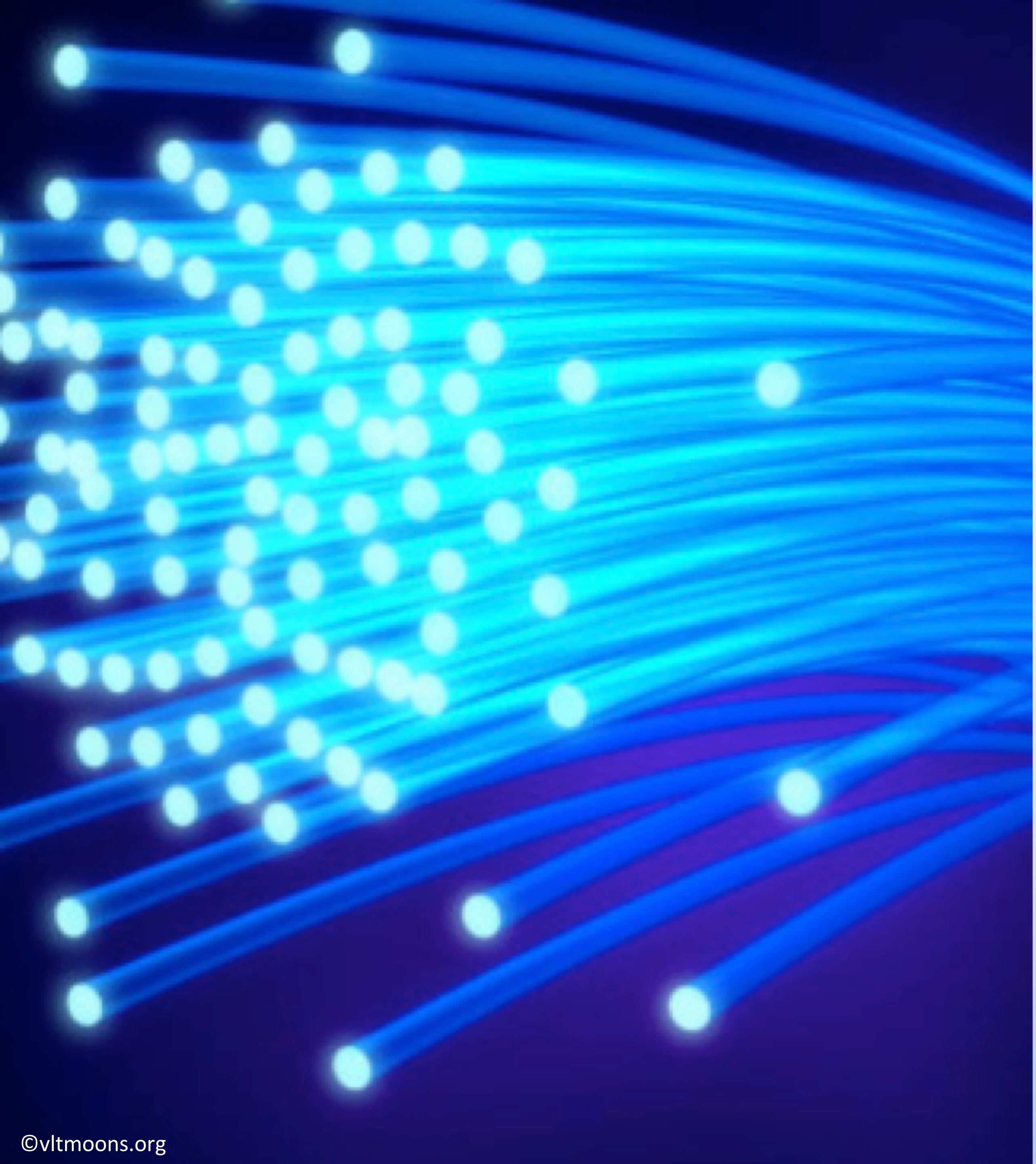


Study of young clusters at INAF in perspective of future multi-object spectrographs

KATIA BIAZZO
INAF – OACatania

collaborators
Nisini, Antoniucci, Giannini (OARoma)
Alcalá (OACapodimonte), Manara (ESO)
Fedele, Randich, Sacco (OAArcetri)
Frasca (OACatania)
& the JEDI and GES teams

The Context

Study of the formation and evolution of young clusters

Main open issues:

- ❑ What is the origin of clusters and their dissolution (e.g., Bravi et al. 2018, and ref therein)
- ❑ Is star formation a fast/dynamic process or slow contraction
- ❑ Disk accretion evolution as a function of mass and metallicity (e.g., Alcala et. al 2017; De Marchi et al. 2017, and ref therein)

Expertise

JEts and Disks @ INAF (JEDI)

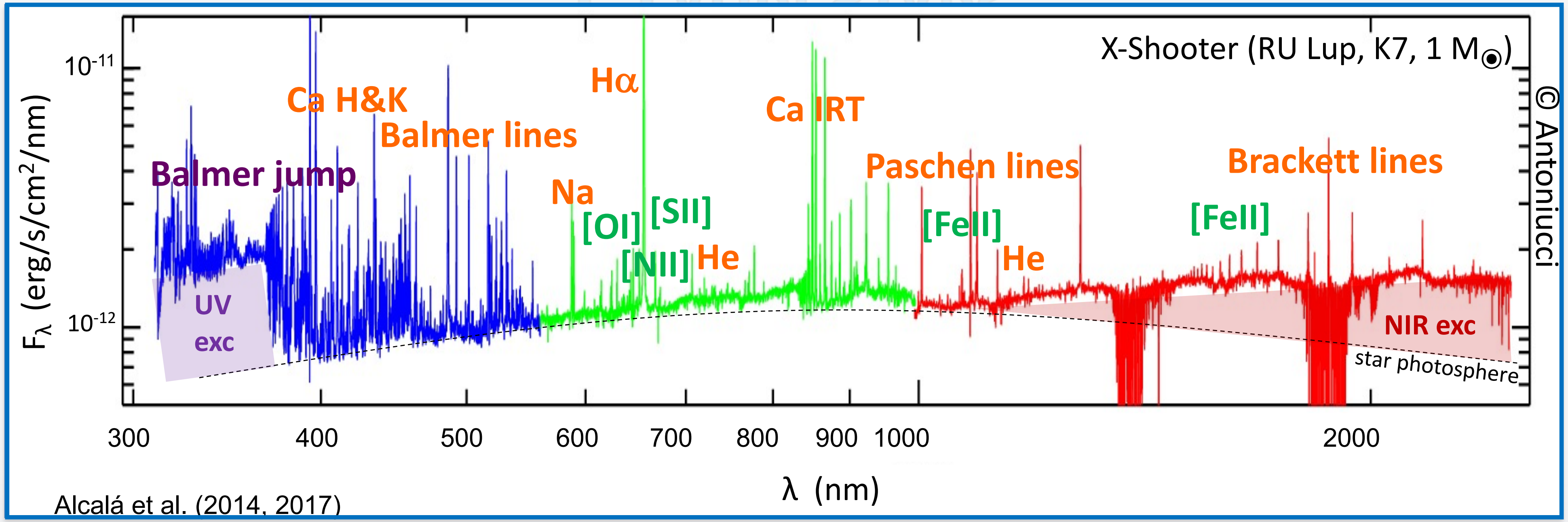
- ❑ Star-forming regions in the solar vicinity
- ❑ Single-objects spectroscopy
- ❑ Medium/high resolution (X-shooter survey + GIARPS science verification/pilot programme)
- ❑ From near-UV to NIR

Gaia-ESO Survey (GES)

