ALFALFA Science Goals and Sensitivities

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- An extragalactic HI line survey covering 7000 sq deg
- with the ALFA multibeam feed at Arecibo
- 1335-1435 MHz (-2000 to + 17500 km/s) with 5 km/s res
- 2-pass, drift mode (eff. integration time per beam ~ 48 sec)
- 1.6/2.3 mJy rms per beam/pixel @ R=30,000
- 4000 hrs of telescope time, 5-6 years
- started Feb 2005

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ALFALFA science goals

1 Determination of the faint end of the HI Mass Function

2 Environmental variation in the HI Mass Function

3 Blind Survey for HI tidal remants

4 HI Diameter Function

5 The low HI Column density environment of galaxies

6 The nature of HVC's around the MW and M33

7 HI absorbers and the link to Lyman α absorbers

8 OH Megamasers at intermediate redshift

ALFALFA Sensitivity summary:

- A 1–second record of a drift scan, after accumulation of both polarizations, will yield a spectrum of $S_{rms} \simeq 13(res/10)^{-1/2}$ mJy, where res is the spectral resolution in km s^{-1} .
- A single drift, position–frequency map spatially smoothed to the spatial resolution of the telescope beam will yield $S_{rms} \simeq 3.5(res/10)^{-1/2}$ mJy.
- A spatially two–dimensional map of two–pass ALFALFA data, smoothed with a kernel of 2' at half power, will have $S_{rms} \simeq 2.3(res/10)^{-1/2}$ mJy per pixel.
- The rms sensitivity per beam area, after a two–pass survey, will be $S_{rms} \simeq 1.8(res/10)^{-1/2}$.
- The 6σ HI column density limit will be $N_{HI,lim} = 1.6 \times 10^{18}(W/10)(res/10)^{-1/2}$ atoms cm^{-2}, for a spectral line of width W km s^{-1} , observed with a spectral resolution of res km s^{-1} .

Can detect 10^6 M_{sun} to D=6.5 Mpc
10^7 M_{sun} to D=20 Mpc

with an effective integration time of 48 sec per beam solid angle

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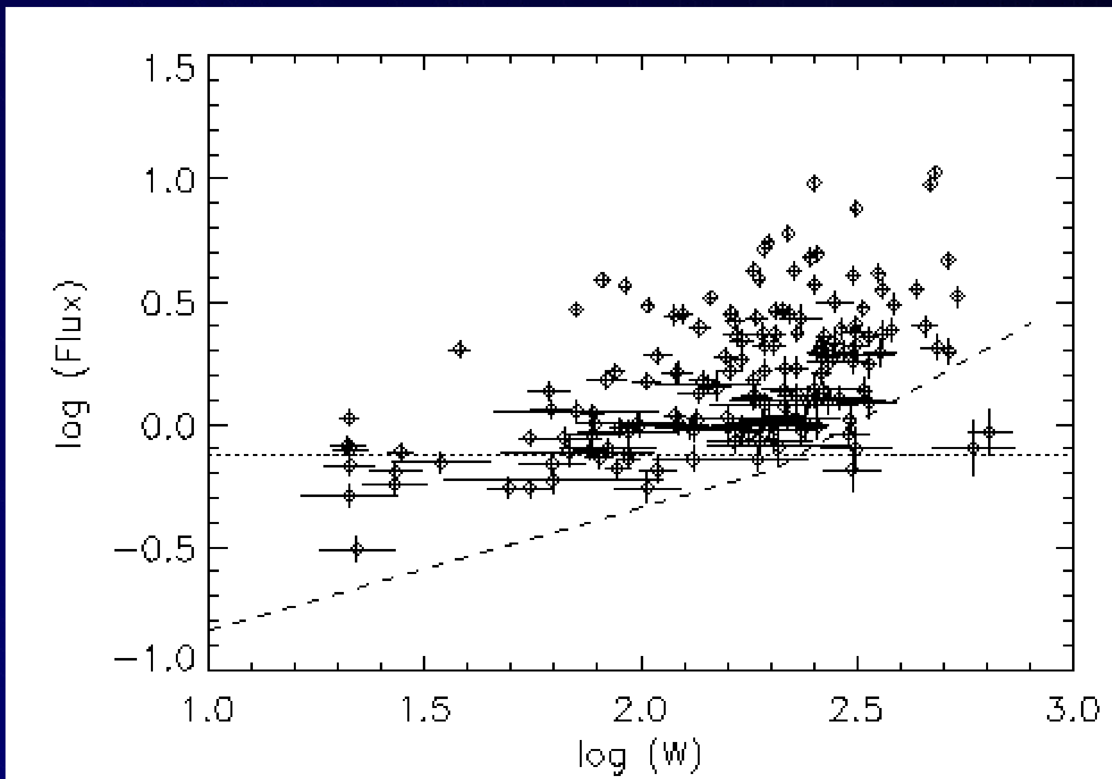
ALFALFA Precursor Run Detections



Completeness depends on Velocity Width

Units of Flux Integral: Jy km/s
Units of Width (full width): km/s

Comparison of blind HI surveys

Survey	Beam arcmin	Area sq. deg.	rms (mJy @ 18 km/s)	min M_{HI} @ 10 Mpc	N_{det}	t_s sec	N_{los}
AHISS	3.3	13	0.7	2.0×10^6	65	var	17,000
ADBS	3.3	430	3.3	9.6×10^6	265	12	500,000
HIPASS	15.	30,000	13	3.6×10^7	4315	460	1.9×10^6
HIJASS	12.	(TBD)	13	3.6×10^7	(?)	3500	(TBD)
J-Virgo	12	32	4	1.1×10^7	31	3500	3200
HIDEEP	15	32	3.2	8.8×10^6	129	9000	2000
ALFALFA	3.5	7,000	1.7	4.4×10^6	16,000?	30	7×10^6

ALFALFA will be ~ 1 order of magnitude more sensitive than HIPASS with 4X better angular resolution.

