How galaxies form stars – Stockholm, 22 August 2016

CLUSTER FORMATION AND EVOLUTION IN M51

Matteo Messa

In collaboration with:

Angela Adamo

the LEGUS team

Introduction

1. SF is a hierarchical process

- Brings to formation of stellar groups and clusters
- **Clusters can be used to study SF**

2. Open question:

   Does the environment affect SF in YSC?

Introduction

YSC properties depends on the environment?

- Inside a galaxy
  - **M83** (Bastian+11,12, Silva-Villa+14, Adamo+15)
  - **NGC1566** (Hollyhead+16), **NGC628** (Adamo+16)
- From galaxy to galaxy
  - LEGUS (PI Calzetti): low Σ_{SFR} galaxies
  - Hi-PEEC (PI Adamo): high Σ_{SFR} galaxies

Introduction

YSC properties depends on the environment?

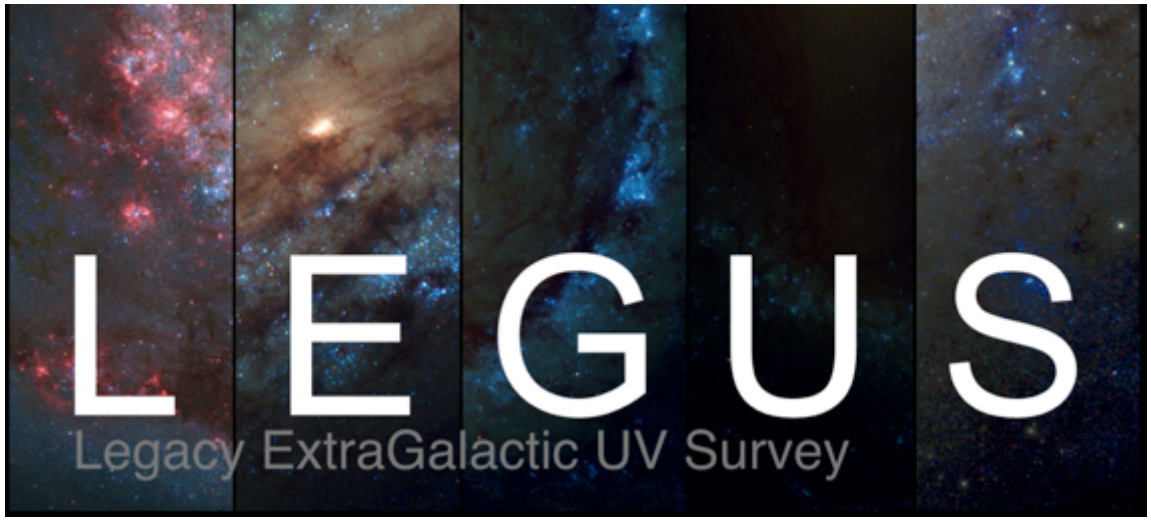
- Inside a galaxy
  - **M83** (Bastian+11,12, Silva-Villa+14, Adamo+15)
  - **NGC1566** (Hollyhead+16), **NGC628** (Adamo+16)
- From galaxy to galaxy
  - LEGUS (PI Calzetti): low Σ_{SFR} galaxies
  - Hi-PEEC (PI Adamo): high Σ_{SFR} galaxies

M51

Our dataset

Our data:

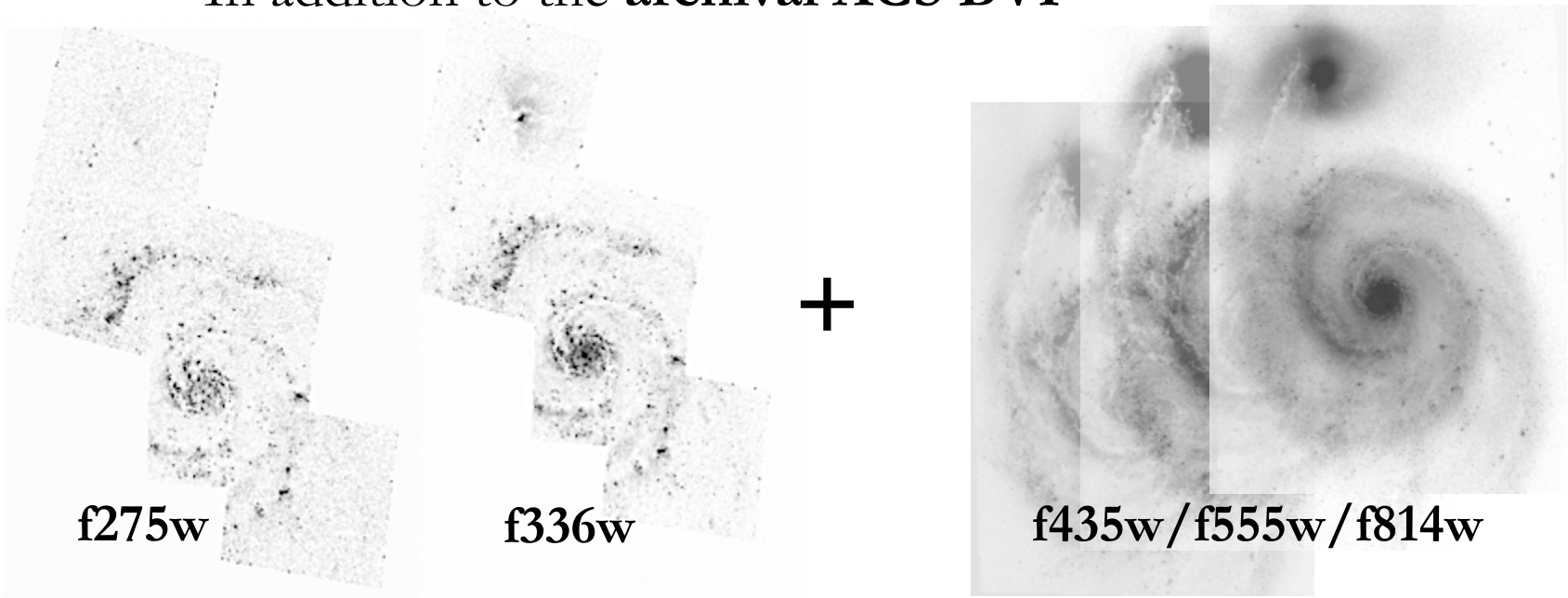
- New observations with HST
- Inside the LEGUS project (Calzetti+2015)



Our dataset

Our data:

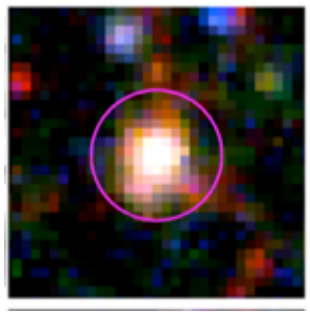
- New observations with HST
- **WFC3 - NUV and U band data** of M51
  - In addition to the **archival ACS BVI**

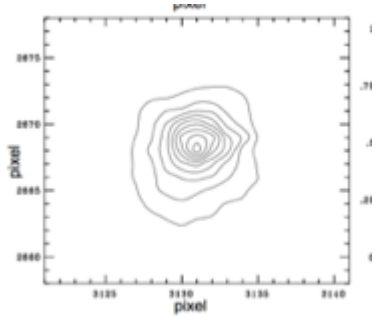


Our dataset

Our data:

- New observations with HST
- **WFC3 - NUV and U band data** of M51
  - Good ages & masses determination
- Why M51?
  - Large cluster population (~3000)
  - Near (< 8Mpc): clusters at limit of resolution





