Scientific Results from Two Years of MAXI Observations

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Nobuyuki Kawai (Tokyo Tech)
on behalf of the the MAXI Team

MAXI Team

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Outline

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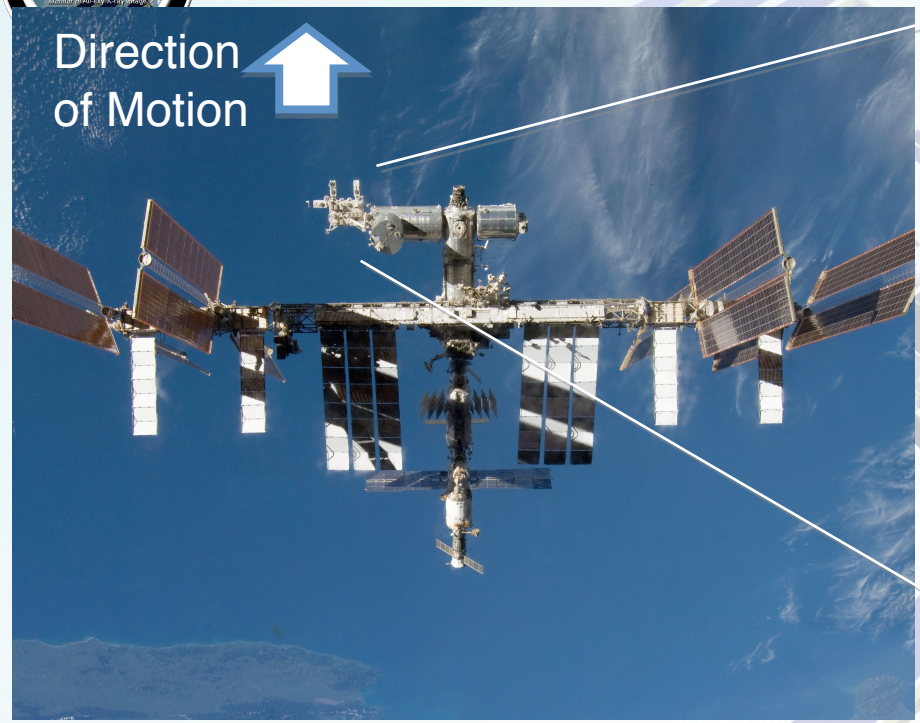
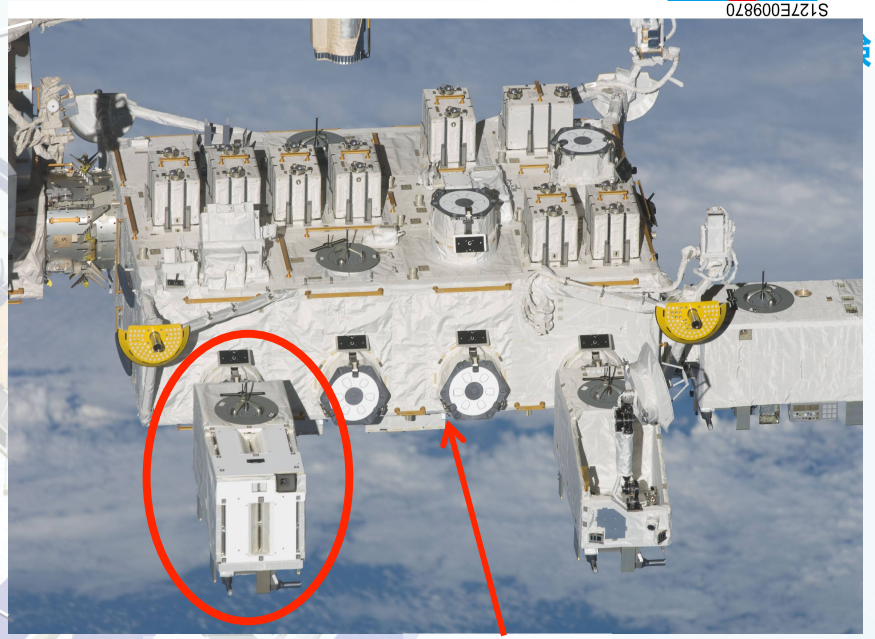
- Mission and Instruments
- Public data and alerts
- X-ray sources seen by MAXI
- Science highlights
  - Black hole candidates
  - Binary pulsars
  - Stellar flares
  - Active galactic nuclei
  - Gamma-ray bursts
  - Others

MAXI Posters

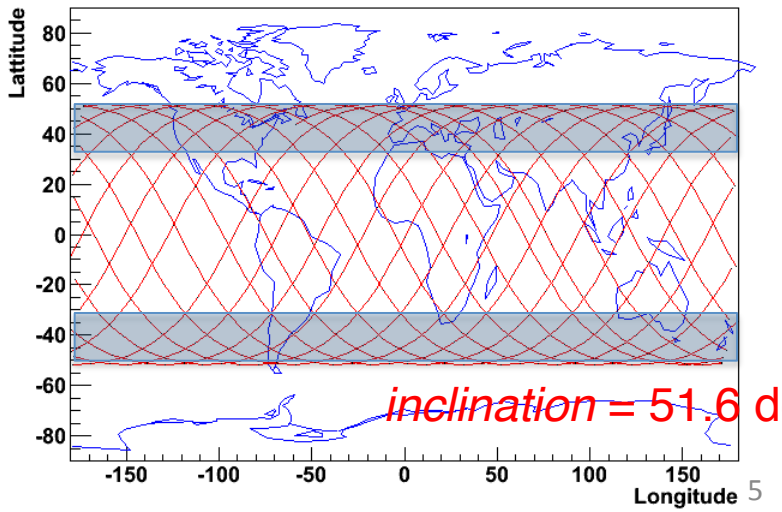
No	Author	Title
38	Kimura	The Diffuse structure observed with MAXI/SSC
44	Matsuoka	A possible contribution of stellar flares by MAXI to the GRXE
46	Tsuboi	An Unbiased Survey of Stellar Flares: New Results from MAXI/GSC
49	Yamamoto	Suzaku Observations of X-ray Binary Pulsar GX 304-1 triggered by MAXI/GSC in 2010 August
57	Tomida	Point Sources Observed with MAXI/SSC on ISS
58	Nakahira	Mass Estimation of the BHB XTE J1752-223 from the Spectral Analyses with MAXI/GSC and Suzaku
59	Negoro	Discoveries of New Black Hole transients MAXI J1659-152 and MAXI J1543-564
71	Hiroi	The First MAXI/GSC Catalog in the High-Galactic-Latitude Sky
92	Usui	Suzaku observation of the transient source Swift J164449.3+573451 (GRB110328A)

MAXI (Monitor of All-sky X-ray Image) on ISS





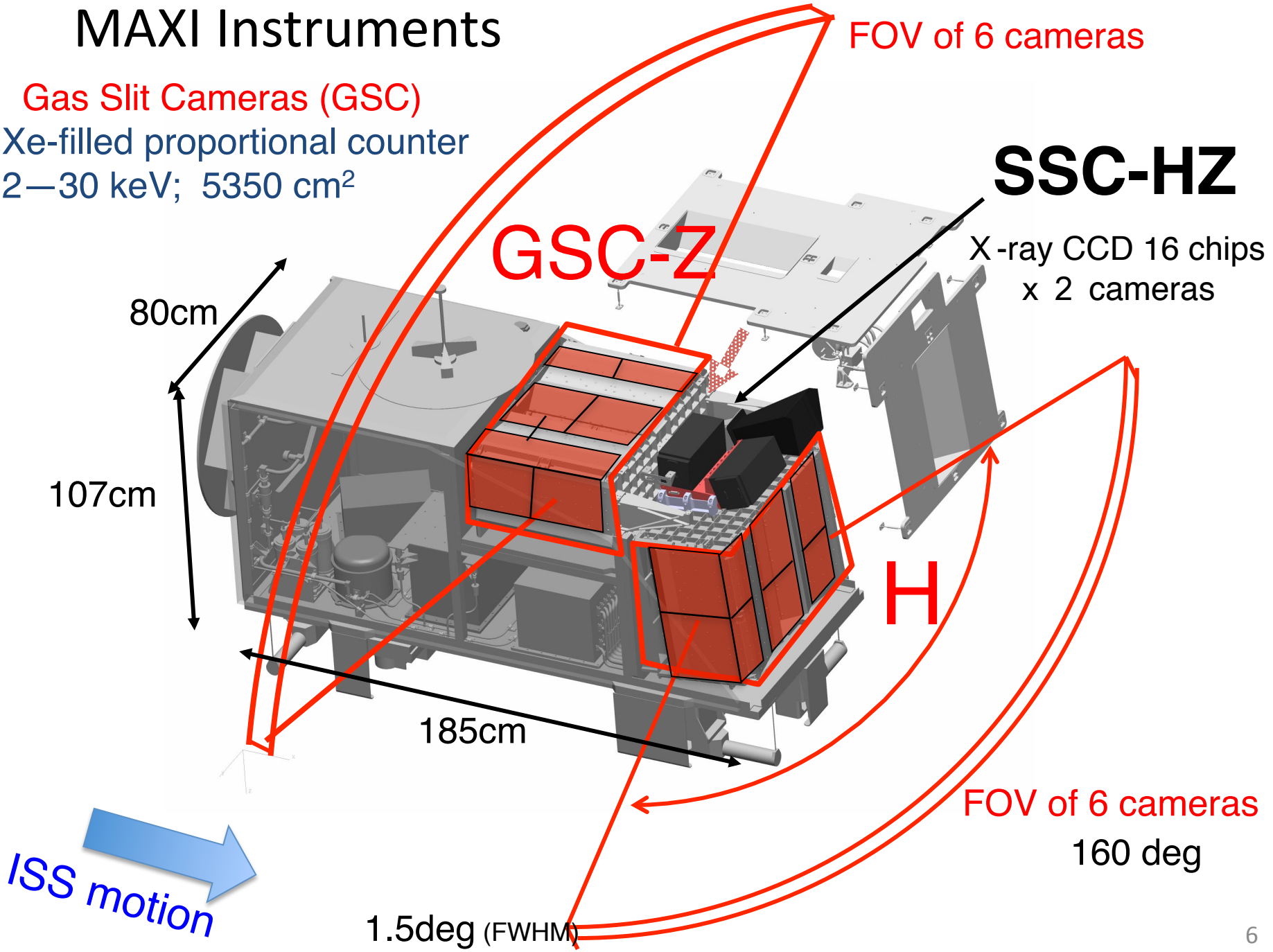
- The first astronomical mission on ISS
- Transported by Space Shuttle (Endeavour) on July16, 2009
- Installed on JEM (Japanese Experimental Module, KIBO) EF (Exposed Facility) on July 23.
- First Light on August 15, 2009.



inclination = 51.6 deg.

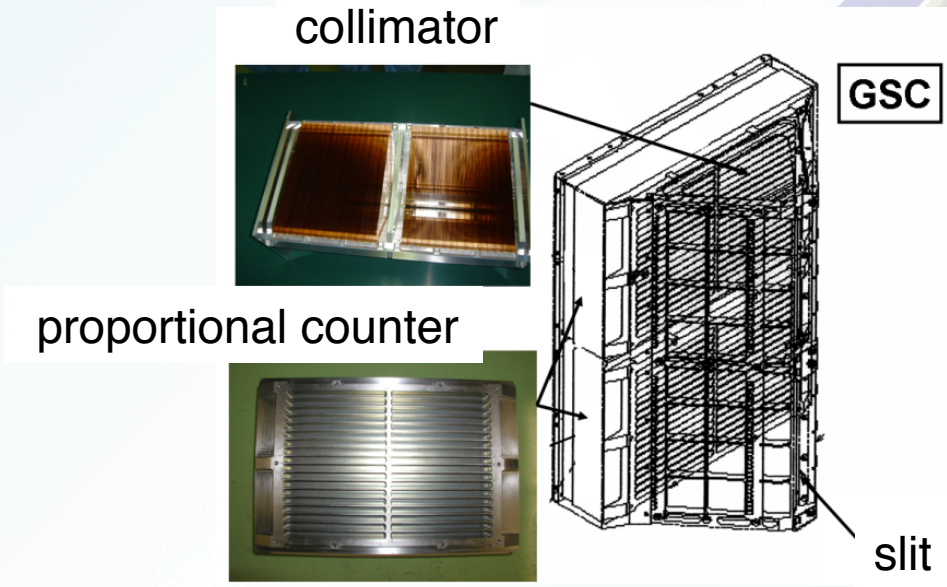
MAXI Instruments

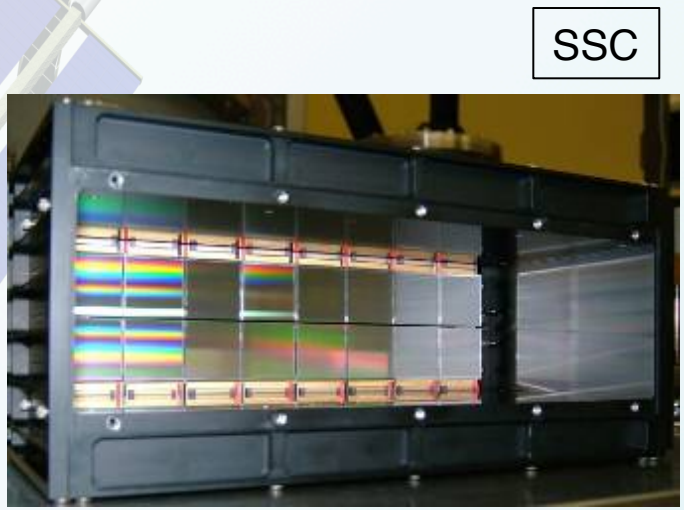
Gas Slit Cameras (GSC)
Xe-filled proportional counter
2—30 keV; 5350 cm^2



Detectors

	GSC (X-ray Gas Camera)	SSC (X-ray CCD Camera)
Detector	Gas(Xe) prop. counter x12	CCD 16 chips x 2 camera
Energy range (Q.E.>10%)	2－30 keV	0.5－12 keV
Energy resolution (FWHM)	15.7%(at 8.0keV)	< 2.5%(150eV) (at 5.9keV)
Time resolution & accuracy	＜200μsec	～6 sec
Instantaneous sky coverage	2.4 % of the whole sky (160 deg x 3 deg x 2 sets)	1.4% of whole sky (90 deg x 3 deg x 2 sets)
Point Spread Function	1.5 degree	1.5 degree
sensitivity	2 mCrab (week)	5 mCrab (week)





