Reverberation mapping of PG 1119+120: Testing Super-Eddington Accretion

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PyROA – Modelling AGN Lightcurves

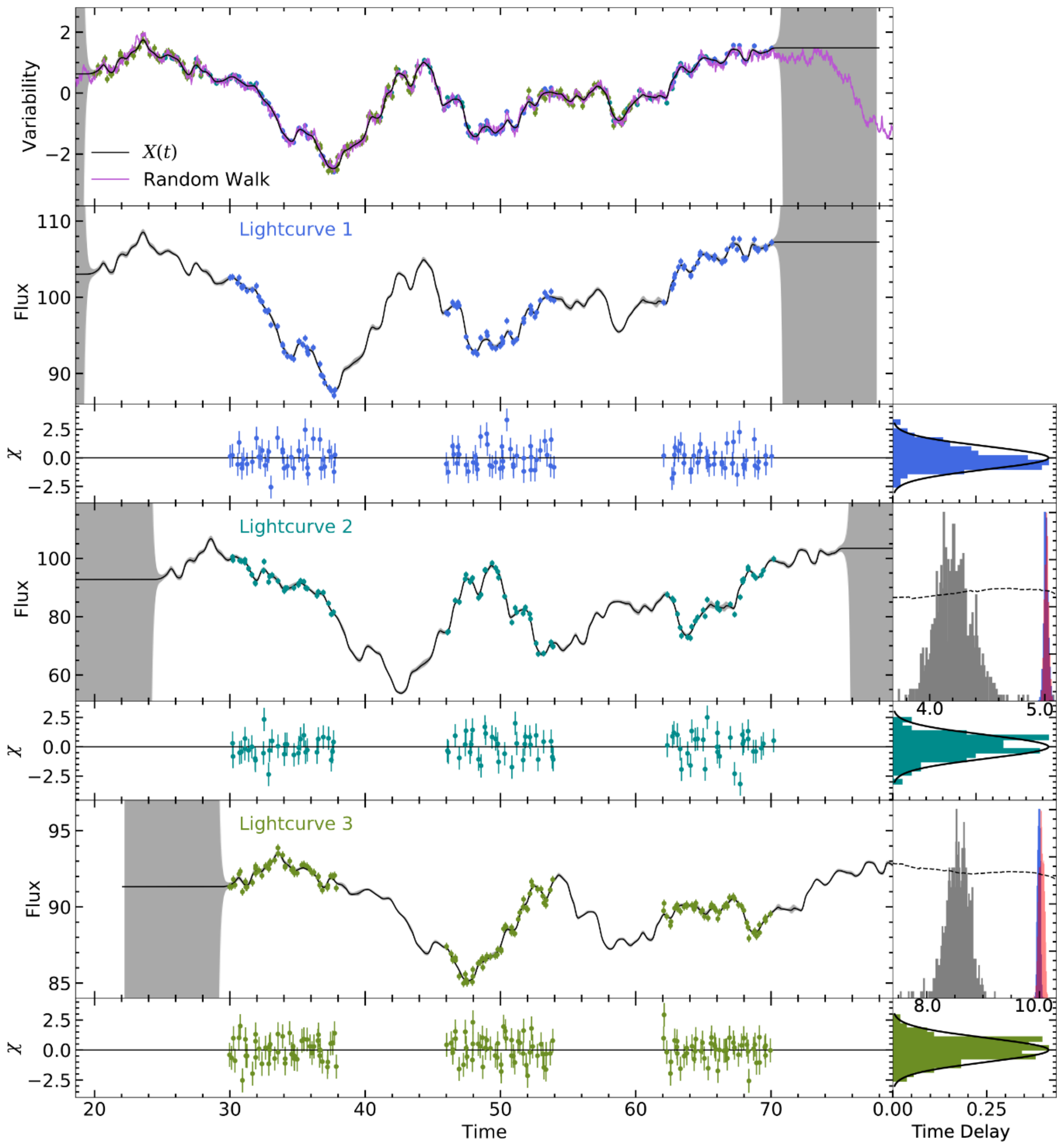
PyROA models the all available lightcurves using a running optimal average (ROA) to generate the driving lightcurve.

The “flexibility” of the running optimal average is optimised using the Bayesian Information Criterion (BIC), which adds a penalty with increasing no. of parameters when the ROA becomes too flexible.

$$f_i(t) = \overset{\text{rms}}{A_i} \underbrace{X\,(t - \overset{\text{time delay}}{\tau_i})}_{\text{Normalised driving lightcurve shifted in time.}} + \overset{\text{mean}}{B_i}$$

rms **time delay** **mean**

Normalised driving lightcurve shifted in time.



