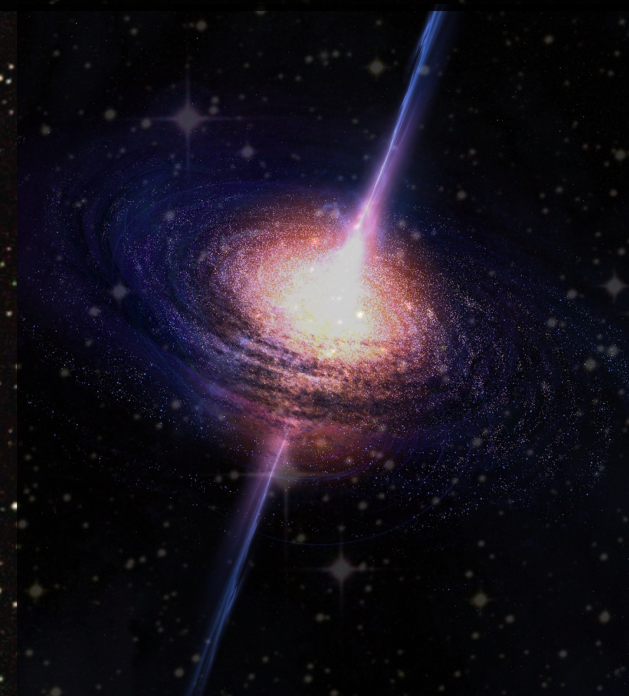
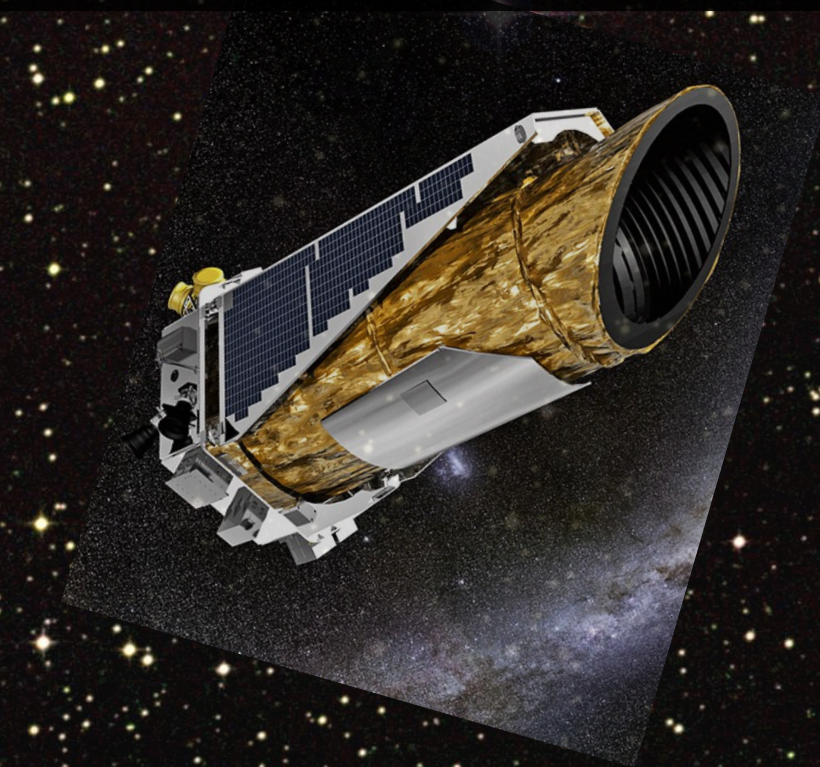


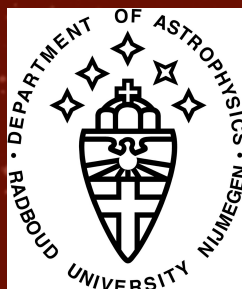
Optical short-time variability properties of AGN



Ester Aranzana

E. Körding, P. Uttley, S. Scaringi

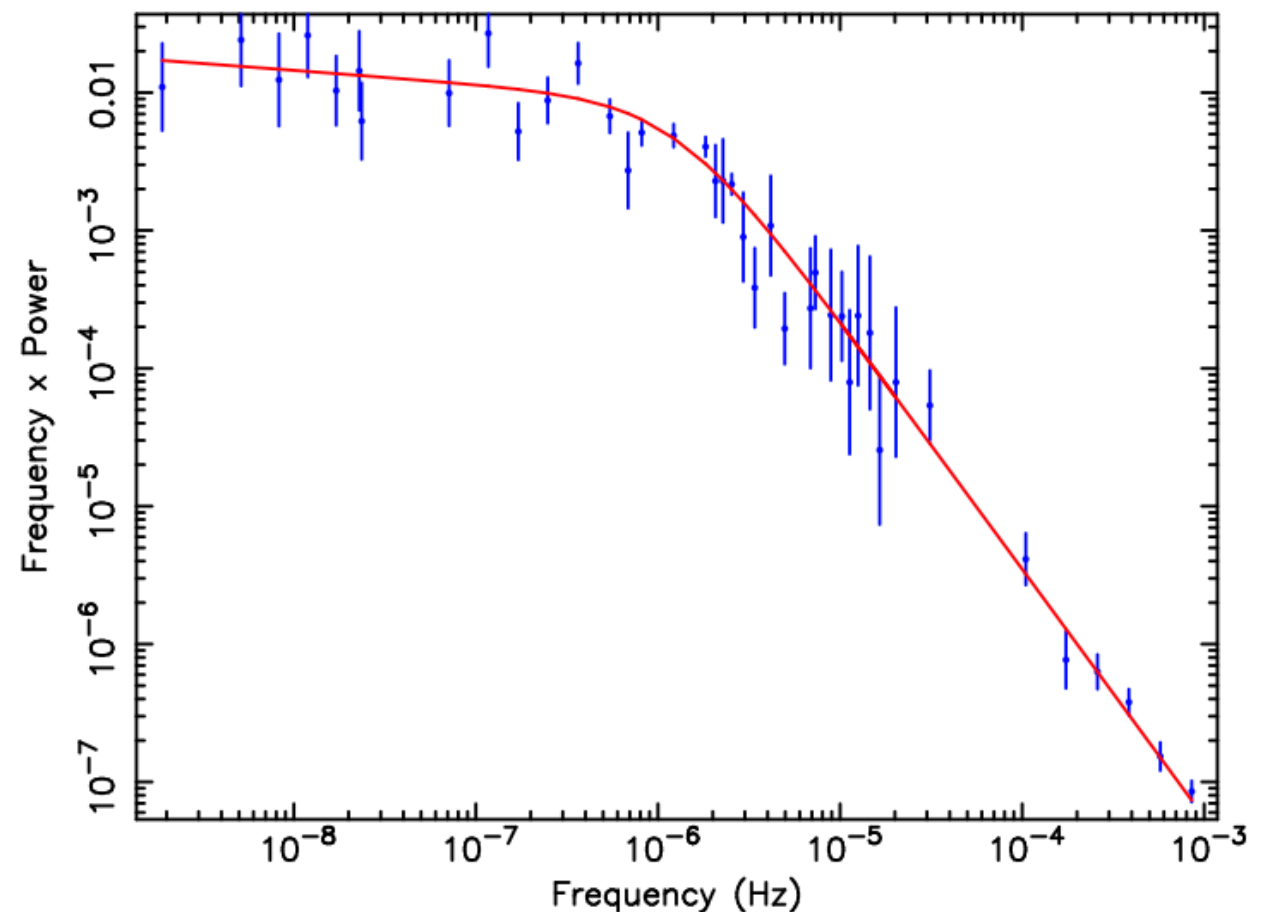
X-ray Universe 6-9 June 2017, Rome



AGN variability

- Characteristic time-scales (different physical mechanisms)

- Light crossing time-scale \sim hours
- Dynamical time-scale \sim days
- Thermal time-scale \sim years
- Viscous time-scale \sim tens of years

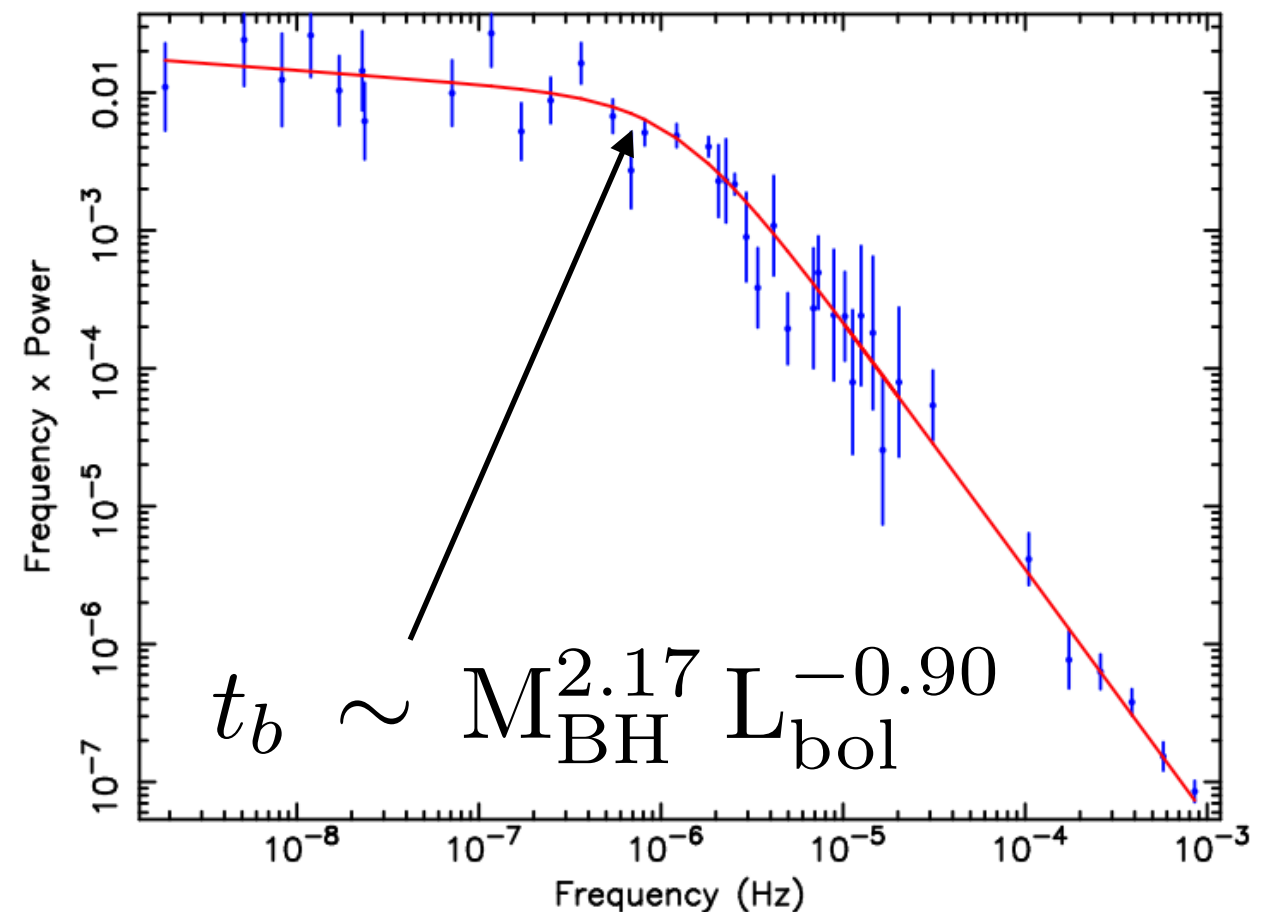


McHardy (2009)

AGN variability

- Characteristic time-scales (different physical mechanisms)

- Light crossing time-scale \sim hours
- Dynamical time-scale \sim days
- Thermal time-scale \sim years
- Viscous time-scale \sim tens of years



McHardy (2009)

