



Abstract

The Atacama Large Millimeter/submillimeter Array (ALMA) is a large radio observatory in northern Chile. The ALMA data processing pipeline, written in Python and built largely upon the Common Astronomy Software Applications package (CASA), produces calibrated measurement sets, images and supporting products. This same pipeline is used to calibrate data from the Karl G. Jansky Very Large Array as well as the Nobeyama Radio Observatory. Here we describe the pipeline as it is used by ALMA.

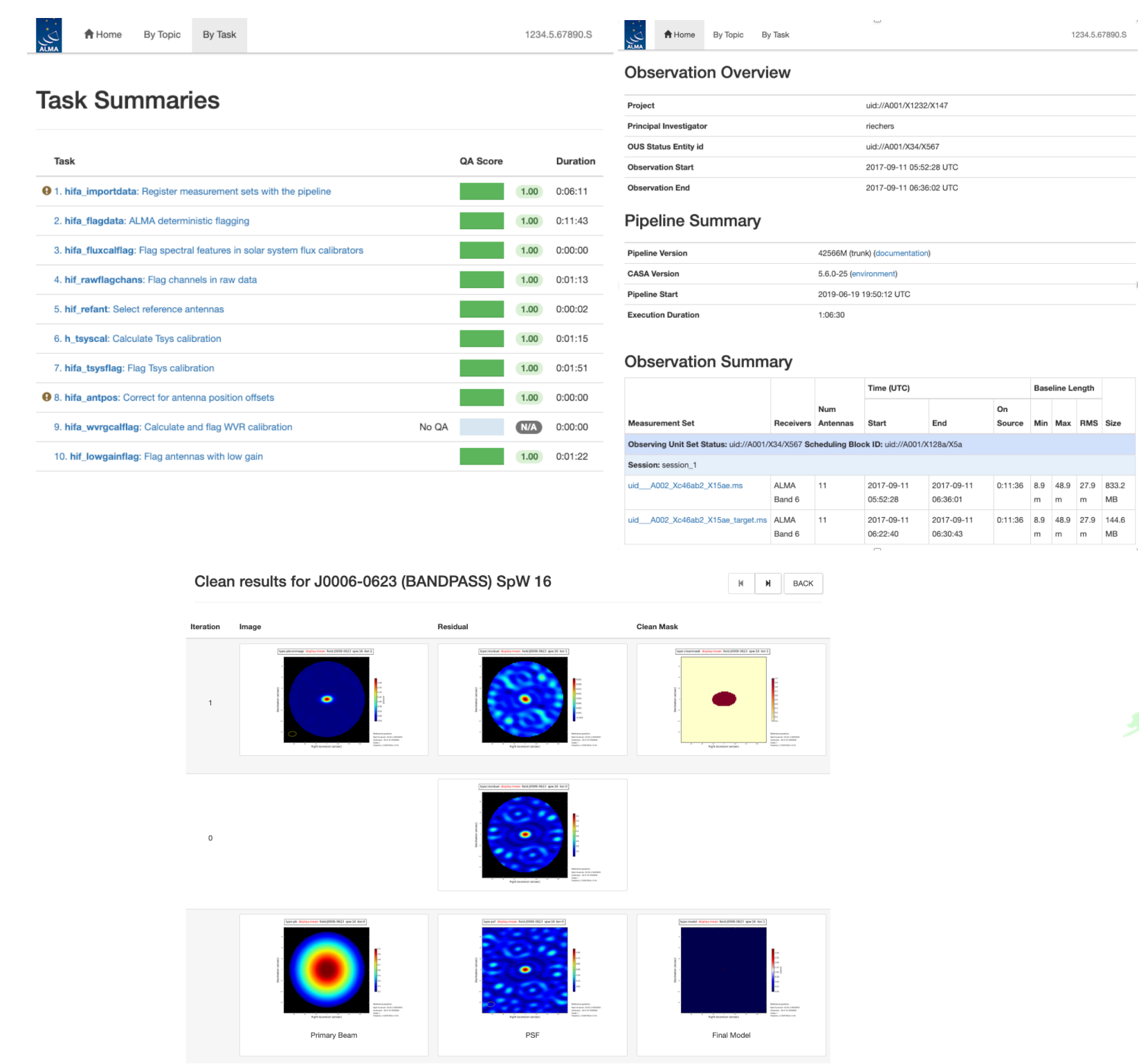
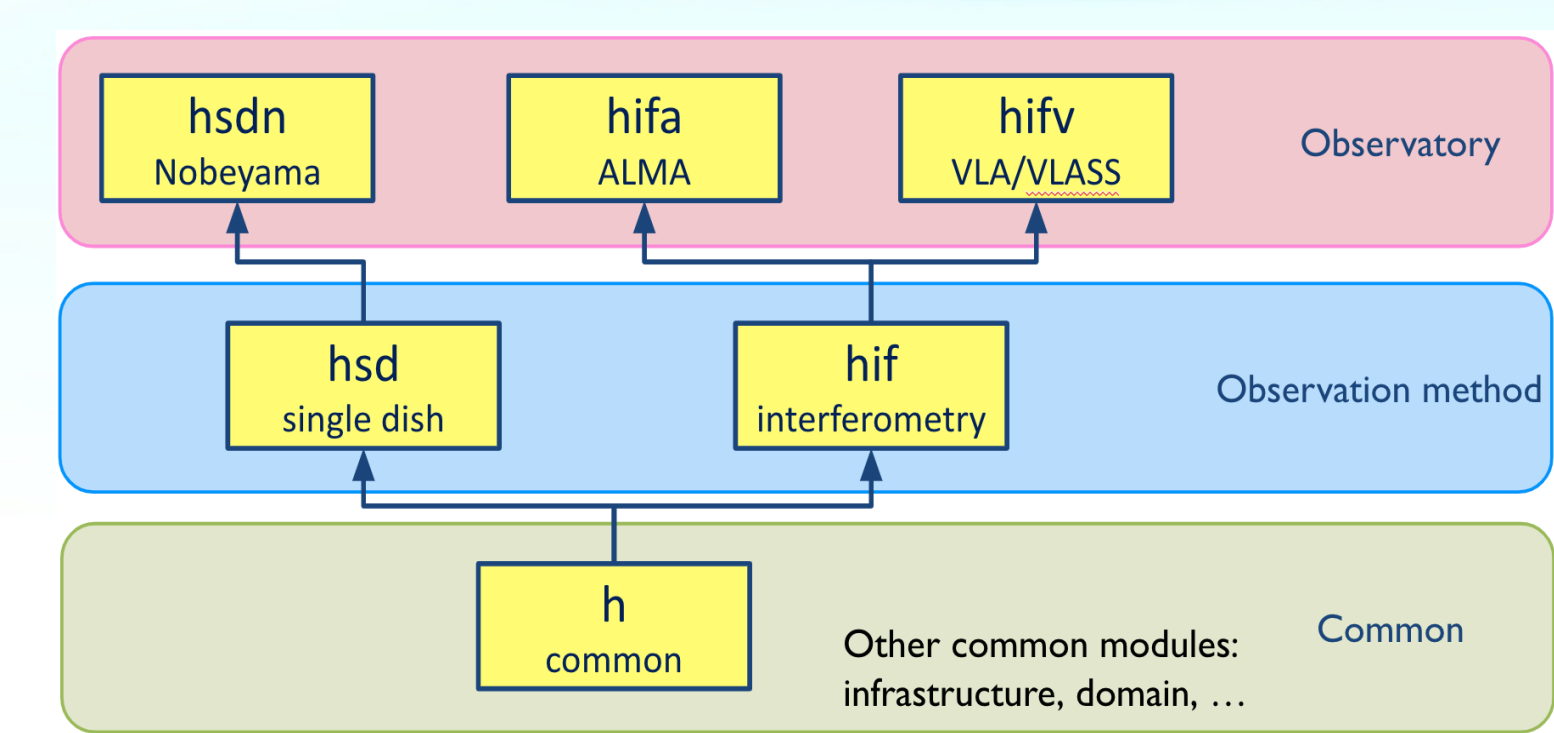
Descriptions of the key tasks, heuristics, processing recipes and products are presented. Pipeline tasks are built upon CASA tasks and tools. A task can be thought of as a mini-application or atomic feature within a larger workflow. For example, import, export and each calibration step are considered as separate tasks. The pipeline heuristics contain all of the calibration and imaging decisions that are driven by the input data. The recipes define the dataflow from raw data to final calibration, imaging and summary products.

The pipeline is developed by an international consortium of scientists and software developers based at the National Radio Astronomical Observatory (NRAO), the European Southern Observatory (ESO), the National Astronomical Observatory of Japan (NAOJ) and the Joint ALMA Observatory (JAO).

