Beware your tracers(?)

Musings from the PAndAS view of the M31 satellite system

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Specific topics for this workshop include:

- How can we optimally use discrete kinematics tracers?
- How do we properly take into account the observational selection effects?
- What is the most appropriate modeling approach, balancing speed versus accuracy?
- How do we incorporate additional information such as chemical properties?
- How do we best treat kinematics from unresolved stellar populations?

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Insights (I got) from photometry alone

- case 1 – distance to M31 satellite galaxies
  - Measurements are not ***x.x*** kpc. Are measurements really ***x.x*** ± ***y.y*** kpc (i.e. Gaussian uncertainties)?
  - What do the data really tell us?
- case 2 – M31 satellite globular clusters
  - Can/Should we do away with the isotropy assumption?
- case 3 – dwarf galaxies are *not* spherical
  - What impact does it have on modeling?

Distance to M31 satellite galaxies

Are measurements really ***xx.x ±yy.y*** ?
What do the data really tell us?

Dwarf galaxies in PAndAS

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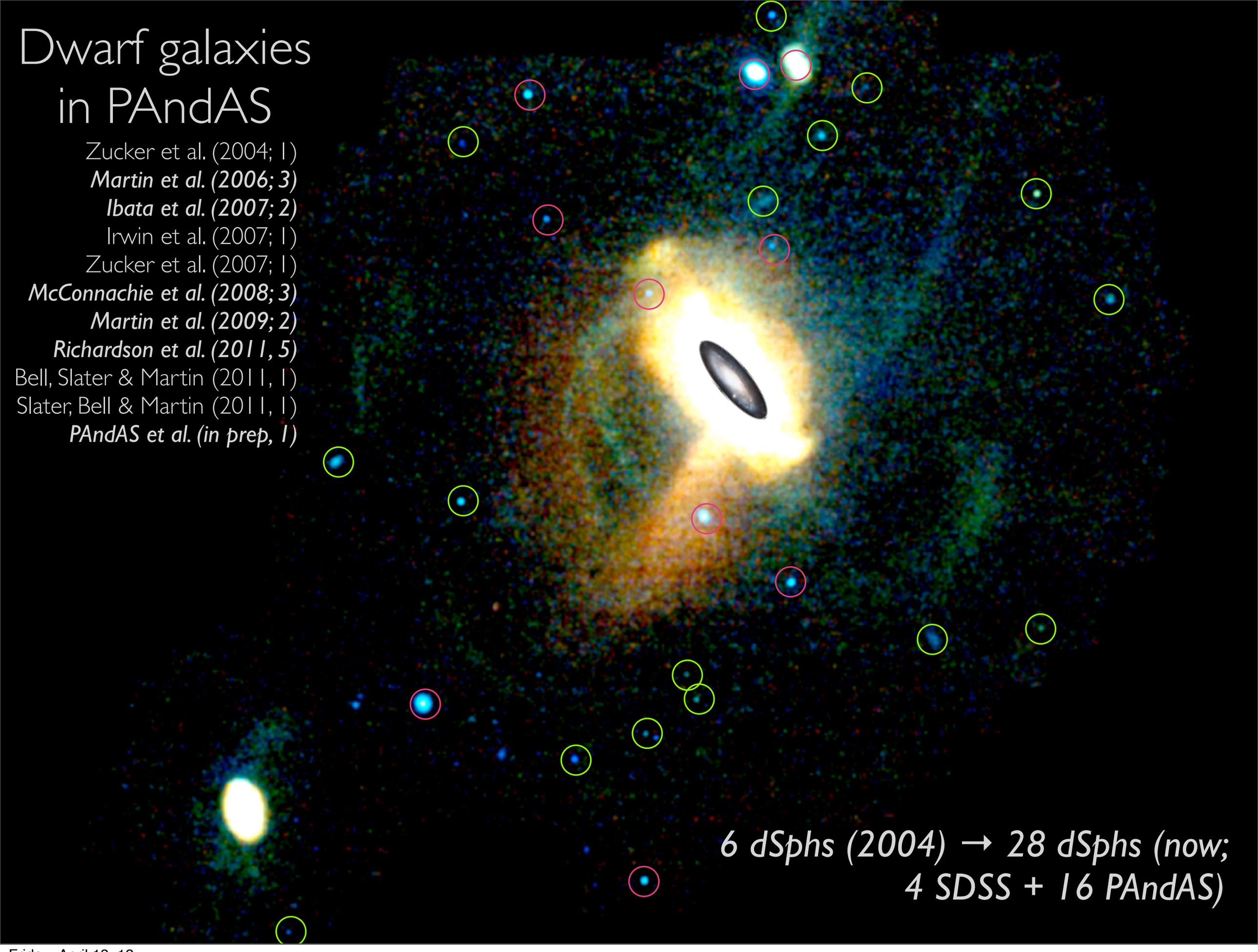
Zucker et al. (2004; 1)
Martin et al. (2006; 3)
Ibata et al. (2007; 2)
Irwin et al. (2007; 1)
Zucker et al. (2007; 1)
McConnachie et al. (2008; 3)
Martin et al. (2009; 2)
Richardson et al. (2011, 5)
Bell, Slater & Martin (2011, 1)
Slater, Bell & Martin (2011, 1)
PAndAS et al. (in prep, 1)



6 dSphs (2004) → 28 dSphs (now; 4 SDSS + 16 PAndAS)

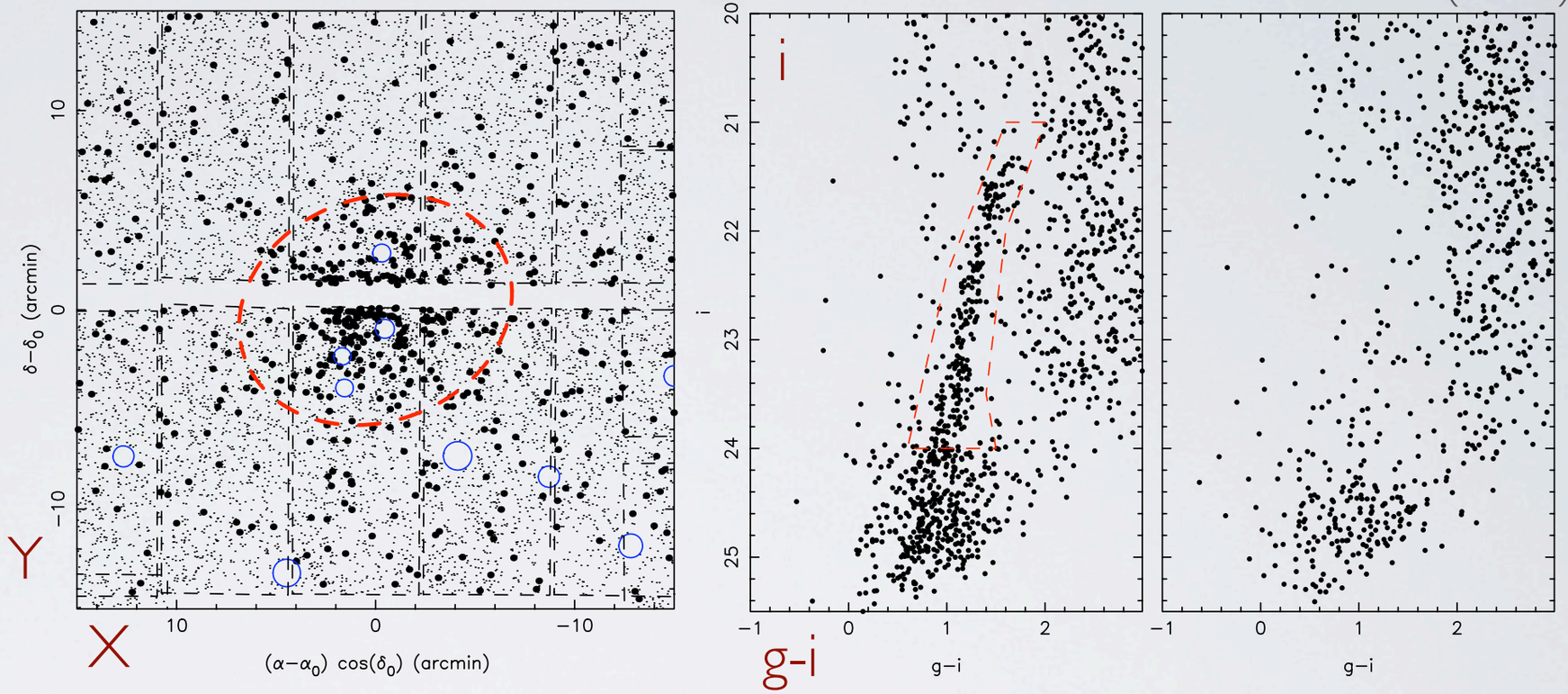
Two examples

Martin et al. (2009)

