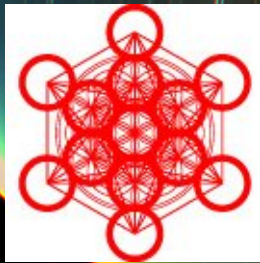


Rapid dynamical processes in the cores of young LMC star clusters



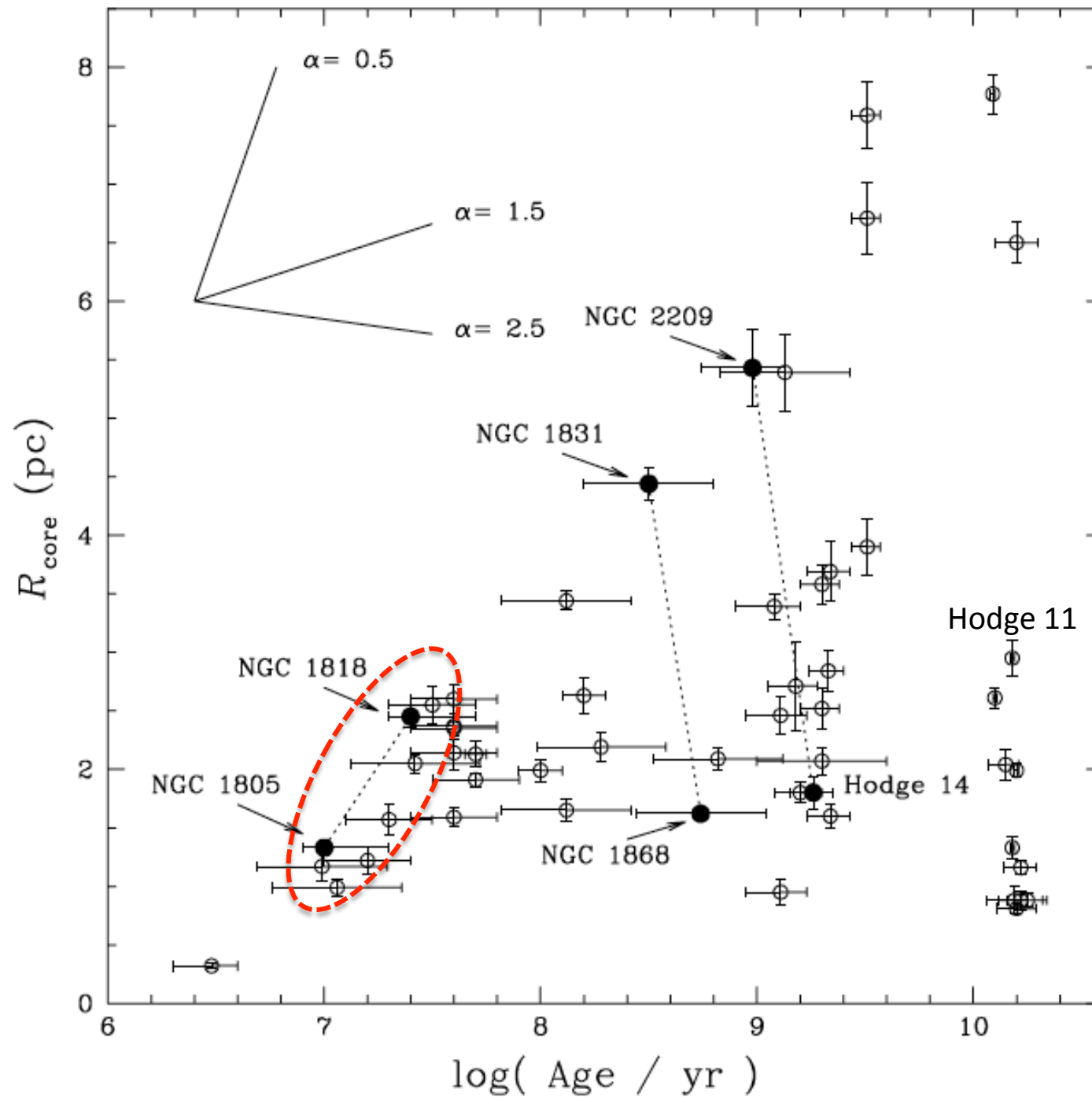
Richard de Grijs | 何锐思
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Peking University, China



Main collaborators:

Chengyuan Li (KIAA, PKU; China), Yi Hu, Licai Deng (NAOC, China), Aaron Geller (Northwestern Univ., USA)

(Chengyuan will soon apply for postdoc positions...)

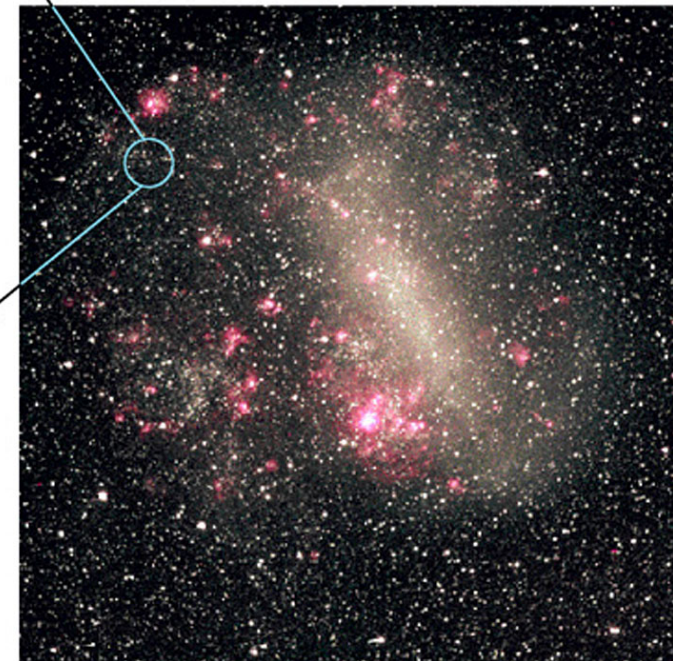
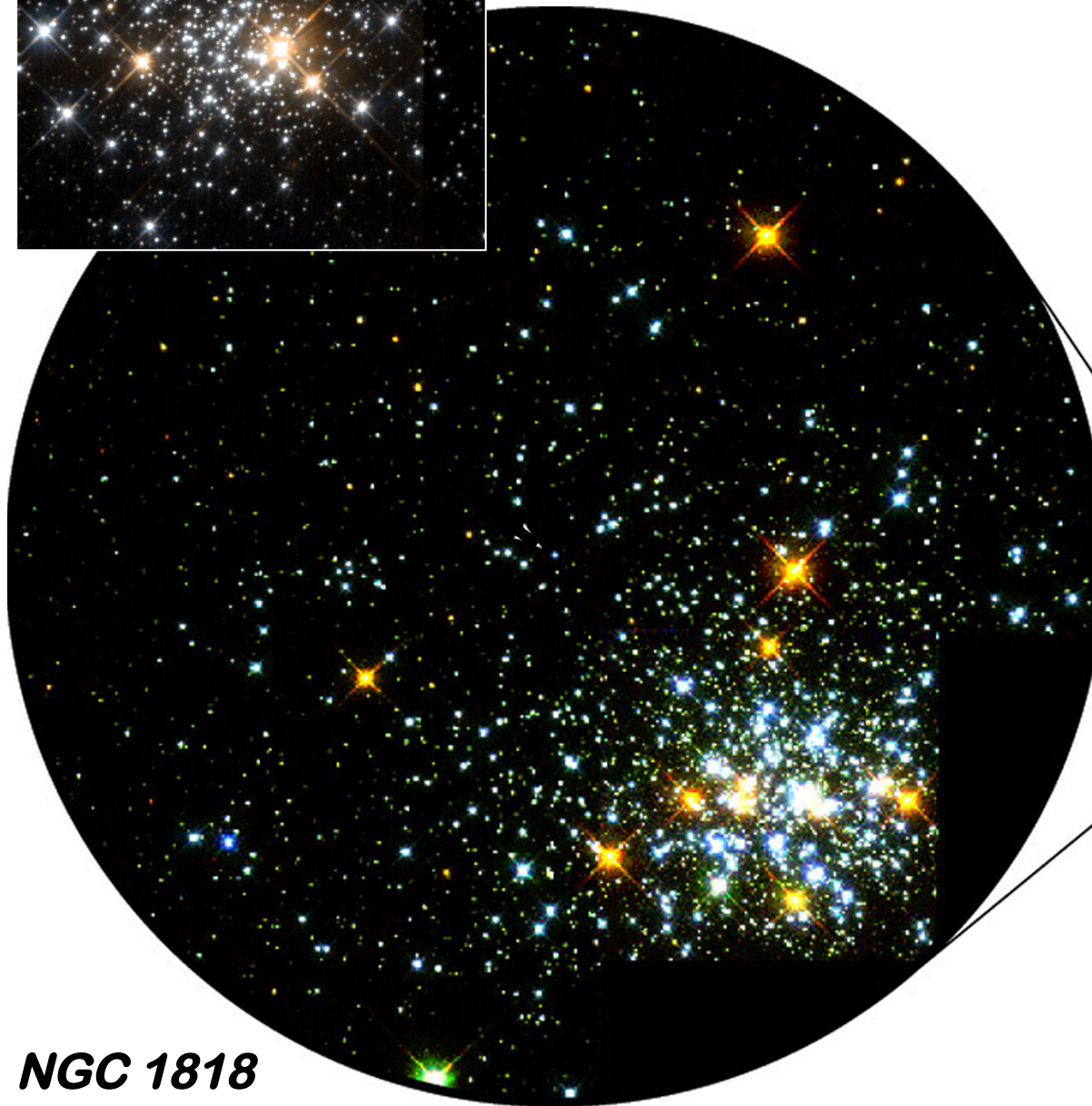


(de Grijs et al. 2002, MNRAS, 337, 597)

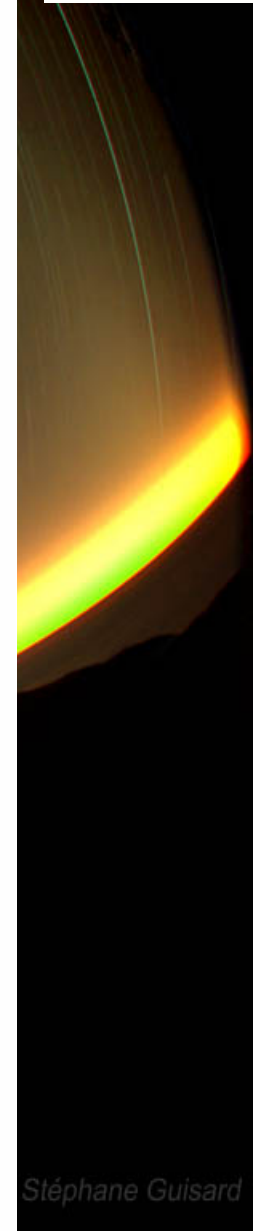
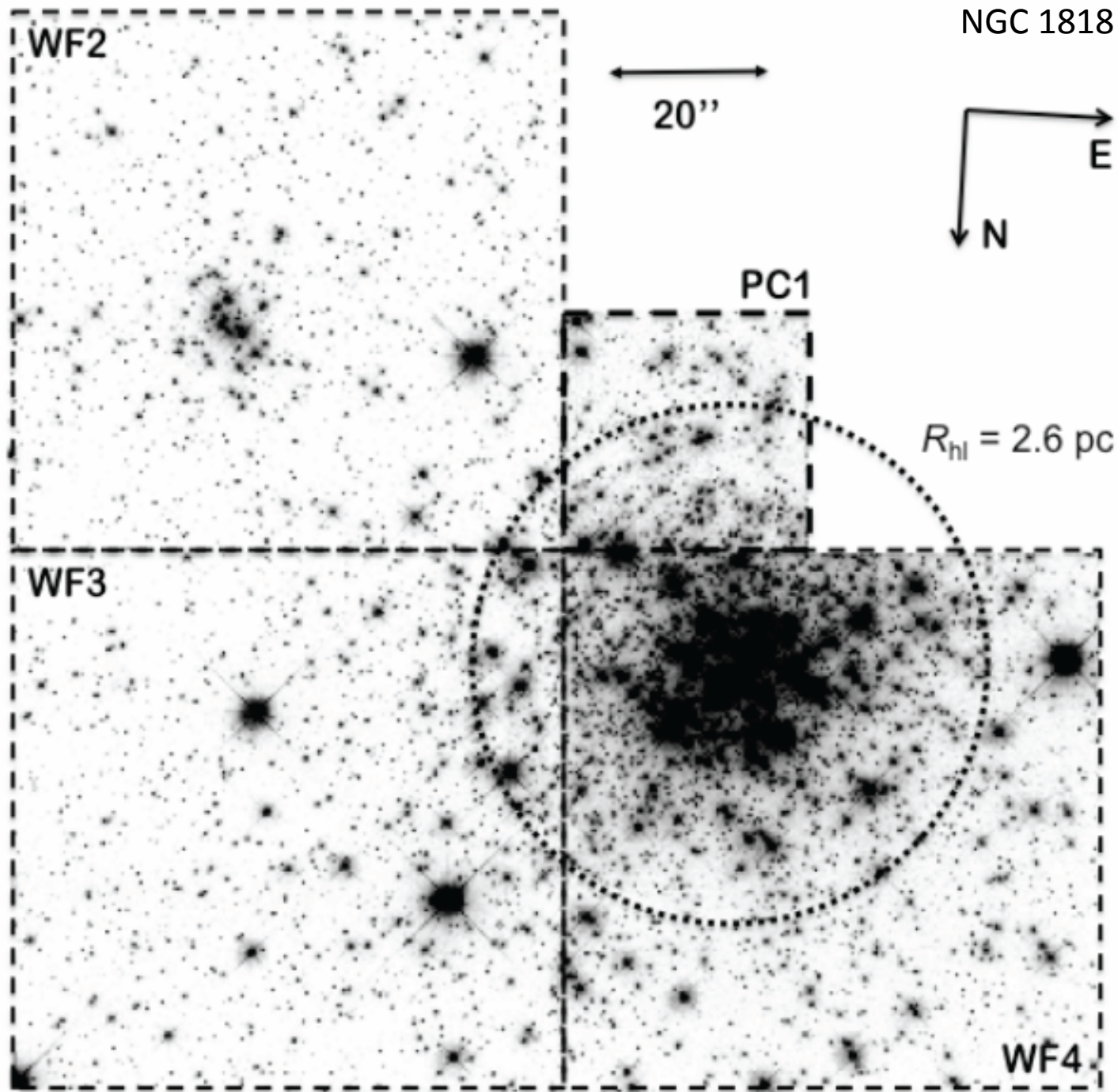
Our young LMC clusters



