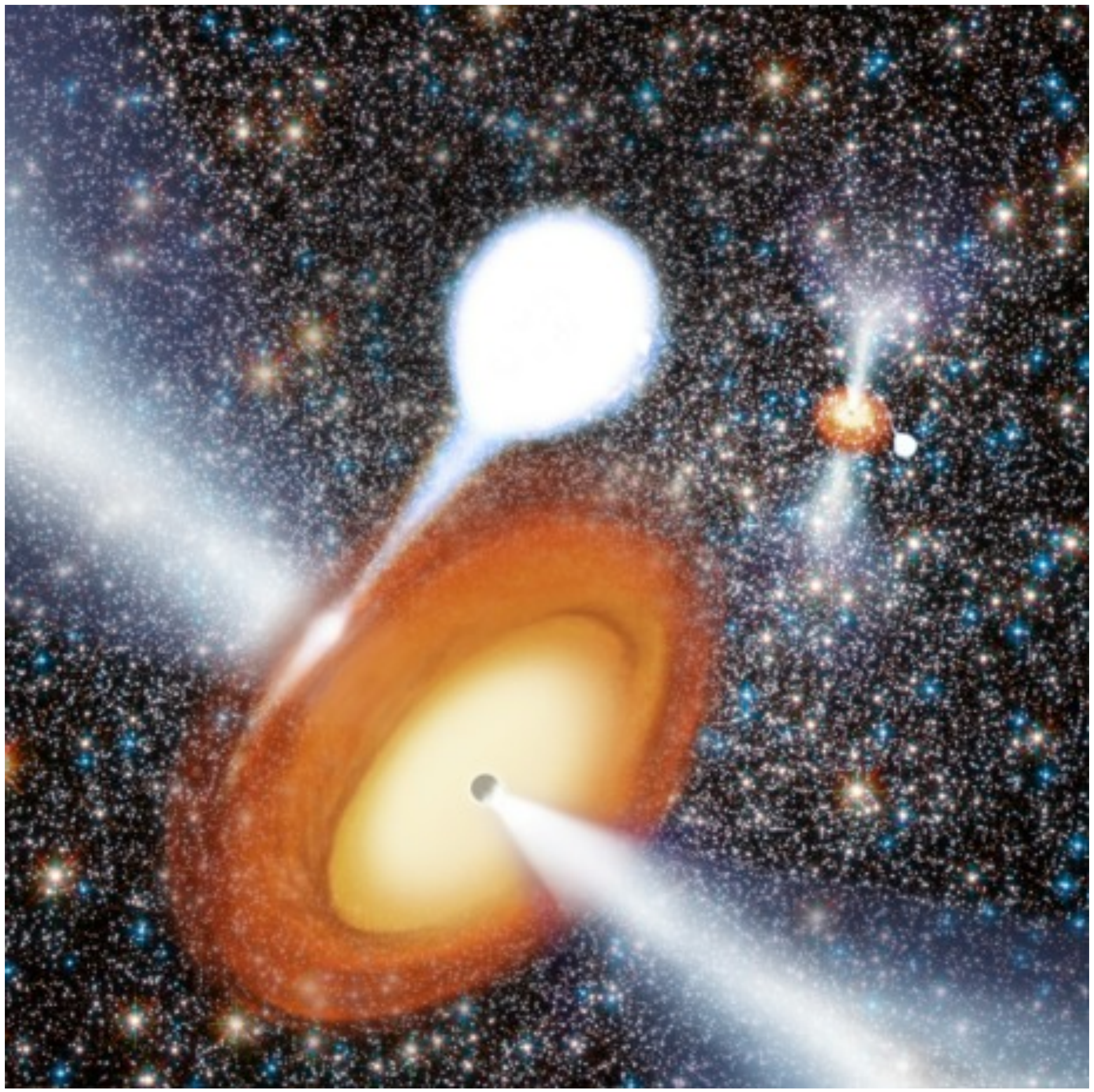
Black holes in globular clusters

Jay Strader (Michigan St)



with

Laura Chomiuk (Michigan St)
Laura Shishkovsky (Michigan St)
Tom Maccarone (Texas Tech)
James Miller-Jones (Curtin)
Craig Heinke (Alberta)
Greg Sivakoff (Alberta)
Anil Seth (Utah)
Eva Noyola (UNAM)

Why do we care?

(i) Can study physics of low-luminosity BH accretion for well-defined sample

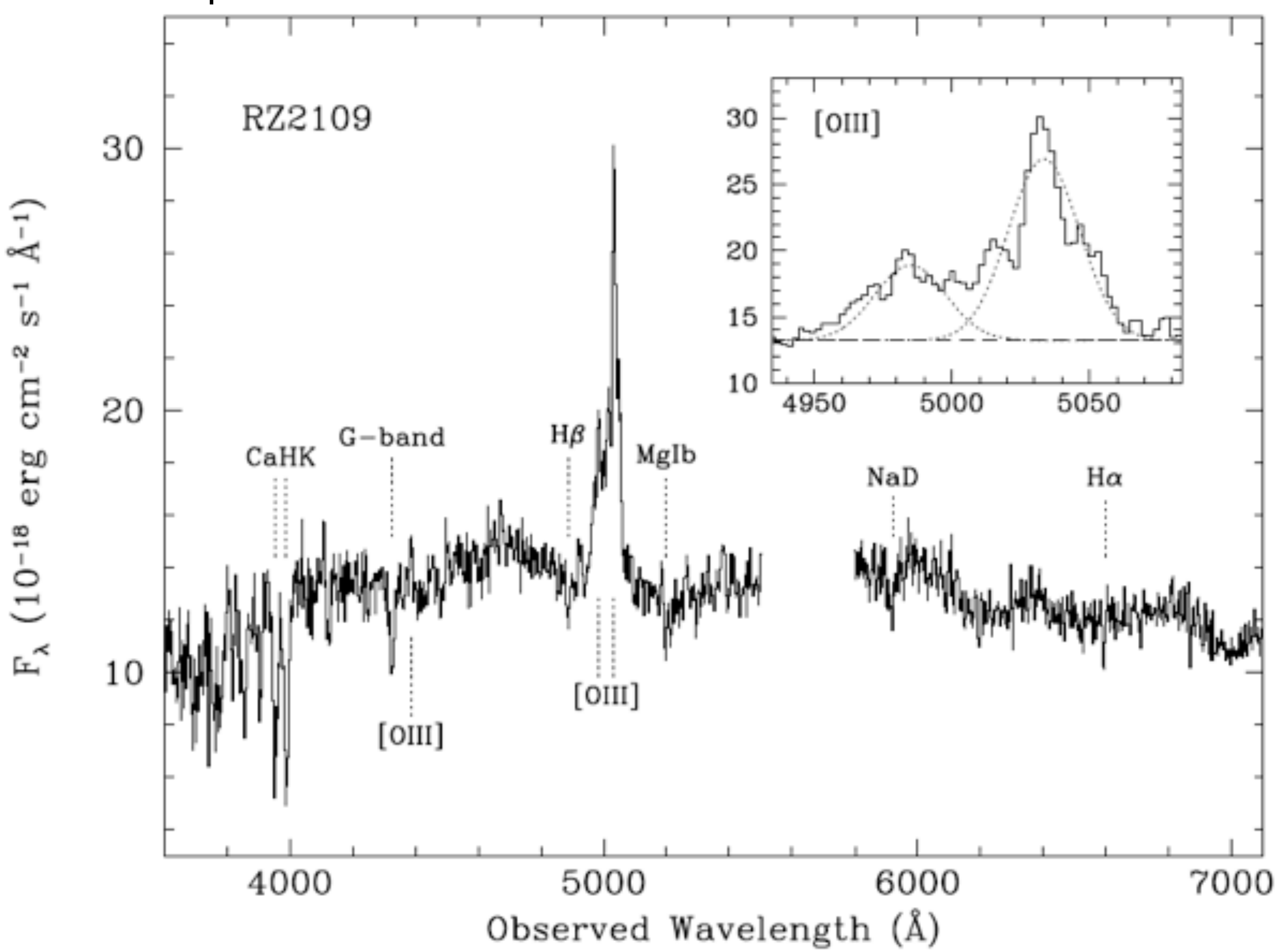
(ii) Could find more massive BHs

(iii) Would increase expected rate of BH-BH and BH-pulsar binaries in local universe

