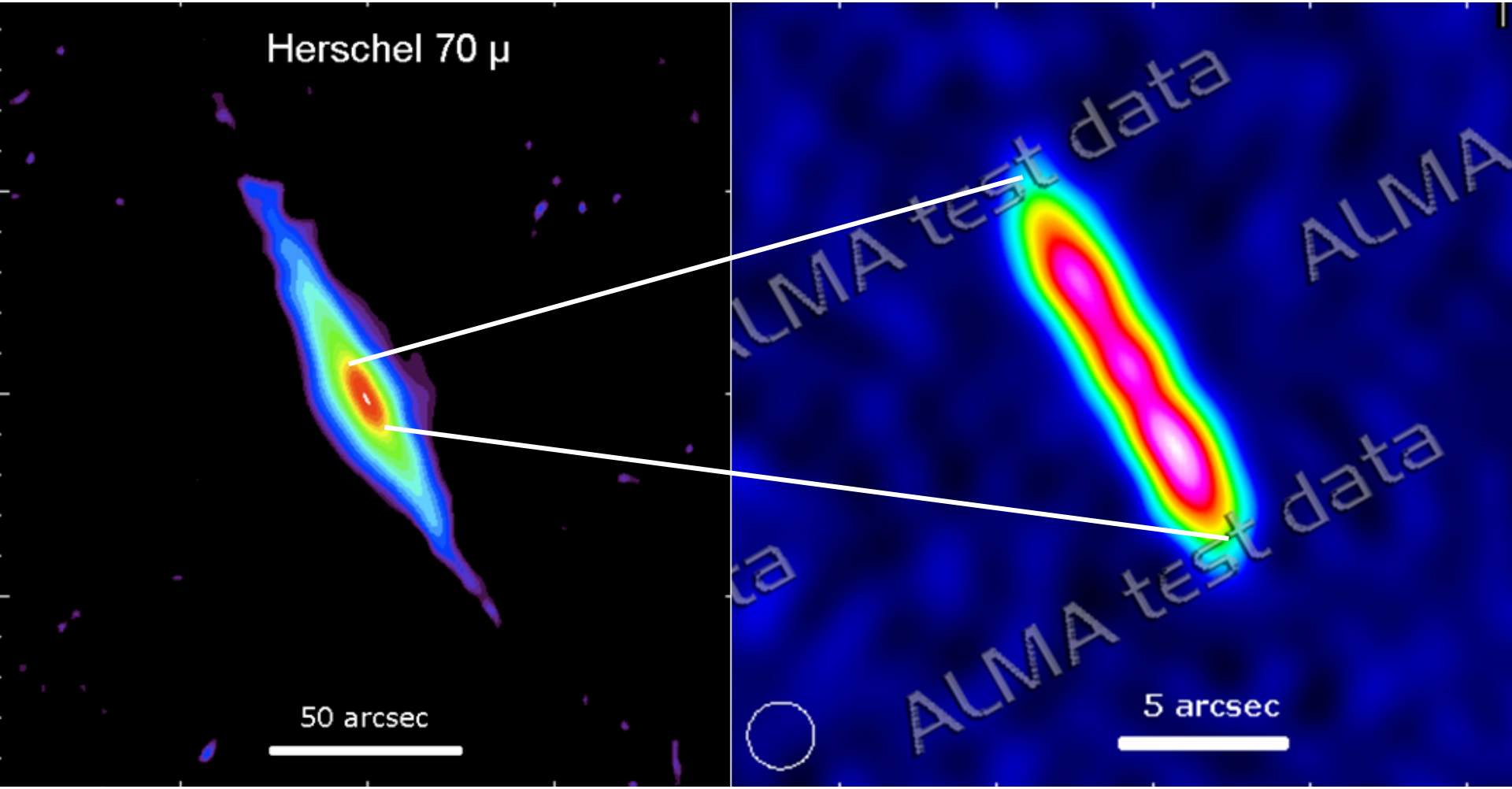
Commissioning Progress

Oct / Nov 2010

- Work continued on a variety of technical issues outlined at the last meeting, but most new development was in a “wait for R 8.0” mode.
- The focus was on running end-to-end tests of Scheduling Blocks and getting the data into CASA.
- Lots of observations of a wide range of objects
- The really seemed too easy and we all had lots of fun!

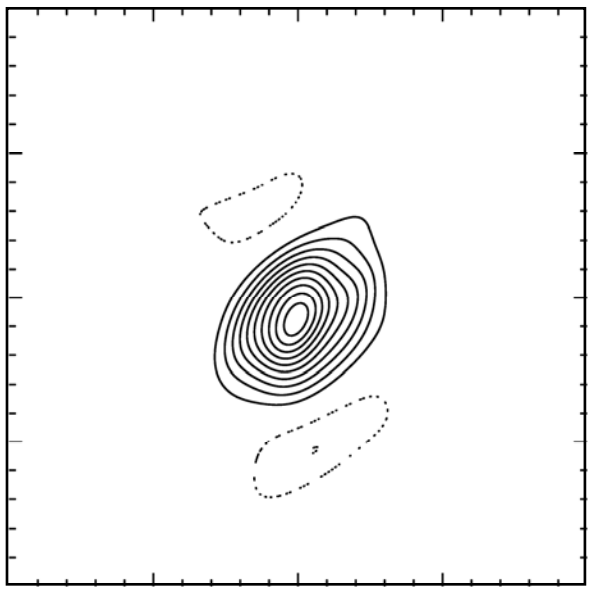
Beta-Pictoris Debris Disk

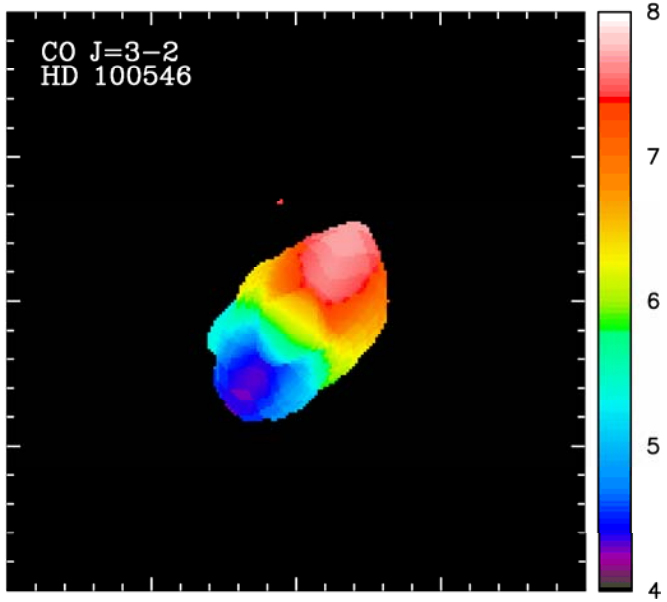
- Herschel ↓ far infrared ALMA Band 7 ↓ (11th Nov)

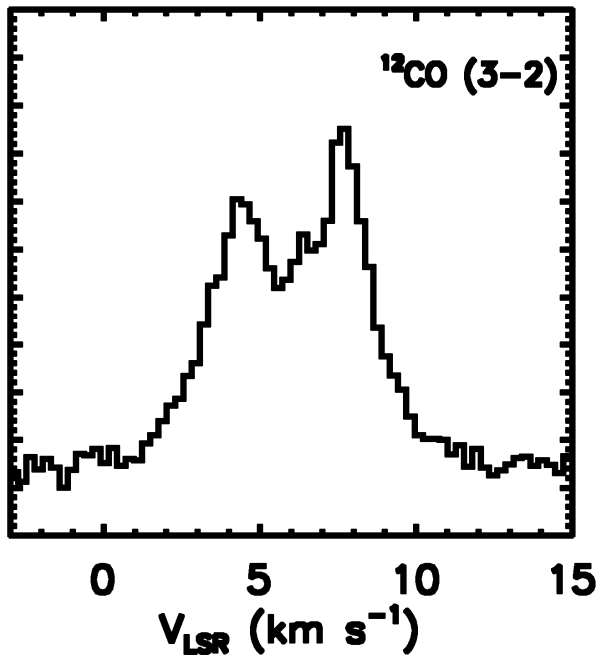


Spectral Data Cube

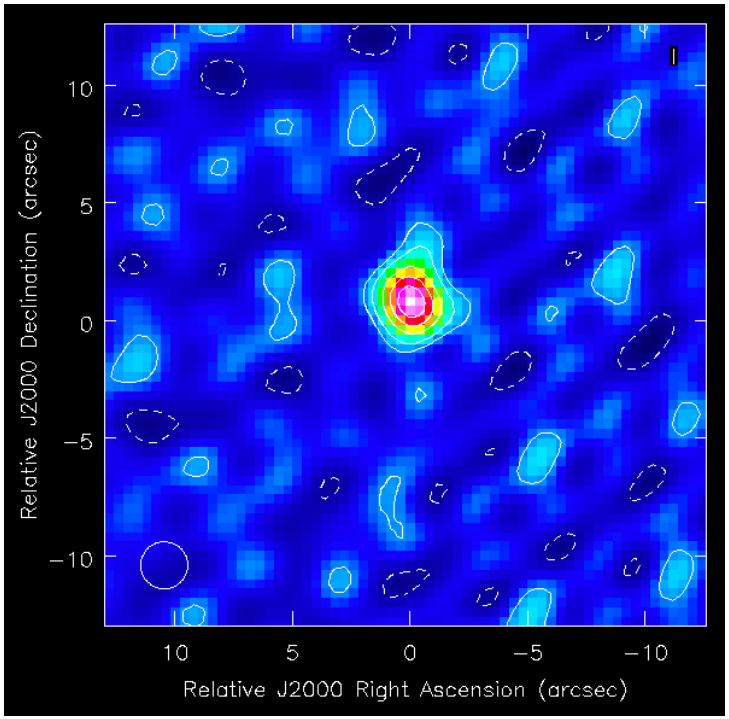
- This shows the 345 GHz CO line from the disk around a Herbig Be star - left, integrated emission, center map of velocity centroid showing rotation, right spectrum at center.

