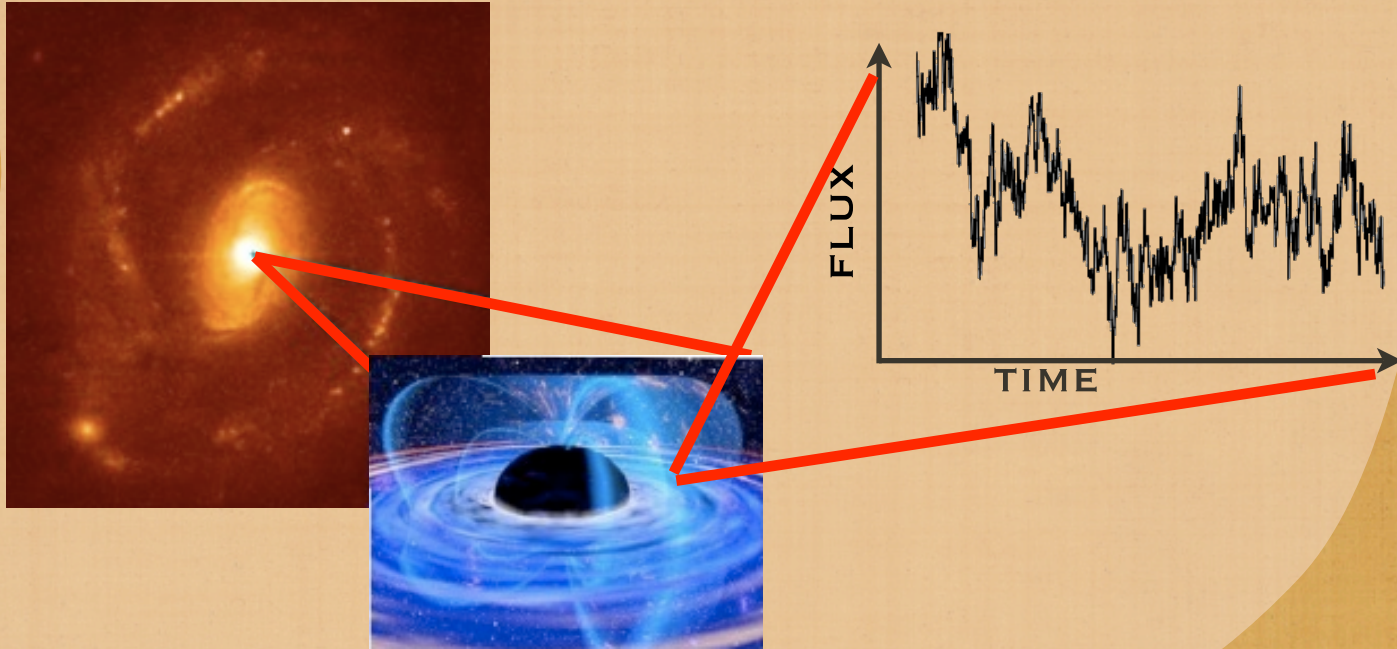


SOFT X-RAY LAGS AND THE CORRELATION WITH BH MASS IN RADIO QUIET AGN



BARBARA DE MARCO
(CENTRO DE ASTROBIOLOGÍA, CSIC-INTA)

COLLABORATORS: G. PONTI, P. UTTLEY, M. CAPPI, G. MINIUTTI,
M. DADINA, A. FABIAN, E. CACKETT

THE X-RAY SPECTRAL VIEW

FROM THE INTERACTION OF PRIMARY RADIATION WITH THE ENVIRONMENT SEVERAL SPECTRAL FEATURES EMERGE

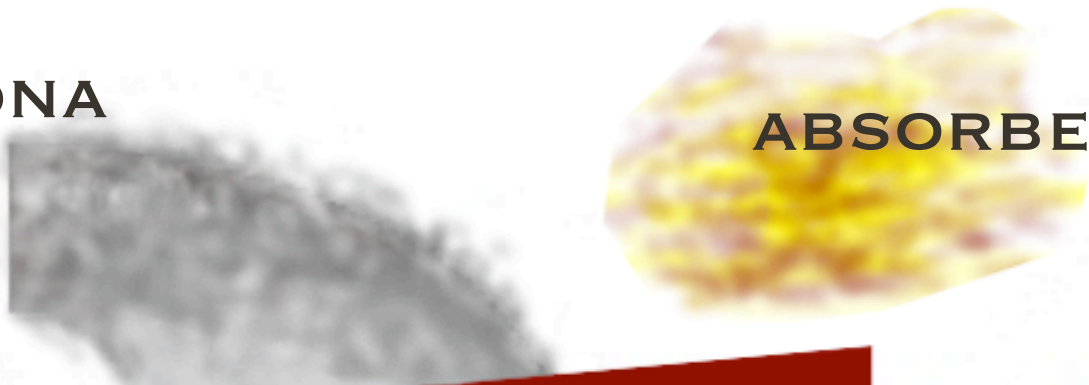
LENGTH SCALE FEW-TO-HUNDREDS GRAVITATIONAL RADII

CORONA

ABSORBER

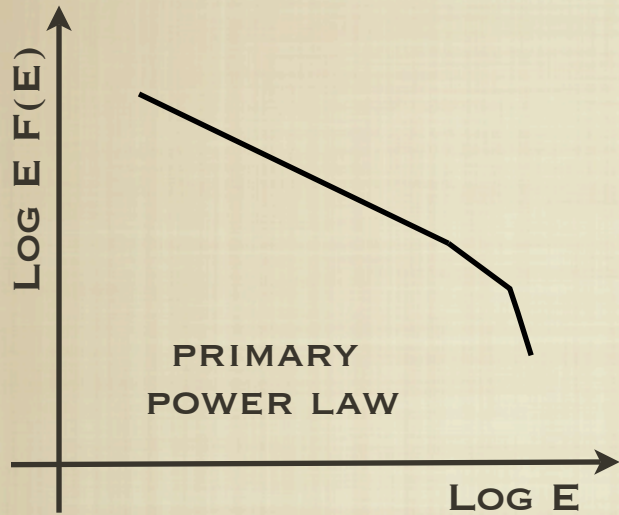
BH

ACCRETION DISK



THE X-RAY SPECTRAL VIEW

FROM THE INTERACTION OF PRIMARY RADIATION WITH THE ENVIRONMENT SEVERAL SPECTRAL FEATURES EMERGE



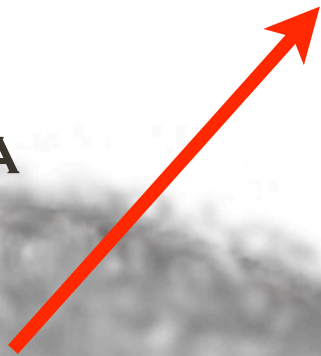
LENGTH SCALE FEW-TO-HUNDREDS GRAVITATIONAL RADII

CORONA

ABSORBER

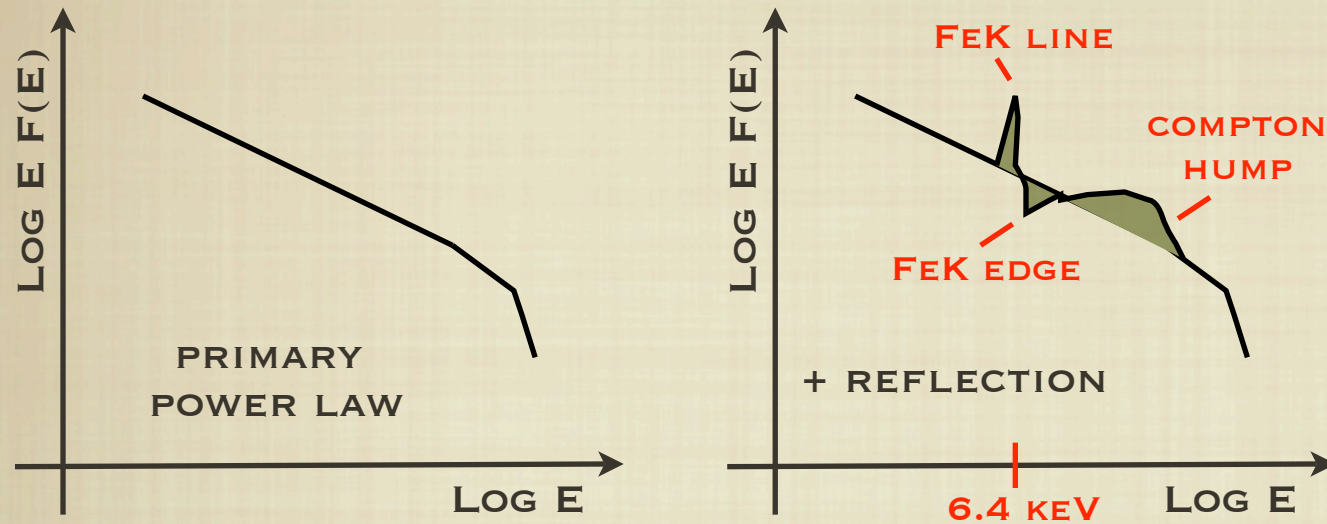
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ACCRETION DISK



THE X-RAY SPECTRAL VIEW

FROM THE INTERACTION OF PRIMARY RADIATION WITH THE ENVIRONMENT SEVERAL SPECTRAL FEATURES EMERGE



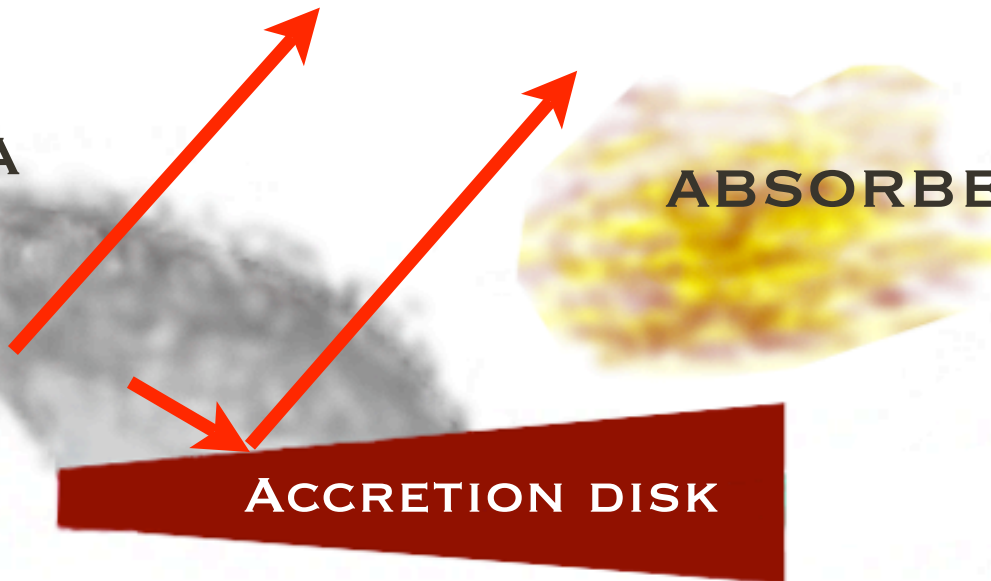
LENGTH SCALE FEW-TO-HUNDREDS GRAVITATIONAL RADII