And XXI

$M_V = -9.9 \pm 0.6$

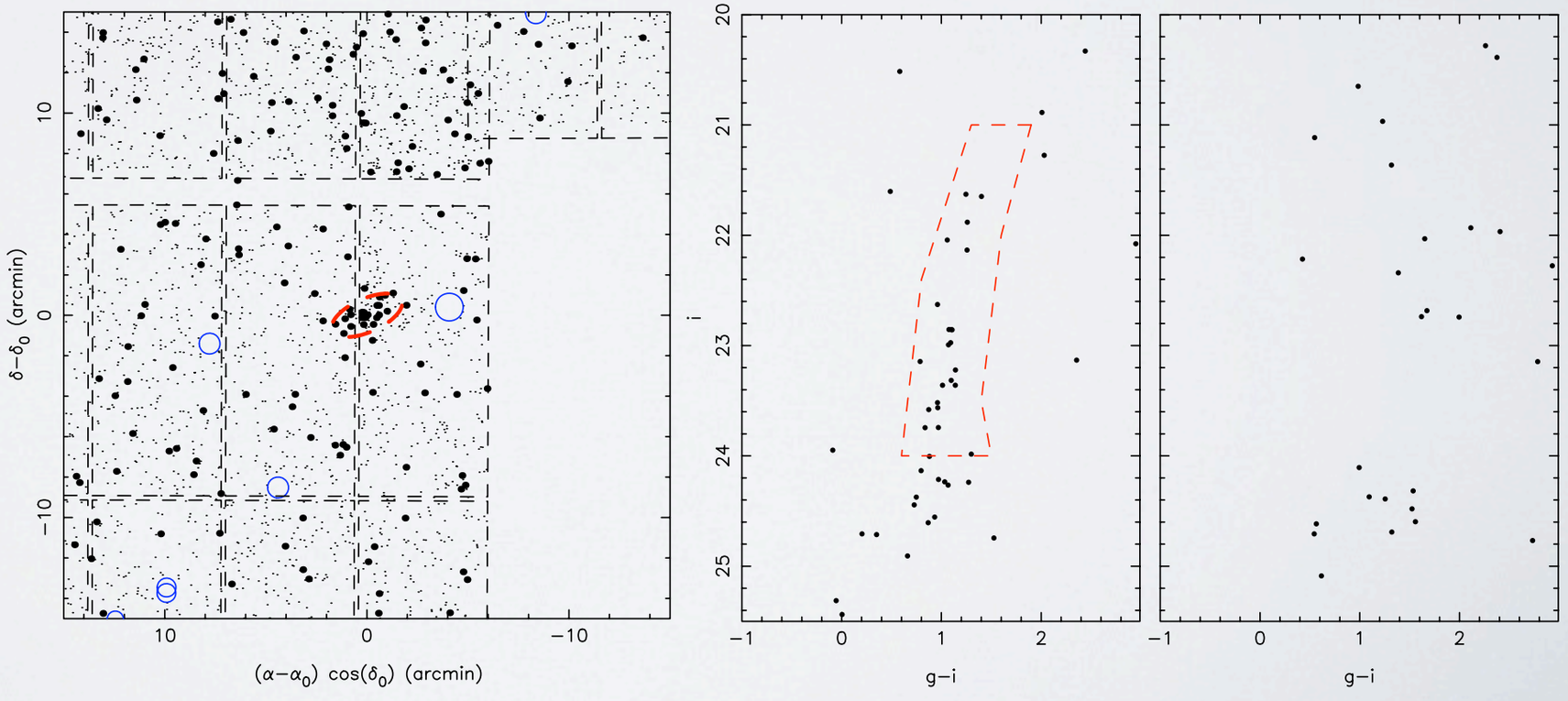
$r_h = 875 \pm 127$ pc



And XXII

$M_V = -6.5 \pm 0.8$

$r_h \sim 220$ pc



Determining distances

A. Conn et al. (2011, 2012)

TABLE 2
M31 SATELLITE PARAMETERS:

Distance and associated parameters of M31 and its companions. All distance measurements utilize the data from the Pan-Andromeda Archaeological Survey (McConnachie et al. 2009), and have been obtained using the method presented in this paper. A value of $M_i^{TRGB} = -3.44 \pm 0.05$ is assumed for the absolute magnitude of the RGB tip in CFHT MegaCam *i*-band, based on the value identified for the SDSS *i*-band (Bellazzini 2008) and justified for use here by the color equations applicable to the new MegaCam *i*-band filter (Gwyn 2010). Values for the extinction in MegaCam *i*-band have been adopted as $A_\lambda = 2.086 \times E(B-V)$ for the same reasons, with uncertainties taken as ±10%. Note that the uncertainties in the M31 distance are based on the sampled distributions while the quoted value is that derived directly from the earth-distance as per Eq. 6. The last column gives alternative distances from the literature. TRGB derived distances are quoted wherever possible.

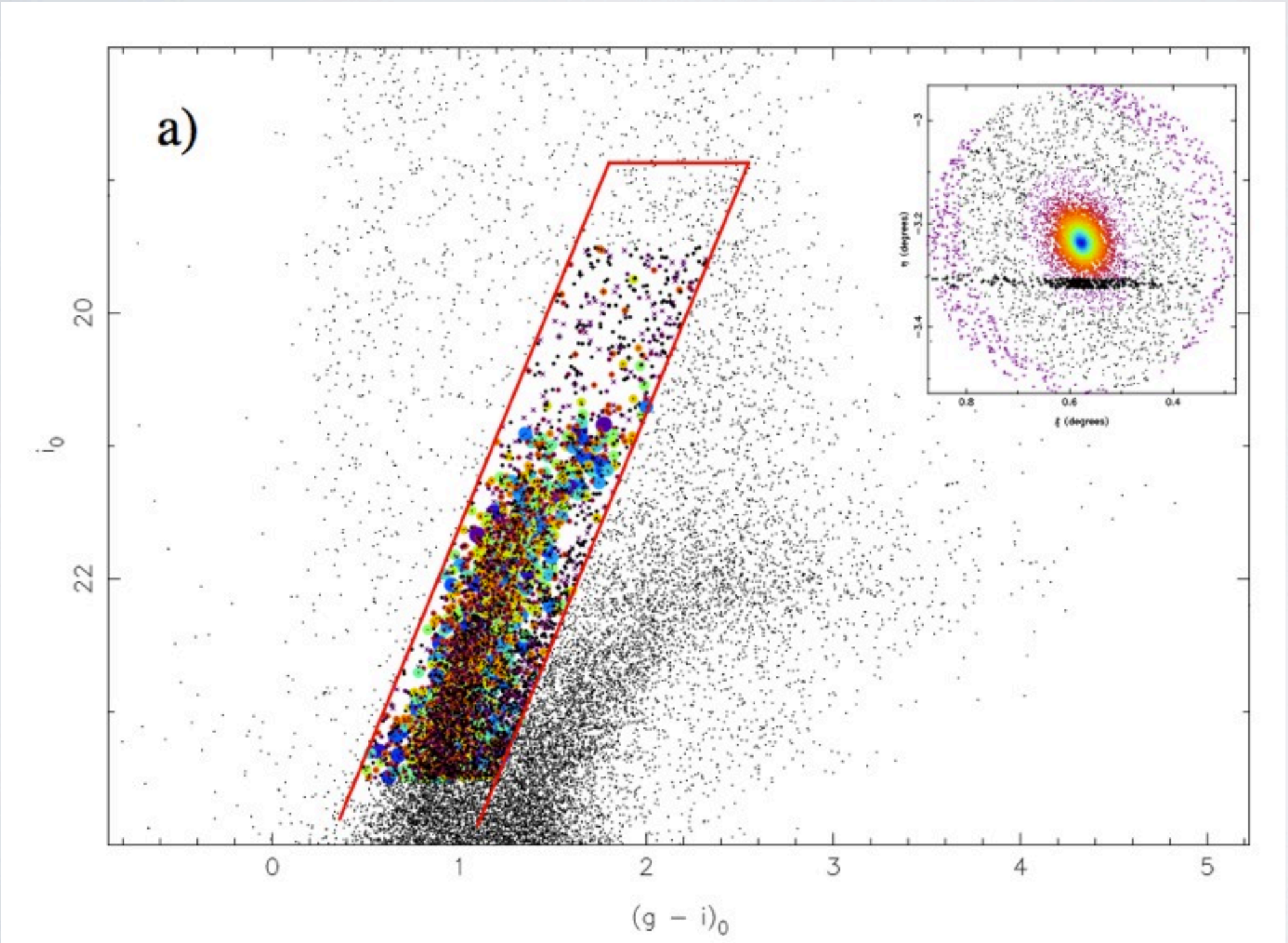
Source	Distance Modulus	E(B-V)	Distance (kpc)	M31 Distance (kpc)	Literature Distance Values (kpc)
M31	$24.46^{+0.05}_{-0.05}$	0.062	779^{+19}_{-18}	–	785^{+25}_{-25} TRGB; McConnachie et al. (2005A) 765^{+28}_{-28} Ceph; Riess, Fliri, & Valls-Gabaud (2012)
And I	$24.31^{+0.05}_{-0.05}$	0.054	727^{+18}_{-17}	68^{+22}_{-16}	731^{+18}_{-17} TRGB; Conn et al. (2011) 735^{+23}_{-23} TRGB; McConnachie et al. (2004)
And II	$24.00^{+0.05}_{-0.05}$	0.062	630^{+15}_{-15}	196^{+21}_{-16}	634^{+15}_{-14} TRGB; Conn et al. (2011) 645^{+19}_{-19} TRGB; McConnachie et al. (2004)
And III	$24.30^{+0.05}_{-0.07}$	0.057	723^{+18}_{-24}	86^{+26}_{-14}	749^{+24}_{-24} TRGB; McConnachie et al. (2005A)
And V	$24.35^{+0.06}_{-0.07}$	0.125	742^{+21}_{-22}	113^{+10}_{-6}	774^{+28}_{-28} TRGB; McConnachie et al. (2005A)
And IX	$23.89^{+0.31}_{-0.08}$	0.076	600^{+91}_{-23}	182^{+37}_{-67}	765^{+24}_{-24} TRGB; McConnachie et al. (2005A)
And X	$24.13^{+0.08}_{-0.13}$	0.126	670^{+24}_{-39}	130^{+56}_{-19}	667 – 738 TRGB; Zucker et al. (2007)
And XI	$24.41^{+0.08}_{-0.32}$	0.080	763^{+29}_{-106}	103^{+146}_{-2}	740 – 955 TRGB; Martin et al. (2006) 735^{+17}_{-17} RR Ly; Yang & Sarajedini (2012)
And XII	$24.84^{+0.09}_{-0.34}$	0.111	928^{+40}_{-136}	182^{+17}_{-87}	825^{+85}_{-159} TRGB; (MCMC without MF) 740 – 955 TRGB; Martin et al. (2006)
And XIII	$24.40^{+0.33}_{-0.49}$	0.082	760^{+126}_{-154}	116^{+207}_{-2}	890^{+360}_{-361} TRGB; (MCMC without MF) 740 – 955 TRGB; Martin et al. (2006) 839^{+20}_{-19} RR Ly; Yang & Sarajedini (2012)

Severely incomplete information!

