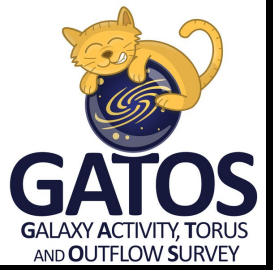
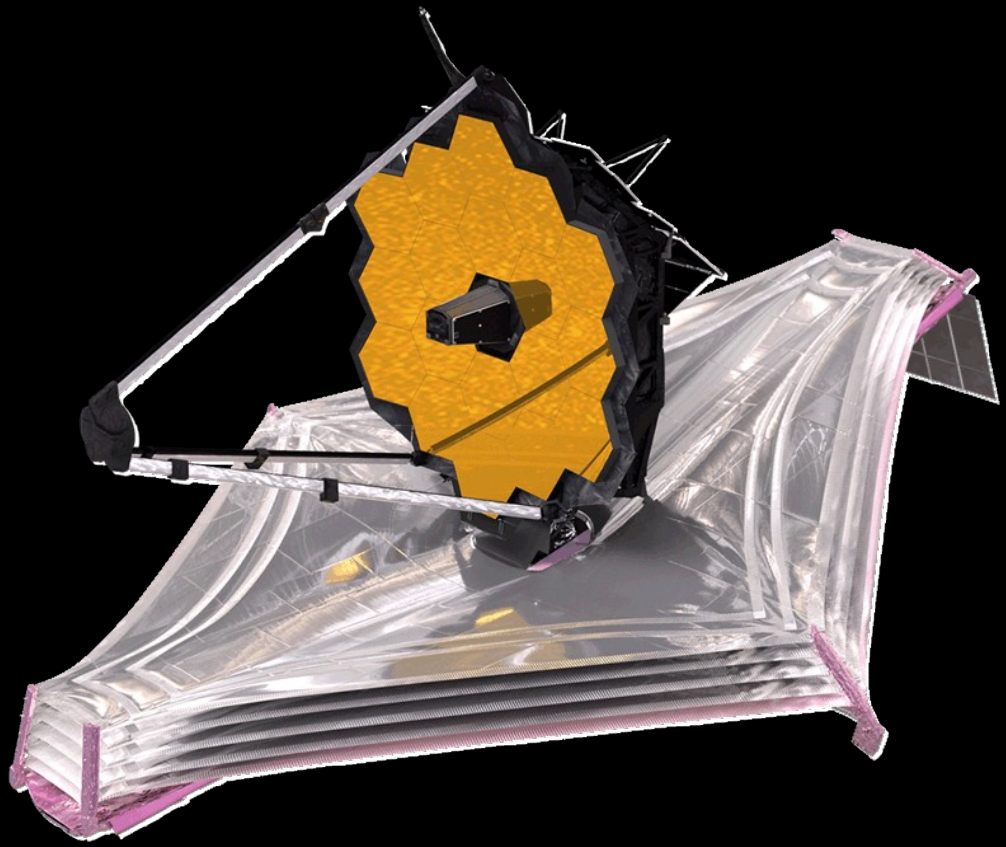


Unraveling the Universe with JWST from galaxies to the Solar System

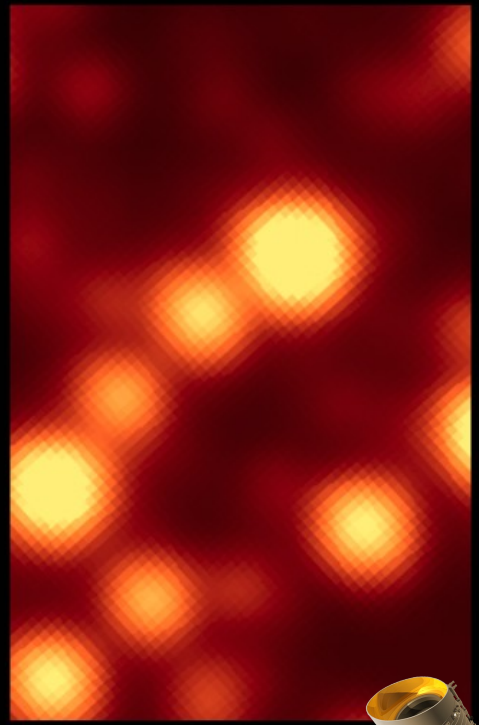
Laura Hermosa Muñoz

Universidad de Oviedo / ICTEA

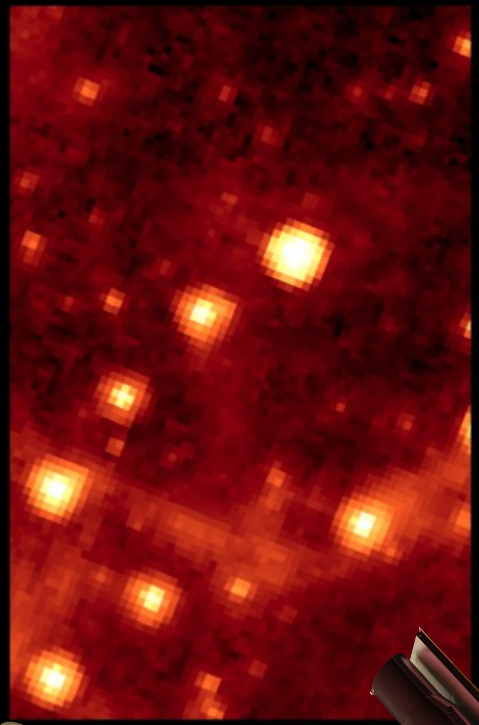
The James Webb Space Telescope (JWST)



The Evolution of Infrared Space Telescopes

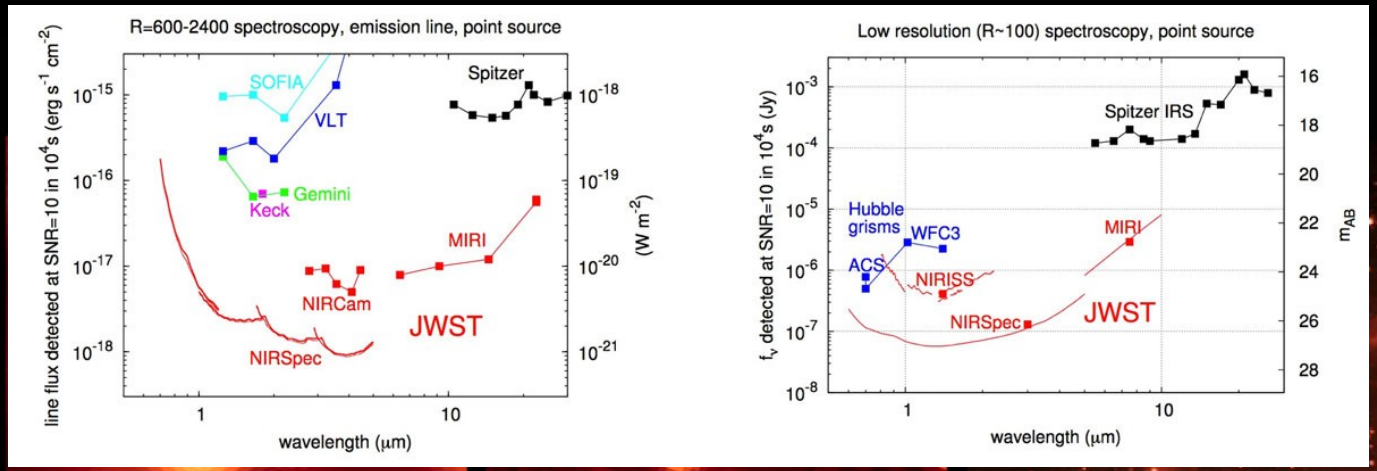


WISE W2 4.6 μm

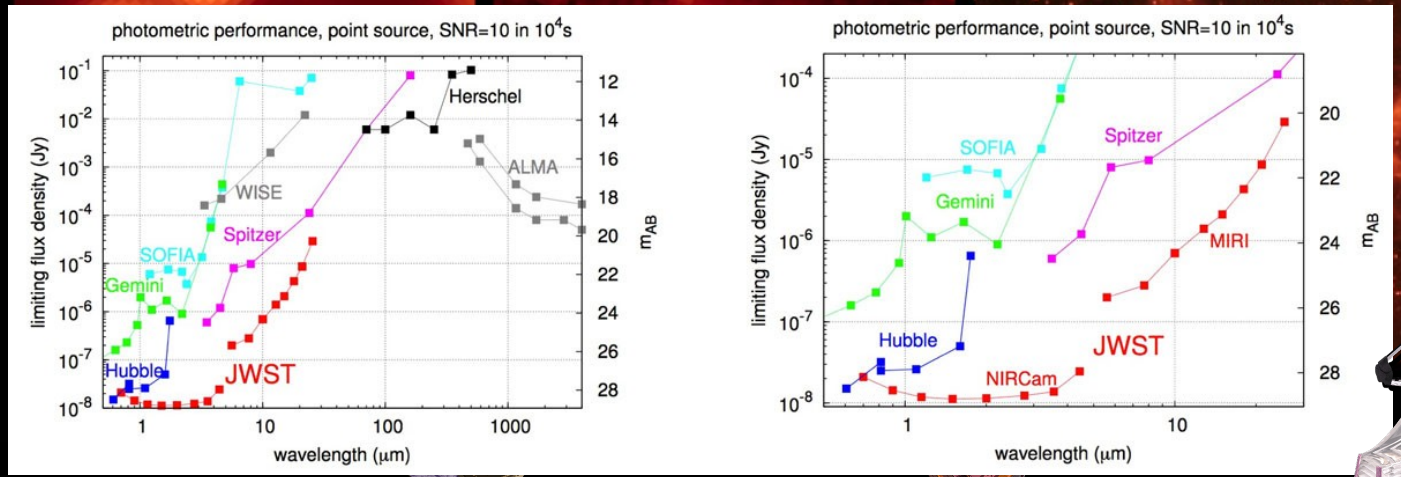


Spitzer/IRAC 8.6 μm

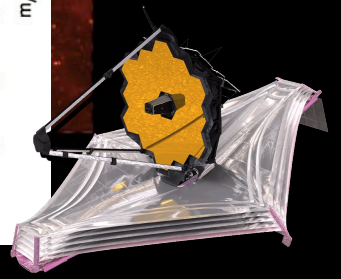
JWST/MIRI 7.7 μm


R=600-2400 spectroscopy, emission line, point source
line flux detected at SNR=10 in 10^4 s (erg s^-1 cm^-2)
(W m^-2)
wavelength (μm)
SOFIA
VLT
Spitzer
Gemini
Keck
MIRI
NIRCam
NIRSpec
JWST

