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**ESO ALMA/ARC Factsheets**

**01 April 2019 – 31 March 2020**

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Distribution to Users Committee, their colleagues with a need-to-know, and their supervisors is authorised.

Users Committee is invited to take note of this document.
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Overview

- The primary purpose of the ESO ALMA Support Centre (EASC) is to carry out and coordinate all ALMA operations-related activities within ESO including the ARC as well as with the ALMA partners and JAO.

- The main tasks of the EASC are the operation of the European ALMA Regional Centre, offsite maintenance support to JAO, the initiation, implementation and supervision of the European ALMA development programme (studies and projects), European ALMA Science and Outreach during ALMA operations as well as being the ALMA-related contact point for the ESO science and technical community and ALMA partners.

- The EASC is part of the Directorate of Operations. The Head of the EASC reports to the Director of Operations.

- The report presented in this section covers the aspects of EASC management, the ALMA Regional Centre, ALMA science, technical support (hardware and software), and the development programme, including studies, at ESO.

- Motivated by the ongoing transition of the ALMA observatory into full operations and the skills and capabilities at JAO, the EASC takes care of a good number of tasks and activities in the areas of science operations and policies, HW maintenance, Computing and general policies and management which go beyond its formal assignment. In particular, the ARC network carries out significantly more tasks than foreseen in the ALMA Operations Plan and the EASC ALMA Technical Team is preparing to provide in-kind support for on-site maintenance activities.

UC Recommendations

UC43.R04: to inform all European ALMA Users, through the ARCs or other ESO channels, that the calibrated measurement sets are currently available upon request for a limited period of time, and whether this will be done by default in the near future (even for a limited period of time).

Reply provided by Zwaan/Testi:

European ALMA users have been informed of this new service through a variety of channels. Specifically, it has been announced in the European ALMA Newsletter, which is sent to all European users registered in the ALMA User Portal, and also many ARC nodes have contacted their regional user base through their newsletters. In addition, the data delivery email that every user receives when their ALMA data is available for download, will soon be updated with a specific reference to this service. We currently have no plans to make the calibrated data sets available by default. From feedback from the users we gather that providing them on demand is fulfilling the user needs.

We would like to thank the UC for raising the importance of making calibrated measurement sets available to users. This service is very popular with European ALMA users, both for PIs and archive researchers: thus far, we have delivered 300 calibrated measurement sets. We have purchased extra storage space to service even more users in the future.

Highlights

- Successful execution of the Cycle 7 submission, proposal review and phase 2 processes, as well as execution of the ACA supplemental call for proposals
- Completed hiring of two ARC Astronomers and one ARC scientist
- Archive Review executed successfully
- The software to support the new Distributed ALMA Proposal Review (DAPR) process has been delivered, validated and deployed in time for the close of the Cycle 7 supplemental call
• The new Archive Query user interface was deployed, providing a much better user experience
• The development project ARI-L’s agreement signed and activities kicked-off
• Completed internal assessment of the recommendations from the ALMA International Visiting Committee.
• Successful execution of the ACA supplementary call for proposal and review process, using the new Distributed Peer Review process and the relative software tools developed by the EASC team.
• Very broad attendance and stunning science program for a great ALMA 2019 Science Conference in Cagliari.
• ARC-USD joint assessment and testing of new Helpdesk software. ALMA and ESO will use the same product, allowing sharing of expertise and uniform experience for the users.
• Setup of EASC participation in the EC Horizon 2020 Opticon RadioNet Pilot proposal, including a new collaboration with the VLTI expertise centers on User Support and imaging techniques for interferometry.
• Successful approval of the ALMA Science Archive acceleration project.
• Successful preparation and internal evaluation of the proposal to develop a new ALMA OT based on modern web-based technologies.
• Completion of the Band 2 contract negotiation and significant advancement of the preparations for preproduction.
• Developed an impact assessment, mitigation and activities re-prioritization for the EASC, following the COVID-19 outbreak and global situation at ESO, Europe, JAO and the ALMA Partners

Concerns

• **Current COVID-19 situation.** The risk of complete observatory shutdown, closure of laboratories throughout Europe and massive home working. For the EASC we have developed an assessment of our ability to carry on our normal off-site operations, identifying the activities that will suffer delays and reprioritizing to focus on executing work that can effectively be done in the emergency. The EASC is working together with the JAO and our partners in North America and East Asia to find solutions for the Cycle 7 and Cycle 8 observing, once observations will resume. Software development and maintenance, as well as most user-facing services, such as the Helpdesk, data reduction support, quality assurance, archive services, etc. continue as before. EASC management meets twice a week to assess the situation and maintain as much regular execution of the activities as possible in the current situation. Weekly meetings are held with JAO and the ALMA Partners to optimize integrated activities and monitor the evolving situation.

