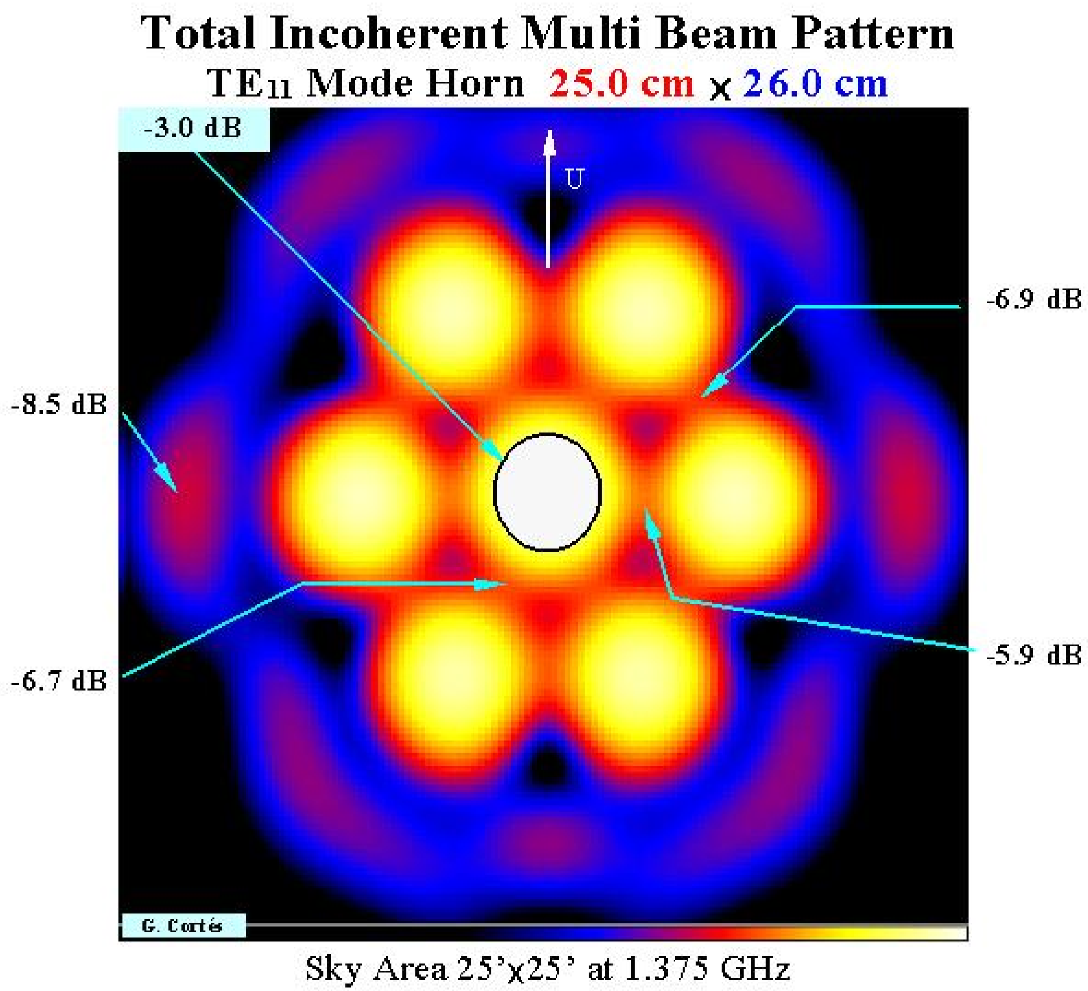
Notes on radio astronomy and ALFA for ALFALFA



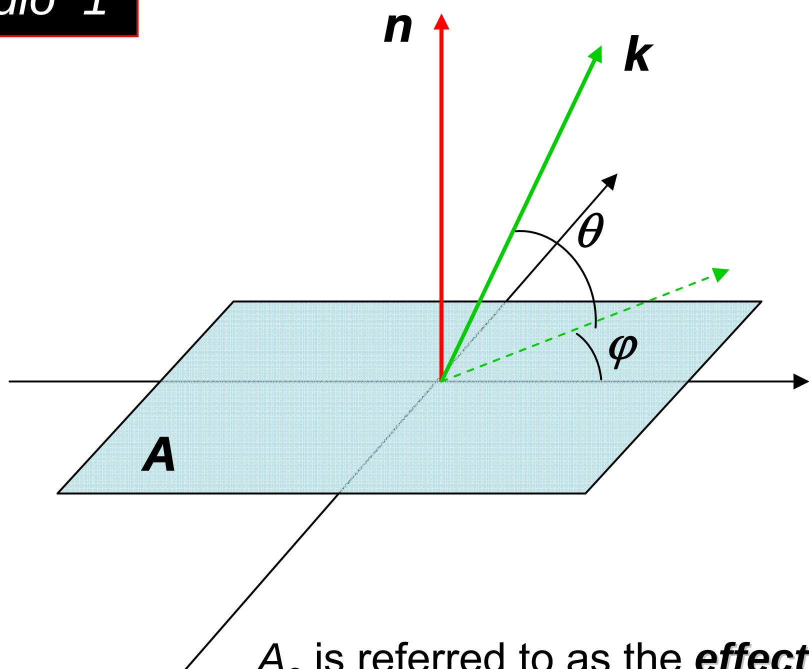
Riccardo Giovanelli and Martha Haynes

Resources

- There are lots of resources: use them!
  - http://www.cv.nrao.edu/course/astr534/ERA.shtml

- Don't treat ALFALFA as a black box!
  - http://egg.astro.cornell.edu/alfalfa/pract_team.htm

Radio 1



Let the area ***A*** represent the collecting area of a telescope.
The radiant energy impinging along the direction ***n*** within the solid angle dΩ on the area ***A***, in the time *Δt* over dν is

$$E = \Delta t \iint I_\nu(\theta,\varphi) A \vec{k}\cdot\vec{n}\, d\Omega\, d\nu$$

Define $A(\theta,\varphi) \equiv \vec{k}\cdot\vec{n} A$

and separate $A(\theta,\varphi) = A_e P_n(\theta,\varphi)$

A_e is referred to as the ***effective area*** in the direction $(\theta,\varphi) = (0,0)$

$$A_e = \frac{\text{Power per unit frequency recorded at antenna terminal [erg s}^{-1}\text{ Hz}^{-1}\text{]}}{\text{Flux of incident in direction (0,0) [erg s-1 Hz}^{-1}\text{ cm}^{-2}\text{]}}$$

$P_n(\theta,\varphi)$ is the ***normalized power pattern***, with $P_n(0,0)=1$, then

$$E = (1/2) A_e \Delta t \iint I_\nu(\theta,\varphi) P_n(\theta,\varphi)\, d\Omega\, d\nu$$

Where the factor ½ derives from the fact that a focal dipole collects only one polarization component of unpolarized radiation. I_ν is the ***specific intensity***.

If A_p is the ***physical aperture*** of the collecting area, then is the ***aperture efficiency***

$$\varepsilon_a \equiv \frac{A_e}{A_p}$$

Radio 2

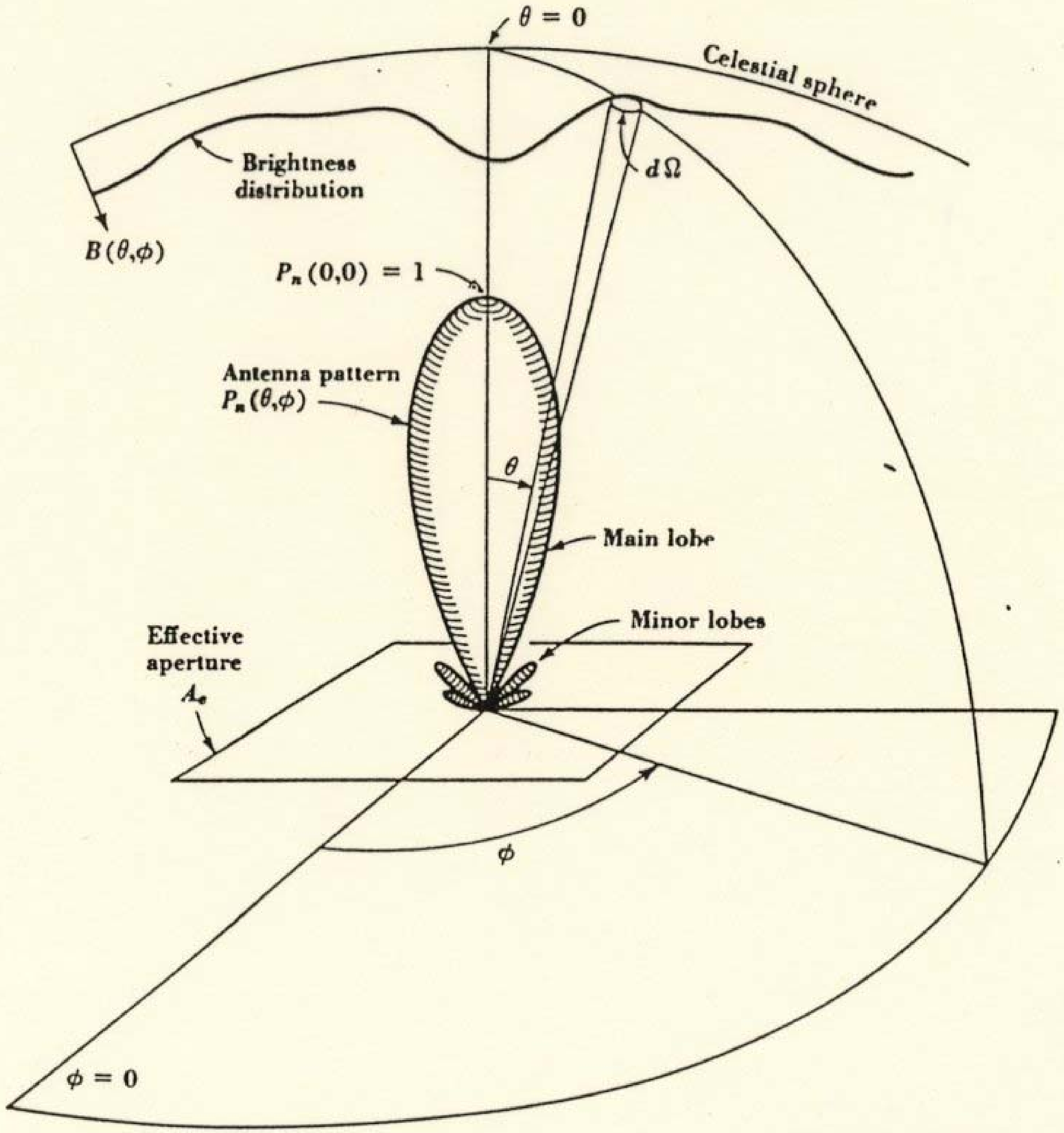


Fig. 3-2. Relation of antenna pattern to celestial sphere with associated coordinates.

Radio 3: Flux density

We define ***flux density*** as: $$S_\nu = \int I_\nu d\Omega$$

In c.g.s units its dimensions are *erg s^{-1} cm^{-2} Hz^{-1}*

Radio astronomers use the ***Jansky*** = 10^{-26} *W m^{-2} Hz^{-1} (prev. known as "flux unit")*

In spectroscopy, it is common to integrate the flux density across the spectral line and use the ***flux integral:*** $S = \int S_\nu d\nu$ usually expressed in *Jy km s^{-1}*

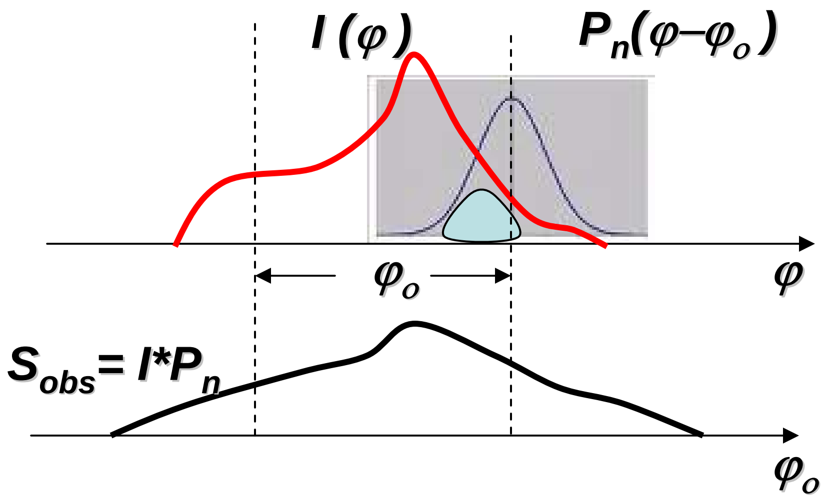
The ***observed flux density***, with an antenna of *Power Pattern P_n is*

$$S_{\nu,obs} = \int I_\nu(\theta,\varphi)P_n(\theta,\varphi)d\Omega \quad \text{and} \quad S_{\nu,obs} \leq S_\nu$$

If the solid angle subtended by the source, Ω_s << *main beam of the antenna,* then $P_n(\theta,\varphi) \cong 1$ over Ω_σ, and $S_{\nu,obs} \cong S_\nu$

Antenna Smoothing

In general, it will be desirable to map the distribution $I_\nu(\theta,\varphi)$



Its structural details will however be *smoothed* by the antenna beam. In one-D, the observed flux density with the antenna pointing in the direction φ_o is:

$$S_{\nu,obs}(\varphi_o) = \int I_\nu(\varphi_o - \varphi) P_n(\varphi) d\varphi \equiv I_\nu * P_n$$

By the *Convolution Theorem,*

$$F.T.(S_{obs}) = F.T.(I) \times F.T.(P_n)$$

By dividing $F.T.(I) = F.T.(S_{obs}) / F.T.(P_n)$ and FT back, we can recover ***I* (φ)**, but we can only do so for the harmonics for which $F.T(P_n) \neq 0$

The fine spatial structure in the source is irremediably lost.

Radio 5

Define:

Beam Solid Angle

$$\Omega_A \equiv \int_{4\pi} P_n(\theta,\varphi)\,d\Omega$$

Main Beam Solid Angle

$$\Omega_M \equiv \int_{mainlobe} P_n(\theta,\varphi)\,d\Omega$$

Beam Efficiency

$$\varepsilon_b \equiv \Omega_M / \Omega_A$$

Suppose the distribution $I_\nu(\theta,\varphi)$ is uniform throughout the sky. Then

ε_b is the fraction of the detected power originating within

$1-\varepsilon_b$ is the fraction of the detected power arriving from everywhere else in the sky and ground.

Radio 6

The total power per unit bandwidth detected by the antenna while pointing in the direction (θ_o, φ_o) is

$$p = A_e \int I_\nu(\theta,\varphi) P_n(\theta-\theta_o, \varphi-\varphi_o) d\Omega$$

If we equate ***p*** with the thermal noise power per unit frequency interval available from a resistor at the temperature T_A which by Nyquist formula is $p = kT_A$ then

$$T_A(\theta_o,\varphi_o) = (A_e / k)\int I_\nu(\theta,\varphi) P_n(\theta-\theta_o, \varphi-\varphi_o) d\Omega$$

Is the ***antenna temperature***

The unit of antenna temperature, 1 K, is equivalent to 1.38×10^{-23} W Hz^{-1} . Antenna temperature is an indication of *power level*; it needs not have any relation to the temperature of any telescope component.

