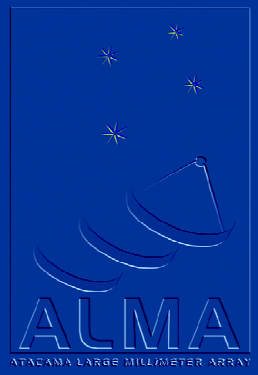
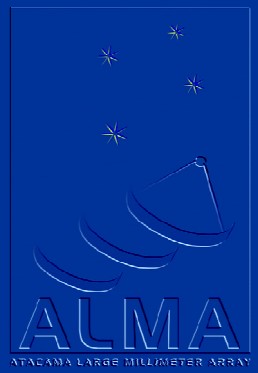


Atacama Large Millimeter/ submillimeter Array - ALMA

Overview & Status

ALMA Development Team

June 2007



ALMA

- International project to build & operate a large (up to 80-antennas) millimeter/submm (λ ~0.85-3mm) array at high altitude site (5000m) in northern Chile.

- Project began in 2002; Japan joined in 2004; site construction, hardware production lines underway, software in development 2007, 66 antennas in production; first antennas 2007; early science ~2010, full science operations 2012.

- Two orders-of-magnitude improvement in mm radio astronomy capabilities.

ALMA – Major Elements

- Partners: ESO – US/Canada – Japan – Chile – Taiwan

- **Array Operations Site – AOS**
- **Operations Support Facility – OSF**
- **Santiago Central Offices – SCO**
- **ALMA Regional Centers – ARCs + ARClets**

- During full operation, the estimated flow of int/SD data into archive ~ 100 TB per year: proposal, u-v data, a reference image with pipeline processing history, calibration data… modern radio astronomy

ALMA Science Requirements

- High Fidelity Imaging.
- Precise Imaging at 0.1” Resolution.
- Routine Sub-mJy Continuum Sensitivity.
- Routine mK Spectral Sensitivity.
- Wideband Frequency Coverage.
- Wide Field Imaging Mosaicing.
- Submillimeter Receiver System.
- Full Polarization Capability.
- System Flexibility.

Technical Specifications

- 54 12-m antennas, 12 7-m antennas, at 5000 m site
- Surface accuracy ±25 μm, 0.6” reference pointing in 9m/s wind, 2” absolute pointing all-sky.
- Array configurations between 150m to ~15-18km.
- 10 bands in 31-950 GHz + 183 GHz WVR.
- 8 GHz BW, dual polarization.
- Flux sens. 0.2 mJy in 1 min at 345 GHz (median cond.).
- Interferometry, mosaicing & total-power observing.
- Correlator: 4096 channels/IF (multi-IF), full Stokes.
- Data rate: 6MB/s average; peak 60-150 MB/s.
- All data archived (raw + images), pipeline processing.

ALMA Median Continuum Sensitivity

(1 minute; AM=1.3; 75% Quartile opacities λ>1mm, 25% λ <1mm)

Frequency (GHz)	Continuum (mJy)	Line 1 km s^{-1} (mJy)	Line 25 km s^{-1} (mJy)
35	0.02	5.1	1.03
110	0.027	4.4	0.89
140	0.039	5.1	1.01
230	0.071	7.2	1.44
345	0.12	10	1.99
675	0.85	51	10.2
850	1.26	66	13.3.

Brightness Temperature Sensitivity

(1 min, AM=1.3, 1.5mm, *0.35 PWV, 1 km/s)

Frequency (GHz)	B_{max} 0.2km T_{cont} (K)	B_{max} 0.2km T_{line} (K)	B_{max} 10km T_{cont} (K)	B_{max} 10km T_{line} (K)
35	0.002	0.050	0.48	130
110	0.003	0.049	0.84	120
230	0.0005	0.054	1.3	140
345	0.0014	0.12	3.6	300
490	0.0030	0.23	7.6	580
675*	0.0046	0.28	12	690
850*	0.011	0.58	27	1400

http://www.eso.org/projects/alma/science/bin/sensitivity.html

ALMA Science

- **Planetary regions, nearby disks**
- Astrochemistry
- Interstellar medium (Galaxy, Local Group)
- High-redshift deep fields

- *+128 projects in first 3yrs – DRSP…*

- *This conference…*


N
W
E
S
Image © 2006 NASA
© 2005 Google

ALMA Site

ALMA

Paranal

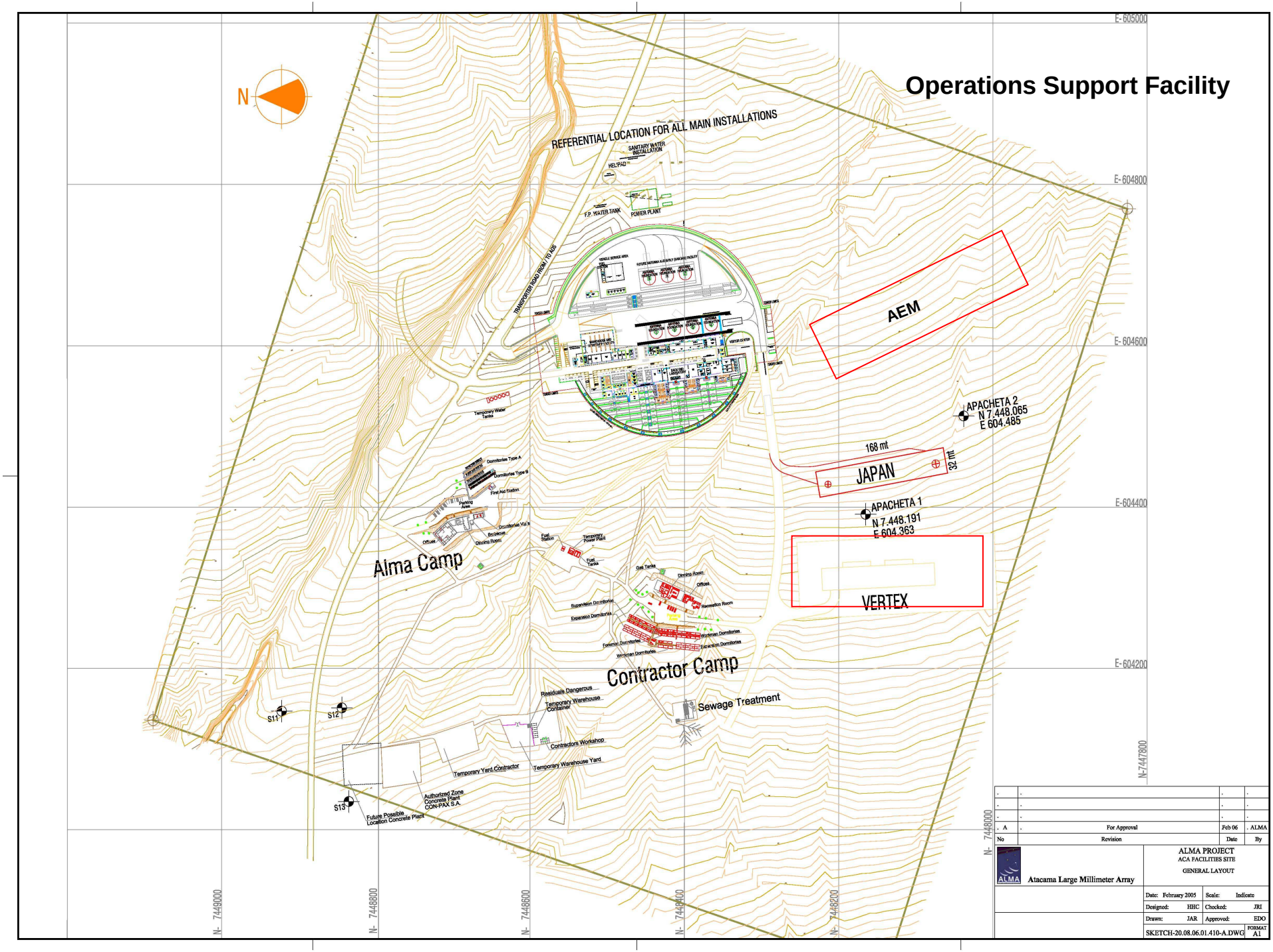
La Serena

Santiago


San Pedro de Atacama,
Atacama Desert, Northern Chile


ALMA Sites
To AOS (43km)
OSF Site (15km)
PARE
60
PELIGRO

Operations Support Facility



No	Revision	Date	By
.	.	.	.
.	.	.	.
.	.	.	.
. A	For Approval	Feb 06	. ALMA

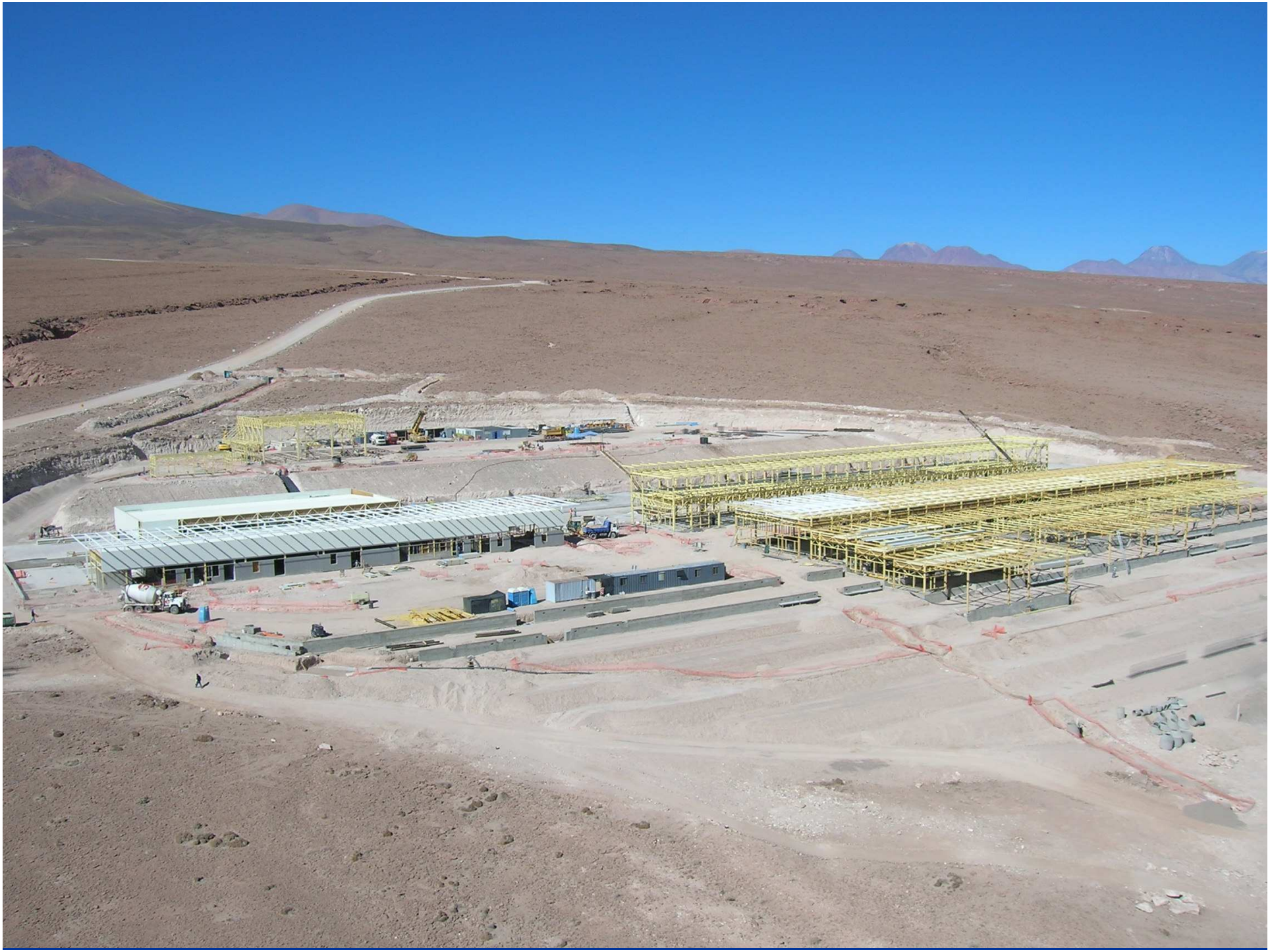
Atacama Large Millimeter Array

ALMA PROJECT
ACA FACILITIES SITE
GENERAL LAYOUT

Date:	February 2005	Scale:	Indicate
Designed:	HHC	Checked:	JRI
Drawn:	JAR	Approved:	EDO

