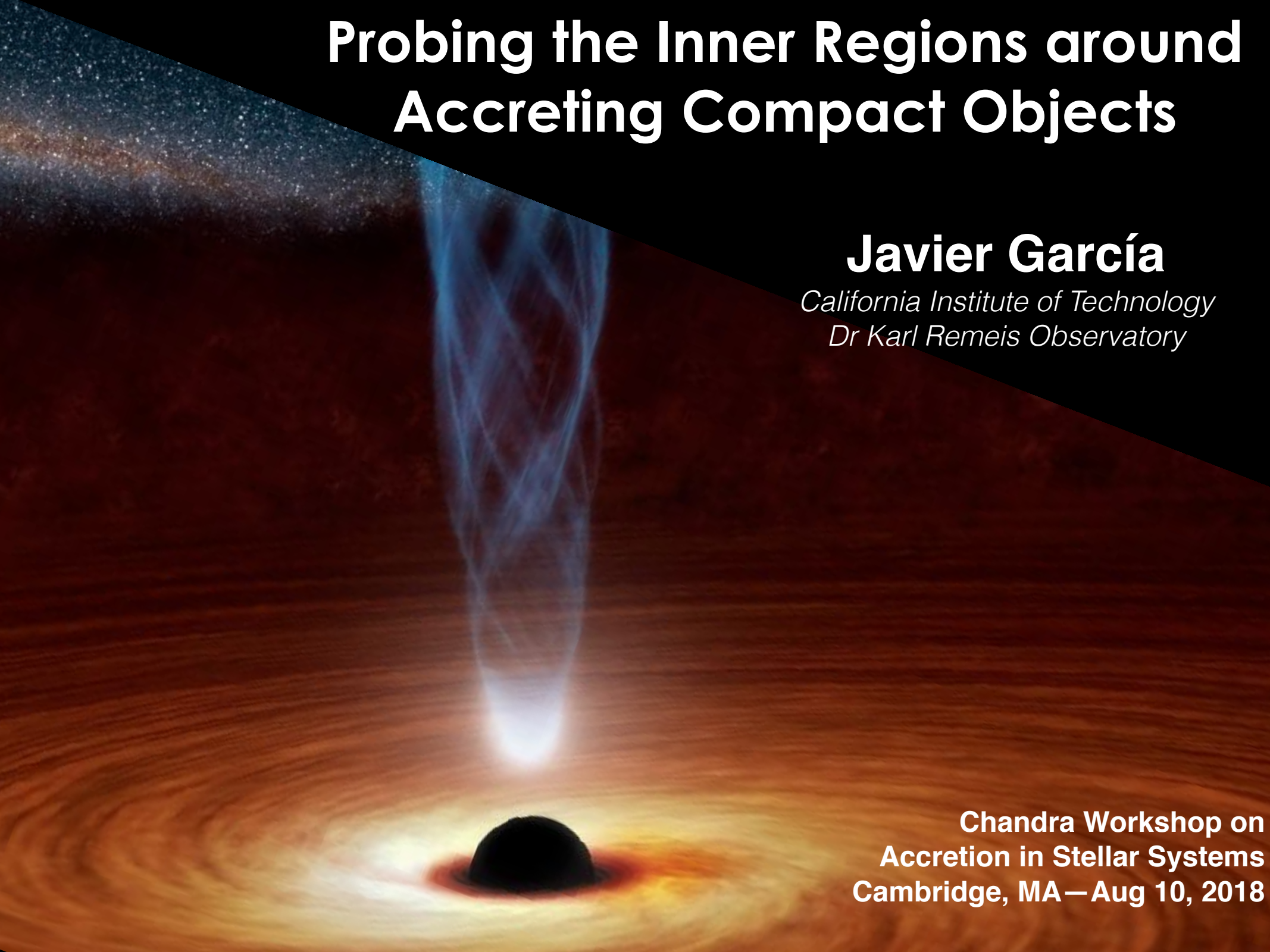


# Probing the Inner Regions around Accreting Compact Objects

**Javier García**

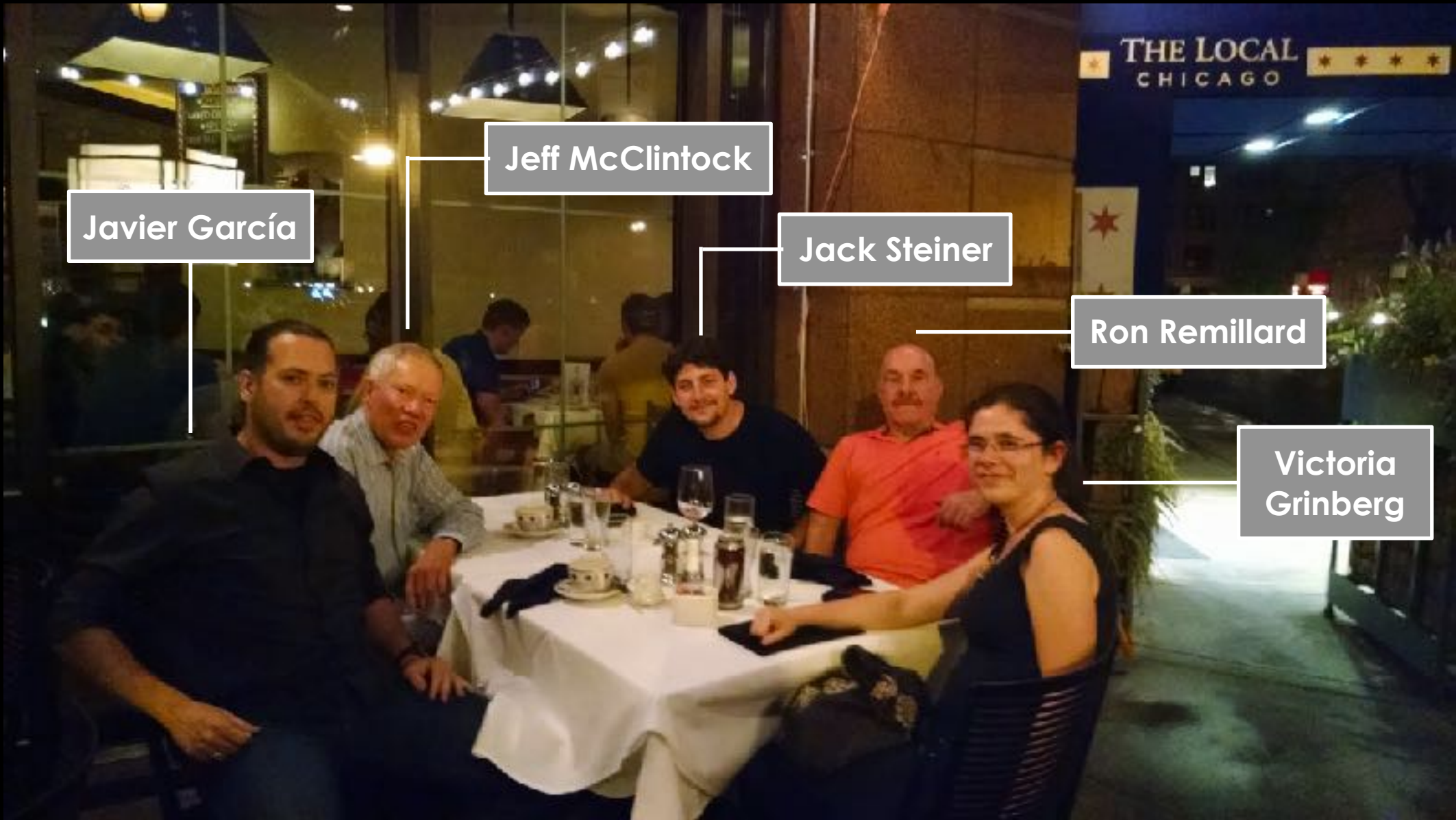
*California Institute of Technology  
Dr Karl Remeis Observatory*

