Accretion and ejection in young stars in the Solar neighbourhood and beyond with MORFEO-MICADO on ELT

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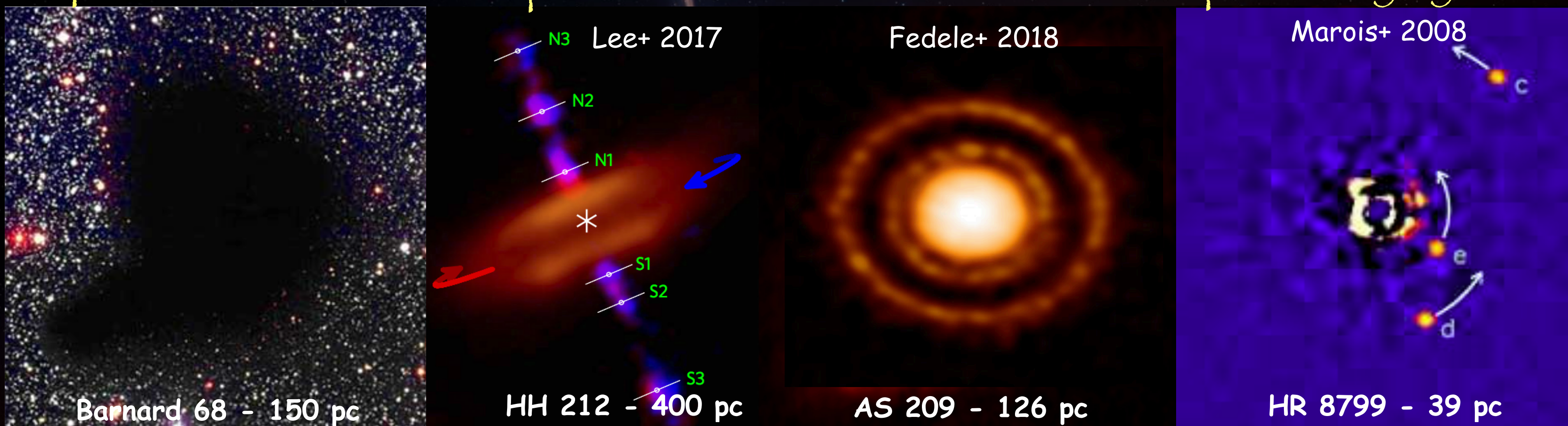
The star and planet formation process

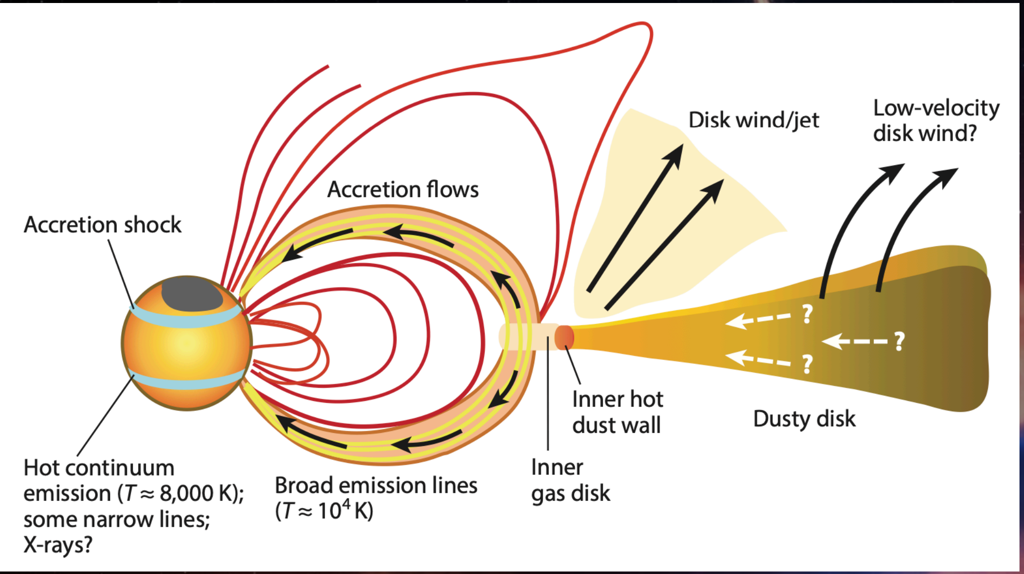
prestellar core | protostar | T Tauri disk | planetary system

from E. Bianchi PhD thesis

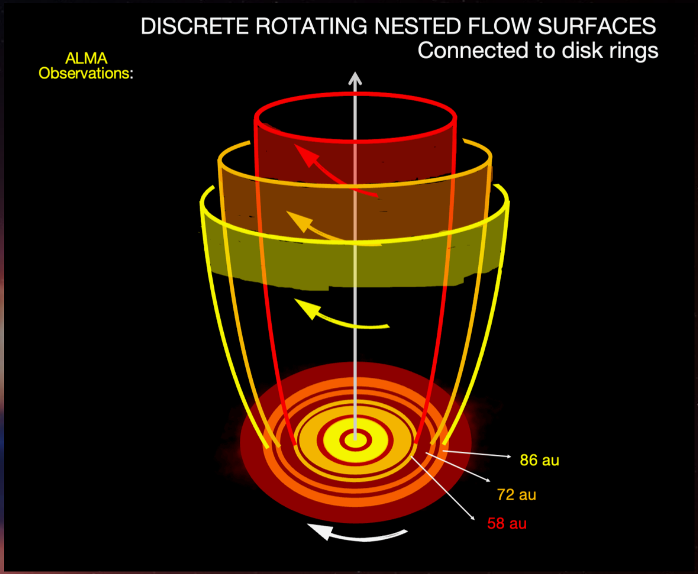


t=0 | 10^4—10^5 yrs | 10^6—10^7 yrs | >10^8 yrs

the properties of the nascent stars and planetary systems are determined by the interplay btw accretion and ejection



Hartmann et al. 2016



Bacciotti et al. 2025, Coffey et al. 2026

- accretion and ejection set the final stellar mass and the timescale for planet formation
- jets and winds extract angular momentum thus allowing accretion onto the YSO
- jets and winds may carve gaps in the disk thus triggering grain growth & planet formation