GSC All-Sky Scan Movie

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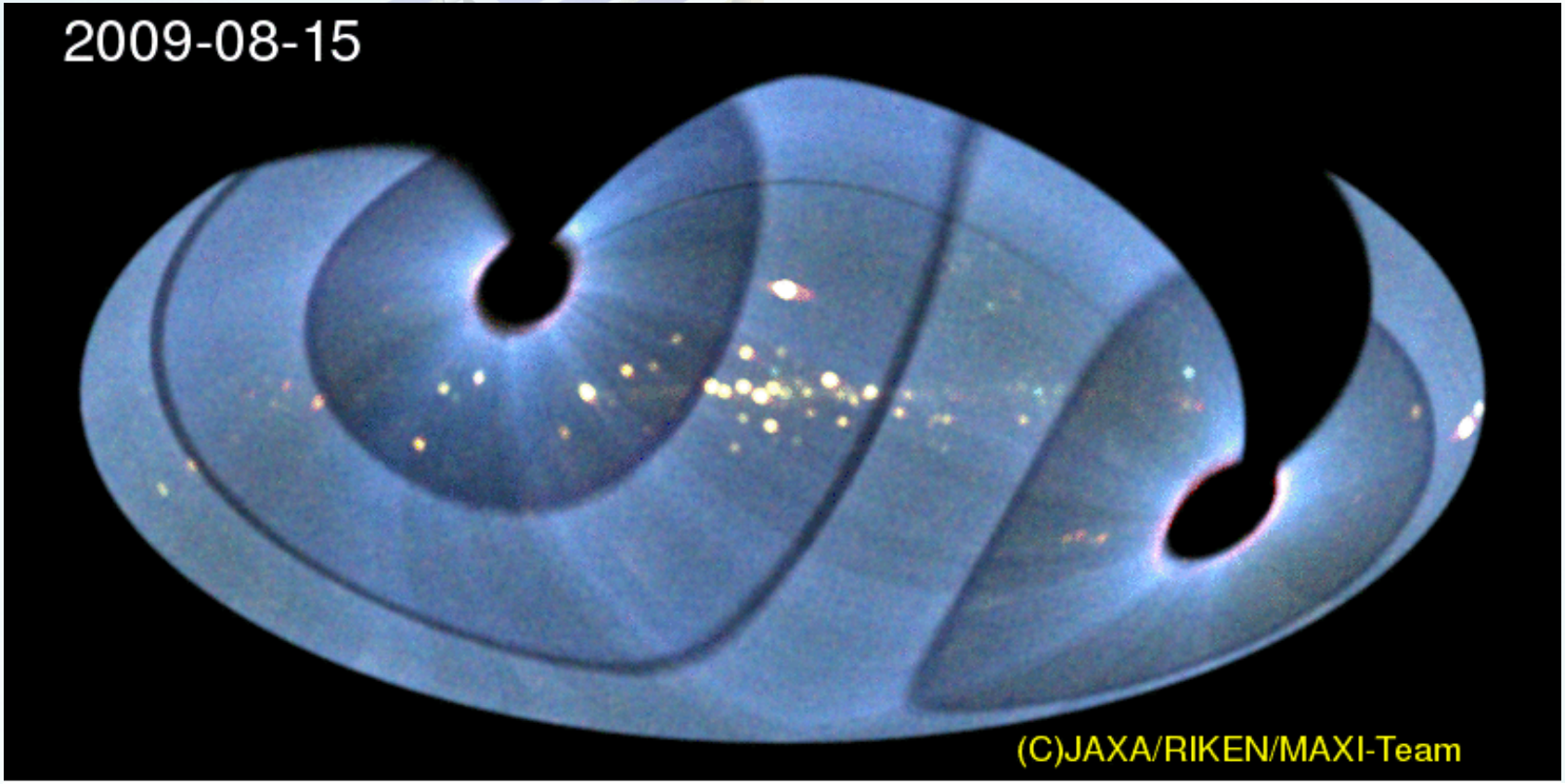
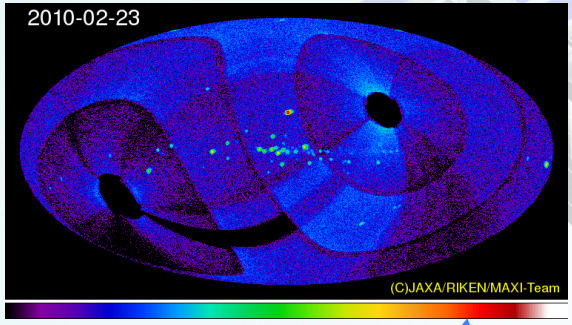
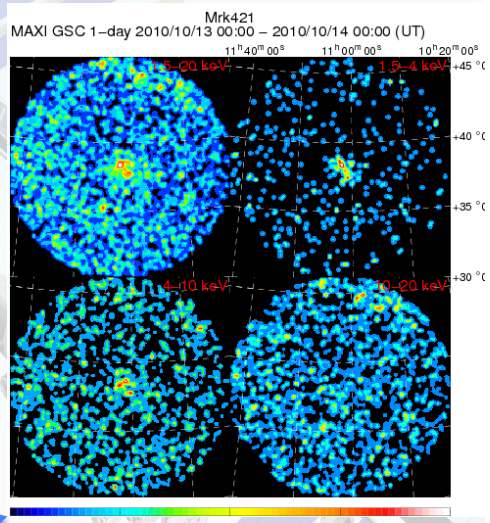
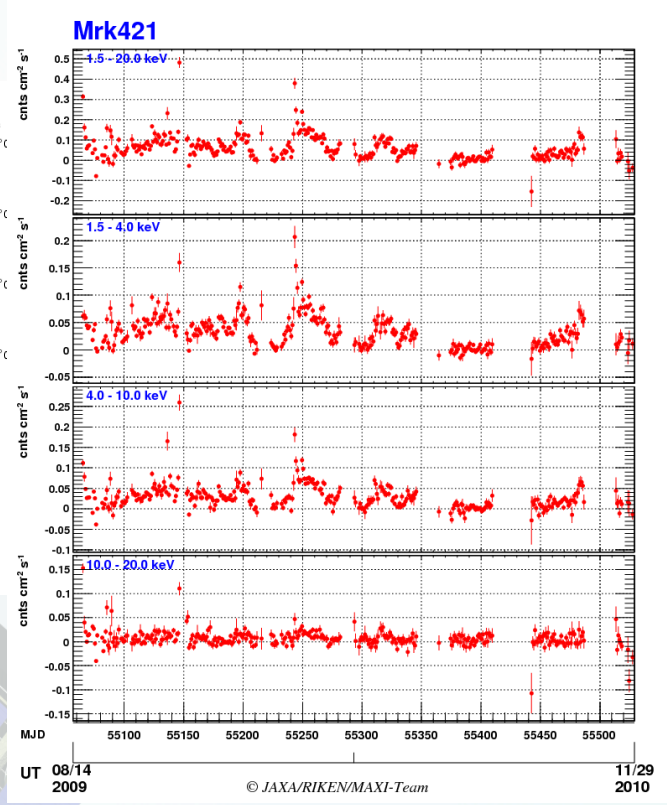


- Red: 2-4 keV, Green: 4-10keV, Blue: 10-20 keV.
- Raw data. Exposure not corrected.
- Not cleaned for background variation, sun-light leak, and solar-paddle reflection.

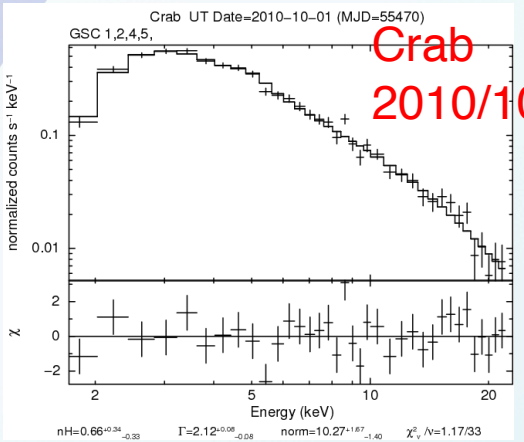
MAXI Public Data (http://maxi.riken.jp)







- Daily all-sky image
- For 259 listed Sources
  - Field image
  - Light curve in three energy bands
  - (updated daily)
- For selected sources (currently ~50 sources)
  - Daily energy spectrum with RMF
  - Sources
    - Crab, Sco X-1, Cen X-3, Her X-1, GX 9+9, GX 9+1, GX 13+1, GX 17+2, GRS 1915+105, Cyg X-2, …



MAXI alerts

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- Transient alert e-mails
  - Sent after human inspection
    - (except for bright new transients)
  - five categories
    - New Transient (incl. GRBs)
      - Automatic alerts for transients with >150 mCrab
      - Rate: ~1 event/month
      - Automatic alerts followed by manual ones
    - X-ray star
    - Nova-CV
    - AGN
    - Supernova
  - Subscribe at maxi.riken.jp
- GCN notices (to be automated soon)
- ATels

MAXI 7-month catalog

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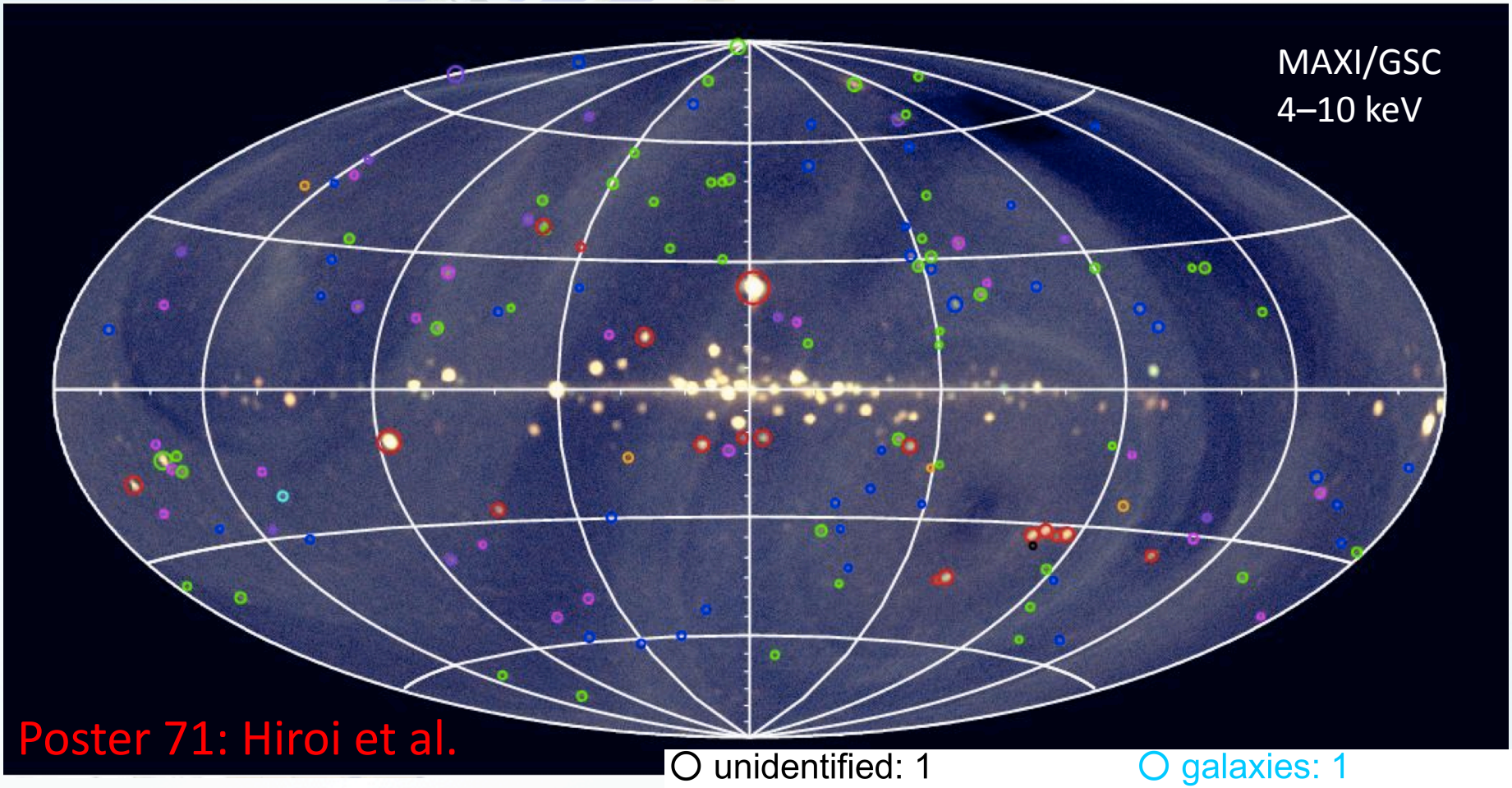
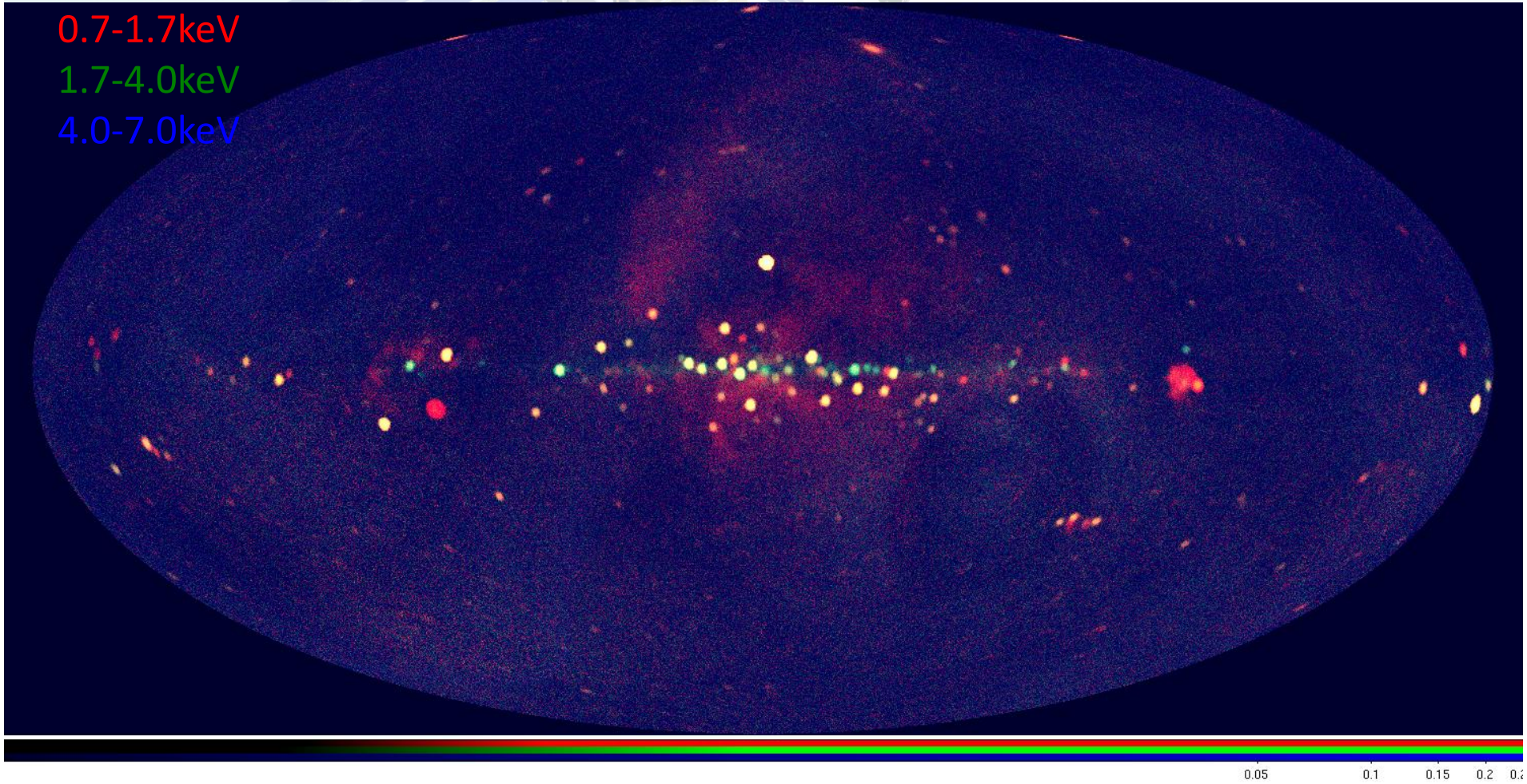


Poster 71: Hiroi et al.

- 143 sources (>7 σ, |b|>10°)
- limiting sensitivity:
  ~1.5x10^{-11} ergs cm^{-2} s^{-1} (4-10 keV)
- Consistent with, but deeper than HEAO A-2

- unidentified: 1
- galaxies: 1
- galaxy clusters: 48
- Seyfert galaxies: 39
- blazars: 12
- CVs/stars: 20
- X-ray binaries: 18
- confused: 4

SSC all-sky map (23 month)



Poster 38: Kimura

Poster 57: Tomida

ROSAT All-Sky Survey

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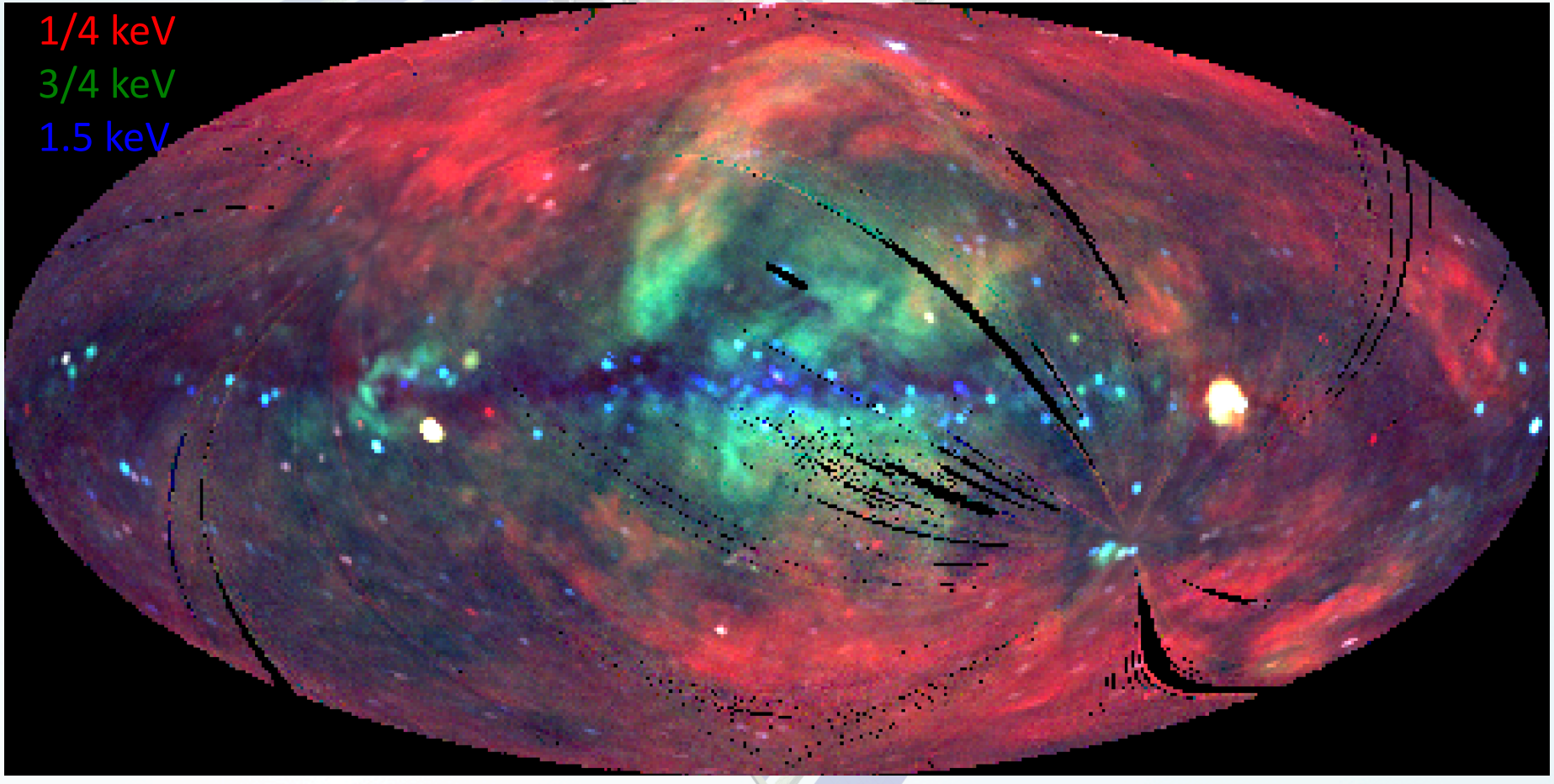

