Kinematical properties of BSS in Galactic Globular Clusters

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Cosmic-Lab

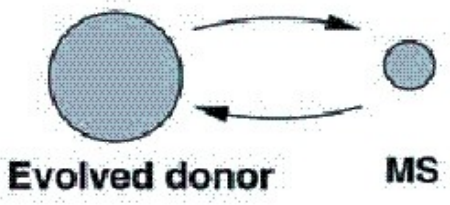
- 5-year project
- funded by the European Research Council (ERC)
- PI: Francesco R. Ferraro (Dip. of Physics & Astronomy – Bologna Univ.)
- AIM: **to understand the complex interplay between dynamics & stellar evolution**
- HOW: using **globular clusters** as cosmic laboratories and

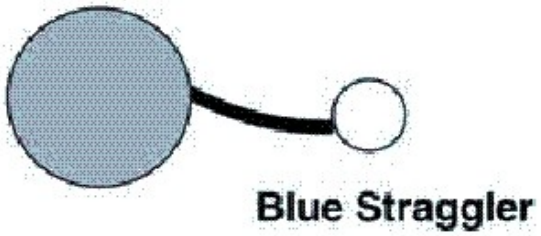
Blue Straggler Stars
Millisecond Pulsars
Intermediate-mass Black Holes

} as probe-particles

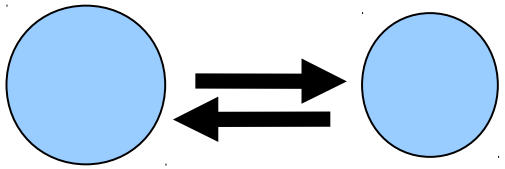
CHEMICAL PROPERTIES

See A. Mucciarelli's talk





MT-BSS → C-O depletion
(Sarna & De Greve, 1996)



COL-BSS → normal C & O abundances
(Lombardi et al, 1995)

WHAT ABOUT KINEMATICAL PROPERTIES?

THEORETICAL PREDICTIONS

MT-BSS → **high rotational velocities expected**
(Sarna & De Greve, 1996)

UNFORTUNATELY
simulations are lacking

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COL-BSS →
- **are FAST rotators**
  (Benz & Hills, 1987)
- **are NOT FAST rotators**
  (Leonard & Livio, 1995
  Sills et al, 2005)

→ **Controversial results**

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(Leonard & Livio, 1995
Sills et al, 2005)

→ **Controversial results**

In **BOTH** processes: **BRAKING MECHANISMS**
(magnetic braking/disk locking)
MAY INTERVENE!!

PREVIOUS OBSERVATIONAL EVIDENCE

1 BSS in 47 Tuc
(Shara et al, 1997)

FOS@HST
R ~ 1300

→ **v sin (i) ~ 150 km/s**

6 BSS in
M3, 47 Tuc,
NGC 6752
(De Marco et al, 2005)

FOS/STIS@HST
R ~ 1300-7000

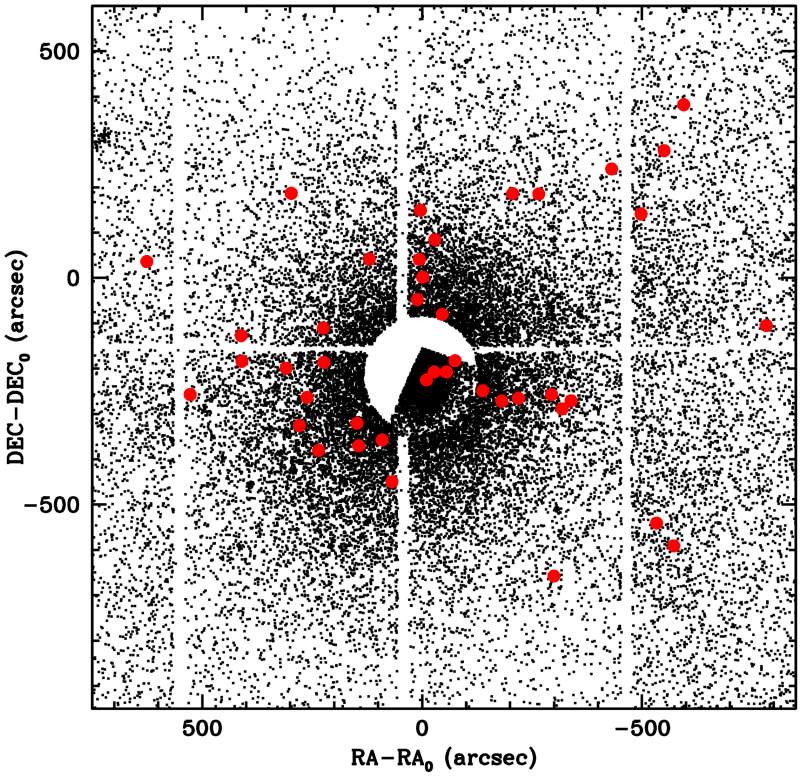
→ **v sin (i) ~ 50-200 km/s**

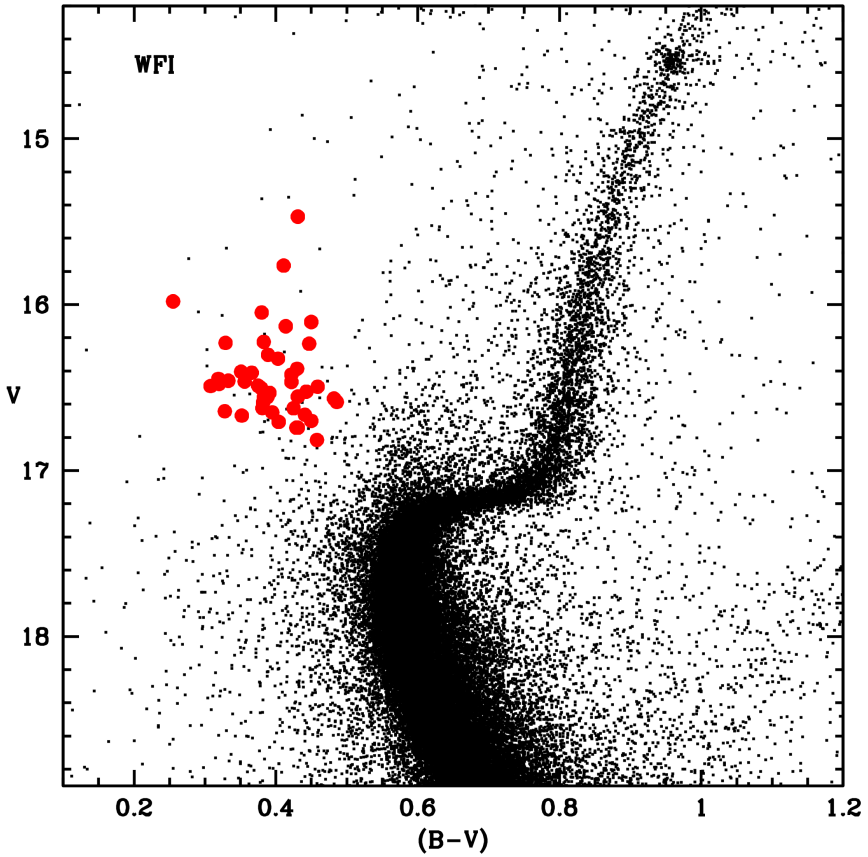
High rotational velocities?

SYSTEMATIC & EXTENSIVE STUDIES ARE LACKING!!

47 TUCANAE
(Ferraro et al, 2006)

42 BSS
FLAMES@VLT





47 TUCANAE
(Ferraro et al, 2006)

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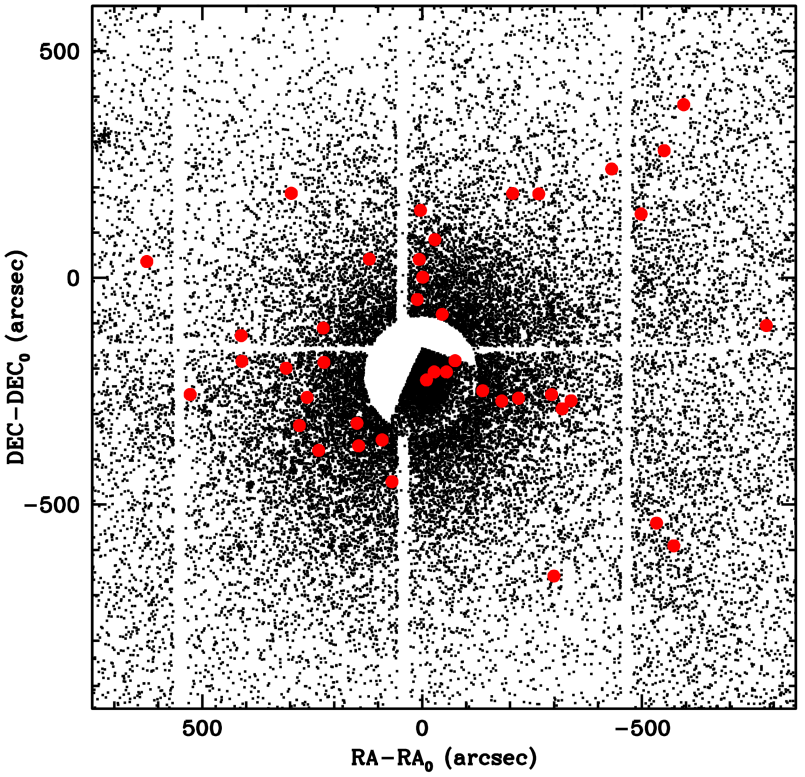
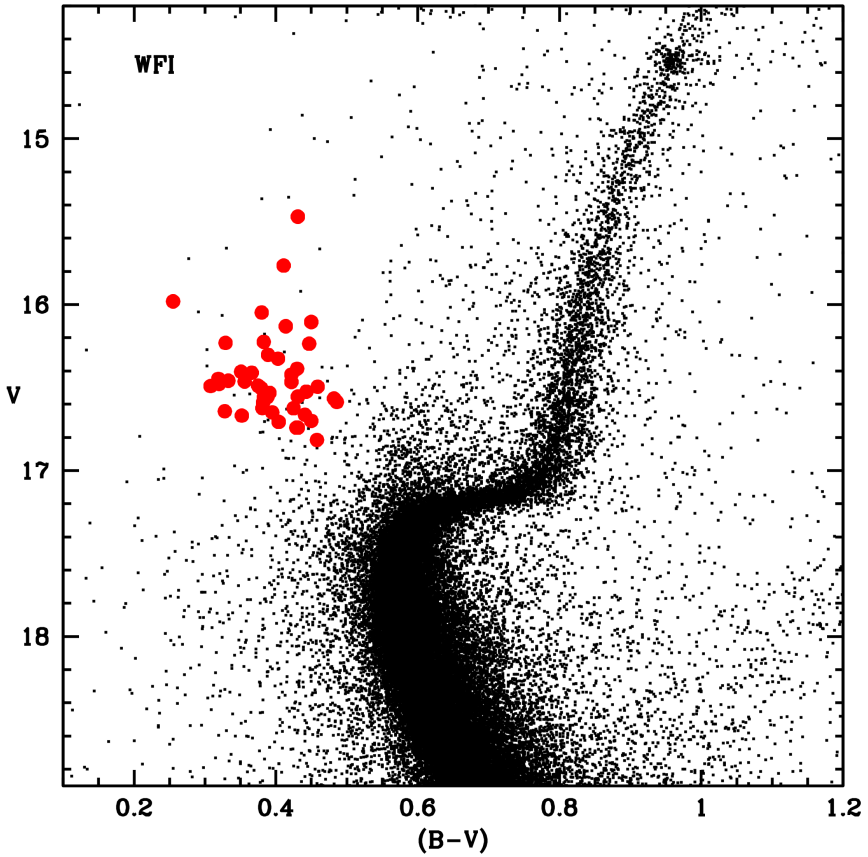
FLAMES@VLT





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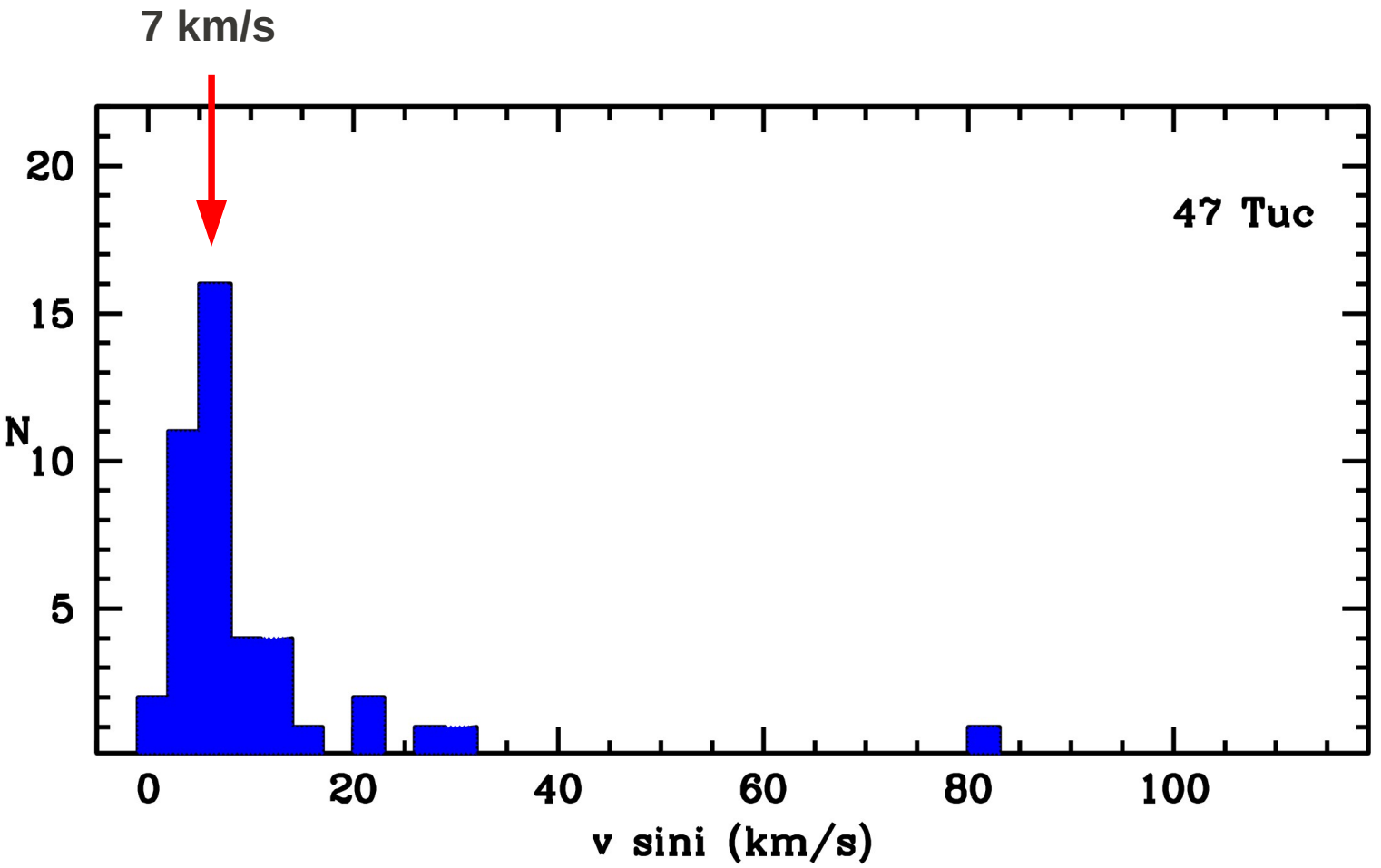