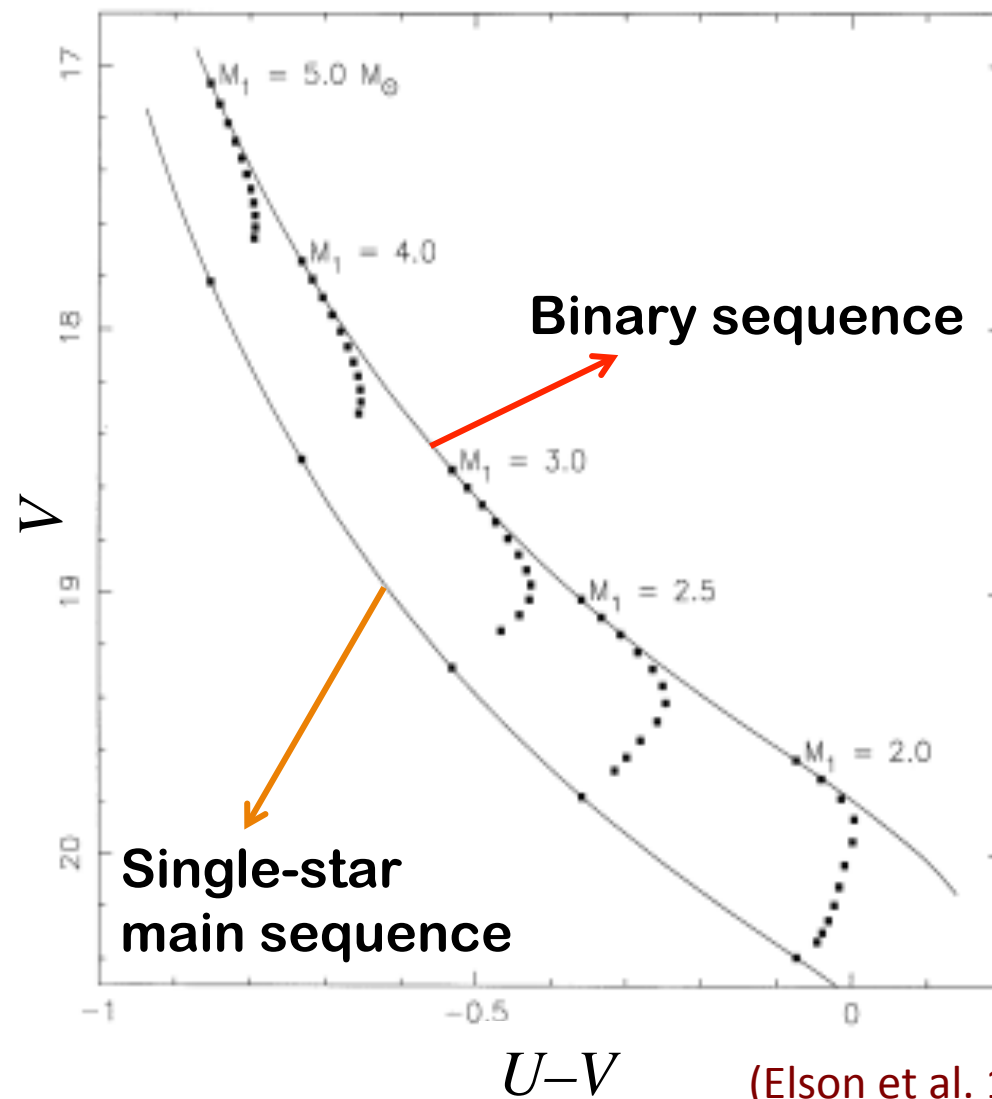
$\log (t/\text{yr})$	7.25–7.65
$[\text{Fe}/\text{H}]$	–0.4 dex
R_{core}	$2.1 \pm 0.4 \text{ pc}$
R_{hl}	2.6 pc
M_{cl}	$2.8 \times 10^4 M_{\odot}$



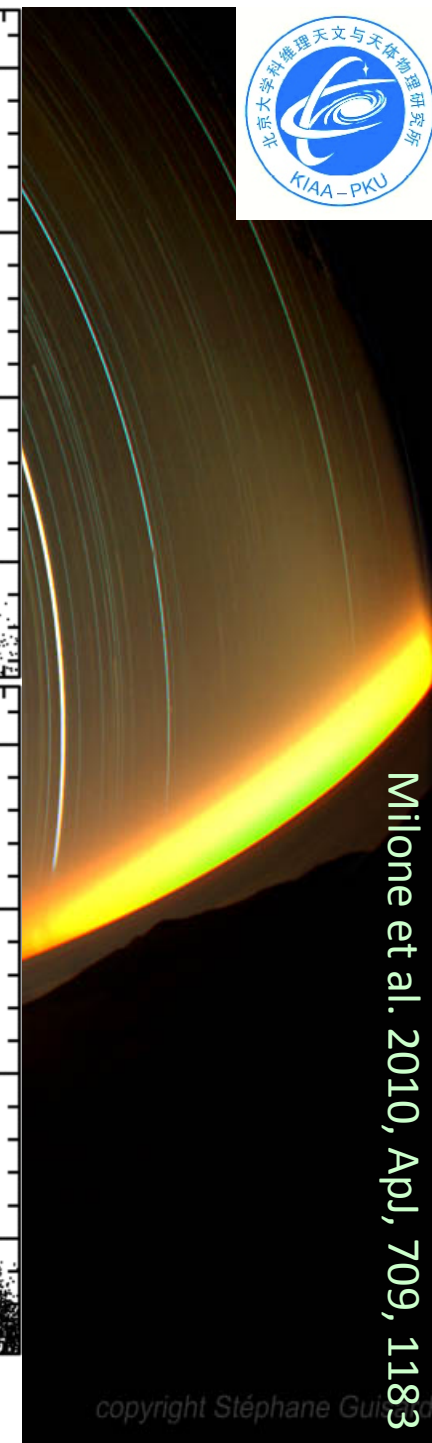
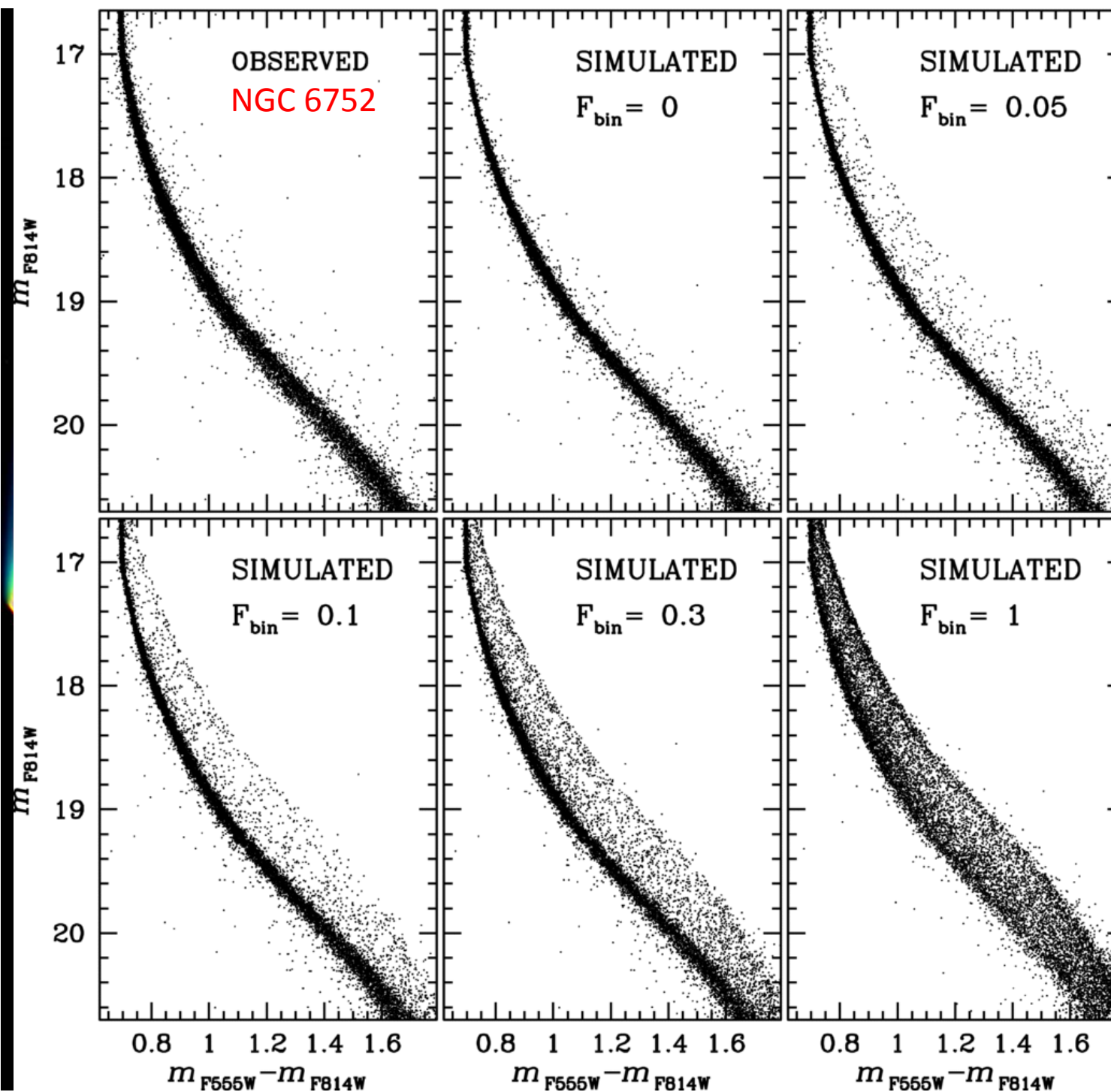
NGC 1818



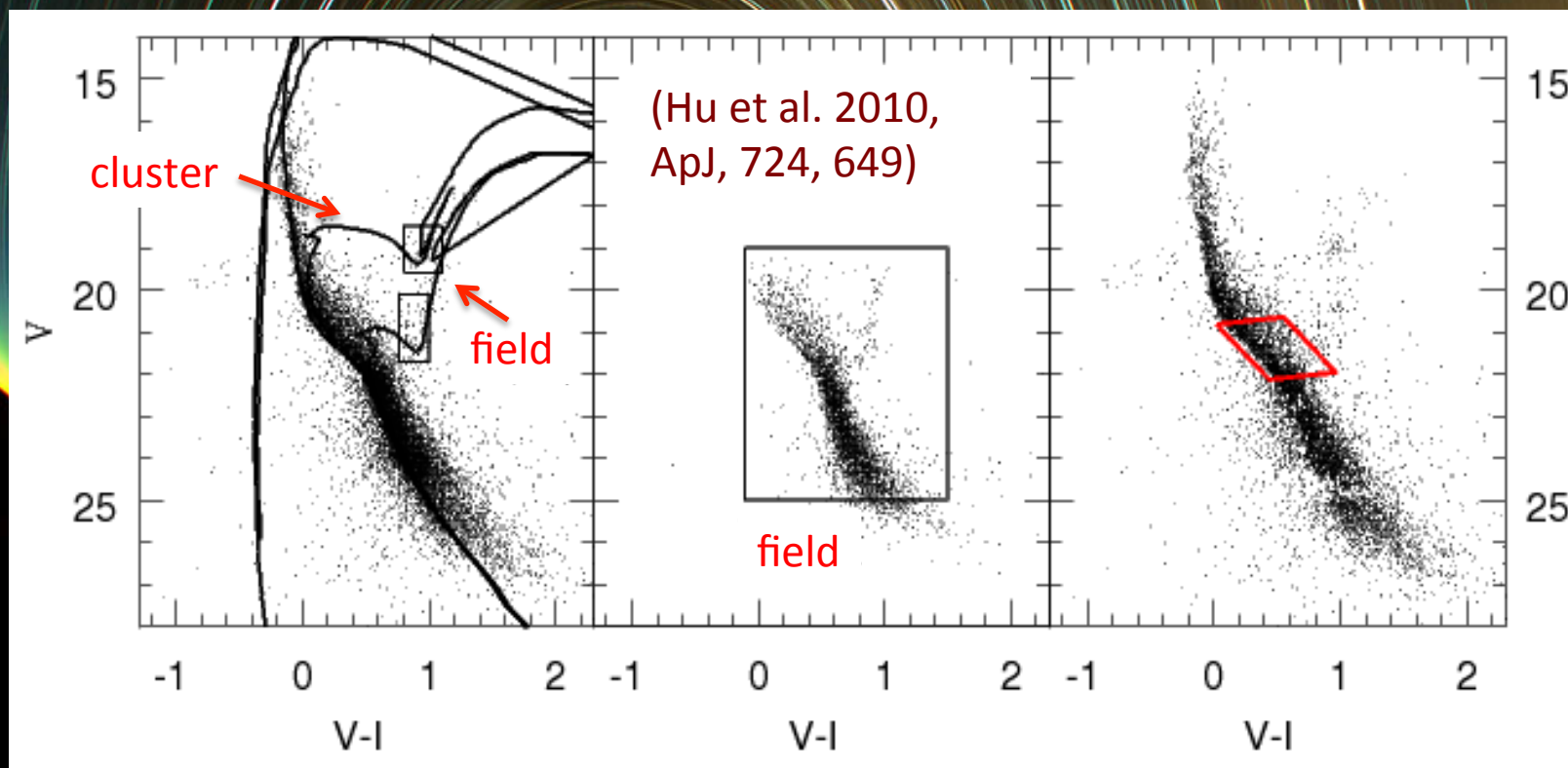
Primordial binaries?

