



ALMA CHANGE REQUEST

Date submitted: 2009-08-07
Revised 2009-09-04
CRE #: ALMA-40.00.00.00-200-A-CRE

TITLE: Change the Band 6 Receiver Output IF range in the ALMA Front End Specifications Document

(To be completed by CR Submitter/Initiator)

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

Change the Band 6 IF range over which all specifications should be met

From: 4.5 – 10 GHz (should perhaps have been 4.3 – 10 GHz)

To: 6 – 10 GHz

The existing design fails to meet noise and output spectral power slope/variation requirement when used in the 4.3 – 6 GHz IF range.

1. Noise performance: The cold cartridge assembly (CCA) as well as the warm cartridge assembly (WCA) exhibit extra noise over the 4.3 – 6 GHz IF range. The overall performance specifications are not met in general for the CCA plus WCA combinations.

For the CCAs, the average noise over 4.3 – 10 GHz IF range does not meet specification. Even more significantly, the noise performance over 4.3 – 6 GHz is significantly worse than that over 6 – 10 GHz IF range. See [Figure 1](#) and [Figure 2](#).

For the WCAs, in some instances the average noise over the full 4.3 – 10 GHz might meet the required specification or only marginally miss it, yet the noise performance over 4.3 – 6 GHz IF range is significantly poorer. See [Figure 3](#) & [Figure 4](#).

2. Spectral gain/power¹ slope: The CCA is estimated to have a 6 dB gain slope over the 4 – 6 GHz IF range, if the best mixer pre-amps measured to date were to be used [[RD1](#)]. See [Figure 5](#). Actual cartridges have been measured to have a gain slope of about 10 dB over the 4 – 6 GHz IF range. Most of the sensitivity loss due to this poor slope could be corrected by incorporating external equalizers, for instance located in the BE IF processor. See [[RD2](#)].

Upgrading the existing CCA and WCA designs to be compliant (or screening for good performance) implies a significant negative impact on the production and delivery schedules. Approval of this change request will permit freezing the current designs for production.

A future upgrade could permit use of the region from 4 – 6 GHz by the following means: redesign of the cold IF amplifier, replacement of the IF hybrid, use of a balanced mixer design to eliminate LO sideband noise, and subsequently retrofitting all cartridges.

Referenced Documents:

[[RD1](#)] Band 6 Cartridge Gain Slope Analysis, [FEND-40.02.06.00-346-A-REP](#)

[[RD2](#)] An EVLA-like gain slope correction scheme for ALMA?, [FEND-40.00.00.00-192-A-MEM](#)

[[RD3](#)] Noise Temperature and Gain Slope Considerations for Band 6 Cartridge Operating over 4-12 GHz IF Band, [FEND-40.02.06.00-165-A-REP](#)

Additional information in attached documents:

None. Appropriate documents are already referenced above.

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

Description of impact:

Relaxation of specification as requested by this CRE would allow manufacture of the Band 6 CCA and the FE LO WCA using the current designs (positive impacts on cost and schedule). But this will have a negative impact on some use cases and the

¹ Although gain and power slope are distinct parameters and the specification is on the spectral power slope with 300 K source, the actual difference between the two quantities is small and measurement of gain slope adequately predicts the spectral power slope, at least for the purpose of this CRE.



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science impact should be studied as a part of the review of this CRE. An example use case involving eight spectral lines in the RF range of 219.560 – 230.538 GHz that could have benefitted from the availability of 4.3 – 6 GHz IF range is provided in Appendix-1 of [\[RD3\]](#).

It must also be noted that thus far the plan was for the Band 6 group to keep outputting power in the 4 – 12 GHz range (regardless of the official IF range) since it was thought to be useful for some observations. With this CRE the power outside the 6 – 10 GHz would be considered "out of band power" and the cartridge will probably miss the corresponding specification limiting the out of band IF power – and require a waiver, unless the cartridge design is altered - a negative cost and schedule hit!

Additionally, this will imply a change to the IF processor in the FETMS at the FEICs, if the in -band and out -of -band power requirements are to be verified by test.

Affected products to be modified:

“Frequency Band 6 Cartridge” (ALMA Product Tree # 40.02.06.00) and therefore the” Front End Assembly” (ALMA Product Tree # 40.00.00.00).