(iv) will affect evolution of globular clusters

BHs in extragalactic GCs

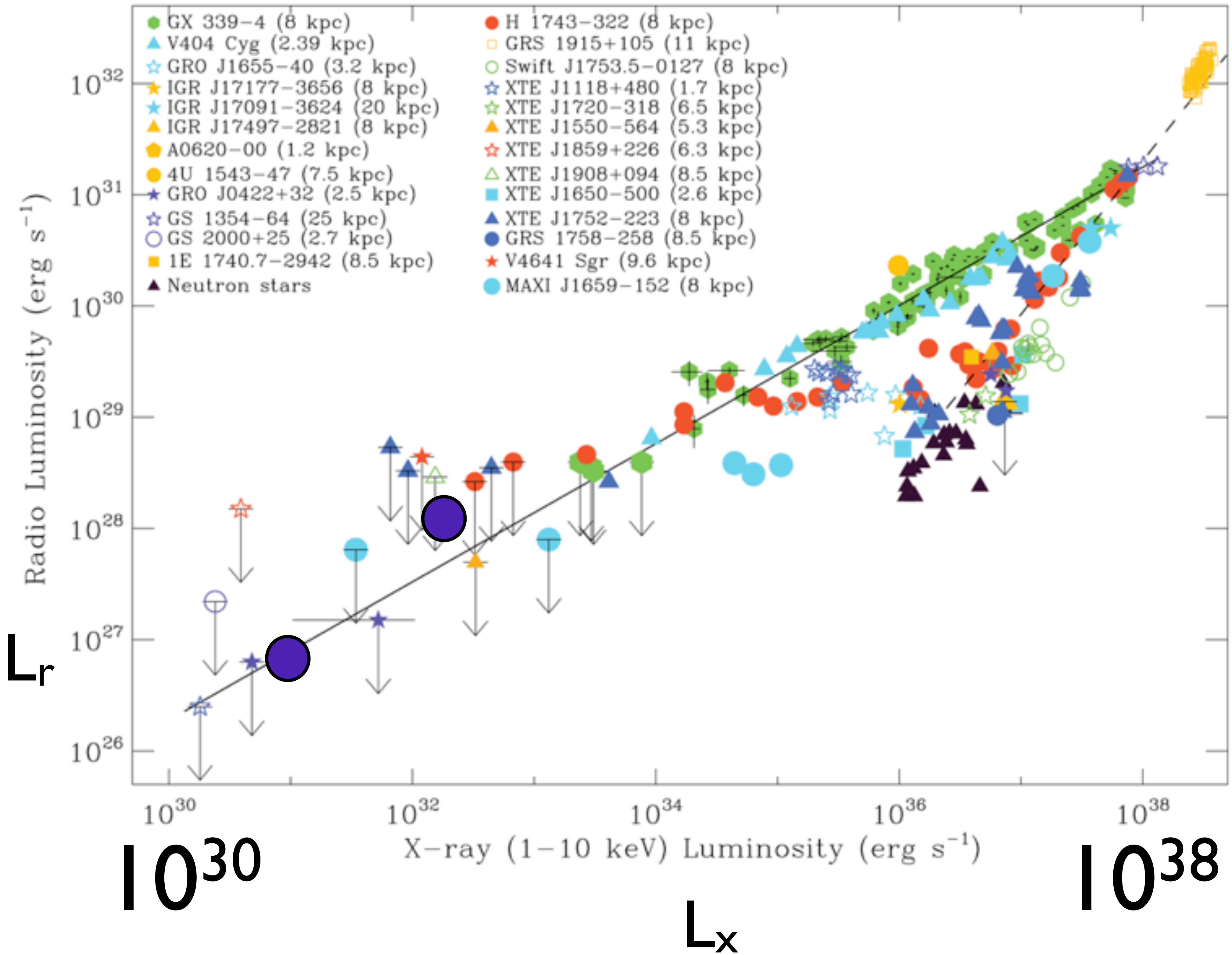
Zepf et al 2008



~ 5 sources >> L_{edd} for a NS

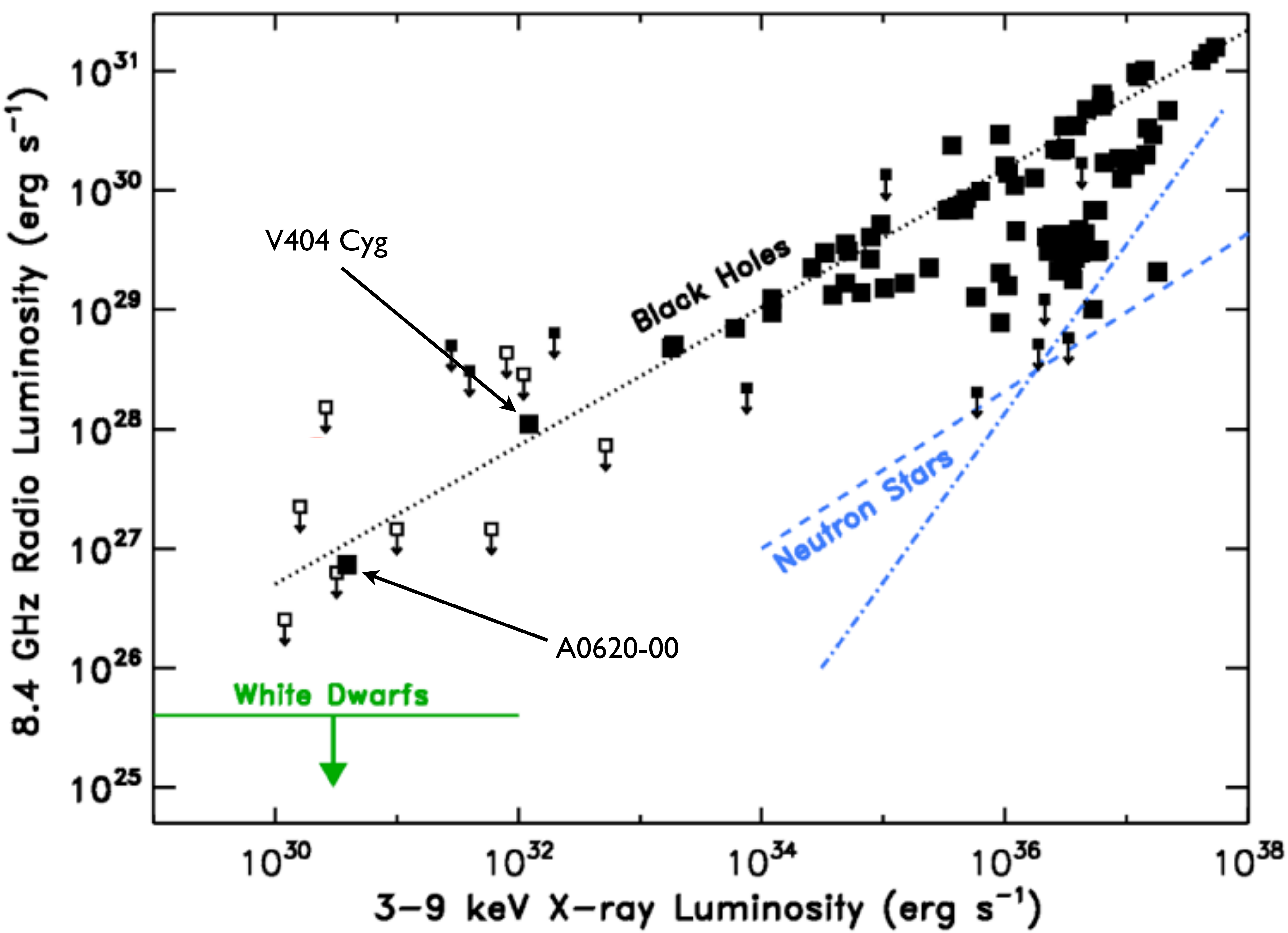
Faint BHs: Easier to Find in Radio

Corbel et al. 2013



$L_r \sim L_x^{0.6}$

Radio & X-ray

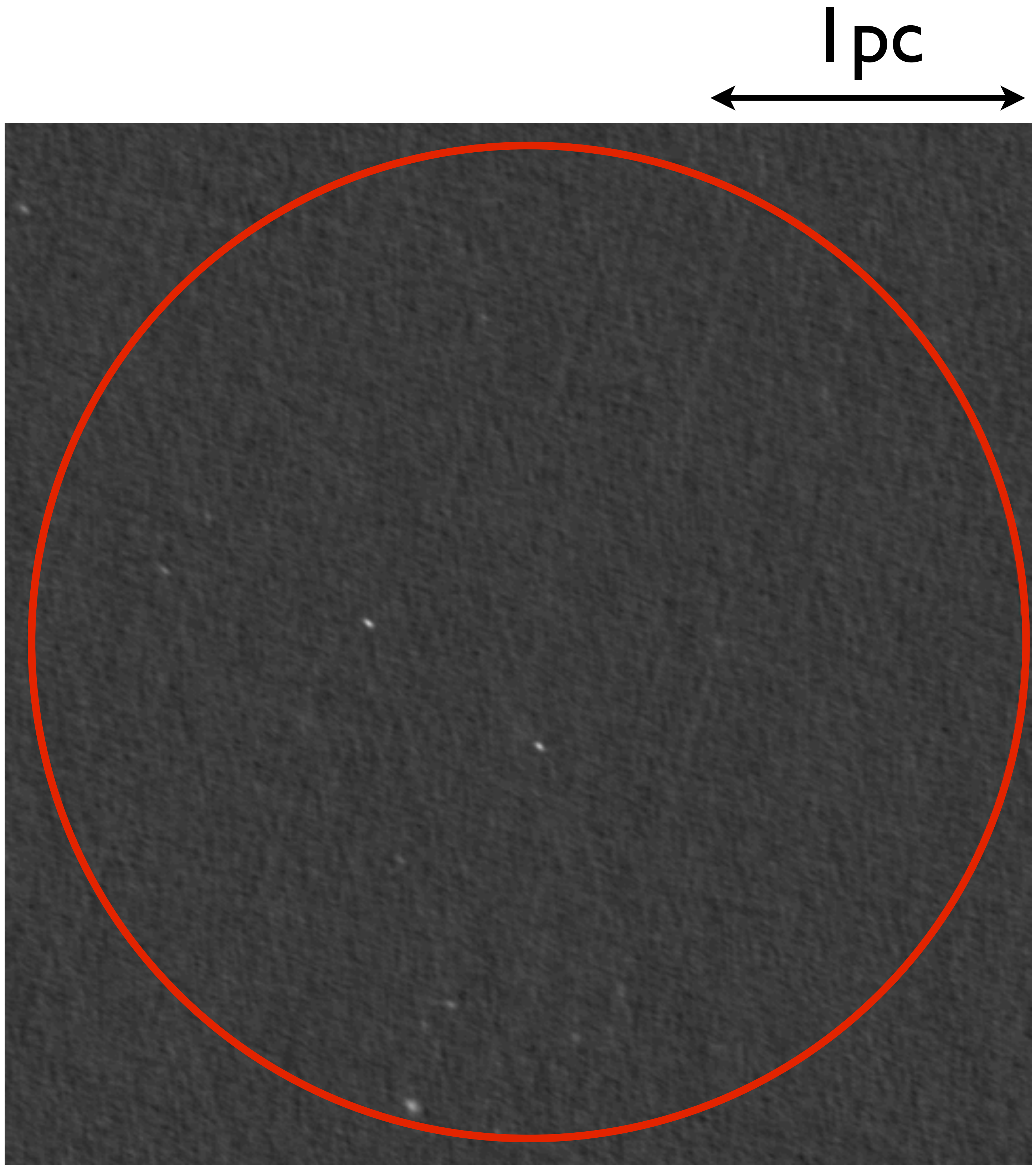


BH much brighter than NS or WD in radio

Karl G. Jansky VLA

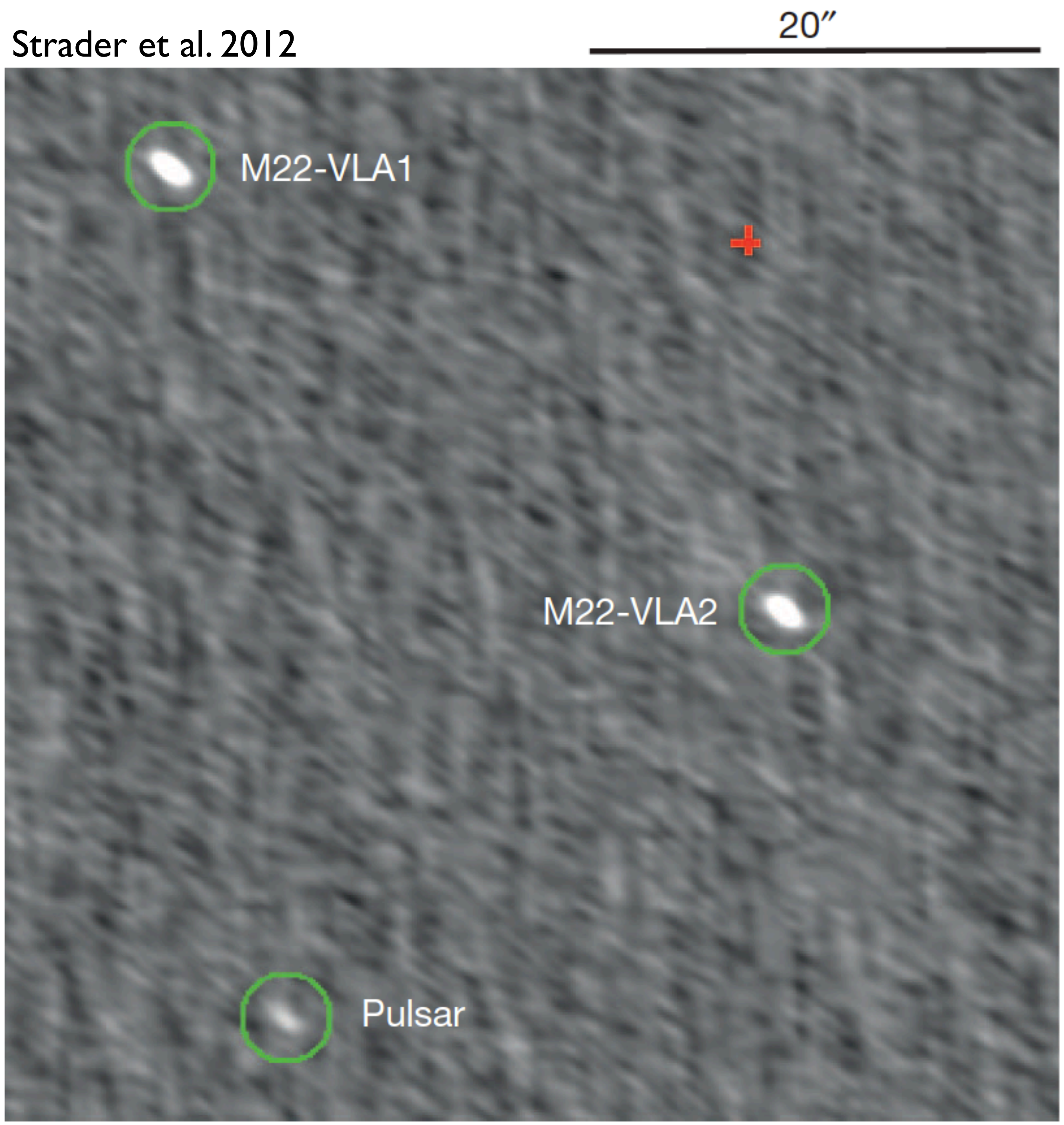
Approved Large Program: The Comprehensive VLA Survey for Black Holes in Globular Clusters

