Rotational Velocities in Globular Cluster Blue Straggler Stars

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Cosmic-Lab

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erc

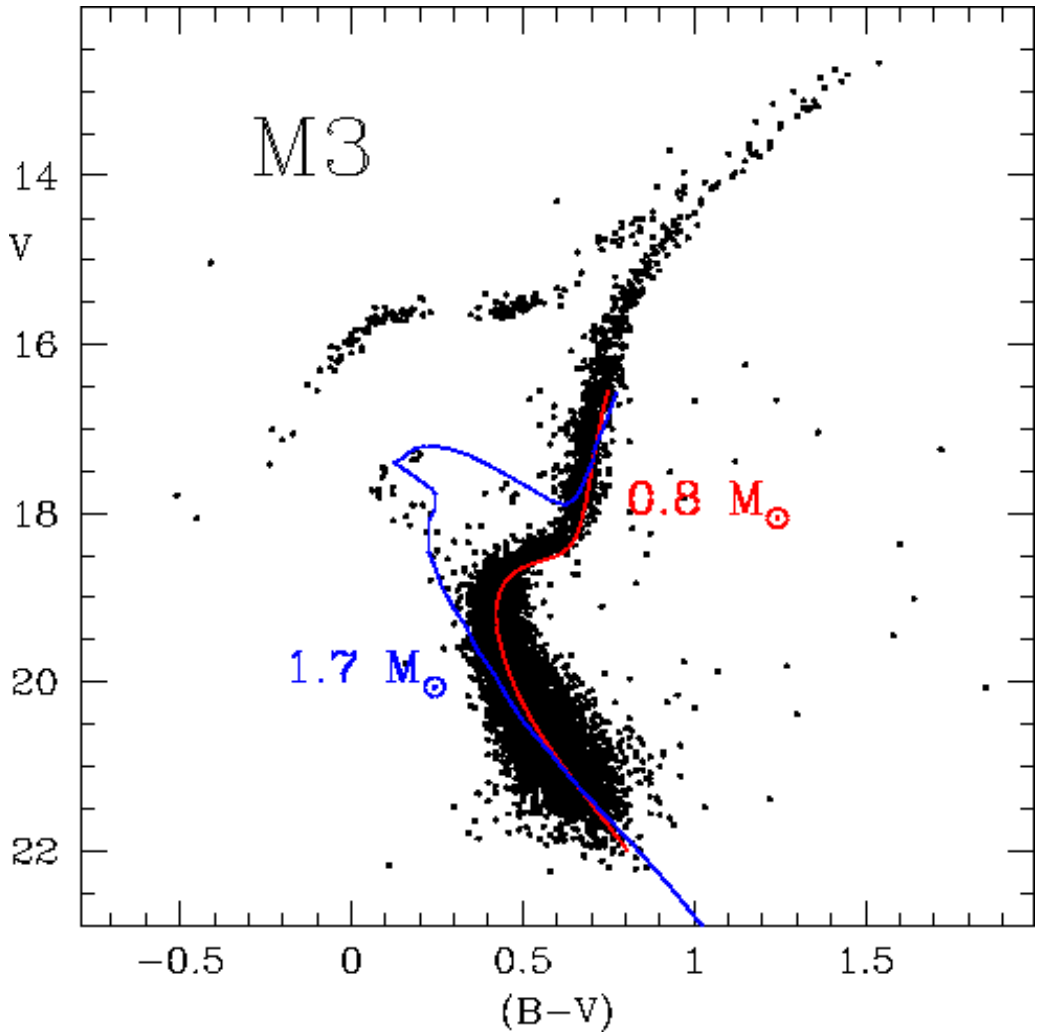
Cosmic-Lab

- 5-year project
- *Advanced Research Grant* funded by the European Research Council (ERC)
- PI: Francesco R. Ferraro (Dip. of Physics & Astronomy – Bologna University)
- AIM: **to understand the complex interplay between dynamics & stellar evolution**
- HOW: using **globular clusters** as cosmic laboratories and

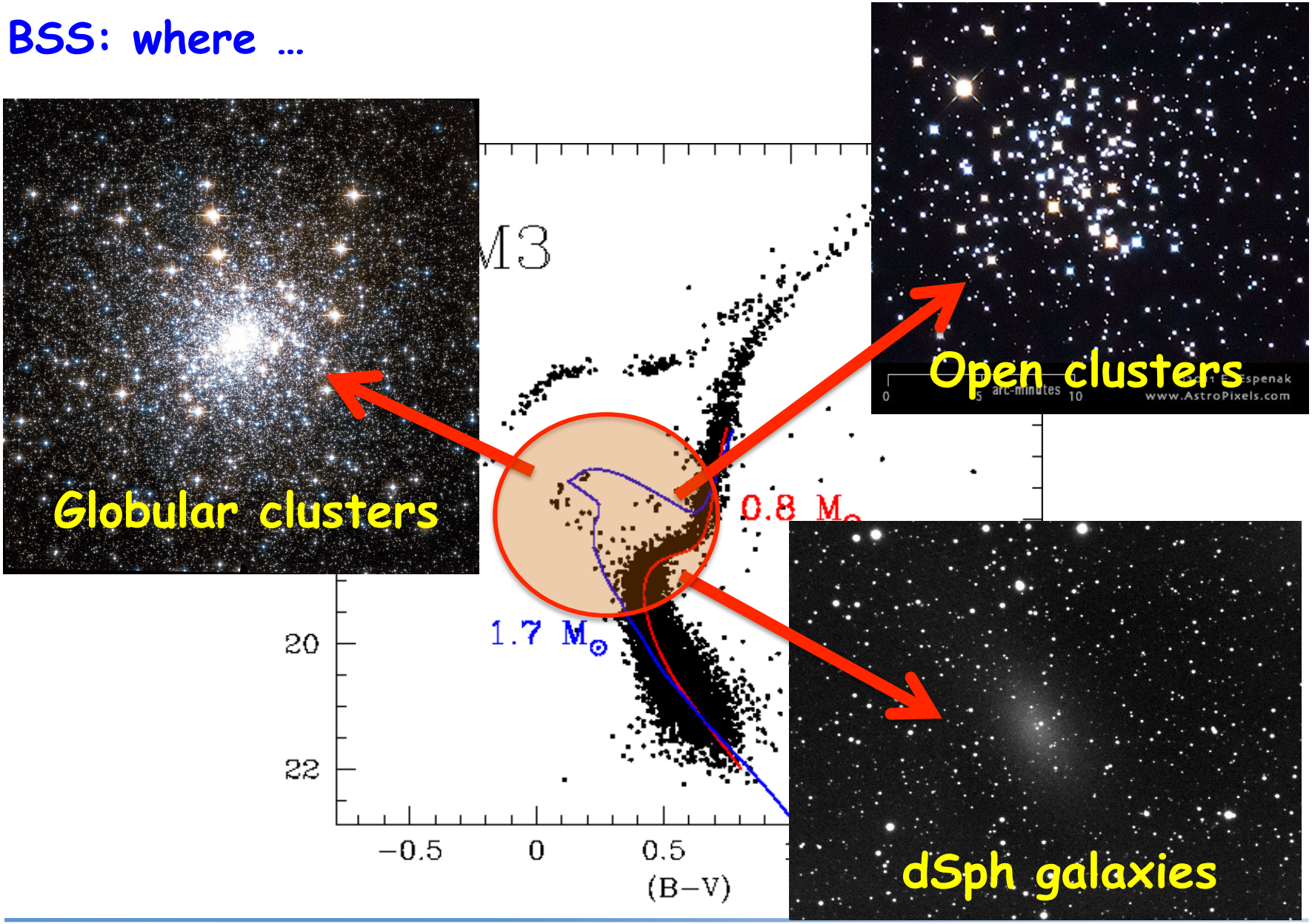
Blue Straggler Stars
Millisecond Pulsars
Intermediate-mass Black Holes

} as probe-particles

BSS: where …



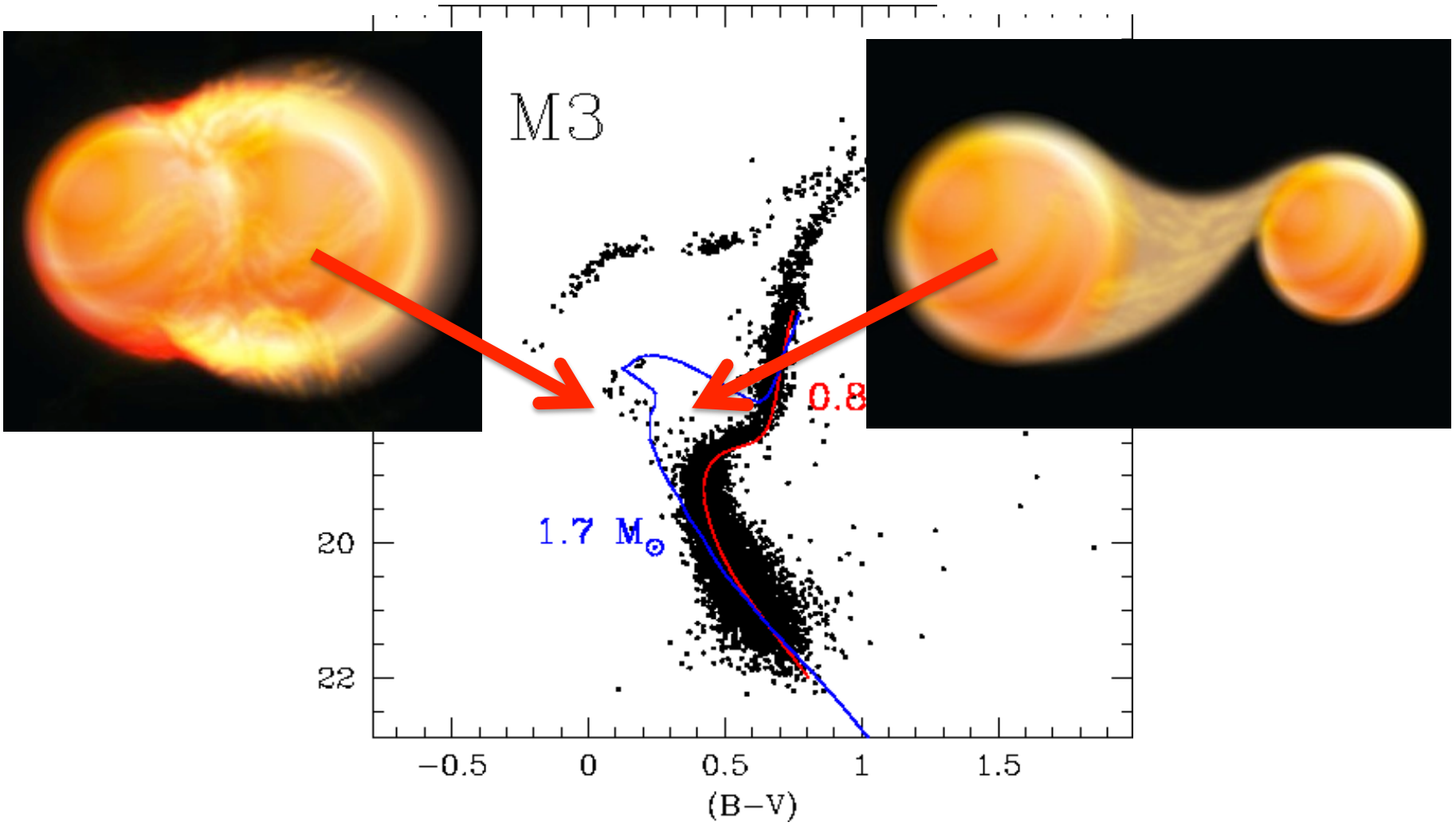
BSS: where …


M3
0.8 M⊙
1.7 M⊙
20
22
−0.5
0
0.5
(B−V)
Globular clusters
Open clusters
dSph galaxies

BSS: … and how

COLLISIONS

MASS TRANSFER



Looking for a distinguish feature …

An observational feature
able to discriminate between
COL-BSS and MT-BSS?