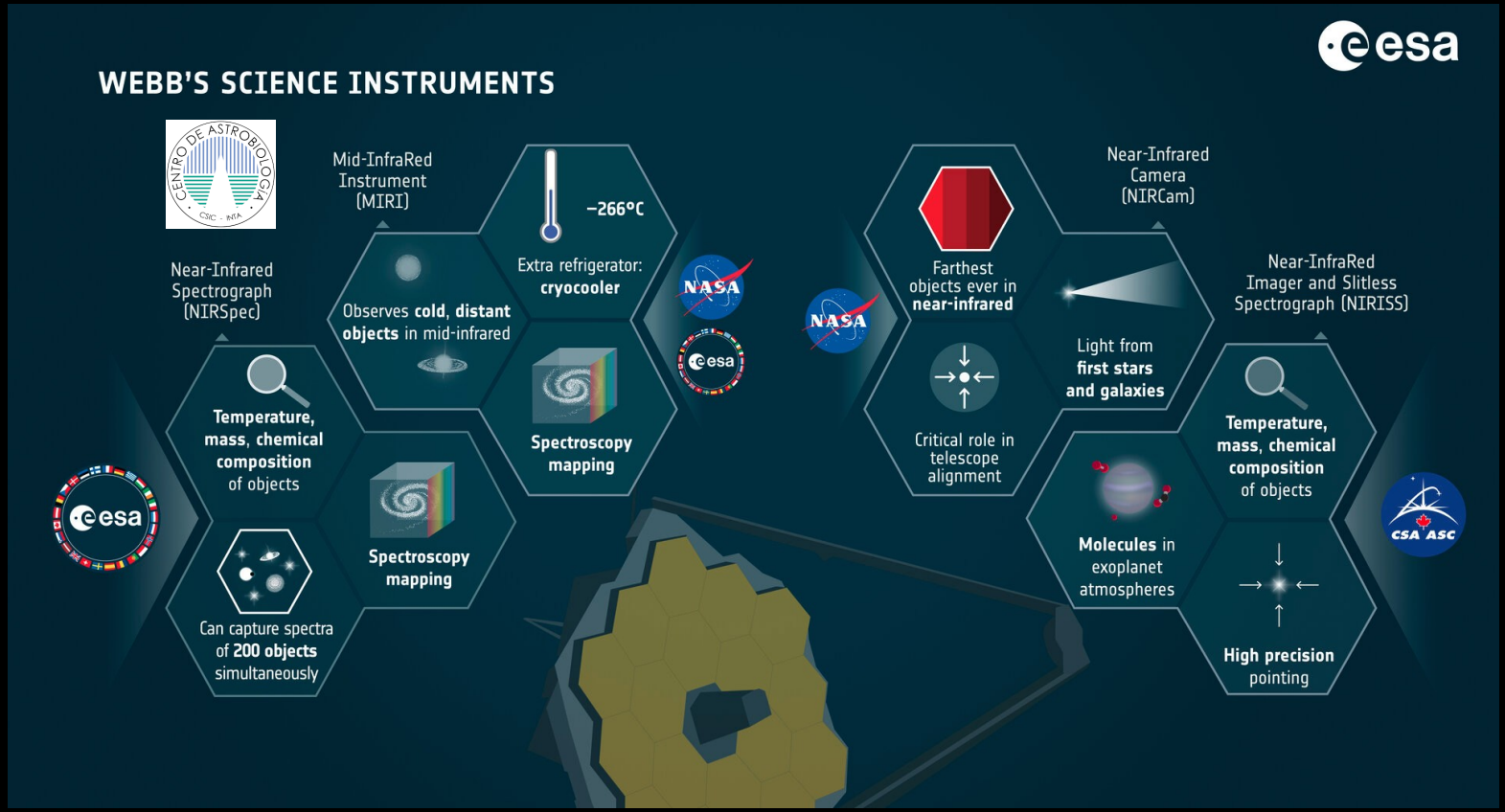
Low resolution (R~100) spectroscopy, point source
f_ν detected at SNR=10 in 10^4 s (Jy)
m_AB
wavelength (μm)
Spitzer IRS
Hubble
grisms
WFC3
ACS
NIRISS
MIRI
NIRSpec
JWST


photometric performance, point source, SNR=10 in 10^4 s
limiting flux density (Jy)
m_AB
wavelength (μm)
Herschel
ALMA
WISE
SOFIA
Spitzer
Gemini
Hubble
JWST

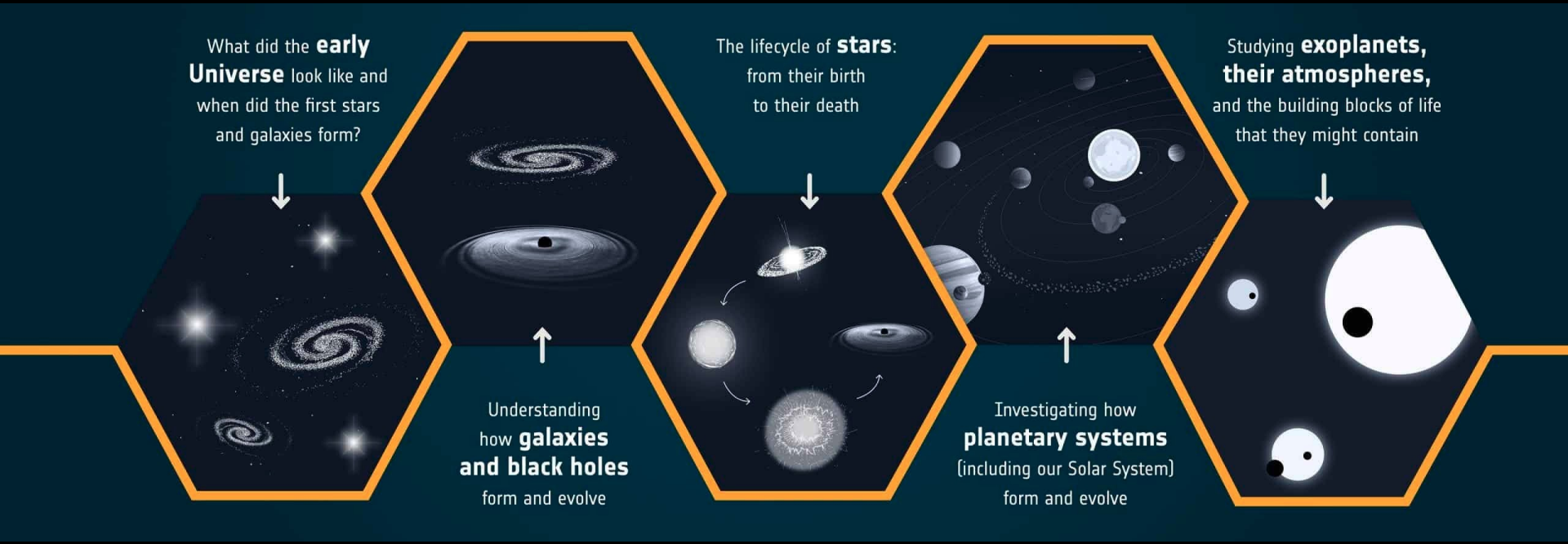
photometric performance, point source, SNR=10 in 10^4 s
limiting flux density (Jy)
m_AB
wavelength (μm)
SOFIA
Spitzer
Gemini
MIRI
Hubble
JWST
NIRCam



