

A black hole with a glowing accretion disk and a blue jet of light. The black hole is a dark sphere at the center, surrounded by a bright, glowing disk of accretion. A blue jet of light is being emitted from the top of the black hole. The background is a dark, starry space with a galaxy visible in the upper left.

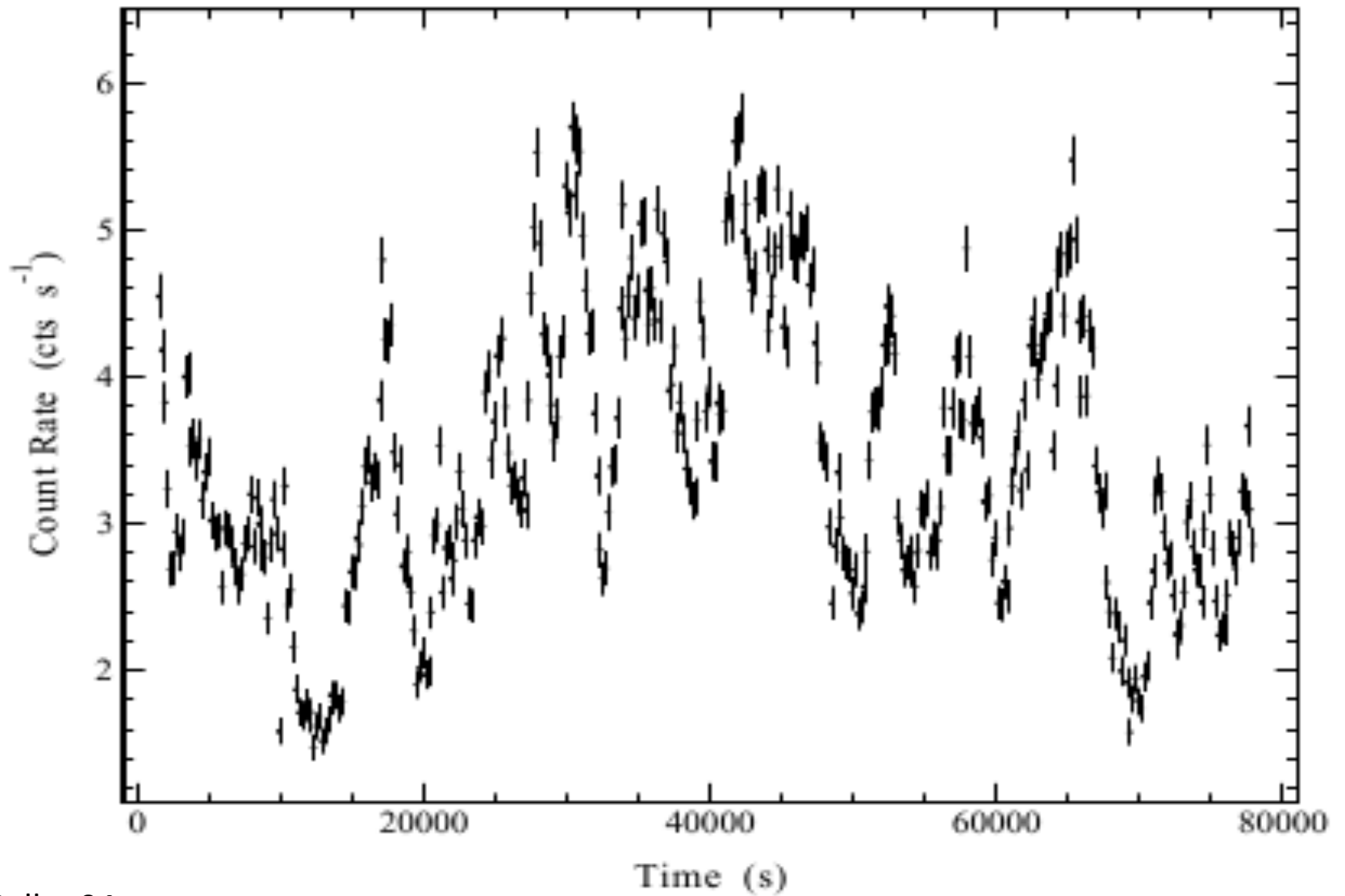
Heading into the Abyss

The Future of X-ray Reverberation from AGN

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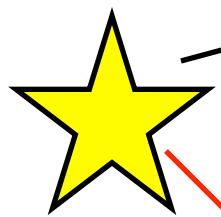
1H0707-495





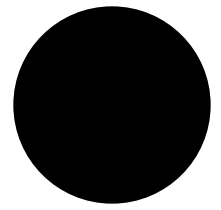
Direct Power-law

To observer



Corona

“Reflection” spectrum

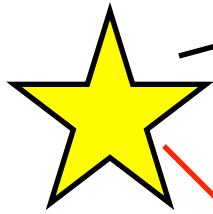


Accretion disc



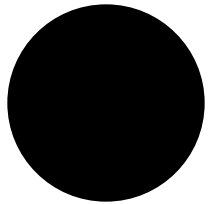
Direct Power-law

To observer



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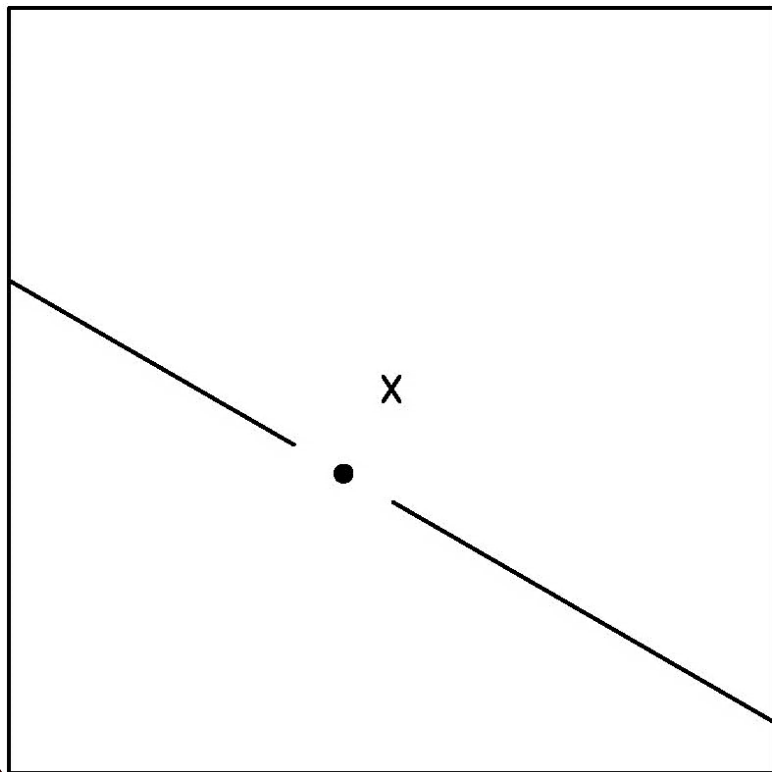
Accretion disc

Path difference leads to

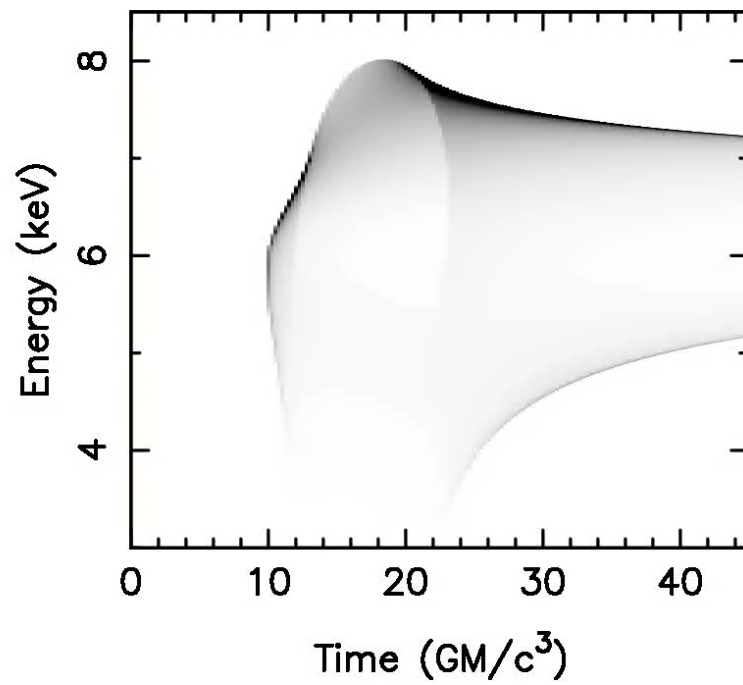
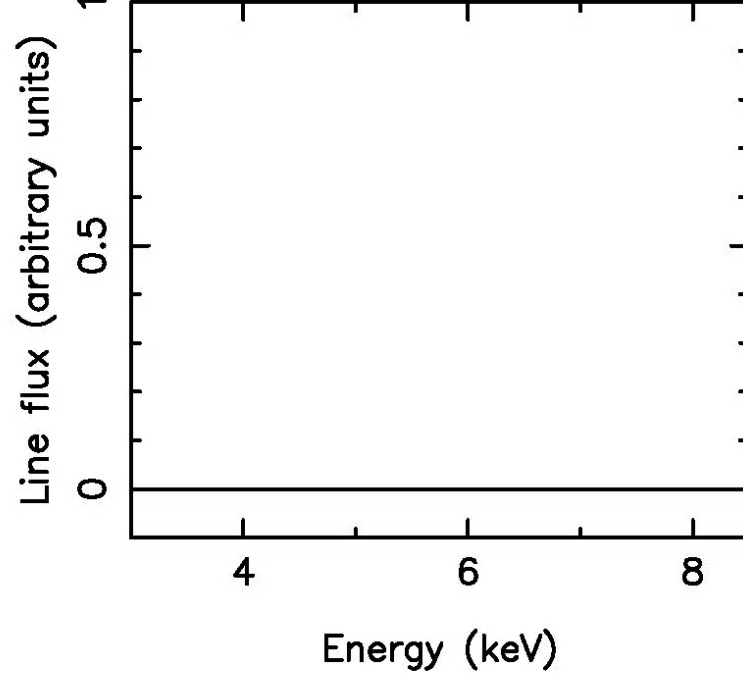
Reverberation

