

# ALFALFA

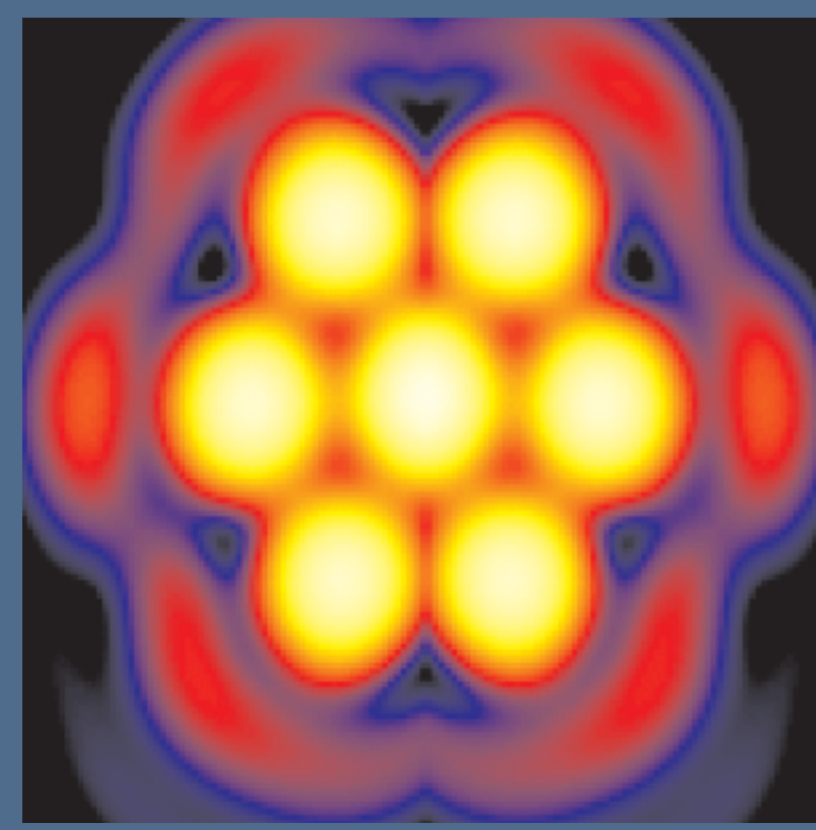


## A SIGNAL EXTRACTION UTILITY FOR THE ALFALFA SURVEY

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### ALFALFA : A SURVEY OF EXTRAGALACTIC HI WITH THE ALFA MULTI-BEAM SYSTEM AT ARECIBO

Sky area that will be covered	7074 deg <sup>2</sup>
Declination range	0° - 36°
Right Ascension range	07h30m-16h30m, 22h00m-03h00m
Frequency range	1335 - 1435 MHz
Velocity range	-1600 to 18000 km s <sup>-1</sup>
Observing mode	Fixed azimuth drift scan
Number of passes	2
Integration time per beam	48 seconds
Telescope time required	4130 hours



