Superstar Clusters and Supergalactic winds

The case of M82

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(The formation and evolution of massive star clusters, November 03)

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Verónica Melo (IAC)
Sergey Silich (INAOE- Mexico)
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Radiative phase before "break-out".

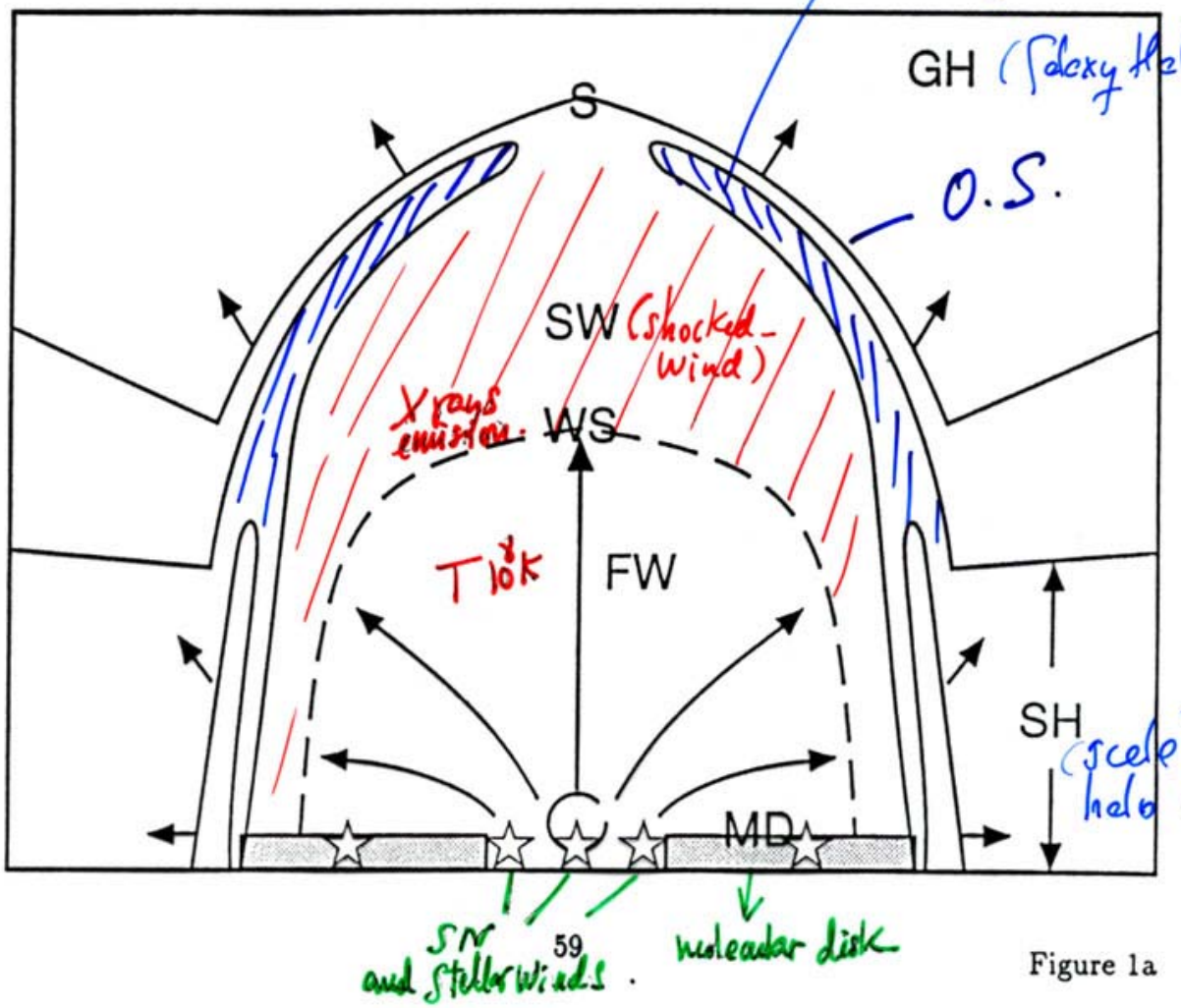
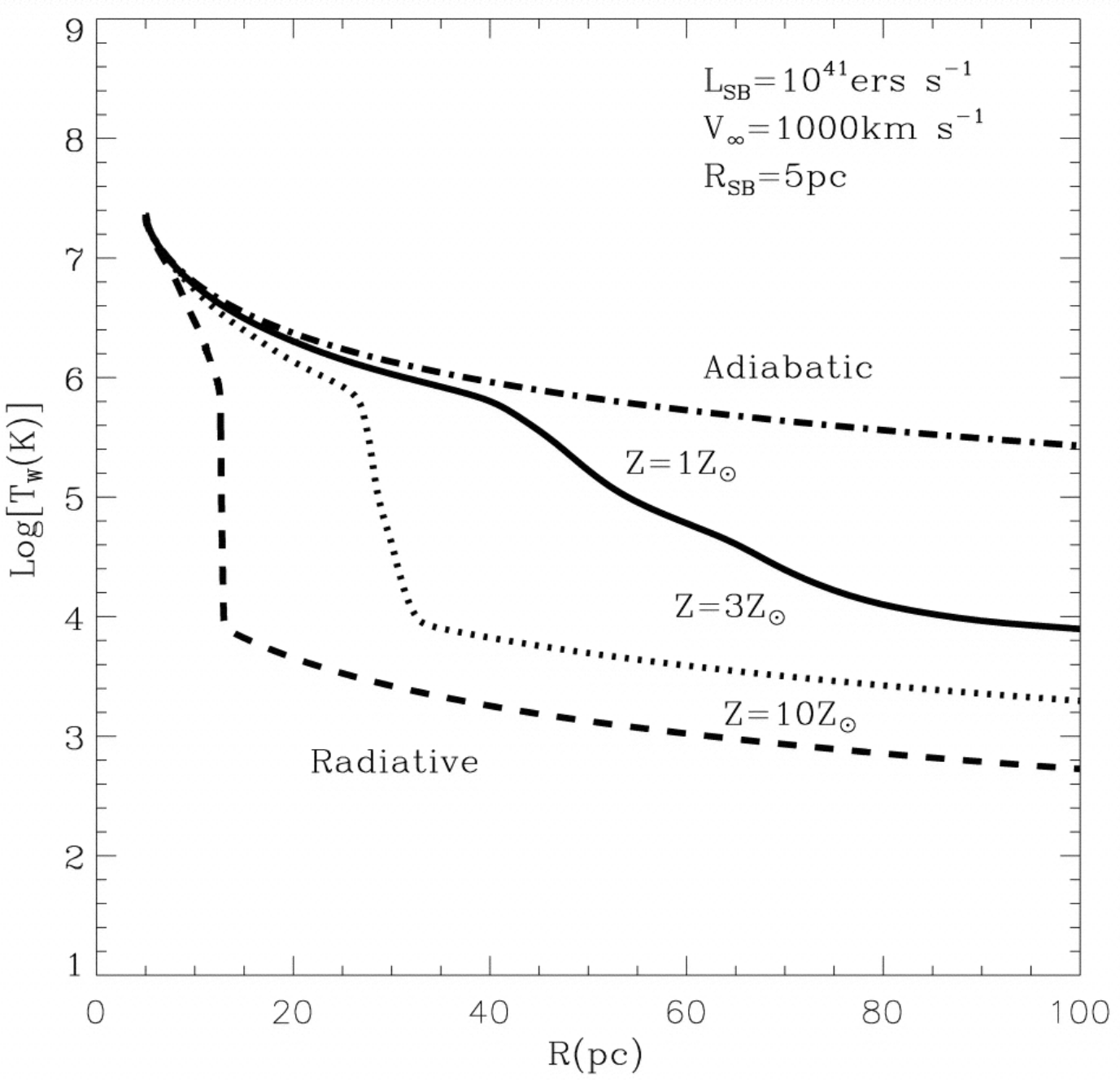