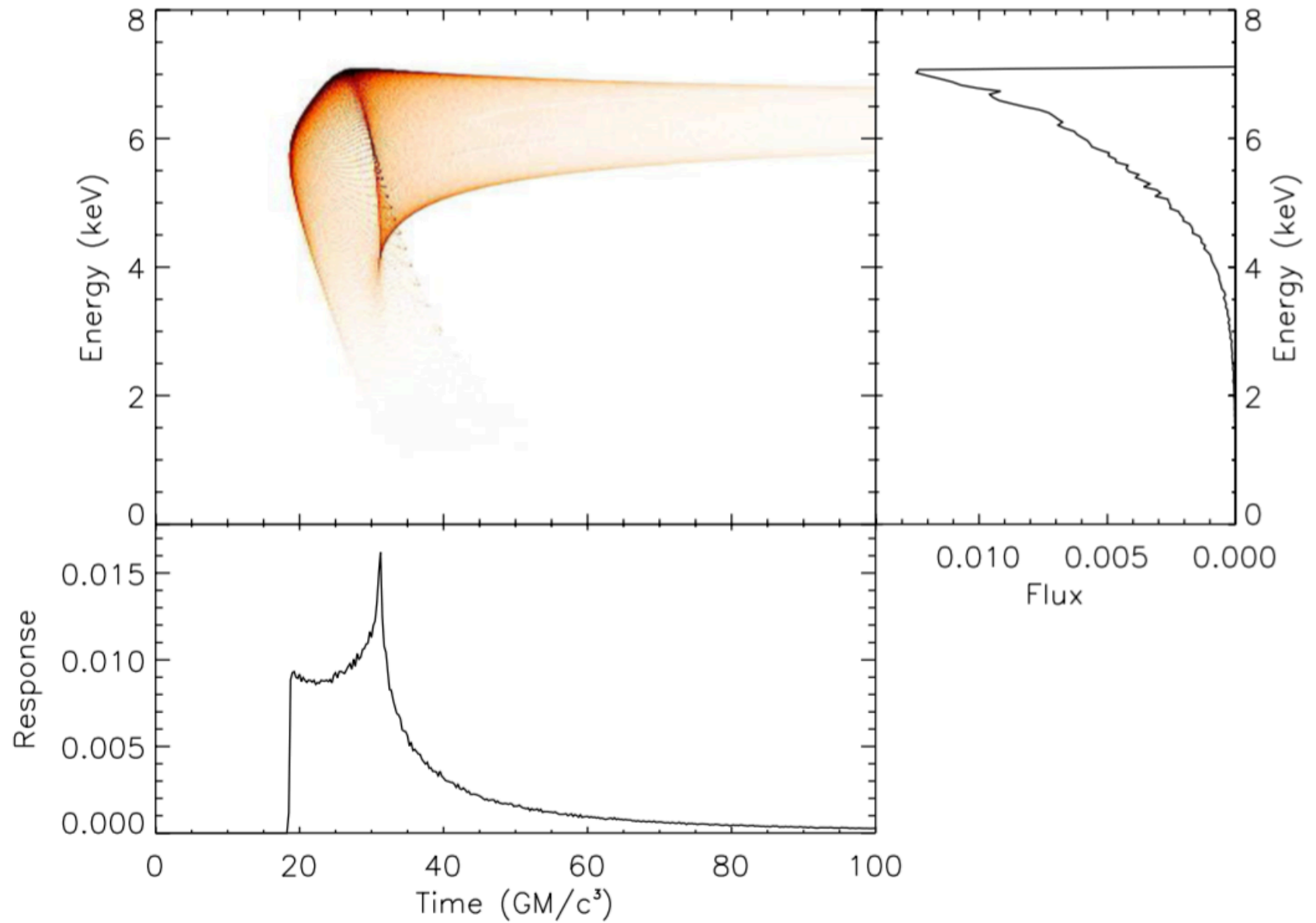


$$h = 10.0 \text{ GM}/c^2, i = 60.0^\circ, \text{ISCO} = 6.0 \text{ GM}/c^2$$
$$\tau = 0.00 \text{ GM}/c^3$$



