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ALMA Science Advisory Committee (ASAC)
Report to the ALMA Board

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General considerations

The ASAC face-to-face meeting was held virtually on October 5-7, 2021, using zoom. ALMA Director Sean Dougherty, Observatory Scientist John Carpenter, and the three regional Program Scientists Daisuke Iono, Crystal Brogan, and Francisca Kemper participated. James Di Francesco participated in the meeting as a liaison to the ALMA Board Science Committee, which is very much appreciated. Liz Humphreys (Head of DSO) and Satoko Takahashi (ObsMode lead) were invited to present material on some of the charges. Ruediger Kneissl joined the discussion on flux calibration issues, and Andrea Corvillón, Adele Plunkett, and Jennifer Donovan Meyer joined the discussion on charge 4 to help answer questions regarding the cycle-8 proposal review process. ASAC appreciates the timely delivery of all the documents and presentations prior to the meeting itself, which aids in ASAC's preparations and gathering of feedback from the regional SACs. No debrief session was arranged during the meeting due to limited availability of time at the virtual face-to-face meeting. Instead, the ASAC chair met Sean Dougherty and John Carpenter via zoom on October 14 to debrief the initial outcomes of the ASAC meeting.

While there were no ad hoc charges from the Board at this meeting, we were aware of some important specific items, which include the assessment of the Cycle-8 proposal review process and Band6v2 proposal. We provide responses accordingly to the appropriate charges below.

Permanent Charge #1. Assessment of the performance of ALMA scientific capabilities: The ASAC shall indicate what information is required from the Joint ALMA Observatory (JAO) to perform this assessment.

Recommendations/findings:

- ASAC appreciates the comprehensive presentation of activities aimed at improving ALMA flux calibration. A number of incremental improvements in the higher bands can be anticipated as a result of current efforts.
- The committee emphasizes the importance of making sure that the community is well aware of the new capabilities being offered. The observatory is encouraged to make advertisement to the community and expanding the community in parallel to new modes after the release of science verification data associated to new observing modes.
- ASAC agrees with the plan for the ObsMode2021/2022 processes.

Flux calibration: ASAC has noted previously that better flux calibration would improve the science outcomes for ALMA data. This is particularly relevant when combining ALMA data with other sources, such as JWST, which expect to achieve uncertainties of a few percent. ASAC received a presentation that reviewed the status of calibration across the ALMA bands. At lower frequencies the uncertainty is of order 2-3%, but it rises to show a scatter of as much as 20% at B9/10. ALMA plans to address the higher bands by combining more comprehensive direct flux monitoring at those bands, exploring an SEFD approach, and more use of solar system object (SSO) observations as part of the calibration process for PI data. Each of these items can help improve flux calibration incrementally. The presentation noted that there are at least 10 instrumental effects that contribute to calibration uncertainty, but there was no conclusion as to the relative contributions of the different elements (i.e., an error budget), which might inform a strategy to significantly improve calibration. We recognize the difficulty of this task, given the dependence on so many factors (such as atmospheric variability, receiver stability and pointing accuracy with small beam sizes) and the different impacts on different bands. ASAC strongly supports efforts to find additional SSO targets that can improve the sky density of suitable flux calibrators. We also note, as discussed by Francis et al (2020), that other objects such as protoplanetary disks should have fluxes that are stable on longer timescales, and could be potential calibrators in some circumstances. We continue to emphasize the importance of understanding the sources of uncertainty in calibration in order for the Observatory to be able to make informed judgements on the feasibility of, and resources needed for, desirable improvements.

New observing capabilities: ASAC noted the low demand and little success in obtaining time for projects that require some of the newly-developed capabilities, such as the pulsar mode. The implementation of new capabilities requires a significant effort and resources, and the little science return from them is a worrisome sign of possible inefficiencies. The committee emphasizes the importance of making sure that the community is well aware of the new capabilities being offered. The observatory is encouraged to make advertisement to the community and expanding the community in parallel to new modes after the release of science verification data associated to new observing modes.

ObsMode process: ASAC appreciates the detailed planning and implementation processes for future observing capabilities. The committee agrees with the plan for ObsMode2021/2022 and is happy to see the

progress despite the difficulties due to the pandemic. ASAC looks forward to seeing the upcoming implementation of new capabilities for the next cycles.

