Quasar variability at 850 microns

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ASIAA

Quasar submm emission

Probes regions of event-horizon scale, at least in nearby low-luminosity AGNs (Doeleman et al. 2008, 2012a,b)

Possible connection to NIR flares, with delay

- Possibly caused by adiabatically expanding plasma, producing NIR flare then submm emission at larger scale
- However, not always observed: maybe submm emission is a combination of outflowing and accreting gas

Data

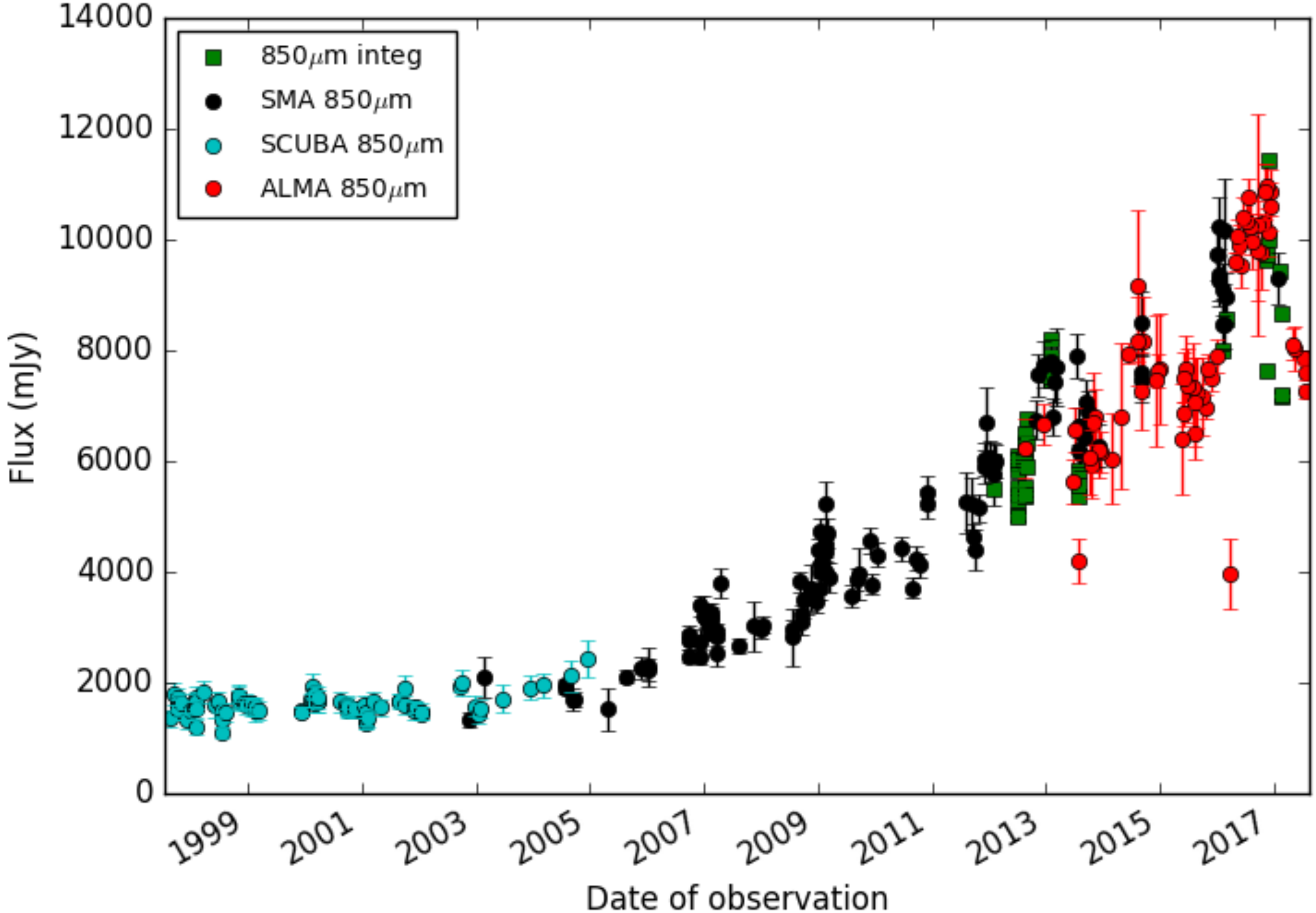
850um data from JCMT SCUBA2 continuum pointing sources − not previously been combined or published