Figure 1a

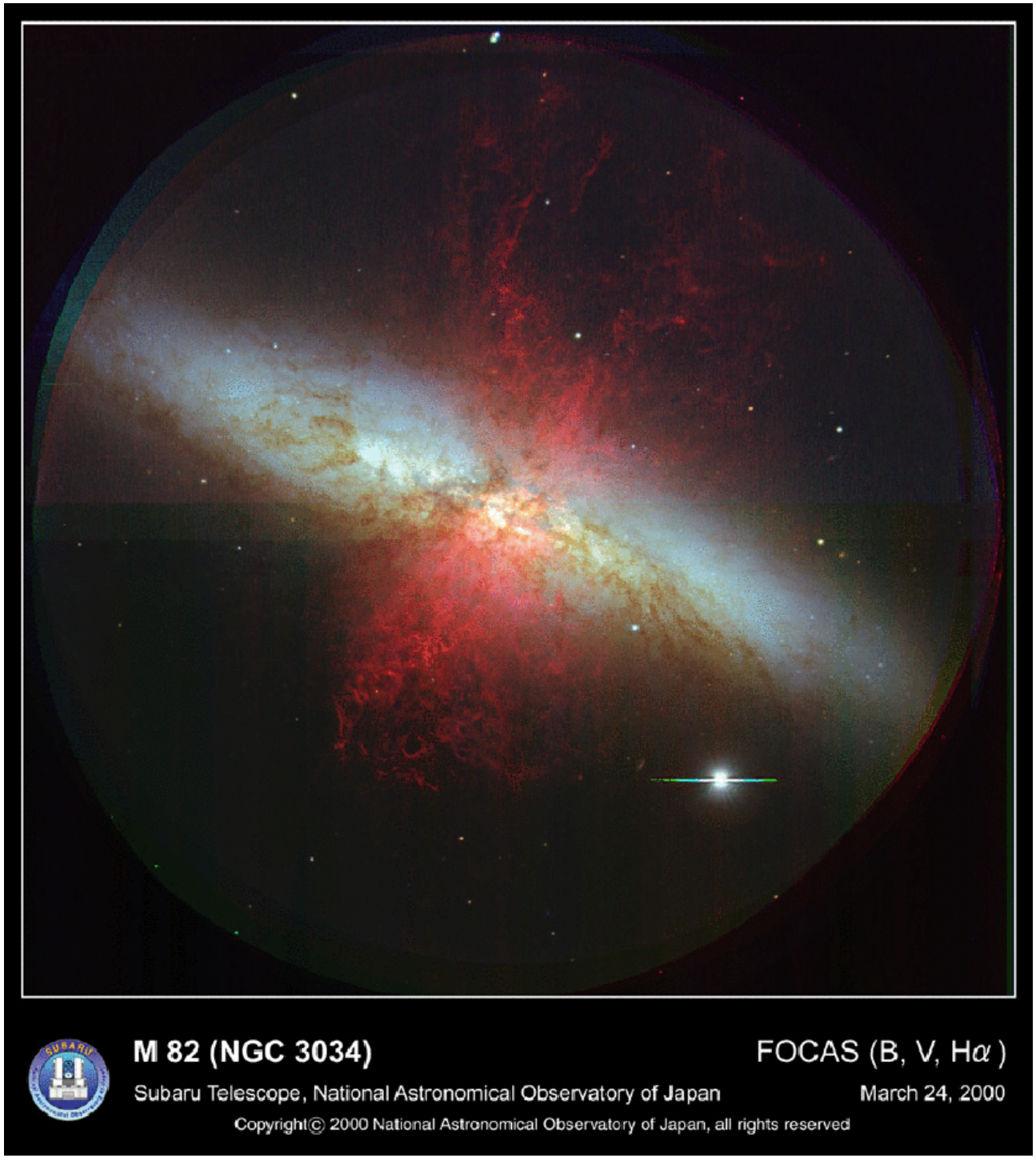
Tomisaka & Ikeuchi (1988)