**Chandra Workshop on  
Accretion in Stellar Systems  
Cambridge, MA—Aug 10, 2018**

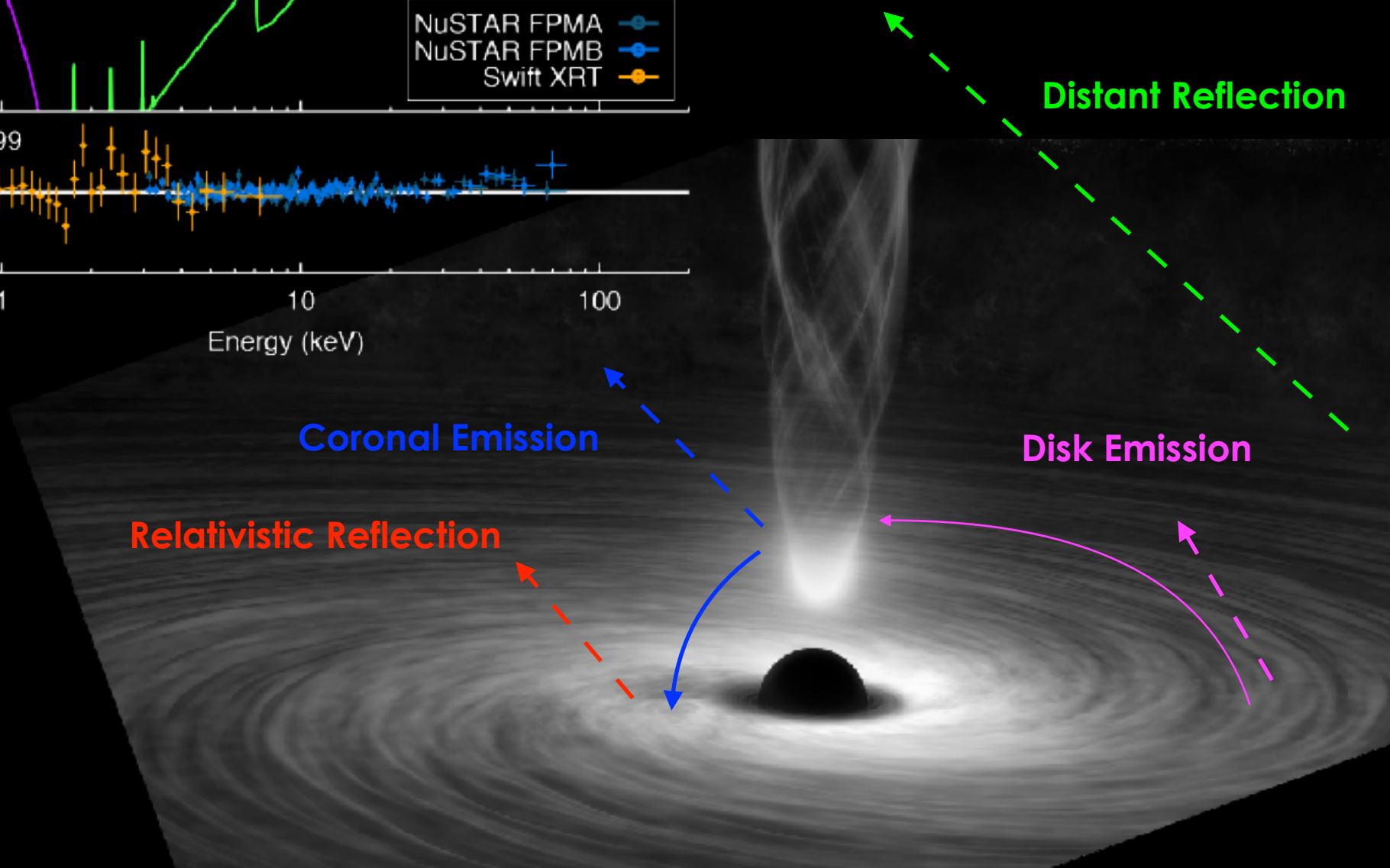
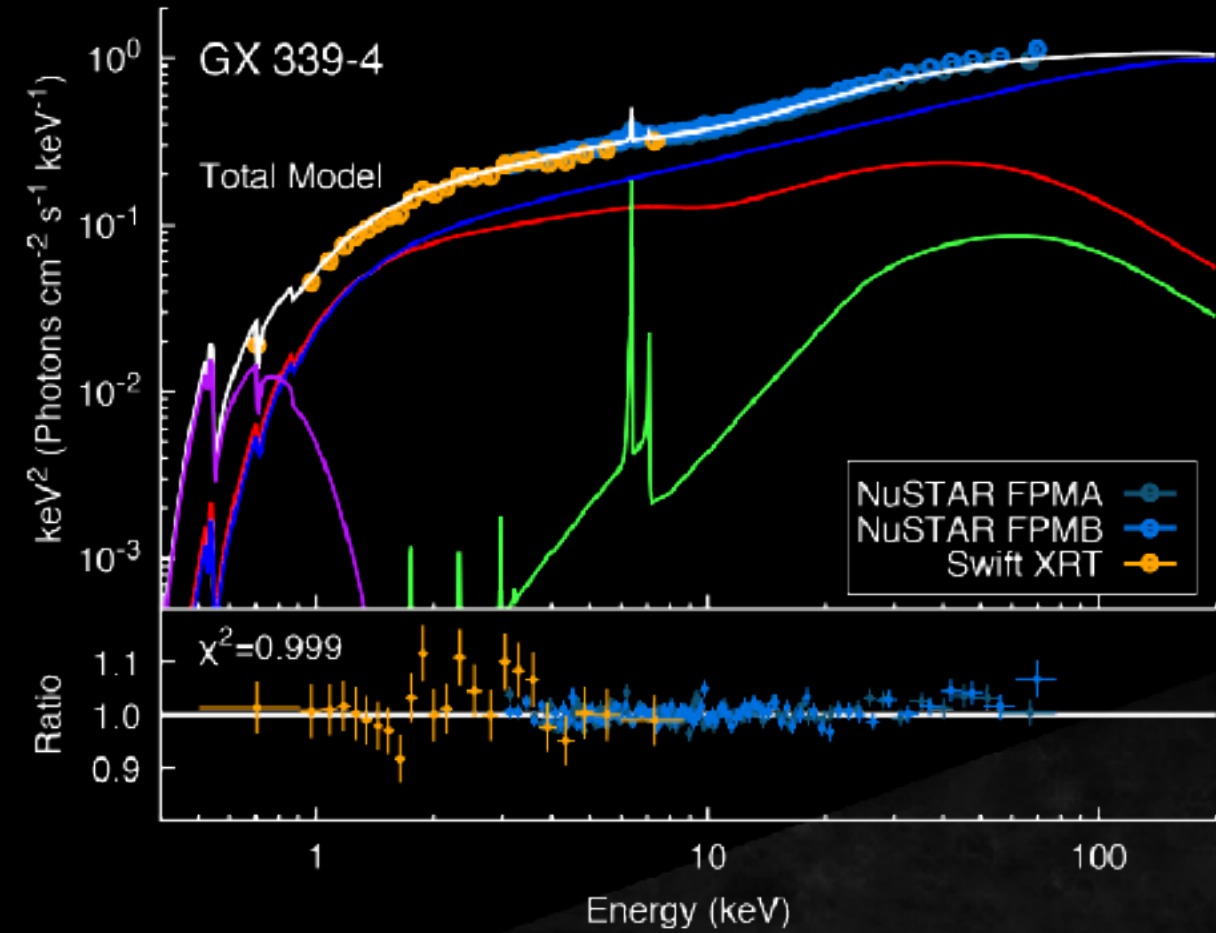


# Research Team

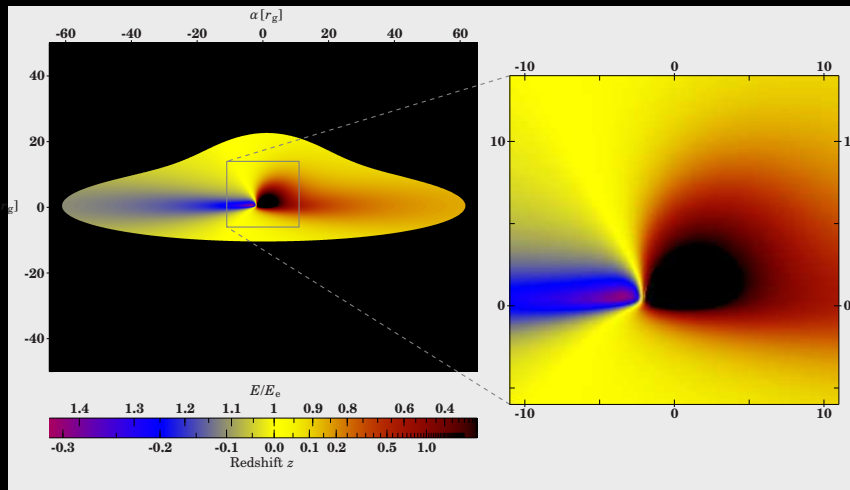
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HEAD 14th Division Meeting, Chicago, IL, Aug 2014



# Modeling Relativistic Reflection

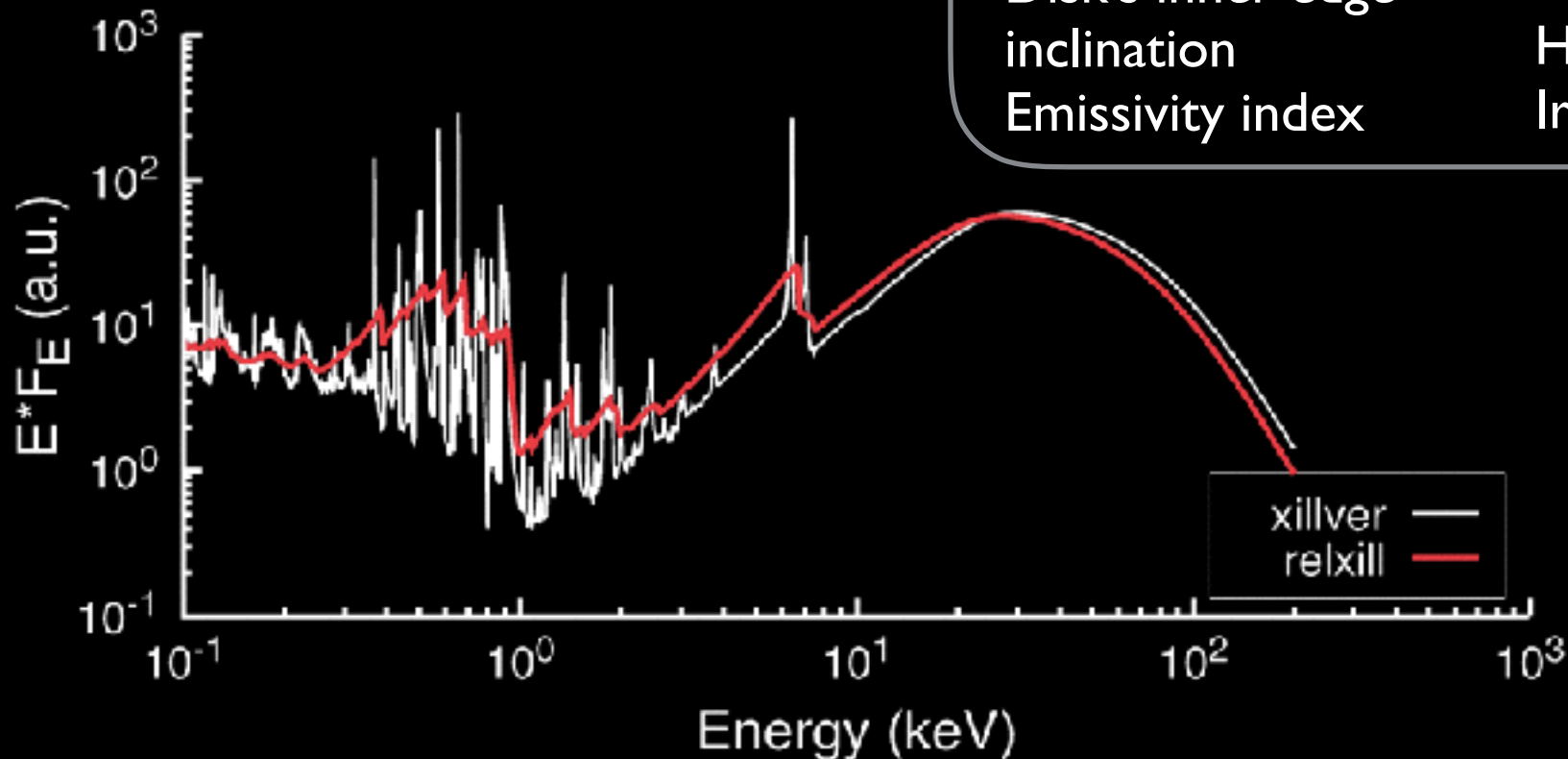


The **relxill** model: Combines ionized reflection spectra from **xillver** (Garcia & Kallman 2010), with the relativistic blurring code **relline** (Dauser et al. 2010)