JEDI-EX COLLABORATION

The MORFEO working team *"Jets, Disks, Exoplanets"* is on:

SC1: Outflow, Wind & Jets *(Podio/Bacciotti)*
SC2: Planet forming disks' streamers *(Ginski)*
SC3: Planet forming disks' substructures *(Toci)*
SC4: Planet forming disks' dust properties *(Ginski)*
SC5: Protoplanets *(Fedele)*
SC6: Exoplanets architectures *(Mesa)*
SC7: Exoplanets atmospheres *(Palma-Bifani)*
SC8: Debris Disks *(Roccatagliata)*
SC9: Free-floating planets & Brown Dwarfs *(D'Orazi)*

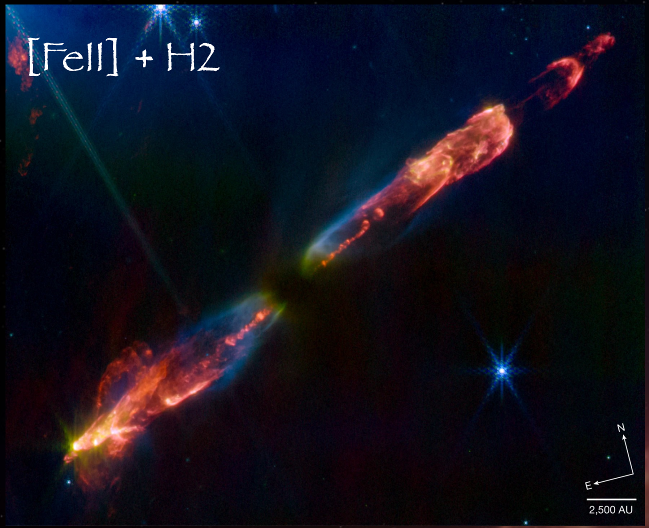
MORFEO-MICADO on ELT will unveil accretion & ejection in YSOs from nearby SFRs to the limits of the MW and beyond

the star-forming region pho-Ophiucus @140 pc seen by JWST

the star-forming region NGC 346 in the SMC @60 kpc seen by JWST

Jets and outflows are observed from UV to mm

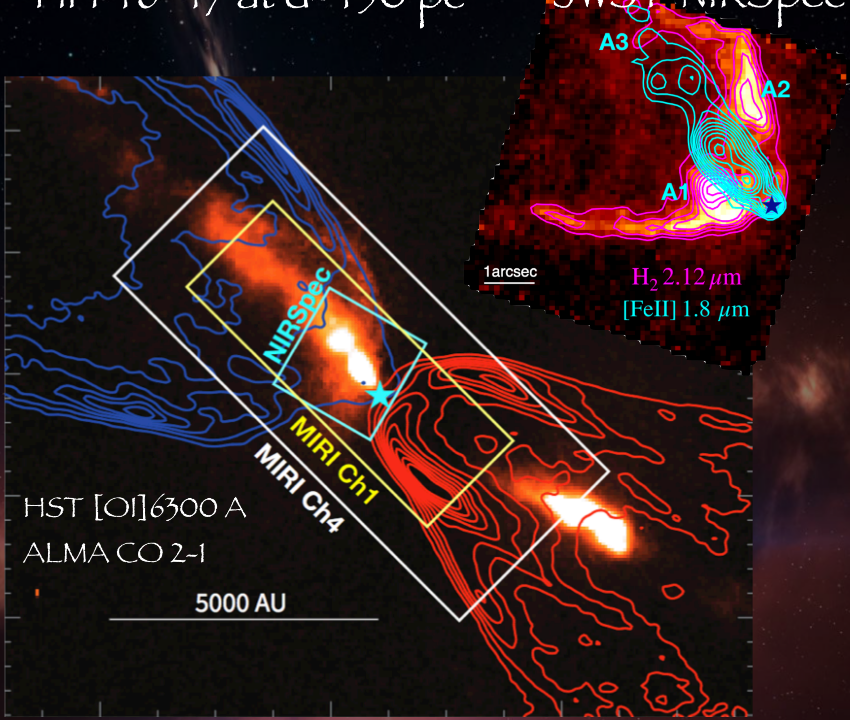
HH 211 (Perseus, 320 pc) observed by JWST



Ray et al. 2024

HH 46-47 at d=450 pc

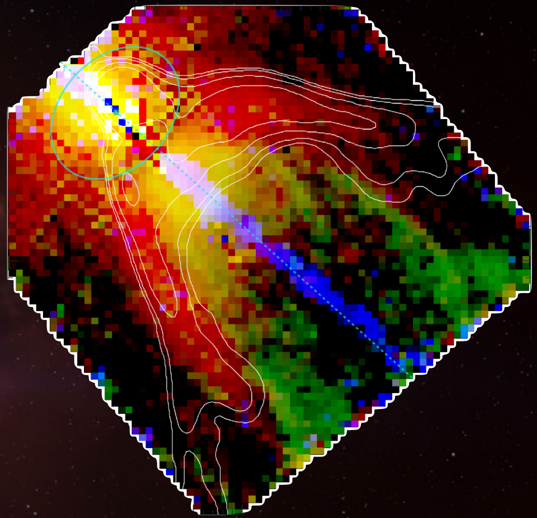
JWST-NIRSpec



Arce et al. 2013 + Erkal et al. 2021 + Nisini et al. 2024

HL Tau at d=150 pc

[FeII] + H2 + CO

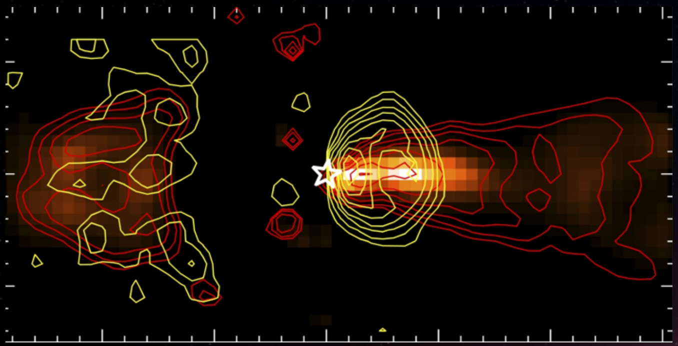


Nony et al. 2026

Jets produce shocks at the impact with the surrounding medium and emit in forbidden & permitted lines in the NIR, e.g. H2 ro-vibrational & [FeII] lines