Staff/organizational matters

The EASC division is part of ESO’s Directorate of Operations and has four departments: ARC, Science, Technical Team, and Computing. The EASC Management Team consists of

• Leonardo Testi, Head of EASC, EU Operations Manager, and ESO-ALMA Programme Manager (construction and operation, including development),
• Martin Zwaan, Deputy Head of EASC, EU ISOpT Lead, ARC Manager and Head of ARC department,
• Francisca Kemper, EU IST Lead, ESO-ALMA Programme Scientist,
• Silvio Rossi, EU IET Lead, Head of ESO-ALMA Technical Team,
• Erich Schmid, EU ICT Lead, Head of ESO-ALMA Computing,
• Carlos De Breuck is Coordinator of the ALMA Development Studies programme,
• Evanthia Hatziminaoglou is Deputy ARC Manager.

The Directorate for Science provides science and outreach support to the EASC.
ALMA Regional Centre

Cycle 7 proposal review

- The APRC meeting was held in Atlanta, USA, the week of June 17th, with 158 reviewers across 25 panels ranking the 1773 received proposals for Cycle 7. The results were sent to the Principal Investigators on July 23rd.
- The distribution of the estimated Cycle 7 execution time for Grade A and B projects by region for the 12-m (left), 7-m (centre), and Total Power (right) arrays is shown in Figure 1. The results for the 7-m and Total Power arrays include both ACA standalone proposals and proposals requesting the 12-m Array + ACA. The distribution of the scheduled execution time for Grade A and B projects by receiver band is shown in the lower panels of the same figure.

Cycle 6 and 7 observing

- ALMA started July 2019 in the hybrid 9/10 configuration and moved then into Configuration-8 by mid-July. All but one Configuration-9/10 SBs with Grade A or B were completed with QA0. Recovering from power outages at the end of June, a power outage in August, high wind speeds at the AOS in July, and snow in September had significant impact on operations. QA0 PASS hours remained behind target on the 12m and TP arrays (by 9% and 14% respectively, at the end of August). On the other hand, these were 30% ahead of target on the 7m array. A relatively high QA0 FAIL rate on the 7m array was related to a correlator platforming issue.
- The total power antennas continued to be used in the baseline array to optimize long-baseline observations. As the antennas were relocated to Configuration-7 and -6 in August/September, total power observations resumed.
- A ‘gap’ in the 7m schedule has opened up in the Cycle 6 schedule. 7m projects approved for Cycle 7 were ‘carried-under’ and observed in Cycle 6 in order to fill the gap. The Cycle 7 supplemental call for 7m proposals will ensure that this situation will not arise again in Cycle 7.

Figure 1: Distribution of the estimated execution time for Cycle 7 Grade A and B projects by region and by receiver band, for the 12-m (left), 7-m (centre), and Total Power (right) arrays.
• Cycle 7 observations started on September 30th 2019. The first Cycle 7 data were delivered within 12 hours from observations. In the first three months of Cycle 7, more than 82% of the ALMA data that went through the pipeline have been delivered within 30 days.

• As a result of a more efficient scheduling a gap in the 12m schedule has opened up for low frequency compact configuration. Subsequently, six projects were “resurrected”, three of which led by EU PIs. The SBs were manually generated by the Phase 2 group and were made available for scheduling soon after the decision was made.

• Cycle 7 observations proceeded, with QA0 PASS executions on all arrays following closely the predicted curves. At the end of January (shutdown) A- and B-ranked projects both reached 25% completion rates on the main array and 60% on the 7m array.

• The completion of Large Programmes (LPs) also follows expectations, with all four Cycle 6 having reached a minimum of 90% completion rates. From the four Cycle 7 LPs, one is nearing completion (>98%), one has already reached 87% completion, while the remaining two require configurations that are yet to come.

• Astronomer-on-duty shifts from the three ARCs schedule for after March 10 have all been cancelled due to the COVID-19 situation.

• Cycle 7 PI observations were terminated on Friday 20 March, when the observatory went into a shutdown. The shutdown will inevitably affect the outcome of the current and future (Cycle 8) cycles and several modifications and adaptations are currently being considered.

### ACA Supplemental Call

• The ACA supplemental call for proposals was opened on 3 September, with a deadline on Tuesday, 1 October 2019. Only Regular Proposals without time constraints that propose to use standard observing modes are accepted. Proposals may request to use the 7-m array only or the 7-m array plus Total Power array. It is anticipated that approximately 2500 hours on the 7-m array will be scheduled in the Supplemental Call. All proposals accepted in the Cycle 7 Supplemental Call receive priority Grade “C” and will have lower observing priority than ACA proposals accepted in the Cycle 7 Main Call.

• Differently to the Main Call, proposals submitted in the Supplemental Call were peer reviewed using a distributed system in which each proposal team selected a designated reviewer to participate in the review process. Each submitted proposal was ranked by ten reviewers, and the final rank-ordered list of proposals was determined by an average of the reviewer rankings.

• No explicit approval for Phase 2 was needed for the Supplemental Call. Phase 2 generation happened in batch mode immediately after the PI notifications.

• The ACA queue was filled at >100% capacity (3500h for the 2500 h offered) to avoid any future gaps.

• Science operations conducted a survey among Cycle 7 PIs, with the main aim of comparing the experience with the panel-based proposal review with the distributed peer review in the supplemental call.