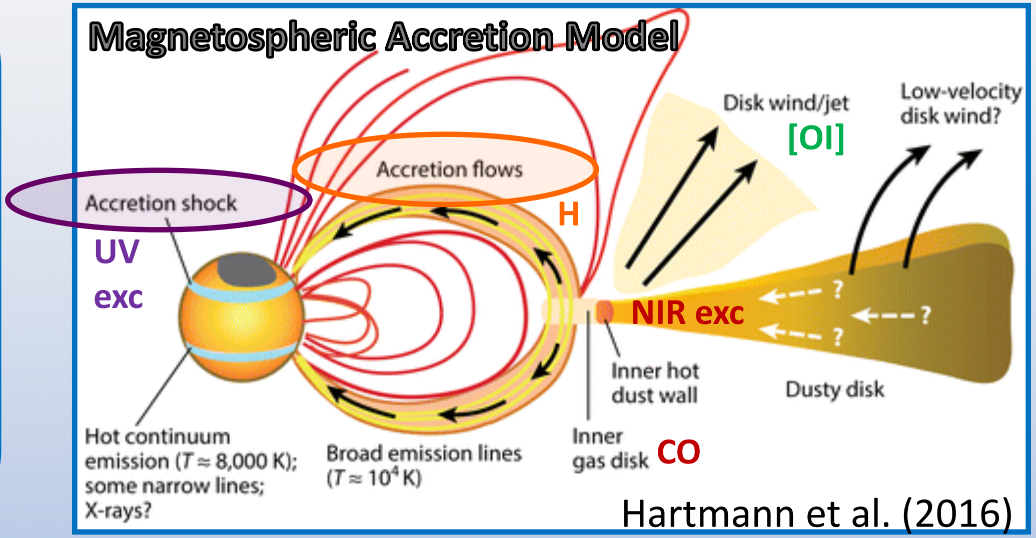
(talk by Germano Sacco)

- ❑ Young clusters at different ages and distances
- ❑ Multi-objects spectroscopy
- ❑ Medium/high resolution (Giraffe+UVES)
- ❑ Optical range

T TAURI STARS



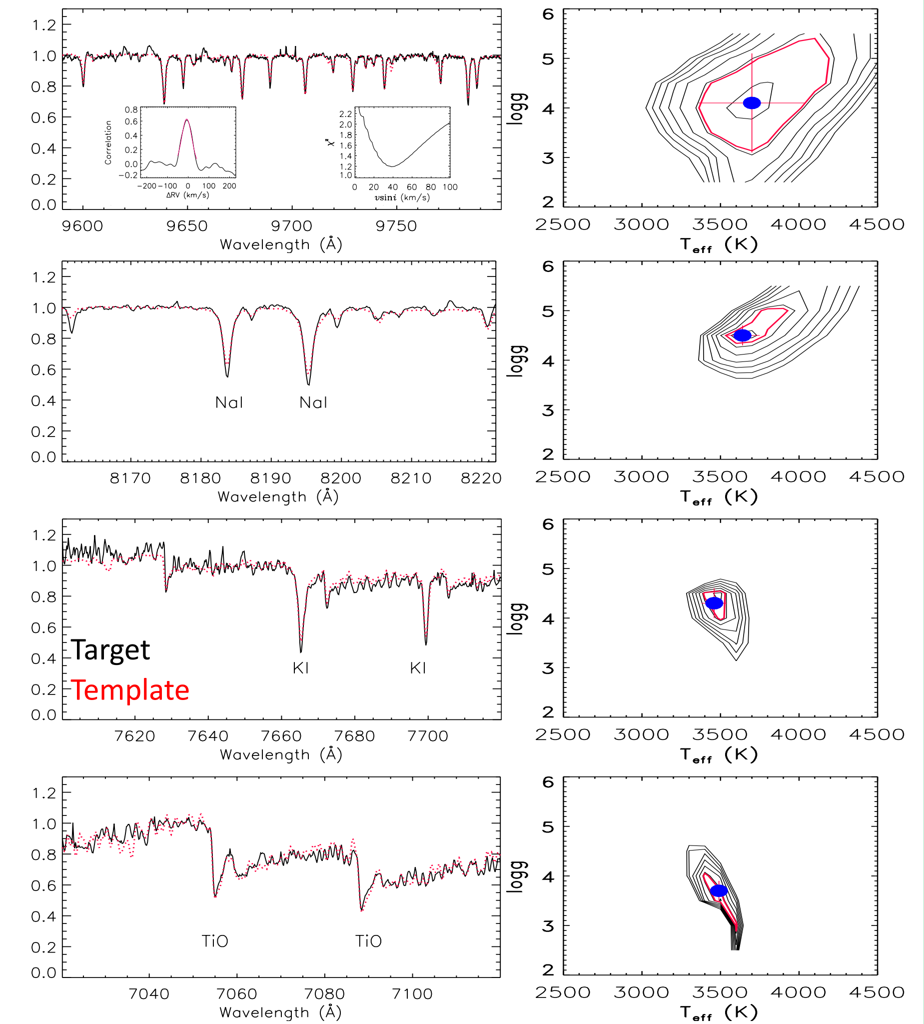
- ✧ Photospheric lines: **Stellar Parameters, Veiling, Abundances, …**
- ✧ UV-optical continuum excess emission: **Accretion shock**
- ✧ Excess (permitted) line emission (H, He, Ca, Fe, Ti, Na, …): **Accretion flows (+Winds) & Chromospheric Activity**
- ✧ Forbidden lines ([FeII], [OI], [SII], …): **Jets (+Winds)**
- ✧ NIR excess + Molecular lines (H_2, CO, …): **Inner disk, Molecular Jets**



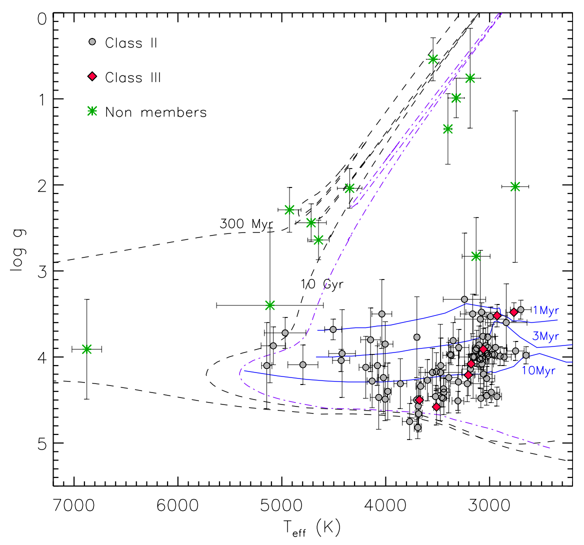
STELLAR PARAMETERS

Characterizing young stellar objects

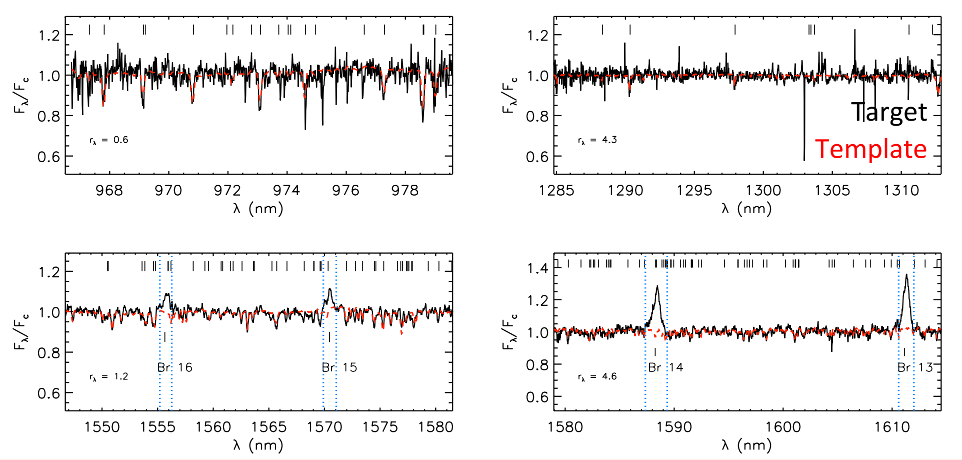
Frasca, KB et al. (2017) - X-shooter
Lupus



