# Discovery of 17 X-ray Transients with MAXI/GSC and their Nature

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# Contents

- How we can find new transients?
- Overview of 17 new transients
- Black Hole Candidates
  - Are we observing distant BHCs in our Galaxy ?
- Neutron Stars
  - Are we observing LMXBs wandering in halo ?
- Unknown/unidentified Short Soft Transients
- Future Works

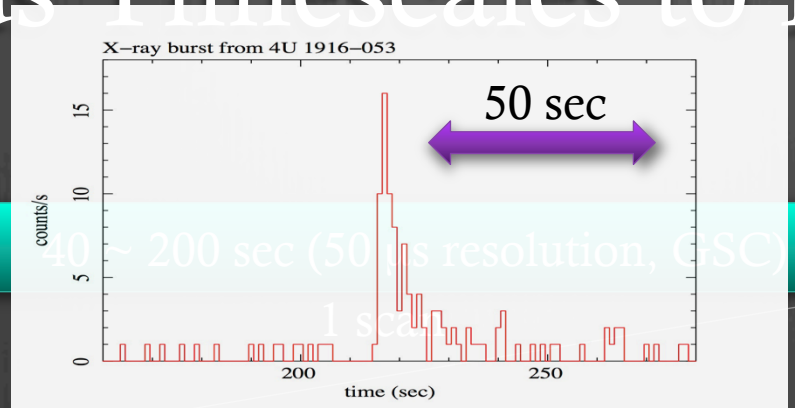
# Various Timescales to Investigate

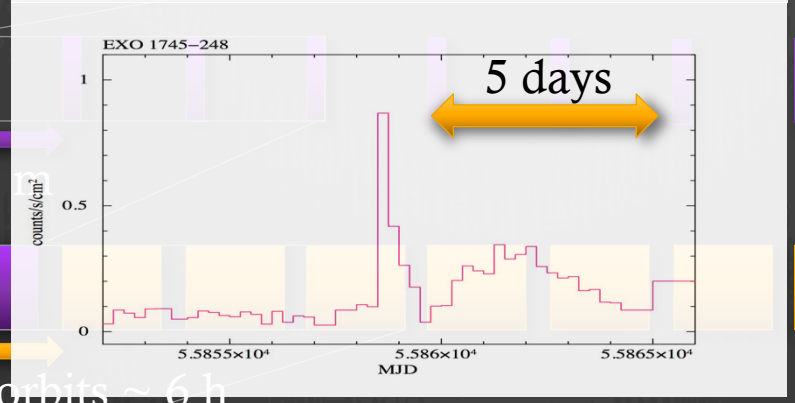
X, γ-ray bursts

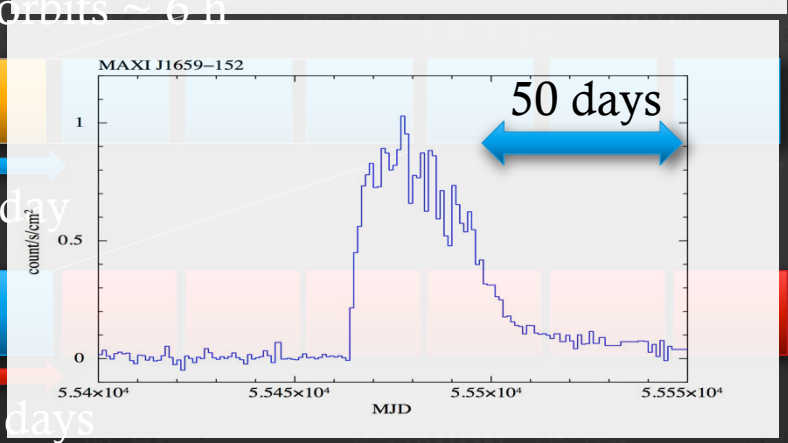
Superburst
SFXT
Star Flares

X-ray novae

AGN Flares




**X-ray burst From 4U 1916-053**

**Superburst + Outburst From EXO 1745-248**

***Serino+ 2012***

**BH Outburst MAXI J1659-152**

***Negoro+ 2010, Yamaoka+ 2011***

# ATel Reports ('09/08~'15/03)

**Table 2.** ATel reports summary: X-ray binaries in our Galaxy, LMC, and SMC.

| Type | Outburst | | State transition | | X-ray burst | Superburst | Brightening, darkening | Mailing list* |
|---|---|---|---|---|---|---|---|---|
| | New | Known | New | Known | | | | |
| BHC | 6 | 6 (13)† | 4 (5) | 7 (14) | — | — | 1 | (19) |
| NS LMXB | 4 | 13 (20) | 0 | 3 | 3 | 6 | 8 | (146) |
| Pulsar | 1 | 18 (42) | 0 | 0 | 0 | 0 | 3 | (84) |
| SFXT | 0 | 2 | 0 | 0 | 0 | 0 | 0 | (9) |
| WD | 1 | 0 | 0 | 0 | — | — | 0 | (3) |
| Unknown‡ | 2(4) | 0 | 0 | 0 | — | — | 0 | (10) |

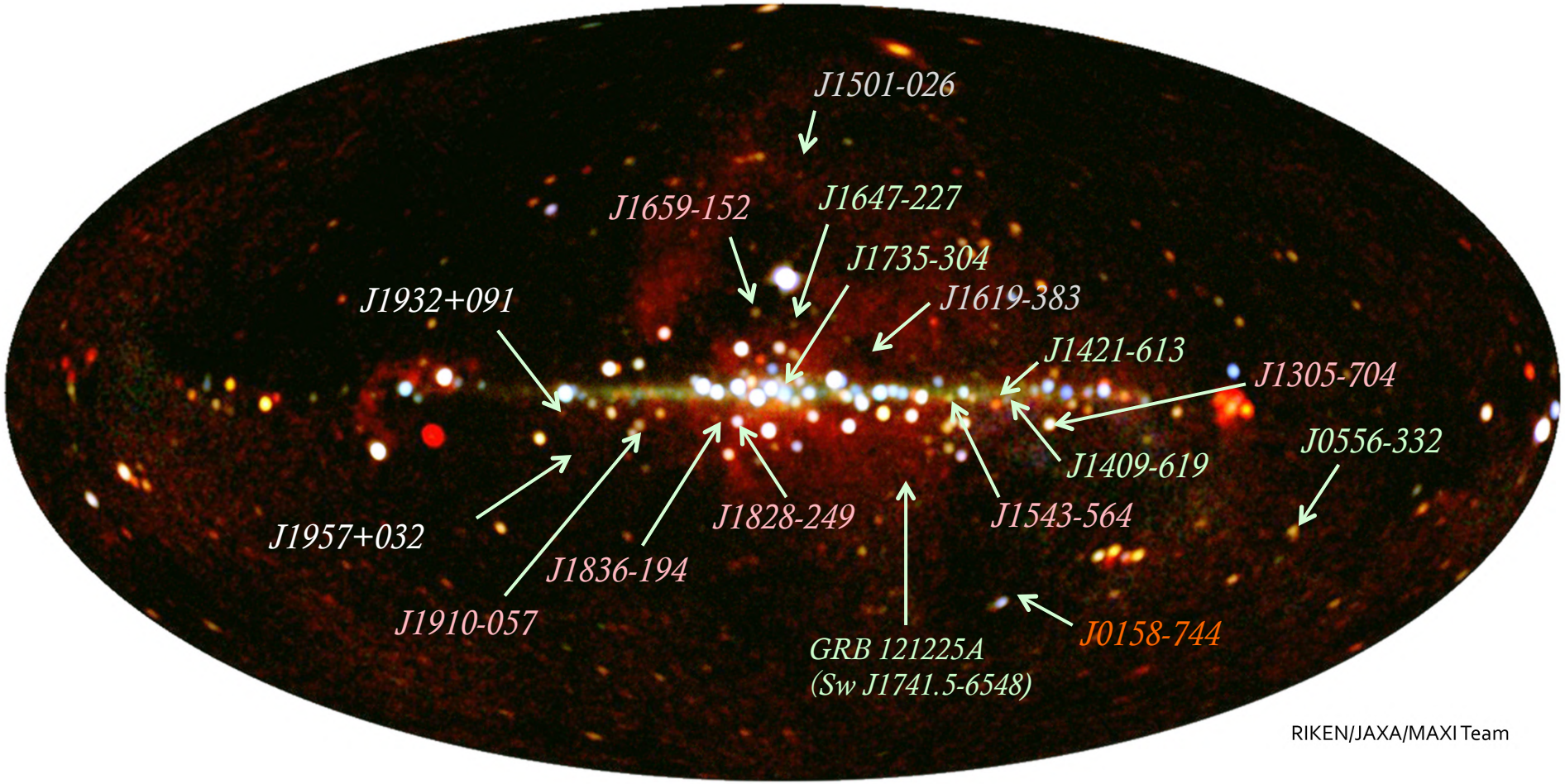
*The numbers in parentheses are the numbers of e-mail alerts sent to the MAXI ML.

†The numbers and those in parentheses are the numbers of sources and telegrams, respectively, reported on to the ATel.

‡MAXI J1932+091 and MAXI J1619−383 are classified as "new/unknown" here. MAXI J0057−720 and MAXI J1807−228 are "known/pulsar" identified as AX J0058−720 and "known/LMXB" as SAX J1806.5−2215, respectively.

