Low mass star formation in the Local Group

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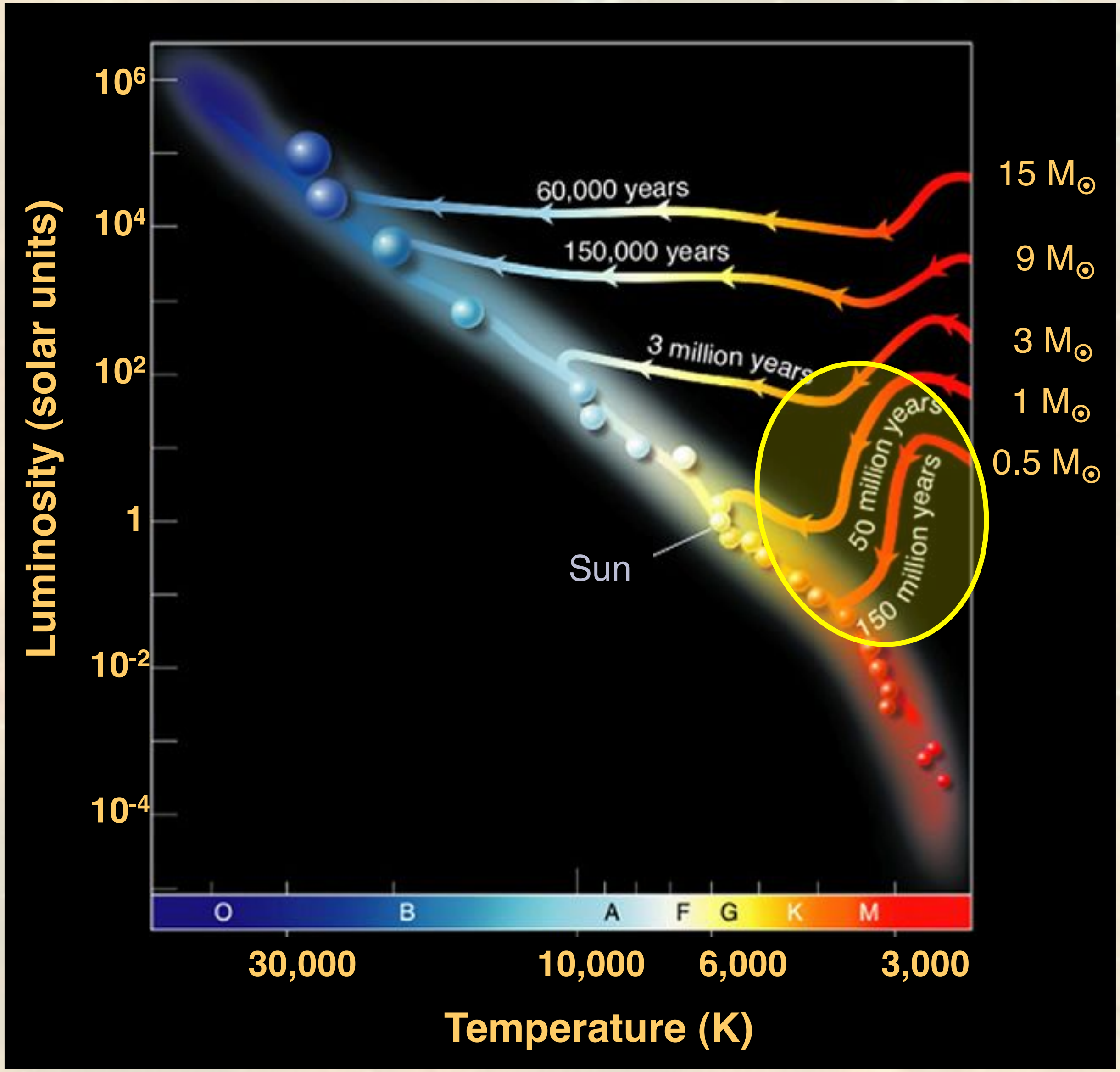
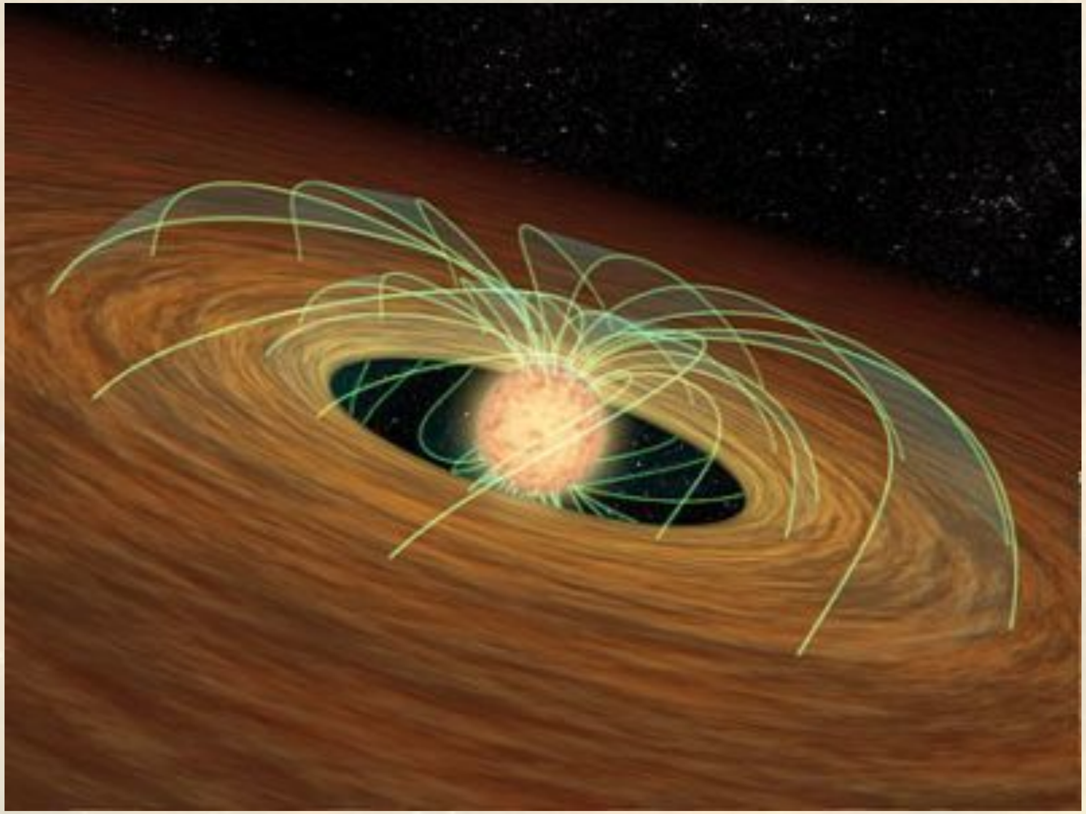
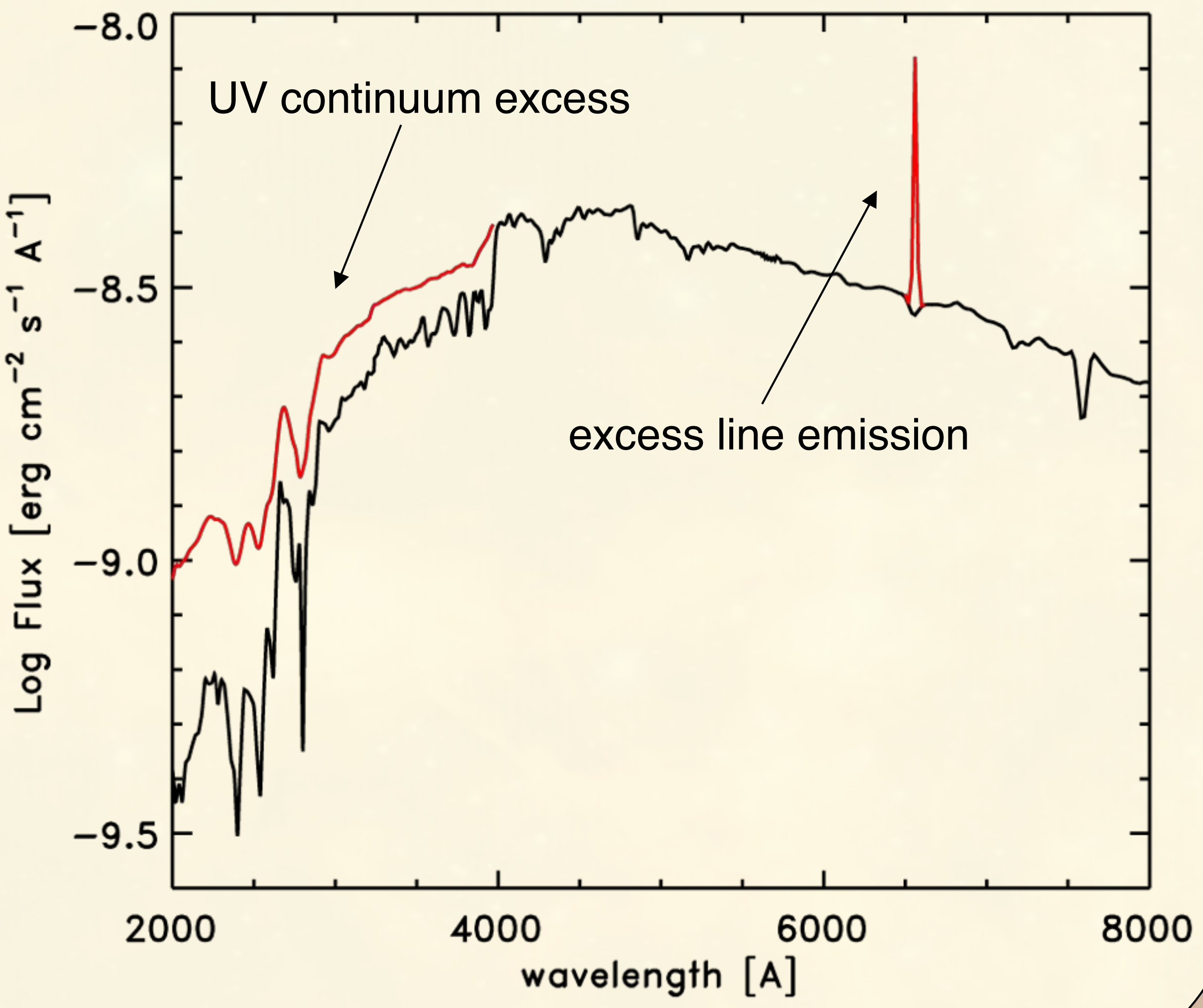
Pre Main Sequence: stellar childhood



Accretion from circumstellar disc



Accretion from circumstellar disc



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 a few hundred objects currently have measured L_{acc} and mass accretion rate

- All regions studied so far are nearby, have low mass, few stars, loose environment, no massive stars, all with solar metallicity

- Conditions not representative of massive starburst clusters

How about other environments?

