A black hole's gotta eat too:

accretion and feedback on LLAGN

Iván E. López
Università di Bologna (UNIBO) - INAF/OAS

Why is so important the BH accretion?

Accretion (and mergers) are the mechanisms that make a BH to growth.

- BH seed
- BH grow as its host galaxy
- BH accretion impact on galaxy evolution

Accretion and feedback are connected

Works

- **On SMBH-host coevolution:**
  - López IE et al. (2023)
- **On LLAGN properties:**
  - López IE (in prep)
- **A study-case of LLAGN Feedback:**
  - Ogle P, López IE, et al (2023)

1. On SMBH-host coevolution

Studying the accretion until $z<2.5$

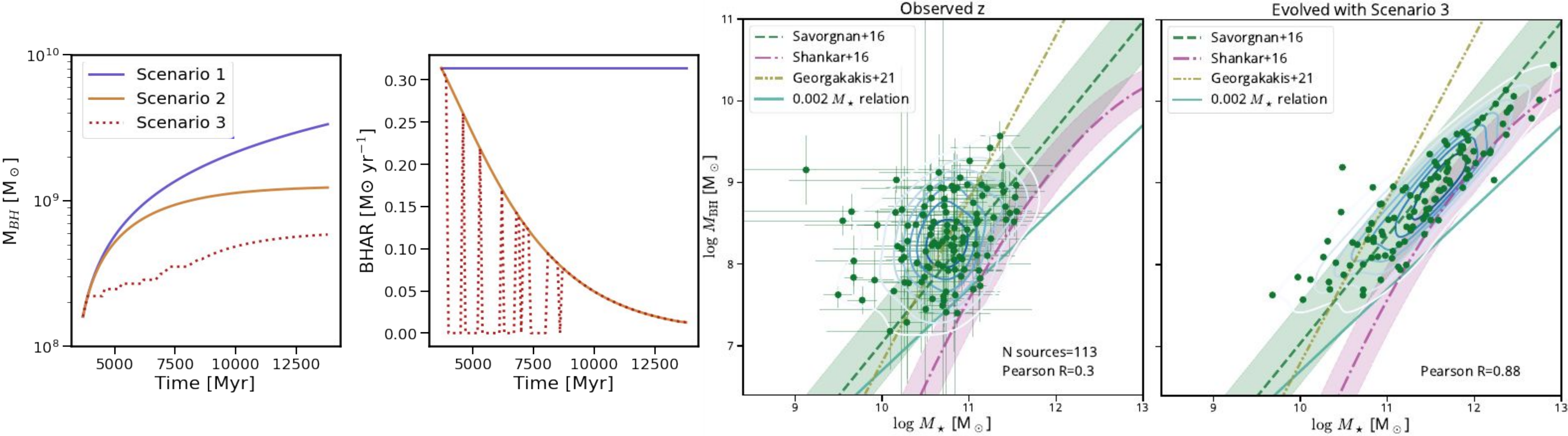
In **López+23** we studied the AGN and host galaxy properties through SED fitting and spectra fitting on the miniJPAS footprint.

The basics:

- SED Fitting using CIGALE with X-ray+UV+56 narrow optical filters+IR
- Got λ_{EDD}, M_{BH}, $\dot{M}_{BH}$ - $M_\star$, SFR
- Compare λ_{EDD} with its proxy $L_X/M_\star$. Large difference (0.6 dex) and ≠ distr
- We studied diverse co-evolution scenarios to arrive from the observed parameters to the ones expected in the local Universe

Forward modeling

- Scenario 3 reproduces expected local relations:
    - SFR follows the fitted SFH
    - BHAR ∝ SFR with an energy budget ($E_{BH} \ngtr E_{gb}$)