We also refer to the sky distribution of brightness via a ***brightness temperature***, with λ being the wavelength of observation

$$T_B = \frac{\lambda^2}{2k} I$$

Then:

$$T_A(\theta_o,\varphi_o) = (A_e / \lambda^2)\int T_B(\theta,\varphi) P_n(\theta-\theta_o, \varphi-\varphi_o) d\Omega$$

➔ The antenna temp. equals the all-sky integral of T_B , weighted by the effective area expressed in square of λ

Radio 7

- The relationship between observed flux density and antenna temperature is then ➔

$$S_{obs} = \frac{2k}{A_e} T_A$$

Suppose you embed the antenna within a black box at temperature ***T***. Then $T_B = T_A = T$

and

$$\Omega_A = \int P_n d\Omega = \lambda^2 / A_e$$

➔ ***The beam solid angle is the inverse of the effective area, measured in square wavelengths.***

- Consider an isotropic antenna, for which:

$$P_n(\theta,\varphi) \equiv 1 \Rightarrow \int P_n(\theta,\varphi) d\Omega = 4\pi$$

We define ***Directive Gain*** ➔

$$D \equiv 4\pi / \Omega_A = 4\pi A_e / \lambda^2$$

a quantity related to ***resolving power:***

$$D \equiv 4\pi / \Omega_A = 4\pi\varepsilon_b / \Omega_M = \frac{4\pi\varepsilon_b}{\eta_b \theta_{HP} \varphi_{HP}}$$

Where η_b is a term accounting for the main beam geometry and the subscript 'HP' indicates the half-power main beam widths.

Example: an effective aperture of diameter 210 m, operating at λ = 21 cm has D ~ 10^7 or 70 dB.

Radio 8

Radio astronomers often express the effective aperture of a telescope in odd, units, e.g. K/Jy. Here is why. Remember:

$$S_{obs} = \frac{2k}{A_e} T_A$$

then:

$$A_e[m^2] = \frac{2 \times 1.38 \times 10^{-23}}{10^{-26}} \frac{T_A[K]}{S_{obs}[Jy]}$$

So 1 K/Jy is equivalent to ~ 2761 m^2 , e.g. a 71 m diameter dish with 70% aperture efficiency.

T_A Antenna temperature relates to total detected power p.u. bandwidth

S_{obs} Is the source's power p.u. bandwidth, *p.u. of effective area*

Radio 9

Again using Nyquist formula, the ***System Temperature*** is defined as

$$T_{sys} \equiv p_{tot} / k$$

where $\boldsymbol{p_{tot}}$ is the *total detected power, including the flux from the source* ***plus everything else:***

$$T_{sys} \equiv T_{src} + T_{sky,bg} + T_{atmo} + T_{rx} + T_{loss} + T_{spillover} + T_{rfi}$$

At 21 cm:

$T_{sky,bg}$ CMB~3K; synchrotron 1-5K f(gal latitude);

T_{atmo} 3K at Zenith

T_{rx} 1-3K

T_{loss} 1-10K

$T_{spillover}$ 5-20K

$\boldsymbol{T_{sys}}$ on "cold sky" ($\boldsymbol{T_{src}}$~ 0) ➔ 15-40 K

Radiometer Noise

$$\sigma_{T,rms} = \frac{kT_{sys}}{\sqrt{t_{\mathrm{int}} \times \Delta\nu \times n_{pol}}}$$

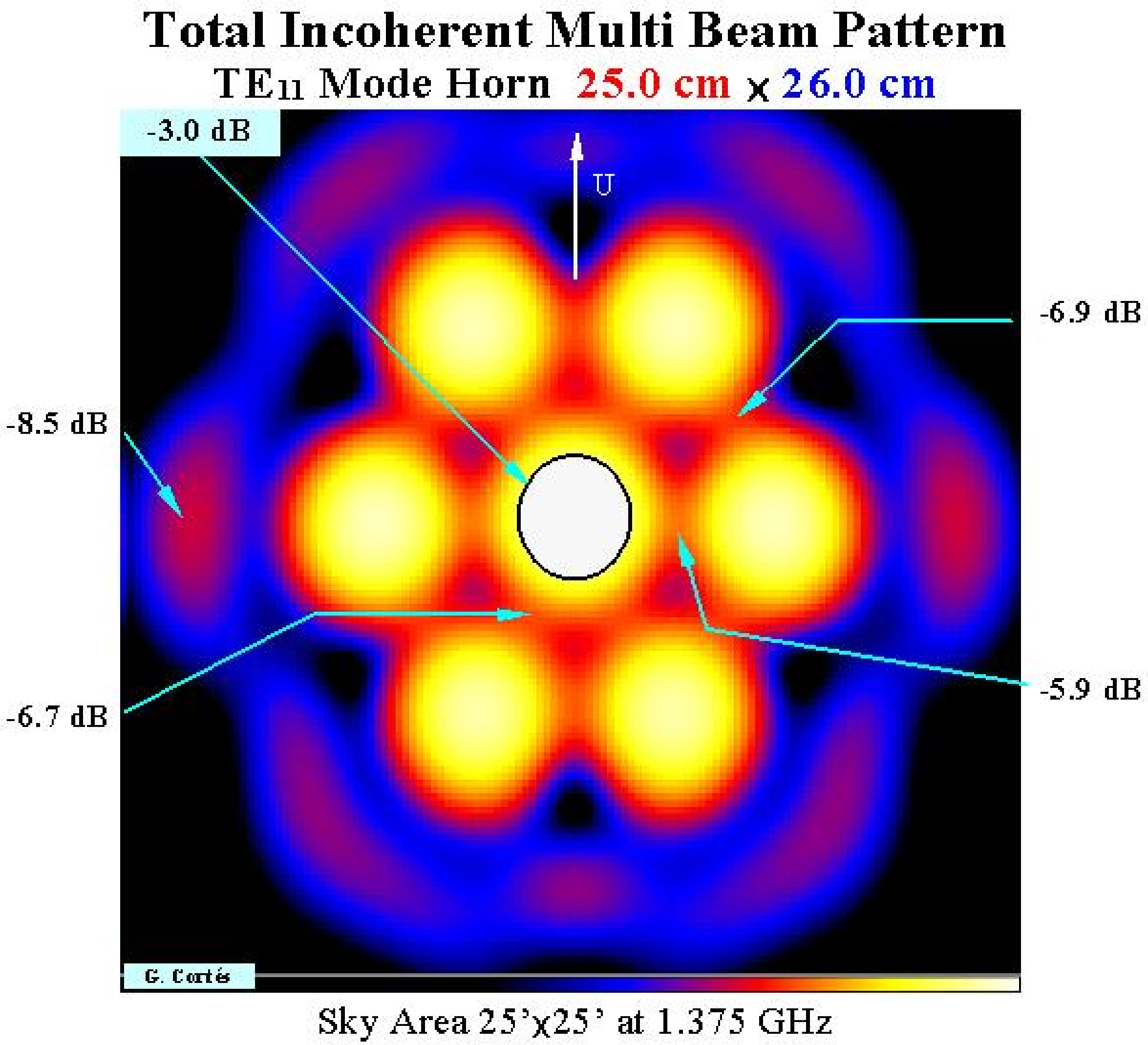
(Where k~1)

Integration time   bandwidth   nr of pols

Continuum Confusion Limit

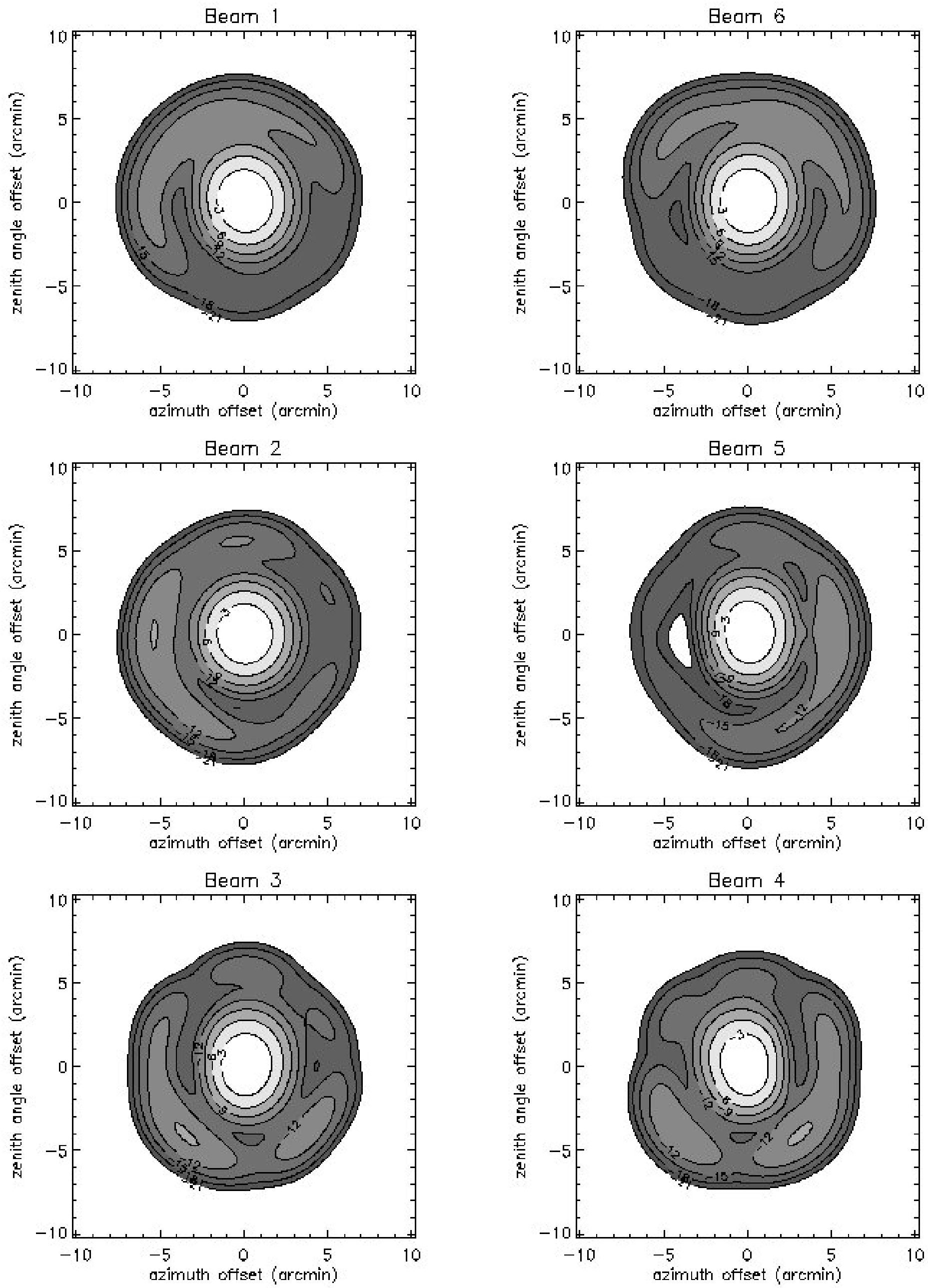
$$\sigma_{conf}[Jy] \approx 3700 \times \nu^{-0.7}[GHz] \times \Omega_A$$