Cackett13





Cackett+14

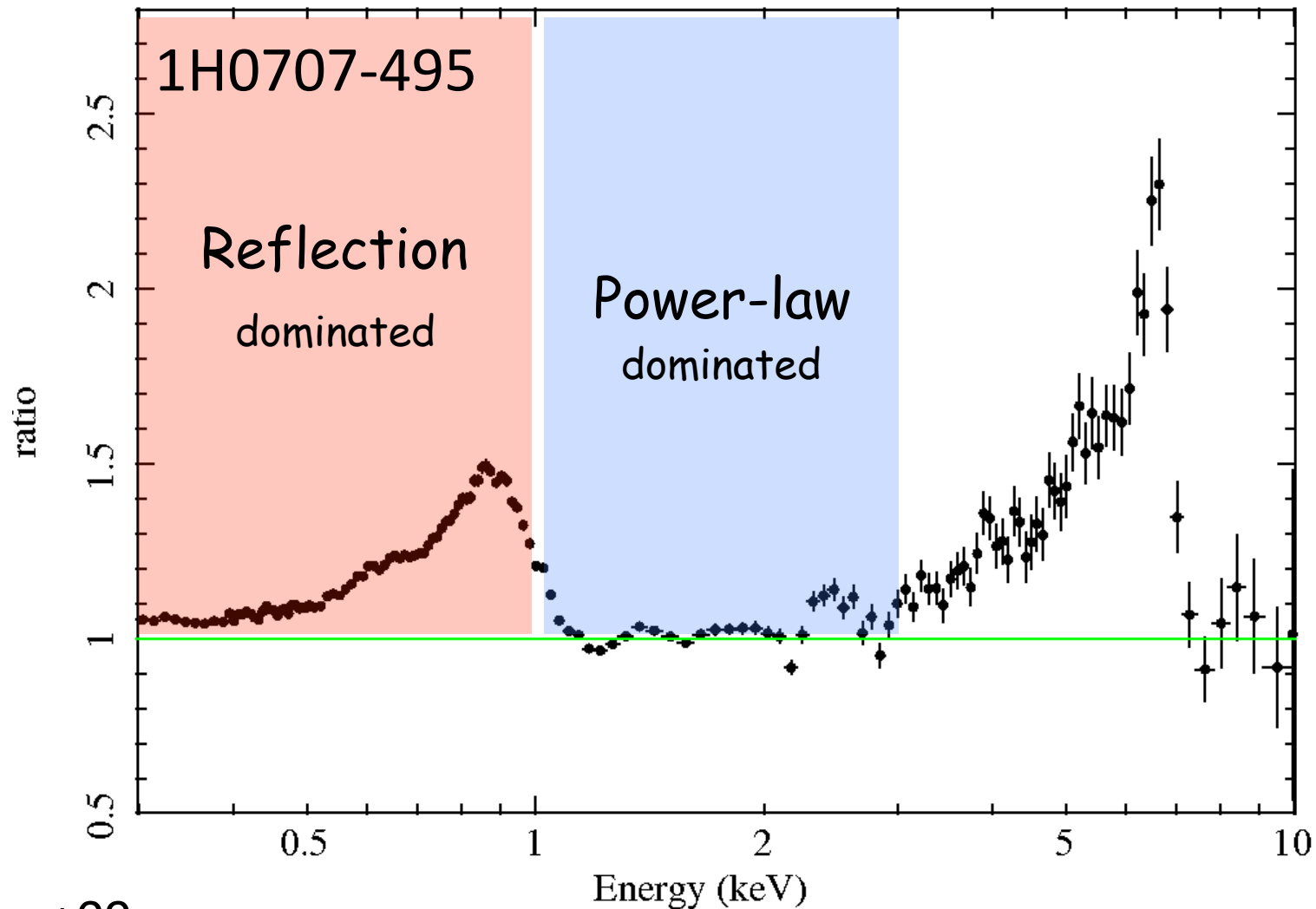
after Campana+Stella95, Reynolds+99

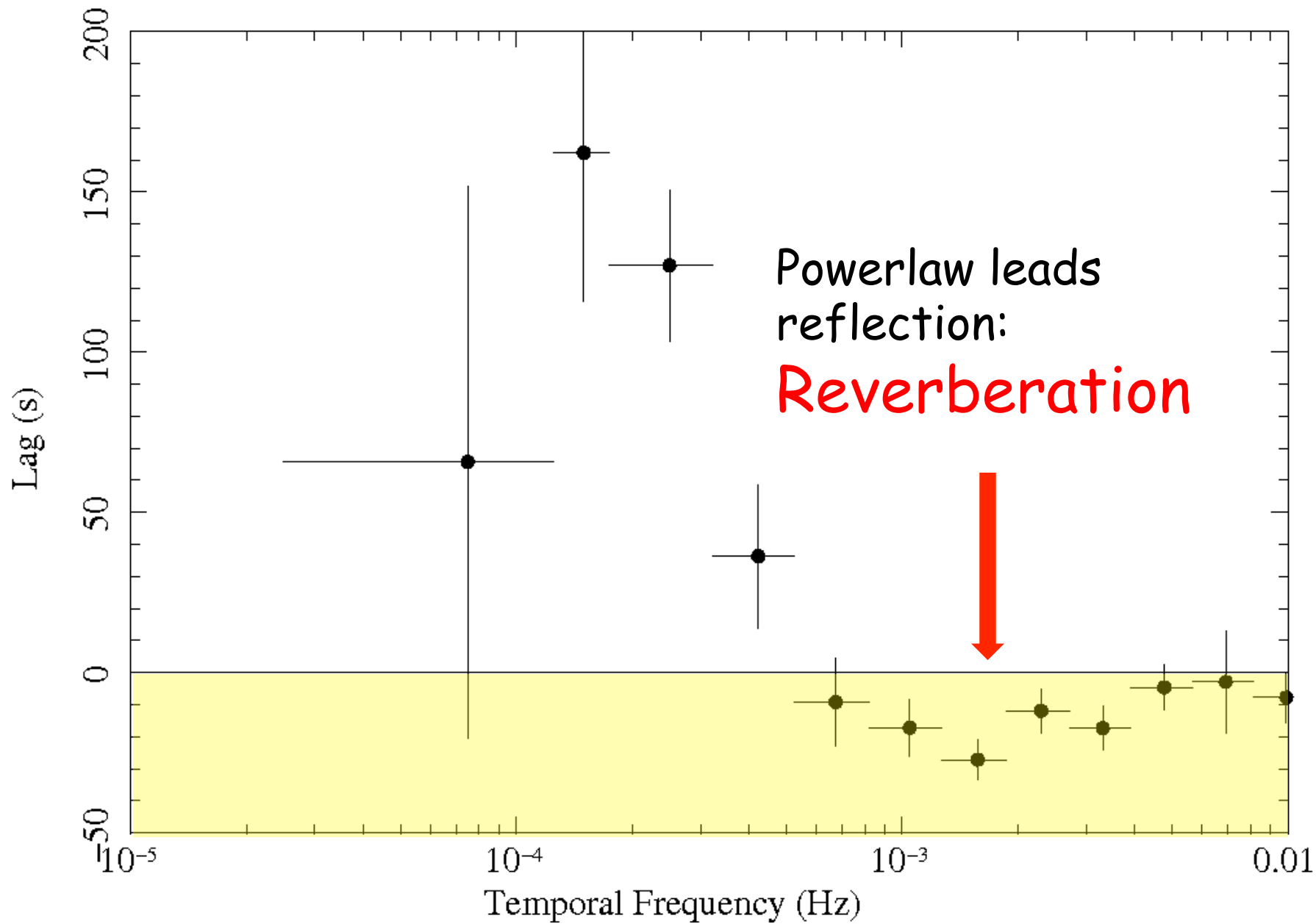
Observations of Reverberation complicated
since see both Direct and Reflection
components together

Separate spectrally
(contributions vary with energy)

Need Spectral Timing

X-ray Reverberation is an XMM discovery

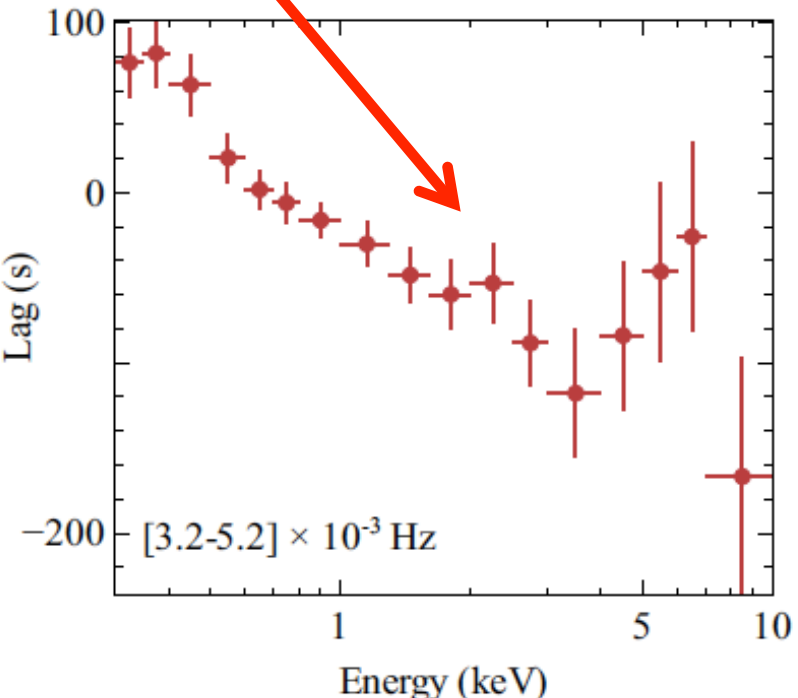
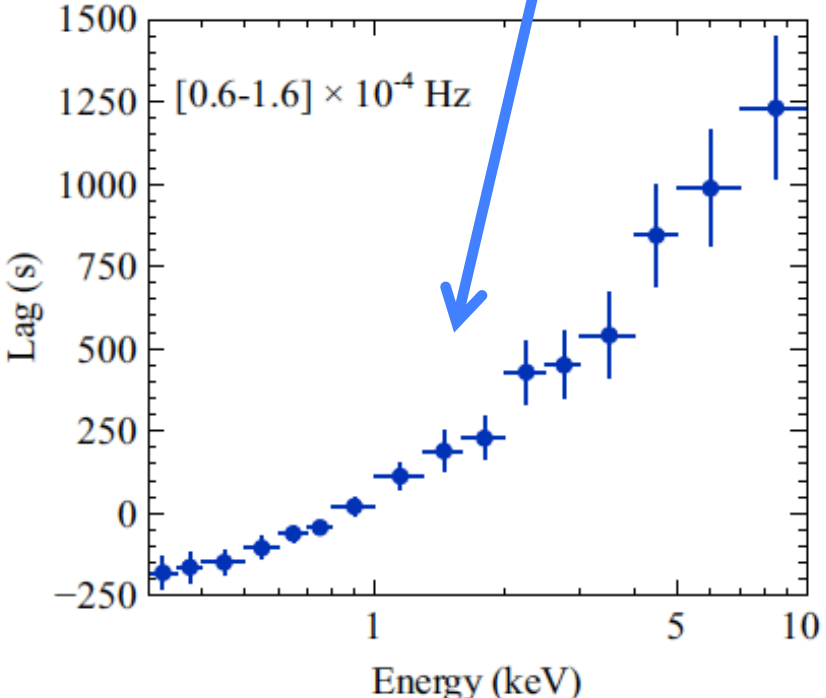
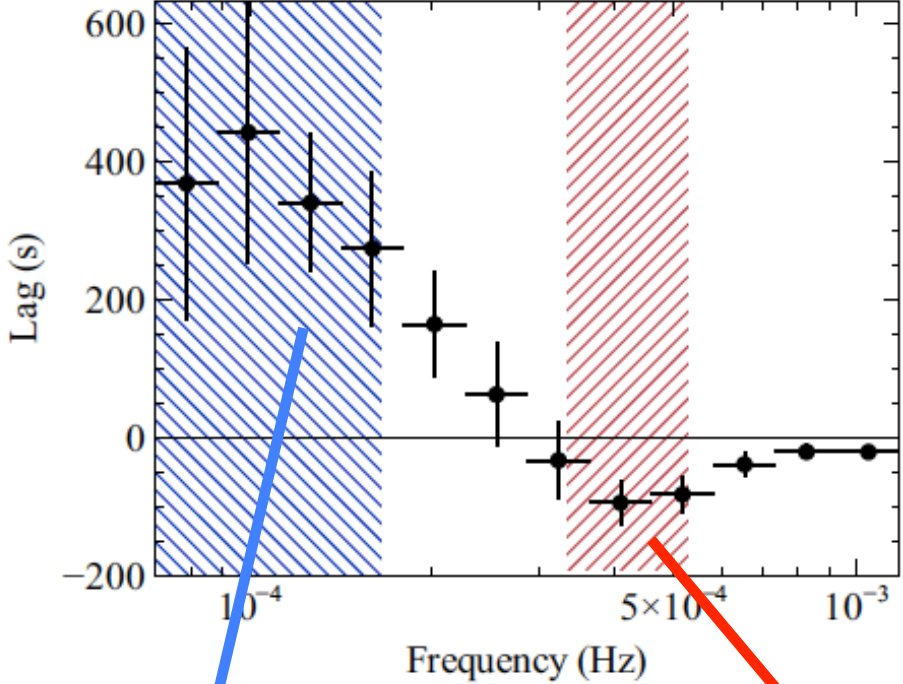