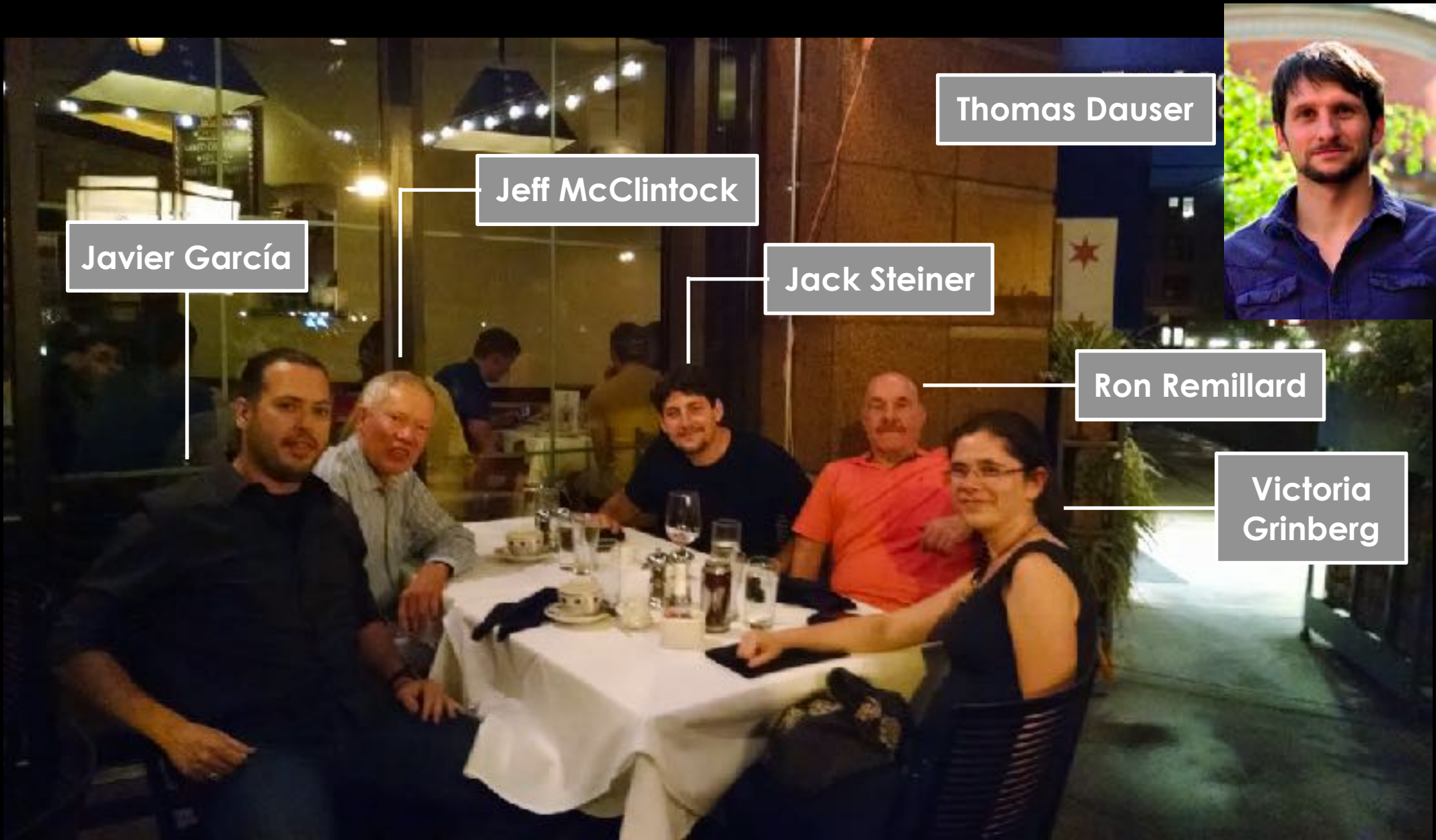
## Model parameters:

Black hole spin  
Disk's inner edge  
inclination  
Emissivity index

Reflection fraction  
Photon index  
High energy cutoff  
Iron abundance



# Research Team



Javier García

Jeff McClintock

Jack Steiner

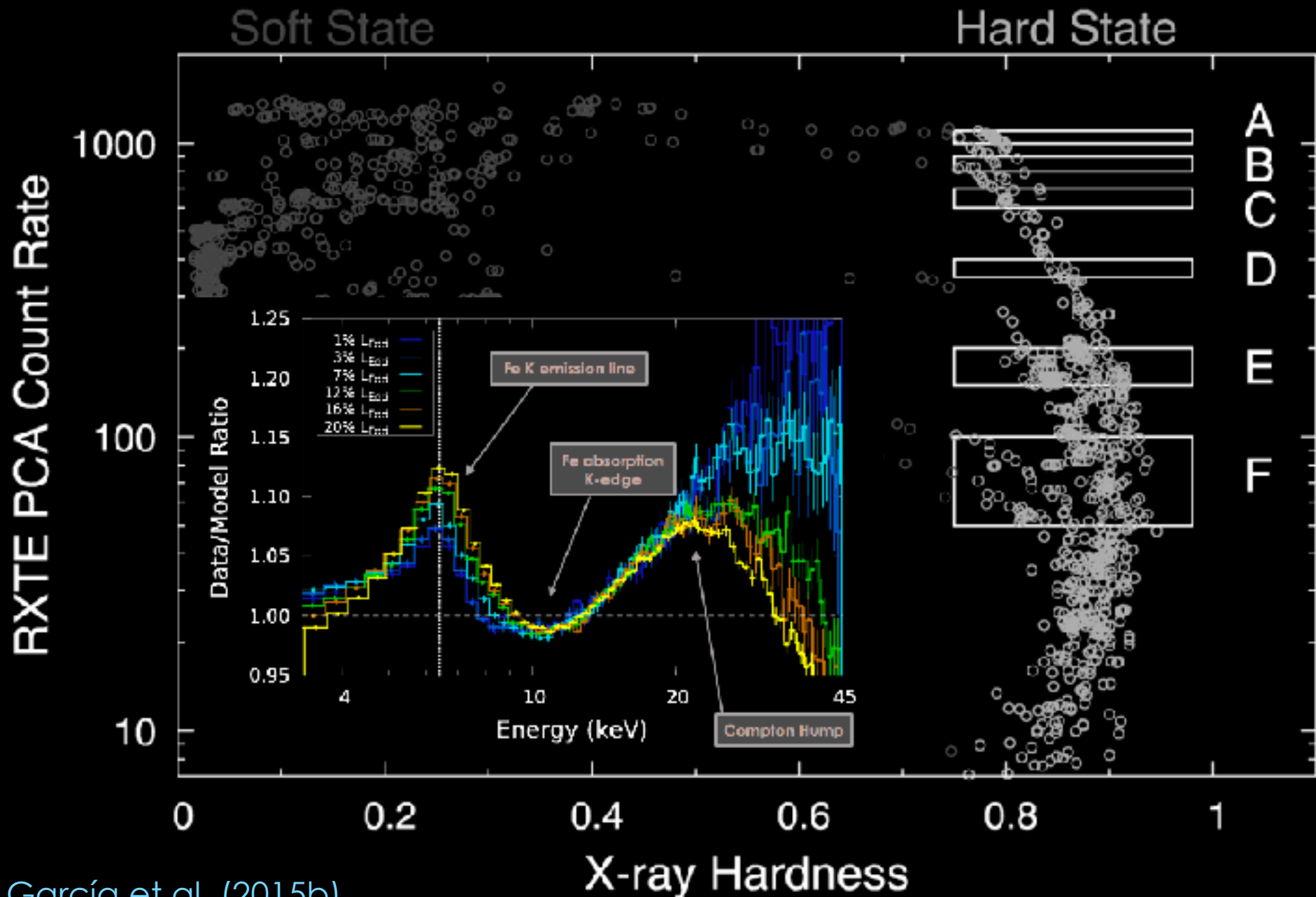
Thomas Dauser

Ron Remillard

Victoria  
Grinberg

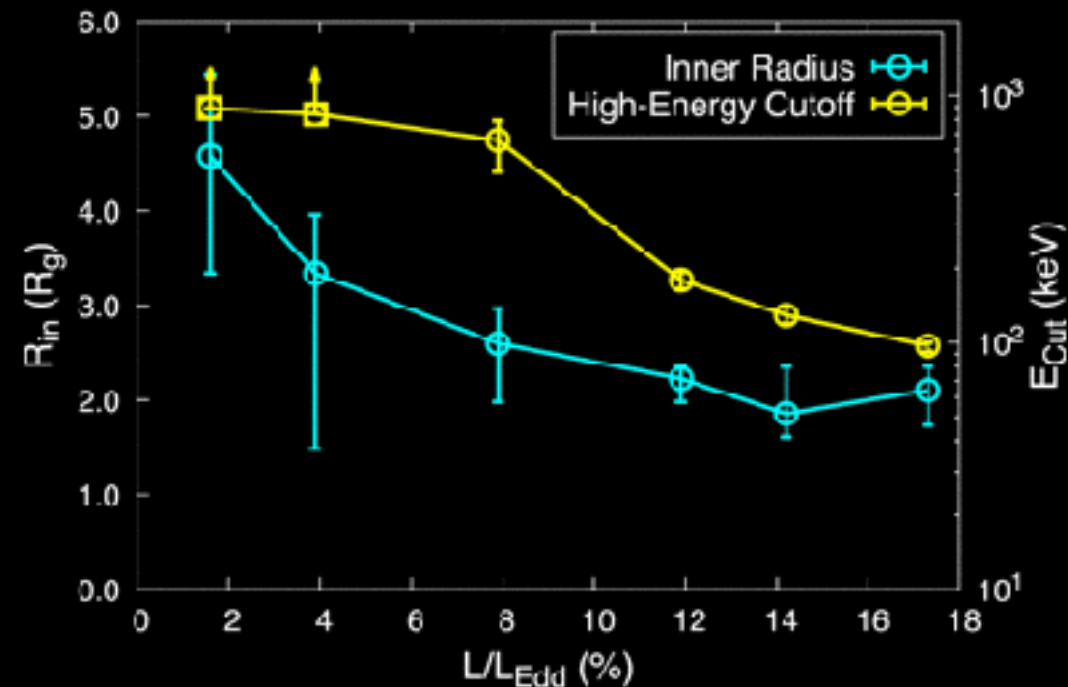
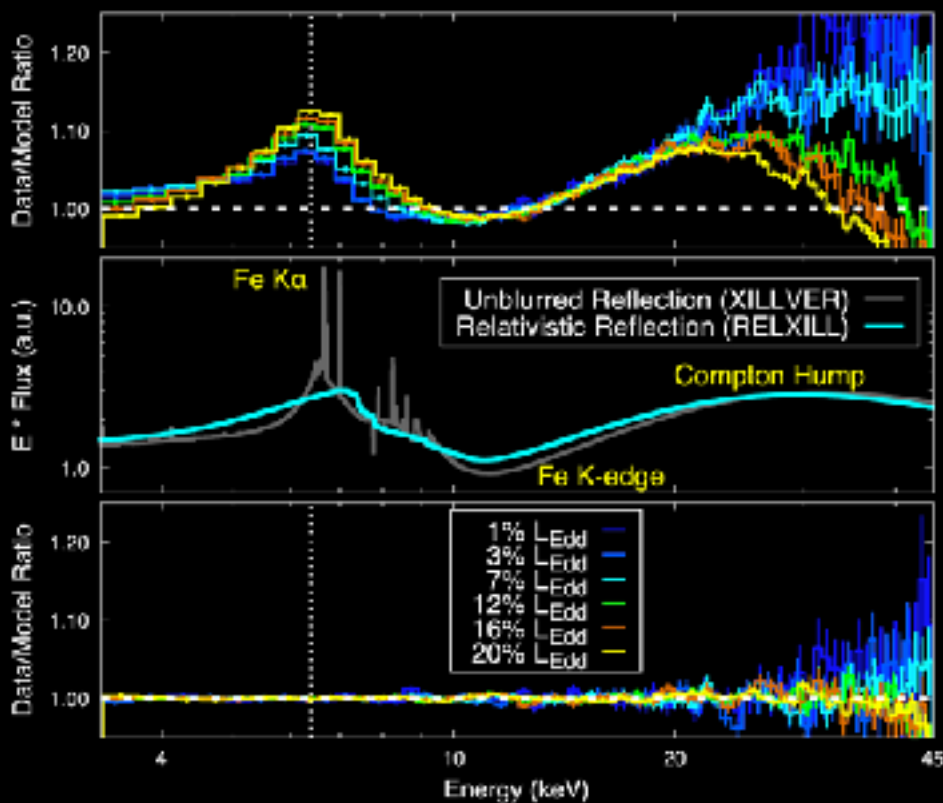
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# The Hard State of GX 339-4



# Disk and Corona Evolution

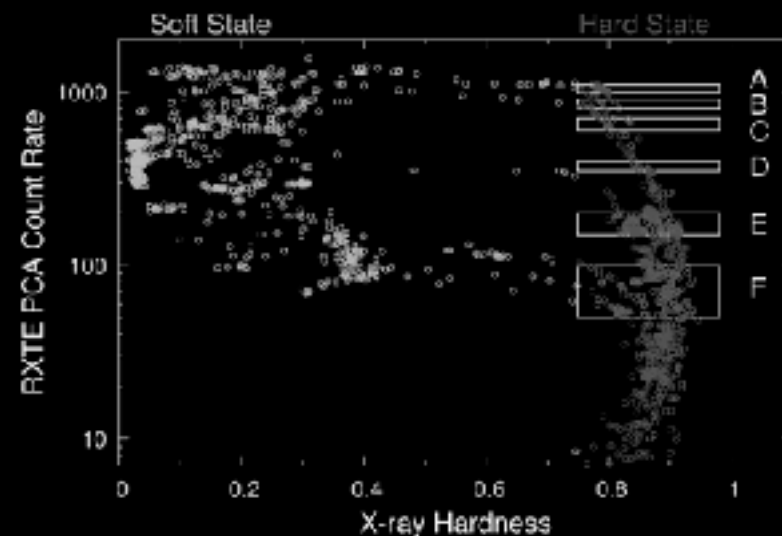
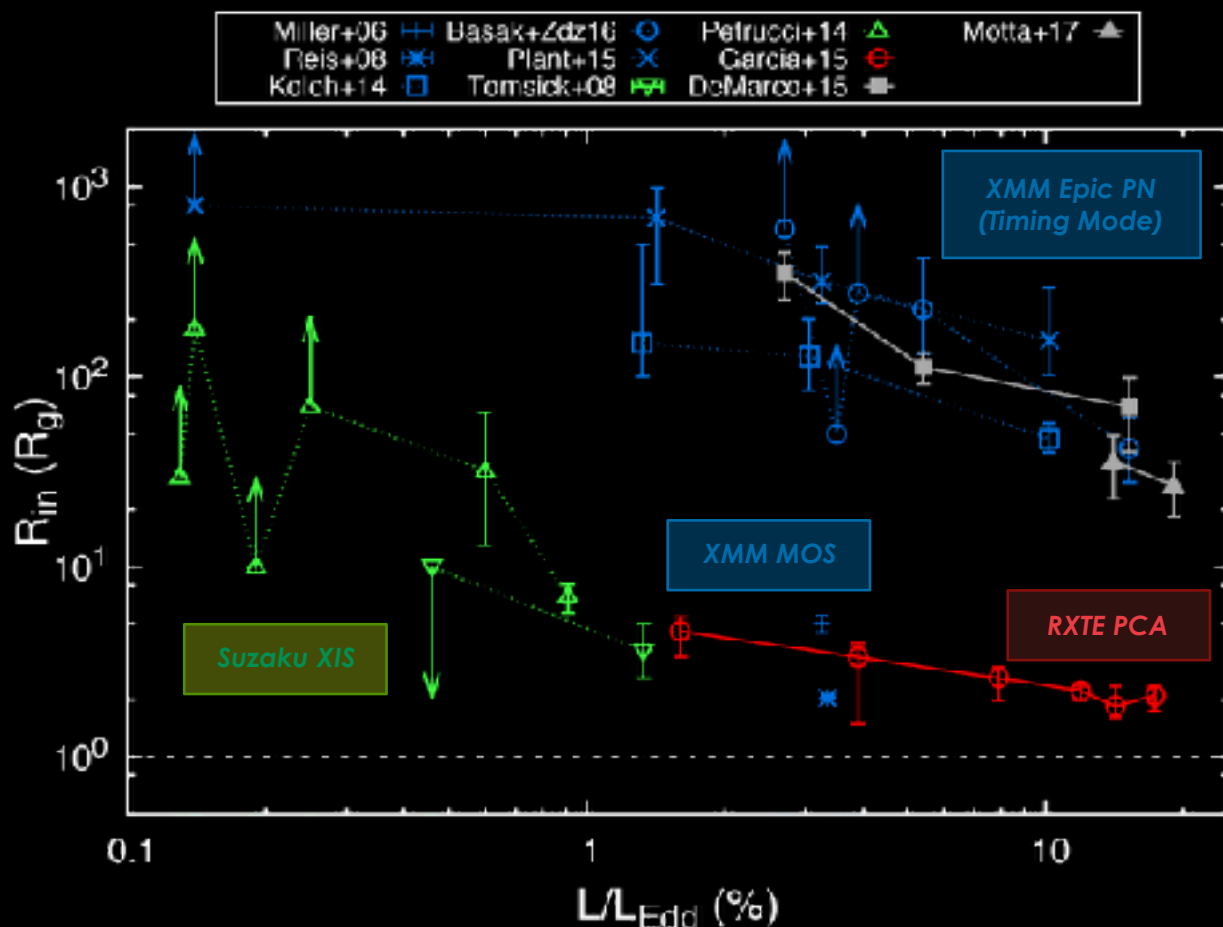
Simultaneous fit of relativistic reflection revealed changes in both the inner **radius** and **coronal temperature**



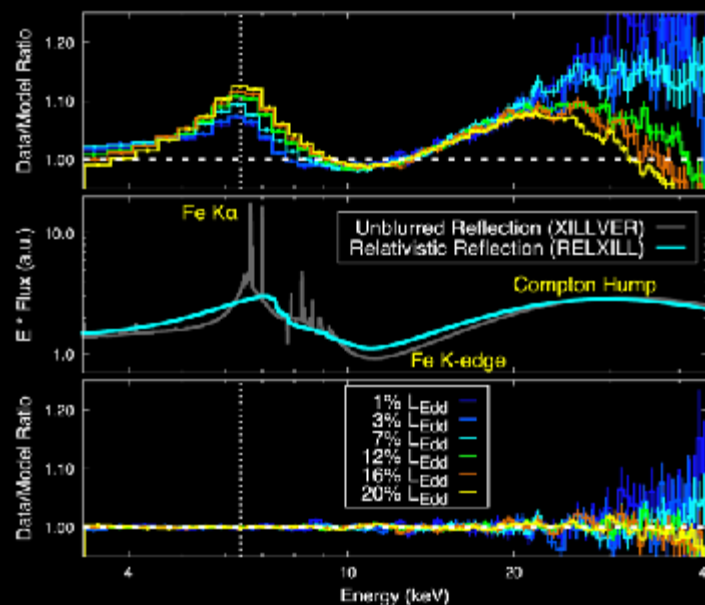
Total of 77 million counts in six **RXTE PCA** spectra (3-45 keV)

