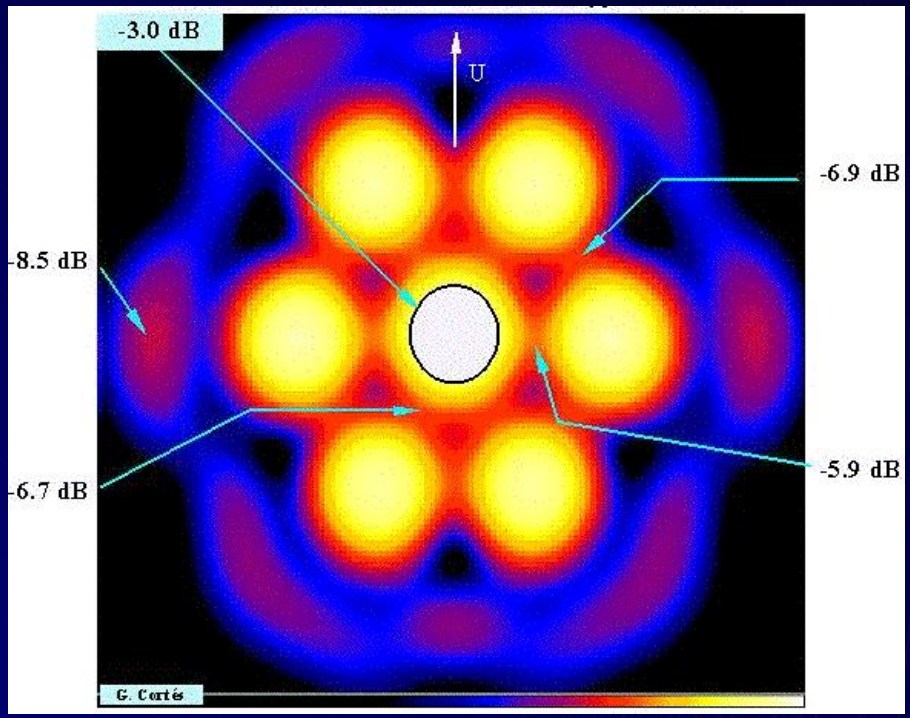
Using ALFA for ALFALFA

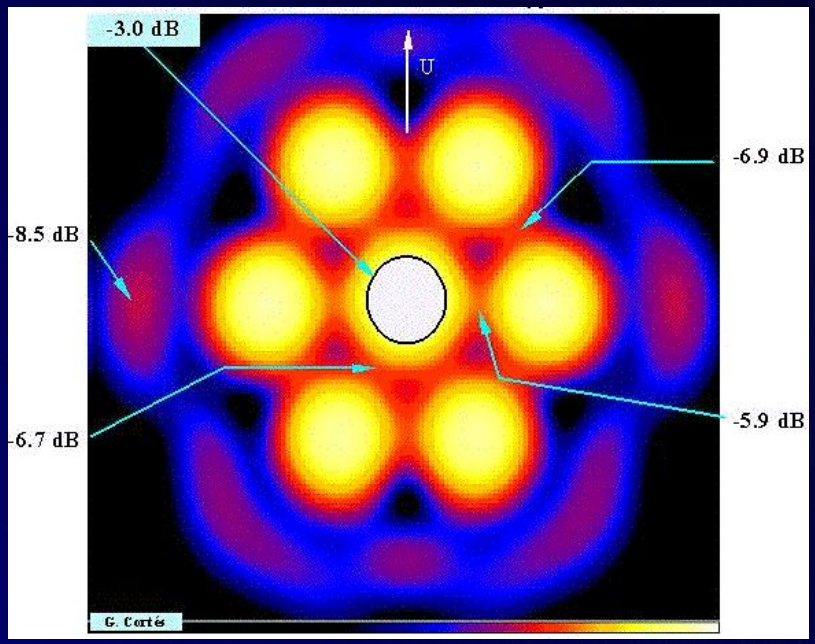


Martha Haynes, Cornell University

2005 ALFALFA Undergraduate Workshop

ALFALFA

ALFA as a Camera



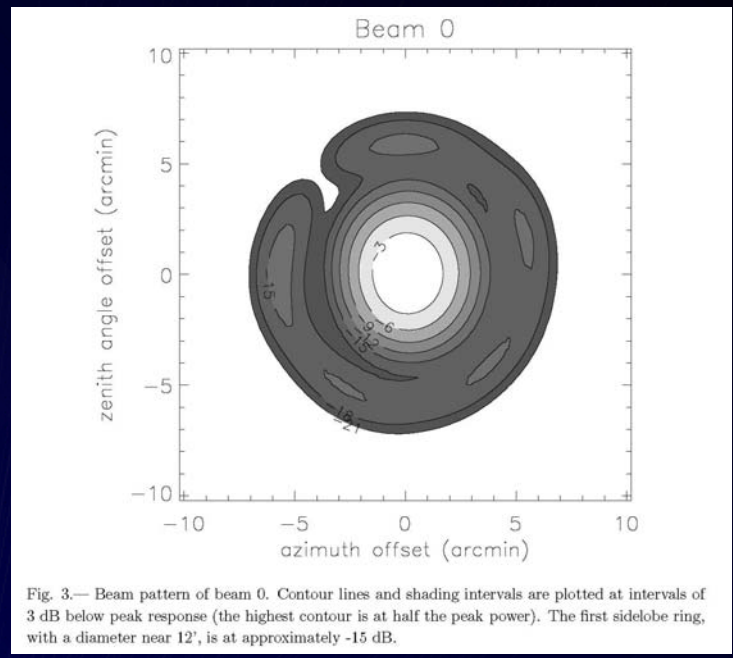
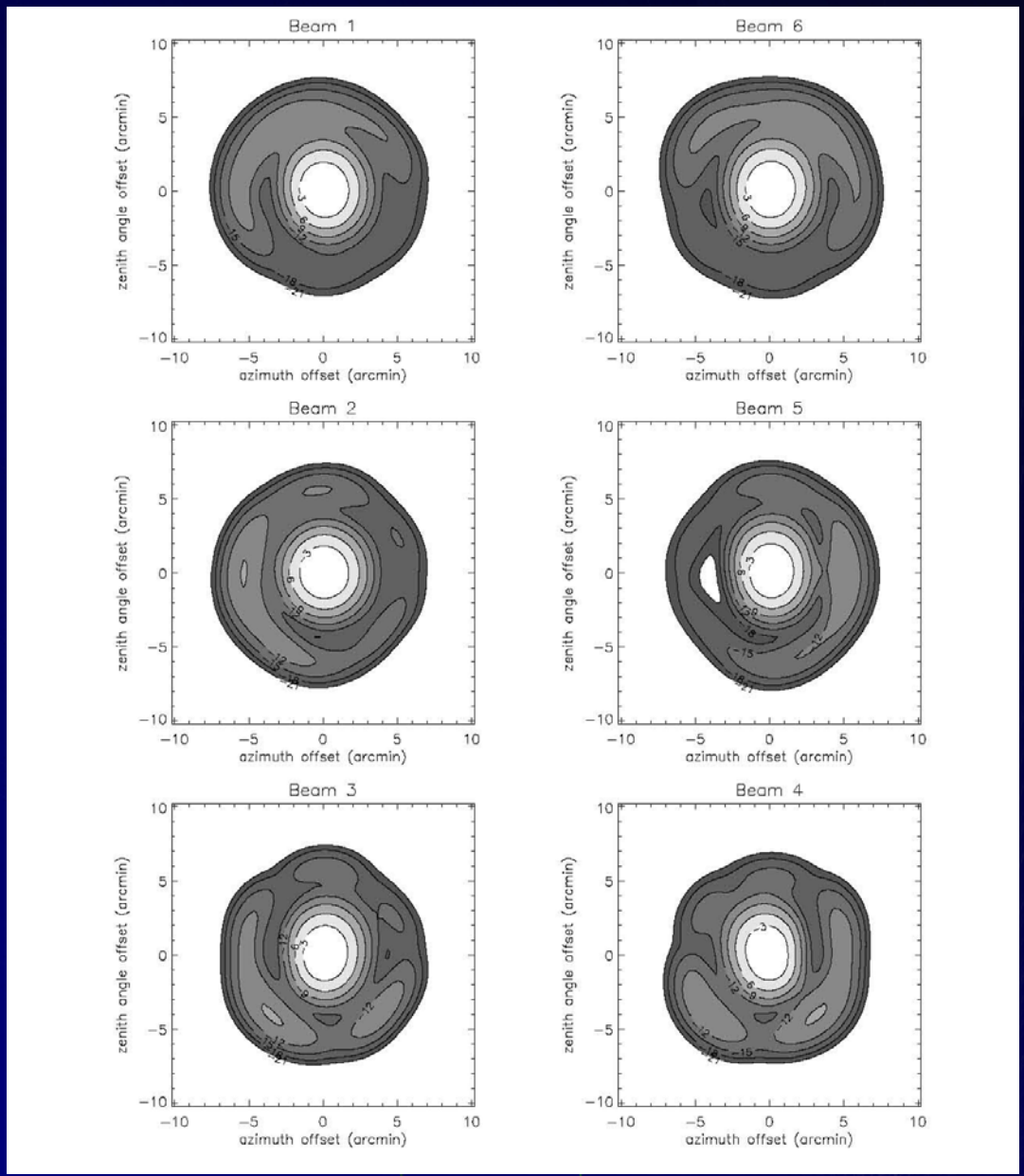


