EUROPEAN SCIENCE FOUNDATION
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CRAF NEWS

Expert Committee on Radio Astronomy Frequencies (CRAF)

Editorial

Astronomers learn as undergraduates that the albedo (= reflectivity) of a planet or moon has a decisive influence on its surface temperature. They also learn that even trace amounts of certain gases change the reflectivity of an atmosphere and, as a consequence, the thermal balance and surface temperature. This is also true for our planet, where a big rise in the carbon dioxide content of the atmosphere will have as a consequence a corresponding rise in average temperatures, as was pointed out in 1900 by the great Swedish scientist, Svante Arrhenius.

A rise in carbon dioxide has already taken place, and the inexorable rise in average global temperature with probable catastrophic consequences for mankind is already happening. Many people, but scientists in particular, are aware of these dangerous prospects and are therefore dismayed with the failure of the Copenhagen climate summit (and the political process in general) to take effective measures for the prevention of a further rise in atmospheric greenhouse gases, and carbon dioxide in particular.

We know that without sufficient energy our civilisation would collapse with dire consequences for all of us. Radio astronomy isn't conceivable without electricity and, knowing that, radio astronomers welcome the use of renewable sources for electricity generation. The new SKA observatory will be located in a remote desert location and solar power is planned to be the major source of energy for the observatory. However, most of the European countries that have radio observatories on their soil are not blessed with so much sunshine. On the other hand, they quite often have plenty of wind. It is therefore sensible to harvest wind power and radio astronomers are seeing that as a move in the right direction. Modern wind power generators are huge structures, nearly 200 m tall in some cases, and many people, even those who welcome renewable energy, react with 'but not in my back yard' when a wind park is to be built close to their homes.

Radio astronomy stations all over Europe are now facing exactly the same situation. Observatories are often in remote and sparsely populated parts of the country, and wind parks are now being planned to be built very close to them. It is known that large structures reflect emissions from terrestrial radio stations, and the not inconsiderable electric power which is generated does not come without significant radio interference. Both may or may not affect a radio observatory's ability to operate. It depends a lot on local conditions and the construction details of the wind power plant. As scientists, radio astronomers cannot afford to be hypocrites and say 'no wind power here', but of course they need to make sure that they can continue to observe without interference.

A local planning process with rules that take into account the vulnerability of radio astronomical observatories, the expected radio emissions and reflections from the wind park, and their shielding by topography and distance is the rational solution to the question of how science can continue to provide answers for us without the destruction of the environment on which all depend for survival. Planning procedures are already in place in most countries for other aspects of modern life that could harm the operation of a radio observatory by causing radio interference. Examples are nearby transmitting stations, industrial plant and local housing developments. However, having wind parks near radio observatories is a very recent development which has not been anticipated by industry, planning authorities and administrations. Time is running out, and we need to act speedily in having a constructive dialogue with the wind power industry and administrations in order to formulate a set of rules that will enable us to have renewable energy generation and sustainable radio observations in the same region at the same time.

CRAF held its 50th meeting on 27-28 April 2010 in Onsala (Sweden) and a pre-meeting one-day discussion focused on this important issue. We cannot afford to imitate the political process and wait until it is too late.

Axel Jessner
CRAF Chairman

Report from the 49th CRAF meeting

The 49th CRAF meeting was held on 5-6 November 2009 at the Jodrell Bank Observatory of the University of Manchester (UK). The meeting was attended by 18 CRAF members and observers, among them John Ponsonby. The ESF was represented by Neil Williams.

