Request for Continuation of the ALFALFA Survey and Proposed Plan for 01Jul06-30Jun07

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28 January 2006

Introduction: ALFALFA, the Arecibo Legacy Fast ALFA Survey, is a two-pass drift scan spectral line survey intended to cover 7000 deg^2 of the high galactic latitude sky visible from Arecibo, with ∼eight times the sensitivity and four times the angular resolution of HIPASS. Because of its wide areal coverage and photometric accuracy, ALFALFA will provide a legacy dataset for the astronomical community at large, serving as the basis for numerous studies of the local extragalactic Universe. Since the survey initiated in Feb 2005, we have moved into full gear, acquiring high quality data and processing it using our own ALFALFA-IDL package. Two papers based on the precusor program A1946 have appeared in the *Astronomical Journal*, and ten ALFALFA presentations were given at the Jan 2006 AAS meeting. Two senior undergraduates are undertaking their senior research projects using ALFALFA datasets, and four graduate students are embarked on Ph.D. thesis research. Attracted by the initial ALFALFA results, new members have been added to the ALFALFA consortium, engaged in the team observations at Arecibo, in complementary observations performed or planned using a number of other telescope facilities and in performing relevant numerical simulations. It should be noted that ALFALFA survey efficiency is extremely high: with the exception of hardware failures, science data are acquired during ∼ 97% of each assigned observing block. Furthermore, the TOGS program has run commensally with ALFALFA since August 2005. In all respects, we believe ALFALFA is living up to its promise.

For the sake of brevity, we provide the URLs of the following documents/websites previously submitted to NAIC or containing information of direct relevance.

- ALFALFA Survey proposal, 15Oct2004, with the complete science justification
  http://egg.astro.cornell.edu/alfalfa/docs/alfalfaprop.pdf
- ALFALFA Year 1: Midterm Report, 15Aug2005
  http://egg.astro.cornell.edu/alfalfa/docs/midterm_report_2005.pdf
- ALFALFA A2010 Spring (Jan-Jun) 2006 Additional Time Request, 18Aug2005
  http://egg.astro.cornell.edu/alfalfa/docs/req_spring2006.pdf
- ALFALFA survey public website
  http://egg.astro.cornell.edu/alfalfa/
- ALFALFA observing team website
  http://www.naic.edu/∼a2010/galaxy_a2010.html

In this document, we provide additional/updated information which specifically demonstrates progress over the last six months and a plan and request for continuation of ALFALFA for the year commencing 01Jul06.

ALFALFA Highlights since August 2005:

- As of 20Jan2006, Project A2010 has conducted observations during 168 separate observing blocks, 99 since Aug2005. Graphical illustrations of the actual map coverage are shown in Figure 1 for the "fall" sky, 22^h <R.A.< 3^h (left) and "spring" sky: 7^h30^m <R.A.< 16^h30^m (right), separately. It should be noted that many of the assigned observing blocks do not cover the full range of LSTs required by ALFALFA; the assignment of more but shorter blocks proves to be more convenient for the AO telescope scheduler to accomodate other observing programs. In fact, 31 blocks of time scheduled between 09Dec05 and 19Jan06 were designed to "fill in" coverage missed in spring 2005. As evident in Figure 1, the time allocation to date, including those of the last month, has allowed us to sample the full LST range, in both passes, only from about +25.8° to +29.2° (rather than +24° to +32°) in the fall sky and +9° to +14° (rather than +8° to +16°) in the spring sky. The most recent observations have helped considerably. We will continue to schedule some of the time allocated in the next months to complete the four 4° strips of tiles we have already started as well as initiating the new ones as proposed here.
- TOGS runs commensally with A2010. In practice, the real-time burden for running the TOGS calibration is borne by the A2010 observer since it is he/she who executes the TOGS command files both before and after the A2010 observations. We have also assumed responsibility for working with NAIC staff to update and then test the modified TOGS calibration script when we evolved the A2010 observing sequence to the latest CIMA version (Dec 2005).