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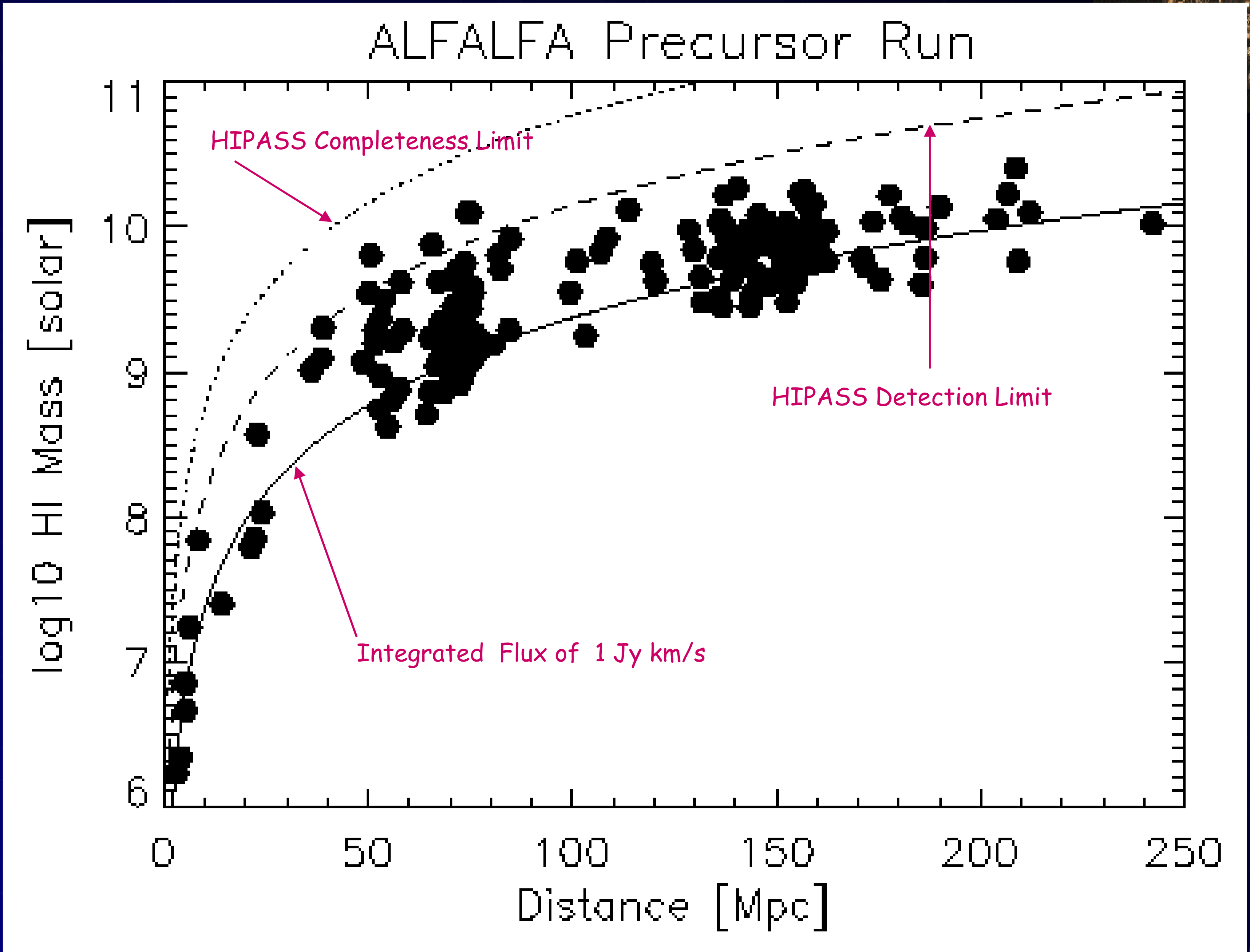
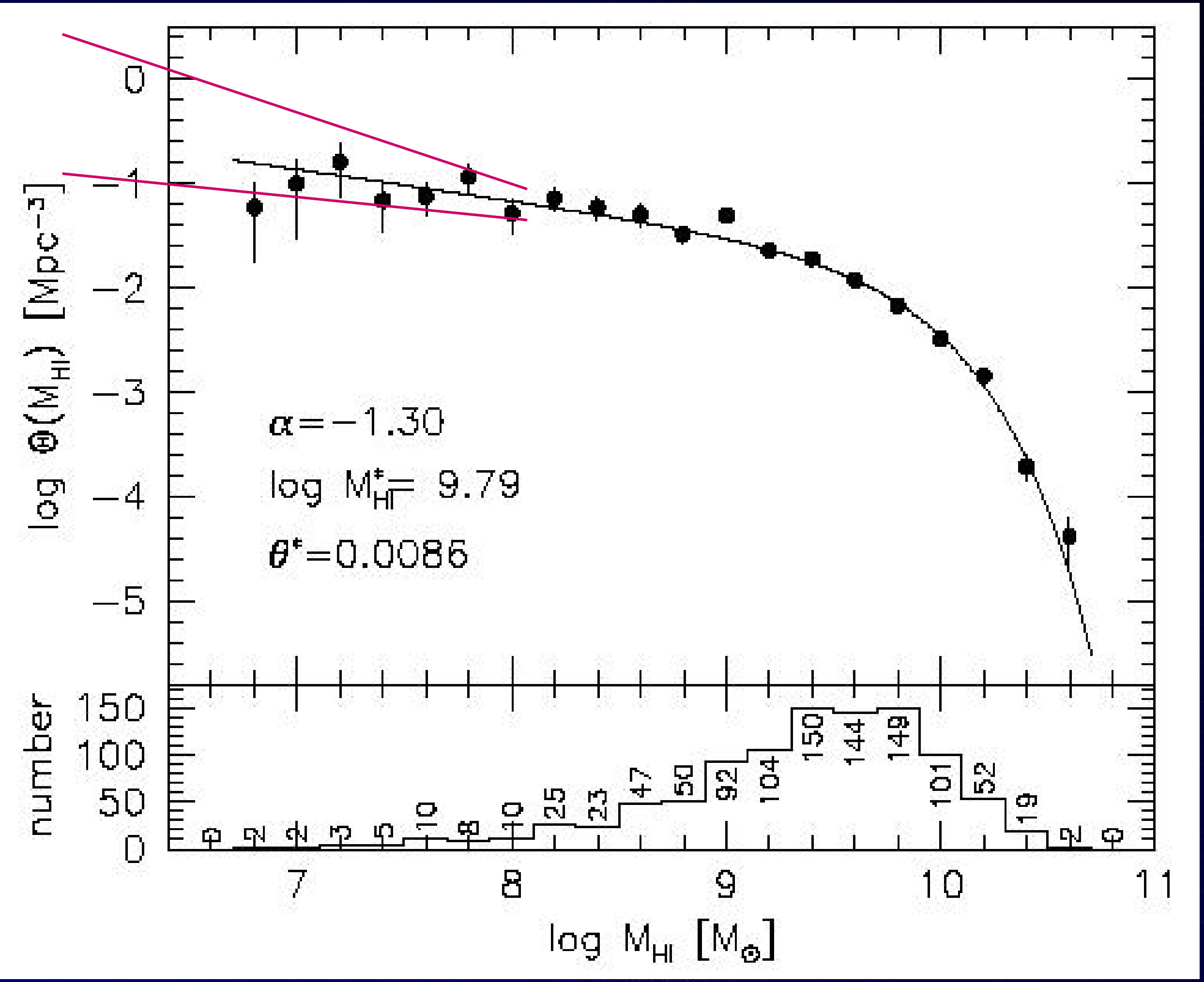

ALFALFA Precursor Run
HIPASS Completeness Limit
HIPASS Detection Limit
Integrated Flux of 1 Jy km/s
log10 HI Mass [solar]
Distance [Mpc]
6
7
8
9
10
11
0
50
100
150
200
250

HI Mass Function
in the local Universe



Parkes HIPASS survey: Zwaan et al. 2003

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▷ For a given HI mass, the volume sampled by a survey

$$V_{survey}(M_{HI}) = \Omega\, D_{max}^3/3$$

can be increased by either (a) surveying a larger solid angle Ω or (b) integrating longer and increasing D_{max}.

