SMA Advisory Meeting Agenda

September 4th

08:30	Executive Session	
09:00	Welcome and Charge to the Committee	Alcock
09:10	Summary of previous meeting and current status l SMA Strengths, Vision for future	Blundell
10:10	Collaboration with ASIAA	Ho
10:25	Break	
10:45	Overview of science enabled by improvements/upgrades since last meeting)	Wilner
11:15	Hilo Operations	Nystrom
11:35	Proposal Process, Time Allocation, Publication results (Including a brief discussion of operating efficiency and Scheduling)	Gurwell
12:00	Tour of SMA Control Room	
12:15	Lunch	
13:30	Science I	
	Solar System	Gurwell
	Protoplanetary Disks	Wilner
	Low Mass Star Formation	Bourke
	Outflows	Hirano
	Magnetic fields	Rao
	Galactic Center	Moran
15:15	Break	
15:45	Science II	
	High Mass Star Formation	Keto
16:15	Planned Short Term Upgrades	Wilson
17:00	Executive Session	
18:30	Dinner	

September 5th

08:30	Executive Session	
09:00	Science III	
	Evolved Stars	Young
	Nearby Galaxies	Petitpas
	Hi-z	Fazio
09:45	Long Term Plans	Blundell
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14:00	Committee's verbal report	
14:30	End of meeting	

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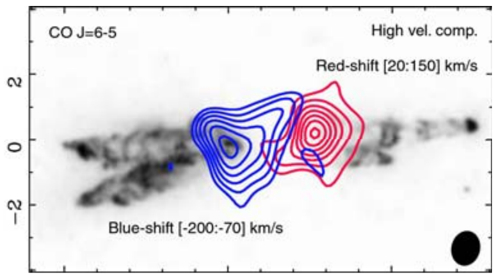
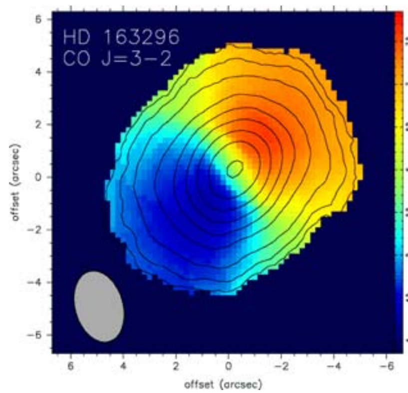
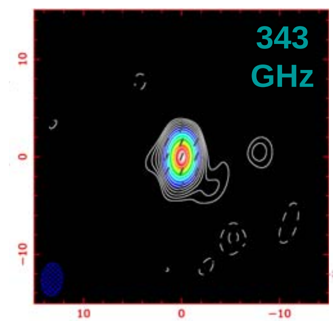
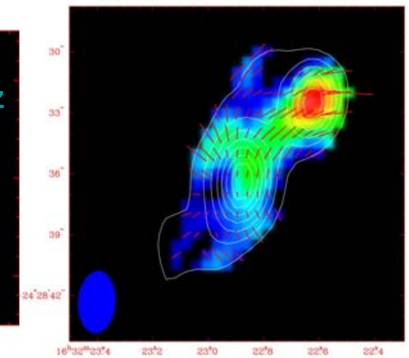
The SMA is a working Instrument

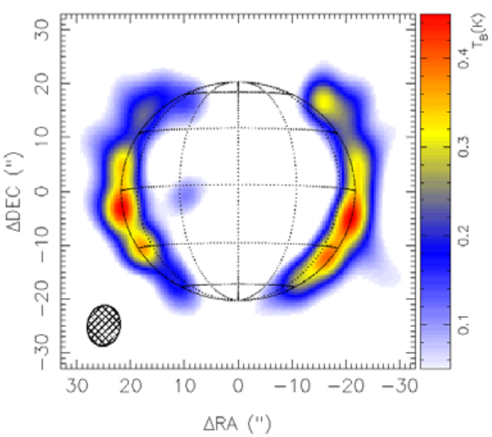
- publication rate now 1 refereed paper per week
- a wide range of very exciting results

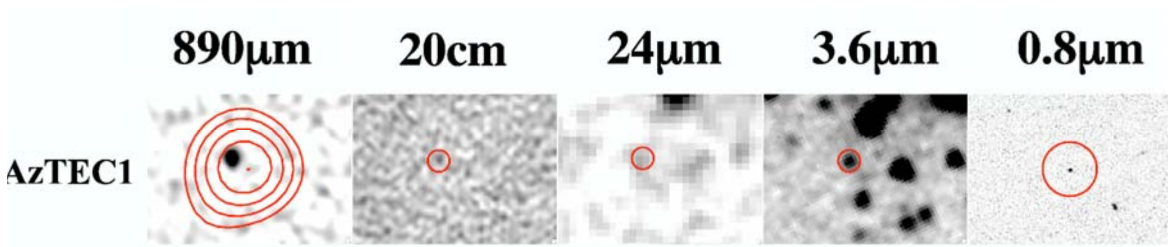












Summary of previous meeting and current status of the SMA

R. Blundell

Introduction

- Brief introduction to the SMA
- Summary of Advisory Meeting, April 2005, and current status of recommendations
  - Management and organization
  - Near term recommendations
  - Mid- and long- term recommendations
- Current status of the SMA
- Brief introduction to long-term prospects

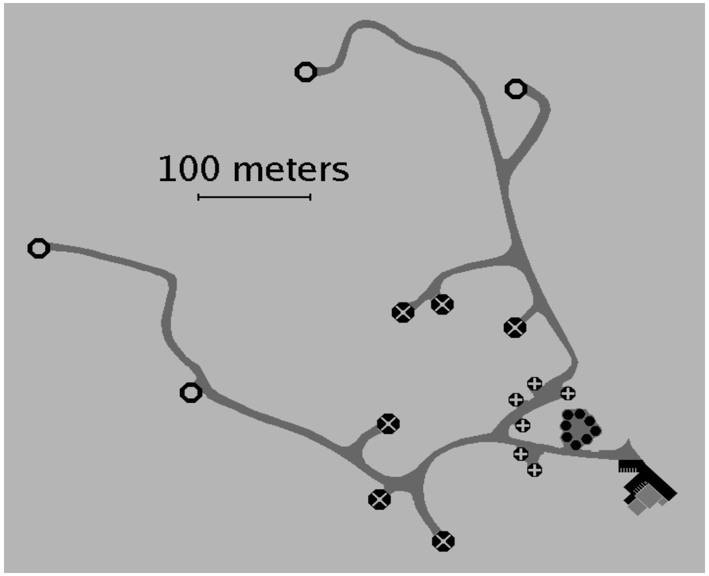
Brief introduction to the SMA

Eight 6 m diameter antennas (Collecting area ~ 225 m^2)
Situated on Mauna Kea, not too far from JCMT and CSO

Performs high resolution science observations most of the major atmospheric windows from about 200 to 700 GHz

Brief introduction – configurations

Array layout



Four configurations used to achieve 5.5 – 0.3" resolution
Reconfiguration takes 2-3 days: pointing, baselines, etc

Brief introduction – instrumentation

Designation	Frequency range	Polarization
200	180 – 250 GHz	↗
300	266 – 355 GHz	↗
400	320 – 420 GHz	↖
650	600 – 700 GHz	↖

Heterodyne receivers to preserve phase – SIS for low-noise
IF centered at 5 GHz, 2 GHz wide
All receivers housed in a single cryostat, cooled to 4 K
Polarization diplexing enables dual receiver operation:
low frequency units can be paired with high frequencies
Dual polarization possible from about 330 to 350 GHz

Management and organization

- Work hard to enhance collaboration with ASIAA
- Optimize information flow and consult with team members in decision making at the working level
- Impression that level of staffing in Hilo needs to be enhanced in the near future

Collaboration with ASIAA

- Collaboration between SAO and ASIAA could not be better at all levels.
  - Charles has encouraged improved collaboration
  - Operations staff in Hilo working well together
  - AMiBA personnel now housed in SMA building alongside ASIAA and SAO SMA staff
  - Receiver personnel in Cambridge, Hilo and Taipei working towards a common goal: to obtain the best sets of receivers in all antennas. Have interchanged mixer chips, mixers, LO's, and even complete receiver assemblies (cryostats and optics) between SAO and ASIAA antennas.
  - SAO and ASIAA staff together improve antennas 7 & 8

Information flow, decision making

- Array status meeting most Tuesdays
  - Cambridge and Hilo (SAO + ASIAA personnel)
- Science meetings roughly every two weeks
- Newsletter every 6 months
  - Contains A-ranked proposal titles, abstracts of published papers, and science and technical news
- Proposal abstracts available to observers
- SMA TAC increased in size 4 to 9 members
- Astronomer survey to identify near, mid- and long-term instrument goals (June 2006)

Astronomer survey to identify near- and longer- term instrument goals

1. Astronomy I have done with the SMA that I find compelling.
2. The most interesting science done with the SMA by others.
3. What improvements could be made to the SMA to best enable my science in the short term, ~ 1 yr.
4. What improvements could be made to the SMA to enable science in the longer term, > 2 – 3 yrs.