Among the many different topics, the following key items were discussed during the meeting:

- **WINDMILLS:** A new document entitled 'Tall structures, wind turbines and radio astronomy stations' is now being produced. It contains an introduction, general information on Radio Astronomical Sensitivity and Interference levels, and finally provides an impact assessment procedure. The document has had a favourable reception by the German and Swedish administrations. Furthermore, during the last CEPT Spectrum Engineering Working Group, following a CRAF proposal, Sweden proposed a study on the potential interference to RAS observatories caused by wind turbines, with the aim of developing an ECC Report to provide guidance on the minimum separation distance between an observatory and wind turbines. This report could be used as a reference by radio observatories in their discussions with companies wishing to install wind turbines. The proposal was supported by Finland, Norway, the Netherlands and Switzerland. However, various concerns were expressed that the issue of interference caused by wind turbines is not strictly a compatibility issue within the scope of the SE WG. Even though this issue may be of interest to many countries, SE WG is not, in principle, entitled to develop any regulations applicable to wind turbines, since this is a purely EMC matter, which should be subject to discussion in the European Committee for Electro-technical Standardization (CENELEC). SE WG therefore decided not to create any formal work item on this issue, but invited the interested parties to discuss on an informal basis the protection of RAS from wind turbines at the next SE21 meeting, based only on written contributions. The outcome will be reported to the SE WG, which would then decide on possible future actions.
- **Third Workshop on RFI Mitigation in Radio Astronomy, 29-31 March 2010 (http://www.astron.nl/rfi/):** During this workshop participants were given a general overview on the regulatory aspects of spectrum management and, specifically, on the allocated bands to radio astronomy. This was aimed at making astronomers aware that over-optimistic claims about the effectiveness of new mitigation techniques can result in calls for the removal of spectrum protection for radio astronomy.
- **IRIDIUM:** The discussions held at various levels in CEPT have resulted in a new ECC/Decision (09)02 regarding "the harmonisation of the bands 1610-1626.5 MHz and 2483.5-2500 MHz for use by systems in the Mobile-Satellite Service", which was approved in June 2009. This Decision will replace the Decision ERC/DEC(97)03. In Decides 2 of this ECC Decision it is stated that "administrations shall not authorise operation of mobile earth stations operating under the control of MSS systems using downlinks in the frequency band 1613.8-1621.35 MHz (space-to-Earth) until compatibility with the radio astronomy service… has been demonstrated…". This represents the strongest CEPT position on this issue. Unfortunately, it has to be mentioned that during the entire process of producing this Decision at the various levels, the Spanish administration constantly expressed a negative position in relation to radio astronomy.

  The last ECC meeting in Skopje approved the "Decision(09)04 on the exemption from individual licensing and the free circulation and use of transmit-only mobile satellite terminals operating in the Mobile-Satellite Service allocations in the 1613.8-1626.5 MHz band". One of this decision's 'considerings' mentions the need for protection of radio astronomy operating in the adjacent band 1610.6-1613.8 MHz.

  In June 2009 the results of new Leeheim measurements of Iridium interference into the radio astronomy band were made public. The measurements showed that all 10 spectral channels that were measured were contaminated by Iridium interference.
- **UWB ISSUES:** A fundamental review of the ongoing process of the European Commission Decision on 24 GHz automotive Short-Range Radar (SRR) has taken place. The EC gave a mandate to CEPT to review the regulatory approach in relation to SRR. This mandate has two parts, called Part 1 and Part 2, containing the views of the CEPT administrations and the views of industry respectively. CRAF contributed to Part 1 during the public consultation process, stating 'that co-existence between the Radio Astronomy (SERVICE) and SRR 24GHz (APPLICATION) is not feasible, since more than 60-80dB are missing for such co-existence based on ECC Report 23, questioning the enforceability of possible mitigation solutions like sufficiently large exclusion zones around radio astronomy antennas. In practical terms, RAS and automotive SRR on 24 GHz co-existence is not possible. CRAF… expressed support for migration of SRR systems to the 79 GHz frequency range'.

  Wide-band Low Active Mode (WLAM) are newly proposed automotive systems wishing to operate in the frequency range 24.05-24.5 GHz. A study may have to be made for an assessment of the effects on radio astronomy operating in the adjacent 24 GHz band.

  CRAF was informed during its previous meetings about the incompatibility of the RAS with material sensing (BMA, ODC) devices using UWB technology. The ECC Decision (07) 01 containing the regulatory provisions for these types of unlicensed devices was under review. Some higher emission levels (compared with the previous version) were proposed, mainly by Germany. CRAF asked ECC to identify regulatory solutions for the protection of European radio astronomy stations.

