

PROBING ACCRETION PROCESSES THROUGH VARIABILITY

2016 TMT Science Forum

Kyoto, Japan

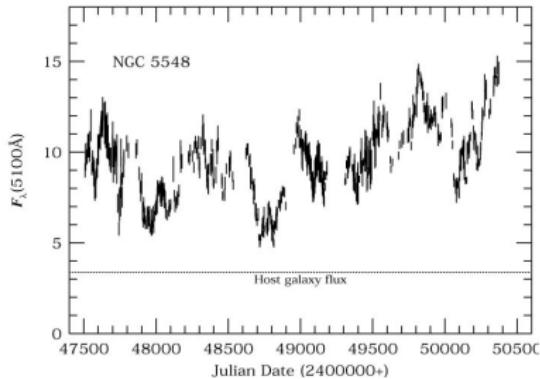
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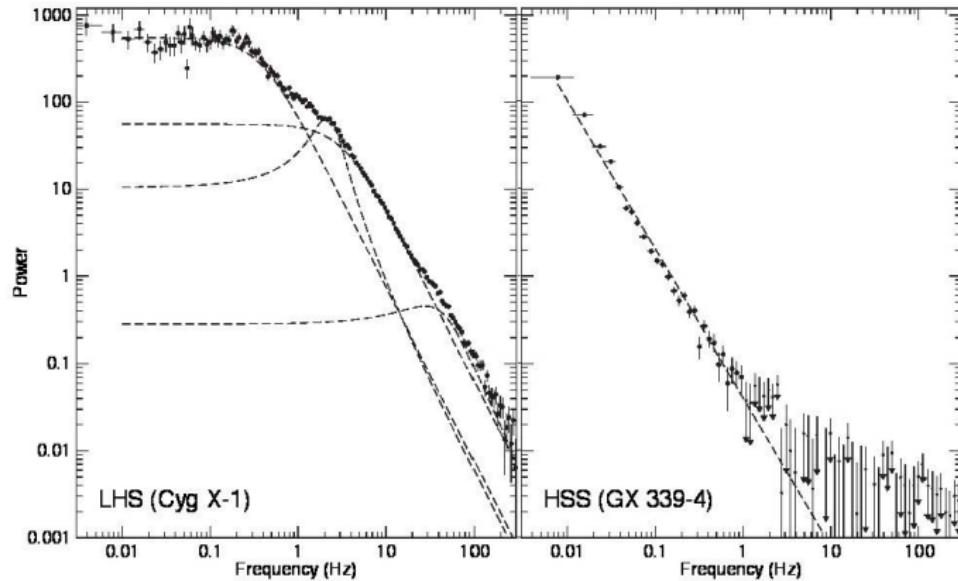
Accretion Characteristic: Rapid, Stochastic, Luminosity Variations (and we do not know why!)



(Peterson et al. 1999)

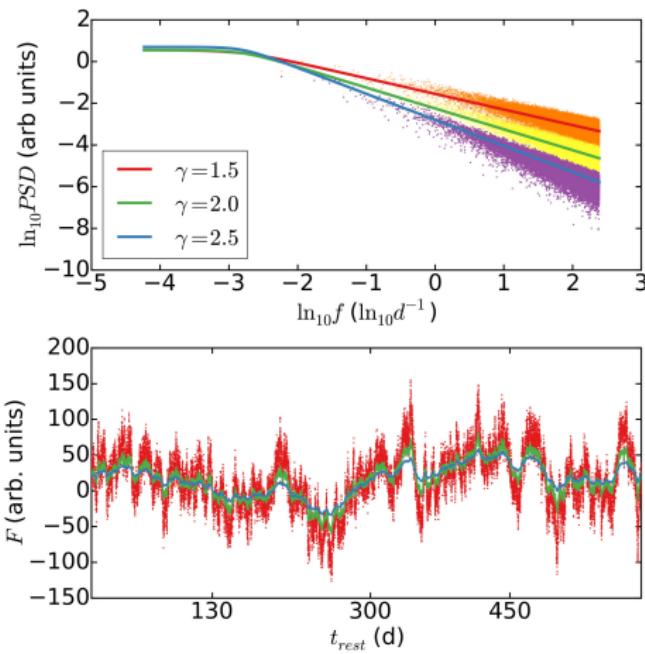
- ✿ ~ 90 % of AGN vary (Sesar et al. 2007)
- ✿ Pan-spectral: shorter $\lambda \Rightarrow$ stronger variability
- ✿ Stochastic! (Peterson 1997)
- ✿ longer λ lag shorter λ (but sometimes backwards!)