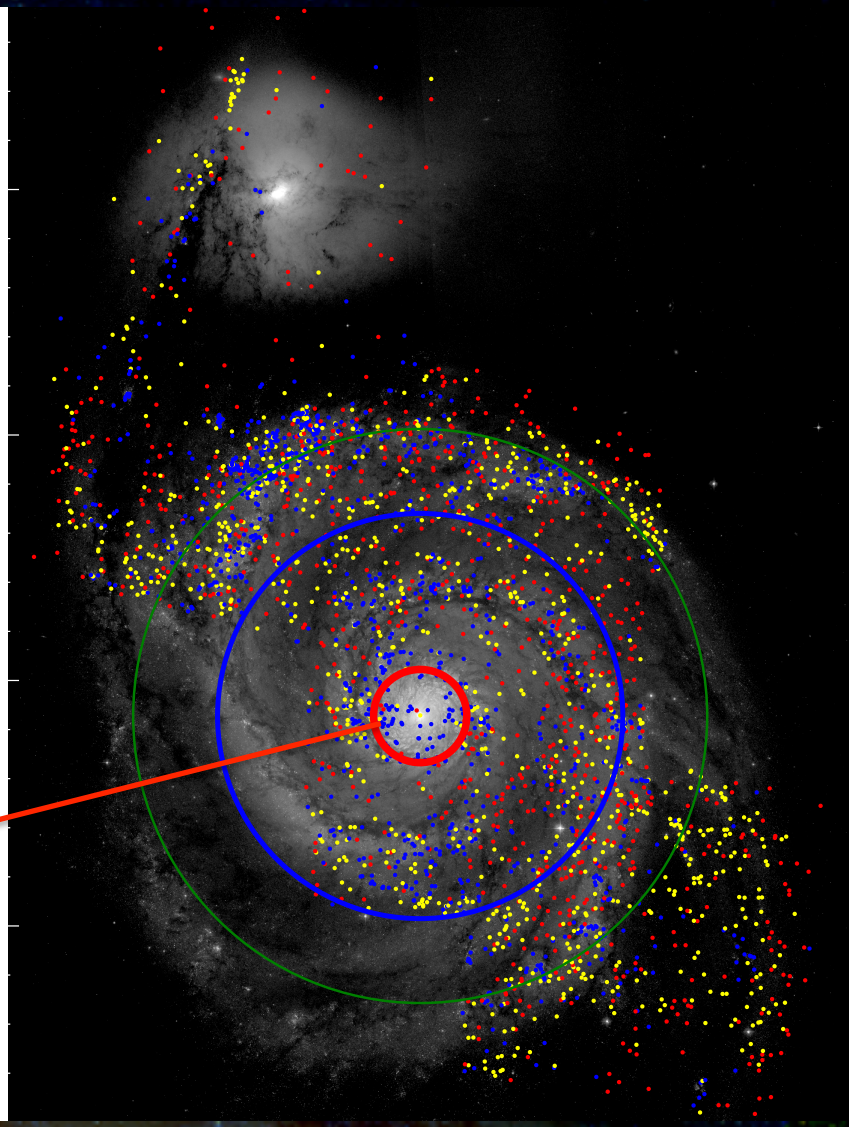
Age Function

Catalog of the cluster population

- Ages, masses and extinctions

To study the environment

- Division in bins
- Different bins trace different environments inside the galaxy



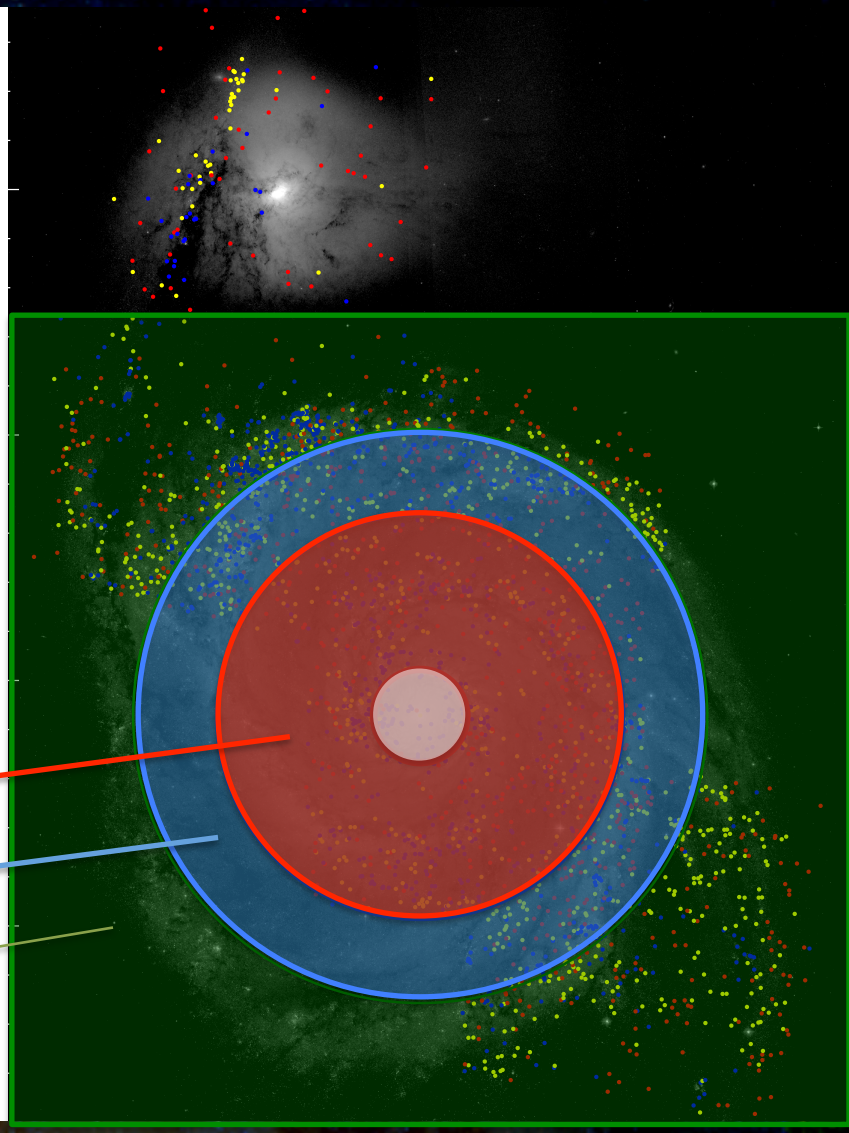
Age Function

Catalog of the cluster population

- Ages, masses and extinctions

To study the environment

- Division in bins
- Different bins trace different environments inside the galaxy



Analysis

How to study the cluster population?

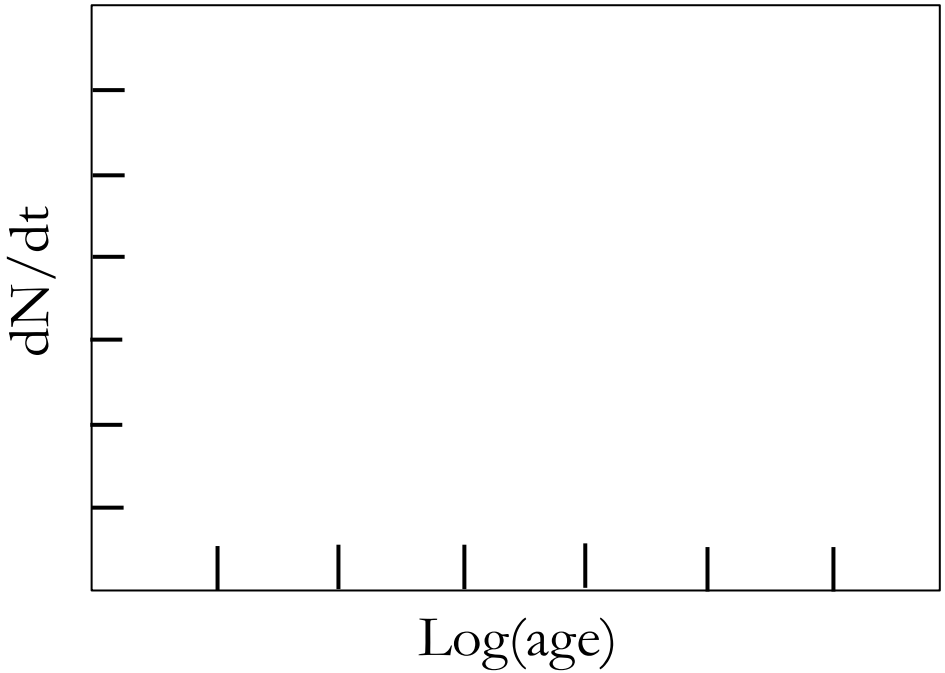
- 2 important properties:

1. Age function
2. Mass function

   – Cluster formation and disruption

Age function

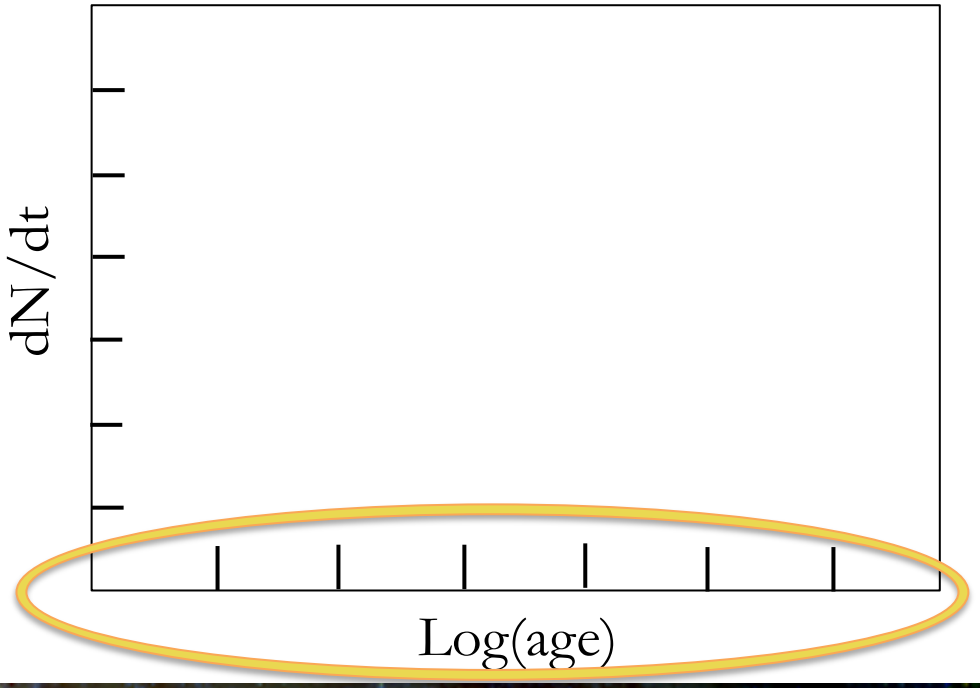
How sources are distributed in age: dN/dt