- In keeping with the adopted ALFALFA guidelines for the science collaboration, a number of specific science projects, most notably six led by students, have been proposed and approved by the ALFALFA Oversight Committee; more are expected in the coming months. Active project summaries can be found at *http://egg.astro.cornell.edu/alfalfa/projects/projects.php*.
  1. Team projects:
     - *"Blended HI signals from Distant Clusters"*, (Lead: Hoffman)
     - *"An H-alpha Imaging Survey for a Volume-Limited Sample of ALFALFA Sources"*, (Lead: Salzer)
     - *"Synthesis Imaging of Low Mass Dwarfs discovered by ALFALFA"*, (Lead: Begum)
  2. Graduate student projects:
     - *"Chemical abundances of low mass galaxies"*, (Lead: Saintonge; Adviser: Giovanelli).
     - *"'First epoch ALFALFA Virgo cluster survey"*, (Lead: Kent; Adviser: Giovanelli).
     - *"Cross-correlation of ALFALFA HI detections with SMUDGES objects"*, (Lead: Nair; Adviser: van Zee).
     - *"ALFALFA survey of the Leo region"*, (Lead: Stierwalt; Adviser: Haynes).
  3. Undergraduate student (senior) projects:
     - *"Low-mass CDM halos in group-free environments"*, (Lead: Altaf; Adviser: Hoffman)
     - *"Rich groups in the ALFALFA survey: Zw1400.4+0949"*, (Lead: Walsh; Adviser: Balonek)
- Two papers based on the original A1946 precursor observations appeared in the December 2005 issue of the Astronomical Journal:
  - *"The Arecibo Legacy Fast ALFA Survey: I. Science Goals, Survey Design and Strategy"*, Giovanelli *et al.*, 2005, Astron. J. 130, 2598
  - *"The Arecibo Legacy Fast ALFA Survey: II. Results of Precursor Observations"*, Giovanelli *et al.*, 2005, Astron. J. 130, 2613.
- Ten presentations, two at the ALFA special session and eight posters, were presented by ALFALFA team members at the January 2006 AAS meeting. The posters included first science results and reports on the ALFALFA undergraduate activities. First science highlights include discovery of several tidal/harassment HI debris fields in the Virgo cluster; detection of HI well beyond the previous maps of the Leo Ring and the Leo Triplet; the discovery of several low HI mass ($\sim 10^7 M_\odot$), very nearby dwarf galaxies; and initial surveys of part of the Virgo cluster, the Leo Group and several other rich groups. Copies of all of the posters and talks can be found at *http://egg.astro.cornell.edu/alfalfa/pubs/aas06.php*.
- The working group on complementary and followup observations engaged in a number of activities leading to the planning and acquisition of new observations. These include:
  - Complementary broadband and narrow-band Hα images were obtained of newly discovered nearby dwarf galaxies with the WIYN 0.9m telescope (van Zee, Salzer), the SAO 6-m telescope (Karachentsev) and the Wise Observatory 1-m telescope (Brosch). Following detection of Hα, long-slit spectra were obtained of selected HII regions with the Palomar 5m telescope for the purpose of determining their metallicities (Lead: Saintonge). These will continue in 2006.
  - VLA-C observations of a newly discovered HI cloud complex in the Virgo cluster obtained on 11Jul05 were fully reduced; further observations of this complex using VLA-D were obtained in Jan2006 taking advantage of a special circumstance short-notice opportunity. (Leads: Spekkens and Momjian)
  - A proposal to determine tip of the red giant branch distances to newly discovered very nearby galaxies was submitted to HST (Lead: Skillman)
  - A proposal to conduct synthesis imaging of several newly discovered nearby dwarfs was submitted to the GMRT. (Lead: Begum)
  - A proposal to map low velocity gas in the vicinity of the Virgo cluster was submitted to the GBT. (Lead: Kent)
  - A proposal for followup time with Spitzer is being prepared for the the upcoming deadline (Leads: Giovanelli and Charmandaris).
- The ALFALFA-IDL package was further developed and extended. Most recent work has focused on gridding routines, visualization and cross-correlation tools exploiting the VO environment, 2-D and 3-D signal extraction and catalog generation, and parameter measurement algorithms. ALFALFA-IDL was successfully installed at two additional sites, Colgate and Indiana Universities, bringing the total now to six, with more to follow. See below for further detail on data status.