$a = 0.95 \pm 0.04$  (90% conf)  
 $i = 48 \pm 1$  deg  
Fe abundance **5x Solar**

# Controversy on the Disk Truncation

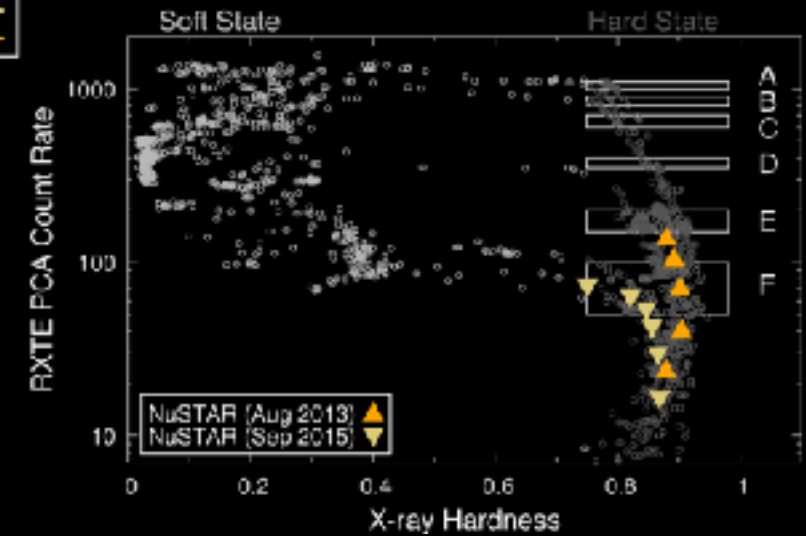
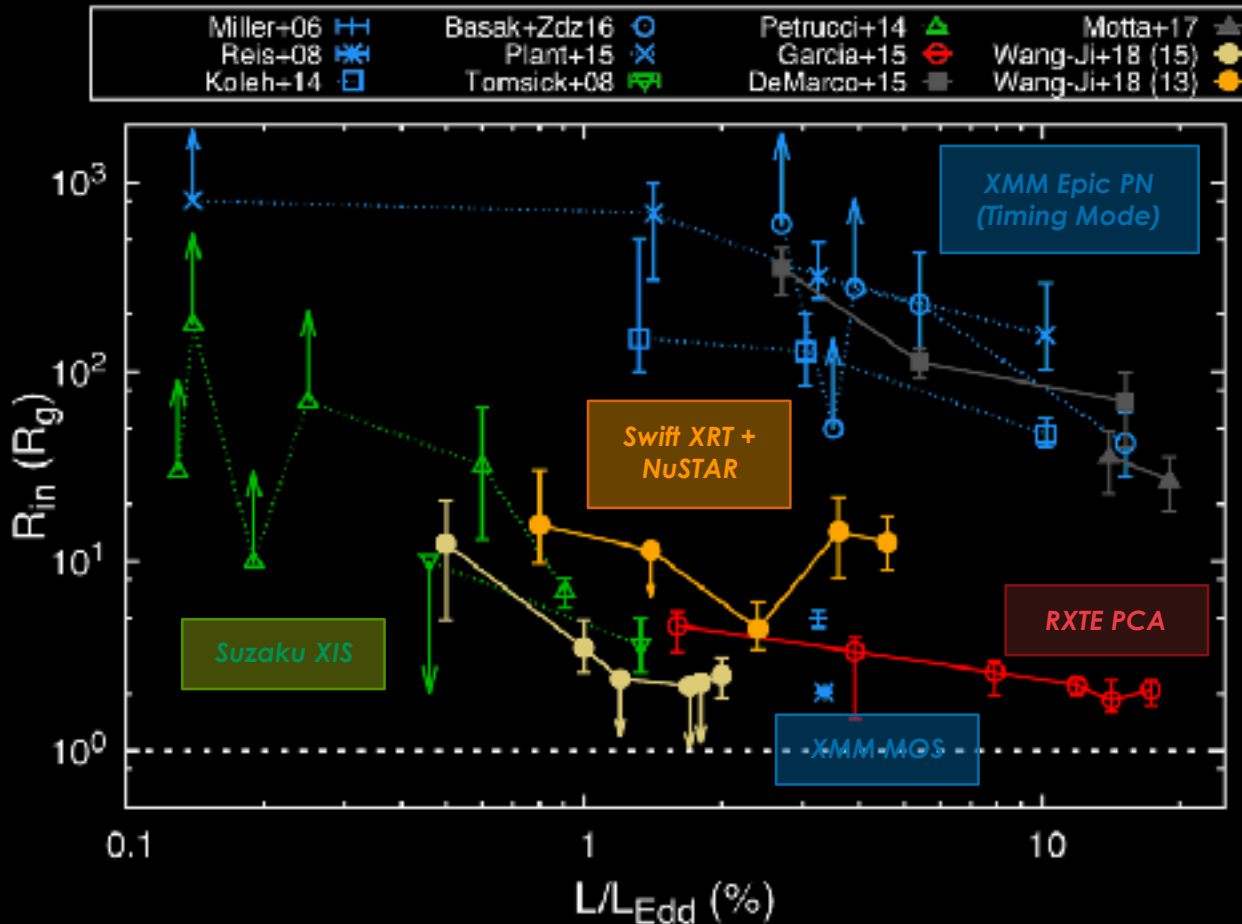


Large discrepancies in the truncation of the accretion disk



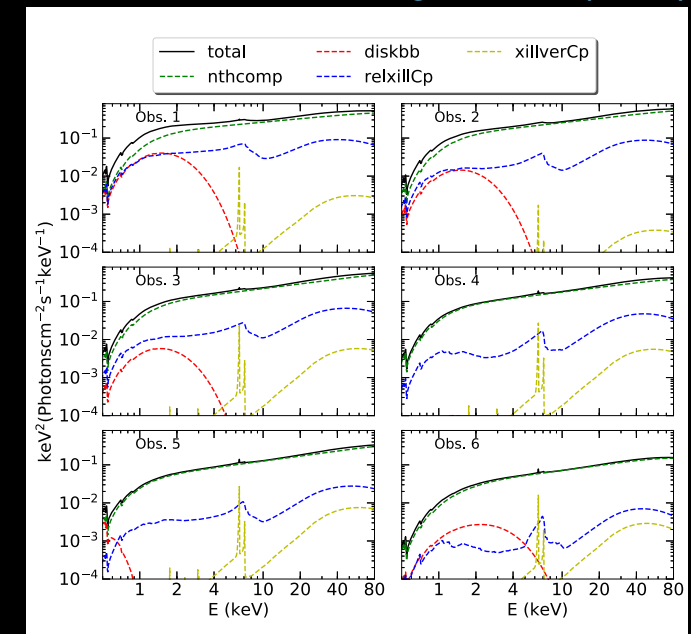


# Controversy on the Disk Truncation

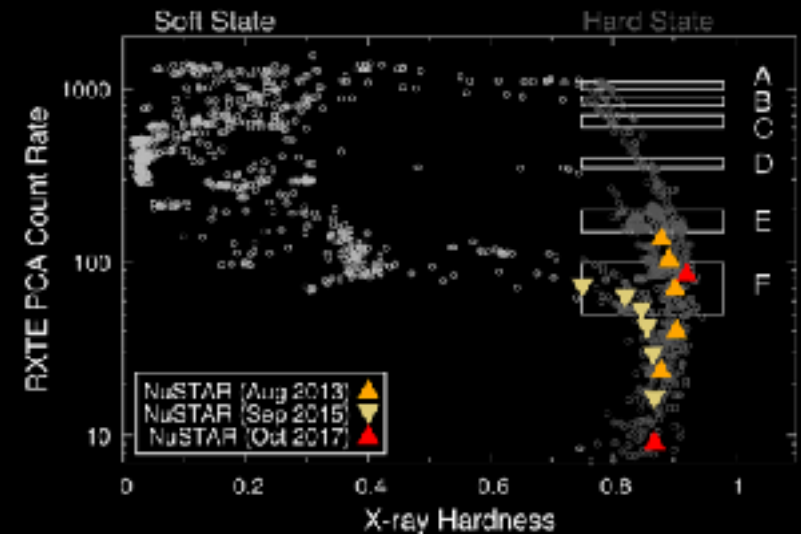
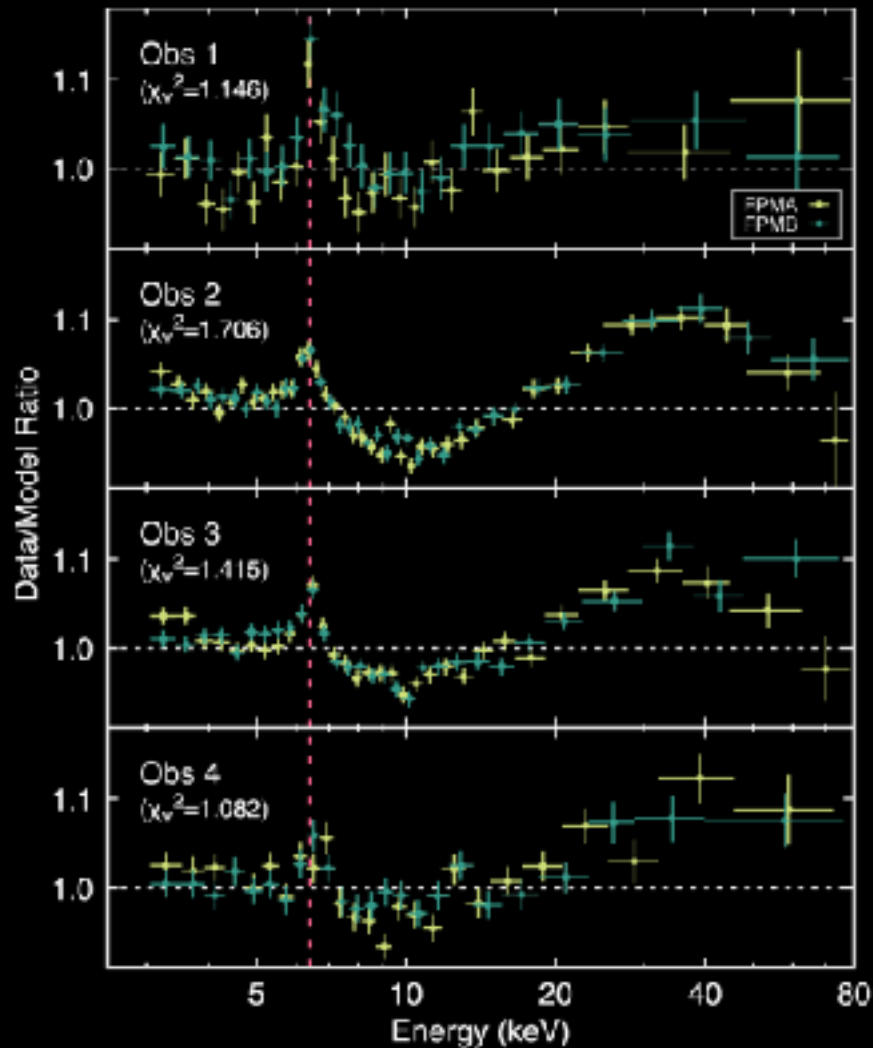


