



Francesco's Legacy

Star Formation in Space and Time

International Conference
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Istituto degli Innocenti
Firenze Italy

Francesco's idea on the lifecycle of
extragalactic molecular clouds

Edvige Corbelli - INAF - Arcetri , Italy

Francesco's extragalactic side

- International Conferences @ Spineto
IMF@50 (2004), SFR@50 (2009), IGM@50 (2015)
- Post-Doc fellowships while Director of Arcetri Observatory
- Chapter “A Universe of Stars” in Stahler-Palla “The Formation of Stars”
- A few papers on extragalactic SF (Hans, Edvige)



IMF@50
wine testing
Montalcino



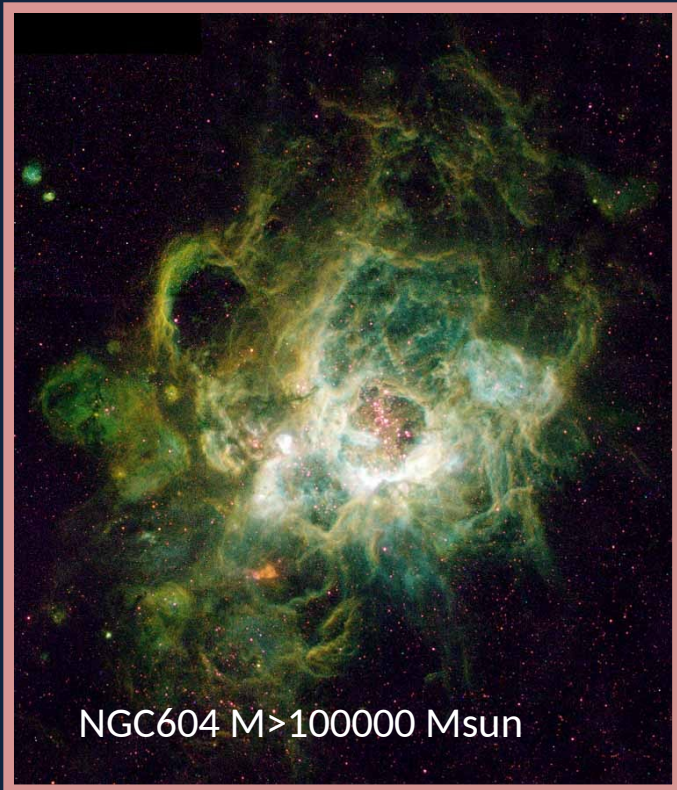
IGM@50 dining
with the SOC



SFR@50 with
Kennicutt & Schmidt

Extragalactic Star Formation

- + Different perspective, large scale features, better statistics
- Poor resolution => closest galaxies, LMC, M33, ..to study individual SF sites



Tracing the SF cycle in spirals requires:

- Molecular gas surveys, individual MCs
- Infrared and radio surveys, embedded sources
- H α , FUV surveys, Young Stellar Clusters
- Optical surveys, Open Clusters

DIFFICULT TASK : test M33!

