Searching for intermediate-mass black holes in NGC3310

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IMBH characteristics

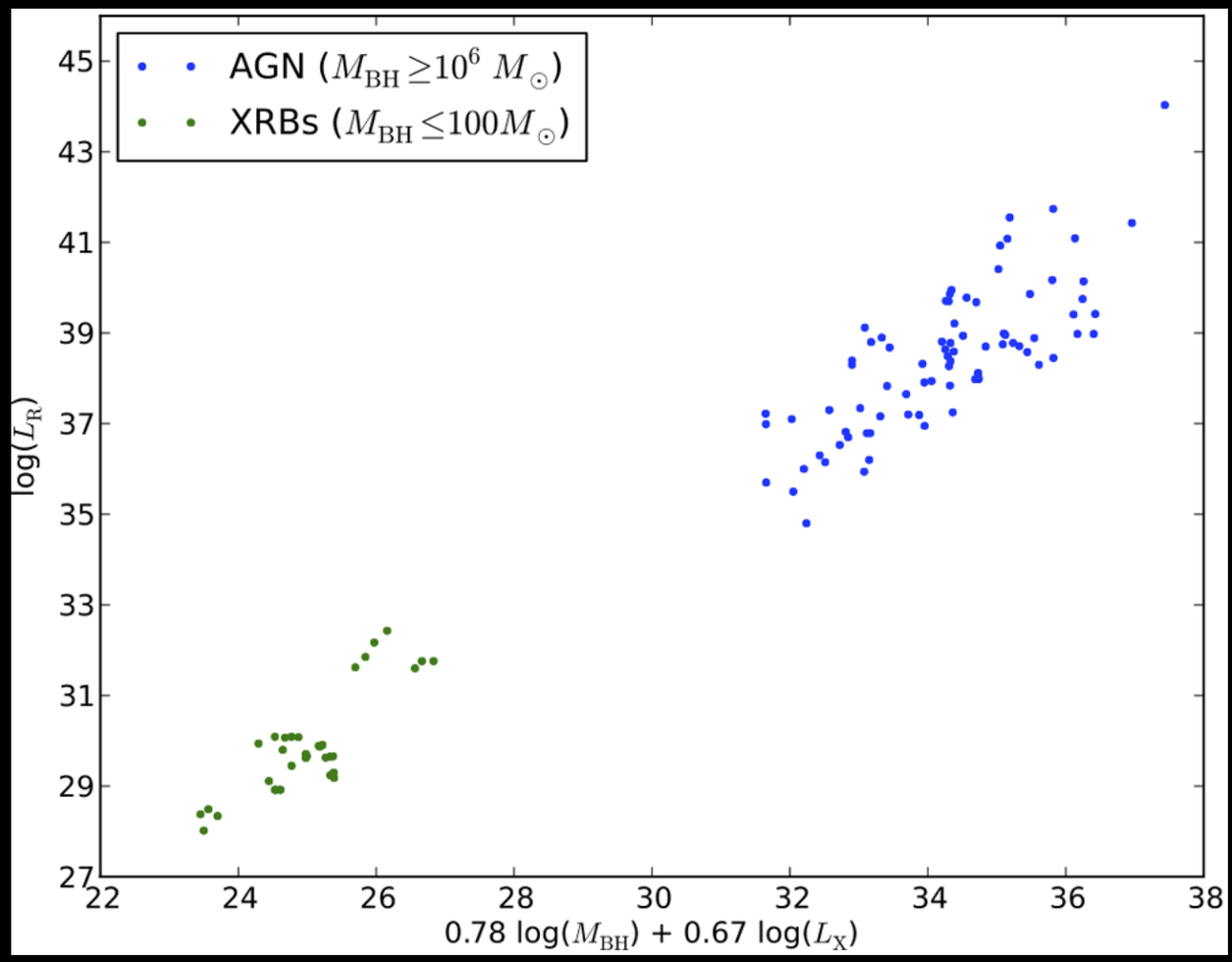
Link between the regimes of stellar mass BHs and SMBHs.