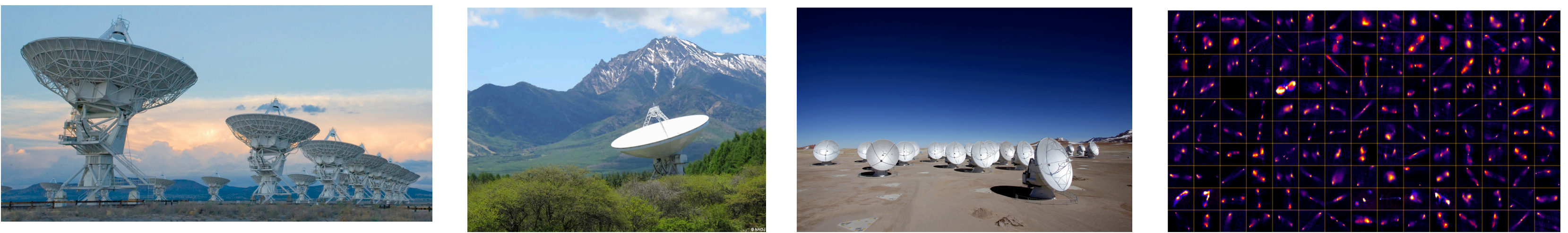
Stakeholders supported by the CASA Pipeline

- ALMA
 - Interferometry calibration and imaging
 - Single dish calibration and imaging
 - Quasar catalog calibration survey
- VLA PI Observations
 - Calibration and calibrator imaging
- VLA Sky Survey (VLASS)
 - Quick look calibration and imaging
 - Single epoch calibration and imaging
- NRAO Science Ready Data Products (SRDP)
 - ALMA User Defined Imaging
 - ALMA / VLA calibrated data downloads
- Nobeyama 45-m telescope
 - Single dish calibration and imaging

To support various observatories and different methods of observation with a common code base, we use a hierarchical set of Python classes. In this way, we re-use code whenever possible.



A team of mostly part-time developers from North America, Europe and East Asia work together on a common code base to support multiple missions.



Download the CASA Pipeline
https://casa.nrao.edu/casa_obtaining.shtml

Detailed information about the ALMA Science Pipeline, including the User's Guide and Reference Manual
<https://almascience.nrao.edu/processing/science-pipeline>

Pipeline Calibration and Imaging for the ALMA Observatory



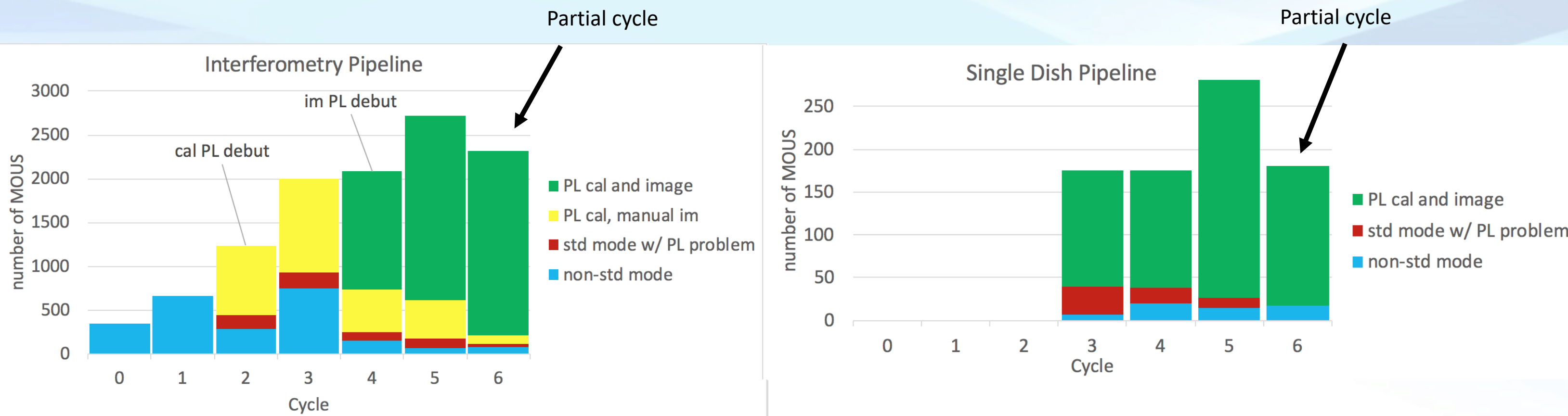
Joe Masters, Brian Kent, Kana Sugimoto, Remy Indebetouw, Crystal Brogan, Todd Hunter, Amanda Kepley, John Hibbard (NRAO)
Takeshi Nakazato, George Kosugi, Hajime Ezawa, Akira Yoshino, Yohei Hayashi (NAOJ)
Stewart Williams, Vincent Geers (UK ATC)
Dirk Muders (MPI Bonn)

ALMA Pipeline

The CASA Pipeline used by various stakeholders was originally developed for the ALMA Observatory. In some ways, this makes the ALMA Pipeline the most capable.

