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The HI content of Early-Type Galaxies: I. Catalogued ALFALFA sources in Virgo

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ALFALFA is surveying 7074 sq. deg. for HI sources brighter than $\sim 0.5 \text{ Jy km s}^{-1}$ (i.e. $\sim 3 \times 10^7 M_{\odot}$ at the distance of the Virgo cluster).

We are using ALFALFA to study the HI content of ETG in a uniform and unbiased way, as a function of galaxy mass and environment.

On the Virgo cluster we select a sample of 943 ETG from the Virgo Cluster Catalogue (VCC) in the declination strip from 8 to 16 deg., which contains more than 70% of the VCC galaxies.

We adopt the galaxy type from the GOLDMine compilation (Gavazzi et al. 2003), including E, E/S0, S0, dE, dE/dS0, dS0.

Our sample contains 460 ETG brighter than $B_T=18.0$, the completeness limit of the VCC.



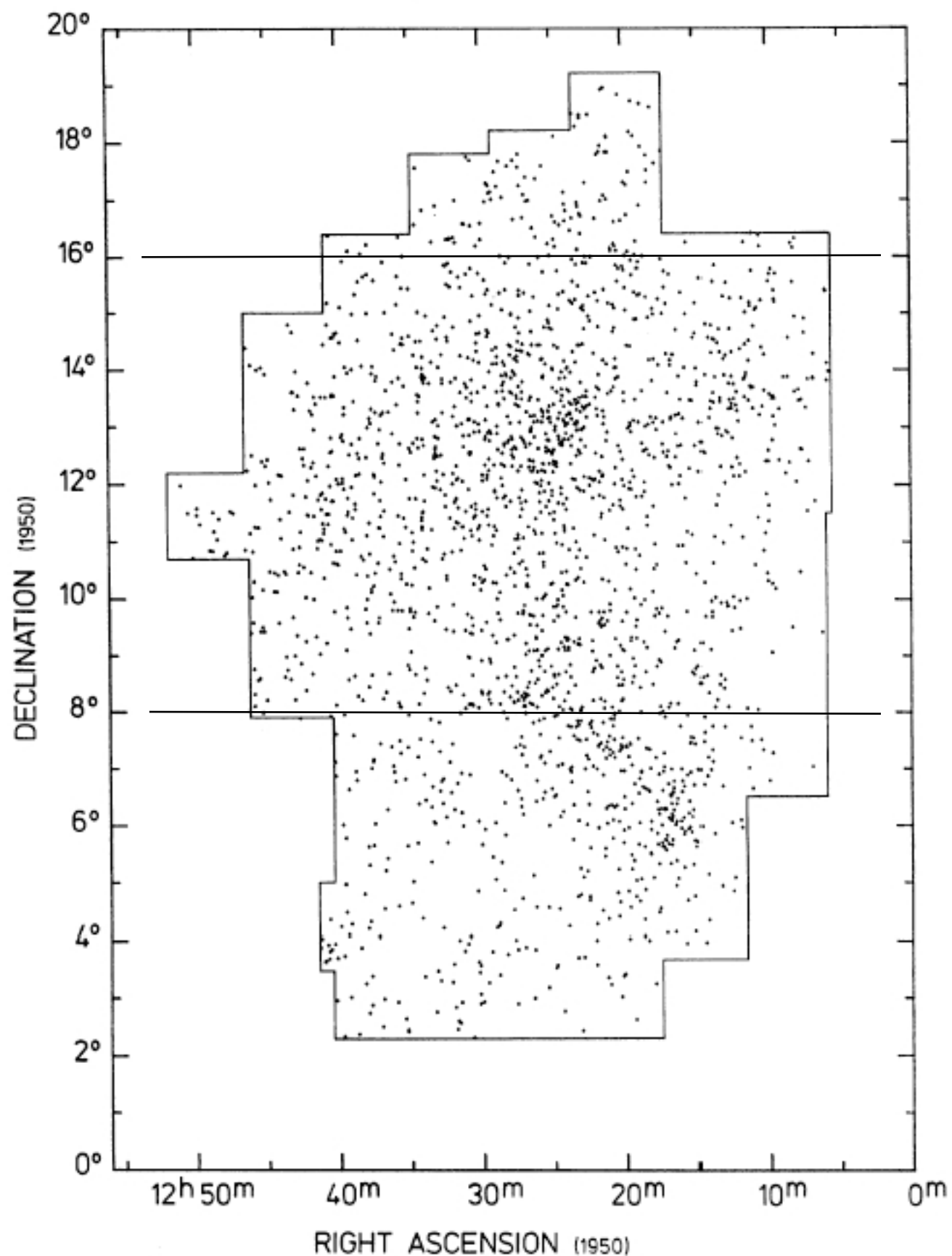
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ETG in the Virgo cluster detected in HI by ALFALFA