Possible seeds of SMBHs.

Implications for understanding how SMBHs (and galaxies) form and grow.

We expect them to be:

- $100M_\odot<M<10^6M_\odot$ (ish)
- off-nuclear
- point sources
- $L_x >= 10^{39}$ erg/s
- difficult to detect!



Fundamental plane of Gültekin+2009 with data from Merloni+2003, (Mezcua+2015)

IMBH candidates

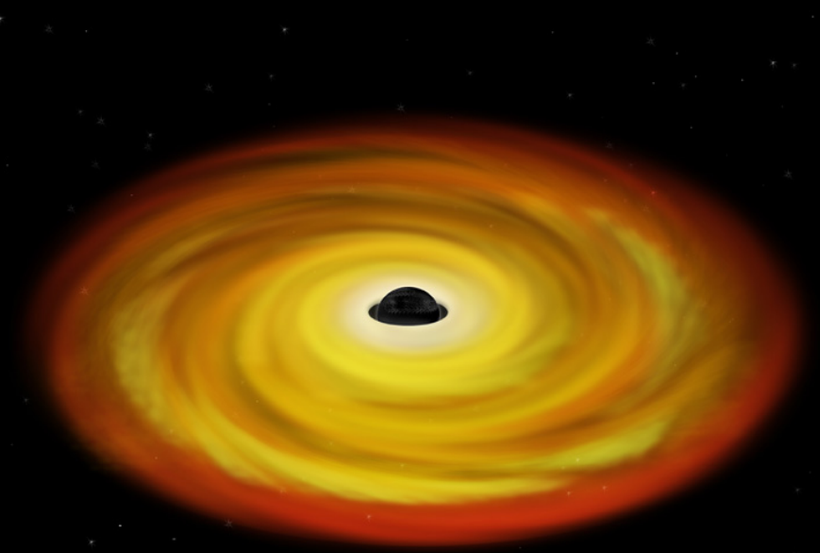
ULX sources?
Evidence that the ULX population is heterogenous; most are stellar mass BHs with super-Eddington accretion (e.g. Earnshaw+2018).

Best candidate is HLX-1 (ESO 243-49) with $L_x \approx 10^{42}$ erg/s, periodic state transitions and radio jets. Mass estimates range from ~10^3 to $10^6 M_\odot$ (e.g. Cseh+2015). Cannibalised dwarf galaxy core?

Globular cluster cores?
Collapse and coalescence in the core, but little gas and dust, so no strong accretion signatures expected.

The best candidate so far is in 47 Tuc (Kızıltan+2017) with $M_{BH} = 2.2^{+1.5}_{-0.8} \times 10^3 M_\odot$ using dynamics of pulsars. No detectable electromagnetic counterpart, likely gas-starved.

Many candidates found by cross-correlating X-ray and optical catalogues (Roberts+2017).



A new ULX catalogue

Earnshaw, Roberts et al (2018, in prep)

Cross-correlated 3XMM-DR4 with RC3 & Catalogue of Neighbouring Galaxies

~2000 nearby galaxies covered

Lots of science possibilities… e.g. L vs host type

Almost 400 ULX sources in nearby galaxies
- point sources with $L_x > 10^{39}$ erg/s
- implies big BHs or super-Eddington accretion

Handful of IMBH candidates for follow-up
One in an old friend…

NGC3310: Vital Statistics

Grand Design spiral
Located in Ursa Major
13Mpc so 1” = 64pc
$10h38^{m}46^{s}$ $+53^{o}30’12”$
(irritatingly circumpolar)

