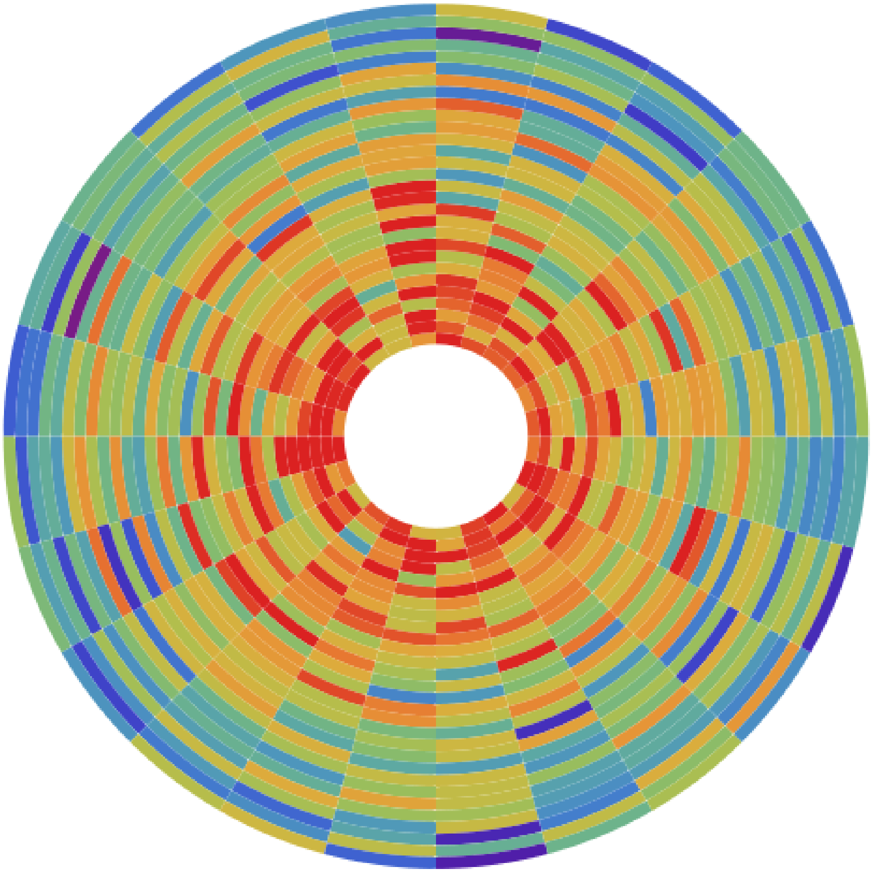

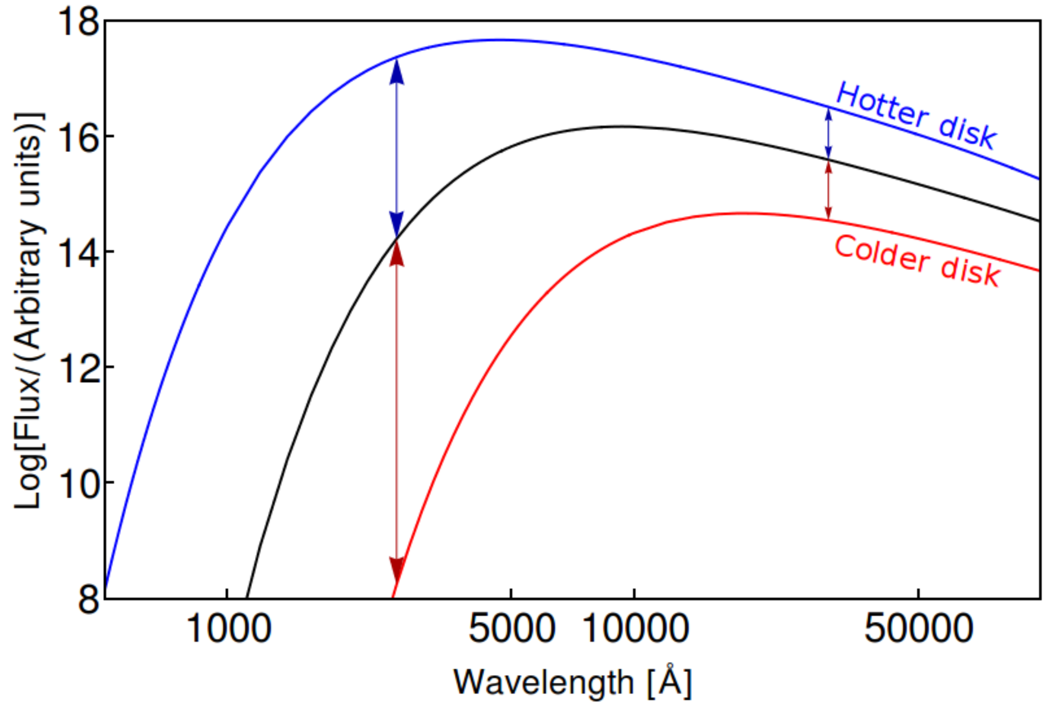

- Optical variability as a consequence of temeperature variations in the disk (Dexter & Agol, 2011)