Staffing - Hilo

- Rob Christensen took charge of summit activity in November 2005 – summit operations working very well
- Ant Schinkel resigned from SMA, December 2006
- George Nystrom Interim Director of Hilo Operations since January 2007 (Hilo staff greatly appreciate having George as Interim – working very well)
- Post-docs are now all based in Cambridge
- Have four telescope operators, about to hire a fifth
- Alison Peck resigned from SMA, April 2007
- Glen Petitpas now schedules observations
  - works very well with SAO TAC chair (Mark Gurwell)

Legacy Science

- Previous advisory committee endorsed concept
  - We implemented a process to accept proposals for large amount of time (potential legacy projects)
  - Projects requesting > 10 nights require more details
  - To date:
    - Low-mass star formation studies (Jorgensen)
    - Galactic Center, Polarimetry towards Sgr A* (Moran)
    - Survey of nearby ULIRGs (Wilson)
    - High-z galaxies (Fazio)
    - Irc+10216 line survey (Patel)
  - What will the SMA be remembered for?
    - Follow science presentations today and tomorrow

Near term recommendations

- Optimize on-telescope 350 GHz performance, increase uniformity of T_{rx}
- Add dual polarization capability at 350 GHz
- Bring all antennas up to the standard of the best
- Follow up with 650 GHz improvements

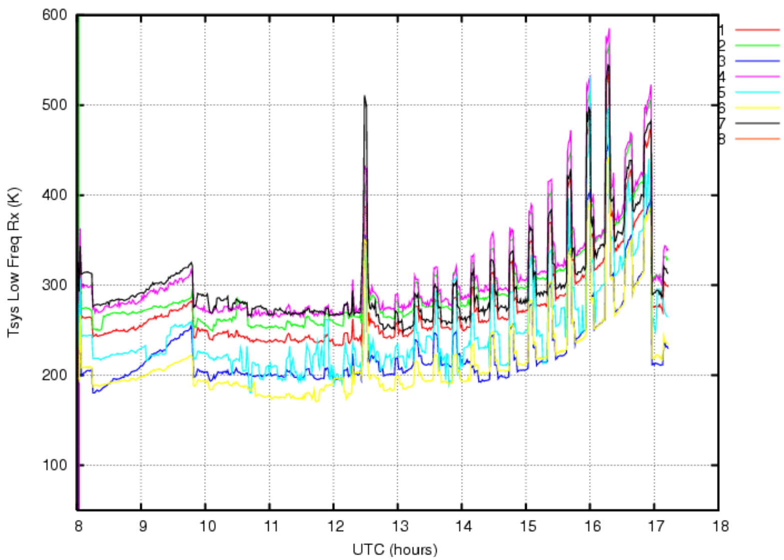
- Endorse working towards e-SMA
- Short spacing impediment – CSO or JCMT?

Optimize 350 GHz performance

- Combination of improvements to improve reliability and reduce T_{rx}
  - Replace multipliers with fixed-tuned units
  - Swap out ageing NRAO-type IF amplifiers
  - Change infra-red filtering at 80 K
  - Select better SIS mixer chips

350 GHz on-telescope performance

05 November 2005



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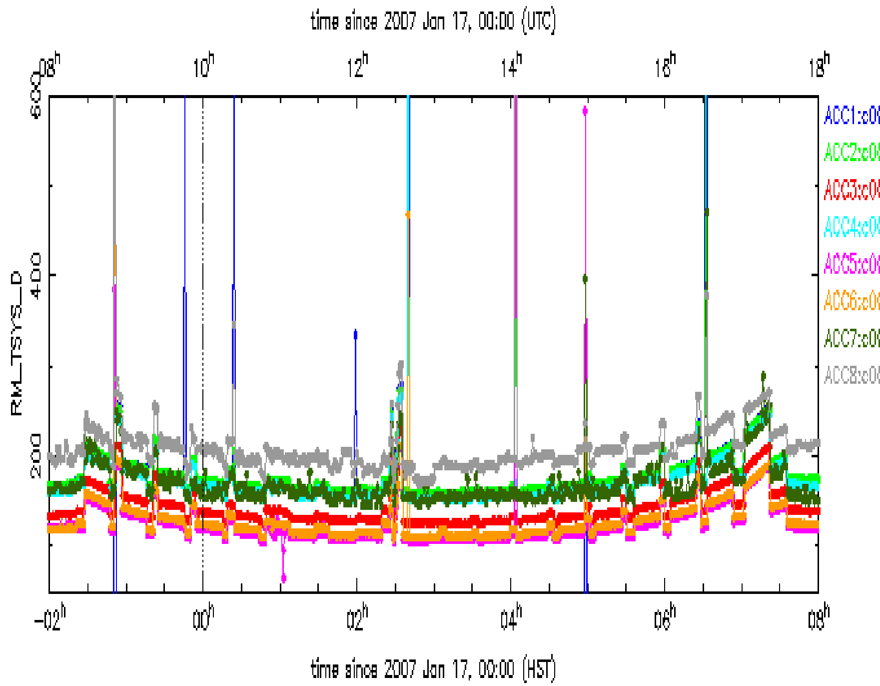
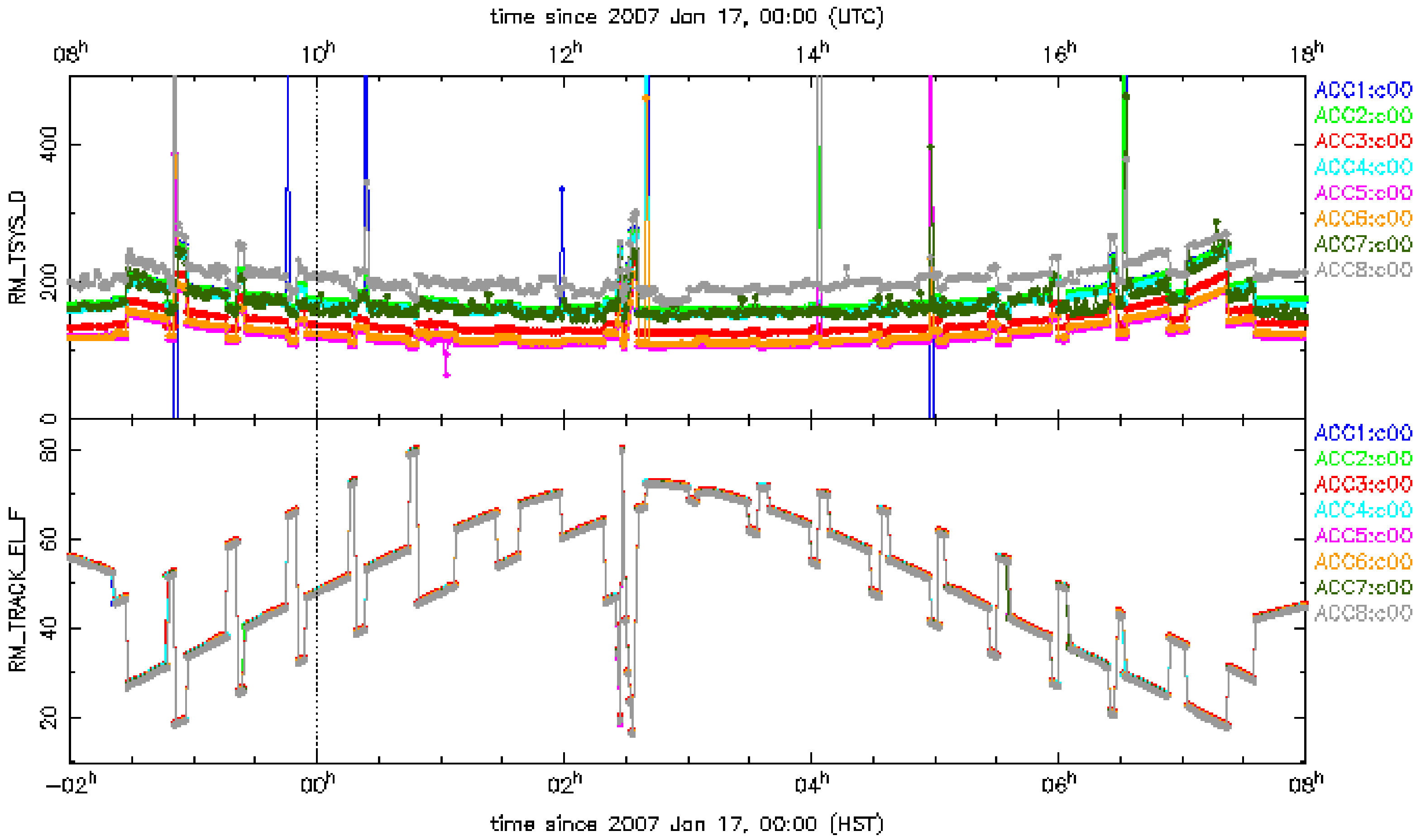