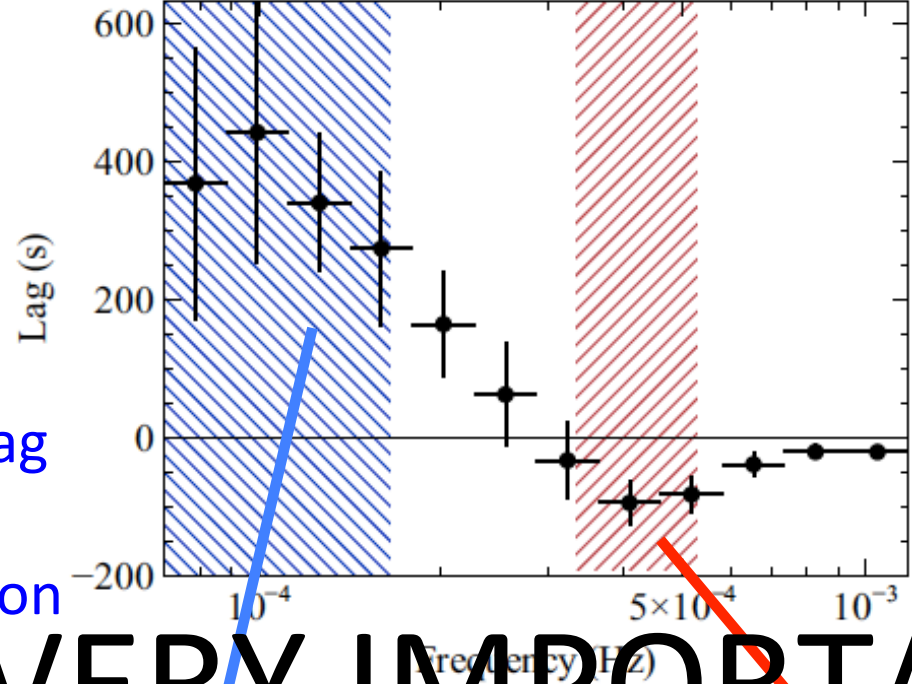
Akn564 Kara+13

Low frequency lag
featureless so
NOT reverberation

High frequency lag
shows iron
So is reverberation



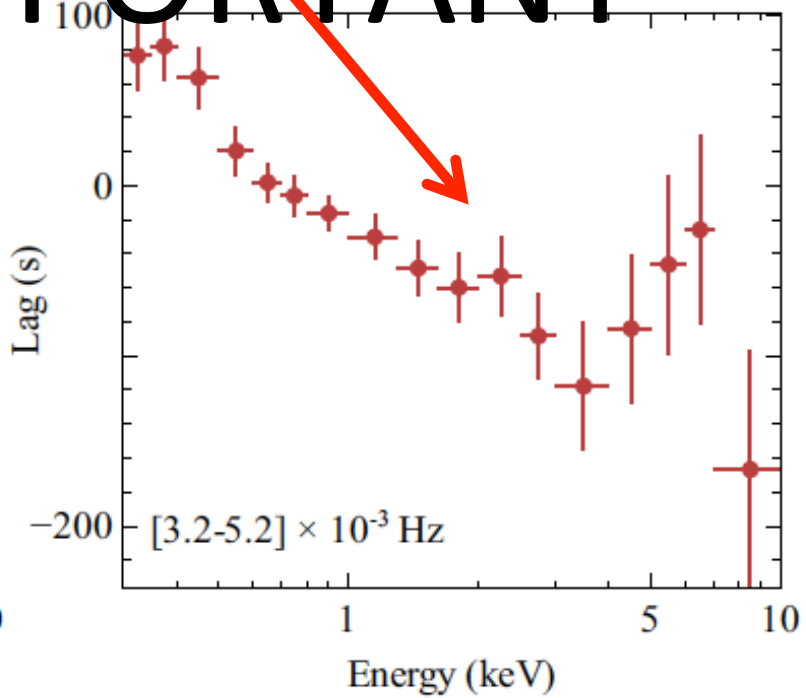
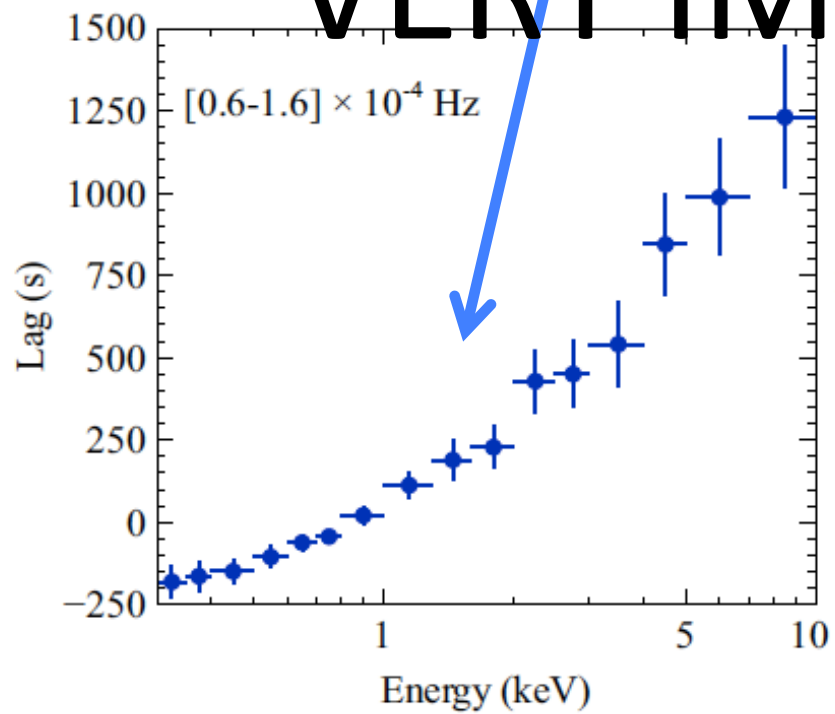
Akn564
Kara+13