### Science Operations updates

• Following the approval by the ALMA board, raw data can be released from now on to all ALMA users upon request.

• DDT projects now remain in the observing queue for the 365 days following their approval.

• The ALMA director approved the preparation of a galactic supernovae readiness observatory project, with no proprietary time. Scheduling Blocks have been prepared jointly by ALMA staff at the JAO and the ARCs.

• The integrated Science Operations Team (iSOpT) met face-to-face in Cagliari for two days right before the ALMA science conference, with the participation of the EU ARC manager. iSOpT met again face-to-face in January in Santiago with the participation of the EU ARC manager. On the same occasion, iSOpT met face-to-face with the other integrated teams.

• Due to the unease in Chile, ALMA moved to minimal operations from October 23 to October 29. Astronomers on Duty (AoD) shifts were covered by JAO staff for a period of three weeks, as for safety and logistics reasons, no AoDs were sent to ALMA from the regions during that period. AoD shifts from the European ARC resumed in mid-November.
• The pre-announcement for Cycle 8 was published on the ALMA Science Portal on December 19. Cycle 8 will see the implementation of a double-anonymous peer review system.
• The Cycle 8 Call for Proposals was opened on March 17, with deadline on April 15 at 17h00 CET. Cycle 8 will see the implementation of a double-anonymous peer review system. The notion of non-standard observing modes is no longer relevant for regular proposals, in an effort to increase the request for e.g. high frequency, long baseline or polarisation observations.
• The Call for Proposals went out in the initial phases of the COVID-19 pandemic. Following the rapid evolution of the situation across Europe, Chile and the ALMA Partners regions, the deadline had to be postponed to a later date (at least 19 May 2020) in order to accommodate the demand from users all over the world that were affected by the extreme safety measures.
• EU ARC Management participates regularly in the weekly Integrated Science Operations Team (iSOpT) telecons and in more frequent shorter a-d-hoc telecons necessary for the assessment of the impact of the COVID-19 situation and the relevant decision making.
• The proprietary times of all data sets that were not public yet on 19 March 2020 were extended by 3 months. This has been communicated on the Science Portal and through messages to affected PIs.

ALMA Regional Centre Staff

• Liz Humphreys, deputy ARC manager, took up the position of Head of the Department of Science Operations at JAO, effective September 1, 2019. Evanthia Hatziminaoglou was appointed the new deputy ARC manager.
• Newly hired ARC astronomers Anna Miotello and Gergo Popping started their positions in the ARC on September 1, 2019 and Fabrizia Guglielmetti started as ARC scientist on 1 April 2020.

Observation preparation: Phase 2

This year's face-to-face meeting of the Phase 2 working group was relocated to Victoria, Canada, and hosted by the North American node in Canada. Besides the usual writing up of the current cycle's "Best Practices", the following issues were specifically discussed:

• The cone searches criteria;
• Band-to-band capability (new observing mode offered for Cycle 7)
• The supplemental call timeline for P2G;
• The development of the global program tracking for P2G;
• New instructions to change already executed SBs to prevent breaking the harvester (part of Archive).

The new working flow for resubmissions was used and tested in practice - aiming to automate detection of resubmissions and dealing with them, which depends on various circumstances. Although some fine-tuning is still required, this has been a major improvement over the manual handling of resubmissions in earlier cycles.

ALMA Helpdesk

• ARC staff and ESO fellows are regularly taking care of the ALMA Helpdesk triage and ticket handling.
• In period April to September 2019, that includes the ALMA Phase 2 deadline, 105 tickets were received. Proposal change requests (35), data reduction (27) and archive-related (13) cover two thirds of the tickets. In the period October 2019 until April 2020, that includes the Cycle 7 Supplemental Call deadline, 222 tickets were received. Data reduction and archive- and data-retrieval- related cover half of the tickets.
• The emergency department for the ACA Supplemental Call opened on September 29 at 23h UT and was handled in shifts by members in the three ARCs.
• The Helpdesk working group had their monthly telecons with ARC staff participation. The planned face-to-face in March was cancelled due to the COVID-19 travel restrictions. Instead,
three telecons were held to discuss the most urgent matters, one of which is the migration to a new vendor.

- Together with the USD department, Helpdesk staff prepared a document that outlines the requirements for a shared ALMA and La Silla Paranal helpdesk system. This document is used as a starting point within ESO and in discussions with NRAO to establish if a common vendor is a viable option for ESO.
- ARC staff, together with USD staff, have participated in the testing of new vendor demos. Following the discussion in the working group and the tests, DeskPro was chosen as the new vendor.