Age function

How sources are distributed in age: dN/dt

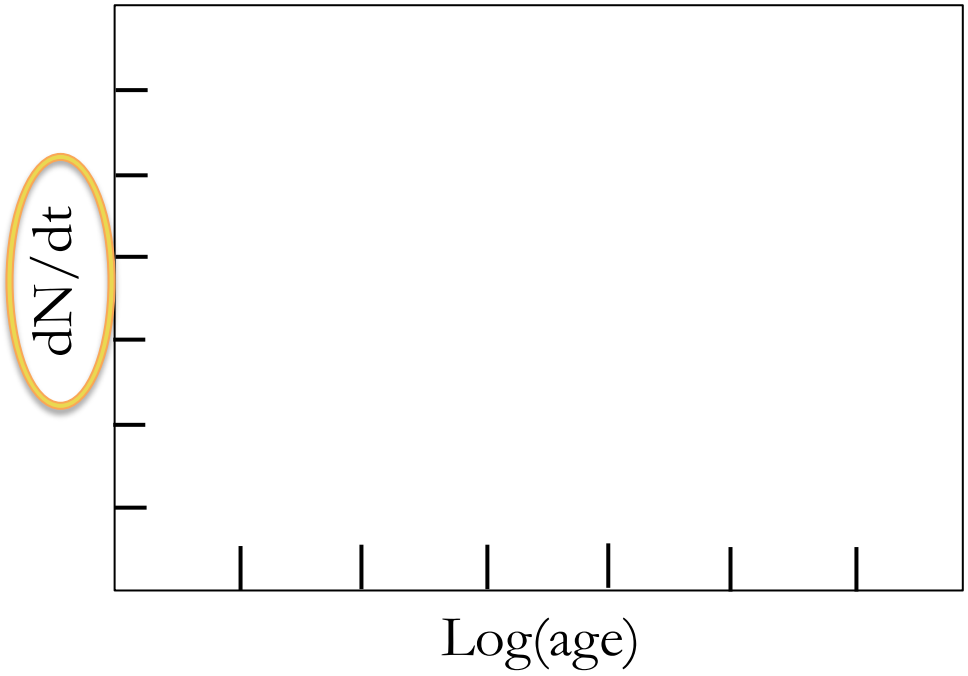
- Divide sources in age bins



Age function

How sources are distributed in age: dN/dt

- Divide sources in age bins
- Consider the number of sources in each bin (normalized)



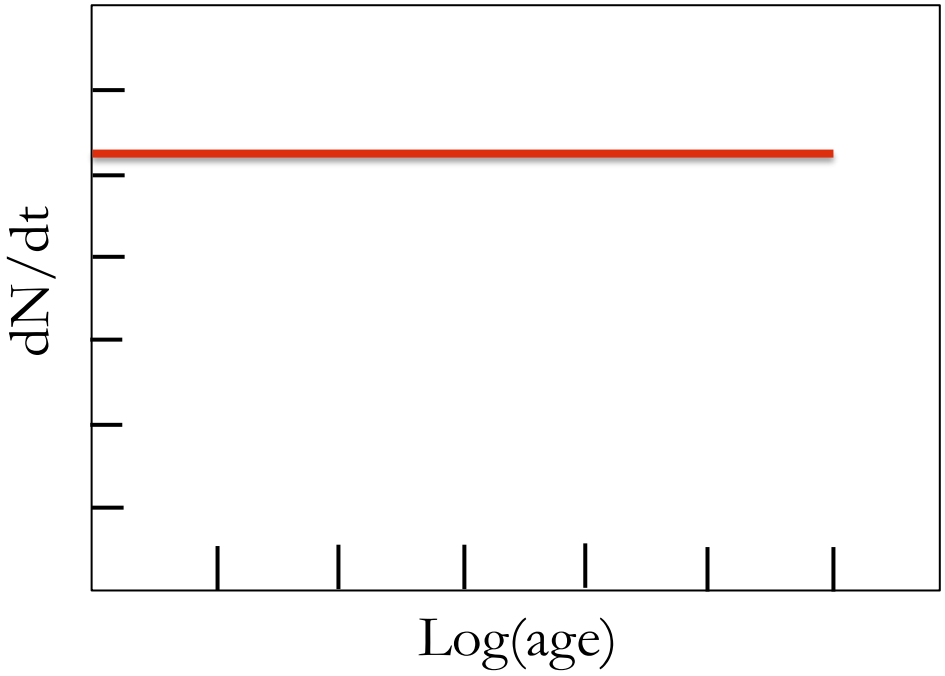
Age function

How sources are distributed in age: dN/dt

- Divide sources in age bins
- Consider the number of sources in each bin (normalized)

Constant SFR:

- Constant value



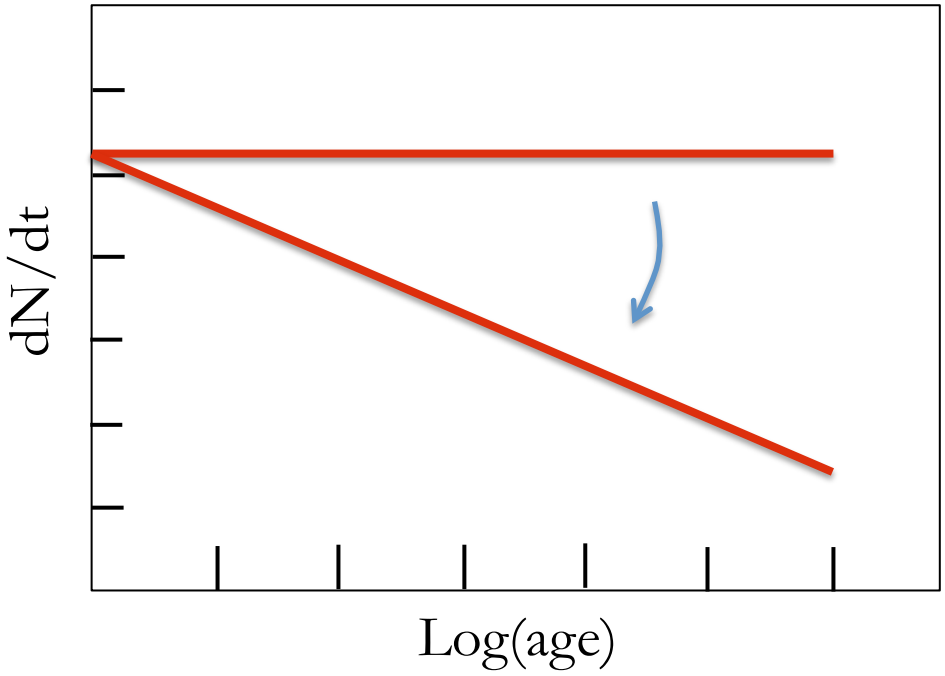
Age function

How sources are distributed in age: dN/dt

- Divide sources in age bins
- Consider the number of sources in each bin (normalized)