SKETCH-20.08.06.01.410-A.DWG FORMAT A1


05.24.2007




19/06/2007 13:56

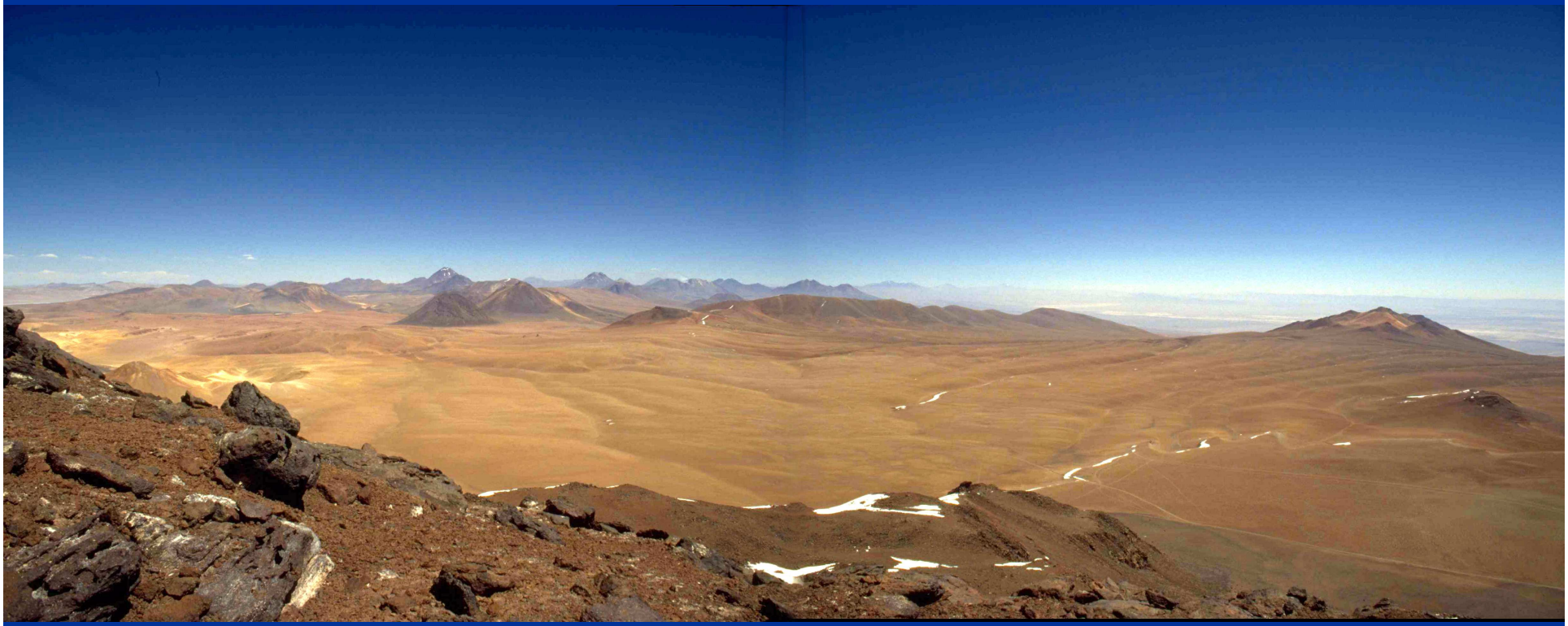

Lascar – April + October 2006

Road: OSF-AOS ← Transporter


QuickTime™ and a
decompressor
are needed to see this picture.

