Summary of ALMA Cycle 0

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Observing Progress

The Cycle 0 Call for Proposals (CfP) was issued on March 30 of 2011, with a proposal submission period from June 1 – 30, 2011. It was anticipated that 500 – 700 hrs of observing time would be available over a 9-month period. From the 919 submitted proposals, 113 "High Priority" (HP) and 51 "Filler" projects were accepted, with an estimated execution time of ~800 hrs.

Cycle 0 observations started on September 30, 2011. Observations were done in "observing sessions" of 5-7 days, every two weeks, with 12-16 hour shifts from late afternoon until morning. During each observing session a number of activities took place besides science observations, such as observatory calibrations and calibrator surveys. Cycle 0 was originally planned to span 22 observing sessions and to end on August 31, 2012, with no science observing in February 2012. At the time of the CfP, it was anticipated that the array would begin in the extended configuration (maximum baselines of ~ 400m). However, due to challenging weather conditions it was necessary to begin instead in the compact configuration (maximum baselines of ~125m). This change was announced to ALMA observers through email notifications and a news item on the Science Portal (Aug 11, 2011).

After three months of observations, it was realized that while the quality of the data collected was excellent, the completion rate of projects was lower than planned. This was due to a number of factors including a lower than expected execution efficiency (see Figure 1) and the complete loss of two out of the first ten observing sessions due to poor weather and technical problems. Therefore the Cycle 0 observing period was extended until January 1, 2013, with a planned shutdown in September 2012 for a correlator upgrade, as announced in a news item in February 13, 2012. Near the end of the observing season, some daytime observing was made available to increase the completion rate of High Priority projects.

In the end, Cycle 0 consisted of 29 observing sessions, out of which three sessions were lost due to weather and technical problems. The dates of each observing session are given in Table 1 along with the number of hours of observations that passed the original phase of quality assurance, QA0, separately for each frequency band. Shaded cells indicate observing sessions that were completely lost or for which the weather was too poor to allow high frequency observations.

Table 1

Band usage (hours) (High Priority & Filler "QA0 pass")							
Observing Session	**Start Date**	**End Date**	**B3 (h)**	**B6 (h)**	**B7 (h)**	**B9 (h)**	**Sum (h)**
1	9/30/11	10/3/11	2.4	2.8	9.6	0.0	14.8
2	10/17/11	10/21/11	0.0	2.5	37.3	2.9	42.7
3	11/2/11	11/5/11	3.5	4.7	28.0	2.9	39.1
4	11/14/11	11/19/11	17.5	0.9	18.8	0.0	37.2
5	11/26/11	11/28/11	2.4	11.0	12.2	0.0	25.6
6	12/12/11	12/16/11	0.0	0.0	0.0	0.0	0.0
7	12/24/11	12/30/11	10.6	6.6	0.0	0.0	17.2
8	1/9/12	1/13/12	20.9	19.2	3.5	0.0	43.6
9	1/23/12	1/26/12	10.5	8.6	3.1	0.0	22.2
10	3/12/12	3/18/12	0.0	0.0	0.0	0.0	0.0
11	3/26/12	3/27/12	9.8	2.3	7.4	0.0	19.5
12	4/6/12	4/10/12	17.2	19.3	13.3	0.0	49.8
13	4/19/12	4/24/12	8.4	21.1	26.4	0.0	55.9
14	5/3/12	5/8/12	23.3	3.1	30.5	0.0	56.9
15	5/17/12	5/22/12	1.2	1.1	33.3	14.1	49.7
16	5/31/12	6/5/12	6.2	2.7	34.9	16.5	60.3
17	6/14/12	6/17/12	2.7	16.2	17.1	0.0	36.0
18	6/30/12	7/3/12	10.3	16.4	13.6	0.0	40.3
19	7/12/12	7/17/12	2.0	15.2	10.8	26.8	54.8
20	1/1/04	7/31/12	26.7	9.7	21.2	0.0	57.6
21	8/8/12	8/15/12	4.5	22.4	19.2	6.9	52.9
22	8/23/12	8/31/12	8.8	10.9	37.7	17.5	75.0
23	10/3/12	10/9/12	0.0	0.0	0.0	0.0	0.0
24	10/18/12	10/23/12	1.5	4.7	29.1	2.1	37.4
25	11/1/12	11/6/12	0.4	7.1	19.2	12.7	39.4
26	11/15/12	11/20/12	8.8	12.8	27.6	0.0	49.2
27	11/28/12	12/1/12	1.4	4.7	1.2	2.8	10.1
28	12/13/12	12/18/12	14.3	1.2	6.3	0.0	21.8
29	12/29/12	12/31/12	0.9	6.2	5.9	12.2	25.1
		Total (h)	216.2	233.4	467.2	117.3	1034.0
		Percent of Total	21%	23%	45%	11%	100%