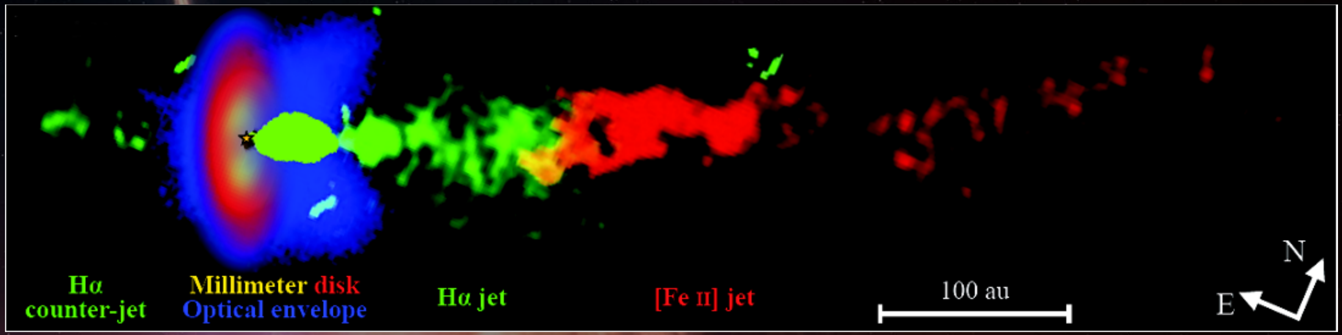
Jets are great targets for AO-assisted imaging and IFU

DG TAU @140pc, [FeII] + H2
with SINFONI IFU (0.2" - R=3000)



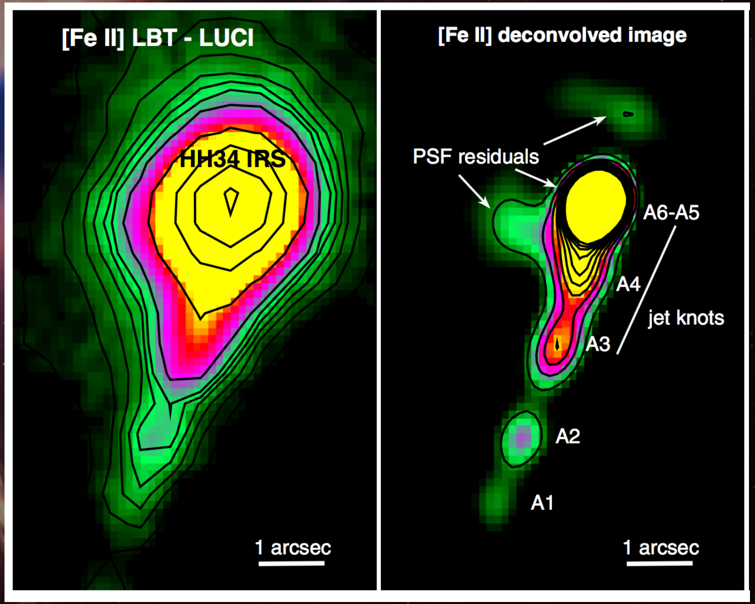
Agra-Amboage et al. 2014

RY TAU @140pc
with SPHERE ZIMPOL & IRDIS (0.1")