Search for timescales in Power Spectral Density (PSD)



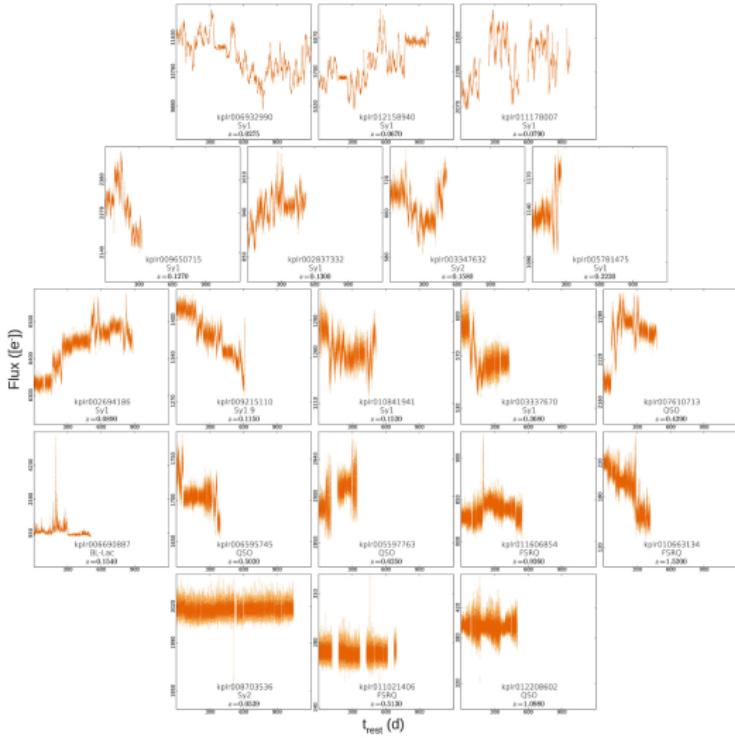
Belloni & Stella (2014)

PSD of the Damped Random Walk



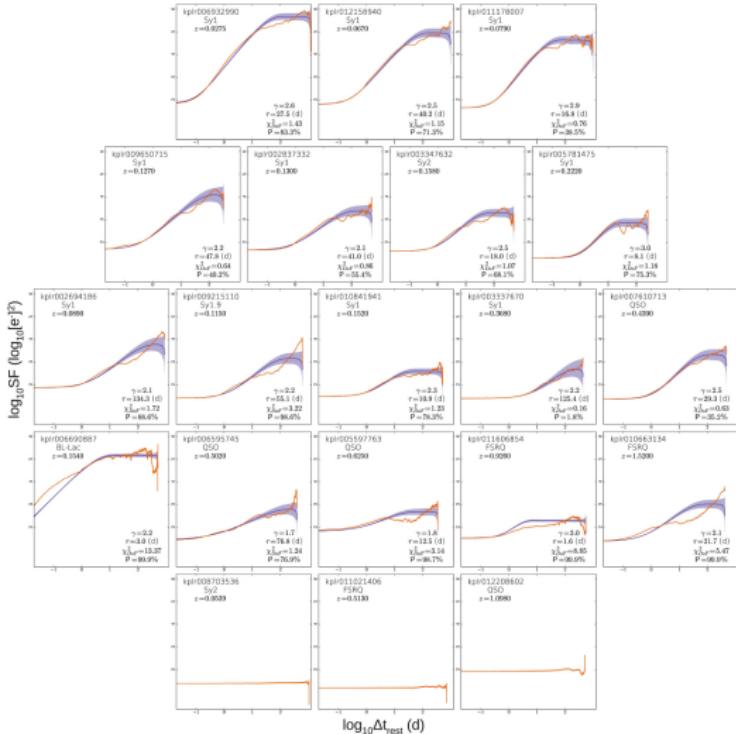
- * $PSD \propto \frac{1}{f^2}$ on short timescales
- * $PSD \propto \frac{1}{f^b} \Rightarrow \sigma_{\alpha-fluc} \propto r^b$
(Lyubarskii 1997)
- * DRW: b is fixed - is this true?
- * Generalize: $PSD \propto \frac{1}{f^\gamma}$ (McHardy et al. 2004)
- * Test with Kepler data!