Data reduction and Quality Assurance

- During the reporting period, more than 900 MOUSs observed in Cycle 6 and 7 were processed and reviewed by the EU ARC. More than 90% of the datasets were pipeline-calibrated, and 85% were pipeline-imaged. The MOUSs that were manually processed, were handled at ESO and the ARC network.
- While the EU ARC pipeline generally remained in a low-activity mode leaving most of the actual computing to JAO, the imaging of all MOUSs belonging to an EU-supported large project was taken over by the EU ARC in order to bypass the size mitigation applied by the standard pipeline. This meant that the cluster was running nearly under full load. The intensity of weblog review work (the main human-time consumer) remained unchanged. Custom processing was performed on many tens of the Large Programmes datasets that are run with script editing in the ALMA pipeline at ESO which are not suitable for automated runs, due to specific data products or problematic data.
- Preparation for ALMA Cycle 7: upgrade of ALMA pipeline installation and related script infrastructure with subsequent verification. Processing of end-to-end cycle 7 dataset that are implementing band-to-band technique. I.e. to use a calibrator at band 3 for band 7 observations, when calibrators are not available at band 7.
- A large fraction of the ALMA VLBI data was finally delivered. Ca. 10 MOUS are still having their calibration revised.
- A scheme for processing the Cycle 1 and 2 datasets affected by the Mosaicing CASA bug at the EU ARC nodes was worked out.
- Testing of cube image noise level in the pipeline compared to those reported/required for QA2 by the data reduction managers and AQUA. Some discrepancies were found but are now understood, such that a recommendation will be made to the AQUA sub-system to obtain the ‘correct’ values in certain unique problem cases.
- A new tool within the AQUA subsystem, the QA2 Dashboard, was put into production for easier tracking of the data processing and assessment process at the different ALMA centres.
- Five analysts received training for reviewing pipeline weblogs (three at the Allegro node, two at ESO) as well as an introduction to pipeline data reduction and task manipulation (Allegro staff). ESO staff created new training material for use during these and future trainings.
- At the beginning of Cycle 7, we transitioned successfully to the new CASA version 5.6.1-8 and the corresponding ALMA pipeline.
- The reprocessing of Cycle 1-3 7M data working with the ARI-L team and related tests were started. A special RHEL 7 build of CASA 4.2.2 was obtained from NRAO, tested on the EU ARC cluster, and gotten to work after some iterations. This will be useful for re-running the imaging on Cycle 1 and 2 datasets without having to use special legacy RHEL 5 machines.

Staging of calibrated data for ALMA users

An automated system was put in place for creating the calibrated measurement sets for a given dataset and staging the measurement sets as tarballs for download. Together with the Archive Operations Group, a procedure was developed to run this system on demand for ALMA users with the necessary credential and entitlement checking. The system was announced on the user portal in September to become available for general use on 1 October.

CASA and script generator
One of the ARC staff is an active member of the CASA development team. Some of the CASA-related activities include:

- After the upgrade of the entire CASA infrastructure to a new operation system as part of the EU ARC cluster upgrade from RHEL6 to RHEL7 in Q2, the creation of support for old versions which need RHEL5 was successfully added and tested in Q3.
- Maintenance of the geodetic and ephemeris reference tables for the worldwide CASA distribution: power failure at IPP led to disk crash in one of the two redundant servers. ARC staff worked with IT staff to replace the crashed disk and completely re-install the system. A UPS was added to prevent power failures from having this impact.
- The ALMA scriptForPI was ported to Python 3 (version 1.30, now in use) and the execfile functionality in CASA 6 was verified.
- The Measures Table update was negotiated with ASTRON to take place on a daily rather than weekly basis. The corresponding change was then applied to the ESO-based update service of the CASA data repository. This was a change requested by the ALMA online system.
- The work on integrating the band-to-band calibration handling in the ALMA calibration script generator was started.

**Observing Tool (OT)**

- The OT for Phase-2 submission was delivered at the end of July and no problems were encountered. This same version was also used for the Supplemental Call starting in early September. This was the first Supplemental Call for which the OT had been specifically configured and the changes required were substantial, including a new interface to enable the Distributed Review Process.
- An update of the OT was released in the first half of September for SB preparation by the Phase-2 Group. The SBs were first generated in batch mode at the JAO and this process went very well.
- ESO hosted the annual OT Working Group F2F meeting in October, which was led by the Subsystem Scientist with the EA and NA Cognisant Leads and the Lead Developer in attendance.
- The Subsystem Scientist presented a progress report on the OT Upgrade Study to the ESAC in October. The request to go ahead with an Upgrade Project was finalised and submitted to the ALMA Management Team in November.
- Most work on the ALMA Observing Tool has related to getting the release ready for the Cycle-8 Call for Proposals. A number of new features are available in the OT, most notably the new VLBI-type capabilities of passive phasing and "pulsar mode".
- As the OT is now built using Java 11, the previously recommended WebStart install option is no longer available. A similar capability has been created in the form of a modern installer based on 'InstallAnywhere'. This has performed well in tests but will not be available for users of the latest Mac OS release (10.15 Catalina). Here the tarball installation method must be used instead.
- As part of efforts to gain approval for the OT Upgrade Project, a talk was given at the February European Scientific Advisory Committee (ESAC) meeting. This talk was subsequently given by the European ALMA Programme Scientist at the ALMA Scientific Advisory Committee (ASAC) meeting in March. The ASAC have consequently recommended that the Upgrade Project be approved.