Publically available SCUBA, SMA, ALMA data

Three often-observed sources: 3C273, 3C279, and 3C84

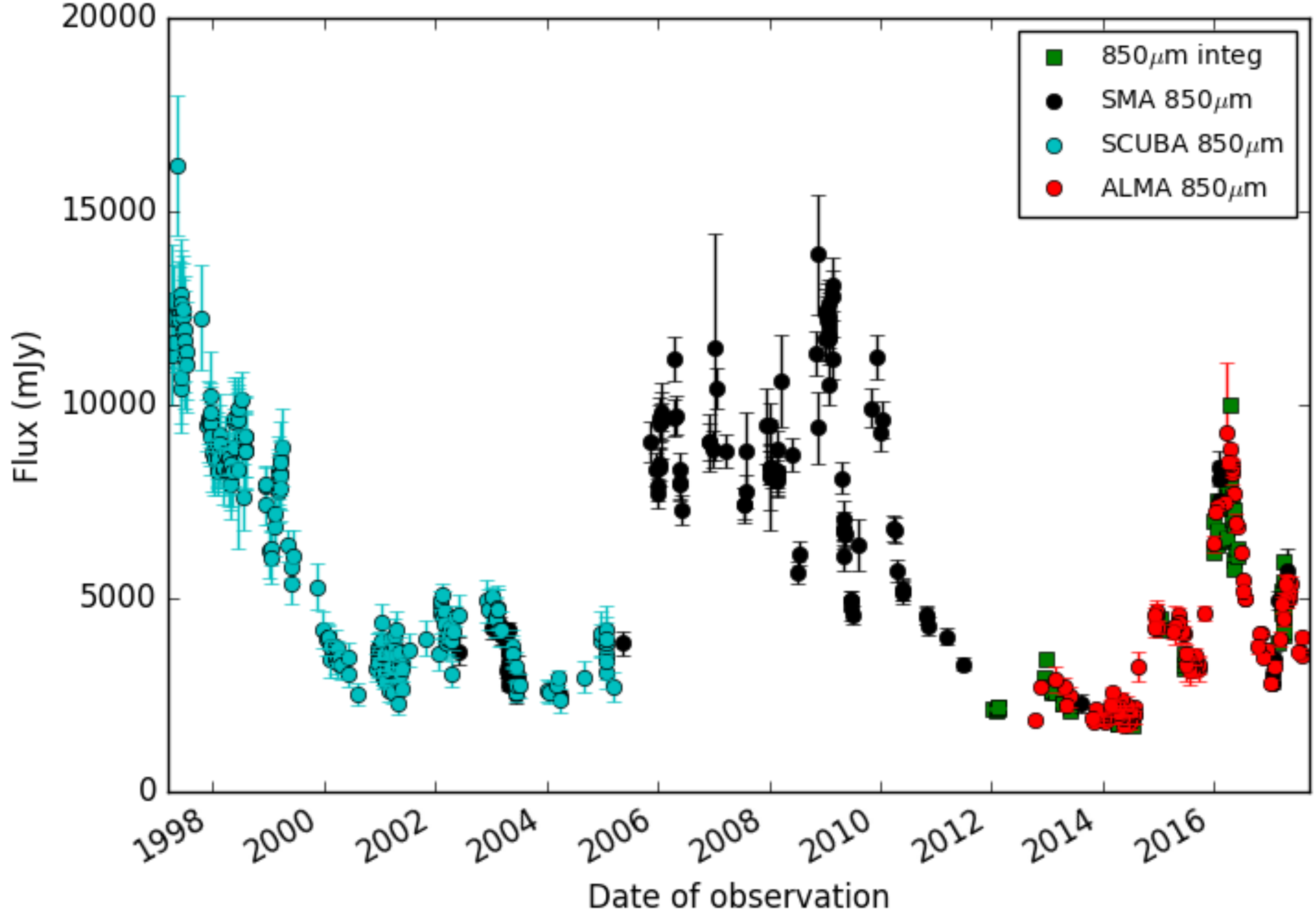
20-year time-series, around 300-600 data points per source

