The spheroid shape from deep surveys

A. Robin and C. Reylé

Besançon Observatory

Methods

- Star count analysis
- General surveys / selected samples (A type, F/G type, Giants,   RR Lyrae
- Inversion vs model fitting

Several issues

- Model dependencies
- Photometric accuracy
- Poisson noise (Giant surveys)
- Galaxy contamination
- Thick disc contamination
- Smoothness

First step

Simple hypothesis :

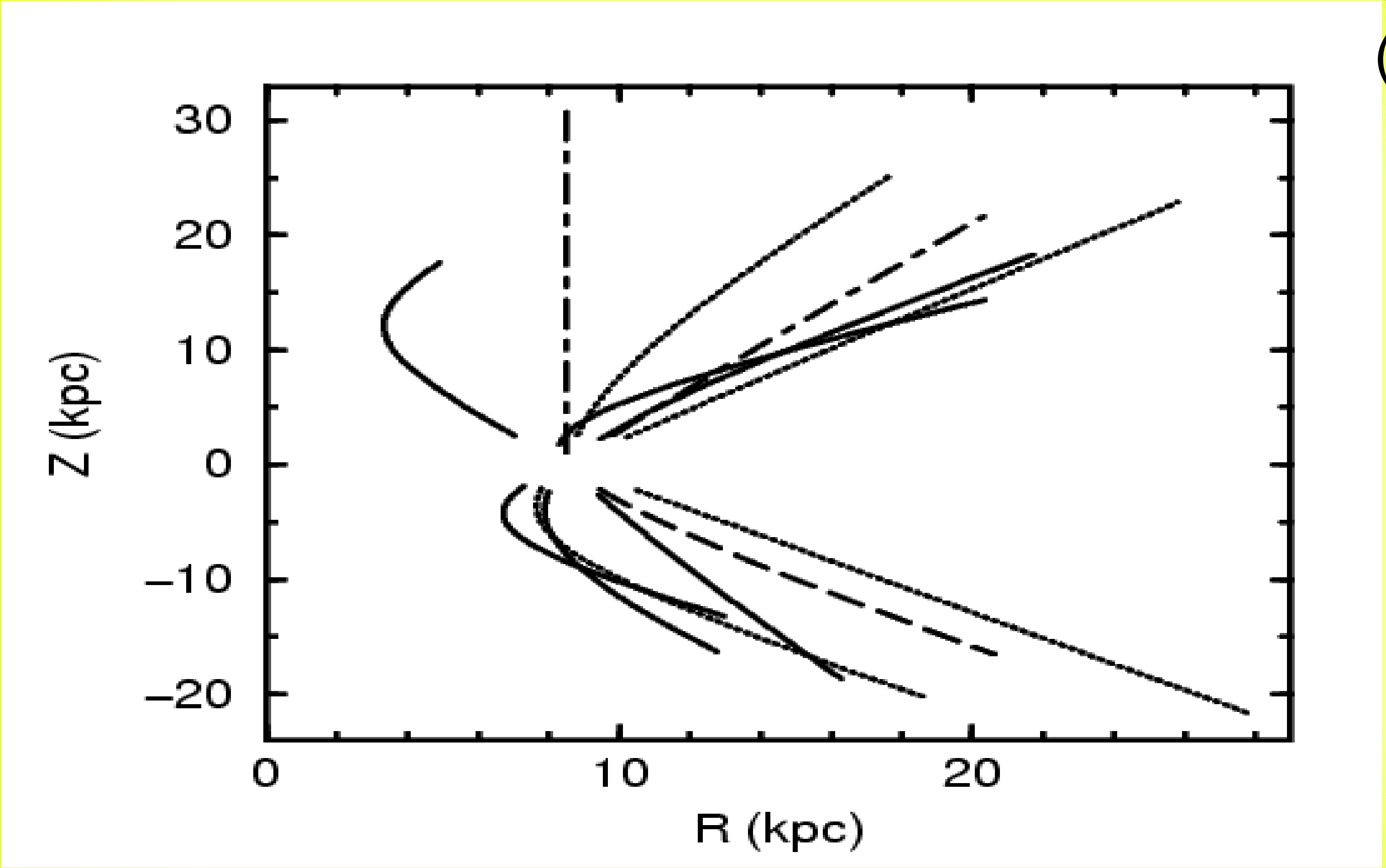
Spheroid (stellar halo) : power law, axisymmetric, local normalization

Most commonly fitted parameters :
- Exponent : 2.5 - 3.5
- Axis ratio : 0.6 – 1.0

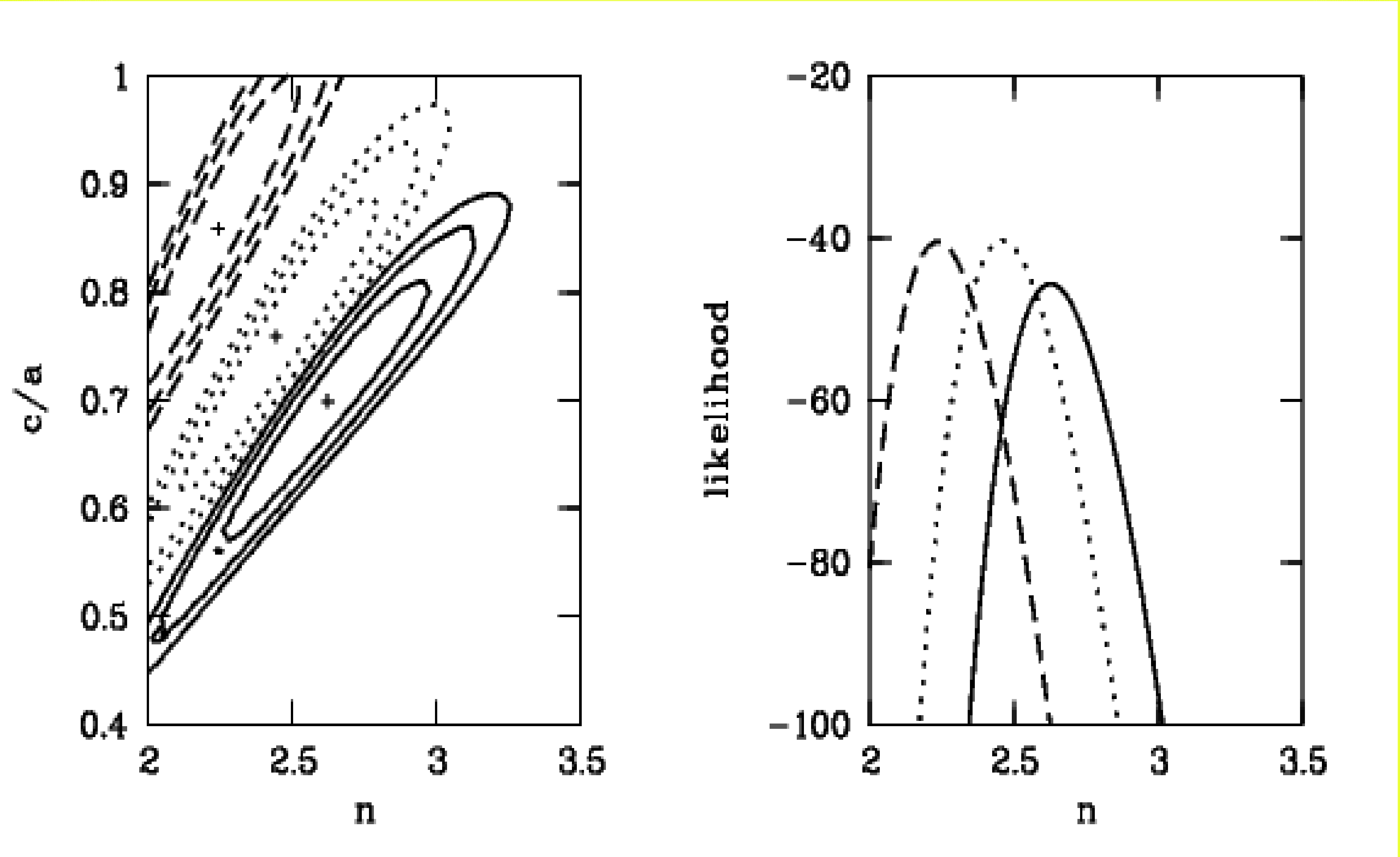
No consensus

Robin, Reylé, Crézé, (2000, A&A 359, 103)

15 fields
1.8 sq. deg
V<22
(2 fields V<24)



Robin, Reylé, Crézé, (2000) : degenerate parameters



Large scale digital sky surveys

Xu et al 2006 (astroph/0602565):

