A comprehensive study of thermonuclear X-ray bursts from 4U 1820-30

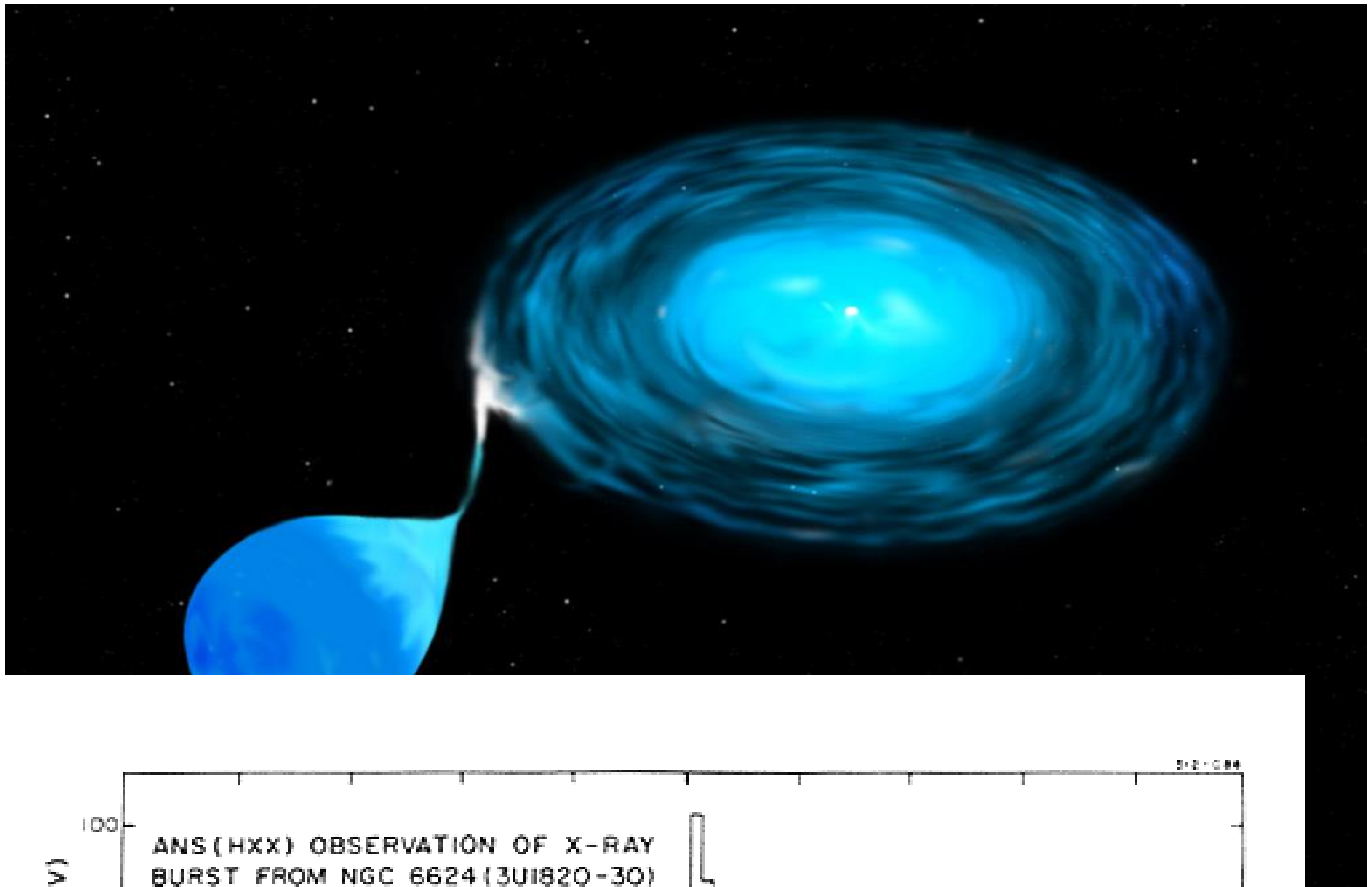
Gaurava K. Jaisawal
DTU Space,
Technical University of Denmark

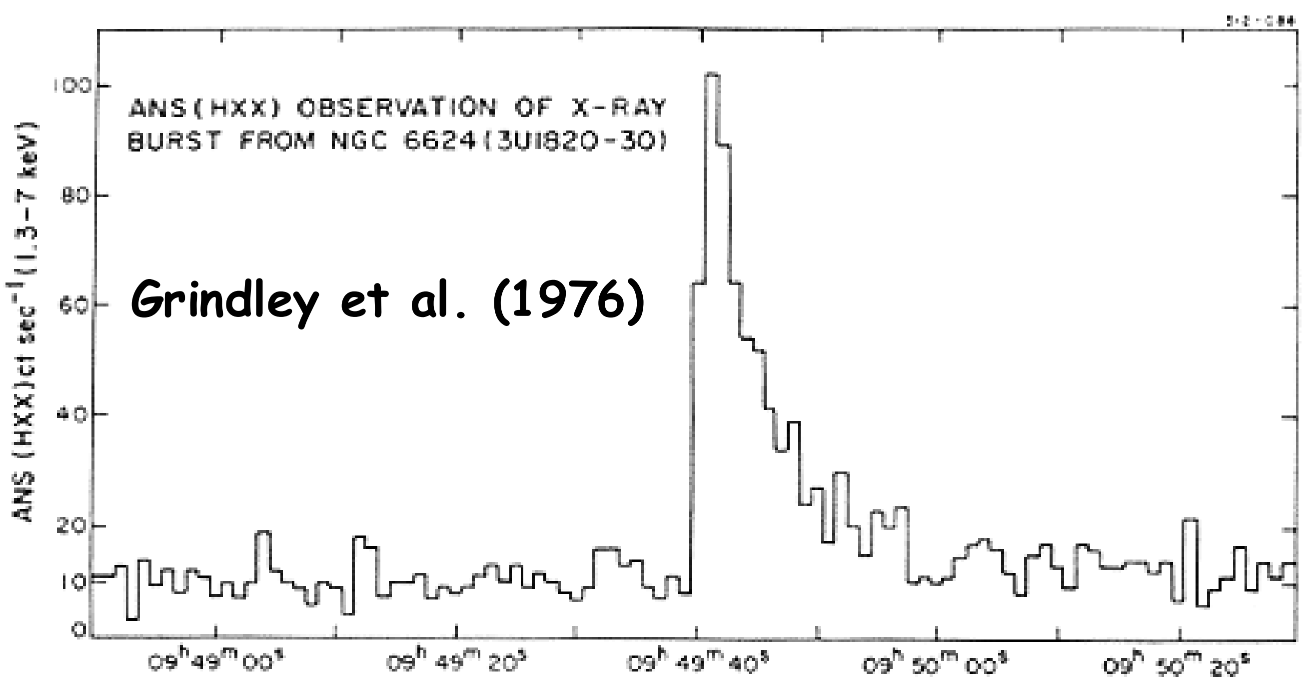
DTU Space
National Space Institute

Collaborators:
J. Chenevez (DTU Space),
T. Güver, Z. F. Bostanci (Istanbul Univ.),
T. E. Strohmayer, K. C. Gendreau, Z. Arzoumanian (NASA/GSFC),
D. Chakravarty (MIT), and other colleagues from NICER science team