### A SIGNAL EXTRACTION UTILITY

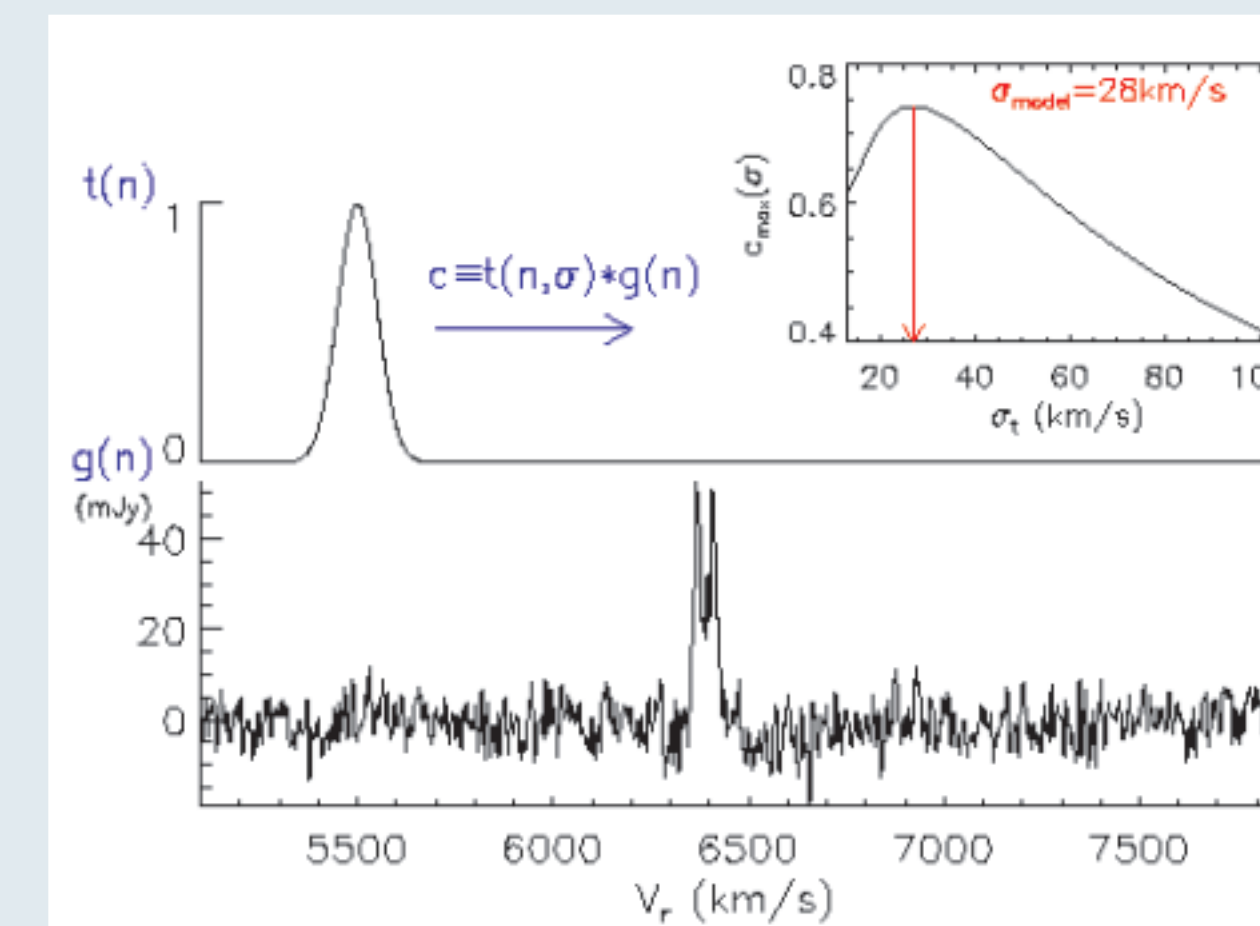


FIG 1. Overview of the matched filtering approach. Gaussian templates of various widths,  $t(n)$ , are convolved with the spectra,  $g(n)$ , in the Fourier space. The template that maximises the convolution is the modeled galaxy signal.

#### OVERVIEW

- A **matched filtering** approach
- Matching **Gaussian templates** with the spectra
- Calculations done in **Fourier space**
- Detections from individual spectra are combined
- **3-D models** of the detected galaxies are made

#### PERFORMANCE

The matched filtering approach and the Fourier space calculations make this signal extraction tool:

- **quick** to perform the calculations and more **robust** and consistent than "human" extraction
- **sensitive** to the *total flux* of the galaxy rather than just the peak flux

We have adopted the following definition for the signal-to-noise ratio

$$S/N = \begin{cases} \frac{F_{\text{peak}}}{\sigma} \left( \frac{W}{2 \text{ res}} \right)^{1/2} & \text{if } W < 200 \text{ km s}^{-1} \\ \frac{F_{\text{peak}}}{\sigma} \left( \frac{200}{2 \text{ res}} \right)^{1/2} & \text{if } W \geq 200 \text{ km s}^{-1} \end{cases}$$

where  $\text{res}$  is the spectral resolution in km s<sup>-1</sup>.

so for instance, a 50 km s<sup>-1</sup> wide feature with a peak flux to noise ratio of 3.5 will here have S/N=5.5

