HIRDLS

TC-LOC-140

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originator: Howard E. Morrow Date: 98-06-15

Subject/Title: **Optical Tolerance Budget**

Description/Summary/Contents:

1. Establishes the Optical tolerance budget for element fabrication and alignment.
2. Alignment method is described in detail, and is part of the tolerance budget.
3. Fabrication, installation and alignment is simulated using a Monte-Carlo method.
4. Numerous performance analyses are carried out on the aligned, perturbed prescriptions.

Keywords:

Purpose of this Document:
(20 char max.)

Reviewed/Approved by: Date (yy-mm-dd):			

Advanced Technology Center, CAGE Code 65113
Lockheed Martin Missiles & Space
3251 Hanover Street
Palo Alto, CA 94304-1191
United States of America

EOS

Table of Contents

1.0 Scope and Purpose 6
2.0 Related Documents 6
3.0 Definitions and Acronyms 6
4.0 Approach to Imager Tolerance Budget 6
4.1 Introduction 6
4.2 Monte-Carlo testing of the imager optics tolerance budget. 7
4.2.1 Initial tolerance budget 7
4.2.2 Monte-Carlo flow plan 7
4.2.3 Perturbation suite 7
4.2.4 Alignment suite 8
4.2.5 Performance suite 8
4.2.6 Randomly applying a tolerance to a parameter 8
4.2.7 Surface figure errors 9
4.2.8 Alignment versus installation 10
4.3 Element Fabrication tolerances (imager path only) 11
4.3.1 Scan Mirror 11
4.3.2 Primary Diffraction Baffle (PDB) 11
4.3.3 Primary Mirror 11
4.3.4 Field Stop 1 (FS1) 11
4.3.5 Secondary Mirror 11
4.3.6 Intermediate Lyot Stop (ILS) 11
4.3.7 Field Stop 2 (FS2) 12
4.3.8 Warm filters 12
4.3.9 Germanium lens L1 12
4.3.10 Fold flat 12
4.3.11 System Aperture Stop (SAS) 12
4.3.12 Germanium Lens L2 13
4.3.13 ZnSe Vacuum Window 13
4.3.14 Cold Filters 13
4.3.15 Detectors 13
4.4 Element location tolerances (imager path only) 14

4.4.1 Scan Mirror 15
4.4.2 PDB 15
4.4.3 Primary 15
4.4.4 FS1 15
4.5 Alignment procedure and tolerances (imager path only) 17
4.5.1 Input collimated alignment beam 17
4.5.2 Primary mirror angular adjustment 17
4.5.3 Primary mirror offset adjustment 17
4.5.4 Secondary mirror adjustment in 5 DOF 17
4.5.5 Centering the ILS 18
4.5.6 Angular adjustment of the fold mirror 18
4.5.7 Alignment of the relay section to the Telescope 18
4.5.8 Alignment of FS2 and the Warm Filter Assembly 18
4.5.9 Alignment of the Dewar Assembly 18
5.0 Performance analyses (Imager) 18
5.1 Field and Pupil Alignment 19
5.1.1 Alignment of Infinity on FS1 19
5.1.2 Alignment of the PDB on the ILS 20
5.1.3 Alignment of FS1 on FS2 21
5.1.4 Alignment of Infinity on FS2 22
5.1.5 Alignment of the ILS on the SAS 23
5.1.6 Alignment of FS2 on the Detector 24
5.1.7 Alignment of Infinity on the Detector 25
5.1.7 LOS error at the PDB 26
5.2 First Order Characteristics 26
5.2.1 Aperture Area 27
5.2.2 Focal lengths and Relay magnification 28
5.3 Diffraction-based Performance 28
5.3.1 Wavefront Error and MTF 29
5.3.2 Vertical Response 30

Table of Figures and Tables

Figure 4.2.6-1 Example of a valley-shaped distribution of random numbers 9
Figure 4.2.7-1 Primary mirror deformed by Zernike polynomials 10
Table 4.4-1 Installation tolerances, Imager path 14

1.0 Scope and Purpose

This TC presents the tolerance budget for the element fabrication, installation, and alignment of the HIRDLS optical subsystem.

For the imager, the tolerance budget has been performance tested using a Monte-Carlo method described herein, and the results are summarized.

