Mem. S.A.It. Vol. 75, 282

Memorie della

The working group "Science with the SRT": tasks, activities, and results

I. Prandoni[1], M. Felli[2]

[1] INAF - Istituto di Radioastronomia, Via P. Gobetti 101, I-40129 Bologna
[2] INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze

Abstract. The Working Group *Science with the SRT* was formed in May 2004, with the aim of providing scientific input to the Board of the SRT, in order to plan the focal plane instrumentation development of the SRT. In the present contribution, tasks and activities of the Working Group are outlined, and the main indications and results are briefly summarized. For a detailed discussion we refer to the IRA Internal Report *"The Sardinia Radio Telescope (SRT). Science and Technical Requirements"* produced by the members of the Working Group.

1. The Working Group

In May 2004, the then-director of the INAF - Istituto di Radioastronomia, Prof. G. Tofani, asked eight researchers to form the Working Group (WG) *Science with the SRT*, which was given the task to outline scientific programs that could be carried out with the Sardinia Radio Telescope (SRT), and to describe the technical requirements necessary to lead these projects to a successful outcome.

The WG was chaired by Marcello Felli and consisted of Jan Brand, Paola Caselli, Karl-Heinz Mack, Sergio Poppi, Andrea Possenti, Isabella Prandoni and Andrea Tarchi.

The installation of a working group was deemed necessary by the Board of the SRT, three years after the SRT Symposium held in Cagliari in November 2001 (D'Amico et al. 2003), in order to present a selection of projects that could maximize the scientific output of the SRT and render it competitive in an international context.

This input (as well as the Symposium mentioned above) would represent a useful guideline for the Board to take decisions about the first-phase focal plane instrumentation, as well as for future developments and requirements.

A working group consisting of several researchers, working in Italian institutions and active in a variety of astronomical fields, should guarantee a wide and unbiased picture of the optimal use of SRT in a scientific framework that should represent as far as possible the real scientific interests of the Italian community. In fact the SRT is a national project, which, in the next years, will absorb a significant fraction of the budget of the Istituto Nazionale di Astrofisica (INAF). Therefore it is important that such a new facility, once operational, will meet the wide-spread interests of the Italian community.

2. The WG's tasks and activities

The WG was asked to:

- survey the various astronomical interests of the Italian community and take them into account in addressing the possible use of the SRT;
- provide a link between the various groups (GAI[1]) involved in the technical development of the SRT and the scientific community interested in the use of the SRT;
- finalise the receiver/backend development of the SRT to the most competitive and useful use of the SRT itself, taking into account also the international framework of the other existing (or up-coming) single-dish large-aperture radio telescopes.

With this in mind, the WG decided to organize its work in two steps: a) the production of a written report; b) the organization of a national workshop.

Both the Report and the Proceedings of the workshop are intended to be used as reference by the Board of the SRT (and/or by the INAF itself) in taking decisions about the future receiver/backend development of the SRT.

3. The Report

The report, entitled *"The Sardinia Radio Telescope (SRT). Science and Technical Requirements"* (Brand et al. 2005), presents a series of feasibility studies related to possible scientific projects that can be carried out with the SRT, together with several general indications and requirements, which were recognized as important by the WG. The goal is to provide a rather complete reference frame which can be used as a guideline in taking decisions on the best telescope use and instrumentation development.

The emphasis of the Report is on scientific themes and on the general features of the equipment necessary for successfully investigating them. In particular, sensitivity and observation-time requirements are outlined, whereas technical details of the antenna performance and focal plane instruments, beyond the scope of the Report, are described only in rather general terms. Also, most emphasis has been put on a single-dish use of the telescope, since the use of the SRT as part of the VLBI network should, at least in part, be established at an international level.

Right from the start, it was felt by the WG that the Report should not describe *all* possible scientific uses of the SRT, but only those that reflect *real* interests in the Italian scientific community. Behind each scientific project presented in the Report, there should be a group of researchers ready to actively work with the SRT once it becomes operational.

In other words, the Report reflects the desires of the Italian scientific community, and is the result of the widest possible collaboration among the members of that community. For that reason, the Report is not only the outcome of the efforts of the WG, but also includes contributions from outside groups, especially for those areas of interest which were not adequately represented within the WG (e.g. planetary astronomy, VLBI, geodesy and Radio Science).

The production of the Report went through different phases. As a first step the WG decided to take a census of the Italian astronomers and technologists possibly interested in the SRT project. The mailing list thus created was used to distribute information about the SRT and to call for new ideas and inputs to the WG's work. A first draft of the Report was then produced by the WG and distributed to the community, which was in turn invited to provide feed-back and new contributions, to be implemented in following versions.

