BAND 5 Overview – Tom Wilson/ESO – 11May2005 – V2

Summary

In Feb. 2005, the EU informed ESO that a contract for the proposal 'ALMA Enhancement', submitted in March 2004, could be negotiated. The EU FP6 will provide funds for the receivers and necessary software. This proposal involves building a prototype and tentatively 8 production receivers for ALMA Band 5 (163-211 GHz) on ALMA antennas and providing software needed to make use of the Band 5 receivers to map the extended 183 GHz water vapor emission. The EU proposal requested funding support for 5 years. The EU has proposed to start funding in the period Jan-Feb 2006. The proposal as accepted involves a consortium consisting of Onsala Space Observatory, the Astronomy Dept. of the University of Chile, IRAM-Grenoble, the Astrophysics Group of Cambridge University and ESO. In the following discussion, we summarize the hardware and software issues.

Hardware History

In 2002, ESAC members were informed of the possibility of additional funding in conjunction with approved construction projects from the EU within Framework Program 6. The decision to submit a proposal for 'ALMA Enhancement' was made by the ESAC in June 2003. The deadline for submitting a proposal, March 5, 2004, was set by the EU in December 2004. After a discussion with the ALMA Director, Massimo Tarenghi, detailed plans were begun starting in mid-January 2004. The decision about the choice of receiver band, ALMA Band 5, covering 163 to 211 GHz, was made about this time. This decision involved discussions with ESAC. The system noise temperature of the band is higher than other millimeter bands because of the atmospheric water vapor line at 183 GHz. This line is also present in astronomical sources, and there is an additional line of the 18-O line of water vapor at 203 GHz. The basic argument was that ALMA 'early science' would overlap with the ESA cornerstone mission Herschel. One of the major programs of the Herschel instruments, HIFI, is to measure water vapor transitions. The Herschel angular resolution is 13" at best, so measurements of sources with Herschel-HIFI would be enhanced by images of the 183 GHz line measured with ALMA. In

recent discussions in ESAC, it was pointed out that in galactic and extragalactic sources, the time variability of the 183 GHz line is slow, so that ALMA measurements could be made at times which are substantially different than those made with Herschel-HIFI.

In January-February 2004, there were a series of detailed discussions with V. Belitsky of the Onsala Space Observatory about costs and time scales for building the Band 5 receivers. In February 2004, there were discussions with L. Bronfman of the Astronomy Dept. of the University of Chile about how they could participate in the receiver construction.

Management Issues for the Band 5 receivers

The responsibility for the management of the hardware part of the EU project will be carried out at ESO. In turn ESO will report to the EU on the progress of the 'ALMA Enhancement' project. ESO will have PDR's and CDR's, following the plan of other ALMA receiver work packages.

The EU will provide funds for six to eight Band 5 receivers. All of the Band 5 performance and interfaces will be in accordance with ALMA receiver specifications. These receivers will be constructed by the Group for Advanced Receiver Development at Chalmers/Onsala Space Observatory. The SIS mixers themselves will be new developments, and the EU proposal has a 2 year development phase for the production of a prototype. Those parts of the Band 5 receivers, such as the multipliers for the LO system, would have to be specific to Band 5. The other parts of the Band 5 receivers, for example the IF sections, would follow the form (perhaps exact copies) of the Band 7 or Band 9 systems. The CDR's and PDR's for the prototype will follow those for ALMA Band 7 and 9. After the prototype is accepted, there will be a 3 year production phase. The JAO has made it clear that the Band 5 systems should not be incorporated into the first 8 pre-production cryostats, and that the cost of the Band 5 integration to the project must be provided from the EU contract. The receiver integration will have to be funded out of the FP6 grant.

As the proposal was originally written, the role of the University of Chile Astronomy Department (hereafter DAS), was to provide two

engineers to help with the building of the Band 5 receivers in Sweden, and then to handle the testing of the Band 5 receivers in Chile. Since the proposal was written, there has been a discussion with the JAO. The JAO wants the Band 5 integration to be dealt with by the project itself. A discussion of a plan for receiver integration at the OSF has begun. The integration will very probably be done at the OSF.

Software History

When we first began the process of selecting what software was basic to ALMA but not in the baseline plan, Joe Schwarz, John Richer and I had a number of phone discussions with NRAO personnel and also investigated what ESO personnel were planning. We selected a few possible areas of interest. In February 2005, the EU told us that from the software only those proposals that were directly related to the use of the Band 5 receivers would be funded. The EU told us that they would fund the 'phase correction with the Water Vapor Radiometers (WVR's)', to be done by the Astrophysics Group at Cambridge University, UK, and 'on-the-fly interferometric mosaicing' to be done at IRAM, Grenoble. The EU eliminated two areas in software: 'scientific data analysis of ALMA data sets' and 'Data Archiving' from the proposal. If there was money left from other higher priority tasks, the part covering 'combining single dish and interferometer data' and 'Bayesian mosaicing' might be funded. This seems to be unlikely at present, so only the 'phase correction with the Water Vapor Radiometers (WVR's)' and 'on-the-fly interferometric mosaicing' would remain in FP6 funding for the 'ALMA Enhancement'.

The EU wants to have this software fully integrated into the ALMA system, and to be available for users as a standard part of the ALMA software.

Management Issues for the Software

The management will be carried out at ESO and the needed resources will be provided to the ALMA Computing IPT. We would expect to have PDR's and CDR's as with other ALMA work

packages. The management responsibility would rest with ESO for all of the software development in the FP6 program.

Since Cambridge University is presently in charge of the 'phase correction with the Water Vapor Radiometers (WVR's)', the work should continue as before, with the standard ALMA software tests, PDR's and CDR's. For the 'on-the-fly interferometric mosaicing', a new set of CDR's and PDR's is needed. Also, we need to be certain that there is no duplication of effort.

There have been questions about the cost of integrating the software produced in FP6 into the ALMA software system. In particular there has been a comparison with the cost assessed by ALMA for the ALMA-J software effort. This would be an extra overhead in regard to the software development. If so, the software development associated with the Phase Correction with the Water Vapor Radiometers (WVR, next section) is already in the project and has been fully integrated in the project. On this basis, the WVR software should need no integration, and thus there should be no overhead. This may not apply to the on-the-fly interferometry, since this is a new development.

Phase correction with the Water Vapor Radiometers (WVR's)

This work has been supported by the Science IPT, with the work being done at Cambridge University, UK. This will be taken over 100% by the EU as of January 2006, provided that we sign the agreement. The funding will actually flow in mid-February 2006, so support is needed up to this point. The goals and methods, PDRs and CDRs will be in full accordance with the previous plans. Thus this part of the work will continue as before. The work will continue to be carried out at Cambridge University.

On-the-fly Interferometry

This contract is with IRAM, as was specified in the EU proposal of 2004. The work consists of development of techniques for on-the-fly interferometry, prototyped first at Plateau de Bure (PdB), and then to be fully deployed and tested for ALMA in AIPS++. A new set of

CDRs and PDRs is needed for this project. These represent new scope and require additional test and integration effort by ALMA Computing IPT, since this product must follow all ALMA Computing IPT standards and practices, and must be integrated into the ALMA offline subsystem and accepted by the Computing IPT. For this reason, there will be an overhead in the ALMA project that needs to be compensated. It is suggested that Computing IPT are represented by Joe Schwarz and Joe McMullin. The on-line part would be used with the ALMA Control System, and the data reduction part would be in AIPS++.