NGC3310: history

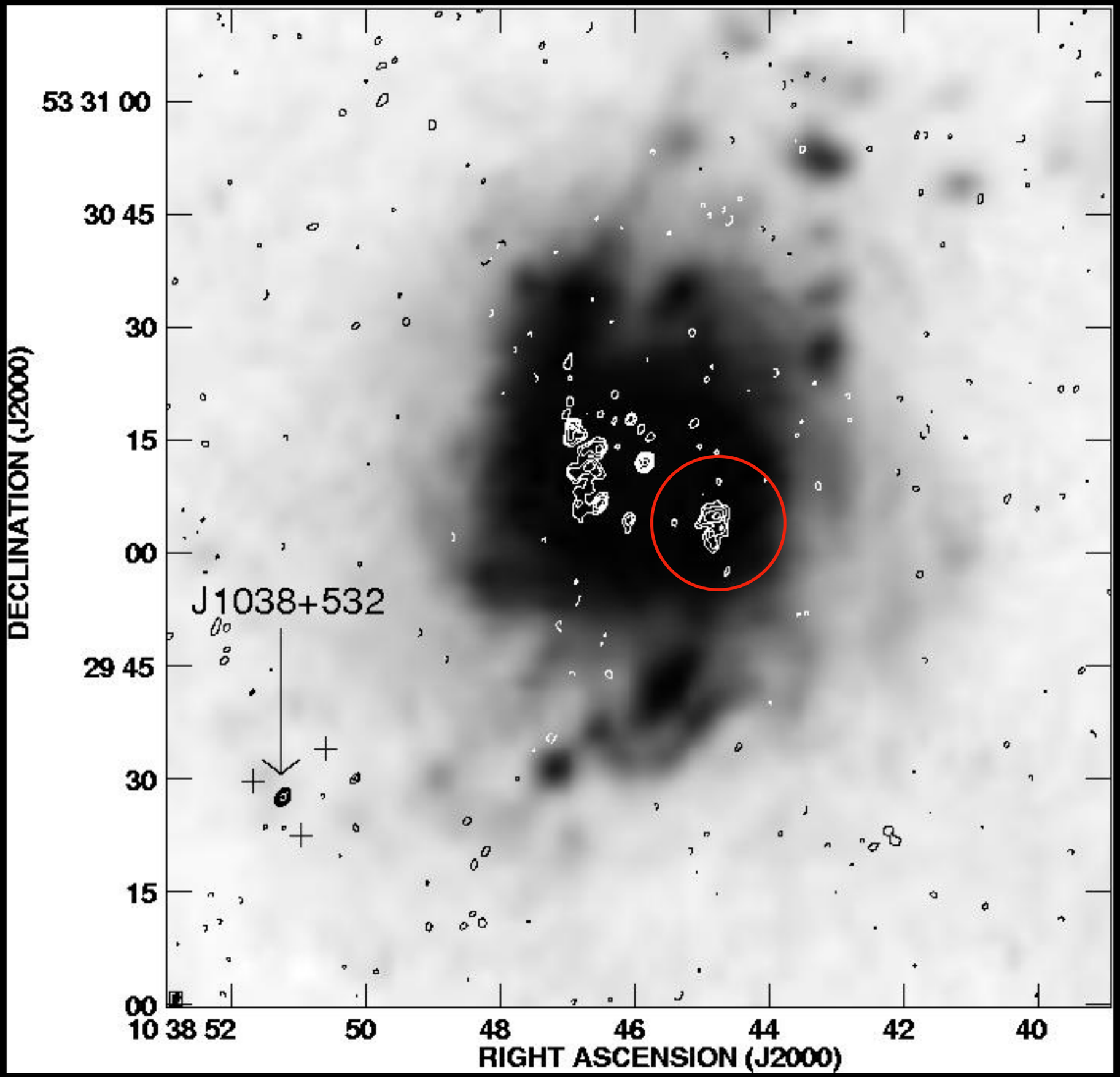
Ongoing active starburst and evidence of past merger activity.

Major merger? (Kregel & Sancisi 2001) from HI kinematics and optical morphology.