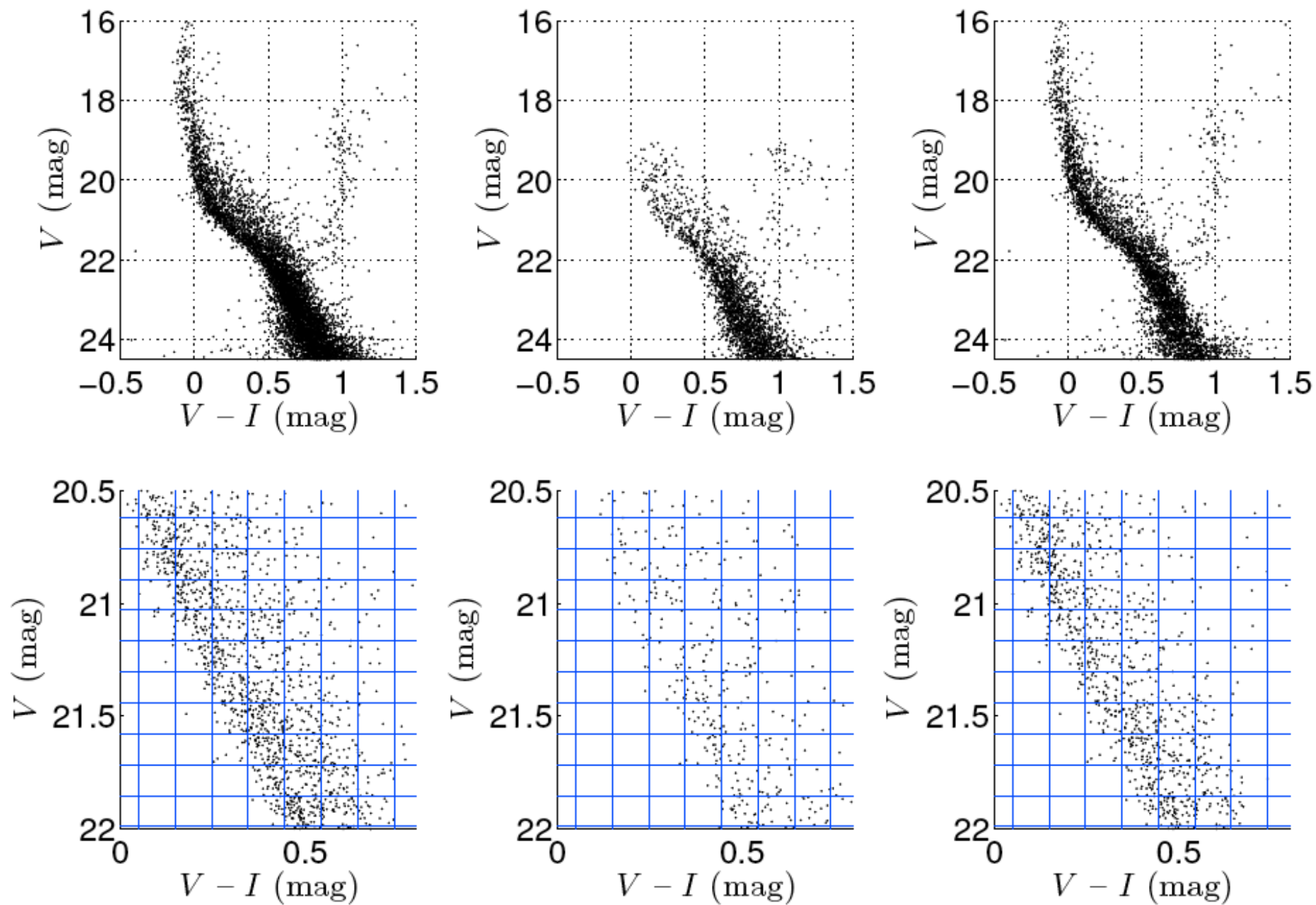


(Elson et al. 1998, MNRAS, 300, 857)



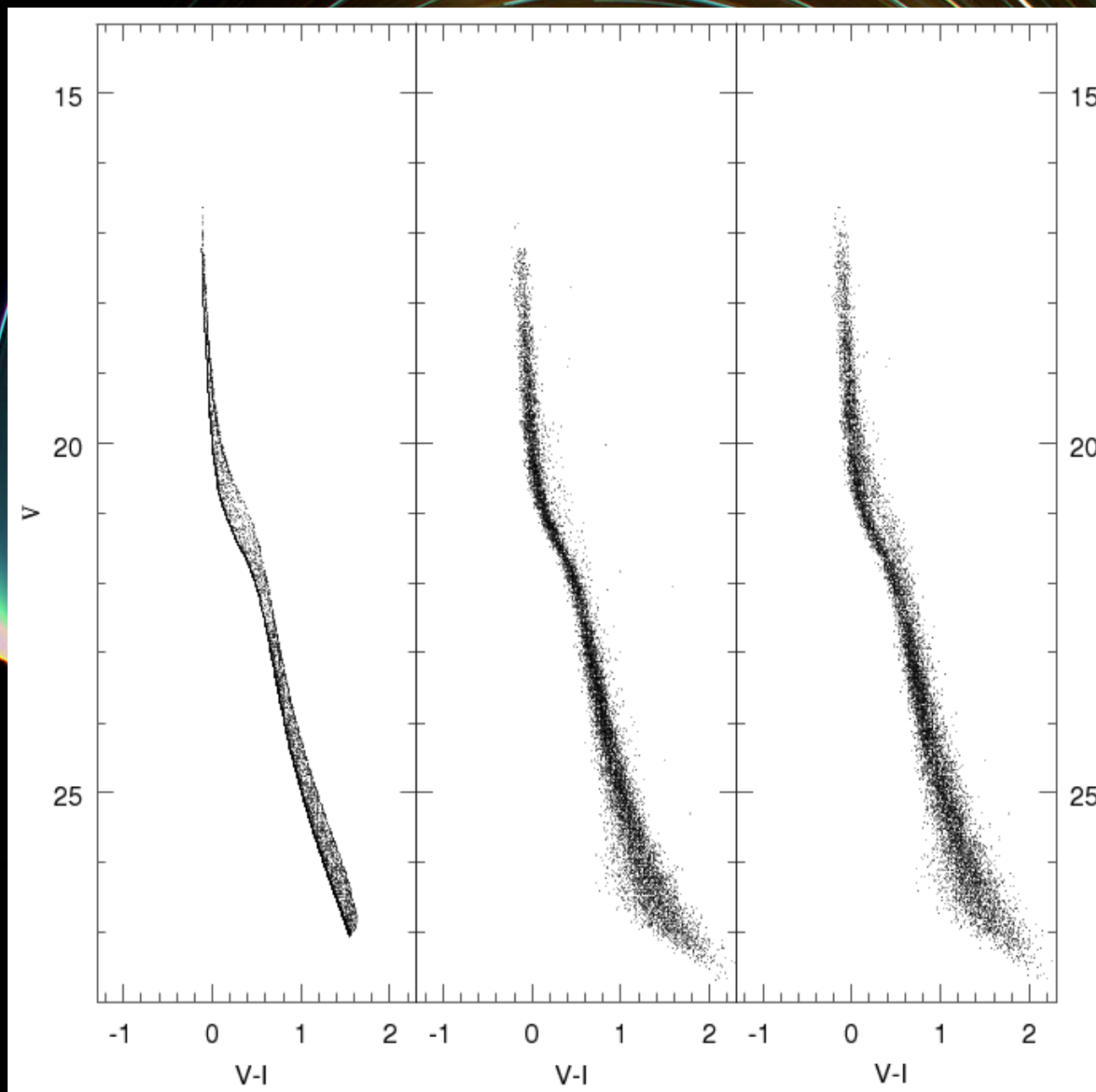
Primordial binaries?



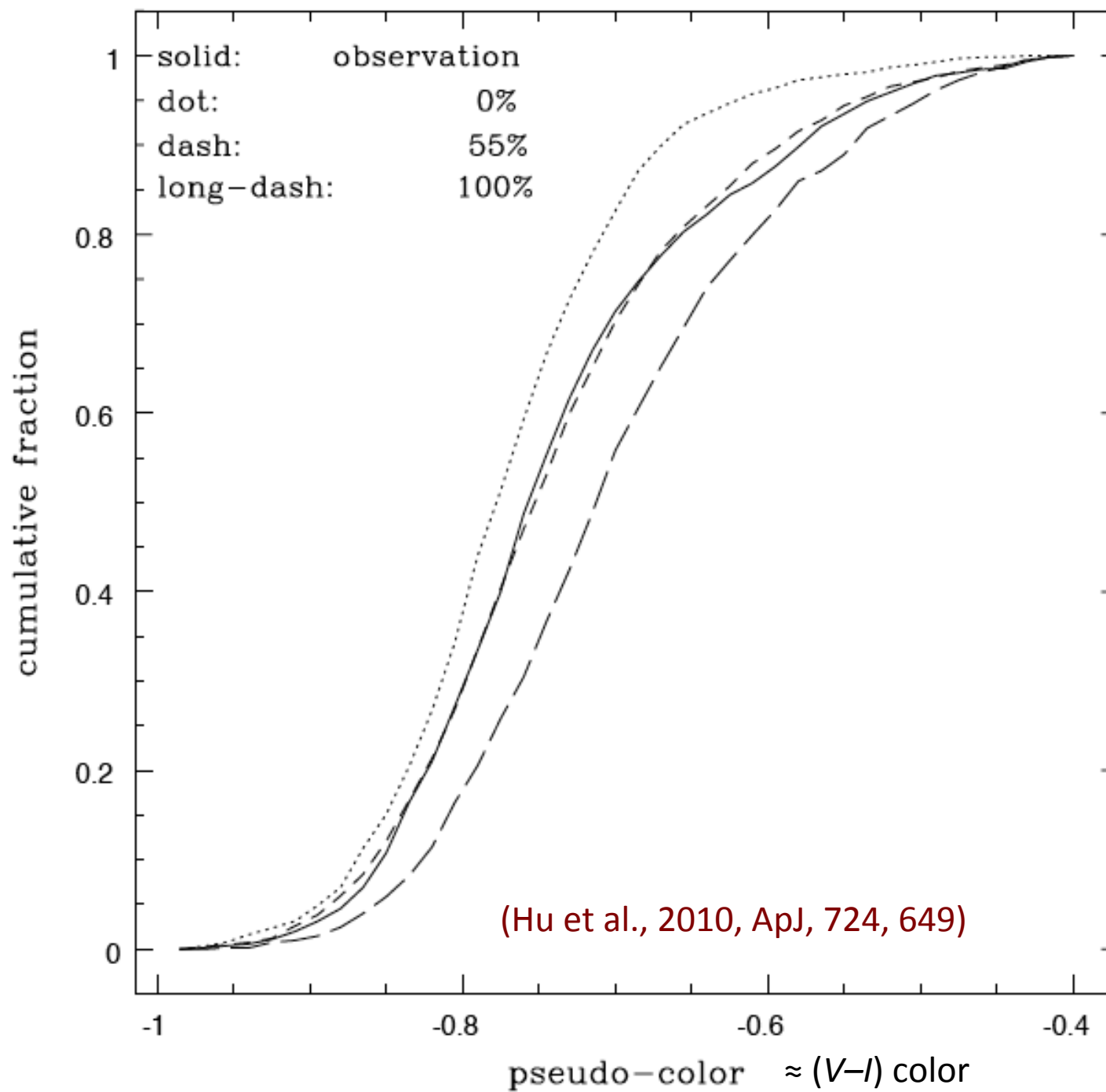


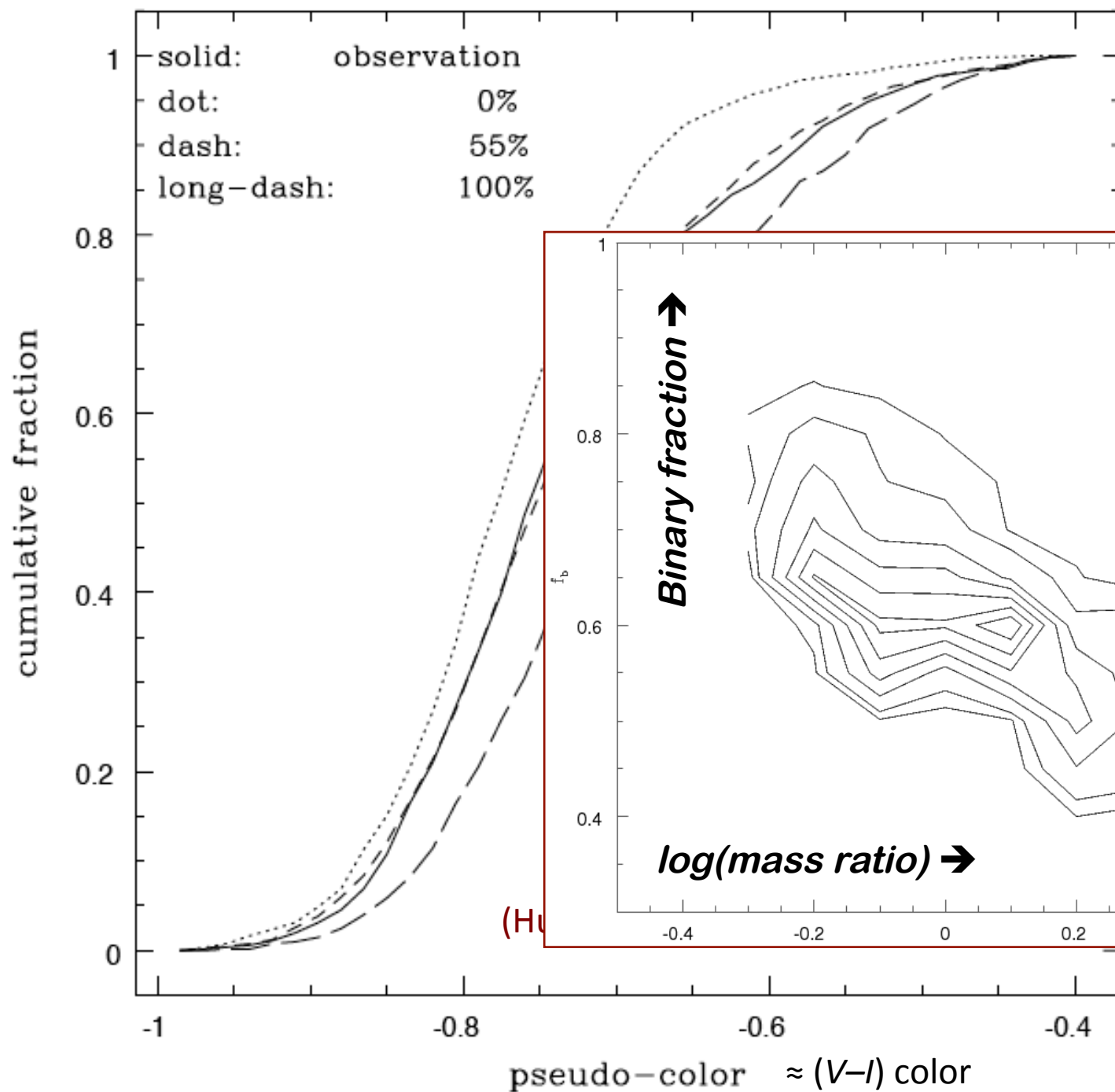
Background decontamination: **NGC 1805**