Fig. 3.— Beam pattern of beam 0. Contour lines and shading intervals are plotted at intervals of 3 dB below peak response (the highest contour is at half the peak power). The first sidelobe ring, with a diameter near 12', is at approximately -15 dB.

- 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.



Outer beams

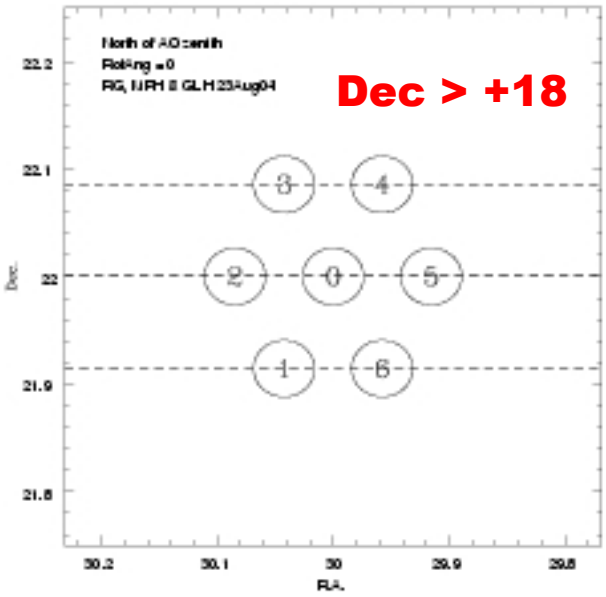
Notice that the sidelobe ring is asymmetric and always appears on the side opposite the central pixel.

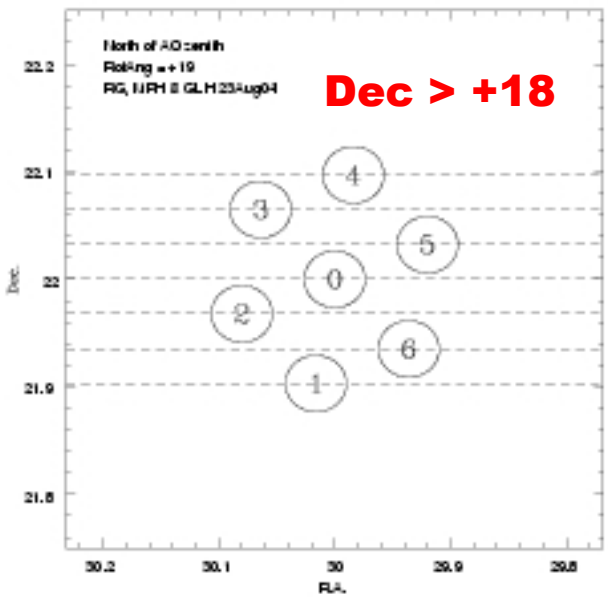
<u>Bottom line</u>:
We need to be wary of sidelobe contamination!

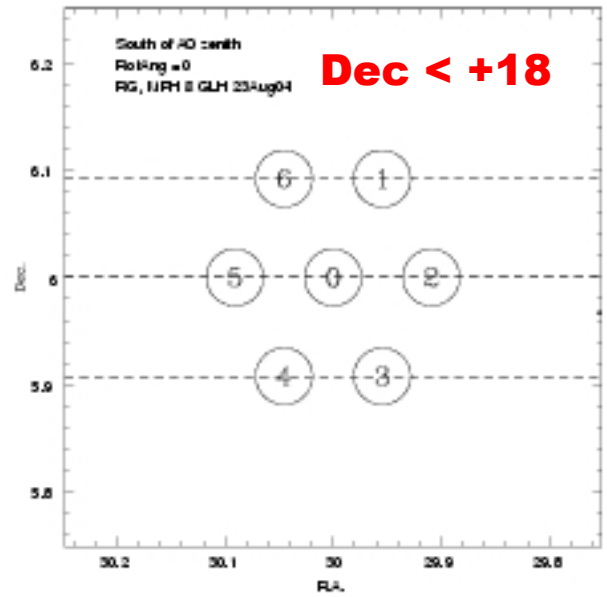
ALFALFA

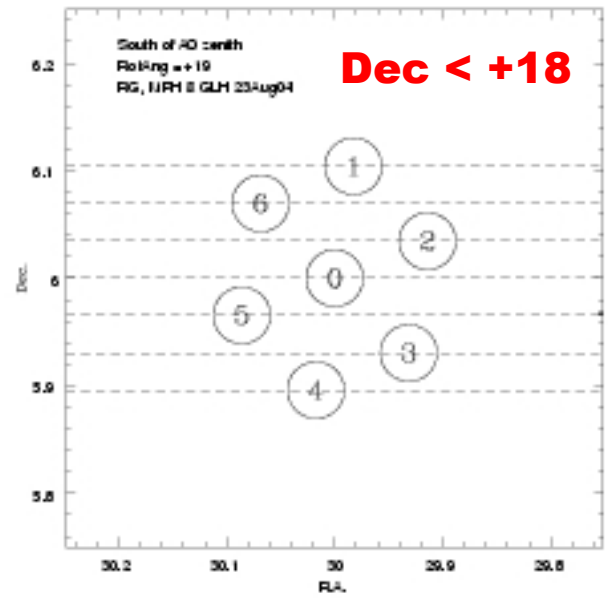
Technical considerations

- 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"