Garufi et al. 2019

HH 34 @390pc
with LBT-LUCI

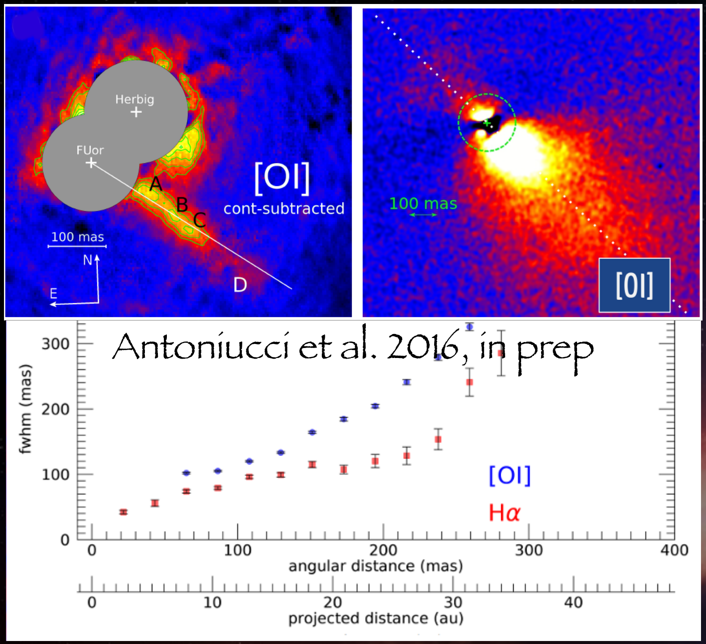


Antoniucci et al. 2014

Linda Podio

Key observables: jet collimation & wiggling

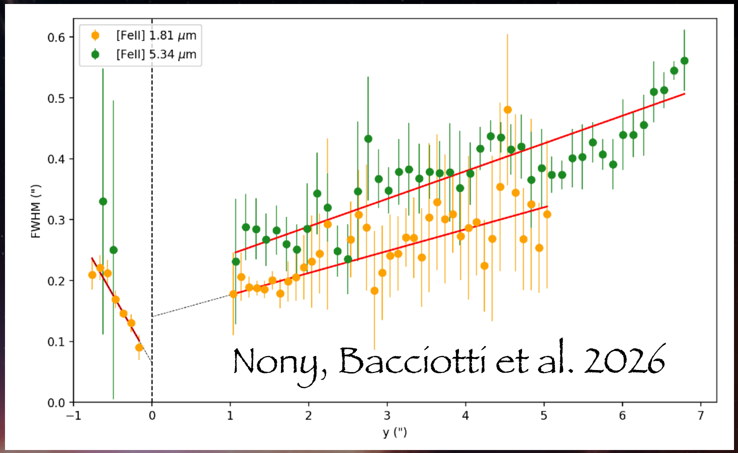
Jets observations with VLT-SPHERE



Antoniucci et al. 2016, in prep

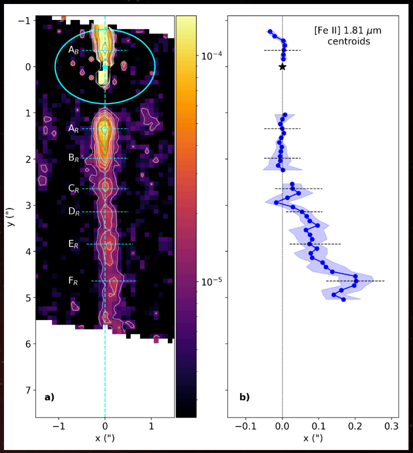
SPHERE allowed to resolve the jet width on <50au distance for bright jets driven by bright sources (R<13-14 guiding stars)

Jets observations with JWST



Nony, Bacciotti et al. 2026

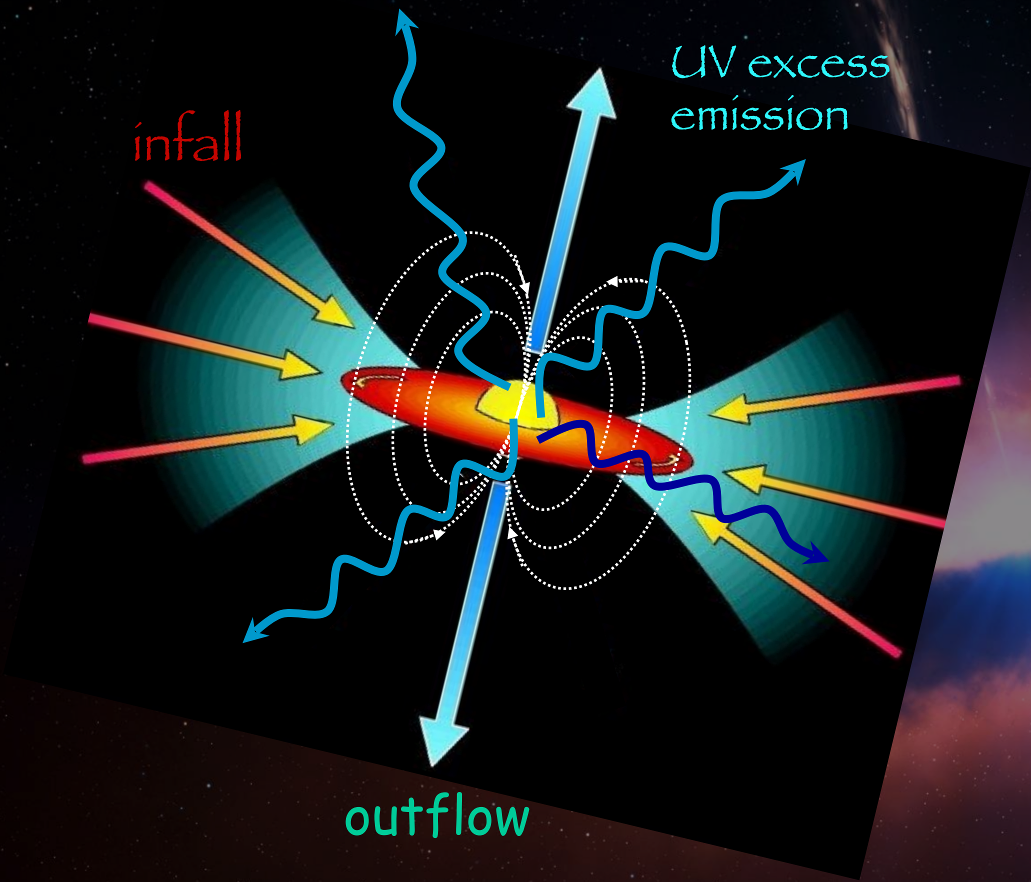
Jets width can point back to the origin of the jet in the disk



Jet wiggling is due to accretion/ejection pulsation and allows to infer the orbit of forming planets

MORFEO-MICADO will observe jet in [FeII] (e.g. 1.25, 1.64um) and H2 (2.12um) line emission in NB filters down to 10-20 mas (a few au for nearby SFRs, d~100 pc): (i) will resolve the launching region, (ii) will explore ejection for more embedded/lower mass YSOs (R<=16 mag with SCAO and ~24 with MCAO)

Magnetospheric accretion and mass accretion rate



T ~10^4 K shocked gas emits in:

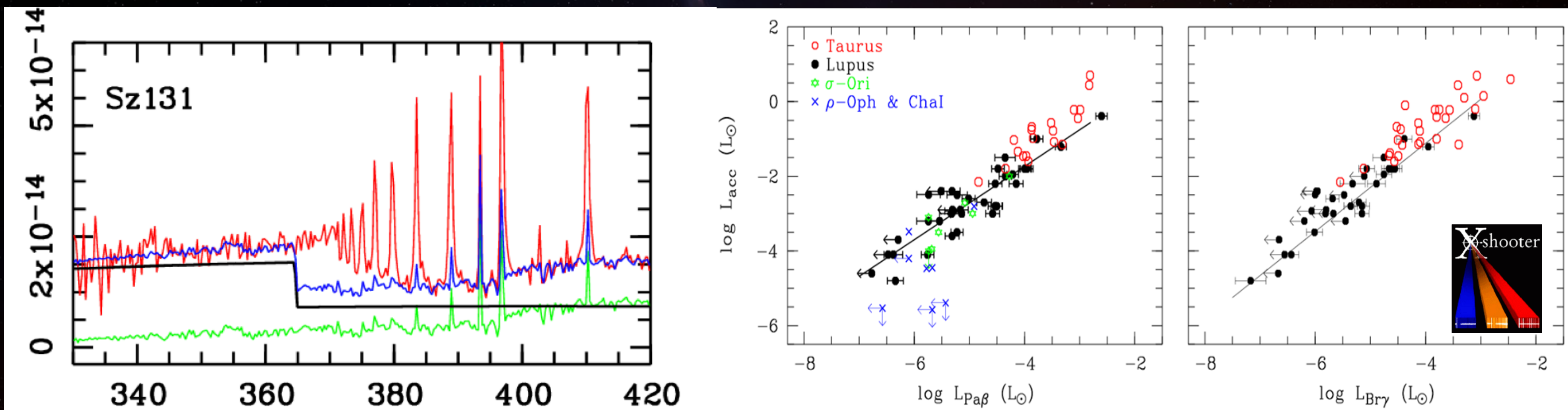
- Balmer & Paschen continua
- Balmer & Paschen series
- CaII IRT, He I, Paβ & Brγ