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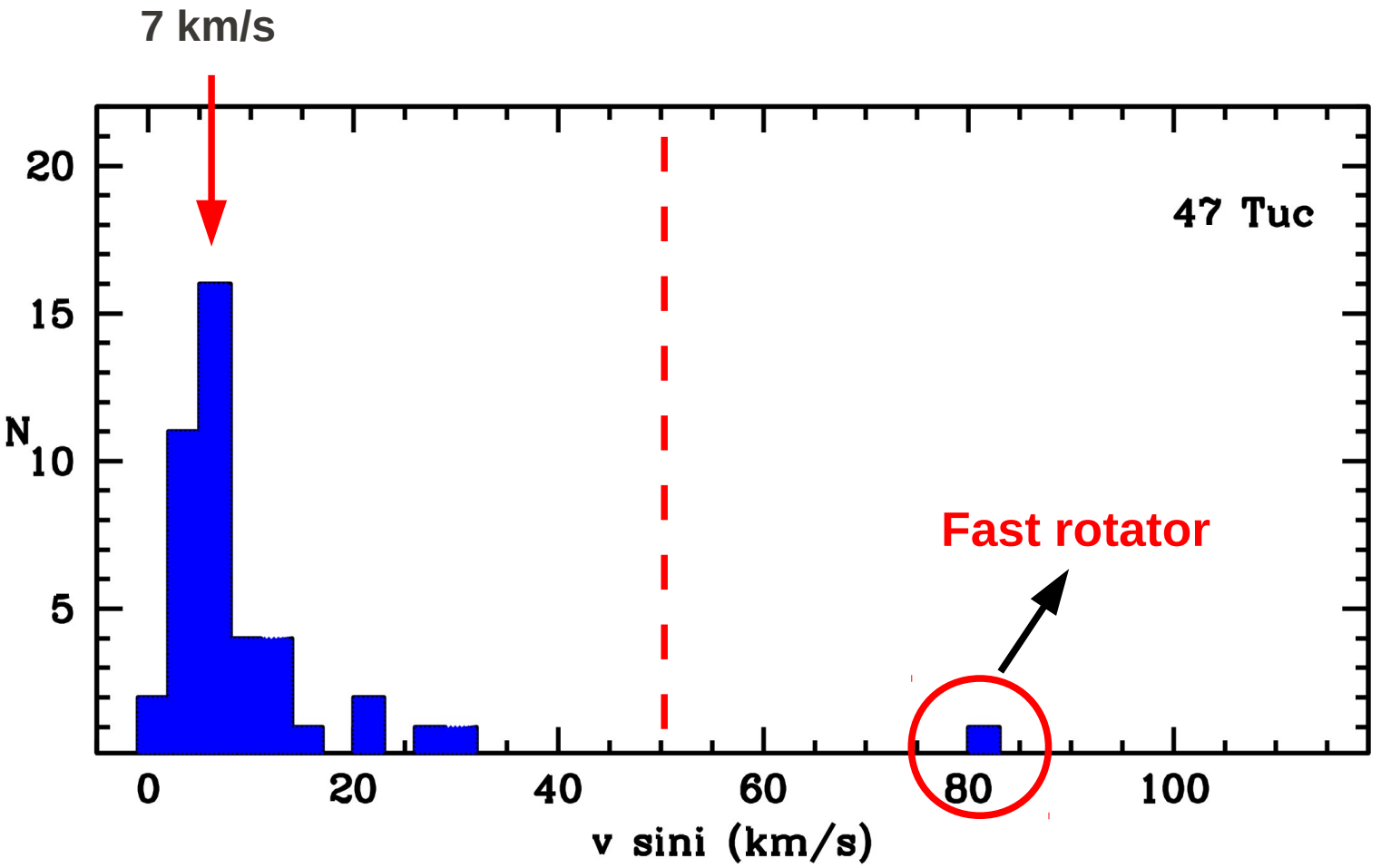
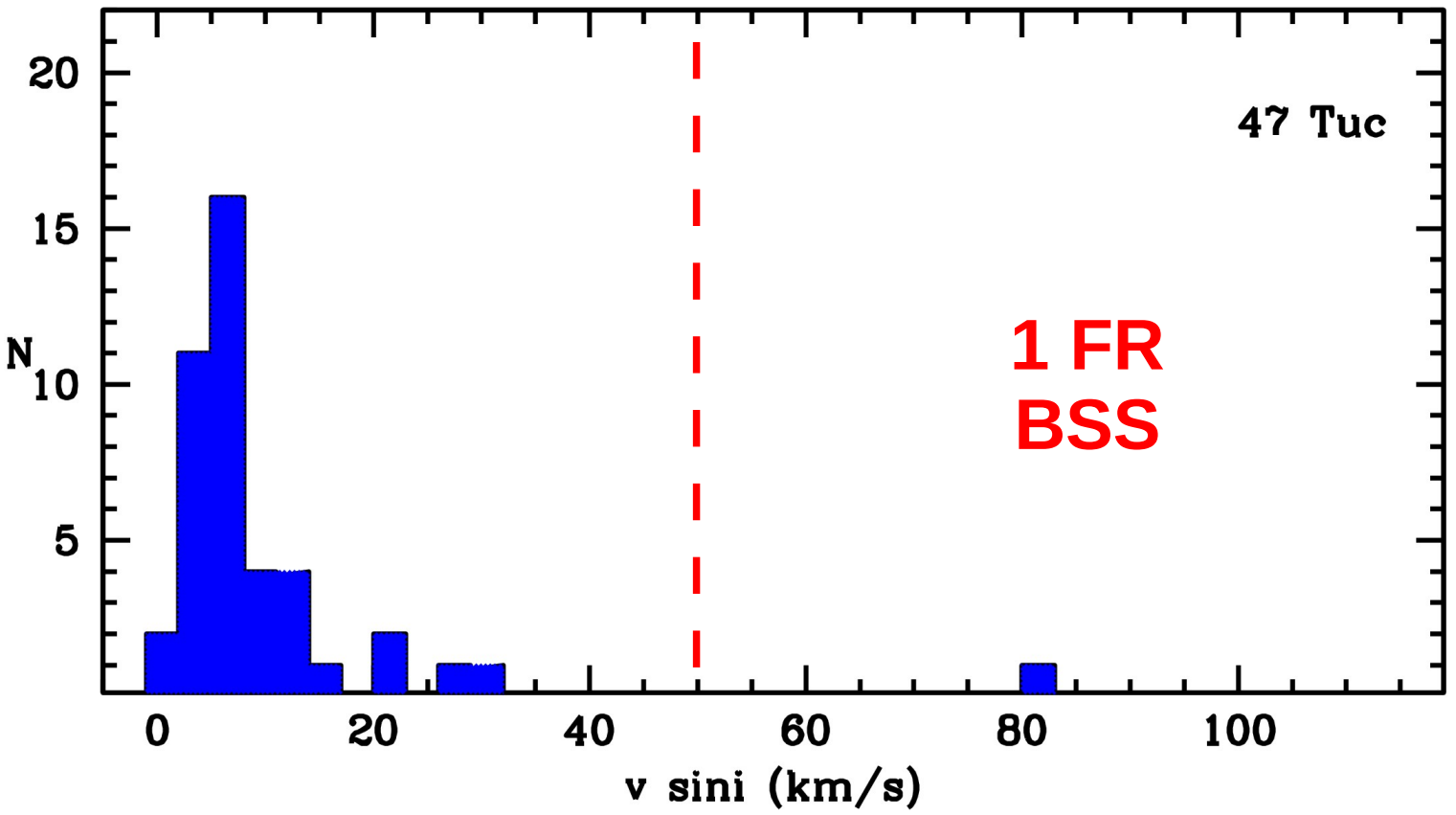


1 FR BSS

47 TUCANAE

(Ferraro et al, 2006)

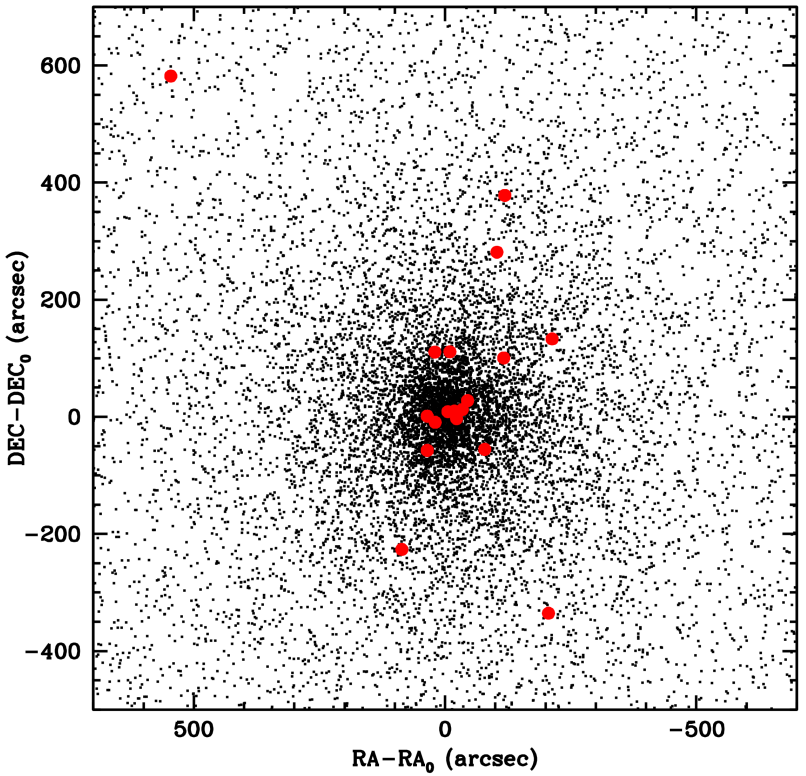


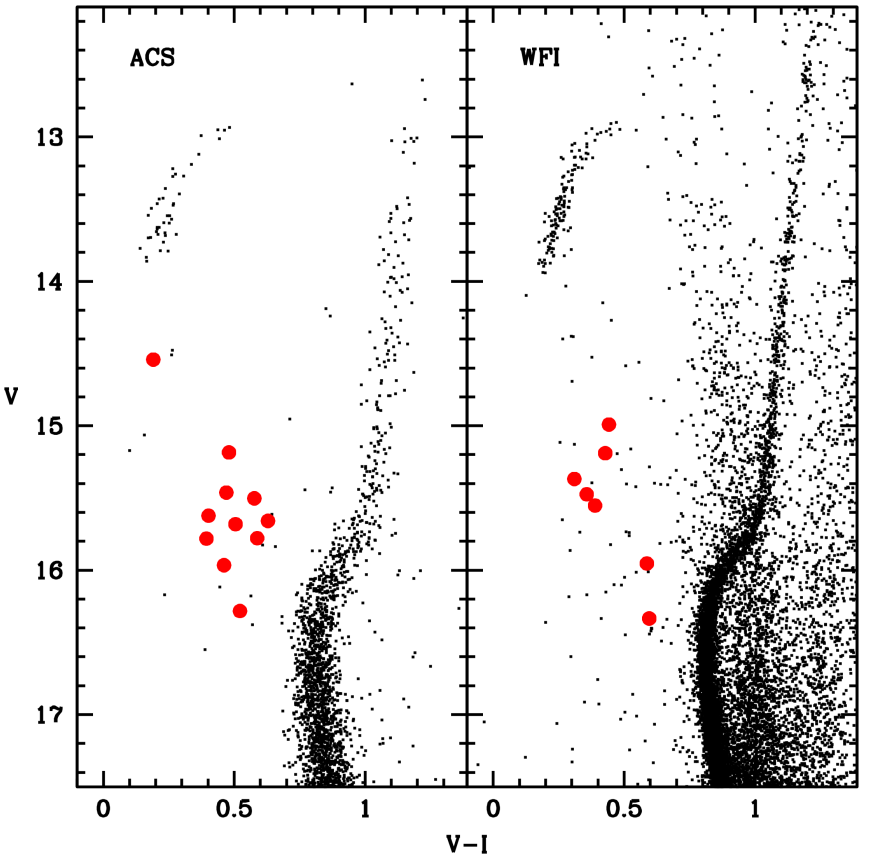
Shara et al, 1997
+
De Marco et al, 2005
+
Ferraro et al, 2006

