# What will become of 30 Doradus?

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E. Terlevich et al (2018) MNRAS, 481, 268-276

**The Tarantula Nebula**
**Image Credit & Copyright:** Processing - Robert Gendler, Roberto Colombari
Data - Hubble Tarantula Treasury, European Southern Observatory

Massive starforming regions like Giant HII Regions (GHIIR) and HII Galaxies (HIIG) are emission line systems ionized by compact young massive star clusters (YMC) (or complexes) with masses ranging from $10^4$ $M_\odot$ to $10^8$ $M_\odot$.

The possible connection between YMCs and globular clusters (GCs) has been discussed in the literature mostly in relation with YMC found in the central galaxy of the Perseus cluster [NGC 1275; (Shields & Filippenko 1990; Holtzman et al. 1992)] in the central regions of interacting galaxies (Portegies Zwart et al. 2010) and in local group galaxies like the LMC and SMC.

Comparable masses and sizes of YMC and GC lead
to the belief that there might be an evolutionary connection
between these massive clusters posing the logical question
of whether YMC could be young GC. (Though interacting galaxies YMC have higer metallicities and are in dense environments).

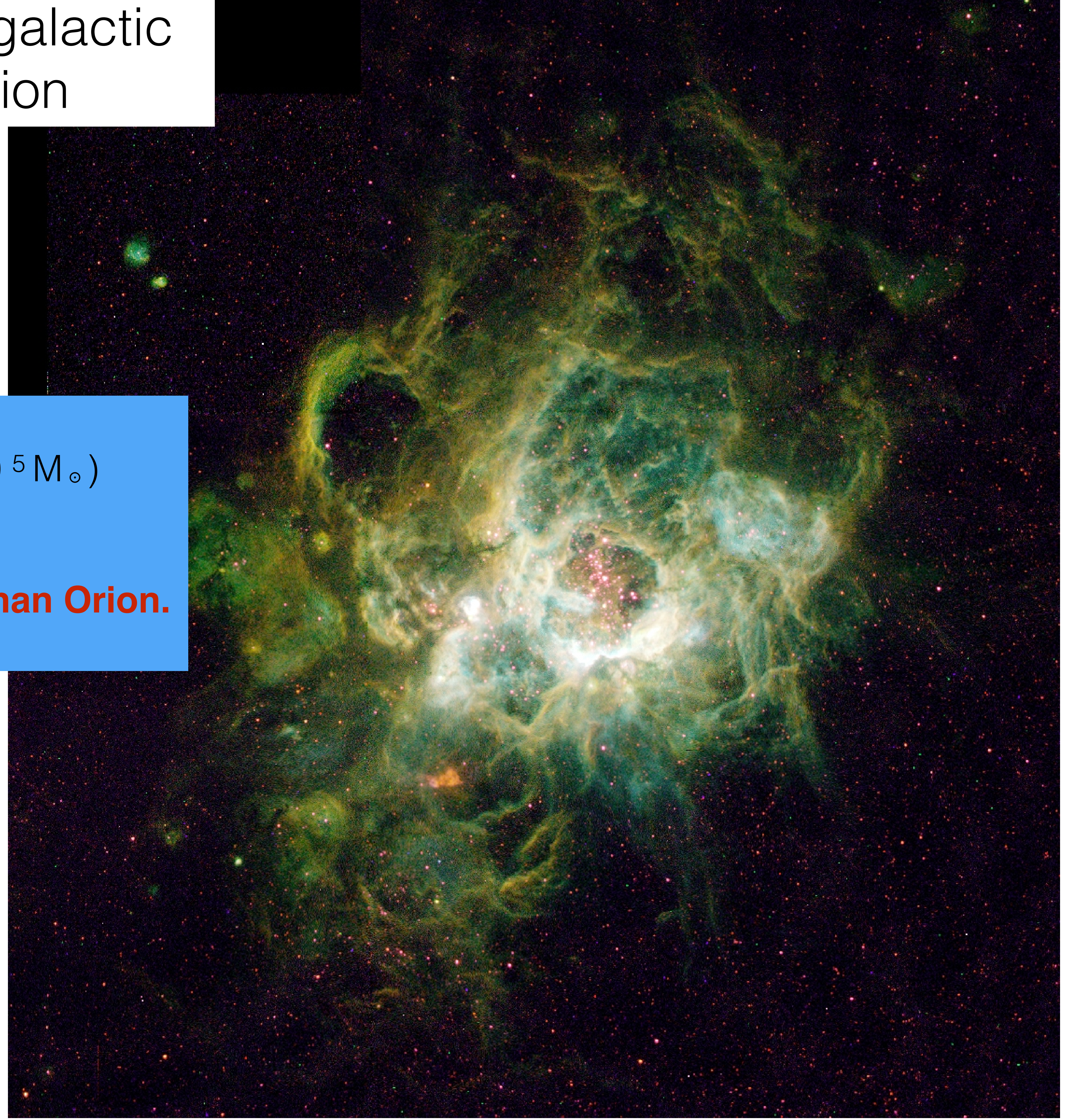
While the YMC that ionize the GHIIR in dwarf irregular galaxies and in the outer regions of late spirals, have a range of masses and element abundances (oxygen, neon, sulphur, argon) substantially subsolar, similar to those found in GCs.

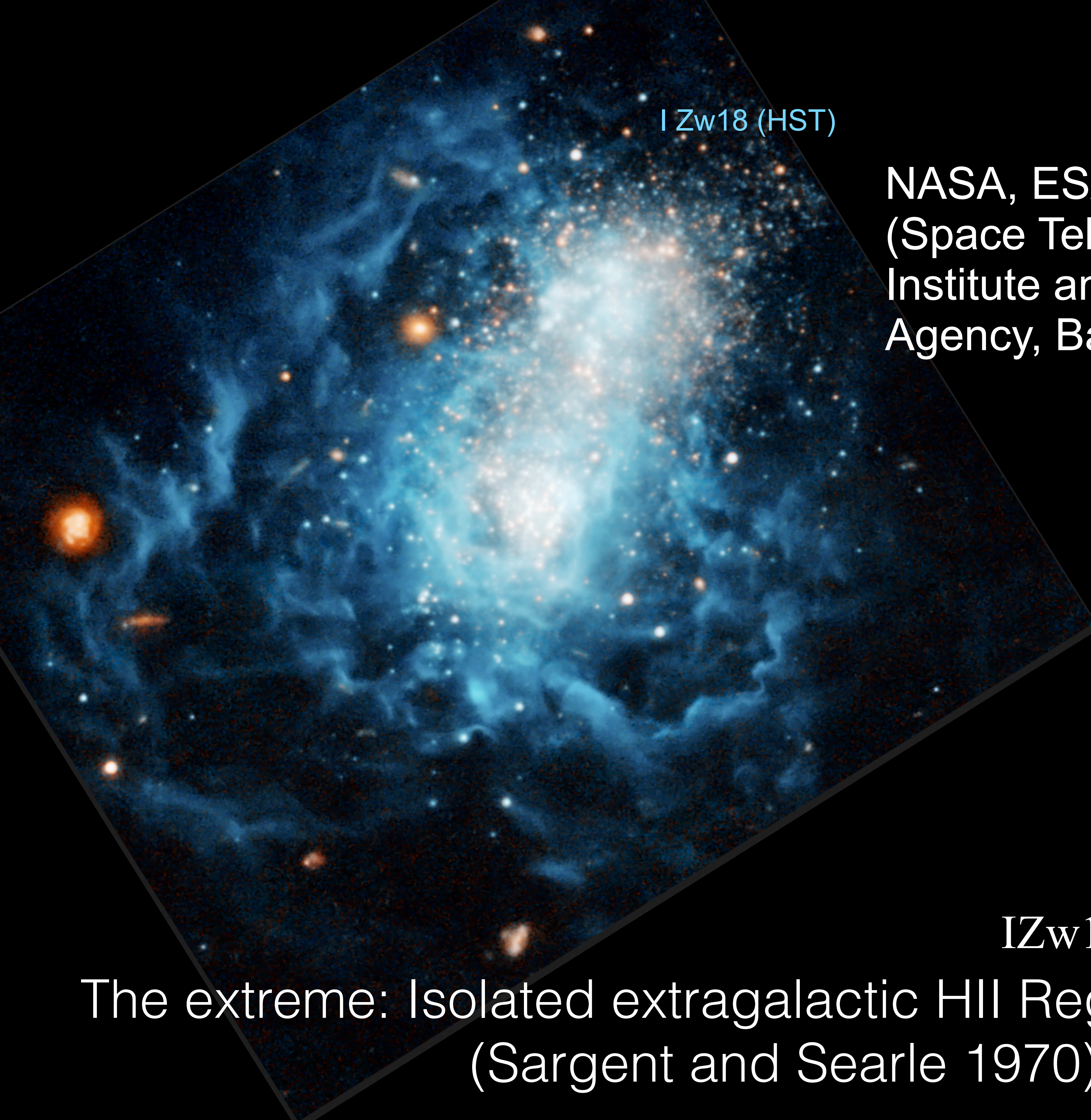
In particular there have been suggestions
that 30-Dor, the prototypical GHIIR in the LMC,
could be a GC progenitor given its mass, size and metal content (e.g. Meylan 1993).