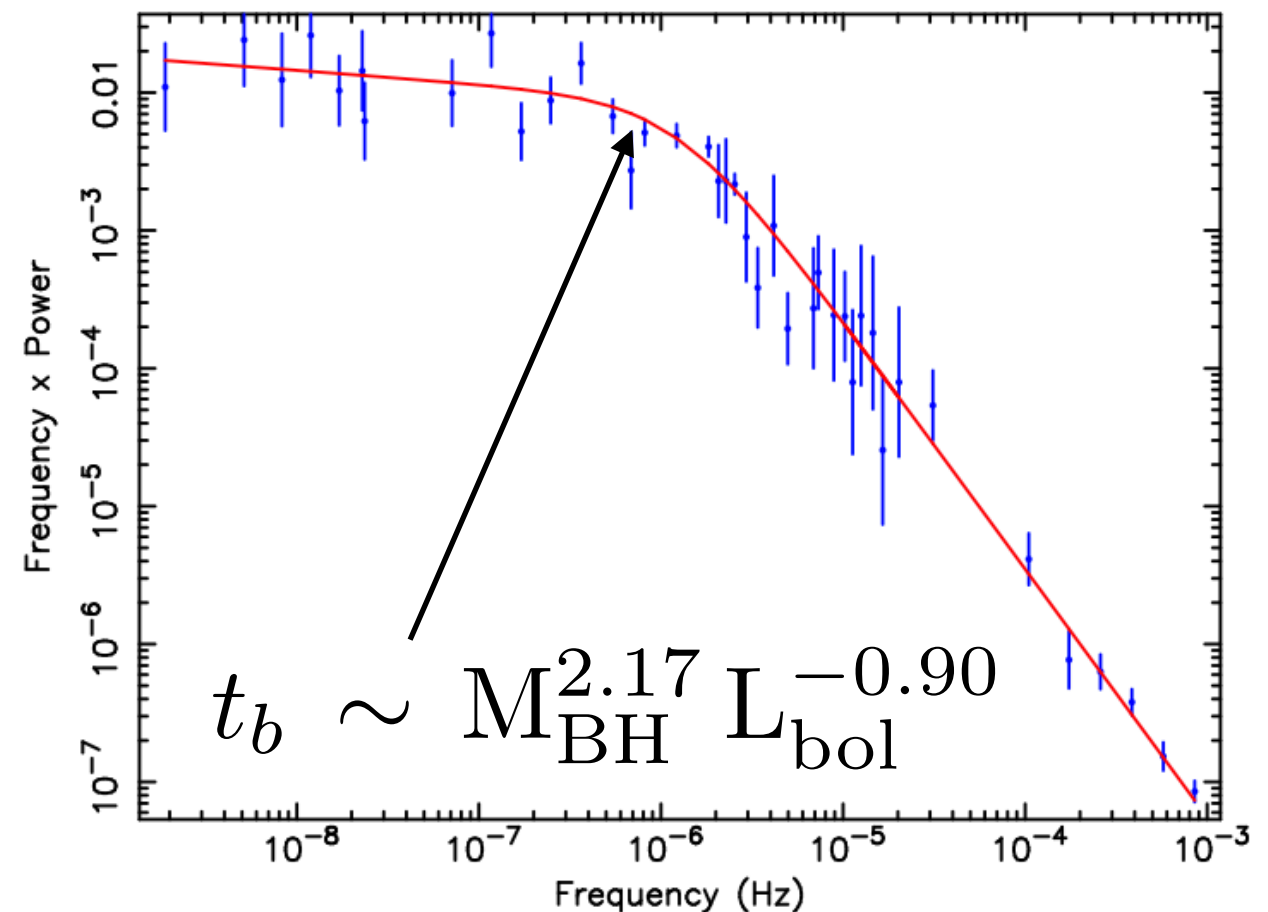
AGN variability

- Characteristic time-scales (different physical mechanisms)

- Light crossing time-scale \sim hours
- Dynamical time-scale \sim days
- Thermal time-scale \sim years
- Viscous time-scale \sim tens of years

- Amplitude of variability

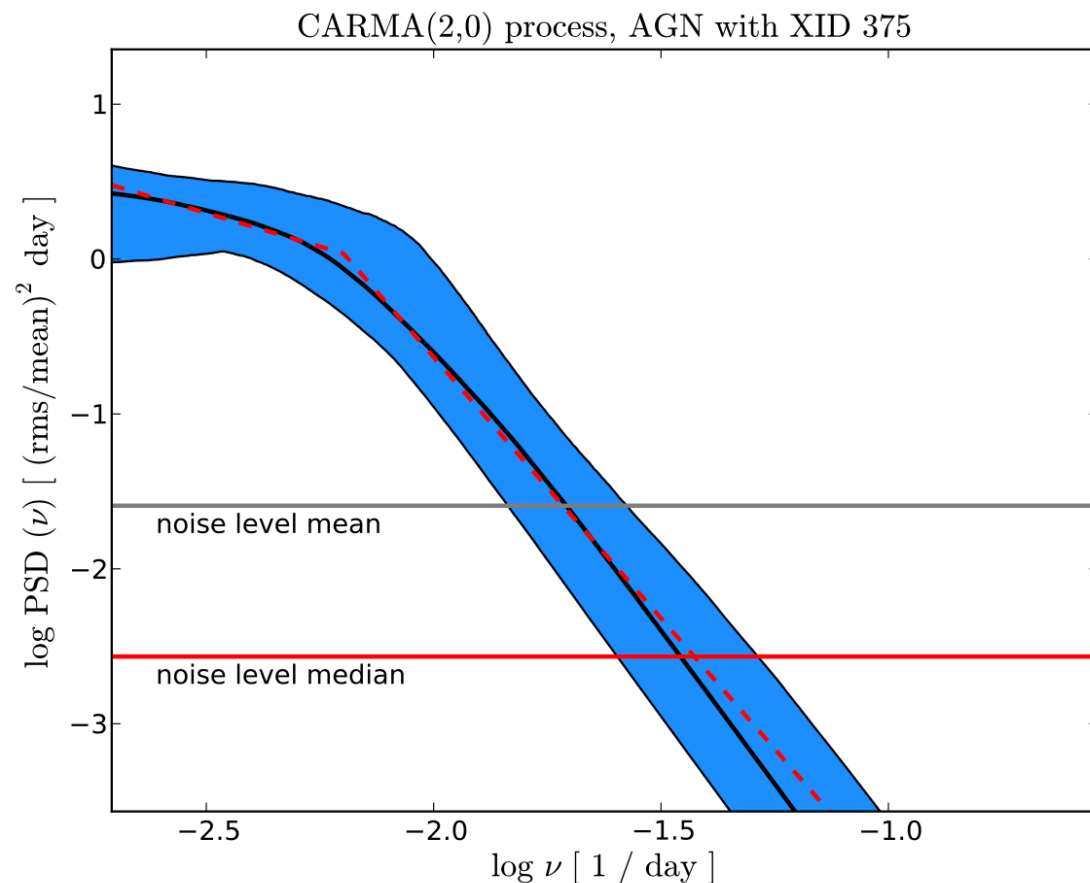
$$\sigma (\%) = \sqrt{\int_{\nu_1}^{\nu_2} P(\nu) d\nu}$$



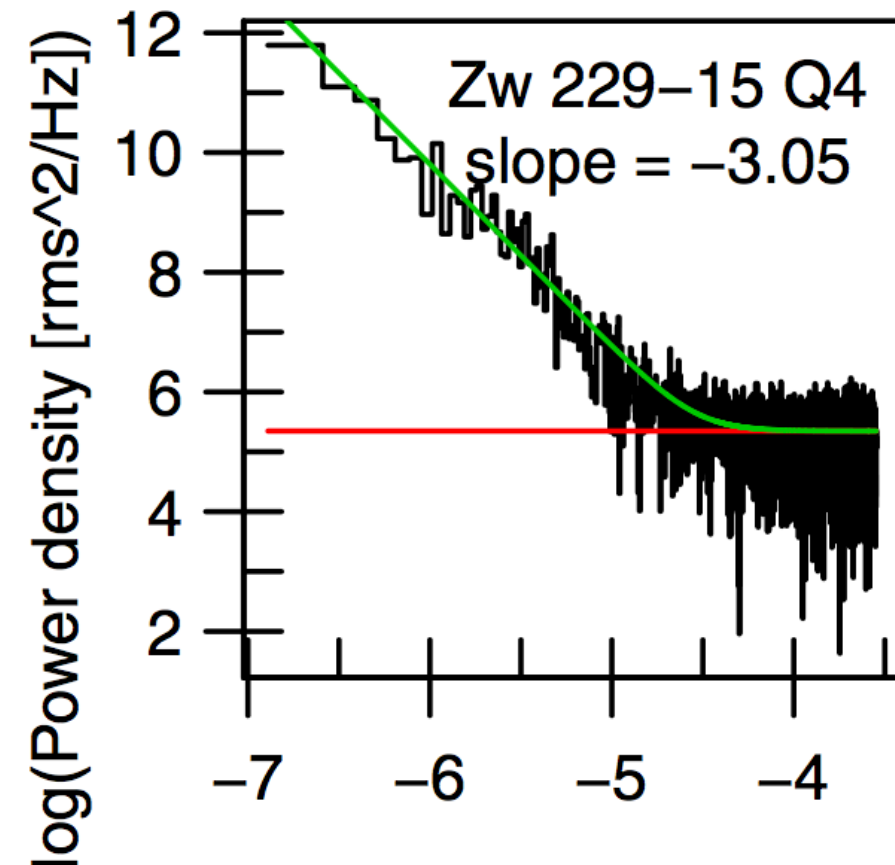
McHardy (2009)

Why studying optical variability of AGN?

- **Long-term variability:**
SDSS, Palomar Green Quasars, PanSTARRS
- **Short-term variability:**
handful of selected sources with Kepler



Simm et al. 2015



Mushotzky et al. 2011

Why studying optical variability of AGN?

Origin of rapid optical variability?

- ★ Jet
- ★ Reprocessing of X-rays
- ★ Disc instabilities

Is there a cosmological evolution on the variability properties of the AGN?

Accretion states?

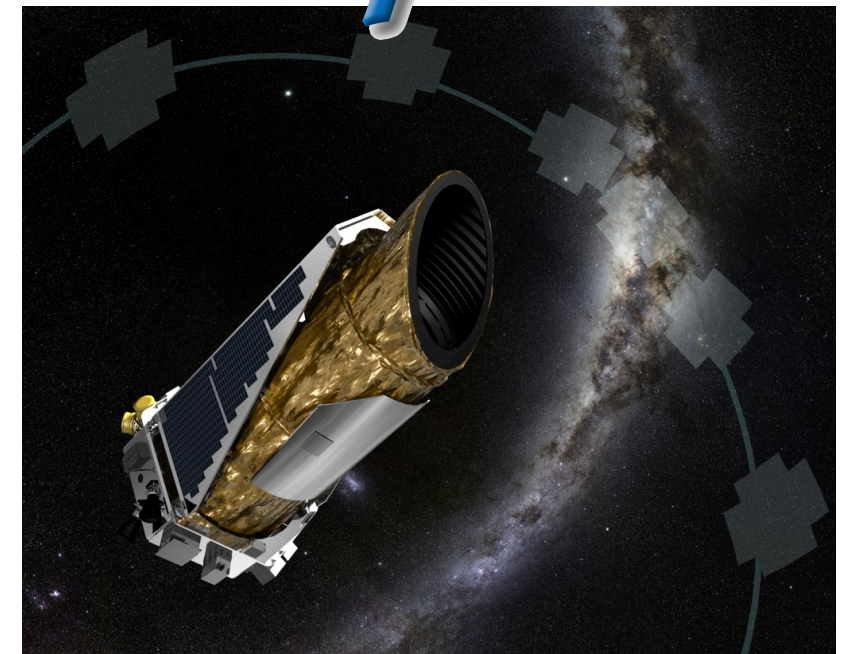
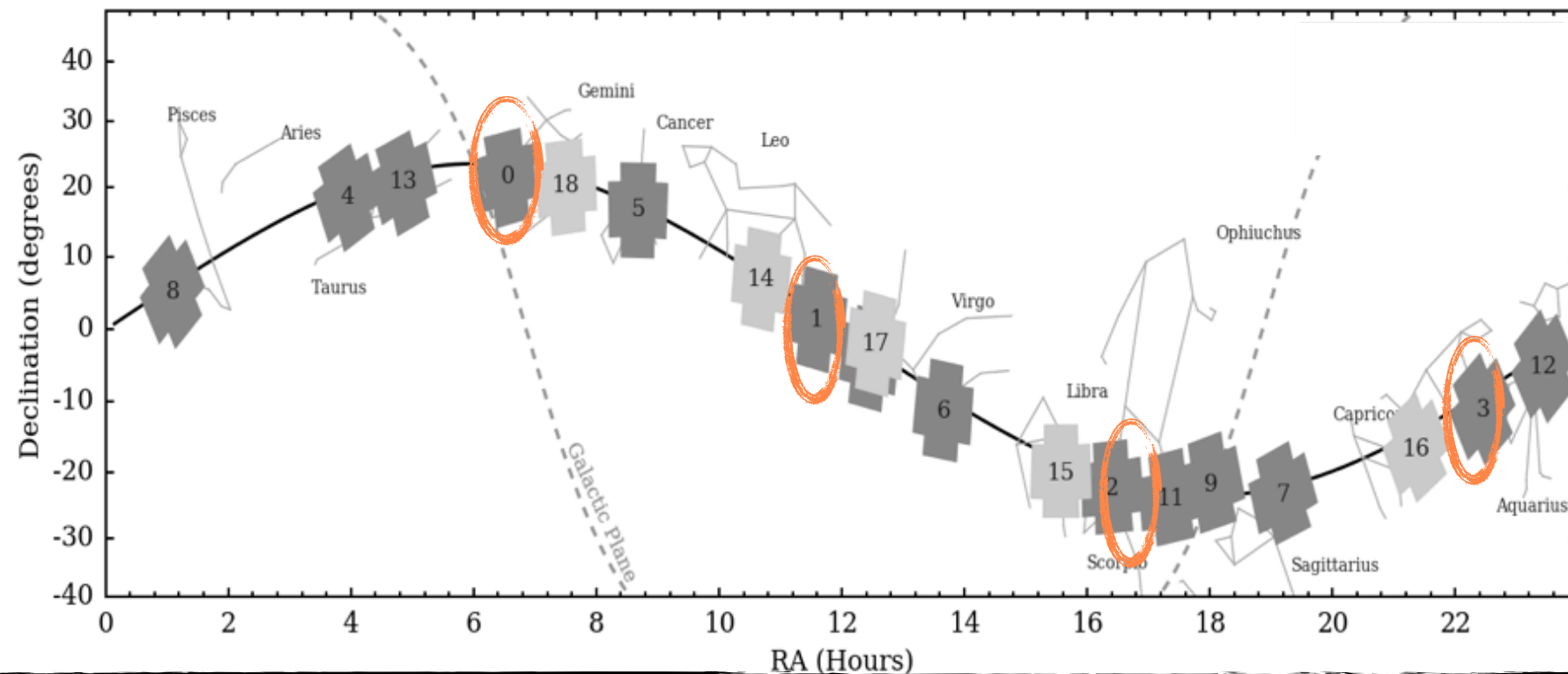
Variability properties associated to a certain BH mass or luminosity?

