# Superstar Clusters and Supergalactic winds

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- MAIN OBJECTIVE: To determine the conditions necessary in a galaxy to develop supergalactic winds (SWG)

- SAMPLE OF GALAXIES:
  - M82 ➔ prototype of starburst galaxy driving a supergalactic wind
  - NGC 253 & NGC 4631 ➔ X ray emission extends to large distance (1-2 kpc) on the disc of the galaxy.

    - NGC 253 → extended dust-halo
    - NGC 4631 → a bubble structure

# Starburst evolution

**Cluster of young and massive stars**

↓

**release material to high speed→ arcs and filaments are formed**

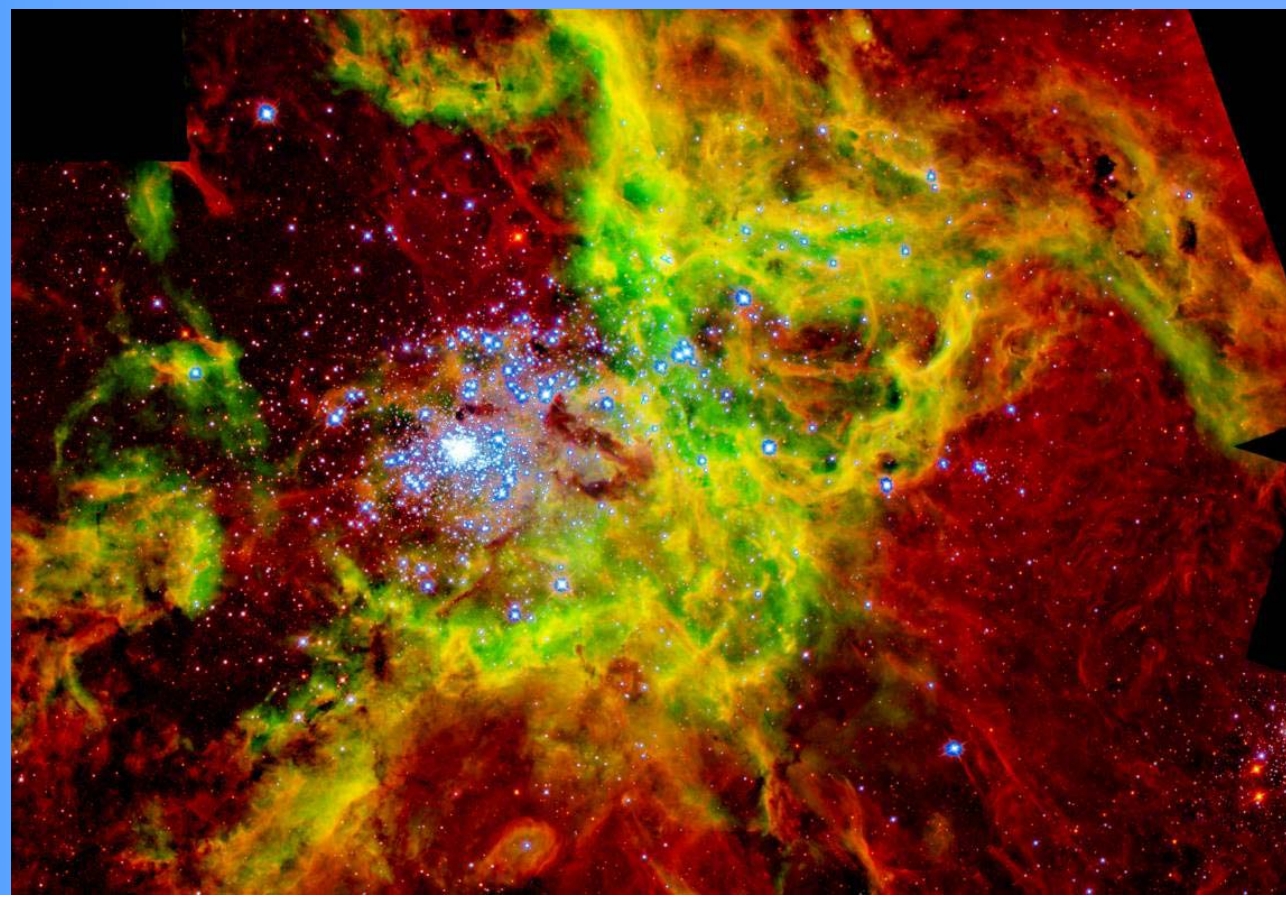
**Flux of ionizing photons → ultraviolet emission**

**Principal energy sources:**

-Stellar winds

-Supernovae explotions

-Ionizing radiation

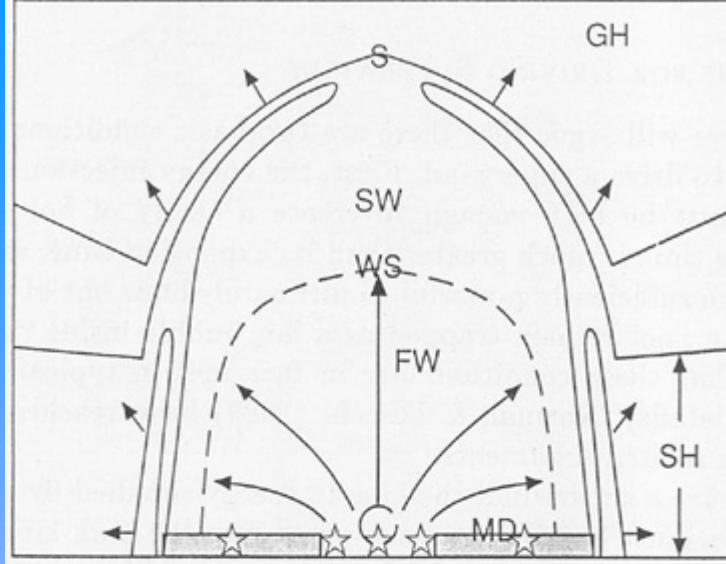


*30 Dorados*

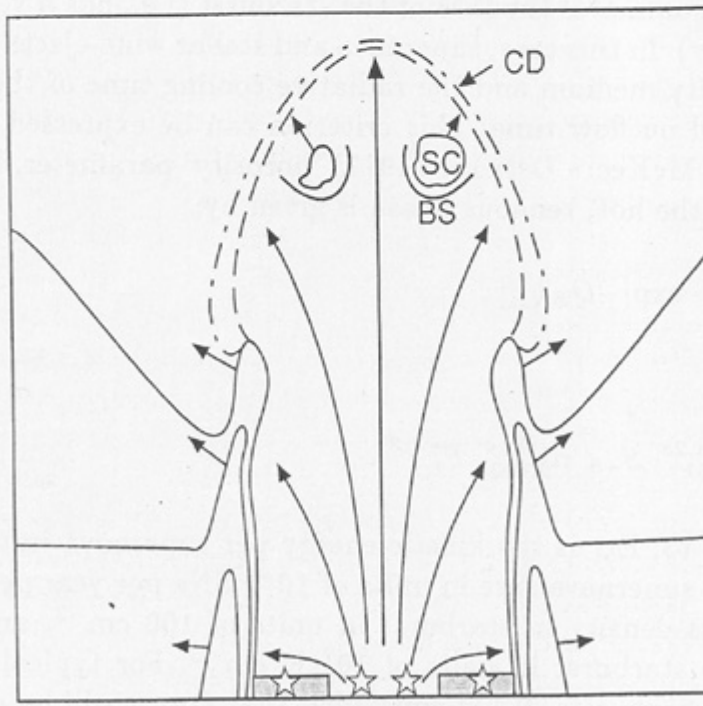
*(J. Maíz-Apellániz)*

# Breakout of bubble

- **Stellar winds** expell processed material to the interstellar medium violently (FW)
- Start to sweep the ISM ➔ produce the development of a outer shock
- ρ, T and P rapidly falling ➔ forming a reverse shock which termalizing the wind kinetic energy