Affected documents to be revised:

1. Front-End Sub-System for the 12m Antenna Array – Technical Specifications, [ALMA-40.00.00.00-001-A-SPE](#); Section 3.3.2 in Table-4 under [FEND-40.00.00.00-00070-00 / R and Section 3.3.3, IF output port bandwidth and centre frequency, [FEND-40.00.00.00-0080-00 / R].

NOTE1: The Band 6 Cartridge Technical Specifications, [FEND-40.02.06.00-001-A-SPE](#) only requires the specification to be met over an IF range of 6 – 10 GHz, and there is no intent to revise this requirement in the CRE, [FEND-40.02.06.00-154-A-CRE](#), filed to update this document. So this document does not need to be revised, if this CRE is approved.

NOTE2: The Band 6 Warm Cartridge Assembly Technical Specifications, [FEND-40.10.06.00-001-C-SPE](#), and the ICD between the FELO and the cold cartridge, [FEND-40.02.06.00-40.10.06.00-C-ICD](#) specify a 10K/μW noise contribution from LO when integrated over the full IF band (without explicitly specifying it), and hence do not need to be modified, if this CRE is approved.

Remarks:

The proposed change was discussed and recommended for consideration by the NSF schedule review panel.

Date Submitted: 2009-08-07 Revised 2009-09-04

Date Decision Required: 2008-08-21

CRE Initiator: Kamaljeet S Saini



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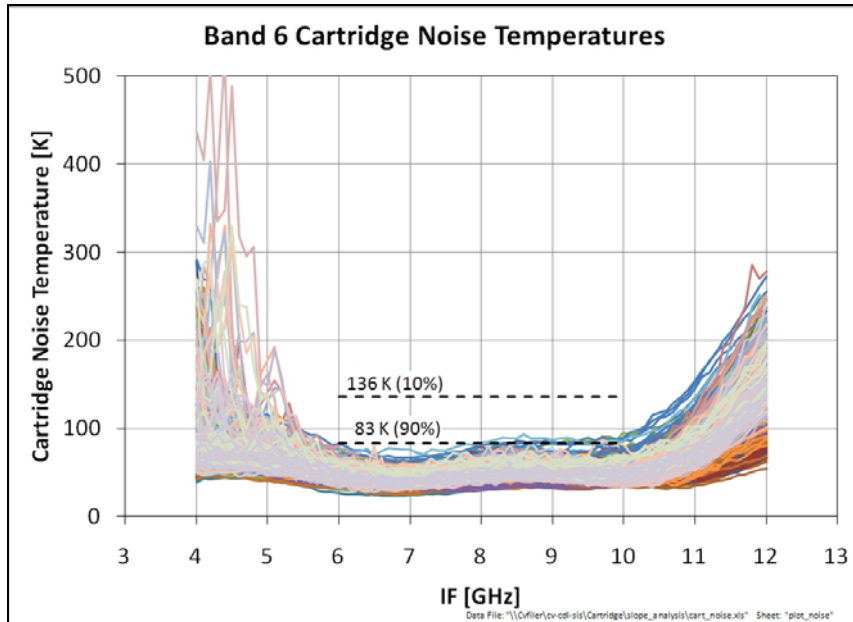


Figure 1: Band 6 Cartridge Noise Temperatures as a function IF frequency (for 22 different mixer-preamplifier pairs and for several LO settings). The dashed lines are the Band 6 cartridge noise specifications shown here for reference. (Note that, strictly speaking, the specifications are on the average noise over the full IF range and not as a function of IF frequency as shown).

