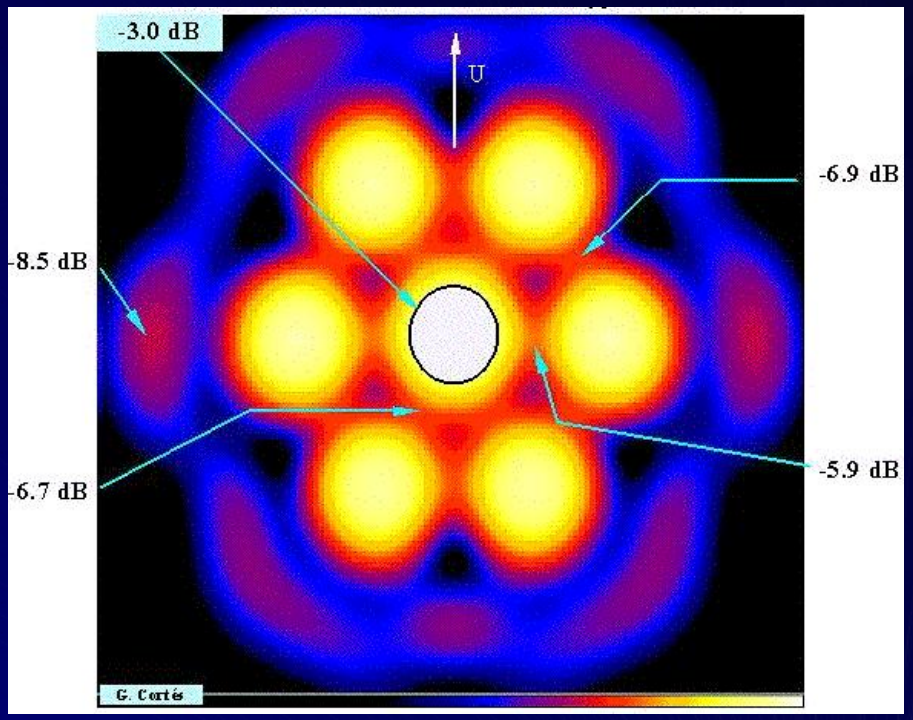
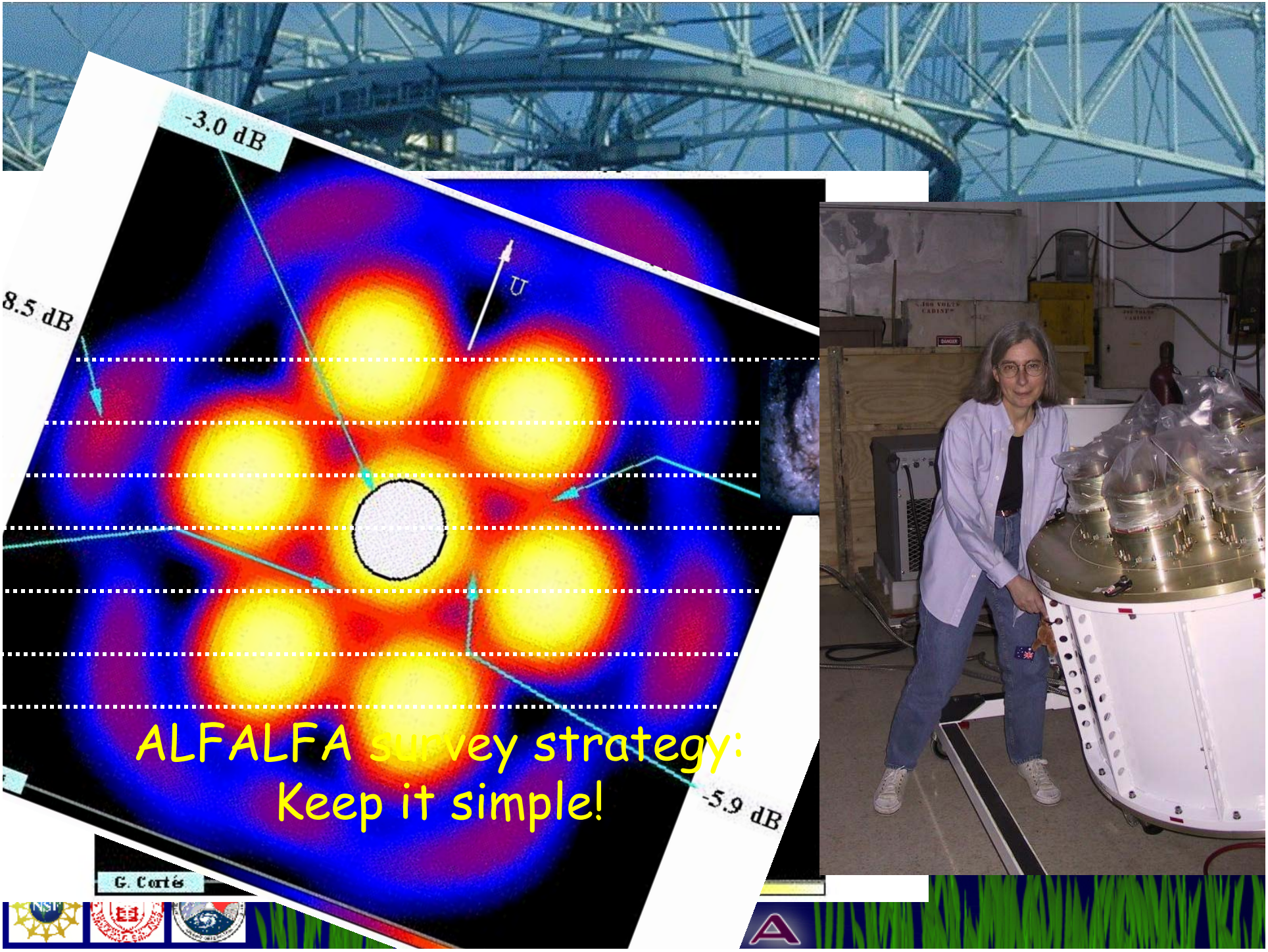
Using ALFA for ALFALFA



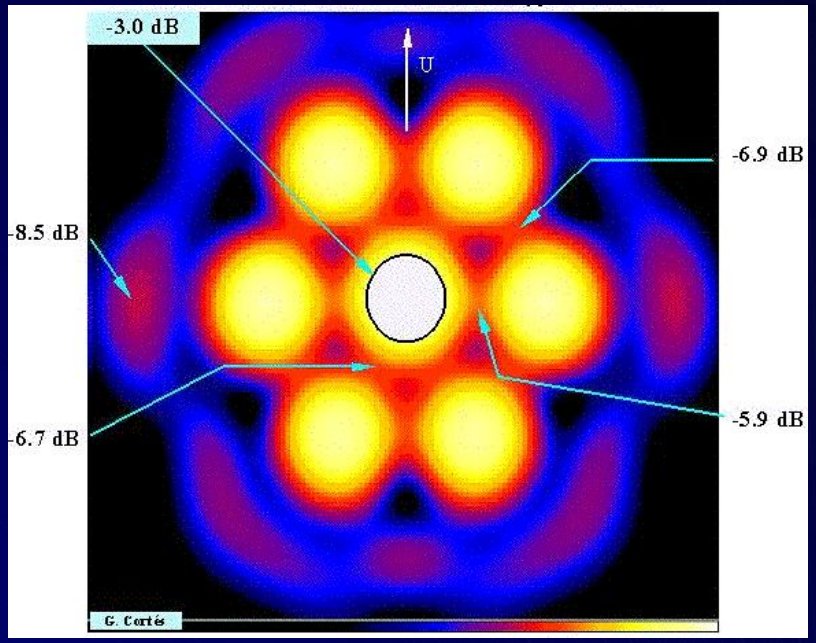
Martha Haynes, Cornell University
2006 ALFALFA Undergraduate Workshop

ALFALFA



ALFALFA survey strategy: Keep it simple!

