ALMA Commissioining Progress

2010 April 12

Al Wootten

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

The push to Early Science…

- ALMA is pushing to issue a Call for Early Science Proposals around the end of this year
- This target is a key driver for the entire project at the moment
- To achieve this requires all of the necessary infrastructure and equipment to be in place and tested
- This activity is being masterminded by the ALMA CSV team, led by Richard Hills and Alison Peck
- The path to the Early Science phase began with the beginning of Commissioning on 2010 January 22.

Start of Commissioning Requirements

- Three antennas operational on the high site
  - Achieved 2009 20 Nov
- Front-ends containing at least bands 3 (3mm; 100 GHz), 6 (1mm; 250 GHz), 7 (.85mm; 345 GHz) & 9 (.45mm; 650 GHz)
  - All current front ends contain these bands
  - Fringes (2 antennas) at 658 GHz obtained on 2009 Nov 21
- Cal units with hot and ambient loads
  - These are installed on all antennas during AIV
- Complete BE and phase stable LO system
  - Installed at the AOS Aug 2009; fringes on two antennas 2009 Oct 21
- Correlator able to process three inputs
  - First quadrant installed
  - Second quadrant installed
- Fringes and phase closure demonstrated
  - 2009 November
- Software for basic operations and data reduction
  - Ongoing upgrades

Early Science Requirements

- 16 Antennas
- Front Ends
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  - Amplitude calibration using multiple-temperature loads
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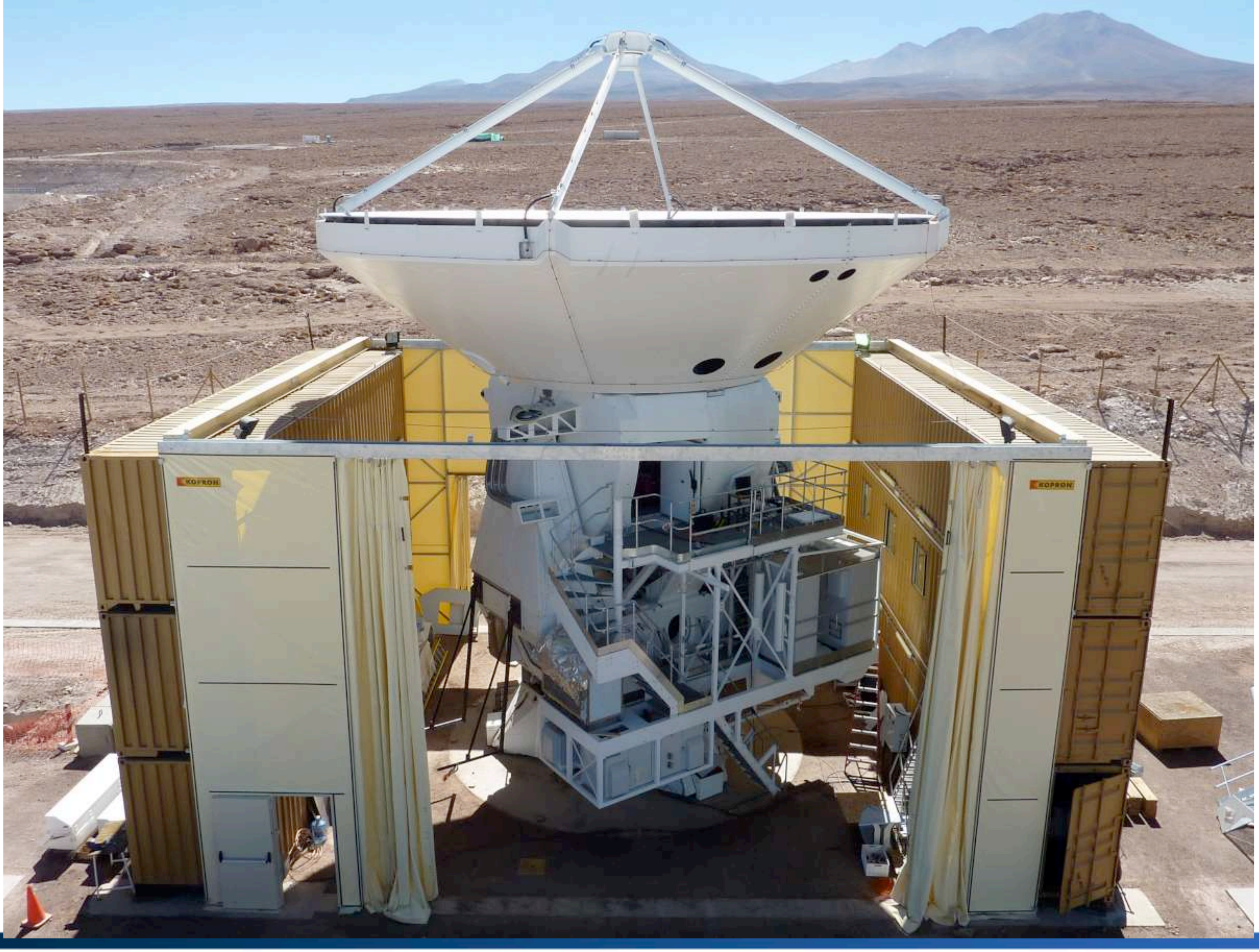
Antennas

