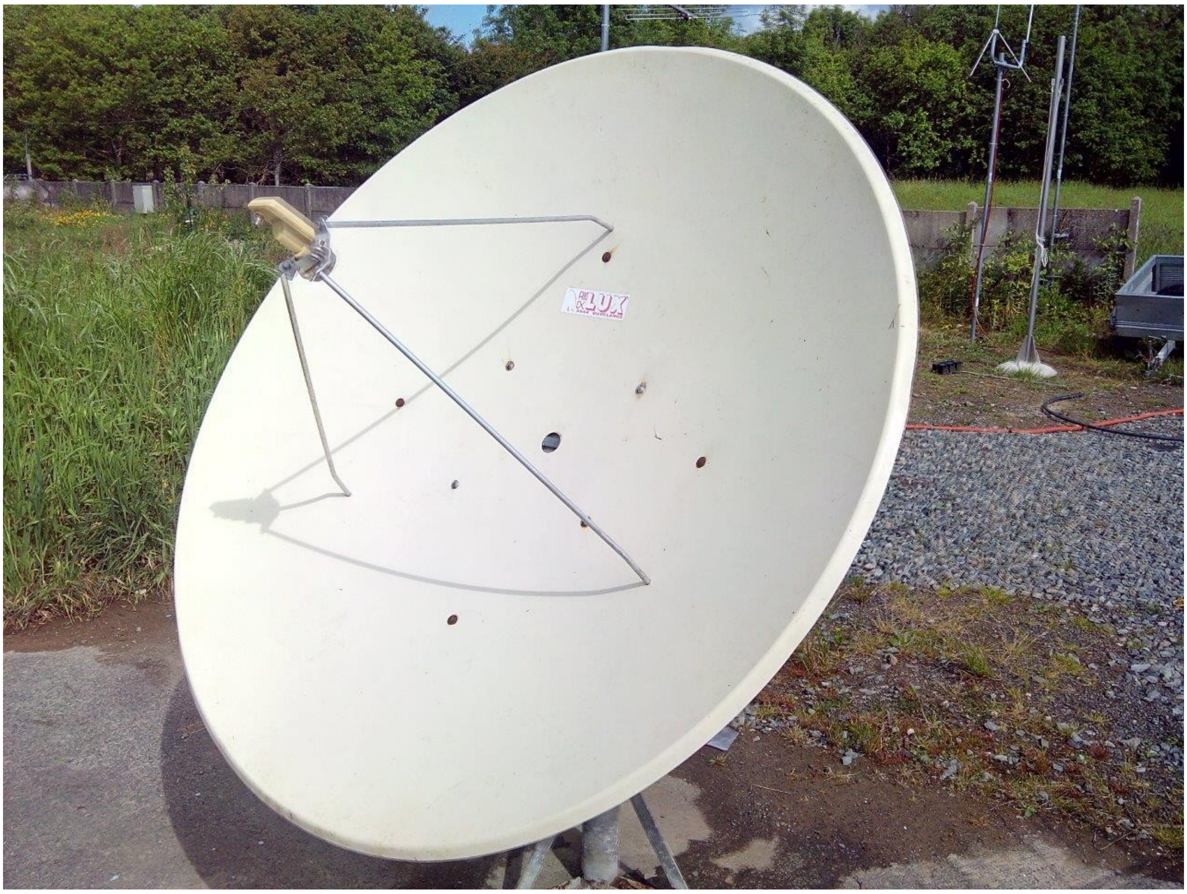

Amateur Radio Astronomy

How to start.

Jean Marie Polard

[F5VLB - 2016]

The book you need to understand and operate an amateur radio astronomy station,

Thank you to **Miguel A. Vallejo EA4EOZ** for the technical reading an to **Peter & Heather** for the English corrections.

Ver 0.1b

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In the beginning...

The beginnings in brief

Karl Jansky discovered in 1933 a radio signal with a period of 23 hours 56 minutes, a sidereal day, the characteristic period of the fixed stars move. This is the first extraterrestrial radio signal received on Earth. In 1937, Grote Reber, having failed to get hired in the team of Jansky, built a radio telescope at his own expense to explore space in the radio field, as an amateur.

After World War II, research began on a larger scale with recycled military equipment (radars). In France, in 1947 Yves Rocard with two German original antennas of 7.5 m diameter creates an observation service run by Jean-François Denisse. In 1952 he obtained the means to build a bigger radio astronomy observatory station in Nancay (France – dpt of Cher) with 32 radio telescopes aligned, inaugurated in 1956.

March 25, 1951, Harold Ewen and Edward Purcell detected the 21-cm line of neutral hydrogen in the Milky Way with a horn antenna.

In 1963, Arno Allan Penzias and Robert Woodrow Wilson discovered the residual radiation of the Big Bang under George Gamow trying to eliminate background noise in their transmission equipment.

In 1965 the cosmic microwave background is discovered. Georges Lemaitre (a Belgian) had predicted in his theory of the early explosion in his article (in French) addressed to Sir Eddington, defines it as the "glow disappeared from the formation of worlds", connecting the theory of Big Bang; what Fred Hoyle, a supporter of the "stationary" theory, had caricatured by appointing this term big bang which thus became the symbol of the theory of the expanding universe. The discipline of astronomy takes an unparalleled boom in the history of astronomy.

In 1967, Jocelyn Bell Burnell detected the first pulsar, but it was his supervisor, Antony Hewish, who received the 1974 Nobel Prize in Physics for his contributions to astronomy - triggering a controversy.

Source : Article *Radioastronomy* on Wikipedia

This young science was built by many radio ham's like Grote Reber , John Kraus, Joe Taylor ...

Why this syllabus?

Since I became interested in radio-astronomy a lot of progress has been made. At first, the difficulty of access to information was a handicap. Now, with the internet and Wikipedia, with modules available at low cost, anyone, with a little skill can make a radio telescope and make beautiful experiences. Certainly there are lots of books, articles, information sources. This syllabus is trying to consolidate all that we could store and to share some of my experience. Feel free to go elsewhere to complete the job and make your station, a good station. Also share your knowledge, your trials, your successes and your failures. Thus it progresses.

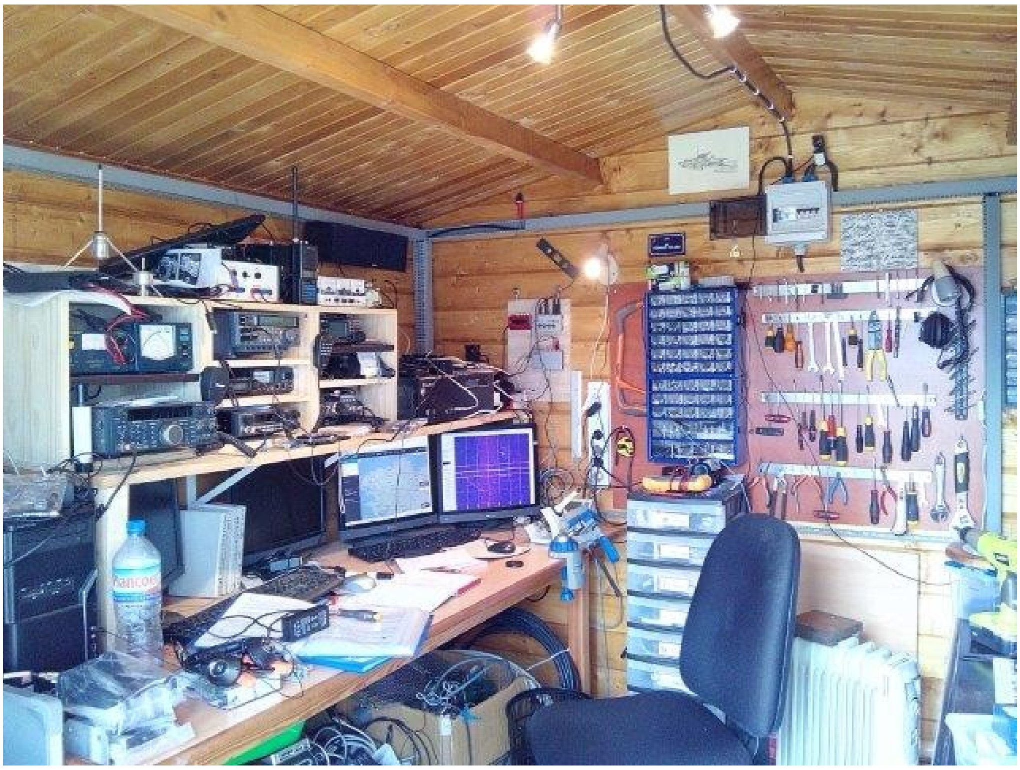
Good reading ….

My debut ...

My first radio astronomy station in ... 1971. I was listening to the sun and Jupiter with a broadcast radio. No computer, no graphic recorder, no spectrum analyser, no money ... just the ears and eyes.

In 1985 with the first PC, but with modules salvaged from television tuners. Suffice to say we received more noise than signal, but I was happy to follow the sun and record transits on a chart recorder.

During the 2000s and using the sound card as an interface between the radio and PC. Listening meteor echoes. I spent hours in front of the 'Spectrogram' spectrum analyzer and analyze the results with the help of EA4EOZ Miguel. With the end of analogue TV, listening meteors has become more difficult to discover the Graves radar explained below. With Miguel, we deigned our first radiometer based on the Satfinder. Probably one of the first developments in radio astronomy using satfinder ever.



In 2014, I bought my first house and installed a wooden garage with the new shack.

The satellite dish of 155 cm will be doubled by another of 2.4m from RF-Hamdesign.

The 2,4m dish antenna (picture from RF Hamdesign) Info here

Sources of Radio Emissions

- Thermal emission : black-body spectrum (e.g. Moon)
- Free-free emission (Bremsstrahlung) : ionized gas (e.g. H II regions)
- Synchrotron emission : charged relativistic particles in magnetic field (e.g. AGN jets)
- Spectral-line absorption : lines seen against background continuum emission (e.g. H I)
- Spectral-line emission : atoms, radicals, molecules (e.g. CO)

For each of these sources, one has several options. I start now with the equipment.

The equipment

The antenna

The key element in RA is of course the antenna. As in optics, it will be used to capture radiations. So its size, shape and position will be crucial to achieve good observations.

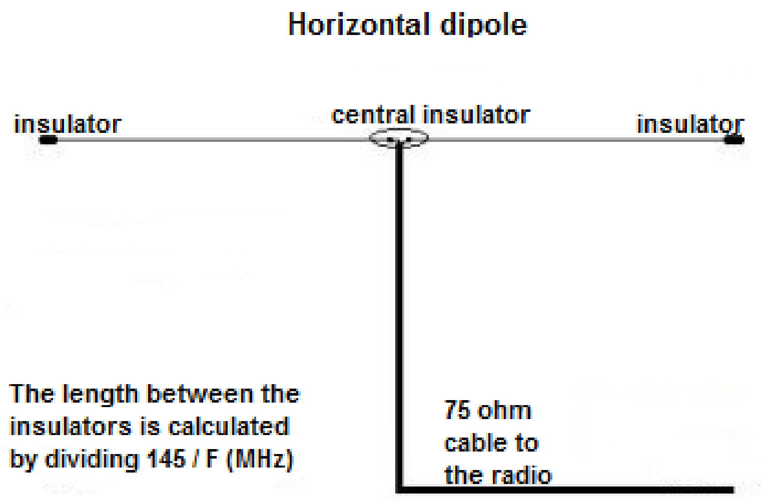
Its size, its shape

An antenna can be made with a tight copper wire between two poles, one or more yagi antennas, a dish (offset or prime focus), a horn ...

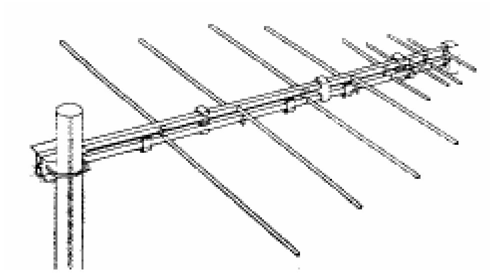
What will determine the type of antenna you will use is the frequency of the radio waves or radiations on which you will work.

If you work between 0 and 10MHz a loop antenna is effective, between 14 and 100 MHz a dipole antenna will suffice, between 100 and let's say 1000MHz a yagi, and above a dish or a horn.

A simple antenna to listen to Jupiter can be made using two copper wires tendered between two poles or two fixed points and that's all. Wires of 1.5² or 2,5² and covered with plastic is perfect. Attached to the fixing points by nylon wire 1m long, for example. Do not tie directly to the insulators hanging points. Between 18 and 24MHz, you can detect signals from Jupiter. See below.



If you are working above 100 MHz, to listen to the sun, pulsars, meteors, a yagi antenna is recommended.



This kind of antenna can be found in all the tv stores, ham radio stores, or can be built by yourself, for the most skillful. It must chosen based on the frequency you will be working. One can assemble several yagis one beside the other, one on the other, remote from each other (interferometer).

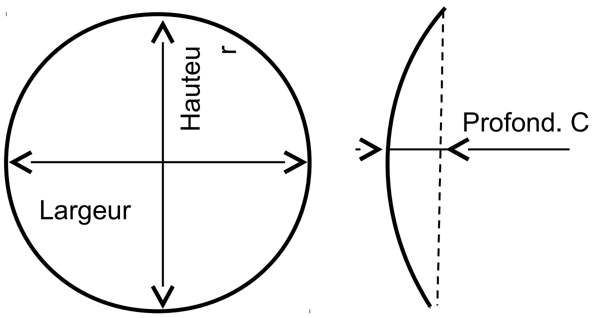
Above 1000MHz, the dish is preferred. So either you opt for a small offset type of dish (the same as used in satellite TV) purchased commercially or recovered at home or dumped (there are beautiful treasures in waste, with their LNB and sometimes motorization). Either you take a prime focus for larger diameters.

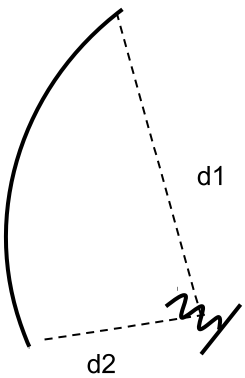
But one thing is evident the greater the diameter the more signal you can capture. That said, with a 60cm off-set dish there is already way to do great work, especially on the sun.

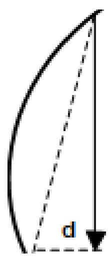
If you have an offset parabola, you may need to find the focal point where to install the LNB. Jean Louis Rault F6AGR has posted a worksheet that can help you. See this link for the calculations excel sheet of F6AGR

This sheet is in French, but with this example you should find your way.

You enter : Hauteur (height) Largeur (width) Profondeur (depth) and you get the results. In the performance (2.5) enter the frequency of use (in MHz) and leave the 0,65 at this value or use 0,6 if you prefer.







Caractérisation d'une source de parabole offset

Cette feuille de calcul permet, à partir de quelques mesures effectuées sur une parabole de récupération de caractéristiques inconnues, de déterminer la position de la source, son orientation, et d'estimer le gain de l'ensemble.

Ces résultats sont théoriques, et les valeurs données sont à affiner avec des mesures menées en terrain dégagé à l'aide, par exemple, d'une balise émettrice fixe.

1. Mesurer la hauteur, la largeur et la profondeur maximale de la parabole et renseigner toutes les cases en bleu-vert

Hauteur D =	1328	mm
Largeur l =	1143	mm
Profondeur C =	152,4	mm

2. Tous les résultats de calcul apparaissent en bleu

2.1 La parabole présente les caractéristiques suivantes:

Distance focale f =	461,1	mm
f/D équivalent =	0,55	

2.2 La source doit être positionnée comme suit:

d1 =	1137,6	mm
d2 =	461,5	mm

2.3 Pour illuminer correctement le réflecteur, la source doit posséder les caractéristiques suivantes:

Largeur lobe source =	97,7	° à -10 dB
Inclinaison source =	52,1	° par rapport à l'horizontale

2.4 Calage en élévation

L'antenne vise l'horizon lorsqu'elle est inclinée en avant d'un angle de 30,6 ° par rapport à la verticale.
Pour obtenir cet angle de 30,6 °, on peut utiliser un fil à plomb accroché au bord supérieur de la parabole.

Il suffit d'incliner la parabole vers l'avant jusqu'à ce que le plomb se trouve à 676,1 mm du bord inférieur du reflecteur.

2.5 Performances d

A la fréquence de 1,535 GHz, le gain théorique est proche de 23,4 dB, si l'on considère qu'on a 65 % de rendement.
L'ouverture du lobe de rayonnement principal est environ égal à 11,1 ° à - 3dB.

2.5 Antenne hélice utilisée comme source

C'est une antenne hélice de 3,25 spires qui est la mieux adaptée à cette parabole.

Vous pouvez adresser vos remarques, questions et critiques par courriel à f6agr@w anadoo.fr

Bibliographie:
Physique et Théorie du Radar de J. DARRICAU
Articles de F4BAY dans bulletins Hyper
Simulations NEC de G6LVB sur antennes hélice
Reference Data for Radio Engineers (ITT)

A similar sheet exists for prime focus dish http://www.setileague.org/software/parabola.xls but not only, a long list of useful xls sheets also !

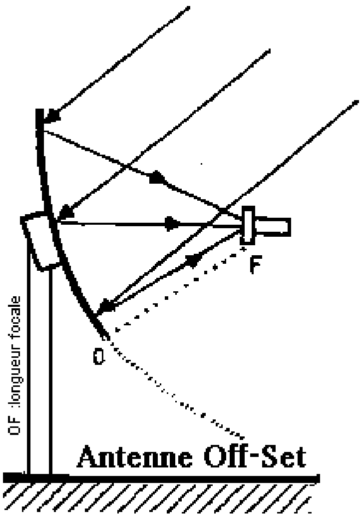
The SETI League, Inc.

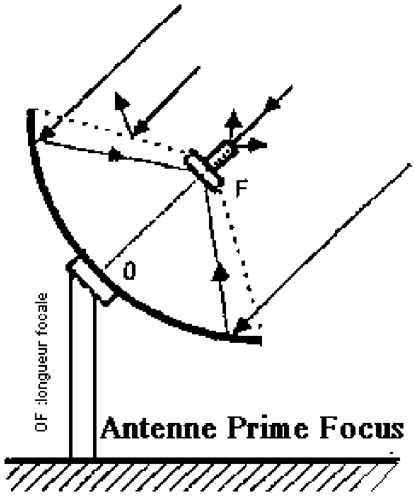
Parabolic Antenna Analysis

User specifies variables shown in **Bold**

Frequency	=	**4000**	MHz;		λ =		7,5 cm		
Reflector Diameter	=	**1,55**	meters	=	5,1	ft			
Reflector Depth	=	**0,40**	meters	=	1,3	ft			
Focal length	=	0,63	meters	=	2,1	ft;		F/D =	0,41
		Feed Illumination Angle	=		2,56	radian	=	147	degrees
		Illumination Efficiency	=		**50**	%			
		Computed Antenna Gain	=		2,1E+03	Ap	=	33,2	dBi
		Antenna Half Power Beamwidth	=		5,0E-02	radian	=	2,85	degrees
		Minimum Drift Scan time	=		1,1E+01	min	=	684,7	sec

So, ready to start calculations ?





Offset antenna

Prime focus antenna

O F : is the focal length

The gain

We use this formula

$$G = 10 \cdot \log(k \cdot \left(\frac{\pi \cdot D}{\lambda}\right)^2)$$

where :

k = performance of the illumination system (source) averaged 0.55 (for small dishes, 0,65 for large ones)

D : diameter parabolic reflector

λ : wavelength used

D and λ are expressed in the same unit

example: a parabolic dish of 155cm will have a gain of 33,3 dBi @ 4GHz (λ = 7.5 cm) check with the excel sheet of the previous page

The half power beam width @ -3dB (HPBW)

We use this formula

θ = 57,3 λ/d

57,3 comes from 180/pi

θ = angle of aperture in degrees (the beam)

λ = wavelength in cm

D = diameter in cm

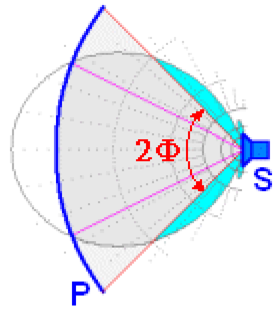
example: a parabolic dish of 155cm will have a HPBW of 2,77°@ 4GHz (λ = 7.5 cm)

one can see a difference between our calculation and the one on the excel sheet … This is because 57,3 λ/d is just a handy approximation. The excel sheet gives an exact value.

The source

Optimization of the illumination, the ratio f / D [1]

The radiating element of the source must be at the center of the dish where all the energy is concentrated. To illuminate entirely the reflector, it is necessary that the diameter thereof corresponds to the radiation lobe of the antenna source. The focal length ratio / diameter (f / D) is a key parameter of the parabolic reflector. It is chosen between 0.4 and 0.8. *A ratio f / D too low gives a very compact antenna and requires a source with a large opening angle. In contrast a ratio f / d higher gives a more compact antenna using a more directional source.*



Higher F/D ratios produce bulky antennas. Not so compact as lower F/D values.

In the figure, the source S has an opening angle @ 10dB (red line) which corresponds to the angle 2Φ under which the parabolic reflector P is seen from the home. The lines in magenta represents the opening angle at -3dB. The part of the lobe colored in cyan-blue misses the reflector.

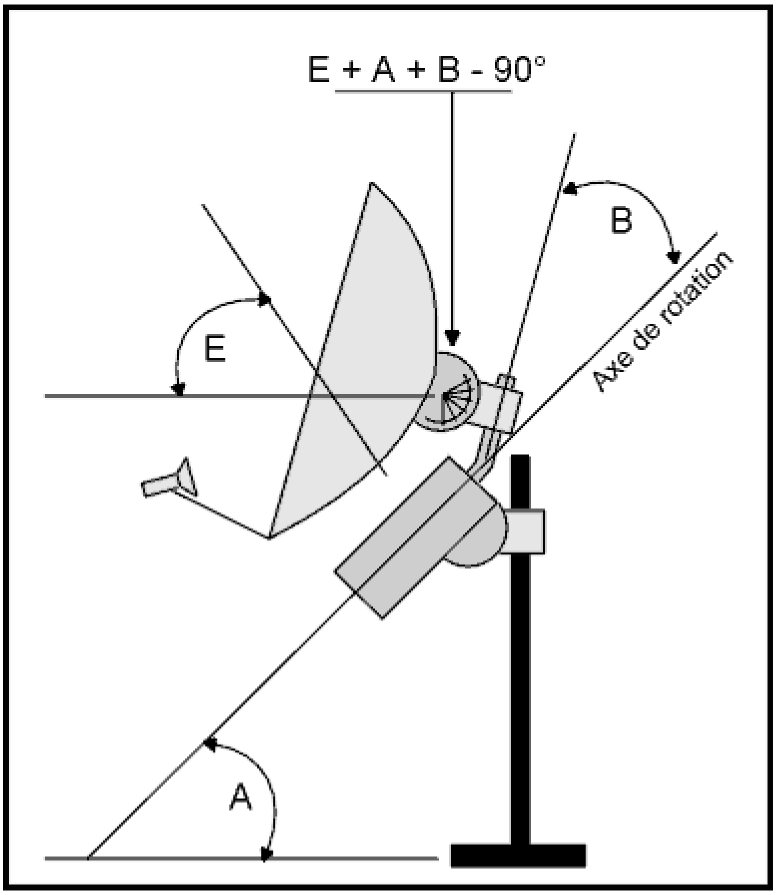
Examples:
Given two parabolas 60 and 100 cm in diameter. Given their ratio f / D, it will take for one a source whose opening angle is 50 degrees while the other will require 80 degrees. Well-trimmed circular cones may agree.

D	f	f/D	θ
60	40	0,66	50°
100	40	0,4	80°

(1) source http://f5zv.pagesperso-orange.fr/RADIO/RM/RM09/RM09i03B.html

The motorization

This is a very delicate point ... because accuracy is required. Personally I prefer a mount in meridian position and make transits. To motorize a large parabolic dish requires application and technology. But rather see what is involved.
For an offset type antenna take a look at the link below (1) which explains the positioning of an antenna facing the Clarke belt where are positioned the television satellites. To adjust the height, it will add a jack.



[(1)] here is a pdf of the commercial company manufacturing the equipment on the picture above. Another interesting site here

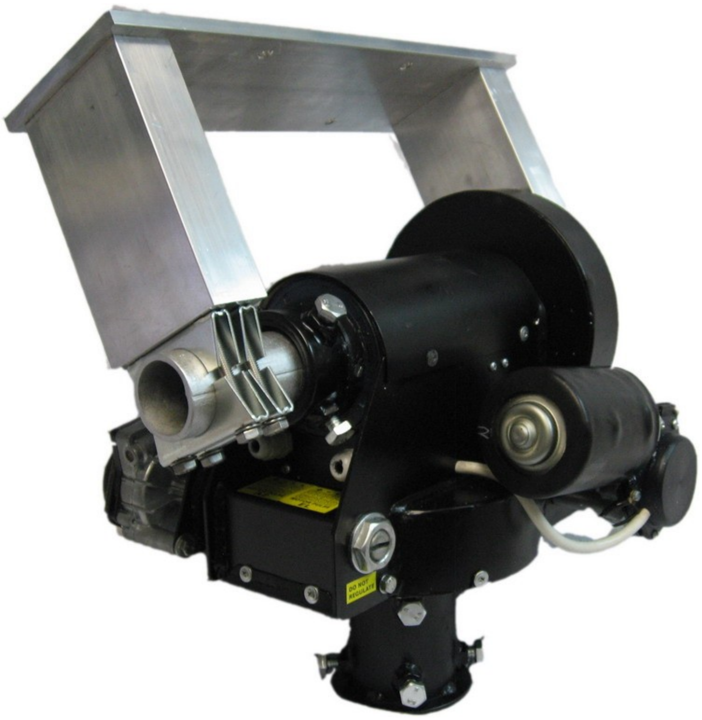
For a prime focus, we will use either one azimuth / elevation couple of motors (expensive) or two actuators (one for azimuth and one for elevation).

Example of a two-axis motor for driving a parabolic antenna prime focus. This material can be controlled via an interface via a PC. Price is approx. 750 to 1000 euros. Jean Louis Rault F6AGR responsible for Radio Astronomy at the Astronomical Society of France delete commented: "They are very reliable (I have had one on my roof for over 15 years for trafficking by sats) but they are not tailored for the parabolic dishes because of their mechanical problems.

For high gain antennas as parabolic dishes it is better to use SPID system for example (see this link) – free advertisement

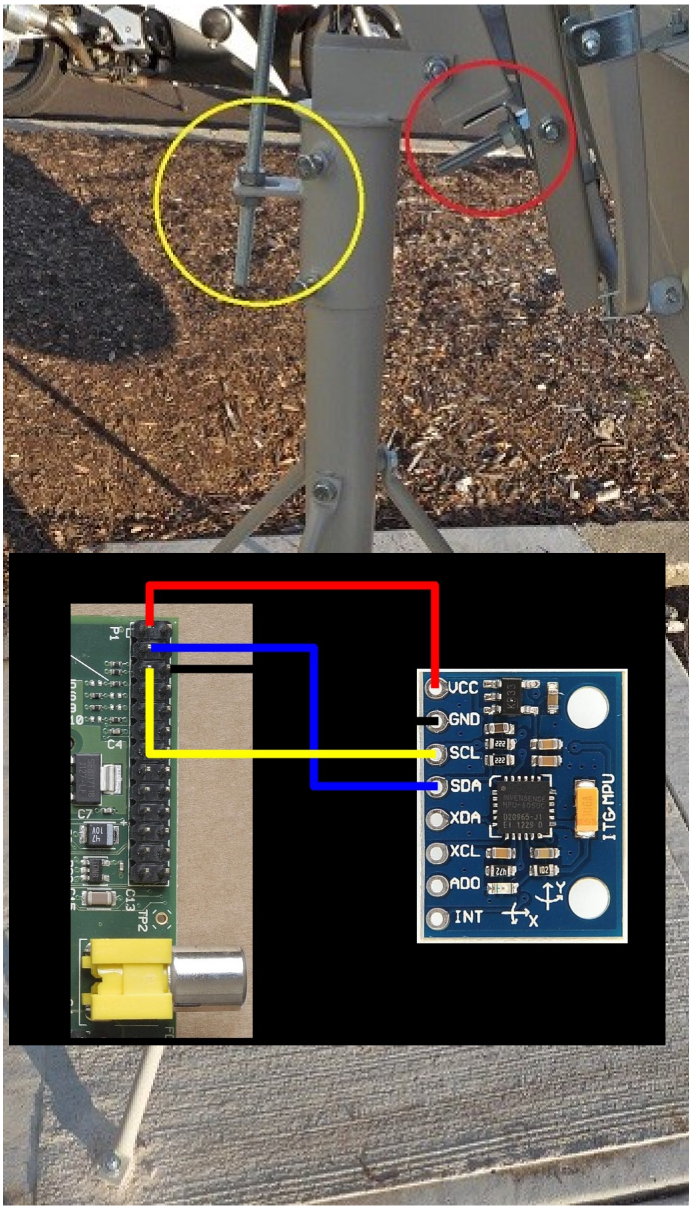
SPID are indeed higher in accuracy, but the price also.

