

The Upgrade Proposal for the VLBI Medicina Antenna

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Abstract. The demand of new enhanced performances in VLBI networks both in sensitivity and in frequency agility calls for an upgrade of the Medicina antenna. Increasing observing frequency, improving the G/T term, switching very quickly among frequencies are needed in radioastronomical field to improve the results and to manage efficiently the observations, both in VLBI and in single dish experiments. In the paper we speak about the various tasks and possible solutions, also adding some calculation about predictable efficiency and attempting to set the time schedule for the upgrading of the antenna.

1. Description

The 32 m Medicina antenna operates since a decade in VLBI networks and for single dish experiments. Many receivers were added through the years from low to higher and higher frequency values and the current availability and performance are showed in Table 1.

The need to change fast and automatically the observing frequency and the demand for a better performance calls for an upgrade of the antenna. Several upgradings need in order to extend the sensitivity up to 43 GHz and to switch among receivers in minutes or less, using a remote control system. A sketch of the job is depicted in Fig. 1. As you see this involves many tasks, having to be performed step by step as funds are available, and different solutions could be thought.

1.1 About increasing max frequency

The rms accuracy required to have a good efficiency at 43 GHz depends on panels accuracy, subreflector surface accuracy, and gravity deformation of the primary reflector. The first two items are “simple” from a technical point of view as high quality commercial reflectors are available today, although panel changing is quite expensive (some hundred thousand dollars).

One possibility is to change all panels (32 m). Alternatively only the inner 25 m could be changed, underilluminating the dish at 43 GHz. In this case the surface has a lower amount of deformation. Also, because of the larger beam, there is less power loss due to pointing error. However, in both cases gravity deformation effect, a primary cause of efficiency loss, have to be overcome. A possibility is to use an active surface, to maintain the parabolic shape of the reflector by moving each panel as the antenna elevation changes. An in depth examination has to be done about this

Table 1. 32 m dish Medicina receivers.

Secondary focus mounting		Polariz. channels	Cooled?	Hemt?	λ/D	Measured HPBW N/S E/W	Gain (K/Jy)	Eff.	Tsys (°K) at zenith L R	Bandwidth (GHz)
22 GHz	1.3 cm	L	Y	Y	1.4'	1.7'	.11	38%	120	22.18-22.46
12 GHz	2.5 cm	L & R	N	Y	2.7'		.13	45%	194	12.028-12.328
5 GHz	6 cm	L & R	Y	Y	6.4'	7.5'	.16	58%	46	4.70 - 5.05
1.6 GHz	18 cm	L & R	N	Y	19.3'	21.9'	.10	35%	100	1.622 - 1.702
1.4 GHz	21 cm	L & R	N	Y	22.6'				100	1.363 - 1.443
Primary focus mounting		Polariz. channels	Cooled?	Hemt?	λ/D	Measured HPBW N/S E/W	Gain (K/Jy)	Eff.	Tsys (°K) at zenith L R	Bandwidth (GHz)
22 GHz	1.3 cm	L&R	Y	Y	1.4'	2.0'	.11	38%	103	21.86-24.14
8.3GHz	3.6cm	L&R	Y	Y	3.9'	4.8'	.14	48%	39	8.18-8.58
2.3GHz	13cm	L&R	Y	Y	14'	18.6'	.13	45%	50	2.20-2.36

*LNA noise degraded. It shall be changed.

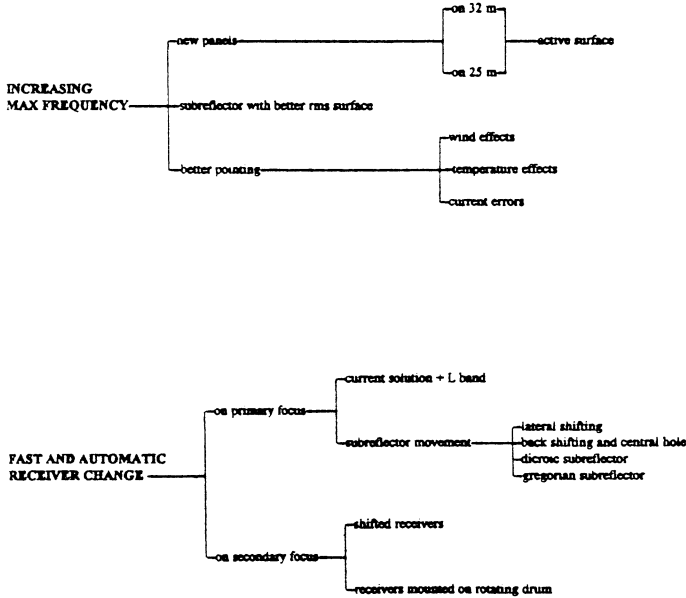


Fig. 1. The upgrade scheme.

not easy problem because it involves up to hundred of actuators so their reliability and the network to the remote control system must be well fixed.