5000m Chajnantor plateau – looking south

Array Operations Site

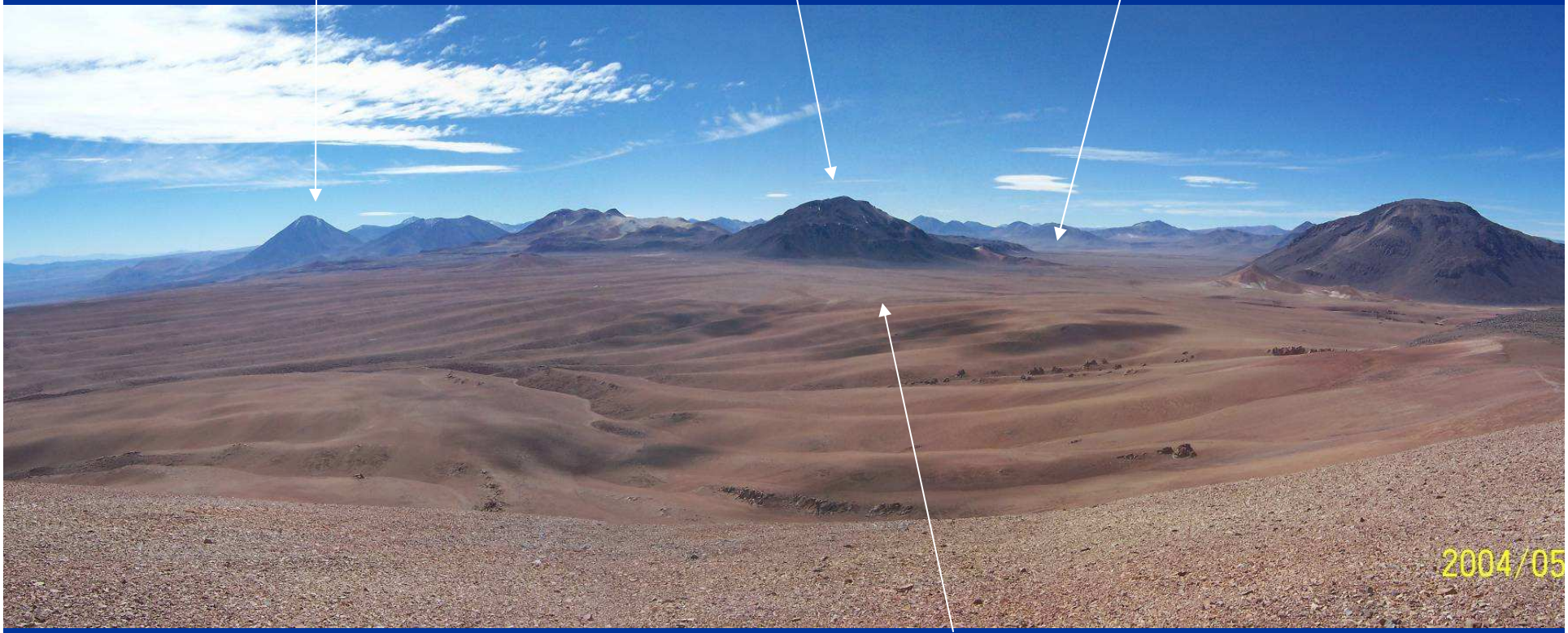


Chajnantor Plateau – looking north

V. Licancabur

Cº Chajnantor

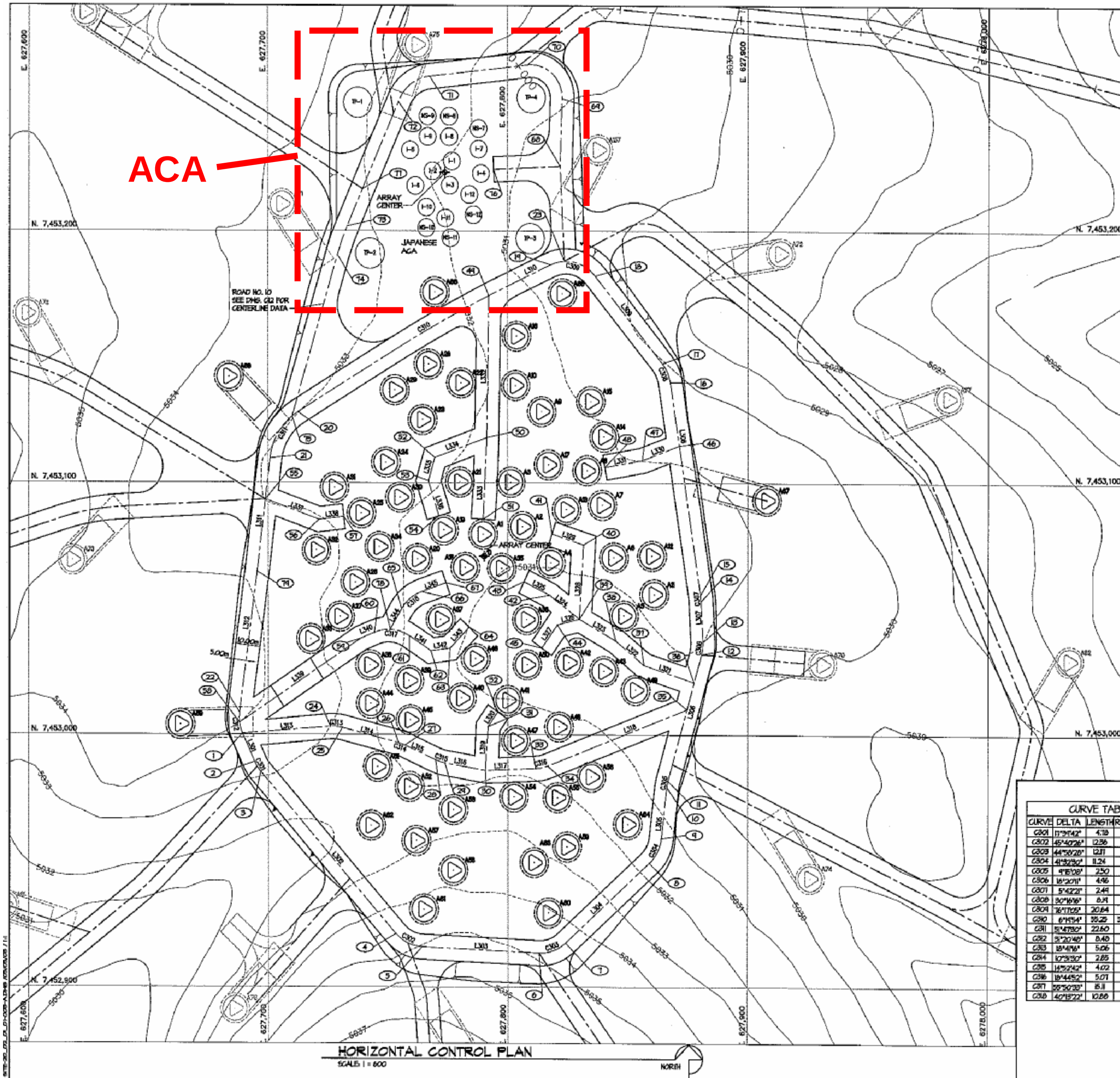
Pampa La Bola



Center of Array

AOS Technical Building – March 2007


Array Center



HORIZONTAL CONTROL PLAN

SCALE 1 = 600

NORTH

ROAD CENTERLINE DATA

NO.	NORTHING	EASTING	GRADE	ELEVATION	DELTA
1	7453000.43	627684.28	5033.82	5033.54	-0.28
2	7452984.13	627694.28	5033.28	5033.52	0.24
3	7452985.13	627646.65	5033.08	5033.49	0.41
4	7452921.16	627758.48	5034.56	5032.85	-1.71
5	7452915.45	627764.32	5035.04	5032.69	-2.35
6	7452913.55	627818.08	5034.86	5031.82	-3.04
7	7452911.56	627824.25	5034.40	5031.60	-2.80
8	7452949.20	627854.20	5031.16	5030.87	0.11
9	7452958.99	627864.20	5031.28	5030.18	0.50
10	7452979.31	627866.44	5030.62	5030.71	0.09
11	7452981.76	627866.92	5030.55	5030.70	0.15
12	7453032.14	627880.43	5030.88	5030.52	-0.36
13	7453051.05	627881.48	5031.00	5030.51	-0.49
14	7453053.21	627880.64	5031.00	5030.49	-0.51
15	7453055.68	627880.45	5031.00	5030.49	-0.51
16	7453140.00	627861.85	5030.14	5030.58	0.44
17	7453147.42	627864.60	5030.03	5030.68	0.65
18	7453182.25	627856.87	5030.34	5031.79	1.45
19	7453186.60	627848.02	5030.76	5031.92	1.16
20	7453121.99	627712.67	5033.01	5032.48	-0.53
21	7453109.63	627700.86	5033.00	5032.73	-0.27
22	7453008.12	627688.09	5034.00	5033.51	-0.49
23	7453188.19	627823.82	5030.62	5031.94	1.32
24	7453008.23	627726.24	5032.99	5032.86	-0.13
25	7453002.79	627731.25	5032.71	5032.71	0
26	7452996.80	627754.65	5031.90	5032.38	0.48
27	7452995.85	627757.35	5031.85	5032.34	0.49
28	7452990.00	627764.93	5031.83	5032.15	0.32
29	7452988.80	627773.76	5031.82	5032.08	0.26
30	7452985.88	627790.61	5031.88	5031.80	-0.08
31	7453003.25	627791.13	5031.36	5031.68	0.32
32	7453004.15	627795.88	5031.17	5031.57	0.40
33	7452986.59	627811.77	5031.85	5031.42	-0.43
34	7452981.63	627816.11	5031.75	5031.32	-0.43
35	7453010.21	627814.83	5030.33	5030.58	0.25
36	7453020.92	627817.81	5030.56	5030.55	-0.01
37	7453027.84	627851.02	5031.00	5030.64	-0.36
38	7453031.49	627845.26	5031.00	5030.68	-0.32
39	7453046.09	627830.08	5031.00	5030.80	-0.20
40	7453075.48	627831.77	5031.00	5030.80	-0.20
41	7453074.15	627818.61	5031.00	5030.98	-0.02
42	7453055.57	627811.68	5031.00	5030.91	-0.09
43	7453060.84	627806.87	5031.00	5031.12	0.12
44	7453043.80	627820.88	5031.00	5030.96	-0.04
45	7453084.55	627814.38	5031.00	5031.14	0.14
46	7453114.71	627871.62	5030.75	5030.44	-0.31
47	7453108.95	627856.38	5030.99	5030.59	-0.40
48	7453106.23	627840.74	5031.00	5030.80	-0.20
49	7453114.34	627792.16	5031.56	5031.87	0.31
50	7453117.95	627791.33	5031.84	5031.50	-0.34
51	7453085.59	627769.82	5031.47	5031.42	-0.05
52	7453109.95	627764.73	5032.12	5031.72	-0.40
53	7453100.75	627767.13	5032.01	5031.76	-0.31
54	7453086.81	627771.40	5031.79	5031.71	-0.08
55	7453018.32	627648.89	5033.00	5032.82	-0.18
56	7453008.32	627721.53	5033.00	5032.48	-0.52
57	7453086.49	627731.43	5032.78	5032.32	-0.46
58	7453004.71	627686.07	5034.00	5033.54	-0.46
59	7453038.25	627736.43	5032.48	5032.42	-0.06
60	7453040.86	627744.74	5032.35	5032.30	-0.05
61	7453039.28	627759.19	5031.92	5032.05	0.13
62	7453033.45	627768.06	5031.49	5031.92	0.43
63	7453034.45	627775.93	5031.17	5031.78	0.61
64	7453042.79	627783.89	5031.00	5031.58	0.58
65	7453050.05	627755.97	5032.03	5032.05	0.02
66	7453056.85	627764.18	5031.75	5031.89	0.14
67	7453060.45	627774.33	5031.47	5031.71	0.24
68	7453225.49	627822.18	5030.71	5031.98	1.27
69	7453252.10	627822.99	5031.07	5031.98	0.41
70	7453265.42	627808.56	5031.61	5031.99	0.38
71	7453260.86	627767.81	5032.49	5032.01	-0.48
72	7453250.13	627754.94	5032.73	5032.01	-0.72
73	7453201.78	627738.52	5033.21	5032.02	-1.19
74	7453140.41	627729.35	5033.33	5032.02	-1.31
75	7453126.36	627710.11	5033.02	5032.51	-0.51
76	7453224.26	627794.33	5031.36	5031.99	0.64
77	7453216.47	627734.95	5033.08	5032.02	-1.06
78	7453204.90	627751.35	5032.17	5032.18	0.01
79	7453064.71	627645.45	5033.84	5033.05	-0.79

CURVE TABLE

CURVE	DELTA	LENGTH	RADIUS	TANGENT
C301	17°39'42"	4.78	15.50	2.41
C302	45°40'26"	12.36	15.50	6.53
C303	44°50'28"	12.11	15.50	6.42
C304	41°32'30"	11.24	15.50	5.88
C305	9°15'08"	2.50	15.50	1.25
C306	18°20'11"	4.96	15.50	2.50
C307	5°42'21"	2.49	25.00	1.25
C308	30°16'16"	8.19	15.50	4.19
C309	76°17'09"	20.64	15.50	12.17
C310	6°19'34"	33.25	300.00	21.66
C311	51°47'30"	22.60	25.00	12.14
C312	31°20'48"	8.48	15.50	4.35
C313	18°41'46"	5.06	15.50	2.55
C314	10°31'30"	2.85	15.50	1.43
C315	14°52'42"	4.02	15.50	2.02
C316	18°44'52"	5.07	15.50	2.56
C317	55°50'33"	15.11	15.50	8.21
C318	40°13'22"	10.88	15.50	5.68

LINE TABLE

LINE	LENGTH	BEARING
L301	12.36	S25°51'16"E
L302	85.43	S41°31'00"E
L303	46.82	S87°11'26"E
L304	41.15	N47°50'06"E
L305	20.44	N06°17'36"E
L306	52.29	N15°32'45"E
L307	16.18	N02°47'26"W
L308	86.26	N08°29'47"W
L309	44.65	N88°43'56"W
L310	15.52	S64°58'51"W
L311	45.24	S06°51'35"W
L312	56.47	S07°24'30"W
L313	37.06	N85°40'06"E
L314	24.15	S75°30'38"E
L315	13.40	S65°07'08"E
L316	17.11	S19°54'49"E
L317	21.18	N87°56'16"E
L318	62.35	N68°45'46"E
L319	11.46	N03°40'30"E
L320	7.18	N84°47'25"E
L321	21.91	N17°35'15"W
L322	15.21	N50°38'28"W
L323	17.44	N60°28'50"W
L324	15.65	N52°42'58"W
L325	12.01	N65°41'10"W

LINE TABLE

LINE	LENGTH	BEARING
L326	9.33	S16°07'21"W
L327	11.31	S85°05'45"W
L328	29.44	N03°17'07"E
L329	13.88	N12°01'26"W
L330	16.36	S64°04'19"W
L331	15.82	S80°06'29"W
L332	56.39	S00°50'42"W
L333	32.40	S02°40'18"W
L334	28.03	S69°40'57"W
L335	9.36	S15°46'51"W
L336	14.58	S17°00'54"E
L337	24.00	S10°32'08"E
L338	10.47	N83°37'52"E
L339	60.89	N86°38'40"E
L340	6.29	N67°30'06"E
L341	10.82	S56°34'21"E
L342	7.93	N62°45'51"E
L343	11.58	N43°39'49"E
L344	9.51	N30°14'26"E
L345	10.77	N10°27'46"E

NATIONAL RADIO ASTRONOMY OBSERVATORY

ALMA

SITE-20.02.01.01-003-A-DWG

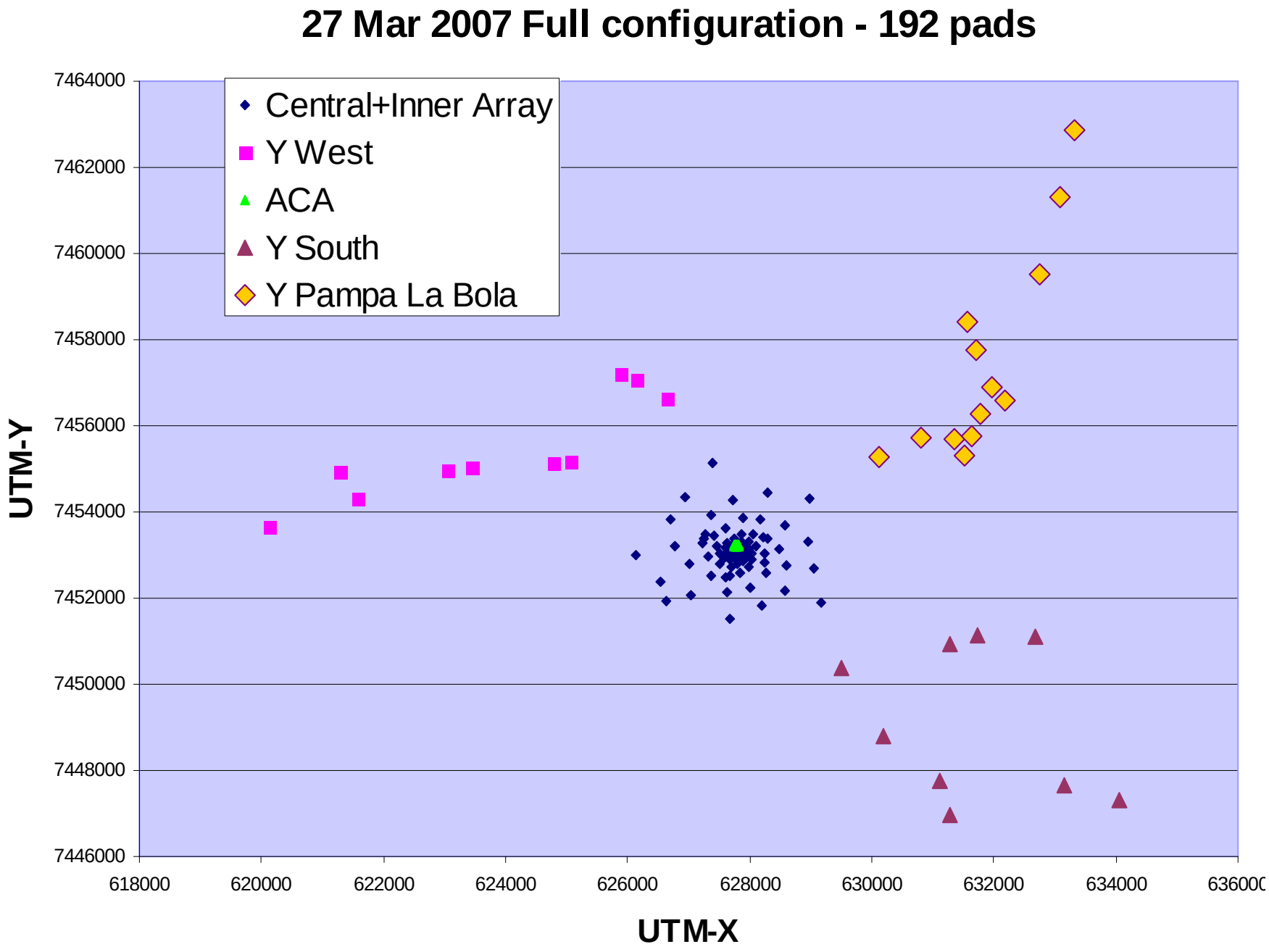
M3 Engineering + Technology Corporation
Tucson, Arizona

Revisions

Drawing Title
CENTRAL CLUSTER
HORIZONTAL CONTROL PLAN

Discipline Sheet Number
C1

M3PN 03082.01


27 Mar 2007 Full configuration - 192 pads
Central+Inner Array
Y West
ACA
Y South
Y Pampa La Bola
UTM-Y
UTM-X
7464000
7462000
7460000
7458000
7456000
7454000
7452000
7450000
7448000
7446000
618000
620000
622000
624000
626000
628000
630000
632000
634000
636000

Antennas

- Demanding ALMA antenna specifications:
  - Surface accuracy (25 μm)
  - Absolute and offset pointing accuracy (2 arcsec absolute, 0.6 arcsec offset)
  - Fast switching (1.5 deg sky in 1.5 sec)
  - Path length (15 μm non-repeatable, 20 μm repeatable)
- To validate these specifications: three prototype antennas built & evaluated at ATF (VLA site)
- Three production contracts – US, Europe, Japan (General Dynamics/Vertex, Alcatel EIE MT Aerospace, Mitsubishi)