Sample selection and observations with K2

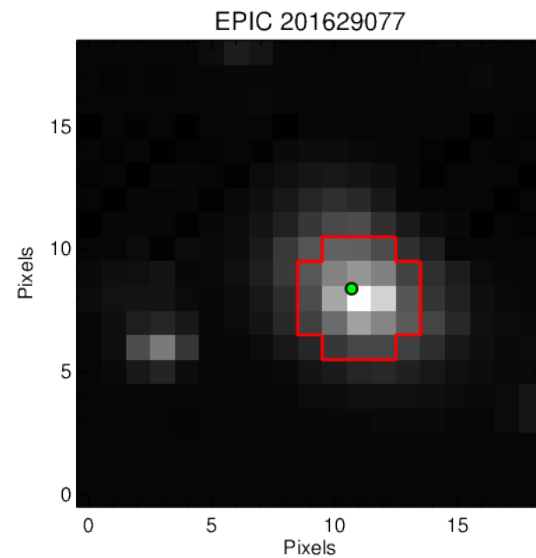
275 AGN selected from the “Million Quasar Catalogue”
with $R > 19$ (Flesch 2013)

Duration: 80 days
Cadence: 29.4 min
Bandpass: 420-900 nm

Kepler

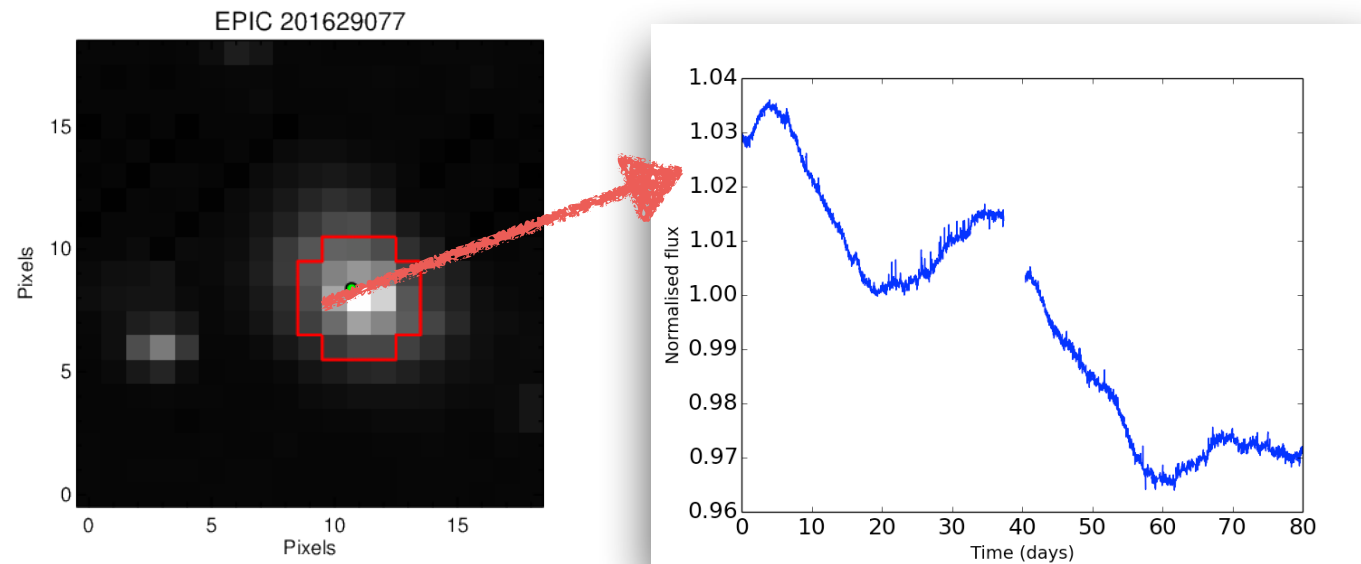


Monte Carlo simulations of power spectra



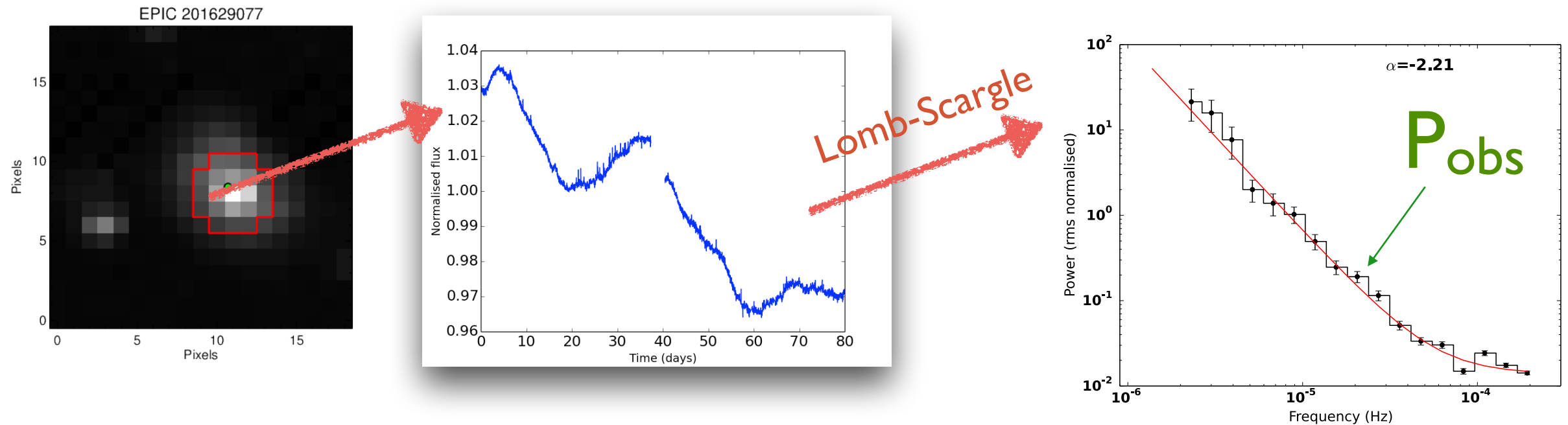
Uttley et al. 2002

Monte Carlo simulations of power spectra



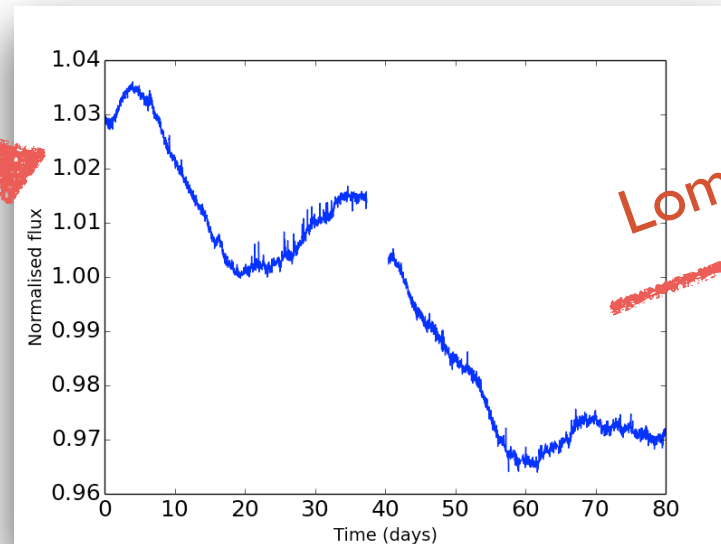
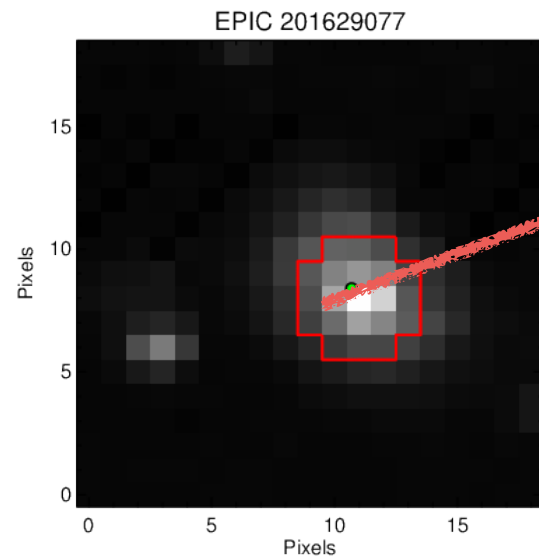
Uttley et al. 2002

Monte Carlo simulations of power spectra

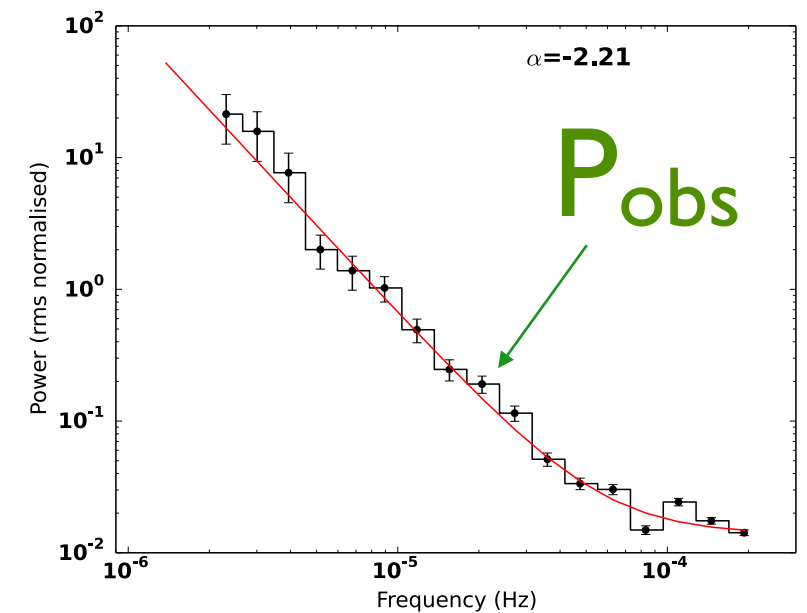


Uttley et al. 2002

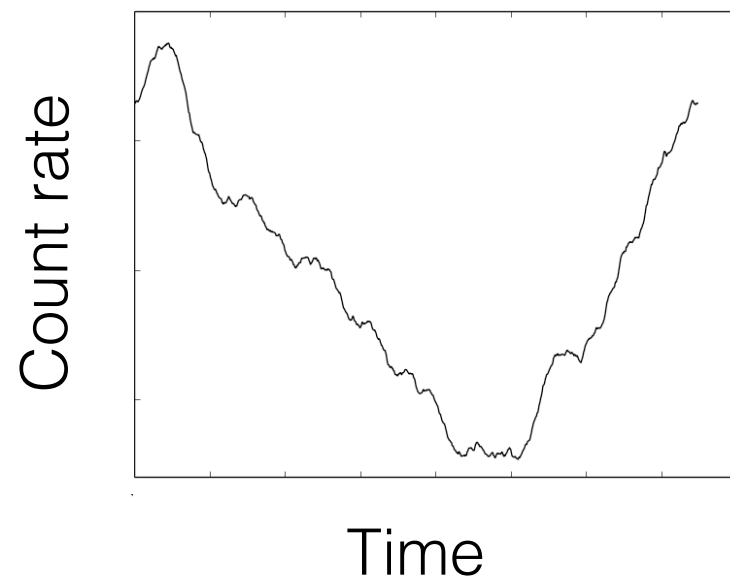
Monte Carlo simulations of power spectra



