

PROBING ACCRETION PROCESSES THROUGH VARIABILITY

2016 TMT Science Forum

Kyoto, Japan

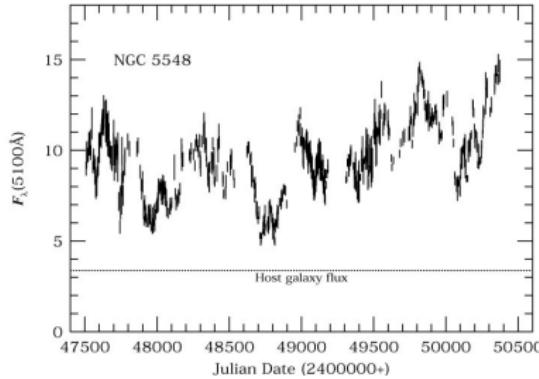
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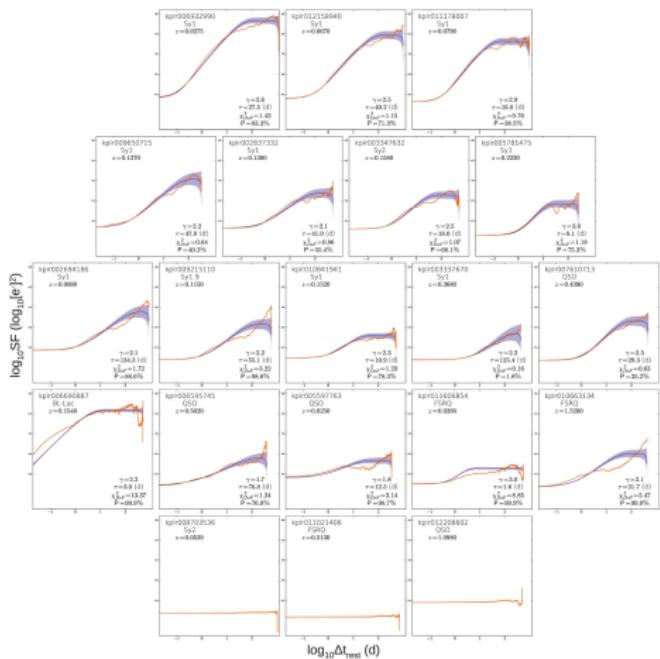
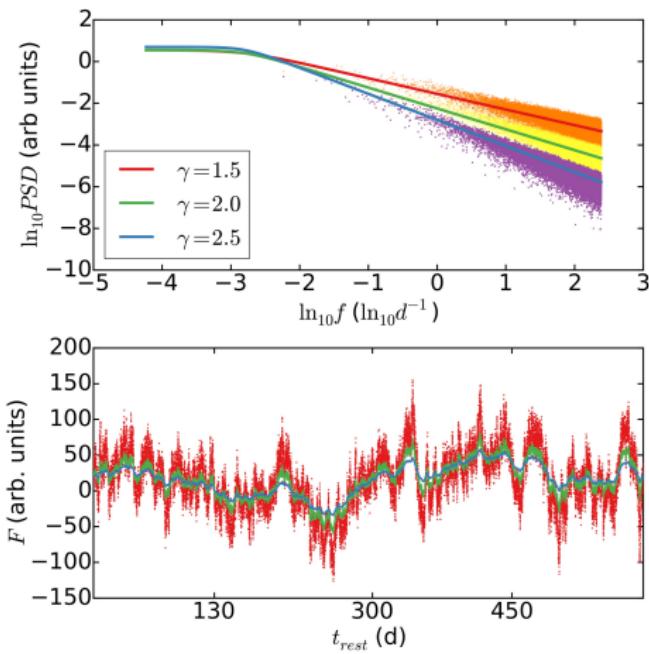
Accretion Characteristic: Rapid, Stochastic, Luminosity Variations (and we do not know why!)



(Peterson et al. 1999)

- ✿ ~ 90 % of AGN vary (Sesar et al. 2007)
- ✿ Pan-spectral: shorter $\lambda \Rightarrow$ stronger variability
- ✿ What can TMT contribute?
- ✿ Stochastic! (Peterson 1997)
- ✿ λ_{long} lag λ_{short} (but sometimes backwards!)