Full AGN sample



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

Structure function fits



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

Kasliwal, Vogeley, & Richards (2015a)

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

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

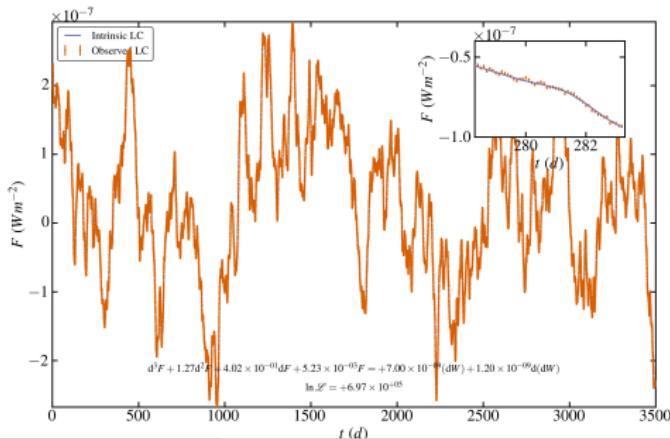
$$d^p x + \alpha_1 d^{p-1} x + \dots + \alpha_{p-1} dx + \alpha_p x = \beta_0(dW) + \dots + \beta_q d^q(dW)$$

- * Uses Itō calculus Davis (2002); Brockwell (2014); Kelly et al. (2014)

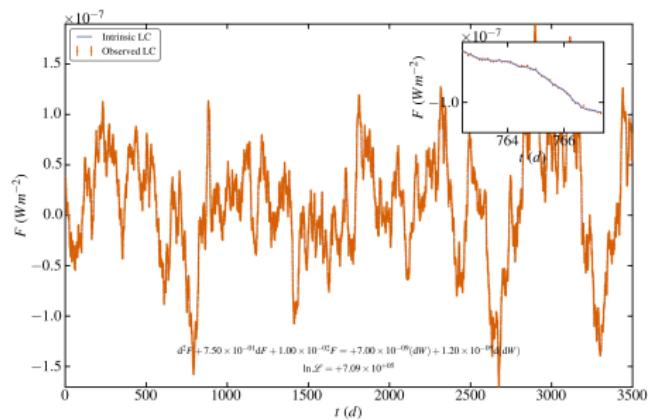
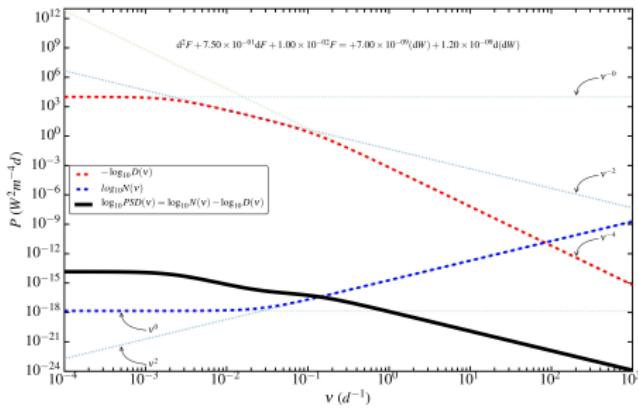
- * LHS comes from linear perturbations of non-linear system