Everyone will do with its means. delete



Info about SPID systems are available here

With two actuators the principle is as follows :



We will replace the two screws on the system with two actuators driven separately.

There are actuators on the internet and it suffices to provide a 36V supply continuously, some buttons and ... a system that will give you angles of azimuth and elevation.

To know the position there is a small module three axes priced two bugs to fit on an Arduino or Raspberry. the HMC5883L

A link to the module is here (1) to make the connections and some info on the module (2) for its implementation

(1) http://blog.bitify.co.uk/2013/11/interfacing-raspberry-pi-and-mpu-6050.html

(2) http://blog.bitify.co.uk/2013/11/connecting-and-calibrating-hmc5883l.html

So you can at any time know the position of your antenna and determine where it is pointing to the sky.

Wiring of the module to the Raspberry.

Its position

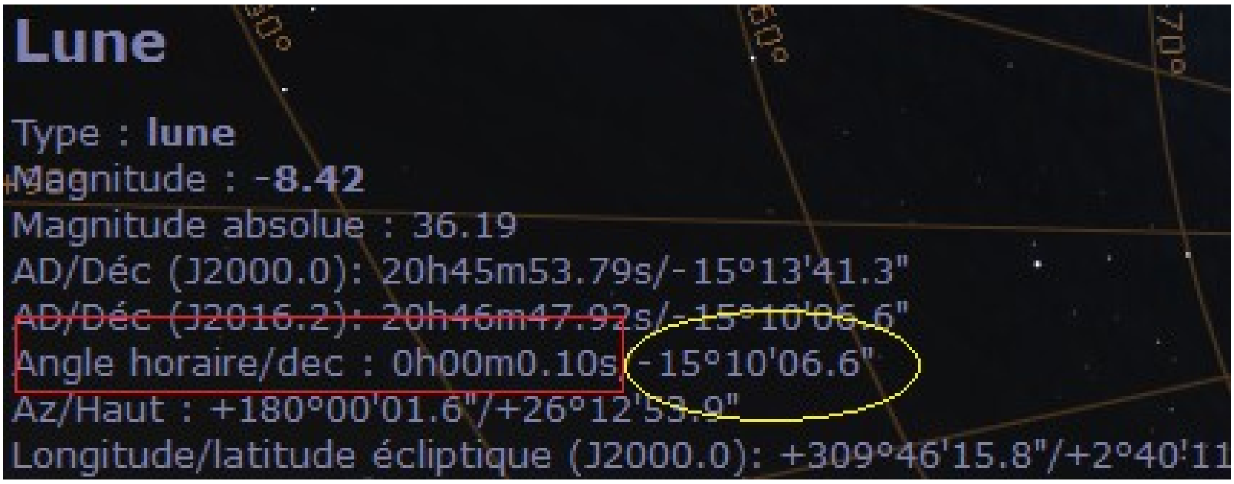
To start, I suggest you position the antenna facing south. Indeed, a star rises as it passes the meridian. The right ascension of a star is constant, the value that is maximum at the transit time is the **elevation** (height above the horizon)

To calculate the elevation of the antenna you must know the latitude of your location, and apply the formula:

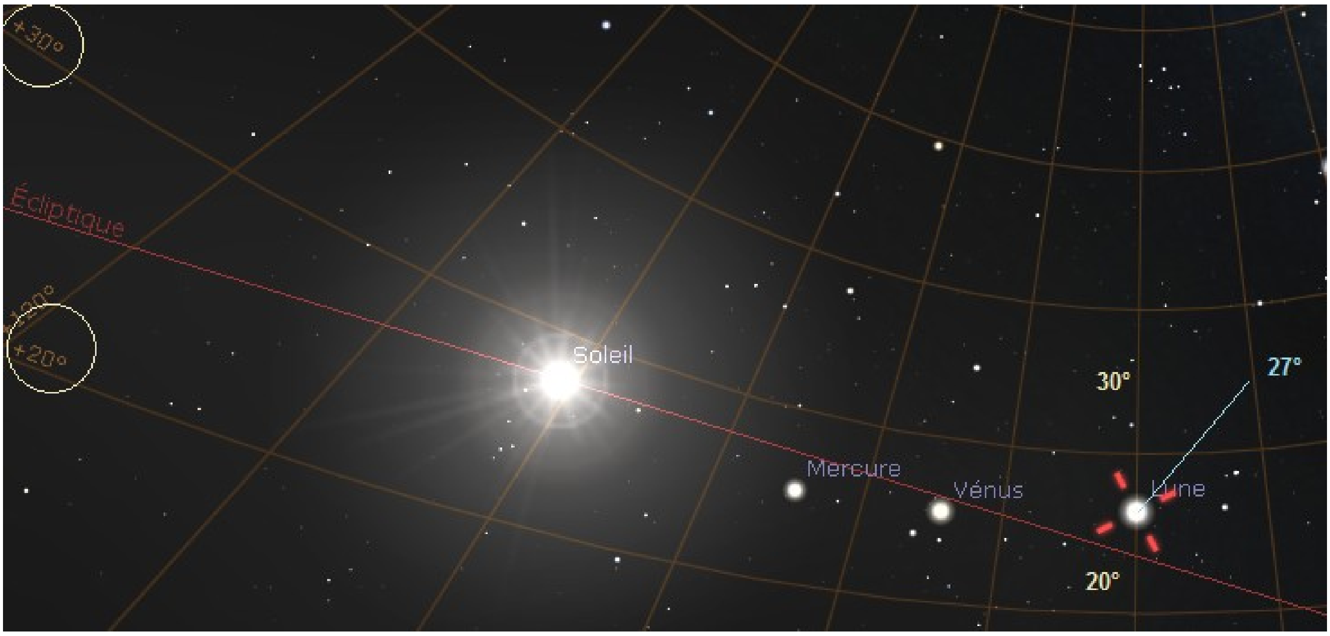
elevation = 90 – latitude of your location + declination of the radio source

example : if the moon rises to -15 ° when it passes the meridian (hour angle 00h00) and you are at 48 ° N latitude, it gives:

90°-48° + (-15°) = 27 ° elevation of the antenna relative to the horizon



the free software "Stellarium" automatically gives you the azimuth and height : in the example 180 ° azimuth (south) and 26 ° 12'59,9 ''. But it is good to know how to calculate it.



South

Length of the transit

Transit time is determined by the right ascension of the object and the local sidereal time. When the value of the local sidereal time is equal to the right ascension of the object it 'transits'.

The duration will therefore depend on HPBW (see above) and the declination of the 'object' using the formula:

t = 4 / cos (declination) * HPBW

t is time in minutes and HPBW is the opening angle at half power of the antenna. Conversely, if one measures the transit time of a star, we will be able to determine the HPBW .... The antenna must be firmly fixed on a support itself in a concrete, or a stable support. We can not imagine a telescope that trills, it is the same for an antenna. The motorization is a luxury, but not insignificant once one has mastered the system. It will allow a source to be tracked and enable different measurements than of a single transit.

Realizing automatically the tracking of the sun from morning to night, for two or three months, we will be able to

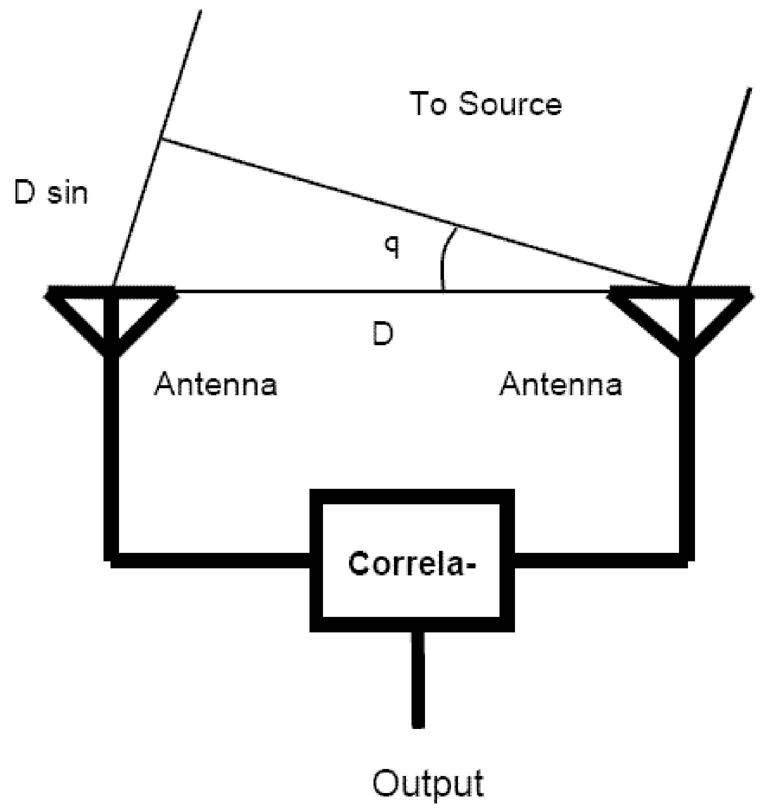
Obviously the sun's rotation and find recurring events related to this rotation (*). If in the same time an optical observation of the sun is carried out, a correlation with sunspots will be sought. And the sun is the closest star to us! So before picking them off, why not get your feet with our neighbour star?

(*) Depending on the frequency used will be measured component of the Quiet Sun, the component slightly variable and the component of the active sun. We'll talk more later.

An interferometer

This is not the purpose of this book to describe such a system, but a nice description can be found here :

http://umich.edu/~lowbrows/reflections/2007/jabshier.1.html



on this site also one has a nice description of the system : http://fringes.org/

> *Such an instrument has two radio receivers, fed by individual antennas. The antennas are spaced some "baseline" distance apart. The two receivers run coherently, meaning that not only do they work at roughly the same frequency, they are precisely phase-locked together. This involves having the two receivers share a common local oscillator (LO). We use a normal stereo soundcard (and some purpose made software) to read the audio output of the two receivers. The baseline distance determines the resolution of an interferometer, so even simple equipment can be used to build high resolution radio telescopes. Interferometers also have other useful properties.*

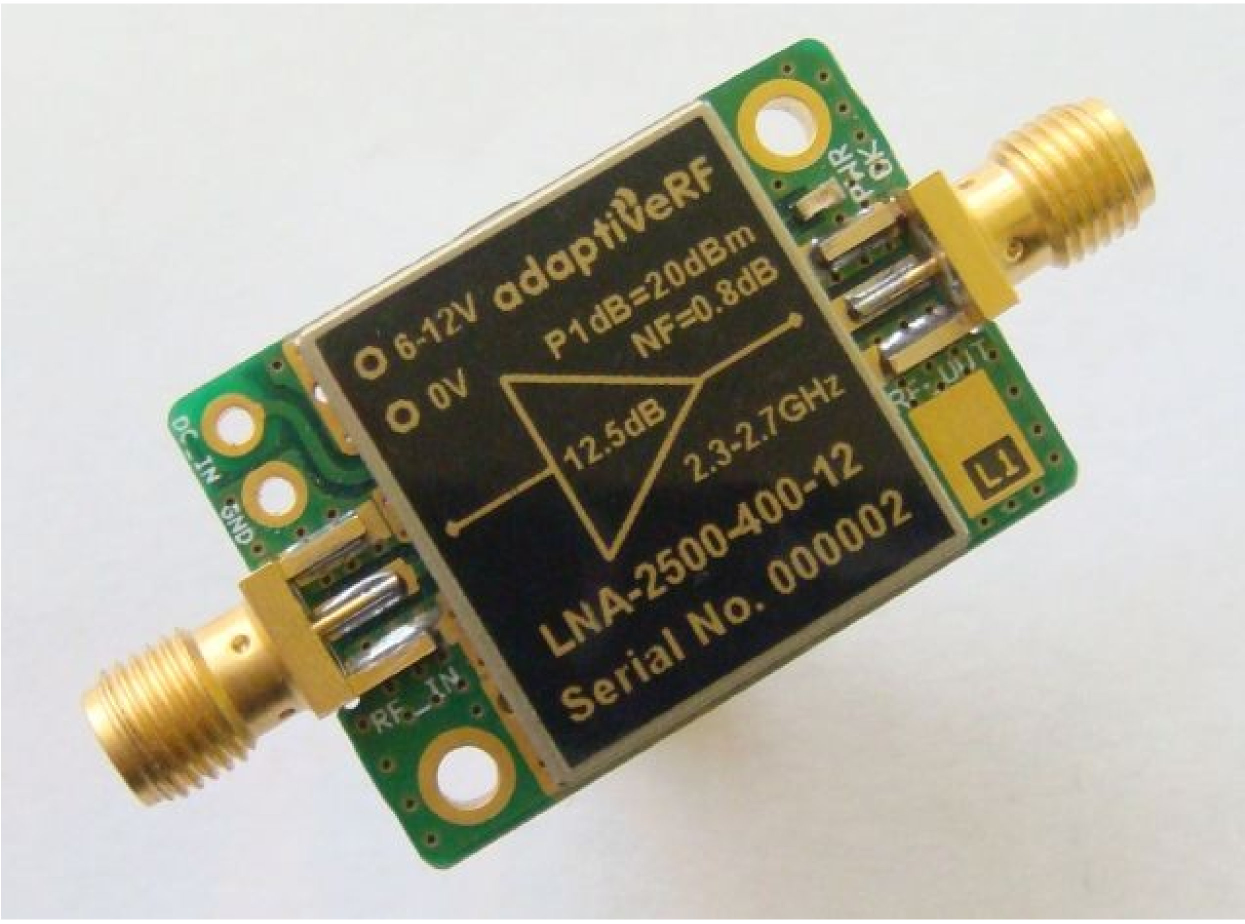
The LNA-LNB

At the focal point of the parabola, we go to place the active element itself, or rather an LNA or LNB, but it can be a dipole, a helix or whatsoever you like.

LNA

Low Noise Amplifier

The low noise amplifier (LNA) is a special type of electronic amplifier used in communication systems to amplify very weak signals captured by an antenna. It is often located very close to the antenna. If the LNA is located close to the antenna, the losses in the transmission line becomes less critical. It is a key element because it is placed at the head of a radio receiver. And in such a system, it is shown that the noise factor (parasites to put it bluntly) is determined by the head of the system. Through the use of an LNA, the noise of all the subsequent stages is reduced due to the gain of the LNA and in addition, the noise of the LNA is injected directly into the received signal. Thus, it is necessary that LNA increases the power of the useful signal while adding as little noise and distortion as possible so that the extraction of this signal is possible in the later stages of the system.

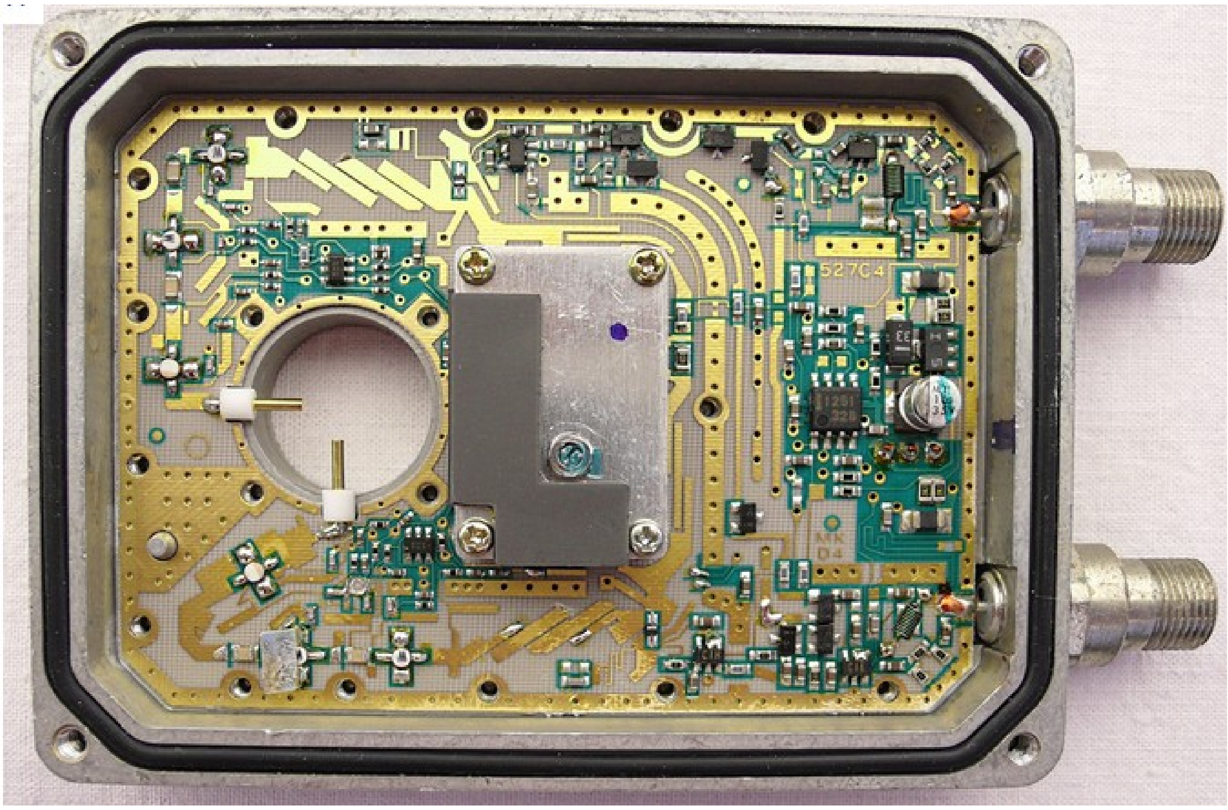


LNA ...

A white paper about LNA can be found here and for skilled people also here needs pills and time to read !

LNB-LNC

Low Noise Block down-converter



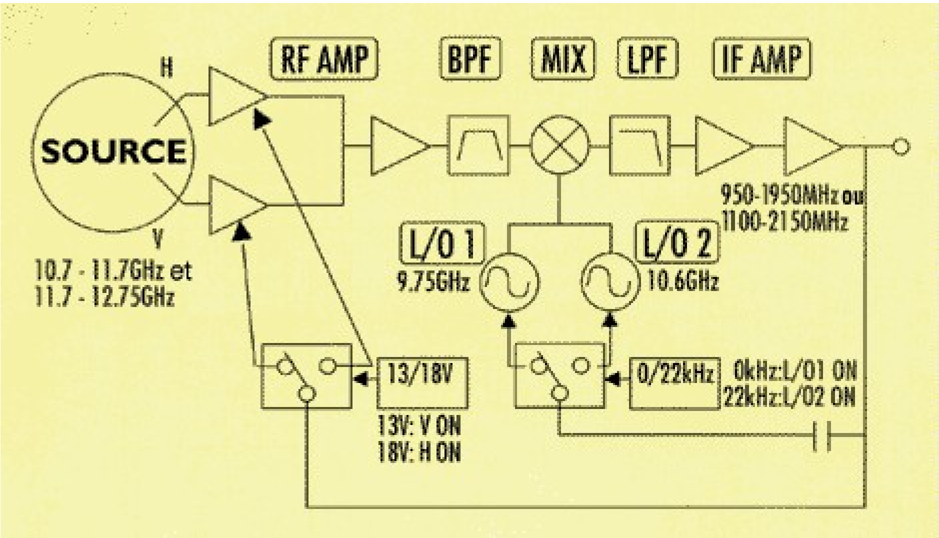
one LNC

The low noise block converter (LNB for *low noise block*, or sometimes LNC, for *low noise converter*) is used in the reception of satellite TV. These satellites use relatively high radio frequencies to transmit their signals. As the microwave signals from satellites do not pass easily through walls, roofs and glass windows, satellite antennas are mounted on the outside, and the signal must be transmitted within a cable. When radio signals are transmitted by cables, the higher the frequency the higher are the losses in the cable per unit length. The signals used for satellite are on a high frequency (in gigahertz) and therefore one must use special cables (expensive) to minimize line losses.

The job of the LNB is to use the superheterodyne principle and take a wide block (or band) of relatively high frequencies, to amplify and convert them to similar signals but on a much lower frequency (called intermediate frequency or IF). These frequencies pass through a cable with much less attenuation of the signal. It is therefore much easier and less costly to design electronic circuits to operate at these lower frequencies (rather than very high frequencies of satellite transmission).

One LNB but they can be of different shapes and sizes

What is inside a LNB/LNC ?



The source is the small pin located in the waveguide and which picks up the signal from the parabola.

The signal received by the source will be amplified by the RF AMP (radio frequency amplifier) before being sent in the block (BPF) which is a bandpass filter. It is a filter which passes a band or frequency range between a low cut filter and a high cutoff frequency. As if optical filter was placed to observe the α ray of the sun. The output is always in the high frequency (in GHz) of the receiver. We'll have to lower it to make it more portable. MIX (= mixer mixer) will complete the work by subtracting the high frequency a frequency generated by a LO (local oscillator) lower so that the resulting frequency is lower.

An example: If my local oscillator generates 9,75GHz and the signal frequency of 10GHz is the resultant will be 10.7 to 9.75 0,95GHz = 950MHz

Remember this because it will help us when we talk about rtl-sdr dongles.

Once the mixed signal we go again filter (LPF - low pass filter, that passes only the low intermediate frequency signals generated by subtraction) before the amplifier (IF amp - frequency amplifier intermediate) to send in the cable. I do not understand this paragraph

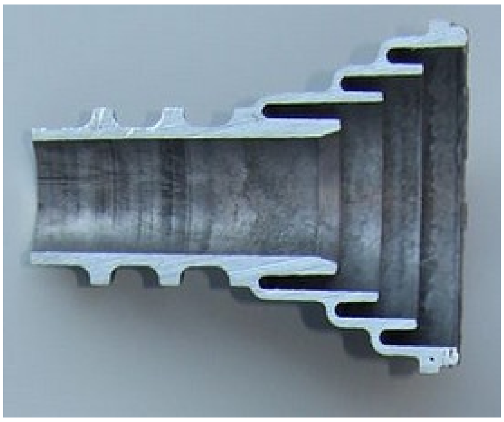
The LNB is supplied through the coaxial cable which also serves to lower the signal to the detection (or the TV receiver TV).

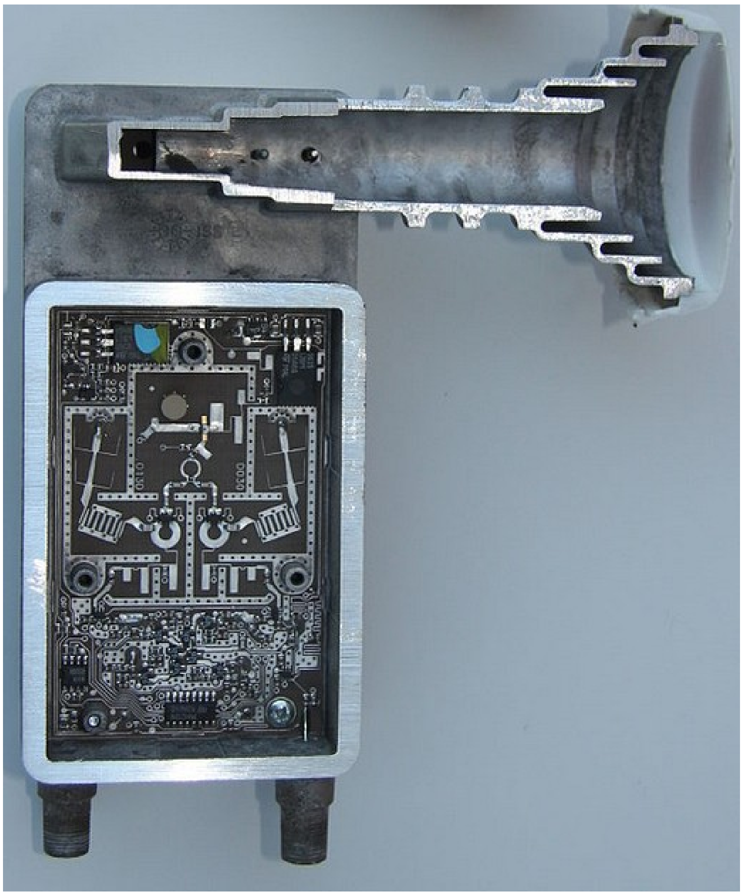
One may further switch two high frequency bands by injecting a 22kHz signal for activating internal electronic switches.

The LNBF

The single LNB is not useful without the horn (feedhorn) that will send the signals received on the small pin. So a LNB fitted with its small feedhorn is a LNBF.

Section of a "small" feedhorn





section of a LNBF complete


AVENGER
by DMS international
DIGITAL KU BAND
SINGLE LNBF
Avenger PLL321S-2
INPUT FREQ.: 10.70 - 12.75 GHz
OUTPUT FREQ.: 950 - 2150 MHz
L.O.FREQ. : 9.750 & 10.600 GHz
NOISE FIGURE: 0.1 dB
THROAT : 40MM
Http://www.dmsiusa.com
MADE IN CHINA
AVENGER
by DMS international
Http://www.dmsiusa.com

This advertising is free! But I use this particular LNBF (until a better substitute comes). Sold $ 11 on EBAY, you can not do without ...
What is said on the box ?

It is a mono band LNBF for Ku-band divided into two segments, the bottom segment of 10.7 to 11.7 and the top segment from 11.7 to 12.75 GHz.

Output frequency: the frequency of the signal output. It is calculated by subtracting the frequency of the LO. FREQ (frequency of the local oscillator) specified below OUTPUT FREQ of the input frequency. As there are two segments there will be two different LO, one for the bottom (9,75GHz) and one for the top (10,7GHz).

Example : (I repeat the reasoning above, but it is important)

in the low segment, if we use the position 11GHz (input frequency) we 'listen' from 11.0 to 9.750 = 1.250 and so we have an output of a signal on 1.25GHz
in the high segment, if we use the position 12,5GHz (input frequency) we 'listen' from 12.5 to 10.7 = 1.80, therefore, it has an output signal of 1.8 GHz

If one uses a RTL-SDR dongle, the first segment is better due to the receptive span of the dongle. One can even listen the ham beacons on 10368MHz …. how ? Try to calculate….

10368 – 9750 = 618MHz tune your sdr on 618MHz SSB and listen the beacon

Noise figure: this is the noise level generated by the LNBF (it is beyond the scope of this document to explain the intrinsic noise level of a LNBF, but it will be used for calculations)

The low noise expression means that special electronic techniques are used so that the signal has less noise (unwanted signals) on the output. Generally, the higher the frequency at which an electronic component is to operate, the higher it is essential that the noise is controlled. If low noise technologies were not used, the sound and satellite TV image would be of very low quality.

Note : the relationship between the noise temperature expressed in dB or K is (with T_{ref} being 20 °C or 290 K)

$$\text{Noise Temperature (K)} = T_{REF} * \left(10^{\frac{NF(dB)}{10}} - 1\right)$$

$$\text{Noise Figure (dB)} = 10 * \log 10\left(\frac{T_{Noise}(K)}{T_{Ref}(K)} + 1\right)$$

Note that unless otherwise specified T_{Ref} = 290 K

To know more about LNBF hereunder are some links in French (sorry) but google translate can help.