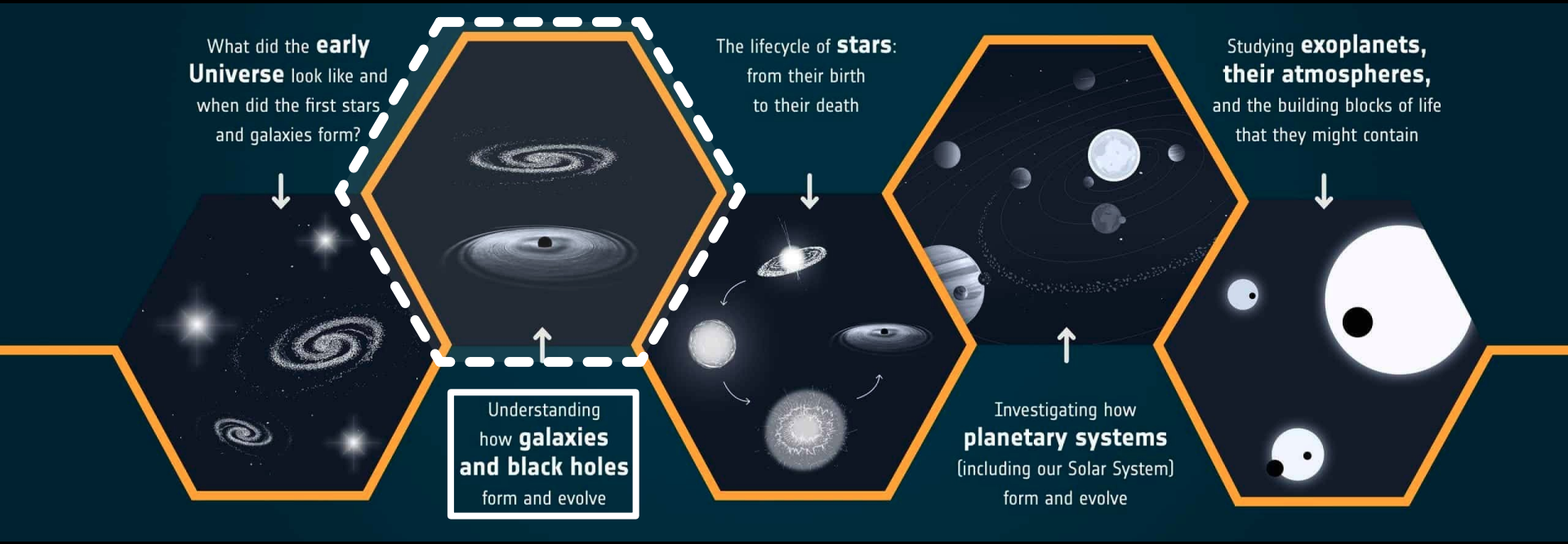
JWST instruments: *near- to mid-IR*



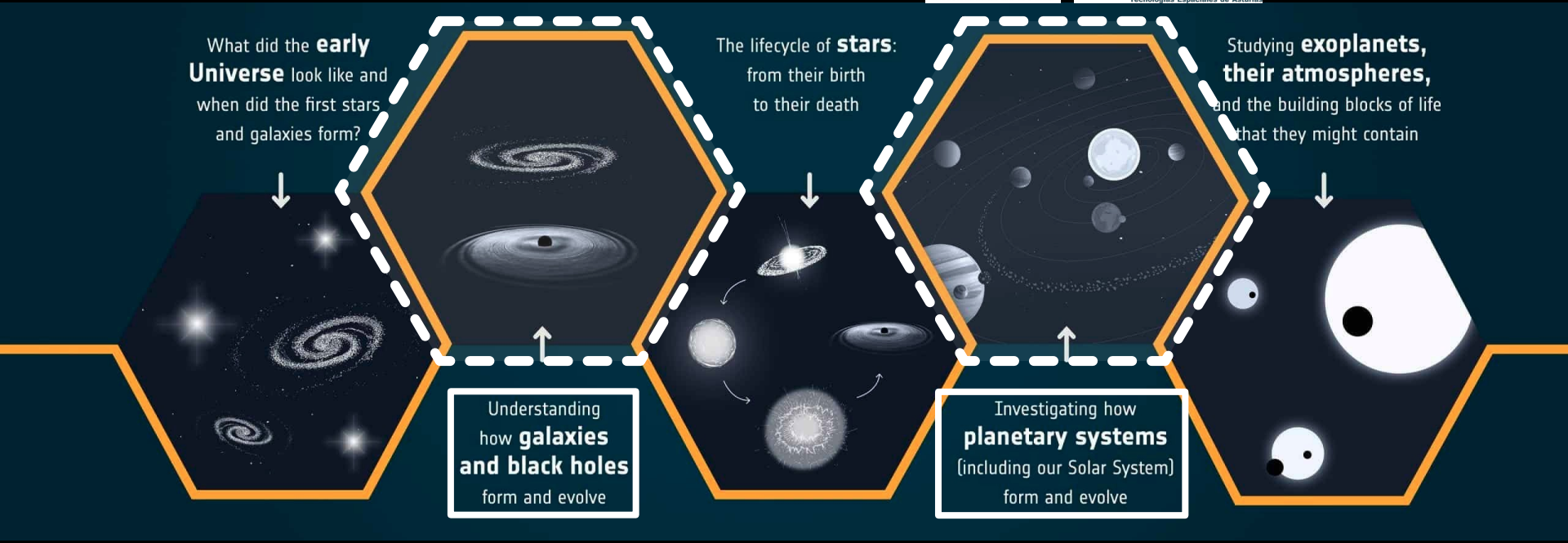
JWST scientific objectives



JWST scientific objectives



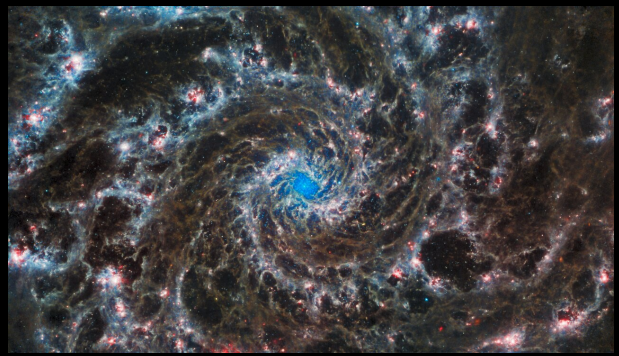
JWST scientific objectives



Why the mid-IR and JWST for studying nearby galaxies?

- Unprecedented sensitivity and spatial resolution in the infrared.
- Access to the full near and mid-IR window (1-28 μm).
- Ideal for penetrating dusty, obscured environments in galactic centers.

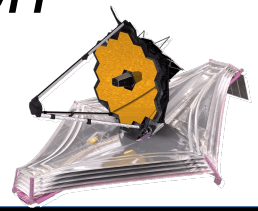
- Suffers from less obscuration than in optical → reveals nuclei
- Access to ionised (e.g. [NeII], [NeIII] or [NeV]), molecular (e.g. warm H_2), recombination (Pfα) gas emission lines, ices, molecules, and other absorption features.
- Allows to study SF, AGN, and other physical processes.



NGC 628. Crédito: ESA/Webb, NASA & CSA, J. Lee, the PHANGS-JWST Team.

MIRI European Consortium

MICONIC: *Mid-Infrared Characterization Of Nearby Iconic galaxy Centers*



MIRI/JWST Guaranteed Time Observations (GTO) program for nearby galaxies

Closest radio galaxy to Earth (D = 3.5 Mpc; 1” = 17 pc):
Alonso-Herrero, HM et al. (2025)
Pantoni et al. (2026)
Evangelista et al. (accepted)
Jones et al. (in prep.)

Centaurus A

Credit: ESO

Nearest ULIRG (D = 84.4 Mpc; 1” ~ 400 pc)
Buiten et al. (2025)
van der Werf et al. (in prep.)

Arp 220

Credit: NASA/ESA HST

Closest merger (D = 111 Mpc; 1” = 526 pc)
Hermosa Muñoz et al. (2025)
Hermosa Muñoz et al. (in prep.)
Pantoni et al. (in prep.)

NGC 6240

Credit: NASA/ESA HST

Nearest BAL-QSO/ULIRG (D ~ 187.6 Mpc; 1" ~ 837 pc)
Alonso-Herrero, HM et al. (2024)

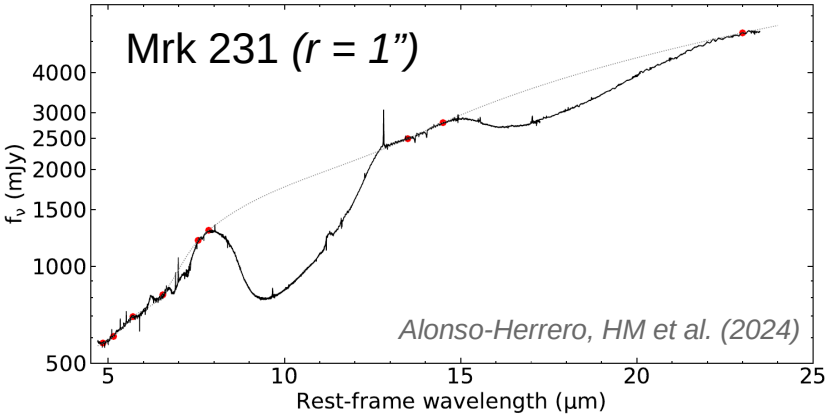
Mrk 231

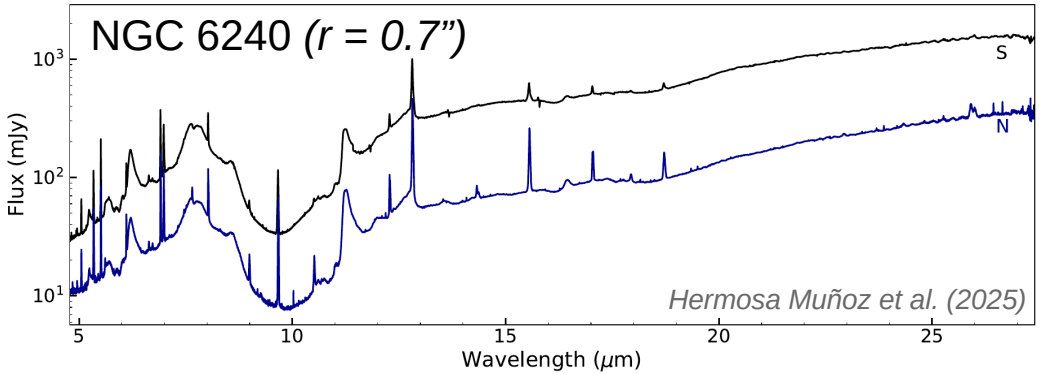
Credit: NASA/ESA HST

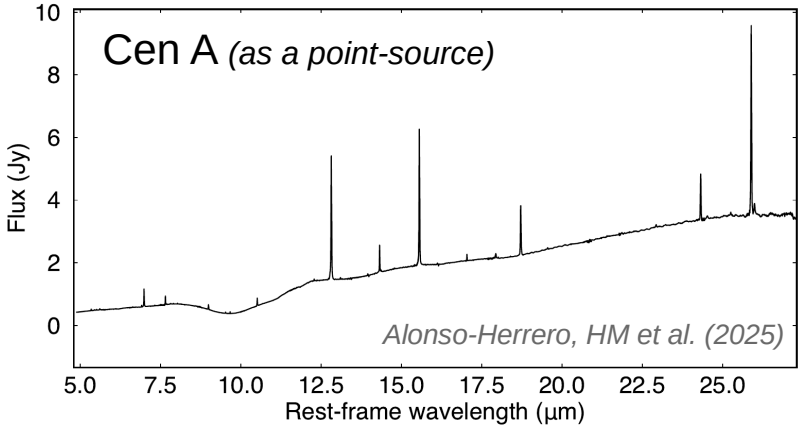
+ region near to the Galactic Centre *(Peißker et al. accepted)* & SBS0335-52