7% are FR

NGC 6397
(Lovisi et al, 2012)

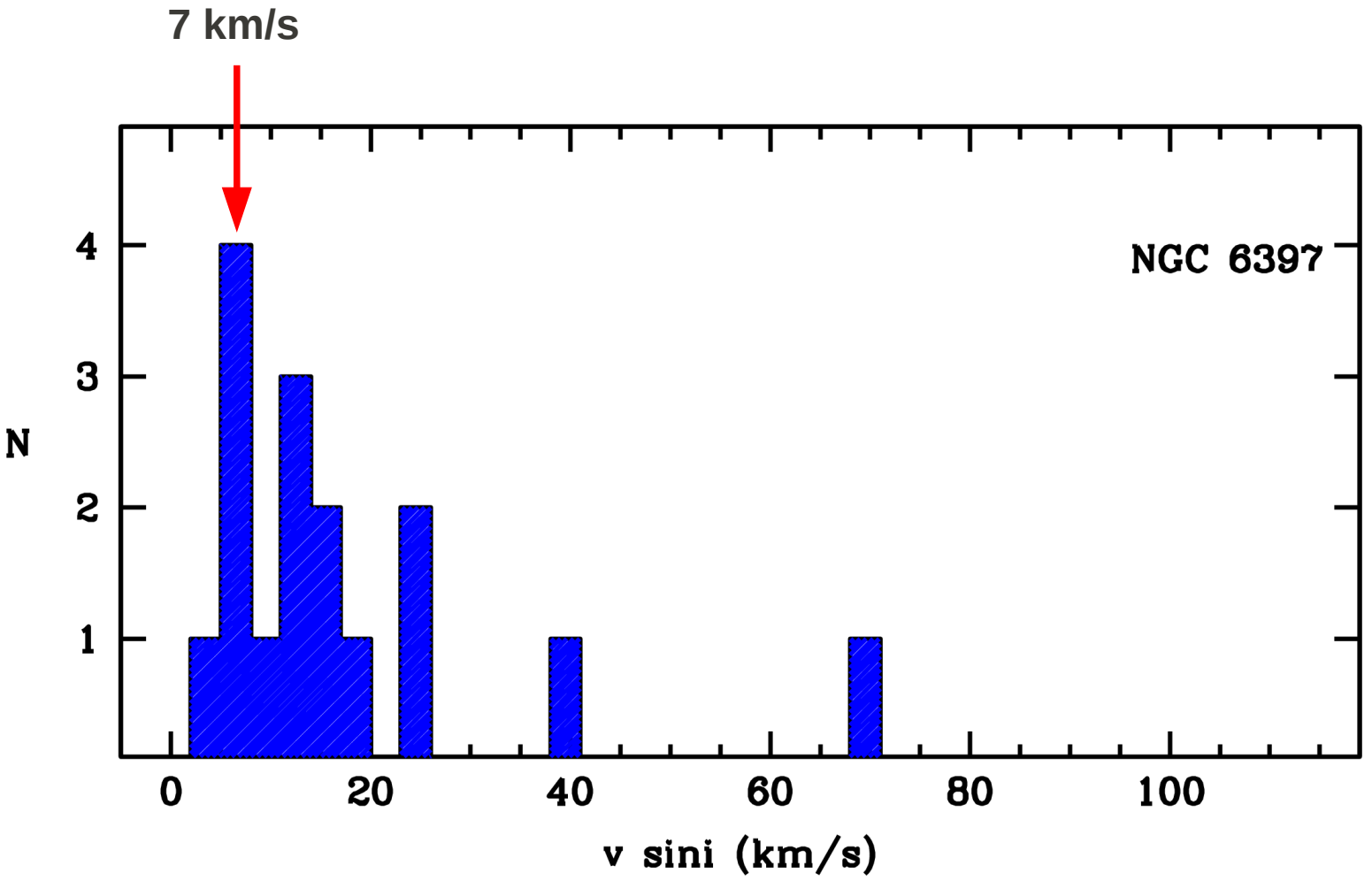
18 BSS
FLAMES@VLT





NGC 6397

(Lovisi et al, 2012)



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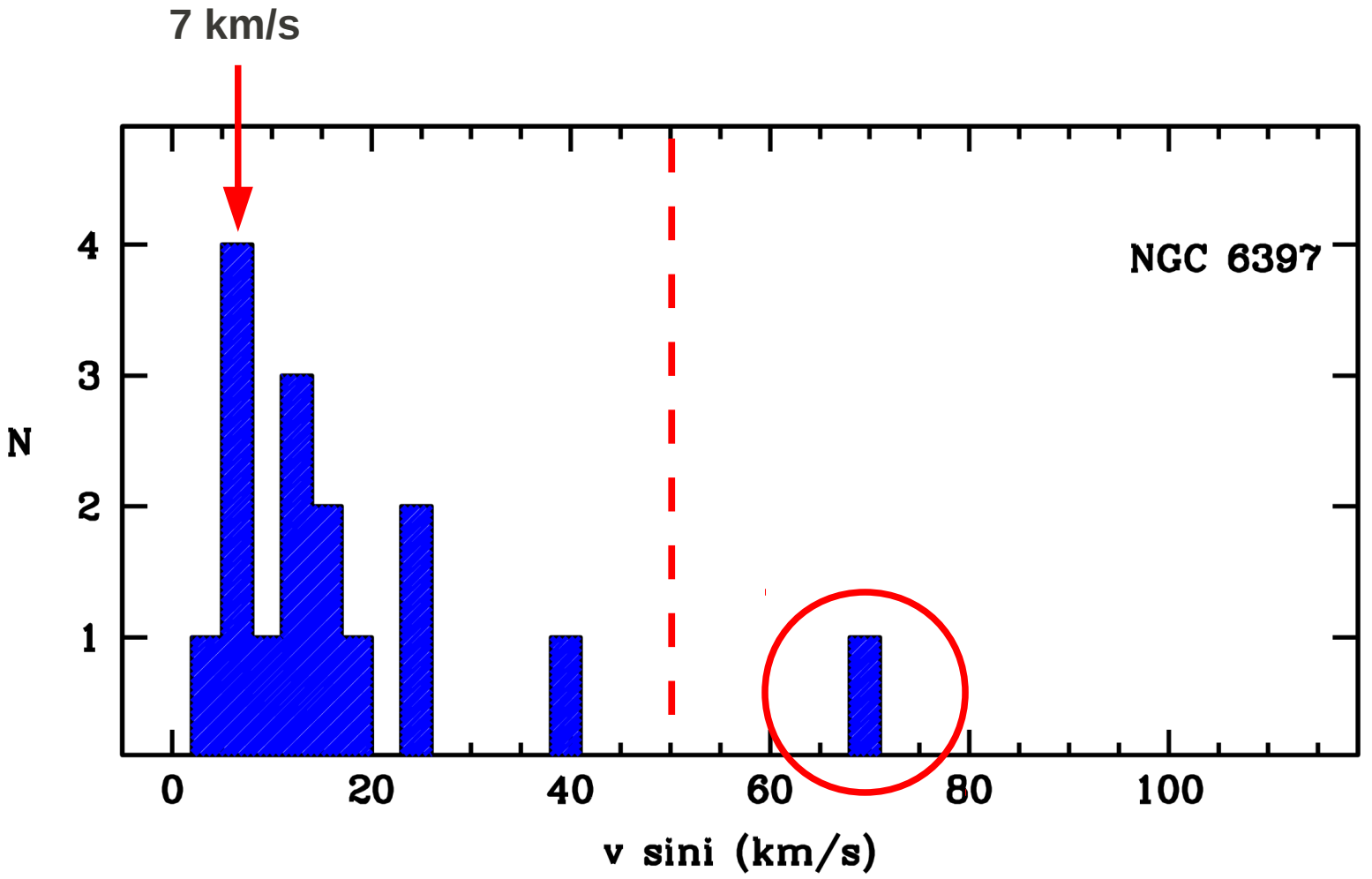


1 FR BSS

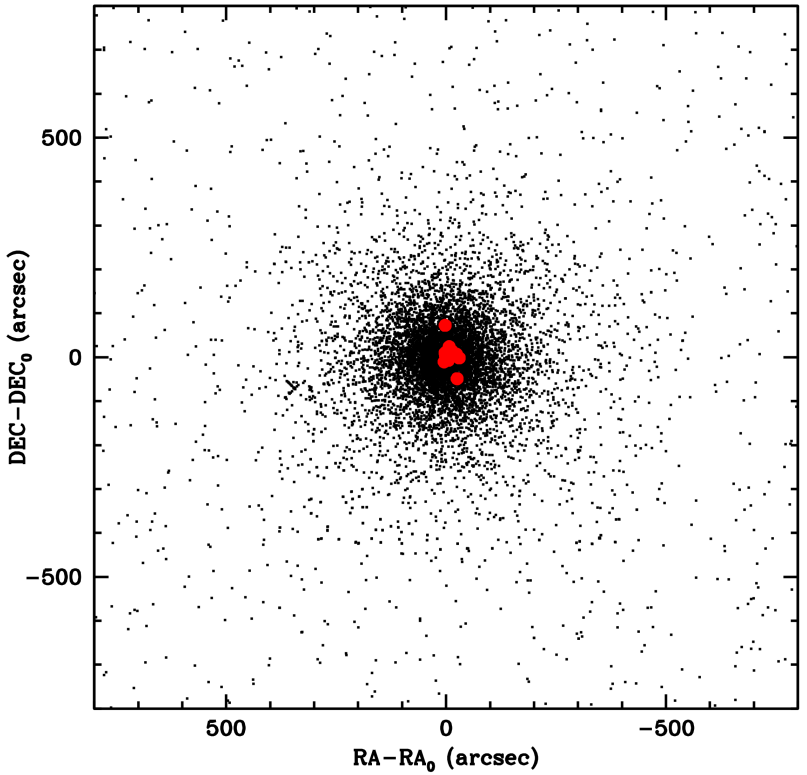
< 6%

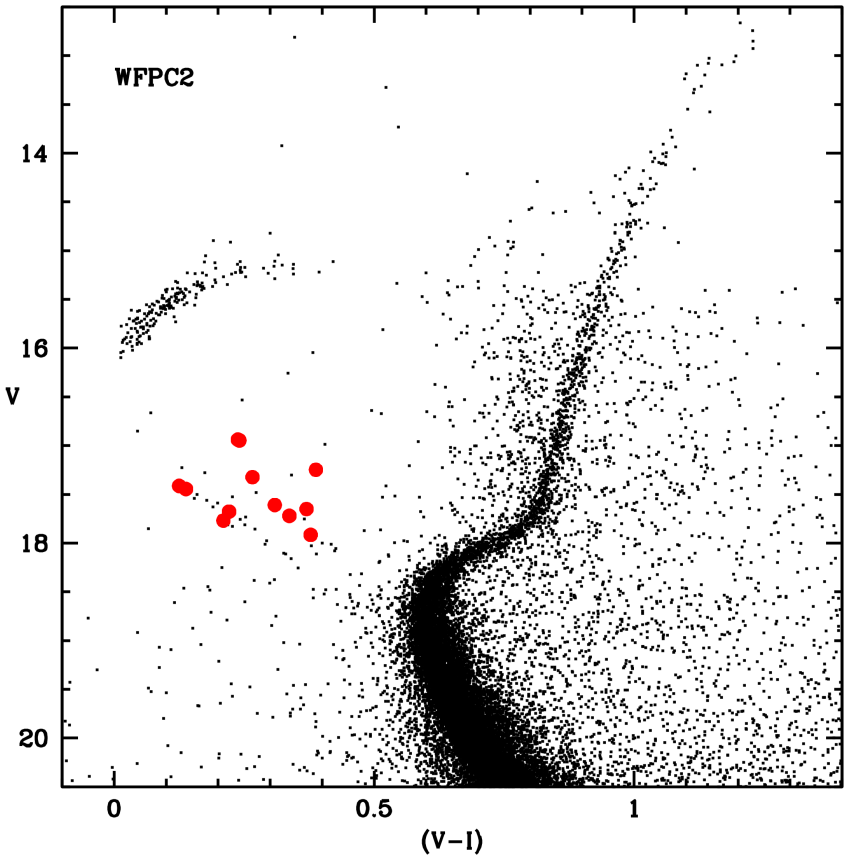
M30

(Lovisi et al, in preparation)