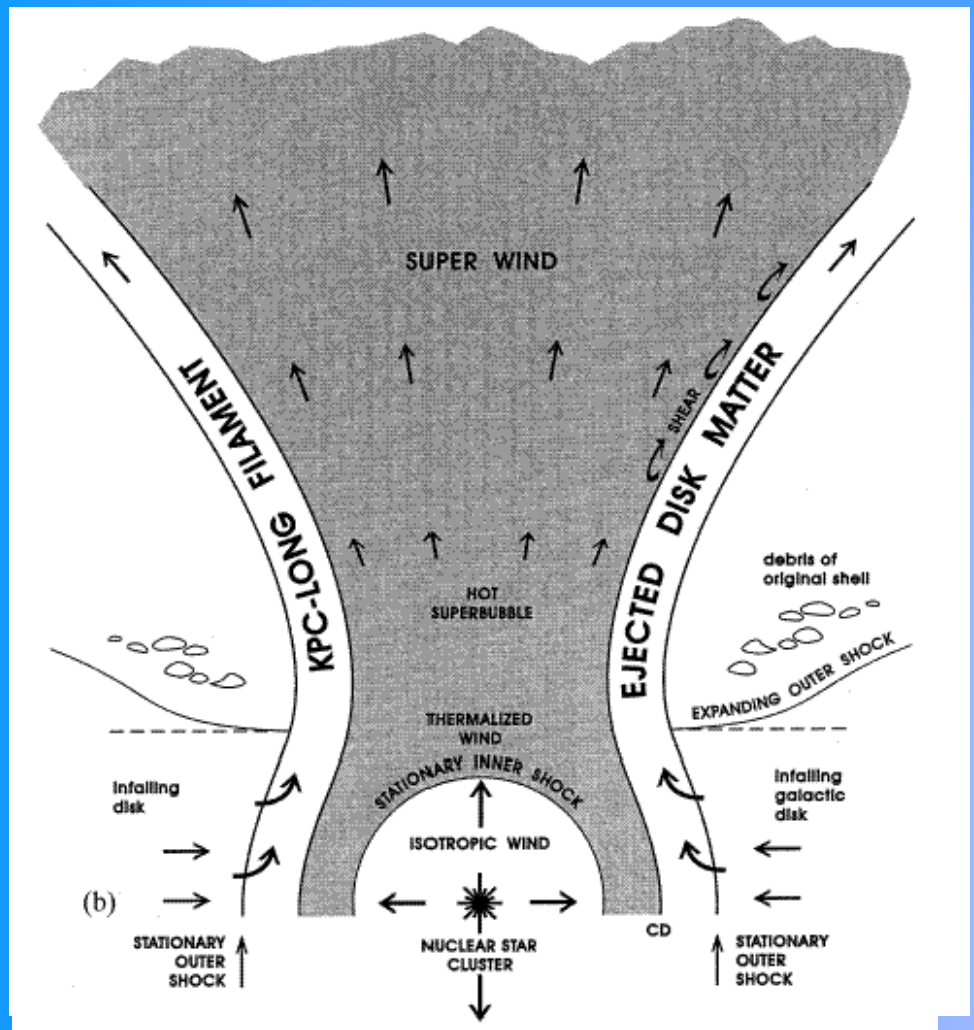



- negative density gradient ➔ breakout of bubble ("blow-out")
- the shell suffers the rayleigh -Taylor instabilities
- If the material reach the galaxy halo ➔ supergalactic winds are formed



# Super Galactic Winds models I

***Tenorio-Tagle & Muñoz-Tuñón (1997, 1998)***




← *First part:* bubble formation and SWG

**New model:**

*G. Tenorio-Tagle, S. Silich & C. Muñoz-Tuñón (2003, ApJ 597, 279)*

- Starbursts are formed by collections of super star clusters

Second part .. →

# Super Star Clusters

- Super Star Clusters (SSC) are very young and compact clusters with high luminosities *(Ho 1997)*
- HST has resolved the starburst nucleus => SSCs are the units of starbursts

- Main features:
  1. Massive: > $10^4$ $M_o$ (Strickland y Stevens, 1999)
  2. Compact: R ~ 1-6 pc (van den Bergh, 1995)
  3. Very young: 1-10 Myr
  4. High luminosities.

# Super Galactic Winds models II

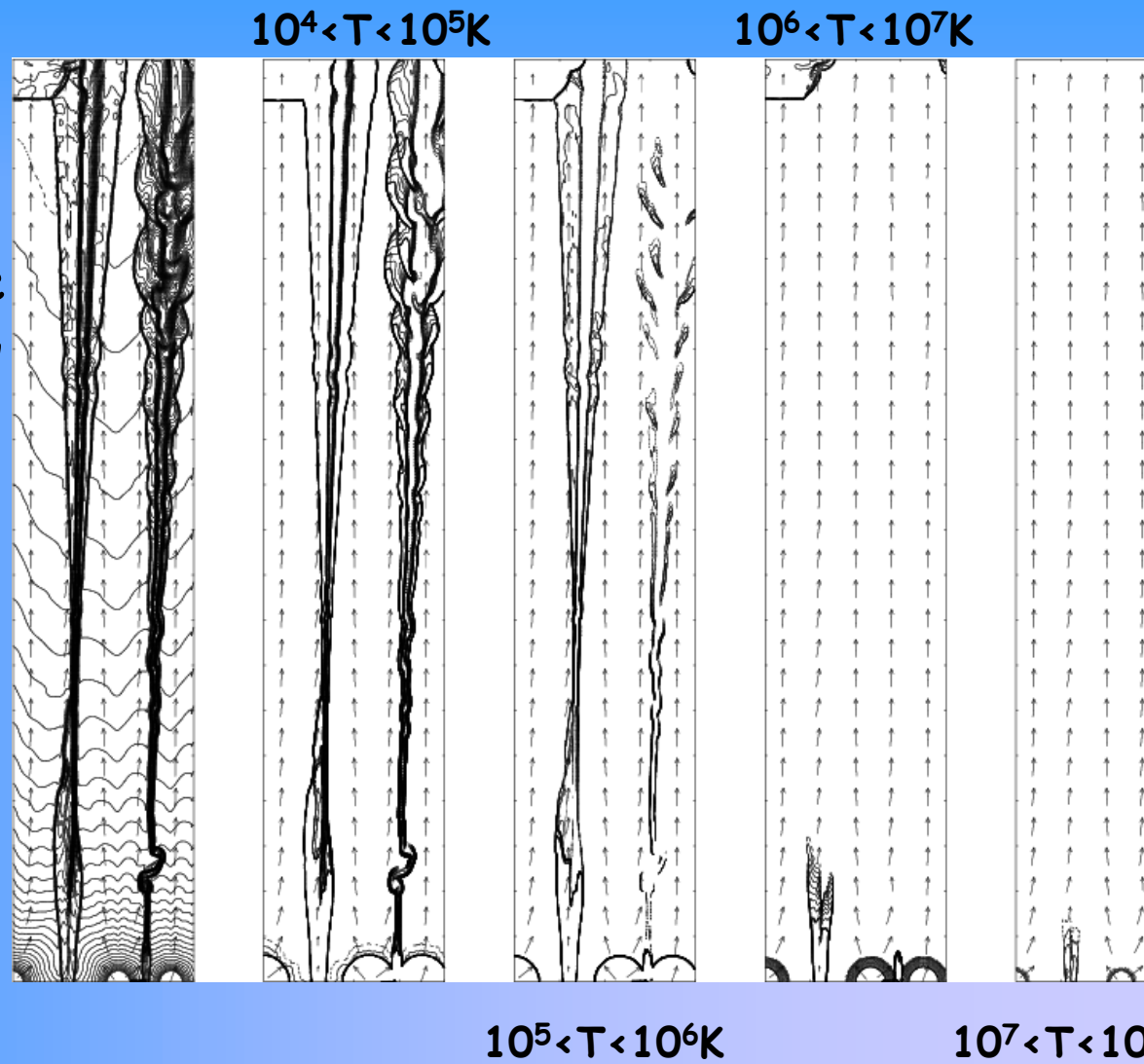
*Second part:* each SSC can produce it own oblique shock.