Wang-Ji et al. (2018)

Recent (2013, 2015) *Swift XRT* and *NuSTAR* observations consistent with **mild** truncation (i.e.,  $R_{in} \sim 10$ 's  $R_g$ , **not** 100's  $R_g$ )



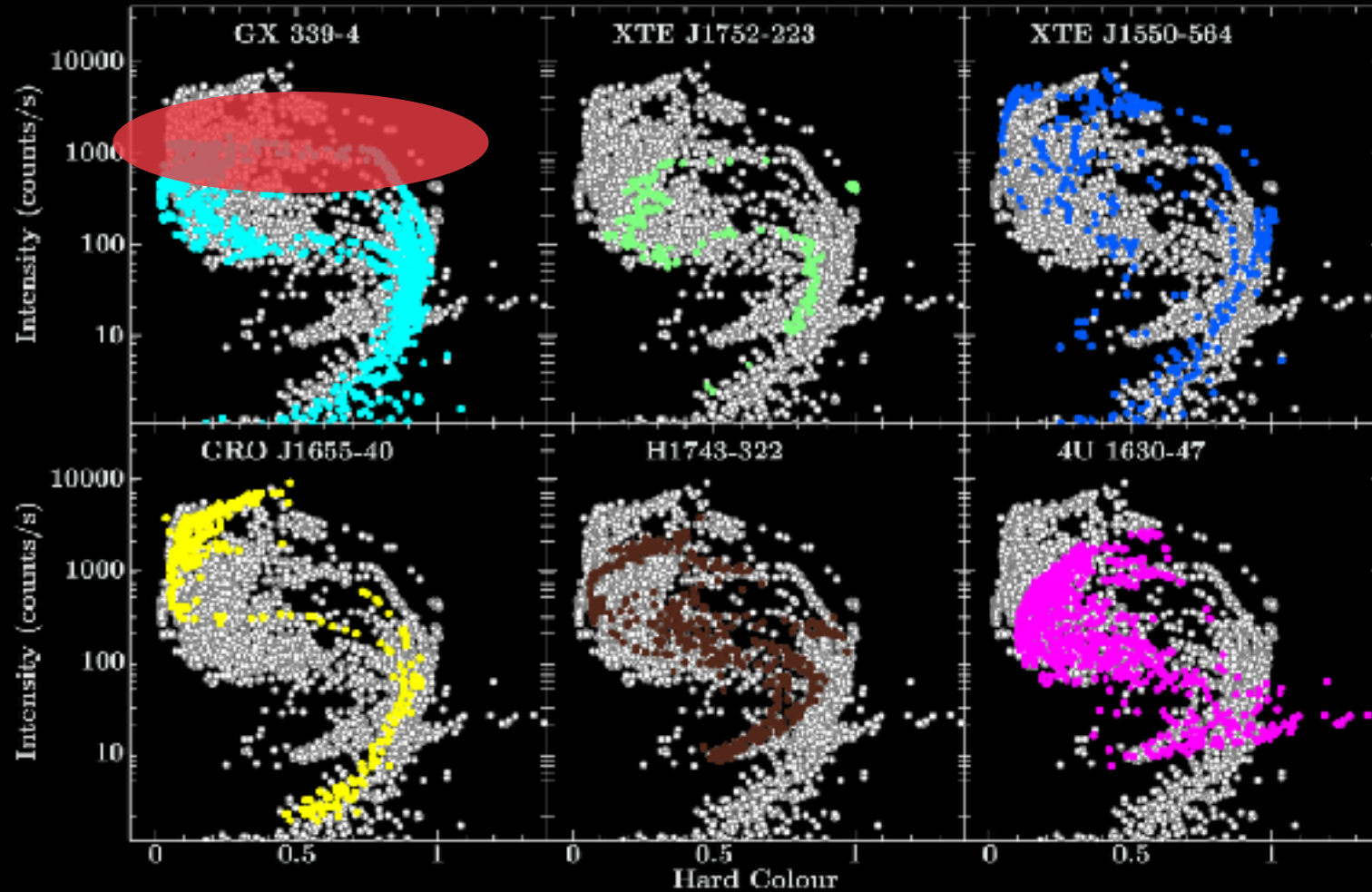
# The 2017 Failed Outburst of GX 339-4



- Signatures of reflection detected in all the *NuSTAR* exposures
- Broad (relativistic) reflection required in the brightest spectra
- Inner-radius consistent with **small truncation** ( $R_{in} \sim 2.4 R_g$ )

# The *RXTE* Archive of BHBs

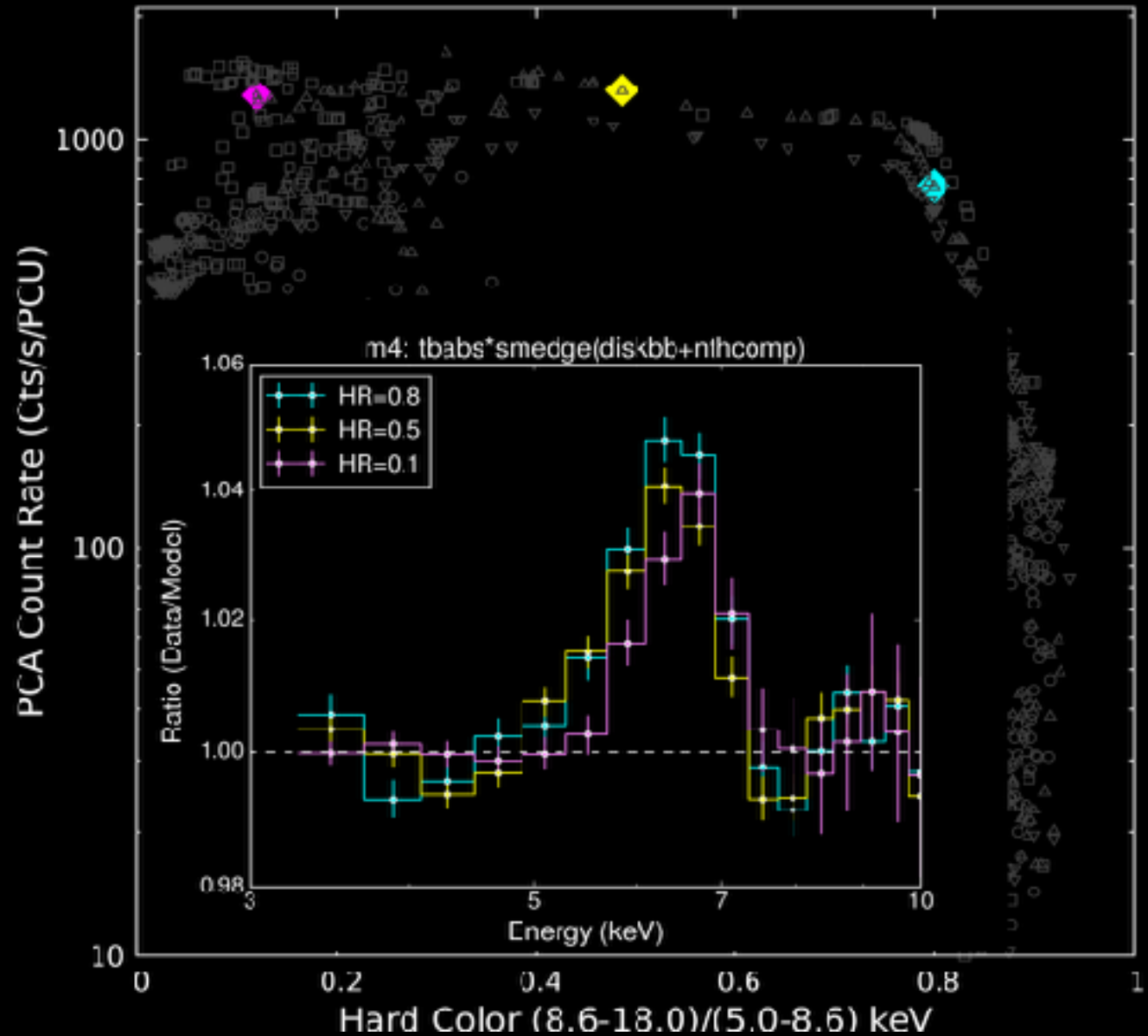
NASA ADAP16: ~15,000 *RXTE* spectra with PCA (3-45 keV) and HEXTE (20-250 keV) for ~30 BHB with ~1 ks exposures