- Since the time required to complete the survey is $t_{survey} \propto (\Omega/\Omega_b)\, t^s$,
- and $D_{max} \propto t_s^{1/4}$,
- then $V_{survey}(M_{HI}) \propto \Omega[D_{max}]^3 \propto \Omega\, t_s^{3/4} \propto t_{survey}\, t_s^{-1/4}$
- Inverting: $t_{survey} \propto V_{survey}\, t_s^{1/4}$

Hence, once t_s is large enough to make M_{HI} detectable,

it is more advantageous to maximize Ω than to increase the survey depth.

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One pass maximizes volume sampled at any HI mass limit.

… however

Two-pass strategy increases signal detection reliability, allows for continuum variability and transient detection, identification of transient rfi, avoidance of having blank coverage in case of single amplifier failure

… at the expense of sacrificing ~17% of volume sampled.

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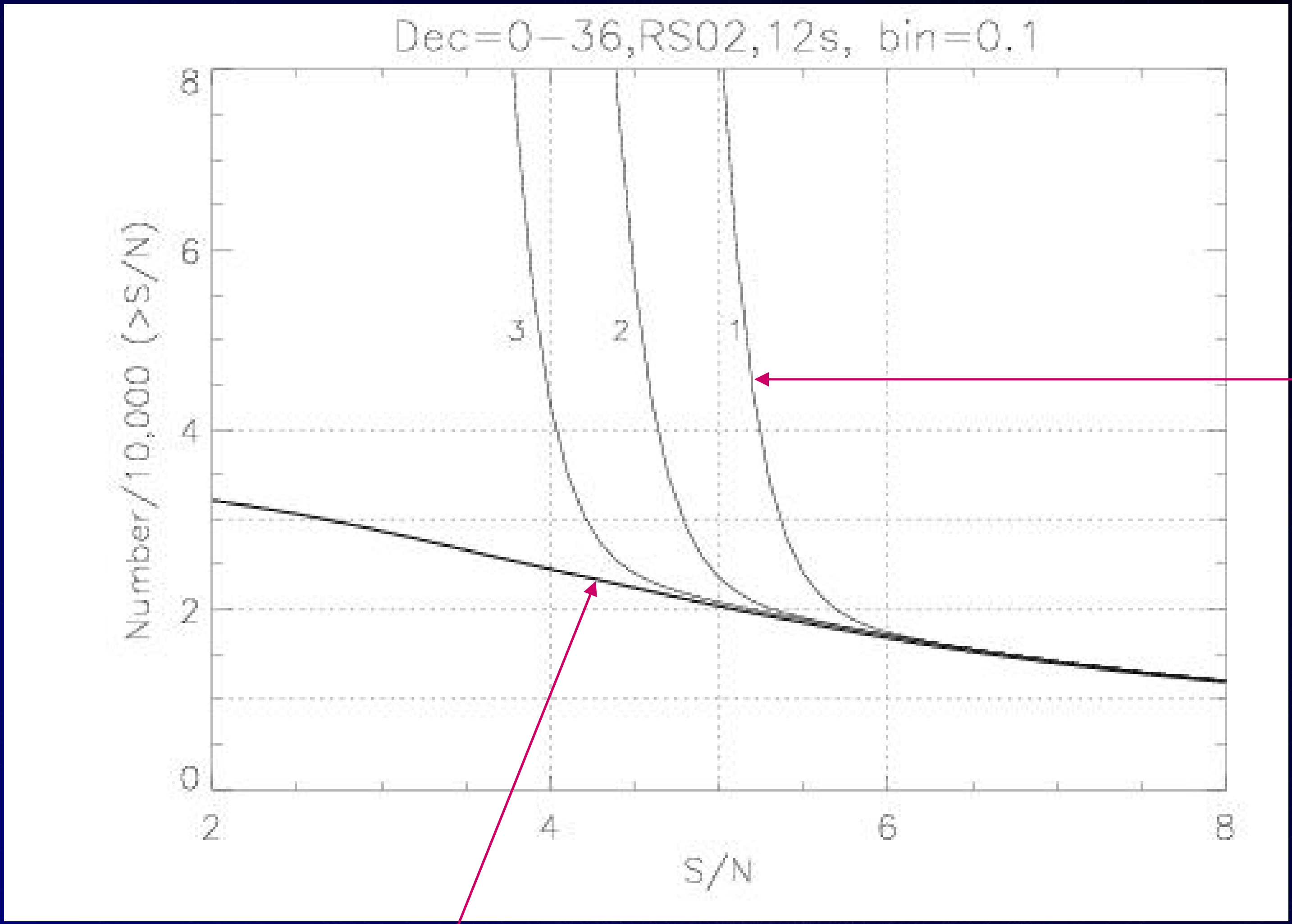