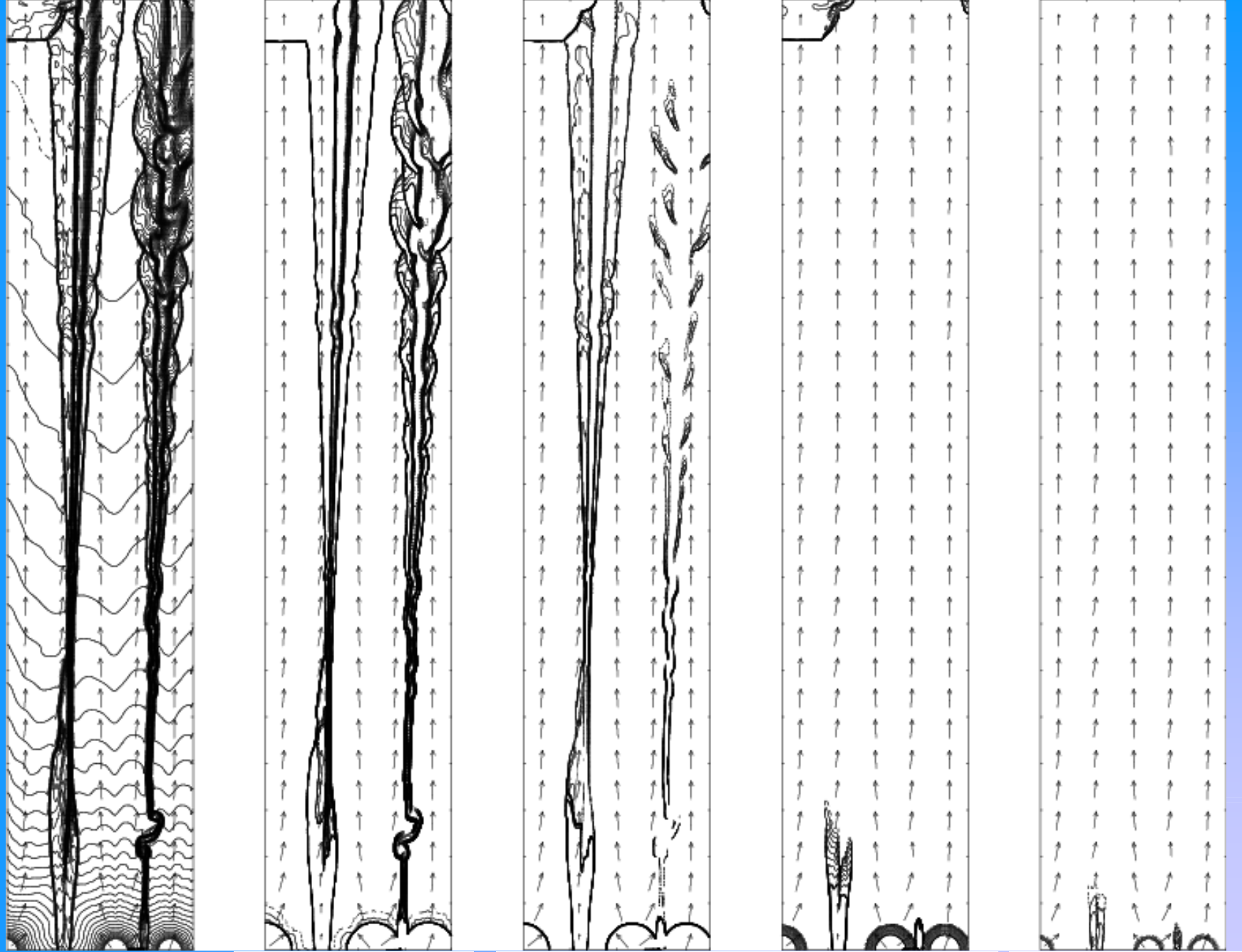
Structure the outflow into a network of dense and cold kiloparsec long filaments