- ALMA has accepted seven antennas
  - Three at AOS in CSV
  - Four at OSF in AIV
  - Twenty in various stages in contractor's camps
- Commissioning Status
  - Astronomical Holography: CSV-98
    - Corder, EmersonD, Villard, Mauersberger, Lucas, Vila-Vilaro, Sheth, Sugimoto
  - Pointing
  - Out-of-focus beam maps: CSV-101
    - Lucas, Barkats, Sawada, Simms, Garcia, Tachihara, Wilson, Sugimoto
  - Moon and Sun Scans: CSV-99
    - Nikolic, Zwaan, Sawada, Barkats, Fulla, Sheth, Sugimoto
  - Antenna tracking: CSV-102
    - Mangum, Mauersberger, Sawada, Simms, Wootten, Kneissl, Vila-Vilaro

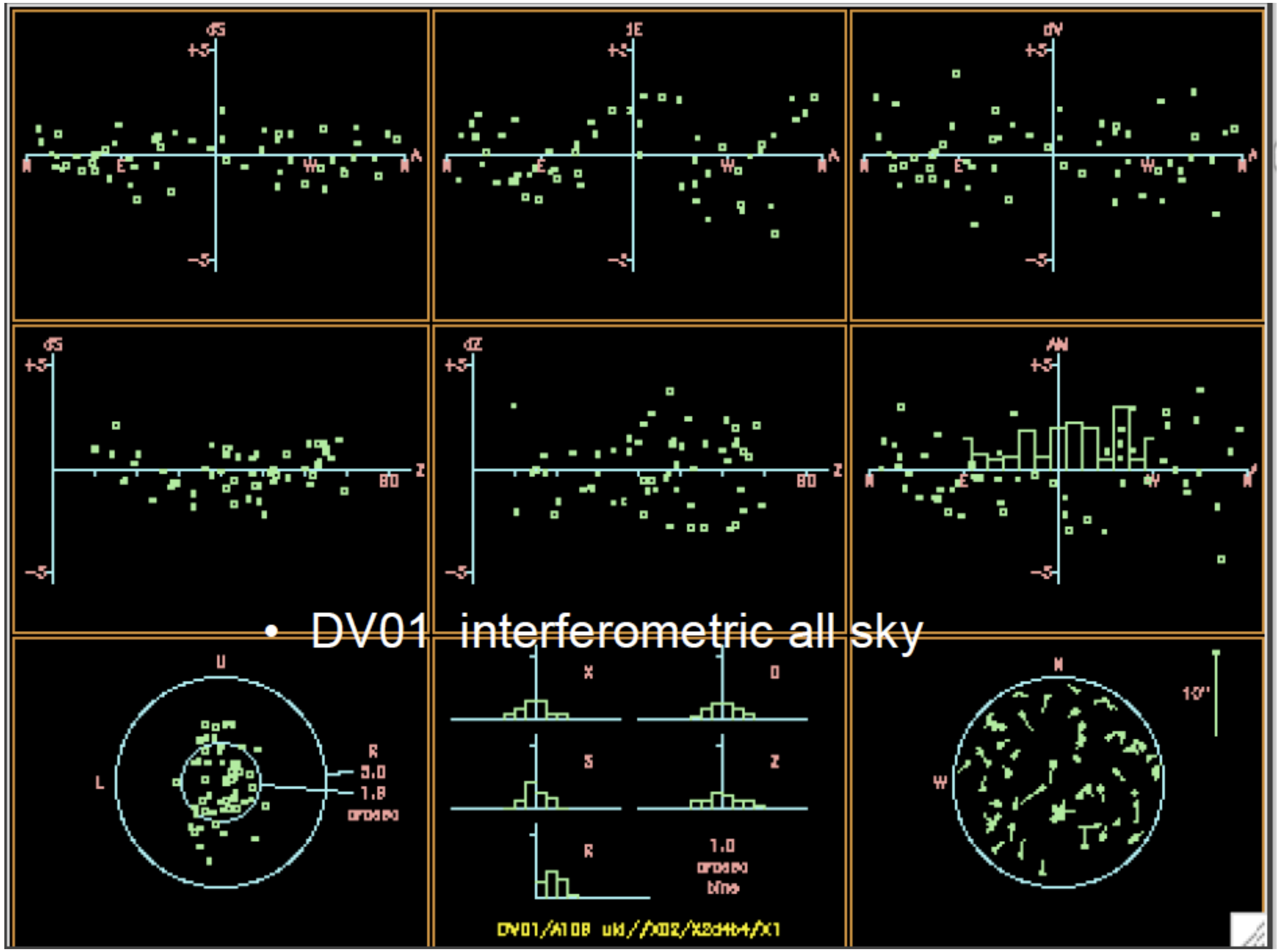
AEM Antennas



ALMA Antennas

- Pointing
  - Some anomalies observed, understood
    - Setting antenna on foundation can introduce an error (DV01)
    - Some iterating on metrology settings (PM03)
  - Tracking and switching motion tests begun on short baselines
- Surface accuracy
  - Tower holography occurred at one elevation
  - Short baselines enable astronomical holography; elevation dependence
  - Extreme environmental conditions occur at AOS, not OSF
  - Far sidelobes probe finescale structure in panel setting (observe Sun, Moon)