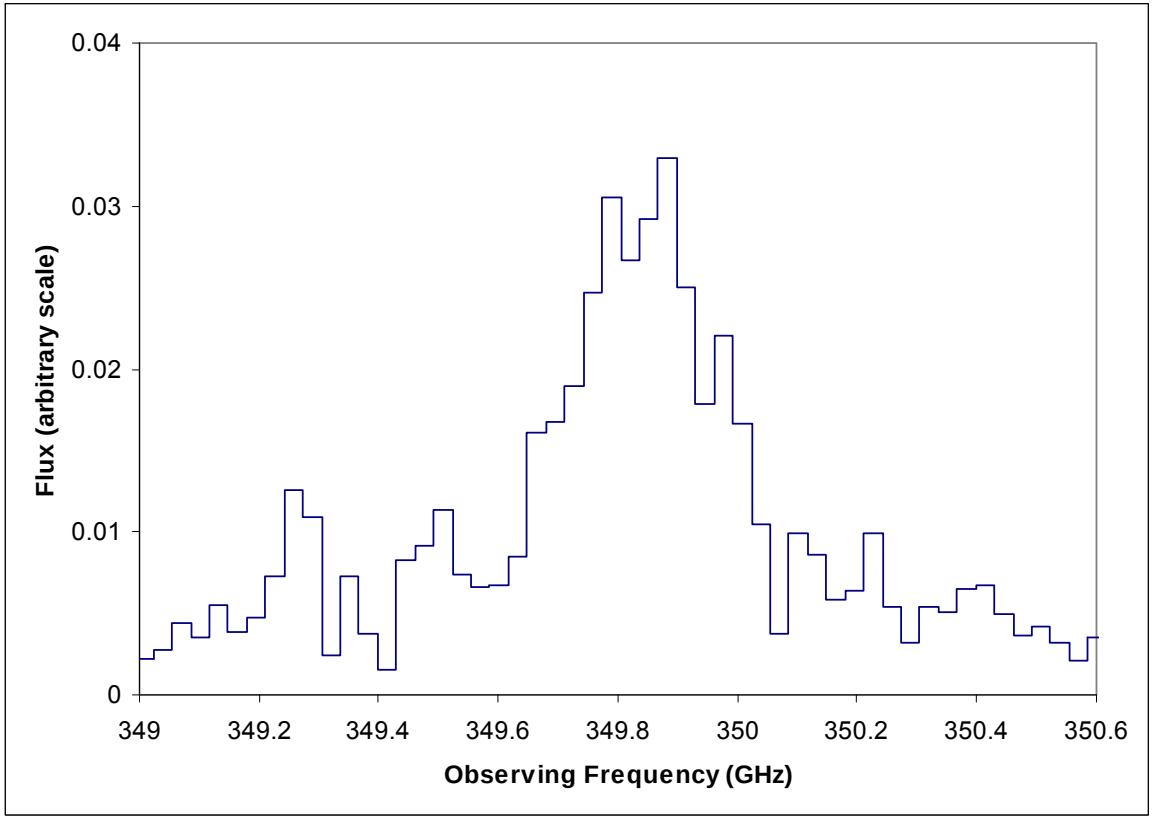


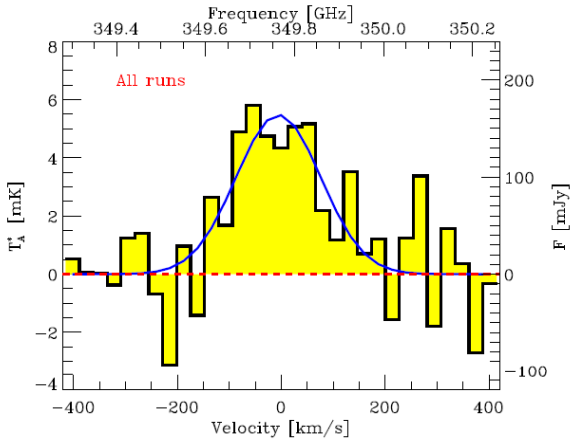




C+ line in BRI 0952 (a quasar at z = 4.4)







Band 7 16th Nov 2010 ↑

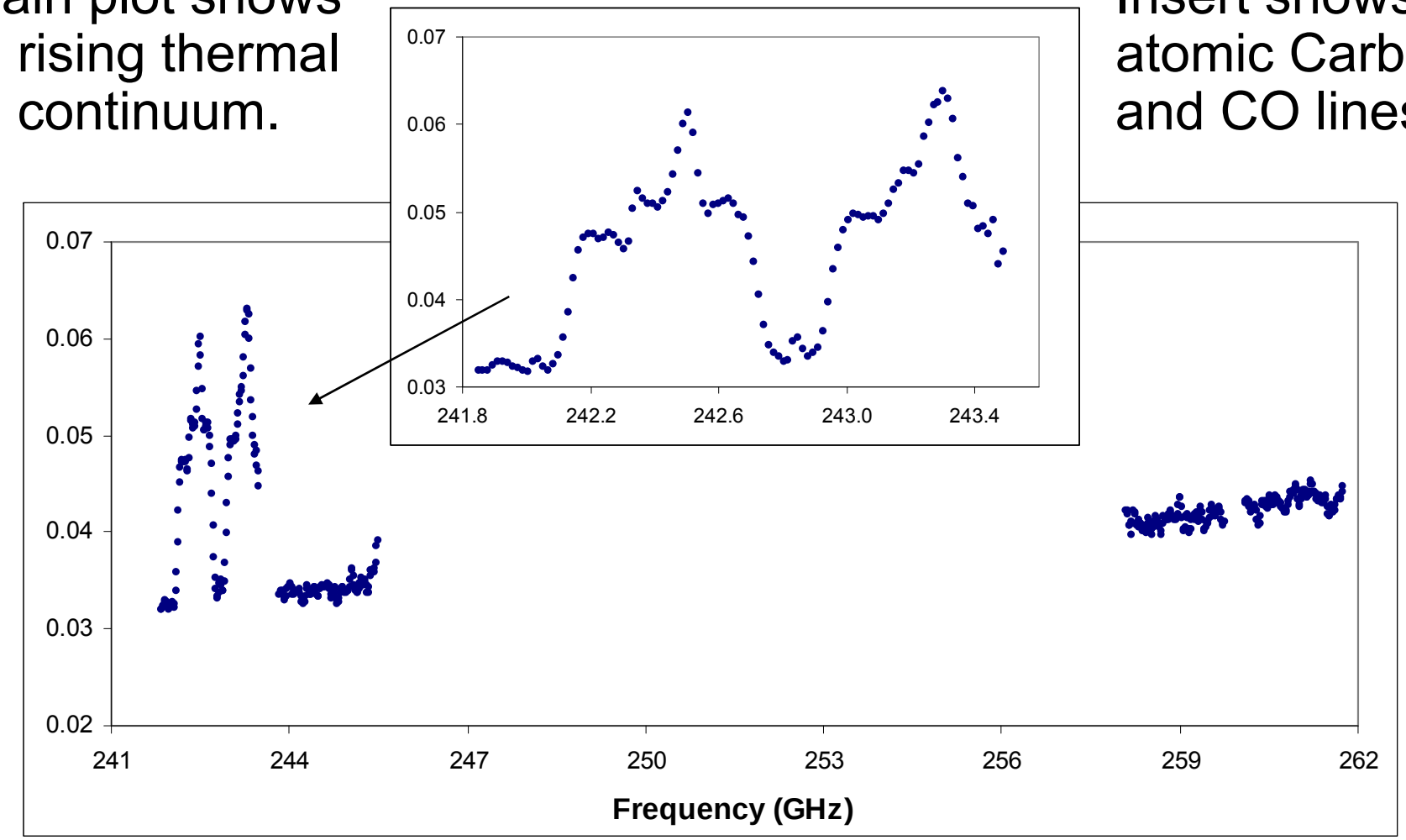
← APEX

Another high-redshift object: the “Cosmic Eyelash”

A lensed star-forming galaxy at z = 2.32 observed in Band 6.

Main plot shows rising thermal continuum.

Insert shows atomic Carbon and CO lines.



The Caveats

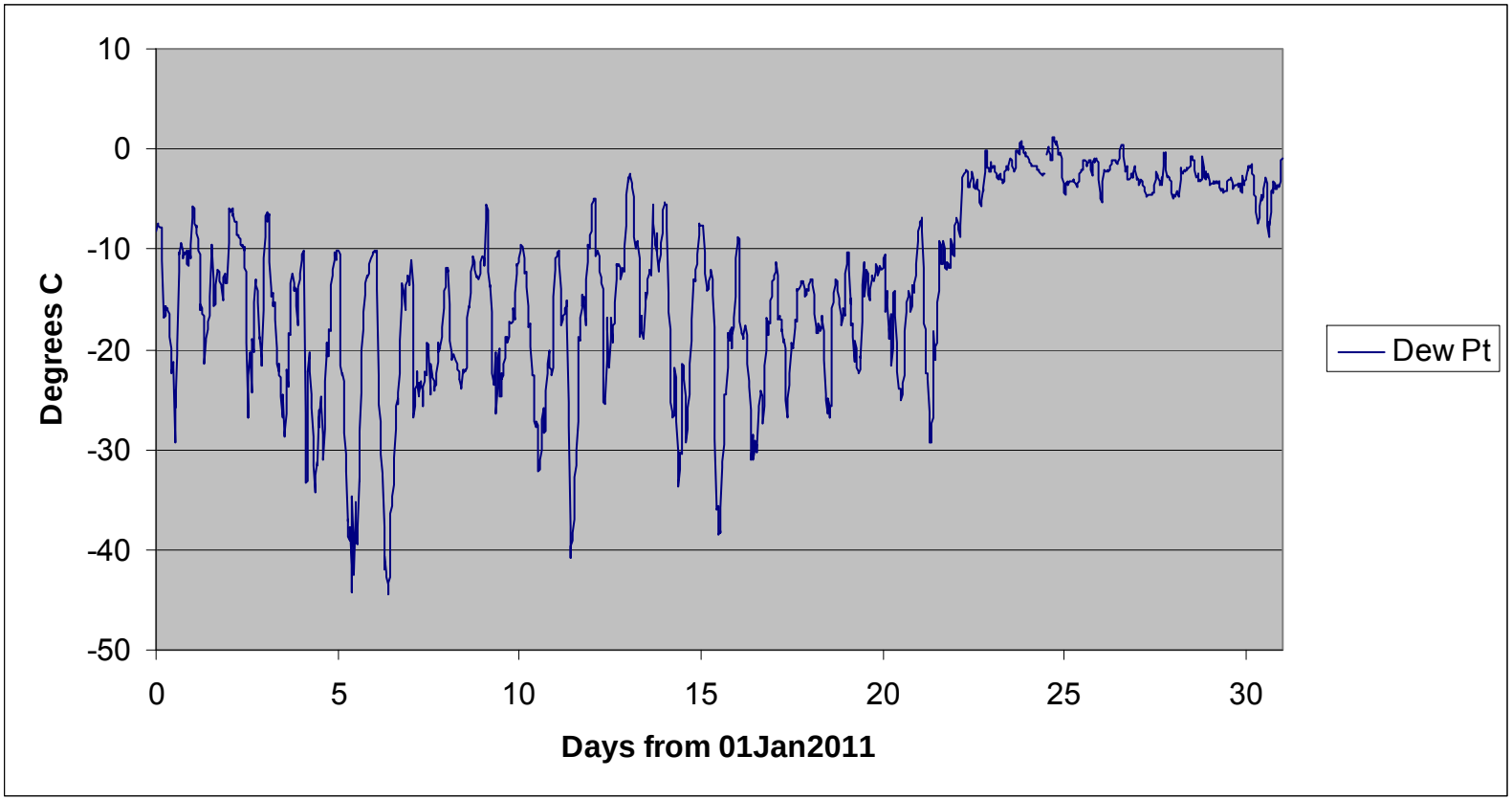
- Data were not calibrated – no amplitude scales
- Frequency scales had to be fudged
- Phases were backwards for upper sideband
- Serious data rate limitations – could not use < ~6 antennas with full spectral resolution.
- Reliability was poor – many tries to make observations, antennas often out of service.
- Many unsolved technical problems – timing errors, dish astigmatism, pointing issues, tuning.
- Worries about delivery of completed antennas with full complement of receivers, etc.

