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#### **ERATec Workshop on**

#### **Multi-Frequency mm-wave Radio Telescopes and other Software Controlled Operations**

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### 1.1 Dissemination Level

Dissemination Level		
<b>PU</b>	Public	X
<b>PP</b>	Restricted to other programme participants (including the Commission Services)	
<b>RE</b>	Restricted to a group specified by the consortium (including the Commission Services)	
<b>CO</b>	Confidential, only for members of the consortium (including the Commission Services)	

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## 2 NA report

Communication, training and scientific interaction between engineers and scientists involved in the development and operation of radio astronomical instruments represent a key issue in keeping these facilities at a world-class technical level. This Technical Workshop, held in Florence, Italy from October 5 to 7, 2015, brought together receiver engineers, software programmers (both engineers and astronomers) and observing astronomers using VLBI techniques. There were two days of general talks on Multi-Frequency VLBI - related issues which are of interest for the entire community followed by one day of talks on telescope software issues.

### 2.1 Participants

During the workshop there were a total of 61 participants, 9 of them were women. In addition, some 3 persons participated via video streaming on some of the days. 10 participants came from outside the European Union (Australia, Russia, South Korea), three of them were invited.

The signed participants list is attached in the appendix of this report.

### 2.2 Meeting programme

#### **Monday, Oct. 5:**

SESSION 1: mm-VLBI Analysis Methods

SESSION 2: mm-VLBI Studies and Key Science Case(s): Continuum

SESSION 3: mm-VLBI Studies and Key Science Case(s): Lines

SESSION 4: Reports from Current mm-VLBI facilities

#### **Tuesday, Oct. 6: Defining the possible (How)**

SESSION 5: Performance Characterization

SESSION 6: Novel mm-VLBI hardware approaches for multi-frequency observations

SESSION 7: RadioNet JRA Proposals for multi-frequency observations

Guided visit to the Arcetri Astrophysical Observatory and to "Villa il Gioiello"

Workshop Dinner at Omero restaurant located in front of "Villa il Gioiello" (last residence of Galileo Galilei) with an aperitif

#### **Wednesday, Oct. 7: Software at Radio Observatories**

SESSION 8: Software at Radio Observatories

The complete Workshop Program is attached in the appendix.

## 2.3 Meeting Photo



## 2.4 Scientific report

### **Summary of the Technical Workshop on Multi-Frequency mm-wave Radio Telescopes and other Software Controlled Operations:**

At the beginning of the workshop Gianni Comoretto gives a welcome to the community introducing the very historic place of the meeting, the Arcetri Observatory at the University of Florence. After him Reinhard Keller welcomes the community in the name of RadioNet3.

The first session of Monday chaired by Taehyun Jung presented the basics and the status of mm-wave VLBI technologies. Maria Riocha in the first talk gave some impressive examples of the possibilities of simultaneous multi frequency observation performed with the Korean VLBI Network and she already invoked first vivid discussions on the possibilities of this principle. The following talks show how multi frequency observations can be used for further scientific investigations, i.e. on magnetic fields or pulsars, not only extending sensitivity.

The following sessions then gave motivation for multi-frequency observation using continuum or line techniques. All examples would profit from the gain of sensitivity by multi-wavelength calibration especially where longer integration times are not possible.

The talks of the last session of the day reported results of current available VLBI facilities. Thomas Krichbaum in the first talk gave an overview on existing VLBI facilities and cooperation currently under operation and their main scientific output. Further speakers presented results of the various compact arrays currently under operation such as ALMA, VLBA and Space-VLBI.

On Tuesday morning the first issue was performance characterization of high frequency VLBI. The biggest block of talks was on hardware approaches for multi frequency observations. Actual systems use optical benches with quasi optics low pass filters in various telescopes around the world, having roots in the KVN. ATCA is added to this configuration by

dividing it into two sub-arrays one operating at 43 GHz and the other on 86 GHz, resulting in a 'quasi-simultaneous' multi - frequency operation mode. First very promising VLBI observations of this extended KVN were shown.

After the coffee break several hardware attempts for multi frequency observations were presented. The most difficult problem still is to have various frequencies simultaneously at the sky. Therefore there are many attempts on this, even thinking of fast switching between frequencies. After lunch these presentations of ideas and projects went on in more detail i.e. of the Korean multi-frequency approach. The last presentation presented a new joint research activity in RadioNet4 'BRAND EVN' on a low frequency but ultra-broad band RX for existing EVN telescopes based on baseband sampling up to 15 GHz.

At the end of the day a panel discussion took place to recap all the new ideas and contributions. For this discussion Paco Colomer and John Romney joined the round. First Richard Dobson in a short presentation concluded the two days and explained his motivation for that workshop. The overall opinion of the panel was to have a good science case to convince the observatory directors to invest in a common receiver system. A draft design should be setup of this community to have a work schedule for fund raising. This and further actions have to have a lead. At the end there was the idea to have one design for all the EVN stations, even the same hardware that has to be adapted to the respective telescope.

On the third day the focus of the workshop was on telescope control software. Heiko Hafok gave an overview of the two tightly connected control systems of APEX and Effelsberg. Connected to this MBFits was presented by Reinhold Schaaf. Further talks showed the details of other telescope controls. Alexander Neidhard introduced the possibility of remote control of telescopes by a save and encrypted internet connection. A special talk in this suite was given by Alessandra Zanichelli on Pre- and Post-observation tools given many helps to the observer but i.e. to the observatory by a dedicated observatory feedback tool.

At the end of the WS Reinhard Keller summarized the three days and gave a short outlook on the next RadioNet proposal and the new structure of its network activities.

Overall the workshop was very successful as many new ideas came up and were discussed in conjunction of the talks but also in the panel discussion on Tuesday. Furthermore many discussions between various groups came up in the breaks and at the dinner. Especially the contact between scientists and engineers was very much appreciated by all of the participants of the workshop.

All presentations and the program can be found on the workshops webpage:

<http://www.ira.inaf.it/eratec/florence/>

The recorded streams are available on: <http://www.ira.inaf.it/~pbolli/ERATEC.html>

## 2.5 Information of the EC financial contribution

The total amount spent for the entire TWS week is 10.694,07 Euros, of which 5.951,57 Euros were used for direct support to participants of the workshop. The co-organization of the two topics allowed us a drastic reduction of financial resources. It also permitted the attendance of persons who would otherwise not have had the possibility to attend.