Noise fluctuations

1. No vicinity trimming
2. One-pass vicinity trimming
3. Two-pass vicinity trimming

cosmic sources

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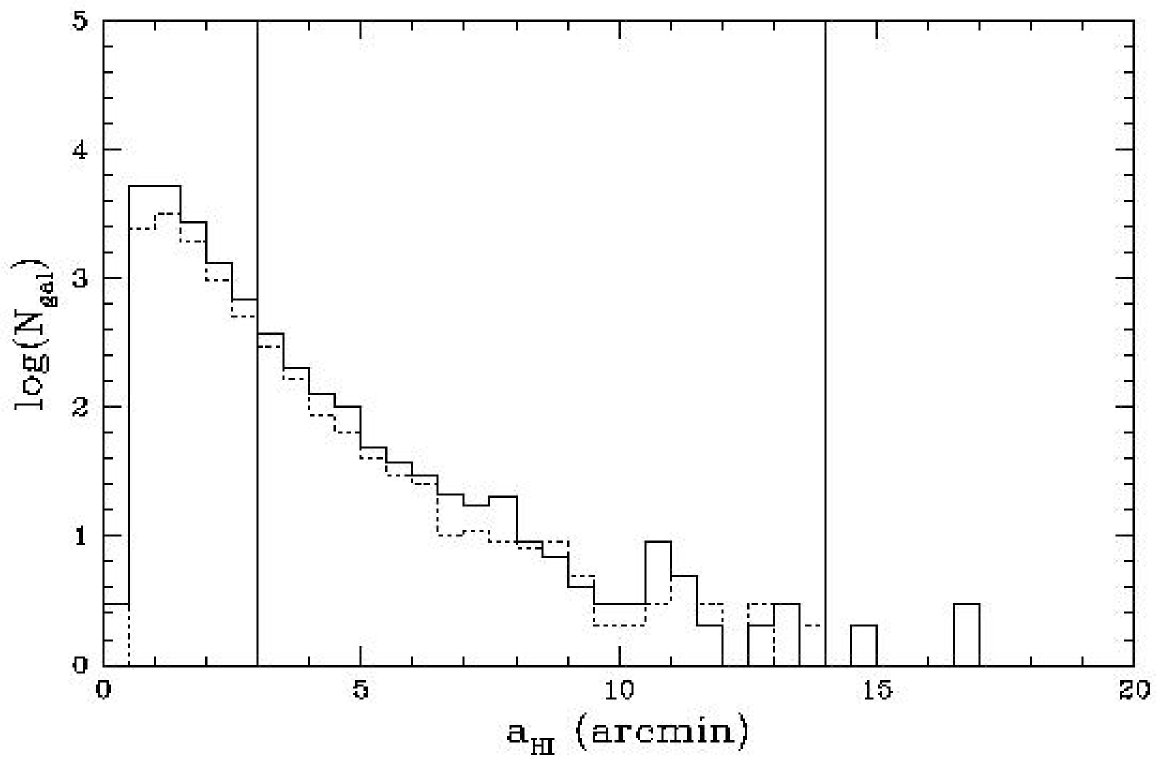
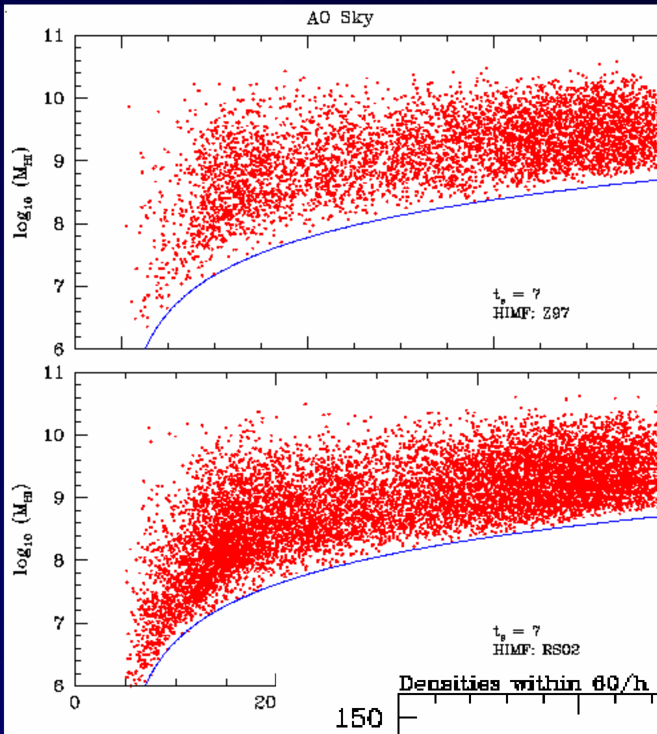
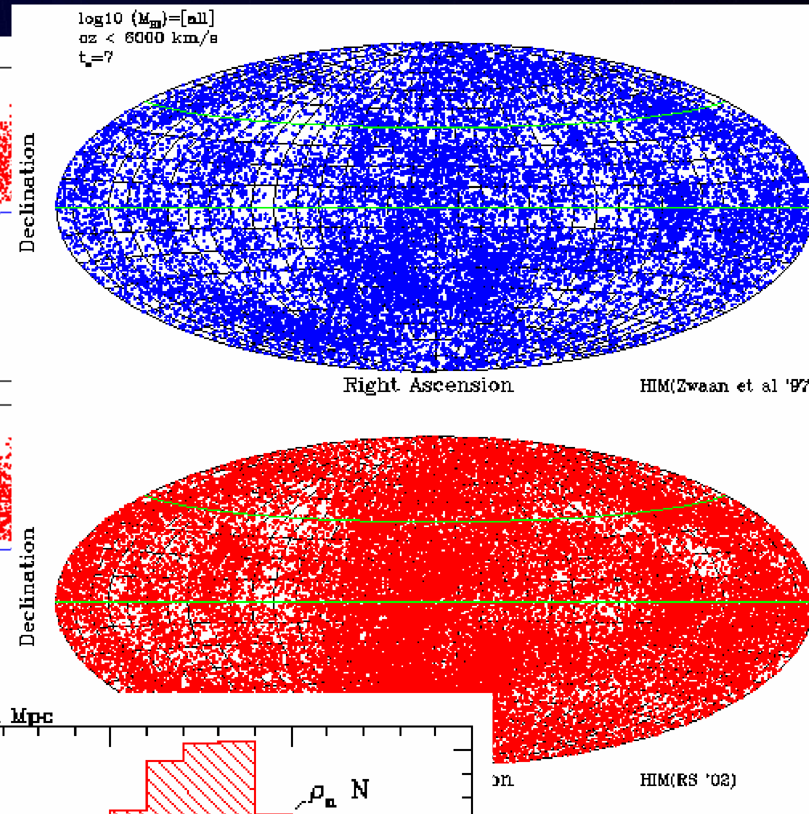
HIPASS production emphasizes the low sensitivity limit expressed in terms of column density:

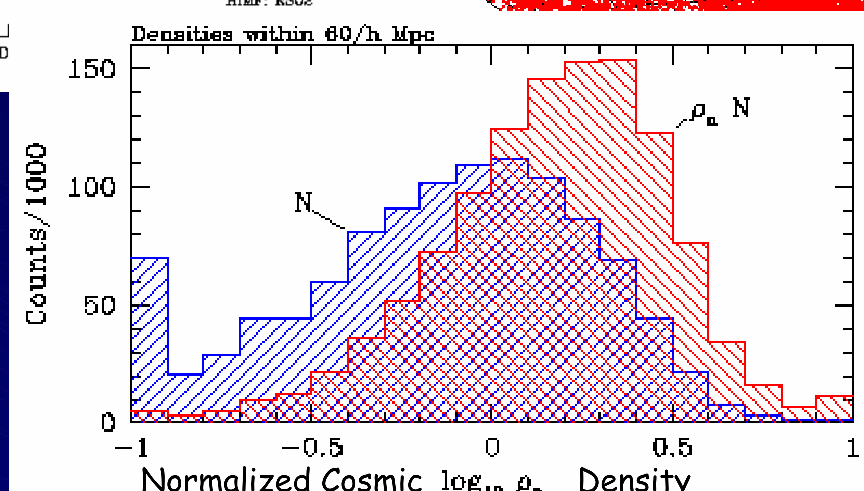
➔" $6x10^{17}$ cm^{-2} per channel for gas that fills the beam"