CORONA

ABSORBER

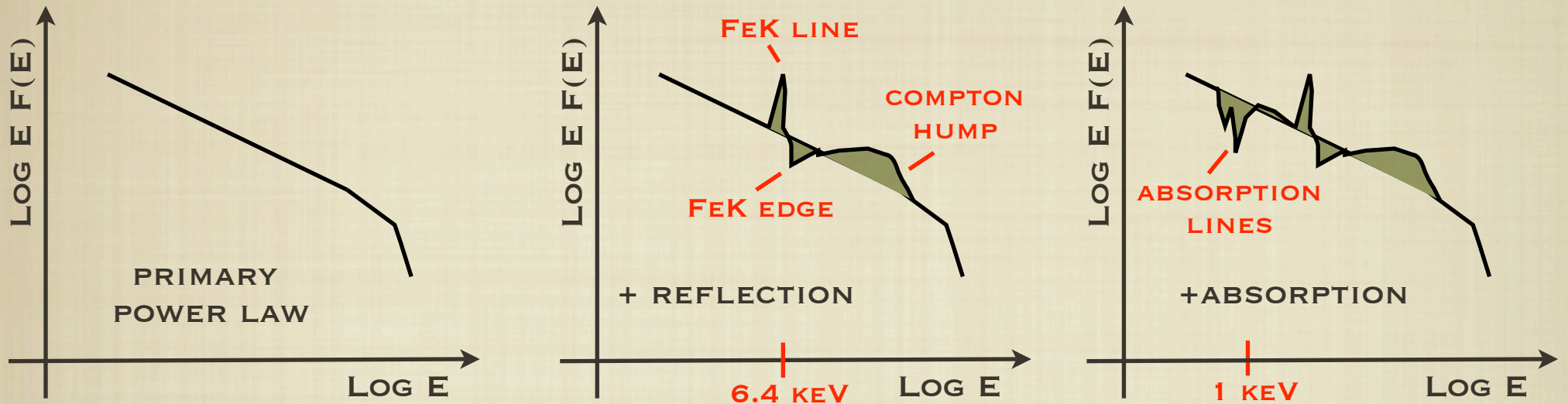
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ACCRETION DISK



THE X-RAY SPECTRAL VIEW

FROM THE INTERACTION OF PRIMARY RADIATION WITH THE ENVIRONMENT SEVERAL SPECTRAL FEATURES EMERGE



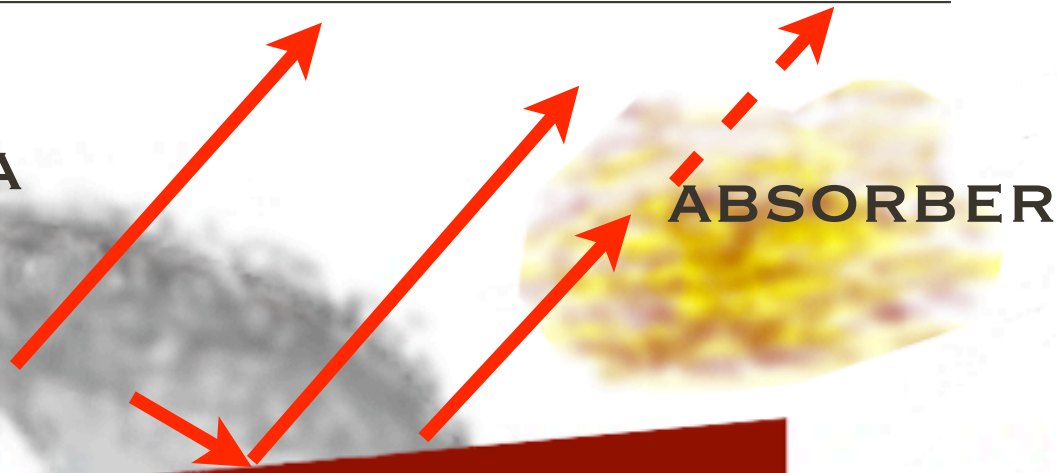
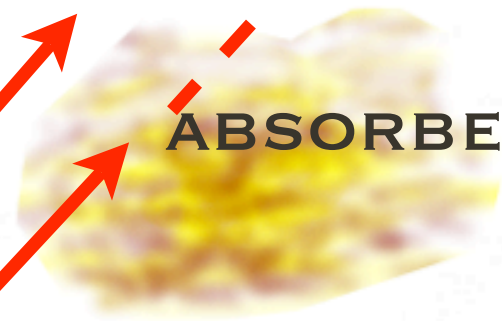
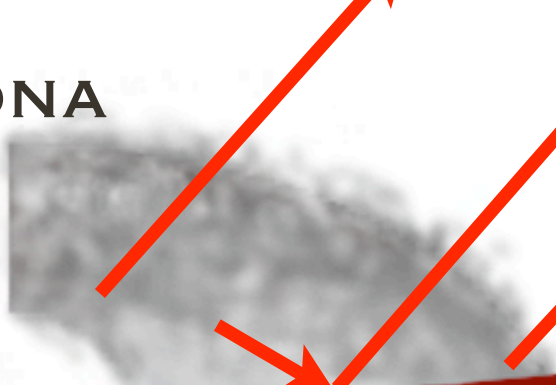
LENGTH SCALE FEW-TO-HUNDREDS GRAVITATIONAL RADII

CORONA

ABSORBER

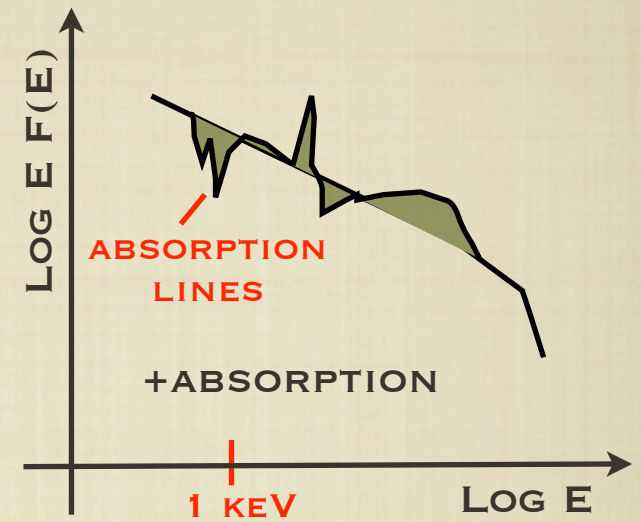
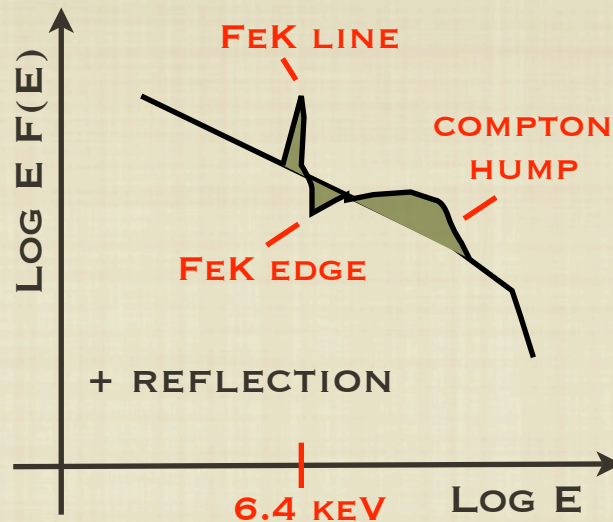
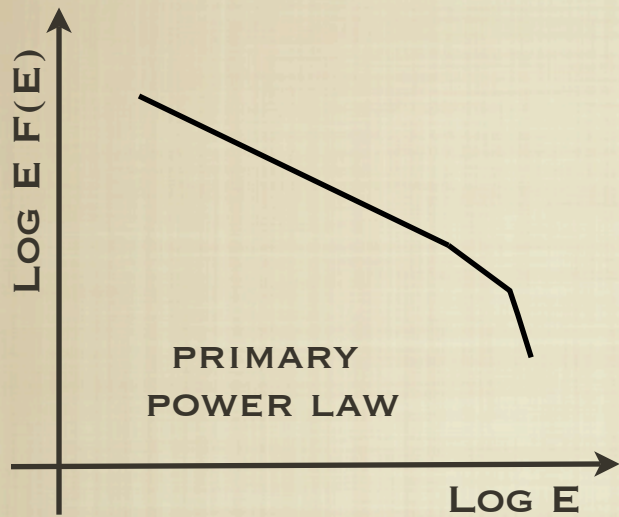
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ACCRETION DISK



THE X-RAY SPECTRAL VIEW

FROM THE INTERACTION OF PRIMARY RADIATION WITH THE ENVIRONMENT SEVERAL SPECTRAL FEATURES EMERGE



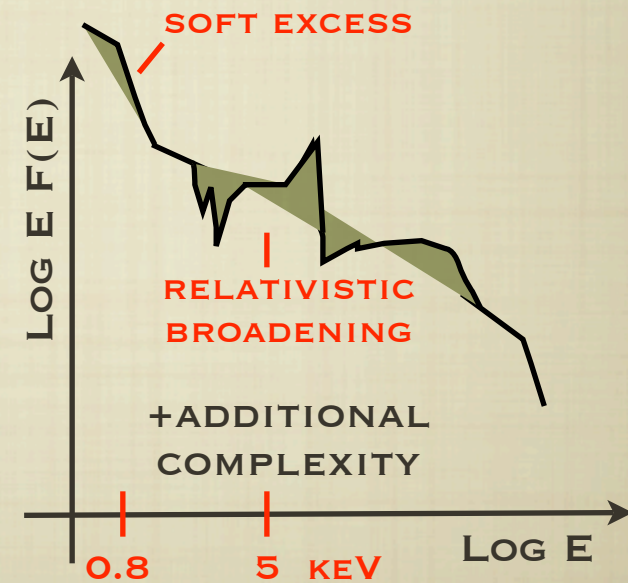
LENGTH SCALE FEW-TO-HUNDREDS GRAVITATIONAL RADII