Radio: M22



M22: Central sources

Strader et al. 2012



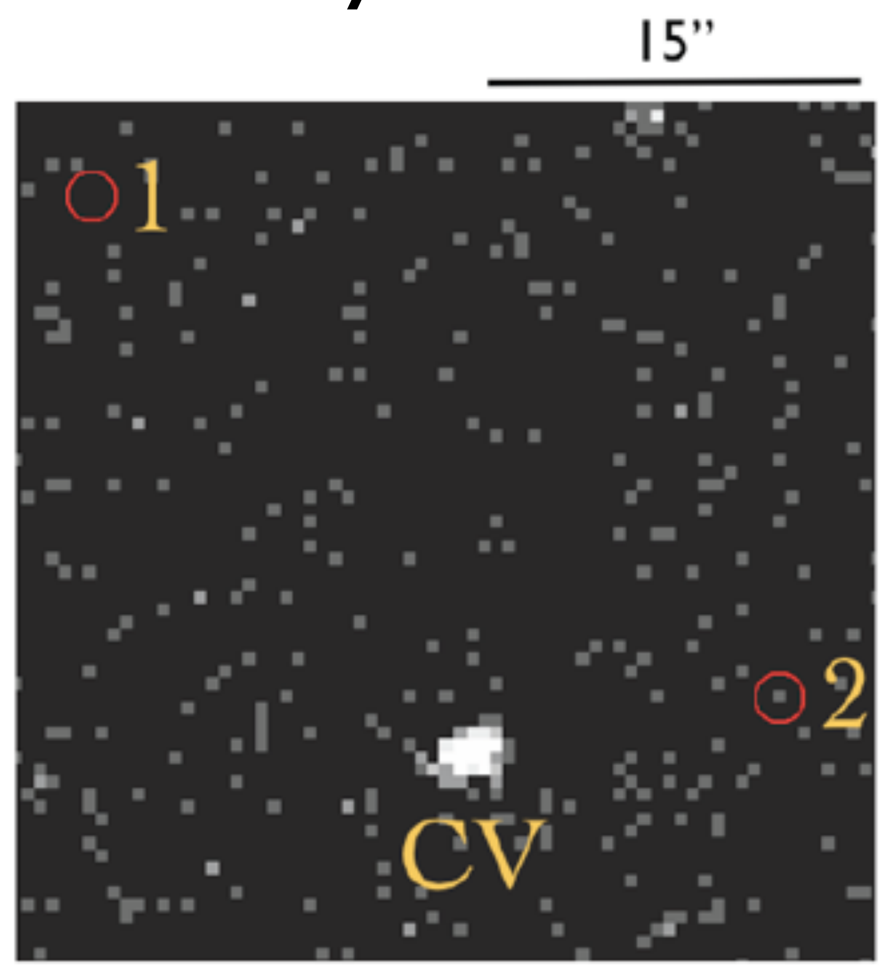
VLA

flux density ~ 55-60 uJy

flat spectrum: $S \sim \nu^{0.0\text{-}0.2}$

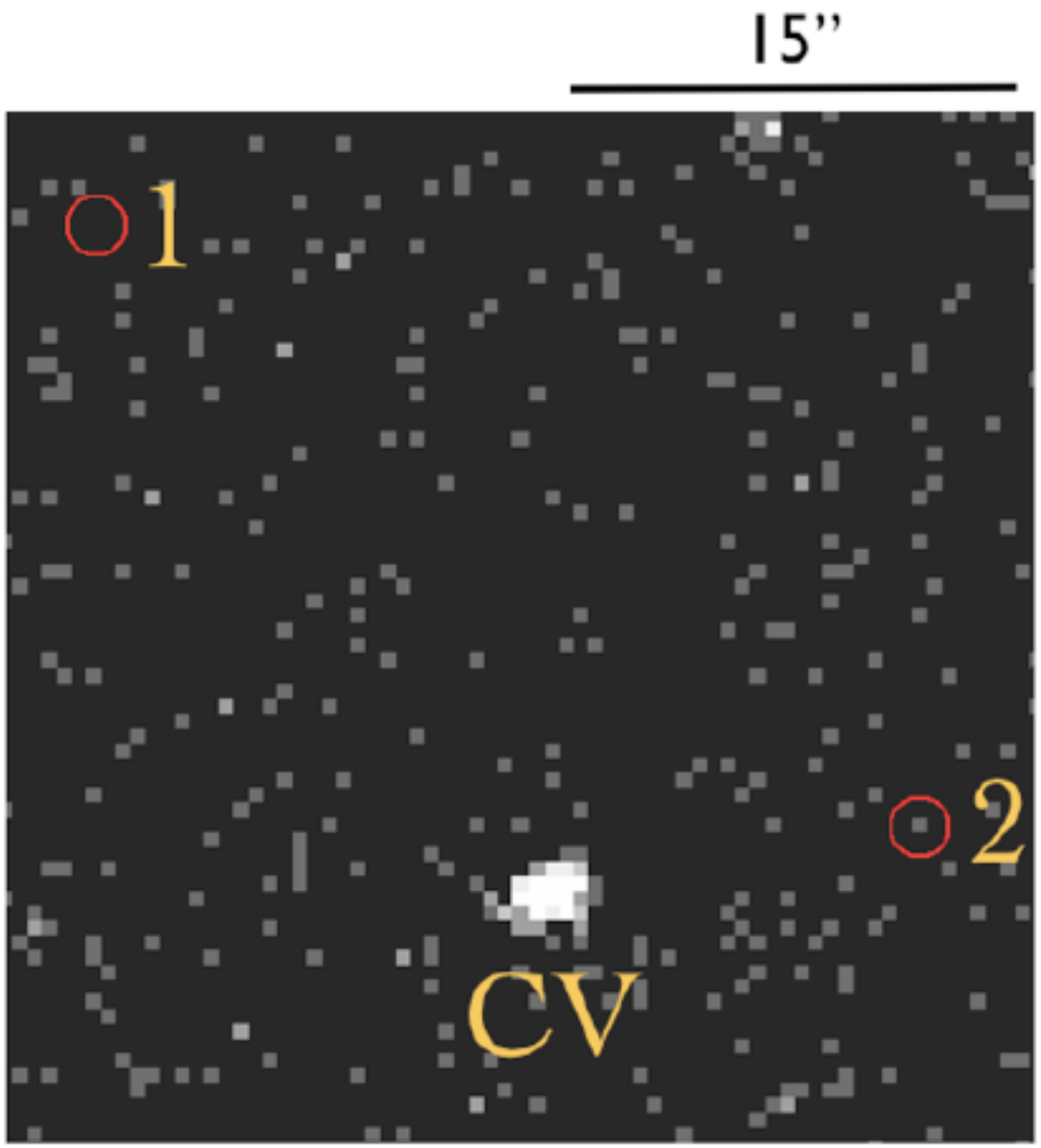
central spatial location

no X-rays

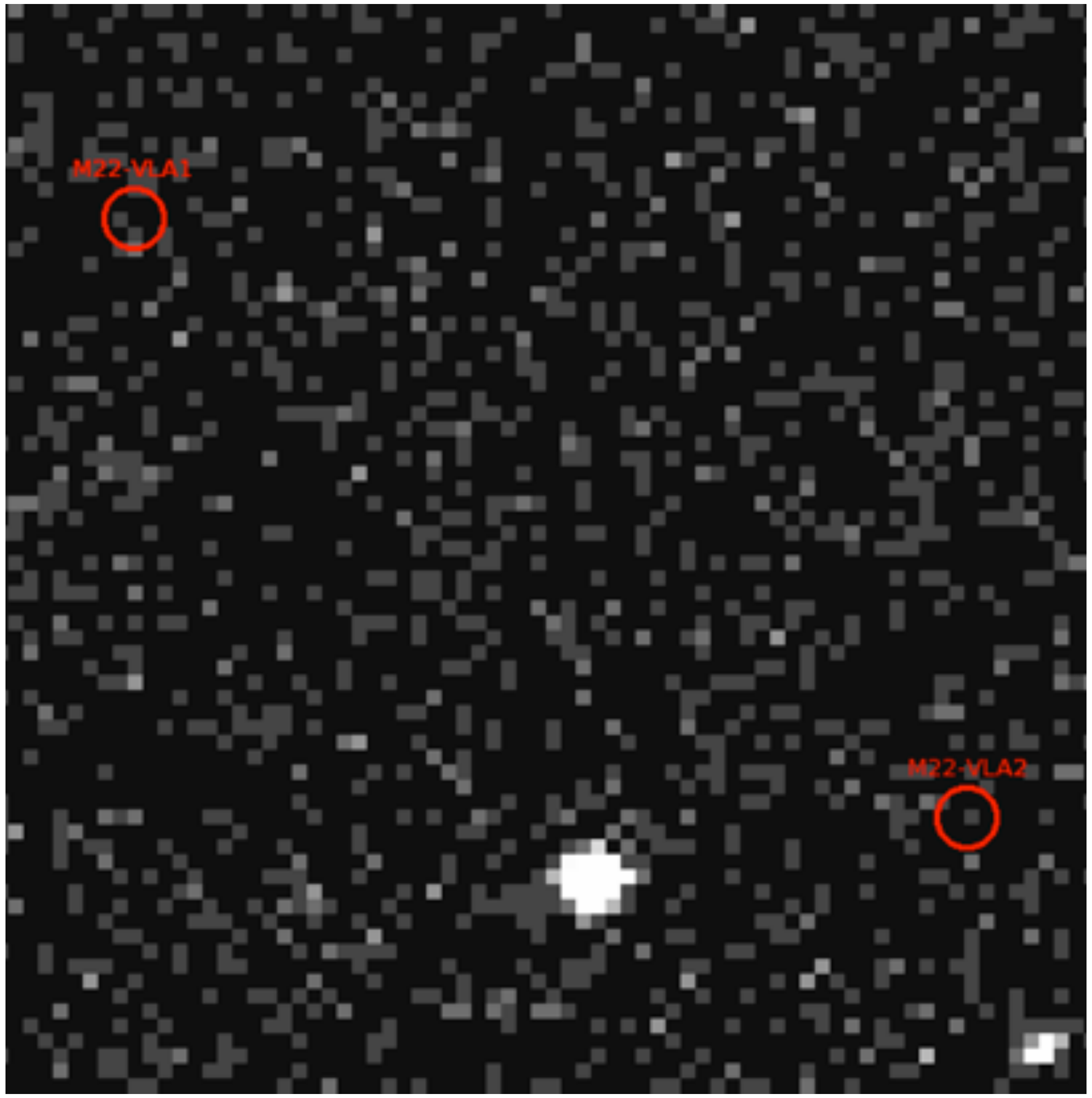


Chandra

New Chandra Data

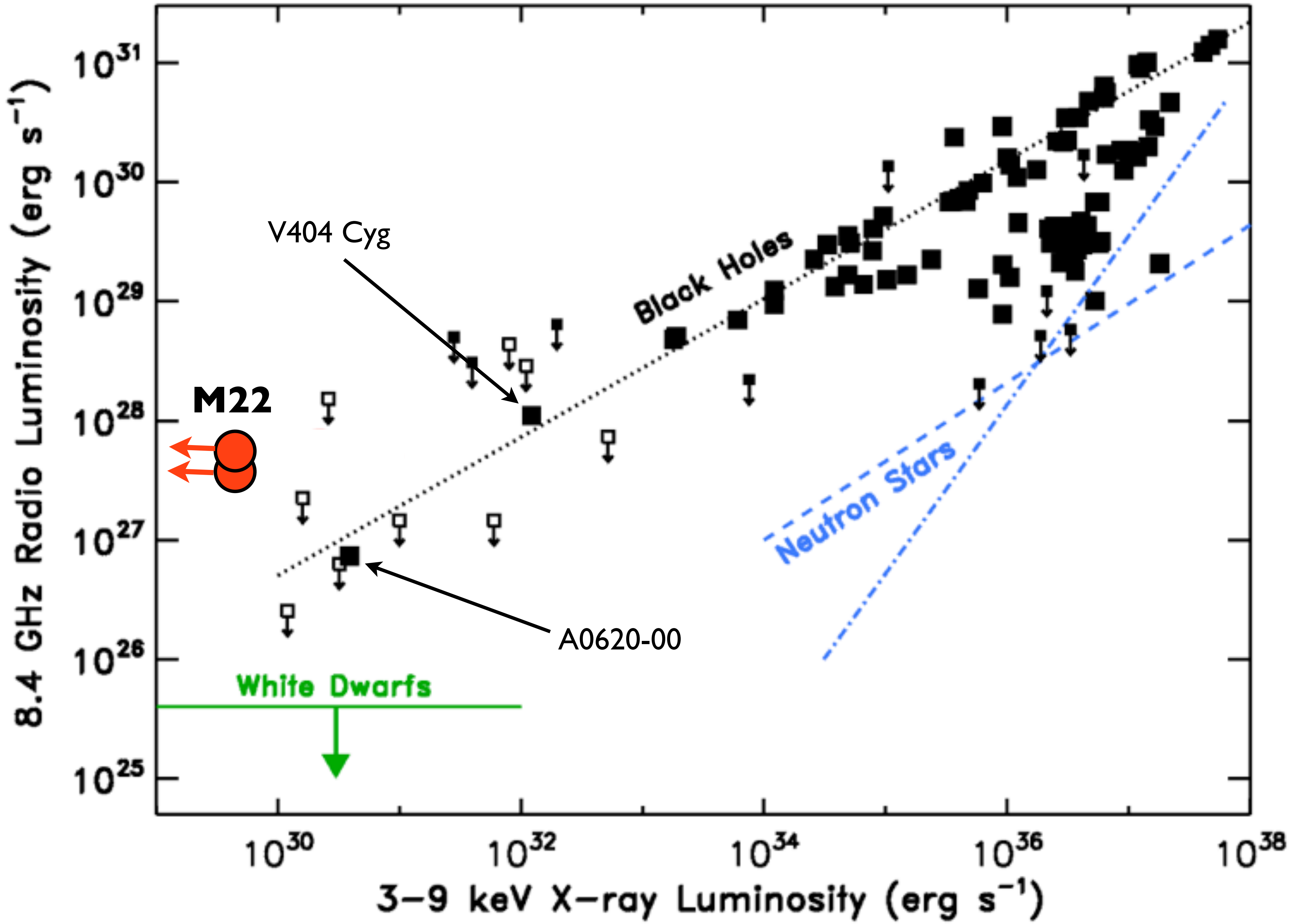


Chandra (2002)



