Strong Limits on Accreting IMBHs in Globular Clusters

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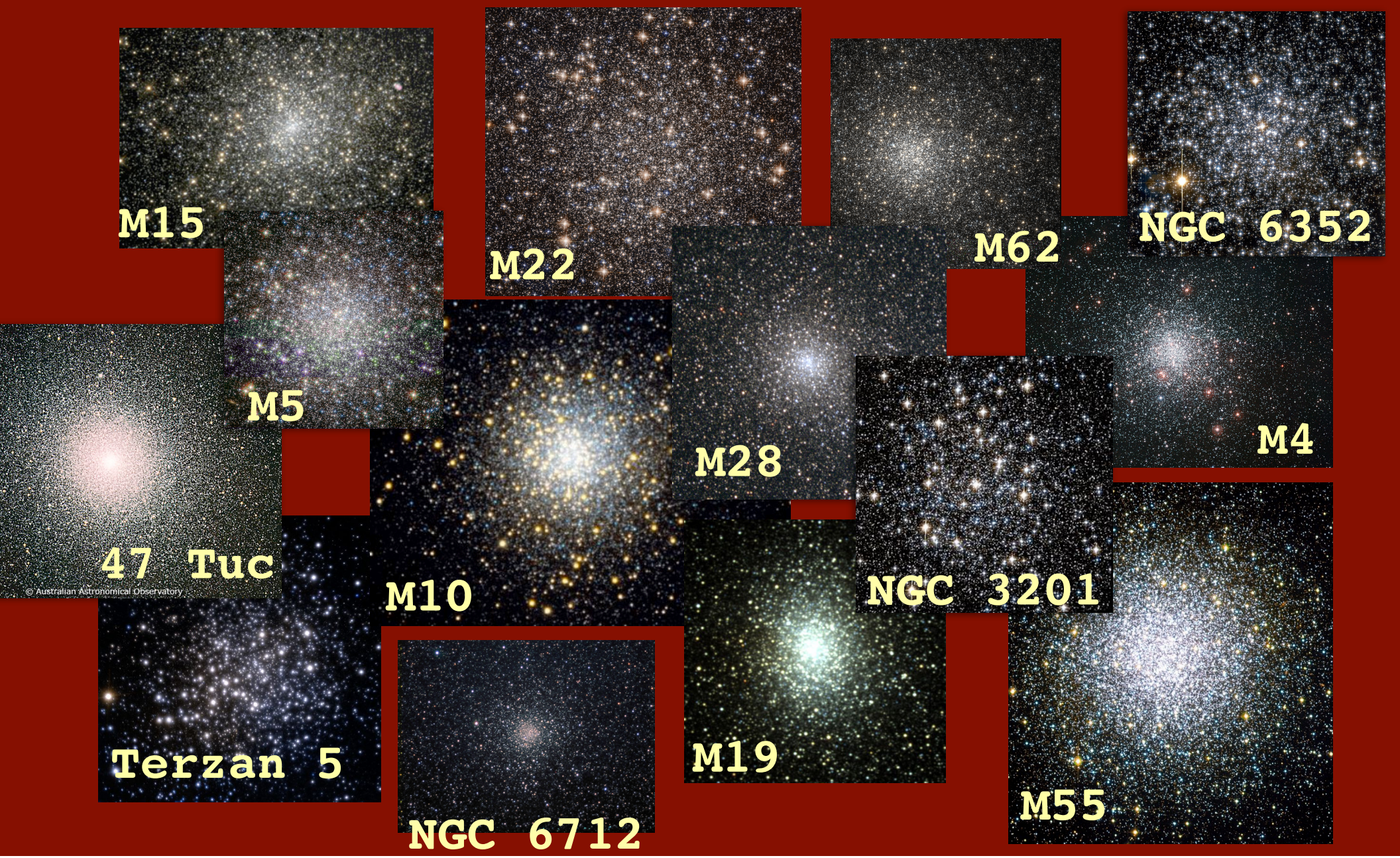
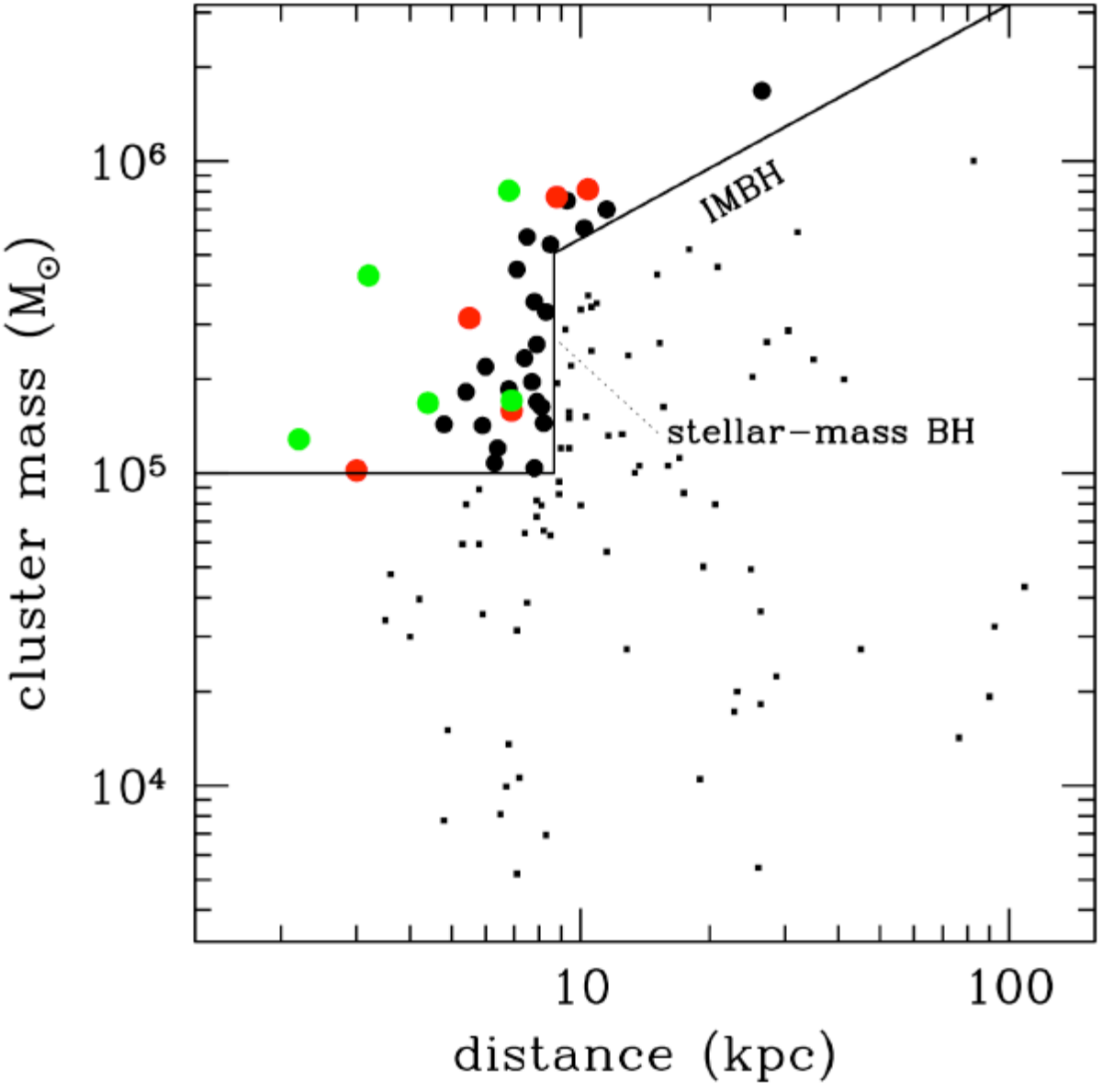
Expanding the sample of GCs with deep radio observations