SDSS asymmetry at the level of 23%
SuperCosmos BJ<20.5: asymmetry level 17%

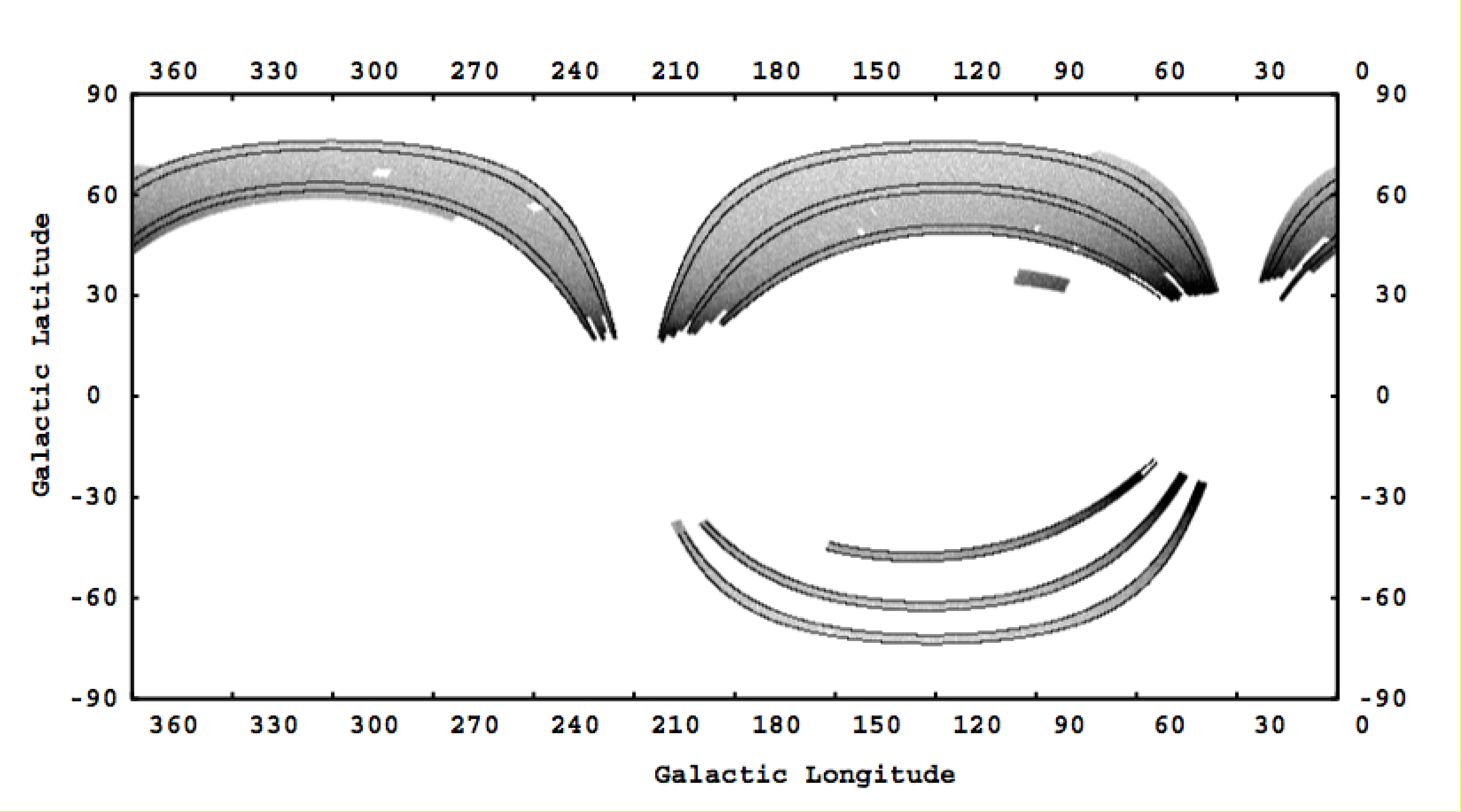
Xu et al 2007 (astroph/0703516):

SuperCosmos fields vs SDSS:
the south pole is less asymmetric than
the north cap. No asymmetry found, estimated error 10%.

Best fit model for axisymmetric power law spheroid :
n=2.8 q=0.7 (2.6-3.2 and q:0.6-0.7)

SDSS : Newberg and Yanny (2006) astroph/0507571

8 (2.5° wide) SDSS stripes, F turnoff stars



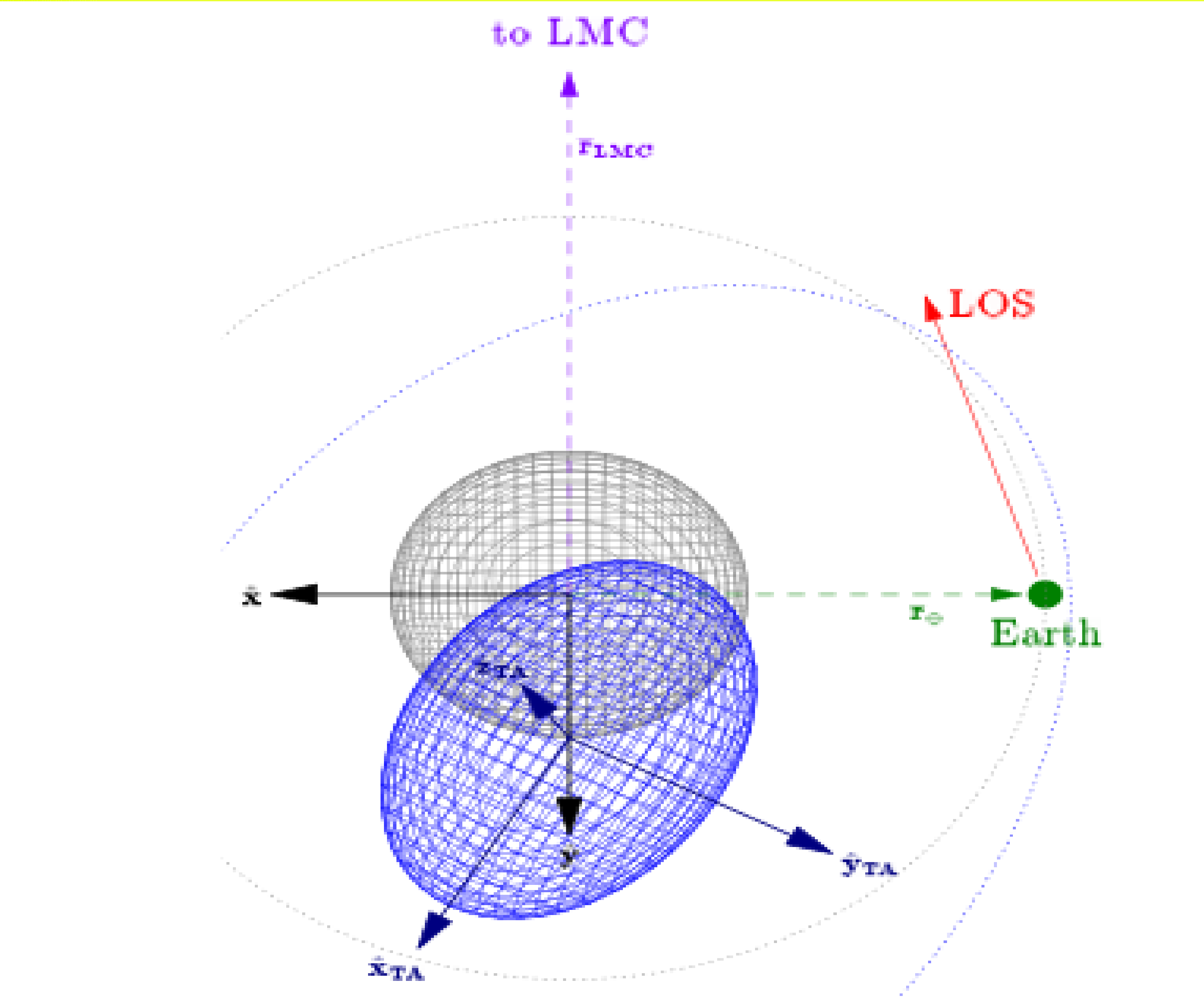
g<24, selection avoiding (photometrically) QSOs and thick disc,
=> g<22 in practice

5 models : 4 triaxial models, 1 axisymmetric model

- 2 Hernquist (centered or not)
- 2 power law (centered or not)
- 1 axisymmetric model power law

Triaxiality: major axis 50°-70° from Sun-Center line, 4-6° from the plan
minor axis 13° from the Z direction

Spheroid center : shifted 3-4 kpc from the Galactic center (?)



Savage et al. 06
astroph/0511046

Newberg & Yanny (2006)

Table 1. Best Fit parameters for five spheroid models described in Section 2. Numbers in bold were fixed; all others were varied to minimize χ^2 fit between the model and the data The units of ρ_0 are kpc^4 for Hernquist models, and kpc^α for power law models.