Galactic Center Region

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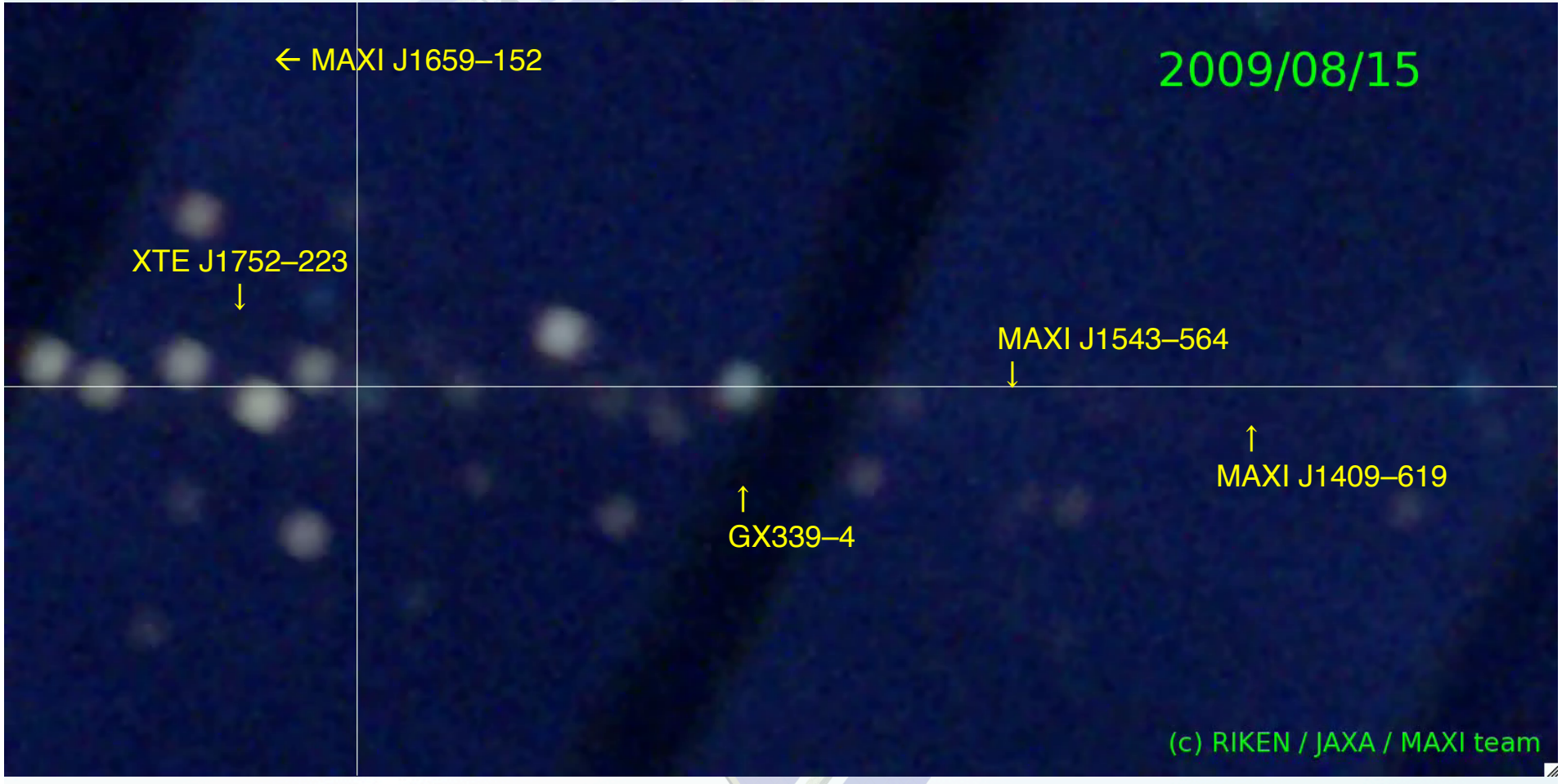

2009-10-26	2010-01-03	2010-09-25	2010-10-17	2011-05-08
XTE J1752–223	GX339–4	MAXI J1659–152	MAXI J1409–619	MAXI J1543–564

Black hole candidates

New Activity, Spectral State Transition

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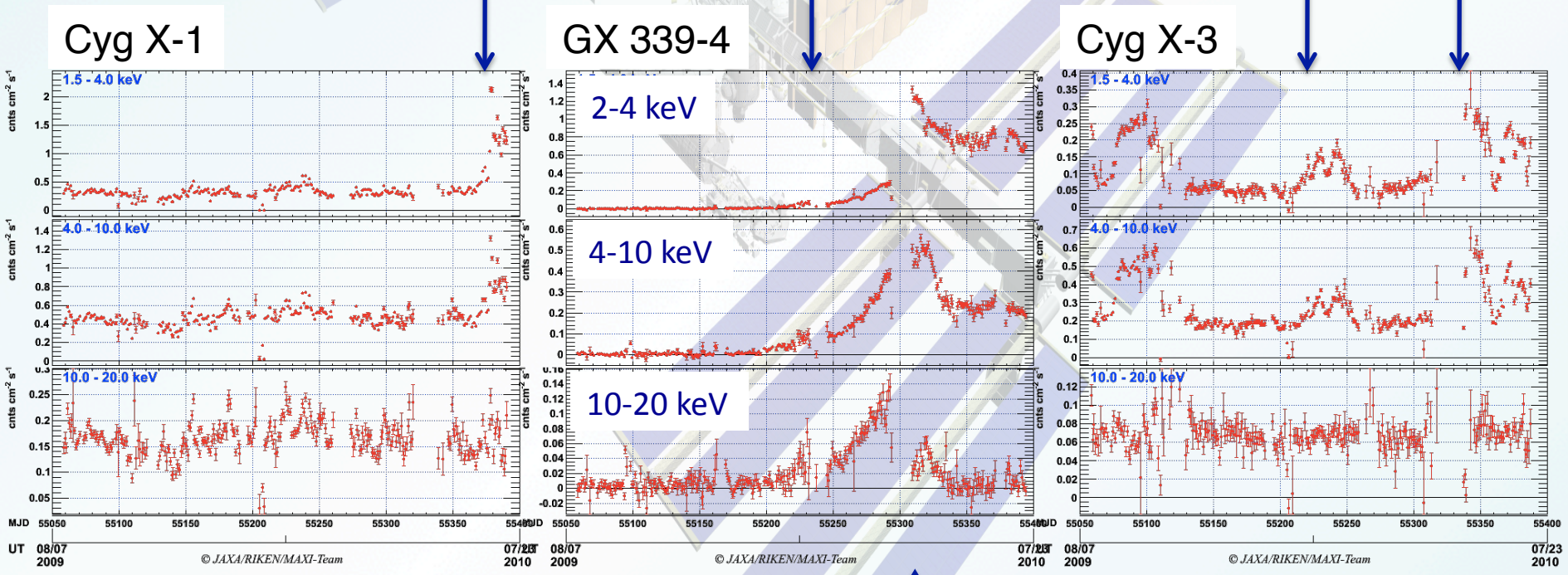
ATEL#2711
Soft X-ray increase

ATEL#2380
Beginning of new activity

ATEL#2404, #2635
State transition



~ 1yr

State transition

Cyg X-1

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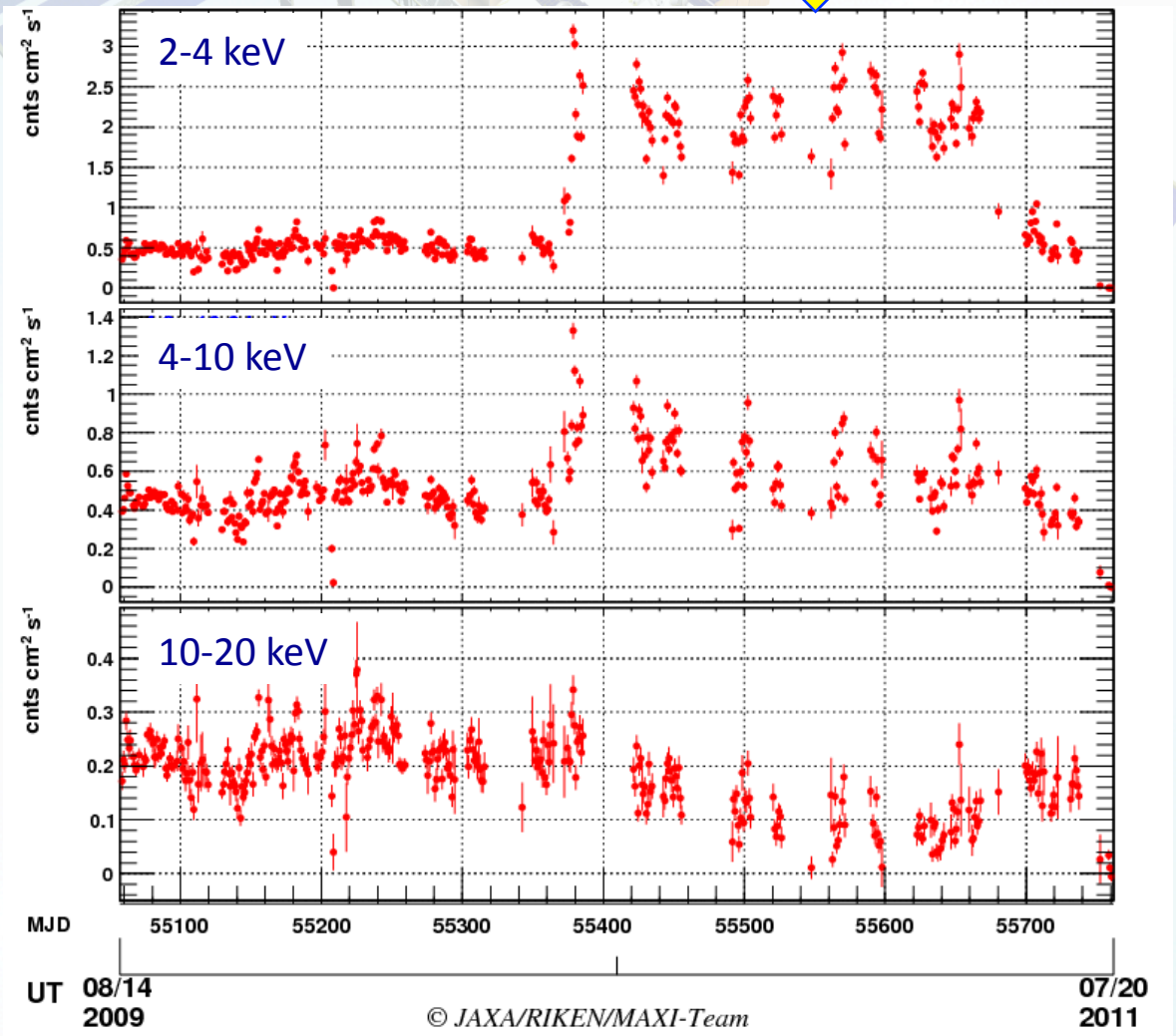
Suzaku → Yamada's talk



XTE J1752-223

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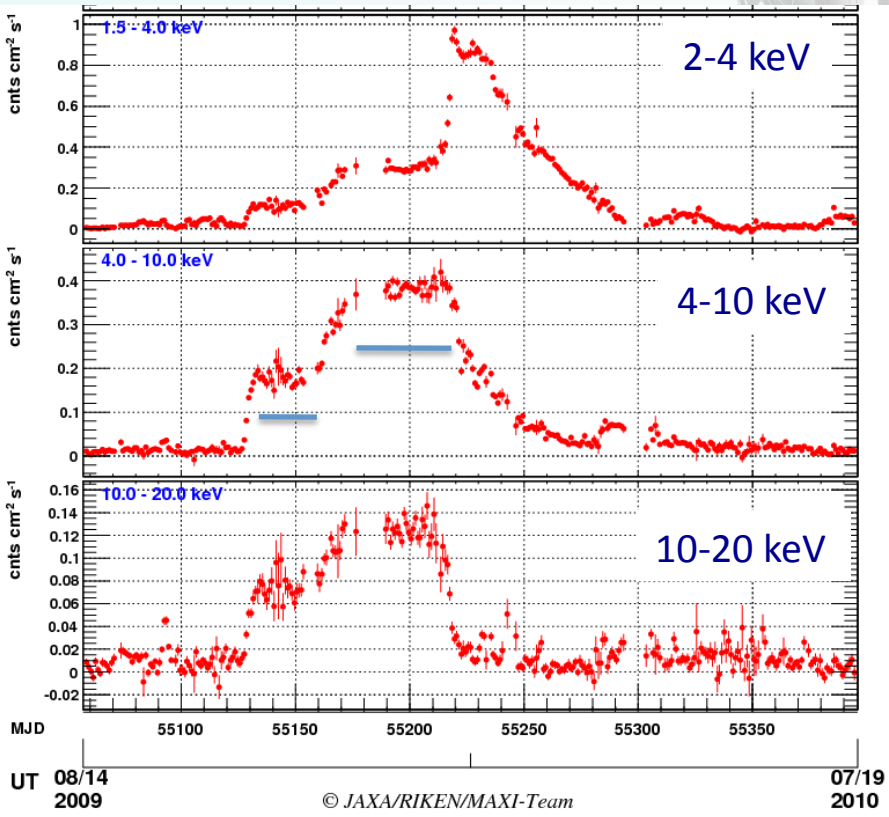
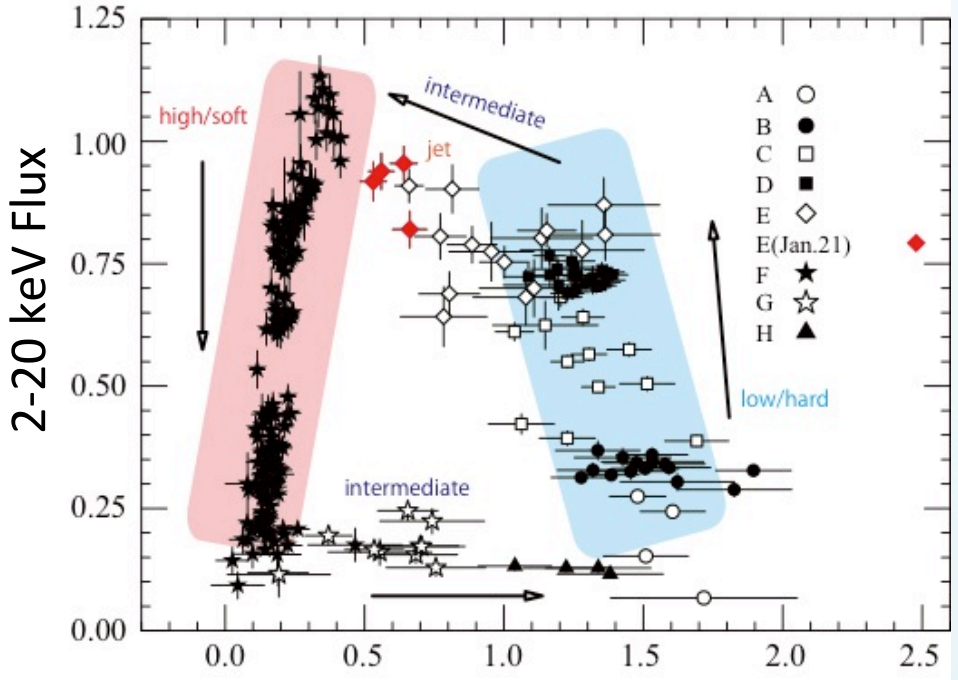
- Black hole candidate discovered by the RXTE Galactic Center scanning observation
- continuous spectral monitoring by MAXI

