

ALMA Receiver Optics Design Workshop

Tucson, 25–29 September 2000

Attendees: Andrey Baryshev (*SRON*), Matt Carter (*IRAM*), Larry D’Addario (*NRAO*), Brian Ellison (*RAL*), Wes Grammer (*NRAO*), Yutaro Sekimoto (*NRO*), James Lamb (*Caltech*). John Payne (*NRAO*) and Darrel Emerson (*NRAO*) attended for review.

Summary

Following a recommendation at the JRDG meeting in Cambridge (7–8 September 2000) a working group was set up to produce an optical layout design for the ALMA receivers. The design documents produced by several groups were reviewed in the light of the clarification of the requirements for the receiver to come up with a final design taking these into account. The meeting started by itemizing the design constraints and goals as noted below. Several decisions resulted from the design work carried out at the meeting, essentially defining the receiver layout. Areas that could not be resolved at the meeting were identified and resulted in action items listed at the end of this document.

At the conclusion of the meeting a clear layout for the dewar and optics was achieved. Three different styles for the bands satisfy most of the goals and requirements. **Style A:** Bands 1 and 2 have cooled feed horns and ambient lenses. **Style B:** Bands 3 and 4 (and possibly Band 5) will have cooled lenses plus two ambient mirrors. **Style C:** Bands 5–10 (possibly not Band 5) will have cooled feed horns plus cooled reflective optics. Further work is required to fully characterize the performance of the designs and determine whether Bands 4 and 5 will be Style B or C.

The major difficulty was to try to meet a goal of 1 % beam squint between the left- and right-circular beams. All of the solutions that were consistent with the other goals typically resulted in a squint of 4–5 %. While every effort will be made to reduce this as the design proceeds it is not likely to approach 1 %.

Further design work has been identified and when this has been completed a comprehensive design document will be issued. This will include the geometry, performance, and tolerances.

Design Procedure/Objectives

1. Practical Goals

- Receivers interchangeable between antennas (no on site alignment)
 - Optics part of Rx — Fixed alignment between optics and dewar
 - Antenna mounting flange should be preset within tolerances
- Cartridges interchangeable between dewars with no re-alignment required
- Alignment sensitivity to thermal contraction minimized
- Alignment insensitive to dewar deflections under vacuum
- Alignment ensured by machining
- Optics in cartridge where practical
- Optics cold where practical
- No moving parts
- Flexible for future upgrades/clearly defined interfaces
- Standardize designs among bands
- Maximize reliability
- Minimize costs

2. Performance Related Goals

- Minimize window apertures (IR loading, RF loss minimized)
- Horn aperture less than 10 wavelengths
- Minimize added noise
- Maximize aperture efficiency: Reduction < 5 %
 - Aberrations < 1 %
 - Truncation loss < 1 %
 - Dissipative losses < 1 %
 - Scattering losses < 1 %
 - Polarization loss < 1 %
- Polarization: Beam squint < 1 % of FWHM

Design Decisions

- 3 styles of band design
 - Preferred
 - . Style A: Bands 1, 2
 - . Style B: Bands 3, 4
 - . Style C: Bands 5–10
 - Alternative (depending on other design constraints)
 - . Style A: Bands 1, 2
 - . Style B: Bands 3–5
 - . Style C: Bands 6–10
- Style A: Cold horn, warm lenses
- Style B: Cold horn, cold optics on cartridge, warm optics
- Style C: Cold feeds (corrugated horn or planar) and optics on cartridge
- Cartridge optical interface not constrained to be at center of cartridge
- WVR pickoff mirror on axis
- Use lenses as vacuum seals for Style A
- Two cartridge diameters:
 - 120 mm for Bands 3, 4
 - 170 mm for other bands
- Optics attached to dewar (not antenna)
- All receivers operating with nominally linear polarization

Action Items

1. Widgets above dewar (particularly ambient temperature load)
 - What widgets
 - Geometry
 - Specifications
 - *Payne and Wild*: To be defined and assigned by 2000-10-16
2. Polarization
 - Tolerances within one antenna
 - Matching antennas
 - *D'Addario*: Draft document by 2000-10-16
3. Dewar deflections
 - Effect on optical alignment
 - *Ellison*: 2000-10-27
4. Tolerances
 - Dewar w.r.t. antenna
 - Warm optics relative to cartridges
 - Cartridges relative to dewar
 - *Carter*: 2000-10-27
5. Analysis of optical performance
 - Aberrations
 - Truncation/Spillover
 - Losses
 - Polarization
 - *Lamb, Carter, Baryshev, Grammer, Sekimoto*: 2000-11-10
6. Interaction of optics aberrations with aberrations of chopping secondary
 - *Lamb*: 2000-10-27
7. Baseline design for each Style
 - *Carter, Baryshev, Grammer, Sekimoto*: 2000-11-10
8. IR filters and windows: Define work packages
 - *Payne and Wild*: 2000-10-16

JWL
OVRO
2000-10-02