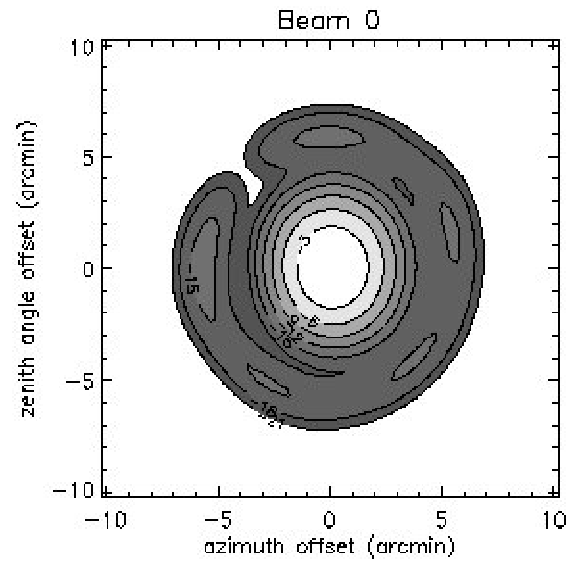
ALFA: Arecibo L-band Feed Array



Power pattern of the 7 ALFA beams

See Giovanelli et al 2005b





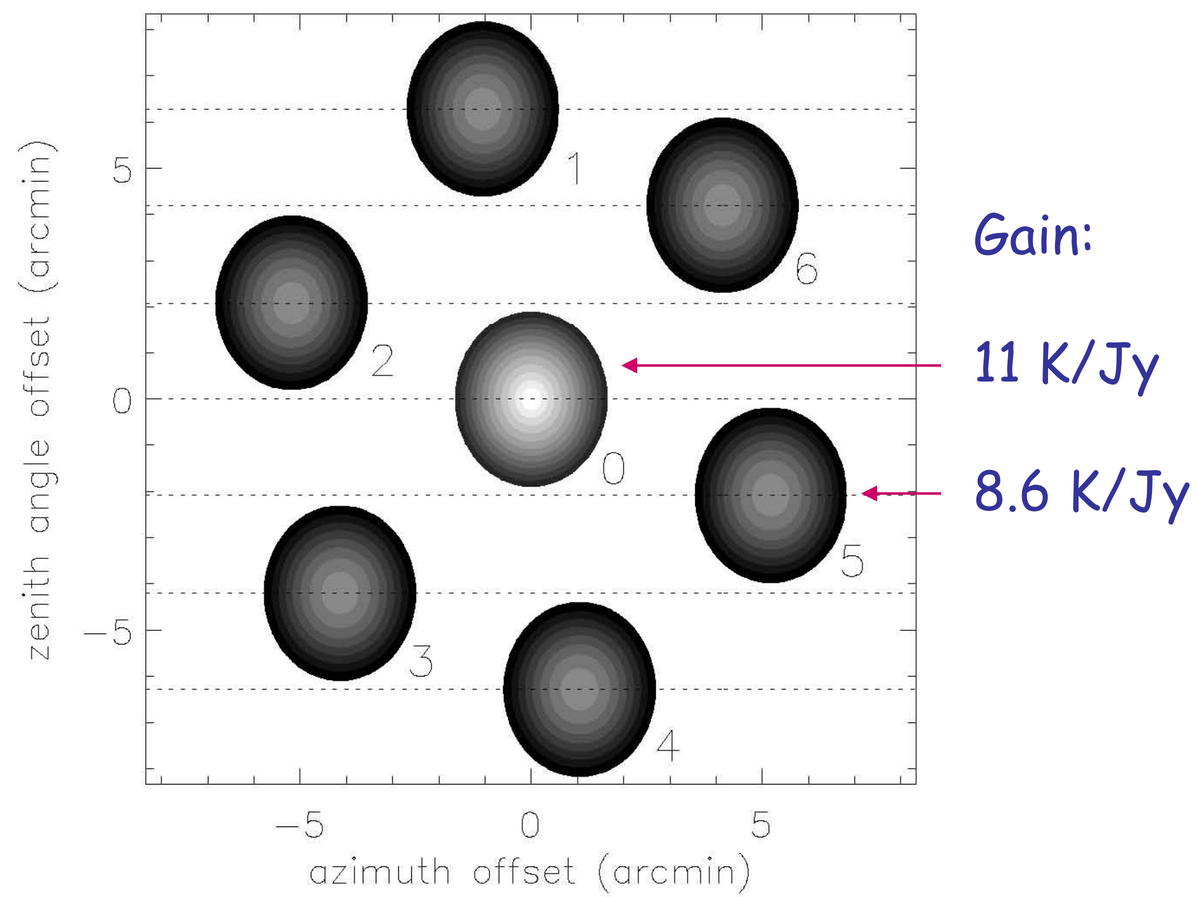
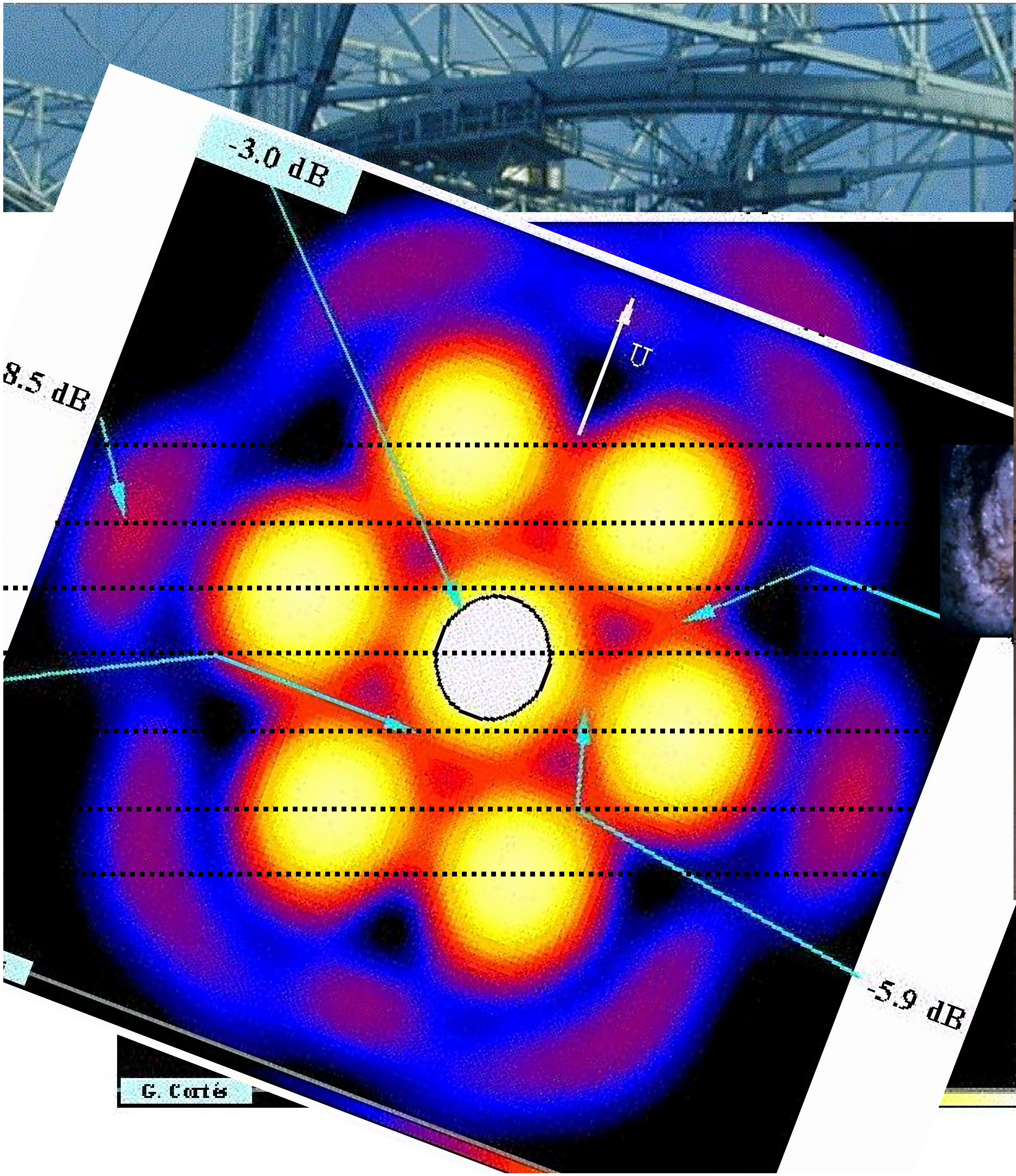
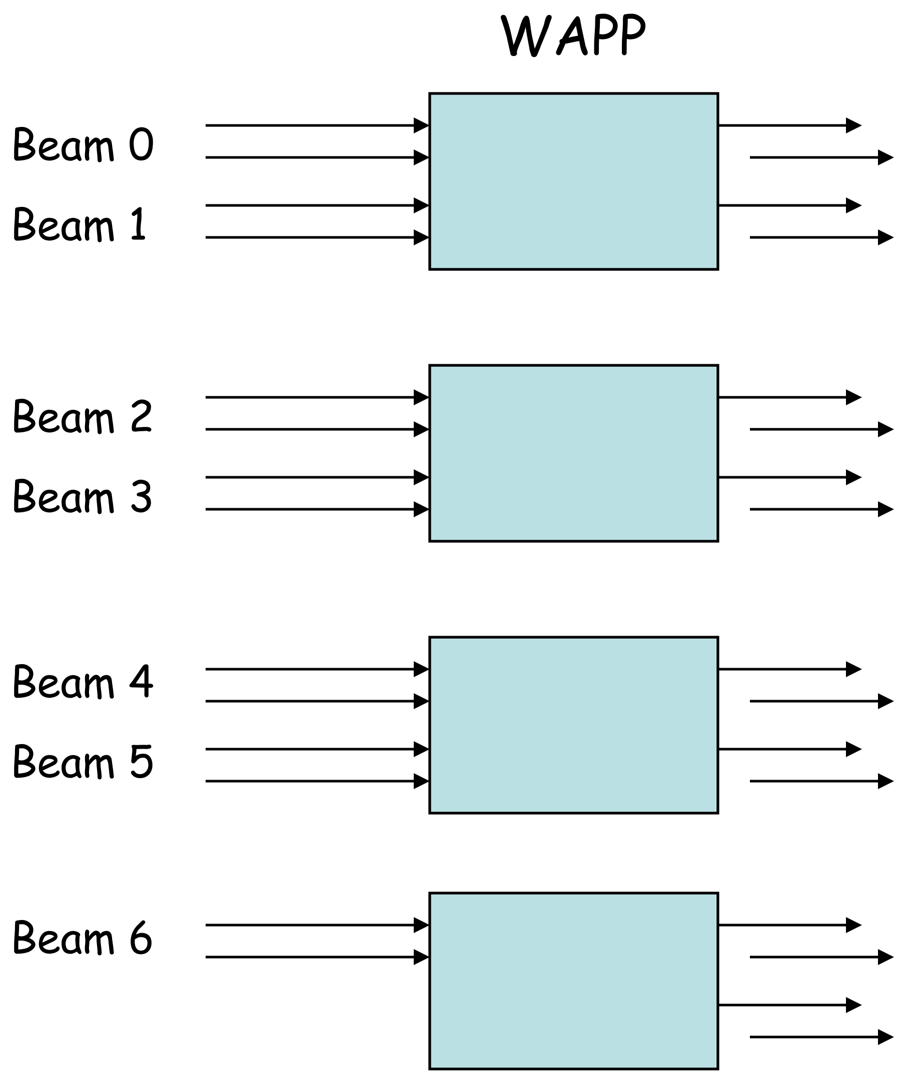


Fig. 2.— Sketch of the geometry of the ALFA footprint, with the array located along the local meridian and rotated by an angle of 19° about its axis. The outer boundary of each beam corresponds to the -3 dB level. The dashed horizontal lines represent the tracks at constant Declination of the seven ALFA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



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



16 x 4096 ch,

100 MHz wide

spectra

At the telescope

The telescope delivers data – about 1 Gbyte per hour – in the form of FITS files. Each FITS file contains one on-sky data unit (600 sec long drift scan) and one accompanying on-cal unit of 1sec

The process ***filecreator*** converts the data stream of the day into IDL *.sav* files; for each drift scan, *filecreator* produces:

1) A drift file nnnnnnnnn.sav, a ***"d"*** structure in IDL
2) A nnnnnnnnnCALOFbegin.sav file - the first record from the drift
3) A nnnnnnnnnCALOFend.sav file - the last record from the drift
4) A nnnnnnnnnCALON.sav file – the on-cal record

The sequence of "CALON", "CALOFbegin", "CALOFend" files are used to calibrate the observing period's data set, in ***Level 1*** stage.

All these .sav files contain IDL arrays of structures with header info and data streams.

Level I: Calibrating an Observing Session. Calib1

*The intensity scale of spectral values is in "instrumental units". The goal of this stage in the reduction is to convert those units to antenna temperatures. We do this in two stages. The first is **calib1**.*

For a given observing session we now have a series of save files, namely the ***drift scans*** and for each of those a triplet of ***calibration*** files.

The scan name with the "CALON" extension corresponds to a scan in which the cal was fired for one second, at the end of each regular 600 sec drift scan. The one with the "CALOFend" extension is the last record of the drift preceding the firing of the cal, and that with the "CALOFbegin" extension is the first record of the drift immediately following the firing of the cal. An average of the spectra of CALOFend and CALOFbegin will constitute the cal OFF record.

A list of the calibration scans is created and the IDL process ***calib1*** is run on it. It runs silently and produces two structures, named ***dcalON*** and ***dcalOFF.***

Level I: Calibrating an Observing Session. Calib2

The second stage of calibration is called ***calib2***. It operates on the two structures ***dcalON*** and ***dcalOFF***, producing an output structure named ***ncalib***.

Calib2 runs interactively, and the user is prompted to monitor the calibration data, weed bad points, select the frequency interval over which to measure continuum levels, etc.

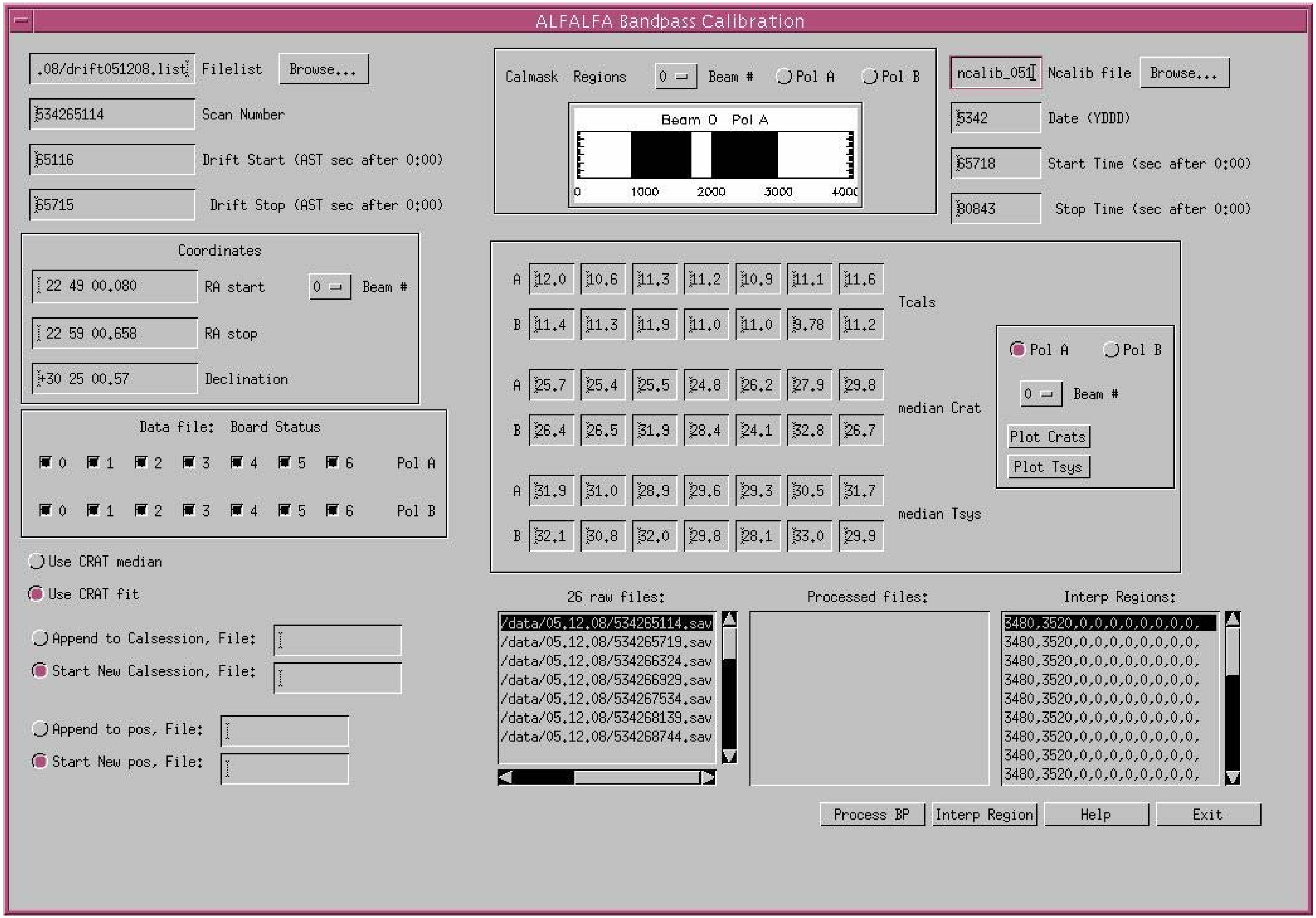
ncalib contains, among other things, a tabulation of System Temperatures for all beams and pols, as well as of the factors to convert instrumental counts to antenna temperatures.

The data in the ***d*** still remains raw, in the original instrumental units. You can access those data in directories listed in the archival tabulations listed in the ALFALFA website. Those names of those directories opportunely contain the string *"idlraw".*

Level I: BPD, “bandpass the drift”

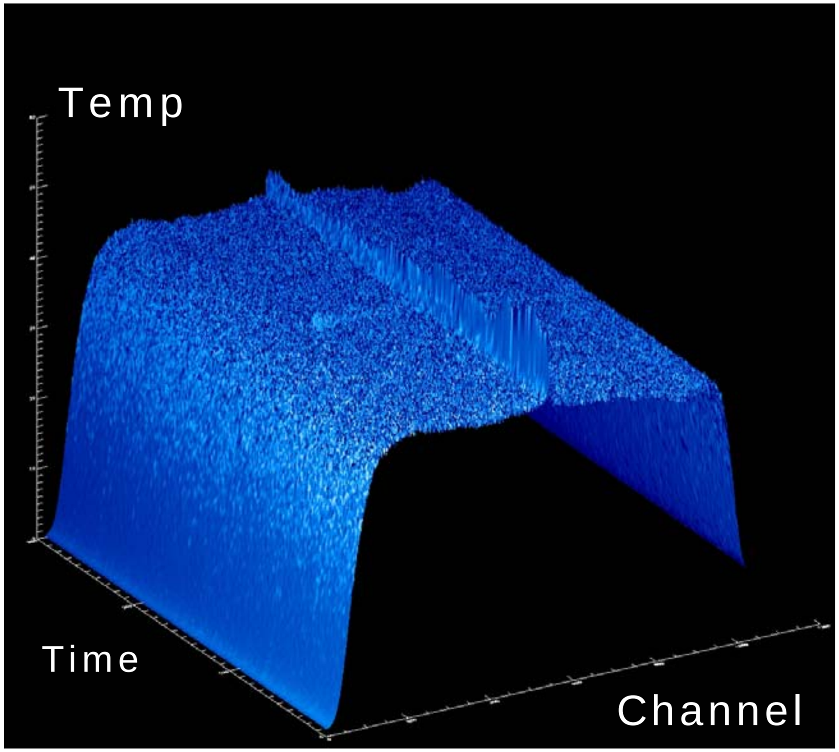
The IDL process ***bpd*** is the guts and ***bpdgui*** the elegant user interface of a grab-bag of many operations: it reads the raw ***"d"*** structure of each drift, computes a bandpass, applies a baseline, extracts continuum data, produces a ***“dred”*** structure with data appropriately scaled, plus much more. It is operated through the GUI shown in the next slide.

A ***log_processing_nnnnnn*** text file is initiated by the user at this time, with pertinent information on the data processing.