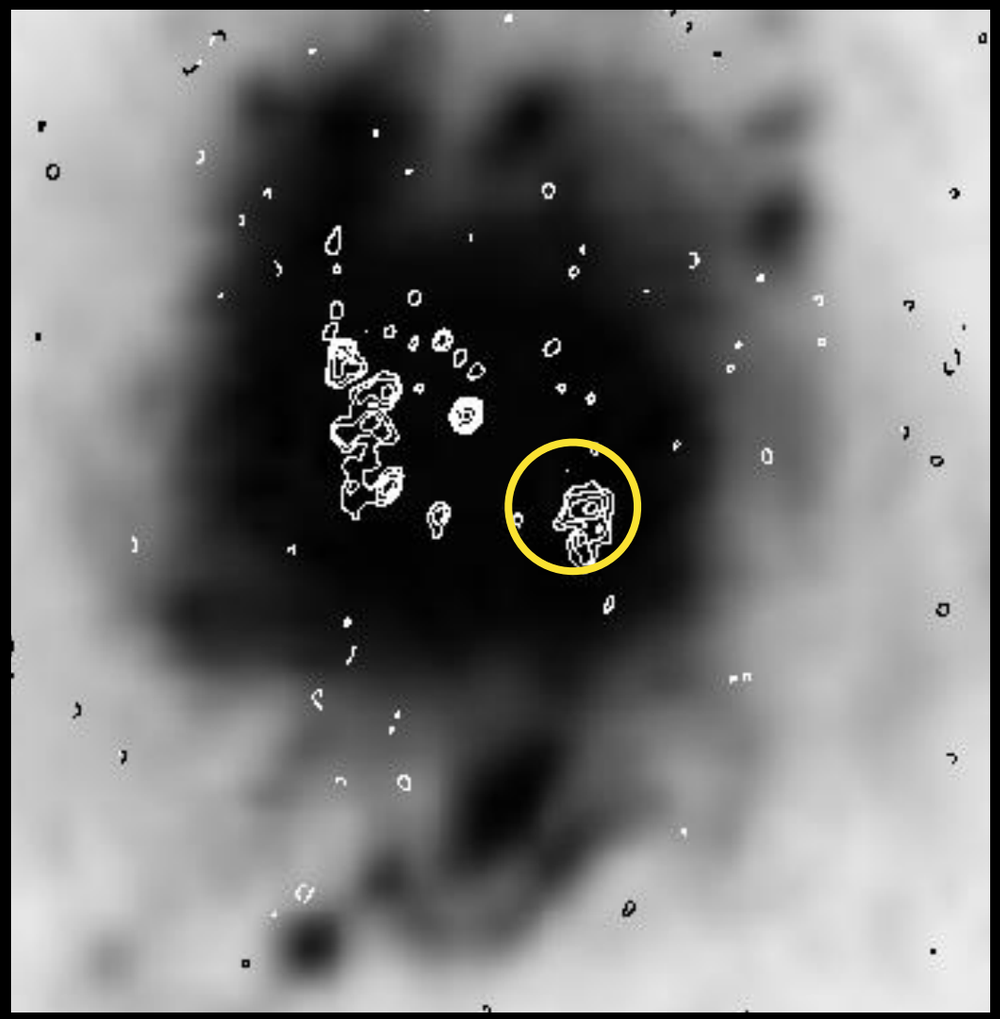
Minor merger? (e.g.Smith+1996)