ALFA as a Camera



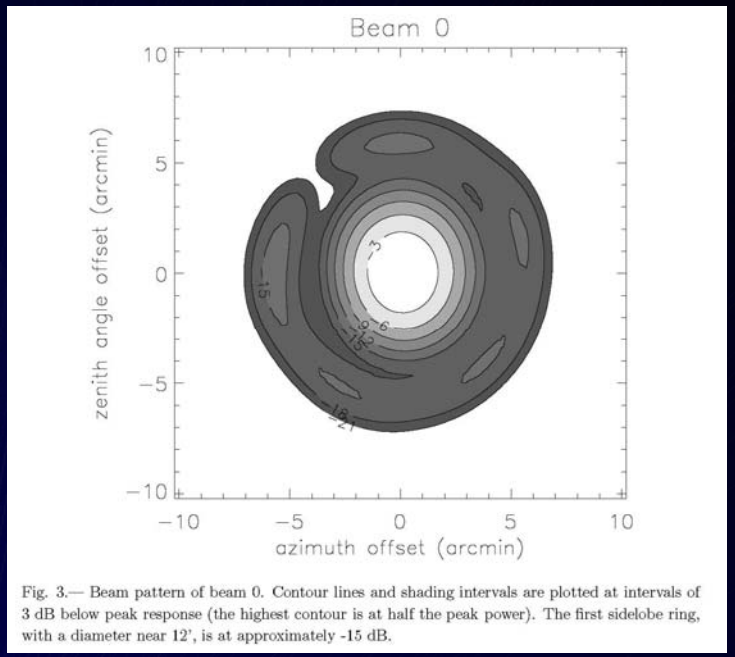
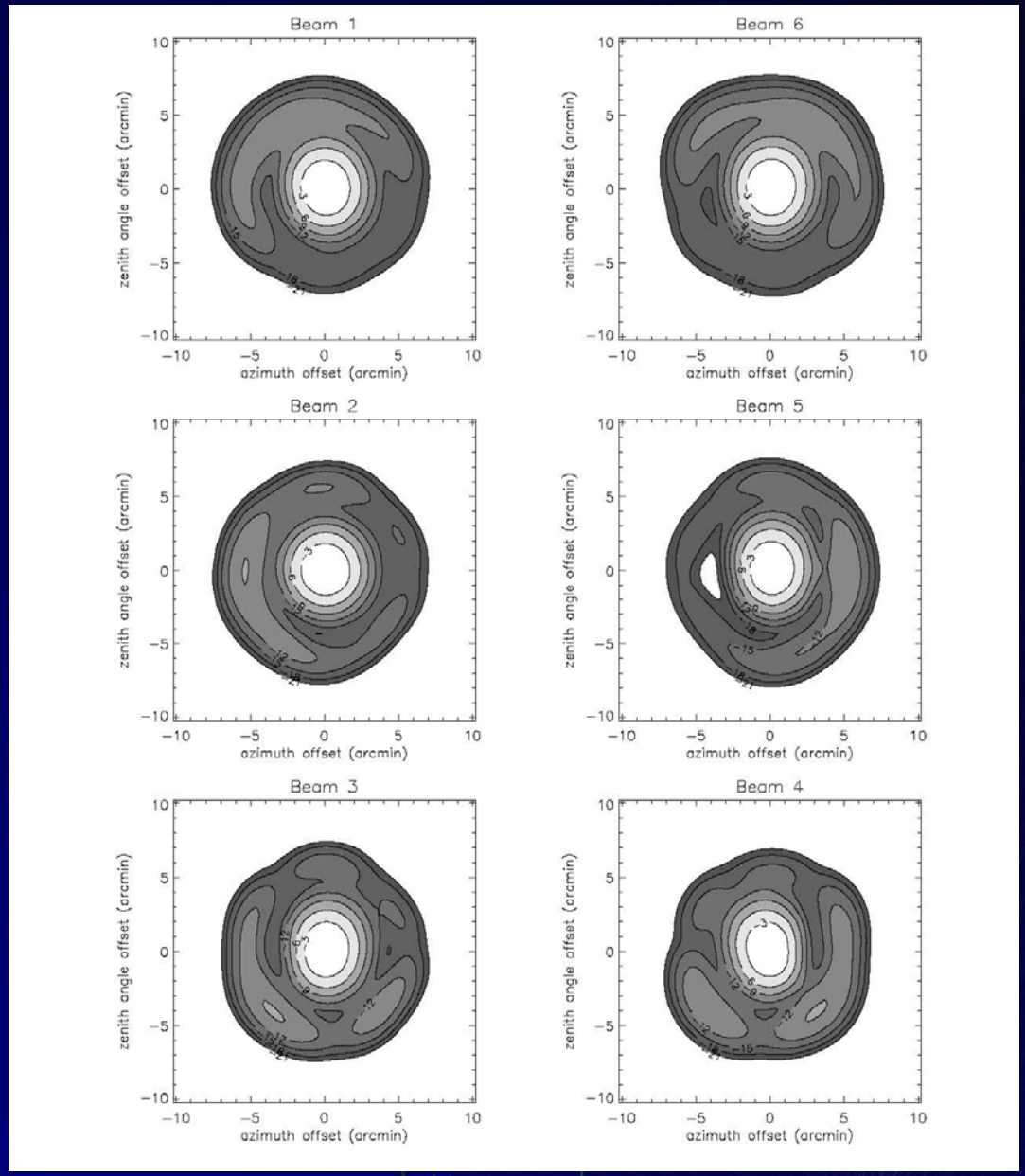


Fig. 3.— Beam pattern of beam 0. Contour lines and shading intervals are plotted at intervals of 3 dB below peak response (the highest contour is at half the peak power). The first sidelobe ring, with a diameter near 12', is at approximately -15 dB.

- The central pixel is more sensitive than the outer ones.
- The beams are really a bit elongated (ignore that for now!)
- The whole array can be rotated around the central beam
- Each beam has sidelobes; they differ from beam to beam.

ALFALFA



Outer beams

Notice that the sidelobe ring is asymmetric and always appears on the side opposite the central pixel.

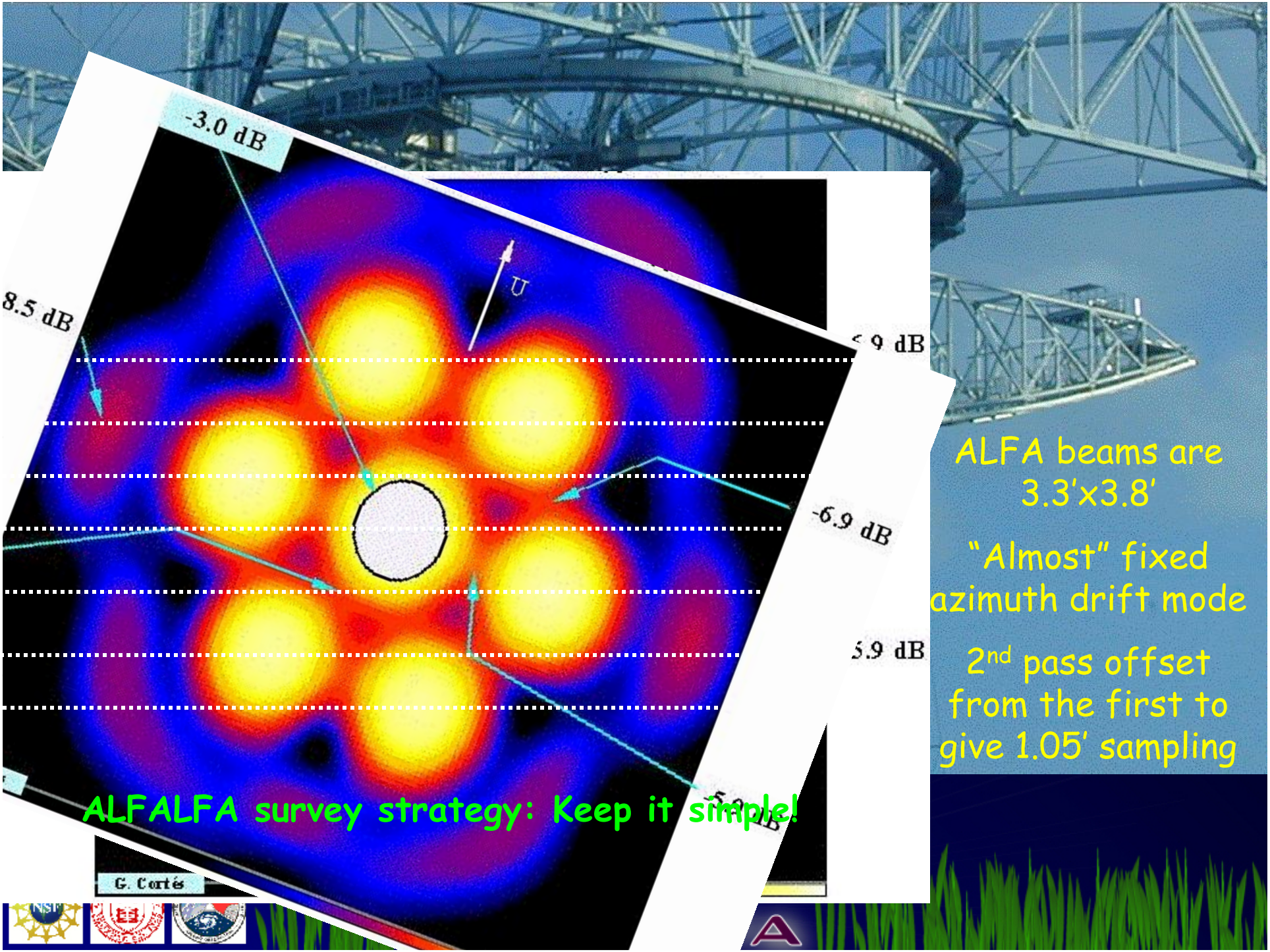
<u>Bottom line</u>:
We need to be wary of sidelobe contamination!