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

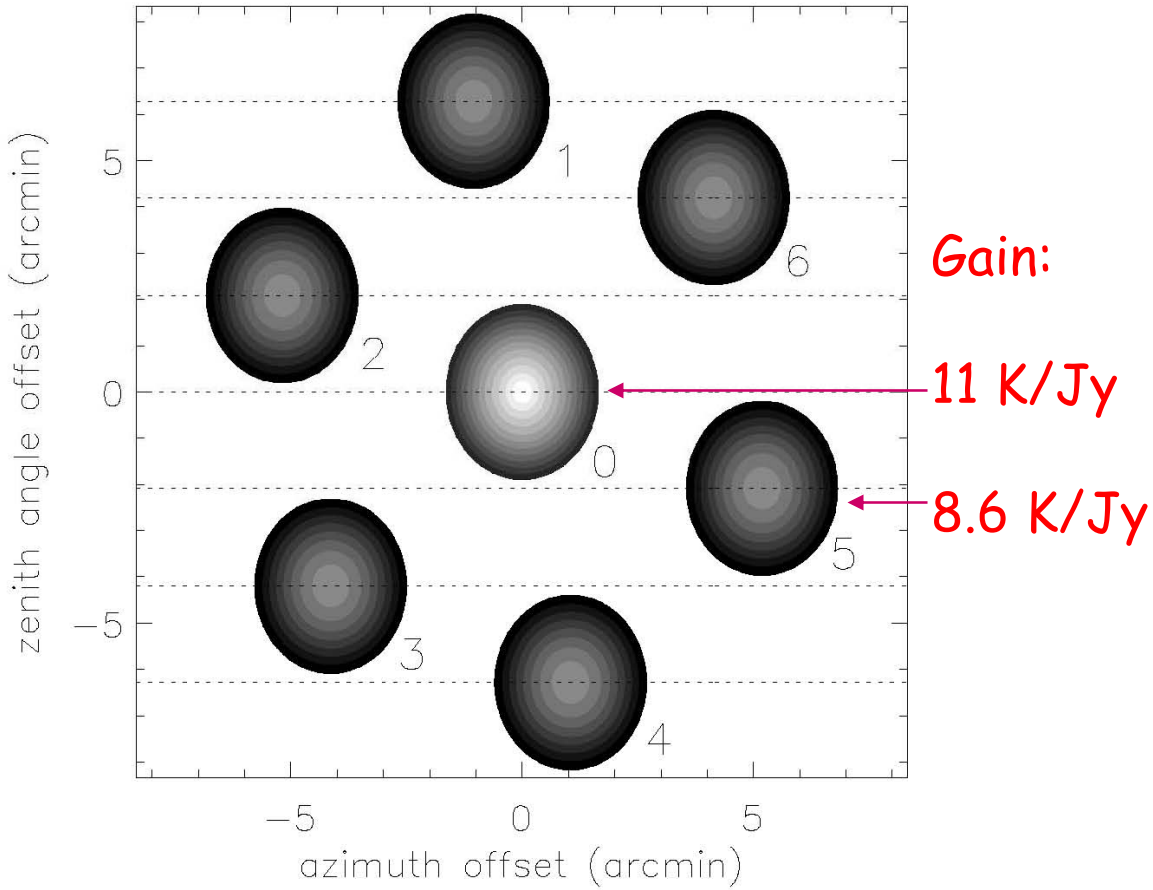


Fig. 2.— Sketch of the geometry of the ALFA footprint, with the array located along the local meridian and rotated by an angle of 19° about its axis. The outer boundary of each beam corresponds to the -3 dB level. The dashed horizontal lines represent the tracks at constant Declination of the seven ALFA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

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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