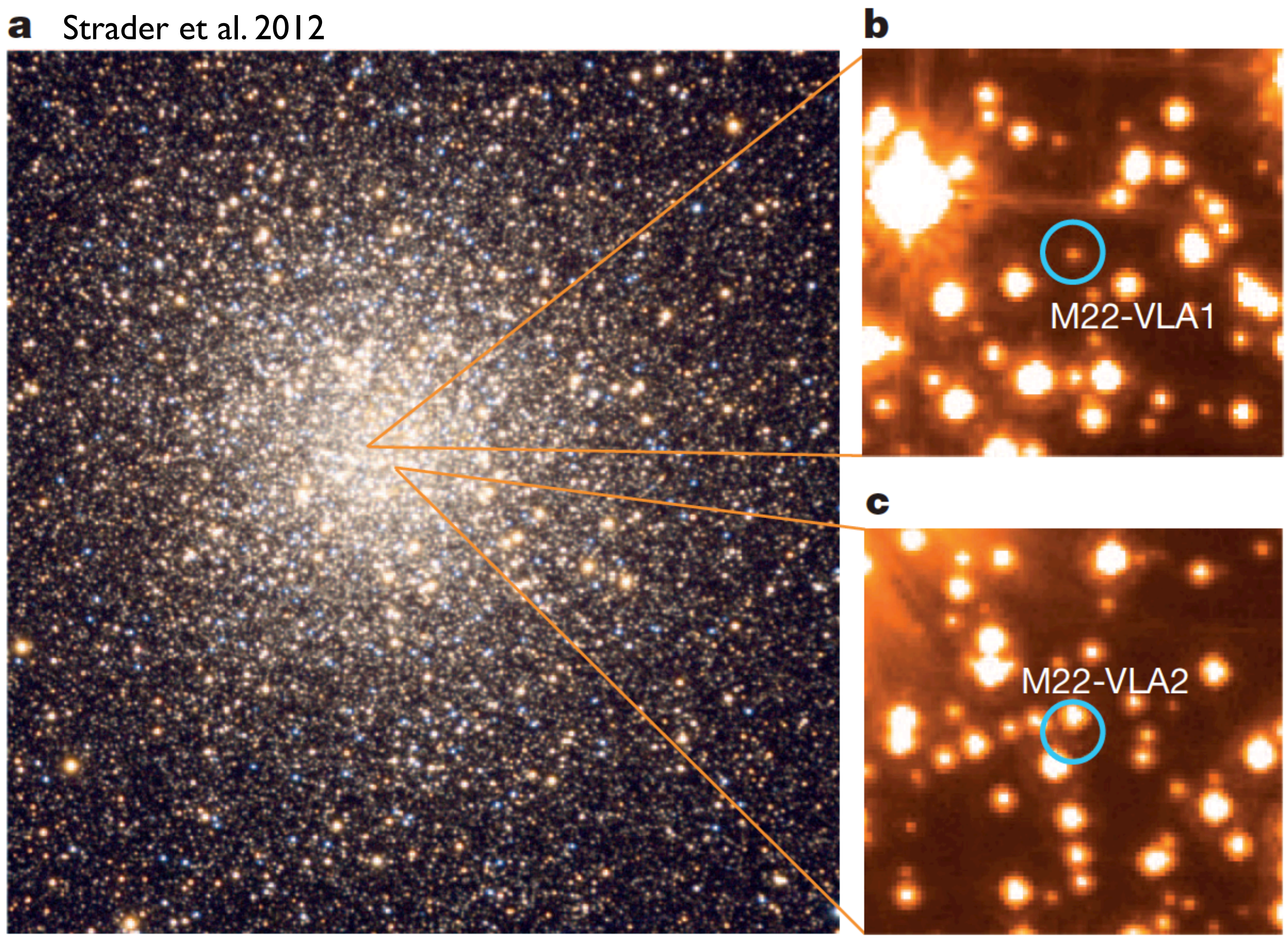
Chandra (2014)

Radio & X-ray



M22
V404 Cyg
A0620-00
Black Holes
Neutron Stars
White Dwarfs
8.4 GHz Radio Luminosity (erg s^{-1})
3–9 keV X-ray Luminosity (erg s^{-1})
10^{25}
10^{26}
10^{27}
10^{28}
10^{29}
10^{30}
10^{31}
10^{30}
10^{32}
10^{34}
10^{36}
10^{38}

Optical Counterparts?



$\sim 0.34\ M_\odot$

$\sim 0.6\ M_\odot$ (?)

WD more likely

World's Most Naive Mass Segregation Analysis

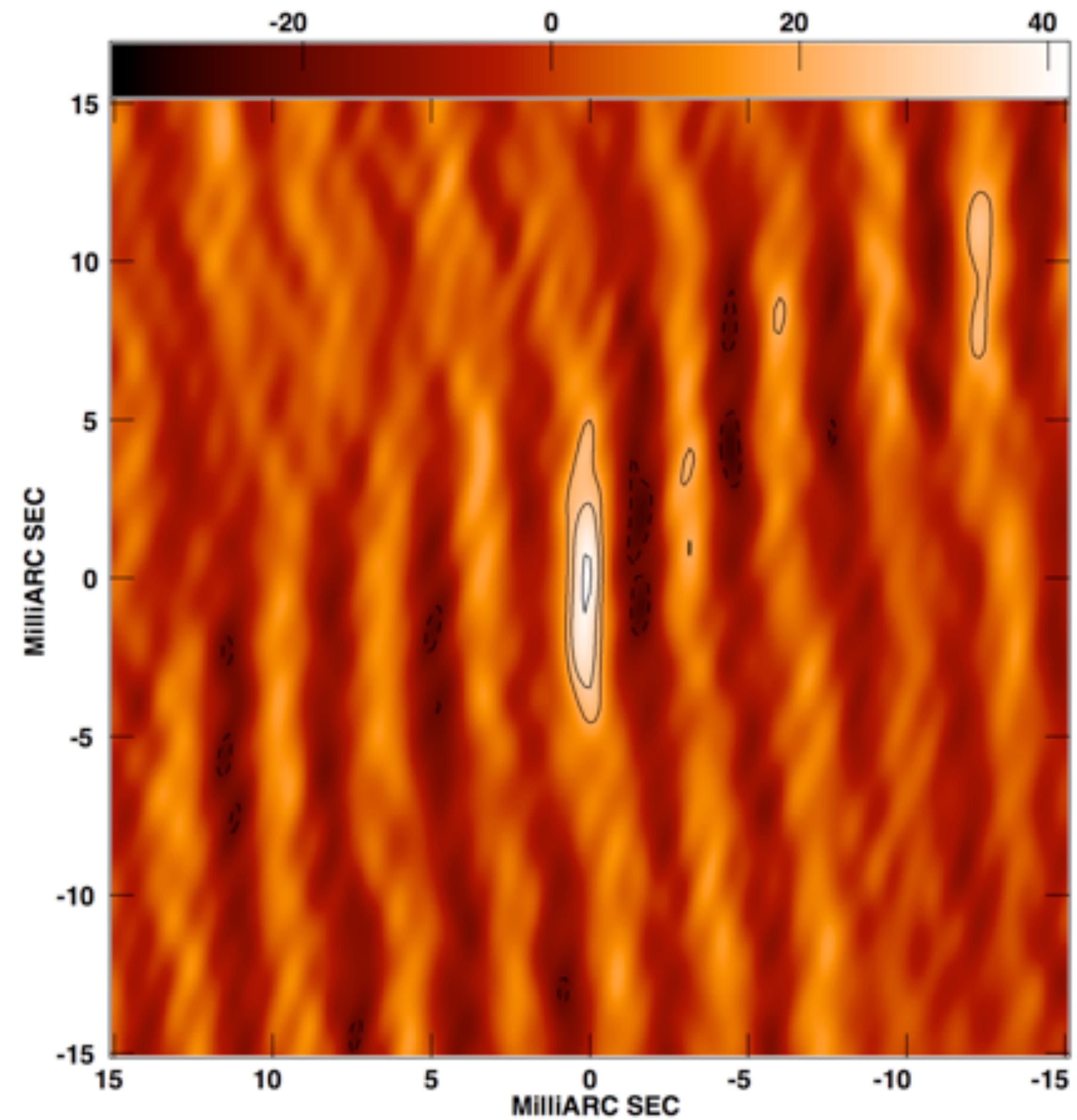
assuming thermalization: $\langle r_{BH} \rangle = 0.26\ r_c \longrightarrow \langle M_{BH} \rangle \sim 15 \langle m_{star} \rangle$

High masses also imply higher radio/X-ray ratio

Halfway to Proper Motions

Background sources not 100% ruled out (HSA proper motion obs---first epoch taken in Sep; second messed up; third soon)

