XMM-Newton X-ray Universe Conference
Dublin, Ireland
18 June 2014

Iron K Reverberation lags with XMM-Newton and NuSTAR

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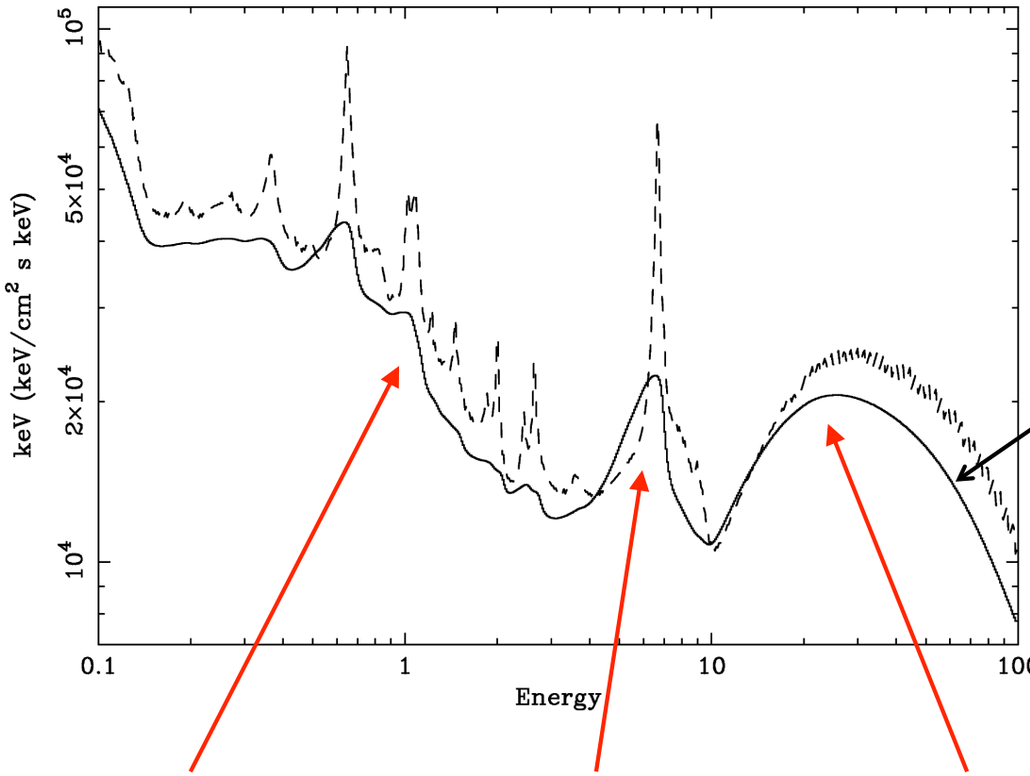
Collaborators: Andy Fabian, Abdu Zoghbi, Ed Cackett, Phil Uttley, Giorgio Matt, Andrea Marinucci, Dom Walton and others from the NuSTAR Science Team

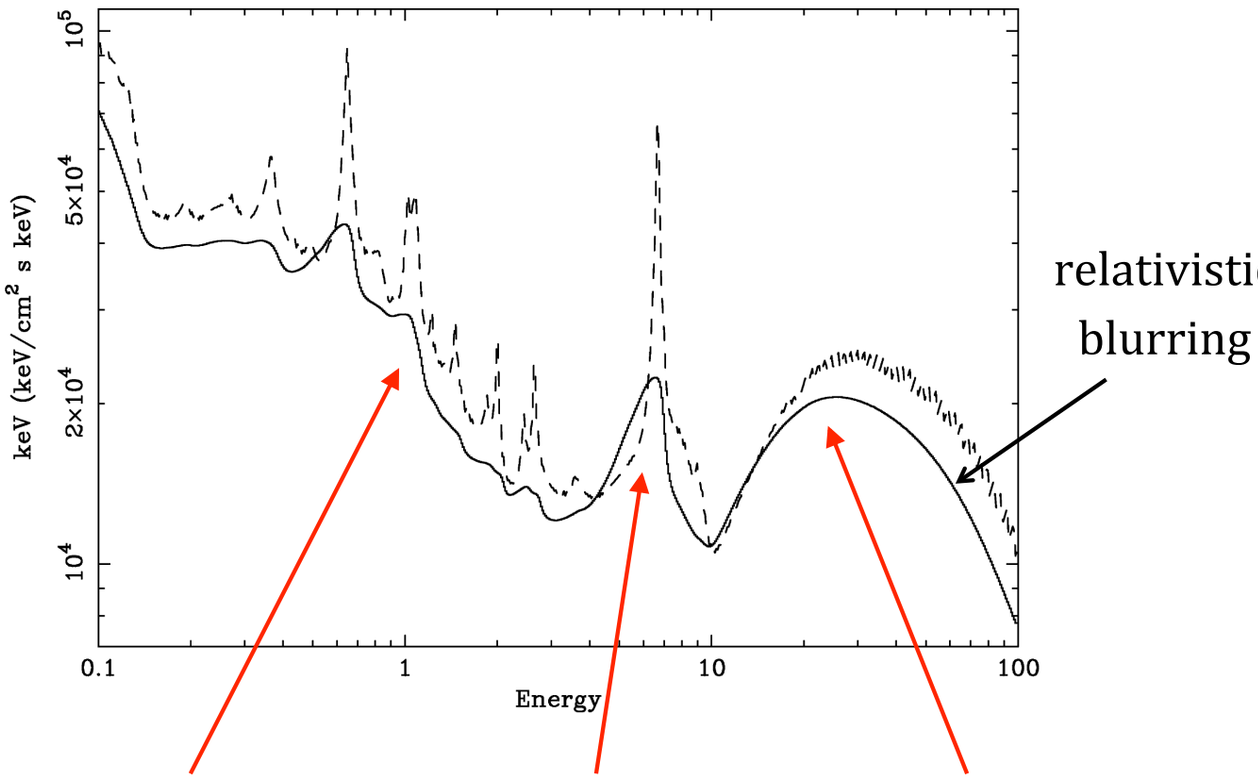
Relativistic Reflection in AGN



relativistic blurring

Soft excess – broad iron line – Compton hump

Relativistic Reflection in AGN



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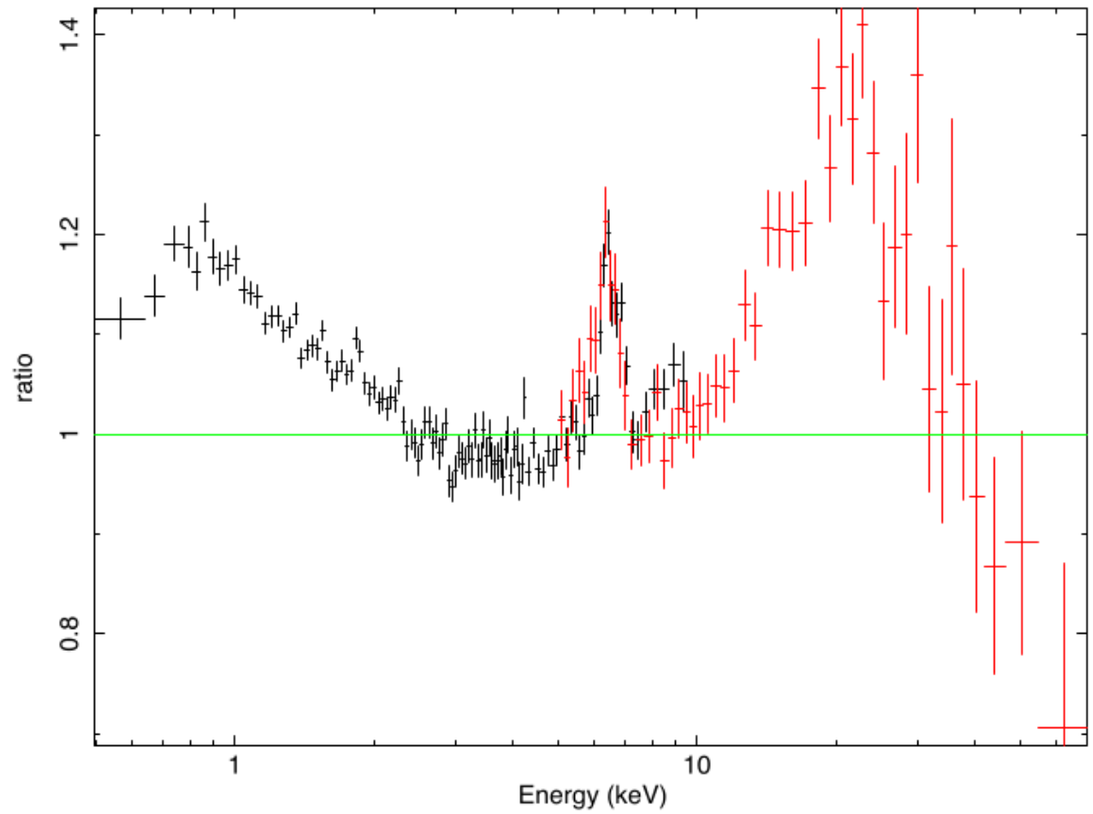
Soft excess – broad iron line – Compton hump