Selecting clusters for likelihood of detecting IMBHs and stellar-mass BHs:



Massive & Nearby
or
Really massive

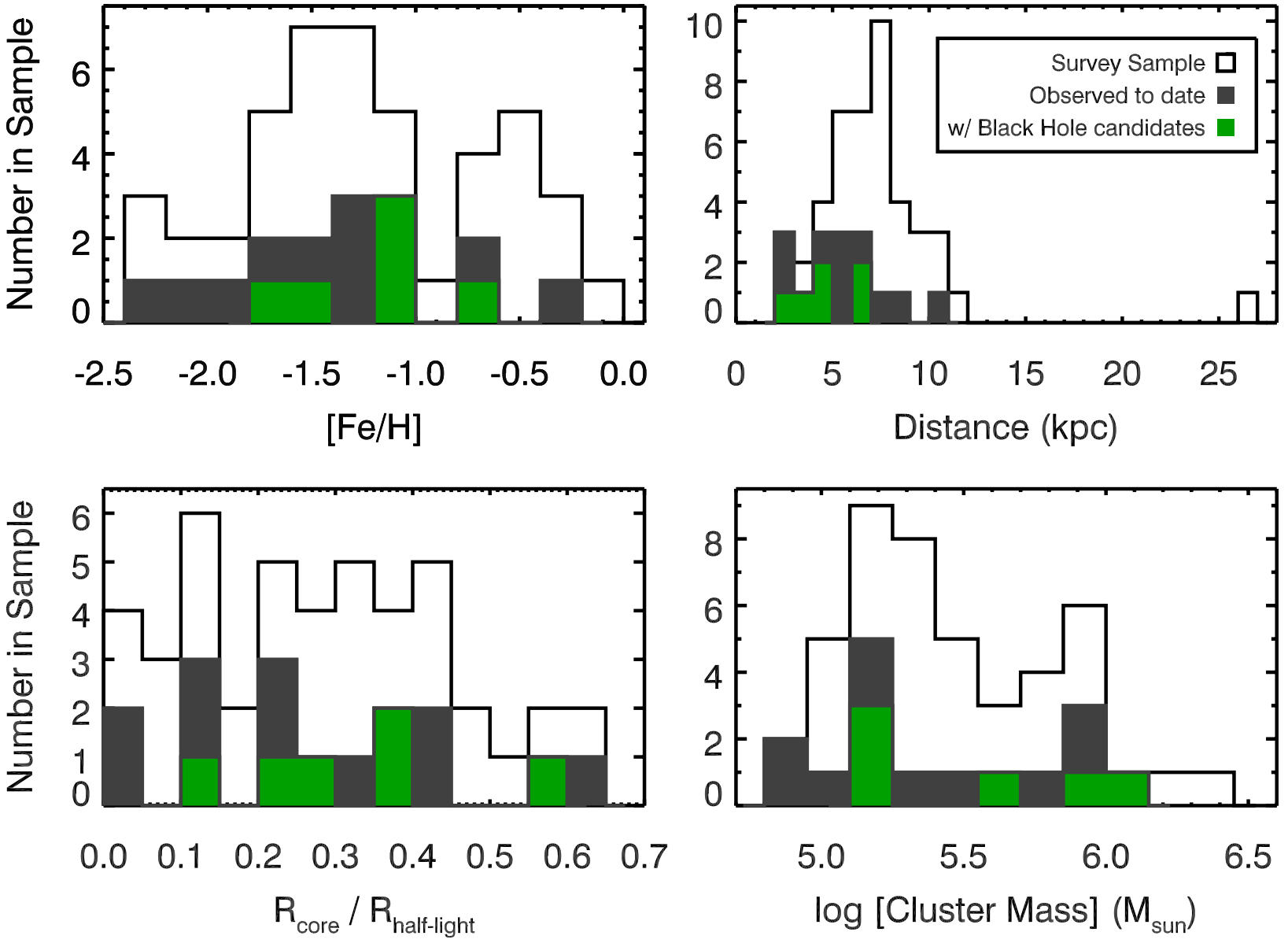
- To be observed
- Yes, BH candidates
- No BH candidates

Expansion Approved!

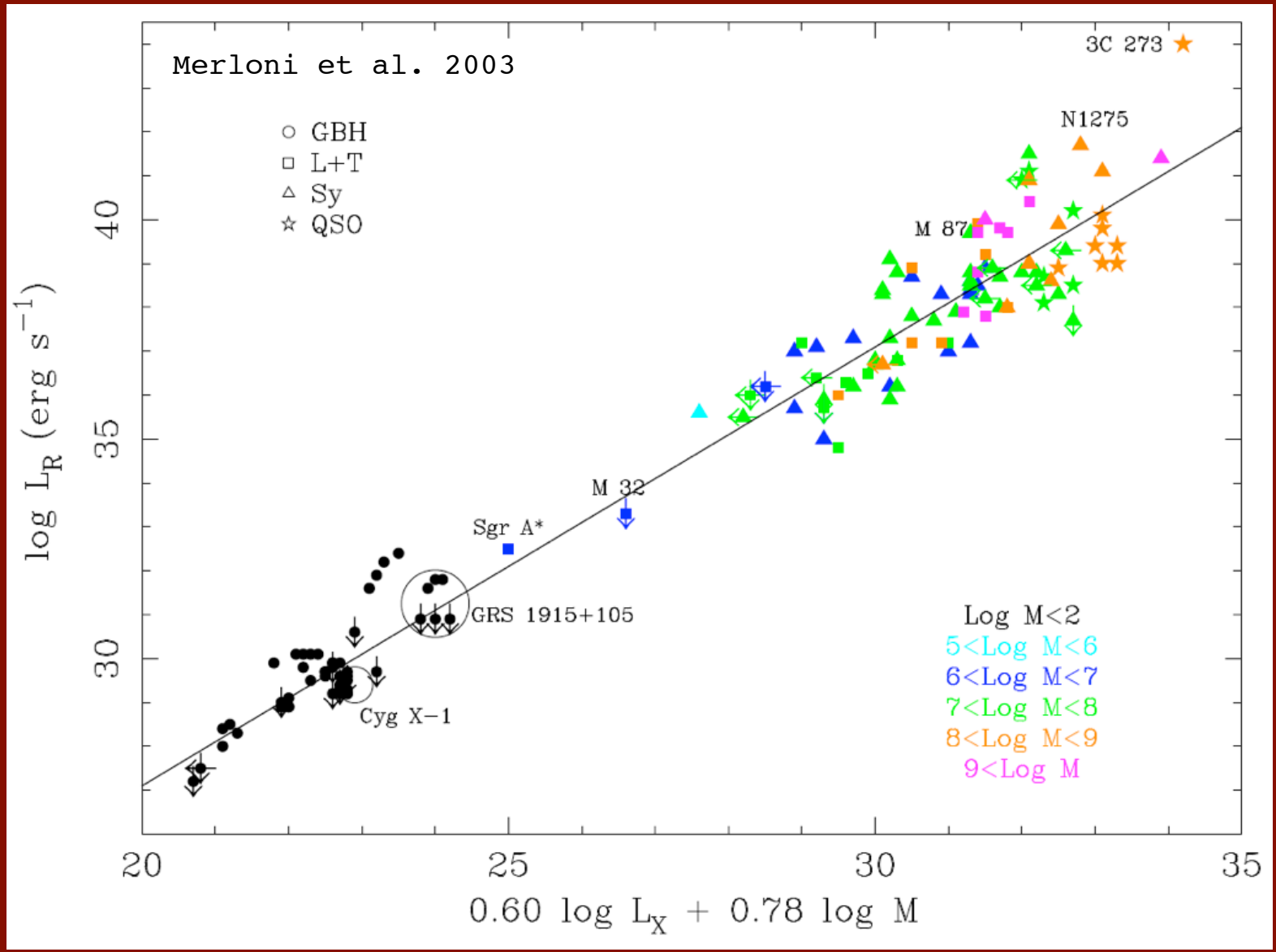
280 Hours on Jansky VLA:
28 GCs (Dec > -35 deg),
each reaching sensitivity
1σ = 1.5 μJy