- **PREPARATIONS FOR THE ITU WORLD RADIO-COMMUNICATIONS CONFERENCE 2012 (WRC-12):** Several committees within CEPT and ITU-R are already preparing for the WRC-12. In CEPT, there is ongoing work on a technical study to support WRC-12 agenda item 1.20 activities [spectrum identification for gateway links for high altitude platform stations (HAPS) in the range 5850-7075 MHz in accordance with Resolution 734 (Rev.WRC 07)]. It was agreed that CRAF would check the relevant information in relation to RAS stations and their protection criteria, and would submit them directly to the October 2009 meeting of SE19. CRAF sent the required information and was then asked to perform a full compatibility study between RAS and HAPS for delivery in January 2010, since nobody else was available to do it.

  (Since this CRAF meeting, ITU WP5C has approved Agenda Item 1.20 to go forward to SG 5 taking into account the radio astronomy view).

  It was proposed that Resolution 950 should address the requirements of EESS-SRS, RAS-SRS and ground-based passive sensors. Regarding the Resolution (RAS-SRS), during the last ITU WP7D meeting, a different approach to that of the CEPT was provided by the US. The result was that the best of the CEPT and US views were combined into a single position, which will be forwarded to future meetings. Two options for the revision of ITU Footnote 5.565 have been proposed, notably to include the list of frequency bands in the footnote or just to make a simple reference to the Resolutions referenced in No. 5.565. These options only differ with regard to the regulatory and procedural considerations.

  (Work was completed by both WP7C & WP7D at their June 2010 meetings and the finally approved CPM text was sent to SG 7 for approval at its next meeting).

  A draft new report is focusing on the essential role and global importance of radio spectrum use for Earth observations and for related applications. During the summer (2009), a preliminary draft new Report ITU-R [ESSENTIAL ROLE OBSERVATIONS] was updated with the information about solar observations, as discussed during the CRAF meeting in Paris, and also with the results of the activities of the ITU's SG 7 correspondence group, which had been established to work on the development of the document.

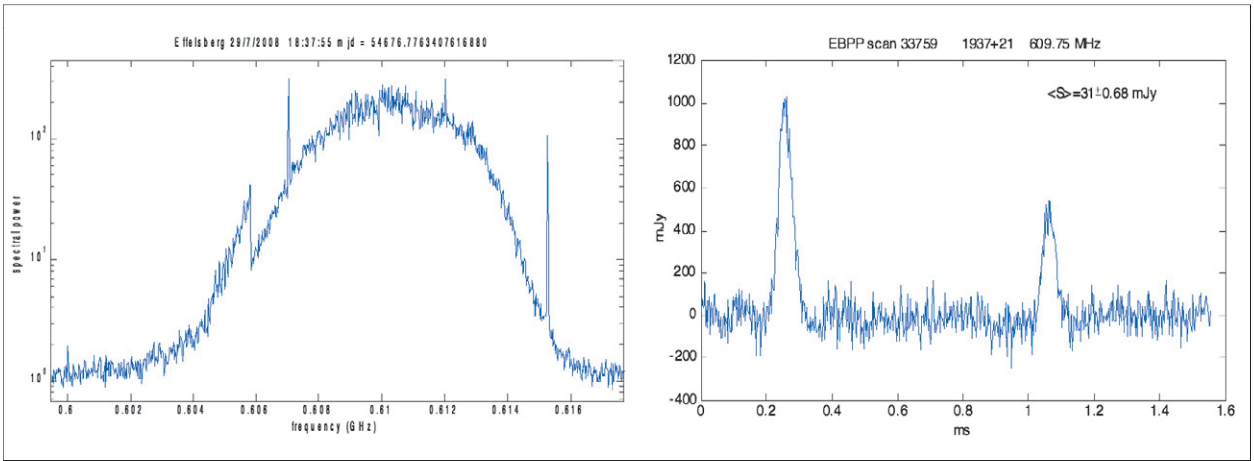
  (WP7C & WP7D both completed their work for the Draft New Report at their meetings in June 2010. The DNR was approved to go to SG 7 for approval subject to editorial corrections to be carried out before the end of August 2010).