L_{acc} can be derived from UV continuum excess and / or emission lines

$$L_{acc} = \frac{G M_\star \dot{M}_{acc}}{R_\star} \left(1 - \frac{R_\star}{R_{in}}\right)$$

Mass accretion estimates from L_{acc} vs L_{line} correlation

The correlation between the accretion luminosity (derived from the UV-excess) and the line luminosity (Pa_{β} & Br_{γ}) has been calibrated from Xshooter spectroscopy of nearby SFRs and extends over ~4 orders of mag



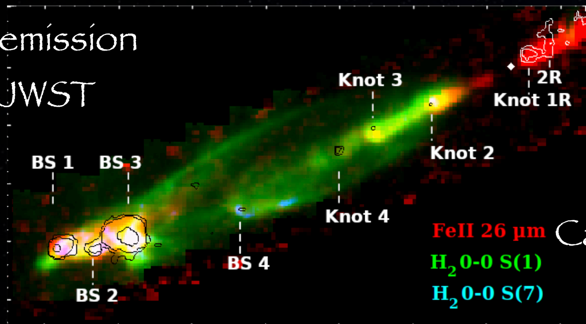
Alcala' et al 2014; 2017

MORFEO-MICADO will observe Pa_{β} & Br_{γ} line emission in NB filters and derive the mass accretion rates for embedded/low mass YSOs (R<=16 mag with SCAO and ~24 with MCAO)

Key observables: jet velocity and mass loss rate

Ellerbroek, Podio+ 2013

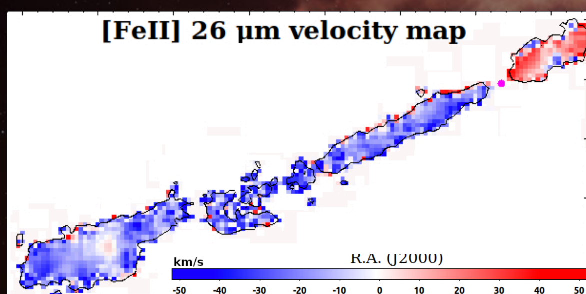
[FeII] + H2 emission seen by JWST



HH 211 jet
Caratti o Garatti et al. 2024

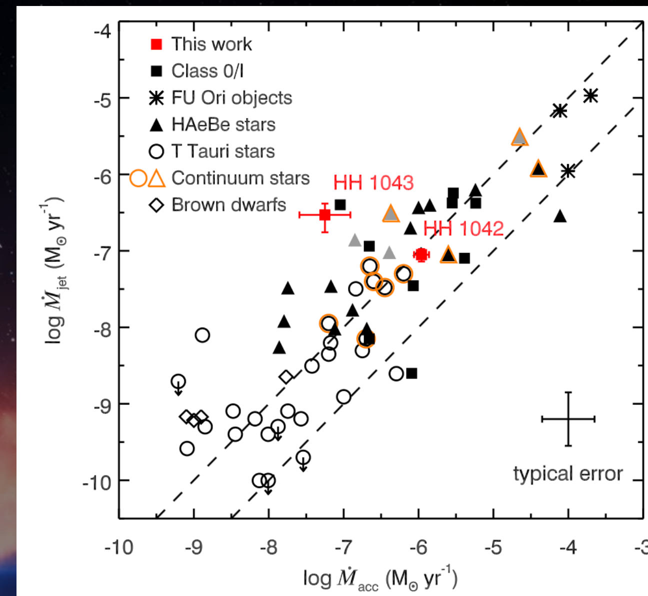
column density of H2 gas

jet velocity



jet mass-loss rate

$$\dot{M}_{jet} = \mu \, m_H \, n_H \, \pi \, r_J^2 \, v_J,$$



mass loss rate vs mass accretion rate

$M_{jet} \sim 0.1 - 1 \, M_{acc}$

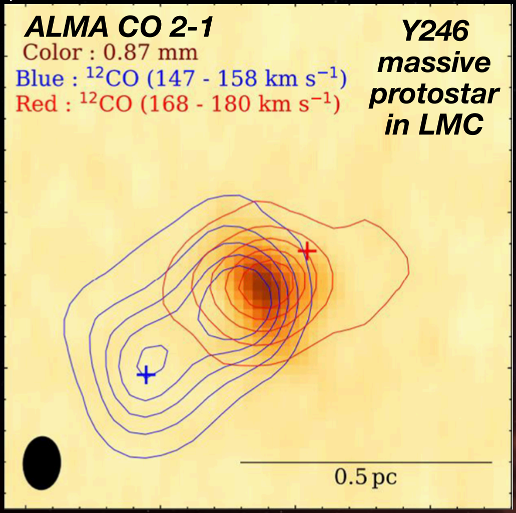
What is the M_{jet}/M_{acc} for more embedded, lower mass YSOs?