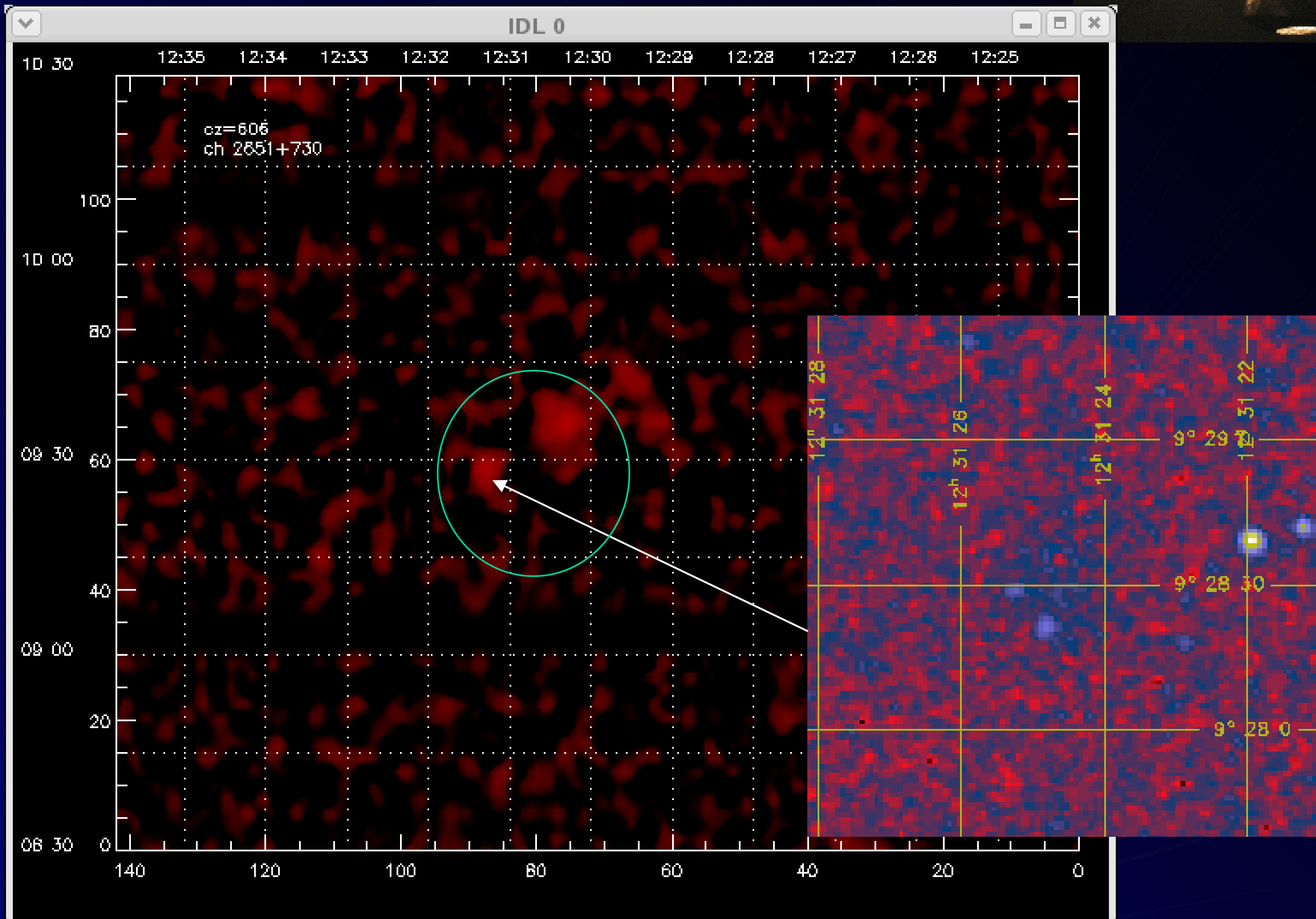
… a useless parameter since the number of objects that fill the Parkes beam are extremely few.




AO Sky
log10 (M_HI)
t_s = 7
HIMF: Z97
t_s = 7
HIMF: RS02
11
10
9
8
7
6
0
20


log10 (M_HI)=[all]
cz < 6000 km/s
t_s=7
Declination
Right Ascension
HIM(Zwaan et al '97)
Declination
HIM(RS '02)


Densities within 60/h Mpc
Counts/1000
150
100
50
0
−1
−0.5
0
0.5
1
N
ρ_n N
Normalized Cosmic log10 ρ_n Density



VCC1357
0.2x0.1
I?
603 km/s

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ALFALFA Precursor Run: A1946

* Aug-Sep 2004
* Candidate Detections Confirmation Run Jan-Feb 2005
* 36 hours of ALFA data

166 confirmed HI sources :

- 25 with HI mass > 10^{10} Msun
- 4 with HI mass < 10^{7} Msun (twice as many as all of HIPASS)
- high positional accuracy:
  we can centroid with a median accuracy of 34"
  virtually all optical counterparts ID'd; median difference position between HI centroid and optical source 33"