Dec to mid-Jan

- Deployment of software version 8.0
- Many problems – even without the weather problems there have been many things that we have not been able to do until recently.
- We have spent a huge amount of time and effort testing software with the antennas in simulation mode. This has made it possible to identify and fix quite a few problems but obviously many things cannot be tested without real signals.
- Discuss in later session

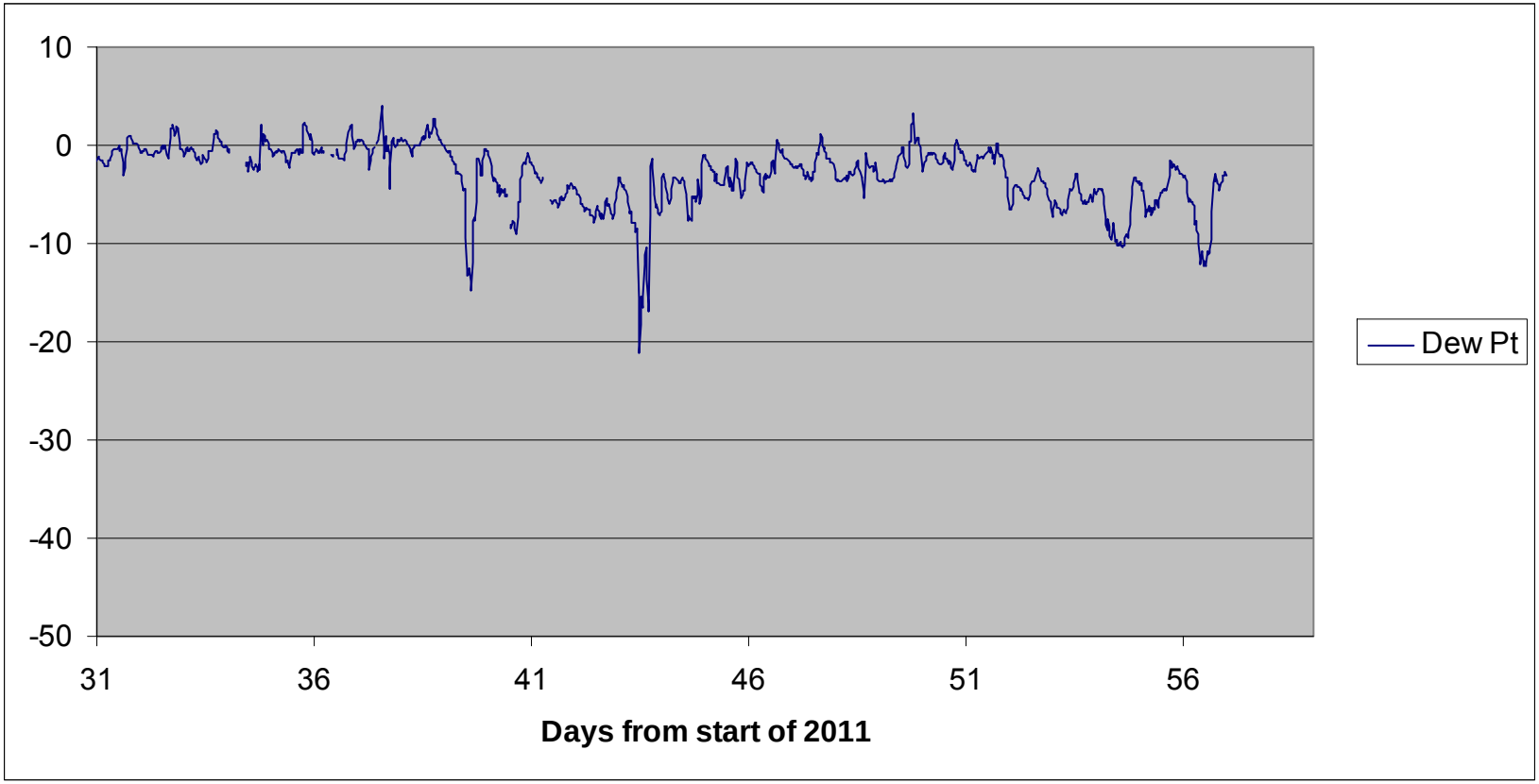
Mid – Jan and Feb

- The weather closed in!



- This shows the dew point which measures how much water there is in the air.

- This is continuing right through February



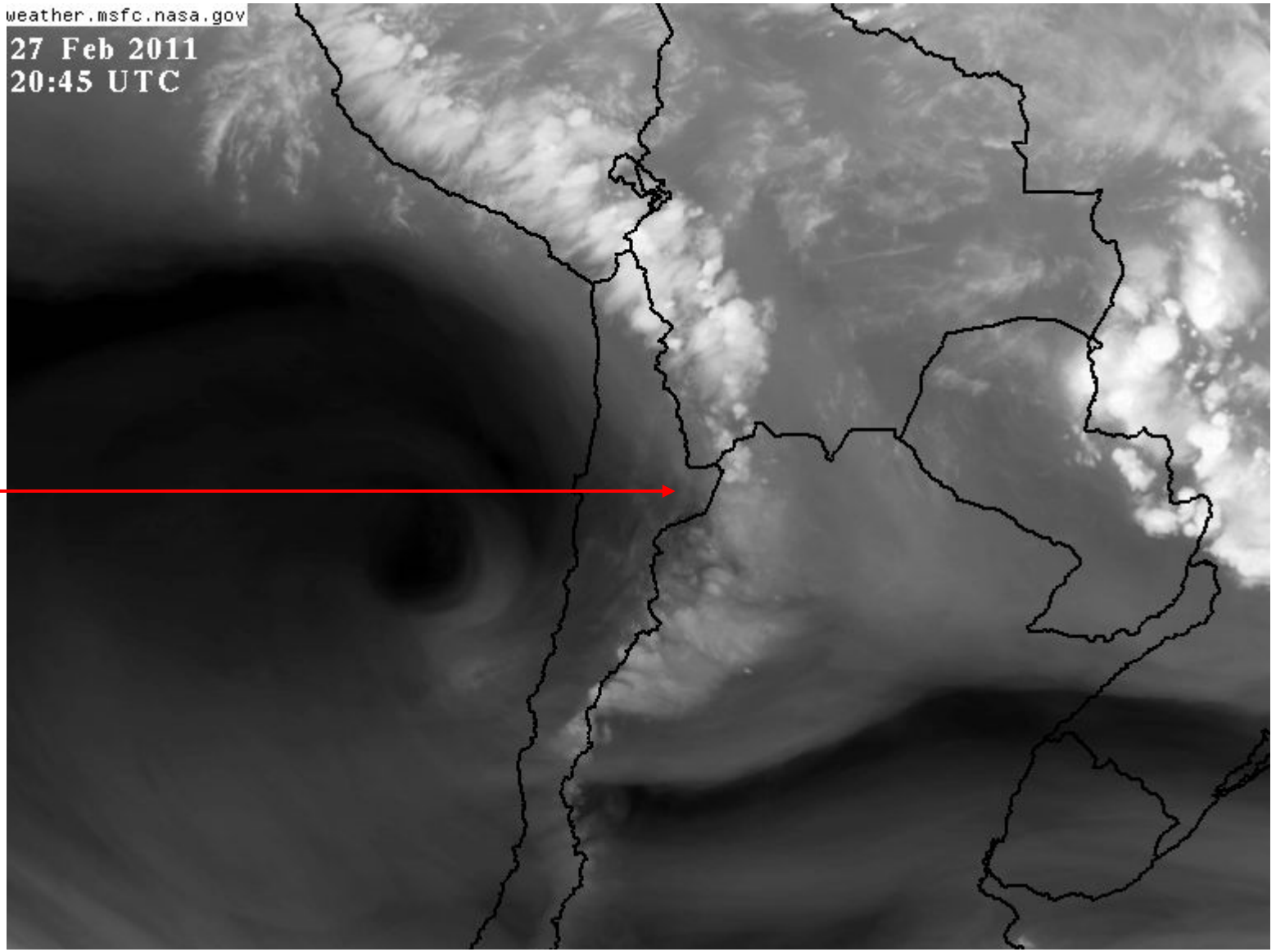
- Median humidity for Feb so far is 93% with the 10th percentile at 60%!

The atmosphere continues to be extremely unstable

We are all becoming amateur meteorologists

Water Vapour Channel

ALMA



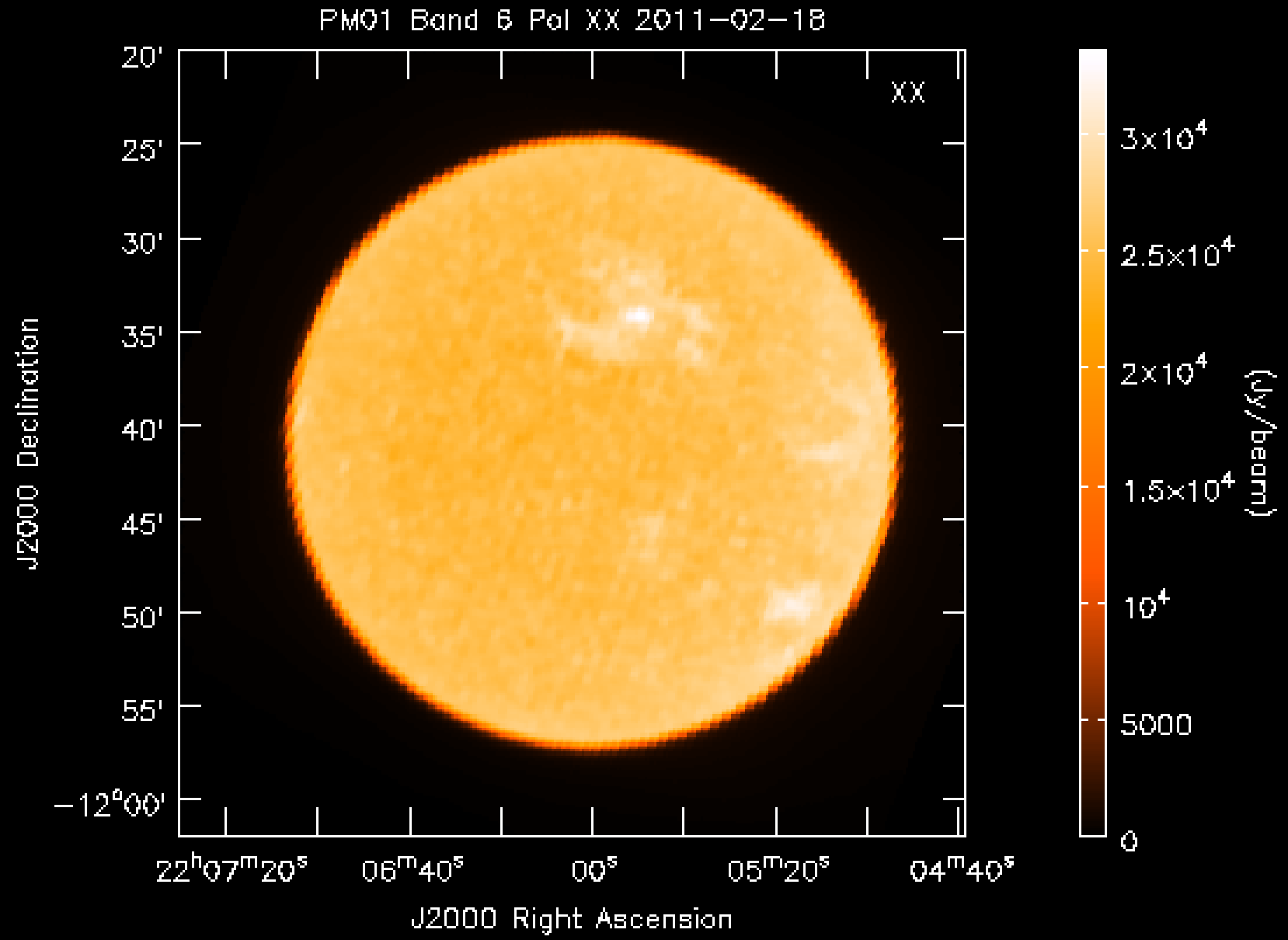
Checking for ice on the antennas is taking up a lot of time and effort

A few things that we have managed to do

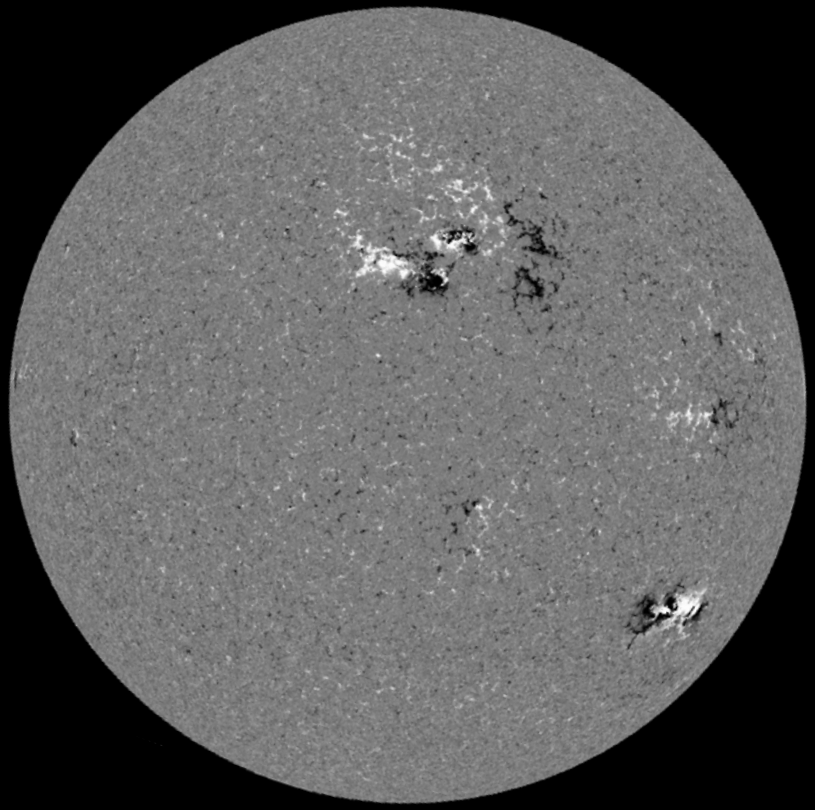
- Amplitude calibration is now working reasonably well. Devices function OK (at least in the warmer weather and work-arounds for incompatabilities are in place.
- System temperatures are now being written into the data files.
- Still experimenting with different strategies of using calibration loads, atmospheric models, etc.
- Phase calibration still looking good in general. We have demonstrated good “phase return” when changing correlator modes. So Cont / Line cal is OK.