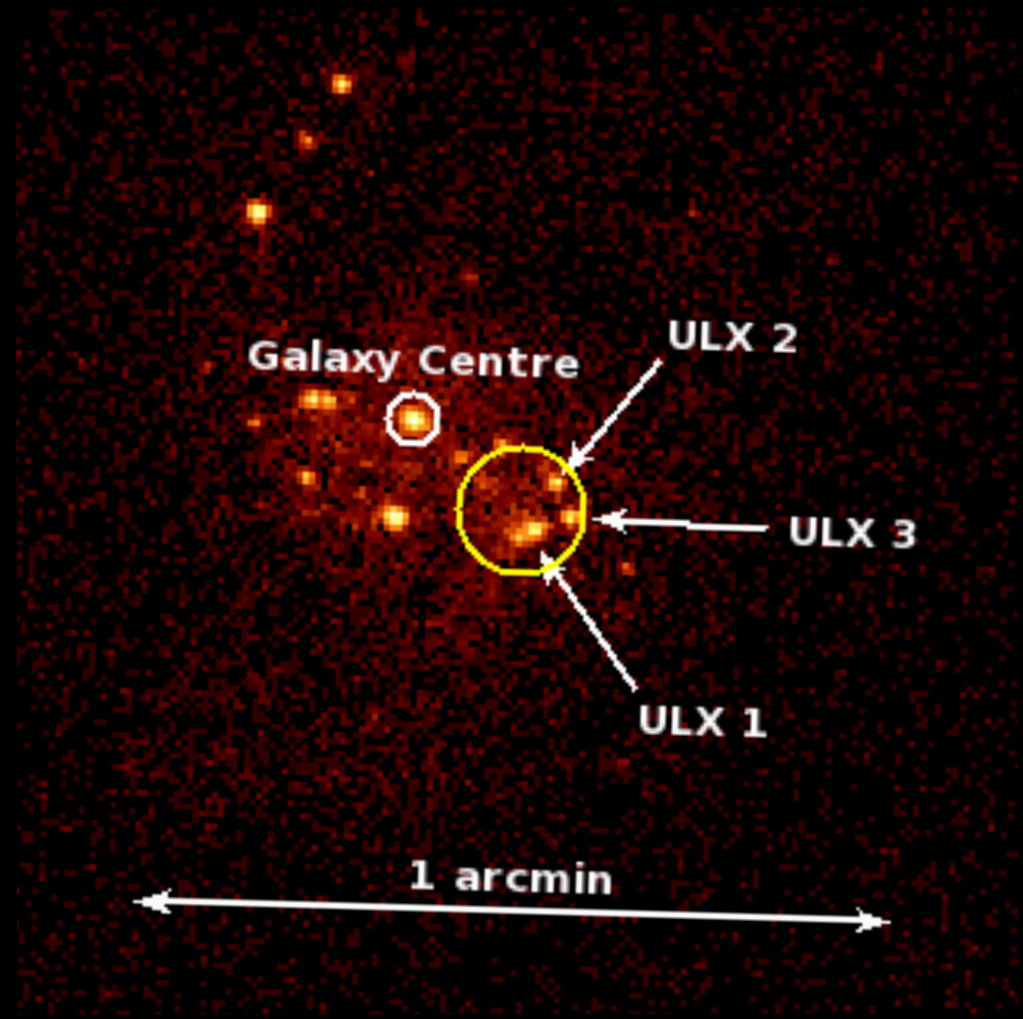
Multiple minor mergers? (Wehner+2006) from photometry of the gas debris.

Could the remains of cannibalised galaxy still present?