3C84



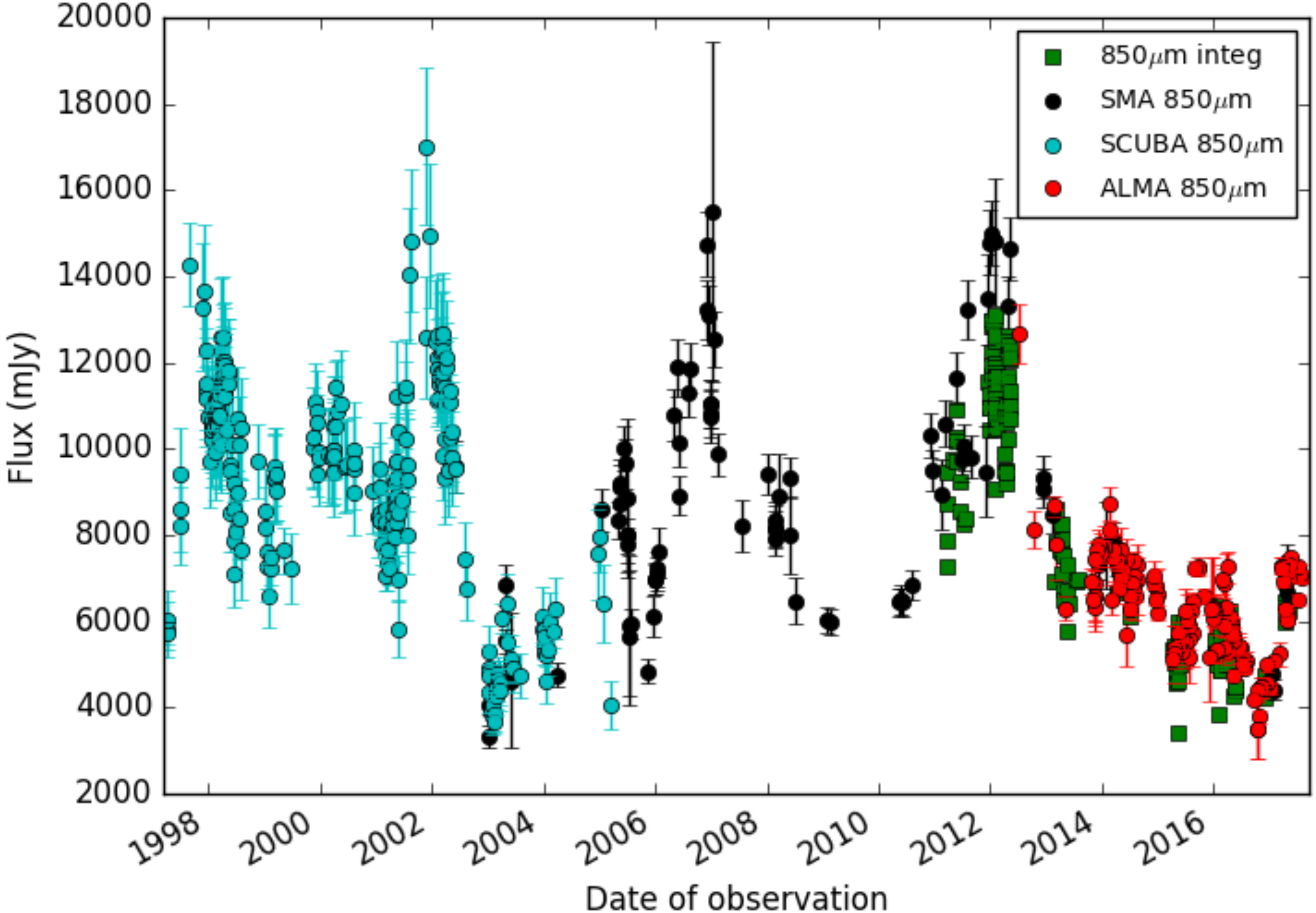
850μm integ
SMA 850μm
SCUBA 850μm
ALMA 850μm
14000
12000
10000
8000
6000
4000
2000
0
Flux (mJy)
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Date of observation

3C273



Flux (mJy)
20000
15000
10000
5000
0
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date of observation
850μm integ
SMA 850μm
SCUBA 850μm
ALMA 850μm

3C279



850μm integ
SMA 850μm
SCUBA 850μm
ALMA 850μm
Flux (mJy)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date of observation

DRW modeling

Damped Random Walk (DRW) characterised by short-term variability and long-term stability