Another very important problem is the efficiency degradation due to pointing errors. The HPBW (half power beamwidth) of the dish is 52 arcsec at 43 GHz while the usual rms pointing error (non systematic) is 15–20 arcsec (the value depending on actual operating conditions, such as temperature, and wind). The possibility of modelling the errors or a real time correction must be investigated. Currently, temperature sensors (PT100) are located on antenna legs and one inclinometer is mounted on truss under elevation encoder and another one on elevation bearings truss. One inclinometer detects relative to elevation direction and the other one to cross-elevation direction. The recording was done in winter and another one in summer (not reported here), both keeping the antenna in stow position. As you can see in Figs. 2 and 3 a large amount of inclination arises whenever legs temperature difference exists. Tight linear correlation is found between the elevation direction inclinometer (EL) and the temperature difference of the two legs “looking” the same direction (Fig. 2). It is not so for the other inclinometer (XEL) and the couple of legs placed at north or south (Fig. 3). In EL direction the amount of inclination is about 35 arcsec for 2.2 degree of temperature difference, or 23 arcsec for 1.4 degree that gives 16"/degree.

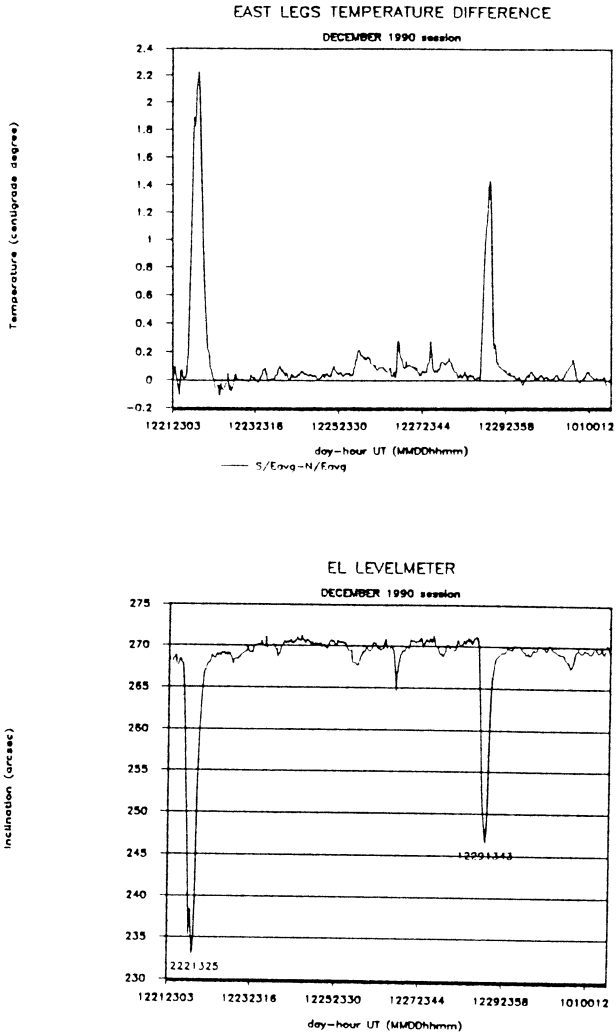


Fig. 2. Inclination versus temperature in el direction.

1.2 About fast and automatic receiver changing system

In order to facilitate the use of current and future receivers in the secondary focus of the antenna we plan to have the possibility to change receivers without dismount them. The bottleneck is the huge 1.4/1.6 GHz horn. Thus, the upgrade procedure starts designing an L band receiver for the primary focus. For this purpose we will place it in the existing box that contains the other primary receivers (in the S, X, K bands). As a second step, all the secondary receivers will be mounted into