Pointing

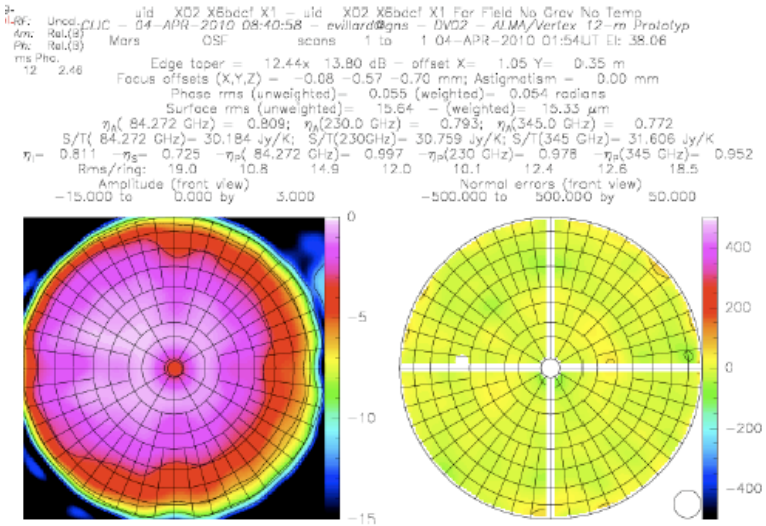


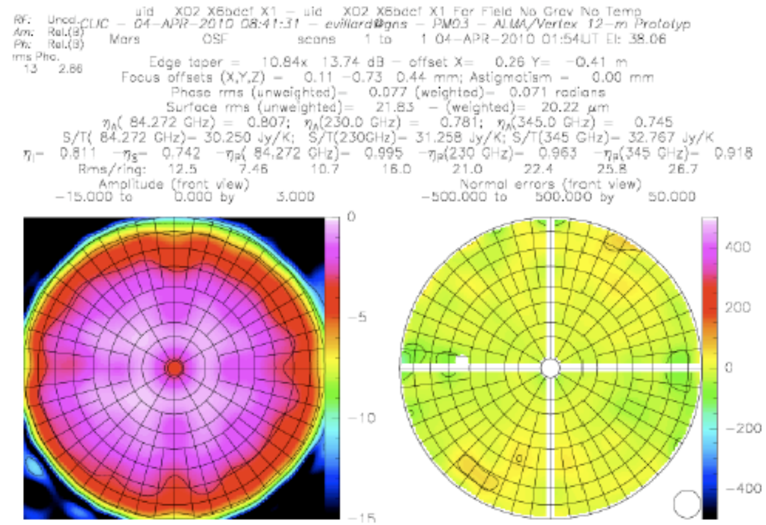
- DV01 interferometric all sky

Surface

Elevation	UT	Target	DV02 rms	PM03 rms
68.24	21:48	0538-440	23.73	36.30
61.51	06:12	3c279	19.13	25.02
57.07	06:35	3c279	20.28	31.33
49.80	07:09	3c279	16.69	33.17
38.06	01:54	Mars	15.33	20.22
35.11	02:17	Mars	15.69	26.53
31.46	02:41	Mars	21.31	24.04
27.40	03:06	Mars	24.84	34.77
23.18	03:31	Mars	20.76	17.78

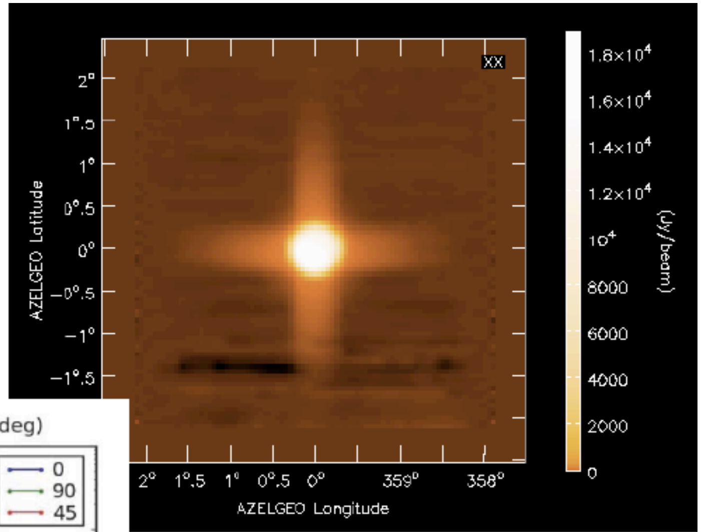
- Mars is a northern object now
- S(0538-440)~8 Jy
- For the most part: excellent so far

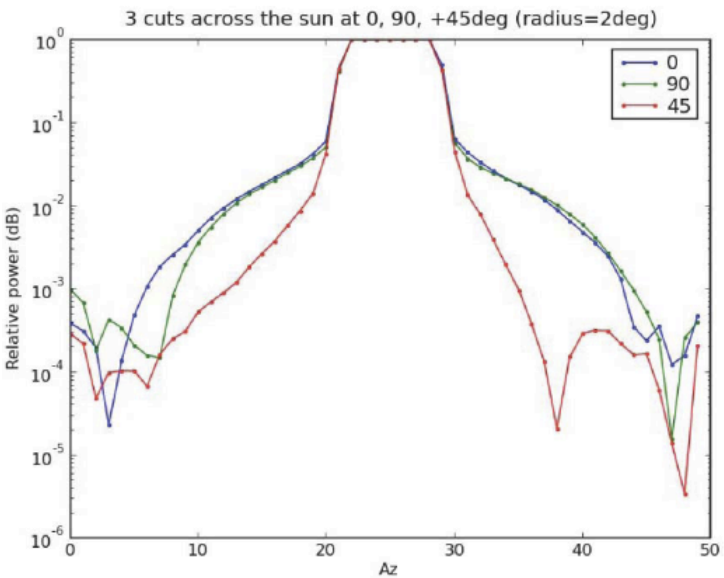




Moon Maps: Small Scale Errors

Measurement of small -scale surface errors





Do high frequencies and fit to a model.