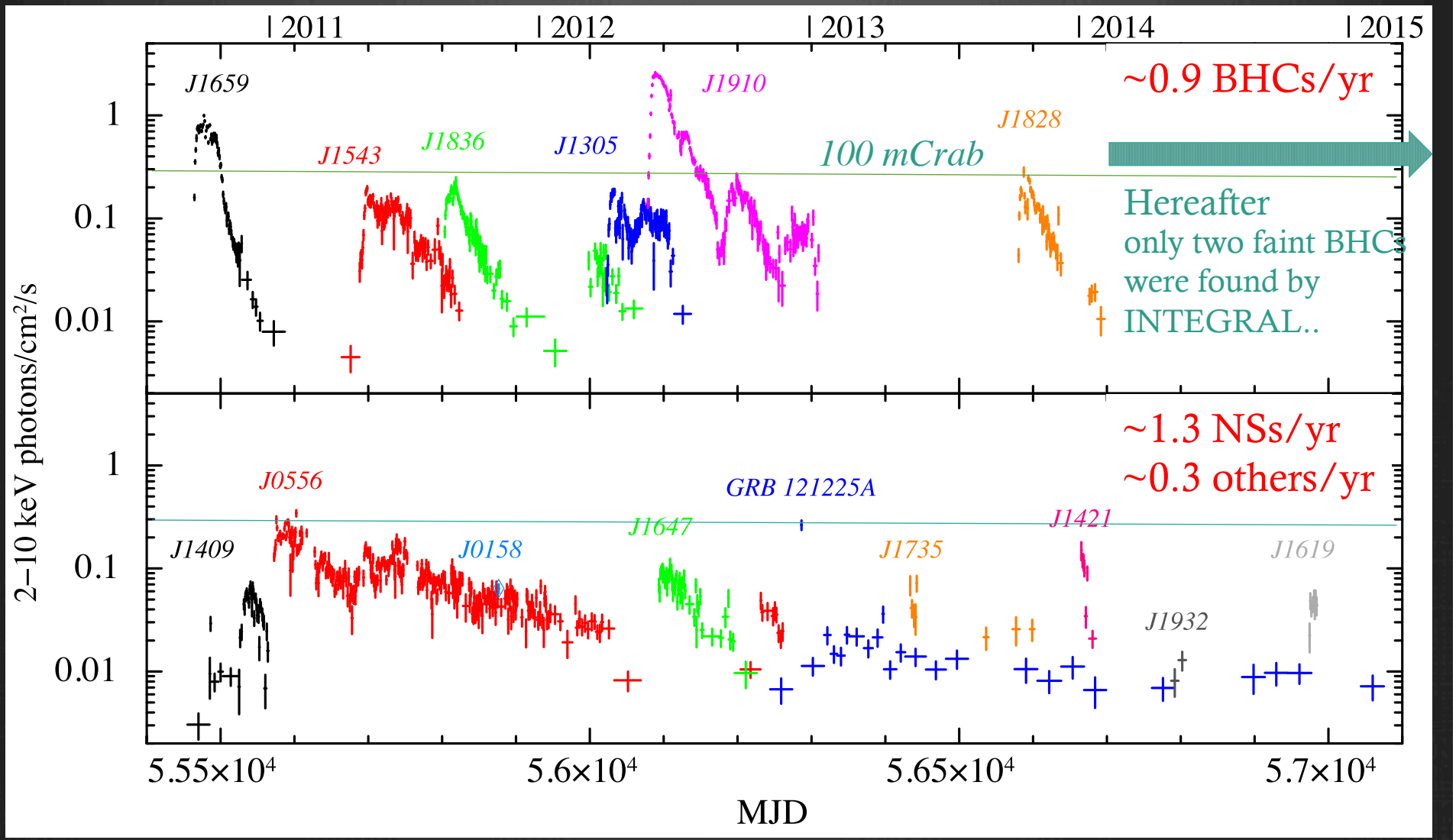
Negoro+ 2016, PASJ

# 17 X-ray Novae MAXI discovered



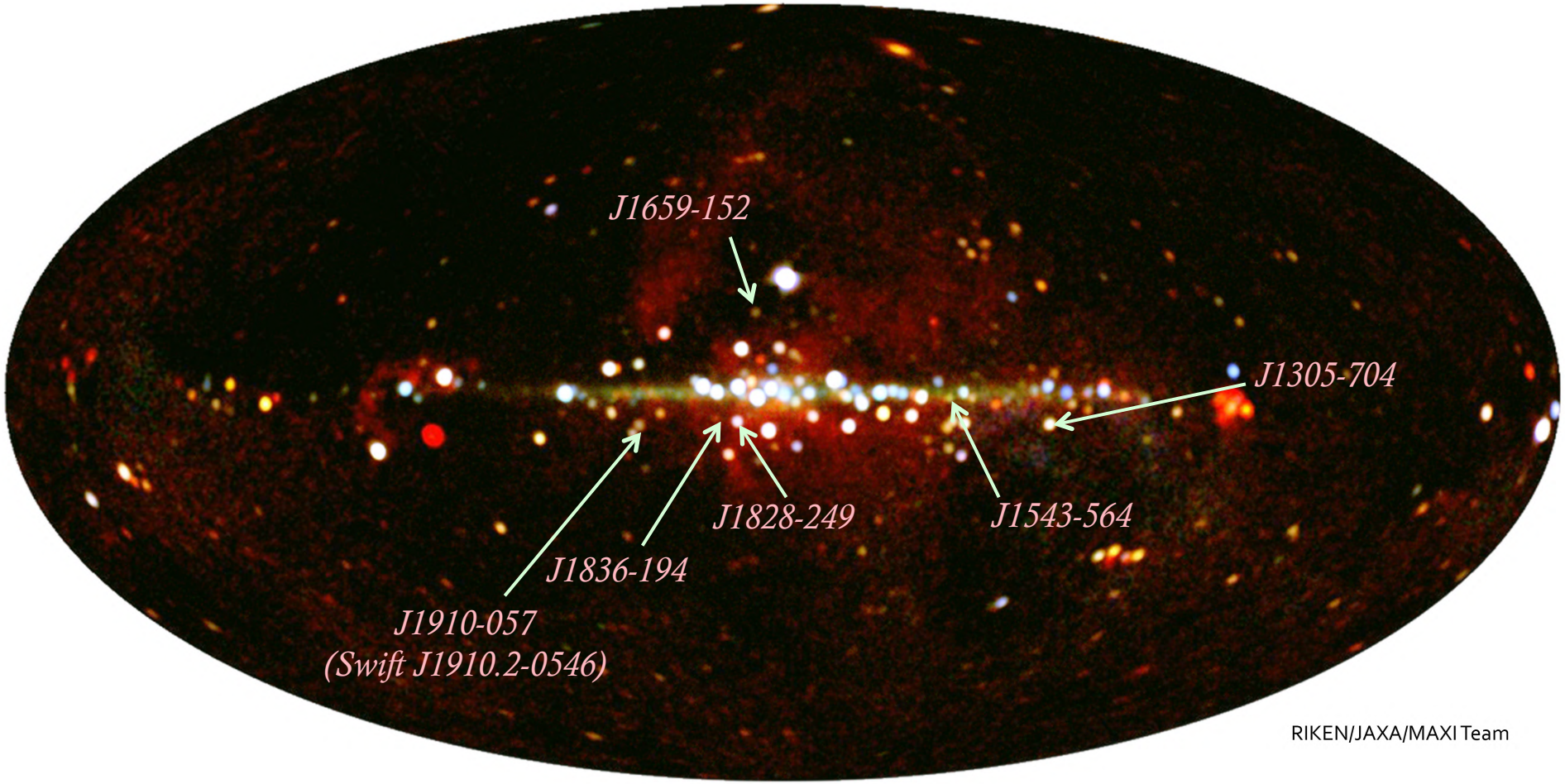

1 White Dwarf 6 Neutron Stars 6 Black Hole Candidates, and 4 unknowns/unconfirmed
(1 White Dwarf 9 probable Neutron Stars 6 Black Hole Candidates, and 1 quite unknown)