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

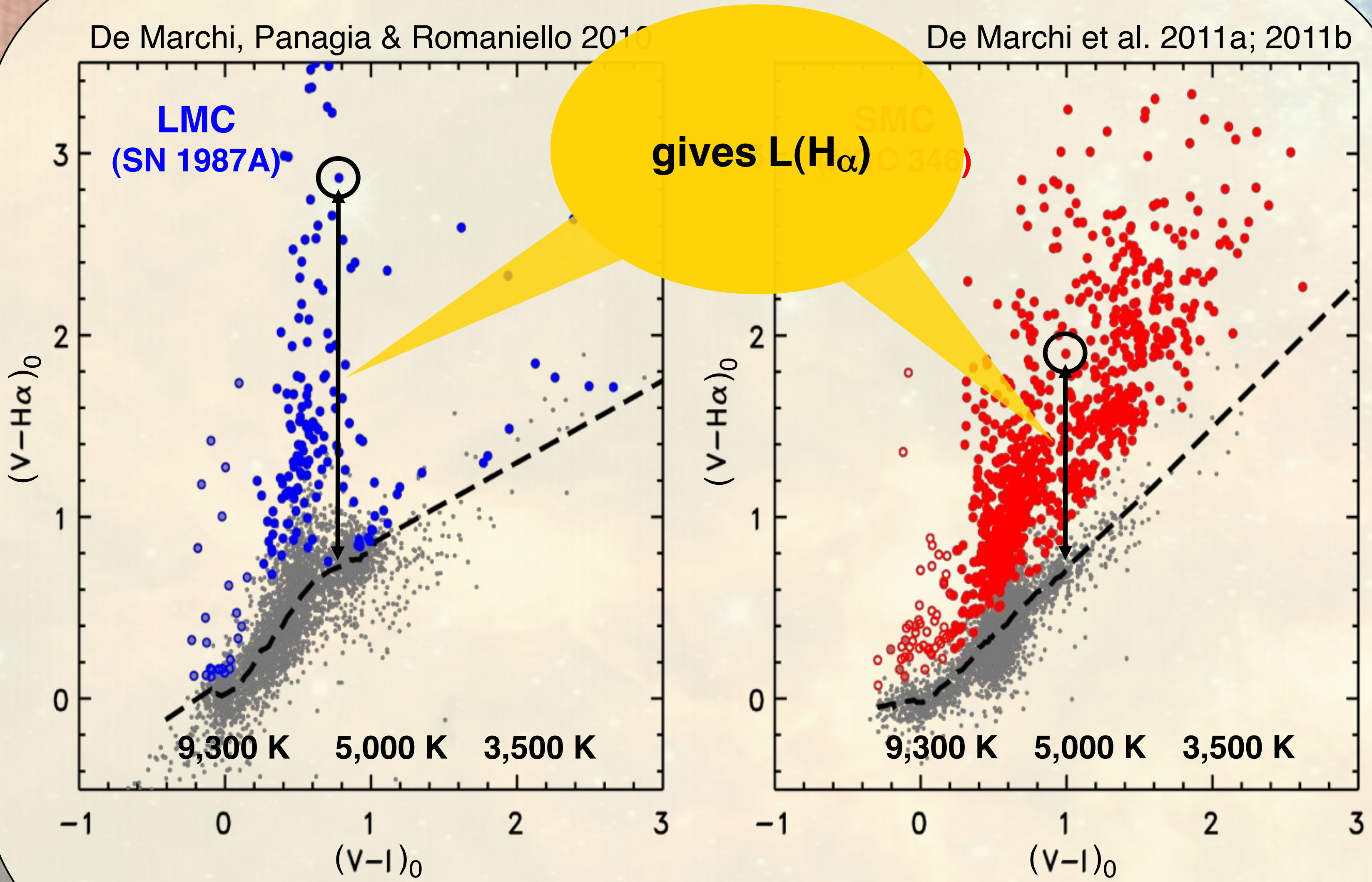
- Spectroscopy of individual stars in MCs hampered by crowding, VLT/Flames observations attempted, but limit is angular resolution

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

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

(De Marchi, Panagia & Romaniello 2010, ApJ, 715, 1
De Marchi, Panagia, Romaniello et al. 2011, ApJ, 740, 11
Spezzi, De Marchi, Panagia et al. 2011, MNRAS, submitted)

H_α photometry



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Mon. Not. R. Astron. Soc. 415, 103–132 (2011) doi:10.1111/j.1365-2966.2011.18674.x

T Tauri candidates and accretion rates using IPHAS: method and application to IC 1396

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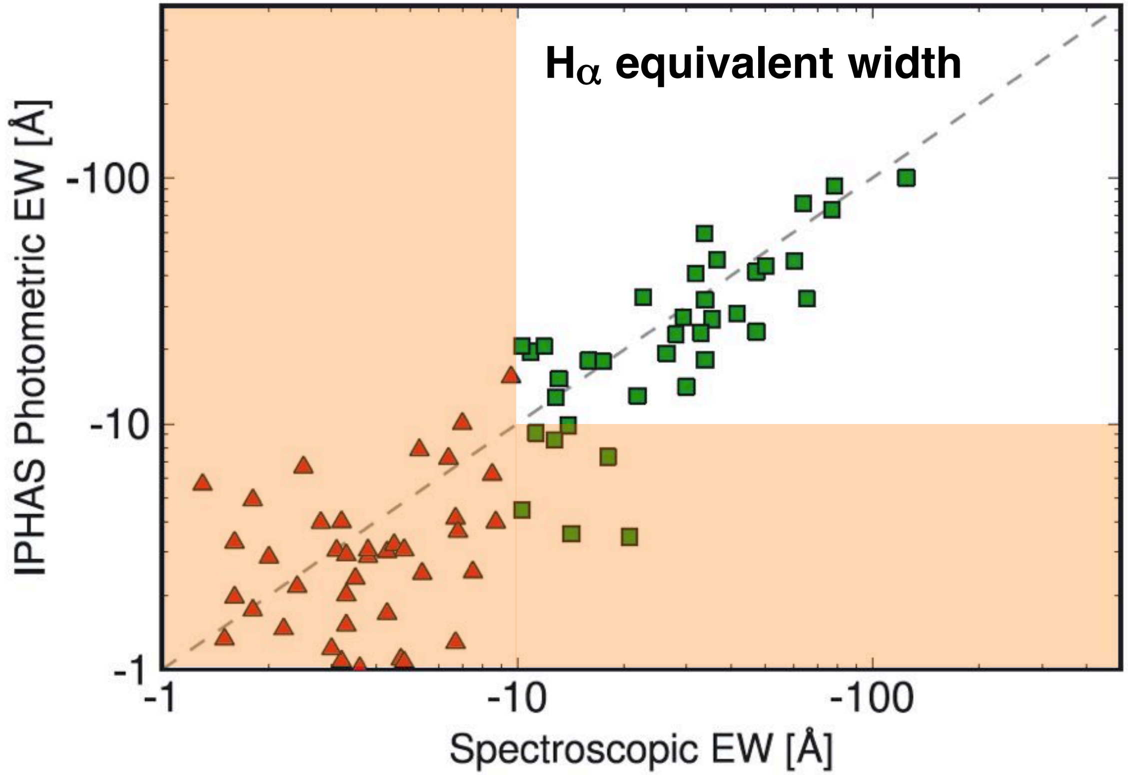
Accepted 2011 March 8. Received