Pietro Bolli

Status of the UHF Band

Radio astronomy has only one allocation between 500 and 1400 MHz, the 'TV channel 38' at 608-614 MHz. This frequency range is important, not only for solar observations, but also for very long baseline interferometry and pulsar studies. Our allocation is right in the middle of the TV bands and, because of that, it has sometimes been very difficult to use for radio astronomy once the number of TV stations started to increase. The high sensitivity of radio astronomy receivers, and the high power and long range of TV transmitters often make it either impossible to make useful radio observations or necessitate the use of special superconducting input filters to suppress strong transmissions on neighbouring channels. The introduction of digital transmissions might help to ease the problem for everybody. The digital transmissions are broad band and make more efficient use of the spectrum, evenly filling the bandwidth, whereas the older analogue technique concentrated most of the transmitted power in a strong and far-reaching carrier signal.

Administrations had to reorganise the transmitters and reallocate TV channels as a consequence of the changeover. It was possible to give radio astronomy better protection, and CRAF members and their national administrations in most cases, although not all (e.g., in the UK), were successful in improving the interference situation on channel 38. In some cases, observations were again possible for the first time for many years.



Band pass at 610 Mhz and a pulsar observation (psr B1937+21) from Effelsberg (2008). The spectral line in the band pass near 612 MHz has been identified as emission from the station's Hydrogen maser frequency standard.

Staff at the Eidgenössisch Technische Hochschule (ETH) in Zurich, Switzerland, have been observing in this channel since 1972 (37 years), and they intend to continue in the future, but with increased precision. Not only is the measurement of dynamic solar spectra foreseen, but also the determination of the solar flux at this frequency with unprecedented precision will generate scientific data for global climate studies. Therefore, protection is required for this channel. Contact with the Swiss OFCOM has been established, but no official response has been received as of now. At the Bleinen observatory the band appears to have little interference exceeding the effective 25 SFU (250 kJy) level. A new consortium comprising ETH (operations and maintenance of the telescopes), the Physikalisch Meterologisches Observatorium Davos (PMOD – scientific aspects), the Fachhochschule Nordwestschweiz (FHNW – computer infrastructure) and the group of Ken Tapping in Penticton (to cover 24h of observations and to exchange experience) is about to be formed to cooperate in solar observations. Other institutes such as the Astrophysikalisches Institut, Potsdam (AIP), the Royal Observatory, Belgium (ROB) and others might eventually also be a part of this new solar astronomy consortium.

Precision pulsar timing measurements require low frequency observations in the UHF band for the accurate determination of the effects of interstellar dispersion. In the past, such observations were made in the sparsely used TV bands at ~860 MHz. However, the introduction of digital TV transmissions has led to reallocations of frequencies and services, and the previously used locally unoccupied TV bands have been taken over by communication services. Even pointing measurements on strong calibrators have now turned out to be impossible at 860 MHz. However, as a result of close cooperation with the coordinators responsible for the broadcast (TV) band in BNetzA, the frequencies of new digital TV stations have been shifted, so that after more than 20 years of dormancy, it has become possible to use the 608-614 MHz band again for pulsar observations in Effelsberg. The band is, however, not totally lost for TV transmissions. In Germany it is used for low power digital TV stations that supply remote areas where topography prohibits the reception from major wide area transmitters. The UHF coordination scheme involves not only Germany, but also neighbouring countries. France has subsequently issued an internal directive to the effect that TV channel allocations should be made such that radio astronomical observations at 610 MHz in Germany, Belgium and the Netherlands will not suffer interference. This is in stark contrast with the UK, where channel 38 is to be formally given up and no protection is afforded to astronomers at Jodrell Bank. UK transmitters are, of course, required to avoid interfering with stations in other European countries, e.g., the Netherlands (see the feature about UK radio astronomy in CRAF Newsletter No. 20).