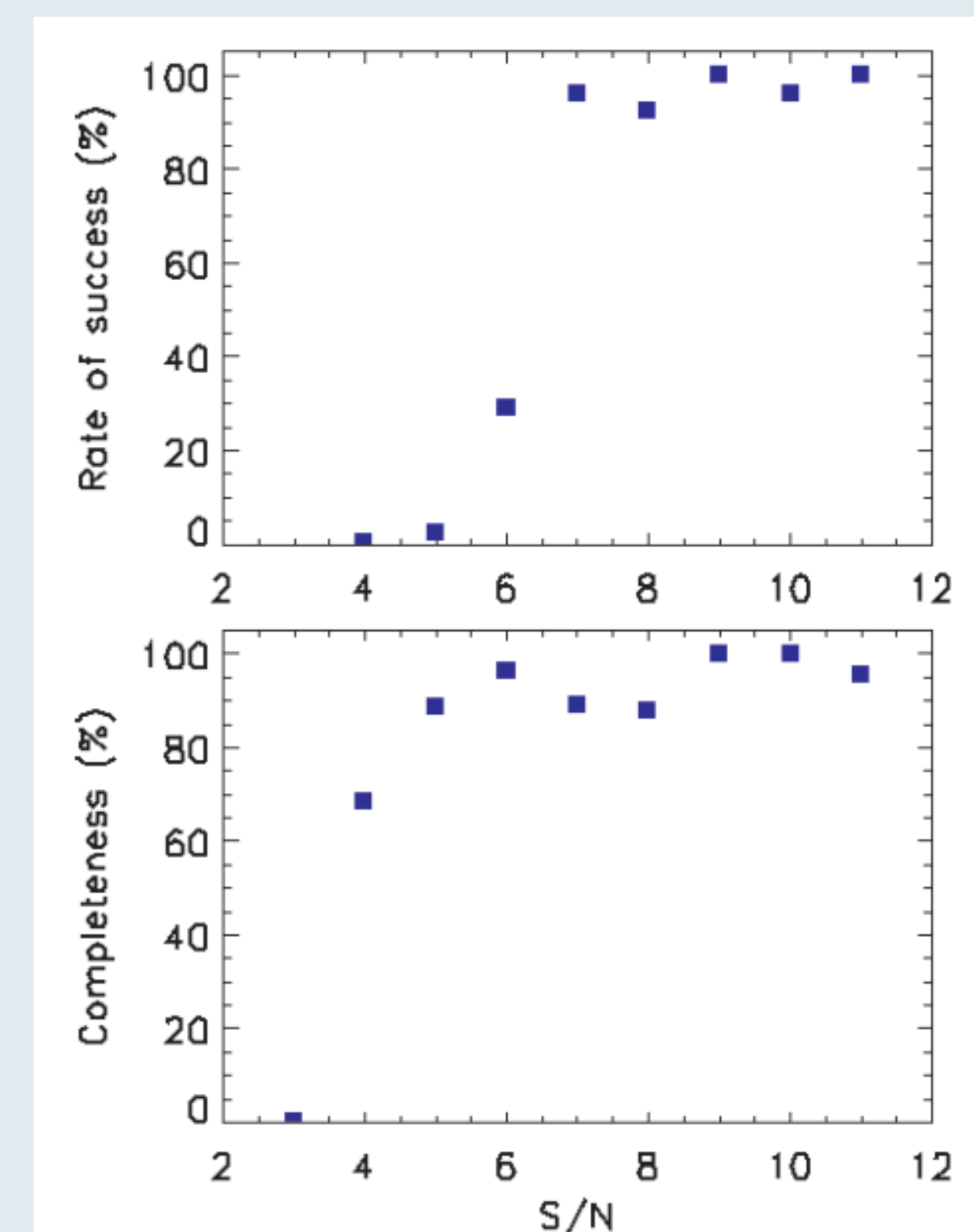


FIG 2. Reliability and Completeness of the signal extraction tool, based on the simulation of 400 galaxies. The top panel is the fraction of detections made as a function of S/N that are good. The bottom panel is the fraction of simulated galaxies that are retrieved as a function of S/N.

The signal extraction utility consists of:

- a **computation module** that works on individual position-velocity maps or on 3-D data cubes
- an **interactive display** to allow the user to view the results of the search
- a final **catalog** containing the detections made above the requested S/N threshold

The catalog contains for each galaxy: a centroid **position**, a **redshift**, a **velocity width**, **scale lengths** for both spatial directions, peak and integrated **fluxes**, **rms noise** and **S/N ratio**.

