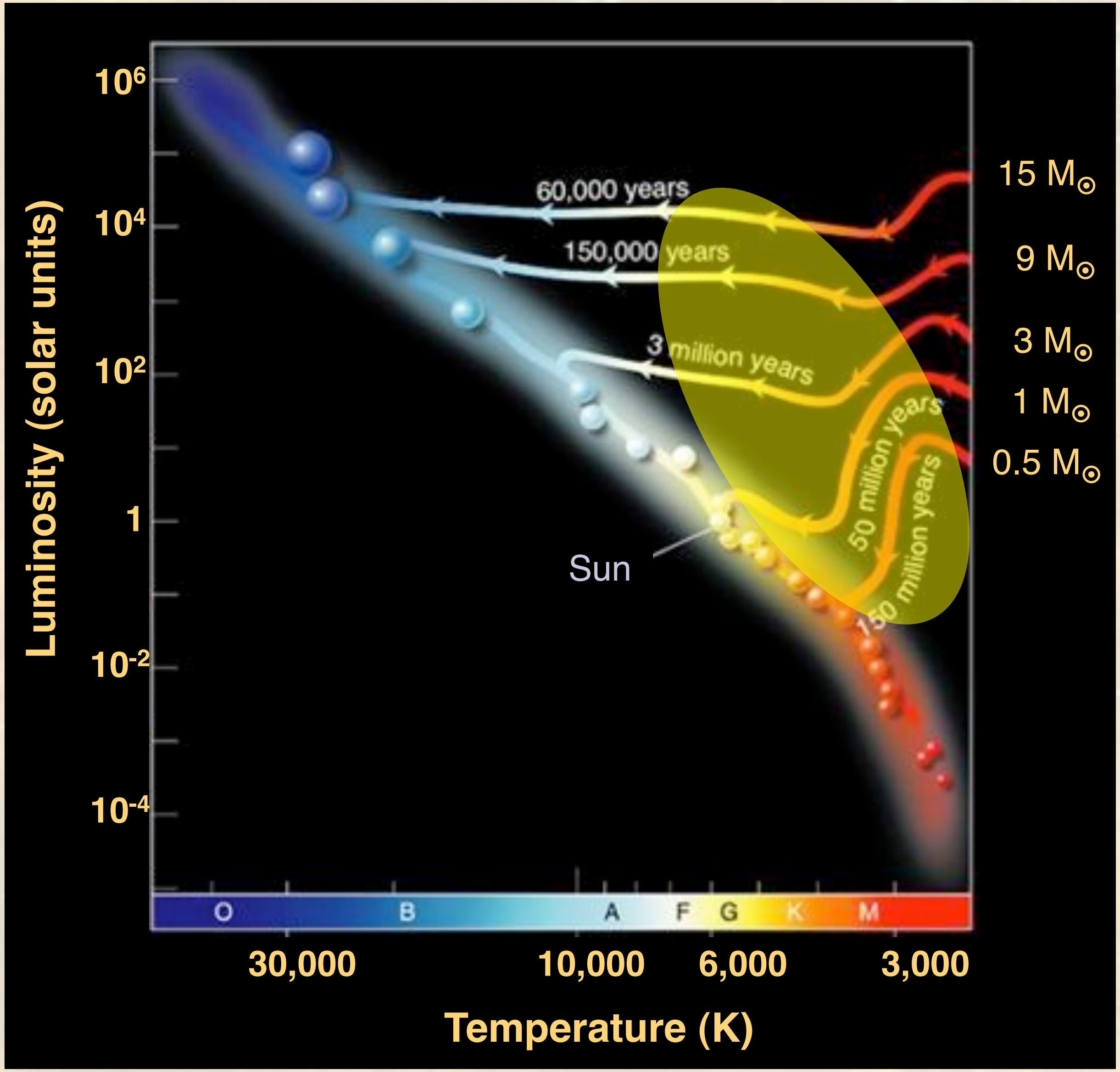
Star formation in the Local Group

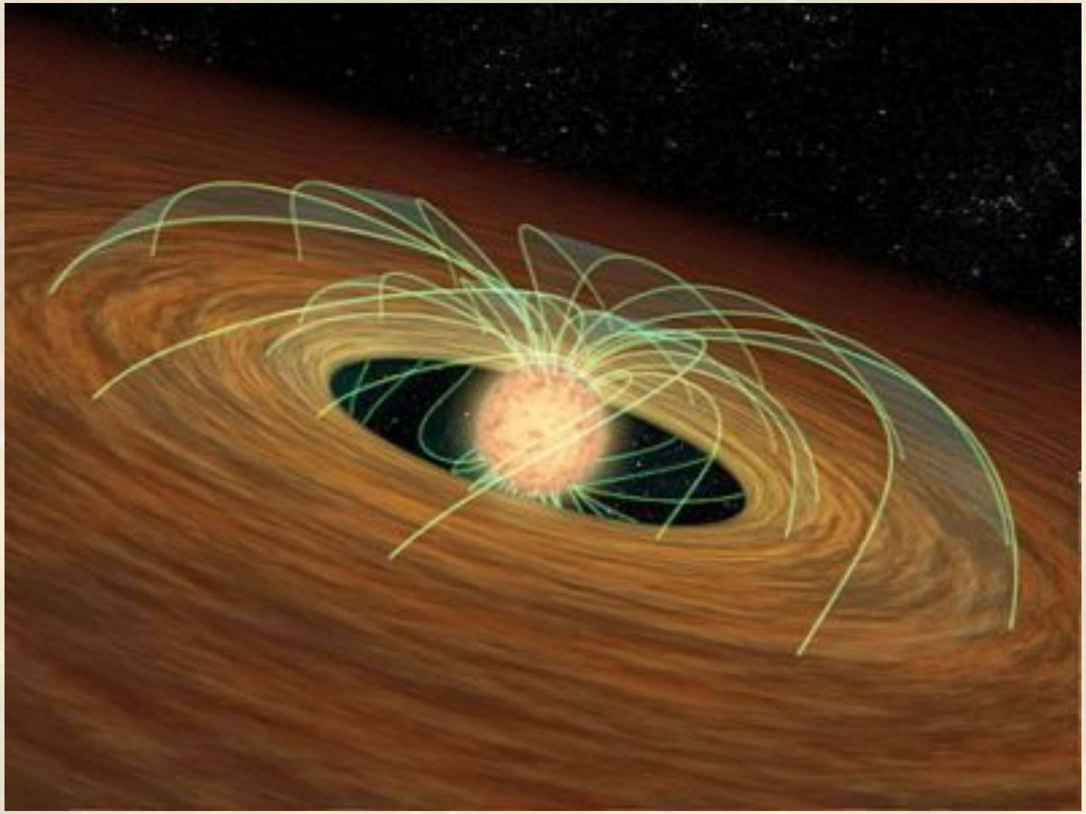
Guido De Marchi (ESA)

Nino Panagia (STScI), Martino Romaniello (ESO), Loredana Spezzi (ESA), Giacomo Beccari (ESA), Francesco Paresce (IASF-BO), Elena Sabbi (STScI), Morten Andersen (ESA), Marco Sirianni (ESA)

Pre Main Sequence: stellar childhood



Accretion from circumstellar disc



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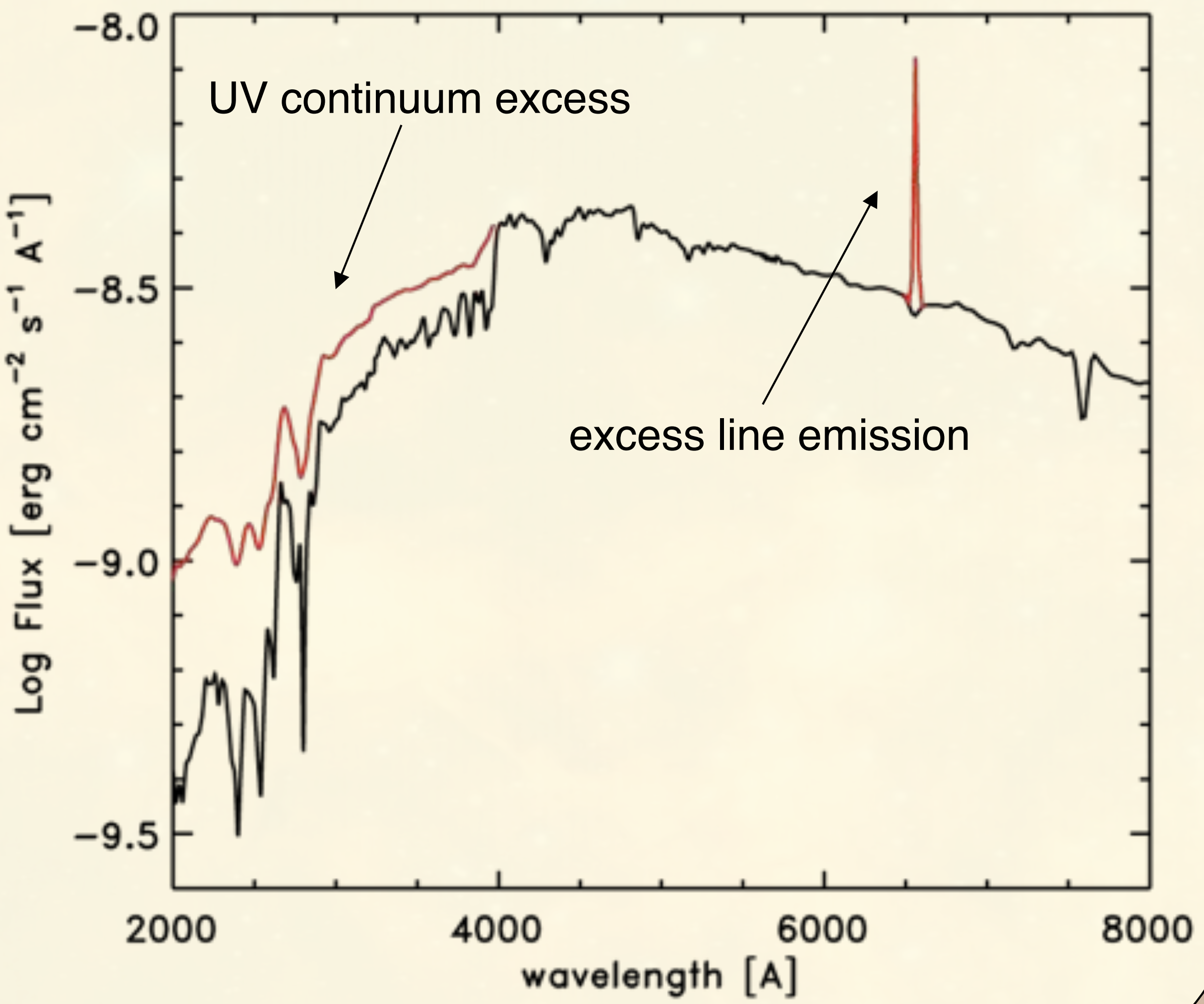