	Tol.	Full Hernquist	Galactocentric Hernquist	Full Power Law	Galactocentric Power Law	Standard Power Law
R_0	0.1 kpc	**8.0 kpc**	8.5 kpc	**8.0 kpc**	8.5 kpc	10.7 kpc
p	0.01	0.73	0.73	0.74	0.72	**1.0**
q	0.01	0.67	0.60	0.66	0.59	0.63
θ	1°	48°	70°	52°	72°	–
R_{core}	0.5 kpc	15.0 kpc	14.0 kpc	–	–	–
dX	0.1 kpc	0.1 kpc	–	0.2 kpc	–	–
dY	0.1 kpc	3.5 kpc	–	3.0 kpc	–	–
dZ	0.1 kpc	0.1 kpc	–	0.0 kpc	–	–
ϕ	0.5°	-8.0°	-4.5°	-6.5°	-4.0°	–
ξ	2°	12°	14°	16°	14°	–
α	0.1	**1**	**1**	2.9	3.0	3.1
δ	–	**3**	**3**	**0**	**0**	**0**
M_f	0.1	**4.2**	**4.2**	**4.2**	**4.2**	**4.2**
ρ_0		1.548×10^8	2.093×10^8	1.065×10^6	2.157×10^6	2.390×10^6
N_{solar}		1081 kpc^{-3}	1096 kpc^{-3}	1412 kpc^{-3}	1341 kpc^{-3}	1539 kpc^{-3}
χ^2		1.37	1.42	1.49	1.51	1.92

H2 H1 P2 P1 axi

Provisionnary conclusion

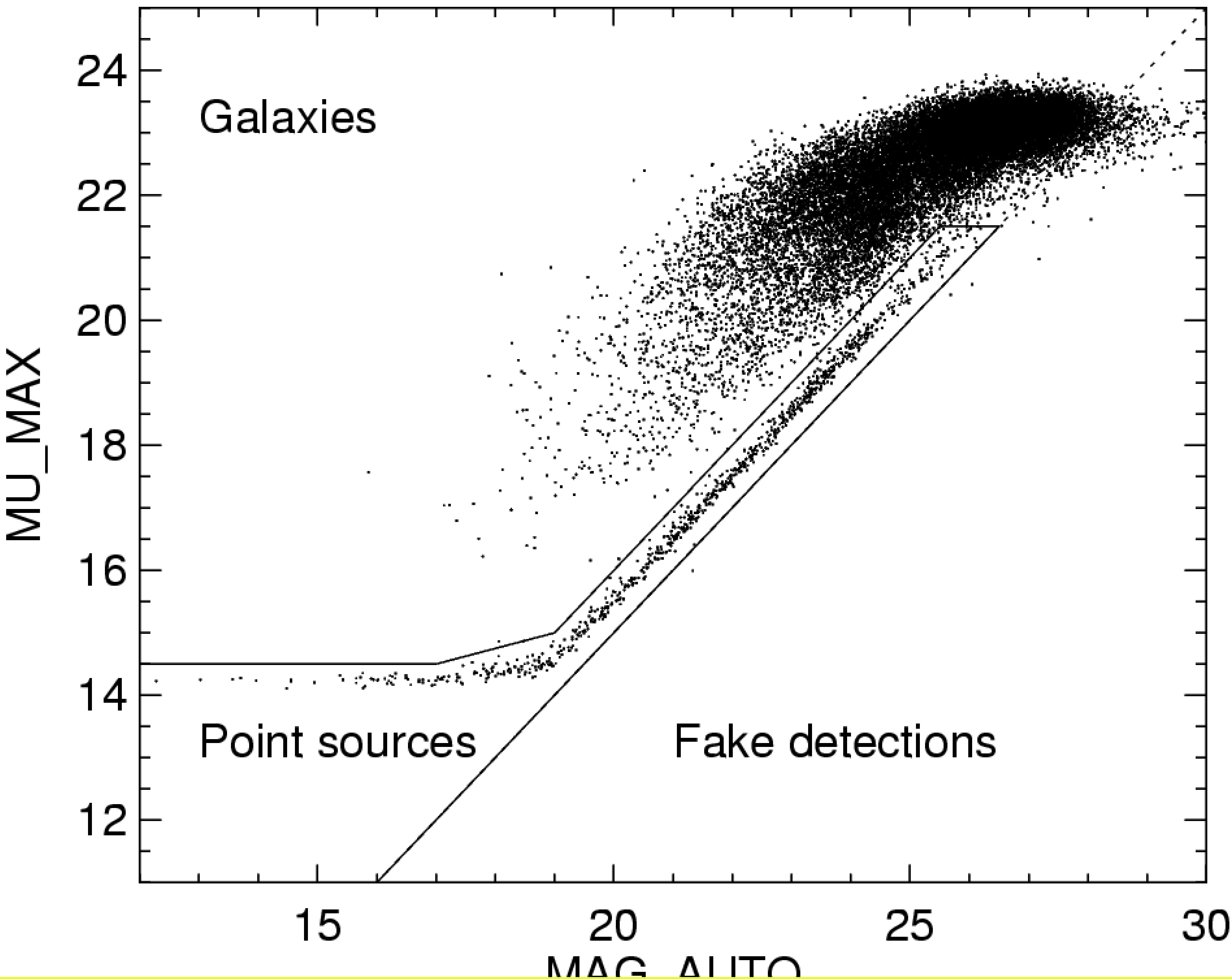
Different models nearly similar Xi2.
Deeper data needed
(issue : not contaminated by galaxies and QSOs)