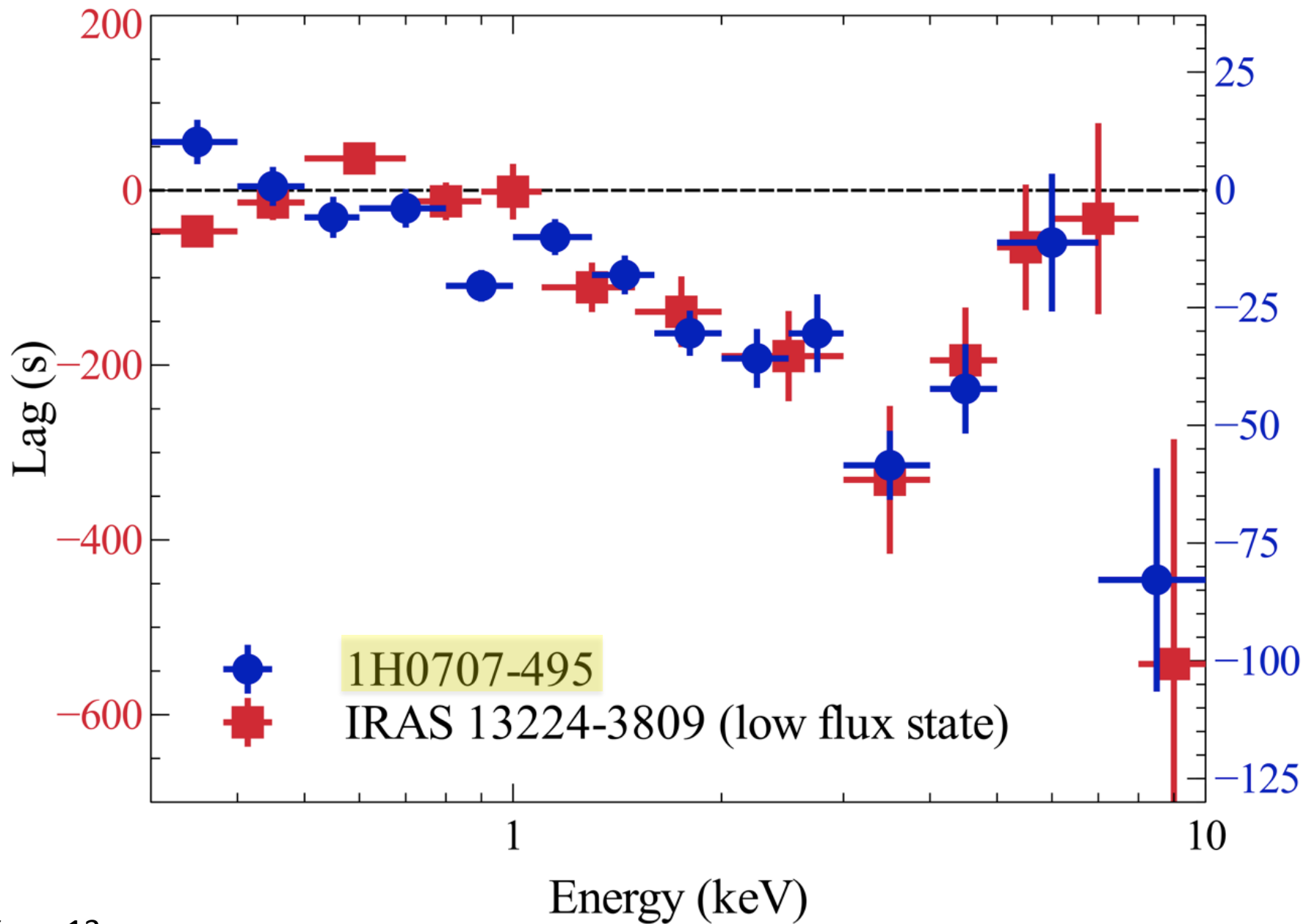


Low frequency lag
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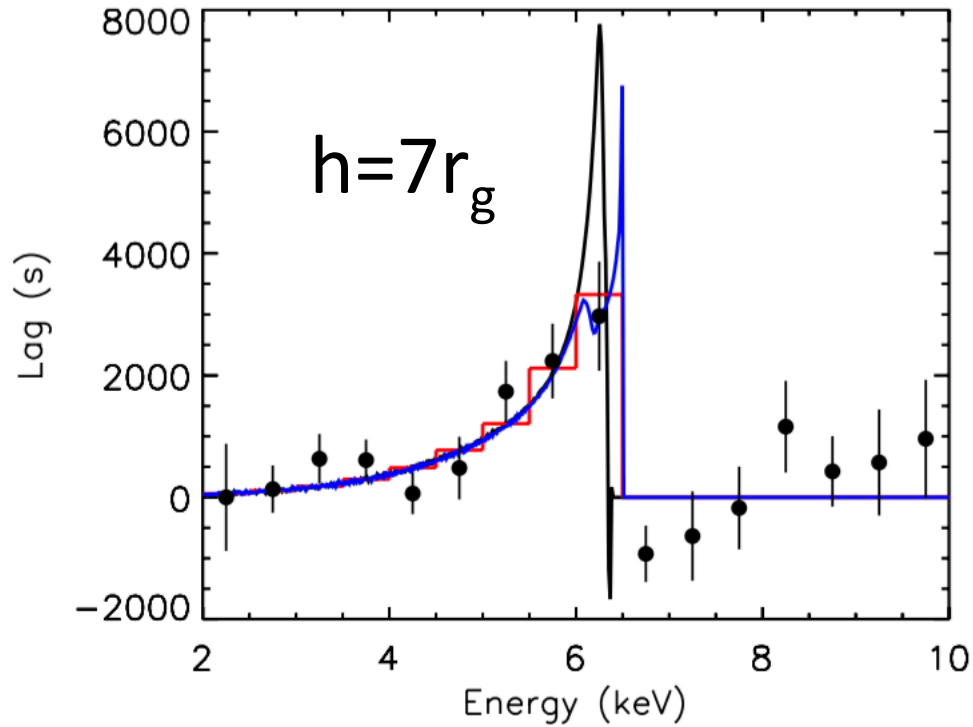
High frequency
lag shows iron
so IS reverberation