# **Giant** Extragalactic HII Region

**NGC 604 in M 33**
**460 pc**
**de diámetro**

Gas photoionized by
a super cluster ($M > \sim 10^{5} M_{\odot}$)
of hot-young
massive O-B stars.
**Much more massive than Orion.**



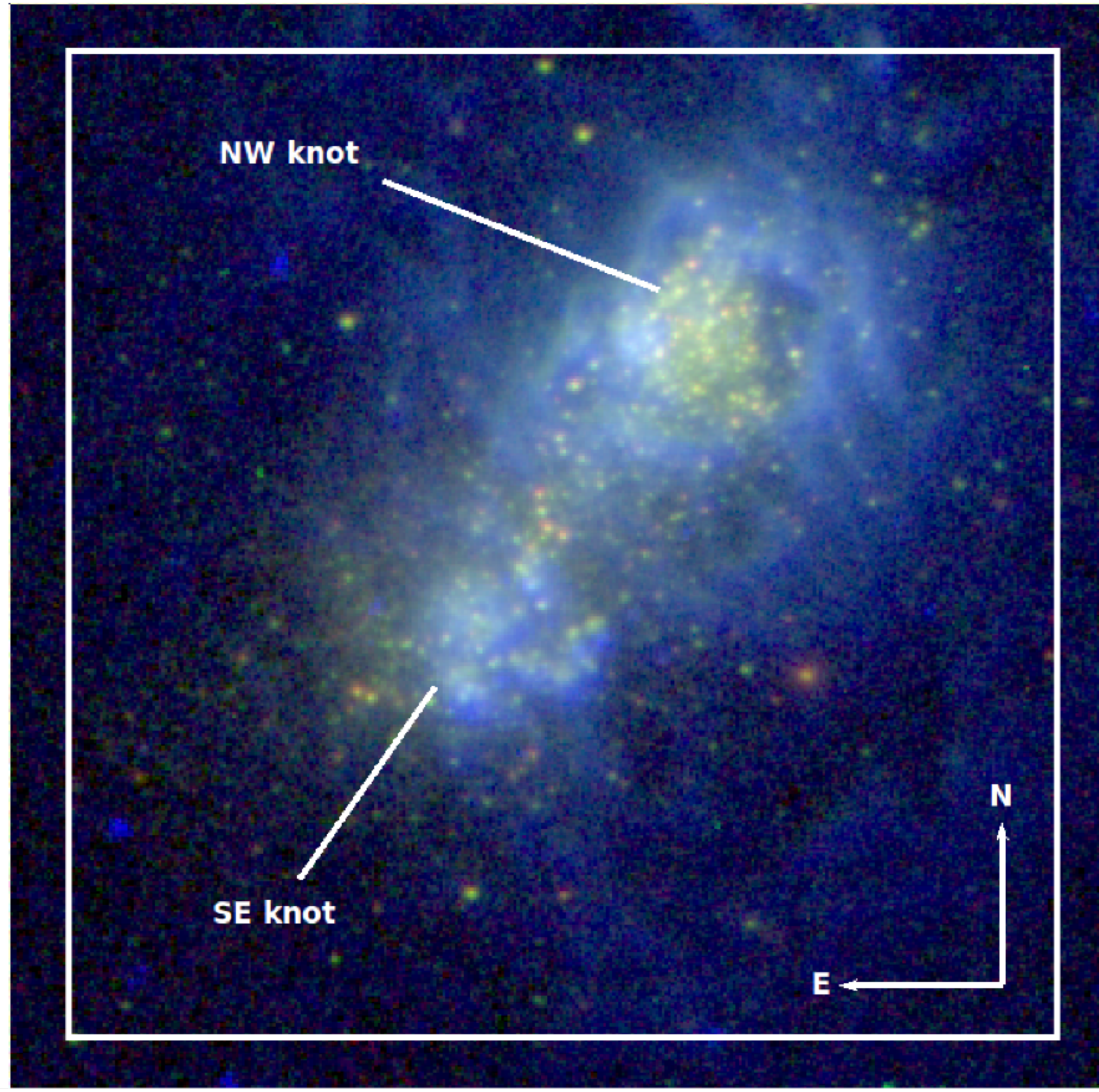



NASA, ESA, and A. Aloisi (Space Telescope Science Institute and European Space Agency, Baltimore, Md.)

IZw18

The extreme: Isolated extragalactic HII Region (HII Galaxy)
(Sargent and Searle 1970)