Swift J2127.4+5654

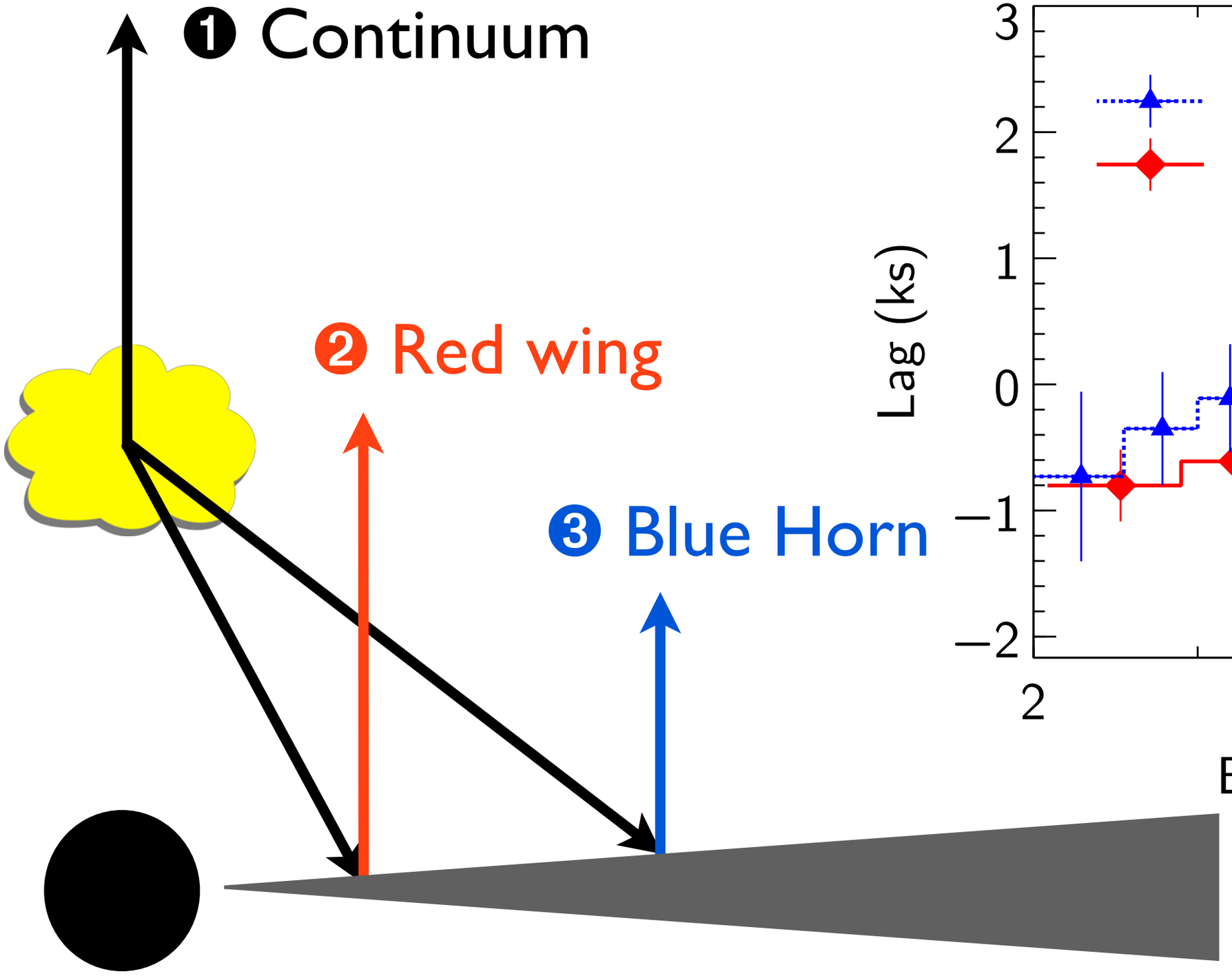
XMM-Newton NuSTAR

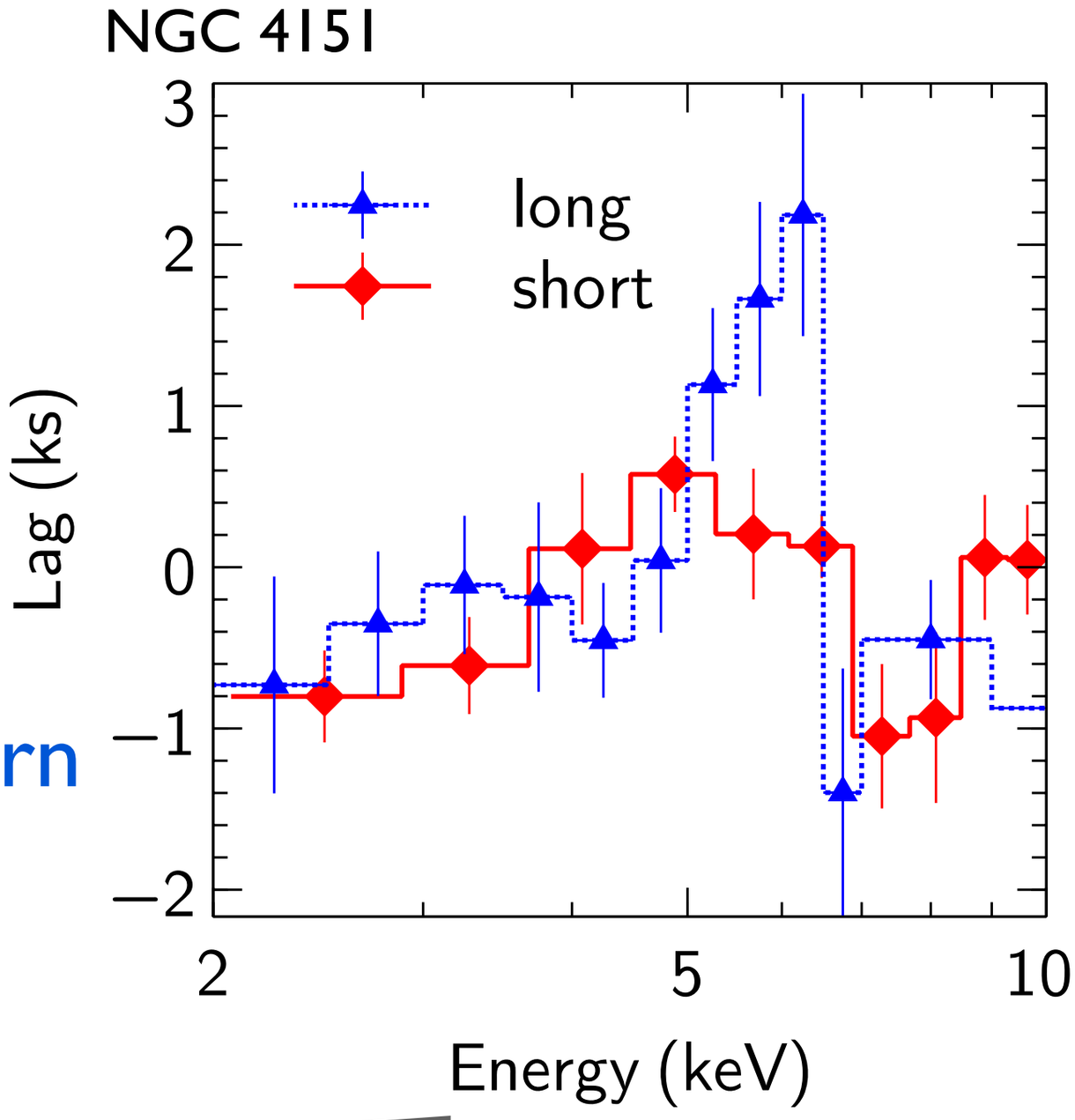


Marinucci+14

See Andrea Marinucci's talk tomorrow

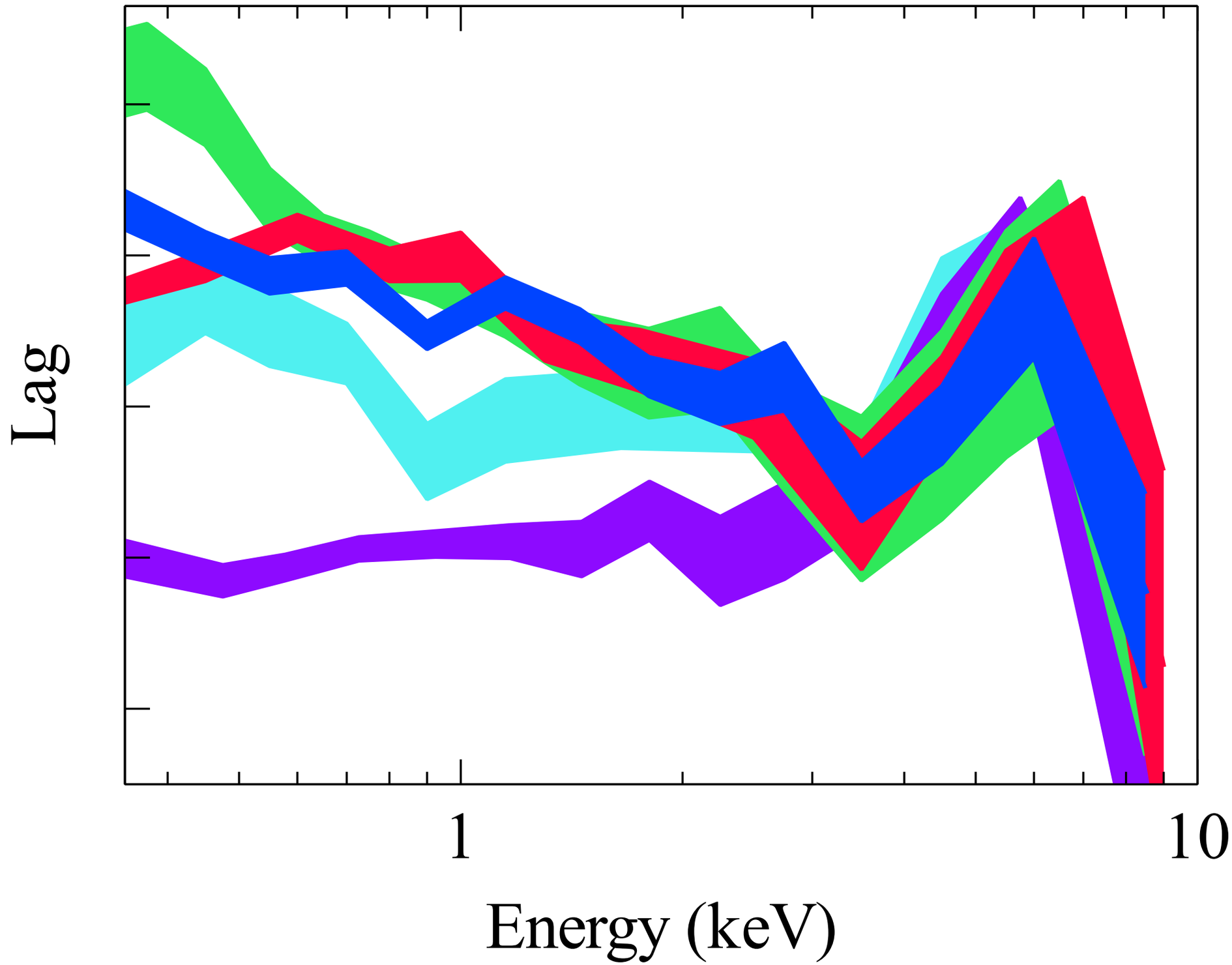
High frequency iron K lags





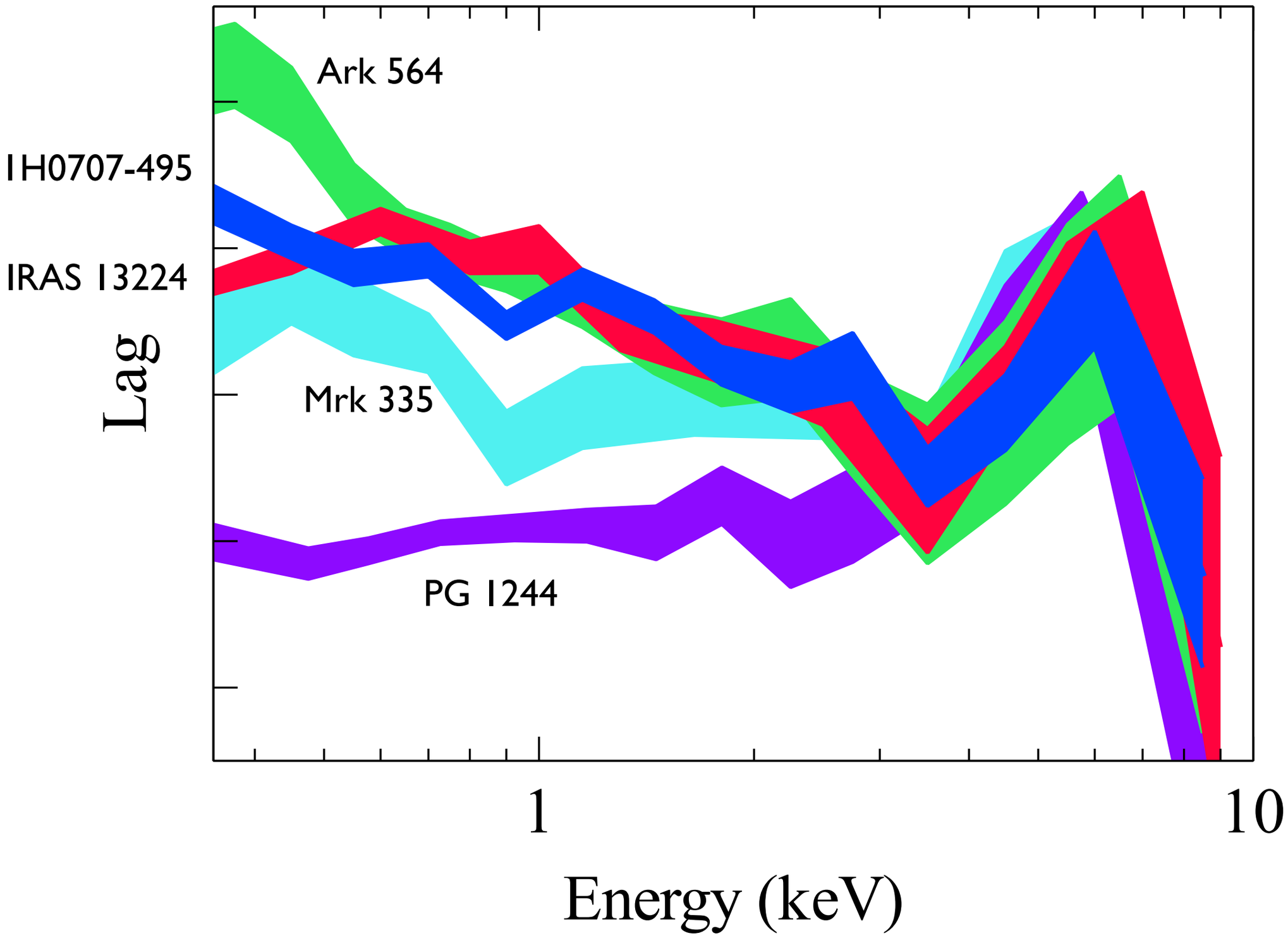
Zoghbi et al 2012

High frequency iron K lags



Uttley, Cackett, Fabian, EK, Wilkins 14
adapted from EK+14

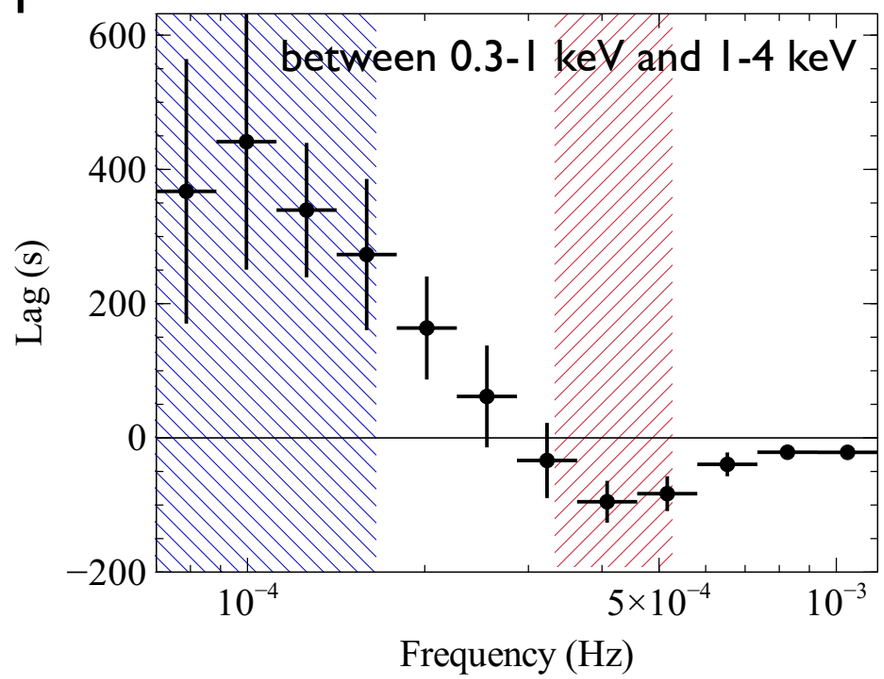
High frequency iron K lags



Uttley, Cackett, Fabian, EK, Wilkins 14
adapted from EK+14