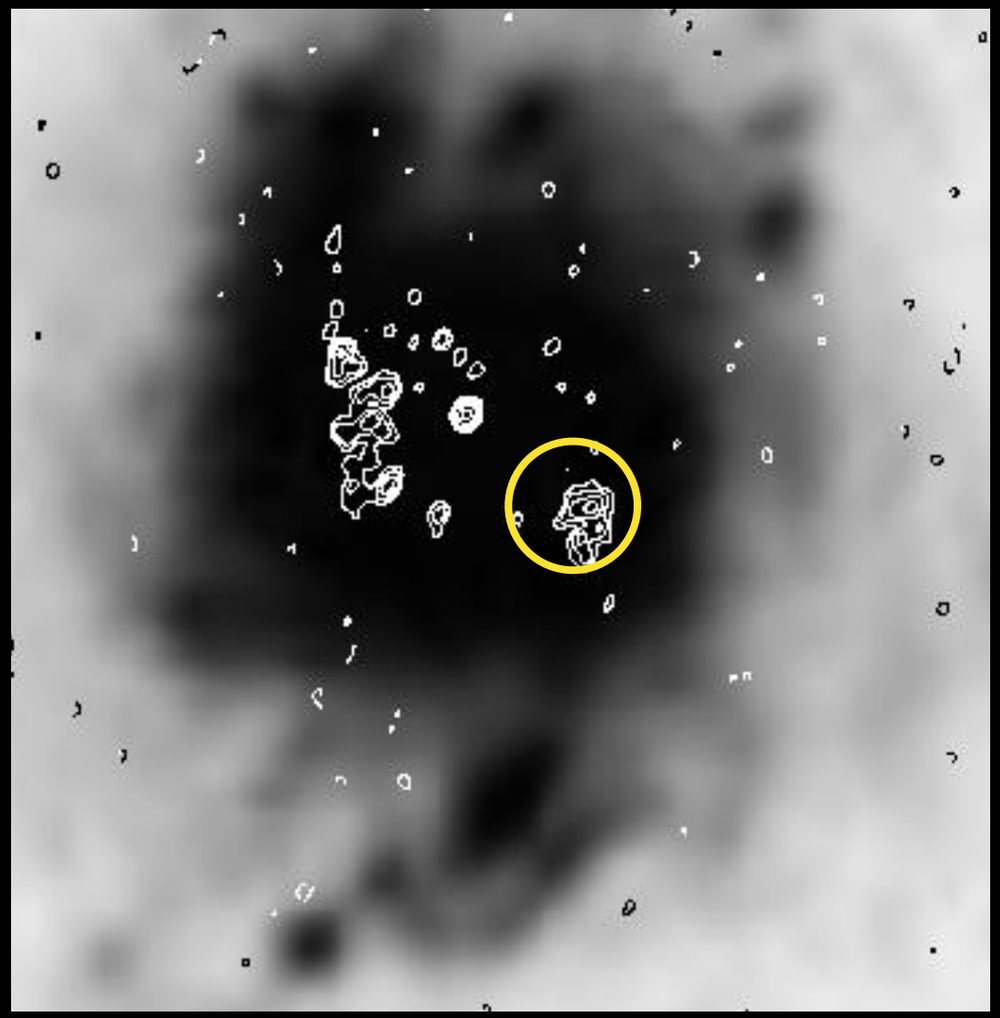

53 31 00
30 45
30
15
00
29 45
30
15
00
DECLINATION (J2000)
J1038+532
10 38 52
50
48
46
44
42
40
RIGHT ASCENSION (J2000)