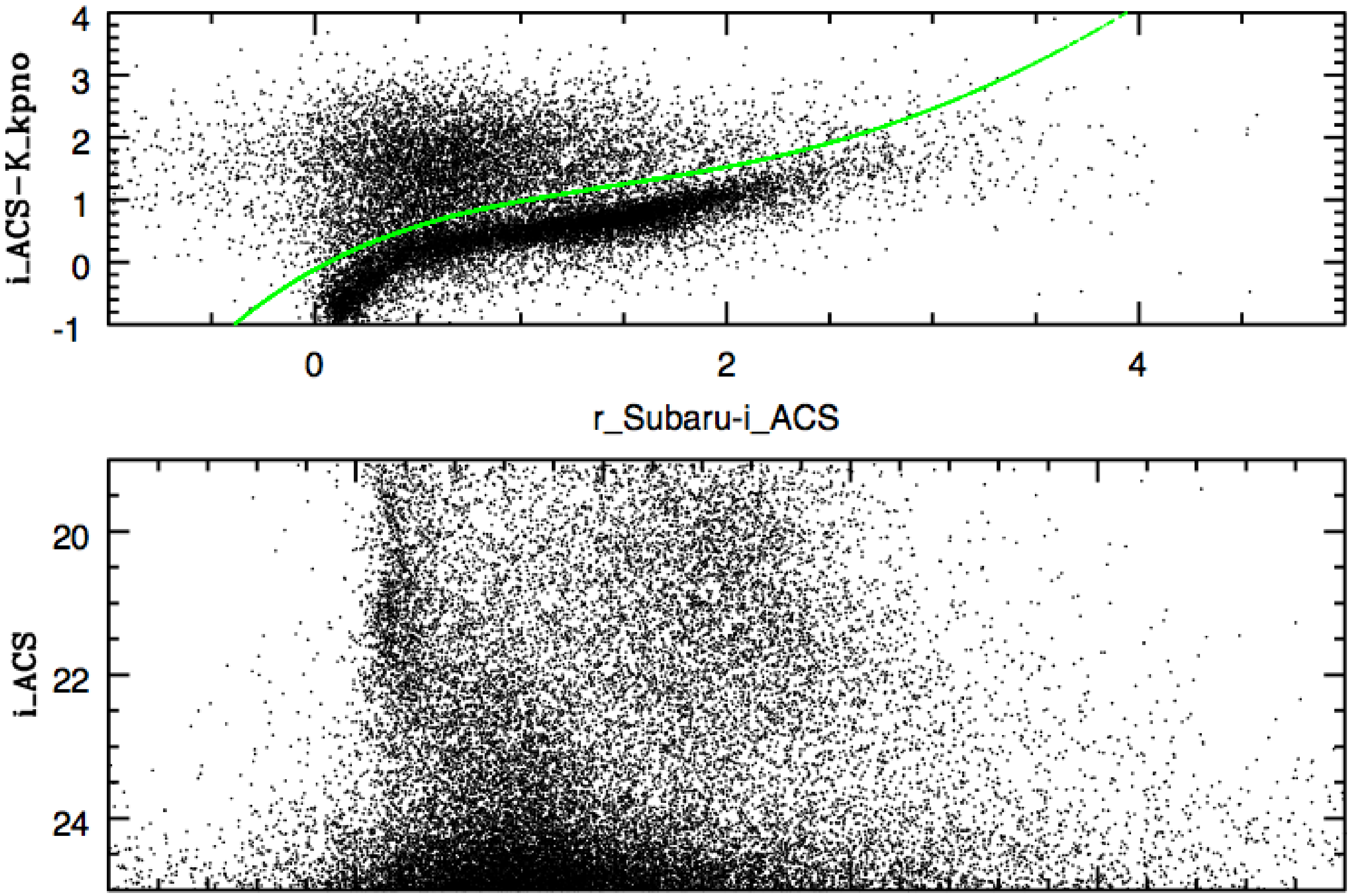
Cosmos field

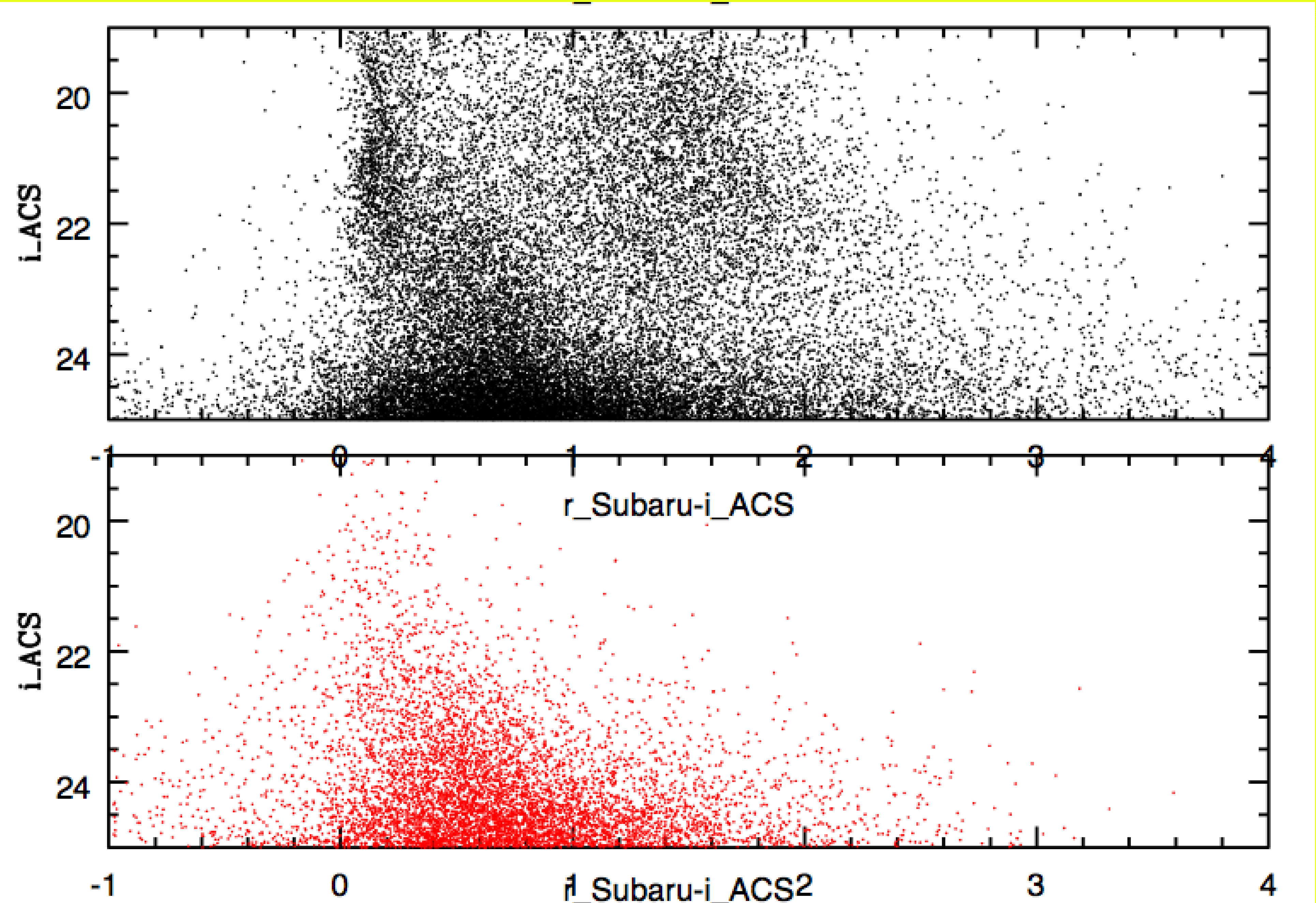
ACS survey 1.6 square degree to i=28
Capak et al. 2007 astroph/0704.2430
Space based : morphological star/galaxy separation

Ground based complementary observations from u to K
=> SED based star/galaxy separation

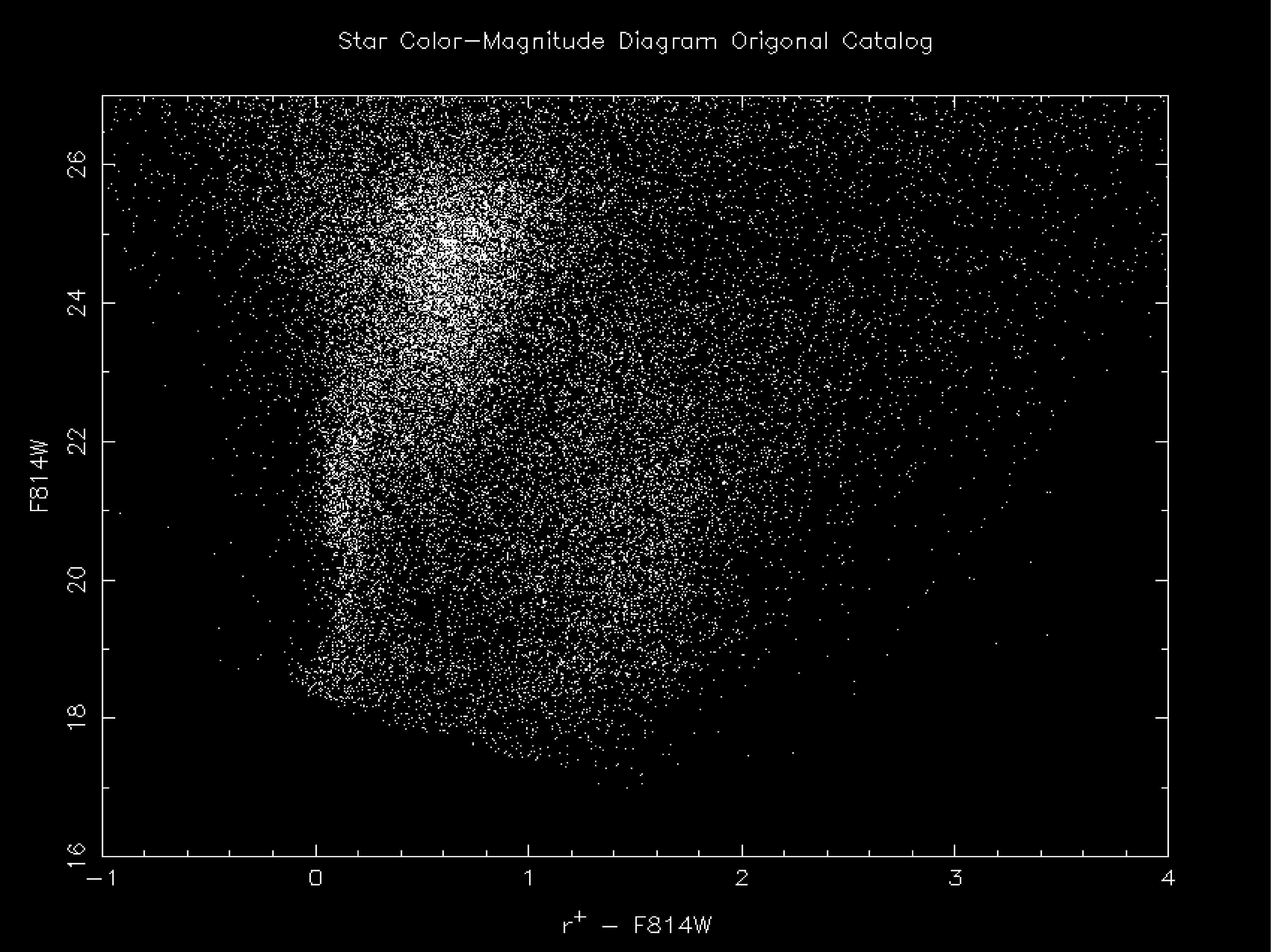
Robin et al. 2006 astroph/0612349 (ApJSupp in press)

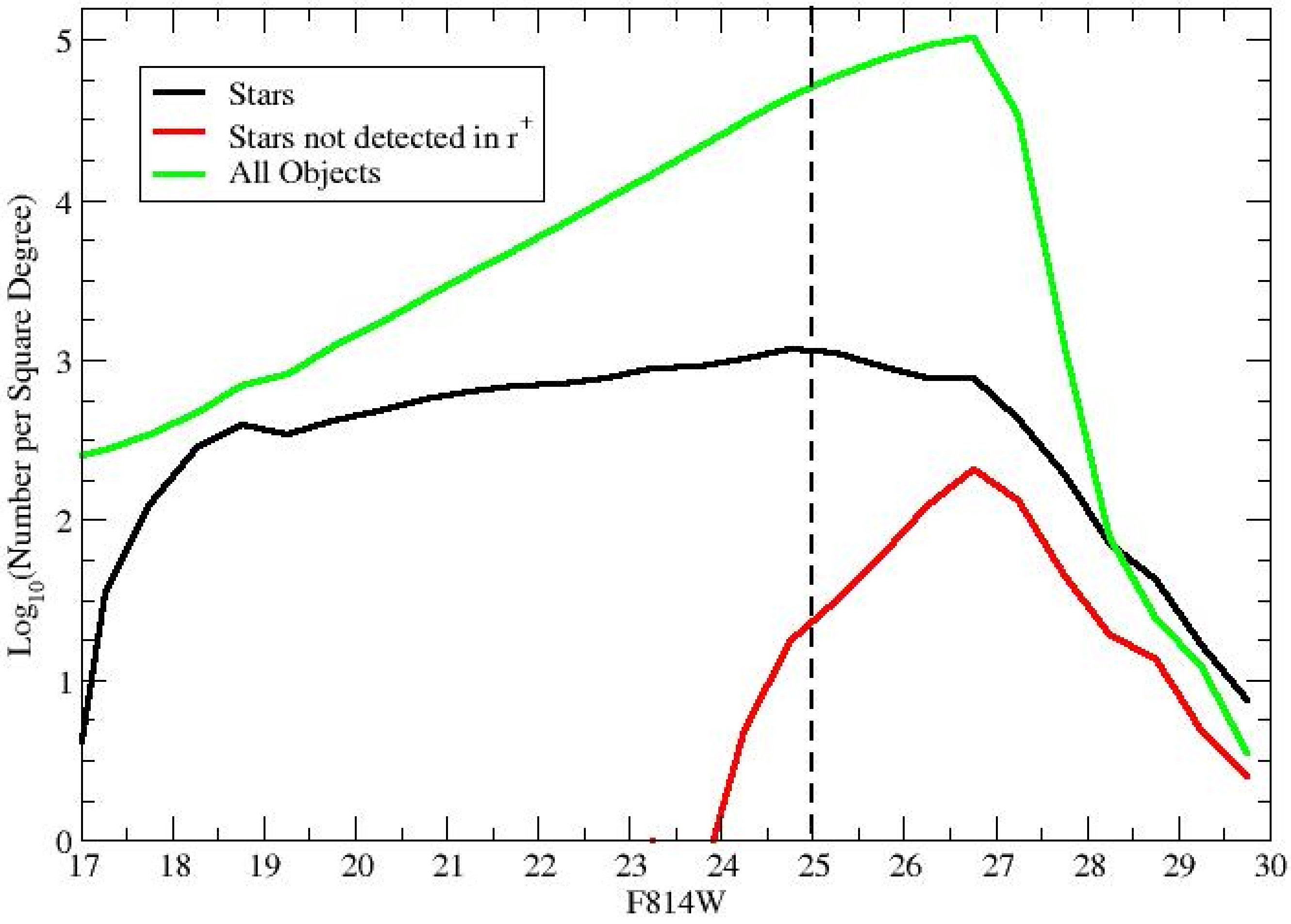

Galaxies
Point sources
Fake detections
MU_MAX
MAG_AUTO
24
22
20
18
16
14
12
15
20
25
30