Photos de l'Intérieur du PLL-LNB et mesures

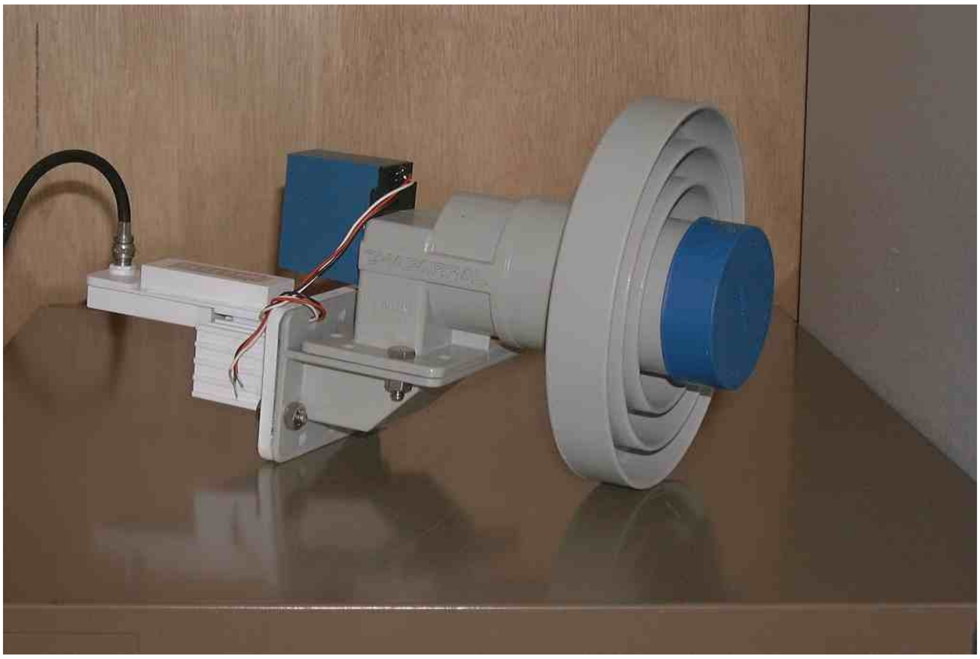
Specification du PLL-LNB Avenger

Data sheet du transistor NE3503M04

and also the nice link from Michel HB9AFO http://www.hb9afo.ch/articles/pll-lnb/10GHz_pll-lnb.htm

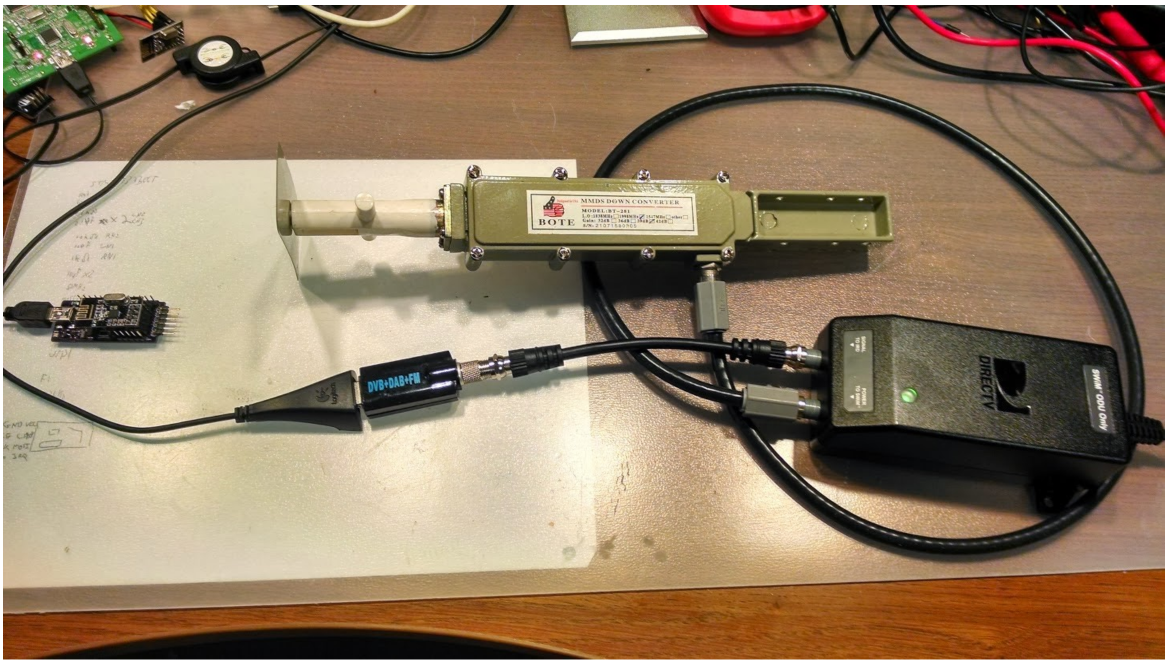
Which one ?

Depending on what you have as a parabolic dish, and what you want to hear, one or the other will be selected LNB.
There are many different types, for several frequencies, you have a large choice.



4GHz LNBF

Input frequency	3.4 - 4.2GHz
Output frequency	950 - 1750MHz
Local Oscillator	5150MHz
Noise figure	17K (typical – that means that value can be between 20K to 35K)
Gain	65dB



MMDS converter for 2,2 à 2,7 GHz

The MMDS downconverter is designed for reception of digital MMDS signals in the standard DVB-C format.

The MMDS downconverter consists of a state-of-the-art receiver integrated with a dipole designed to be placed at the focal point of standard wire mesh antennas.

This downconverter provides unequalled phase noise and noise figure performance. It includes integrated front-end filters to protect from interference from WLAN, GSM and 3G.

Other performance characteristics in addition to low phase noise include high linearity and low in-band ripple,

The downconverter can be easily mounted directly on the antenna.

Example :

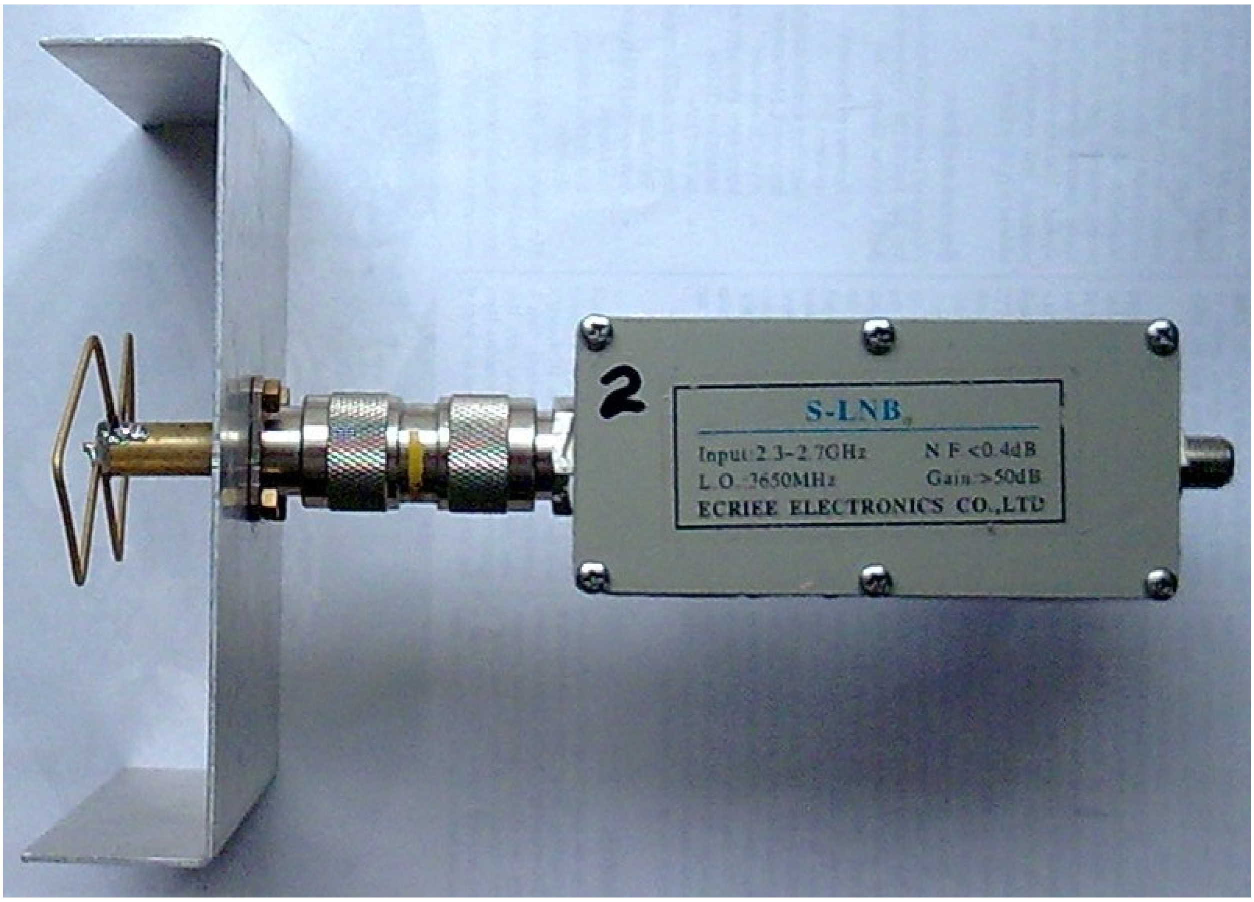
A transmission on 2330 MHz is received on 2330-1998 = 332 MHz.

So again a RTL-SDR can be plugged on the output for experiences.

MMDS Downconverter Model DC02-201	
Electrical Specifications	
Input Frequency:	2500 ~ 2686 MHz
Output Frequency:	222 ~ 408 MHz
RF to IF Gain:	36 dB
Gain Stability:	±2 dB
Gain Flatness:	±0.1 dB @ 6MHz ±1.5 dB @ 222~408 MHz
Local Oscillator Frequency:	2278 MHz
Local Oscillator Stability:	±25 KHz over temperature.
Local Oscillator Phase Noise:	-85 dBc/Hz @ 1KHz -92 dBc/Hz @ 10 KHz -99 dBc/Hz @ 100KHz
Local Oscillator LO Leakage:	-60 dBm max. @ Antenna port. -45 dBm @ IF port.
Noise Figure Room Temp:	2 dB typ.
Noise Figure Over Temp:	3 dB max.
Image Rejection :	70 dB min.
IF Rejection:	80 dB min.
PCS Rejection:	90 dB min.
WCS Rejection:	52 dB min.
Spurious in F Band :	-80 dBm max.
Interface Specifications	
Input Interface Impedance:	75 ohm
Input Interface Connector:	"F" Type Female
Antenna Interface	Dipole (focal length for 18 dBi and 21 dBi mesh antennas)
Power Supply Voltage:	+15 to +24 VDC
Power Supply Current :	150 mA max. (@ 15 VDC)
Environmental Specifications	
Temperature:	-30°C ~ +70°C
Humidity:	100% water proof
Lighting Protection:	Meet or exceeds IEEE specifications
Dimensions:	11.5"W x 2.16"H x 1.22"D (294 mm x 55 mm x 31 mm)

[1] Specifications subject to change without prior notice.

Example of the technical data of such a converter

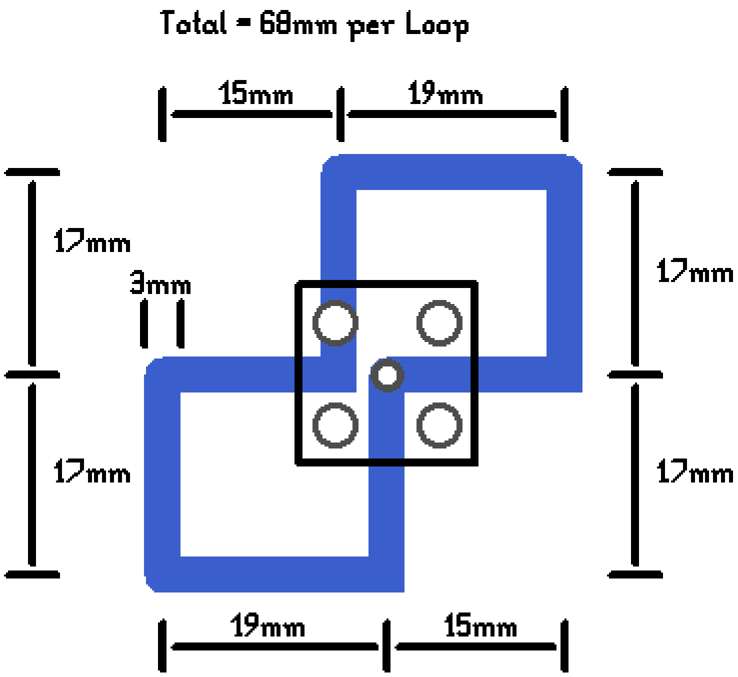


<u>One LNB for the 2,3 – 2,7GHz band</u>

Input frequency	2.3 to 2.7GHz, 2.2 to 2.7GHz,2.3 to 2.9GHz, 2.5 to 2.9GHz
Local oscillator	3650,3750,3850,3950MHz
Output frequency	950 to 1350 MHz, 1050 to 1550 MHz,1050 to 1650 MHz
Stabilty of the L.O.	±1.5MHz(-40°Cto+70/25°C)
Noise factor	0.4dB
Gain	55dB

to find it on the web enter S-LNB Bowei on Google (and be patient the link is weak)

The source is a bi quad for 2,4GHz. Here are the dimensions.



And here is the link for more info : http://www.ko4bb.com/ham_radio/2.4GHz_Stuff/ and also http://marty-bugs.net/wireless/biquad/

S band 3620MHz lnbf for SES-7 indovision (Malaysie) 2520/2670MHz to find it on the net try here

Input frequency	2520 ~ 2670 MHz
Output frequency	950 ~ 1100 MHz
Gain	48 dB (Min.) 58 dB (Max.)
Error on a band of 27MHz	±0.75 dB / 27 MHz
Noise figure	36 K (Max.)
Image rejection	25 dB

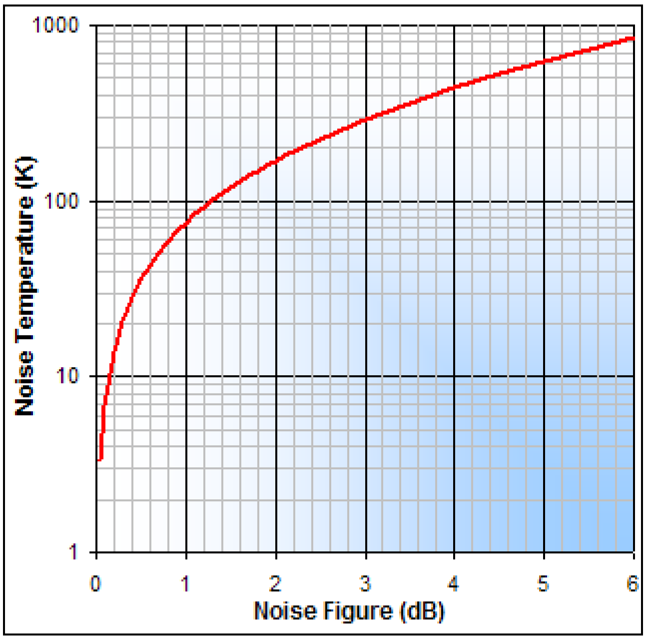
At this level I'll give you a link to calculate the noise temperature and noise factor.

Reference Temperature: 290 K

Calculate Noise Figure: 3.01 dB = 290.0 K

Noise Temperature: 290 K = 3.01 dB

NF(dB)	T_N (°K)	NF(dB)	T_N (°K)
0.1	7	2.1	180
0.2	14	2.2	191
0.3	21	2.3	202
0.4	28	2.4	214
0.5	35	2.5	226
0.6	43	2.6	238
0.7	51	2.7	250
0.8	59	2.8	263
0.9	67	2.9	275
1.0	75	3.0	289
1.1	84	3.1	302
1.2	92	3.2	316
1.3	101	3.3	330
1.4	110	3.4	344
1.5	120	3.5	359
1.6	129	3.6	374
1.7	139	3.7	390
1.8	149	3.8	406
1.9	159	3.9	422
2.0	170	4.0	438



Source : http://www.rfcafe.com/references/calculators/noise-figure-temperature-calculator.htm

So the above LNBF with a noise T° of 36K correspond a ± 0.5 dB noise

Remember, the more the noise level is low the better the signal. However, the manufacturers of data is often overrated !

When searching for an exotic LNB or LNBF, search on the net, it is an inexhaustible source. And share your discoveries on groups as Yahoo or Facebook.

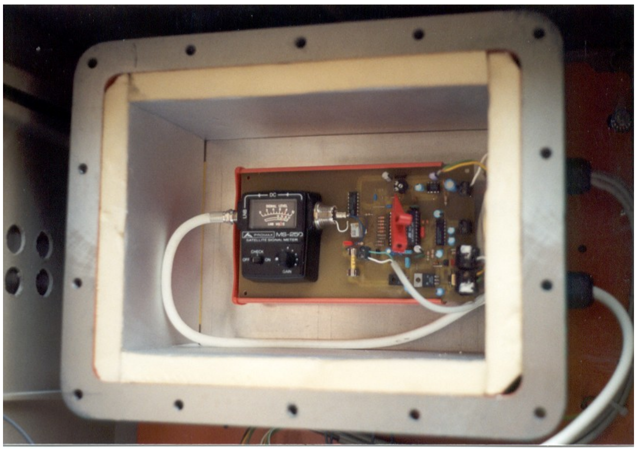
Then now we send the signal to the rtl-sdr dongle or an interface to the PC.

The next step : the detection

Early 2000's, with Miguel EA4EOZ we conceived a small board called Merlin to integrate on one single PCB the satfinder, the CAD, the COM port and the power supply of the LNB.

The first version 'Escort'

and Merlin



fitted inside a flameproof enclosure with foam to keep it warm.

The output of the system was sent via a COM port to a PC.

End of this parenthesis about the past ….

Now, we have the signal coming out from the LNA or the LNB.

This signal is conveyed by a cable which enters the observation station. We'll have to extract the maximum information. We will have to detection.

I retained two easy solutions to implement.

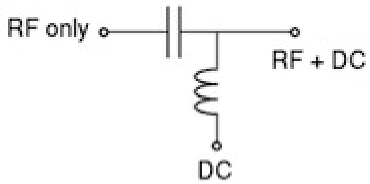
The satfinder (my first love)

The simplest and most economical way is the sat finder, the satellite researcher. This is an electronic module sold a € 15 in supermarkets.

It is inserted between the LNB and the satellite receiver to measure the signal received by the antenna and so see if it is well oriented. It is powered by the antenna cable and therefore a little manipulation required to replace the sat TV receiver which feed it. We will use a power injector. This is a small module that supplies voltage and so feed power to the LNB and the satellite finder via the coaxial cable.

The power injector

Hereunder a picture of such a device, the power injector with the connector (check on the web for sources)



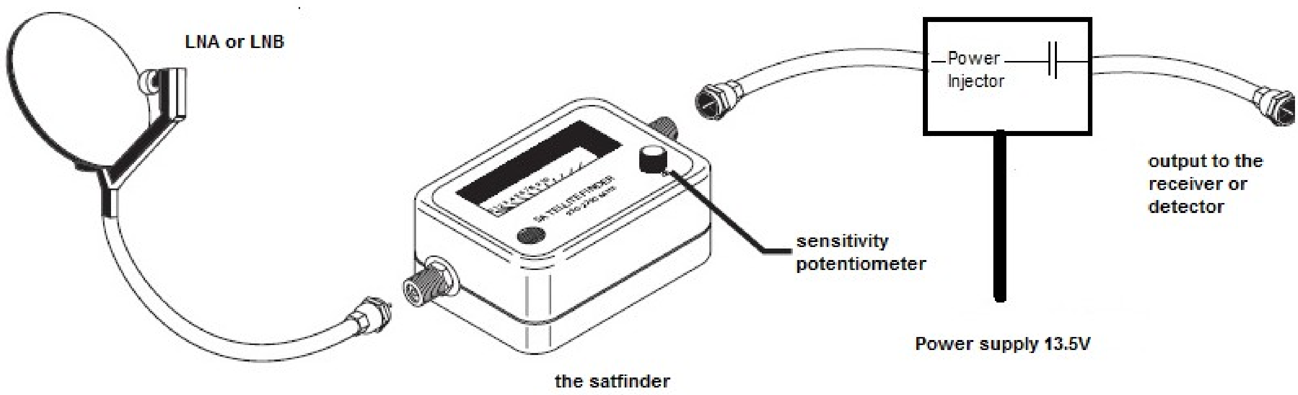
To receiver

To LNA

The RF + DC connector is for the LNA, the connector DC is the input power voltage and RF only is output connector to the receiver.

Always take care on the wiring ! The signal to the receiver is on the side of the capacitor represented by two vertical lines. Else you will kill your system.

The idea is to send a positive voltage to the DC input via the small self. The capacitor will block the positive voltage (and therefore will not shoot receiver input stages) but as there is no obstacle to its passage (left) it goes back to the LNB via the satfinder. Conversely the radio signal (RF) will be blocked by the choke and pass through the capacitor to go to the receiver.



Once all the equipment is assembled we will have a try. You point your antenna to the ground, which is around 20°C, therefore its absolute value is 295K. This already corresponds to an interesting radio signal, because every body emits radio waves depending on its temperature, this is a heat radiation.
You set the small sensitivity button of the sat finder for a reading of some units. Now, you point the antenna toward the sun. I explained above how to point the antenna.
And there when you have the sun at the focal point, you must have a reading on the sat finder. The needle should go to the extreme right and the buzzer should make its typical noise. You made your first experience in radio astronomy.

Now if the antenna is fixed, turn it slightly to the right, the needle will go down. Wait until the sun comes back at home and watch the needle. This is a transit of the sun. The needle should climb slowly as the sun passes in front of the antenna.

You will think, it's the heat of the sun which makes the variation of the needle by heating the LNB. This is not wrong but not the real effect. Indeed, if the sky is overcast you can also do this experiment. So the LNB was not heated!

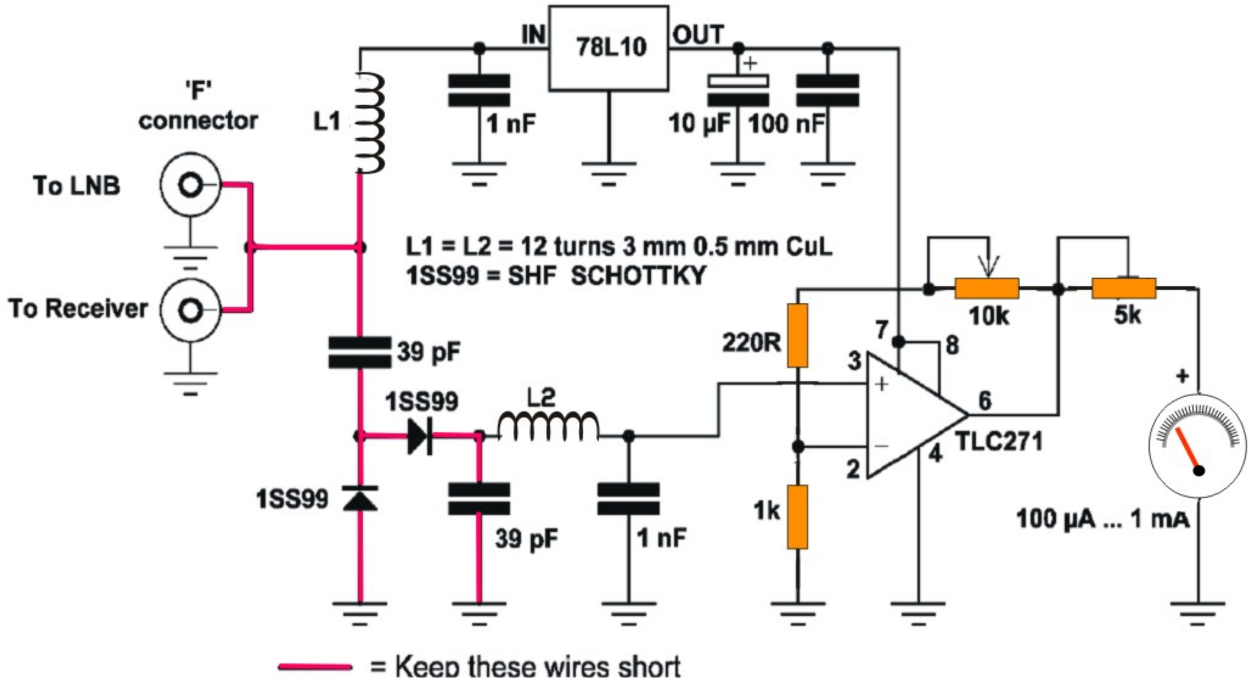
The waves from the sun were detected by our system, like any radio source.

We can also use satfinder signal for reprocessing and send it to a software.

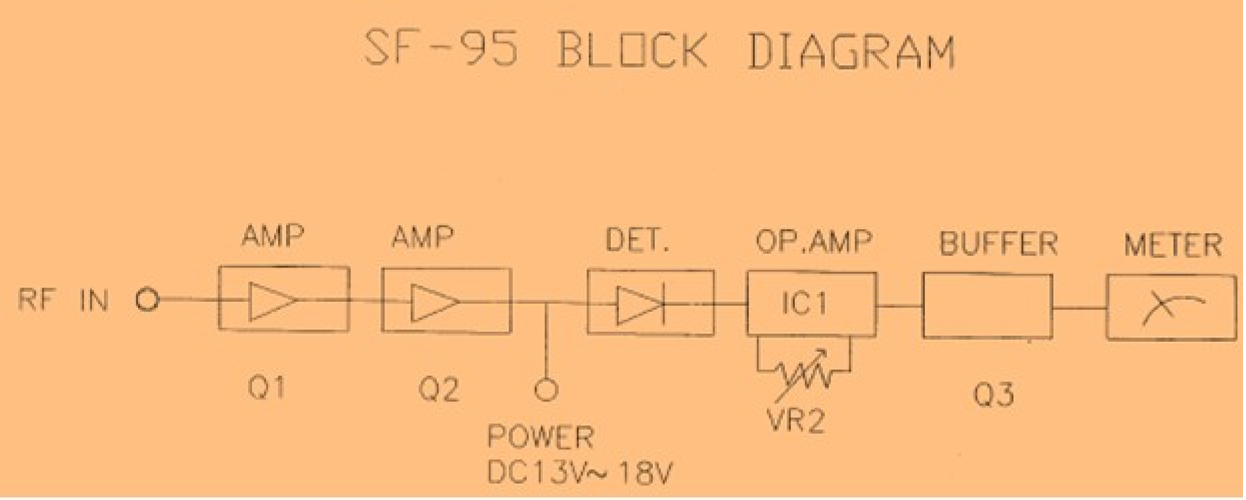
Indeed if the needle of the galvanometer and the buzzer of the satfinder give a good indication of signal strength received by the antenna, that we should be able to record this signal is a plus.