05.07.06 : Tonight's block

Block	Date	AST	LST	#	DecJ
05.07.06	W 06Jul	18h45-20h30	13h18-15h03	22p1	+051354

ALFALFA

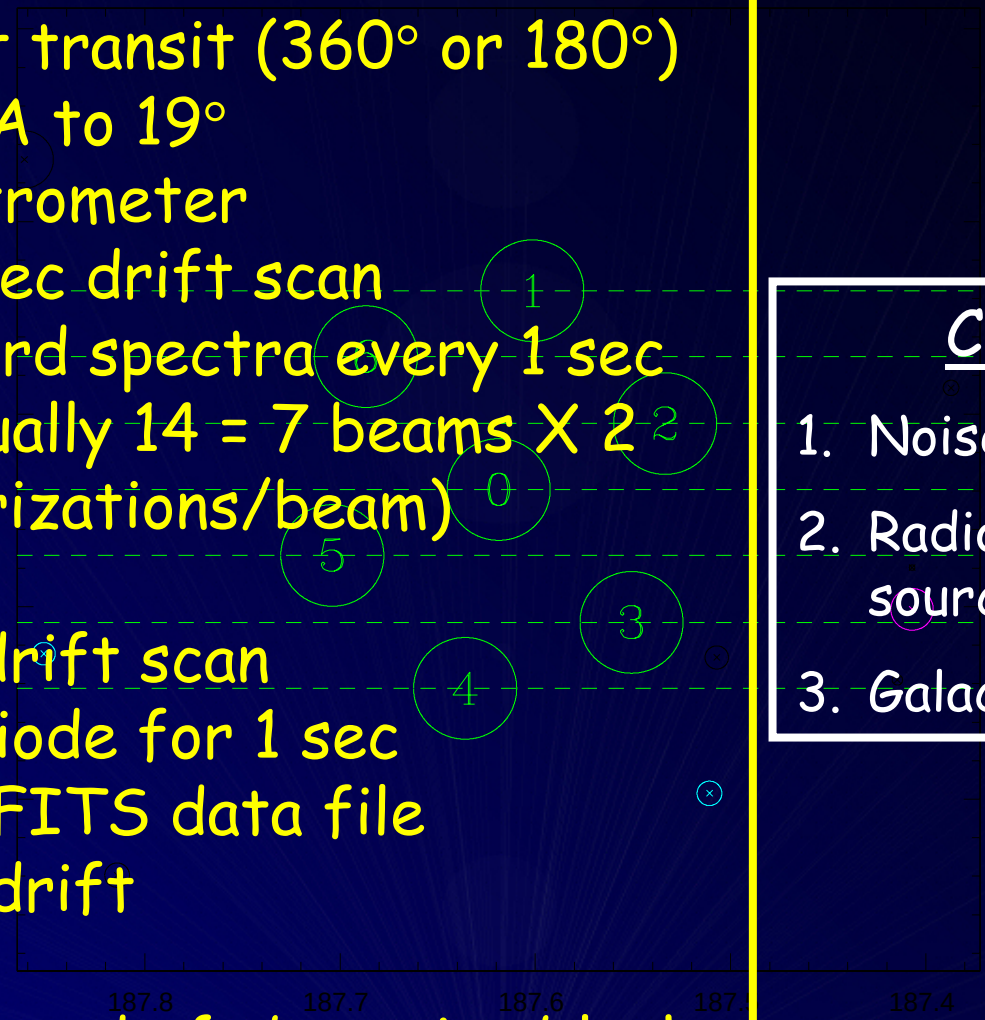
ALFALFA observing sequence

- 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

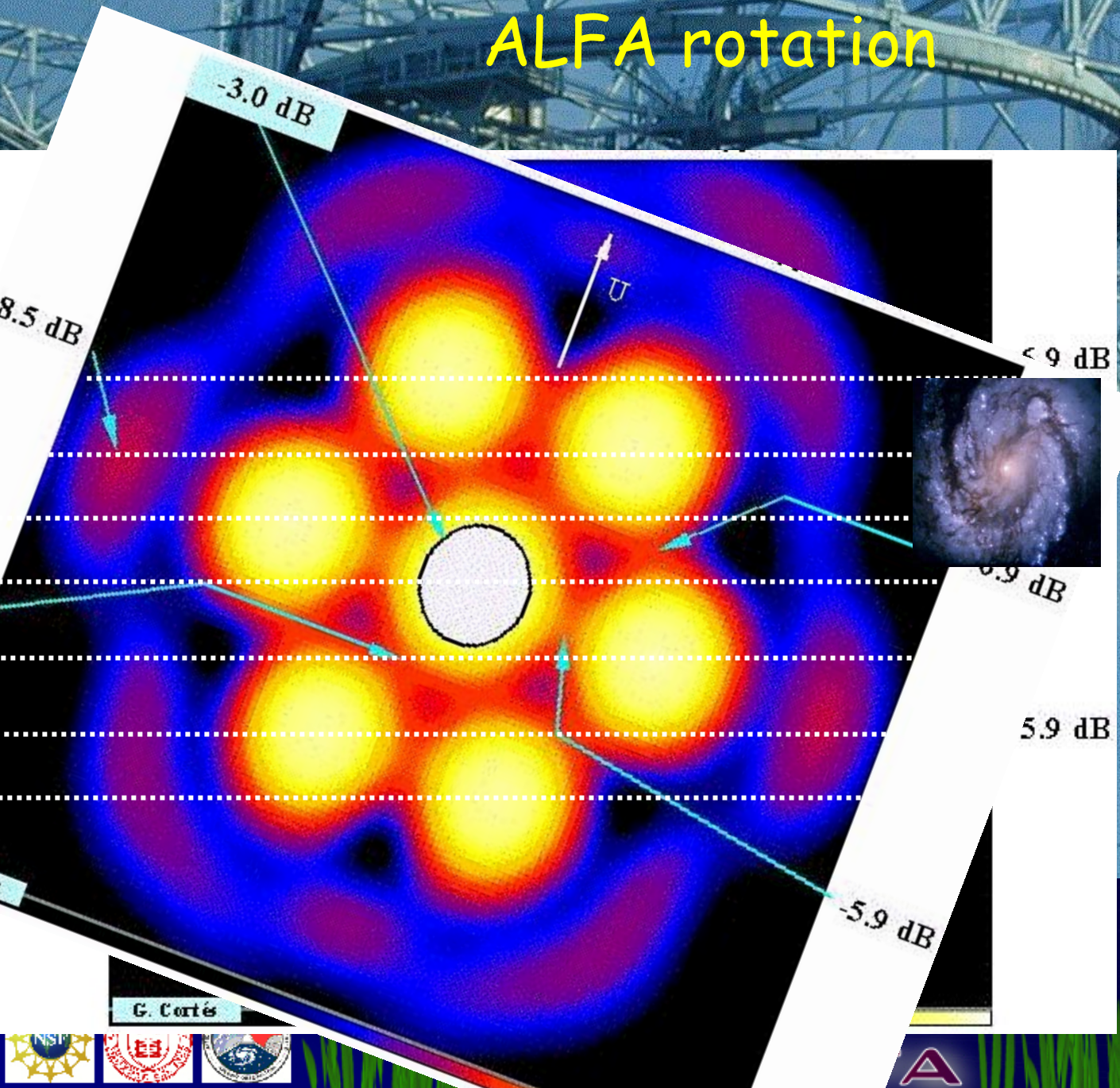


Calibration:

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

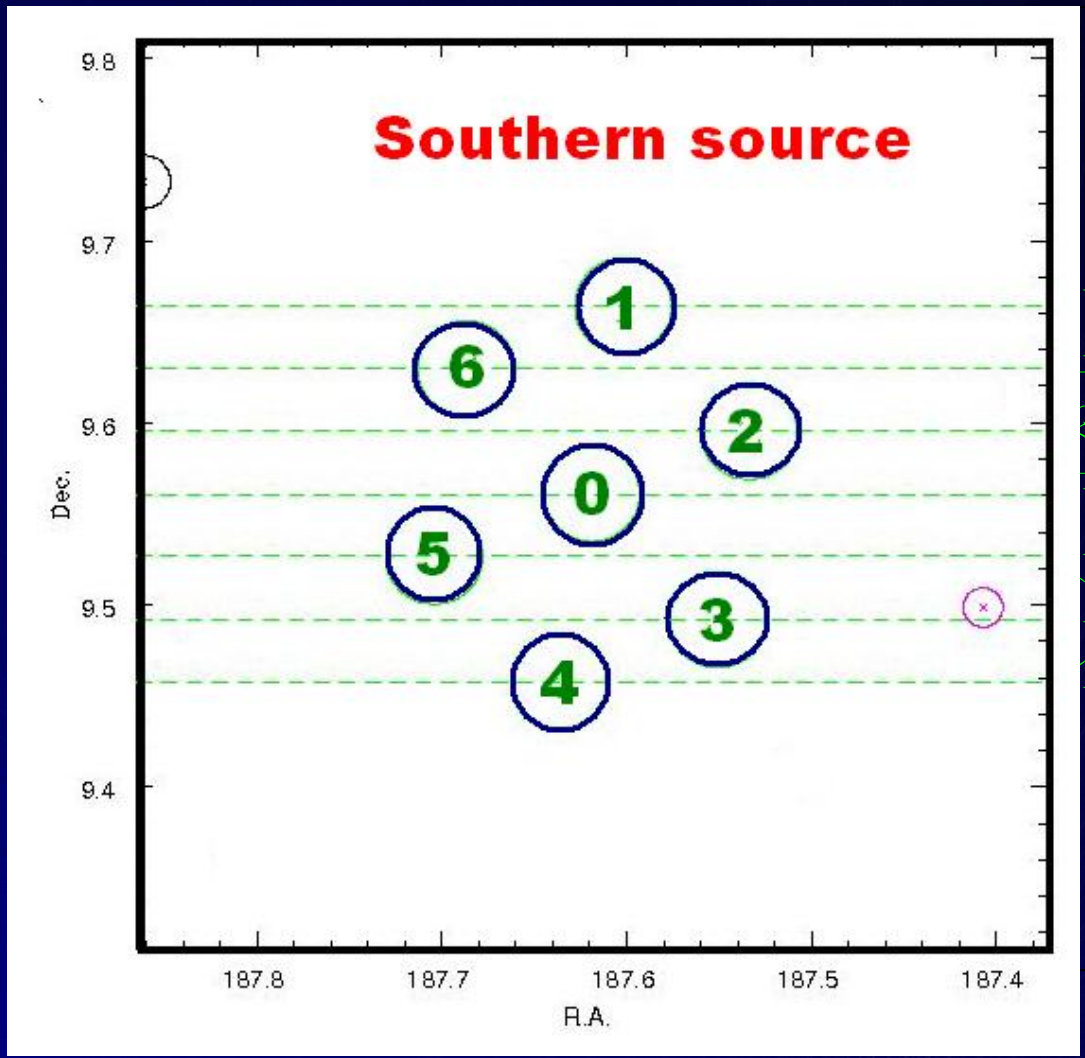
ALFALFA

ALFA rotation



7 elliptical beams
Avg(HPBW)=3.5′
on elliptical pattern
of axial ratio ~1.2

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.

