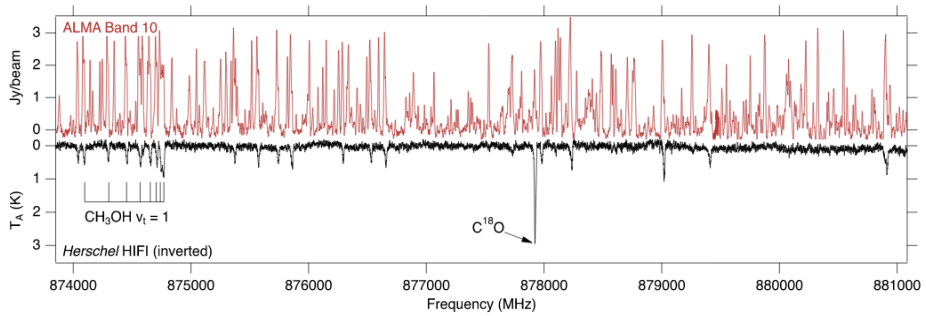
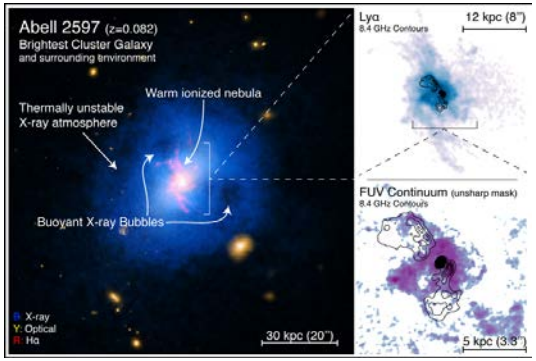


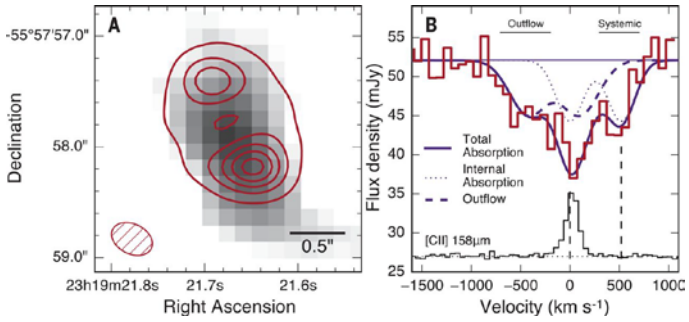
Results from ALMA Band 10: the Cat's Paw

McGuire et al [2018ApJ...863L..35M]

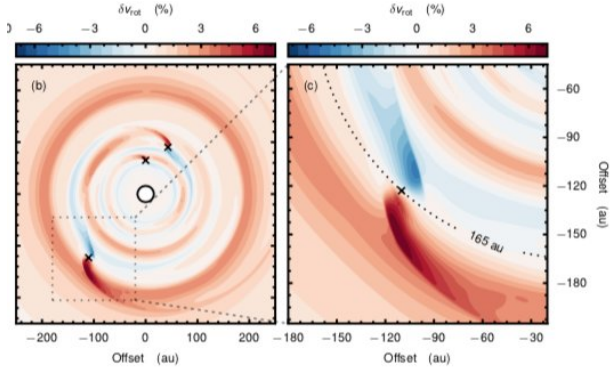


Galaxy-Scale Fountain of Cold Molecular Gas Pumped by a Black Hole

Tremblay et al. ApJ 865



Fast Molecular Outflow from a Dusty Star-Forming Galaxy in the Early Universe ***Spilker et al Science 361, p1016***



ALMA Provides *Kinematic* Evidence for Planets in the HD163296 Disk

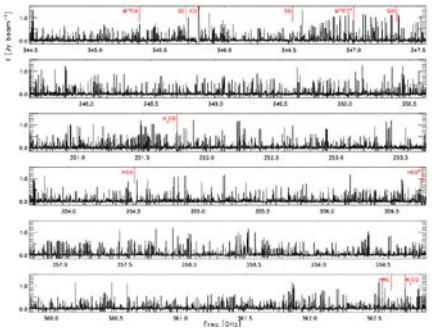
Teague et al (arXiv:1805.10290)