In general, the continued or renewed access to channel 38 for radio astronomers can be seen as an example of how CRAF members and national administrations can cooperate successfully in having optimal use of a very desirable frequency band for TV, and at the same time for radio astronomy.

Axel Jessner

Solar Radio Spectrometer – Network: e-CALLISTO

Investigation of the Sun has made great progress in the past decade because of satellite and space probe observations of solar particles, X-rays, extreme UV and white-light coronal emission. However, the radio emission from solar flares, first observed more than sixty years ago, is not understood, indicating that the dynamics of the solar corona and its plasma phenomena (i.e., the emission of radio waves) are unknown. Thus, even after many decades of study, solar radio emission, as observed from ground-based telescopes, still poses many enigmas. Progress in our understanding of the radio emission can only come from a combination with observations at other wavelengths from space. Irrespective of this, radio waves at metre wavelengths can be used as a diagnostic of the solar processes and they provide the first signature of flare shocks (Type II events) and electron beams escaping from the Sun on open magnetic field lines (Type III bursts). There is also unexplained emission from active regions and long-lasting emission after large flares. Most recent interest focuses on the predictive potential of radio emission regarding Coronal Mass Ejections (CMEs) heading towards the Earth. These greatly disturb our local space weather and are potential hazards for space missions. There are only a few ground-based solar radio instruments that are capable of surveying a large part of the spectrum and, whereas space probes can observe fulltime, the full coverage of the solar radio spectrum is limited to daylight in Europe.

The Compact Astronomical Low-cost Low-frequency Instrument for Spectroscopy and Transportable Observatory (CALLISTO), which has been described in detail by Benz *et al.* (2004), is a spectrometer constructed from a handful of standard electronic components available from the consumer market, and a few others from ‘eBay’, assembled on a single printed circuit board (PCB). The PCB fits into a standard aluminium box and has connectors for an antenna, computer, power supply, focal plane unit and – as an option – to an external 1 MHz clock source. A complete set of drawings, parts list, procedures,

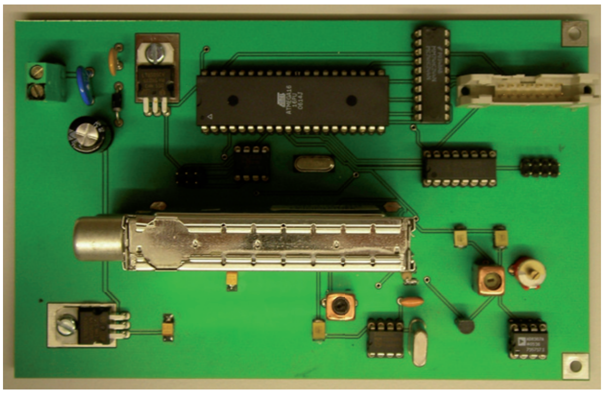


Figure 1. CALLISTO printed circuit board (top view) assembled by apprentices at ETH Zurich.

PCB-layout and also the complete software is freely available on the internet (for the address, see the link at the end of this article). Up to now, almost all CALLISTO spectrometers have been assembled by young apprentices in the physics department of the Eidgenössisch Technische Hochschule (ETH) in Zurich, Switzerland (Figure 1). Each CALLISTO has been fully tested using an automated test setup, controlled by a PC connected to a programmable radio signal generator via an IEEE488 interface bus. The most important test results of every manufactured CALLISTO are also available on the internet.

CALLISTO spectrometers have been shipped (or taken by an ETH engineer) to more than 12 hosting institutes worldwide, as shown in Figure 2. They have been used to automatically observe the solar radiation, and in particular solar flares, with their data being collected every day via the internet and stored in a central data base. A public web-interface exists, through which data can be browsed and retrieved. This e-CALLISTO network, as it has become, was initiated as a part of the developments in the International Heliospheric Year 2007, with the aim of obtaining 24-hour coverage of the metre and decimetre radio emission of the Sun. Identical spectrometer units, provided by ETH Zurich, have been delivered to the 'local' partners, who have provided an antenna and a PC interface to the internet. Figure 3 shows the log periodic antenna of the e-CALLISTO system in Mauritius. About half of the present host sites have built their antennas from standard aluminum profiles in local workshops. All others procured broad-band radio amateur antennas from local stores. The number of stations is still growing, as redundancy is desirable for full 24-hour coverage of the solar radio emission in the metre and low decimetre band. In fact, the e-CALLISTO system has already proven to be a valuable new tool for radio monitoring, for monitoring solar activity and for space weather research.