Permanent Charge #2. Assessment of the technical aspects of the ALMA system performance: The ASAC shall indicate what information is required from the JAO to perform this assessment.

Recommendations/issues:

- ASAC commends for the very successful return to operations handled smoothly and the relocations to the hybrid longest baseline configuration completed under the very difficult conditions imposed by the pandemic.
- The observatory is encouraged to prioritize efforts for resolving renormalization issues and make appropriate communication to potential observers.
- ASAC is concerned by the low completion fraction of high-frequency observations (Bands 9/10). We encourage the observatory to figure out the causes of such a low completion fraction, and to adjust the priority of high-frequency programs to improve the completion fraction of high-frequency observations if it is necessary.
- The committee suggests assessing the impact of supplemental calls and statistics in regular calls to motivate the need for supplemental calls.

Successful return to operation and reconfigurations: The committee commends for the very successful return to operations handled smoothly. Furthermore, it was a great achievement to reach the hybrid longest baseline configuration with only limited staff at the OSF allowed during the return to operations and the very challenging weather conditions. ASAC applauds the observatory on these impressive achievements despite the very difficult conditions imposed by the global pandemic.

Renormalization issues: ASAC acknowledges the report on the intensive efforts to resolve the renormalization issues, which severely impact the data processing. The root cause traces back to the way observations are currently carried out, and a dedicated team has been proposed to analyze the different methods and choose the one that produces high calibration quality while keeping a reasonable execution efficiency. The committee endorses these activities led by the world's leading experts and encourages JAO to prioritize efforts for resolving renormalization issues. The observatory is also encouraged to extend the effort to appropriately publicize the issues among the community.

Completion fraction of high-frequency band observations: ASAC is concerned by the fact that no Band 10 projects and a minority of the Band 9 projects approved for Cycle 7 have been observed. While these high-frequency projects represent a minority among the whole set of approved proposals, they require unique atmospheric conditions only achievable at the ALMA site. Given that the observation of these high-frequency bands was a main driver to build ALMA at a very high site with a great economic cost, it seems important to make sure that such high-frequency projects are observed if approved. ASAC encourages the observatory to investigate the causes of such a low completion fraction, and to adjust the priority of high-frequency programs to improve the completion fraction of high-frequency observations if it is necessary.

Supplemental calls: It has been noted that the ACA supplemental call is a very significant workload on the PHT and Science Operations. It was also noted that shifting the timeline of the call would make the problem worse rather than better. Obviously, accepting enough projects of the ACA standalone mode at the regular call may reduce significant workload. ASAC is therefore curious to know whether enough projects from ACA+TP can be accepted at regular calls, and if it is not the case, then would like to know the reason. For some specific LST ranges, there exist a large gap (~200 hrs) to fill. It would be worth investigating the statistics of ACA-only proposals versus 12-m Array proposals in Cycle 8 to see if any bias against ACA-only proposals during the evaluation of ALMA proposals.

Permanent Charge #3. Assessment of the science outcomes from ALMA: Statistics on publications, citations, press releases, web sites, etc. collected by the Executives shall be collated by the JAO, and analyzed by the ASAC.

This charge is considered once per year and so will be revisited at the March 2022 ASAC meeting.

Permanent Charge #4. Recommendations of ways to maximize ALMA's scientific impact: This includes review of the scientific effectiveness of the Proposal Review Process after each Proposal cycle.

Recommendations/issues:

- ASAC recommends that JAO explore ways to increase the quality of the comments that the DPR reviewers provide to proposers, including the possibility of creating a structured format similar to the one used in the panel consensus report.
- ASAC recommends that JAO explore ways of improving the effectiveness of Stage 2 in DPR, including the possibility that reviewers can react to comments written by others both positively or negatively.
- ASAC supports the JAO initiatives to minimize conflicts of interest for reviews of Large Programs. It is imperative that these programs receive a broad review from a representative scientific panel.
- ASAC recommends that JAO investigate inter-regional differences in proposal scores in more detail, examining different hypotheses.
- ASAC is concerned by high oversubscription rates, which may result in a loss of a part of the community if the rates become too high. The committee recommends the JAO consider what is the right balance between LP and smaller programs.