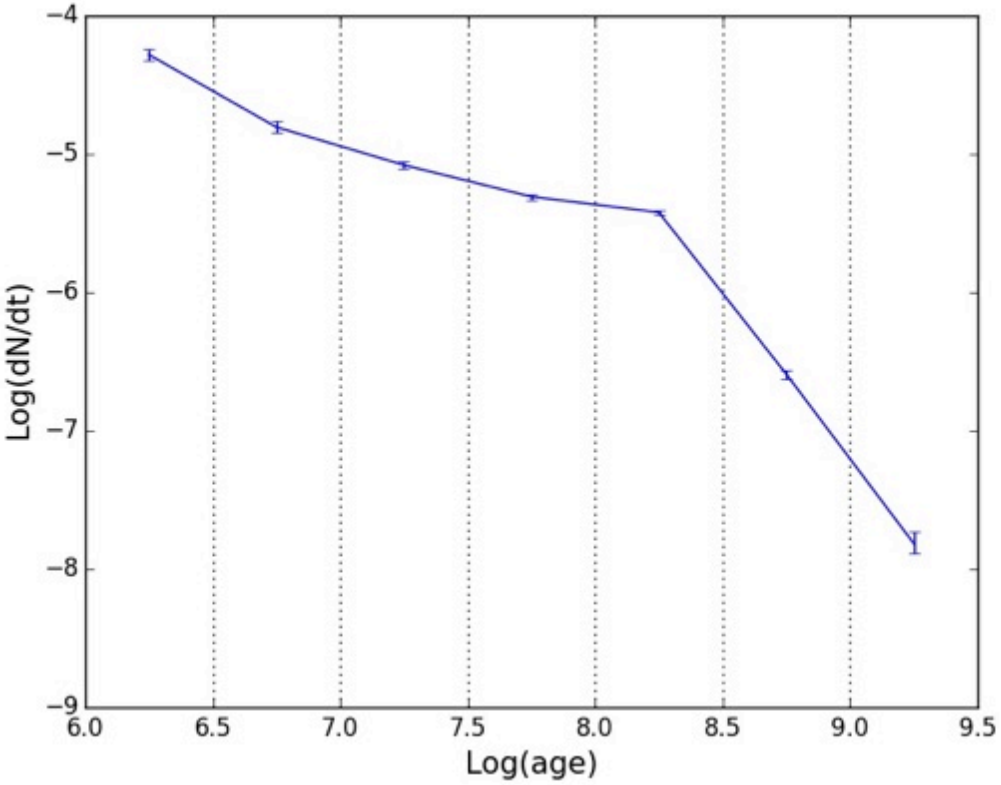
Constant SFR:
- Constant value

Disruption:
- Steepening
- Slope depends on the strength



Age function

We can build the age function of our population

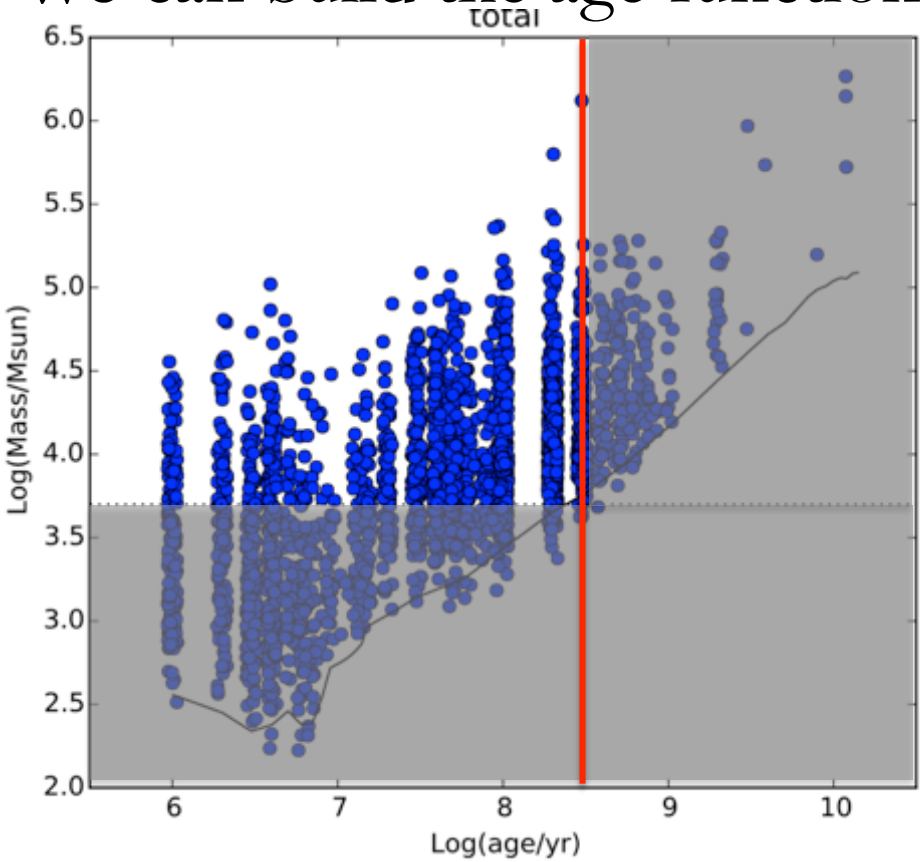


WARNING: Incompleteness!

Divided in bins of 0.5 dex

Age function

We can build the age function of our population

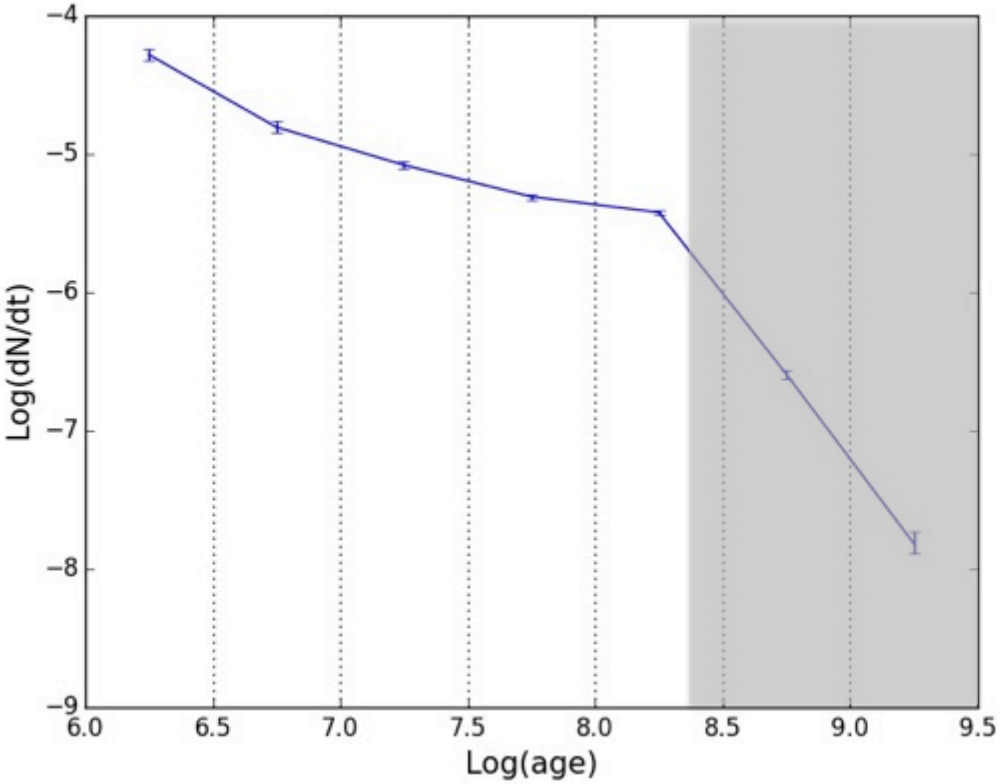


WARNING: Incompleteness!

Mass limited sample: $M > 5x10^3 M_{SUN}$

Age function

We can build the age function of our population

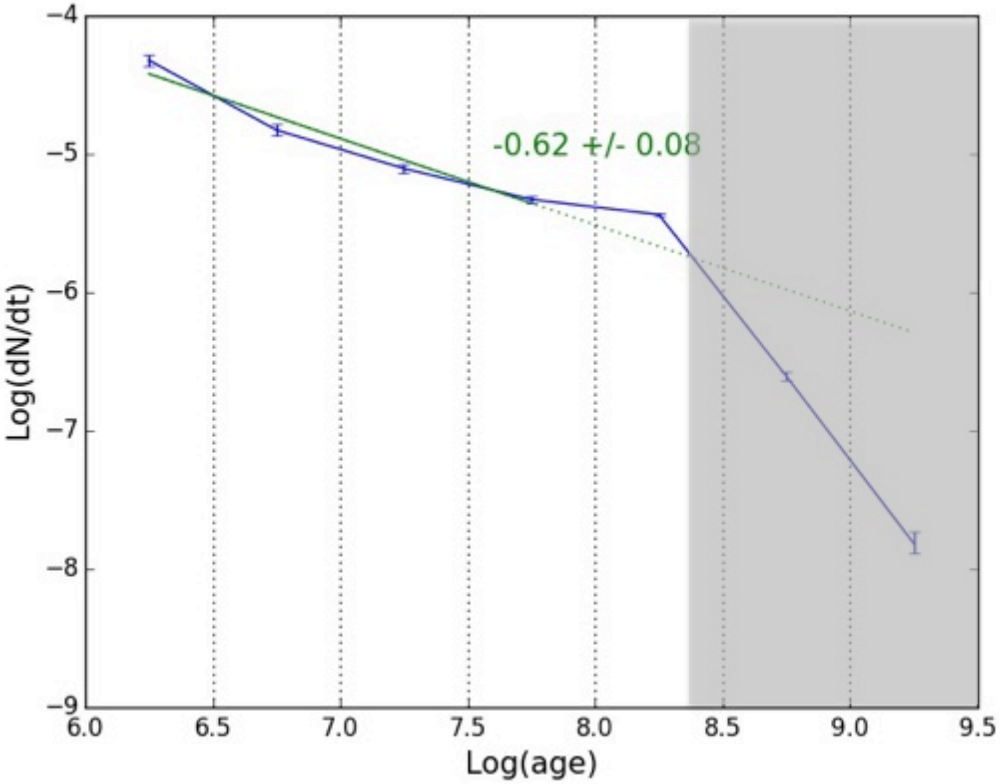


WARNING: Incompleteness!