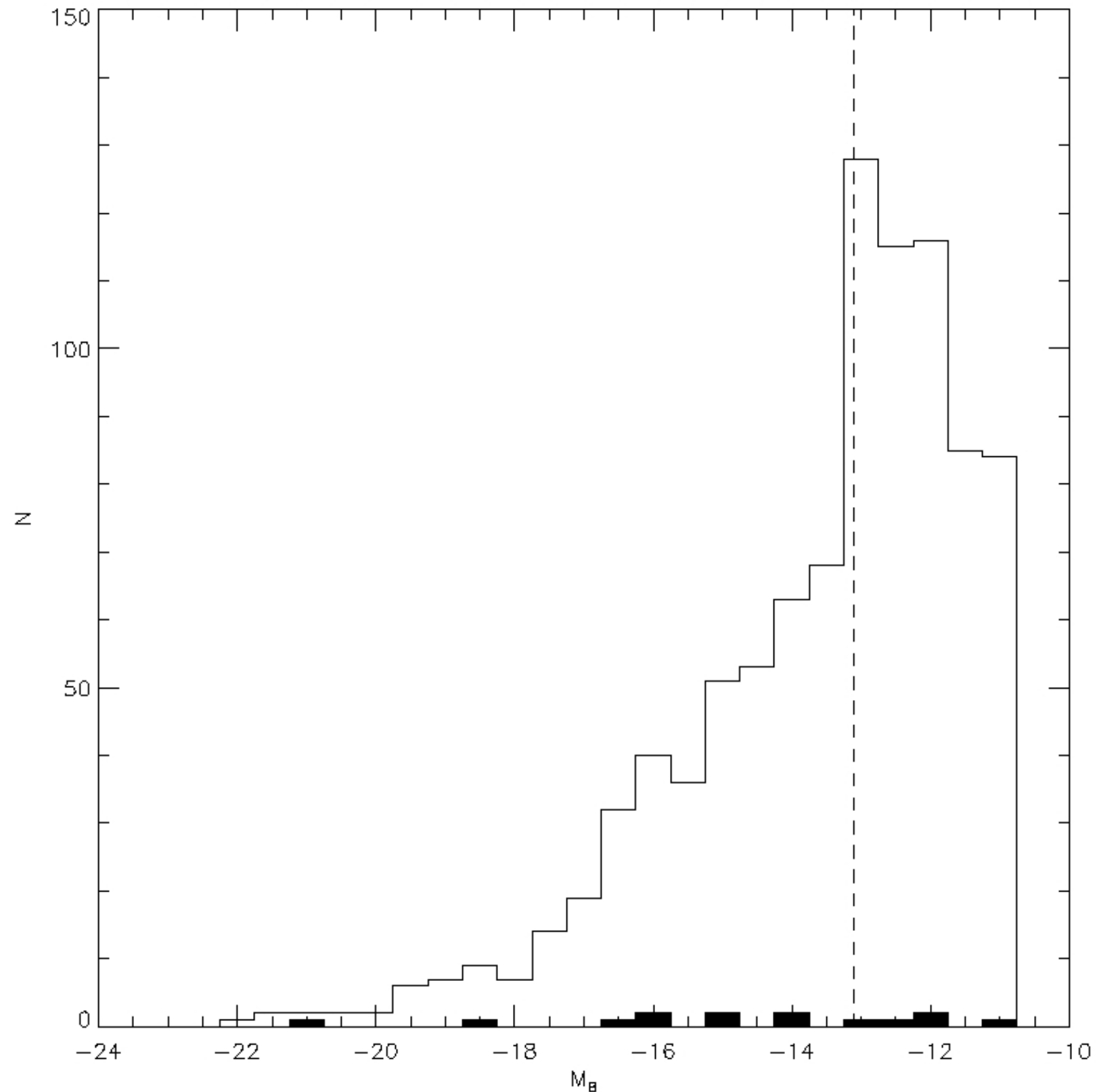
We have searched our sample of 943 VCC ETG for HI detections in the catalogue of detected ALFALFA sources, which is available for the declination strip with $8^\circ \leq \delta \leq 16^\circ$ (Giovanelli et al. 2007).