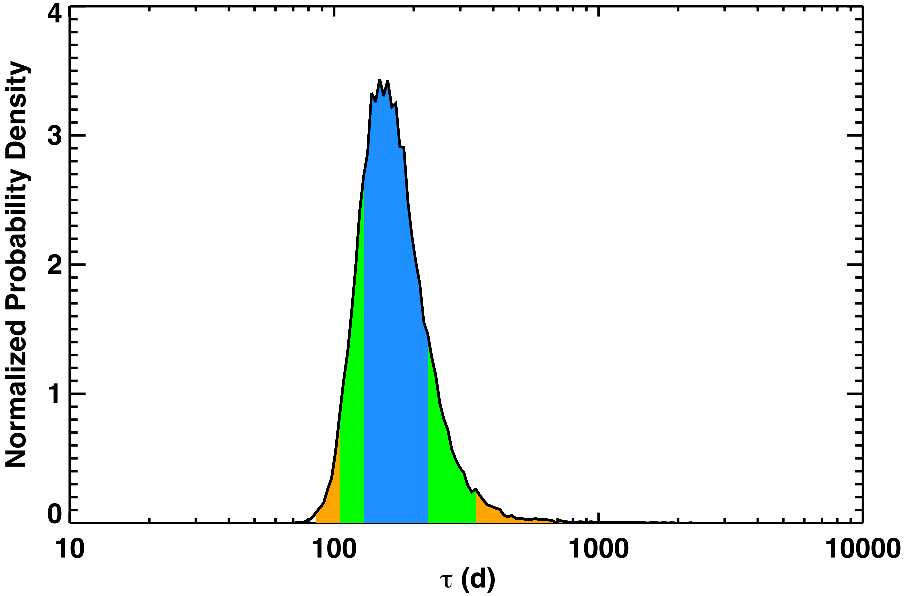
- Red noise at short times and white noise on long timescales
- Characteristic timescale τ where noise characteristics change
- Corresponds to a maximum fluctuation scale

Constrain τ for 3C279 to be 160^{+60}_{-40} days (1σ errors)

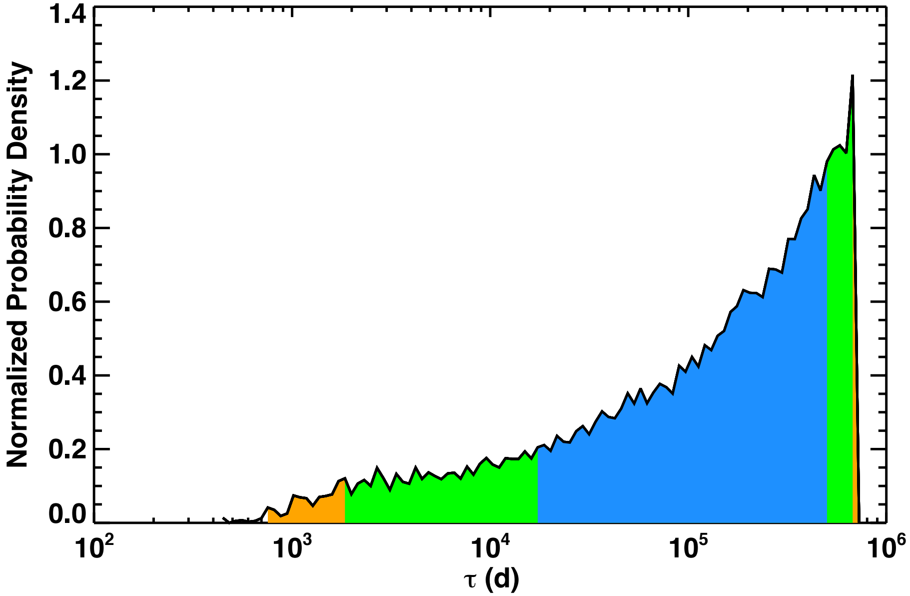
- For the others find only lower limits: $\tau > 300$ days and $\tau > 1000$ days for 3C273 and 3C84, respectively