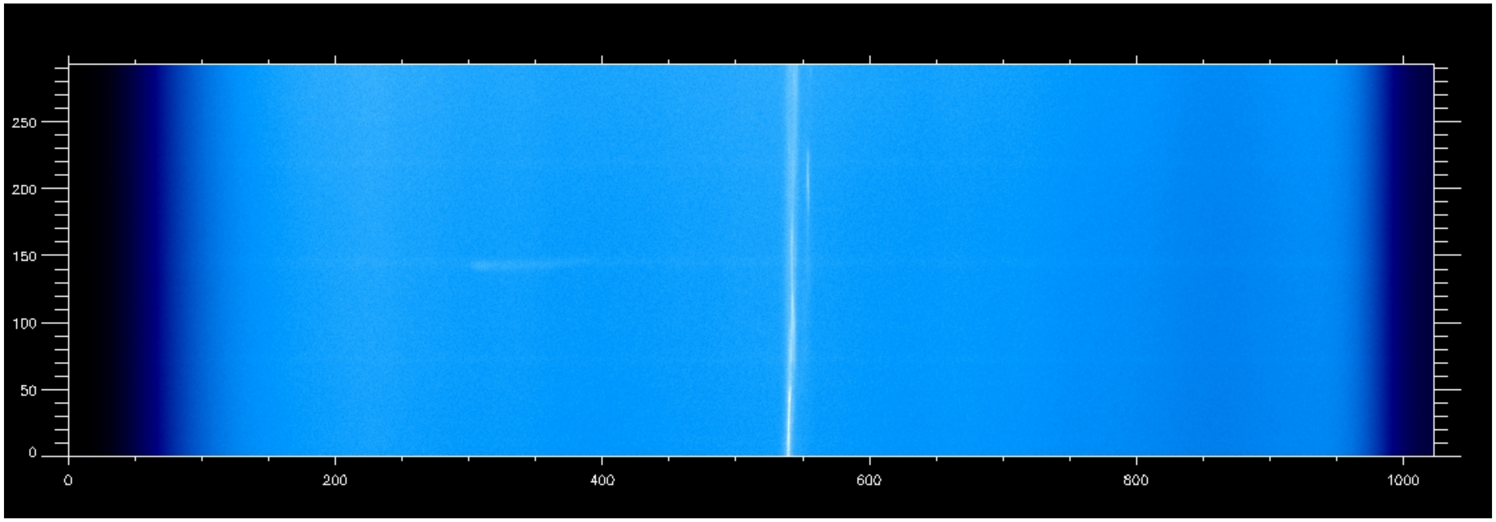

ALFALFA Bandpass Calibration
.08/drift051208.list
Filelist
Browse...
534265114
Scan Number
65116
Drift Start (AST sec after 0:00)
65715
Drift Stop (AST sec after 0:00)
Coordinates
22 49 00.080
RA start
0
Beam #
22 59 00.658
RA stop
+30 25 00.57
Declination
Data file: Board Status
0 1 2 3 4 5 6 Pol A
0 1 2 3 4 5 6 Pol B
Use CRAT median
Use CRAT fit
Append to Calsession, File:
Start New Calsession, File:
Append to pos, File:
Start New pos, File:
Calmask Regions
0
Beam #
Pol A
Pol B
Beam 0 Pol A
0
1000
2000
3000
4000
ncalib_051
Ncalib file
Browse...
5342
Date (YDDD)
65718
Start Time (sec after 0:00)
80843
Stop Time (sec after 0:00)
A 12.0 10.6 11.3 11.2 10.9 11.1 11.6
Tcals
B 11.4 11.3 11.9 11.0 11.0 9.78 11.2
A 25.7 25.4 25.5 24.8 26.2 27.9 29.8
median Crat
B 26.4 26.5 31.9 28.4 24.1 32.8 26.7
A 31.9 31.0 28.9 29.6 29.3 30.5 31.7
median Tsys
B 32.1 30.8 32.0 29.8 28.1 33.0 29.9
Pol A
Pol B
0
Beam #
Plot Crats
Plot Tsys
26 raw files:
/data/05.12.08/534265114.sav
/data/05.12.08/534265719.sav
/data/05.12.08/534266324.sav
/data/05.12.08/534266929.sav
/data/05.12.08/534267534.sav
/data/05.12.08/534268139.sav
/data/05.12.08/534268744.sav
Processed files:
Interp Regions:
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
3480,3520,0,0,0,0,0,0,0,0,
Process BP
Interp Region
Help
Exit

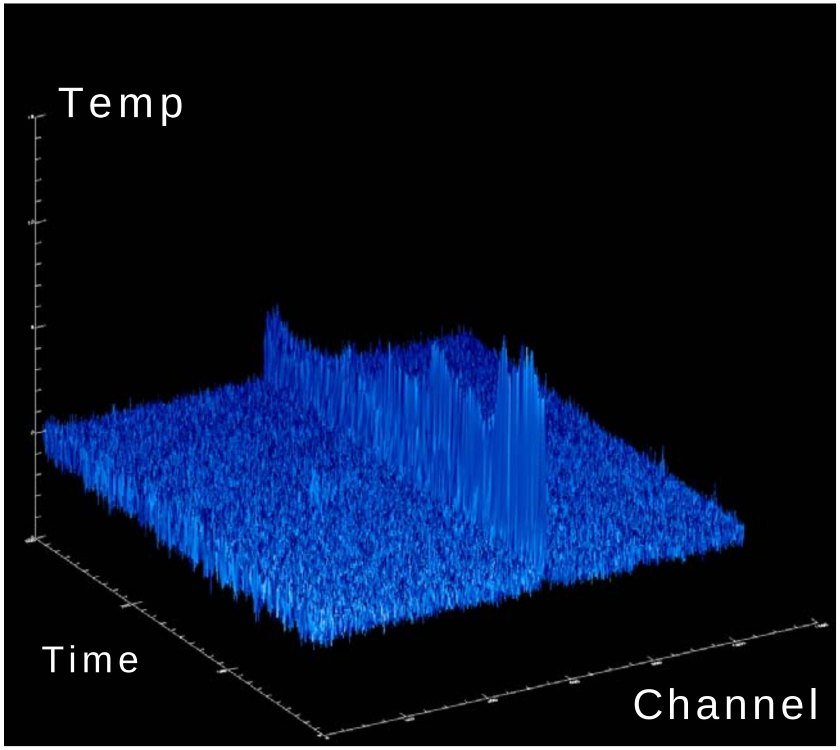
The output of **bpdgui** consists of:

**dred*, the bandpass subtracted, baselined, continuum-subtracted, scaled (to K) drift structure;
**caldrift*, a calibration monitoring structure that tracks changes in the cal values
**calsession*, an array of caldrift structures appended with every drift reduced during that observing session;
**runpos*, a "positions" structure containing positional information for all the drifts of a given observing session or run;
**mc* a set of continuum profiles for the drift, measured over several narrow bandpasses across the 100 MHz of the survey;
**BP2*, the bandpass spectra for the drift;
**mask*, the spectral mask used to measure continuum flux, for the given drift;
**cont_bg*, a continuum power profile of the drift, after removal of the point sources;
**cont_pt*, point source continuum power profile of the drift.

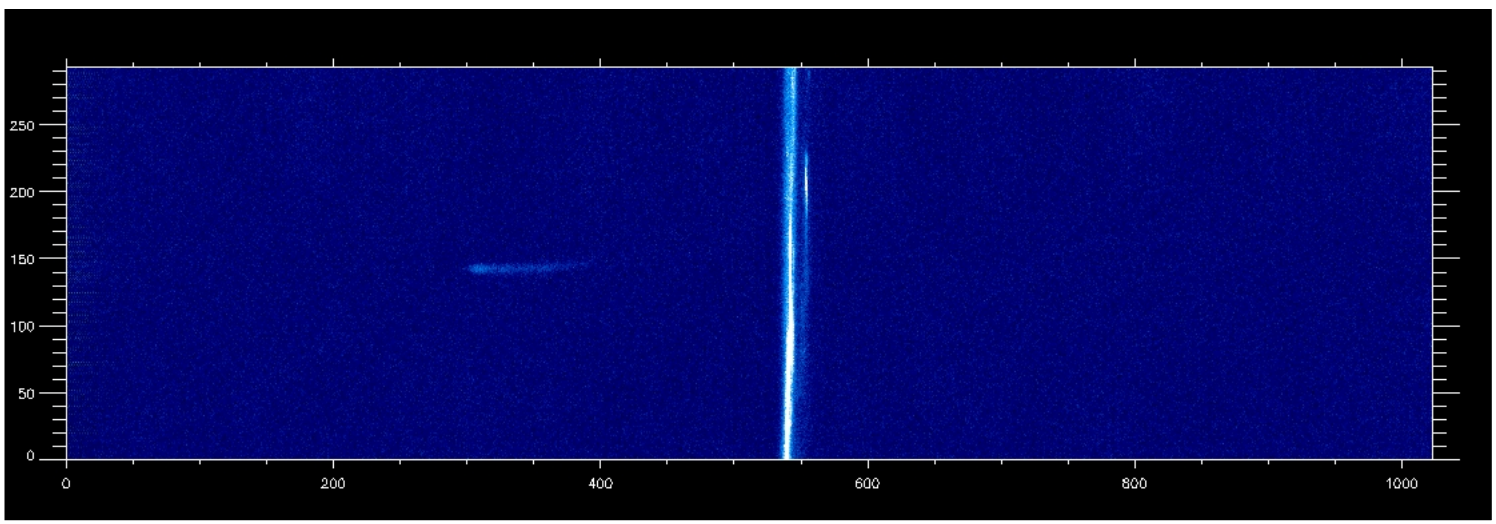


🡐 A Drift scan, before bandpass correction (bpd)





← A Drift scan, after bandpass correction (bpd)



Level I: flagbb, “flag the bad boxes”

In the data processing stream, ***flagbb*** allows for the first visually detailed inspection of the data. One beam/pol at a time – *14 times per drift scan* – the user inspects a 600x4096 pixel image, frequency along the x-axis, time along the y-axis.

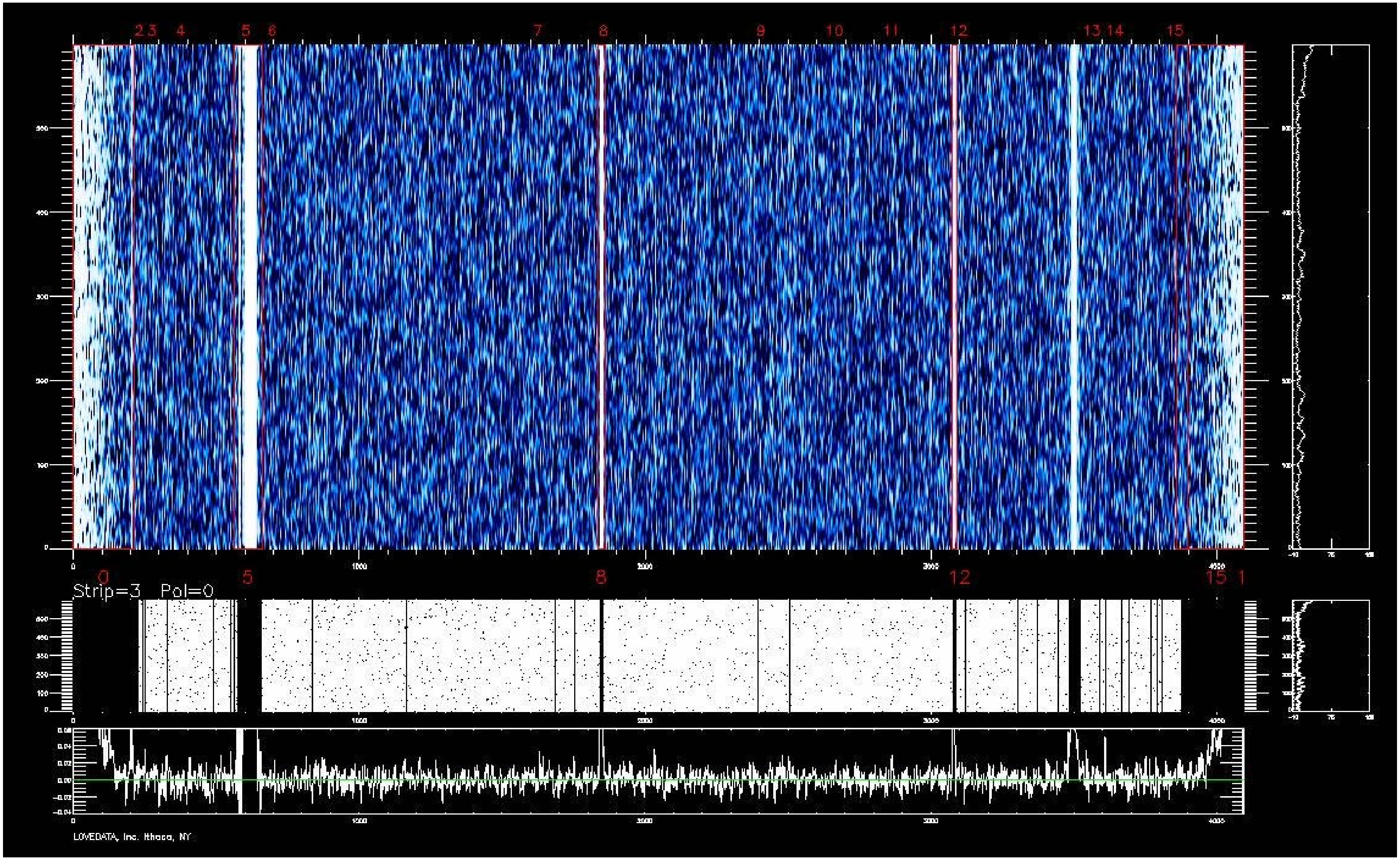
Besides the close inspection, the user creates interactively a set of “***bad boxes”*** i.e. rectangular regions in the map that contain flawed data. The pixel coordinates of those bad boxes are stored in a structure called ***“pos”***, for “position”. The structure contains the sky coordinates of each spectrum in each drift scan in the observing session, with an indication of quality, or ***weight***.

Flagbb does not alter any of the contents of the ***dred*** structures; it just modifies ***pos***.

Flagging is an interactive process, but the program has some built-in smarts to ease the task.

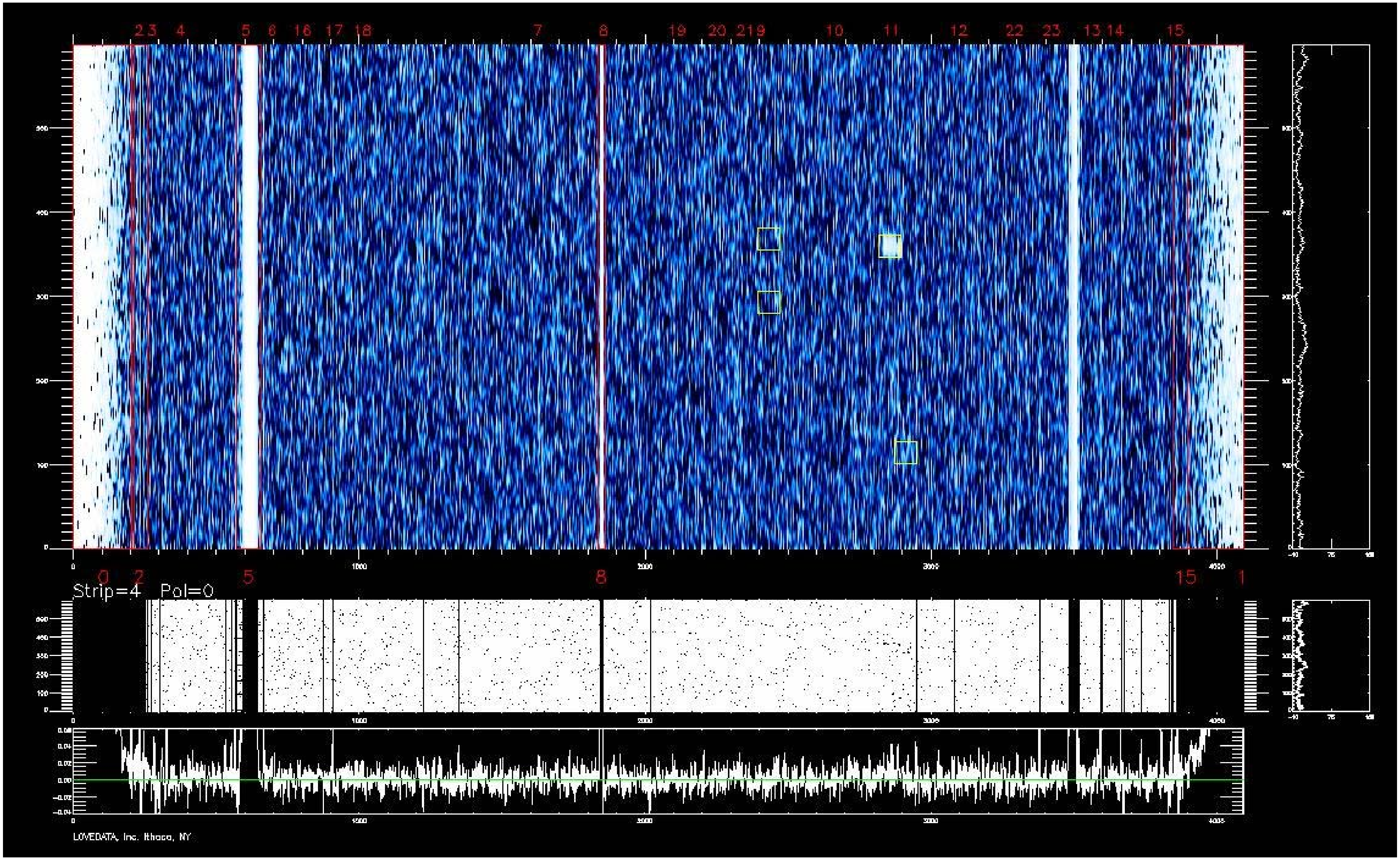
A variation on flagbb, for pure inspection, is available: ***reviewbb***.