The INTEGRAL Workshop, ESAC Madrid, 21-24 October 2024

4U 1820-30



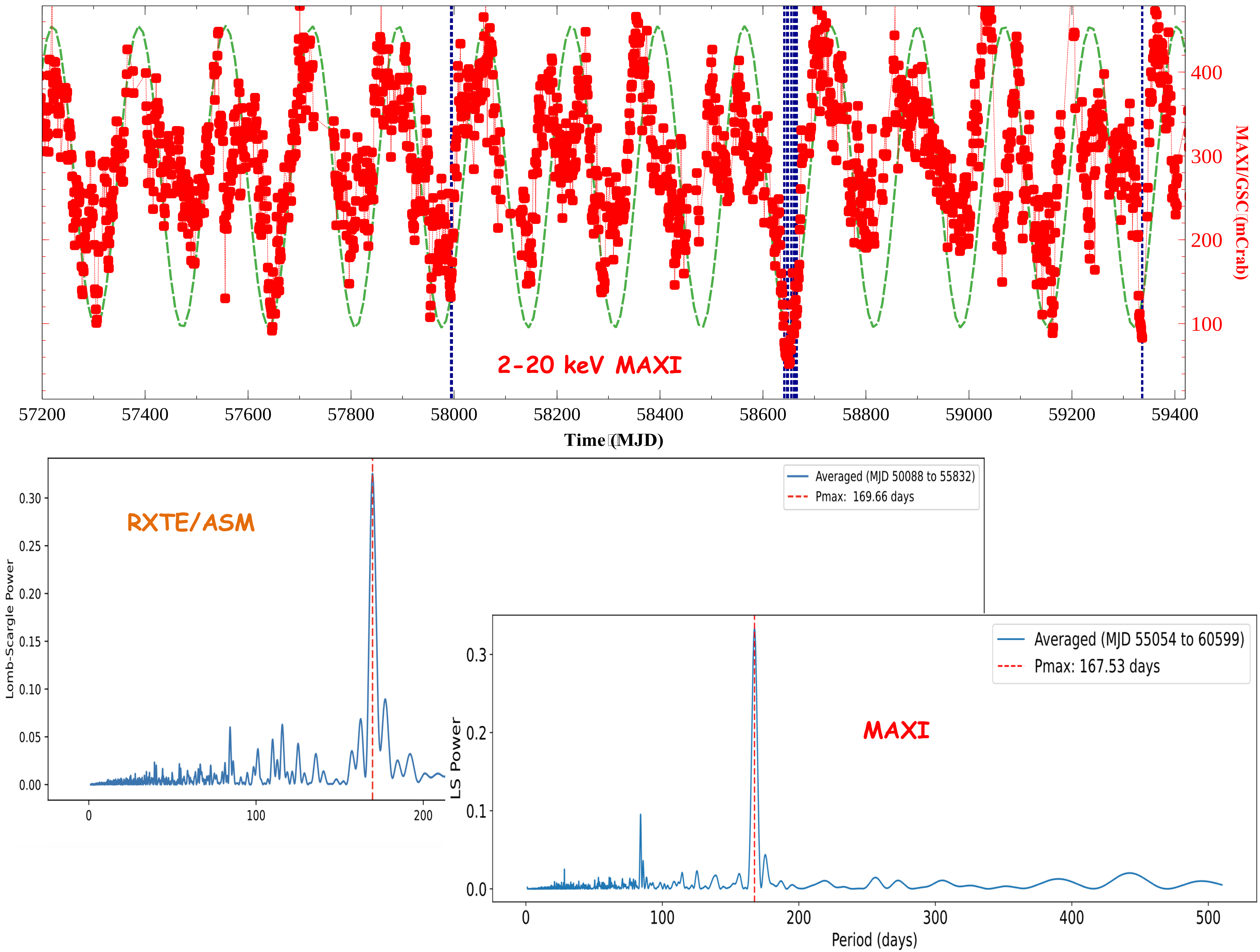


First thermonuclear X-ray burst

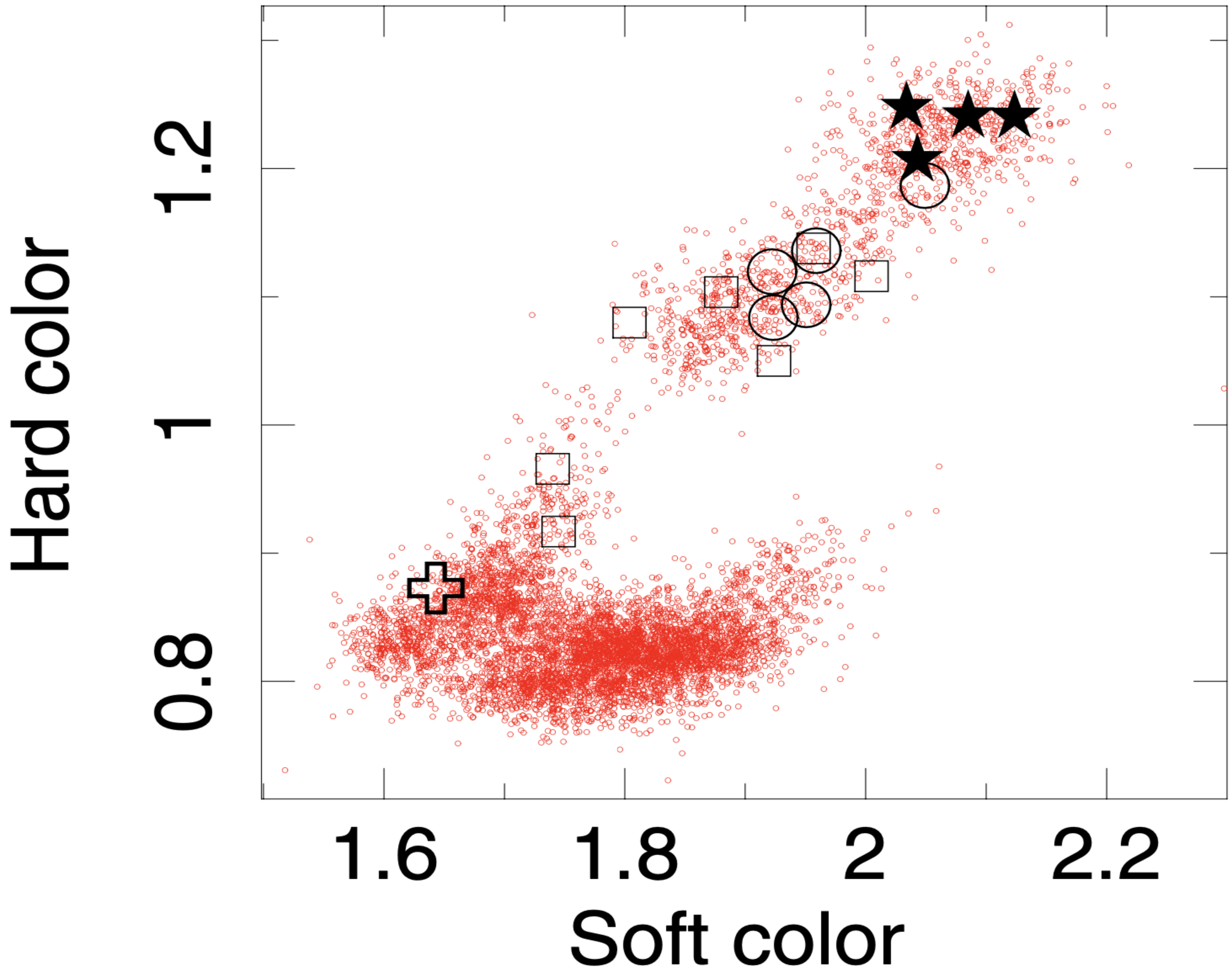
LMXB discovered in early 70s.