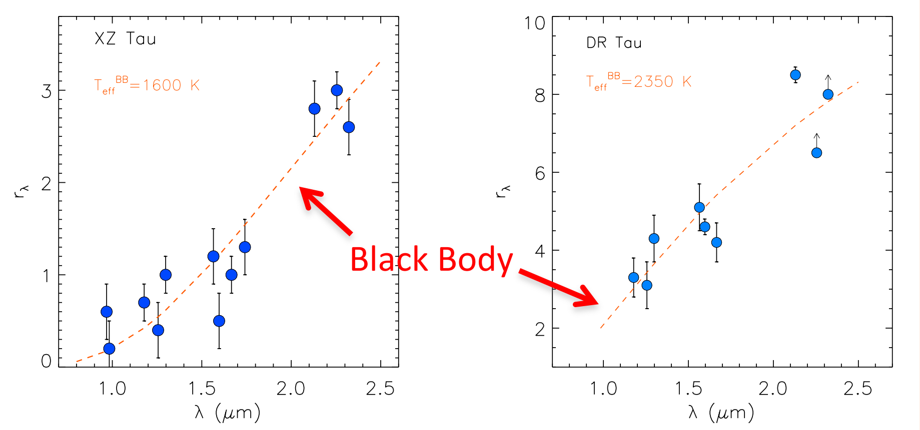
V_{rad}, vsini, T_{eff}, logg



Antoniucci, Nisini, KB et al. (2017) – GIANO
Taurus



V_{rad}, vsini, veiling



Excess emission from internal disk

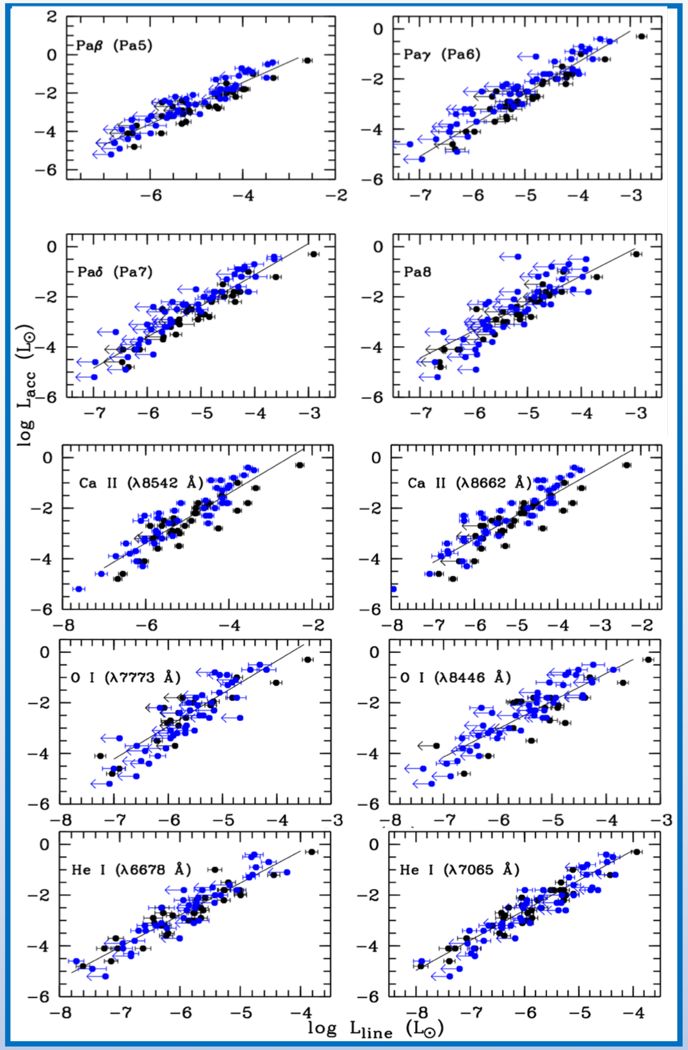
Disk Accretion Parameters

Bimodal M_{acc}-$M_\star$ relationship?

L_{acc}-L_{line} relationships

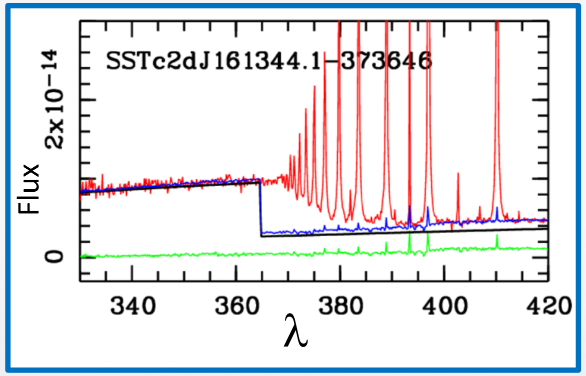
available from UV (H15) to NIR (Brγ)

Alcalá, Manara et al. (2017) - X-shooter Lupus



L_{acc} from Balmer jump

L_{line} from line EW



Observed spectrum

Photospheric template spectrum

Synthetic continuum spectrum

Reproduced spectrum

Hartmann (1998)

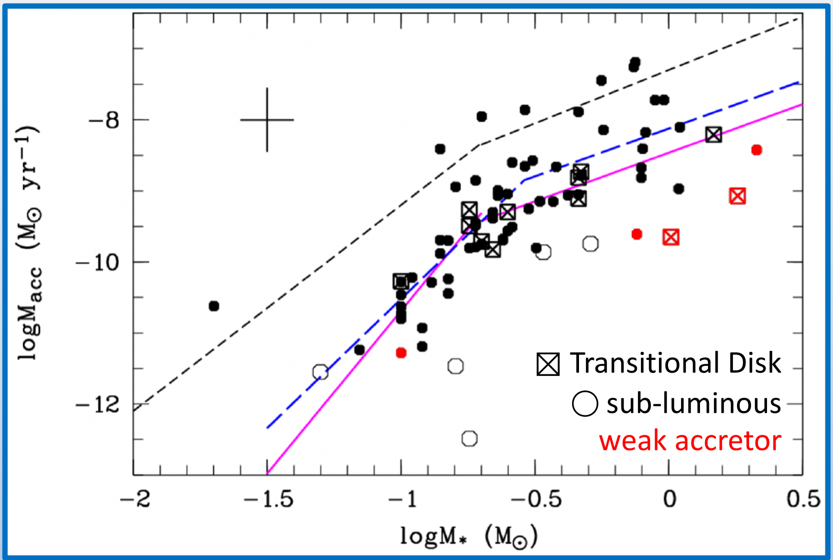
$$\dot{M}_{acc} = \left(1 - \frac{R_\star}{R_{in}}\right)^{-1} \frac{L_{acc} R_\star}{G M_\star} \approx 1.25 \frac{L_{acc} R_\star}{G M_\star}$$