Level I: flagbb, "flag the bad boxes"



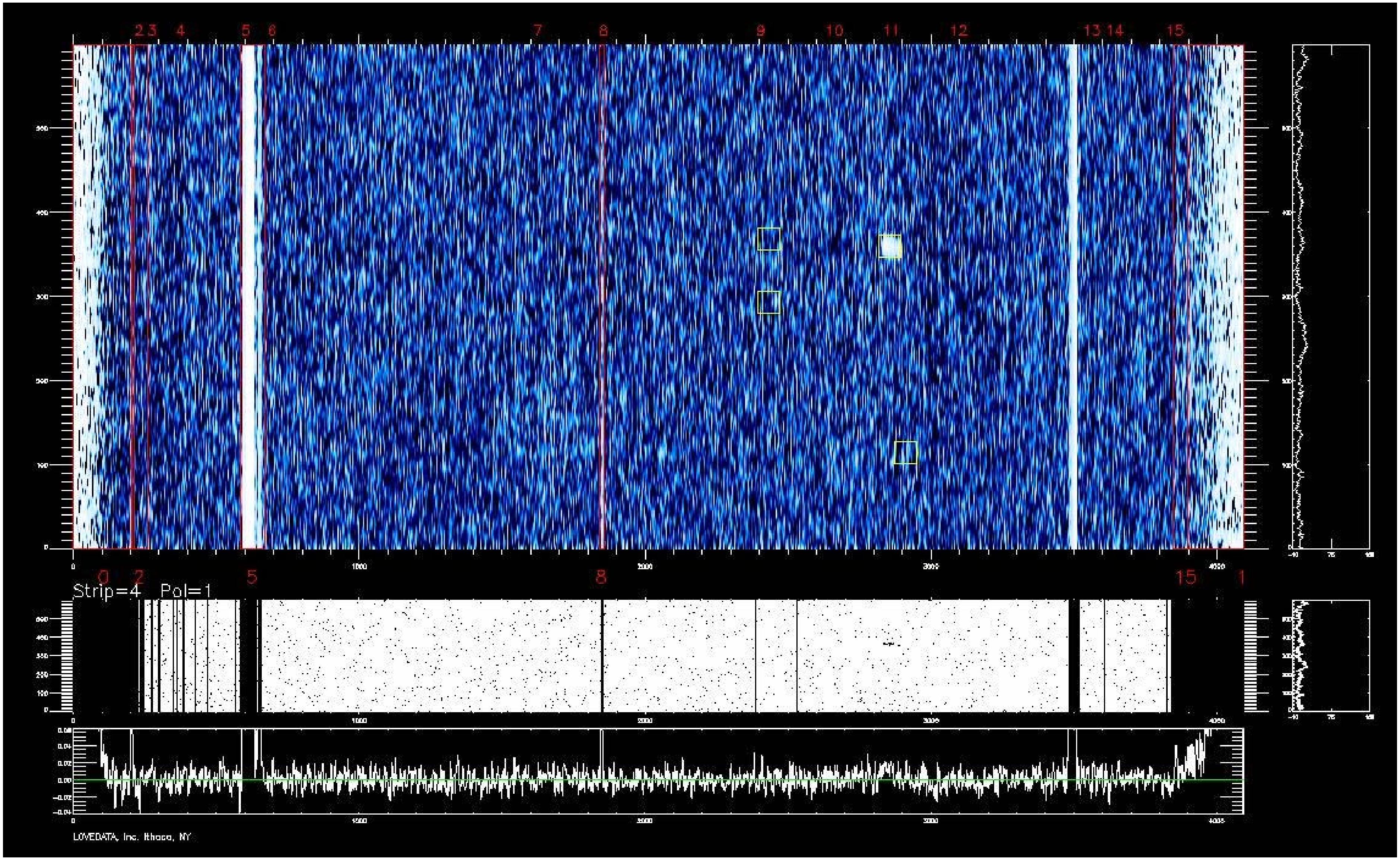
Flaggg display, no extragalactic HI sources

Level I: flagbb, “flag the bad boxes”



Flagbb display, pol 0: 4 AGC gals, 1 (more?) HI detection

Level I: flagbb, “flag the bad boxes”



Flagbb display, pol 1, same beam: 4 AGC gals, 1 confirmed HI detection

The "pos" structure

The ***pos*** structure is an array of N substructures, where N is the number of drift scans in an observing session. Thus, a single ***pos*** structure is common to all the ***dred***s in the observing session.

Each element of the array contains:

- *name, scan number and telescope configuration information of a given drift scan*
- An array of 600x8 *positions for each spectrum, each beam* in the drift (nr 8 is redundant)
- The *continuum power* at each record/beam/pol, 2x600x8
- The *status* of each record/beam/pol, 2x600x8
- The *badbox* coordinates 100x2x8x4

There is "room" for 100 *bad boxes* per beam, per pol, per drift scan. Each bad box is identified by 4 pixel values: upper left x,y; lower right x,y.

A "master" of locations of all *pos* files is kept in a safe place and periodically modified by the masters of the game.

ALFALFA LOG - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://caborojo.astro.cornell.edu/alfalfalog/archspring.php

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ALFALFA

A2010 Official Data Archive   Spring Sky Drifts

See the version organized by observing block   **See the Fall archive**

Green boxes indicate data reduction not yet started.

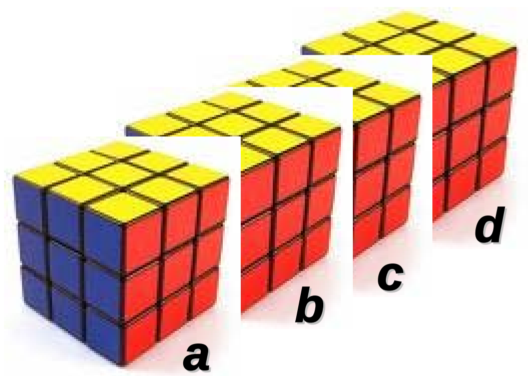
Yellow boxes indicate Level I processing is in progress.

Olive boxes indicate bad/no data that might as well be discarded so don't bother to flag.

Disclaimer: This file may not be as up-to-date as the listing by observing block!

DecJ	Block	RA	Raw files disk	Level I	Who	#	QA	Backup	Notes
00p1 -000718	08.05.29	1350-1652	dor13/idlraw						
00p2 +000001	08.05.28	1351-1643	dor13/idlraw						
01p1 +000718	08.05.02	1345-1646	dor13/idlraw						0B issues
01p2 +001436	08.05.26	1352-1656	dor13/idlraw						
02p1 +002154	08.05.01	1355-1647	dor13/idlraw						0B issues
02p2 +002912	08.05.25	1350-1642	dor13/idlraw						

Making Data Cubes, a.k.a. Grids



When a region of the sky is fully mapped, we combined drift scans crossing it to produce an evenly gridded data cube, or ***grid***.

The standard ALFALFA grids are 2.4°x2.4°, evenly sampled at 1' spacing: thus the spatial dimensions of a grid are 144x144.

Such a region of the sky is split into 4 frequency (cz), partially overlapping cubes, respectively grids

a -2000 < cz < 3300 km/s

b 2500 < cz < 7900

c 7200 < cz < 12800

d 12100< cz < 17900o

Standard ***grid centers*** are pre-determined, separated by 8min in RA and 2° in Dec, e.g. 23:08+15:00, 23:16+15:00, 23:16+13:00... etc.

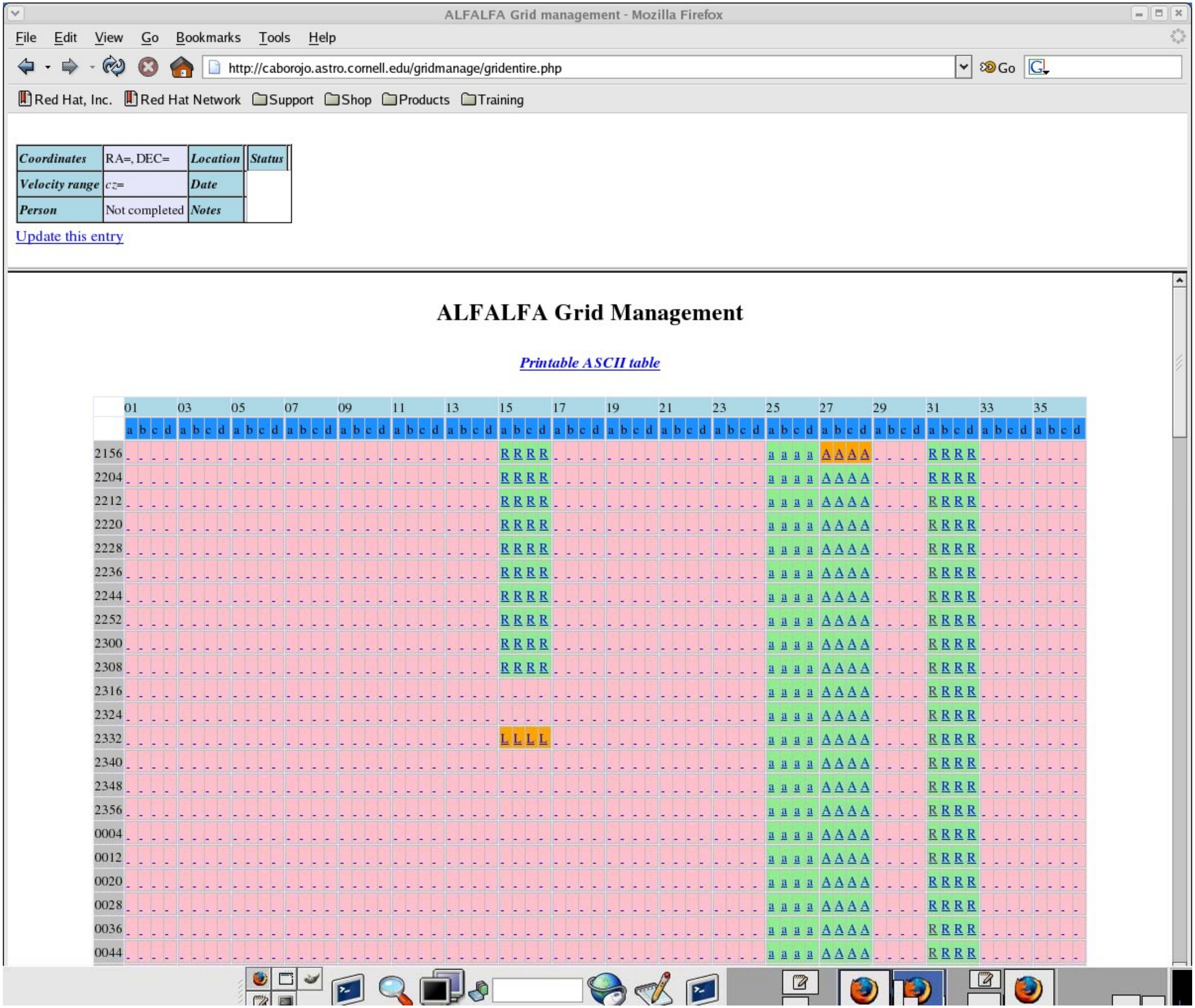
Making Data Cubes, a.k.a. Grids

Grids are made running an IDL procedure named ***grid_prep***. It requires minimal input and runs silently for a few hours per set of four (a,b,c,d) grids. This is a CPU *and* I/O intensive task, eased by the availability of ***pos*** files.

The output of *grid_prep* is a set of 4 grid structures, stored as IDL *.sav* files, named, e.g. *grid_2308+15a.sav, grid_2308+15b.sav, grid_2308+15c.sav, grid_2308+15d.sav.*

The *grid_prep* process also changes the spectral intensities from K in antenna temperature to mJy in flux density, correcting for the zenith angle variations in gain of the telescope.

The flux density scale is corroborated by comparing the ALFALFA flux densities of continuum sources in a set of contiguous grids with the flux densities of the same sources as reported by the NVSS. If a discrepancy is found, all fluxes in those grids are corrected by a multiplicative factor.



ALFALFA Grid management - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://caborojo.astro.cornell.edu/gridmanage/gridentire.php

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Coordinates	RA=, DEC=	***Location***	***Status***
Velocity range	*cz*=	***Date***	
Person	Not completed	***Notes***	

Update this entry

ALFALFA Grid Management

Printable ASCII table

	01				03				05				07				09				11				13				15				17				19				21				23				25				27				29				31				33				35			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
2156	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
2204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
2212	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
2220	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
2228	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
2236	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
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2332	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	L	L	L	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	a	a	a	a	A	A	A	A	-	-	-	-	R	R	R	R	-	-	-	-	-	-	-	-
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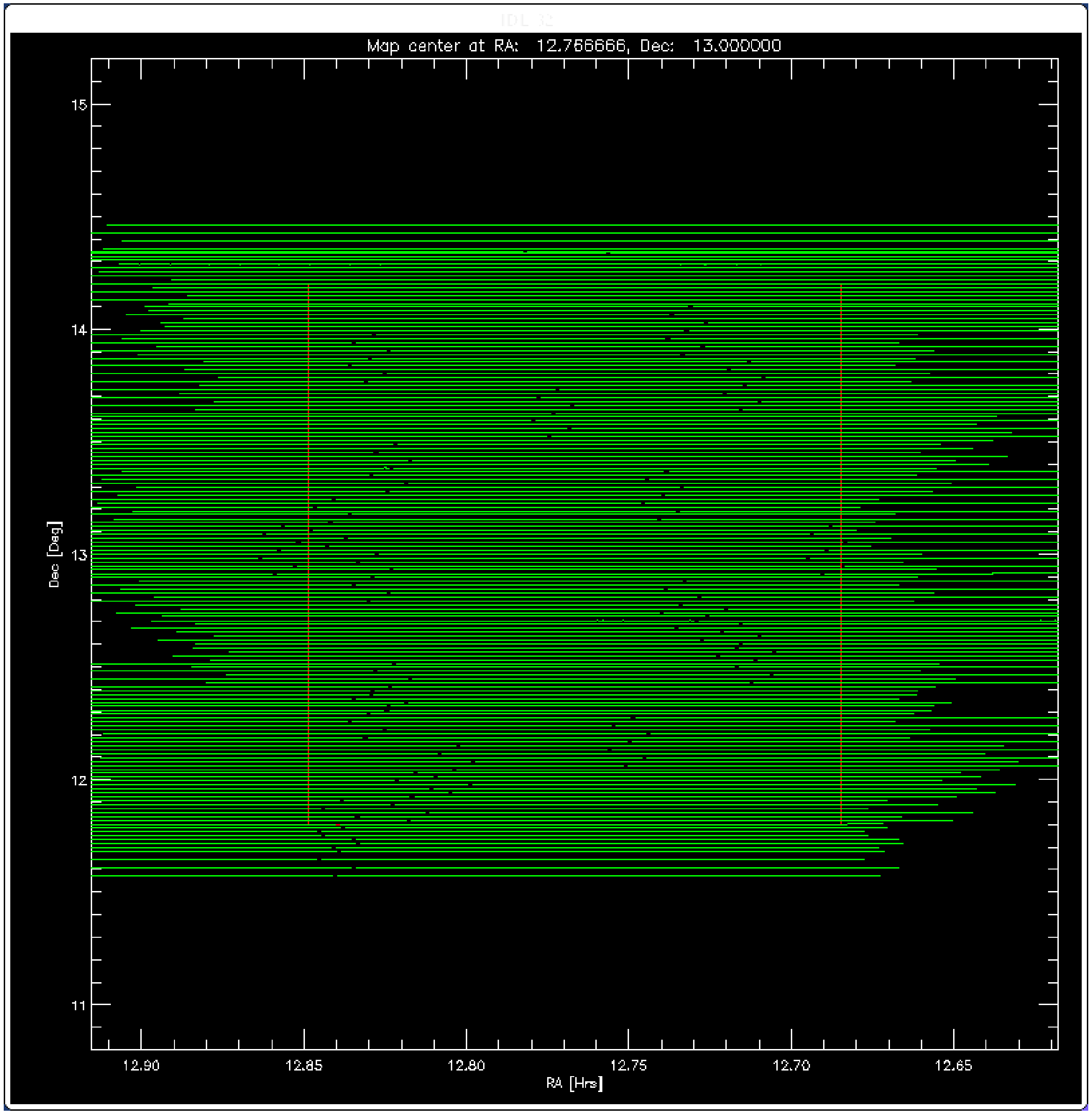
Gridding