TRGB distances

Tip of the Red Giant Branch

A. Conn et al. (2011, 2012)



And I

TRGB distances

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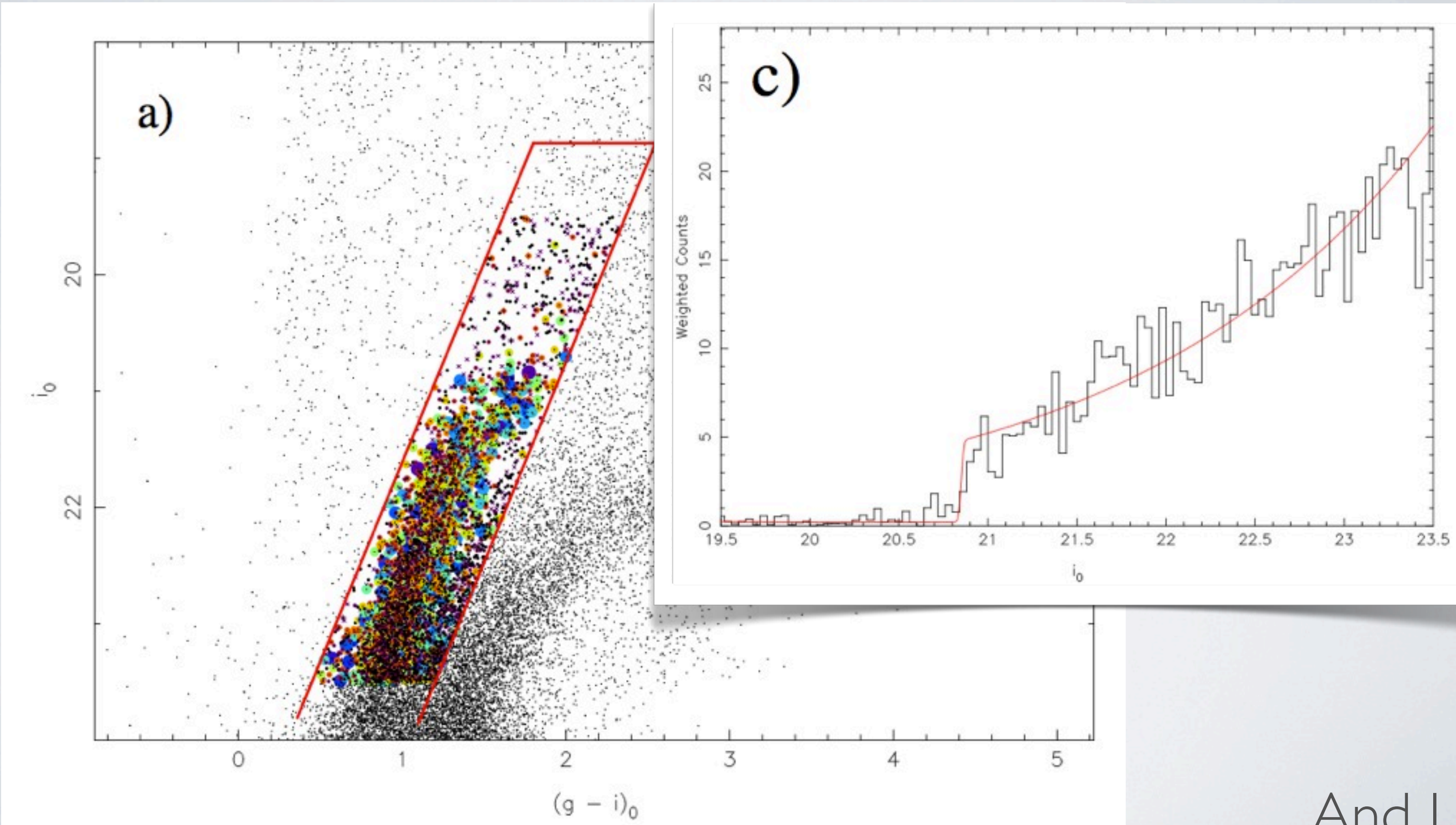
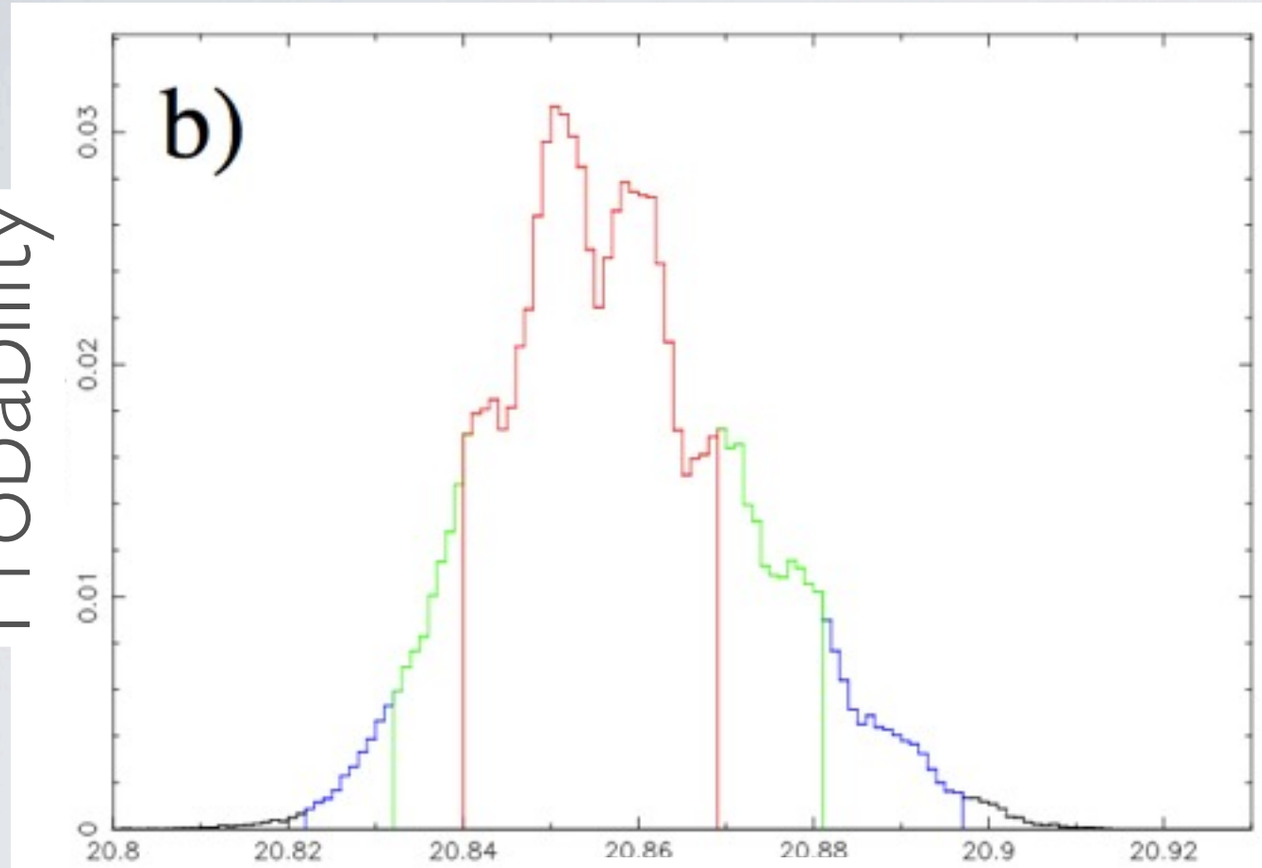