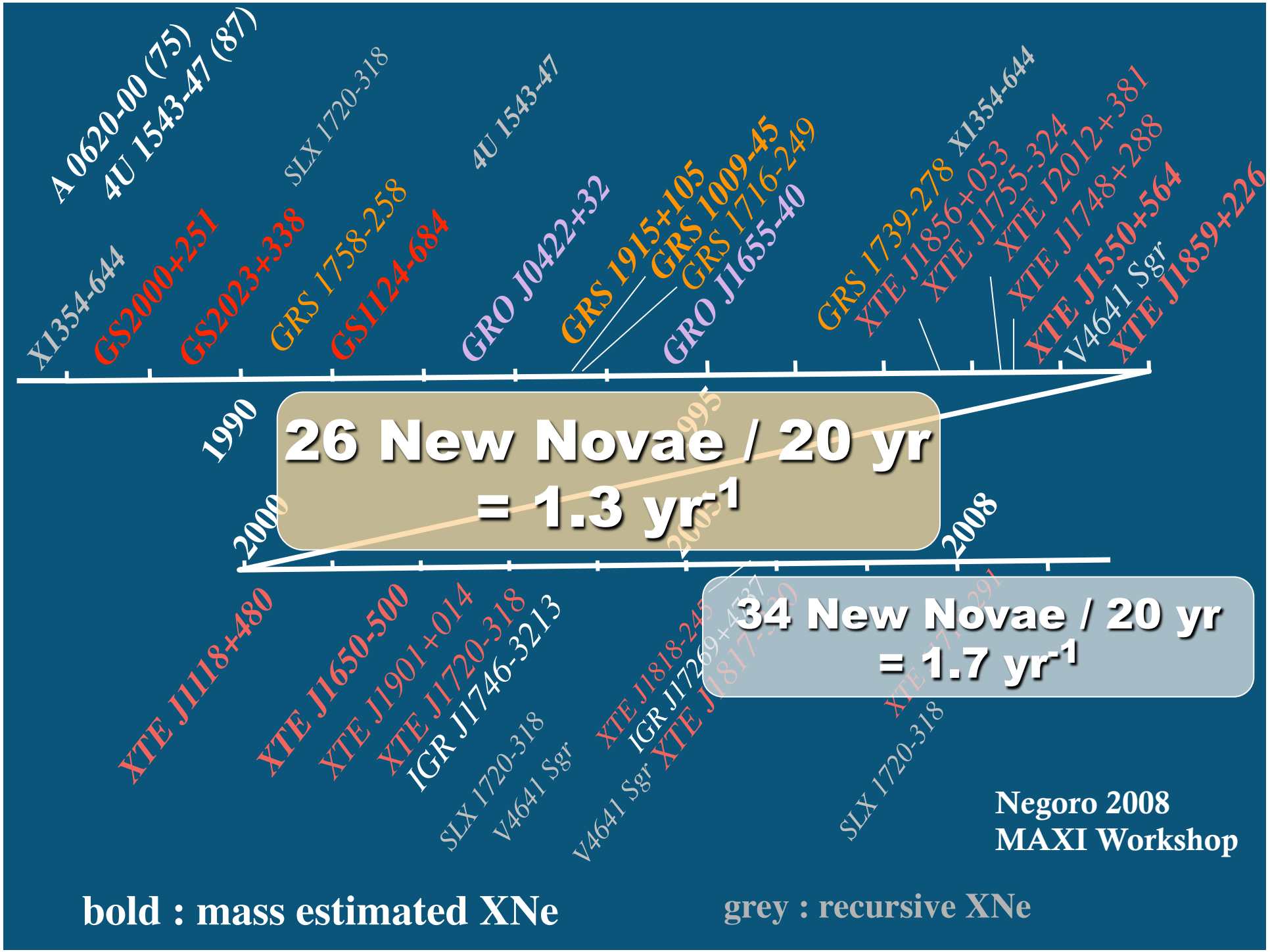
# Discovery Rate

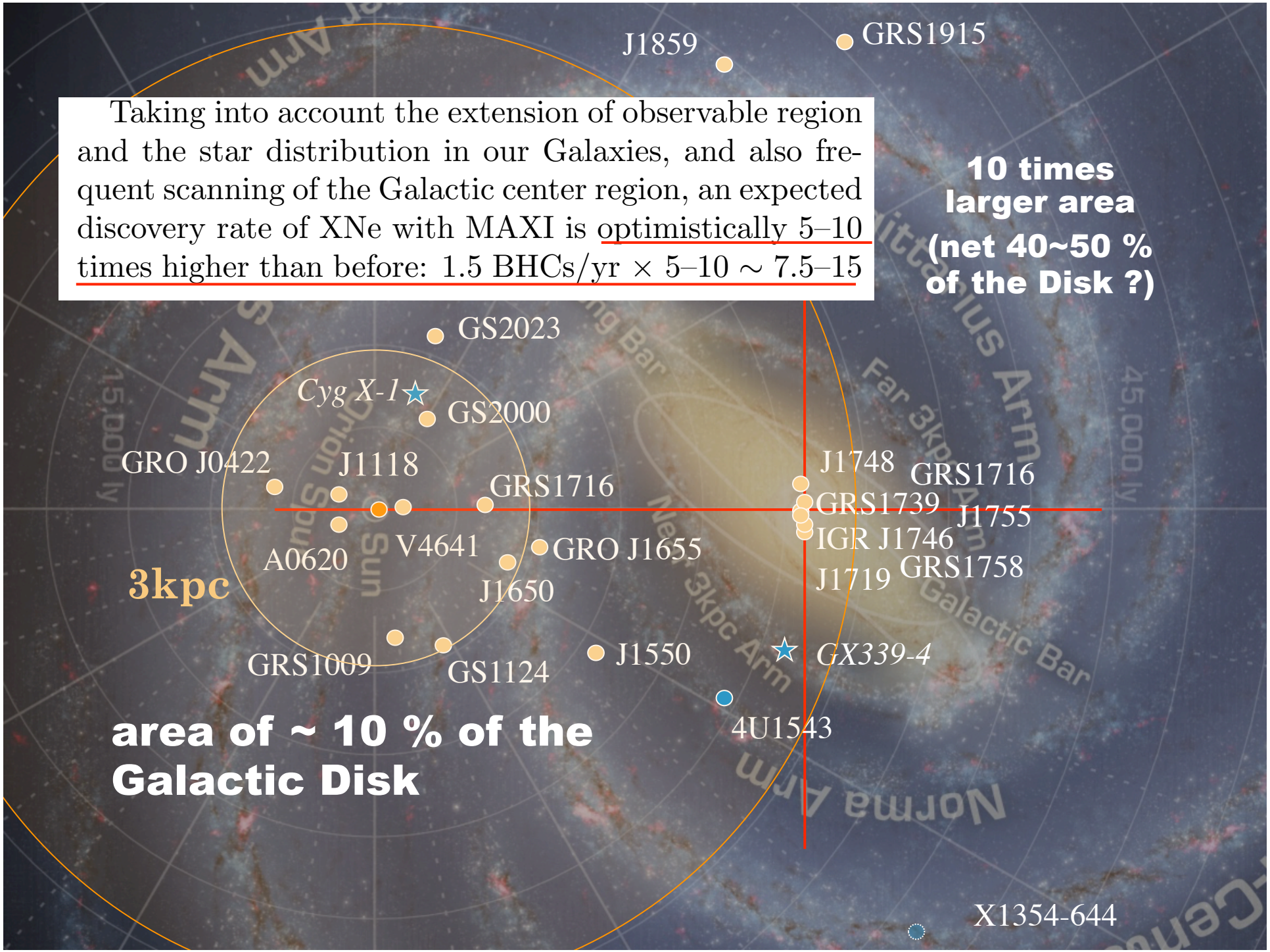


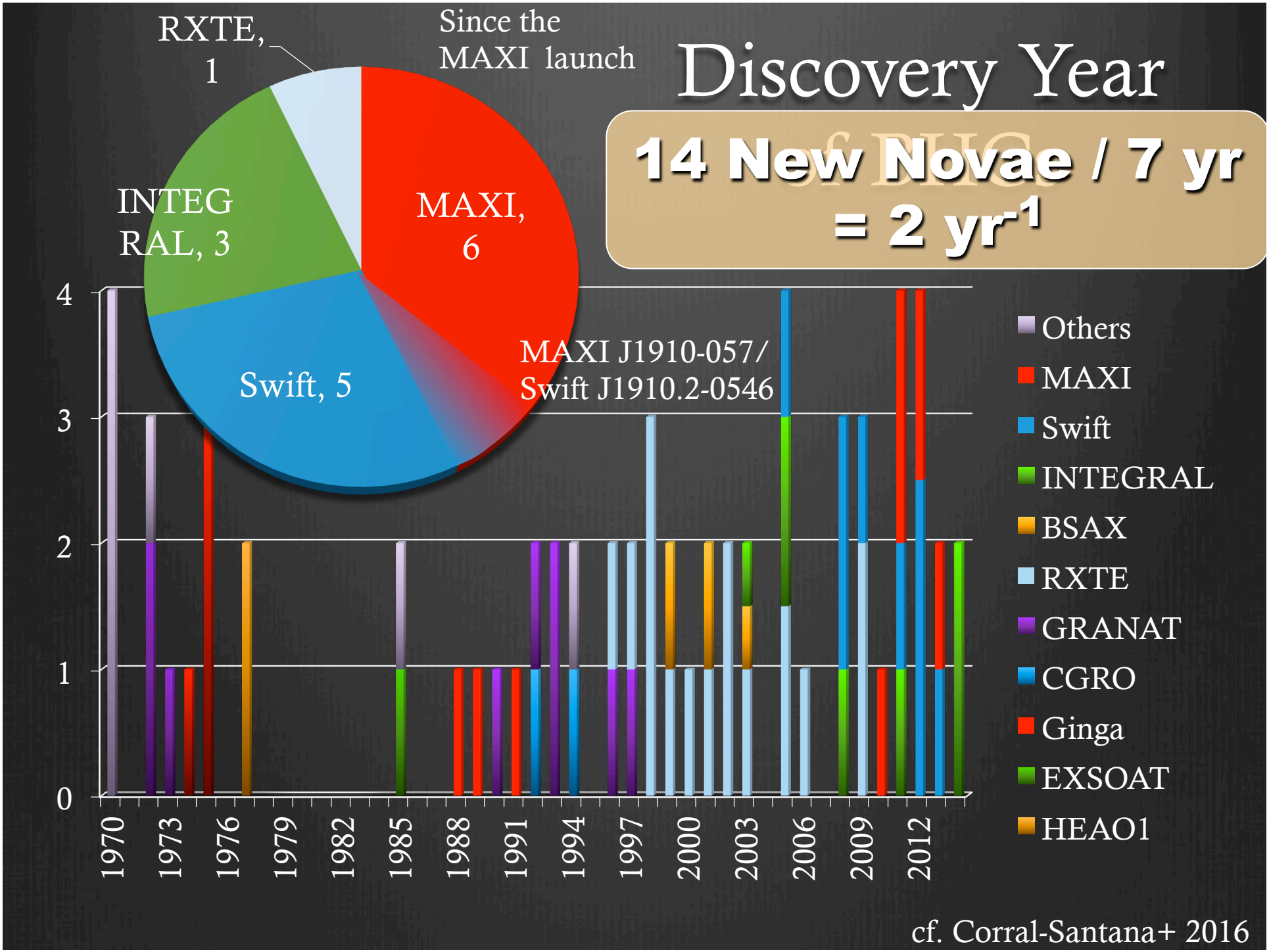

Negoro+ 2016, PASJ

# 6 Black Hole Candidates

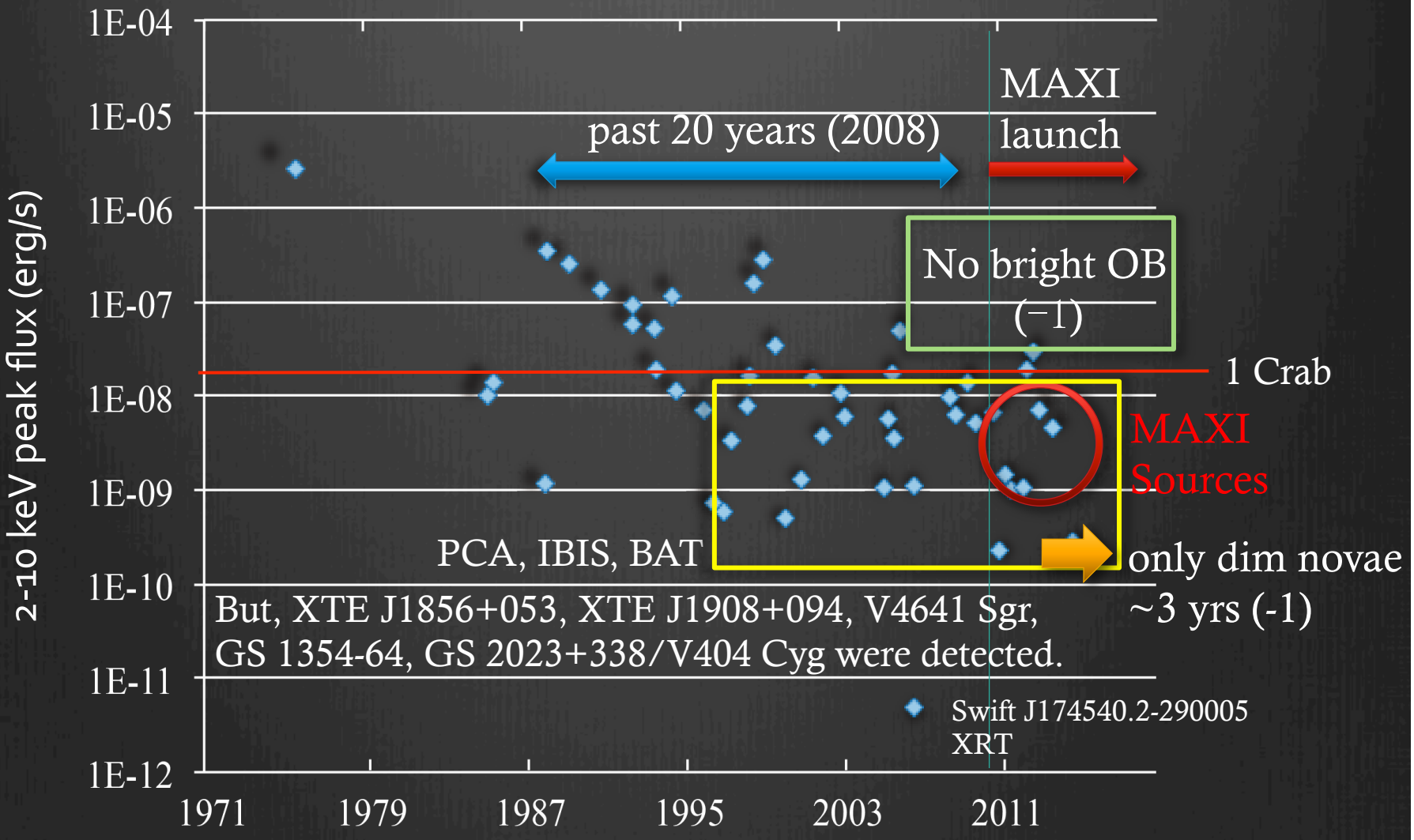



A 0620-00 (75)
4U 1543-47 (87)
SLX 1720-318
4U 1543-47
X1354-644
GS2000+251
GS2023+338
GRS 1758-258
GS1124-684
GRO J0422+32
GRS 1915+105
GRS 1009-45
GRS 1716-249
GRO J1655-40
GRS 1739-278
X1354-644
XTE J1856+053
XTE J1755-324
XTE J2012+381
XTE J1748+288
XTE J1550+564
V4641 Sgr
XTE J1859+226
1990
2000
2008
26 New Novae / 20 yr
= 1.3 yr-1
34 New Novae / 20 yr
= 1.7 yr-1
XTE J1118+480
XTE J1650-500
XTE J1901+014
XTE J1720-318
IGR J1746-3213
SLX 1720-318
V4641 Sgr
XTE J1818-245
IGR J17269+4737
V4641 Sgr
SLX 1720-318
Negoro 2008
MAXI Workshop
bold : mass estimated XNe
grey : recursive XNe


Taking into account the extension of observable region and the star distribution in our Galaxies, and also frequent scanning of the Galactic center region, an expected discovery rate of XNe with MAXI is optimistically 5–10 times higher than before: 1.5 BHCs/yr × 5–10 ~ 7.5–15