* C-ARMA $\xrightarrow{\text{sample}}$ ARMA

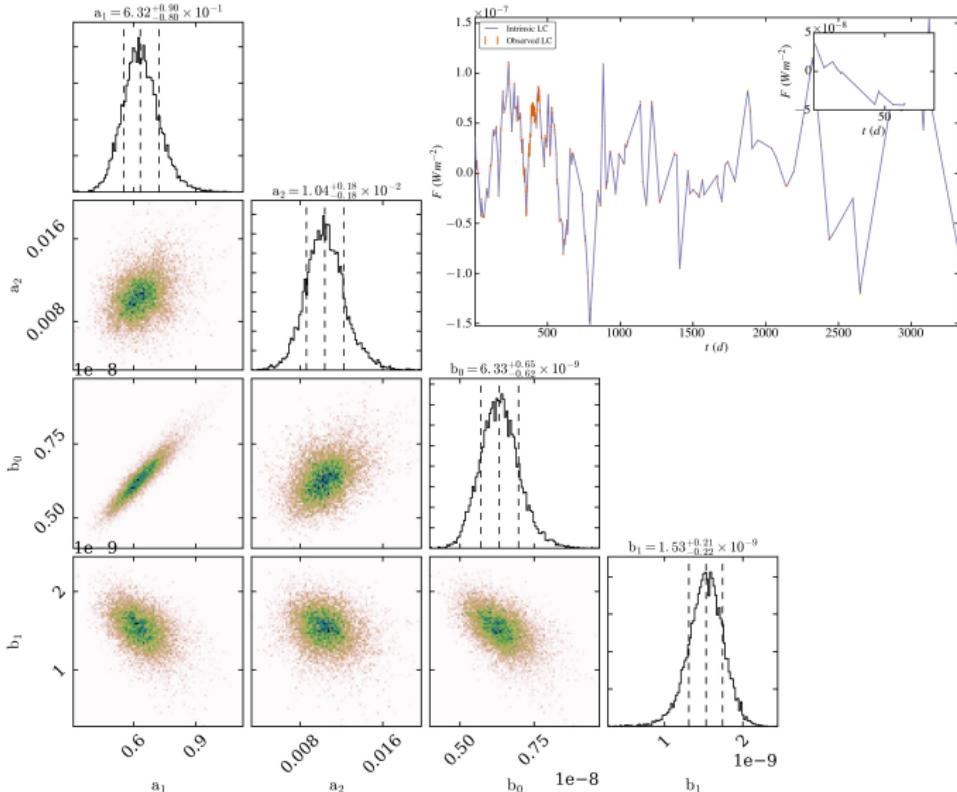
- * PSD is a ratio of even polynomials in frequency