JEDIEX SC1a: Ejection and accretion in nearby SFRs with ELT MORFEO-MICADO

- detect jet emission lines ([FeII], H2) using NB filters on MORFEO-MICADO down to a few au from YSO and for low mass, embedded YSOs
- derive jet collimation and launching point in the disk
- detect accretion emission lines (Paβ, Brγ) using NB filters on MORFEO-MICADO
- derive M_{jet} from L_{line} (+ jet velocity) and M_{acc} from L_{line} (+ stellar parameter)

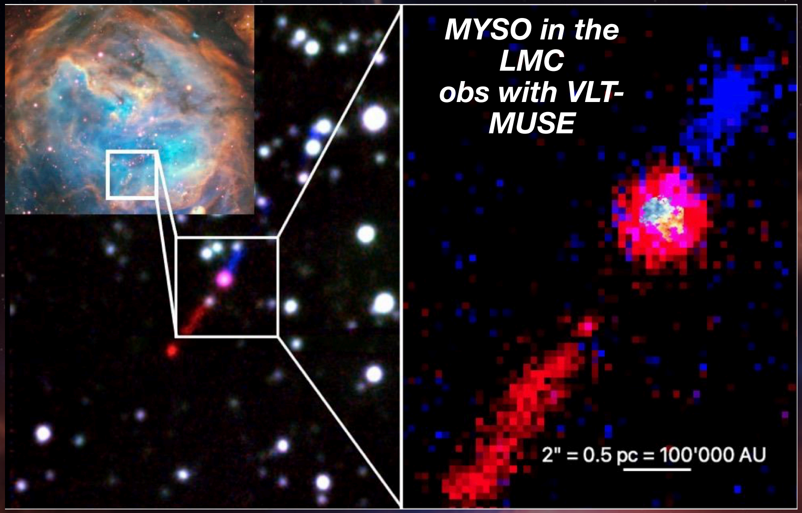
What are the ejection/accretion properties of YSOs in low-metallicity environments ?

CO 2-1 outflow driven by the massive protostar Y246 revealed by ALMA @0.25"



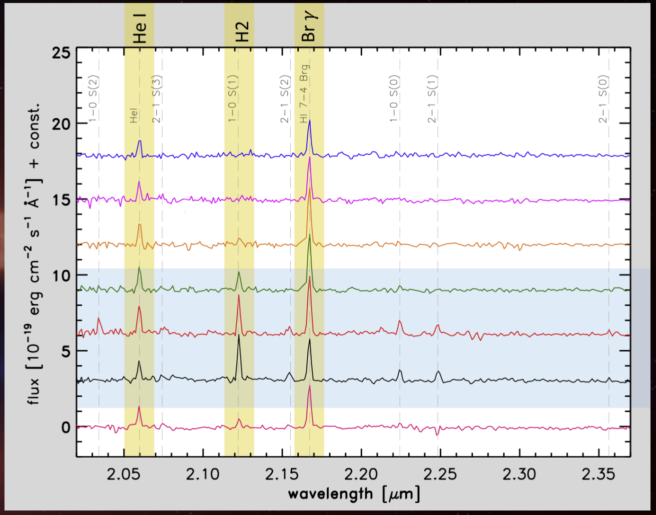
Tokuda et al. 2022

the HH 1177 bipolar jet driven by a MYSO in the LMC observed with VLT-MUSE



McLeod et al. Nature 2024

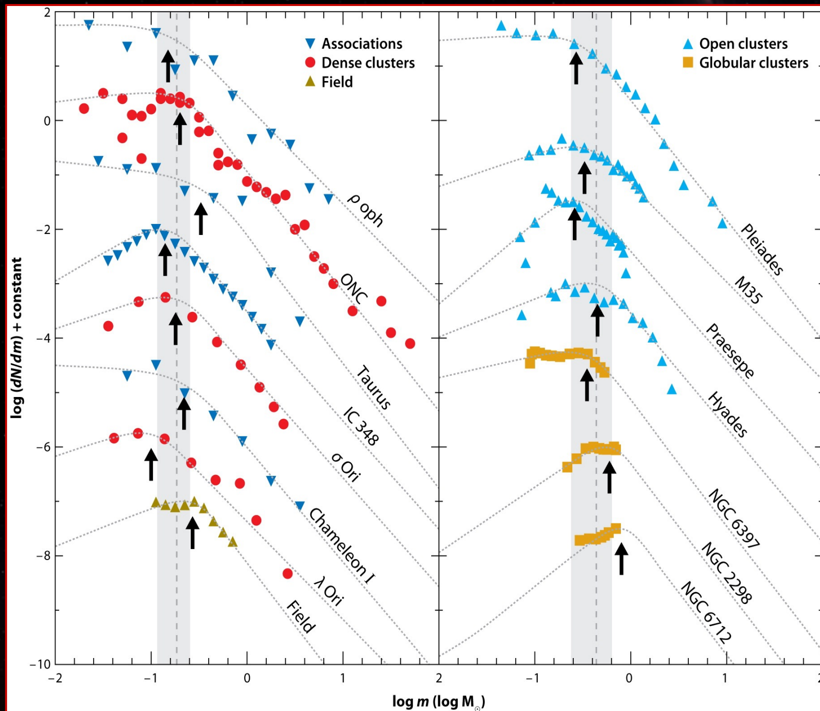
Sun-like YSOs in the NGC 346 SFR in the LMC observed with HST