- slightly better detection rate than expected (high side),
  i.e. our ability to reliably dig in low S/N territory is high
- system hardware performance, "hands-off" bandpass calibration and baselining (IDL processing pipeline) gave excellent results.

Papers Submitted to the AJ:

Manuscript #: 204779
Title: The Arecibo Legacy Fast ALFA Survey: II. Results of Precursor Observations
Authors: Riccardo Giovanelli, Martha P. Haynes, Brian R. Kent, Philip Perillat, Barbara Catinella, G. Lyle Hoffman, Emmanuel Momjian, Jessica L. Rosenberg, Amelie Saintonge, Kristine Spekkens, Sabrina Stierwalt, Noah Brosch, Karen L. Masters, Christopher M. Springob, Igor D. Karachentsev, Valentina E. Karachentseva, Rebecca A. Koopmann, Erik Muller, Wim van Driel, and Liese van Zee

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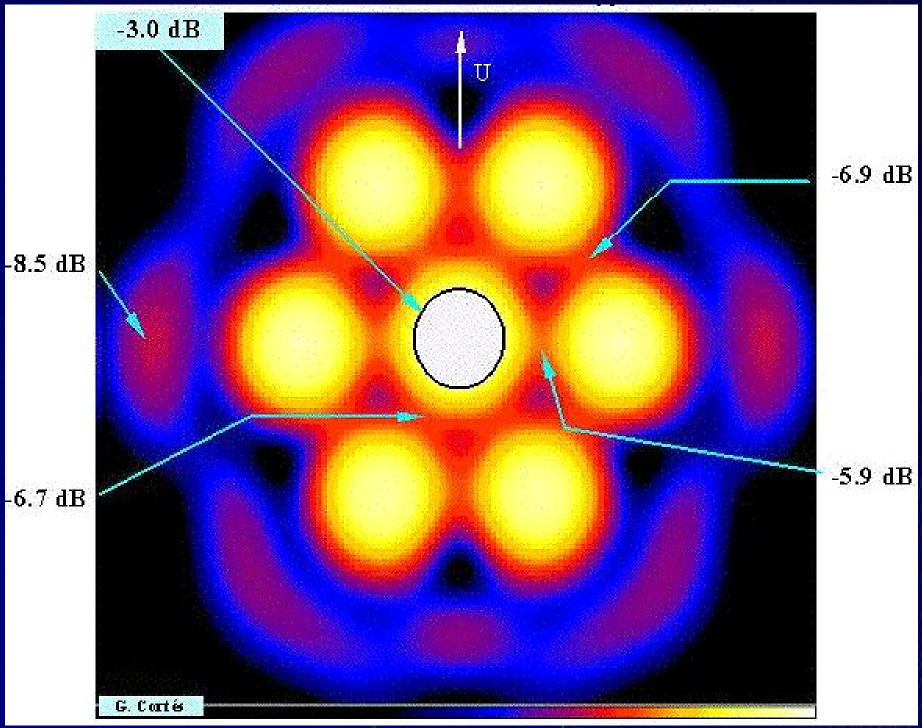
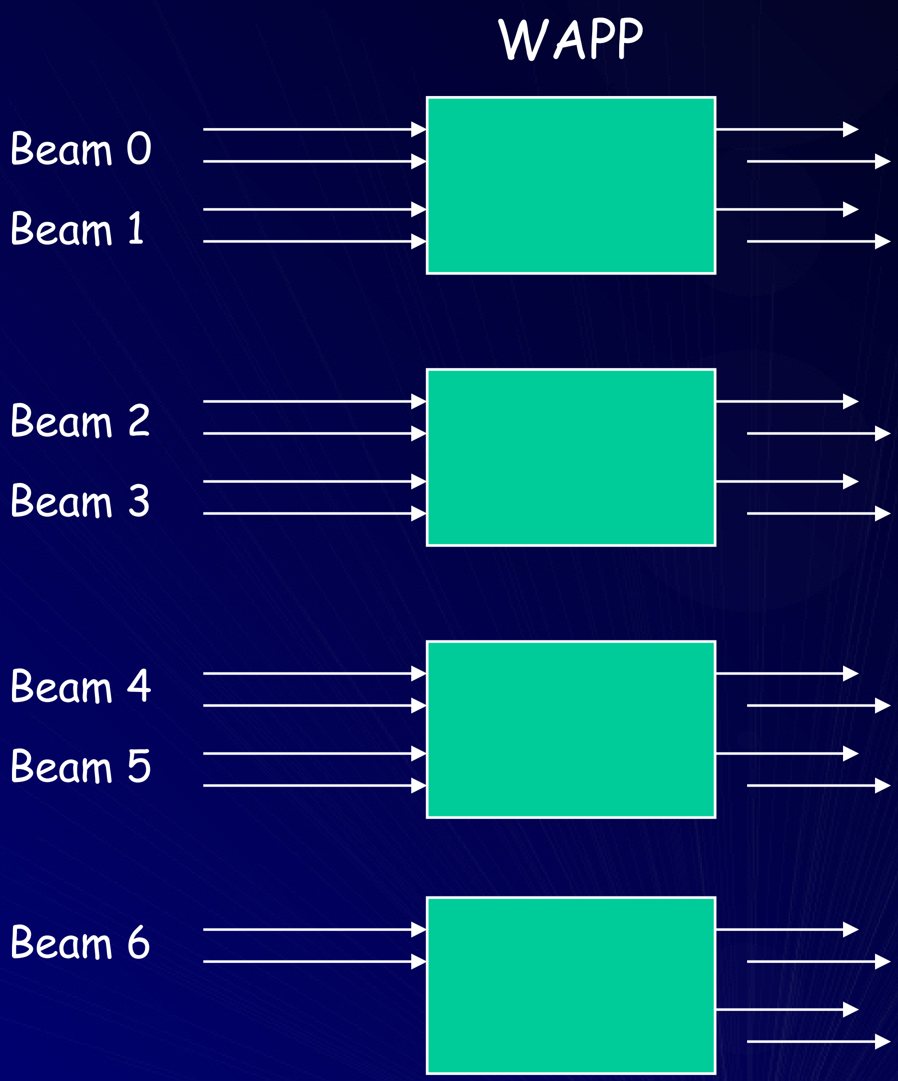
ALFA and ALFA backends