Located in a globular cluster NGC 6624.

Short orbital period of 11.4 min – Ultra-compact X-ray binary, suggesting the companion is an He WD (Stella et al. 1987, Rappaport et al. 1987).



2-20 keV MAXI
MAXI/GSC (mCrab)
100
200
300
400
57200
57400
57600
57800
58000
58200
58400
58600
58800
59000
59200
59400
Time (MJD)
RXTE/ASM
Lomb-Scargle Power
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
100
200
Averaged (MJD 50088 to 55832)
Pmax: 169.66 days
MAXI
LS Power
0.0
0.1
0.2
0.3
0
100
200
300
400
500
Period (days)
Averaged (MJD 55054 to 60599)
Pmax: 167.53 days



in 't Zand et al. (2012)

CCD with RXTE

Thermonuclear X-ray bursts are detected during the low-hard state (Island state).

A Comprehensive Study of Thermonuclear X-ray Bursts from 4U 1820–30 with *NICER*: Accretion Disk Interactions and a Candidate Burst Oscillation

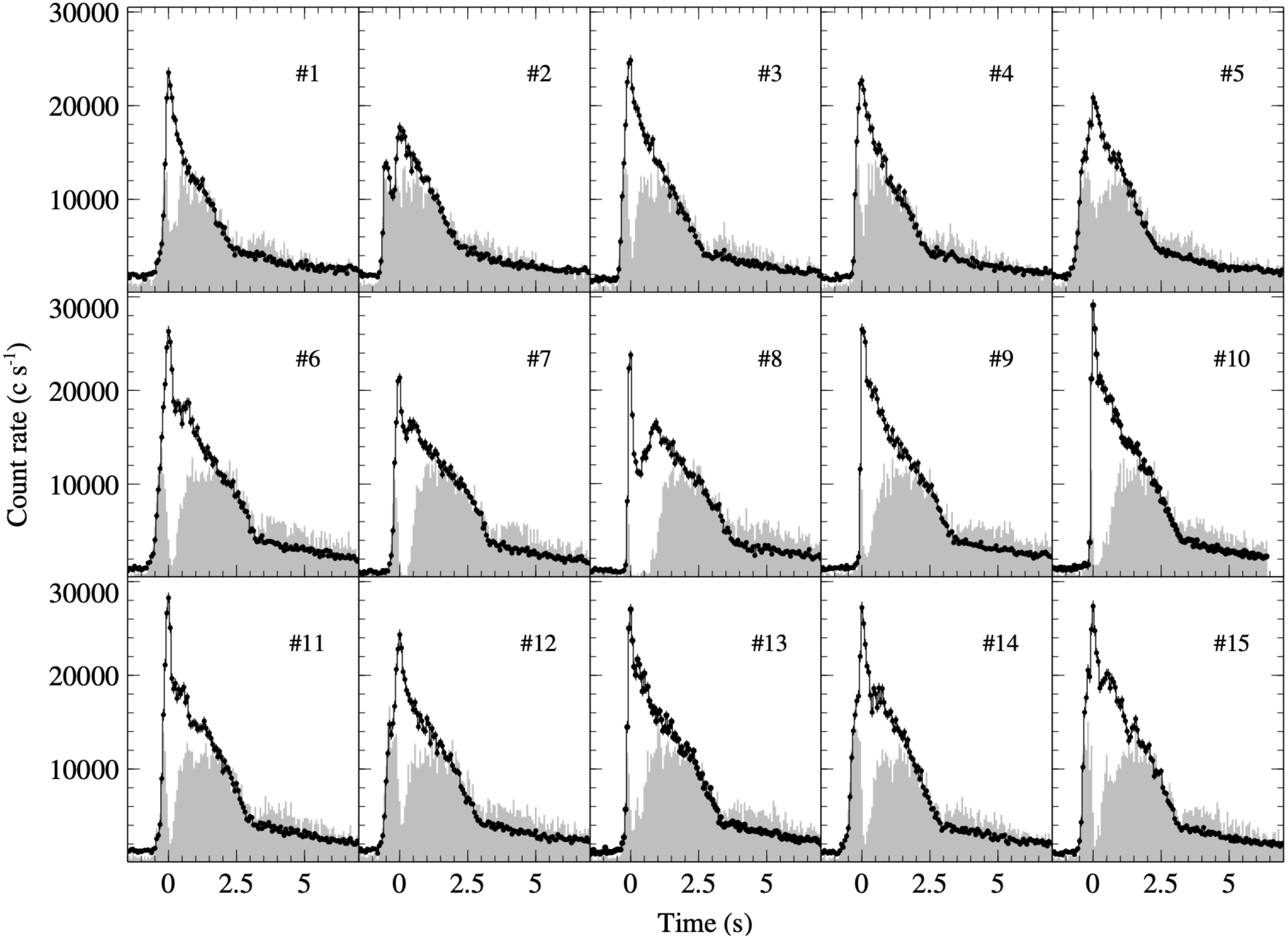
Gaurava K. Jaisawal,[1] Z. Funda Bostancı,[2,3] Tuğba Boztepe,[4] Tolga Güver,[2,3]
Tod E. Strohmayer,[5] David R. Ballantyne,[6] Jens H. Beck,[1] Ersin Göğüş,[7] Diego Altamirano,[8]
Zaven Arzoumanian,[9] Deepto Chakrabarty,[10] Keith C. Gendreau,[9] Sebastien Guillot,[11,12]
Renee M. Ludlam,[13] Mason Ng,[10] Andrea Sanna,[14] and Jérôme Chenevez[1]