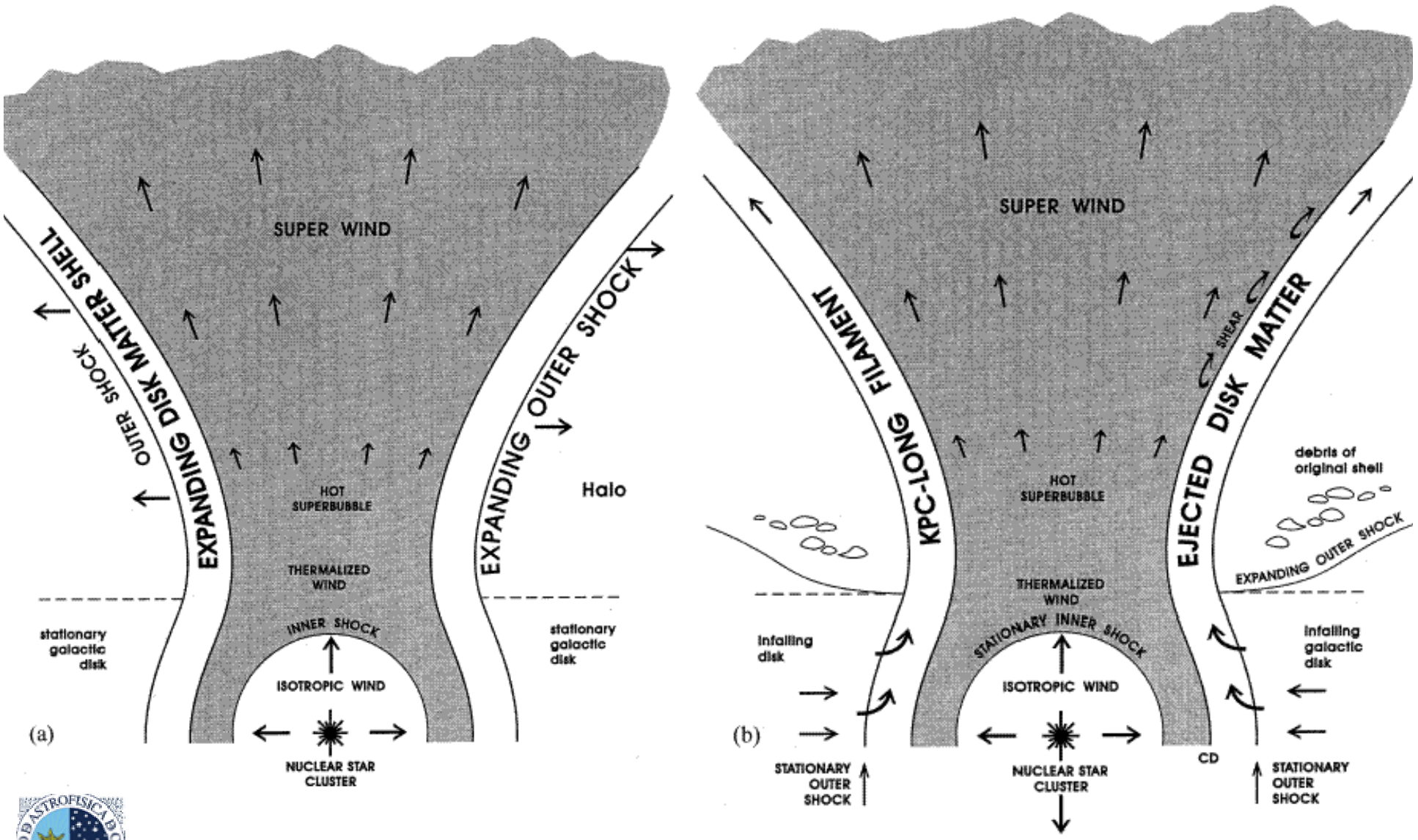
Silich etal., 2003, Ap. J., 590, 791-796.



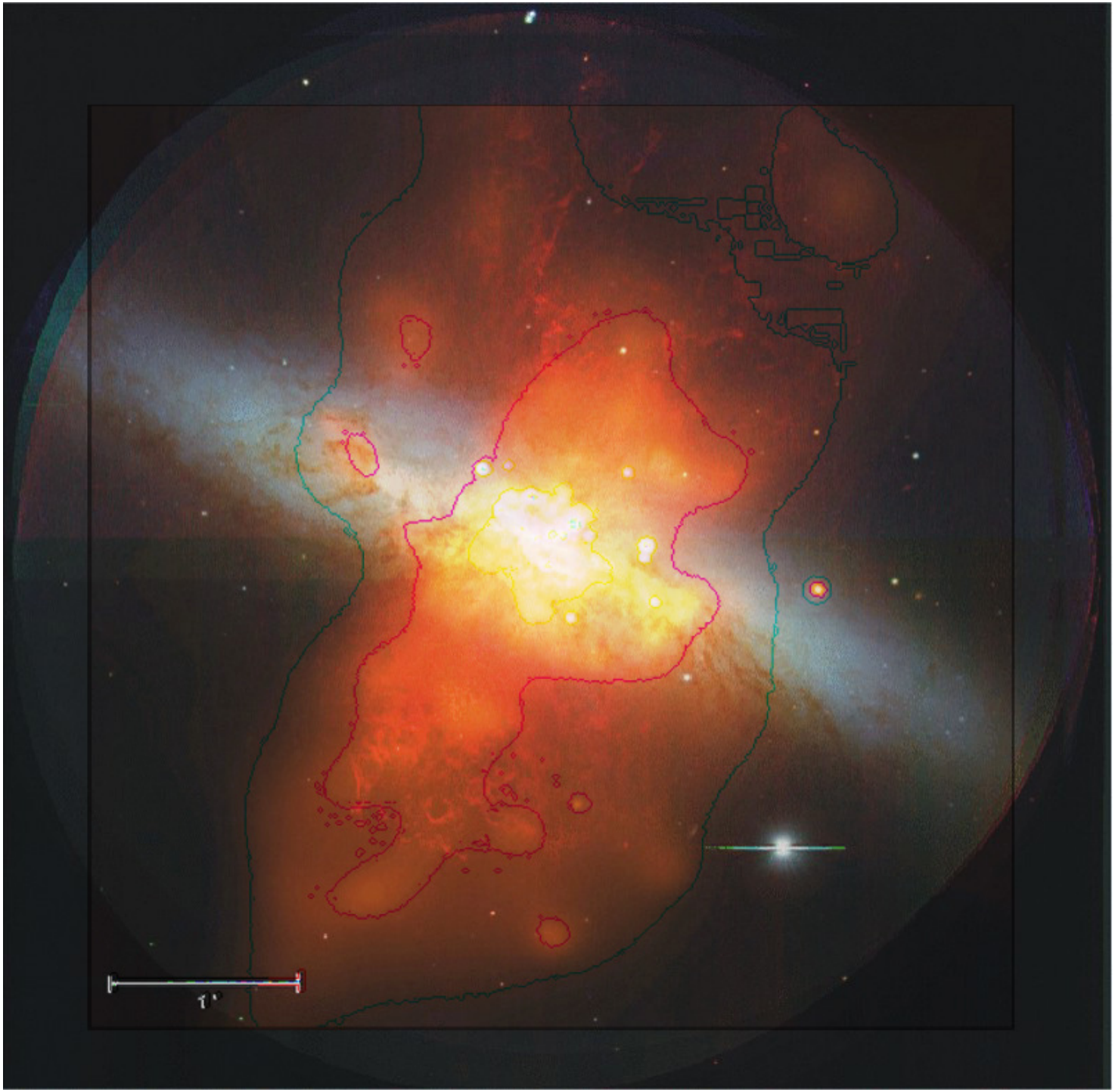
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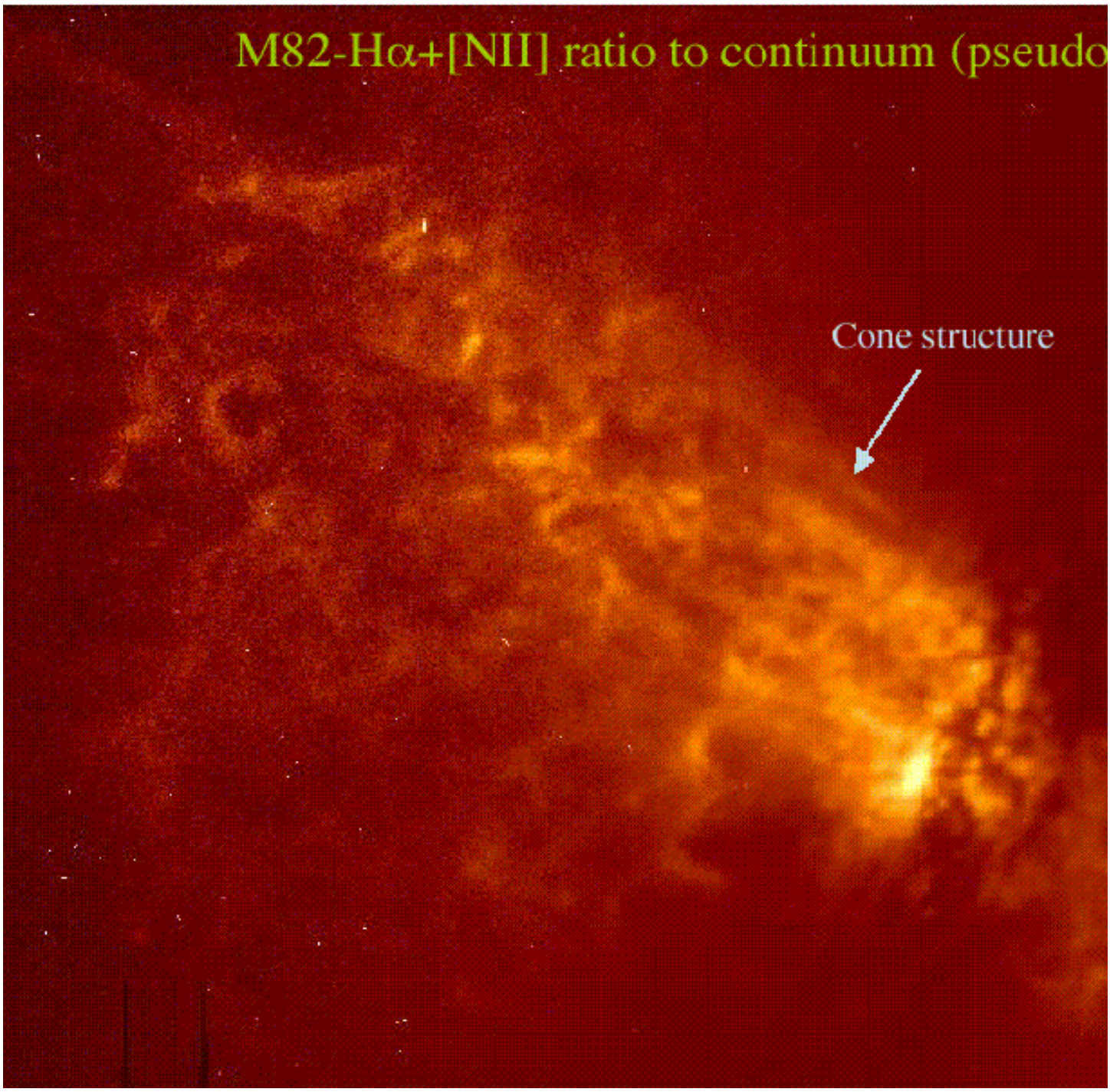