350 GHz on-telescope performance

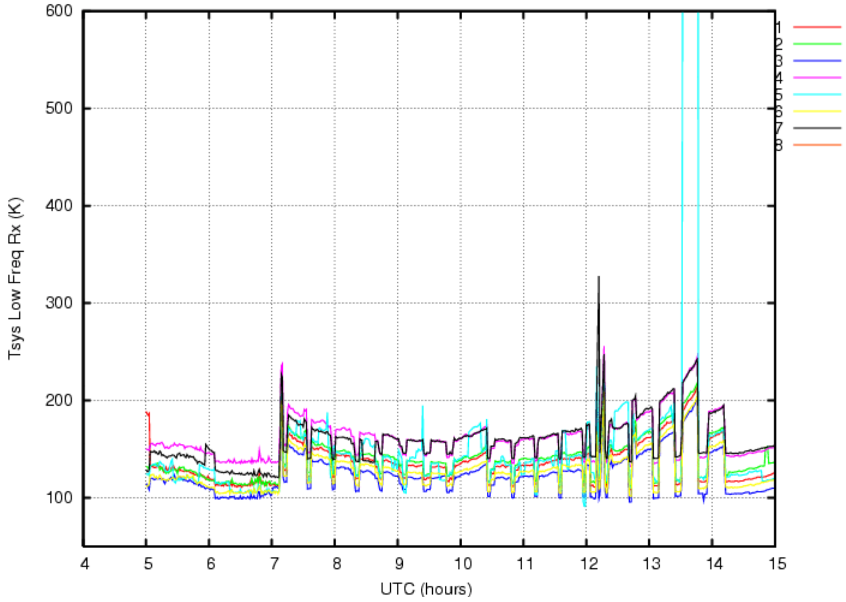


350 GHz summary

- Improvements have also been made to:
  - Reliability and ease of receiver tuning
  - Antenna surface accuracy
  - Number of antennas in operation
- Much improved, but can do better
  - especially for continuum observations as doubling IF BW appears straightforward

200 GHz on-telescope performance

07 November 2005



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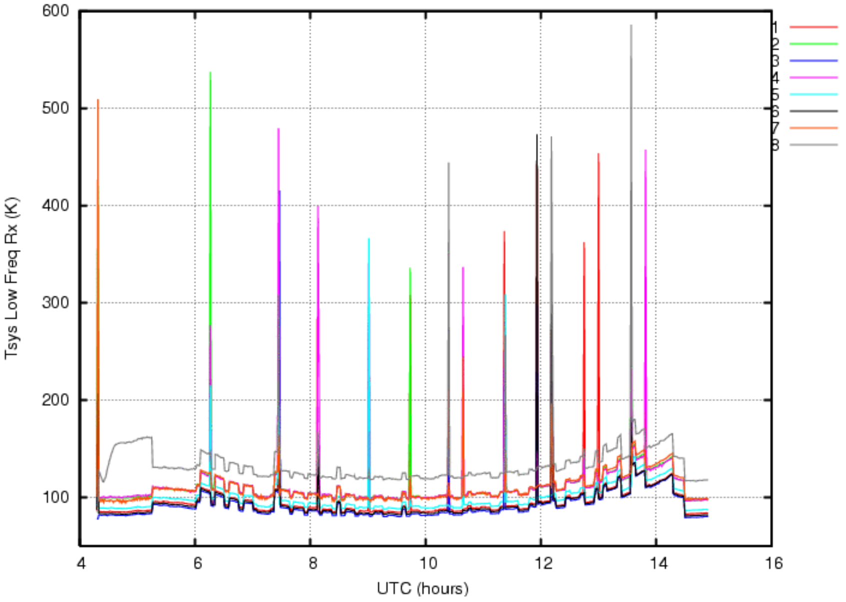
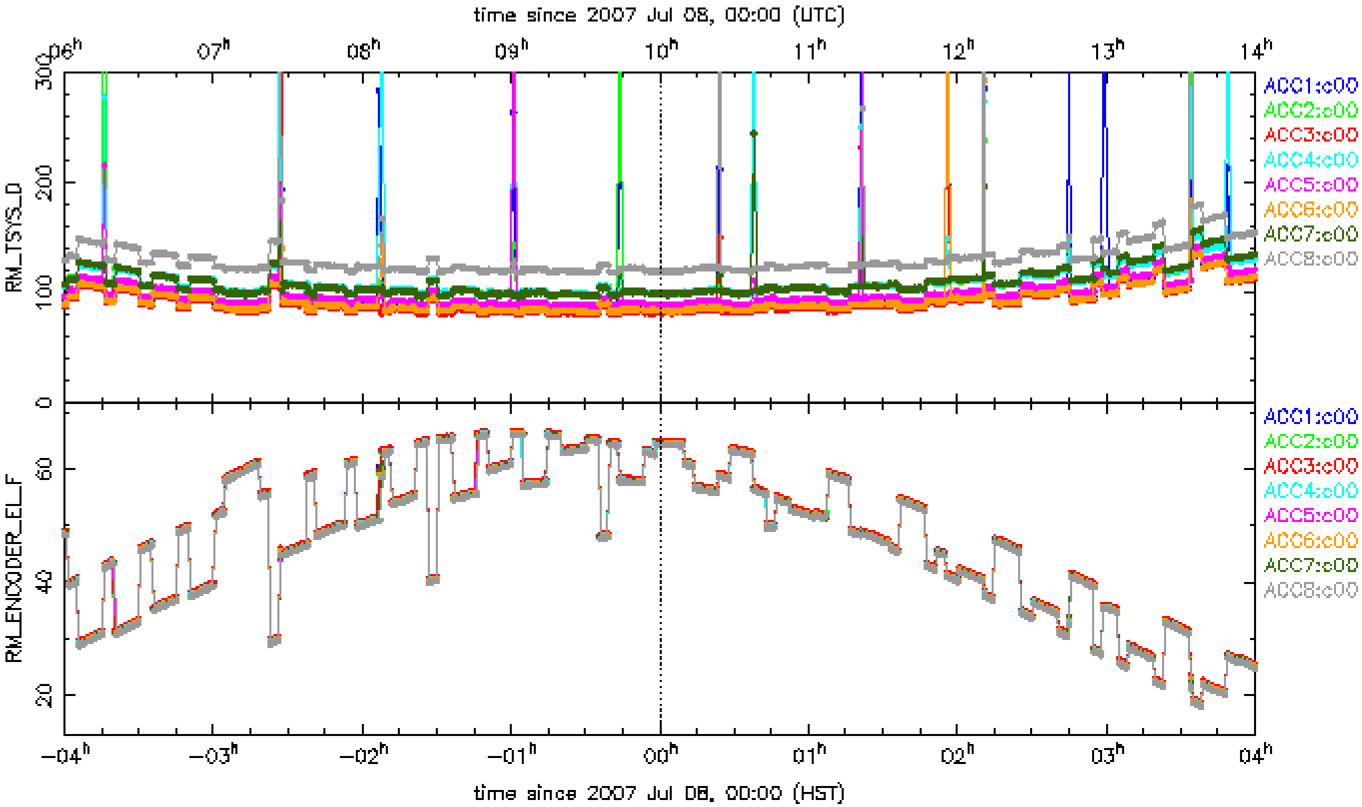


