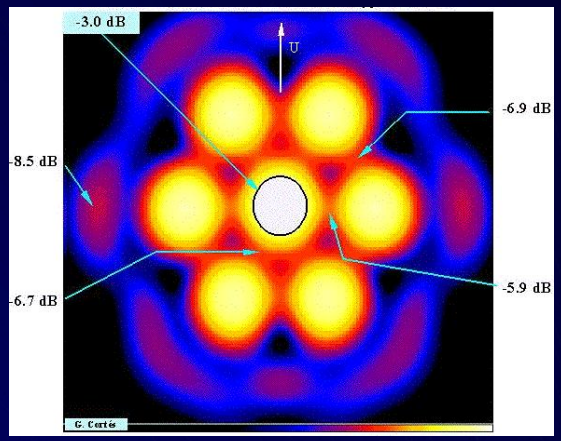


ALFALFA

The Arecibo Legacy Fast ALFA Extragalactic Survey
(An Exploration of the z~0 HI Universe)

Riccardo Giovanelli (Cornell University)
for the ALFALFA team

Venezia Aug 07

ALFALFA

ALFALFA, a Legacy Survey

- A
- T
- 1
- 5
- 2
- 2
- 4
- s

The Arecibo Legacy Fast ALFA Survey

Main People Science Schedule Data Documentation Links Publications Undergrads
Non-experts News/Events Observing/Data Team

Overview

Arecibo is the world's most sensitive radio telescope at L-band. In addition to that all-important sensitivity advantage, Arecibo equipped with ALFA offers important and significant improvements in angular and spectral resolution over the available major wide area extragalactic HI line surveys such as HIPASS and HIJASS. To break ground into new science areas, extragalactic HI surveys with ALFA must exploit those capabilities to explore larger volumes with greater sensitivity than have the previous surveys. The lowest mass objects will only be detected nearby; wide areal coverage is the most efficient means of increasing the volume sampled locally. An extragalactic survey covering the high galactic latitude sky visible from Arecibo will produce an extensive database of HI spectra that will be of use to a broad community of investigators, including many interested in the correlative mining of multiwavelength datasets; we thus dub this program the *Arecibo Legacy Fast ALFA* survey: ALFALFA. A comparison

http://egg.astro.cornell.edu/alfalfa

ALFALFA

Who is ALFALFA?

ALFALFA is an open collaboration: anybody with a valid scientific interest can join.

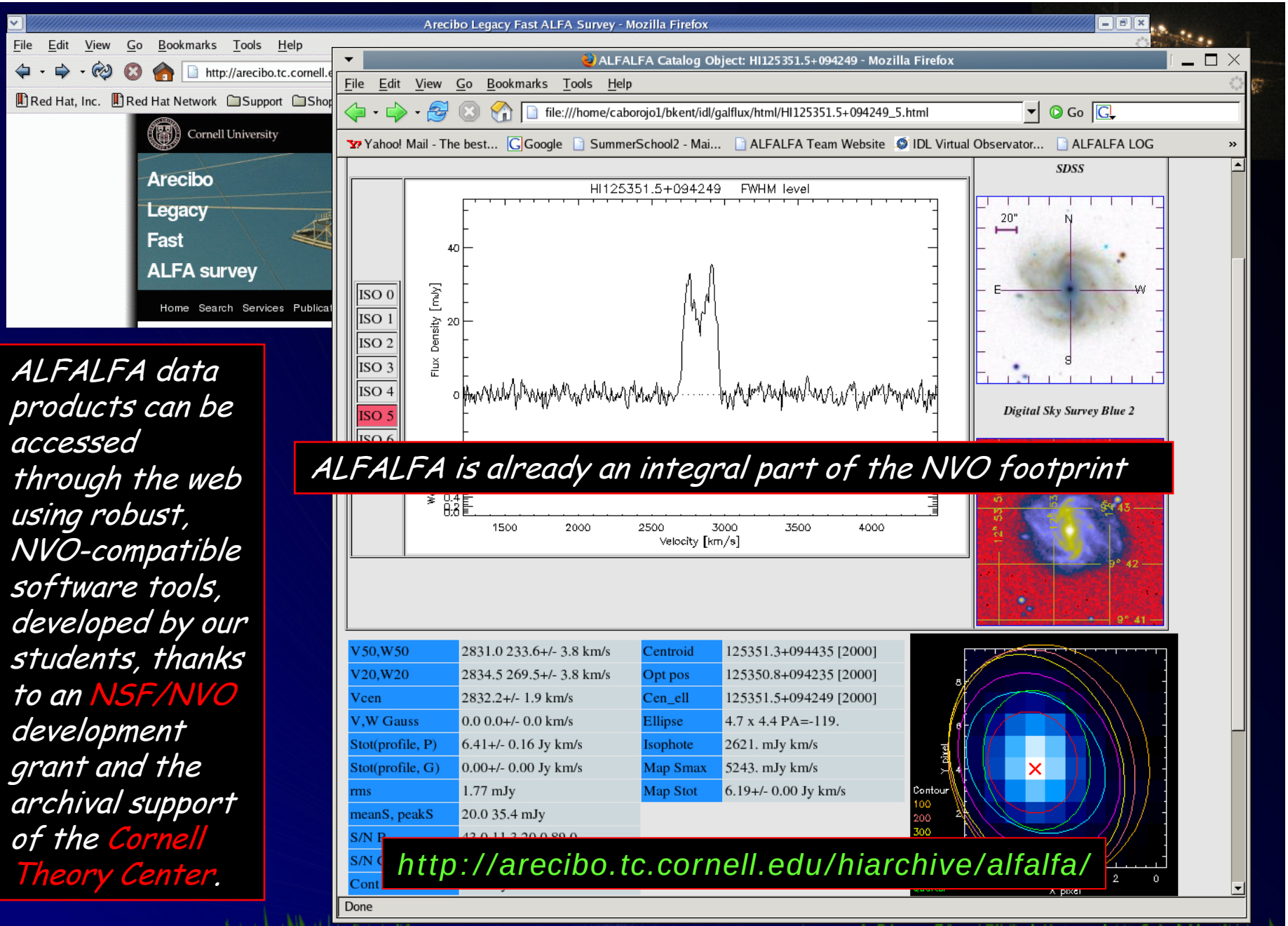
For participation guidelines, see:
http://egg.astro.cornell.edu/alfalfa/joining.php

Recommended guidelines for authorship can be found at:
http://egg.astro.cornell.edu/alfalfa/projects/authorshipguidelines.php

Project Guidelines:
http://egg.astro.cornell.edu/alfalfa/projects/projectguidelines.php

Projects (Team/PhD/undergrad):
http://egg.astro.cornell.edu/alfalfa/projects/projects.php

ALFALFA



ALFALFA data products can be accessed through the web using robust, NVO-compatible software tools, developed by our students, thanks to an NSF/NVO development grant and the archival support of the Cornell Theory Center.

ALFALFA is already an integral part of the NVO footprint

ALFALFA

Science Goals to Be Addressed by ALFALFA:

1 Determination & environmental variation of the faint end of the HI Mass Function and the cosmic abundance of low mass halos

2 Global properties of HI-selected galaxy samples

3 The LSS of HI sources, the "void problem" & metallicity

4 Blind Survey for HI tidal remnants & "cold accretion"

5 HI Diameter Function

6 The low HI Column density environment of galaxies

7 The nature of HVC's around the MW (and beyond?)

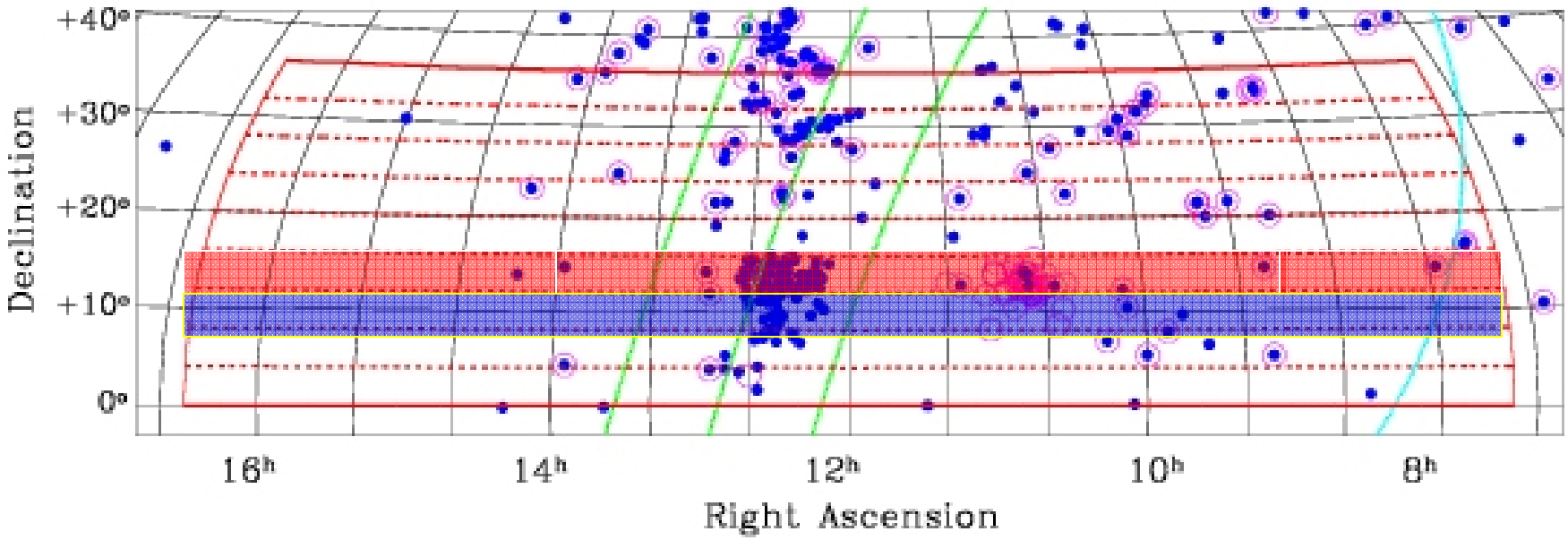
8 HI absorbers and the link to Lyman α absorbers

9 OH Megamasers at intermediate redshift

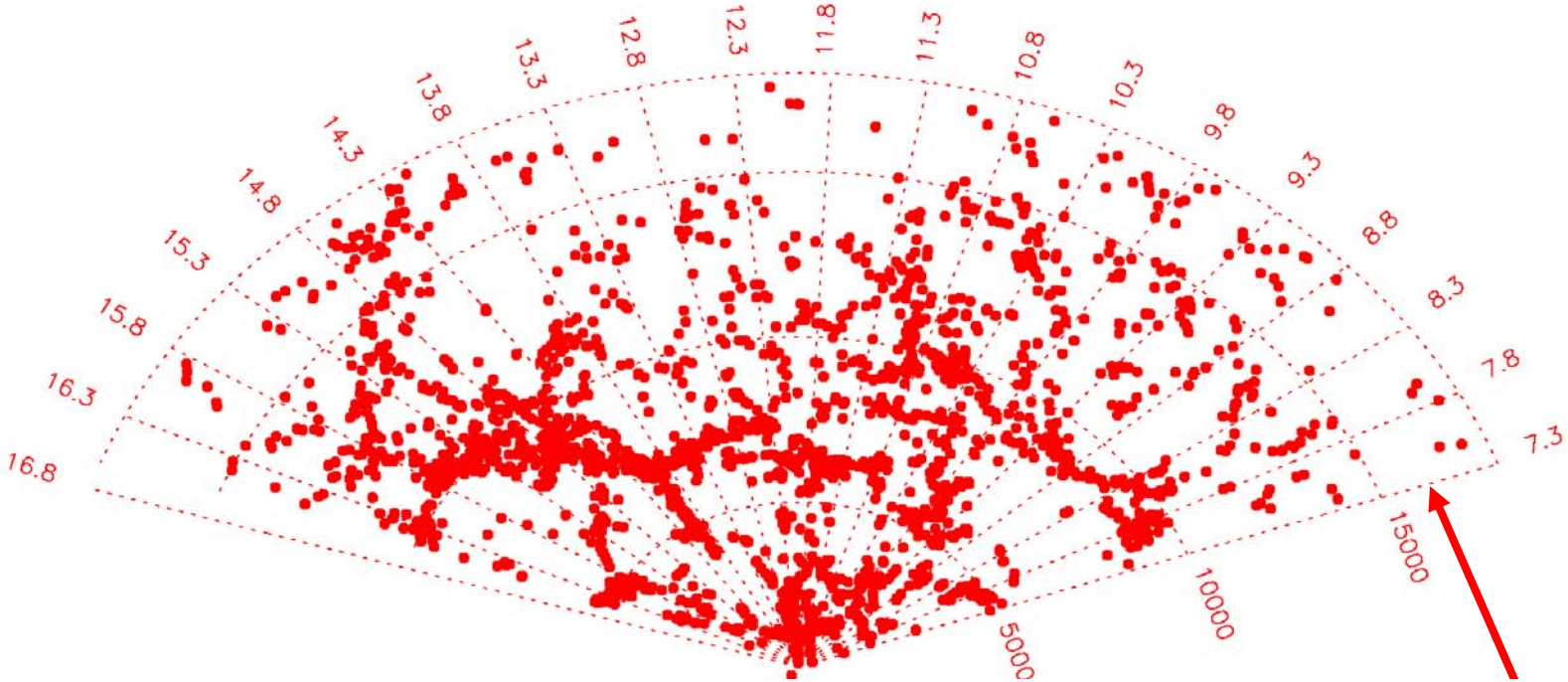
ALFALFA

ALFALFA: Preliminary Results from 2 strips through Virgo

RA: 07:40h to 16:30h
Dec: 12deg to 16deg and
08deg to 12deg
Solid Angle: 1028 sq deg
(15% of survey)