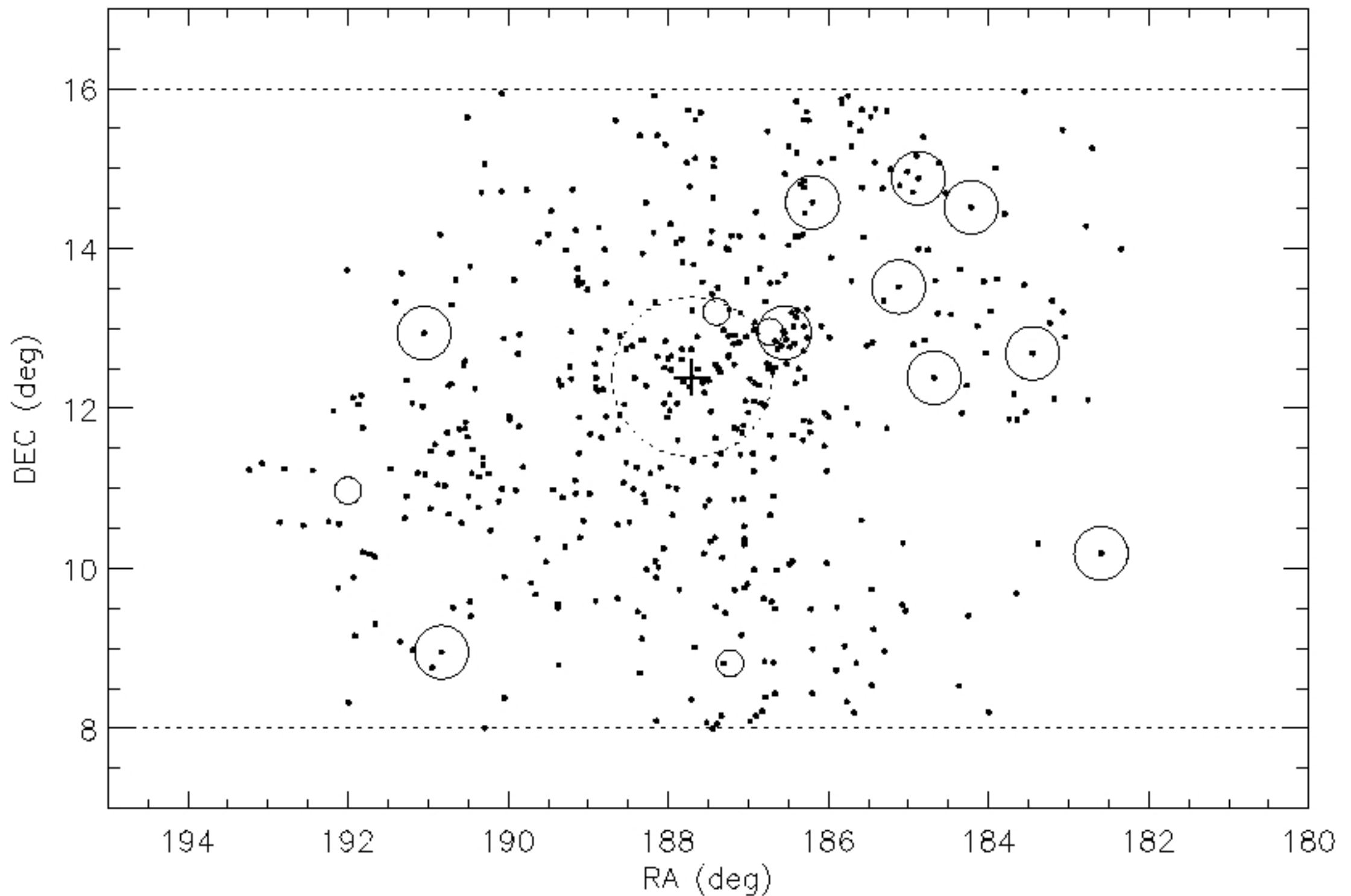
We found 14 ETG detected in HI, 10 of which brighter than $B_T=18.0$. Only two of these sources were known before to have HI.

The detection rate of HI with $M_{\text{HI}} \gtrsim 3 \times 10^7 M_\odot$ for VCC ETG with $B_T \leq 18.0$ is 2.2% (10 out of 460).

Within the accuracy allowed by the number of detected ETG, the detection rate does not depend on luminosity.

Most importantly, more than 800 ETG (390 with $B_T \leq 18.0$) in the VCC have been observed but not detected, so they have $M_{\text{HI}} \lesssim 3 \times 10^7 M_\odot$.





If one considers the 60 ETG with $B_T \leq 18.0$, which are in the low ALFALFA sensitivity region within 1 deg. of M87, then the detection rate of HI with $M_{\text{HI}} \gtrsim 3 \times 10^7 M_\odot$ for VCC ETG with $B_T \leq 18.0$ is raised to 2.5% (10 out of 400). The detected ETG tend to lie at the periphery of the Virgo cluster.