$M_\star$, $R_\star$ stellar mass and radius

$R_{in} \approx 5R_\star$ disk inner radius

G universal gravitational constant

$\dot{M}_{acc}$-$M_\star$

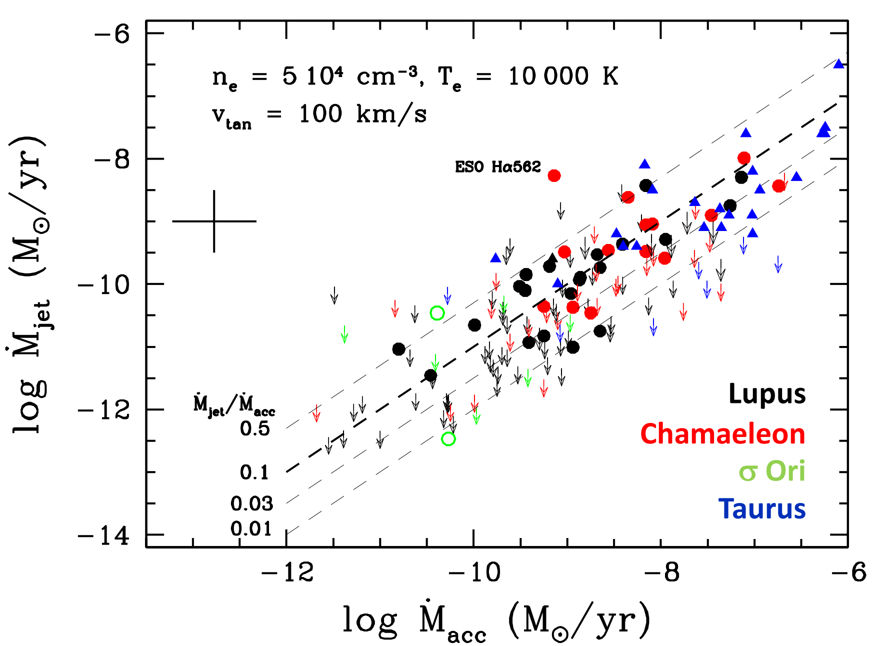


To be confirmed observing other clusters with different age

Accretion vs Jets/Disk/Activity Parameters

Nisini, Antoniucci, Alcalá et al. (2018) - Xshooter

$\dot{M}_{jet}$-$\dot{M}_{acc}$

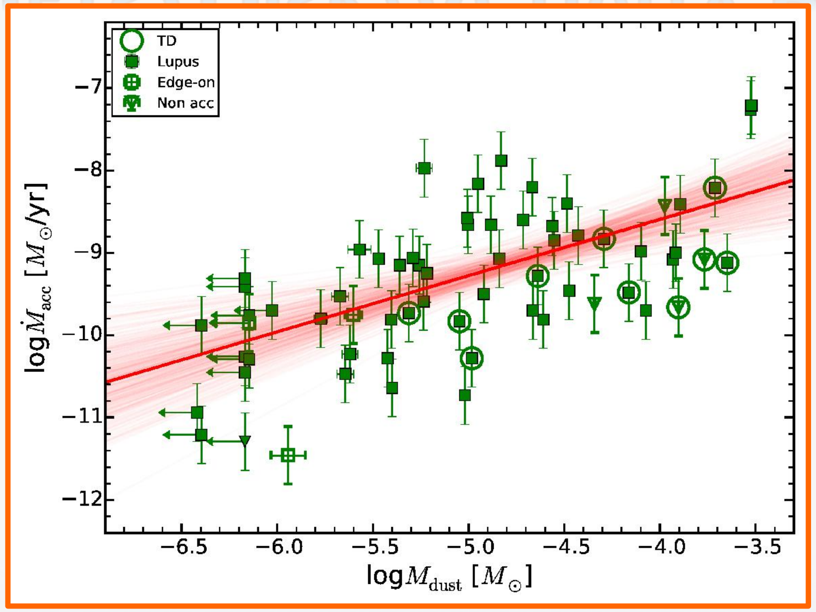


$$\dot{M}_{jet} = M \times V/l$$

M total mass of the flow

V projected velocity

l projected length



Manara et al. (2016) - X-shooter/ALMA

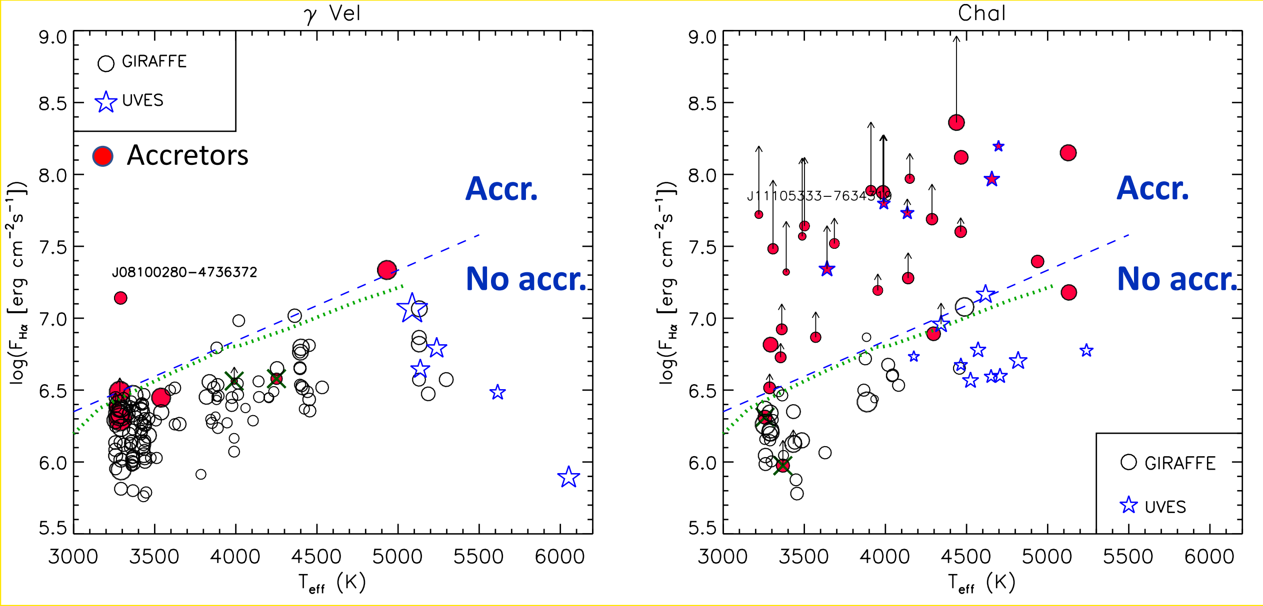
Lupus

$\dot{M}_{acc}$-M_{dust}

Frasca, KB et al. (2015) – Giraffe/UVES

γ Vel & ChaI

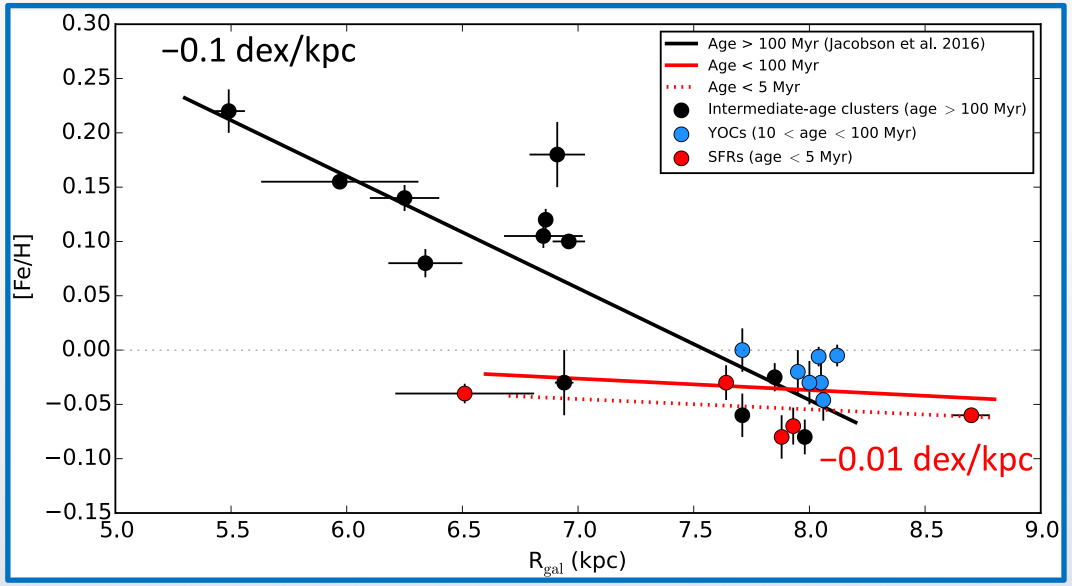
F_{line}-T_{eff}



Elemental Abundances

Shallower metallicity gradient at younger ages?