ALFALFA

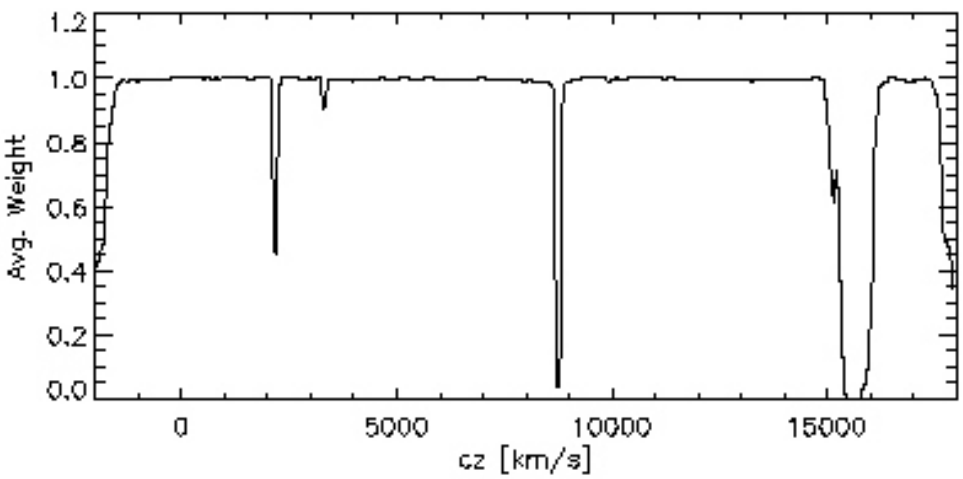


Over the ~1000 sq. deg. including the northern part o

➔ ***ALFALFA detects 5200 sources, HIPASS 178 (several unconfirmed)***

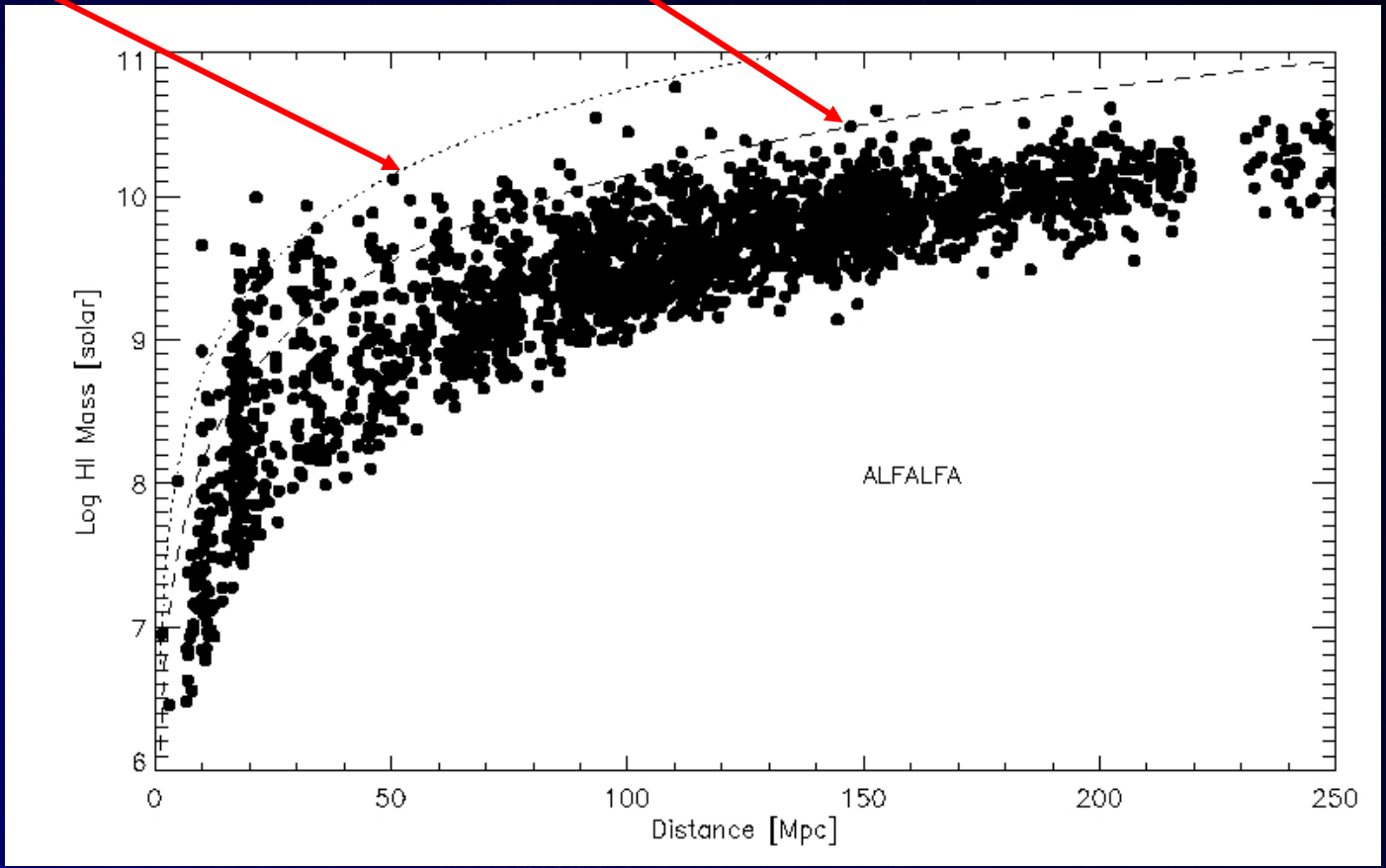
➔ *While this region is perhaps the most intensively stu in the local Universe, at all wavelength bands (includ HI, using optically selected samples),*

➔ ***69% of ALFALFA detections are new*** *(the convent wisdom on which optical targets would turn out to HI-rich appears to have been limited)*



HIPASS Completeness Limit

HIPASS Limit

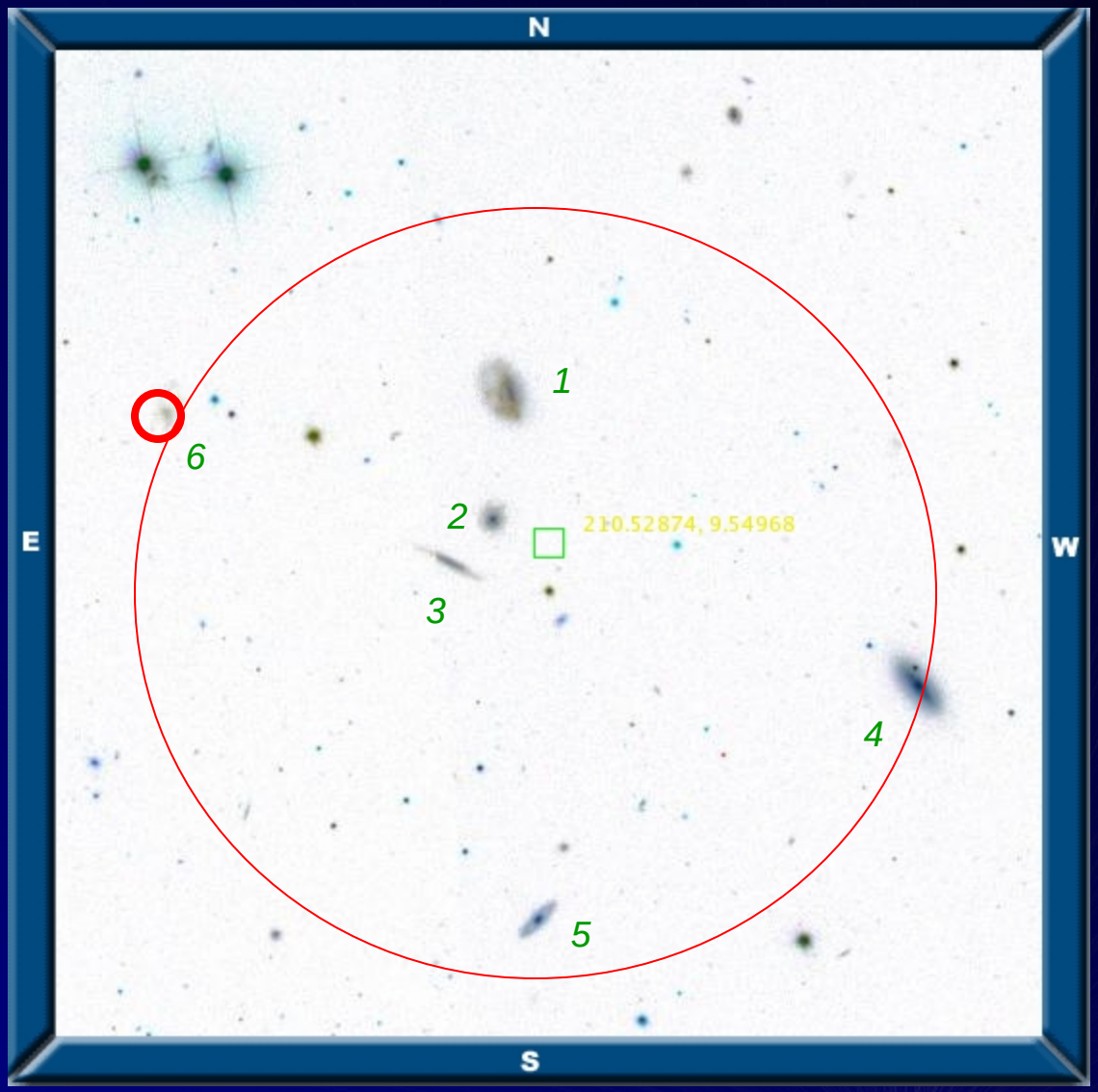


ALFALFA

Source extraction and identification of counterparts at other wavelength regimes can be a painful experience…

…source centroiding as accurately as possible is thus highly desirable

ALFALFA



Centroiding accuracy goes roughly as

HPFW(PSF)/(S/N)

Suppose HIPASS detects a source at S/N~6 near 3000 km/s in this field. The position error box will have a radius of ~2.5'.

The opt counterpart could be gal #1, 2, 3, 4, 5 or 6.

ALFALFA will detect the same source with S/N~50

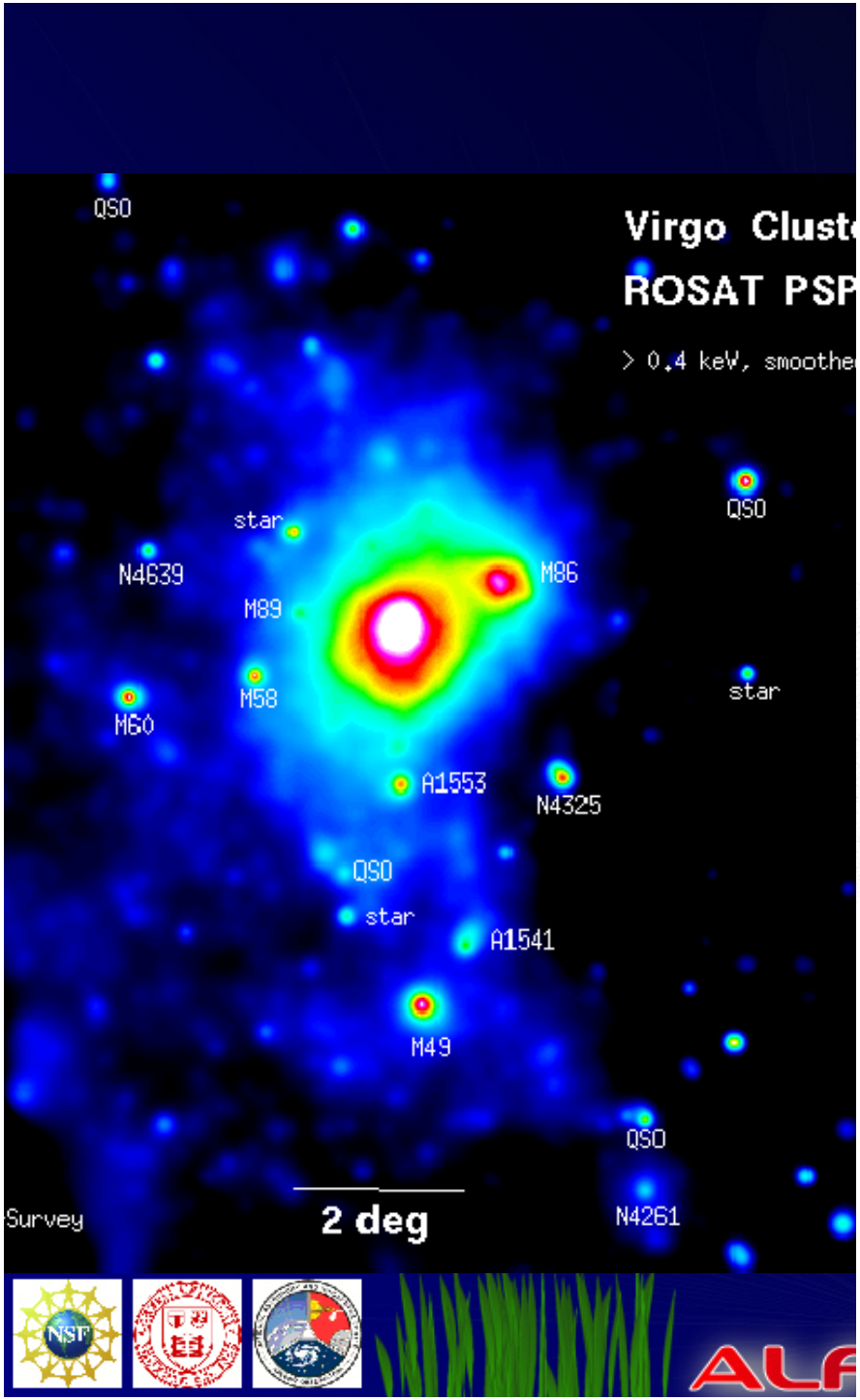
and the Arecibo beam is ¼ as wide as the Parkes one