ETG in the Virgo cluster detected in HI by ALFALFA

Table 1. VCC Early Type Galaxies detected in ALFALFA

ID	Other Name	B_T	Type ^a GM	Type VCC	ALFALFA Name	cz_{HI} km/s	M_{HI} $10^7 M_\odot$	Code ^b	S/N	M_B	$\log(M_{HI}/L_B)$ $M_\odot/L_\odot$
VCC 21	IC 3025	14.75	-3	dS0(+)	HI121025.7+101141	485	5.3	2	9.4	-16.36	-1.02
VCC 93	IC 3052	16.3	-1	dE2	HI121348.0+124125	841	3.5	1	6	-14.8	-0.58
VCC 209	IC 3096	15.15	-3	dS0?	HI121651.2+143041	1263	3.6	1	7.4	-15.96	-1.03
VCC 304		16.3	-1	dE1 pec?	HI121842.5+122307	132	3.2	1	6.2	-14.8	-0.65
VCC 355	NGC 4262	12.41	1	S0	HI121929.2+145223	1367	49.1	1	53	-18.70	-0.99
VCC 421		17.0	-1	dE2	HI122034.9+133130	2098	3.4	2	5.1	-14.1	-0.31
VCC 748		17.3	-1	dE4:	HI122451.1+143503	2782	2.9	4	4.3	-13.8	-0.26
VCC 881	NGC 4406	10.06	0	S0 ₁ (3)/E3	HI122612.0+125636	-302	8.0	2	6.9	-21.05	-2.72
VCC 956		18.75	-1	dE1,N:	HI122655.3+125736	2151	9.2	1	10.3	-12.36	0.82
VCC 1142		19.0	-1	dE	HI122856.1+084835	1306	4.7	1	13.7	-12.1	0.62
VCC 1202		20.0	-1	dE?	HI122930.3+131150	1215	14.5	1	8	-11.1	1.51
VCC 1964		18.0	-1	dE4:	HI124316.2+085700	1495	4.3	4	4.1	-13.1	0.25
VCC 1993		15.3	0	E0	HI124417.7+125633	925	4.5	2	5.8	-15.8	-0.87
VCC 2062		19.0	-1	dE:	HI124757.2+105823	1141	32.7	1	79.9	-12.1	1.47

^a GOLDMine type: -3=dS0 -2=dE/dS0 -1=dE(d:E) 0=E-E/S0
1=S0

^b See the text for explanations

ALFALFA detection codes:

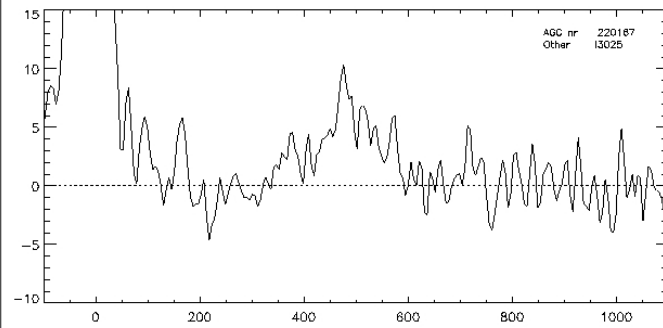
1 $\equiv$ $S/N \gtrsim 6.5$,

2 $\equiv$ $4.5 \lesssim S/N \lesssim 6.5$ with optical counterpart of known similar redshift,

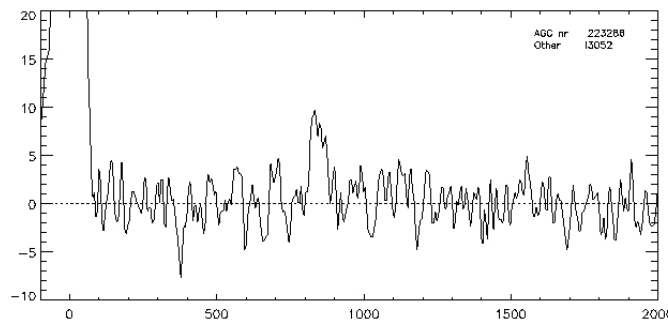
4 $\equiv$ $S/N \lesssim 4.5$

The majority of the detected ETG have peculiar or uncertain morphology.

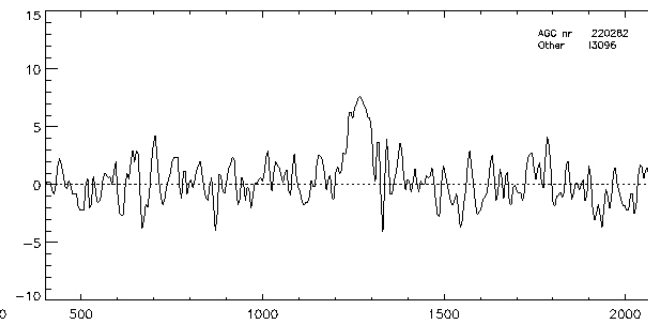
21 cm ALFALFA spectra for the Virgo ETG detected in HI