Summary on Status of NA Development Projects and Studies: Jan 2019

A. Wootten, ALMA Program Scientist for NA

Acting on ALMA2030 vision

- Expanding ALMA's processed bandwidth
  - ***Correlator Upgrade Project (CUP)*** The Correlator Upgrade Project (CUP) will significantly enhance the spectral capabilities of the ALMA 12-m array correlator and allow for processing of twice the instantaneous bandwidth compared to what is presently possible. The CUP has been split into two phases, based on technology readiness:
  - Phase 1 – 8 times more channels per baseband
    - All changes happen in the correlator and downstream to handle increased data rate
    - 4x4 bit sampling (all but 4GHz bands): the spectral sensitivity improves by 12.2%. This is equivalent to adding 6 antennas to a 48-antenna array!
  - Phase 2 – Double the total bandwidth
    - With changes to the digitizers, tunable filter bank cards
  - Phase 1 of the CUP was passed PDR Feb 28-March 1, 2018 and received ALMA Board approval for construction in April. It will be deployed in Cycle 10 2022/2023



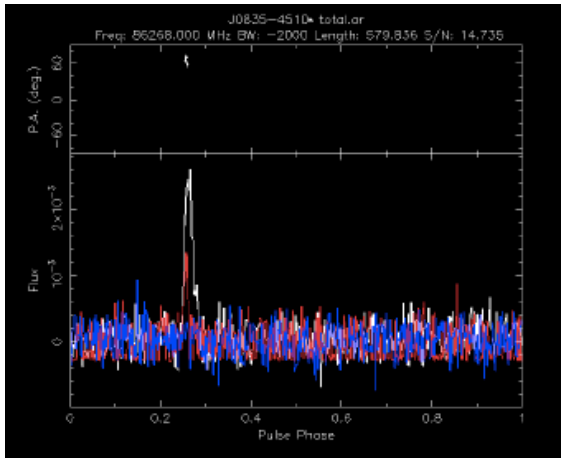
PILS was executed in Band 7, 18 executions Post Phase 1 CUP provides 4x larger bandwidth at the same spectral resolution; would take 1/3 the time.

Two Projects began during FY2018.

NA Development Program

Current NA Project Overview

- ***ALMA Phasing Project, Phase 2*** began FY18
  - Building on Cycle 3 & 4 Studies, APP-1 Project
  - a Delay Fix,
  - a Source Modeler,
  - Additional phasing bands (B7, B1),
  - Phasing on weak sources,
  - Spectral Line mode,
  - Single-dish VLBI
- See VLBI slides