12 BSS

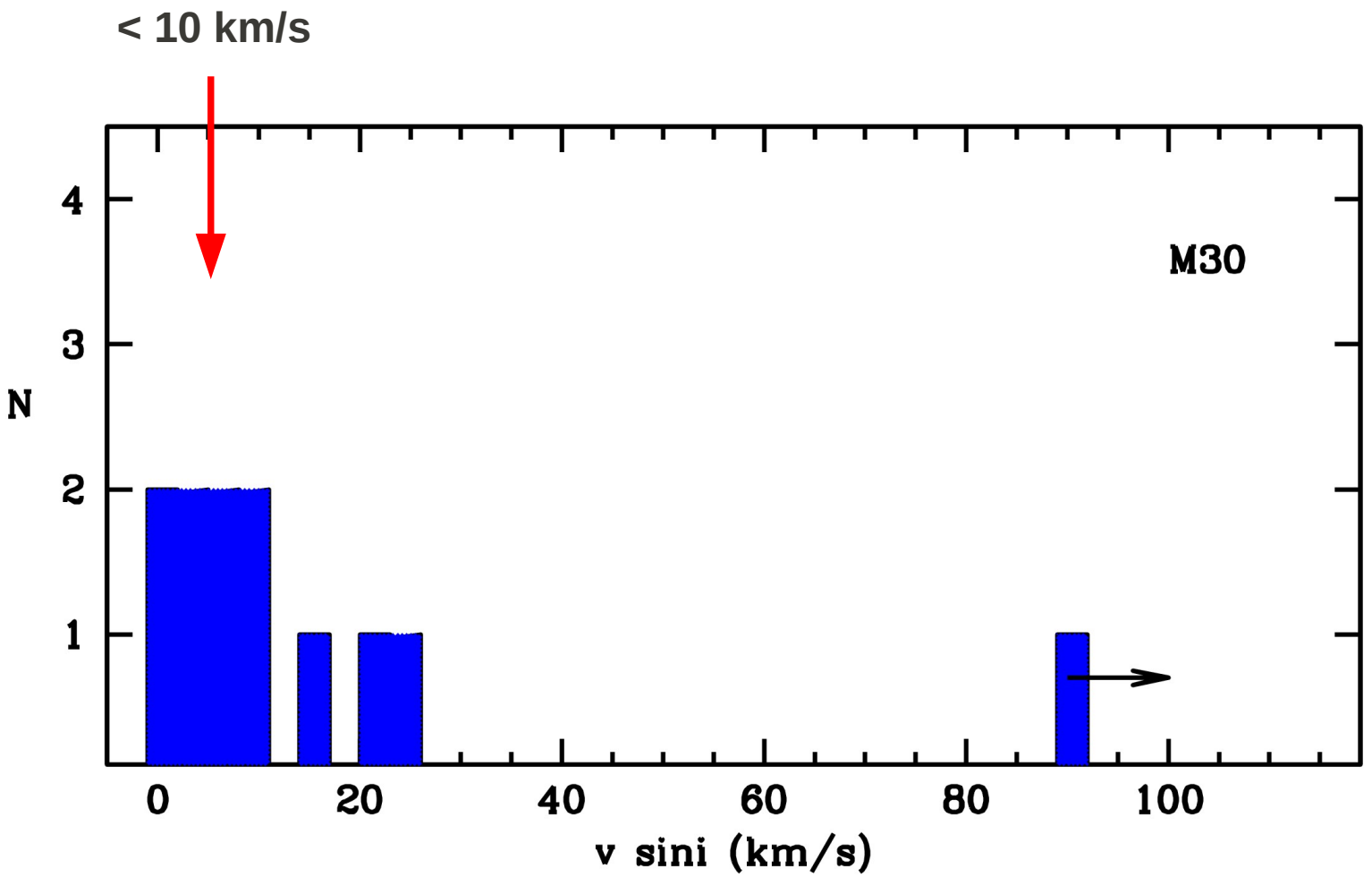
FLAMES@VLT





M30

(Lovisi et al, in preparation)



M30

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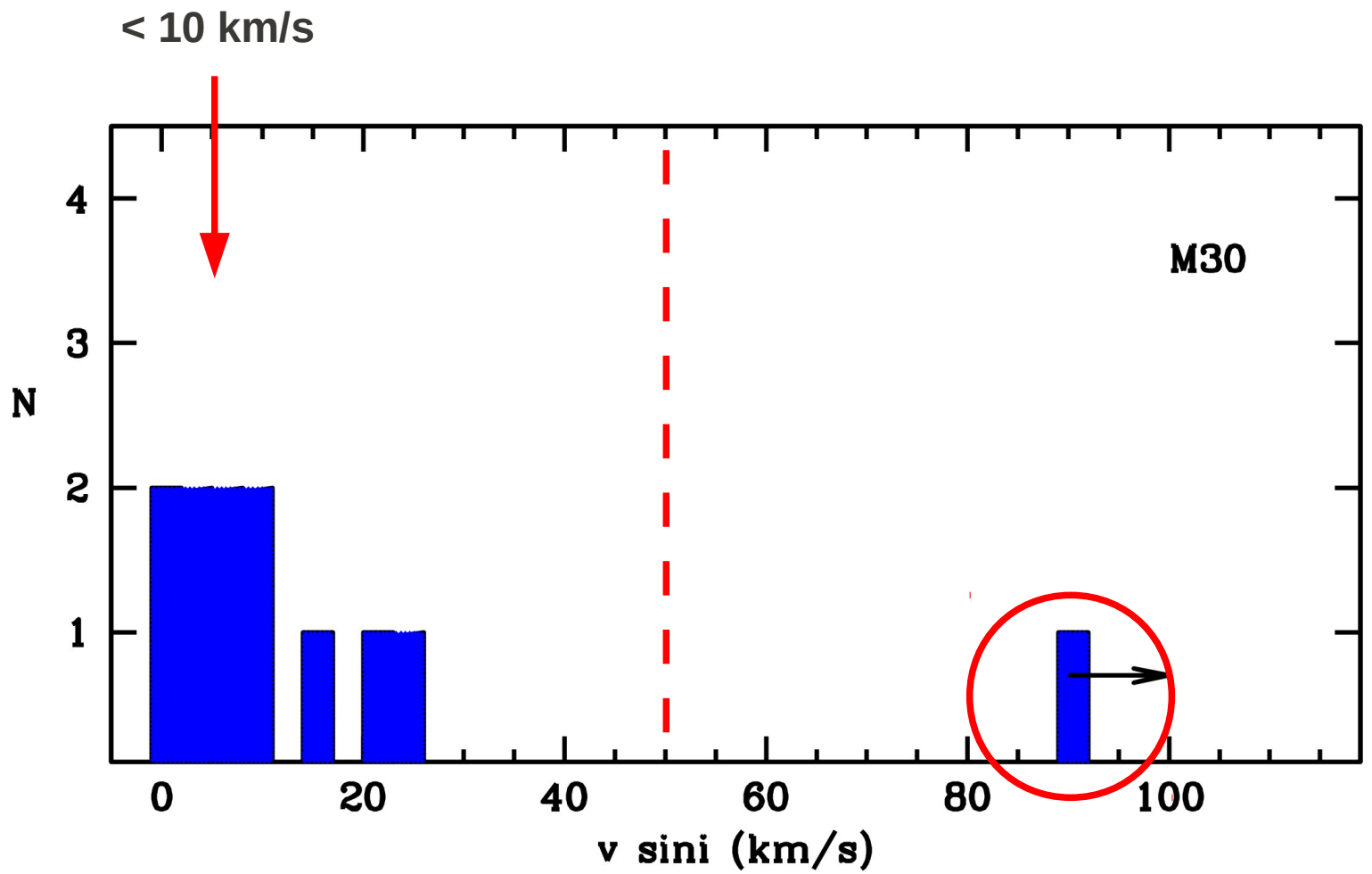


1 FR BSS

~ 8%

47 Tuc → ~ 7%

NGC 6397 → < 6%

M30 → ~ 8%

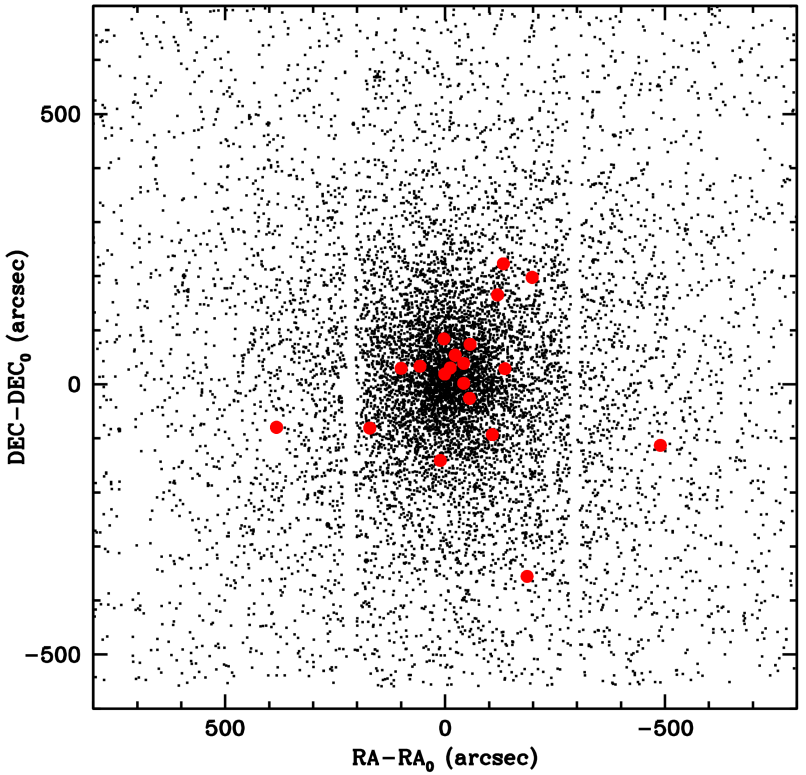
Low percentage of FR BSS

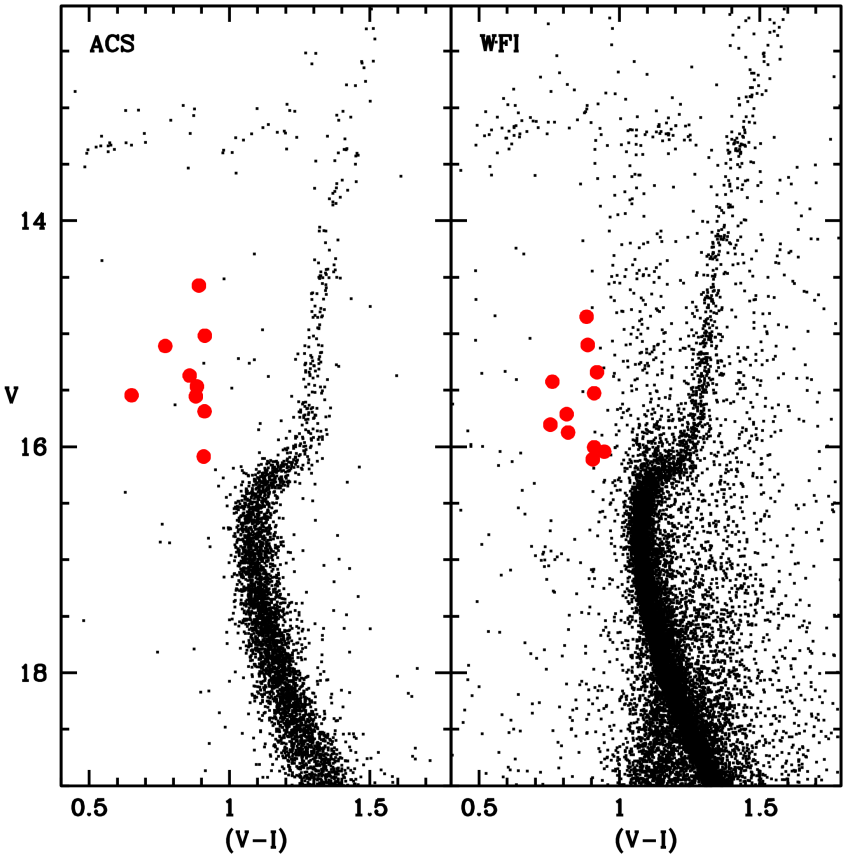
Apparently most of the BSS rotate SLOWLY

BUT...

M4
(Lovisi et al, 2010)

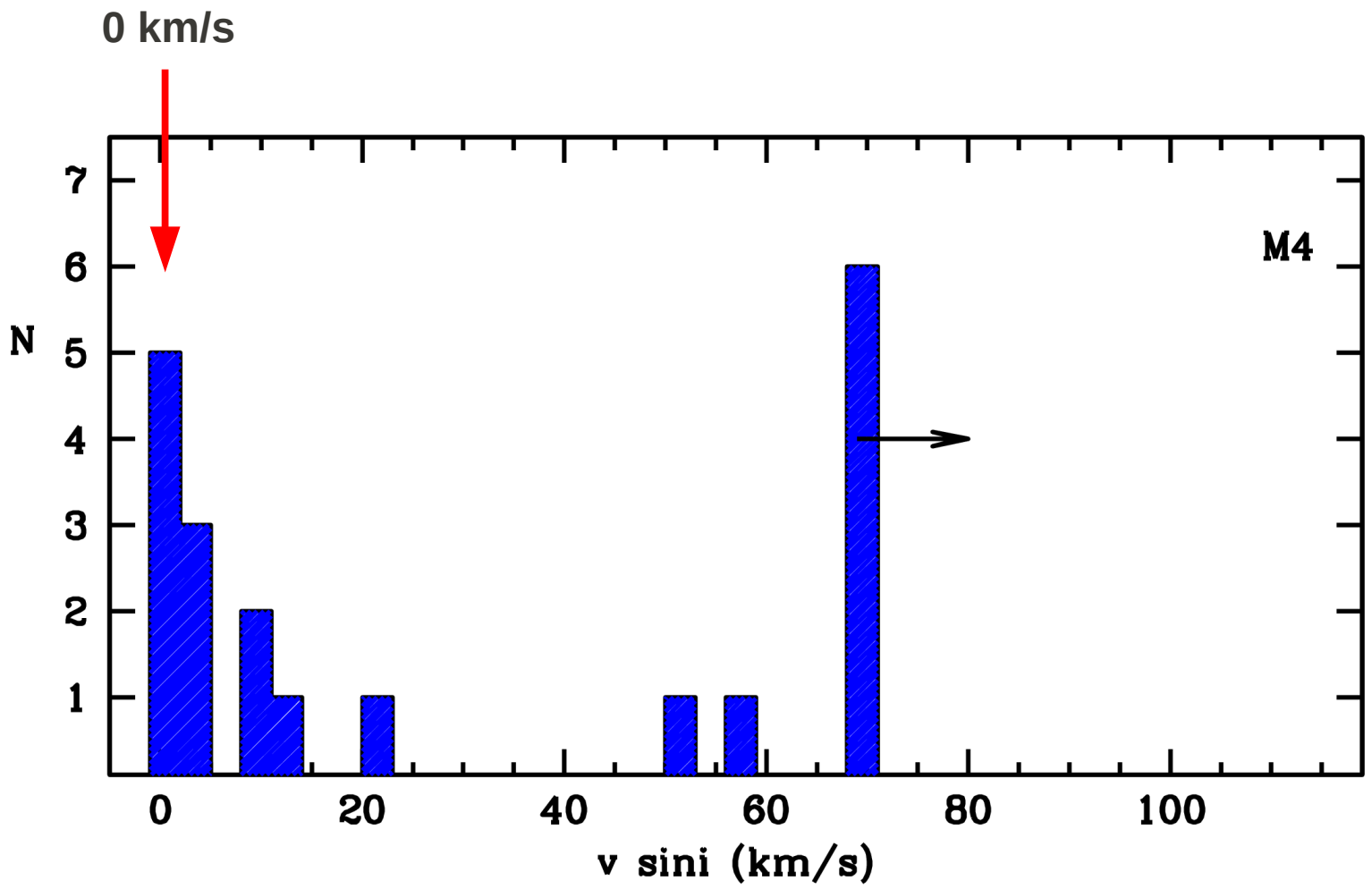
20 BSS
FLAMES@VLT





M4

(Lovisi et al, 2010)