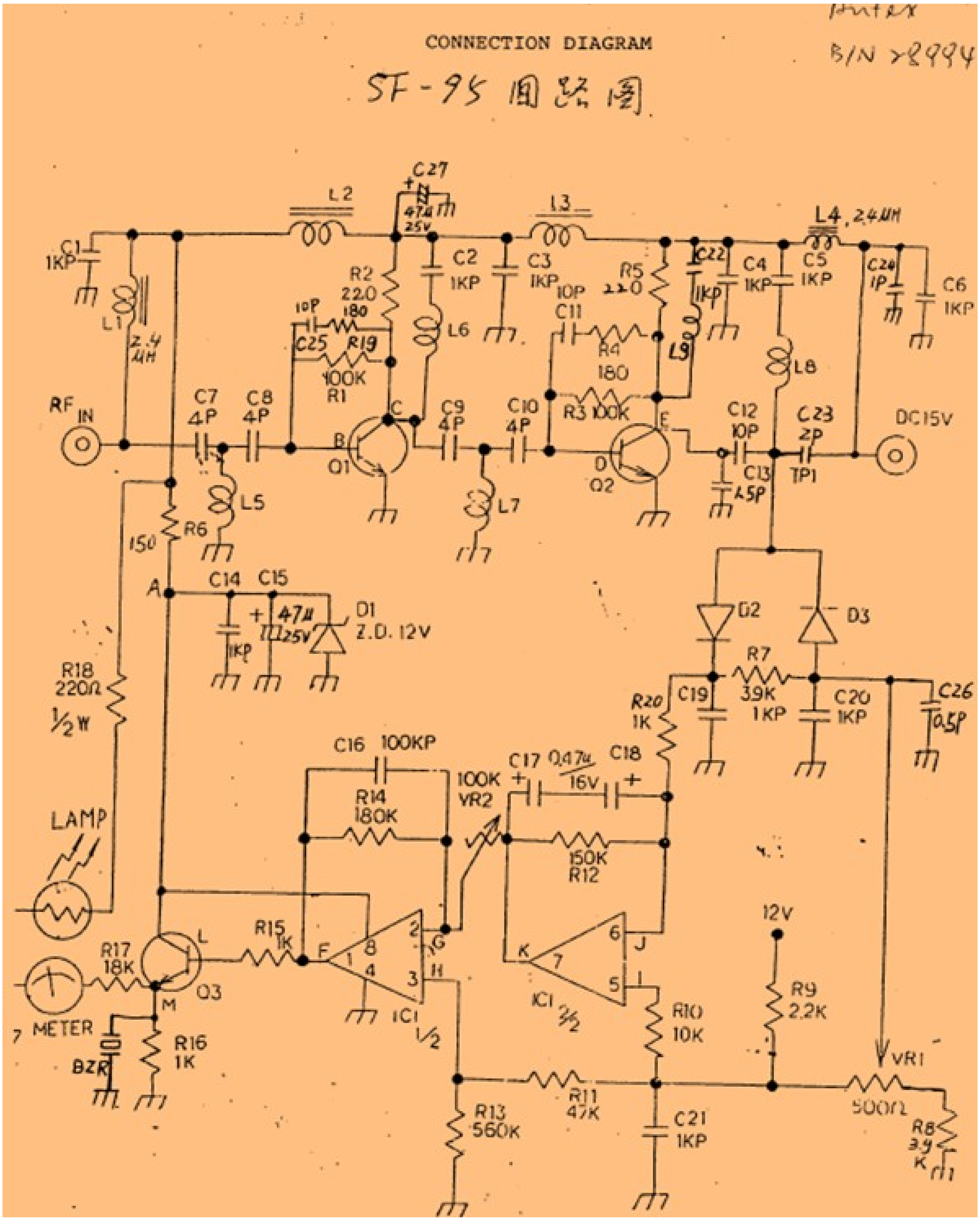
This is the next step ….

Here is a typical diagram of a satfinder :



Without going into details, right after the 5k resistance on the right side, is the signal to the meter. So we will take the (analog) signal before the resistance to send it to a digital converter. Software likes only digital signals. For the more advanced, here is another diagram of a satfinder



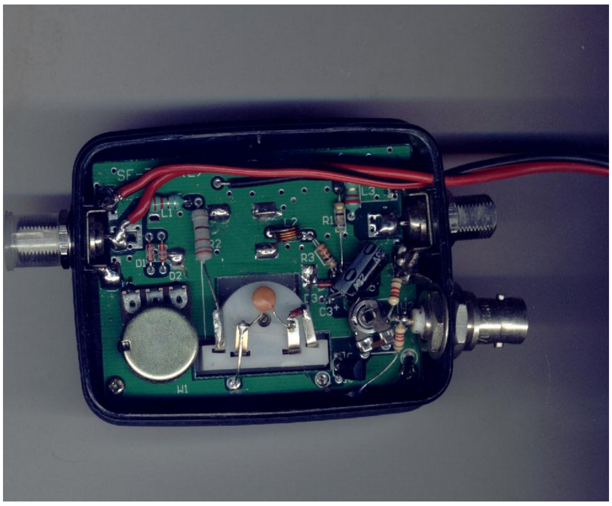


Changes (citing work of students of the Lycée La Bourdonnais Mauritius: Nicholas Motta, Arjuna Tatayah and Shane Seetul)

1) Get rid of the demodulator (the tv receiver)

It is easily understandable that the unique role of the demodulator is to feed the satfinder and LNB via coaxial; so if you want to do mobile radio astronomy you must get rid of it. So the first change consists of feeding the satfinder that operates between 13V and 18V. finding?

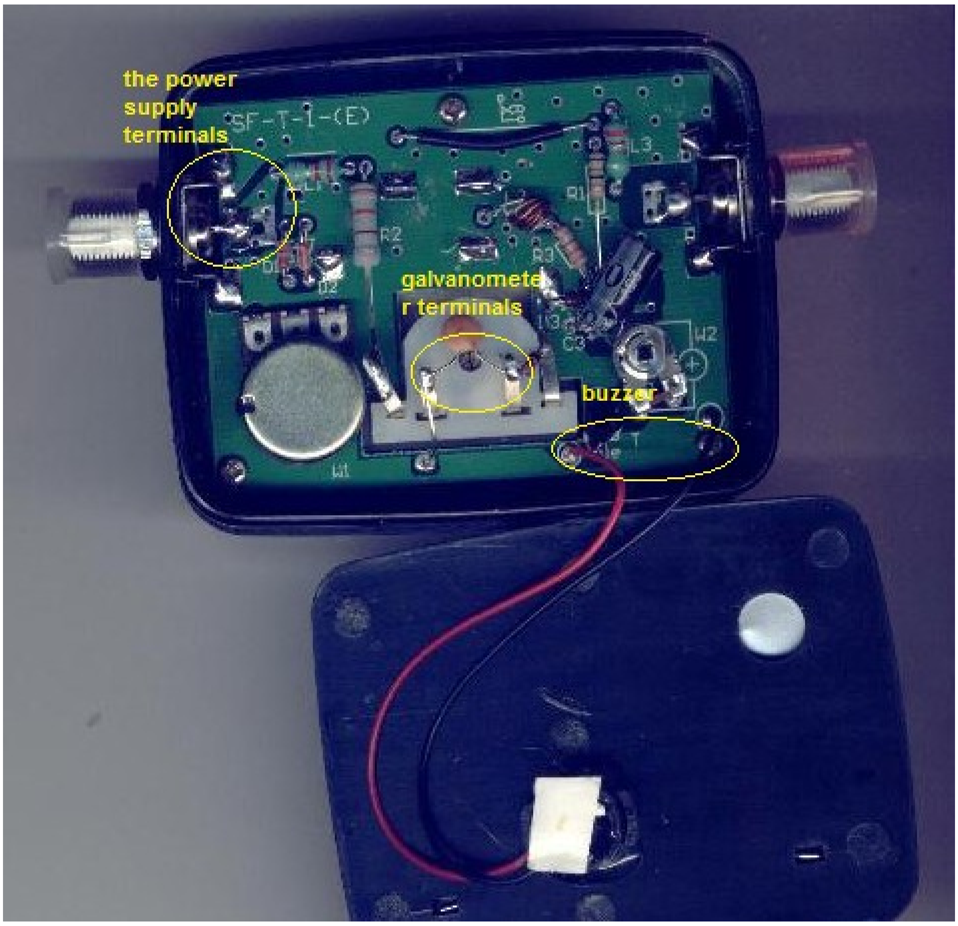
For this we work on the F type connector labeled "TO REC". We solder a red wire on the central pin and a black wire on the adjacent ground; which correspond to the input terminals. Take out these 2 wires through a small hole at the edge of the box. Feed choosing a 15V power supply.



To ensure that this change is made, one connects the 2 wires to the power supply, you turn the gain setting fully clockwise and the needle go to the end. You can leave the tv receiver box now!

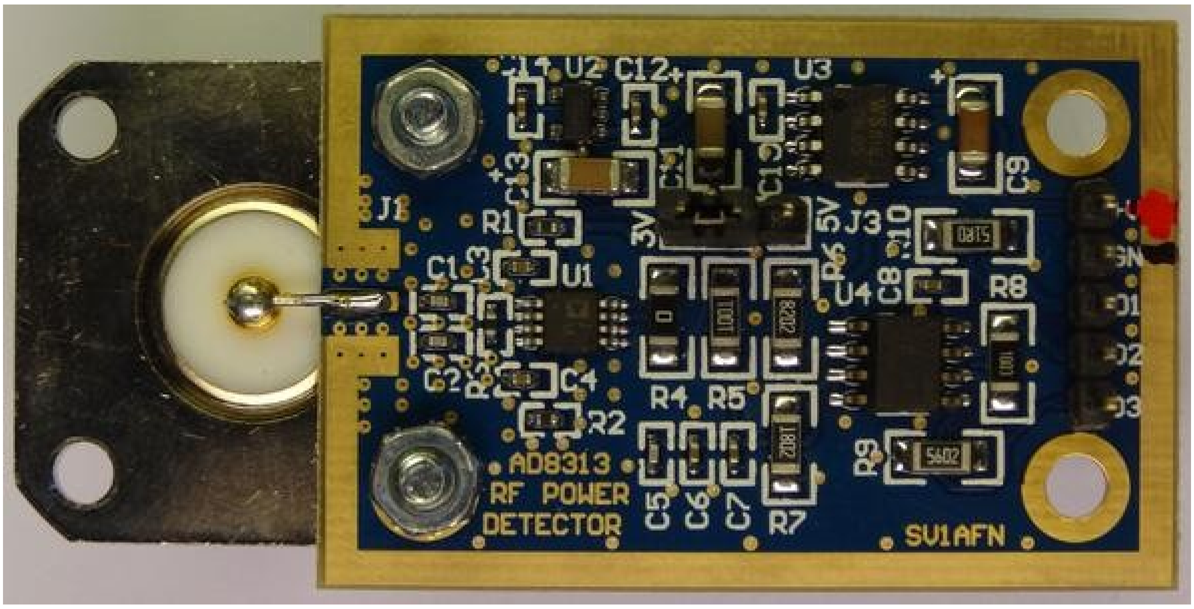
2) Accuracy !

This second modification is done to obtain more accurate values than those obtained on the meter. This requires us to collect a voltage across a component of the satfinder. The PCS10 (from Velleman – we will discuss this component later) has 4 input channels. However we decided to use 2 source of signal: the buzzer and the galvanometer. Locate the buzzer. There are two wires feeding it. Thus the positive (red) and negative (black) terminals are indicated on the buzzer, for the galvanometer let's use a multimeter to find the polarity of the terminals. We finally make 2 small holes in the housing and take out 4 electrical wires which will go through the channels of the recorder.



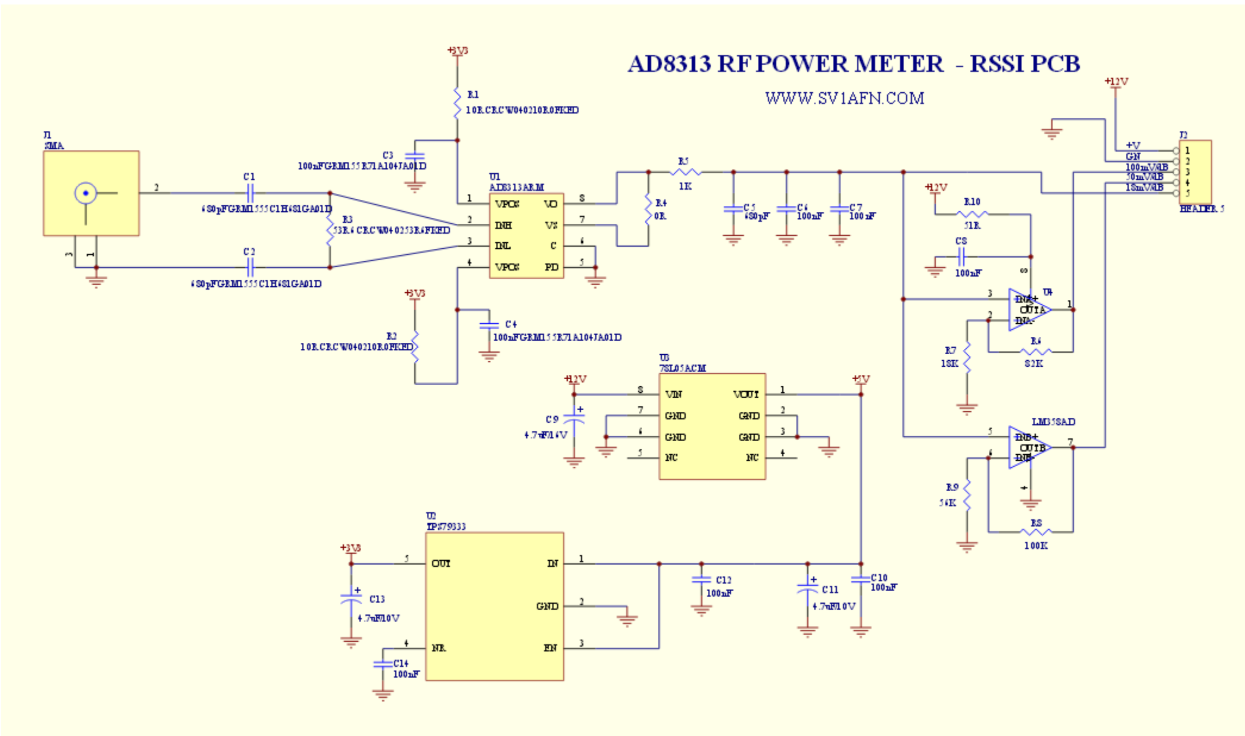
At this stage, you have a system that works…. Normally, else go back to page 1 again !

Another solution : The RF probe



General view of a radio wave detection module. Its size 30x25mm max.

source : https://www.sv1afn.com/



There are a lot of online manufacturers of small cheap modules that do a remarkable job. I opted for a detector at 20 € made by a ham radio amateur (SV1AFN). The principle is to enter the radio signal on one side and outputting a voltage proportional to the signal at the other side.

Based on the Analog Devices AD8313ARM chip, this module is a complete RF Power meter head for 50 ohm systems working from below 100 MHz to more than 2500 MHz. The RF input SMA is terminated to a 53.6 Ω - 0.1% resistor (R3) to match the AD8313 input resistance to 50 Ohms. It draws under 12 mA at 12 VDC and has two internal voltage regulators.

For low noise operation, a special ultra low-noise 3.3 V voltage regulator is used. The TPS79333 is made by Texas Instruments and is optimized for RF circuits. This one powers the AD8313 chip. Its input is connected to an on-board 5 V voltage regulator (LM78L05) to facilitate wide range for the input voltage.

The AD8313 output voltage is routed to the output connector pin 5 for 18mV/dB measurements (O3).

On that track, two 100 nF and one 680 pF capacitors are connected to the ground and can be removed or modified.

Two op-amp DC amplifiers (LM358) multiply the output voltage to 2.77x (50 mV/dB) routed to pin 4 (O2) and to 5.55x (100 mV/dB) routed to pin 3 (O1).

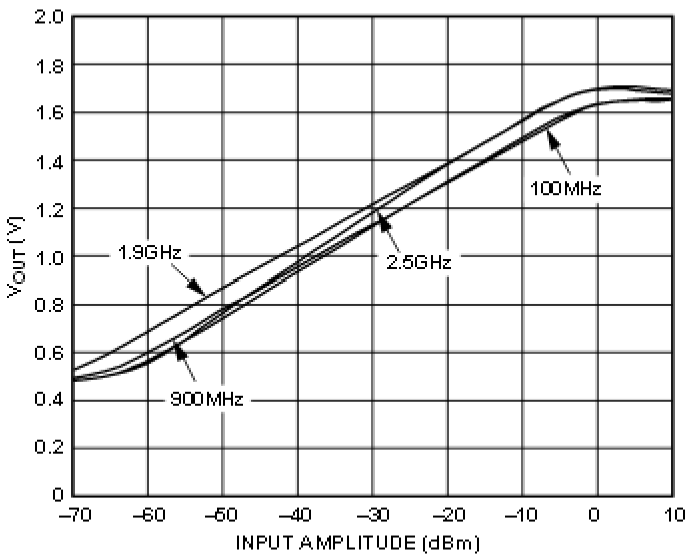
If used, the op-amp chip should be powered by a higher voltage supply (say 12V) in order to be able to deliver higher voltages at higher RF levels.

The op-amp gain scaling resistors are of 1206 size for easier handling if they should need changing.

The PCB dimensions are 30 x 45 mm and a special gold-plated band is provided on the edges to help soldering any shielding material (copper clad board, tin etc).

Please note that the current version of boards has a new jumper (J3) to select 3.3V or 5V for the chip operating voltage. Lowering the voltage makes the chip more sensitive to low-power signals but it misses linearity on stronger signals. If you choose to operate at lower voltage, you can use external attenuators to extend the dynamic range. Working at 5V is also possible by placing the J3 jumper at the 5V position.

Digitization will then take over to transform this voltage into a digestible signal by the measuring software.



Evolution of the output voltage depending on the amplitude of the input signal for different frequencies.

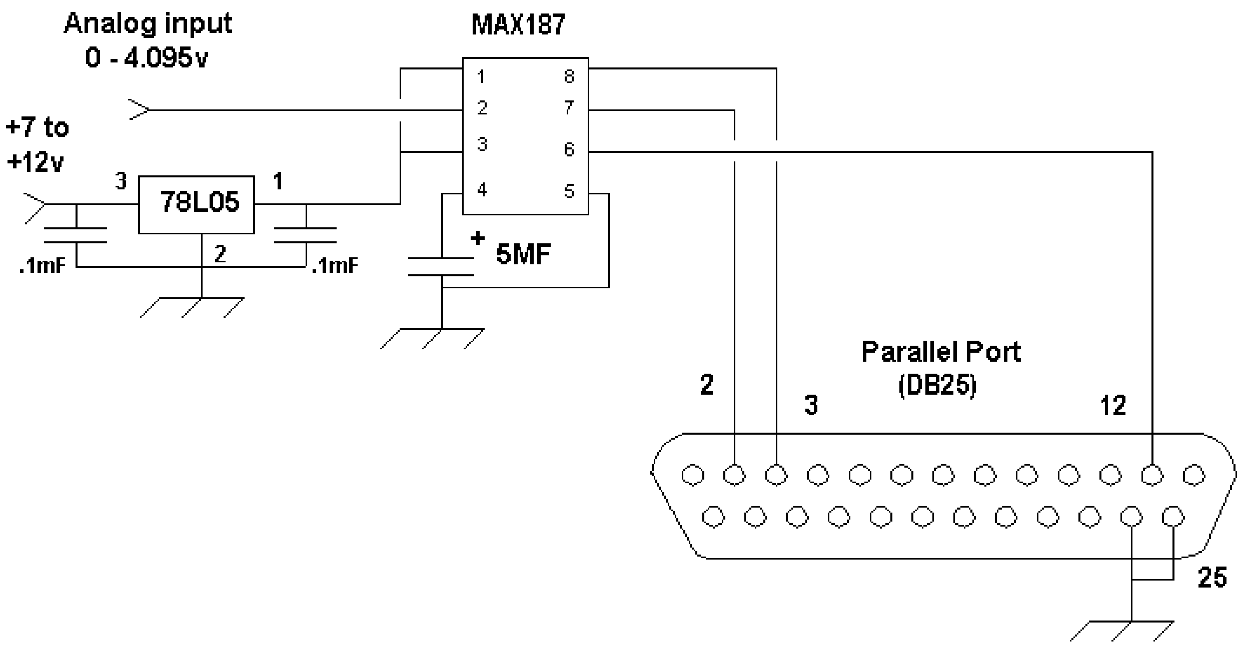
Digitalization of a signal

The digitizing module will transform the analog signal from the detector into a digital signal which may be exploited by software.

We also have several solutions.

Jim Sky's software

Either one works with a serial port RS232 or parallel type (printout) (there were all older PCs) or via USB.
Jim Sky described a small house serial interface sufficient for many applications.

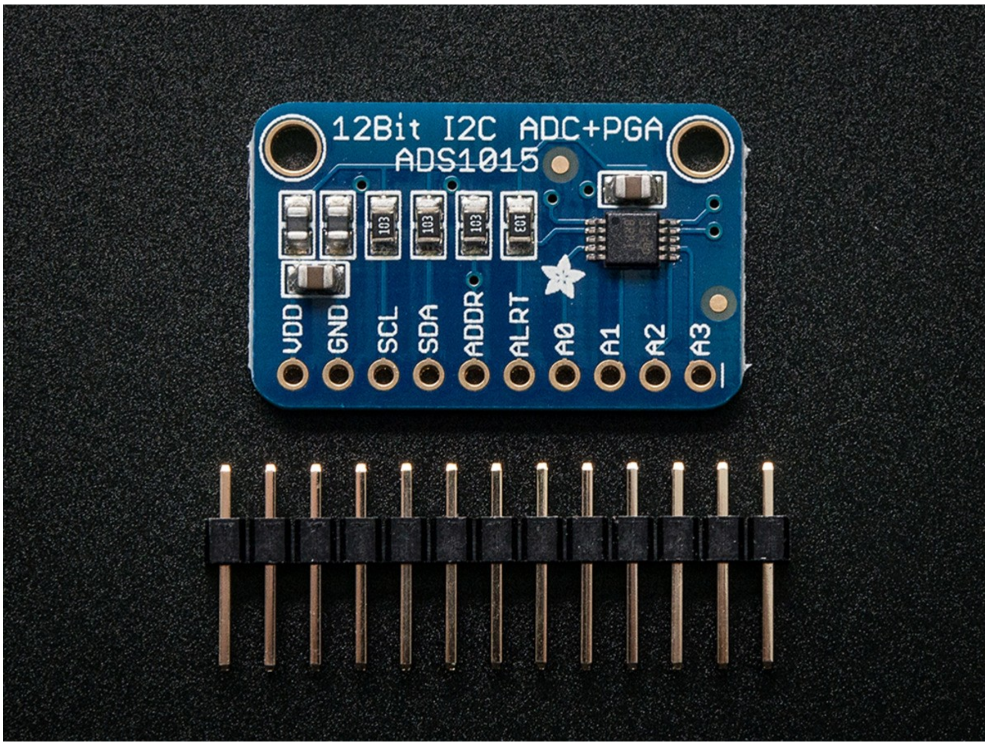


http://www.radiosky.com/dcla2d.html

This small interface is relatively easy to build. We enter a signal that varies from 0 to 4V from the previous interface and converts the bit before sending it to the PC printer port.
Jim's software, which will be studied further, will then record and display the signal from the antenna.

The Arduino module

Another solution is to use a smaller module coupled to an Arduino or raspberry.



The ADS1015 is 12-bit converter 4-channel amplifier with programmable gain. Ref 1083 (±10€) Here too, we enter the signal from the previous module (the RF sensor module or the satfinder) , and we output via the I²C module to the Arduino or RPI.

If you master one of these computers you will know how to implement that. Otherwise there are good websites that will guide you to make the programming part and waveform display. However, here are some useful links.

Guide of the analog/digital converter ADS1015 : Adafruit 4-Channel ADC Breakouts

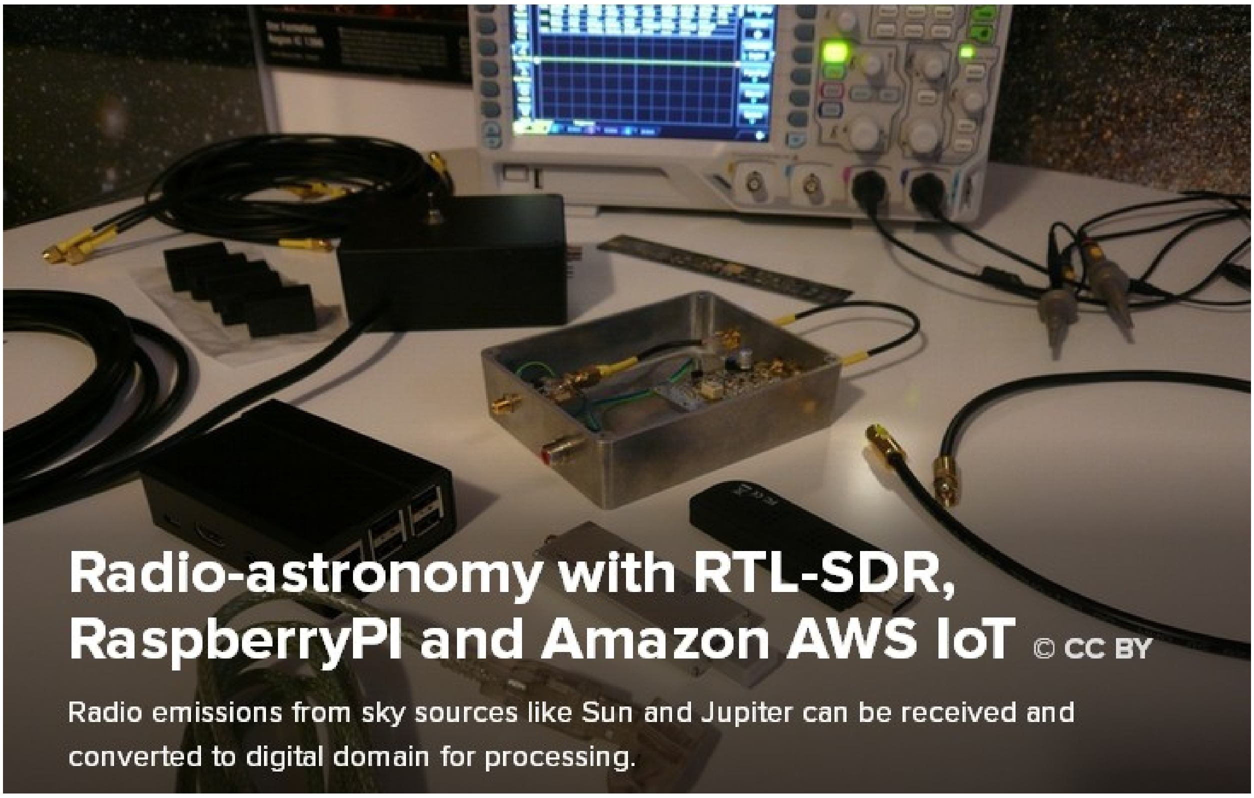
Samples of code:

For the Raspberry Pi: Adafruit Pi Python library

For the Arduino : ADS1X15 Arduino library repository

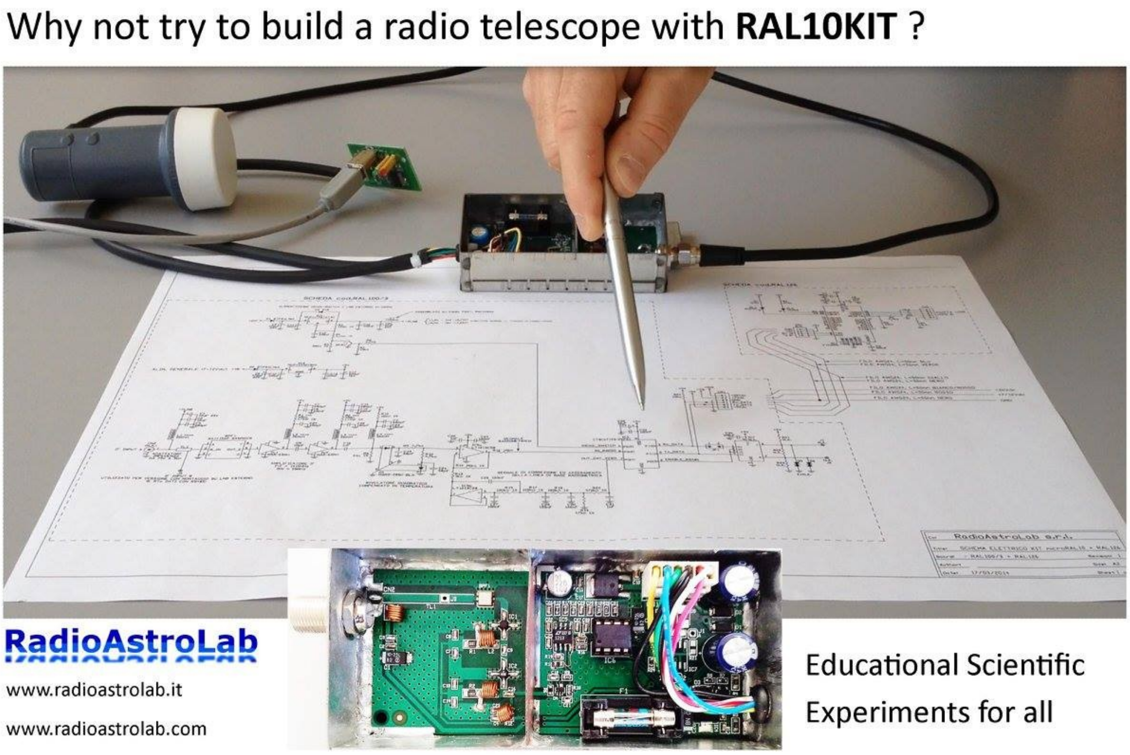
Another one for info : https://www.hackster.io/mariocannistra/radio-astronomy-with-rtl-sdr-raspberrypi-and-amazon-aws-iot-45b617

Mario Cannistrà explains step by step the realization of a functional system using the RPI 2 in radio astronomy.