Figure 1 shows the observing efficiency of each session (time used for successful executions – including calibration source surveys – divided by the total time scheduled) as well as the downtime due to weather or technical reasons. Note that the observing efficiency and downtime does not normally sum to 100%, because of other overheads during the observations, such as calibrations, reintegration of antennas, time between executions and system tests. Out of a total of 2724 hrs allocated for Cycle 0 observing, a total of 1034 hrs (38%) were used for successful executions.

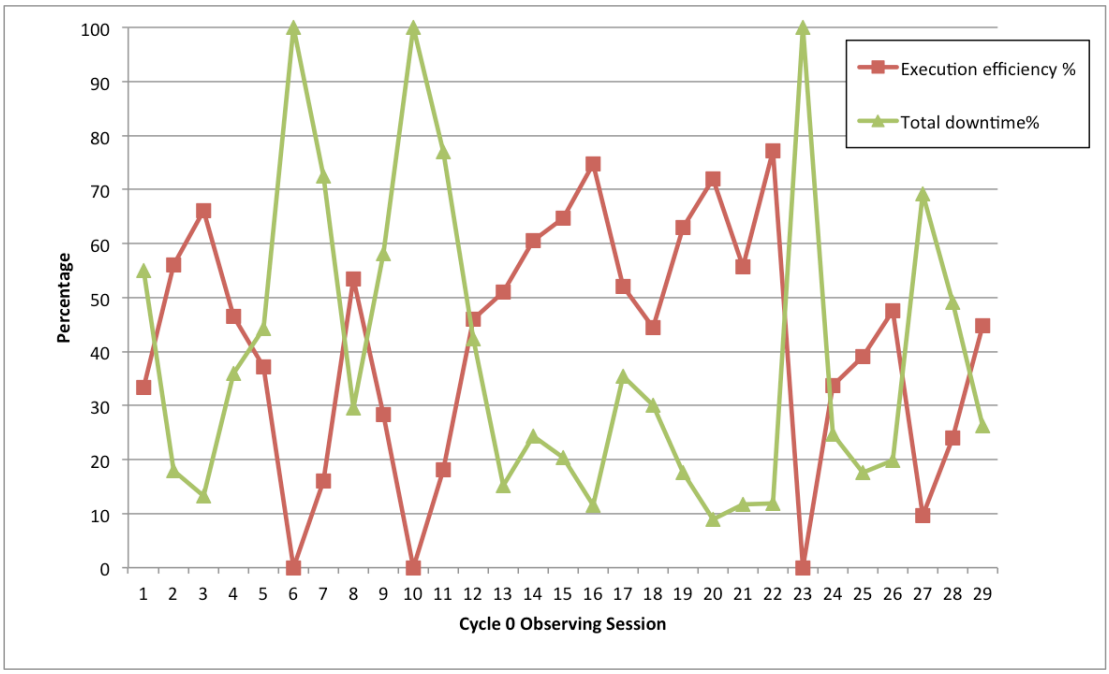

Figure 1: Execution efficiency (red) and total downtime for weather and technical problems (green) for the Cycle0 observing sessions (see text for details).

Each project was comprised of one or more scheduling blocks (SBs). In order to fulfill the sensitivity requirements of each SB and due to their limited duration (usually under 1 hour), each SB was assigned a given number of executions (or execution blocks).

During each observing session, a list of SBs were made available to the Astronomer on Duty (AoD) who selected them for execution taking into account (in rough order of priority): project priority group ("High Priority" or "Filler"), the weather conditions and array configuration, source constraints (e.g. availability of target and calibrators), number of remaining executions needed to complete a SB and parter share. Within a given priority group (i.e. High Priority or Filler) the highest frequency band available for any given weather condition was given priority. This was determined by the amount of precipitable water vapour (PWV) in the air and the phase stability. The conditions for Band 9 observing and Band 7 around 374GHz were PWV < 0.5mm and good phase stability; for Band7 outside of the water lines it was PWV < 1.2mm and good phase stability; in Band 6 < 3mm, and Band 3 for everything else. In Cycle 0, observations in Band 9 accounted for 11% of the total observing time, and in Band 7 for 45% of the time (see Table 1). All other things being equal, the project with the highest scientific rank was observed. As Cycle 0 progressed, the “partner share” was also considered for project execution. The goal was that the on-sky time for HP projects for each of the four ALMA primary regional partners (Chile, East Asia, Europe and North America) roughly achieved the agreed-upon observing fractions or “partner share” between the regions. The regional distribution of observing time on HP projects at the end of Cycle 0 is listed in Table 2, along with the resulting time fractions and targeted partner shares.