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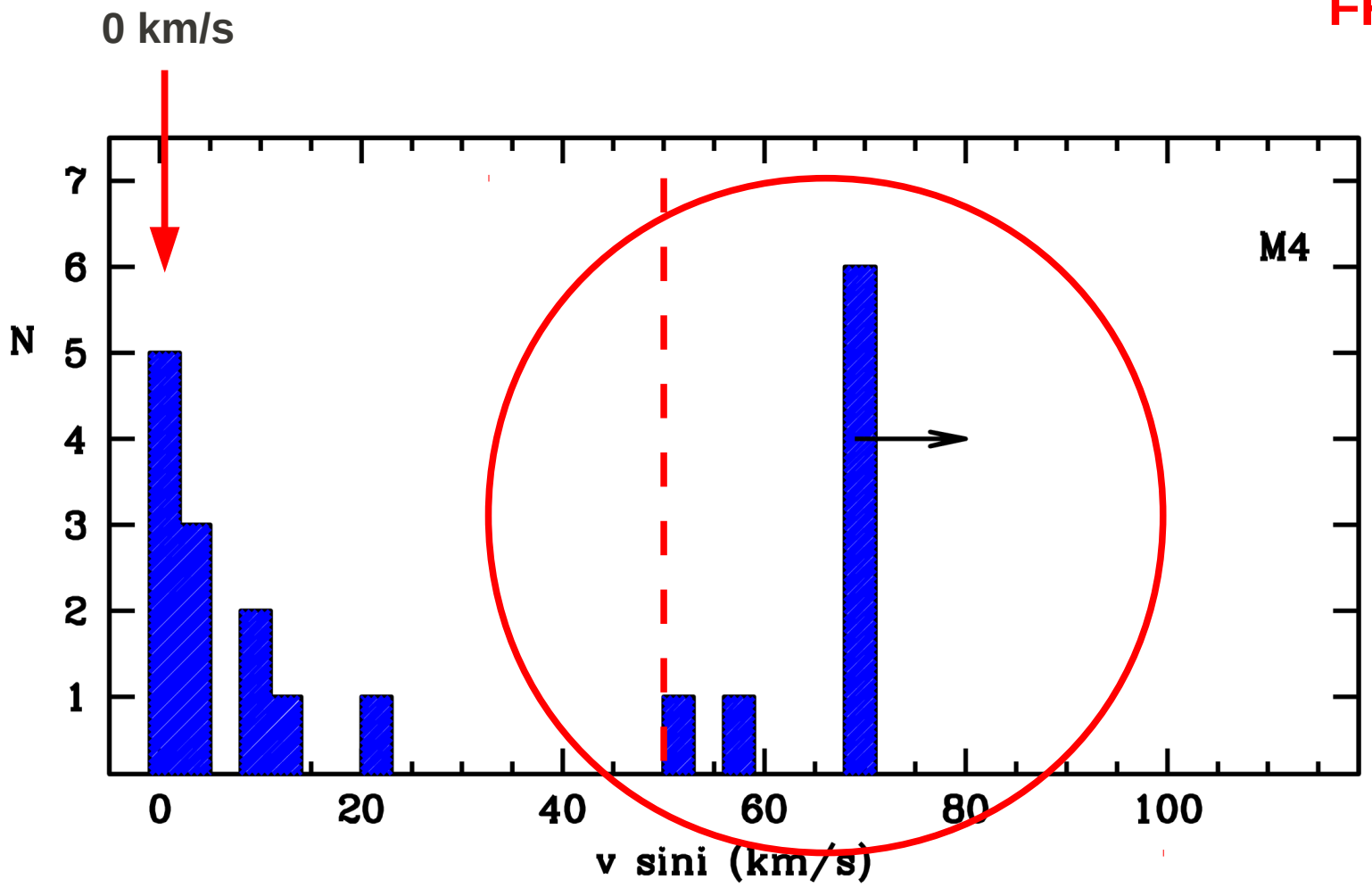


VERY HIGH FRACTION!!

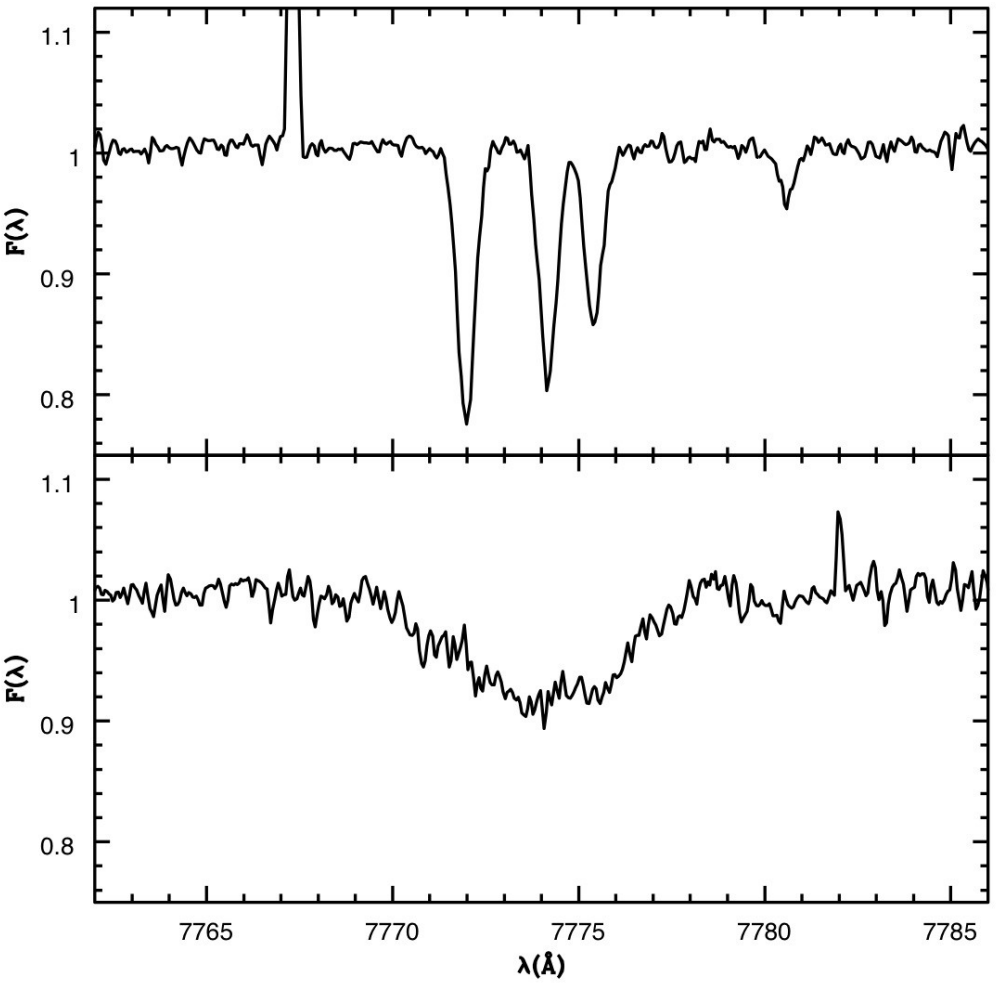
8 FR BSS

~ 40%

M4
(Lovisi et al, 2010)

Low rotating BSS

FR BSS

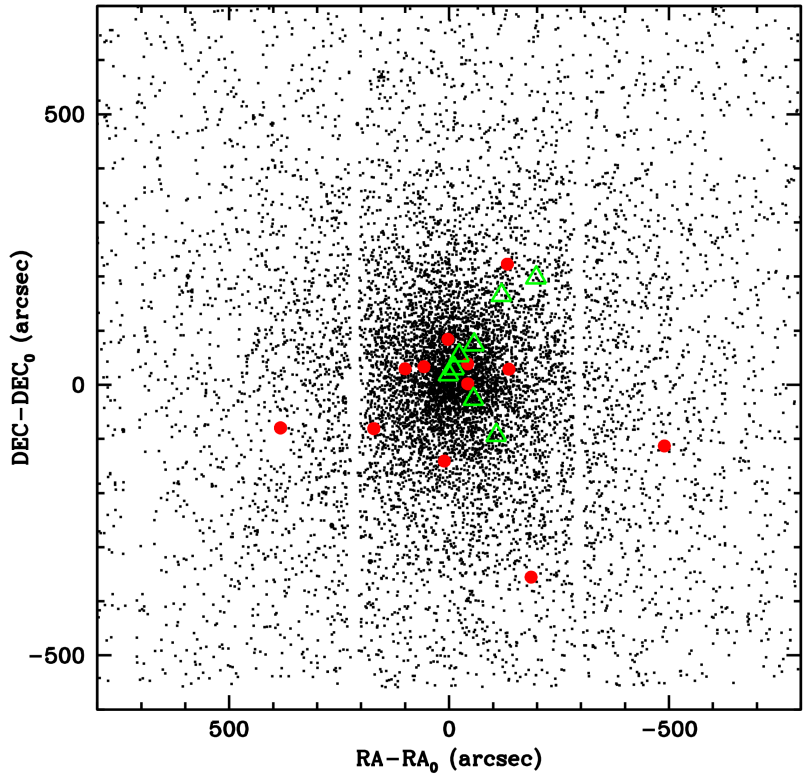


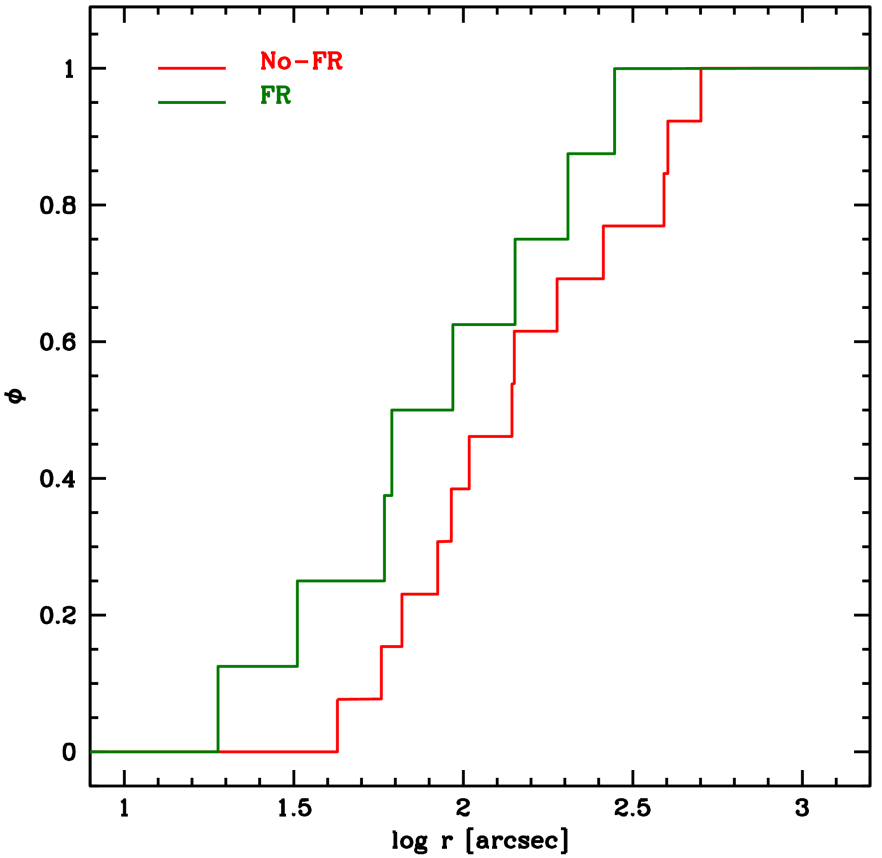
OI triplet

M4

(Lovisi et al, 2010)

FR are more centrally concentrated
(low statistical significance)





ωCentauri

(Mucciarelli et al, in preparation)