Depends on ages and distances between SSC

The winds from each SSC interact causing oblique and crossing shocks

Self-collimated flows

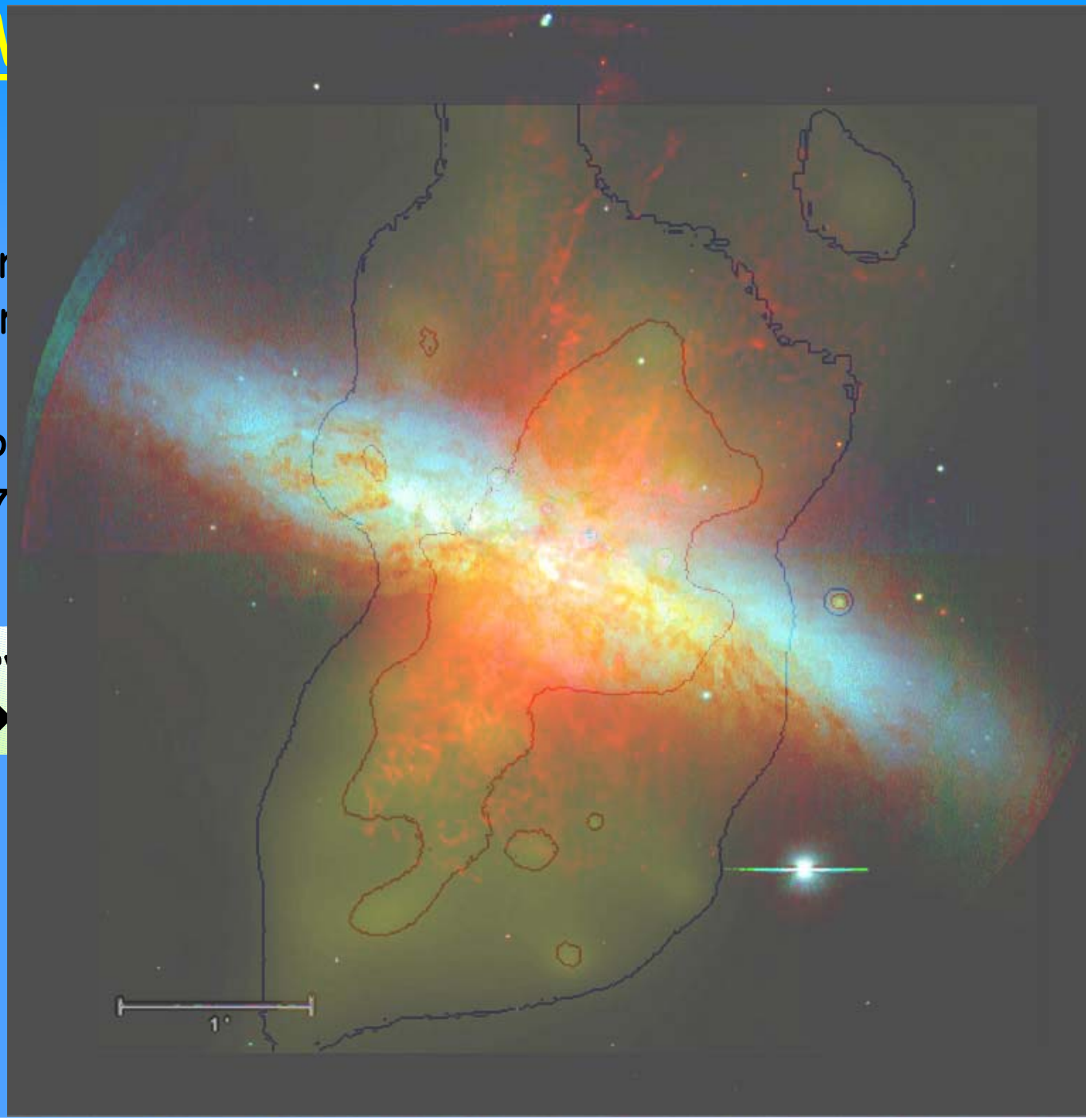



1 Kpc
$10^4<T<10^5$K
$10^5<T<10^6$K
$10^6<T<10^7$K
$10^7<T<10^8$K

# M

- M82 is a near irregular star galaxy
- Distance: 3.6
- Scale: 1″ = 17

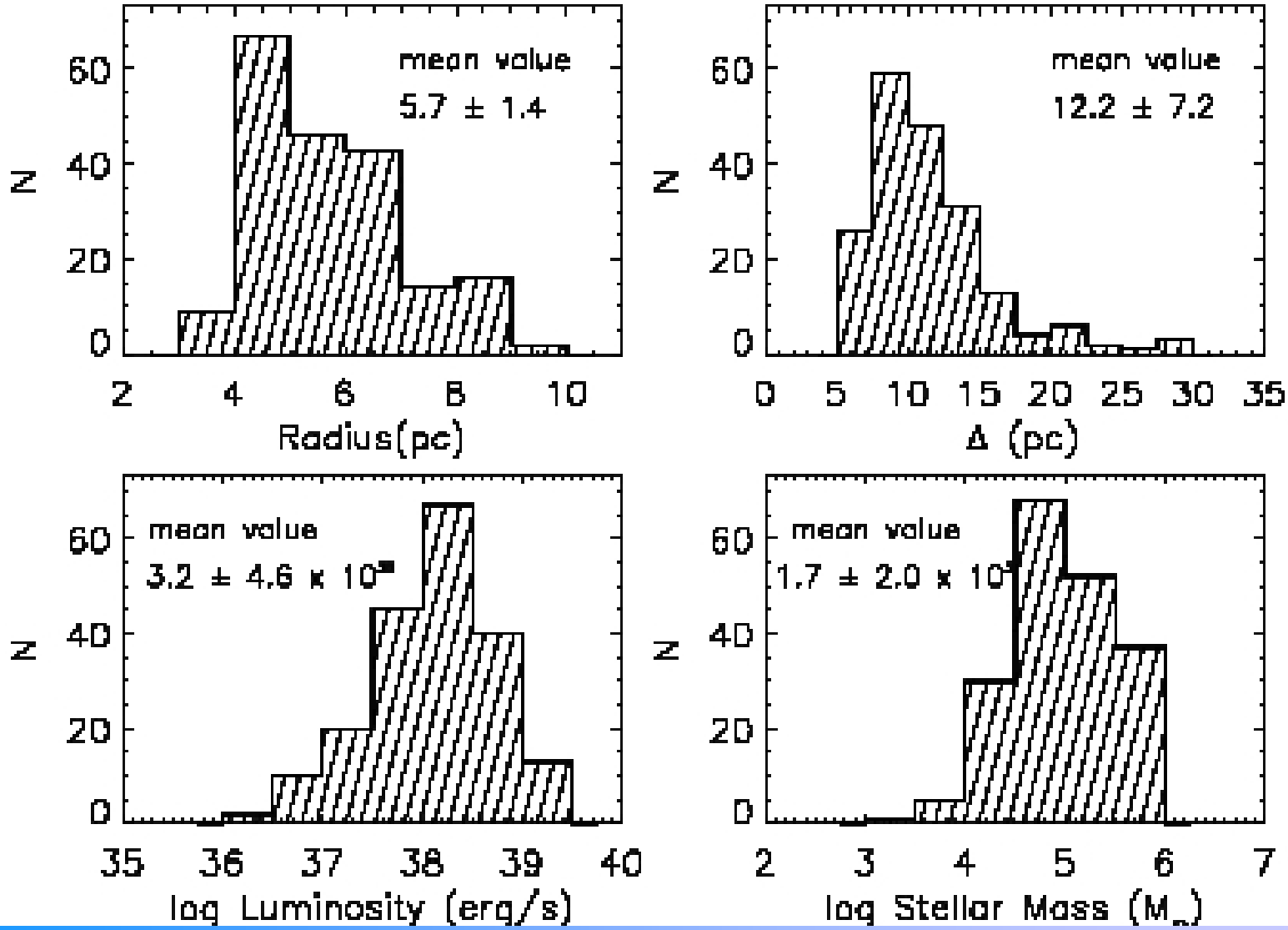