Spina, Randich et al. (2017)
UVES+Giraffe
[Fe/H]-R_{gal}



To be confirmed observing other SFRs and YOCs at different distances

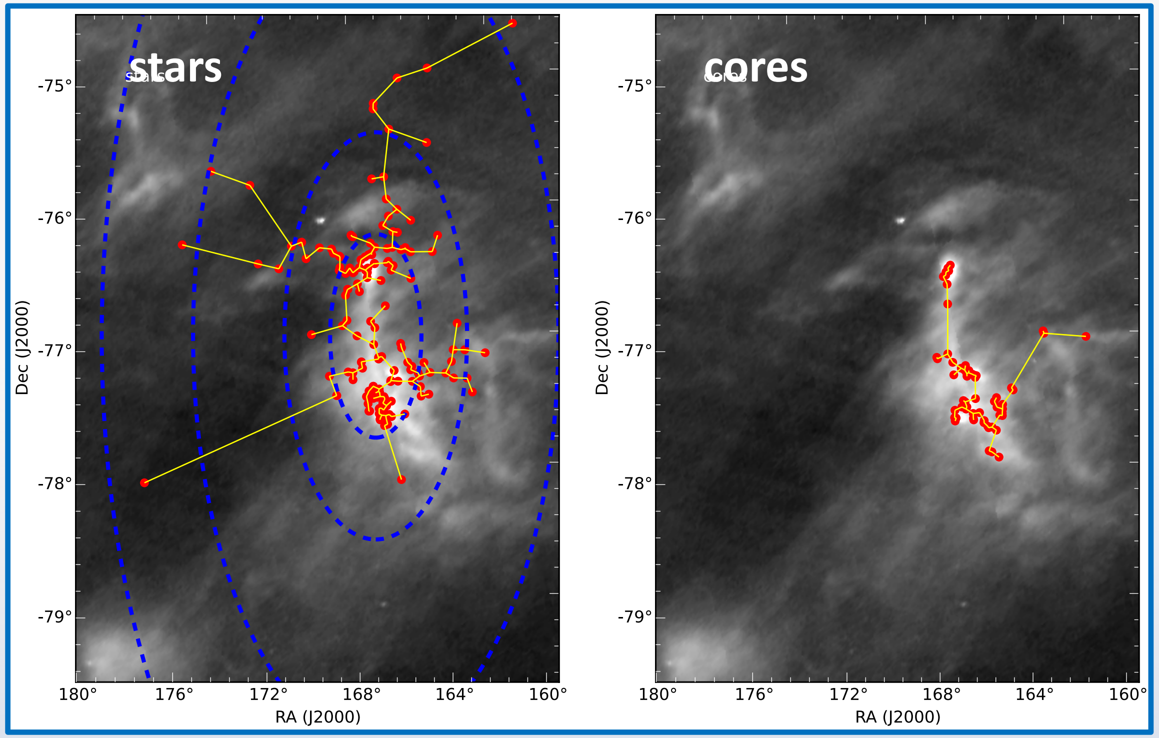
Similar results were found by KB, Randich et al. (2011a,2011b)

Cluster	Age (Myr)	Rgal (kpc)	[Fe/H] (dex)
NGC 6530	1-2	6.50	−0.04
Carina	1-3	7.64	−0.03
ρ Oph	2-3	7.88	−0.08
Chamaeleon I	2-5	7.93	−0.07
NGC 2264	1-3	8.70	−0.06
IC 4665	30	7.71	0.00
IC 2602	30	7.95	−0.02
IC 2391	55	8.00	−0.03
NGC 2547	35	8.04	−0.01
γ Velorum	10-20	8.05	−0.03
NGC 2451A	50-80	8.06	−0.05
NGC 2451B	50	8.12	−0.01
Berkeley 81	860	5.49	0.22
NGC 6005	1200	6.00	0.16
Trumpler 23	800	6.25	0.14
NGC 6705	300	6.34	0.08
Pismis 18	1200	6.85	0.11
Trumpler 20	1500	6.86	0.12
Berkeley 44	2900	6.91	0.18
NGC 4815	570	6.94	−0.03
NGC 6802	1000	6.96	0.10
NGC 6633	630	7.71	−0.06
NGC 3532	300	7.85	−0.03
NGC 2516	163	7.98	−0.08

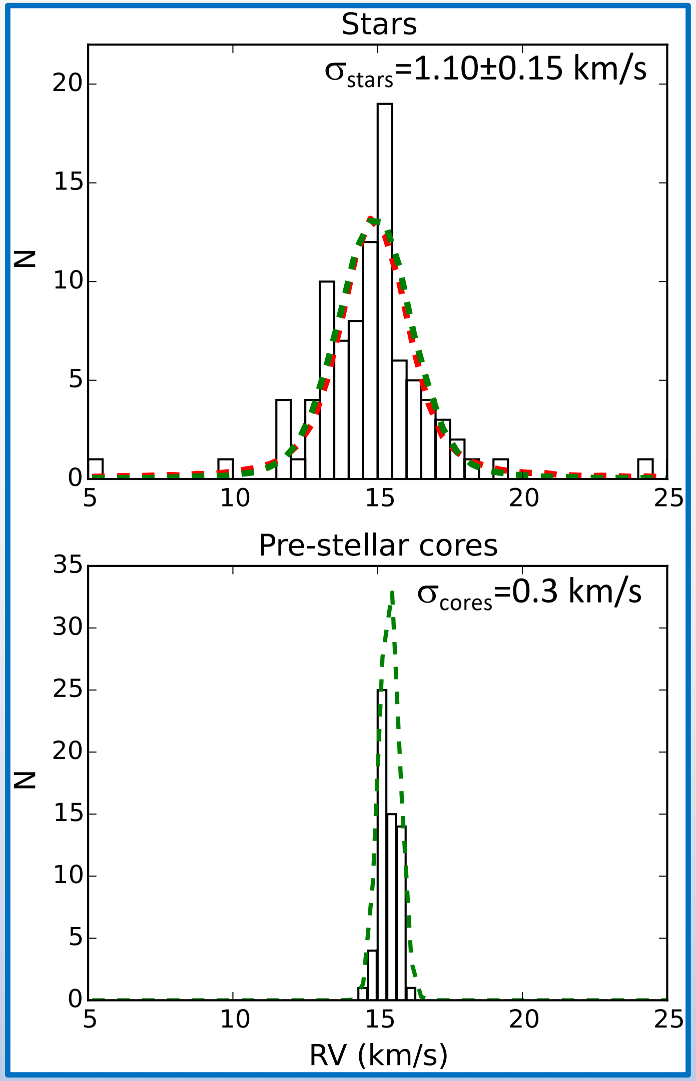
Kinematics and Dinamics

Different velocity dispersion?

Chamaeleon I



Sacco, Spina, Randich et al. (2017)



RV distribution from the GES (UVES+Giraffe)

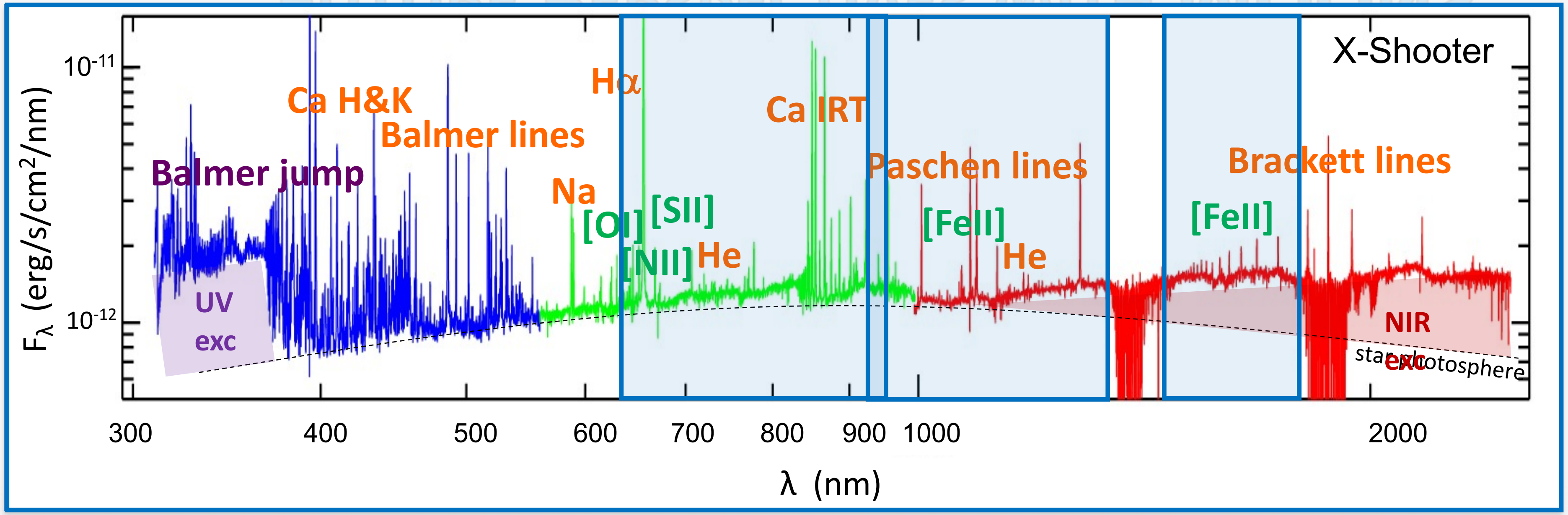
RV distribution from the CO molecular transitions (Tsitali et al. 2015)

Unclear origin of the velocity dispersion

Similar results in ρ Oph, NGC1333, and Orion; (Rigliaco et al. 2016, Foster et al. 2015, Stutz & Gould 2016)