Accretion from circumstellar disc

- **UV and optical continuum excess, from which L_{acc} can be derived**

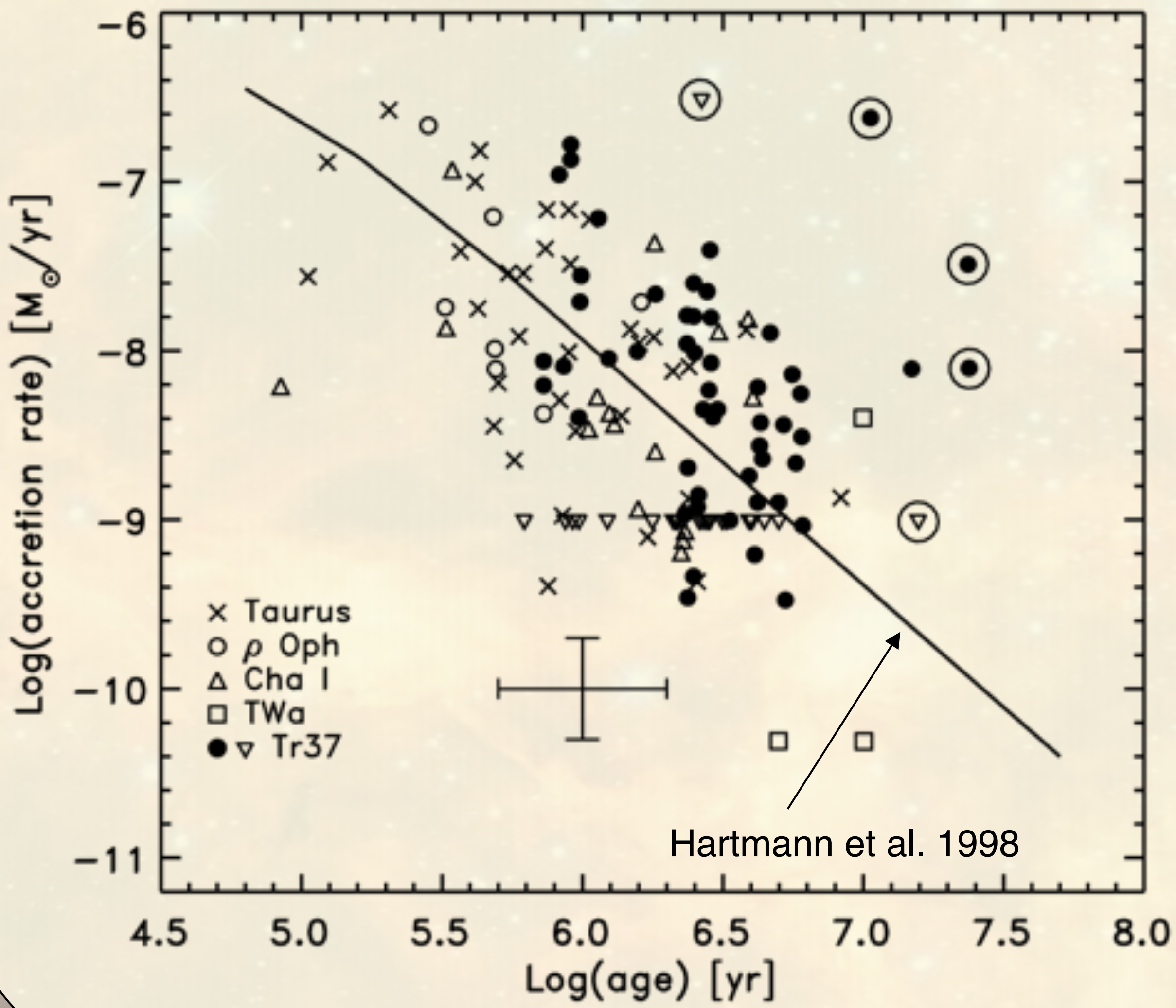
- **Strong emission lines in infalling gas** (e.g. review by Calvet et al. 2000)

$$\mathrm{Log}\,(L_{acc}) = \mathrm{Log}\,(L_{H\alpha}) + (1.72 \pm 0.47)$$
$$\mathrm{Log}\,(L_{acc}) = (1.03 \pm 0.16)\ \mathrm{Log}\,(L_{Pa\beta}) + (2.8 \pm 0.58)$$
$$\mathrm{Log}\,(L_{acc}) = (1.20 \pm 0.21)\ \mathrm{Log}\,(L_{Br\gamma}) + (4.16 \pm 0.86)$$

- **All methods require spectroscopy, very laborious, hence only ~100 objects currently have measured L_{acc} and mass accretion rate**

Accretion evolution with time

Sicilia-Aguilar et al. 2006



How about other galaxies?

- Most stars in the Universe formed at redshift z~2, when metallicity was lower, 1/3 - 1/10 solar, like in the nearby Magellanic Clouds, but ...

- Spectroscopy of individual stars in MCs hampered by crowding, VLT/Flames observations attempted, but limit is angular resolution

- New simple method combines broad- (V, I) and narrow-band (H_α) photometry and allows us to:

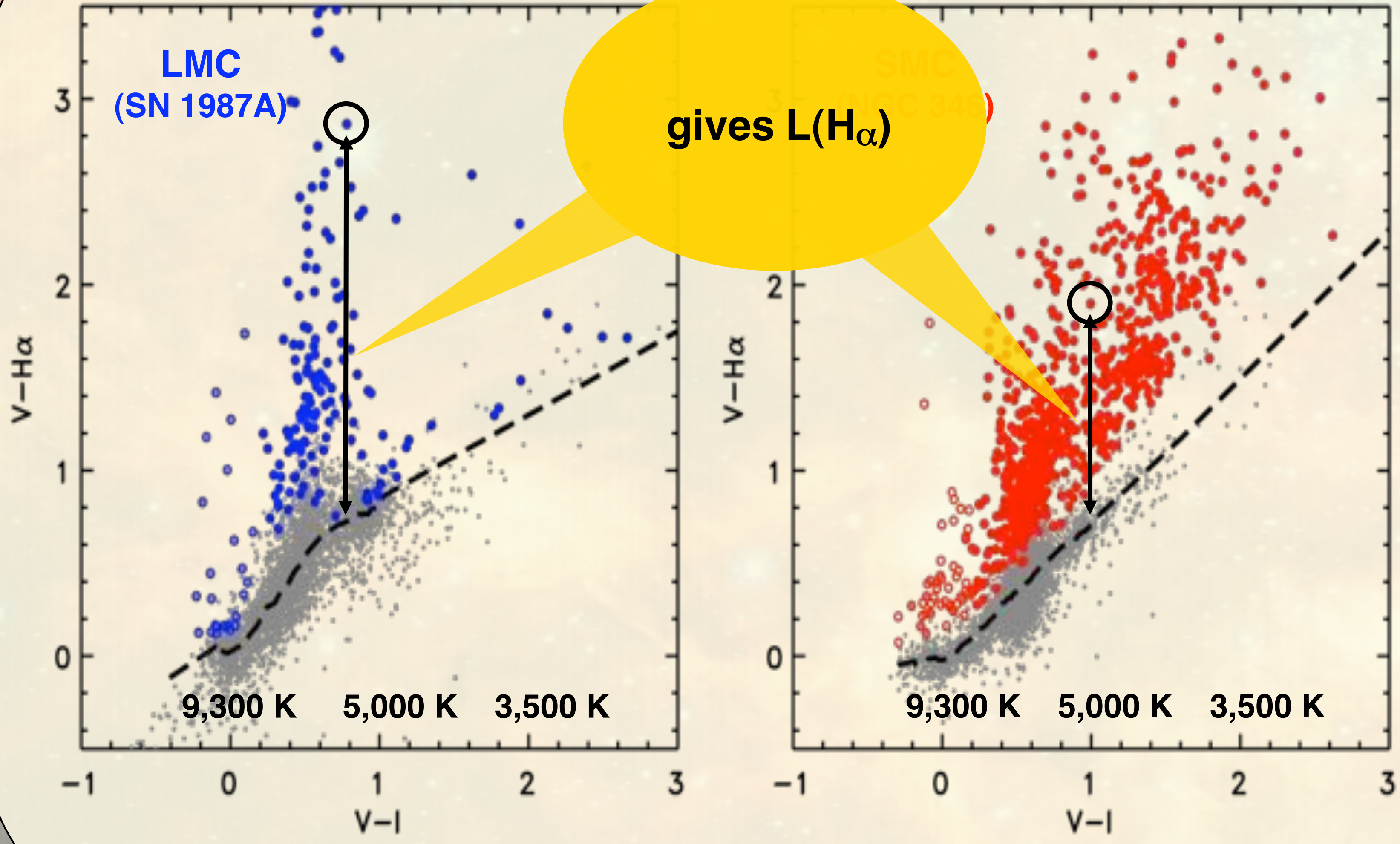
✓ identify all objects with H_α excess emission
✓ derive their accretion luminosity and mass accretion rates
✓ for hundreds of stars simultaneously!

(De Marchi, Panagia & Romaniello 2010; *astro-ph: 1002.4864*)

H_α photometry

De Marchi, Panagia & Romaniello 2010

De Marchi et al. 2010



Stars physical parameters

- **H$_\alpha$ luminosity $L_{H\alpha}$ gives accretion luminosity L_{acc} via relationship calibrated using spectroscopic data** (e.g. Dahm 2008)

$$\text{Log}(L_{acc}) = \text{Log}(L_{H\alpha}) + (1.72 \pm 0.47)$$

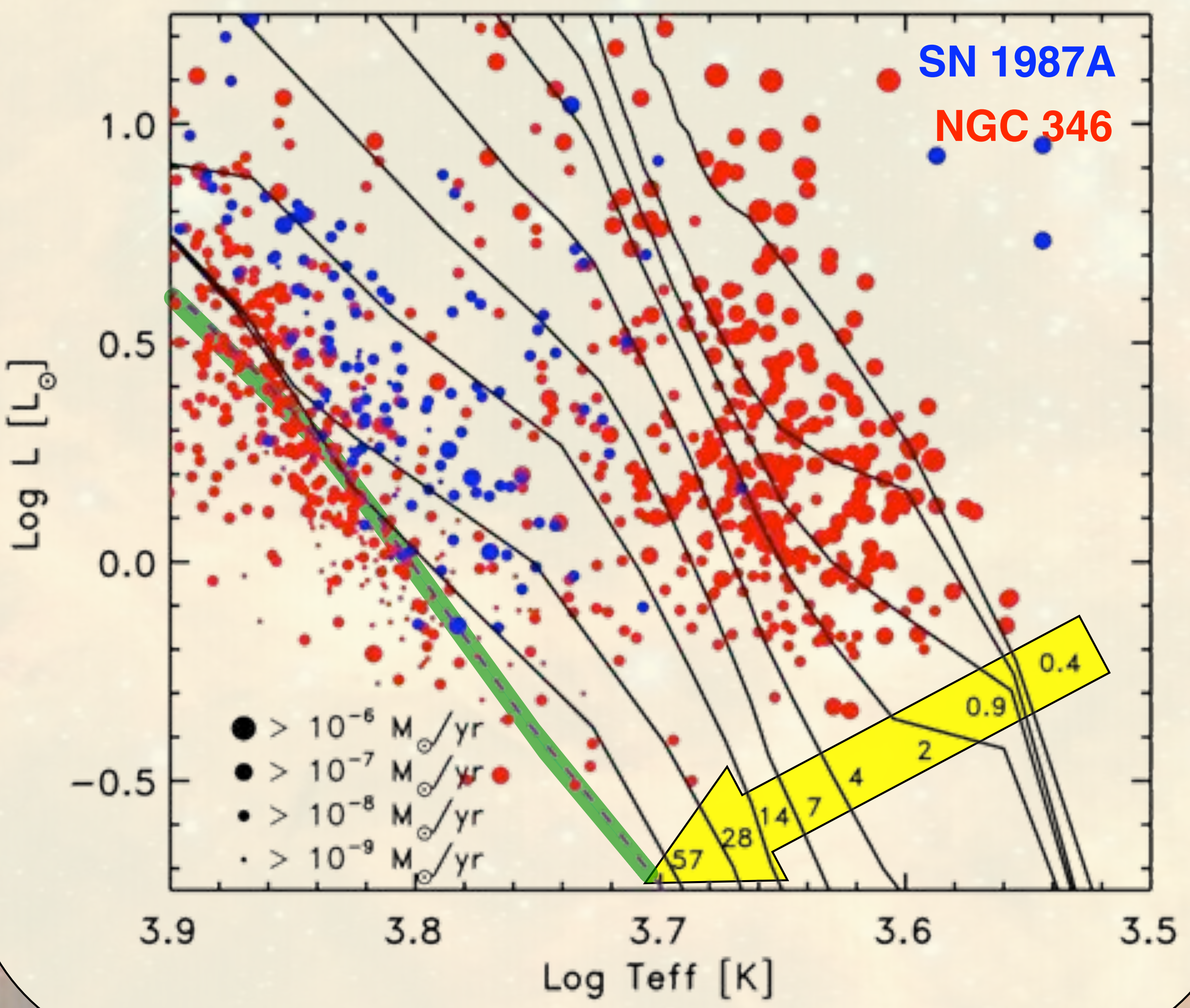
- **Mass $M_\star$ radius $R_\star$ and age $t_\star$ from PMS isochrones in HR diagram**