Prototype Antennas at ATF

12-m, Carbon Fiber Support Structure

Vertex Antenna #1

Vertex #1 – April 2007


04/27/2007


Mitsubishi #1 - Mar 2007

3. Shipping to Chile

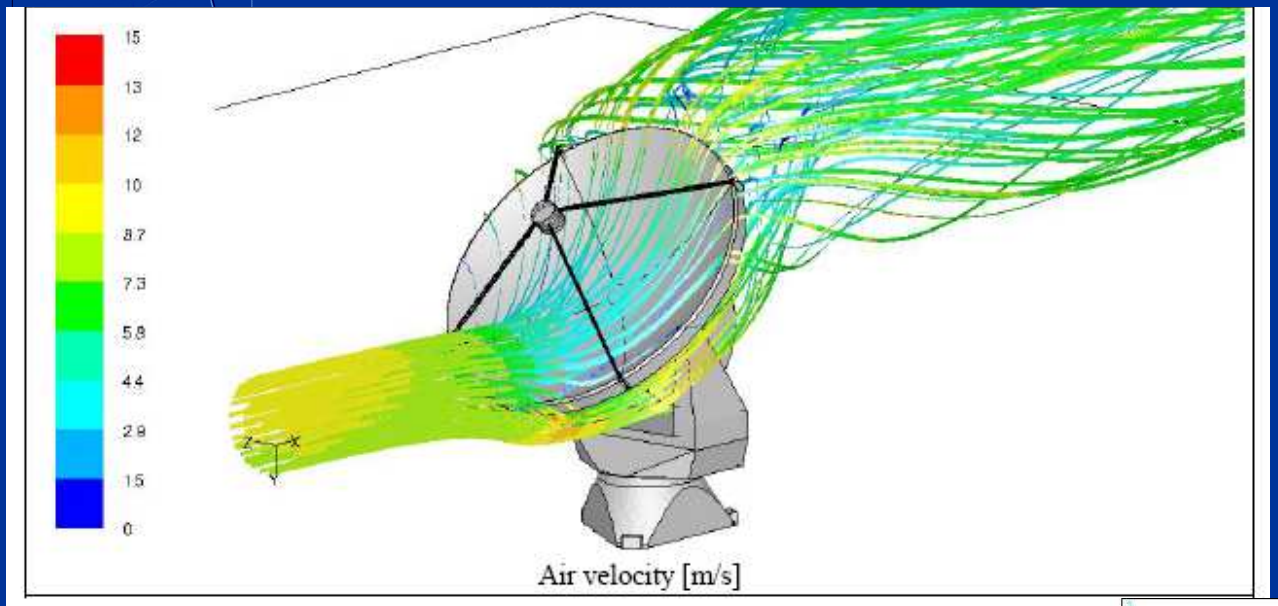
Changes for the Better

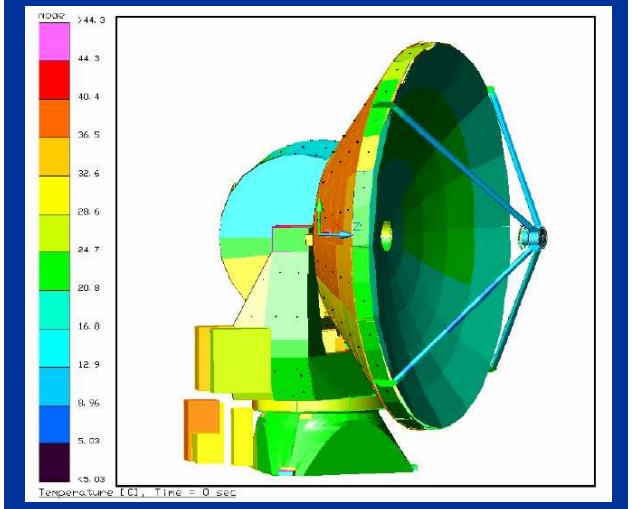
Mitsubishi #1,2,3 - June 2007

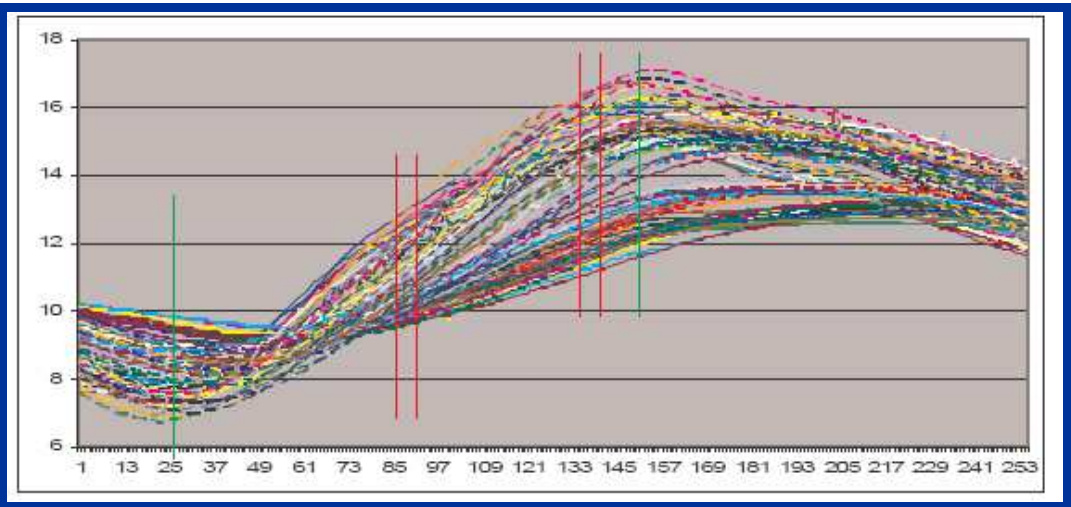
Loading to Barge

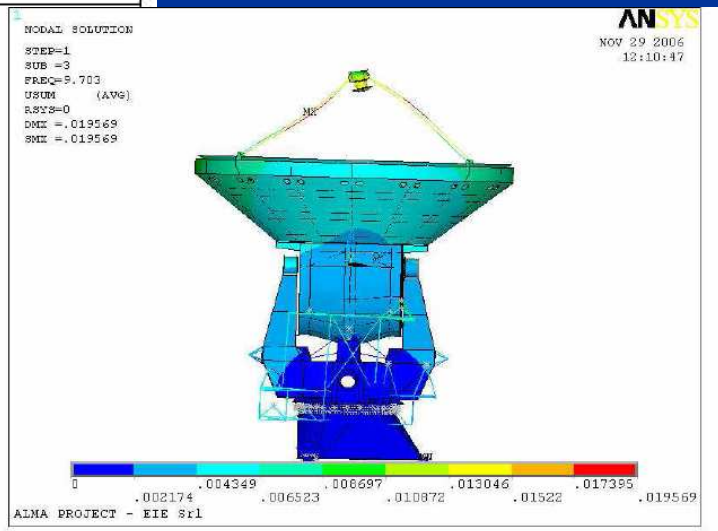
Transfer from Barge to Ship

AEM - PPDR Design Analysis – Jan 2007



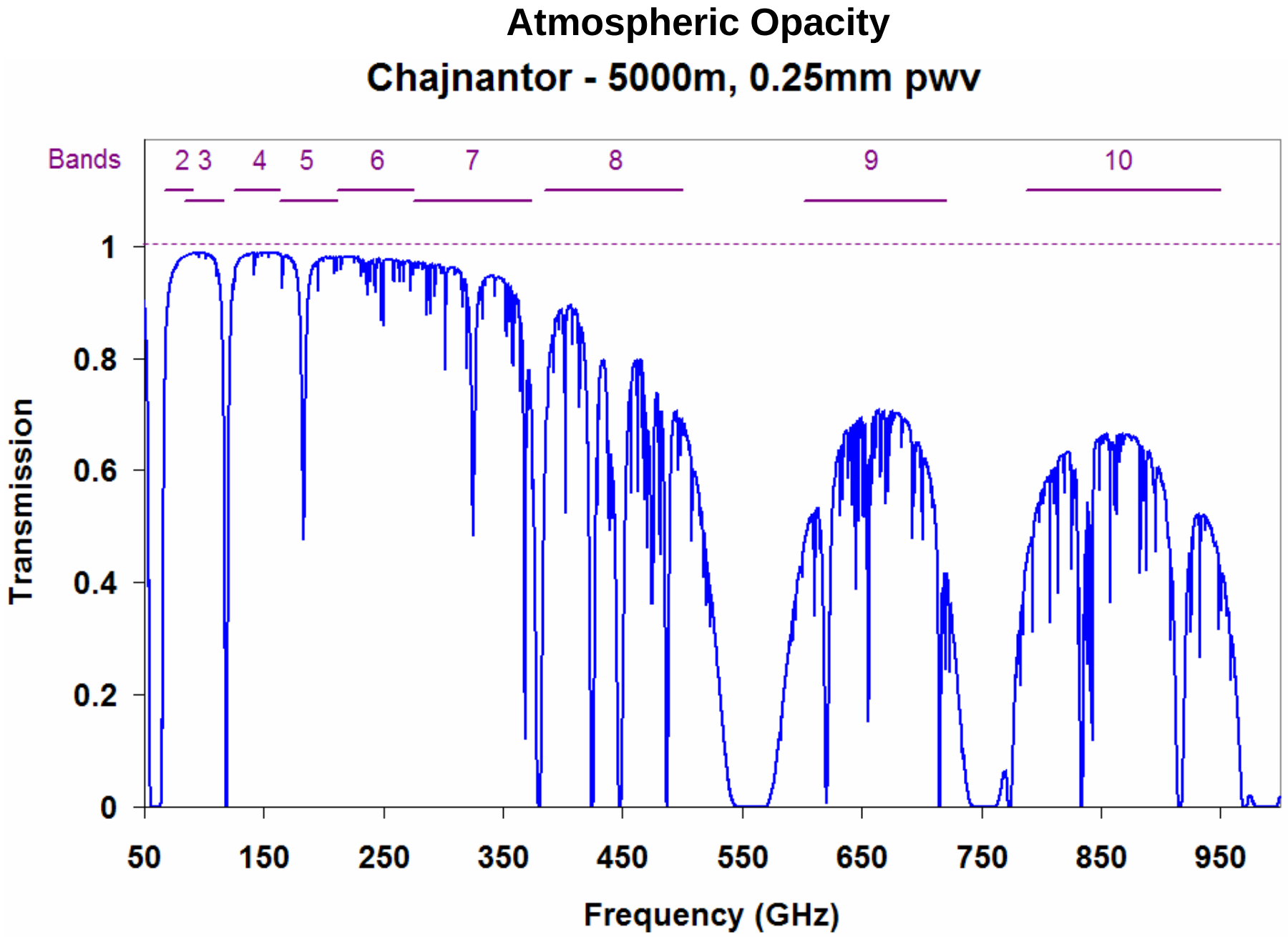







ALMA Transporter


Transporter – May 2007


Atmospheric Opacity
Chajnantor - 5000m, 0.25mm pwv
Bands
2 3
4
5
6
7
8
9
10
1
0.8
0.6
0.4
0.2
0
Transmission
50
150
250
350
450
550
650
750
850
950
Frequency (GHz)

Receivers/Front Ends

ALMA Band	Frequency Range	Receiver noise temperature		Mixing scheme	Receiver technology
		T_{Rx} over 80% of the RF band	T_{Rx} at any RF frequency		
1	31.3 – 45 GHz	17 K	28 K	USB	HEMT
2	67 – 90 GHz	30 K	50 K	LSB	HEMT
3	84 – 116 GHz	37 K	62 K	2SB	SIS
4	125 – 169 GHz	51 K	85 K	2SB	SIS
5	163 - 211 GHz	65 K	108 K	2SB	SIS
6	211 – 275 GHz	83 K	138 K	2SB	SIS
7	275 – 373 GHz	147 K	221 K	2SB	SIS
8	385 – 500 GHz	98 K	147 K	DSB	SIS
9	602 – 720 GHz	175 K	263 K	DSB	SIS
10	787 – 950 GHz	230 K	345 K	DSB	SIS

- **Dual, linear polarization channels:**
  - **Increased sensitivity**
  - **Measurement of 4 Stokes parameters**

- **183 GHz water vapour radiometer:**
  - **Used for atmospheric path length correction**

