



# Band 2+3 Workshop

## Aims of the Meeting

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# Outline



- Context
  - ALMA Development Programme
  - ESO Call for Studies
- Objectives
  - Understand current status
    - Face-to-face meeting for EU/Chile/NAOJ Study: Band 2+3
    - Update on NRAO project: Band 2
  - Discuss key technical areas
    - Specifications: noise, IF bandwidth, ...
    - Optics
    - LNA's
  - Path to production
    - What to build
    - Collaborations

**Follow-up of Florence meeting in 2014**  
**Many more test results**





# ALMA Development Programme



- ALMA has a funded Development Programme
  - Total US\$ ~13.5M / year (currently)
  - Split 37.5/37.5/25% EU/NA/EA
- Regional flavours
  - Small Development Studies
    - EU and NA fund in open competition
    - **Band 2+3 (2010, 2013)**
  - Larger Projects
    - EU strategy has been to concentrate resources on one large project at a time (currently Band 5)
    - NA has funded a larger number of medium-scale projects: **Band 2 prototype**
    - EA about to embark on Band 1 full production
  - Leverage national and EU funding
    - EU FP6 Programme for Band 5 pre-production
    - ALMA Phasing Project (NSF, MPIfR)
    - **Band 2+3 STFC, INAF, U Chile**





# Near/mid-term Development Strategy



- Initially driven by the regions; now more coordinated
- Top priority: complete commissioning of rebaselined ALMA trilateral programme
  - Full polarization, single dish, observing efficiency, solar modes, ..
- Then: restore capability lost in descopes before 2005
  - mmVLBI; Bands 1, 2, 5; subarrays; data rate
  - whenever possible, tighten specifications, use new technology
- In parallel: studies in support of future programme
  - Increase bandwidth to at least 16 GHz/polarization
  - Improved receivers, digital electronics, correlator, software
  - Reliability and operational cost reduction (e.g. cryocooler)
  - Software



# ALMA 2030 and follow-up



- Science priorities for ALMA Development
  - Led by ASAC + Regional Programme Scientists
- Outputs
  - Major Science Themes 2020-2030
  - Landscape of major facilities in 2030
  - Pathways to Developing ALMA
- Development Working Group (2016-17)
  - Led by ALMA Director
  - Observatory Scientist + Regional Programme Scientists + JAO Systems Engineer + ...
  - Starting from ALMA2030, articulate a strategy for ALMA Development with priorities and approximate costs





# ESO Development Plan Studies 2016 Call



- Follows Calls for Studies in 2010 and 2013 (both including Band 2+3)
- Process
  - Call ~ now
  - Deadline August/September
  - Review October 2016 (ESO/ESAC)
  - Start ~Jan 2017
- Topics
  - Preparation for production
  - Software (e.g. data analysis, simulations)
  - Research and development studies (hardware and software)
  - Calibration techniques (phase, amplitude correction, ...) and new observing modes
  - **New: focus on ALMA2030 objectives, particularly increased bandwidth**

**Workshop here, Wednesday - Friday**





# Bands 2 and 2+3



- **Band 2: 67-90 GHz**
  - $T < 30\text{K}$  (80% band), 47K (full band)
  - Original concept single sideband, 4-12 GHz IF
- **Band 3: 84-116 GHz**
  - In operation
  - $T < 37\text{K}$  (80% band), 60K (full band)
  - SIS, sideband-separating, 4-8 GHz IF
- **Band 2+3: 67-116GHz**
- **Science cases for Band 2 and 2+3**
  - Fuller et al. arXiv 1602.02414
  - Beltran et al. arXiv 1509.02702
  - NRAO Band 2 Science Workshop 2013
  - Talks by Gary Fuller and Al Wootten





# The story so far

- ESO Studies
  - Focused on feasibility of full frequency range 67-116 GHz
  - 2010 (U Man, IRAM, INAF, RAL): science case, optics and system designs, prototype feed horn and OMT
  - 2013 (U Man, INAF, RAL, U Chile, NAOJ, ESO)
    - Consider (but rule out) SIS design, warm/cold reflective optics
    - Phase A (complete): bench test of optics (lens, feed horn, OMT)
      - **Conclude that wideband system is feasible**
    - Phase B (just starting): prototype ALMA cartridge, including optics, LNA and downconversion (series of talks)
    - **LNA design and test** (Danielle George)
- NRAO Project
  - Prototype Band 2 cartridge
  - **Test results** (Kamaljeet Saini)



# Band 2+3 Strategy



- Band 2
  - General agreement on importance of science case
  - Prototype cartridge development by NRAO to meet original ALMA specification but with 16 GHz IF bandwidth
- Band 2+3 or Band 2 – EU/ESO view
  - We should now be designing to meet more ambitious science specifications if this is technically feasible
  - The next generation of receivers should aim to meet the requirements set by ALMA2030
  - There are science drivers for a wider band (67 – 116 GHz)
  - This would also free up a 4K slot in the cryostat
  - Optics, feed horn and OMT will work over the full range
  - Even if production LNA's do not initially cover the full range, we should consider designing the optics and LO to support it with a view to future upgrades
- But:
  - Must at least maintain performance in Band 3 as well as meeting existing Band 2 specifications with 16 GHz bandwidth per polarization



# Key Questions



- Specifications
  - What is the right goal for IF bandwidth? 16GHz/polarization or even higher?
  - Noise temperature: ambitious but realistic goals
- Optics
  - Warm lens is a major contributor to the noise: do we have the best material/design?
- LNAs
  - What is the state of the art?
  - What are the compromises between noise temperature and bandwidth?
- System Design
  - Any other concerns?
- Strategy
  - Band 2, Band 2+3 or evolution?
- Production
  - Who, what, when?