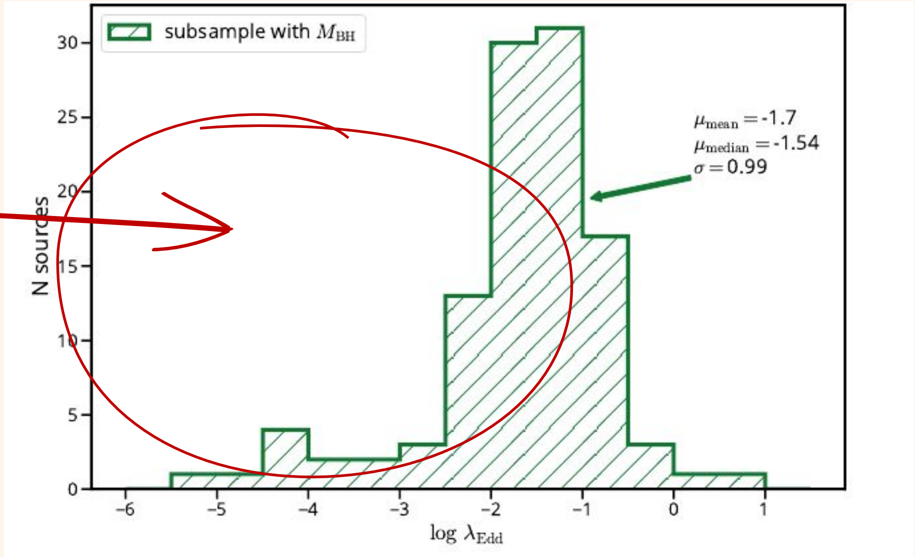


Studying the biases

In **López+23** we studied the AGN and host galaxy properties through SED fitting and spectra fitting on the miniJPAS footprint.

But:

- What is happening to **log λ_{EDD} < -3**?
    - Low-luminosity AGN
    - Adult phase

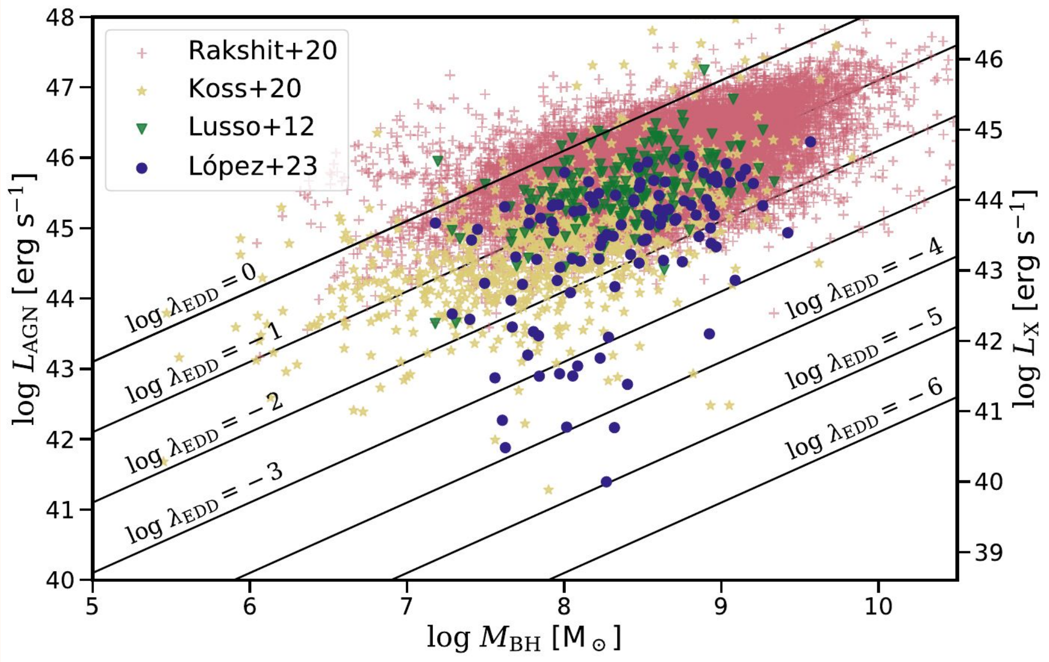


2. On LLAGN properties

Where is the LLAGN population?

This is an usual problem in AGN studies, even for large surveys like:

- SDSS QSO (Rakshit+20)
- BASS (Koss+22)



LLAGN - Accretion

- What is happening to **log λ_{EDD} <-3**?
    - Low-luminosity AGN
    - possible accretion by:
        - Truncated disk (TDk)
        - Advection Dominated Accretion Flow (ADAF)
- How far they are from QSOs?