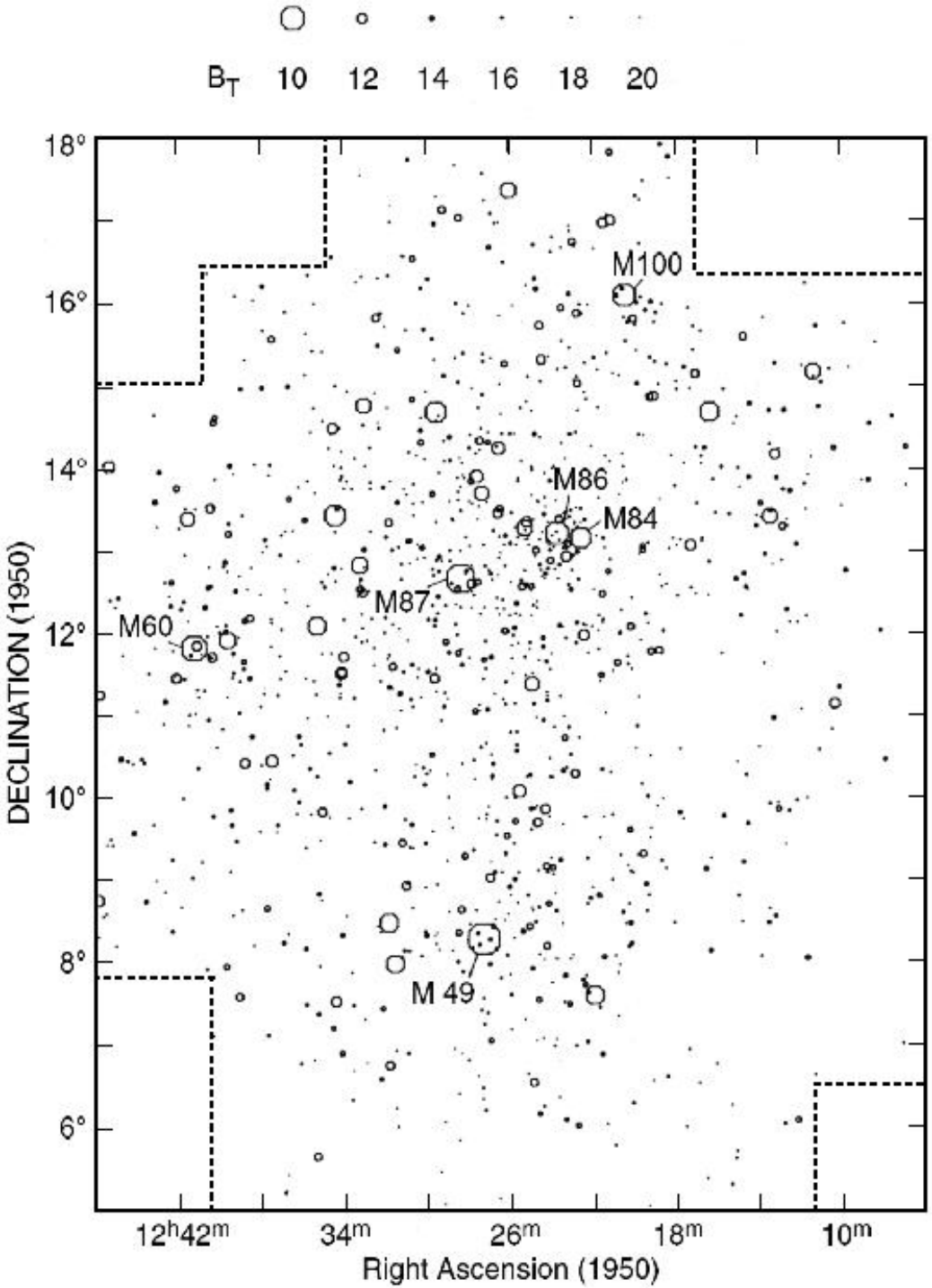
➔ *The same source will have an ALFALFA position error of ~ 0.1'*

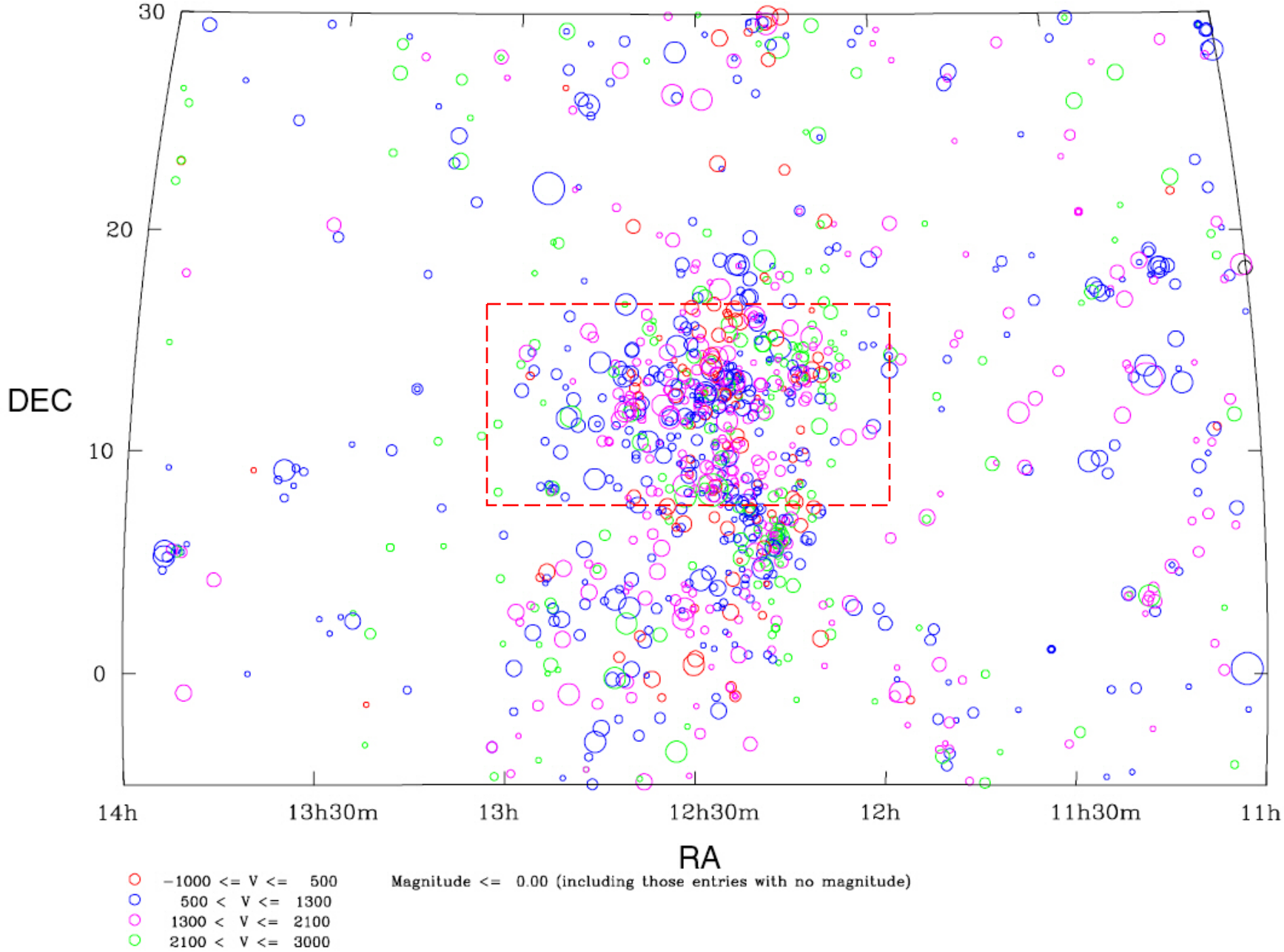
ALFALFA

A quick look at the Virgo Cluster

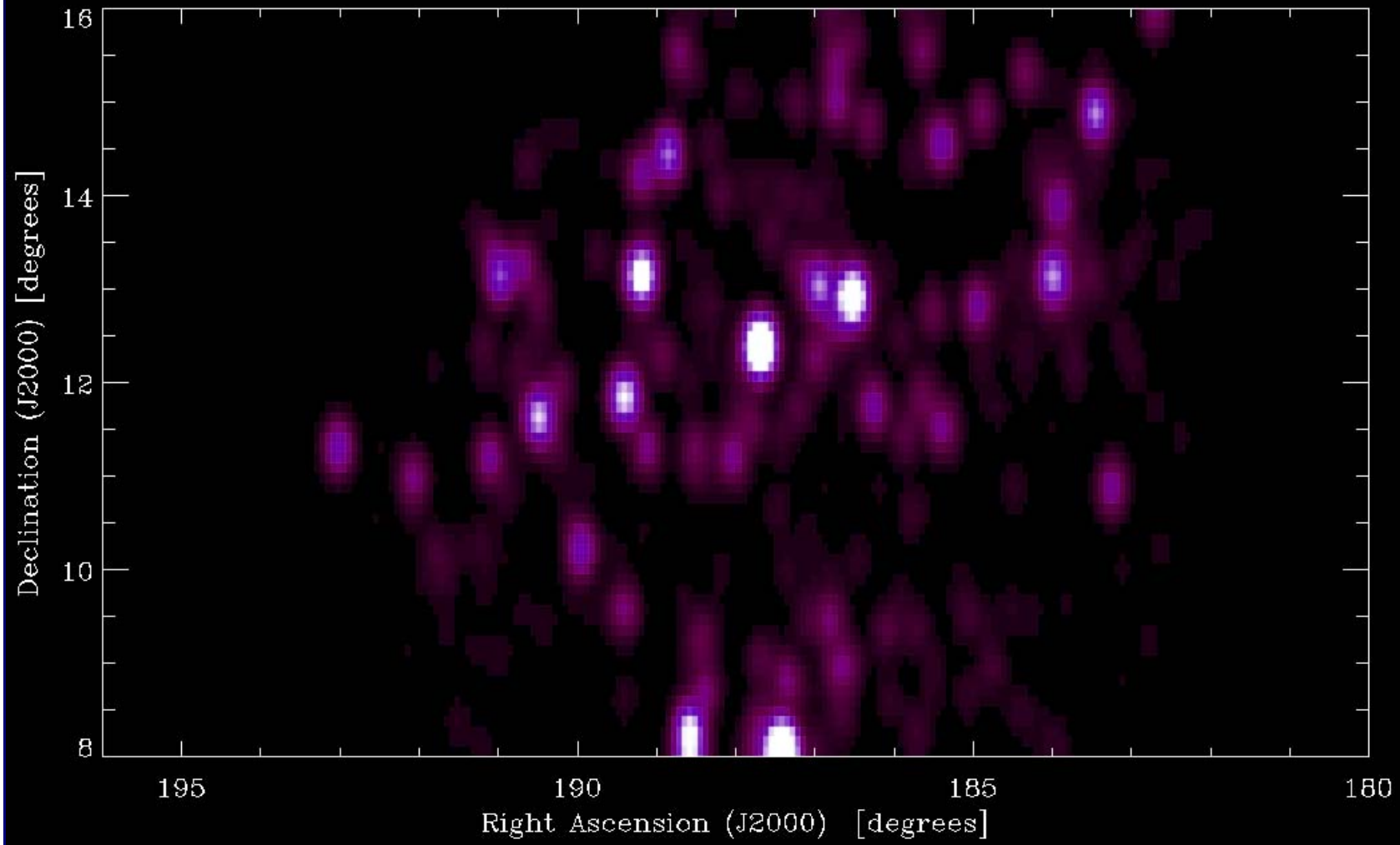
ALFALFA


Virgo Cluste
ROSAT PSP
> 0.4 keV, smoothe
QSO
star
N4639
M89
M86
M58
M60
A1553
N4325
QSO
star
A1541
M49
QSO
N4261
2 deg
Survey