# The Fe K line Profile across States

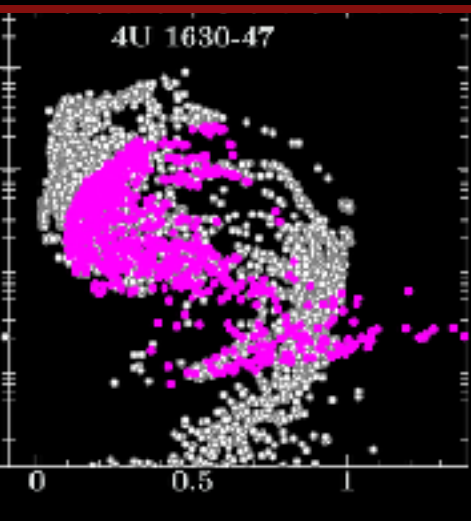
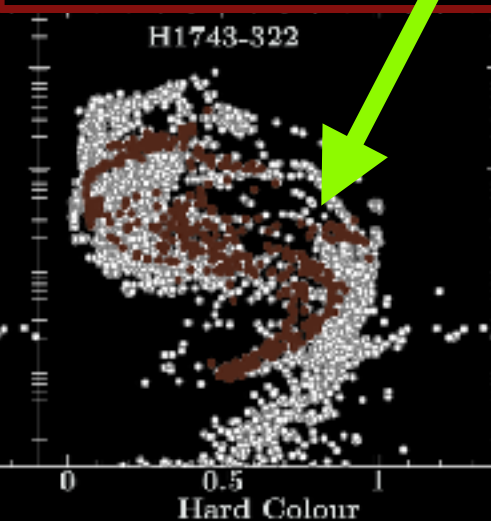
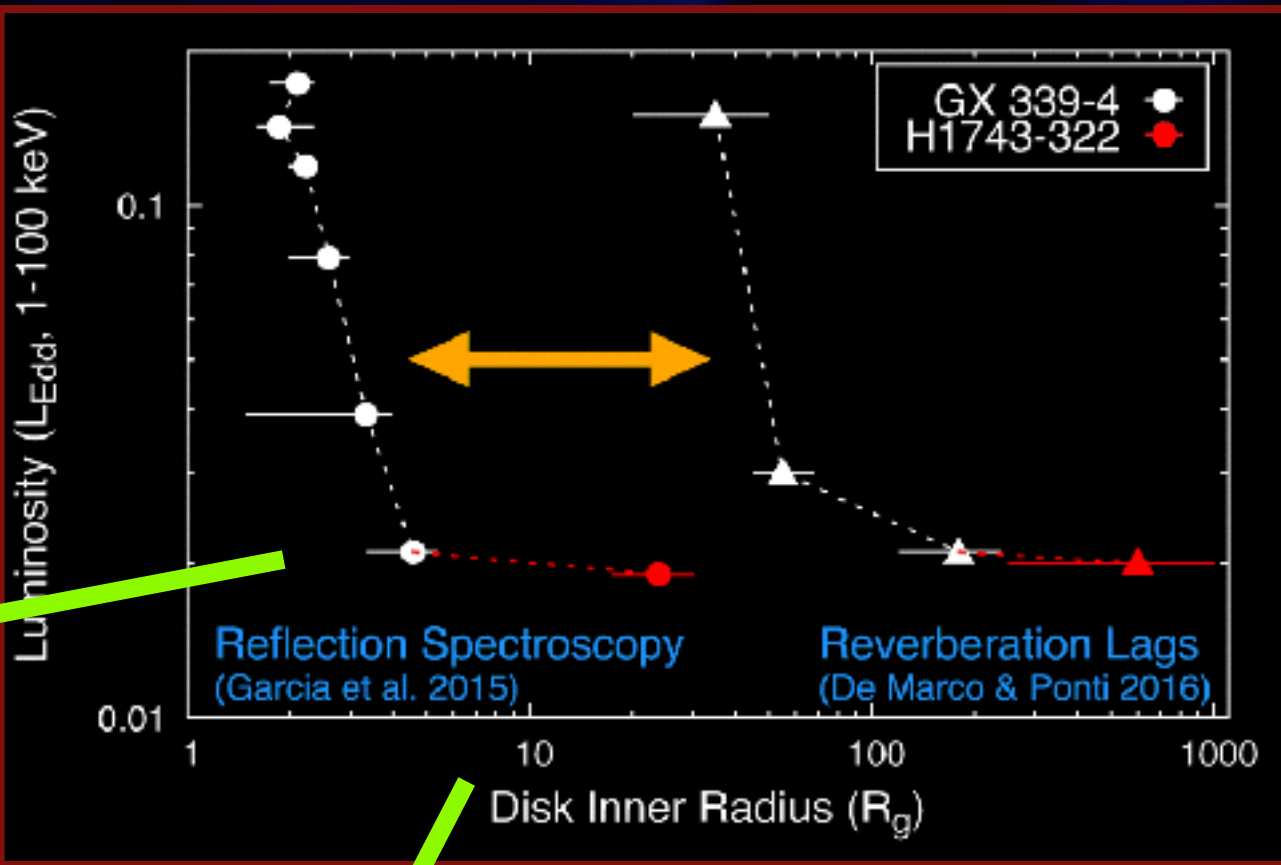
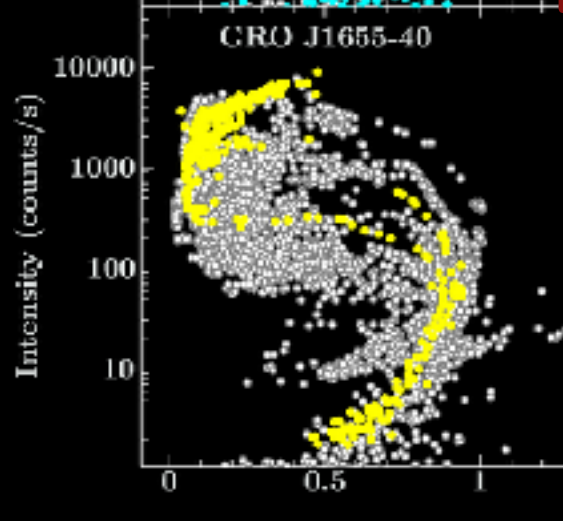
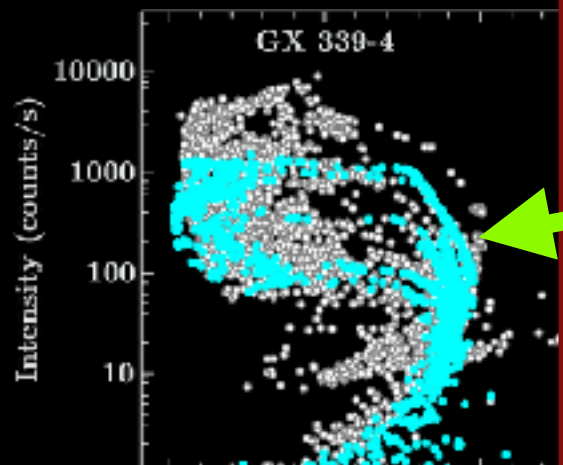
Same Fe K profile for different accretion states

This suggest that the disk has reach the ISCO before it makes the transition



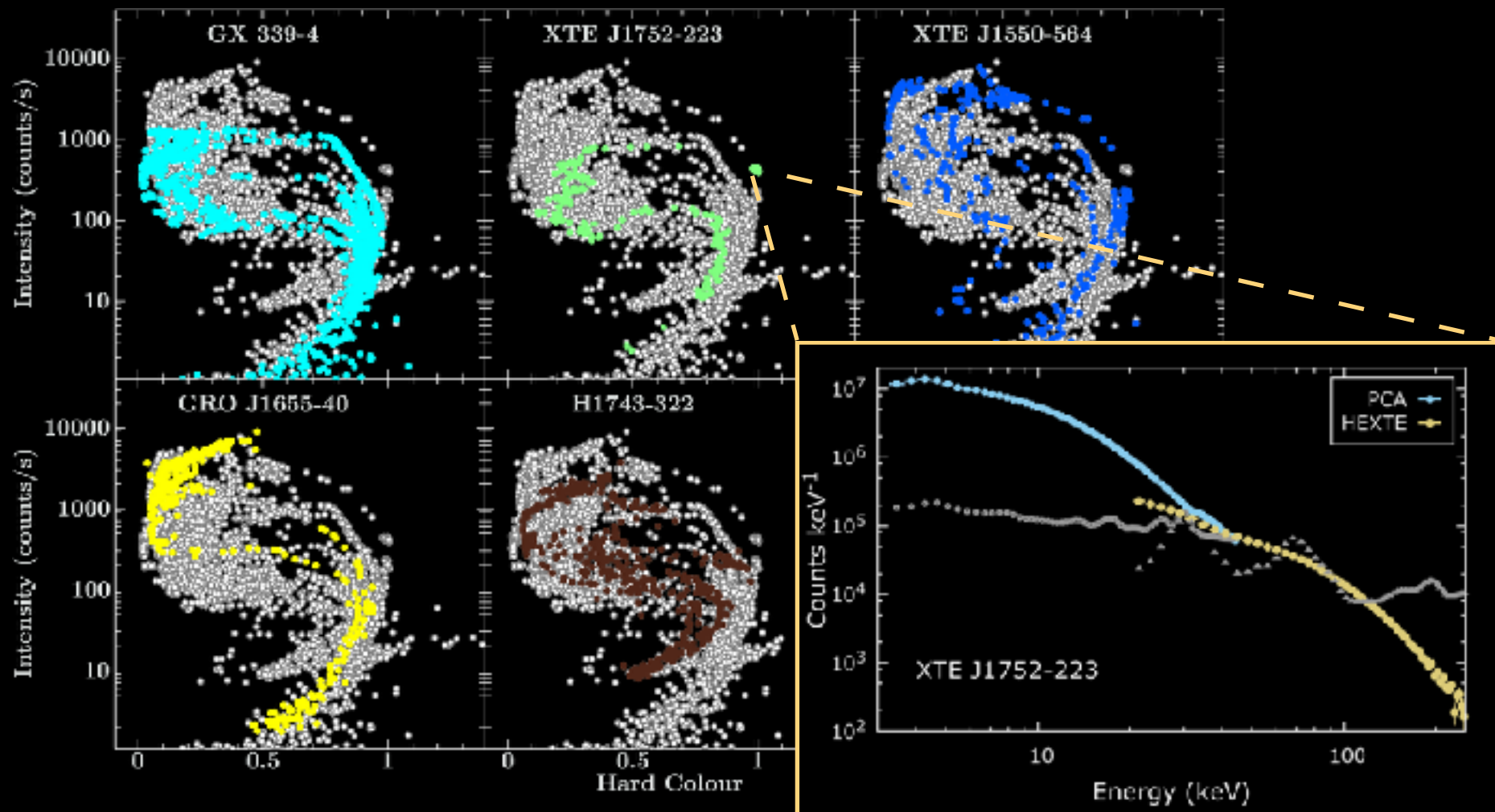
# The *RXTE* Arch

NASA ADAP16: ~15,000  
HEXTE (20-250 keV)