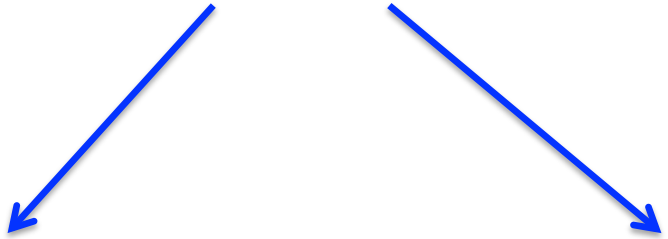
Spectroscopic survey with FLAMES@VLT (R~20000) to study chemical composition + rotational velocities

7 globular clusters ~ 250 BSS

47 Tucanae (Ferraro+06)
M4 (Lovisi+10)
NGC6397 (Lovisi+12)
M30 (Lovisi+13)
NGC6752 (Lovisi+14)
Omega Centauri (Mucciarelli+14)
M55 (Mucciarelli+15, in prep.) *New entry*

Looking for a distinguish feature …

(1) CNO chemical abundances



Collisional BSS

Negligible mixing between inner cores and outer envelopes (Lombardi et al. 1995)

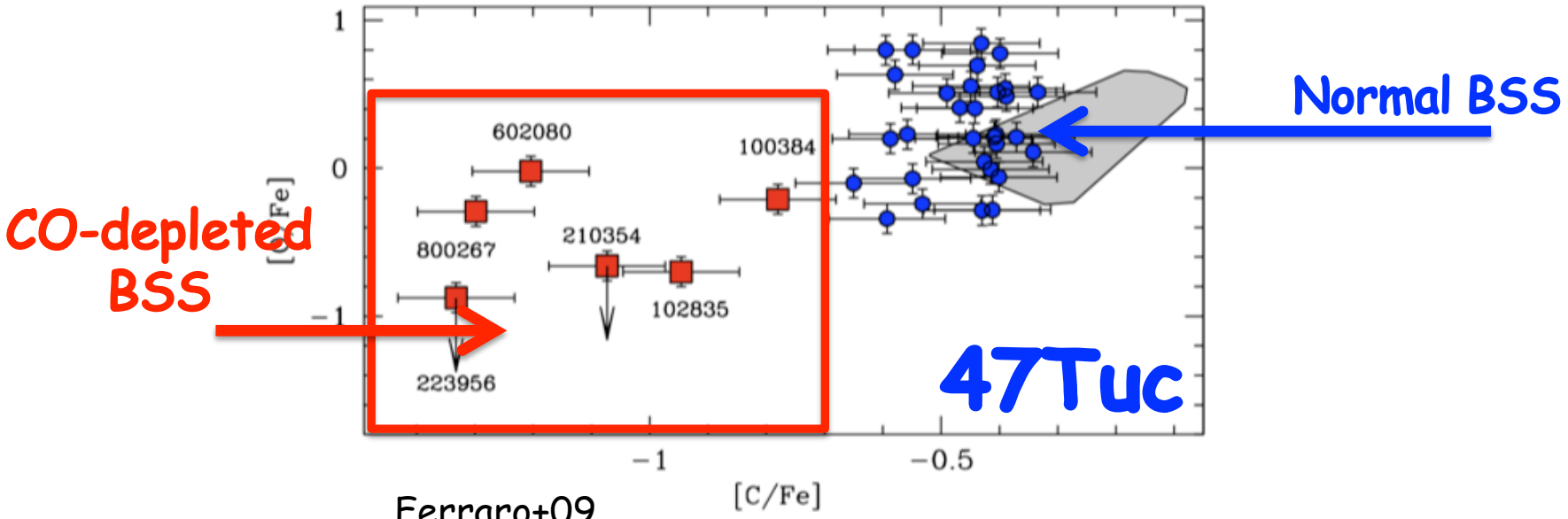
No chemical signatures

Mass Transfer BSS

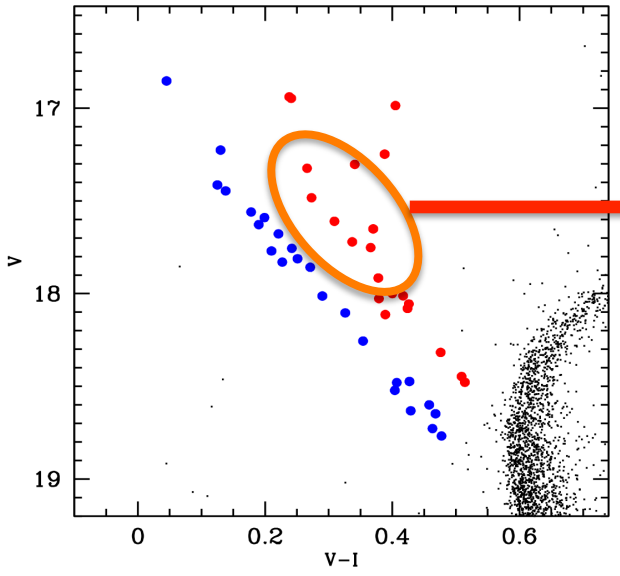
Mixing with material coming from stellar regions where CNO burning occurs (Sarna & de Greve 1996)

Chemical signatures (**CNO**)