A much simpler approach was taken for the calibration path and the space view path. The tolerances for these paths are included in a separate chapter.

2.0 Related Documents

3.0 Definitions and Acronyms

4.0 Approach to Imager Tolerance Budget

4.1 Introduction

The imager path uniquely requires diffraction limited wavefront performance. The classical approach to establishing a tolerance budget for diffraction limited imagers is to construct a “Wavefront Error Tree” wherein a RMS wavefront error is assigned to each perturbation (such as element figure error, or displacement error), and all the individual RMS errors are mathematically combined to a final RMS wavefront error. This is a fairly simple approach, even when such error trees are extensively detailed.

For the HIRDLS imager however, the driving wavefront-related performance parameter is Vertical Response, not wavefront error. There is no well established method to derive the wavefront error from Vertical Response or vice-versa. In addition, since the imager is a relay system with three real pupils (PDB, ILS, and SAS), and three real fields (FS1, FS2, and detectors) all of which must be overlaid in aligned conjugation, there is also alignment and magnification performance which must be tracked. Magnification depends upon first-order errors, such as focal length and placement errors, and is not accounted for in a WFE tree.

Finally, it would be futile to expect that the optical elements could be simply laid in place without optical alignment and get satisfactory performance in all arenas. It is alignment which keeps tolerance values from becoming too tight. The alignment strategy must be an integrated part of the tolerance analysis, and alignment errors must be part of the tolerance error budget.

4.2 Monte-Carlo testing of the imager optics tolerance budget.

4.2.1 Initial tolerance budget

Over the course of several months, an initial error budget was negotiated with the optics vendor, Sensor Systems Group. Every degree of freedom of element fabrication and installation was considered, often calling on the experience of optics fabrication and test technicians, as well as opto-mechanical engineers. As a part of the process, a detailed alignment plan was evolved over the course of the effort, and alignment uncertainty (or tolerance) was set for each alignment degree of freedom.

As a result of testing the tolerance budget by a Monte-Carlo method, certain of the initial tolerances were refined to form the final tolerance budget described later in this report.

4.2.2 Monte-Carlo flow plan

The Monte-Carlo process consists of three suites of OPTIMA Macro programs written expressly for the HIRDLS imager. Starting with a pristine optical prescription of the imager which includes all the details of all the channels and filters, the suites of macros perform the following tasks:

Perturbation suite:	Creates a prescription where every parameter is perturbed
Alignment suite:	Simulates the imager alignment, with errors
Performance suite:	Tests the aligned & perturbed prescriptions for performance

Both the perturbation and alignment suite apply randomized errors to the nominal parameters. In practice, the three suites of macros are used to produce a set of 20 perturbed and aligned prescriptions so that statistics of the various measures of performance can be extracted. (As these are large prescription files, no more than 20 perturbed prescriptions will fit into the lens library.)

4.2.3 Perturbation suite

The perturbation suite is controlled by the macro named TOLSET, which calls 11 subsequent macros each of which performs a certain type of perturbation task.

Macro TOLSET (Creates perturbed imagers)

Gets unperturbed imager		Lean version for set up tolerancing
Call	FABTEL	Telescope element fabrication errors
	FABLEN	Relay element fabrication errors
	FABFLT	Filter fabrication errors
	FABDET	Detector narrow dimension & height error
	FIGSCN	Scan mirror figure error
	FIGPRI	Primary mirror figure error
	FIGSEC	Secondary mirror figure error
	FIGL1	Germanium lens L1 equivalent figure error
	FIGL2	Ge lens L2 equivalent figure error
	LOCTEL	Telescope element installation errors
	LOCLEN	Relay element installation errors
Store perturbed imager		Using a contiguous block in lens library

TOLSET can be repeated until up to 20 perturbed imagers have been created and stored.

4.2.4 Alignment suite

The alignment suite is controlled by the macro named ALINEM, which calls 8 subsequent macros each of which performs a specific alignment task.