Table 2 Distribution of hours dedicated to high priority projects during Cycle 0 among the ALMA partners. CL, EA, EU and NA represent the ALMA partners Chile, East Asia, Europe and North America, respectively. "Other" includes PIs from outside these regions.

Number of hours	CL (h)	EA (h)	EU (h)	NA (h)	Other (h)	Sum (h)
Total	107.0	214.8	326.6	326.0	12.9	987.3
Percent of Total	10.8%	21.8%	33.1%	33.0%	1.3%	100.0%
Partner Share	10.0%	22.5%	33.8%	33.8%		

After each SB execution, QA0 was performed by the AoD. A positive assessment meant that the SB executed completely, was successfully exported to CASA, and appeared to have sufficient calibration and target data for data processing.

During Cycle 0 ALMA construction continued with highest priority. The CfP specified 16 antennas and initial time estimates were based on this. In reality the number of antennas increased throughout Cycle 0. The array was in the Compact configuration from September 2011 until March 2012, after which it was rearranged into the Extended configuration. After session 21 (August 2012) there were enough antennas on pads with short baselines that Compact configuration observations could once again resume. At this time, the number of executions for the remaining SBs was re-estimated assuming 23 antennas. This situation was described in a Science Portal news item from October 8, 2012, which also included a summary of Cycle 0 observing progress and remaining executions.

The final observing progress is depicted in Figure 2, which shows the number of SB executions that were considered successful at the telescope (i.e., passed QA0) both for HP and HP+Filler projects, compared to the observing success rate needed for HP projects if Cycle 0 were only to span the originally planned 22 observing sessions. As can be seen, the extension of Cycle 0 to 29 sessions was sufficient to make up for the lost observing sessions, longer execution times, and lower SB and execution efficiency that were experienced in Cycle 0.

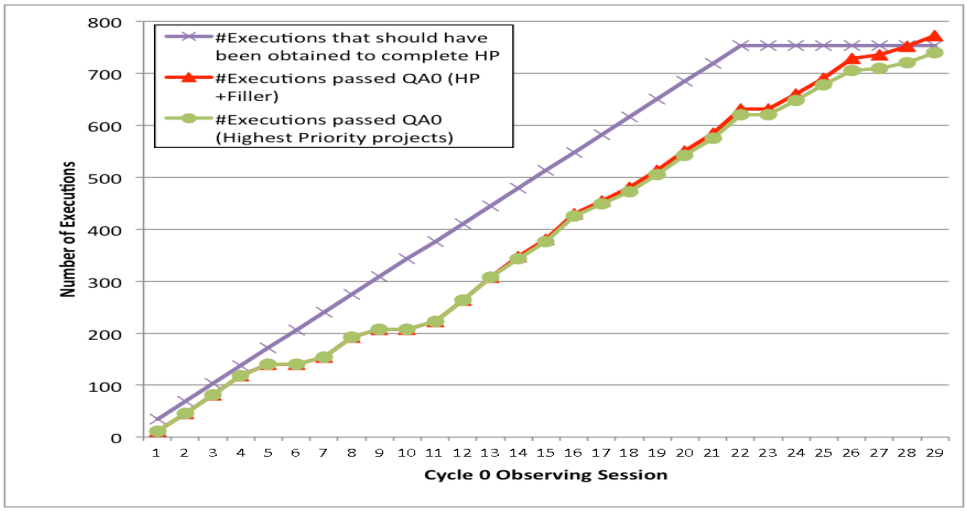

Figure 2: Progress for Cycle0 observing in terms of the number of successful SB executions ("passed QA0"), compared to the observing rate necessary if all High Priority (HP) projects were observed by the original end of Cycle 0 (originally session 22).

LST Distribution

Figure 3 shows the LST distribution of the number of required SB executions at the start of Cycle 0 (upper plot) and remaining SB executions at the end of Cycle 0 (lower plot) for High Priority projects color-coded by frequency band. The lower plot shows also the LST distribution for all prepared but unexecuted Filler projects.