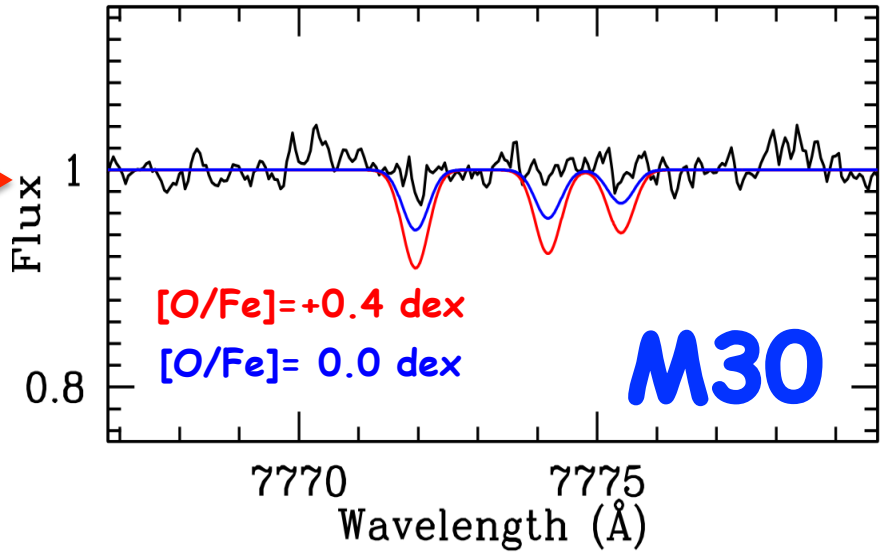
Ferraro+06



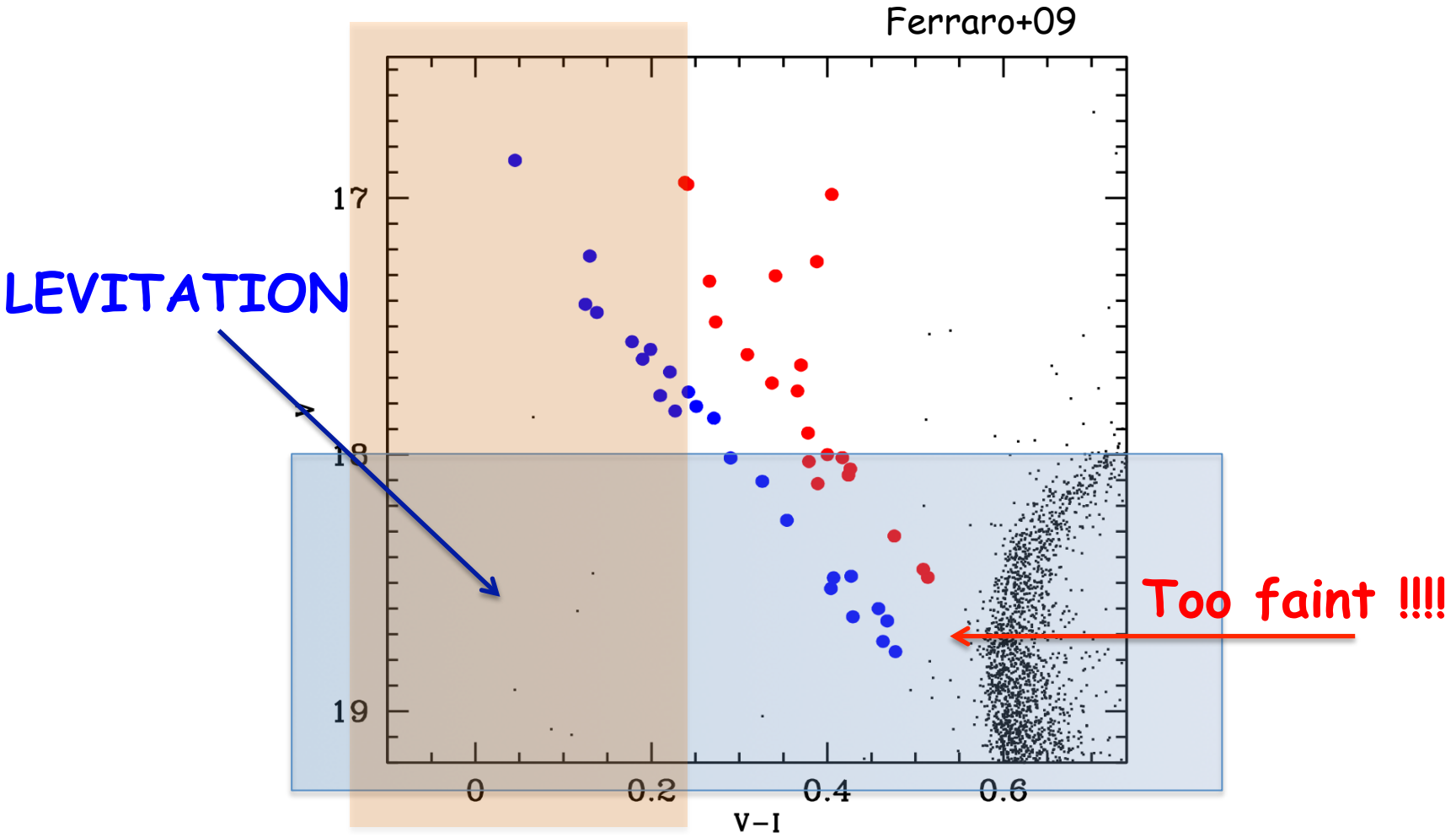
Ferraro+09



Lovisi+13

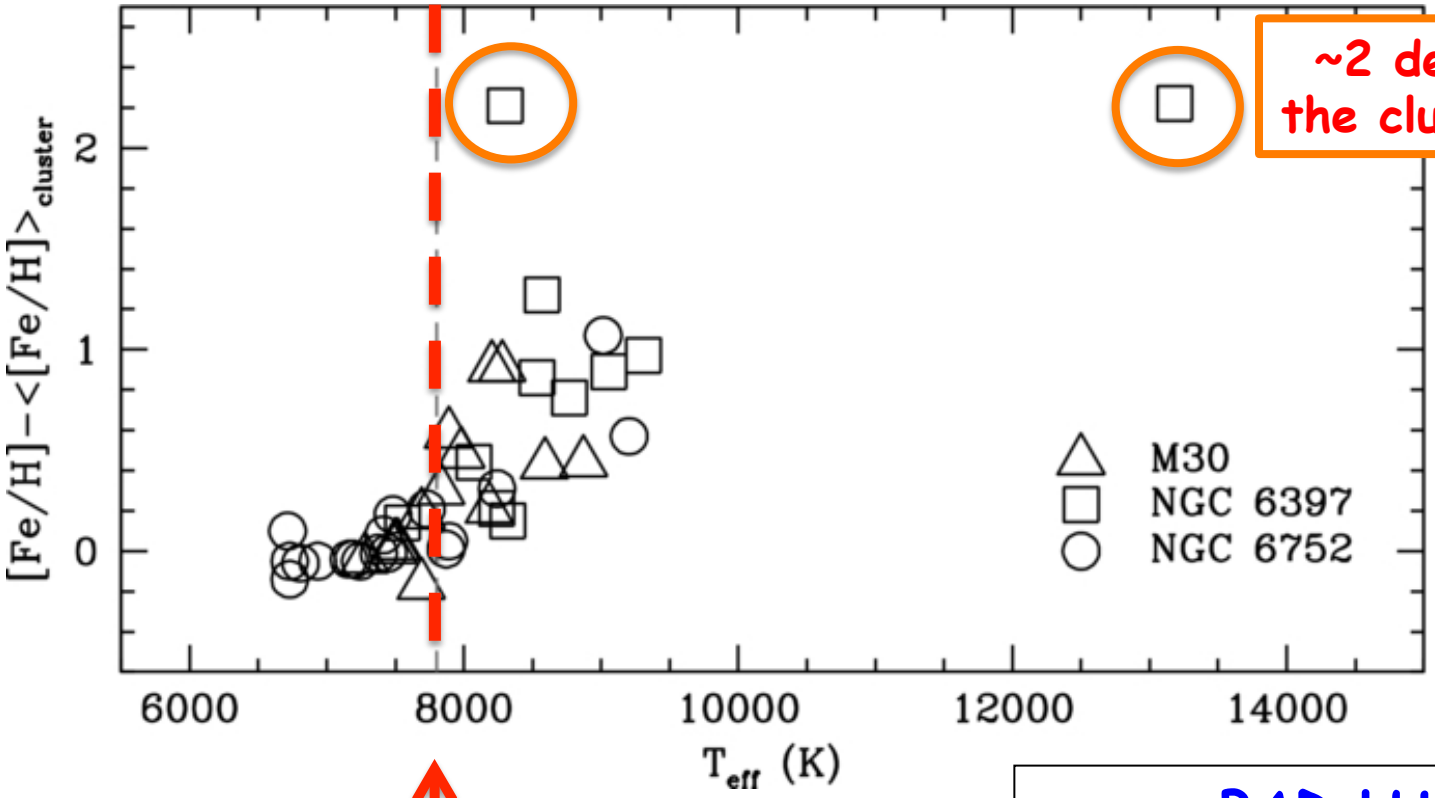


High-res spec for BSS … a challenging task



High-res spec for BSS … a challenging task

Lovisi+14



~2 dex higher than the cluster metallicity

Onset of the radiative levitation

BAD LUCK !!!

We cannot study the true chemical composition of hot BSS

Looking for a distinguish feature …

(2) Projected rotational velocities

Collisional BSS
(Benz & Hill, 1987)

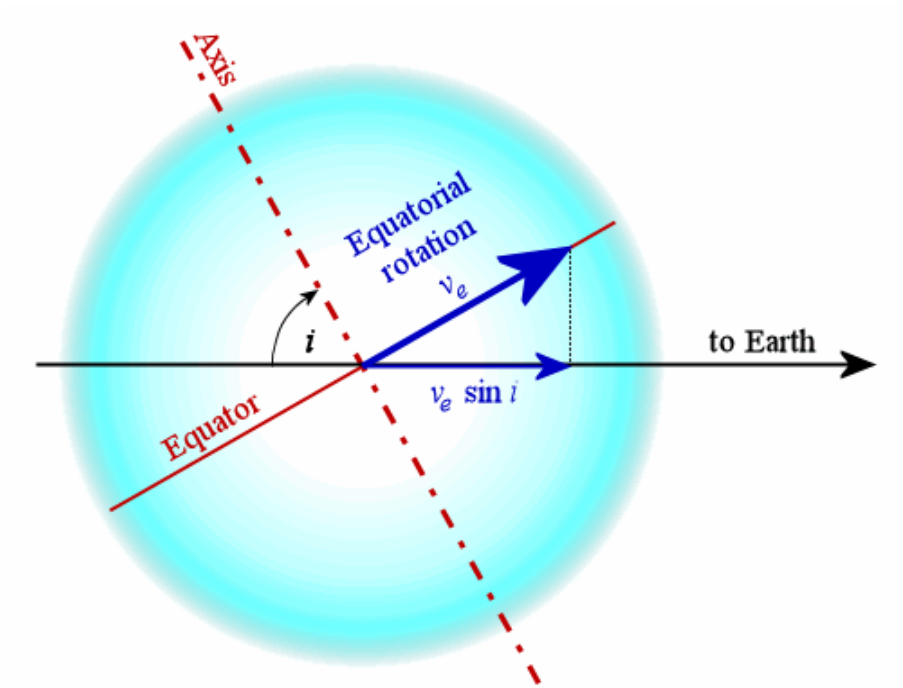
Mass Transfer BSS
(Sarna & de Greve, 1996)

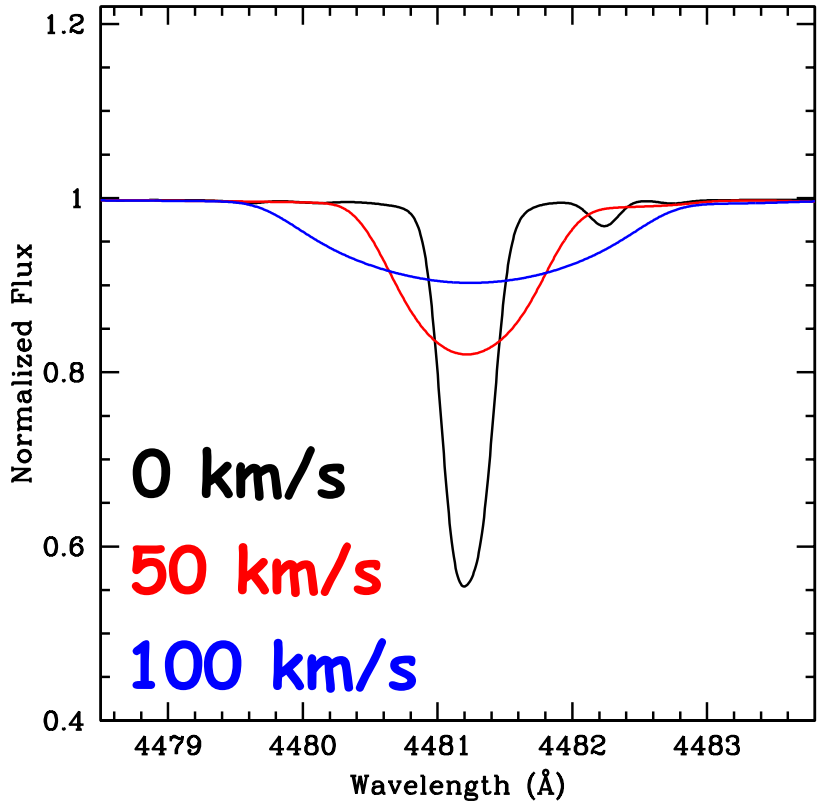
High rotational velocities

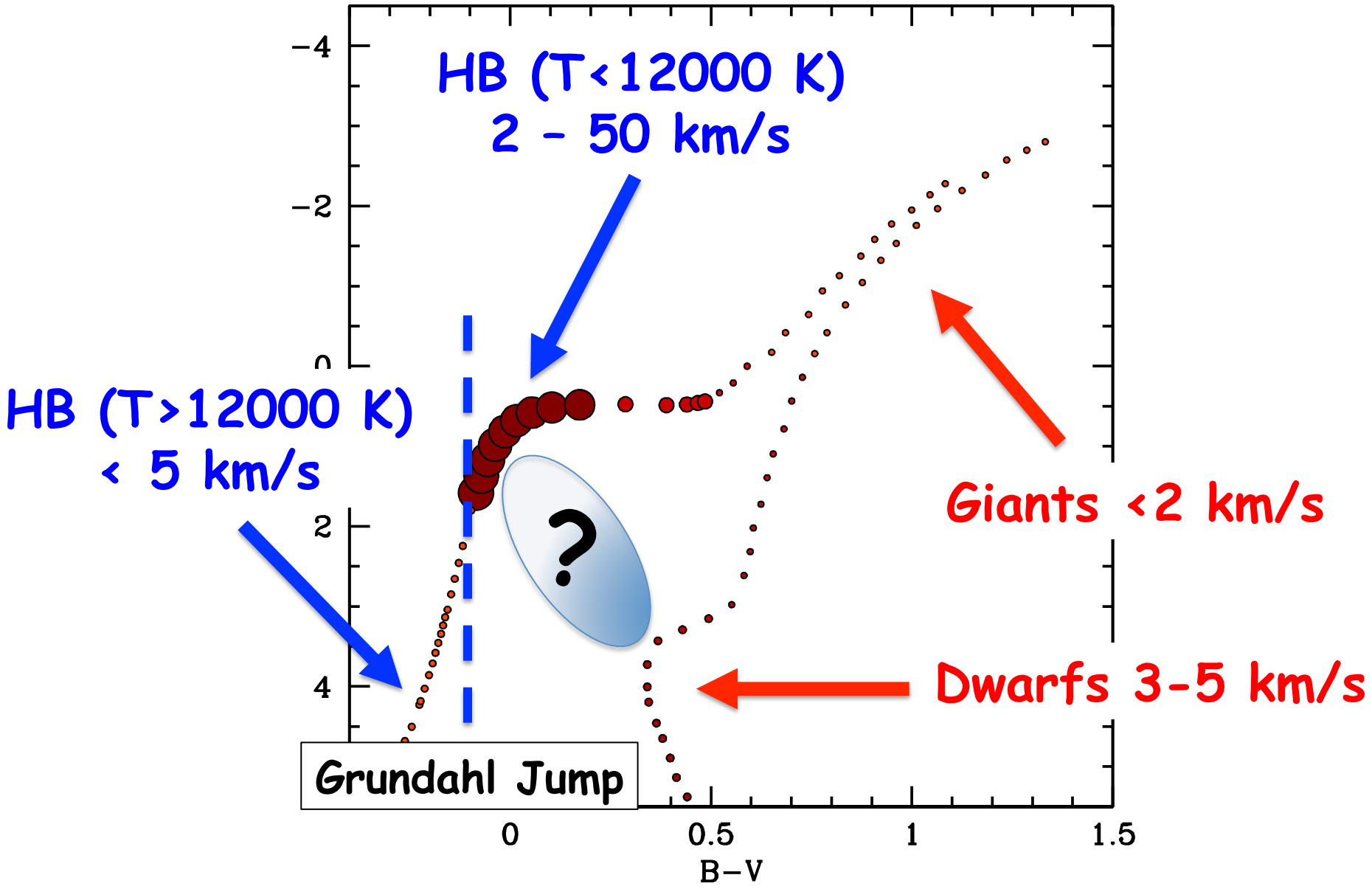
BRAKING MECHANISMS
MAY INTERVENE
(Leonard & Livio, 1995, Sills+05)