CORONA

ABSORBER

BH

ACCRETION DISK



THE X-RAY VARIABILITY

AGN PRIMARY EMISSION IS HIGHLY VARIABLE

THE X-RAY SECONDARY COMPONENTS ACT LIKE FILTERS TO THIS RADIATION

CORONA

ABSORBER

BH

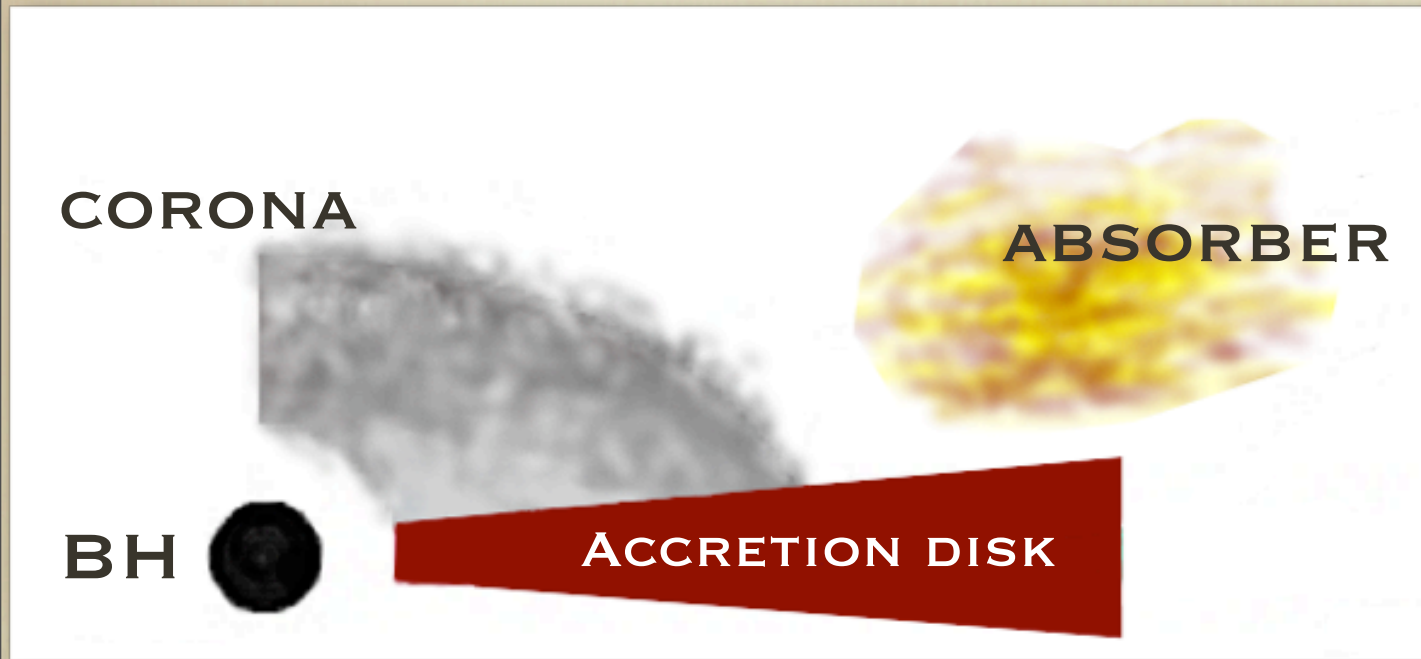
ACCRETION DISK

INPUT



FILTER

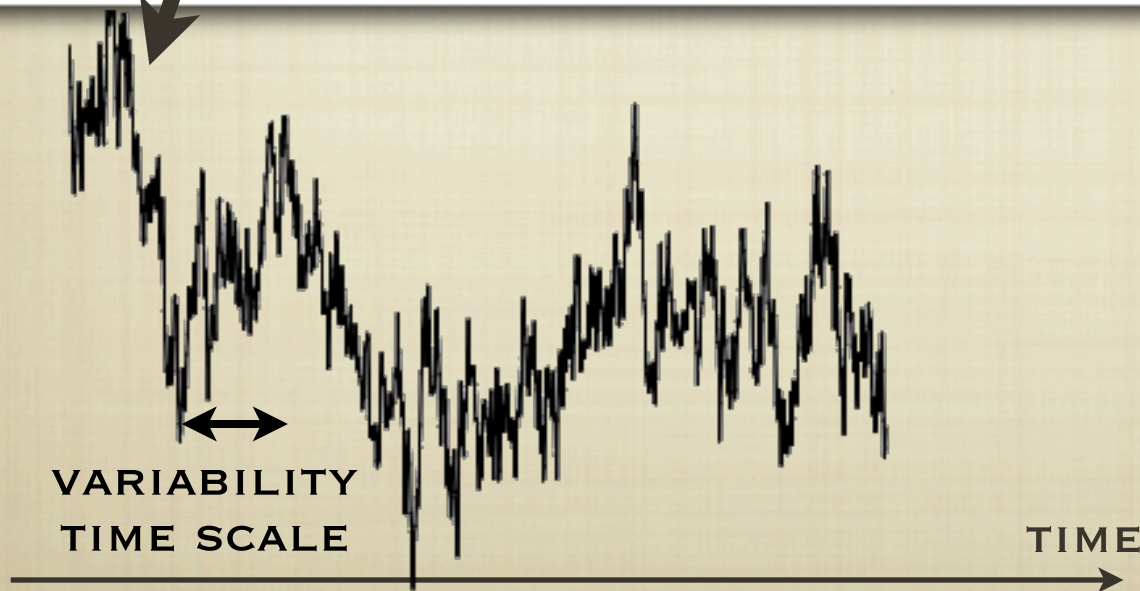
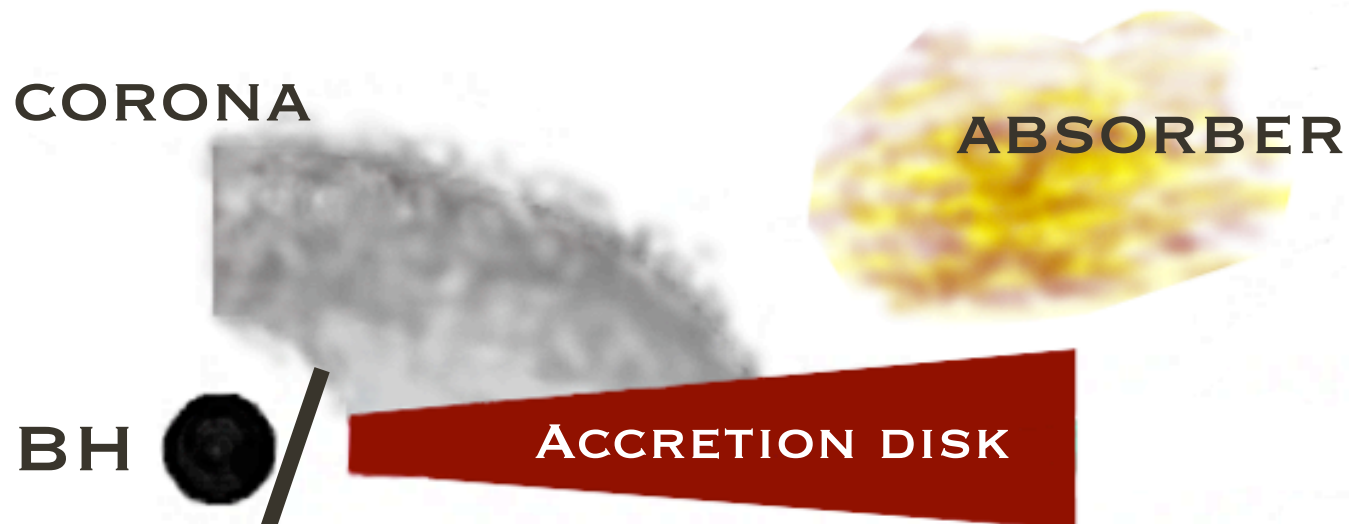
OUTPUT



THE X-RAY VARIABILITY

AGN PRIMARY EMISSION IS HIGHLY VARIABLE

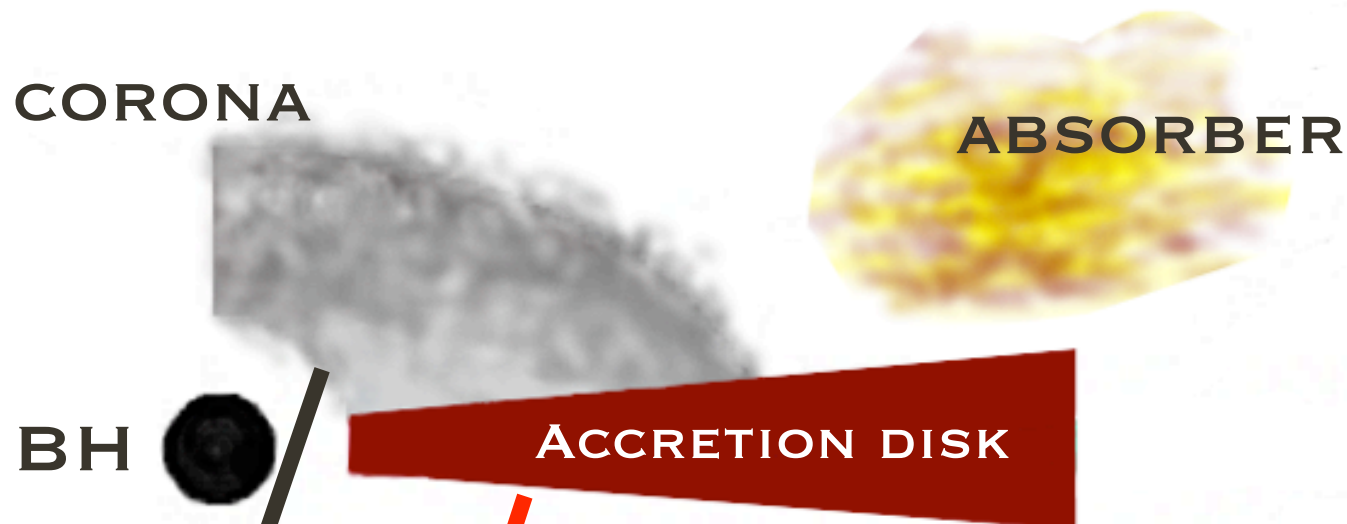
THE X-RAY SECONDARY COMPONENTS ACT LIKE FILTERS TO THIS RADIATION



THE X-RAY VARIABILITY

AGN PRIMARY EMISSION IS HIGHLY VARIABLE

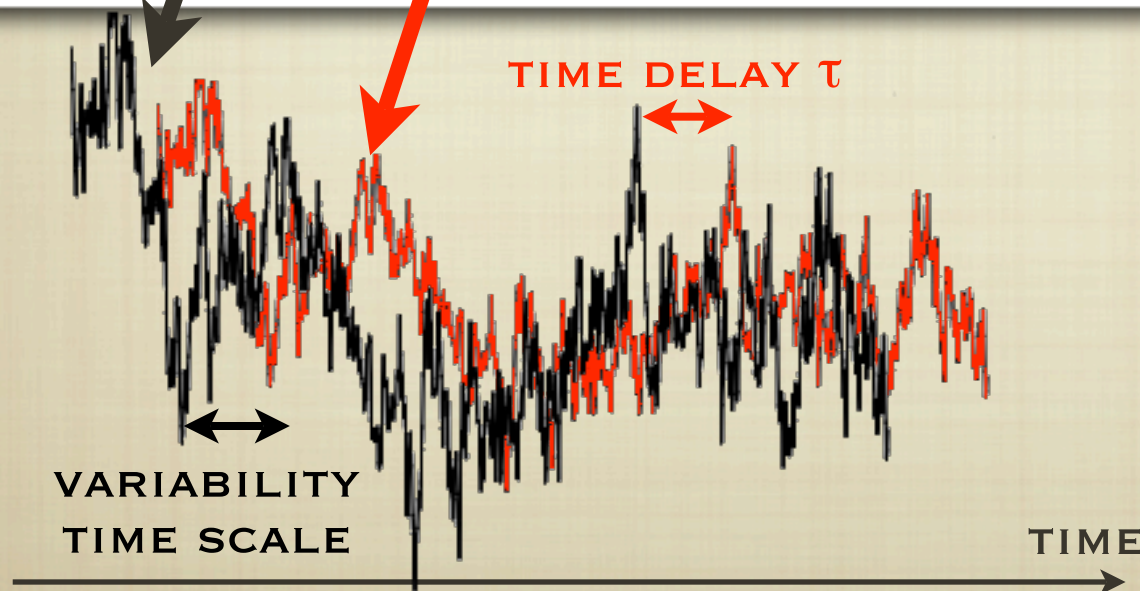
THE X-RAY SECONDARY COMPONENTS ACT LIKE FILTERS TO THIS RADIATION