Stars physical parameters

- **H_α 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 $\dot{M}$**

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

- **We can study how star formation has proceeded in space and time**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Introduction
We are a group of European scientists interested in the star f... young clusters in the Local Group,
mostly the Galaxy and Magellanic Clouds. ... of our papers. Some are published, others have
been submitted and some are still being writt... scroll down or use the navigation bar here on the left to
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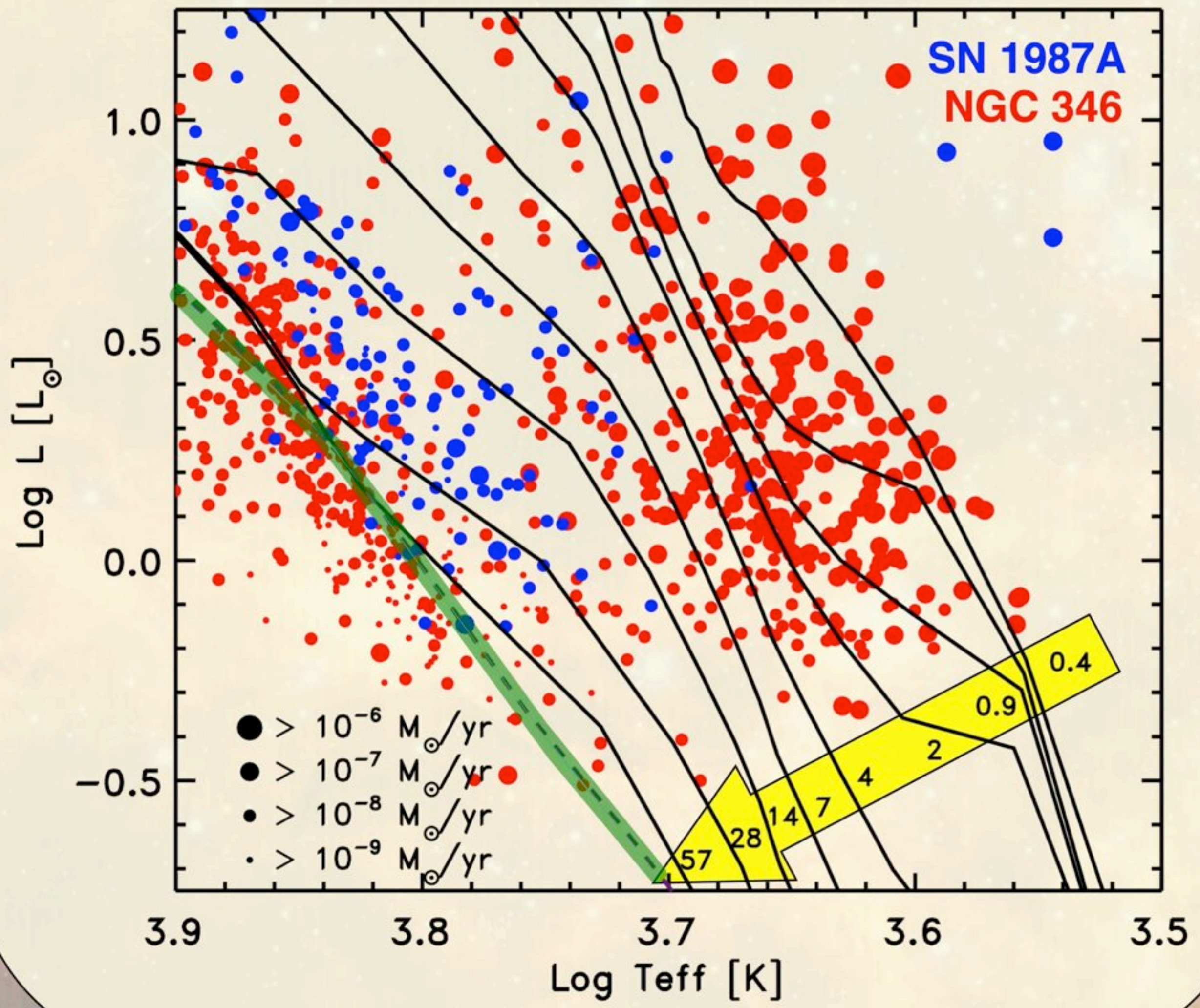
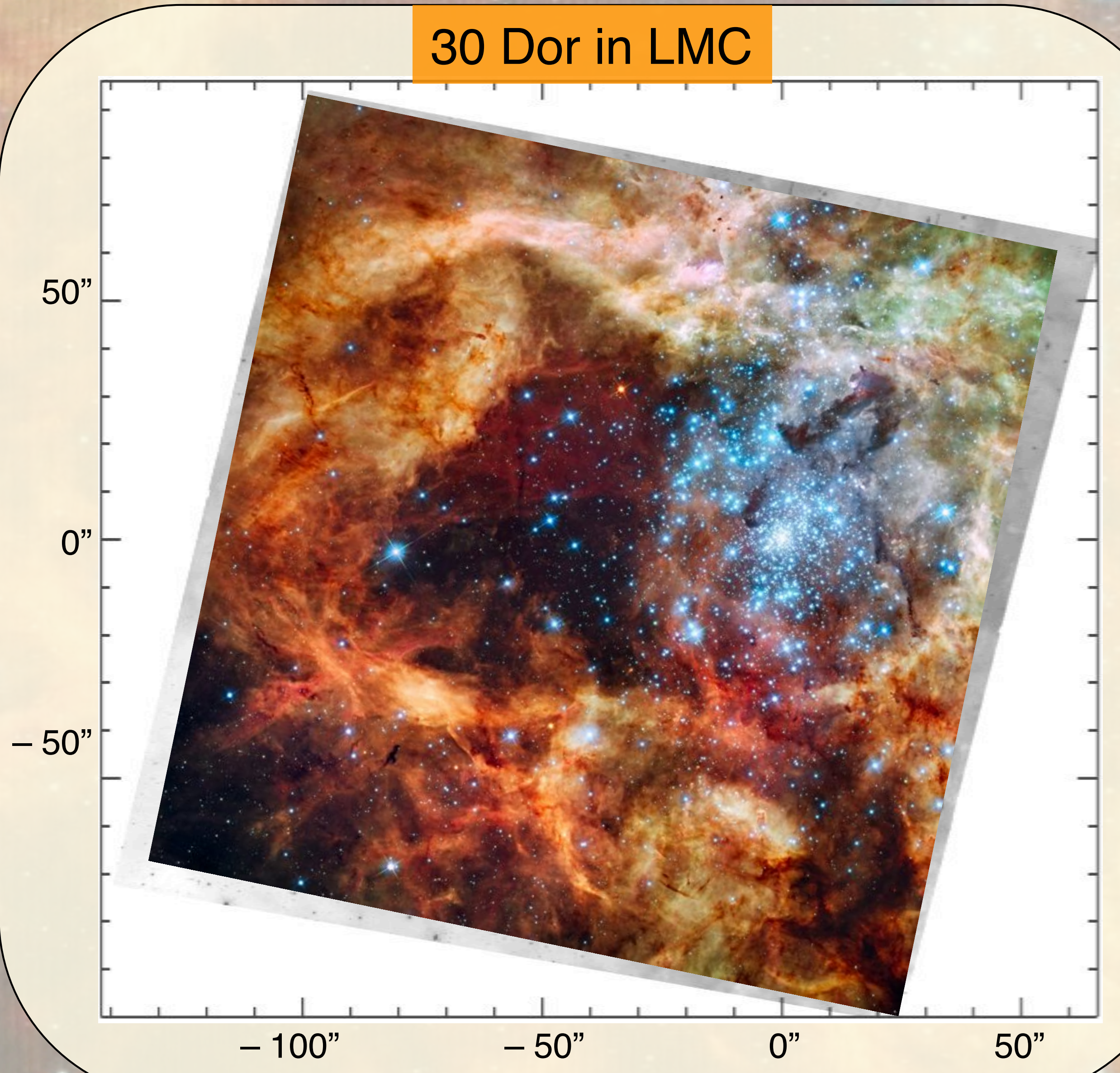
Photometric determination of the mass accretion rates of pre-main sequence stars. I. Method and application to the SN1987A field
Guido De Marchi (ESA), Nino Panagia (STScI, INAF-CT, Supernova Ltd), Martino Romaniello (ESO)
www.starformation.eu

Accretion rates in the H-R diagram

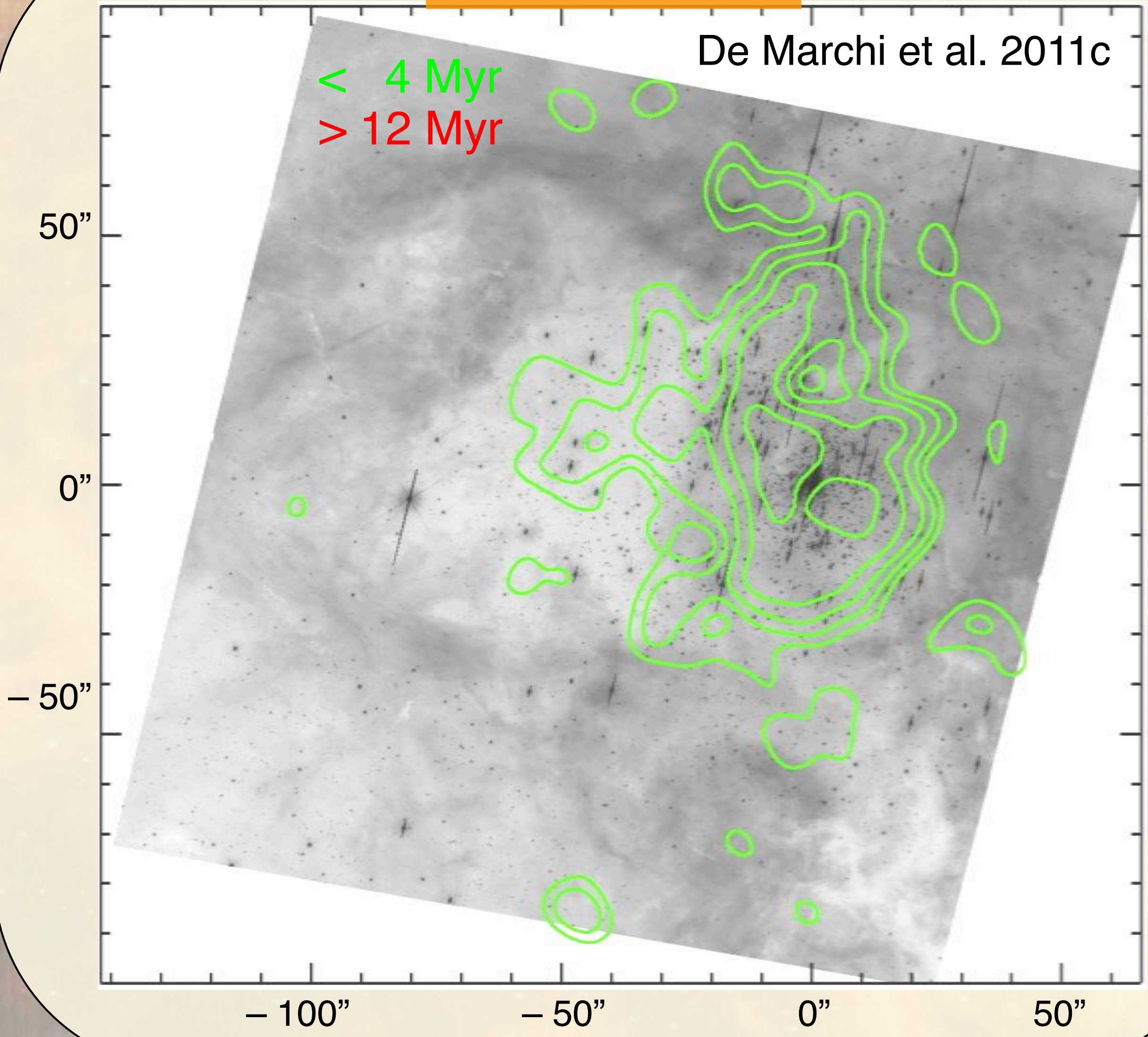


Multiple but unrelated generations



Multiple but unrelated generations

30 Dor in LMC



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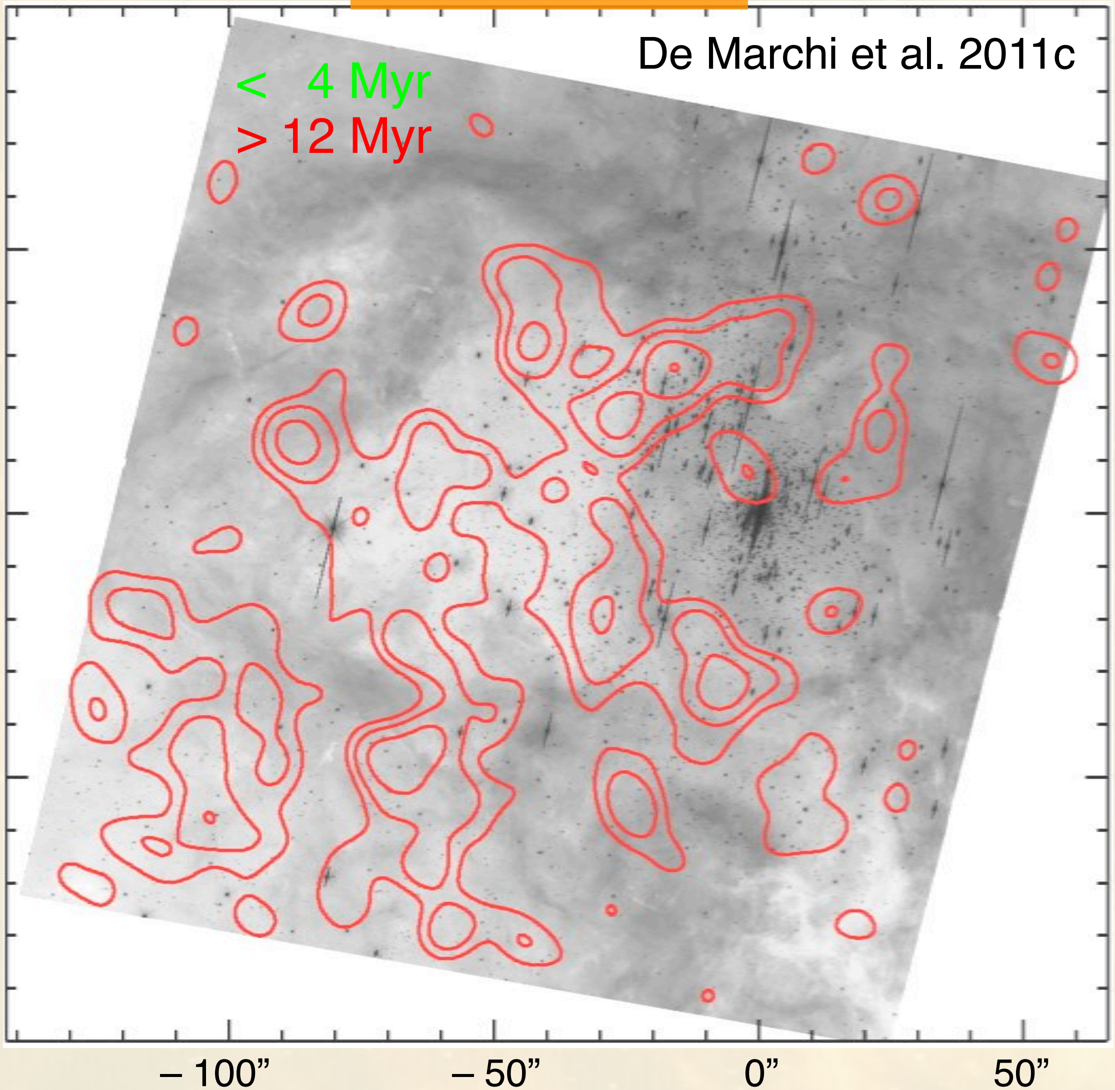