- *2.4º x 2.4º x 5400 km/s data cubes (grids) are created via:*
  - *Examining "pos" structures maintained in a "masterpos"*
  - *For every grid point, a record is kept that describes which record, from which scan, which beam, which pol, does contribute to spectrum at that point*
  - *An array of "weights" is carried for each spectral value of the grid.*



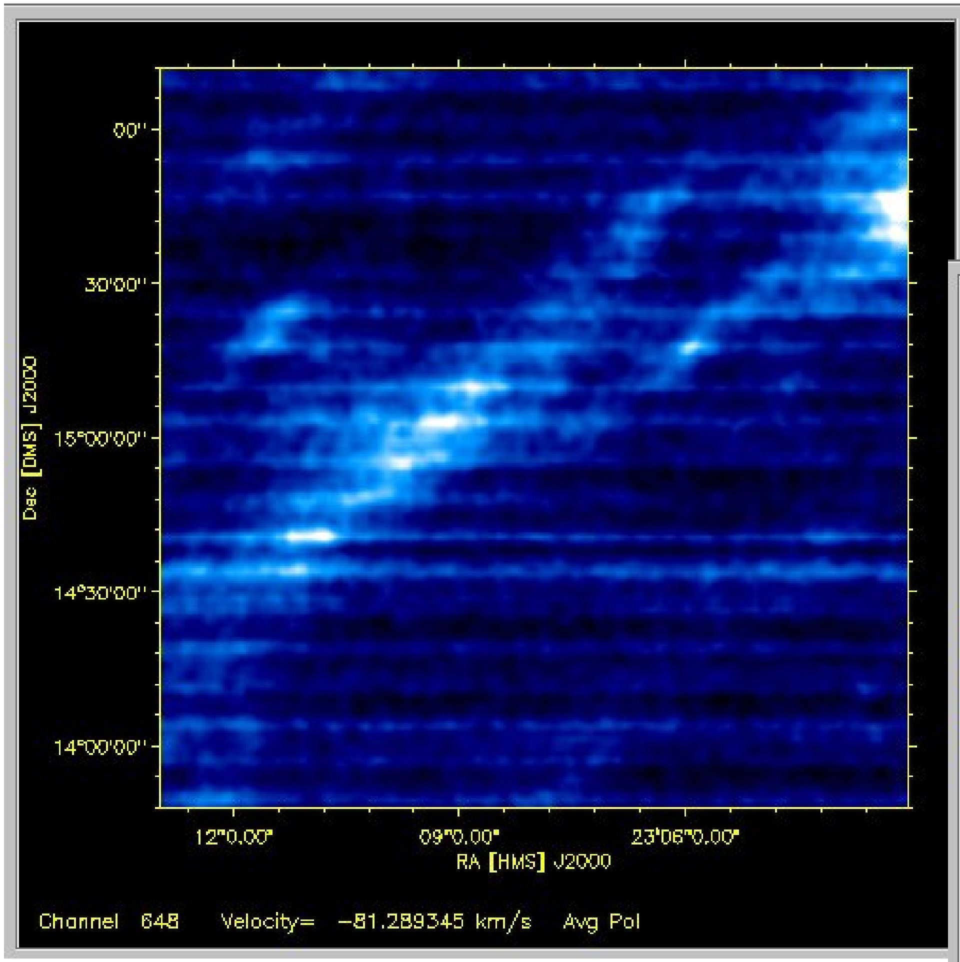
Improving Grids

The combination of drifts taken at different epochs, with small variations in calibration, the “blind” baselining done by *bpd* and the drift nature of the data taking, produce various systematic blemishes in the data cubes. Partial correction of those blemishes Is achieved by the procedured ***grid_base*** and ***grid_flatfield***.

grid_base allows for re-baselining the gridded data *along the spectral dimension.* ***grid_flatfield*** does so *in the spatial dimensions,* something akin to flatfielding optical images.
The two procedures allow a great deal of interactive massaging, but in most of the cases, we use “*accelerators*” .

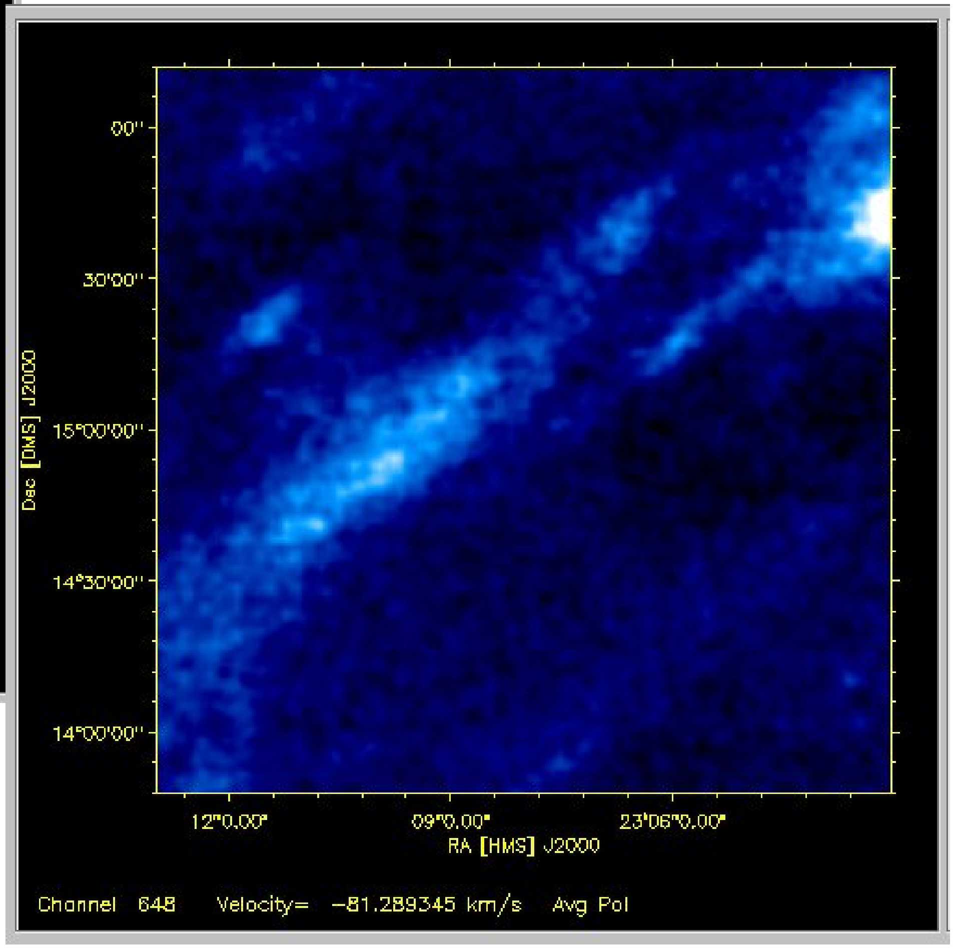
The *baselined, flatfielded grids* are stored in .sav files with names such as *gridbf_2308+15a.sav, gridbf_2308+15b.sav, gridbf_2308+15c.sav, gridbf_2308+15d.sav.*

When the “gridbf_…” files are deemed satisfactory, the “grid_…” files are deleted.



Before Grid_flatfield

After Grid_flatfield



Signal Extraction

An automatic signal extraction algorithm by A. Saintonge is applied to the sanitized grids, which produces a catalog of possible source detections to any desired S/N level.

Ex3dh operates in the Fourier domain; it is thus more computationally efficient and relatively less vulnerable to baseline instabilities than peak-finding algorithms.

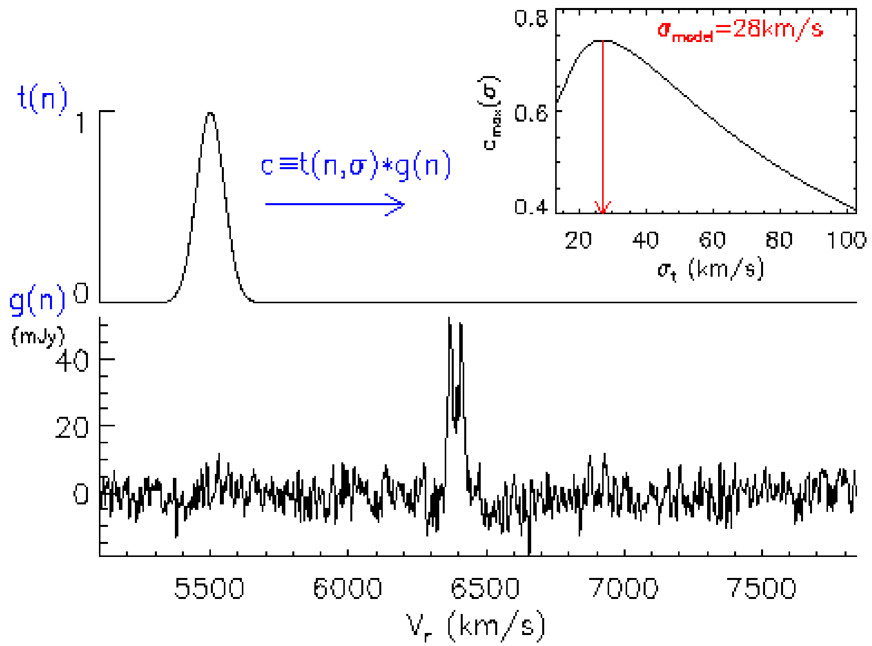
Ex3dh uses templates that are Hermite polynomial expansions and provide a good representation of the shapes of extragalactic 21cm line profiles.

Once a catalog of candidate detections has been obtained, the module ***ex3d_d*** allows rapid inspection and sifting.

Signal Extractor -- Introduction

The signals are extracted by cross-correlations of a template with the spectra.

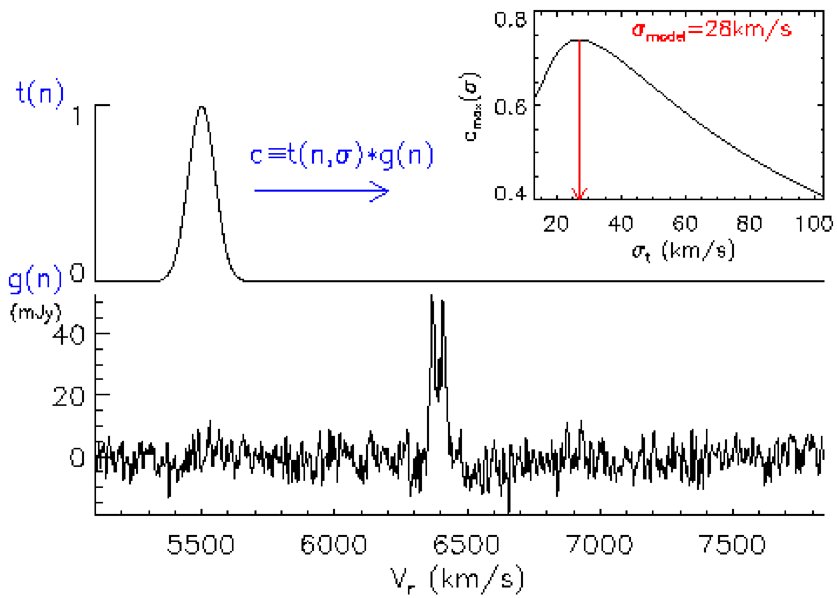
- More sensitive than peak-finding algorithms.
  - sensitive to total flux, not only peak flux
  - especially important for low mass systems
- Using FFT's, cross-correlations are fast
- It's a matched-filter algorithm



Slide: Amelie Saintonge

Signal Extractor -- Application(2)

The process is :



Repeat for a range of widths of the template

e.g. 10 km/s – 600km/s

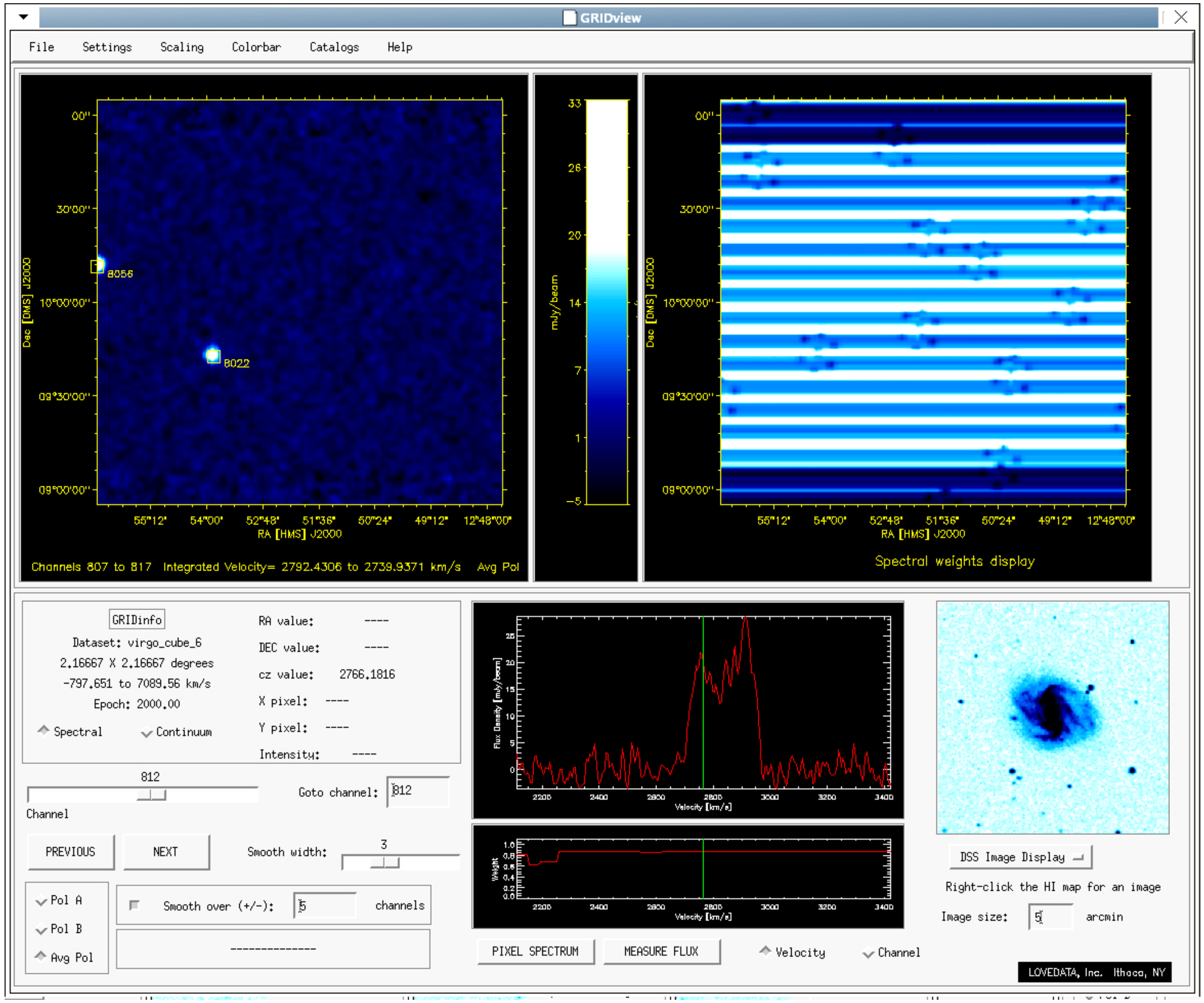
Choose the width for which the convolution is maximised --> position of the signal