INPUT

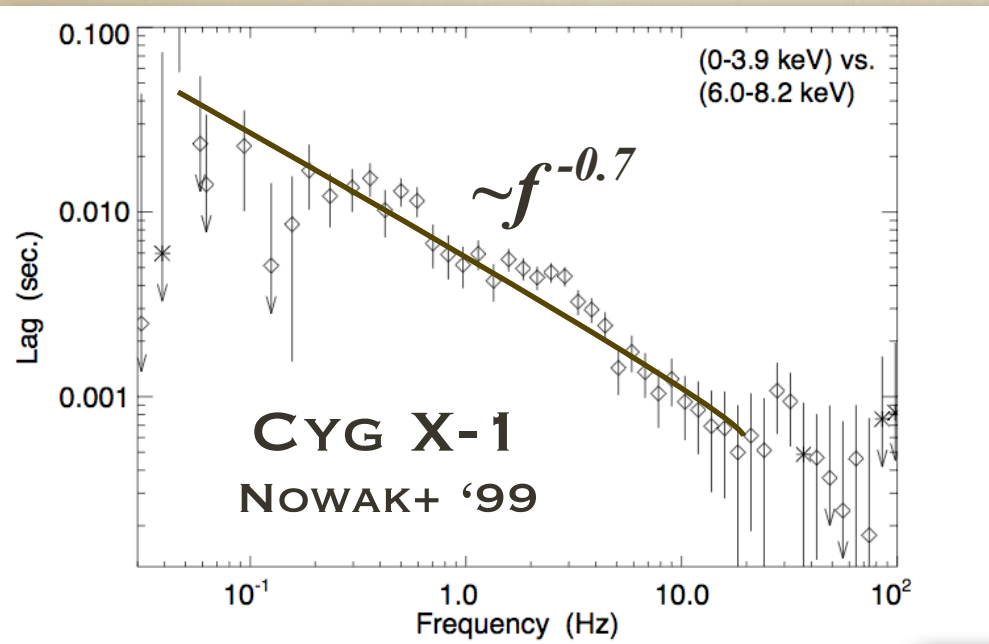


OUTPUT



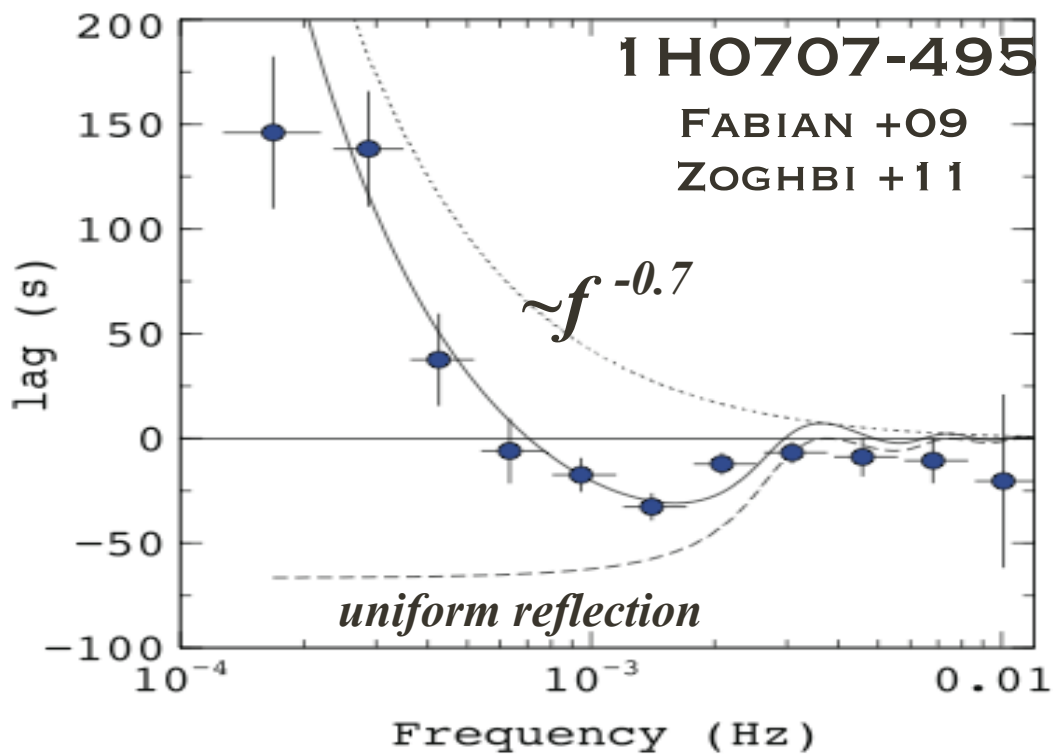
POTENTIALITY:
MAPPING THE GEOMETRY OF
THE INNER REGIONS

X-RAY LAGS IN BH ACCRETING SOURCES

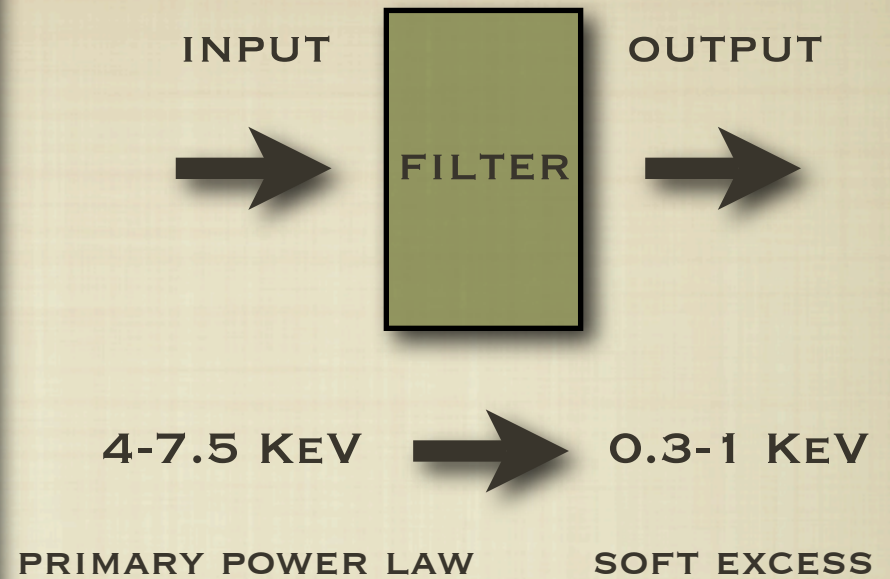
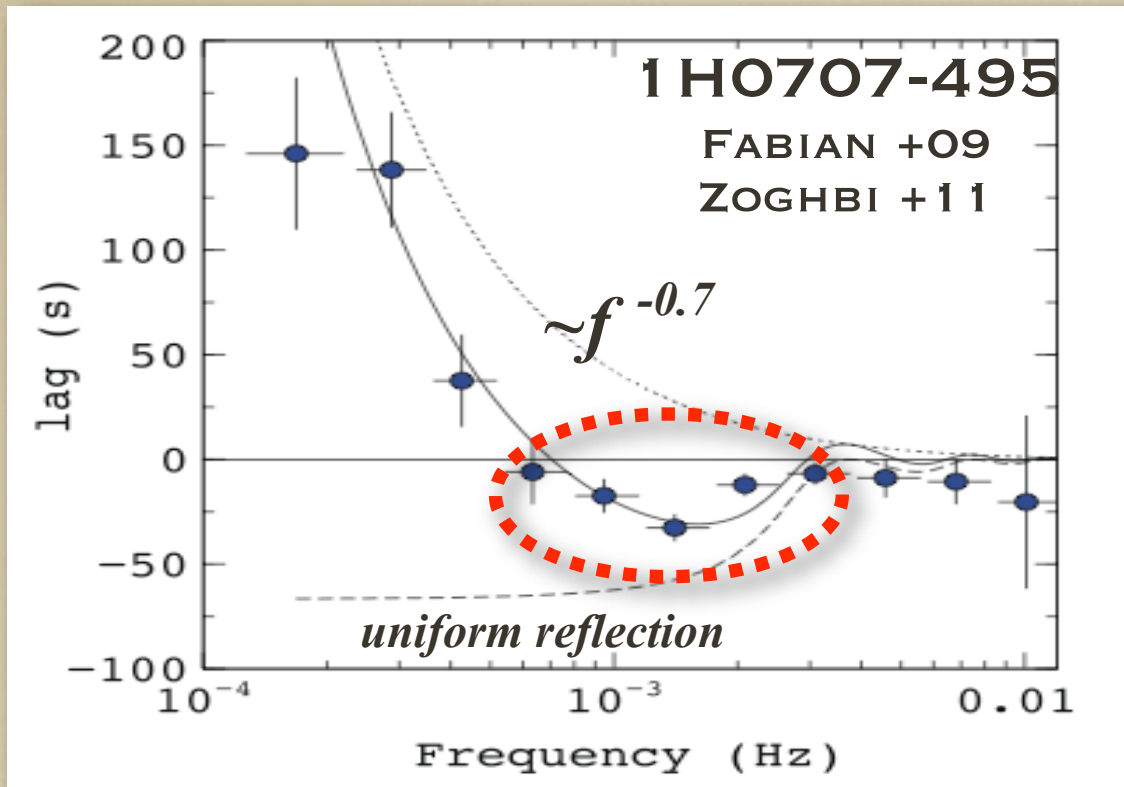


GBHS DO COMMONLY SHOW HARD X-RAY LAGS (E.G. DUE TO PROPAGATION OF MASS ACCRETION RATE FLUCTUATIONS, KOTOV + 11)