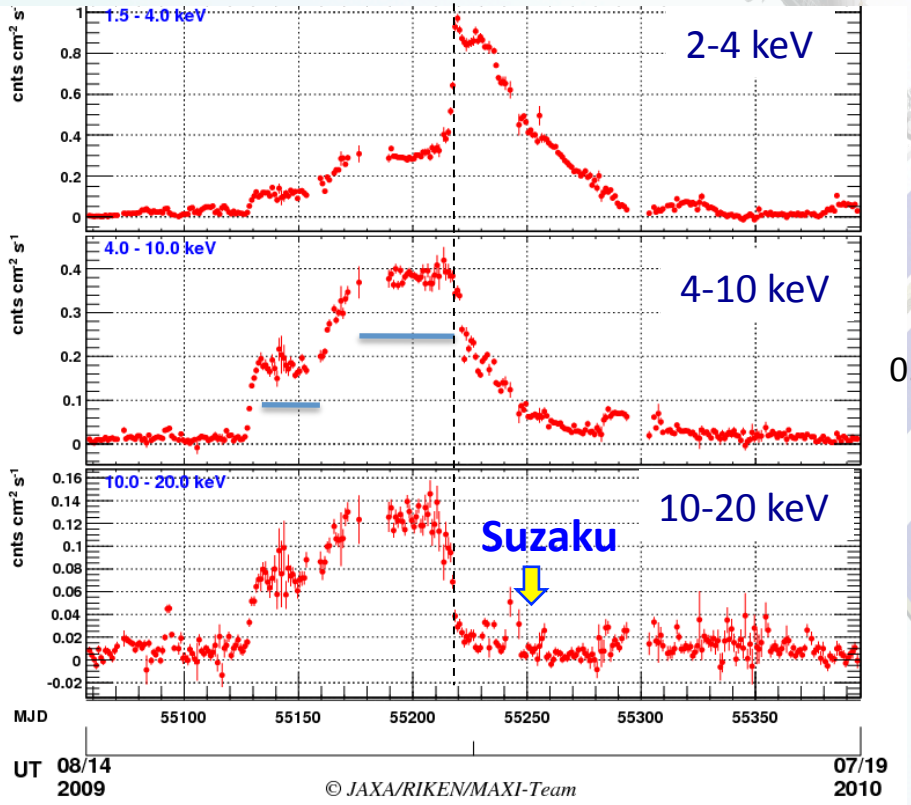


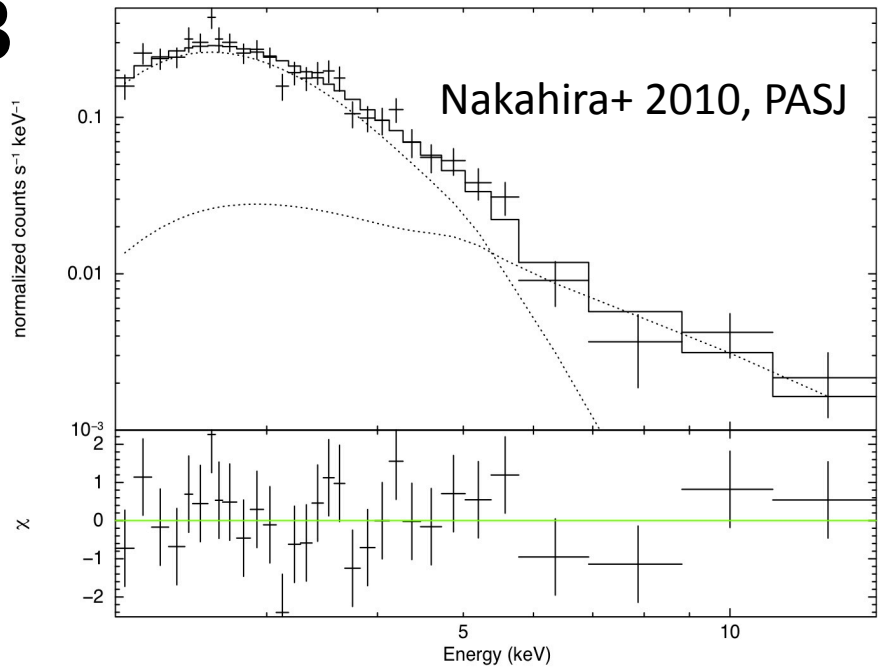


Poster 58 : Nakahira

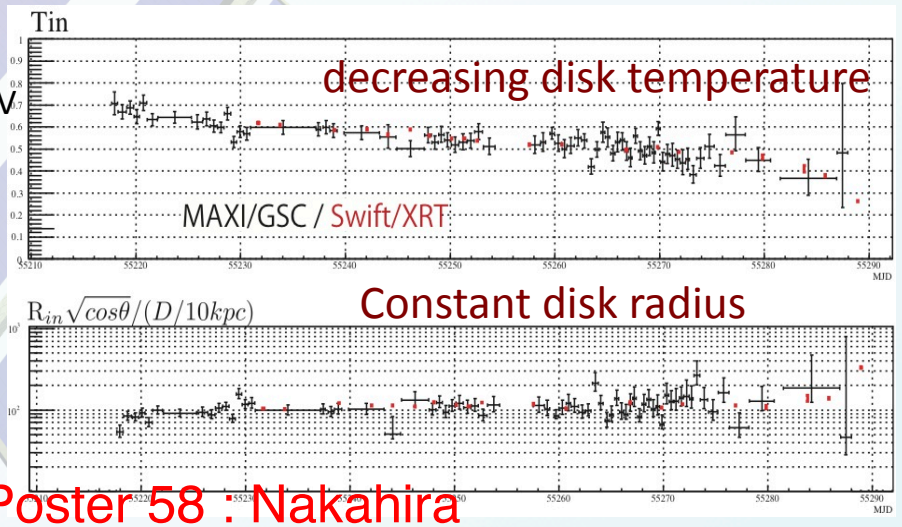
Continuous spectral monitoring of XTE J1752-223

hard states　　soft state





0.7 keV



Poster 58 : Nakahira

MAXI J1659-152

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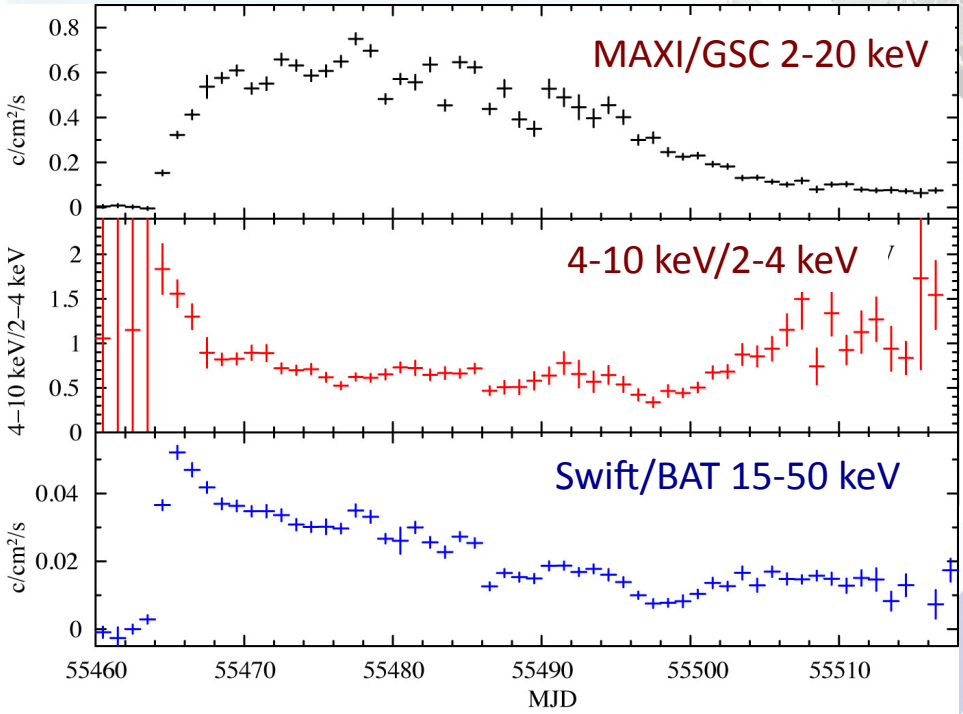
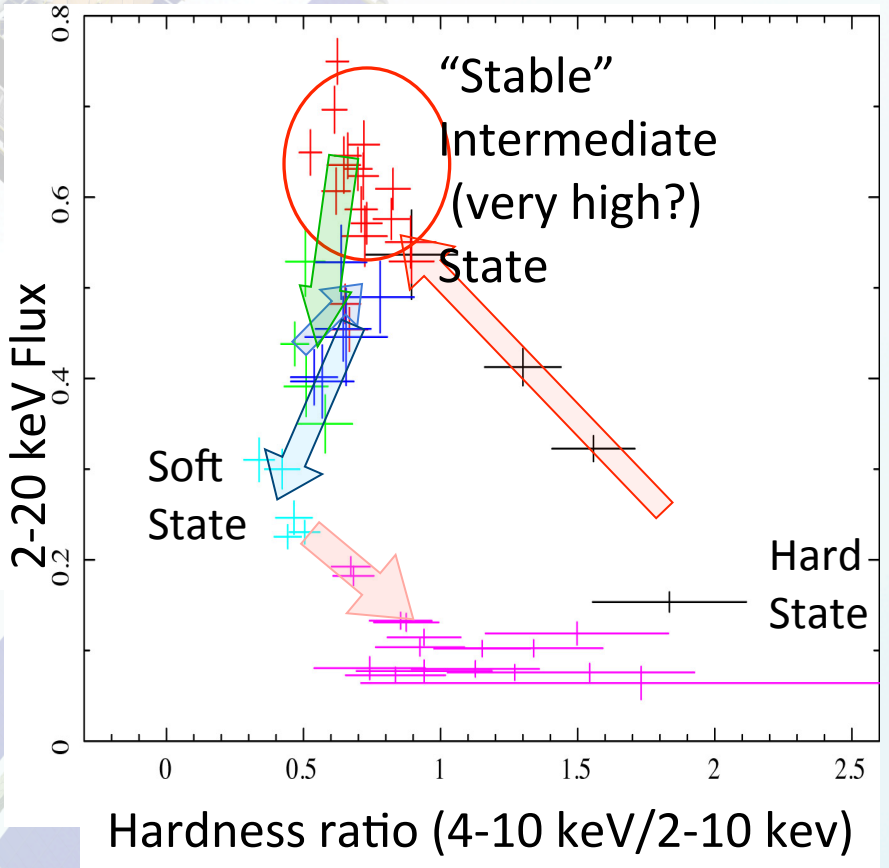
- Discovered by MAXI and Swift
- Black hole suggested based on QPO (1.6 Hz, 3.3 Hz; RXTE)
- State transition



Suzaku



Poster 59: Negoro

MAXI J1659-152

Energy Spectra by *Suzaku*

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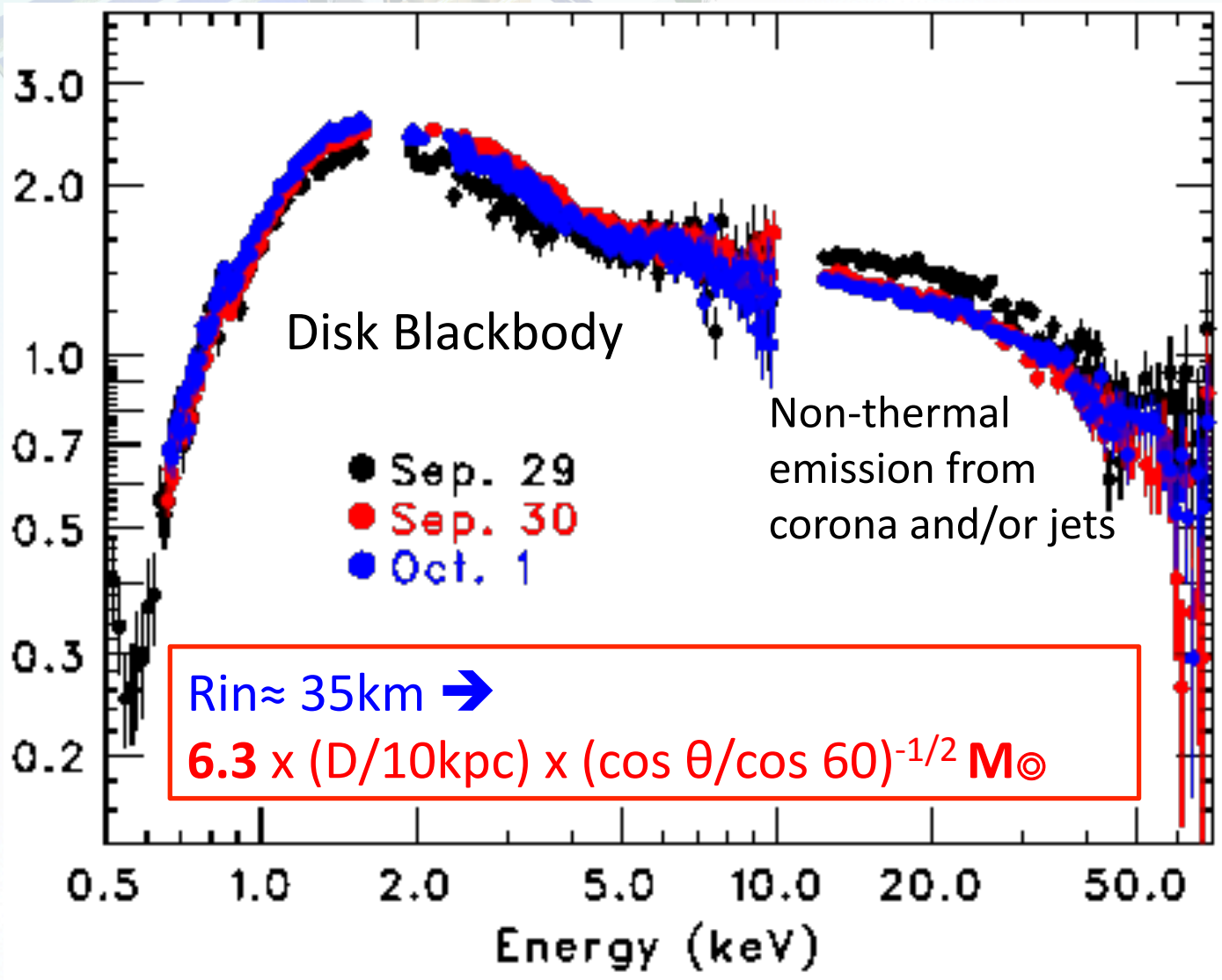

MAXI J1659-152 optical light curve

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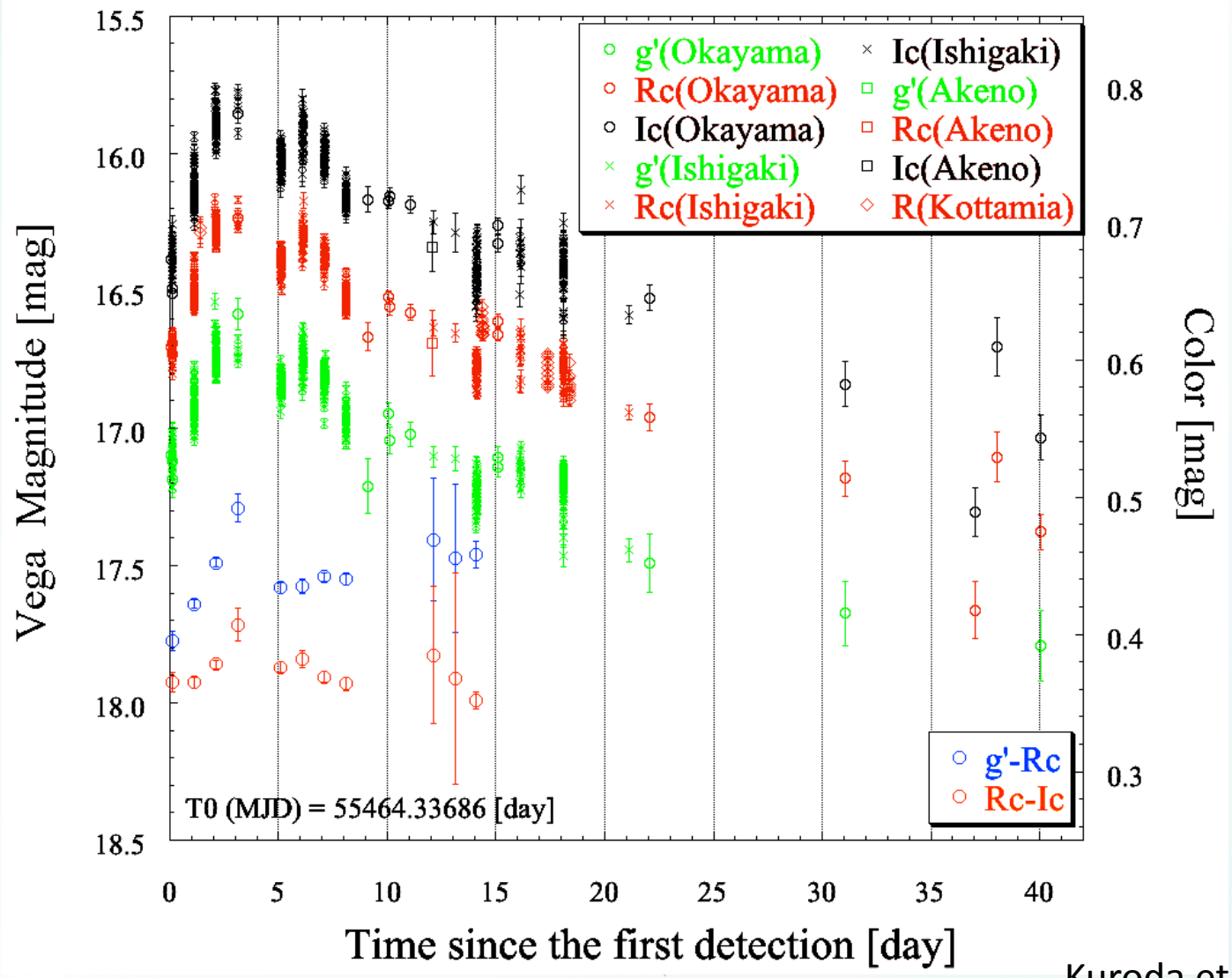