Lomb-Scargle

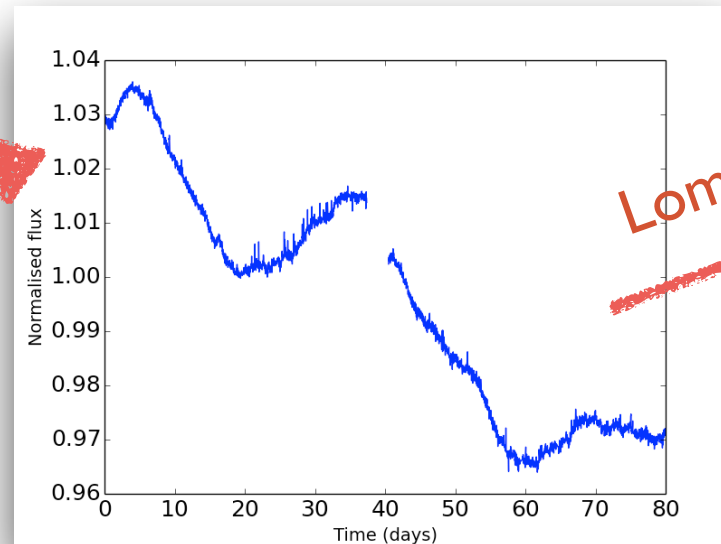
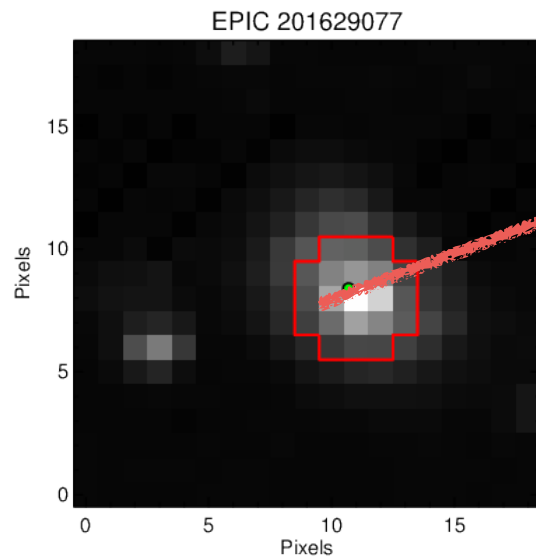


$$P_{\nu} = A \left(\frac{\nu}{\nu_0} \right)^{-\beta}$$

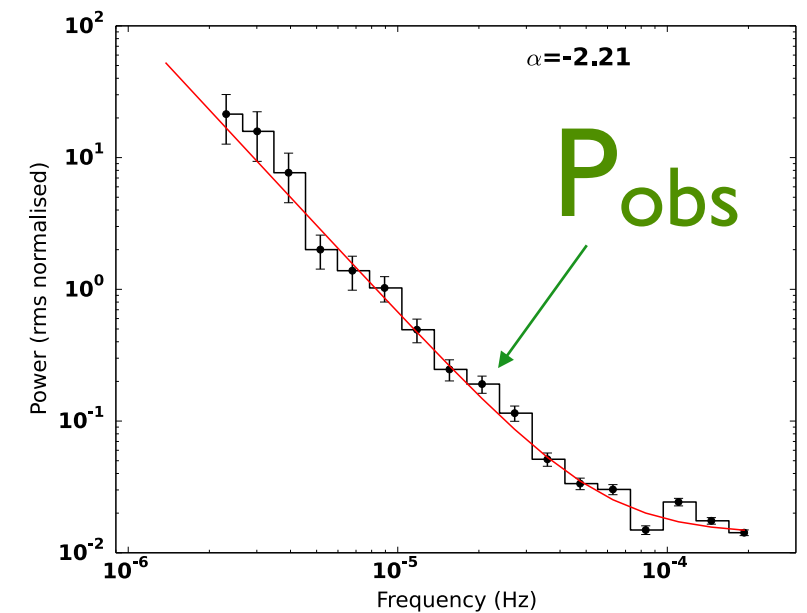


Uttley et al. 2002

Monte Carlo simulations of power spectra

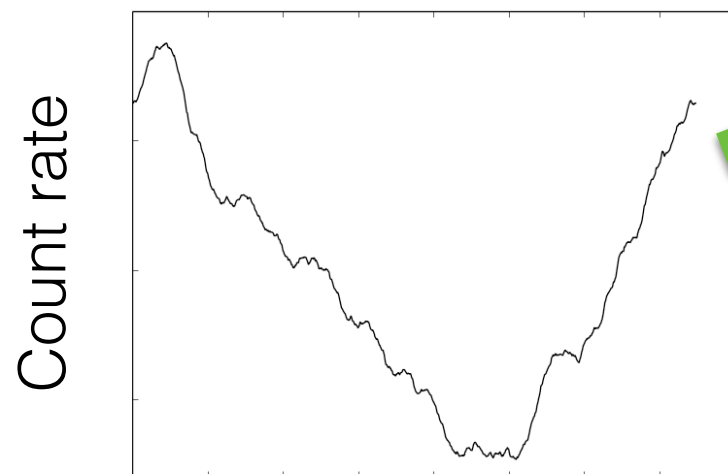


Lomb-Scargle



$$P_{\nu} = A \left(\frac{\nu}{\nu_0} \right)^{-\beta}$$

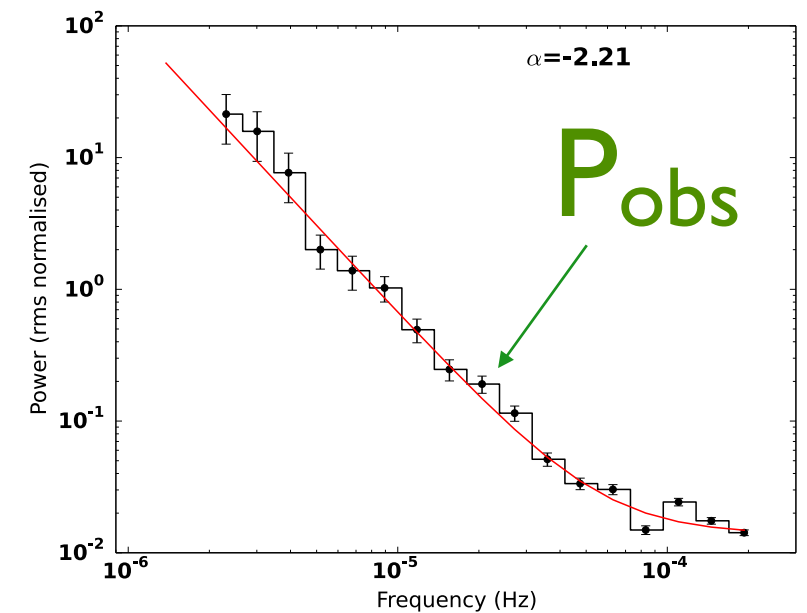
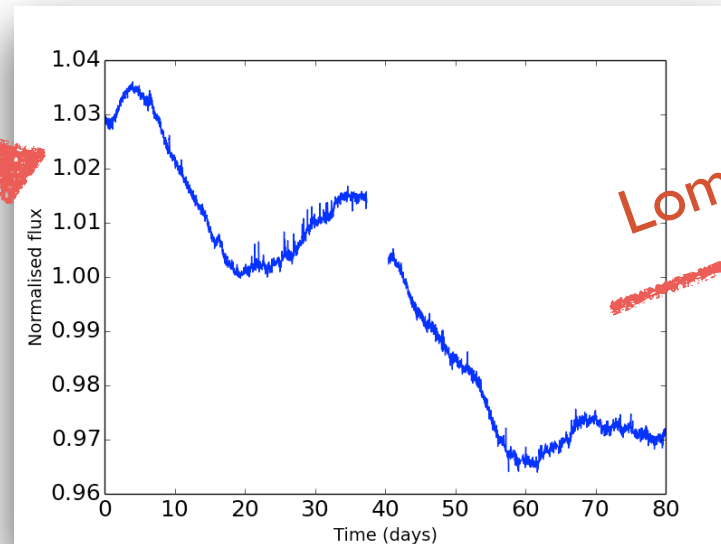
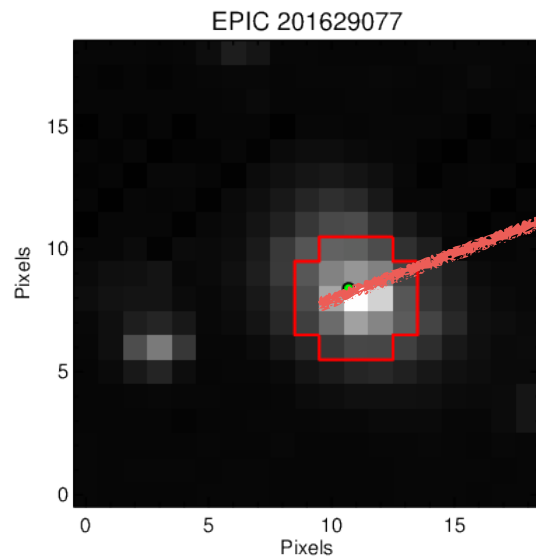
P_{sim}



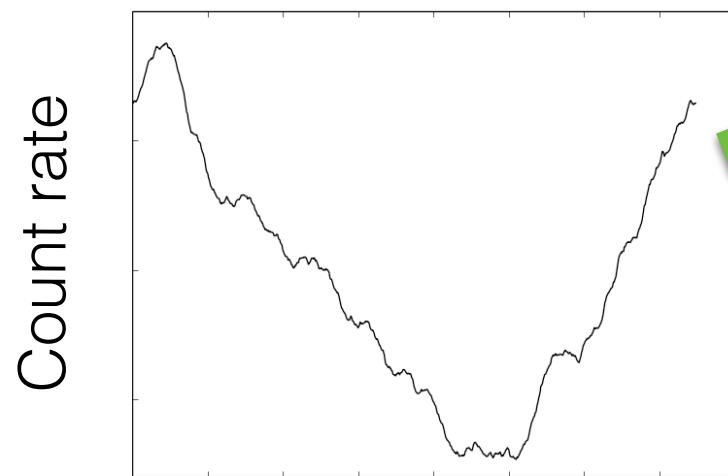
Time

Uttley et al. 2002

Monte Carlo simulations of power spectra



$$P_{\nu} = A \left(\frac{\nu}{\nu_0} \right)^{-\beta}$$

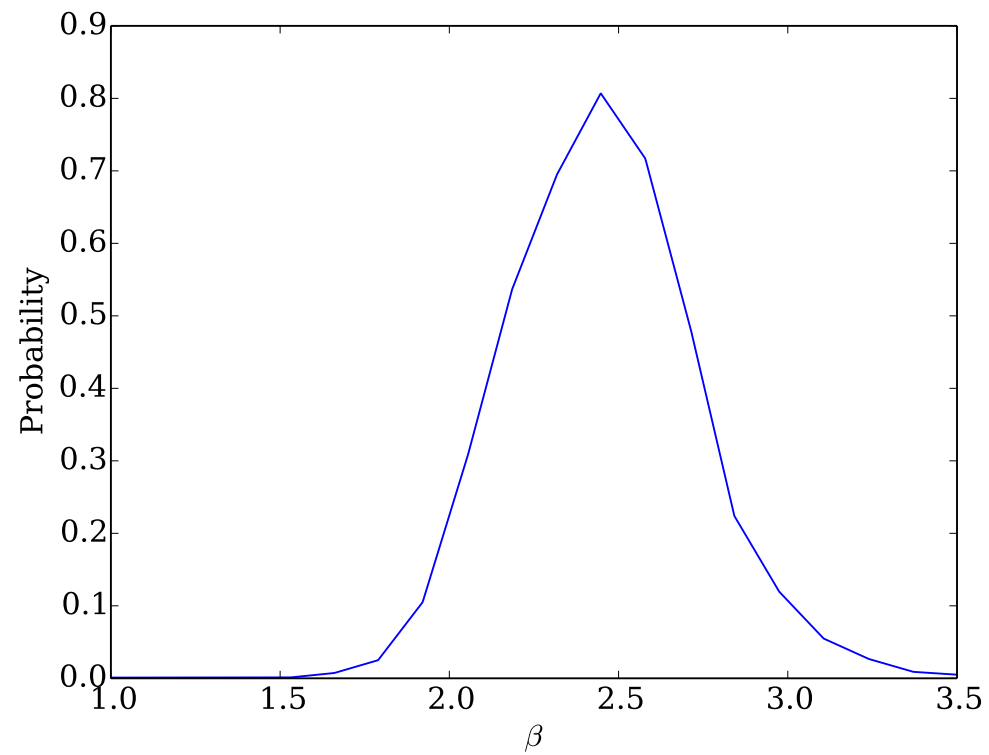


$$\chi^2_{\text{dist}} = \sum_{i=1}^N \frac{(P_{\text{sim}} - P_{\text{obs}})^2}{(\Delta P_{\text{sim}})^2}$$