Kehrig et al. 2016



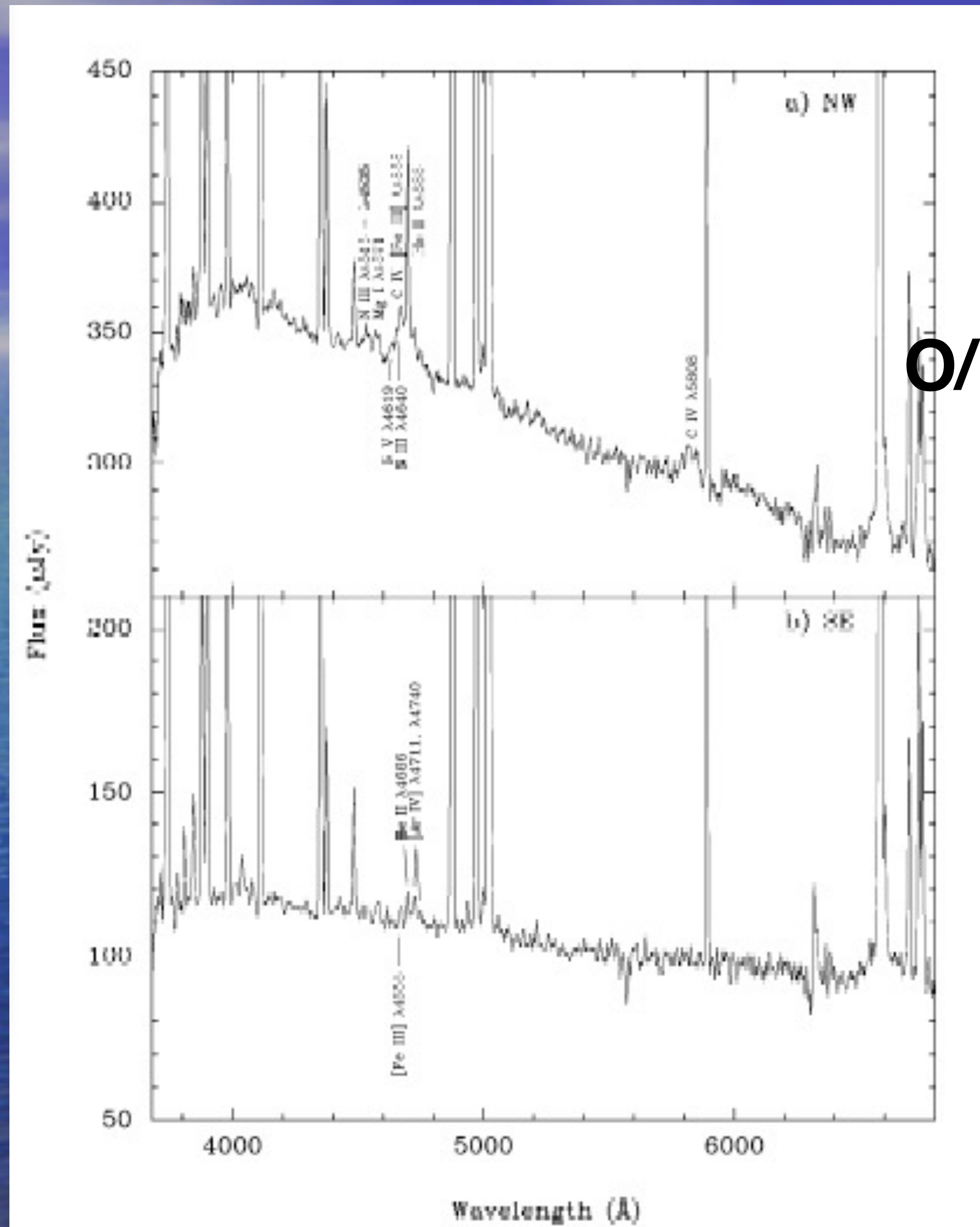

Spatially resolved integral field spectroscopy of the ionized gas in IZw18★

Mon Not R Astron Soc. 2016;459(3):2992-3004. doi:10.1093/mnras/stw806

# I Zw 18

NW

SE




O/H~1/50th Solar

The HIIR spectrum dominates the galaxy

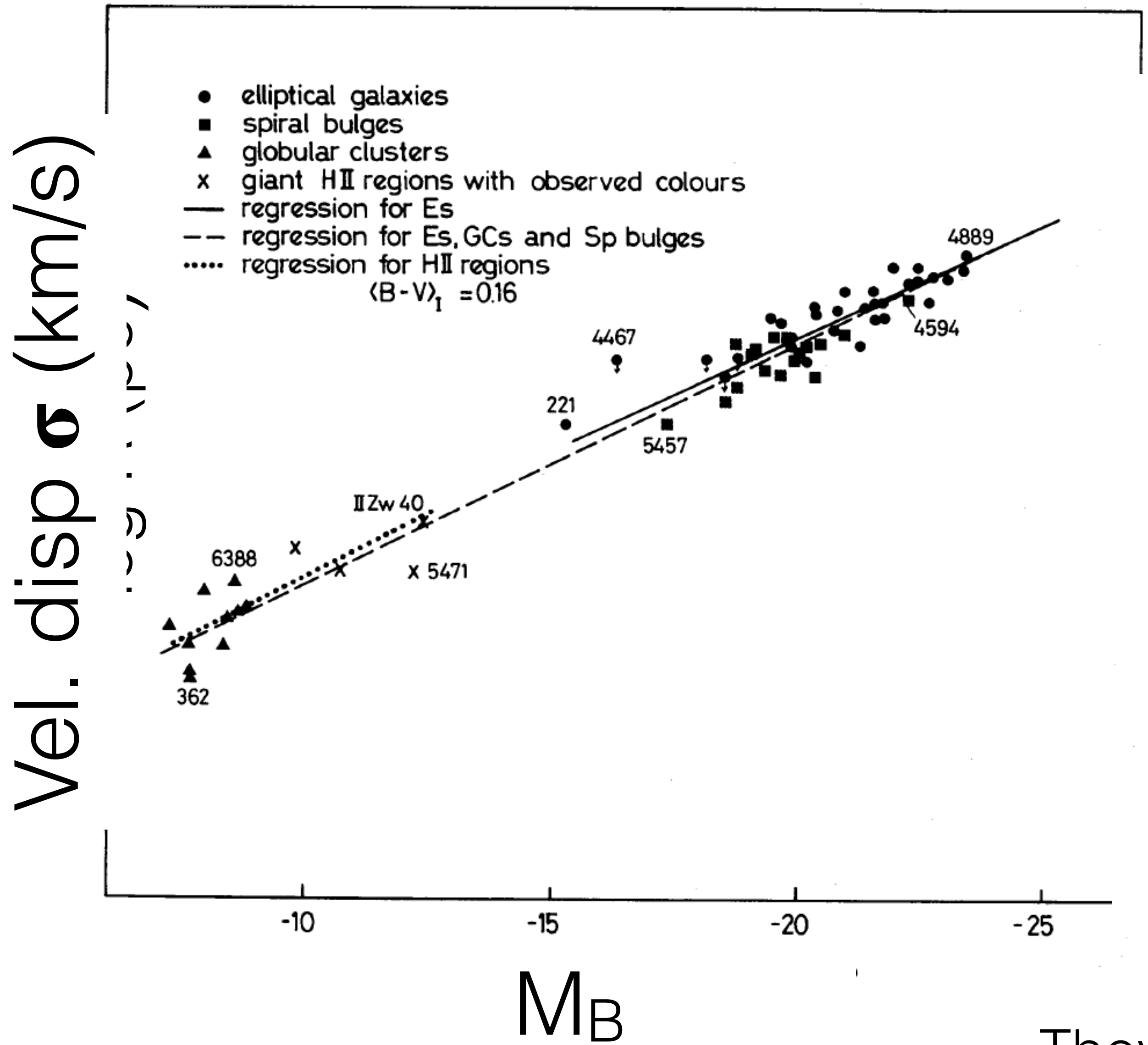
We have found (Chavez et al. 2014; Terlevich et al. 2015) that the properties of low- and high-z HIIG are similar in every parameter that we have measured (mass, velocity dispersion, luminosity) thus strongly suggesting that the study of low z YMC can provide important clues to the formation and evolution of GCs.

HIIG are narrow emission line compact starforming systems selected from spectroscopic surveys as those with the largest emission lines equivalent width (EW), e.g. EW(H$\beta$) > 50Å (or EW(H$\alpha$) > 200 Å) in their rest frame.

The lower limit in the EW of the recombination hydrogen lines guarantees that a single and very young starburst, less than 10Myr in age, dominates the total luminosity output (cf. Dottori 1981; Dottori & Bica 1981; Leitherer et al. 1999; Melnick et al. 2000; Chavez et al. 2014).

# Very Early work

R. Terlevich and J. Melnick




*Mon. Not. R. astr. Soc.* (1981) 195, 839–851

**The dynamics and chemical composition of giant extragalactic H II regions**

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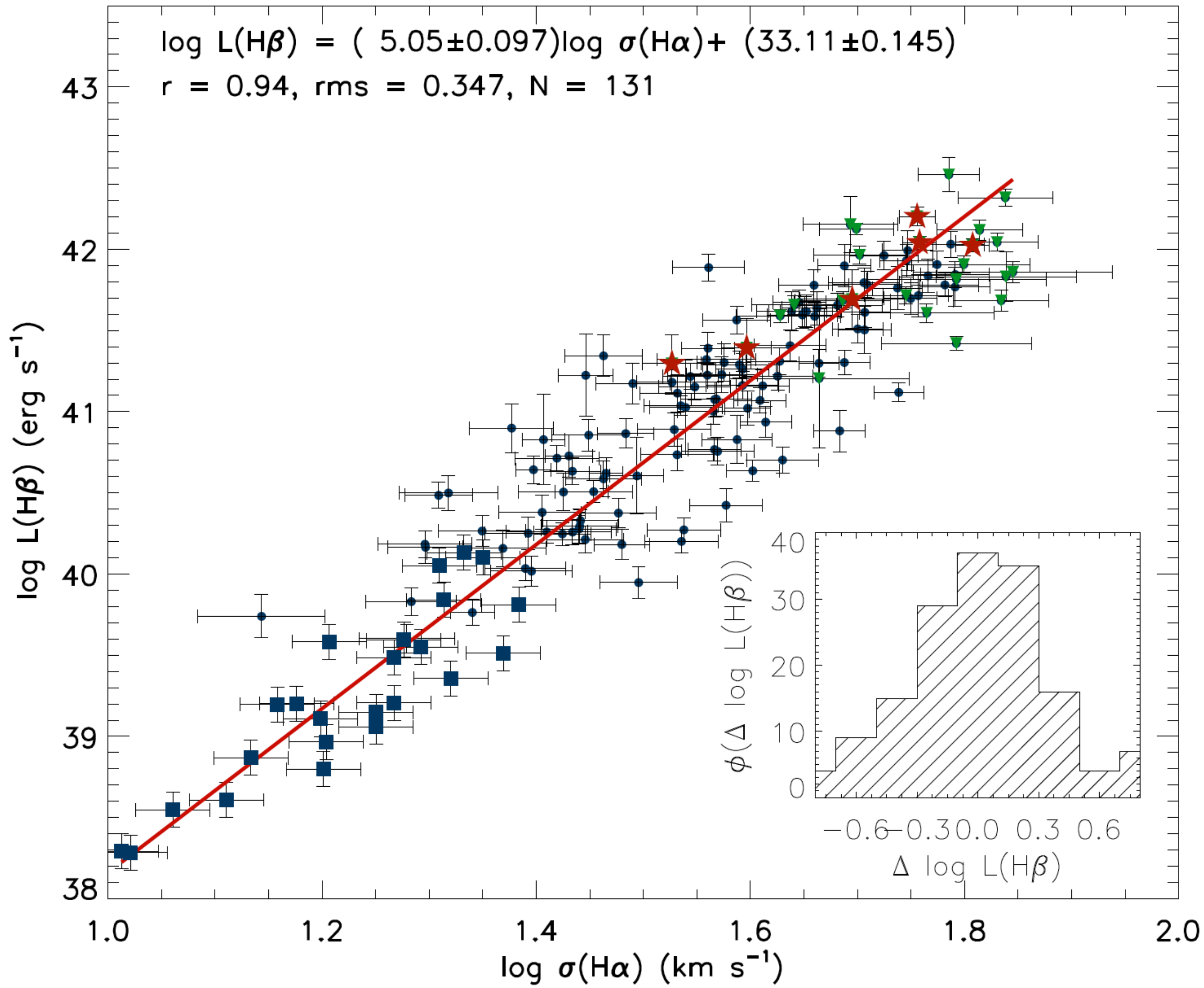
Received 1980 October 13; in original form 1980 June 10