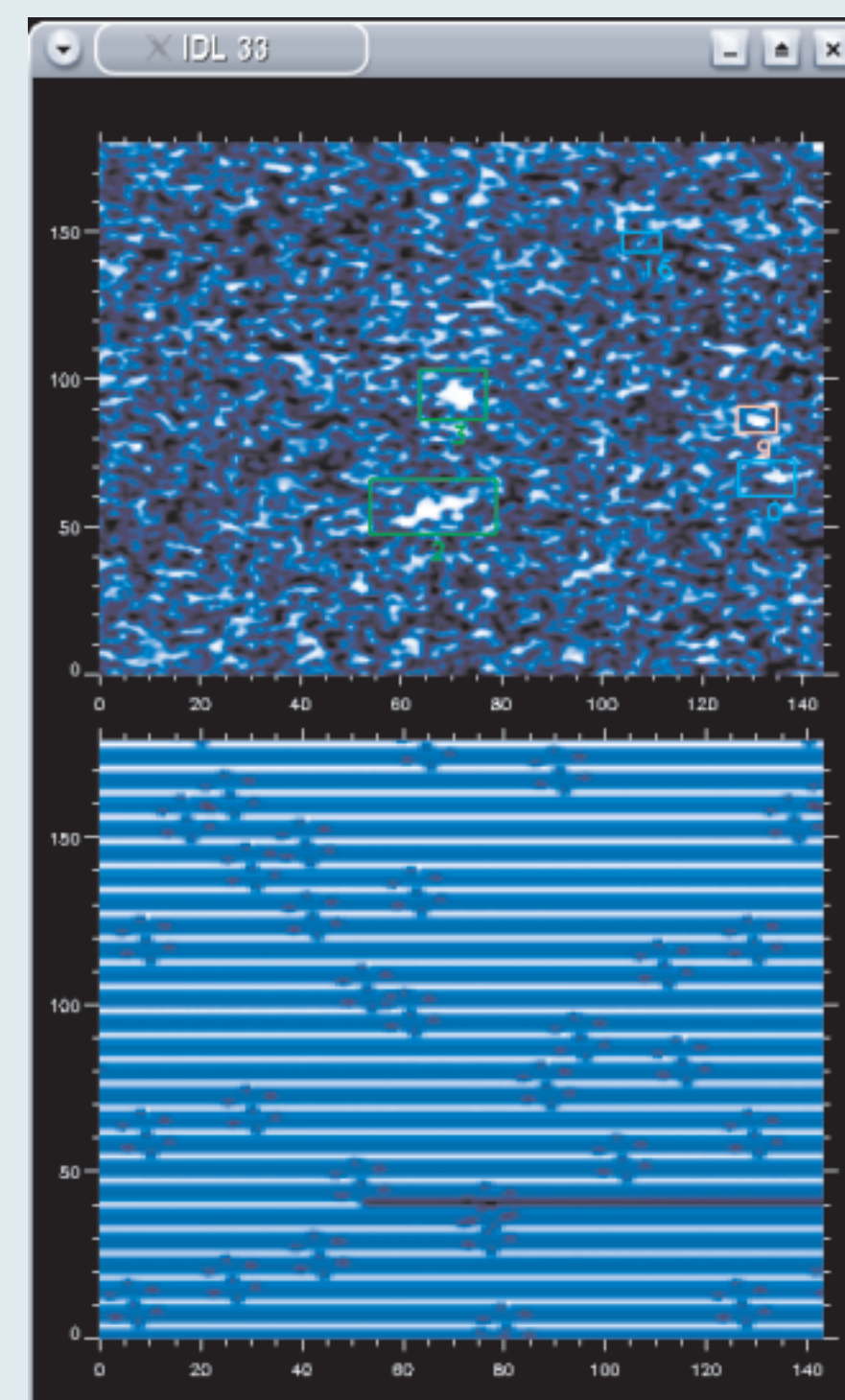


FIG 3. Example of the interactive display unit. The top panel is a slice of the data cube showing the RA-DEC plane at a constant velocity, and the bottom panel is the survey coverage over the same area.

## APPLICATIONS OF THE SIGNAL EXTRACTION TOOLS

### A VERY LOW SURFACE BRIGHTNESS GALAXY

No optical counterpart down to the surface brightness limit of the DSS2 blue.