Finally there is a system that achieves all this in a single module the RAL10-kit. Let's go to Italy ….

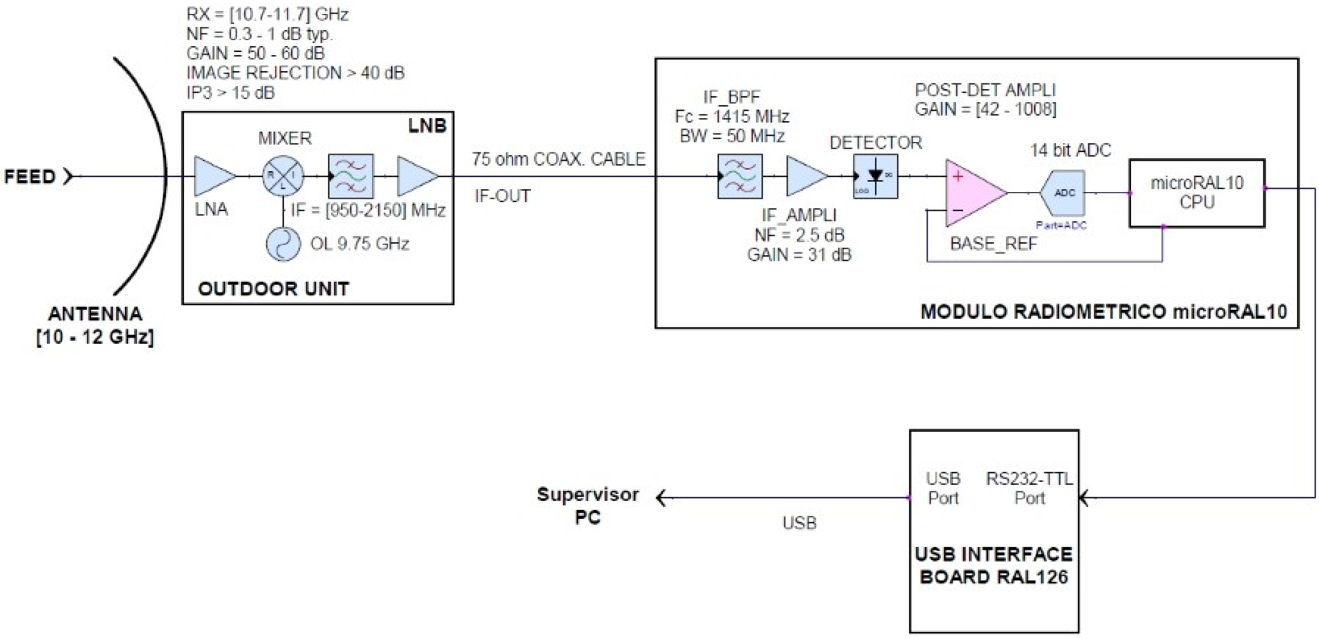
RAL10-kit



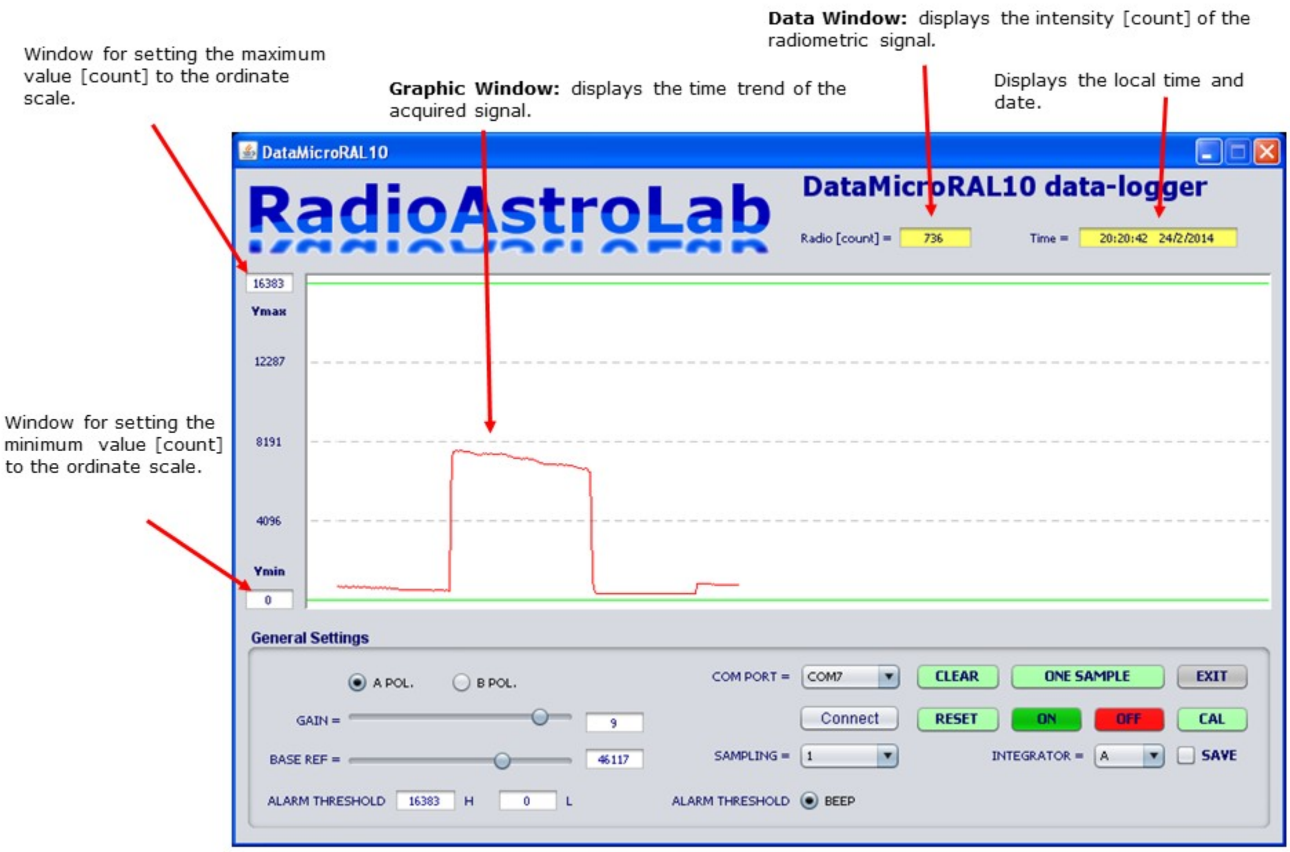
The RAL10kit is a complete package including the supply of LNB signal detection, its digitizing and sending to a USB port. Software accompanies this module and I translated the manuals into French. They can be downloaded here:

http://www.radioastrolab.com/documentation-for-french-users#contents

RAL 10 kit does exactly the same work discussed earlier. Its main advantage is having everything in one box but that has a cost.



Flavio has done a nice project for beginners. You can have a look here. It correspond to what I described in this book. On the diagram here above you can see a complete system. Hereunder is a screen copy of the result displayed by the software delivered with the RAL10kit.



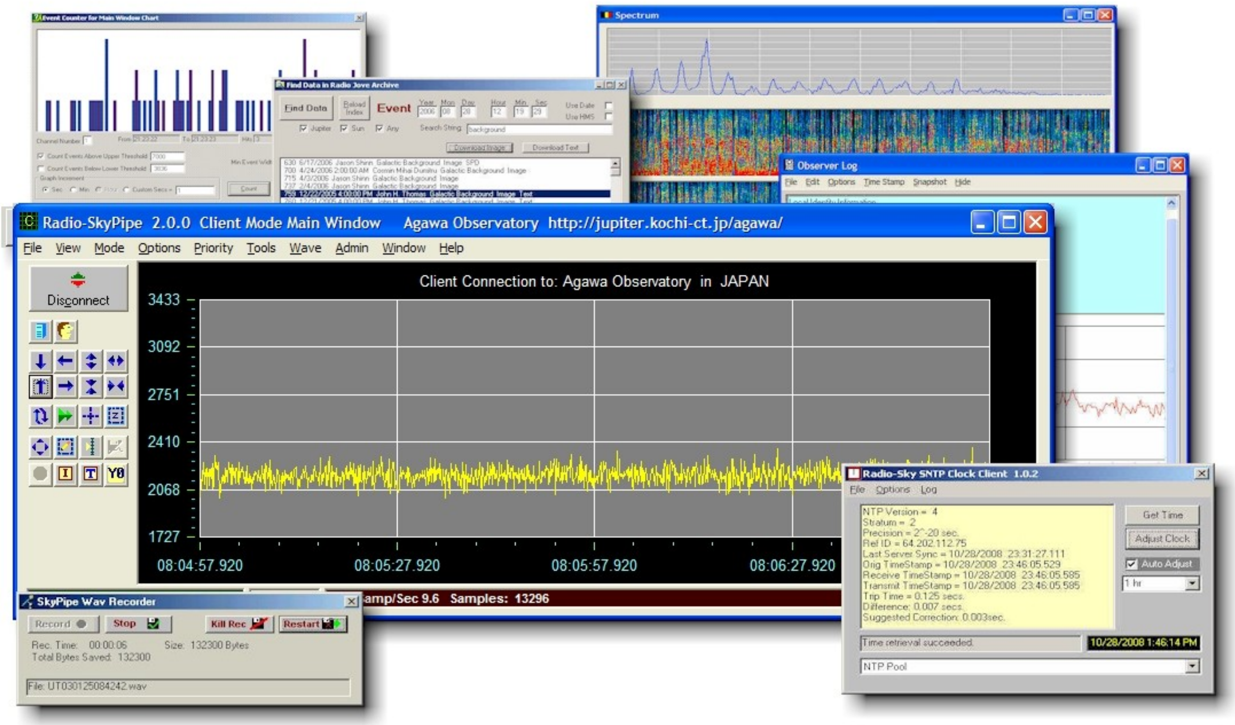
Basic settings of the program, sliders and buttons for the remote control of the instrument.

The recording

The digital signal finally arrives in the PC. We now need to visualize and record it.
Jim Sky provides a suite of software that performs several functions. We will review them.

Source : http://www.radiosky.com/softwarehome.html

Radio-SkyPipe II



A free software (with limited features) called Radio Sky Pipe. Coupled with the small module described above, the software will display in real time and gather data on your PC using your sound card or a simple analog to digital converter. Store files, retrieve and modify them with header information secured within the file itself.

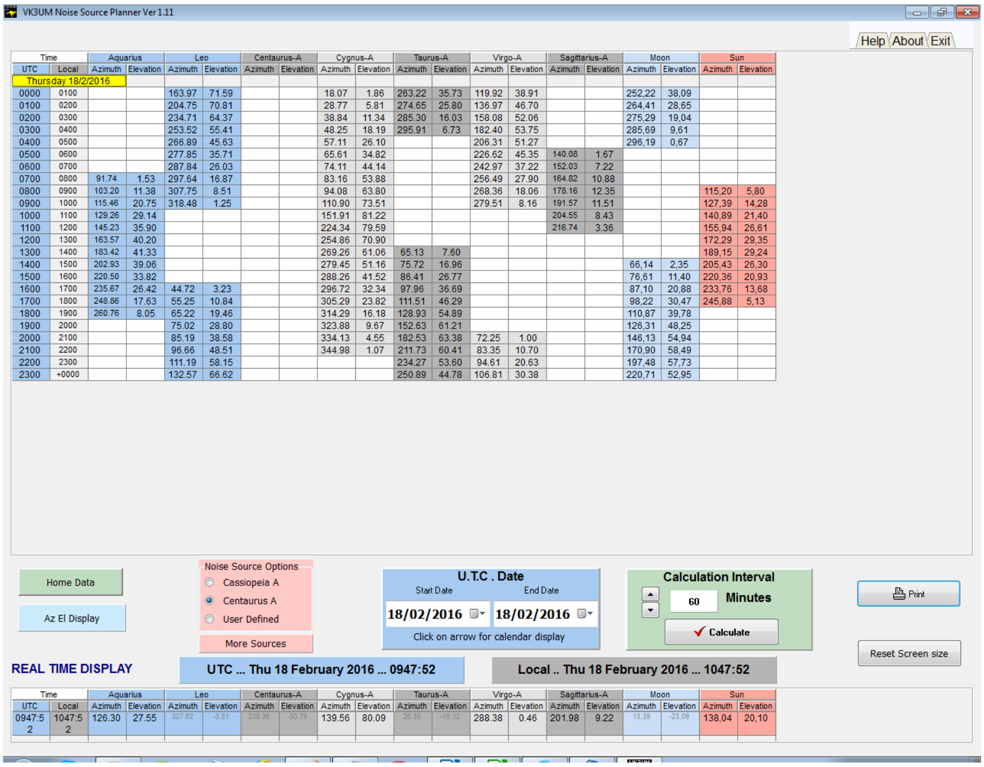
- Collect data on your PC using your sound card or a simple analogue to digital converter
- Store, retrieve, and edit strip chart files with header information secured within the file itself.
- Share your real-time data with others over the internet even if you use a dial up connection.
- Send live data to multiple recipients.
- Send and receive data simultaneously from multiple sources.
- Use in Stand Alone mode for local use only.
- A built in chat window allows you to communicate with others during observations.
- Can be used for radio astronomy, seismology, weather, any scientific or industrial monitoring tasks.
- Automate real world tasks using LabJack ADCs, control industrial processes, home heating, solar power.
- Connect directly to your Arduino projects and graph your data!.

Forecasting and analysis software

To help us to predict the time of transit of the main sources and to use the measures, there is a suite of free software written by an amateur radio enthusiast. Some run on WIN7 but I prefer to run under WIN XP. It is up to you.

They can be downloaded free here: http://www.vk3um.com/software.html and English manuals are also available on the site. I recommend this software if you want to achieve an impeccable job.

Source planner



A Source and Planet Planner that provides the ability to select either a Planet or a Noise or Quiet source and display its Azimuth and Elevation (or RA Dec if Polar) along with the Moon and Sun positions, if visible, at the time. Printing the display is an additional option if required.

For those wishing to make subjective measurements and check received/receiver performance, it would be beneficial to know the positions of the Sources in advance so the most appropriate time can be chosen commensurate with the availability and position of the Sources.

This software will provide (similar to the EME Planner) the ability to select the start and end dates of when you wish to make observations as well as the calculation increment desired.

The Noise Source Planner also provides a Real Time Display of all Sources which include :

- Aquarius and Leo (Quiet Sources)
- Cassiopeia-A, Cygnus-A, Taurus-A, Virgo-A, Sagittarius-A (Noise Sources)
- An additional range of other Super Nova remnants, Radio Galaxies and Nebulas.
- And both the Moon and the Sun added for good measure!

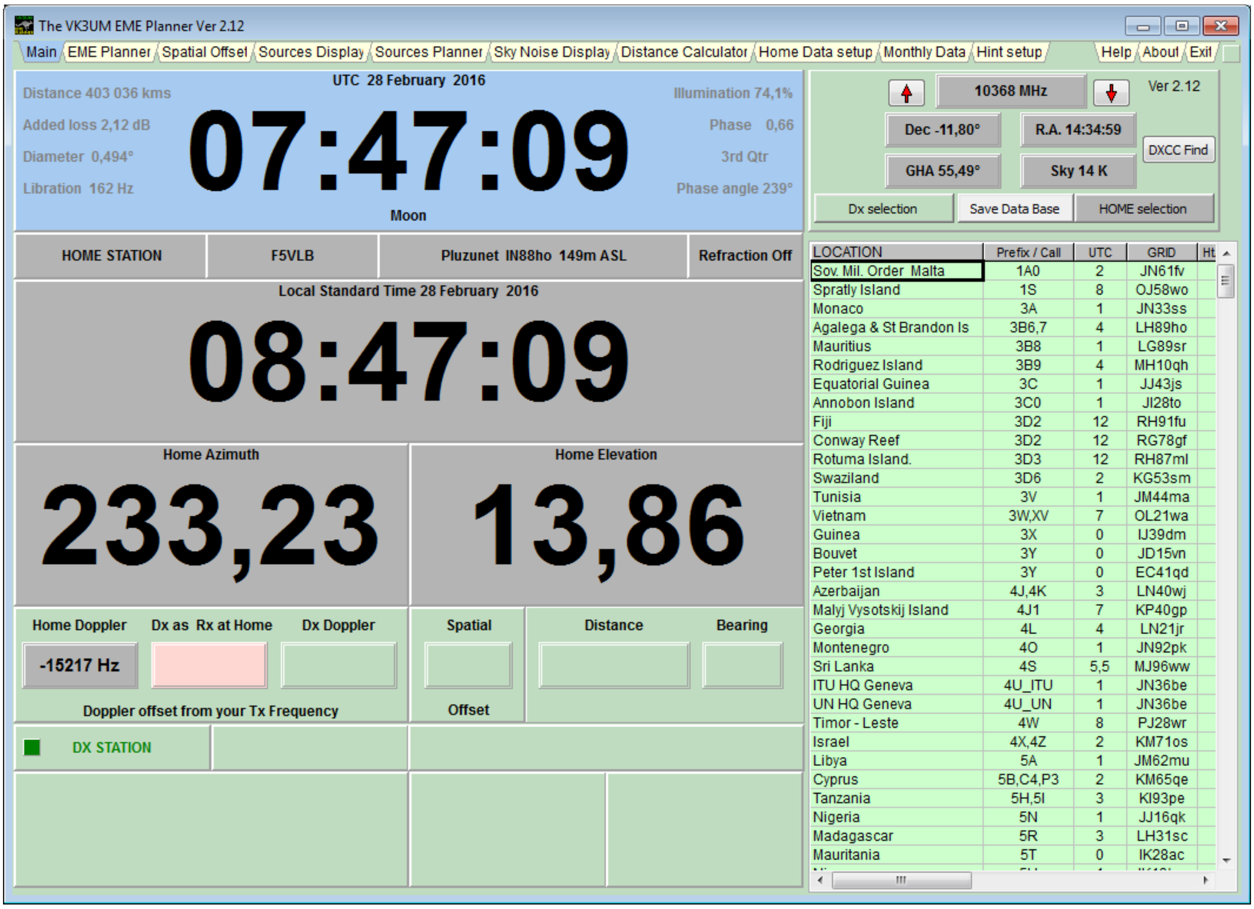
For those that use a Polar Mount this may be selected as well as the conventional Azimuth / Elevation Display.

The facility for printing your calculation (in landscape) is also provided.

Enter your Home Data and then Save. The program also saves your Calculation and Display mode chosen as default.

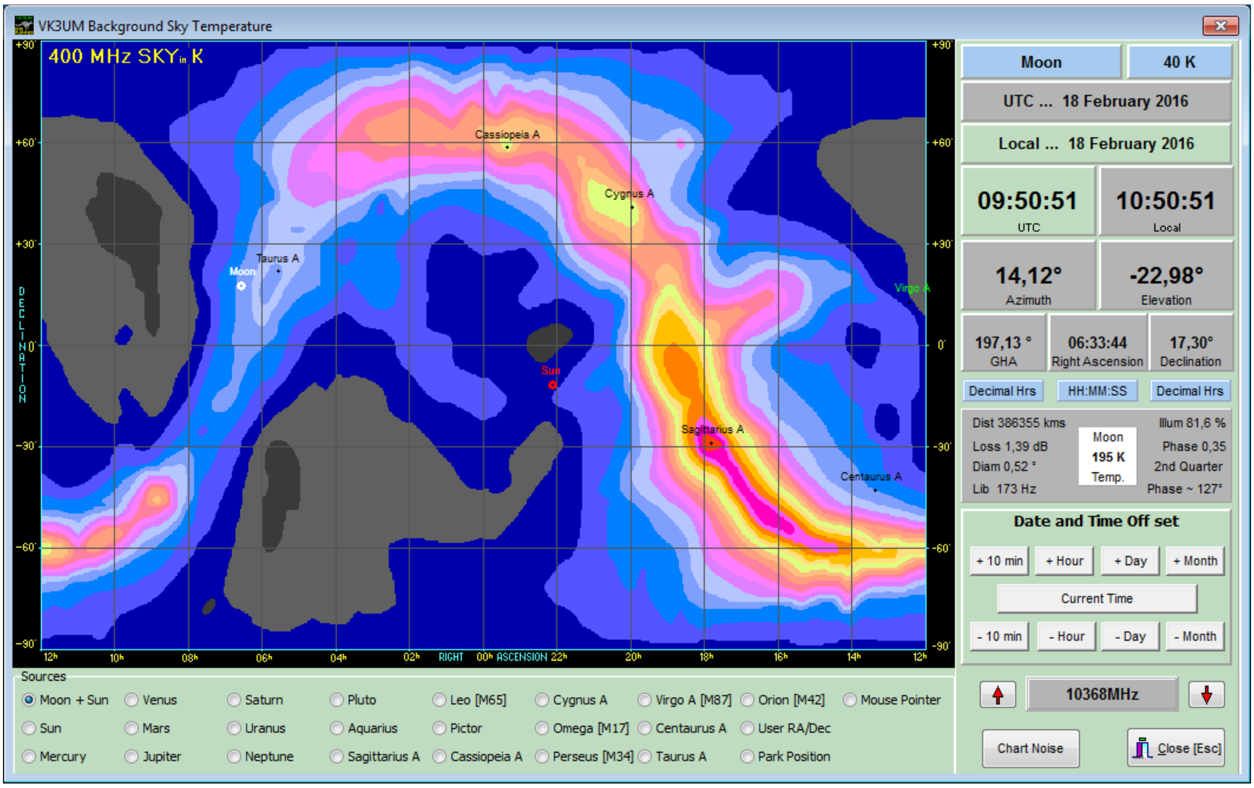
EME planner

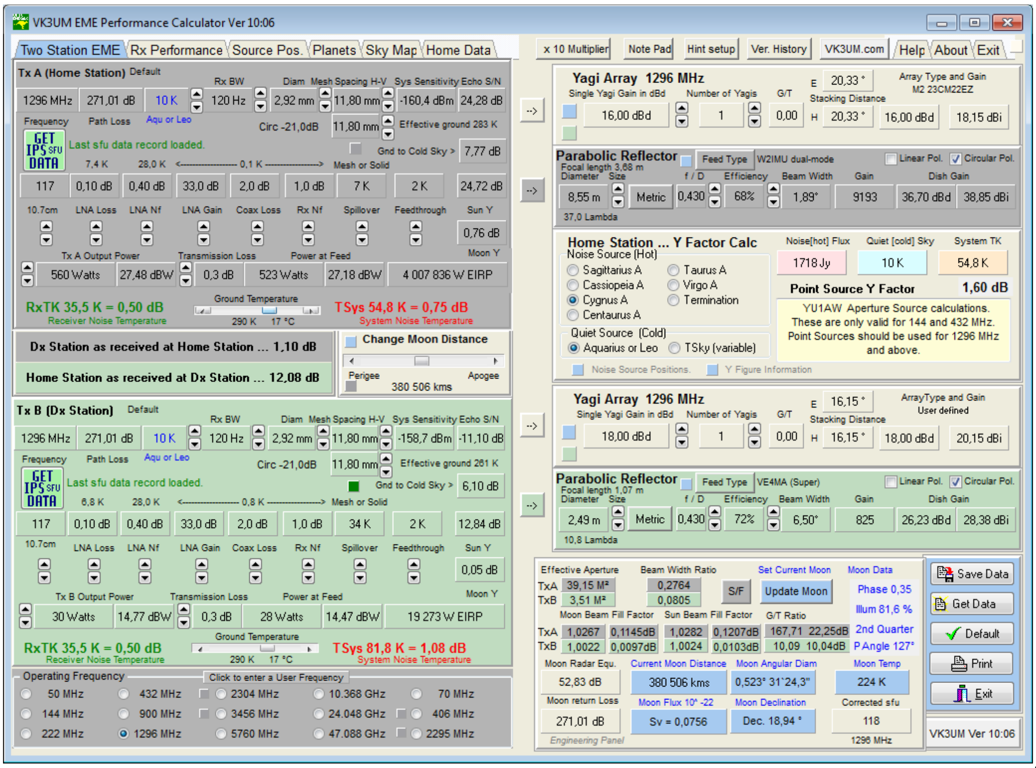
http://www.vk3um.com/eme%20planner.html



The VK3UM Planner is just that, an EME Planner, and supports a lot of feature usable in radio astronomy.

A Sky Noise Map that provides the Sky Noise Temperature behind the Source chosen, Park position indication and Mouse Az/El tracking across the screen based on your location at that specific time. The time may be shifted to observe future or past situations on Sky noise temperature.





and a delete software to calculate the performance of the station

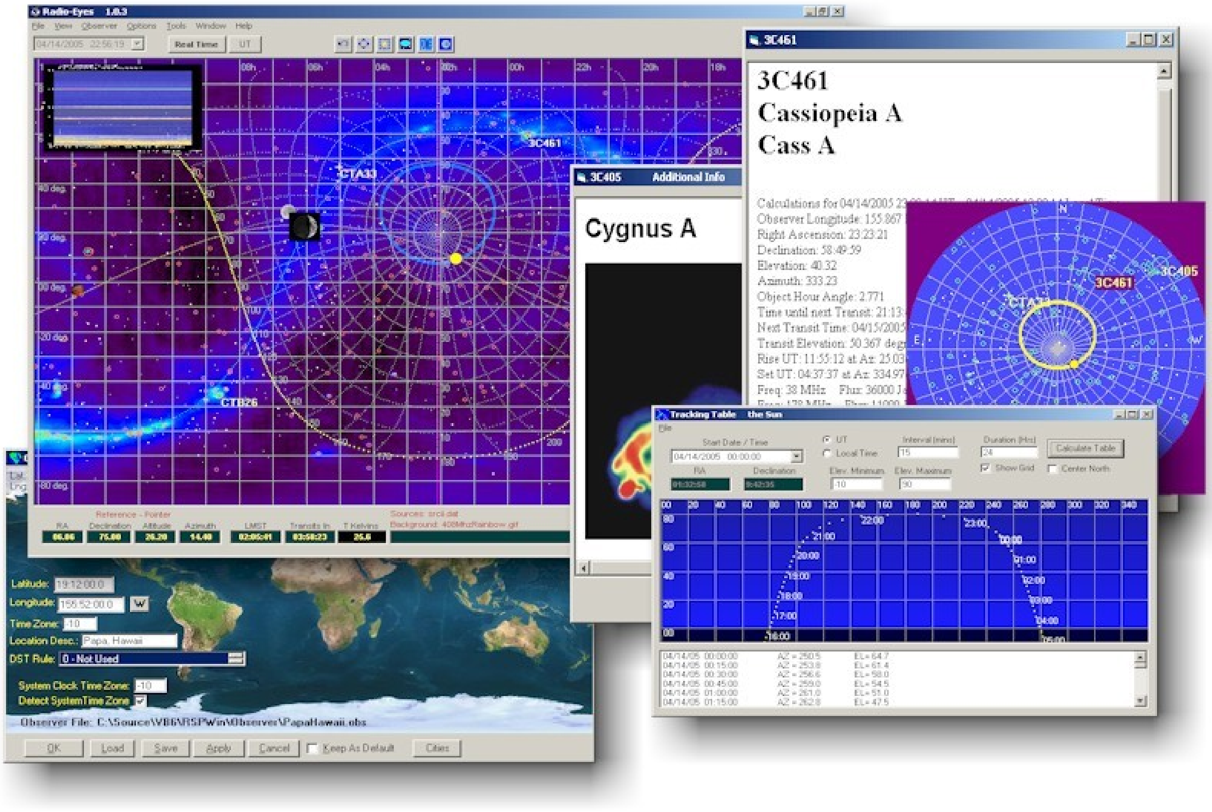
Another suite of free software is that of Jim Sky.
We have already spoken of its digitization interface. Let us now see its software suite.