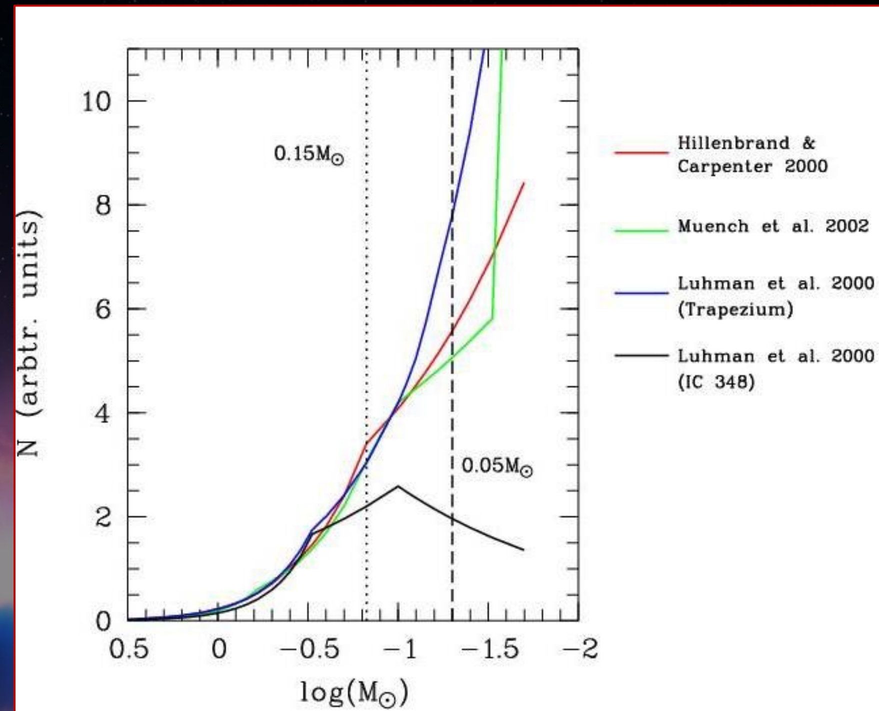
De Marchi, Giardino, Biazzo et al. 2024

molecular outflows, i.e., the guidepost of the disk accretion, as well as keplerian rotating disks, and accretion probes such as Paβ, Brγ might be universally associated with protostars across the metallicity range of ~0.2–1 Z⊙ .

What are the effects of the local environment on the properties of the forming stars?
What are the IMF, mass accretion rate & disk lifetime in low-metallicity environments?



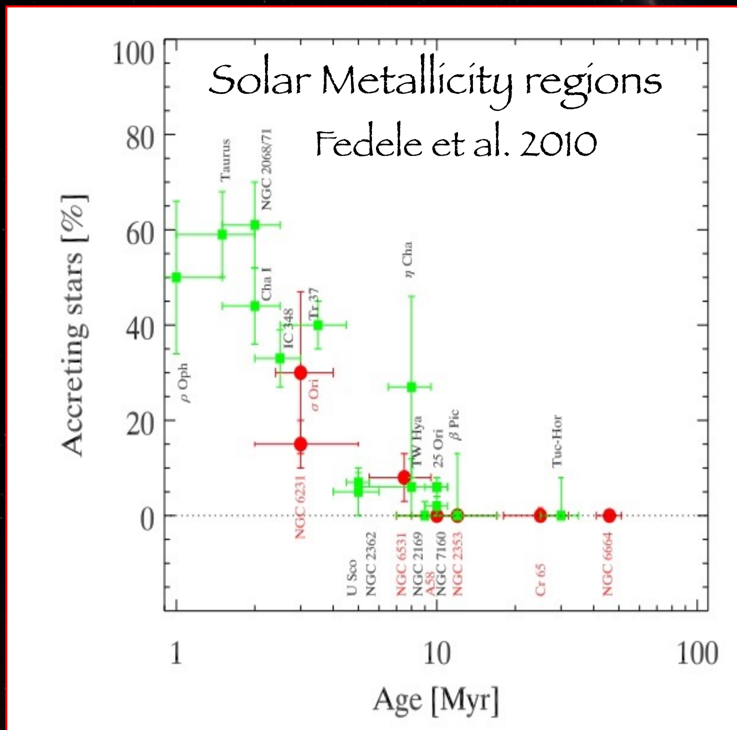
Bastien et. al. 2010 ARA&A

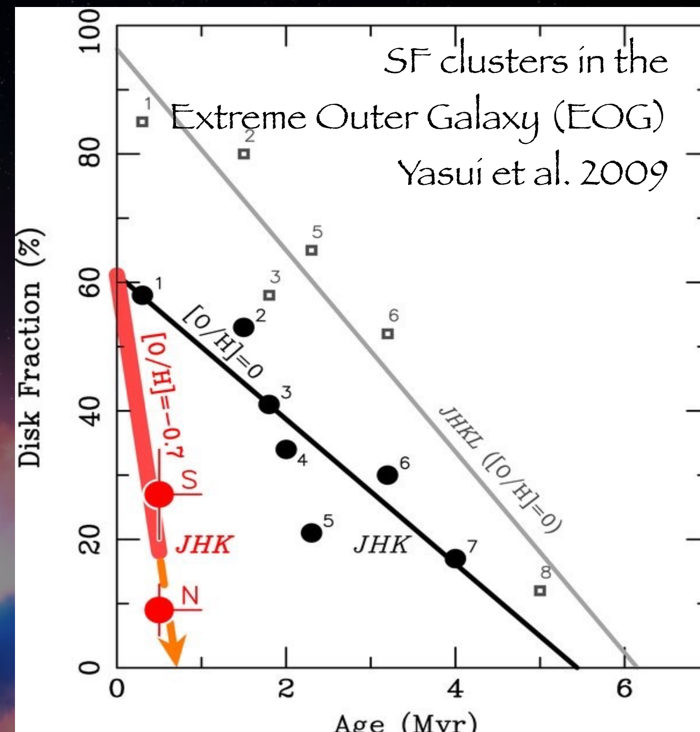


- good agreement for $M > 0.3\ M_\odot$
- very uncertain in the low-mass and sub-stellar regimes