75 BSS

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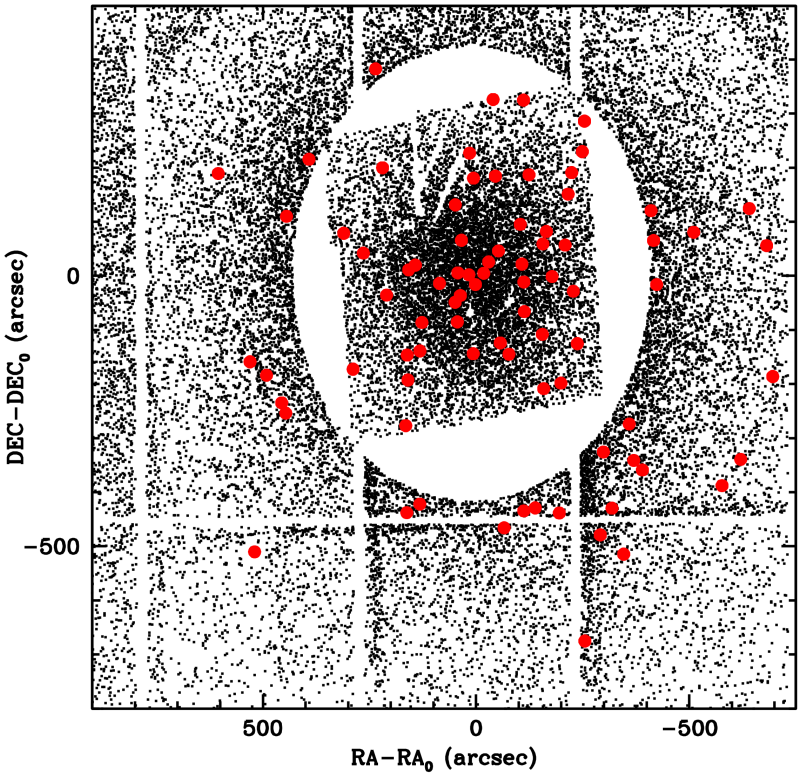

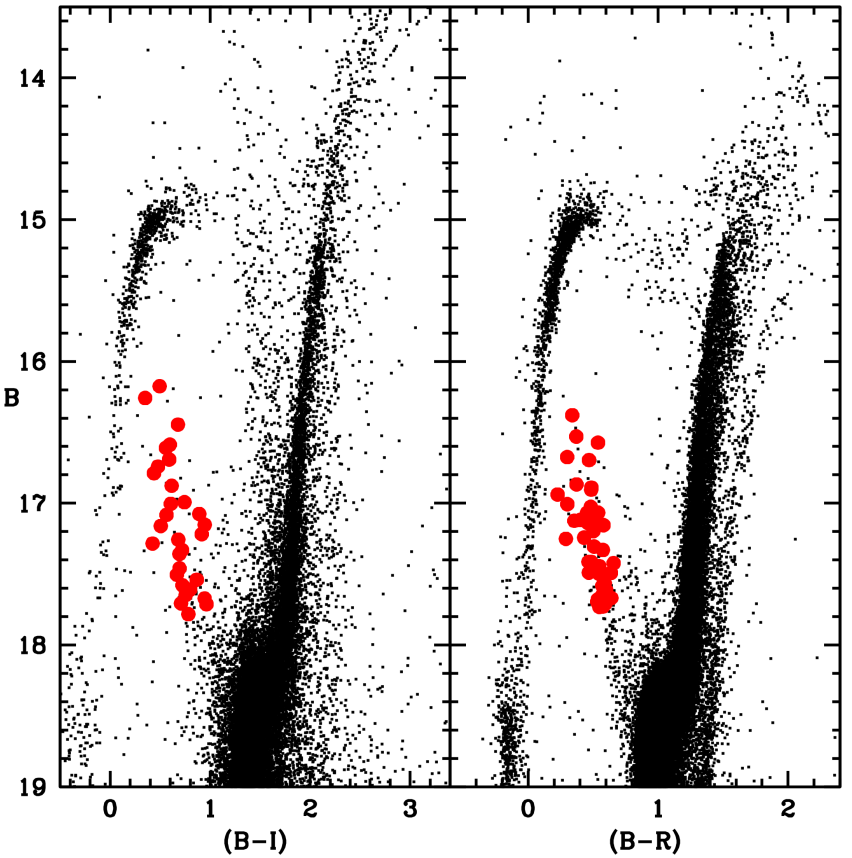

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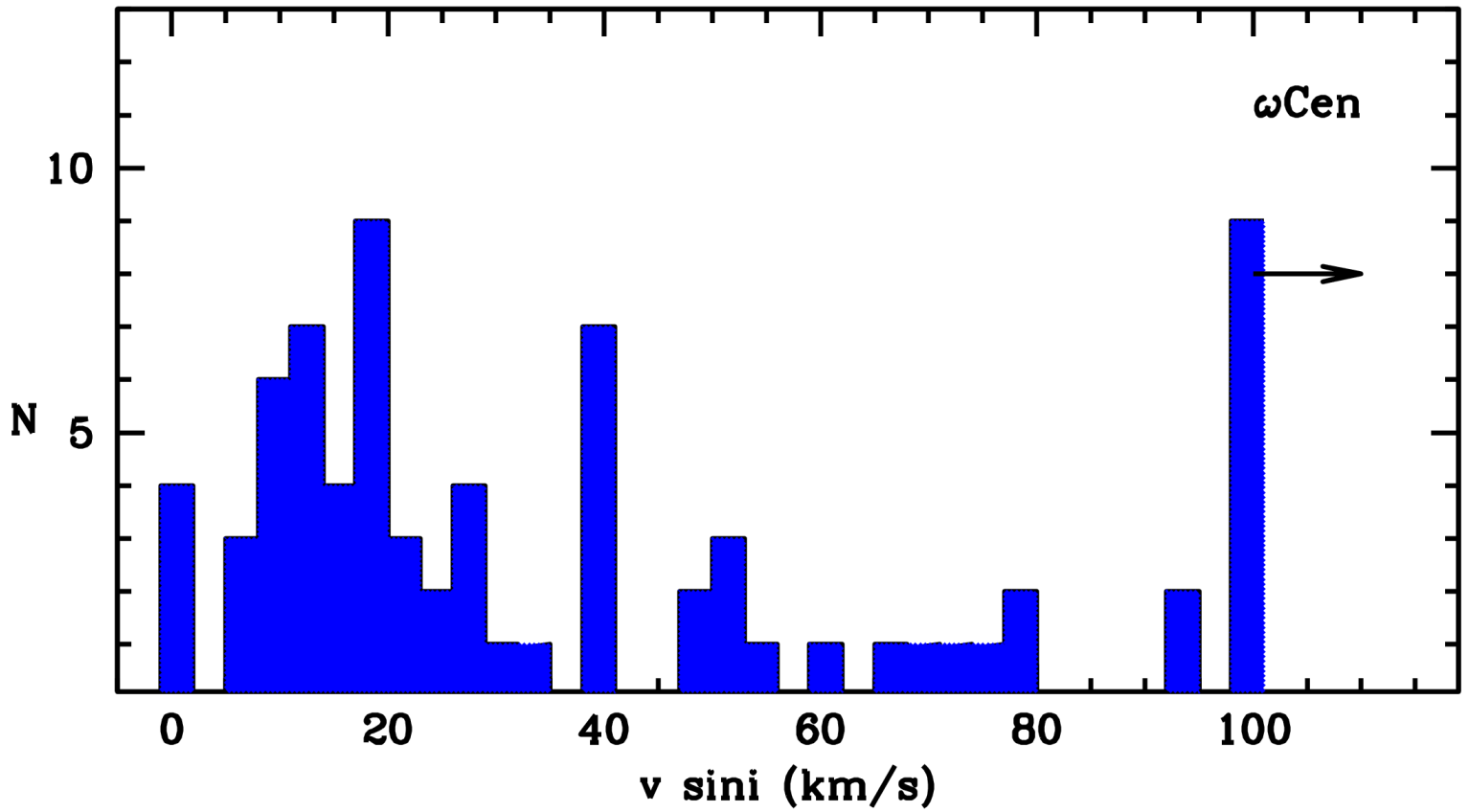

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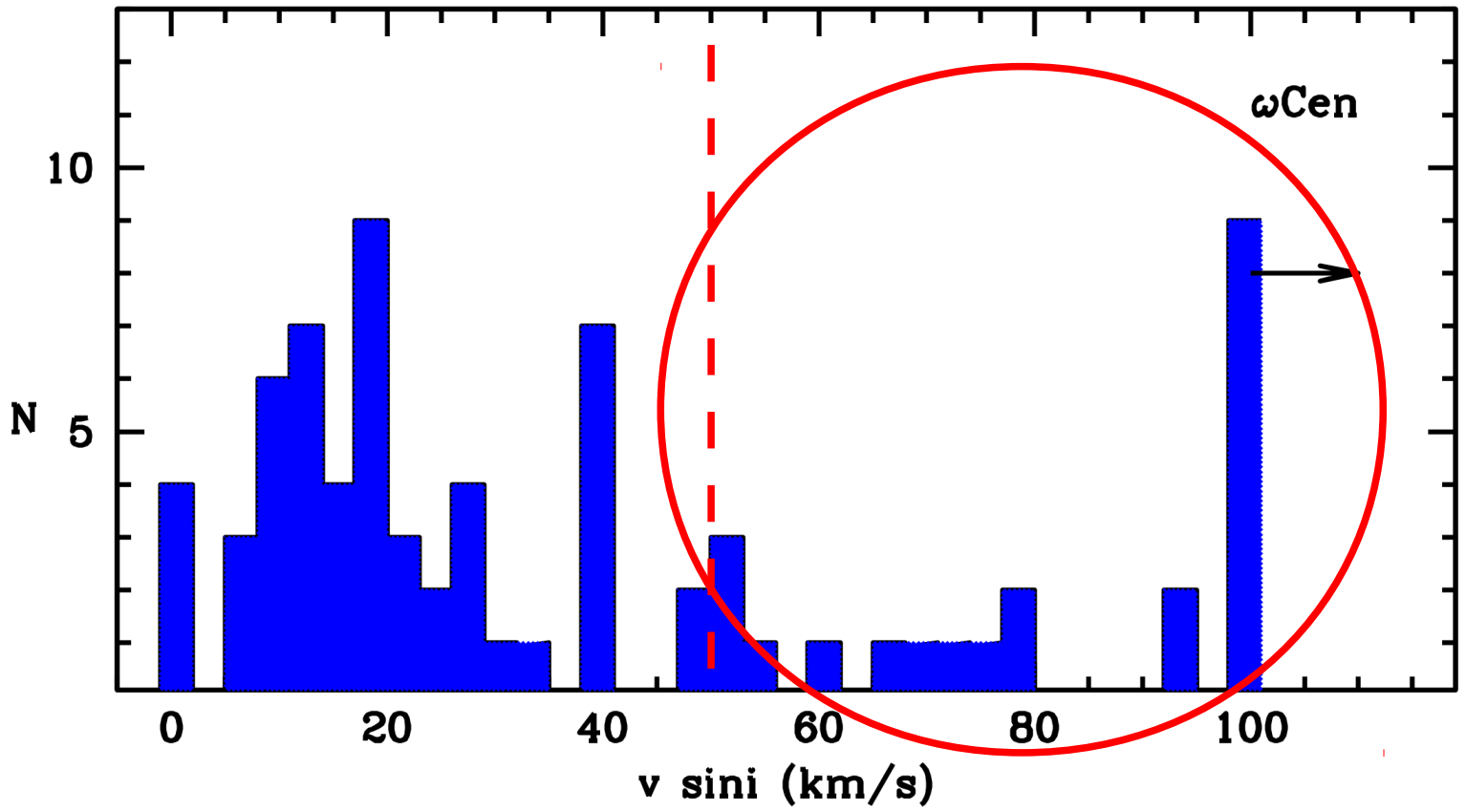


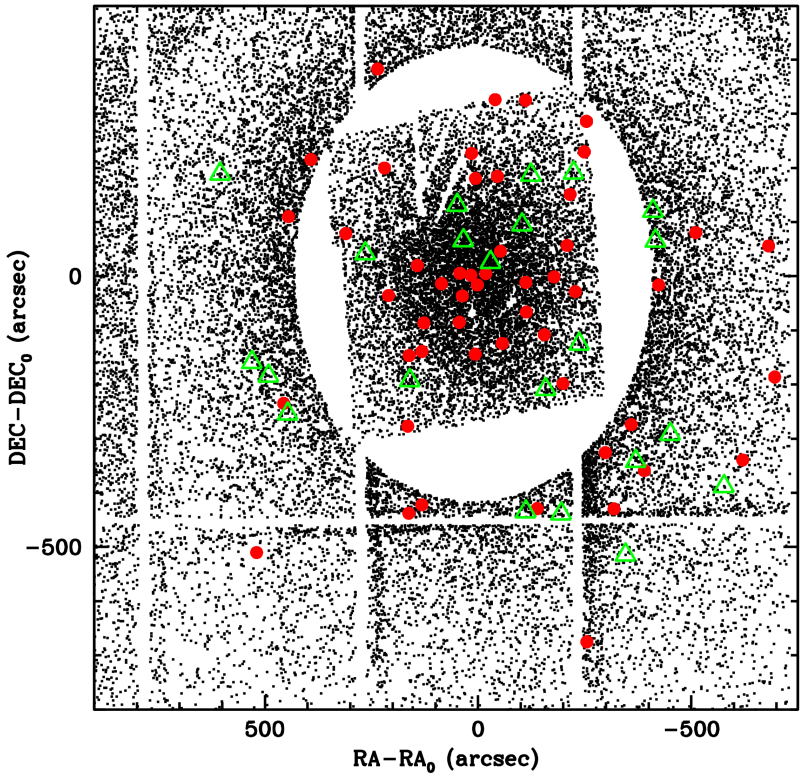
23 FR BSS

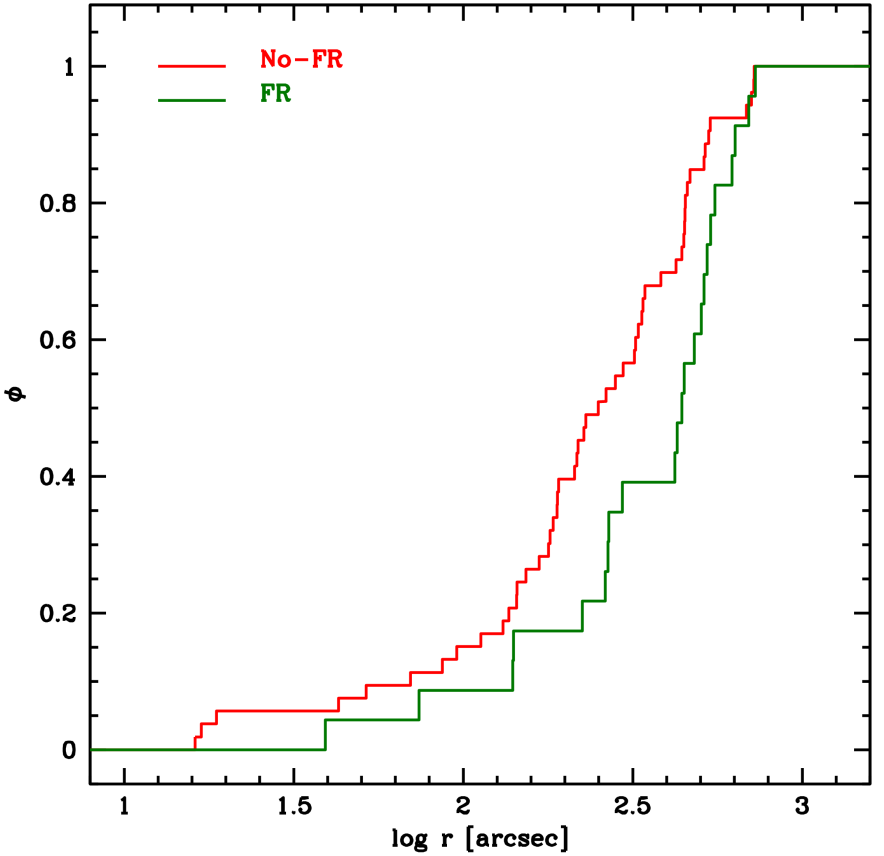
~ 30%

ωCentauri

(Mucciarelli et al, in preparation)