- For testing single-dish modes, we decided to make scans of the Sun. This was making good use of the high atmospheric attenuation!

Band 6 Raster Map on 2011-02-18



SDO HMI Magnetogram Image

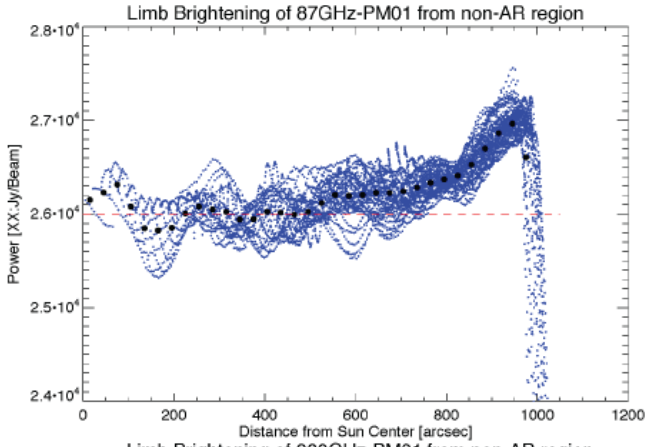


http://sohowww.nascom.nasa.gov/data/realtime/hmi_mag/512/

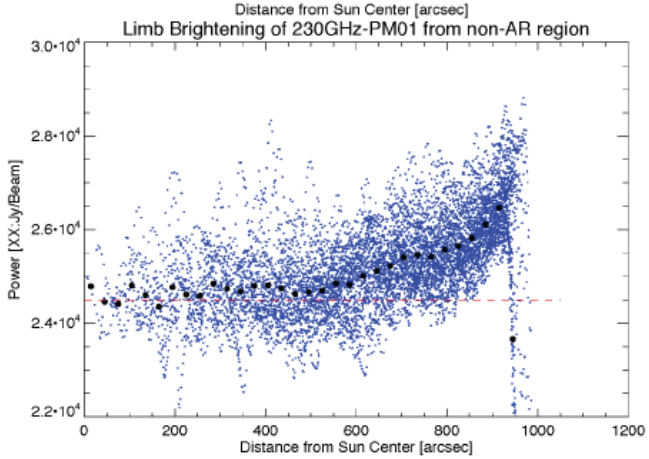
Radial averages of quiet Sun

Analysis by Shimojo-san

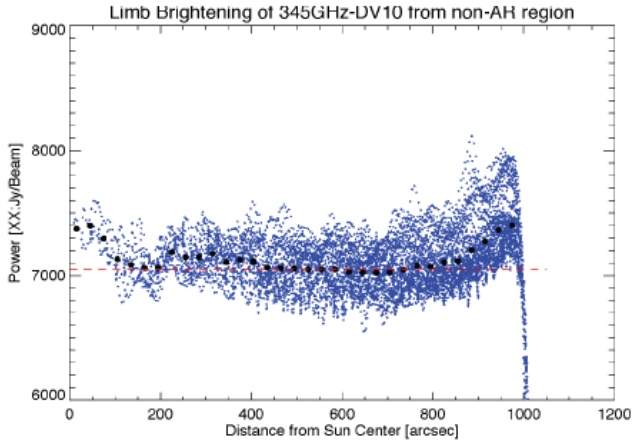
87GHz (Band 3)
2011-02-21 19:23~19:54UT



230GHz (Band 6)
2011-02-18 13:40~14:02UT



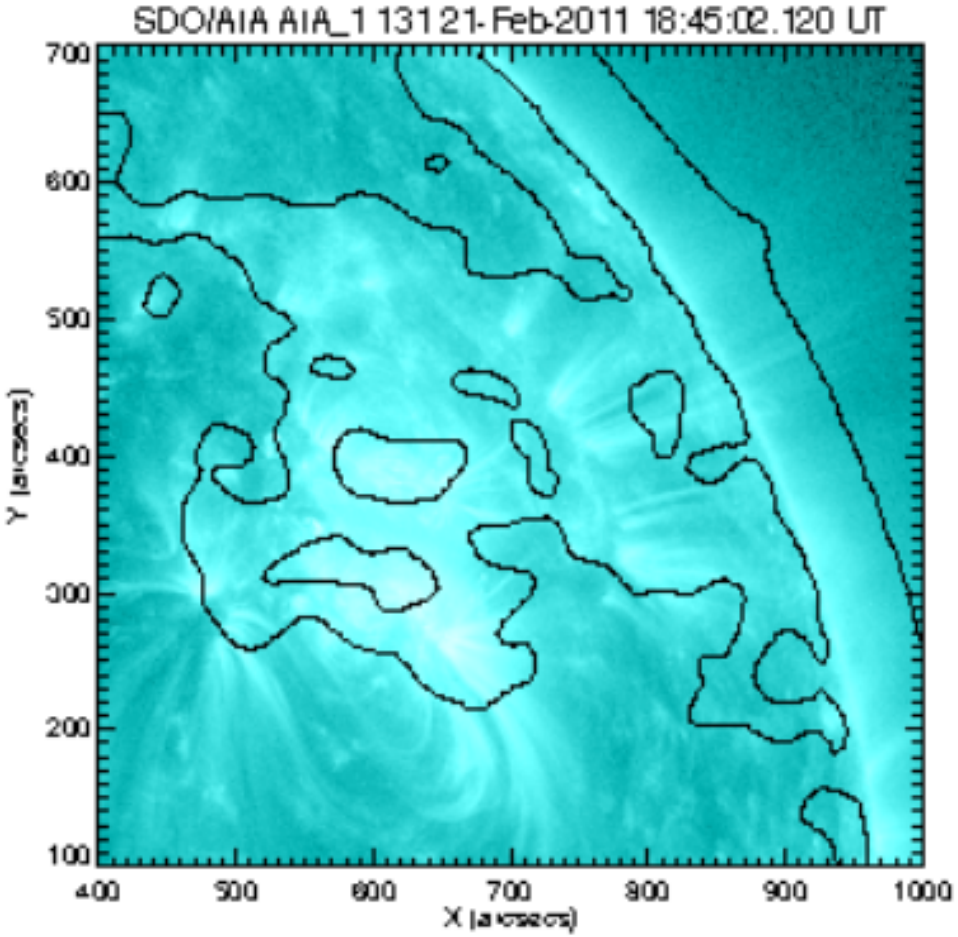
345GHz (Band 7)
2011-02-21 18:32~19:03UT



Active region.

Contours ALMA at 345 GHz

Blue EUV from SDO.



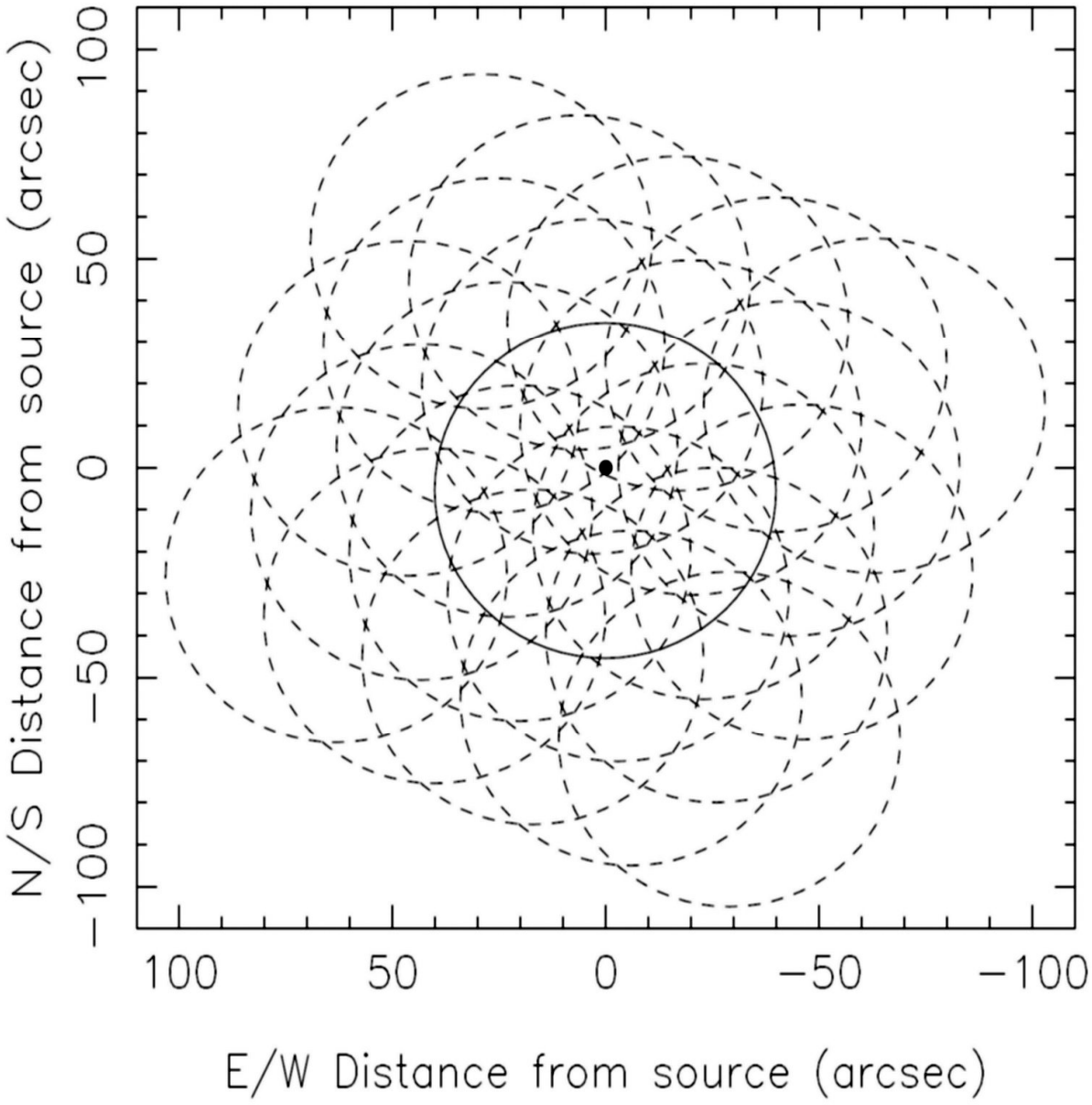
Temp.:13MK + 0.5MK

- Those data were taken with simple unidirectional scanning which has large overheads. That is not important for the Sun.
- With R 8.0 we have bi-directional scanning with fast turn-arounds and are starting to work on that.
- Solar observing is not on the list for Early Science (we do not have even prototype solar filters) – still aiming for Cycle 1.