- L–σ as ell. gals, bulges of spirals, and gl.cl., after correction for luminosity evolution.
- R-Linewidth as ell.gals and gl.cl.
- Self-gravitating stellar systems where σ represents the motion of discrete gas clouds in the grav. potential of the gas-star complex.

They share fundamental relationships with normal galaxies between size (luminosity or Mass), kinematic properties (**σ**, $V_{max}$) and surface density (**μ**) [Fisher; Faber, Jackson; Tully, Fisher; T,M; Djiorgovsky, Davis; Dressler+ …] used for relative distances and to map the local structure of the Universe [Lynden-Bell+ 7 Samurais]

# To-date L(Hβ)-σ correlation for GEHIIR and HII Galaxies

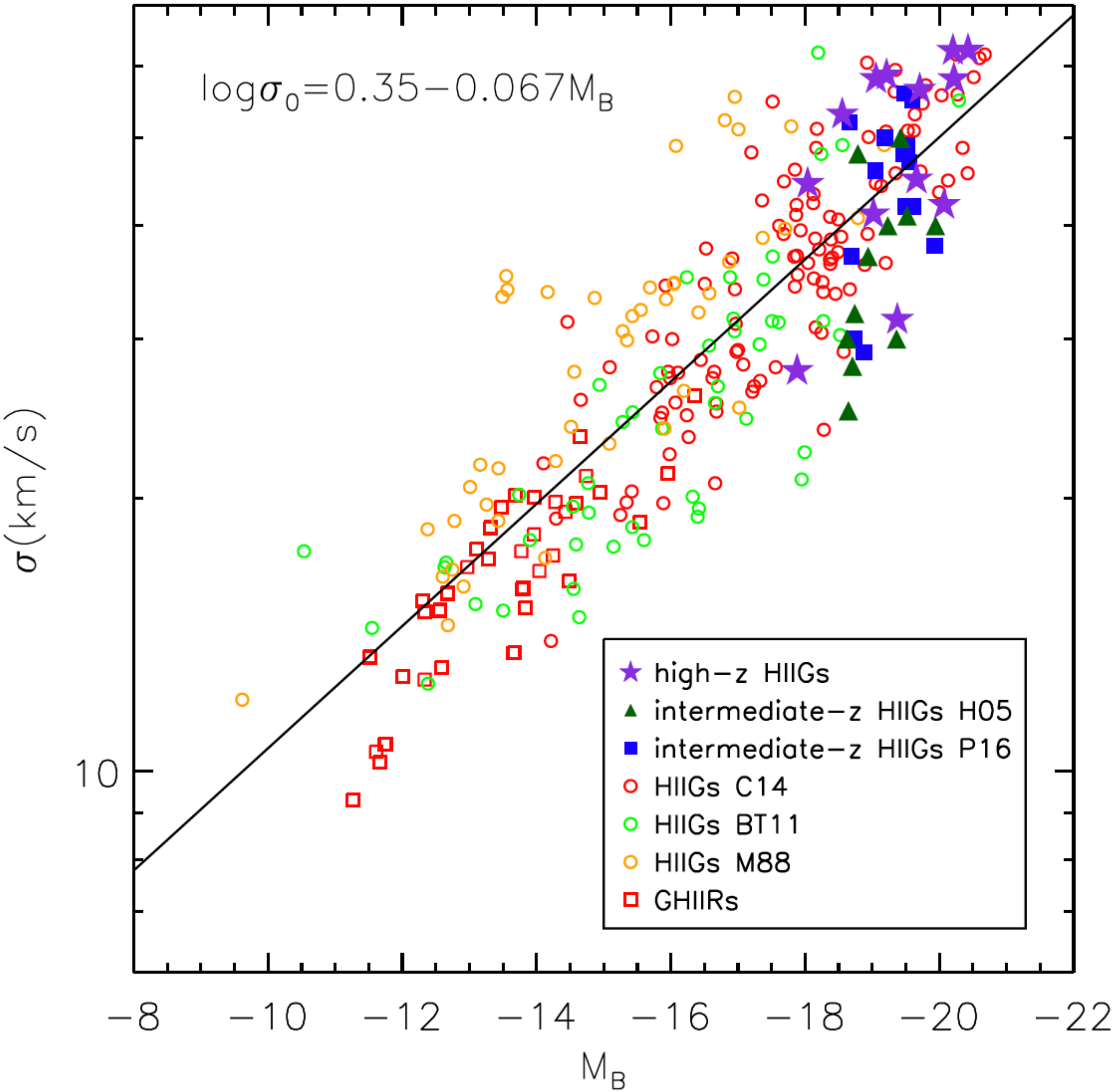
- Many line broadening mechanisms, better stellar evolution and dynamical models and codes.
- How to form massive clusters (literature).
- State-of-the-art telescopes and detectors, computers and computer codes,…
- **Time to re-do the work**