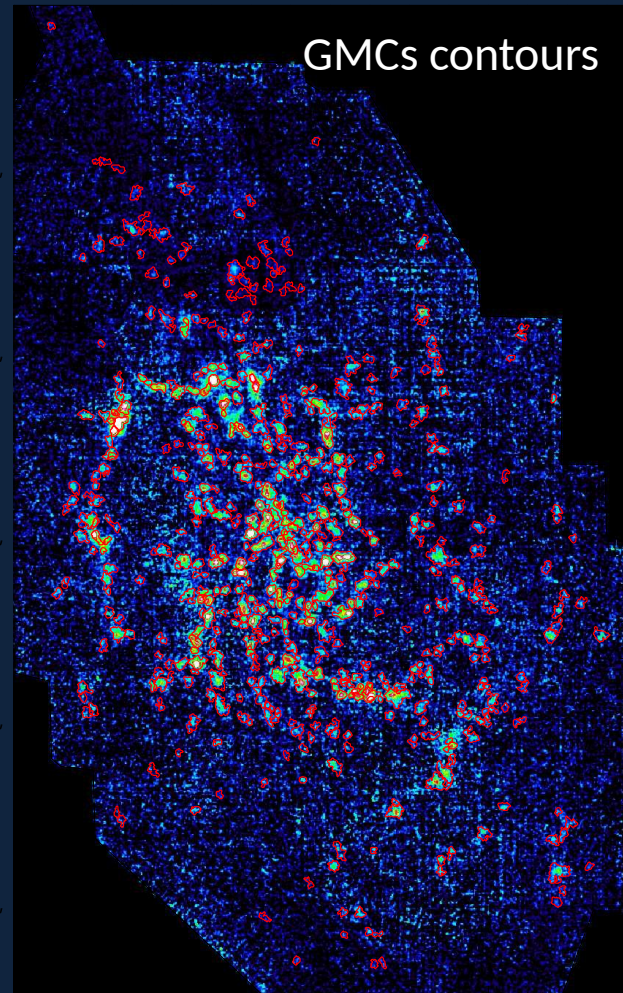
IRAM-30m CO J=2-1 all-disk map

Gratier et al. 2010-12, Druard et al. 2014

Using this database:

566 GMCs with mass $2 \times 10^6 - 2 \times 10^4 M_{\odot}$
make up $\frac{1}{2}$ of total molecular mass

Corbelli, E., Braine J.,.....Palla, F. 2017, A&A



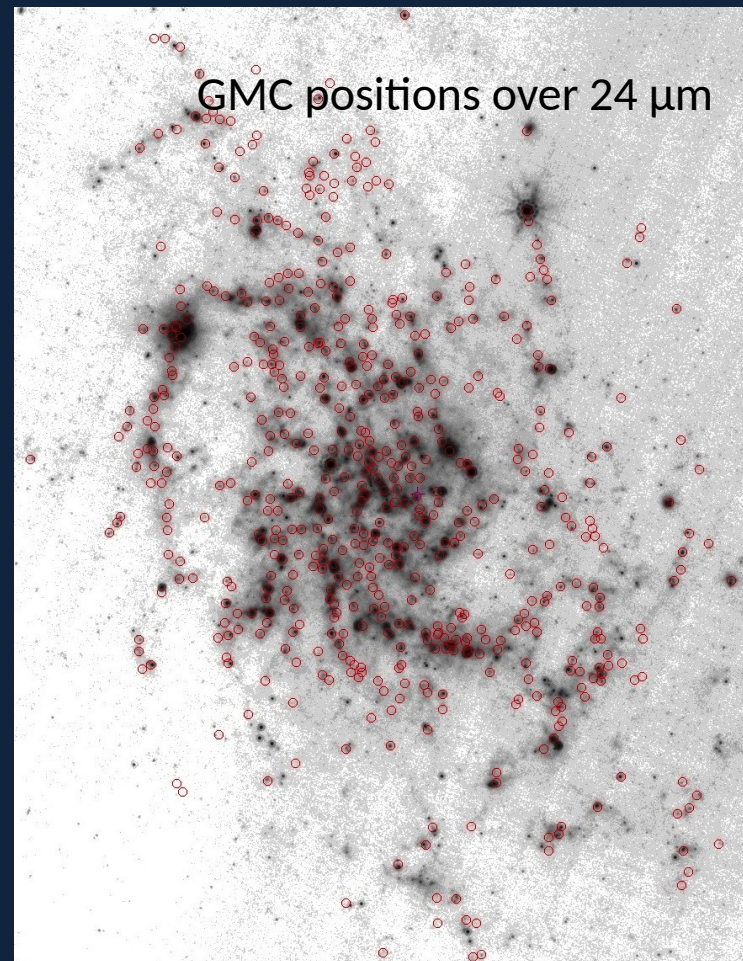
Spitzer MIR maps

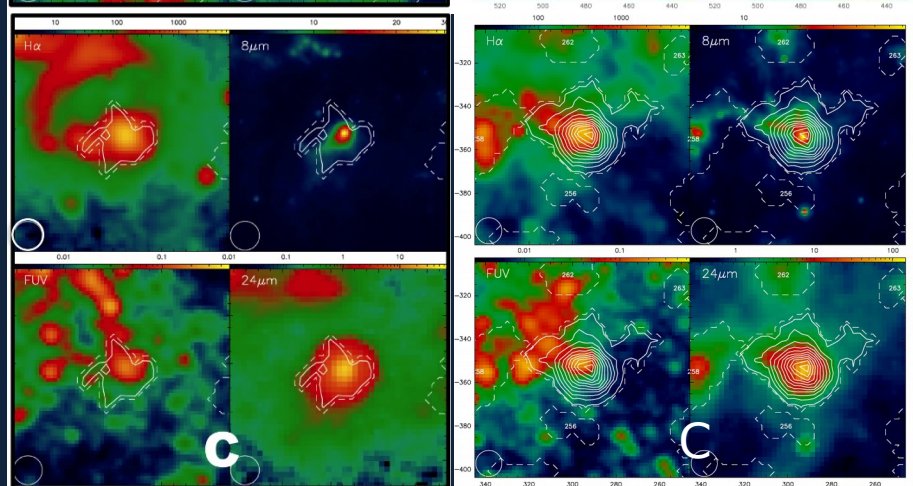
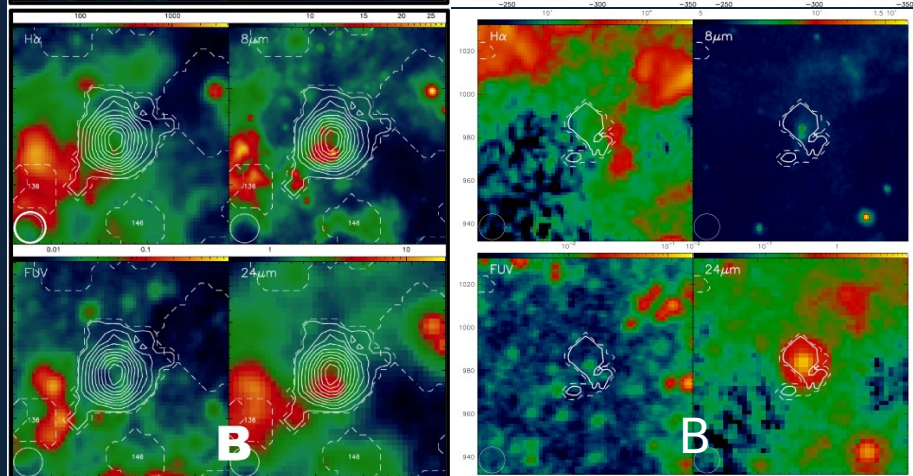
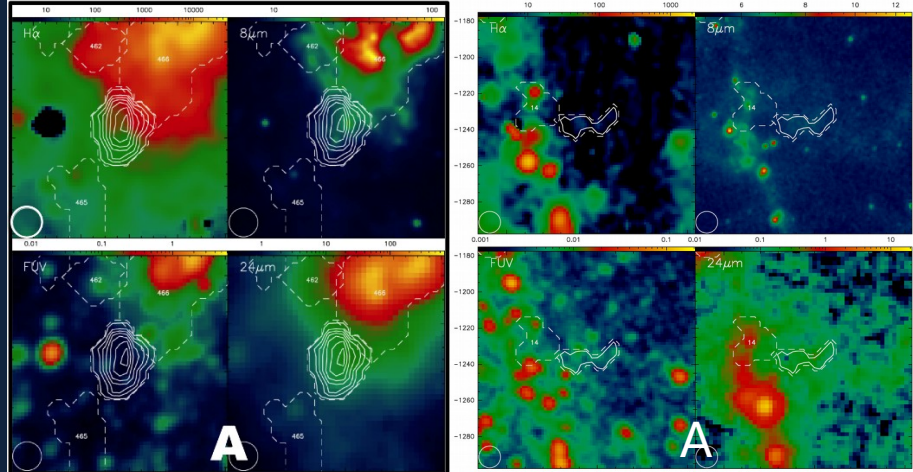
Verley et al. 2007,09

Using the 24 μm map:

915 MIR-FIR sources, 630 of which
are likely YSCCandidate at $R < 7 \text{ kpc}$
Several SED-fits => masses & ages

Sharma, S., Corbelli, E..... Palla, F. 2011, A&A



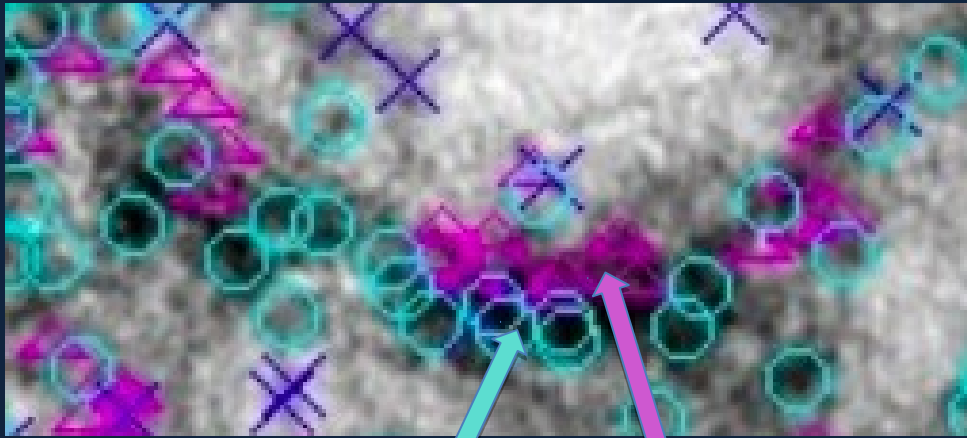


Use H α , FUV, 24-8 μ m to classify GMCs as:
 A (inactive - 32%)
 B (embedded SF - 16%)
 C (exposed SF - 52%)

Panels for H α , FUV, 8 and 24 μ m show the different GMCs types. evolutionary sequence?

Similarly but independently we use H α , FUV, CO to classify YSCCs

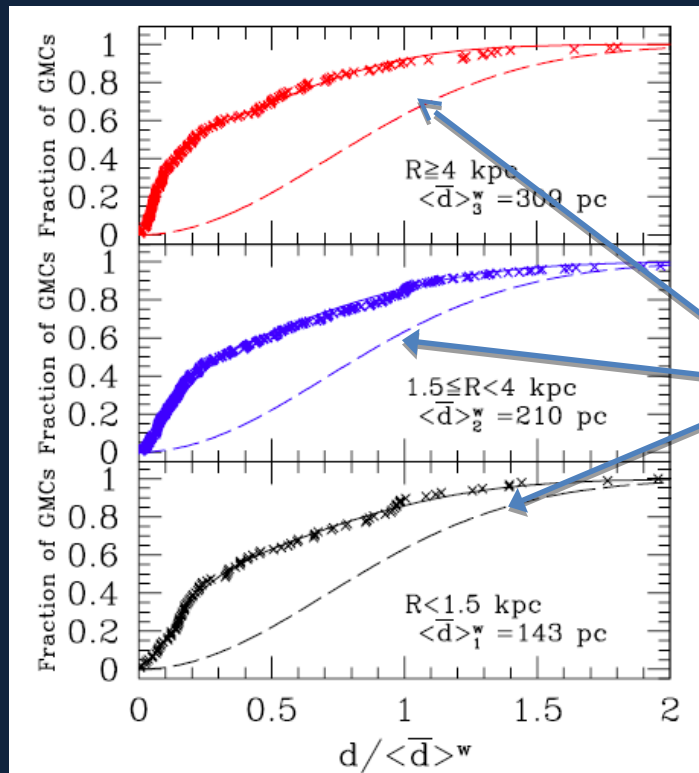
Southern Spiral Arm in HI



GMCs with exposed SF

Inactive GMCs

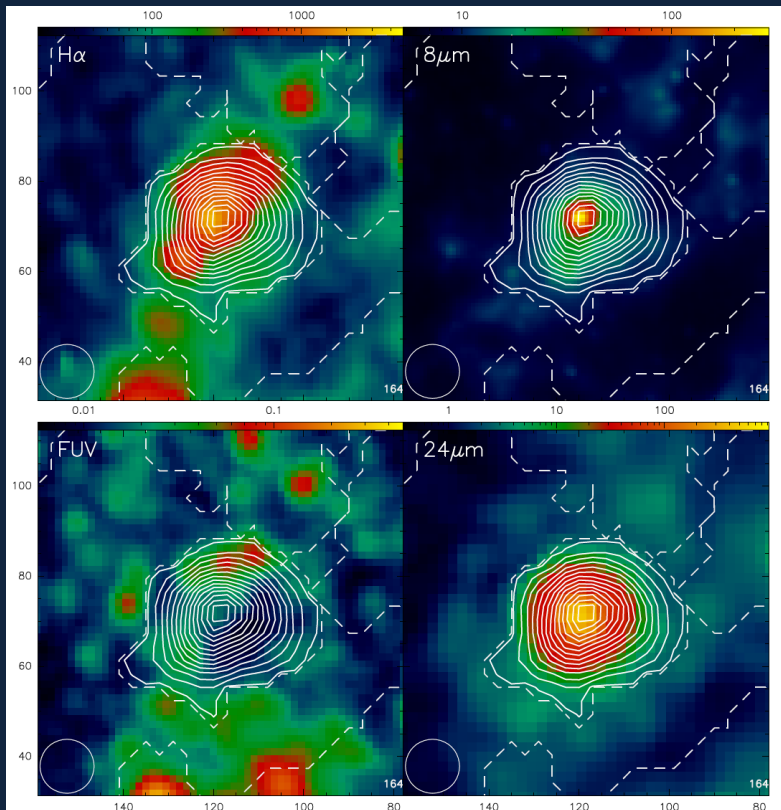
- Inactive clouds populate inner part of the southern arm
- GMCs grow in mass from A to B to C
- Strong spatial correlation between MIR-YSCCs and GMCs: typical separation 17pc (of order CO $J=2-1$ resolution)