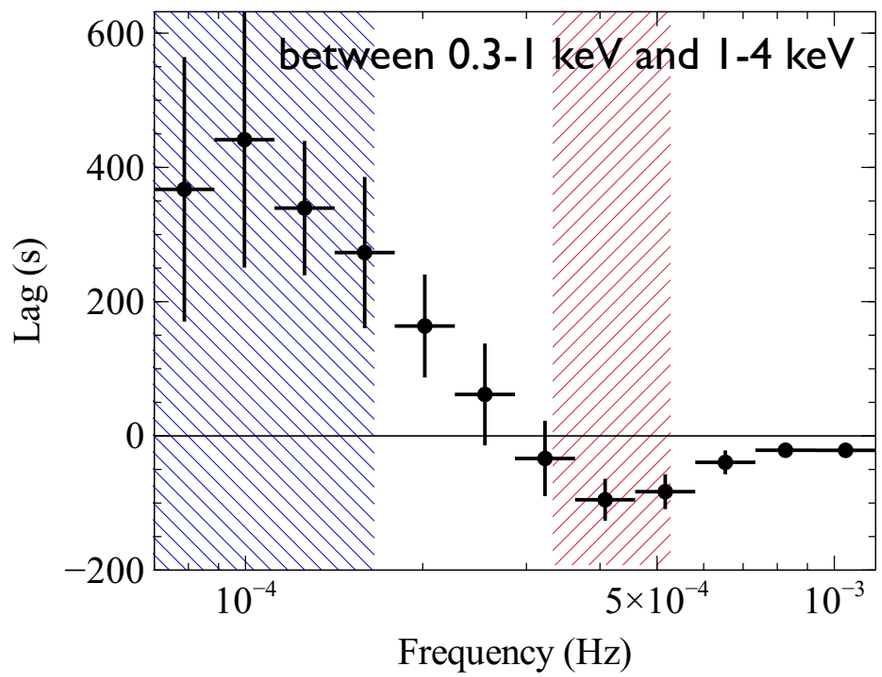
Low-frequency lags

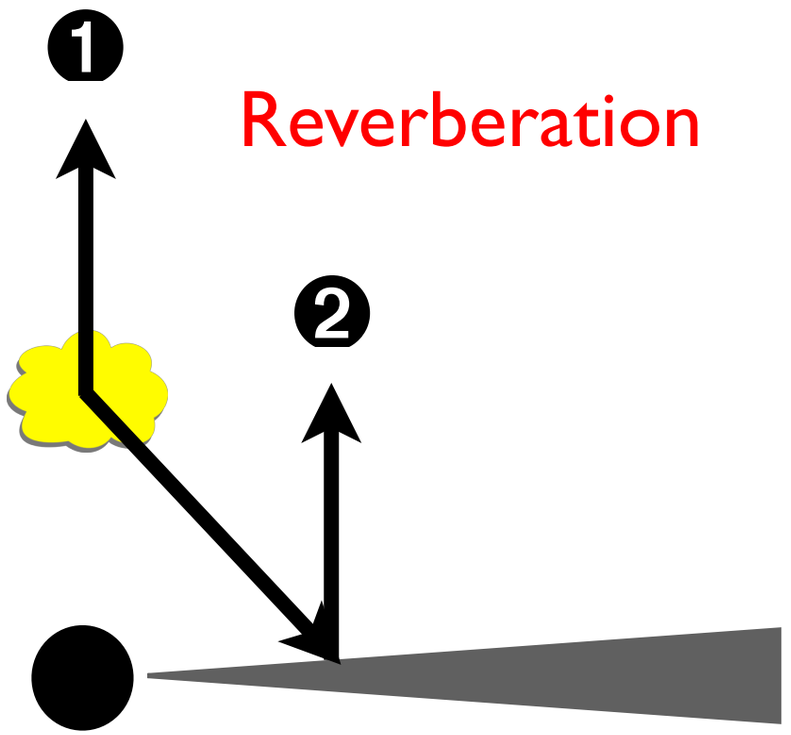
Ark 564



EK+13

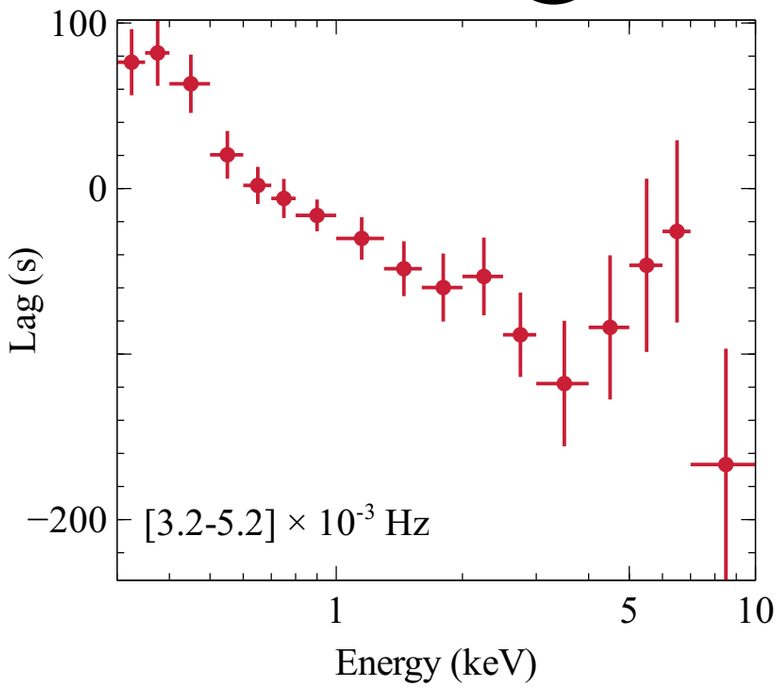
Low-frequency lags





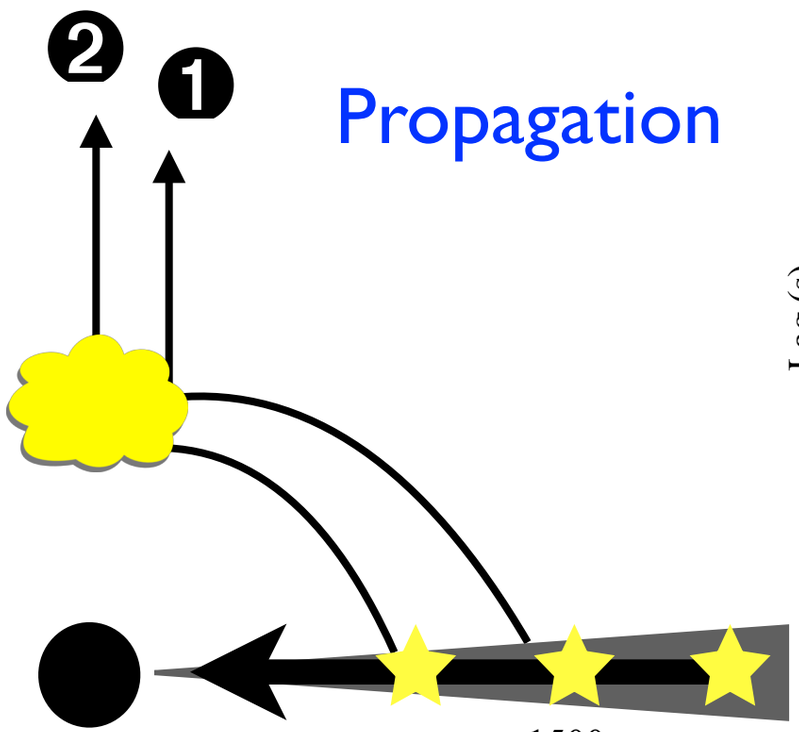
Reverberation

Fabian+09

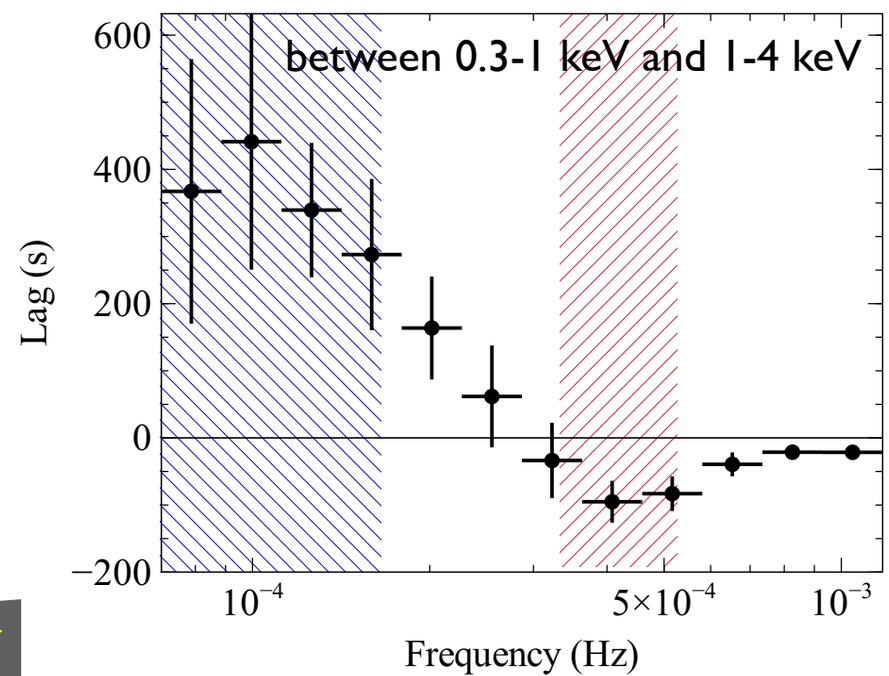


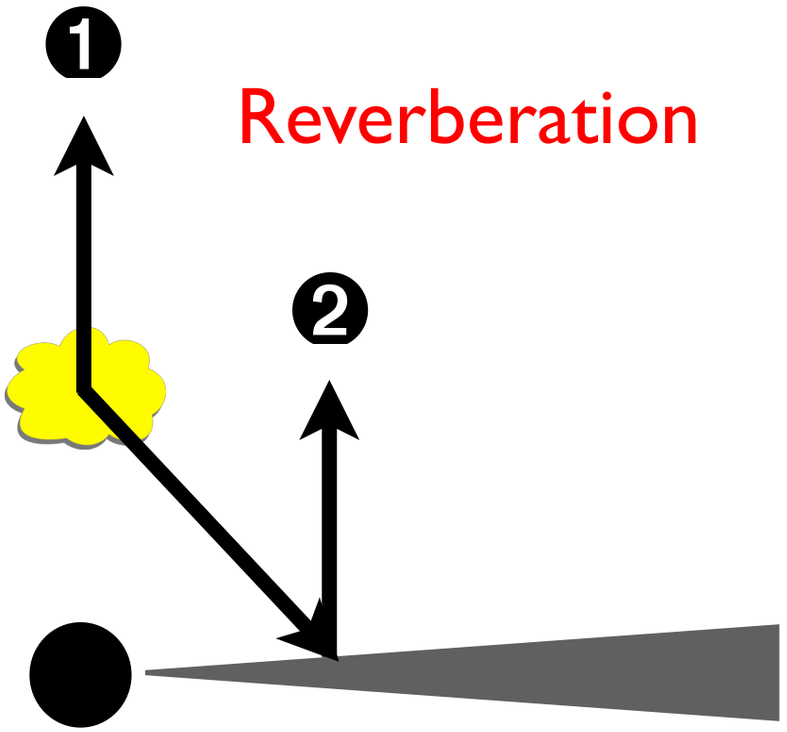
EK+13

Low-frequency lags



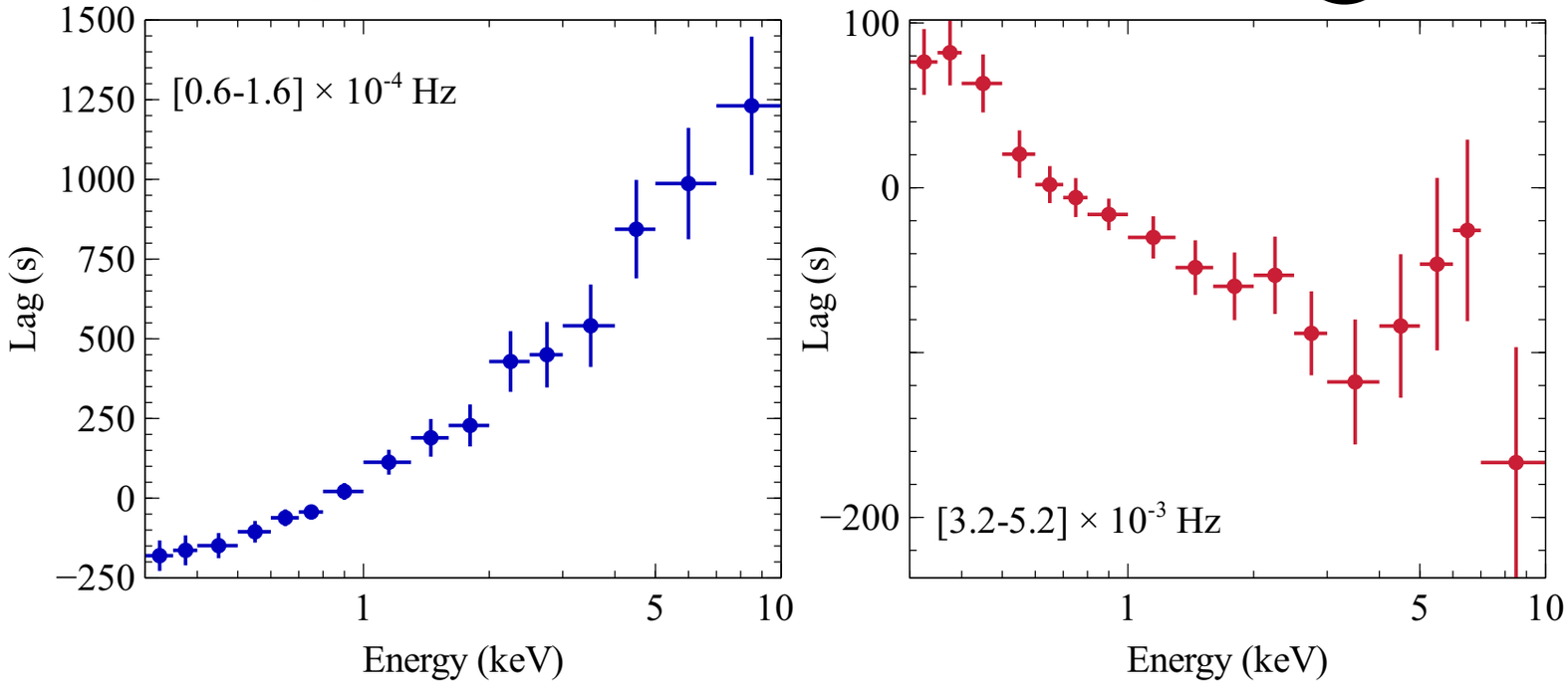
Propagation





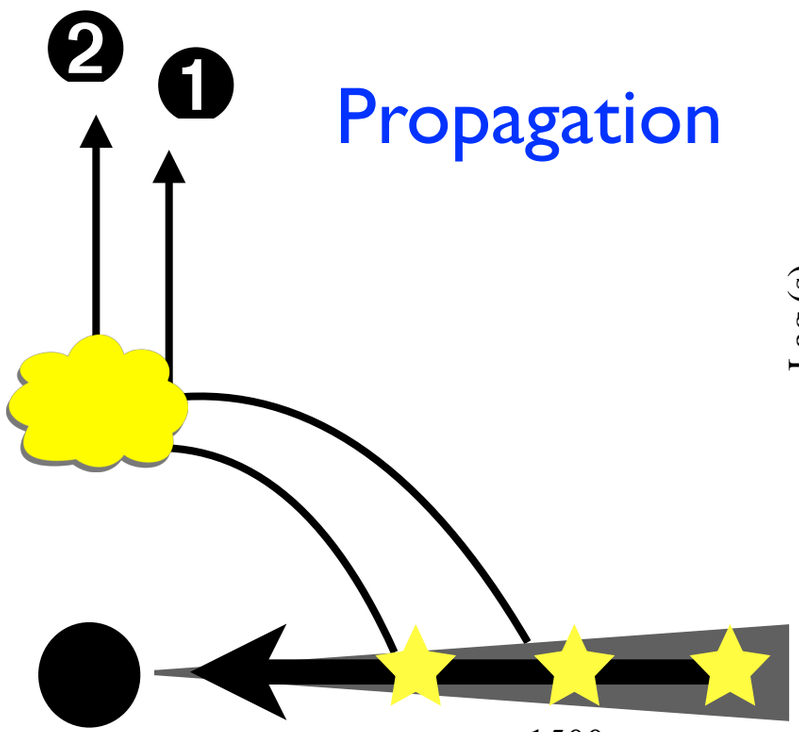
Reverberation

Papadakis+01
Arevalo+Uttley 06

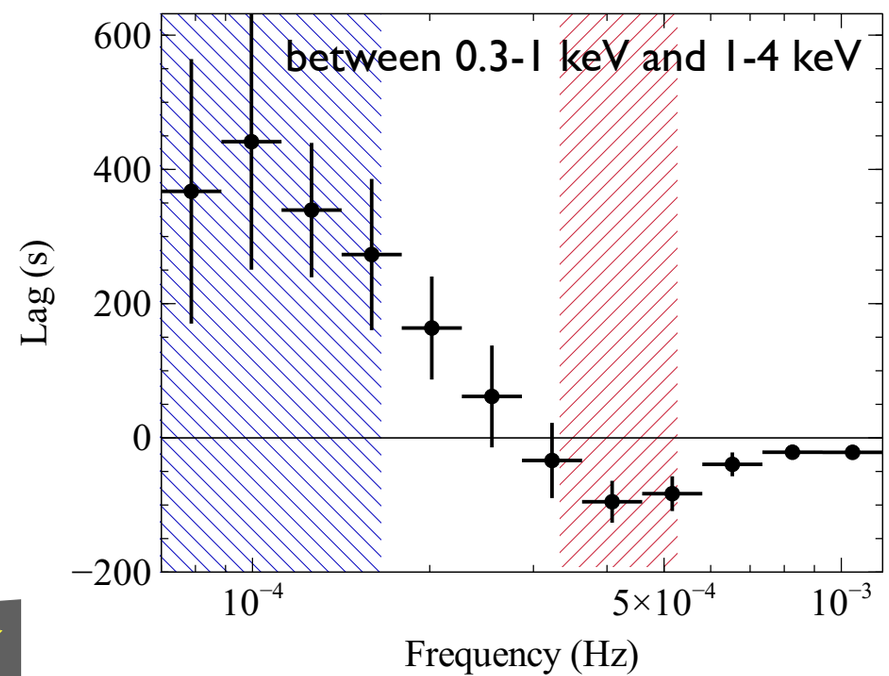