i_ACS−K_kpno
r_Subaru-i_ACS
i_ACS
4
3
2
1
0
-1
0
2
4
20
22
24



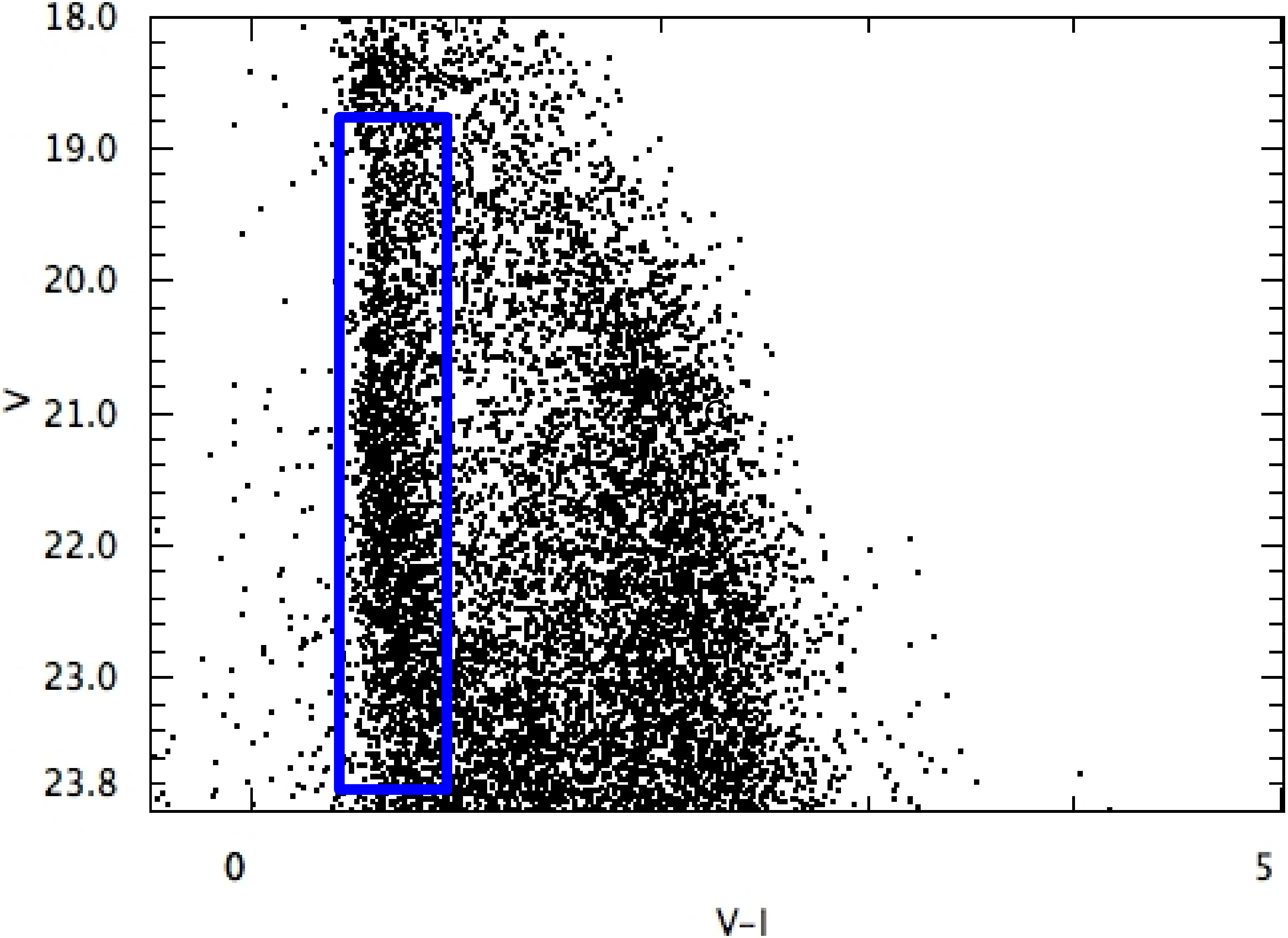
20
22
24
i_ACS
-1
0
1
2
3
4
r_Subaru-i_ACS
20
22
24
i_ACS
-1
0
1
2
3
4
r_Subaru-i_ACS


Star Color-Magnitude Diagram Origonal Catalog
F814W
r^+ - F814W
16
18
20
22
24
26
-1
0
1
2
3
4



Stars
Stars not detected in r+
All Objects
Log10(Number per Square Degree)
F814W
0
1
2
3
4
5
17
18
19
20
21
22
23
24
25
26
27
28
29
30

« Cosmos » field (237, 42) : turnoff



Turnoff method

Estimation of the halo density law from the turnoff sequence

M_V=4.0   and V-I= 0.38

distance_modulus = $10^{(0.2*(i+1.28))}$

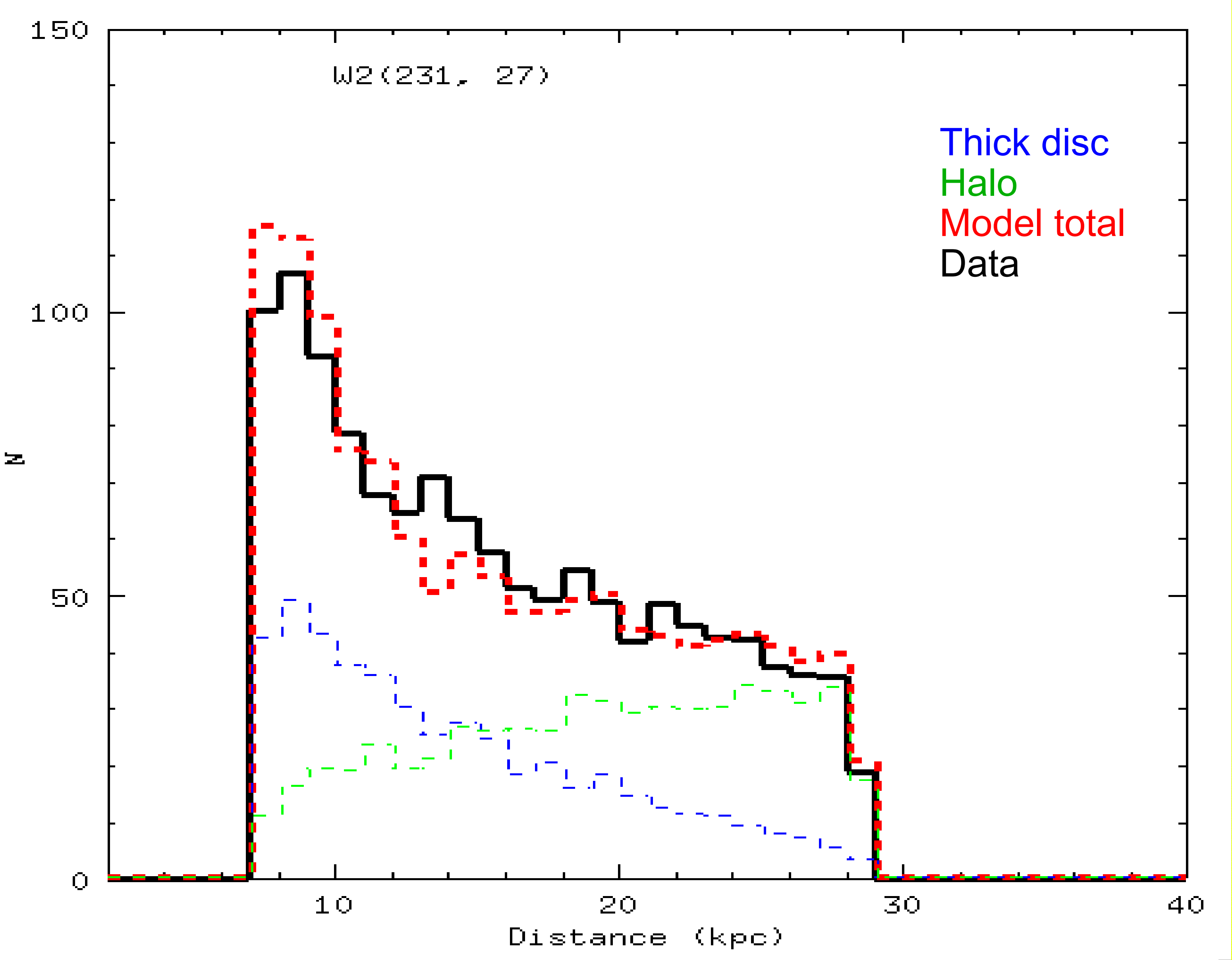
(i in CFHTLS photometric system)

Uncertainties in the density determination from the turnoff

- Contamination by the thick disc (short distances / bright mag.)