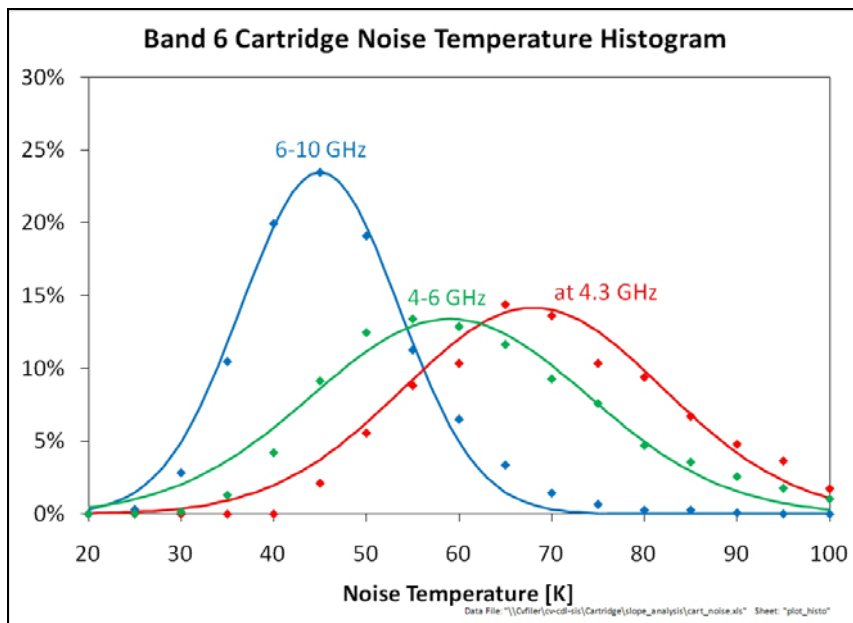


Figure 2: Histogram showing the distribution of mixer-preamplifier pairs based on their noise performance over 6 – 10 GHz IF range, over 4-6 GHz IF range, and at 4.3 GHz spot IF.



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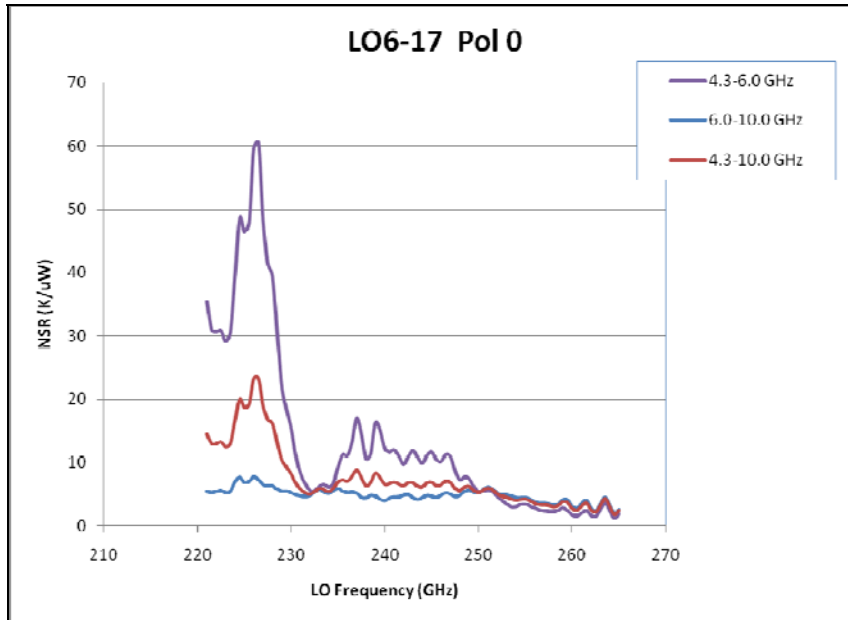


Figure 3: Noise performance of a Band 6 WCA for various scenarios - averaged over 6 - 10 GHz (meets specification), averaged over the full 4.3 - 10 GHz (meets specification except at the low end of the band) and averaged over 4.3 - 10 GHz showing how much poorer the performance is over the part of the IF.

