

RFI SELECTION CRITERIA FOR NEW RADIOTELESCOPES

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Abstract: Man made Radio Interferences are still one of the major threats in the selection of sites suitable for the installation of new radio telescopes. The use of a mobile station to monitor spectrum occupancy can help in recognizing and identifying the most intense sources of interference, coming in particular from terrestrial transmitters. However many more actions should be taken in order to reach the level of radio quietness required by the class of new radio telescopes planned to become operational in the years 2010-2020.

Planning for such measurement campaigns requires many trade-offs in order to collect, in a reasonable amount of time, a meaningful set of data, suitable to characterise each site. Finally even the interpretation of such database needs particular attentions because it could be easily misinterpreted by judges a priori biased in favour of one site respect to the other.

Keywords: frequency management, site surveying, RFI monitoring, new radiotelescopes.

1. INTRODUCTION

Radio astronomers have developed very exciting projects for the new instruments of year 2005-2010-2020. These instruments, using new technologies, are currently in the commissioning stage or even in the design and construction phase. The antennas range from single dish telescopes (fully steerable, about 100m in diameter) like the GBT [1] (the Green Bank Telescope) or the smaller SRT [2] (the Sardinia Radio Telescope), to systems with tens of clustered stations with even larger collecting areas, each made by elementary apertures all combined together, like in the SKA (the Square Kilometre Array) [3] or one of its test beds, LOFAR (the Low Frequency Array) [4].

The frequency coverage of such instruments spans across the whole radio spectrum, from as low as 10 MHz and up to about a THz like ALMA [5] (the Atacama Large Millimeter Array).

2. RADIO TELESCOPES/TECHNICAL CHARACTERISTICS

These new instruments use cutting edge technologies for achieving many different strategic objectives at the same time. We list here only some of them. The acquisition of the final radio astronomical observables

can be speed up by the multiple and instantaneous receptions of many different beams that are synthesized from the same array of antennas. System sensitivity can reach quasi the quantum limit by top performance radio receivers cryogenically cooled at front ends. The antenna gain variation with the pointing Elevation angle can be greatly reduced by optically scaled countermeasures like the active and adaptive mirror compensators. Finally the extremely high phase stabilities (spectral purity) now achieved by locking the local oscillators to atomic frequency standards can make possible to integrate cosmological signals over hours and up to hundred of GHz of sky frequencies.

Since radio telescopes are often interference-limited, many of these smart technologies still find in handling correctly the radio interference, RFI, their most challenging demands. The more than enormous difference in power levels between the natural signals coming from the Universe (or even its contour when it was at the initial state) and the locally produced manmade transmissions impose the development of new design strategies like robust (high dynamic range) receivers, data collection free from artefacts and mitigation algorithms.

3. NEED FOR PROPER SITE SELECTION

As far as the sensitivity of the new radiotelescopes improves the harder becomes the effort to find suitable sites where they can take full advantage of those technologies.

Beyond the first order constraints related to the obvious logistics and operational requirements, in particular avoidance of harmful interference becomes a selection criterion that is difficult both in the implementation and interpretation.

A radio telescope is designed and built to achieve a sensitivity to guarantee adequate data quality necessary for the research projects which are undertaken with this instrument. Only when the final radiotelescope will be fully operational one would achieve the sensitivity level suitable to judge the real degradation of these observational data due to the RFI. This scenario can of course not fully be taken into account in the design phase of the instrument. Since a radio telescope is not meant to be an instrument to monitor spectrum occupancy, all efforts must be made to provide the radio astronomers with an instrument

with which real science with the required quality can be made.

As a matter of fact the sensitivities for which the new instruments are designed and built are a few orders of magnitude better than those outlined in Recommendation ITU-R RA.769-1 that gives the protection criteria for radio astronomy. These sensitivities are so high that only under very special conditions they can be reached with the simpler antennas and receivers, that can be used in a preliminary selection campaign.

The interference scenario of transmissions from space differ fundamentally from that due to terrestrial or aeronautical interference. Considering that the interference produced by satellites is almost site independent, a realistic approach for the selection of the best site relies on measurement campaigns with a mobile unit, equipped for identifying only terrestrial sources of interference.

One of such units has been extensively used for the site selection of the SRT (Sardinia Radio Telescope) [6], and a similar one is under development for the SKA project. In this case a dedicated working group has planned a rather extensive survey, both at high and intermediate level of RFI [7].

4. SITE SELECTION

Having the information of the radio environment of different potential sites, a selection needs to be made from this information. Obviously, the interpretation of the spectrum monitoring measurements is not free from uncertainties.

They are mainly due to the limited amount of information collectable in a reasonable amount of time at any of the sites, proposed as possible alternatives. Radio interference is usually the result from the contributions from an aggregate of interfering signals with various levels. The limited sensitivity of these measurements and now the wide range of possible signal coding used by each interferer, very often do not allow to recognise the identity of each single interference.

When this is possible instead, some countermeasures can be devised at the most appropriate level. In the most simple cases, it can be simply a direct negotiation with the active user or it can require the most tedious reaction through the higher level of the Frequency Management authorities.

Sometimes the use of a mobile or a mobile station can help a lot such work of identification. Operations like triangulation, careful sight seeing, even asking the local inhabitants can be the crucial tool in such cases.

At this end it is wise to travel across the radio horizon as seen from the new telescope site and further away up the transmitting installations located on top of the higher nearby mountains

Depending on the radio frequency, also additional aspects require attention, such as:

- the anomalous propagation conditions, like troposcatter, E-sporadic reflections, superrefraction

and others, for evaluating in a statistical sense the degradation to the radio astronomy service

- the possible development of the scenario concerning the interfering transmitters in terms of developments of power level and bandwidth extension, at the time of the operational lifetime of the radio telescope

it will be possible to make reasonable estimates of what site that can be considered for the most interference-free location or the “less worst”.

5. CONCLUSION

The successful utilization of the newest radiotelescopes, at the level of efficiency they were planned to operate, requires many different strategies before and after their design phase: regulatory aspects [8], radio quiet zones [9] are crucial in these respects as well as a careful choice of the site where they will be installed.

6. REFERENCES

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BIOGRAPHICAL NOTES

Dr. Roberto Ambrosini, since January 2004, is chairman of the Committee on Radio Astronomy Frequencies of the European Science Foundation, CRAF. His research experience is in the field of tests of General Relativity by Doppler tracking of interplanetary spacecraft, being member of the Radio Science Team of the Cassini mission. He participated in the design and technical development of the cryogenic receivers and Time & Frequency stations of the Italian VLBI radiotelescopes at Medicina, Noto and now as Project Team member of the SRT (Sardinia Radio Telescope). He can be reached at: Istituto di Radioastronomia, CNR, via Gobetti 101, 40129 Bologna, (I) tel.: +39-051-6399361, telefax: +39-051-6399431, email: ambrosini@ira.cnr.it.