There were peaks at ~4-5hrs, 11-12hrs and 16-18 hrs. At the end of the season, a peak at 11-12hr remained, due mostly to the low efficiency of observing (especially at high frequency bands) at the end of 2011 and again at the end of 2012.

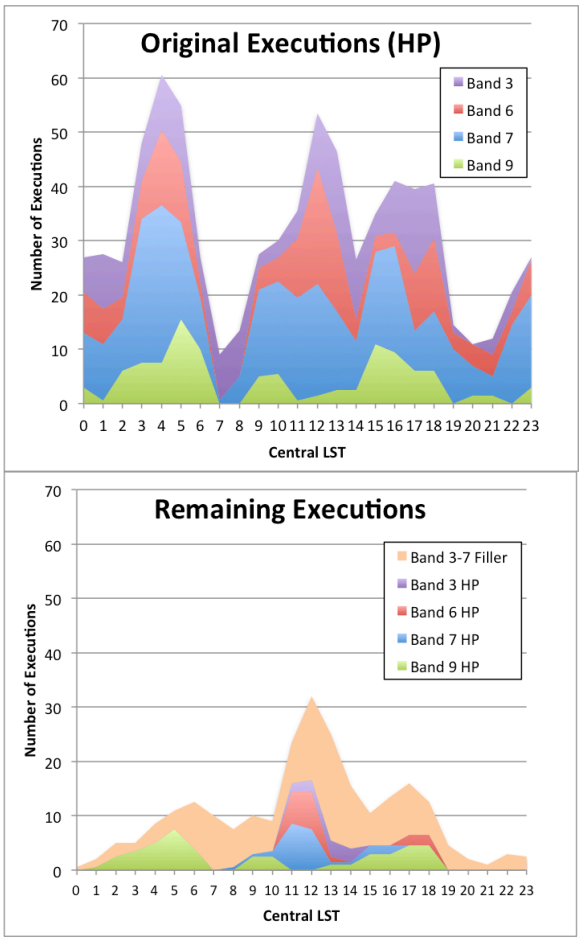

Figure 3: Number of required executions as a function of LST at the start of Cycle 0 (upper panel) and at the end of Cycle 0 (lower panel), Different colors represent the different observing bands. In the upper panel, only high priority projects are represented, as no filler projects were originally prepared. In the lower panel, the remaining filler projects are all shown in as a single color. Filler projects were only prepared for the lower frequency bands (Band 3, 6, 7).

The LST distribution is presented separately for each band in Figure 4.