Random distribution

Francesco's interest and its favorite cloud

#178



→ 80, 110

Palla's \uparrow clouds \Rightarrow highly peaked in CO
mol

Cloud #				
401	425	11	125	201
429	435	24	147	205
440		49	148	233
461		68	149	257*
466		67	150	260
467		73	155	278
			160	280
			163	283
			164	
			174	
			178**!	
			183	
			184	

321
357
369/3
41

From molecules to young stellar clusters: the star formation cycle across the disk of M33

Edvige Corbelli¹, Jonathan Braine², Rino Bandiera¹, Nathalie Brouillet², Françoise Combes³, Clément Druard², Pierre Gratier², Jimmy Mata², Karl Schuster⁴, Manolis Xilouris⁵, and Francesco Palla¹,

- All-disk CO J=2-1 + Spitzer-MIR survey of M33
- ID of 566 GMCs and 630 MIR-YSCCs
- Classification of GMCs and of YSCCs
- Association/correlation GMCs – YSCCs
- GMC lifetime and timescale of 3 phases using estimated ages of YSCCs

Francesco's suggestion

- 1) Determine the duration of several GMC phases in M33.
- 2) Understand possible projection/resolution effects

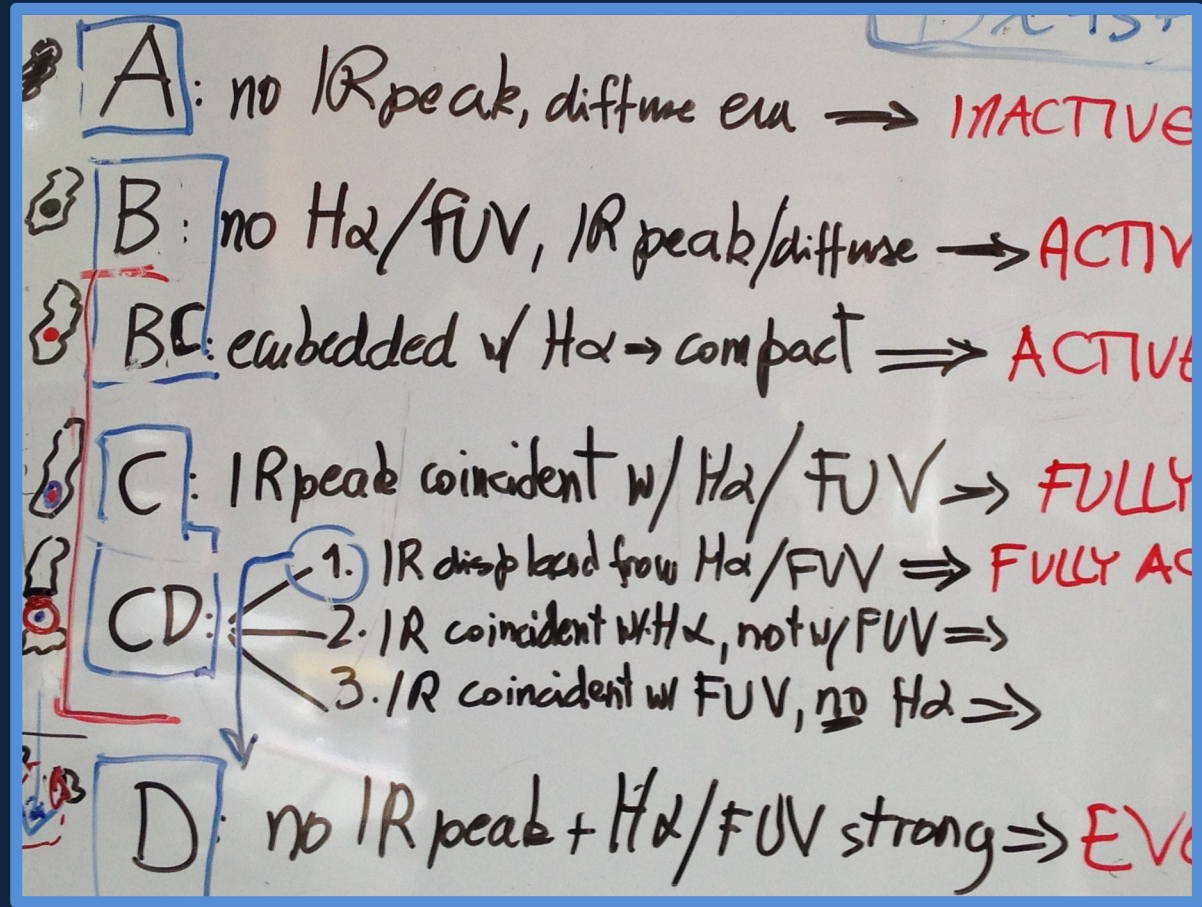
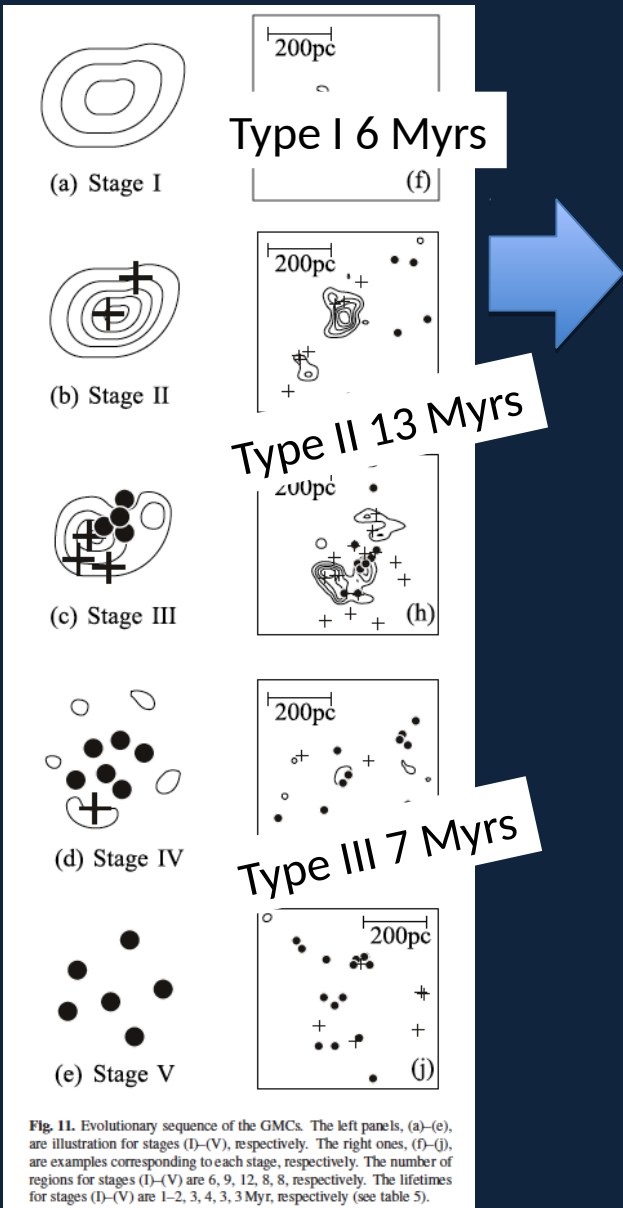
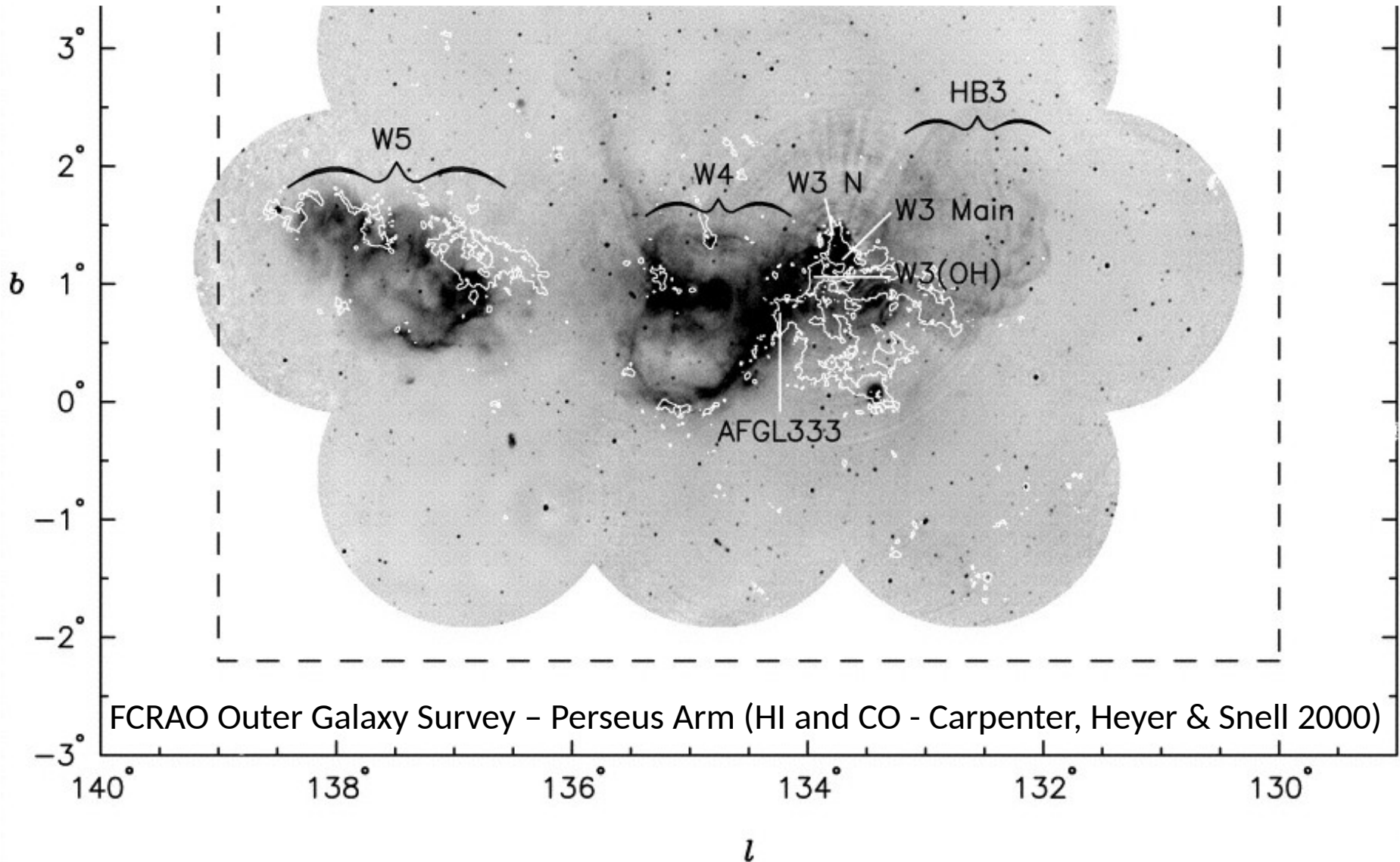


Fig. 11. Evolutionary sequence of the GMCs. The left panels, (a)–(e), are illustration for stages (I)–(V), respectively. The right ones, (f)–(j), are examples corresponding to each stage, respectively. The number of regions for stages (I)–(V) are 6, 9, 12, 8, 8, respectively. The lifetimes for stages (I)–(V) are 1–2, 3, 4, 3, 3 Myr, respectively (see table 5).

M33: CO, H α , MIR, FUV, no optical YSCs

Francesco's favorite galactic equivalent for cloud complexes in M33 (gas dispersal + triggered SF)



Molecular cloud timeline in M33

- Using YSCC age determination we infer GMC total lifetime prior to dispersal : 14 Myrs (Type I+ II LMC =19 Myrs)
- A=Inactive phase 4 Myrs
- B=Fully embedded phase 2 Myrs .

A+B=Type I LMC (6 Myrs)

--- Duration of various phases of Type III clouds is still undetermined. We need more accurate photometry and age determination or higher resolution CO observations