VERY IMPORTANT

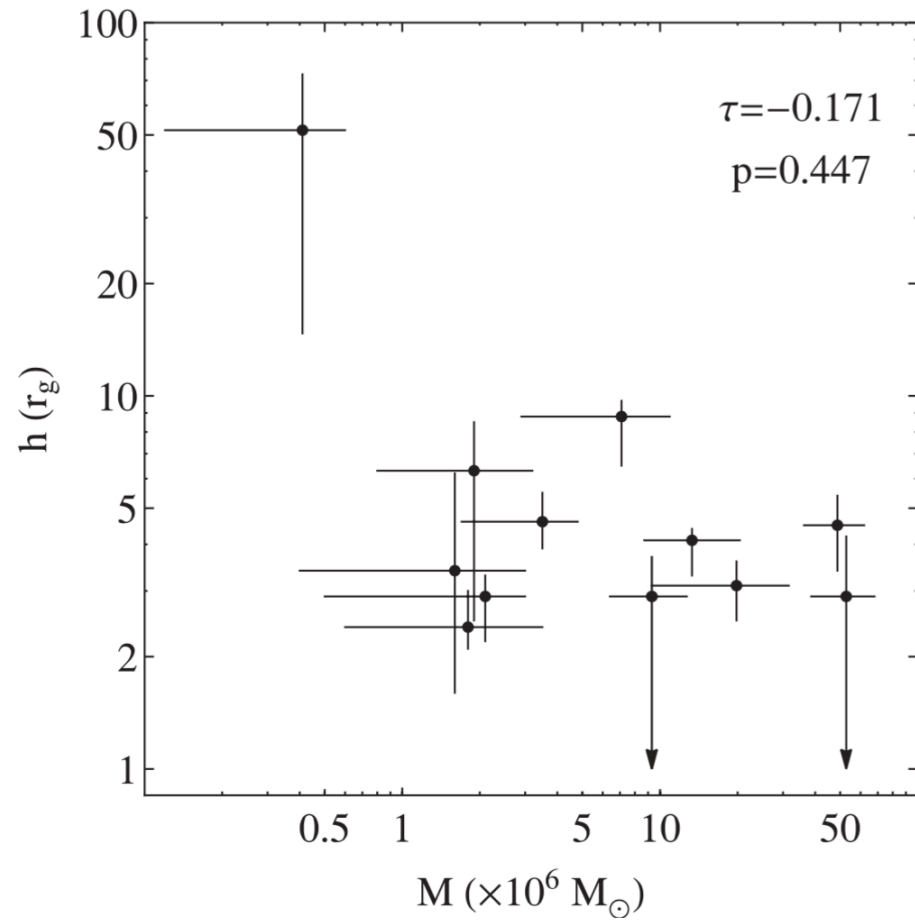




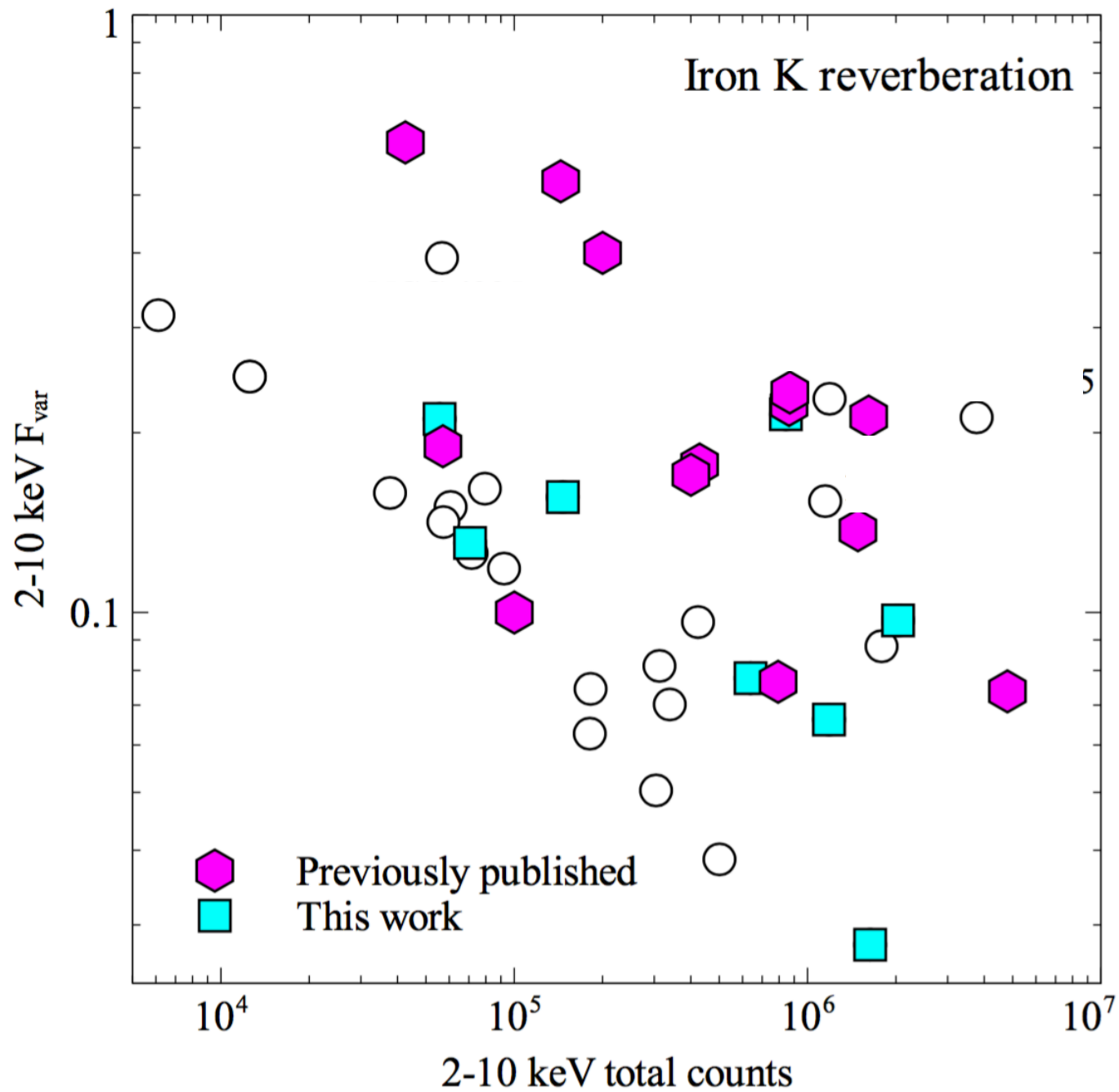
GR Modelling



Cackett+14



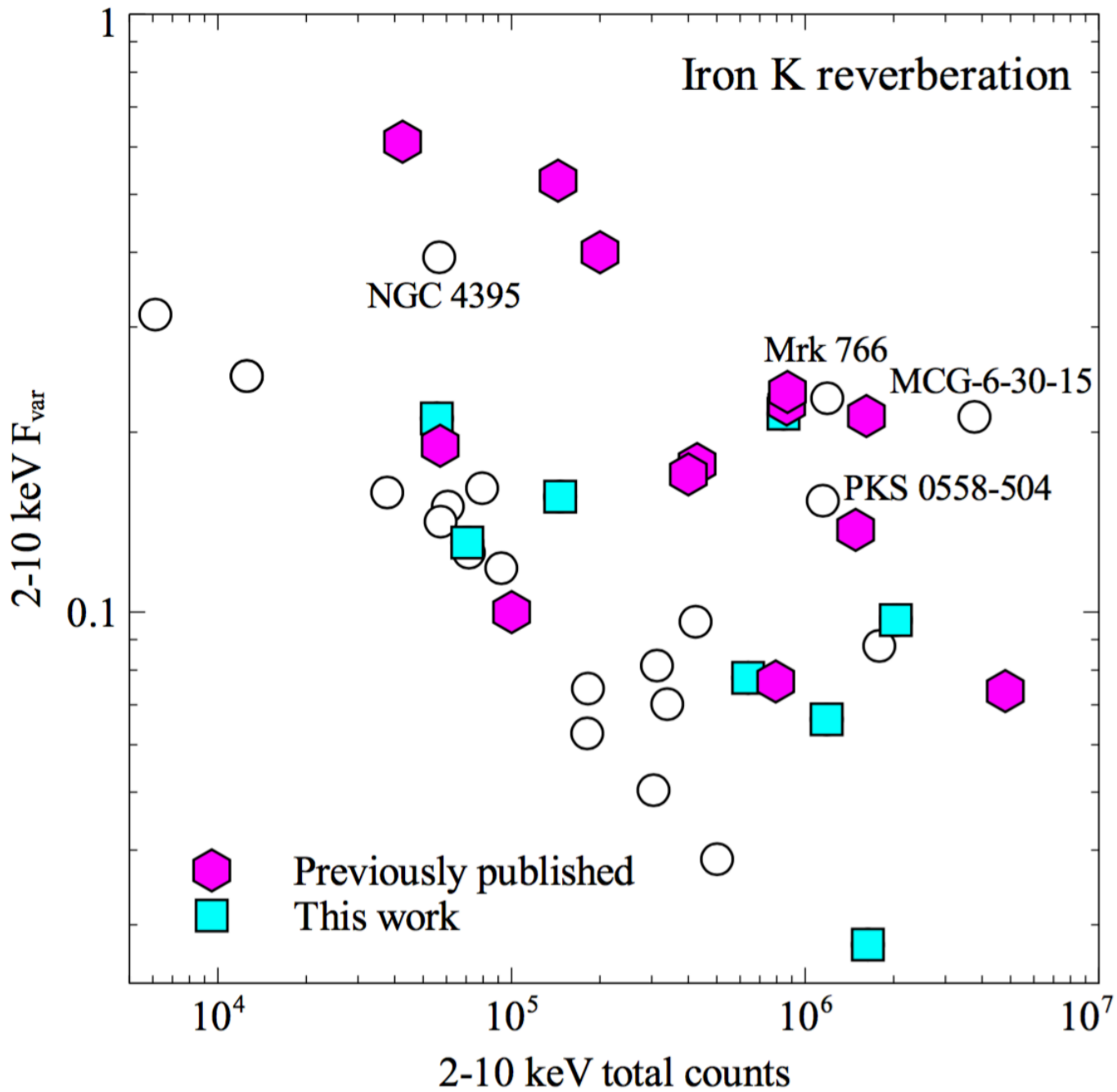
Emmanoulopoulos+14



XMM
archive

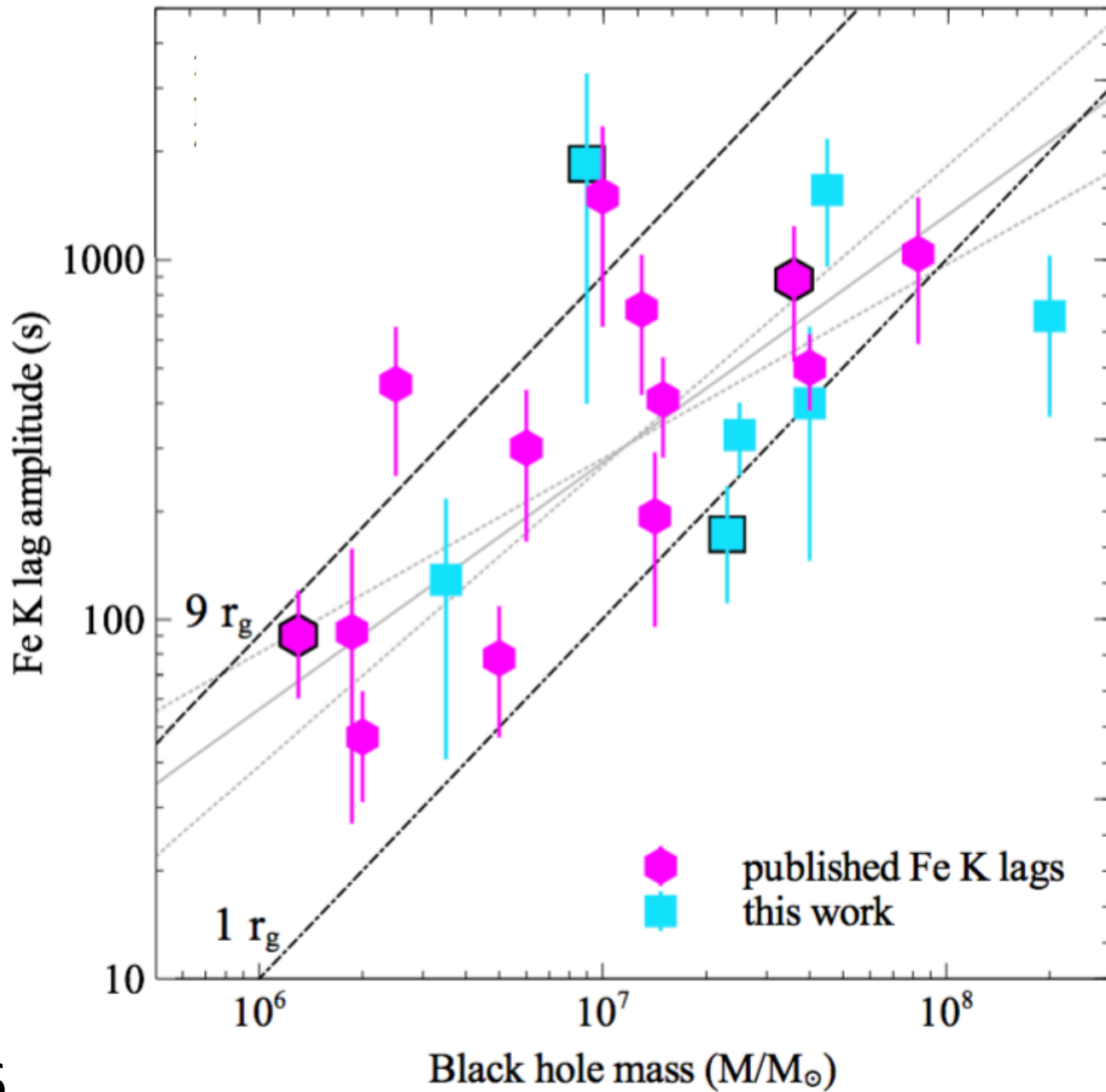
Fe K lags
42 sources
13 published
8 new

Kara+16
(today)