Minor improvements: IF amplifiers, infrared filtering, made alongside 350 GHz receiver upgrades

200 GHz on-telescope performance



Besides reduction in average T_{sys}, improvements have been made in uniformity and reliability (+ number of working systems)

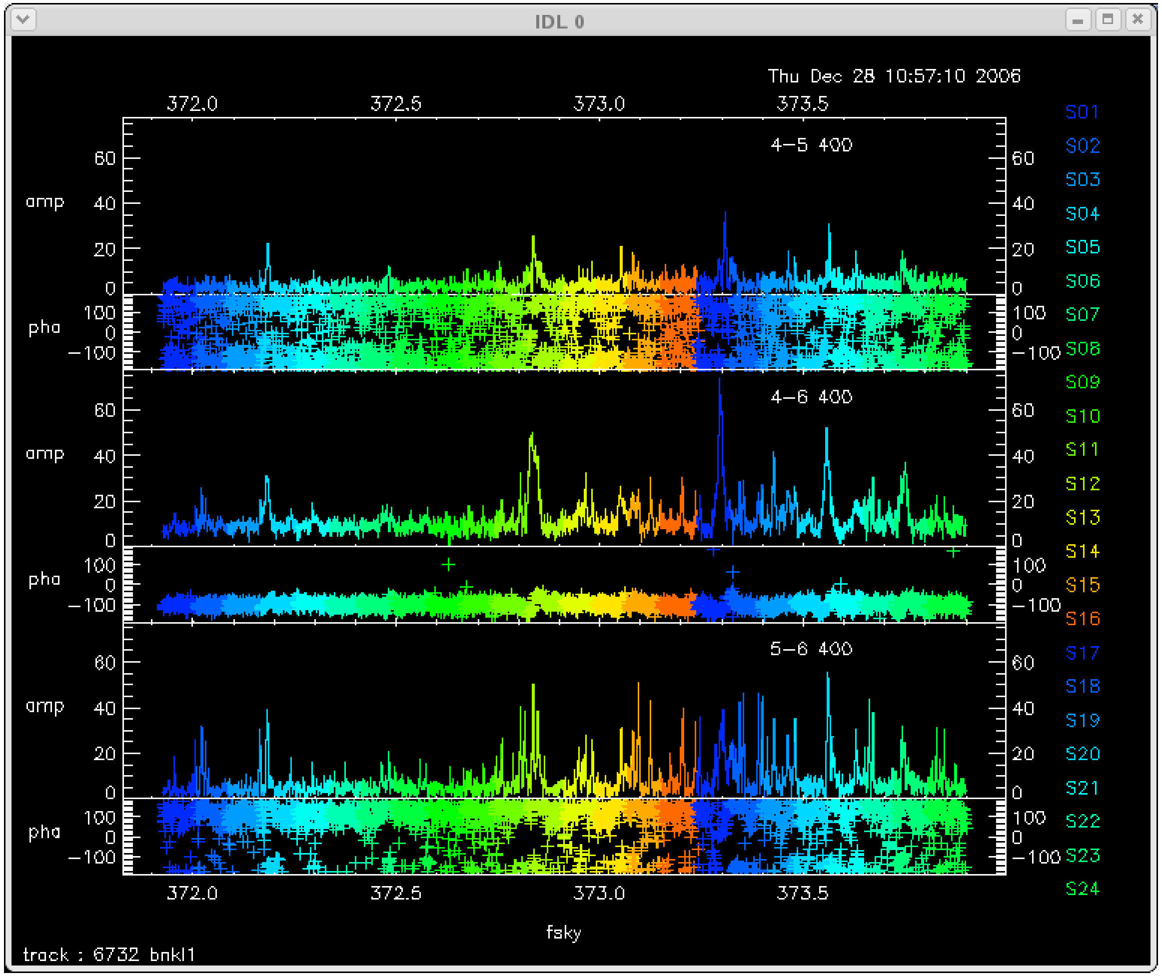
Add dual polarization capability

- Add additional receiver sets for 330 - 420 GHz
  - Will of course extend frequency coverage of the SMA
  - Will increase angular resolution over 350 GHz by 20%
  - Should improve phase transfer tests
- Simultaneous use with 300 GHz receivers
  - Full polarization capability across 320 – 340 GHz
  - Increased sensitivity over 325 – 355 GHz frequency range
  - Simultaneous observations of:

    $C^{18}O(3\text{-}2)$, $^{13}CO(3\text{-}2)$, $C^{17}O(3\text{-}2)$, $^{12}CO(3\text{-}2)$
- Simultaneous use with 200 GHz receivers
  - Observe different transitions of same molecular species