10 times larger area (net 40~50 % of the Disk ?)
J1859
GRS1915
GS2023
Cyg X-1
GS2000
GRO J0422
J1118
GRS1716
J1748
GRS1716
GRS1739
J1755
IGR J1746
GRS1758
J1719
V4641
A0620
GRO J1655
J1650
3kpc
GRS1009
GS1124
J1550
GX339-4
4U1543
area of ~ 10 % of the Galactic Disk
X1354-644
Sagittarius Arm
Orion Spur
Sun
Near 3kpc Arm
Far 3kpc Arm
Norma Arm
Galactic Bar
15,000 ly
45,000 ly


Discovery Year
14 New Novae / 7 yr
= 2 yr-1
Since the
MAXI launch
RXTE,
1
INTEG
RAL, 3
MAXI,
6
Swift, 5
MAXI J1910-057/
Swift J1910.2-0546
Others
MAXI
Swift
INTEGRAL
BSAX
RXTE
GRANAT
CGRO
Ginga
EXSOAT
HEAO1
0
1
2
3
4
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
cf. Corral-Santana+ 2016

# Peak Fluxes of BH Outbursts




data are mostly from Corral-Santana et al. 2016

# How we can estimate the distance?

*At the Soft-to-Hard Transition*

$F = \alpha L_{\mathrm{Edd}} / 4\pi d^2$

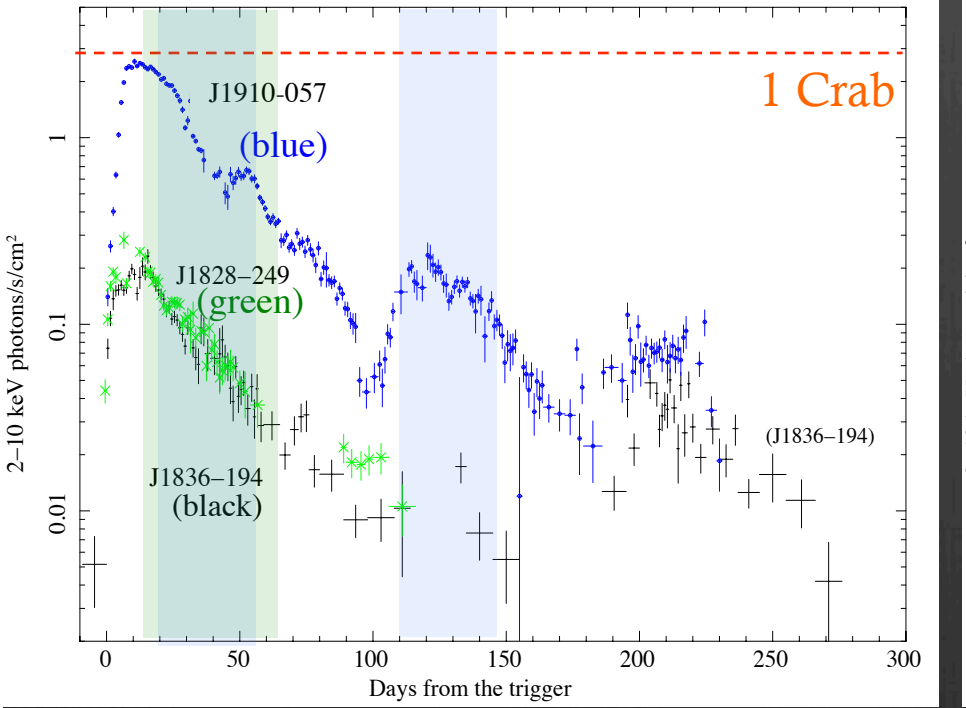
$\alpha$ = *1-4%* (Maccarone 2003)

~ *0.5-10%* (Dunn et al. 2010)

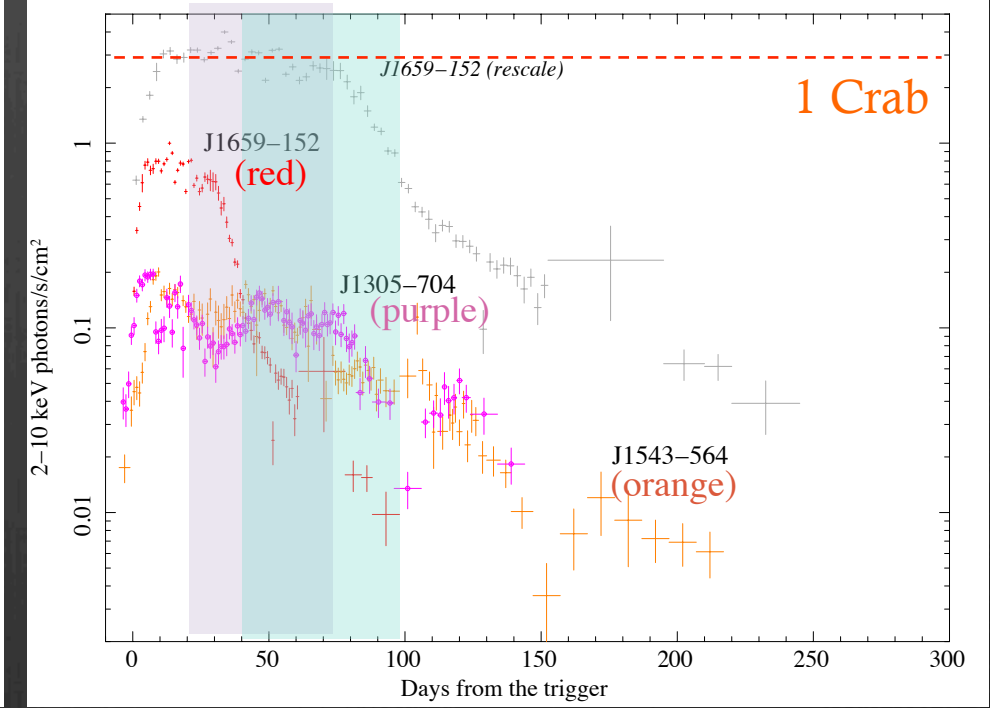
(for MAXI results, see Masumitsu's Poster)