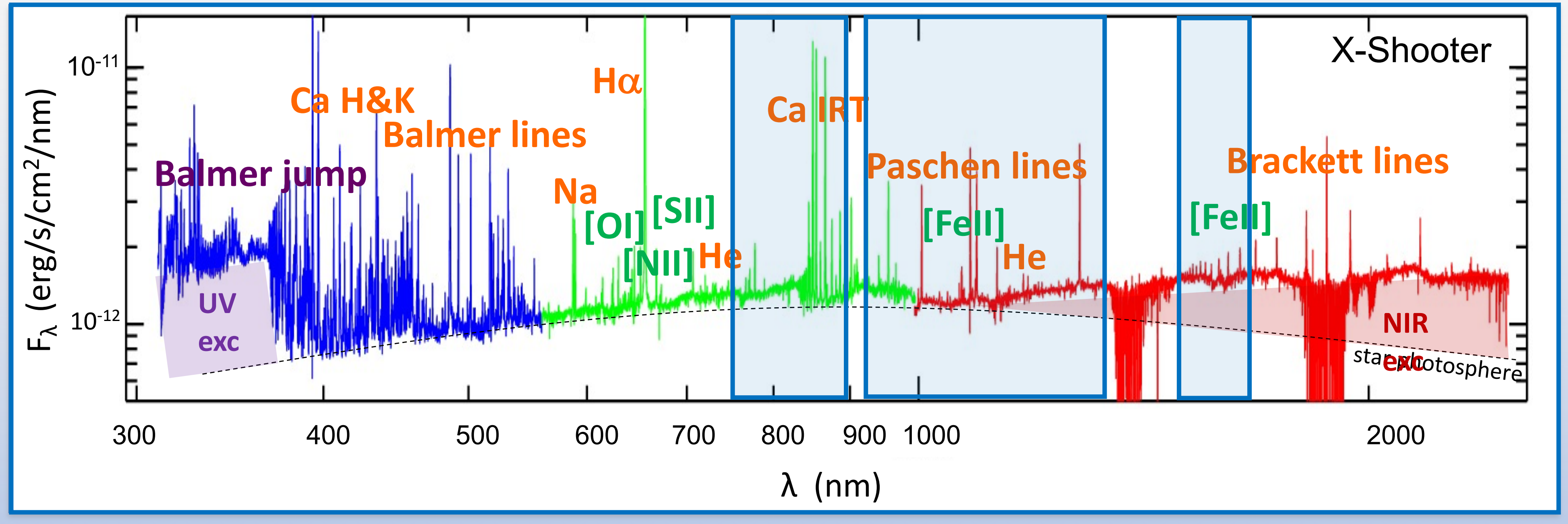
Katia Biazzo

Future Perspectives with MOONS



MR

Hα
CaII IRT
NaI
OI
Paschen
He
[SII]
[NII]
[OII]



HR+MR

CaII IRT
NI
OI
Paschen
Brackett
He
[FeII]
[NI]
[SI]

FUTURE PERSPECTIVES WITH MOONS

Thanks to the capabilities of **MOONS**, we aim to characterize very **low-mass YOs** (in **embedded clusters**) in terms of:

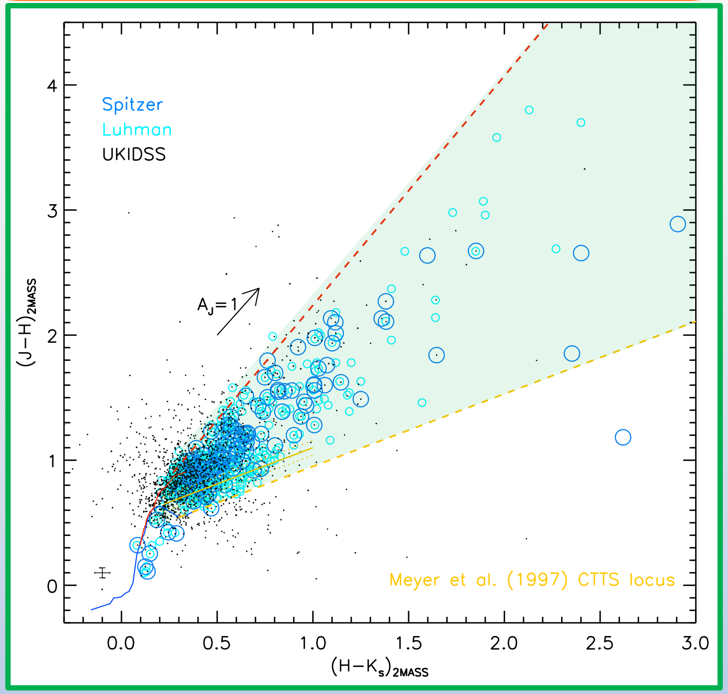
- ❑ **kinematics**
- ❑ **stellar parameters (+abundances)**
- ❑ **accretion (+internal disk)**
- ❑ **chromospheric activity**

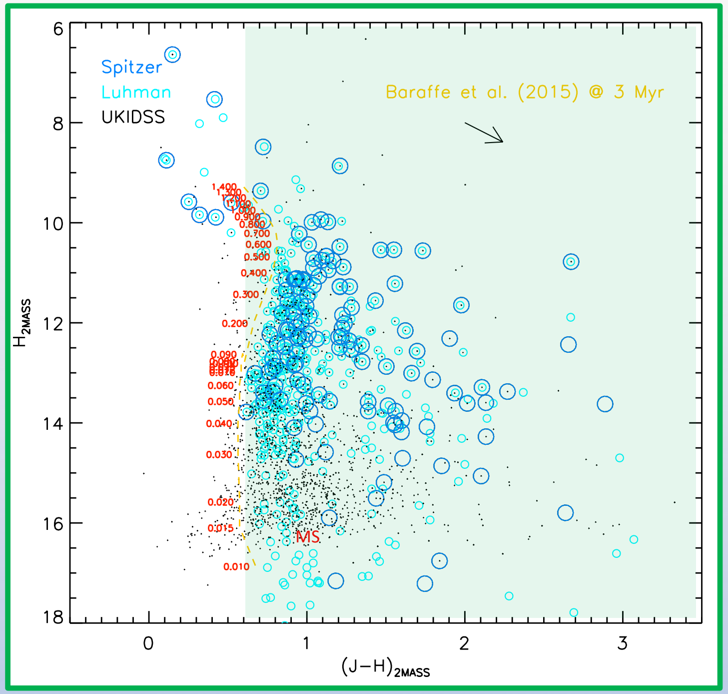
CLUSTERS properties

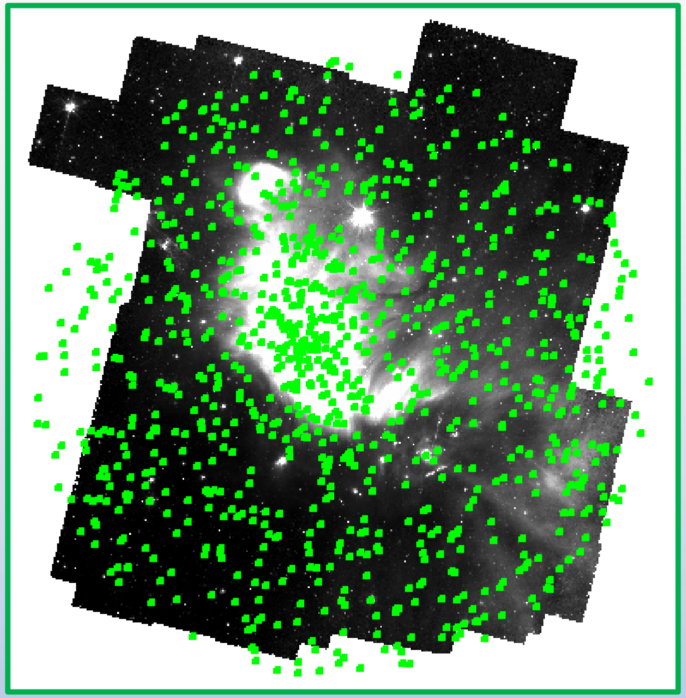
- ❑ Age (1-10 Myr)
- ❑ Distance (150-4500 pc)
- ❑ Dimension
- ❑ Density
- ❑ Metallicity
- ❑ Number of sources
- ❑ Stellar mass