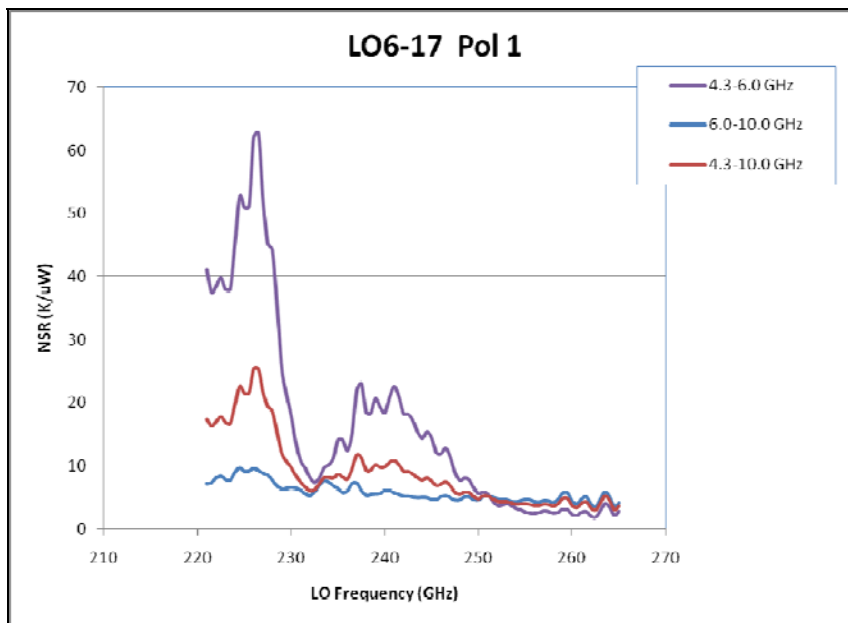


Figure 4: Noise performance of a Band 6 WCA for various scenarios - averaged over 6 - 10 GHz (meets specification), averaged over the full 4.3 - 10 GHz (meets specification except at the low end of the band) and averaged over 4.3 - 10 GHz showing how much poorer the performance is over the part of the IF.



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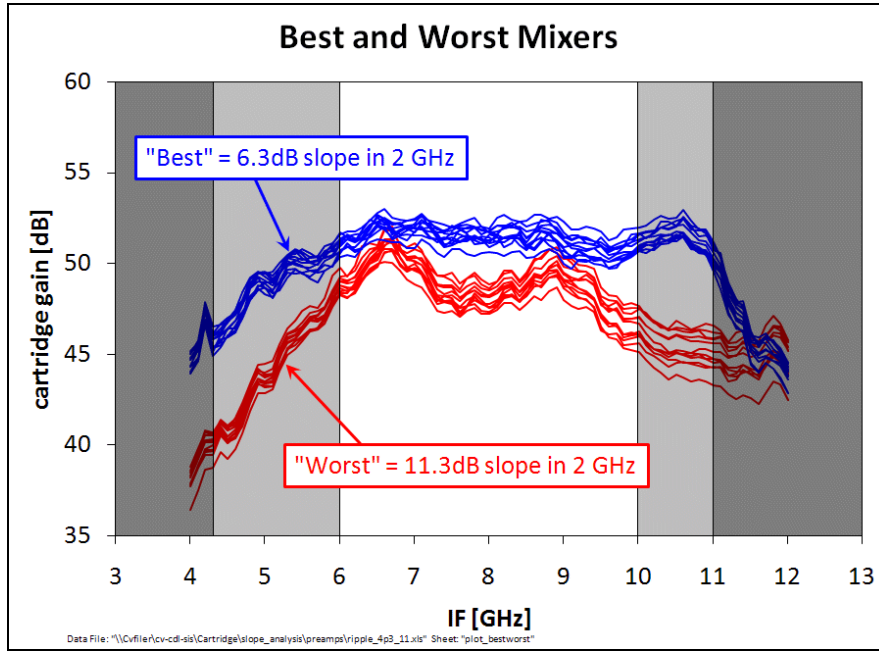


Figure 5: Predicted cartridge gain for the best and worst mixer-preamps measured to date.



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SUMMARY STATEMENT

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

Relaxation of specification as requested by this CRE would allow manufacture of the Band 6 CCA and the FE LO WCA using the current designs (positive impacts on cost and schedule). But this will have a negative impact on some use cases and the science impact should be studied as a part of the review of this CRE.

Upgrading the existing CCA and WCA designs to be compliant (or screening for good performance) implies a significant negative impact on the production and delivery schedules. Approval of this change request will permit freezing the current designs for production.

A future upgrade could permit use of the region from 4 – 6 GHz by the following means: redesign cold IF amplifier, replace IF hybrid, use balanced mixer design to eliminate LO sideband noise, retrofit all cartridges.

Summary of Schedule Impact:

Approving this change would help the Band 6 cartridge group and the FE IPT to meet the published schedule.

It must be noted however that thus far the plan was for the Band 6 group to keep outputting power in the 4 – 12 GHz range (regardless of the official IF range) since it was thought to be useful for some observations. With this CRE the power outside the 6 – 10 GHz would be considered "out of band power" and the cartridge will probably miss the corresponding specification limiting the out of band IF power – and require a waiver, unless the cartridge design is altered - a negative cost and schedule hit! Additionally, this will imply a change to the IF processor in the FETMS at the FEICs, if the in -band and out -of -band power requirements are to be verified by test.

Summary of Budget Impact:

Approving this change could have some budgetary impact. See explanation above. Disallowing will have both budgetary and schedule impact.

Remarks:

The proposed change was discussed and recommended for consideration by the NSF schedule review panel.

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"/>