- Mosaics, however, are included in the stretch goals and proper handling of this was new in R 8.0.
- Various software issues had to be fixed both in taking the data and in reading it into CASA.
- First test is just to observe a quasar. Ed Fomalont has just now managed to generate a first test image.

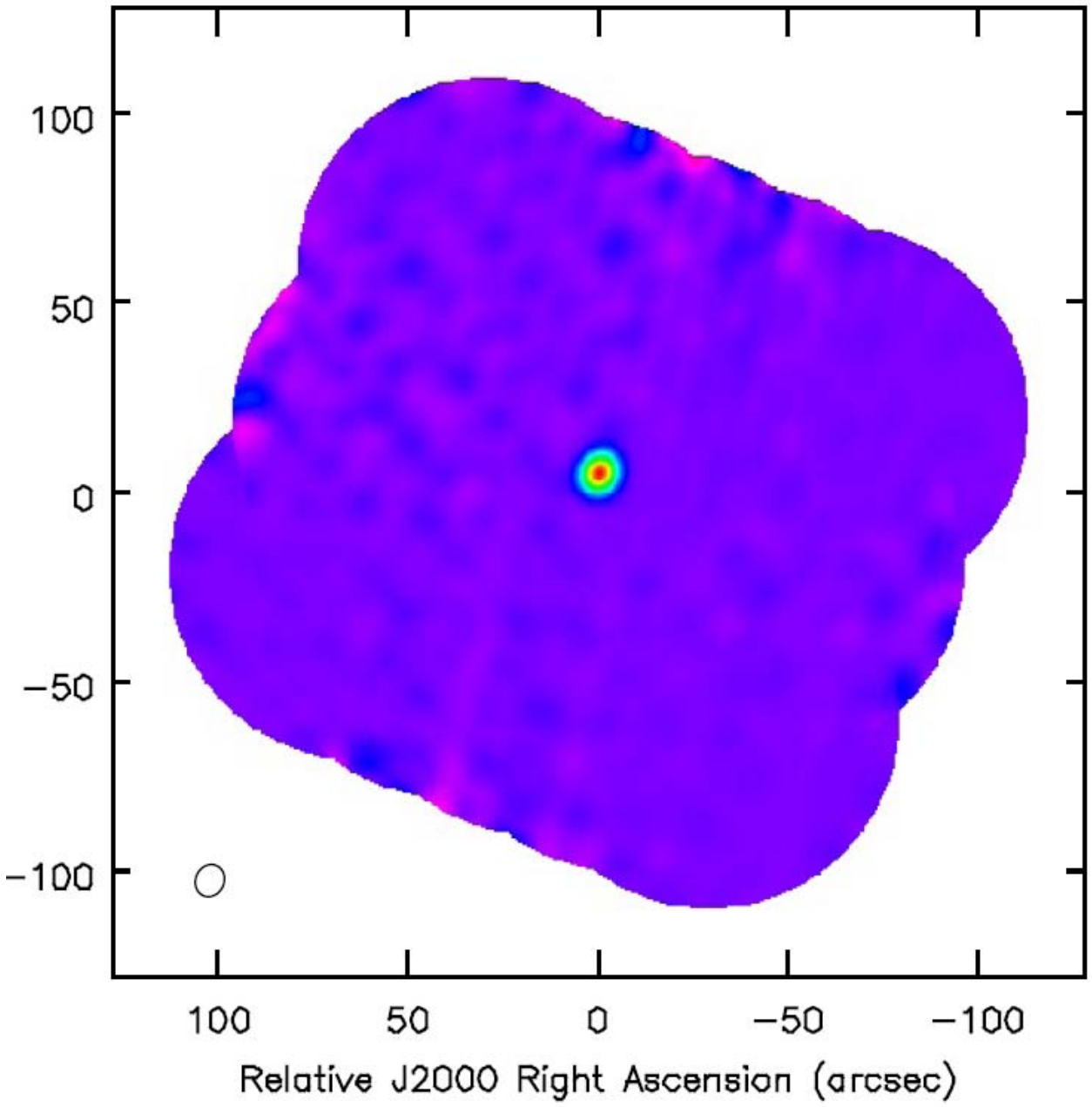
Test of Mosaicing

- Circles are the 20% power beam at 100 GHz
- 12 seconds per pointing
- 7 seconds overhead at present



First Test Mosaic Image

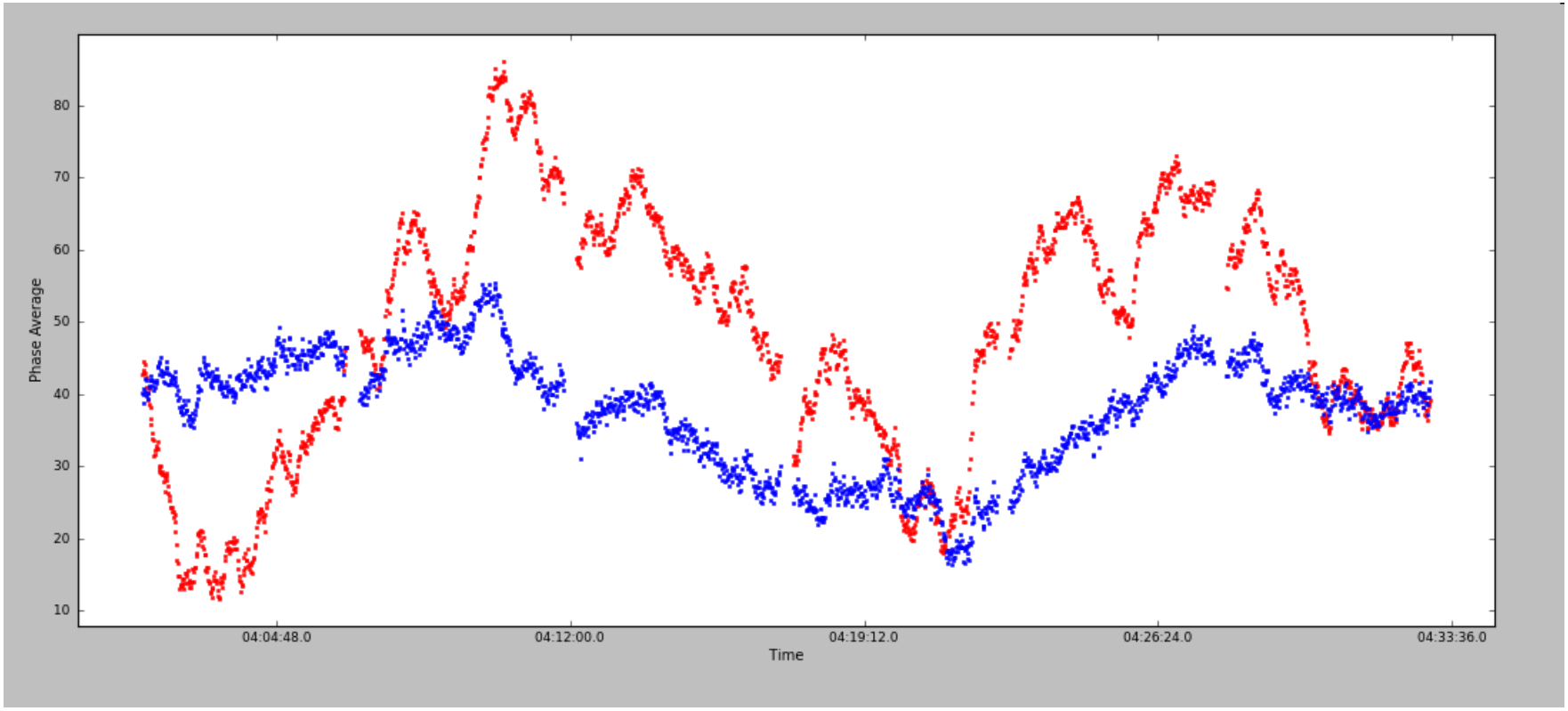
The source (0538-440) could be detected in nearly all mosaic pointings. The source position was within 0.5" (1/10 resolution) even for mosaic fields that were 40" from the source – at the 10% power level of the primary beam.



Data on long (650m) baselines

- We had DV09 on a long baseline from late December to mid-January.
- No unexpected problems were encountered and the phase correction performed as expected.

  Red is uncorrected phase, blue is corrected.

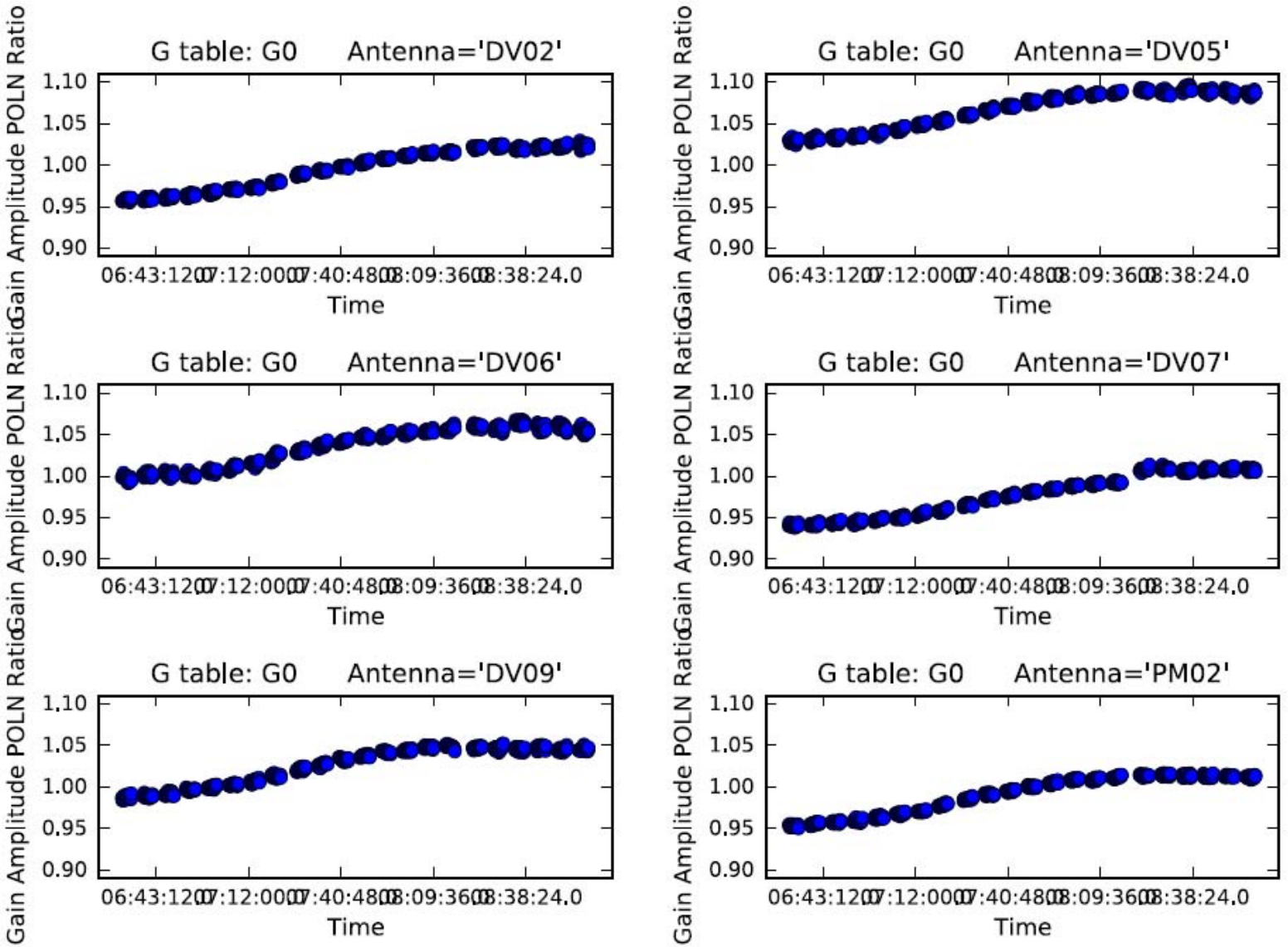


More long baselines

- We had to move DV09 into the array and we were not able to do most of the quantitative tests planned due to the state of the software and the poor weather.
- We have therefore put DV01on a long baseline.