Macro ALINEM (Aligns the perturbed imagers)

Get a perturbed imager		Created using TOLSET
Call	COLPDB	Aligns “Collimator” to PDB, with errors
	ANGPRI	Tilts primary for best image, with errors
	OFFPRI	Puts best primary image in FS1 center, with errors
	ADJSEC	Secondary adjustment, FS1 on FS2, with errors
	SETILS	Adjusts ILS onto PDB image, with errors
	DOFOLD	Tilts Fold mirror, ILS image on SAS, with errors
	INTEG	Centers & squares relay to telescope, with errors
	FINFOC	Fine focus and center of detector, with errors
Store aligned perturbed imager, repeat until done		

4.2.5 Performance suite

The performance suite is controlled by the macro named CHEKEM, which calls 11 subsequent macros each of which performs a certain performance check.

Macro CHEKEM (Analyses the perturbed imagers)

Get each perturbed imager		Created by TOLSET, aligned by ALINEM
Call	INFFS1	Quality/alignment of infinity in FS1
	PDBILS	Alignment/margin of PDB image on ILS
	FS1FS2	Alignment of image of FS1 on FS2
	INFFS2	Quality/alignment of infinity in FS2
	ILSSAS	Alignment/margin of image of ILS on SAS
	FS2DET	Alignment and quality of image of FS2 on Detector
	INFDET	Alignment and geometric quality of infinity on detector
	FIRSTA	Major First-order properties of full imager system
	FIRSTB	More 1-st order properties, lens EFLs
	MTFDET	WFE and MTF image performance
	VRPCH,n	Vertical Response required data for selected Channel n (Run VRPCH for as many Channels as necessary)

As a matter of practice a pristine (unperturbed) imager prescription is analysed by the CHEKEM suite as a reference check.

4.2.6 Randomly applying a tolerance to a parameter

The tolerance values t for each parameter are listed in the macro which applies the error. The routines add a value (N*t) to the parameter to introduce perturbations to the prescription. N is a random number where $-1<N<+1$.

There is a random number generator available which supplies evenly distributed random numbers N from -1 to+1. However, the user has the option to raise the random number to a power (while retaining its sign) which has the useful effect of redistributing the values over the interval. In a so-called pessimistic distribution, values near zero almost never occur: the distribution is valley-shaped. An example of such a distribution is given in figure 4.2.6-1 below. The plot also shows the normalized integration of the distribution.

In the plot, the “distribution factor” of 0.2 is typical of that used for the imager tolerances. If the factor approaches unity, the distribution becomes flat (uniform); approaching zero, the distribution becomes steeper and approaches ±1.0.

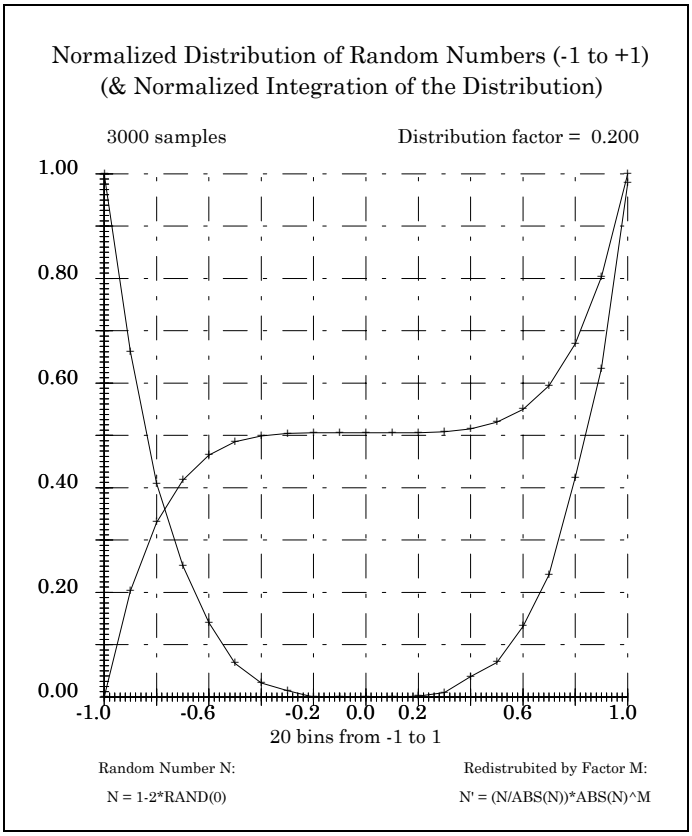

Figure 4.2.6-1 Example of a valley-shaped distribution of random numbers

With the singular exception of certain parameters on the germanium lens L1, all the tolerances have been applied symmetrically, i.e., the distribution of the tolerance multipliers N are symmetric around zero. The L1 tolerances are explained in paragraph 4.3.9 below.