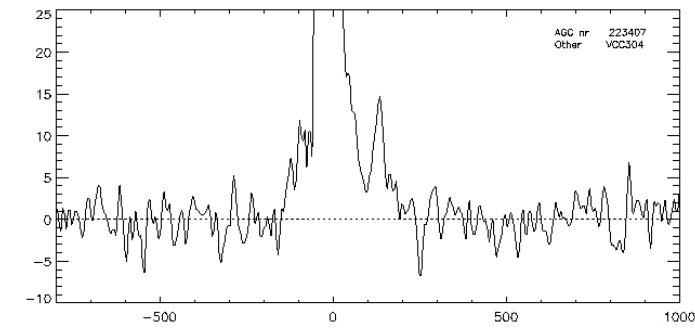
VCC 21, code=2, S/N=9.4



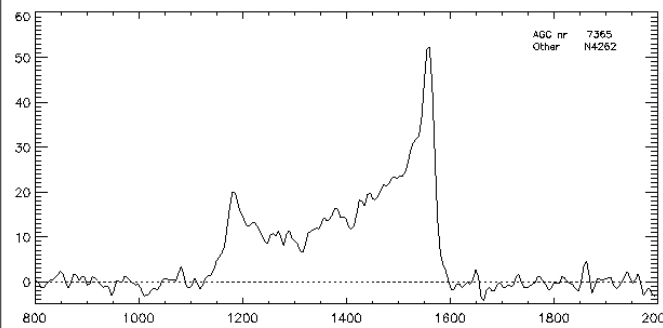
VCC 93, code=1, S/N=6



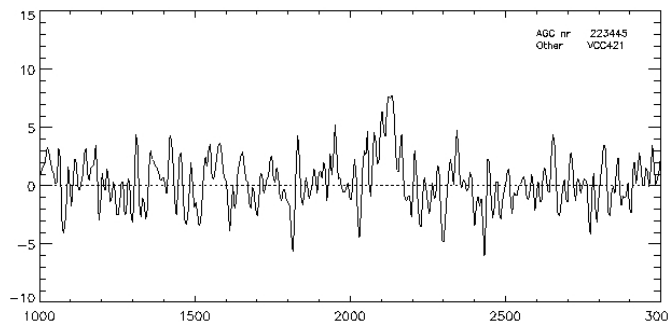
VCC 209, code=1, S/N=7.4



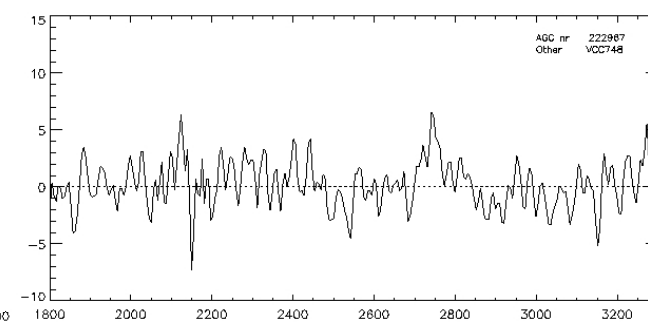
VCC 304, code=1, S/N=6.2



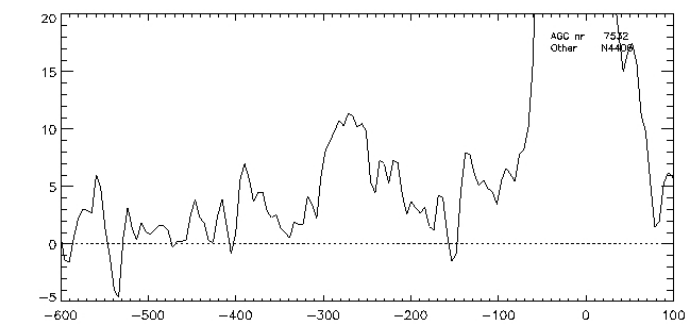
VCC 355, code=1, S/N=53



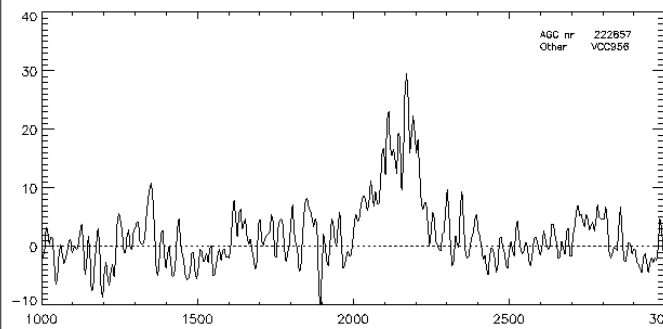
VCC 421, code=2, S/N=5.1



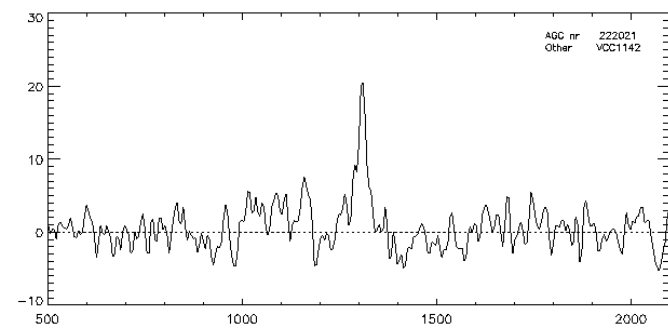
VCC 748, code=4, S/N=4.3



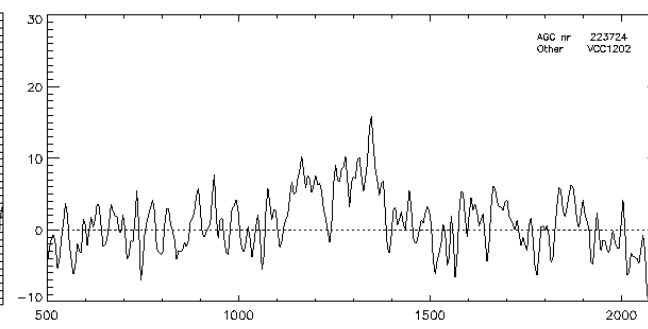
VCC 881, code=2, S/N=6.9



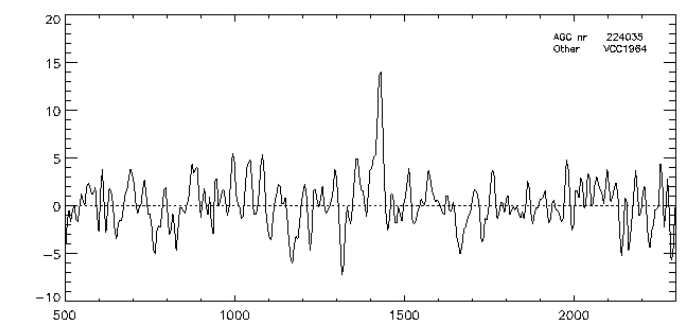
VCC 956, code=1, S/N=10.3



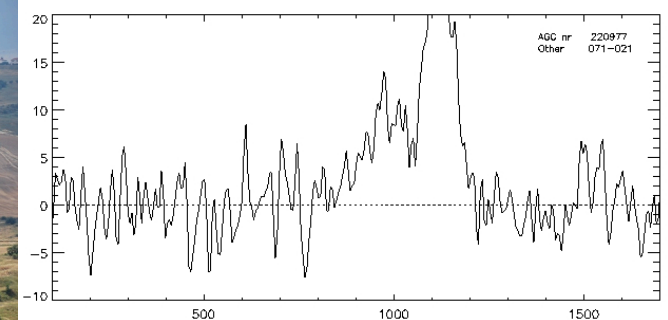
VCC 1142, code=1, S/N=13.7