At 1mm 50mm scale gives 1 degree structure

Antennas Summary

- Two types of antennas tested extensively
  - Surface appears good, with differences among types
  - Pointing appears good
    - Transporter setting down procedure needs work
    - Metrology can pose problems
  - Further tests under different conditions of weather, illumination
  - More tracking tests under way
- Three antenna types remain untested
  - Refurbished Mitsubishi prototype
  - AEM
  - Mitsubishi 7m

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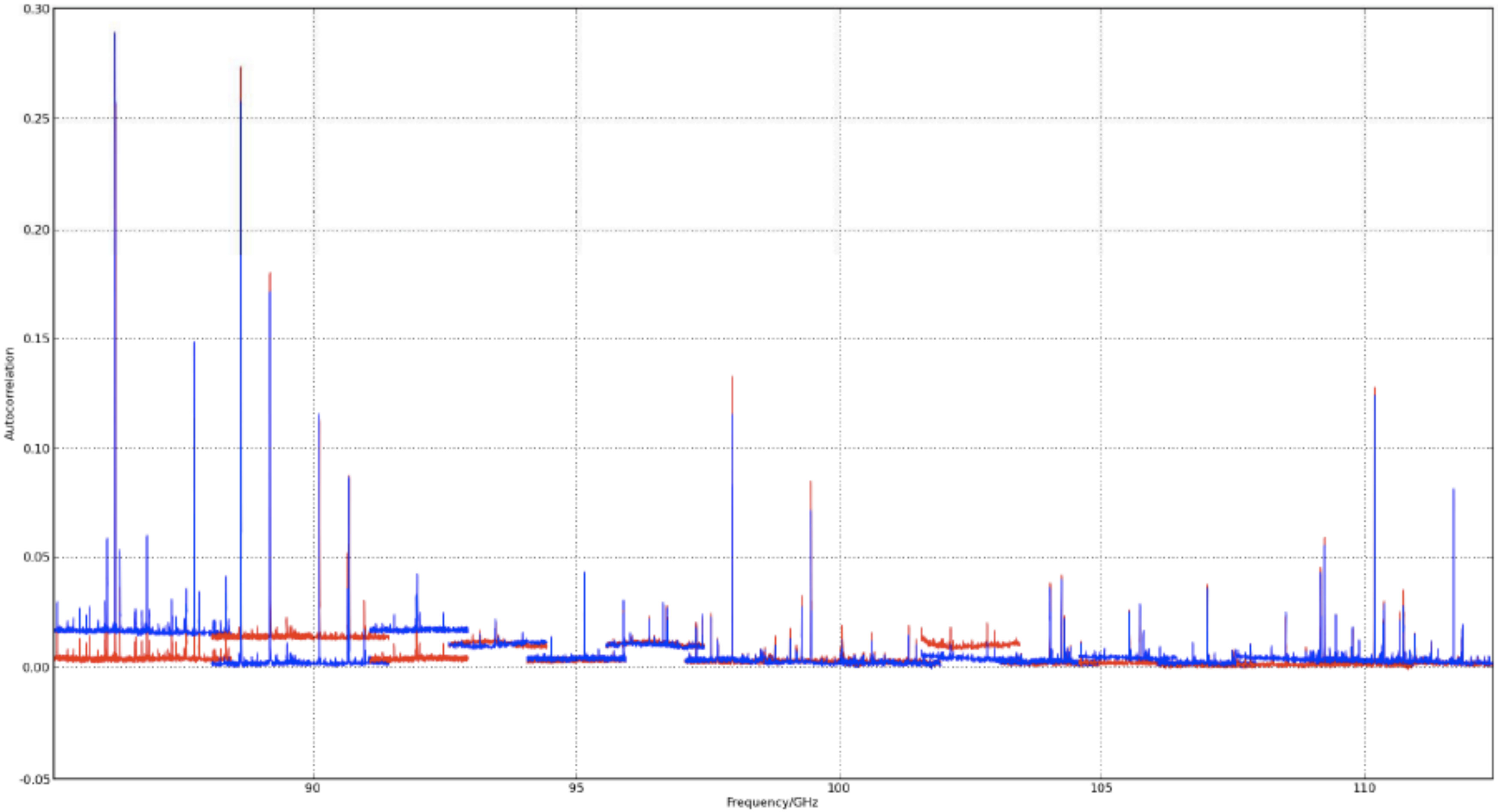
'Tunability'