DRW model results

3C279



3C84



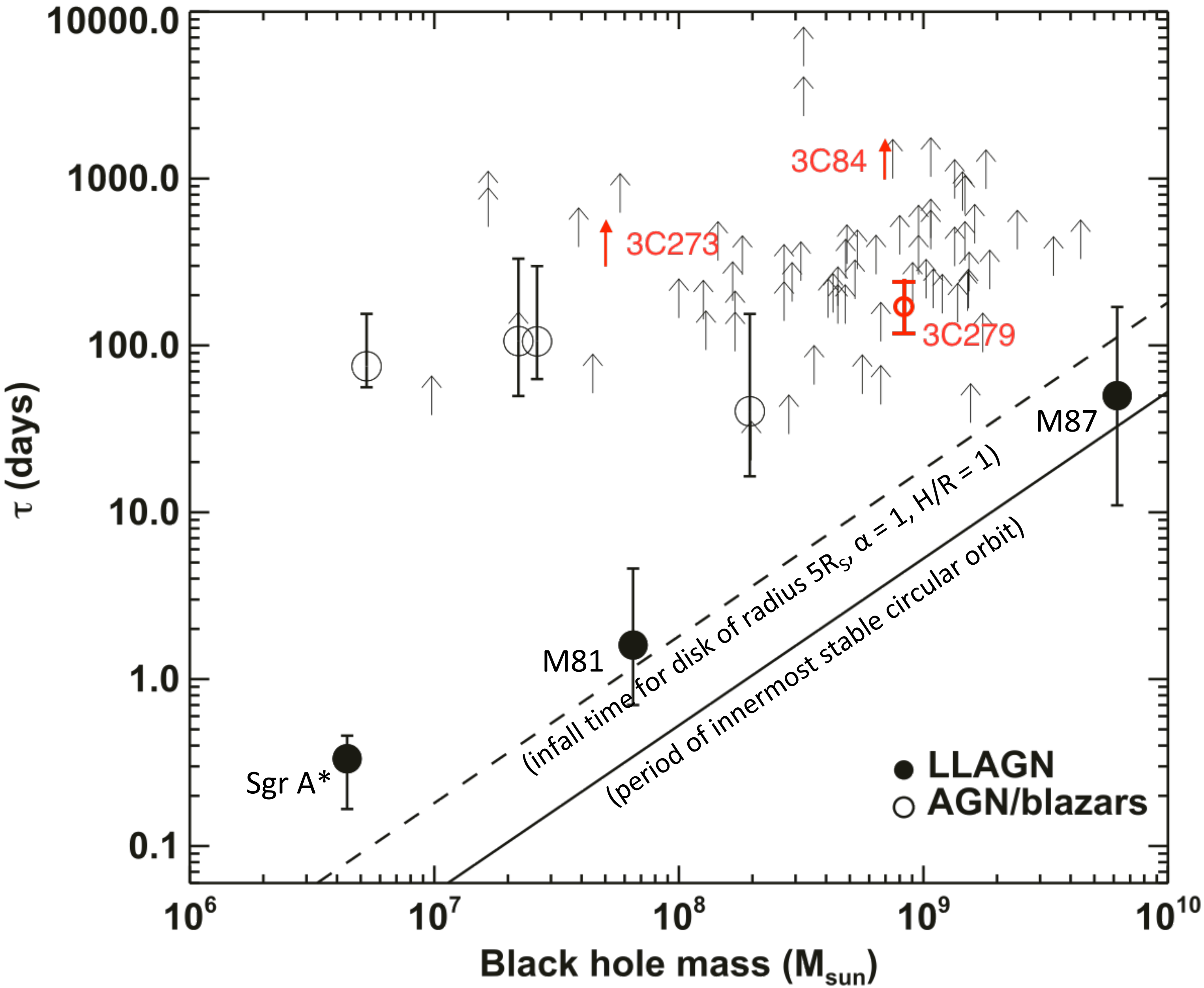
Characteristic timescales

Bower et al. 2015 found a linear correlation between τ and black hole mass for three low-luminosity AGNs (Sgr A*, M81, M87)

- Surprising coherence between sources with vastly different scales, environments, and physical properties
- Time scale effectively tells you the radius at which the variability originates; close to the event horizon
- In Sgr A*, τ consistent with the viscous timescale (~10 orbital times)

Higher-luminosity AGNs show larger τ (mainly lower limits) and no clear correlation with M_{BH}

- Emission originates further from the event horizon; may be due to optical depth or relativistic outflow in the jet



Bower et al. 2015, Figure 4. SMA quasar data (1.3mm)

Result & Extension

Our data is consistent with Bower et al. 2015

- ~2x longer timeseries
- Smaller errorbars

Working on adding another ~20 sources with sufficient data from SCUBA/SMA/ALMA/SCUBA2

- Measure many more τ
- Improved uncertainties will constrain potential correlation with M_{BH}

Damped random walk model

Model quasar light curves as continuous time first-order autoregressive process (see Kelly et al. 2009; Dexter et al. 2014)

- E.g. power spectra are a first-order autoregressive process
- Continuous time: natural way to handle irregular sampling

DRW described by a stochastic differential equation

$$dX(t) = \frac{1}{\tau} X(t)dt + \sigma\sqrt{dt}\varepsilon(t) + bdt$$

- X(t) = quasar flux, with mean $b\tau$ and variance $\tau\sigma^2/2$
- τ = characteristic timescale
- $\varepsilon(t)$ = a white noise process with zero mean and unit variance
- σ = variability on short timescales