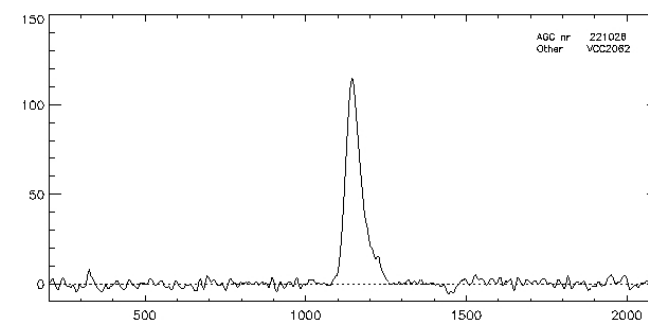
VCC 1202, code=1, S/N=8



VCC 1964, code=4, S/N=4.1



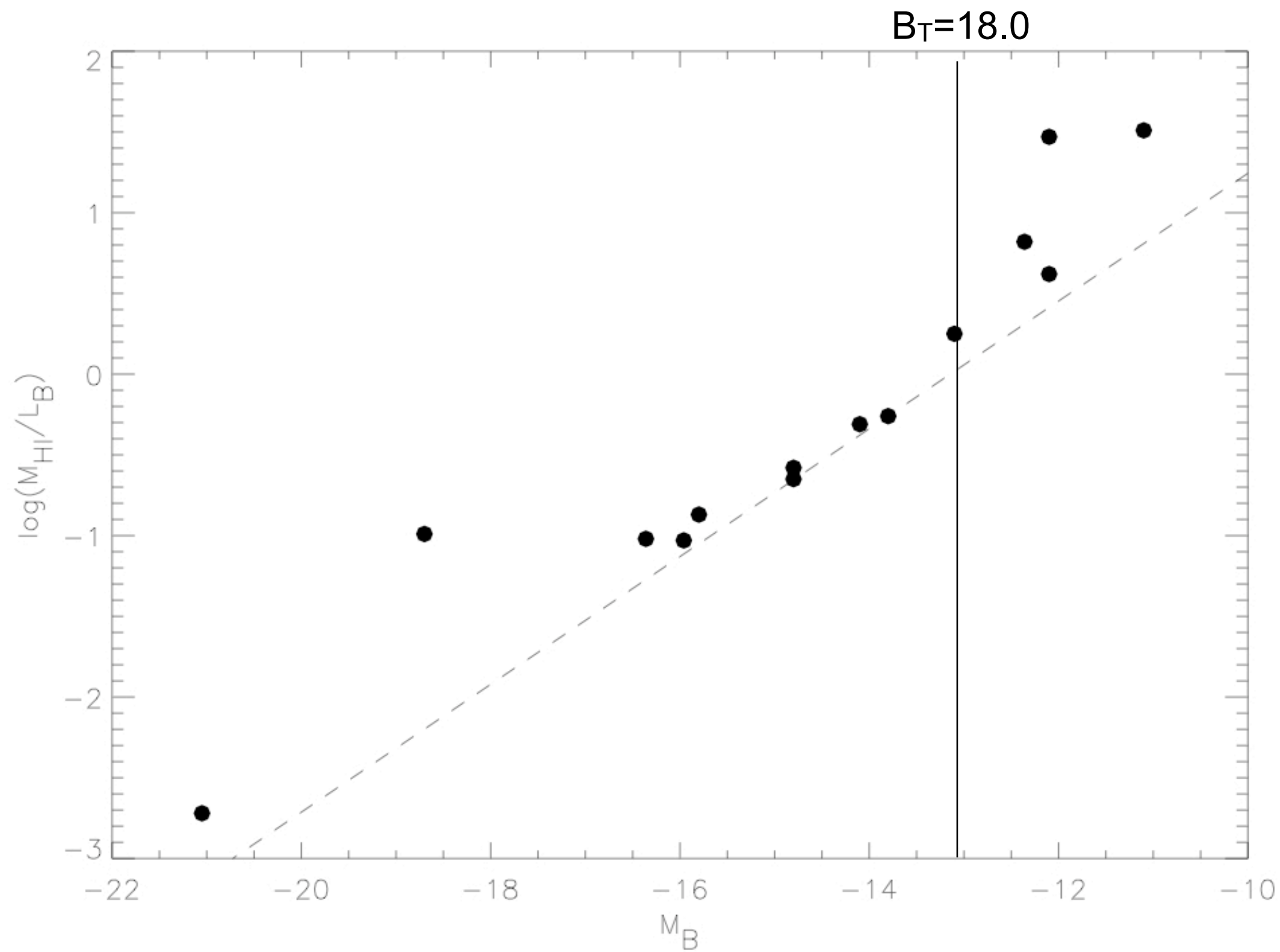
VCC 1993, code=2, S/N=5.8



VCC 2062, code=1, S/N=80



How much neutral gas per stellar light?



Previous estimates of the HI detection rate in ETG

- Knapp et al. 1985: 15%, 23 detections in 152 E/S0 galaxies from the literature.
- Bregman et al. 1992: 5% to 45%, depending on morphological type, from E to pec.E and S0, from a review of the detections in the literature.
- Conselice et al. 2003: 15%, 7 detections out of 48 dwarf elliptical galaxies in the Virgo cluster with radial velocity, observed in HI, which is half of those present (97).
- Morganti et al. 2006: 75%, 9 detections (4 E + 5 S0) out of 12 observed (4 E + 8 S0). These are the ETG with $\delta \geq 23^\circ$ out of the 24 ETG (12 E + 12 S0) in the field SAURON sample, which in turn are selected out of the 133 field ETG in LEDA with $cz \leq 3000$ km/s, $M_B \leq -18.0$, $-6^\circ \leq \delta \leq 64^\circ$. However they would have detected only 7 ETG (58%) at the higher HI detection threshold of ALFALFA ($3 \times 10^7 M_\odot$) and at their higher absolute magnitude limit ($M_B \leq -18.0$) we would have detected only 2 ETG out of 35, with a detection rate which is still 10 times lower than of Morganti et al. 2006.