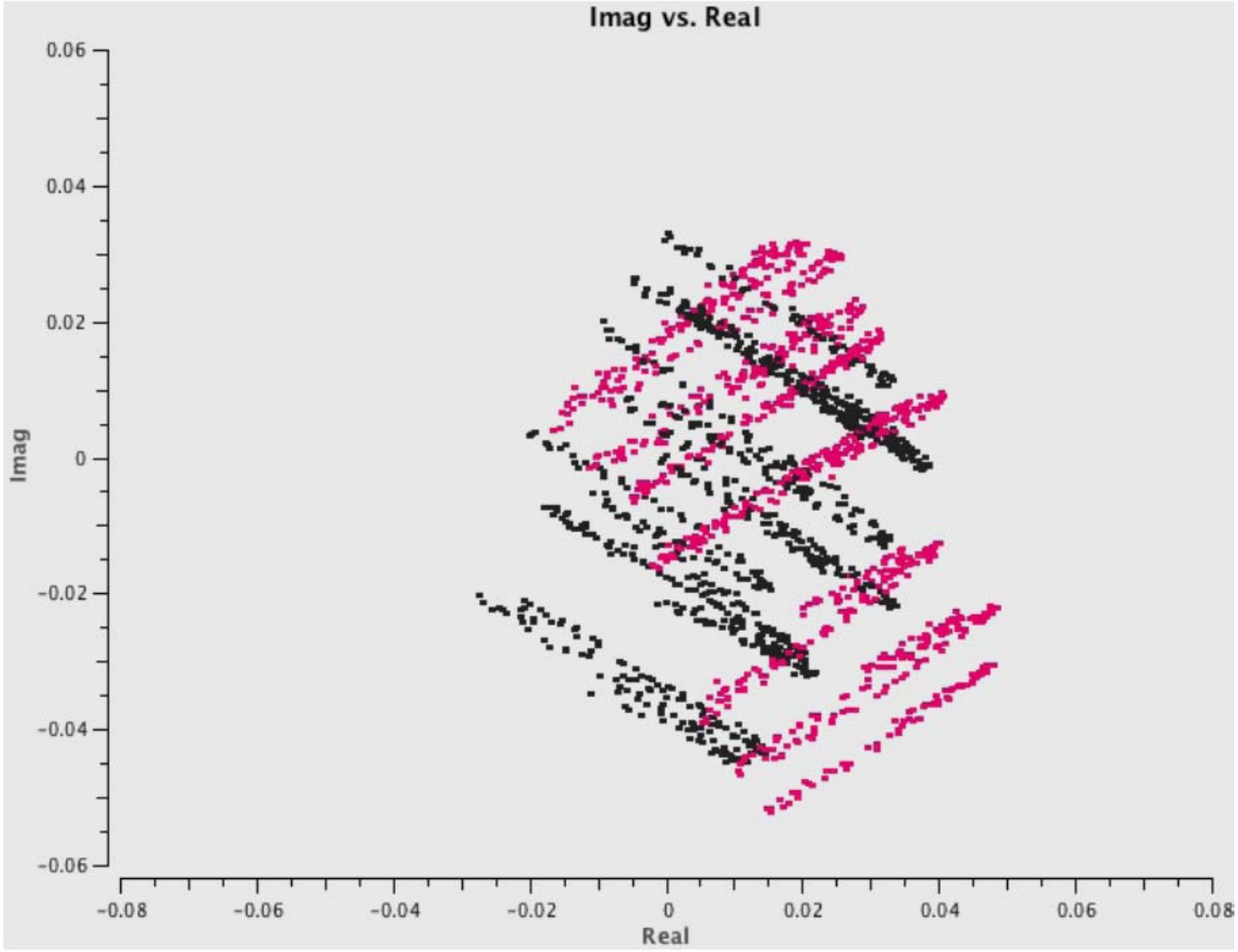
Polarization

- Key steps were:
  - Restore the capability of writing the 4 polarization products to the data files (in R 7.1).
  - Set up CASA to process linear polarization case and accept ALMA data.
  - Sort out the ordering of the baselines for the cross-hands products.
  - Get the Polarization team here (Crutcher, Mollenbrock, Rao) 14th Feb to 2nd March
  - Fix the swapped-over cross-hands XY ↔ YX
  - Get some decent data!
  - Has been extremely frustrating but we now at least have some Band 3 data sets on bright quasars.