- **Free fall equation gives mass accretion rate $\dot{M}$**

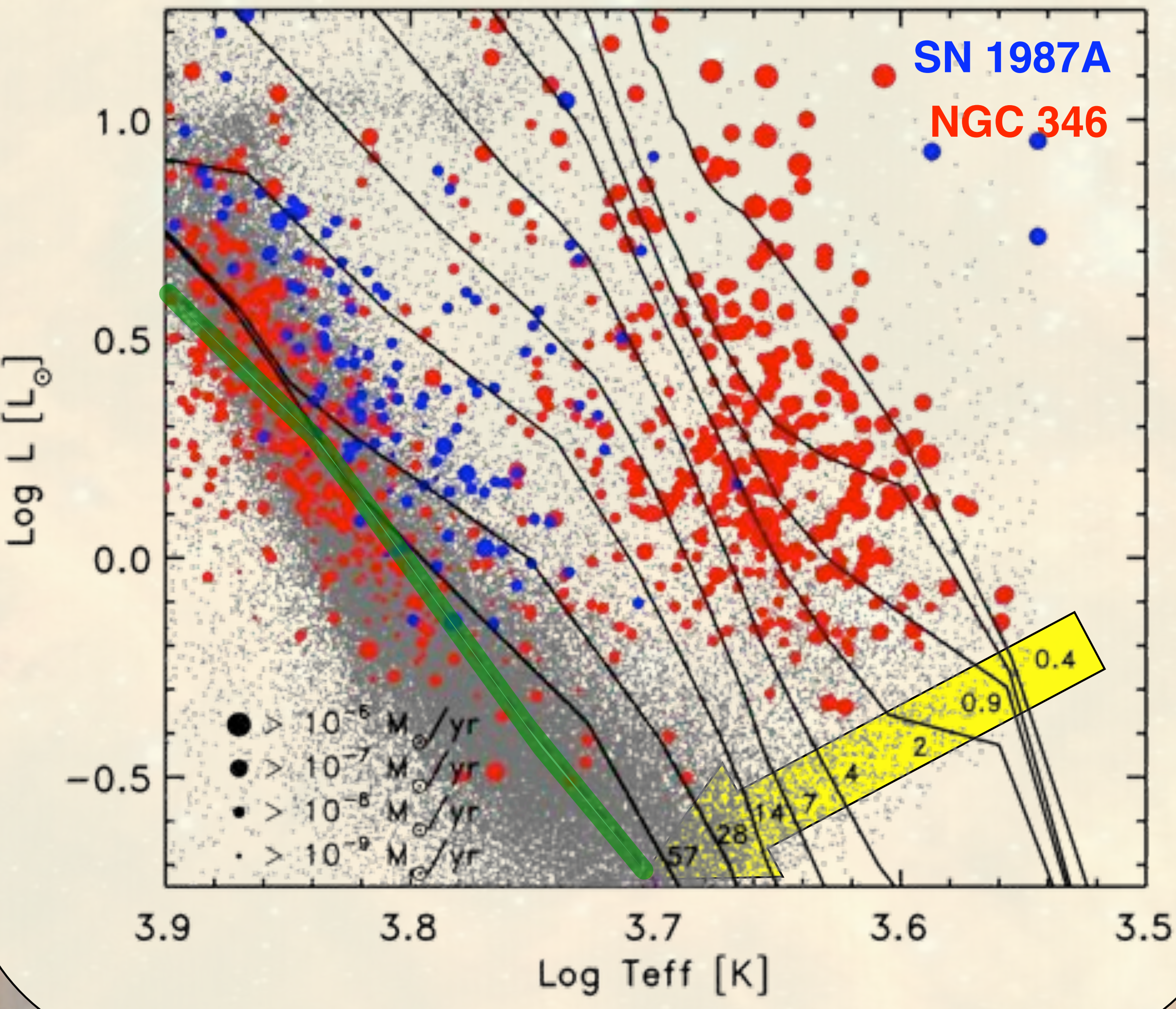
$$L_{acc} \simeq \frac{GM_*\dot{M}}{R_*}\left(1 - \frac{R_*}{R_{in}}\right)$$

- **We can study how star formation has proceeded in space and time**

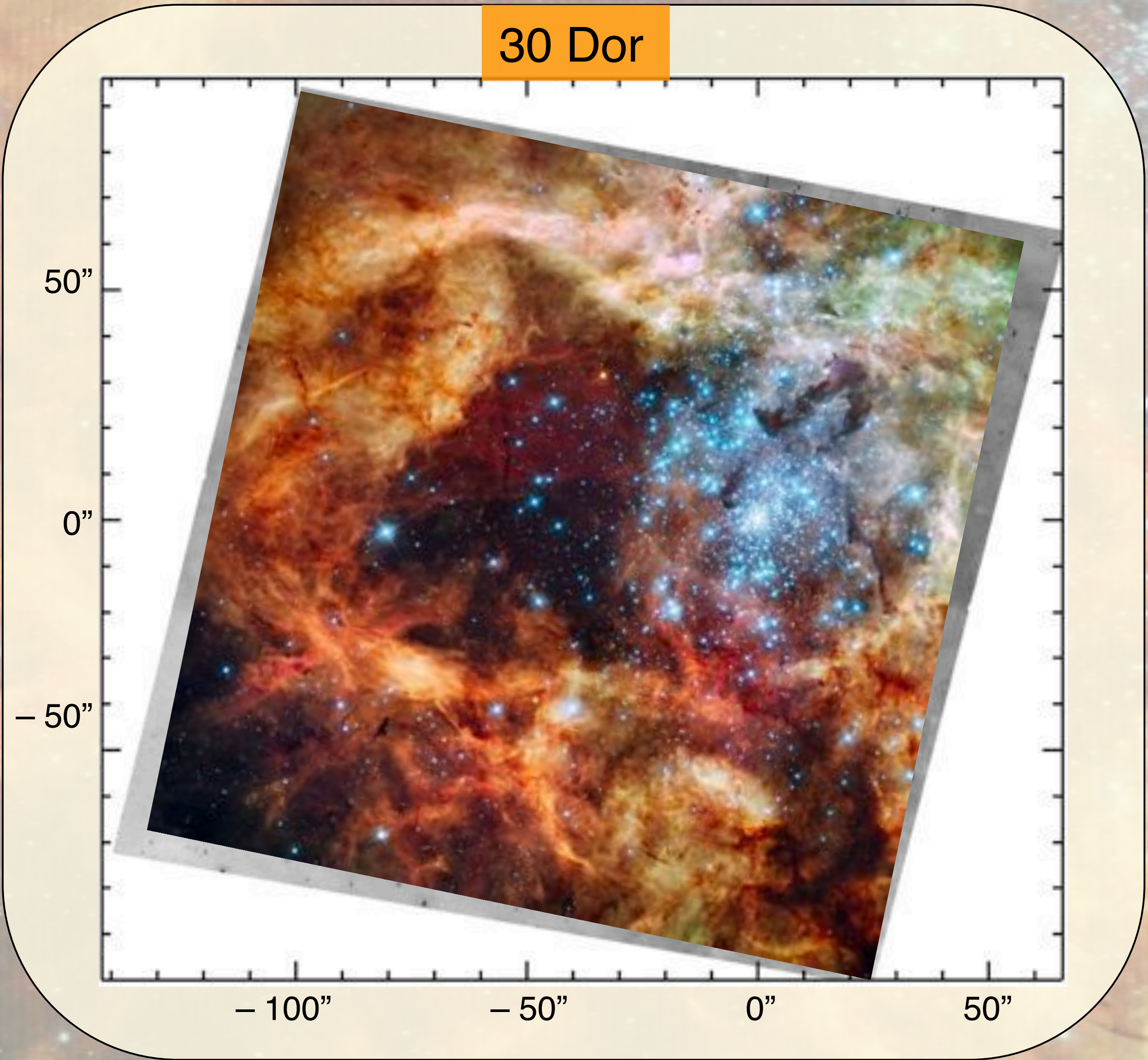
Accretion rates in the H-R diagram



Accretion rates in the H-R diagram



Multiple but unrelated generations



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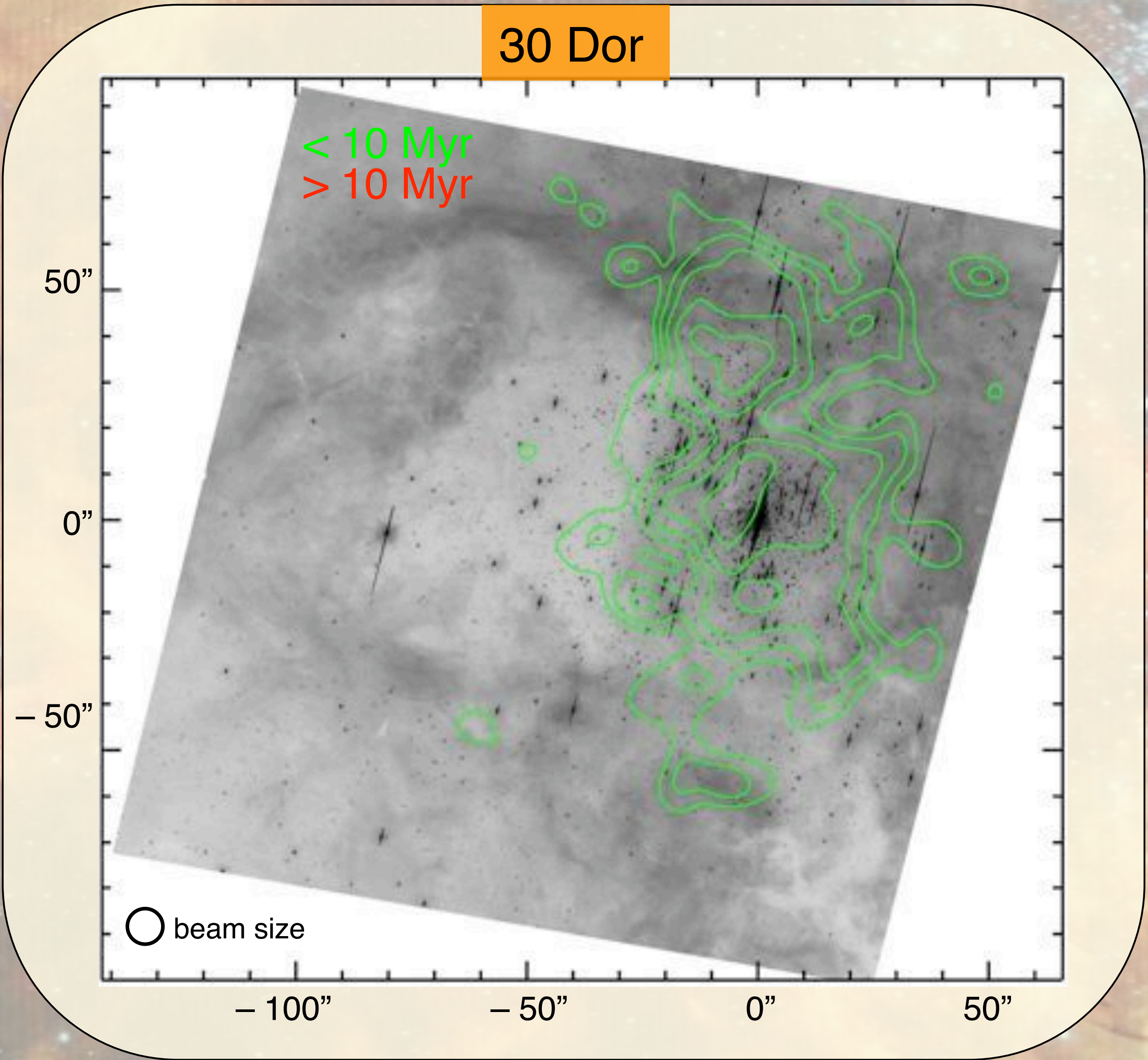