FR are less centrally concentrated
(high statistical significance)





47 Tuc → ~ 7%

NGC 6397 → < 6%

M30 → ~ 8%

Low percentage of FR BSS

M4 → ~ 40%

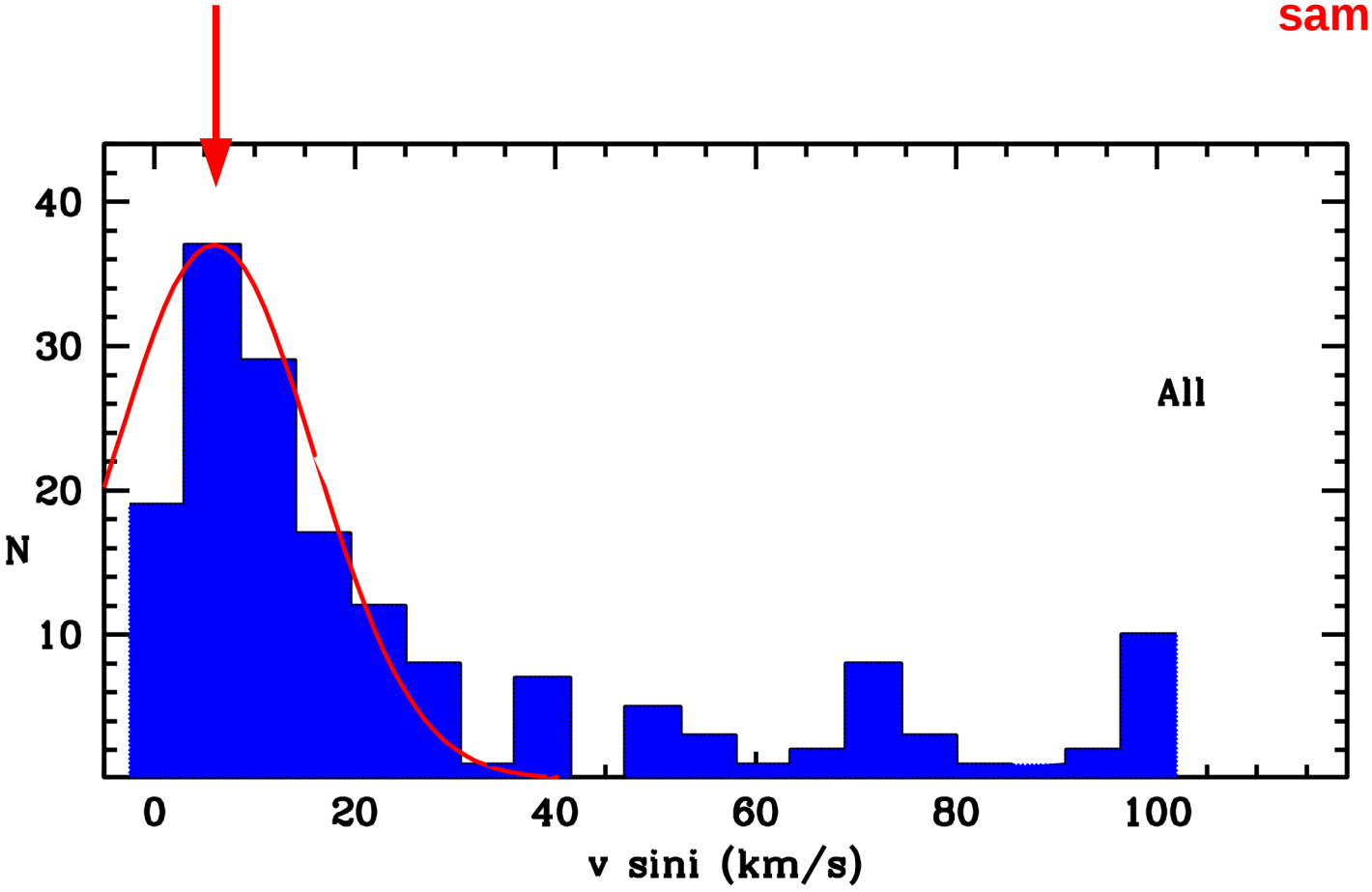
ωCen → ~ 30%

The highest fraction ever found in GCs!!

Cumulative distribution

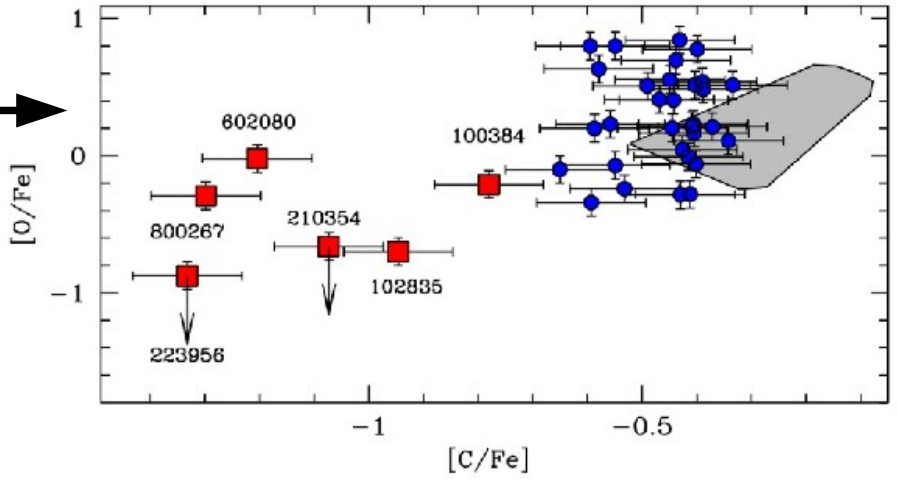
6 km/s

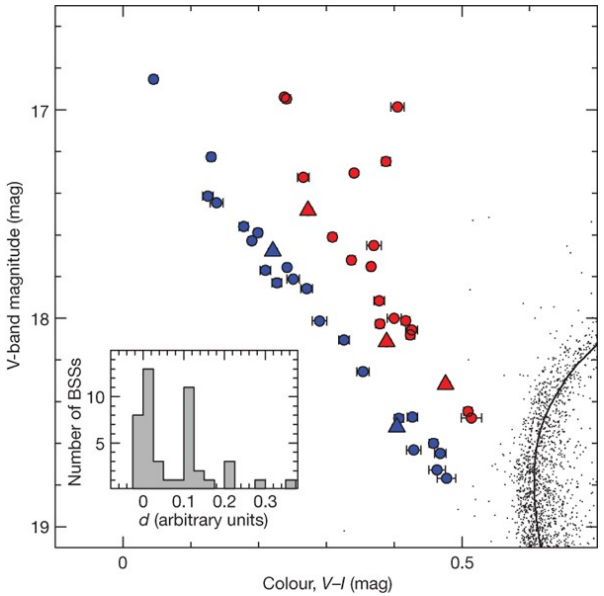
Different size of the samples



ANY LINK WITH THE FORMATION MECHANISM?

47 Tuc
(Ferraro et al, 2006)





M30
(Ferraro et al, 2009)

ωCen
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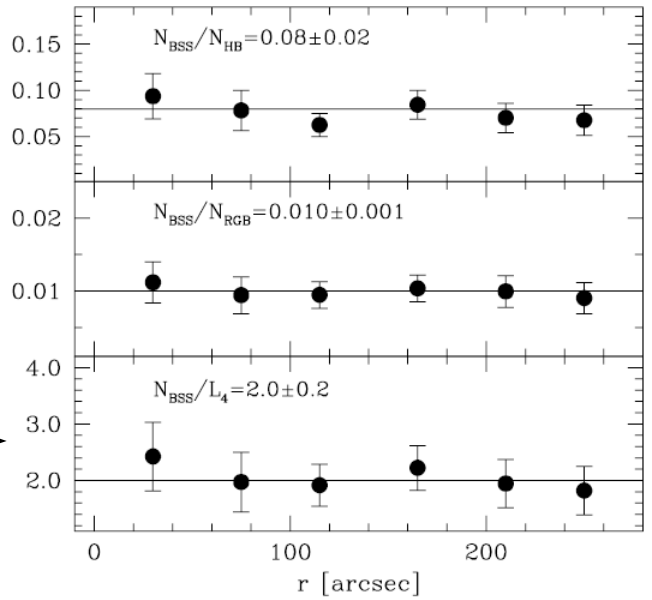
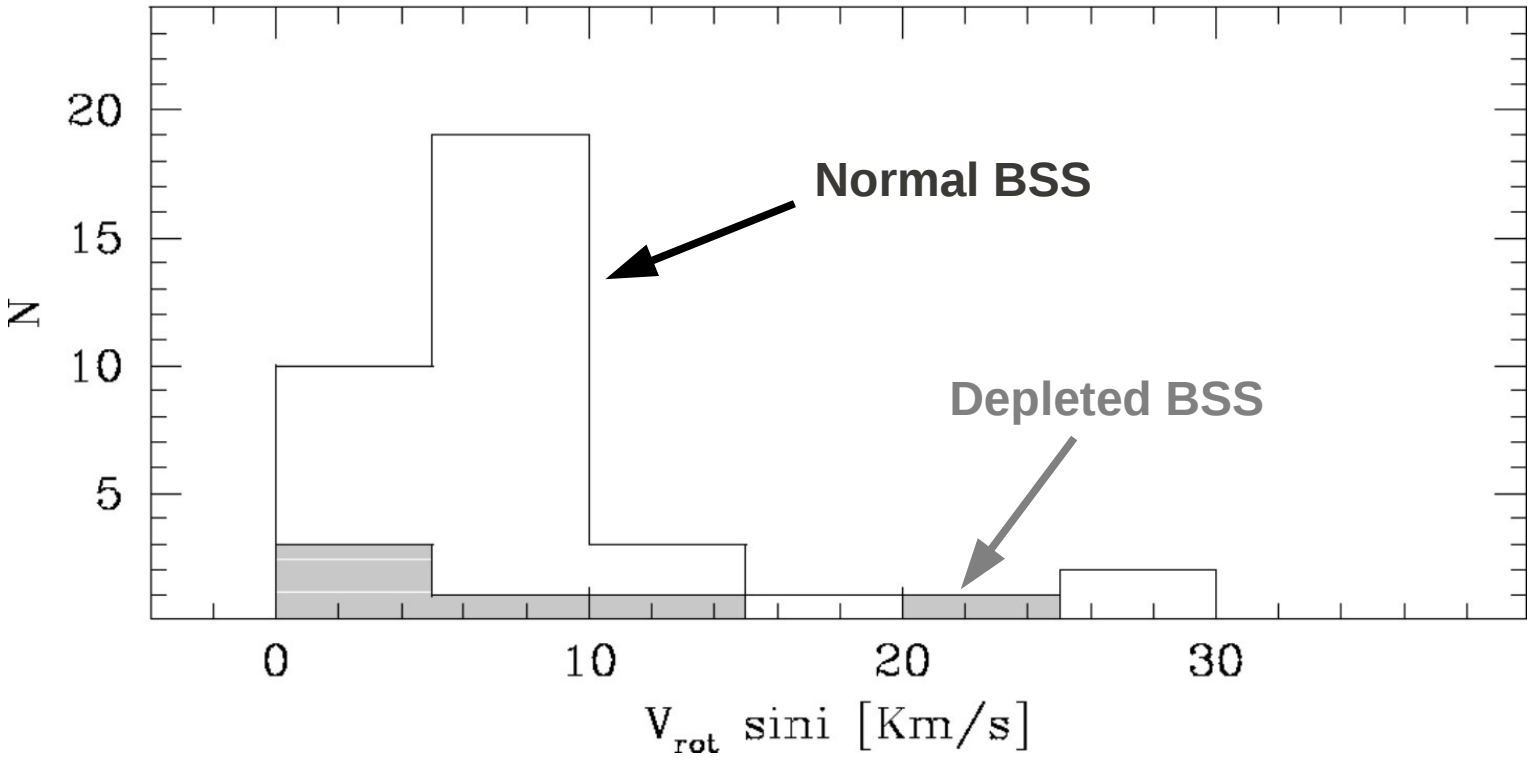