The IMBH candidates





The IMBH candidates



ULX1 10:38:44.8 +53:30:04)
$L_{x,1}$ = (8.81 ± 1.62) x 10^{39} erg/s

ULX2 (10:38:44.6 +53:30:07)
$L_{x,2}$ = (6.09 ± 0.60) x 10^{39} erg/s

ULX3 (10:38:44.4 +53:30:05)
$L_{x,3}$ = (5.57 ± 0.53) x 10^{39} erg/s

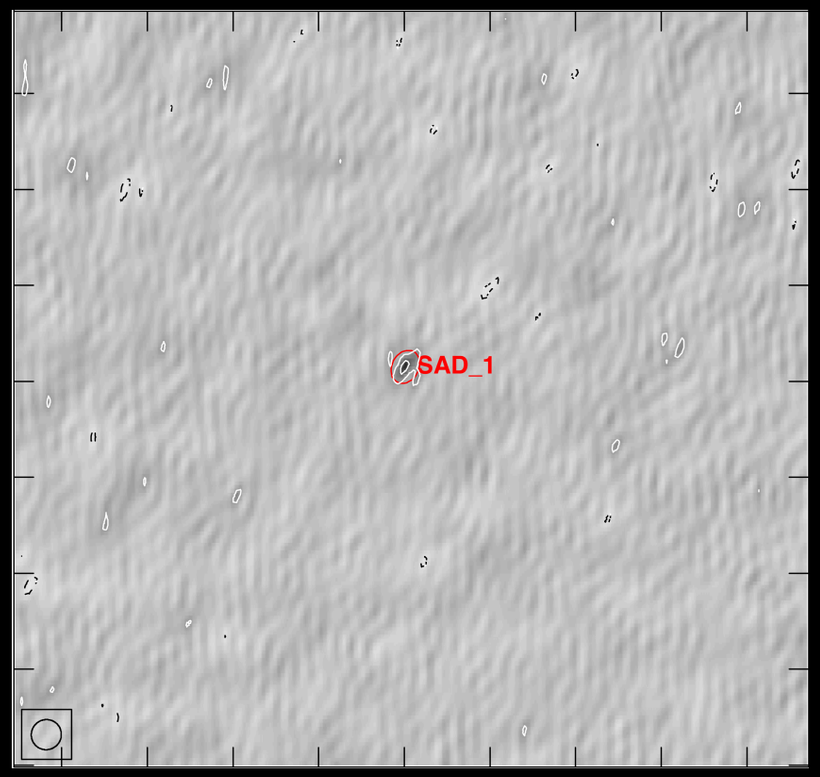
NGC3310: Observations

- EVN+e-MERLIN
- L-and C-band
- 6 hours each
- Phase ref: J1044+5322
- Theoretical RMS: 6μJy/beam
- Observed 2016

NGC3310: Detections?

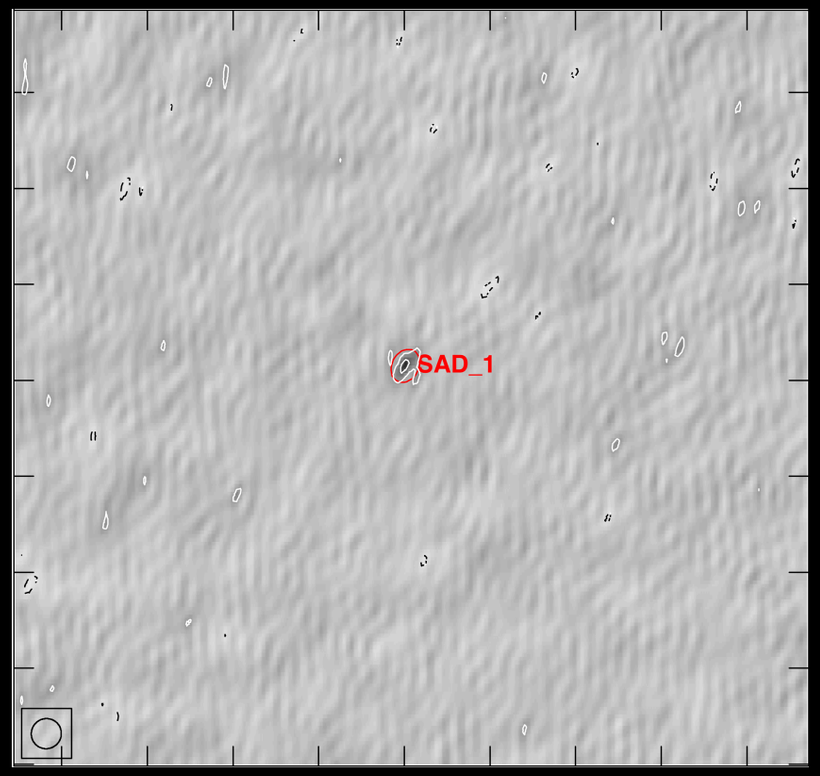
May be…

NGC3310: Detections?



7σ detection at C-band
within 1” of ULX1
peak 69μJy/beam

NGC3310: Caveats



7σ detection at C-band within 1” of ULX1 peak 69μJy/beam

Using the fundamental plane relation of Gültekin+2009 gives a BH mass of ~6000$M_\odot$ *assuming* association with ULX1. Needs a careful examination of the field.

e-MERLIN data not included.

L-band data has issues - in progress.