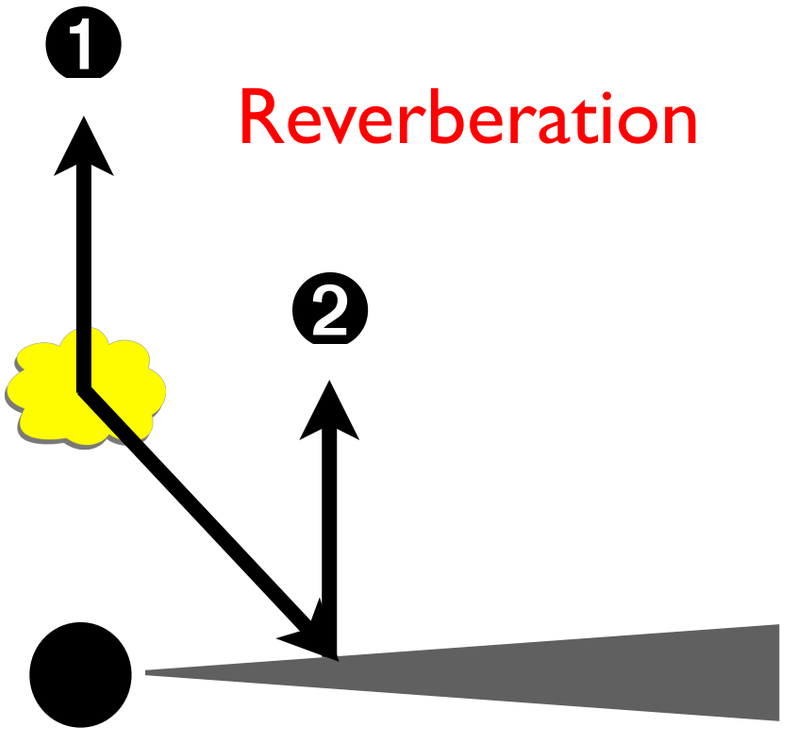
EK+13

Low-frequency lags

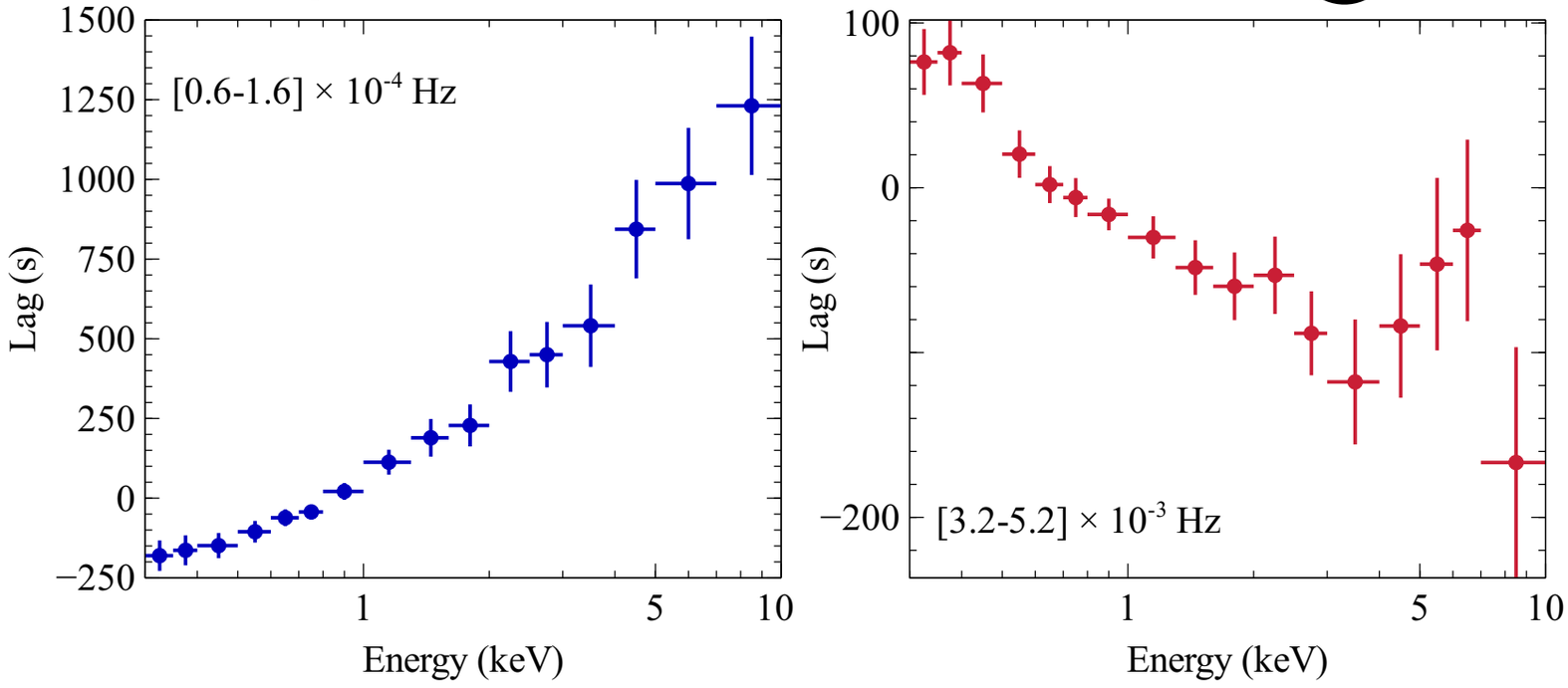


Propagation



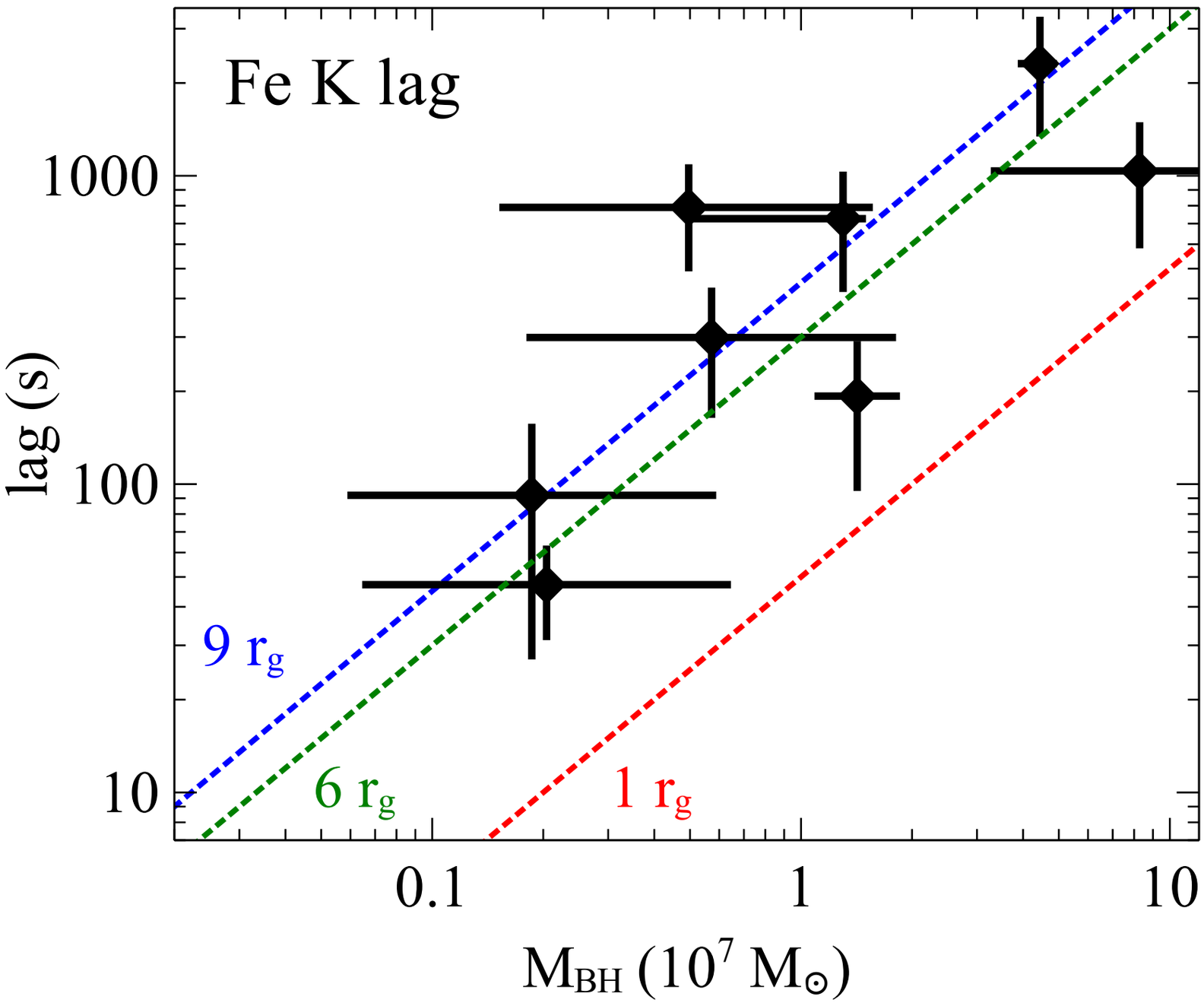


Reverberation



Lag-energy shows that reverberation is coming from a small, nearby reprocessor, not a large, distant one

Fe K lags scale with black hole mass



EK+13

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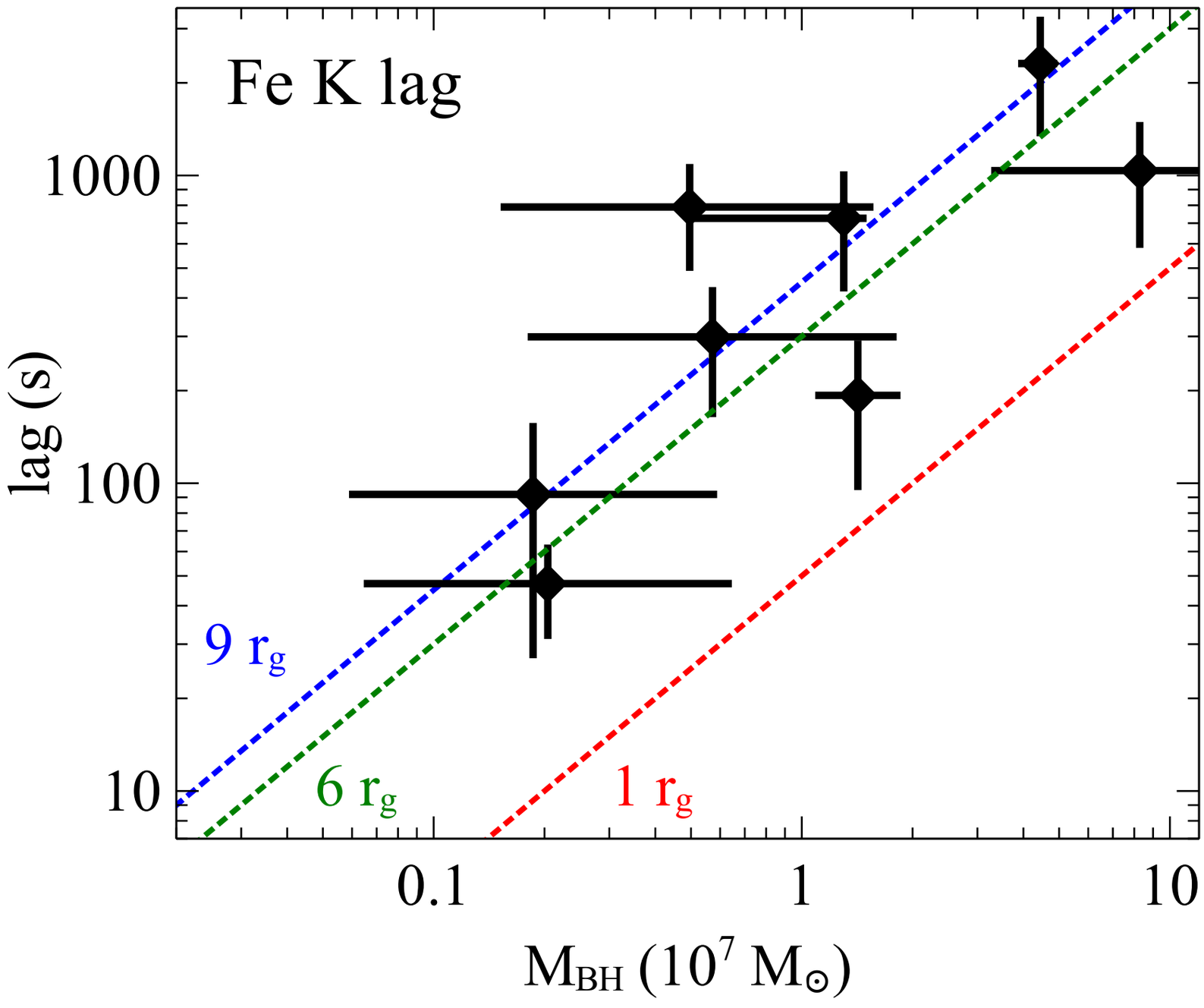
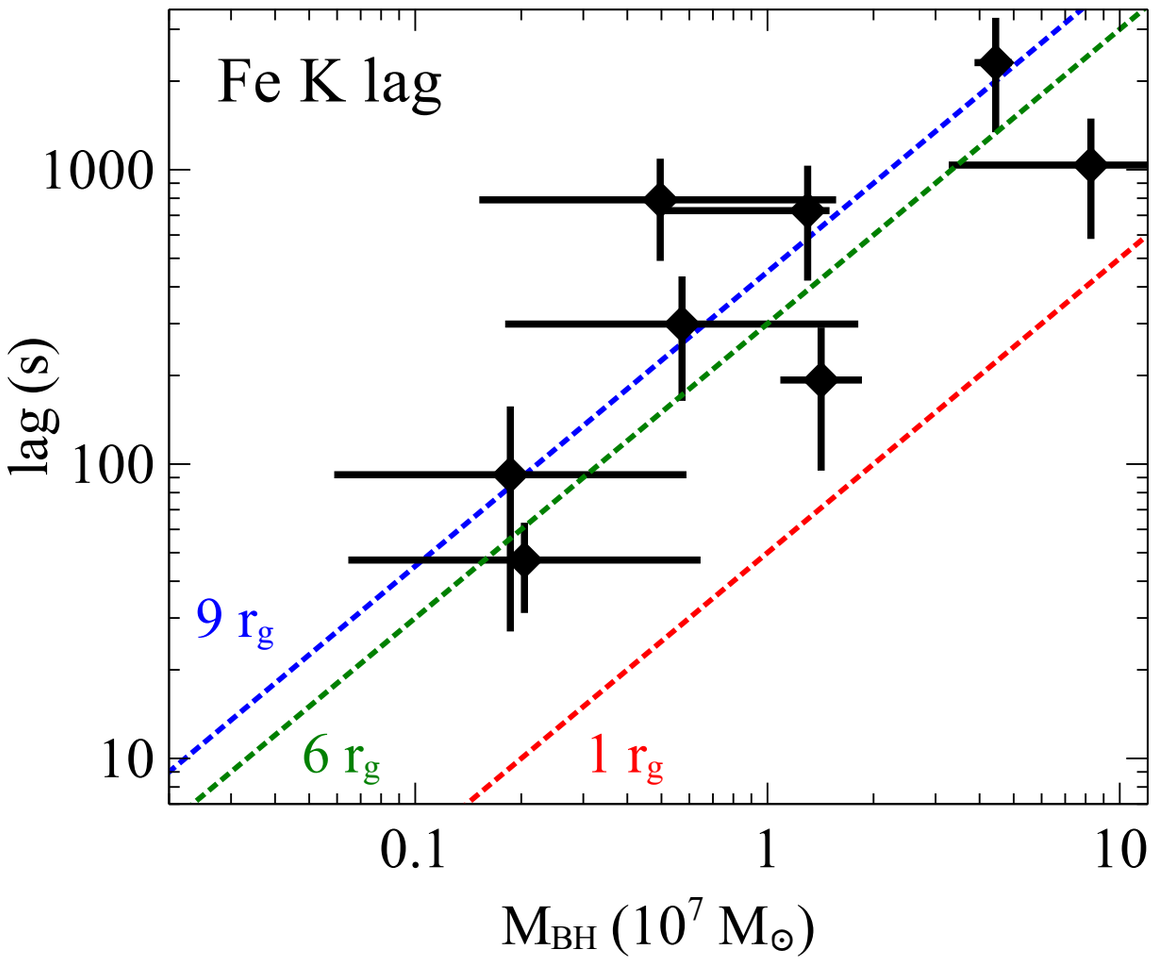


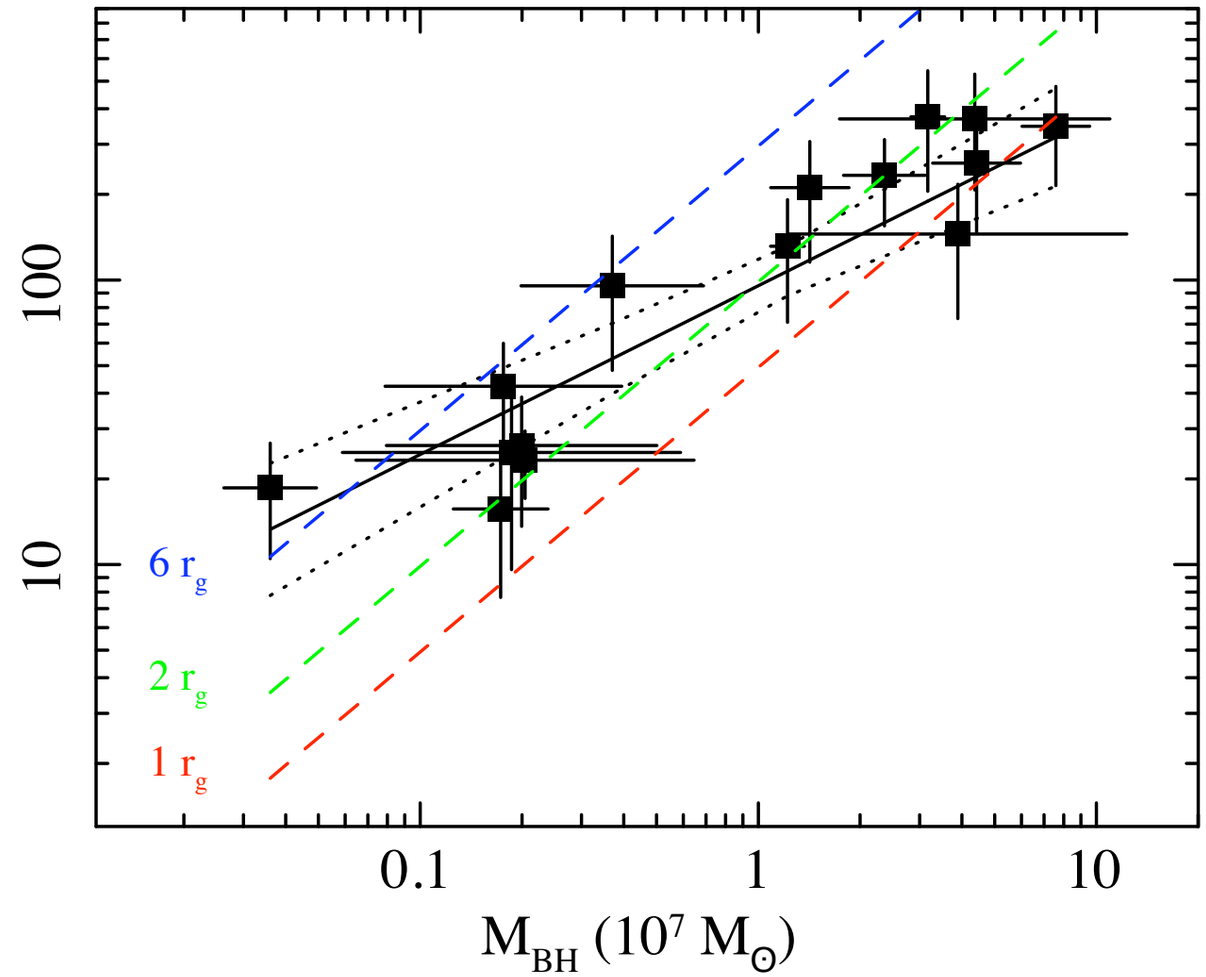
Caveats:

- Dilution
- Inclination
- Coronal Geometry
- Emissivity of disc

EK+13

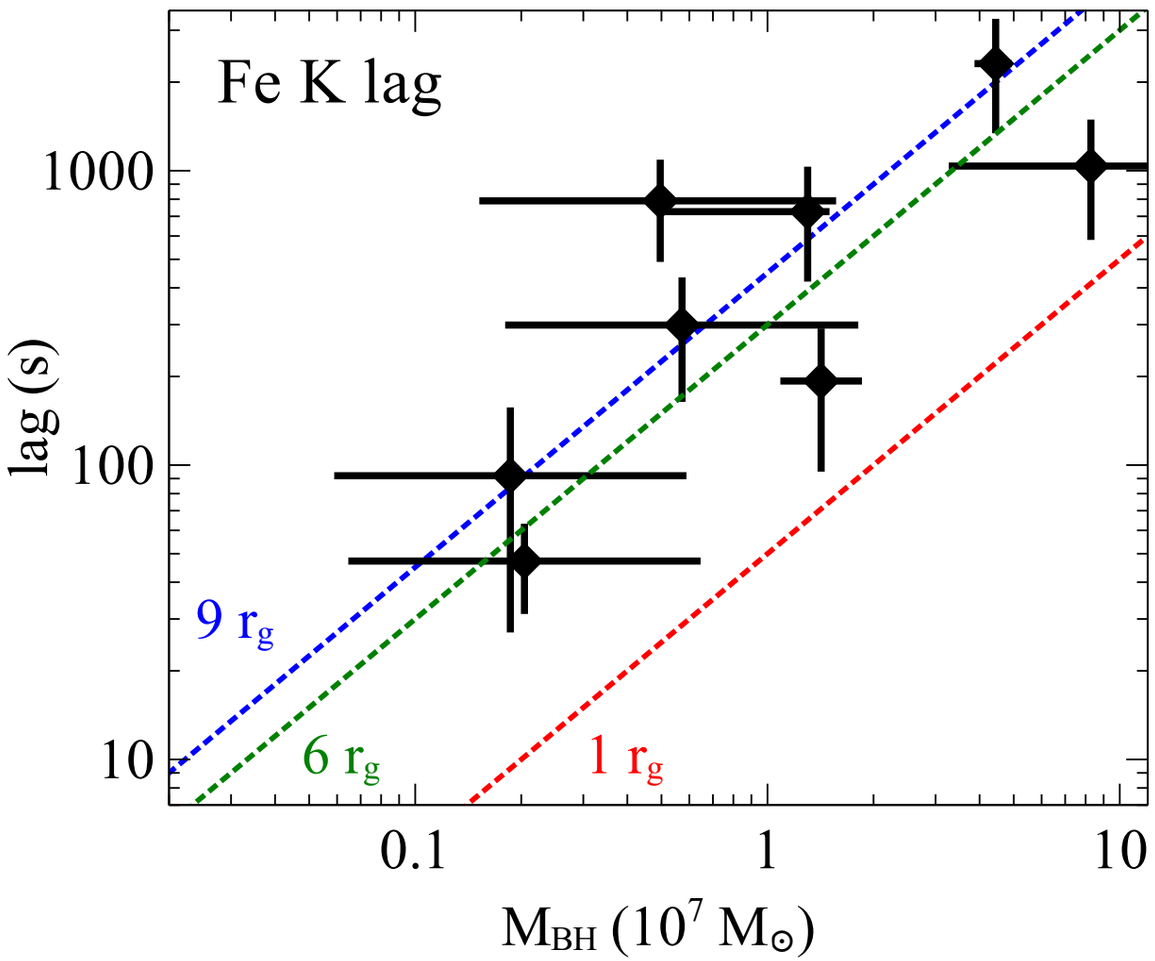
Fe K lags scale with black hole mass

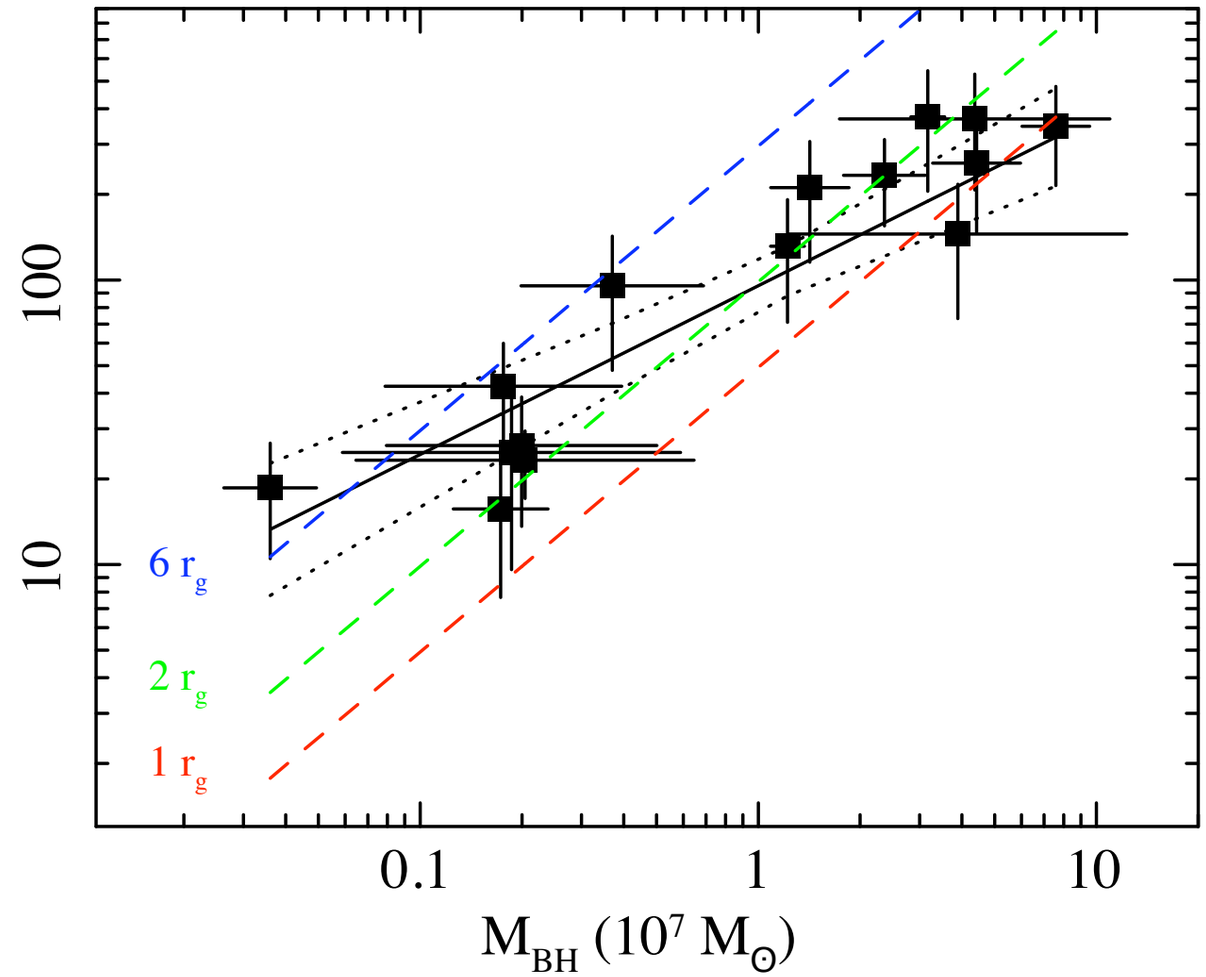




De Marco et al, 2013

Fe K lags scale with black hole mass

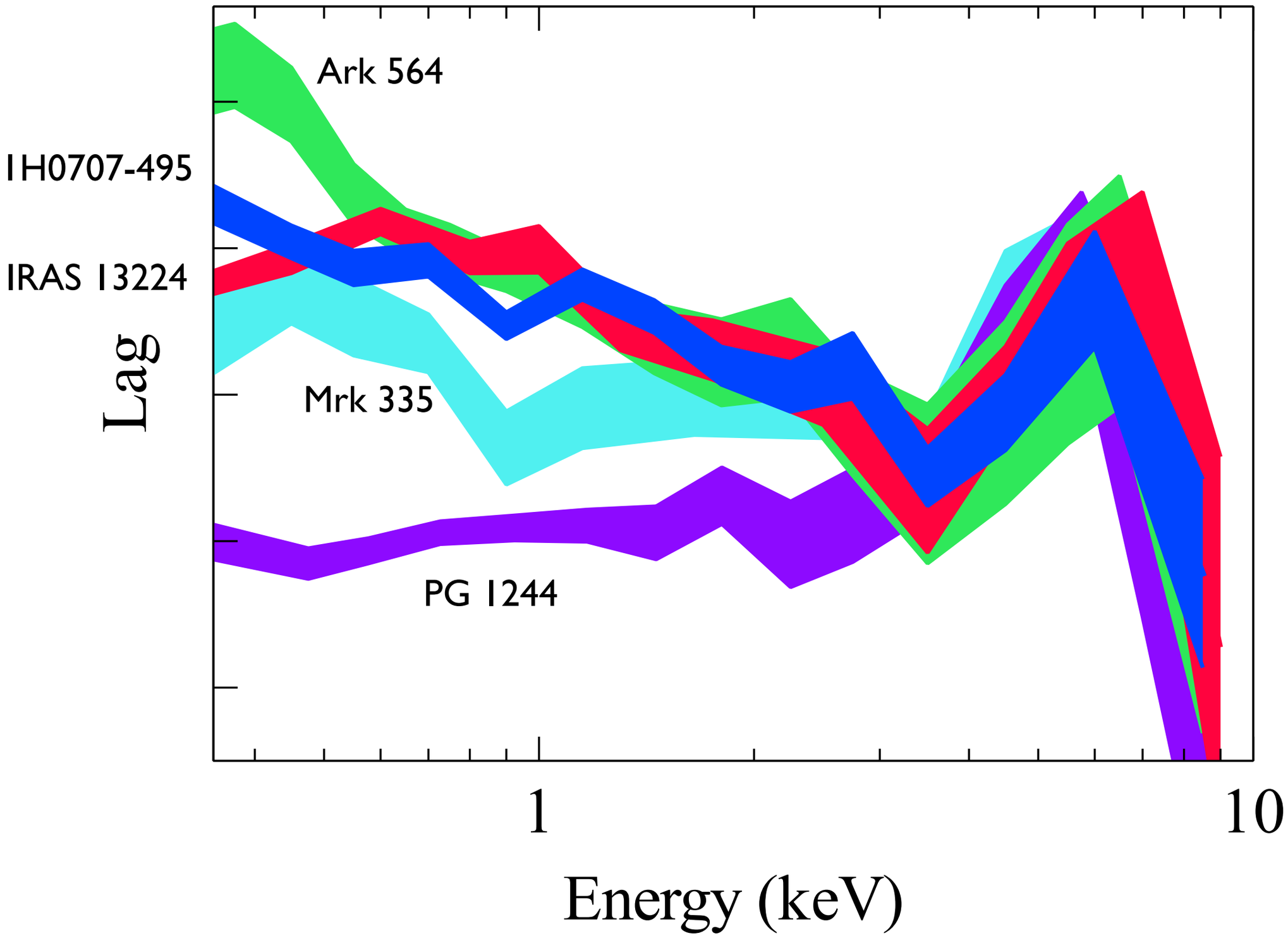




De Marco et al, 2013

Fe K emitting region and
soft excess emitting region are small

High frequency iron K lags

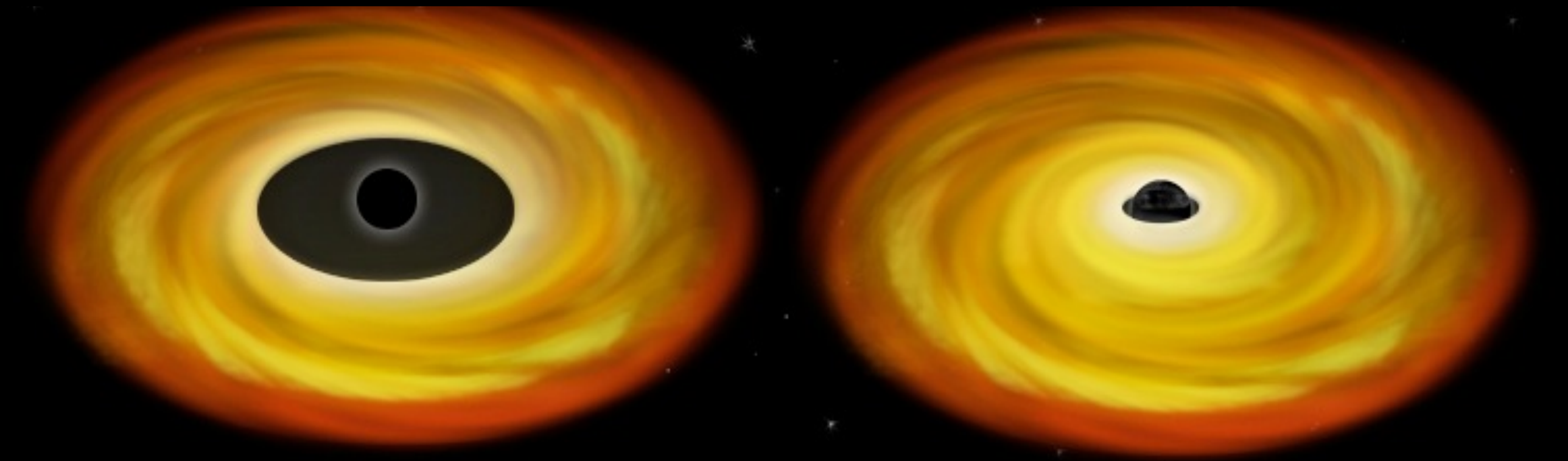


Uttley, Cackett, Fabian, EK, Wilkins 14
adapted from EK+14

Black hole spin

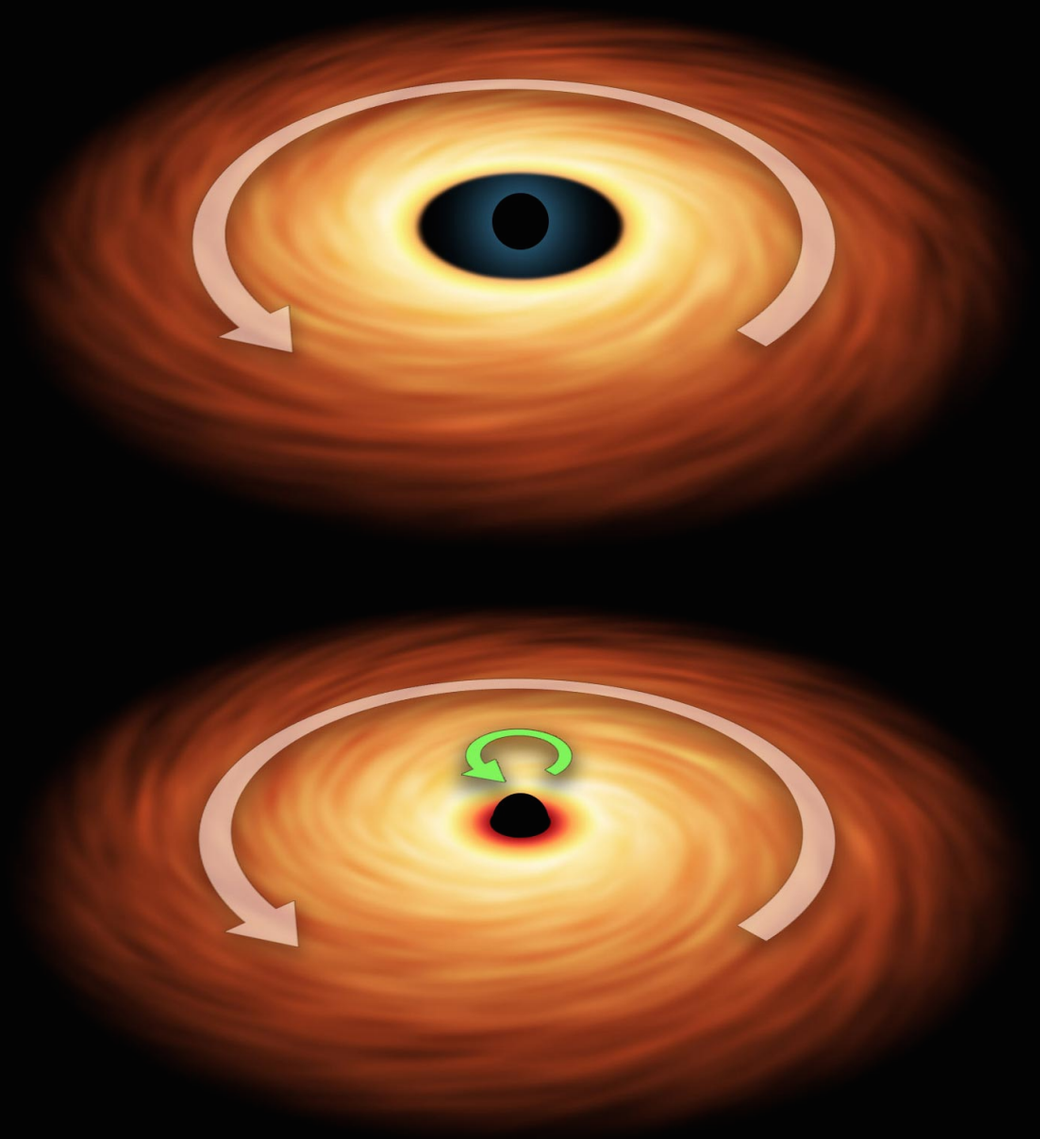
Schwarzschild Metric
(non-rotating)

Kerr Metric
(maximally rotating)