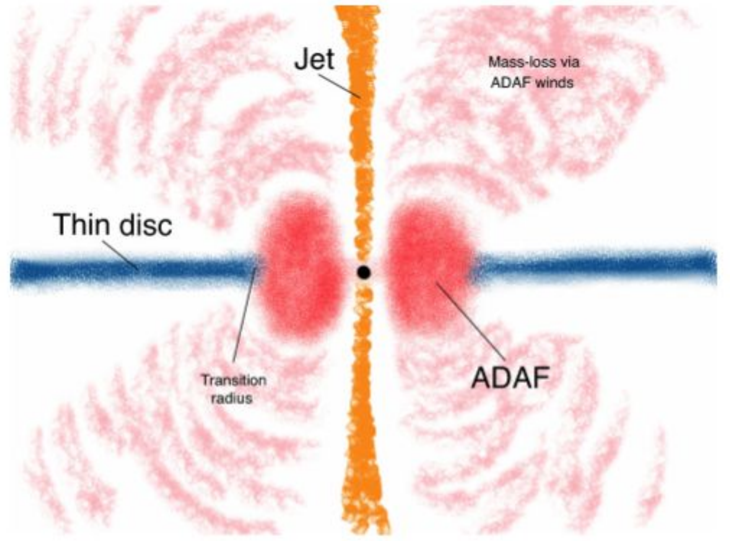


Figure 1. Cartoon illustrating the model for the central engines of LLAGNs. It consists of three components: an inner ADAF, an outer truncated thin disc and a relativistic jet.

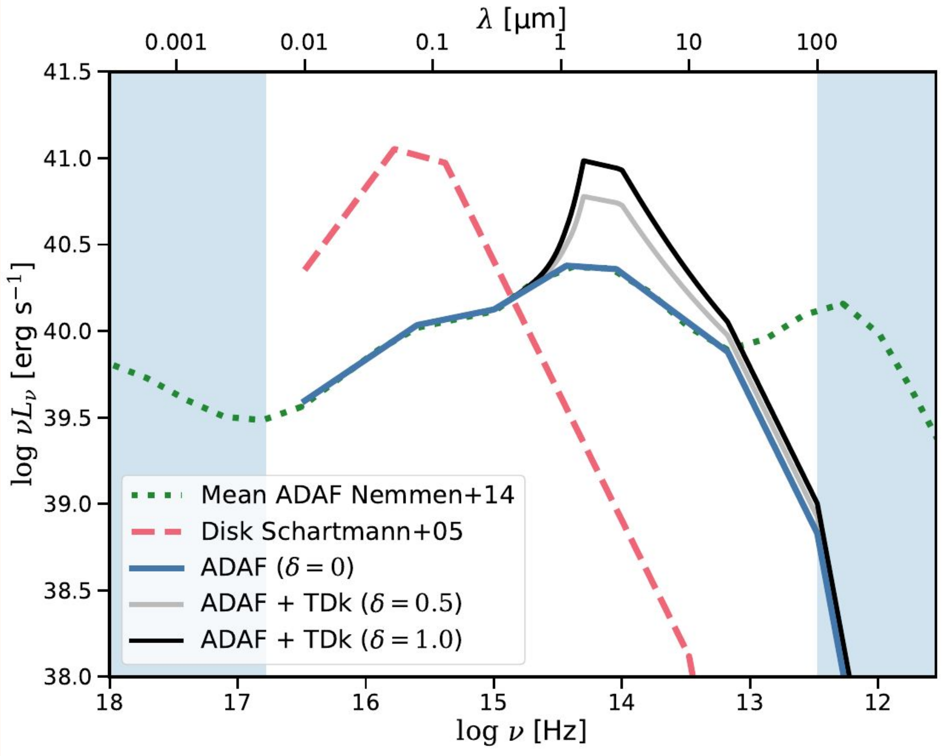
Nemmen+14

LLAGN - Accretion

- How far they are from a typical accretion disk?
  - Optically thick, geometrically thin disk are a sum of Blackbodies
  - A TDk will not have the inner and hotter orbits, so less UV photons
  - ADAFs are Synchrotron + Bremsstrahlung + IC
  - Different SEDs
    - **So current CIGALE cannot fit them!**