Looking for a distinguish feature …

(2) Projected rotational velocities





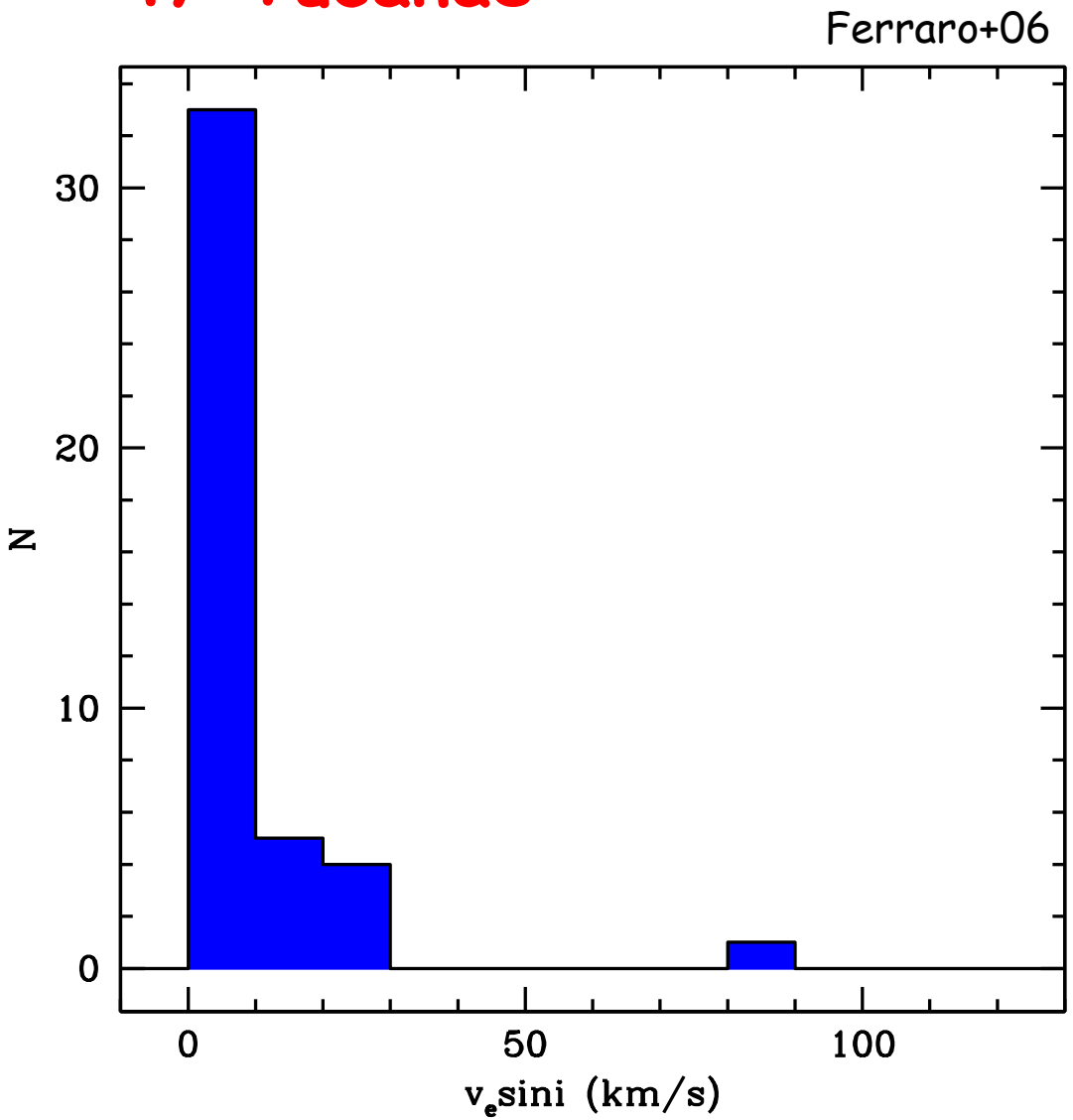

HB (T<12000 K)
2 - 50 km/s
HB (T>12000 K)
< 5 km/s
?
Giants <2 km/s
Dwarfs 3-5 km/s
Grundahl Jump
−4
−2
0
2
4
0
0.5
1
1.5
B−V

(1) Are BSS (preferentially) slow or fast rotators?

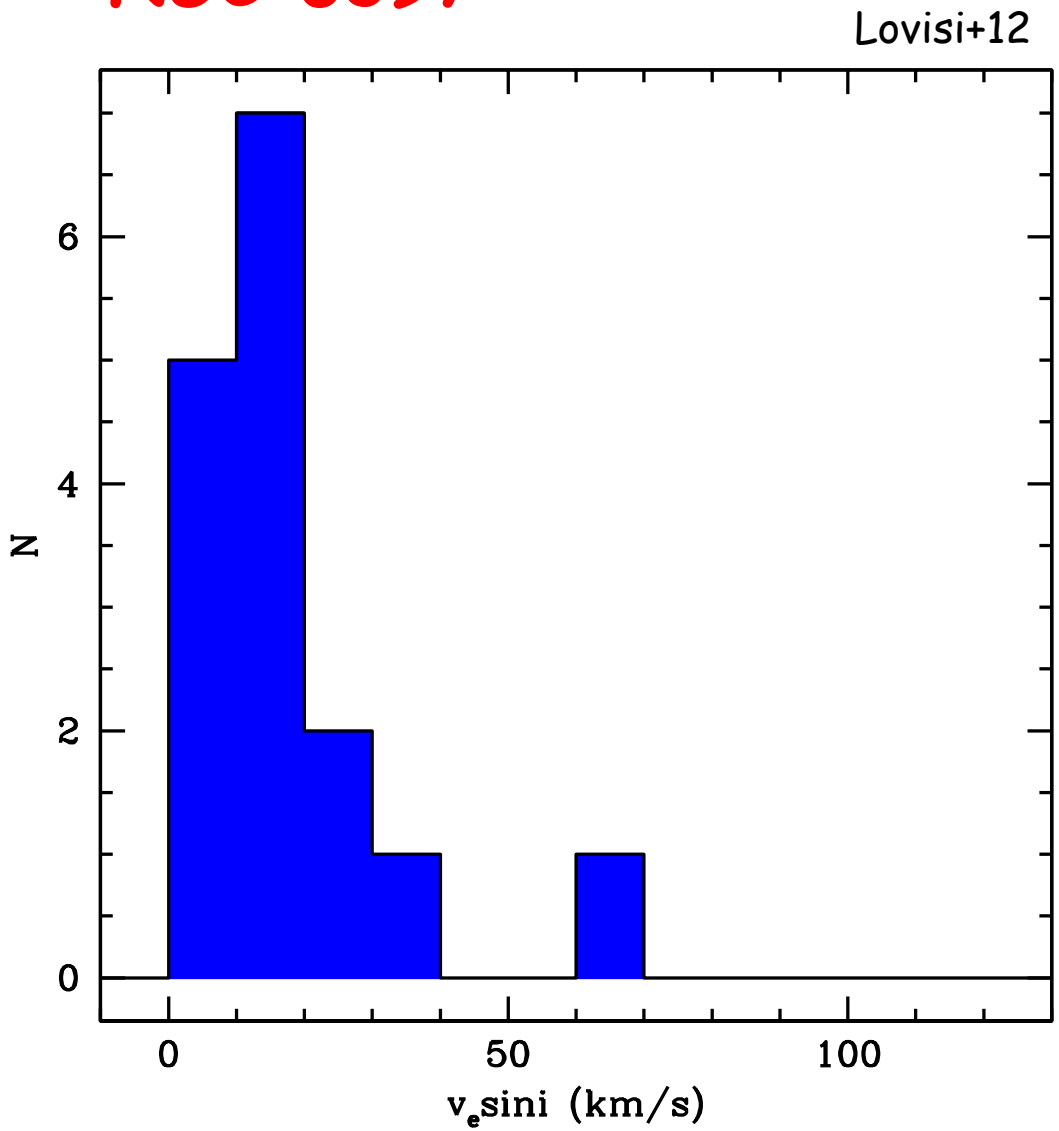
(2) Any link between $v_e$sini and BSS formation mechanisms?

(3) Any link with the cluster environment?