Kuroda et al. 2011

MAXI J1659-152

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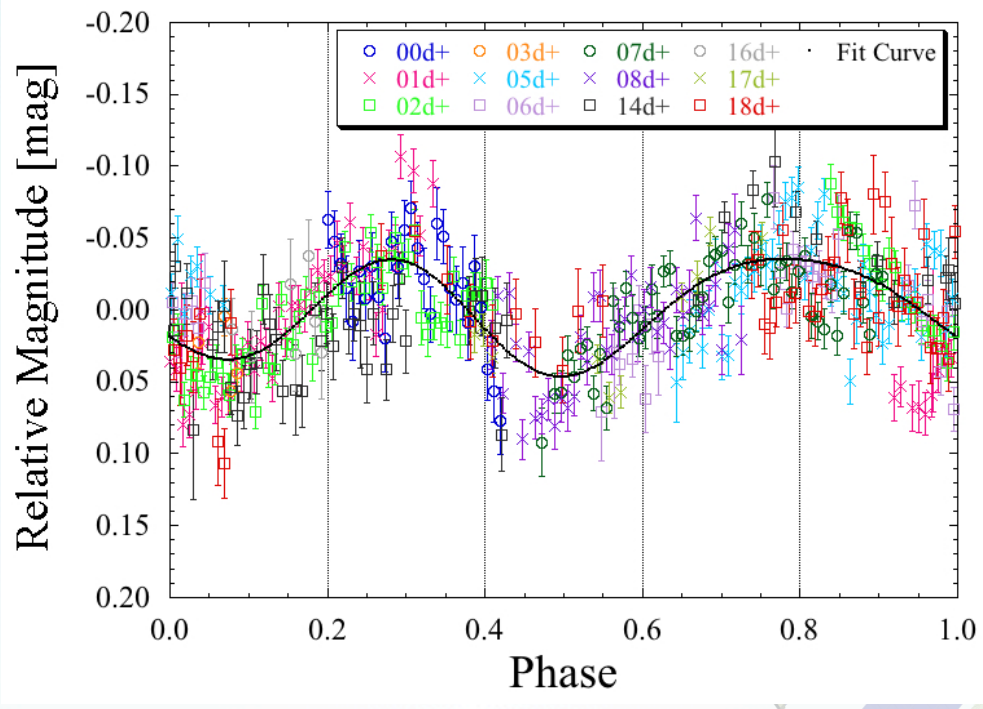
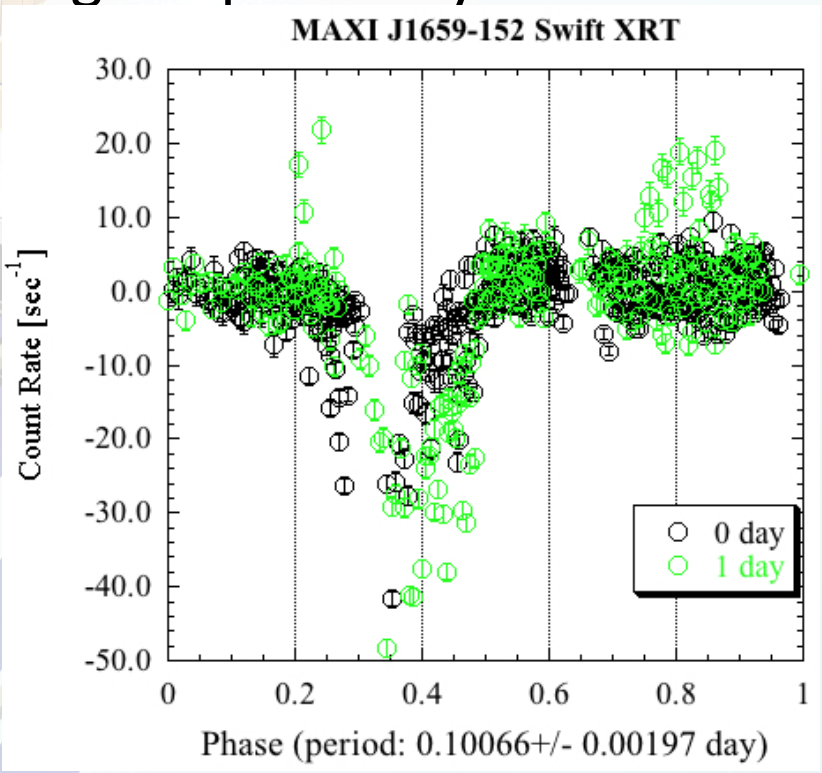
- 2.4-hour periodicity
  - Double-peaked in optical, single dip in X-ray





Kuroda et al. 2011

MAXI J1409-619

confirmed and accurately localized by Swift

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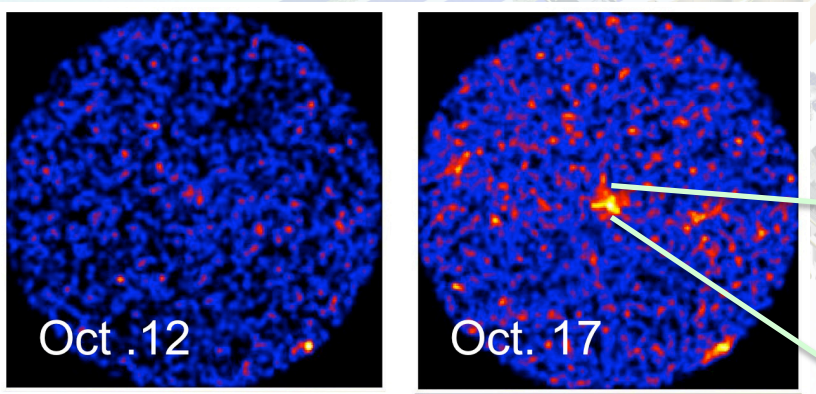

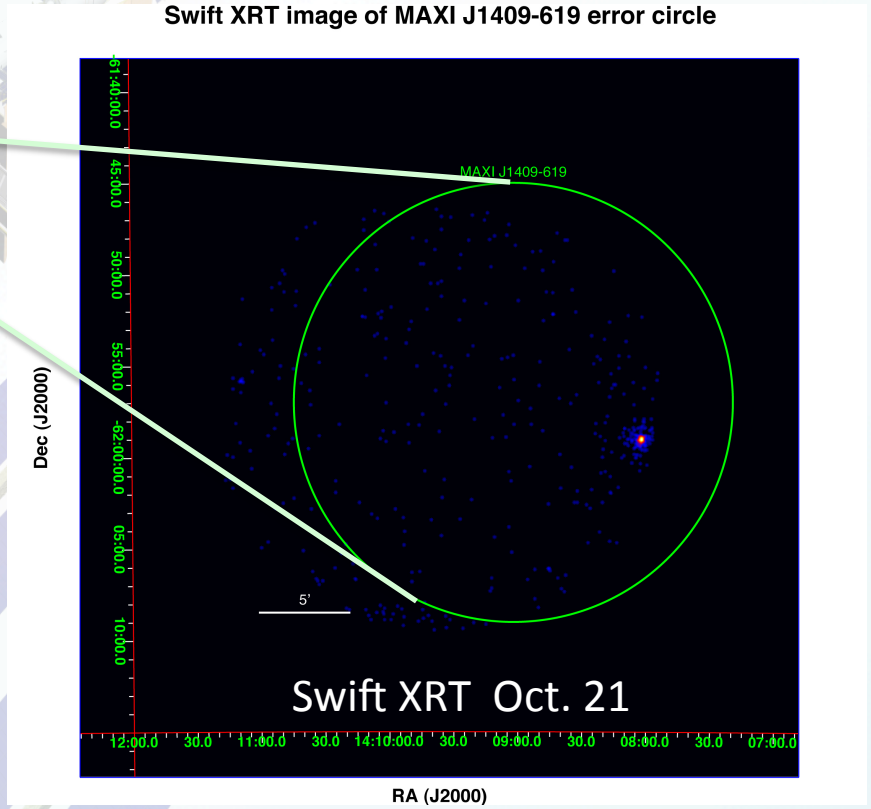

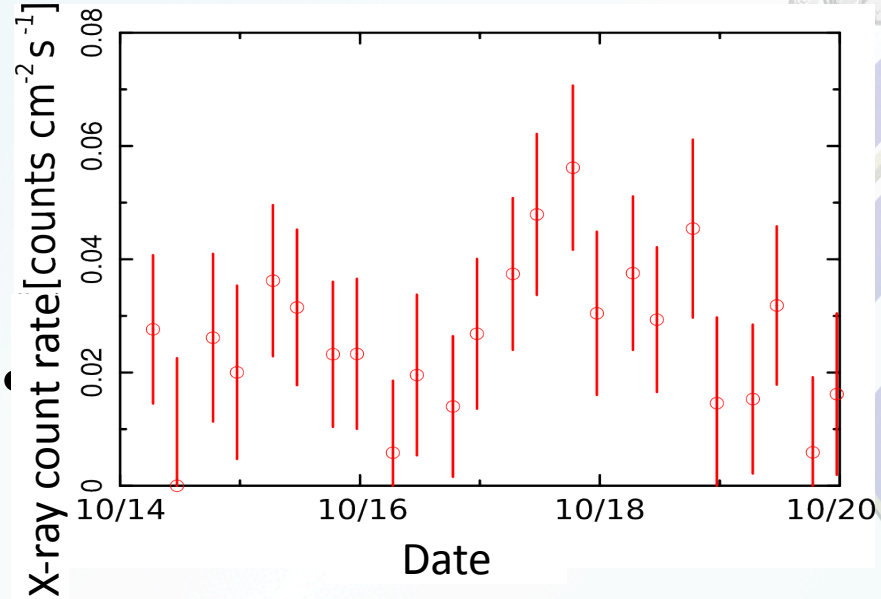

Kennea et al. 2010

MAXI J1409-619

turned to a 500s accreting pulsar

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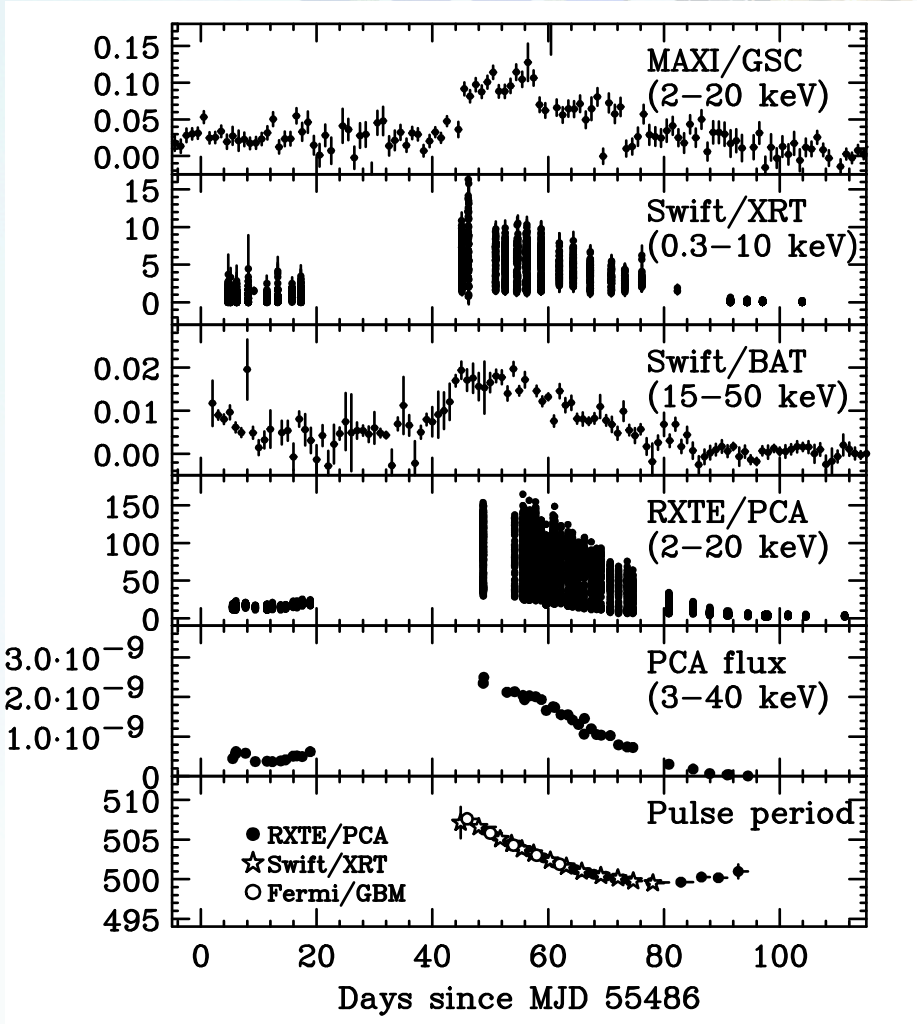
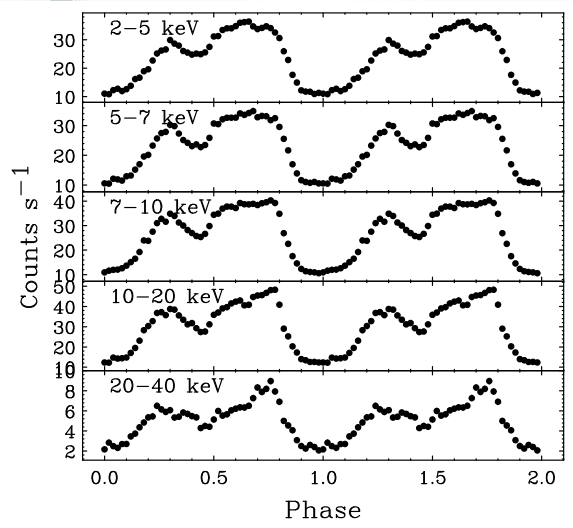
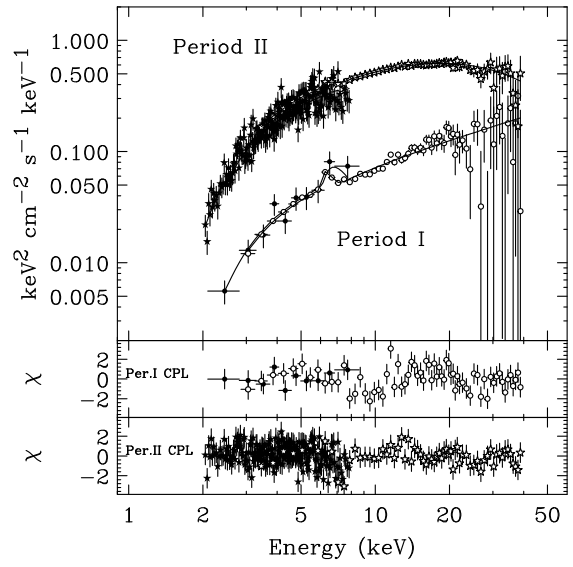