4.2.7 Surface figure errors

Figure errors are the deviation from the mathematically perfect shape specified on optical surfaces by the pristine prescription. For the imager tolerance budget, figure errors were applied to each significant surface by judicious use of Zernike coefficients. Figure errors were modeled for these 5 surfaces: scan mirror, primary and secondary mirrors, L1 and L2. All the other surfaces were judged not to need such modeling because their figure errors are not going to contribute enough to the overall wavefront error.

The figure error macros use a clever algorithm which computes the RMS deviation from a plane of a Zernike surface given the coefficients. After the user selects the maximum polynomial order of Zernike terms to apply, the program randomly modifies the coefficients, computes an interim RMS deviation, then scales all the coefficients to attain

the target RMS deformation specified in the tolerance budget. Thus the *full* RMS surface figure error is always applied, but in a different detailed form for each surface, and different each time the lens is perturbed.

An example is shown in figure 4.2.7-1 for the primary mirror. The vertical scale is in millimeters (±.0005 mm full scale). This is a fourth-order deformation using 14 coefficients. The RMS deformation is .057 microns.

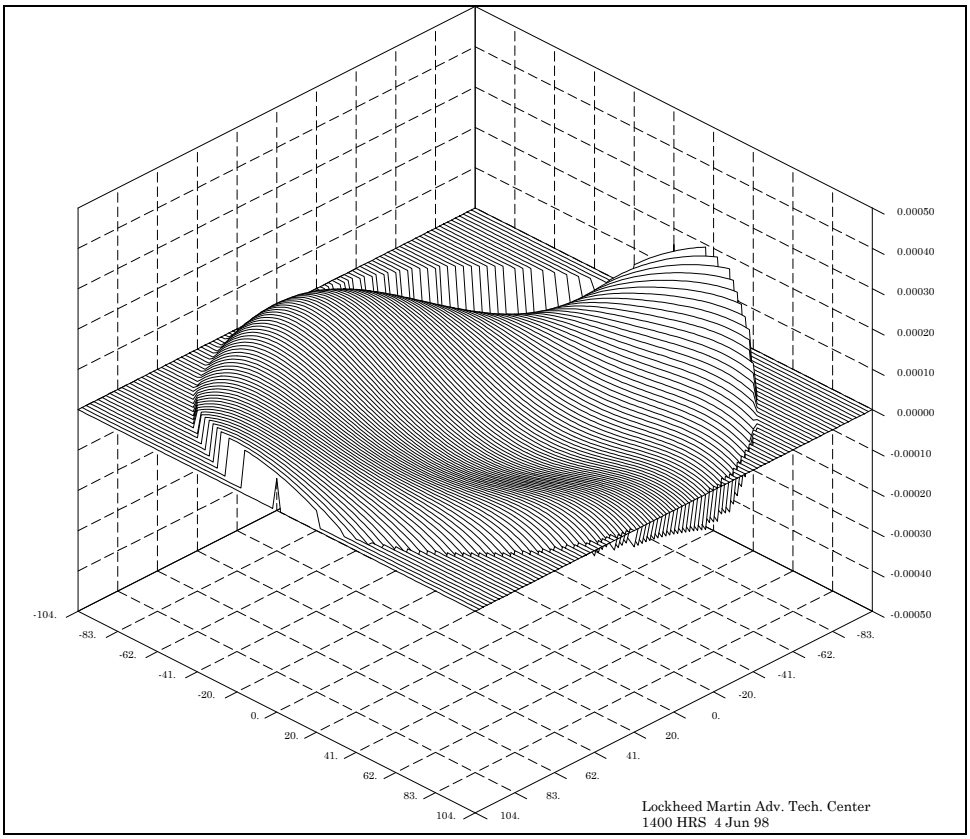

Figure 4.2.7-1 Primary mirror deformed by Zernike polynomials

All optical figure errors specified are to apply to the element after mounting in the instrument, and in the worst-case operational environment (usually thermal gradient).