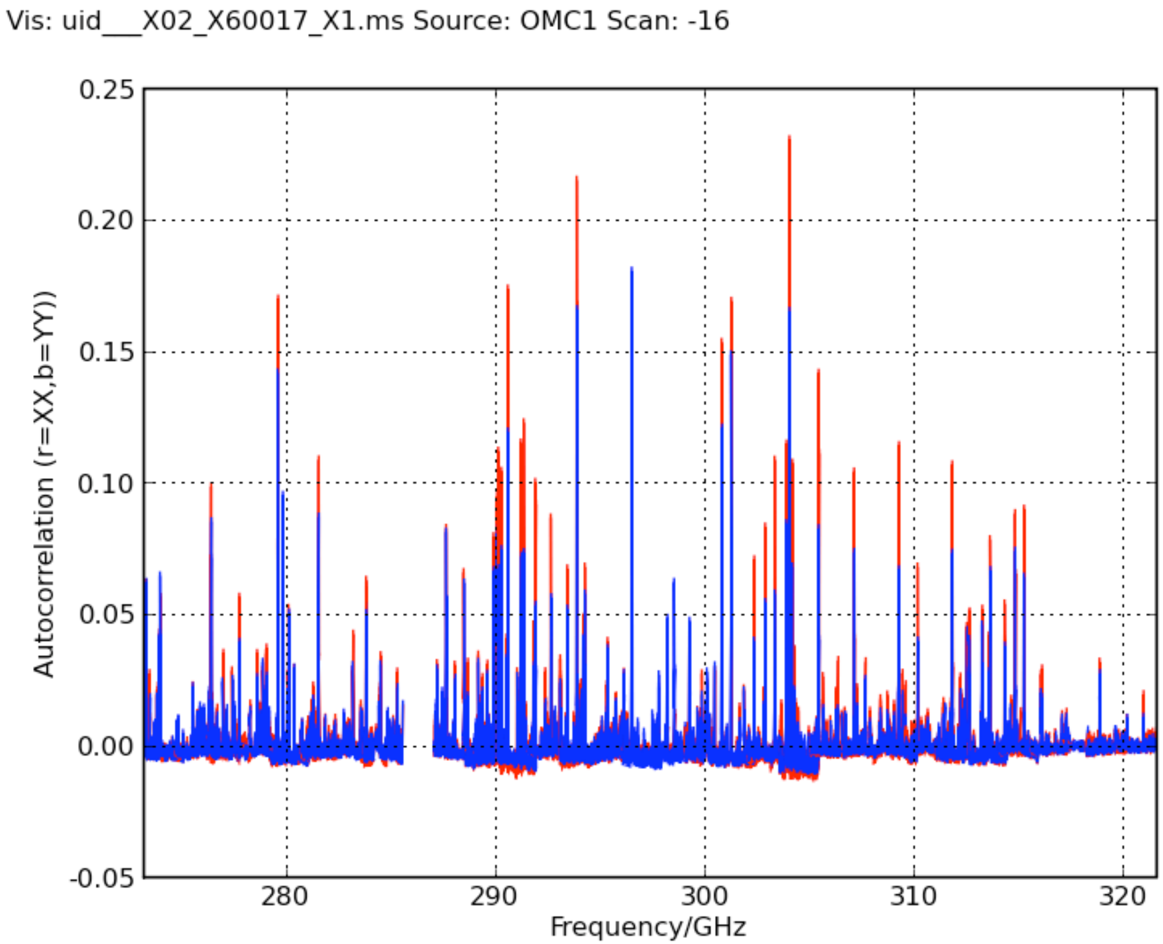
- Tunability - can we tune randomly using CCL and SBs: CSV-113
  - Peck, Simms, Wootten, Dent, Wiklind, Zwaan, Barkats, Bhatia
- Some hiccups but in general good performance
  - Honing of lookup table parameters
  - Some correlator problems
    - 'platforming'
    - Output limitations

Band 3



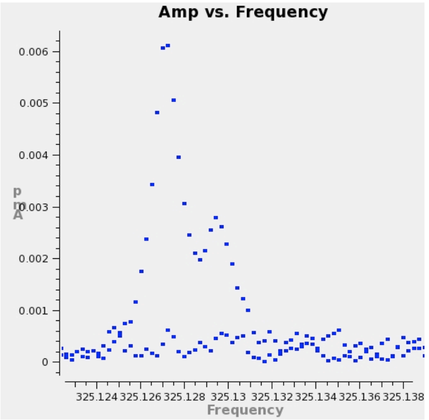
- N.B. Absence of CN, CO – now resolved

Band 7 (275-373 GHz/1.1-.8mm)