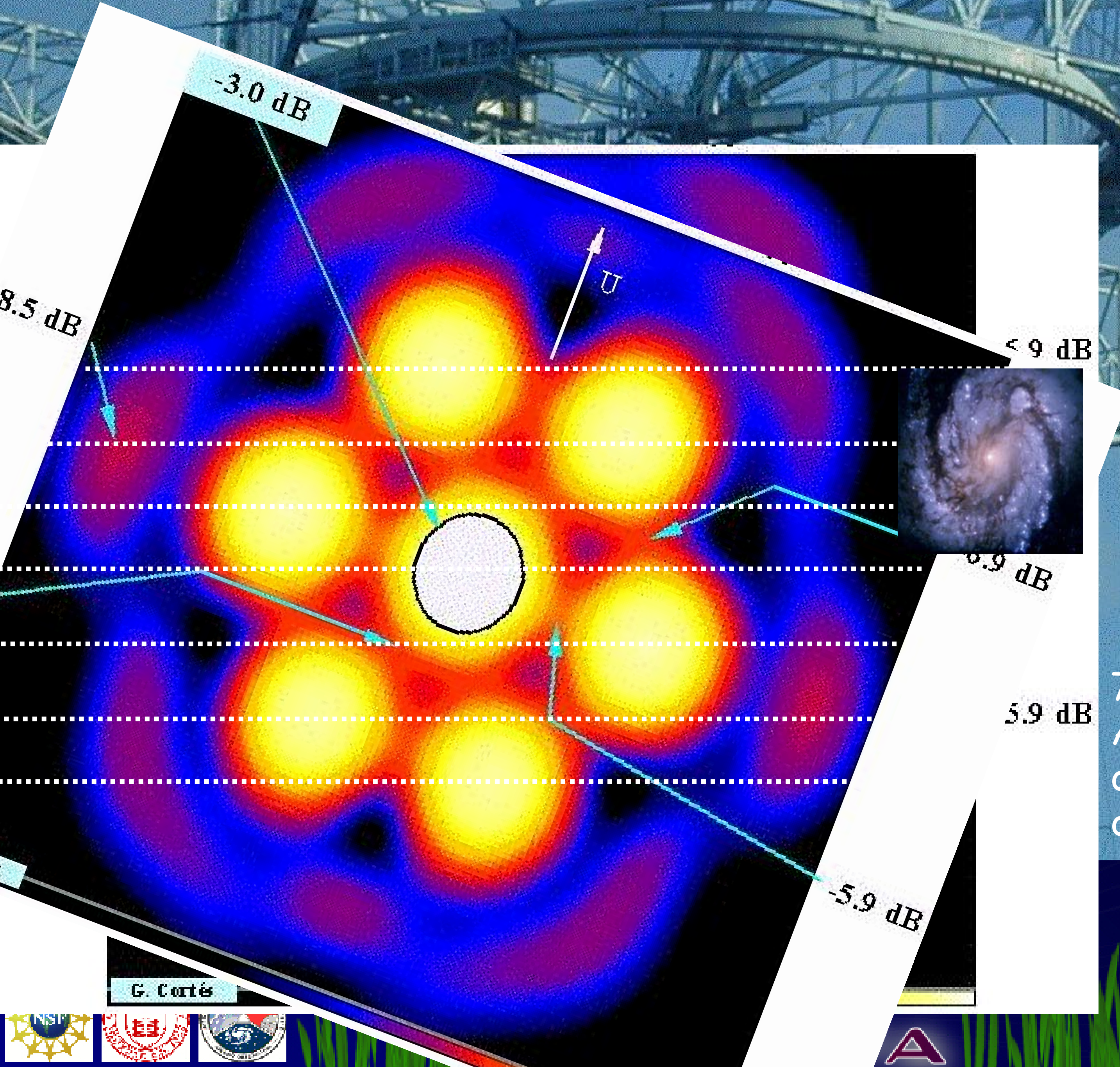




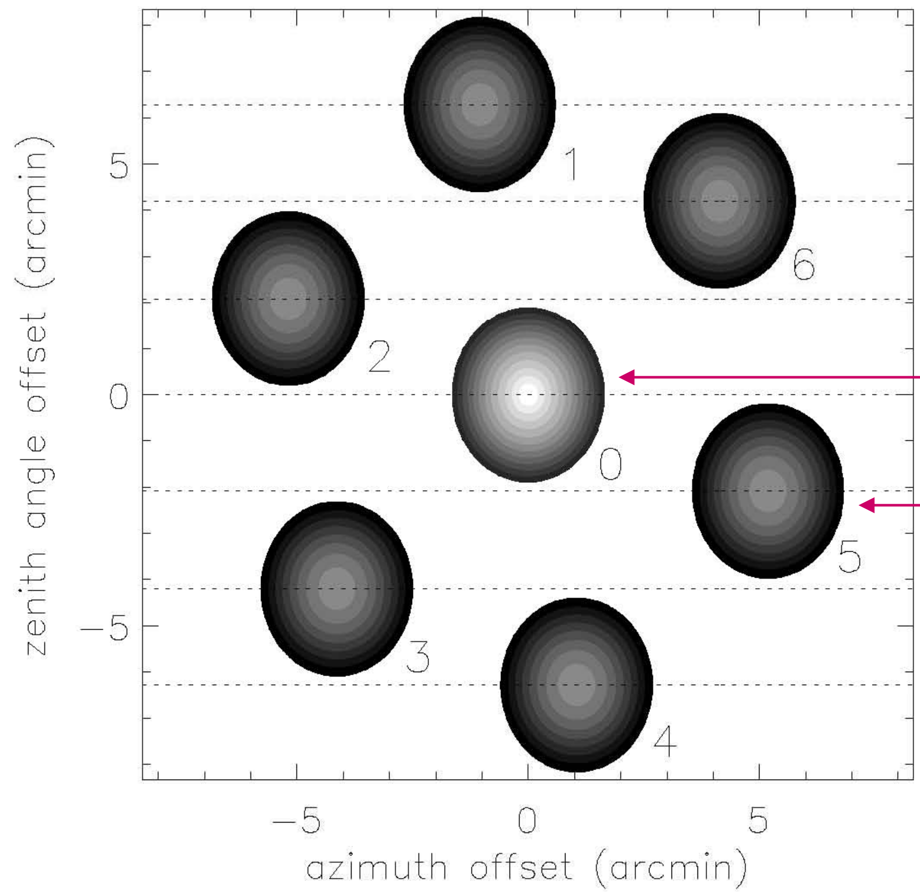
16 x 4096 ch,

100 MHz wide

spectra



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



Gain:

11 K/Jy

8.6 K/Jy

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.

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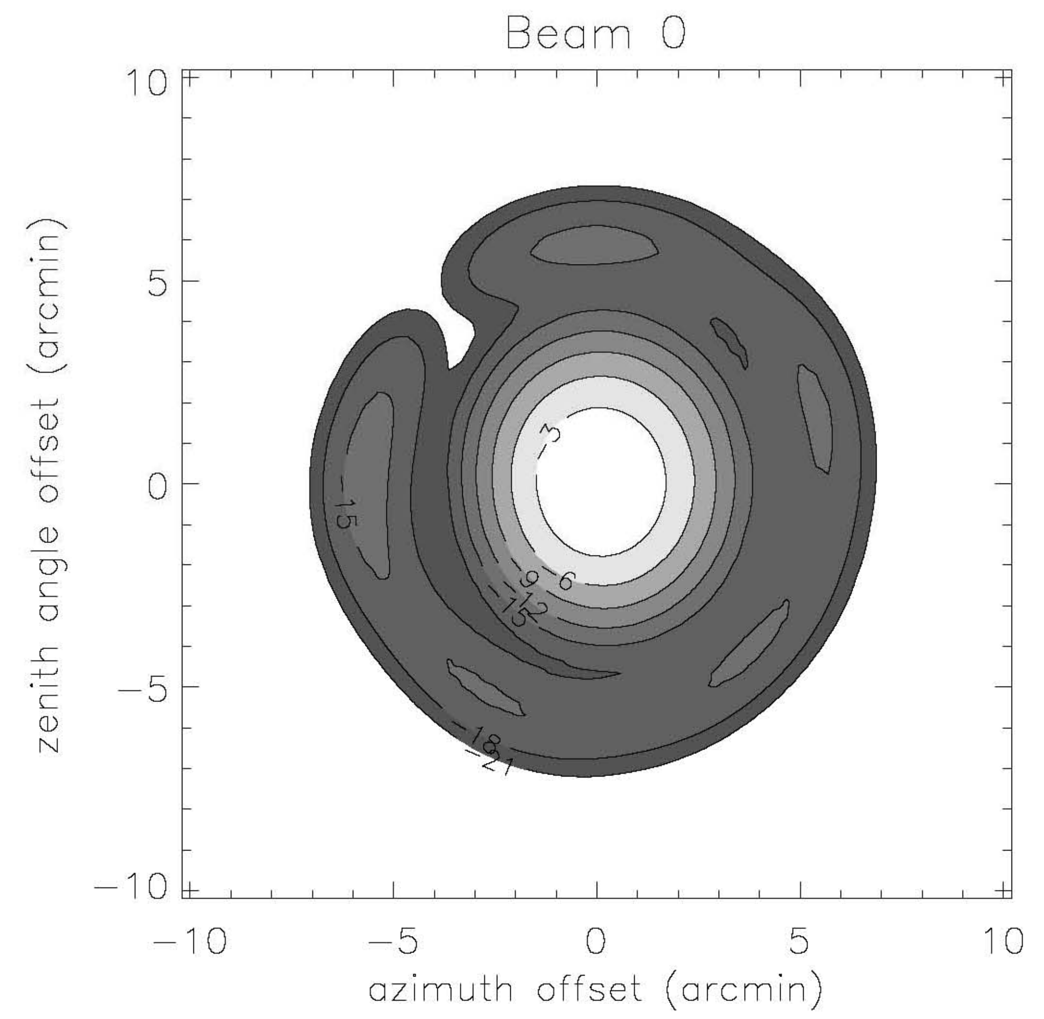

Fig. 3.— Beam pattern of beam 0. Contour lines and shading intervals are plotted at intervals of 3 dB below peak response (the highest contour is at half the peak power). The first sidelobe ring, with a diameter near 12', is at approximately -15 dB.