- Results of the precursor observations were placed in an SQL database in the public domain using a PHP interface; see *http://egg.astro.cornell.edu/alfalfa/data* from which it is possible to download the catalog in XML/VOTable format or perform an SQL query. It should be noted that the precursor data do not have full ALFALFA sensitivity and do not conform to final ALFALFA standards.
- We have joined a Cornell collaboration involving the Cornell Theory Center and other large dataset holders on campus for development of hardware and software tools for the permanent storage of and access to the ALFALFA data archive. The AGES collaboration has asked to take advantage of our developments in this area.
- Further development of the data product protocol for ALFALFA was accomplished using the existing Cornell HI Digital Archive (Springob *et al.* 2005, ApJS, 160, 149) by Brian Kent as his project for the 2005 NVO School. The HI archive can be accessed as a prototype cone search and using a VO interface IDL client. In addition, this work will be extended to ALFALFA using the VO compliant SSAP for data cubes.
- Cornell ALFALFA "experts" provided on-site instruction and training to team members at Arecibo, including several students and first-time Arecibo visitors. In December 2005, Becky Koopmann (Union) and her undergraduate student Bilal Mahmood and graduate student Prasanth Nair (Indiana) accompanied Martha Haynes. In January 2006, Tom Balonek (Colgate) and his undergraduate student Brian Walsh accompanied Cornell graduate student Sabrina Stierwalt.

Plan for the Next Year: Figure 2 illustrates the current and proposed ALFALFA sky coverage, particularly in the context of local large scale structure. The coverage planned for 2005 is shown shaded in blue; further observations in 2006 are necessary to complete this area. We had originally proposed to cover during by June 2006, two more sets of "spring" tiles, one centered at Dec = +06° (green shaded areas in Figure 2) and a second one, further north, centered at Dec = +30°. Because of time allocation pressure and the fact that we did not start ALFALFA until Feb 2005 (whereas the "spring" time allocation ideally would have begun in December 2004), it does not appear that we will be able to map both of those sets this spring. In conversation with NAIC staff, we have agreed to concentrate on completion of the drifts not yet acquired in the tiles targeted in 2005 (+10° and +14°; shaded blue) and to attempt to complete a single addtional one at Dec = +06° (green). However, we hope over the following year to continue ALFALFA sky coverage at the proposed rate of two sets of 4° tiles per year. For the year beginning 01Jul06, these are the magenta shaded strips of tiles in Figure 2: the +06° and +14° set of tiles in the "fall" and +26° and +30° in the "spring". The priority for coverage of these strips is motivated by the desire to achieve the principal ALFALFA science objectives, with special attention to the timely acquisition of datasets required for PhD theses. Particular reasons for the choice of these particular sets of tiles is highlighted briefly below.

- Coverage of the Dec = +06° spring strip will extend the Virgo cluster survey to the south, providing fertile ground for the Ph.D. thesis of graduate student Brian Kent (Cornell). Coverage of the same set of tiles in the fall sky will produce complete overlap with the optical SMUDGES strip being surveyed at BVI wavelengths (van Zee). As part of his Ph.D. thesis research, graduate student Prasanth Nair (Indiana) will perform a cross-correlation of ALFALFA with the SMUDGES dataset.
- The chosen strips provide maximum overlap with the SDSS outside of the equatorial zone (which because it lies at high zenith angle as view from Arecibo is of lower sensitivity) including the SDSS strip at Dec = $\sim$ +15° in the fall sky.
- The +26° and +30° spring strips will map both the Coma cluster (Abell 1656; z= 0.0232) itself and its supercluster environment, extending southward towards Abell 1367. Gavazzi, Scodeggio and collaborators have a large collection of multiwavelength data covering this region in their *GOLDMINE* database. Additionally, these strips cut across the supergalactic plane nearly parallel to the more southerly ALFALFA strips but offset by more than 15° in SGL, providing an excellent sampling of the central regions of the Local Supercluster.
- The fall Dec = +14° strip includes the AGES precursor target, the group around NGC 628, allowing comparison of the ALFALFA and AGES datasets. The AGES observations covered only 5 deg^2; ALFALFA will trace the group structure over a much wider region including its possible extention southward towards the NGC 660 group. This strip will also contain part of the AGES7448 region; we have already surveyed AGES33PP, AGESGAL2082, and AGESVC2, all future AGES (A2048) targets.