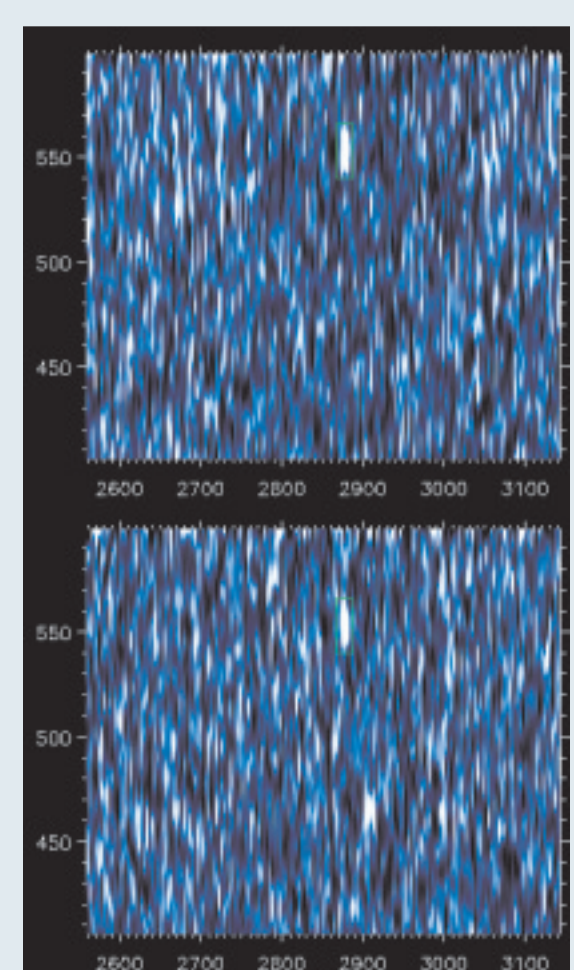


FIG 4. Position-velocity map showing the detection in channel 2880 ( $cz=3264 \text{ km s}^{-1}$ ) for both polarisations. The green box shows the extent of the galaxy as determined by the signal extractor.

$$\begin{aligned} cz &= 3264 \text{ km s}^{-1} \\ F_{\text{peak}} &= 20 \text{ mJy} \\ W &= 37 \text{ km s}^{-1} \\ M_{\text{HI}} &= 3.7 \times 10^8 M_{\odot}^* \\ M_{\text{dyn}} &= 4.2 \times 10^9 (r/1') M_{\odot}^* \end{aligned}$$

\* assuming that the source is not resolved by the 3.5' beam of ALFA

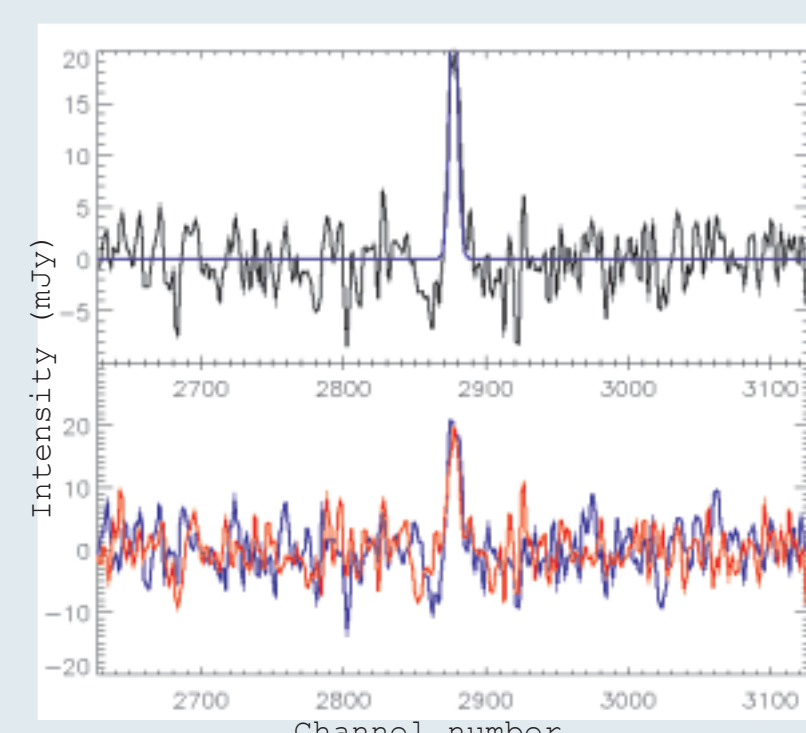


FIG 5. ALFALFA spectrum of the detection. The top panel shows the spectrum in black and the best model found by the signal extractor in blue. The bottom panel presents the two individual polarisations.