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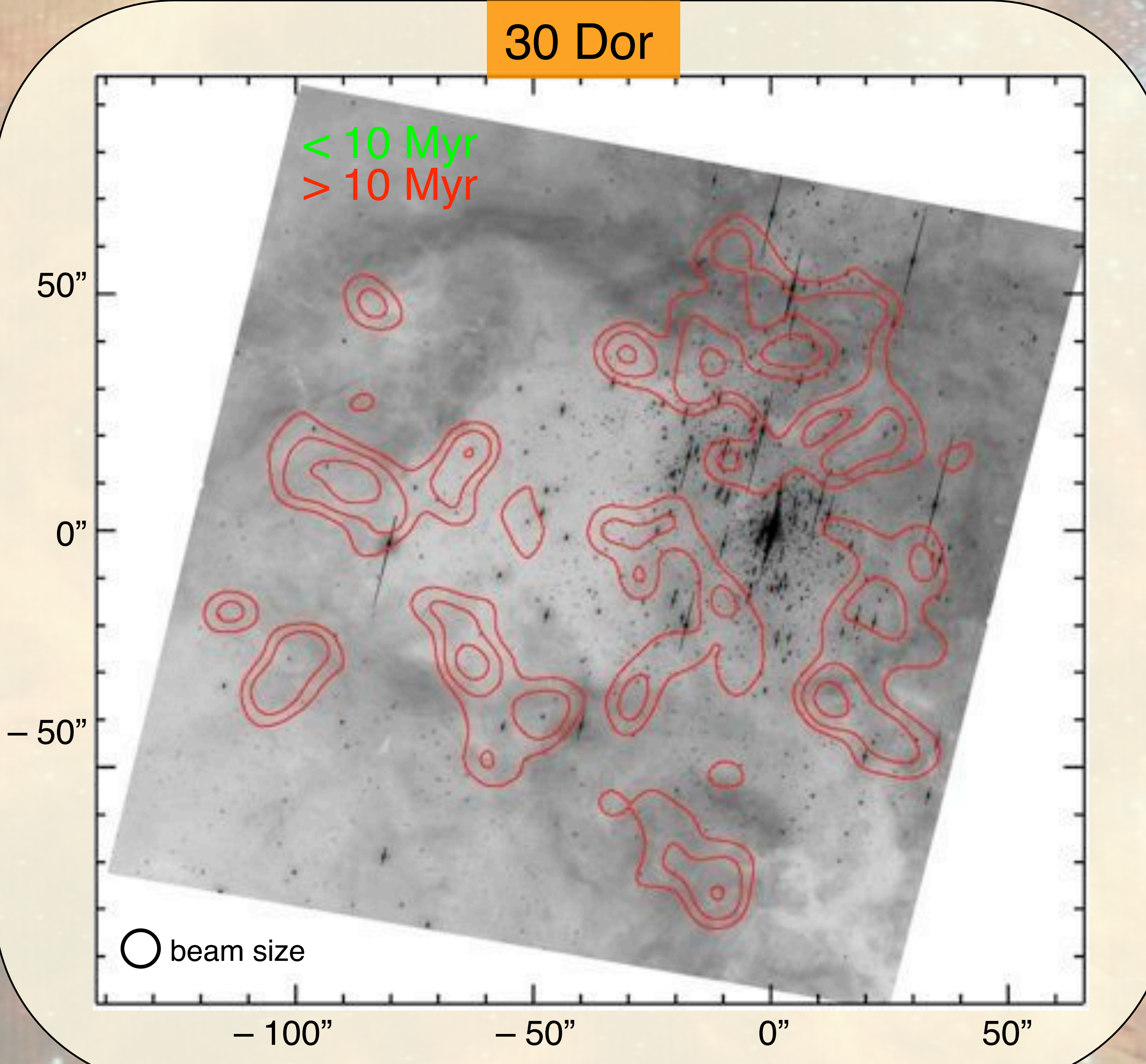

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NGC 3603

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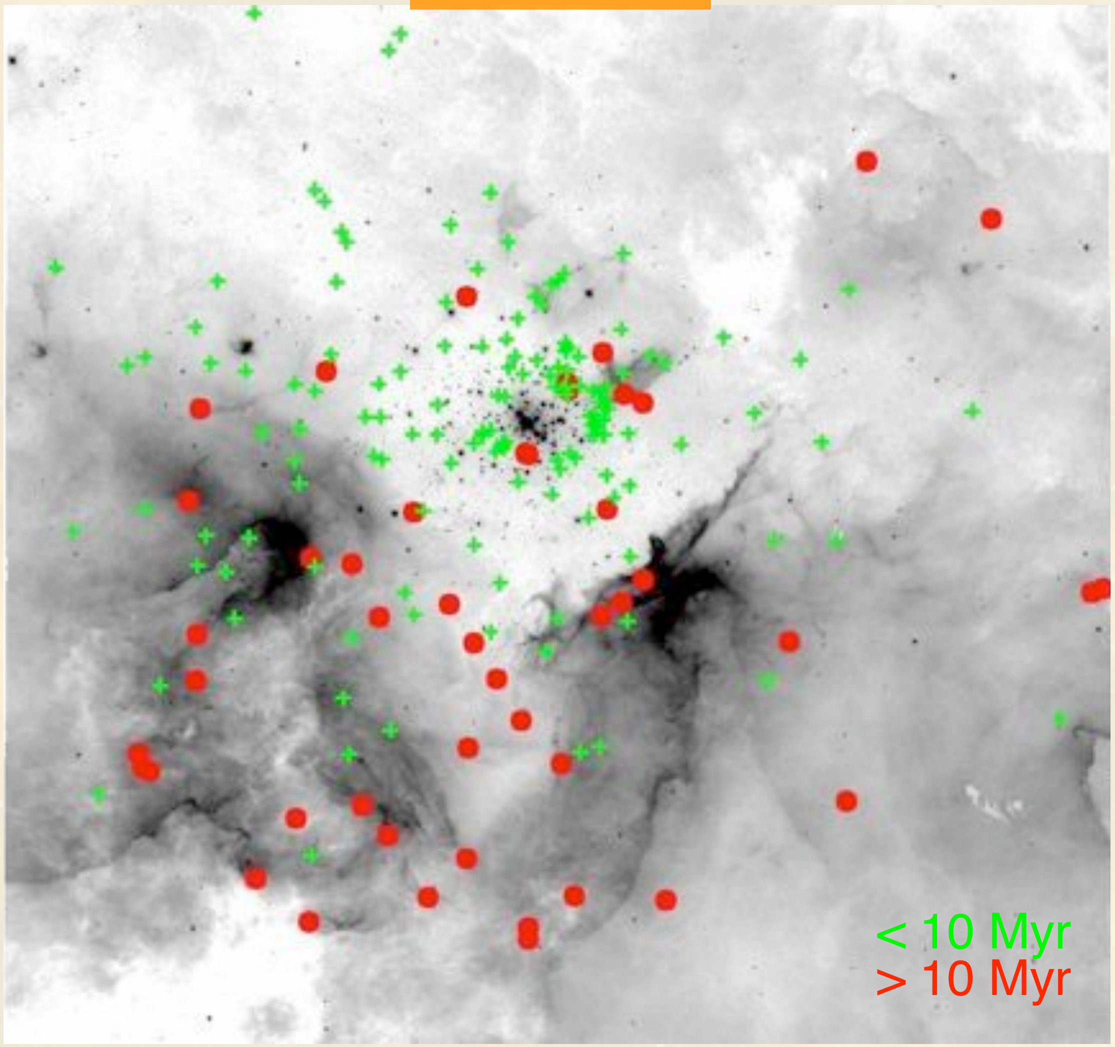

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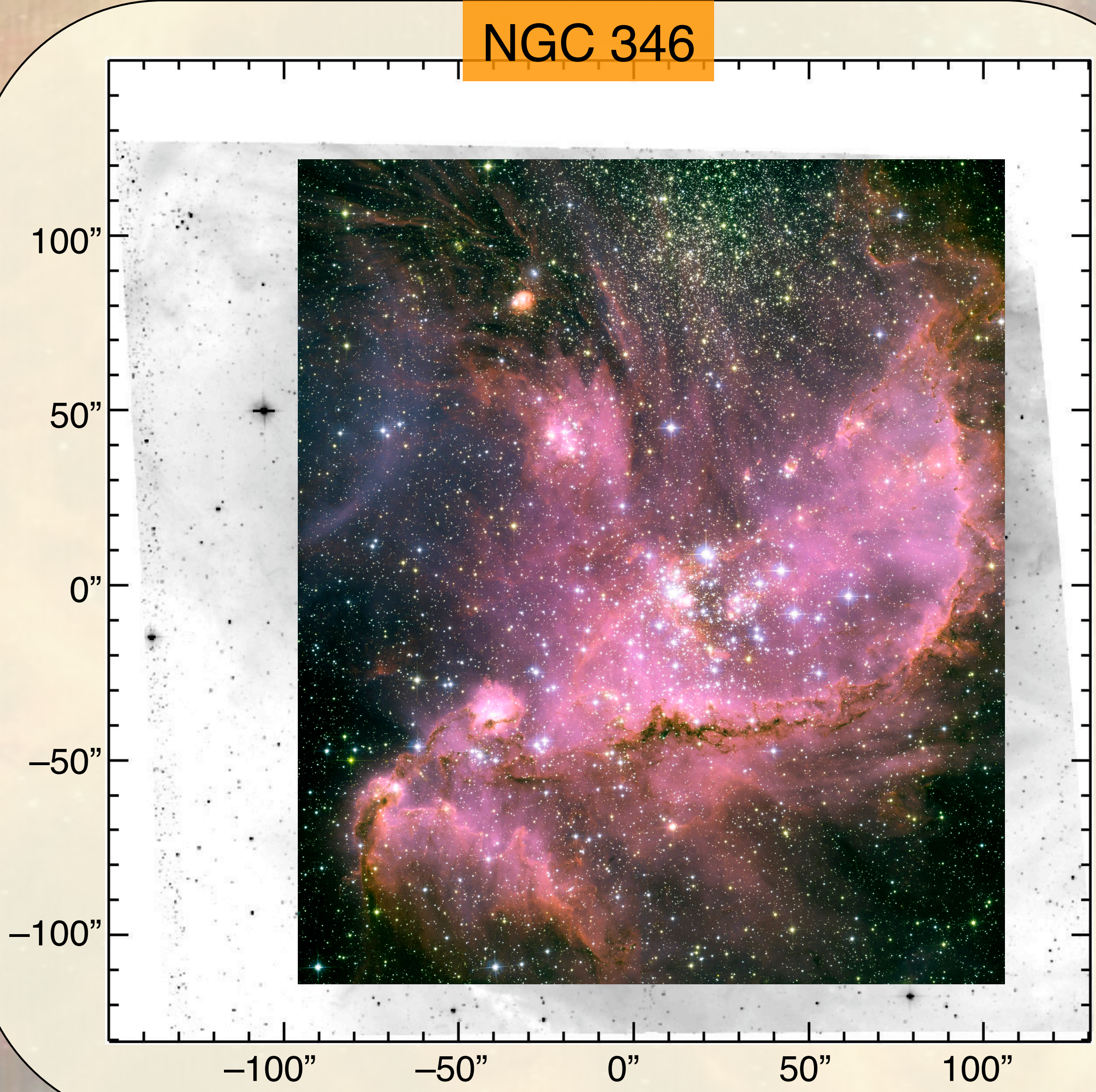