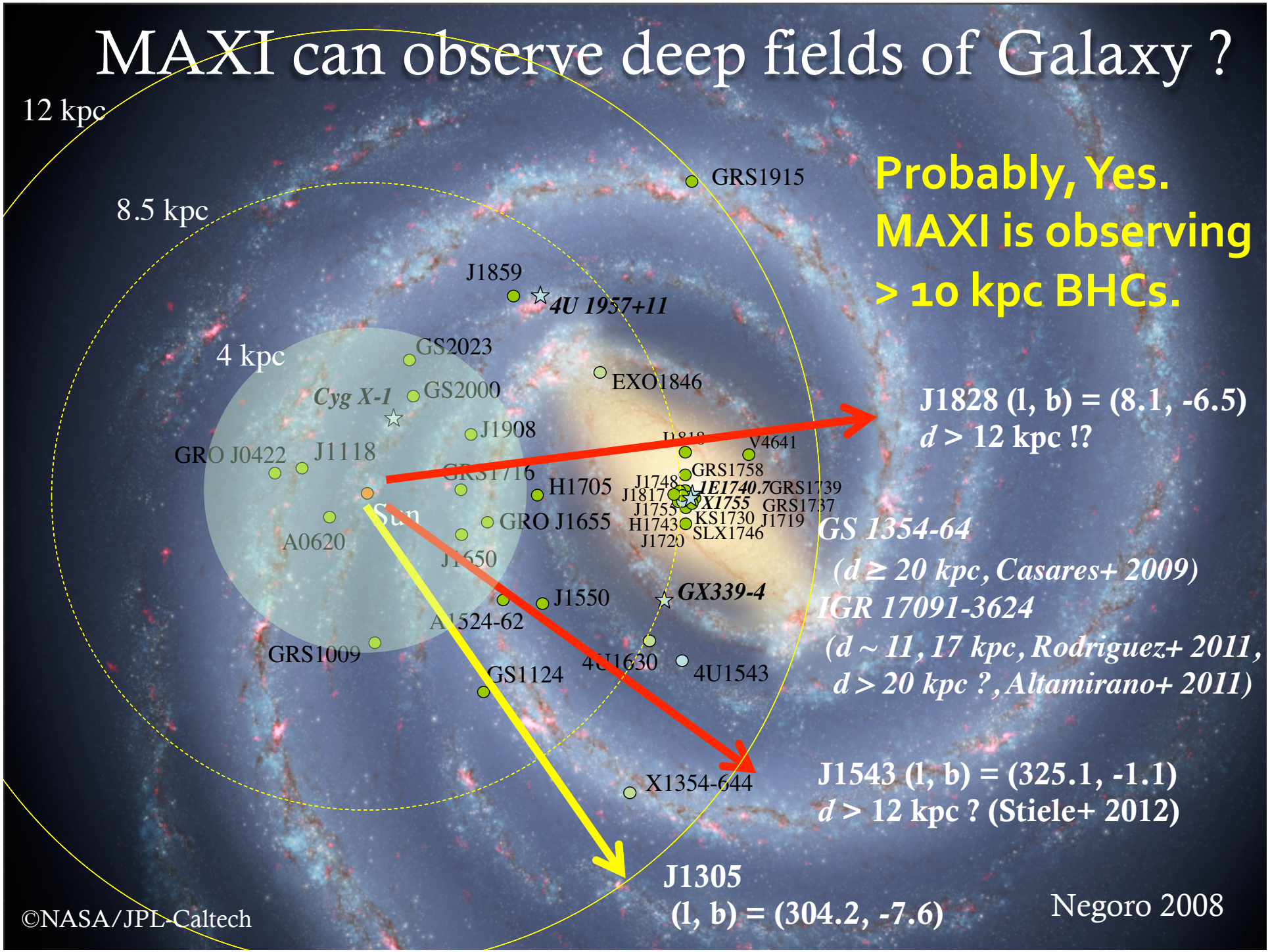
Negoro 2014

FRED (*First Rise and Exponential Decay*) Type

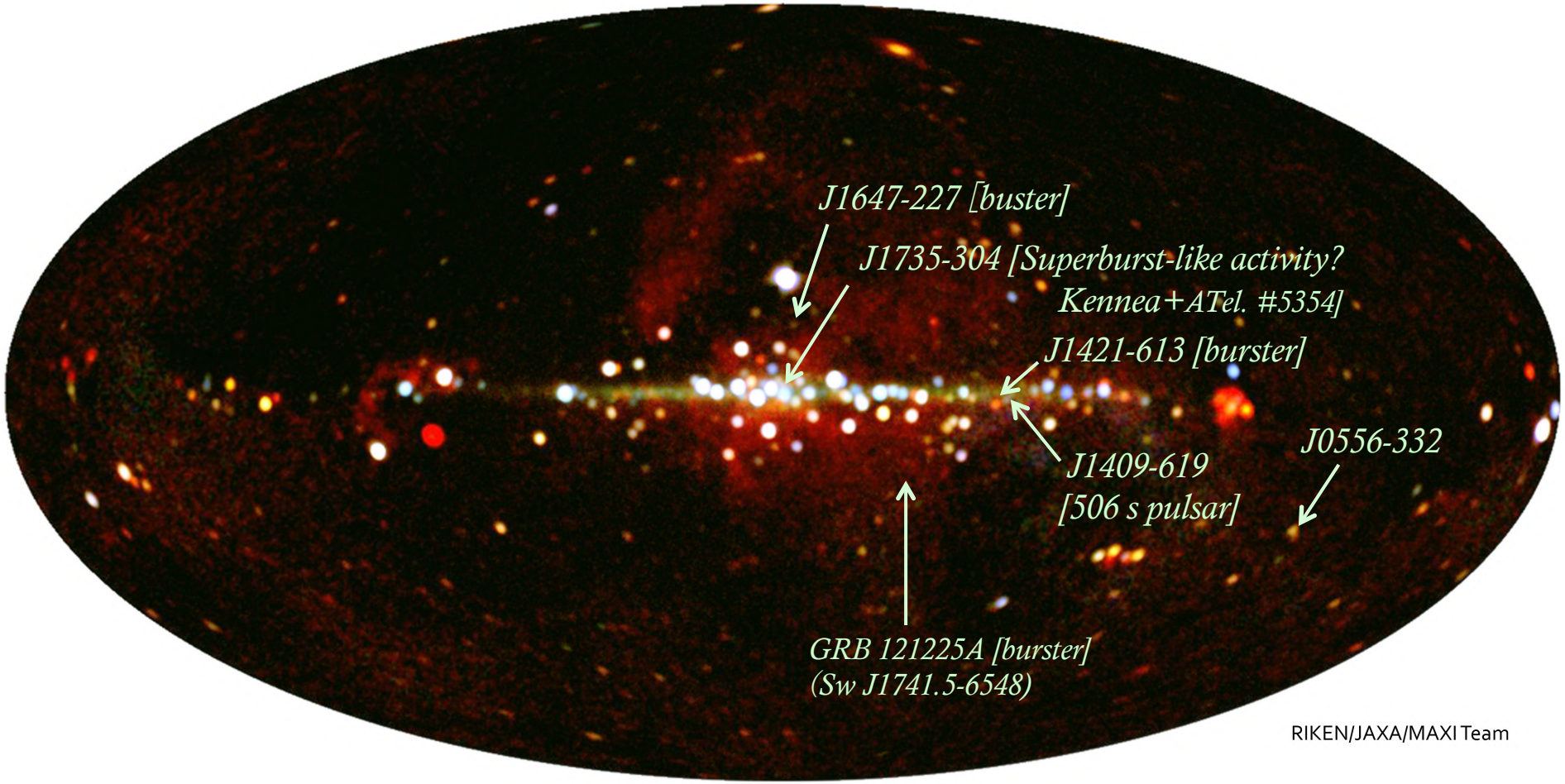



FRFT (*First Rise and Flat Top*) Type

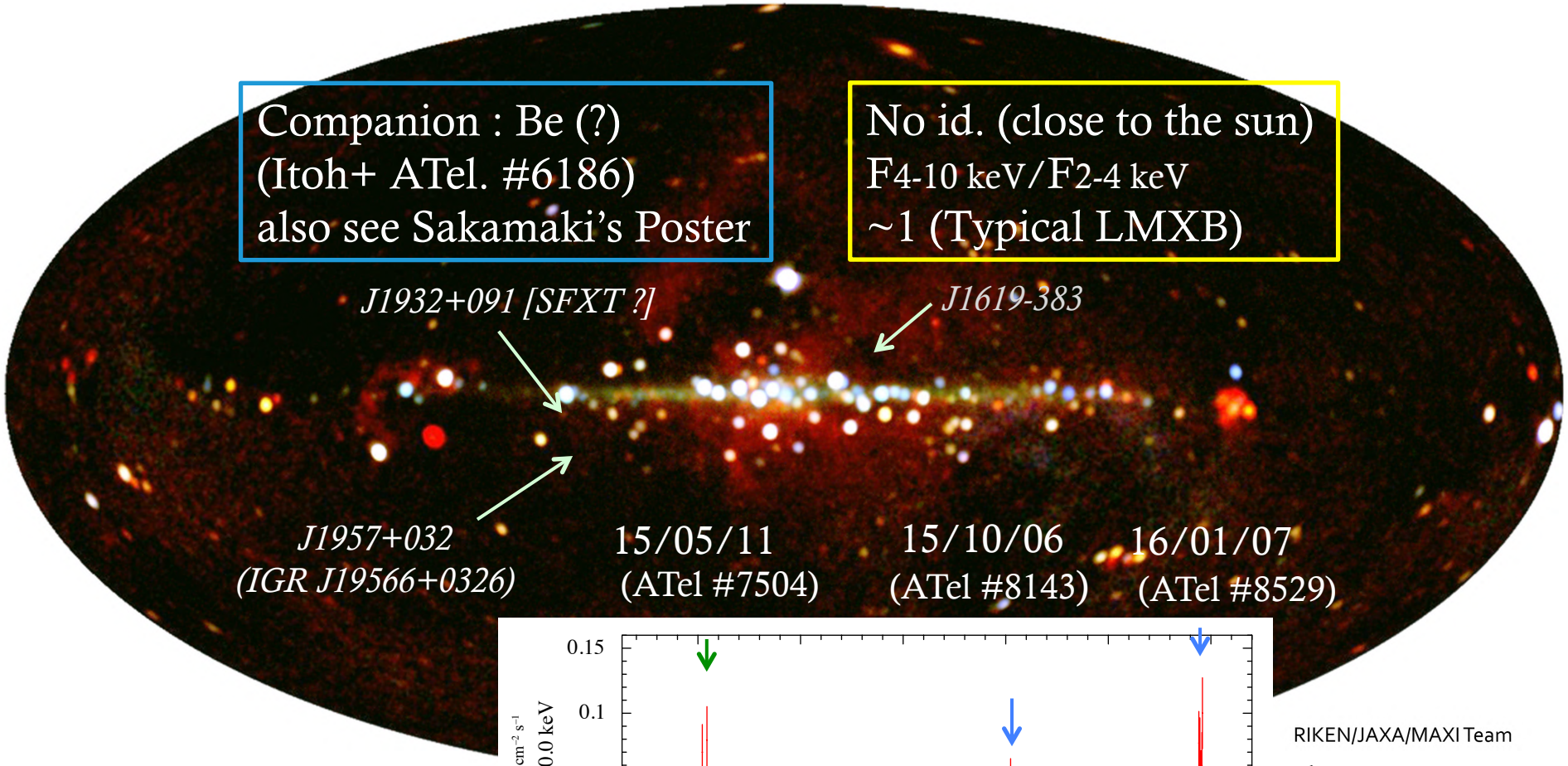



MAXI can observe deep fields of Galaxy ?
12 kpc
8.5 kpc
4 kpc
GRS1915
J1859
4U 1957+11
GS2023
GS2000
Cyg X-1
EXO1846
J1908
GRO J0422
J1118
V4641
GRS1758
H1705
J1748
1E1740.7
GRS1739
J1817
X1755
GRS1737
J1755
KS1730
J1719
H1743
SLX1746
J1720
GRO J1655
A0620
Sun
J1550
GX339-4
A1524-62
GRS1009
4U1630
4U1543