(Li, de Grijs, & Deng 2013, MNRAS, 436, 1497)



(Hu et al., 2010,
ApJ, 724, 649)

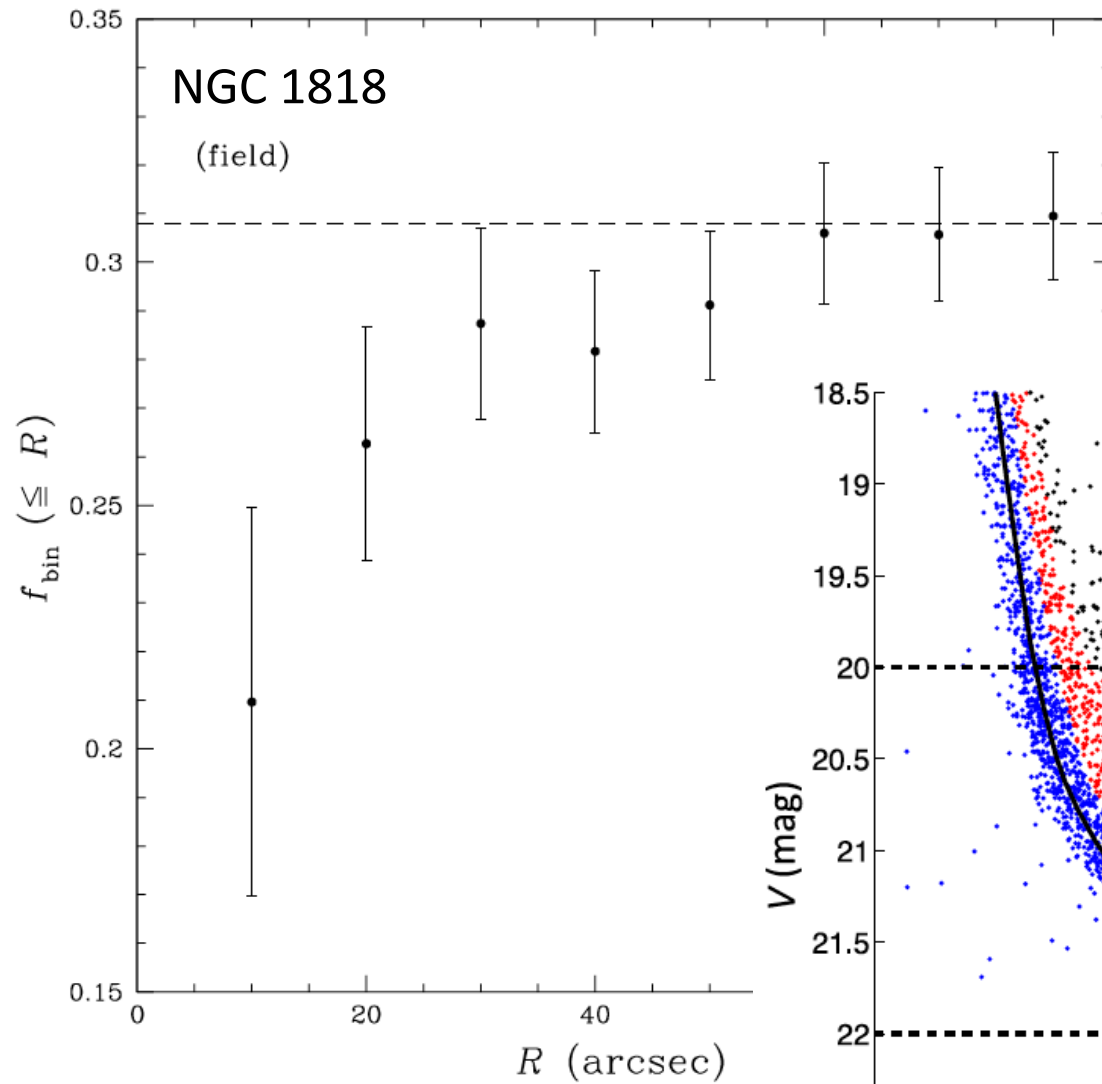




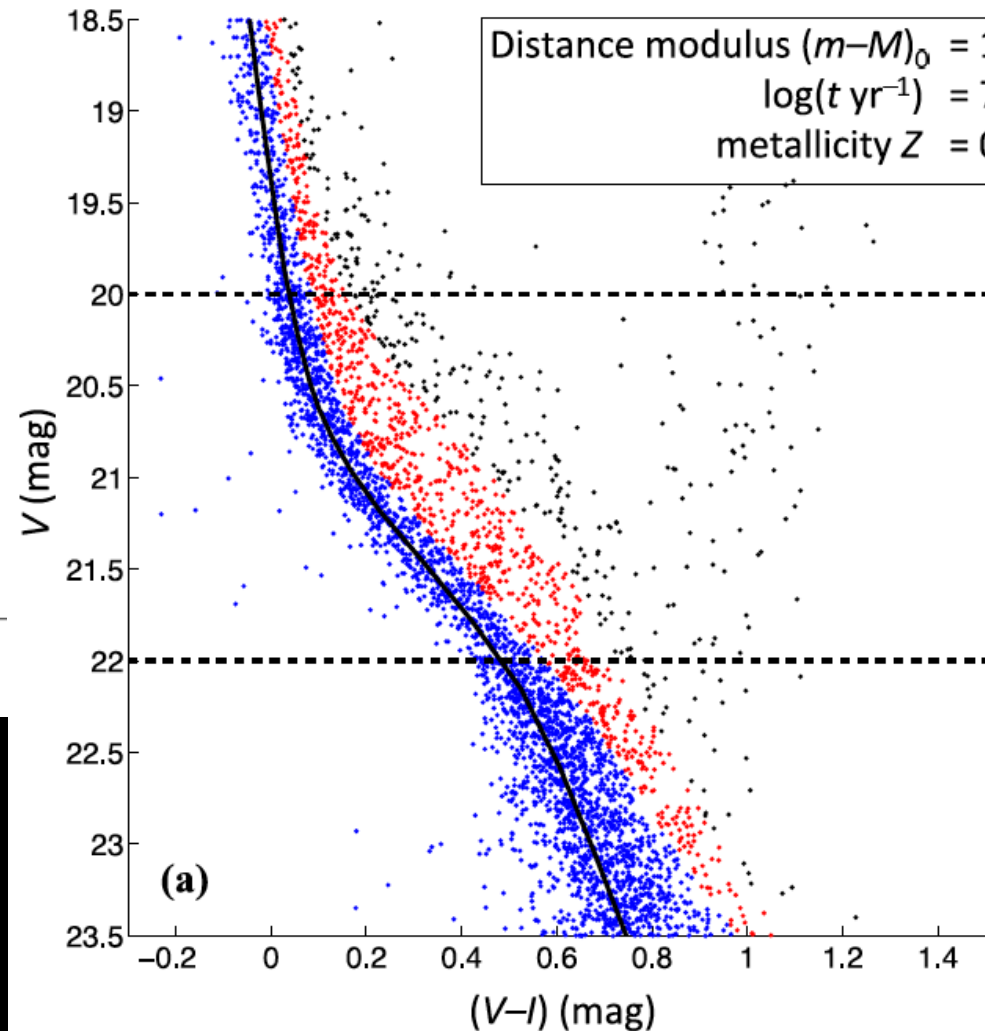
Binaries ...

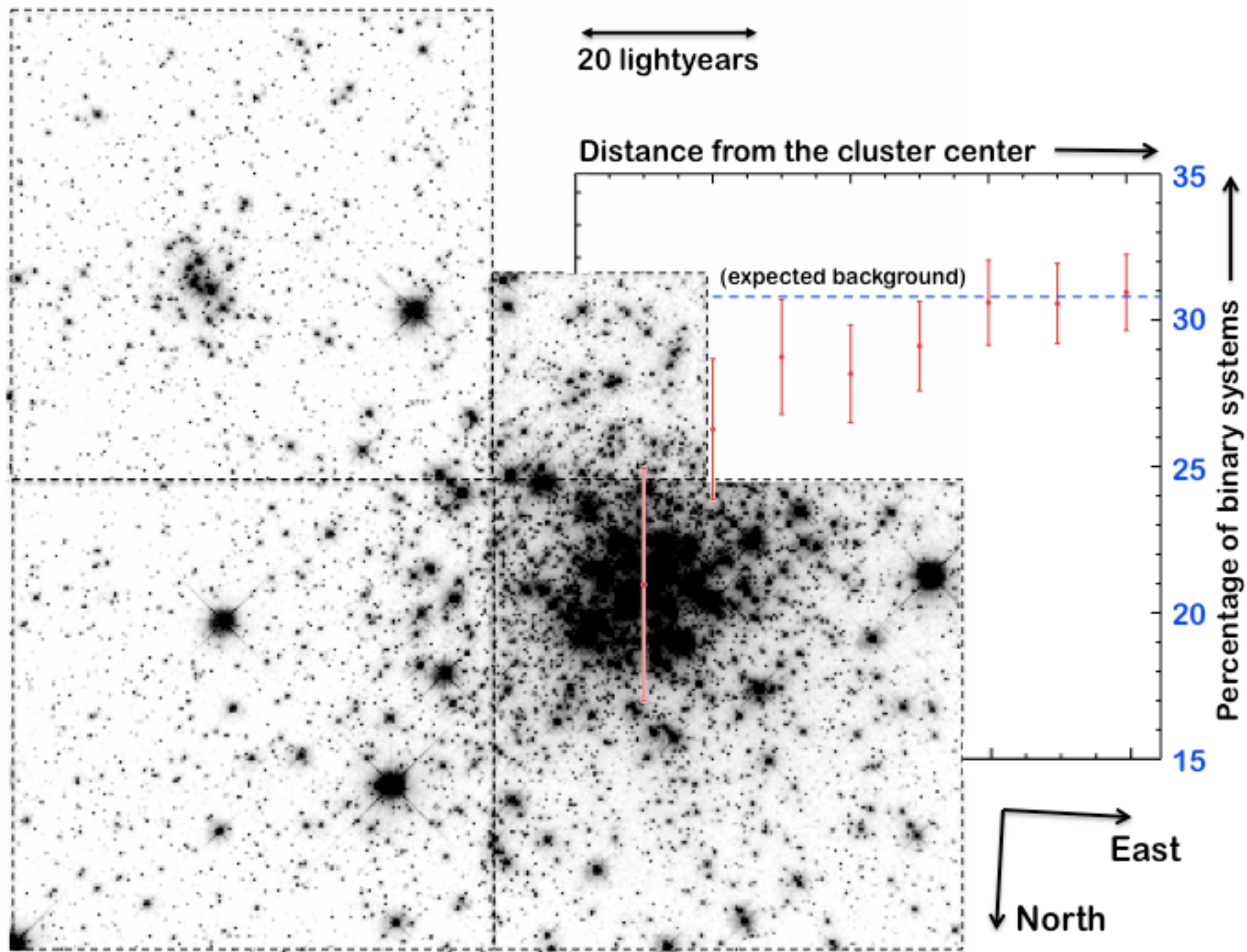
(de Grijs et al. 2013a, ApJ, 765, 4)

Distance modulus $(m-M)_0 = 18.54$ mag
 $\log(t \text{ yr}^{-1}) = 7.25$
metallicity $Z = 0.015$