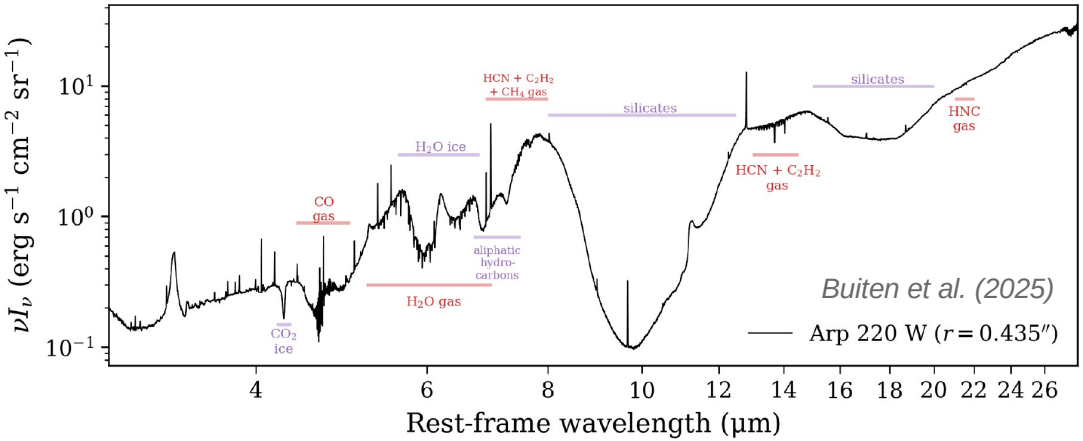
lhermosa@cab.inta-csic.es

MICONIC: *Global overview*



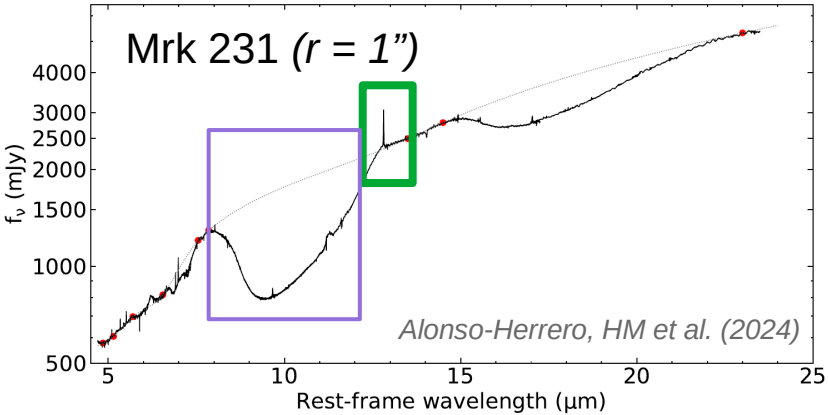


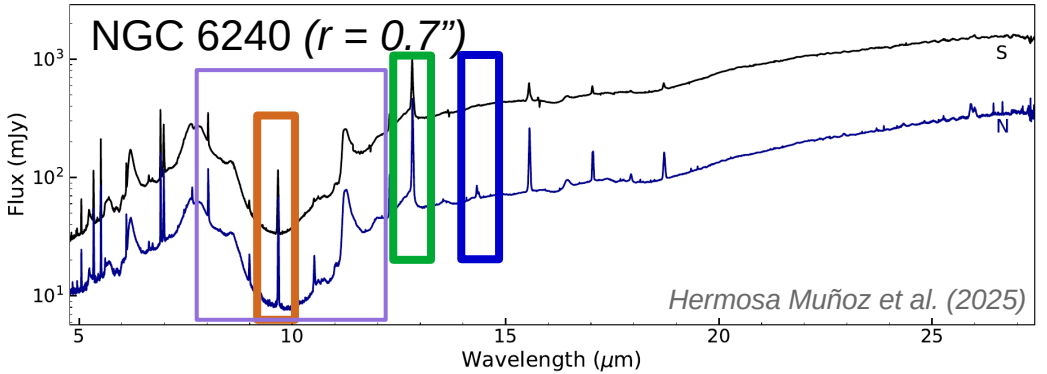


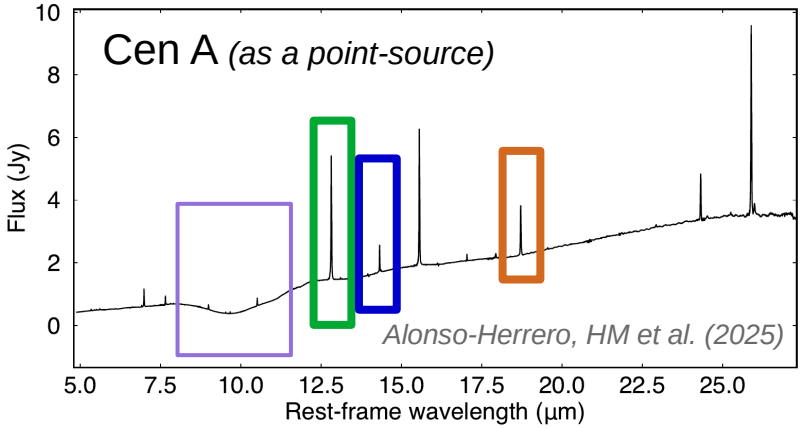


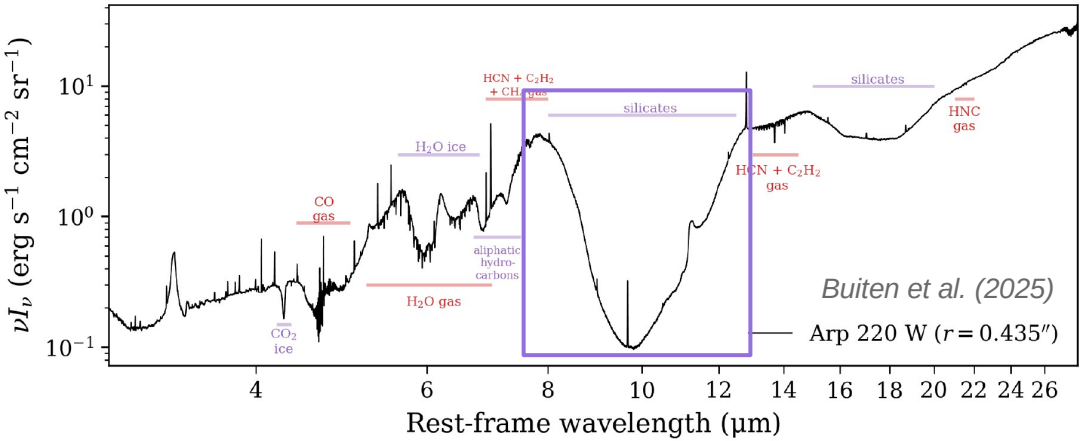
MICONIC: *Global overview*

Low excitation ionised gas
High excitation ionised gas
Warm molecular gas
Silicate absorption + molecules