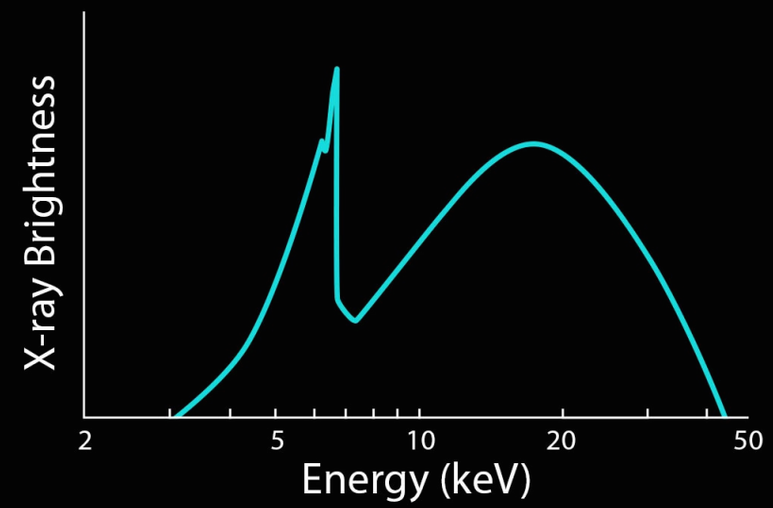


ISCO dependent on black hole spin

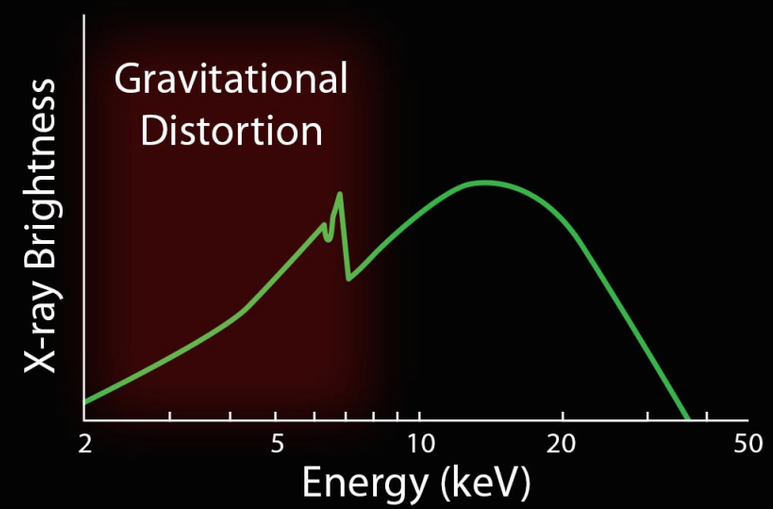
Black hole spin



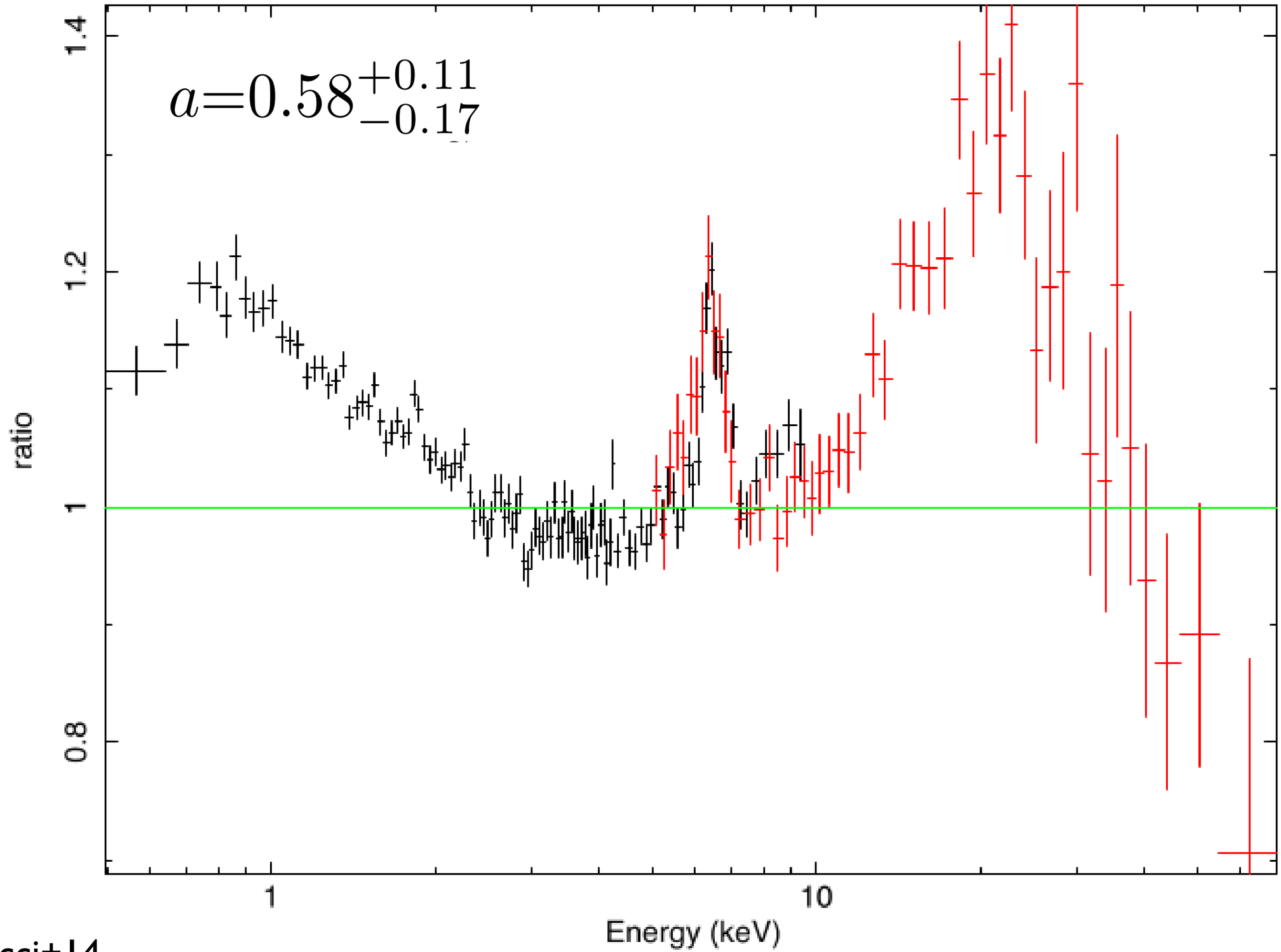
No Black Hole
Rotation



Prograde
Rotation



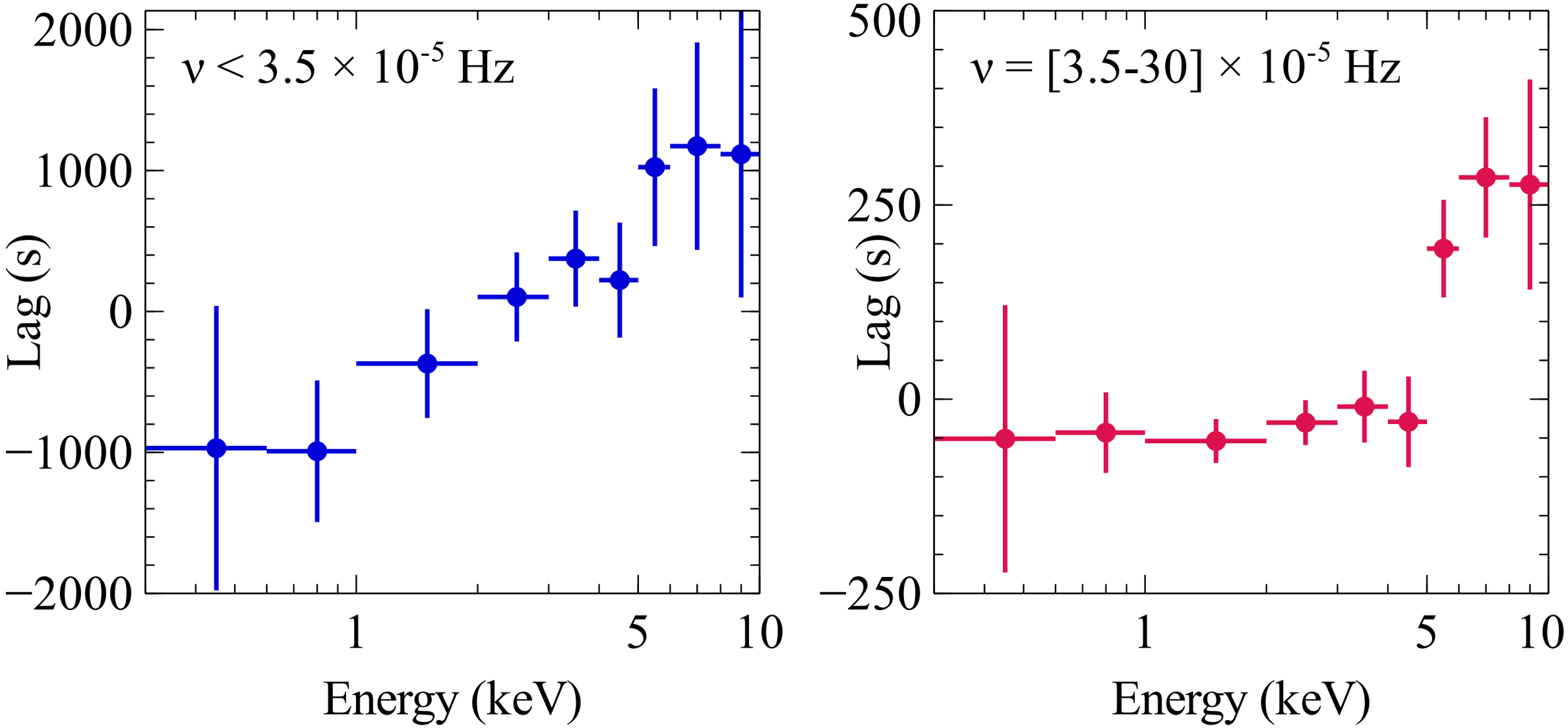
Swift J2127.4+5654



Marinucci+14

Swift J2127.4+5654

$$a=0.58^{+0.11}_{-0.17}$$



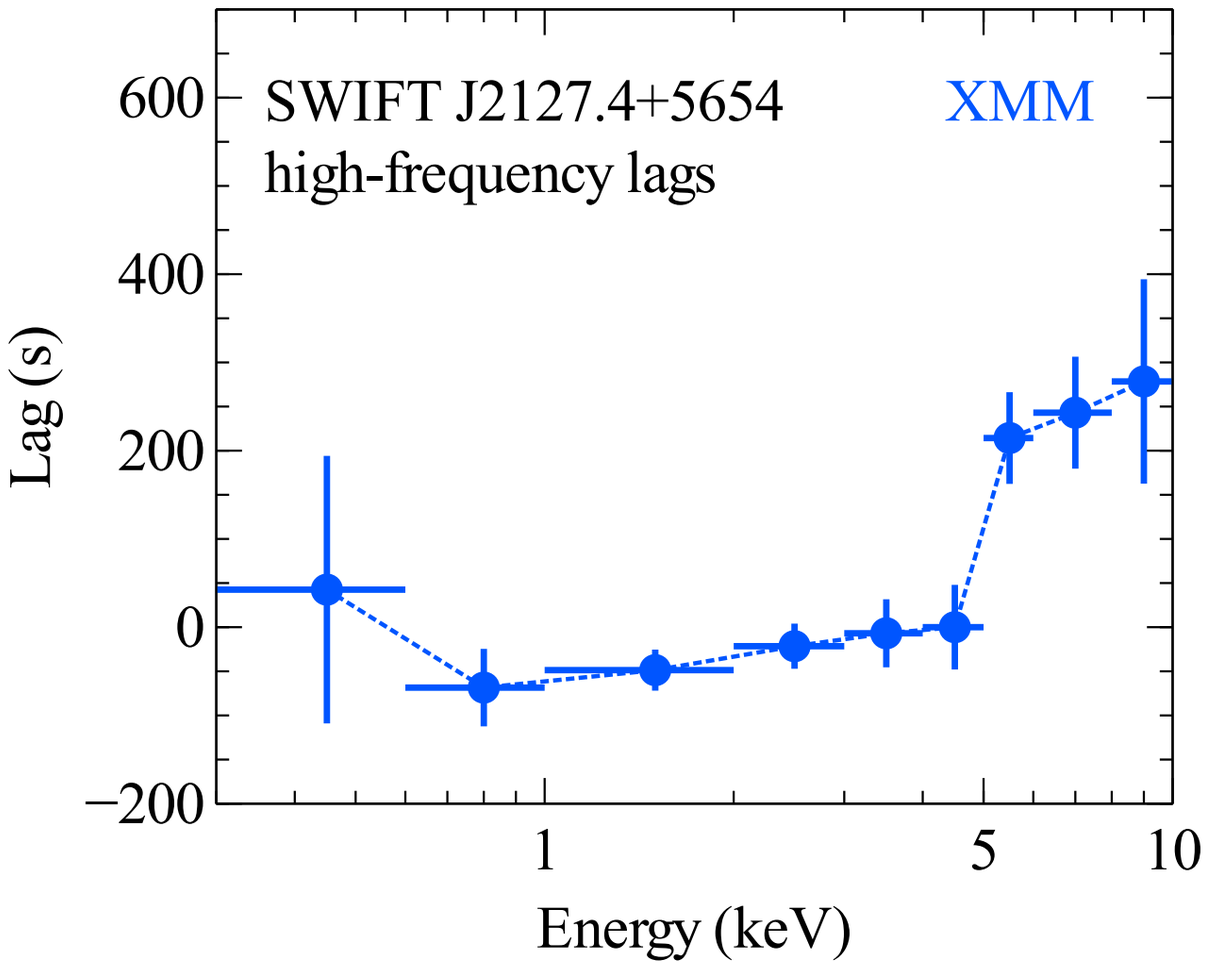
Marinucci+14

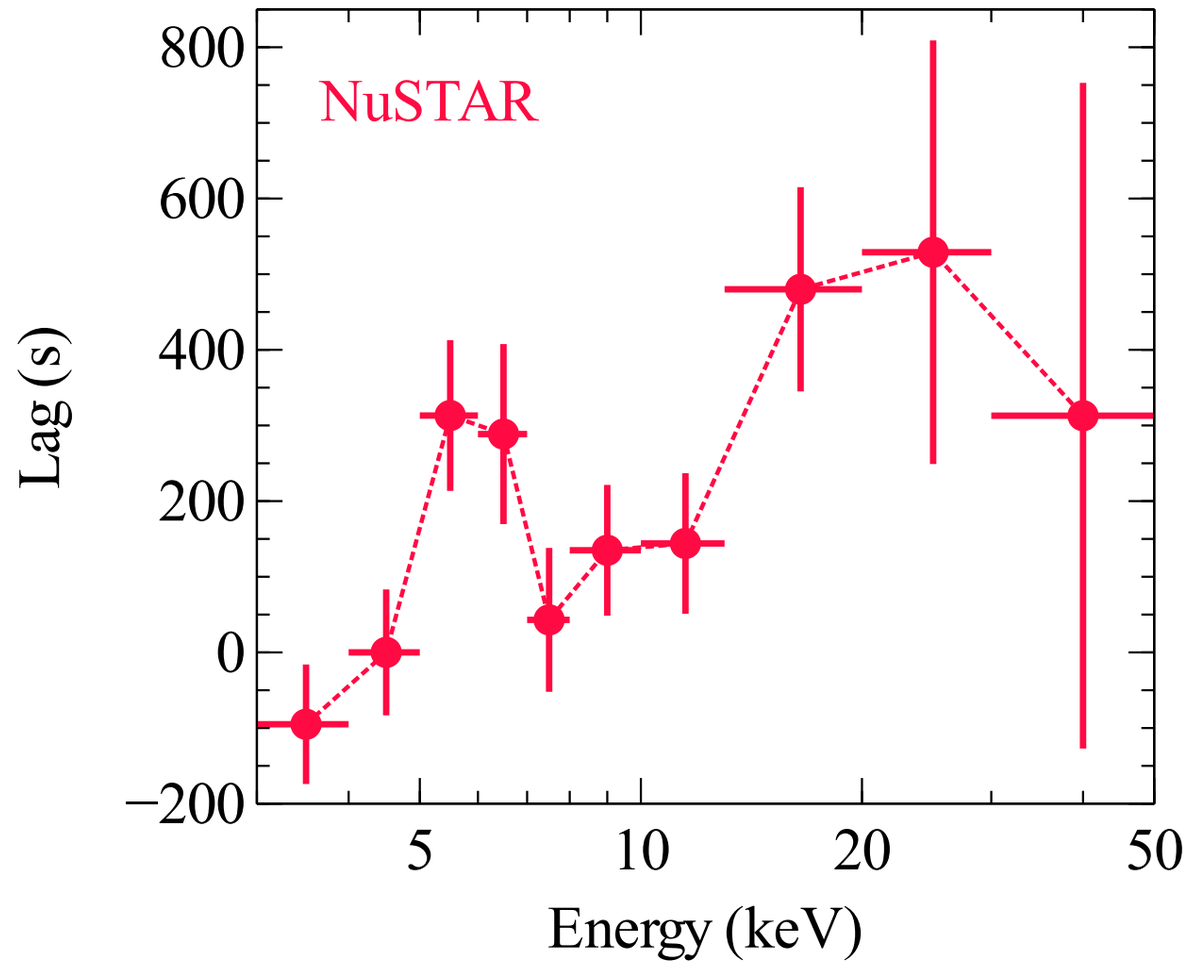
Swift J2127.4+5654

$$a=0.58^{+0.11}_{-0.17}$$

EK+14, submitted

NuSTAR Lags (using code from A. Zoghbi)