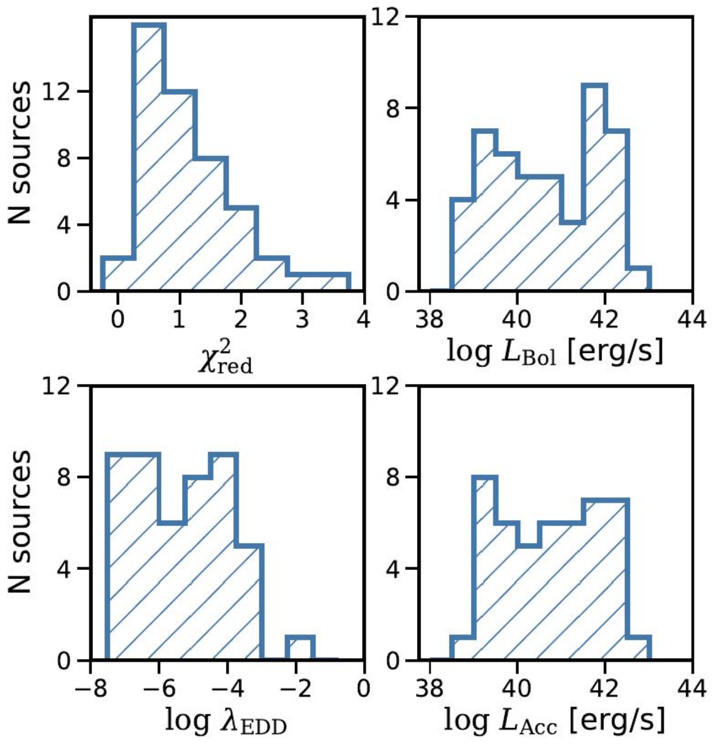
Our approach

- IRX-CIGALE (López in prep.)
- Change the seed photons:
  - ADAF + Truncated Disk (Nemmen+14)
- Change the X-ray prior:
  - Instead of α_{ox}, we use L_X–L_{IR} (Asmus+15)