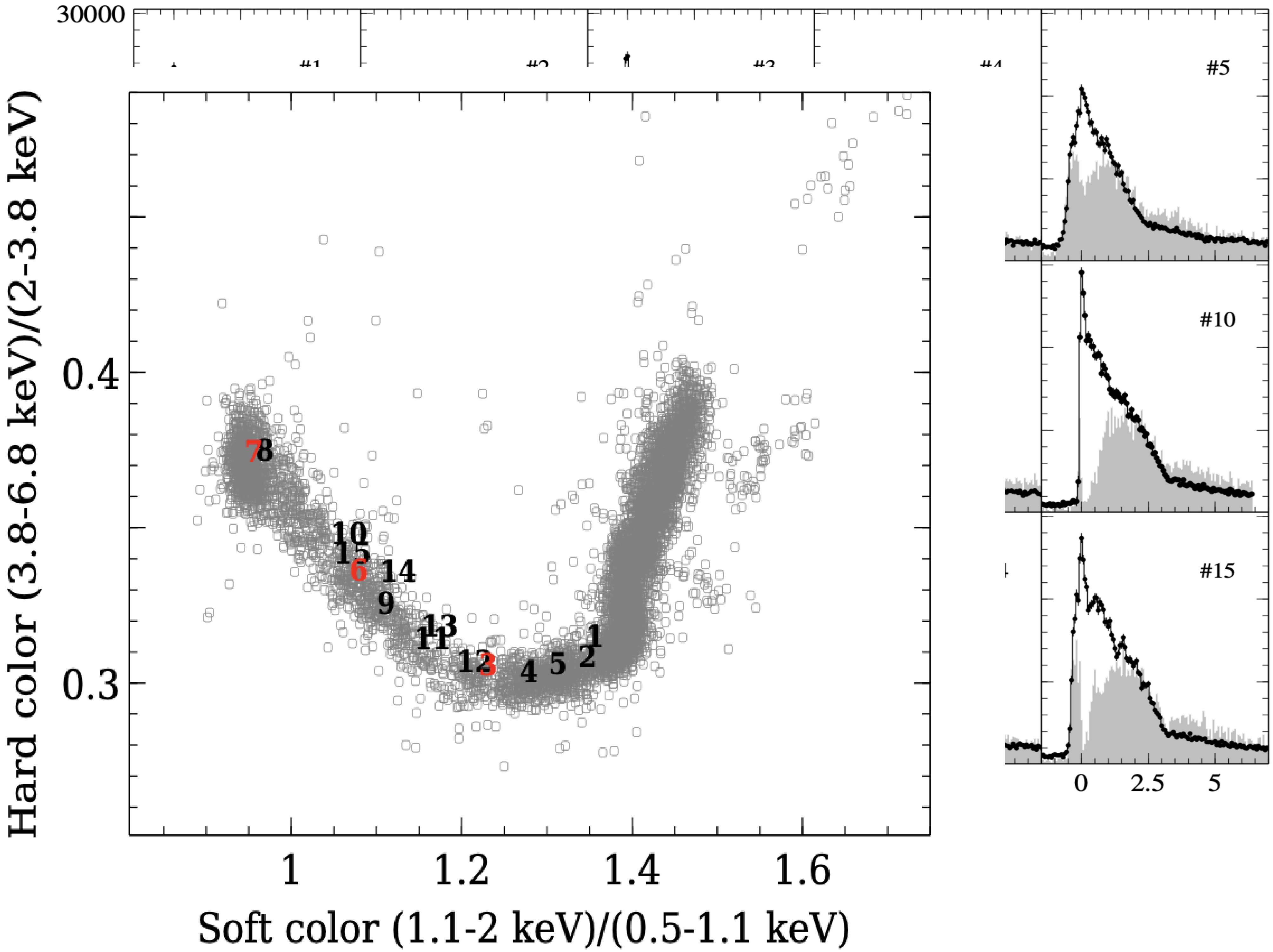
[1] *DTU Space, Technical University of Denmark, Elektrovej 327-328, DK-2800 Lyngby, Denmark*
[2] *Istanbul University, Science Faculty, Department of Astronomy and Space Sciences, Beyazıt, 34119, İstanbul, Türkiye*
[3] *Istanbul University Observatory Research and Application Center, Istanbul University 34119, İstanbul Türkiye*
[4] *Istanbul University, Graduate School of Sciences, Department of Astronomy and Space Sciences, Beyazıt, 34119, İstanbul, Türkiye*
[5] *Astrophysics Science Division and Joint Space-Science Institute, NASA's Goddard Space Flight Center, Greenbelt, MD 20771, USA*
[6] *Center for Relativistic Astrophysics, School of Physics, Georgia Institute of Technology, 837 State Street, Atlanta, GA 30332-0430, USA*
[7] *Faculty of Engineering and Natural Sciences, Sabancı University, Orhanlı-Tuzla 34956, İstanbul, Türkiye*
[8] *School of Physics and Astronomy, University of Southampton, Southampton SO17 1BJ, UK*
[9] *Astrophysics Science Division, NASA's Goddard Space Flight Center, Greenbelt, MD 20771, USA*
[10] *MIT Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA*
[11] *IRAP, CNRS, 9 avenue du Colonel Roche, BP 44346, F-31028 Toulouse Cedex 4, France*
[12] *Université de Toulouse, CNES, UPS-OMP, F-31028 Toulouse, France.*
[13] *Department of Physics & Astronomy, Wayne State University, 666 West Hancock Street, Detroit, MI 48201, USA*
[14] *Dipartimento di Fisica, Università degli Studi di Cagliari, SP Monserrato-Sestu km 0.7, I-09042 Monserrato, Italy*