M 82 (NGC 3034)
FOCAS (B, V, Hα)
Subaru Telescope, National Astronomical Observatory of Japan
March 24, 2000
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Super Galactic Winds: models I



Tenorio-Tagle y Muñoz-Tuñón 1997, Ap. J., 478; 1998, MNRAS, 293.


1'


M82-Hα+[NII] ratio to continuum (pseudo
Cone structure

NEW INGREDIENTS...young stellar clusters

-The “new” star formation unit in starbursts, unveiled by the HST.

-SSC: compact, young and luminous stellar clusters(Ho, 1996).

-SSCs in merging galaxies...(Whitmore, Schweizer, Meurer, O´Connell....since 1995)

-Proto- globular clusters? . Distance and spatial resolution.

-SSCs formation and evolution. Their lifetime and luminosity function. Their IMF?...experts in Cancun´s meeting, this year.

- ✓Range of masses > 10^4 - $10^7 M_o$
- ✓Small: R ~ 1-6 pc (van den Bergh, 1995)
- ✓Very young: 1-10 Myears
- ✓Very luminous >R136 in 30 Dor. L_{bol}= 10^{40}-$10^{42.5}$ (Strickland y Stevens, 1999).

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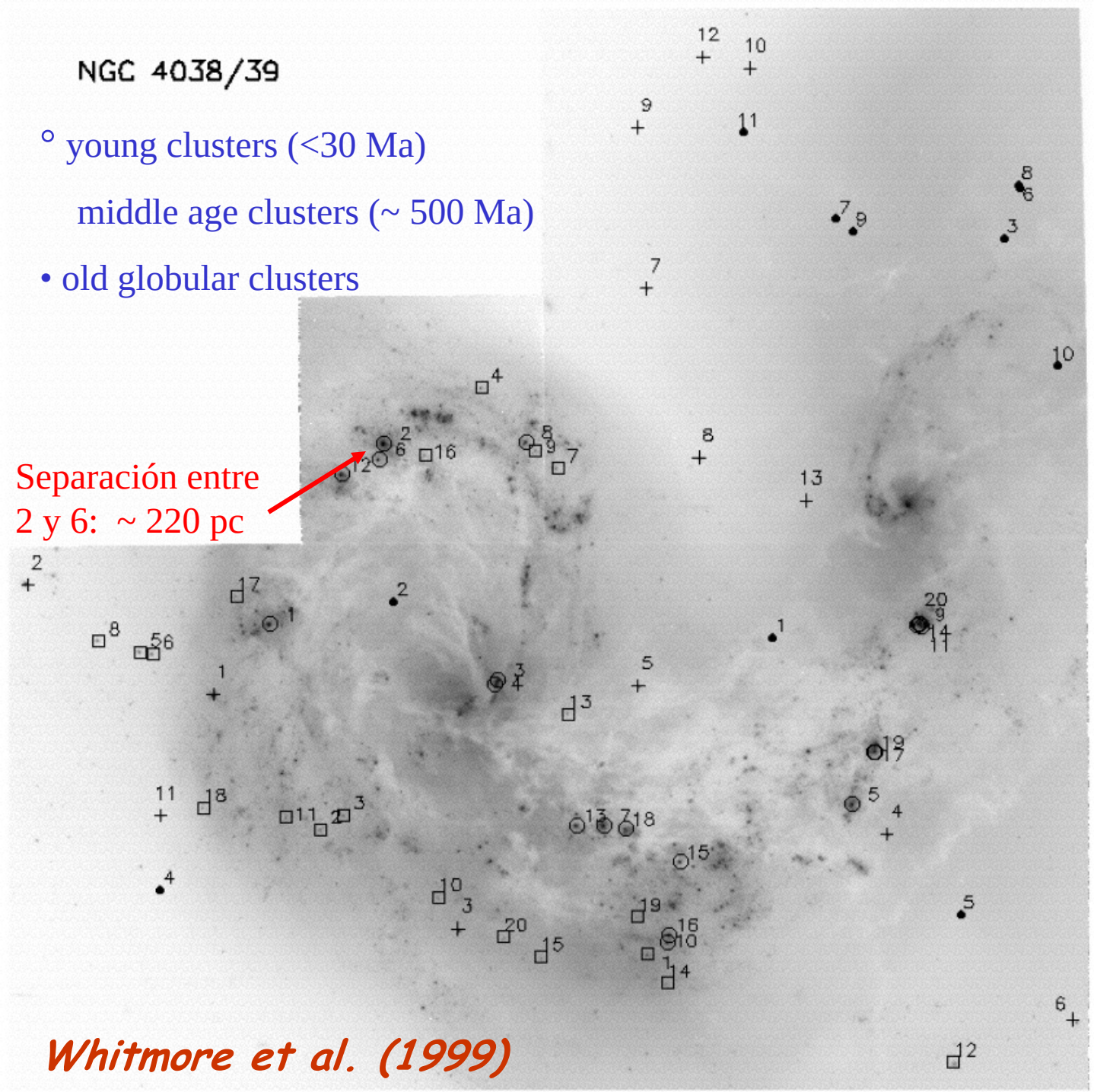
NGC 4038/39