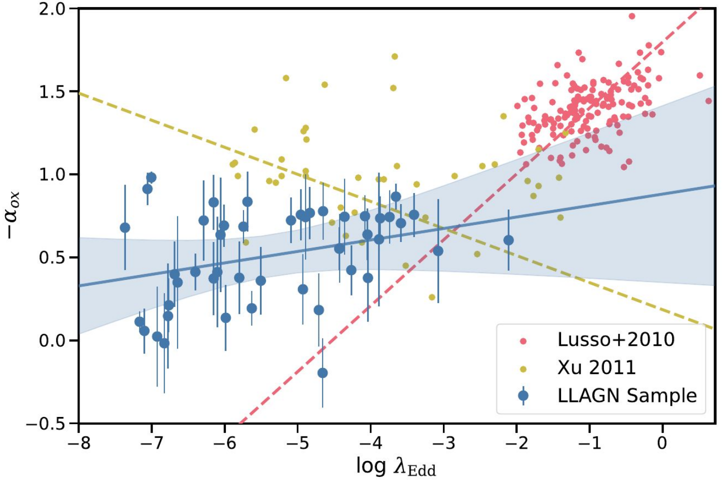
Our results

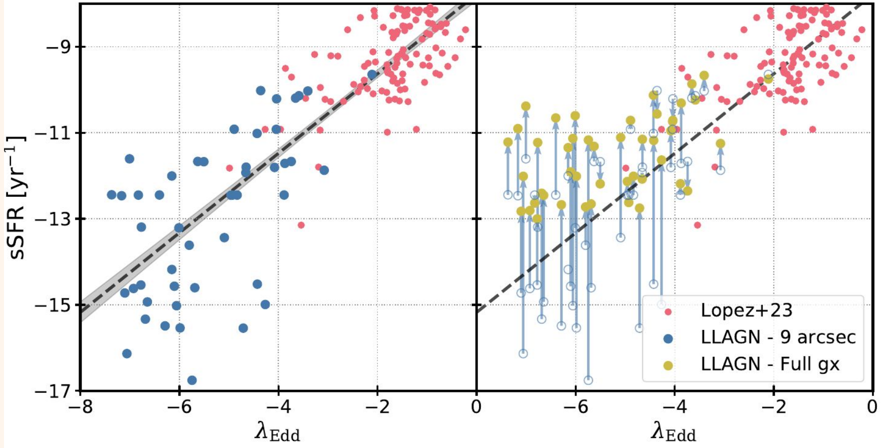
- 52 local LLAGN with X-ray fitting
  (Williams+22,Osorio-Clavijo+22,Gonzalez-Martin+08,+)
- Performed 9" photometry from UV to FIR
- IRX-Cigale SED fitting allow us arrive to:
  - log λ_{EDD} ~ -7
  - log L_{AGN} ~ 38 erg/s



Our results

- Calculate a X-ray Bolometric correction up to 10^{38} erg/s
- Study the modeled α_{ox} for different accretion regimes
- Similar results even in full galaxy contamination
- Compare the sSFR for the 9" aperture vs the full galaxy





3.

A LLAGN feedback case

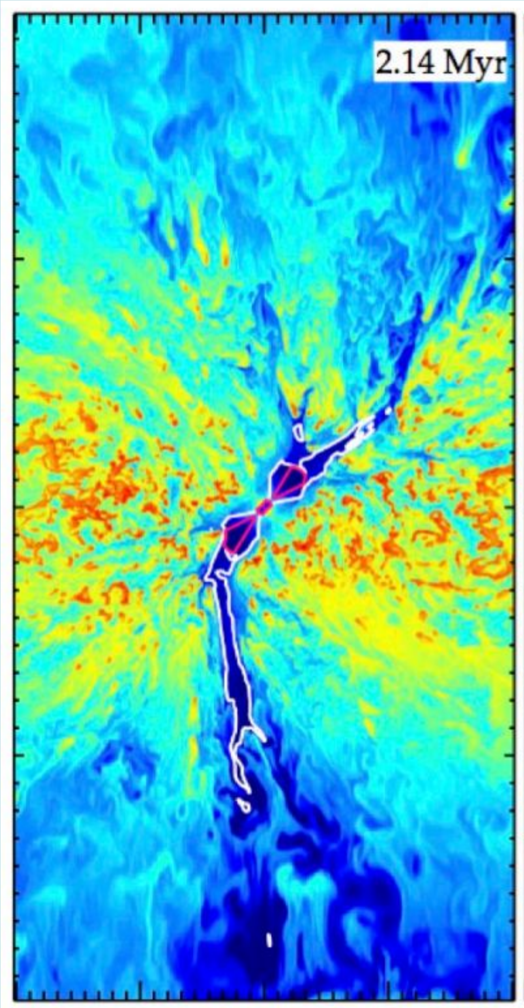
Is LL-AGN feedback relevant to galaxy evolution?

AGN Feedback can impact the:

- ISM with winds (radiative mode)
- ICM/ISM with jets (kinetic mode)