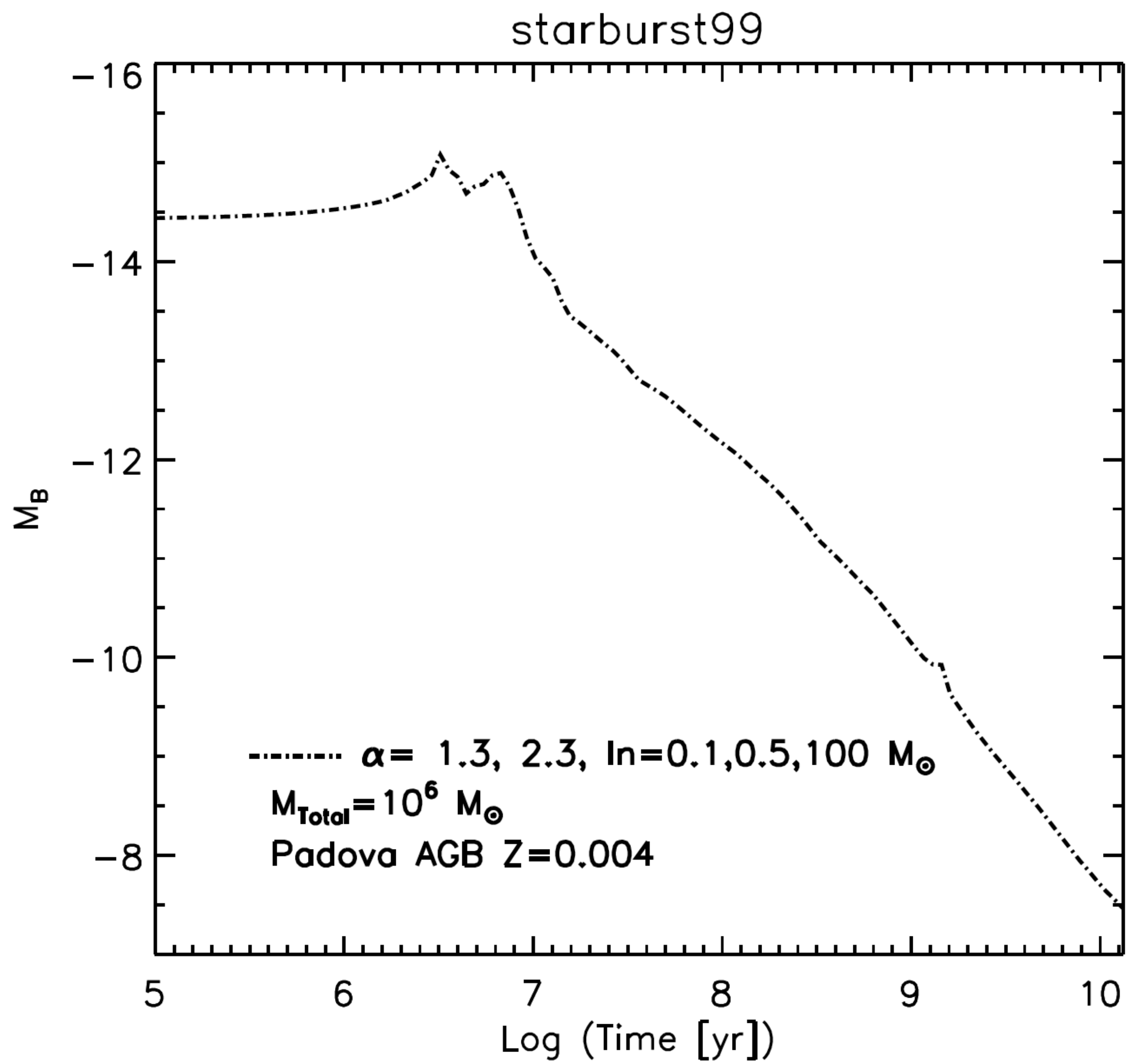

Terlevich et al. 2015

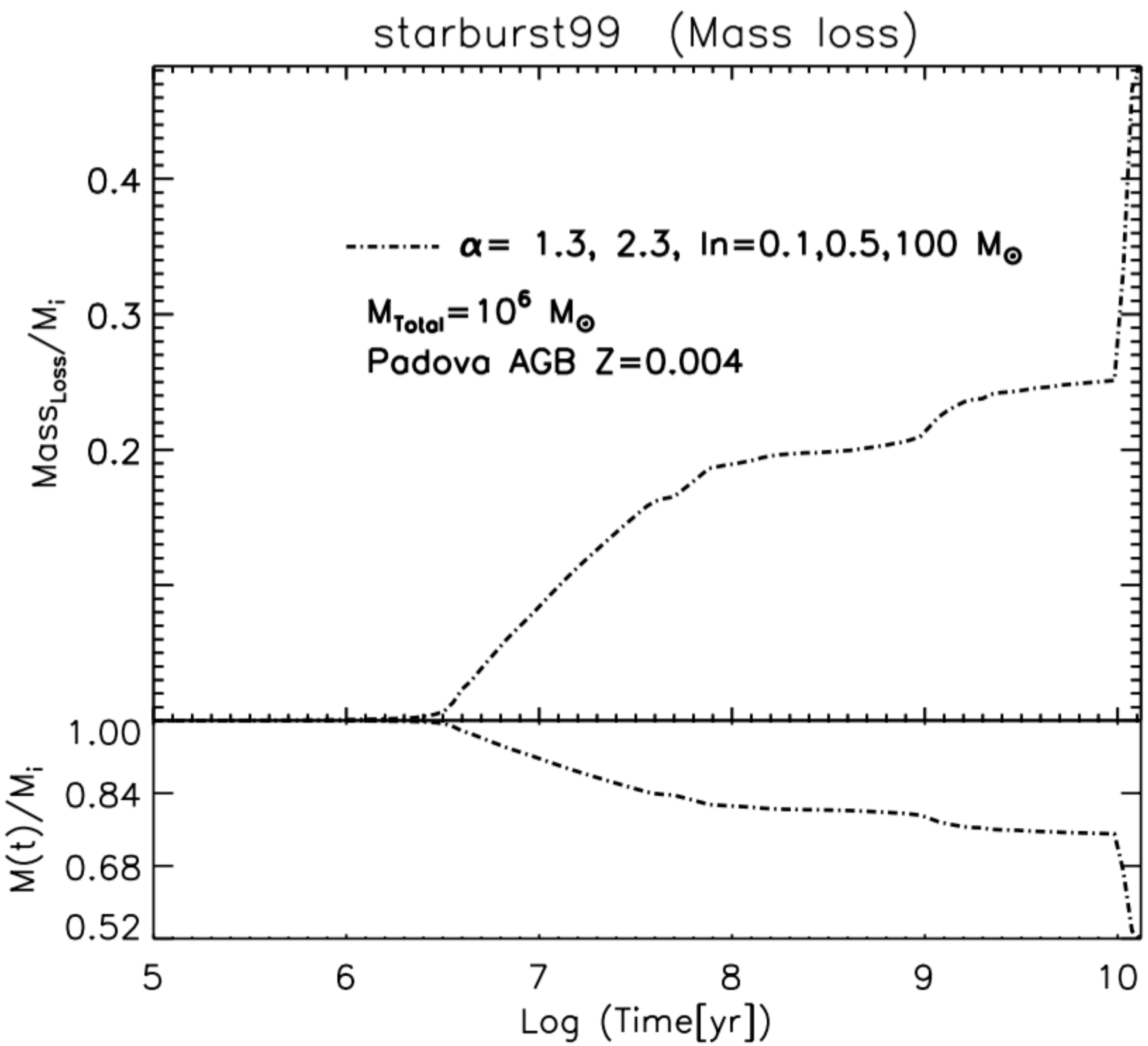
We assume that these systems are massive young virialised super stellar clusters (see Roberto's talk), evolve them consequently (analytically and with numerical simulations) and see where that hypothesis takes us.