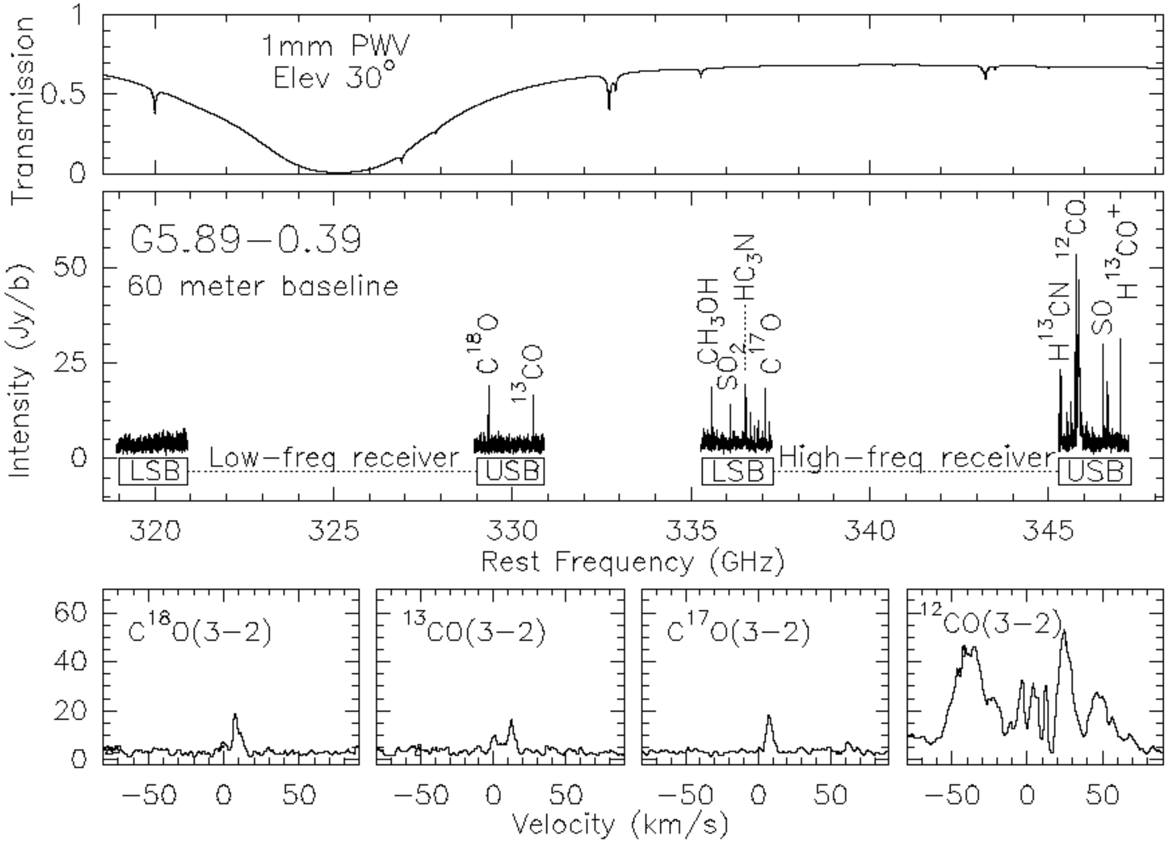
Extend frequency coverage

- Frequency coverage now includes 355 - 420 GHz

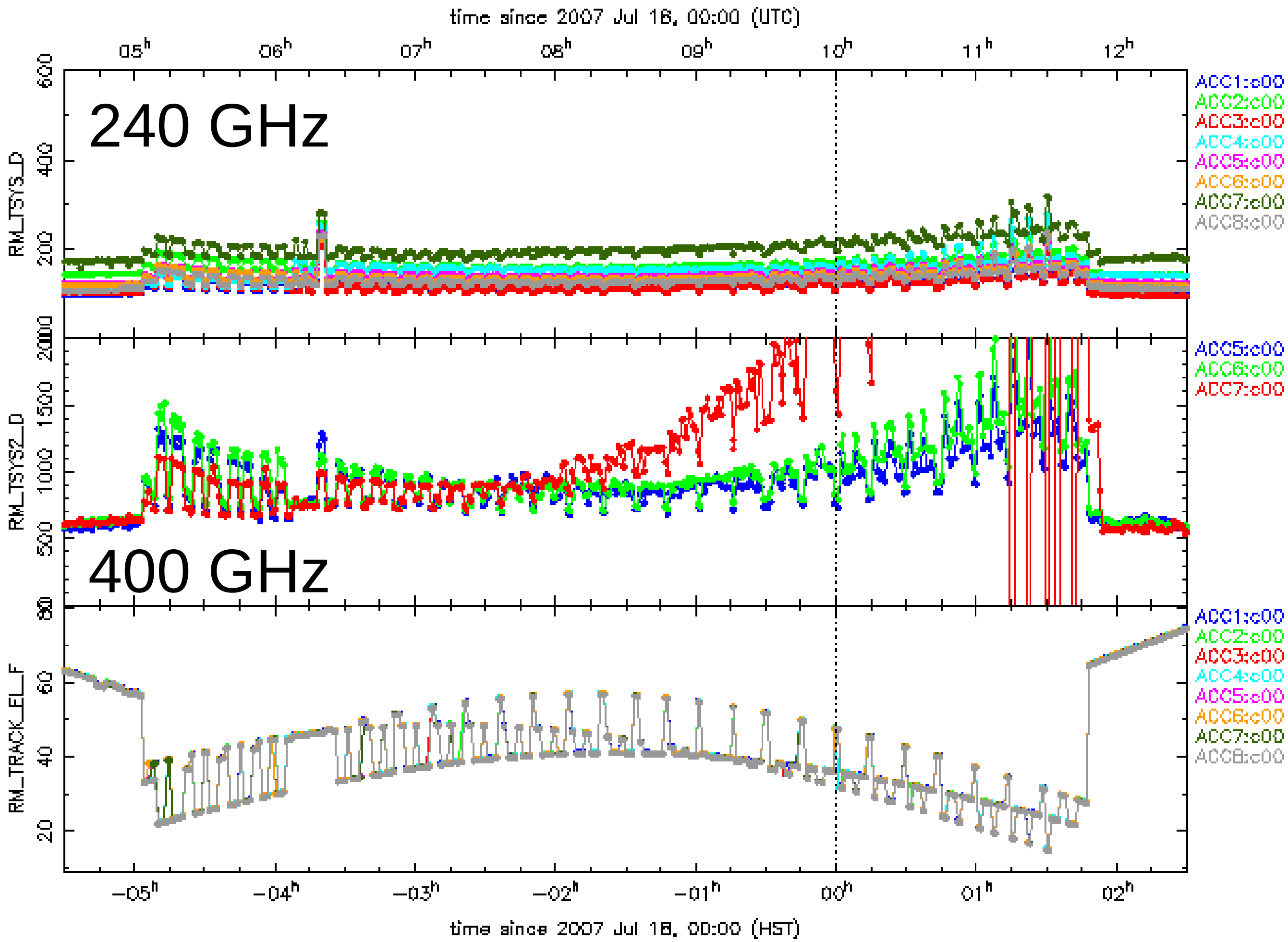


400 and 300 GHz receivers together

– Simultaneous observations of:
$C^{18}O(3\text{-}2)$, $^{13}CO(3\text{-}2)$, $C^{17}O(3\text{-}2)$, $^{12}CO(3\text{-}2)$

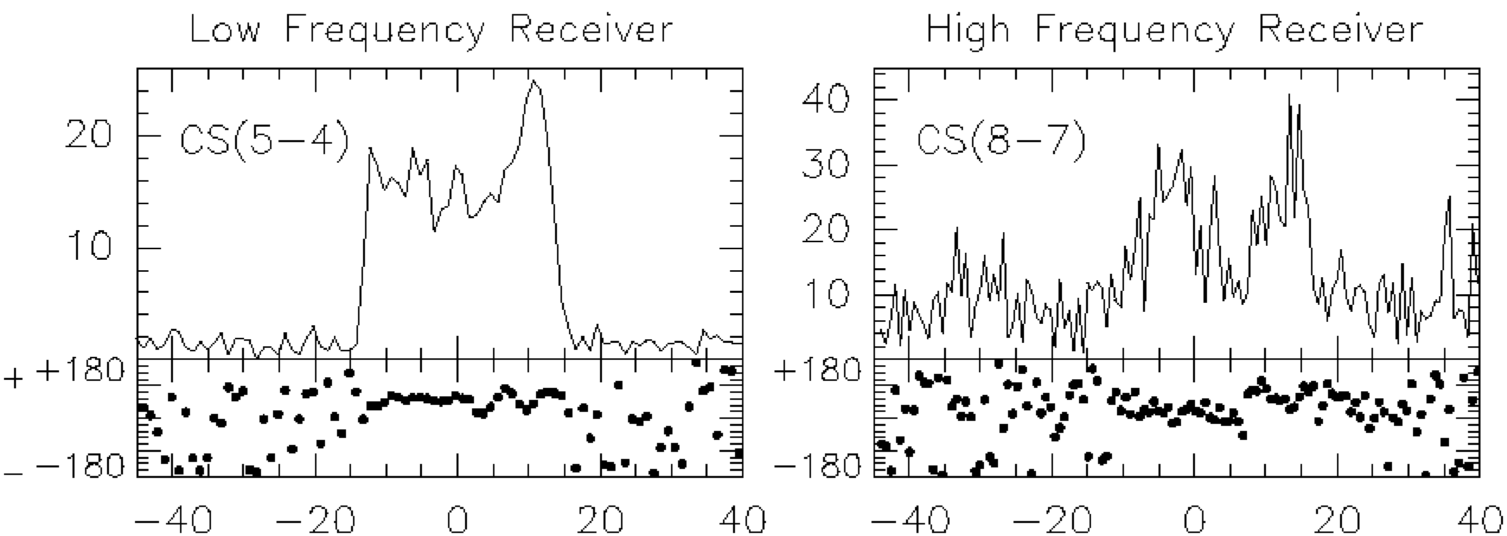


Dual frequency polarimetry tests



400 and 200 GHz receivers together

- Observe two rotational transitions of same molecule



CS (5 – 4) and CS (8 – 7) Towards Irc +10216

Completion of antennas 7 and 8

- Major effort by Hilo-based SAO and ASIIA staff, and by staff in Cambridge and Taipei
  - Antenna 7 completion took about 10 months
  - Antenna 8 completion took about half that time
- Work included
  - Elevation lead-screw, azimuth encoders, roof repairs, air handler replacement, various electrical upgrades, cryostat rebuild and numerous receiver modifications, antenna optics and receiver alignment