- Temperature: $T(r) \propto \Delta M^{1/4} M^{-1/2} f(r)^{3/4} (r/r_g)^{-3/4}$
  - Temperature correlated with spin (f parameter in equation above)

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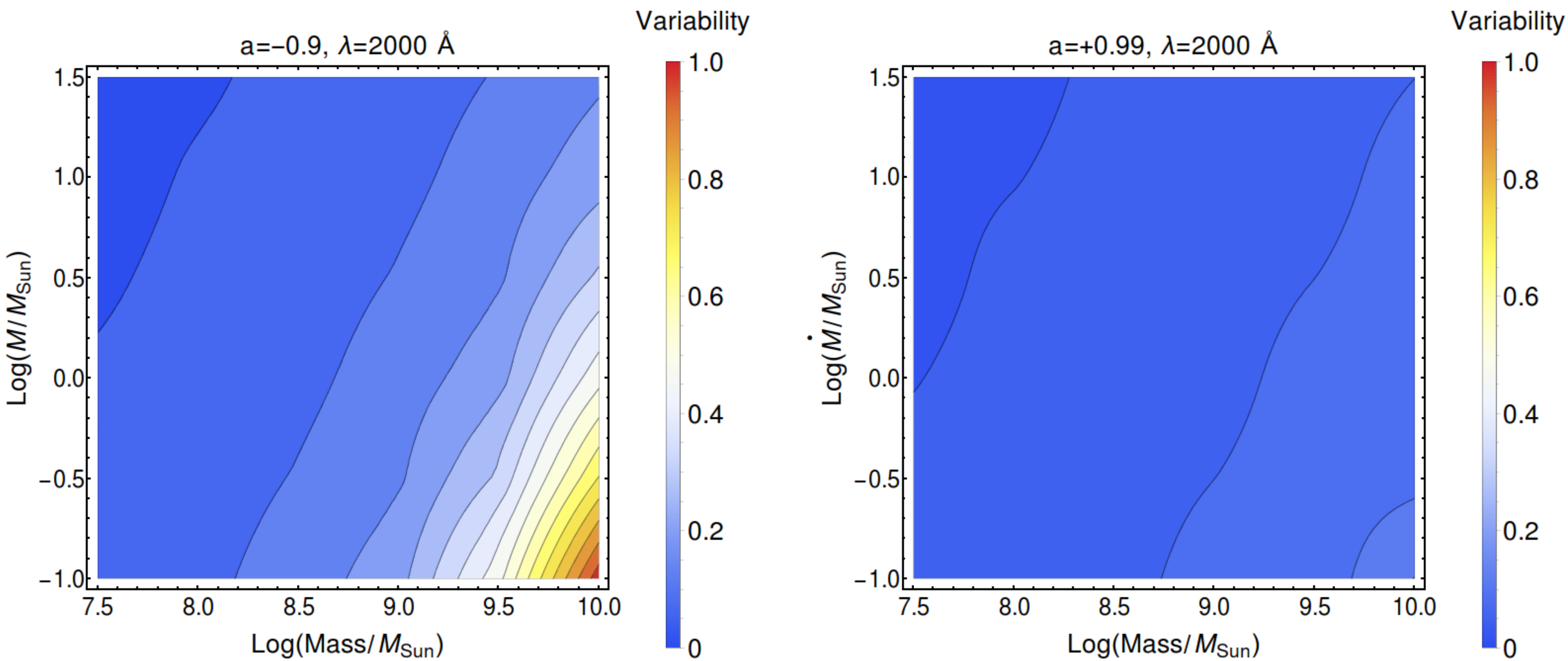