Mass limited sample: $M > 5x10^3 M_{SUN}$

Age function

We can build the age function of our population



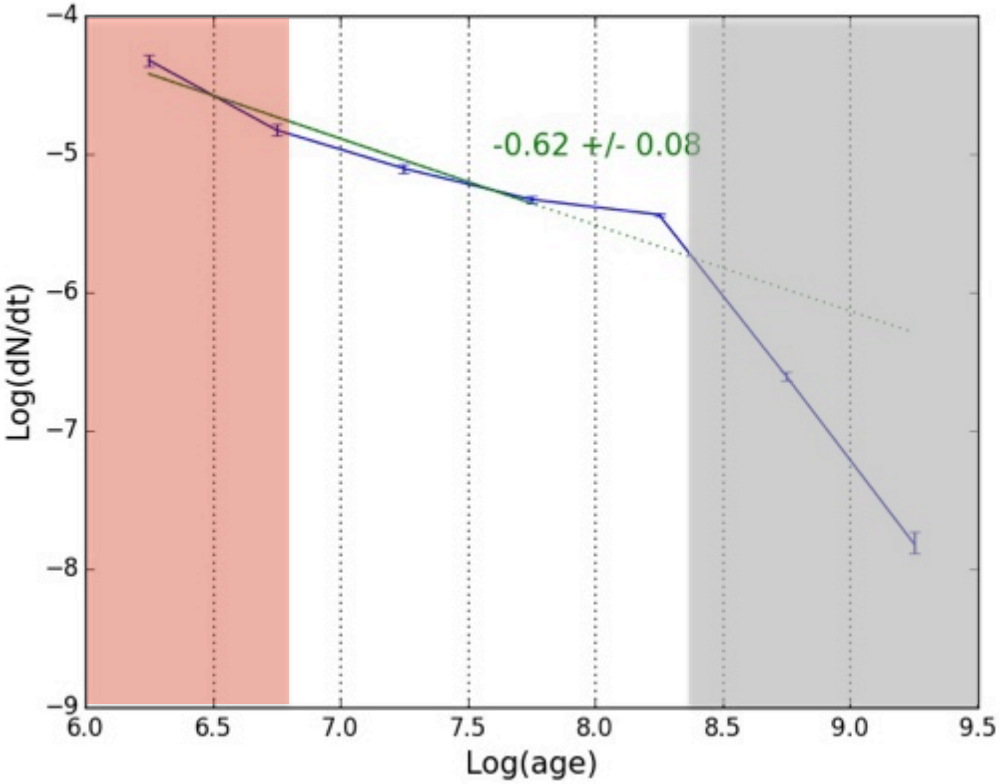
WARNING: Incompleteness!

Similar slope to previous works and e.g.:
Chandar+ 2016: -0.6/-0.7

Mass limited sample: $M > 5x10^3 M_{SUN}$

Age function

We can build the age function of our population



Mass limited sample: $M > 5x10^3 M_{SUN}$

WARNING: Incompleteness!

Similar slope to previous works and e.g.:
Chandar+ 2016: -0.6/-0.7

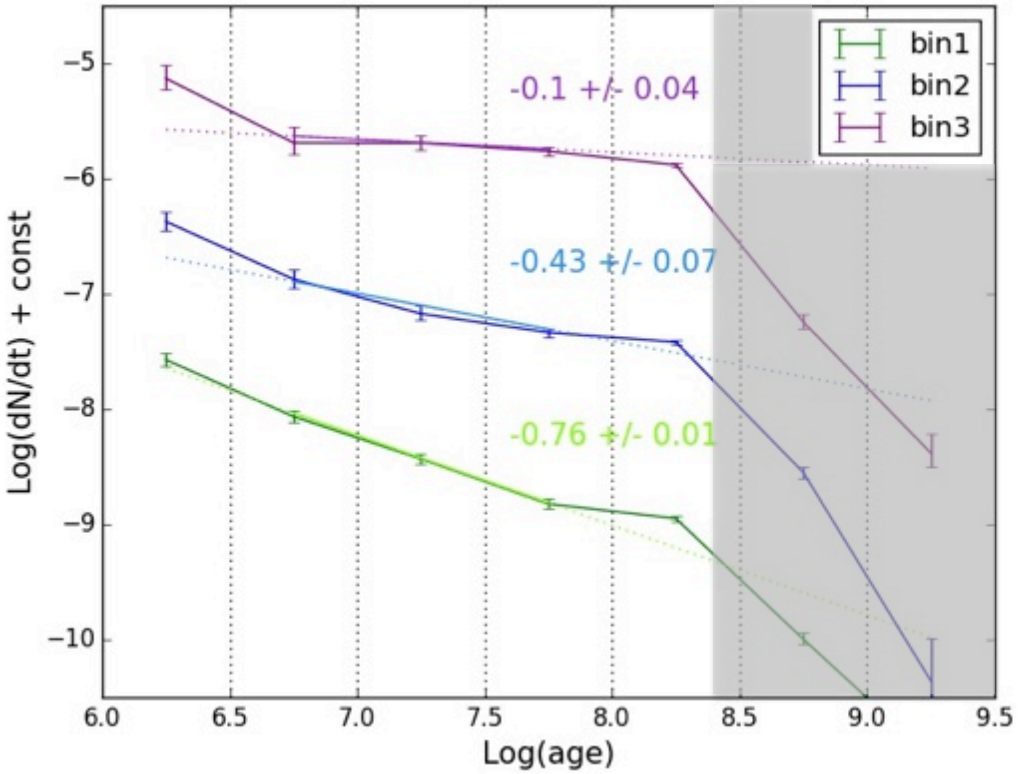
WARNING 2: young ages!