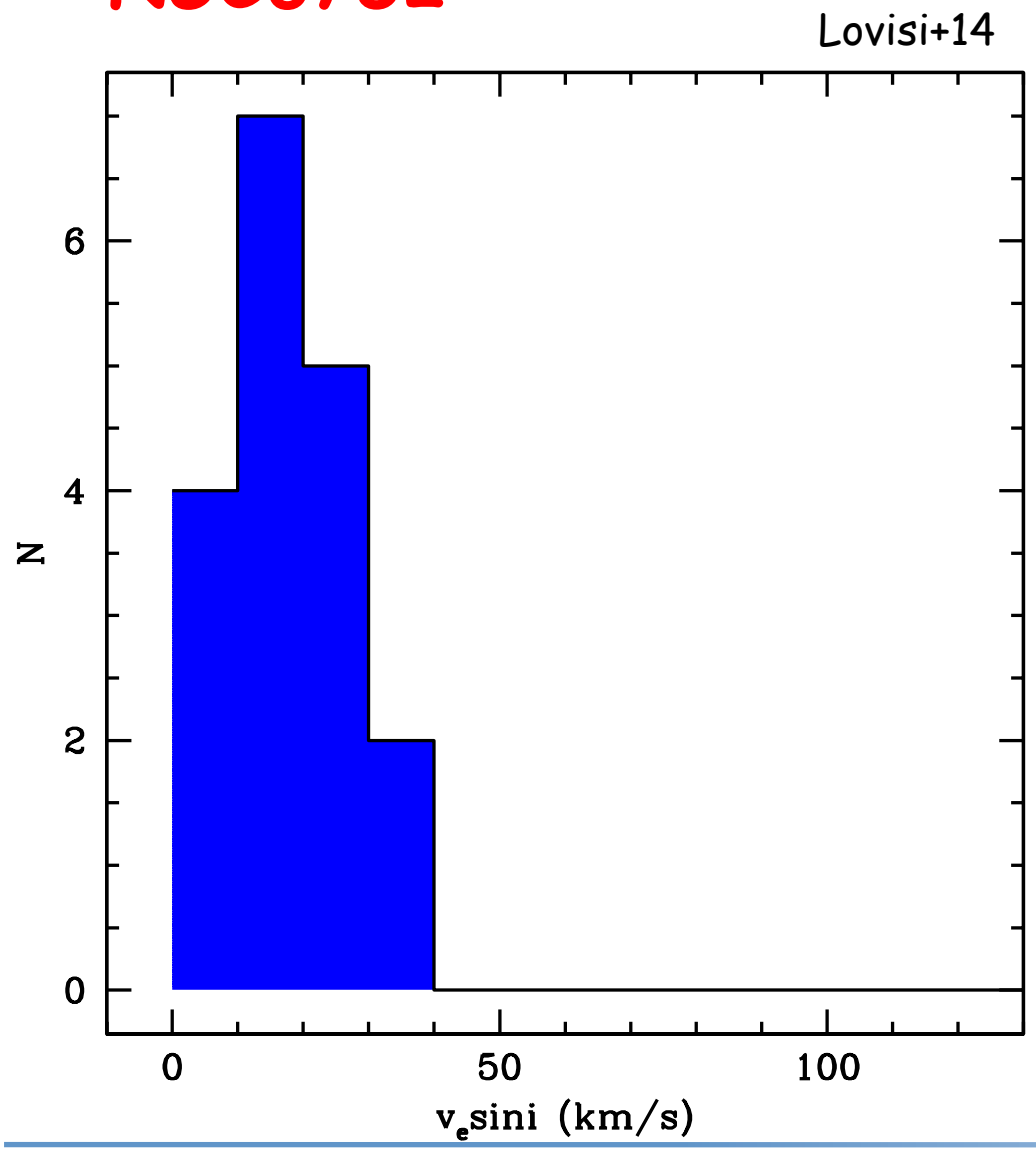
47 Tucanae



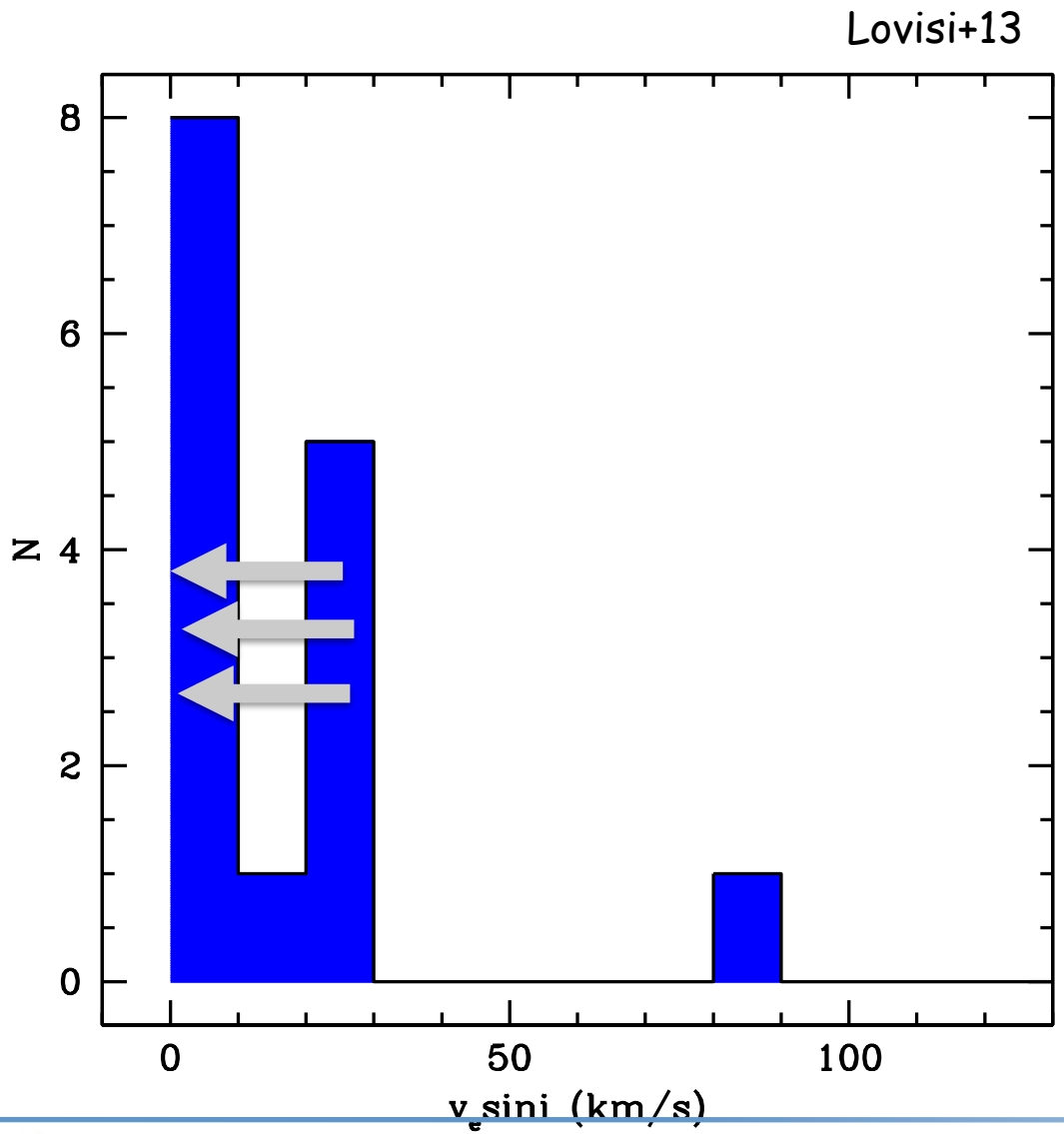
NGC 6397



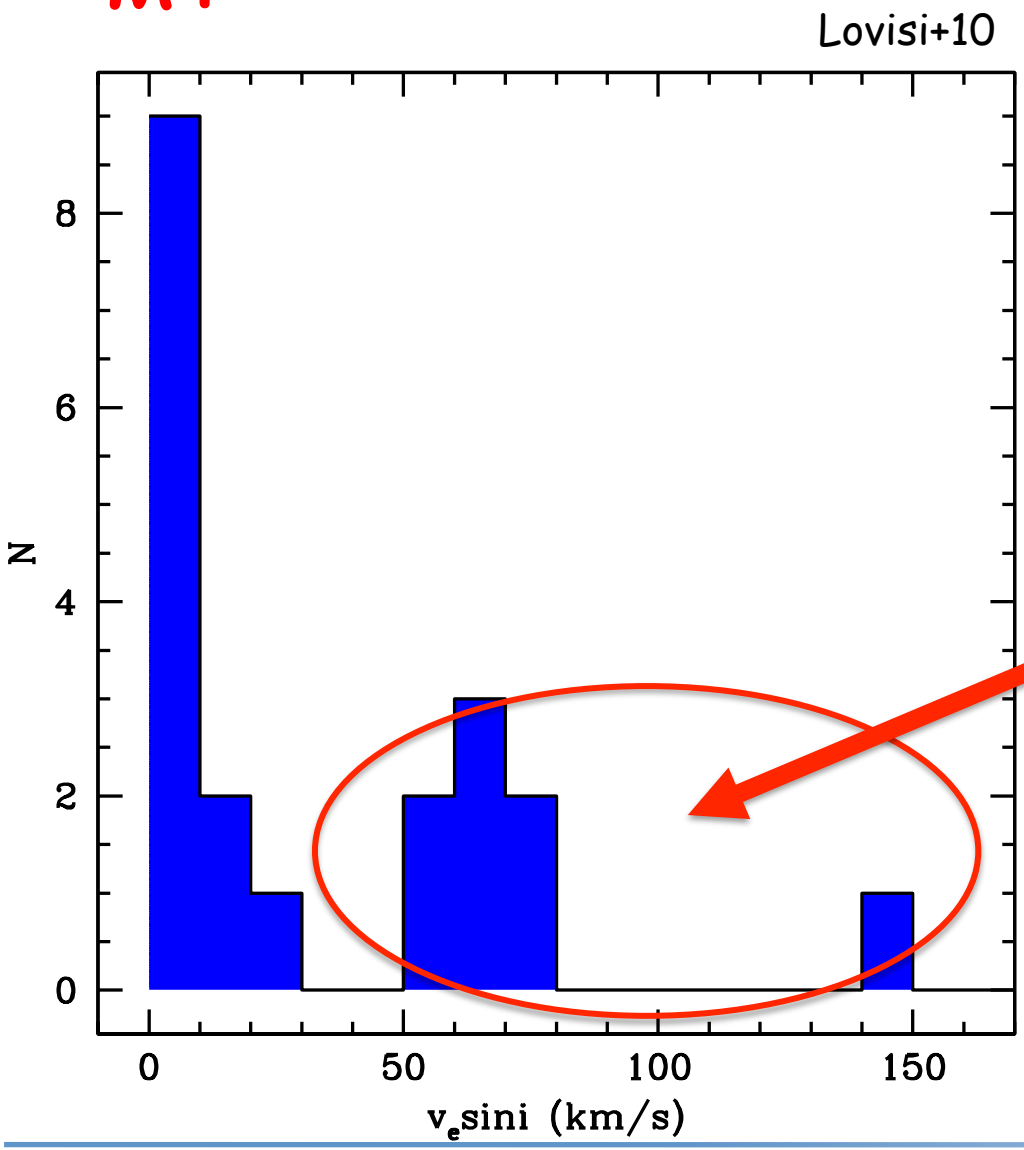
NGC6752



M30

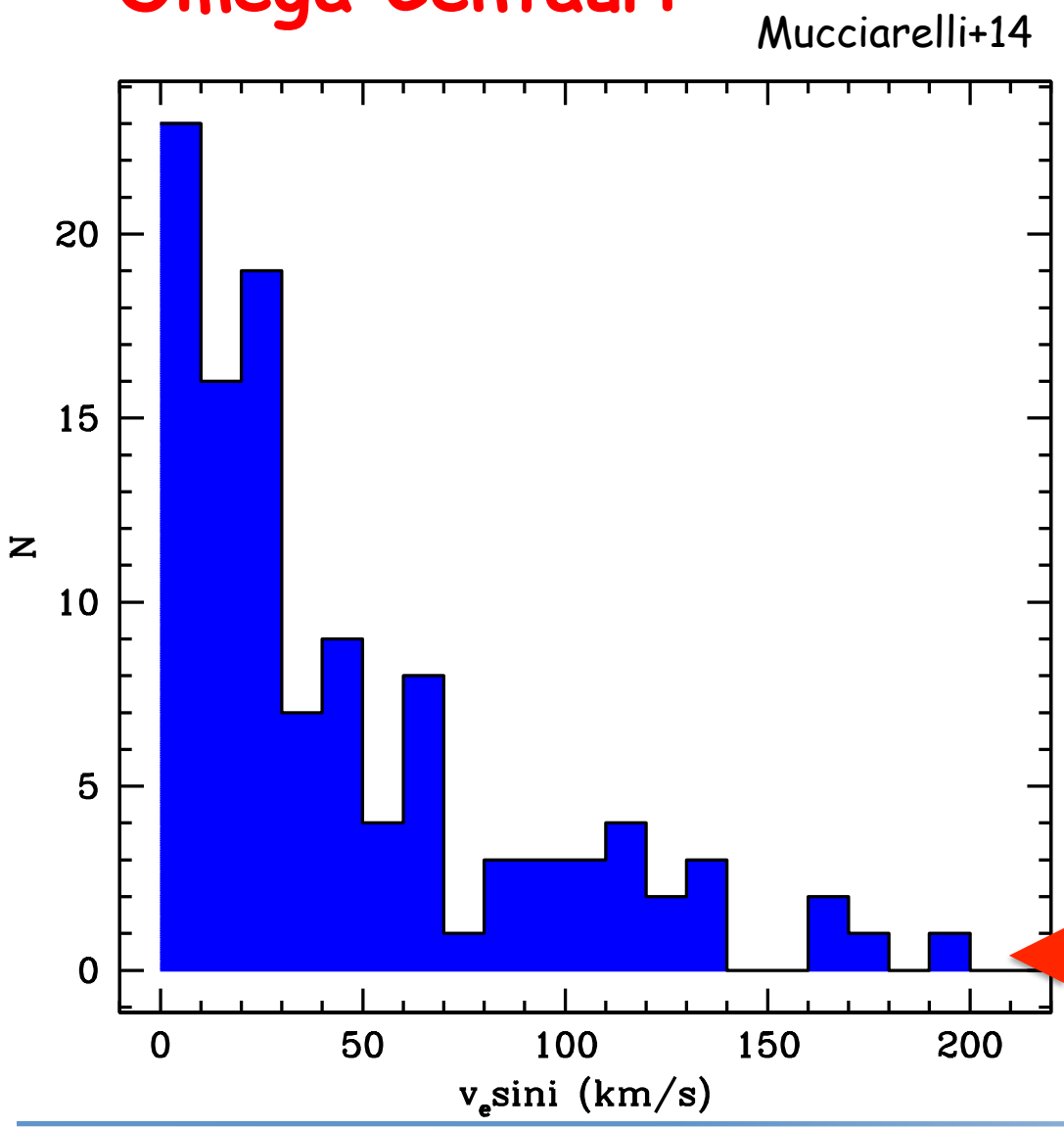


M4



~40% of the BSS in M4 are FR

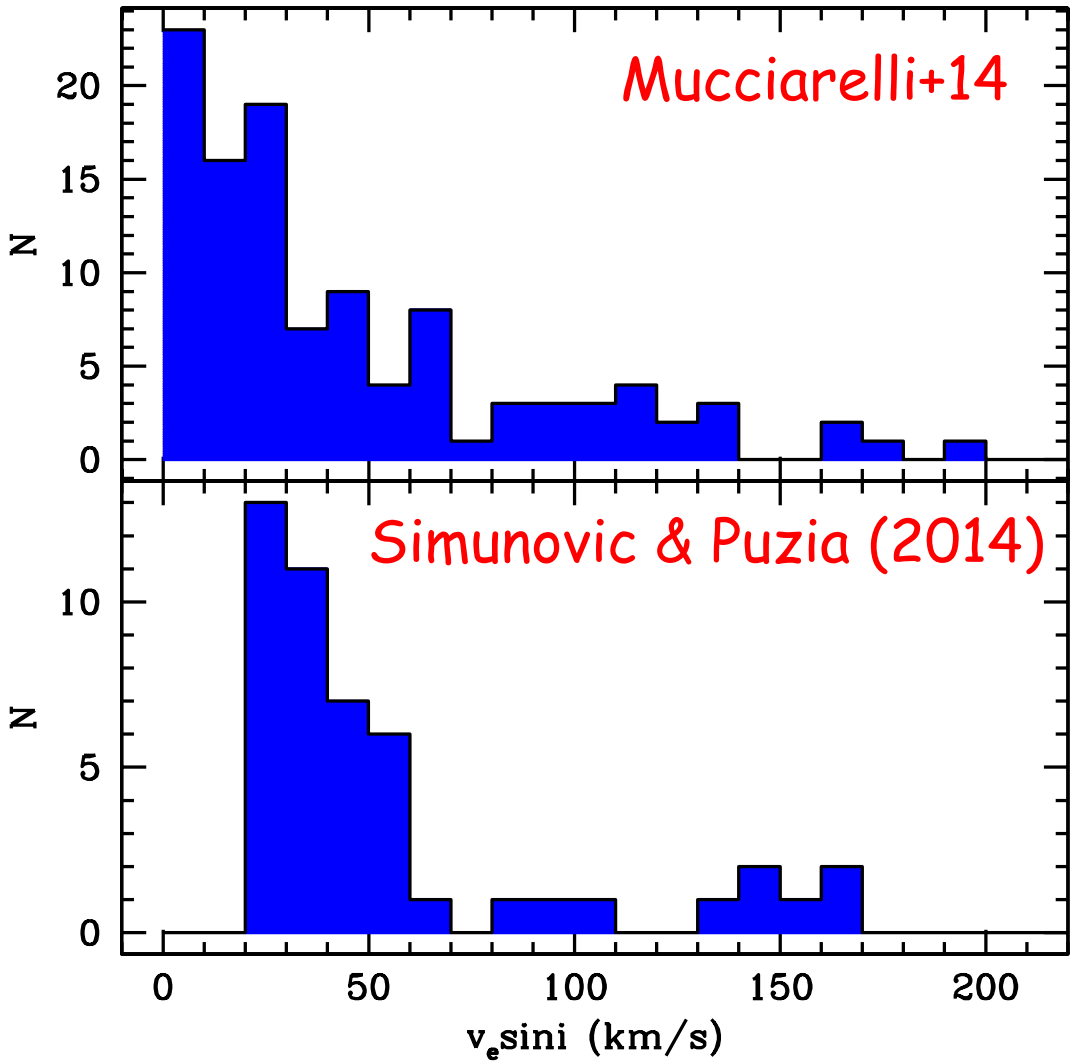
Omega Centauri



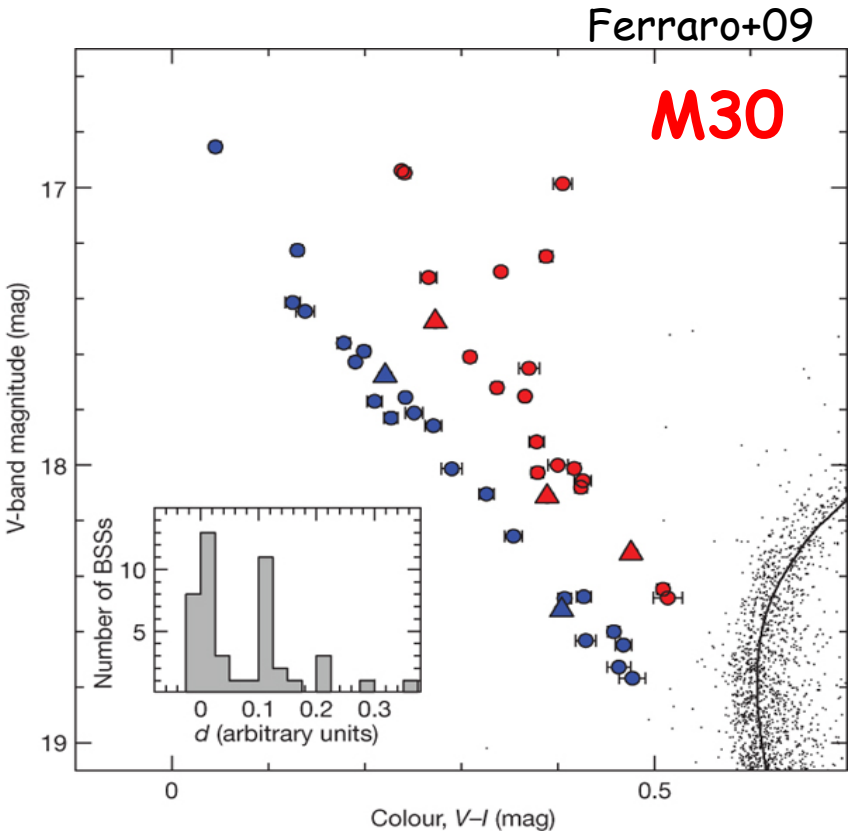