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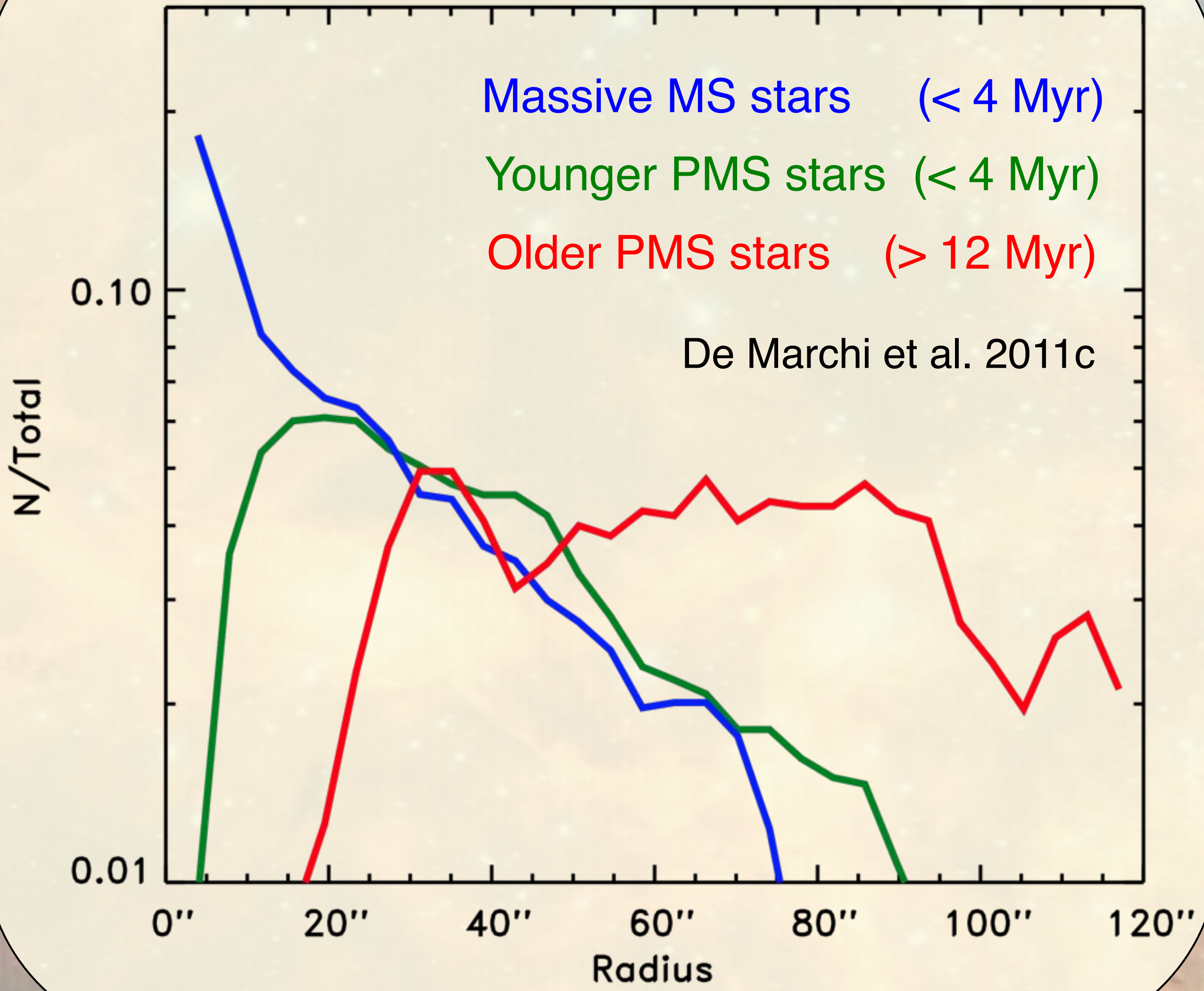

Multiple but unrelated generations

NGC 3603 in MW

Multiple but unrelated generations

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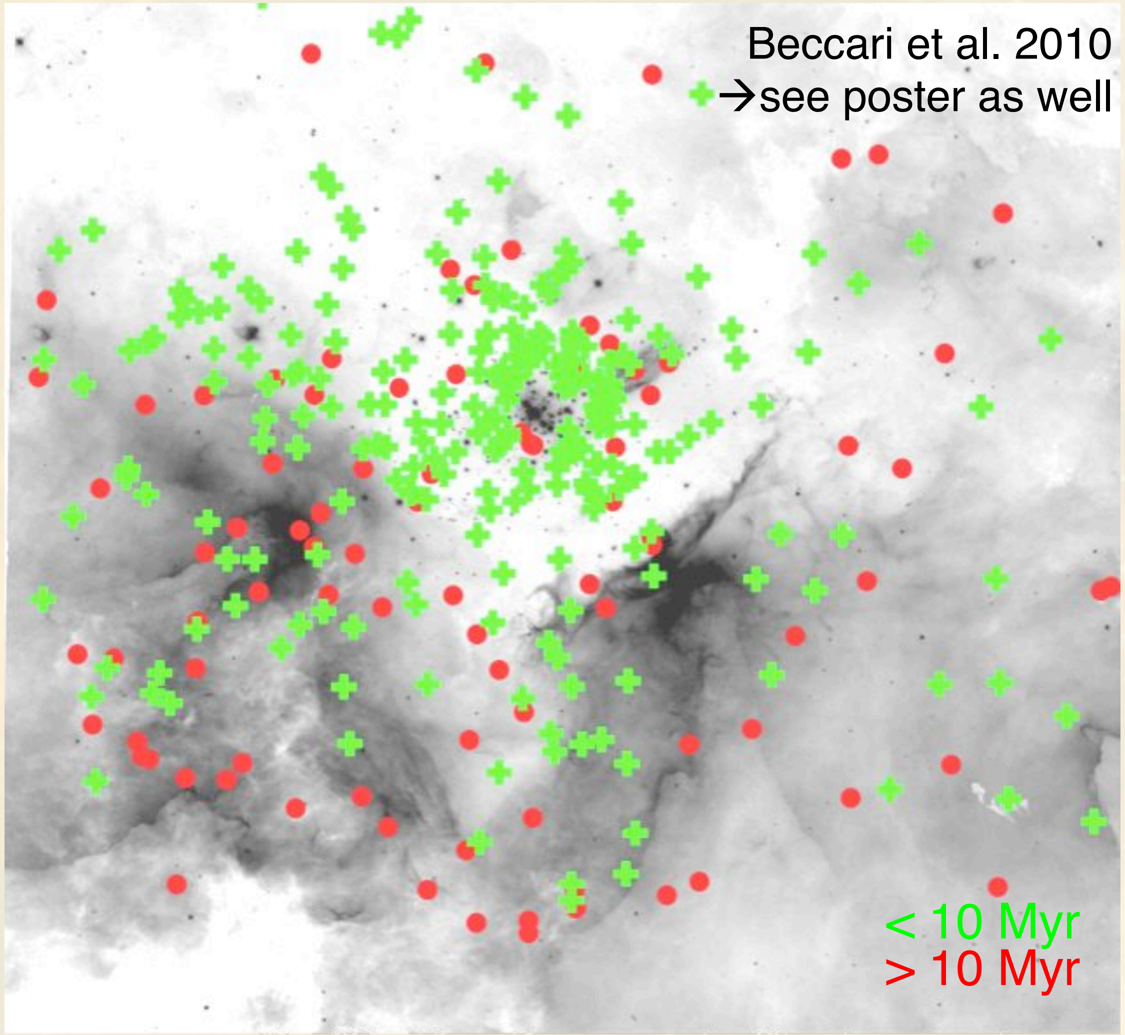
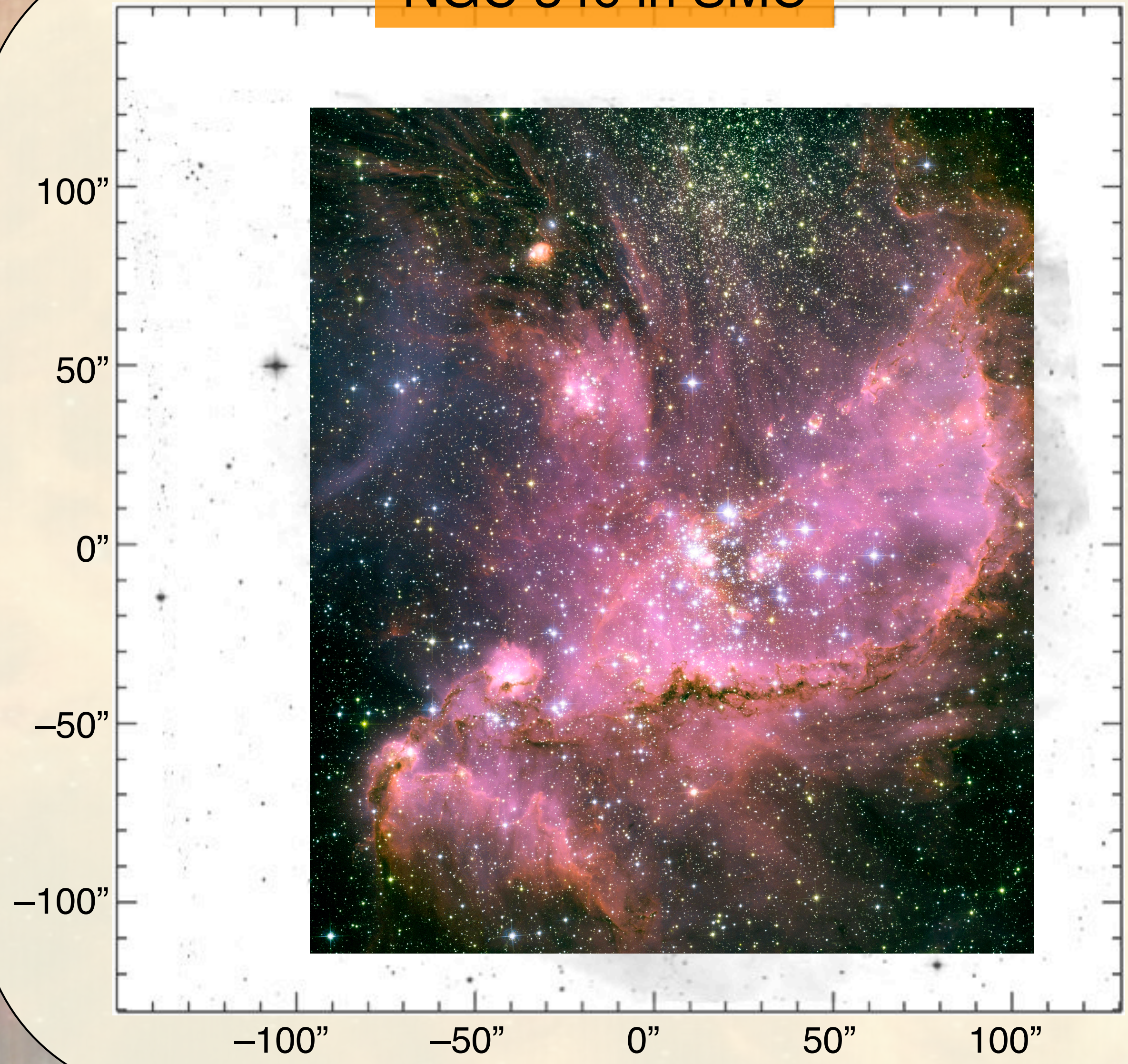