560 Hours on ATCA:
26 Southern GCs,
each reaching sensitivity
1σ = 3.5 μJy

Spanning a range of cluster properties



Searching for IMBHs with the "Fundamental Plane" of BH activity



valid in low/hard state

$L_r \sim L_x^{0.6}$

Predicting radio emission from IMBHs

1. Globular clusters have gas from giants
2. *Some* gas will accrete onto IMBH
3. Accretion will produce X-ray and radio emission with some efficiency

Predicting radio emission from IMBHs

(i) ICM density: 0.2 cm^{-3}

(ii) Accretion rate: 3% of Bondi

(iii) efficiency: $\epsilon \propto \dot{m}$ (not 0.1)

(iv) $L_X = \epsilon \dot{m} c^2$

(v) IMBH is on fundamental plane

formalism: Maccarone (2004), Maccarone & Servillat (2008), Strader et al (2012)

Predicting radio emission from IMBHs: Typical Numbers

$$\dot{m}/\dot{m}_{\rm edd} \approx 5 \times 10^{-7}$$

$$\dot{m} \approx 5 \times 10^{-12}\ {\rm M}_\odot\ {\rm yr}^{-1}$$

Accretion rate is 0.1% of wind from a single red giant.

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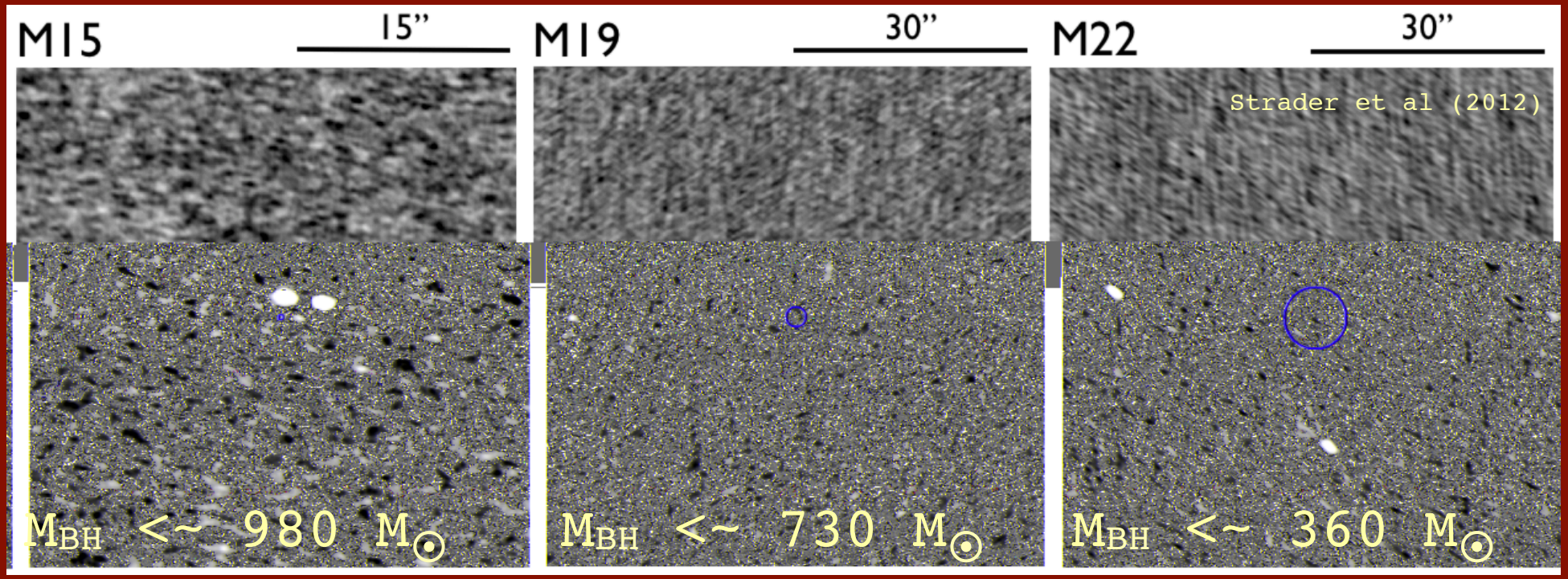
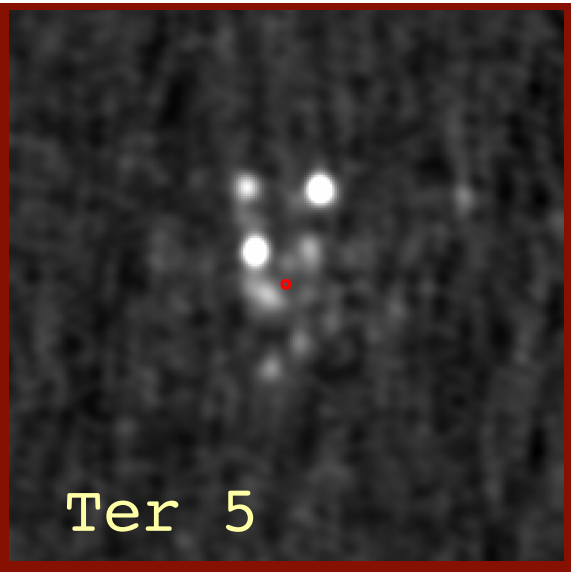
$$\epsilon \approx 10^{-6}$$