Has been obser
Subaru in Hα ➔



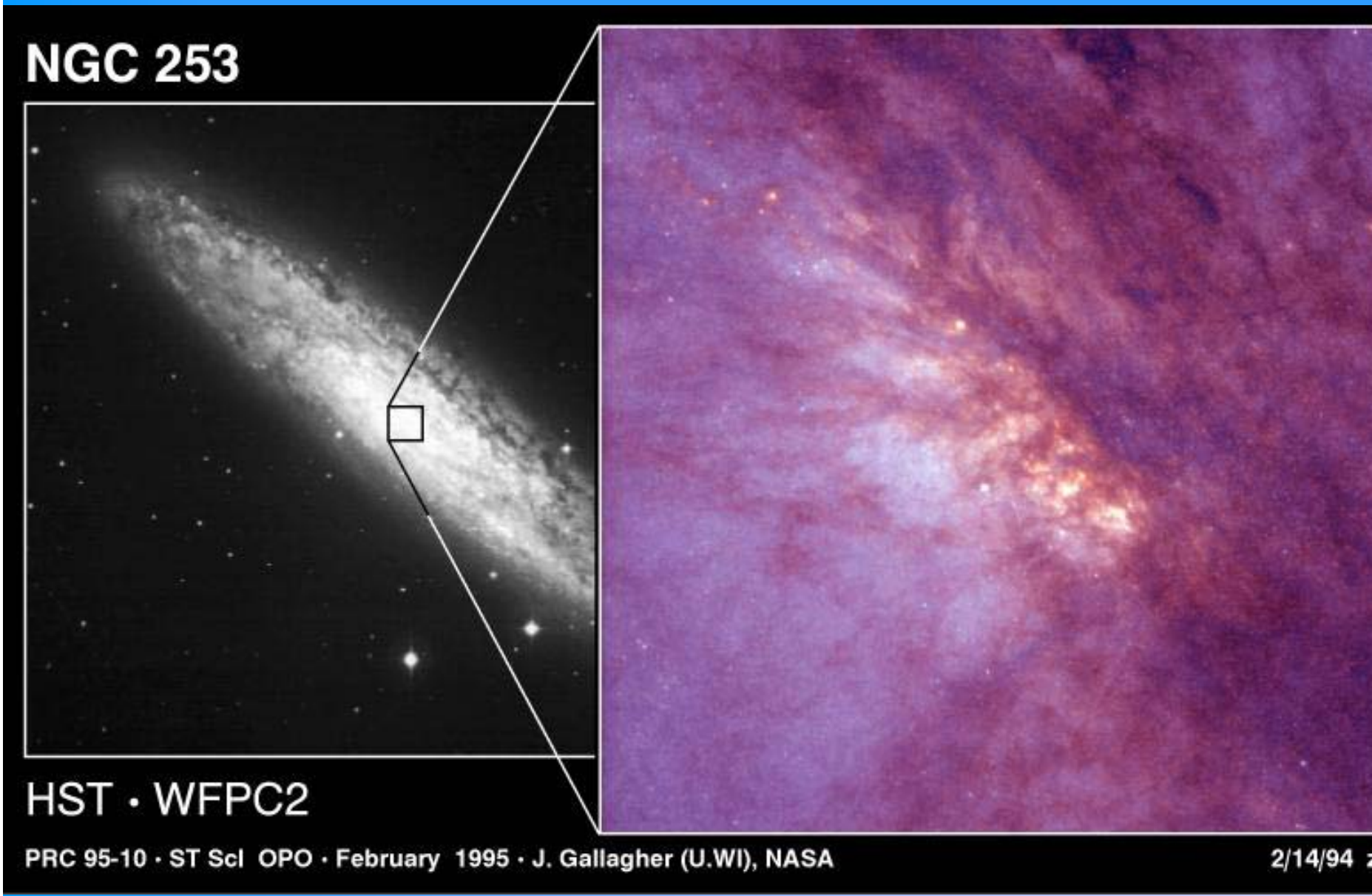
# Results for M82

**197 SSCs**

Melo et al. 2005 (ApJ)

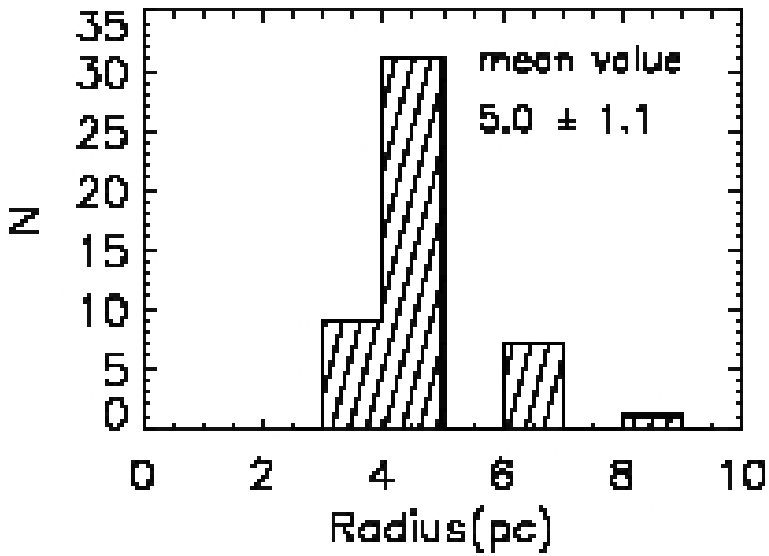


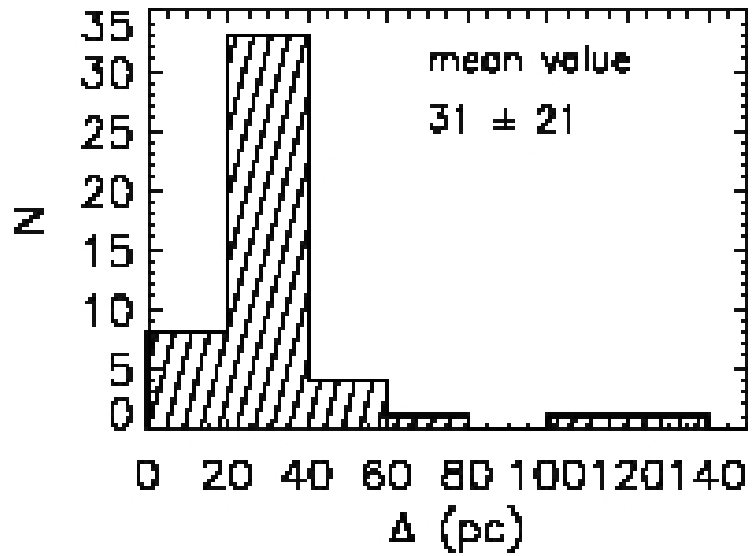
# NGC 253

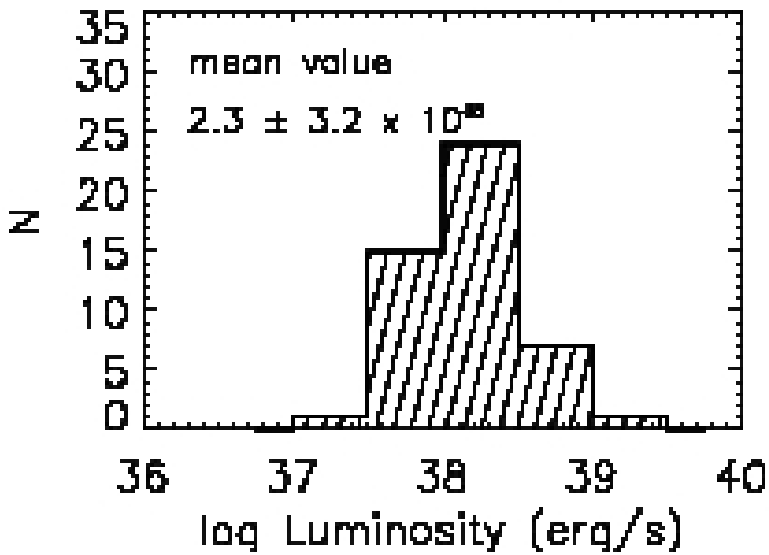

NGC 253
HST • WFPC2
PRC 95-10 · ST ScI OPO · February 1995 · J. Gallagher (U.WI), NASA
2/14/94

