REPORT ON THE RADIONET3 NETWORKING ACTIVITY

TITLE: **ALMA LONG BASELINE CAMPAIGNE WORKSHOP**

DATE: 2-3 JUNE 2014 **TIME:** (WHOLE DAY)

LOCATION: GRENOBLE

MEETING WEBPAGE: NONE

HOST INSTITUTE: IRAM

PARTICIPANTS NO: 19

MAIN LEADER: IRAM

REPORT:

1. Program of the meeting

See attached

2. Scientific Summary

The Atacama Large Millimetre/Sub-millimetre Array (ALMA) is an aperture-synthesis array designed to operate in the frequency range 35 – 950 GHz in 10 receiver bands and therefore located at an altitude of 5000 m on the Chajnantor Plateau in Northern Chile. It has 54 12 m and 12 7 m antennas, with a range of baselines up to 16 km. The construction of ALMA has been managed by an international partnership led by ESO (Europe), NRAO (North America) and NAOJ (East Asia). ALMA has been in Early Science operations for the last three years as its capabilities are progressively tested and commissioned. The initial ALMA configurations had relatively short baselines (typically <1.5 km). A major enhancement in its capabilities, planned for late 2014, is the commissioning of the long baselines, thus enabling the full resolution of the array to be achieved. The purpose of the Long-Baseline Planning Meeting, held on June 2-3 2014, was twofold: to discuss techniques for the calibration and imaging of high-resolution observations in general and to plan the commissioning campaign (September - November 2014) in detail. To that end, the meeting participants included experts from a number of observatories with relevant experience as well as members of the ALMA commissioning team. Of the 19 participants, 6 were female. 11/19 were from Europe, with the remainder from North and South America and East Asia (a geographical distribution reflecting that of the ALMA partnership). By the nature of the meeting, all were established researchers. The general discussion on calibration and imaging is of wider interest, and is described below.

A key problem in the calibration of interferometric data at mm wavelengths is the measurement and correction of atmospheric phase errors, which become more important at longer baselines and higher frequencies. ALMA uses several different methods to do this: fast switching between calibrator and target source, water-vapour radiometry (WVR) and self-calibration. Results from all of these techniques were presented at the meeting.

The WVR method works by measuring emission from the 183-GHz atmospheric water line above each antenna, which can be related to the water-vapour column. Since atmospheric delay errors are dominated by the wet component, this allows effective correction on timescales of 1 s - a few minutes. The technique has been pioneered at ALMA and is in routine use for science observations. It is an important tool for characterisation of the atmosphere over the ALMA site, for example the typical power spectrum and outer scale of water-vapour fluctuations. The technique was discussed in detail, comparing on- and off-line corrections, evaluating the effectiveness of the corrections and considering subtleties such as dispersion. One important limitation is that the component of atmospheric delay due to dry air is not measured, and this becomes dominant in very dry conditions. Methods for estimating the dry component (for example using atmospheric oxygen lines) were also outlined.

The ALMA antennas have been designed to switch very rapidly between science target and calibrator, again to allow calibration of rapidly varying atmospheric phase errors. The first results of tests with cycle times as short as 10 s were presented at the meeting.

Improved methods of applying phase solutions derived from calibration sources to the science targets are also important. These include more sophisticated phase interpolation algorithms (e.g. cubic splines) and the use of delay and rate fitting (as is standard practice in very long baseline interferometry).

ALMA is scheduled flexibly, primarily in order to ensure that the most demanding programmes (i.e. at the highest frequencies) are scheduled in the best weather conditions. It is important to quantify the criteria, which are used to assess performance, and phase metrics were another subject of the meeting.

For high-resolution observations and precision astrometry, accurate measurement of antenna positions is also crucial. This in turn requires an accurate model of the atmosphere (including the wet and dry components). Improving the astrometric accuracy of the array and understanding the

factors that limit performance were both discussed.
Finally, the ability to locate suitable phase calibrators is a potential issue for long-baseline operation. Calibrator surveys were considered, as was the optimisation of primary amplitude calibration (the problem there being that many of the best primary calibrators, such as planets and moons, will be resolved).
The meeting was very successful in its aim of identifying solutions to the important technical issues for the ALMA long-baseline campaign. The success of that campaign is amply demonstrated by the spectacular image of the protoplanetary disk around HL Tau obtained during the campaign and shown in Fig. 1.

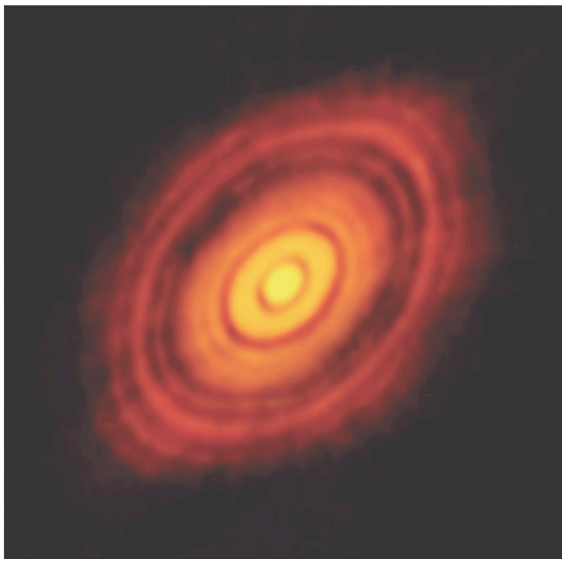

Figure 1: ALMA long-baseline image of the protoplanetary disk around the star HL Tau at 230 GHz.