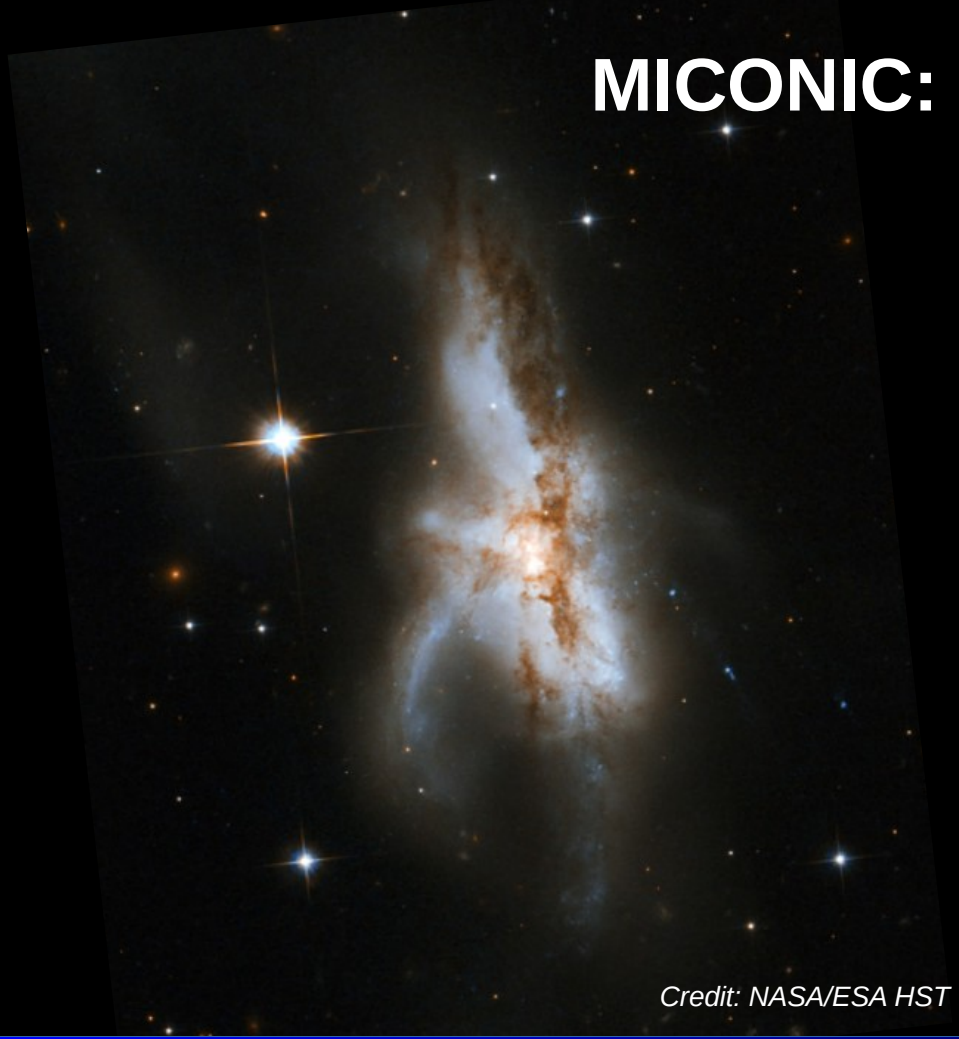








MICONIC: *NGC 6240*

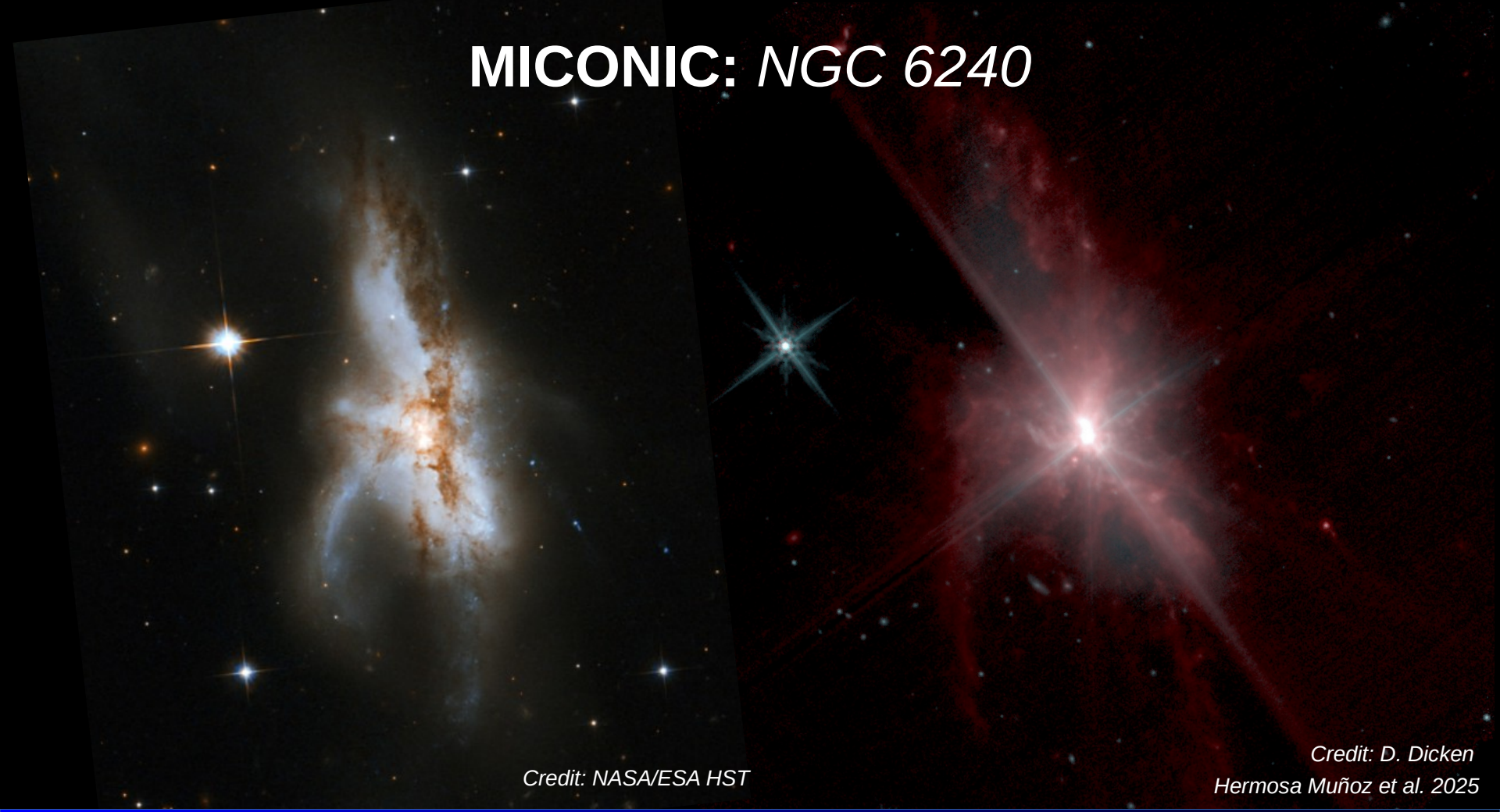


Credit: NASA/ESA HST

Z ~ 0.0244, D ~ 111 Mpc; 1'' ~ 526 pc
Dual AGN: type-2 Seyfert & LINER
(L_{bol} 2.6×10^{44} erg s^{-1} & 8×10^{44} erg s^{-1}, *Müller-Sánchez+18*)

Observed: 14th August 2023
GTO program 1265

MICONIC: *NGC 6240*



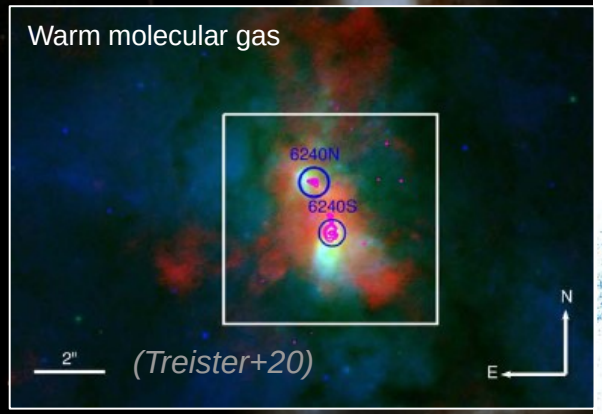
Credit: NASA/ESA HST

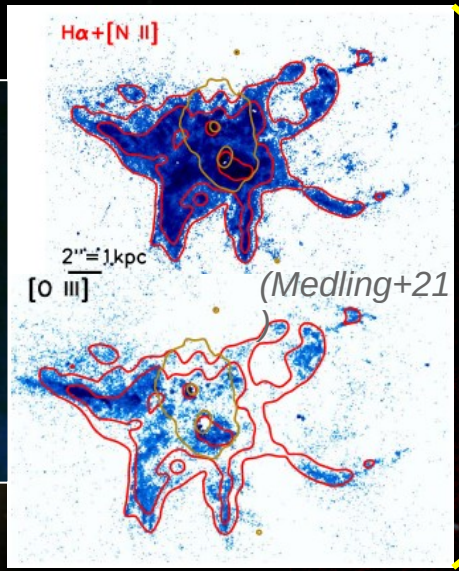
Credit: D. Dicken
Hermosa Muñoz et al. 2025

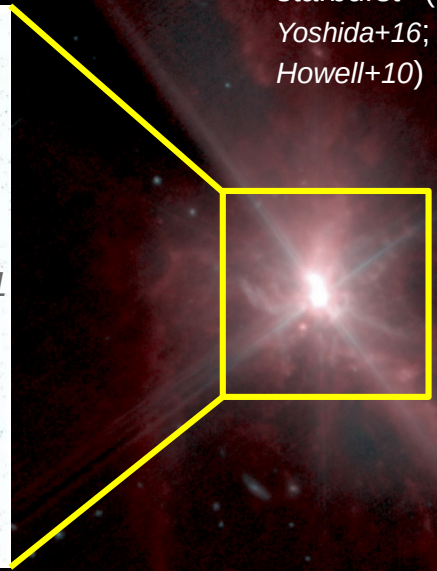
MICONIC: *NGC 6240*

LIRG – $\log(L_{IR}/L_{sun})= 11.93$ *(Kim+13)*

Dual AGN ~0.7 kpc + nuclear starburst (6-9 Myr ago *Tezca+10, Yoshida+16*; SFR > $100M_{sun}$/yr, *Howell+10*)