Other antenna upgrades

- New azimuth encoders on all but antenna 5
- Air handler systems for cabin temperature control
  - Maintain cabin air temperature to better than 1°C
- Improvements to holography system
  - Remote switching between antennas
  - Can measure two antennas simultaneously
  - Can also use two receivers in a single antenna (useful for diagnostic purposes)

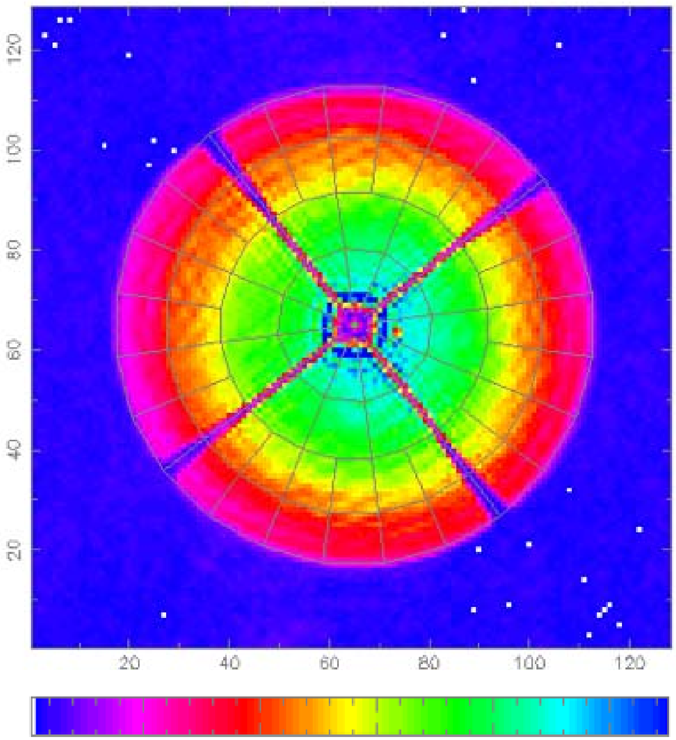
Antenna surface improvements

Antenna number	1	2	3	4	5	6	7	8
April 2005	22	14	15	18	20	22	20	21
July 2007	12	13	16	17*	14	17*	12	11

- *Offset illumination pattern, needs to be corrected

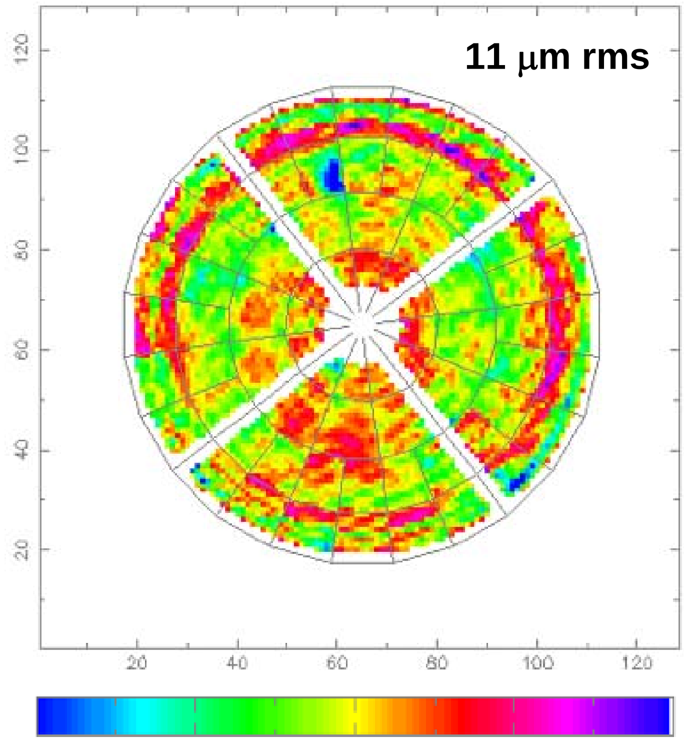
Antenna eight surface maps

Illumination pattern



0.1 0.2 0.3 0.4 0.5
(Volts)

Surface error map



-20 0 20
Microns

Endorse working towards e-SMA

- Remains low priority for the SMA
- Resolution gain 20% to JCMT, 40% to CSO
- Sensitivity gain potentially up to 50%. Not yet realized – could be much less.
- Science workshop was hosted in Leiden (Feb 2007). However, we need to define a sharper science case.
- Certain spectral line observations would benefit, also certain observations requiring the highest resolution.
- This is a difficult project, however some progress has been made

Short spacing impediment

- No formal arrangement with other observatories
- Pi’s currently request single dish time elsewhere
- SMA sub-compact array helps somewhat – gives good u-v overlap with JCMT and pretty good with CSO

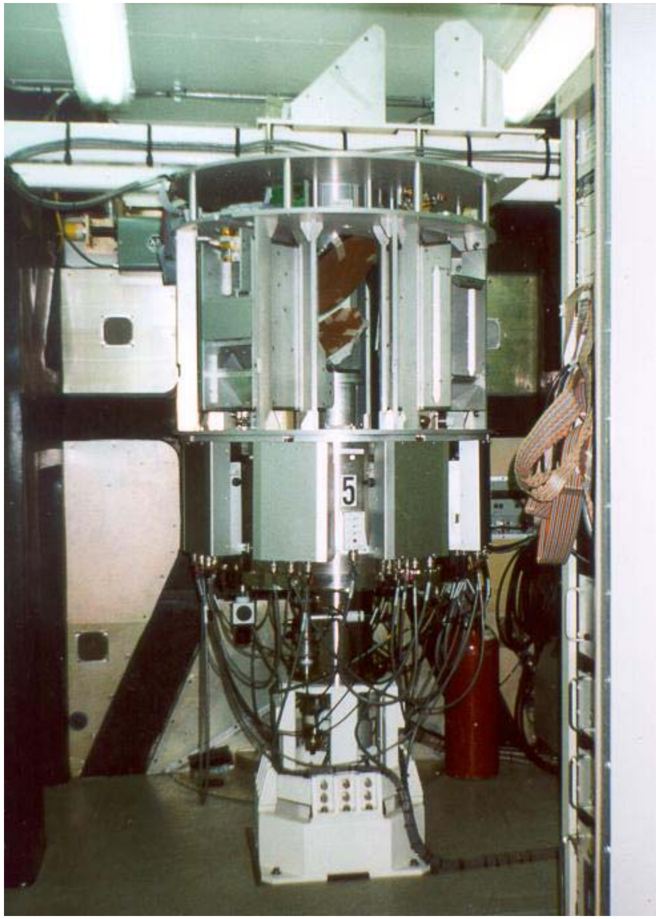
Mid- and long- term recommendations

- Develop a working phase correction scheme
  - Essential for routine long-baseline operation
  - and for sub-arcsecond resolution at all wavelengths
- Develop reliable anti-collision system
  - Enable true compact configuration
- Develop wide bandwidth continuum system ?
  - Coupled with other improvements, this could result in an order of magnitude increase in sensitivity
- Develop and implement other frequency bands