Beyond the Damped Random Walk

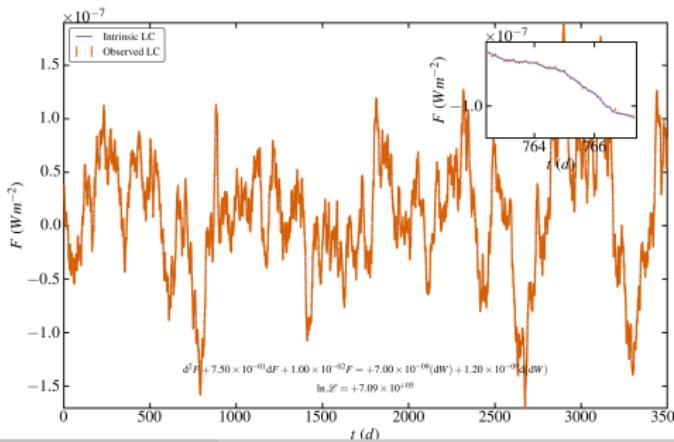


Continuous-time AutoRegressive Moving Average (C-ARMA) Processes

$$dW \sim \mathcal{N}(0, dt)$$

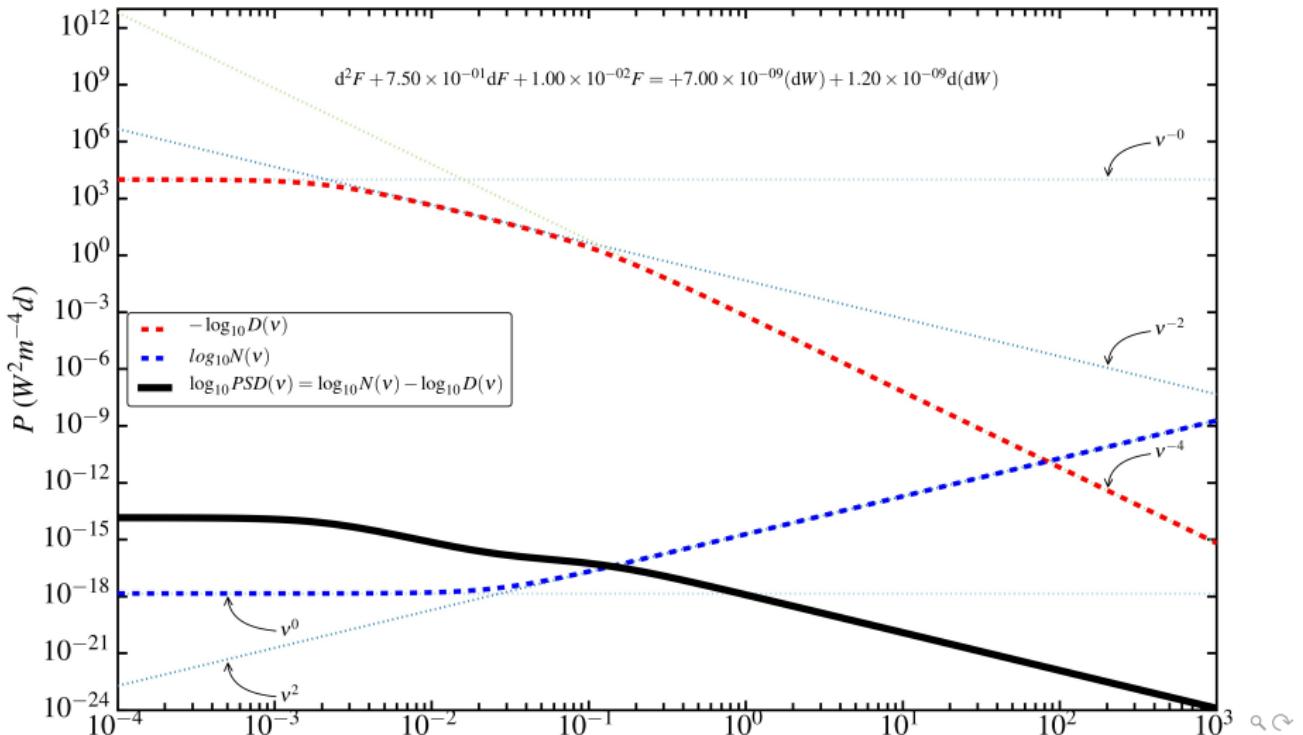
$$d^p x + \alpha_1 d^{p-1} x + \dots + \alpha_{p-1} dx + \alpha_p x = \beta_0(dW) + \dots + \beta_q d^q(dW)$$

- * Uses Itô calculus Davis (2002); Brockwell (2014); Kelly et al. (2014)
- * RHS: Correlation structure of all perturbations.
- * LHS: Evolution of individual perturbations.
- * PSD: ratio of even polynomials of frequency.