ALFALFA

Technical considerations

- Gain, T_{sys}, footprint, sidelobes, RFI all change with Az, ZA, so adopt "fixed azimuth" mode
- Sensitivity falls off quickly beyond ZA > 15°
  i.e., Dec south of +3° or north of +33°
- Beam 0 has higher gain than outer pixels
- Beam orientation/spacing change with Az, ZA, ALFA RotAngl; desire drift tracks equally spaced in Declination
- Dome cannot track through zenith; minimum ZA for dome ~1.7°: "zone of avoidance"

ALFALFA

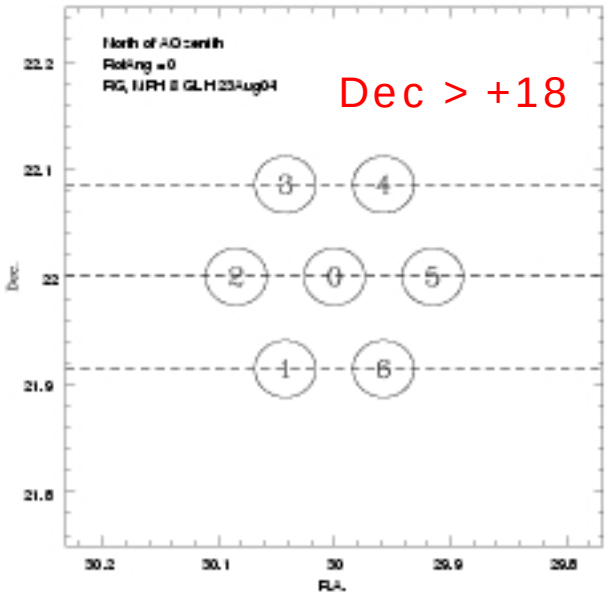


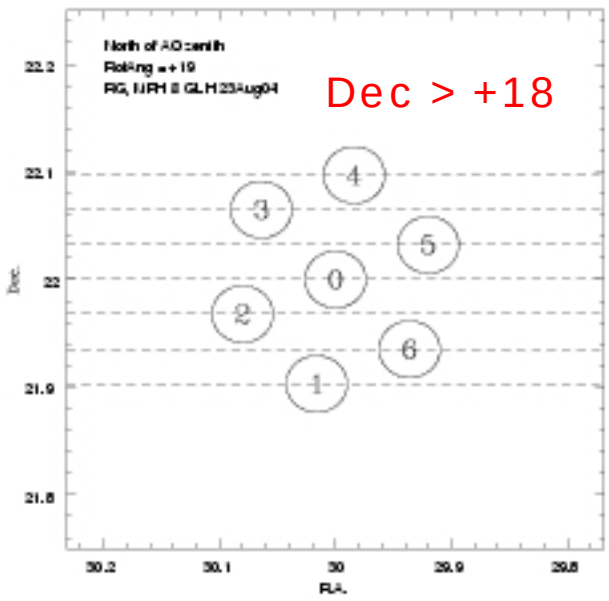
ALFALFA survey strategy: Keep it simple!

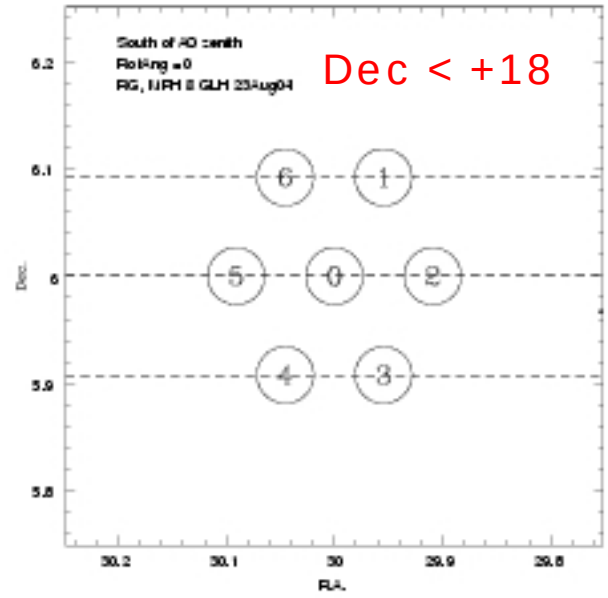
ALFA beams are 3.3′x3.8′

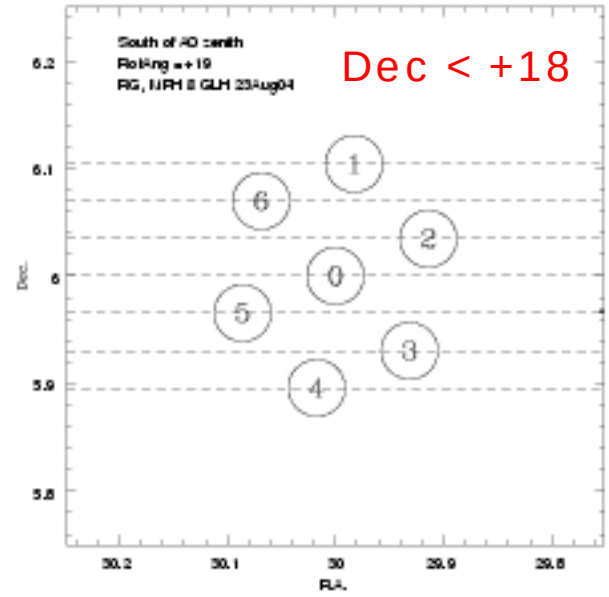
"Almost" fixed azimuth drift mode

2nd pass offset from the first to give 1.05′ sampling









Array rotation

The individual feed horns move along an elliptical ring oriented in Az, ZA.

Note: The beams are actually elliptical, NOT circular as implied in this cartoon.

ALFALFA

On meridian, 19° rotation

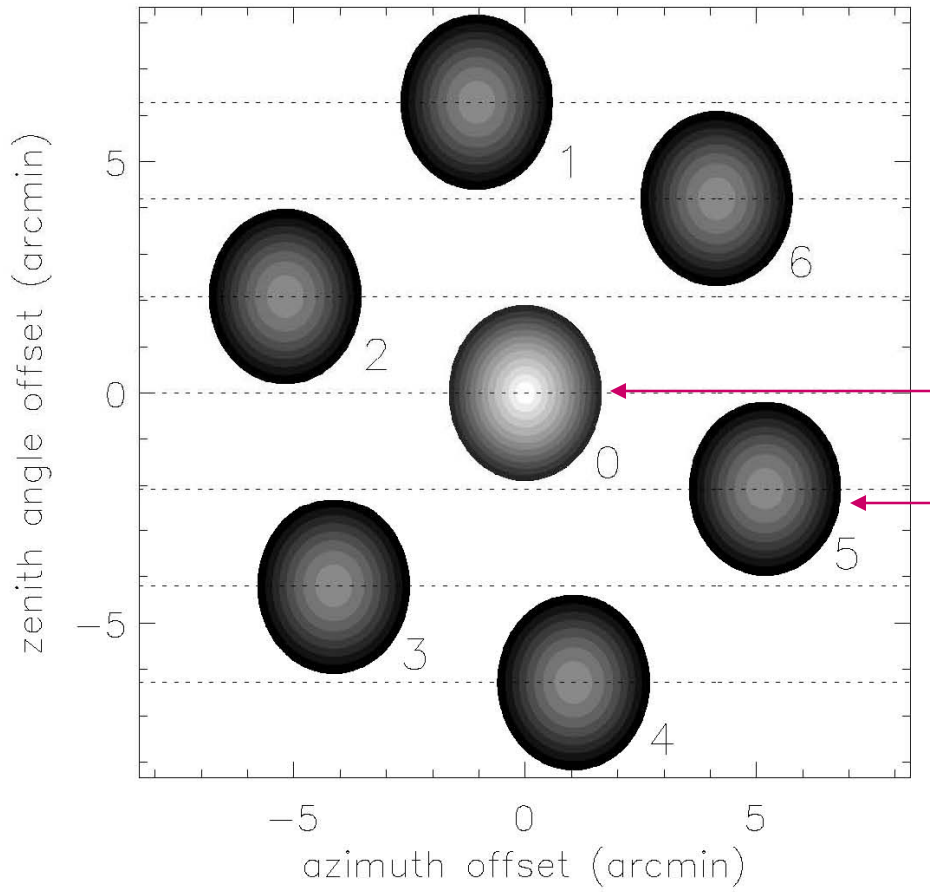
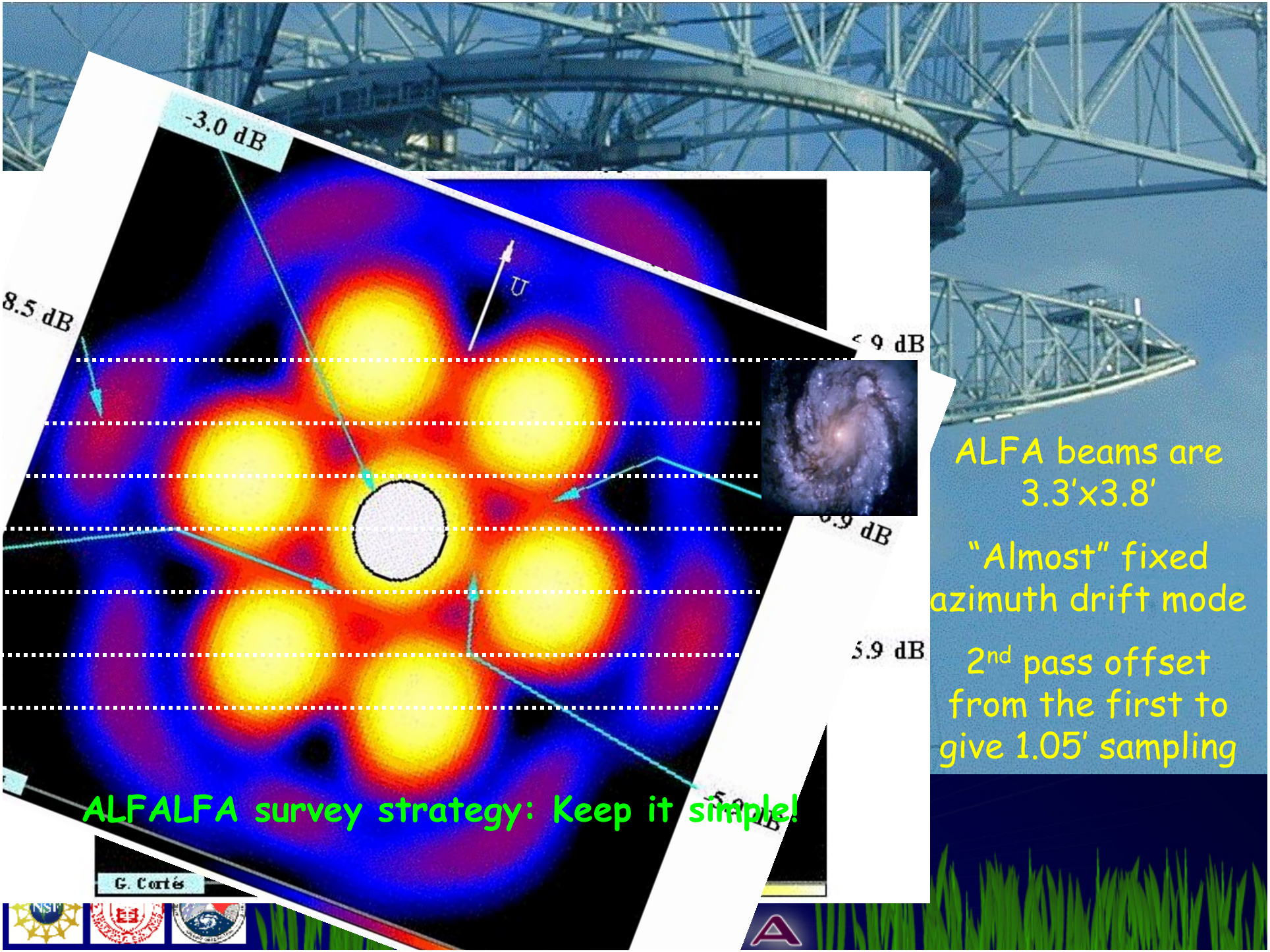