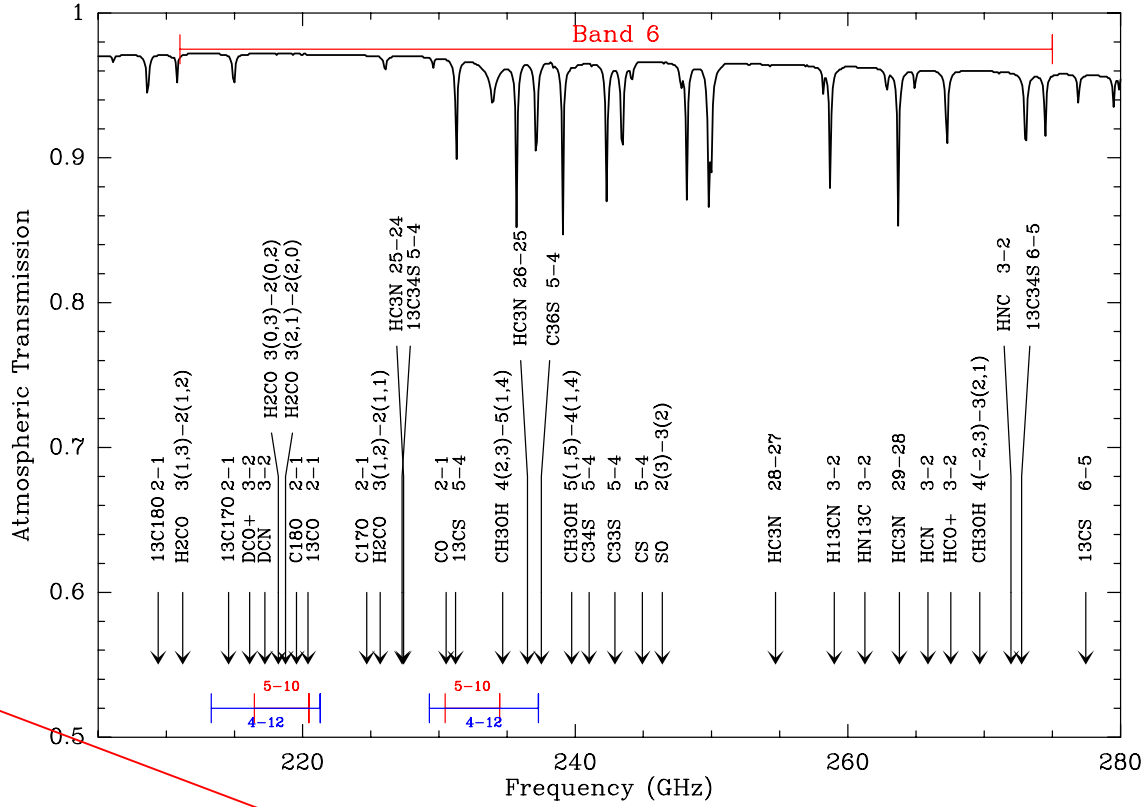


Pulse profile of the Vela pulsar at 86 GHz, using Pipeline 1 to analyze 10 min of data. One cycle of phase is shown after folding the data at the predicted 89ms pulsar period. (Cordes+,2017)

Two Projects began during FY2018.

Upgrading the Receivers

- Increasing receiver sensitivity, bandwidth
  - 2nd generation SIS receiver development –Kerr
    - ***B6v2 passed conceptual design review Sept '18***
    - Band 6 v2, ALMA's Bread and butter band
    - Current ALMA Band 6 receiver's limited IF range of 5 to 10 GHz imposes limitations to the science that ALMA can conduct
    - Wider IF bandwidth, flatter and improved noise performance
    - In conjunction with correlator and IF upgrade, will result in Band 6 science meeting the new Key Science Goals
    - A PILS-like B6 survey could be done in 3 hours rather than ~26 now

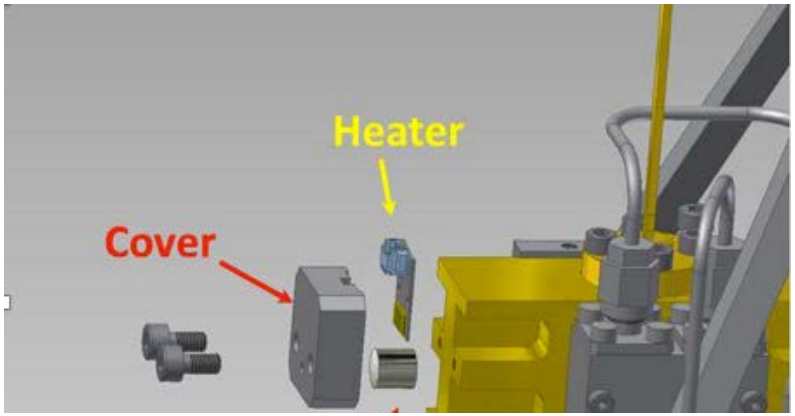


Transition Pairs	Upgraded IF (4-12 GHz)	Current IF (5-10 GHz)
$^{12}CO/^{13}CO/C^{18}O$ 2-1	Yes	Yes (with limitations)
$HCN/H^{13}CN$ 3-2	Yes	No
HCN/HNC 3-2	Yes	No
$HCN/H^{13}CN/HCO^{+}/H^{13}CO^{+}$ 3-2	Yes	No

Project being developed during FY2018.