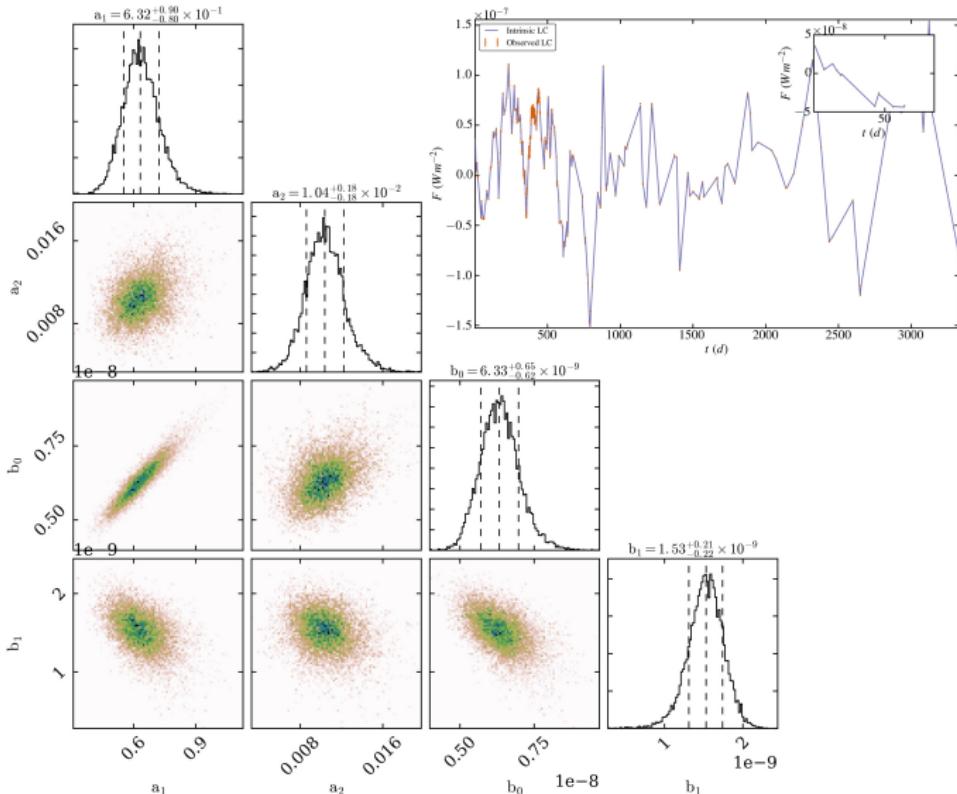


Power Spectral Density

Eg. C-ARMA(2,1)