Develop a phase correction scheme

- Investigate the problem jointly with the ALMA WVR group
- Use eight channels to sample the 183 GHz water line
- Cambridge: Sideband-separated correlating radiometer
- Onsala: Dual Dicke-switched DSB system
- Prototypes installed at the SMA in January 2006
- Coupled to the SMA antennas just like SMA receivers
- Installed to be coaxial with the astronomical beams
- WVR control/data collection integrated with SMA software
- Tests were carried out under differing weather conditions and on a number of baseline lengths

WVR prototypes installed Jan 2006

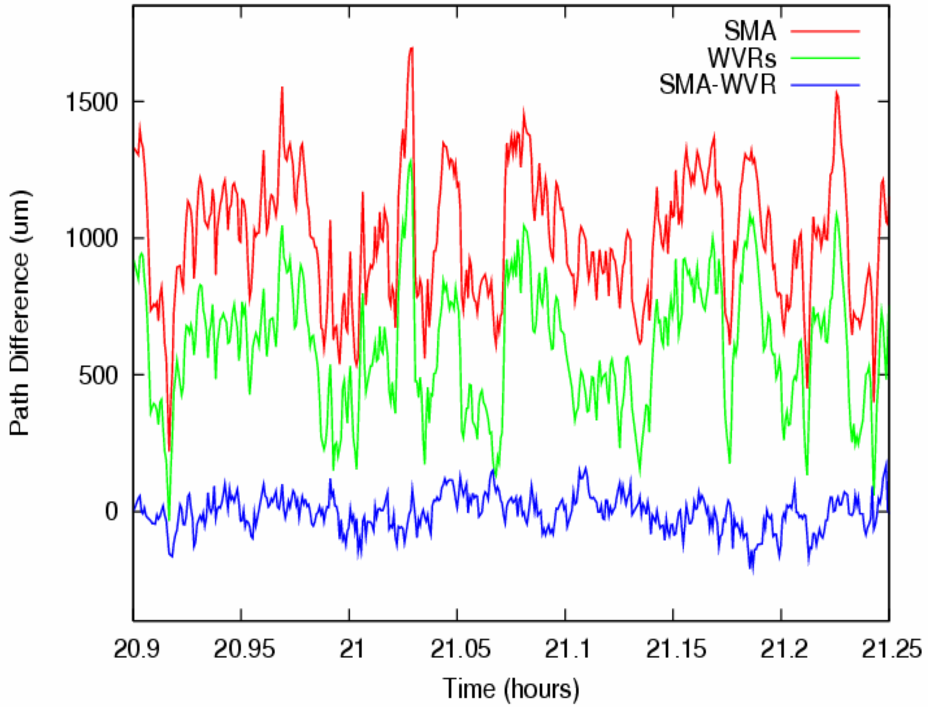


WVRs installed into
Antennas 5 and 6

WVR phase correction results

- Data from 200 m baseline under poor weather conditions
- SMA data averaged across sidebands (2.5 s integrations)
- WVR phase is basically the delay, from PWV estimate, scaled to wavelength
- While some systemic noise exists in both the WVRs and the SMA, data shows most of the noise is atmospheric.

SMA interferometry and WVR data towards 3c273



Phase correction summary

- Under poor atmospheric conditions
  - Raw SMA path length difference ~ 300 microns
  - Corrected path length difference ~ 70 microns
- Under average-good atmospheric conditions
  - Raw SMA path length difference ~ 80 microns
  - Corrected path length difference ~ 50 microns
- Under exceptional conditions
  - Corrected path length difference ~ 30 microns
- Does not meet ALMA specification of 15 microns
  - Improvements could be made, also the best conditions on Chajnantor somewhat better than on Mauna Kea

Phase correction scheme for the SMA

- Drawbacks with ALMA scheme
  - Requires dedicated set of purpose-built receivers
  - Lose one SMA polarization
  - Costs expected to be ~ 150 – 200 k$ per unit

- We propose to use existing SMA receivers
  - Measure line contrast of stratospheric ozone
  - Existing SMA receivers can do this
  - Need dedicated spectrometer in each antenna
  - Tests underway

Develop antenna anti-collision system

- Use elevation hard stops to prevent collisions
- Sub-compact array in operation since February

Wide bandwidth continuum system

- IF fiber transmission system can support ~ 12 GHz
  - However, many of the receiver and room-temperature IF components would have to be replaced
  - Huge lab effort required (replace all cryogenic components)
  - Design and build dedicated continuum correlator
  - Expensive and not immediate
  - Longer term (new transmitters/receivers) could support 18 GHz

- Propose much simpler scheme
  - Increase IF bandwidth from 2 to 4 GHz
  - While gains are less, very simple, low cost, almost immediate
  - However, this scheme loses one polarization

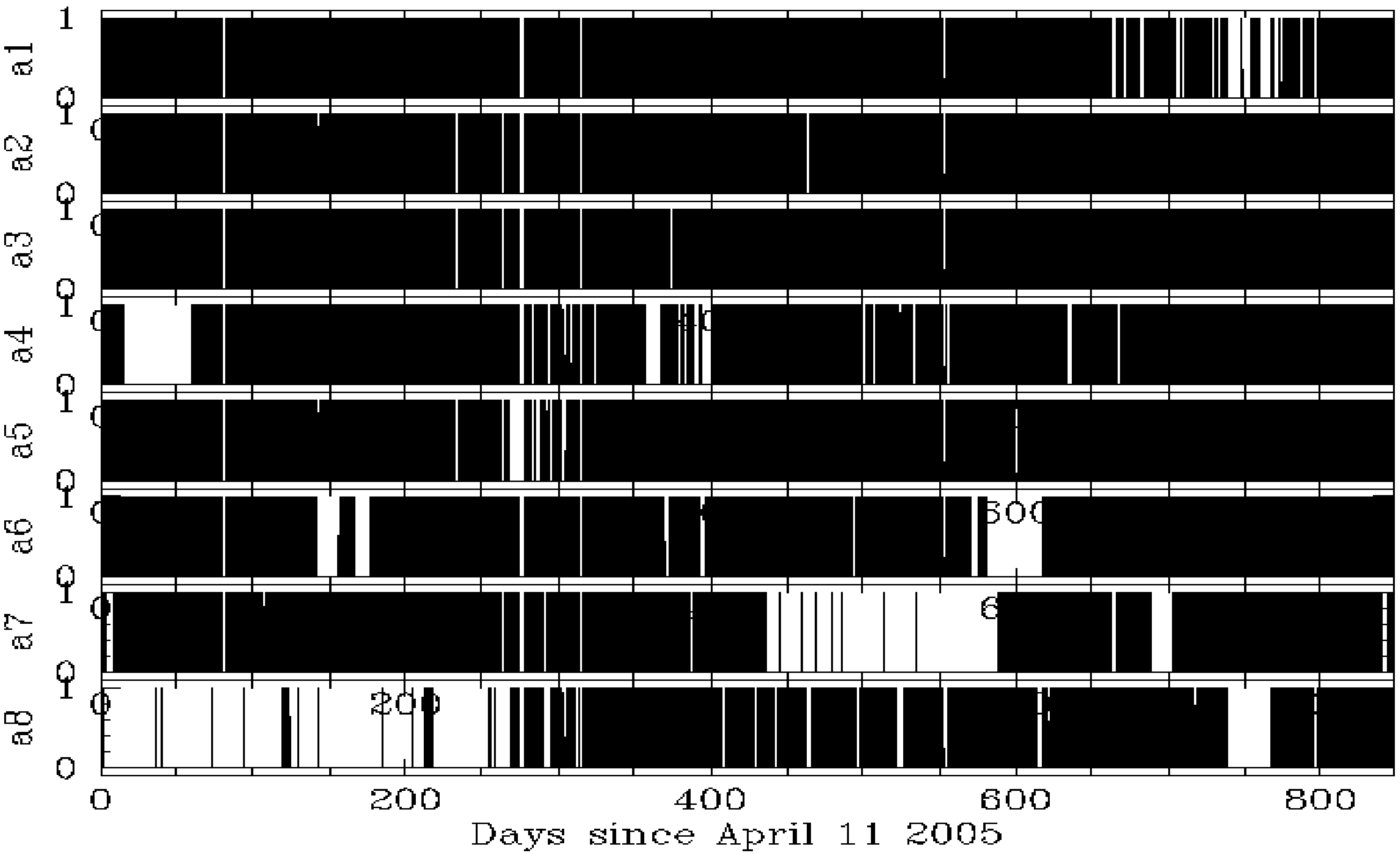
Develop other frequency bands

- Resource limited
  - Need first to improve 650 GHz receiver sets
  - Without exceptional science case the atmosphere above Mauna Kea is not good enough for 850 GHz
  - Have some components for 460 GHz receivers
    - Mixers were designed and fabricated > 10 years ago with good performance
    - As time permits (or priorities change) could equip three antennas for tests at almost no cost
    - 460 GHz observations likely much easier than 690 GHz due mainly to much better receiver performance