Calculate the amplitude of the signal from the width

Slide: Amelie Saintonge

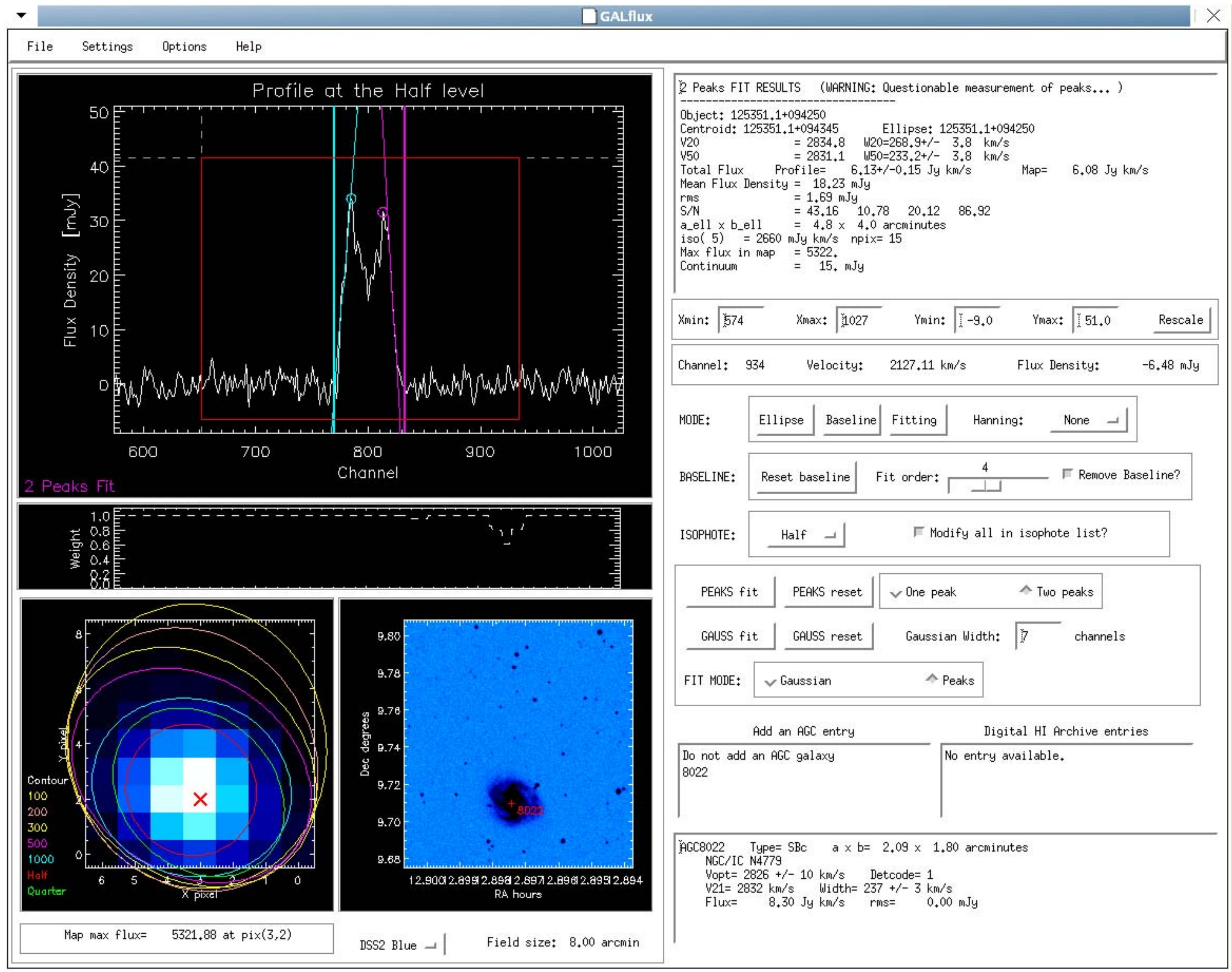
Gridview: Data cube visualization (Brian's opera summa)

- Data cubes and corresponding 3D catalogs are examined in GRIDview.
- The upper left display is a channel map; at upper right is the corresponding weights map.
- Controls allow user to view channel or integrated maps at different velocities.
- DSS, DSS2, Sloan, NVSS images can be fetched.
- NED and other on-line catalogs – including internal ones – can be accessed and overplotted

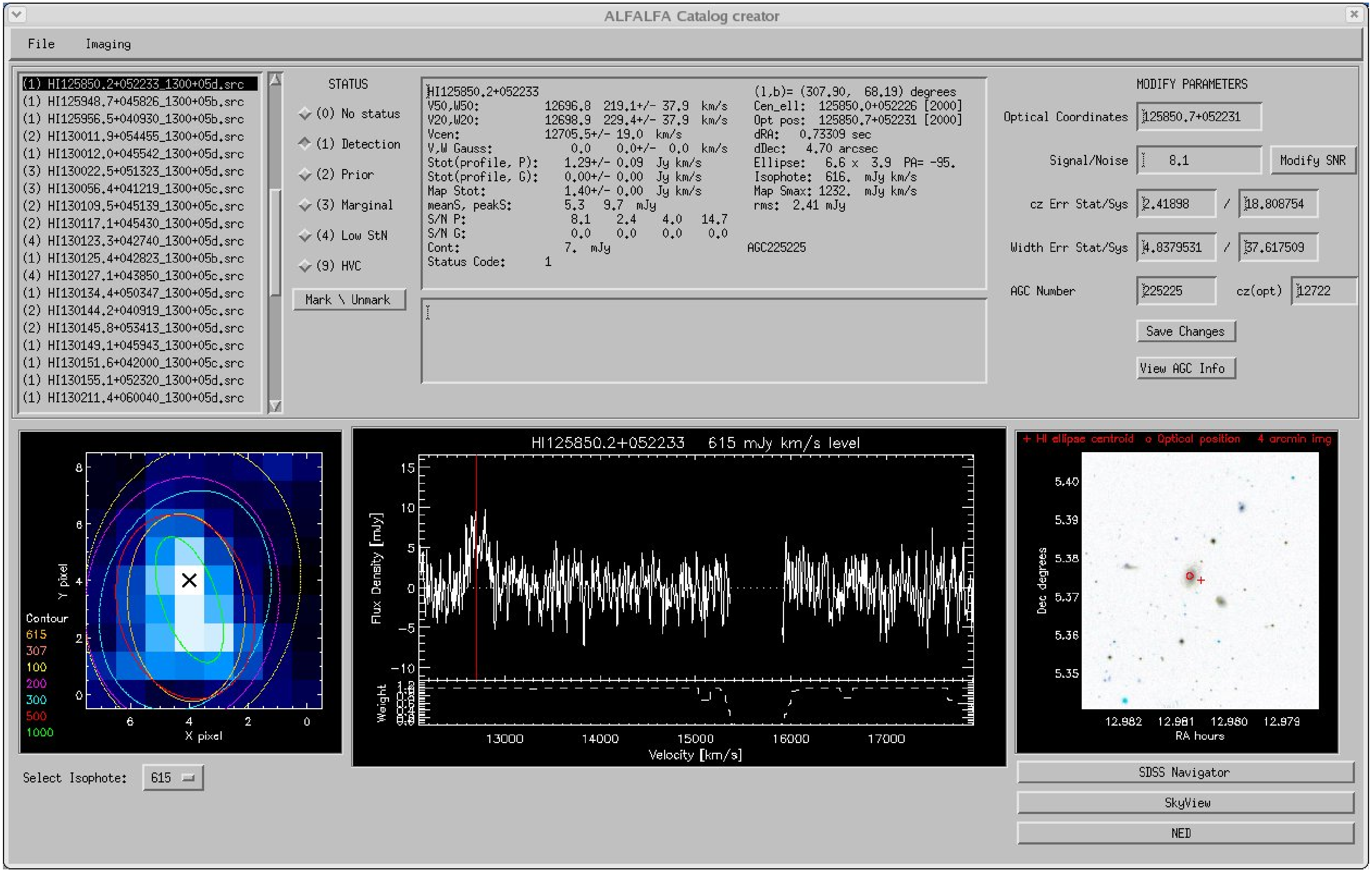


Galflux: Source Measurement

- *Centroid positions are determined*
- *Ellipse parameters are calculated.*
- *Integrated profiles are created – measurements are recorded in src (source) structures*
- *Data are compared with database archives.*

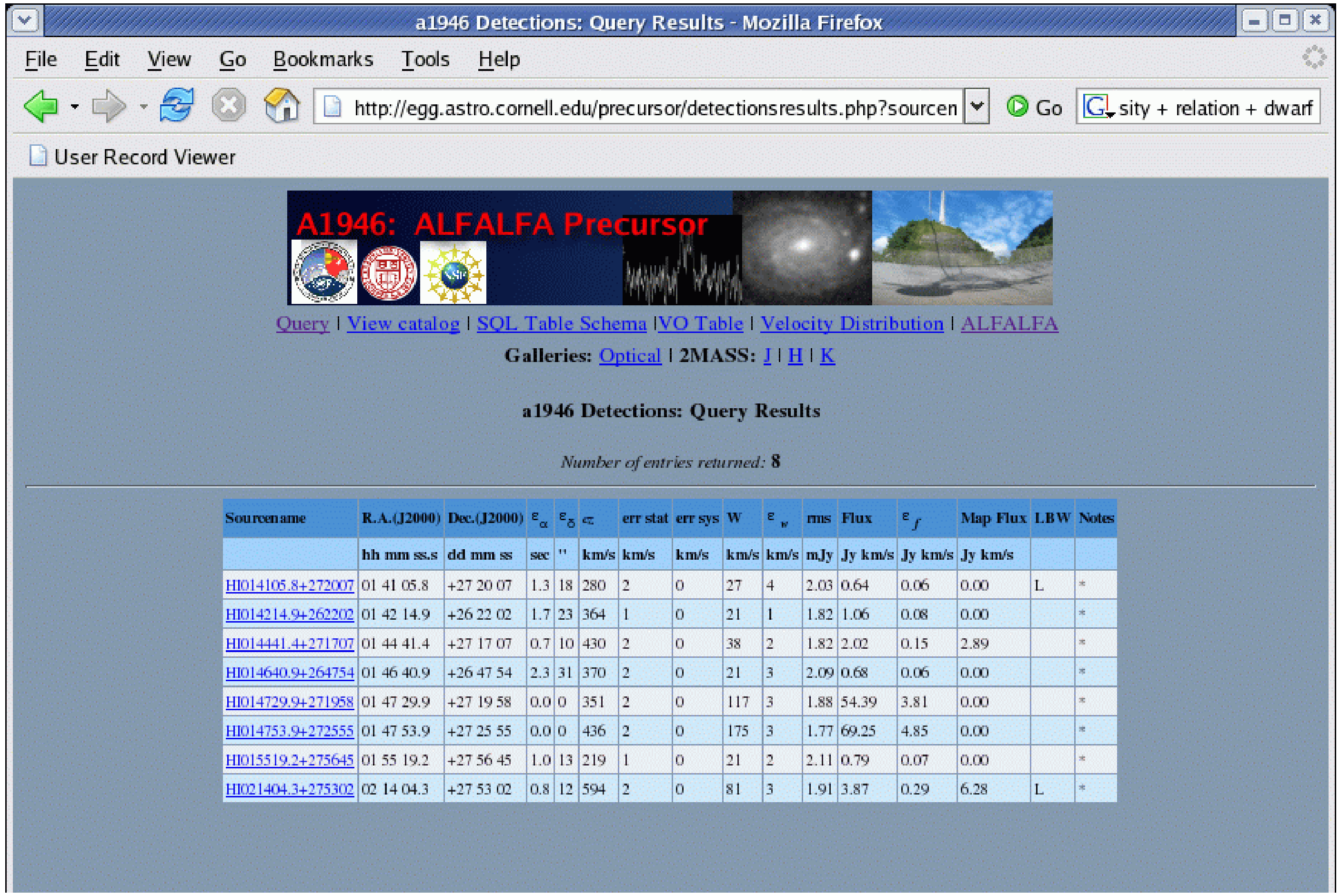


Galcat: Making a Catalog



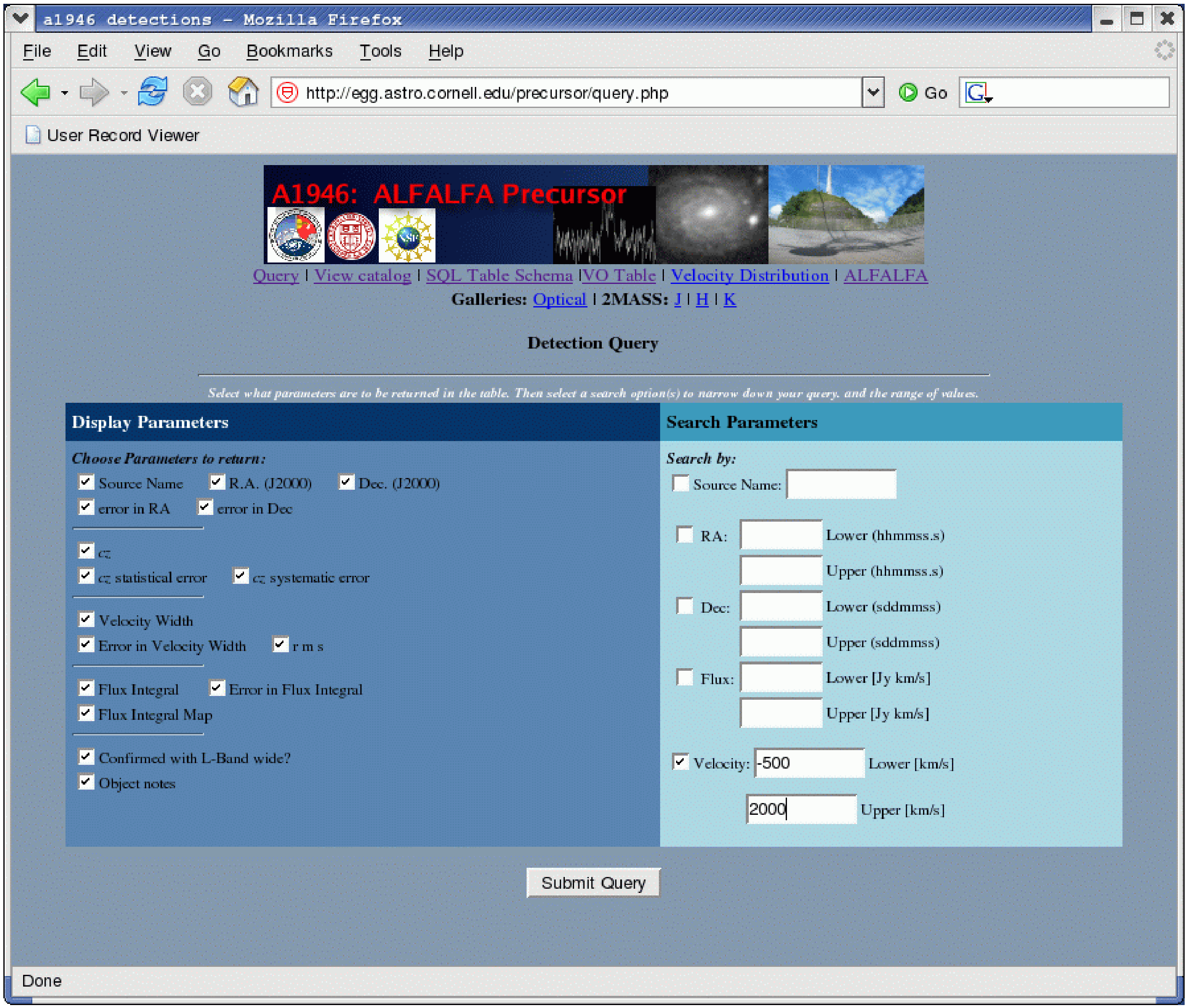
ALFALFA Data Products

- SQL database
- PHP interface
- Download catalog in XML/VOTable format
- Spectra
- Cross reference with DSS, 2MASS and SDSS images