° young clusters (<30 Ma)

middle age clusters (~ 500 Ma)

• old globular clusters

Separación entre
2 y 6: ~ 220 pc



Whitmore et al. (1999)

NGC 1569 *Anders et al. MNRAS 2000(astro-ph/0309153)*

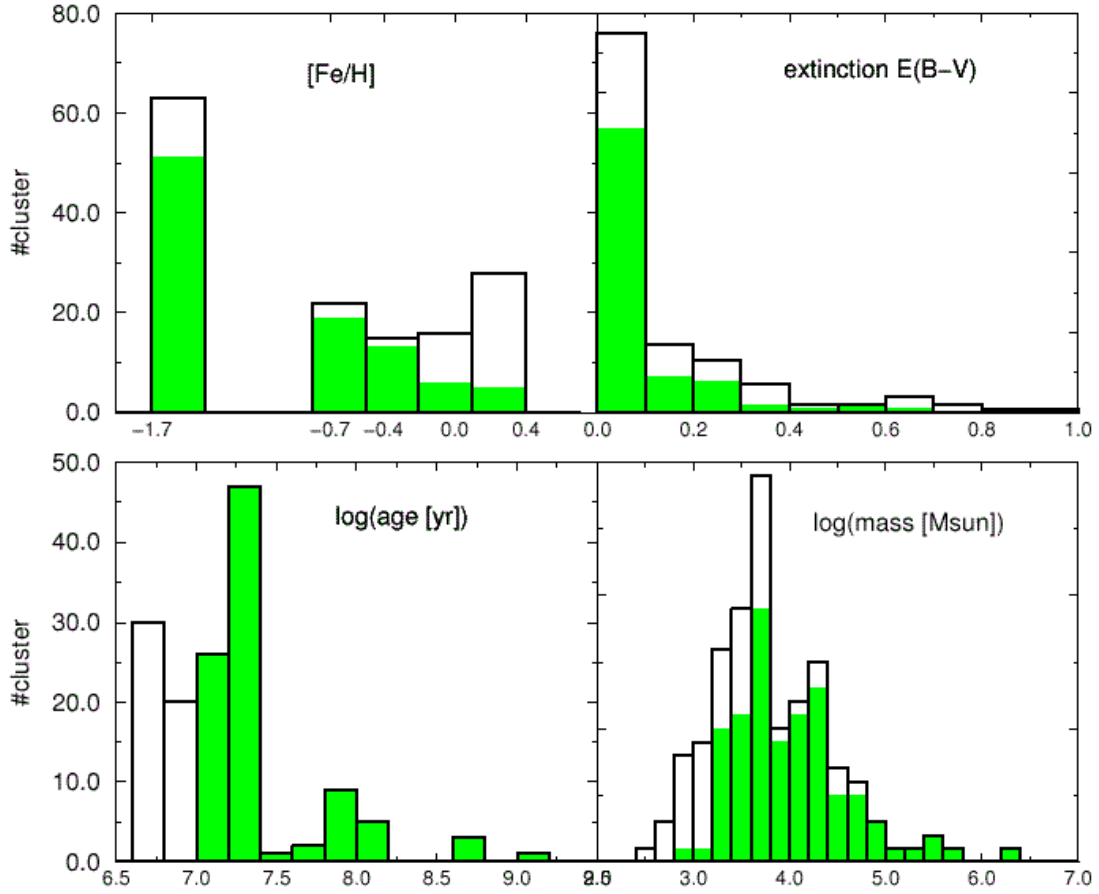


Figure 5. Parameter distributions of the clusters in the small FoV; open histograms: all ages, shaded histograms: only ages > 8 Myr.

NGC 6745 *De Grijs et al. 2003,MNRAS 343, 1185*

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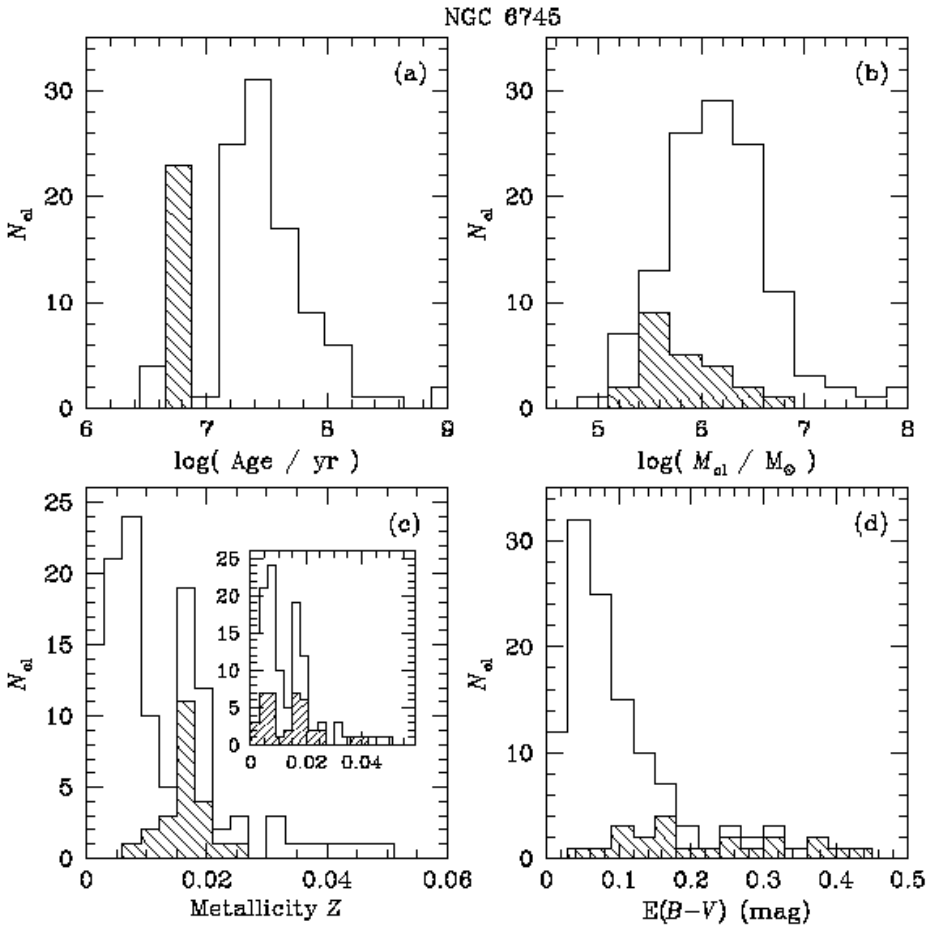