- Contamination by mis-classified galaxies (large distances / deepest counts)

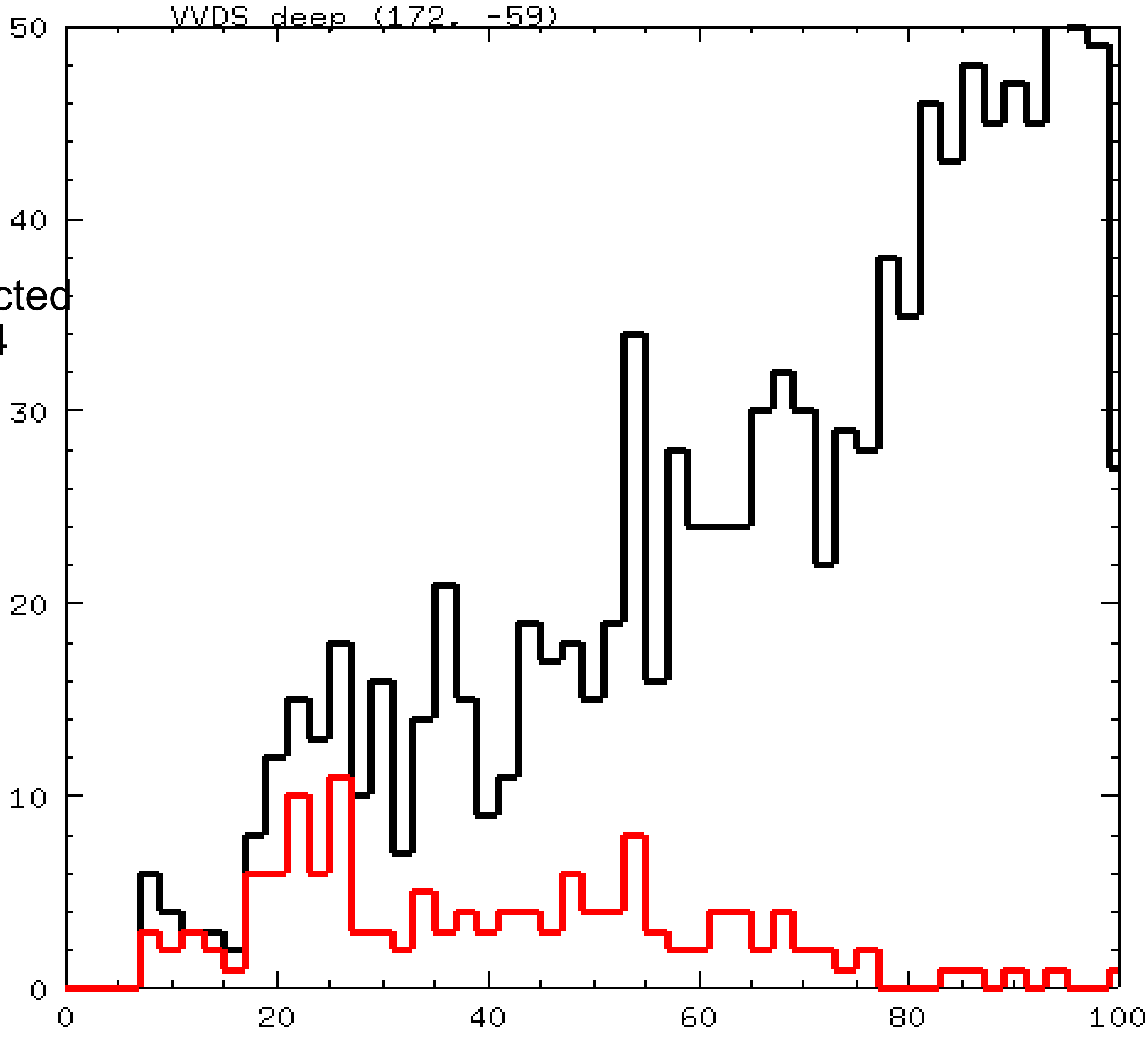
Contamination by thick disc stars : estimation from model simulations
Field CFHTLS-Wide 2 : l=231°, b=27°

