



ALMA CHANGE REQUEST

Date submitted: 2008-02-30

CRE #: ALMA-40.00.00.00-122-A-CRE

TITLE: Pointing Errors arising in the Front End

(To be completed by CR Submitter/Initiator)

Description of change (detailed description of change proposed) and Justification:

The present version of the Front End specifications (ALMA-40.00.00.00-001-A18-SPE) places no restriction on the magnitude of pointing errors on the sky that could be caused by deformations taking place in the Front End. This CRE attempts to remedy this by adding a suitable set of requirements.

Proposed change of specifications. These should be inserted in section 4.3, Optics Requirements, as follows:

4.3.4. Pointing Errors

A lateral shift in the position of the beam at the focal plane causes an error in the pointing on the sky. To keep these pointing errors to an acceptable level, the lateral shifts in the beam position, arising from changes in elevation or azimuth, temperature changes or shocks occurring during antenna transport and earthquakes, are required to be within the limits given in the following sections. Note that the beam position should be taken to be the mean of those of the two polarization channels and that positions should be measured relative to the Receiver Mounting Flange where the FESS attaches to the antenna.

4.3.4.1 “Repeatable” movements of any of the beams must be less than 10mm. These are the movements which can be taken out by the standard pointing model, which means that they include only the deformations that it depend on just the current elevation and vary as a function of elevation in a way which matches relevant terms in the pointing models – i.e. the movements are proportional to a combination of sin and cosine of elevation only. *Question – do we have any terms like $\sin^2(\text{elevation})$?*

4.3.4.2 “Residual” movements of less than 0.35 mm rms (radial). This excludes the repeatable movements above, but includes all other deformations resulting from, but not during, operational antenna motions (elevation changes, fast-switching and raster scanning) and the allowed temperature changes in the receiver cabin, but not the shocks mentioned above.

4.3.4.3 “Short-term” movements of less than 0.10 mm rms (radial) due to temperature changes occurring within 15 minutes of time, elevation changes of up to 2 degrees and the forces resulting from, but not during, fast-switching motions.

4.3.4.4 “Differential” movements of less than 0.10 mm rms (radial) between the locations of the beams of any two receivers on all timescales. This includes movements due to all causes, other than the removal of cartridges from the cryostat.

Justification:

The ability to “point” the telescopes accurately is one of the most fundamental of the system requirements. The error budgets for pointing should include contributions from both the Antennas and the Front Ends since both are involved, but presently they do not. An earlier version of the Front End Specifications (1st Sept 2003) did contain the requirement:

“4.2.4. Pointing stability

[FEND-40.00.00.00-00190-00 / T]

Tipping of the Front End assembly from the zenith to the horizon shall result in an RF pointing change of less than 0.1 arc-seconds....”

This was however removed in subsequent versions for reasons which are unclear.

The overall pointing errors are as follows (see ALMA-34.00.00.00-006-A-SPE for details): “repeatable” 90 arcsec, “absolute” 2 arcsec RSS (radial) and “offset” 0.6 arcsec RSS (radial). Given that the Cassegrain focal length is 96 metres, the conversion to lateral motions in the focal plane (the “plate scale”) is 465 microns per arc second, so these figures correspond to 42mm, 0.93mm and 0.28mm. The present antenna designs take up essentially all of these error budgets – there is no margin that we can assign to the front ends. This means that in practice any contribution from the front ends will produce a loss of system performance relative to current expectations, so the best we can do is to try to set reasonable goals that will keep this loss to a minimum.

In practice the “repeatable” pointing errors are of no great significance – the original value was probably chosen to ensure that the terms to be fitted were not so large as to make second-order terms significant. Accordingly we can assign a soft requirement here. The value of 10mm proposed would increase the overall “repeatable” errors by ~25% (we have to assume that these front end errors will be completely correlated with those in the antenna). Any reasonable design will have much smaller deformations than this. Note however that, if different front-ends have deformations that are repeatable but differ from one front-end to another, the relevant terms in the pointing model will need to be re-determined after a change of front-end.