Yamaoka et al. in prep



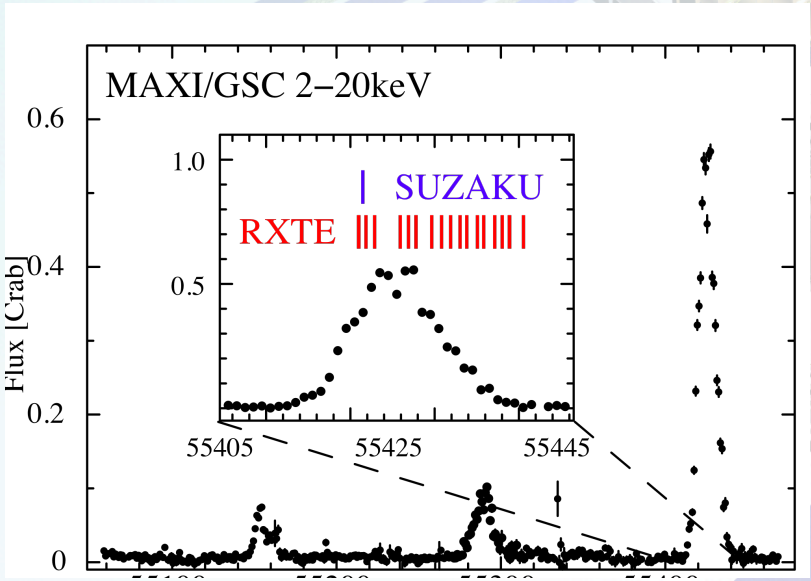
RXTE

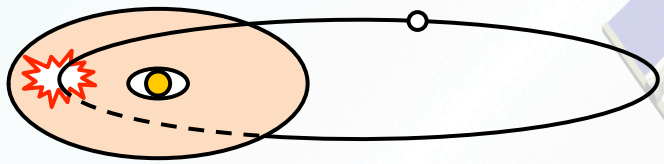


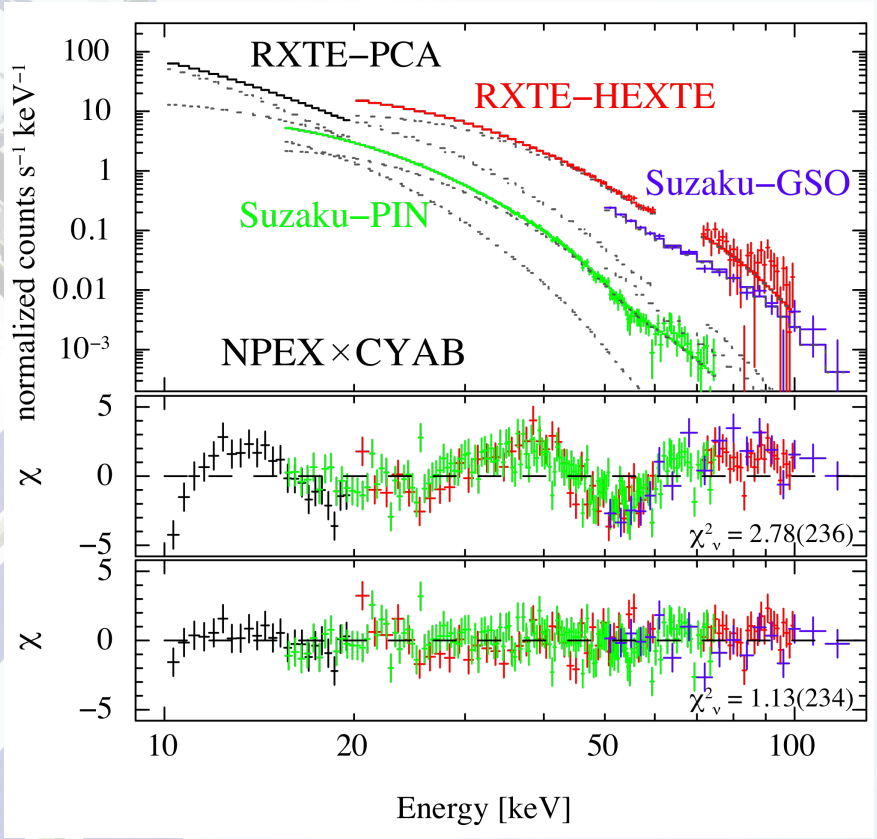
RXTE

GX 304–1

Accreting X-ray pulsar with a Be star companion







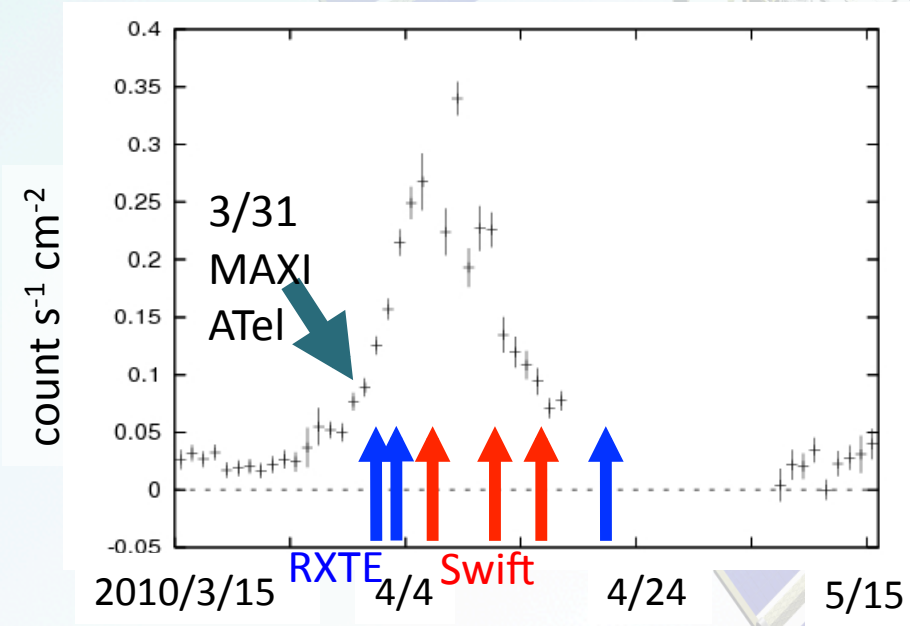
- Be binary pulsar (P_{orb} = 132.5 d)
- MAXI detection of outburst ➔

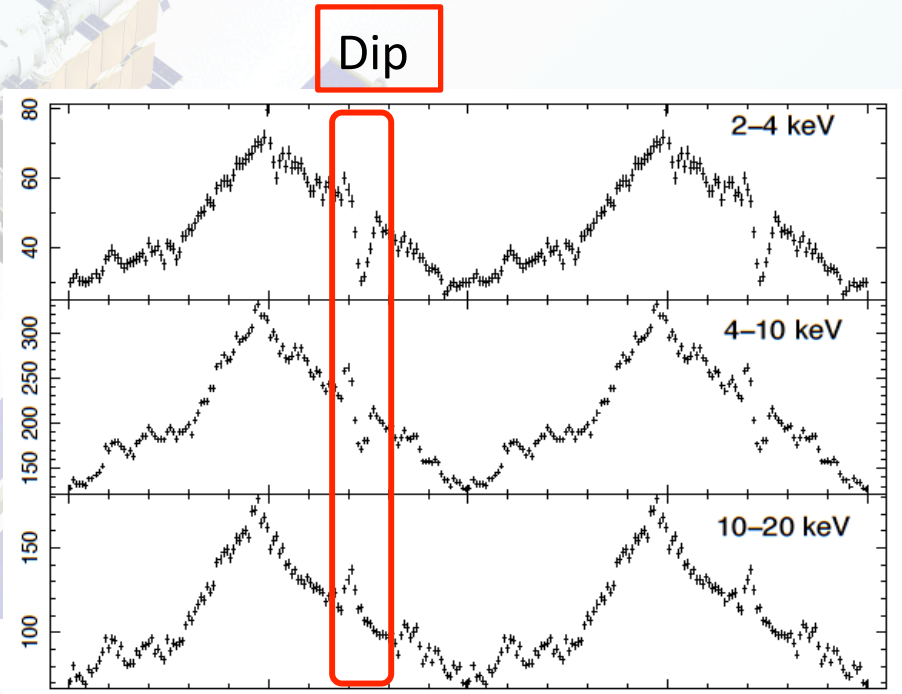
Poster 49: Yamamoto

- Discovery of cyclotron line by Suzaku/RXTE follow-up obs.
- 54 keV → 4.7 x 10^{12} gauss

LS V +44 17

Accreting X-ray pulsar with a Be star companion





- MAXI detection of first outburst from this source
- Followed up by Swift and RXTE

Usui et al. 2011

- Pulse profile (2 cycles) by RXTE follow-up observation reveals absorption dip by accretion column
- Dip seen only near outburst peak

Low-Mass X-ray Binaries

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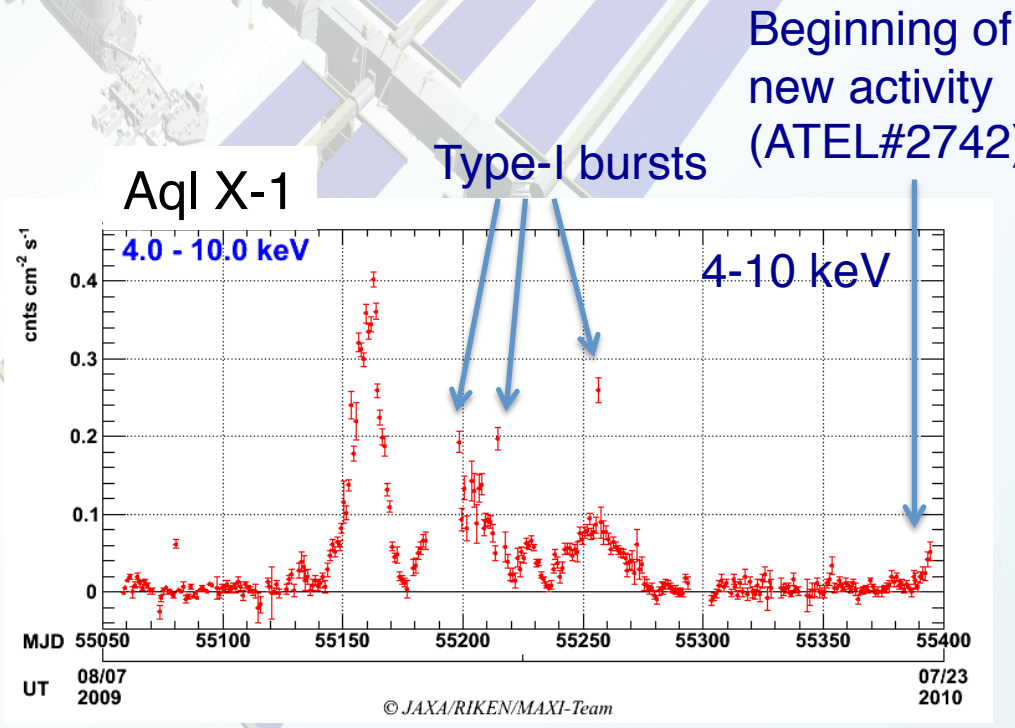
- Aql X-1
- Cir X-1
- NGC 6640 X-2
  (SAX J1748.9-2021)
- M15 X-2
- 4U 1608-22
- 4U 1323-619
- 4U 1954+319
- RX J1709.5-2639

- Monitoring activities of bursts and jets.



~ 1yr

Active Stars

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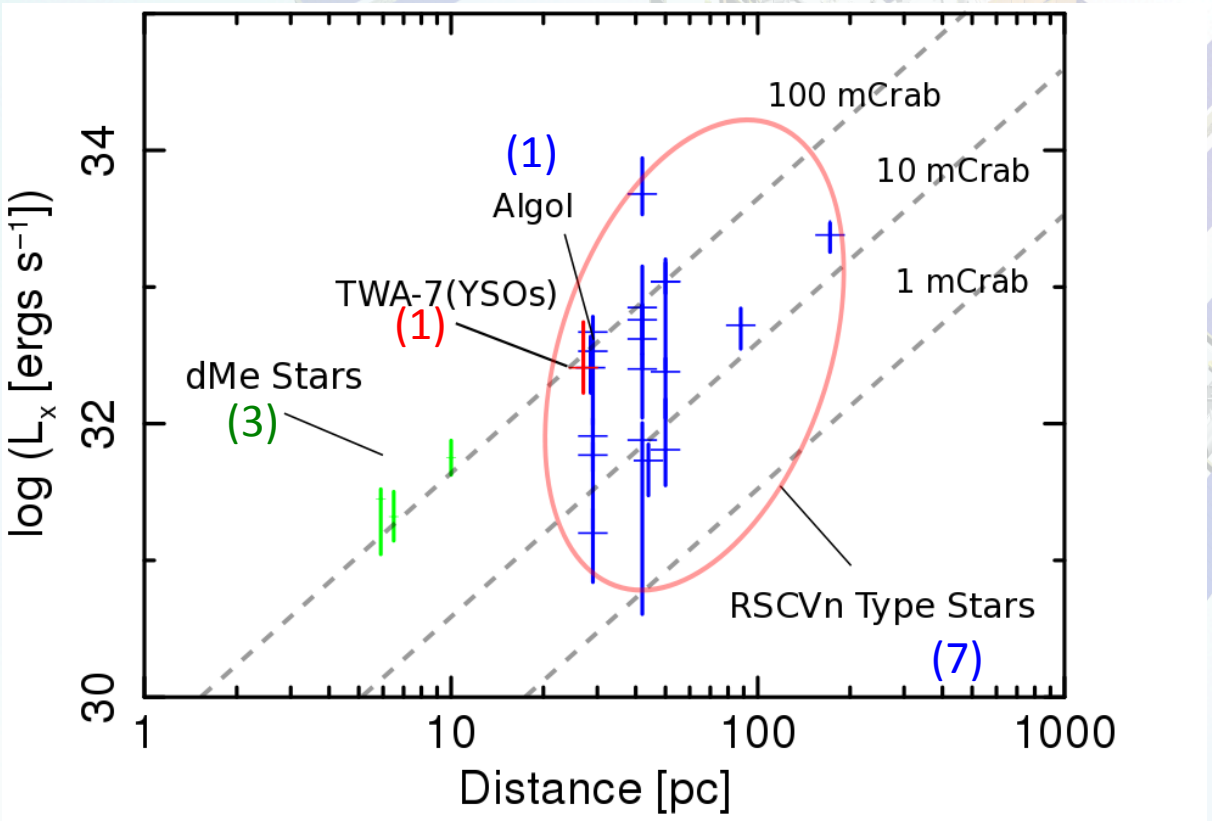
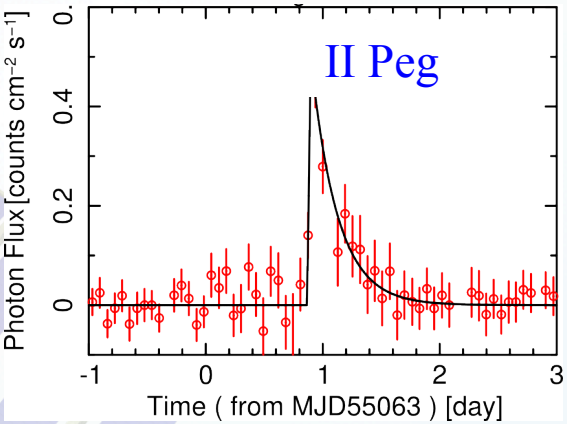
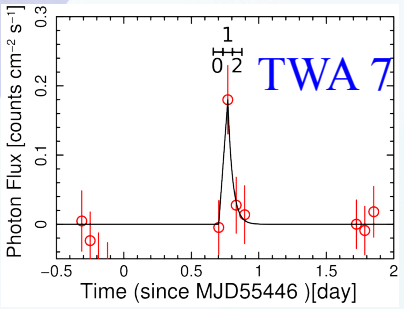
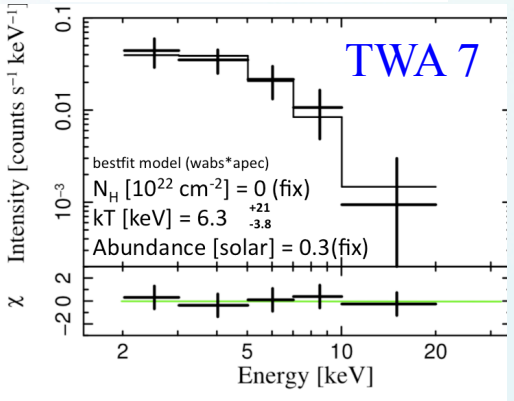
- 23 flares from 12 stars in 2 years









Poster 46: Tsuboi

Uzawa et al. 2011

Active Stars (RS CVn, YSO, …)

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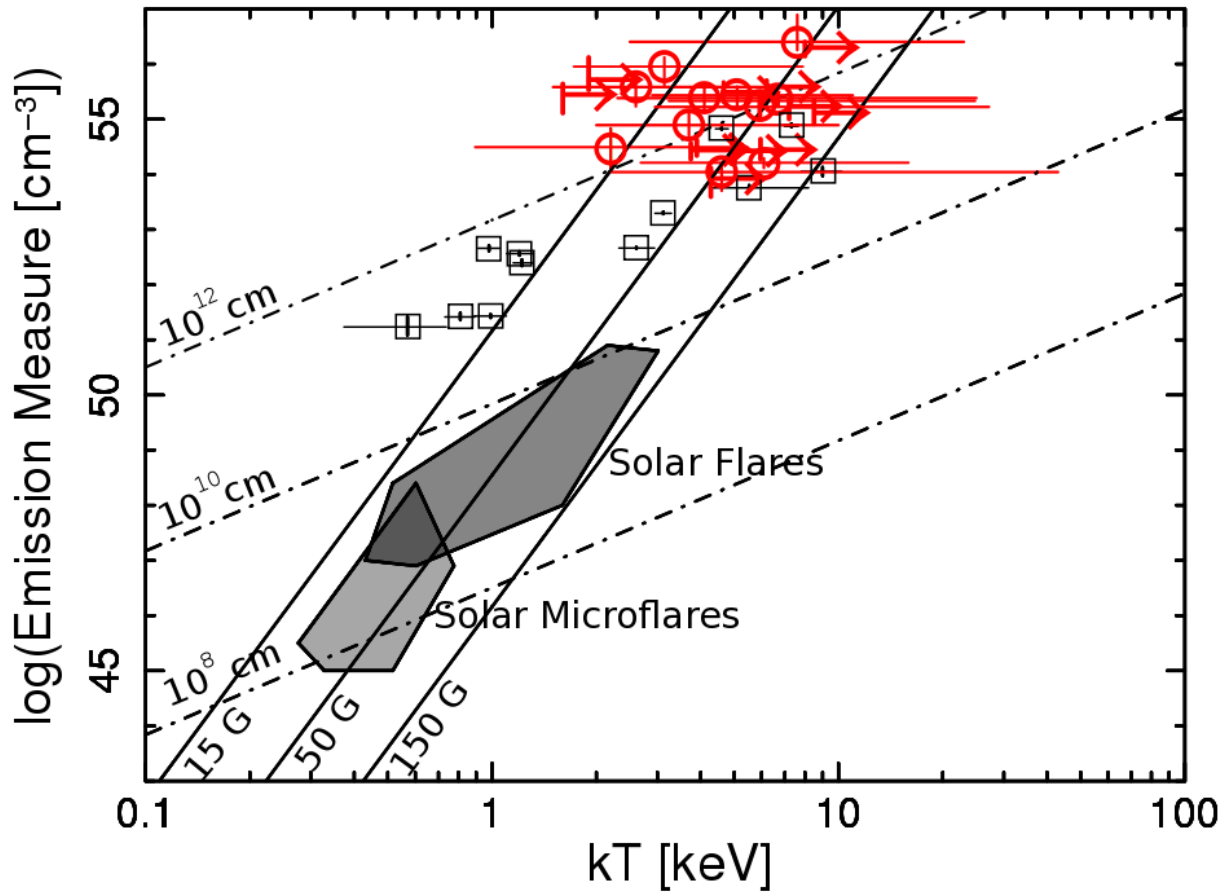


Scalable from solar flares with constant magnetic field

Poster 46: Tsuboi

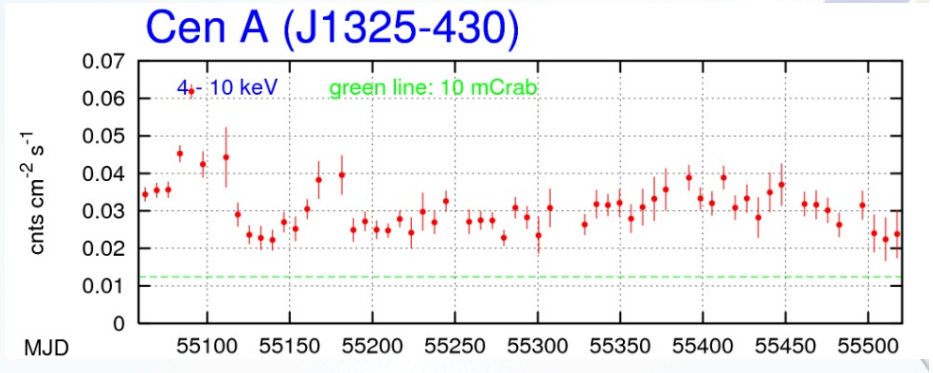
Stellar flares as major contribution to Galactic Ridge X-ray Emission?