Power Spectral Density

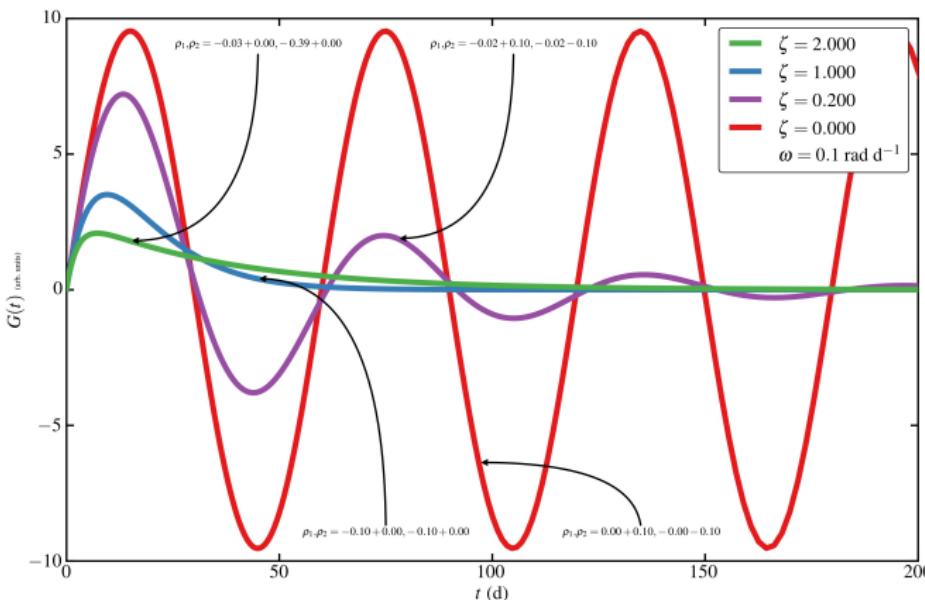


Confidence Interval Estimates



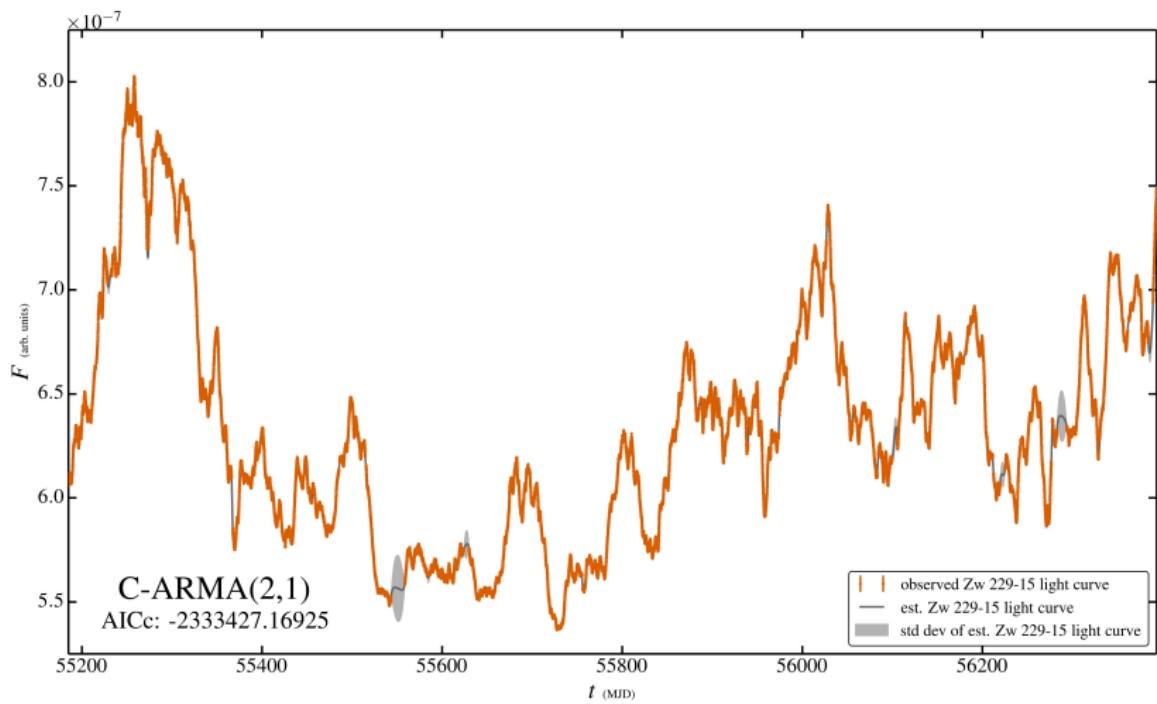
How to Interpret?: Green's Function of LHS (eg. C-ARMA(2,1)...)