**Science Portal and Newsletter**

- The the face-to-face meeting of the Science Portal Working Group took place in June (at the East Asian ARC), following which preparative work for the Supplementary Call for Proposals
was carried out, with various parts of the Portal being updated. The Call happened on the 3rd of September, with a smooth transition of the Portal from Cycle 7 to Cycle 7.5.

- Two European ALMA Regional Centre newsletter were published, along with several regular announcements.

**Archive**

- The official processing for the ALMA development project 'ARI-L' has started. Work on the ARI-L software has been carried out. See under 'Development' for more details.
- Following the Archive Review, an ALMA Science Archive acceleration development project was prepared and approved (See Development section).
- Further user-testing of the new archive interface has been coordinated by ARC staff. The new interface is show in the Figure.
- A 4-day face-to-face meeting for the ALMA Science Archive was held in Taipei, Taiwan. The entire program and planning for the Science Archive were discussed and 29 pages of action-items and decisions have been produced.
- A user-survey for the ALMA Science Archive was crafted and sent to all registered ALMA users. Over 400 answers were collected. Over 40 pages of comments to the different questions were received. The analysis is still ongoing.
- A face-to-face meeting with the Cube Analysis and Rendering Tool for Astronomy (CARTA) developers was held over three days in Garching, preparing the installation of remote visualization at ESO.
- Work within the ESCAPE project has been carried out and a 2-day workshop at ESO has been attended
- The software to create previews for ALMA observations was re-designed and rewritten from scratch following ICT software standards. This process is completed at the 80% level.
- Work was carried out within the ESCAPE project helping the team with continuum subtraction and retrieving spectral classifications. A two-day ESCAPE workshop was held at ESO.
- Work on the Docker container set up was done together with colleagues from the East Asian ARC. The CARTA remote visualization server was equipped with the software and testing of the NGAS mounts was carried out successfully.

![Figure 2: The new ALMA archive interface, with an instantaneous search, zoomable spectral window viewer, a display of the spectral lines falling in the selected frequency range and much more.](image)
- In-kind contributions were given to the astroquery team by providing software that is compatible with the new ALMA request handler (RH) to them. A docker image was provided to ICT testing to allow to check easily that new RH development will not break astroquery.

Scheduling

- For the first time, the time on source and the hour angle at the time of observing will be taken into account to project the antenna baselines and calculate a more accurate beam with the aim of reducing QA2 failures due to beam size. Other features in the new release include, among other things, handling of polarization observations with calibrators up to 3 hours away from target.
- First discussions with USD to define the requirements for the VLT scheduler, to understand the shared problems/constraints between VLT and ALMA and see where synergies or common solutions can be found.
- The changes for Cycle 7 regarding beam calculation aimed to reduce the fraction of QA2 failures have been successful. As of 7th of January, the fraction of failures due to beam size for all Cycle 7 observed MOUS that are evaluated with Cycle 7 QA2 criteria is 0.9% (down from > 10% in Cycle 6). This has a significant impact in the observing efficiency of the observatory since the QA2 failed datasets are most of the times re-ingested to the observing queue and thus the reduced fraction of failures implies 10% additional observed datasets. A significant reduction in beam ellipticity has also been achieved, implying an improvement on the quality of the observed datasets.
- An ALMA development study proposal was submitted and, subsequently, approved to evaluate the feasibility of a UV-based approach for quality evaluation and scheduling in Cycle 9 and beyond.
- Analysis of the Cycle 6 data on long-baseline configurations is ongoing, to evaluate the risk of an increase of QA2 failures due to beam size in Cycle 7 due to the known offset of the calibration used by the OT/DSA and the fact that in Cycle 7 the configurations will move from more compact to more extended.
- Also, ongoing analysis of SBs that have been assigned to a C43-6 configuration but are schedulable both in C-6 and C-7 to take action on the type of SBs being generated.

Extension and Optimization of Capabilities (EOC)

- Analysis and report from processing of 13 High-Frequency long-baseline campaign EOC datasets was carried out during the reporting period. The aim was to look forward to unlocking the fully capabilities of ALMA, all bands all baselines for Cycle 9. The tests datasets were band 9 and band 10 observations achieving between 5 and 10 mas resolution. Imaging was successful but a number of limitations were also identified.
- The final report for the High-frequency Long-baseline campaign was presented to JAO staff and has been acknowledged for the basis to use for future EOC using the band-to-band (B2B) mode. The report was also accepted to be used for developing into a publishable peer-reviewed paper.
- A number of inputs were provided to JAO collaborators with a forward look to the 2020 Cycle 7 long-baseline campaign which will focus again on the B2B technique. This technique is almost certainly required for any Band 9 and Band 10 observations. The initial plan for observations and priorities have been submitted to the EOC lead. Although not due for decisions at OBSMODE8 (for Cycle 8 due to no long-baselines), the work was discussed and is still set for a ‘GO’ in Cycle 9 when long-baselines are offered again.
- The summary paper of the long baseline high frequency campaign work from 2017 has is now published (ApJS 247 23A, 2020). It showcases the testing images of HL Tau and VY CMa at band 9 with resolutions circa 10mas, released to the community right before the call for proposals. The campaign and continued Extension of Capabilities work is a result of strong collaborations between ESO and JAO staff.