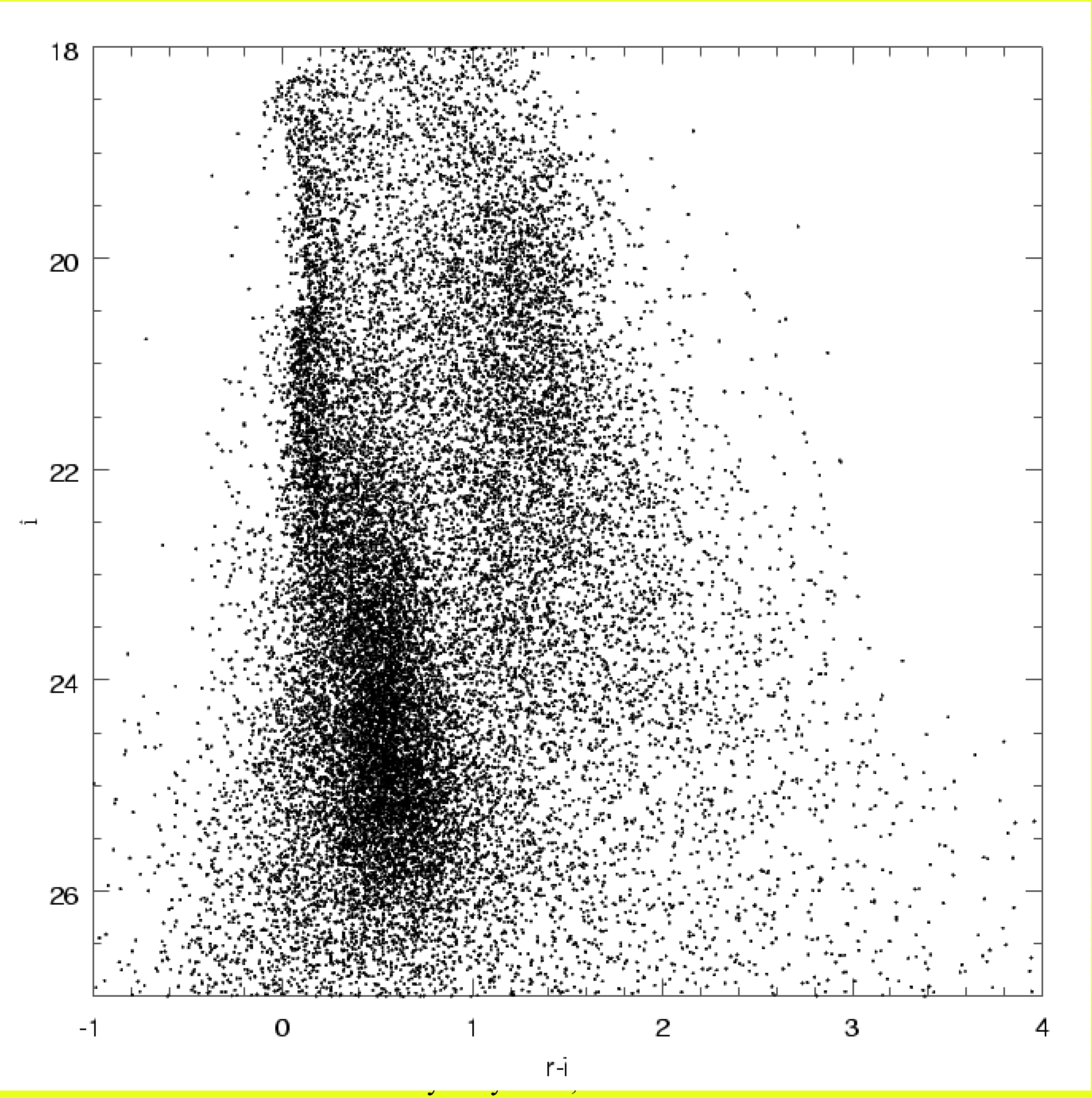


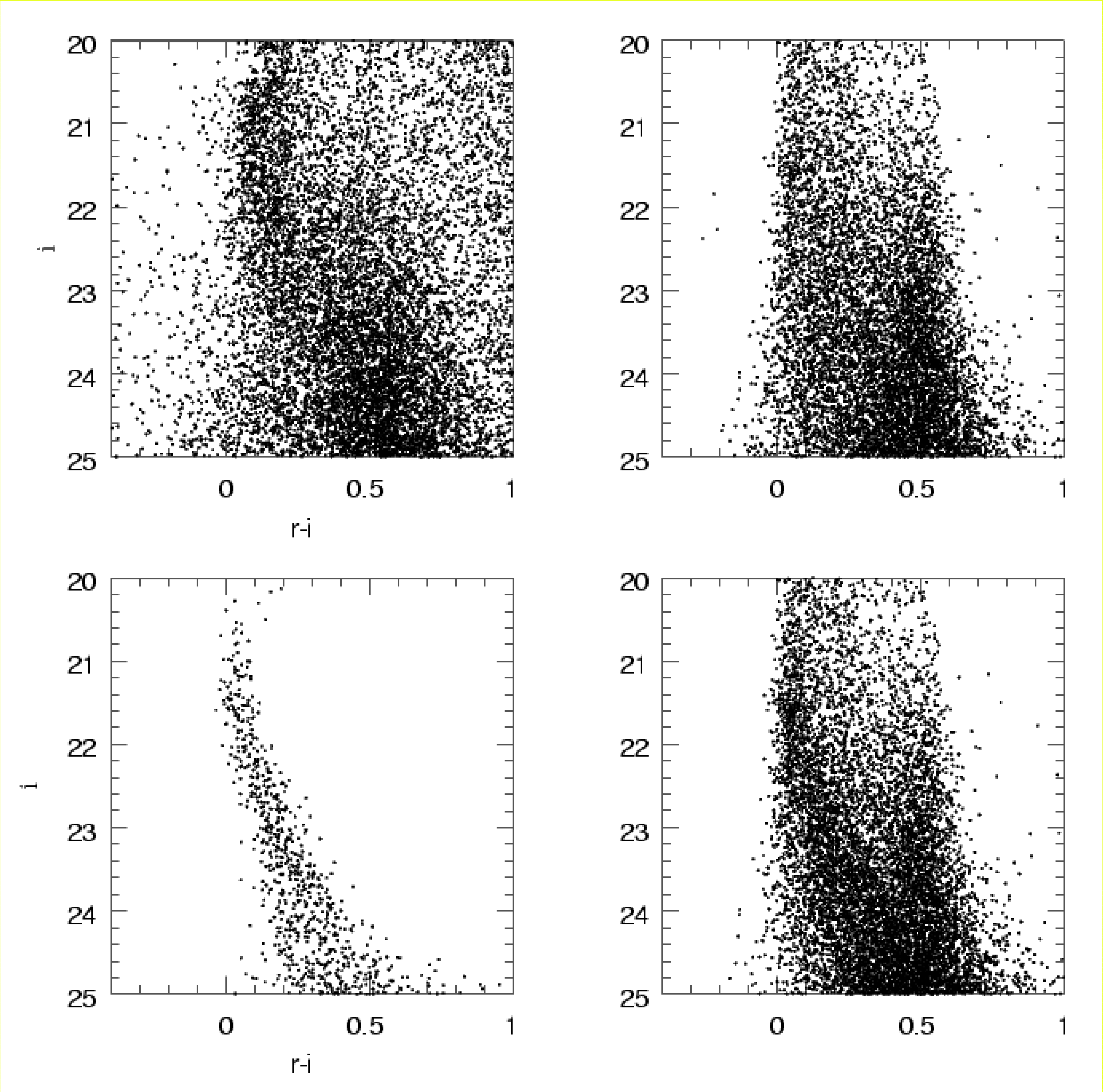
Turnoff selected down to i=24

All objects

Stars




18
20
22
24
26
i
-1
0
1
2
3
4
r-i



20
21
22
23
24
25
i
0
0.5
1
r-i

Provisionnary conclusion (2)

Density estimation from turnoff selection from Cosmos data:

- Need to go deep enough (i=24 means a redshift selection from ground, or morphological selection from space + photometric redshift)

- Contamination by thick disc at bright magnitude (distance < 15 kpc)

- the edge of the halo is at d>80 kpc

-smoothness : possible substructure in Cosmos field (?)

- no constraints on spheroid shape (n, q) from a single field

Combining several deep fields to constrain Newberg & Yanny halo models

16 fields (total 42 sq deg)

magnitude range 18-24

Different photometric systems

Including : CFHTLS-Wide (3 fields), Cosmos data, VVDS data (1 field)

Fitting : local density, IMF, axis ratio

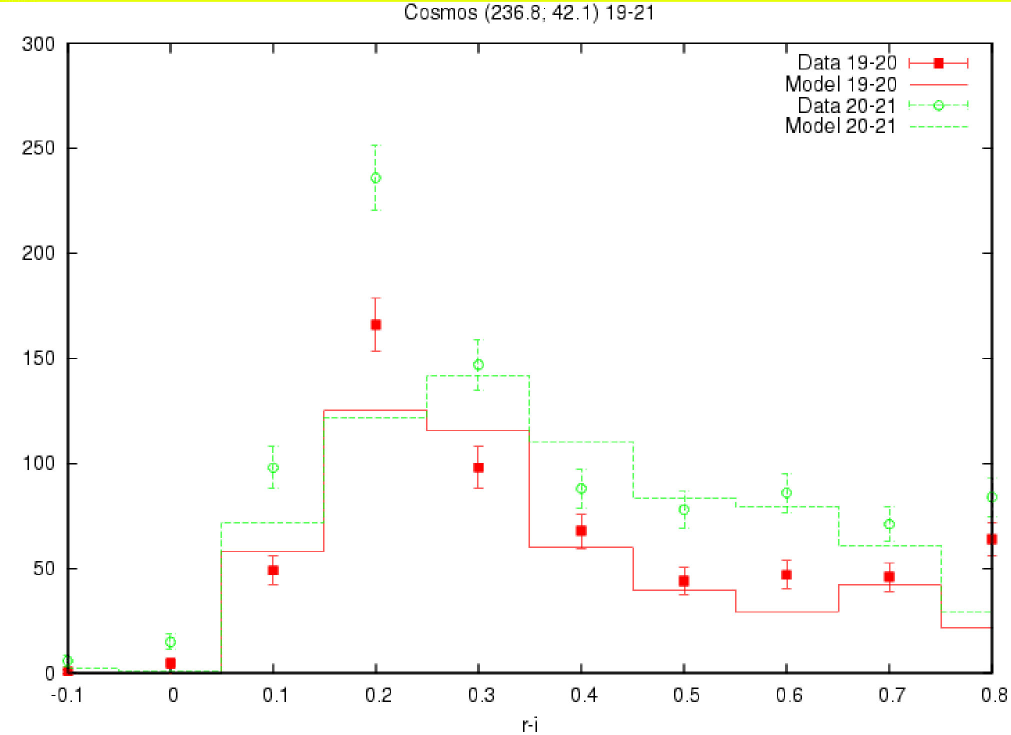
Likelihood fit in magnitude and colour

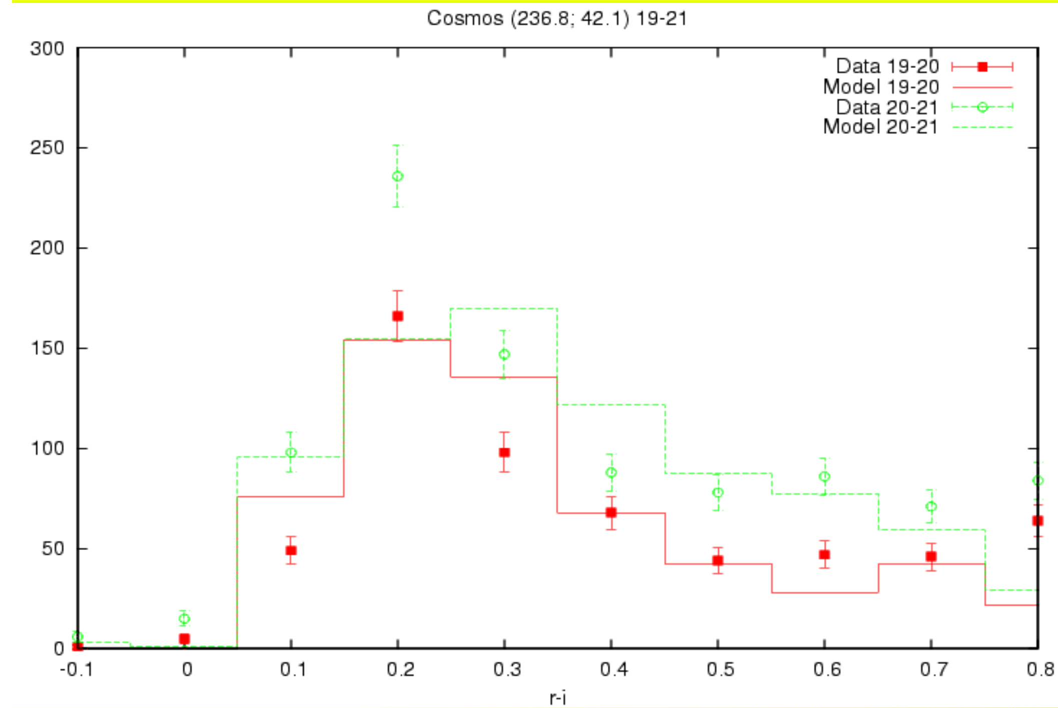
Model	density	p	q	IMF	Lr
H1	1.8	0.5	0.73	1.5	-477.
H2	2.7	0.6	0.73	1.5	-525.
P1	2.7	0.5	0.72	1.5	-484.
P2	3.1	0.6	0.74	2.	-585.
Model	density	p	q	IMF	Lr
n=3	3.1	1.	0.5	1.	-321
n=2.44	2.4	1.	0.5	1.	-412