Front End assembly

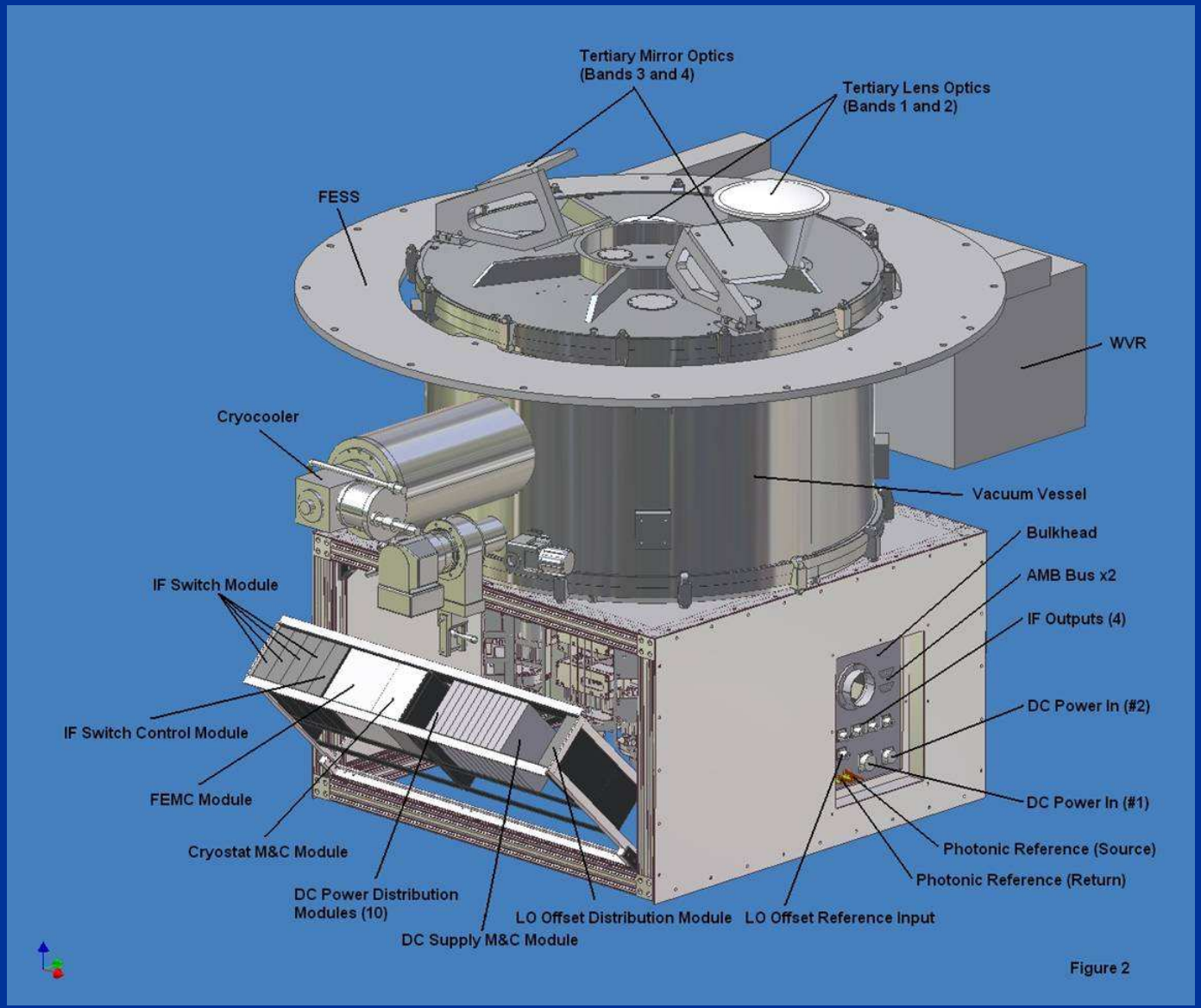
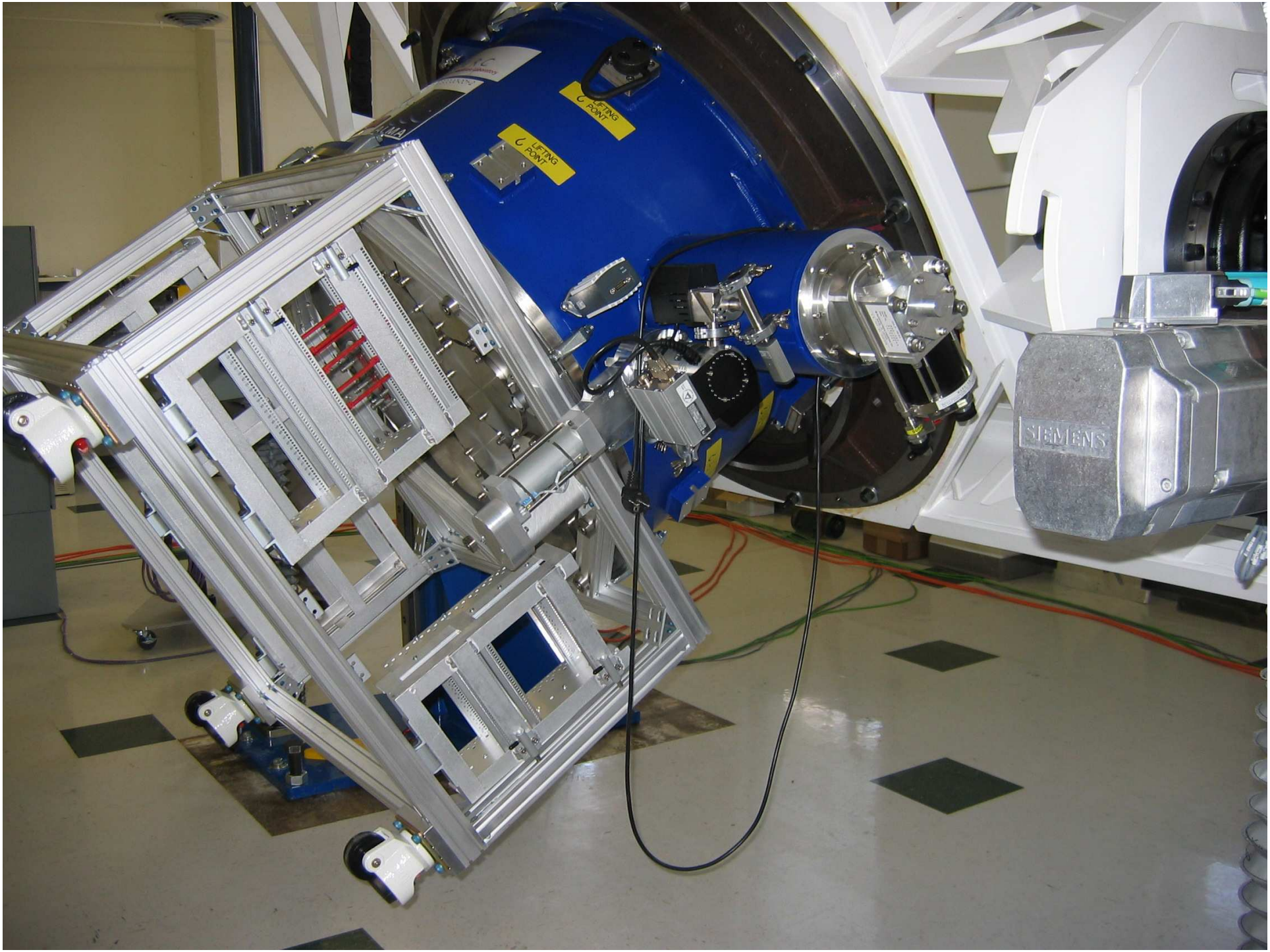
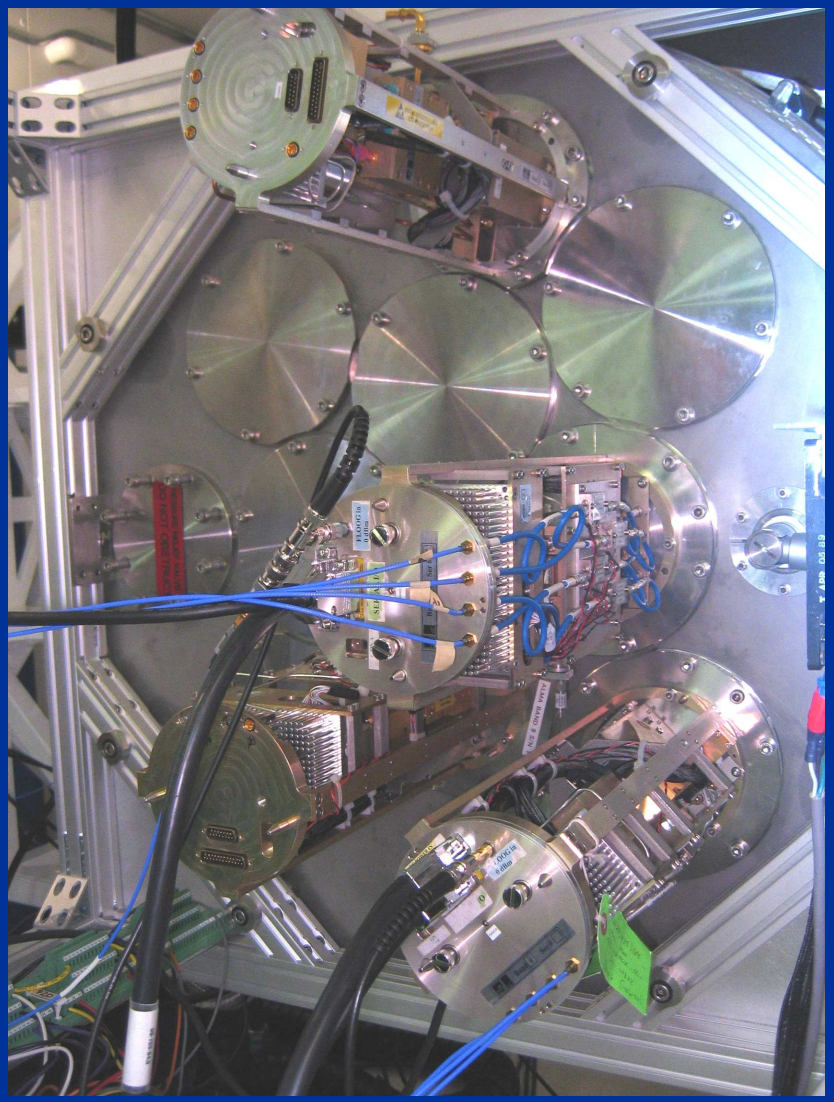