ABSTRACT

Jaisawal et al. 2024, ApJ, In press,
https://doi.org/10.3847/1538-4357/ad794e

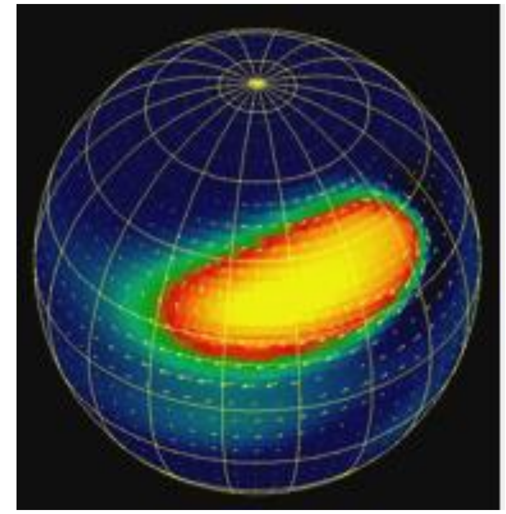
X-ray bursts from 4U 1820-30 with NICER



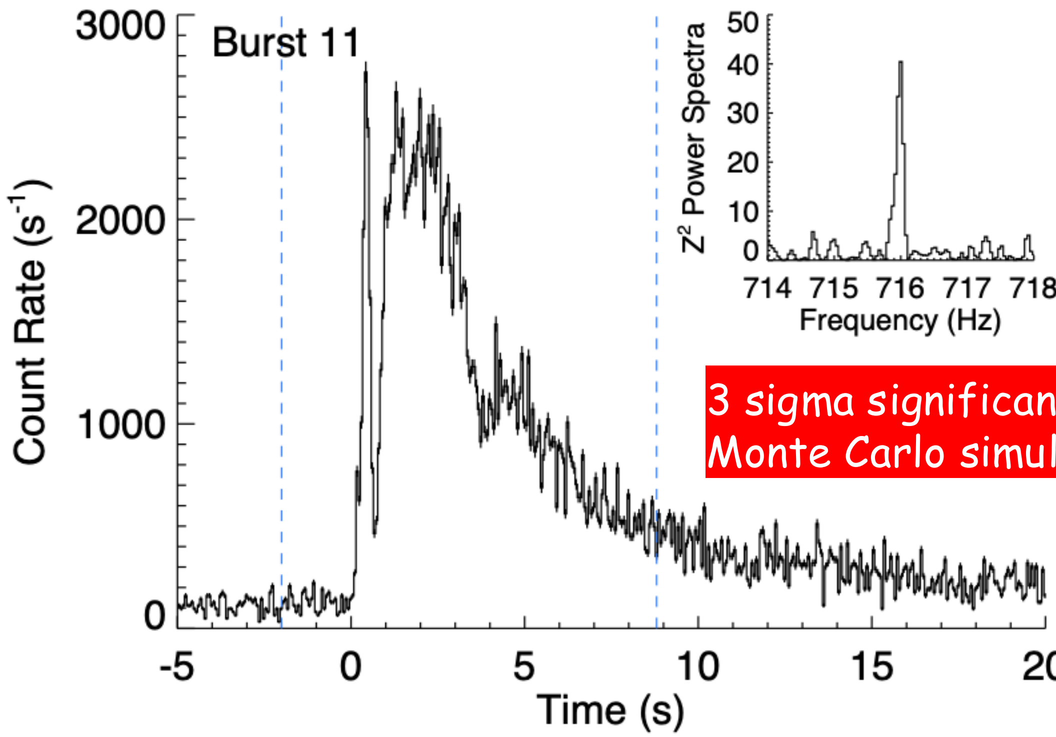


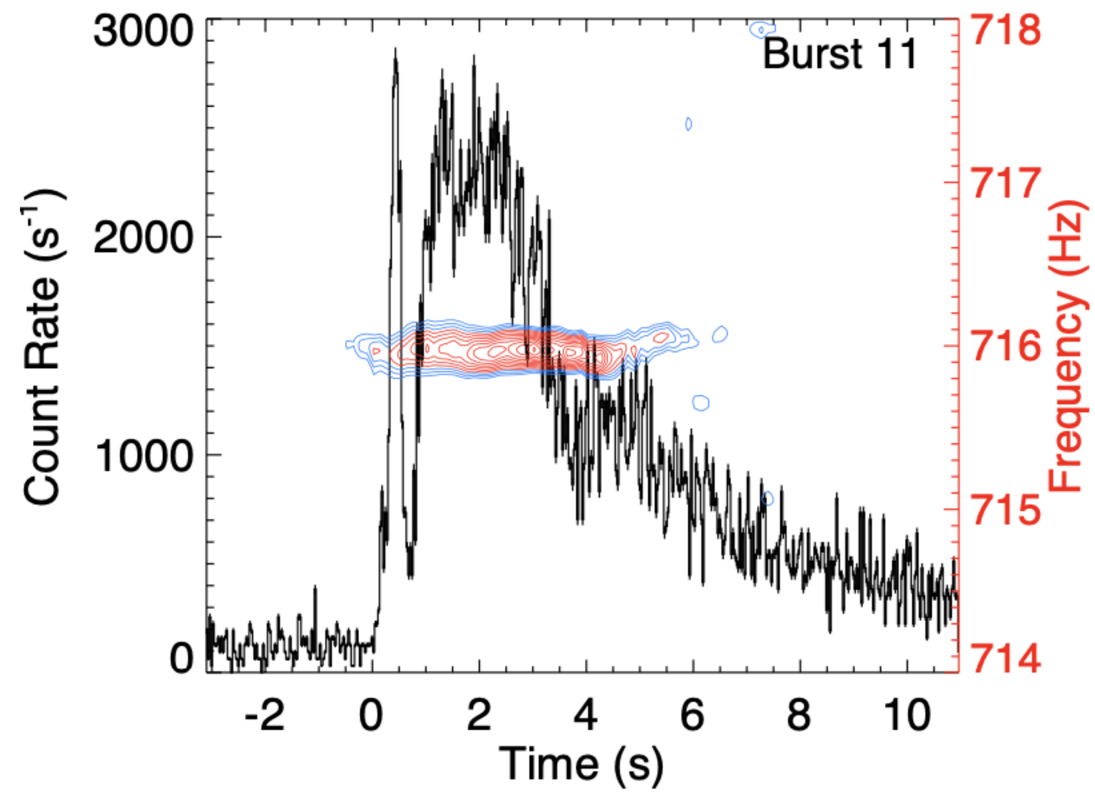
NICER bursts are occupied in one branch

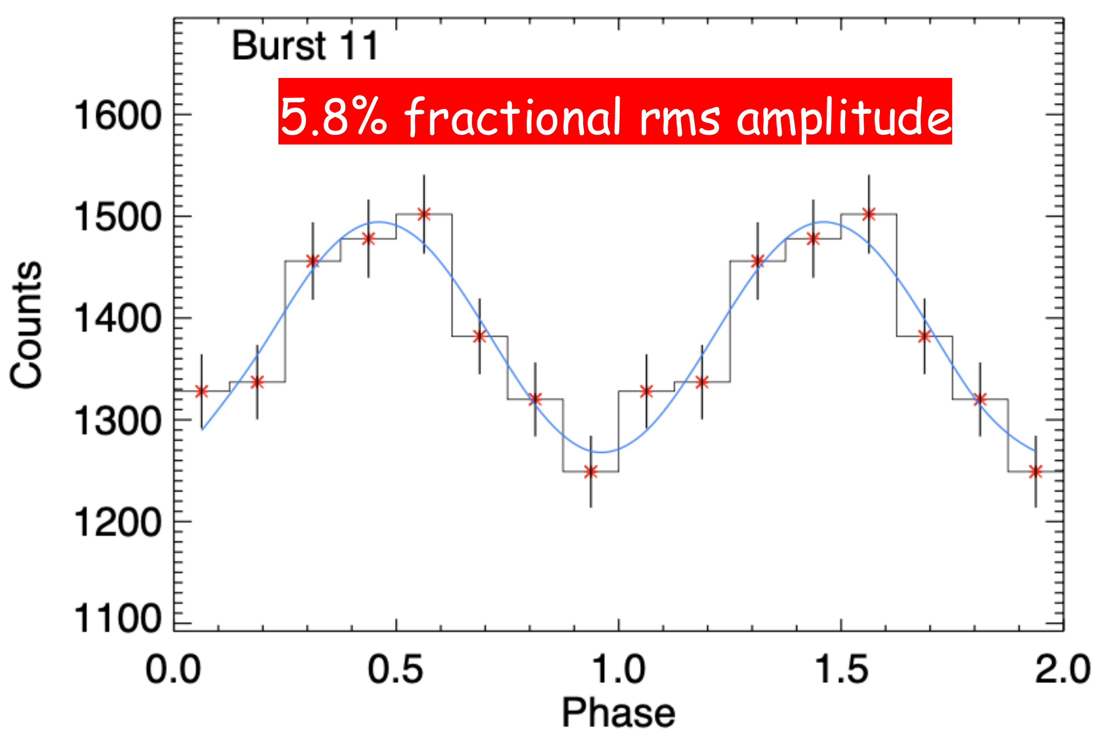
A candidate burst oscillations at 716 Hz from 4U 1820-30



BOs originate from bright patches of thermonuclear explosions on the NS surface, and they coincide with the NS spin frequency.