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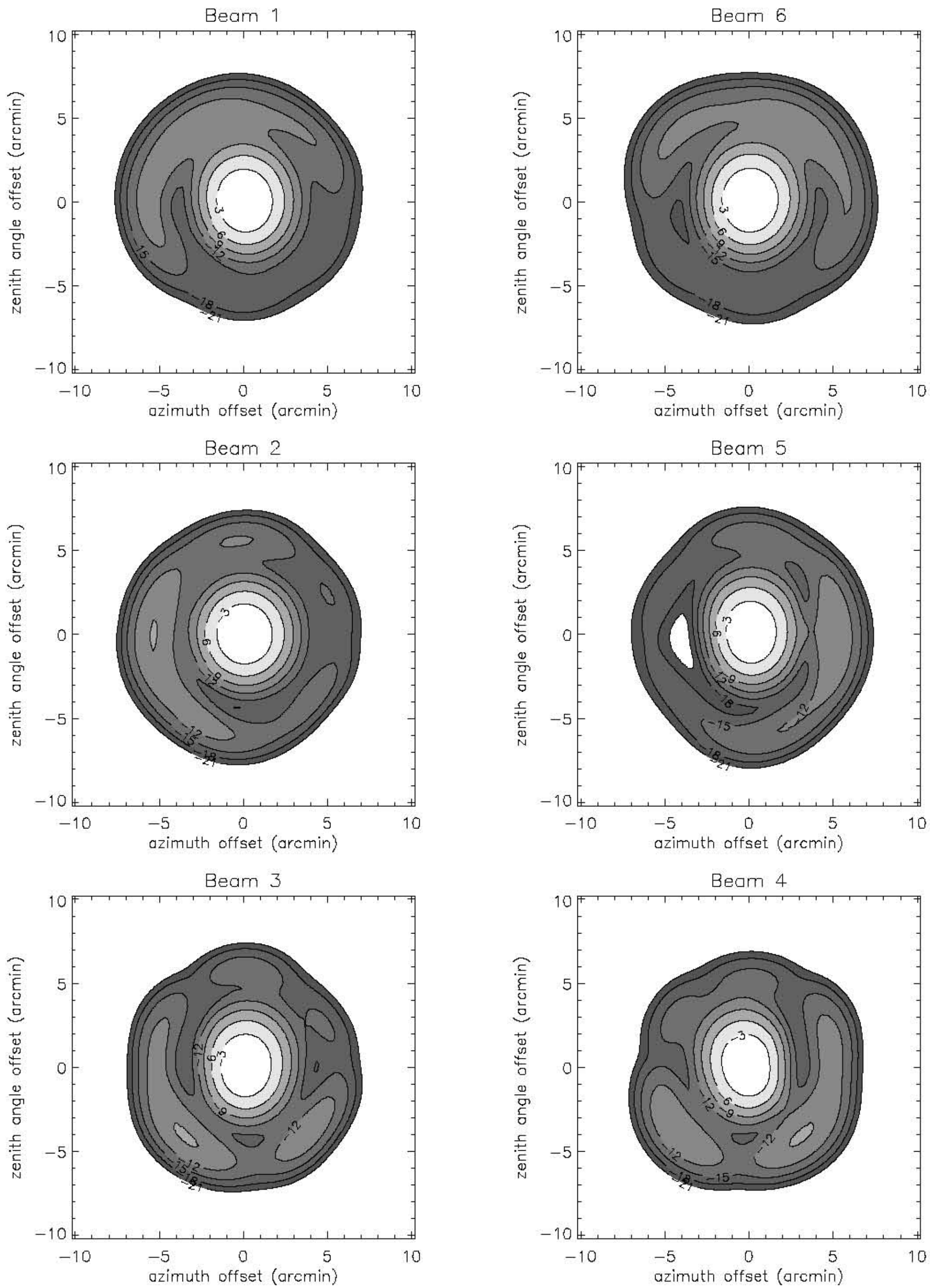
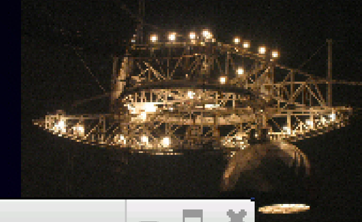
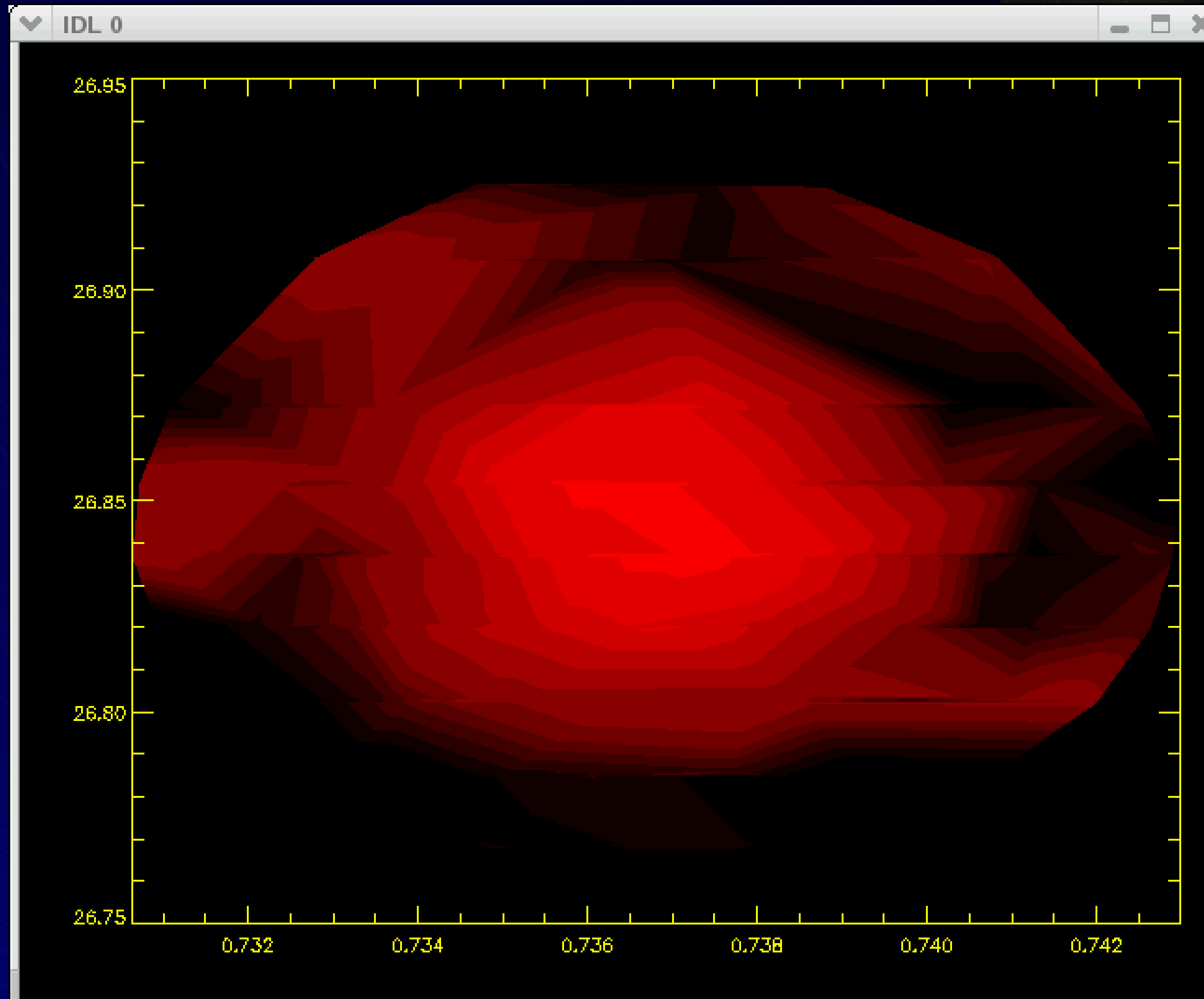


Beam 1
Beam 6
Beam 2
Beam 5
Beam 3
Beam 4
zenith angle offset (arcmin)
azimuth offset (arcmin)



Sidelobes and Striping due to Pointing and ALFA Rotation Errors



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Lessons Learned:

1. After amplifier failure, loss of beam may be lengthy
2. Noise calibration with CIMA protocol can be iffy
3. Calibration drifts occur over timescale of weeks
4. Cleaning maps of very extended sources will be tough
5. Observing remotely is occasionally acceptable, but not a good substitute for being on site
6. Fixed AZ drift observing was excellent choice
7. Internally generated RFI can be major nuisance
8. Tracking LO isn't tracking on long drifts
9. N>3 level sampling of ACF would be nice
10. Bookkeeping, bookkeeping, bookkeeping…

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