Fig. 2.— Sketch of the geometry of the ALFA footprint, with the array located along the local meridian and rotated by an angle of 19° about its axis. The outer boundary of each beam corresponds to the -3 dB level. The dashed horizontal lines represent the tracks at constant Declination of the seven ALFA beams, as data is acquired in drift mode.

Beam tracks are spaced equidistant in declination.

For a source south of zenith, the dome should be at azimuth 0° (or 360°).

ALFALFA



ALFA beams are 3.3′x3.8′

"Almost" fixed azimuth drift mode

2nd pass offset from the first to give 1.05′ sampling

ALFALFA survey strategy: Keep it simple!

ALFALFA drift mode

- "Almost" fixed azimuth drifts
  - Track in J2000 Declination
  - Declination of all survey drifts specified, except for +16° < DecJ < +20° (zenith "Zone of Avoidance")
- Specify observing "block" according to date/time at start, specified as yy.mm.dd

06.07.12 : Tonight's block

Block	Date	AST	LST	#	DecJ
06.07.12	W 12Jul	17h00-18h30	11h55-13h35	16p2	+035336

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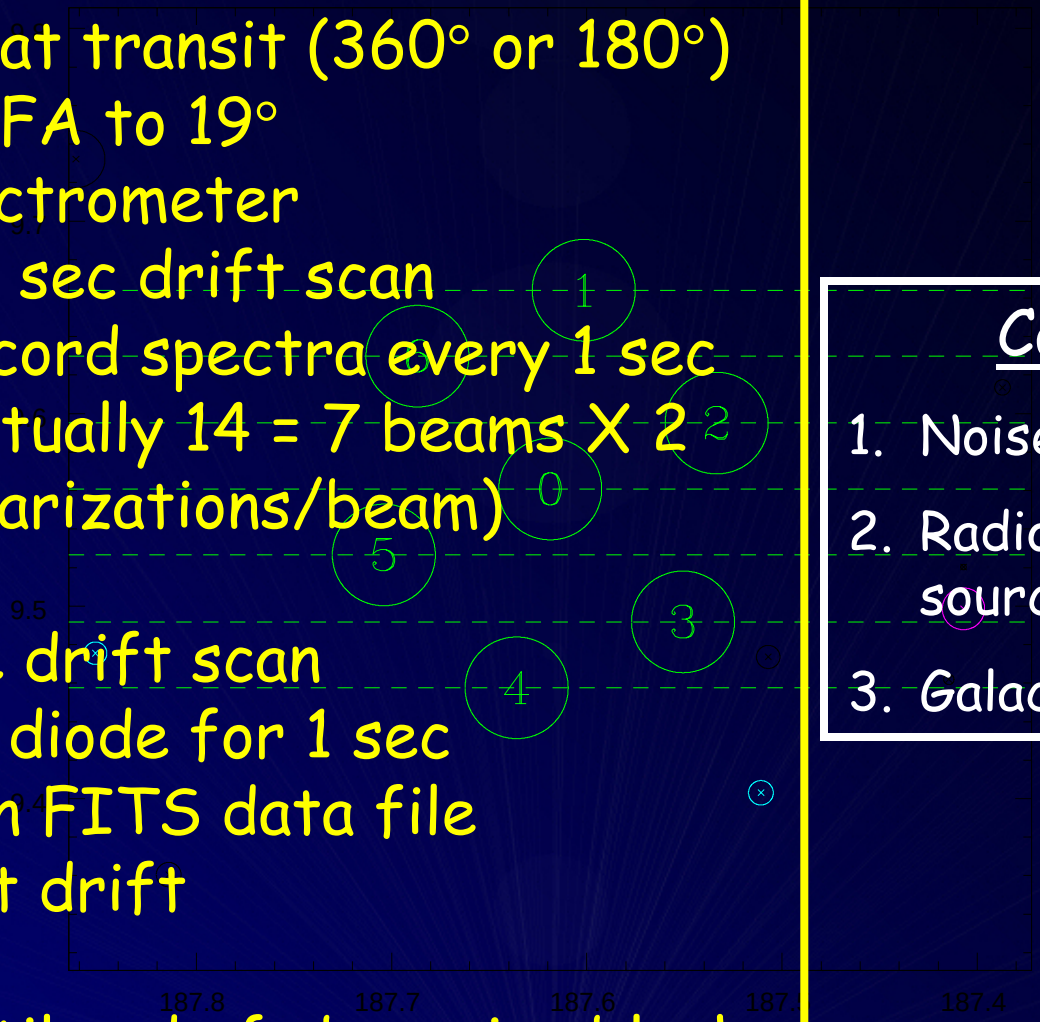
ALFALFA observing sequence

- Set dome at transit (360° or 180°)
- Rotate ALFA to 19°
- Setup spectrometer
- Start 600 sec drift scan
  - Record spectra every 1 sec (actually 14 = 7 beams X 2 polarizations/beam)

  .....
- Terminate drift scan
- Fire noise diode for 1 sec
- Close/open FITS data file
- Start next drift

  .....

  Repeat until end of observing block



Calibration:

1. Noise diode
2. Radio continuum sources of known flux
3. Galactic Hydrogen

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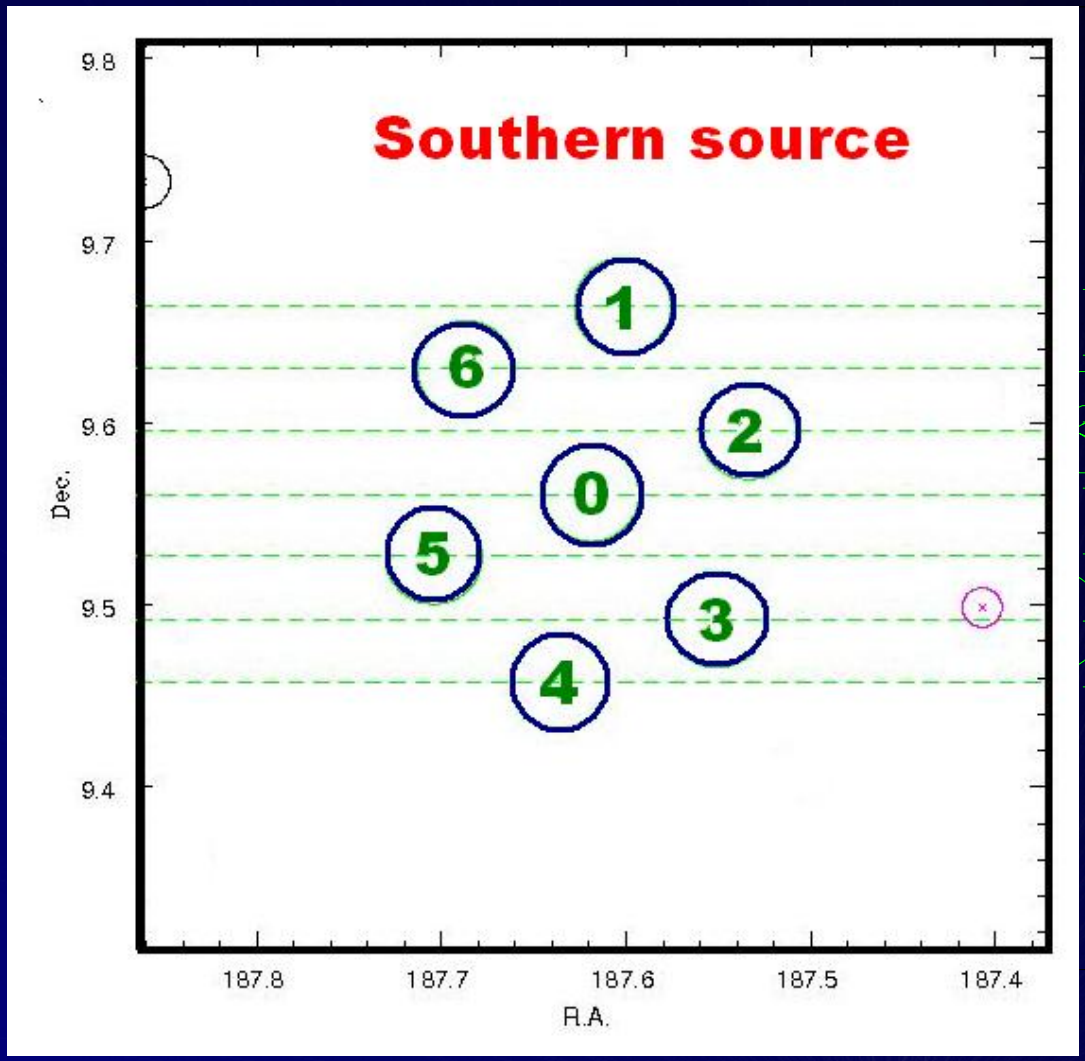
Beam layout on the sky



Beam orientation for source on meridian south of AO zenith, for ALFA rotation angle of +19°.

For this ALFA configuration, the tracks are spaced every 2.1 arcmin in Declination.

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Radio Frequency Interference

- Man-made signals are much stronger than cosmic ones!
- Some are always present; others come and go.
- Radars (e.g. FAA at San Juan airport) occur with some regular period (e.g. 12 sec)
- Some RFI is so strong that it "saturates" the front end.

We have to live with it (but we don't have to like it!).

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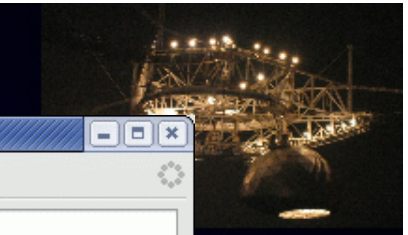
RFI List



Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.naic.edu/%7Ephil/rfi/rfilist.html#lband%20birdies

Go

User Record Viewer

1241.75 1244.6 1256.5 1261.25	1.67	jan97	active Radar	**Aerostat** radar ballon in lajas. dual freq or quad freq modes. 160 usec per pulse, chirped. Rotation rate 11.59 secs. Blanks toward AO. (see radar info)
1270/1290	.2	feb02	active Radar	**Remy Radar** at the end of the runway .(fps20-93a). 12 sec rotation rate, single ipp of 2781. Runs in 1270 or 1290 mode (not simultaneously). (see radar info)
1287.5/1299.84 1300,1399.83 1400 1411.52 1412.5	<.025	jan01 apr02		**Distomat** birdies. Occur every 2 minutes for a few seconds. Az dependent.Distomats have a 27 Mhz clock. Data was measured in jan01 (before shielding work) Data was remeasured in apr02 (after some shielding work). The window was changed
1330/1350	.2	jan97	active Radar	**FAA airport radar**.12 sec rotation, 5 ipps about 2.5 ms,5 usec pulse, 1350 then 1330 pulse sent each ipp. (radar info)
1366.2/1382.66 1324/1340 1387.3/1371.0		feb01	Radar	**Radars with 1.94 sec rotation** rates. (more info). These radar were probably associated with military ship practices. Fast rotating radars are needed when objects move far within 1 rotation (planes near aircraft carriers,etc..)
1381.05	1	sep91	active	**GPS L3** downlink. (more info)
1388.55	.024	98		**beeper** harmonic (3rd of 462.85)
1388.6	.024	93		**beeper** harmonic (3rd of 462.875) (borinquen beepers)
1388.858 1417.495	<190 (hz)	may02		**dome camera** birides. part of a comb of 14.3185 Mhz. (more info).
1390.8	.024	feb93		**beeper** harmonic (3rd of 463.6 (mr. beeper)
1407	.3	apr01	fixed	**tvChan20** arecibo. Drifted around with time. They were having trouble with their transmitter. (more info)
1422.5				**tvChan54** 2nd harmonic
1525-1545		aug03		**Inmarsat stdBC** ship,portable earch downlinks **Inmarsat stdM** ship downlinks

Done

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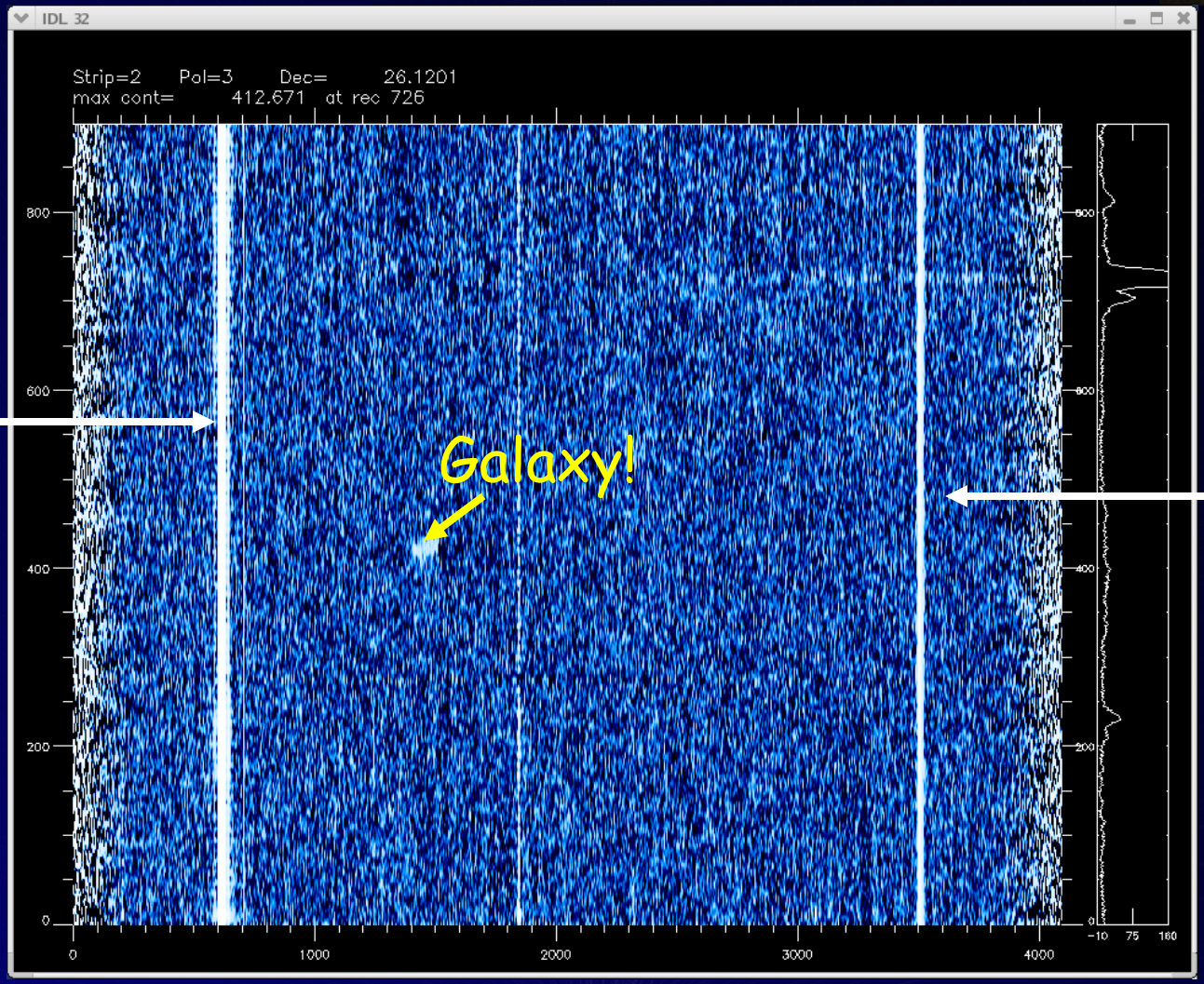
RFI is ugly



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Two-pass strategy

We want to drift across each stop on the sky TWICE

- Double integration time
- Helps to discriminate cosmic sources from
    1. Noise
    2. RFI

We offset the 2nd drift by half of the beam spacing.