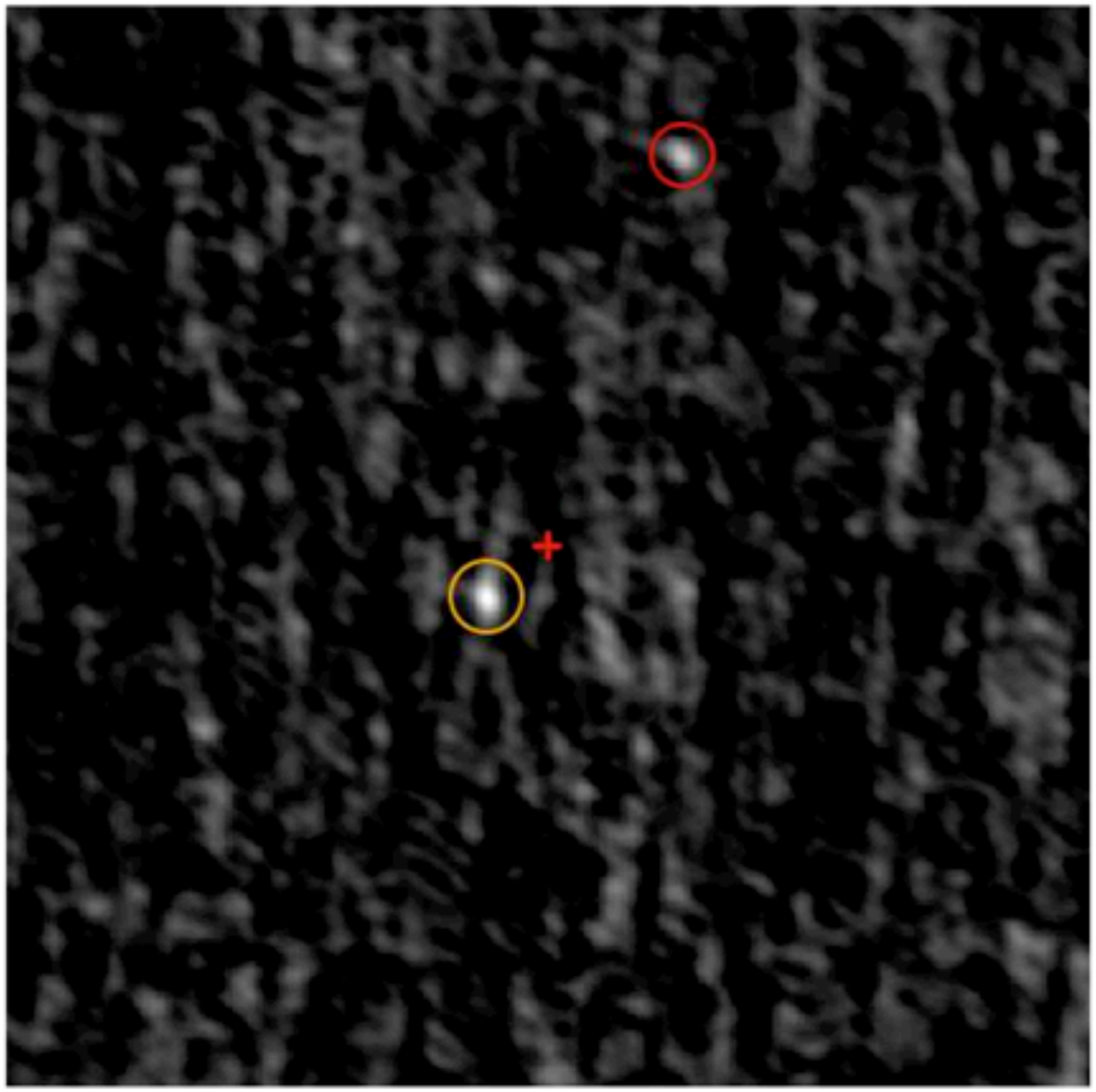
Miller-Jones et al, in prep

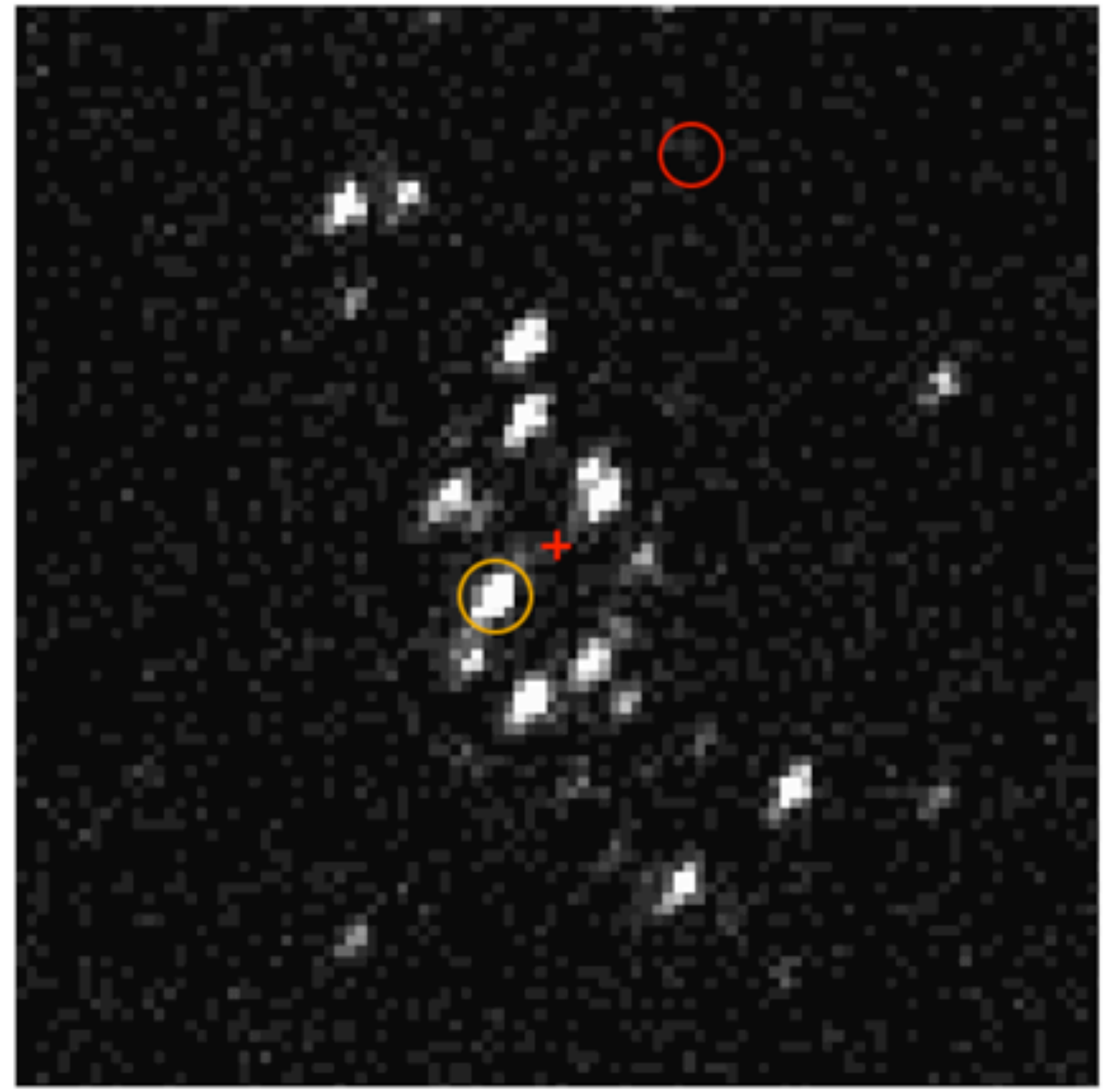


M62: A super-good BH candidate

25''

Chomiuk et al 2013



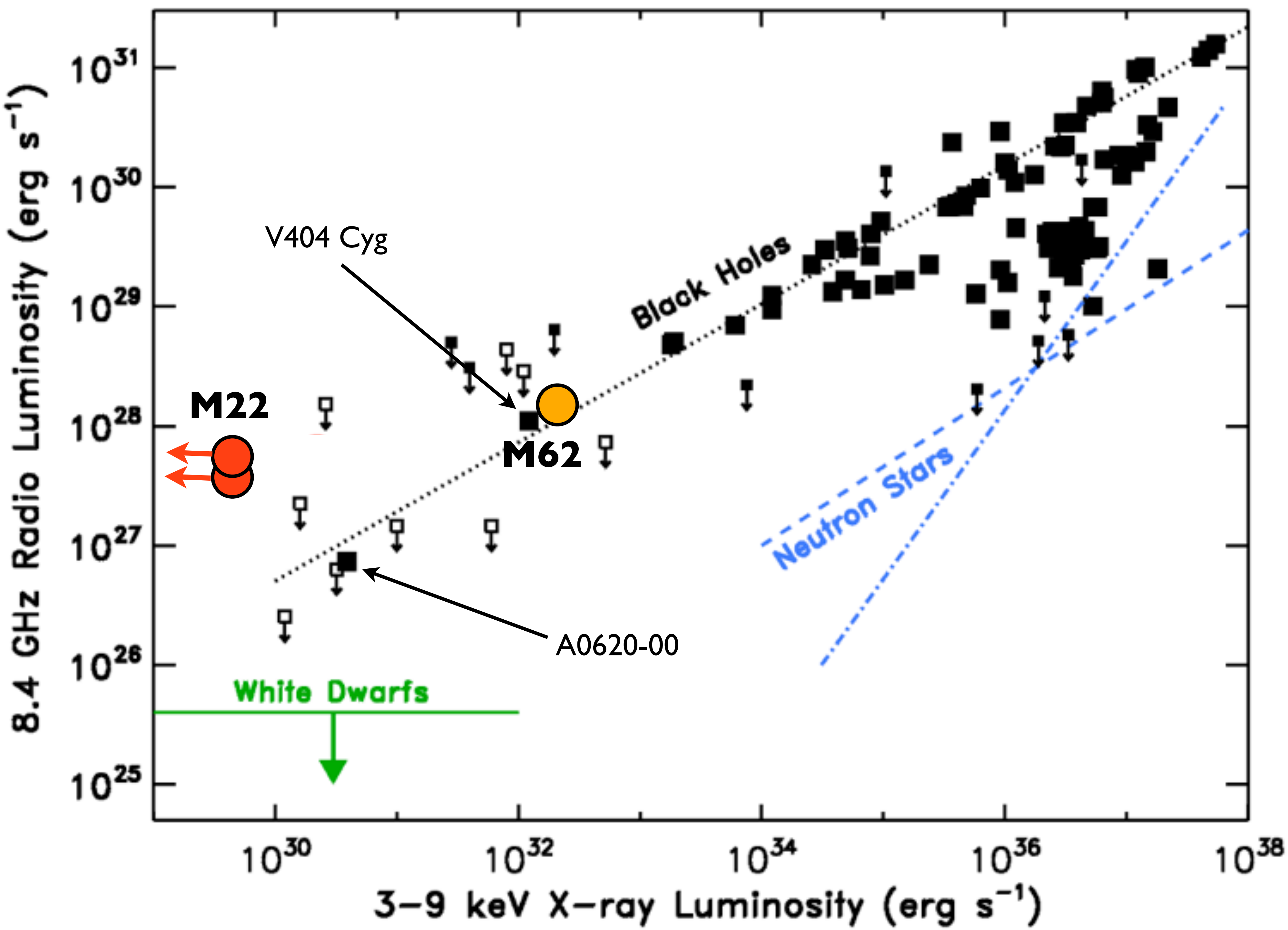


VLA

(only 19 uJy = faint)

Chandra

Radio & X-ray



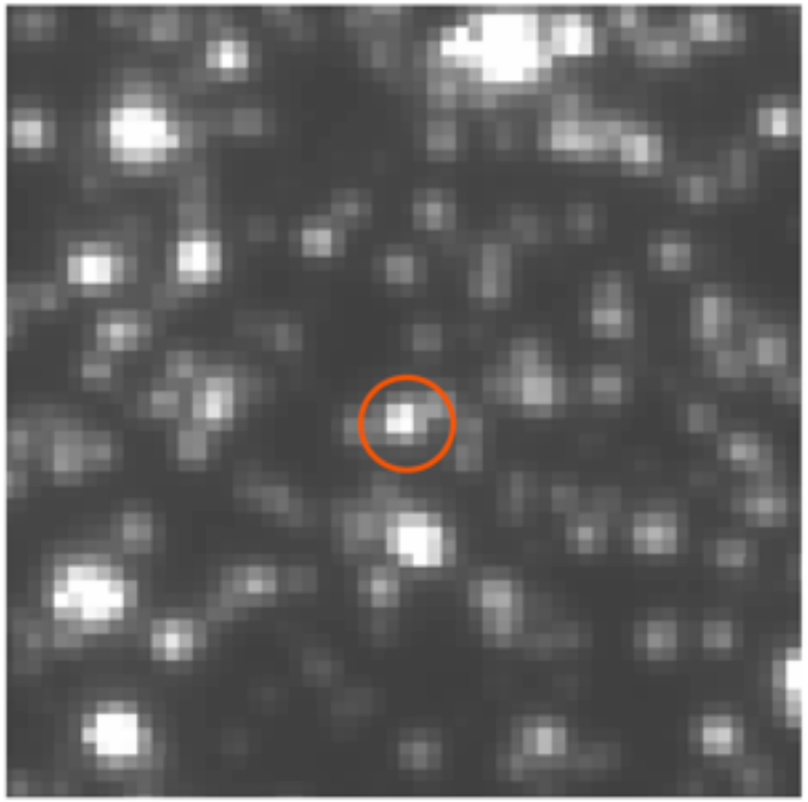
similar to V404 Cyg, which has:

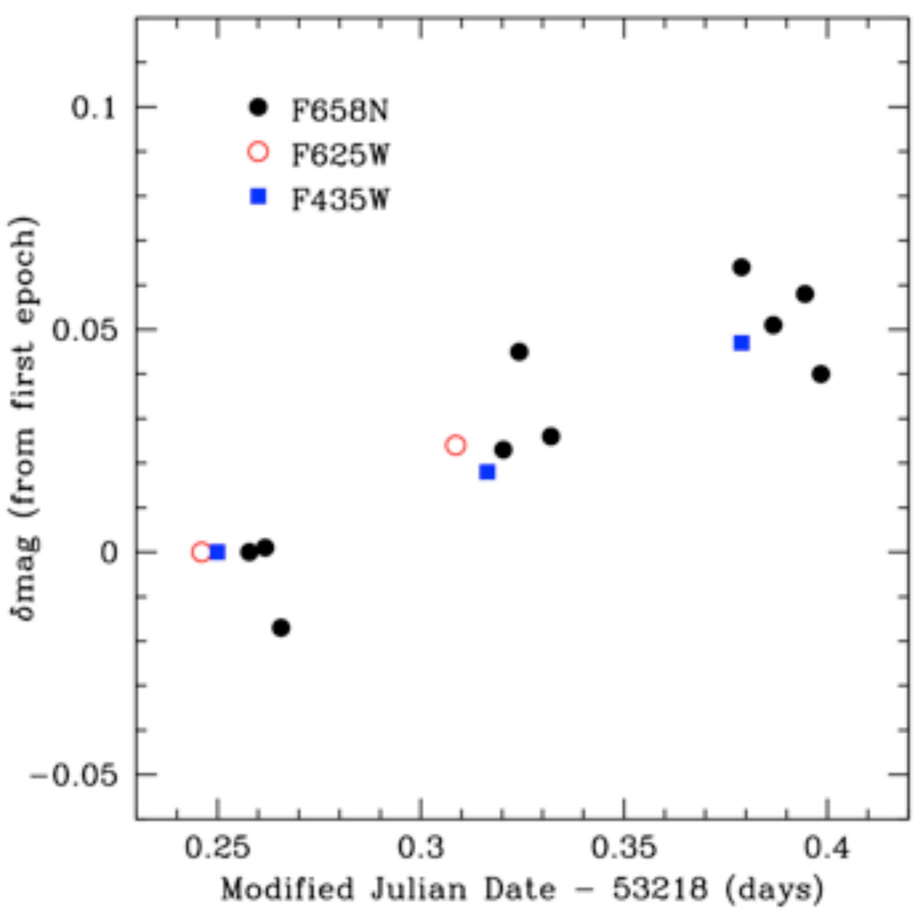
~6.5 d period

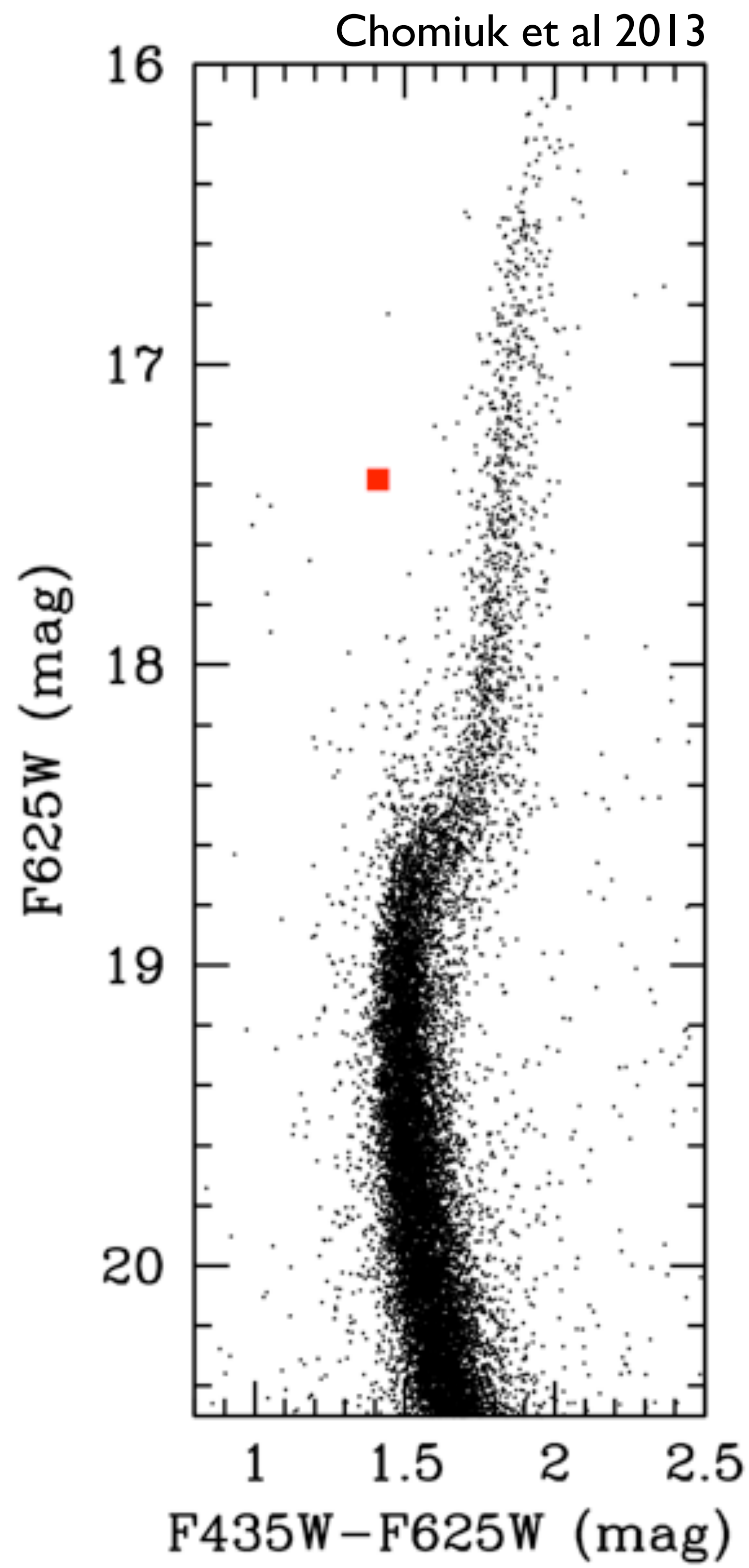
subgiant companion

~ 10 Msun BH

Candidate RG counterpart







VLT proposal for AO RV monitoring should be executed soon

Kobe, August 2012 (MODEST-12)

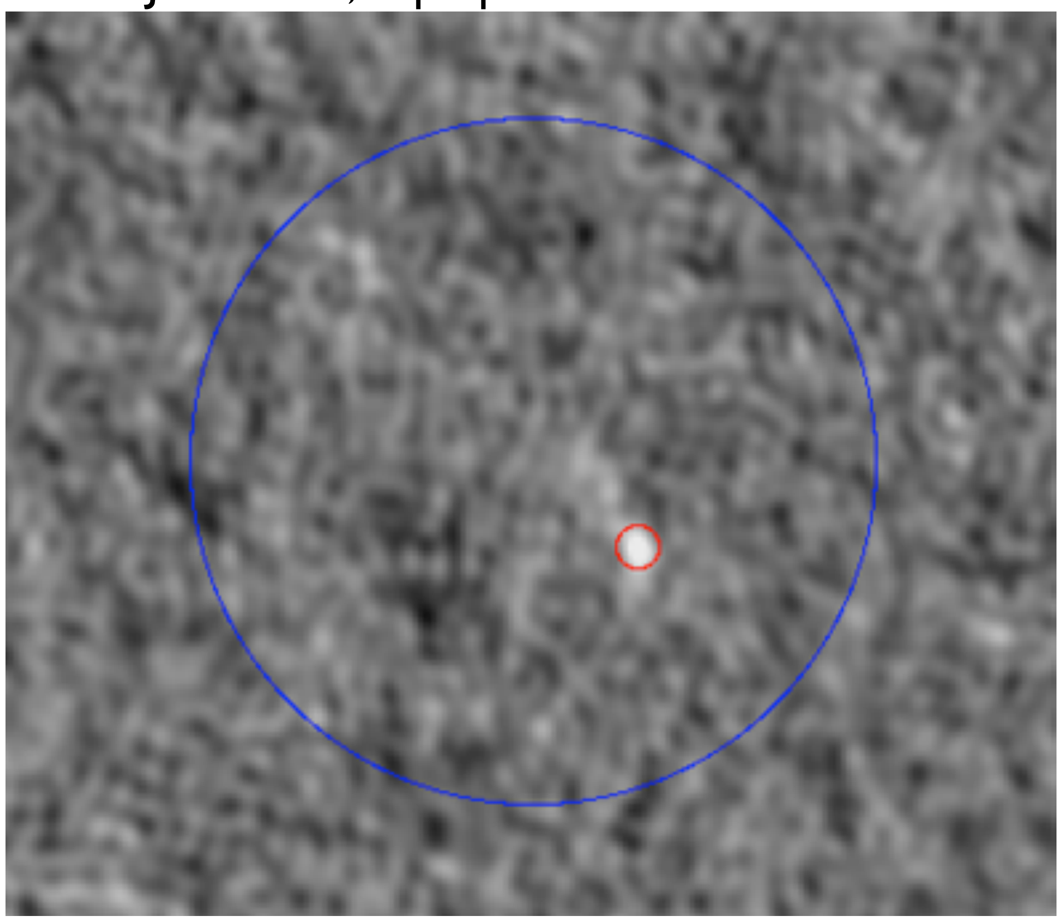
"If any cluster has black holes, it's 47 Tuc."

Douglas Heggie

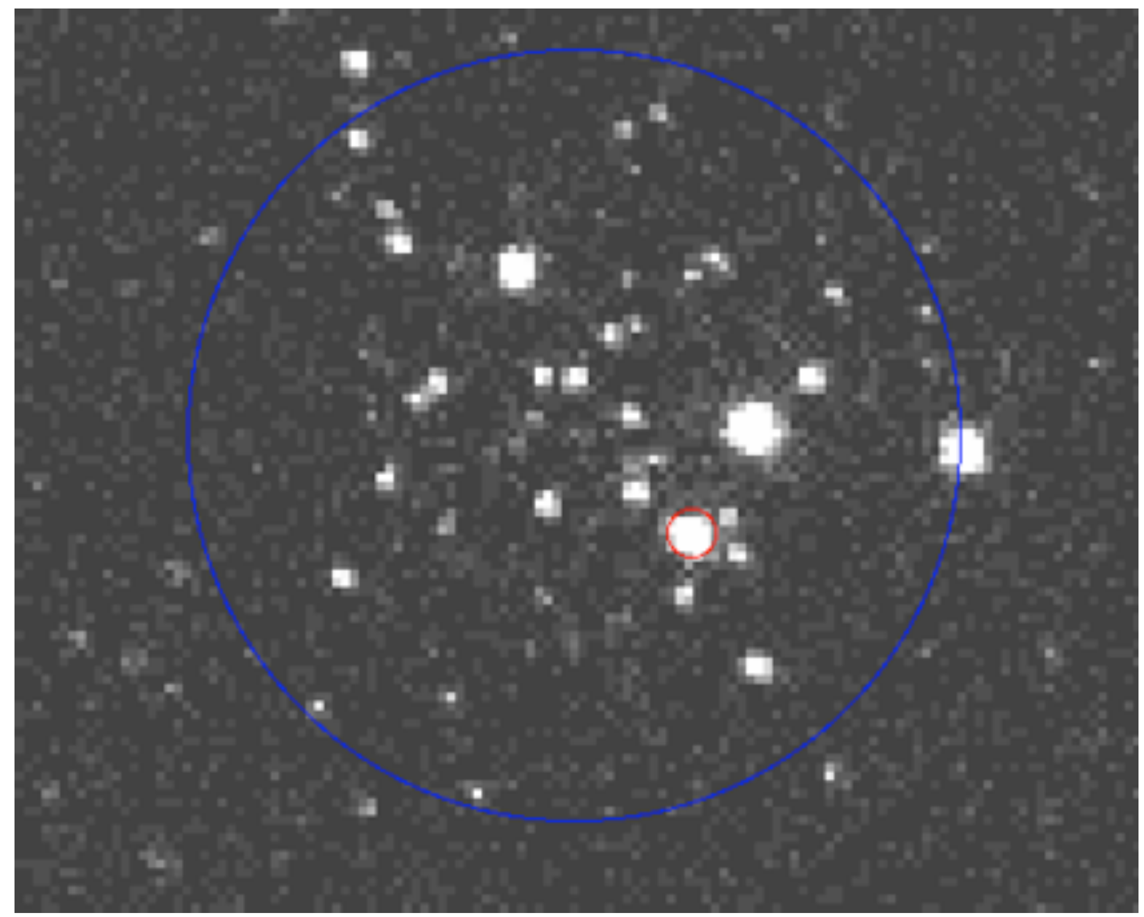
A new candidate in 47 Tuc

20”