4.2.8 Alignment versus installation

The *installation* tolerance is specified with up to 6 degrees of freedom for an element. All element locations are assumed to be in IRCF global coordinates, and so the errors in location are all independent of one another. The vendor is free to choose any method to verify element location. Purely mechanical methods, e.g., a Coordinate Measuring Machine (CMM), as well as optical methods can be used. However, the intent is not to *require* optical alignment when specifying installation tolerance.

Optical *alignment* means that an element or group is adjusted after installation using one or more precisely defined optical beams until some observable criterion is achieved, even if this results in displacing the element or group outside an initial installation tolerance.

4.3 Element Fabrication tolerances (imager path only)

These tolerances are intended to include only those errors which would be introduced in the optics fabrication shop. Such errors can be measured on the elements in isolation, and exclude anything to do with grouping of the elements in a train.

All mechanical aperture tolerances have been left up to the vendor and are not specified in this budget. The vendor is free to choose precision mechanical diameters to control location tolerance, or some other method not requiring precision diameter control.

Elements for the other paths are covered in paragraph xx.xx.xx.

4.3.1 Scan Mirror

Surface figure ≤ ¼ wave pk to pk at .6328 μm.

This has been modeled only as randomly rotated "saddle error" (astigmatism). The amplitude of saddle is randomly applied with very pessimistic distribution (power = 0.1).

4.3.2 Primary Diffraction Baffle (PDB)

Radius of the aperture tolerance ≤ .050 mm. (±.100 mm on the inner diameter).

4.3.3 Primary Mirror

Radius of curvature ± 1.0 mm.
Conic Constant ± .001.
Vertex offset ± .085 mm.
(Distance from the mechanical center to the vertex; applied to both x and y offset)
Surface figure ≤ .057 microns RMS.

Surface figure is based on the following components (.6328 μm test wavelength), and assumes that RMS ≈ (pk-to-pk)/4:

Shop figure .25 λ pk-pk	→	.0000396 mm RMS
G-release .167 λ pk-pk	→	.0000264 mm RMS
Bimetallic .200 λ pk-pk	→	.0000316 mm RMS
RSS total	→	.0000572 mm RMS

4.3.4 Field Stop 1 (FS1)

Square aperture tolerance is ≤ .025 mm.

4.3.5 Secondary Mirror

Radius and Conic tolerance values are not used. Neither can *unique* radius and conic tolerance values be derived from the quantities given here:

Separation of foci = 260 ± .500 mm.
Vertex to near focus = 130 ± .600 mm.
Vertex offset ± .085 mm.
(Distance from the mechanical center to the vertex; applied only to local y offset)

4.3.6 Intermediate Lyot Stop (ILS)

Radius of the aperture tolerance ≤ .040 mm. (±.080 mm on the diameter).

4.3.7 Field Stop 2 (FS2)

FS2 masks are not modeled with tolerances in the Monte Carlo simulations. Rather, it is intended to compute and fabricate a custom aperture mask based on measured values for the actual Cold Filter Array and relay magnification. The tolerances to be applied to mask fabrication are:

Aperture corner locations ± .020 mm.
Angles ± 30 arcsecs.
Radius in corners ≤ .130 mm.

4.3.8 Warm filters

Thickness ±.075 mm.
Wedge ≤ 40 arcsecs.
Figure (flatness) ≤ .7 λ RMS (visible), each side.

4.3.9 Germanium lens L1

Radius 1 is on the warm filter side. (Note asymmetric tolerances!)

Radius of curvature (side 1),-.076, +0 mm. (More concave only!)
Radius of curvature (side 2),-0, +.026 mm. (Less convex only!)
Thickness -.050, +0 mm. (Thinner only!)
Conic on radius 1 ± .0006.
Wedge ≤ .025 mm (Total indicated runout of edge thickness).
Equivalent Surface Figure ≤ .000196 mm RMS (see note below).

Equivalent Surface Figure is a combination of surface deformation for each surface and bulk optical inhomogeneity. (It directly address the transmitted wavefront error for the finished lens in a suitable null test.) Assumes that RMS ≈ (pk-to-pk)/4, and test λ is .5461μm or 3.39μm.

Surface figure (each) with .5461μm ≤ 1 λ pk-pk	→	.0001365 mm RMS (each surf)
Inhomogeneity for λ 3.39μm ≤ .02 λ RMS	→	.0000226 mm RMS (surf equiv.)
RSS total		.000196 mm RMS

Surface equivalent inhomogeneity is computed as (RMS*λ/(n-1)).