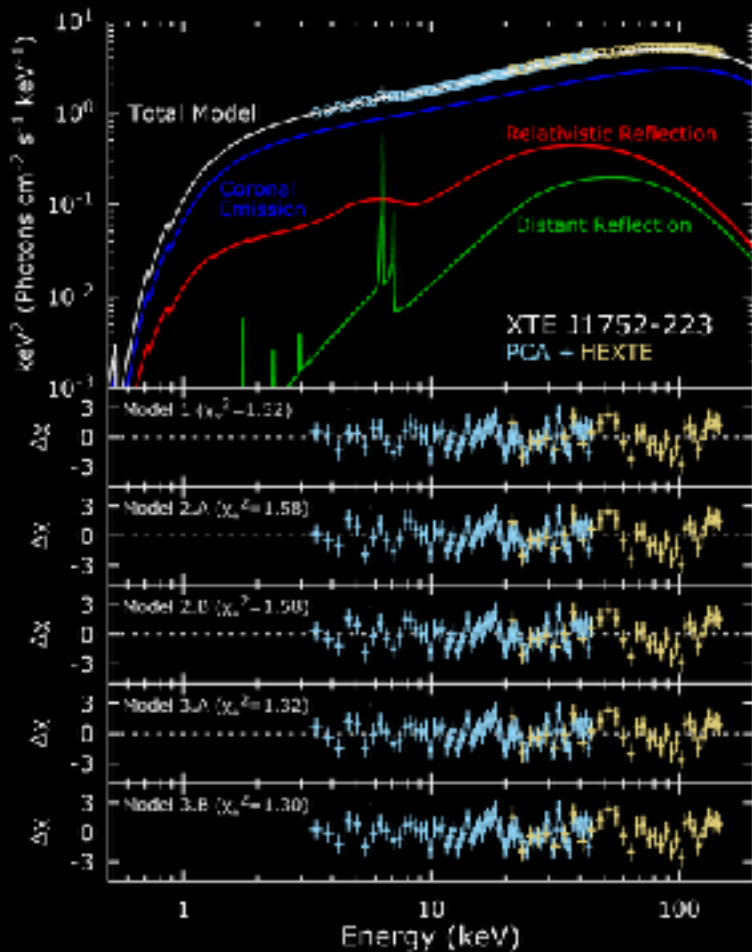
# The *RXTE* Archive of BHBs

NASA ADAP16: ~15,000 *RXTE* spectra with PCA (3-45 keV) and HEXTE (20-250 keV) for ~30 BHB with ~1 ks exposures



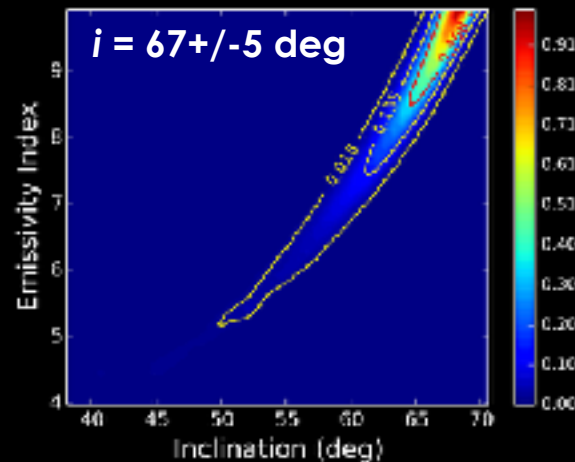
**XTE J1752-223:** Hard-state spectra with over 100 million counts (eq. 300 ks exposure)

# The Hard State of XTE J1752–223

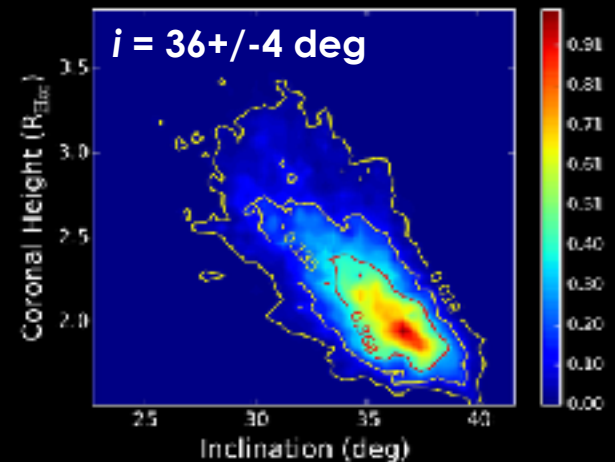


Highest signal-to-noise  
reflection spectrum to date!  
**(S/N ~ 3000)**

Power-law Emissivity



Lamppost Geometry



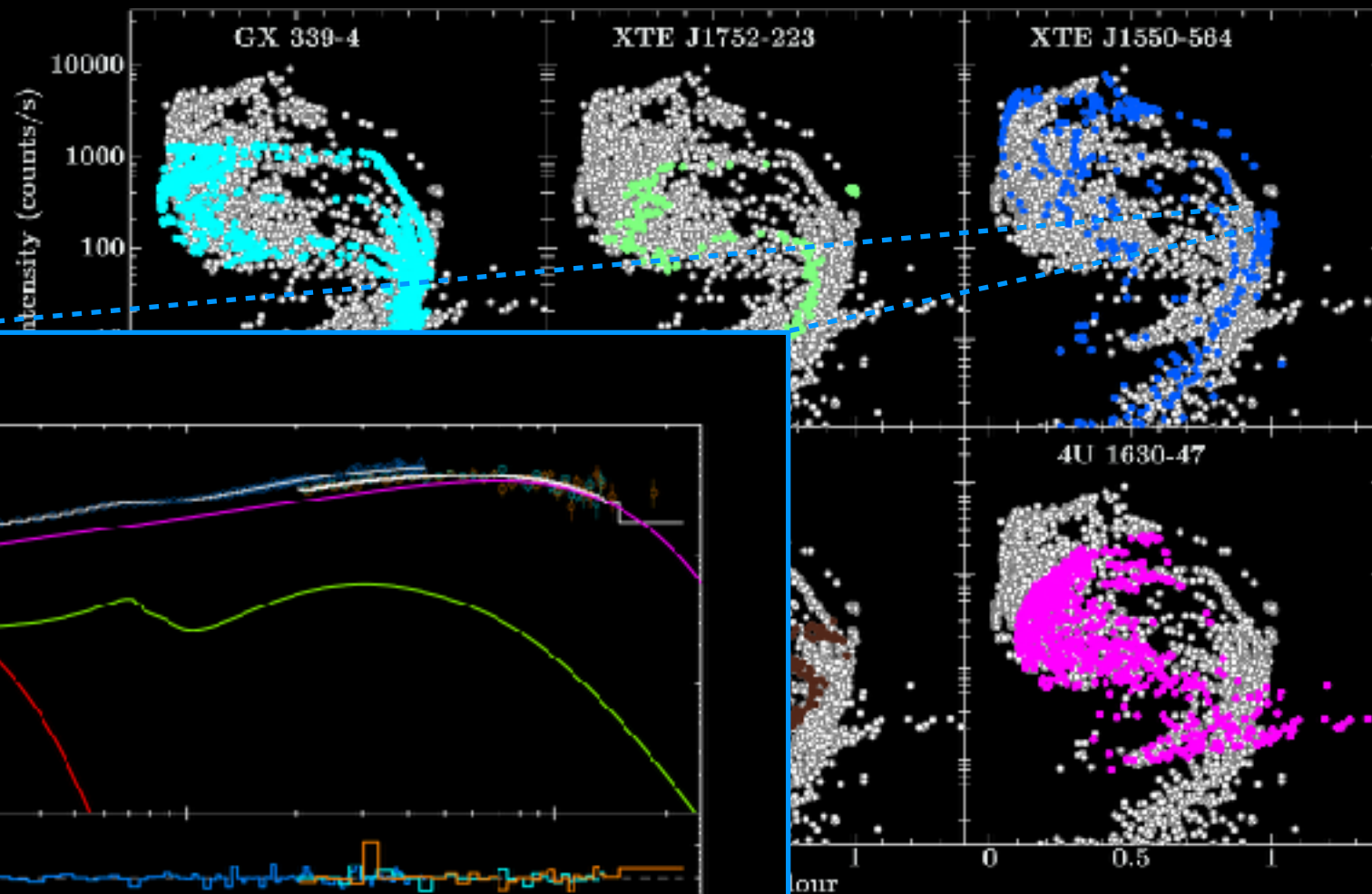
Inclination from the lamppost model consistent  
with radio jet determinations of  **$i < 49$  deg**  
(Miller-Jones et al. 2011).

Other parameters consistent  
among models:

- Inner radius =  $1.7 \pm 0.4 R_g$
- Spin =  $0.92 \pm 0.06$
- Coronal Temp = 57–70 keV
- Iron Abundance = 3.3–3.7 Solar

# The *RXTE* Archive of BHBs

NASA ADAP16: ~15,000 *RXTE* spectra with PCA (3-45 keV) and HEXTE (20-250 keV) for ~30 BHB with ~1 ks exposures



**XTE J1550-564:** Intermediate spin ( $a \sim 0.5$ ) from continuum fitting method



# Research Team



Riley Connors



Thomas Dauser



Jeff McClintock

Jack Steiner

Javier García

Ron Remillard

Victoria Grinberg

HEAD 14th Division Meeting, Chicago, IL, Aug 2014

# Summary

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- **Reproducibility** is one of the main principles of the scientific method
- The **systematic** and **consistent** analysis of the reflection spectra using the vast **RXTE** archive will provide a panoramic view of black hole behavior while significantly improving spin measurements
- The abundance of **RXTE** data allows to **track the evolution** of physical parameters throughout a complete outburst cycle

*"You know how excited I am about our work -- keep it up!"* --Jeff McClintock