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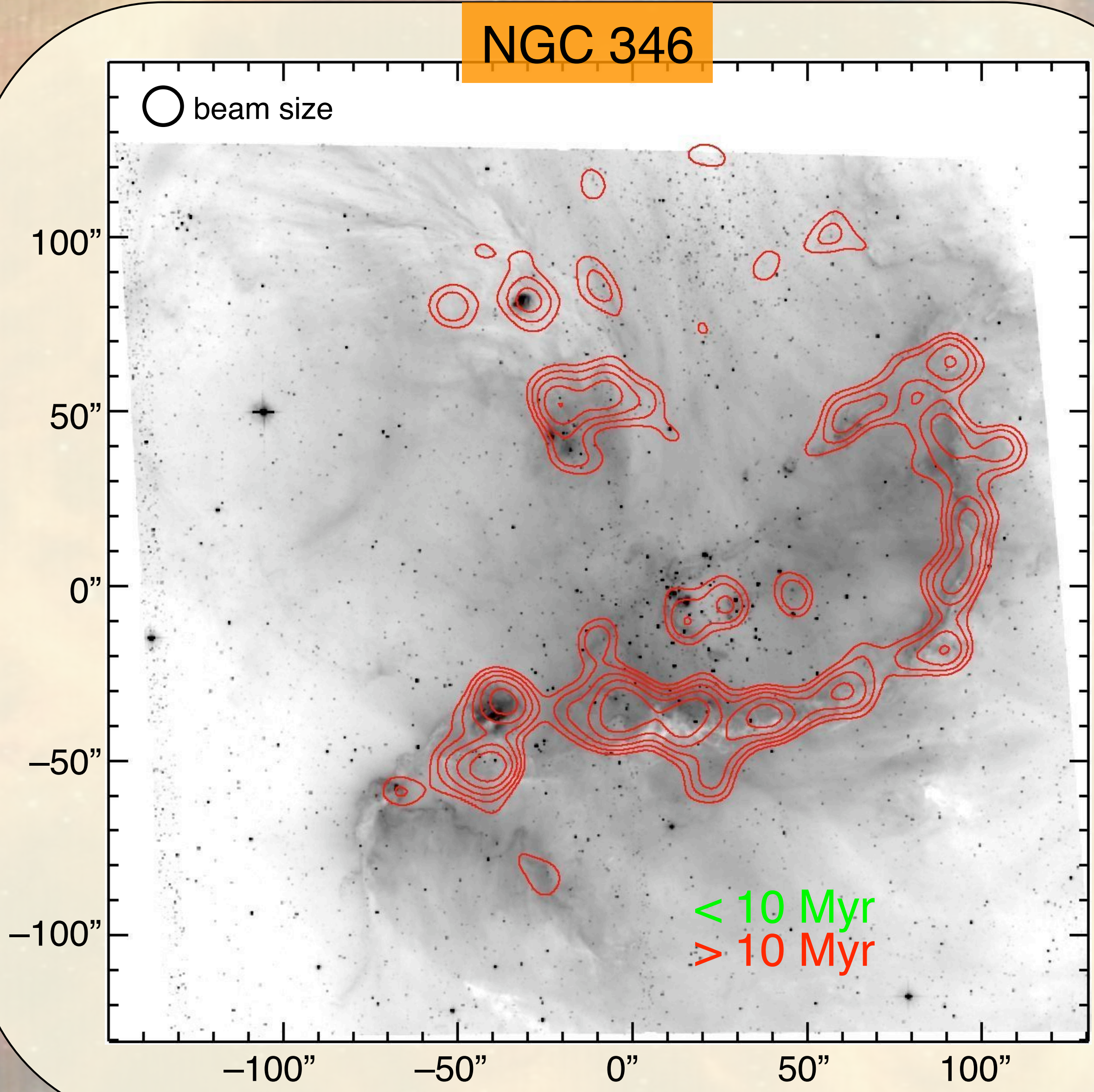

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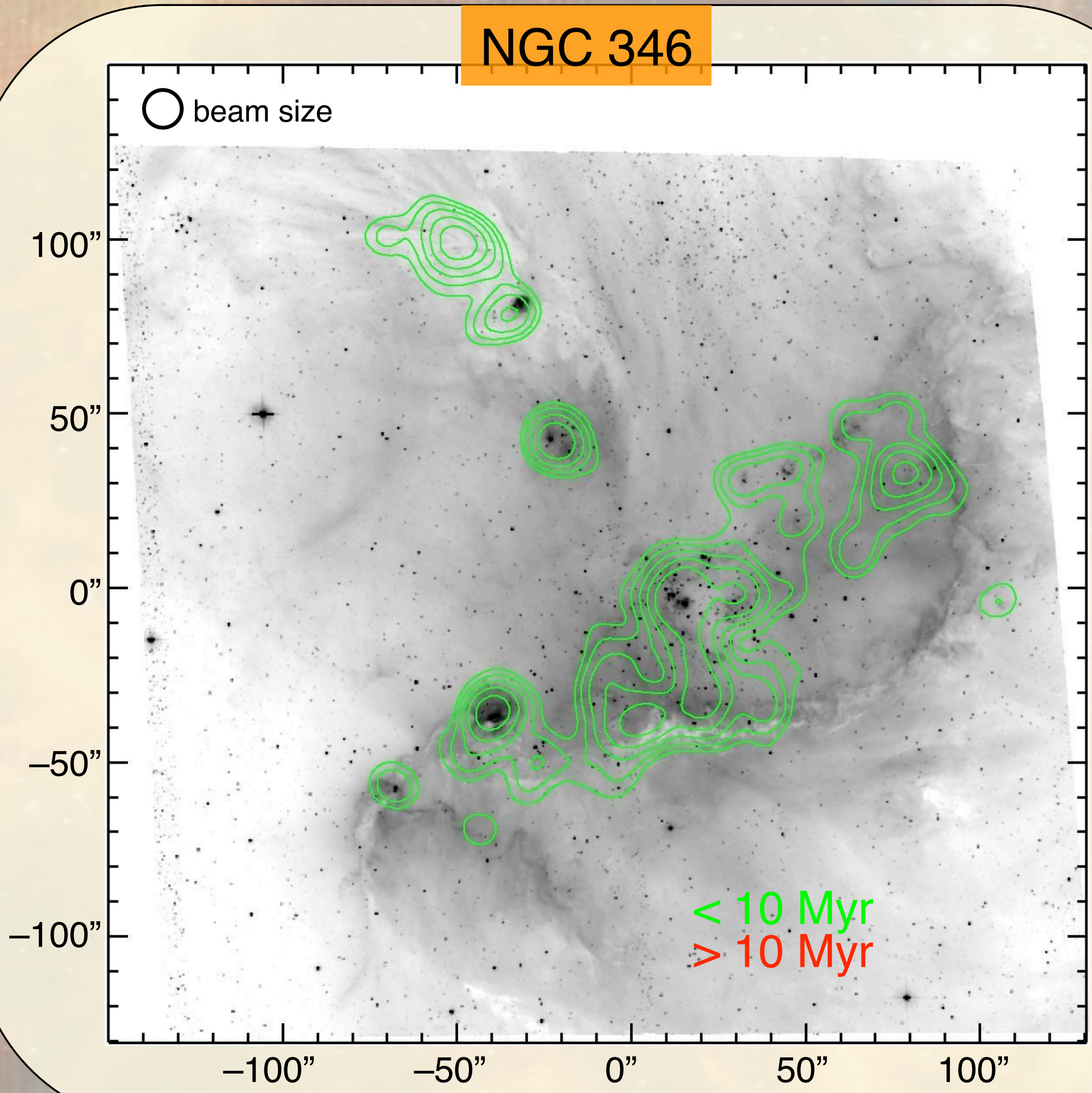
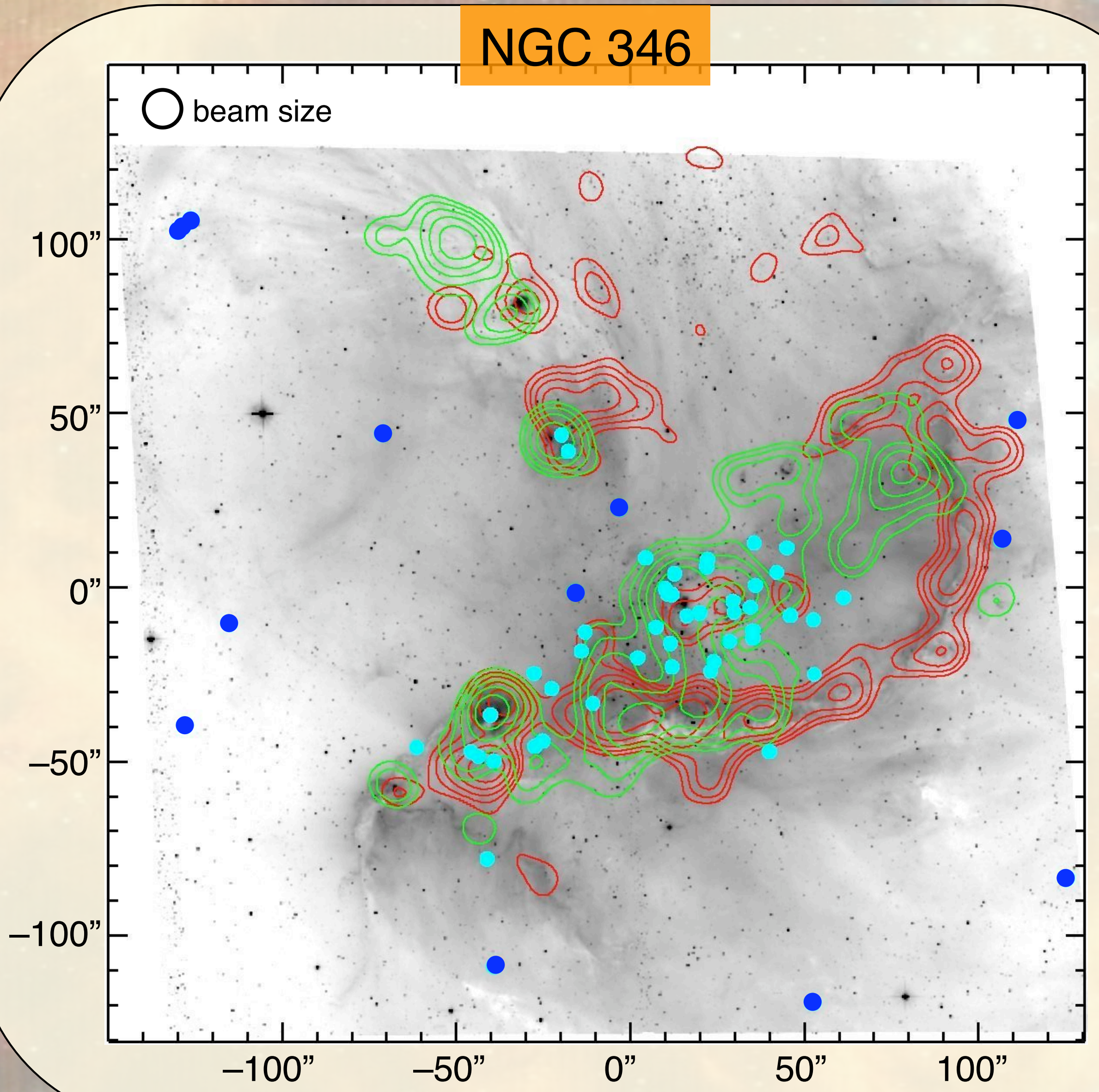
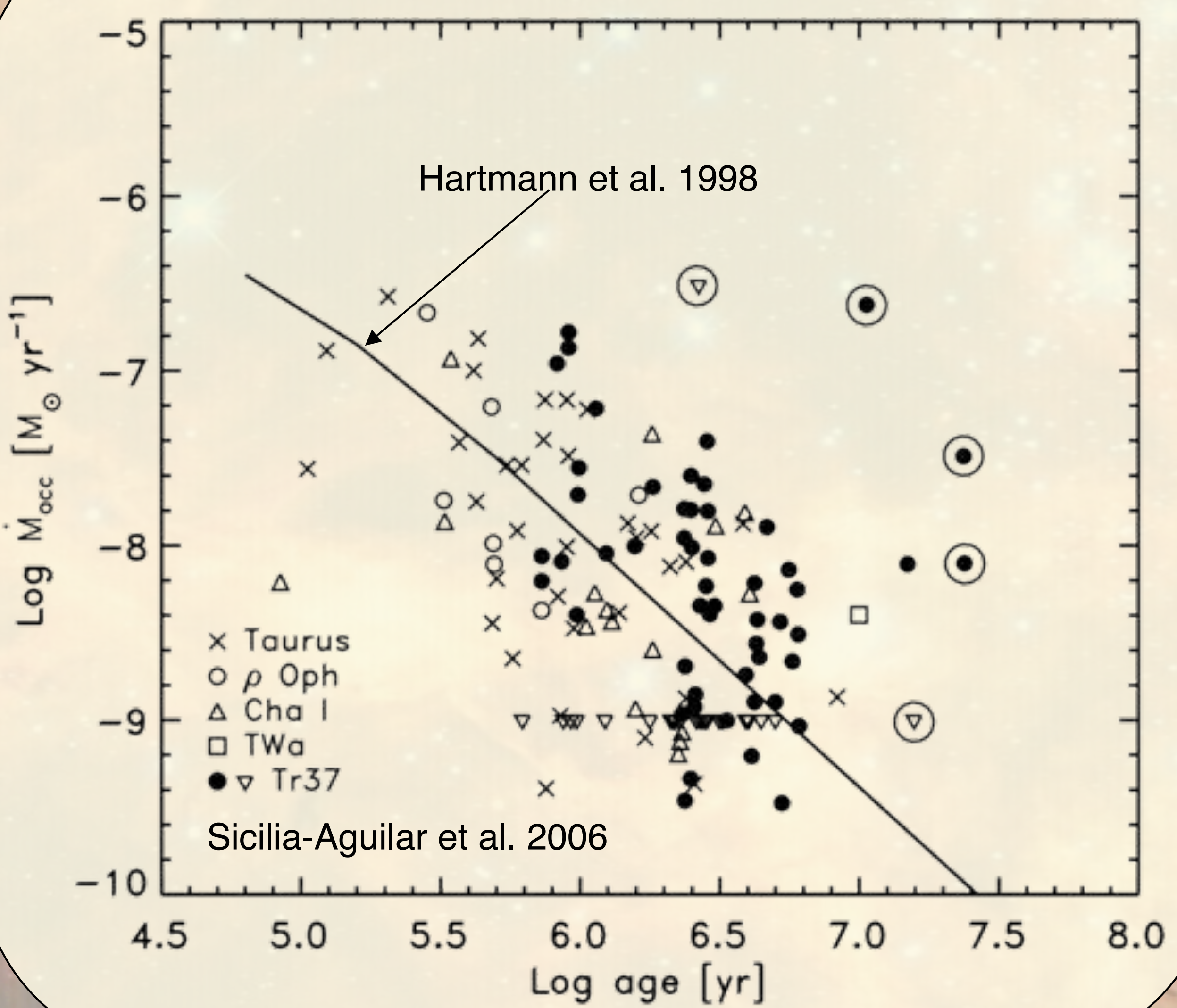