Astronomer on duty support
The European ARC contributed 12 astronomer-on-duty (AoD) shifts during this year. However, all EU ARC AoD shifts schedule to happen after March 10 have been suspended due to the travel restrictions related to the COVID-19 situation.

**ESO ARC and ARC Network activities**

- The ALMA Phase 2 period is a time of intense interaction between Contact Scientists (CSs) and PIs. European CSs support 250 ALMA Cycle 7 accepted projects from the main call and have interacted with PIs and the Phase 2 Group (P2G) in Europe during this period advising PIs on the validation of their Phase 2 material and change requests. This work was done in parallel with the regular support of the EU-supported Cycle 6 approved projects, including 10 approved DDT proposals, two carried under ACA proposals and one Large Programme.
- The European ARC nodes perform Contact Scientist duties for ~90% of all EU-supported Cycle 7 approved projects, including 43 projects from the Supplemental Call, three approved DDT proposals and two Cycle 7 Large Programme, in addition to all the still active Cycle 6 projects.
- The Nordic node organized the EU network software tool workshop in Gothenburg in September, with the participation of approximately 20 EU ARC network staff.
- IRAM held the 30m summer school in Spain on September 6-13, 2019.
- The EU ARC nodes continued providing face-to-face support to EU-supported PIs as well as archival projects. An important fraction of these visits are regularly funded by the RadioNet MARCuS work package.
- The EU ARC network all-hands 2.5-days meeting took place in Königswinter near Bonn at the beginning of November with a total of 60 participants (including members from the AMT, the observatory scientist and a JAO staff member). During this meeting, the ARC network Coordinating Committee (ACC) met with the AMT in a dedicated session.
- Allegro (the Dutch ARC node) organised and hosted the third Netherlands ALMA science day on November 22, with 30 participants including ESO staff. PIs from the Dutch community were invited to present their results and share their experience with data reduction and imaging.
- The ARI-L development project processing was officially started. ARI-L is led by the Italian node, with strong participation from ESO staff. ARI-L has successfully processed more than 1000 MOUSs at the time of writing, with the first datasets already ingested into the ALMA archive as externally contributed products.
- The Czech node organised a three-day workshop (19-21 November) in Slovakia (Astronomical Institute in Tatranska Lomnica) on the use of ALMA in astrophysical research (interferometry basics, proposal preparation in OT, CASA data reduction).
- Members of the EU ARC network (including ESO staff) form the Science Organising Committee of a EAS2020 Special Session on the joint EU ARC network and EU ALMA PIs effort in maximising the scientific output of ALMA.
- The North American ARC Liaison (Adele Plunkett) visited the ARC at ESO, the Allegro node in Leiden and the Nordic node in Onsala and shared views on user support practices and communications across the ARCs.
- ALMA Cycle 8 proposal preparation events were scheduled throughout Europe by the EU ARC nodes. Due to the COVID-19 situation, some have already been cancelled and some will happen in the form of virtual meetings.
- Due to the COVID-19 situation the yearly ARC network Coordinating Committee (ACC) face-to-face meeting scheduled for March 9 and 10 was converted into a 2.5h video conference during which the most important items of the face-to-face agenda were discussed.
- Staff from the Czech node in Ondrejov co-lead the “1st International Workshop on Solar Imaging with ALMA”, an initiative that addressed advanced (science-ready) processing of the solar ALMA data.
- A social media presence was established for European ALMA network on Facebook, Instagram and Twitter, a collaboration between the ESO ARC and the ARC nodes. Postings range from European ALMA science highlights to reports from workshops or portraits of individual EU ARC staff members.
ALMA Development projects

Band 2

ESO continues to coordinate and support the science case, technical development, and preparations for production of a new ALMA receiver covering the original ‘Band 2’ frequency range, 67 to 90 GHz, with the option to extend this out up to 116 GHz. Following the ALMA development priorities, the receiver will be the first one to have at least 16 GHz (with a goal of 28 GHz) IF bandwidth per polarization channel. The work is being done by a consortium of several European institutes, ESO, UC Chile, and NAOJ.

The Band 2 preproduction project has been approved by the ALMA Board in the April 2019 meeting, with the expectation to move into Full production depending on the performances of the preproduction units. This phase encompasses detailed design and pre-production series of the Cold Cartridge Assemblies (CCA) and Warm Cartridge Assemblies (WCA).

The two contracts for the Band 2 cold and warm cartridges have been finalized and the signature process started.

Low noise amplifiers (LNA) and vacuum lens are the two key components which primarily define the sensitivity of Band 2 receivers. Both of these elements are in the final stage of development.

Prototype LNAs from three suppliers, University of Manchester (UMAN), Low Noise Factory (LNF), and NRAO have been tested in the reporting period on unit level. Two of these LNAs have also been installed and tested in a prototype cartridge to access full system performance. The remaining LNA test in the prototype cartridge was originally planned for March, however is currently on hold due to coronavirus related restrictions. This implies that the selection of the LNA for Band 2 production will have to be postponed as well.