- Helps with position centroiding
- Evens out the gain scalloping

We conduct the 2nd pass 3-9 months after the first.

- Cosmic sources will have shifted in frequency due to the Earth's motion around the Sun, but terrestrial ones won't have.
- Some interference comes and goes.

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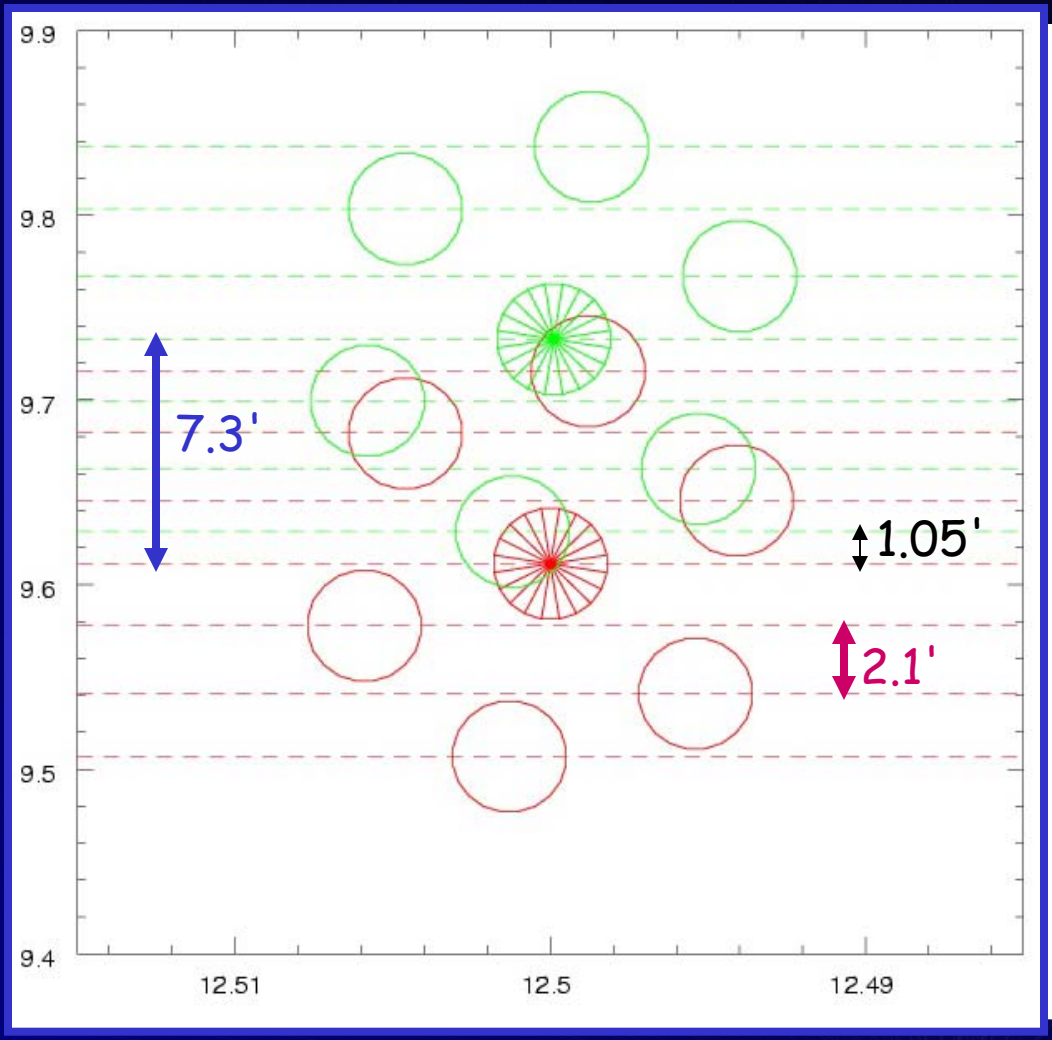
2-pass beam layout



Final coverage for 2 pass strategy

- For the 2nd pass, Beam 0, which has higher gain than the others, is offset by 7.3 arcmin from its 1st pass position.
- Some smoothing of gain scalloping.
- 2-pass sampling thus at 1.05 arcmin
- 2nd pass occurs 3-9 months after the 1st pass (vs. RFI)

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ALFALFA schedule notation

- "Master list" of drift declinations preassigned, starting at 0° and moving northward to +36° => DriftN, N = 1, 148
- Two passes: p1 and p2

41p1	+095118
42p1	+100554
42p2	+101312

14.6 arcmin

7.3 arcmin

Drift declination assignments

40	40p1	9.611670	+093642	40p2	9.733337	+094400
41	41p1	9.855003	+095118	41p2	9.976671	+095836
42	42p1	10.098337	+100554	42p2	10.220005	+101312
43	43p1	10.341671	+102030	43p2	10.463339	+102748
44	44p1	10.585	16p2 +03°53′36″		0.706673	+104224
45	45p1	10.828			10.950006	+105700
46	46p1	11.071672	+110418	46p2	11.193340	+111136
47	47p1	11.315006	+111854	47p2	11.436674	+112612
48	48p1	11.558340	+113330	48p2	11.680008	+114048
49	49p1	11.801674	+114806	49p2	11.923342	+115524
50	50p1	12.045008	+120242	50p2	12.166676	+121000
51	51p1	12.288342	+121718	51p2	12.410009	+122436

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Tile coverage

Follow "tile" layout: each covers 4° in Declination

- Az = 0° for DecJ = +2°, +6°, +10°, +14°
- Az = 180° for DecJ = +22°, +26°, +30°, +34°
- Az ~ 90° for DecJ ~ +18° (close to zenith)

Proposal: Cover 2 tile tracks/per year, spring and fall

Spring and fall tiles not necessarily the same

Spring 2005: +10° and +14°

Fall 2005: +26° and +30°

Spring 2006: Complete also +06°

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ALFALFA Scheduling Strategy

- ALFALFA aims to survey 7000 square degrees of high galactic latitude sky.
- "Fixed azimuth drift" mode: the telescope moves only slightly, to maintain constant Dec (J2000); Drifts offset by 14.6 arcmin.
- A "tile" of data will contain all beam positions within a box of 20 min in RA by 4 degrees in Dec.
- Within a single observing block, the data taking sequence consists of a series of 600 second (10 min) drifts at constant Dec J.
- Over a season, we try to "complete" sets of drifts within a tile: 16 drifts/tile/pass.
- The second pass occurs 3-9 months after the 1st pass (to aid RFI identification and signal confirmation).

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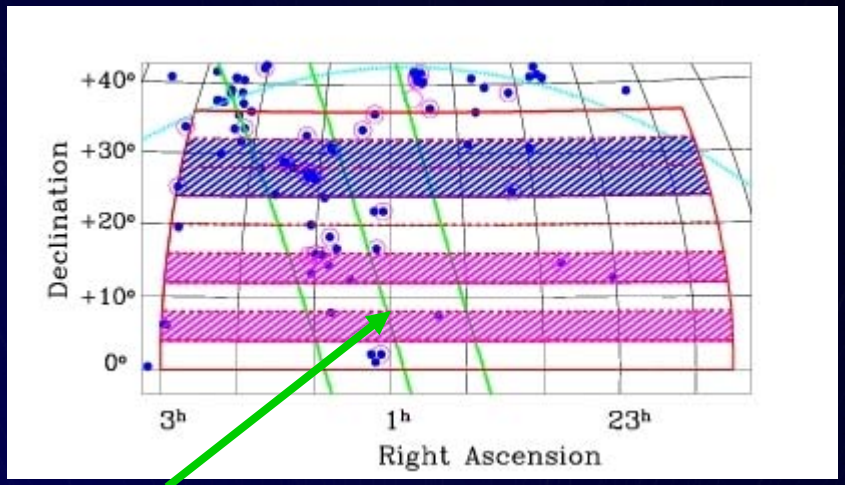
ALFALFA Survey 2005-7