Dataset and product status: Processing of the data is proceeding according to schedule. Raw data in FITS format are converted to IDL and transferred to Cornell daily. Processing to Level I typically occurs within days to weeks using a standard pipeline in ALFALFA-IDL. The most laborious part of Level I processing is the flagging of RFI, a necessary (unfortunately) and extremely beneficial exercise. Construction of final data products has been limited by the incomplete coverage of datasets due to the spottiness of time allocation, but we believe we are well positioned for a first data release in mid 2006. A few points are worthy of note:

- About 1 TB of Level I datasets (2-D) are currently housed at Cornell for quick access. Reduction status as of 25Jan2006 can be found at *http://egg.astro.cornell.edu/alfalfa/data/arch060125.htm*; nearly all data acquired prior to Dec 2005 have been processed to Level I. The Level I datasets are produced by numerous team members following a very strict protocol and after a thorough training session by a reduction "expert". Each Level I dataset is later checked for quality by a senior member (RG) of the team before being delivered into the archive. Cataloguing and archiving is also carried out by a senior individual (MPH), providing a second check.
- Signal extraction in both the 2-D and 3-D datasets is performed using a Fourier domain technique developed by graduate student Amélie Saintonge and makes use of confirmation in both polarizations, both passes and adjacent beams. Because of the extreme value of these multiple "confirmation" checks, it is necessary to have all data in hand to produce final catalogs of reliable detections.
- The construction of "dirty" 3-D grids from the entire Level I is possible using a single, simple routine which searches the "positions" database to identify quickly those 2-D datasets which contribute to the desired grid. This "positions" IDL structure also records the RFI flags, baselines and other information of relevance to future processing, especially the identification of signals using the detection algorithms.
- As part of the initial examination, we perform a preliminary "eyeball" inspection of the 2-D drifts for possible HI detections and an immediate cross correlation with other public datasets (NED, NVSS, DSS2 and, where available, SDSS). Although the data are not, at this stage, at full sensitivity nor of highest quality, this quick inspection has allowed us to identify immediately the most exciting targets for complementary and followup observations.

Additional activities planned during 2006:

- A Year 2 workshop for the team is planned for June 2006 in Ithaca, similar to the ones held in Milan and in Ithaca in 2005.
- A second workshop for undergraduates involved in summer research related to ALFALFA is planned for July 2006, again at Union College. In addition to the schools participating last year, additional invitations will be extended to Deborah Elmegreen (Vassar) and Bruce Partridge (Haverford), both of whom have expressed interest in attending.
- Becky Koopmann (Union) and Tom Balonek (Colgate) will both spend their AY06-07 sabbatic leaves at Cornell engaged in ALFALFA research and analysis. Having participated in ALFALFA observing at Arecibo recently, they will also spend time at Arecibo next year carrying out ALFALFA observations and helping to develop educational materials geared for undergraduates. Noah Brosch (Tel Aviv) will spend part of his AY06-07 sabbatic at Arecibo and at Cornell.
- We will continue to provide training sessions for less experienced ALFALFA team members on site in Arecibo. In Feb 2006, Martha Haynes will be joined at Arecibo by Dave Kornreich (Humboldt State) and graduate student Shea Brown (Minnesota). Other similar trips will be scheduled later in the year.

Summary of Request: Completion of a single strip of ALFALFA 4° tiles in 2-pass mode requires 33 observing sessions with the second half occuring 3-9 months after the first. We understand that it is more convenient for the AO scheduler to schedule A2010 in more, but shorter blocks, which we can then stitch together to provide complete coverage of the ALFALFA survey region. Such a scheme, while somewhat less efficient and more burdensome in terms of bookkeeping, is quite acceptable to us. We therefore request for the period 01Jul06-30Jun07 that A2010 be scheduled for **the equivalent of 66 sessions from LST 21^h40^m to 03^h10^m during the period Aug06-Jan07** and **the equivalent of 66 sessions from LST 07^h10^m to 16^h40^m during the period Dec06-Jun07**. As always, TOGS will run commensally with ALFALFA.