Should be variable if accretion-powered - need more data!

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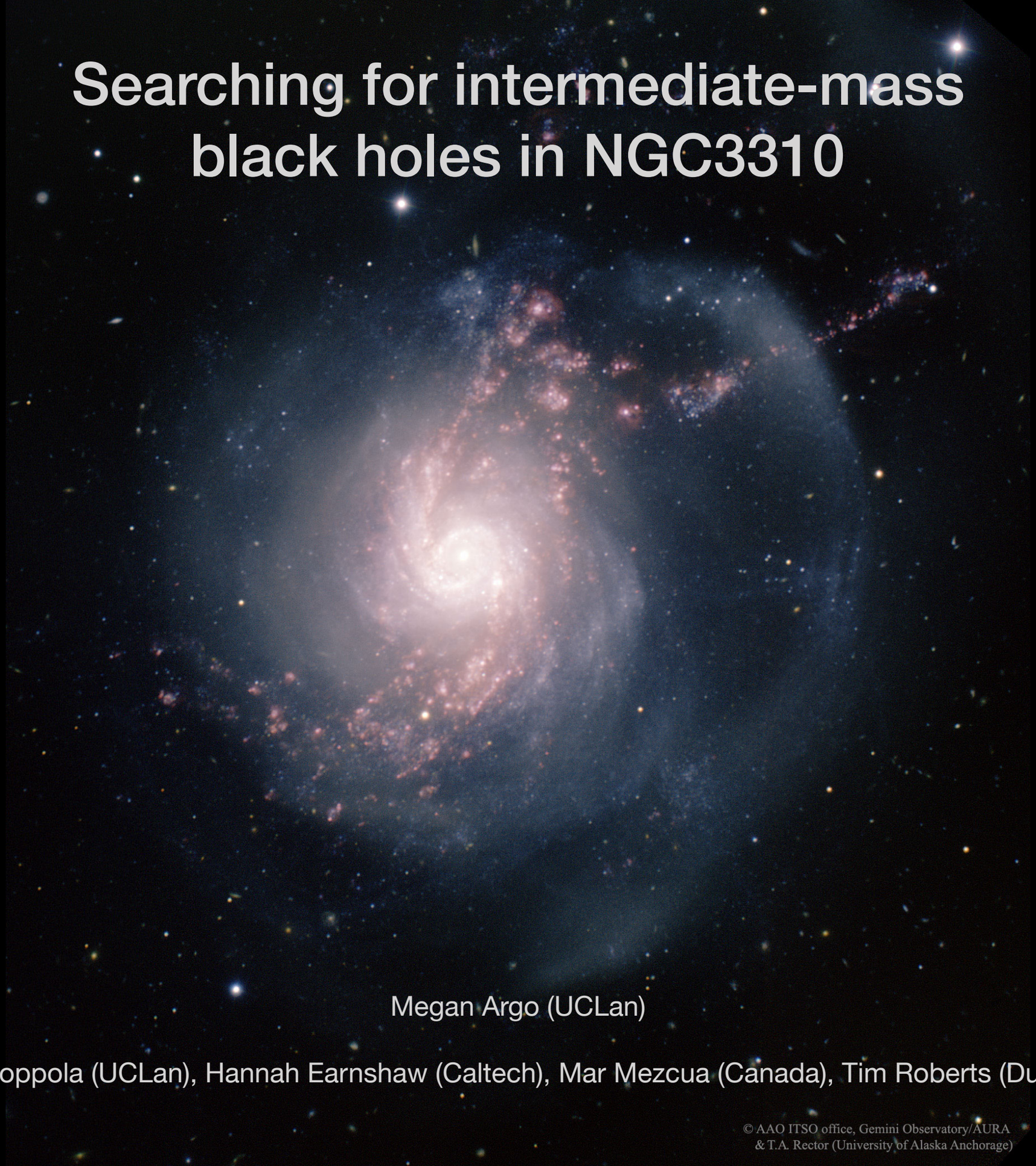

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