Asymmetric tolerances must be applied to L1 to control the size of the image of the inner rim of the ILS on the rim of the SAS. Symmetric tolerances sometimes result in a magnification error where parts of the ILS image was smaller than the physical diameter of the SAS and would have compromised the straylight control intended.

4.3.10 Fold flat

The fabrication errors of this small flat are not modeled in the Monte Carlo simulations.

Figure (flatness) ≤ 1/6 λ RMS (visible).

4.3.11 System Aperture Stop (SAS)

Radius of the aperture tolerance ≤ .050 mm. (±.100 mm on the diameter).

4.3.12 Germanium Lens L2

Radius 2 is on the Vacuum window side.

Radius of curvature (side 1), ± .026 mm.
Radius of curvature (side 2), ± .150 mm.
Thickness, ± .050 mm.
Conic on radius 2 ± .0017.
Wedge ≤ .020 mm (Total indicated runout of edge thickness).
Equivalent Surface Figure ≤ .000196 mm RMS (see note for L1, above).

4.3.13 ZnSe Vacuum Window

Thickness, ± 100 mm
Wedge ≤ .009 mm (Total indicated runout of edge thickness).
Figure ≤ ½ wave RMS irregularity (visible), each surface

(Figure error is not modeled in the Monte Carlo simulations.)

4.3.14 Cold Filters

Thickness, ± .010 mm

(Any reasonable figure error on the cold filters would not be possible to verify after dicing, and would have a negligible effect on image quality. No figure is specified.)

4.3.15 Detectors

The error in the projected Full Width Half Max (FWHM) value for each channel is dominated by two components. One of the components is error of the system Equivalent Focal Length (EFL) for which statistics are shown in paragraph 5.2.2 below, and which affects all channels equally. The other component is the error of the corresponding physical dimension (*height*) of the detector, which can effect channels independently. (Height in this context is not *thickness*, which is one of the errors producing channel dependent *focus* error, covered below.)

Deterioration of wavefront error affects FWHM only weakly, but does affect other measures of vertical response.

The 21 detectors are fabricated in 7 groups called “clips”, and errors tend to be nearly the same within each clip. Therefore, a two-tier error allocation was developed: clip-to-clip, and within a clip.

Parameter	Clip-to-clip	Within a clip
Height	± 3 μm	± 1 μm
Thickness	± 9 μm	± 0.5 μm

A more detailed summary of channel-to-channel focus error is presented in paragraph xx.xx.xx below.

4.4 Element location tolerances (imager path only)

The location tolerances for all the elements are given in table 4.4-1 below. All of the tolerance values are in IRCF coordinates, and may lead to confusion unless the IRCF coordinate system is firmly in mind, or the reader has a handy picture of the IRCF and the optics layout at hand (for example, Fig 3 in SP-LOC-139, Detailed Optical Design Specifications). Thus a δz error for L1 is primarily a local y-shift of the lens with a small focus component since the local y axis for L1 is not quite parallel to the IRCF z-axis. Similarly, an α or Rx rotation error for FS1 is mainly an in-plane roll error of the Field Stop mask local z-axis.

Units are mm and degrees for x,y,z and α,β,γ respectively. Values which are in parenthesis ( ) are going to be optically aligned. These values can be considered as an initial location preliminary to optical alignment.

Values shown in *italics* have little effect on any measurable performance parameter, and are shown as suggested values only.