An important first step following the installation of a spectrometer has been a site evaluation using a special function of CALLISTO, which allows the measurement of the whole frequency range from 45 MHz to 870 MHz in steps of 62.5 KHz (i.e., 13200 channels). These surveys have sometimes revealed unexpected interference from nearby radio transmitters, and the high resolution spectra have been used to create dedicated frequency programmes, which avoid channels with terrestrial interference. Observations using these programmes are only made at frequencies with low RFI, and automatic 'jumps' can be made over spectral ranges such as the FM band between 80 MHz and 110 MHz. The results from several spectral surveys during the last few years are available online (see link below).

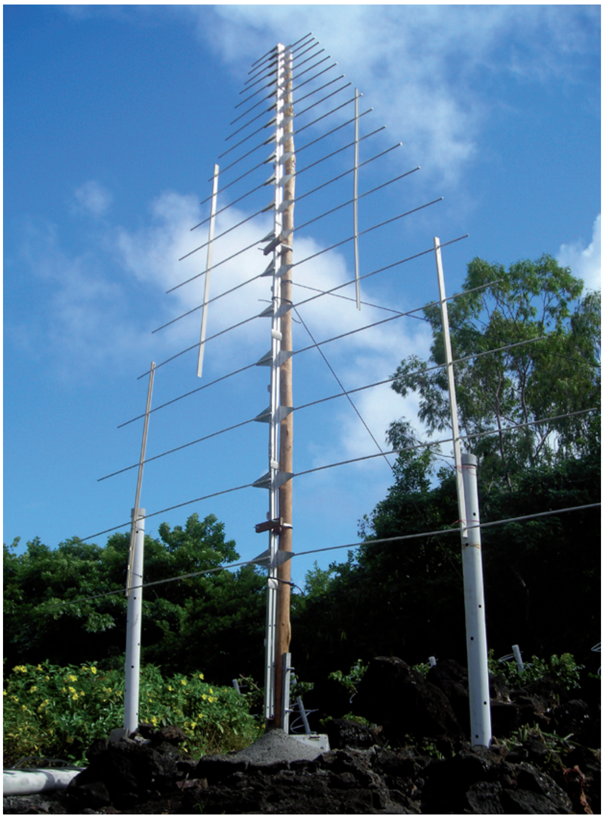


Figure 3. Logarithmic periodic antenna 45 MHz – 900 MHz of e-CALLISTO in Mauritius.

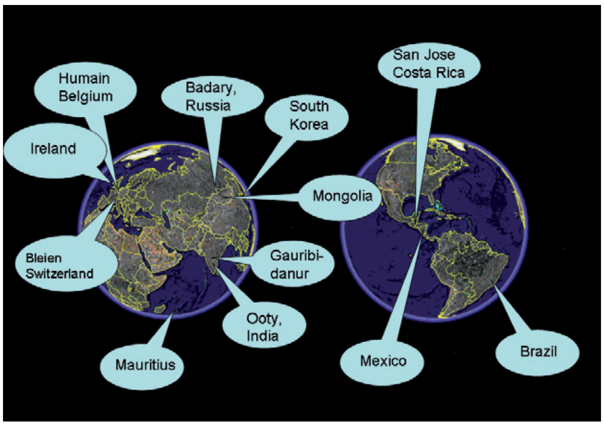


Figure 2. Geographical distribution of CALLISTO host sites in March 2009. Hawaii, Mannheim, Perth and Melbourne are in the starting phase, while the Czech Republic, Morocco, Turkey, Ecuador, Indonesia and Malaysia are in the planning phase. All stations shown above are delivering data to our database.