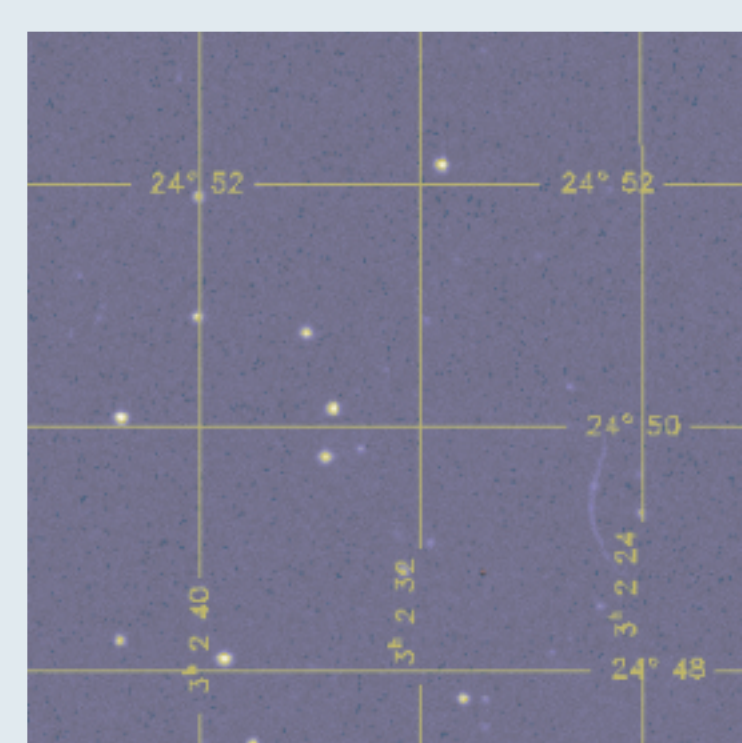


FIG 6. 10x10' image centered on the HI detection from the Digitized Sky Survey.