Good progress has been made in the vacuum lens development. The antireflection layer for the lens has been optimized and successfully tested. Also the lens material was selected, the lenses will be fabricated from the ultra-high molecular weight polyethylene (UHMWPE), which demonstrated better performances than HDPE traditionally used in this frequency range. A bulk of UHMWPE material has been procured from alternative suppliers and samples from all of those made to assure material properties, which may depend on the manufacturing process. After that, a pre-production series of the lenses will be made from the selected batch. Since UHMWPE material testing involves working in the lab, this project will also have to be delayed due to the current situation with coronavirus.

Band 2 related Small projects

Two development studies and two small projects supported Band 2 development and preparation for production:

“Band 2+3 optical components”

- Prototype versions of the optical components (feedhorn and OMT), developed by U Chile, INAF, and NAOJ, have been manufactured and evaluated.
- The final prototypes from these three suppliers have been delivered to ESO in late 2018. They were all tested individually for the key performances and also integrated in a prototype receiver.
- The obtained results were evaluated in a “Band 2 Critical Components Baseline Selection Review” held on 18 June 2019. The review panel noted the impressive and fairly similar performances of all three types of optics. At the end, upon consideration of the ultimate performances and the remaining performance and manufacturing risks, the panel recommended to select NAOJ design as a baseline. In September 2019, the ESO and NAOJ operation managers have formally approved this baseline selection.
- The study passed successfully its mid-term review on 15 July.
InP MMIC LNAs for ALMA Band 2+3

- Five LNAs have been designed and produced by the University of Manchester (UMAN) from an MMIC wafer fabricated by NGC in July 2018. This LNA batch includes the original UMAN design from 2015, proven to be successful, and also two new designs, one with a larger gain (additional stage), and one with optimized noise performance between 70-90 GHz. The LNAs are currently being tested at Yebes, results are expected in October this year.
- A new batch MMIC by a commercial alternative supplier, Low Noise Factory in Sweden, is being completed now. The packaged LNAs are expected to be produced and tested in October this year.

“Band 2 receiver: Optimization and preparation for production”:

- This small project was focused on the technically critical areas, and where the selection of receiver components needed to be done: passive optical components and LNAs. For this purpose, a full prototype receiver has been designed and manufactured. This receiver has been used in the reporting period to test the LNAs and the prototype optics, see relevant small project above. The final review for this study has been held on 15 July, and the study is completed by now.

“Vacuum lens development”:

- This small development project focuses on the choice of material and optimization of the antireflection layer for the vacuum lens.
- Based on the comprehensive literature review and prototypes testing, it has been decided to pursue two materials: high resistivity silicon, and ultra-high molecular weight polyethylene (UHMWPE), which show better performances than HDPE traditionally used in this frequency range.
- The remaining activities are to optimize the antireflection layer geometry in UHMWPE, and also the lens size, a trade-off between the loss in dielectric and truncations at the lens.

ARI-L

ARI-L: The Additional Representative Images for Legacy (ARI-L) project is a development project working to pipeline re-process the majority (>70%) of ALMA data from Cycles 2-4, with the goal of substantially improving the value of the data products in the ALMA Science Archive. The project, which started in the summer of 2019, is on track, having processed over 420 member ObsUnitSets (MOUS) with over 75% acceptance rate by Feb 2020, though we caution the data processed may not be representative of the full sample (>2400 MOUS).

ASA Acceleration

Following the recommendations from the Archive Review Board, a Small Development Project was designed to accelerate the development of the ALMA Science Archive. The Project will deliver resources to supplement the Archive development team with one additional FTE for two years, with the goal of completing the planned development of ASA on a shorter timescale.

OT Upgrade project proposal

Forthcoming: the OT upgrade project proposal has been evaluated within the Partnership, presented to the external science advisory committees ESAC, ASAC, and STC for recommendation, and the ALMA Directors Council has recommended to submit the proposal to the ALMA Board for approval at its forthcoming meeting on April 20.
ALMA Science and Upgrade Studies

The EASC Science Team is responsible for tracking the scientific performance and outcome of the observatory as part of the ALMA Integrated Science Team, but specifically focusing on the European activities, and to coordinate the European ALMA Upgrade Studies.

ALMA Science

- An ALMA-wide science conference entitled ALMA 2019: science results and cross-facility synergies was held from 14-18 October 2019 in Cagliari, Italy. With approximately 220 participants, from across all regions and all fields of science, the conference was a resounding success. Initially, the conference was hugely oversubscribed, forcing us to waitlist otherwise deserving registrants and posters, but eventually, the oversubscription issue resolved itself, and the waitlist dwindled to zero, allowing everyone who wanted to, to attend. A typhoon hitting the metropolitan Tokyo area in the weekend ahead of the conference unfortunately prevented many Japanese participants from travelling to Cagliari, forcing them to cancel participation at the last minute. The conference was organized by ESO in collaboration with the local INAF institute in Cagliari. The organizers at INAF have been instrumental in all local arrangements, and also contributed significantly to the scientific and administrative aspects of organizing the ALMA2019 conference. A detailed report on the conference will be published in a forthcoming issue of The Messenger.