B_T 10 12 14 16 18 20
18°
16°
14°
12°
10°
8°
6°
DECLINATION (1950)
M100
M86
M84
M87
M60
M 49
12^h42^m
34^m
26^m
18^m
10^m
Right Ascension (1950)

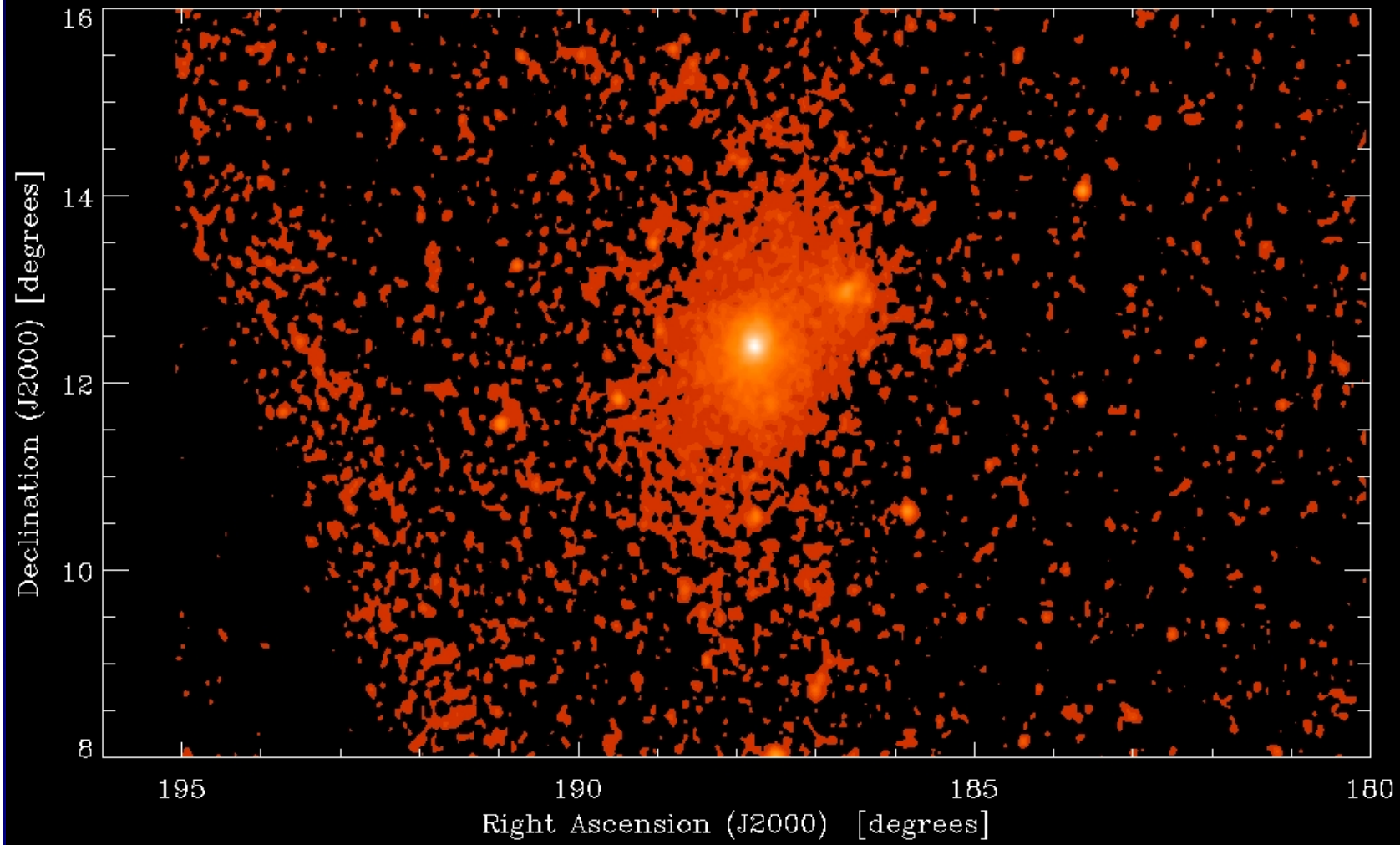

30
20
10
0
DEC
14h
13h30m
13h
12h30m
12h
11h30m
11h
RA
−1000 <= V <= 500
500 < V <= 1300
1300 < V <= 2100
2100 < V <= 3000
Magnitude <= 0.00 (including those entries with no magnitude)