In most cases, the detected interference has come from 'local' computers or other electronic devices. A major advantage of the CALLISTO instrument is the programmable maximum gain of the receiver, which can limit the input power to be in the range -70 dBm up to -30 dBm to cope with a variety of radio frequency interference levels at the different locations. If other frequency ranges besides 45 MHz to 870 MHz need to be observed, a heterodyne up- or down-converter can be switched in between the antenna and the CALLISTO receiver. Figure 4 shows an example of the output from an 'up-converter system' located at Bleien observatory in Switzerland. It shows a type III solar radio flare collected with a biconical antenna in the decametre wave range from 20 MHz to 80 MHz.

In general, there is no need for a permanent operator. Once the system has been powered and configured, it runs automatically, controlled by an internal scheduler of the PC. This scheduler allows automatic starting and stopping of observations as well as control of an optional focal plane unit with up to 64 different configurations.

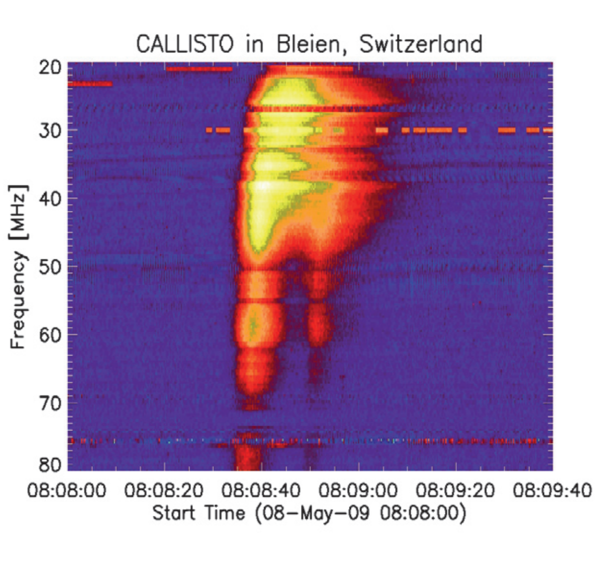


Figure 4. Spectrogram of a low frequency type III radio event observed in Bleien, Switzerland. The e-CALLISTO spectrometer was connected to an up-converter and a biconical antenna.

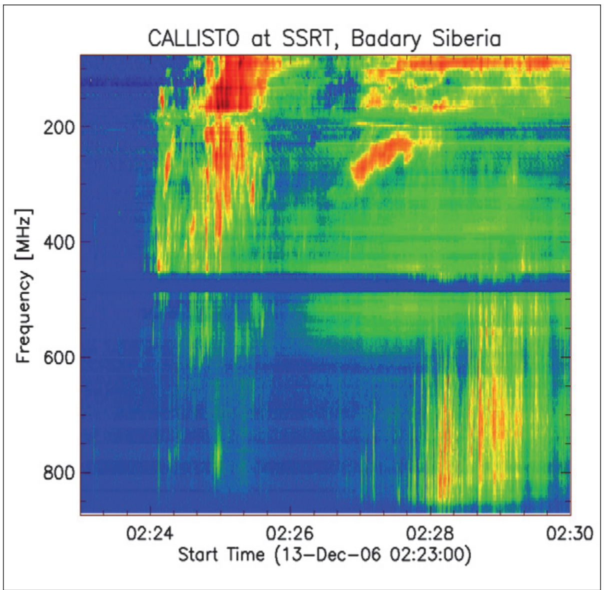


Figure 5. Spectrogram of a complex broad-band radio event observed with e-CALLISTO spectrometer in Badary (Siberia), operated by the Institute of Solar-Terrestrial Physics (ISTP), Siberian Branch of Russian Academy of Sciences, Irkutsk, Russian Federation. It shows different types of solar flares and decimeter pulsations.

All data and log files between local sunrise and sunset at each host site are first stored on a local data disk. After sunset a PERL script, running on an ETH server, connects to every host in all the different countries and assembles the FITS-files data. However, only data files relating to times of flares as reported in the list of NOAA are transferred to the server, all others being ignored. It means that only data with a certain probability of containing a solar radio event are collected. The finally transferred and stored data are then sorted into a structured archive on the server, which is accessible to everybody.