Upgrading the Receivers

- B3 upgrade to deliver improved TP stability



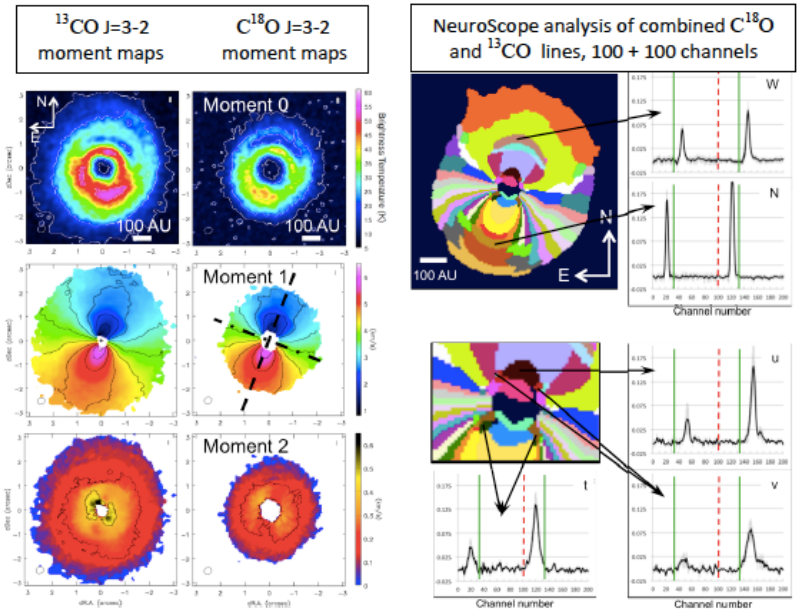
Project continues during FY2019.

NA Development Study Overview

Cycle 5 Study Overview

Acting on the ALMA2030 vision:

- Increasing receiver sensitivity, bandwidth
  - Wideband Low-Noise Balanced IF Amplifiers for ALMA Band 6, with Future Application to ALMA Bands 3-10 - Kerr
- Expanding/increasing ALMA's instantaneous RF bandwidth
  - *Quantum-Limited Very-Wideband 4-Kelvin RF and IF Amplifiers for ALMA - Noroozian*
- Improved data characterization
  - *Neural Network Analysis of ALMA Datasets* - Merenyi
- Full-field primary beam models will be developed for use in imaging software
  - *Full-Mueller Mosaic Imaging with ALMA*, PI Sanjay Bhatnagar
- All discussed at 2018 URSI ALMA2030 session; presentations available.



Neural Network analysis highlights departures from Keplerian disk motion in HD142527.

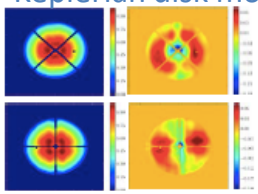


Figure 2A: The average real and imaginary parts of DA (top row) and DV antennas (bottom row) [Kundert et al, 2016]

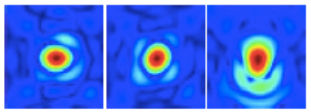


Figure 2B: Range of antenna-to-antenna variations in PB derived from aperture illuminations shown in Fig. 2A.

Imaging with different antennas

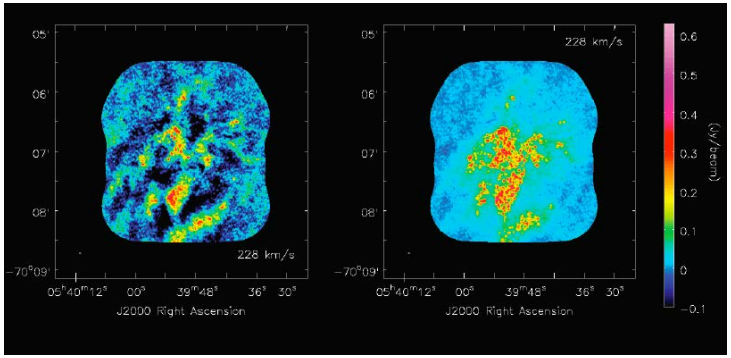
Four Cycle 5 Studies Commenced FY2018.

NA Development Study Overview

Cycle 4 Study Overview

Acting on ALMA2030 vision:

- Increasing receiver sensitivity, bandwidth
  1. 2nd generation SIS receiver development –Kerr
  2. Upgraded ALMA B3 mixer block – Henke
- Expanding ALMA's processed bandwidth
  1. Upgrade of Backend Antenna Article to match correlator upgrade - Ford
- Improved data use
  1. Improved interactive CLEAN
  2. Improved imaging with combined arrays
- Maximizing point source sensitivity and resolution
  1. Weak source and spectral line VLBI-merged into APP2 Project

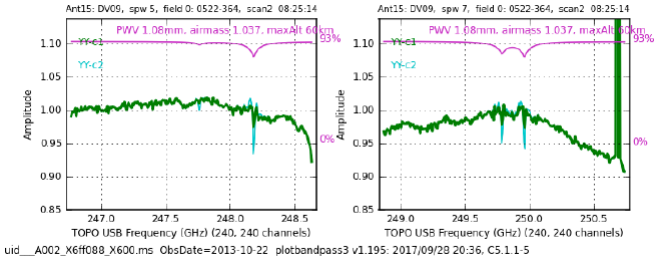


A comparison of three cleaned channel maps of Cloud 197 with TP (left) and without TP (right). The red, green, and blue correspond to the TP, 7m, and 12m visibilities. (Koda)

Six Cycle 4 Studies delivered.