The “absolute” pointing errors are significant as they affect our ability to acquire sources when moving a new part of the sky, which ALMA is likely to do rather frequently. The loss of performance of performance is on observing efficiency rather than the quality of the data produced. The “residual” motions described above will contribute to the “absolute” pointing errors. They are again likely to be correlated with the equivalent errors arising in the antenna. If we assume a 50% correlation, the proposed value of 0.35mm will produce a 23% increase in the overall “absolute” pointing errors. *Whether or not this is acceptable is a point for discussion. Note there is a requirement on RF pointing of the antennas and we will have problems accepting them if there is a large and/or poorly known contribution from the front ends.*

Finally we have the “offset” pointing. The definitions above have been chosen to represent the two ways in which the observations will be made. In particular 4.3.4.3 relates to the case of making offset pointing measurements with the same receiver as is being used for science and 4.3.4.4 to the case where a different receiver is used. Offset pointing performance is critical for many aspects of data quality, including especially the quality of images made using mosaicing. The original value of 0.6 arc seconds was chosen after detail studies and clearly we have to try to keep any loss of performance here to a minimum. Making the perhaps optimistic assumption that any front end contributions would not be correlated with those arising in the antenna, we find that the proposed value of 0.10 mm (0.21 arc seconds on the sky) would produce a 6% increase in the overall offset pointing errors.

Additional information in attached documents:

Impact: X Specifications X Science Cost Schedule Safety Technical Other (specify):

Not yet clear whether cost and schedule will be impacted.

Description of impact:

The initial impact is that additional analysis needs to be made of test data that has already been taken. If this data is not of adequate quality then additional measurements will need to be made. If this analysis indicates that that the first or second front-end meets these requirements, then no further action will need to be taken apart from including these parameters in the test procedures. If the analysis shows that there are excessive deformations then appropriate investigations, probably involving both further measurements and engineering analysis, will have to be undertaken. In the worst case it may be necessary to modify the design of the cartridges and/or the cryostat to meet these requirements.

Affected products to be modified:

Possibly Front End Cartridges and/or Cryostat but, it is to be hoped, none.

Affected documents to be revised:

Front End Specification, Cryostat Specification and presumably the specifications of the individual cartridges. The System Specification should really be revised as well to reflect the consequences for the overall performance.

Remarks:

Obviously it is unfortunate that this has arisen at such a late date, but we cannot simply ignore this issue.

Date Submitted: 21st Feb 2008

Date Decision Required: ASAP

CRE Initiator: Richard Hills



ALMA CHANGE REQUEST SUMMARY STATEMENT

Date submitted: yyyy-mm-dd
CRE #: ALMA-00.00.00.00-000-A-CRE

Summary Statement for CRE # : ALMA-00.00.00.00-000-A-CRE

Summary of Technical Impact (state concerns and/or merit):

As a minimum some additional work to analyse test data is required as well as updating of documents. It is likely that additional tests will be required, together with analysis. Some changes to design may be necessary in the worst case.

Summary of Schedule Impact:

Not yet possible to estimate.

Summary of Budget Impact:

Not yet possible to estimate.

Remarks:

Name	Signature	Date	App	Rej	Name	Signature	Date	App	Rej
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	NRAO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	ESO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>	JAO CONTROLLER			<input type="checkbox"/>	<input type="checkbox"/>
IPT LEAD			<input type="checkbox"/>	<input type="checkbox"/>				<input type="checkbox"/>	<input type="checkbox"/>
SYSTEMS LEAD			<input type="checkbox"/>	<input type="checkbox"/>	CCB SECRETARY			<input type="checkbox"/>	<input type="checkbox"/>
SYSTEMS LEAD			<input type="checkbox"/>	<input type="checkbox"/>	JAO PROJECT DIRECTOR			<input type="checkbox"/>	<input type="checkbox"/>