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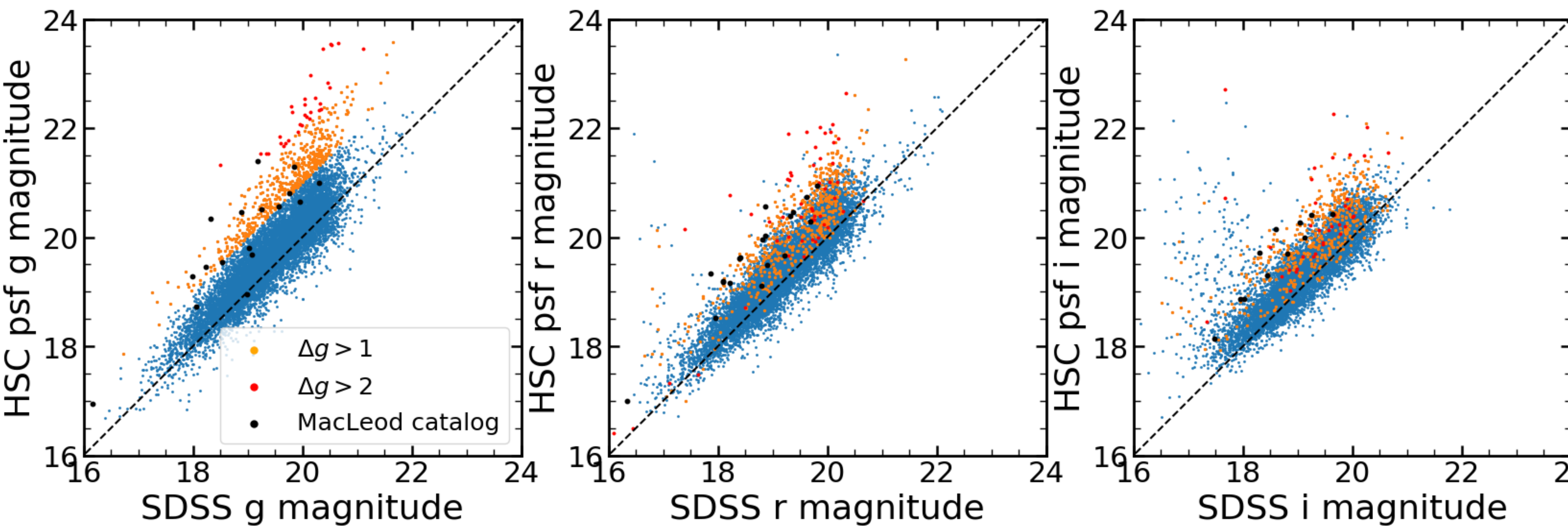