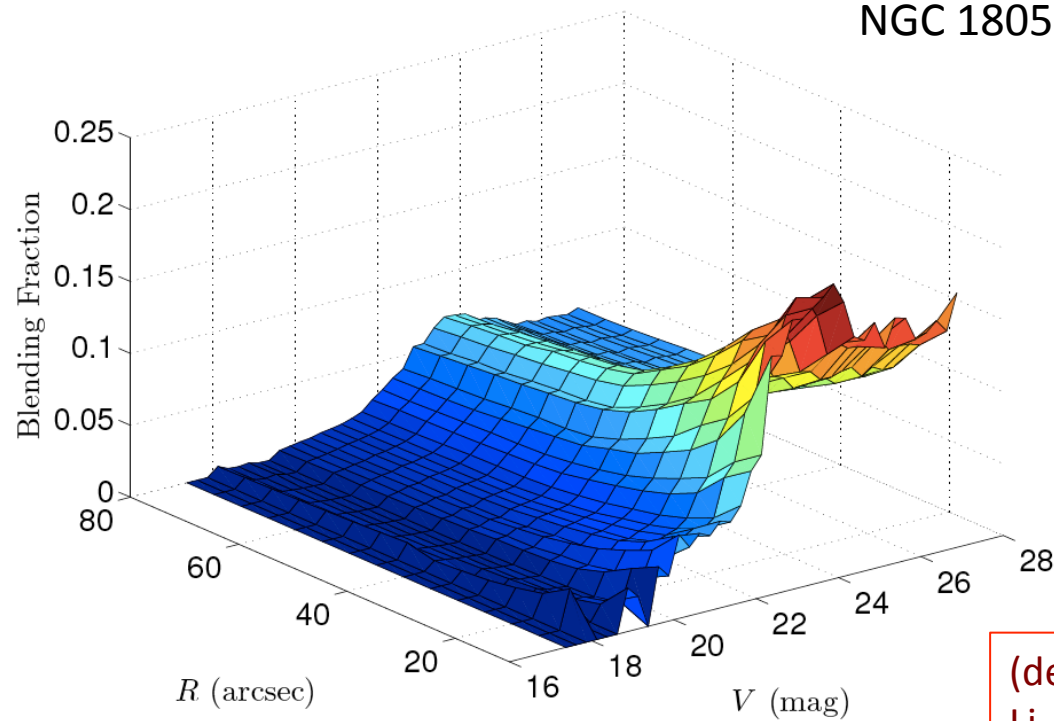


*... and mass
segregation*





NGC 1805

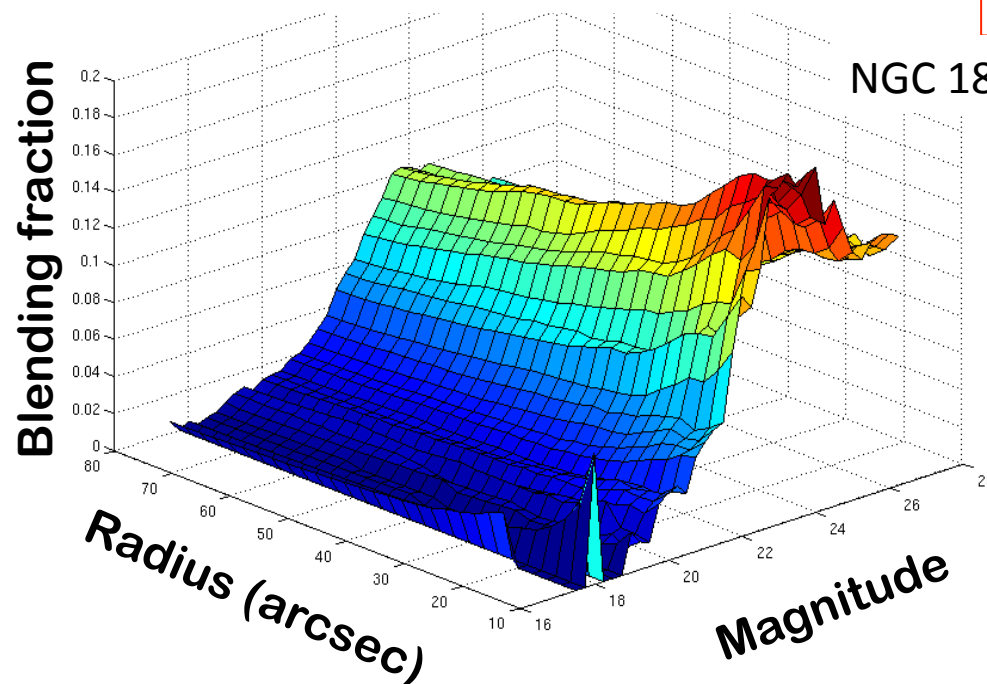


$$f_{\text{bin}} = \frac{N_b}{(N_b + N_s)} - f_{\text{opt}}$$

blending

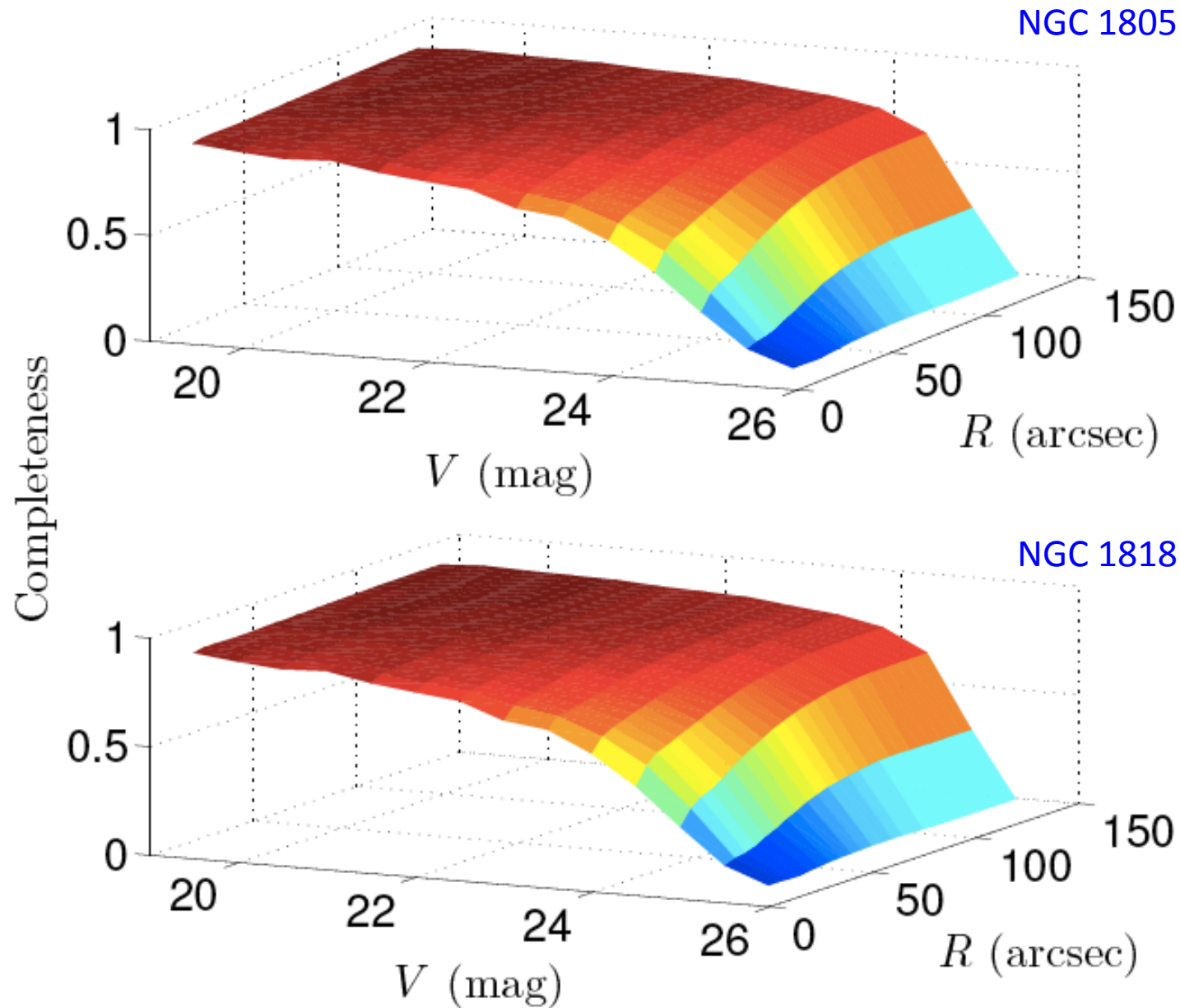
(de Grijs et al. 2013a, ApJ, 765, 4;
Li, de Grijs, & Deng 2013, MNRAS, 436, 1497)

NGC 1818



2 pixel resolution = 0.05 pc
Separations < 10,000 AU

***Correcting
for blends ...***



(de Grijs et al. 2013a, ApJ, 765, 4;
Li, de Grijs, & Deng 2013, MNRAS, 436, 1497)

... and incompleteness

(Li, de Grijs, & Deng 2013, MNRAS, 436, 1497)

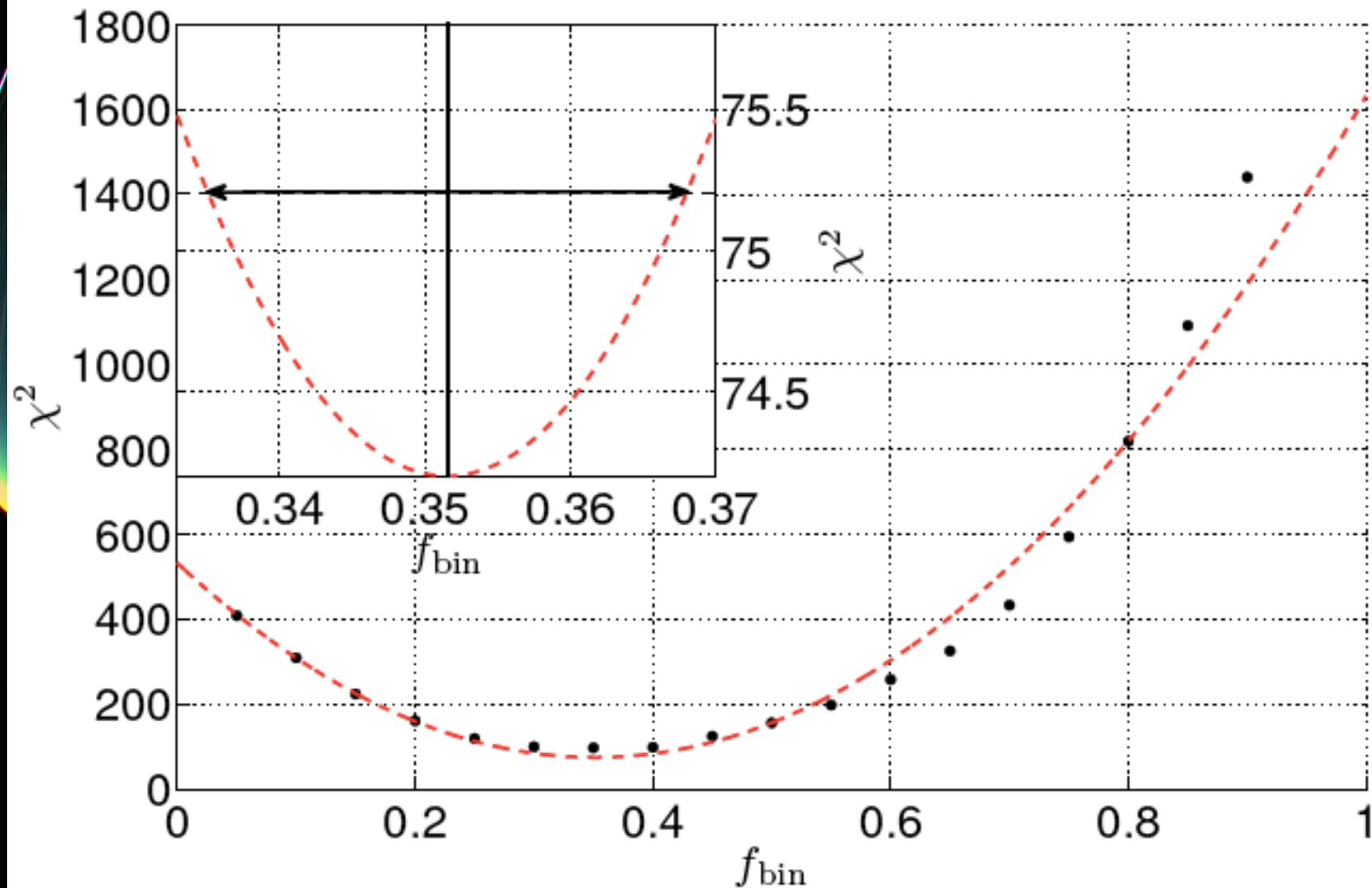
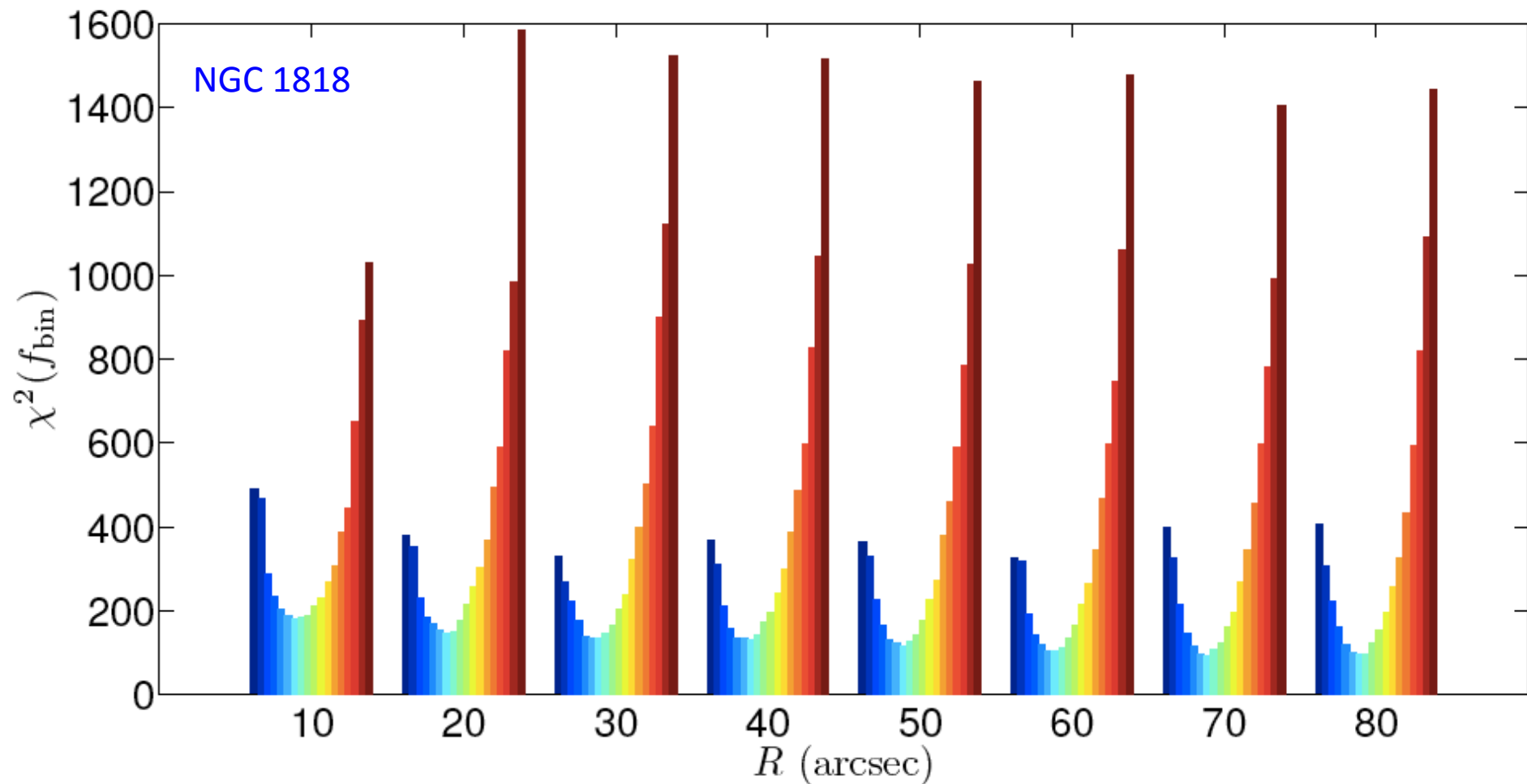
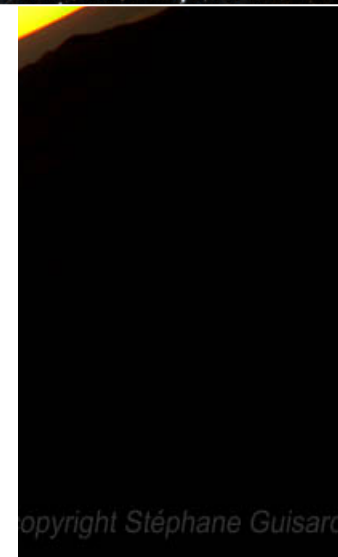
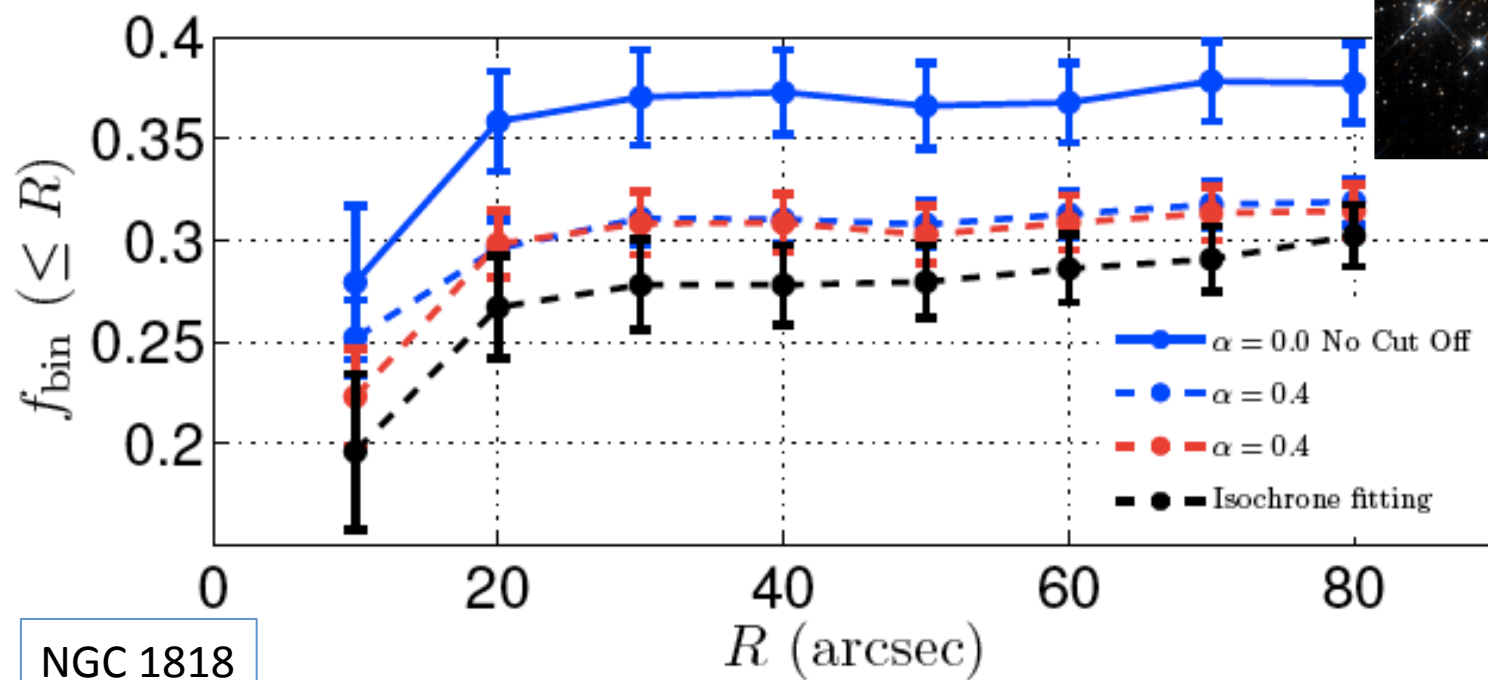
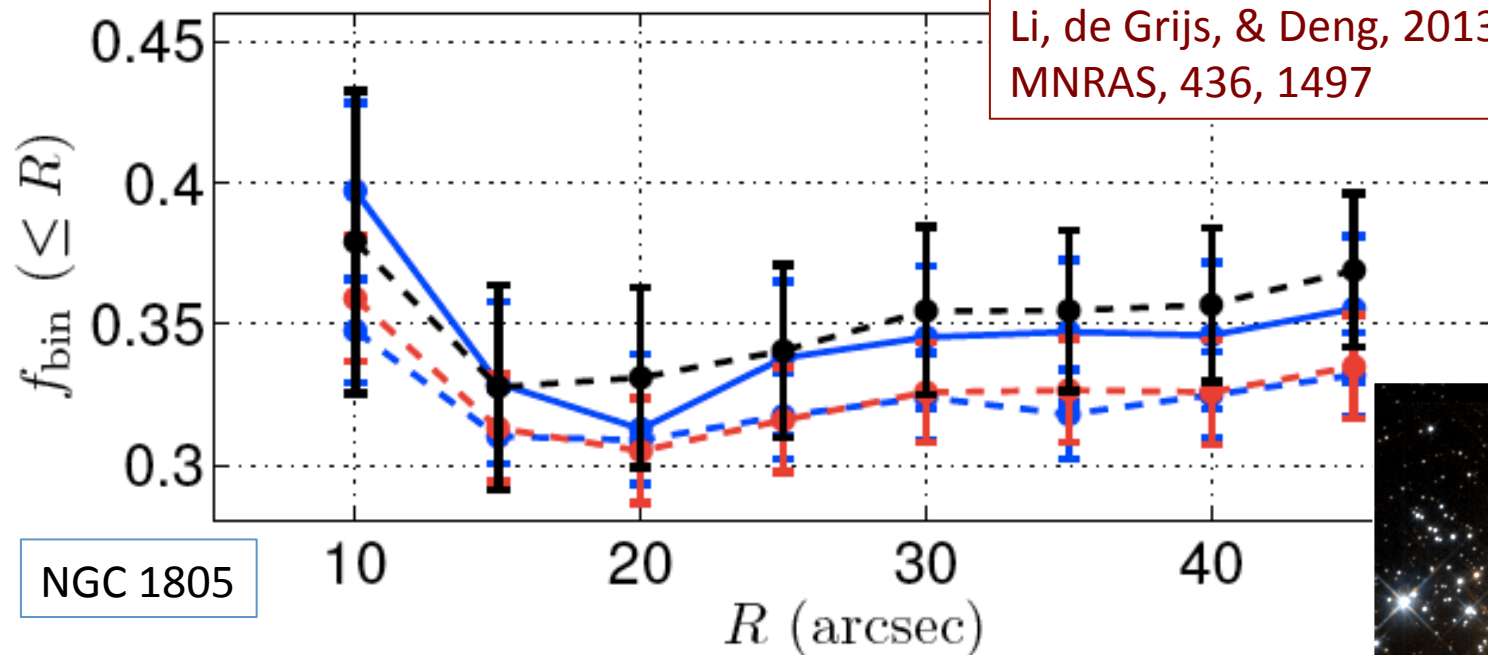