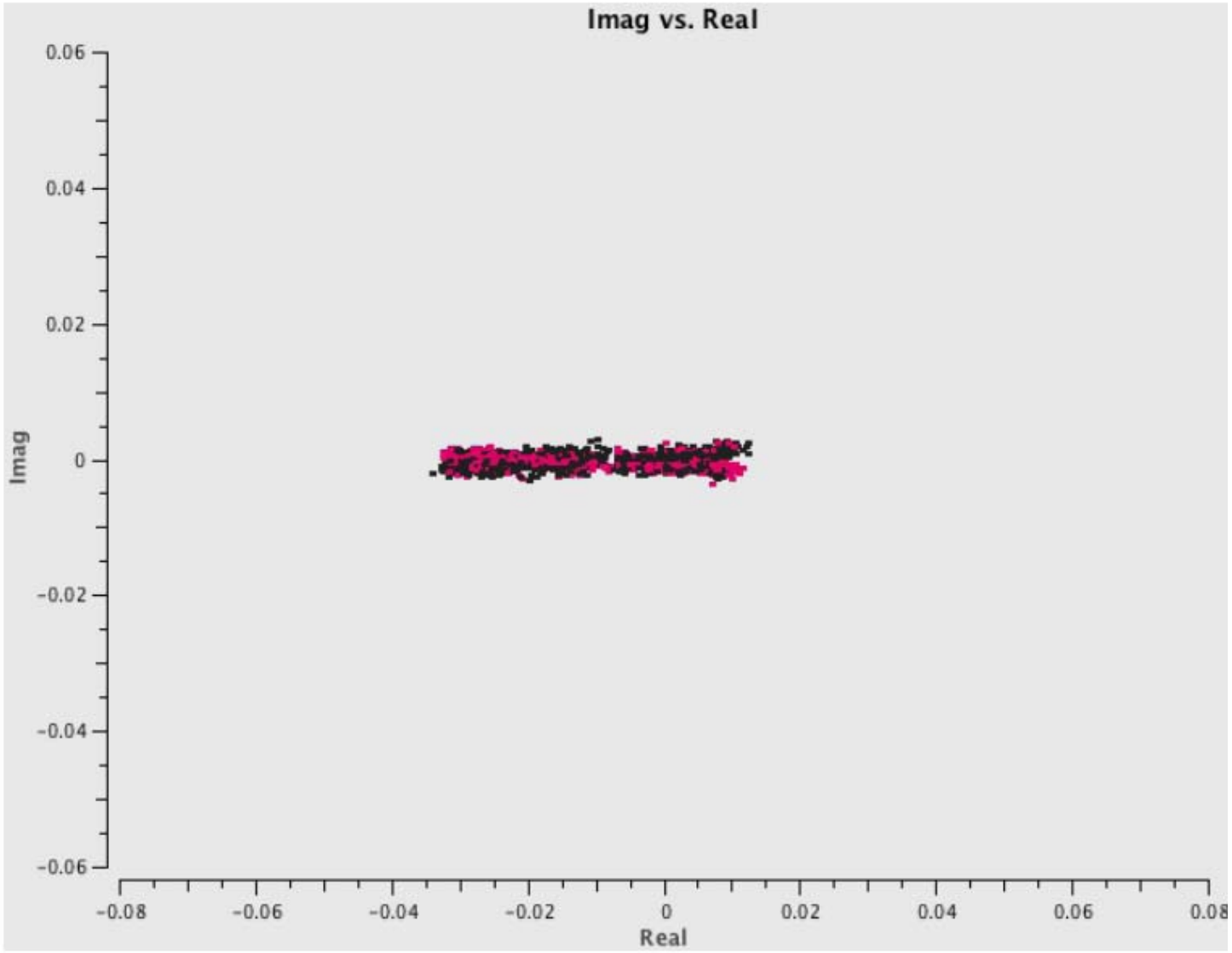


X/Y Amplitude vs. Time: Source Linear Polarization Signature

Cross-hands Terms – XY and YX
Dots are samples All baselines



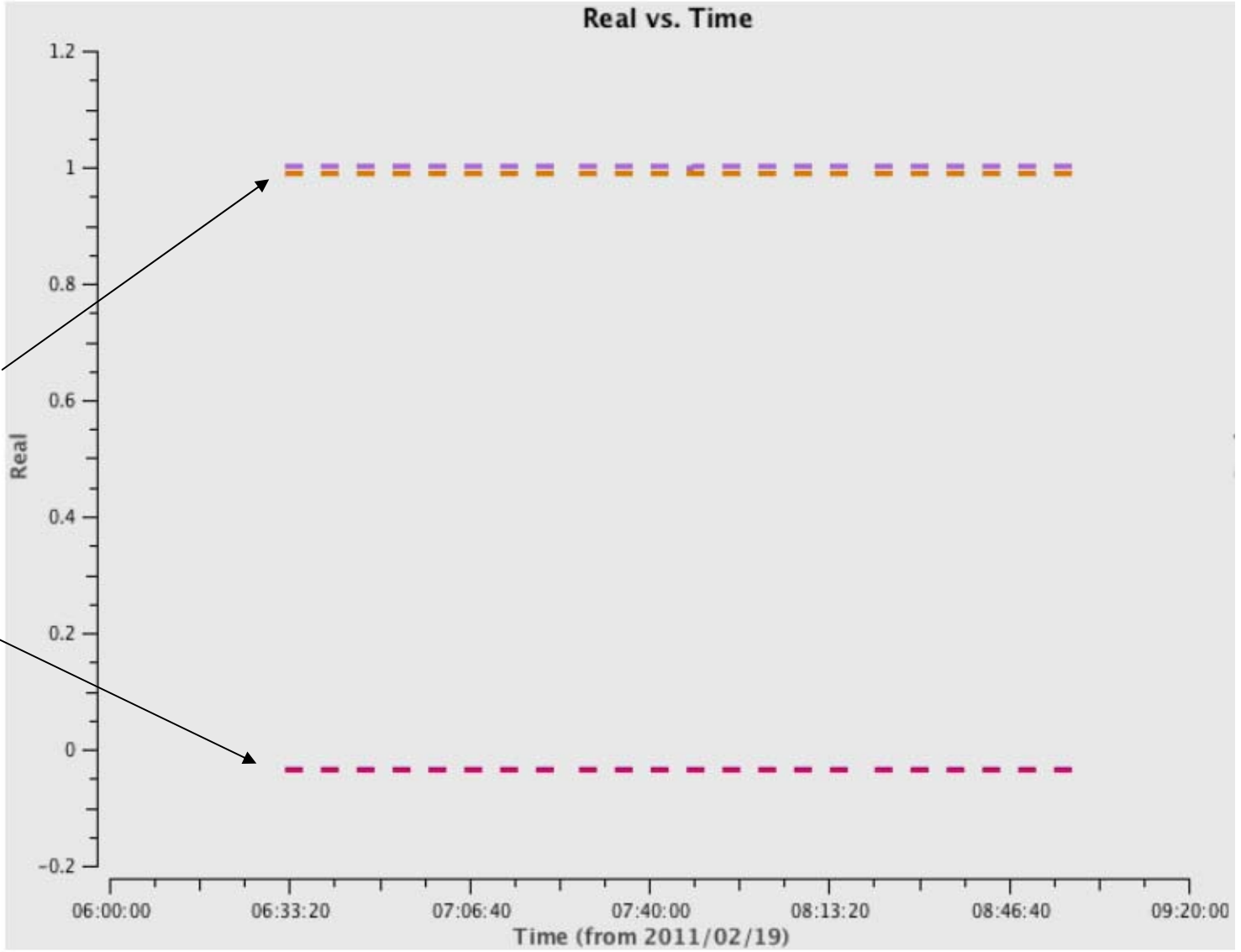
After solving for Delays and X-Y phase



Full solution

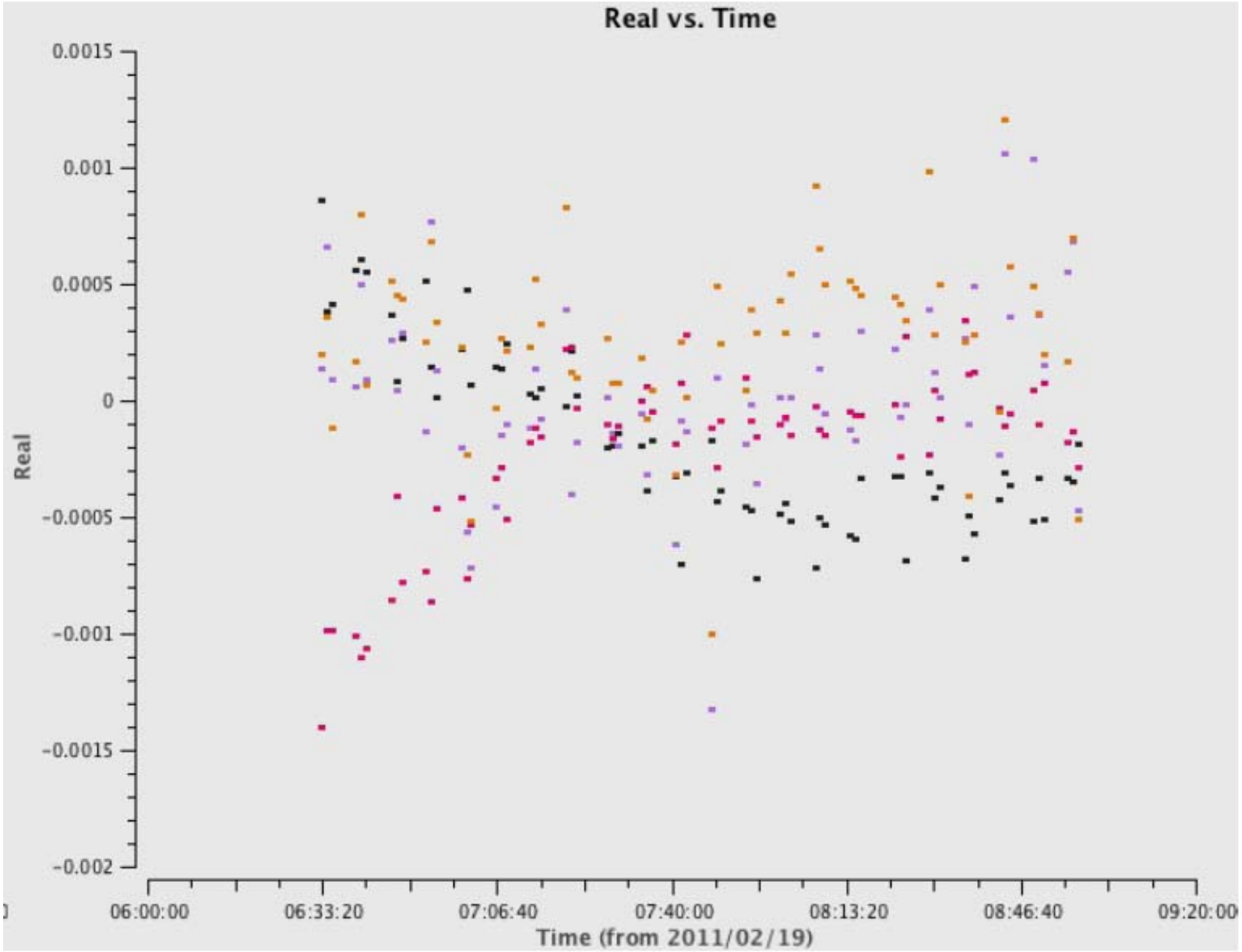
Co-hands

Cross-hands



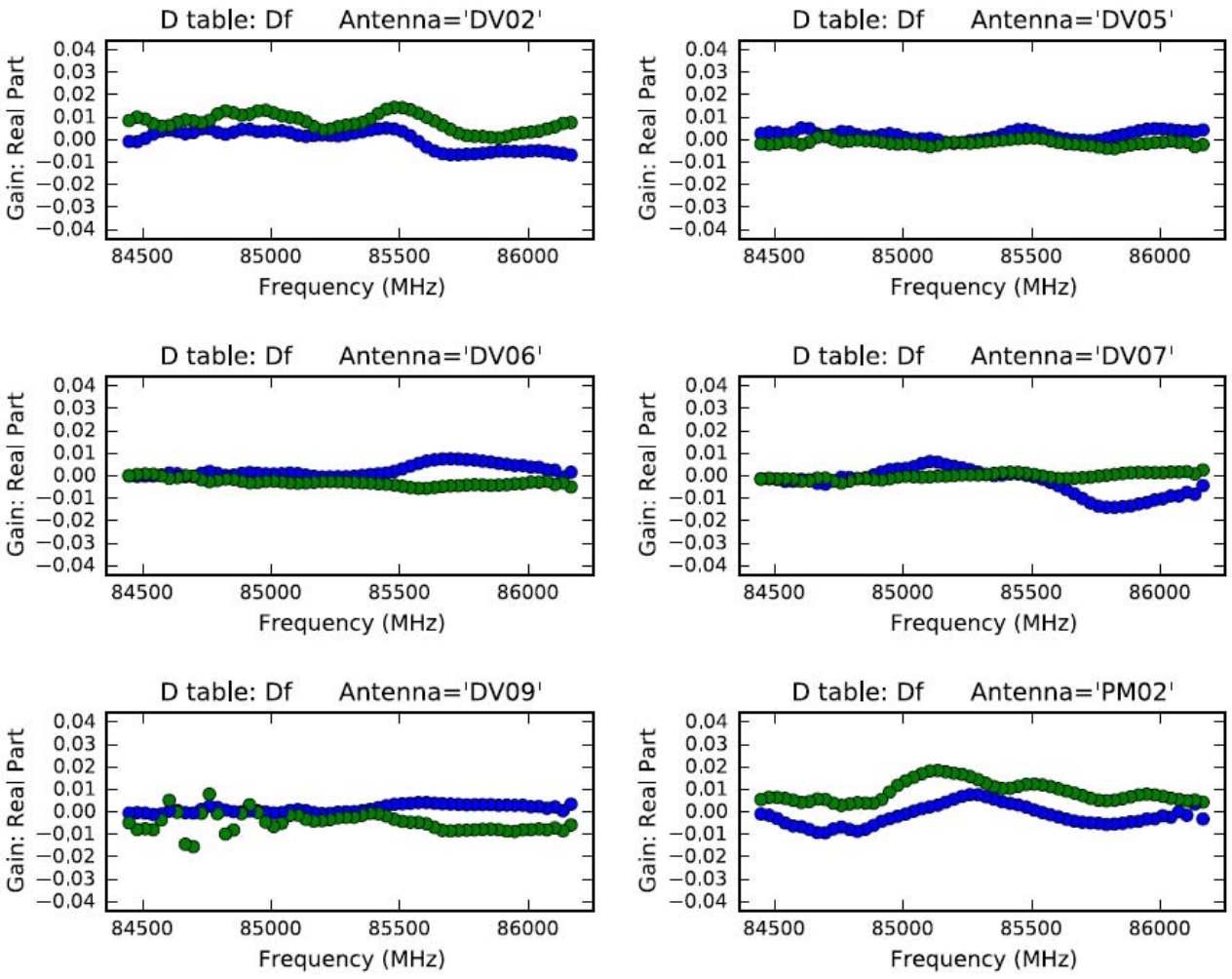

```
# X-Y phase = -33.9835 deg.
# Fractional Poln: Q = -0.00573286, U = 0.0306477; P = 0.0311793, X = 50.2975deg.
# Net (over baselines) instrumental polarization: -0.00106147
```

Residuals


Real vs. Time
Real
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
06:00:00
06:33:20
07:06:40
07:40:00
08:13:20
08:46:40
09:20:00
Time (from 2011/02/19)

BUT all this is the broad band average

Leakage as a function of frequency shows lots of structure



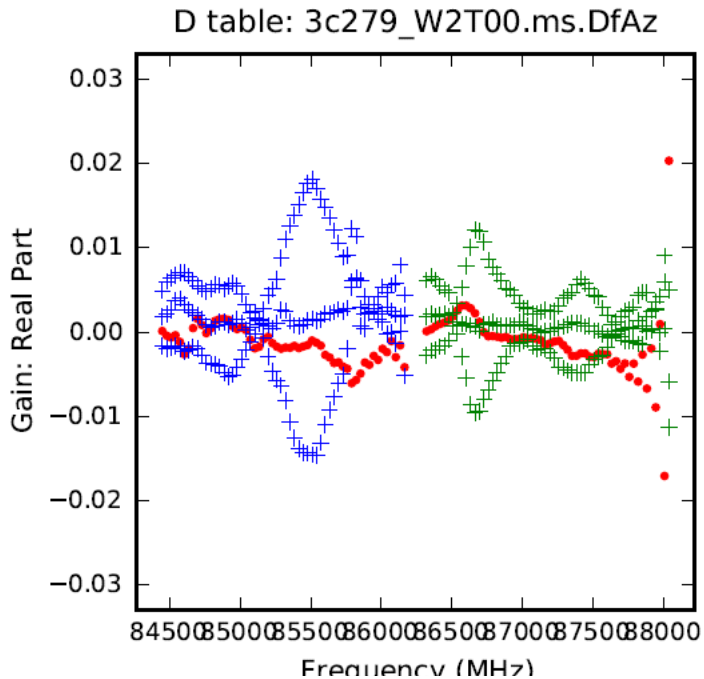
D Real vs. Freq

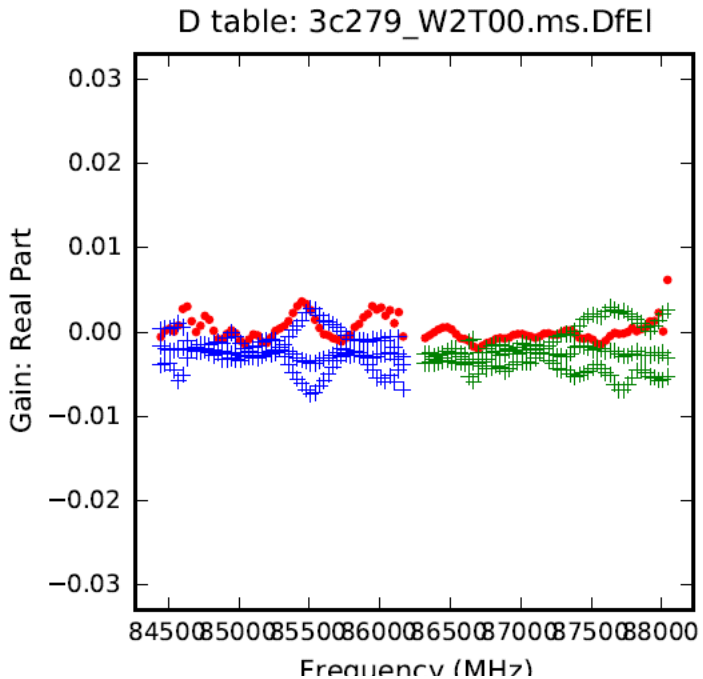
Bad news for spectro-polarimetry?