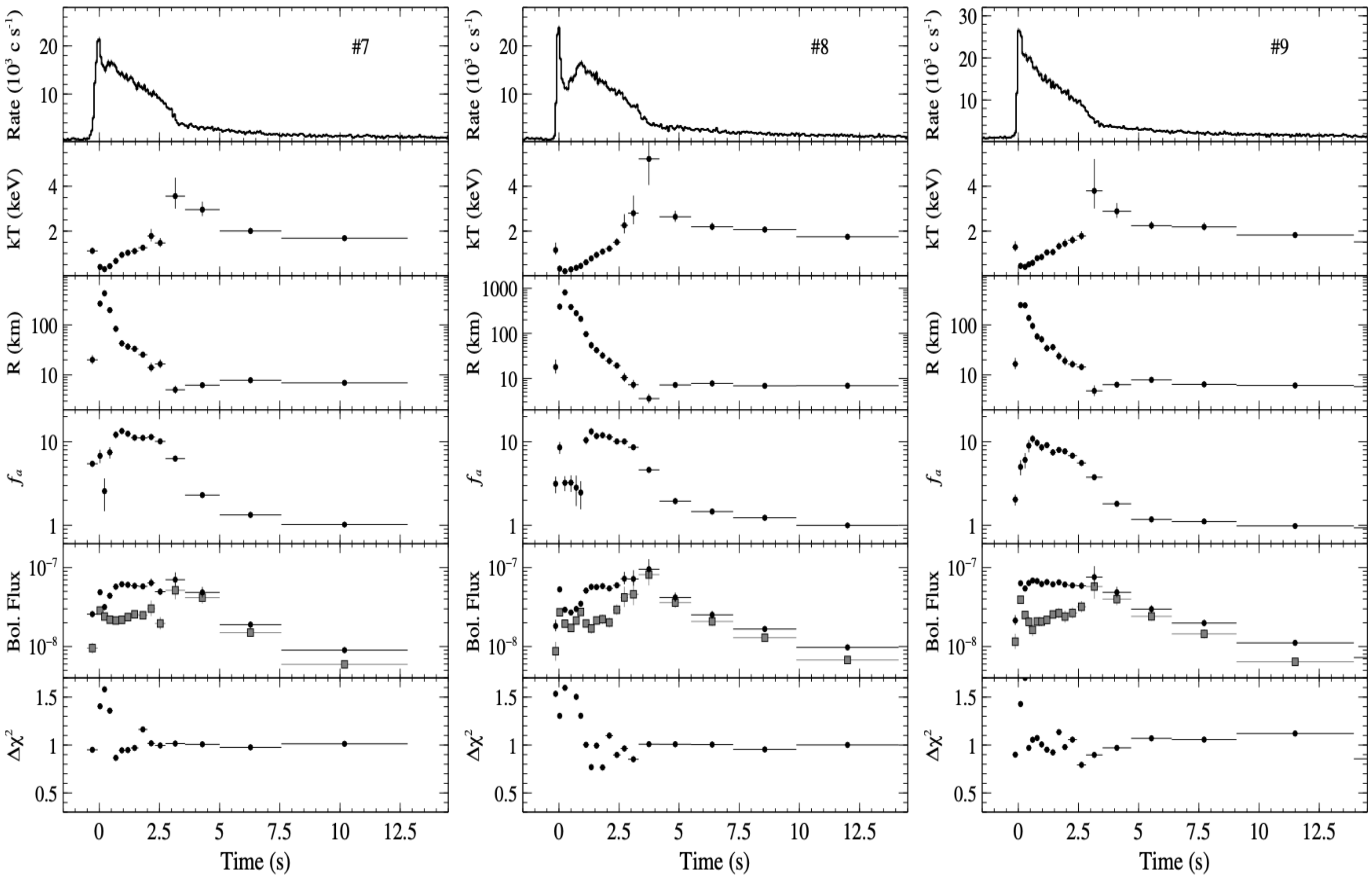






The fastest radio pulsar is PSR J1748–2446ad in the globular cluster Terzan 5 has 716 Hz spin freq. (Hessels et al. 2006).

