

# Digital Correlator and Phased Array Architectures for Upgrading ALMA

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Université de Bordeaux / LAB  
on behalf of

*ngCorrelator Study Team*

ALMA Developers' Workshop, May 25th-27th, 2016

# Digital Correlator and Phased array Architectures for Upgrading ALMA



# Digital correlator and phased array architectures for upgrading ALMA

- **One year development study on ngALMA Correlator**
  - Study start date: April 2016; Kick-off: 10-11 May, 2016
  - Final report: end of May 2017
- **Core team**

J. Weintroub (PI, SAO/Harvard), A. Baudry (U. Bx/LAB), B. Carlson (CNRC), S. Doleman (Harvard), R. Escoffier(NRAO), R. Lacasse (NRAO), M. Rupen (CNRC), A. Saez (JAO)
- **Attending part or all of Kick-off meeting**

*SAO:* L. Blackburn, R. Blundell, L. Greenhill, J. Moran, R. Primiani, E. Tong, R. Wilson, A. Young

*Berkeley:* J. Hickish

*Haystack:* G. Crew, M. Hecht, L. Matthews

*NRAO/Socorro:* S. Ashton, C. Langley

# Objectives

A conceptual design for a new generation ALMA correlator

Proposed specifications:

- 16GHz/sideband per polarization
- Natively integrated features (4 bits, phased array)
- Very long baselines (eg 300 km)
- Additional antennas, etc
- Multibeam (10 to 100? could be traded against BW)

Prepare final report for May 2017:

- Validate assumptions and design flows
- Correlator location question (AOS vs OSF)
- A conceptual design with sufficient detail to . . .
- . . . propose for follow-on development project to detail design

# Kick off meeting agenda

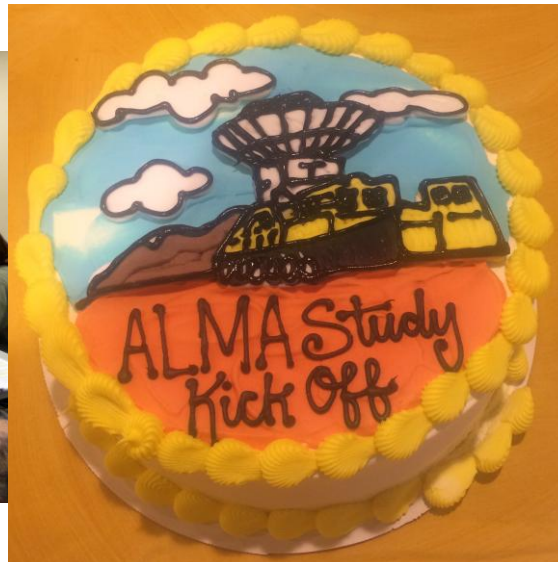
ALMA Correlator/Phased Array Development Study: Kickoff Meeting Agenda  
 Meeting Dates: 10, 11 May, 2016 Concord Avenue, Room M340

| Date and Time   | Topic  | Speaker or Facilitator                                | Comments                                 |
|---|--|---|--|
| <b>Tuesday 10 May 2016</b>                                  |  |   |  |
| 8:30am to 9:00am  | Coffee, light snacks   |   |  |
| 9:00-9:05am   | Welcome  | Charles Alcock  |  |
| <b>Session A: Study plan and science drivers</b>            |  |   |  |
| 9:05 to 9:15am  | The wideband SMA project: SMA as test bed for ALMA.                                    | Ray Blundell  |  |
| 9:15 to 9:20am  | Meeting plan and logistics   | Jonathan Weintroub                                    |  |
| 9:20 to 9:40am  | science drivers for ALMA   | Michael Rupen   |  |
| 9:40 to 10:00am   | ALMA bandwidth limits in the year 2025   | Rich Lacasse  |  |
| 10:00 to 10:20am  | The HT and ALMA  | Shep Doeleman   |  |
| 10:20 to 10:40am  | The ASAC documents: "Pathways to Developing ALMA" and "A Road Map for Developing ALMA" | Alain Baudry  | ASAC: ALMA Scientific Advisory Committee |
| 10:40 to 11:00am  | coffee break and discussion  |   |  |
| <b>Session B: Contemporary Correlators</b>                  |  |   |  |
| 11:00 to 11:20am  | SWARM  | Rurik Primiani  |  |
| 11:20 to 11:40am  | ngVLA  | Michael Rupen   |  |
| 11:40 to 12:00 noon   | The VLA correlator (WIDAR)   | Brent Carlson   |  |
| 12:00 to 1:10pm   | Lunch  | List of quick food shops in walking distance provided |  |
| 1:10pm to 1:30pm  | The HERA correlator  | Jack Hickish  |  |
| 1:30pm to 1:40pm  | Strong and weak points of the current ALMA correlator                                  | Ray Escoffier   |  |
| 1:40pm to 2:00pm  | The ALMA Correlator Enhancement Dev. Study   | Ray Escoffier   |  |
| <b>Session C: Recent developments in VLBI Phased Arrays</b> |  |   |  |
| 2:00 to 2:10pm  | The ALMA Phasing Project   | Shep Doeleman   |  |
| 2:10 to 2:30pm  | APP phased array algorithms  | Geoff Crew  |  |
| 2:30 to 2:50pm  | SWARM Phased Array   | Andre Young   |  |
| 2:50 to 3:20pm  | discussion over coffee   | all   |  |
| <b>Session D: Miscellaneous topics</b>                      |  |   |  |
| 3:20 to 3:35pm  | Fibers to DSF: location of the next ALMA digital backend                               | Shep Doeleman   |  |
| 3:35 to 3:50pm  | Discussion: correlator modes and feature creep   | Facilitated by Michael Rupen                          |  |
| 4:05 to 4:35pm  | Electrical power for ALMA: provision and consumption.                                  | Facilitated by Rich Lacasse                           |  |
| 4:35 to 4:45pm  | Transport planning for BBQ   | Jonathan Weintroub                                    |  |
| 4:45 to 5:15pm  | Discussion, integration of day's proceedings   | Facilitated by Brent Carlson                          |  |