Figure 2


LIFTING POINT
LIFTING POINT
SIEMENS

FE #1 (4 cartridges) – Mar07

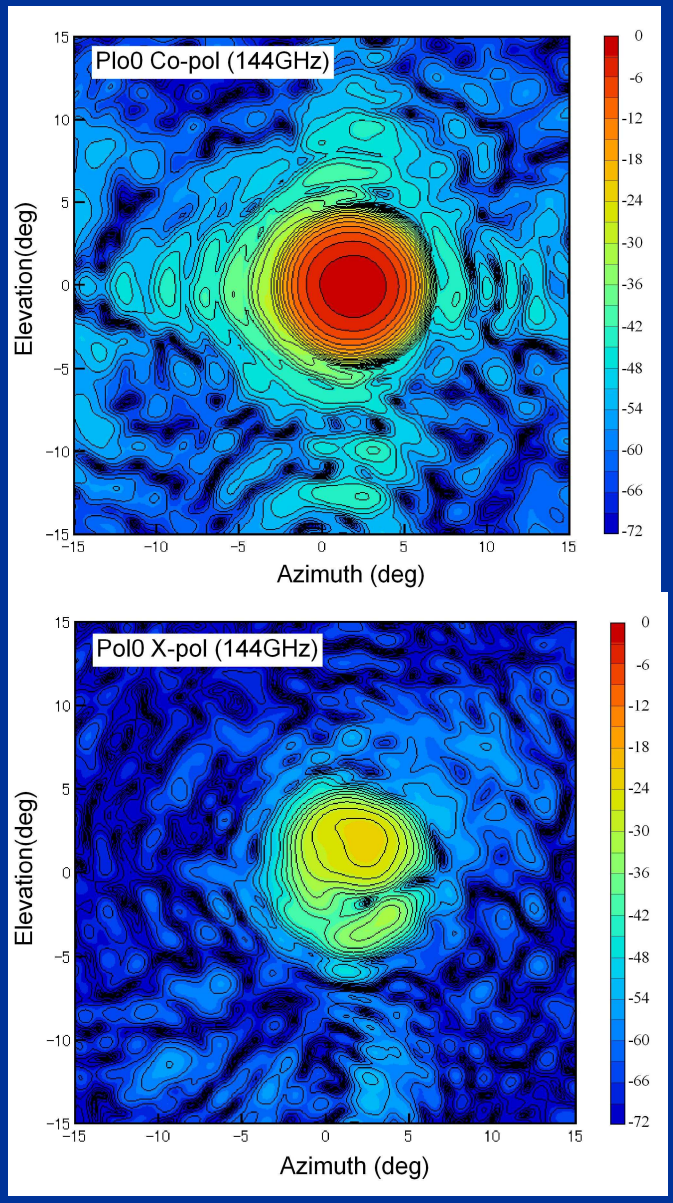
Band 3

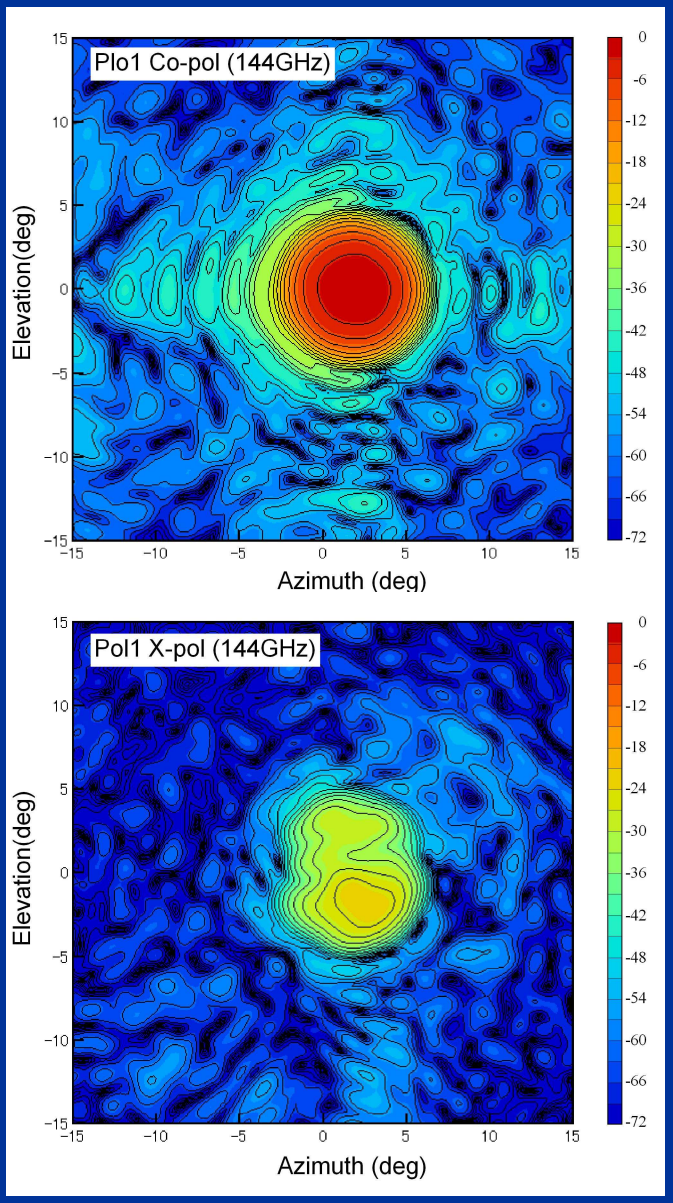


Band 7

Band 9

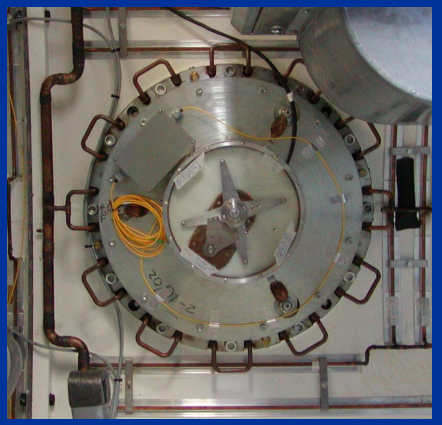
Band 6

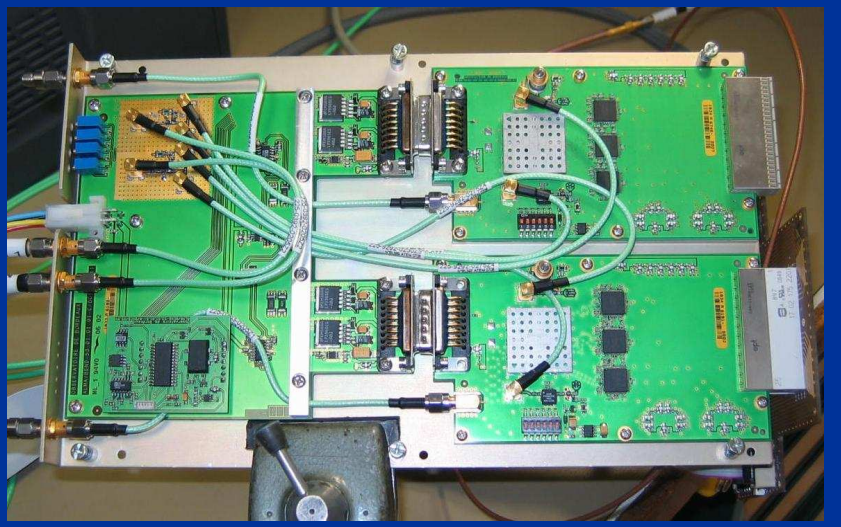

Plo0 Co-pol (144GHz)
Pol0 X-pol (144GHz)
Elevation(deg)
Azimuth (deg)
15
10
5
0
−5
−10
−15
0
-6
-12
-18
-24
-30
-36
-42
-48
-54
-60
-66
-72


Plo1 Co-pol (144GHz)
Pol1 X-pol (144GHz)
Elevation(deg)
Azimuth (deg)
15
10
5
0
−5
−10
−15
0
-6
-12
-18
-24
-30
-36
-42
-48
-54
-60
-66
-72

Band 4 – ALMA-J

Back End – LO, DTS





Correlator Specifications

Number of antennas	64
Number of IF pairs per antenna	4
Max. sampling rate per IF pair	2 x 4 GHz
Digitizing format	3 bit, 8 level
Correlating format	2 bit, 4 level
Max. delay range	30 km
Channels per IF pair	4096
Autocorrelation channels per baseline	1024
Polarization	Full stokes (4 products)

Correlator Quadrant #1 (of 4)

Complete correlator contains 2912 printed circuit boards and 5200 interface cables; there are more than 20 million solder joints.

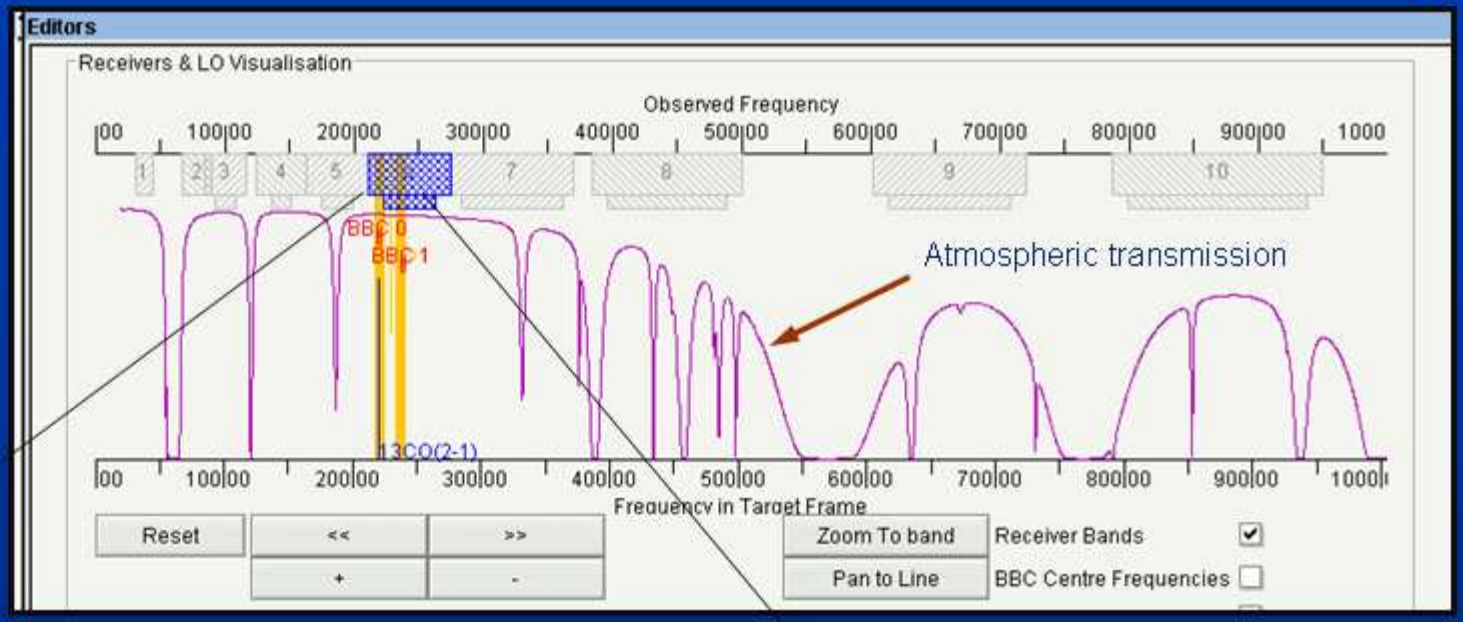
Jan 2007 – second quadrant in production + new test correlator completed

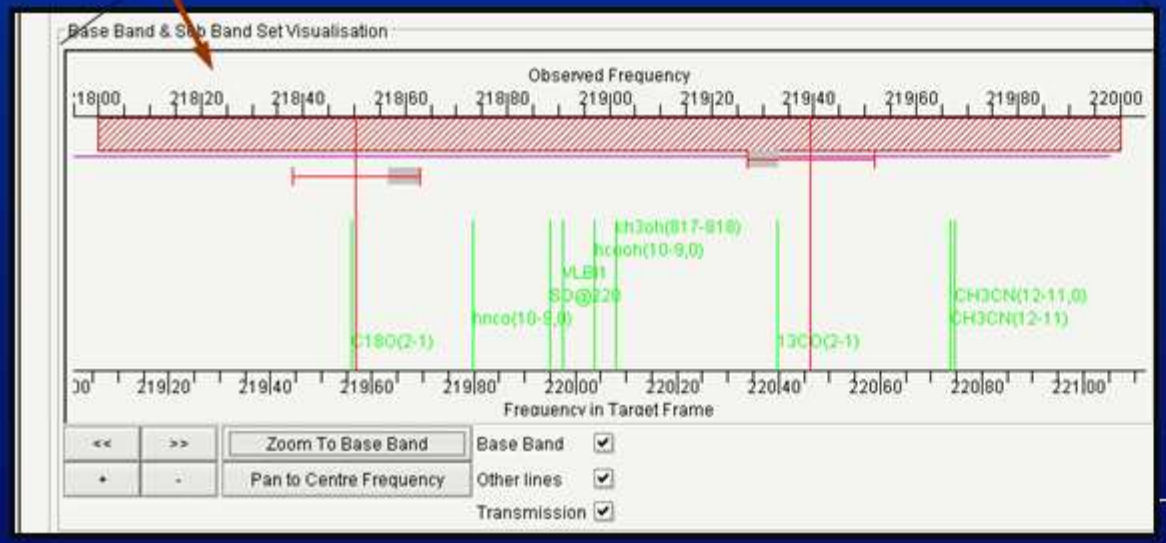
Computing

- The fundamental output of the CIPT will be a ~2M SLOC “end to end” software system running on over 200 computers on 4 continents.
- Difficult distributed development – software engineering practices, travel
- Using CASA as the offline system (also AIVC)