Caveat: no gas in the simulations



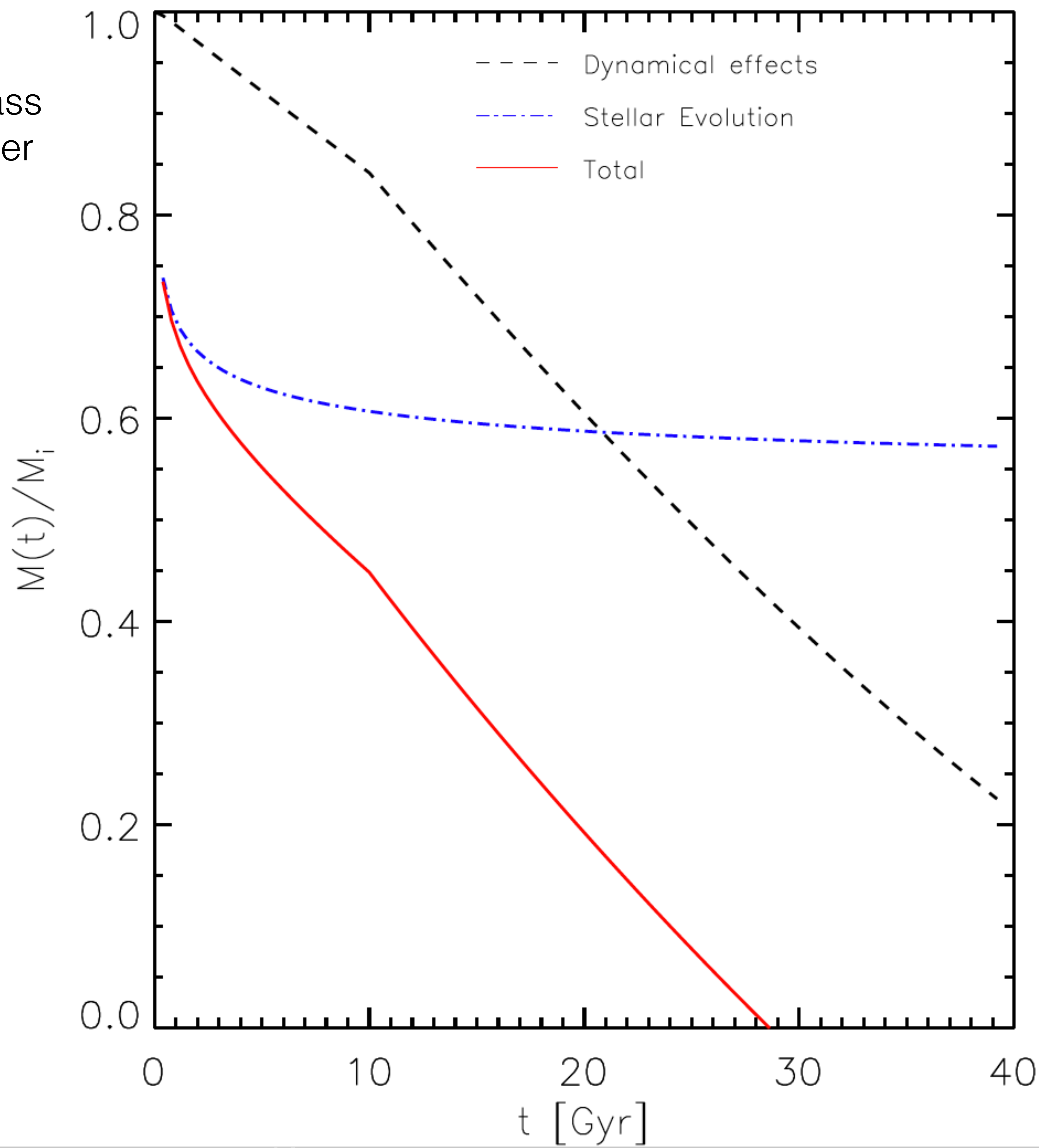
logσ0=0.35−0.067MB
σ(km/s)
10
−8
−10
−12
−14
−16
−18
−20
−22
MB
high−z HIIGs
intermediate−z HIIGs H05
intermediate−z HIIGs P16
HIIGs C14
HIIGs BT11
HIIGs M88
GHIIRs


starburst99
$M_B$
Log (Time [yr])
α= 1.3, 2.3, In=0.1,0.5,100 M⊙
M_Total=10^6 M⊙
Padova AGB Z=0.004


starburst99 (Mass loss)
Mass_Loss/M_i
M(t)/M_i
Log (Time[yr])
α= 1.3, 2.3, In=0.1,0.5,100 M⊙
M_Total=10^6 M⊙
Padova AGB Z=0.004

Mass-loss rates and the mass evolution of star clusters after Henny J. G. L. M. Lamers, Holger Baumgardt and Mark Gieles