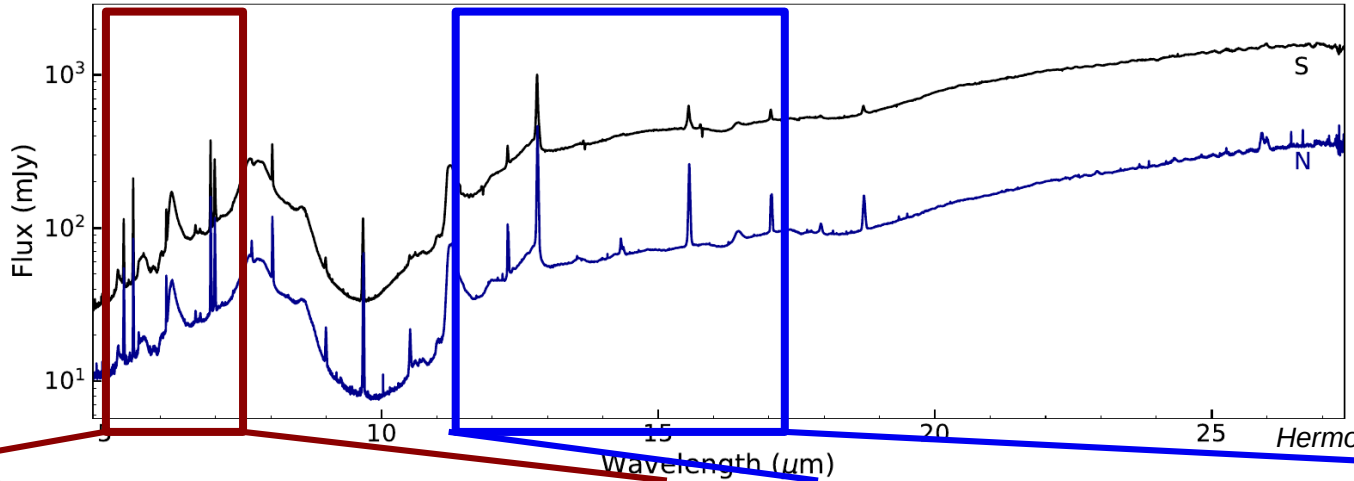
Hermosa Muñoz et al. (in prep.)

Credit: NASA/ESA HST

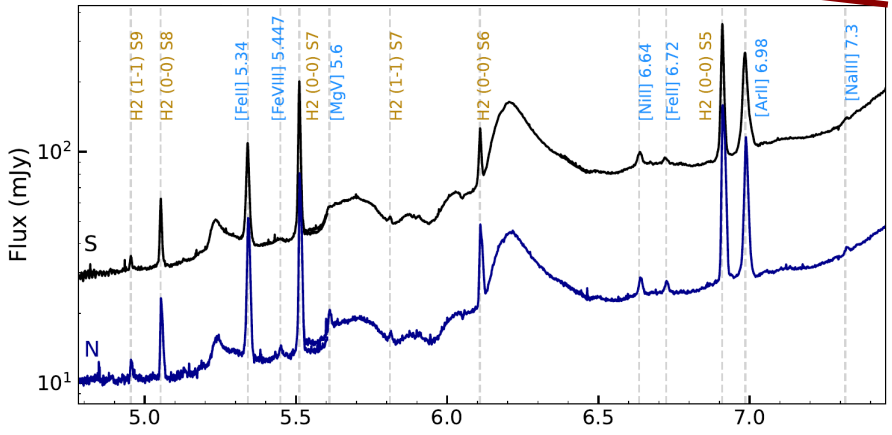
Credit: D. Dicken

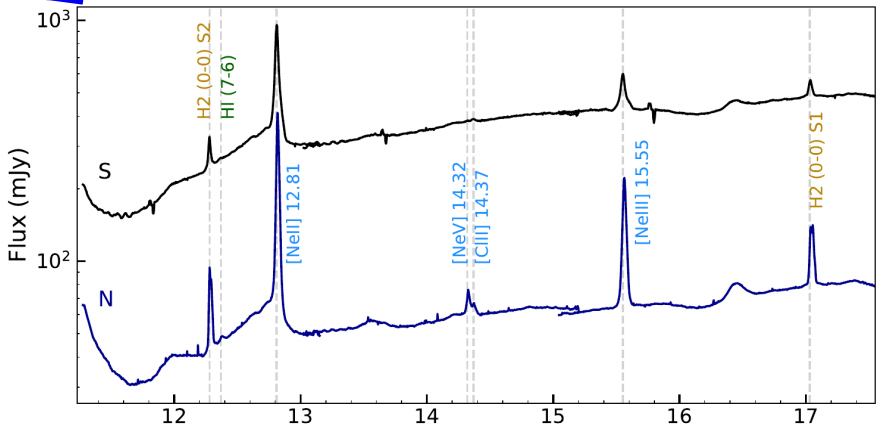
Hermosa Muñoz et al. (2025)

Integrated MIRI/MRS spectrum per nuclei (r = 0.7”)

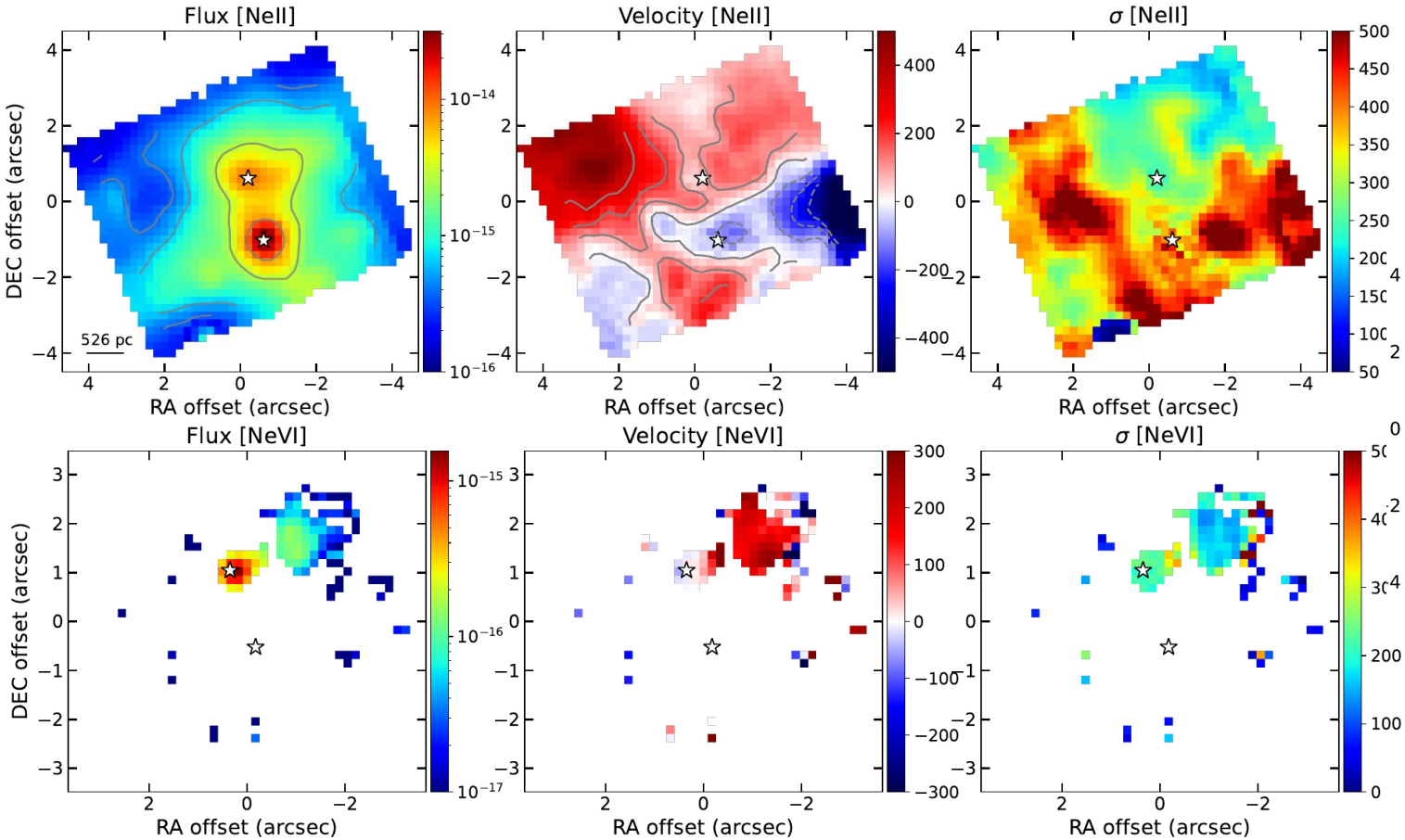


Hermosa Muñoz et al. 2025

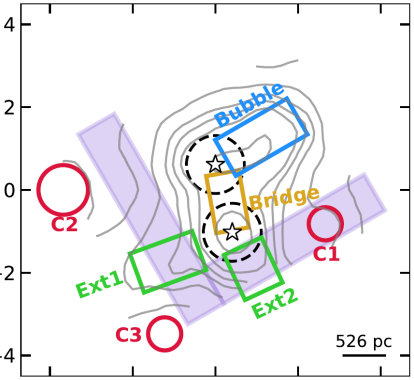




NGC 6240: *kinematic maps for the ionised gas*



We are now comparing with the warm molecular gas properties.