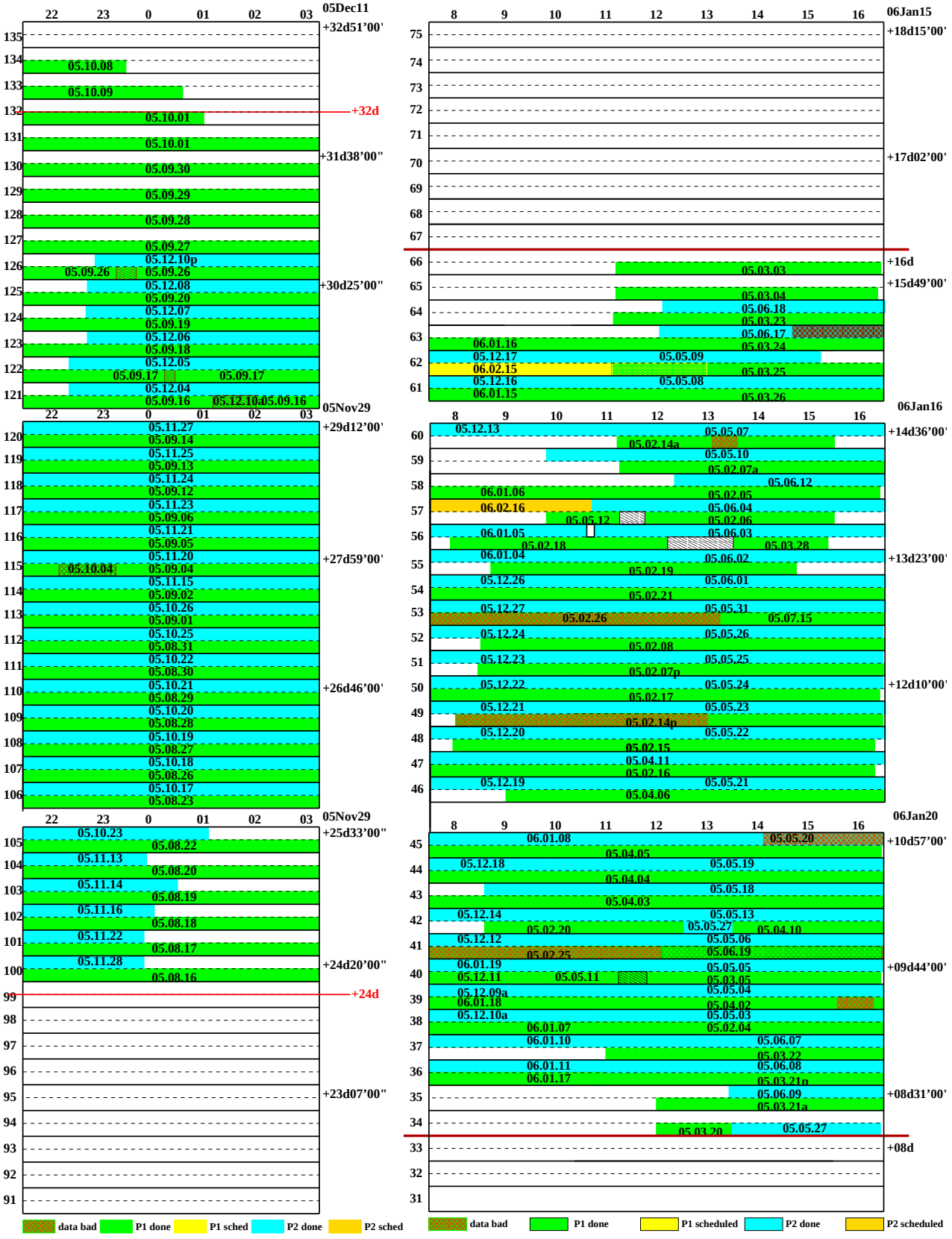

Figure 1: Actual ALFALFA survey sky coverage for the "fall" (left) and "spring" (right) tiles as of 20 Jan 2006; the two passes are indicated separately. The vertical label indicates the drift designation (corresponding to the declination of Beam 0) in our two-pass strategy; see *http://www.naic.edu/∼a2010/alfalfa_driftmaster.txt*. These diagrams are updated regularly at: *http://egg.astro.cornell.edu/alfalfa/scheds/index.php*.