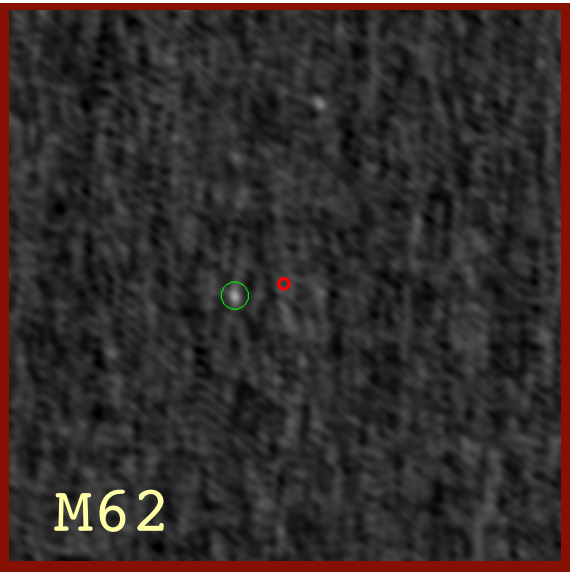
Radiative efficiency comparable to Sgr A*.

$$L_X \approx 10^{30}\ {\rm erg/s}$$

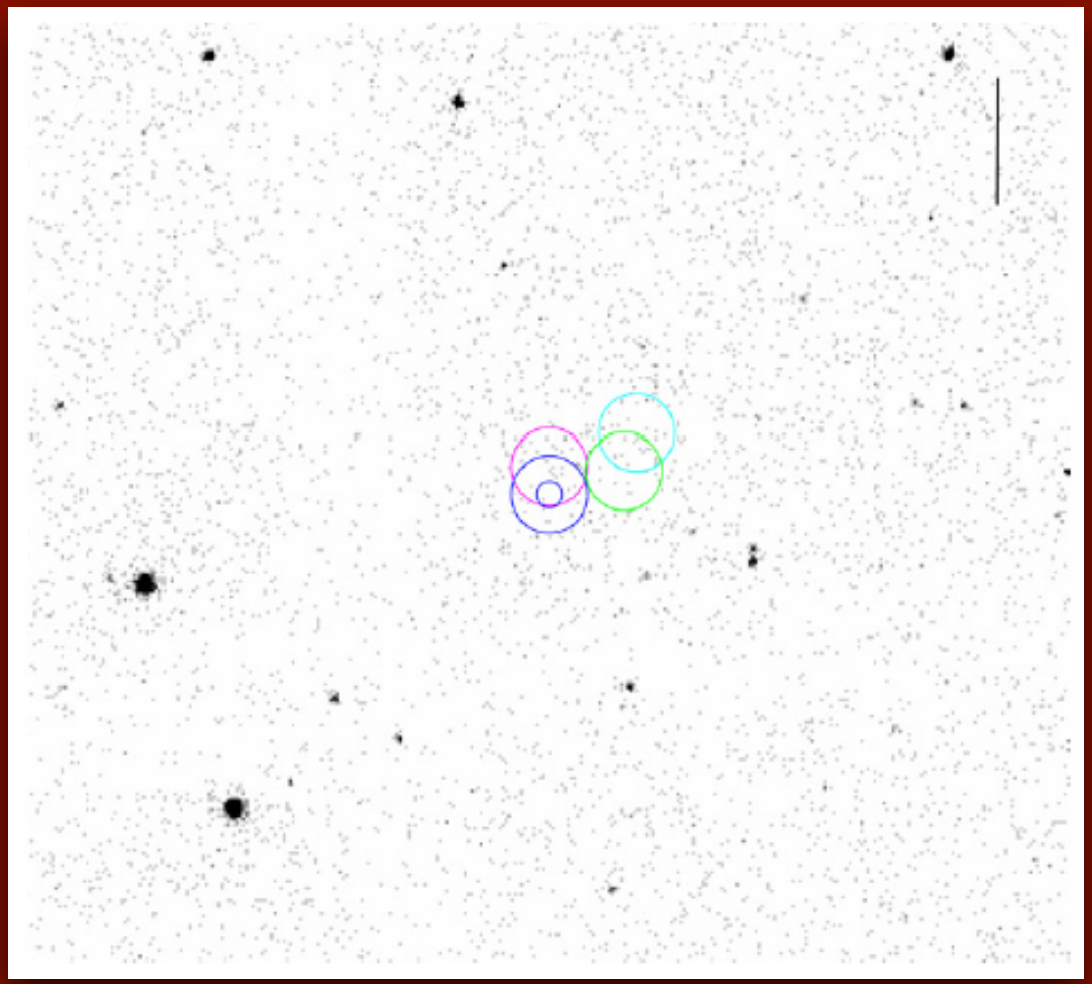
IMBH Non-detections in all GCs (16, to date)







X-ray observations place similar limits.



ω Cen

(Haggard et al. 2013)