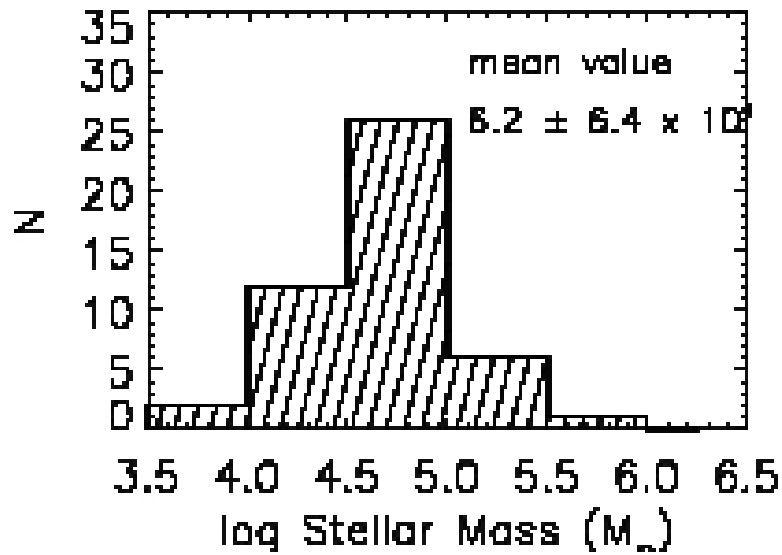
# Results of NGC 253

48 SSCs

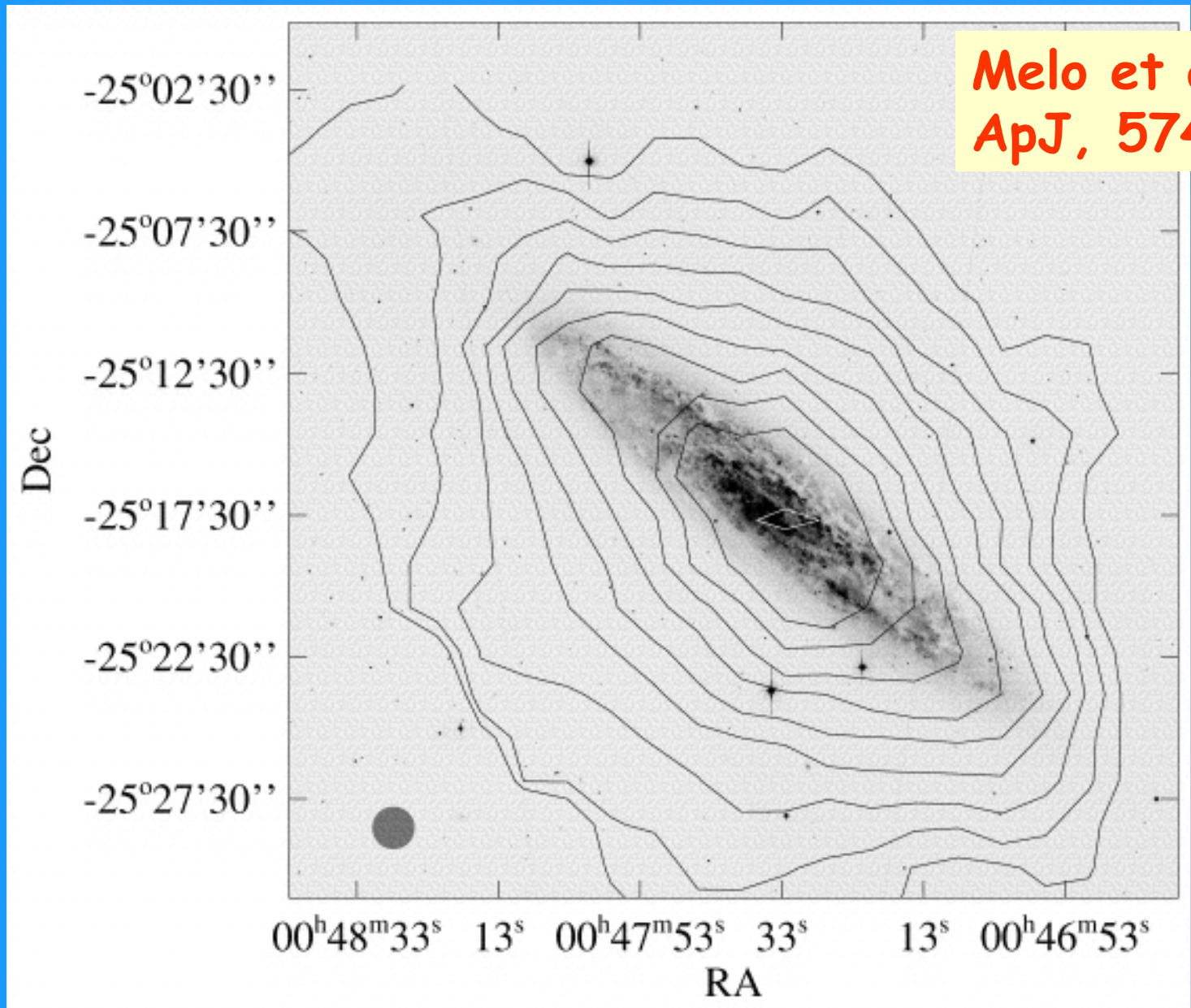


# Extended cold dust halo in 180μm ➔ very difficult to form SGWs




Melo et al, 2002, ApJ, 574, 718

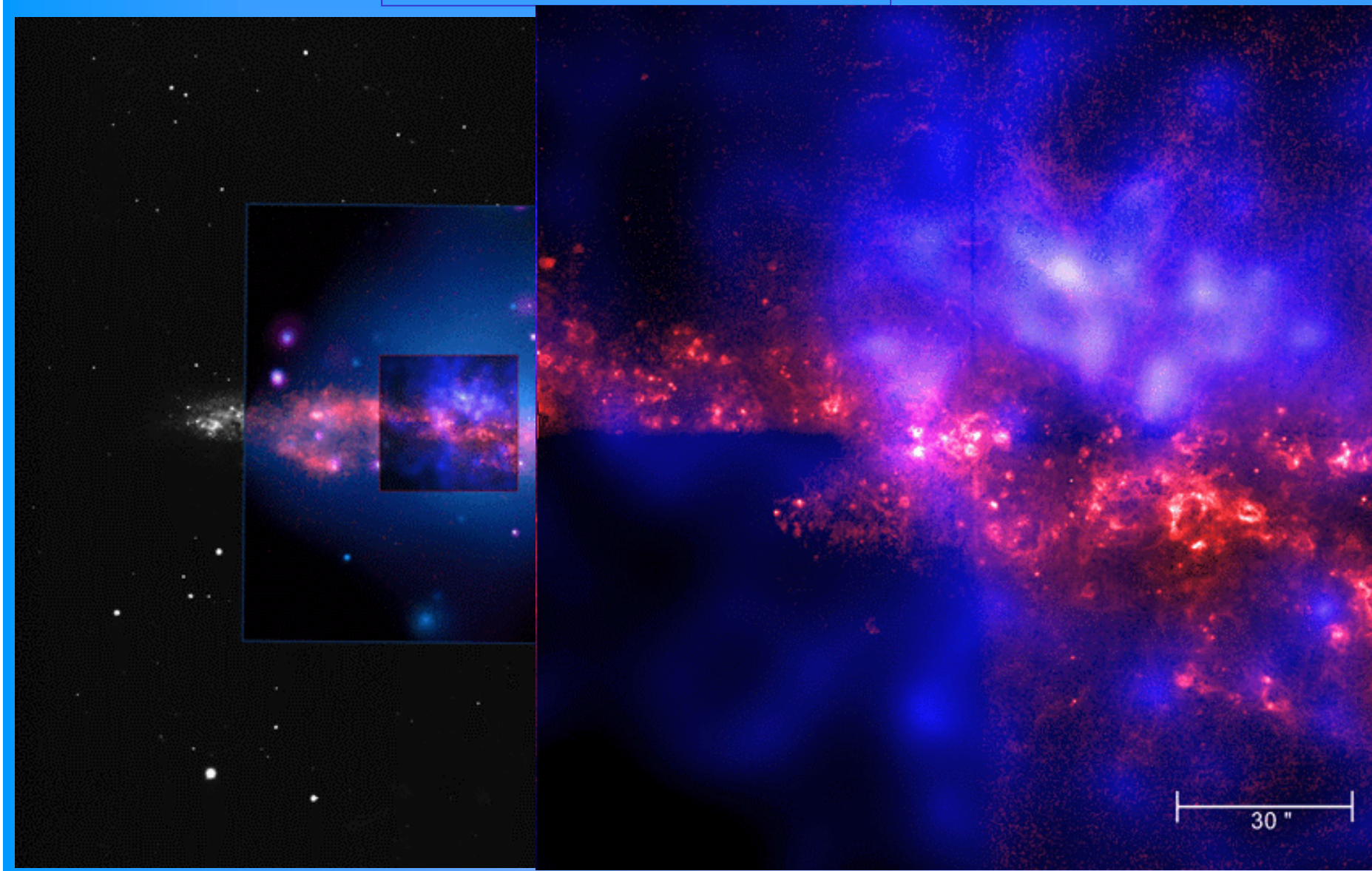
# NGC 4631

Visible – NOAO/aura/NSF

X Rays – NASA/Umass/D.Wang et al.