ALFALFA



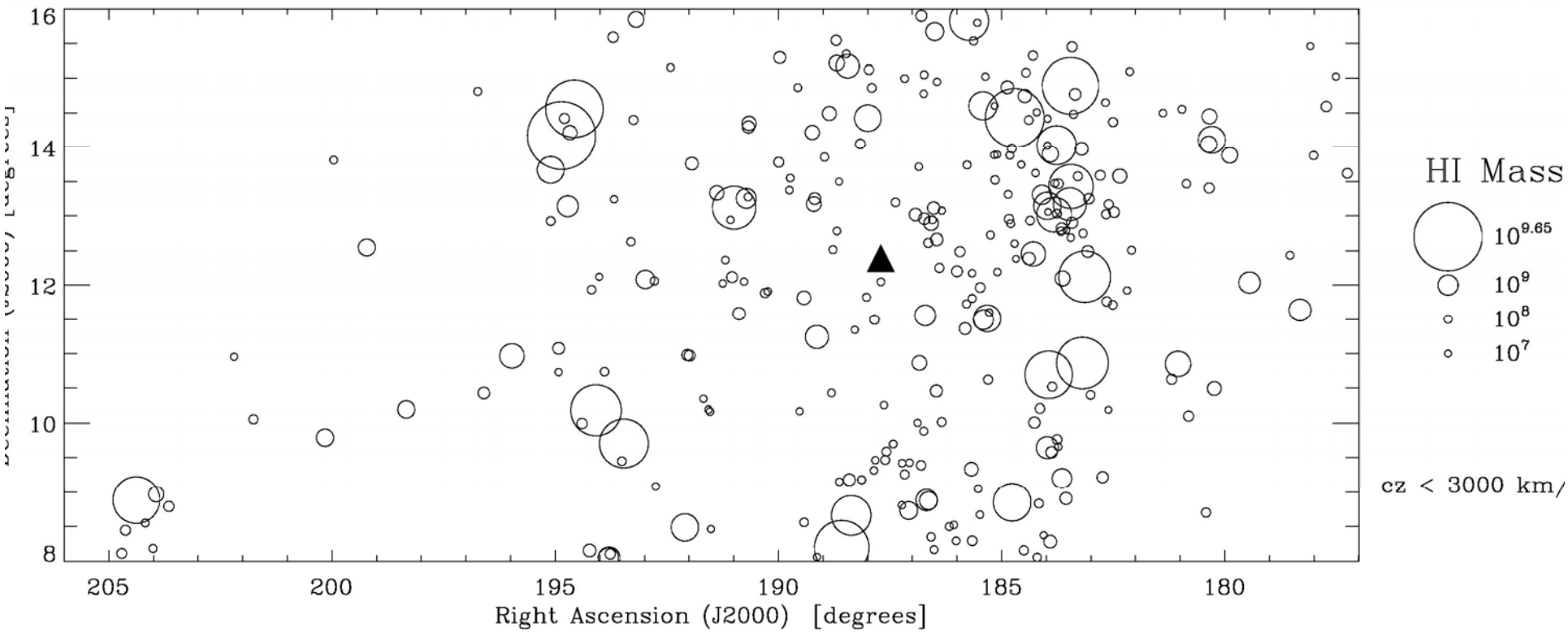
B. Kent Ph.D. Thesis

ALFALFA



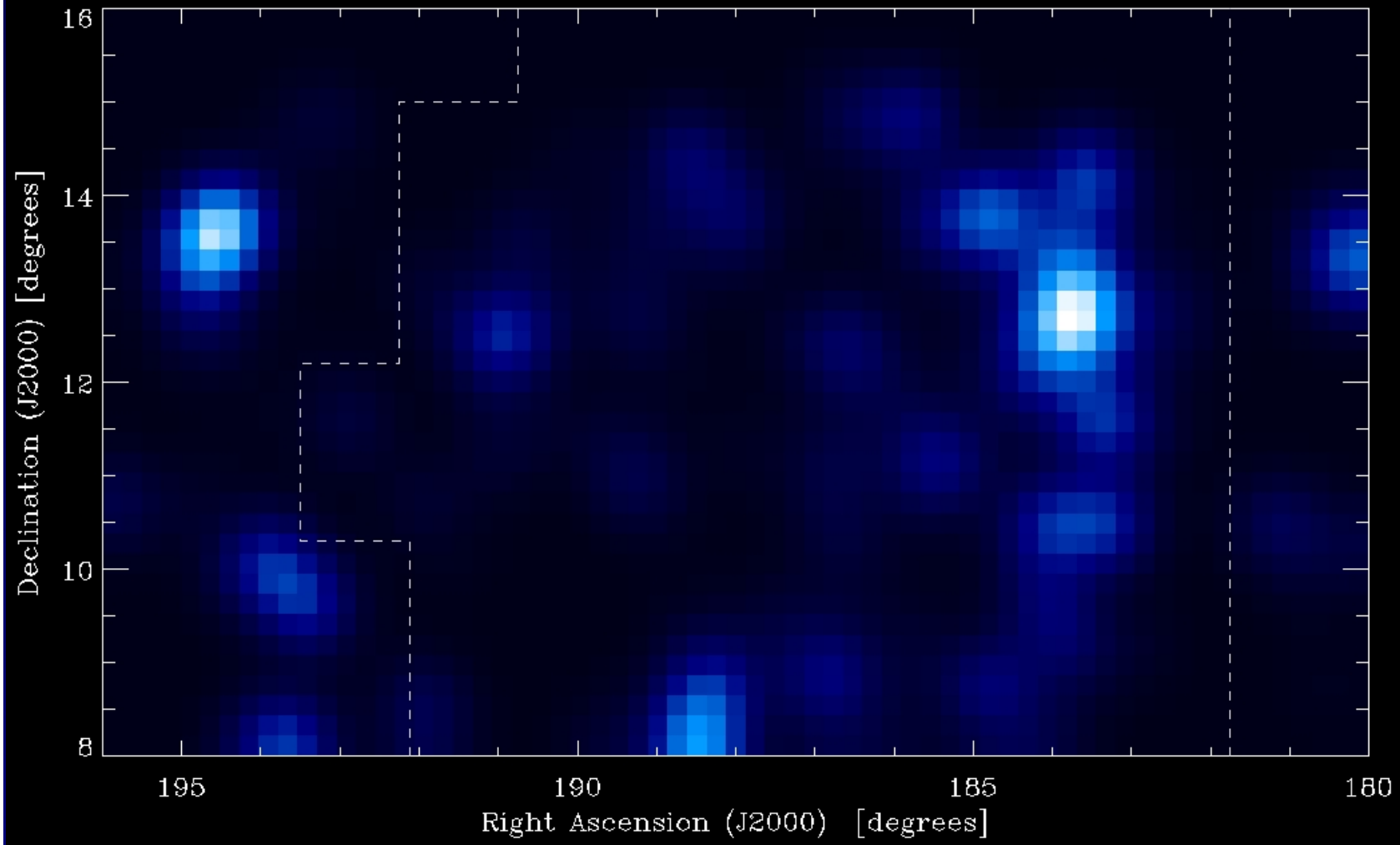
B. Kent Ph.D. Thesis

ALFALFA



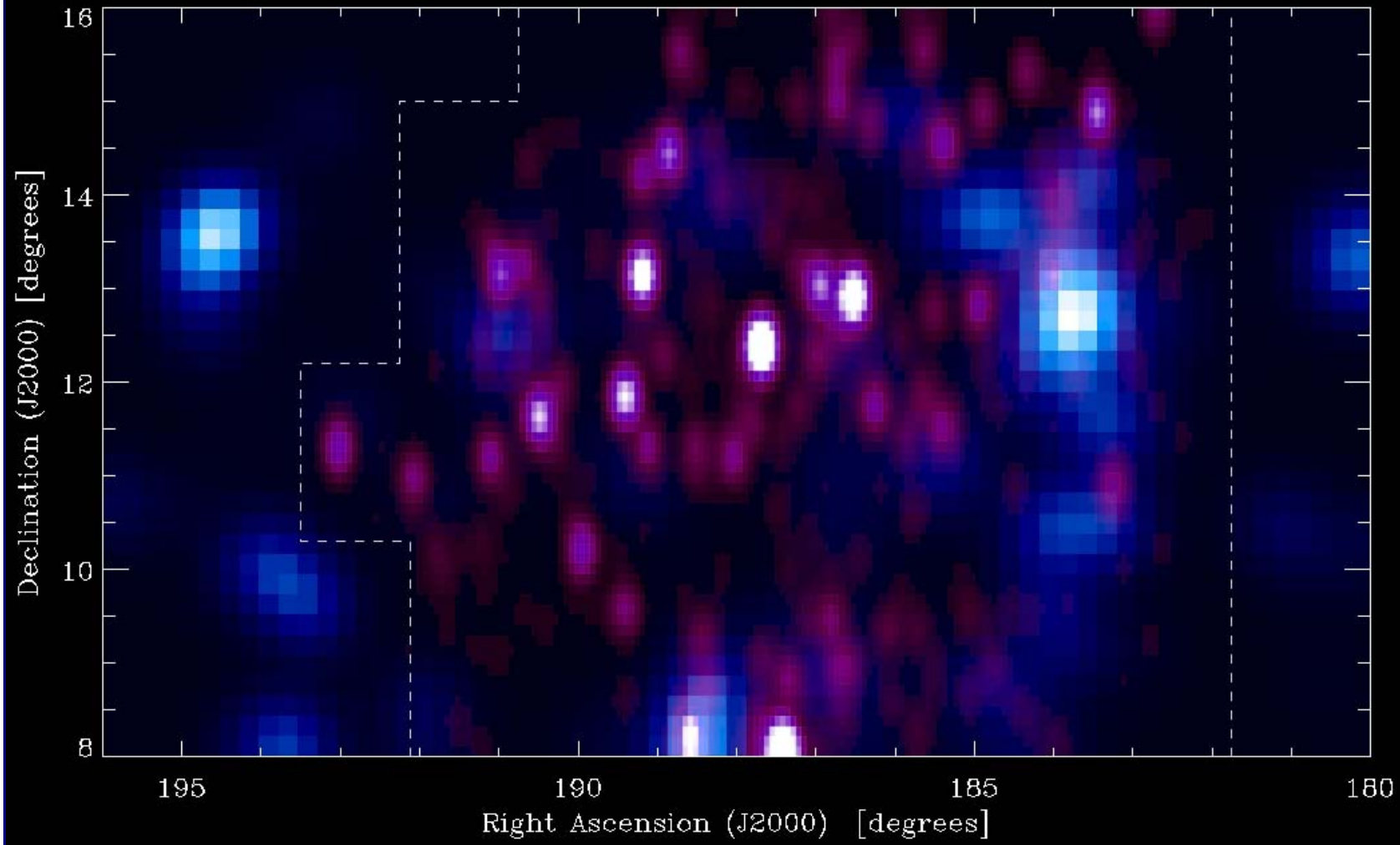
B. Kent Ph.D. Thesis

ALFALFA



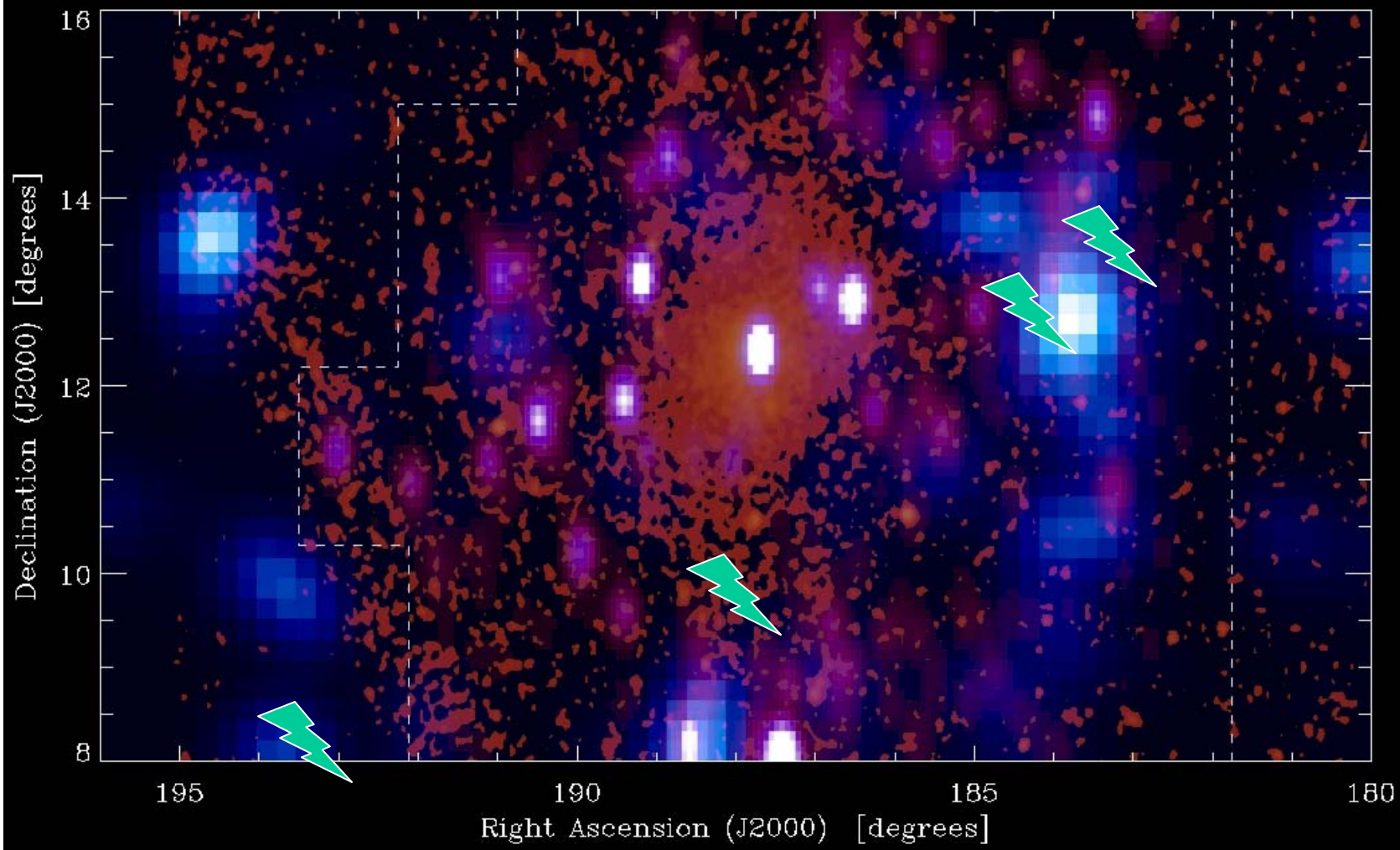
B. Kent Ph.D. Thesis

ALFALFA



B. Kent Ph.D. Thesis

ALFALFA



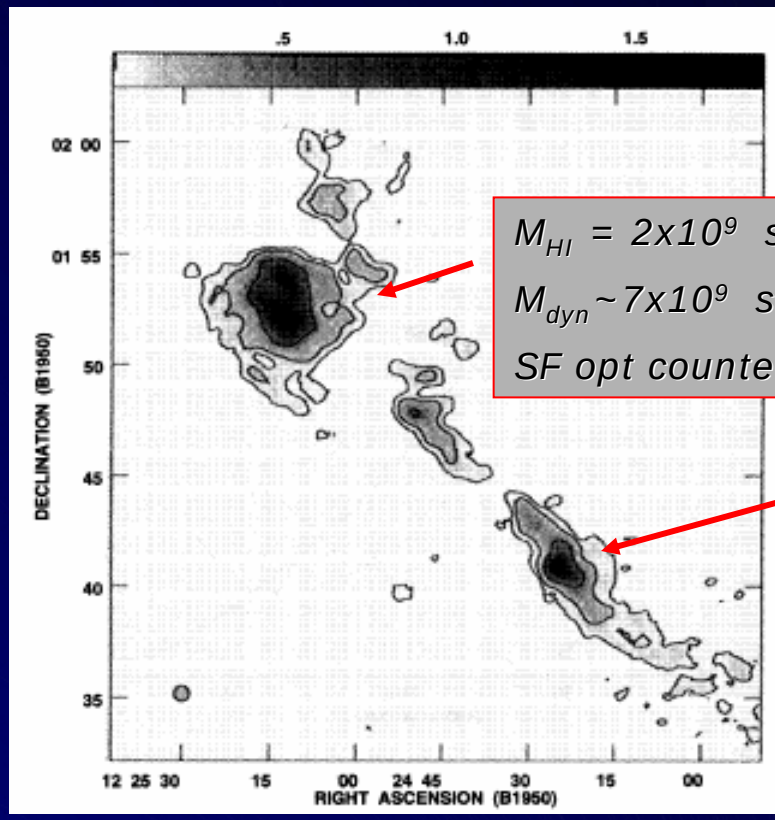
Brown: Xray
Purple: Opt
Blue: HI

B. Kent Ph.D. Thesis

ALFALFA

What about "dark galaxies"?

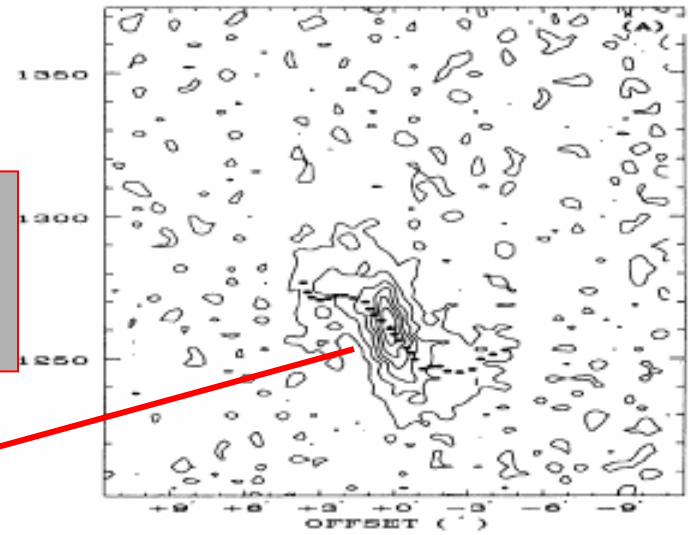
ALFALFA



M_{HI} = 2x10^9 solar

M_{dyn}~7x10^9 solar

SF opt counterpart



- No optical counterpart
- Evidence of rotation: V_{rot}~13 km/s
- M_{HI}=6x10^8 solar
- M_{dyn}(<3')~7x10^8 solar

HI 1225+01

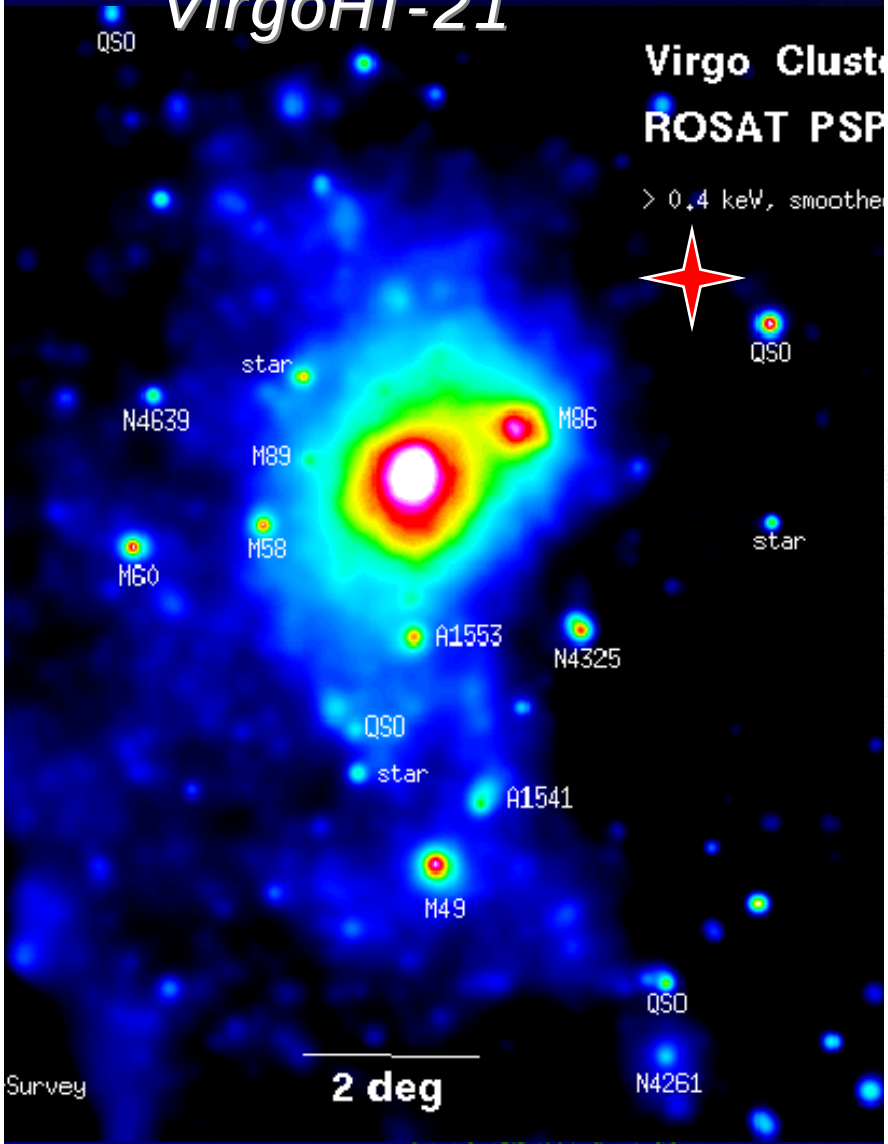
Giovanelli & Haynes 1989 ApJ 346, L5 : Arecibo discovery