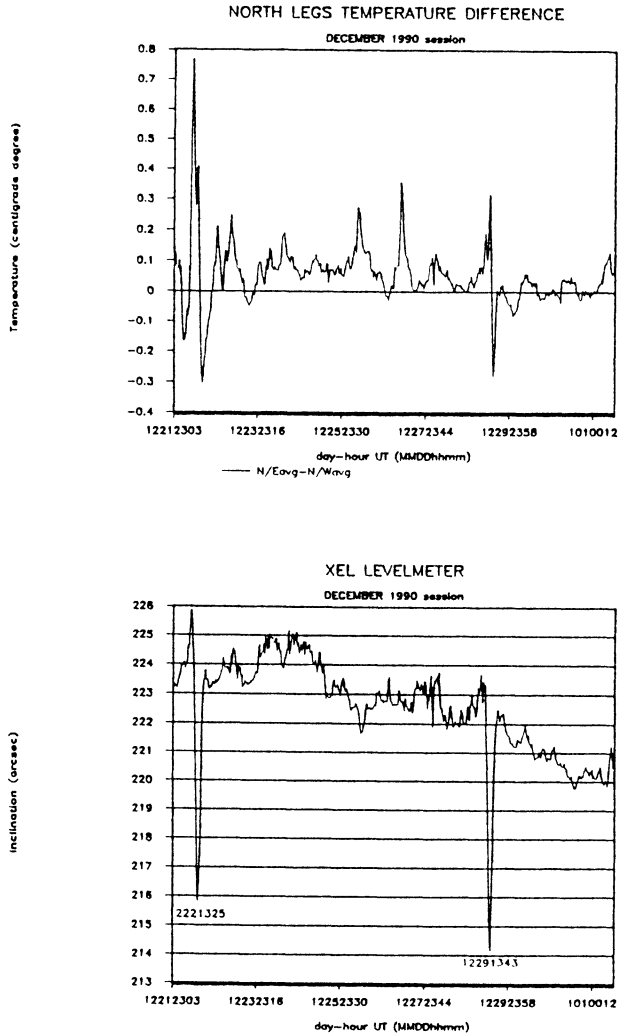


Fig. 3. Inclination versus temperature in cross-el direction.

the vertex room (3 m × 3 m large), each slightly shifted respect to antenna phase center, with the feeds lying in a circle on the phase plane. The five position axes of the subreflector shall move in order to match the position of the feed to be used. We discarded another possible solution, to mount the receivers on a rotating drum, maintaining each of them in the phase center. This is more complicated and expensive, use only half of the room available and gets problems to manage cooling helium tubes.

The completion of the receivers automation needs to set aside the subreflector, avoiding to dismount it when primary focus receivers have to be used. This is the more difficult step because a disk of 800 kg and 3.2 m in diameter has to be moved. In principle, different ways exist (Fig. 1). The solution seems to fit our antenna is the lateral shifting, or using a Gregorian subreflector. Anyway, the substitution of the subreflector moving parts (lighter than now) and the rearrangement of some mechanical parts on primary focus cannot be avoided.

2. Forecasts

In this paragraph we give the sensitivity expected at 43 GHz for the present setup and for the proposed upgrade.

Currently, expected efficiency ranges from 0.09–0.1 to 0.17 depending on antenna elevation. This corresponds to an antenna gain in the range 0.029 K/Jy–0.05 K/Jy, a very poor gain, usable only for very strong signals. 43 GHz receiver tests confirm these numbers.

On the other hand, using new panels with 0.12 mm rms and a subreflector surface of 0.1 mm rms we could expect an efficiency ranging from 0.15 to 0.33–0.34 (0.04 K/Jy and 0.1 K/Jy). That is about the same gain we currently have at 22 GHz. These numbers increase if an active surface and some form of pointing control are implemented; in this way the antenna should be used at full efficiency (about 0.5).

The proposal is also a chance to improve the general performances of the antenna on the various bands. For example, the new L band receiver will show better performance than the old one and we expect about 0.5 efficiency and 50 K noise temperature (see the old one performance in Table 1). It will not be cooled, but it will be when the new secondary focus setup will be ready.

The upgrade time schedule depends on several factors including funds availability and manpower constraints. At the moment the L band receiver design has started and another 43 GHz receiver is in progress. Possibly, next summer we will substitute the antenna rail and repaint the antenna structure. We hope to have the vertex room setup for the end of the same year, as well as the receivers. At that moment, 1995, the panels substitution and subreflector matter will be topical.

3. Figures Explanation

Table 1 shows many information about Medicina frequencies. You should note two 22 GHz receivers. When automatic secondary focus will be ready the primary one will disappear to leave room for a cooled L band and the secondary one will be upgraded (two polarization channels). Beside the measured HPBW the beamwidth for uniform illumination is reported to give a feeling about actual illumination. Normally primary focus feeds exhibit larger edge taper to save spillover effects from ground temperature.

In Figs. 2 and 3 temperature and inclination are reported versus the acquisition date and time. For example, 12212303 means December, 21 at the 23:03 (UT time), or 1010012 means January, 1 at the 00:12.