~40% > 50 km/s
~20% > 20 km/s

$v_e$sini up to ~200 km/s

Omega Centauri



Searching for a link between $v_e$sini and BSS formation mechanisms … M30



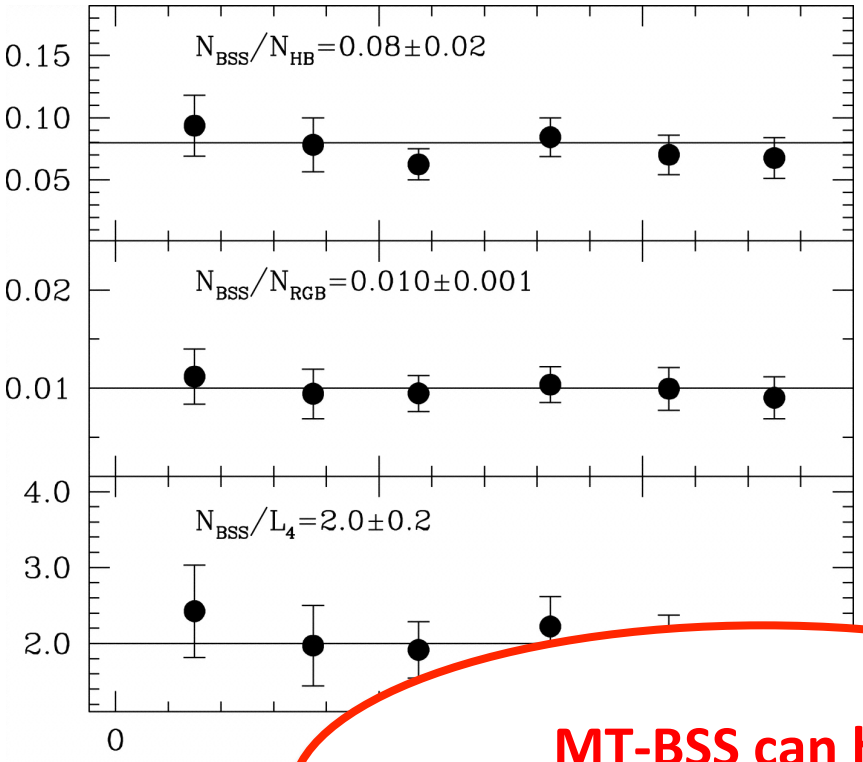
Blue BSS : collisional

Red BSS : mass transfer

Red and blueBSS share the same $v_e$sini distribution