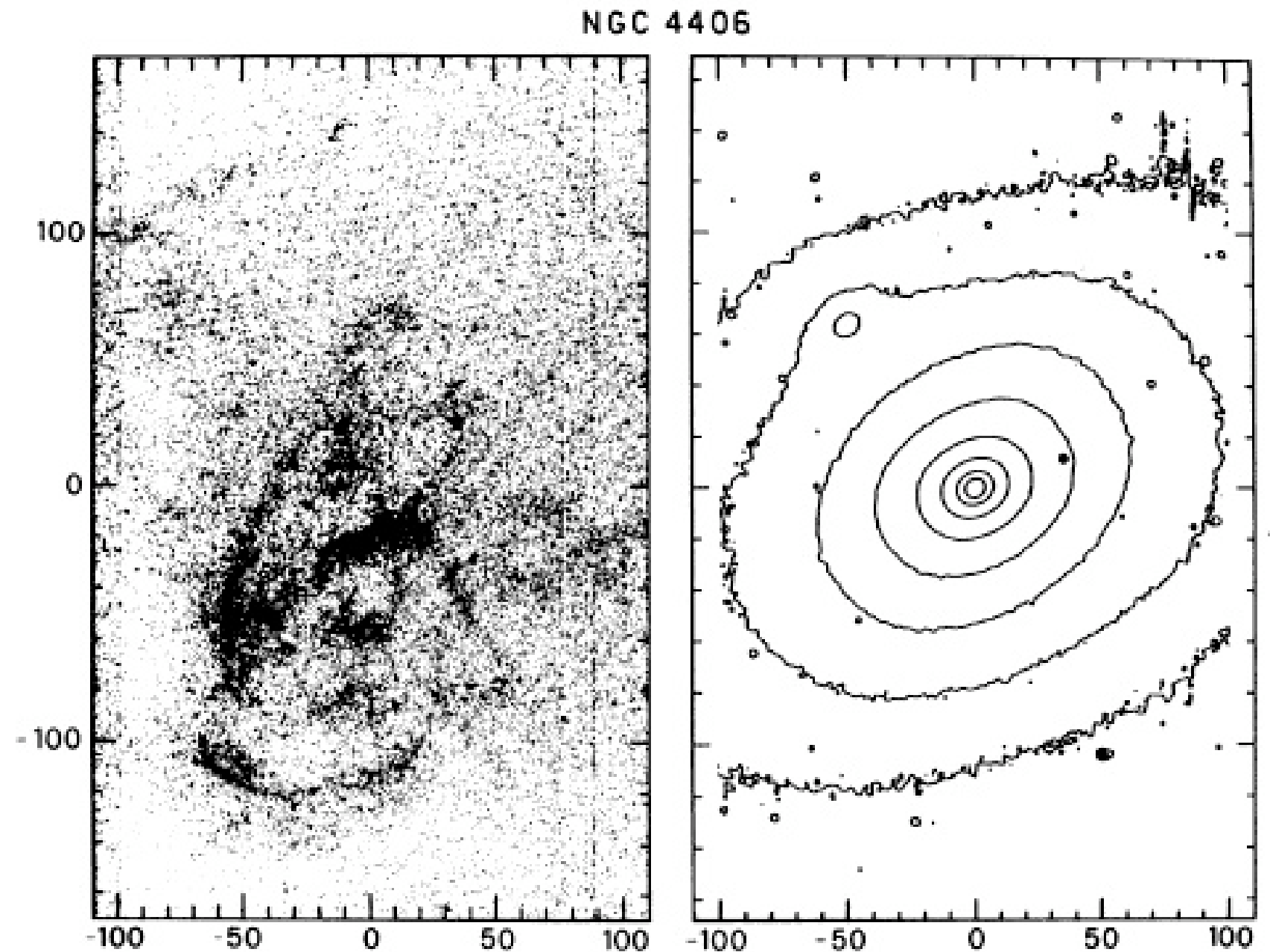
Interaction between gas phases

M86 $\equiv$ NGC 4406 $\equiv$ VCC 881

$M_{\text{N.G.}} = 8 \times 10^7 M_{\odot}$

$\log L_{\text{H}\alpha} = 40.58 \text{ erg/s,}$
 $M_{\text{I.G.}} \sim 10^6 M_{\odot}$

$\log L_X = 41.48, M_{\text{H.G.}} \sim 10^{10} M_{\odot}$



Trinchieri & di Serego Alighieri, 1991

Summary and future plans

- We are using the ALFALFA survey to study the HI content of ETG as a function of galaxy mass and environment.
- The cross-correlation of the 943 ETG in the VCC and the catalogue of detected HI ALFALFA sources with $M_{HI} \gtrsim 3 \times 10^7$ in the 8-16 deg. declination strip gives 14 ETG.
- The HI detection rate for ETG down to the VCC completeness limit of $BT=18.0$ is 2.5 or 2.2%, depending on whether or not one considers the region of lower ALFALFA detection sensitivity around M87, considerably lower than previous estimates.
- The detected galaxies tend to be at the periphery of the cluster and to have peculiar morphology.
- We are currently improving the HI detection sensitivity and upper limits by a search in the ALFALFA datacubes at the optical positions, and velocities, when available.
- We are also planning to investigate with ALFALFA the HI content of a complete sample of ETG in the field.

Thanks, Edvige, Raffaella & Simone!