Miller-Jones et al, in prep



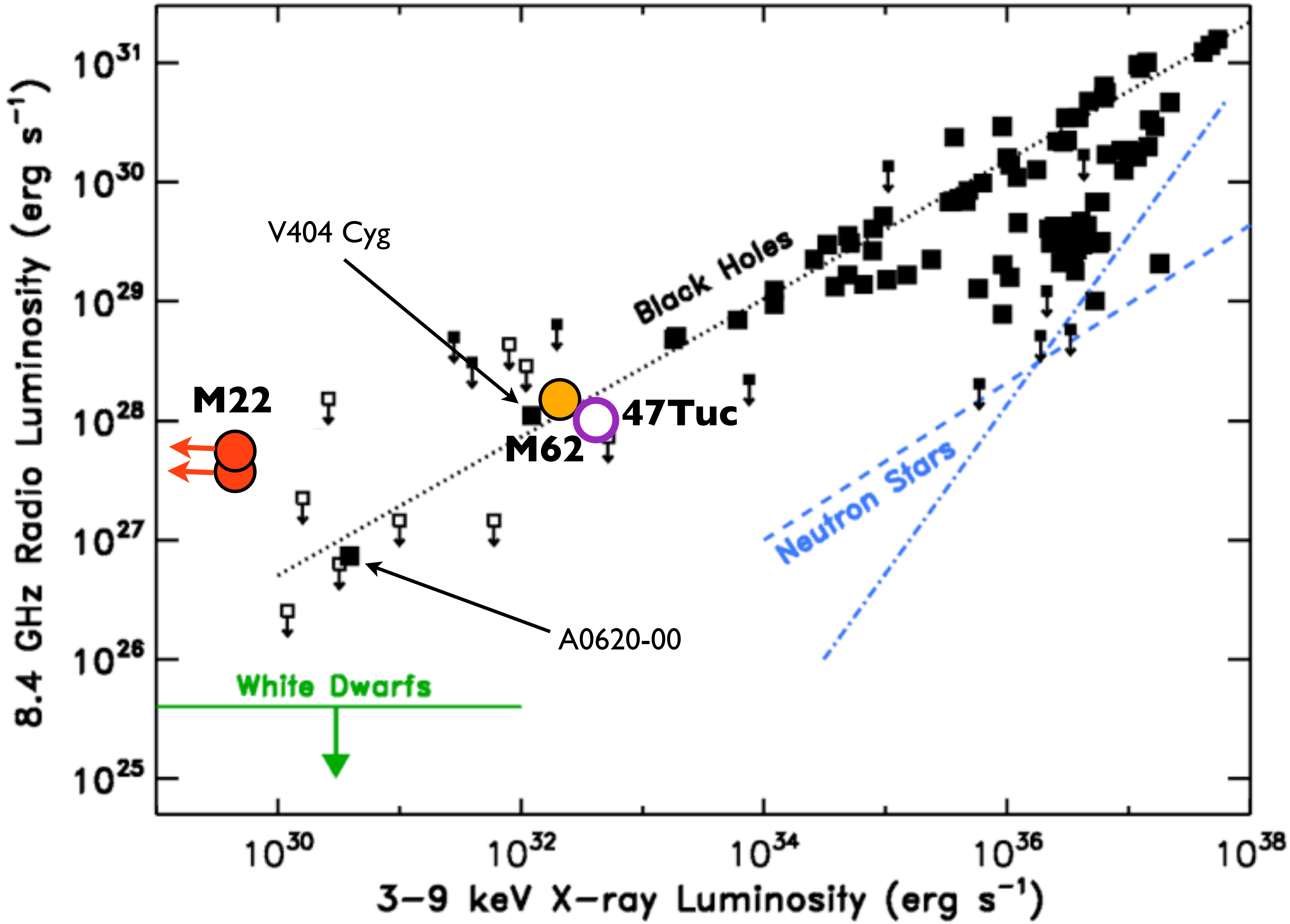
ATCA



Chandra

radio source matches X9=W42=V1

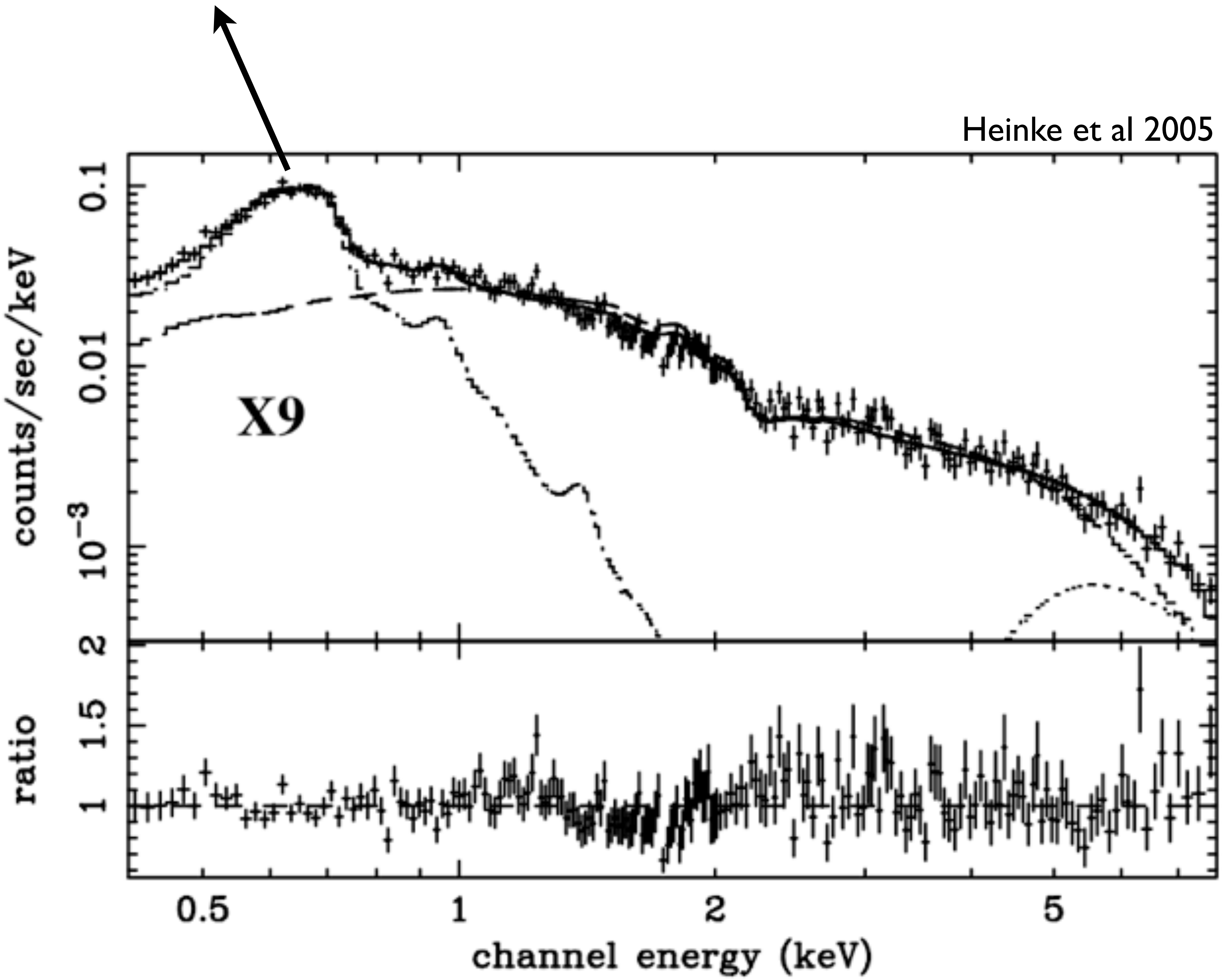
Radio & X-ray



8.4 GHz Radio Luminosity (erg s^{-1})
3–9 keV X-ray Luminosity (erg s^{-1})
10^{31}
10^{30}
10^{29}
10^{28}
10^{27}
10^{26}
10^{25}
10^{30}
10^{32}
10^{34}
10^{36}
10^{38}
V404 Cyg
Black Holes
M22
M62
47Tuc
Neutron Stars
A0620-00
White Dwarfs

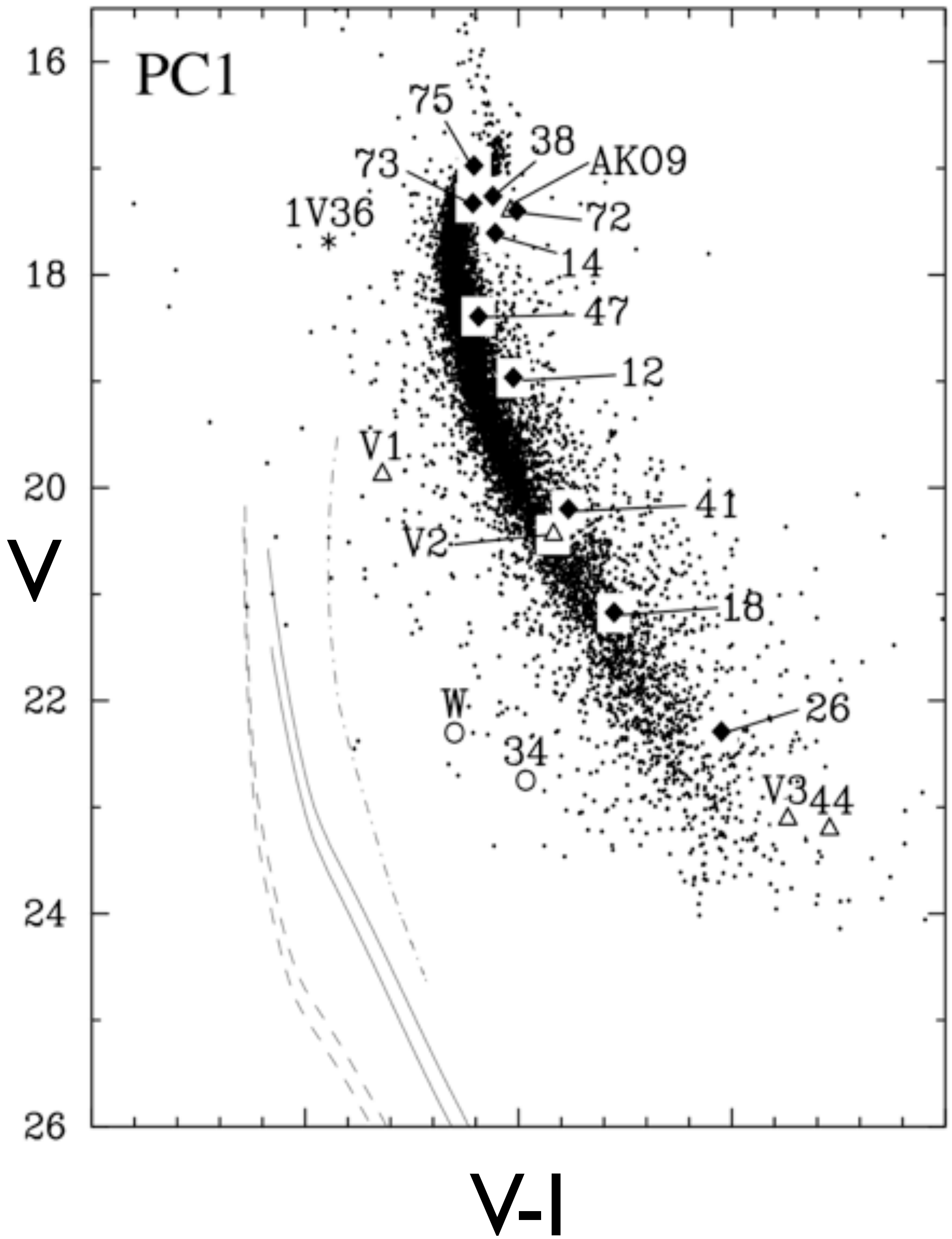
X-ray Data

probably OVIII (very strong!)