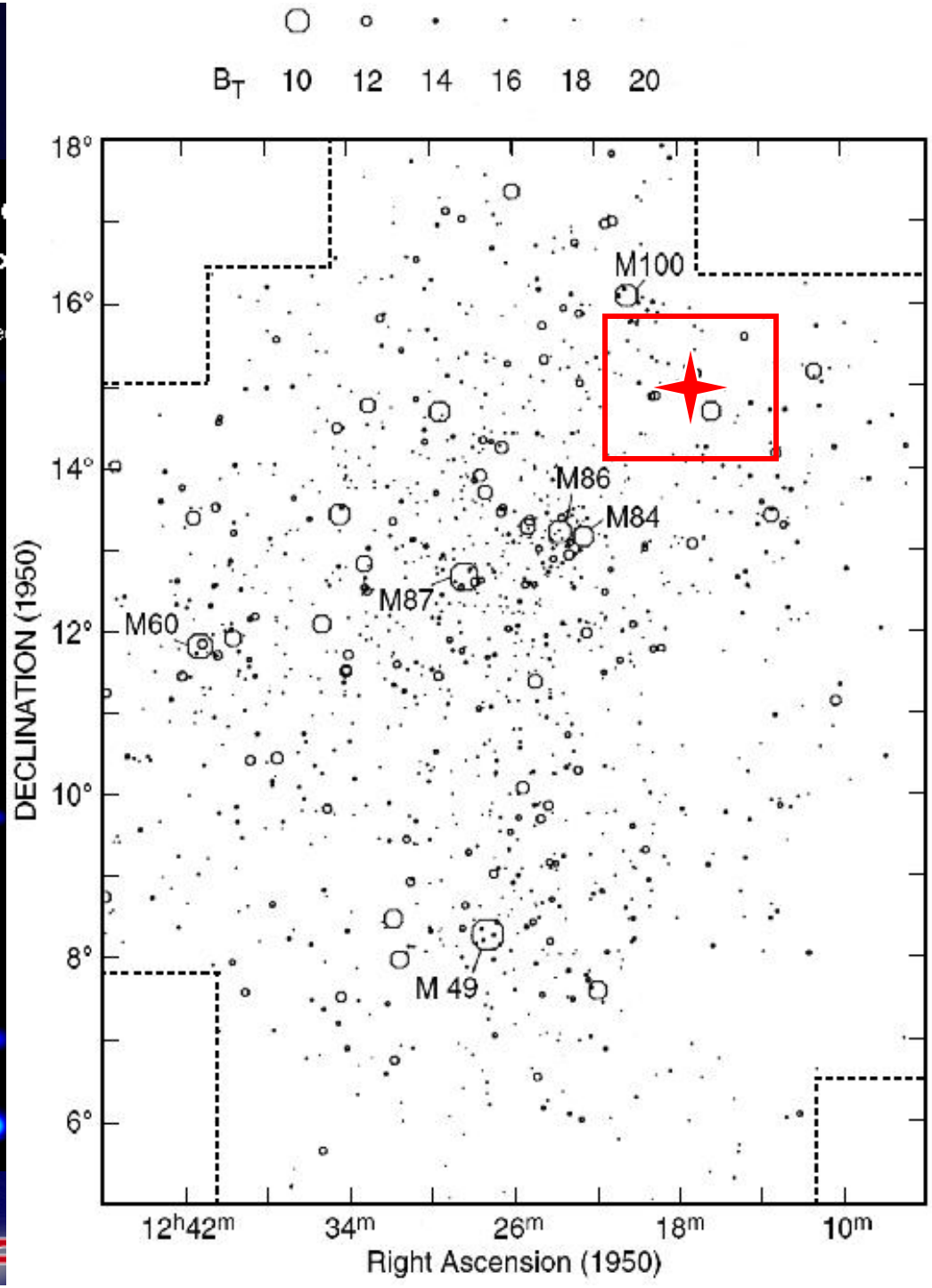
Chengalur, Giovanelli & Haynes 1995 AJ 109, 2415: VLA map

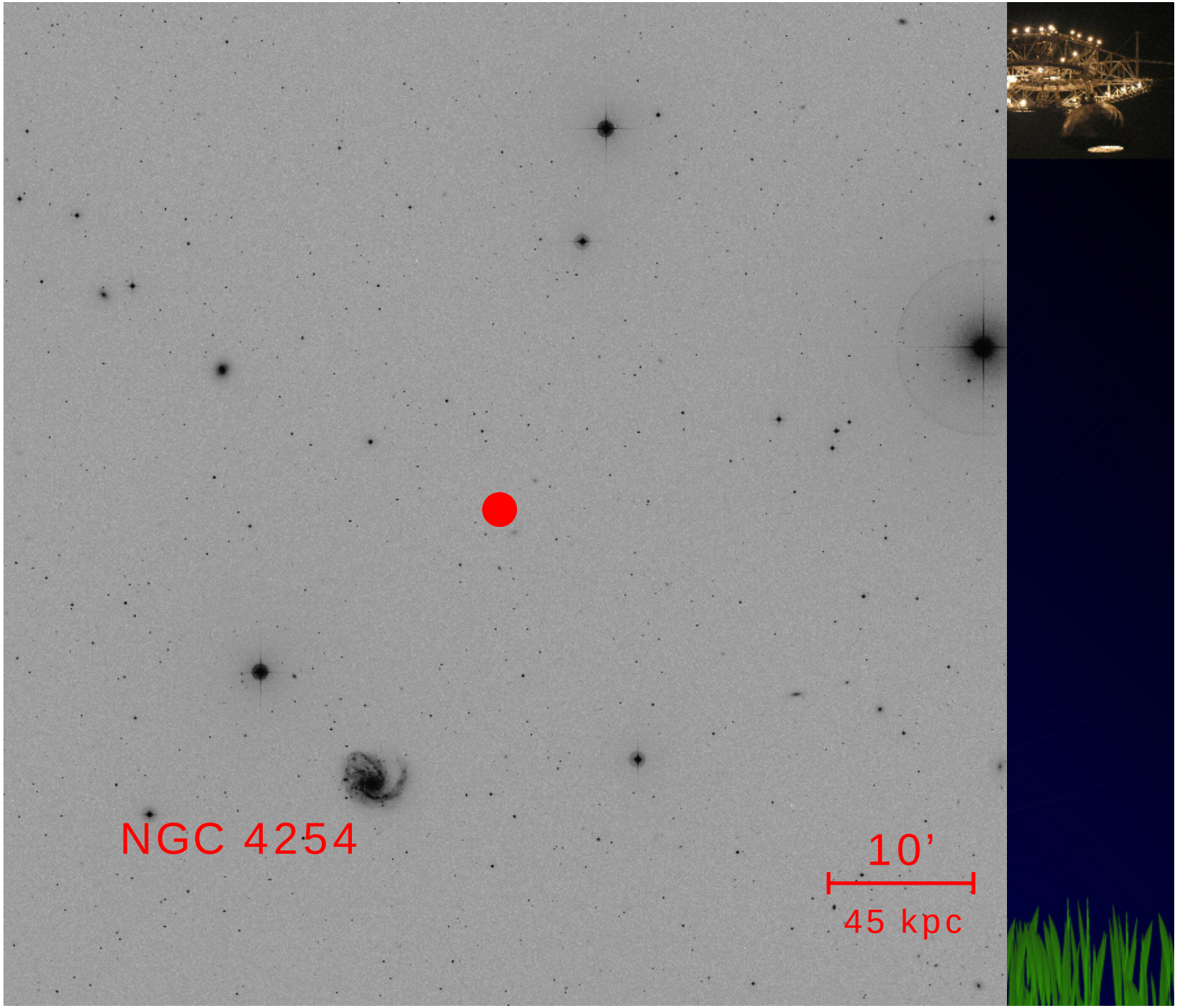
But do such objects exist in isolation?