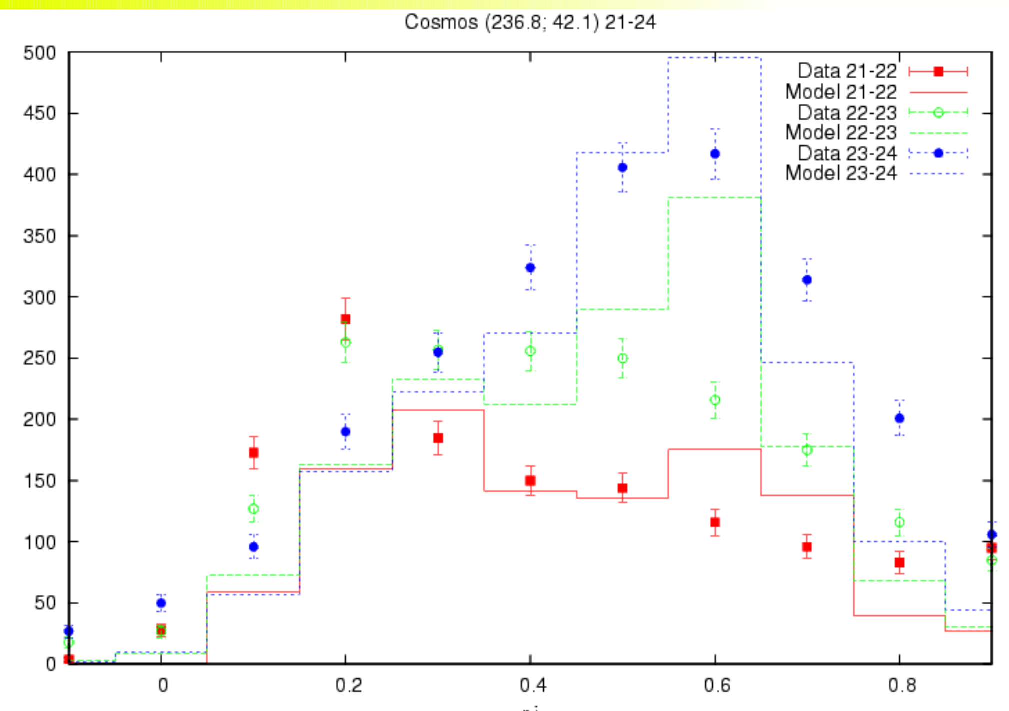
Centered model slightly better (compared to decentered model)

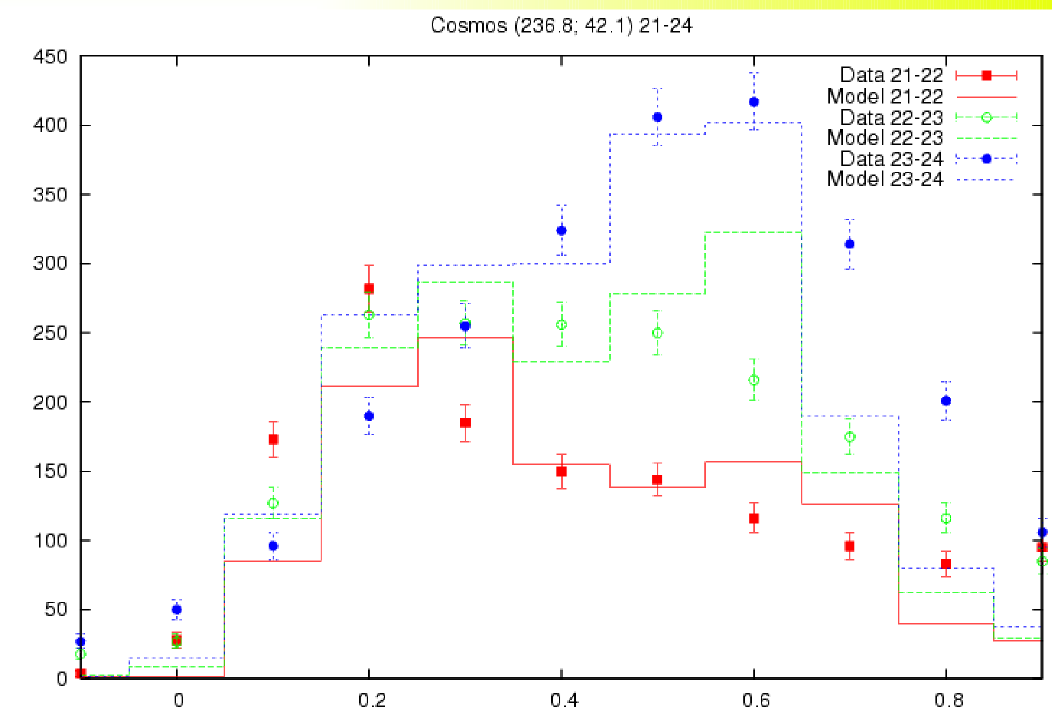
Power law axisymmetric still better (!)

Sensitive to density up to r=80 kpc (Cosmos)
rather than 30 kpc (g<22)









H1

axisymmetric

Main difference :

H1 turnoff turns too fast in the CMD
the density goes down too fast in distance,
density too strong at intermediate distances.
Sensitive at faint magnitudes (i>22)

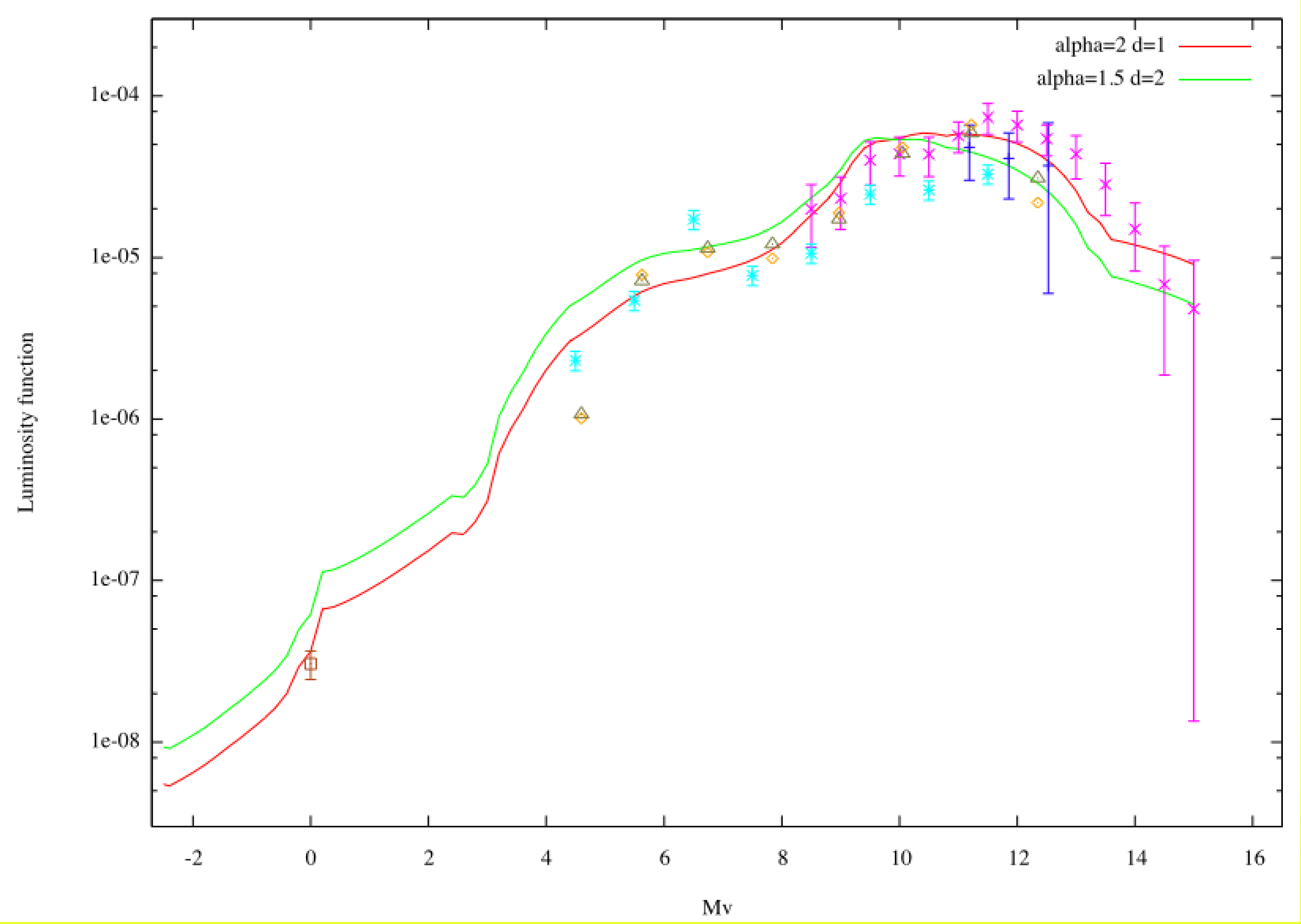
Fit of H2 :

adjusting dy : for H2 models the best is still with dy=3.5 kpc (when the axis are rotated, dx is not 0.)

Fit of angle : theta=80. better, but worse than axisymmetric

Spheroid luminosity function :
Digby et al (2003),Gizis & Reid (1999), Dahn et al (1995)

Fct luminosité halo / IMF



Density
r0=1.64e-4

IMF slope
alpha

Conclusions

Try to find complementary constrains to SDSS at deeper magnitude from Cosmos data and other surveys (CFHTLS and VVDS)

- No clear evidence for triaxiality and off-centering of the spheroid
- Need deeper data and more space based data (or spectro surveys) to avoid galaxy contamination
- Possibility of a stream in Cosmos field (?)
- Uncertainties on the general contamination of a « smooth » halo by streams