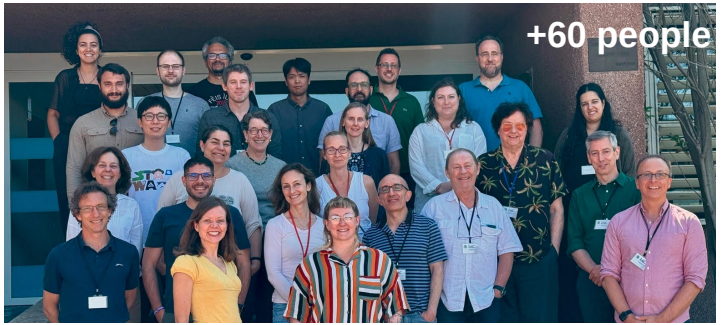


Hermosa Muñoz et al. 2025

GATOS:

Galaxy Activity, Torus, and Outflow Survey

Study of the fuelling and feedback processes taking place in the central few kpc of active galaxies, polar dust emissions, the torus, and obscuring materials. Our efforts also extend to shedding light on star formation, galaxy evolution, and other cosmic phenomena, crucial for understanding co-evolution of galaxies and SMBH.



A&A 652, A98 (2021)
https://doi.org/10.1051/0004-6361/202141075

Astronomy & Astrophysics

The Galaxy Activity, Torus, and Outflow Survey (GATOS)

I. ALMA images of dusty molecular tori in Seyfert galaxies

S. García-Burillo[1], A. Alonso-Herrero[2], C. Ramos Almeida[3,4], O. González-Martín[5], F. Combes[6], A. Usero[1], S. Hönig[7], M. Querejeta[1], E. K. S. Hicks[8], L. K. Hunt[9], D. Rosario[10], R. Davies[11], P. G. Boorman[12], A. J. Bunker[13], L. Burtscher[14], L. Colina[15], T. Díaz-Santos[16], P. Gandhi[7], I. García-Bernete[13], B. García-Lorenzo[3,4], K. Ichikawa[17], M. Imanishi[18,19], T. Izumi[18,19], A. Labiano[15], N. A. Levenson[20], E. López-Rodríguez[21,22], C. Packham[23], M. Pereira-Santaella[15], C. Ricci[24,25], D. Rigopoulou[13], D. Rouan[26], T. Shimizu[11], M. Stalevski[27,28], K. Wada[29,30,31], and D. Williamson[7]

(Affiliations can be found after the references)

Received 13 April 2021 / Accepted 22 June 2021

A&A 652, A99 (2021)
https://doi.org/10.1051/0004-6361/202141219

Astronomy & Astrophysics

The Galaxy Activity, Torus, and Outflow Survey (GATOS)

II. Torus and polar dust emission in nearby Seyfert galaxies

A. Alonso-Herrero[1], S. García-Burillo[2], S. F. Hönig[3], I. García-Bernete[4], C. Ramos Almeida[5,6], O. González-Martín[7], E. López-Rodríguez[8], P. G. Boorman[9], A. J. Bunker[4], L. Burtscher[10], F. Combes[11], R. Davies[12], T. Díaz-Santos[13], P. Gandhi[3], B. García-Lorenzo[5,6], E. K. S. Hicks[14], L. K. Hunt[15], K. Ichikawa[12,16,17], M. Imanishi[18,19,20], T. Izumi[21], A. Labiano[1], N. A. Levenson[23], C. Packham[24,18], M. Pereira-Santaella[22], C. Ricci[25,26], D. Rigopoulou[4], P. Roche[4], D. J. Rosario[27], D. Rouan[28], T. Shimizu[12], M. Stalevski[29,30], K. Wada[31,32,33], and D. Williamson[3]

(Affiliations can be found after the references)

Received 30 April 2021 / Accepted 30 June 2021

GATOS: *JWST GO time*

ID	Program Title	PI & Co-PIs	Exclusive Access Period (months)	Prime/ Parallel Time (hours)	Instrument/ Mode	Type
1670	Closing in on the Launching Sites of AGN Outflows	PI: Thomas Shimizu	12	34	MIRI/MRS	GO
2064	Dust in the Wind: Testing a New Paradigm for the Nature of AGN Feedback	PI: David Rosario Co-PIs: Sebastian Hoenig and Leonard Burtscher	12	19.3	MIRI/Imaging	GO
3535	Unveiling the AGN-host connection with PAH molecules	PI: Ismael Garcia Bernete Co-PI: Dimitra Rigopoulou	12	11.88/0	MIRI/MRS NIRSpec/IFU	GO
4225	First spatially resolved characterization of the warm molecular torus in the Circinus galaxy	PI: Takuma Izumi	12	3.25/0	MIRI/MRS	GO
4972	Hunting the Kinetic Mode Feedback of AGNs via PAH Features	PI: Lulu Zhang	12	12.32/0.0	MIRI/MRS NIRSpec/IFU	GO
5017	AGN and their outflows: probing fragmentation and survival of polycyclic aromatic hydrocarbons	PI: Ismael Garcia Bernete Co-PIs: Almudena Alonso-Herrero and Dimitra Rigopoulou	12	18.53/0.0	NIRSpec/IFU	GO
7195	Deciphering the torus and extended dust properties of local active galactic nuclei	PI: Almudena Alonso-Herrero Co-PIs: Ismael Garcia Bernete and Sebastian Hoenig	12	32.7/0.0	MIRI/MRS NIRSpec/IFU	GO
7429	Unraveling Effects of Different Modes of AGN Feedback via PAH Features	PI: Lulu Zhang	12	11.6/0.0	MIRI/MRS NIRSpec/IFU	GO
7802	Dust in shocks: The missing link in AGN feedback	PI: Houda Haidar	12	14.1/0.0	MIRI/MRS	GO
9652	The hot dusty phase of active galaxies as observed by JWST interferometry	PI: Enrique Lopez-Rodriguez	12	109.7/0.0	NIRISS/AMI	GO

Cycle 1

Cycle 2

Cycle 3

Cycle 4

Cycle 5

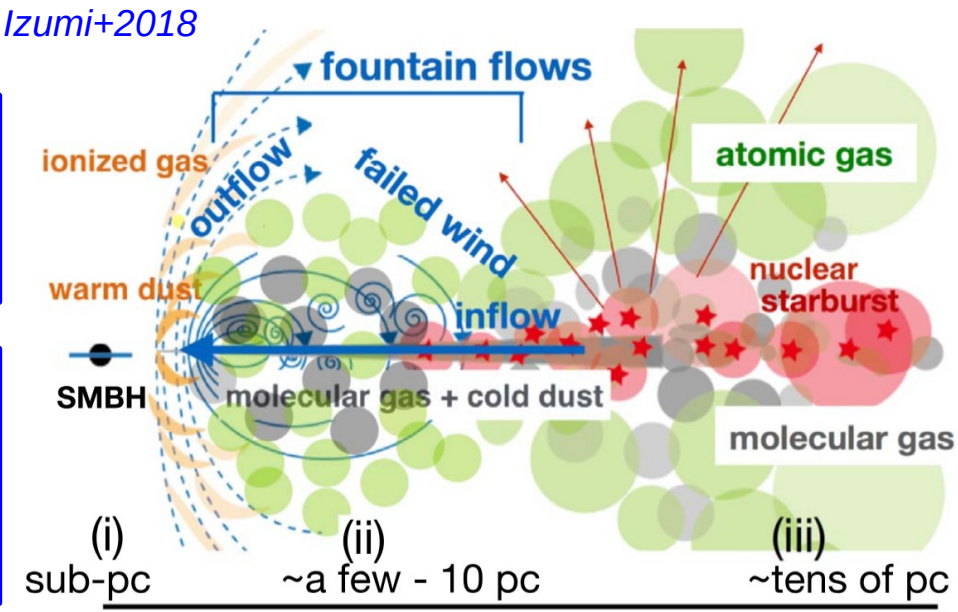
~270 h !

GATOS
GALAXY ACTIVITY, TORUS AND OUTFLOW SURVEY

GATOS: *recent JWST works*

GATOS
GALAXY ACTIVITY, TORUS AND OUTFLOW SURVEY

Izumi+2018



PAHs:
García-Bernete+2024c, Zhang+2024b, Donnan+2026

Extended dust emission: Leist+2024, Haidar+2024,+2026, López-Rodríguez+2025, Campbell+2025