Sourcename	R.A.(J2000)	Dec.(J2000)	ϵ_α	ϵ_δ	cz	err stat	err sys	W	ϵ_w	rms	Flux	ϵ_f	Map Flux	LBW	Notes
	hh mm ss.s	dd mm ss	sec	''	km/s	km/s	km/s	km/s	km/s	mJy	Jy km/s	Jy km/s	Jy km/s		
HI014105.8+272007	01 41 05.8	+27 20 07	1.3	18	280	2	0	27	4	2.03	0.64	0.06	0.00	L	*
HI014214.9+262202	01 42 14.9	+26 22 02	1.7	23	364	1	0	21	1	1.82	1.06	0.08	0.00		*
HI014441.4+271707	01 44 41.4	+27 17 07	0.7	10	430	2	0	38	2	1.82	2.02	0.15	2.89		*
HI014640.9+264754	01 46 40.9	+26 47 54	2.3	31	370	2	0	21	3	2.09	0.68	0.06	0.00		*
HI014729.9+271958	01 47 29.9	+27 19 58	0.0	0	351	2	0	117	3	1.88	54.39	3.81	0.00		*
HI014753.9+272555	01 47 53.9	+27 25 55	0.0	0	436	2	0	175	3	1.77	69.25	4.85	0.00		*
HI015519.2+275645	01 55 19.2	+27 56 45	1.0	13	219	1	0	21	2	2.11	0.79	0.07	0.00		*
HI021404.3+275302	02 14 04.3	+27 53 02	0.8	12	594	2	0	81	3	1.91	3.87	0.29	6.28	L	*

SQL Query


a1946 detections - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://egg.astro.cornell.edu/precursor/query.php
Go
User Record Viewer
A1946: ALFALFA Precursor
Query | View catalog | SQL Table Schema |VO Table | Velocity Distribution | ALFALFA
Galleries: Optical | 2MASS: J | H | K
Detection Query
Select what parameters are to be returned in the table. Then select a search option(s) to narrow down your query. and the range of values.
Display Parameters
Choose Parameters to return:
Source Name
R.A. (J2000)
Dec. (J2000)
error in RA
error in Dec
cz
cz statistical error
cz systematic error
Velocity Width
Error in Velocity Width
r m s
Flux Integral
Error in Flux Integral
Flux Integral Map
Confirmed with L-Band wide?
Object notes
Search Parameters
Search by:
Source Name:
RA:
Lower (hhmmss.s)
Upper (hhmmss.s)
Dec:
Lower (sddmmss)
Upper (sddmmss)
Flux:
Lower [Jy km/s]
Upper [Jy km/s]
Velocity:
-500
Lower [km/s]
2000
Upper [km/s]
Submit Query
Done

VO Table

a1946 Detections: Query Results - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://egg.astro.cornell.edu/precursor/detectionsresults.php?sourcename

Go

User Record Viewer

A1946: ALFALFA Precursor

Query | View catalog | SQL Table Schema |VO Table | Velocity Distribution | ALFALFA

Galleries: Optical | **2MASS:** J | H | K

a1946 Detections: Query Results

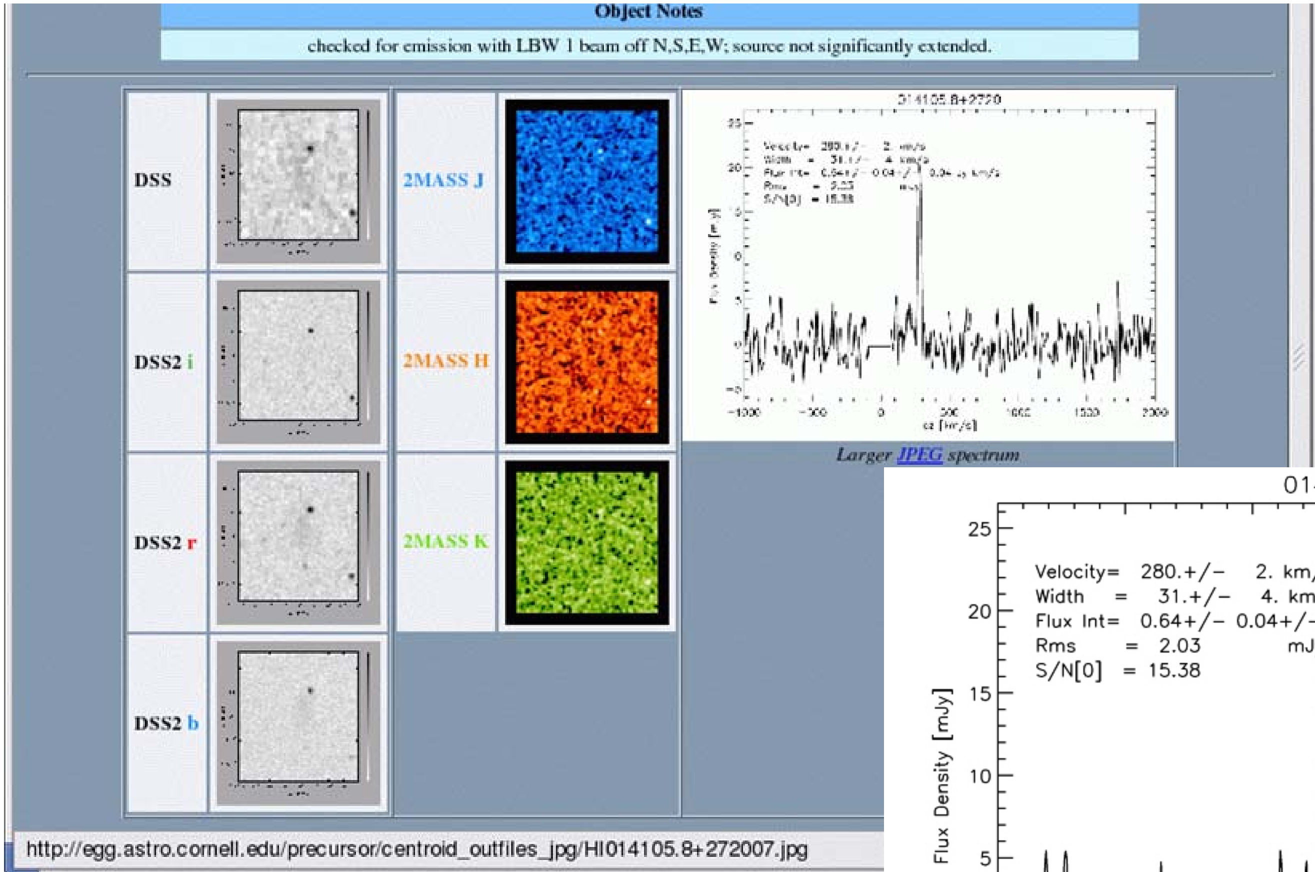
Number of entries returned: **14**

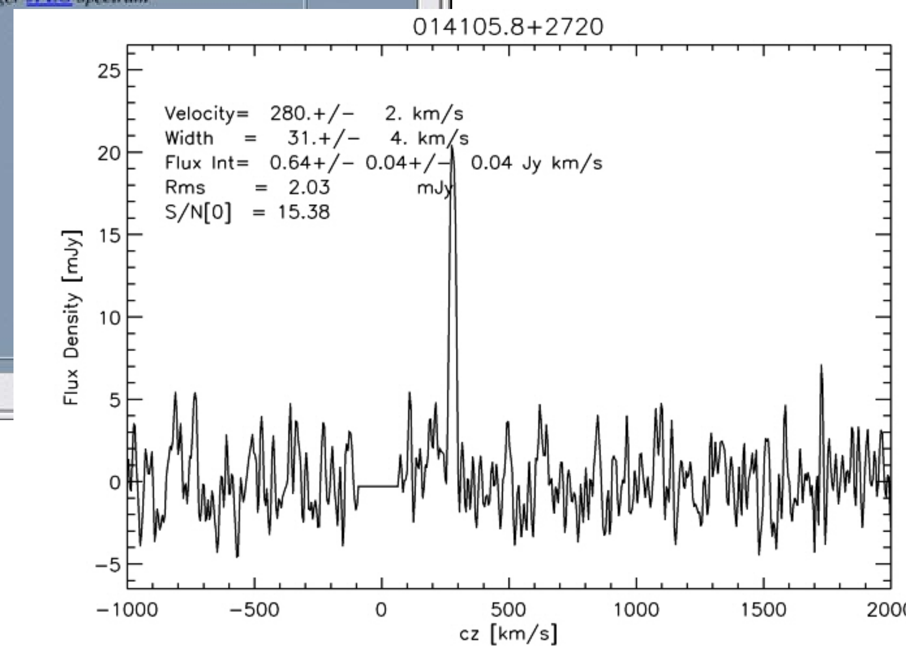
Sourcename	R.A.(J2000)	Dec.(J2000)	ϵ_α	ϵ_δ	cz	err stat	err sys	W	ϵ_w	rms	Flux	ϵ_f	Map Flux	LBW	Notes
	hh mm ss.s	dd mm ss	sec	''	km/s	km/s	km/s	km/s	km/s	mJy	Jy km/s	Jy km/s	Jy km/s		
HI014105.8+272007	01 41 05.8	+27 20 07	1.3	18	280	2	0	27	4	2.03	0.64	0.06	0.00	L	*
HI014214.9+262202	01 42 14.9	+26 22 02	1.7	23	364	1	0	21	1	1.82	1.06	0.08	0.00		*
HI014441.4+271707	01 44 41.4	+27 17 07	0.7	10	430	2	0	38	2	1.82	2.02	0.15	2.89		*
HI014640.9+264754	01 46 40.9	+26 47 54	2.3	31	370	2	0	21	3	2.09	0.68	0.06	0.00		*
HI014729.9+271958	01 47 29.9	+27 19 58	0.0	0	351	2	0	117	3	1.88	54.39	3.81	0.00		*
HI014753.9+272555	01 47 53.9	+27 25 55	0.0	0	436	2	0	175	3	1.77	69.25	4.85	0.00		*
HI015519.2+275645	01 55 19.2	+27 56 45	1.0	13	219	1	0	21	2	2.11	0.79	0.07	0.00		*
HI021404.3+275302	02 14 04.3	+27 53 02	0.8	12	594	2	0	81	3	1.91	3.87	0.29	6.28	L	*
HI022919.3+272107	02 29 19.3	+27 21 07	1.7	25	1553	4	0	26	5	2.43	0.57	0.06	0.00	L	
HI023058.9+275709	02 30 58.9	+27 57 09	0.8	11	1596	1	0	71	1	2.13	2.93	0.21	0.00		
HI023138.9+271130	02 31 38.9	+27 11 30	2.6	45	985	4	0	21	6	2.87	0.51	0.06	0.00	L	
HI023329.2+270136	02 33 29.2	+27 01 36	2.2	35	1666	5	0	76	7	1.90	0.78	0.07	0.00	L	
HI024055.2+264046	02 40 55.2	+26 40 46	4.0	75	1487	5	0	49	6	2.30	0.55	0.06	0.00	L	
HI042739.5+260545	04 27 39.5	+26 05 45	4.4	96	1936	9	26	70	39	3.28	1.13	0.11	0.00	L	*

Done

ALFALFA and NVO

Using VO Tools





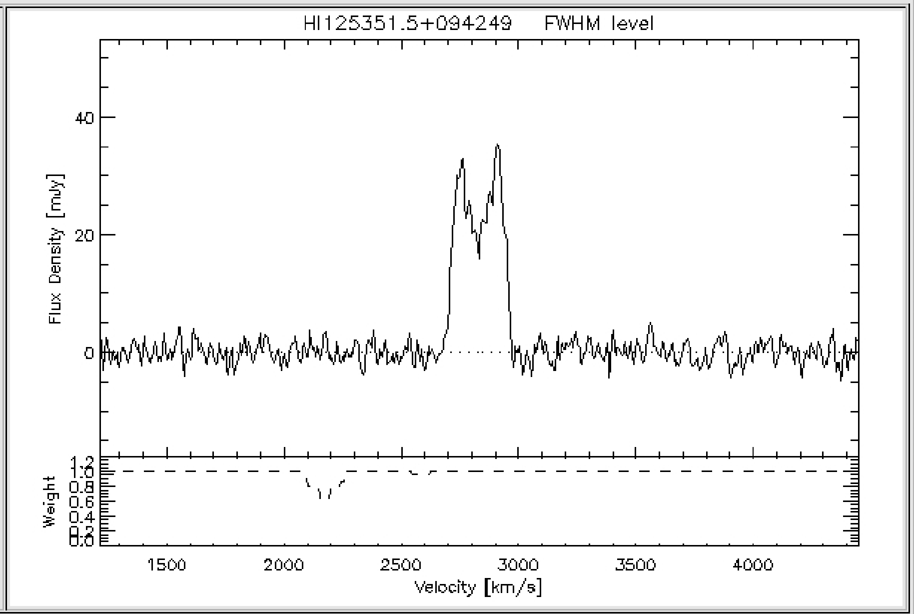
ALFALFA Catalog Object: HI125351.5+094249 - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

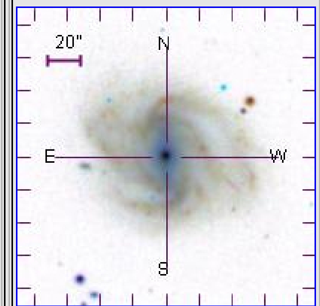
file:///home/caborojo1/bkent/idl/galflux/html/HI125351.5+094249_5.html Go

Yahoo! Mail - The best... Google SummerSchool2 - Mai... ALFALFA Team Website IDL Virtual Observator... ALFALFA LOG

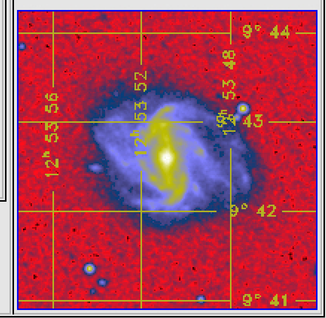
ISO 0
ISO 1
ISO 2
ISO 3
ISO 4
ISO 5
ISO 6



SDSS

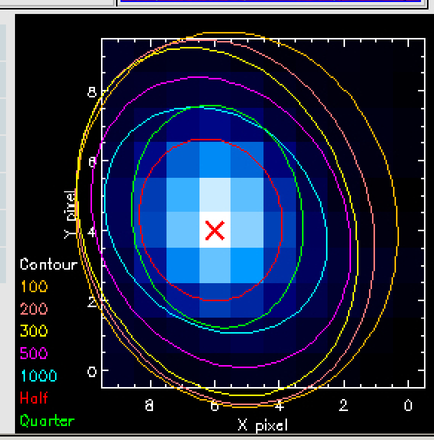


Digital Sky Survey Blue 2



V50,W50	2831.0 233.6+/- 3.8 km/s
V20,W20	2834.5 269.5+/- 3.8 km/s
Vcen	2832.2+/- 1.9 km/s
V,W Gauss	0.0 0.0+/- 0.0 km/s
Stot(profile, P)	6.41+/- 0.16 Jy km/s
Stot(profile, G)	0.00+/- 0.00 Jy km/s
rms	1.77 mJy
meanS, peakS	20.0 35.4 mJy
S/N P	43.0 11.3 20.0 89.0
S/N G	0.0 0.0 0.0 0.0
Cont	15. mJy

Centroid	125351.3+094435 [2000]
Opt pos	125350.8+094235 [2000]
Cen_ell	125351.5+094249 [2000]
Ellipse	4.7 x 4.4 PA=-119.
Isophote	2621. mJy km/s
Map Smax	5243. mJy km/s
Map Stot	6.19+/- 0.00 Jy km/s



Done