- Not well-constrained ages
- No dynamical info

Age function

Study the age in function of environment

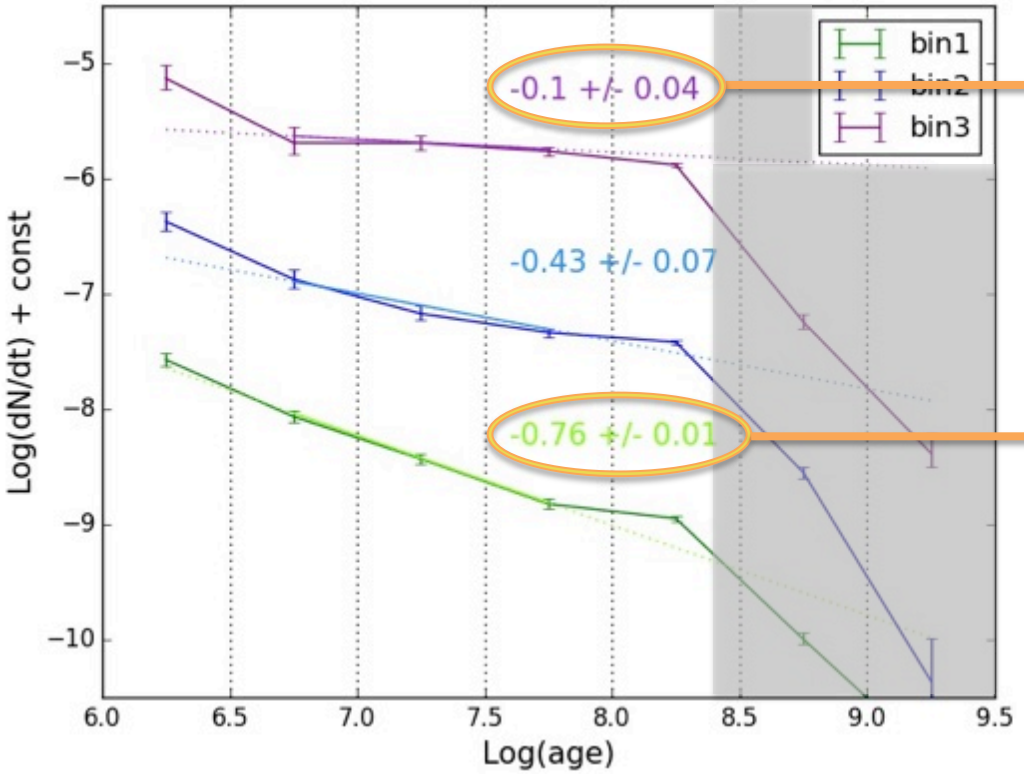
- Divide the sample in radial bins



Age function

Study the age in function of environment

- Divide the sample in radial bins



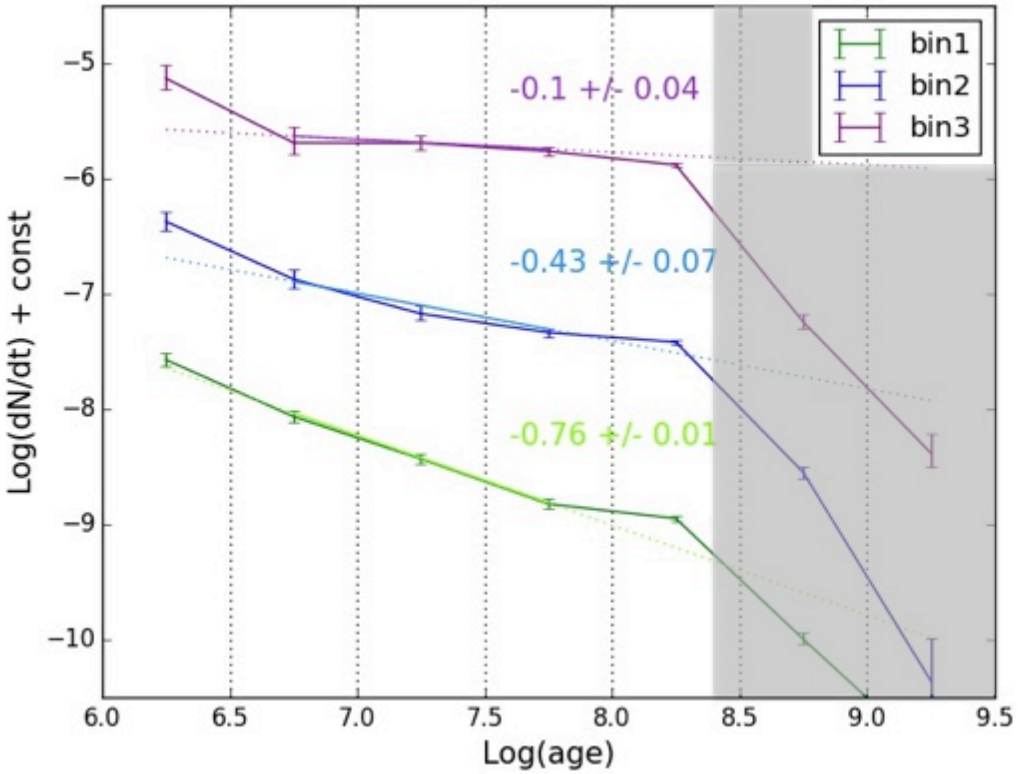
EXTERNAL:
~ no disruption

INTERNAL:
rapid disruption

Age function

Study the age in function of environment

- Divide the sample in radial bins



Stronger disruption towards the center

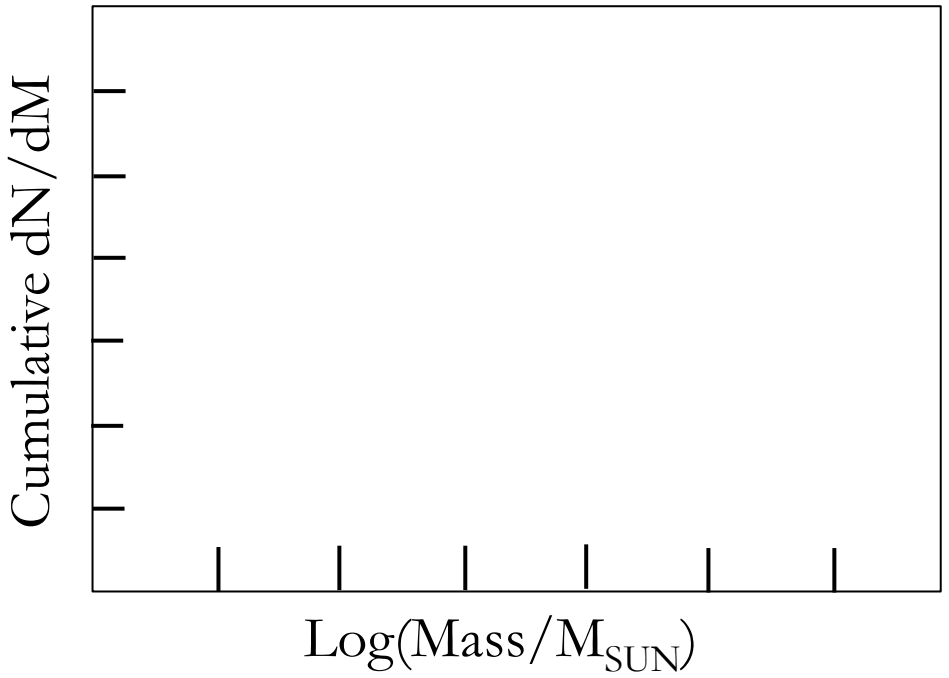
- Center is the densest region (GMC)
- Environmental dependence

Models: Elmegreen & Hunter 2010
Obs: M83 (e.g. Silva-Villa+14)
NGC628 (Adamo+in prep)

Mass function

How sources are distributed in mass: dN/dM

- We consider the cumulative function (e.g. Bastian+2012)
  - same behavior as the standard one
  - More sensitive at high masses



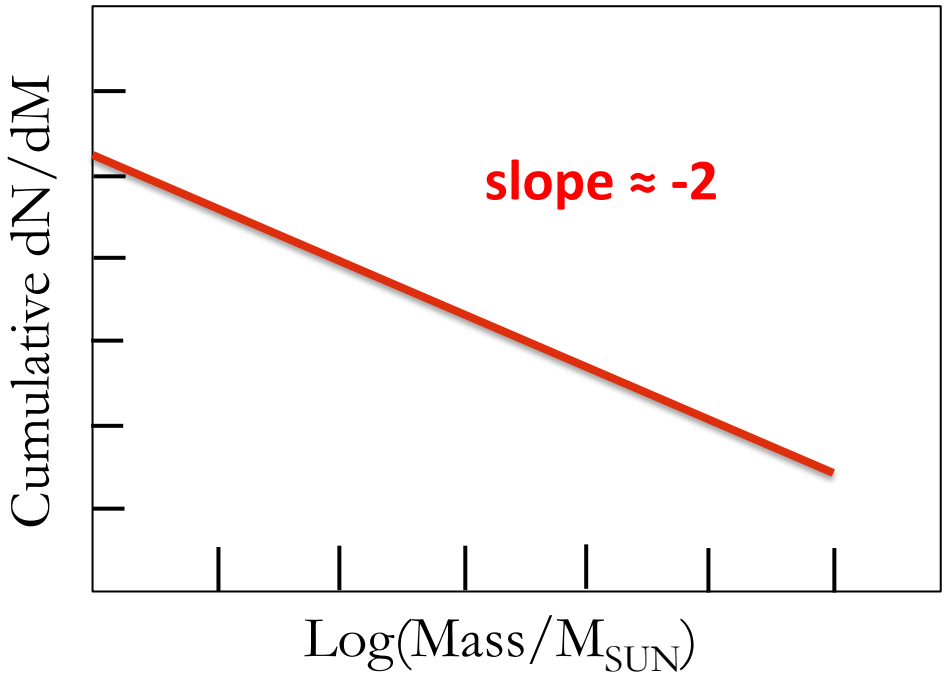
Mass function

How sources are distributed in mass: dN/dM

- We consider the cumulative function (e.g. Bastian+2012)
  - same behavior as the standard one
  - More sensitive at high masses