GS1124
X1354-644
Probably, Yes.
MAXI is observing
> 10 kpc BHCs.
J1828 (l, b) = (8.1, -6.5)
d > 12 kpc !?
GS 1354-64
(d ≥ 20 kpc, Casares+ 2009)
IGR 17091-3624
(d ~ 11, 17 kpc, Rodriguez+ 2011,
d > 20 kpc ?, Altamirano+ 2011)
J1543 (l, b) = (325.1, -1.1)
d > 12 kpc ? (Stiele+ 2012)
J1305
(l, b) = (304.2, -7.6)
©NASA/JPL-Caltech
Negoro 2008

# Neutron Star Binaries



# Probable Neutron Star Binaries

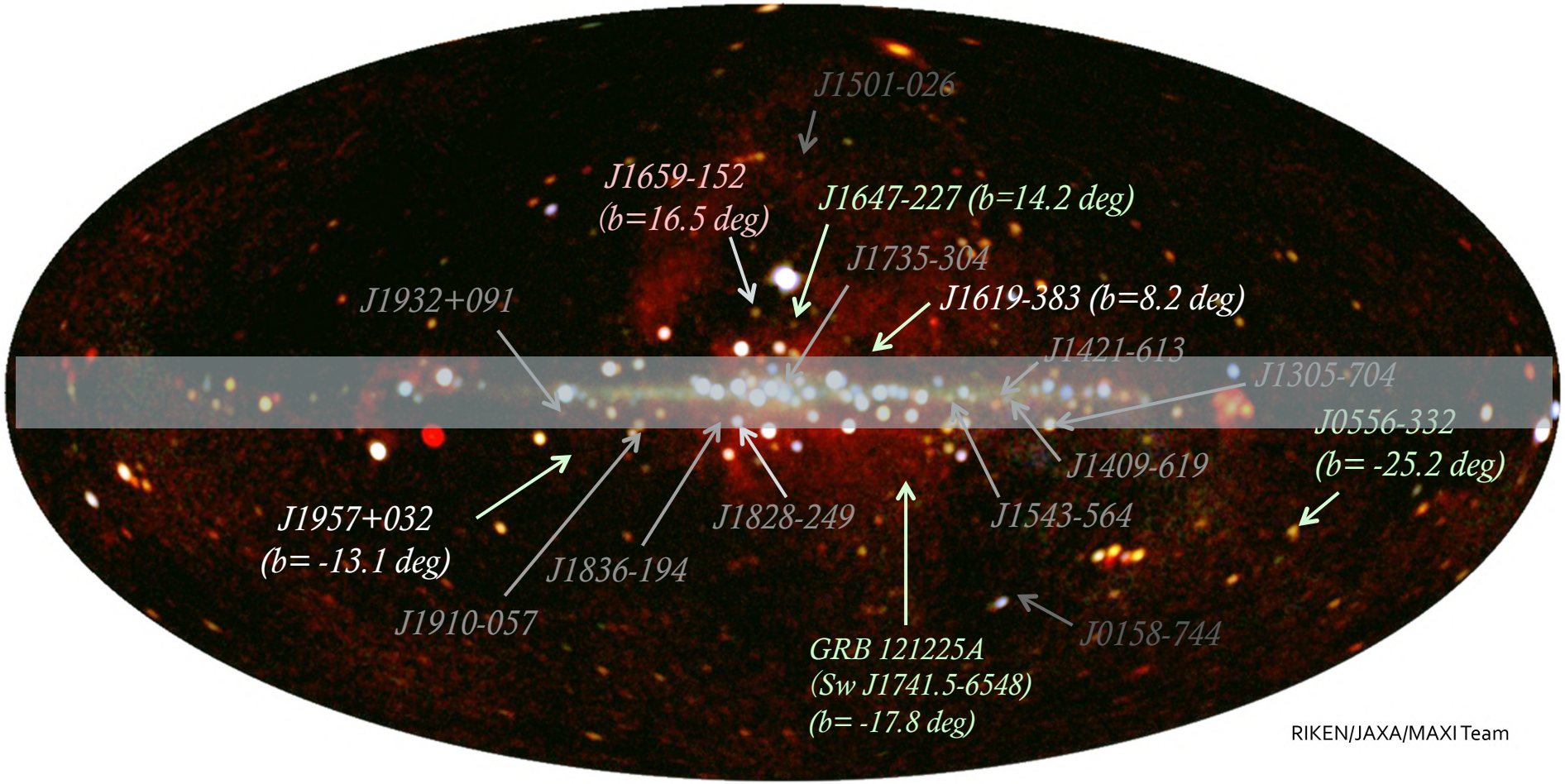



RIKEN/JAXA/MAXI Team

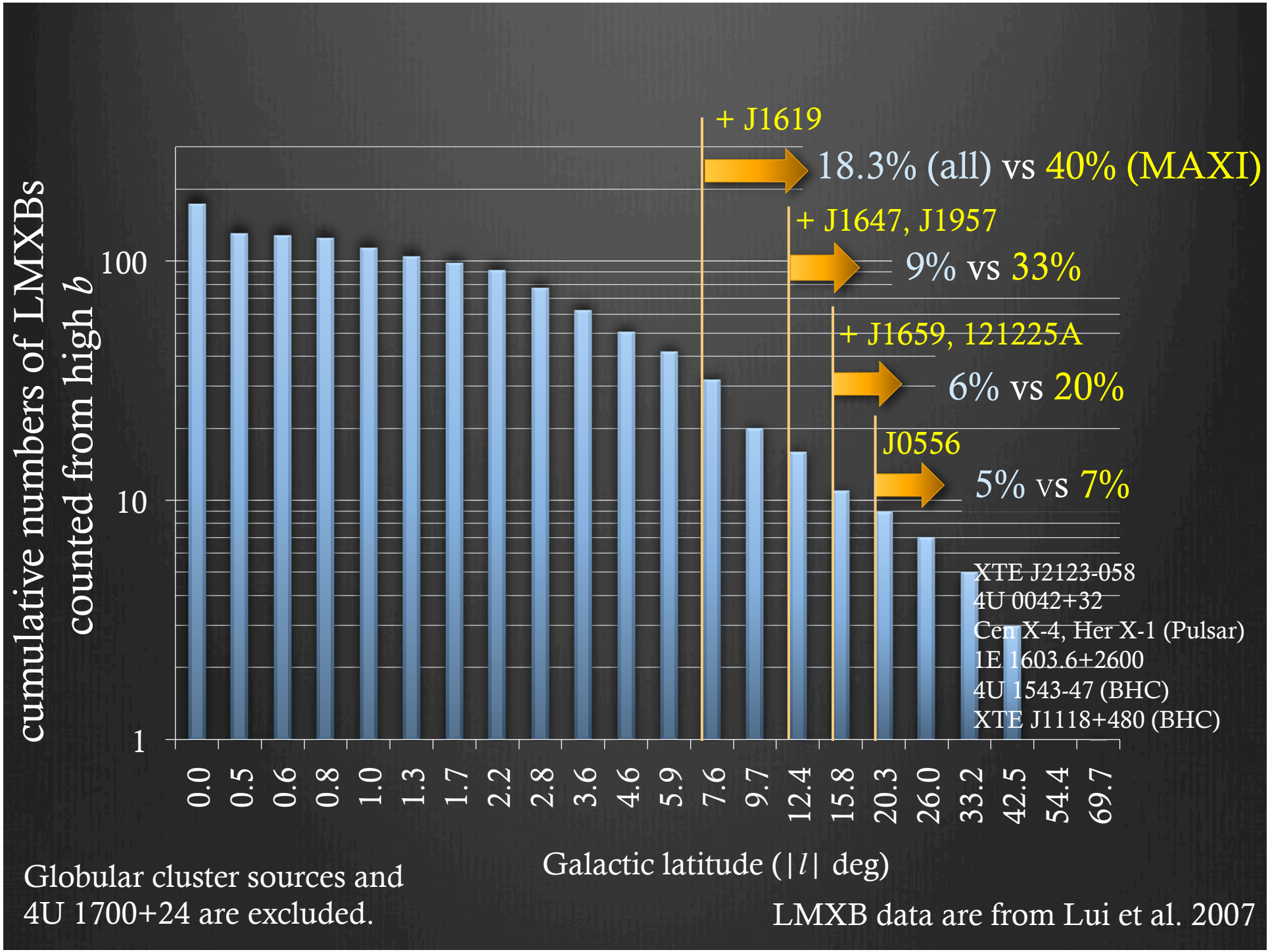
4th: 16/09/29
(ATel #9572)