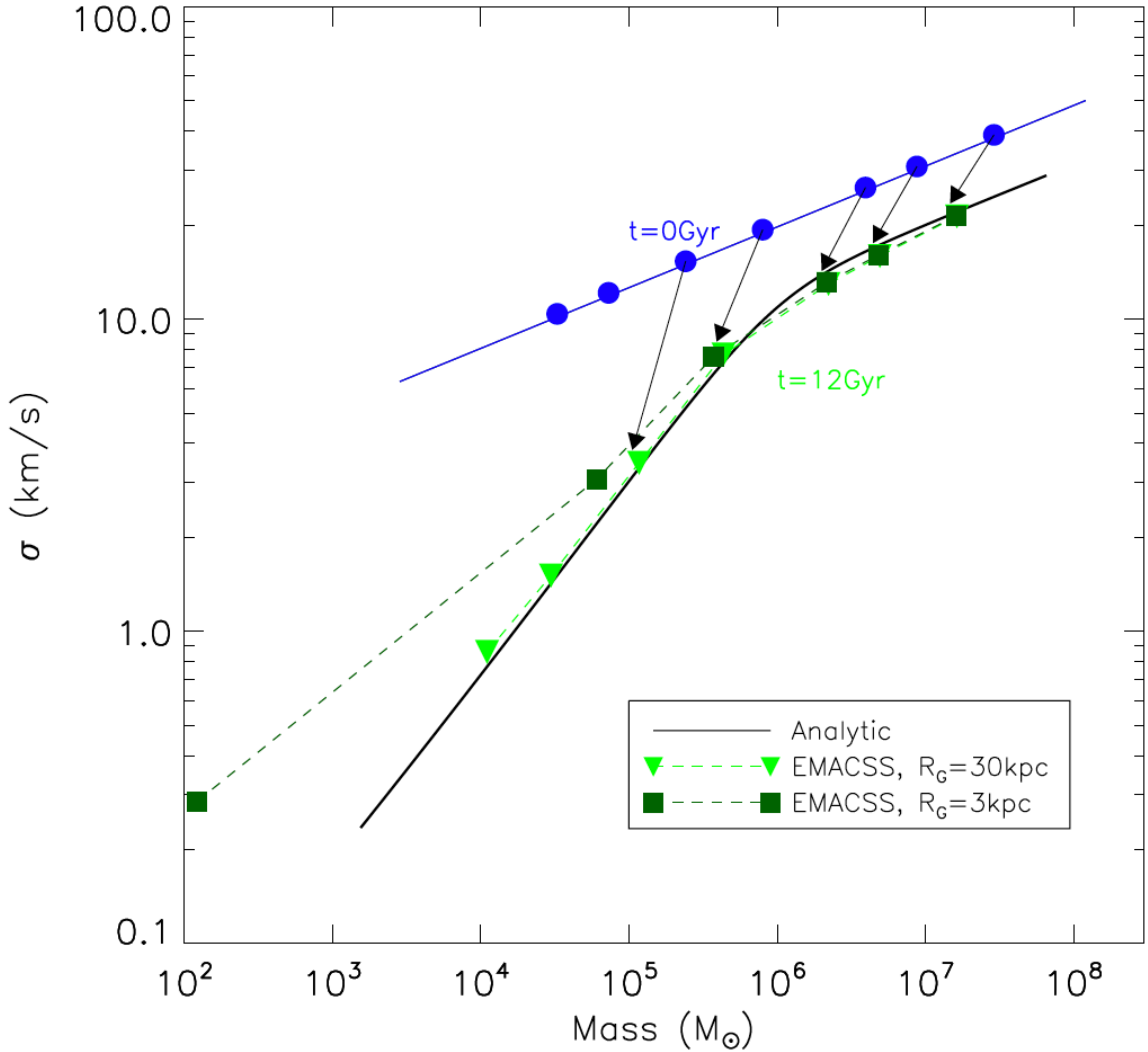
**MNRAS, 2010, 409, 305**

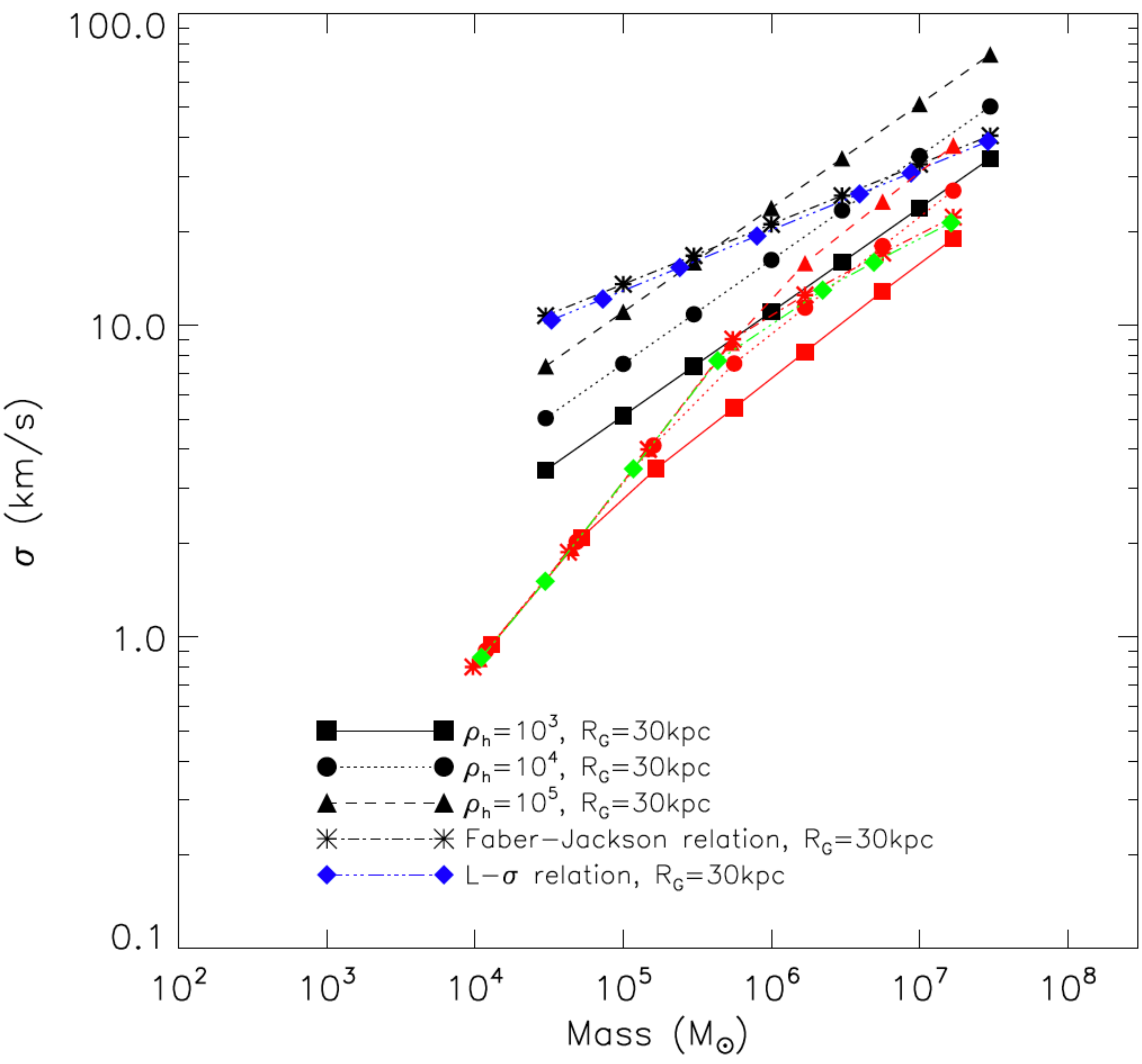


We use the fast cluster evolution code **Evolve Me A Cluster of StarS** (Alexander et al., 2014).

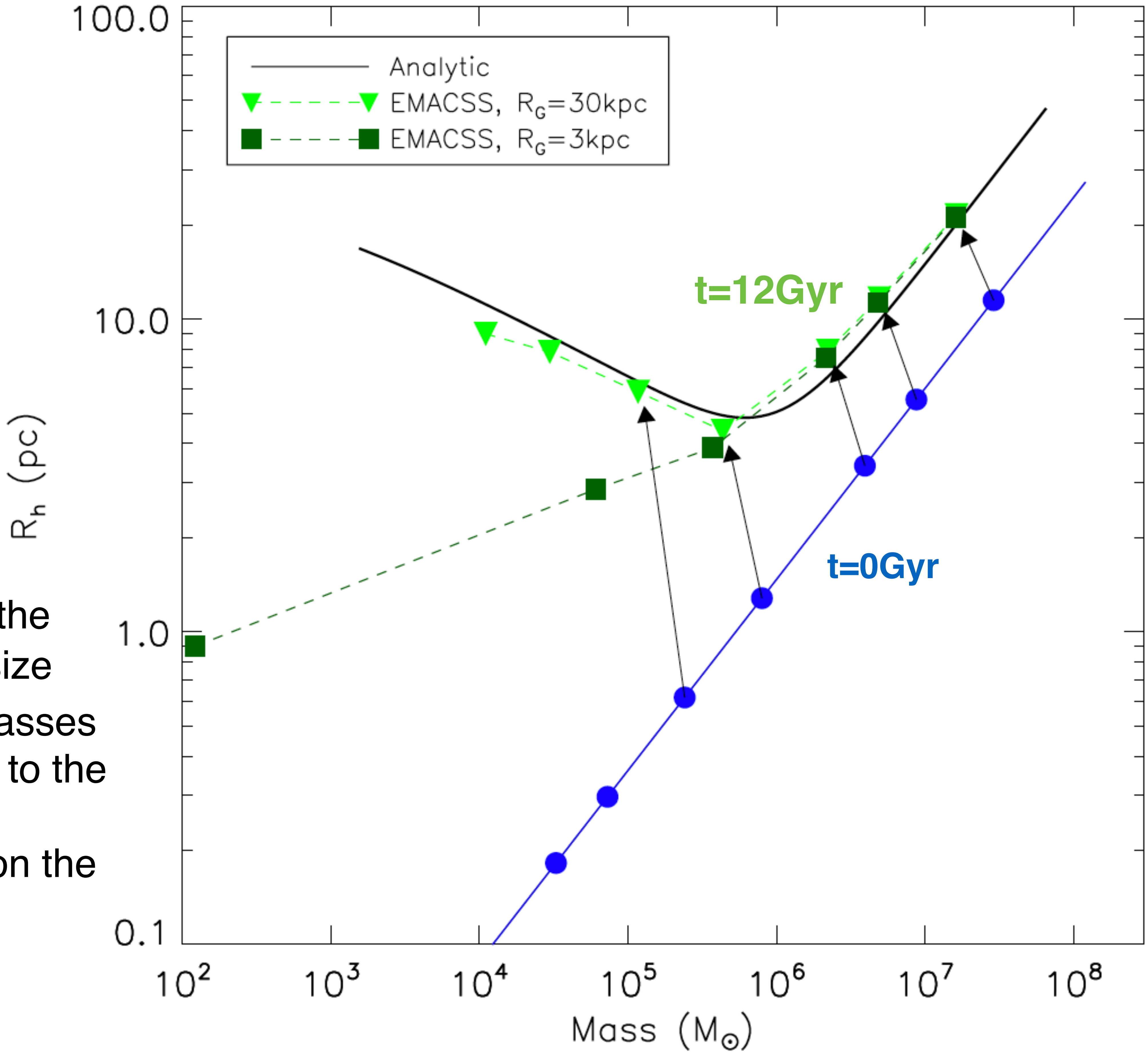
Initial masses between $3 \times 10^4$ M$\odot$ and $3 \times 10^7$ M$\odot$ in two different tidal fields: a singular isothermal halo with circular velocity of 220 km $s^{-1}$ at galactocentric radius RG = 3 kpc and RG = 30 kpc