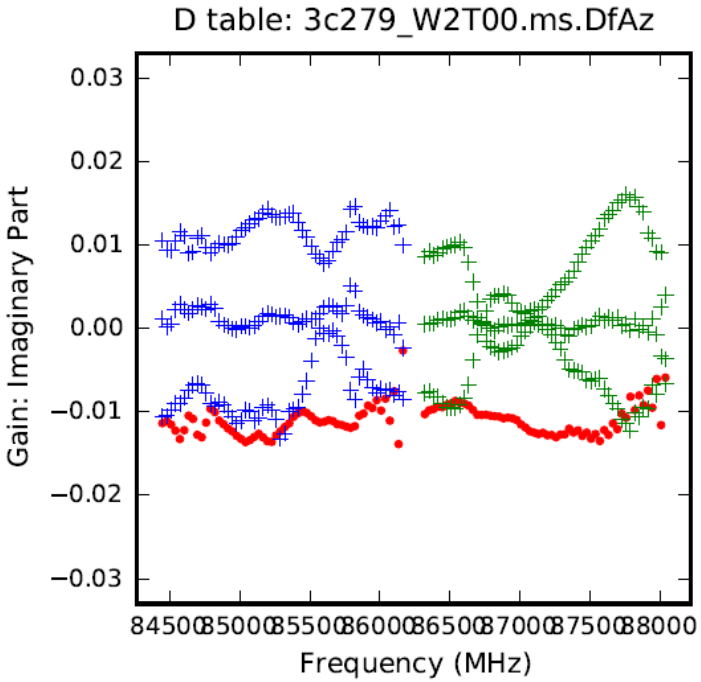
- This is very new – all within the past week.
- It is fixed with respect to RF not IF – strong evidence that it is “in front of” the mixers, e.g. in the optics.
- Appears to imply that there is multipath scattering that is coupling one polarization to another. Not just a simple ripple – many paths?
- It depends strongly but rather systematically on where the source is in the beam.
- It does appear to be reasonably stable with time.
- Characterizing it well enough to calibrate it out is going to be a major task and is only viable at all if it is stable to within the accuracy required.
- Multi-path effects were completely overlooked in the ALMA optics design and no testing is being done.

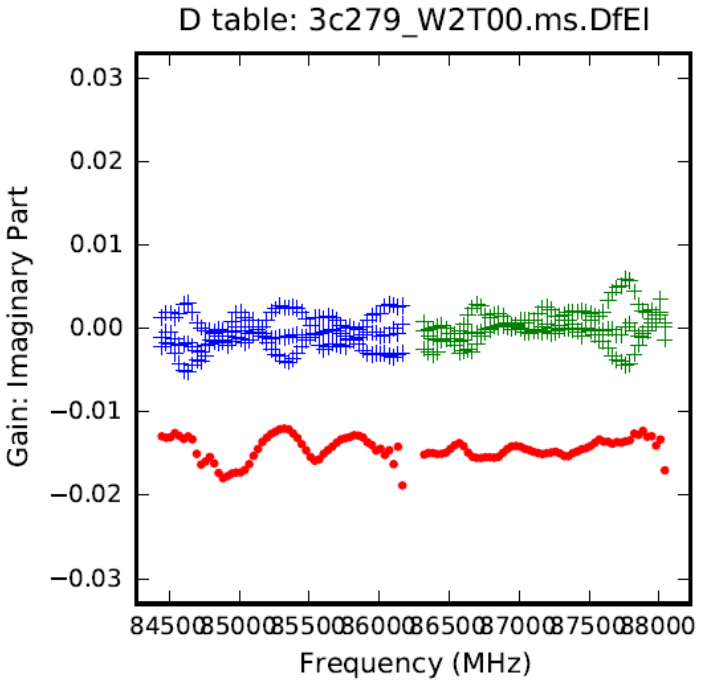
VERY QUICK solution for D-terms +/0/– 30” for one antenna over band of 4 GHz

Left Y pol move in AZ (worst)
Right X pol move in El (best)









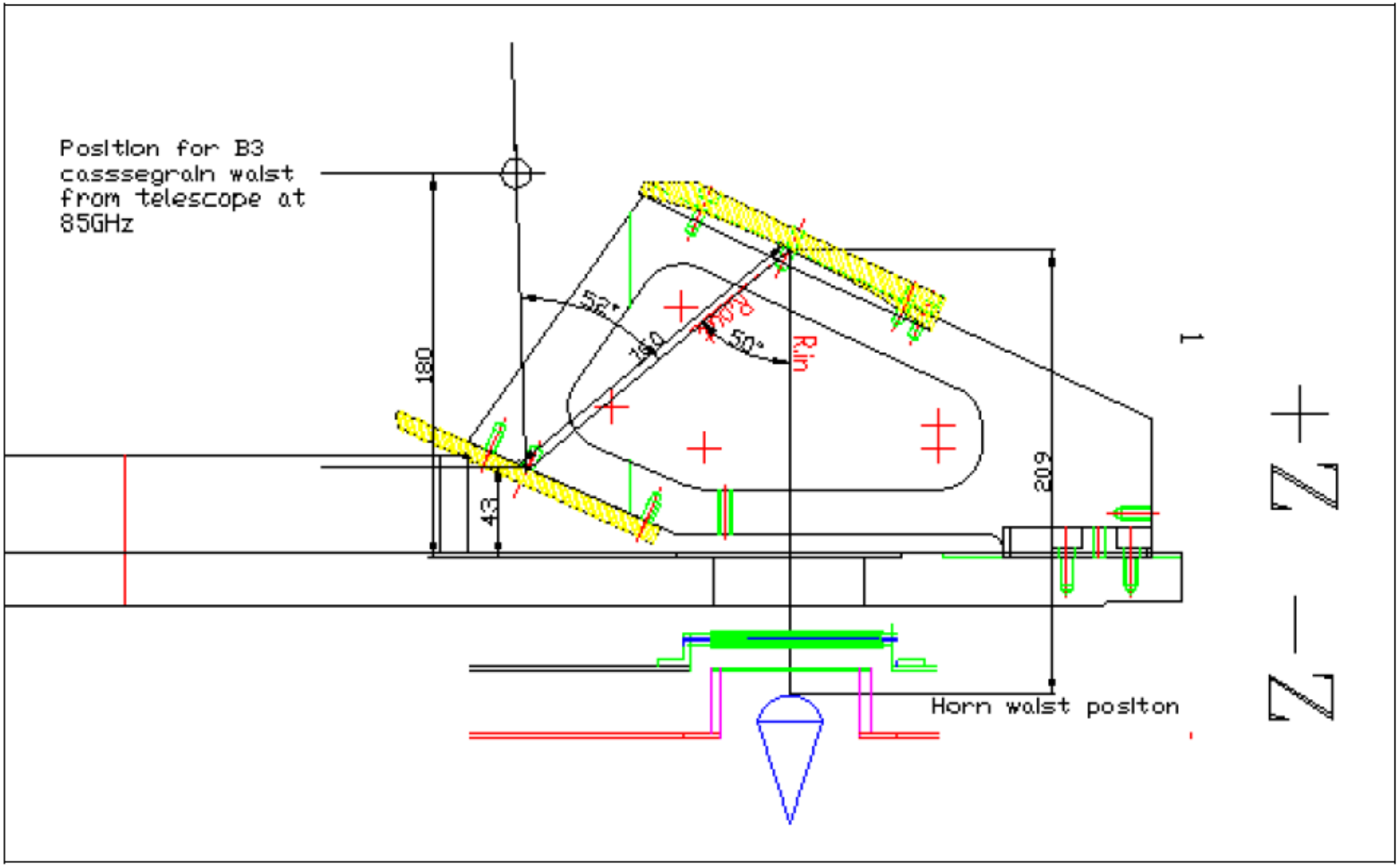


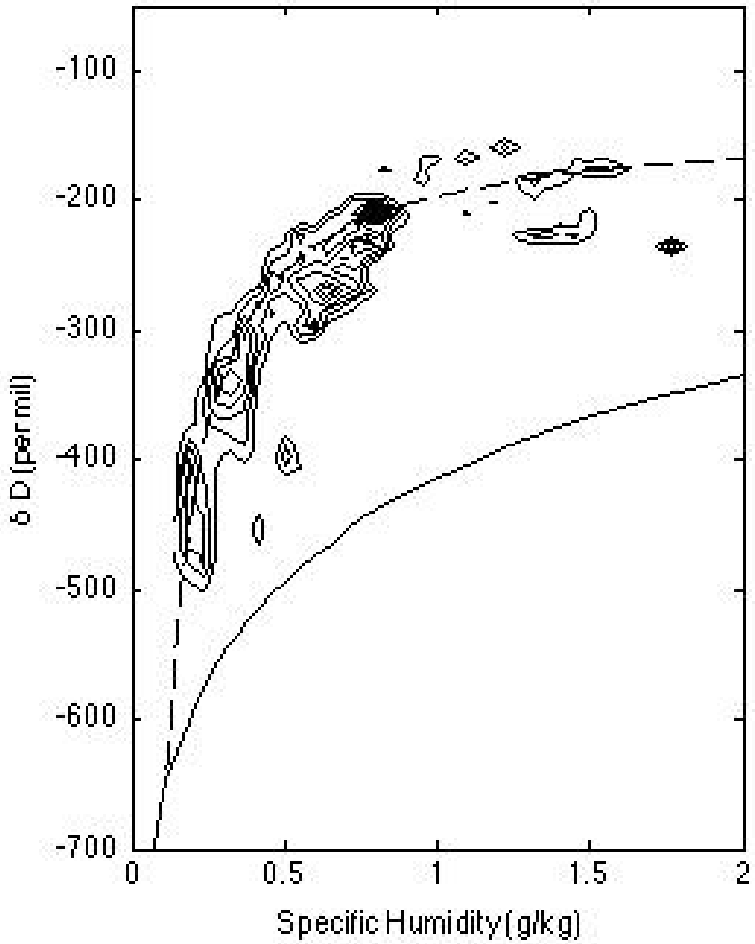
Figure 11: Band 3 schematic layout

Not to be forgotten

- Many other technical problems remain to be resolved.
- Probably the biggest is the astigmatism in the dishes. Values as high as 30 microns rms have been seen. We have now eliminated the holography system and misalignment of the subreflector as possible causes. The most plausible suggestion remaining is that a thermal effects. We could be putting in the correction for the know thermal deformations with the wrong sign or the deformation is highly non-linear with temperature.
- We also see that the phase errors increase with baseline even after correction for water vapour fluctuations. This is most likely to be the “dry component” of the atmospheric fluctuations and may set limits on phase stability under good conditions.

Interesting Item

- An experiment to monitor isotope abundance variations in the water vapour has asked if it could come to the ALMA site.
- Strong variations on HDO and $H_2{}^{18}O$ are due to “distillation” in the atmosphere.
- At first sight it looks as if the changes are significant for our model of the atmospheric absorption at some frequencies.
- Letter of support has been sent.
- Plan is to put is in central weather station.



Other Issues

- Continuing slippage of the deliveries. We now have 9 antennas at the high site. Prediction at the time of the last face-to-face meeting was 14.
- Antenna stations. Again the expectation was that we would have the central cluster and surrounding pads by now. Presently hoping to have NE quarter of central cluster by mid-March.
- Reliability continues to be a concern. The bad weather has show up quite a few weaknesses in the designs.
- Staffing. Present situation is (just) OK, although excessively complex. Significantly strengthened by NAOJ this year. Worry (from CSV point of view) is that several of the key people want to move into operations posts and others are likely to leave before we reach full operations.