And I

Posterior TRGB and distance PDFs

A. Conn et al. (2011, 2012)



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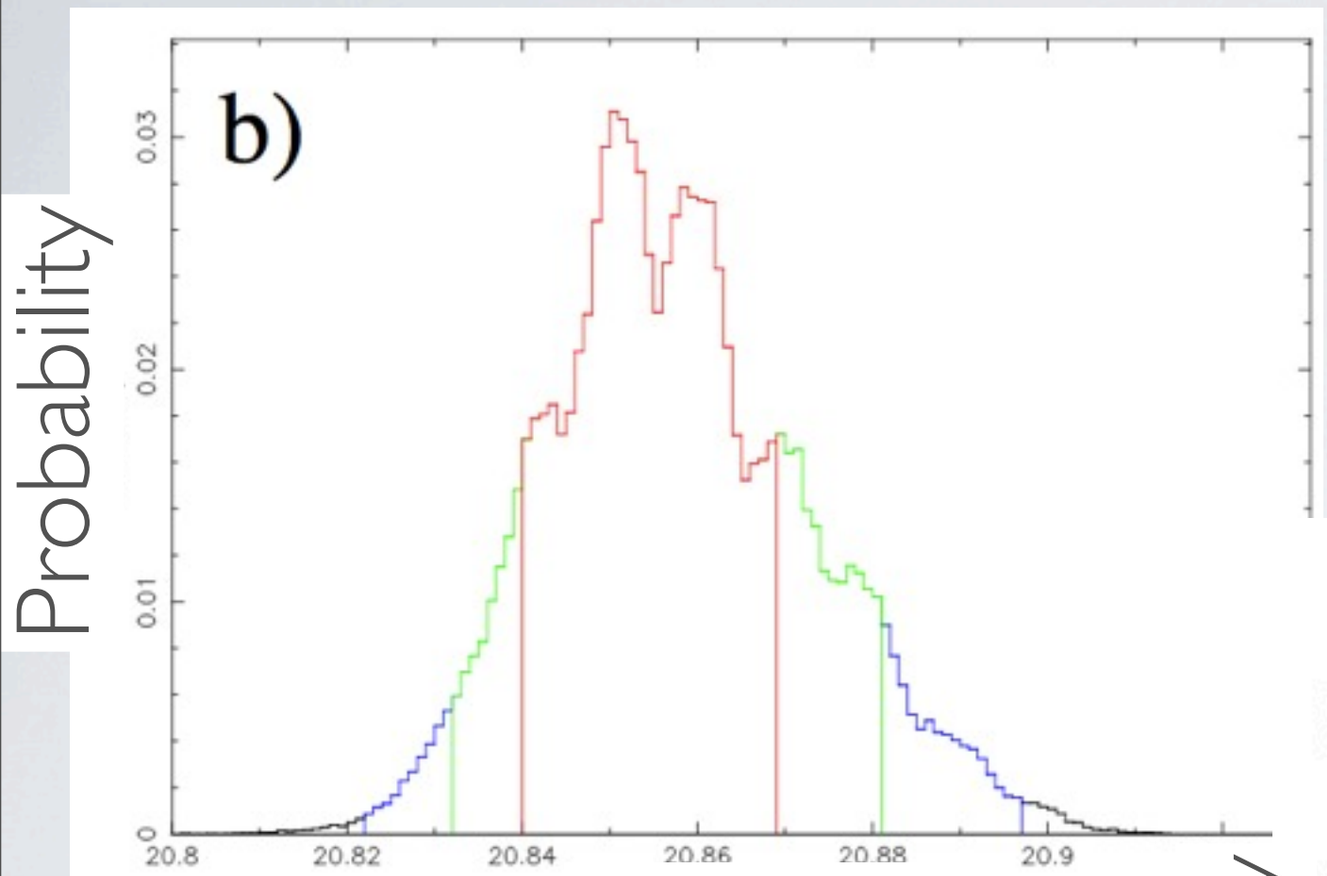
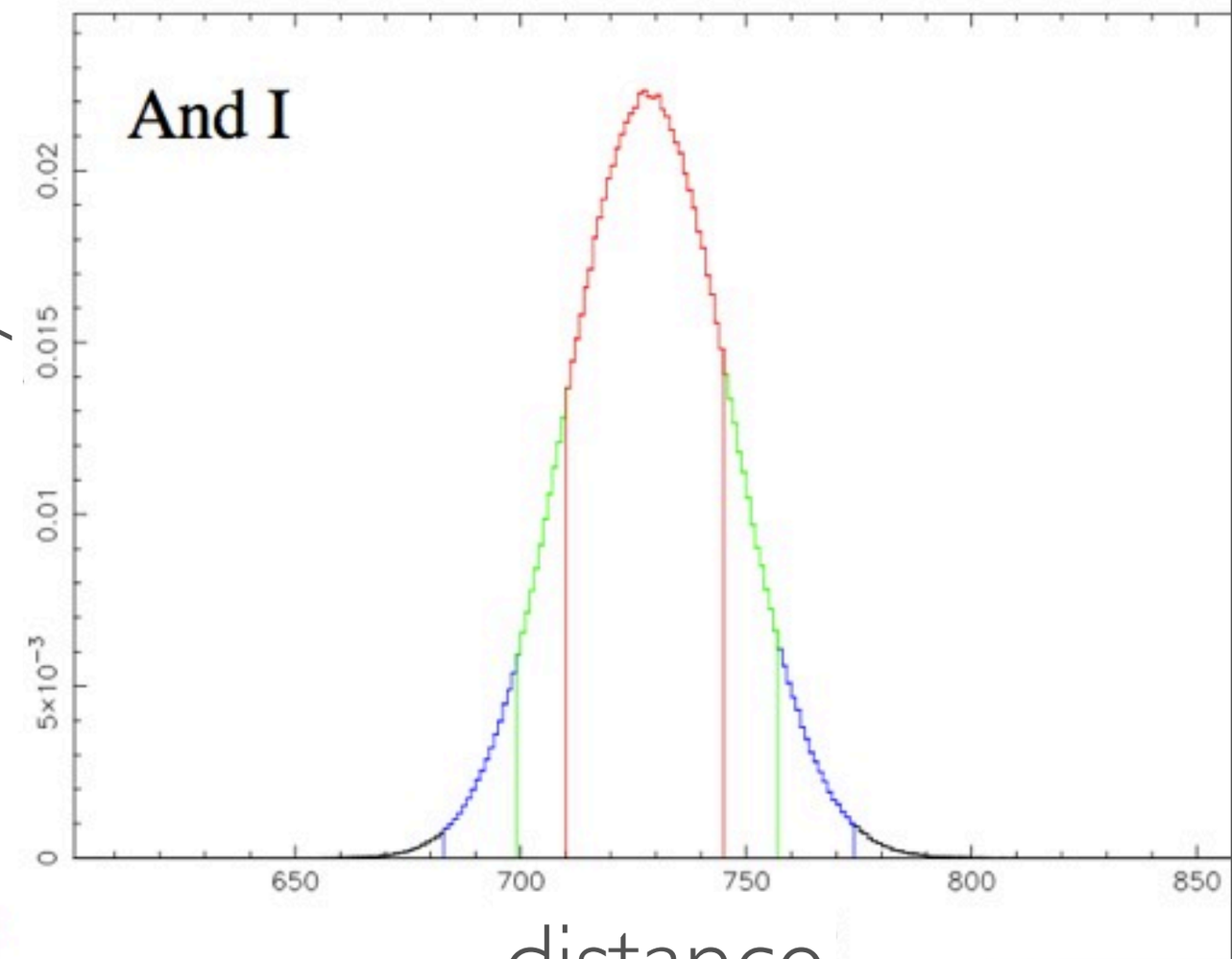


Some prior knowledge of radial density of M31 satellite system



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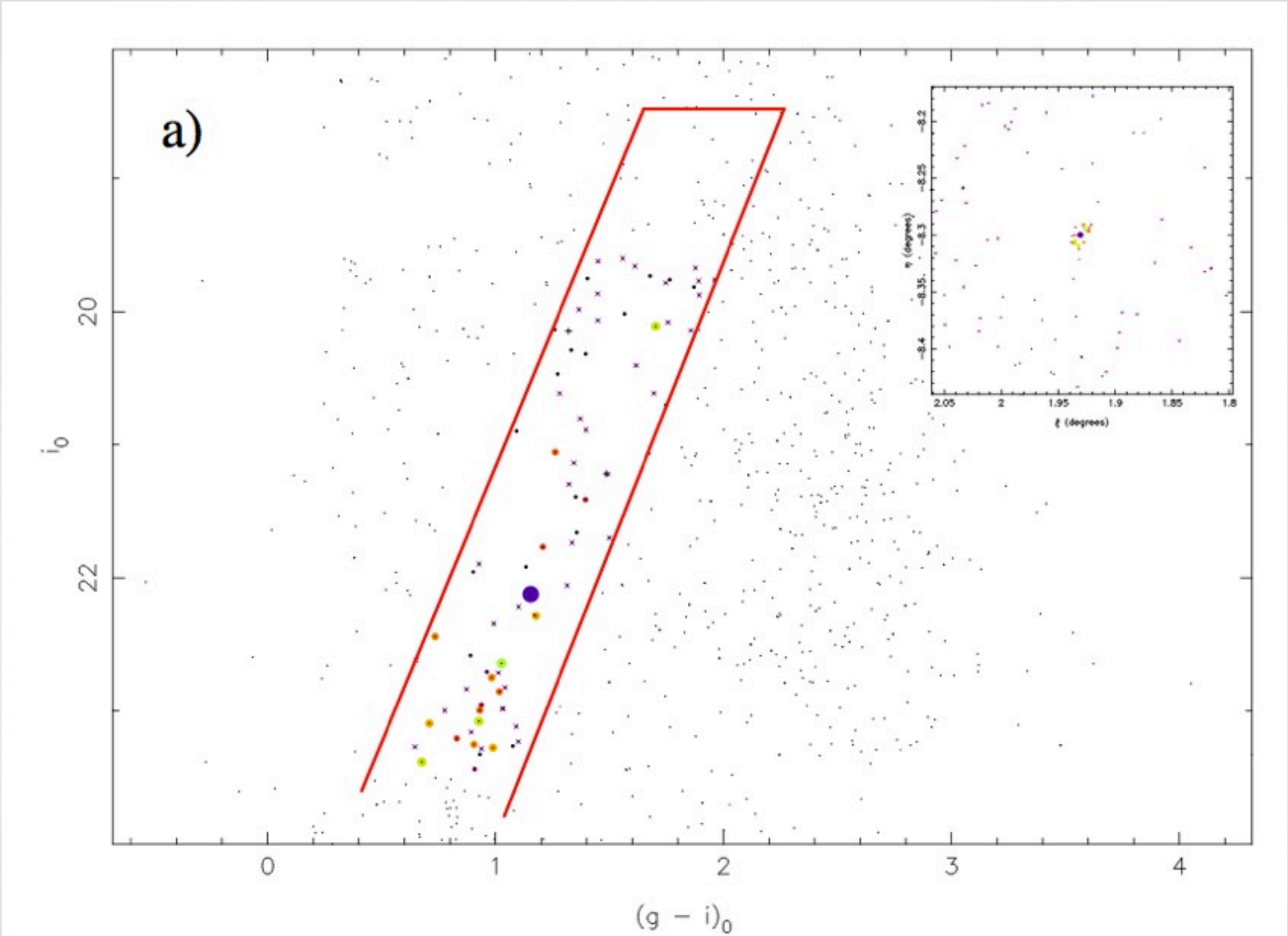