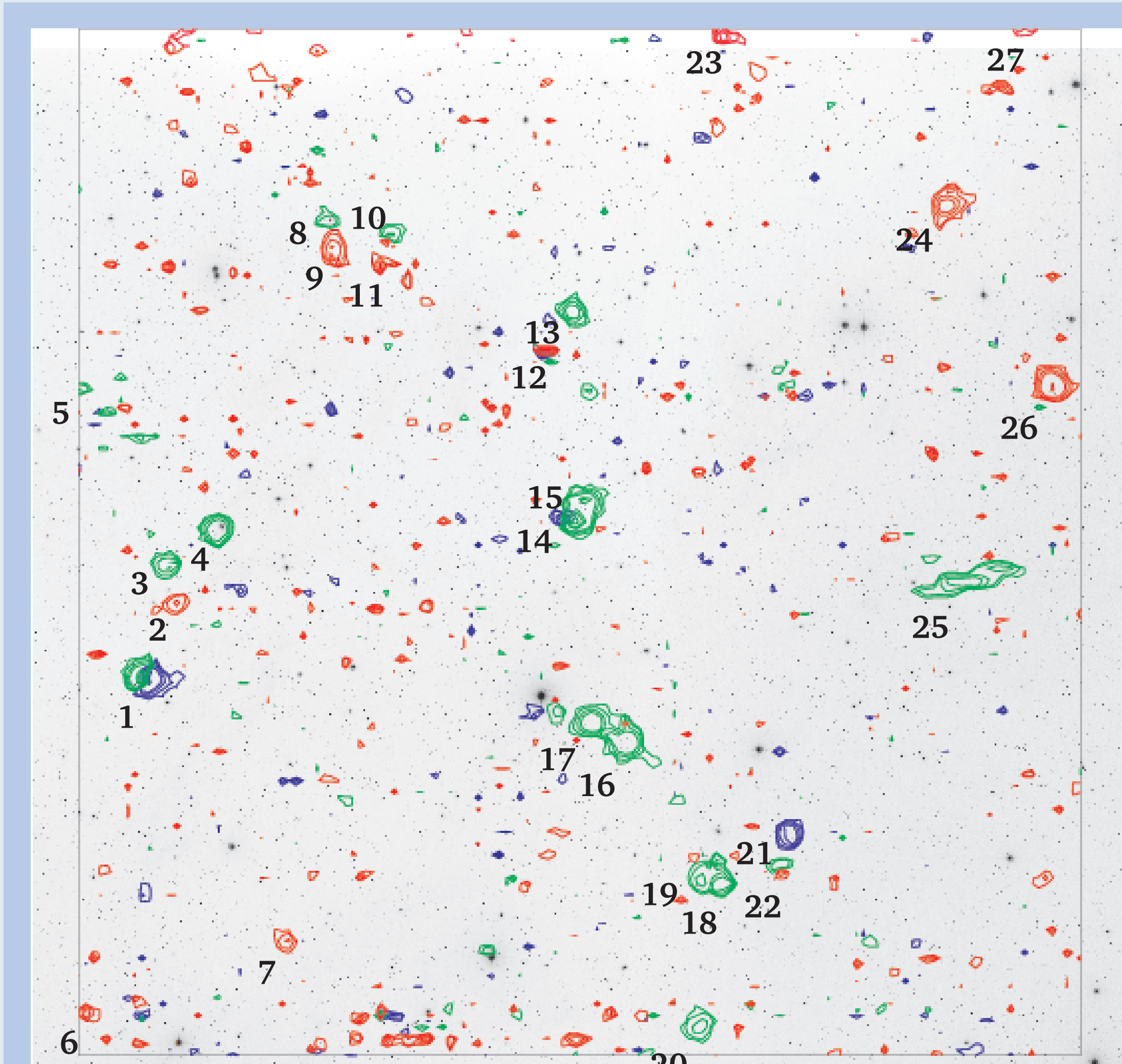
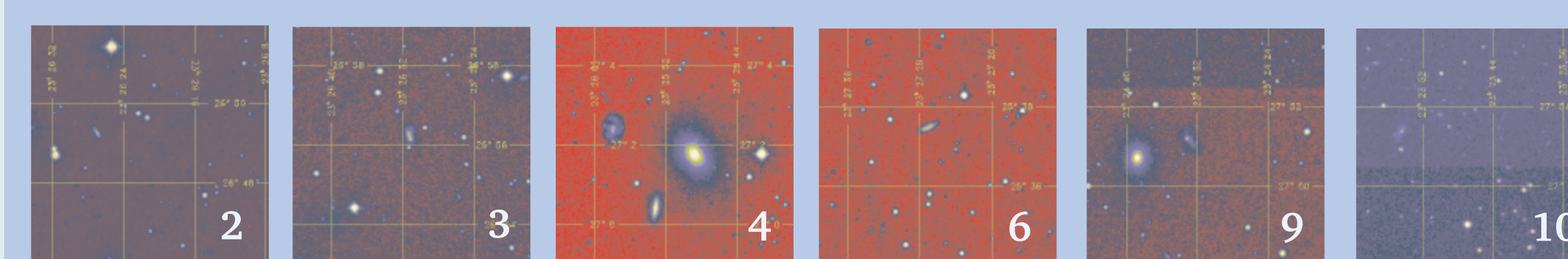


FIG 7. ALFALFA contours overlaid on the DSS2 blue image of a 3x3 degree region centered on UGC 12546 (RA=23 21 41, DEC=+27 05 14). The redshift ranges are: blue: 5000-5750, green: 5750-6250, and red: 6250-7680 km s<sup>-1</sup>.



### THE USGC844 GROUP

27 confident detections with S/N>5.5, 12 of which had no previously known optical counterpart or catalogued redshift.

FIG 8. 6x6 images from the DSS2 blue.

#	AGC #	cz (km s <sup>-1</sup> )
1	330451/2	5756
2	-	7609
3	-	5825
4	-	6110
5	-	6152
6	-	6636
7	-	6604
8	FGC2499	5895
9	-	6760
10	-	6233
11	-	7311
12	-	6690
13	330281	5943
14	12545	5761
15	12543/6	5989
16	330263	5852
17	331622	5880
18	12514	5884
19	330247	6056
20	330249	6077
21	12499	5590
22	330226	6238
23	4C+28.56	6389
24	-	7078
25	-	6147
26	330168	7338
27	12470	6809

### THE NGC 672 GROUP

Three galaxies with  $M_{\text{HI}} < 10^7 M_{\odot}$ , one previously unknown.