High galactic latitude sky visible from AO

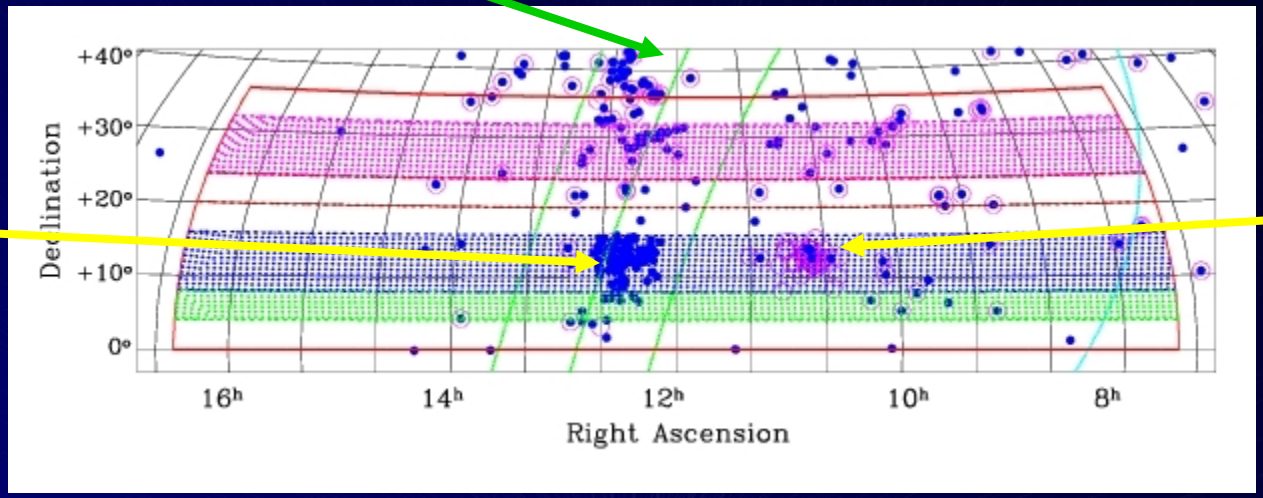


- Commensal with TOGS HI
- Does not compete with galactic plane surveys

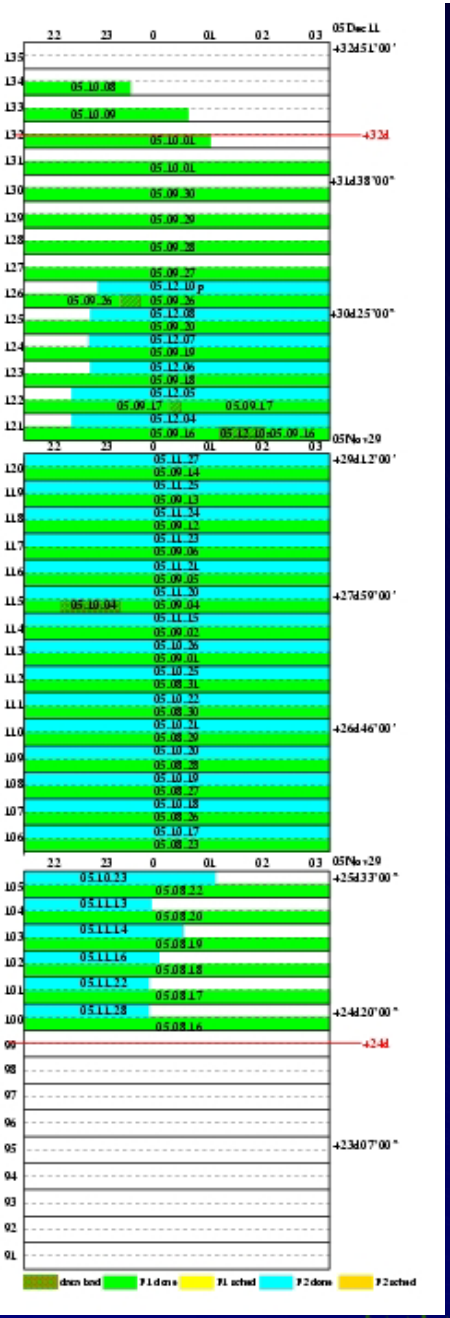
Supergalactic plane

Virgo cluster

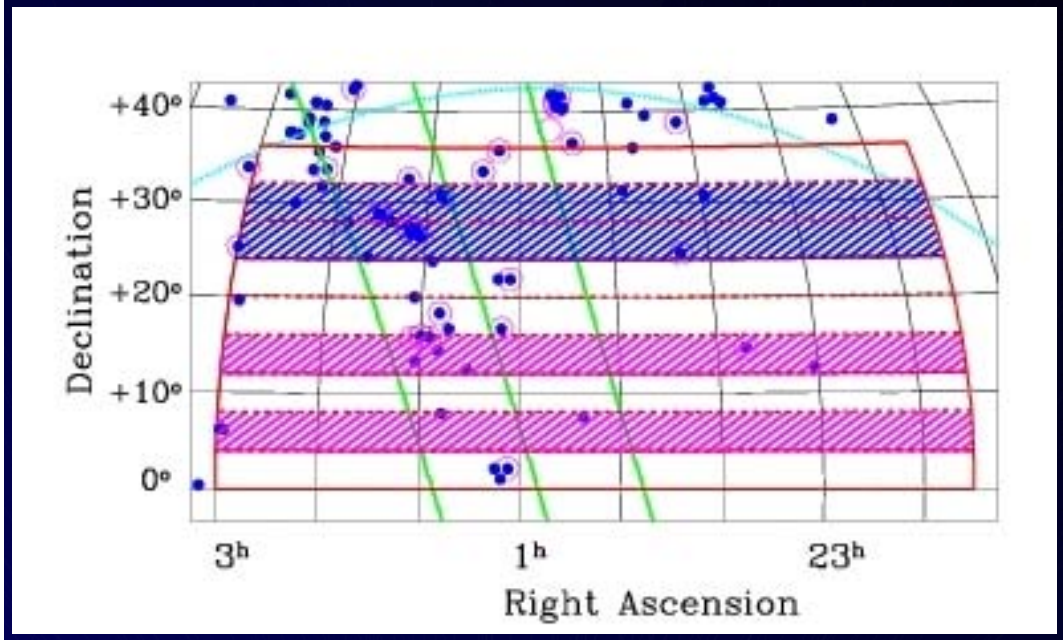
Leo Group



ALFALFA



ALFALFA: 22^h < RA < 3^h



Status of Fall 2005:

- Complete only +26° to +29°

Plan for Fall 2006:

- Complete +24° to +32°
- Complete +12° to +16°
- Complete +04° to +08°

- M33 and HVC's
- Several D<10 Mpc groups
- anti-Virgo Local volume
- Pisces-Perseus

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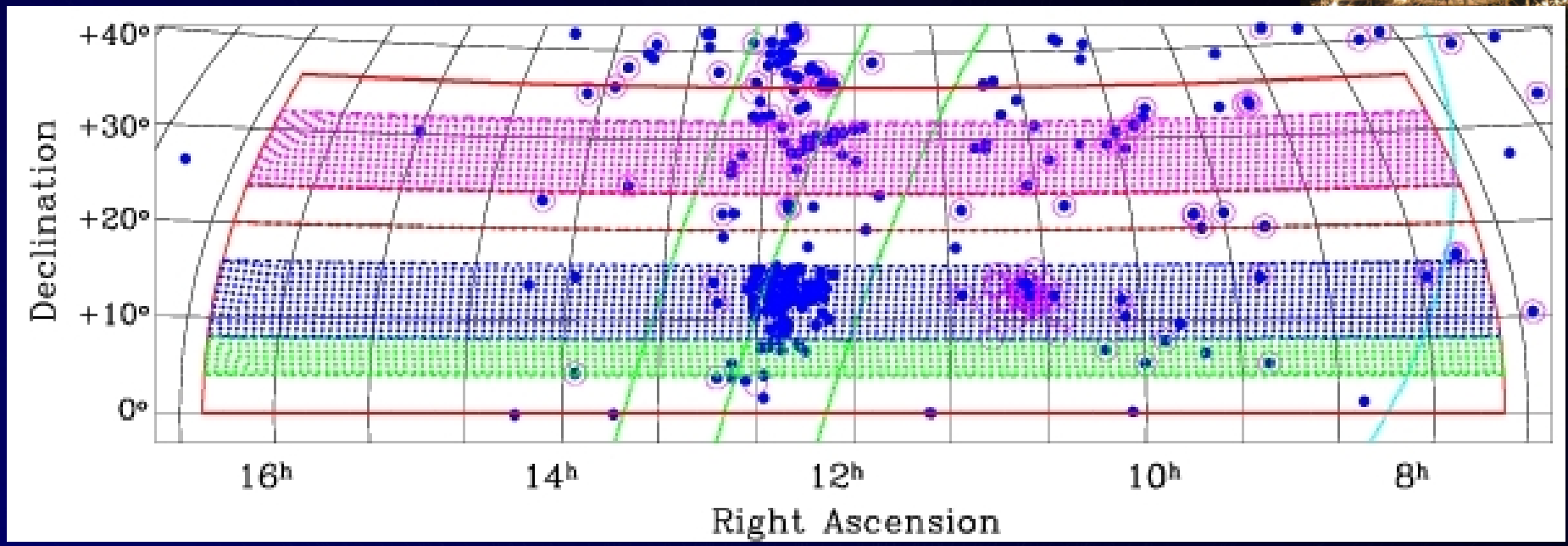
ALFALFA: $07^h30^m < RA < 16^h30^m$



- Virgo cluster
- Leo region
- Coma cluster
- + lots more!

Status as of June 22, 2006:

- Complete only +05° to +16°
- Some coverage +04° to +05°
- First pass +26-30°, RA>11^h

Plan for Spring 2007:

- Complete +04° to +05°
- Complete +24° to +32°

ALFALFA

Maximizing Observing Efficiency

- Telescope time is precious and competition is stiff.
- Our science goals demand high quality data.
- The legacy nature of ALFALFA raises the standards for data product generation and delivery.
- Arecibo and ALFA are complex instruments to use.
- RFI is nasty and inevitable.
- ALFALFA uses a lot of telescope time and generates a lot of data!
- The A2010 proposal was approved pending periodic reviews of our ability to perform the survey.
    - We were recently told we've "passed" this year.