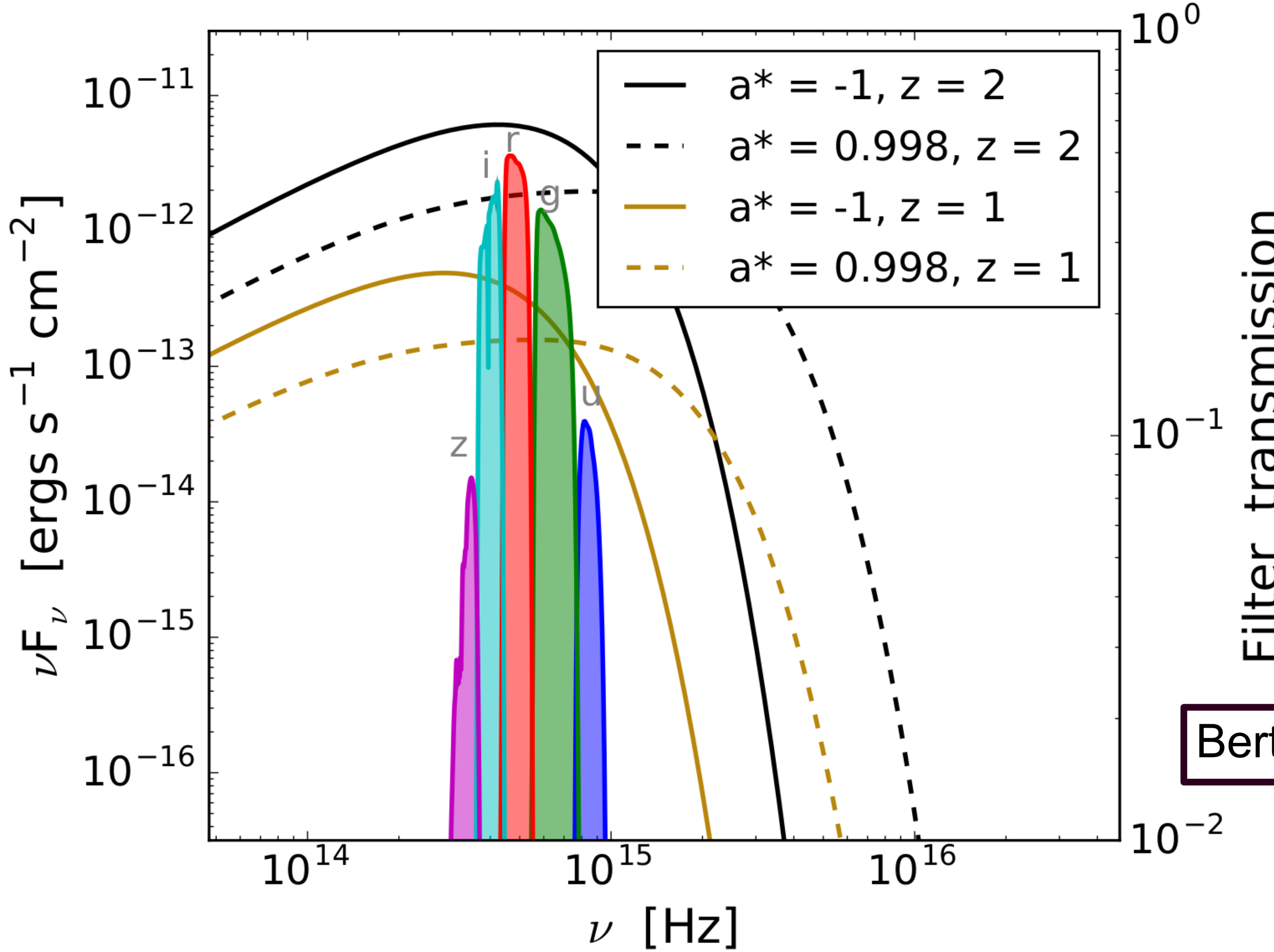
III. Changing look AGN in Hyper-Suprime Cam