$$d^2G + 2\omega\zeta dG + \omega^2 G = \delta(0)$$

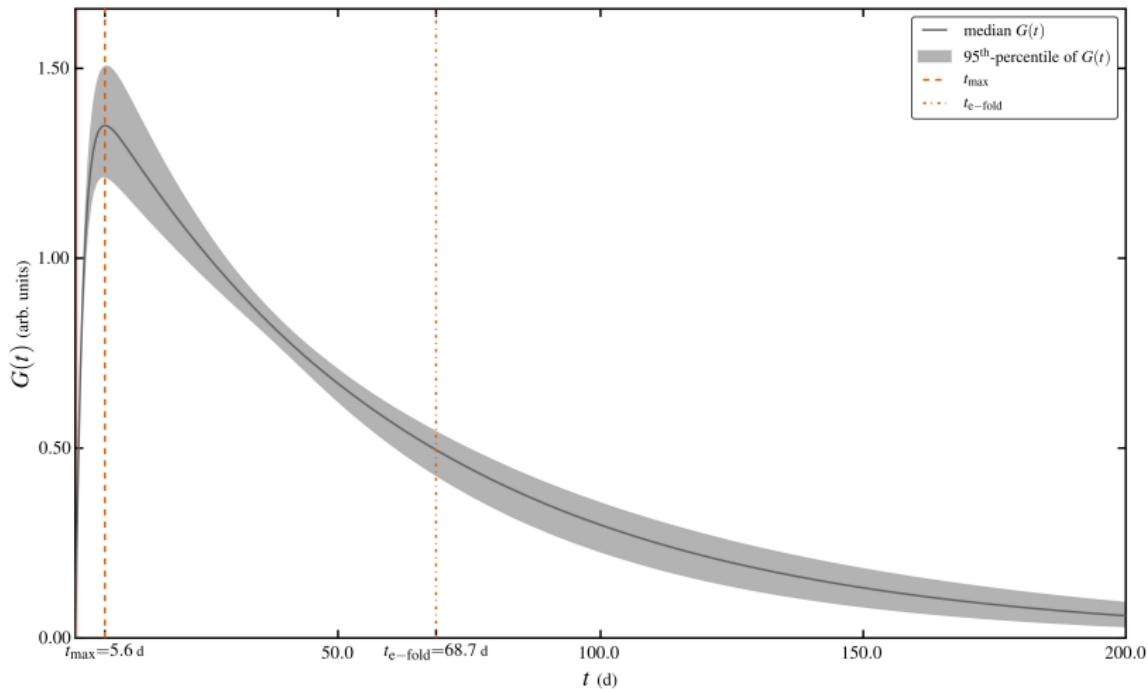


C-ARMA(2,1) model of Zw 229-15

Smoothed light curve

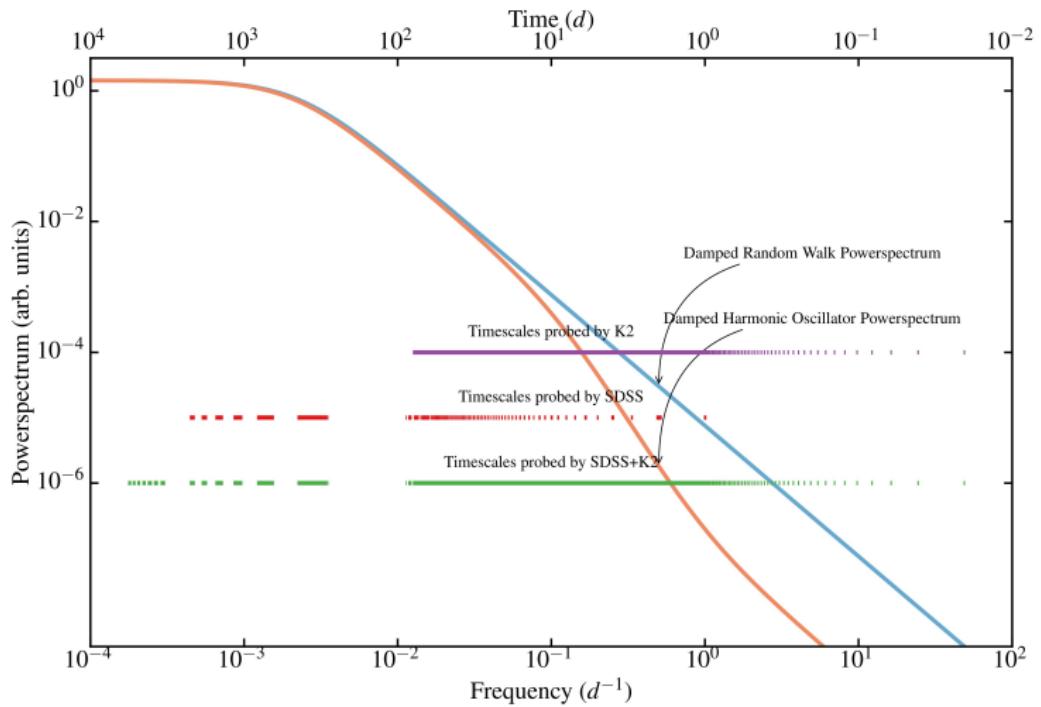