ALFALFA

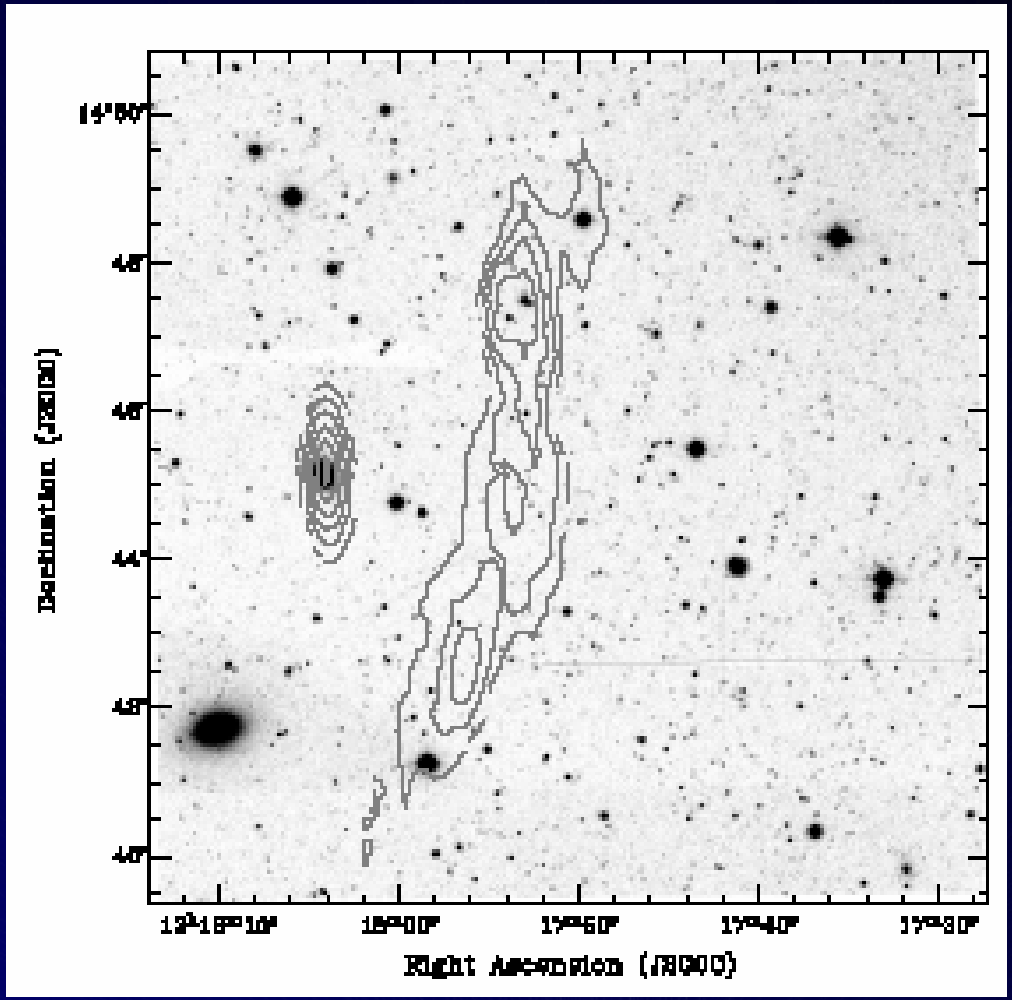
The Cardiff "Dark Galaxy" VirgoHI-21





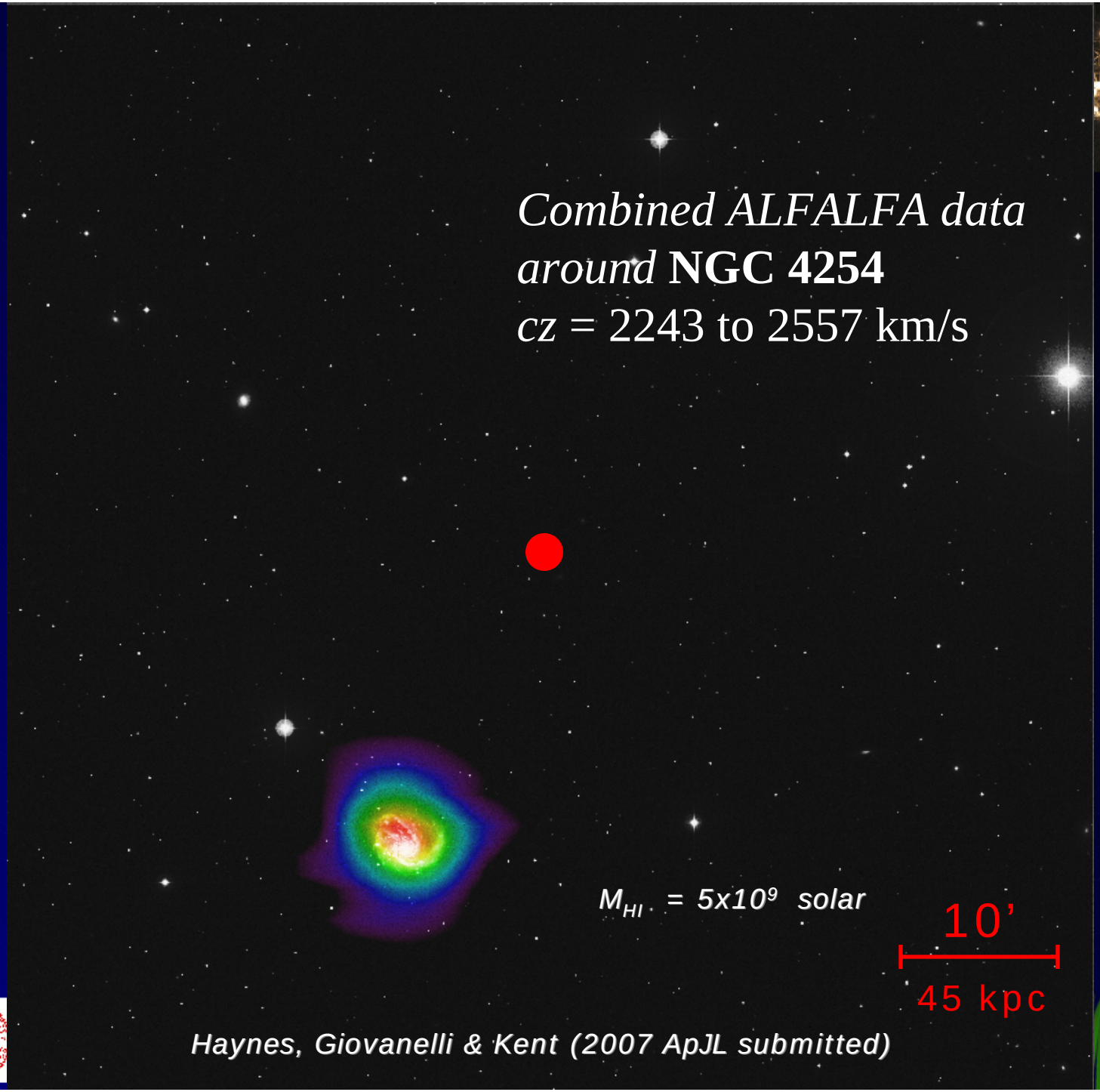


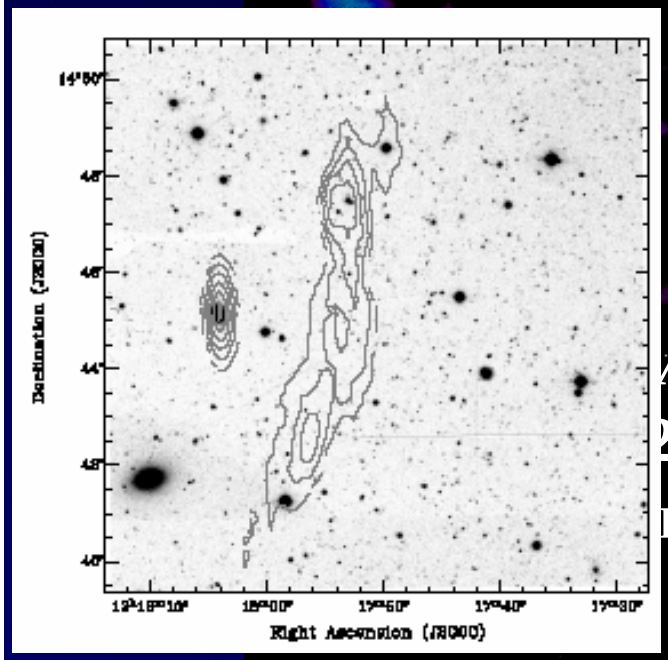
DSS2
Blue



Minchin et al 2007 (WSRT)

ALFALFA


Combined ALFALFA data around **NGC 4254**
cz = 2243 to 2557 km/s
M_{HI} = 5x10^9 solar
10'
45 kpc
Haynes, Giovanelli & Kent (2007 ApJL submitted)

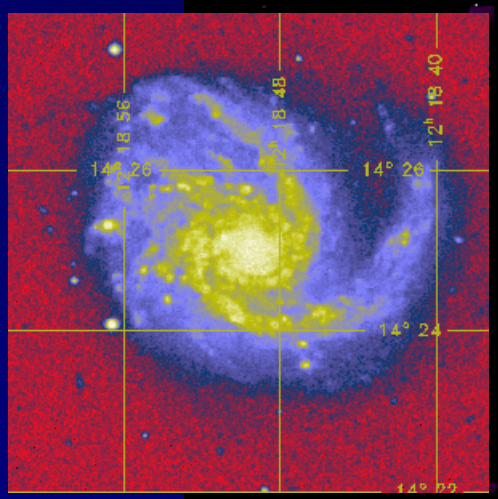


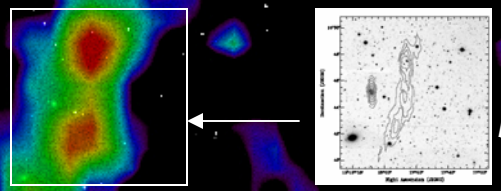
A data

21

m/s

Minchin et al 2007 (WSRT)



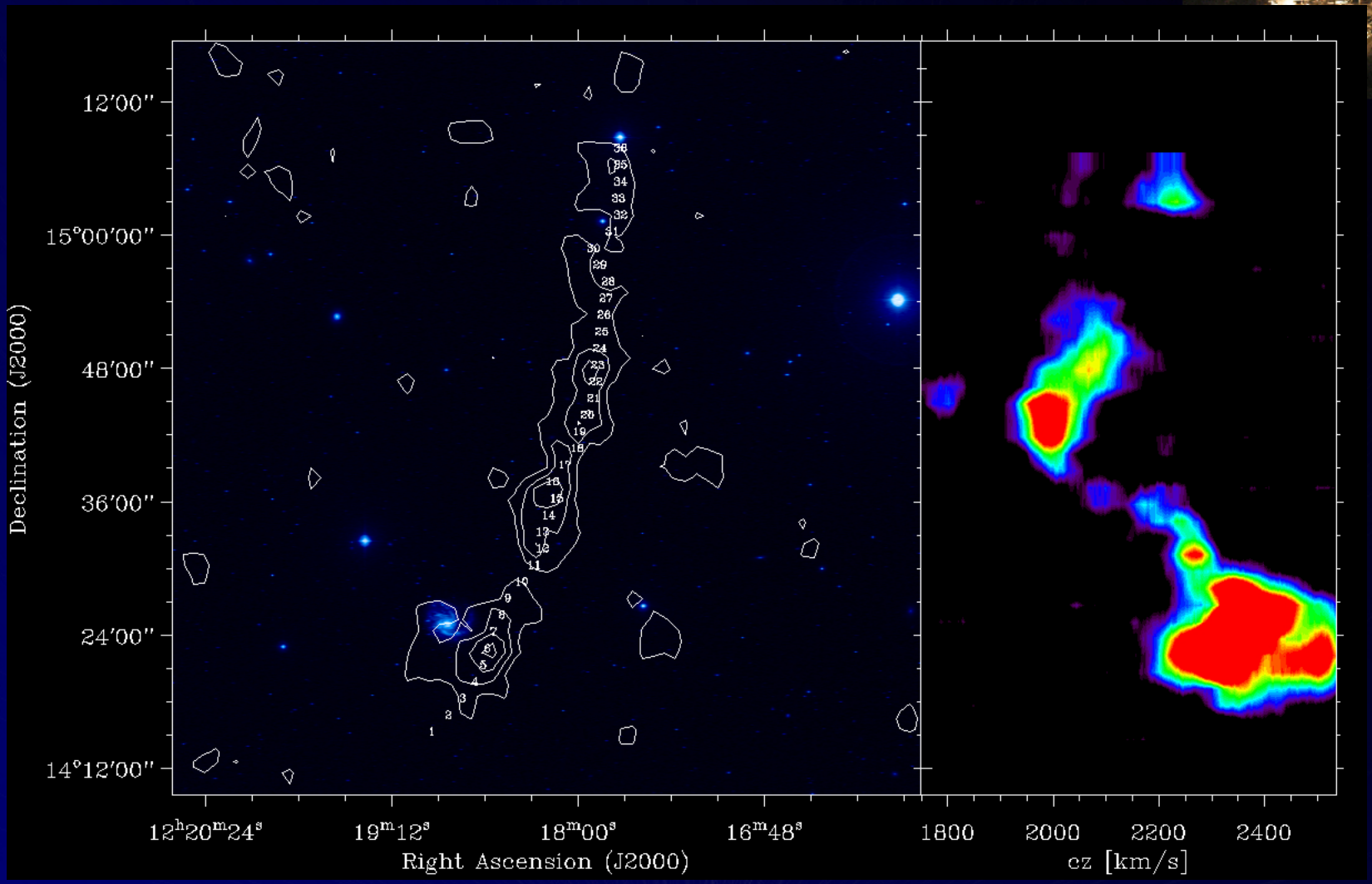


M_{HI} = *5x10⁸ solar*

10'

45 kpc

Haynes, Giovanelli & Kent (2007 ApJL)



Haynes, Giovanelli & Kent 2007, ApJL

ALFALFA

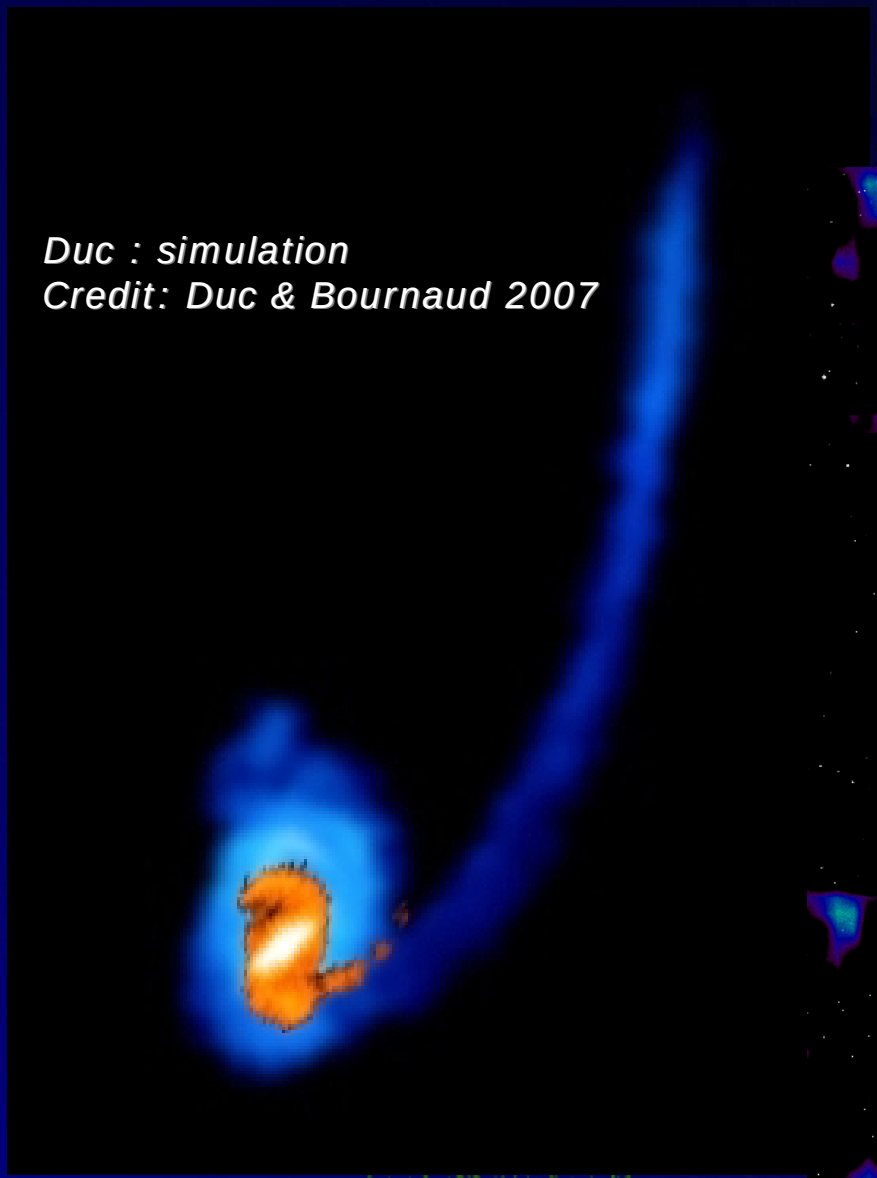
Note the following:

- *The prominent, anomalous m=1 spiral structure of N4254 is visible in the gas and in the old stellar pop:* ***gravity at work***
- *The HI mass in the stream is only 10% of HI mass in N4254: albeit spectacular, disturbance of NGC 4254 is relatively mild*
- *Velocity field of the stream shows the coupling of the tidal force and rotation of NGC 4254, suggesting an interesting timing argument:*
- *The stream exhibits memory of a full rotational cycle*
- *From the VLA map of N4254, we get the outer HI radius and Vrot at that radius ➔ rotation period ~ 800 Myr*
- *Hence the duration of the tidal encounter*