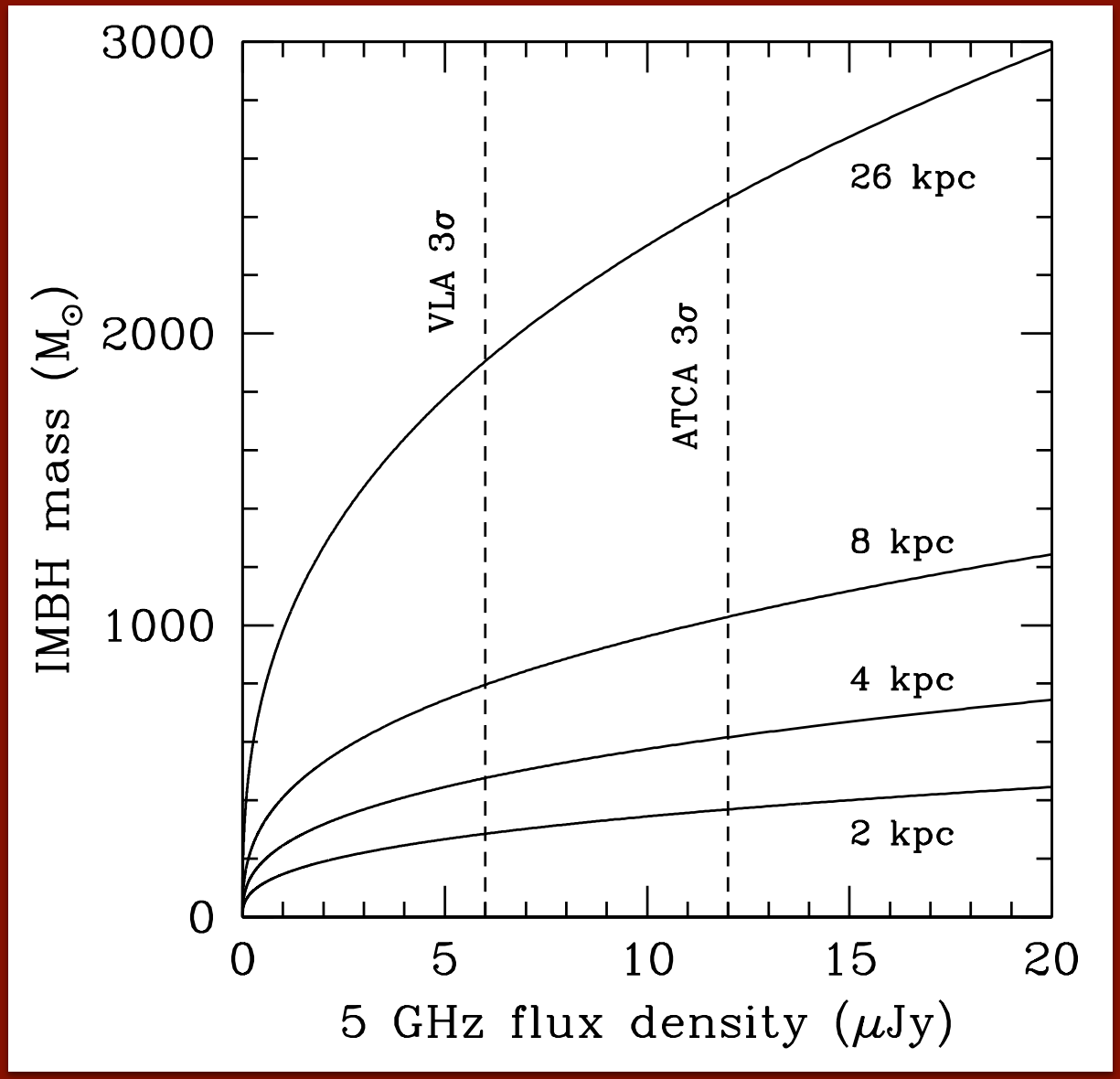
291 ks of *Chandra* time

At center:

$< 1.6 \times 10^{30}$ erg/s

$M_{BH} < 4 \times 10^{3}\ M_{\odot}$

But radio observations are more efficient.

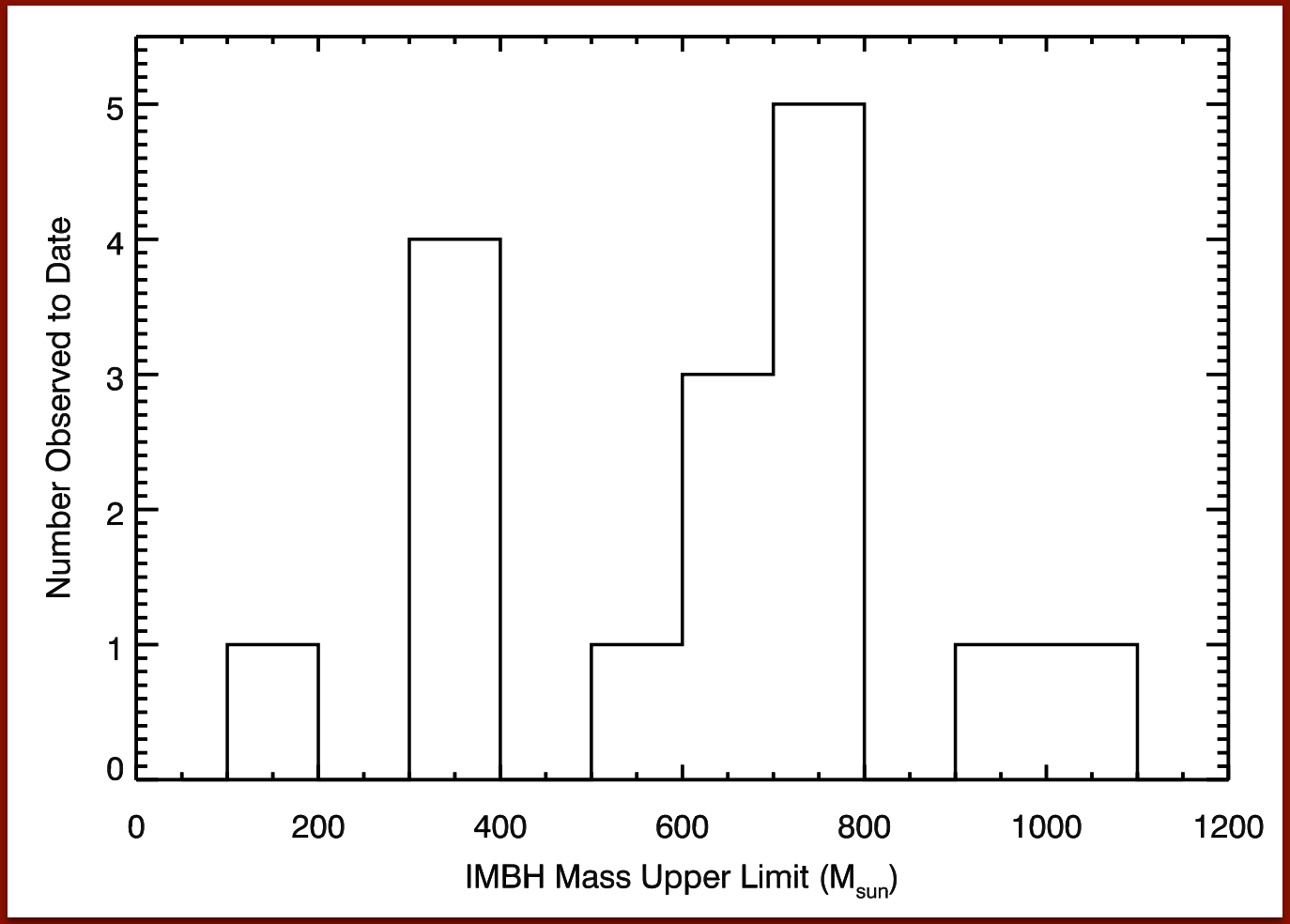


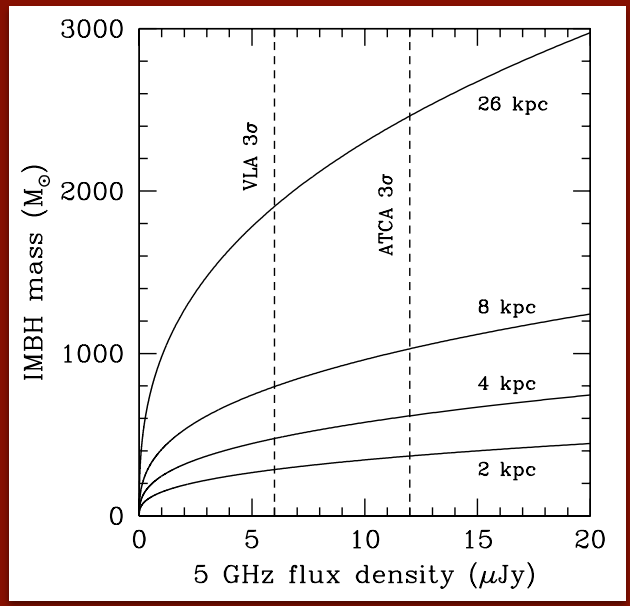
7 μJy radio
(8 ks on VLA)
or
(36 ks on ATCA)

equivalent to

1.6×10^{30} erg/s X-ray
(291 ks on *Chandra*)