Cyclc-8 proposal review process: Proposals in Cycle 8 were evaluated with a new system that combines being dual anonymous with a distributed peer review (DPR) for proposals requesting less than 25 h on the 12-m Array or less than 150 h on the 7-m Array. Larger programs were evaluated by a panel. In total, 1735 valid proposals were submitted, with 1497 going to DPR and 238 going to panel review. The total number of proposals represents a 2% decrease with respect to Cycle 7, although the number of submitted Large

Programs nearly tripled. Overall, there was a significant increase in the amount of requested time (37% on 12-m Array), which resulted in large oversubscription factors not seen since Cycle 0 (more than 7 for EU and more than 5 for NA and EA).

Despite the significant changes in the proposal system with respect to previous cycles, its implementation was mostly successful both from the ALMA and PIs' perspective. Concerning dual anonymity, 132 proposals were flagged by reviewers for possible violations of the guidelines, and were later inspected by the Proposal Handling Team. 60 of these proposals were considered to contain minor violations, and the PIs were notified but no action was taken. Nine proposals were considered to contain significant violations of the guidelines and were ultimately rejected. Using this experience, JAO will attempt to improve compliance of the dual-anonymous requirement in Cycle 9 by clarifying the documentation and providing more examples. ASAC supports these actions.

Efficient use of DPR stage 2: With respect to the DPR system for short proposals, it was implemented by having each proposal being ranked anonymously by 10 different reviewers who were assigned from the pool of proposers using expertise keywords provided by the reviewers themselves. For Stage 1, there was a very high level of compliance (99.7%), and ultimately only 1 submitted proposal was rejected for missing the Stage 1 deadline. For Stage 2, reviewers could read the comments from the other reviewers and change their rankings and comments accordingly. Participation was moderate (58% of the proposal sets were submitted in Stage 2), and it only led to small changes from the Stage 1 results: 8% of the ranks were changed, and mostly by only one position, and 9% of the comments were changed, but only by a few words. It is somewhat surprising that it has had such little effect in the final rankings of Cycle 8. Whether this is a natural consequence of the DPR system or represents a problem with its implementation is not clear. In any case, we suggest that the JAO explores ways to improve the efficiency of Stage 2, since this stage has the potential of allowing reviewers to correct misunderstandings in their proposal evaluation, which is especially important for proposals in fields where not all reviewers may be true experts (e.g., pulsars, solar, etc.). A possible way of improving the efficiency of Stage 2 could involve allowing reviewers to provide anonymous feedback on the comments of other reviewers. ASAC recommends that JAO explore this and other possible options.

DPR review quality issue: To evaluate the degree of satisfaction with the DPR system, JAO asked PIs for feedback, and received responses that represented 48% of the submitted proposals. The four main complaints from PIs were the quality of some reviews, the high dispersion of the ranks, a mismatch between comments and rank assigned, and the expertise of DPR reviewers. The first and third complaints indicate the need of improving communication between reviewers and proposers, which is critical for the community support of DPR. ASAC suggests requiring the use of a structured format for the comments, like the one used in the consensus panel report, which may help provide a more uniform and detailed evaluation of proposals. The high dispersion of the ranks could possibly be reduced by improving the efficiency of Stage 2, as described above. Finally, the complaints about the expertise of the reviewers suggests that an effort should be made to provide training options for reviewers, especially those at an early career stage. Additional measures to improve the quality of the reviews include refining the set of scientific categories and keywords used to match proposals with reviewers and enforcing that mentors of student reviewers check their results. JAO should explore these options.

Systematics and biases: In addition to the PI feedback study, JAO has carried out an extensive analysis of the possible systematics present in the DPR results. ASAC commends JAO for this detailed study, which has explored systematics with respect to gender, region, experience, science category, receiver band, and type of array. On the positive side, the study shows that the new system has maintained the lack of gender differences already obtained in previous cycles. It has also maintained a lack of differences between proposals from experienced PIs and from PIs with at least one previous submission, which was achieved in Cycle 7 when the list of investigators was randomized (proposals from first-time PIs still receive lower rankings). The study also shows that some systematics remain, especially concerning regional factors. The most notable one is that proposals from EA and Chile receive lower rankings compared to NA and EU. The results for EA are similar to previous cycles, while the results for Chile are somewhat better than previous cycles except for Cycle 7. The cause of these systematics is not yet understood. For the case of EA, the lower ranks come from reviewers in both EA, EU, and NA, while the lower ranks for Chilean proposals primarily come from reviewers in EA and NA. Since these systematics may indicate unconscious biases in the review process, ASAC recommends that JAO continues analyzing the results from future cycles for any type of systematics, and that it uses the available data to further investigate possible causes of the regional biases. ASAC also recommends addressing the newly-introduced lack of balance between reviewers of the different regions caused by the DPR system. This system has increased the number of reviewers from the regions and groups with the largest number of proposals, and ASAC is concerned that as a result of this, some research fields may be unconsciously favored, resulting in a decrease of the diversity of the science carried out with ALMA.