Searching for a link between $v_e$sini and BSS formation mechanisms … Omega Cen

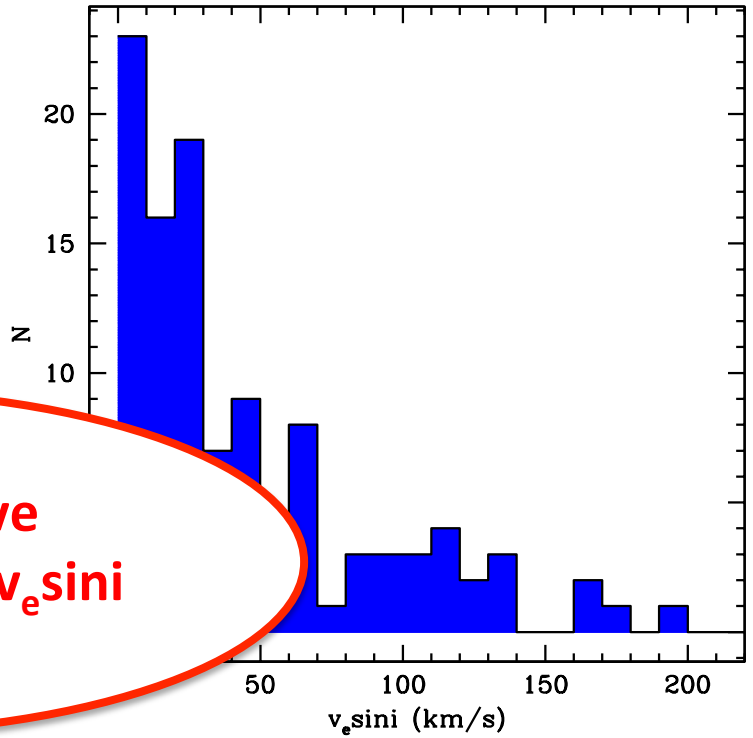
Ferraro+06



Flat distribution

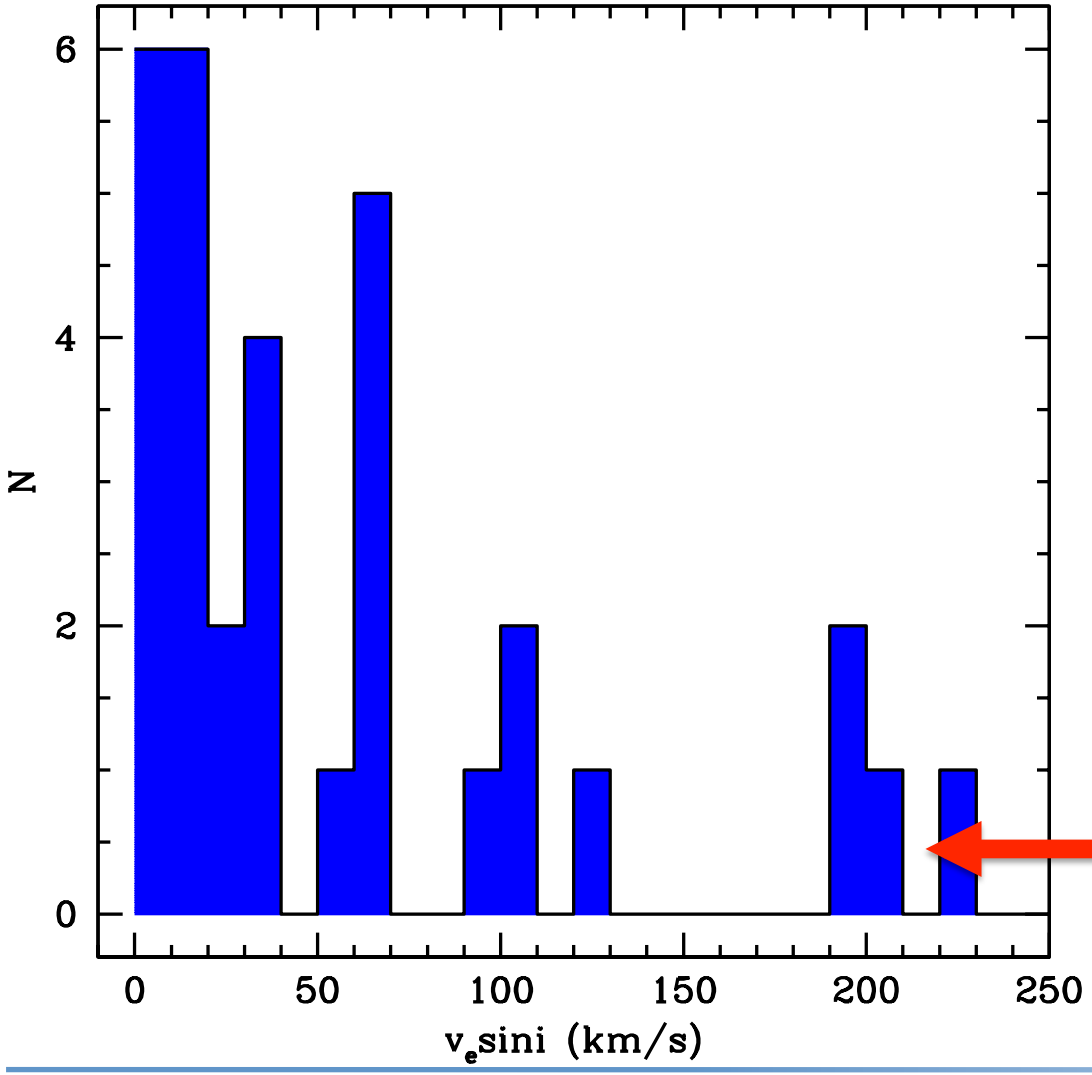
No-mass segregation

Non-collisional BBS population



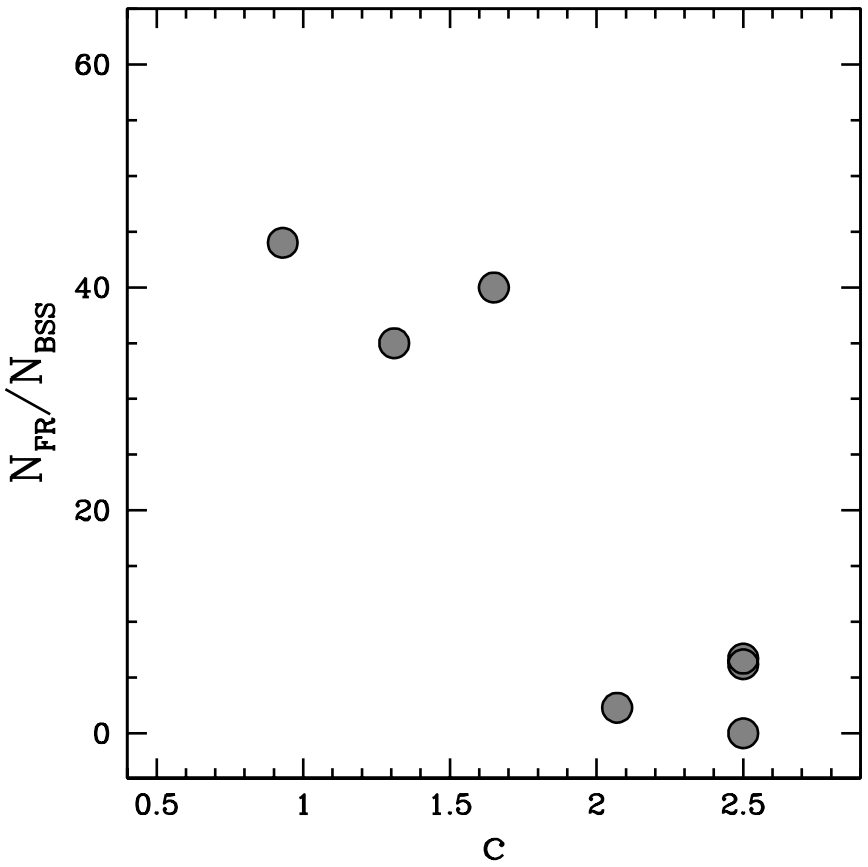
MT-BSS can have both high and low $v_e$sini