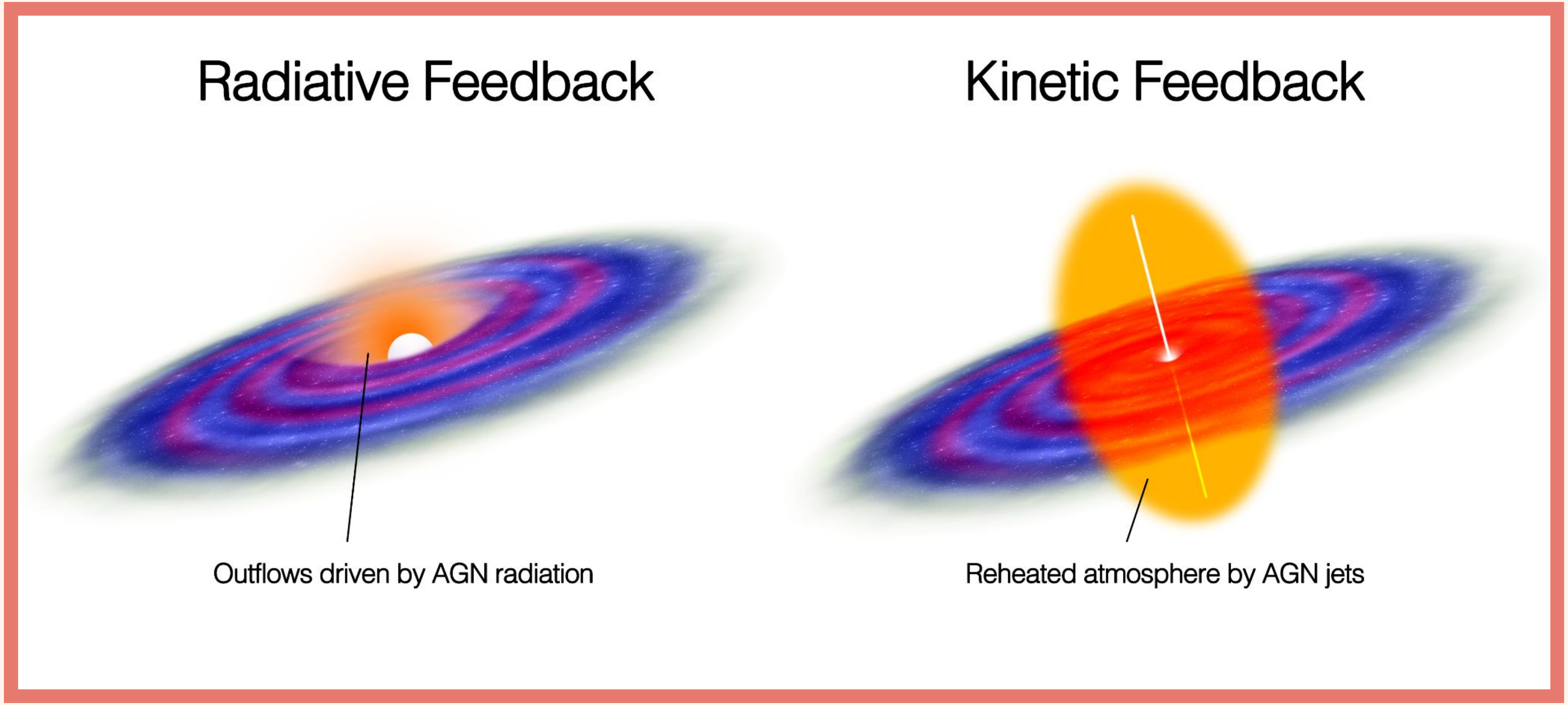
LLAGN accretion:

- LLAGN winds can also suppress SF (Almeida+23)
- Low-power jets ($P_{jet} \sim 10^{36\text{-}38}$W) can get trapped in the host gx, heating the ISM (Mukherjee+16)



AGN feedback:

- Self-regulated cycle that connects subpc to Mpc scale

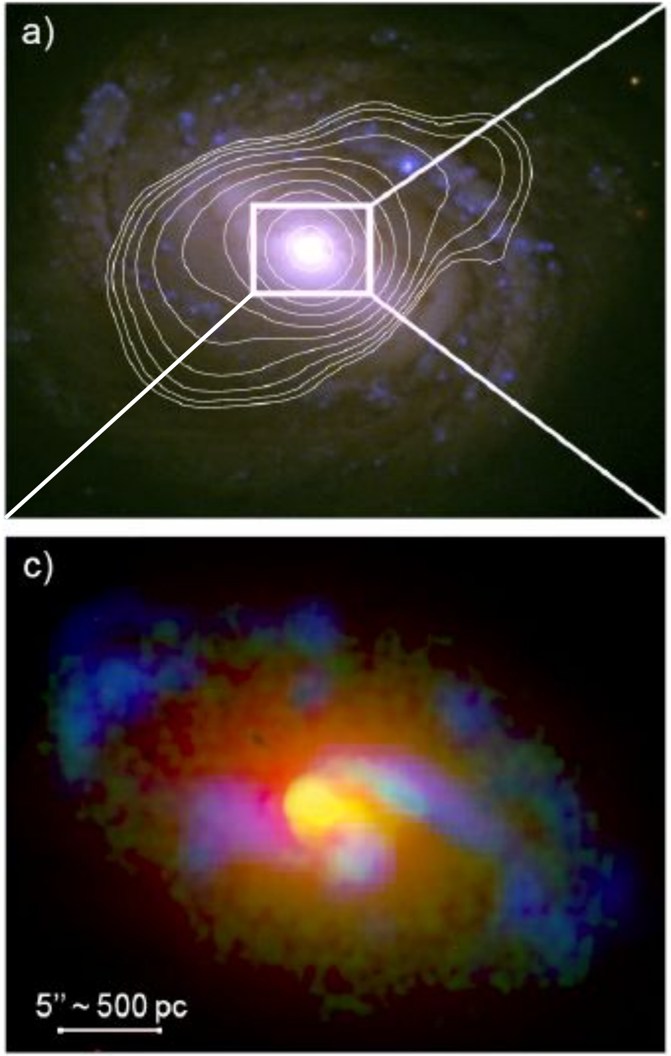


M58 a case for LLAGN Feedback

- Warm cocoon at center kpc full with H_2
- Supressed SF there without PAH destruction

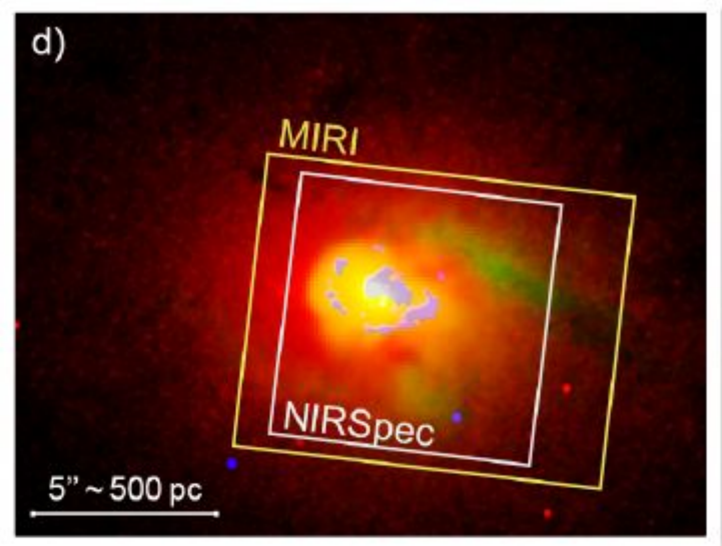
LLAGN accretion:

- LLAGN winds can also suppress SF (Almeida+23)
- **Low-power jets** (P_{jet} ~ 10^{36-38}W) can get trapped in the host gx, heating the ISM (Mukherjee+16)



M58 a case for LLAGN Feedback

- Details in Ogle, López, et al. 2023
- Next year:
    - 17hs in JWST to resolve the impact at ~10pc scale
    - 150ks in Chandra ACIS HETG to resolve ADAF winds
- Resolve ADAF vs jet



ID	Program Title	PI & Co-PIs	Exclusive Access Period (months)	Prime/ Parallel Time (hours)	Instrume Mode
3671	Radio Jet Feedback in the Nearby Spiral Galaxy M58	PI: Ivan Lopez	12	16.73/0.19	MIRI/Imaging MIRI/MRS NIRCam/Imag NIRSpec/IFU

Summary

- To assess the impact of LLAGN in galaxy evolution we need:
    - Understand the demography of LLAGN
        - IRX-Cigale as a tool to do SED Fitting *(López in prep)*
        - J-PAS + eRosita and Lemmings to go for a LLAGN/SMBH census
    - Understand how? ADAF winds, trapped jets?
        - M58 as a case test *(Ogle+23 + JWST/Chandra future data)*
        - RevealLLAGN *(7 other gx observed with JWST)*