**Evolution in the mass-σ plane from n-body simulations including stellar evolution (EMACSS)**

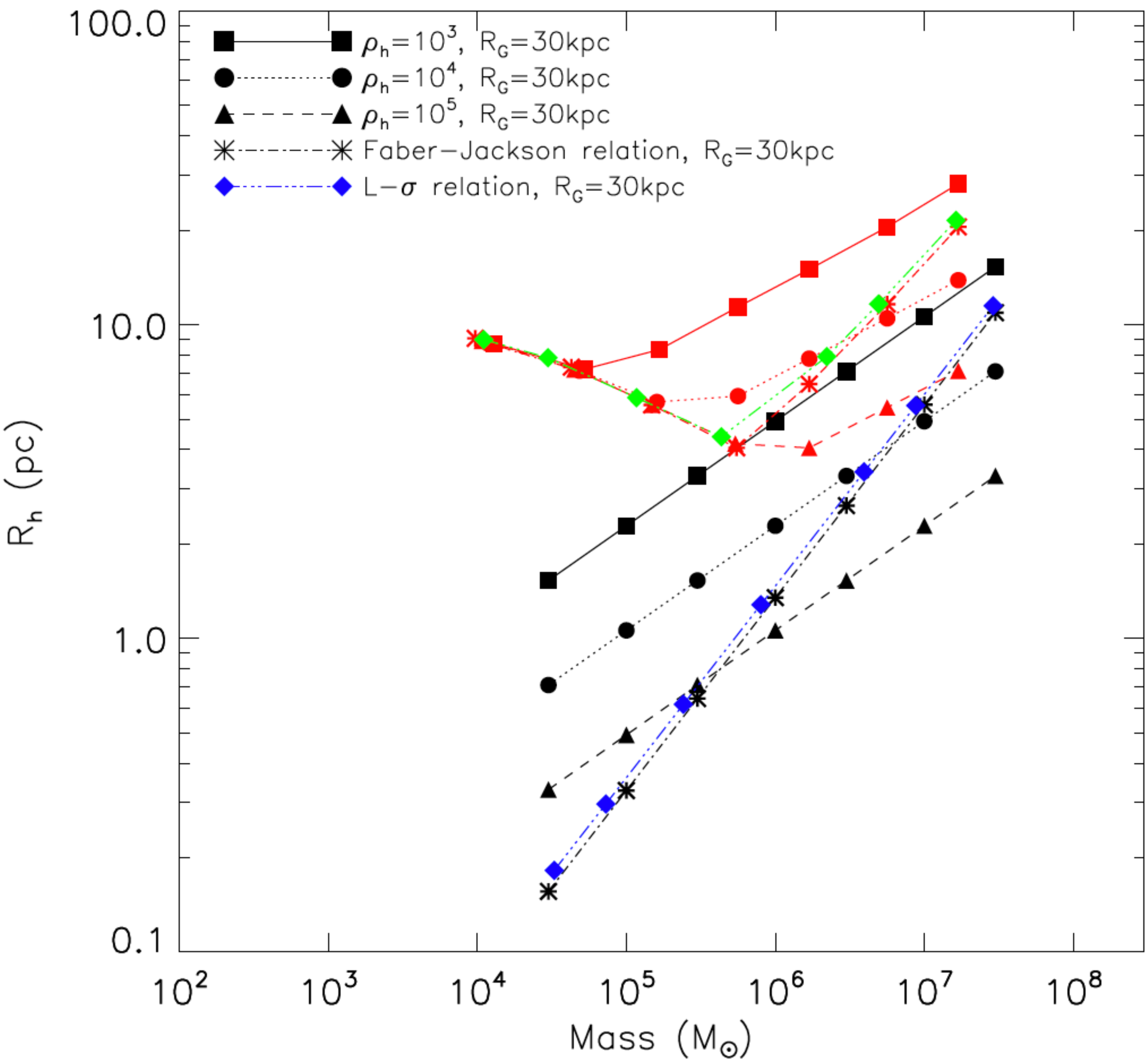




100.0
10.0
1.0
0.1
σ (km/s)
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
$10^7$
$10^8$
Mass ($M_\odot$)
$\rho_h=10^3$, $R_G$=30kpc
$\rho_h=10^4$, $R_G$=30kpc
$\rho_h=10^5$, $R_G$=30kpc
Faber–Jackson relation, $R_G$=30kpc
L–σ relation, $R_G$=30kpc

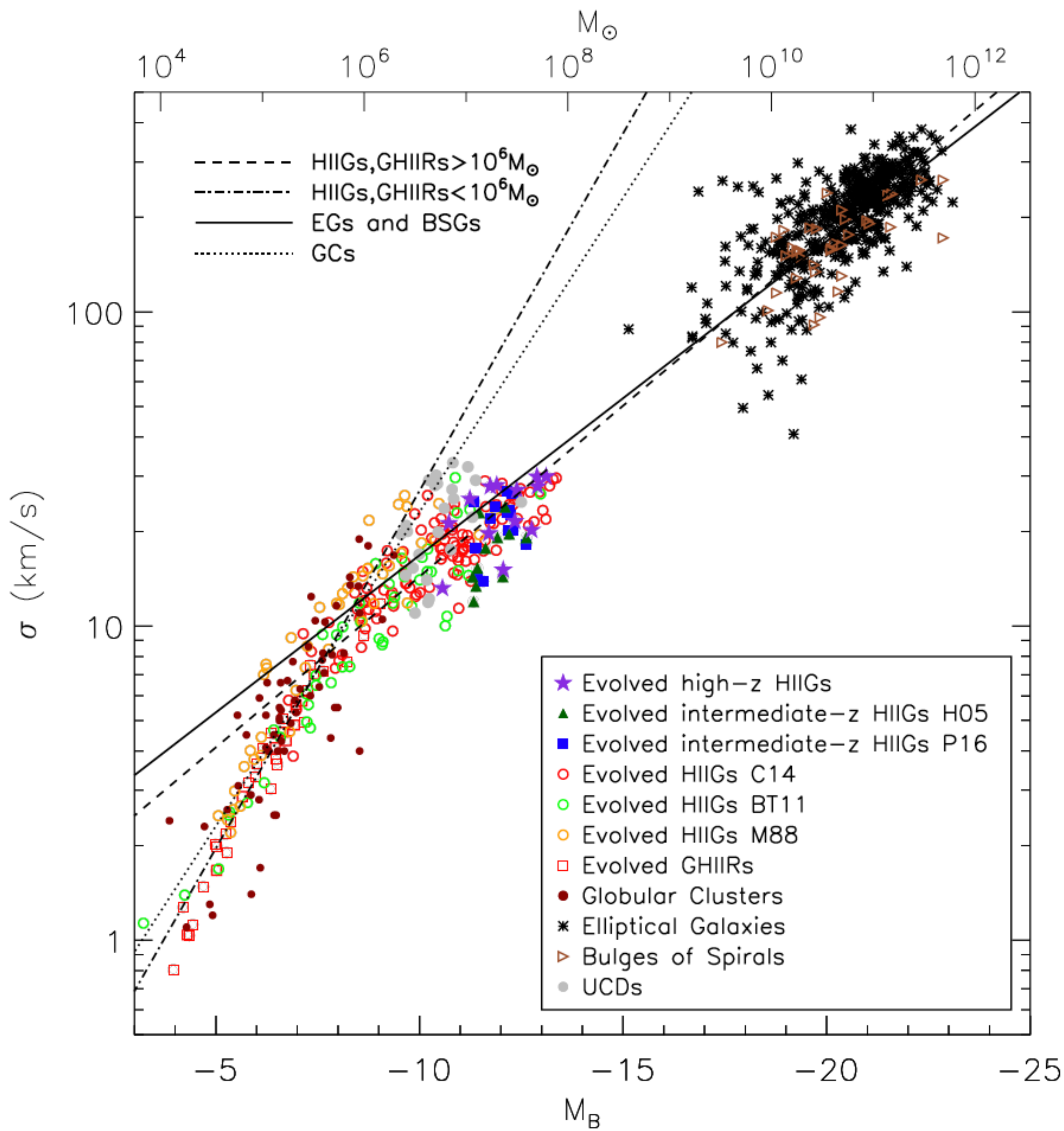



The slope change in the $M_B - \sigma$ and $M_B$ — size relations at cluster masses around $10^6 M_\odot$ is due to the larger impact of the dynamical evolution on the lower mass clusters.



$\rho_h=10^3$, $R_G$=30kpc
$\rho_h=10^4$, $R_G$=30kpc
$\rho_h=10^5$, $R_G$=30kpc
Faber−Jackson relation, $R_G$=30kpc
L−$\sigma$ relation, $R_G$=30kpc
100.0
10.0
1.0
0.1
$R_h$ (pc)
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
$10^7$
$10^8$
Mass ($M_\odot$)

The slope change in the $M_B$ — $\sigma$ and $M_B$ — size relations at cluster masses around $10^6 M_\odot$ is due to the larger impact of the dynamical evolution on the lower mass clusters.



# Conclusions

- The dynamical and photometric evolution for 12 Gyr of Extragalactic GHIIR and HIIG, i.e. young Super Star Clusters, move them in the $\sigma$–$M_B$ plane into the zone occupied by globular clusters and ultra compact dwarf ellipticals.
- For these objects, $\sigma$ is mainly determined by the gravitational potential well of the stellar cluster with no much room for any other broadening mechanism.

so, we postulate that:

- Giant HII regions (30 Dor lookalikes) are globular cluster progenitors.

- HII Galaxies are progenitors of compact dwarf ellipticals.

# To Do

- Simulate the evolution of SSC complexes, their possible merging and what it implies for the chemical evolution of the resulting globular clusters (if we can).


Felicidades, Nidia!