Go http://www.radiosky.com/ to know everything. In short it offers:

Radio-SkyPipe	PC Based Strip Chart and Data Logger
Radio Eyes	Sky Simulator for Radio Astronomy
Radio-Jupiter Pro	Jupiter Noise Storm Observation Planner
Sidereal Clock	Free Sidereal Clock for Your PC
More...	Free Scientific Software

Radio-Sky Pipe was seen here above

Radio Eye

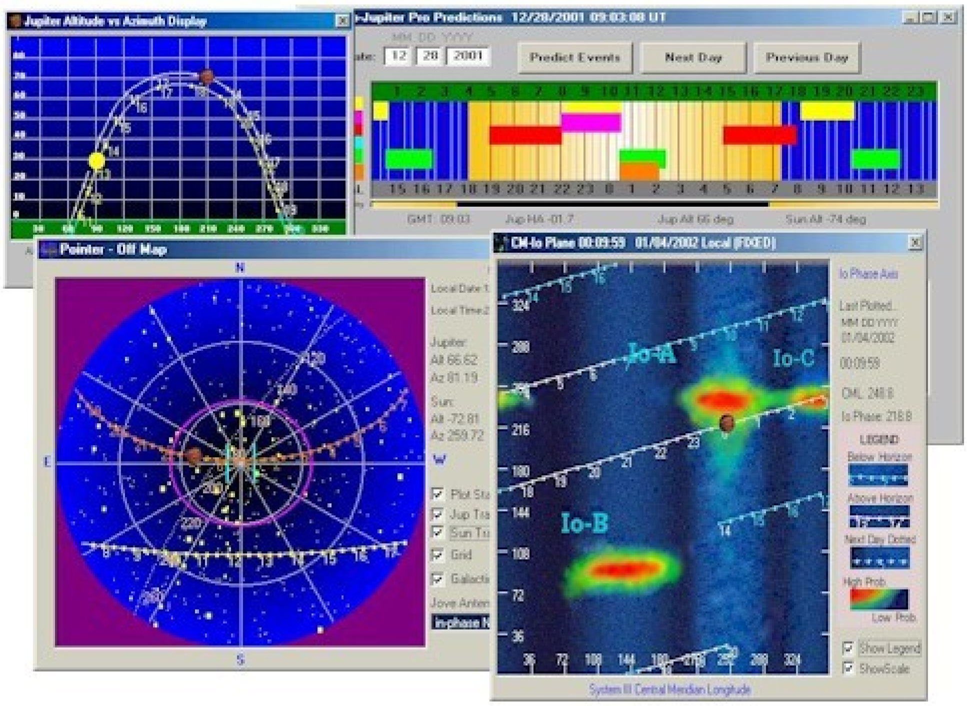


The Sky Viewing Program for the Radio Sky

There are dozens of good sky viewing programs for optical enthusiasts, but until now there has been a lack of modern sky viewing software for radio astronomy enthusiasts. Radio Eyes is not just a typical sky viewer that has mappings for radio objects. It is a tool to help you plan and execute your radio observations. Some of the features include:

- RADEC and Dome type sky views.
- Customizable catalogues of radio objects.
- Separate pulsar catalogue.
- Load background maps for various frequencies.
- Customize labels for presentation graphics.
- Antenna beam object.
- Develop drift scan tables.
- Track objects.
- Create active content from internet sources.
- Switch to the views from other observatories.
- Plot JPL Ephemeris data.
- Show planets, stars, constellations.
- Antenna positioning support.
- Control your radio telescope remotely.

Radio Jupiter

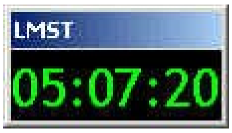


If you really want to observe Jupiter's radio noise storms, this is a must have program. RJPro3 does just about everything you can imagine to help you plan and execute your Jupiter observations. Above are just a few of the many views available. Look at the list of features:

- Predictions and positional information customized to your location.
- Quick Look prediction chart helps you spot the best storms easily. Click on a noise storm and update other views such as the sky map to show you more about Jupiter's position or other parameters for that storm.
- Customizable prediction reports simplify long range planning.
- See when Jupiter season is coming with the yearly visibility chart.
- Real time sky map helps you see where Jupiter is in your antenna beam. Plots the Sun, stars, and even the galactic plane.
- CML Io-Phase chart allows you to visualize and follow Jupiter through high probability areas.
- Observer log with Quick Log feature simplifies observation records with timestamps, position info, and one click burst notation.
- Chart the Jovicentric declination of the Earth.
- Run data collection and other programs in response to Jupiter position and storm events using the versatile Automation Engine. You can even write scripts to run an antenna rotator via the com or LPT port. If you have Radio-SkyPipe Pro you can send current Jupiter and Solar info directly to that program for inclusion in observer logs or retransmission to your clients.
- Many more features than can be enumerated here!

Sidereal Clock for Your Desktop

What is a sidereal clock? Astronomy buffs (radio and the other kind) often use a special clock which is based upon "star time". If you used your normal clock and timed when a distant star passed due south of you each night, you would find that each night it passed about 4 minutes earlier. That happens because in addition to the 360 degrees the Earth rotates in 24 hours it also moves 1/365.25 of its orbit around the Sun. Thus, we swing into position to see a given point in the sky a little earlier every night.



Example :

Object Name	RA (hh mm ss)	Dec (dd mm ss)	Epoch	Flux Density (Jy)	Frequency (MHz)	Other Name
3C 461	23 23 24	58 48 54	2000	2477	1,420	SNR-Cassiopeia A
CTA 59	13 22 28	-42 46 00	1950	2010	960	Cent A NGC5128
CTB 42	17 42 09	-28 50 00	1950	1800	960	Sag A Galactic Nuccleus

Cassiopeia A has the right ascension (RA) 23h 23 '24' 'and well when your sidereal clock indicates 23h23'24' ' Cas A will be just in the south of your location. And as your antenna is always pointed south (if you made transit) simply tilt to it is 58 ° 48'54 ''

yes but how to calculate the slope?

source height above the horizon = 90 ° - latitude + your observing the declination of the source

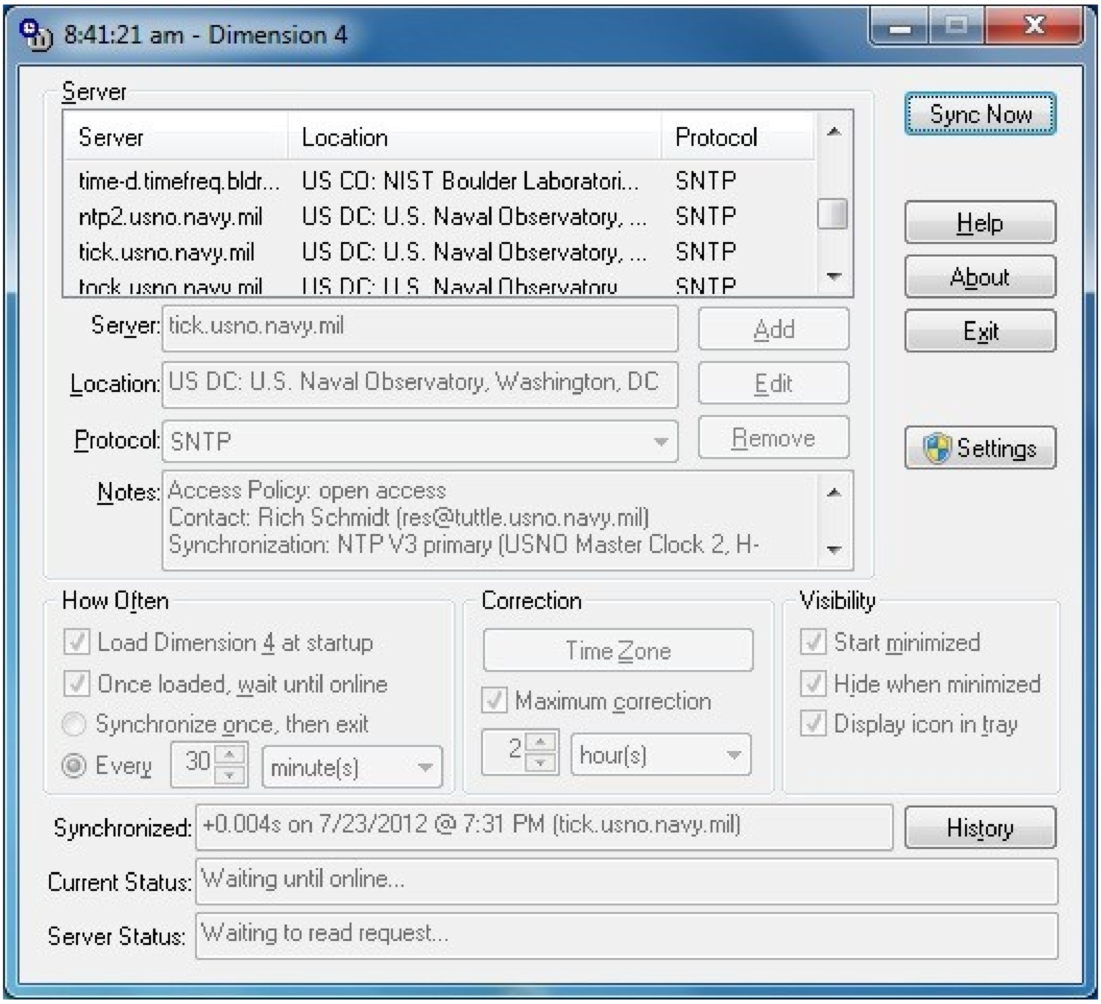
example: the declination of the source is above 58 ° 48'54 '' hey we will stick to 58 ° and a latitude of 50 ° Observation

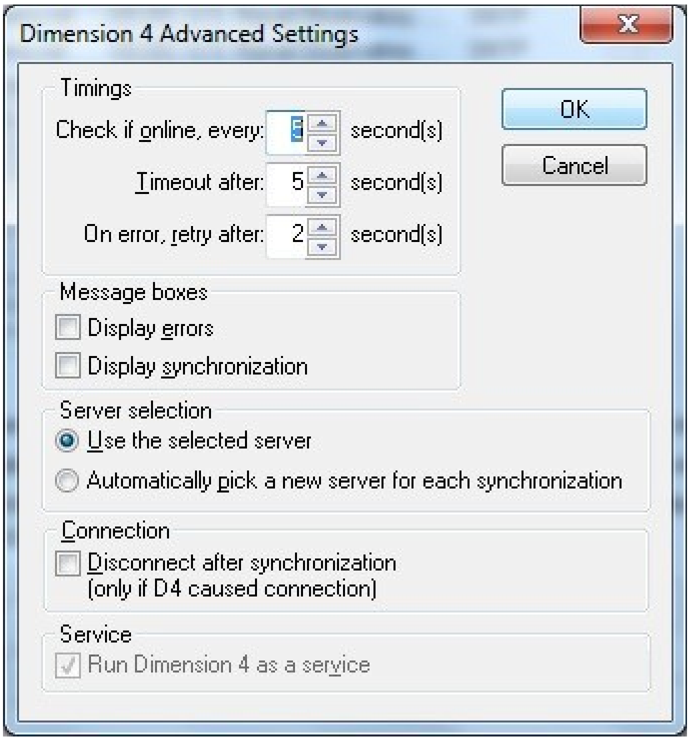
90 ° - 50 ° + 58 ° = 98 ° therefore almost at the zenith

With a VK3UM's software you would have had that without also calculating ...

Time synchronization

There is free software for setting the time of the PC (there are several in fact) but I use Dimension 4 that one can download here http://www.thinkman.com/dimension4/





Why Dimension 4 ?

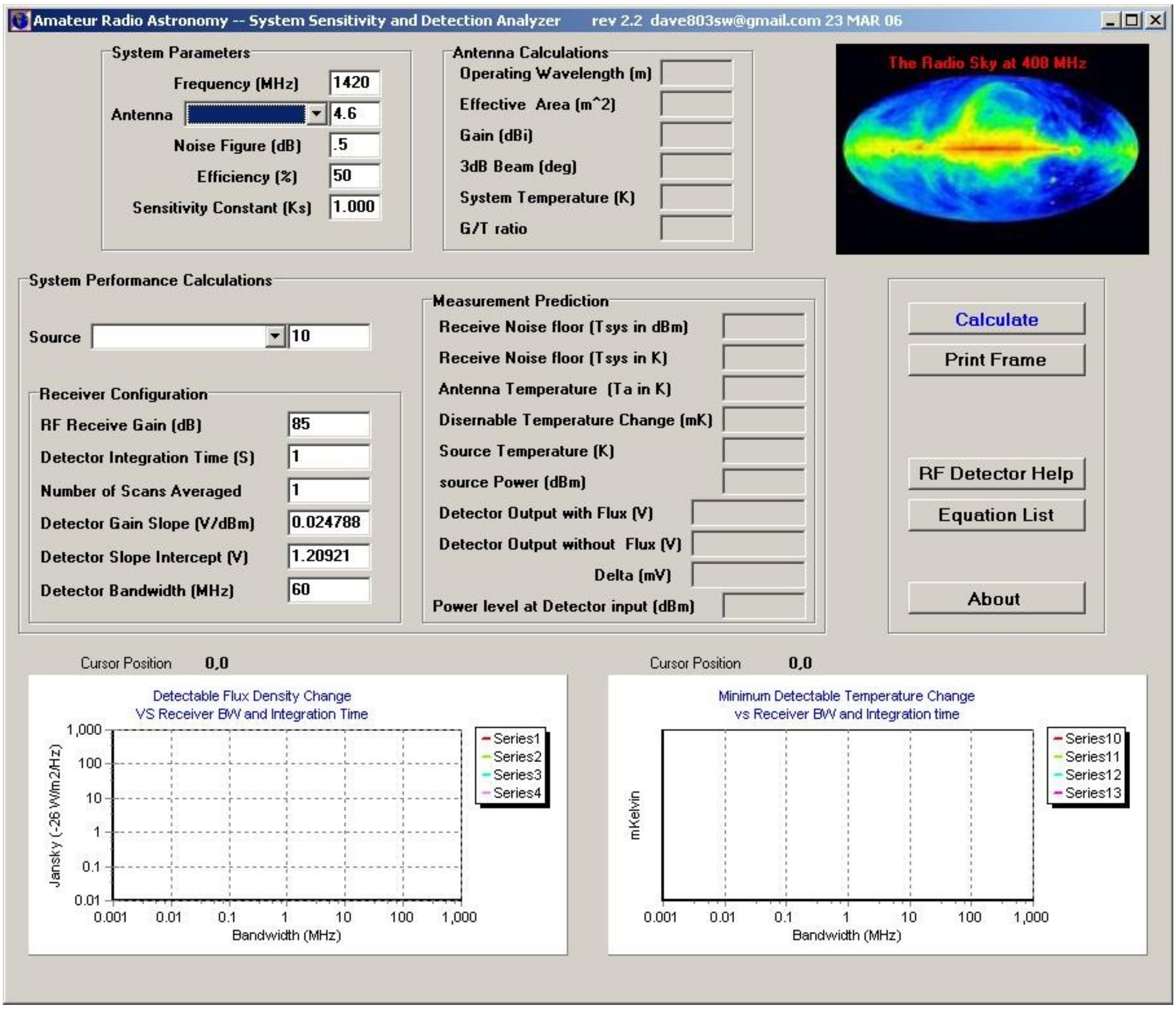
Dimension 4 is the fastest and the

easier way to synchronize the clock if you use your computer system operating based on Windows. Once Dimension 4 is installed, you will forget it is running. It is automatic.

Once installed, you can be assured that at least one of your clocks is synchronized. It is based on time internet server active for over twenty years and therefore reliable.

Sensitivity of the System

Minimum Detectable Signal Program by Dave Halley



This useful Windows program calculates the theoretical lower limit of the signal strength that can be detected by a radio telescope. Several parameters are required, yielding graphs for various bandwidths and integration times.

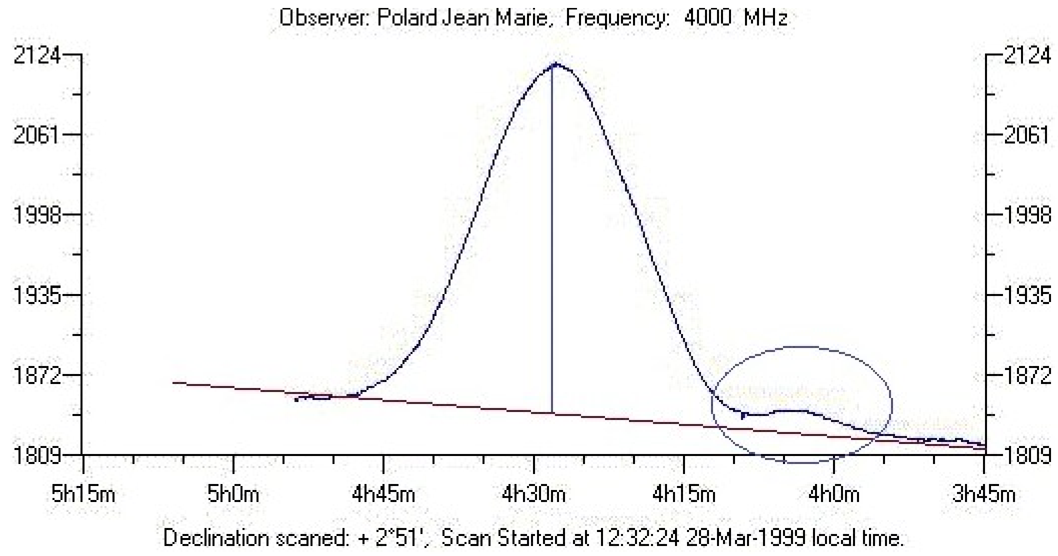
This program is Free! courtesy of Dave Halley, the author. Please note: all technical support for this program is provided by its author only. After running the program, see the program About box for contact information. There is no installation program, just download the program to a handy place (such as your desktop) and run it.

[Download Now]

Processing the data

In radio astronomy, while the antenna works, counting the long work begins. It is examining generated graphics, and to highlight the information that interests us.

Let's start with a scan of the sun

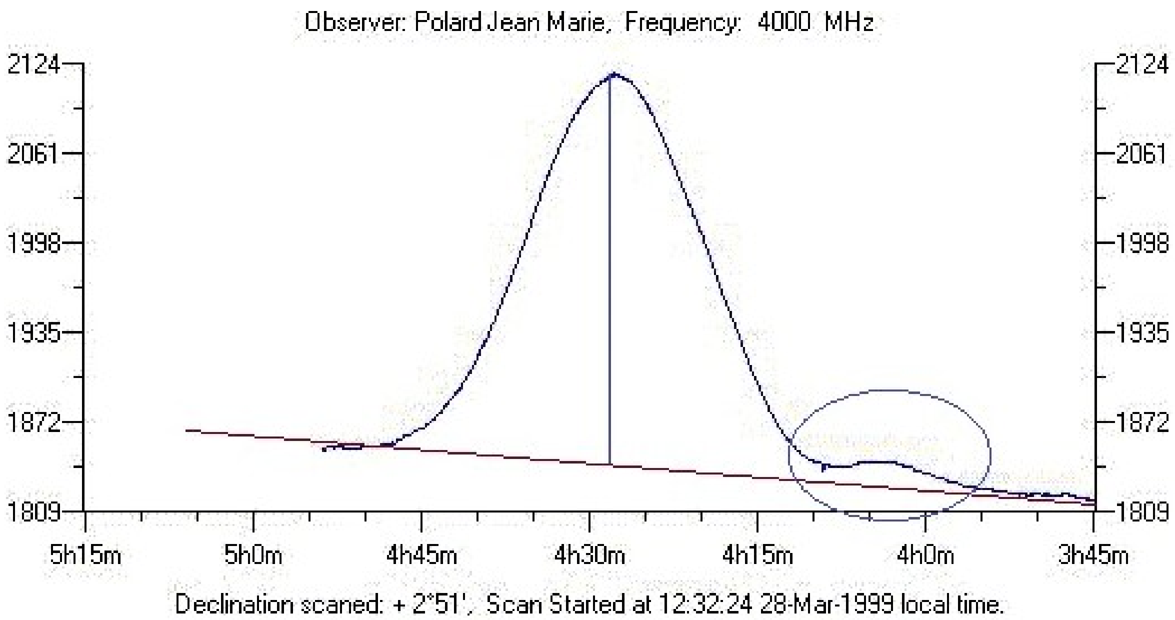


What can we deduce from this curve? You remember the dish is 1,55m diametre, 630mm focus, 2,77° aperture at HPBW, and 33,5dBi of gain.

1 - baseline varies with time it starts from ± 1850

This is due to the heating of the LNB box. The temperature rises due to the focusing of sunlight (white plain dish) and can even melt the rain protection cap. If the LNB heats the amps heat and thus the signal varies. You must take that into account in the measurements. A solution is to thermostatically control the LNB. Or protecting it from direct sunlight, either by cooling with a Peltier block. A parabola with mesh does not present much of temperature variations. (but ambient air can produce the same variation)

LNB protection sunburned



Palancade Jean Pierre F1OI explains : The origins of the drift are often due to a change in humidity atmospheric layers (clouds among others). Stabilizing T ° can be achieved by making position long before the transit.

2- transit lasts about 30 minutes, which means that the sun takes 30 minutes to cover the antenna lobe, it will give us the opening of the antenna (because we know the angle tense sun) and once the opening is known we can determine the extent of other radio sources.

3 there is a small bump on the right (surrounded by a circle) So either this is another source, but most likely it is a lobe of the antenna or the LNB is offset relative to the focus.

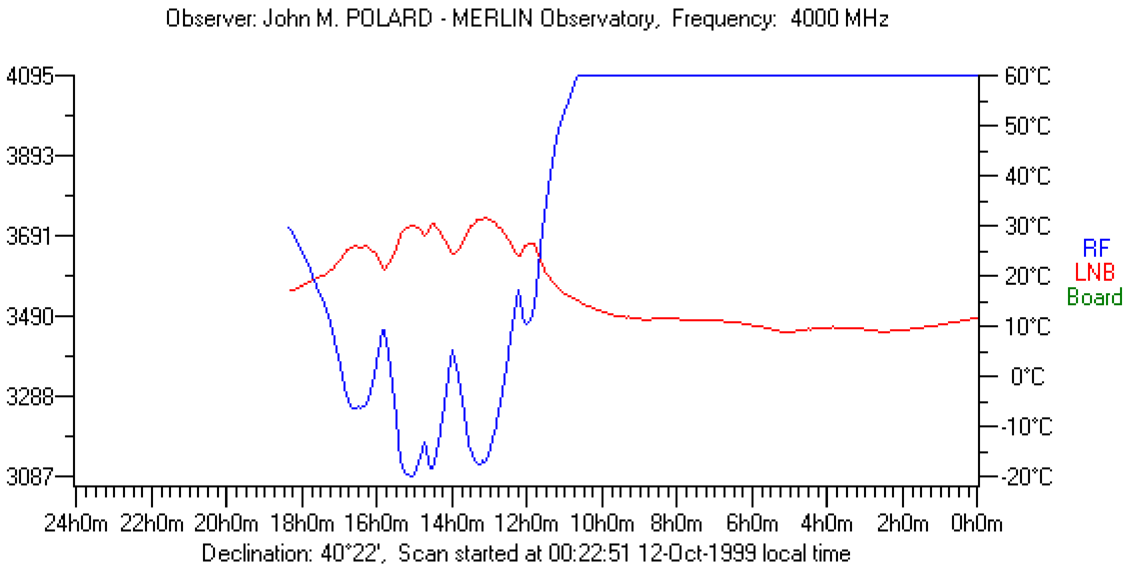
4 the amplitude of the signal is of 2124-1850 = 274 units.

We have here a typical scan obtained with an amateur radio telescope.

This highlights the problem of external temperature influences the actions and side lobes of a parabola.

When the actual measurement, we have a beautiful curve of the transit of the sun.

But before continuing, here is a scan of the lnb output and the t° sensor

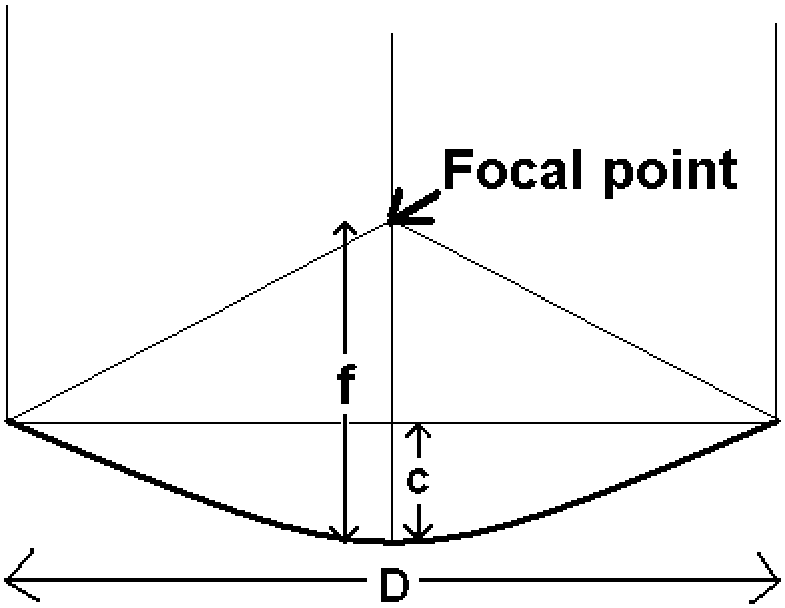


The Transit (blue) and the recorded t ° of the lnb (in red) : the correlation is quickly done!

Now we have to extract some value from this curve. But we will quickly understand that the system sees trouble . Indeed with this diameter and this frequency the source is smaller than the resolving power. ... Let us calculate !

Verification of the opening angle.

My antenna is a 1.55 m diameter (D) with a focal / diameter ratio of 0.4. It has a gain of at 42,3dBi 11 GHz and a focal length of 630mm. I work at 4GHz 0.075 m wavelength, the theoretical gain of 33,5dBi (see with the spreadsheet presented above p12).



The resolving power of an instrument depends on the diameter and wavelength. two stars are separated when their distance is at least equal to 0.85 times the radius of the diffraction spot. This value comes from a study of the distribution of light for two stars to shine, not too weak, not too bright.

If one wants to test the properties of an instrument, he has to stand in those conditions.

Of course,weather should be very good ... By analogy, this applies to radio sources. The sky can be cloudy, but storm, heavy rain, lightnings are not really appreciated by delicate electronics.

We define the theoretical resolving power of an instrument through the above directions:

$p = 0.85 * r = 0.85 \times (1.22 * \lambda / D) = 1.037 \lambda / D$

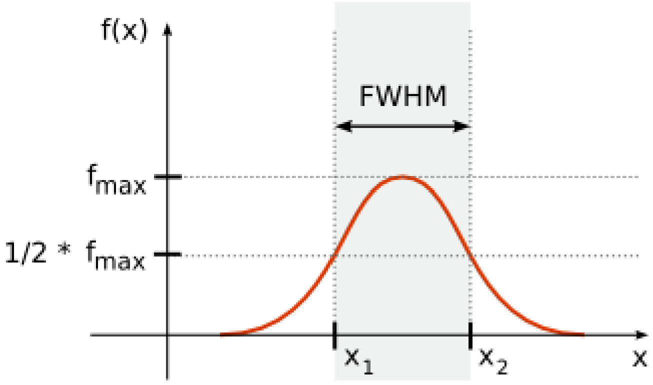
Let D = 155cm the diameter of the instrument and λ = 7.5cm wavelength; the resolving power is given in radians:

$p = 1.037 \lambda / D$ so if one works at 4GHz (or wavelength 7,5cm) p = 1,037x7,5cm / 155cm = 0.05 radian

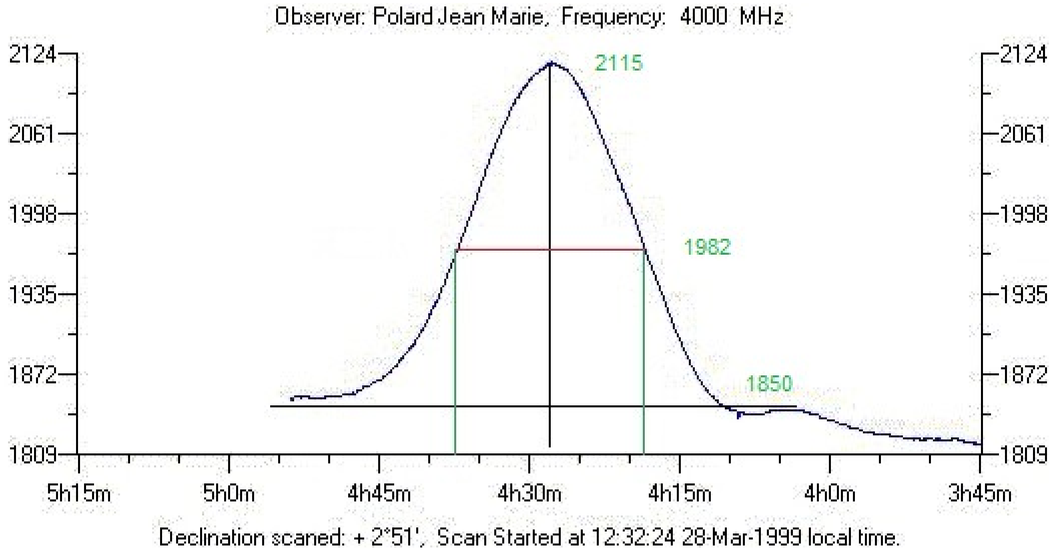
Multiplying by 180 / π is 57.34, we get the value of p in degrees:

$57.34\ p = \lambda / D$ in our case 2.77 ° or 2 ° 46

Then we determine the width at half height of the signal (the FWHM) for our measurements.



or (2115+1850)/2=1982



the difference in time is 18 minutes

Now we know that the Earth rotates by 1 ° every 4 minutes (360 ° every 24 hours).