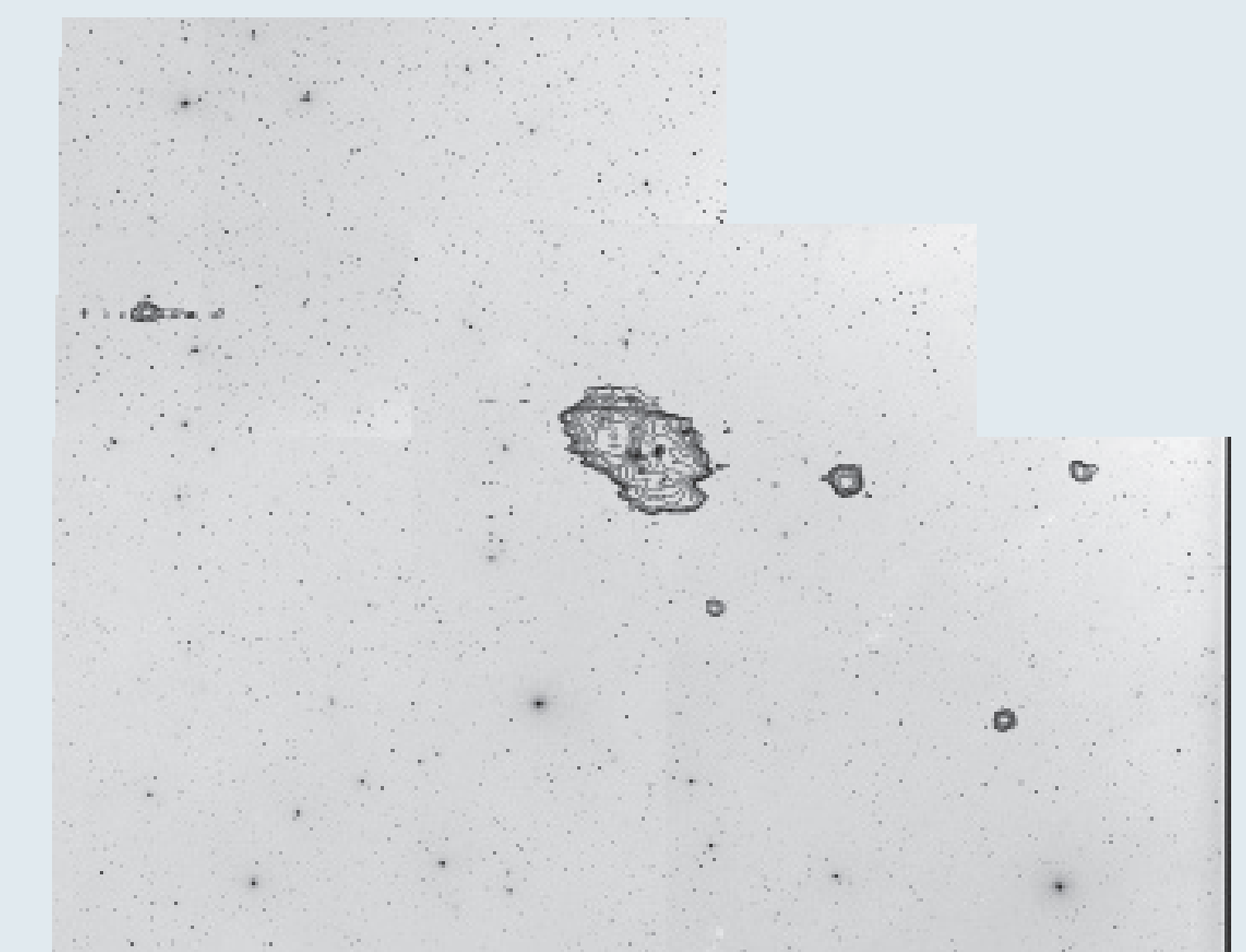


FIG 9. ALFALFA detections in a 4 x 3.5 degree region centered on NGC 672 / IC 1727 with velocities between 100 and 600 km s<sup>-1</sup>. The optical image is from the Digitized Sky Survey.

AGC #	RA (J2000)	DEC (J2000)	cz (km s <sup>-1</sup> )	log(M <sub>HI</sub> /M <sub>⊙</sub> ) *
112521	01 41 05.0	+27 19 00	278	6.77
110482	01 42 15.0	+26 21 00	366	7.13
111945	01 44 42.8	+27 17 19	428	7.66
111946	01 46 40.0	+26 48 00	371	6.95
1249 (NGC 672)	01 47 29.9	+27 20 00	345	8.82
1256 (IC 1727)	01 47 54.5	+27 25 58	422	9.05
111977	01 55 15.0	+27 57 00	210	6.75

\* HI masses from Giovanelli et al. 2005, AJ, 130, 2613