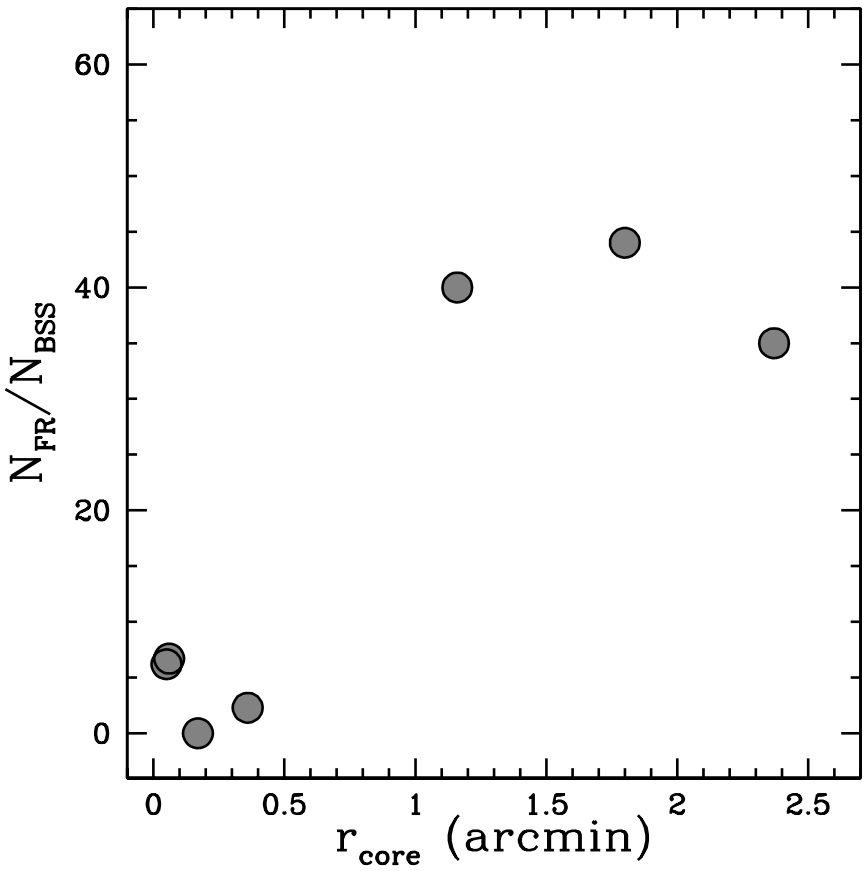
M55



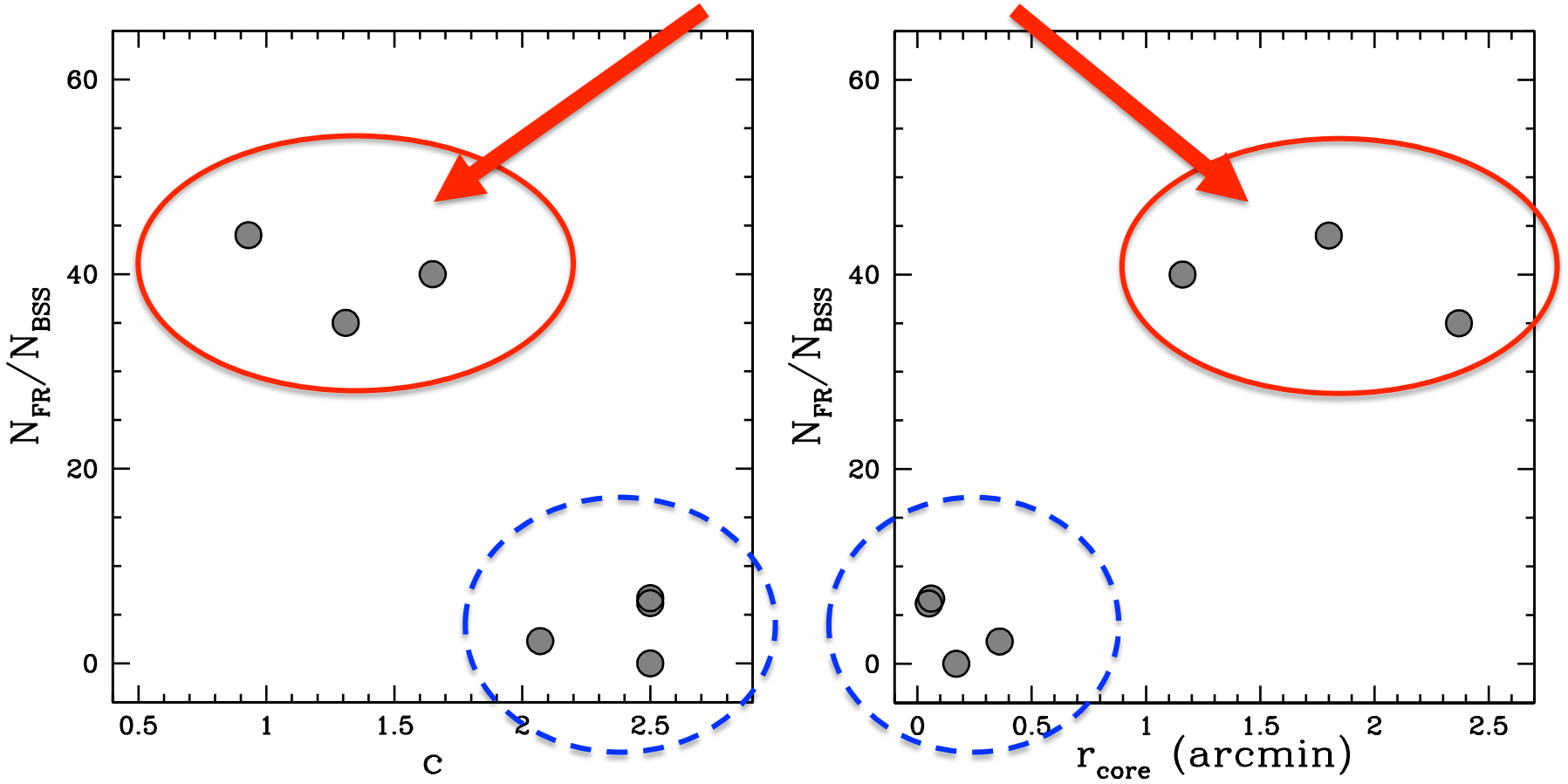
~43% of the BSS with $v_e sini > 50$ km/s

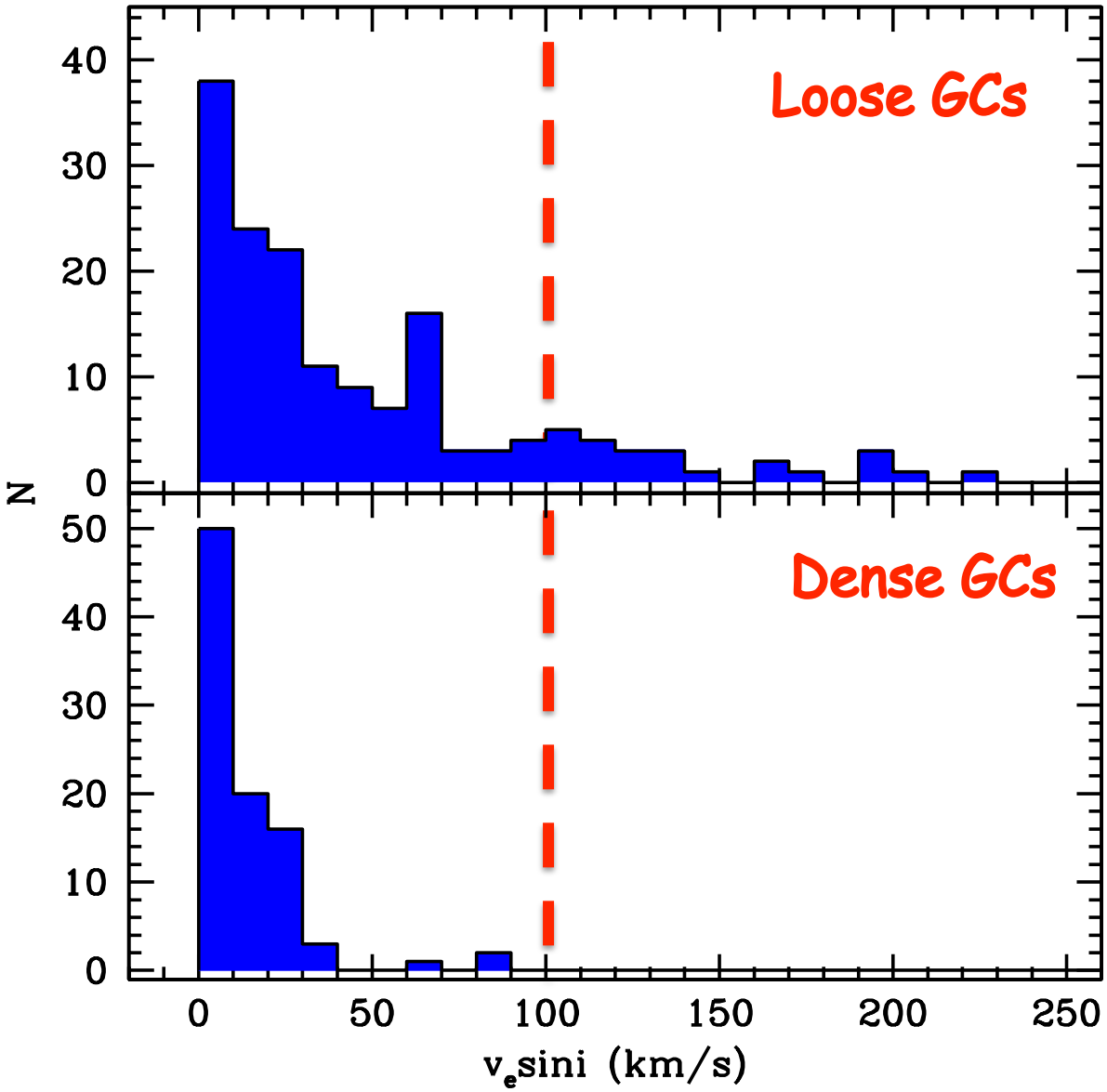
BSS with $v_e sini > 200$ km/s !!!


60
40
20
0
N_{FR}/N_{BSS}
0.5
1
1.5
2
2.5
c


60
40
20
0
N_{FR}/N_{BSS}
0
0.5
1
1.5
2
2.5
r_{core} (arcmin)

Fast-rotating BSS in loose GCs





FR (> 50 km/s) ~40%

FR (> 70 km/s) ~20%

FR (> 100 km/s) ~15%

FR (> 50 km/s) ~3%

FR (> 70 km/s) ~2%

FR (> 100 km/s) 0%

Ruminations about this finding …

First evidence of a direct link between the BSS physical properties and the characteristics of the host cluster

Recurrent stellar interactions might be efficient in decreasing the BSS rotational velocities **(low FR fraction in dense GCs)**

In loose GCs, where stellar interactions are less frequent, the initial rotational velocities of BSSs might be preserved
(high FR fraction in loose GCs)

Summary

First systematic survey of ~250 BSS in 7 GCs

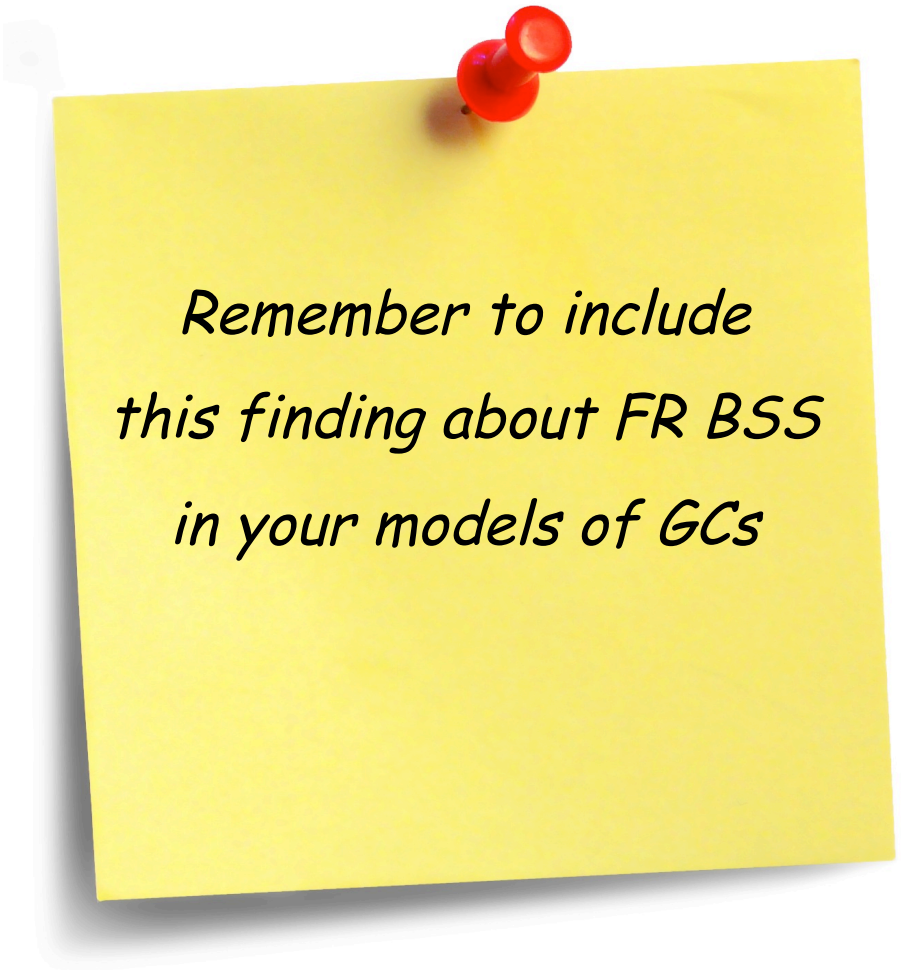
(1) BSS are essentially slow rotators
(but they can also have $v_e \sin i > 200$ km/s)

(2) No clear link with the formation mechanisms

(3) High fraction of FR BSS in loose GCs

New constraint
for the models !!!!

Future perspectives



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The End