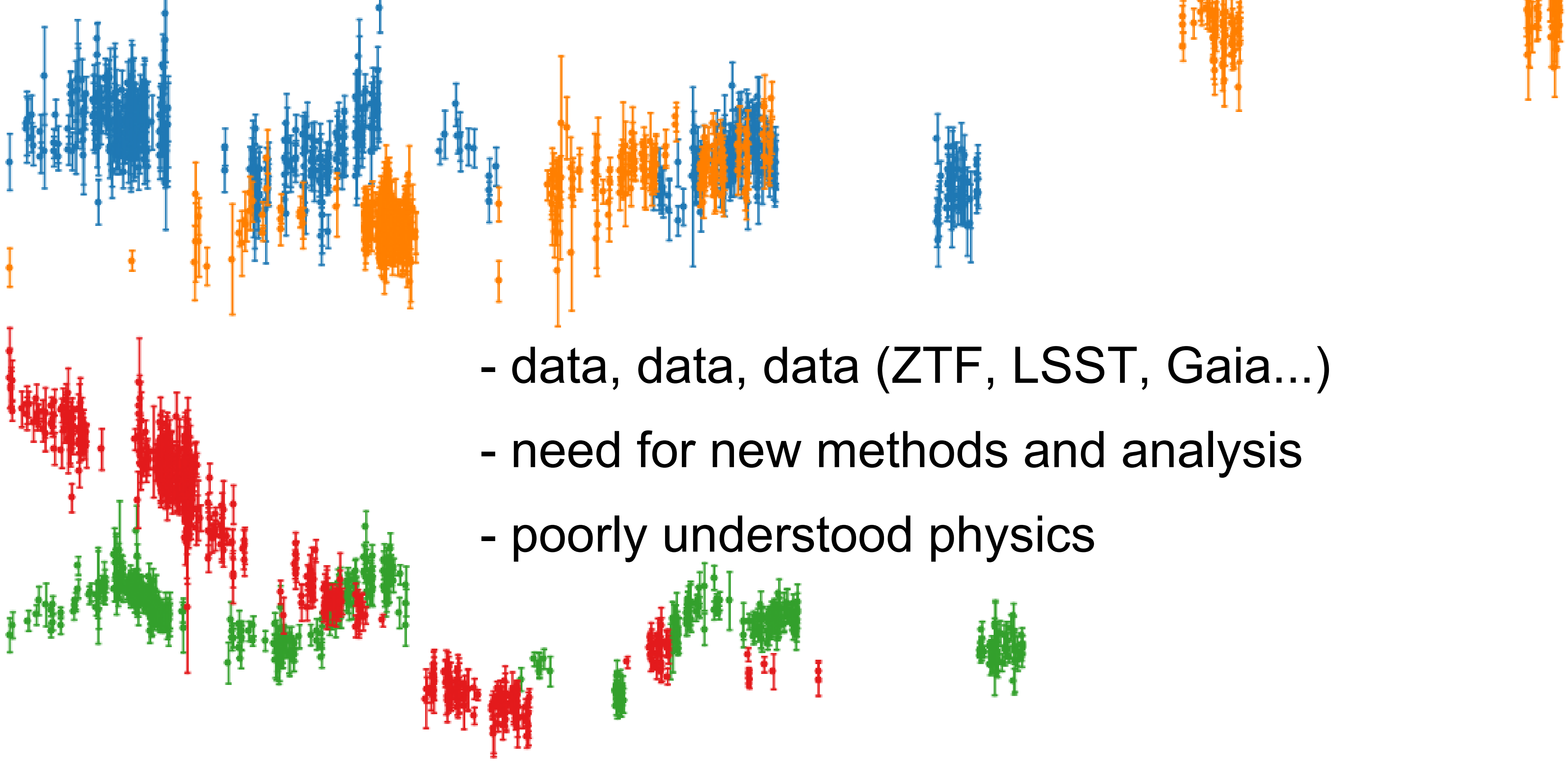
- AGN that exhibit extreme variability - changing look candidates
- Andy is also interested...

IV. Select extraordinary AGN with variability



Bertemes + 16

- No obvious reason that variability would be suppressed or different!
- Study large number of objects – high risk, high reward!



- data, data, data (ZTF, LSST, Gaia...)
- need for new methods and analysis
- poorly understood physics

I. Quantify influence of thePSD effect on AGN periods

II. Constrain spin from variability

III. Changing look AGN in Hyper-suprime Cam

IV. Select extraordinary AGN with variability