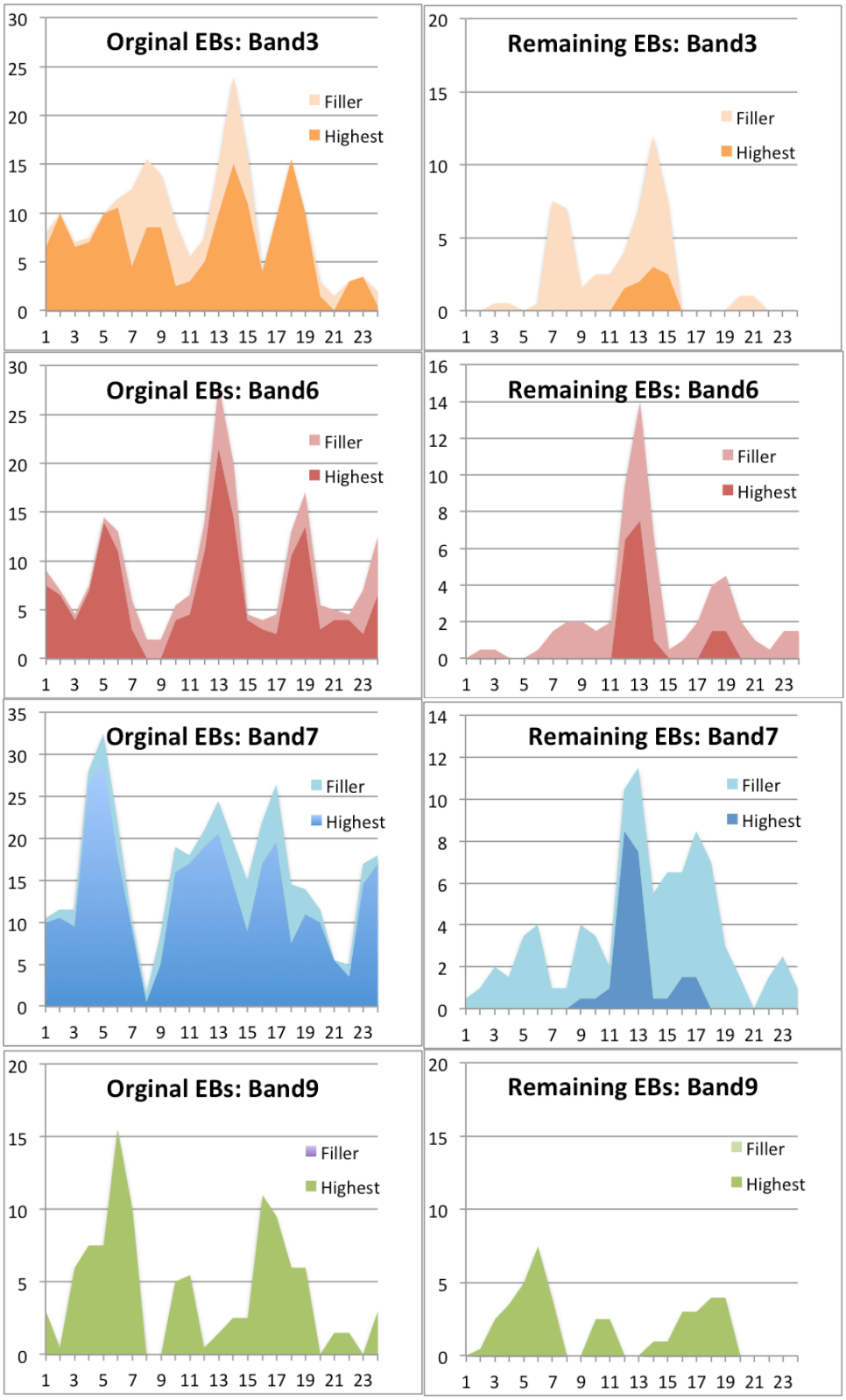

Figure 4: Number of required executions as a function of LST at the start of Cycle 0 (left) and at the end of Cycle 0 (right), as a function of observing band. Executions of High Priority/Filler projects are dark/light shaded. Filler projects were only prepared for the lower frequency bands (3, 6 and 7).

Data Processing & Delivery

After an SB was observed for the originally estimated number of executions, it was assigned to an ALMA scientist for data reduction using CASA and python.

The data processing procedure was first established using Science Verification data, for which sets of CASA guides were written (http://casaguides.nrao.edu/index.php?title=ALMAguides). These guides are intended to help the user understanding the various stages in ALMA data reduction. The final step of data reduction involved imaging and "cleaning" the final cubes, which were compared to the science goals specified by the PI. If the data calibration (including bandpass, amplitude and gain calibration) was successful, the images were not affected by instrumental artifacts, and the measured noise was within a factor of 1.4 of that requested by the PI, the data were judged to pass the second phase of quality assurance, QA2, and delivered to PIs. During the data reduction process, some of the initial "QA0 pass" SB executions were found to not be useful for inclusion in the final imaging products. If the remaining set of useful executions were sufficient for the SB to pass QA2, the non-useful executions were included in the data package and the reason for not using them in the calibration/imaging noted for the PI.

If a dataset was determined not to meet the PIs specifications, the project was marked as "QA2 fail" and the SB marked for additional executions. If this occurred after the end of Cycle 0 observing, then the data were delivered to the PI with a description of why they failed QA2. In the end, 771 executions passed QA0, while 659 (85%) were used in the final imaging products that passed QA2.

After packaging, the data were made available to the PI and ingested into the archive. A total of 20 TB of data were processed and archived. The archive query tool is now available through the science portal and can be used to search for all Cycle 0 datasets that passed QA0, along with their public release date.

The original goal was to reduce data within three workweeks and achieve a total delivery time of six weeks. In the end, there were many issues that prevented us from reaching this goal, including a long delay to establish the calibration procedure for Band 9 data, a problem with Tsys that held up data reduction for six weeks during the summer, issues with data transfer to the ARCs, and individually challenging or problematic projects. Table 3 shows the different steps of data processing and delivery together with the associated timescales.

Table 3: Median data delivery timescales.