C-ARMA(2,1) model of Zw 229-15 Green's Function



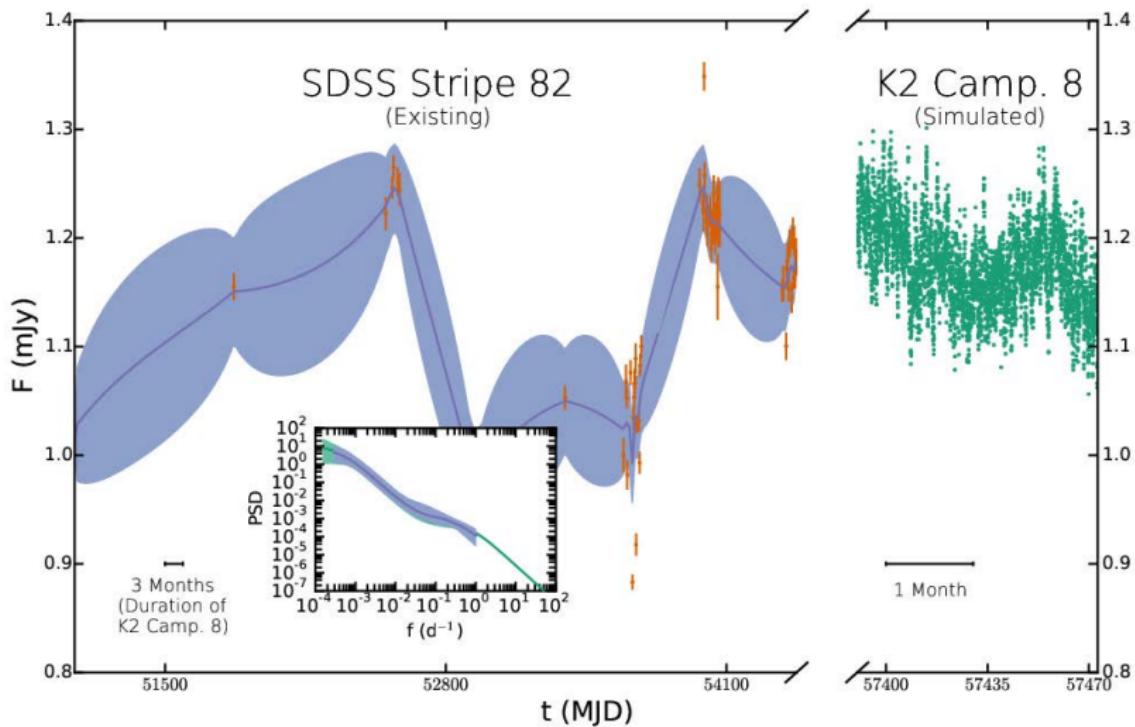
Work in Progress

Power of SDSS+K2



Work in Progress

K2 observations of Stripe 82 QSOs



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