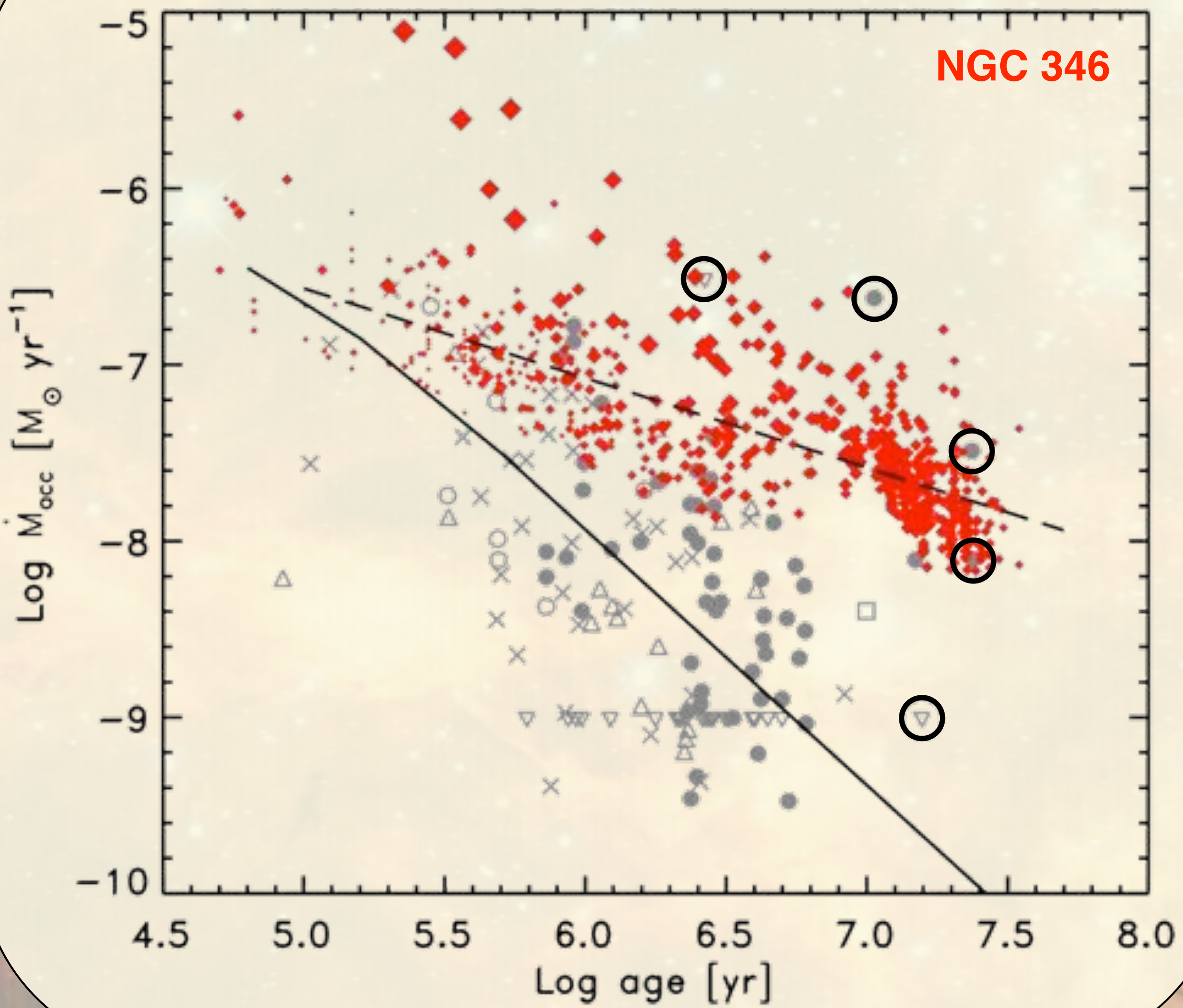
Low- and high-mass stars mismatch



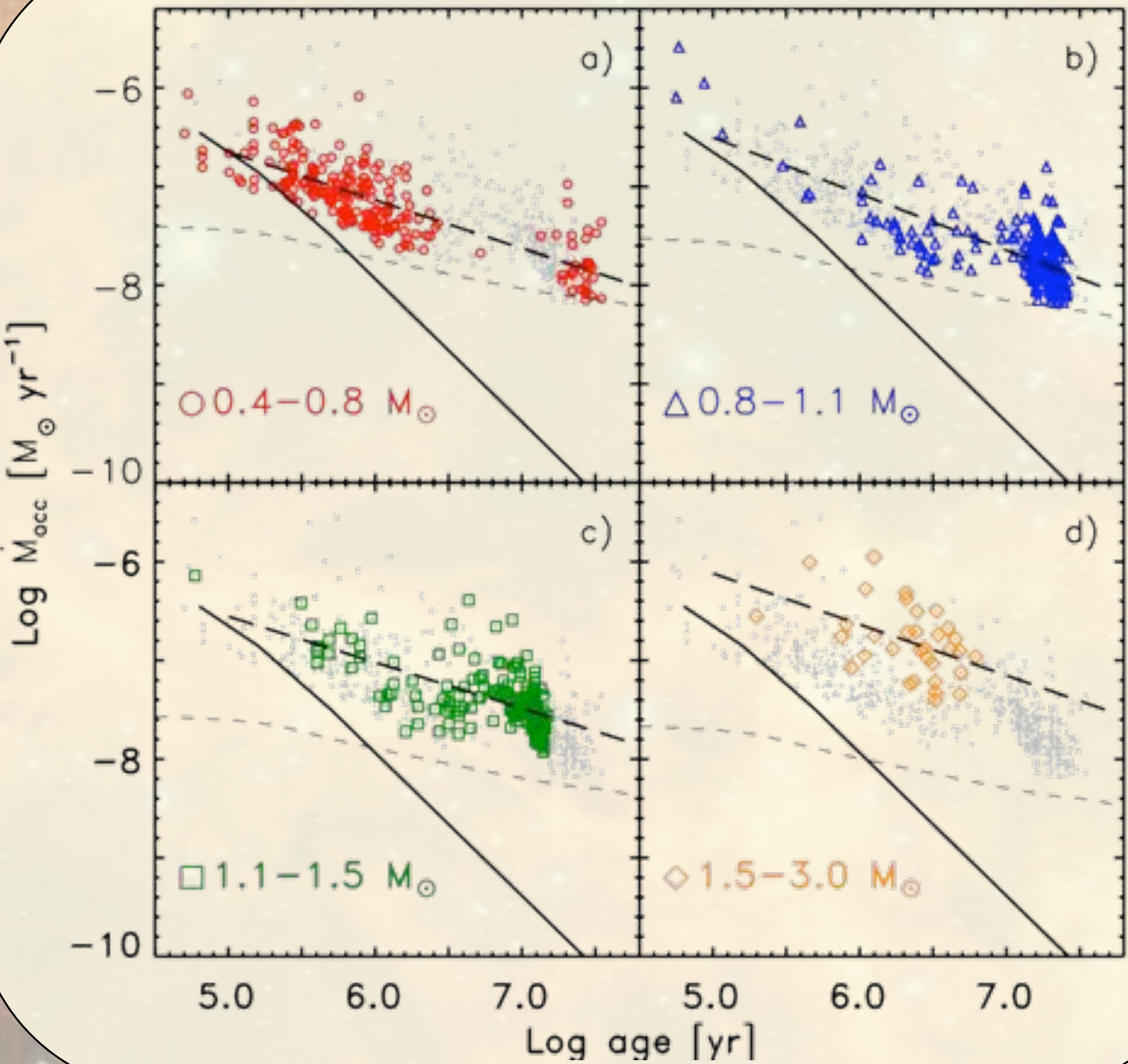
Accretion evolution with time



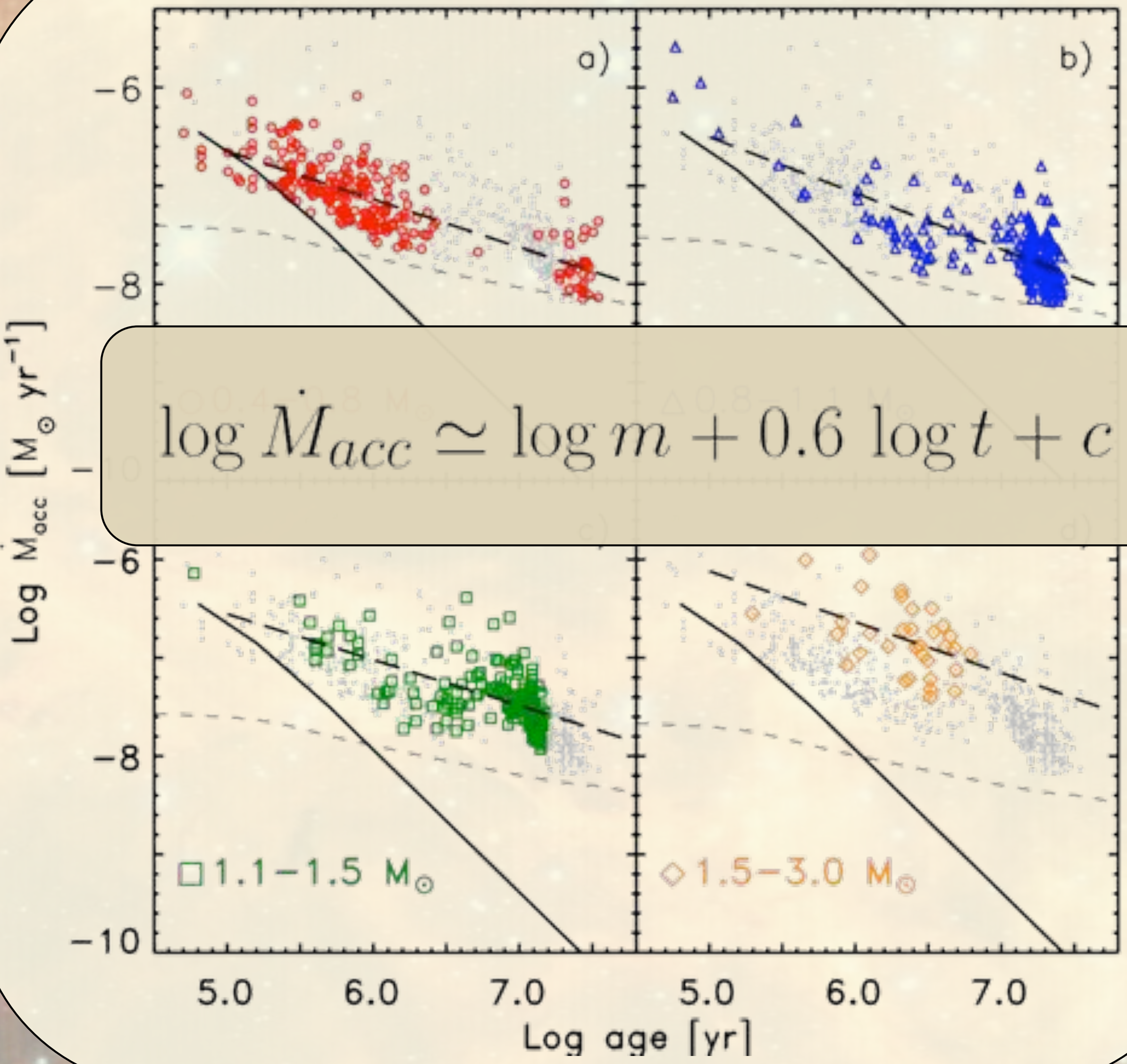
Accretion evolution with time



Accretion evolution with time & mass



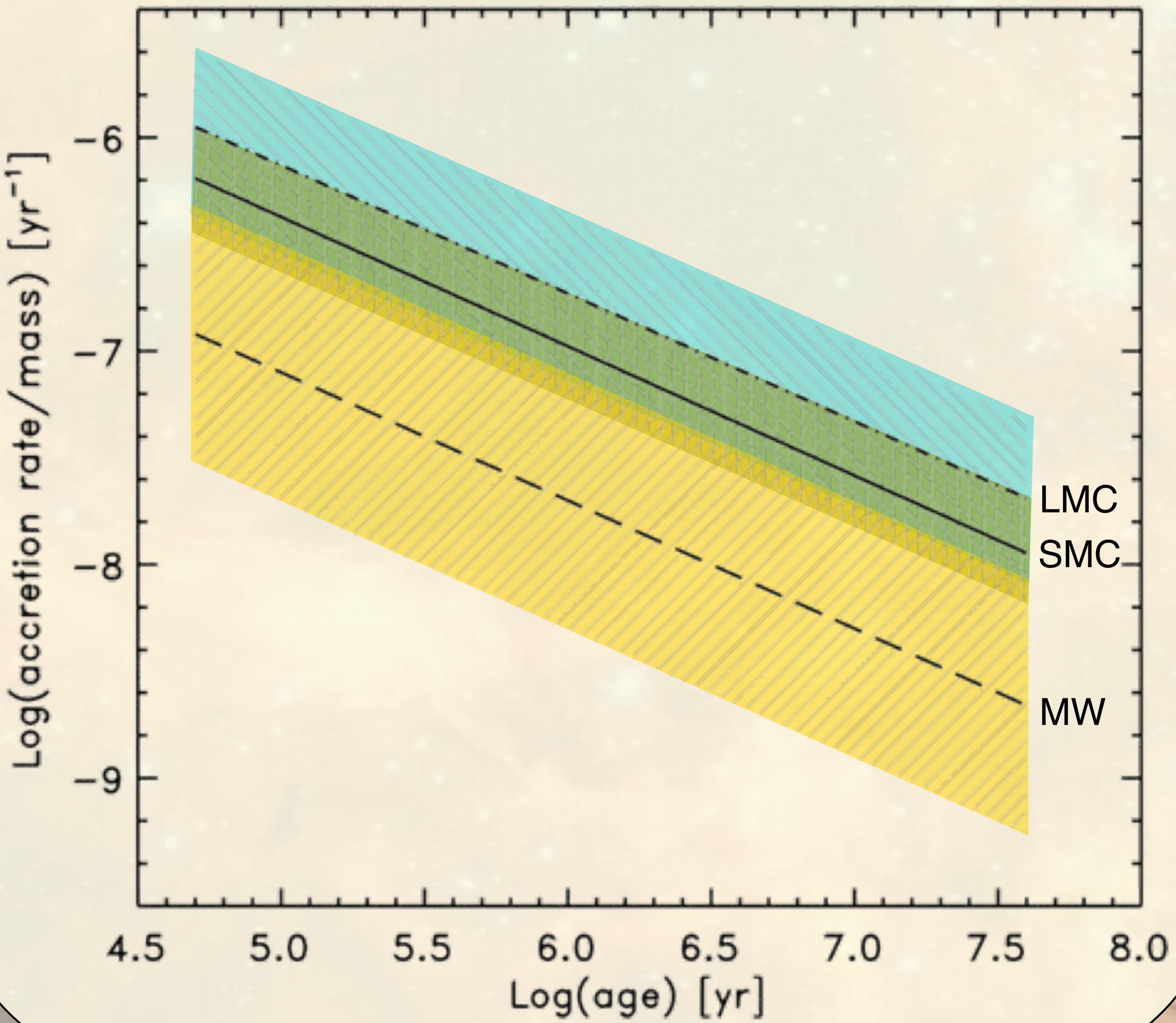
Accretion evolution with time & mass



$$\log \dot{M}_{acc} \simeq \log m + 0.6\, \log t + c$$

Accretion rate and metallicity

$$\log \dot{M}_{acc} \simeq \log m + 0.6\ \log t + c$$



Ground truth with NIRSpec on JWST