Fe K lags
42 sources
13 published
8 new

Kara+16

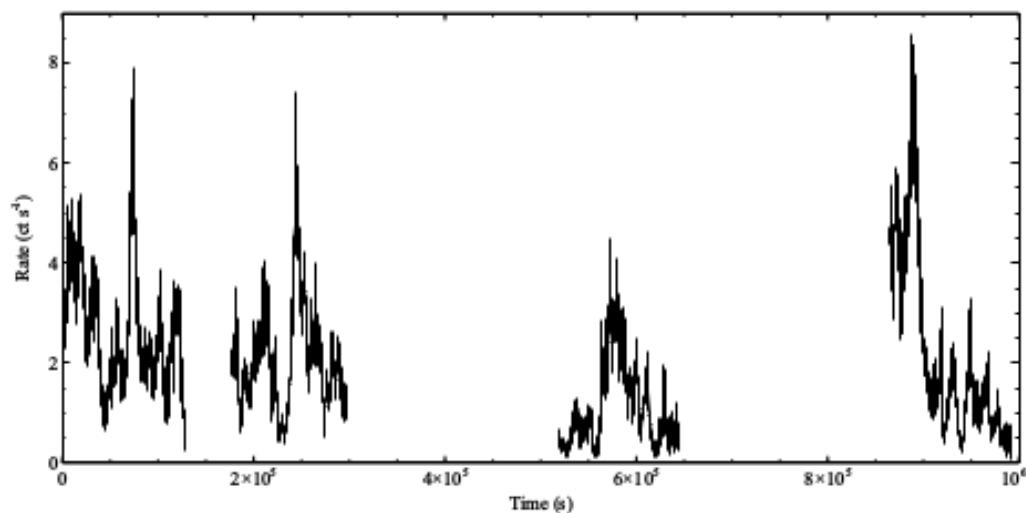


Kara+16

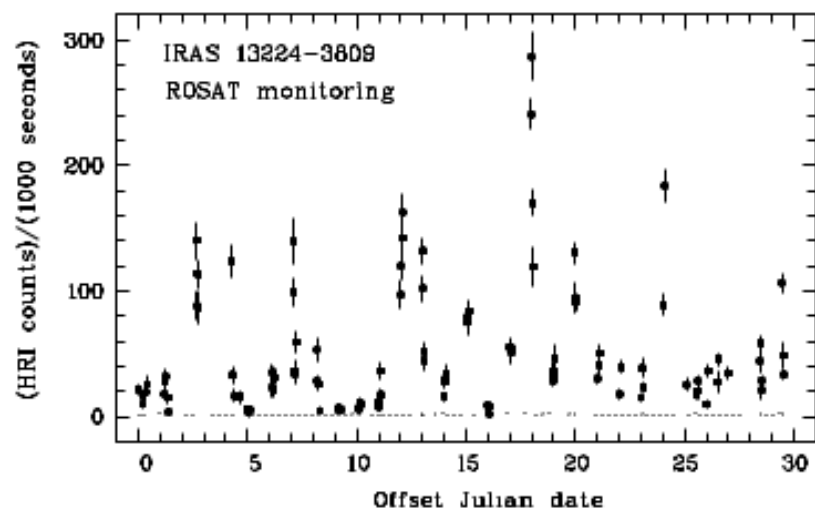
The Near Future

- Time to go to the next order of complexity!
- The corona is dynamic and not a simple static spherical lamppost!
- VERY LONG (Ms) observations of Key Objects will study dynamic behaviour of corona

IRAS13224-3809 - a key object

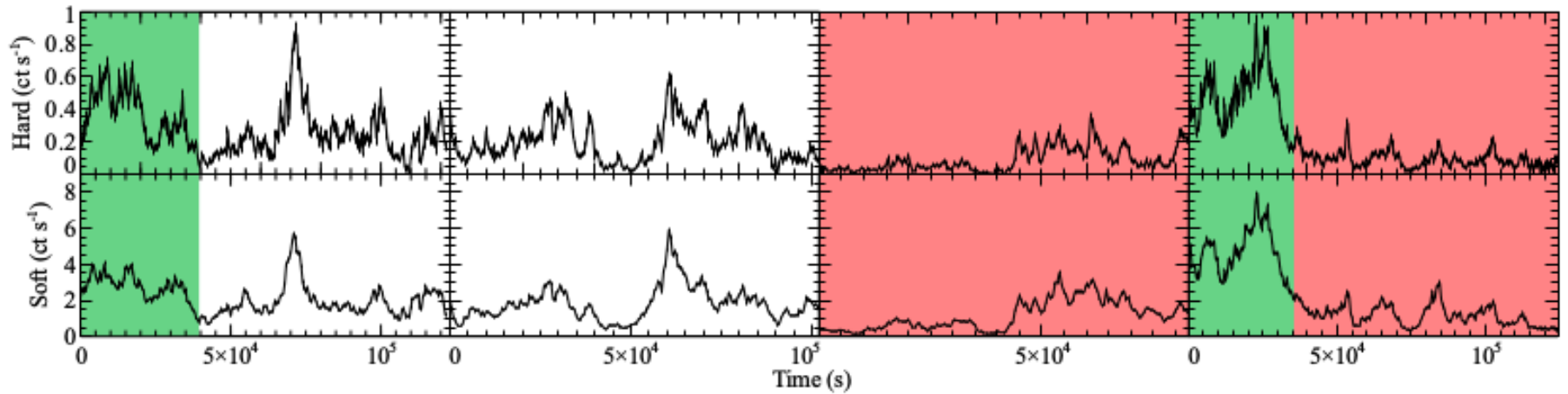


Fabian+13

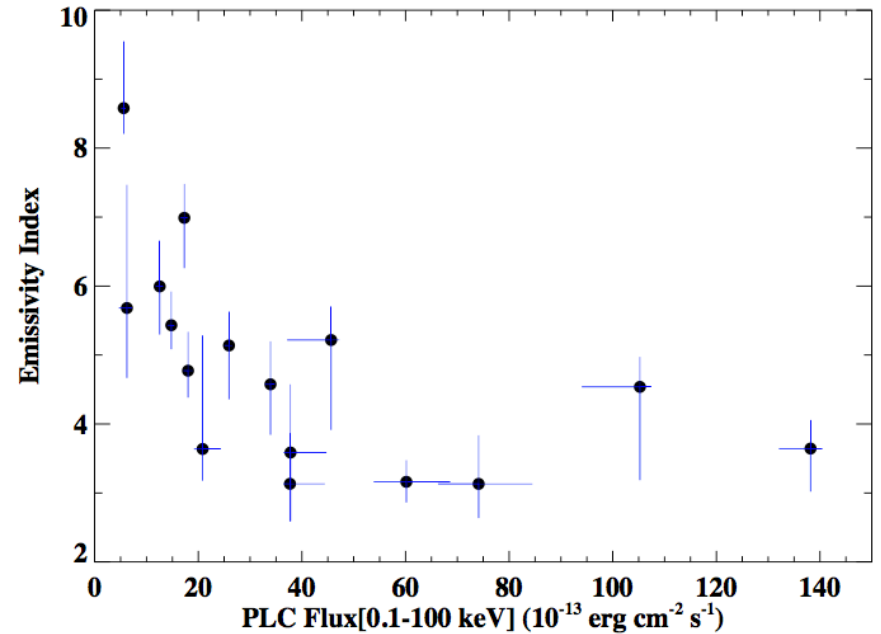
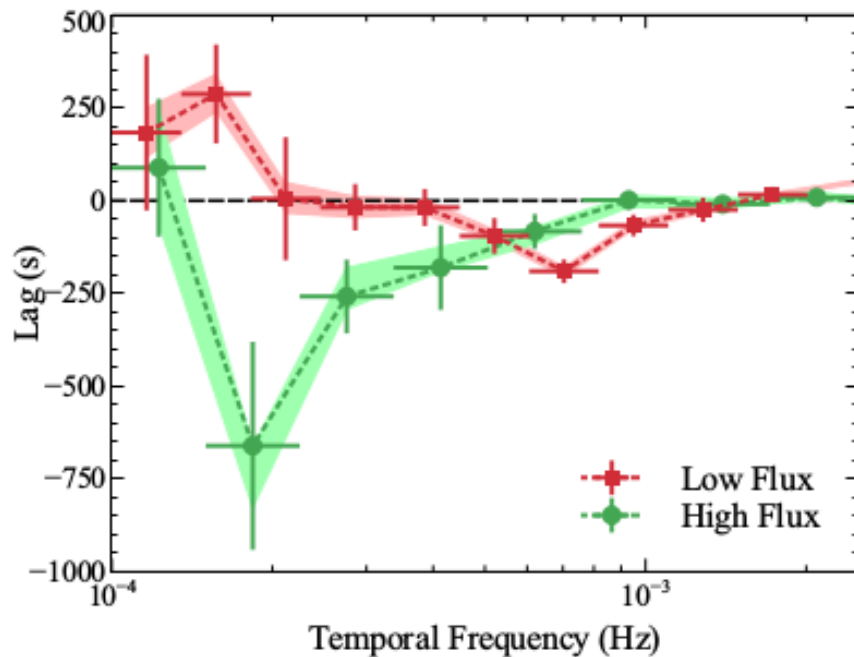