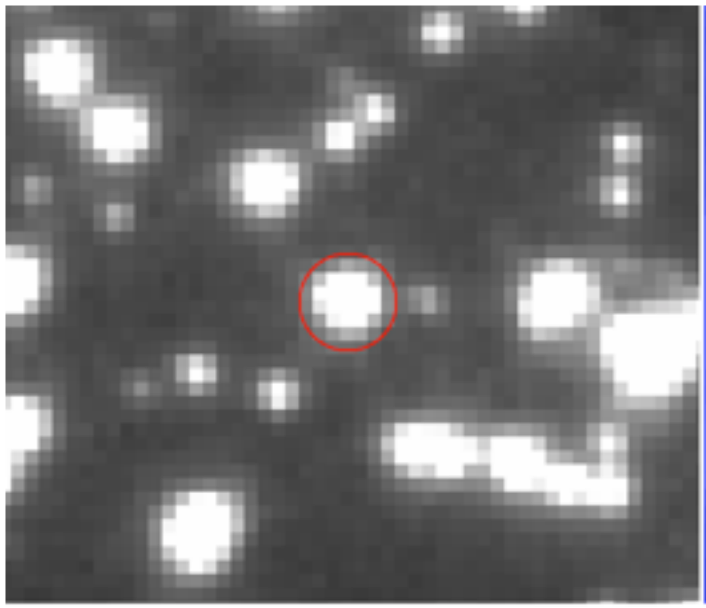


UV/Optical Data

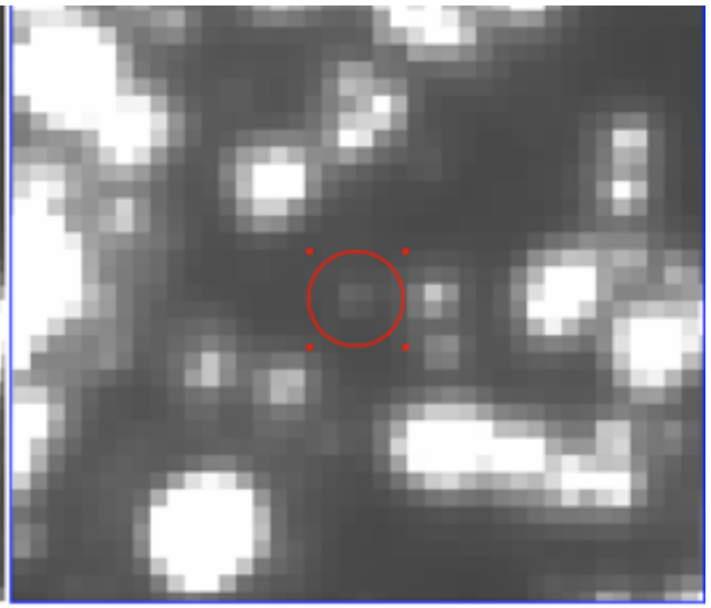
Edmonds et al 2003



Optical counterpart is well-known UV-bright variable (period unclear)



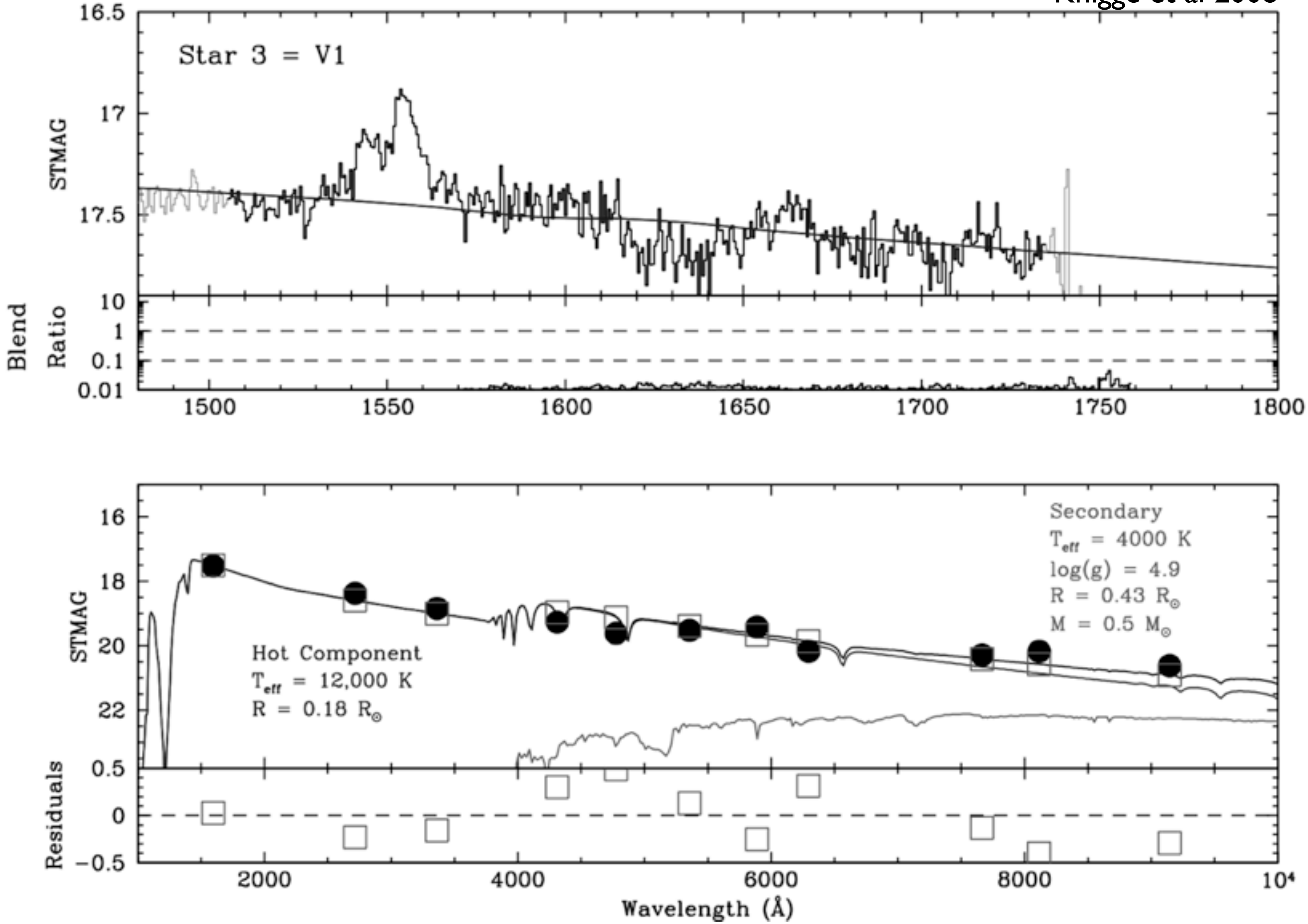
HST (275W)



HST (814W)

UV/Optical Data

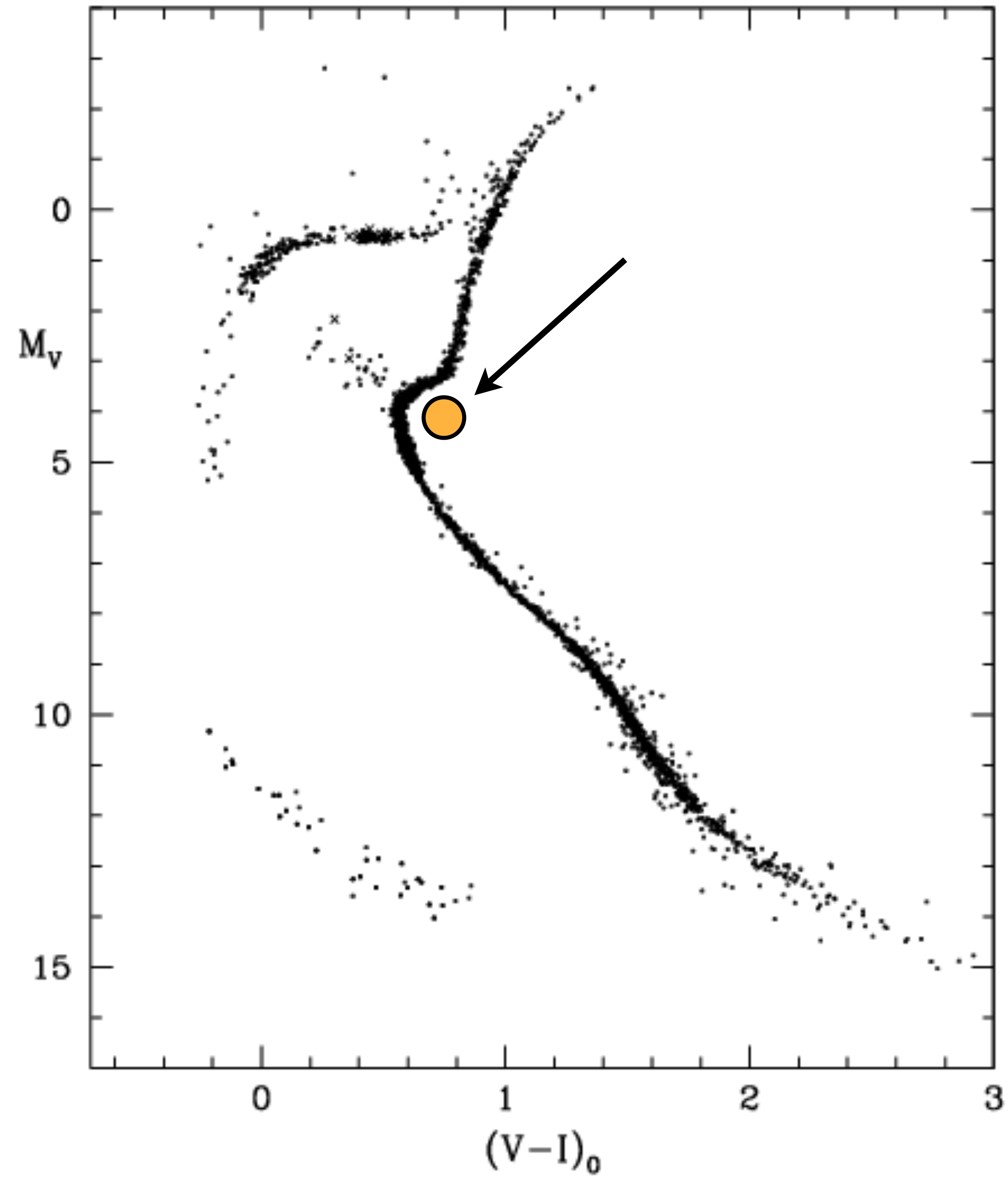
Knigge et al 2008



secondary could be ~ 0.5(?) Msun MS star, or WD

Candidate in [REDACTED]

Harris 2001



"subsubgiant" or
"red straggler"

isolated enough that can get ground-based spectroscopy

SOAR radial velocities show a change of > 100 km/s over a few hours

Scorecard

	# BH	2nd	mass	dist (kpc)	t_{rh} (Gyr)	log rho_0
M22	2	MS/WD	$4 \times 10^5\ M_\odot$	3	2	3.6
M62	1	RG	$10^6\ M_\odot$	7	1	5.2
47 Tuc	1	MS or WD	$10^6\ M_\odot$	5	4	4.9
M15	0		$4 \times 10^5\ M_\odot$	10	2	5.1
M19	0		$7 \times 10^5\ M_\odot$	9	2	4.0
N6397	0		$1 \times 10^5\ M_\odot$	2	0.4	5.8
N6352	0		$5 \times 10^4\ M_\odot$	6	1	3.2
w Cen	0		$3 \times 10^6\ M_\odot$	5	12	3.6

v. prelim candidates in ~ 4 other GCs

Musings

3/8 (~40%) of GCs surveyed have candidate accreting BHs (getting radio data for 18 more GCs)

depending on formation, expect few to many times as many BHs as observed in accreting binaries

Increasing observational evidence for significant population of BH binaries in GCs --- and some may be well-known sources!

Is there any accretion evidence for IMBHs in Galactic GCs?

No.