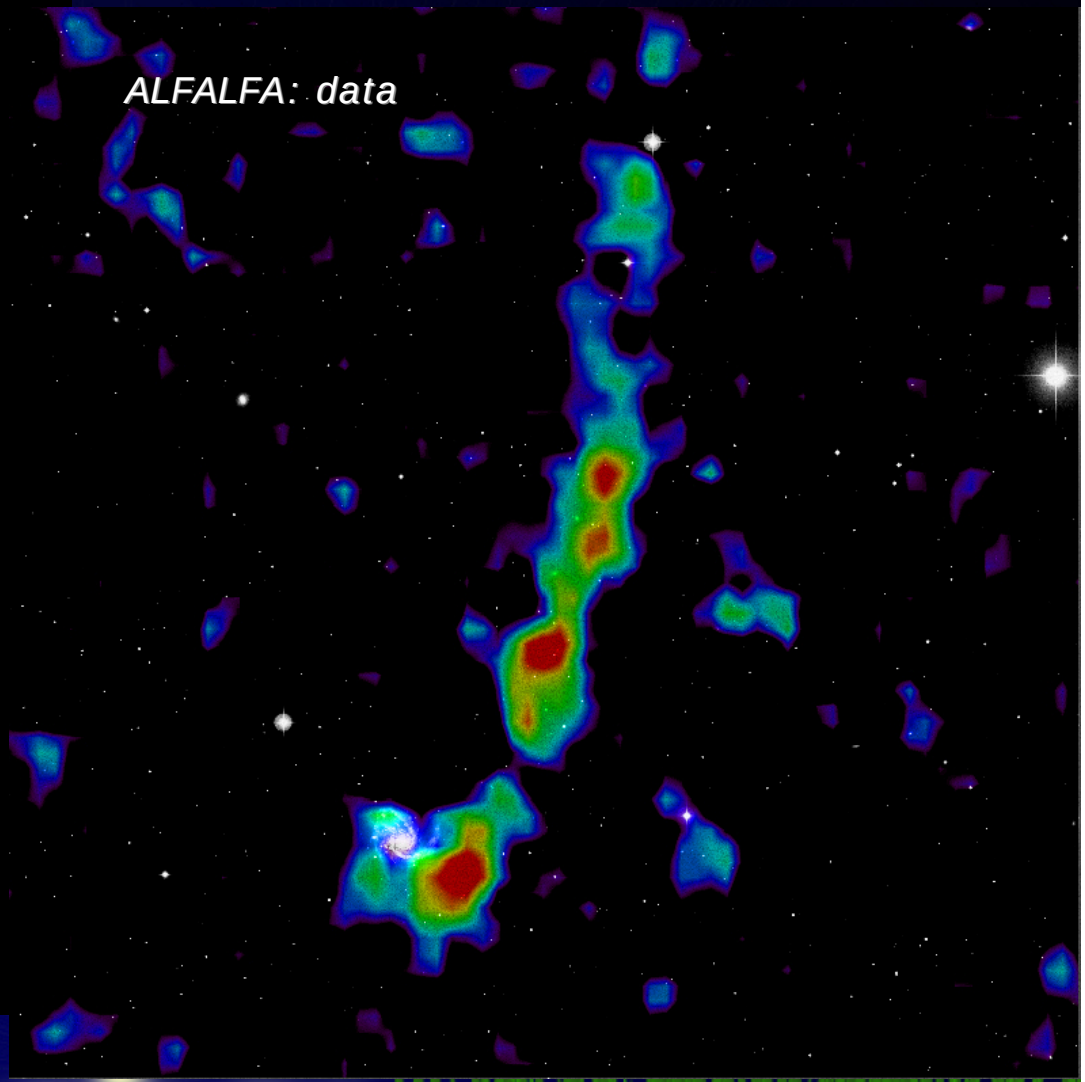
  ~800 Myr, comparable with the cluster crossing time

➔ we're witnessing an event of mild harassment of NGC 4254 in its high velocity transit through the periphery of the cluster

ALFALFA

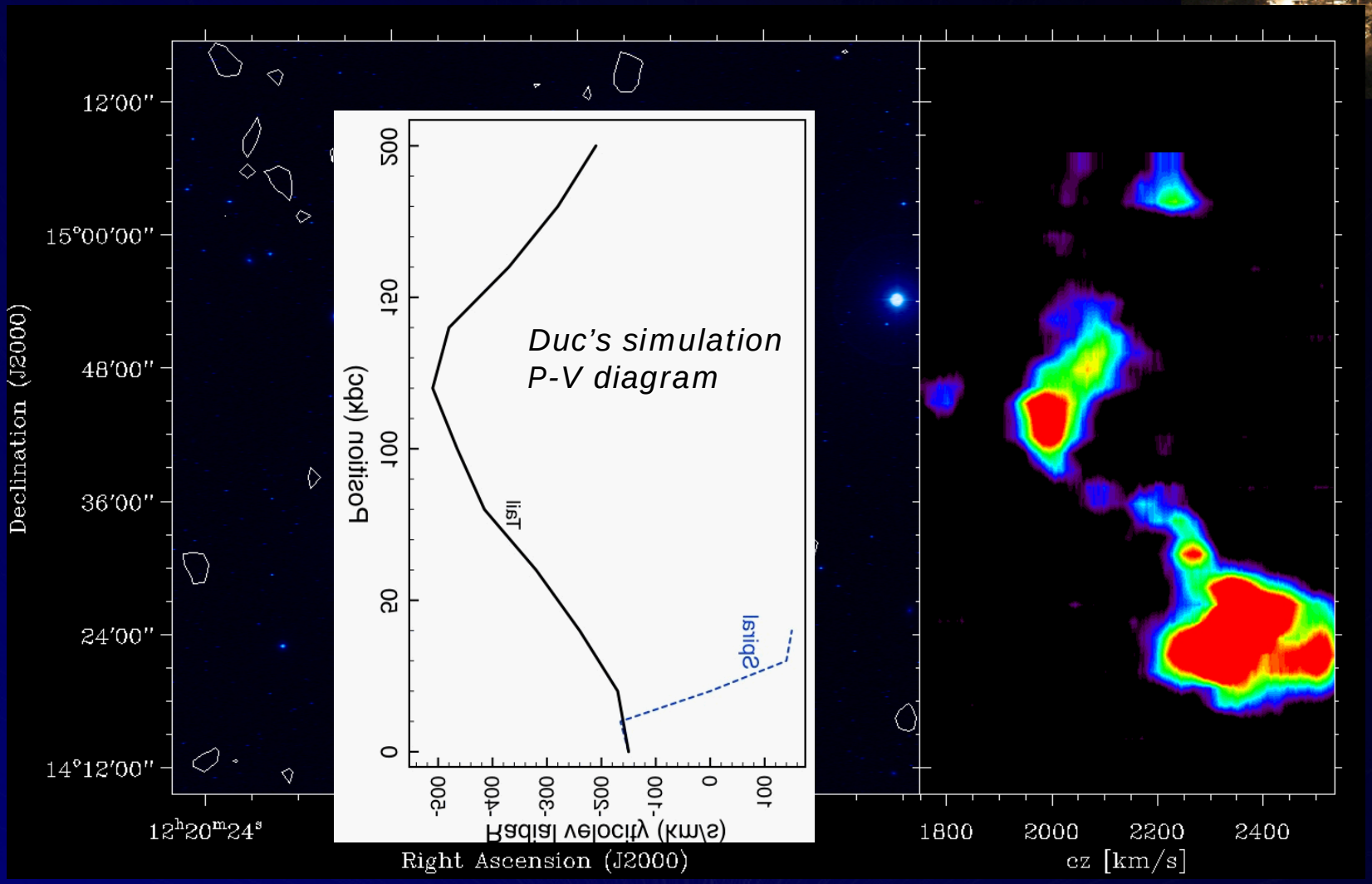


Duc : simulation
Credit: Duc & Bournaud 2007



ALFALFA: data

ALFALFA



Haynes, Giovanelli & Kent 2007, ApJL

ALFALFA as a low z HI Cosmology Survey

Does a cosmologically important population of optically faint but baryon rich low mass halos exist?

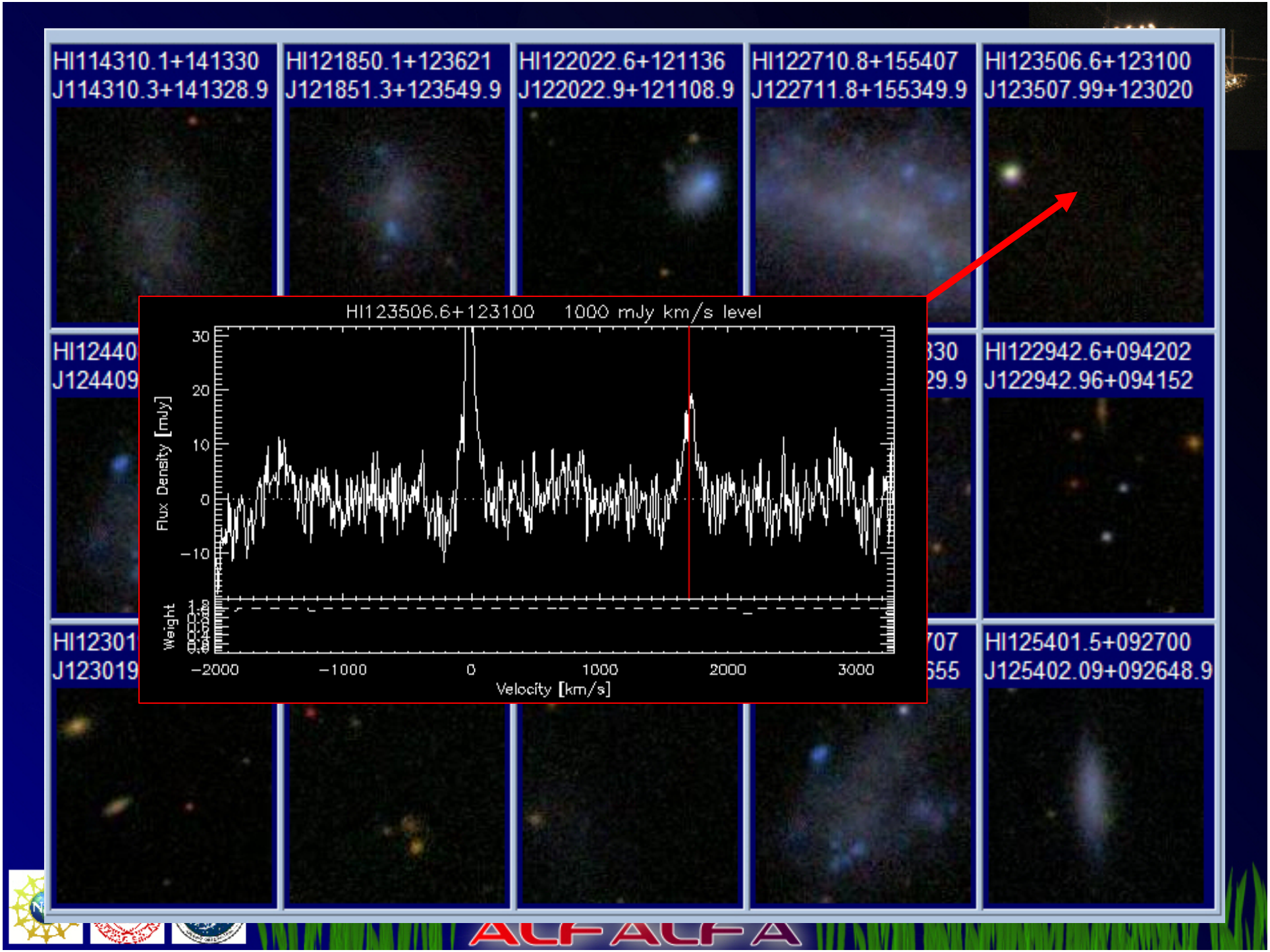
Do such objects preferentially exist in regions of low cosmic density ("voids"), in which massive galaxies are known to be underrepresented?

Does a significant population of optically "dark galaxies" exist?

If they exist, are such objects primordial or the result of secular processes?

Is there a cosmic density dependence of metallicity, i.e. do low mass systems in voids have preferentially lower heavy element abundances?

ALFALFA


HI114310.1+141330
J114310.3+141328.9
HI121850.1+123621
J121851.3+123549.9
HI122022.6+121136
J122022.9+121108.9
HI122710.8+155407
J122711.8+155349.9
HI123506.6+123100
J123507.99+123020
HI12440
J124409
HI122942.6+094202
J122942.96+094152
HI12301
J123019
HI125401.5+092700
J125402.09+092648.9
HI123506.6+123100 1000 mJy km/s level
Flux Density [mJy]
Weight
Velocity [km/s]
30
20
10
0
−10
−2000
−1000
0
1000
2000
3000
ALFALFA

ALFALFA as a low z HI Cosmology Survey

Does a cosmologically important population of optically faint but baryon rich low mass halos exist?

yes

Do such objects preferentially exist in regions of low cosmic density ("voids"), in which massive galaxies are known to be underrepresented?

no; Saintonge 2007 PhD thesis; Haynes' talk

(Basilakos et al 2007)

Does a significant population of optically "dark galaxies" exist?

Optically inert objects detected; see Kent et al. 2007 ApJL

If they exist, are such objects primordial or the result of secular processes?

the latter; Haynes et al. 2007 ApJL

Is there a cosmic density dependence of metallicity, i.e. do low mass systems in voids have preferentially lower heavy element abundances?

Prob no; Saintonge 2007

ALFALFA

http://egg.astro.cornell.edu/alfalfa

For participation guidelines, see:

http://egg.astro.cornell.edu/alfalfa/joining.php

Catalog access at:

http://arecibo.tc.cornell.edu/hiarchive/alfalfa/

ALFALFA