Figure 12. Distribution of $\chi^2_R(f_{\text{bin}})$ for NGC 1818, from $R \leq 10$ to $R \leq 80$ arcsec. The colour scale represents f_{bin} , from 5 to 90 per cent.

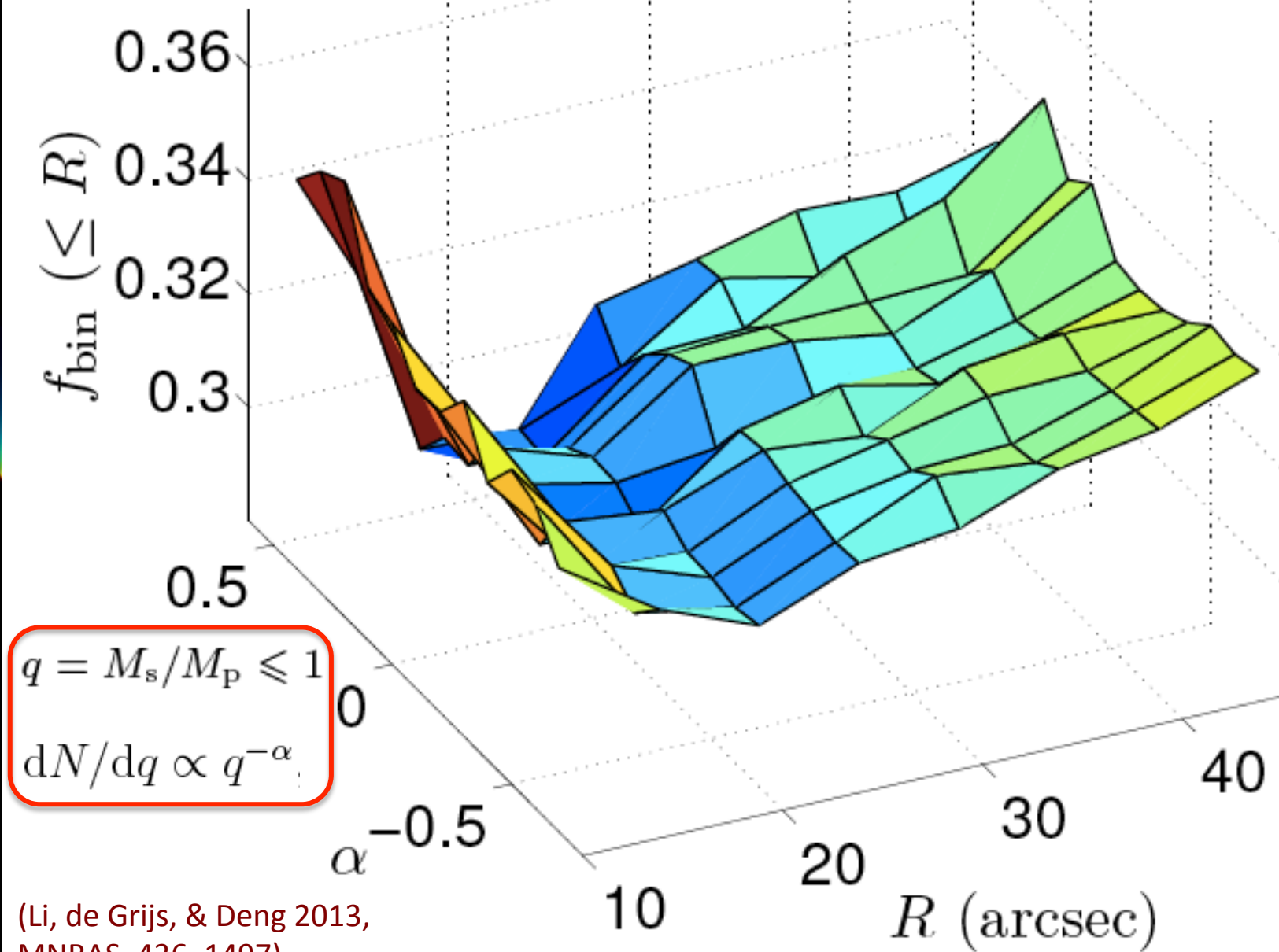


(Li, de Grijs, & Deng 2013, MNRAS, 436, 1497)

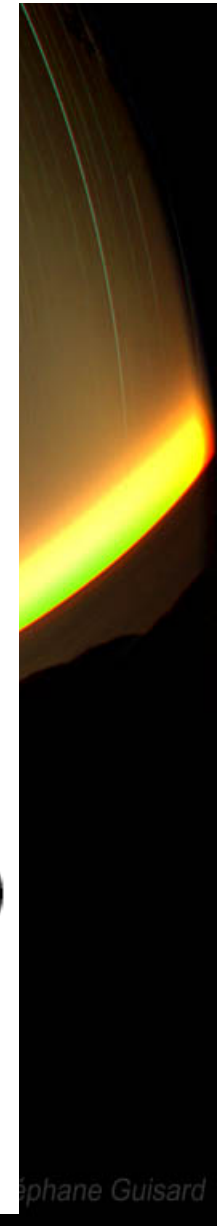
Li, de Grijs, & Deng, 2013, MNRAS, 436, 1497