PyROA is able to handle large gaps in the lightcurves where the CCF fails (grey posteriors). Additionally PyROA includes a noise model to deal with underestimated flux errors.

https://github.com/FergusDonnan/PyROA

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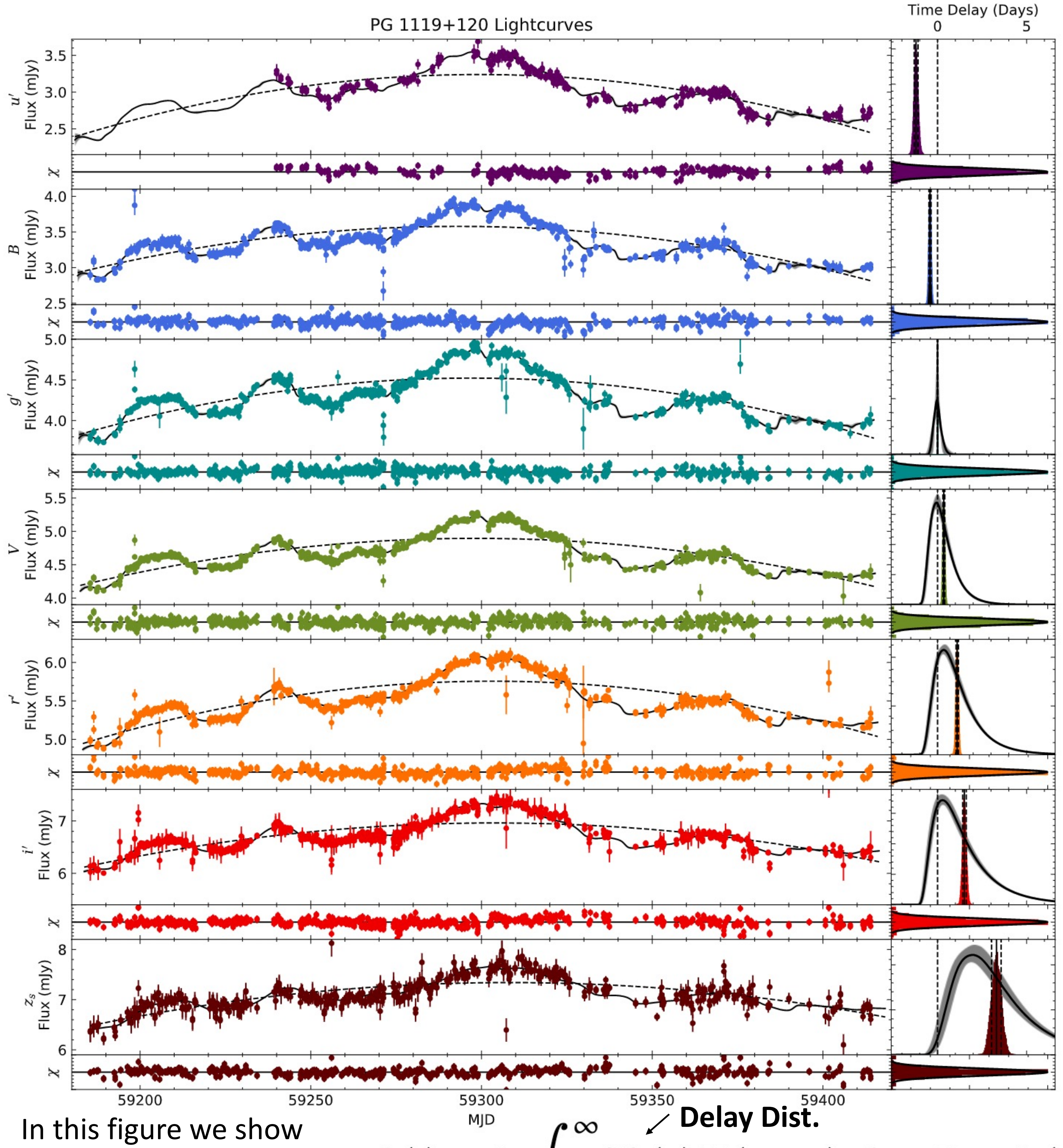
PG 1119+120

PG 1119+120 is a local (*z=0.05*) quasar observed with the Las Cumbres Observatory (LCO) in the u’, B, g’, V, r’, i’, z filters and spectroscopic monitoring with Calar Alto (CAHA). This object is ideal to test the accretion structure at high accretion rates with intensive continuum reverberation mapping.