4U 1820-30: Burst time-resolved spectrsocopy using fa-model



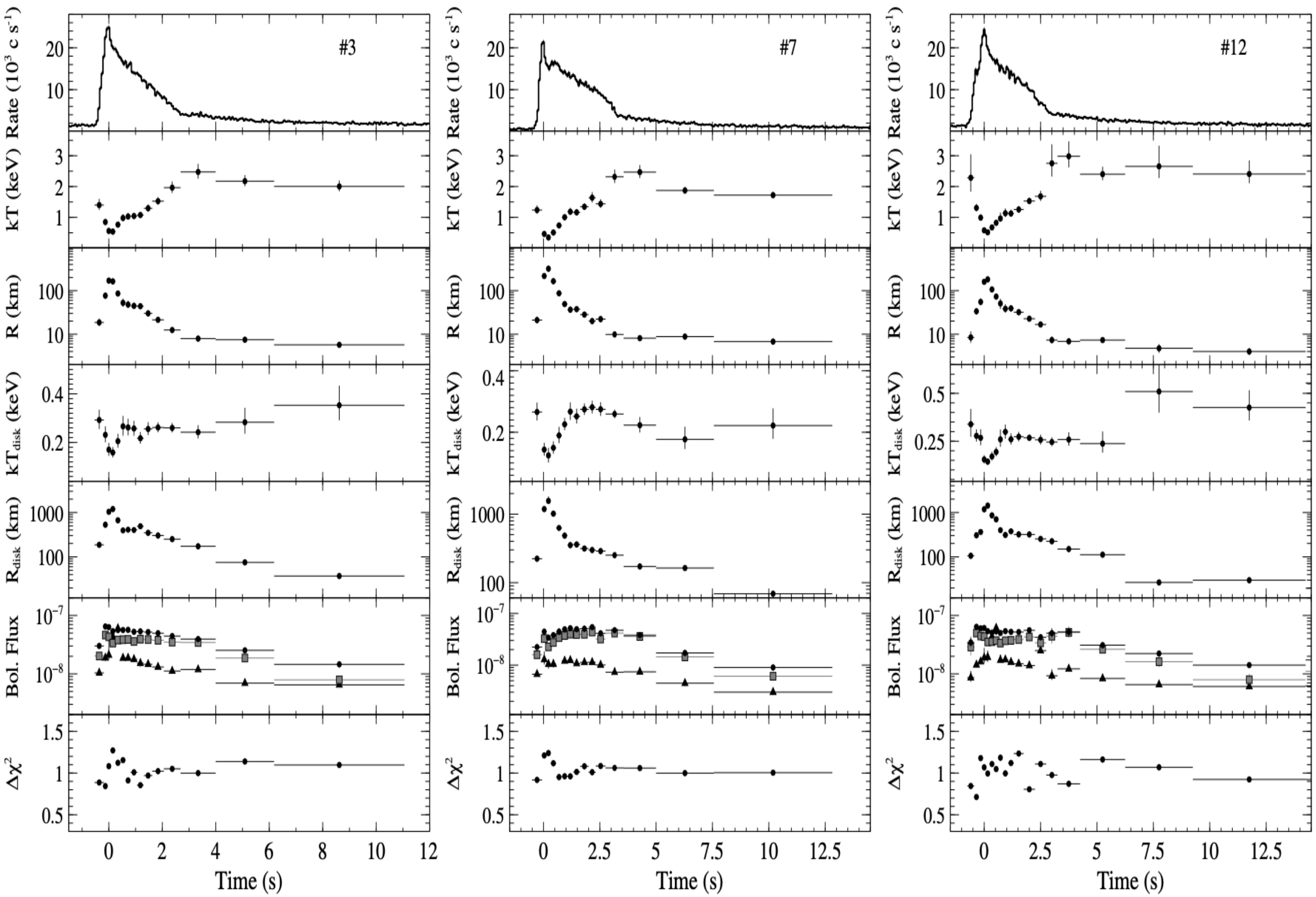
All 15 bursts shows sign of PRE

NS photosphere expanded for >50 km.

"Super-exapasion burst" with NICER (Int' Zand et al. 2012).

Scaling factor increased to 10 times at the peak – signify changes in pre-burst accretion

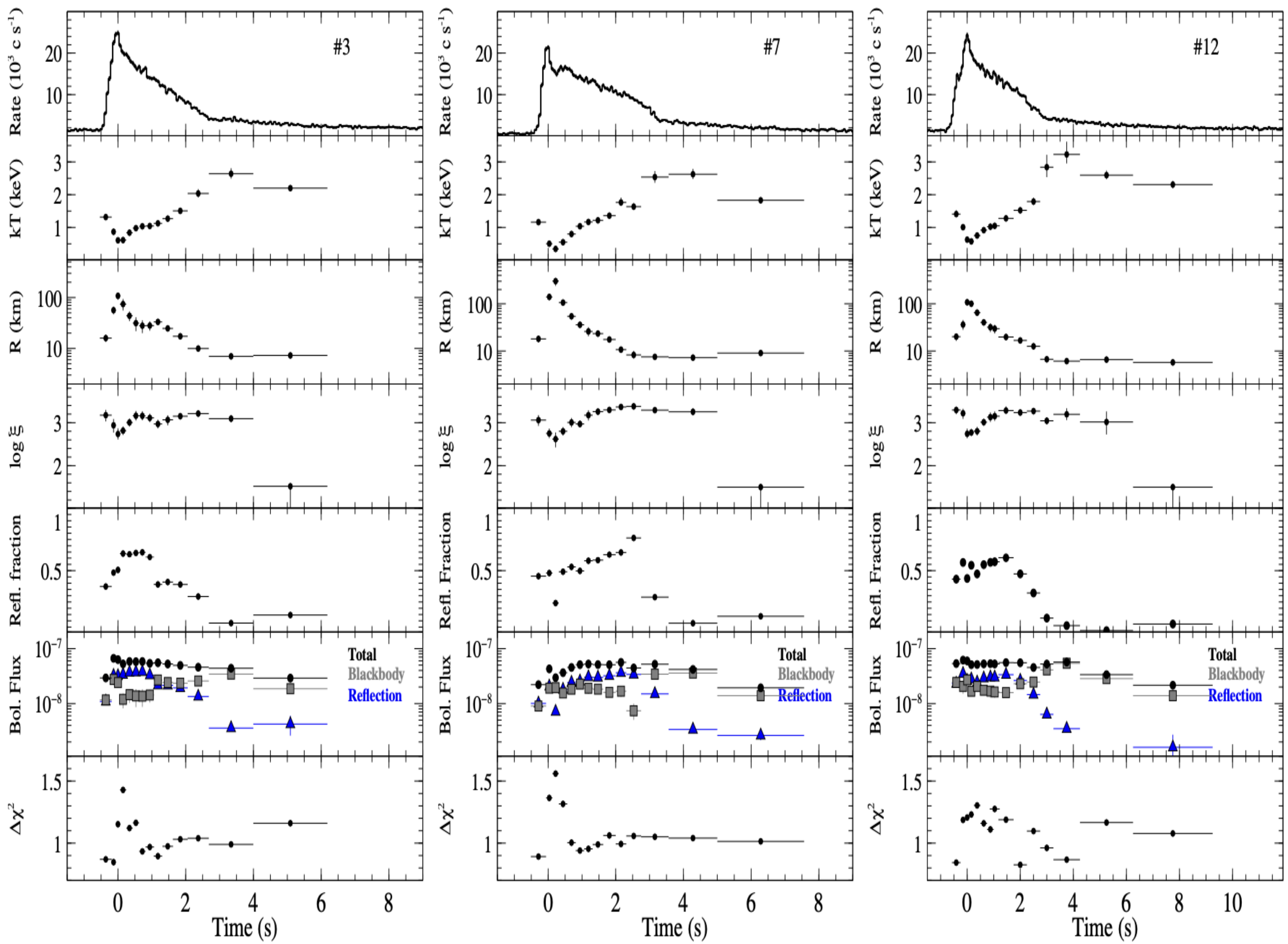
4U 1820-30: Burst time-resolved spectrsocopy using an alternative method