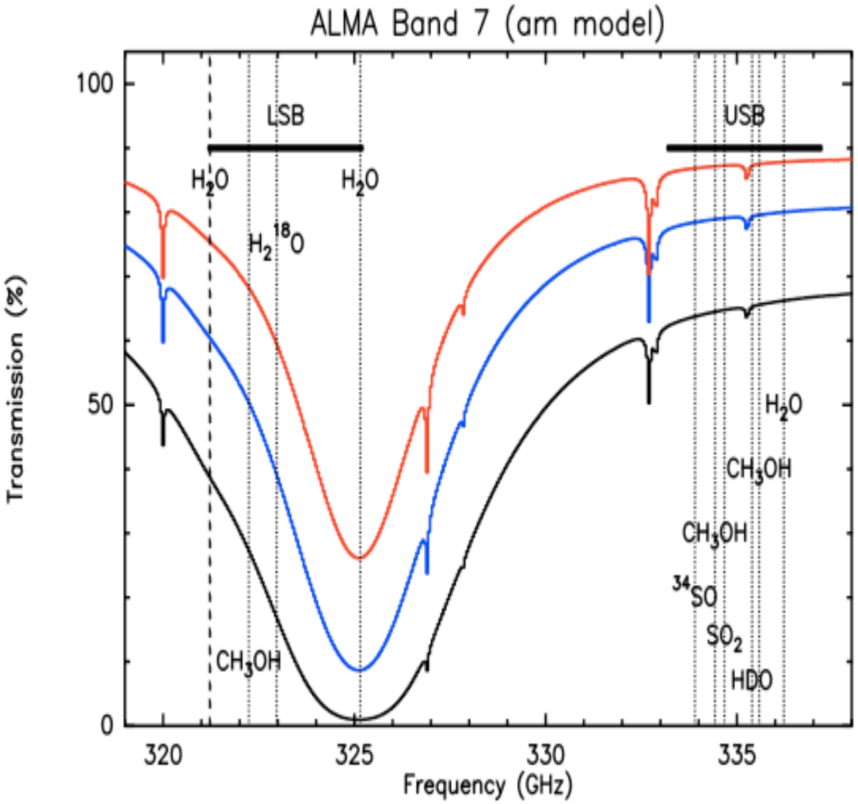


Atmospheric Suppression

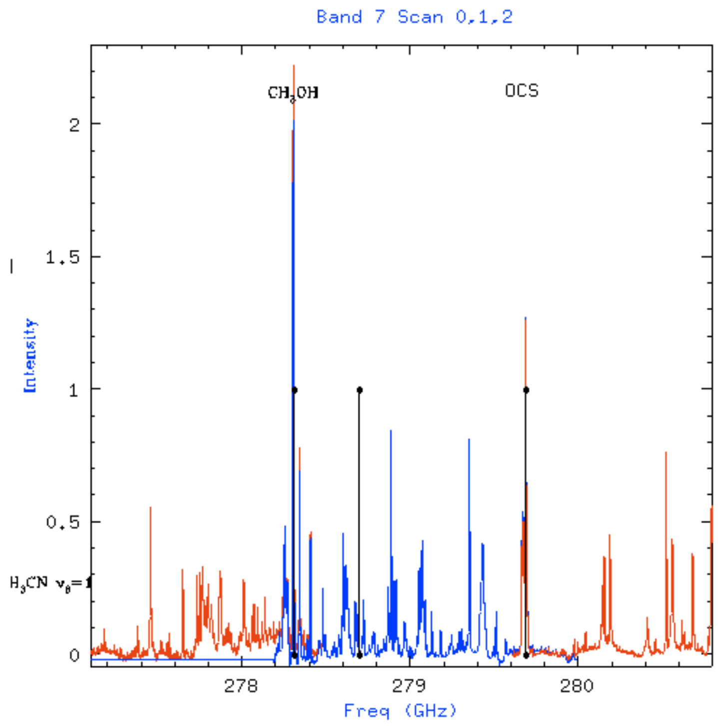
- Strong Water line at 325 GHz limits transmission there
- But the line is visible in stars from the excellent ALMA site

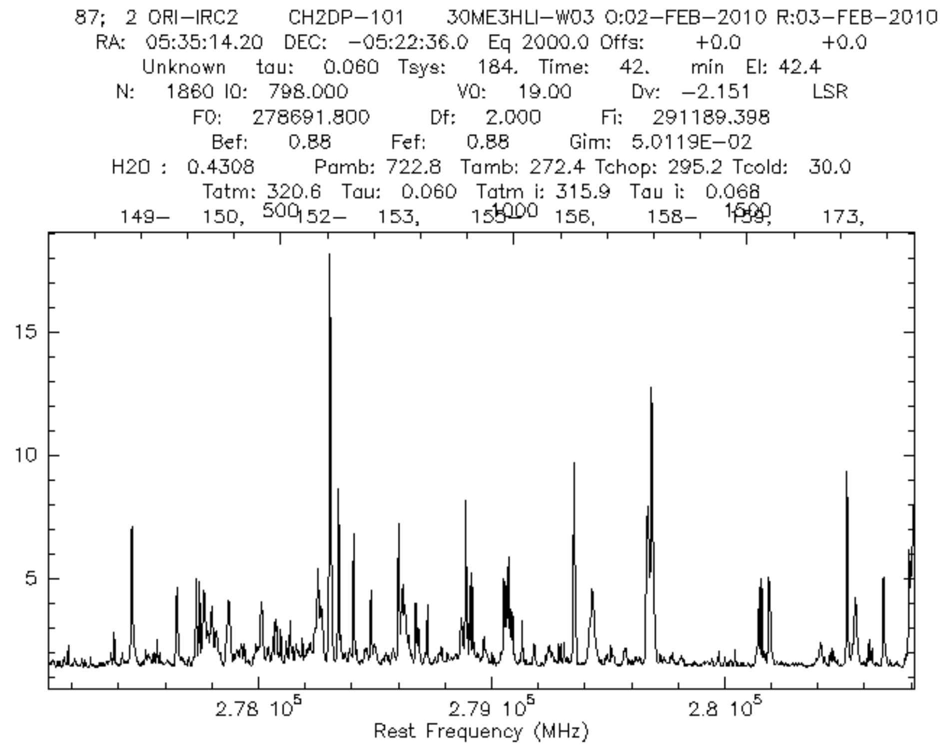


- W Hya



Comparison with IRAM 30m





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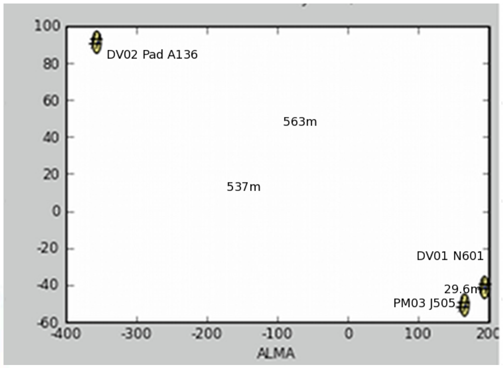
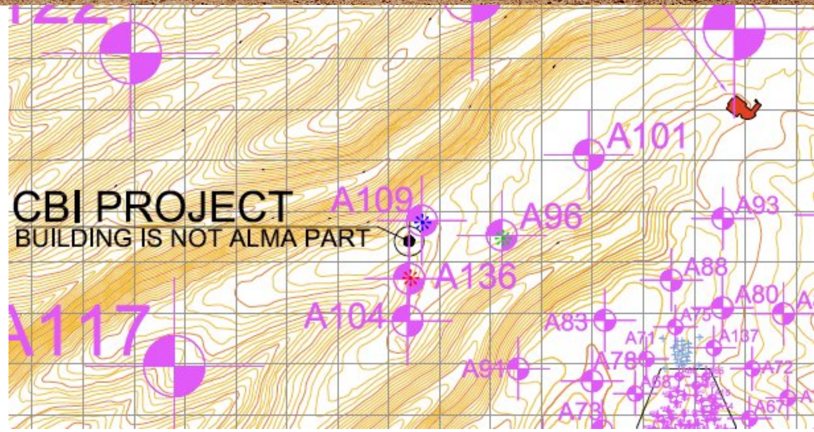
Antennas at AOS