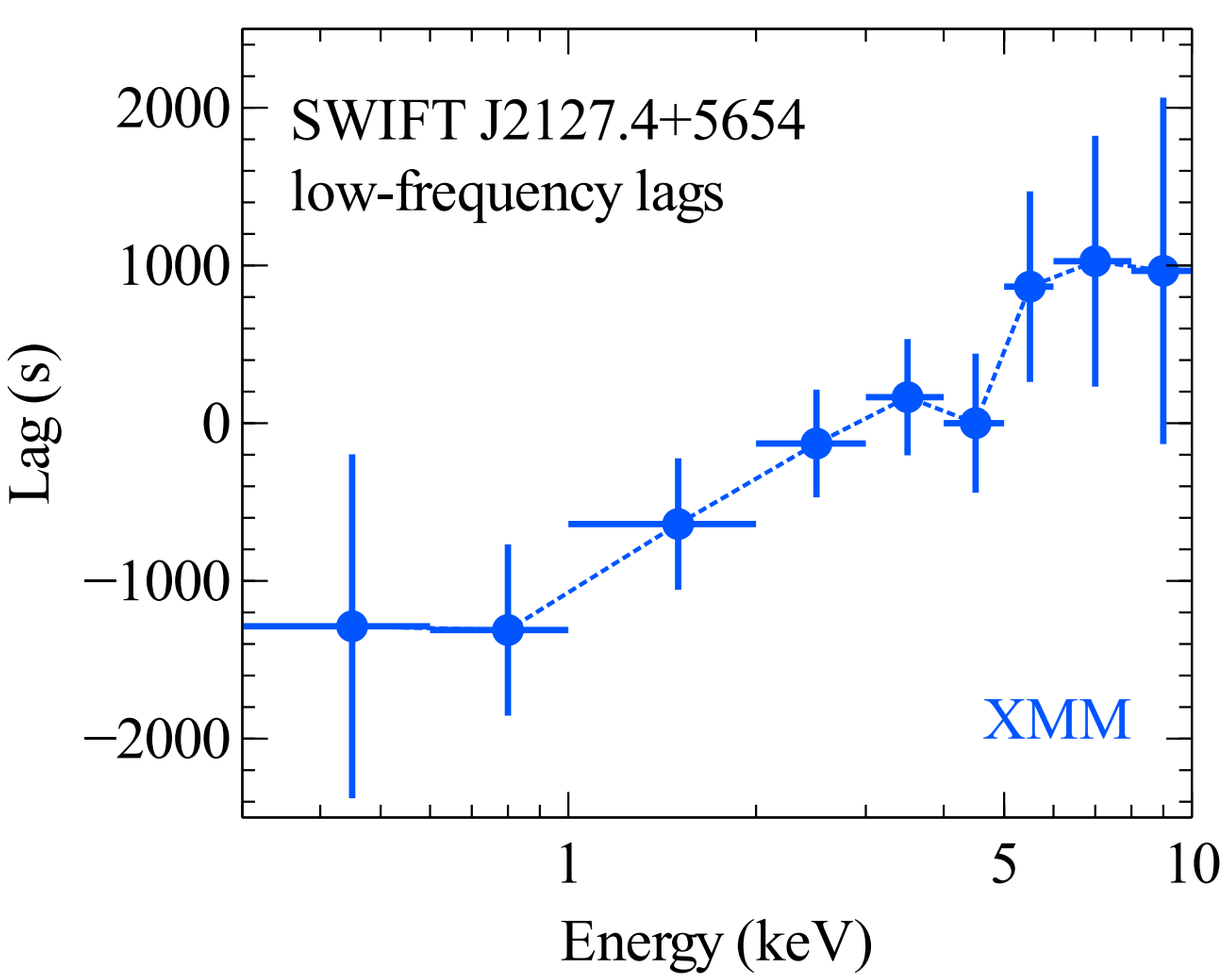


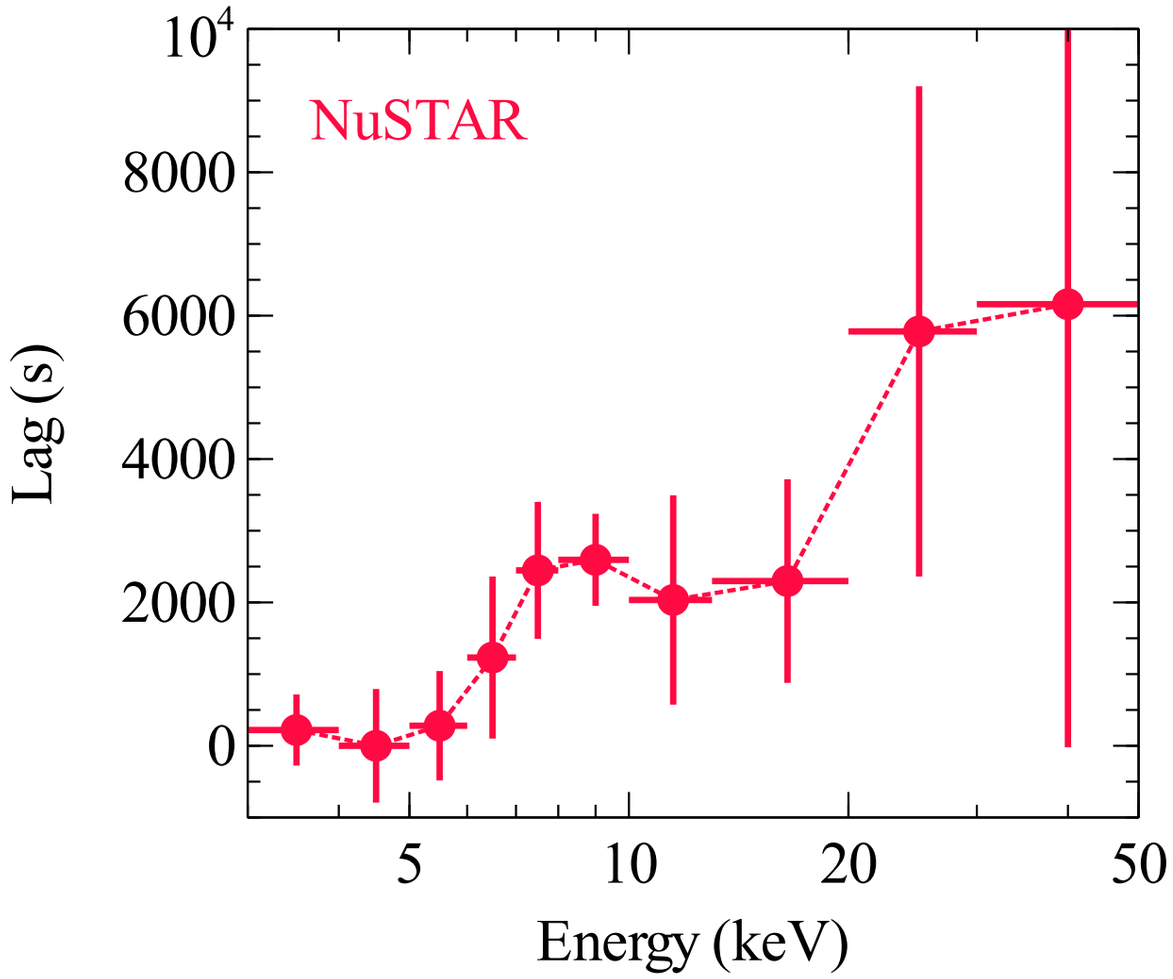
Clear detection of narrower Fe K and Compton hump lag;
See A. Zoghbi's talk for first detection in MCG-5-23-16

Swift J2127.4+5654

$$a=0.58^{+0.11}_{-0.17}$$

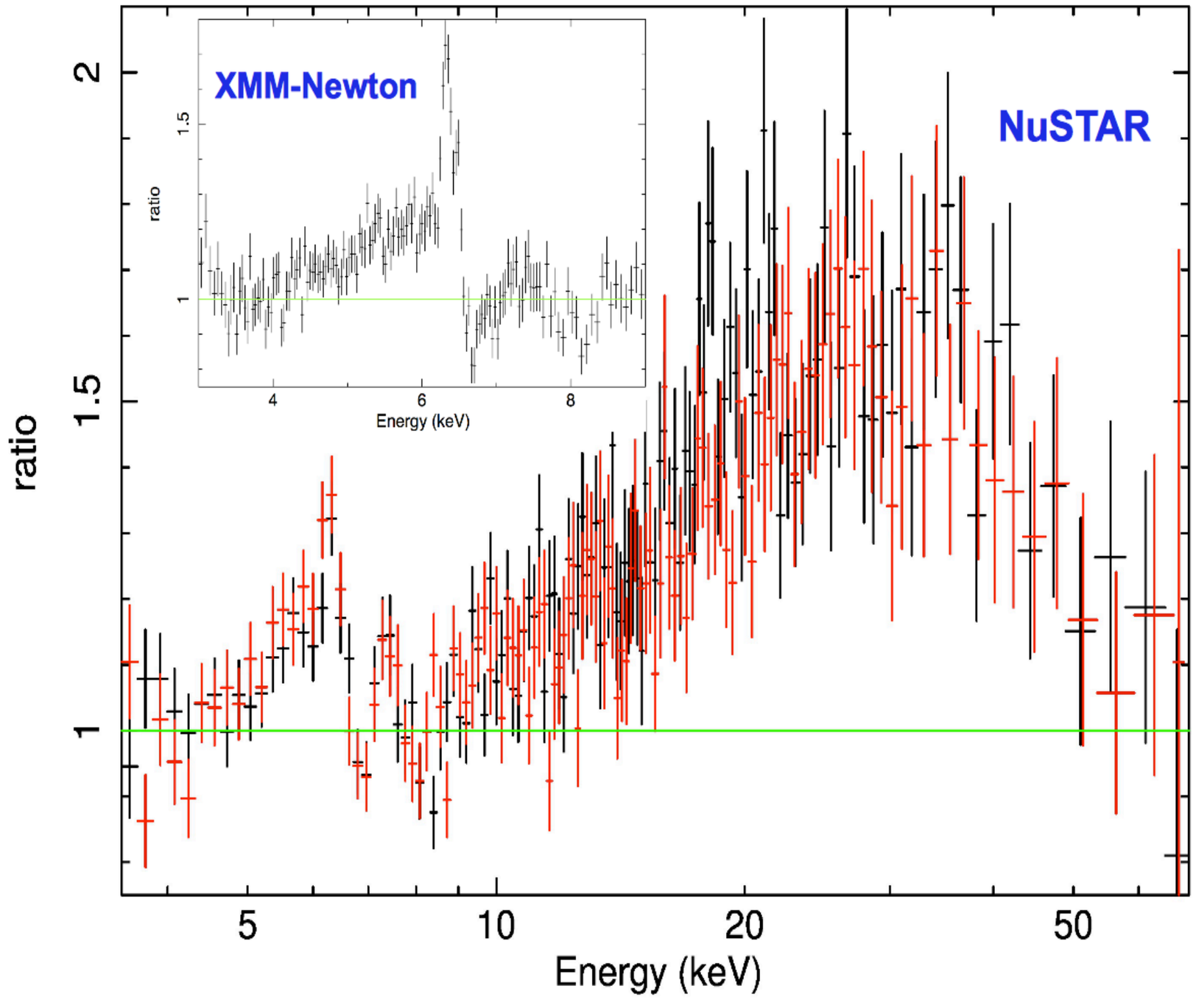
NuSTAR Lags (using code from A. Zoghbi)