IC348

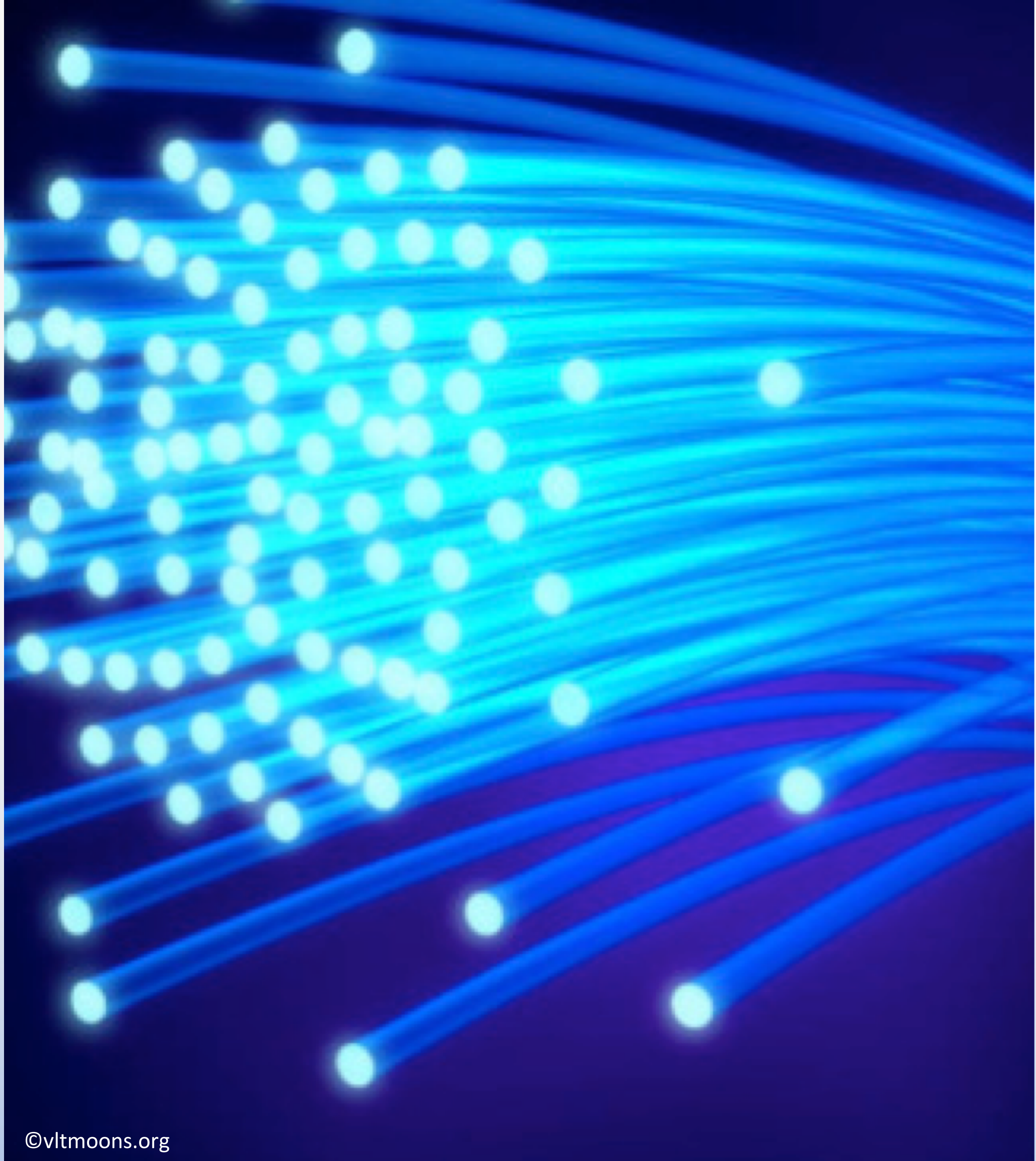
- ❑ ~40x40 arcmin^2 cluster in Perseus
- ❑ ~300 pc
- ❑ low-mass star formation
- ❑ ~2-3 Myr
- ❑ ideal for MOONS (nearby, rich)
- ❑ if H^{lim}_{AB} = 18.5 mag → 0.015 $M_\odot$
- ❑ 3000 sources → 1200 PMS candidates



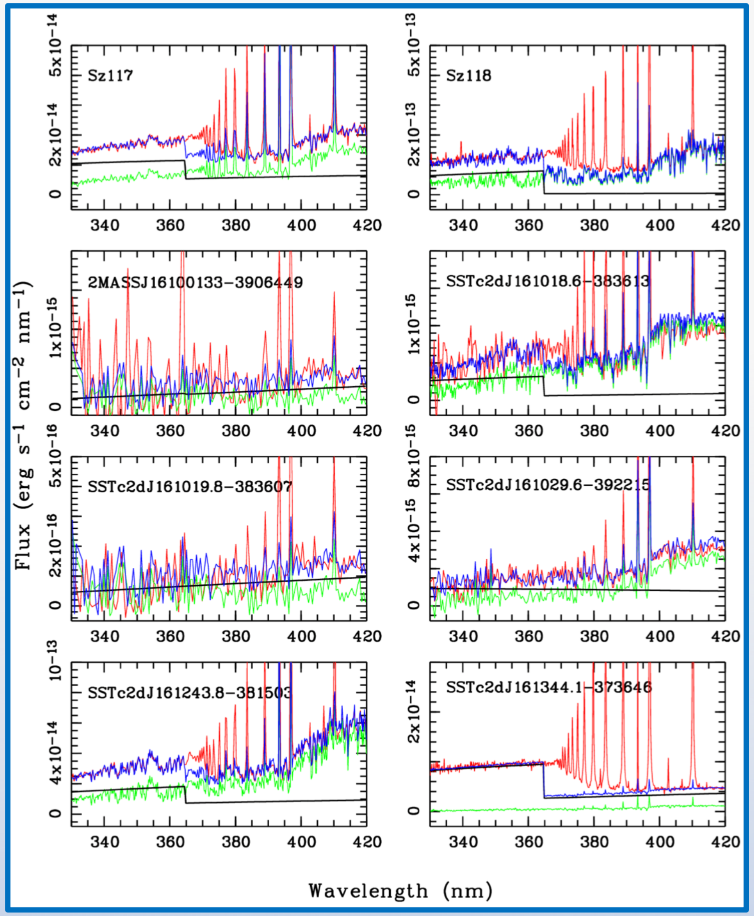


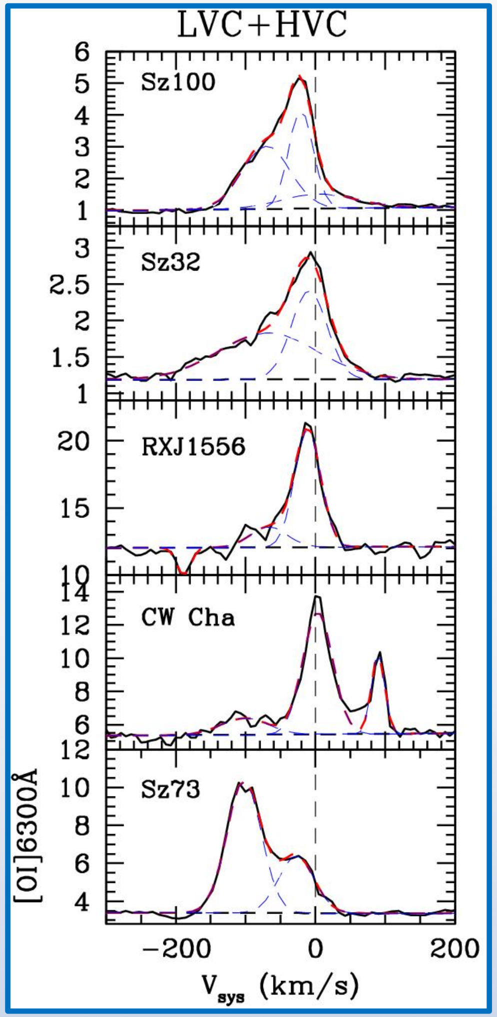


Grazie !