While sub-Eddington accretion is well tested, consistent with a geometrically thin accretion disc, super-Eddington accretion is expected occur through a “slim” accretion disc, where the radiation pressure increases the scale height.



In this figure we show a fit where we expanded PyROA to model a distribution of delays:

$$f_i(t) = A_i \int_{-\infty}^{\infty} \overset{\text{Delay Dist.}}{\Psi_i(\tau)} X\,(t - \tau_i)\ d\tau + B_i + \overset{\text{Slow Variations (Polynomial)}}{S_i(t)}$$

Delay Dist.

Convolution of driving lightcurve with delay distribution

Slow Variations (Polynomial)

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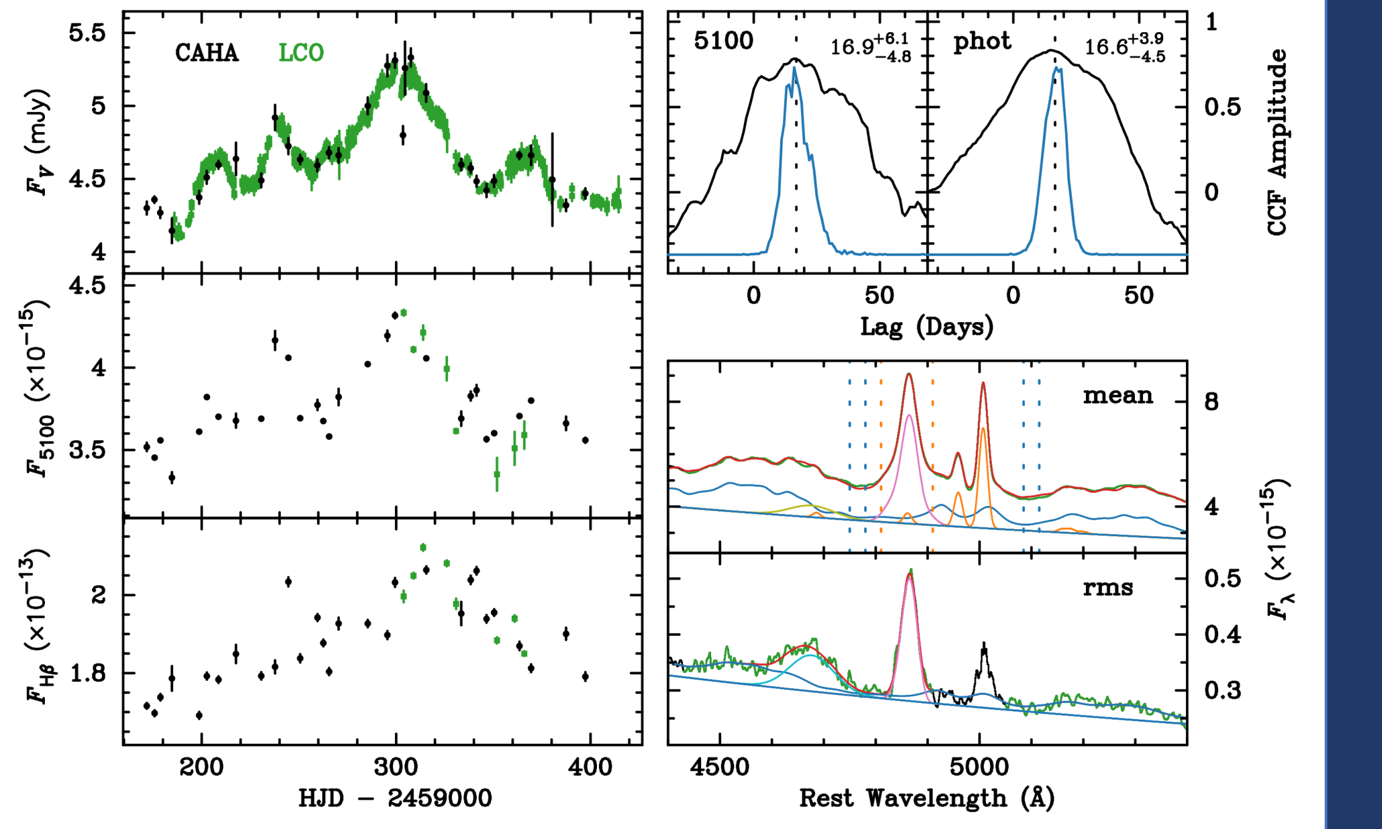
Testing Super-Edington Accretion