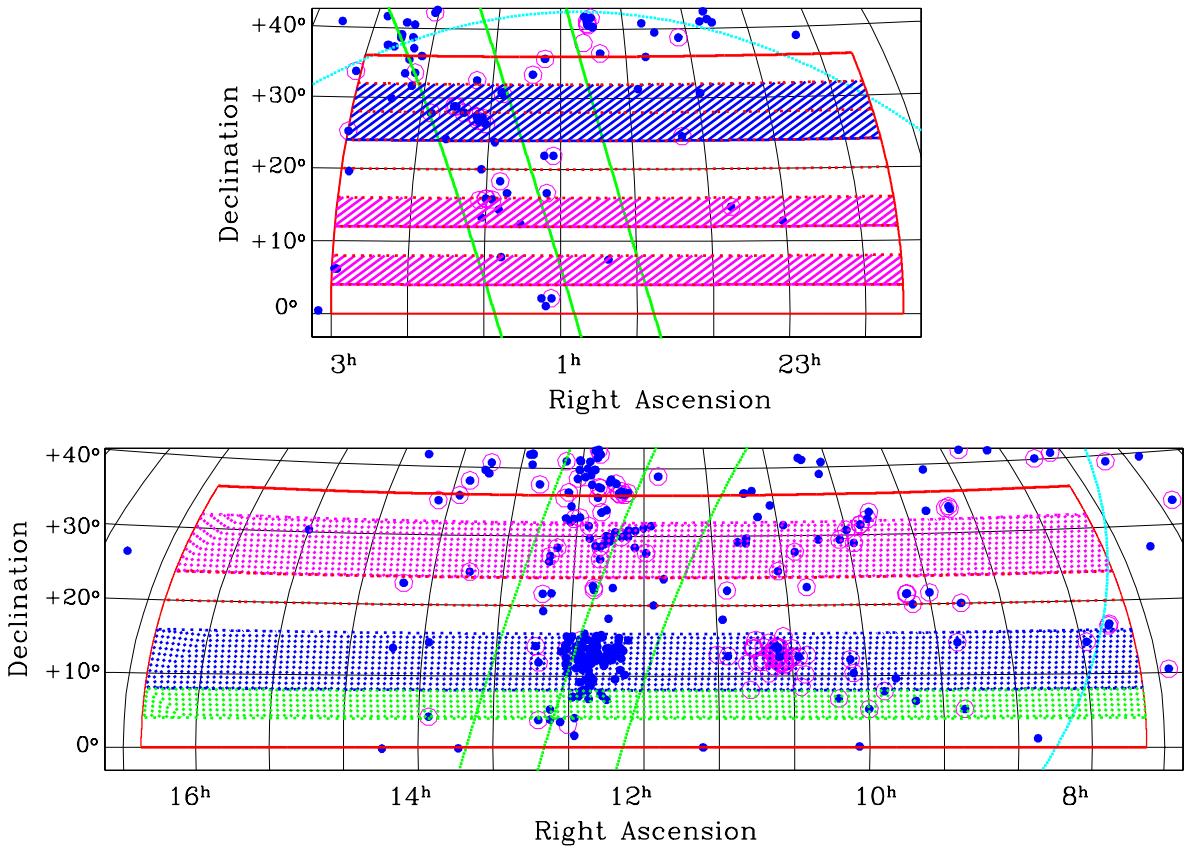

Figure 2: Proposed A2010 sky coverage for the next year: Fall 2006 (upper) and Spring 2007 (lower). Blue shaded areas outline the coverage planned for 2005, from 7^h30^m <R.A.< 16^h30^m, $+8^\circ$ < Dec.< $+16^\circ$ and 22^h <R.A.< 3^h, $+24^\circ$ < Dec.< $+32^\circ$. Actual coverage to date is detailed in Figure 1. Further allocations in Dec2005 through June 2006 will aim to complete the two spring sets of tiles begun in 2005 and the 4° wide strip at Dec. = $+06^\circ$. (shaded green). The allocation requested here for the year starting 01Jul2006 targets the 4° wide tiles at Dec. = $+06^\circ$ and $+14^\circ$ (fall) and Dec. = $+26^\circ$ and $+30^\circ$ (spring) shown as the magenta shaded areas. The solid red lines outline the proposed survey area for the full ALFALFA survey, while dotted red lines make the designated ALFALFA tile boundaries. The cyan line traces b = $+20^\circ$, while the green lines trace SGL = -10°, 0° and $+10^\circ$. Blue filled circles mark galaxies with observed heliocentric recessional velocities cz < 700 km s^{-1} while open magenta circles denote objects believed to lie with 10 Mpc, based largely on primary distances (Karachentsev *et al.* 2004).