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!).

RFI List

Mozilla Firefox

File Edit View Go Bookmarks Tools Help

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

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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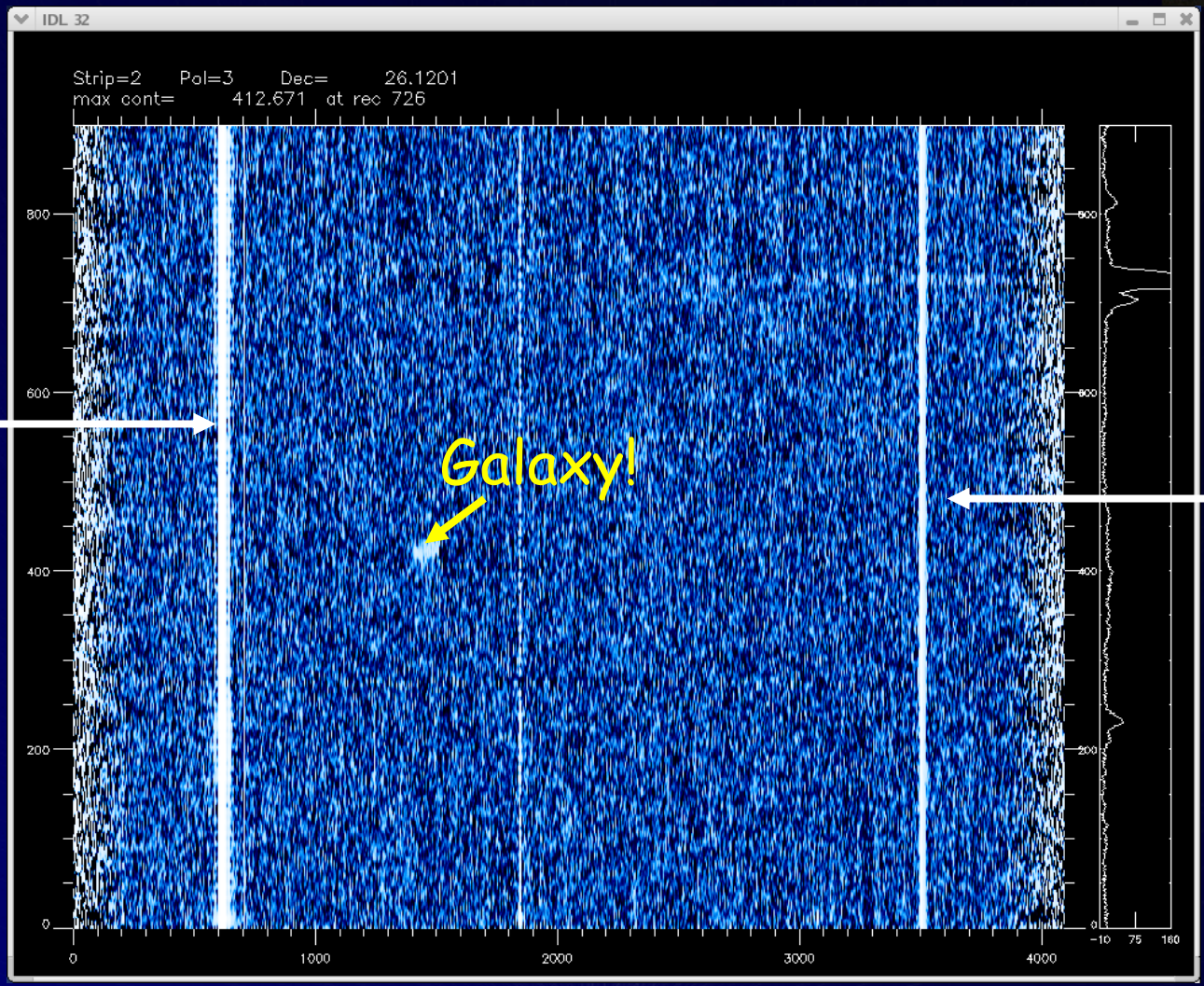
RFI is ugly



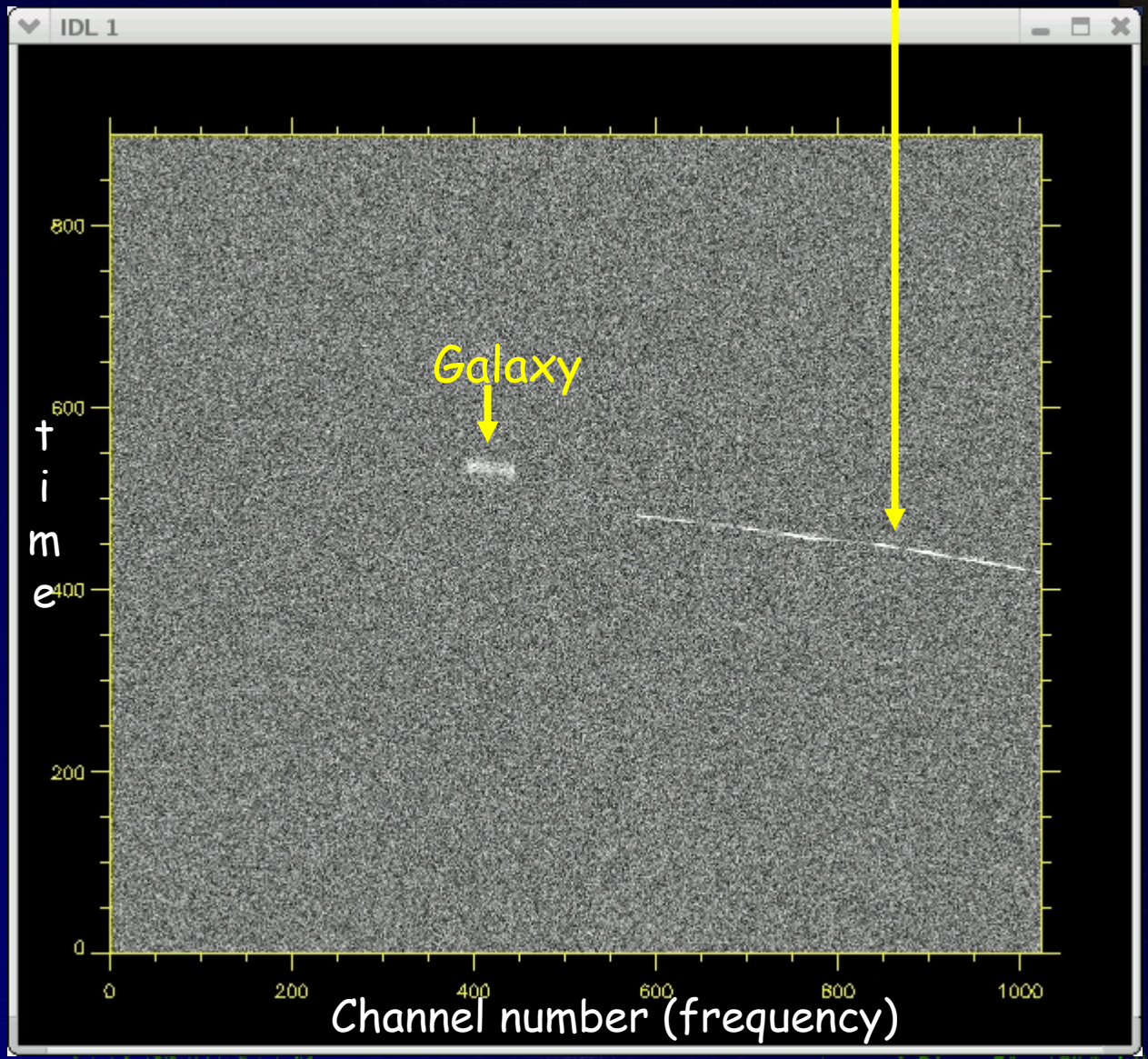
FAA radar

Galaxy!