Allowed a component of pre-burst to vary

Rapid changes in diskbb parameters around PRE phase

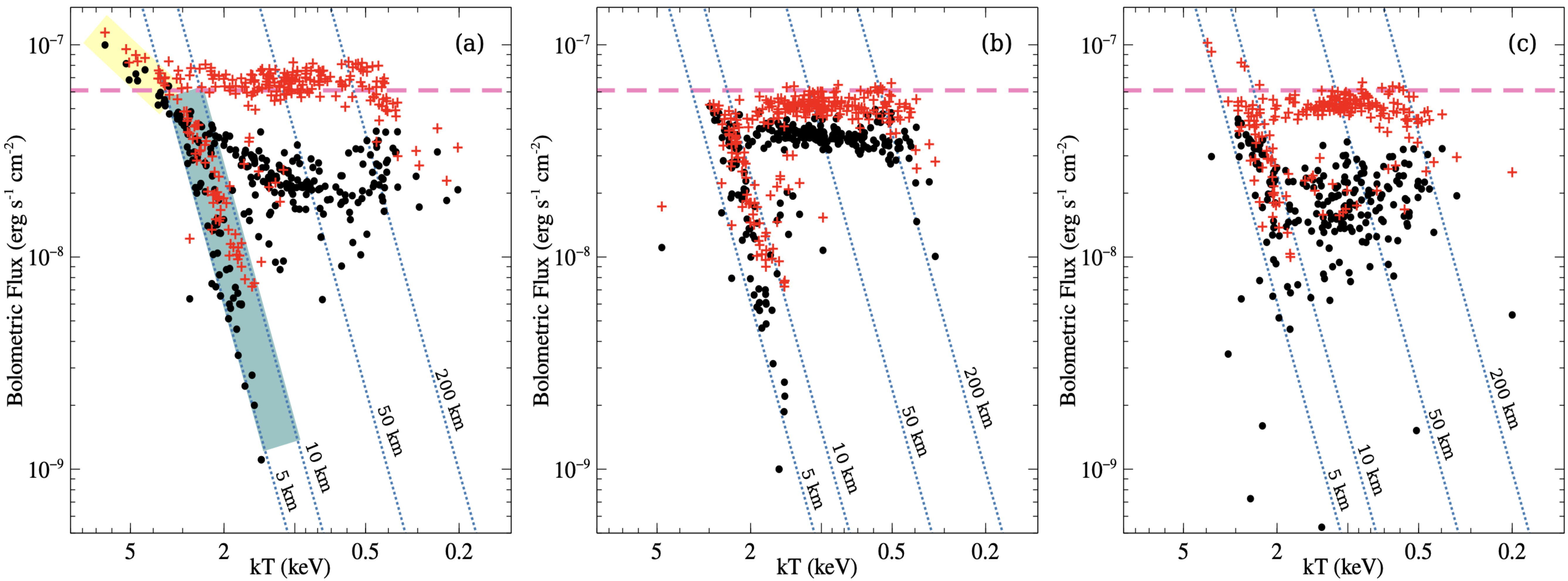
4U 1820-30: Burst time-resolved spectrsocopy using reflection-model



Systematic drop in ionization parameter around PRE phase

Contribution from weakly ionized inner accretion disk and/or from outer disk

Flux-temperature diagram



Variable peristent emission (fa-model)

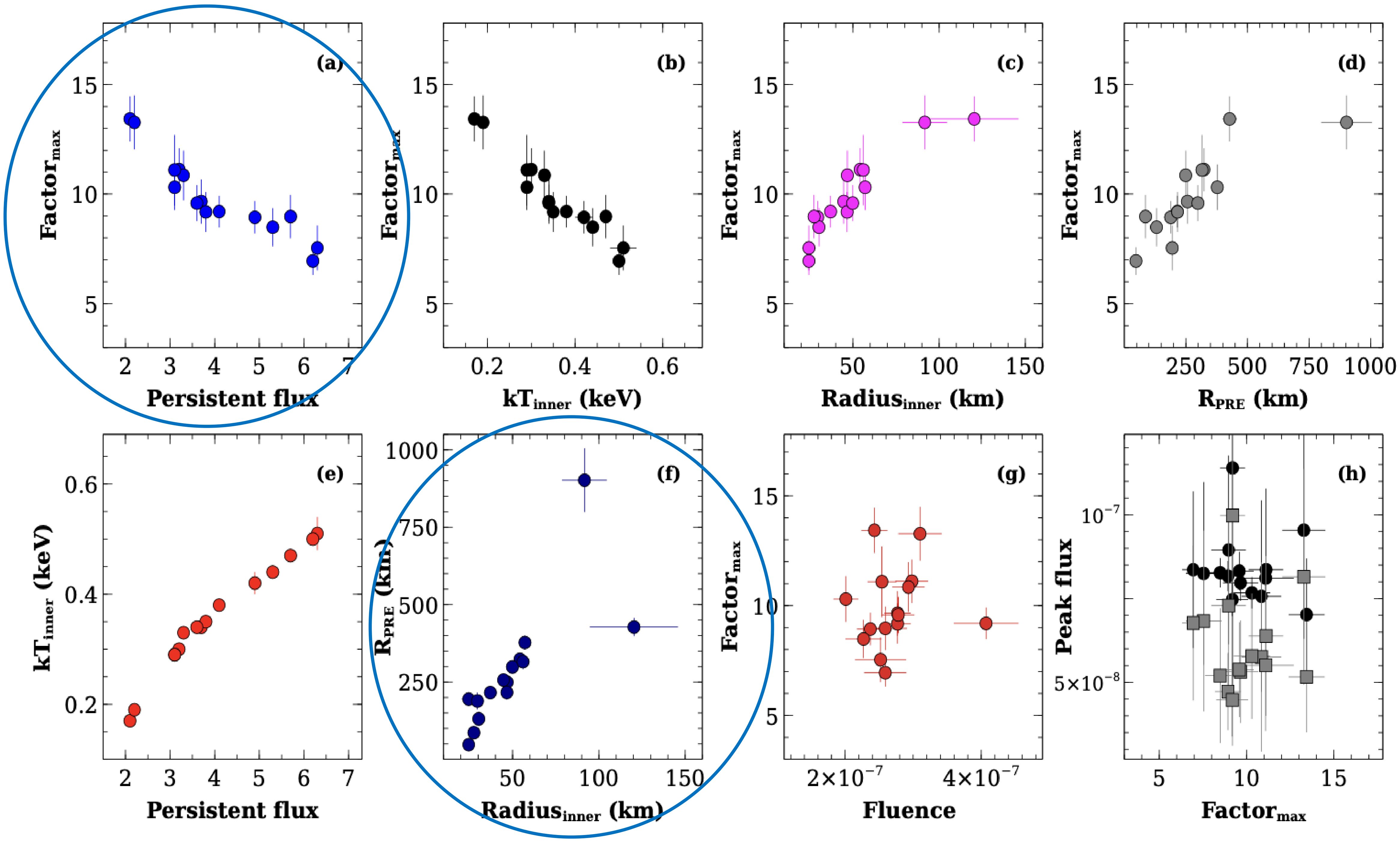
Variable pre-burst component

Reflection model

+ Total model flux (bolometric)

• Burst blackbody flux (bol.)

Can accretion geometry control the maximum expansion radius observed during X-ray bursts?



4U 1820-30: A relation between X-ray bursts and accretion emission parameters

Conclusions

- Strong X-ray bursts from 4U 1820-30 observed with NICER
- Detection of a candidate BO at 716 Hz
- Photospheric radius expansion bursts from 4U 1820-30 – probe on the accretion environment.
- Does the accretion environment hold control over photospheric radius expansion of PRE bursts?

Thanks

(gaurava@space.dtu.dk)