The response of the community has been very positive. Also very fruitful has been the interaction with the the GAI-group headed by A. Orfei, responsible for the SRT receiver development, that allowed to link the community's instrumentation requirements to the actual development plan and to the actual performance expectations.

In its final form the report has been published in January 2005 as IRA Internal Report IRA 371/05 (Brand et al. 2005[2]).

[1] Gruppi di Attività Integrata, see `http://www.ca.astro.it/srt/people.htm`

[2] The Report is available on the web at `http://www.ca.astro.it/srt/index.htm)`

4. The Workshop

The organization of a national workshop was the second step of the WG’s activity. The main purpose of this workshop was to raise the awareness of the Italian astronomical community of the fact that in a few years a large (64-m) state-of-the-art radio telescope would come into operation, for which it is important to think about its potential use in ways that can advance astronomical (and geodetical) research both on a national and international level.

The national workshop *Science with the Sardinia Radio Telescope* was held in Bologna (Italy) on May 10-11, 2005. The workshop was very successful, with more than 100 participants, both scientists and engineers, demonstrating that behind the SRT telescope there is a wide community interested in both developing and using it, once it will be operational.

The direct aim of the Workshop was for the astronomers to show the science that can be done with the SRT, and to specify the instrumentation needed to successfully carry out the various projects, and for the engineers to outline the technical possibilities both present and future.

In general, presentations from new groups, whose work was not already included in the Report were priviledged. In this sense the Workshop (and the present Proceedings) can be considered complementary to the Report itself.

The Workshop also represented a good opportunity to discuss various technical, organisational, and financial aspects of the SRT project, in the presence of both the INAF management and the Board of the SRT.

5. General Indications from the WG

The first clear indication that emerged from the WG’s activities is that the number of possible scientific uses of the SRT is large, as reflected by the wide-spread interests of the Italian community. Examples are given in Table 1 (taken from the Report), where for each possible receiver band the proposed scientific projects included in the Report are listed, with the requested backend and receiver type indicated. Both low- and high- frequency bands and both single-dish and VLBI observing modes are requested, even though there is more pressure for a single-dish use of the SRT at frequencies $\geq$ 20 GHz.

While the SRT is a general-purpose radio telescope, capable of operating with high efficiency from 300 MHz to over 100 GHz, it is clear that priorities have to be established in the SRT receiver/backend development, which would optimise the scientific use of the telescope and fully exploit the SRT capabilities. In this respect it is very important to consider the SRT in comparison with the other existing or up-coming competitor telescopes.

The SRT’s natural competitors are: the Parkes telescope (64-m, Australia), the Effelsberg telescope (100-m, Germany) and the Green Bank Telescope (100×110 m^2, United States). However, in the 3-mm band, the SRT also has to compete with large-aperture mm-telescopes, like the IRAM 30-m, the Nobeyama (NRO) 45-m telescope and the forthcoming Large Millimetre Telescope (LMT, 50-m, Mexico).

A description of the SRT’s design and technical specifications can be found in e.g. Olmi & Grueff (these Proceedings), while a summary of the SRT’s most relevant features is given below:

- large aperture: 64-m;
- great versatility: 300 MHz - 100 GHz and 3 focal positions (Primary, Gregorian, Beam Wave Guide);
- active primary surface: maximum expected antenna efficiency from $\sim$ 65% (at 10 GHz) to $\sim$ 35% (at 100 GHz);
- shaped primary and secondary reflectors: minimization of spillover and multiple reflections;
- good site quality: low radio frequency interferences; low wind speed ($< v >=$ 4m/s); low humidity for a consistent fraction of the time.

A general comparison between the SRT and the other competitor radio telescopes is given by Possenti (these Proceedings) and by Cenacchi (2005). A more specific discussion of the SRT's performance in the 3-mm band, in comparison with other mm-telescopes, is presented by Olmi (these Proceedings).

Establishing priorities for the receiver/backend development was beyond the scope of the WG, but it appears clear to the WG that new competitive opportunities for the SRT can be opened only following these general criteria:

- for single-dish applications:
  – use of the SRT at the highest possible frequency;
  – implementation of multi-beam arrays;
  – use of bandwidths as large as possible, for the continuum and for spectral line work, so that more lines can be observed simultaneously, either over a large bandwidth at low resolution or at higher resolution by centering several smaller bandwidths around different frequencies;
  – spectroscopy (galactic and extragalactic) in non-standard bands;
  – *ad hoc* hardware for lower-frequency projects (as for instance pulsars, polarimetry);

- for VLBI:
  – non-standard frequencies;
  – frequency agility;
  – Mark V;

- for geodesy:
  – SX receiver systems;
  – Mark V;
  – co-located GPS;

- for radar:
  – radar transmitter;

- for Space Science:
  – Doppler tracker.