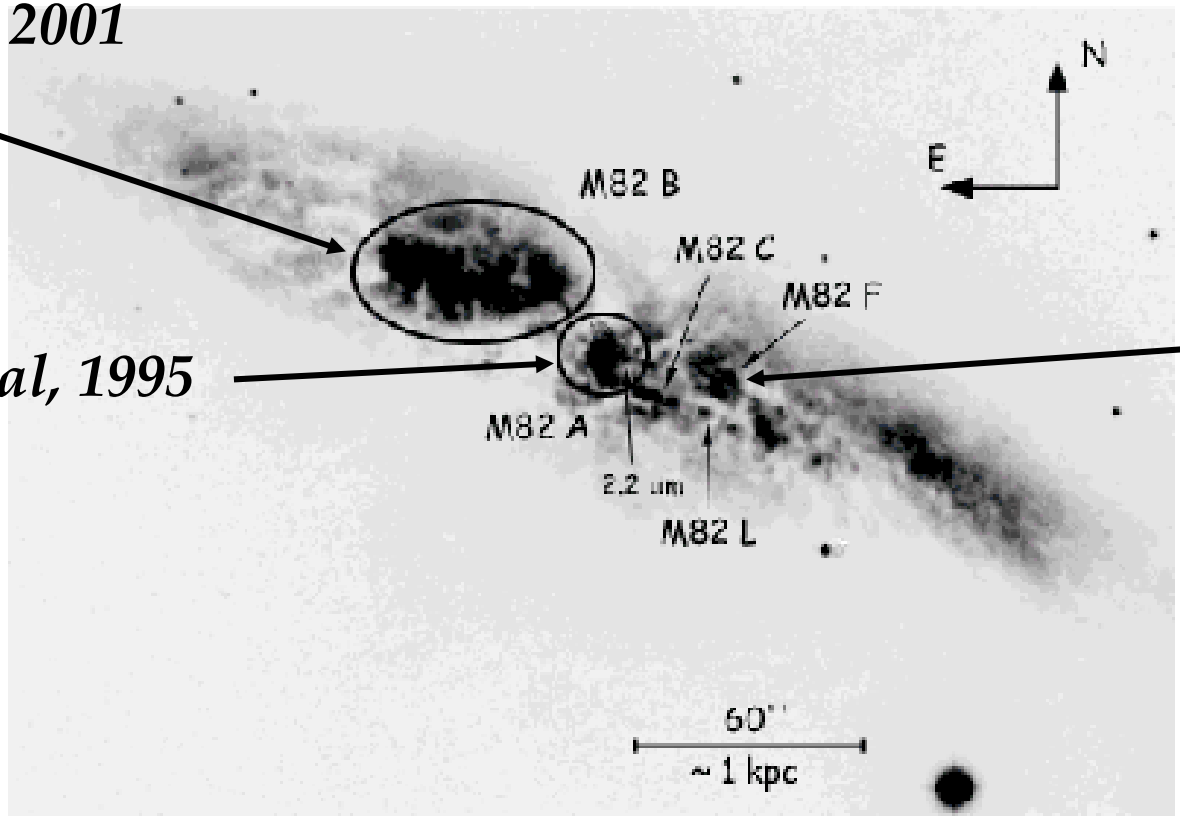
Figure 9. Age, mass, metallicity and extinction distributions of the clusters in NGC 6745, based on our four-passband fitting technique used to determine age, metallicity and extinction estimates simultaneously. Although the main properties of these distributions are reasonably correct, the shaded histograms are affected significantly by the age–metallicity degeneracy: the shaded histograms, corresponding to the young-age peak in panel (a), show a distinct second peak at close-to-solar metallicity (panel c), compared to the other clusters that peak at much lower metallicities. The shaded histogram in the inset in panel (c) is the metallicity distribution of the clusters in the most actively star-forming region connecting the main galaxy with its smaller companion.

De Grijs et al, 2001

M82 - B

O´Connell et al, 1995

M82 - A



Smith & Gallagher, 2001

M82 - F & L

Figure 1. M82 *B*-band image obtained at the Palomar 5m telescope, taken by A. Sandage (exposure time 20 minutes, seeing $\leq 1''$). The locations of the active starburst core in M82 A and C, and the older starburst region M82 B are indicated, as well as the brightest star clusters, F and L. We have also indicated the location of the 2.2 μm peak coincident with the galactic centre.