Galactic hydrogen

ALFALFA

The wandering birdy



ALFALFA

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

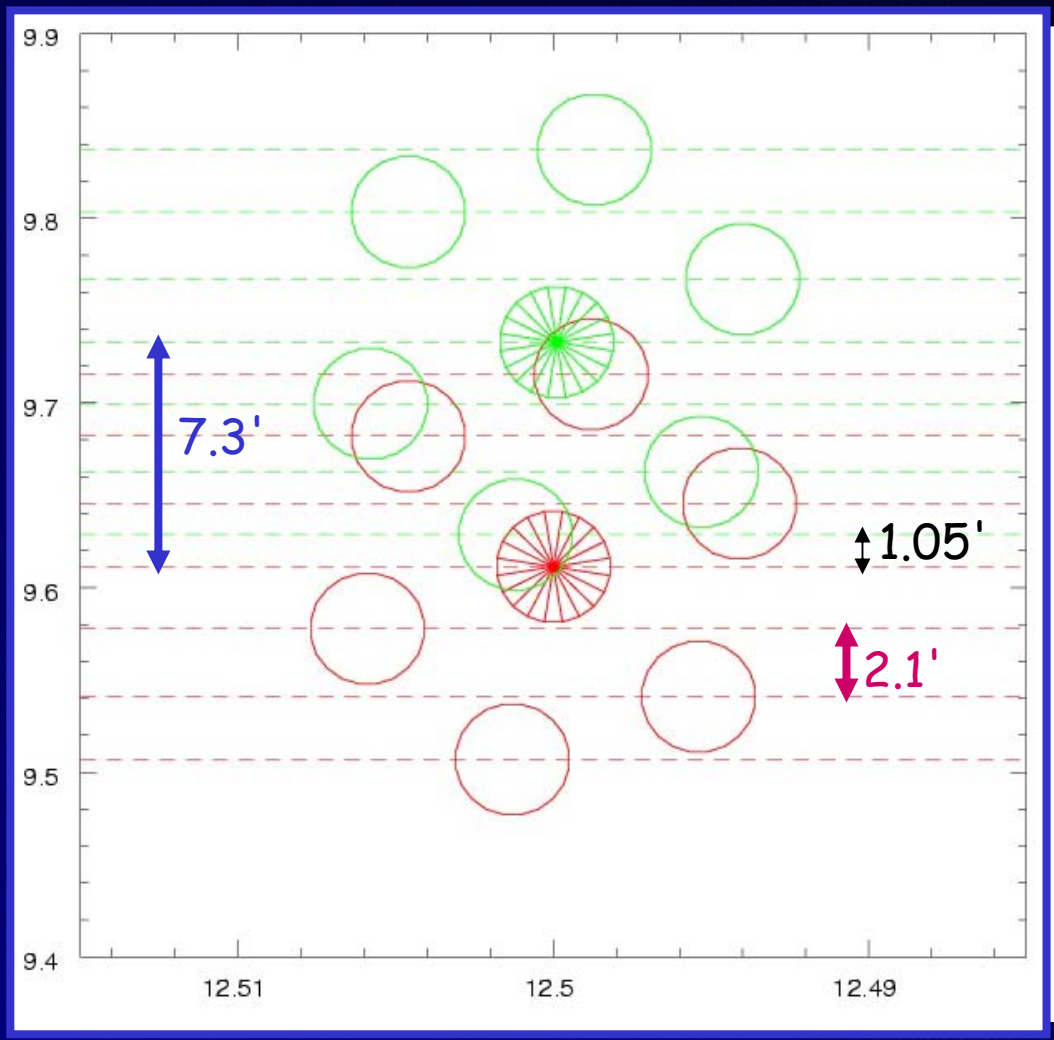
We offset the 2nd drift by half of the beam spacing.

- 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.

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)

ALFALFA

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	22p1 +05°13'54"		.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

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

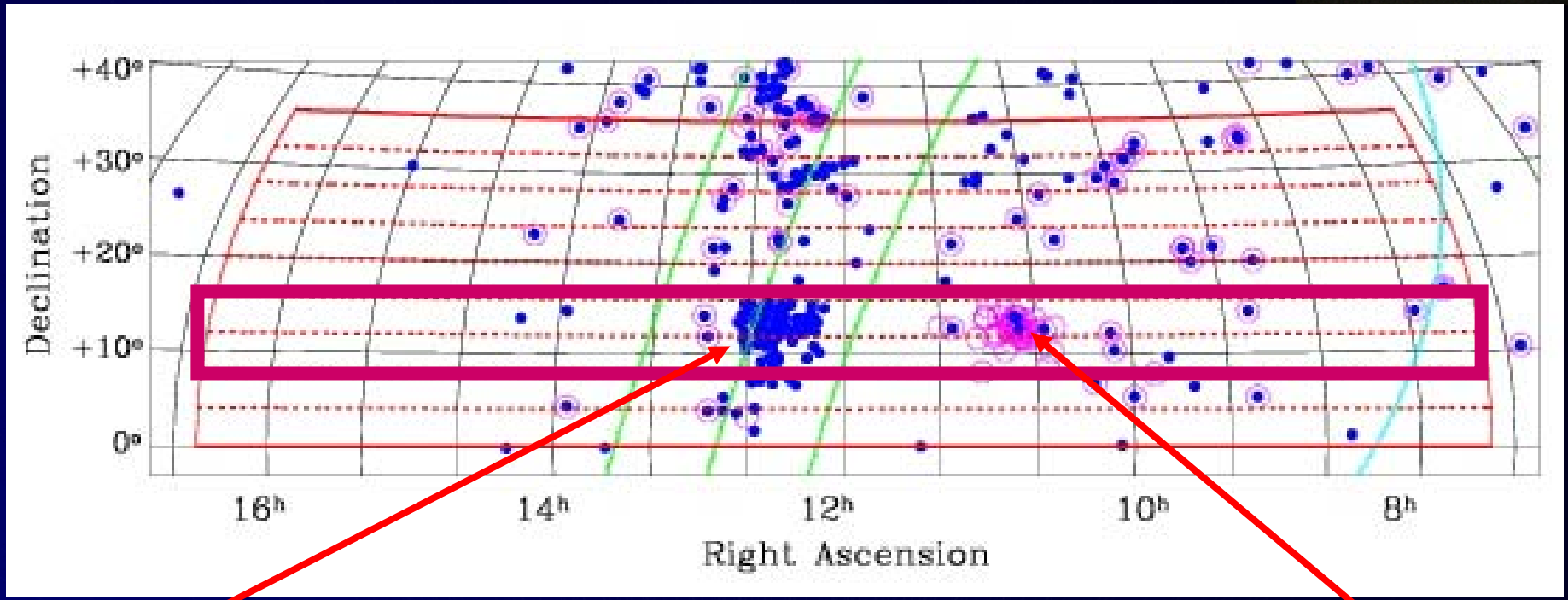
Spring 2005: +10° and +14°

Fall 2005: +26° and +30°

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).