Propagation lag appears to increase above 10 keV

NGC 1365

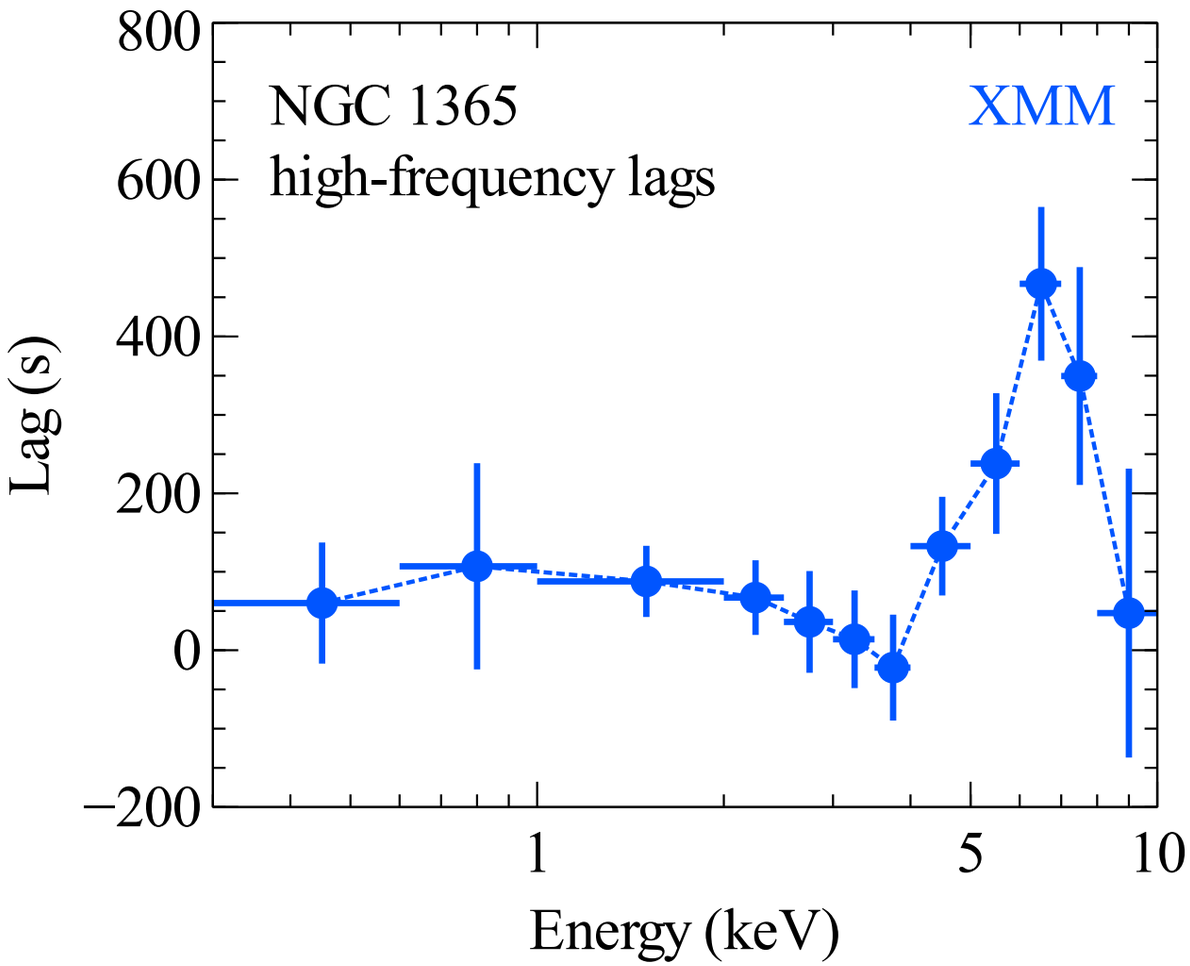


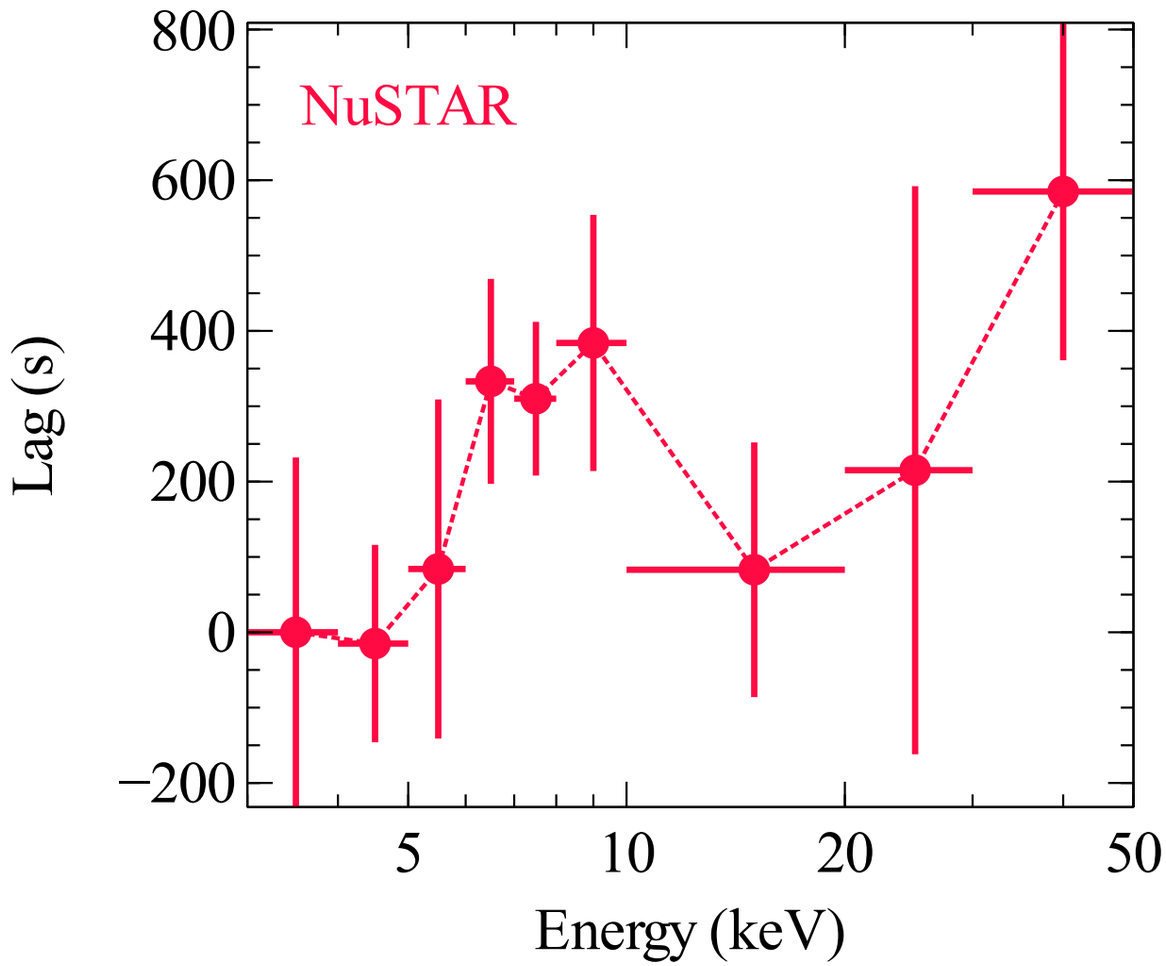
Risaliti et al., 2013
Walton et al., 2014

First clear NuSTAR detection of Compton Hump

NGC 1365

Orbit 3

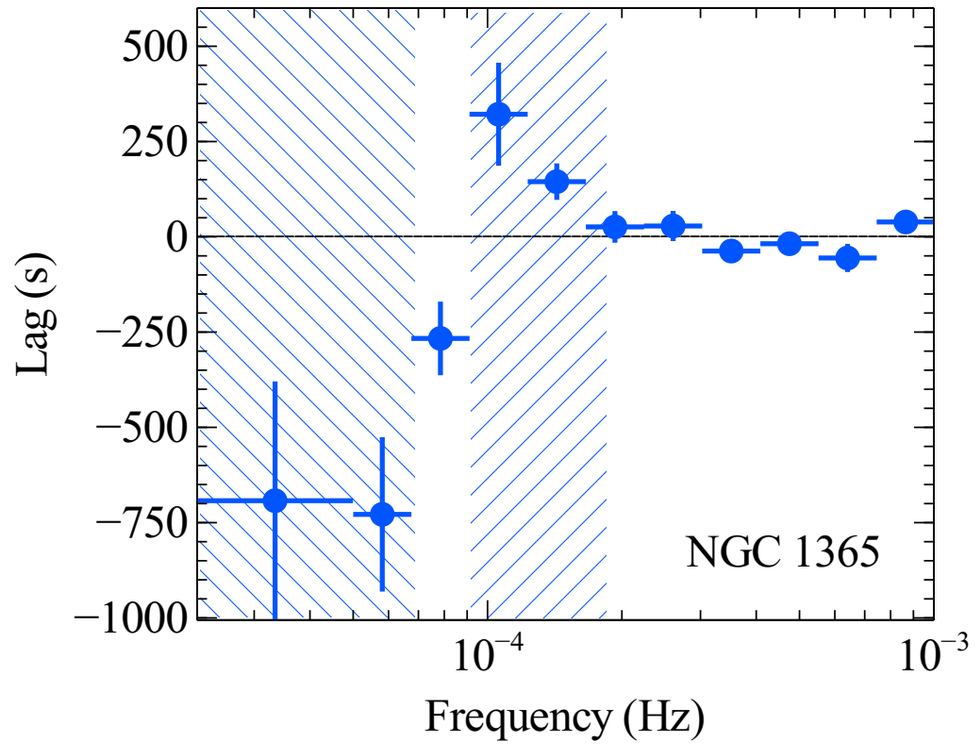




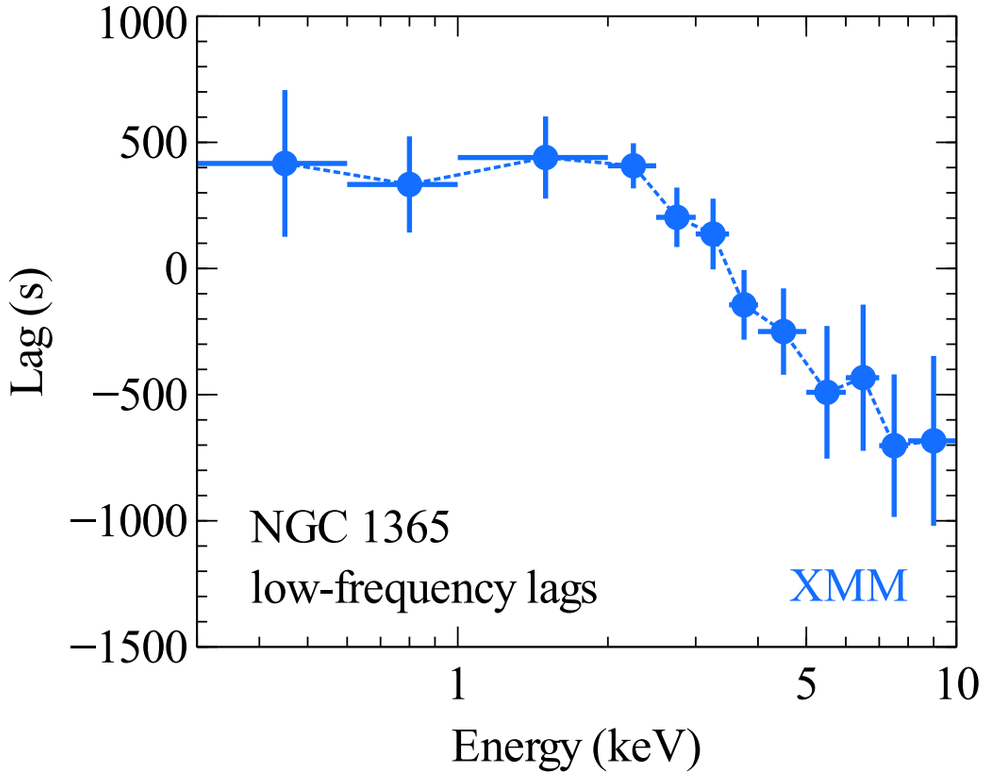
EK+14, submitted

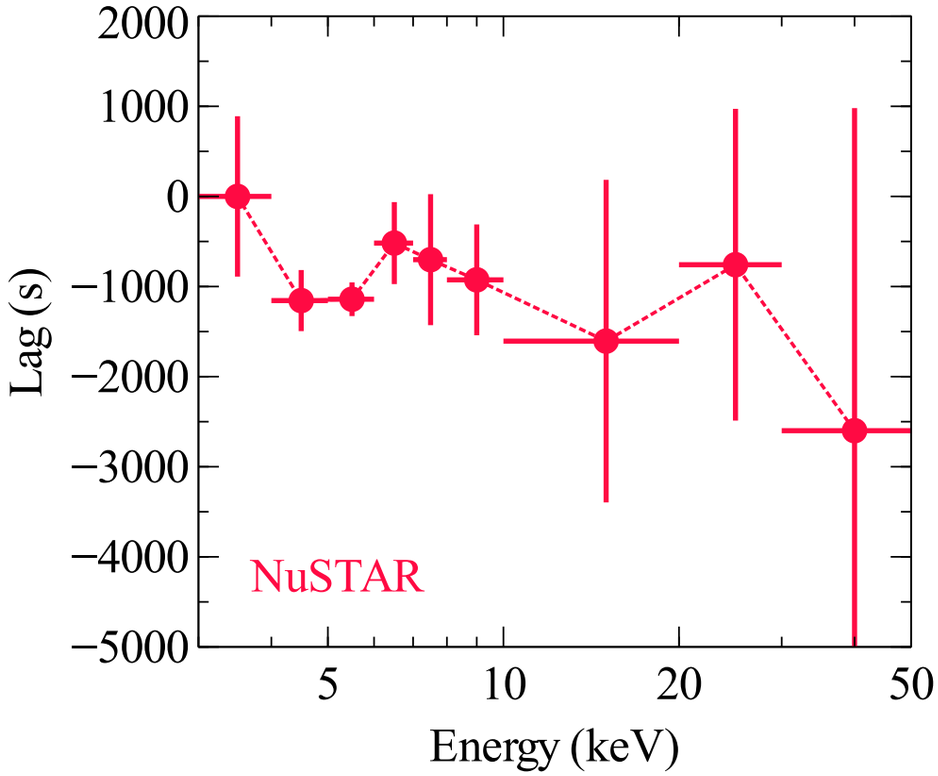
NGC 1365

Orbit 3



between 2-4 keV and 4-7 keV
positive lag indicates
line centroid lags
red wing of Fe K line

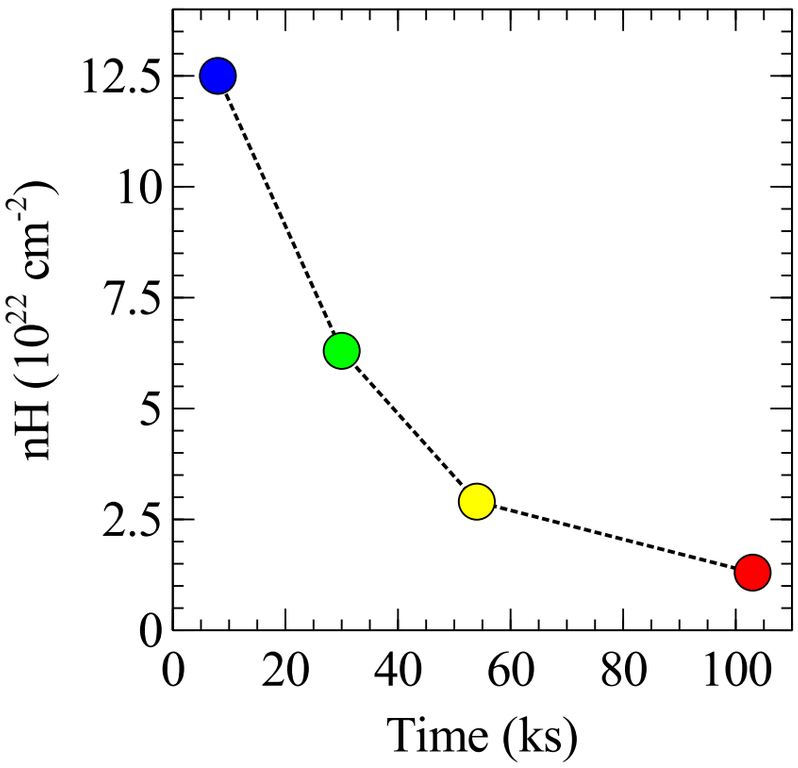


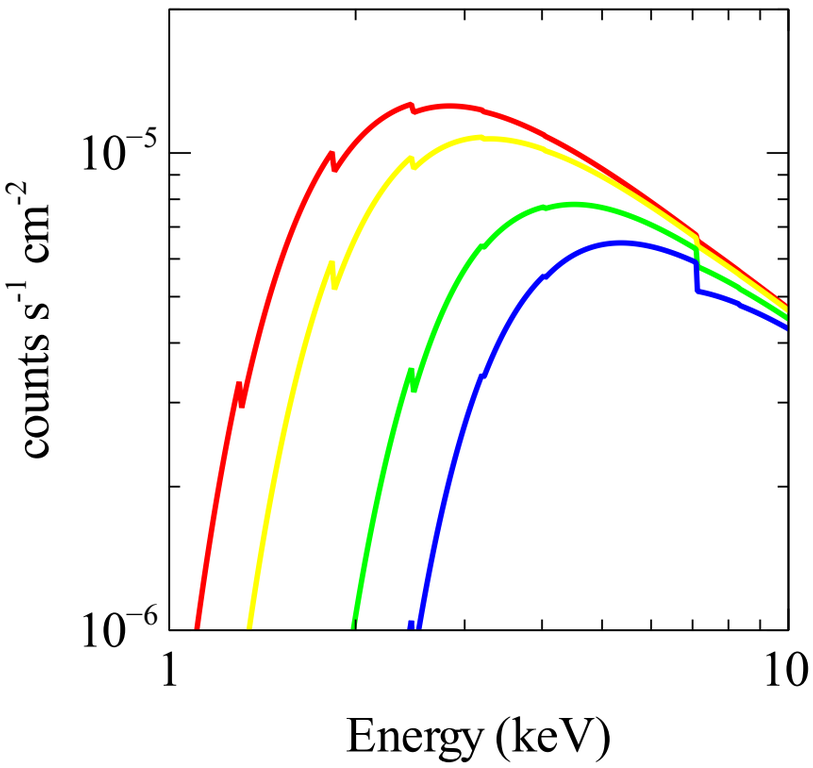


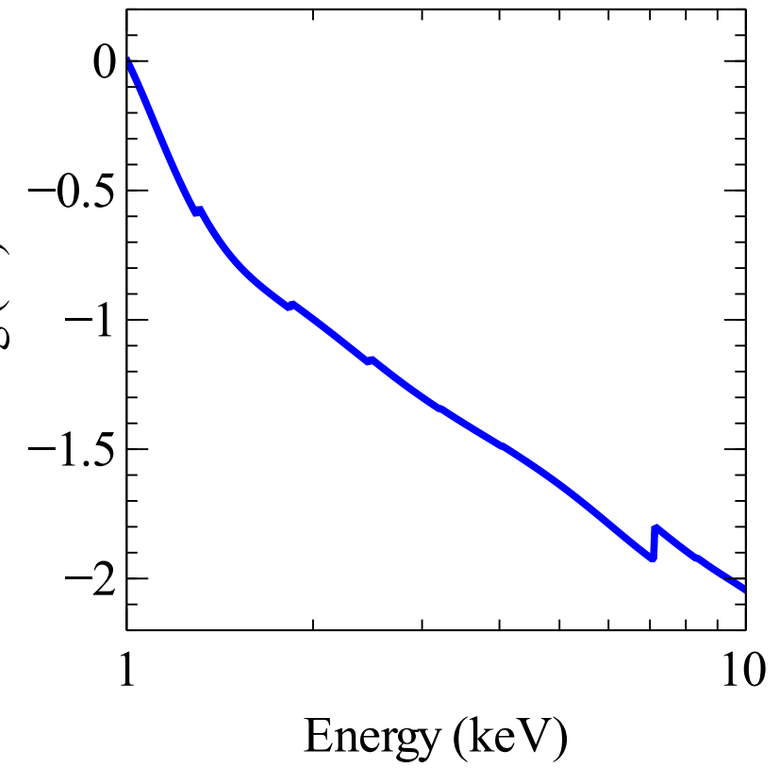
EK+14, submitted

NGC 1365

Low-frequency soft lag due to nH decreasing during observation







Absorption lag can be disentangled from inner disc reverberation lag

EK+14, submitted

Conclusions

- SWIFT J2127.4+5654 (a=0.5 with iron line fitting method) shows narrower Fe K lag

- Clear indication of Compton Hump lag in SWIFT J2127.4+5654, and hints in NGC 1365

- Eclipsing clouds moving into and out of our line of sight will cause lags (i.e. low-frequency soft lag in NGC 1365)

- NuSTAR is probing a new energy band, revealing the reverberation lags associated with the Compton Hump

- Future work modelling the lags will help put constraints on the geometry and kinematics of the accretion flow
(see poster of M. Dovciak)