Strong Limits on IMBHs in GCs (16, to date)



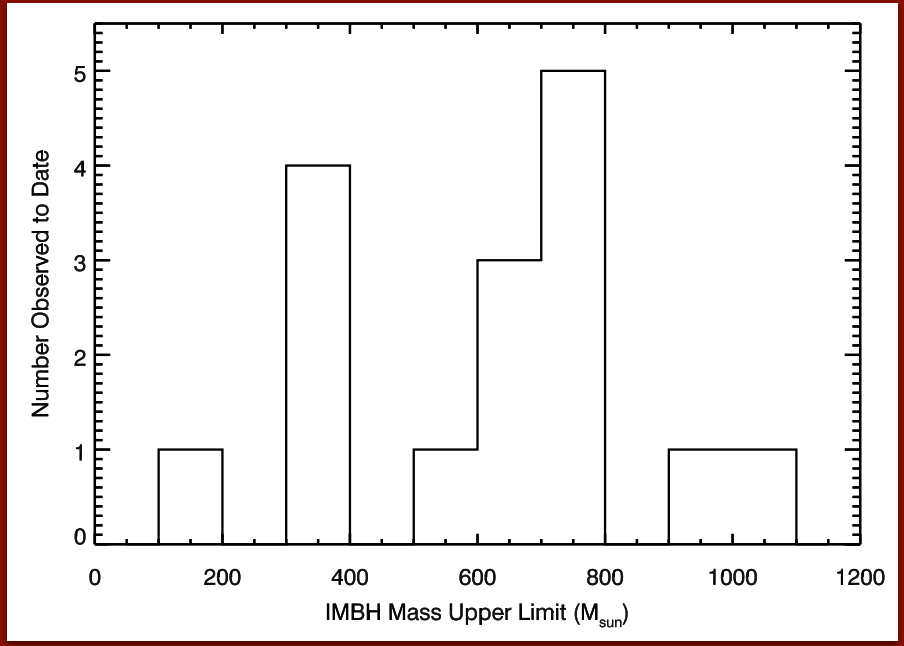


(Distance matters)

IMBHs aren't so massive.

or

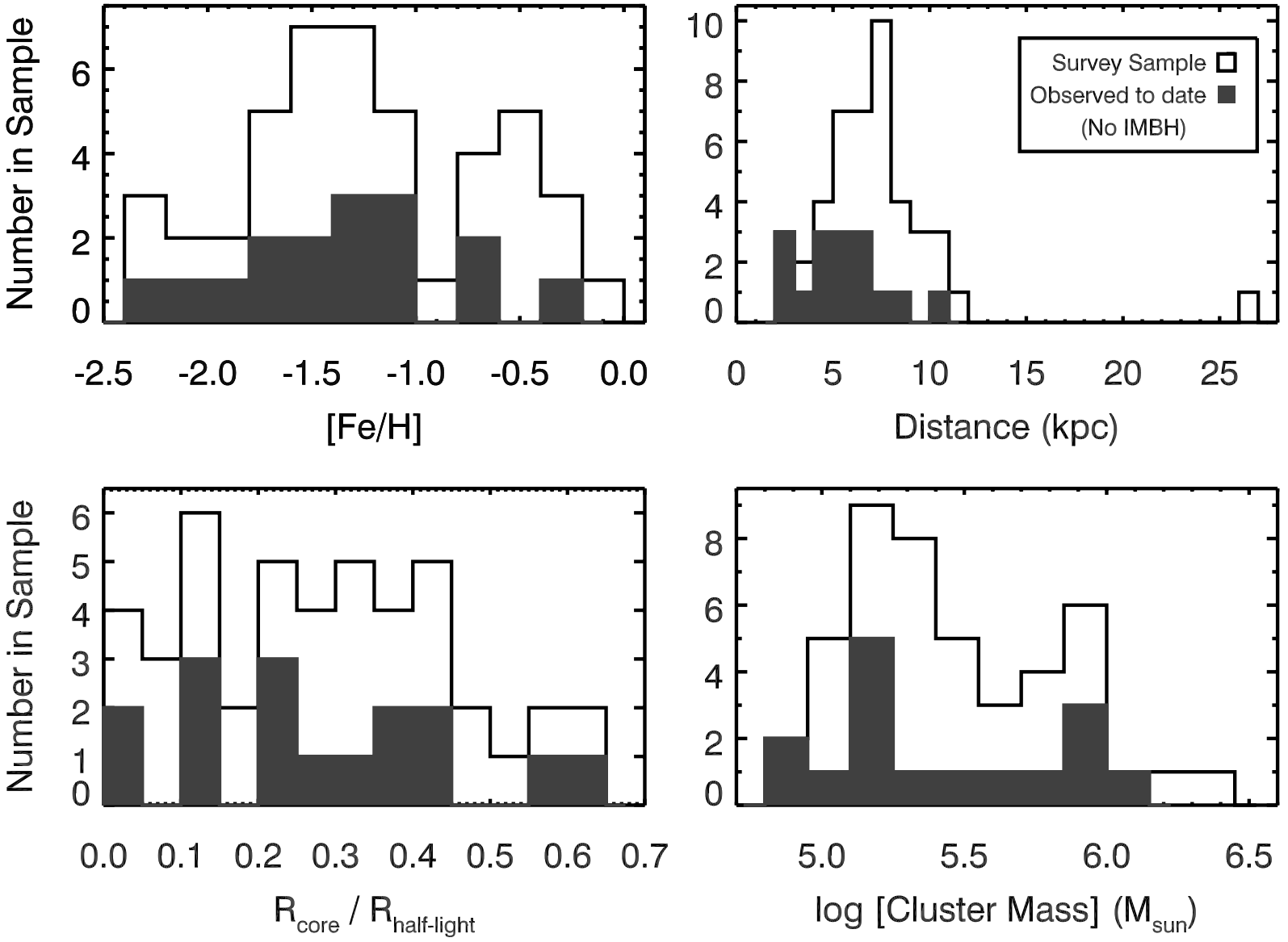
Accretion is very inefficient.