3. Attendance list signed by the participants and confirmed by the organizer

Catherine	Joint ALMA Office	Chile
Ed Fomalont	Joint ALMA Office and NRAO,	Chile/US
Liz Humphreys	ESO, Garching	Germany
Remo Tilanus	Leiden University/Radboud	Netherlan
Nuria Marcelino	INAF-IRA, Bologna	Italy
Robert Lucas	IRAM, Grenoble	France
Dominique	IRAM, Grenoble	France
Anita Richards	JBCA, Manchester	UK
Yoshiharu Asaki	ISAS/JAXA, Sagamihara	Japan
Satoki	ASIAA, Taipei	Taiwan
Richard Hills	Cambridge University	UK
Bojan Nikolic	Cambridge University	UK
Taehyun Jung	KASI, Daejeon	S-Korea
Robert Laing	ESO, Garching	Germany
Roberto Neri	IRAM	France
Frederic Gueth	IRAM	France
Todd Hunter*	NRAO, Charlottesville	USA
Crystal Brogan*	NRAO, Charlottesville	USA
Vivek Dhawan*	NRAO, Socorro	USA

* Denotes participation by video link. Confirmed by Robert Laing, ESO,

June 3, 2014

R. A. Laing

4. RadioNet3 contribution

RadioNet contributed 343.50 € for logistics and supported the attendance of Richards Hills and Nuria Marcelino with 530.79 and 334.33 € respectively.

5. Conference proceedings and Web page

The outcomes of the meeting were solutions to technical issues regarding the ALMA long baseline campaign. There are no published proceedings and presentations are not made available online.

ALMA Long Baseline Campaign Workshop

IRAM, Grenoble, 2-3 June 2014

Final Agenda

The idea of the format of this meeting is to share information and ideas during the discussion sessions, rather than have long presentations.

Talk slots include 5 minutes for questions except where topics are in common (e.g. WVR) in which case questions will be taken after all the speakers have presented. Each session will be followed by an ample discussion session for any further follow-up questions.

Note that some presenters are asked to coordinate their presentations to avoid overlap and provide useful lead-in to the subsequent discussion session.

Times below are CEST. For remote participants, this is:

UK (CEST -1), Chile (CEST -6), Socorro (CEST -8)

Monday 2 June

08:30 - 08:50 Coffee

08:50 - 08:55 Welcome to Grenoble and IRAM..... **Gueth**

08:55 - 09:10 Greetings, meeting logistics and motivation..... **Laing**

Overview of EOC/JAO Plans for Long Baselines (Chair: Hills)

09:10 - 09:30 EOC/JAO Long Baseline Campaign Plan..... **Vlahakis**

09:30 - 10:00 Long Baseline Campaign technical needs and goals by 2015 ..... **Fomalont**

10:00 - 10:20 Science Verification at long baselines..... **Vlahakis**

10:20 - 10:40 Imaging uv-coverage and SV imaging strategy..... **Hunter** (by telecon)

10:40 - 11:00 Coffee

Imaging Concerns (Chair: Vlahakis)

11:00 - 11:20 Lessons from the Band 7 & 9 H2O maser Science Verification data ..... **Richards**

11:20 - 11:40 CASA needs for long baseline data reduction..... **Brogan** (by telecon)

11:40 - 12:00 Pipeline/OT concerns..... **Humphreys**

12:00 - 12:20 Astrometry..... **Fomalont**

Discussion Session 1 (Chair: Vlahakis)

12:20 - 13:20 Discussion of imaging, Science Verification and other topics from this morning

13:20 - 14:20 Lunch

WVR (Online and Offline): Part 1 (Chair: Laing)

14:20 - 14:40 WVR use for the long-baseline campaign and beyond ..... **Fomalont**

14:40 - 15:25 Offline WVR (15 min talks - questions in following discussion) ..... **Nikolic, Tilanus & Hills**

15:25 - 16:00 Discussion of Offline WVR (including questions; Chair: Laing)

16:00 - 16:20 Coffee

WVR (Online and Offline): Part 2 (Chair: Fomalont)

16:20 - 16:50 Online WVR (15 min talks. - questions in following discussion) ..... **Lucas & Broguiere**

16:50 - 17:20 Discussion of Online WVR (including questions; Chair: Fomalont)

Discussion Session 2: (Chair: Laing)

17:20 - 18:30 Discussion of Online versus Offline WVR (compatibility), WVR improvement and other topics from today

19:30 Dinner

Tuesday 3 June

Long Baseline Phase Referencing (Chair: Richards)

09:00 - 09:40 Measuring and Removing Systematic Antenna-based Phase Terms ..... **Lucas**

09:40 - 10:20 Determining phase referencing metrics..... **Matsushita & Asaki**

10:20 - 10:40 Calibrator concerns with long baselines..... **Marcelino**

10:40 - 11:00 Coffee

Other Experiences with Phase Referencing: (Chair: Fomalont)

11:00 - 11:20 The Korean VLBI high frequency phase reference experience ..... **Jung**

11:20 - 11:40 ALMA Band-to-Band Tests..... **Impellizzeri** (by telecon)

11:40 - 12:00 The EVLA and VLBA experience..... **Dhawan** (by telecon)

Discussion Session 3 (Chair: Fomalont)

12:00 - 13:00 Discussion of Phase referencing metric and experiences

Meeting Summary

13:00 - 13:20 Meeting Summary..... **Laing**

13:20 - 14:30 Lunch

Discussion Session 4: (Chair: Vlahakis/Fomalont)

14:30 - 16:30 Open discussion of topics from both days and thanks

(or later for those staying on; coffee break will be scheduled)