ALFALFA: Spring Sky



Virgo cluster
D=16.7 Mpc

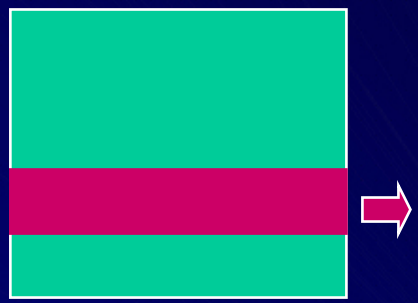
Leo I group
D=10 Mpc

2005: Tiles at +10° and +14°

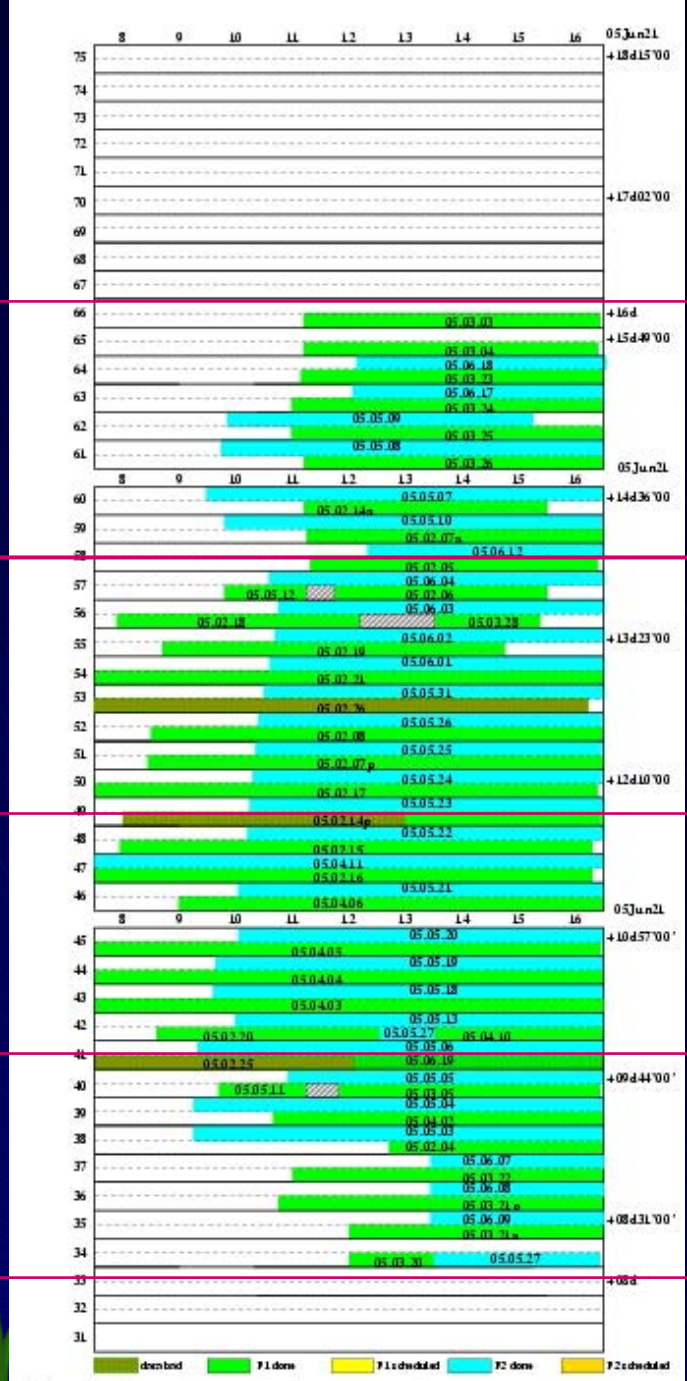
- **Leo to Virgo region**
- **Leo Group**
- **Virgo cluster core**

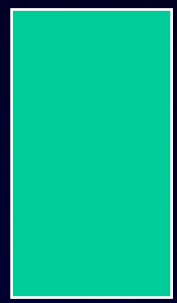
ALFALFA

ALFALFA Current status



7.5h 16.5h





22h 03.5h

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.

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

Typical A2010 schedule

TRANSMITTERS

2380 | 430 | HF

Opt | 47

System Checks

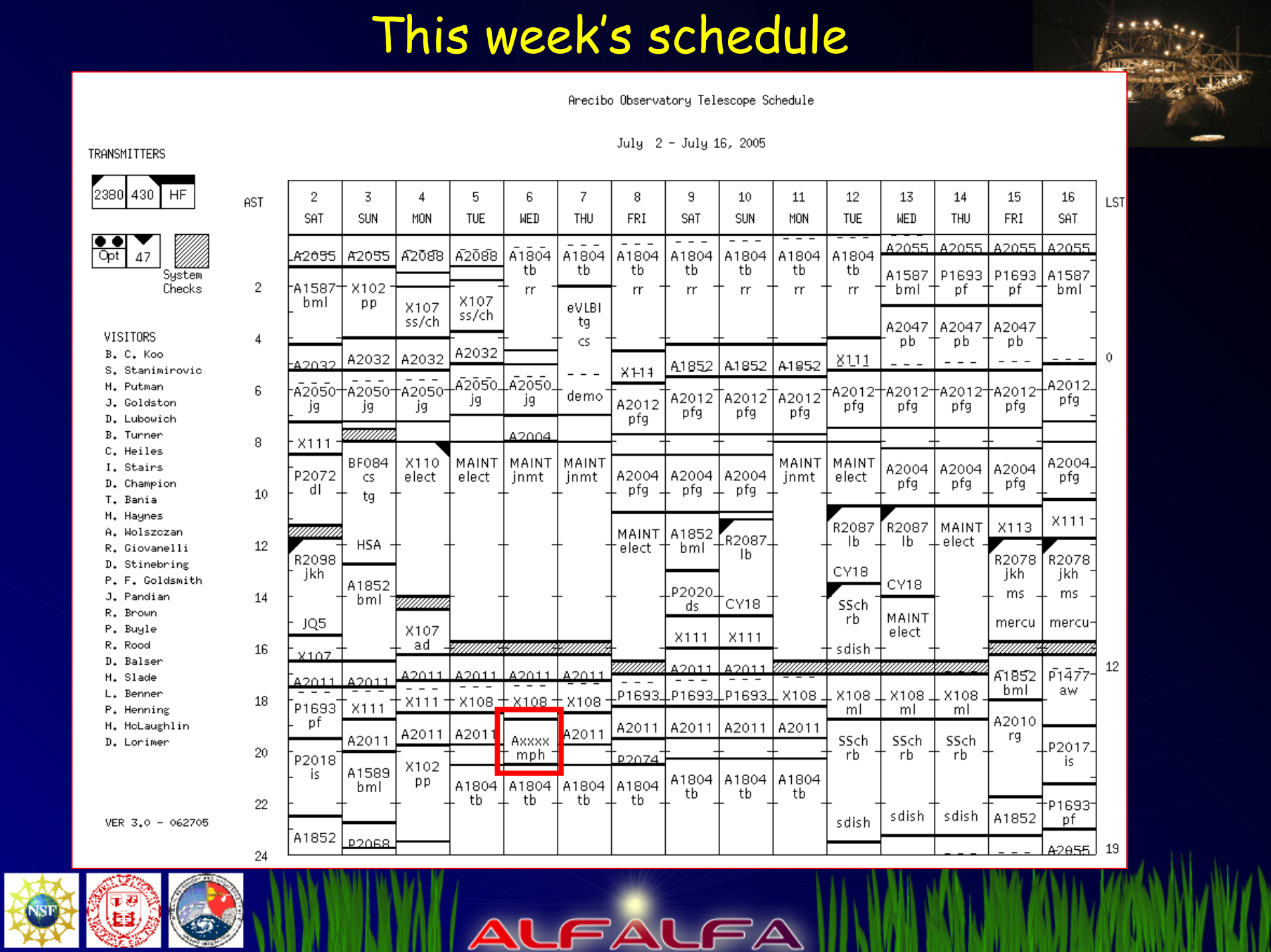
VISITORS
E. Muller
M. Haynes
R. Giovanelli
S. Schneider
W. van Driel
J. Pandian
A. Wolszczan
J. Hessels
D. Stinebring
D. Nice
D. Backer
P. Demorest
S. Stanimirovic
A. Brown
E. Berger
S. Kulkarni
F. Jenet
D. Champion
J. Goldston
C. Heiles
F. Camilo
I. Stairs
M. Putman
J. Cordes
M. K. Shepard
L. Olmi
R. Cesaroni