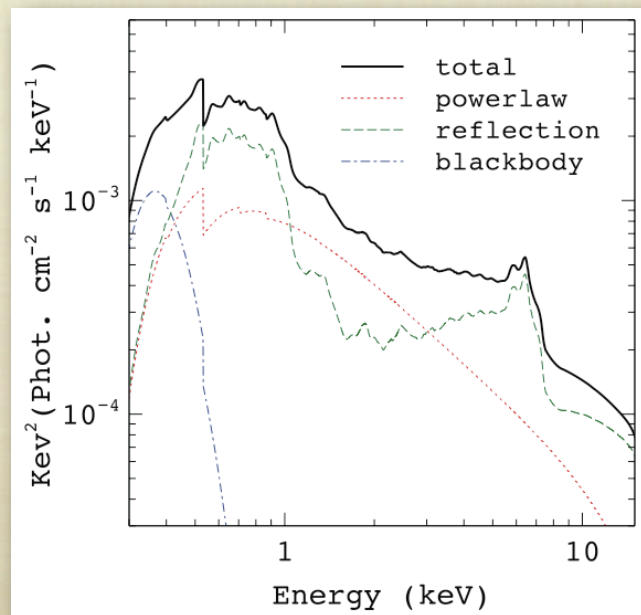
FIRST HIGHLY SIGNIFICANT DETECTION OF A HIGH FREQ SOFT X-RAY LAG IN A NLSY1



1) INTERPRETATION



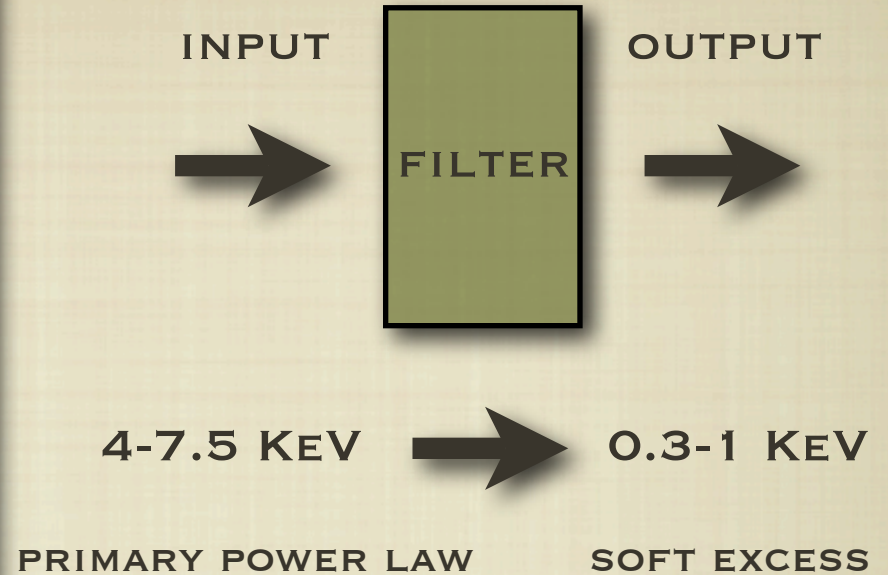
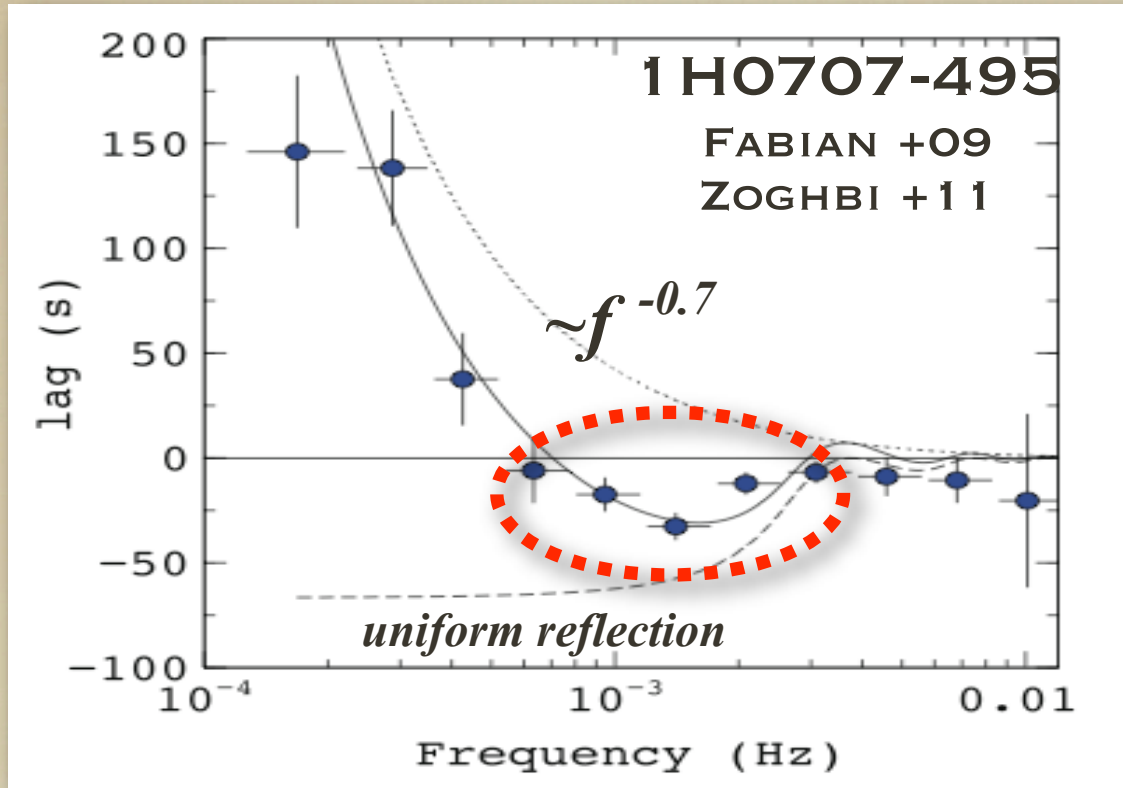
RELATIVISTICALLY
BLURRED REFLECTION



→

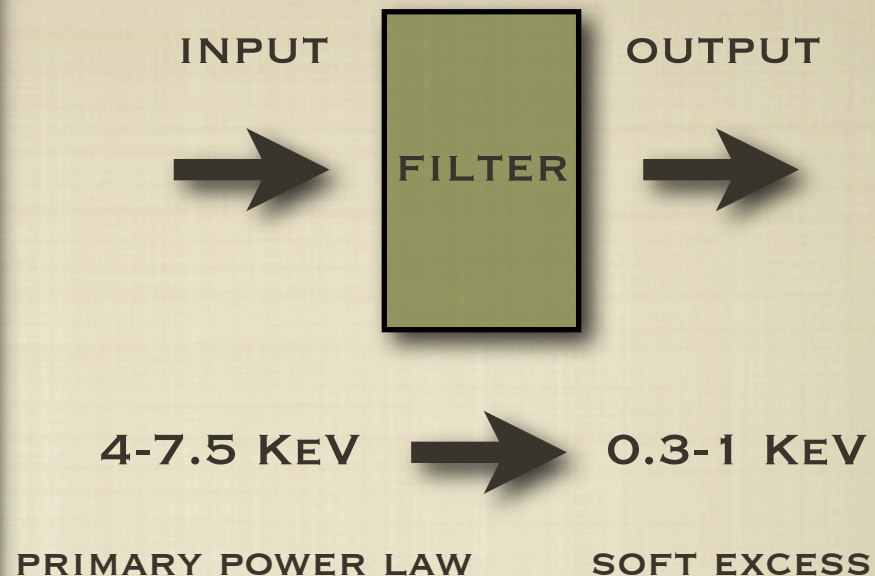
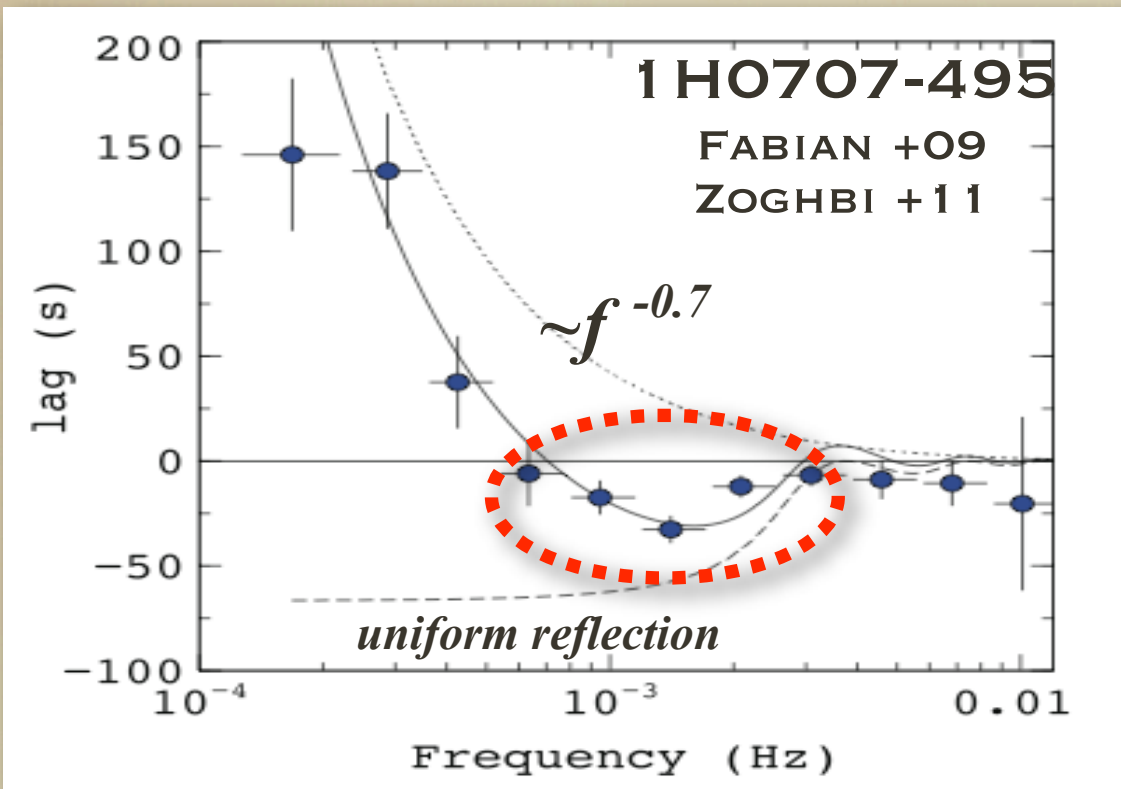
THE SOFT X-RAY LAG
MAPS INNER DISK
REVERBERATION
TIME SCALES

1) INTERPRETATION



ALTERNATIVELY THE SOFT LAG
MAPS REVERBERATION OF
DISTANT REFLECTORS CLOSE TO
THE LINE OF SIGHT
(MILLER +11)

1) INTERPRETATION



OTHER DETECTIONS FOLLOWED:

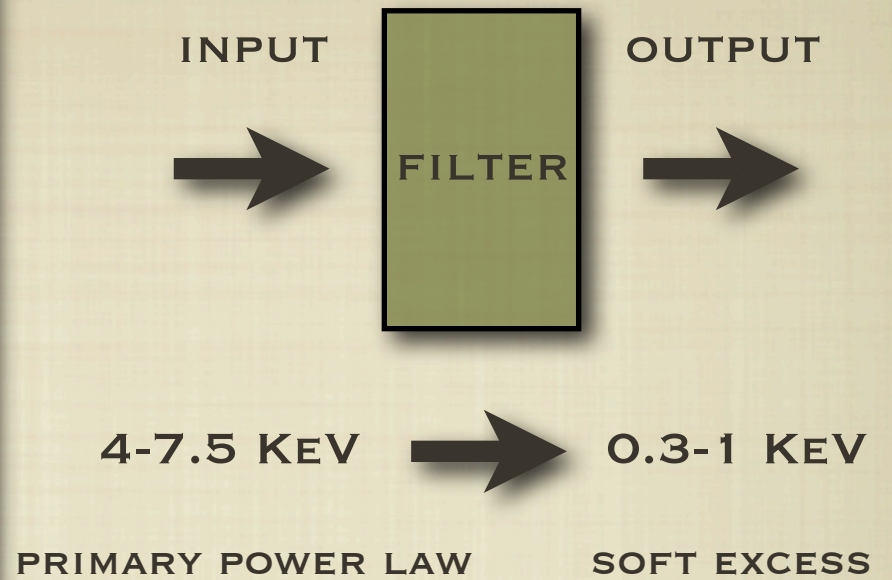
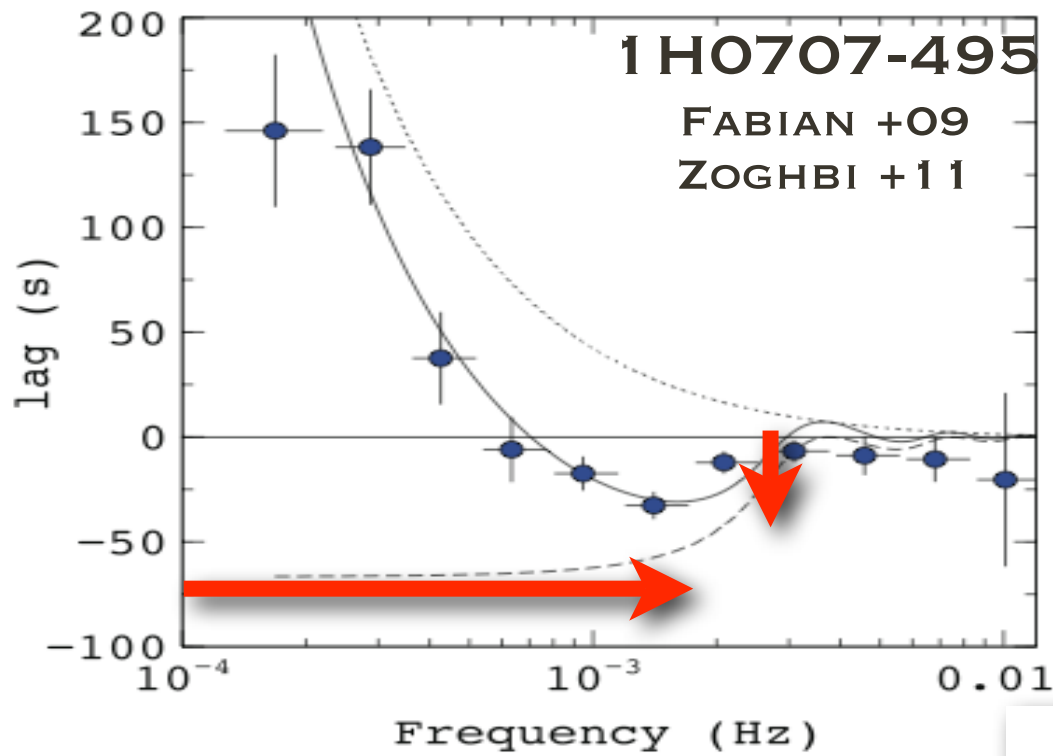
MRK 766 & MCG-6-30-15
(EMMANOULOPOULOS +11)

MRK 1040
(TRIPATHI +11)

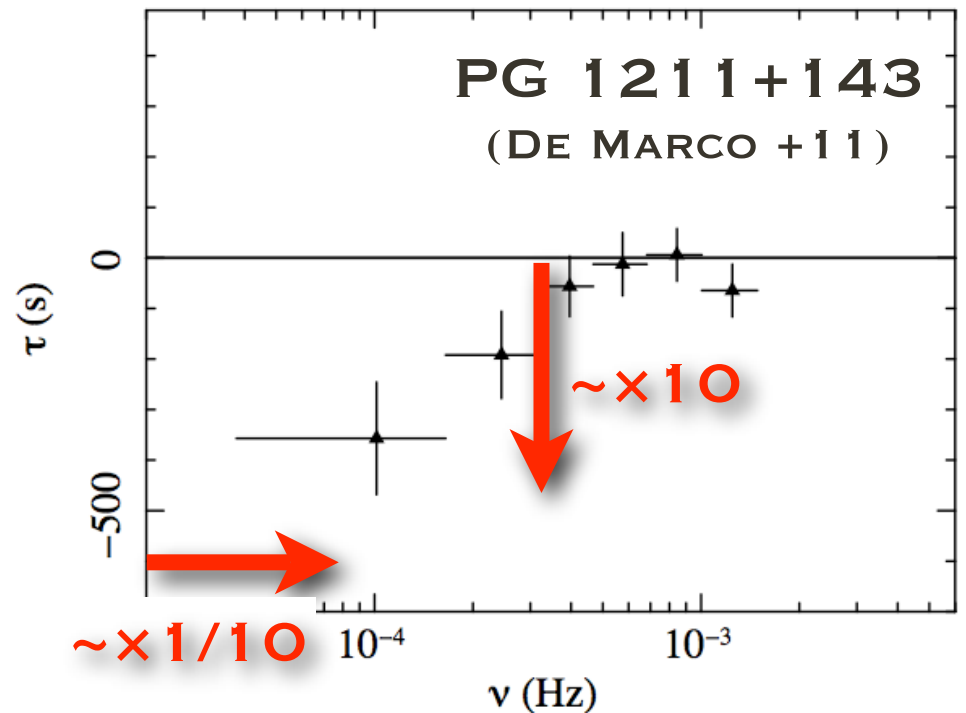
REJ 1034+396
(ZOGHBI & FABIAN +11)

PG 1211+143
(DE MARCO +11)

2) PROFILE CHANGE



**~x10 IN
BH MASS**



HOW COMMON IS THIS?

TYPE 1 (I.E. UNOBSCURED) AGN

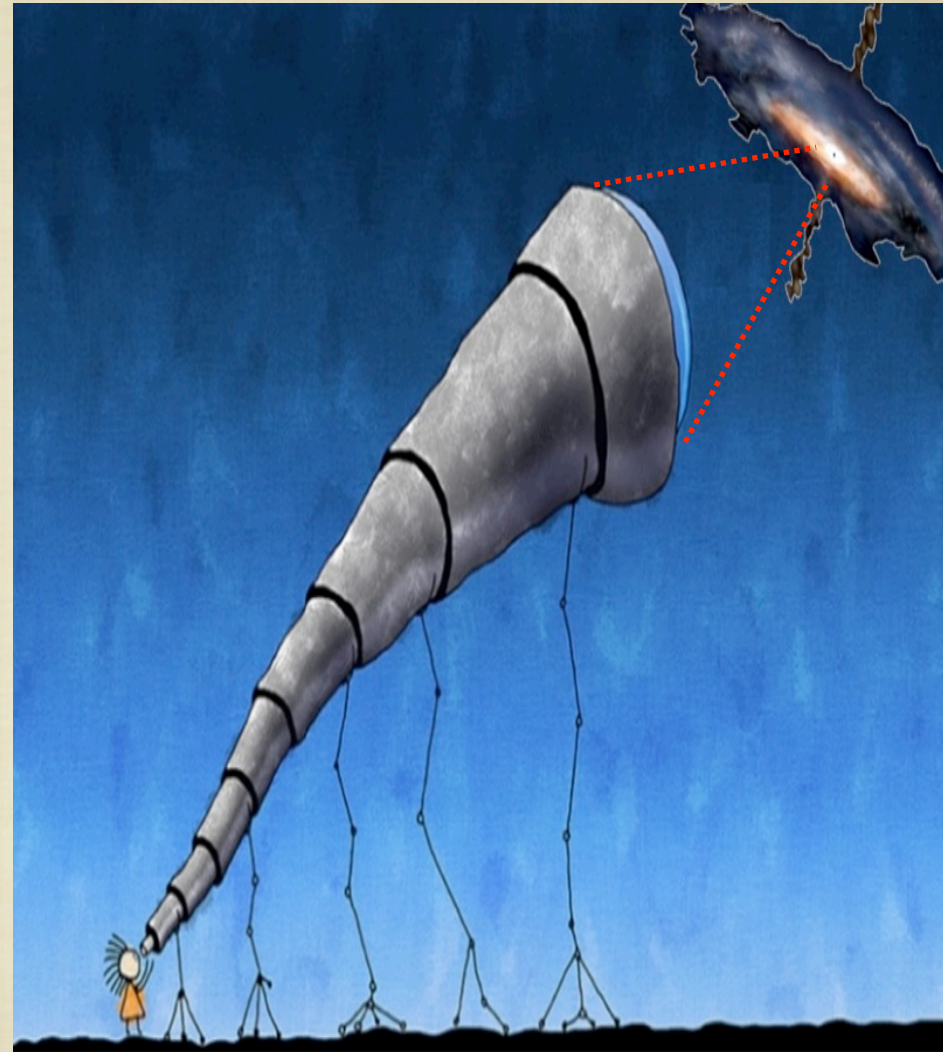
FROM XMM-NEWTON ARCHIVE EXPOSURE
 ≥ 40 KS

VARIABLE IN HARD X-RAY BAND
(USING TABULATED VALUES OF EXCESS
VARIANCE IN CAIXAVAR SAMPLE PONTI +11)

TABULATED BH MASS ESTIMATES

THE SAMPLE INCLUDES 32 SOURCES
COVERING A RANGE OF ~ 3 ORDERS OF
MAGNITUDE IN BH MASS

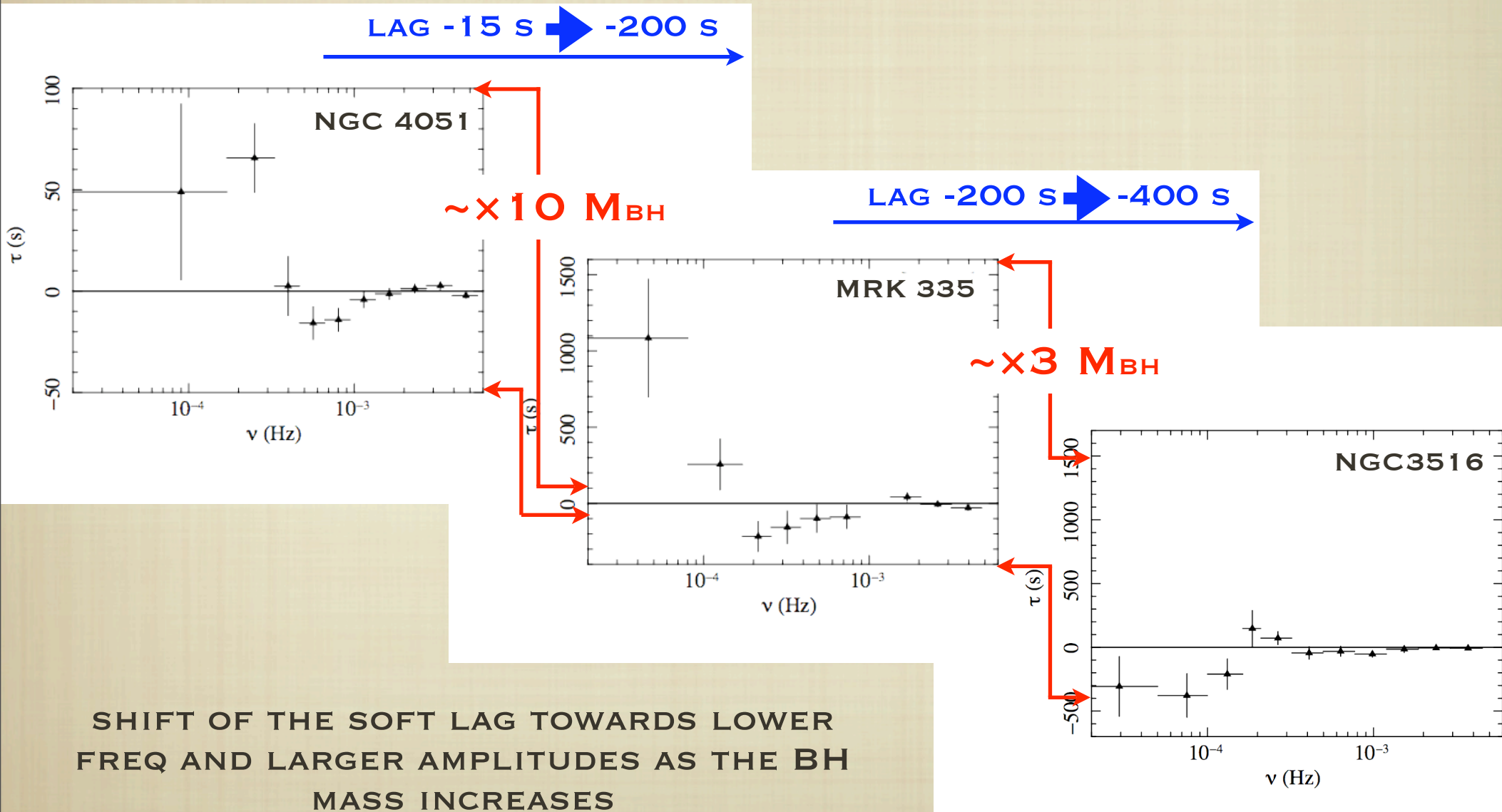
CROSS-SPECTRAL ANALYSIS BETWEEN
SOFT EXCESS-DOMINATED AND POWER
LAW-DOMINATED ENERGY BANDS