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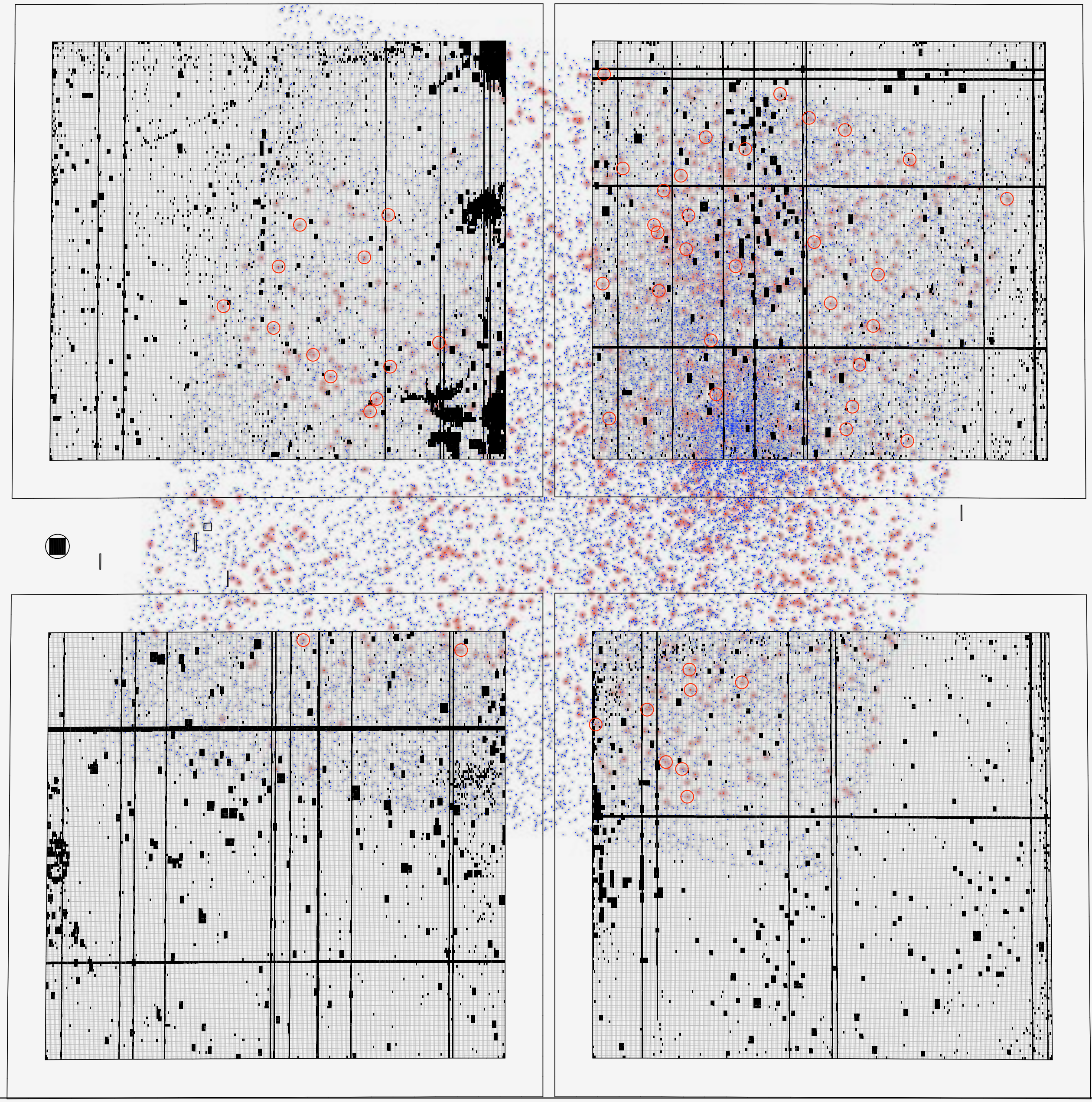
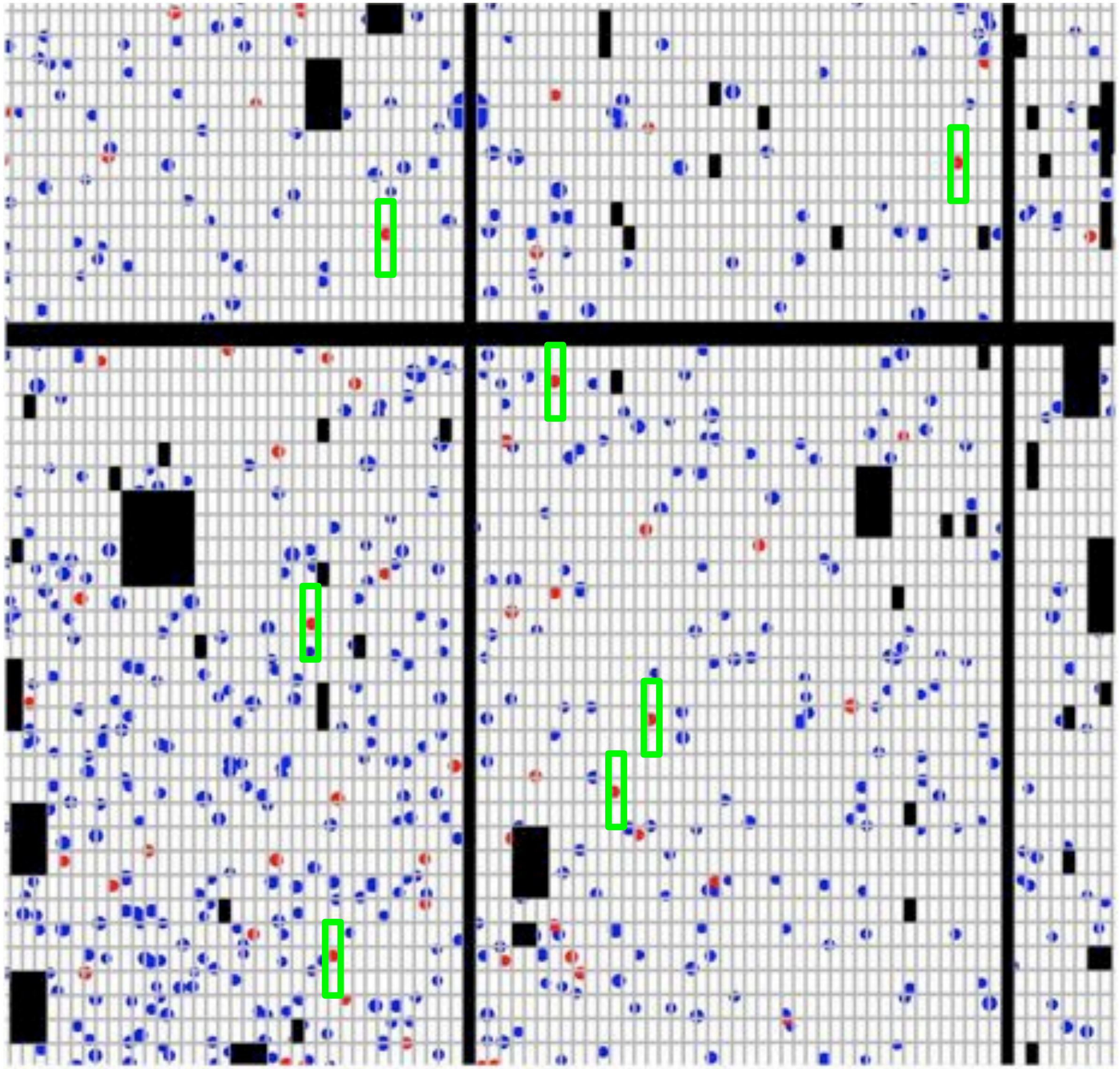
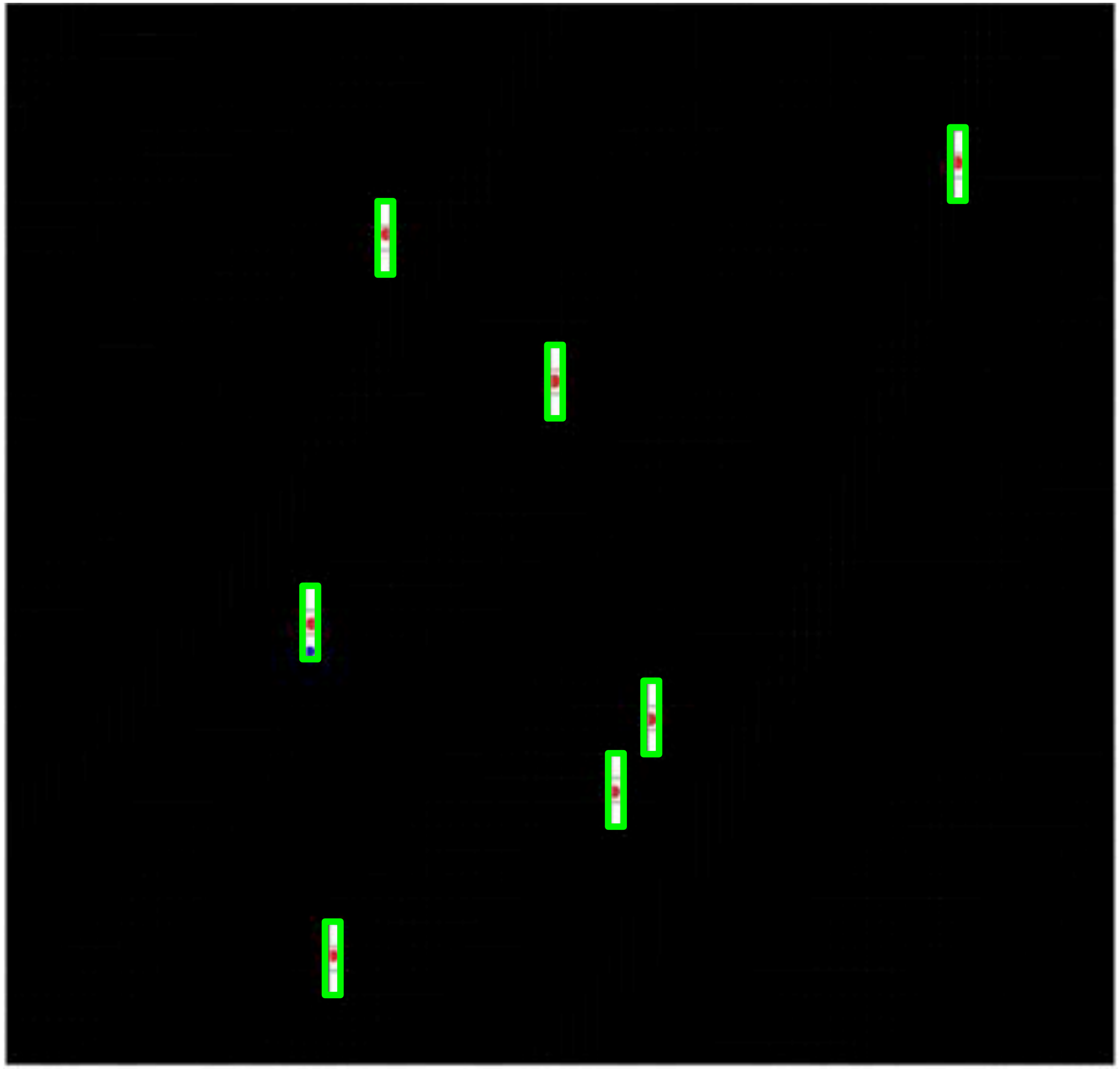


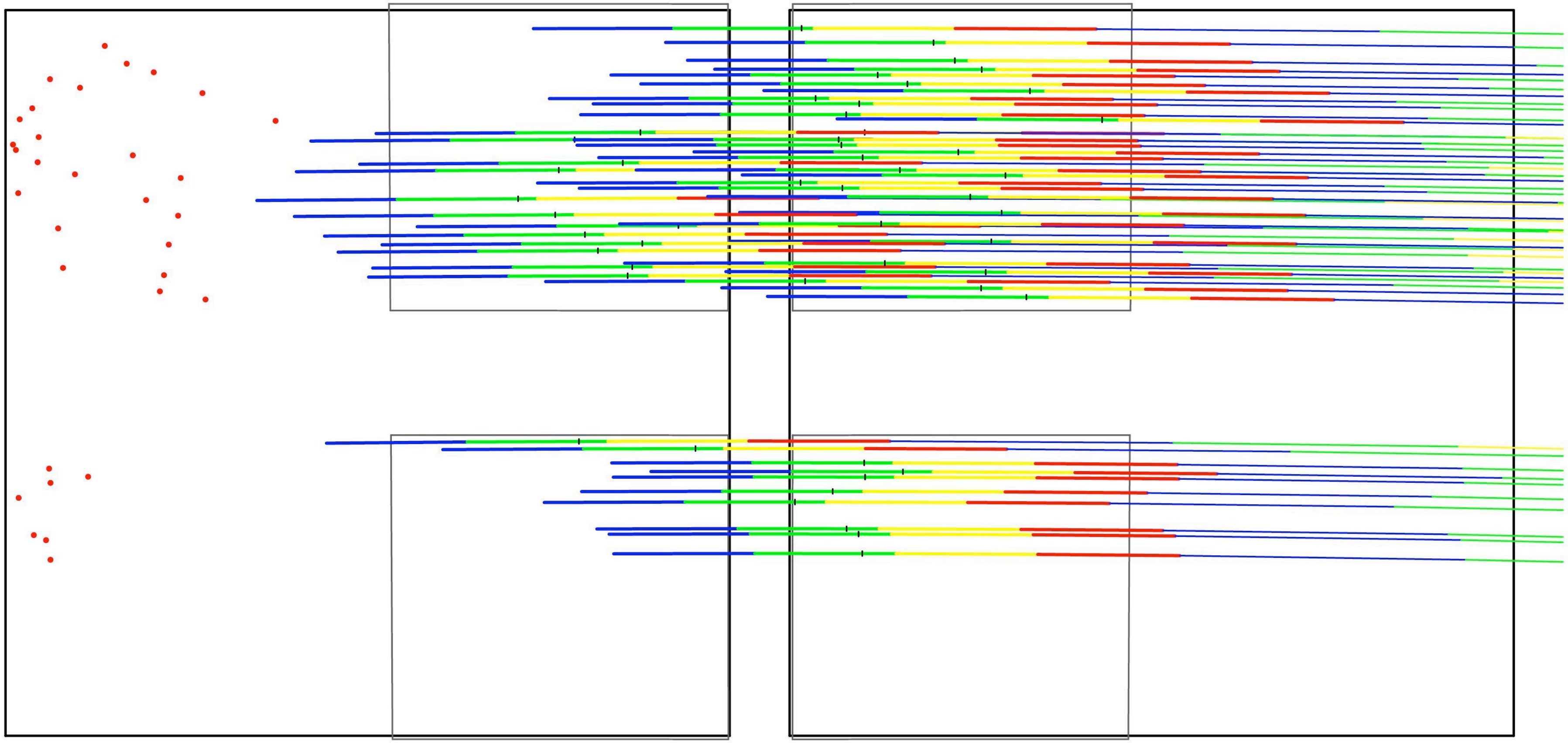
Ground truth with NIRSpec on JWST



Ground truth with NIRSpec on JWST



Band II (1.7 – 3.0 μm) R~1000



Looking further ahead and farther away

- ELTs can extend this science further out in the local group, for example M31 & M33 in the North or NGC 3109 & Sextans A in the South ($Z < Z_{SMC}$)
- Spatial resolution and sensitivity are crucial, so until AO available in the visible, PMS stars must be searched and studied with IR spectroscopy
- Typical cluster size, ~7.5 pc, corresponds to ~ 350 HST spatial resolution elements if in LMC and ~350 HARMONI resolution elements in Andromeda
- HARMONI high spatial resolution IFU with R~4000 is a good match, although reaching K=26 with SNR~5 requires about one night
- But if ExAO in Hα band is possible (e.g. EPICS, IRIS), photometric detection of PMS stars via their Hα excess emission would be much more efficient!