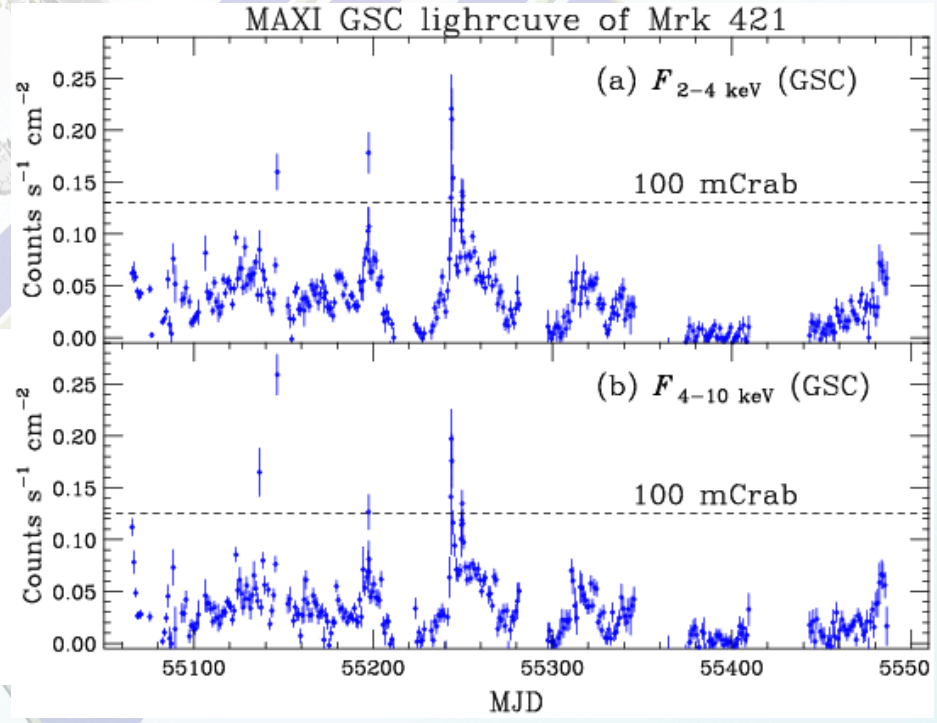
Poster 44: Matsuoka et al.

Active Galactic Nuclei

- Mrk 421
- 3C 273,
- Cen A,
- NGC 4151
- IC 4329A
- …

- Monitoring
  - Large flare events
  - Long term variation





Isobe et al. 2010

Two Flares from Mrk421

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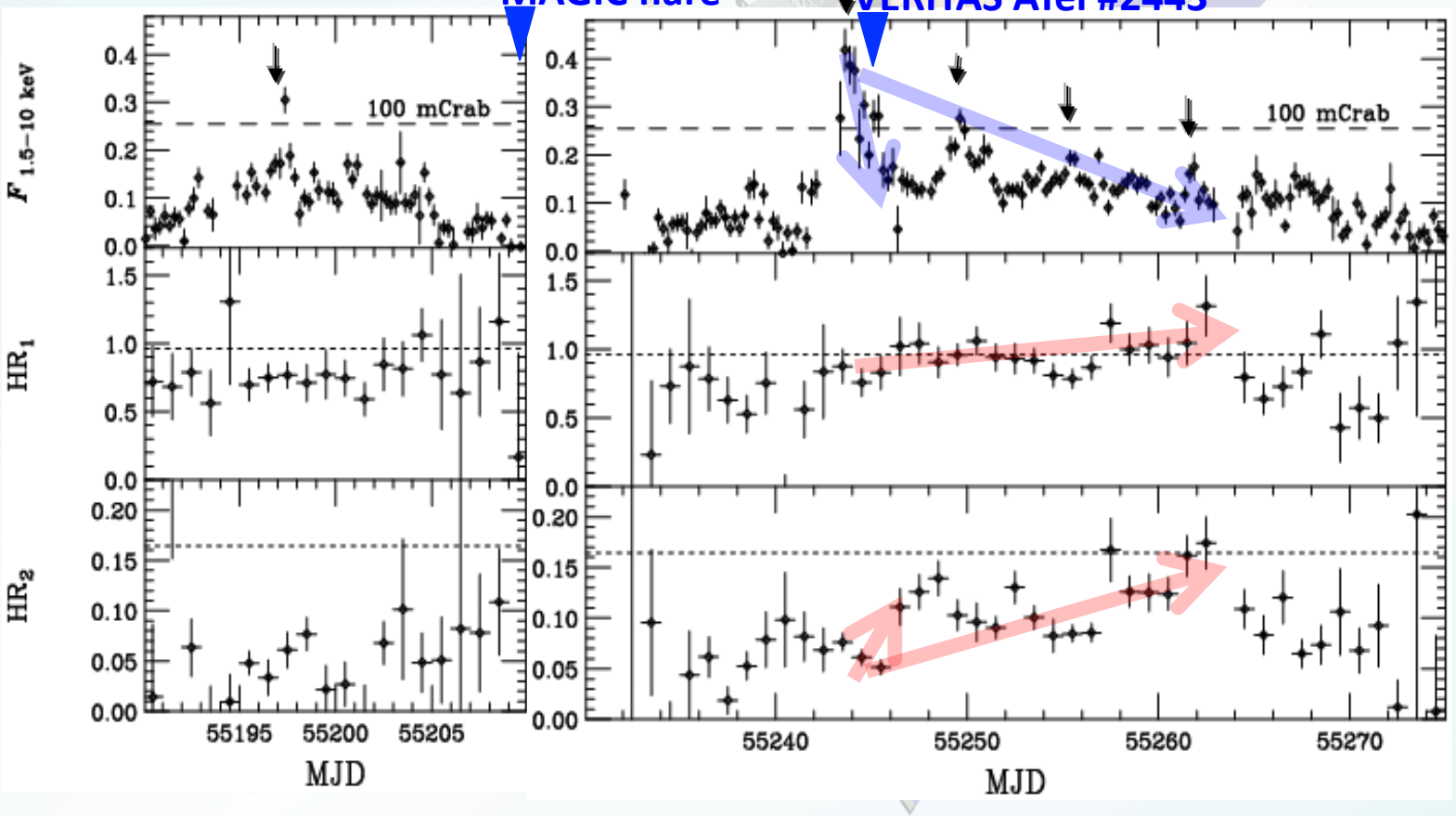
Jan. 1, 2010 ~120 mCrab. Feb. 16, 2010 ~164 mCrab.



MAXI
2 – 4 keV
(6 hour)

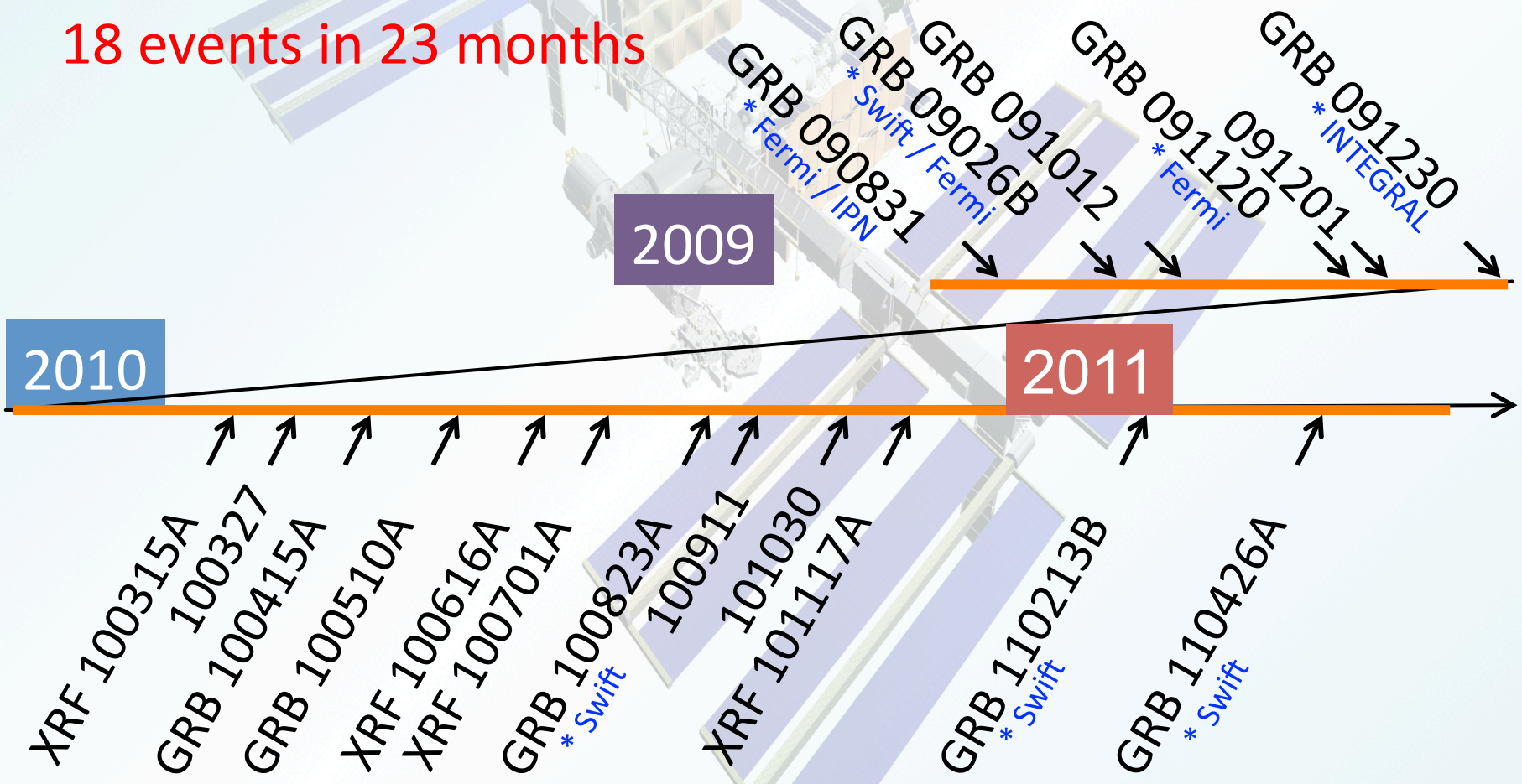
$\frac{F_{4\text{-}10\ keV}}{F_{2\text{-}4\ keV}}$

$\frac{F_{15\text{-}50\ keV}}{F_{2\text{-}4\ keV}}$

Isobe et al. 2010, PASJ

MAXI bursts

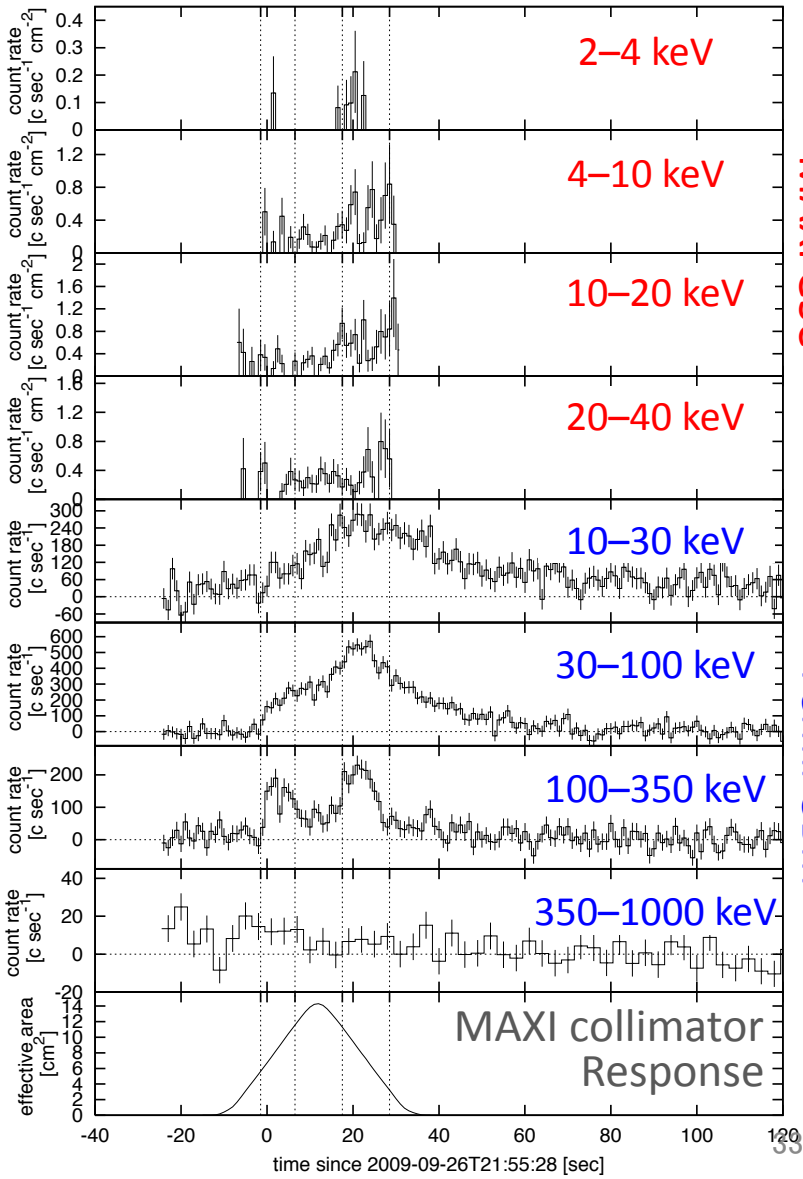
18 events in 23 months



* 7 are simultaneously detected by other satellites

GRB 090926B

- light curve
  - maxi detected the first 25 seconds of the burst
  - no significant emission above 350 keV
  - low flux below 4 keV