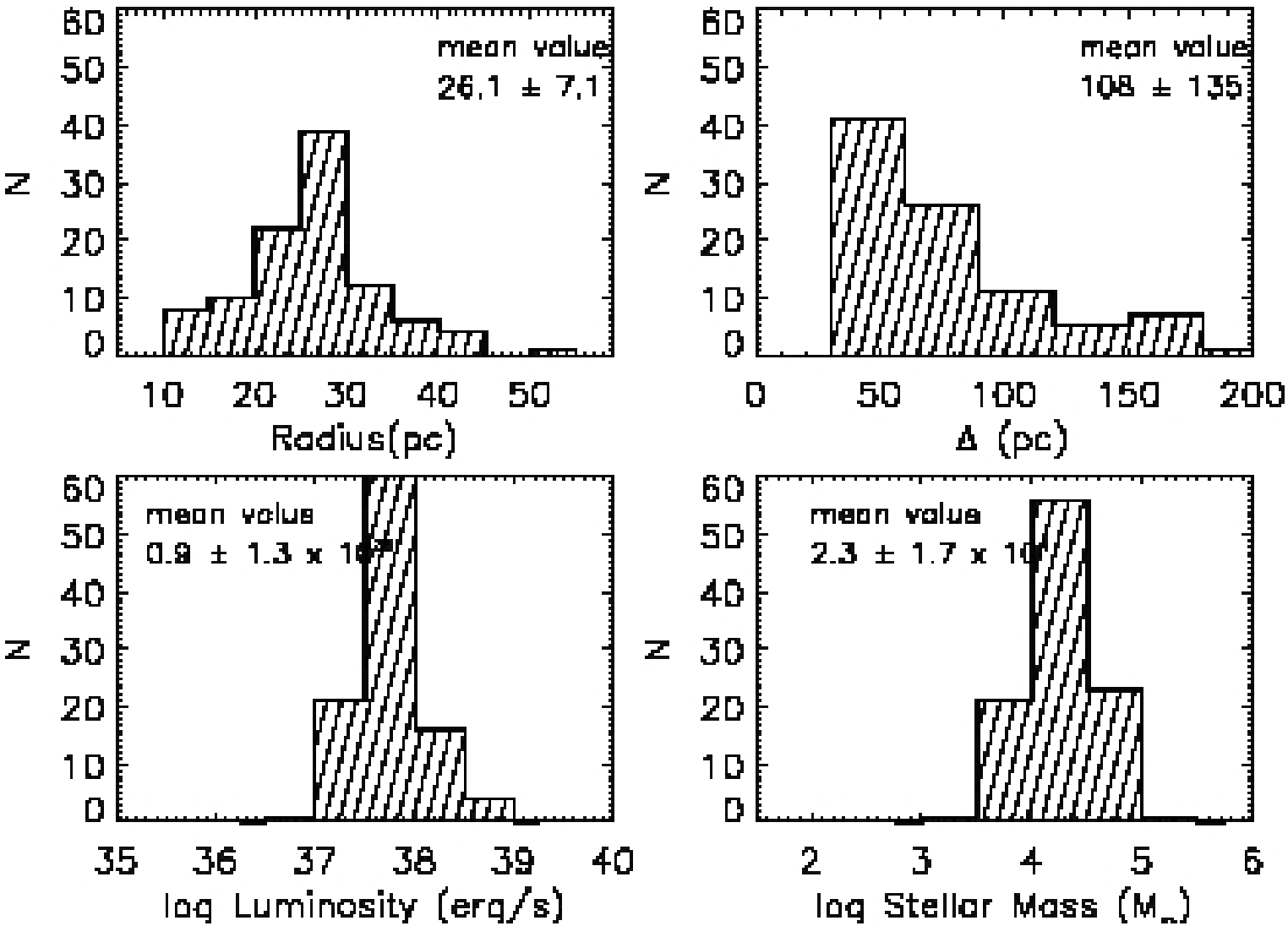
UV – NASA/GSFC/UIT

Hα – NASA/HST/D.Wang et a



# Results of NGC 4631

**102 SSCs**

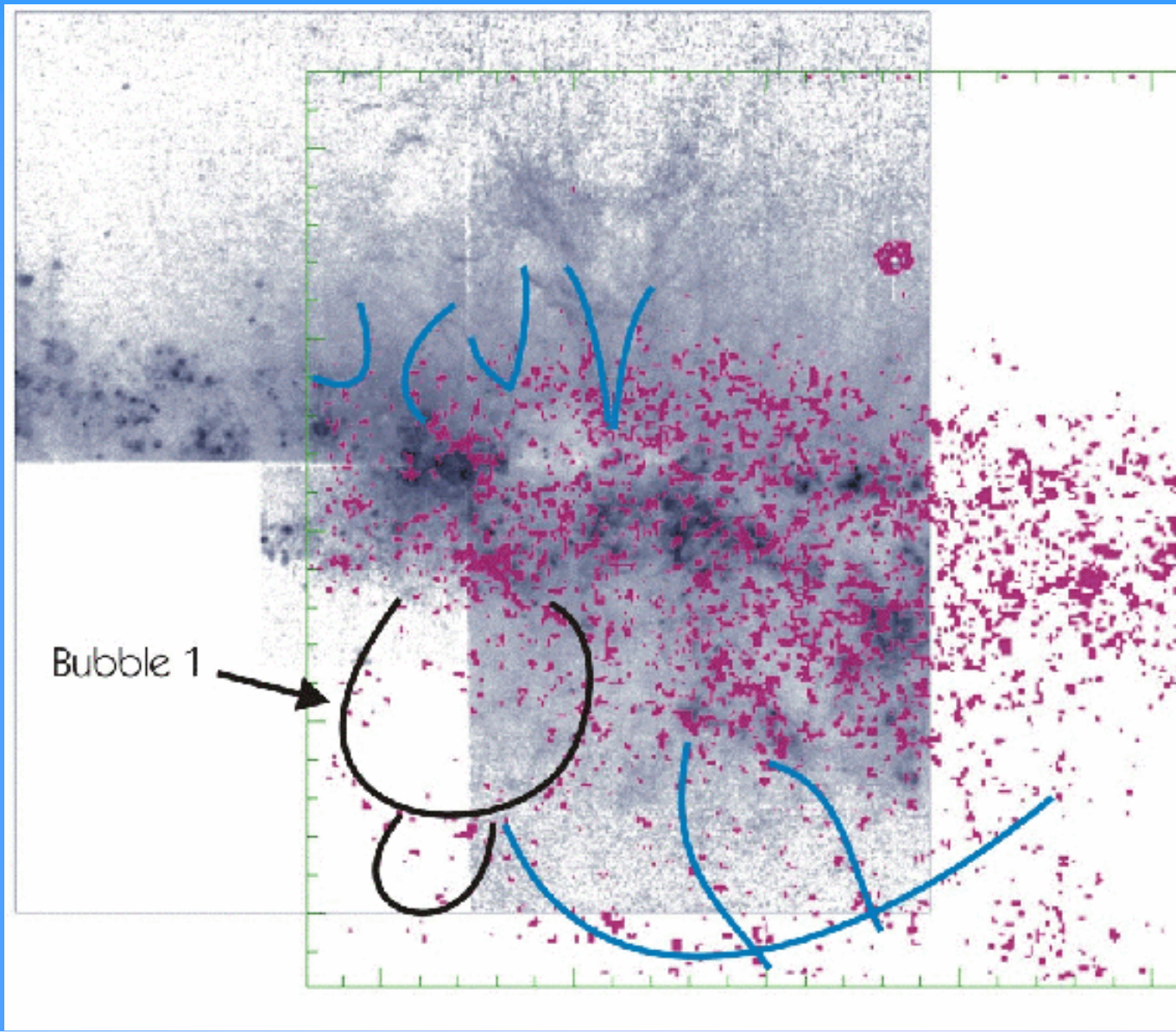


# Features of NGC 4631

Hα/HST image (bottom)

Red: where sigma is minimum (edges of bubbles)

Arcs and bubbles are drawed



# TAURUS cube analysis

- **We have studied the region #20+21** of NGC4631
- Check if bubble structure is real
- We measured size and velocity in the centre of the bubble:

**R = 1100pc -- V = 85 km/s**

- The mechanic luminosity **needed** to form this bubble is (*Tenorio-Tagle et al., 1996*):

$$E_{mec,vwind} = 5.804 \times 10^{40} \text{ erg/s}$$

- The mechanic luminosity of the burst inferred using Starburst99 is

$$E_{mec,burst} = 6.11 \times 10^{40} \text{erg/s}$$

*relevant parameters:*

-High density of SSCs

-Compact

-NEAR TO THE NEIGHBOR CLUSTERS!!

-High masses and luminosities

| G | | | | |
|---|---|---|---|---|
| M | | | | |
| N | | | | |
| NGC253 | 48 | 462 x 380 | 1p = 1.65pc (1"= 16.5pc) | 48 |