The e-CALLISTO system has already had its first success. In December 2006, when the last large flares of the present cycle occurred, X-class flares were observed by the then newly launched Hinode satellite. As these may be the only large flares observed by this satellite in the near future, they are currently being studied by several groups around the world. None of the flares were observed from the ground during their entire period because of the short December daylight in the Northern hemisphere. However, e-CALLISTO, then operating in Switzerland, India and Siberia, covered more than 60% of the time.

Figure 5 shows the solar flare radio emission of 13 December 2006, observed by the e-CALLISTO spectrometer element in Siberia. The data are displayed as a spectrogram; intense emission is represented by the bright yellow region, no emission by blue. The vertical axis is channel number (there are 200 of them); the horizontal one is time, which is increasing to the right. The pseudo three-dimensional representations of time, frequency and intensity produce an image that can be interpreted more easily. The frequency is given in MHz on the left, but increasing downwards. As the emission is proportional to the density (plasma emission), the vertical axis also represents altitude in the solar atmosphere, in this case from one to two solar radii above the photosphere. As the density decreases with altitude, the height is increasing upwards in the picture. The radio emission is tilted towards the right, indicating that an exciter is moving upwards. Assuming a density model of the corona, its speed can be estimated, and has been found to be approximately a third of the speed of light. The emission is therefore interpreted as the signature of an electron beam escaping from the Sun. Note the low level of interference in Figure 5. Only a few terrestrial emissions are seen as horizontal lines.

The e-CALLISTO network is growing and has produced its first results. Currently, the data can be retrieved automatically from 12 stations every day. In fact, some stations have worked reliably for nearly four years. The interest of researchers in joining the network is still great, with more stations being planned. However, travel money and the availability of engineers are limiting this. Growth in the Pacific area (see Figure 2) is desirable from a scientific point of view. The e-CALLISTO network will be a reliable tool to observe and study solar activity during the upcoming ascending and maximum phases of cycle 24. The learning effect and motivation of the people involved may be another justification, which will be interesting to evaluate in a few years.

Link to documents:
http://www.exp-astro.phys.ethz.ch/astro1/Users/cmonstei/instrument/callisto/index.php

Christian Monstein

CRAF RFI database

At the present time the RFI database based on the MySQL engine is almost ready to be released for testing by astronomers. It has been organised to accept manual entries from simple and intuitive web pages. Two web pages are available: one for RFI data entry and a second one for querying the database. However, the same structure of database may be easily updated to be automatically fed directly by the monitoring system. The current version of the database has been improved following comments and requests raised during the last few CRAF meetings. The most recent modifications have been:

1. adding three levels of user with different privileges:
   a. *simple users:* only allowed to insert data and to query the database; this user is considered to be a generic astronomer;
   b. *administrator of RFI data:* this higher level user can delete or modify a RFI record, for instance in the case of a mistake during the input of RFI data; this user should be the CRAF member of each station;
   c. *administrator of the database:* this is the highest profile, with the ability to fully manage the structure of the database.
2. For each RFI record, the input parameters have been enriched with the personal information (name, surname and email) of the person who enters the data.
3. In the query page for data analysis, a further selection is now possible: the RFI data can indeed be extracted depending on the station selected. With a drop-down menu it is possible to select the name of the station where the RFI occurred.

So far the queried data are reported only in tabular form – no plots/graphs are available. Additional features to accomplish more complex data output will be implemented following feedback from the astronomical community concerning the effective use of the current database. The database is now ready to be linked into the CRAF website. Once this is done, the whole community will be informed of the presence of the database and will be able to provide further external comments.

Pietro Bolli

Committee on Radio Astronomy Frequencies (CRAF)

CRAF is an Expert Committee of the European Science Foundation. Established in 1988, it represents all the major radio astronomical observatories in Europe. Its mission is to coordinate activities to keep the frequency bands used by radio astronomers in Europe free from interference.

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