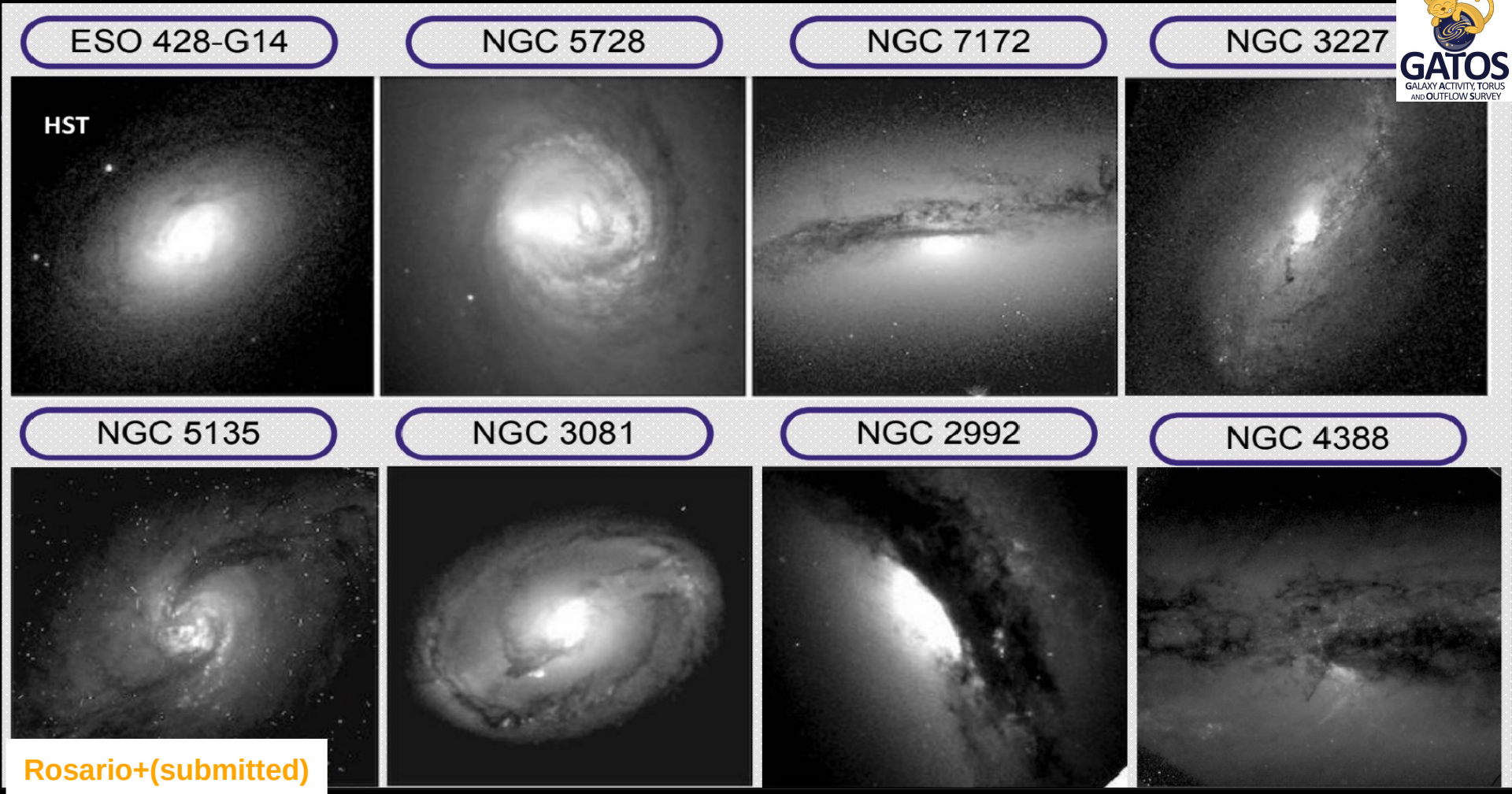
Ionised and warm molecular outflows:
Hermosa Muñoz+2024b, Zhang+2024a, Davies+2024, Esparza-Arredondo+2025, Delaney+2025,+2026, Veenema+2025,+2026

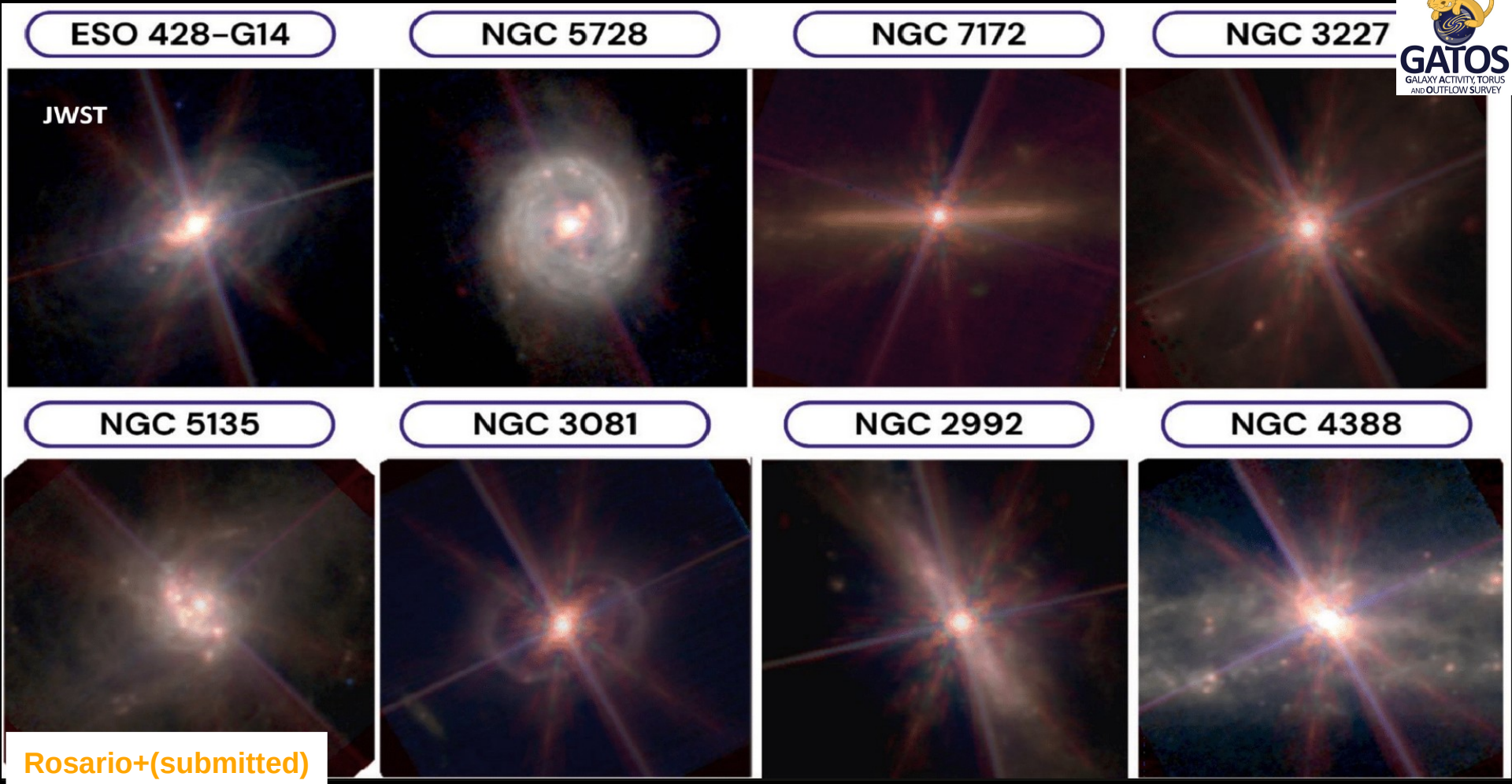
Torus modelling and ices:
García-Bernete+2024a, González-Martín+2025

IA/ML: Hermosa Muñoz+2026

+ 3 JWST papers submitted
+ several others in prep.

+ other works with other facilities:
ALMA, MEGARA, VLT, SOFIA, ...


ESO 428-G14
NGC 5728
NGC 7172
NGC 3227
HST
NGC 5135
NGC 3081
NGC 2992
NGC 4388
Rosario+(submitted)


ESO 428–G14
NGC 5728
NGC 7172
NGC 3227
JWST
NGC 5135
NGC 3081
NGC 2992
NGC 4388
Rosario+(submitted)

The Galaxy Activity, Torus, and Outflow Survey (GATOS)

XII. Unveiling physical processes in local active galaxies. Unsupervised hierarchical clustering of JWST MIRI/MRS observations

Astronomy & Astrophysics

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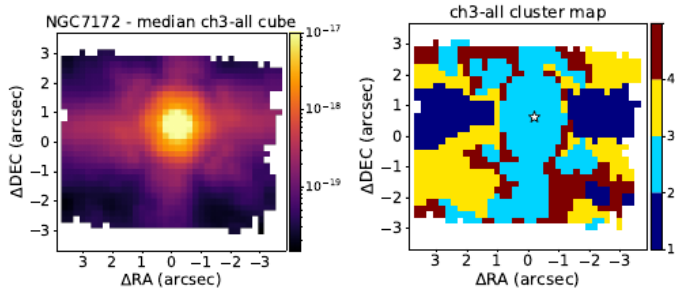

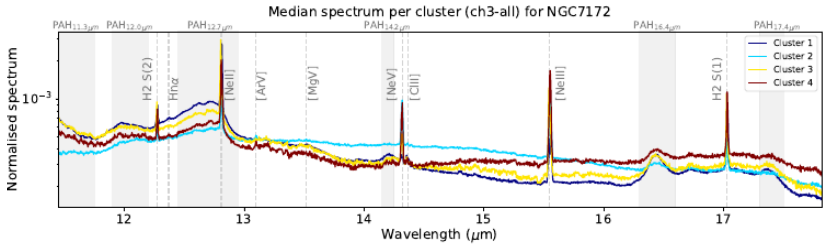

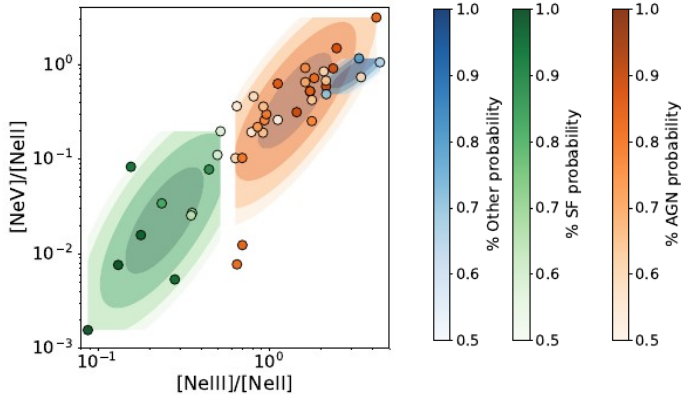

Clustering of any data cube (tested on MIRI/JWST).

Automatic identification and classification of the main ionising source of the gas present in the galaxies.

Summary

JWST is allowing us to observe nearby objects in the infrared with an unprecendent spatial and spectral resolution.

DiSCO + TNOs → The best is yet to come!

Thank you for your attention!