P_{sim}

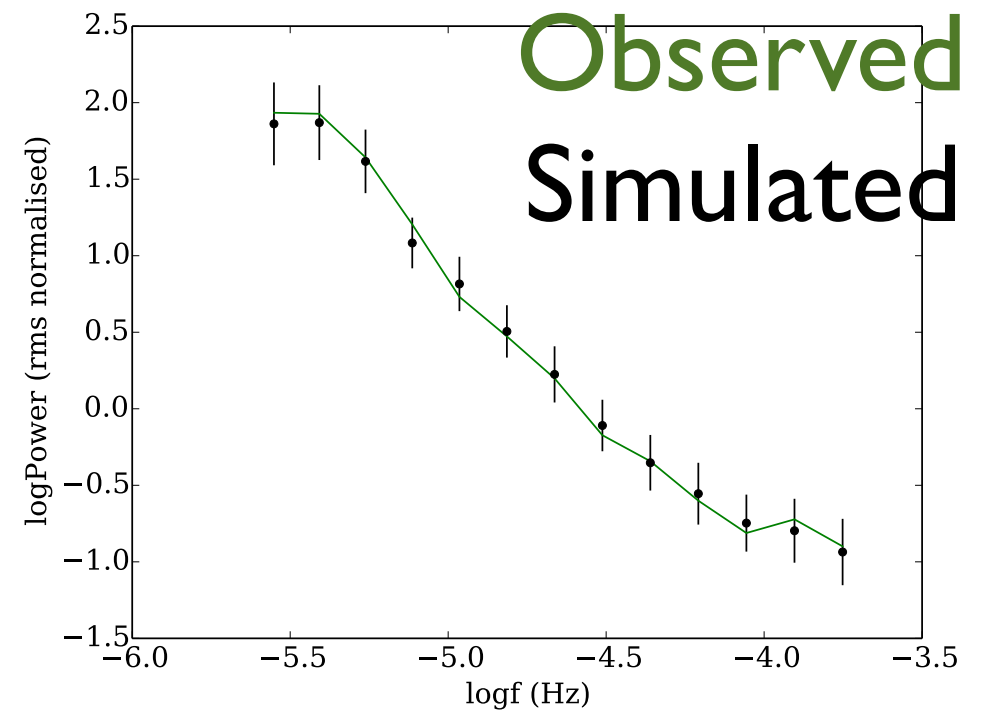
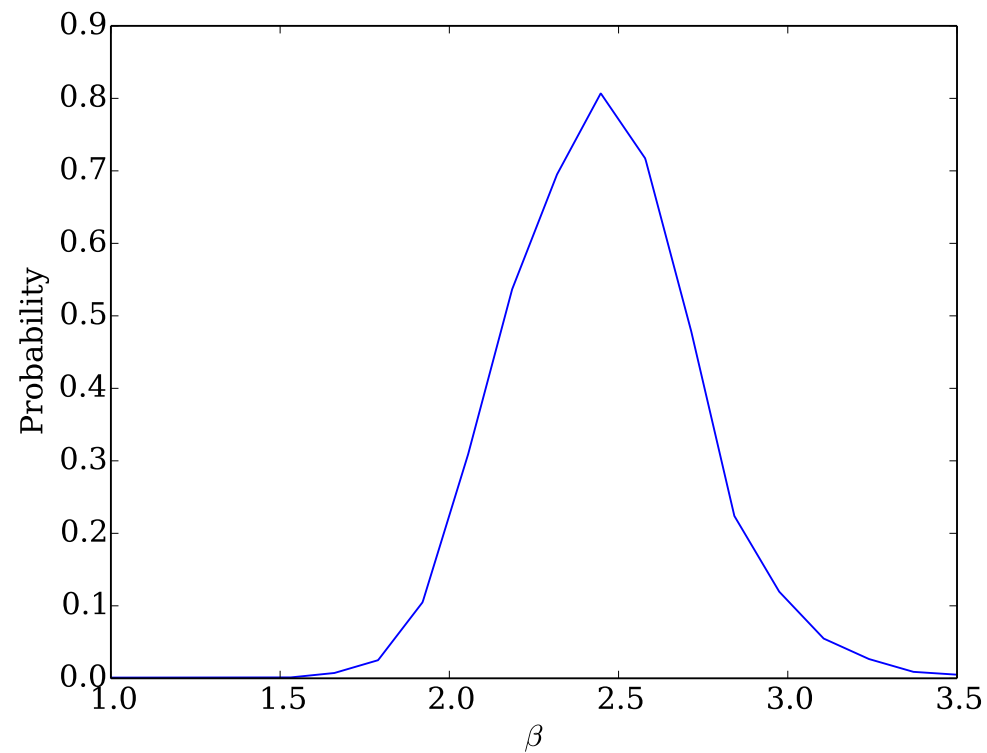
Uttley et al. 2002

Power-law model



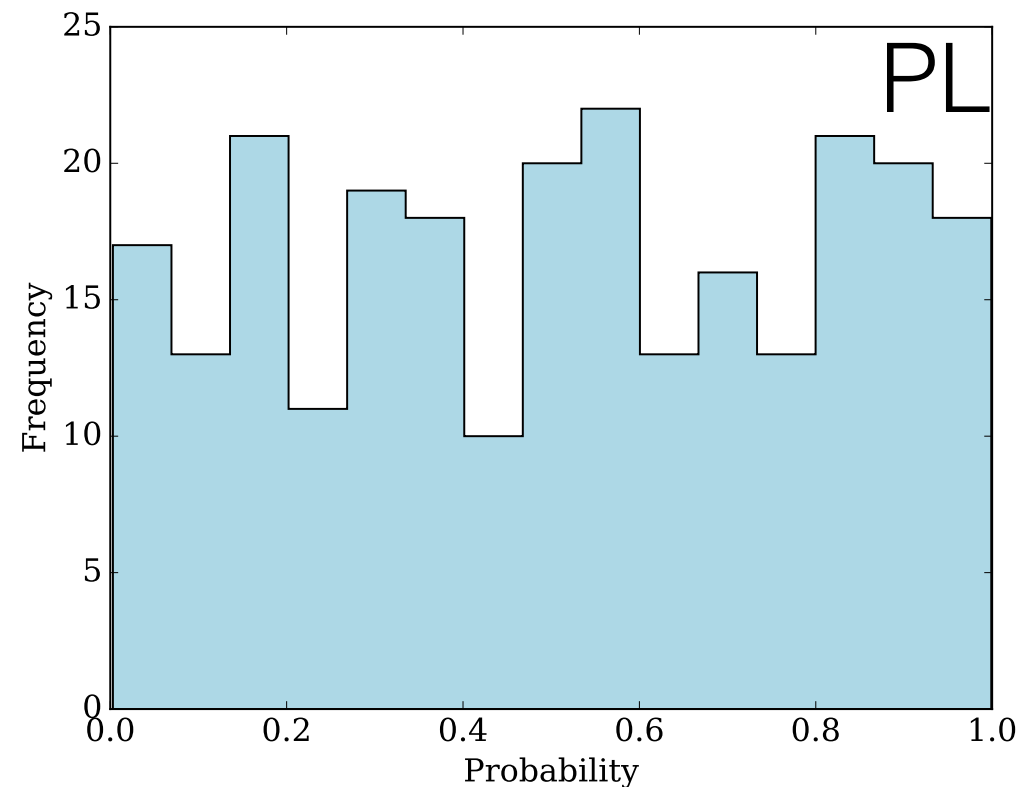
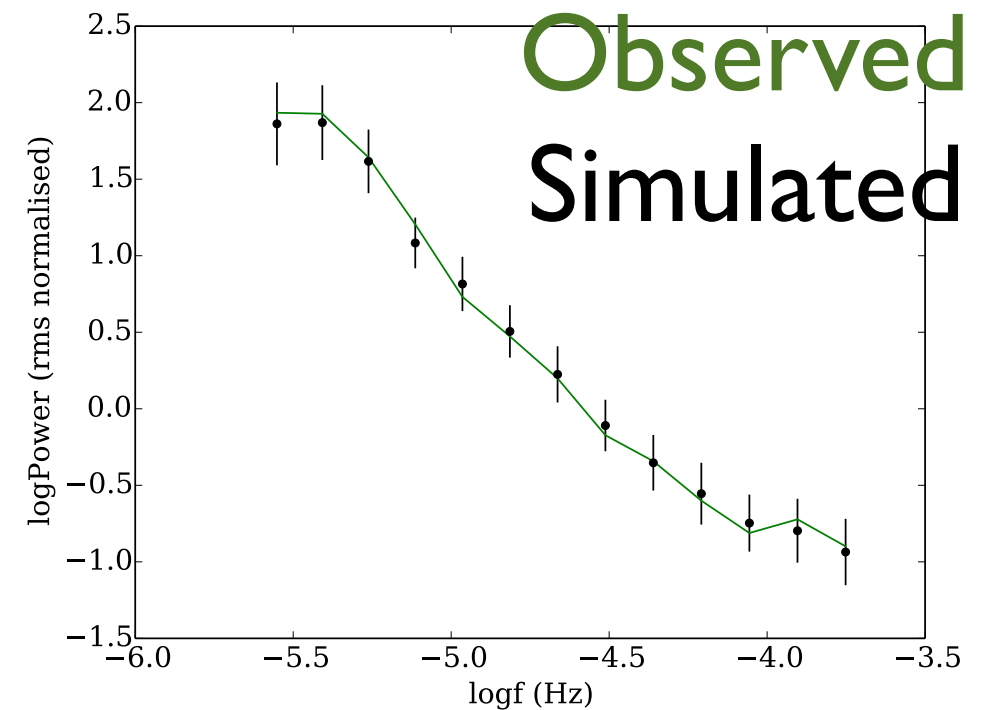
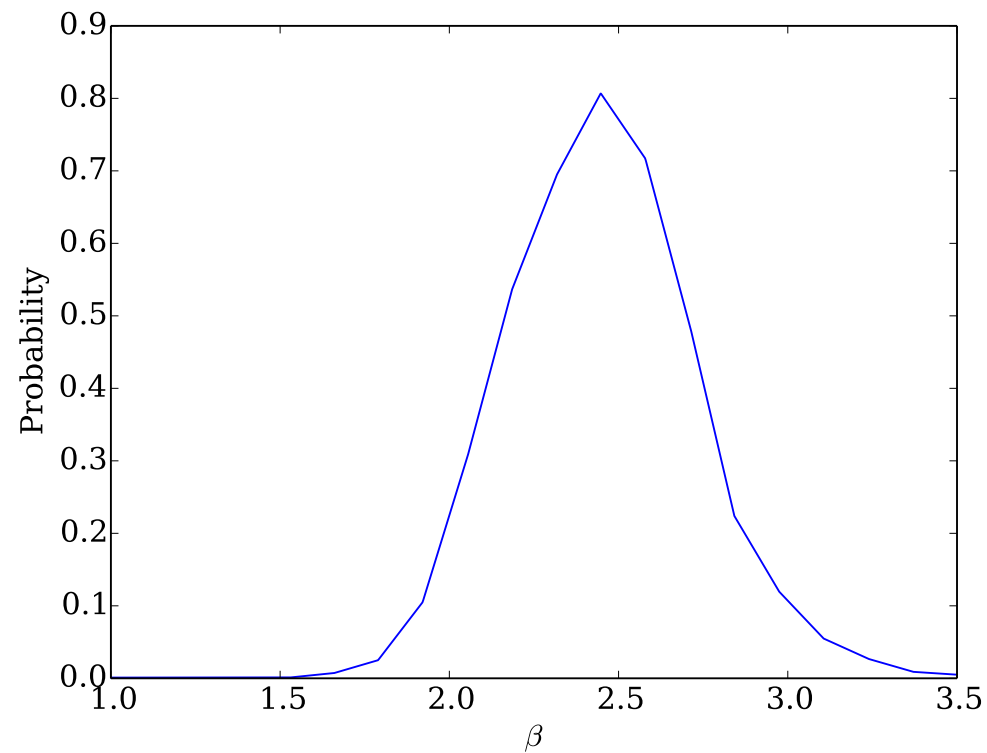
Aranzana et al. 2017 (submitted)

Power-law model



Aranzana et al. 2017 (submitted)