Boller+97

Kara+13



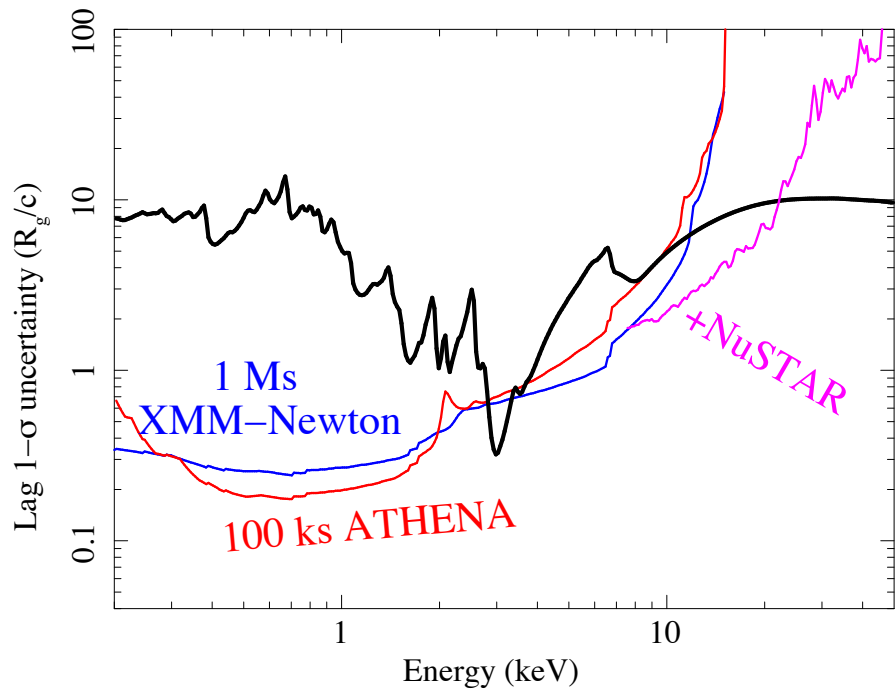
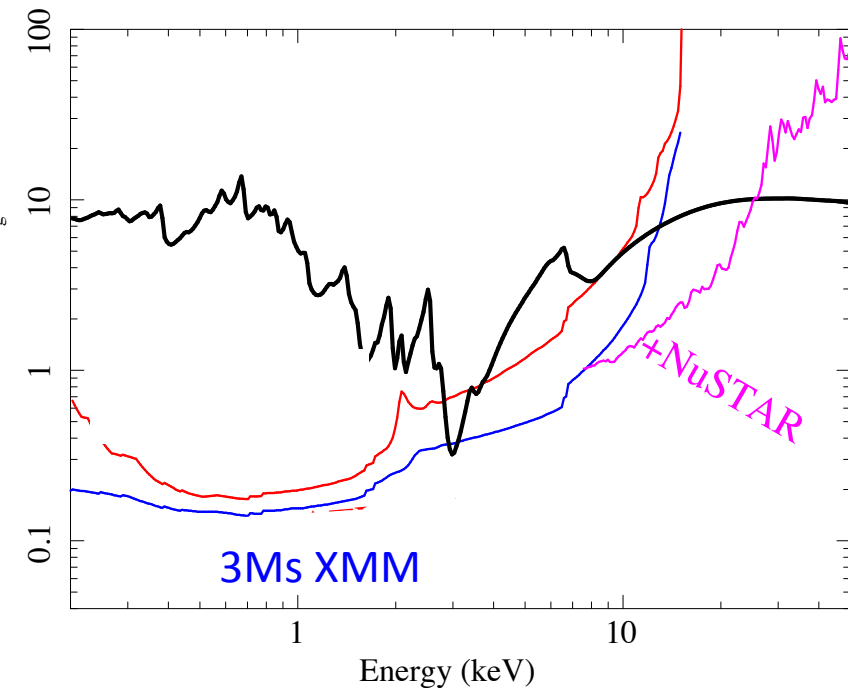
A dynamic corona



Legacy Proposal

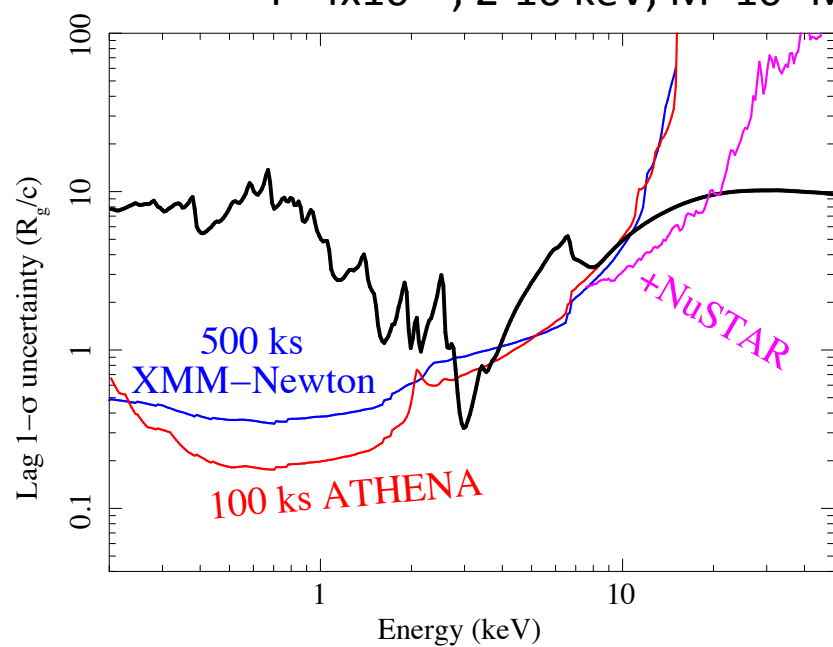
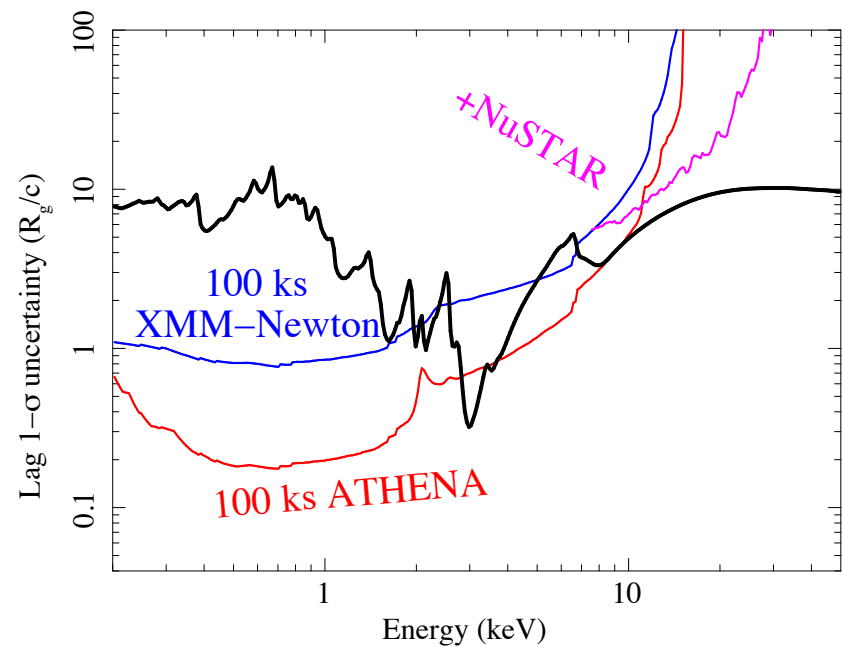
(on behalf of Reverberation Group)

- Make at least one x 1Ms exposure per year of a bright, rapidly variable, AGN to measure reverberation. (XMM will take 200 Ms of observations over next 10 yr.)
- Make several x 3Ms exposure of the best targets.
- Goal is to understand dynamic behaviour of inner disk and corona : How quasars work.
- **Only XMM can do this** before ATHENA



P. Uttley+14

$F=4 \times 10^{-11}$, 2-10 keV, $M=10^6 M_{\text{sun}}$



Ultra-Deep Observations

- There is much untapped potential for ultradeep reverberation observations:
- Returning radiation
- Jet launching
- Wind launching
- QPOs
- Disk structure
- ISCO
- Blandford-Znajek mechanism?
- **A wide discovery space very close to black hole**

Ultra-Deep Observations

- The ultimate dynamic map of the inner workings of an accreting black hole