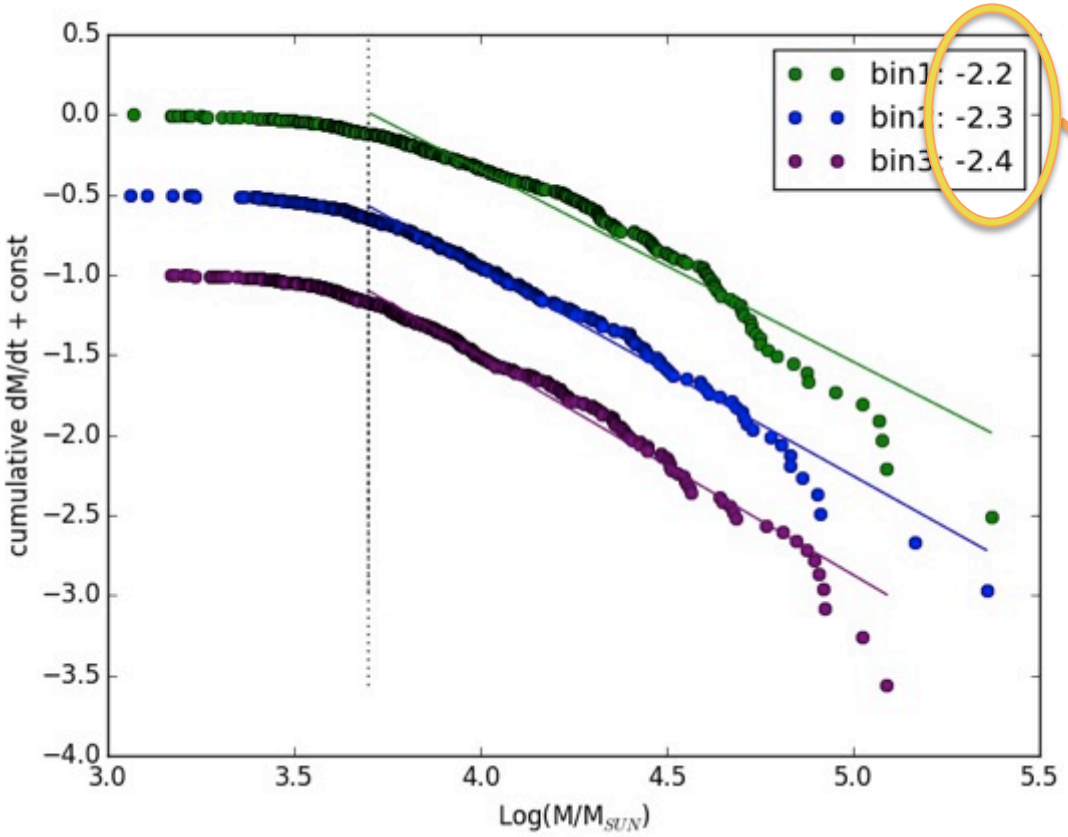
Power law with slope ≈ -2 in many different galaxies

- Hierarchy of star formation



Mass function

How sources are distributed in mass: dN/dM



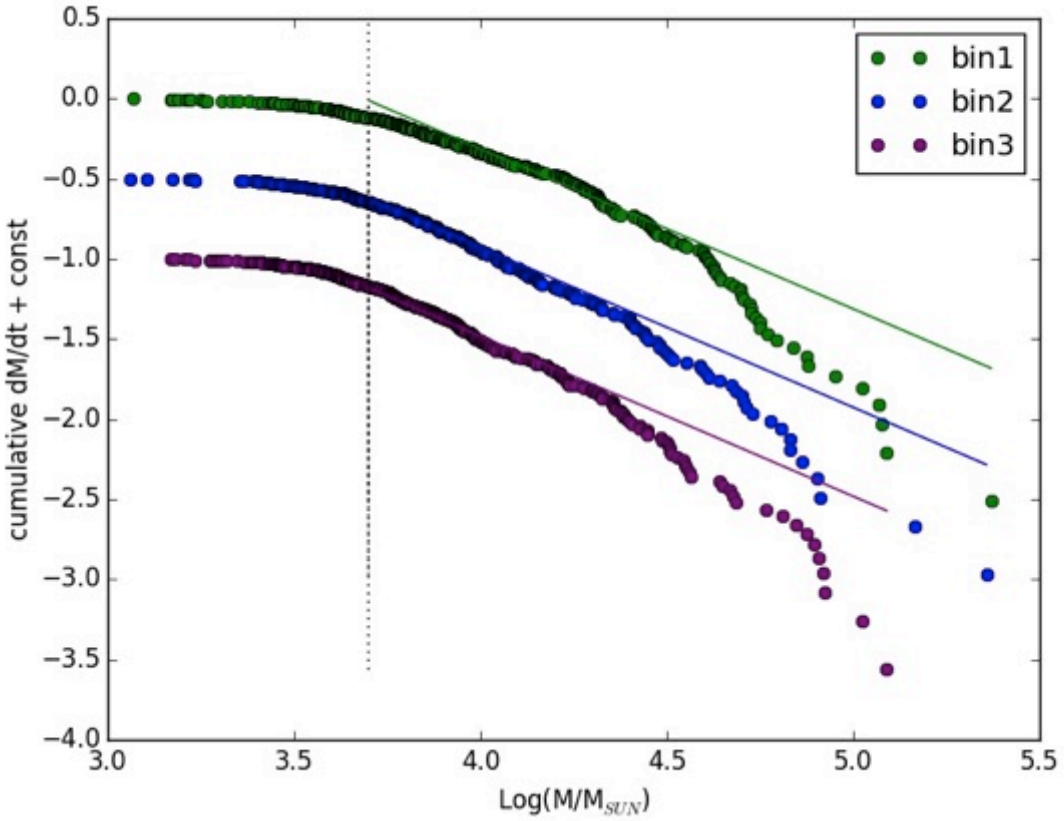
SIMPLE POWER LAW FIT

All $\gtrsim$ -2

Similar to older results:
Gieles+2009
Chandar+2016

Mass function

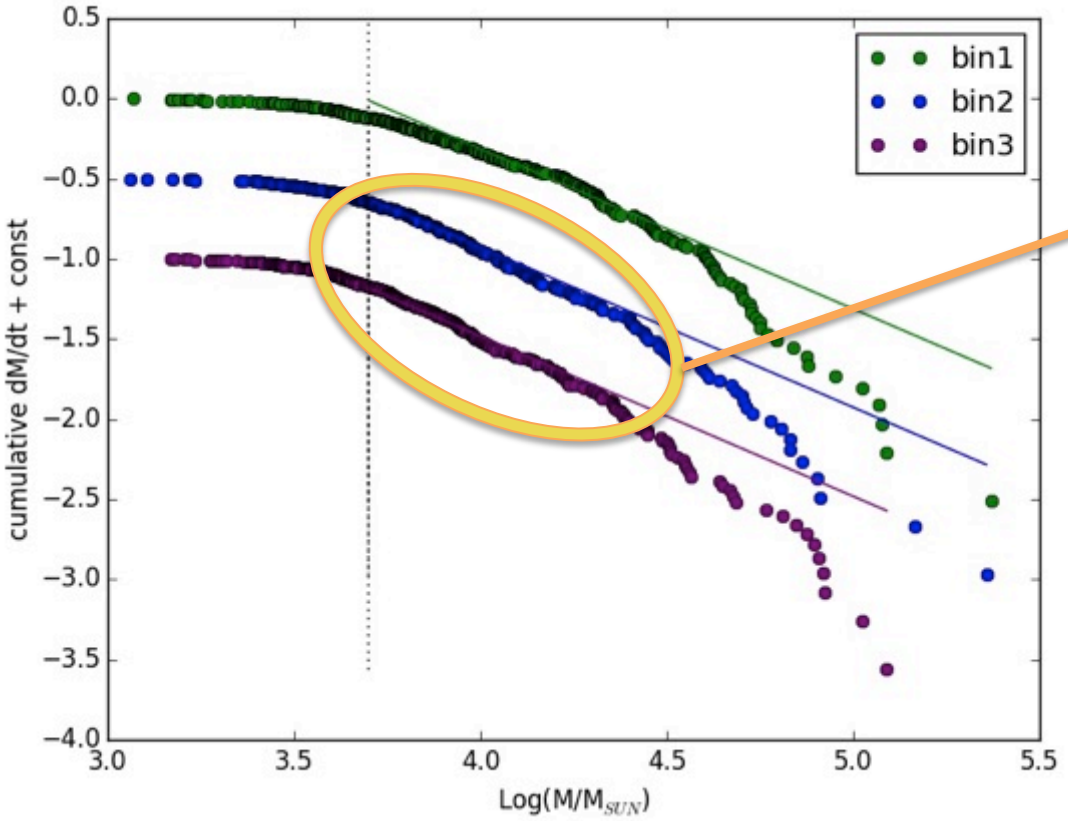
How sources are distributed in mass: dN/dM