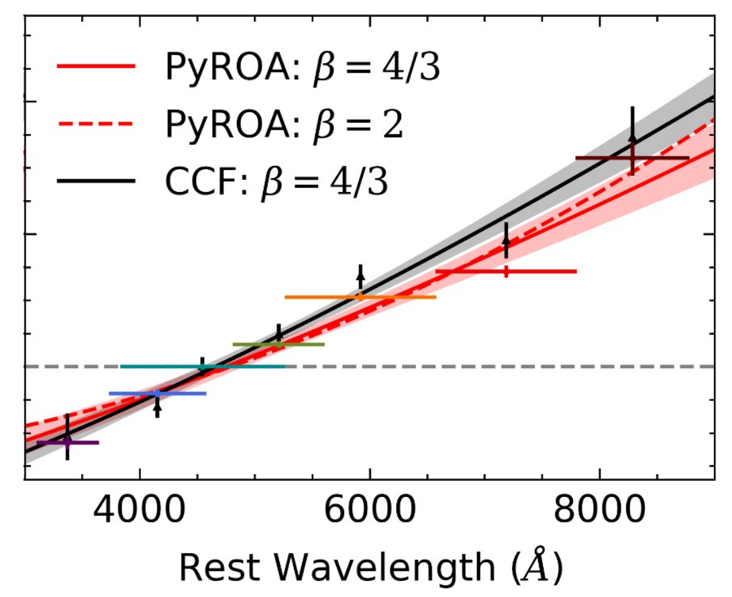
BH Mass:

$$M_\bullet = f\,\frac{\Delta V^2\,\tau c}{G}$$

From Hβ lag & linewidth => $\log\left(M_\bullet/\mathrm{M}_\odot\right) \;=\; 7.0$



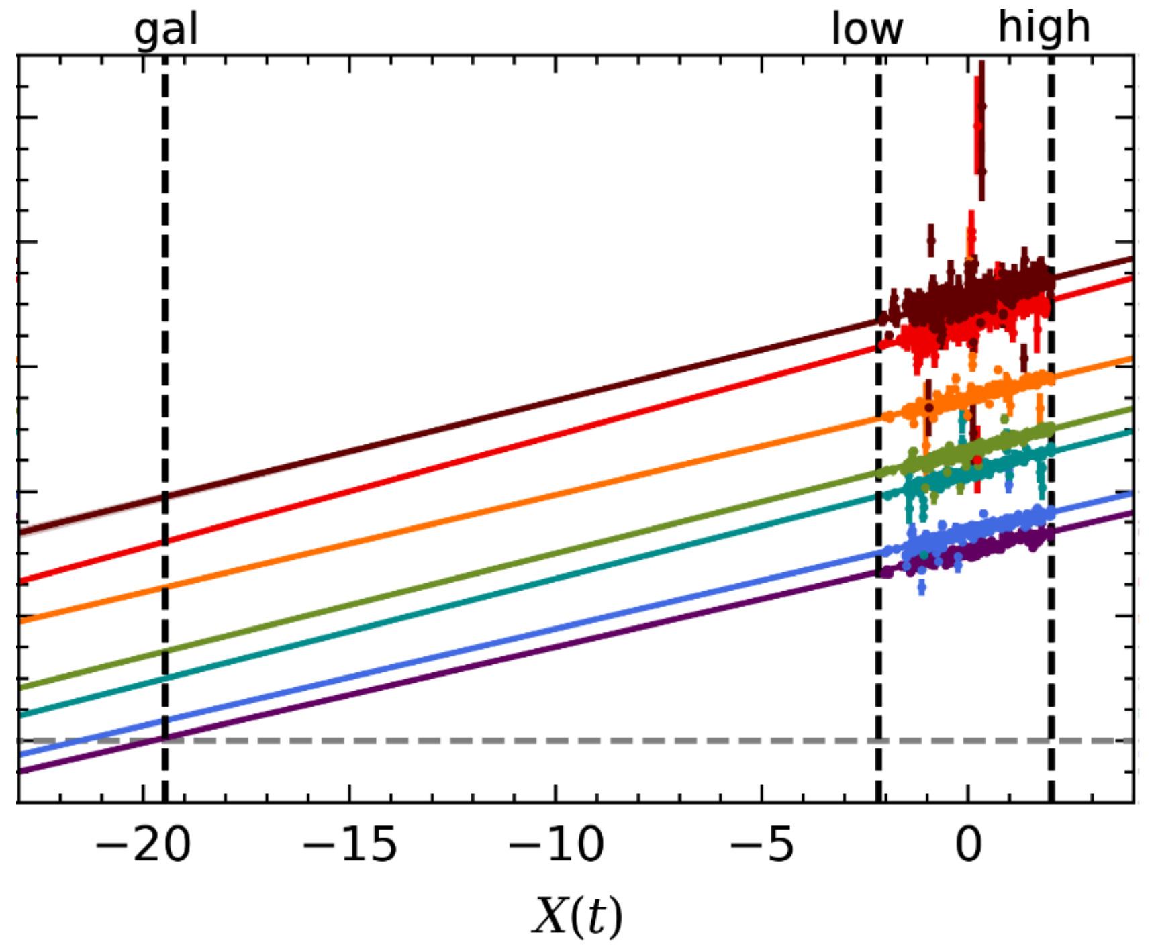
Lag Spectrum:



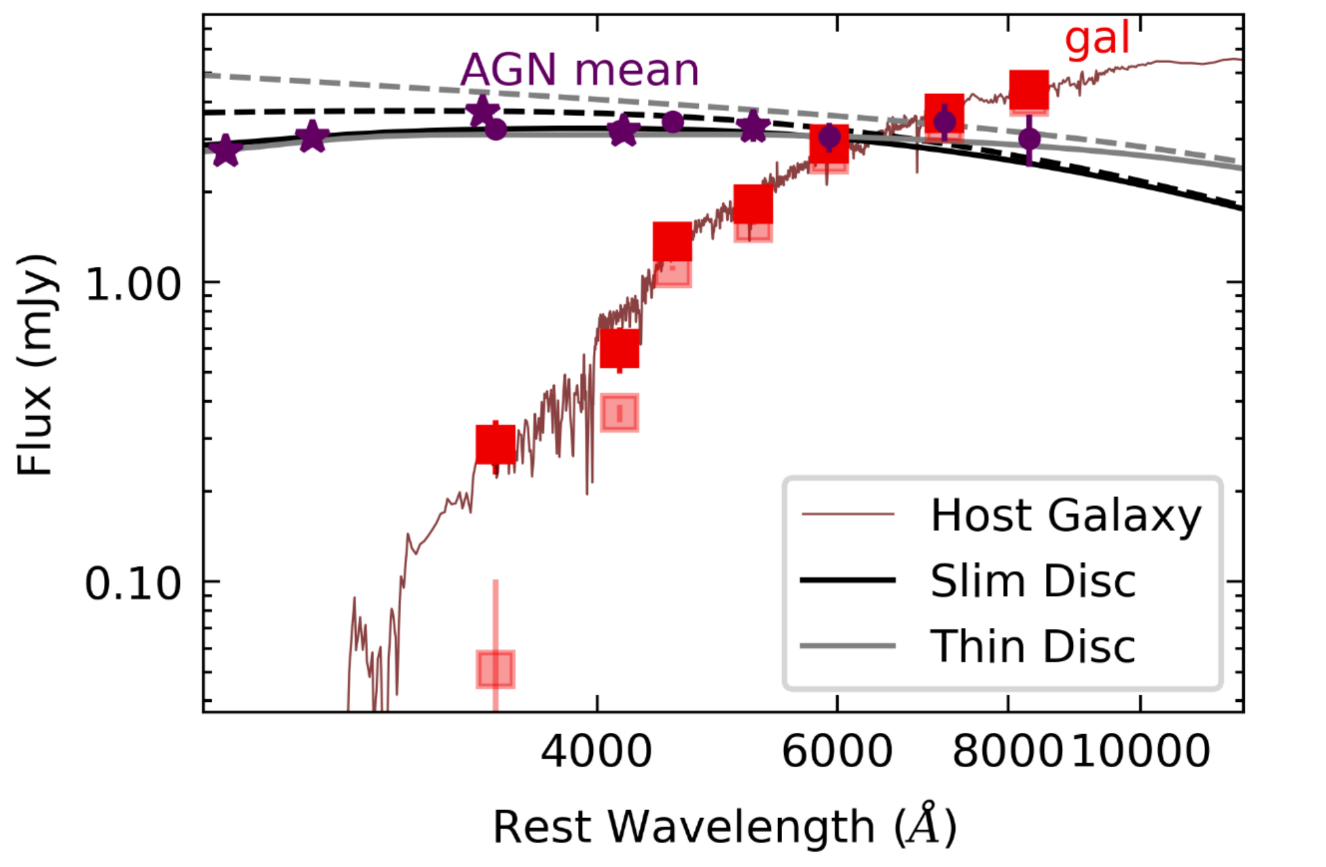
For an accretion disc temperature structure $T(R) \propto R^{-1/\beta}$, the lag spectrum follows $\tau \propto \lambda^\beta$.