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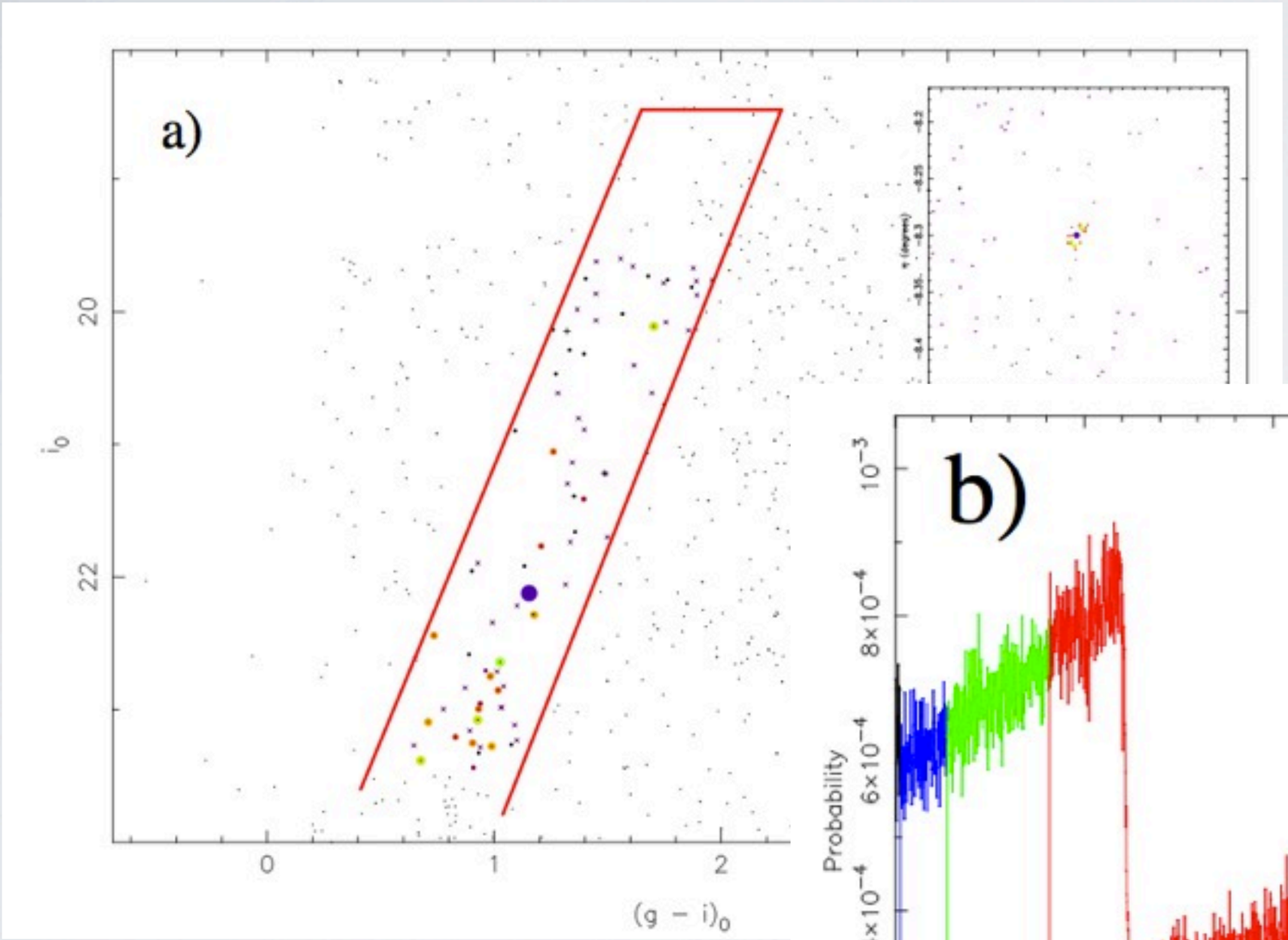

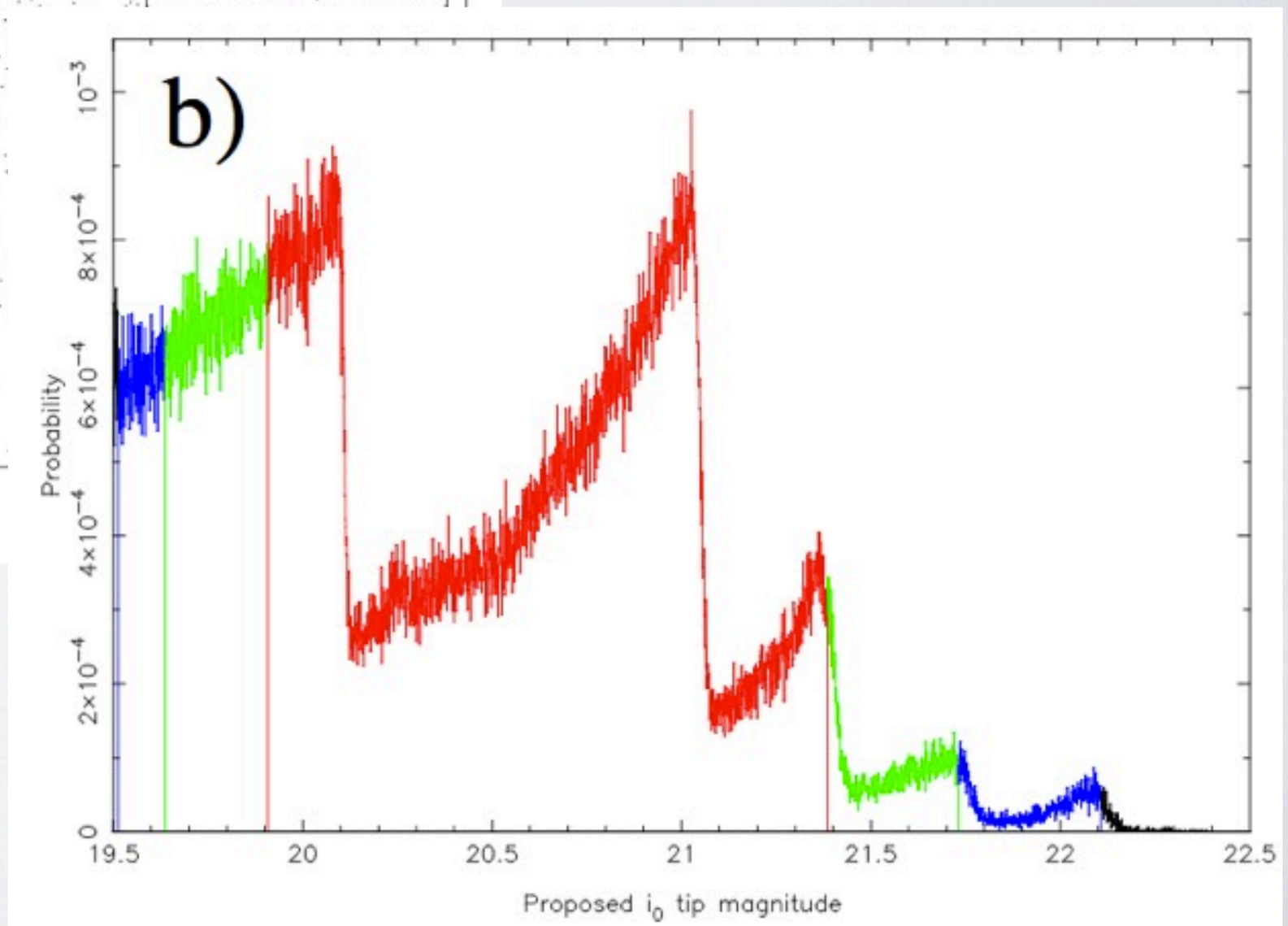

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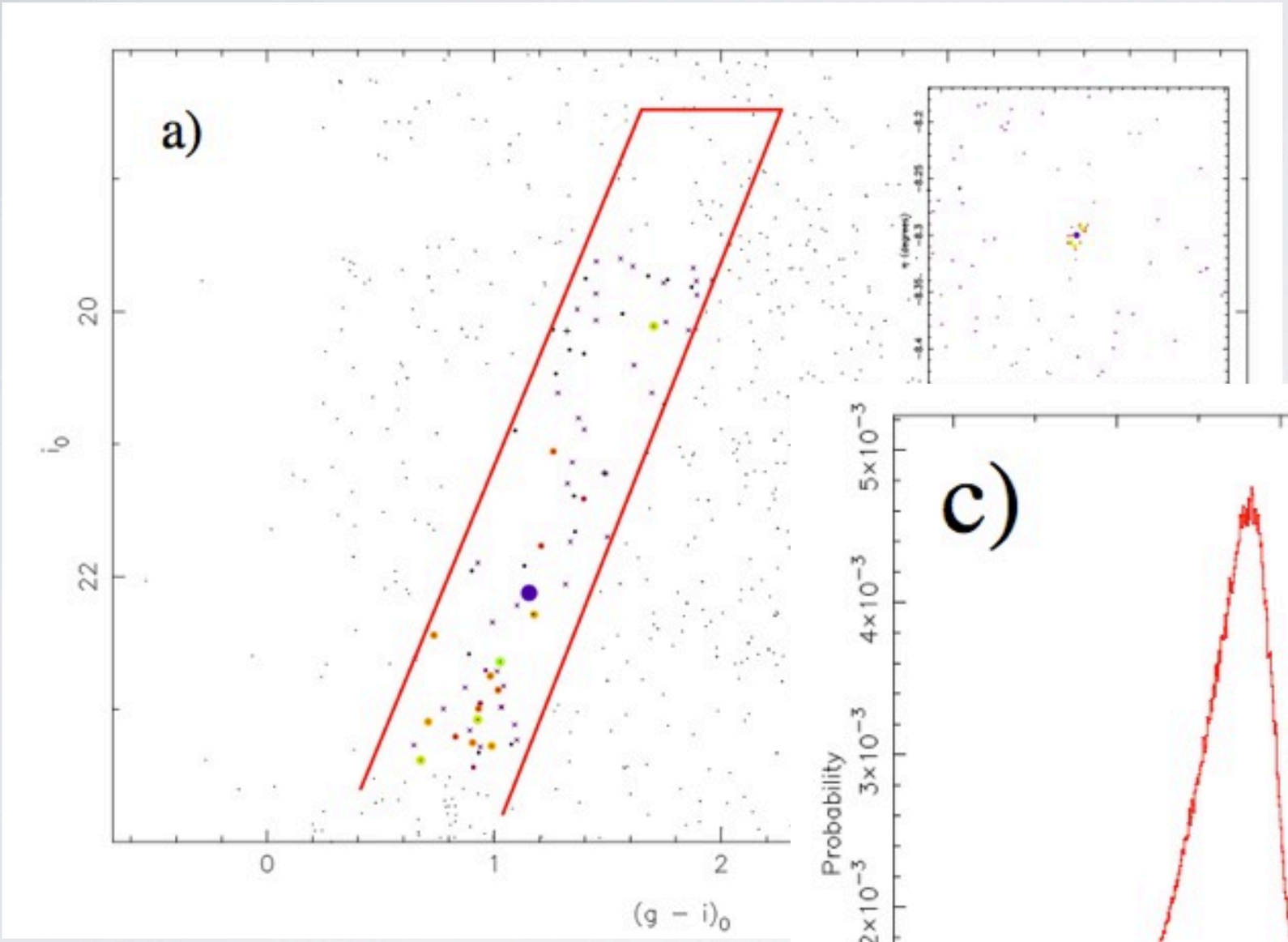