Other improvements and current status

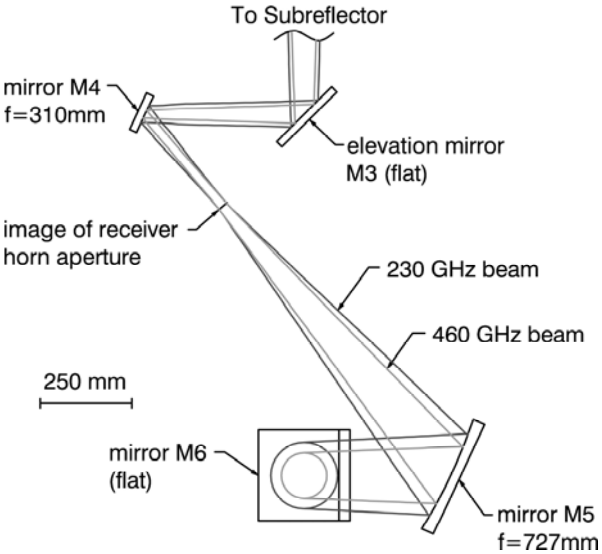
- Antenna up-time
- Two temperature calibration scheme
- High resolution correlator mode
- Emergency generator
- Observing
  - Procedural changes
  - Second-shift operations
- Proposals: short, submission, tracking
- Software improvements / upgrades

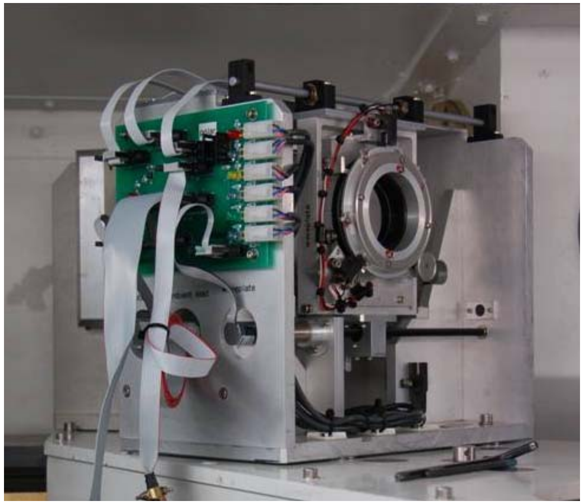
Antenna usage 2005 - 2007



Two temperature calibration scheme

Automatically switched room-temperature and heated loads, plus waveplate selection and operation





High resolution correlator mode

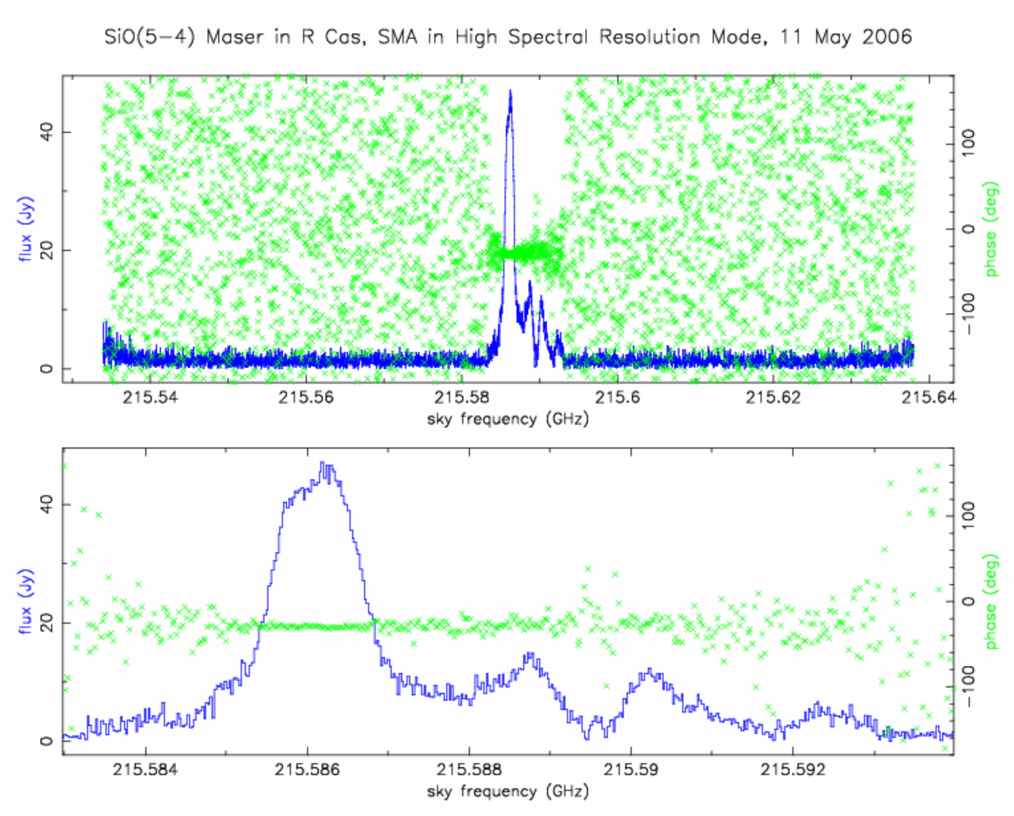
Completed April 2006

25 kHz now available

or 22 m/s at 350 GHz

Is being used for science

However some sacrifice in continuum bandwidth



Emergency generator (Sept 2006)

- Provides power in case of HELCO failure
  - 900 kW de-rated for altitude to 500 kW

Observing

- Procedural changes
  - Array brought into operation with engineering staff at summit
  - Public land, cannot deny access

    Observers tour array to check for members of the public
- Second-shift observing
  - Installed 3 more IR cameras to aid remote observing
  - 4 days each week from Cambridge, one from Taipei
  - Dedicated control room in Cambridge, also acts as focal point for SMA scientists and engineering staff

Proposals

- Proposals tracked on-line from submission to completion
  - Pi's can log on to view status of observing proposals
  - Data examined on a daily basis to determine quality
  - Automatic tracking of time devoted to partner institutes
- April 2007 internal proposals for short time requests
  - Idea is to move towards maximizing array usage
  - Some limitations on proposal types (partner institutes only)
  - Move to daytime observing (tests planned at 230 GHz)

Software improvements / upgrades

- Walsh cycle phase switching problem solved
  - Improved sideband rejection by ~20 dB
  - Also minimum integration time reduced by ~ 4
- Can control CSO JCMT just like SMA antennas
- Engineering database much faster
  - Can examine numerous engineering parameters real time via a web-based interface and data plotter
- Night-time engineering summary provided

Long term prospects (not exhaustive)

- ALMA project early science, February 2011
  - Up to 16 antennas with similar frequency coverage
- Options for the SMA
  - Continue with current planned instrument upgrades
  - Exploit the northern hemisphere with substantial investment on Mauna Kea. This could include more antennas, lower receiver noise, additional frequency bands, wider bandwidth, etc.
  - Pioneer higher frequency interferometry from 6000 m altitude in northern Chile (or elsewhere?)

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