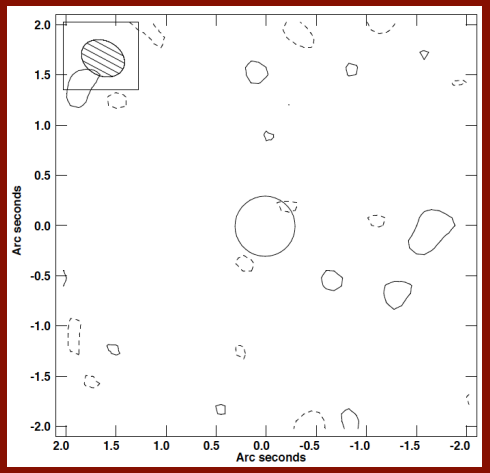
1) ICM density
2) Fraction of Bondi
3) Radiative efficiency:

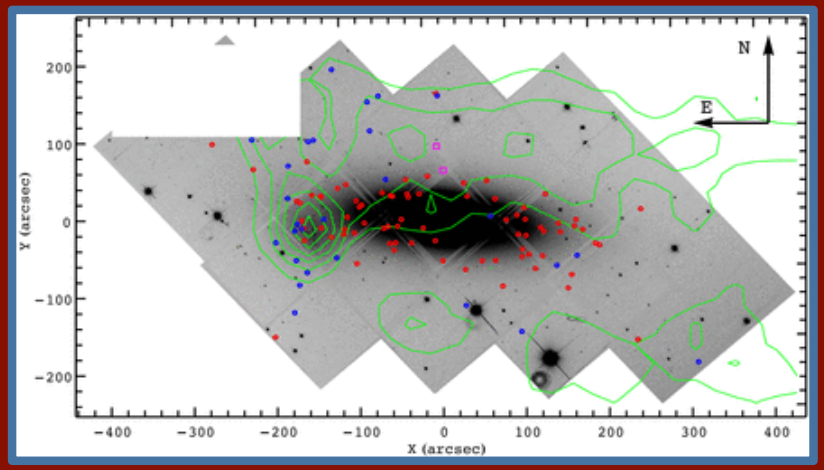
$$\epsilon = 0.1\,((\dot{M}/\dot{M}_{\rm edd})/0.02)$$

Strong Limits on IMBHs in GCs (16, to date)

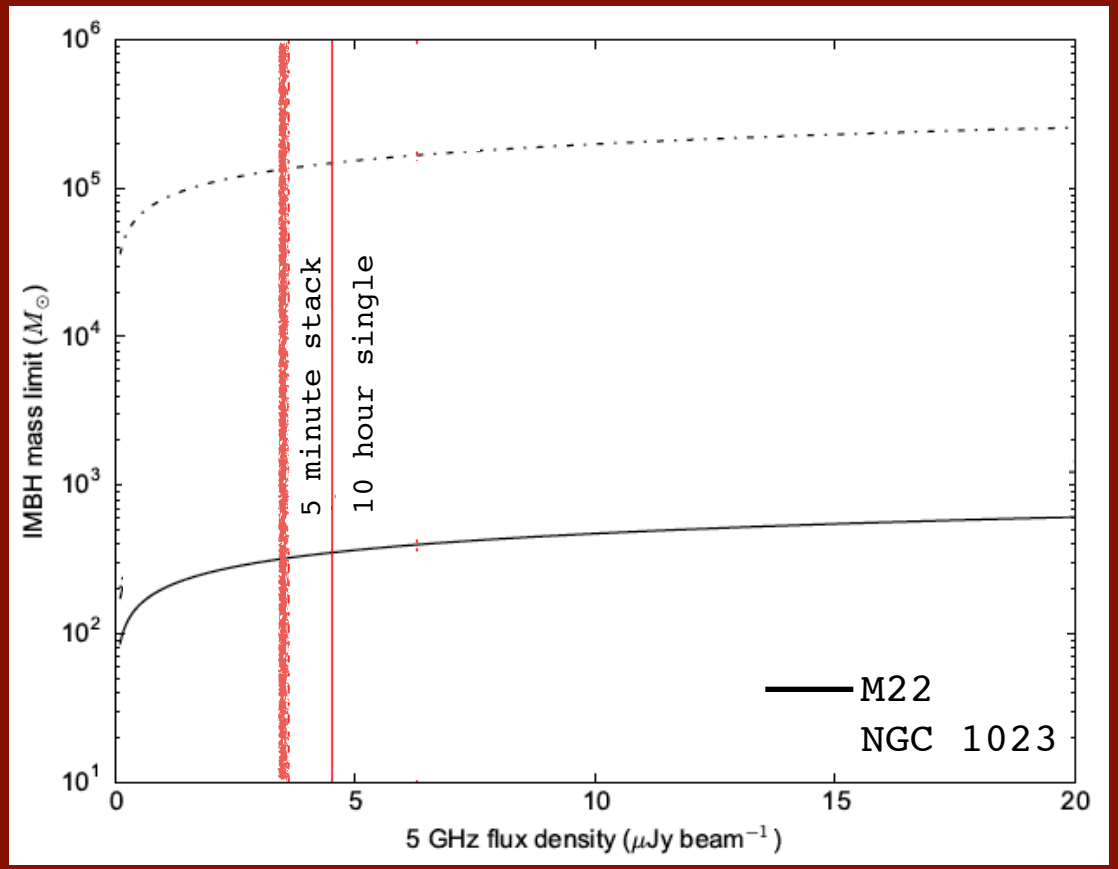


A clever strategy for expanding IMBH searches





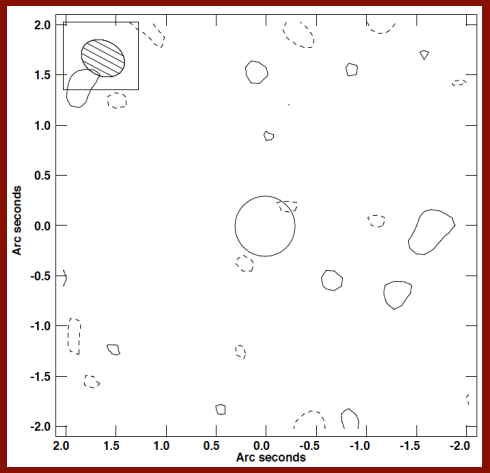
Wrobel, Miller-Jones & Nyland in prep

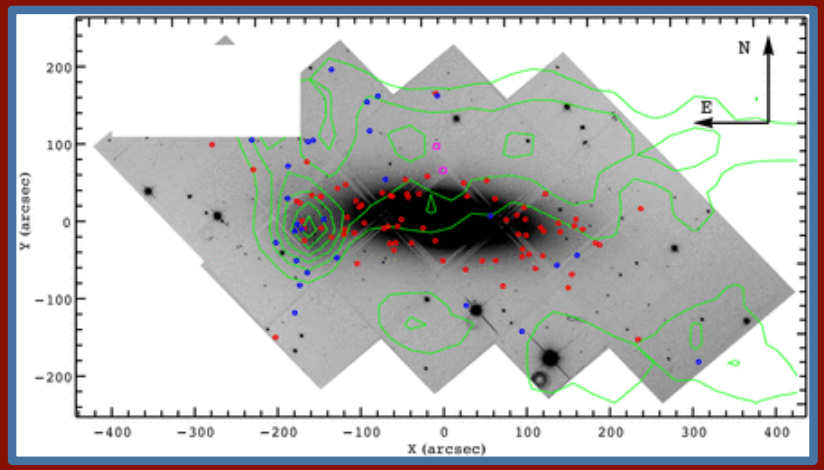


Stack of 245 GCs in NGC 1023 (11 Mpc)

rms ~ 1.2 μJy/beam in just 5 minutes on source!