Peculiar spectrum

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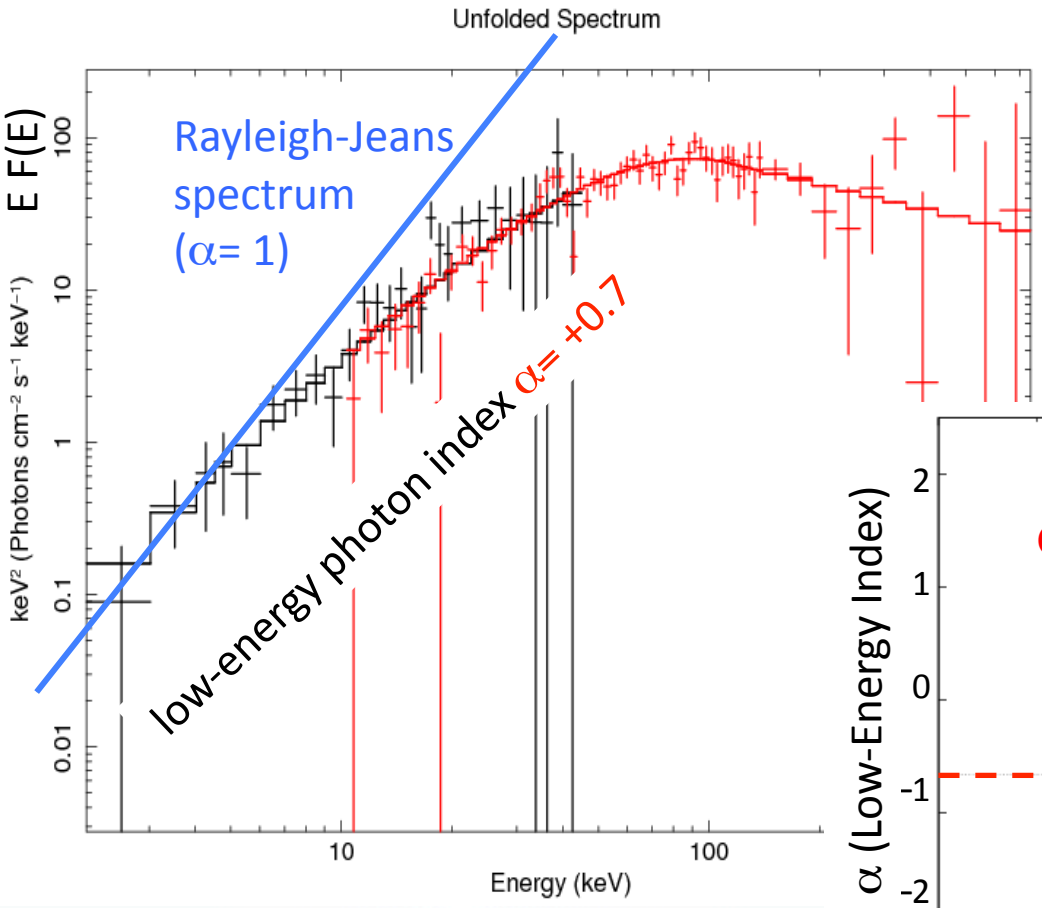
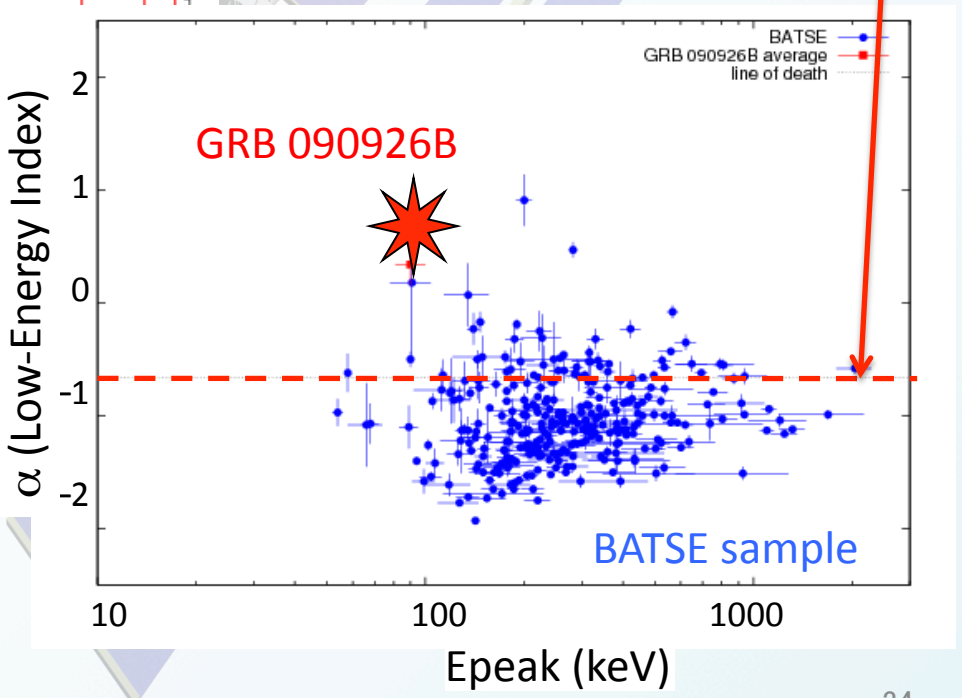


upper limit for a synchrotron spectrum (α= −2/3)



photospheric emission?

Swift J164449.3+573451

Tidal disruption (?) at z=0.35

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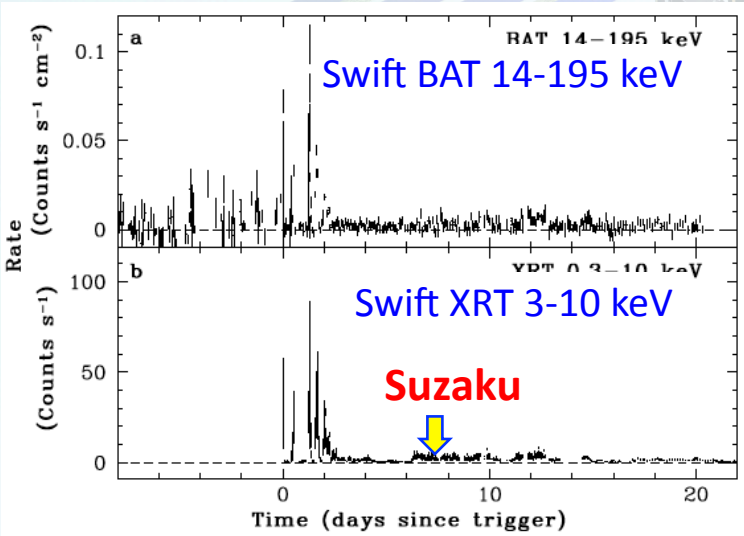
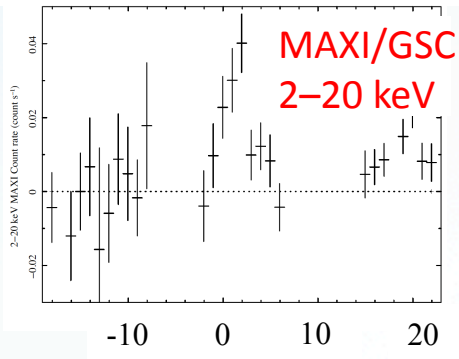
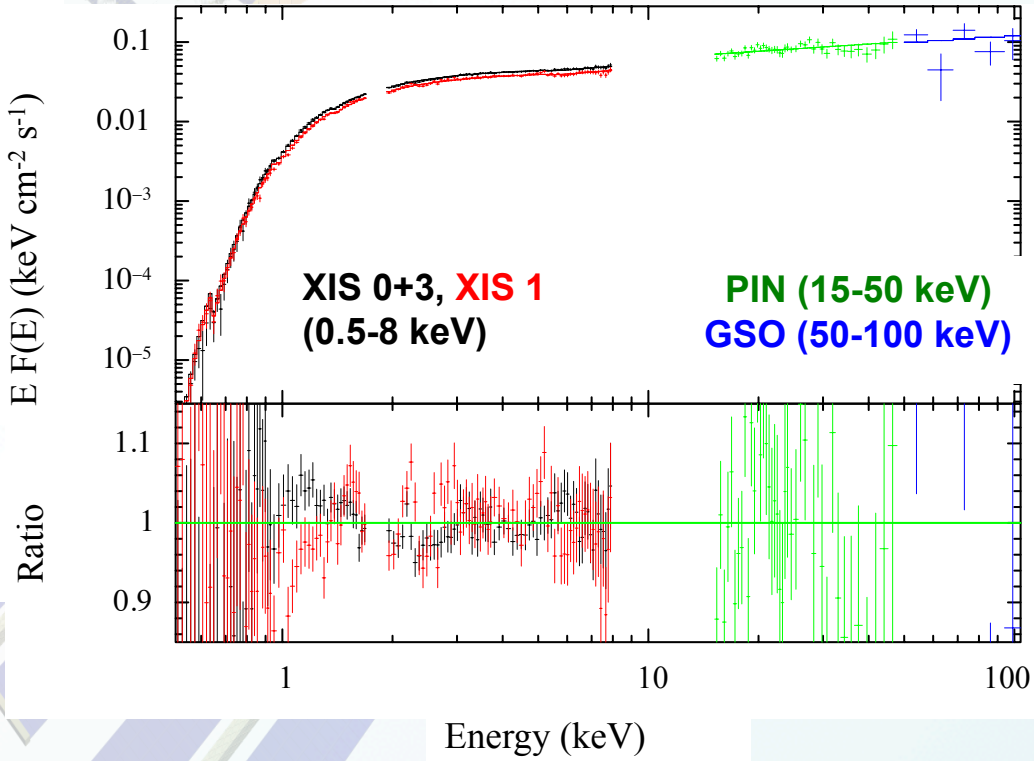




- MAXI pre-outburst upper limit
  $< 1.1 \times 10^{-11}$ erg s^{-1} cm^{-2}

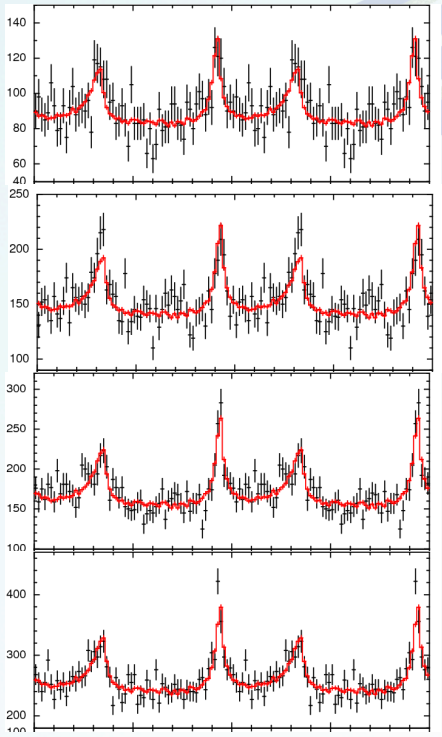
Suzaku "unfolded" spectrum

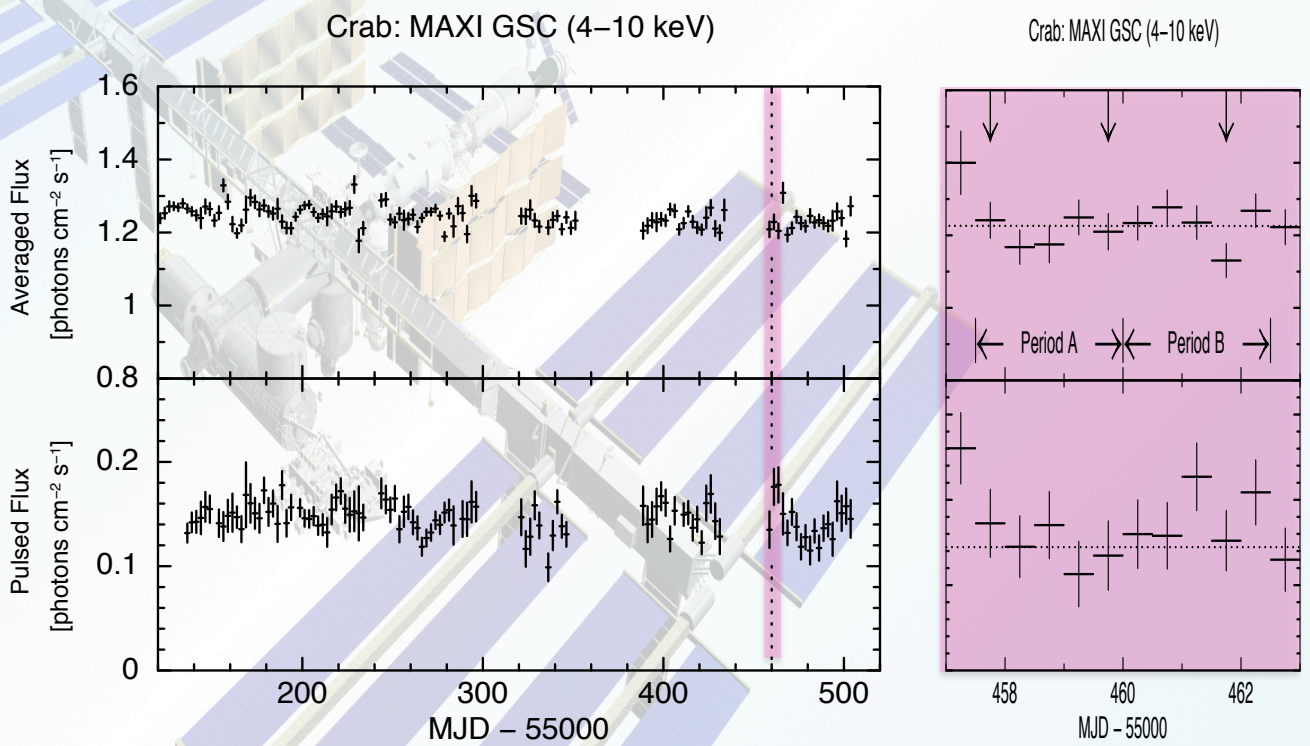


- High column density (N_H=2x10^{22} cm^{-2})
- Featureless wide-band spectrum
- Highly variable
- 5mHz QPO

Poster 92: Usui

Crab at GeV flare





- No significant variation in the pulse fraction during the gamma-flare in September 2011

Morii et al. 2011

Summary

- MAXI is detecting variable X-ray sources of all classes.
- MAXI provides continuous monitoring of light curves and spectra for outburst episodes.
- Follow-up and multiwavelength observations are tremendously valuable
- Unanticipated detections, new class of sources emerging
- Please support MAXI, so that it can continue beyond the “official” 2 year mission

GSC All-Sky Scan Movie

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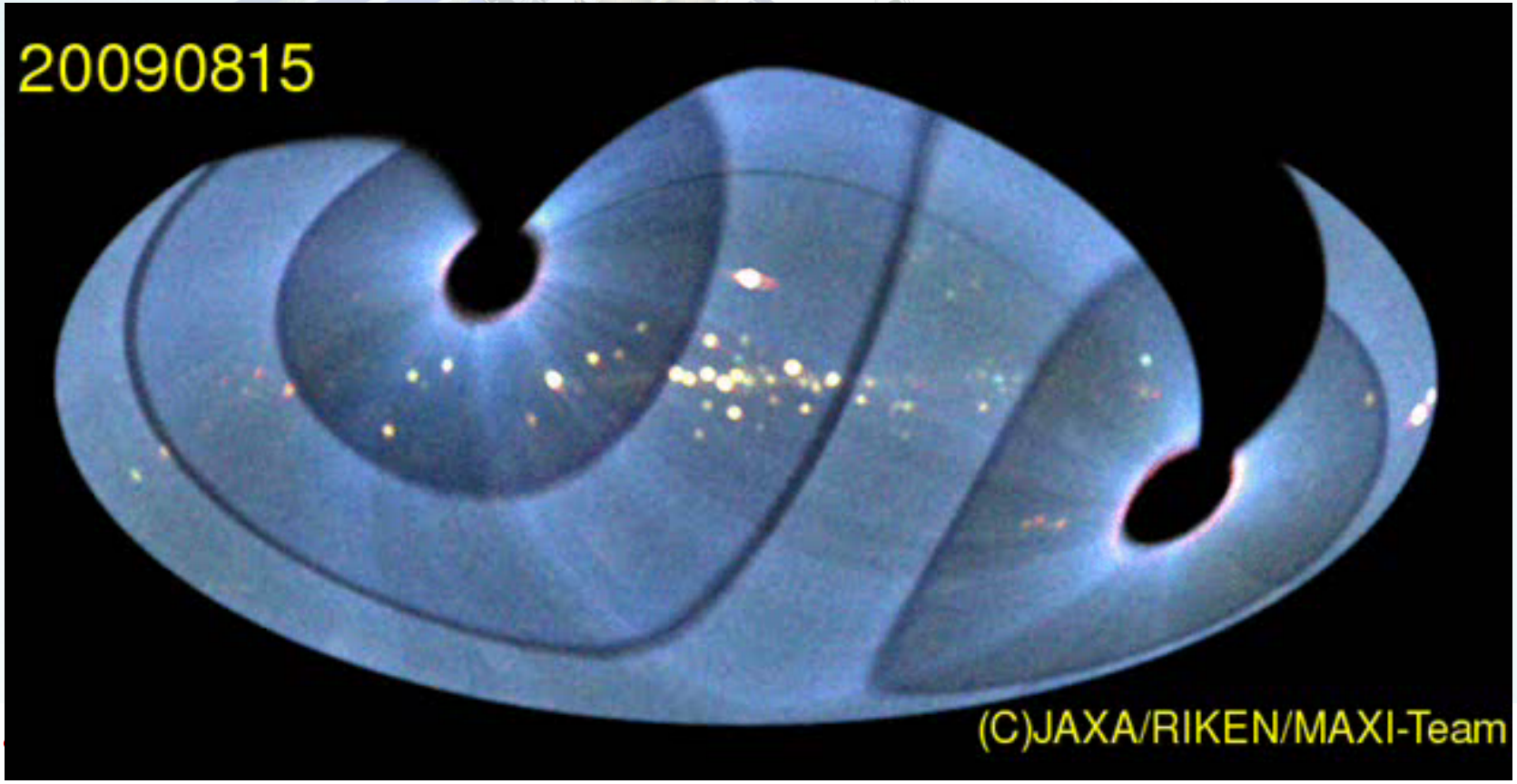

- Raw data. Exposure not corrected.
- Not cleaned for background variation, sun-light leak, and solar-paddle reflection.