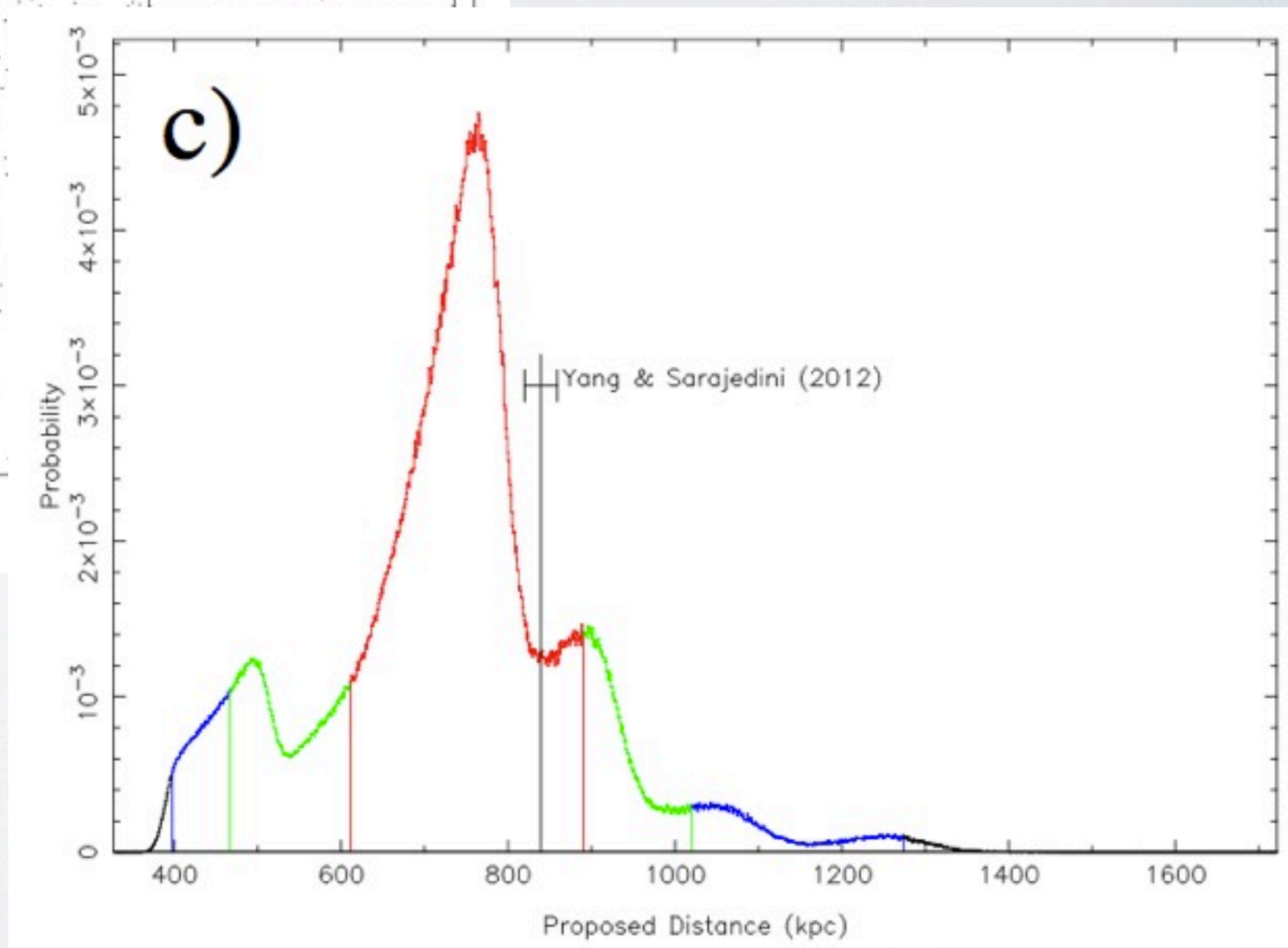

What the data really say…

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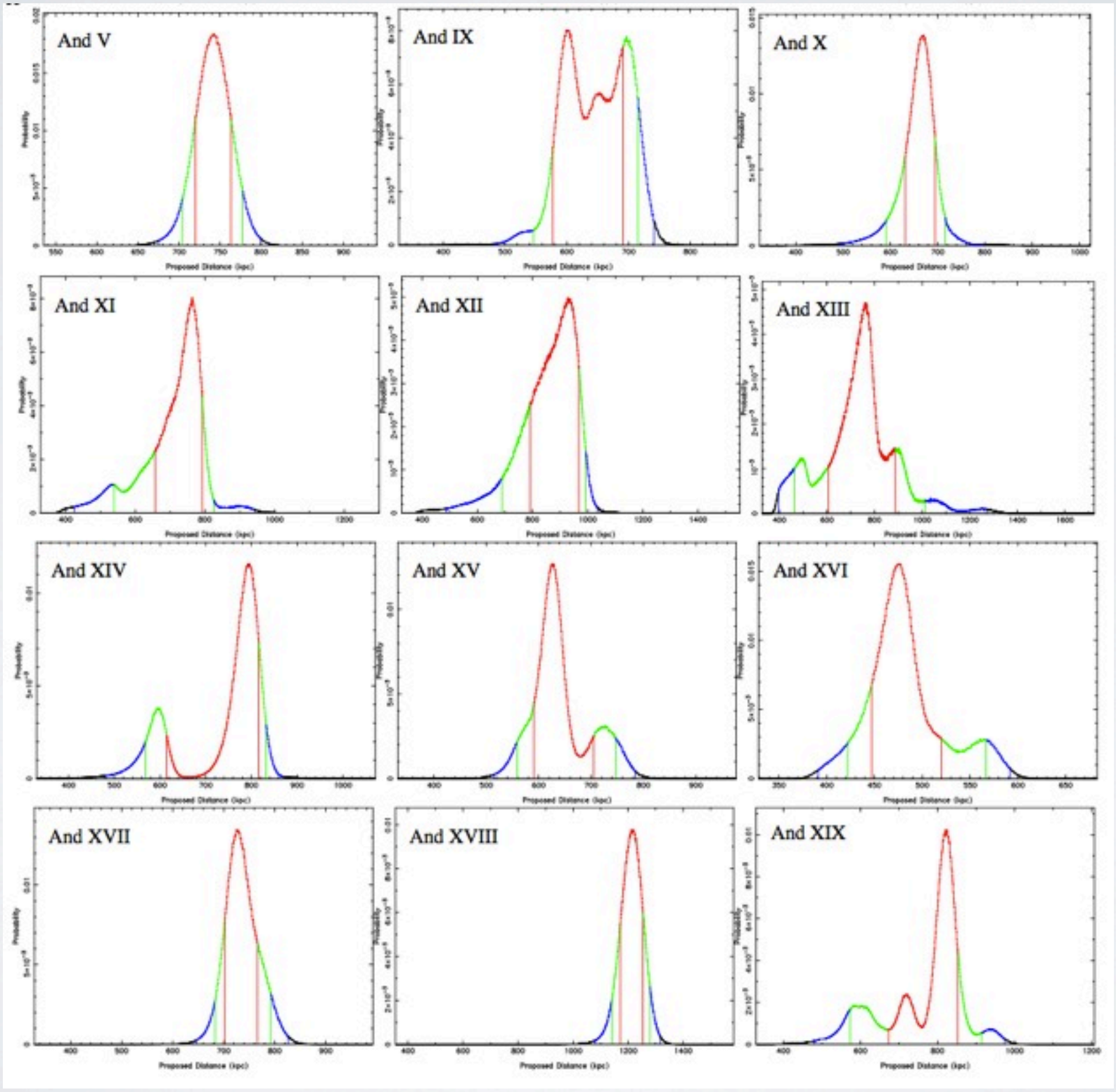