Power-law model

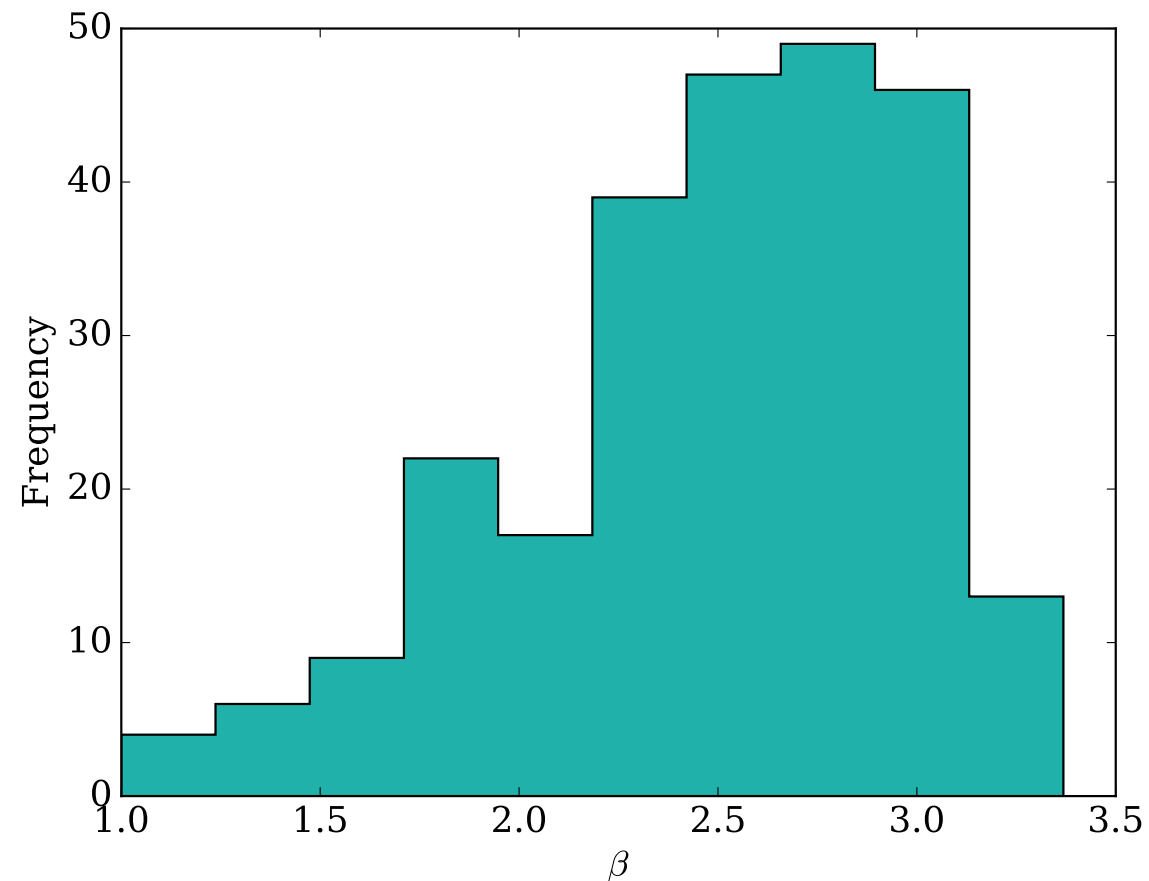


PL model works! 🥰💧

Aranzana et al. 2017 (submitted)

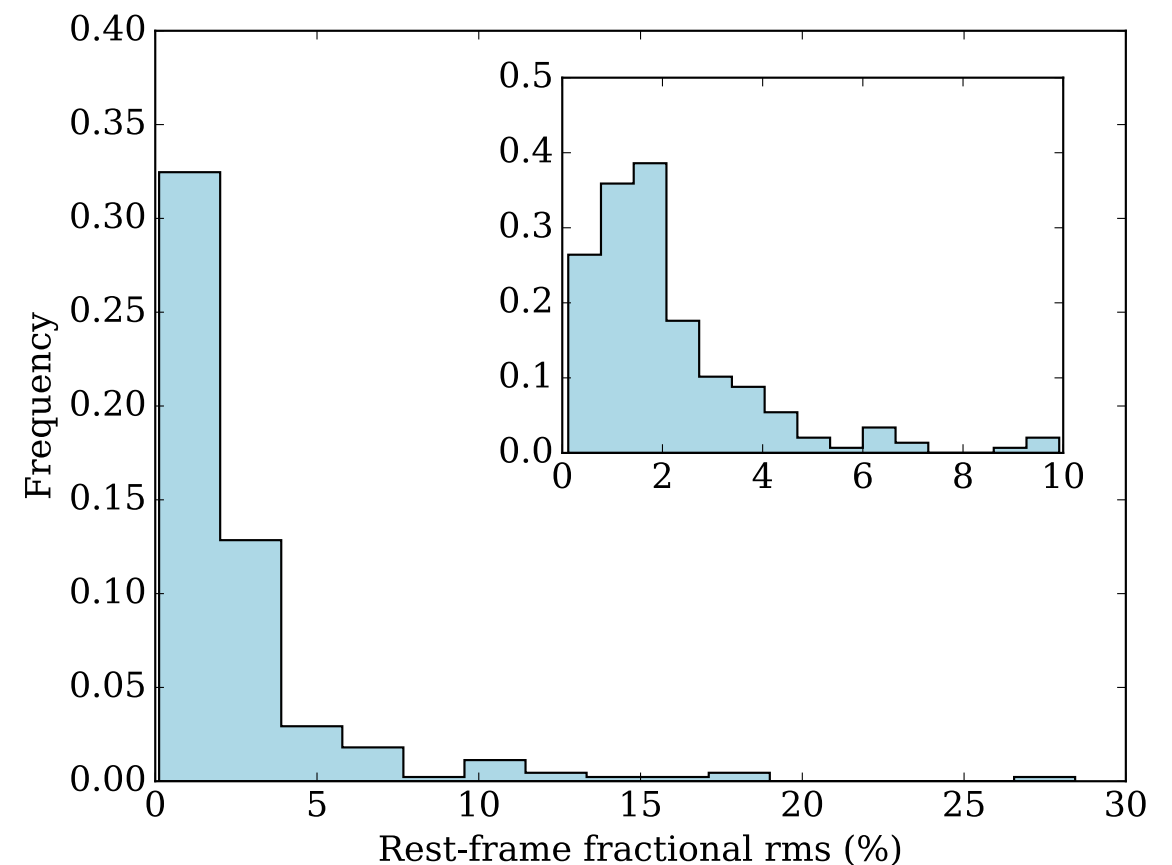
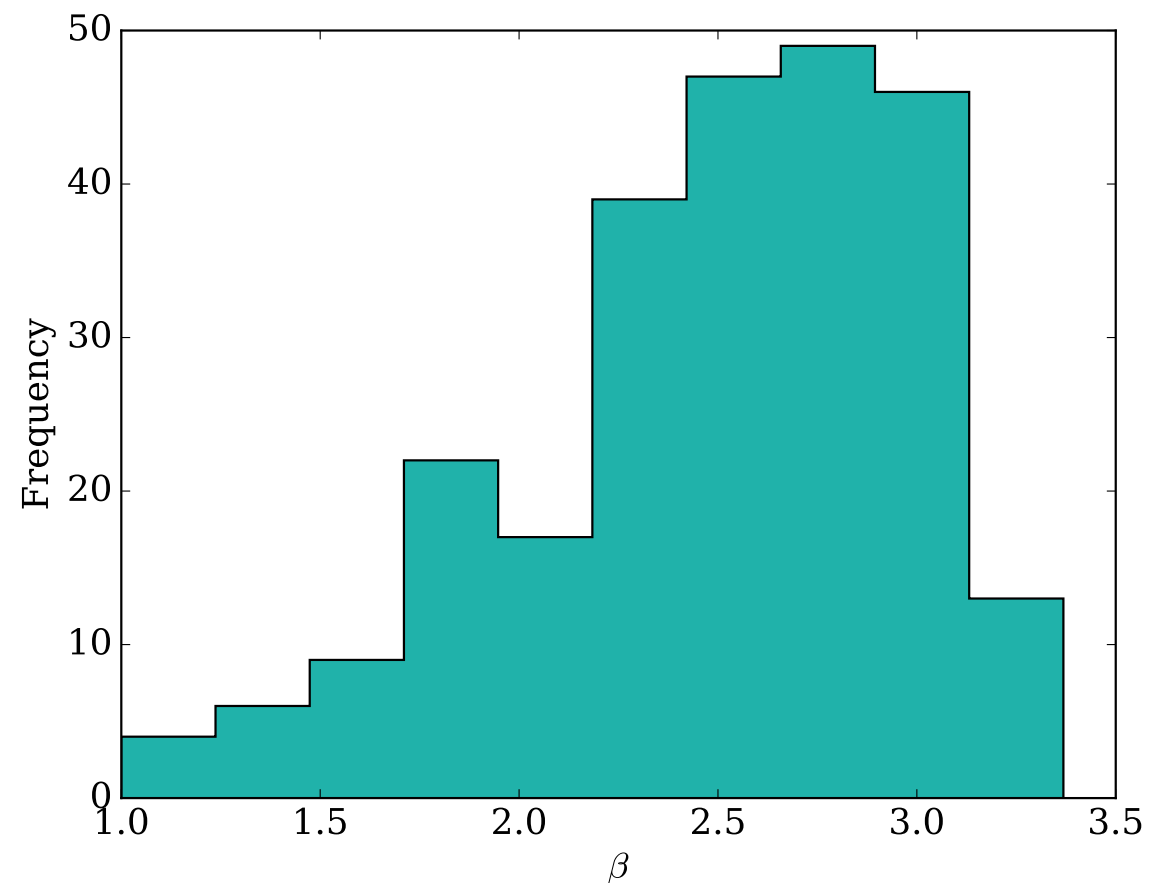
Results