SOFT LAGS DETECTIONS

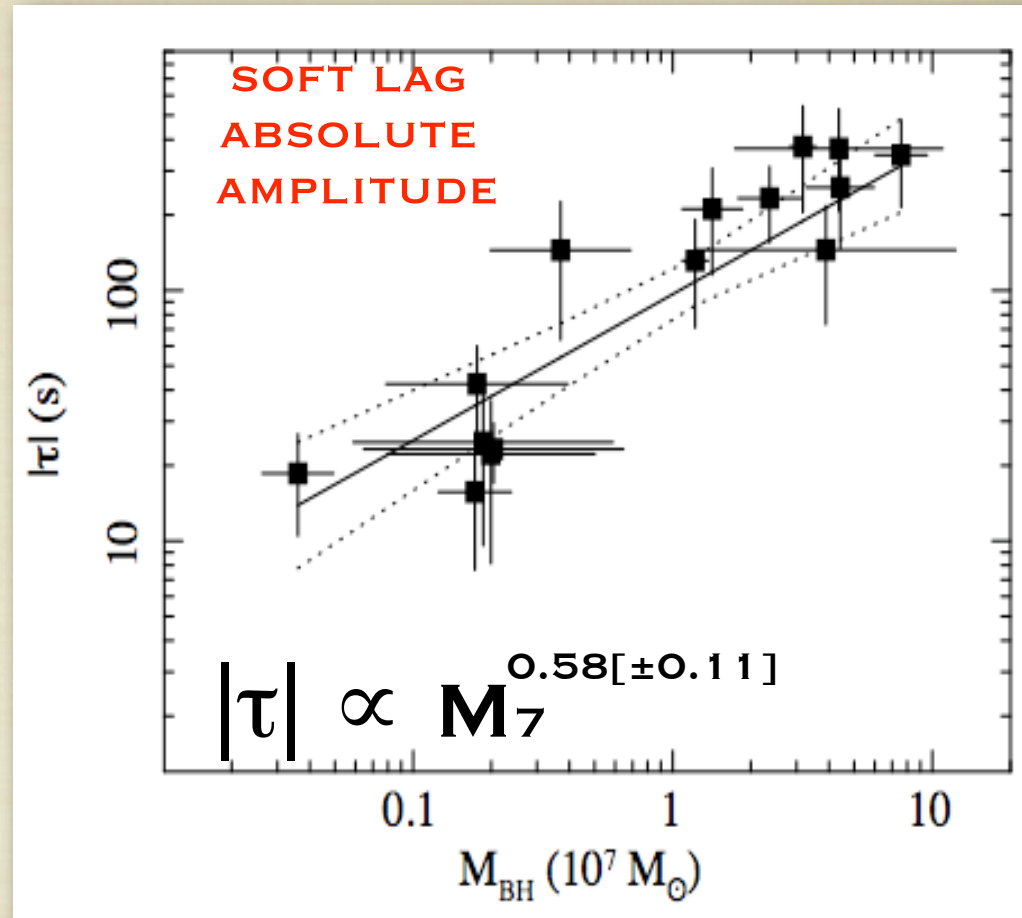
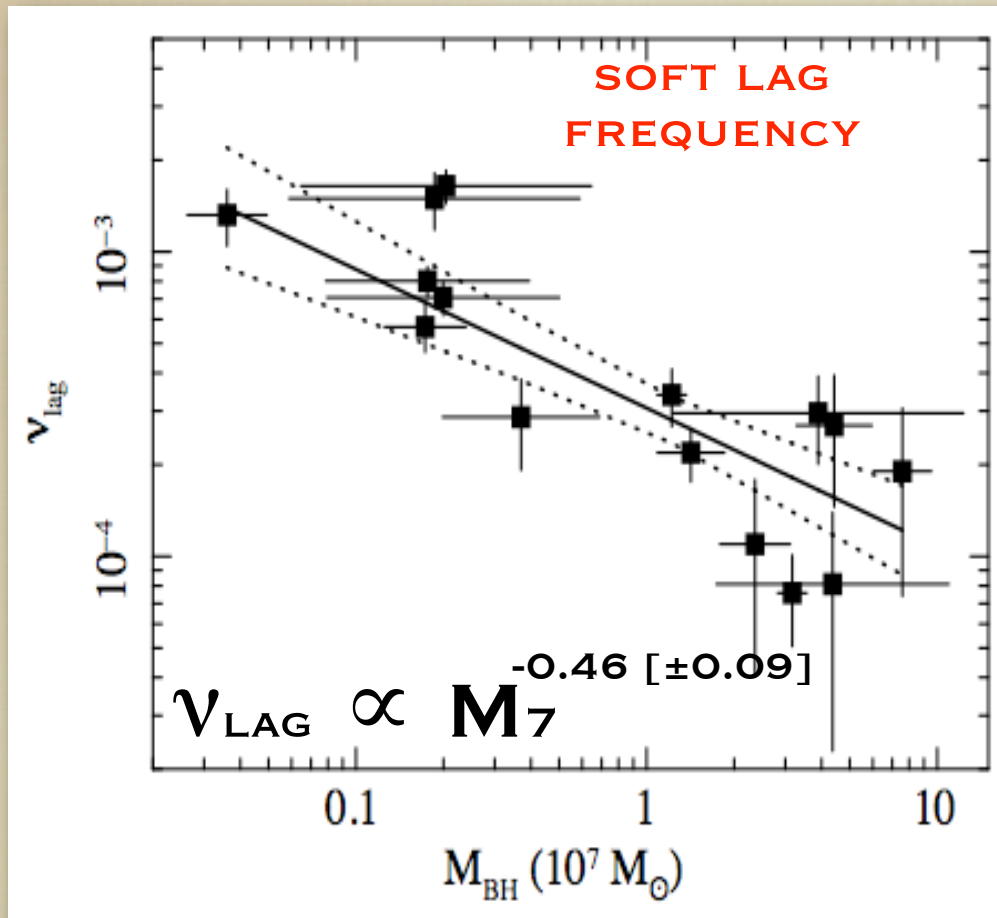
WE DETECTED SOFT X-RAY LAGS IN 15/32 SOURCES, SPANNING ~ 3 ORDERS OF MAGNITUDE IN AMPLITUDE (τ) AND FREQUENCY

EXAMPLES:



SOFT LAGS vs BH MASS

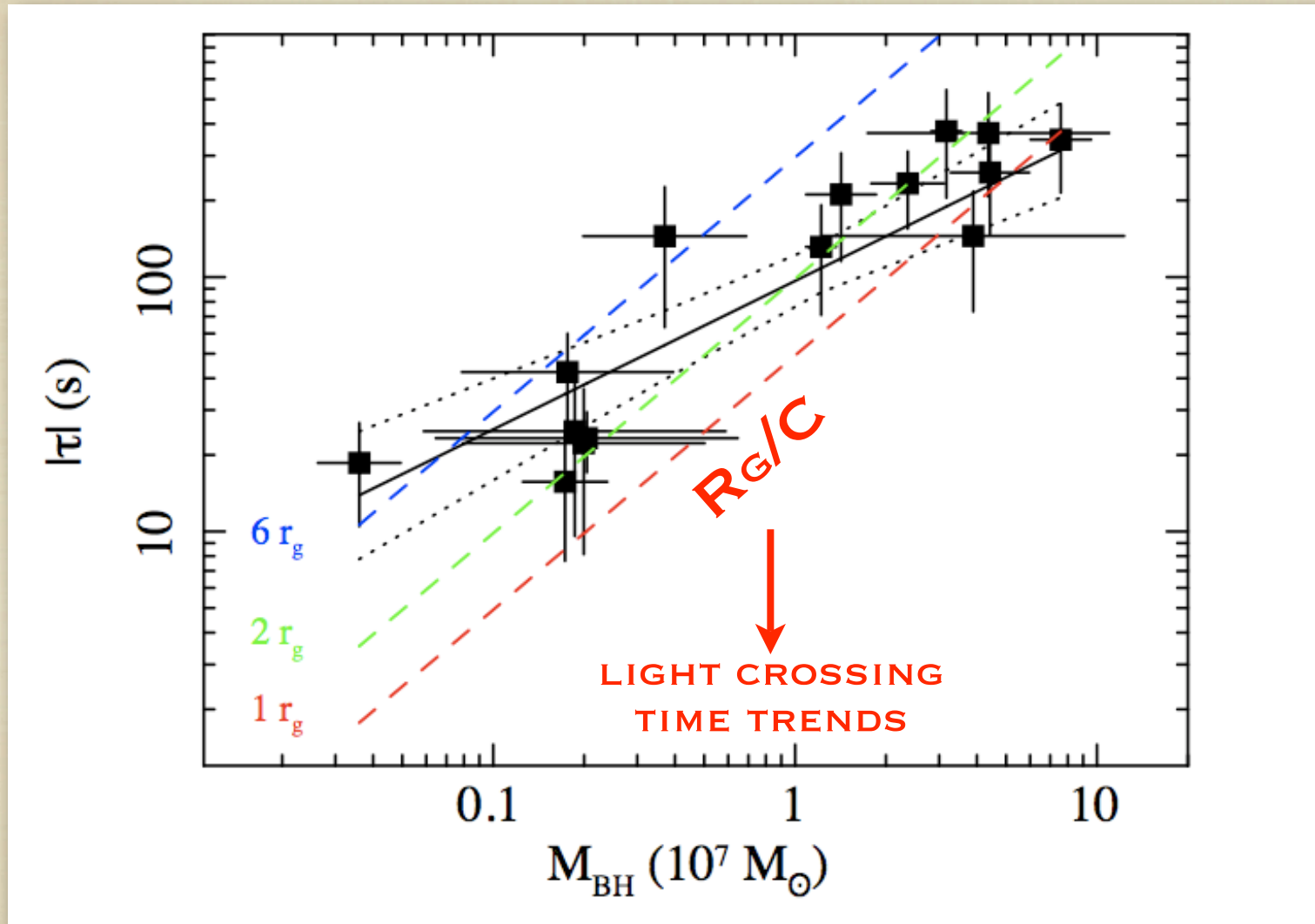
THE SOFT X-RAY LAGS SCALE WITH BH MASS



CORRELATION SIGNIFICANCE $\gtrsim 4\sigma$

SOFT LAGS vs BH MASS

VERY SHORT DISTANCES INVOLVED



CONCLUSIONS

SOFT X-RAY LAGS ARE DETECTED IN A SIGNIFICANT NUMBER OF SOURCES OF THE SAMPLE

SOFT X-RAY LAGS SCALE WITH BH MASS

SOFT X-RAY LAGS MAP VERY SHORT DISTANCES, OF THE ORDER OF FEW GRAVITATIONAL RADII

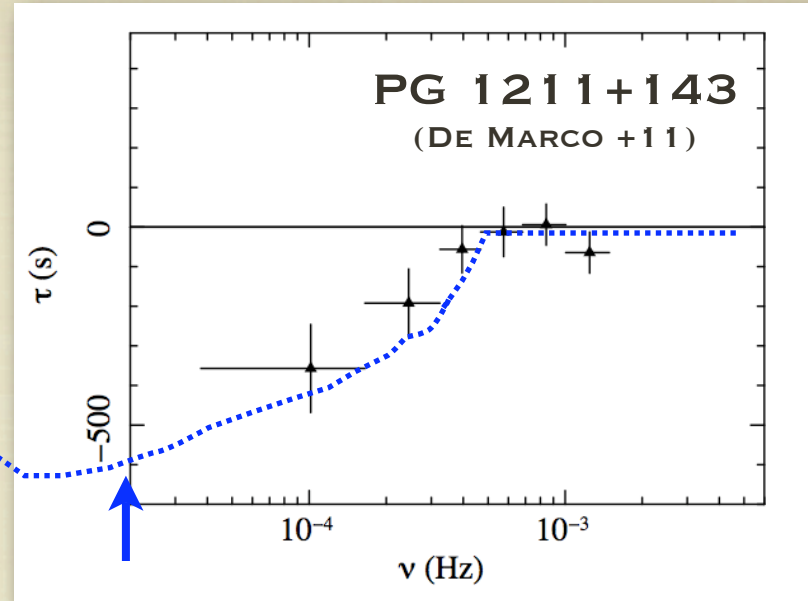
THIS IS ALL CONSISTENT WITH EXPECTATIONS FROM DISC REVERBERATION

THANKS FOR YOUR ATTENTION!

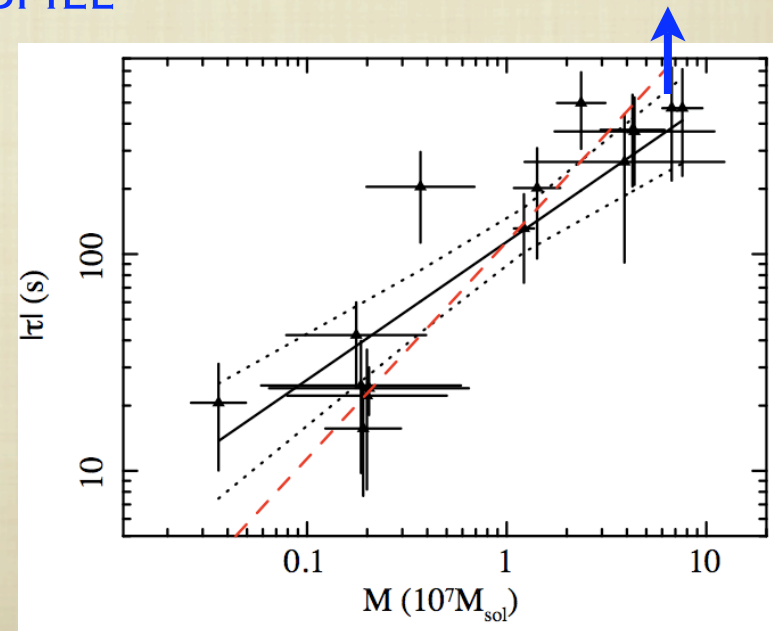
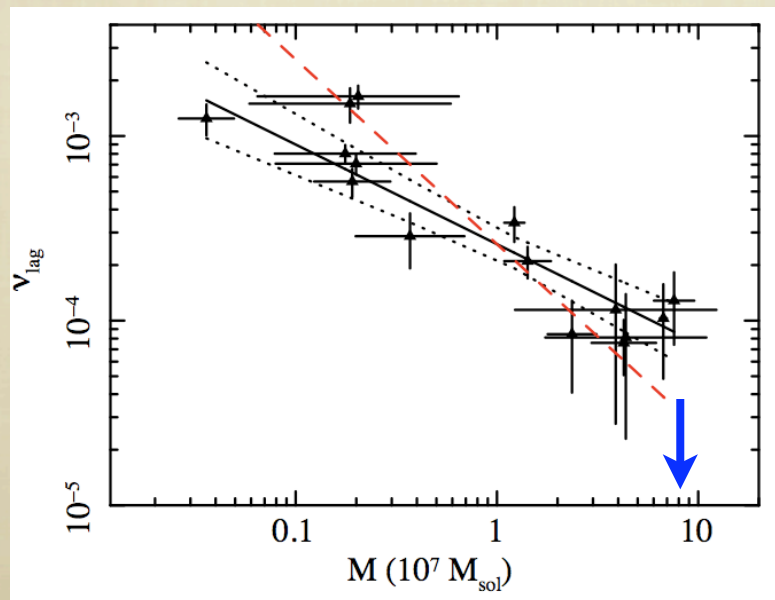
SUPPLEMENTARY

NOTE ABOUT BIASES IN THE CORRELATION

HIGH BH MASS

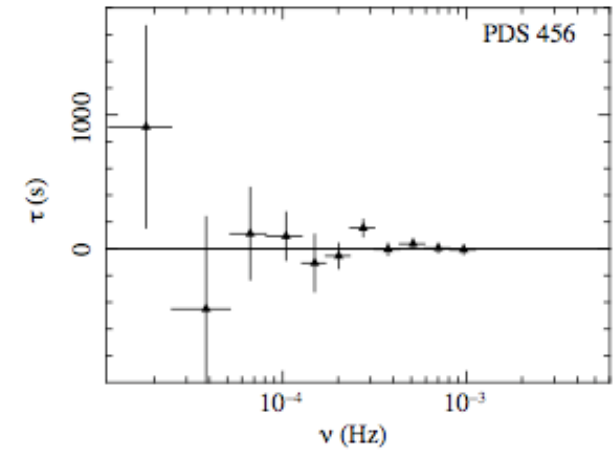
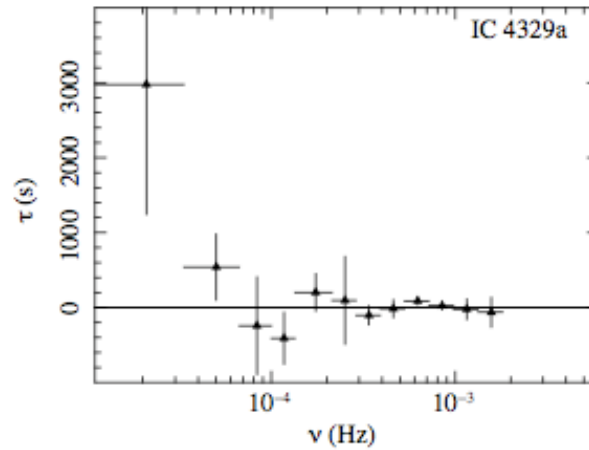
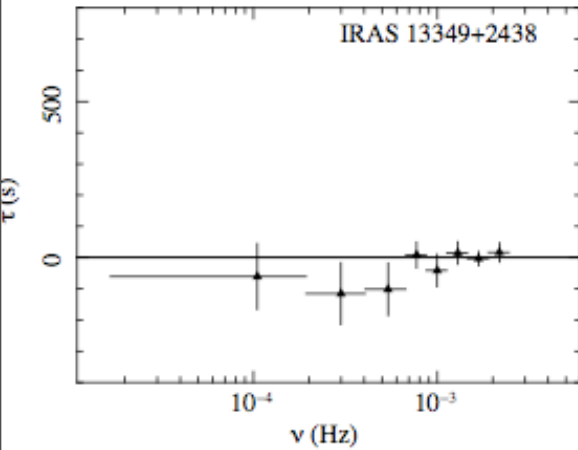


THE LIMITED LENGTH OF THE OBSERVATIONS
DOES NOT ALLOW TO OBSERVE THE ENTIRE
SOFT LAG PROFILE



NON-DETECTIONS

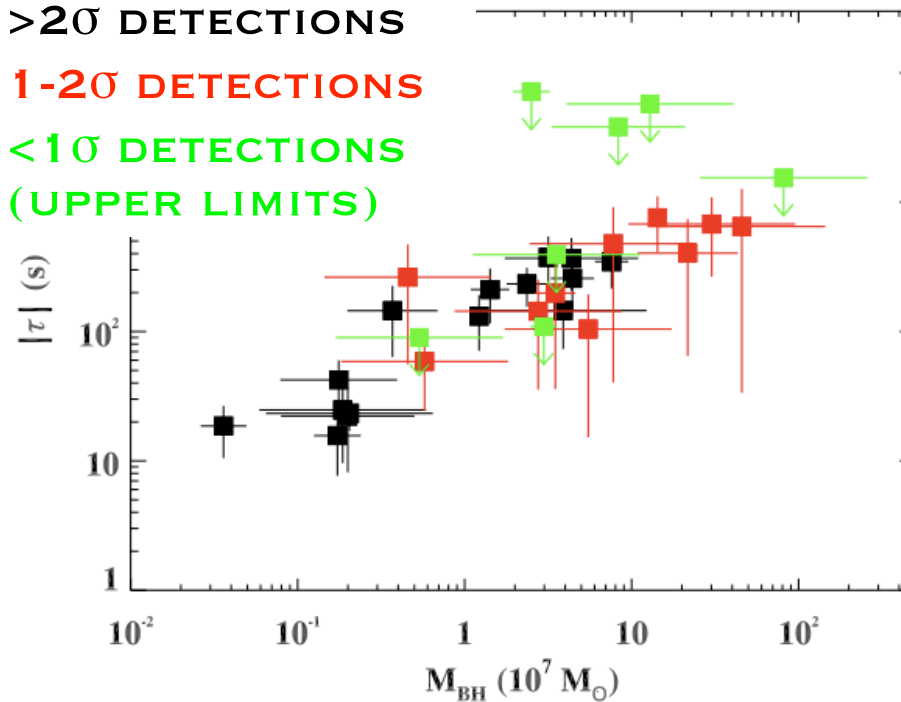
EXAMPLES:



>2 σ DETECTIONS

1-2 σ DETECTIONS

**<1 σ DETECTIONS
(UPPER LIMITS)**



CORRELATION
SIGNIFICANCE $\gtrsim 5\sigma$