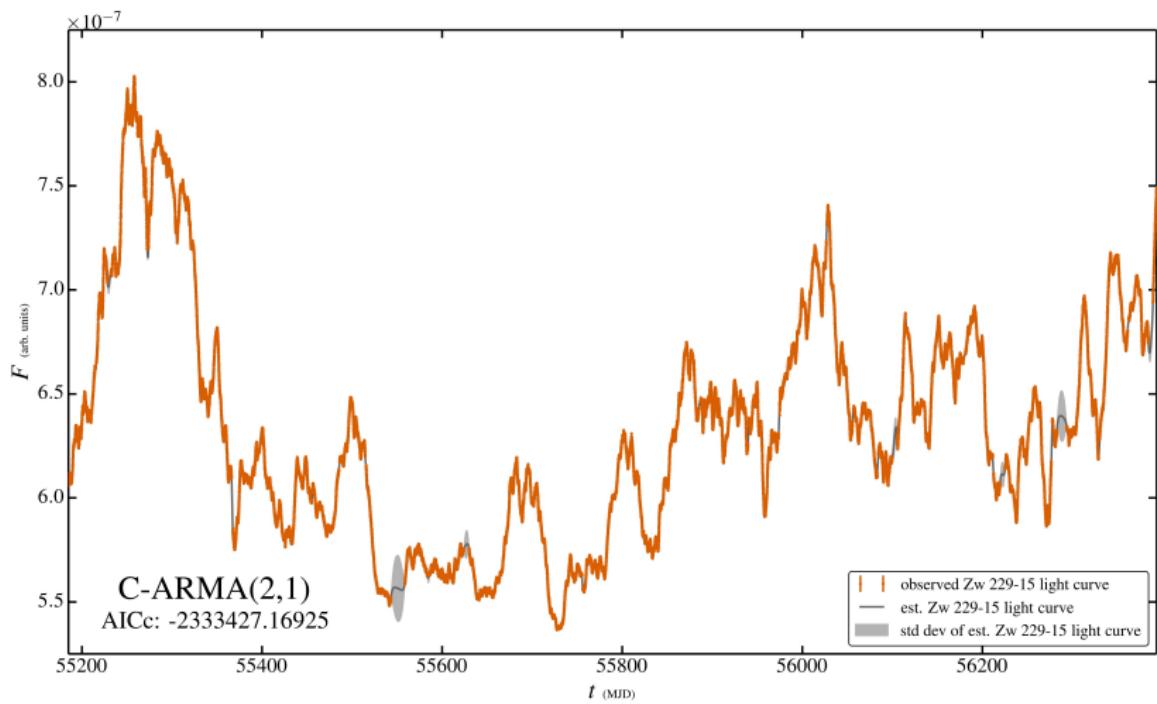


Confidence Interval Estimates

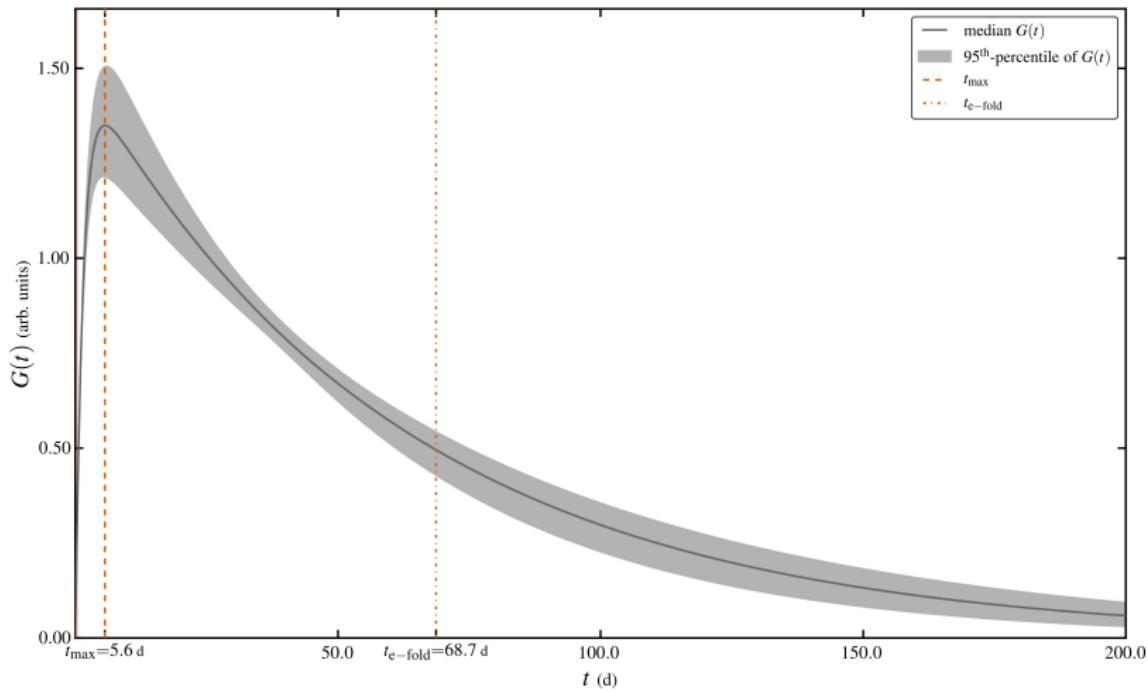


C-ARMA(2,1) model of Zw 229-15