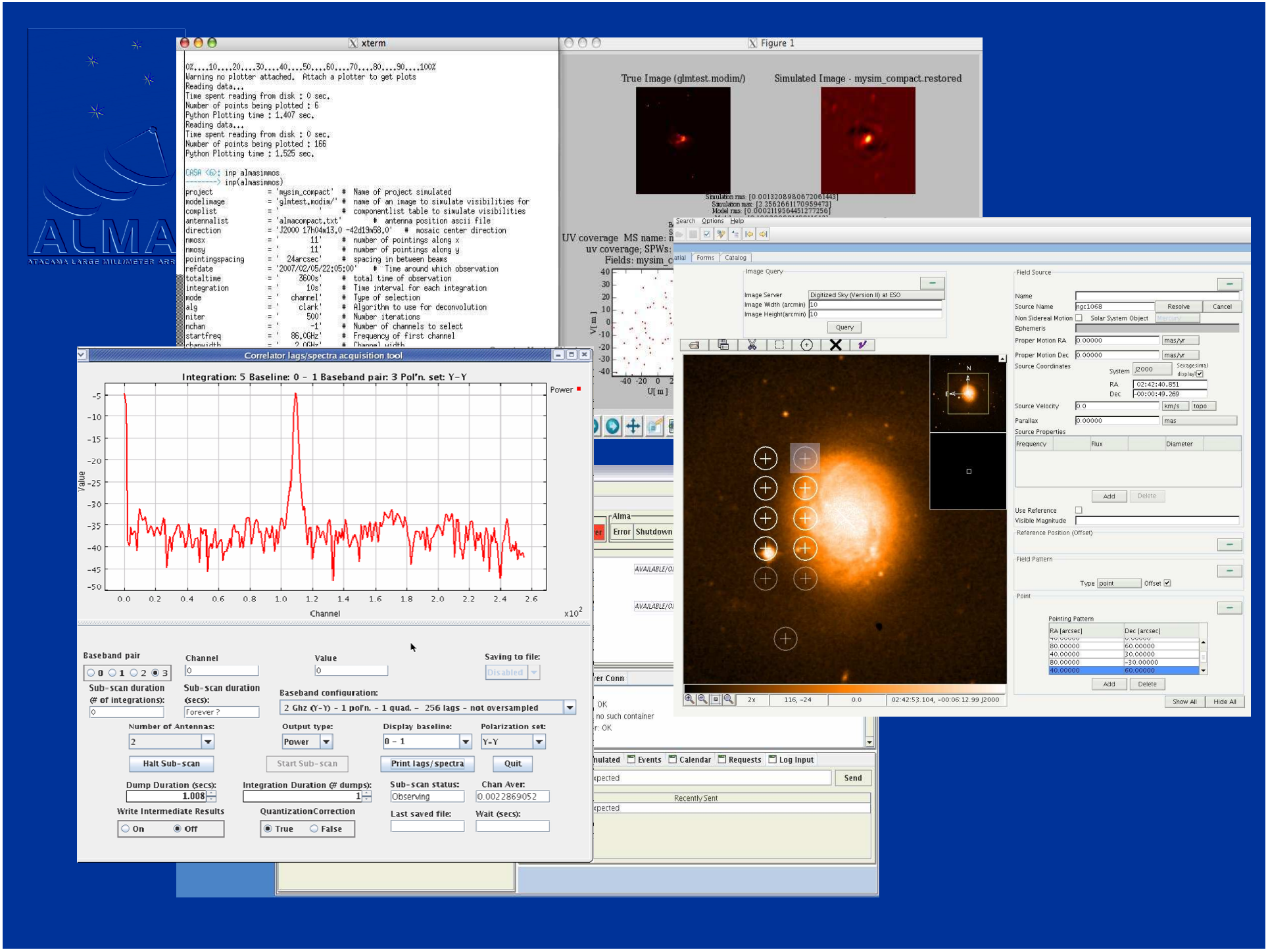
Observing Tool

Band 6 close up showing lines in spectral database and windows on selected lines.

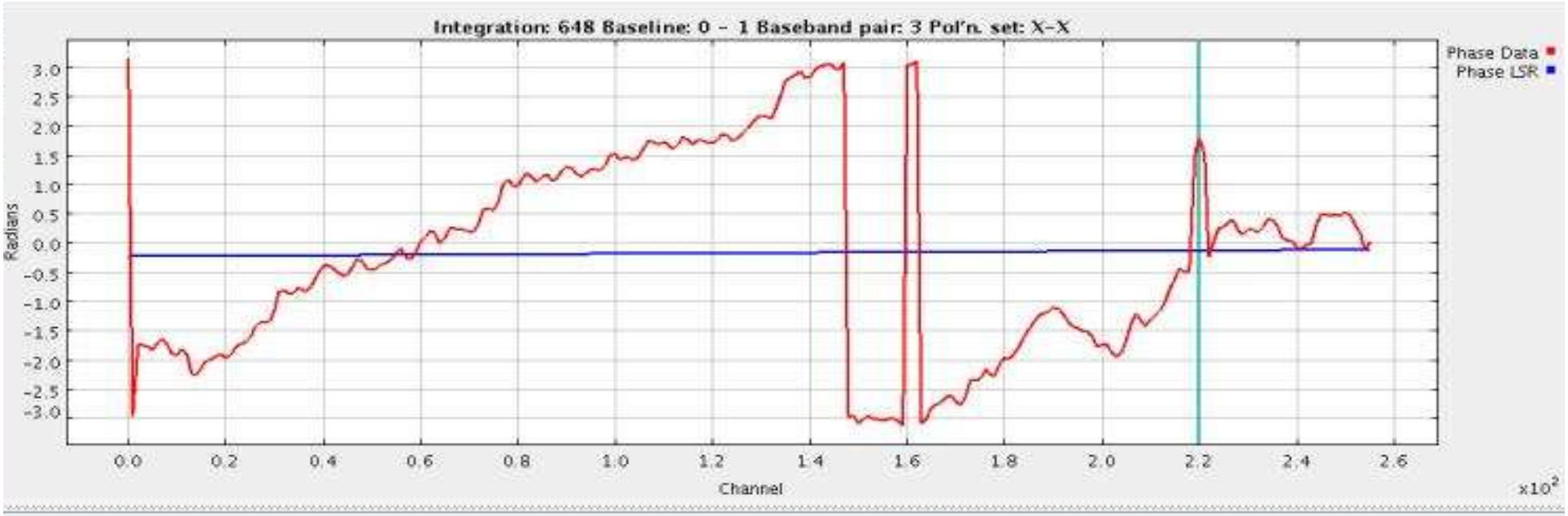




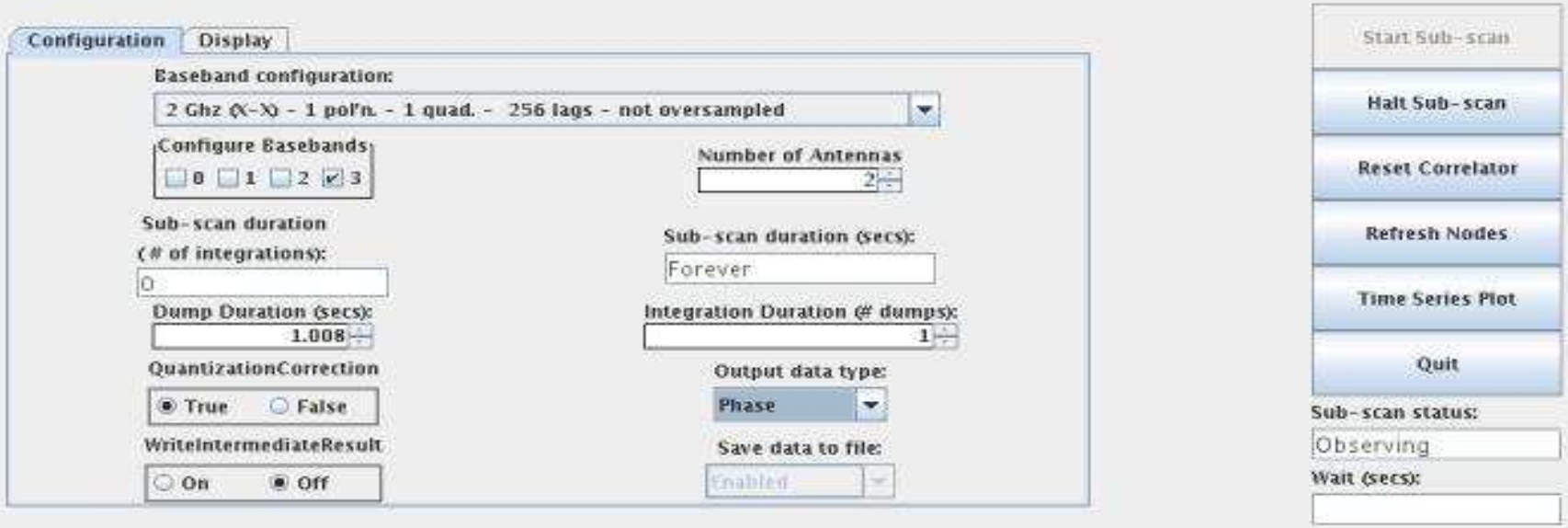
Target source visual representation of correlator setup to observe multiple lines at 1mm Band 6 ($C^{18}O$ 2-1 & ^{13}CO 2-1)


ALMA
ATACAMA LARGE MILLIMETER ARR
xterm
0%....10....20....30....40....50....60....70....80....90....100%
Warning no plotter attached. Attach a plotter to get plots
Reading data...
Time spent reading from disk : 0 sec.
Number of points being plotted : 6
Python Plotting time : 1.407 sec.
Reading data...
Time spent reading from disk : 0 sec.
Number of points being plotted : 166
Python Plotting time : 1.525 sec.
CASA <6>: inp almasimmos
--------> inp(almasimmos)
project = 'mysim_compact' # Name of project simulated
modelimage = 'glmtest.modim/' # name of an image to simulate visibilities for
complist = '' # componentlist table to simulate visibilities
antennalist = 'almacompact.txt' # antenna position ascii file
direction = 'J2000 17h04m13.0 -42d19m58.0' # mosaic center direction
nmosx = 11 # number of pointings along x
nmosy = 11 # number of pointings along y
pointingspacing = '24arcsec' # spacing in between beams
refdate = '2007/02/05/22:05:00' # Time around which observation
totaltime = '3600s' # total time of observation
integration = '10s' # Time interval for each integration
mode = 'channel' # Type of selection
alg = 'clark' # Algorithm to use for deconvolution
niter = 500 # Number iterations
nchan = -1 # Number of channels to select
startfreq = '86.0GHz' # Frequency of first channel
Figure 1
True Image (glmtest.modim/)
Simulated Image - mysim_compact.restored
UV coverage MS name:
uv coverage; SPWs:
Fields: mysim_c
V[m]
U[m]
Correlator lags/spectra acquisition tool
Integration: 5 Baseline: 0 - 1 Baseband pair: 3 Pol'n. set: Y-Y
Power
Value
Channel
Baseband pair
Channel
Value
Saving to file:
Disabled
Sub-scan duration (# of integrations):
Sub-scan duration (secs):
Forever ?
Baseband configuration:
2 Ghz (Y-Y) - 1 pol'n. - 1 quad. - 256 lags - not oversampled
Number of Antennas:
Output type:
Power
Display baseline:
0 - 1
Polarization set:
Y-Y
Halt Sub-scan
Start Sub-scan
Print lags/spectra
Quit
Dump Duration (secs):
1.008
Integration Duration (# dumps):
Sub-scan status:
Observing
Chan Aver:
0.0022869052
Write Intermediate Results
On
Off
QuantizationCorrection
True
False
Last saved file:
Wait (secs):
Image Query
Image Server
Digitized Sky (Version II) at ESO
Image Width (arcmin)
Image Height(arcmin)
Query
Field Source
Name
Source Name
ngc1068
Resolve
Cancel
Non Sidereal Motion
Solar System Object
Ephemeris
Proper Motion RA
Proper Motion Dec
Source Coordinates
System
J2000
RA
02:42:40.851
Dec
-00:00:49.269
Source Velocity
Parallax
Source Properties
Frequency
Flux
Diameter
Add
Delete
Use Reference
Visible Magnitude
Reference Position (Offset)
Field Pattern
Type
point
Offset
Point
Pointing Pattern
RA [arcsec]
Dec [arcsec]
Show All
Hide All
Alma
Error
Shutdown
Events
Calendar
Requests
Log Input
Send
Recently Sent


First Astronomical Fringes
– Mar 2nd 2007
Operator MasterClient
Correlator lags/spectra acquisition tool
Integration: 438 Baseband pair: 3 Pol'n. set: Y-Y
Phase Data
Phase LSR
Channel
Baseband pair
Sub-scan duration (secs):
Number of Antennas:
Flatt Sub-scan
Dump Duration (secs):
Write intermediate results
On
Off
Value
Baseband configuration:
2 Ghz (Y-Y) - 1 pol'n. - 1 quad. - 256 lags - not oversampled
Output type:
Phase
Start Sub-scan
Integration Duration (# dumps):
Quantization Correction
True
False
Display baseline:
0 - 1
Print lags/spectra
Sub-scan status:
Observing
Last saved file:
Saving to file:
Polarization set:
Y-Y
Quit
Chan Aver:
Wait (secs):
DELL