-2 SLOPE

Mass function

How sources are distributed in mass: dN/dM

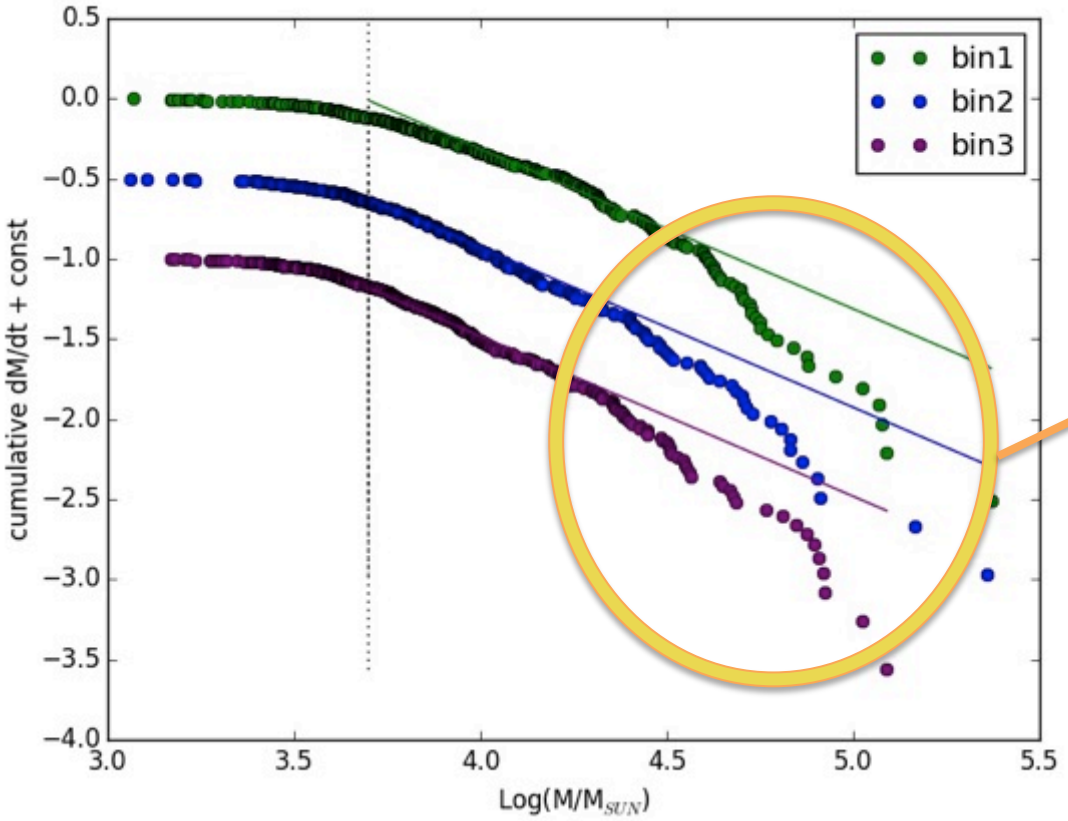


-2 SLOPE

Good description of the low-mass part

Mass function

How sources are distributed in mass: dN/dM



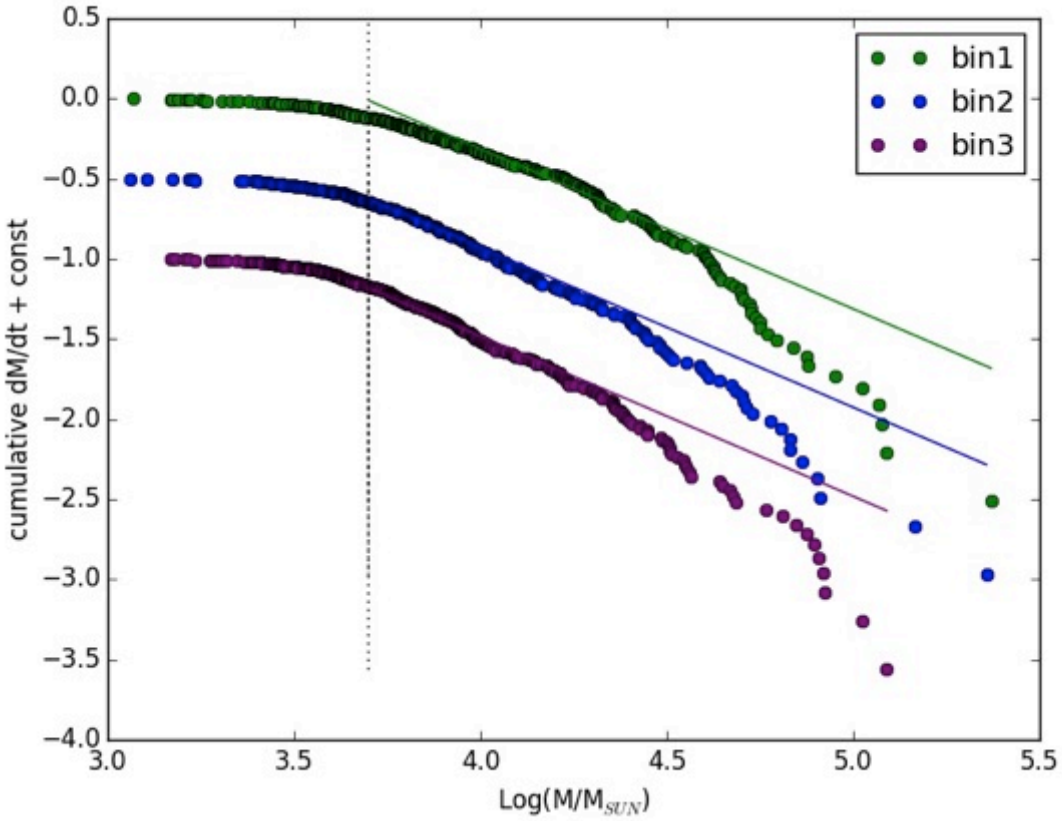
-2 SLOPE

Good description of the low-mass part

Not good at high masses (few sources)

Mass function

How sources are distributed in mass: dN/dM



-2 SLOPE

Good description of the low-mass part

Not good at high masses (few sources)

Cutoff mass higher in the center

Schechter function – cutoff mass

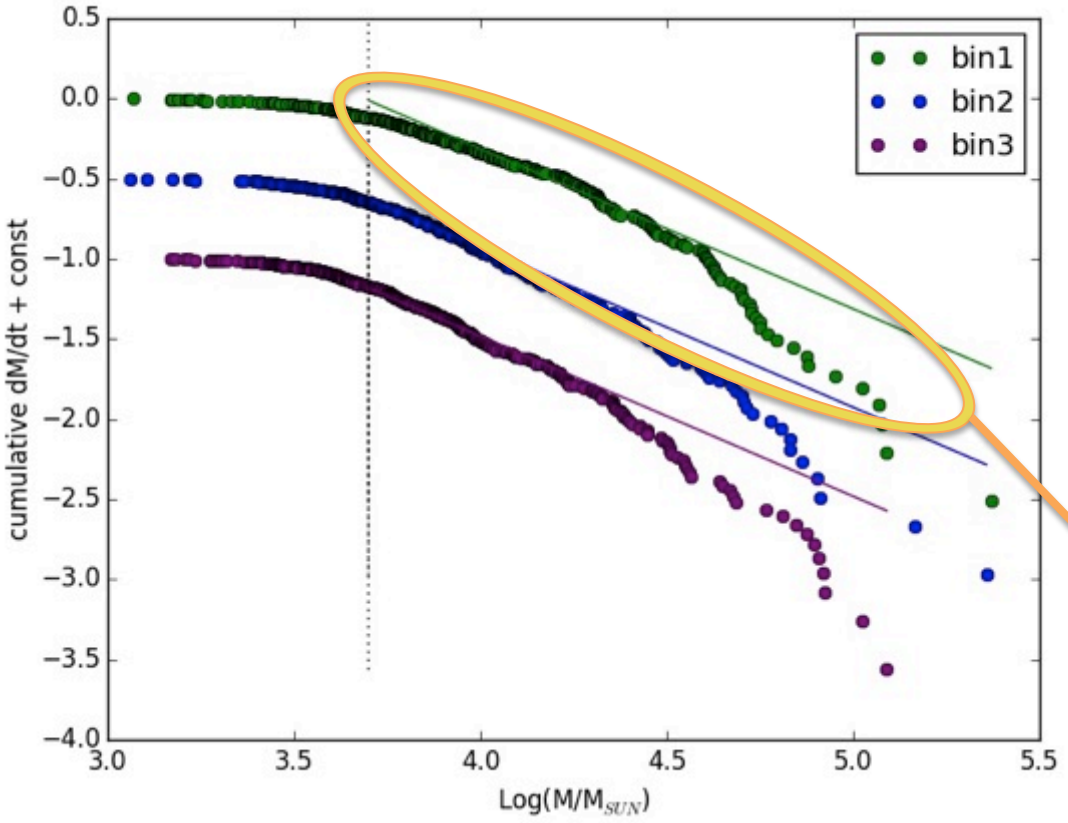
BIN1: $1.37 \times 10^5 M_{SUN}$

BIN2: $0.86 \times 10^5 M_{SUN}$

BIN3: $0.86 \times 10^5 M_{SUN}$

Mass function

How sources are distributed in mass: dN/dM



-2 SLOPE

Good description of the low-mass part

Not good at high masses (few sources)
Cutoff mass higher in the center

Not a good description of the **internal bin**

- Evolved function?

Combined analysis → future

Conclusions

Do YSC properties depends on the environment?

Catalog:

~3000 clusters with well-determined ages and masses

Age function:

Disruption is stronger near the center of the galaxy

Mass function:

Cutoff mass is higher in the center of the galaxy

Conclusions

Do YSC properties depends on the environment?

FUTURE:
Combined analysis of ages and masses

Mention again:

Increase number of galaxies:

- LEGUS
- Hi-PEEC