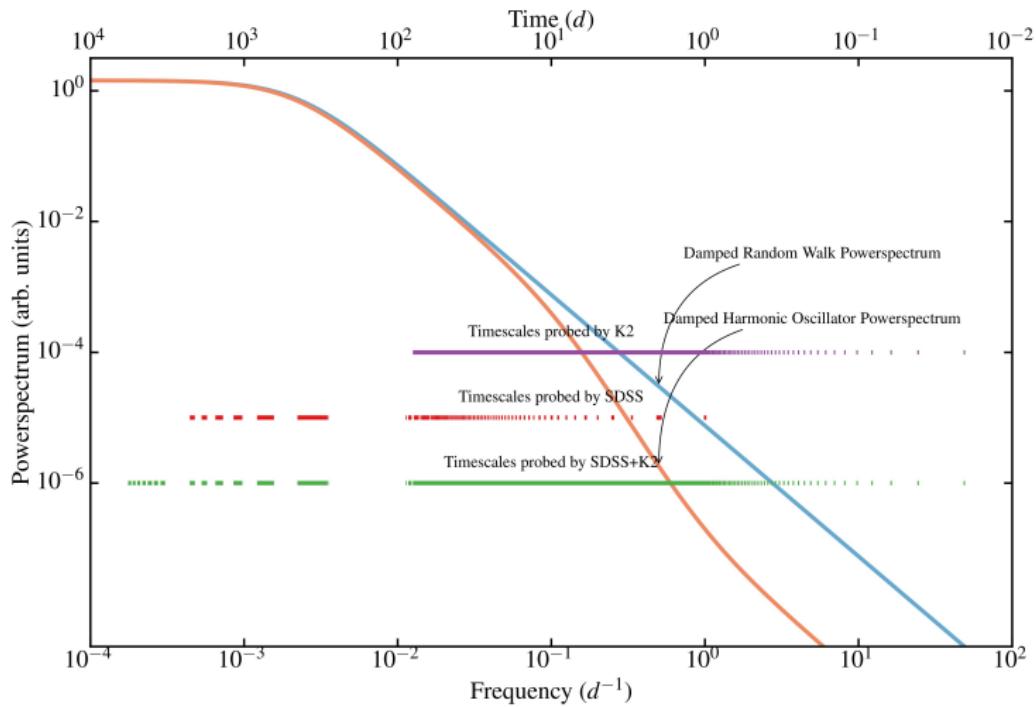
Smoothed light curve



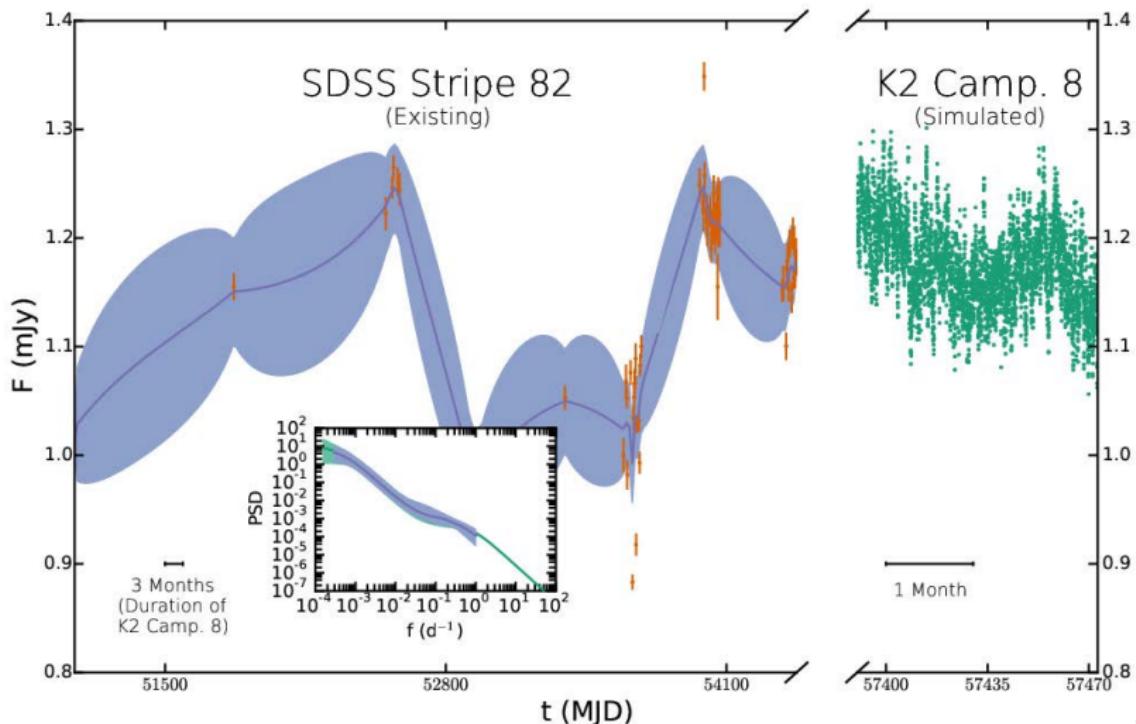
C-ARMA(2,1) model of Zw 229-15 Green's Function