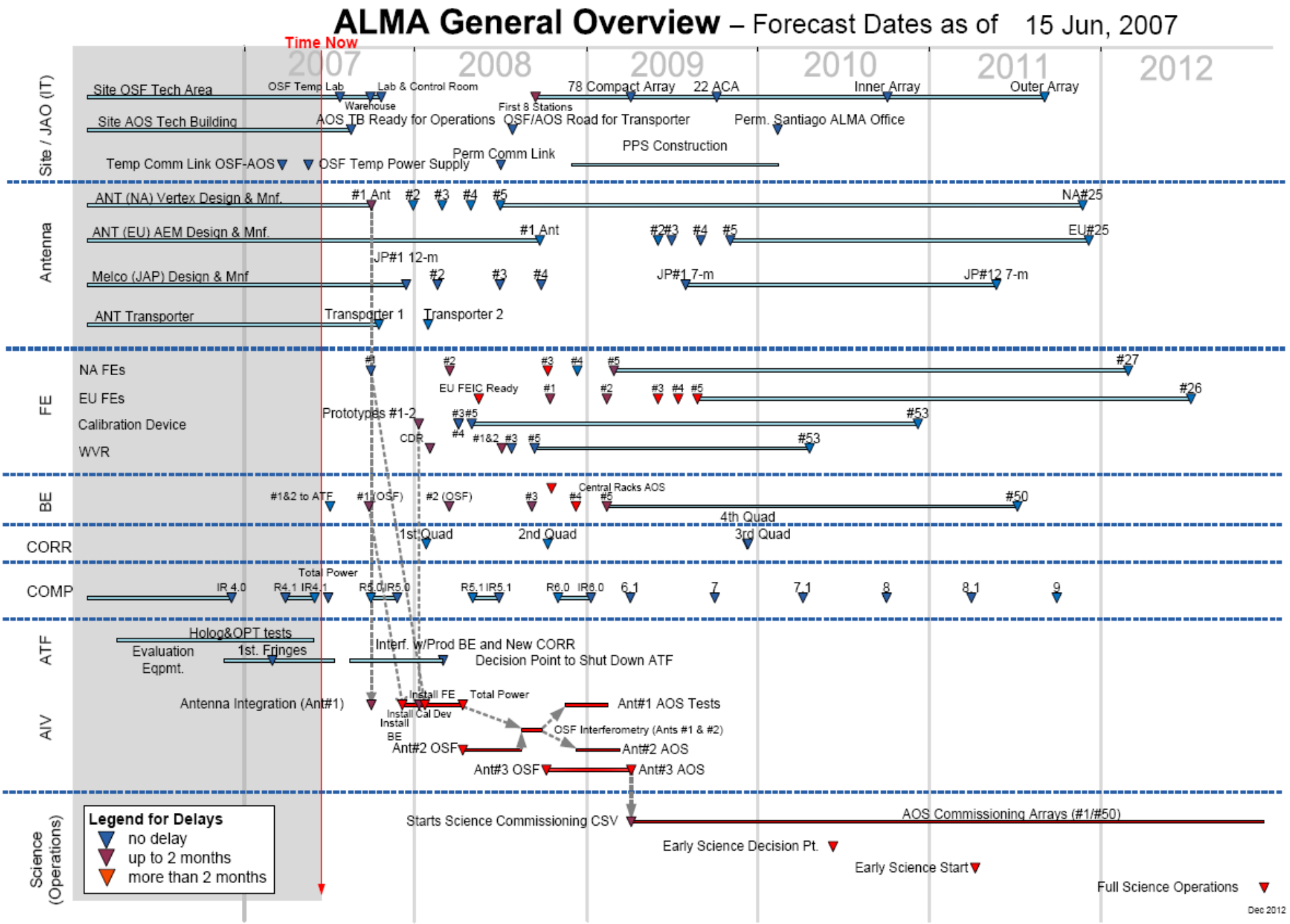


ATF “Second Fringes”, 19:14 hrs UTC June 18th 2007 - Venus.



Budget

- ALMA concept: mid 90s….
- Original project budget (2002): $592M
- 2004: rebaselining (scope, budget, sched)
- Budget: 40% ($224M)↑ N: 64→50
- Complex multi-currency, 10-yr budget
- Issues: power… staffing profile/skills…


ALMA General Overview – Forecast Dates as of 15 Jun, 2007
Time Now
2007
2008
2009
2010
2011
2012
Site / JAO (IT)
Site OSF Tech Area
OSF Temp Lab
Lab & Control Room
Warehouse
78 Compact Array
22 ACA
Inner Array
Outer Array
Site AOS Tech Building
AOS TB Ready for Operations
First 8 Stations
OSF/AOS Road for Transporter
Perm. Santiago ALMA Office
PPS Construction
Temp Comm Link OSF-AOS
OSF Temp Power Supply
Perm Comm Link
Antenna
ANT (NA) Vertex Design & Mnf.
#1 Ant
#2
#3
#4
#5
NA#25
ANT (EU) AEM Design & Mnf.
#1 Ant
#2#3
#4
#5
EU#25
JP#1 12-m
Melco (JAP) Design & Mnf
#2
#3
#4
JP#1 7-m
JP#12 7-m
ANT Transporter
Transporter 1
Transporter 2
FE
NA FEs
EU FEs
Calibration Device
WVR
#1
#2
#3
#4
#5
#27
EU FEIC Ready
#1
#2
#3
#4
#5
#26
Prototypes #1-2
#3#5
#53
CDR
#4
#1&2
#3
#5
#53
BE
#1&2 to ATF
#1 (OSF)
#2 (OSF)
#3
#4
#5
Central Racks AOS
#50
4th Quad
1st Quad
2nd Quad
3rd Quad
CORR
COMP
Total Power
IR 4.0
R4.1
IR4.1
R5.0
IR5.0
R5.1
IR5.1
R6.0
IR6.0
6.1
7
7.1
8
8.1
9
ATF
Holog&OPT tests
Evaluation Eqpmt.
1st. Fringes
Interf. w/Prod BE and New CORR
Decision Point to Shut Down ATF
AIV
Antenna Integration (Ant#1)
Install FE
Total Power
Install Cal Dev
Install BE
Ant#1 AOS Tests
OSF Interferometry (Ants #1 & #2)
Ant#2 OSF
Ant#2 AOS
Ant#3 OSF
Ant#3 AOS
Science (Operations)
Legend for Delays
no delay
up to 2 months
more than 2 months
Starts Science Commissioning CSV
AOS Commissioning Arrays (#1/#50)
Early Science Decision Pt.
Early Science Start
Full Science Operations
Dec 2012

Schedule

- First fringes: ***ATF Q2 2007*** ✓
- AOS, OSF: ***Complete early 2008.***
- Antennas: ***#1 2007, #2 2007… #66 2011.***
- Front Ends: ***#1, #2 2007, → production.***
- BE/DTS: ***→ production.***
- Correlator: ***Q1 done… Q4 2008; ACA2008.***
- Software: ***R4… AIVC 2007, Ops 2008.***
- Call for Early Science: ***Q1 2010***
- Early Science: ***2011***
- Full Operations: ***04 Sep 2012***

Moving forward….

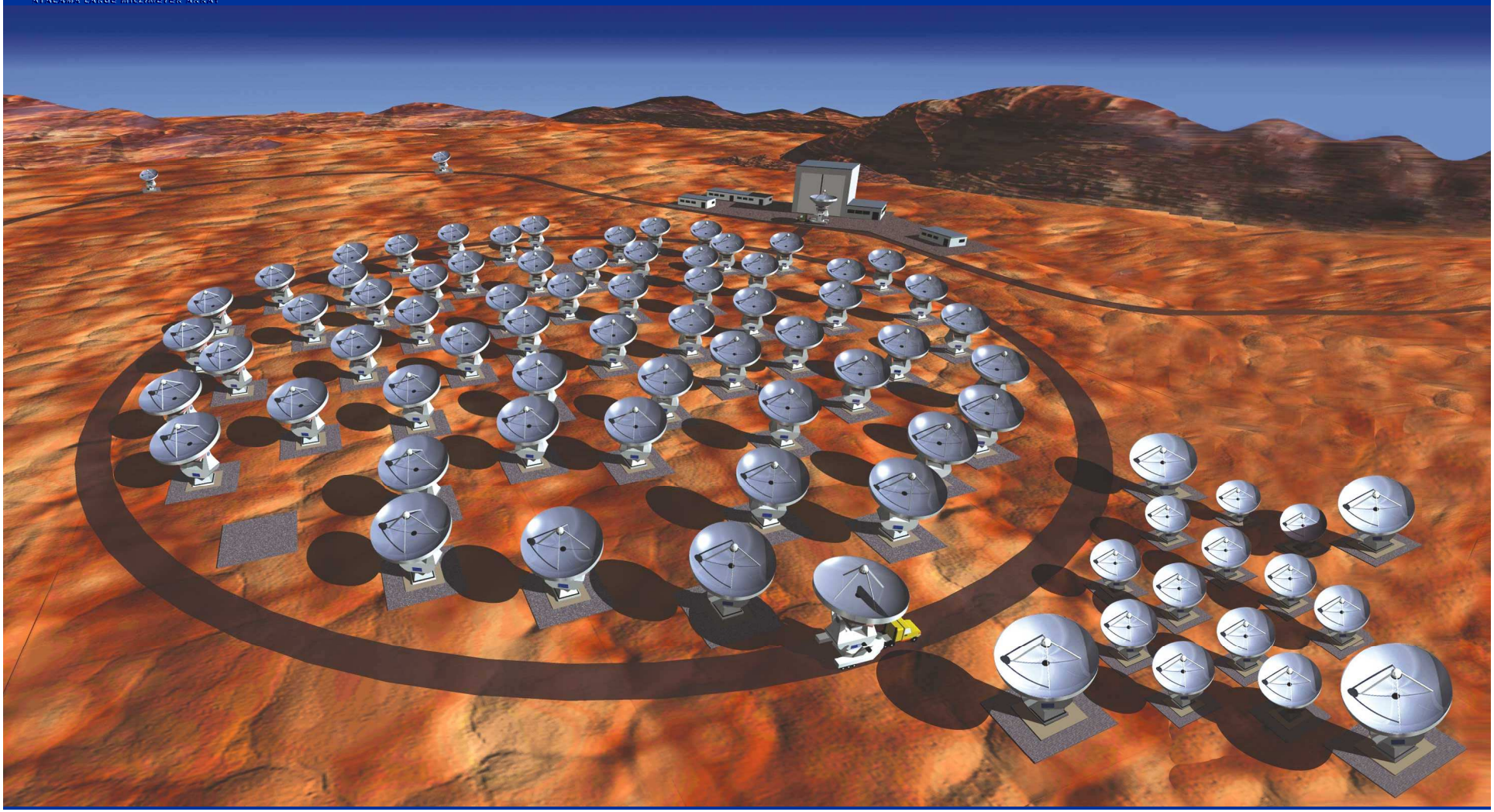
Japan – ALMA-J

- New partner: Agreement signed between the NSF-ESO-NINS Sept 2004/July 2006.
  - Four additional 12-m antennas (total power)
  - Twelve 7-m diameter antennas in compact configuration: Atacama Compact Array
  - Separate ACA correlator
  - Receiver: Bands 4, 8… 10

Atacama Compact Array – ACA

- Significantly improves low surface brightness sensitivity of ALMA; add precision total power data

ALMA + ACA →
Atacama Large Millimeter/submillimeter Array




Your proposal here
2010

www.alma.info

The Atacama Large Millimeter/submillimeter Array (ALMA), an international astronomy facility, is a partnership among Europe, Japan and North America, in cooperation with the Republic of Chile. ALMA is funded in Europe by the European Organization for Astronomical Research in the Southern Hemisphere, in Japan by the National Institutes of Natural Sciences (NINS) in cooperation with the Academia Sinica in Taiwan and in North America by the U.S. National Science Foundation (NSF) in cooperation with the National Research Council of Canada (NRC). ALMA construction and operations are led on behalf of Europe by ESO, on behalf of Japan by the National Astronomical Observatory of Japan (NAOJ) and on behalf of North America by the National Radio Astronomy Observatory (NRAO), which is managed by Associated Universities, Inc. (AUI).