Multiple but unrelated generations

NGC 346 in SMC



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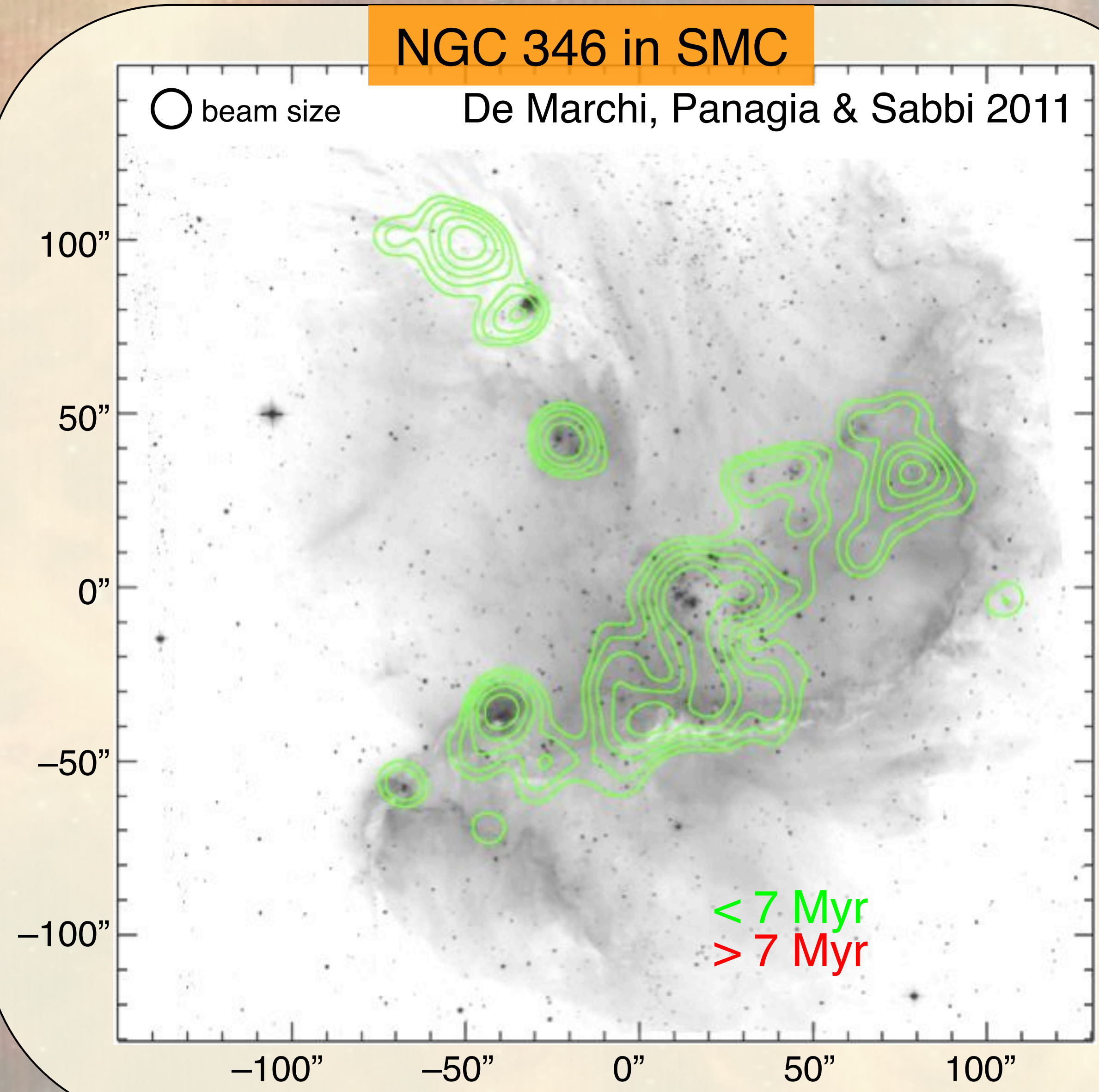

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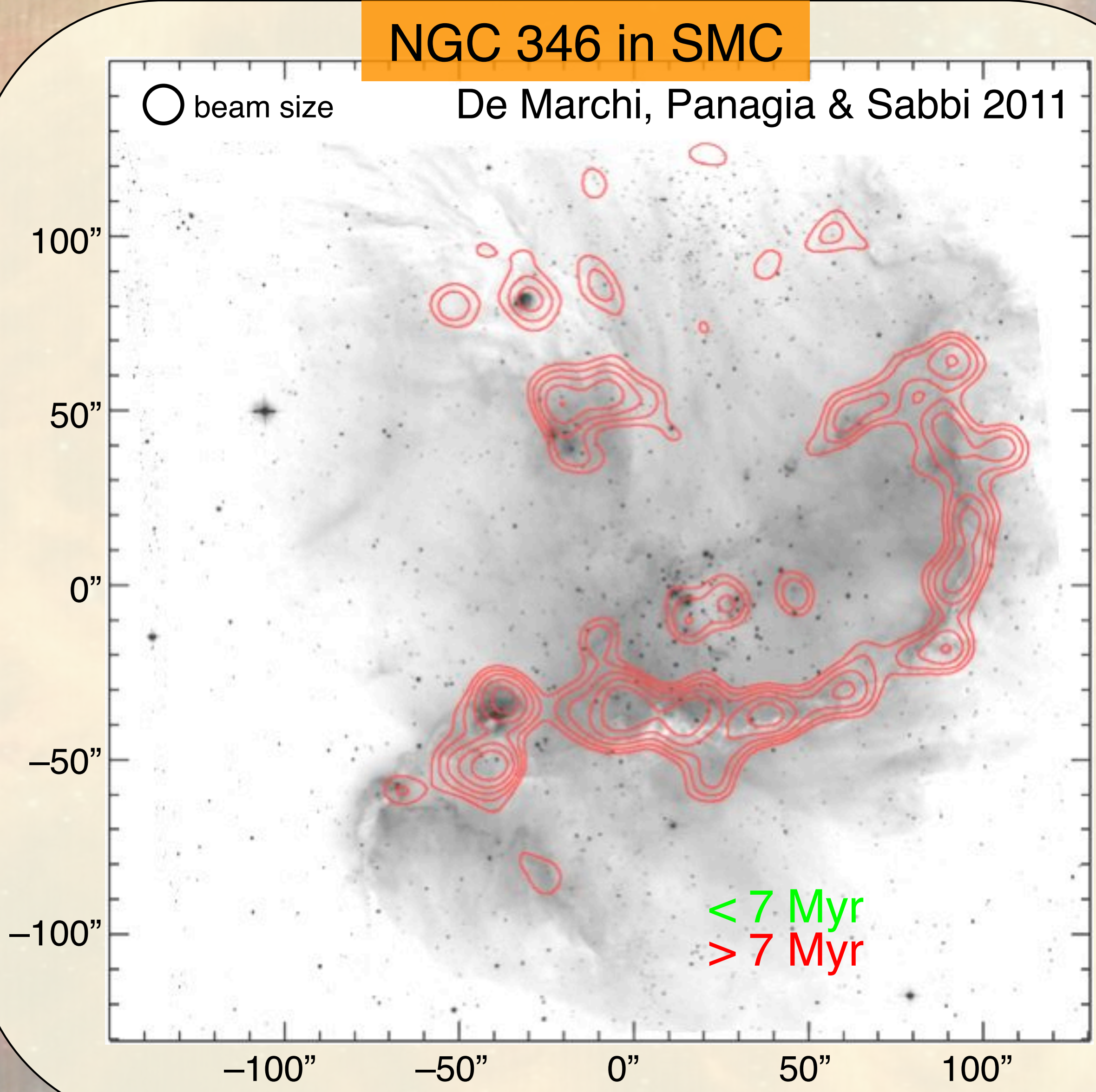
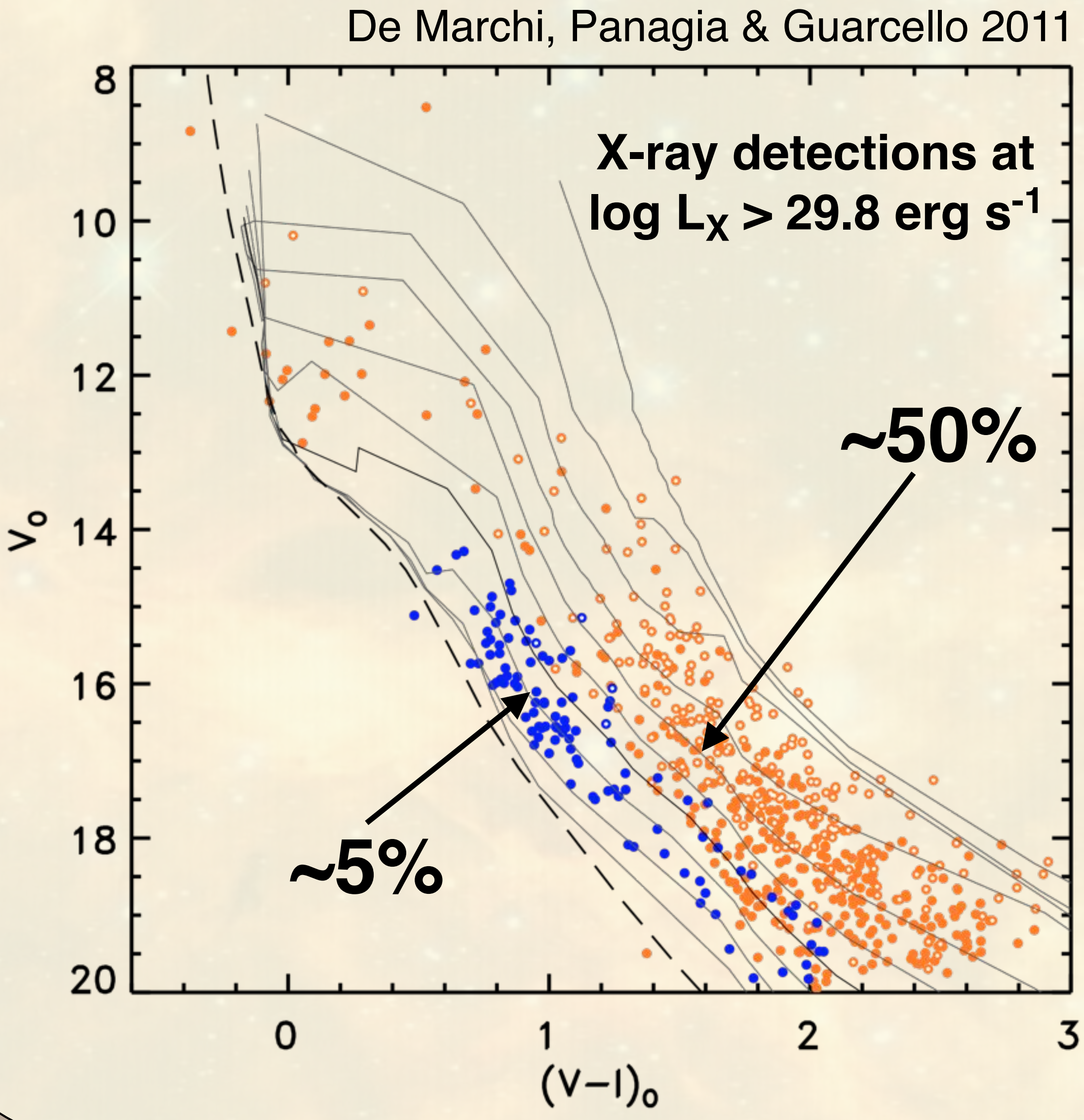
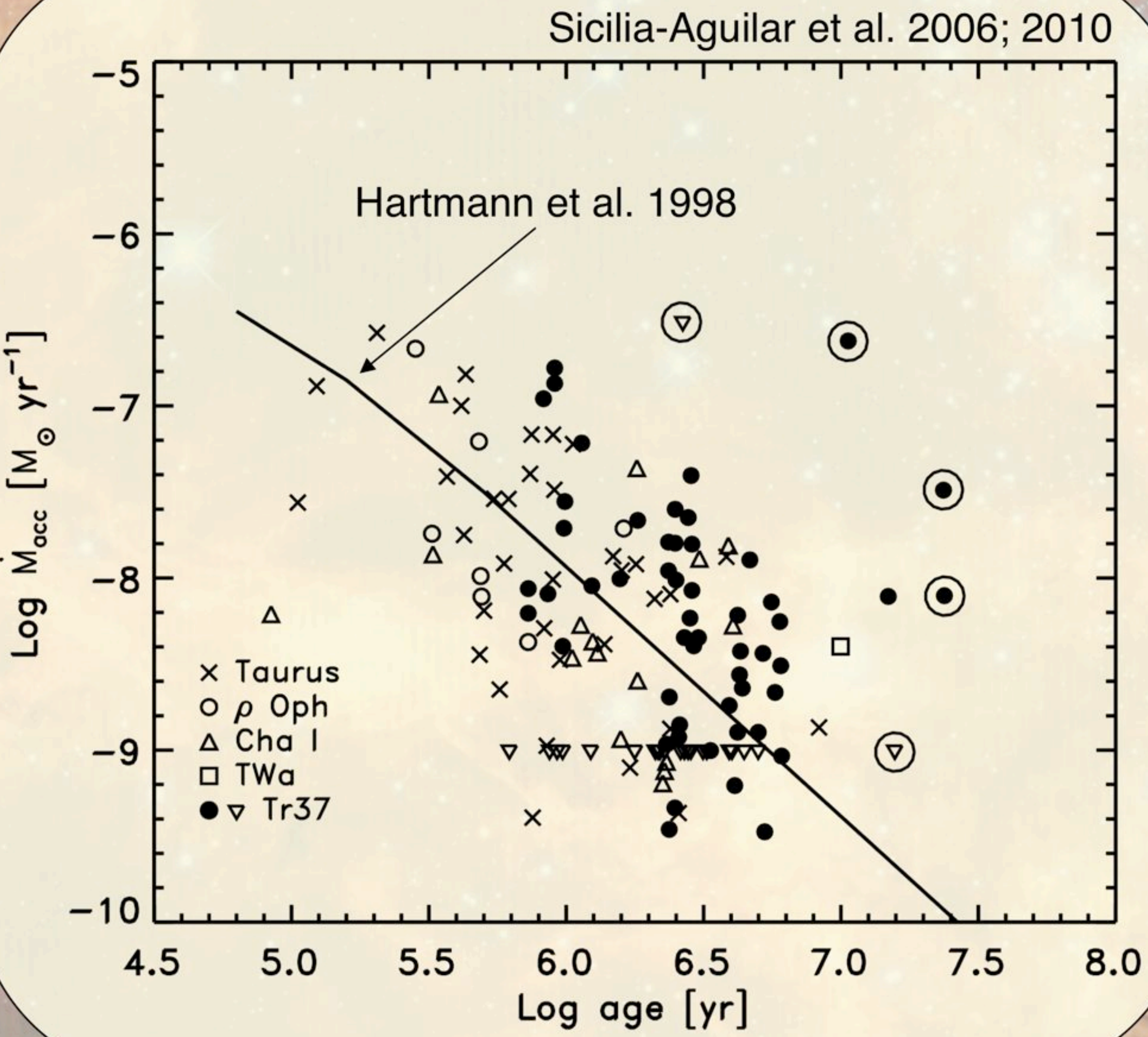