Data Processing & Delivery timescales	Median (days)
Days between last SB execution and SB posted for assignment	7
Days between "available for assignment" and QA2	45.5
Days between QA2 and Delivery	11
Total time (days)	84

While the observing season ended on January 1, 2013, the Cycle 0 data delivery effort continued into Cycle 1. Figure 5 shows the rate of data reduction and delivery during Cycle 0.

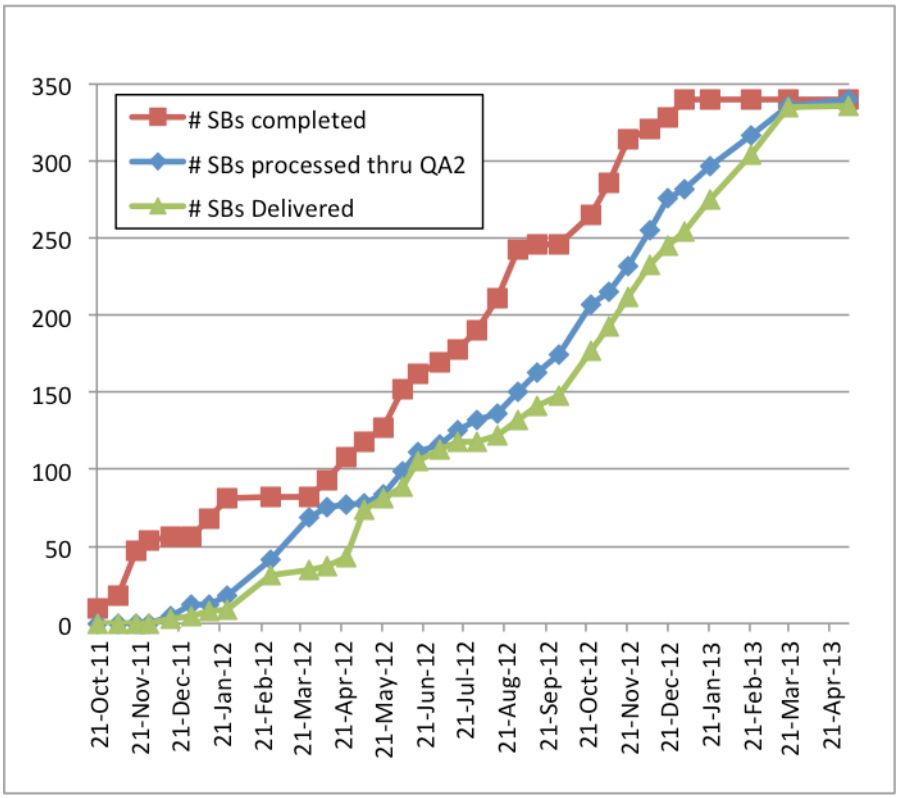

Figure 5: ALMA cycle 0 processing status. The red curve shows the number of SBs that have been observed the requisite number of times, while the other curves show the number of datasets that have been processed through QA2 (blue) and delivered to PI's (green).

Project Completion

Cycle 0 initially consisted of 113 high priority projects. Two projects were cancelled, leaving 111 high priority projects to be observed.

Tables 4 and 5 show the completion statistics of "High Priority" and "Filler" projects, respectively, along with the corresponding number of SBs and SB Executions.

In summary, 108 "High Priority" PI projects (97%) received some data, 98 (88%) completed some of the individual science goals, and 77 (69%) completed all of the individual science goals.

Table 4. Completion of high priority projects, SBs and executions at the end of Cycle 0. 'Passed' or 'failed' refers to QA2 status for SBs and to QA0 status for executions. A project is complete when all the SBs have been completed. "Completely delivered" means all executions of all SBs were delivered (regardless of QA2 status). "Completely passed/failed" means that all SBs associated with the project had that QA2 status.

Priority=Highest	Projects	SBs	Executions
Total Number (non-canceled)	111	374	754
Started	108	327	738
With SBs that passed QA2	98	302	633
Completely delivered	96	327	684
Completely passed & delivered	77	302	633
Completely failed & delivered	10	25	51
No Executions	3	47	0

1. 'Started' refers here to executions that passed QA0

Table 5.As table 4, but for Filler projects.

Priority=Filler	Projects	SBs	Executions
Total Number (non-canceled)	44	105	182
Started	13	19	33
With SBs that passed QA2	10	12	26
Completely delivered	11	19	33
Completely passed & delivered	7	12	26
Completely failed & delivered	3	7	7
No Executions	31	86	0