NA Development Study Overview

- Focus on ALMA2030 science improvements:
- Correlator upgrade:
  1. Delivering more channels, higher spectral resolution and wider bandwidth
  2. Next generation correlator
- Maximizing point source sensitivity, spatial resolution
  1. Extending VLB phasing to B7, optimize phasing, data reduction
  2. Enable a phased ALMA for pulsars & transients
- Improved data use
  1. Improved calibration through atmospheric spectral features
  2. Data cube visualization enhancements
- Increased sensitivity
  1. 2nd generation receiver mixer studies



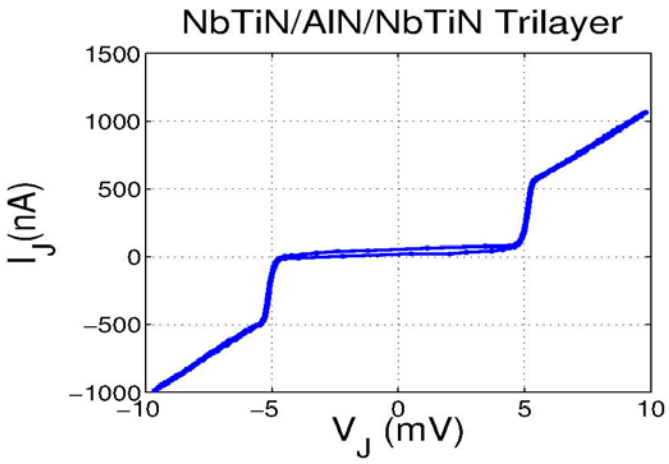
Example of applying the results after applying simulated FDM T_{sys} spectrum (cyan) to PI astronomy data of calibrated Band 6 spectra of a quasar vs after applying the observed TDM Tsys (green profile). TDM application misses fine ozone line structure.

Seven Cycle 3 Studies delivered.

We are excellently positioned for the next generation of ALMA SIS mixers

SIS Material Systems suitable for 2nd gen ALMA

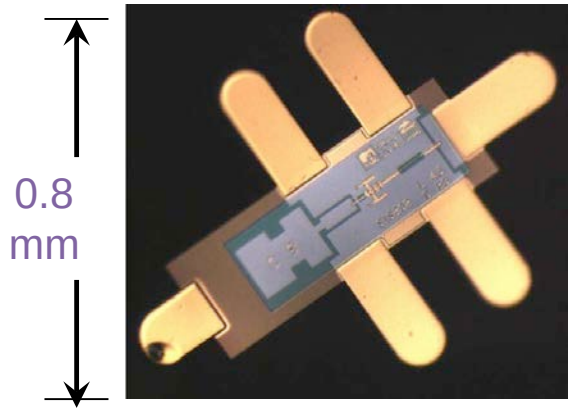
- Nb/Al-AlN/Nb (B6, B7)
- Nb/Al-AlN/NbTiN (B8-B10)
- NbTiN/AlN/NbTiN (B10)



All NbTiN 5mV gap

SOI Architecture *(3-5um Si chip w/beamleads)*

- More accurate chip size and registration to metallization
- No time intensive lapping-thinning/dicing required
- Close to drop in chip placement in waveguide block



Miscellaneous

- Developing rapid, whole wafer, dc cryogenic probing/screening of mixer chips
- Miscellaneous circuits (superconducting RF & IF Hybrids & LO Couplers)

Immediate Future

- Projects
  - NA has two new projects, Correlator Upgrade 2 and B6v2 ready
  - New Call for Projects forseen depending on funding
- Studies
  - NA: Call closed 1 May 2017; four new Studies selected.
  - Current Call planned for Cycle 7 = FY 2020
  - Dates:
    - Study CfPs: 1 Dec 2018
    - Deadline for submission: 15 Mar 2019
    - Anticipated Funding start: 1 Oct 2019
  - ESO Development Studies
    - Please also note the ALMA Development Workshop at ESO Garching, 3 - 5 June, 2019 (http://www.eso.org/sci/meetings/2019/ALMADevel2019.html)

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