# Galactic High Latitude Sources

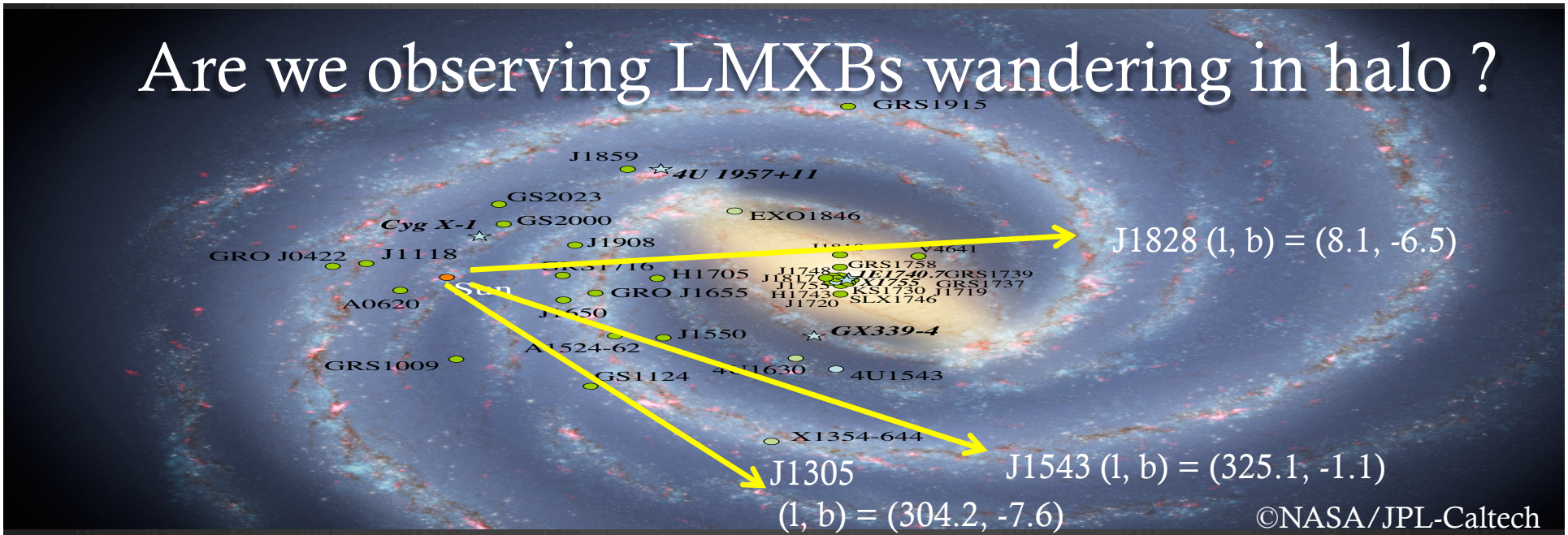
Suggesting the presence of a number of runway LMXBs
(no corresponding globular clusters)



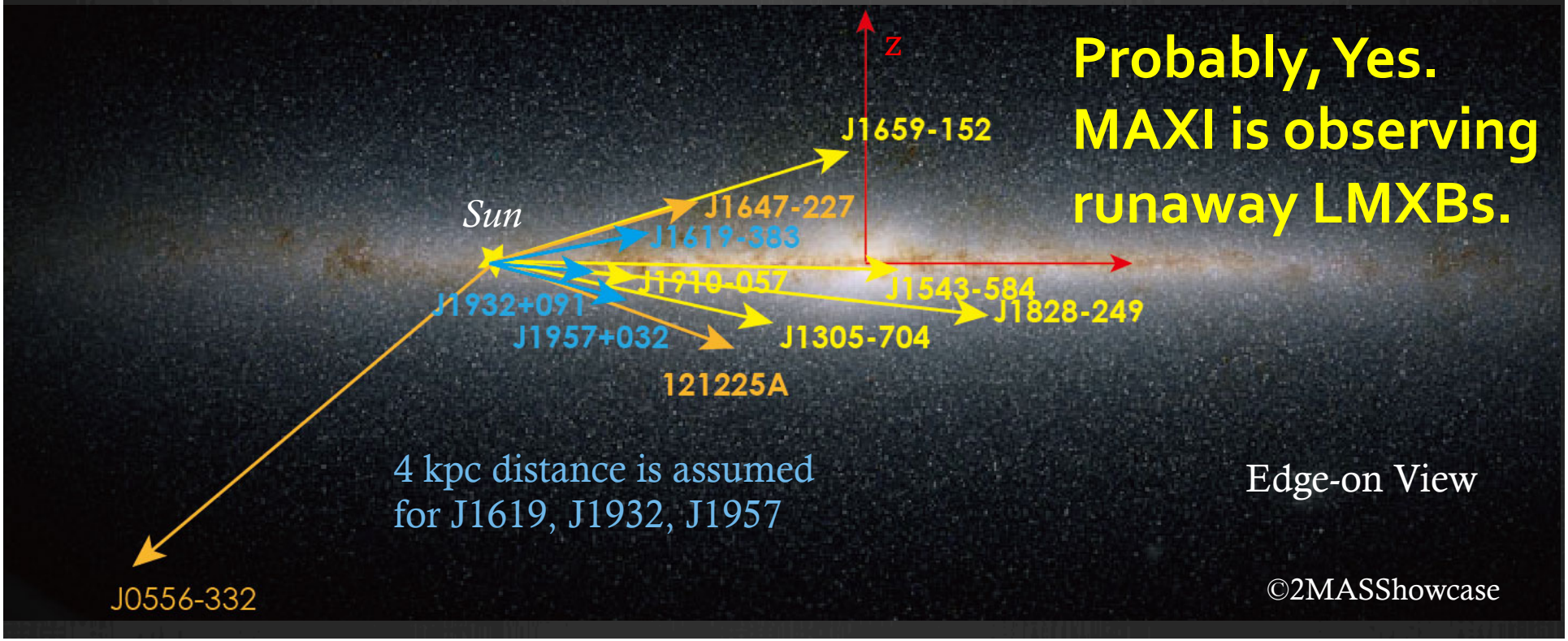

1/6 BHCs, 3/6 (or 5/9) NSs are at $|b| > 8$ deg


+ J1619
18.3% (all) vs 40% (MAXI)
+ J1647, J1957
9% vs 33%
+ J1659, 121225A
6% vs 20%
J0556
5% vs 7%
XTE J2123-058
4U 0042+32
Cen X-4, Her X-1 (Pulsar)
1E 1603.6+2600
4U 1543-47 (BHC)
XTE J1118+480 (BHC)
cumulative numbers of LMXBs counted from high b
100
10
1
0.0
0.5
0.6
0.8
1.0
1.3
1.7
2.2
2.8
3.6
4.6
5.9
7.6
9.7
12.4
15.8
20.3
26.0
33.2
42.5
54.4
69.7
Galactic latitude (|l| deg)
Globular cluster sources and
4U 1700+24 are excluded.
LMXB data are from Lui et al. 2007