|  |  |   |  |
|--|--|---|--|
| <b>Wednesday 11 May 2016</b>                                 |  |   |  |
| 8:30am to 9:00am   | Coffee, light snacks   |   |  |
| 9:00-9:05am  | Review and adjustments   | Jonathan Weintroub                                    |  |
| <b>Session E: Next generation hardware</b>                   |  |   |  |
| 9:05 to 9:25am   | PowerMX framework  | Brent Carlson   |  |
| 9:25 to 9:35am   | CASPER framework   | Jonathan Weintroub                                    |  |
| 9:35 to 9:45am   | LEDA correlator  | Lincoln Greenhill                                     |  |
| 9:45 to 10:05am  | Fast Digitization and Digital Transmission for Upgraded ALMA Bandwidths              | Alain Baudry  |  |
| 10:05 to 10:20am   | Multi-core ADC artifacts and calibration   | Bob Wilson  |  |
| 10:20 to 10:30am   | ADC clock offset scheme  | Brent Carlson   |  |
| 10:30 to 10:40am   | SMA Receiver Upgrade   | Edward Fong   |  |
| 10:40 to 10:50am   | discussion   |   |  |
| 10:50 to 11:10am   | coffee   | all   |  |
| <b>Session F: Software and ALMA Culture</b>                  |  |   |  |
| 11:10am to 11:30am   | Discussion: interaction with Joint ALMA Observatory                                  | Facilitated by Mike Hecht                             |  |
| 11:30am to 11:45am   | ALMA Software Environment considerations   | Alejandro Saez  |  |
| 11:45am to 12:00 noon  | The importance of diagnostic tools: lessons from the current correlator deployment   | Alejandro Saez  |  |
| 12:00 to 1:00pm  | lunch  | List of quick food shops in walking distance provided |  |
| 1:00pm to 1:30pm   | Meeting in M340, walk to 60 Garden for group photo (discussion during photo session) | All   |  |
| 1:20pm to 1:30pm   |  | all   |  |
| <b>Session G: Integration, project planning, and wrap up</b> |  |   |  |
| 1:30 to 2:00pm   | Discussion: design methodology in proposal   | Facilitated by Rurik Primiani                         |  |
| 2:00 to 3:00pm   | Round table discussion: AAV vision of the next ALMA correlator, and specifications   | Facilitated by Lindy Blackburn                        |  |
| 3:00 to 3:15pm   | C'ville meeting feedback   | Facilitated by Rich Lacasse                           |  |
| 3:15-3:30pm  | coffee   | all   |  |
| 3:30 to 3:40pm   | Socorro ADC Study  | Chris Langley and Dylas Ashton                        |  |
| 3:40 to 5:00pm   | Study planning, work assignments, deadlines  | Facilitated by Jonathan Weintroub                     |  |

# Selected examples of work packages

- Draft first scientific specifications with reference to ASAC
- Iteration of a design methodology memo
- Explore DSP platforms (ASIC vs FPGA vs GPU vs CPU)
- Large channelizer analysis for FX architectures
- F to X cross-connect methodology
- X-engine design project
- Study of cooling methods
- Scenarios for proof of concept follow-on project



- *Next Generation ALMA correlator study is **NOT** the ALMA Enhancement study led by NRAO (PI, R. Lacasse)*
  - Enhancement study: another 1 year study; concerns ALMA Baseline Correlator
- *Enhancement study Objectives*
  - x2 processed BW & x8 spectral resolution
  - Decrease the number of cards (4 times less correlator cards) and improve power dissipation
  - Use current infrastructure, minimum disruption
  - Evaluate costs
    - Main cost driver: the new correlator chip
    - New Digitizer (X2 BW), New DRx & TFB cards, New Correlator cards

***Enhanced Correlator is interim, prior to the ngALMA Correlator***