Practicalities of Scheduling

- Arecibo telescope time is in high demand.
- Arecibo serves a diverse set of scientists.
- We elect to observe only at night.
  - Reduced RFI levels
  - Minimal thermal effects
  - No solar interference
- Pass 2 needs to take place 3-9 months after Pass 1
- The telescope schedule changes on short timescales
  - Targets of opportunity (killer asteroids, etc)
  - Hardware failures (theirs or ours)

A2010 blocks often cover only part of the RA range

ALFALFA

Typical A2010 schedule

Arecibo Observatory Telescope Schedule

August 13 - August 27, 2006

TRANSMITTERS

2380 | 430 | HF

Opt | 47 | System Checks

VISITORS
R. Giovanelli
M. Haynes
M. Shepard
L. Benner
S. Ostro
I. Stairs
D. Stinebring
J. Rankin
G. Wright
D. Nice
R. Ferdman
A. Wolszczan
S. Stanimirovic
J. Cordes
F. Camilo
M. Putman
H. Carlson
F. Djuth
H. Carlson

COMMENSAL PROJECTS:
- A2059c with A2010

VER 2.0 - 071006

AST	13 SUN	14 MON	15 TUE	16 WED	17 THU	18 FRI	19 SAT	20 SUN	21 MON	22 TUE	23 WED	24 THU	25 FRI	26 SAT	27 SUN	LST
2	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	P2178 dn is	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	T1892 fd ms	Txxxx sg ms (?)	0
4	EALFA	EALFA	EALFA	EALFA	EALFA	EALFA	EALFA	EALFA	X102 pp	EALFA	EALFA	EALFA	EALFA	5/5		
6	BK127 tg													(DB)	(DB)	
8	L-w	MAINT elect	MAINT elect	X111 to MAINT f/ut	X111 to MAINT f/ut	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc PALFA	eVLBI tg cs	X111 to MAINT f/ut	P2030 jc/fc PALFA	X102 pp MAINT f/ut	MAINT elect	T2212 fd hc ms	T2212 fd hc ms	
10	X111 to					MAINT elect	X111 to	X111 to	MAINT elect		MAINT elect		T1892 fd ms			
12	A1852 bml						P1693 pf	A1852 bml								12
14	R2207 ms						P2111 aw									
16	LB6	X108	X108					P2178 dn is rf								
18	R2207 ms	R2207 ms	R2207 ms	R2207 ms	X108 ml	A1589 bml	P1693		X108 ml	X108 ml	X108 ml	X111 to				
20	2100	2100	2100	2100	P2176 P2076	P2176 P2202 jr	P2176 P2202 jr		P2176	P2176	P2176 pf	P2076				19
22	P2180 ls	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2177 dn	-gw-	-gw-		P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc PALFA	5/5 (DB)	(a) (SB)	(a) (SB)	
24																

ALFALFA

This week's schedule

Arecibo Observatory Telescope Schedule

July 2 - July 16, 2006

TRANSMITTERS

2380 | 430 | HF

Opt | 47 | System Checks

VISITORS
Q. Zhou
Y. Morton
M. Brenneman
R. Nikoukar
J. Cordes
F. Camilo
J. Davies
D. Nice
I. Stairs
R. Ferdman
R. Giovanelli
B. Kent
M. Putman
S. Stanimirovic
M. McLaughlin
D. Stinebring

COMMENSAL PROJECTS:
- A2059c with A2048

VER 4.0 - 071006

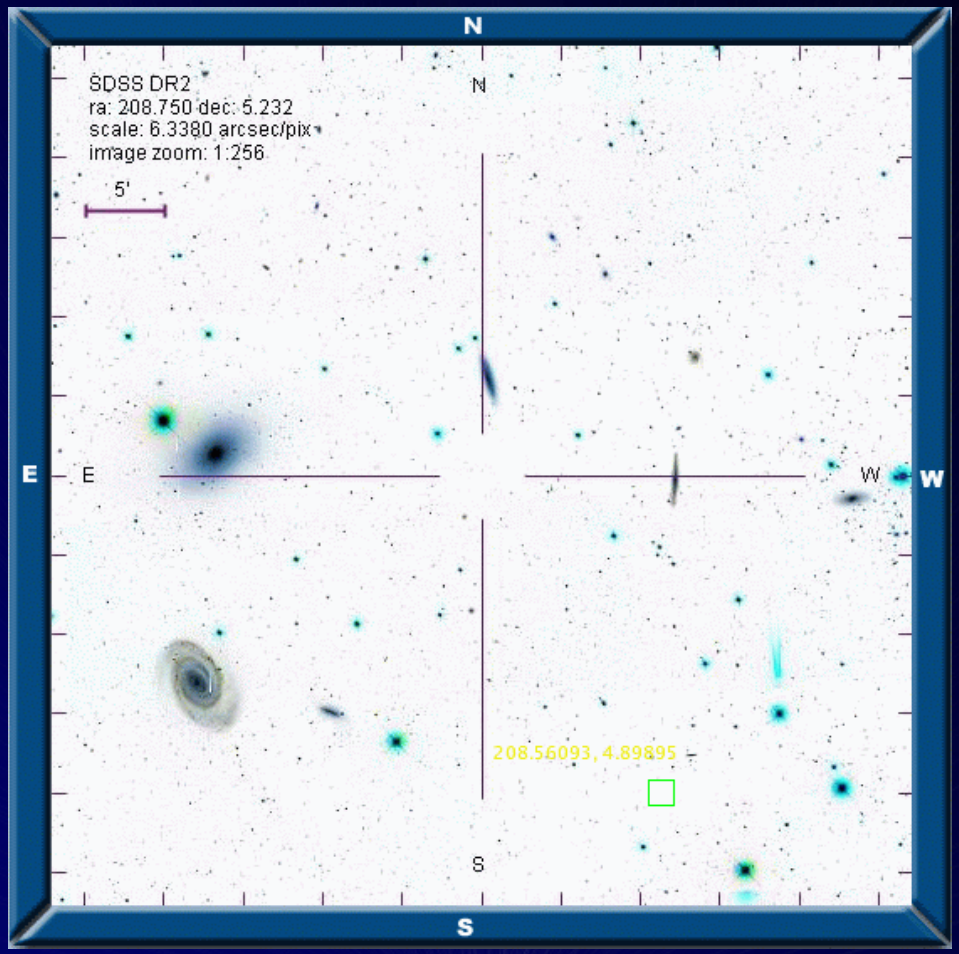
AST	2 SUN	3 MON	4 TUE	5 WED	6 THU	7 FRI	8 SAT	9 SUN	10 MON	11 TUE	12 WED	13 THU	14 FRI	15 SAT	16 SUN	LST
2	T2090 rn ms	T2165 qz mb	T2165 qz mb	T2165 qz mb	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc PALFA	P2030 jc/fc	P2178 dn is rf	P2030 jc/fc	P2180	P2109 A1852	P2030 jc/fc	P2030 jc/fc	P2030 jc/fc	
4					A2048 jd AGES	A2048 jd AGES	A2048 jd AGES	A2048 jd AGES		A2048 jd AGES	A2048 jd AGES	A2048 jd AGES	A2048 jd AGES	A2048 jd AGES	A2048 jd AGES	0
6					X111 to	A1852 bml	X102 pp cs	X102 pp cs	X111	P1693 pf	X111 to	A1852 bml	P1693 pf	X102 pp cs	X102 pp cs	
8	T2029 qz ym jz	T2029 qz ym jz	T2029 qz ym jz		MAINT elect	MAINT f/ut			MAINT f/ut	MAINT f/ut	MAINT elect	MAINT elect	X108 ml	X111 to	P2030 jc/fc PALFA	
10							P2030 jc/fc PALFA	P2030 jc/fc PALFA					S1662 eh	S1662 eh		
12				MAINT elect			X111 to	X111 to					Merc	Merc	X111 to	
14													X113	A1852 bml	P1693 pf	12
16	(DB)	(DB)	(DB)				A2215 rg -bk-	A1852 bml								
18	T2165 qz mb	T2165 qz mb	T2165 qz mb	X108	X108	X111			X108	X108	A2140	X108	X111			
20				A2049 tg cs	A2049 tg	A2049 tg	A1589 bml	P2178 dn is	A2049 tg	A2049 tg	A2049 tg	A2049 tg	A2049 tg	A2049 tg	A2049 tg	
22					P2176	P2176			P2176	P2176 pf	P2176	P2176	P2176	P2176		
24				P2076	A2060 mp	A2060 mp	A2060 mp		A2060 mp	P2180	P2076	A2060 mp	A2060 mp	A2060 mp	A2060 mp	19

ALFALFA

ALFALFA websites

- Cornell website (public)
  - http://egg.astro.cornell.edu/alfalfa
- Cornell website (team only; password required)
  - http://caborojo.astro.cornell.edu/alfalfalog
- Arecibo A2010 website (not obvious)
  - http://www.naic.edu/~a2010/galaxy_a2010.html
- Milano Followup Team wiki (password required)
  - http://cosmos.iasf-milano.inaf.it/alfalfa_wiki/

So, enough talk; let's observe….



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