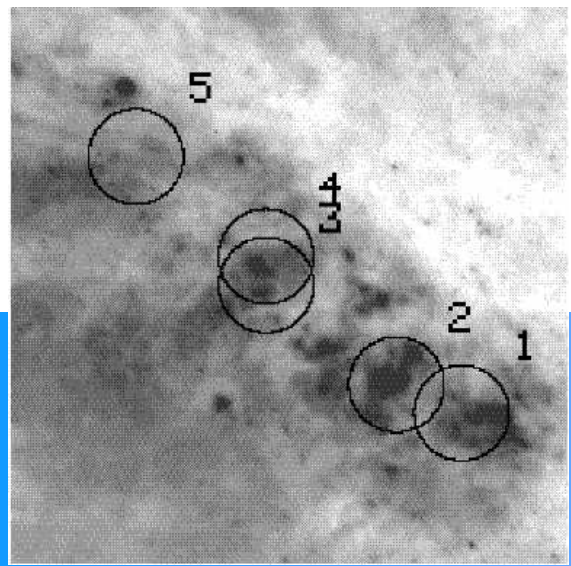
| Galaxy | R | D | L | F/area | Mass |
|---|---|---|---|---|---|
| M82 | 5.7 | 12 | $3.2 \times 10^{38}$ | $8.5 \times 10^{-17}$ | $1.7 \times 10^{5}$ |
| NGC4631 | 26 | 108 | $0.9 \times 10^{38}$ | $2.65 \times 10^{-18}$ | $2.3 \times 10^{4}$ |
| NGC253 | 5.0 | 31 | $2.3 \times 10^{38}$ | $4.6 \times 10^{-17}$ | $6.2 \times 10^{4}$ |

# Tipos de objetos según la edad para NGC 253
# ¿FIM de cúmulos?

*En el pasado...*

Regiones HII ultradensas

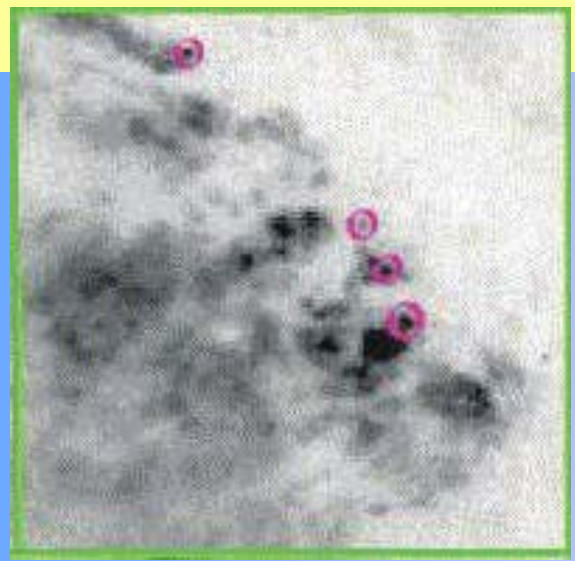
5 UDHII regiones en NGC253 (*Johnson et al. 2001*)




*En el presente...*

Super Cúmulos Estelares

4 SCE (*Watson et al. 1996*)



*En el futuro...*

Cúmulos Globulares

**Características UDHII**

*Tamaño*: pocos parsecs

*Masas estelares*: $10^{4-6} M$

*Luminosidades de ionización*: $Q_{Lyc} \sim 10^{51-53}$ s

*Edades*: pocos $10^5$ años

IYN

2003

ection

oposal

# NICMOS images

**NIR (2mm):**

**McCrady et al 2003**