- PM02, DV01 and DV02
- Three configurations
  - 1st: ~150m baselines
  - 2nd: ~30m, one 550m
  - 3rd: ~30m
- Next antenna Week after next!
  - Location TBD



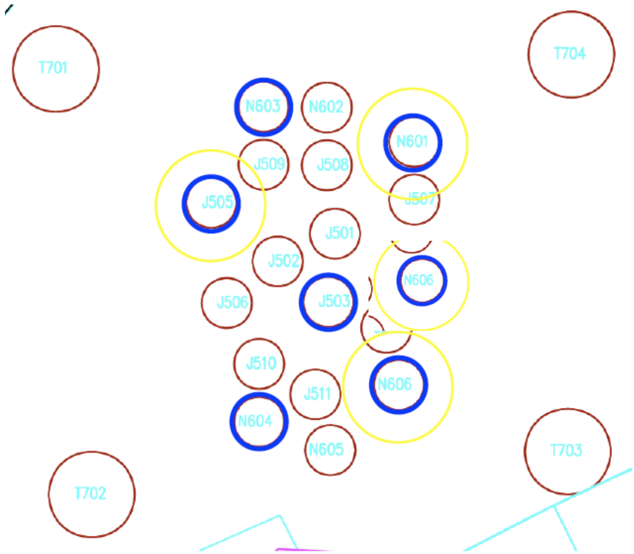
- Configuration 2

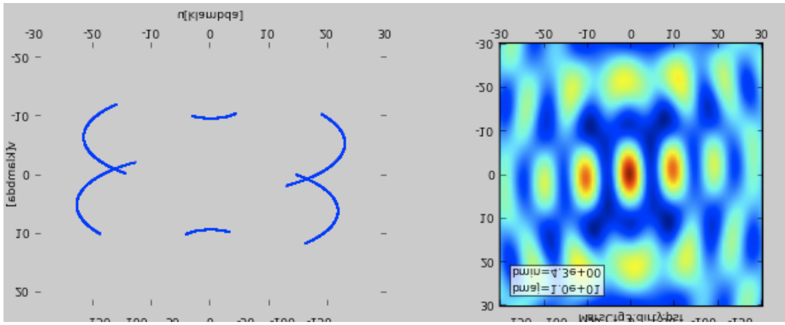


- Configuration 1

Current Configuration

- Three 12m antennas on future ACA 7m foundations





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Correlator Modes

- A. Mode 70. Pseudo-continuum in TDM with full polarization.
- B. Modes 7 and 9. Two polarizations in respective bandwidths of 2 GHz and 500 MHz and 4096 channels each. At 230 GHz this corresponds to a velocity coverage of 2621 km/s and 656 km/s, and resolutions of 0.64 km/s and 0.16 km/s respectively. The latter is sufficient for most Galactic work (and drops to values of 0.11, 0.08, 0.06 km/s at 345, 460, and 650 GHz, respectively). The two polarizations increase the S/N by 2 while still retaining a large bandwidth coverage.
- C. Mode 12. Two polarizations in a bandwidth of 62.5 MHz and 4096 channels, the highest spectral resolution available (0.02 km/s at 230 GHz over a bandwidth of 82 km/s). This will satisfy even the most detailed requirements for high spectral resolution.
- D. Mode 18. Full polarization in a bandwidth of 62.5 MHz and 2048 channels, the highest spectral resolution available (0.04 km/s at 230 GHz over a bandwidth of 82 km/s). This mode should allowed detailed studies of the Zeeman effect. It is noted that mode 70 provides the complementary capabilities of full continuum polarization.
- While the above modes are listed in order of priority, ASAC expects that these five modes will all be commissioned at the start of Early Science…
- Status: All tested, those highlighted tested extensively.

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'Imaging'

- Three antennas limit the quality of 'imaging' particularly since most early configurations have been limited by pad availability.
- Nonetheless, 'images' of the Orion SiO maser and other lines have been obtained from short tracks.
- Here is shown ~30 minutes
- Several realistic observing sessions have been carried out
  - Use of Observing Tool to create 'Schedule Blocks'
  - Execution of the Schedule Blocks on the array
  - Export of the ASDM files to Measurement Sets
  - Calibration and imaging of data in CASA; development of scripts and techniques which may be used for the general dataset.