There are 24x60 minutes in a day, so 360 ° / 1440 'are 0.25 ° per minute.

So 18 minutes time represent an angular variation of 18x360 / (24x60) = 4.5 ° (or 4 ° 30 ').

As the antenna lobe width of 2.77 °; one could deduce that the width of the Sun is about 4.5°- 2.77 °=1.73 or 1 43'48 '' but it is ± 32 '

Notes:

31.67 is the apparent angle at which the moon is seen and 31.98 is the apparent angle under which we see the Sun (± 0.5 °). The size of the sun ± 32 'is the optical dimension, the more the crown is involved as a source of radiation the more that dimension is great. We know that if the frequency is growing the more we are dealing with inner layers of the chromosphere & photosphere …

These numbers are right, but only for a sun just at the celestial equator. If the sun is above or under the equator, it moves slower than 0.25º per minute. Think for example something at the north pole: It moves 0º per minute / hour or day.

The real formula is 360º / 1440 * cos(Declination)

The main lobe is characterized by its HPBW - half power band width

HPBW = 57.34 ° * wavelength / diameter   so for my antenna   57.34° *7,5cm / 155cm = 2.77 °

it is valid only for small values (HPBW less than about 10 °). That means that, for a beam width of less than 1 °, the antenna must have a diameter greater than 60 wavelengths.

For the Ku band, with about 2.7 cm wavelength, we need a 1.62m dish diameter!

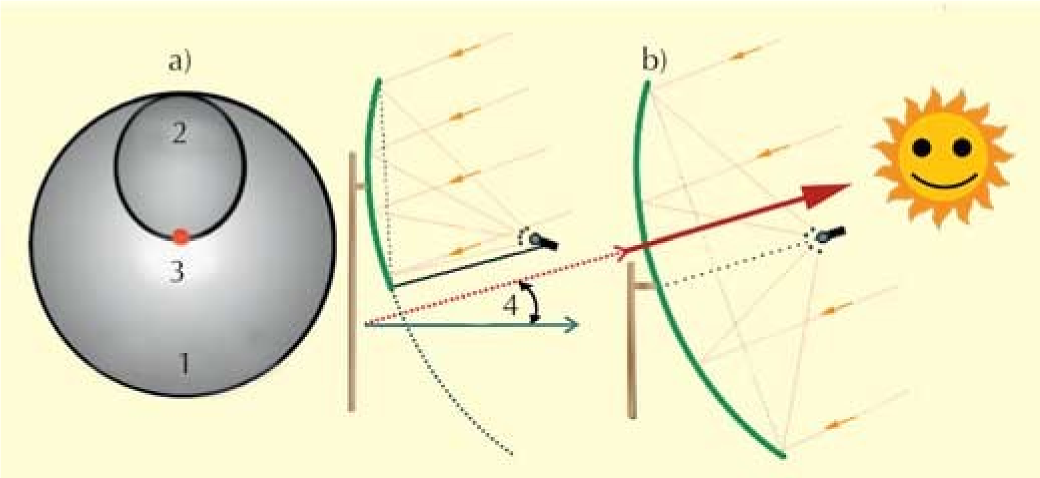
Calculating the brightness temperature (Tb)

For this calculation, we will use

• the ground temperature of the day of measurement, example : 27 ° C or 275 + 27 = 302 K
• Maximum value of the Sun on the curve here 2115
• The difference between max value of the Sun and the sky background 2115-1850 = 265
• area ratio between the Sun and the parabolic dish of the lobe 2.77° / 32 = 0.086

and do calculations : Tb = (302x 2115/1850) x 1 / 0,086> Tb = 4015 K

Verification of the LNB position and alignment of the antenna



a) A front view of two types of parabola: dish (1) and offset (2), showing the position of the LNB (3)
b) cutting of an offset parabolic antenna (left) and a parabolic antenna prime focus (right) showing the angle of elevation (4) relative to the horizontal.

Projects for radio telescopes

We will review some projects accessible to amateurs. This list is not exhaustive and only your imagination is the limit. Check on the net. There is more and more information available . This book is just a starter, you have to expand your knowledge.

The Sun

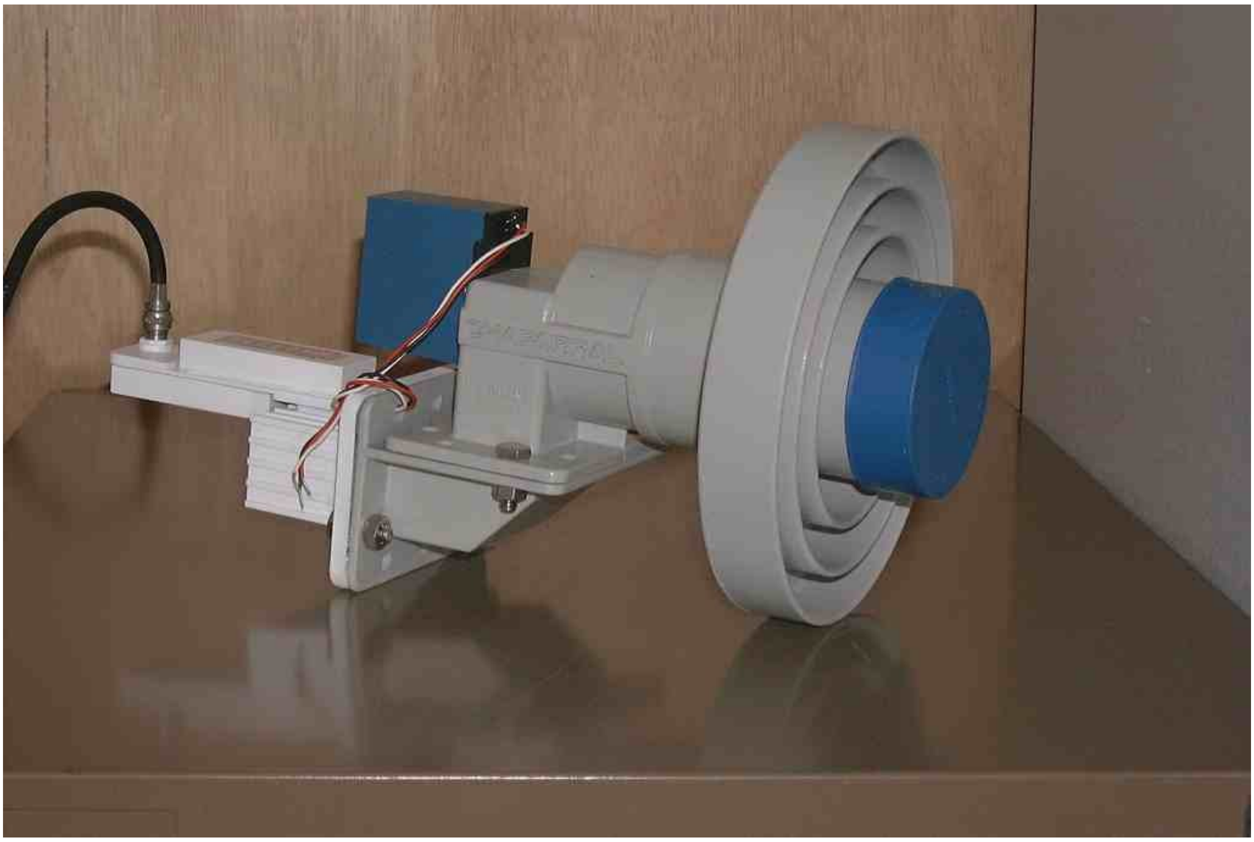
The nearest star to us, the more easily observable with little equipment.

Equipment used;	dipole, yagi, dish
Frequency:	the entire frequency band (from VLF to ...)
Difficulty:	easy

To observe the Sun continuously, you have to use an equatorial mount. (31.1 '± 0.6) as shown below and directed by Hans PA0EHG. On an equatorial mount for optical astronomy, he mounted a small dish with counterweight. The followed? is provided by the micro controller built into the system. Hans used this small dish to listen to echo from a beacon via the moon ! The less we can say 'a real challenge'?

For reception, a satellite head purchased in a supermarket or online. Reread the paragraph on the LNB above!

I opted for a 4GHz head higher in frequency because solar flares are not detectable.



Such a radio telescope can be used to monitor solar activity for one or more months. The data analyzed to study the periodicity associated with the rotation of the sun. It should be noted that rotation is not uniform and depends on the solar latitude. A correlation with the sunspot is studying.?

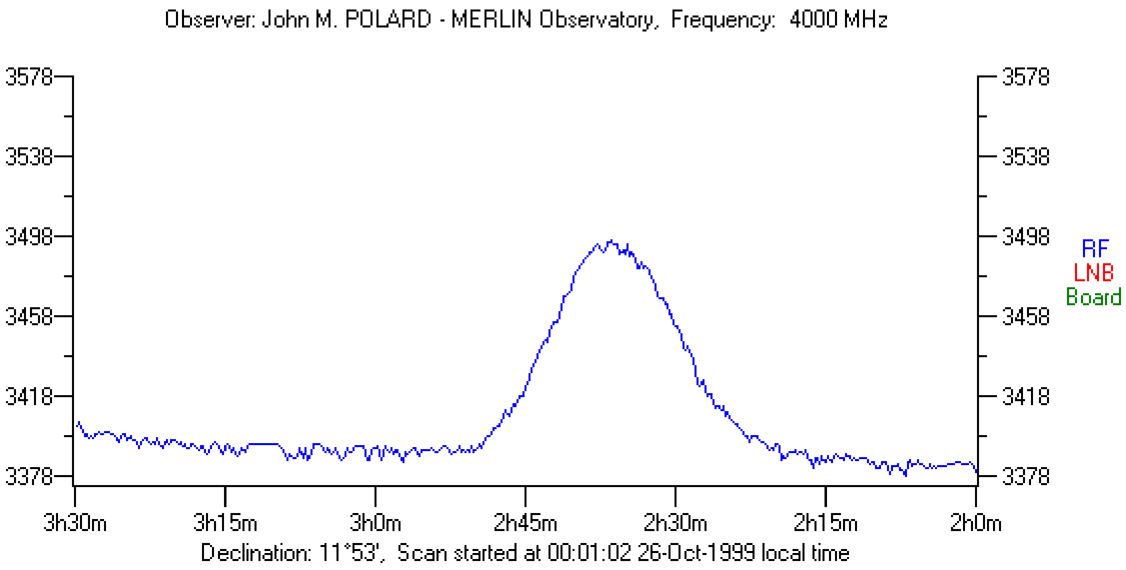
The Moon

The Moon is the nearest body of us, can be observed with little equipment and some communication can be made using the moon as a reflector of radio waves.

Equipment used;	dipole, yagi, dish
Frequency:	the entire frequency band
Difficulty:	easy

The moon is a solid body with no significant atmosphere. So it shines like a cold solid body (thermal radiation). The beam width of the antenna is 1.55m is larger than the angular diameter of the Moon 0.31 °. The moon will be a point source for the antenna and a transit of the moon will produce a record with the properties of the antenna beam: namely a detection which is about 2.77 °. However, it is always an interesting exercise to try to detect a radiant body cold, purely thermal.

The moon does not have a strong magnetic field and no ionized gas atmosphere may contain free electrons, so there is no mechanism that can generate non-thermal radio emissions.



Scan the moon to 4 GHz with antenna 1.55m

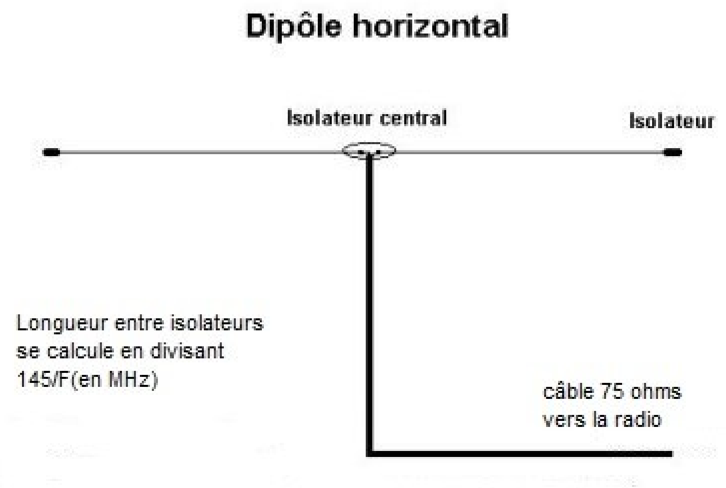
Jupiter

Jupiter, often considered as a failed star emits in a broad band of spectra. The complex emission process (1) sends us waves as noise.

Equipment used	dipole, yagi
Frequency:	the whole HF frequency band, with limitations
Difficulty:	easy

Emission	Power
Radio (KOM, <0,3 MHz)	~1 GW
Radio (HOM, 0,3–3 MHz)	~10 GW
Radio (DAM, 3–40 MHz)	~100 GW

To observe Jupiter (2) the easiest is a good dipole as mentioned above, a pre-selector filter to remove interference signals and an adjustable receiver 18 to 40MHz (with a dongle converter is also the case).



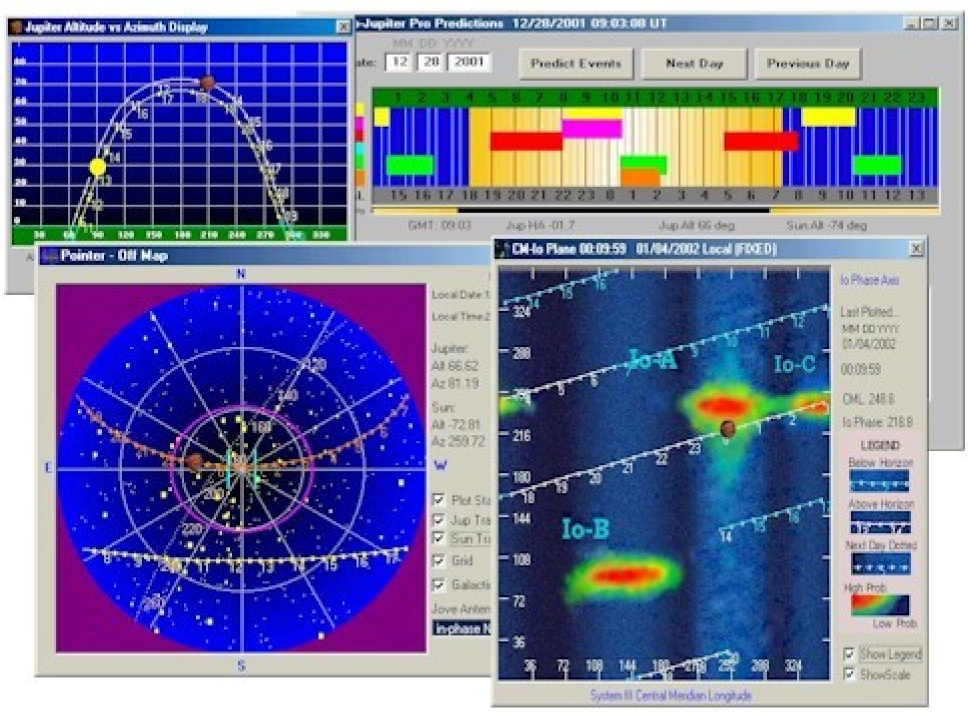
(1) Read the wikipedia article on Jupiter's magnetosphere

https://en.wikipedia.org/wiki/Magnetosphere_of_Jupiter

(2) Read the paper of Jean Louis Rault on observing Jupiter

http://files.astrosla.webnode.fr/200000203-b935eba311/radioastronomie_JupiterIo.pdf

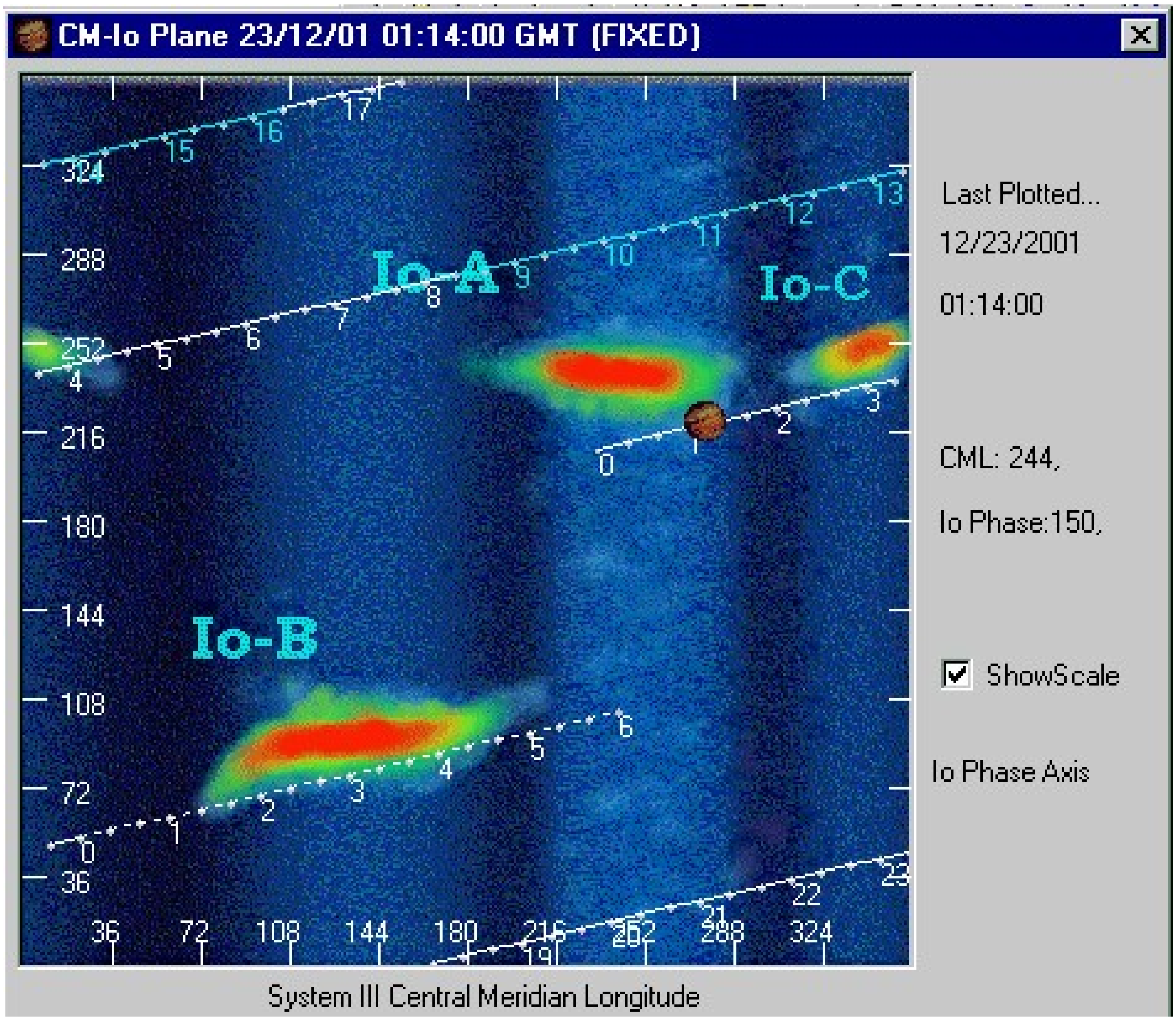
There is software dedicated to the observation of Jupiter. As these emissions are not continuous, it is necessary to determine the observation windows.



I again recommend Jim Sky software

(http://www.radiosky.com/softwarehome.html)

The Java program is comprehensive and will give the observation windows for your location and other helpful information to make a good study of Jupiter HF.


CM-Io Plane 23/12/01 01:14:00 GMT (FIXED)
Io-A
Io-B
Io-C
Last Plotted...
12/23/2001
01:14:00
CML: 244,
Io Phase:150,
ShowScale
Io Phase Axis
System III Central Meridian Longitude

The other planets

A very nice article of 14 pages, Franck Tonna F5SE, can be read here download pdf . This is in French, but is really a high level information.

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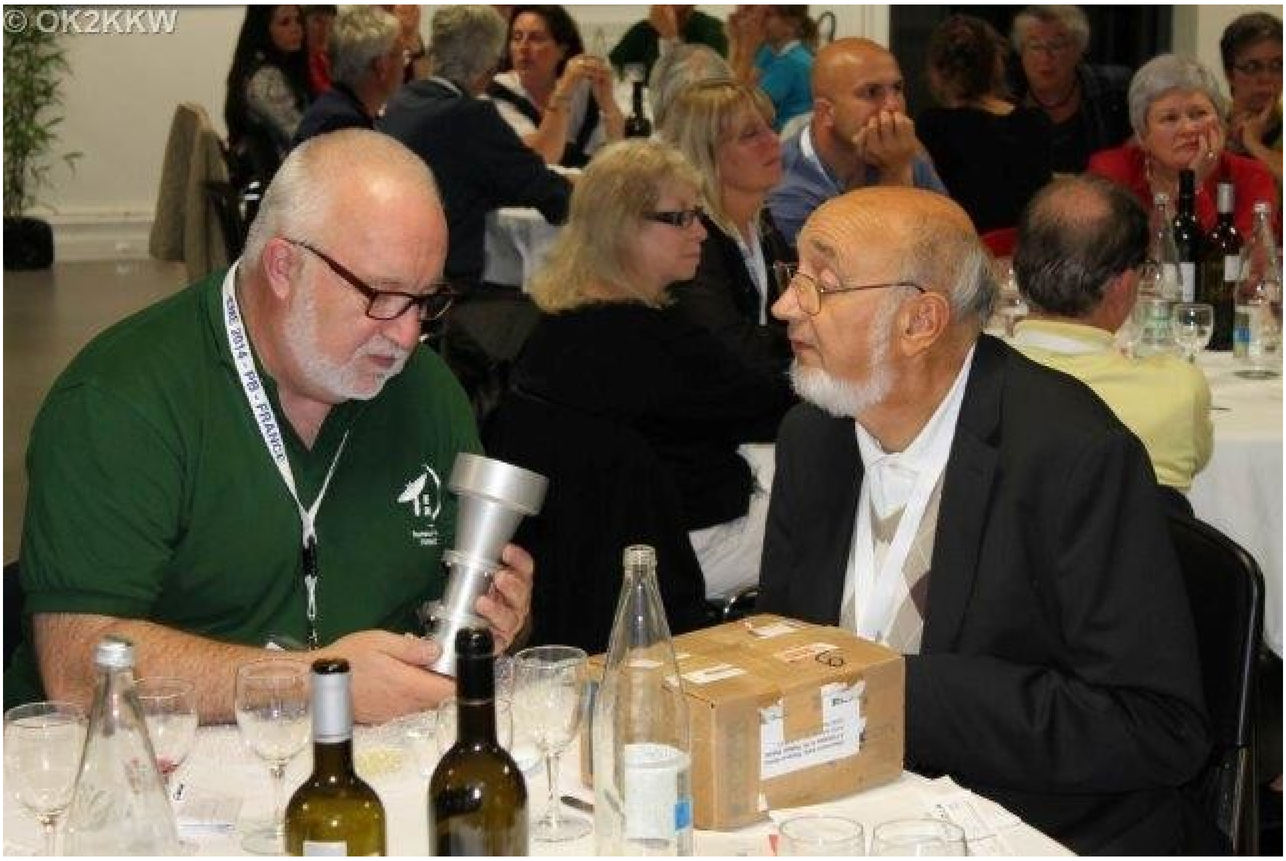


F5VLB (left) and F5SE (right) at EME 2014 in Plemeur-Bodou (France)

The Meteors

Echoes of meteors are observable with little equipment.

Equipment used: yagi, FM or SSB, audio spectrum analysis software

Frequency: the entire VHF frequency band (but tests are made VLF)

Difficulty: easy

Observation of meteors is surely part of the most accessible to the amateur radio astronomer.

When the TV transmitters were still analog, you could use them as source of emission.

When a meteor strikes the earth, it happens at high speed (up to 72km / second). The size

a grain of sand (but there may have bigger cars called) it enter our

atmosphere to 100km altitude and during their journey, tear electrons ionize and therefore a tube along the path. This tube will reflect radio waves of issuers located in or nearby. What is going

detect, is the wave produced by the reflection and deduce the radial velocity of the meteor.

Precision F6AGR Jean Rault Louis: Actually, this is not the fact that they are passed to the modulation

digital which we can no longer use them, but it is the fact that in passing digitally, they

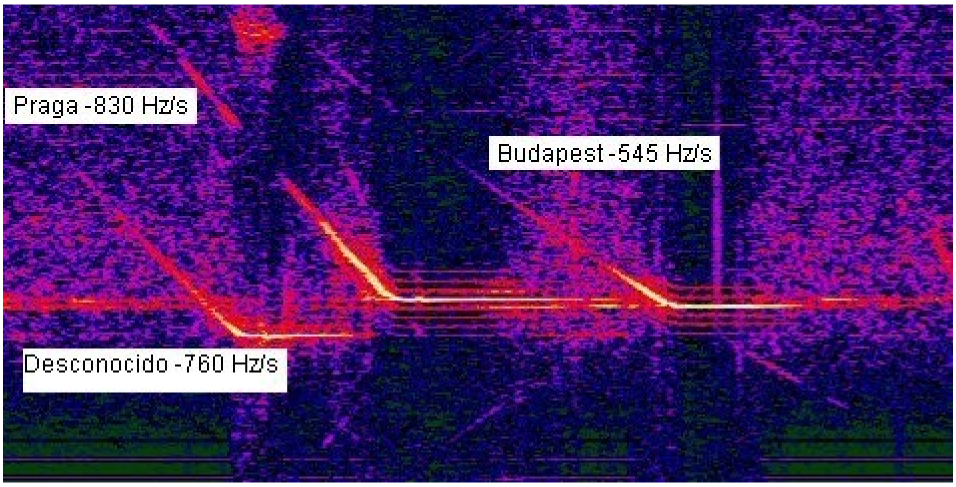
at the same time I left the band (50 MHz) and the VHF band to switch to UHF. If we had

even digital TV transmitters in Band I and VHF, we may continue to use them for

meteors, because the spectrum of a digital broadcast includes many pure and stable lines

(CW). But passing in UHF, we lose the ability to see the trails that are not dense enough to

reflect the very high frequencies.Missing text?