VER 3.0 - 050605

May 7 - May 21, 2005

AST	7 SAT	8 SUN	9 MON	10 TUE	11 WED	12 THU	13 FRI	14 SAT	15 SUN	16 MON	17 TUE	18 WED	19 THU	20 FRI	21 SAT	LST
2	A2010 rg	A2010 rg	A2010 rg	A2010 rg	A2010 rg	X102 pp	A1589 bml	A2010 rg	P2016 dn db pd	A1785 tg	P1920 jh	P2017	A2010	A2010	A2010	
	A2034	A1967 lo rc	A1967 lo rc					A1972 ss		A2034 emm		A2034	A2034	A2034	A2034	
4	P2030 jc/fc			A1859 jp	A1859 jp	A1859 jp	A1859 jp	P1871 fj			P1979 ss	P1979 ss	P1979 ss	P1979 ss	P1979 ss	19
6				P1693 pf	A1587 bml	A2005 eb sk	A2005 eb sk	P1681		P1693 pf	X111 to	P1693 pf	A1852 bml	X102 pp	X102 pp	
8	A1972 ss wvd	X111 to	MAINT jmnt	MAINT jmnt	MAINT elect			P1918 A2005 eb		MAINT elect	MAINT elect	MAINT jmnt	MAINT jmnt	X113 pp	P1693 pf	0
10		A1852 bml				MAINT elect	X107		X111 to					A2011	A2011	
12	X111 to						X113 pp	A1852 bml						X108 ml	X111 to	
14	P1693 pf	X111 to							P1693 pf					MAINT elect		
16							A2005 eb	A2005 eb		A2006 ab	A2006 ab				A1852 bml	
18		P2020 ds	X108 ml	X108 ml	X108 ml	X108 ml			P2020 ds			X108 ml	P1927 ds	X111 to		
20	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg	A2010 rg	A2010 rg mh	X111 A2005	X111 to	P1927 ds	X102 pp	A2010 rg mh	A2010 rg mh	A2010 rg mh	A2010 rg mh	12
22					R2096 mks	R2096 mks		P1477 aw	A2031 eh Templ	P1920 jh	A2031 eh Templ					
24								P2016	A1785		P2017					

This week's schedule



Arecibo Observatory Telescope Schedule

July 2 - July 16, 2005

TRANSMITTERS

2380	430	HF

Opt 47 — System Checks

VISITORS

B. C. Koo
S. Stanimirovic
M. Putman
J. Goldston
D. Lubowich
B. Turner
C. Heiles
I. Stairs
D. Champion
T. Bania
M. Haynes
A. Wolszczan
R. Giovanelli
D. Stinebring
P. F. Goldsmith
J. Pandian
R. Brown
P. Boyle
R. Rood
D. Balser
M. Slade
L. Benner
P. Henning
M. McLaughlin
D. Lorimer

VER 3.0 - 062705

AST	2 SAT	3 SUN	4 MON	5 TUE	6 WED	7 THU	8 FRI	9 SAT	10 SUN	11 MON	12 TUE	13 WED	14 THU	15 FRI	16 SAT	LST
	A2055	A2055	A2088	A2088	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A2055	A2055	A2055	A2055	
2	A1587 bml	X102 pp	X107 ss/ch	X107 ss/ch	rr	eVLBI tg cs	rr	rr	rr	rr	rr	A1587 bml	P1693 pf	P1693 pf	A1587 bml	
4	A2032	A2032	A2032	A2032			X111	A1852	A1852	A1852	X111	A2047 pb	A2047 pb	A2047 pb		0
6	A2050 jg	A2050 jg	A2050 jg	A2050 jg	A2050 jg	demo	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	A2012 pfg	
8	X111				A2004											
10	P2072 dl	BF084 cs tg	X110 elect	MAINT elect	MAINT jnmt	MAINT jnmt	A2004 pfg	A2004 pfg	A2004 pfg	MAINT jnmt	MAINT elect	A2004 pfg	A2004 pfg	A2004 pfg	A2004 pfg	
12	R2098 jkh	HSA					MAINT elect	A1852 bml	R2087 lb		R2087 lb CY18	R2087 lb CY18	MAINT elect	X113	X111	
14	JQ5	A1852 bml	X107 ad					P2020 ds	CY18		SSch rb	MAINT elect		R2078 jkh ms mercu	R2078 jkh ms mercu	
16	X107							X111	X111		sdish					
18	A2011 P1693 pf	A2011 X111	A2011 X111	A2011 X108	A2011 X108	A2011 X108	P1693	A2011 P1693	A2011 P1693	A2011 X108	X108 ml	X108 ml	X108 ml	A1852 bml	P1477 aw	12
20	P2018 is	A2011 A1589 bml	A2011 X102 pp	A2011	Axxxx mph	A2011	A2011 P2074	A2011	A2011	A2011	SSch rb	SSch rb	SSch rb	A2010 rg	P2017 is	
22	A1852	P2068		A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	A1804 tb	sdish	sdish	sdish	A1852	P1693 pf	
24															A2055	19

Observing Team Tasks

- Designated observer (Sabrina: May 18-Jun 4)
  - Executes and monitors observing
  - Writes log file of scans with times, notes, etc.
  - Creates list of good fits files
  - Updates Arecibo website with log, cimalog, fitslist
  - Converts FITS to raw IDL
  - Verifies data quality (first check)
- Designated Arecibo file monitor (Barbara/Brian/Martha)
  - Checks that files were converted properly
  - Checks that IDL files are transferred to CU
- Designated CU archivist (Martha/Brian)
  - Relocates files to proper disks at CU
  - Insures and logs file status and location
  - Updates CU website with file info
- Designated scheduler (Martha/Brian)
  - Produces and maintains detailed schedule
  - Checks/updates a2010.cat at Arecibo
  - Updates Arecibo/CU websites with scheduling info

So, enough talk; let's observe....