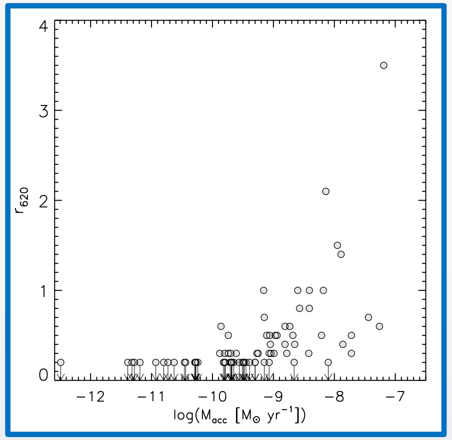


L_{acc}





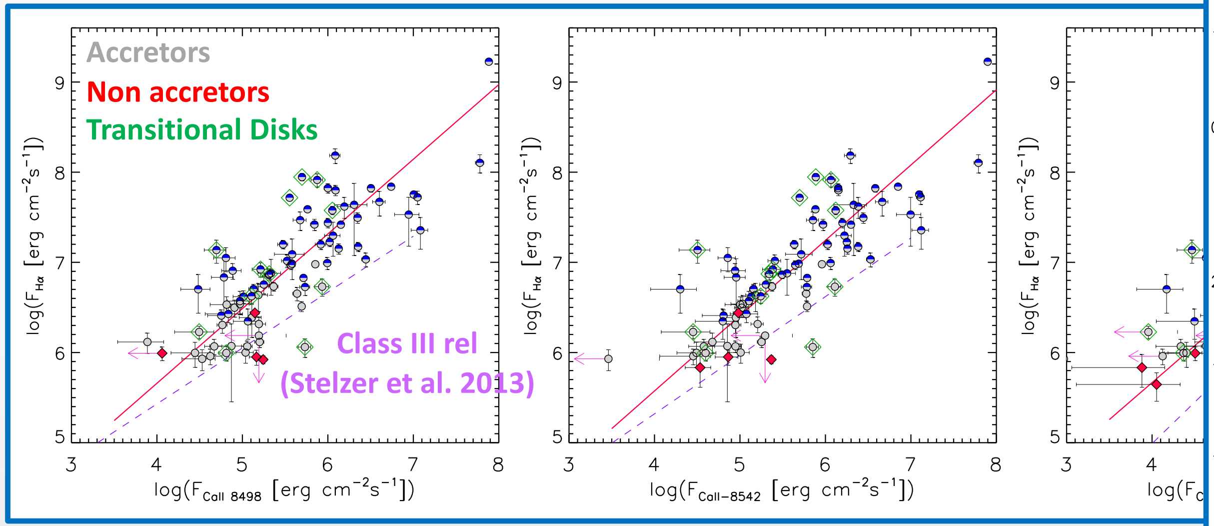
HVC -> collimated jets
LVC -> disk winds?

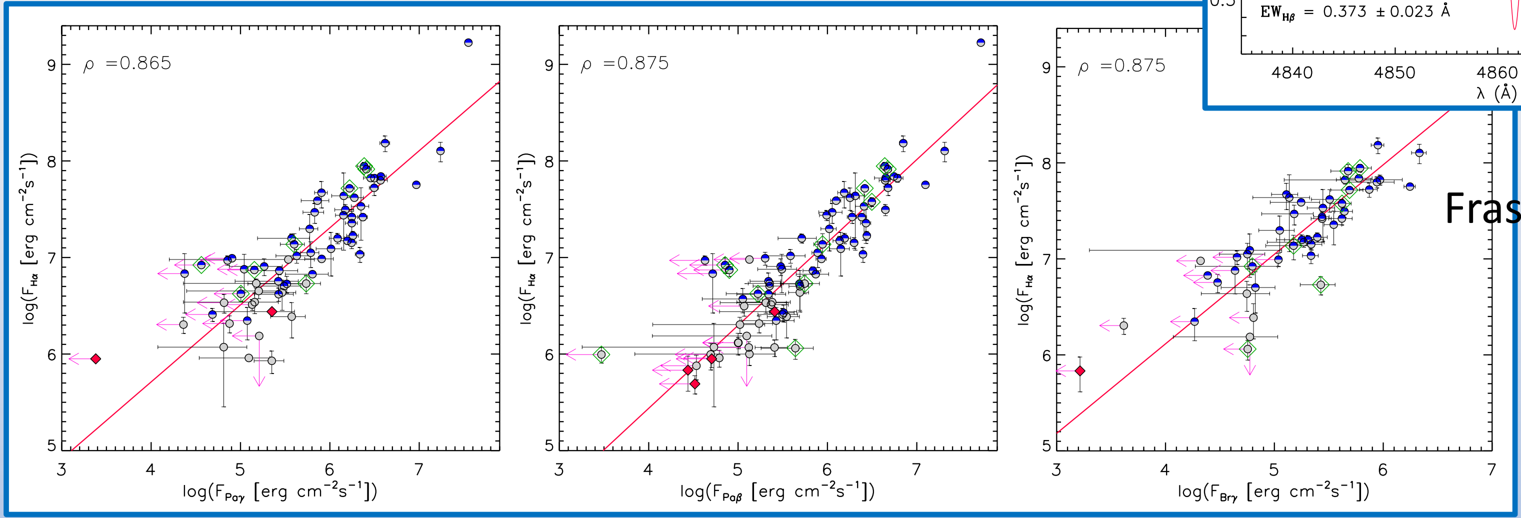


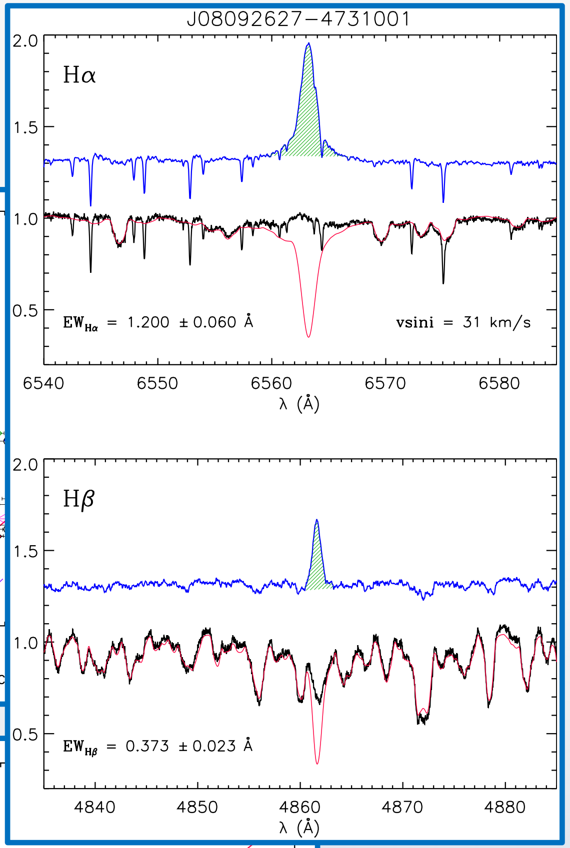
Frasca et al. (2017) - X-shooter Lupus

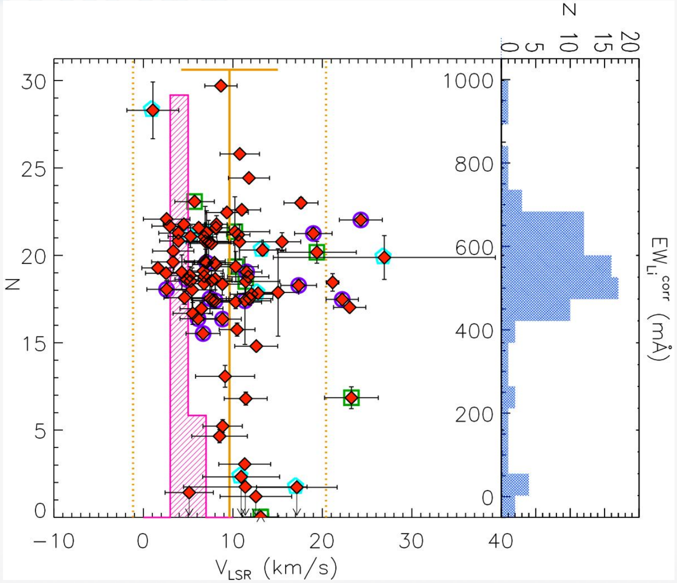
Chromospheric Activity and Lithium

Frasca et al. (2017) - X-shooter
Lupus









Frasca et al. (2015) - Cha I