- Steep PL -2.5, steeper than X-ray PSDs



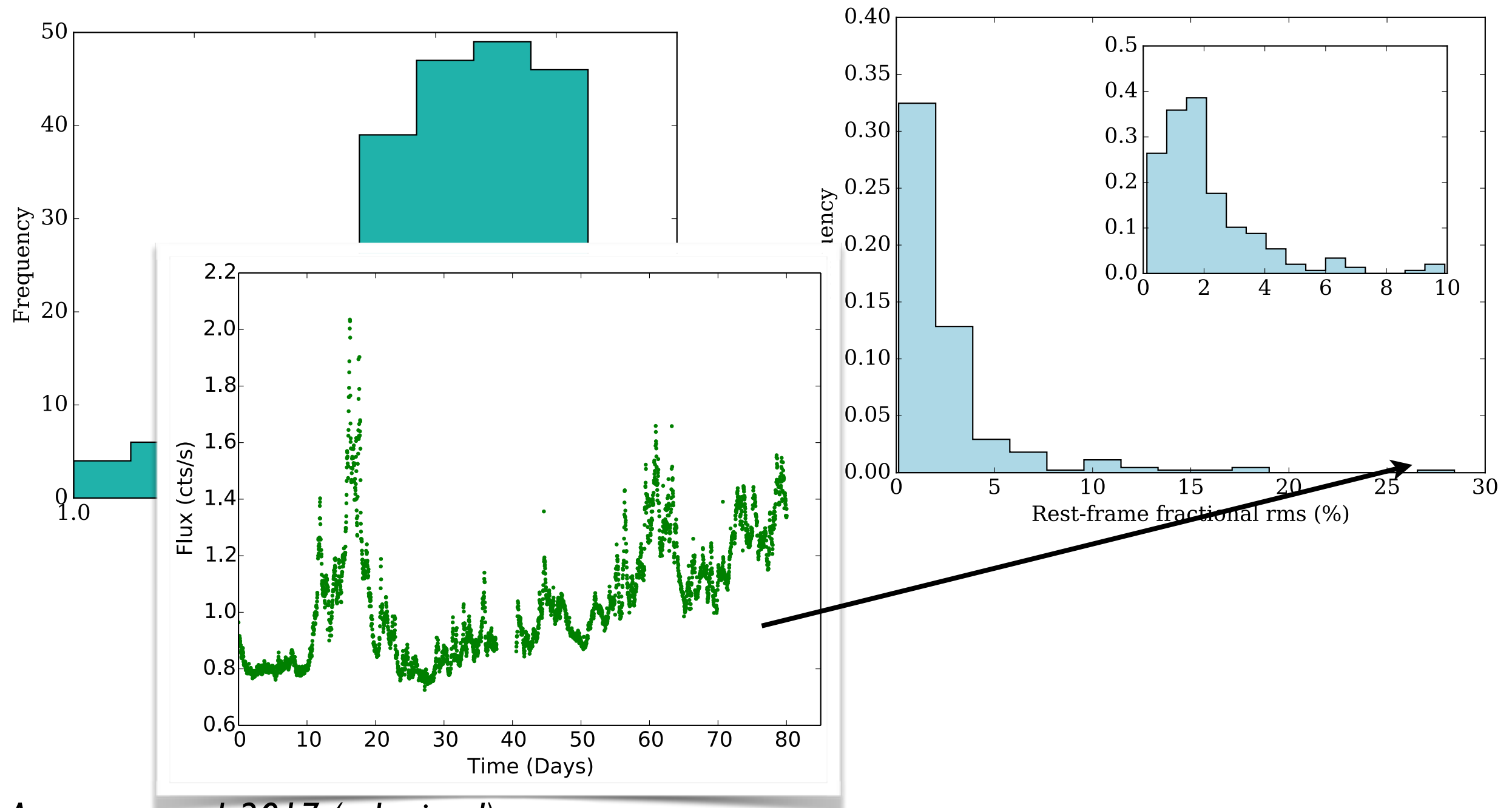
Results

- Steep PL -2.5, steeper than X-ray PSDs
- The amplitude of variability is 2.6 %



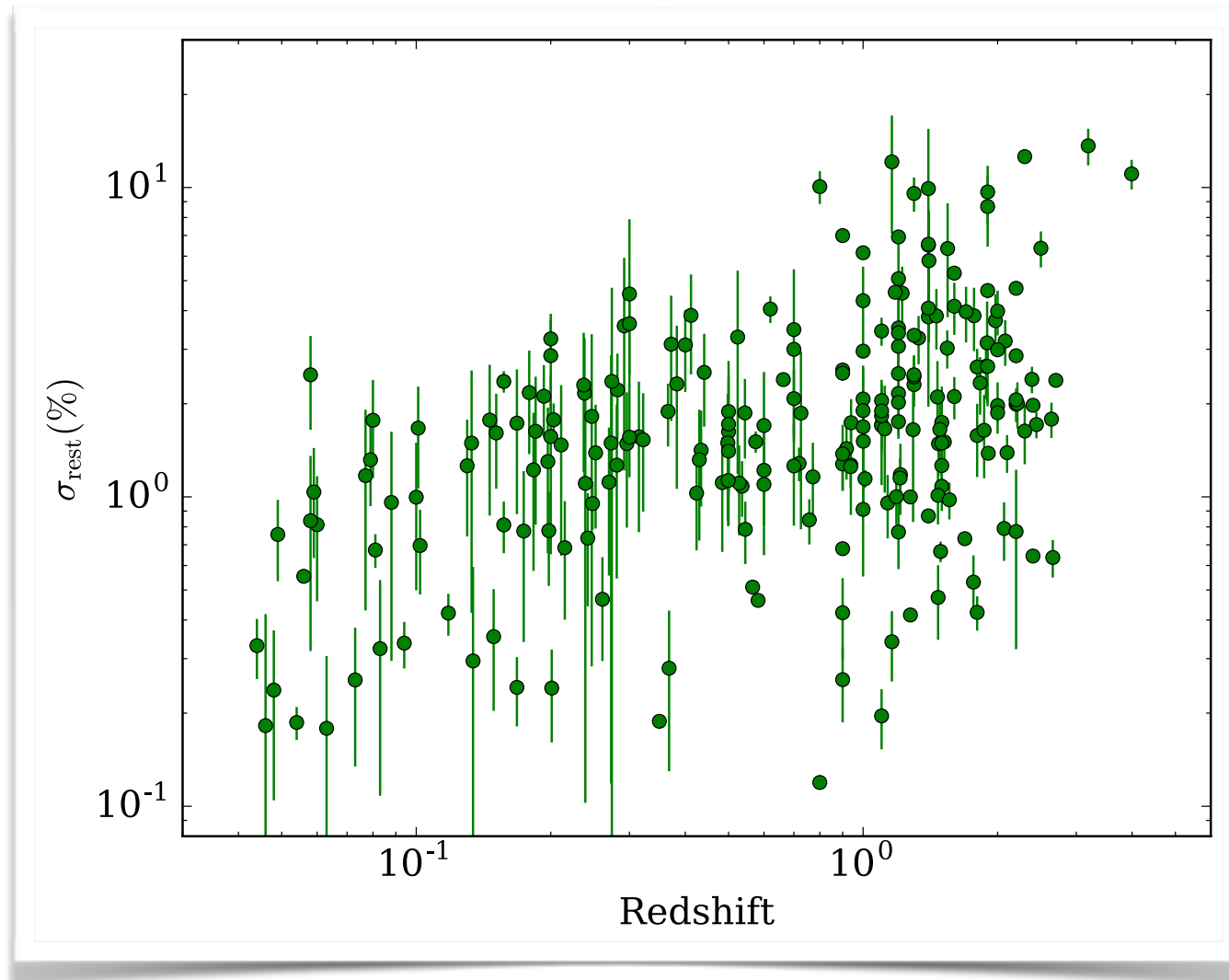
Results

- Steep PL -2.5, steeper than X-ray PSDs
- The amplitude of variability is 2.6 %



Aranzana et al. 2017 (submitted)

Cosmological evolution of AGN?



It is attributed to a wavelength dependence of the variability

Aranzana et al. 2017 (submitted)

Summary

- ◆ First AGN catalogue with K2
- ◆ PSDs of Kepler AGN are well described by a PL model
- ◆ PSDs steeper than the PSDs in X-rays
- ◆ Correlation amplitude of variability and redshift associated to wavelength dependence
- ◆ No anti-correlation found between the variability and the bolometric luminosity
- ◆ Short-time optical variability studies are excellent to identify blazars and confirm AGN candidates

Follow-up:
Correlations with black hole mass, radio loudness...

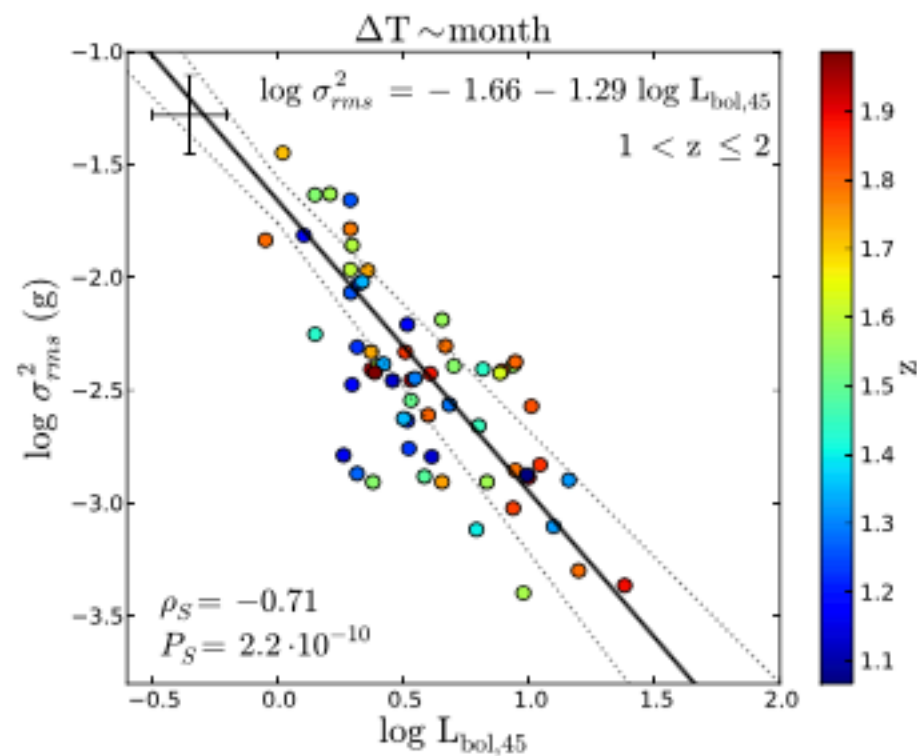
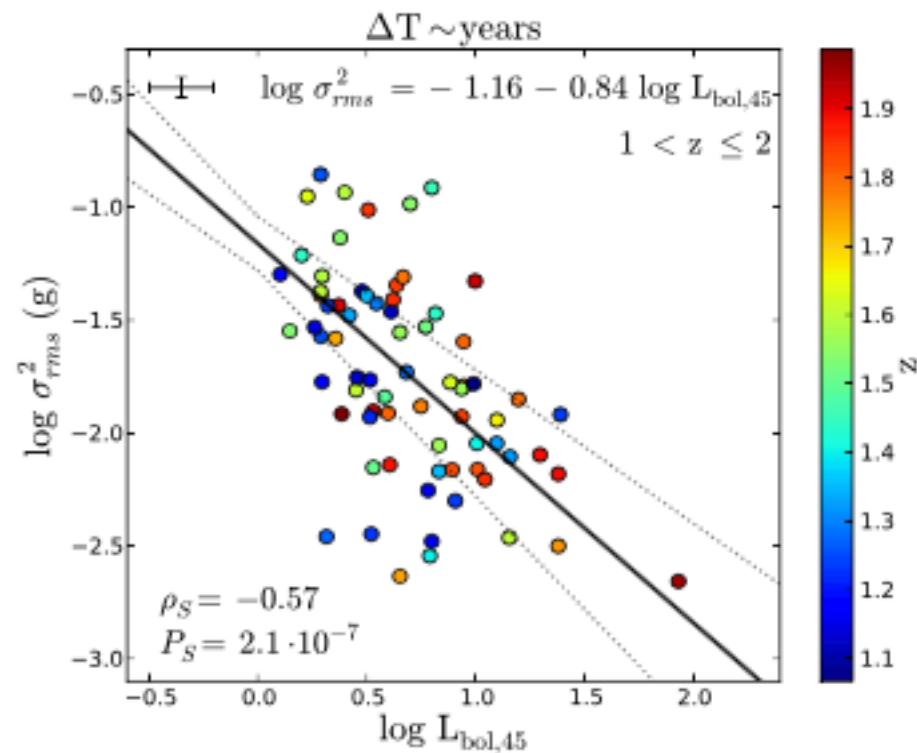
Difference with X-ray PSDs

Associated to two effects:

- Viscous damping of high-frequency fluctuations
- Filtering effect of the extended region observed with Kepler

see Arevalo & Uttley 2006

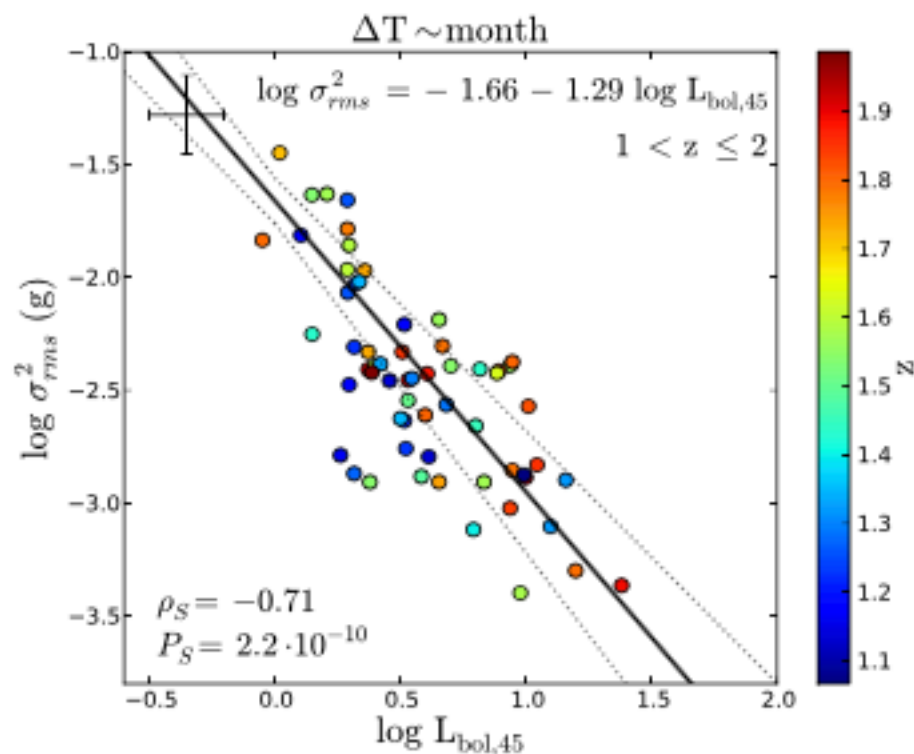
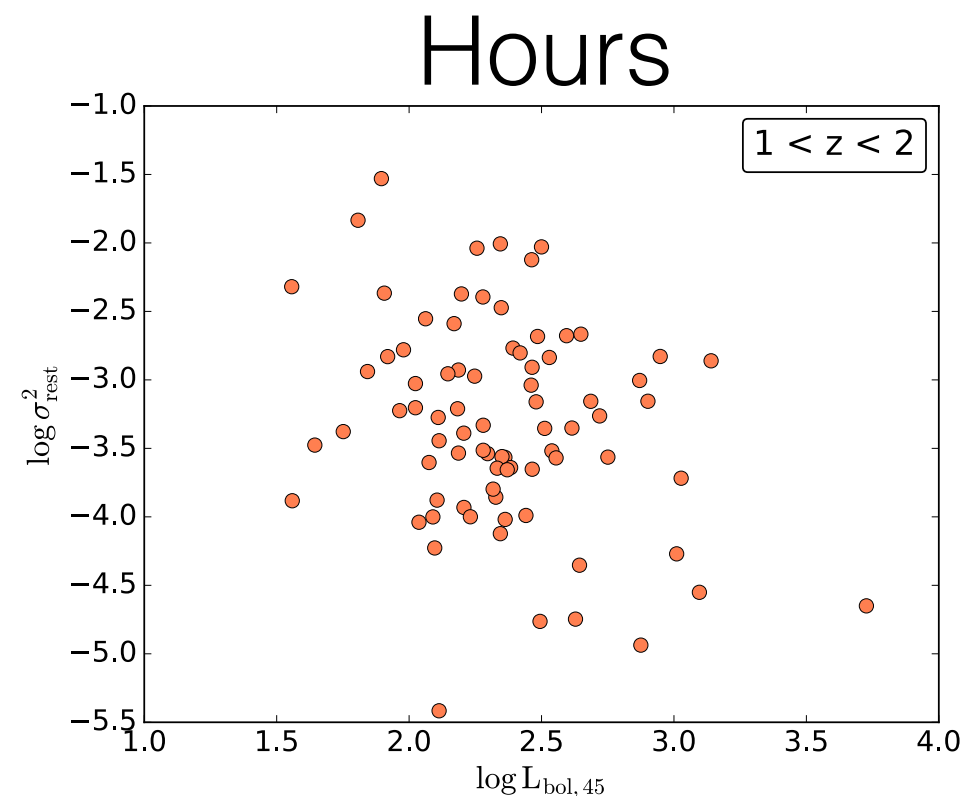
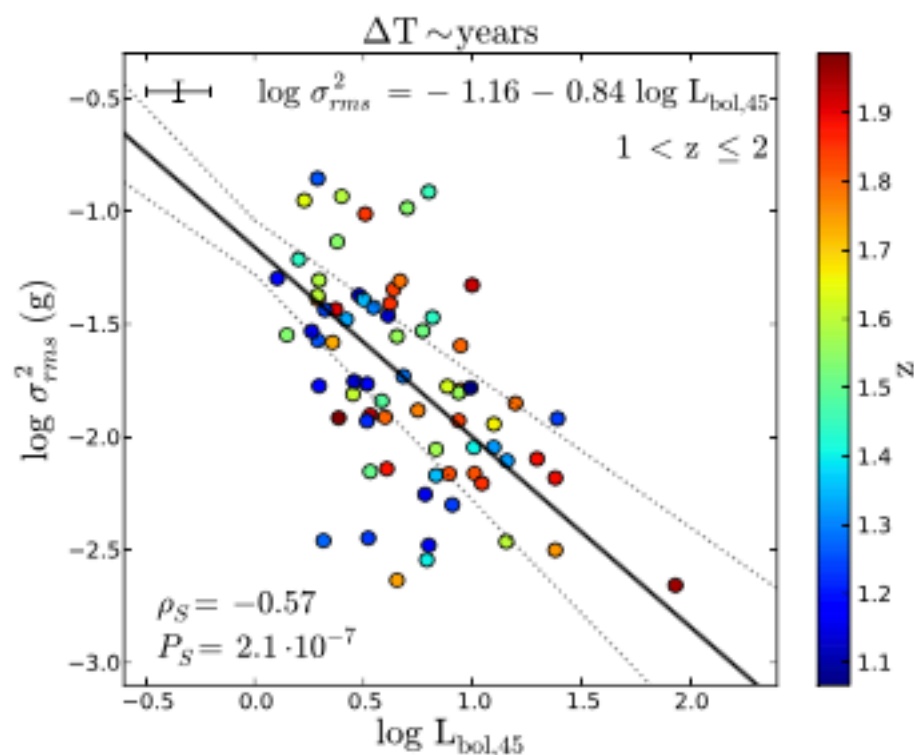
Anti-correlation with bolometric luminosity?