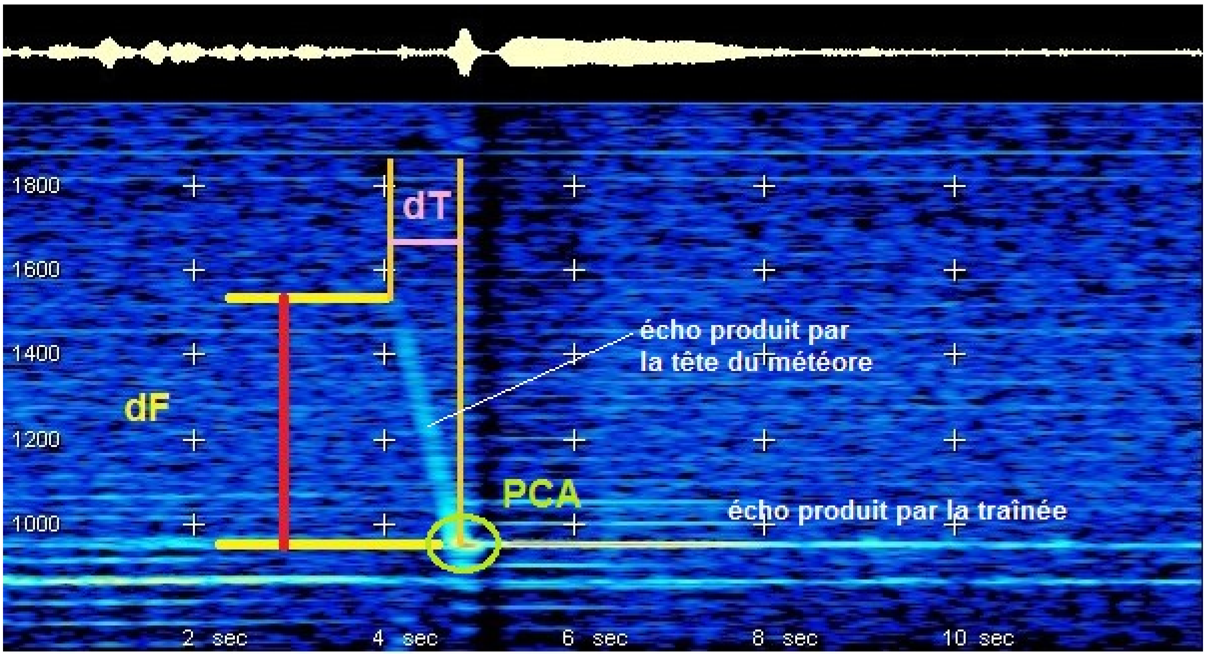
Currently we use the Graves radar. It transmits on 143,050MHz. A wealth of information is available on this link

http://f6crp.pagesperso-orange.fr/ba/graves.htm

To summarize this document, just a rake antenna (Yagi) for the 2m band (144-146MHz) amateur radio, a dongle and a PC. You configure the system 143,049MHz USB and you point your antenna to the south. Pinging you'll hear are the echoes meteor entry.
When you've heard enough, you can begin to study them.

If you use software like Spectravue, Argos, Spectrum Lab (see via Google) you can get a spectrum like this:

recorded on 49MHz with (arbitrary value for example) an dF of 950Hz and a dT 1 second

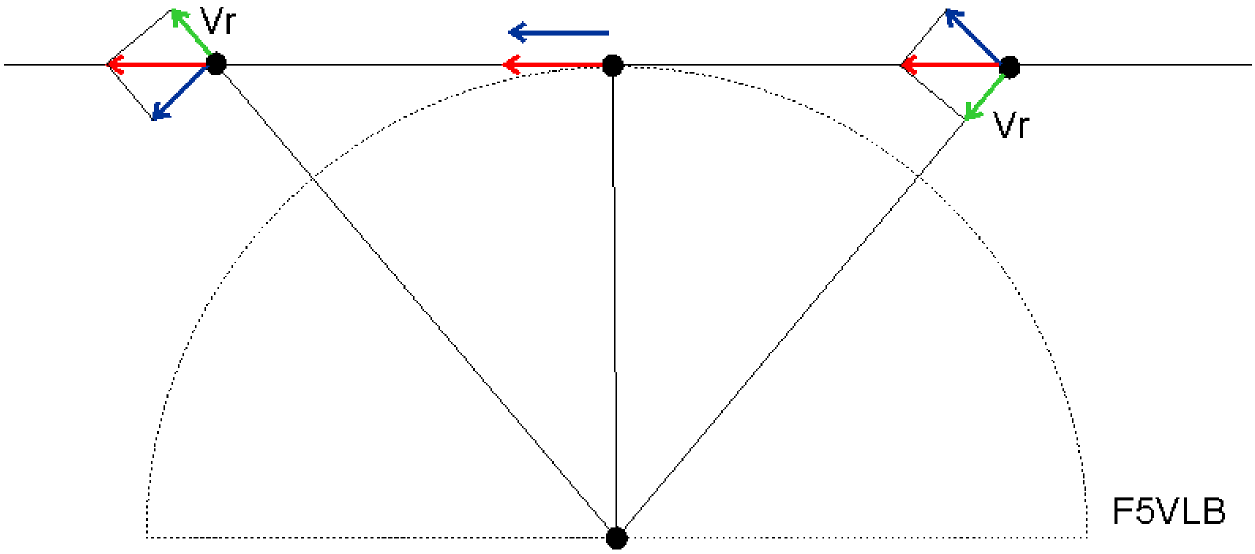


The PCA is the point of closest approach
to estimate the radial velocity formula is: Vr = c * dF / F carrier
in our case we have:

Vr = 299792458 m/s * 900 Hz / 49000000 Hz

Vr = 5506 m/sec

is the radial component of the velocity
By convention, a positive radial velocity indicates that the object is moving away and a negative velocity as the object approaches.



Thus the drawing above, following the meteor moving parallel to the ground (1) one can note that its radial velocity (green arrow) and not its actual speed (horizontal red arrow). It is against possible to deduce with some accuracy the true speed and direction if the radial velocity of the target is taken at regular intervals. Indeed, the radial component varying as the cosine of the angle of sight between the antenna and the meteor, it is possible to extract numerical analyzes information on the actual speed.

The knowledge of the radial velocity and estimates the type of meteor and hence its likely origin. Note: This is really a summary, the determination of the radial velocity involves so many parameters that it would take several chapters to everything apart. But it can make a great theme for personal research. (1) the movement is oblique, but understanding the horizontal path is accepted Finally, here are some data on the swarms of meteors I don't understand

Nom	Dates	Pic	Ascension droite	Déclinaison	Vitesse (km/s)	THZ (/h)	Intensité
Quadrantides	1er janvier - 5 janvier	3 janvier	15° 20'	+49°	41	120	Intense
Gamma vélides	1er janvier - 15 janvier	5 janvier	08° 20'	−47°	35	2	Faible
Alpha crucides	6 janvier - 28 janvier	15 janvier	12° 48'	−63°	50	3	Faible
Delta cancrides	1er janvier - 31 janvier	17 janvier	08° 40'	+20°	28	4	Moyenne
Alpha hydrides	5 janvier - 14 février	19 janvier	08° 52'	−11°	44	2	Faible

this table is available here https://fr.wikipedia.org/wiki/Pluie_de_m%C3%A9t%C3%A9ores

What catches our attention are the speeds. They are given full speed! So this is not the radial velocity which is a component of the actual speed.

Note:
1 / Although it is possible to work in all directions, if you use the radar Graves, point your antenna to the south.
2 / With the radar Graves, and from Brittany, I could hear the echoes on the moon and ISS. See the folder on Graves cited above.

Dont' miss visiting the site of Miguel EA4EOZ here this is a good source of fresh information

The Milky Way and the line H²

Equipment used; parabolic dish
Frequency: 1.4 / 1.5 GHz

Difficulty : easy to moderate

To examine the Milky Way we have several possibilities:

In a narrow spectrum: The spectral line of hydrogen of 1420 ... 1421 MHz

In a wider spectrum: thermal emission: the dispersion of free electrons in the ionized hydrogen produces a thermal emission spectrum which can be either constant or fallen out of the frequency band as a function of t° of the gas.

Synchrotron emission: generated by electrons moving at a speed close to that of light in a magnetic field, giving a non-thermal spectrum whose intensity increases with the wavelength

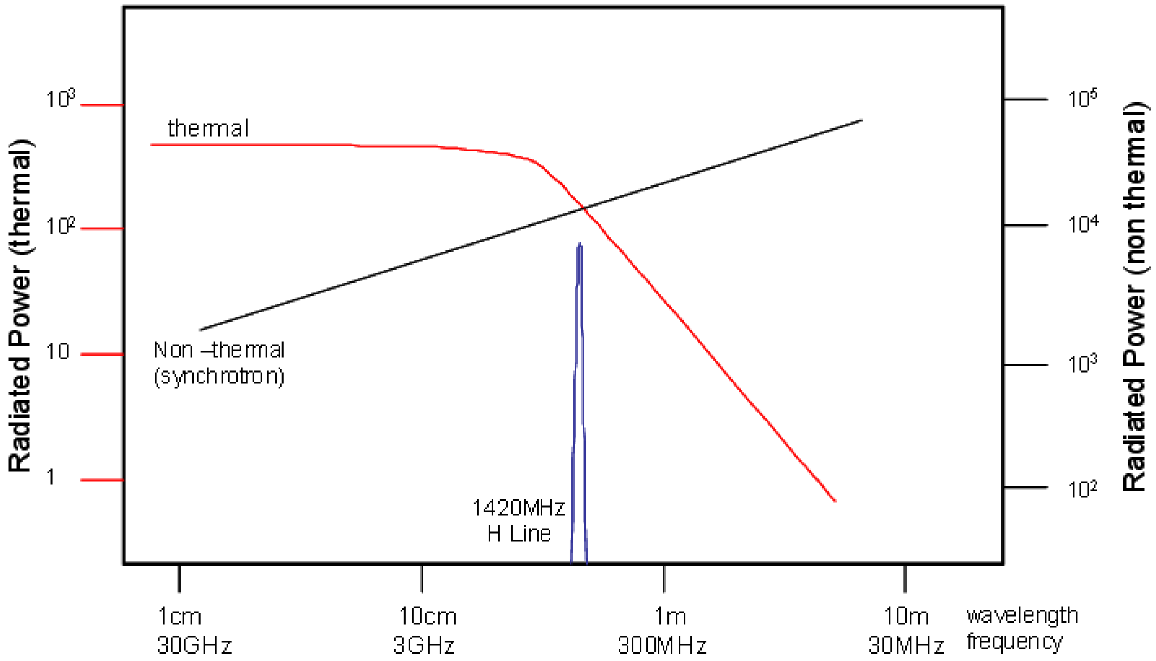


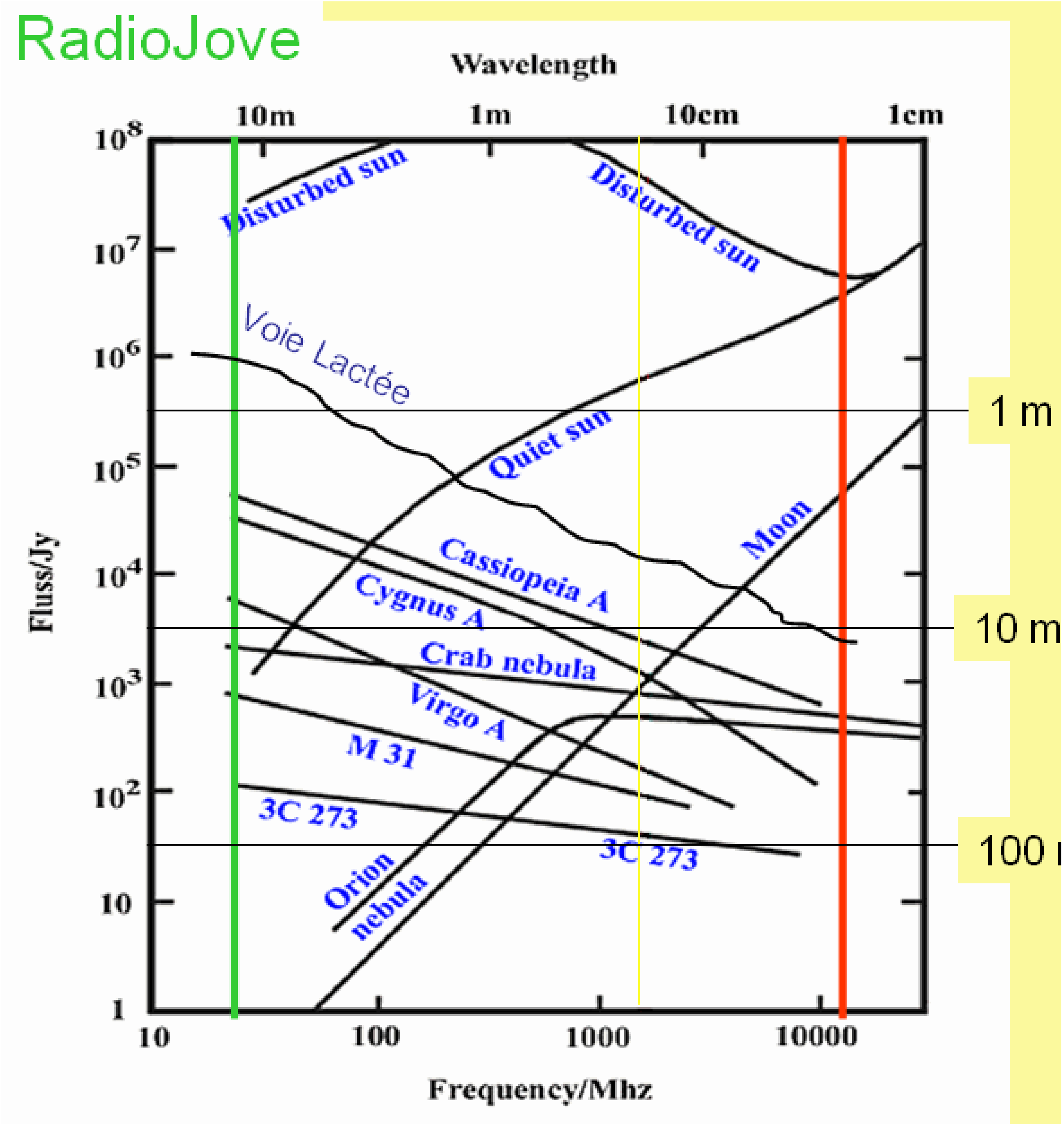
Figure 1 - Typical Radio Emission Spectra (following Hay 1971) [2]

Both mechanisms produce large radio spectra - see Figure 1 and are quite distinct from the narrow band of the spectral line 'produced by the emission of neutral hydrogen (blue). To measure the emission broadband 1450MHz and the issuance of the spectral line at 1420 MHz is to examine how these sources vary in intensity and position in our galaxy.

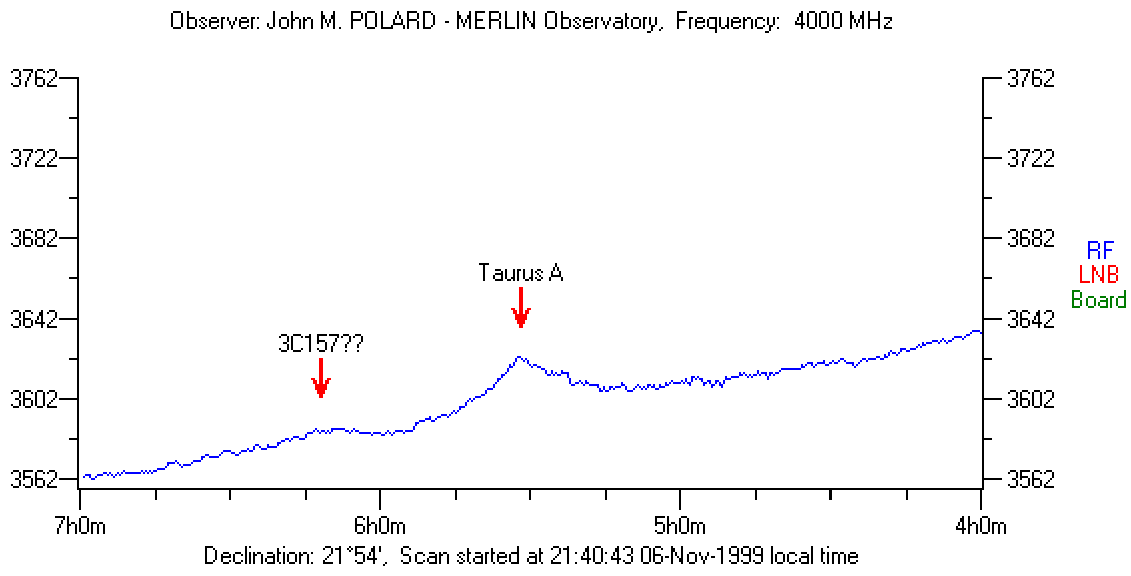
Visit also this nice site : http://www.y1pwe.co.uk/RAProgs/index.html

This frequency was chosen to be sufficiently separated from the frequency of the hydrogen line and there would be no contribution from this source, but close enough that the same antenna head and the receiver configuration can be used to measure emissions of H^2 line and broadband. In addition it is also a "quiet frequency" and practically free from radio interference.

The powerful radio-sources



John Kraus (W8JK) gives a table with the main sources and depending on their frequency flow ... Jansky. We see that the higher the frequency and the flow decreases, except for the quiet sun and moon.



Below an example of a scan of the sky to 4 GHz showing two 'bumps' and the corresponding sources.

The HEP (high energy pulses)

A rather complex but not unfeasible project since it is the amateurs who mentioned these HEP for years. This would be done in short pulses appear to come from the center of the galaxy. Recent start of observations in the field gamma coming from the same region leave to assume that fans were right. To locate them, two or more stations will be interconnected (with internet it has become easier) and coordinate their actions. The description of this kind of study is beyond the scope of this book, but there are many websites that talk about it.

The Pulsars

Much more difficult, but not impossible. The signals are very low (<1JY) so for this application of satellite dishes of at least 10m, materials with very low noise and post processing software.

Here are some links for those interested. These sites are in English.

http://moetronix.com/pulsar/index.htm

http://www.k5so.com/Radio_astronomy_pulsars.html

http://i1ndp.altervista.org/pulsar.html

Note that in March 2016 one ham radio from France with a 3m dish recorded the stronger pulsar of the north hemisphere.

The VLF

A book is not enough to talk about the subject is so vast. But radio astronomy low or very low frequency is an exploration and field fans can make beautiful searches.

I refer you to some sites or interesting links (but not exhaustive) on this subject.

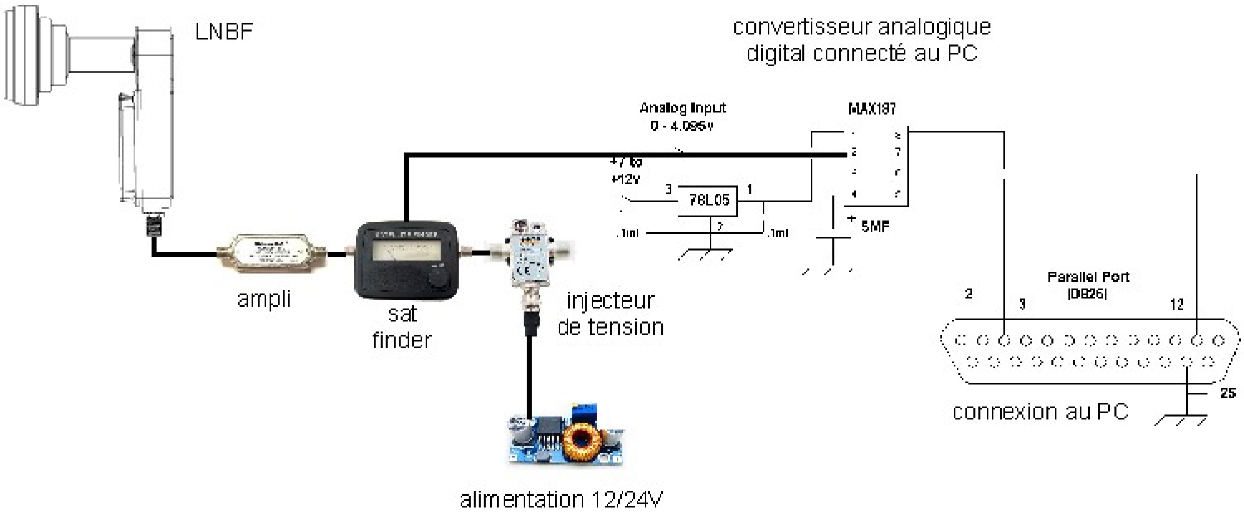
The www.vlf.it site is probably the bible on the subject, idem for the site Lionel Loudet on SID with a link here

I use a crossed loop antenna with 200 turns per branch, 4m circumference.

Once the tests are performed, it will be the time to come to talk in another syllabus.

A realization among others.

Schematic diagram



Purchasing Equipment

I give you below ideas about components, indication, no ads and no financial interest for me. Again, look on internet, search with Google and buy.

The LNBF

For 3,4-4,2GHz : http://www.ebay.com/itm/C1W-PLL-lite-C-band-LNBF-65db-Gain-Phase-Lock-Loop-Wideband-3-4-4-2GHz-LNB-/141465278659

For 10-12 GHz : http://www.ebay.com/itm/Universal-Single-Ku-Band-LNBF-0-2dB-FTA-Satellite-Dish-Liner-LNB-Bracket-Holder-/190965196625

For 2,1-2,3GHz : http://www.aliexpress.com/store/product/High-quality-MMDS-Down-converter-2-1-2-3GHz-With-1838MHz-For-Digital-TV/402505_1690180274.html

The amplifier

http://www.amazon.co.uk/Satellite-Signal-Amplifier-Booster-electrosmart%C2%AE/dp/B003S5LBVQ

The sat finder

http://www.ebay.com/itm/Digital-Satellite-Signal-Finder-Meter-Compass-FTA-TV-Signal-Receiver-Finder-UL-/161862710860?hash=item25afc4f64c:g:XuEAAOSwwbdWJJI3

The power supply

Check on Google : Velleman K1823

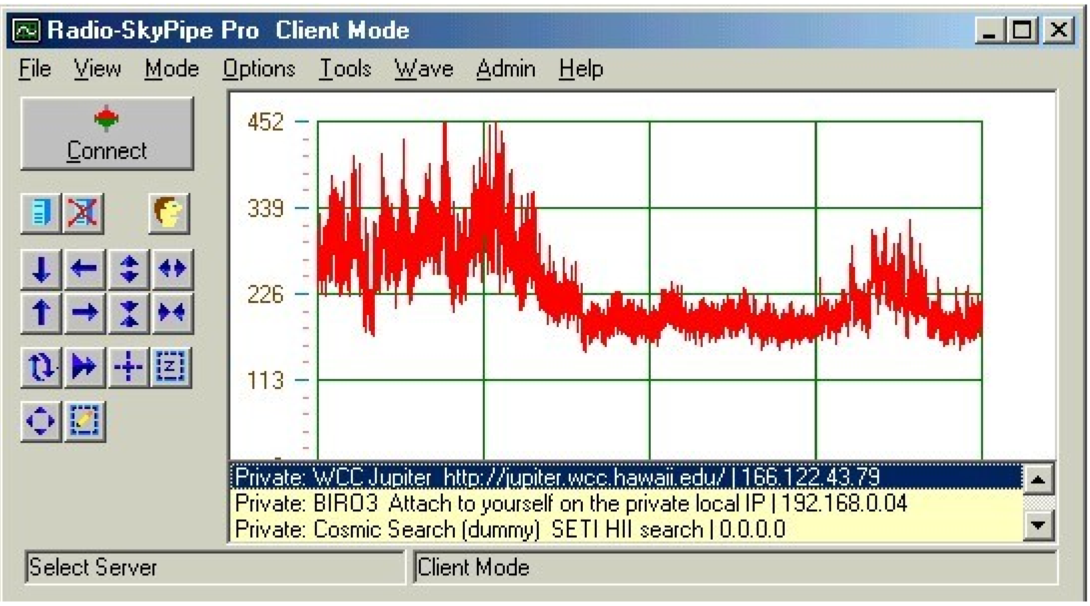
The analog digital converter

Check on google Velleman : http://www.velleman.eu/products/view/?country=be&lang=en&id=350526

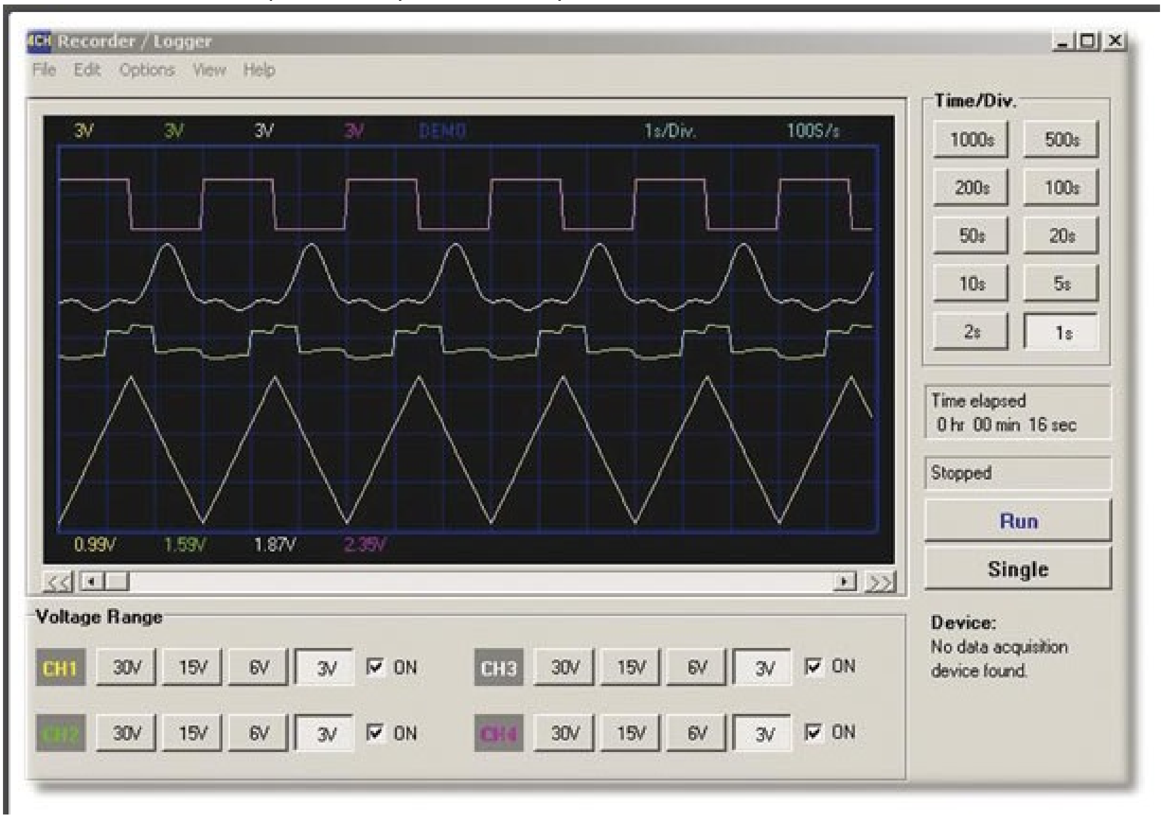
delivered with a free software

Tracing and recording software

Either at Radio Skypipe (one free version available) if you use interface built by yourself:



Either the software provided by Velleman if you use the interface card



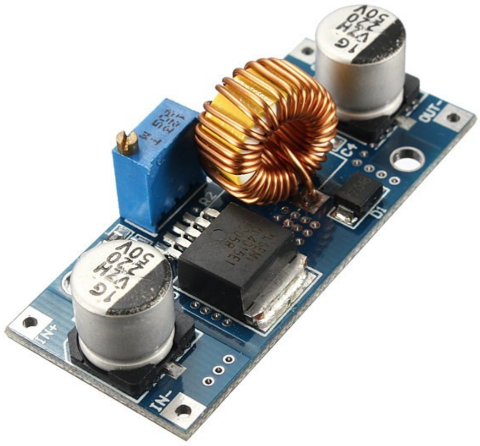
connections

Buy the satellite television and cable connectors and follow the procedure explained on this wiki

http://www.satcure.co.uk/tech/fplugs.htm#fit

power supply

About power supply, adjust the output voltage for 14V. You will also need a transformer to lower the voltage 230V to 30V so your module can get between 12 and 24V enough to use both bands with the LNBF, but this is not an obligation. A power supply of 14 or 15V will be enough.



Link : http://www.banggood.com/XL4015-5A-DC-DC-Step-Down-Adjustable-Power-Supply-Module-p-945599.html

First tests

Adjust satfinder mid coarse with the potentiometer. Apply voltage. If this does not smoke, point the LNBF to the ground and into the sky and see if the needle moves. If so, congratulations and welcome to the club. It only remains to mount the LNB on the dish and get started.

Some links to continue

Internet

our group on Facebook : https://www.facebook.com/groups/radioastro/

free pdf

A good book from J.S. Hey (1971)

https://ia700405.us.archive.org/21/items/TheRadioUniverse/Hey-TheRadioUniverse.pdf

Thank you for reading. You can share your experiences and ask your questions. f5vlb@kermaz.com