Other general requirements that the WG has indicated as being very important for an efficient use of the SRT regard technical issues like specific hardware and software development and site monitoring and calibrator observing campaigns. Other important issues that could have an impact on the scientific output of the SRT and should be taken into account by the Board of the SRT or by the INAF, regard policies and strategies that should be applied to the use of the SRT. A selection of the afore-mentioned issues and requirements are (for a more detailed discussion see Brand et al. 2005):

– scheduling strategy: few key-projects vs. many small-sized projects; dynamical scheduling at high frequency (see also Possenti, these Proceedings);
– observing strategy: remote vs. on-site; dedicated staff vs. assistant operators;
– calibration strategy: routine calibration plan vs. single user calibrations;
– data archiving strategy;
– observing and reduction software development;
– training of young researchers, system scientists and telescope operators.

References

Brand J., Caselli P., Felli M., Mack K.-H., Poppi S., Possenti A., Prandoni I. & Tarchi A. (Eds.) 2005, *The Sardinia Radio Telescope (SRT). Science and technical requirements*, IRA Internal Report 371/05

Cenacchi E. 2005, Laurea Thesis, Università di Bologna (Italy), available at `http://www.ca.astro.it/srt/index.htm`

D'Amico N., Fusi Pecci F., Porceddu I. & Tofani G. (Eds.) 2003, *SRT: The Impact of Large Antennas on Radioastronomy and Space Science*, Procs. of the SRT Symp. held in Cagliari (Italy) on Nov. 7-10, 2001, Conf. Procs. Vol. 81 (SIF)

Table 1. For each planned receiver band this table identifies the projects (among the ones presented in the Report) that use it, together with the backend and receiver type (see Table A.4 of the Report).

Planned RXs Bands vs Requested Projects			
Planned RF Bands (GHz)	*Requesting Projects*	*Requested Backend*	*Requested RX*
0.31÷0.35	Pulsar VLBI	Spectrometer MK5	Monofeed
0.58÷0.62	VLBI	MK5	Monofeed
0.7÷1.3	VLBI	MK5	Monofeed
1.3÷1.8	Maser ISM Mol. Active Binaries Pulsar Extragal. HI VLBI SETI	Spectrometer Total Power MK5	Mono/Dual Multifeed
3.22÷4.3	Pulsar Active Binaries SETI	Spectrometer Total Power	Mono/Dualfeed
4.3÷5.8	ISM Mol. Active Binaries CMBP Extragal. RM VLBI SETI	Spectrometer Polarimeter Total Power MK5	Monofeed
5.7÷7.7	Active Binaries VLBI SETI	Spectrometer Total Power MK5	Monofeed
2.3/8.4	VLBI Planetary Radar	Spectrometer MK5	Monofeed
10.3÷14.4	Maser ISM Mol. Active Binaries Blazar Monitoring Comets	Spectrometer Total Power Polarimeter	Mono/Dualfeed
14.4÷19.8	ISM Mol. Megamaser H_2O Active Binaries VLBI Blazar Monitoring Comets	Spectrometer Total Power MK5 Polarimeter	Mono/Dual/Multifeed

Table 1. Continued.

Planned RXs Bands vs Requested Projects			
Planned RF Bands (GHz)	*Requesting Projects*	*Requested Backend*	*Requested RX*
18÷26	Maser Gal. NH_3 ISM Mol. Megamaser H_2O Extragal. sky survey Extragal. source survey Extragal. GRG VLBI X-ray Binaries Protostar Blazar Monitoring Sunyaev-Zel'dovich Comets	Spectrometer Total Power Polarimeter MK5	Mono/Dual/Multifeed
26÷36	ISM Mol. Active Binaries Extragal. CO Extragal. sky survey Extragal. source survey Extragal. GRG Blazar Monitoring Planetary Radar	Spectrometer Total Power Polarimeter	Mono/Dual/Multifeed
35÷48	Maser ISM Mol. Active Binaries Extragal. CO Extragal. survey Extragal. source survey VLBI Protostar Blazar Monitoring Sunyaev-Zel'dovich Comets	Spectrometer Total Power Polarimeter MK5	Mono/Dual/Multifeed
70÷90	DCO^+, N_2D^+ ISM Mol. Extragal. CO Extragal. source survey VLBI Protostar Blazar Monitoring Comets	Spectrometer Total Power Polarimeter MK5	Mono/Dual/Multifeed
90÷115	ISM Mol. Extragal. CO Blazar Monitoring Comets	Spectrometer Total Power Polarimeter	Mono/Dual/Multifeed