Simm et al. 2015

Aranzana et al. 2017 (submitted)

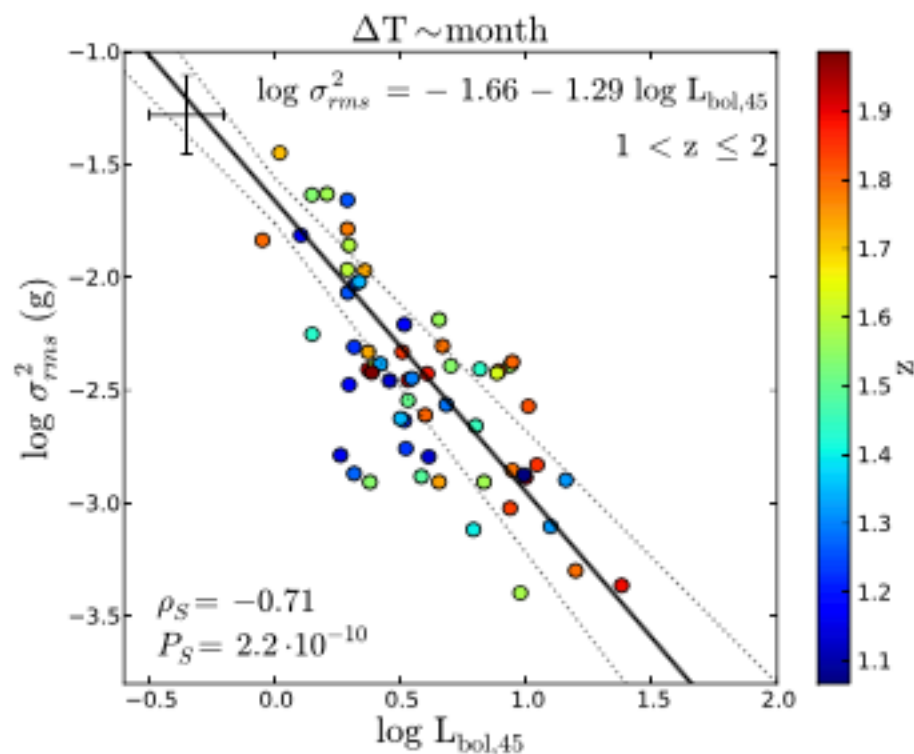
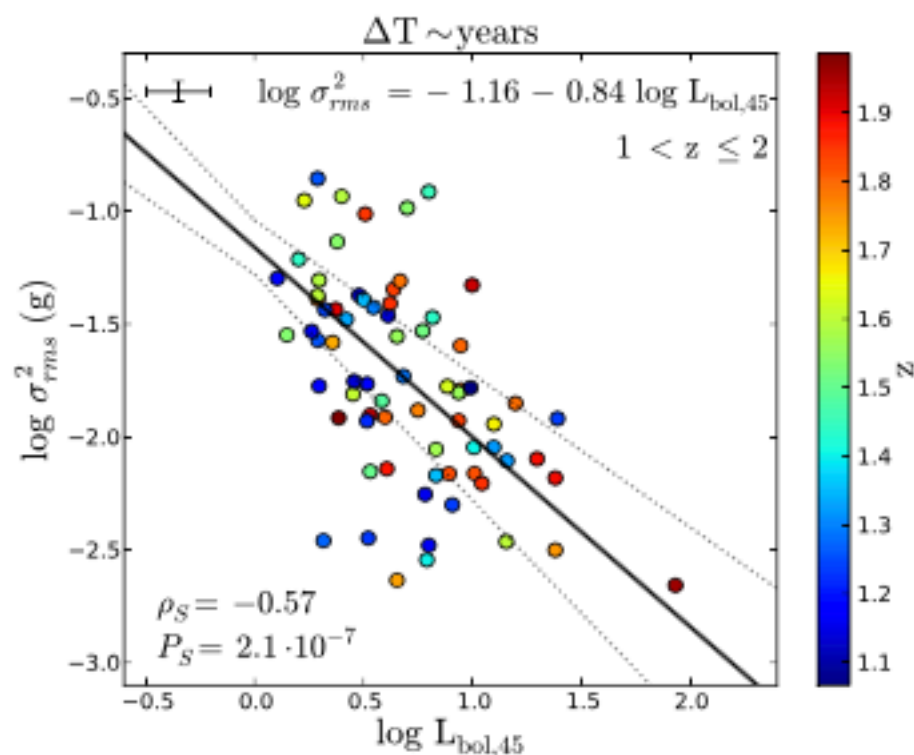
Anti-correlation with bolometric luminosity?



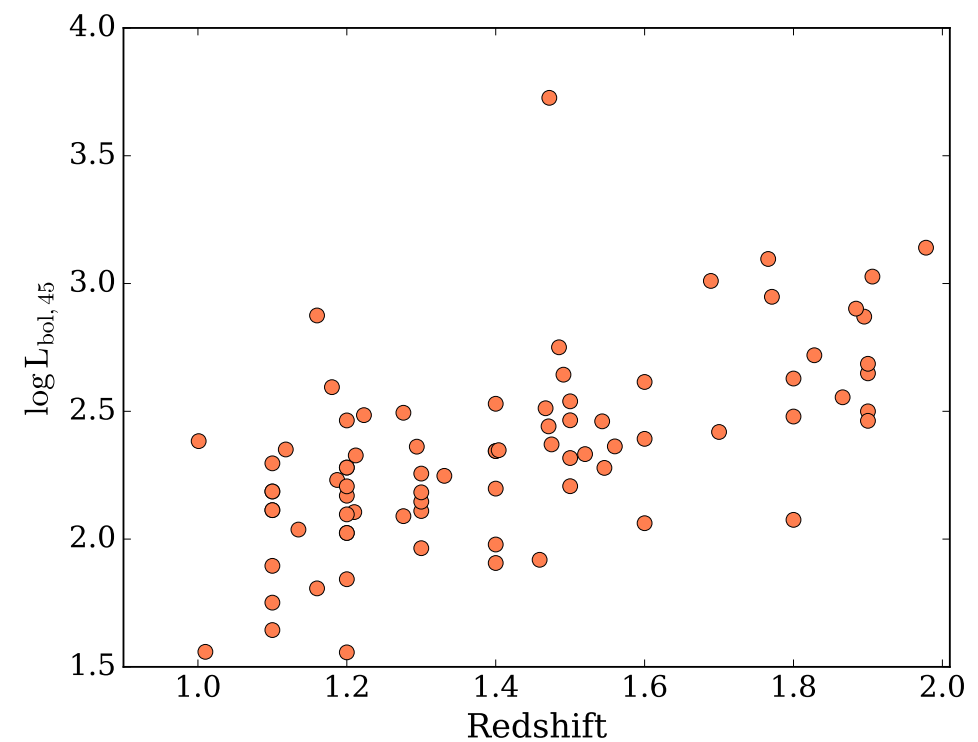
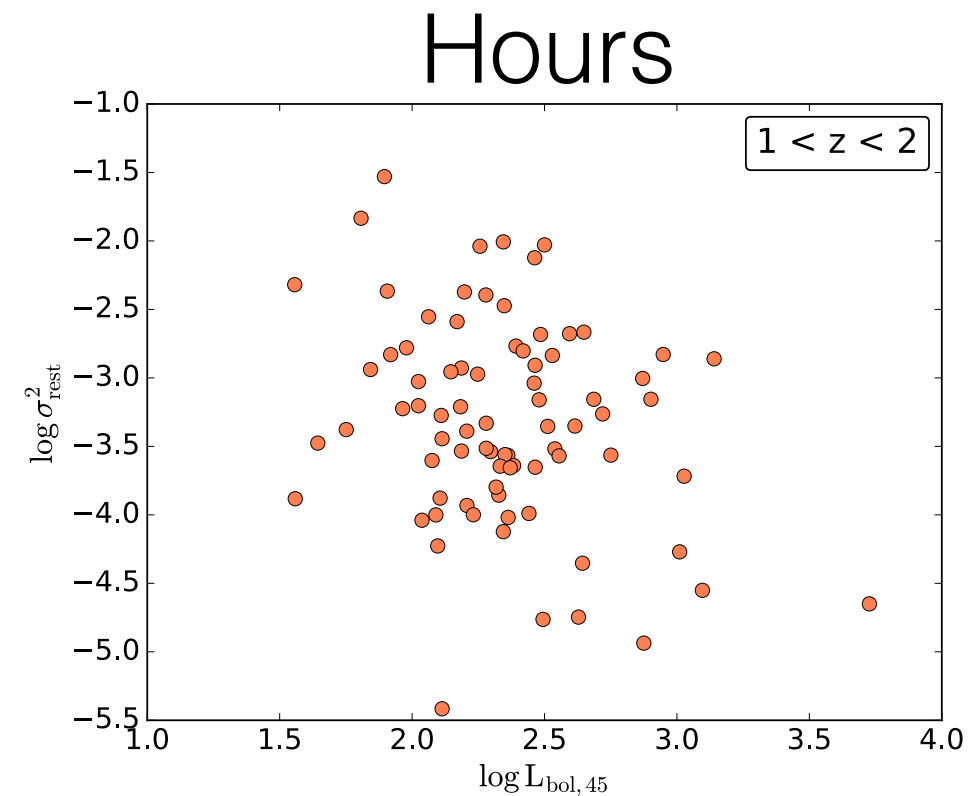
Simm et al. 2015

Aranzana et al. 2017 (submitted)

Anti-correlation with bolometric luminosity?



Simm et al. 2015



Aranzana et al. 2017 (submitted)