- Standard mode* observing capabilities supported by the pipeline include
- Receiver Bands 3-8 (wavelengths of about 3.0-0.35 mm)
 - 12-m telescope array configurations with up to 16.2 km baselines (depending on band & configuration)
 - Spectral-line and continuum observations with the 12-m Array and the 7-m Array in all bands
 - Single-field interferometry (all bands) and mosaics (Bands 3 -9) with the 12-m Array and the 7-m Array
 - Single-dish spectral-line observations in Bands 3 to 8.

Operational Pipeline

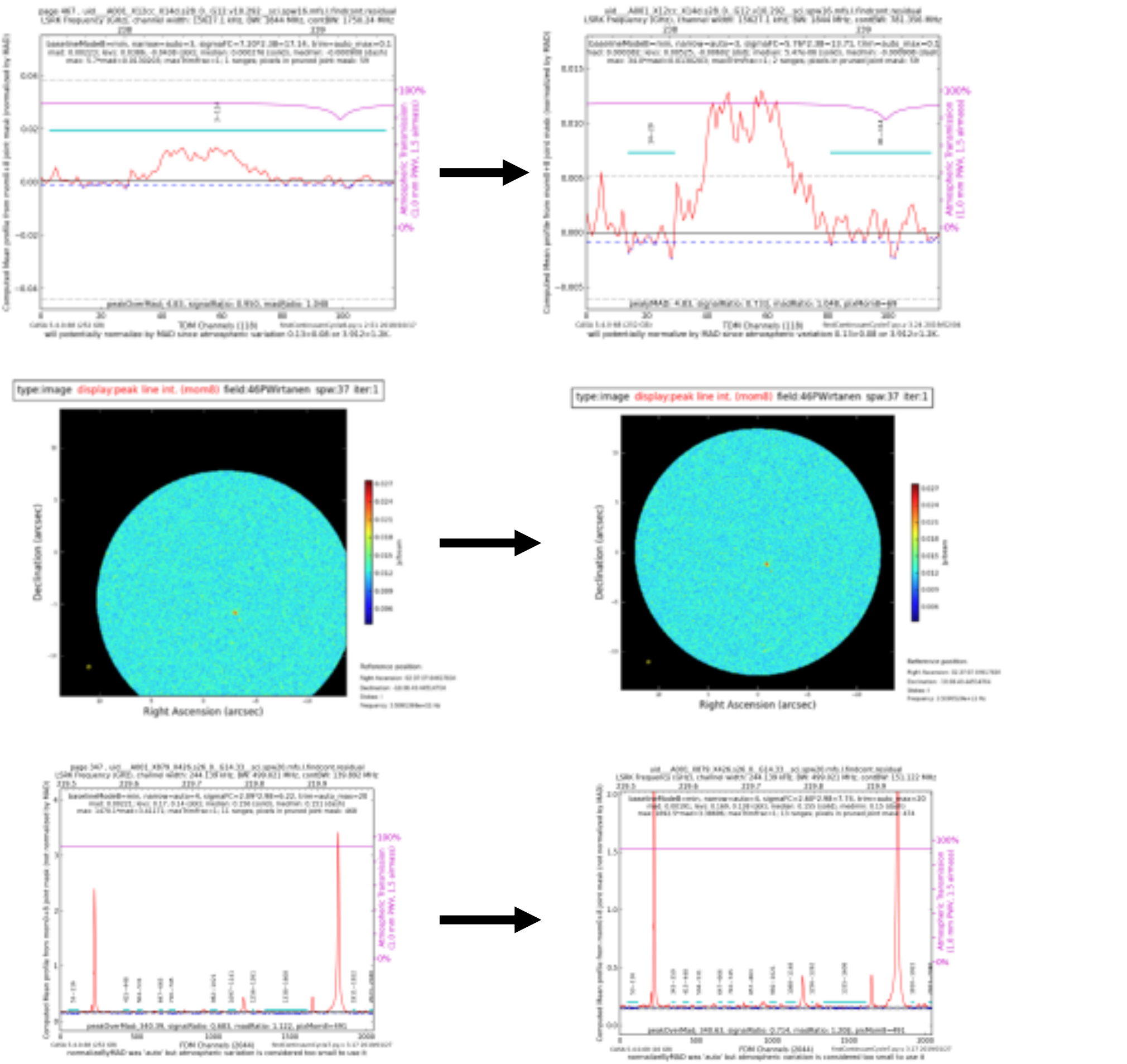
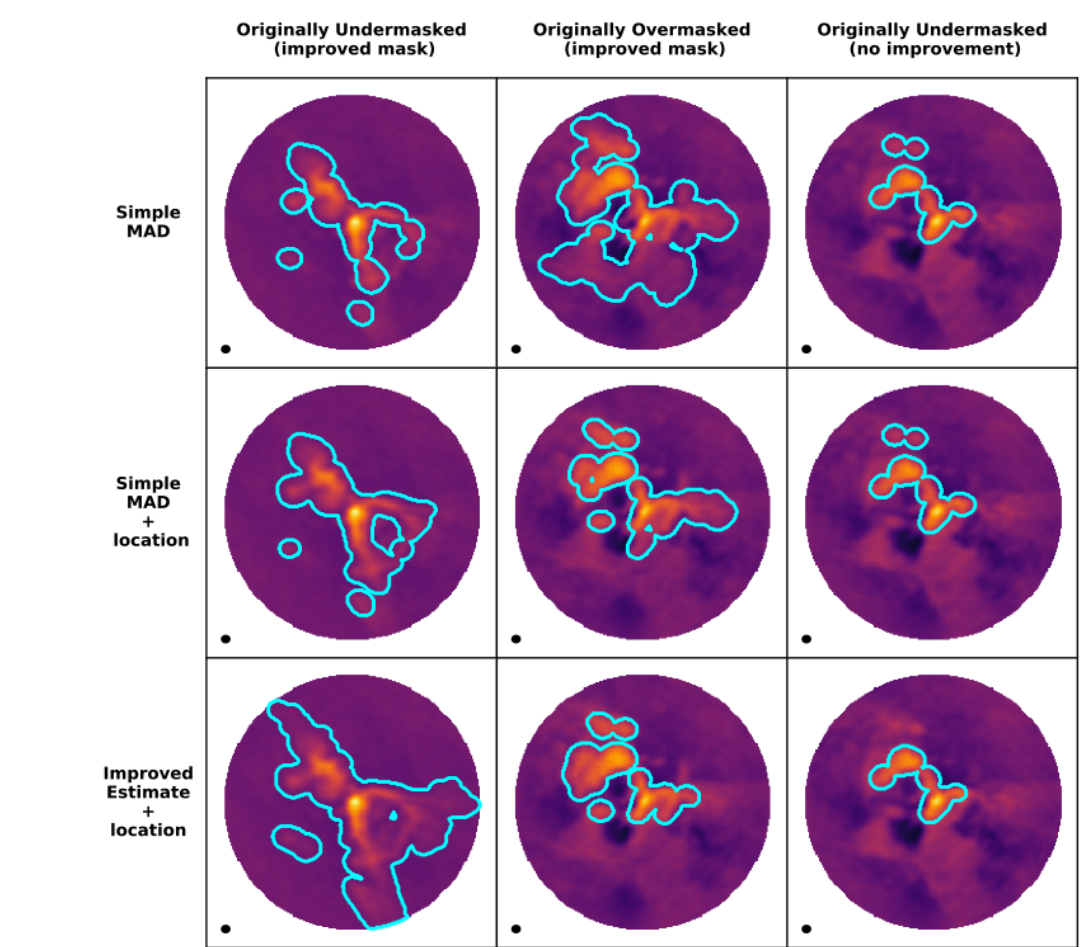


The ALMA Pipeline succeeds at processing the vast majority of observations. As shown in the charts above, the fraction of observations that are successfully calibrated and imaged by the pipeline continues to grow. Success is determined not by the production of data products, but instead by generating products that meet quality standards set by the observatory and goals of the PI (e.g. sensitivity and spatial resolution).

Pipeline refinement – Cycle 7

With each ALMA cycle, the pipeline adds new capabilities and improves the data products sent to the astronomer. The ALMA Cycle 7 Pipeline, put into operations at the Joint ALMA Observatory in early October 2019, continues this trend.

- Weak line finding improved.
- A parallax correction for nearby objects improves the imaged field of view.
- Plot scaling improve to show weak lines next to strong lines.



- Improved noise estimates, in cases with significant emission and absorption, when auto masking.

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