- ESO published three press release related to ALMA over the last year. One press release showed a set of charismatically entangled protoplanetary disks in a multiple stellar system in formation. The system was dubbed the cosmic pretzel in recognition of the timing of the press release during the Oktoberfest in Munich. Other press releases showed results from ALMA and Rosetta combined to understand the evolution of phosphorus in planet-forming systems. ALMA revealed the spatial distribution of phosphorous-bearing molecules in the circumstellar environment of massive stars in formation. Specifically, it is detected in the walls surrounding the cavity that the massive star has created in its natal cloud. The detection of phosphorous-bearing molecules by ESA’s Rosetta mission in comet 67P/Churyumov-Gerasimenko demonstrates that these molecules can successfully be transported to the inner Solar System. A press release on HD101584 shows the enigmatic evolved star HD101584 in molecular line emission. The complex structure suggests the presence of an unseen secondary object, required to explain the level of sculpting seen in the circumstellar environments.

- There was European involvement in two press releases by the ALMA observatory in 2019: “Spiralling giants: witnessing the birth of a massive binary star system”, with involvement from Chalmers University of Technology in Sweden, and “What 100,000 star factories in 74 galaxies tell us about star formation across the universe”, which reports on the PHANGS large program.

Upgrade studies

The EASC runs a programme of ALMA development studies supported by EASC Science Team staff and, as required by the nature of the study, by the ARC, Computing or Engineering staff. External proposals are collected in response to a “Call for ALMA Upgrade Studies”. In the first half of 2020, we are transitioning from the studies in response to the 2016 call to the ones from the 2019. This scheme has proven very effective in engaging institutes in the ESO Member States with the ALMA development process and has successfully allowed to leverage on expertise outside ESO.

Progress of the running studies from the 2016 call that are not yet completed:

- Band 2+3 optical components: The details of this project are described in the Development Projects section.
- InP MMIC LNAs for ALMA Band 2+3: The details of this project are described in the Development Projects section.
- Digital Front End (NOVA): the response of the DFE working group to the Final Review recommendations was unsatisfactory, despite several reminders. A number of meetings with the team were held in February and March to decide to terminate of complete this study.
• SIS Junction Technology (Chalmers): This study is nearing completion with the production in March of new Nb/AlN/Nb junctions with almost optimal RnA values. Completion will require some additional access to the Chalmers clean room facility, which may be compromised by the covid-19 containment measures. The date of the final review in Q2 2020 will depend on these exceptional circumstances.

• Full 2SB Band 9 receiver (NOVA): The main results in Q1 2020 were the first complete measurements of the IF bandwidth. The mixers can reach IF values up to 24 GHz, but the measurements above ~16 GHz, and especially above 20 GHz are strongly affected by standing waves caused by a bad coupling between the mixers and the cryogenic LNAs. The plan is that NOVA will produce their own bias tee, while Yebes will be working on improved LNAs. It was agreed that the main focus of the study should be on the IF range 1.9 to 18.1 GHz, with higher frequencies remaining part of the study too. The other important topic of the study is to test how many of the existing mixers from the Band 9 production can be re-used for an upgrade from DSB to 2SB. The first tests on 16 mixers from an almost depleted wafer showed a high yield of 15 mixers with good performance. These are now being tested inside the cryostat.

• High cadence Solar Imaging (Onsala/Oslo): The team have been progressing well with producing the simulated image sequence to use as input for their data processing. A masters student has been working on realistic atmospheric phase screen simulation to use as part of the visibility generation to produce realistic observed phase fluctuations to test self-cal techniques with. A workshop on ALMA Solar imaging was held in Oslo on March 3-7, in which there was a lot of productive discussion and testing of self-cal techniques, and the team presented their pipeline and the high cadence study. Real test high cadence observations were taken by the observatory for this study in Dec/Jan, each composing of a 7.5 minute stare with 0.2s spectral integration time sampling and 16ms channel-average time sampling. Initial executions highlighted a performance problem in the online calibration (TelCal) software that resulted in failures. This was addressed, and then the observations ran to completion in January. During the observations the fast time sampling showed clearly a problem in the delay tracking when observing the Sun. Unfortunately this turned out to be a serious bug affecting all Solar observations to date, which results in astrometric errors of up to ~50 arcsec, and unstable tracking within about an arcminute of the barycentre. The full impact and how to handle the affected PI datasets is now being discussed within the observatory (to some extent it is already mitigated by the way the data are used by the solar community, including the use of self-cal, and registering the ALMA images with those of other observatories). This was an example of on-sky tests for a development study generally helping improve the observatory performance.

The first contracts for the new studies from the 2019 call for proposals are currently being sent to institutes to allow kick-off meetings in May 2020, provided the Covid-19 containment measures do not further impact the schedule.
Figure 3. ALMA image of HD 101584 in molecular line emission, showing the complex structure in three dimensions with the red parts designating gas moving away from us and the blue parts gas moving towards us.