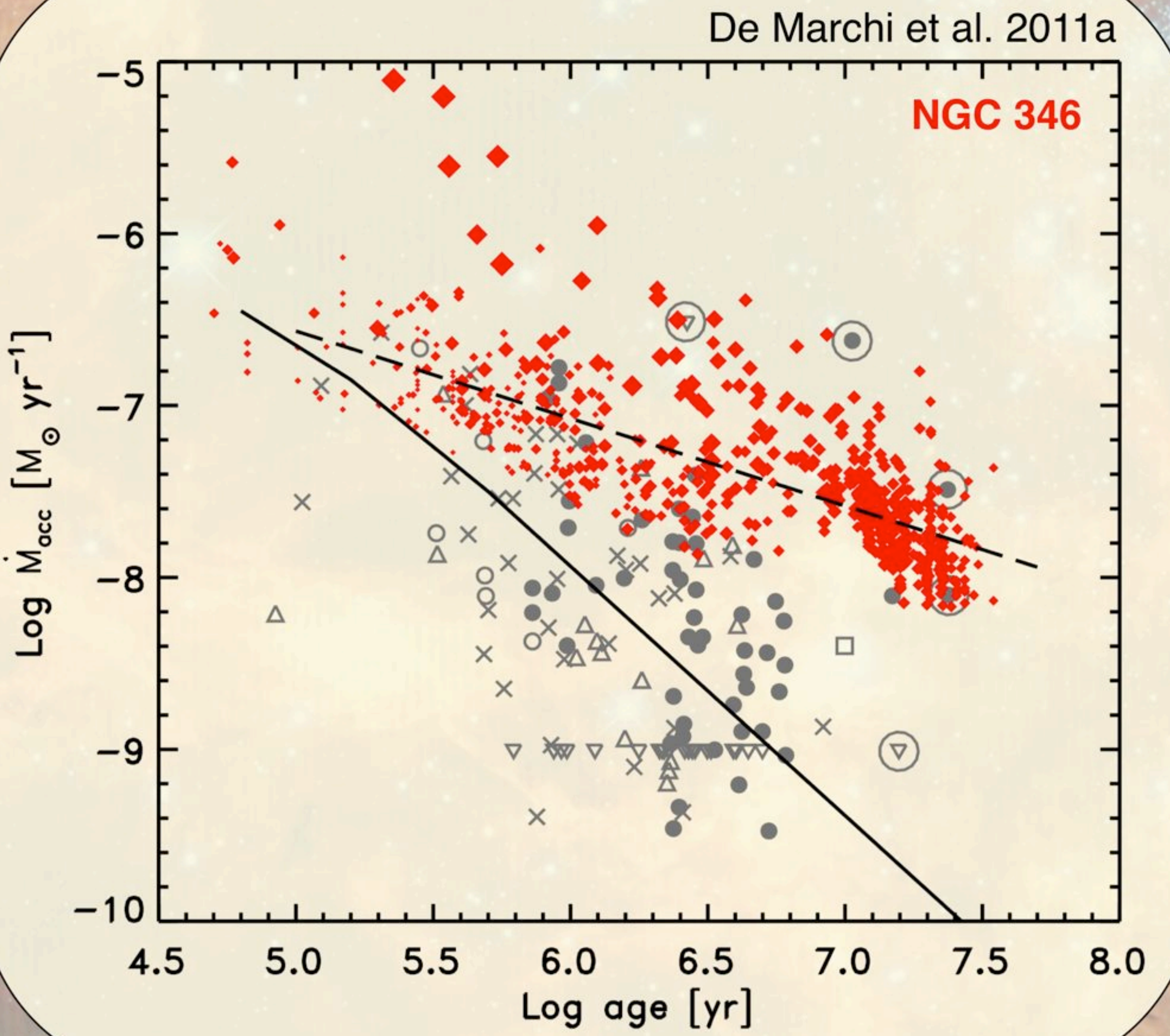
Older stars with NIR excess in M16



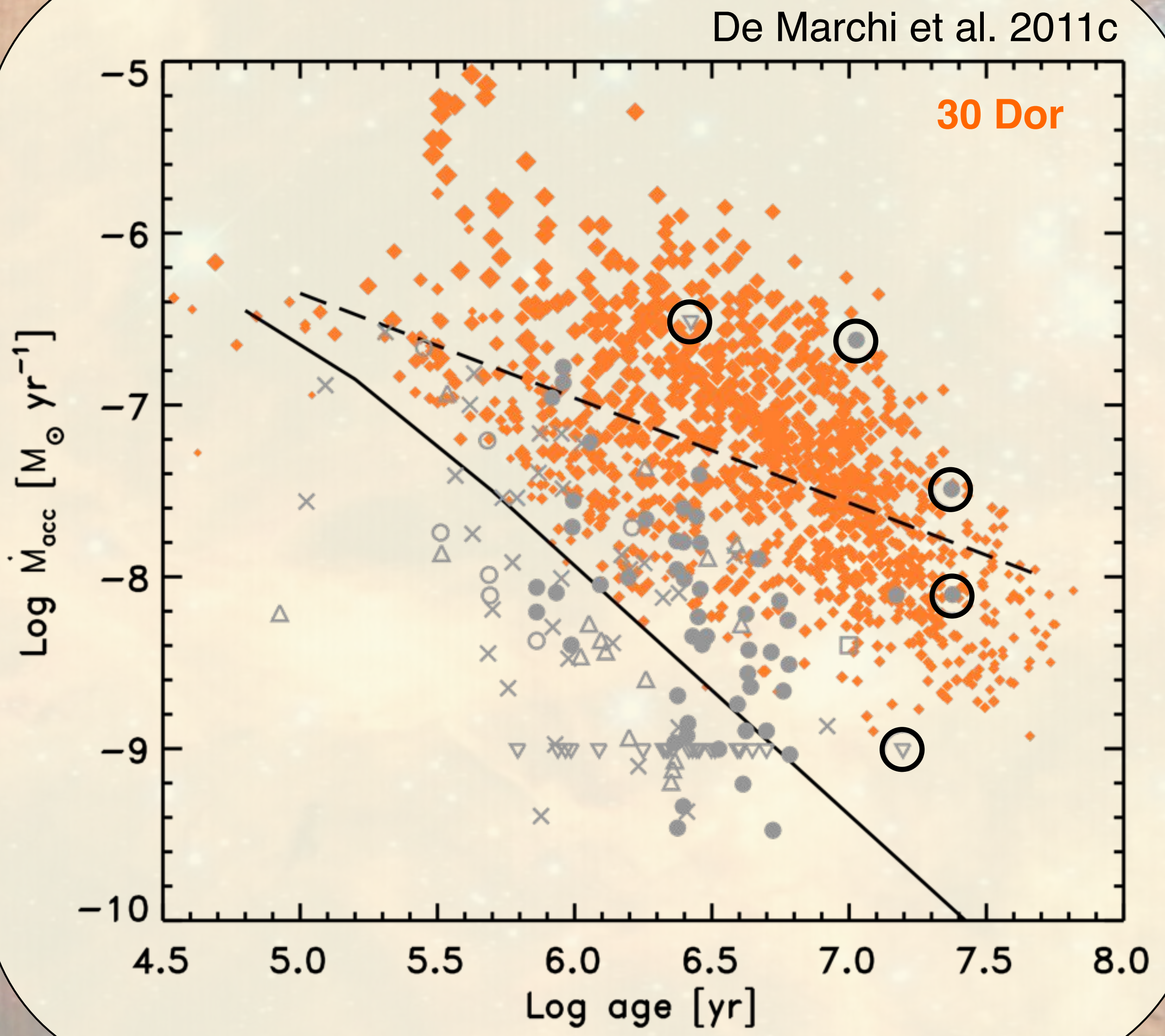
Accretion evolution with time



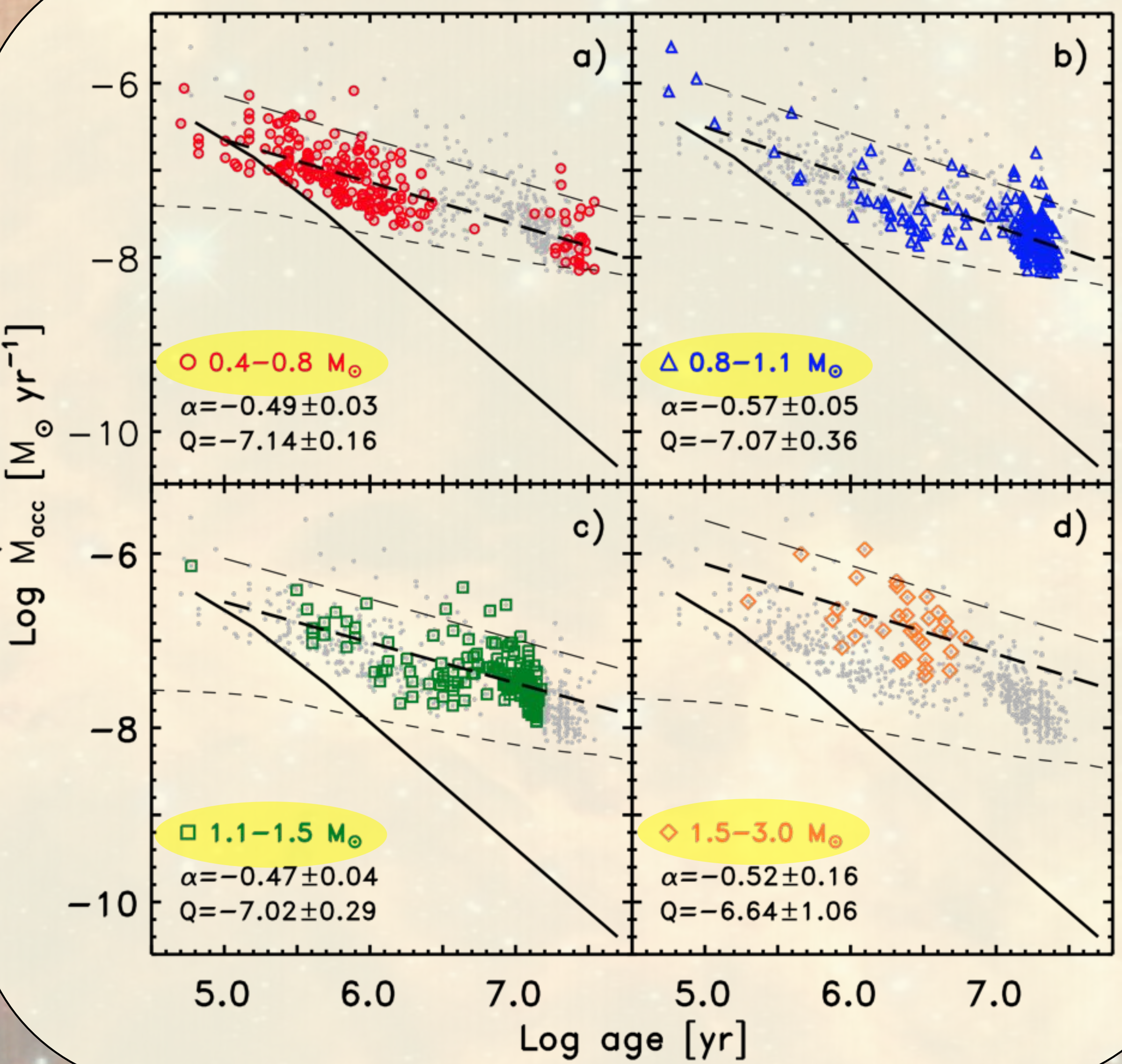
Accretion evolution with time



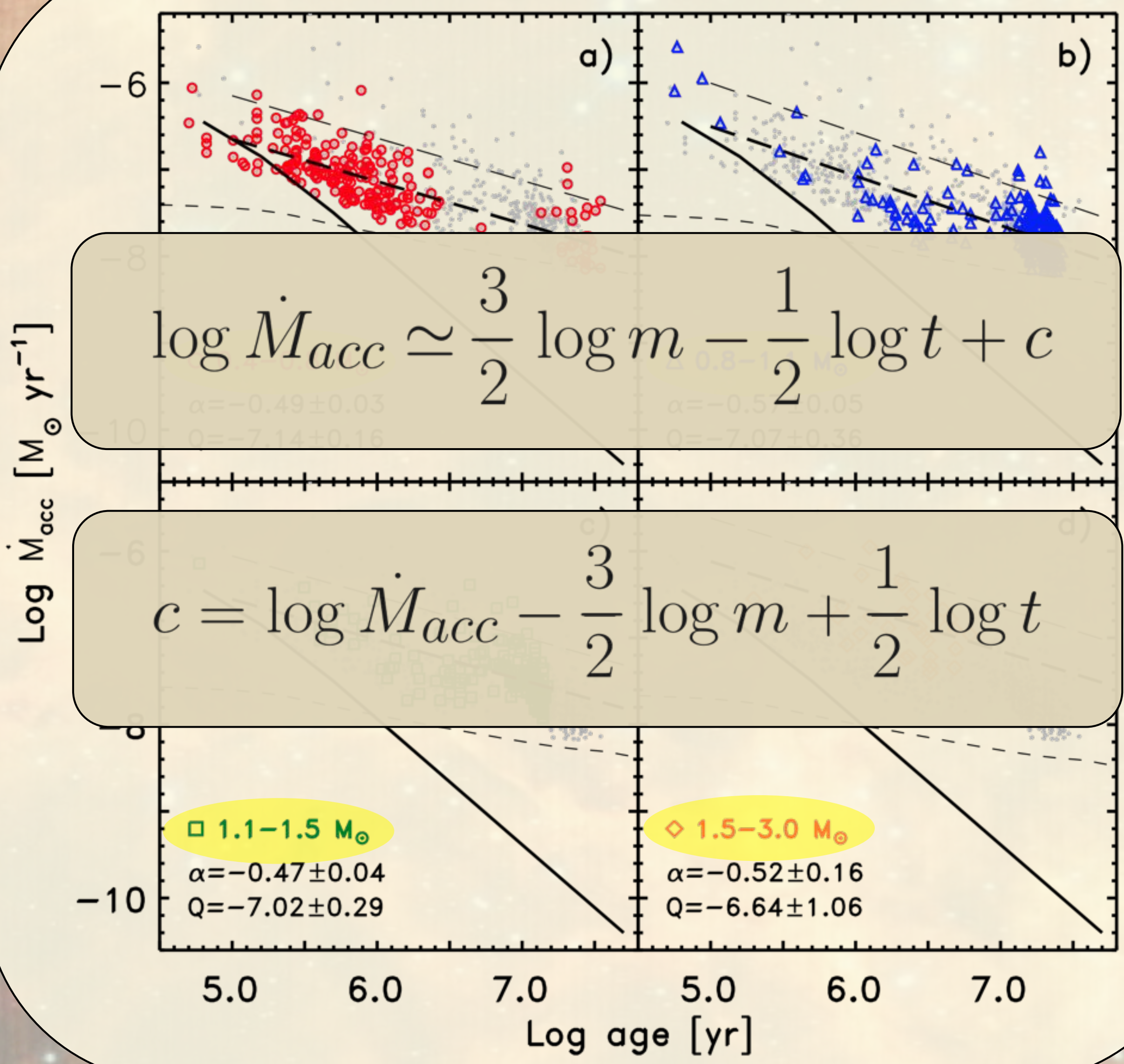
Accretion evolution with time



Accretion evolution with time & mass



Accretion evolution with time & mass



$$\log \dot{M}_{acc} \simeq \frac{3}{2} \log m - \frac{1}{2} \log t + c$$