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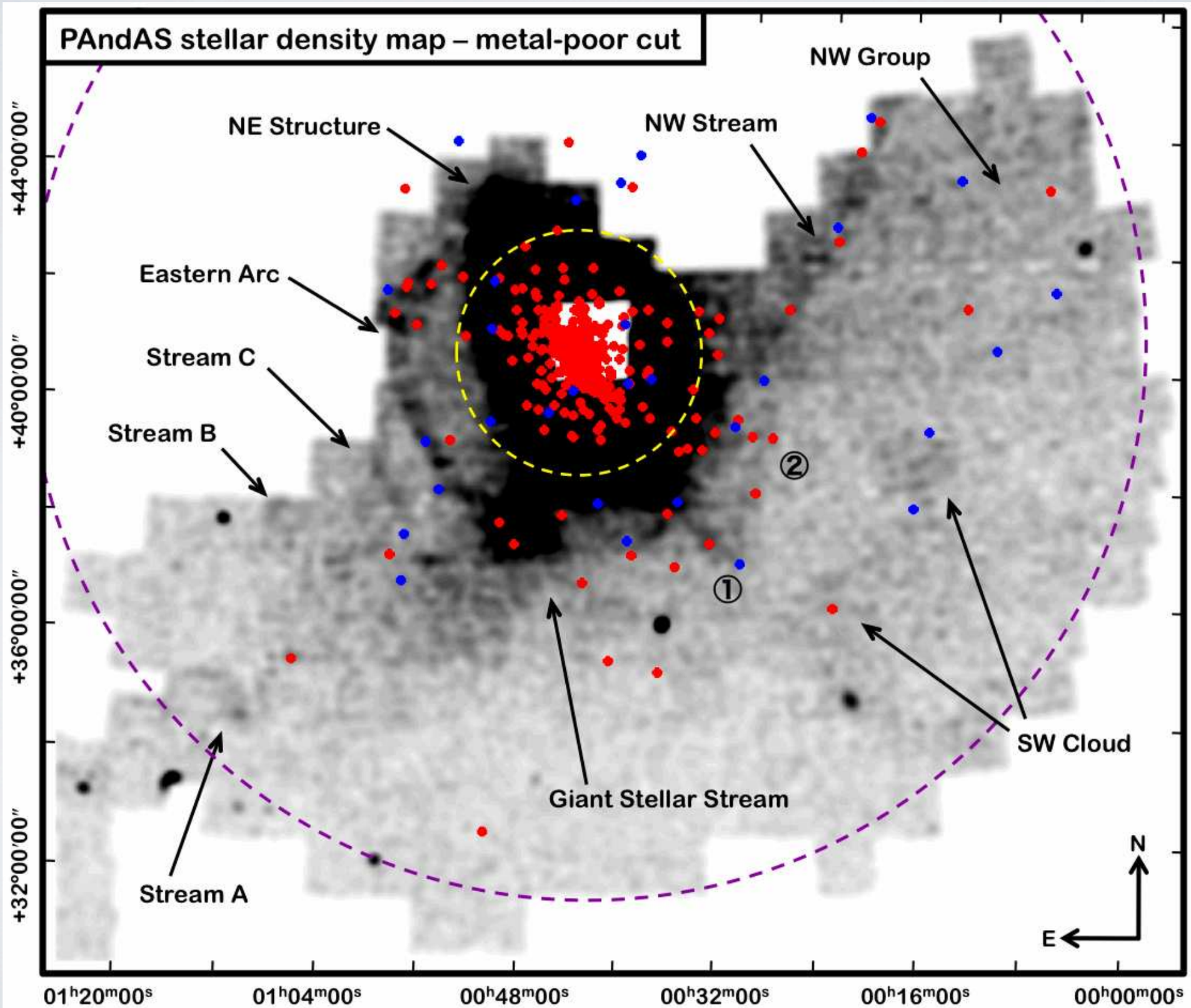
M31 globular clusters

Can/Should we do away with the isotropy assumption?

Globular Clusters is PAndAS

Mackey et al. (2010)



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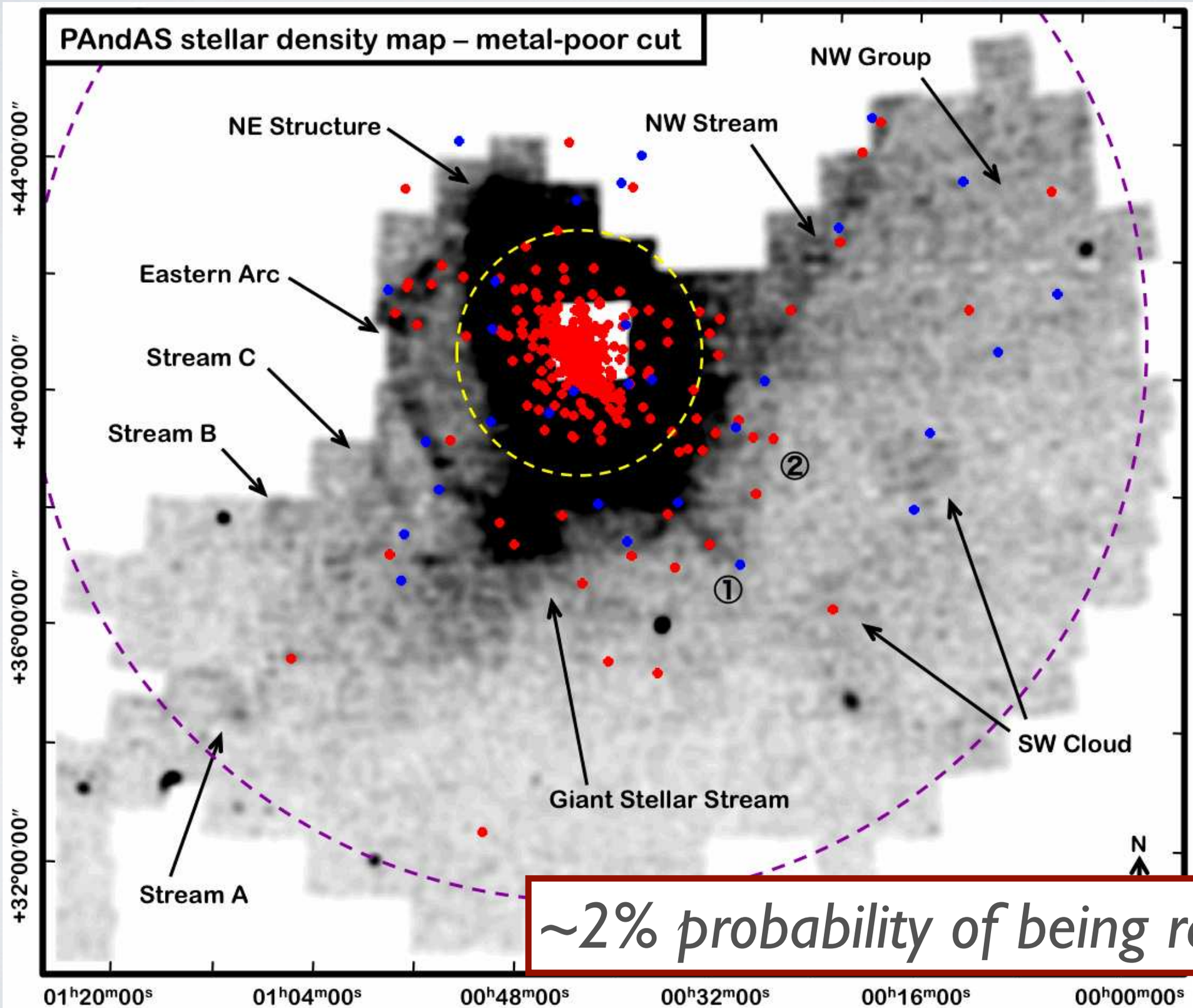