Both thin disc (β = 4/3) and slim disc (β = 2) models consistent with lag spectrum.

Spectral Decomposition:



Decompose photometric flux into fixed (host galaxy) and variable (AGN) components by extrapolating linear model to “turn off” variability.



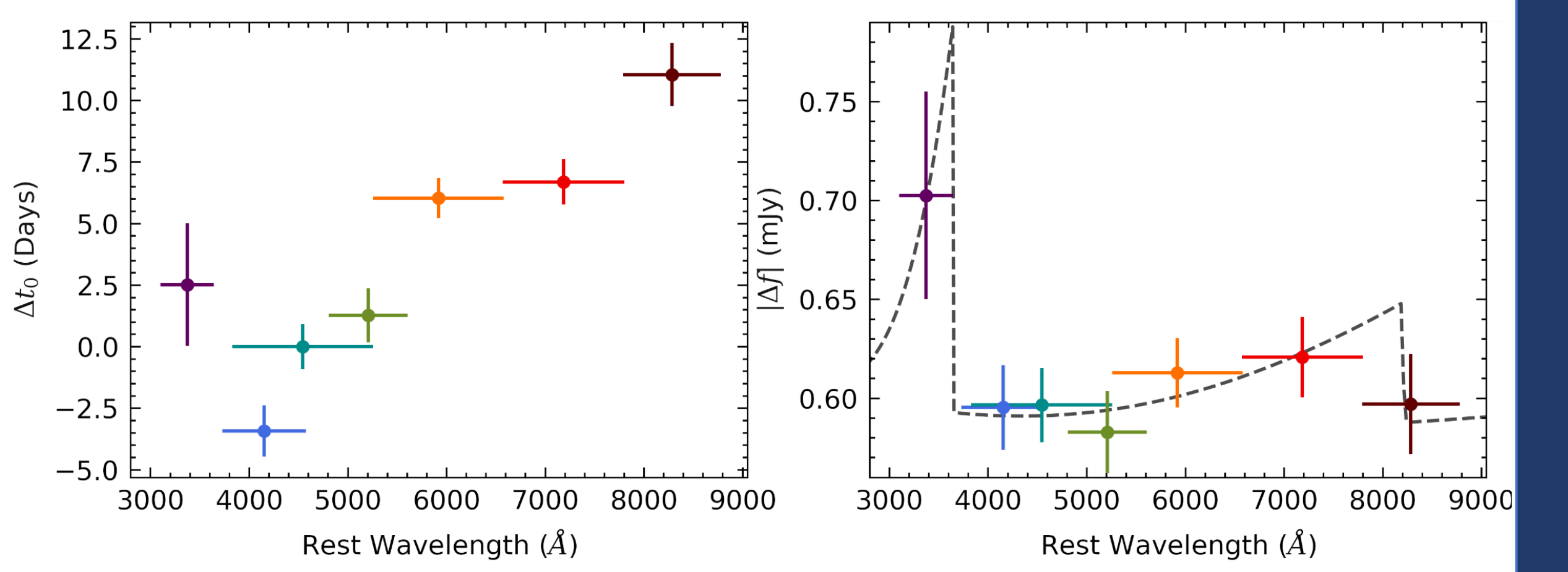
We fit the AGN SED with accretion disc models (including dust extinction), finding the Slim disc to provide a slightly better fit with an Eddington ratio of $\lambda_{\rm Edd}\ =\ 3.26^{+0.20}_{-0.17}$

BLR Diffuse Continuum Emission:

Slow variations show excess delay in the u’ band and a larger of amplitude variations =>

Diffuse bound-free continuum emission from BLR!

Spectrum matches shape of bound-free emission



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