Prototype for LSST+TMT: Combining SDSS with K2



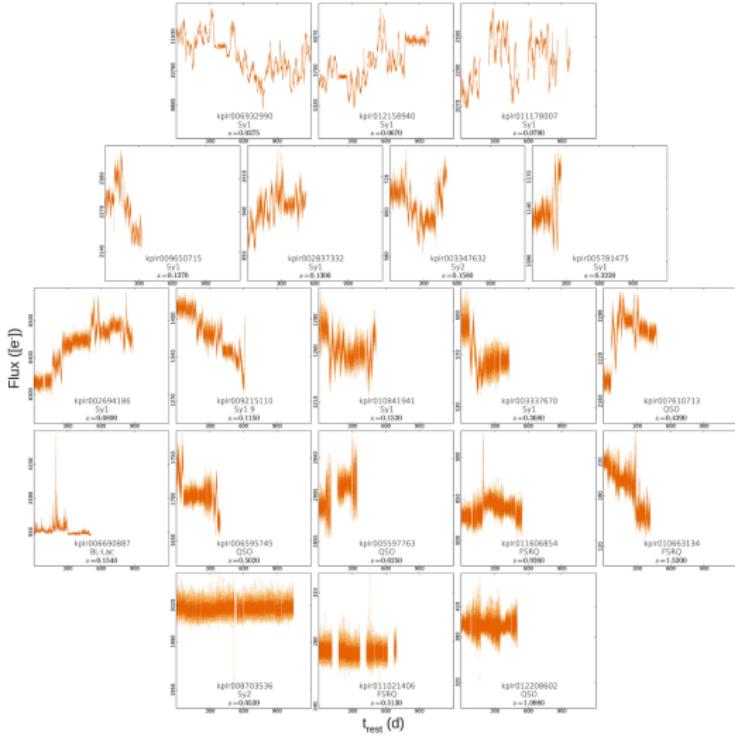
Prototype for LSST+TMT: K2 observations of Stripe 82 QSOs



Conclusions

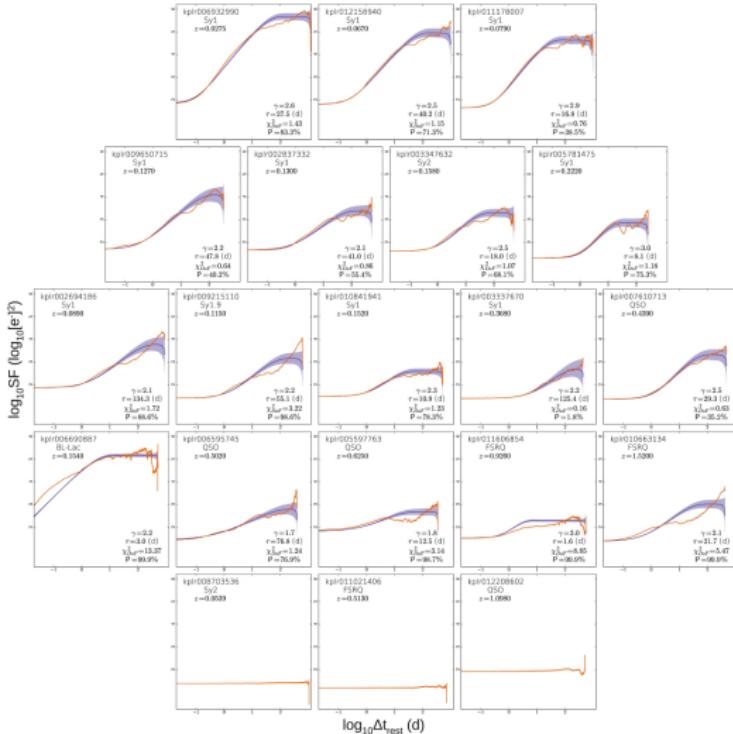
- * DRW does **not work** for all AGN
- * Variability \Rightarrow C-ARMA process
- * C-ARMA(2,1) process \Rightarrow Zw 229-15 variability
- * Zw 229-15 \Rightarrow **Damped Harmonic Oscillator + Colored Noise**
- * Future time-domain surveys: **combine multiple data sources**

Full AGN sample



- * $z \sim 0.02\text{-}1.5$
- * $\delta t_{\text{rest}} \sim 14\text{-}28 \text{ min}$
- * $N \sim 16k\text{-}60k$
- * Wide variety of behavior!

Structure Function fits



- * Not all AGN ~ DRW
- * PSD model too simple
- * Variability onsets over ~ 1 hr to ~ 1 d

Kasliwal, Vogeley, & Richards (2015)

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