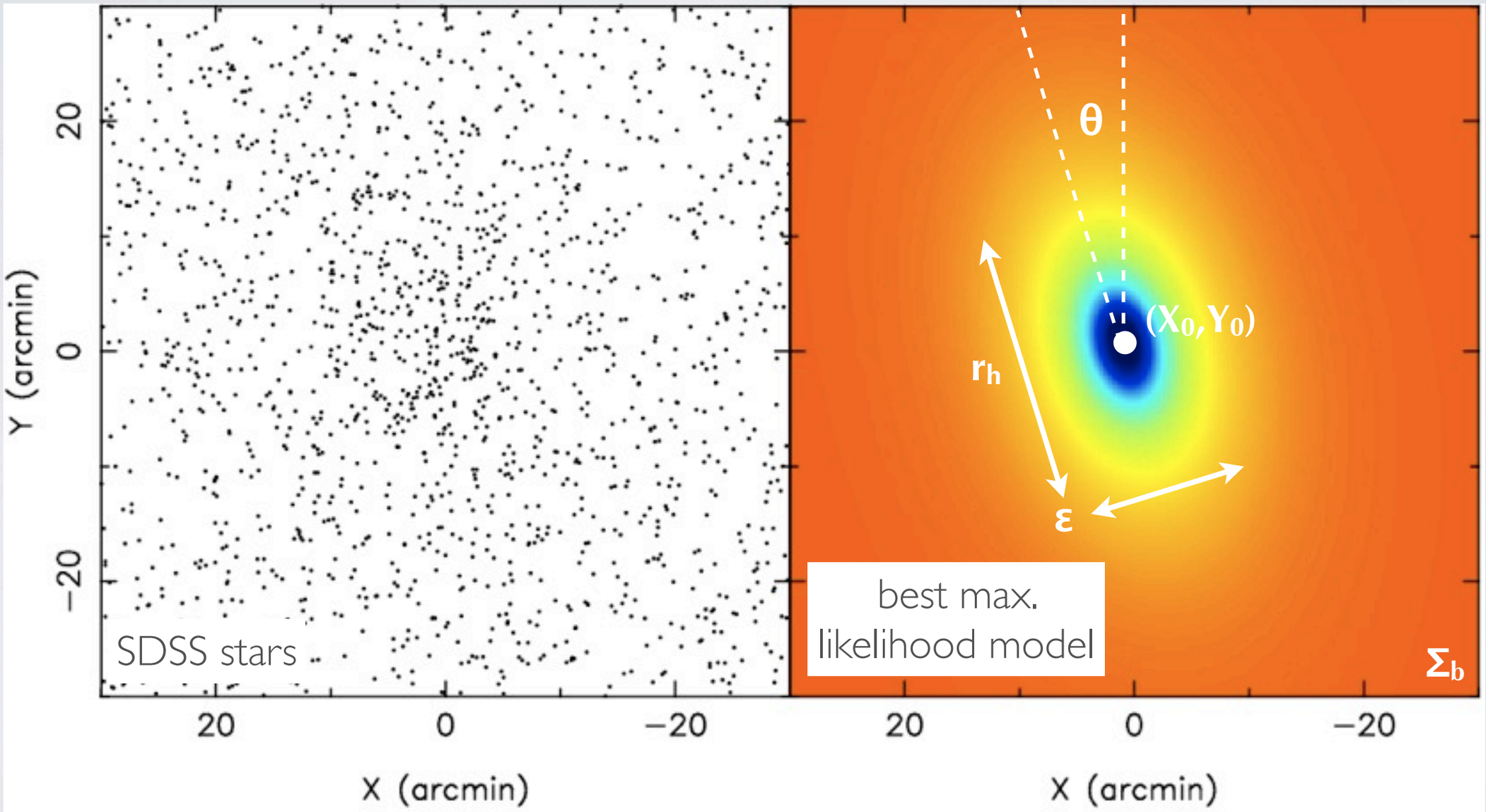
~2% probability of being random

Dwarf galaxies are *not* spherical

What impact does it have on modeling?

Ellipticity of MW satellites

Martin, de Jong & Rix (2008)



Boötes I

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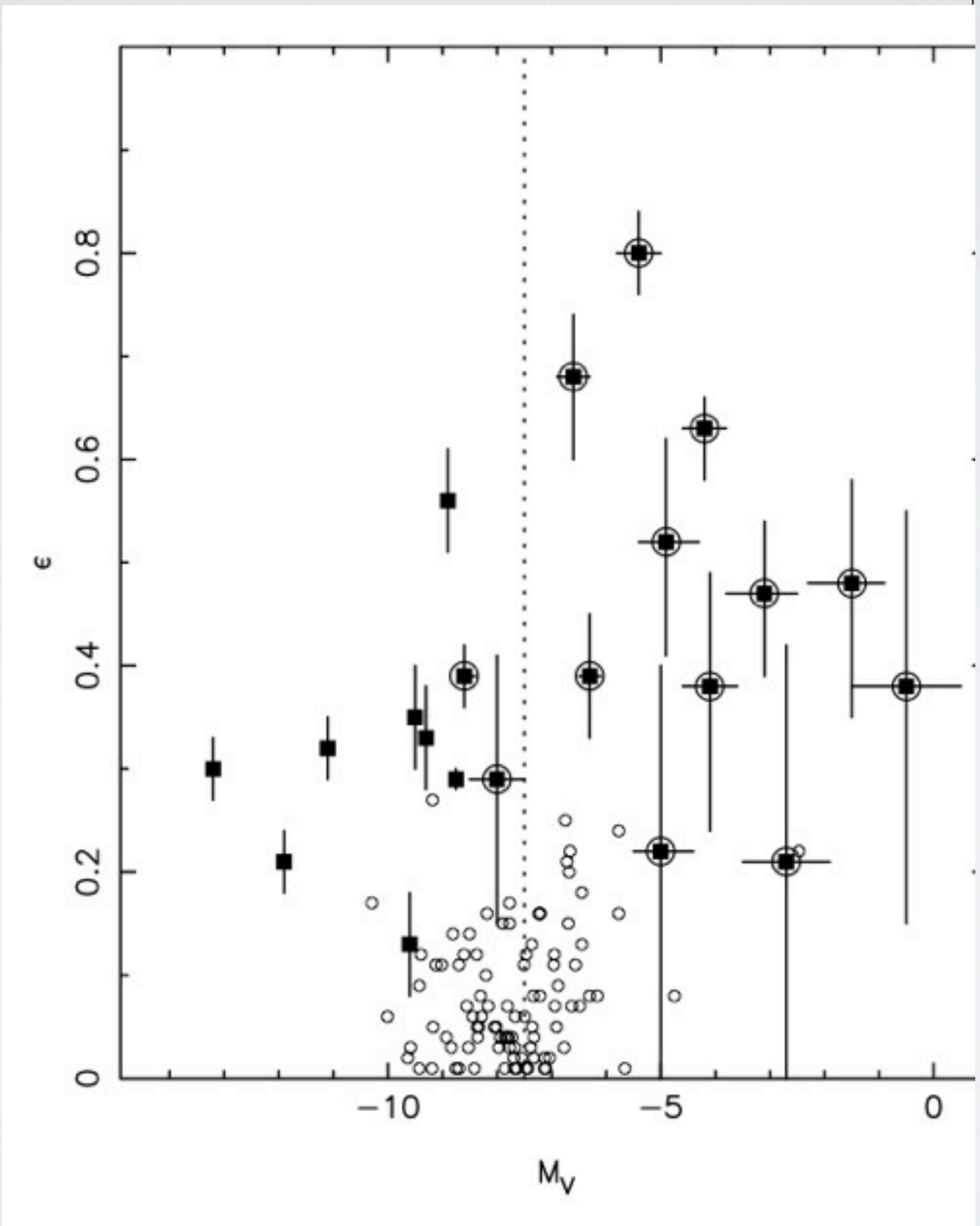
Martin, de Jong & Rix (2008)



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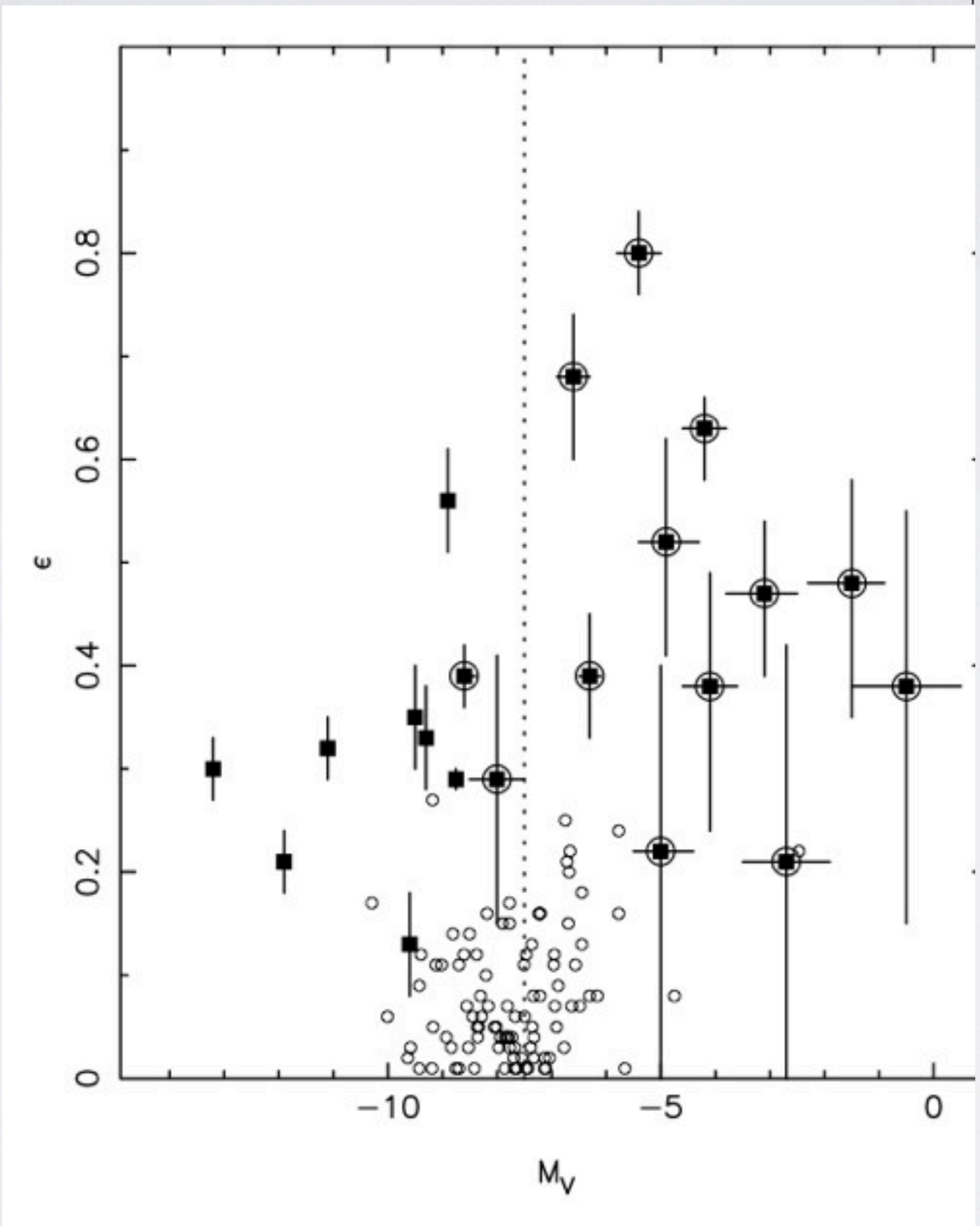

My musings

- case 1 – What data really do tell us
  - Uncertainties matter…
  - Shall we stop using ***xx.x ± yy.y*** when it's not warranted and move to publishing PDFs?
- case 2 – isotropy/homogeneity assumption
  - Does it matter?
- case 3 – dwarf galaxies are *not* spherical
  - Shall we move to non-spherically symmetric models? (Or show it doesn't matter.)