A clever strategy for expanding IMBH searches





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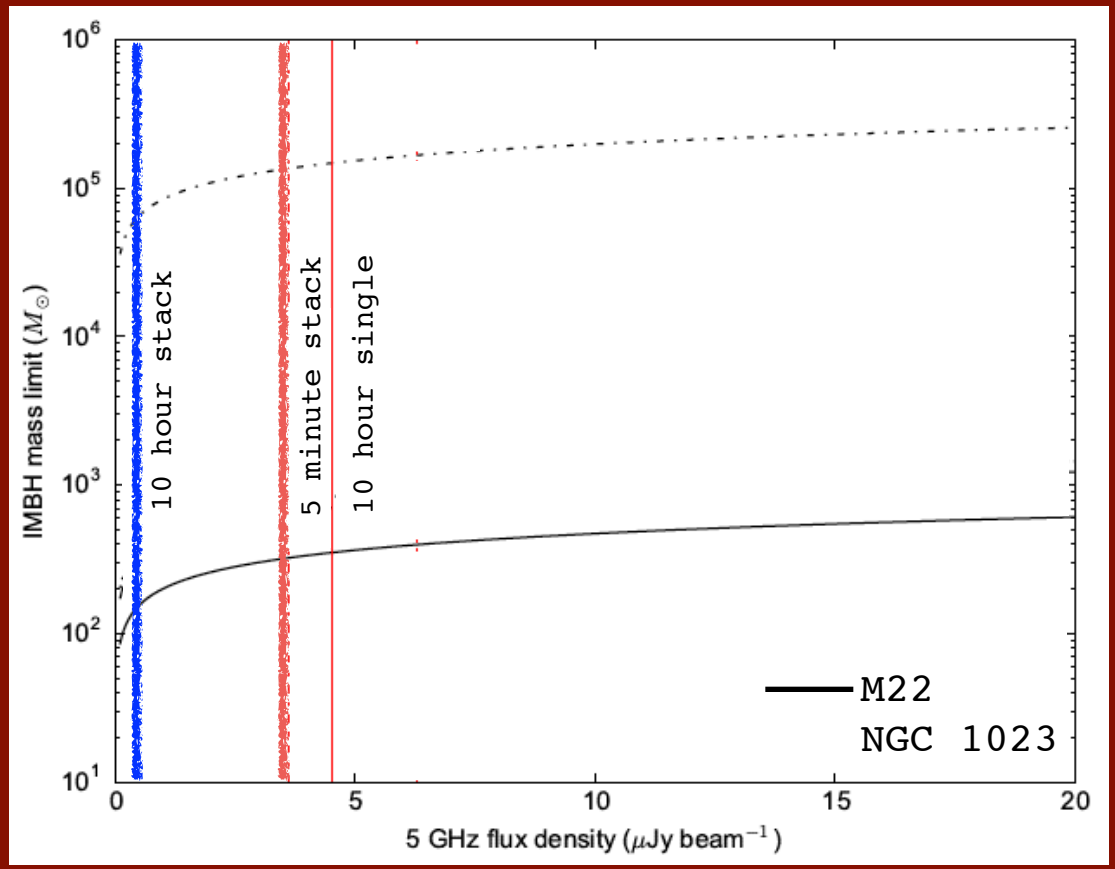

Stack of 245 GCs in NGC 1023 (11 Mpc)

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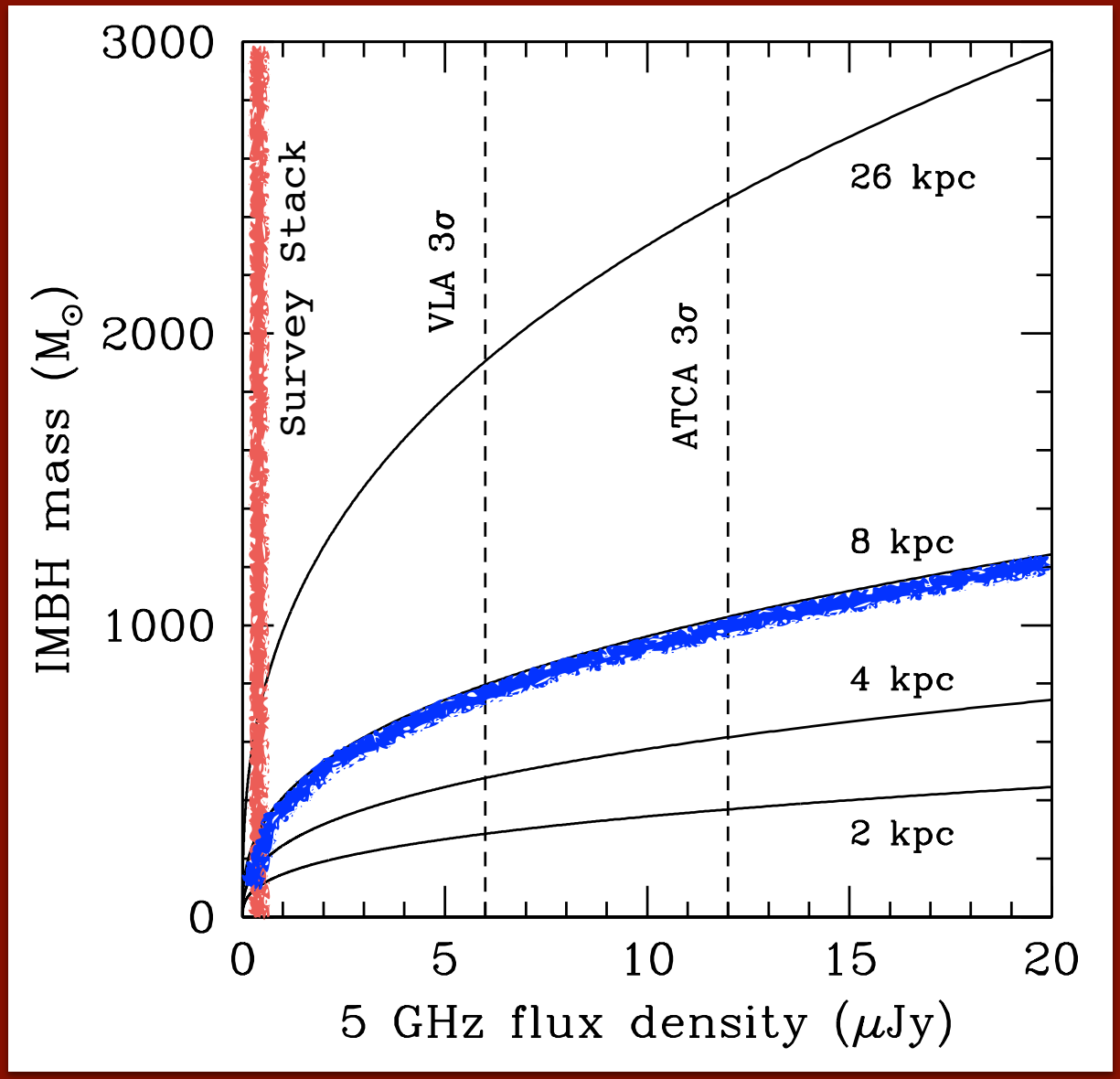
Future stacks of MW GCs will give deepest limits.



❮ ≲300 $M_\odot$ ❯
at ❮ 7 kpc ❯

Stay Tuned!