R. De Grijs, Astrophysics and Space Science, 281, 131 (2002)



HST - Observations

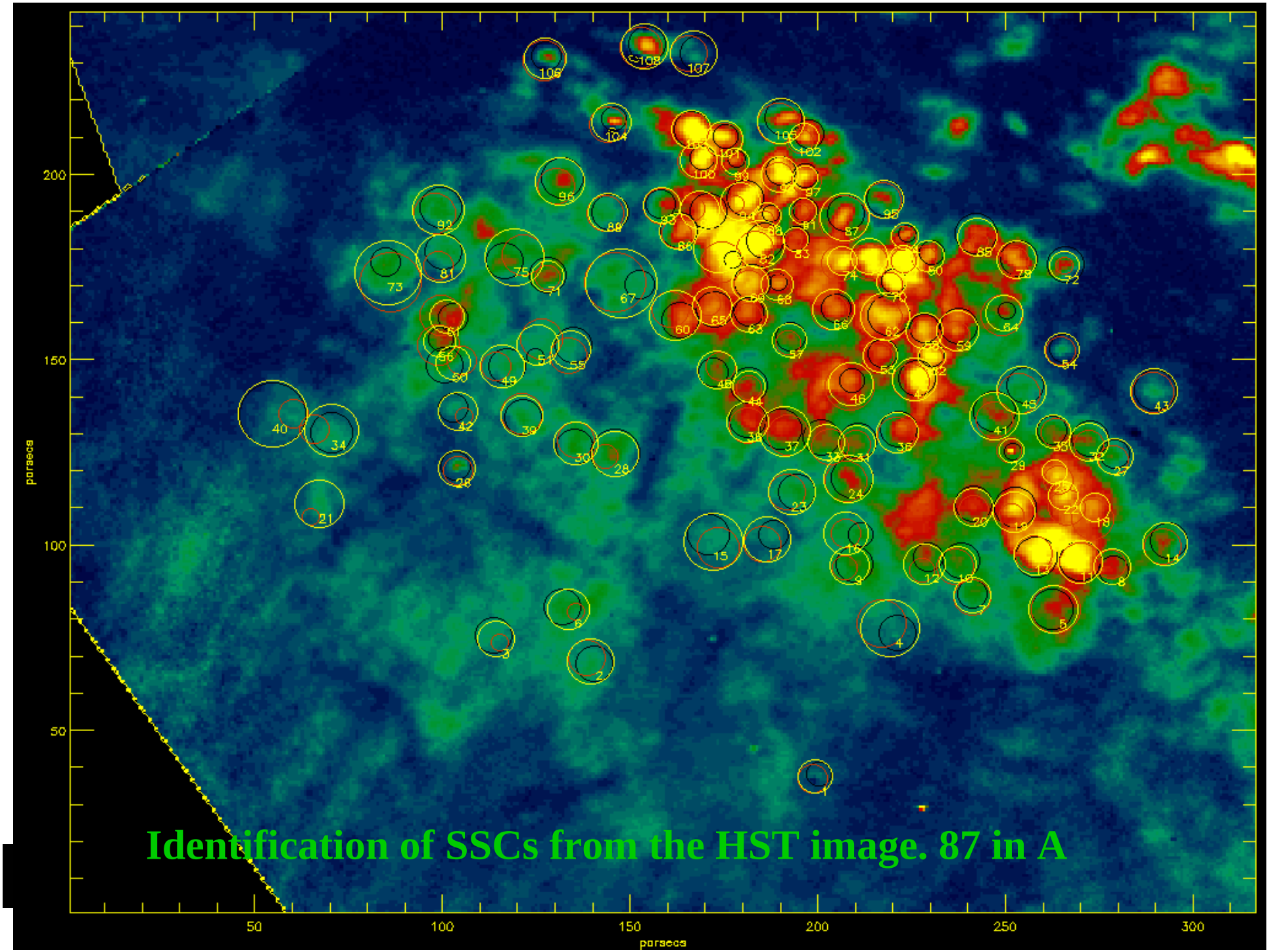
- Hα (F656N) => PC camera (P.I.: Sparks)
- NII (F658N) => PC camera (P.I.: Shopbell)
- V (Strömgren y – F547M) => PC camera (P.I.: Shopbell)
- I (F814W) => WF4 camera (P.I.: O´Connell)
- B (F439W) => WF4 camera (P.I.: O´Connell)

PC – FOV = 36.8´´ x 36.8´´

PC – pixel size = 0.046 ´´

WF – FOV = 80´´ x 80´´

WF – pixel size => 0.1 ´´

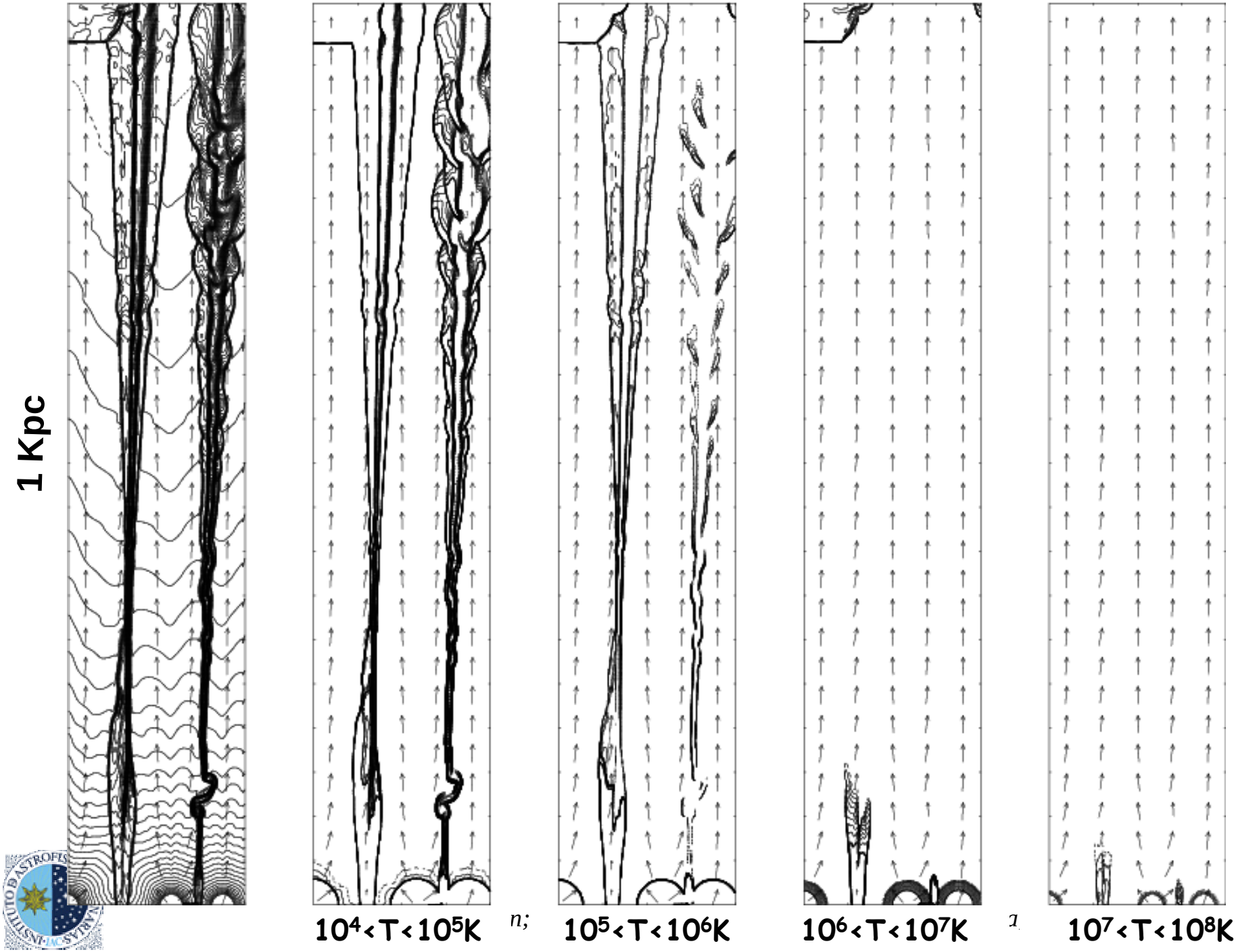

parsecs
50
100
150
200
250
300
Identification of SSCs from the HST image. 87 in A

Supergalactic Winds driven by multiple superstar clusters

Tenorio-Tagle, G.,Silich, S. & Muñoz-Tuñón, C. 2003, Ap. J., Nov.