Large proposals: ASAC also has some concerns about several issues related to the Large Programs. As mentioned above, the number of Large Program proposals nearly tripled in Cycle 8 with respect to Cycle 7 (40 vs. 14). This increase created a high number of conflicts of interest when rating the proposals since PIs and co-Is of Large Programs can serve in the panels but cannot review any Large Programs or serve in the APRC. As a result, the number of reviewers rating Large Programs was less than optimal in Cycle 8. A possible solution would be to relax the policy of conflict of interest for co-Is, which is now stricter than that of ESO and HST/JWST. ASAC supports this move and stresses the need of an expert and well-balanced review of the Large Programs since their preparation represents a significant effort by large teams and the programs are awarded an increasing fraction of the observing time with ALMA.

Balance between the large and regular proposals: An additional concern related to the Large Programs is their balance with the regular programs. Since Cycle 4, the number of high-priority programs (Grade A+B) that require the 12-m Array has decreased by a factor of 2 (from 470 to 234 in Cycle 8) due to an increase in the amount of time requested by each proposal. As a result, the number of PIs with access to the telescope has significantly decreased, a problem that is exacerbated by the increasing share of observing time allocated to Large Programs, which when approved automatically receive Grade A. In order to maintain the engagement of the community and the diversity of good science coming from ALMA, ASAC requests that JAO pays close attention to the balance between large and regular programs, and requests a more clear description of how the relative time allocated to these two types of programs is determined.

Permanent Charge #5. Reporting on operational or scientific issues raised by the wider community as communicated by the three regional Science Advisory Committees (ANASAC, ESAC and EASAC).

No new issues were raised for this topic that are not covered elsewhere in the report.

Permanent Charge #6. Assessment of the scientific impacts of the ALMA Development Program, and particularly of new projects that are proposed.

Recommendations/issues:

- ASAC acknowledges the presentations on the progress of the development activities for ALMA 2030. It is good to see clear and dedicated effort being made for the realization of the ALMA 2030 roadmap.
- The committee finds that the Band6v2 proposal is in line with the scope of the ALMA 2030 roadmap, and therefore strongly endorses it for the next step. ASAC encourages the group to consider the cost-benefit analysis for each improved mode and create a priority list.
- ASAC commends the regions for well-coordinated effort on development projects.

ASAC was provided with a general report on the ALMA 2030 development plans and status as well as reports from each region on their current studies and projects.

The NA presentation included a detailed presentation on the Band6v2 proposal which will be presented to the board in November. This presentation provided a good motivation for a Band6 upgrade given it is the most utilized receiver. The planned upgrades will increase the efficiency of the receiver (better sensitivity, fewer tuning needed) as well as provide new capabilities enabled by the wider band (lines can be observed simultaneously). The committee finds that the Band6v2 proposal is in line with the scope of the ALMA 2030 roadmap, and therefore strongly endorses it for the next step. This is a big project and ASAC encouraged the group to think about priorities for each improved mode considering the cost and benefit; and map out which new science cases are enabled by each new mode. The NA development team is also overseeing a new large project to build the 2nd Generation Correlator which will be presented to the Board in April 2022. A new correlator is a crucial part of the ALMA 2030 vision.

Current development projects from all regions are mostly on track despite the pandemic. The EA development group achieved first light/fringes in Band 1 and is on track to deliver the receiver by Oct 2022. Progress is excellent for the ACA spectrometer which is scheduled to be offered in Cycle 10. Progress has also been made on a number of active studies. The EU development group experienced a minimal 3 month pandemic related delay with Band 2 and is on track for critical design review in Q1 2022. The EU development group also continues to make progress on ngOT and ARI-L. They are overseeing a number of development studies including Band 9 and 7 upgrades and improvement of the atmospheric model.

ASAC commends the well-coordinated progress that has been made towards ALMA 2030 despite the pandemic.