$$c = \log \dot{M}_{acc} - \frac{3}{2} \log m + \frac{1}{2} \log t$$

Accretion rate and metallicity

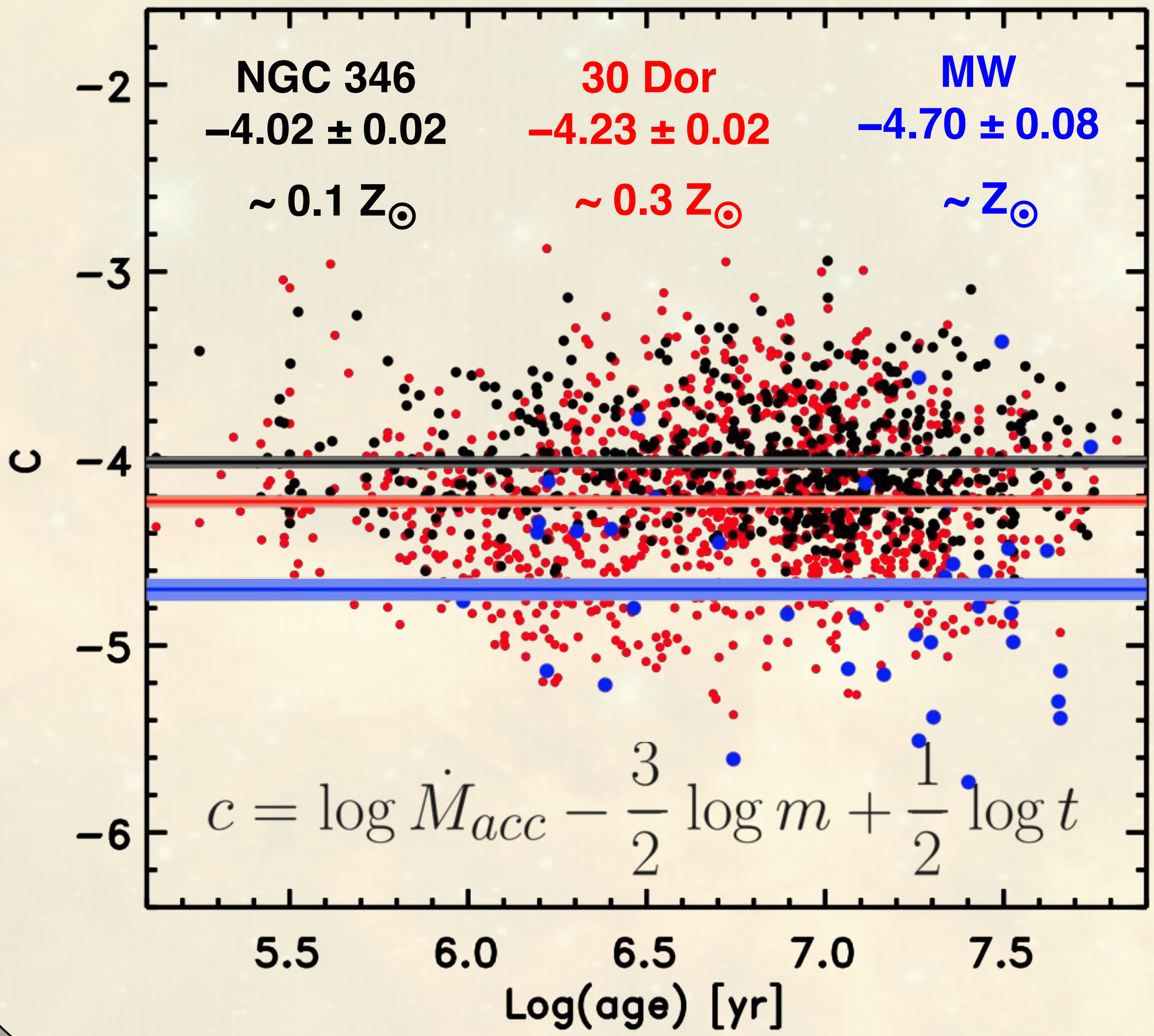


Photo-evaporation of PMS discs

De Marchi, Panagia & Romaniello 2010

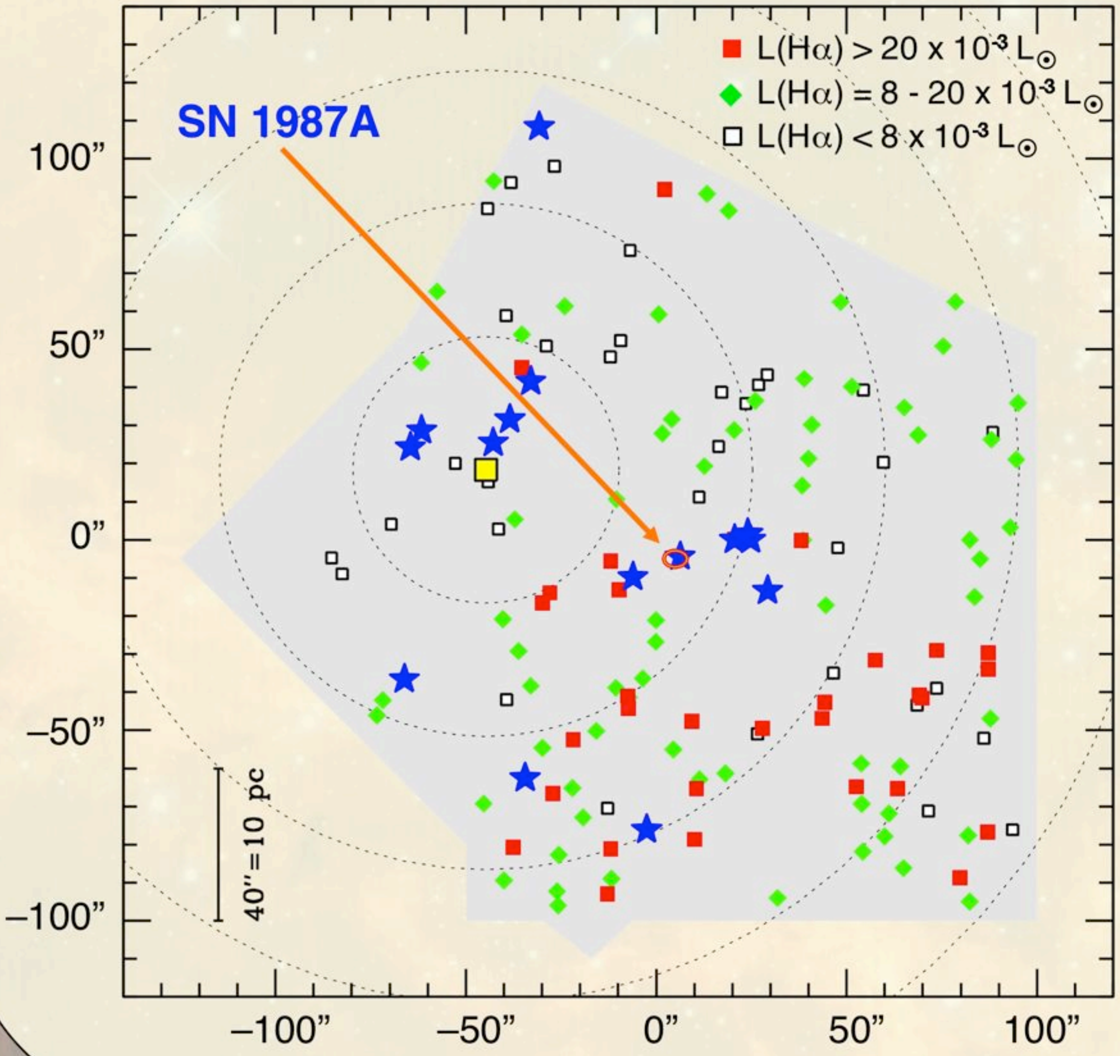
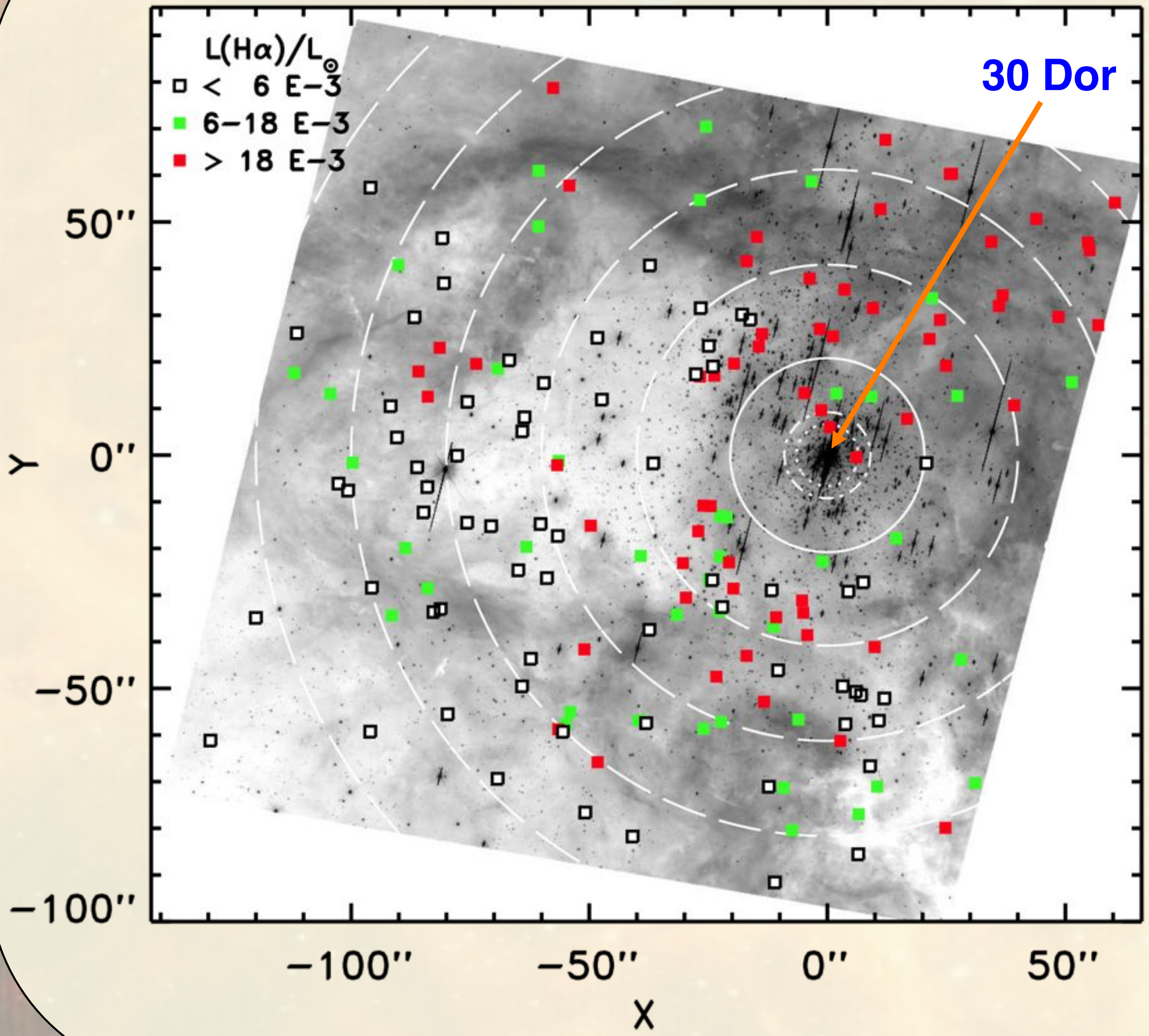


Photo-evaporation of PMS discs

De Marchi et al. 2011c



Conclusions

- Multi-generation pattern always seen, Δt ~ 10 Myr
- Star formation episodes not spatially correlated
- Younger generation usually more concentrated
- Strong mass function variations across star-forming regions
- $\log \dot{M}_{acc} \simeq \frac{3}{2} \log m - \frac{1}{2} \log t + c$
- Mass accretion rate systematically higher at lower metallicity
- Effects of photo-evaporation

➔ important constraints for theory of star formation