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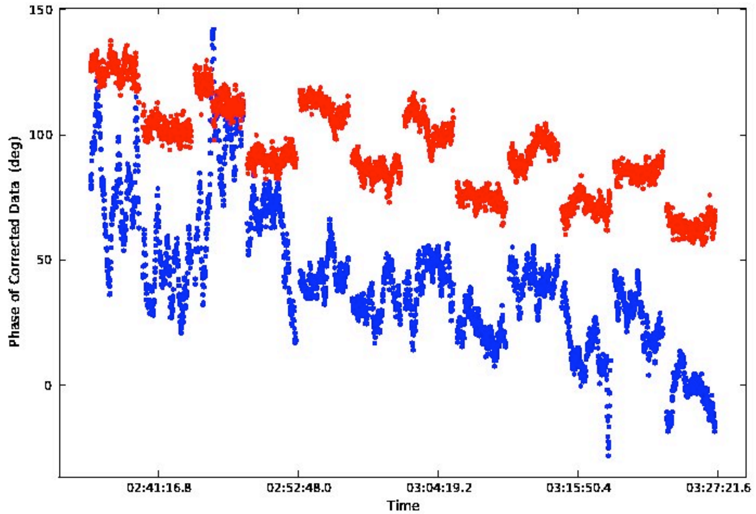
Calibration

- Amplitude Calibration Device can be inserted and removed from beam
- Water Vapor Radiometer
  - Provides multichannel data in all crosscorrelation datasets
  - Nikolic program wvrgcal provides phase correction through a gain table which may be applied in CASA
  - Under many circumstances, correction is near spec
  - Only simple atmospheric modeling so far
    - Some thoughts on corrections for liquid
    - No amplitude correction currently

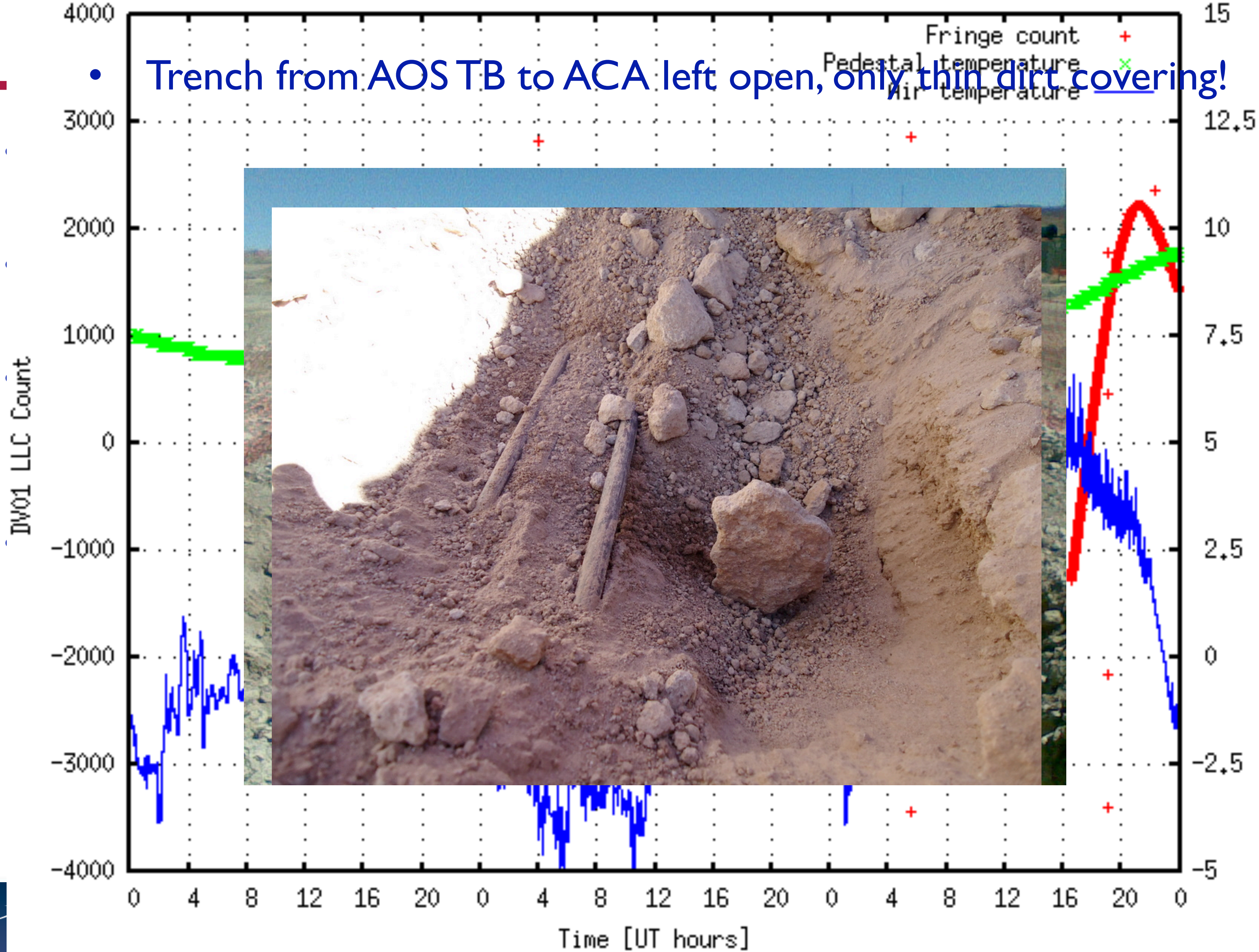
Example WVR Data

- One baseline, two calibrators alternating, ~150m baseline
  - Blue: no correction—can barely see the two calibrators
  - Red: corrected data—clearly two calibrators are present
- Taken during improving conditions—lightning thunder and rainbows initiated the session
- Data now taken on 550m baseline—more challenging in some conditions (esp. day)



L

- Trench from AOS TB to ACA left open, only thin dirt covering!



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