# Are we observing LMXBs wandering in halo ?



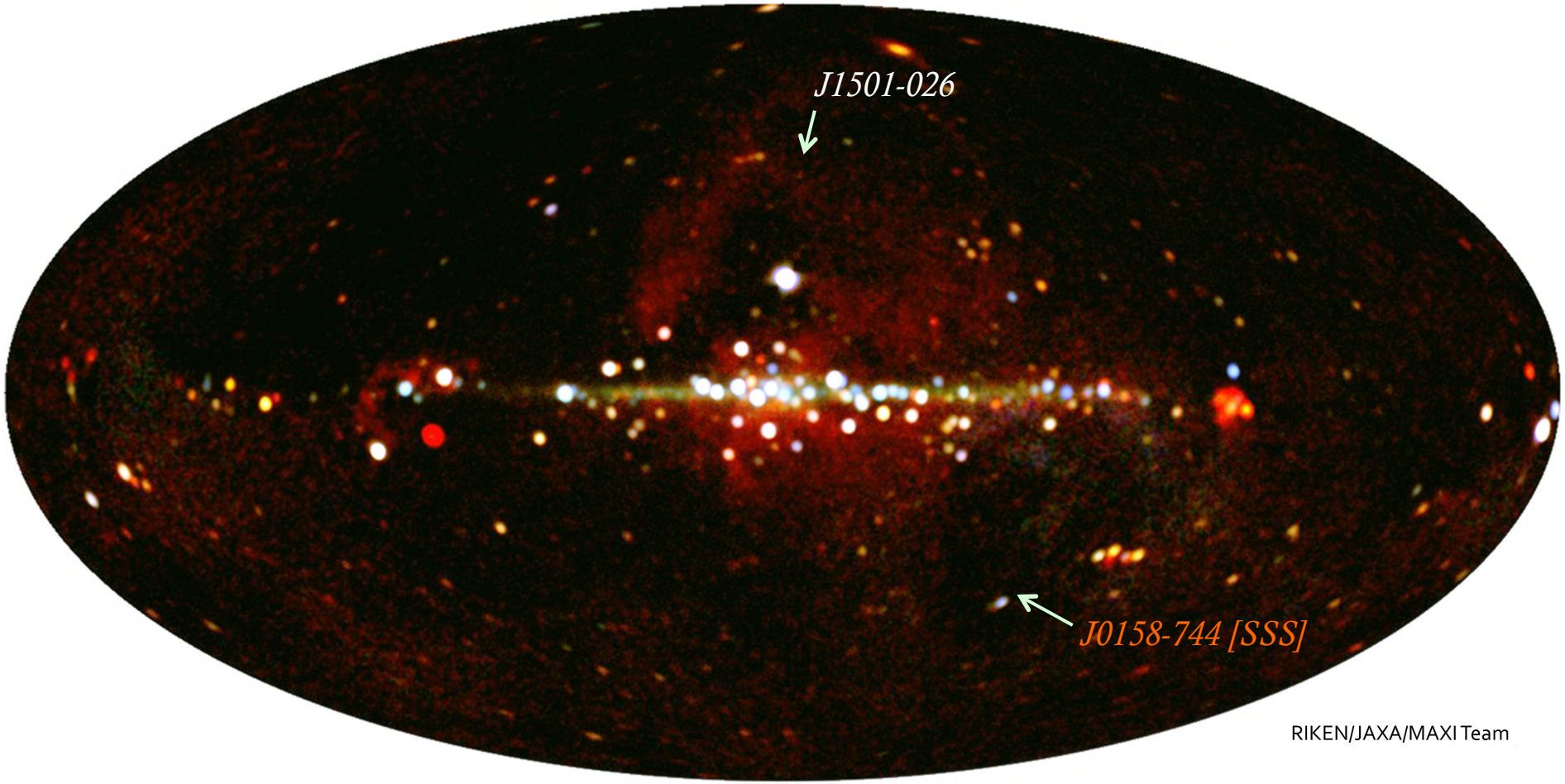

©NASA/JPL-Caltech




**Probably, Yes.**
**MAXI is observing runaway LMXBs.**

©2MASShowcase

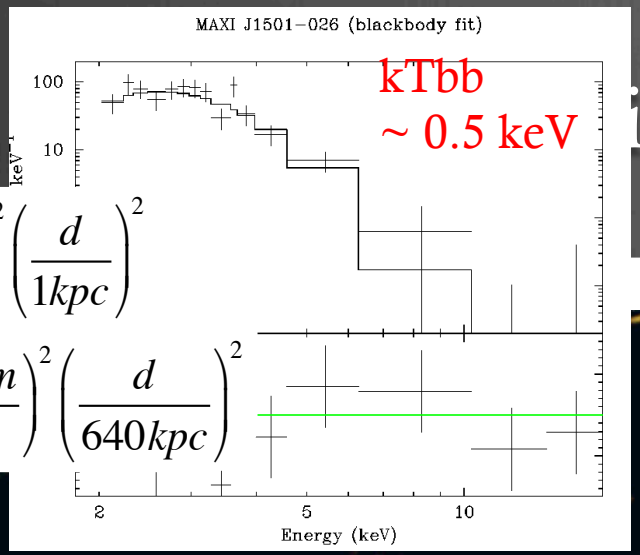
# Soft X-ray Transients & Unknown



# ients & Unkn

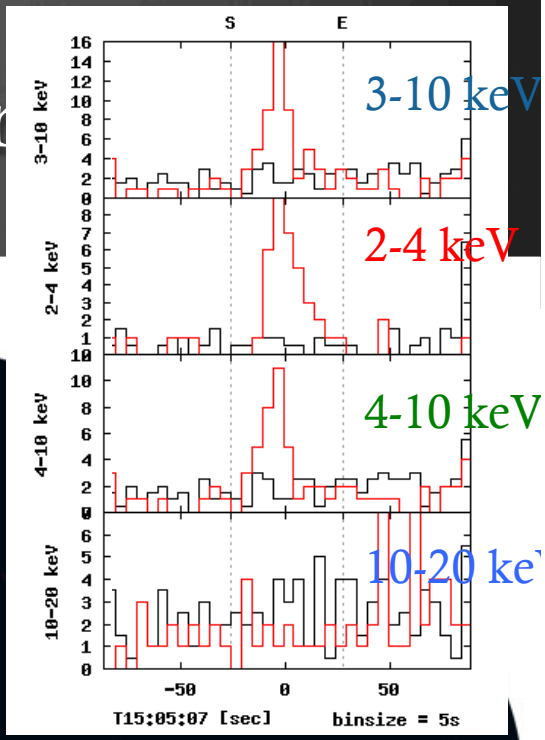
$$1.2E4 \sim \left(\frac{11km}{R}\right)^2 \left(\frac{d}{1kpc}\right)^2$$

$$\sim \left(\frac{7000km}{R}\right)^2 \left(\frac{d}{640kpc}\right)^2$$




ATel #7954, no counterpart

*J1501-026*



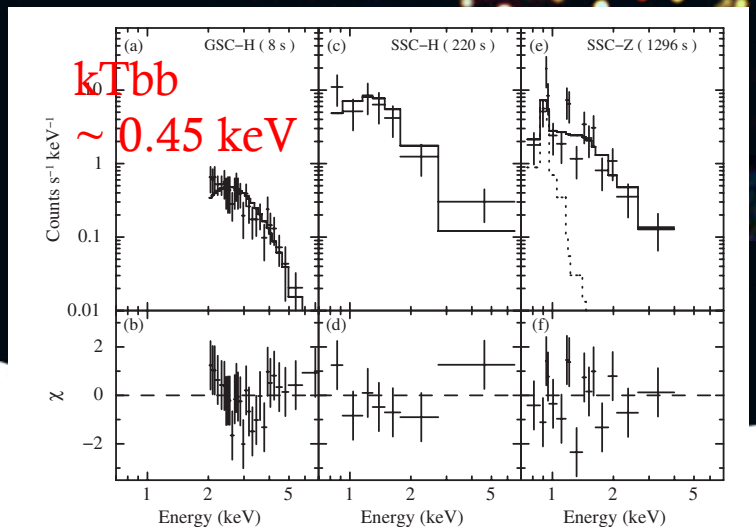

ATel #8983

*J0758-456*

= CV 1RXS ?

ATel #8988, 8993

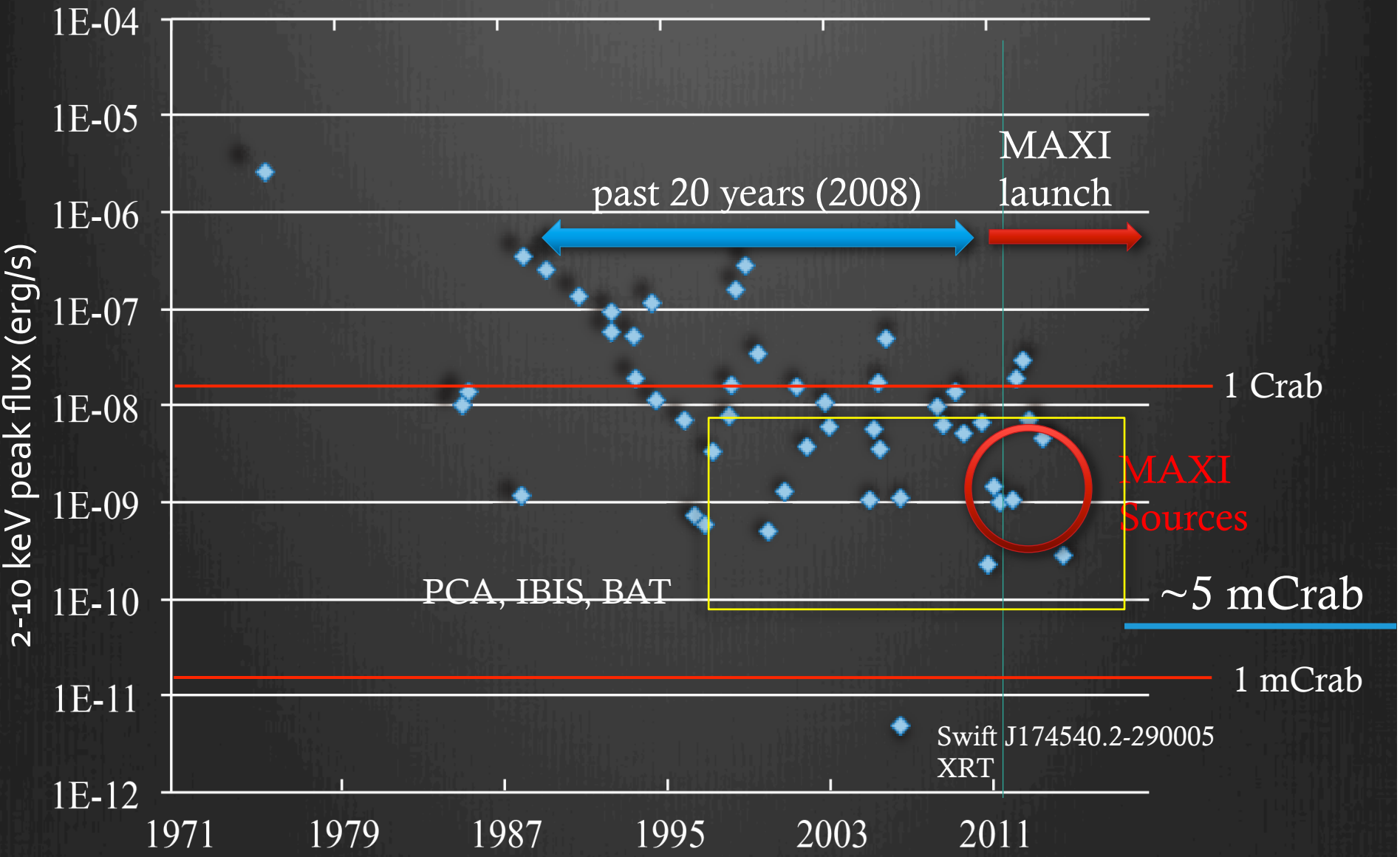
*J0158-744 [SSS]*




Morii et al. 2013, ApJ

# Future Works

- Use of longer time (16, 32 days) bins



# Summary

- MAXI has discovered 17 X-ray transients.
  - 6 BHCs, (6 or) 9 NS binaries, 1 SSS, and (4 or) 1 unknown
- Are we observing distant BHCs in our Galaxy ?
  - Yes. Probably, more than 10 kpc distance
  - But, fewer than expected. Because ..
    - No bright XNe for > 7 yrs, and No XNe for ~3 yrs
    - But, recurrent XNe were detected.
- Are we observing LMXBs wandering in halo ?
  - Yes. But, we need more statistical study to obtain firm conclusion.
- Short Soft X-ray Transients are very interesting.
- More faint XNe will be detected soon by using longer time bins.