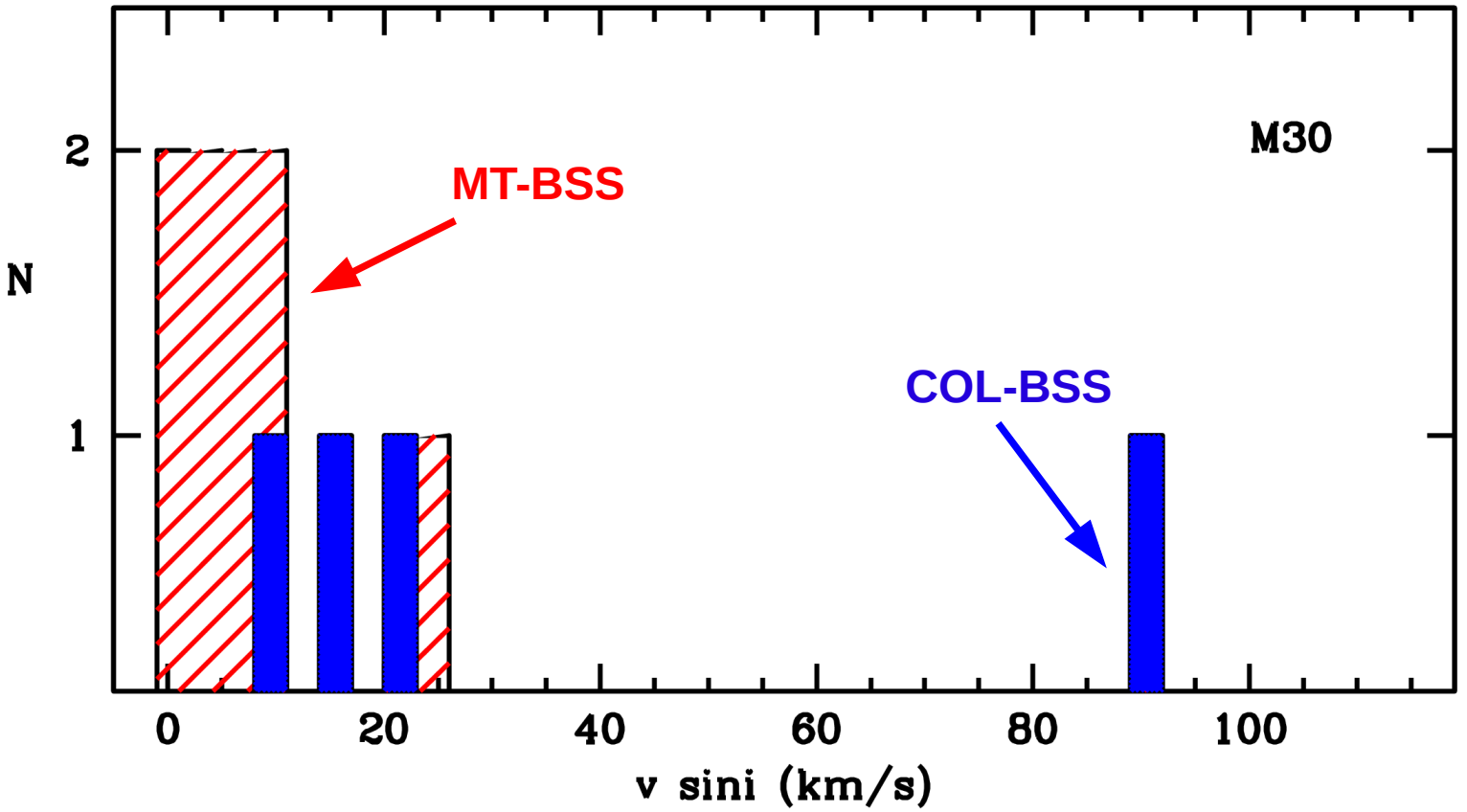
47 TUCANAE

Ferraro et al, 2006



NO link with the chemical abundances

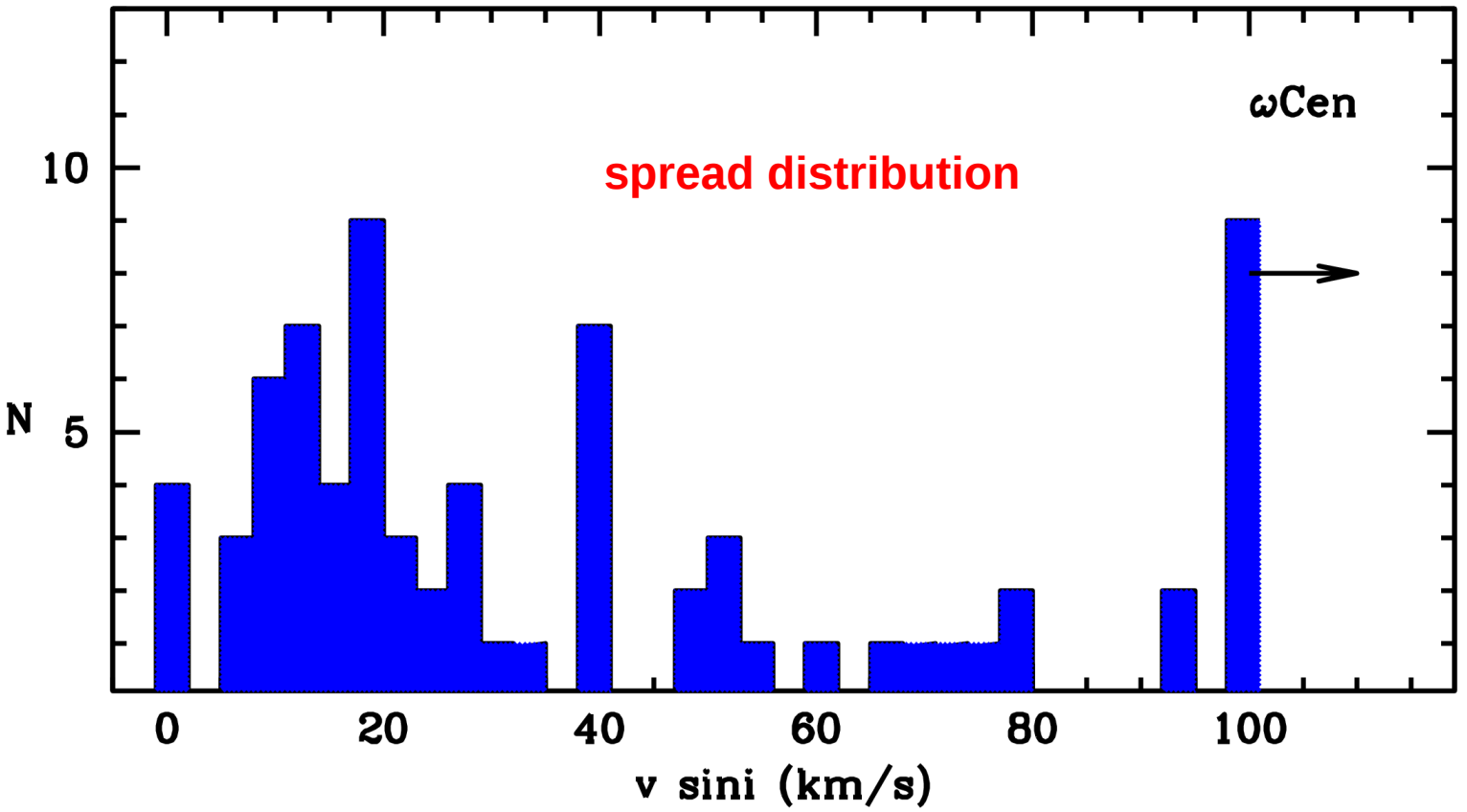
M30



Xshooter spectra might tell something more

COL-BSS rotate faster than **MT-BSS**?

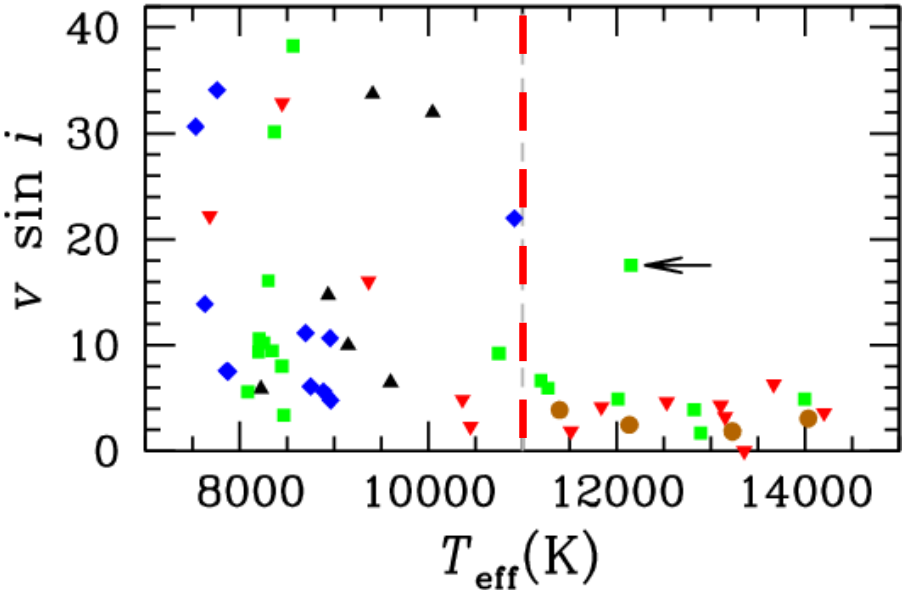
ωCentauri



both low and high values

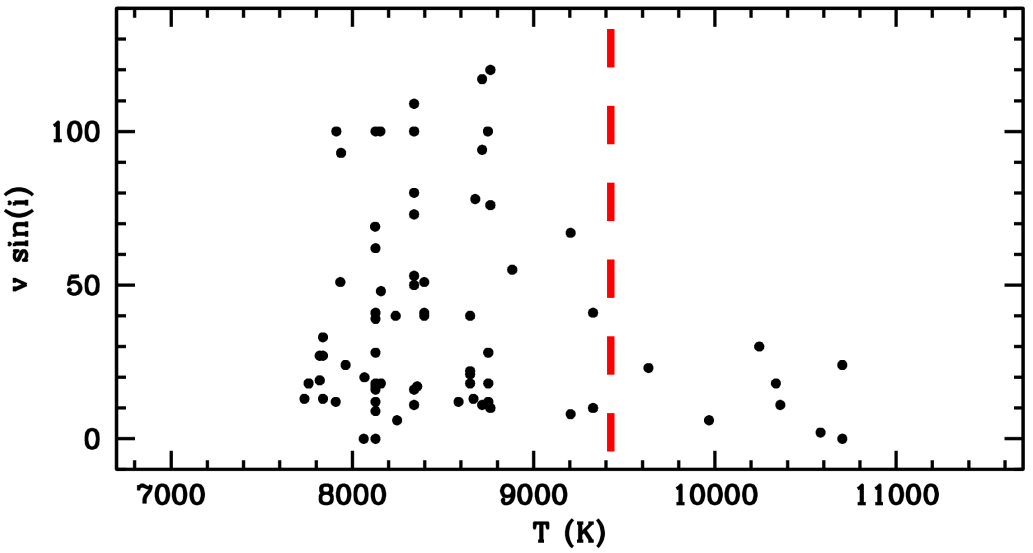
ωCentauri:
rotational velocity & radiative levitation

Quievy et al, 2009 **HB**

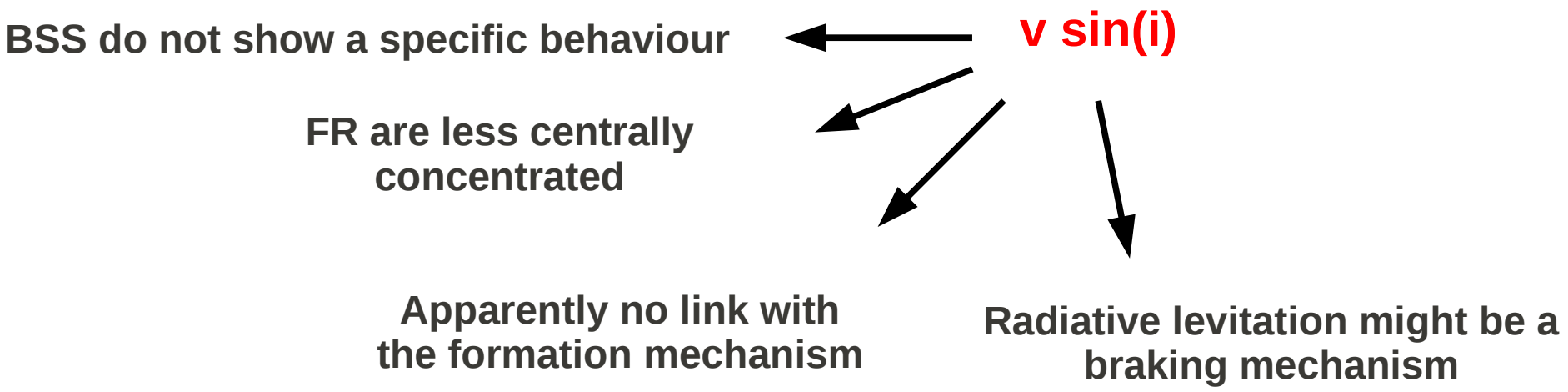


RADIATIVE LEVITATION MIGHT BE A BRAKING MECHANISM

Mucciarelli et al, in prep. **BSS**



CONCLUSION



We need a lot of work in both the theoretical and the observational fields

...observational...

ESO proposal P91(A)

M12 **NGC 3201**

Thank you!

Visit our web-site: www.cosmic-lab.eu