- *Several identical but separated SSCs (each one with a $L_{SB}=10^{41}$ erg s^{-1})*
- *The winds from each SSC interact causing oblique and crossing shocks*
- *Cases with different metallicity ($3Z_o$-$10Z_o$).*
- *Free expanding wind (with cooling) ...breakout from the galactic disc or halo already happened.*




1 Kpc
10⁴<T<10⁵K
n;
10⁵<T<10⁶K
10⁶<T<10⁷K
10⁷<T<10⁸K

Catalogue with 87 young SSCs in M82(A)

(Melo etal.2004, enviado)

- Luminous and massive

  peak at about 4 10^6 Msun
- High ρ (N/area)

  87 SSCs/(242 x 242 pc) = 1486 SSCs/Kpc^2
- <Size> $\approx$ d

  6.37 pc < d < 15 pc; 3.22 pc < R < 8.86 pc
- Perhaps the features needed to produce a SGW "a la m82"



Summary/ properties// other starbursts

NGC 1569:

$\log(M_{cl}/M_o) < 5$ - only 2 SSCs separated ~72 pc

NGC 6745 (interact.):

Massive clusters

$6.5 < \log (M_{cl}/M_o) < 8.0$ - 177 SSCs

Arp 220:

SFR↑↑ - SSCs not resolved

M83 (NGC 5236):

$2.85 < \log (M_{cl}/M_o) < 4.86$

ρ= 36 SSCs/(126 x 198 pc) = 1443 SSCs/Kpc^2

0 pc < R < 7 pc

M82 (A region):

SFR↑↑

Massive clusters $5.75 < \log (M_{cl}/M_o) < 7.36$

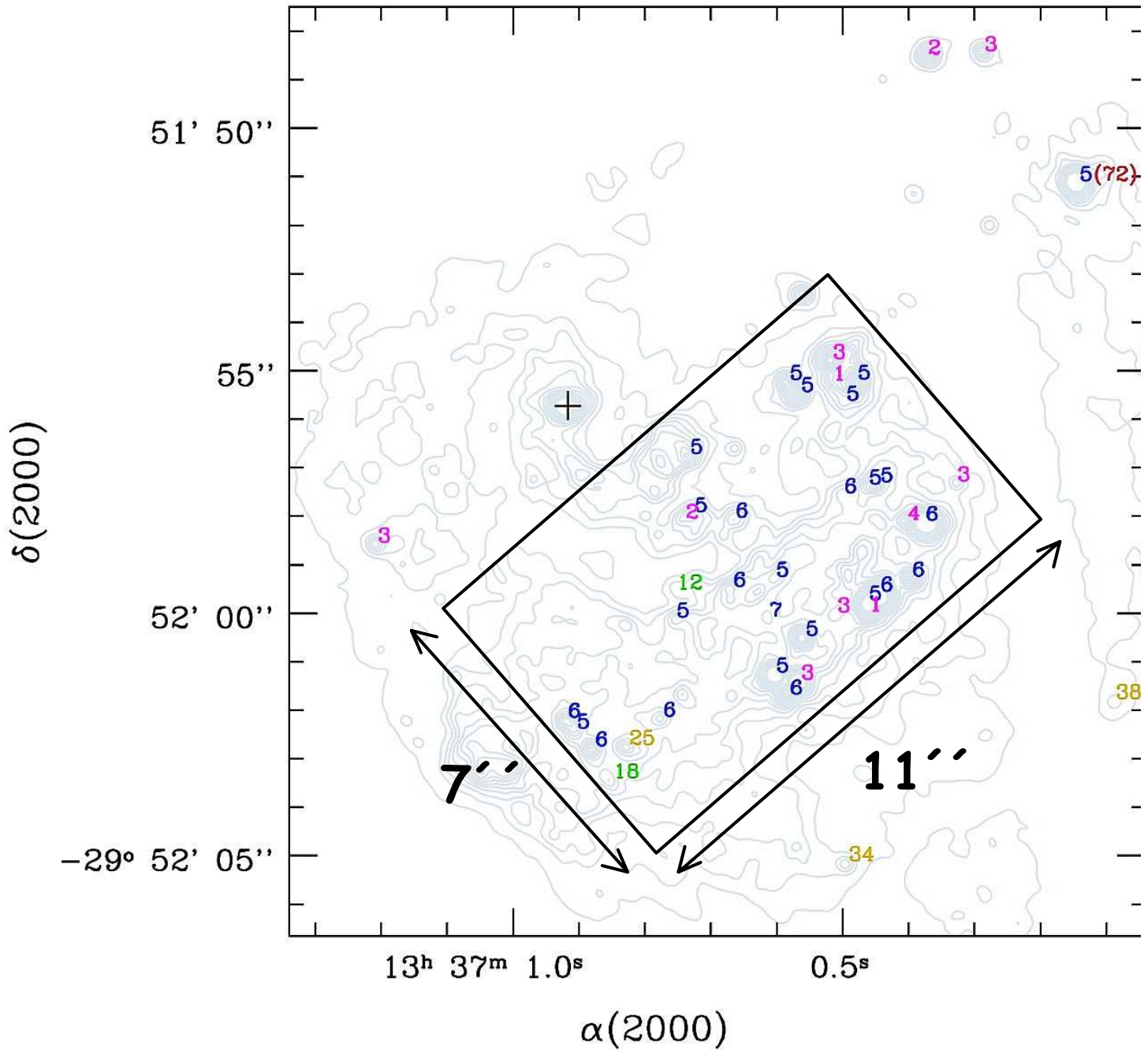
ρ = 87 SSCs/(242 x 242 pc) = 1486 SSCs/Kpc^2

90 % $\rightarrow$ 6.37 pc < d < 15 pc

3.22 pc < R < 8.86 pc **d≈R**

Harris et al., 2001, AJ 122, 3046

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Super Galactic Winds New possibilities

- Radiative cooling
- Starburts as a collection of star clusters. All of them distributed on a preferential plane.

Separate engines working together and leading to:

- *Self-collimated flows*
- *Cold-extended (kpc) filaments emerging from the base of the outflow.*
- *Extended (difuse) X rays*
- *Coincident Hα and X rays structures*

Young SSCs in M82(A)

- *87 Luminous and massive SSC; peak at about 4 10^6 Msun*
- *High ρ (N/area) 87 SSCs/(242 x 242 pc) = 1486 SSCs/Kpc^2*
- *<size> $\approx$ d; 6.37 pc < d < 15 pc; 3.22 pc < R < 8.86 pc*
- *Perhaps the features needed to produce a SGW "a la m82"*

More things to come.....

Are the photons able to reach the cap (at 11kpc)?

What is the predicted metallicity ...cooling...filaments

Whow many SSCs merge to be “the SSW engine”...

Is the cap a fosil structure....? The broken shell?

Conection of SSCs and SW structures

The Xrays and Halpha conexión

.....

Look for other candidates (use the HST archive)