➡ low metallicity IMF not determined yet

Accretion & dIsk lifetime vs Metallicity



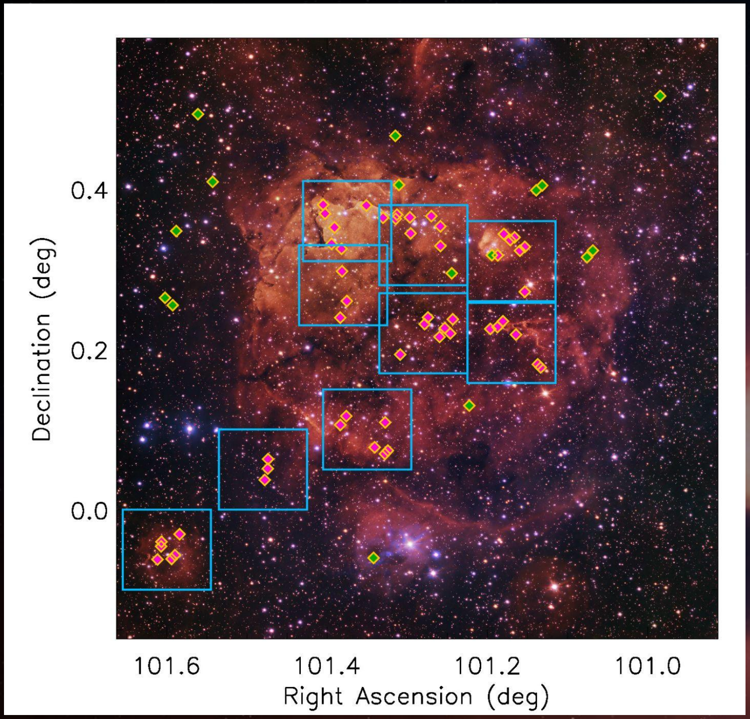


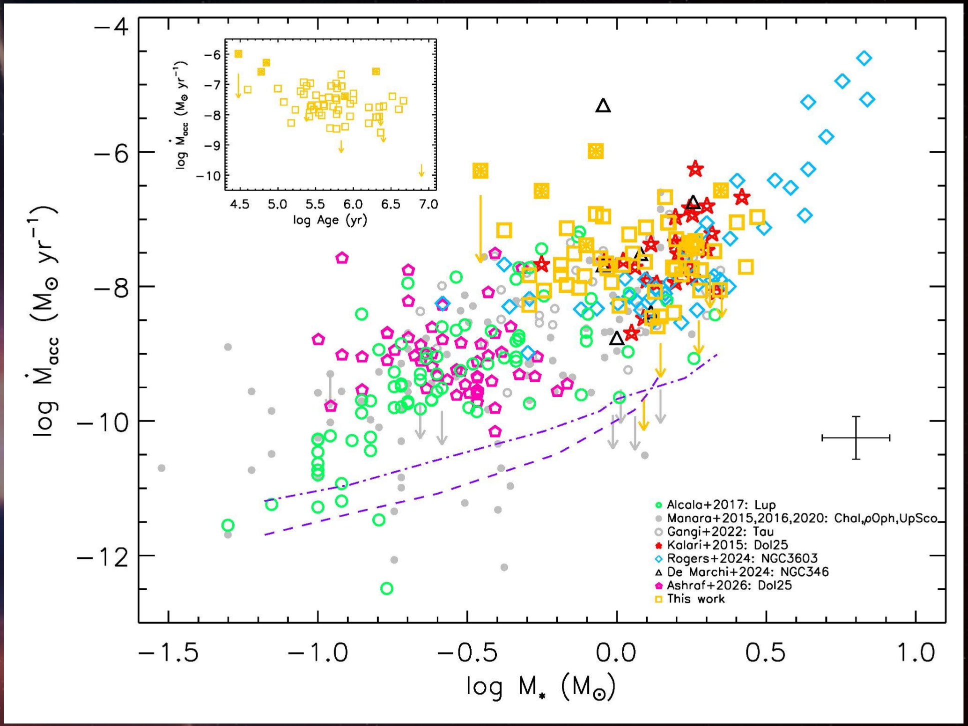
- much lower disk fraction @ low Z (< 0.2 Z⊙)
- disks lifetime much shorter at low Z

➡ much higher accretion rates at low metallicity ?
consequences for planet formation

Accretion & disk lifetime vs Metallicity

Sh2-284, d~4.5 kpc, Z ~1/6 Z⊙, LBT - MODS: ~65 YSOs



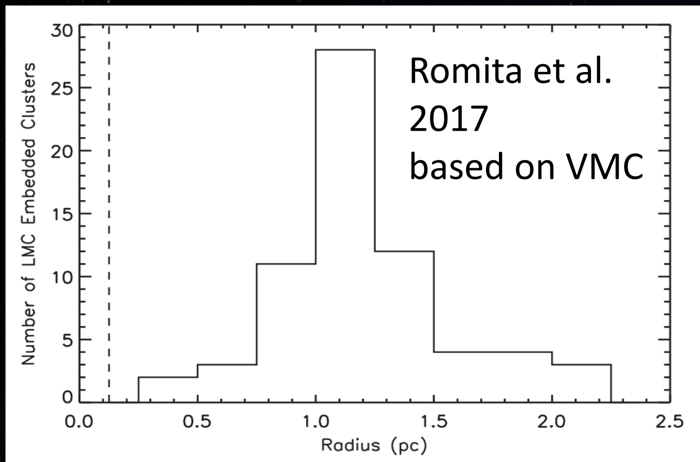


Biazzo, Alcalà, Cusano et al. 2026

Estimates of M_{acc} show accretion properties similar to those in $Z_\odot$ SFRs

ELT-MORFEO to study IMF, accretion/ejection in distant SFRs

Typical size of embedded clusters in the LMC



Typical size of embedded clusters in the Milky Way: 1 - 4pc

ONC: size ~33'
~4 pc @ d~400pc

- in the LMC @50 kpc the cluster size range is 4 - 16 arcsec
- excellent targets for MORFEO-MICADO
- with MCAO FoV 20" x 20": whole cluster in a single shot
- angular resolution 6-12 mas (1,5 mas/pixel) (a factor ~5 better than JWST in ang res, >10 in pixel scale)
- sep. ~500 au @ 50kpc, i.e. wide binaries !

Most YSOs in 0.04 x 0.04 pc^2
@ 50 kpc : 0.17 x 0.17 arcsec^2

The high spatial resolution mandatory for IMF studies in distant, low-Z SFRs

JEDIEX SC1b: Accretion/ejection & disk fraction in low-Z environment with ELT MORFEO-MICADO

the star-forming region NGC 346
in the SMC @60 kpc seen by JWST

- characterise embedded clusters in LMC-SMC
- investigate low-mass (2 – 0.1 $M_\odot$) YSO members
- detect Paβ & Brγ emis. lines with NB filters & single out accreting YSOs
- derive M_{acc} from L_{acc}-L_{line} correlation calibrated for nearby SFR
- investigate disk fraction through spectroscopic NIR excess
- disk-fraction, M_{acc} in low-Z YSOs in comparison with solar metallicity YSOs in the Milky Way

MORFEO-MICADO on ELT
to unveil accretion and ejection in young stars in the Solar neighbourhood and beyond

Thank you !


Meeting della strumentazione ELT a guida italiana - 12-15 May 2026
Linda Podio