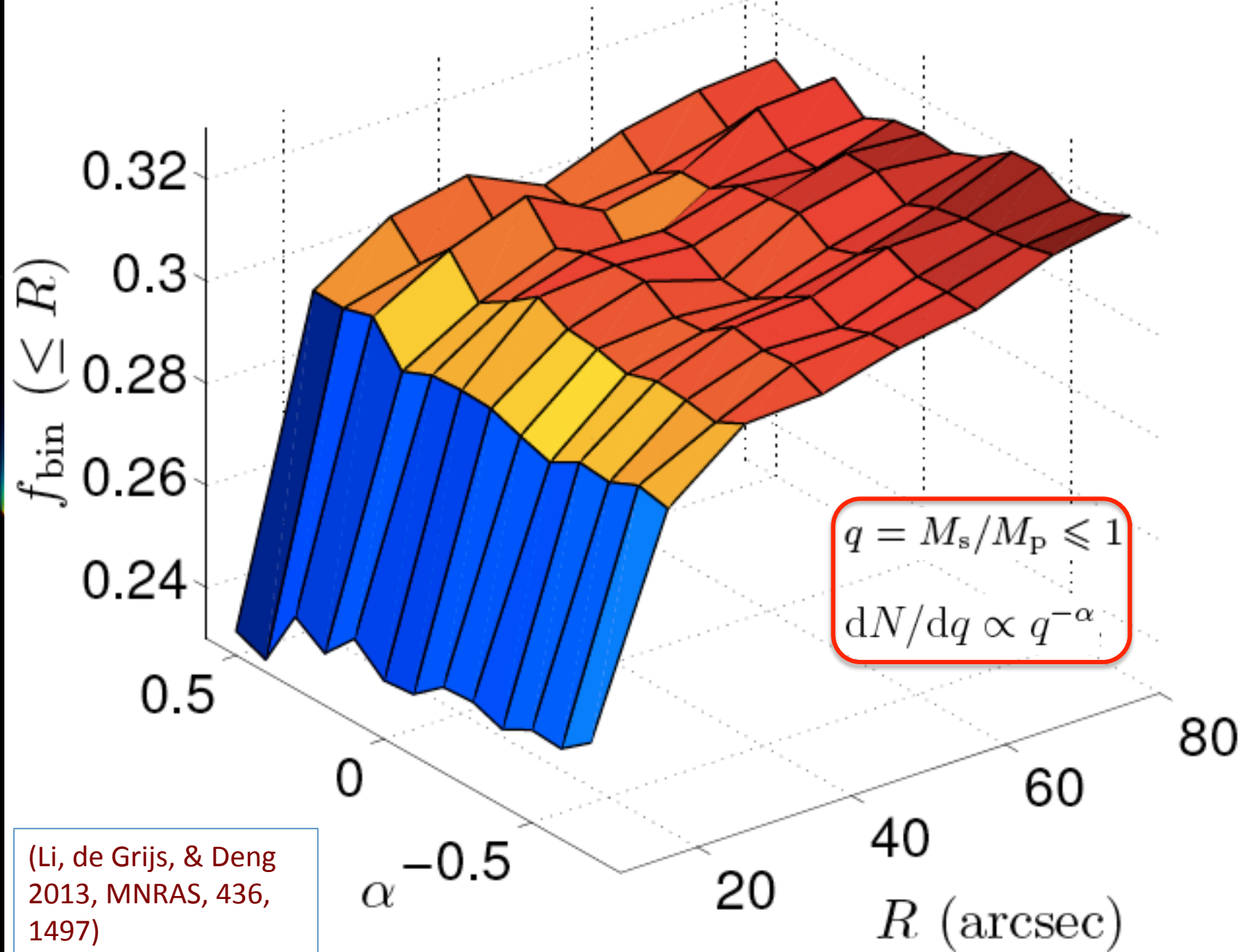
NGC 1805



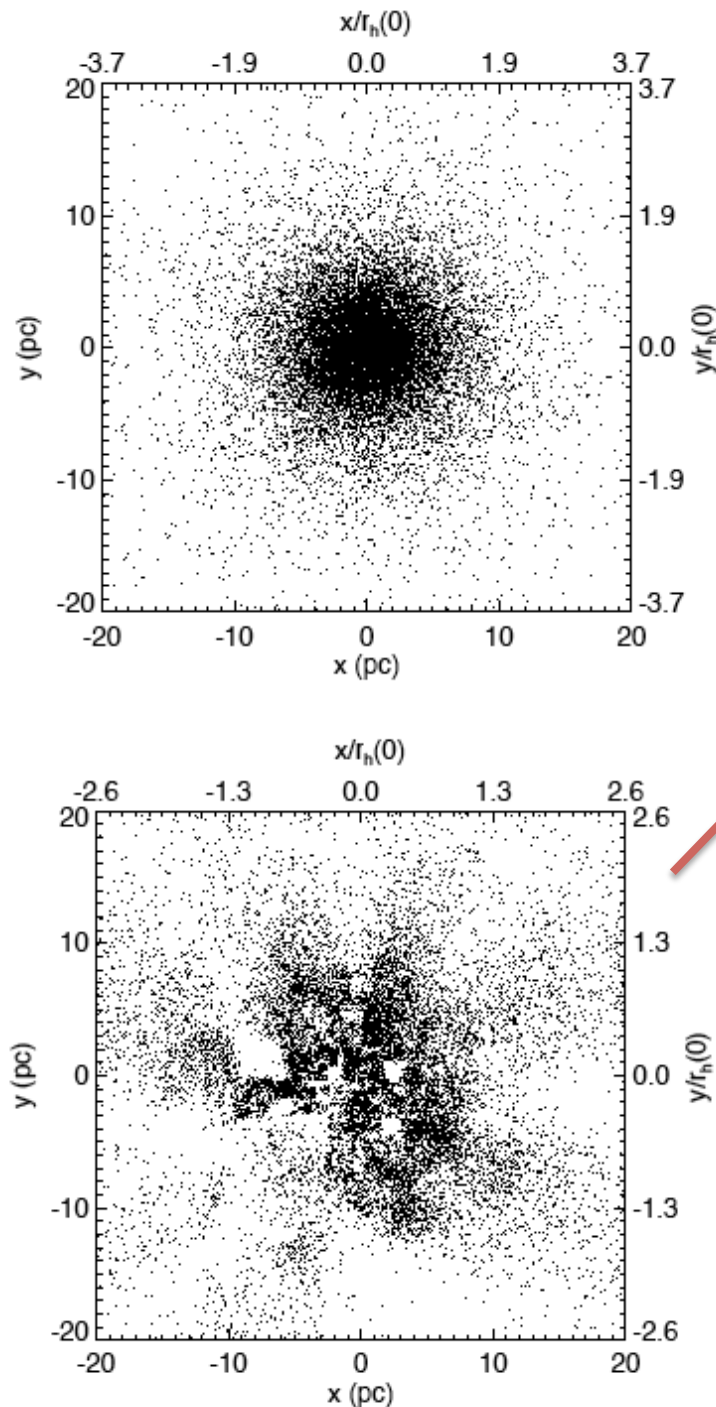
(Li, de Grijs, & Deng 2013,
MNRAS, 436, 1497)



NGC 1818

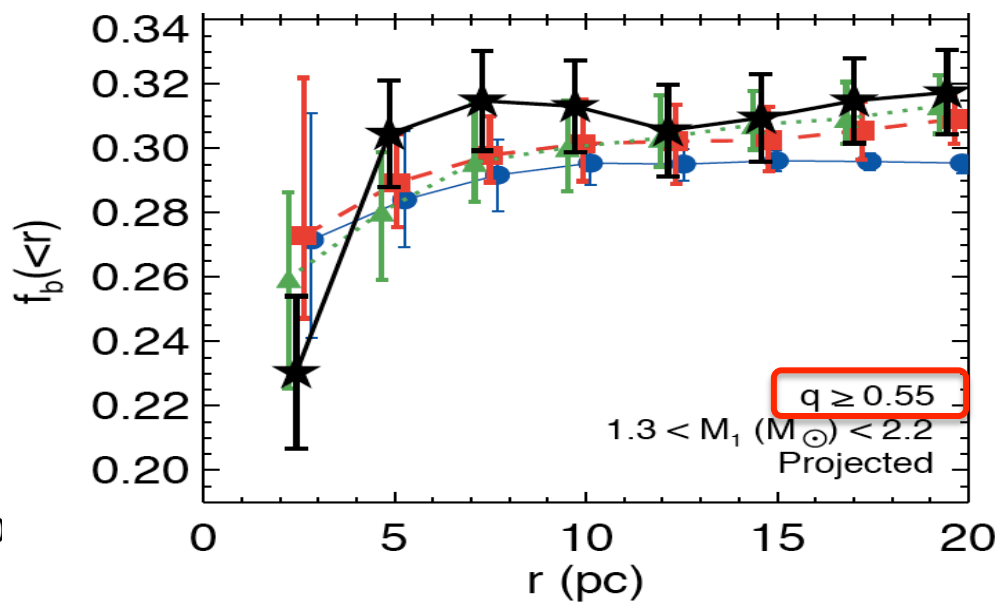
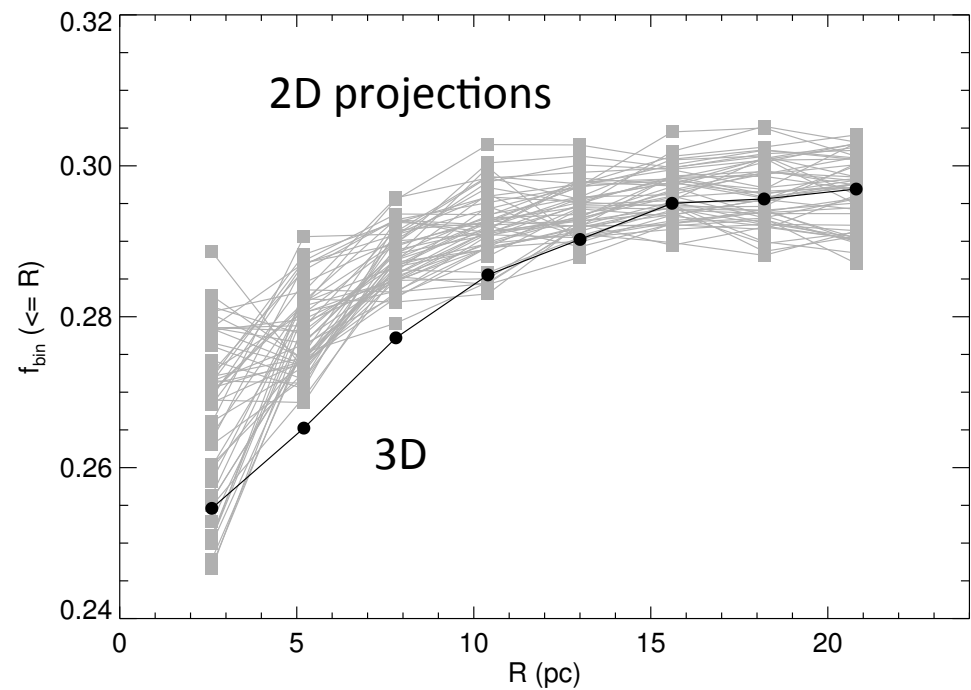
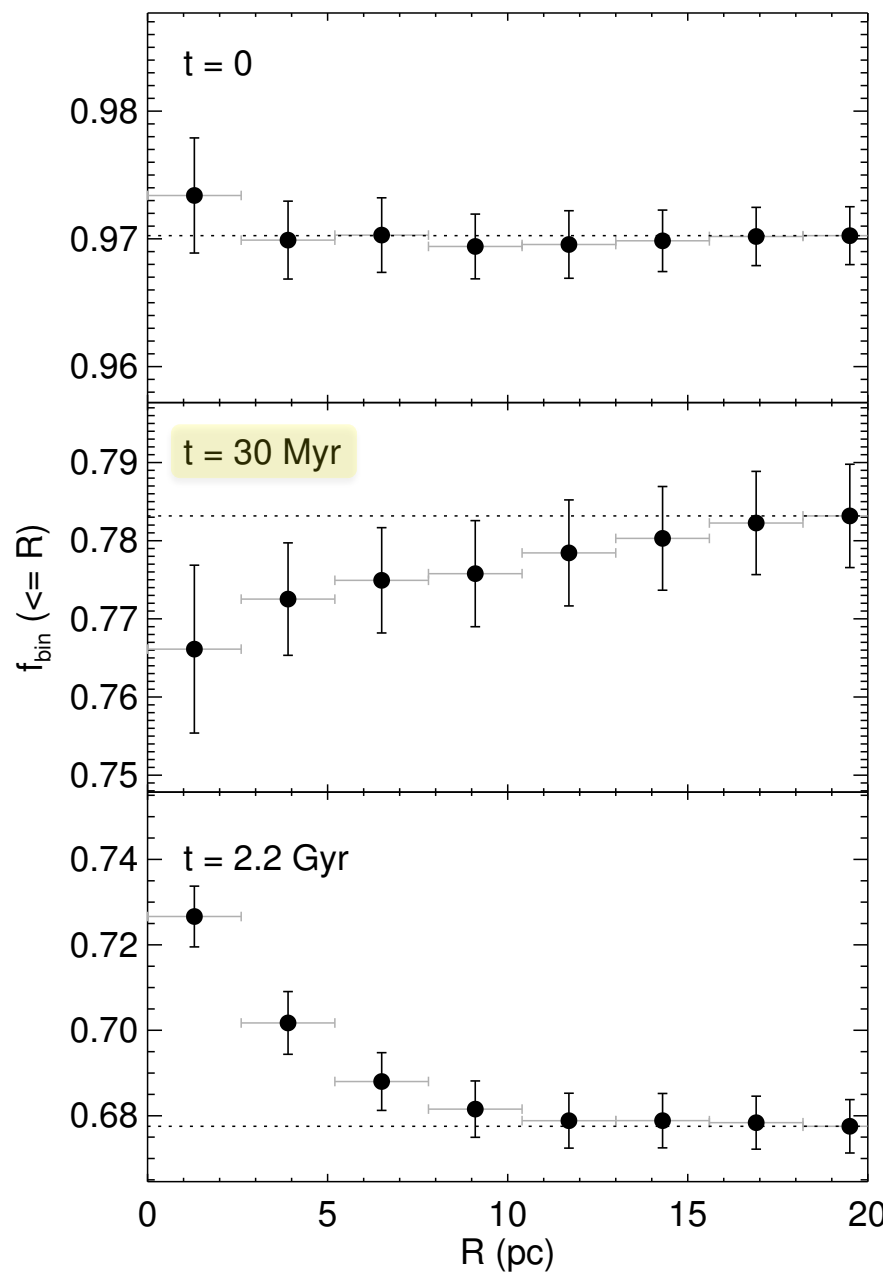


(Li, de Grijs, & Deng
2013, MNRAS, 436,
1497)

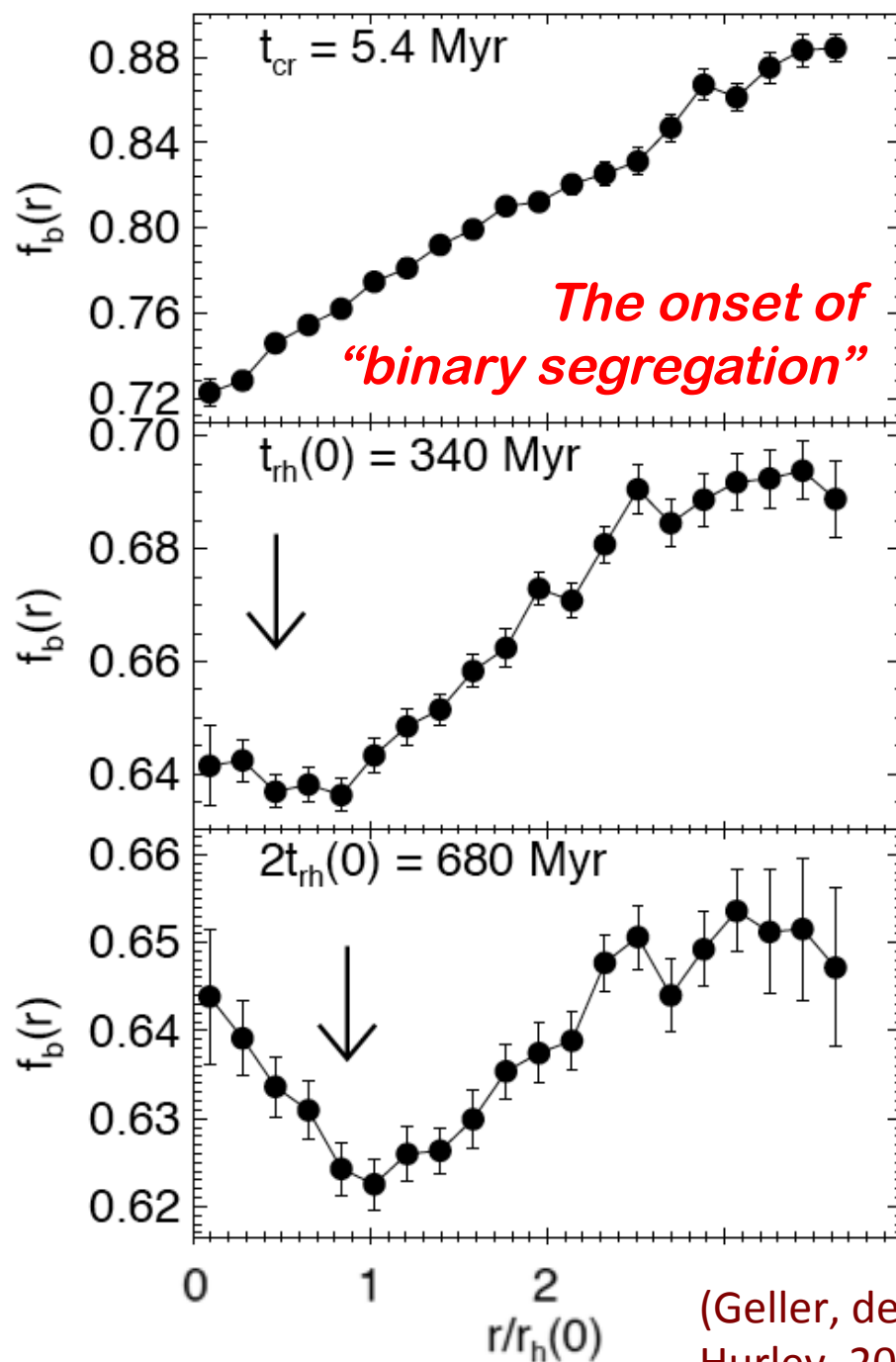


(Geller, de Grijs, Li & Hurley, 2013, ApJ, 779, 30)
 $N = 36,000$, $M_{cl} \sim 21,800 M_{\odot}$

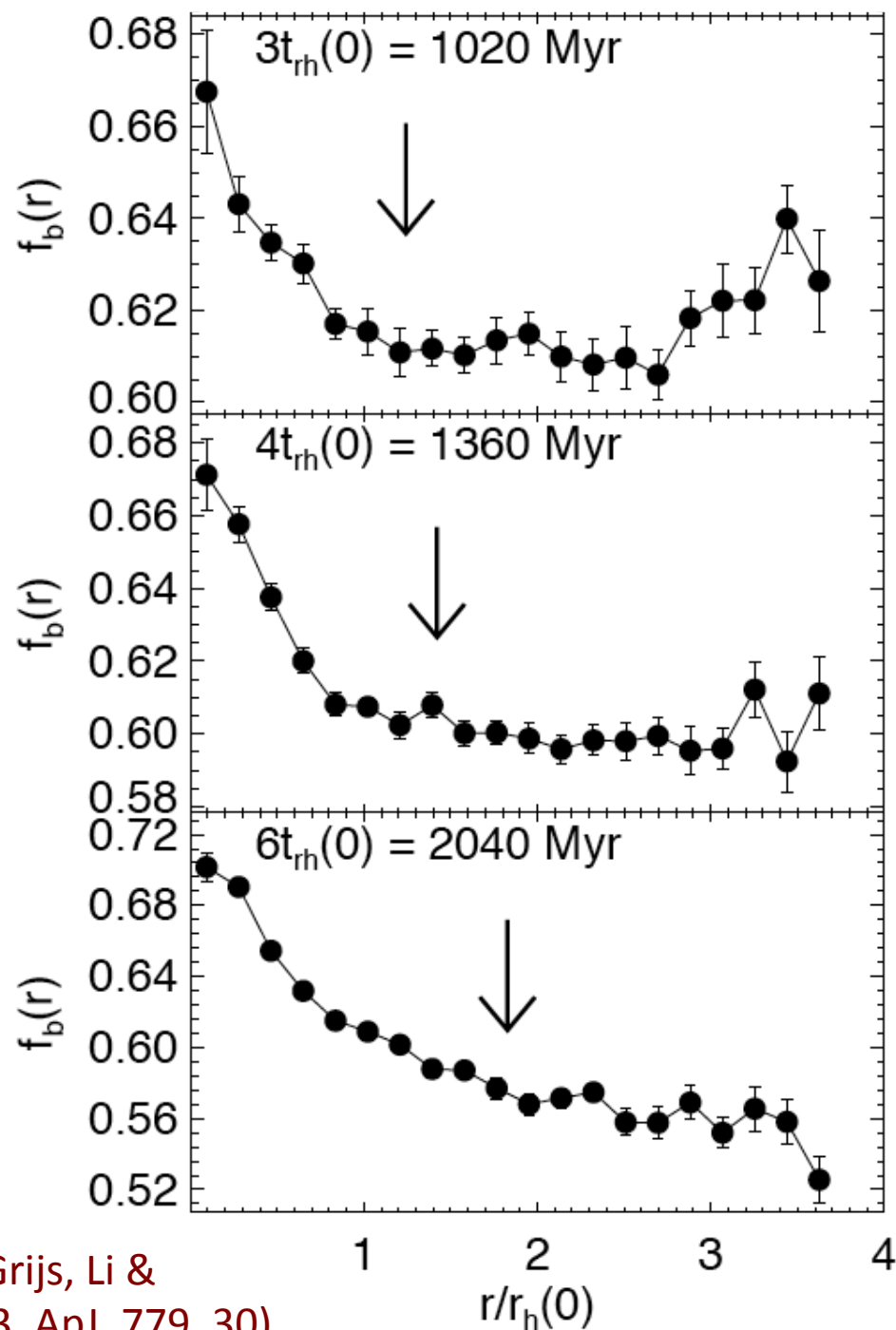
Figure 1. Stellar positions for one $[Q,D] = [0.5,3.0]$ cluster simulation (top at $t = 0$) and one $[Q,D] = [0.3,2.0]$ simulation (middle at $t = 0$ and bottom at $t = 15$ Myr, the minimum age estimate for NGC 1818), demonstrating the difference between smooth and clumpy (i.e. fractal) initial density distributions and also that the simulations with clumpy initial conditions relax to smooth density distributions by the age of NGC 1818. The simulations are shown in projection along the z axis; each simulation begins with the x direction facing away from the LMC center, and the cluster orbits in the $x - y$ plane. The positions are shown in pc and also in fractions of the respective initial half-mass radii, $r_h(0)$. For the $[Q,D] = [0.5,3.0]$ simulation, $r_h(0) = 5.38$ pc, and for the $[Q,D] = [0.3,2.0]$ simulation, $r_h(0) = 7.69$ pc. Each binary is plotted as a single point at the center-of-mass of the given system.

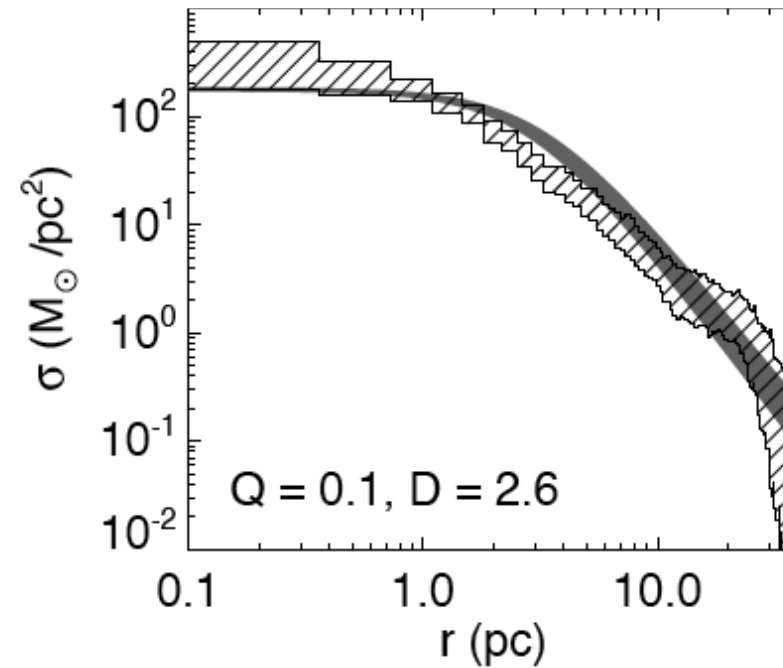
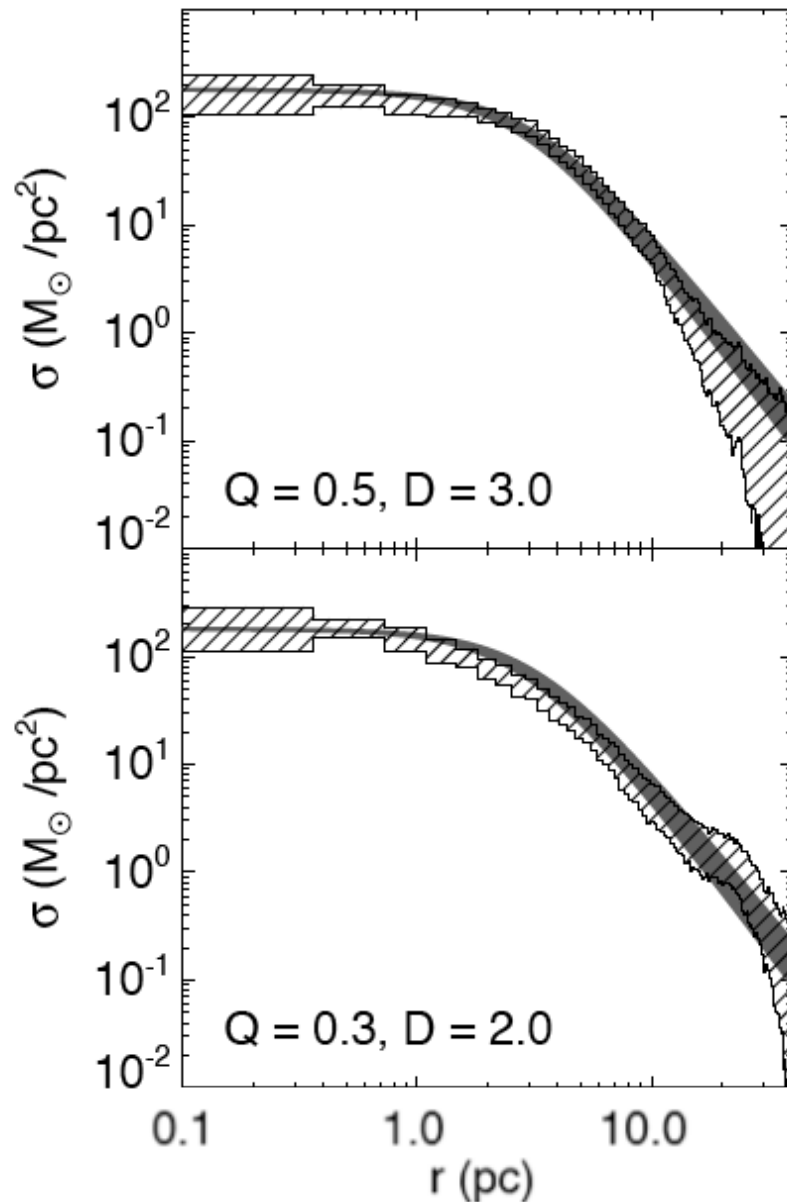


(Geller, de Grijs, Li & Hurley, 2013, ApJ, 779, 30)



(Geller, de Grijs, Li & Hurley, 2013, ApJ, 779, 30)





$t = 30 \text{ Myr}$

Figure 5. Projected radial mass surface density profiles for three simulations compared with the EFF profile fit to observations of NGC 1818 by [Mackey & Gilmore \(2003\)](#). We show results from three specific simulations at 30 Myr defined by [0.5,3.0] (top panel), [0.3,2.0] (middle panel) [0.1,2.6] (bottom panel) with the hatched regions. Each bin for the respective simulations shows the range within which fall 95% of our 1000 random sight lines. The solid gray band shows the region encompassed by the [Mackey & Gilmore \(2003\)](#) EFF model, with parameters $\log \mu_0 = 3.35 \pm 0.02 \text{ L}_{\odot} \text{ pc}^{-2}$, $a = 52 \pm 3 \text{ pc}$, and $\gamma = 2.76 \pm 0.12$.



- We have shown that the compact, 15–30 Myr-old Large Magellanic Cloud cluster NGC 1818 exhibits *an increasing fraction of F-star binary systems with increasing radius*
- This offers support of the theoretically predicted but thus far unobserved *dynamical disruption processes* of the significant population of ‘*soft*’ *binary systems* in star clusters; “normal” dynamical evolution occurs on longer time-scales
- The (approximately) equally old LMC cluster NGC 1805 exhibits *the opposite behaviour*
- This likely implies *a significant difference in dynamical age* (rather than chronological age)



XXIX IAU General Assembly

Honolulu Hawai'i, 3-14 August 2015



29th IAU General Assembly

Pre-announcement: IAU Symposium on the
“Formation, evolution, and survival of massive star clusters”

SOC: Corinne Charbonnel (**co-chair**), Antonella Nota (**co-chair**),
Holger Baumgardt, Peter Cottrell, Richard de Grijs, Bruce Elmegreen,
Yasuo Fukui, Patrick Hennebelle, Eva Noyola, Jan Palous,
Margarita Sharina, Nicole St Louis, Elena Terlevich