Table 4.4-1 Installation tolerances, Imager path

Element	δ-x	δ-y	δ-z	δ-α	δ-β	δ-γ	Notes
Scan Mirror	*.1*	*.1*	*.1*	*n/a*	*.01*	*.01*	4.4.1
PDB	.1	.1	.1	.03	.03	.03	4.4.2
Primary	(.1)	(.1)	(.1)	.023	(.023)	(.023)	4.4.3
FS1	.1	.1	.1	.5	*1.0*	*1.0*	4.4.4
Secondary	(.1)	(.1)	(.1)	.023	(.023)	(.023)	4.4.5
ILS	.1	(.1)	(.1)	*1.*	*1.*	*1.*	4.4.6
FS2	.1	.1	.1	.25	*1.*	*1.*	4.4.7
L1	.1	.1	.1	*n/a*	.01	.01	4.4.8
Fold	.1	.1	.1	.01	(.01)	(.01)	4.4.9
SAS	.1	.1	.1	*1.*	*1.*	*1.*	4.4.10
L2	.1	.1	.1	.01	*n/a*	.01	4.4.11
Vac Window	*.1*	*.1*	*.1*	*1.*	*1.*	*1.*	4.4.12
Cold Shield	.1	.1	.1	*1.*	.2	*1.*	4.4.13
Detector				.1		.1	4.4.14
Dewar Ass'y	(.1)	(.1)	(.1)	.1	(.1)	.1	4.4.15

4.4.1 Scan Mirror

Scan mirror location errors are not part of the imager performance controlled by this tolerance budget. The actual location tolerances for the scanner are important to Line Of Sight precision and accuracy, and are covered in xxxxxxxxxxxxxxxxx.

4.4.2 PDB

The angular orientation of the PDB is critical to the initialization of the whole optical alignment concept. The .1 mm location accuracy is consistant with the .03 degree angle accuracy for a 180 mm aperture (arctan(.1/180) = .03 deg). If certain alignment pads around the edge of the PDB were within .1 mm of their theoretical IRCF locations, then the normal of the plane of such pads will lie within .03 degrees of the Projected Optical Axis (POA) requirement. This could be checked with a CMM, for instance.

4.4.3 Primary

Note that only 'roll', or rotation roughly about the local surface normal at the center of the mechanical aperture, is not to be *optically* aligned. The roll alignment tolerance may be met by mechanical methods using suitable scribe marks. For example if a pair of accurately made scribes at the 3- and 9-o'clock points on the edge of the primary have the same IRCF Z coordinates within .08 mm, the roll (or clocking) of the primary is achieved.

4.4.4 FS1

The center of FS1 will be an alignment target for the primary mirror. The only important angular tolerance is local roll (or clocking). One-half degree roll error will throw the alignment channel notch off about 50 microns, or about 3% of its diameter.

4.4.5 Secondary

As with the primary, the secondary will be aligned in 5 degrees of freedom, with only local clocking mechanically set at installation.

4.4.6 ILS

Only alignment in the local plane of the ILS will be required. Tilt errors as large as 1 degree should present no observable performance effect.

4.4.7 FS2

The centering tolerance of FS2 is important because it is the target for alignment of the secondary. A special alignment mask/target should be substituted for FS2 for this task, where the mask can be replaced with the channeled FS2 mask with precision no more than the tolerances listed in the table.

The alignment issues of FS2 are rather complicated. The roll error of .25 degrees produces a 65 micron offset at a radius of 15 mm on FS2. This is projected to a 13 micron error at the edge of the detector where the edges of the apertures in FS2 are matched onto the cold filter boundaries. However, it is currently planned to roll the dewar housing to produce this alignment, where the observable is expected to be the centering of the FS2 alignment fiducial on the alignment detector. But since there is only 1 alignment detector, offset error can not readily be distinguished from roll error.

Finally, the whole relay segment, from FS2 to the detectors, needs to be adjusted in roll so the projected detector assembly remain aligned to the earth horizon over the scan mirror azimuth range. This final adjustment must not de-align the FS2 mask from the cold filters.

4.4.8 L1

Be cause germanium is opaque in the visible, optical alignment of this segment was kept to a minimum. These installation tolerances are intended to be well within conventional mechanical lens mounting practices. Local roll error of the lens has no observable effect.

4.4.9 Fold Flat

The adjustment in local tip/tilt of the fold mirror is intended to align the image of the ILS onto the mechanical boundary of the SAS. A direct method would require infrared sourcing and sensing, a challenging proposition to say the least. Any alignment approach using optical tooling in visible light which achieves the same result is preferred, even if such an approach seems somewhat complicated at first.

4.4.10 SAS and retro-sphere

This is intended to be just "indicated in" mechanically. The 1 degree tilt error should not compromise the background suppression or dewar purpose of the retro-sphere.

4.4.11 L2

As with L1, conventional mechanical lens mounting practices should be sufficient.

4.4.12 Vacuum Window

Offset errors are simply not seen by the wavefront, and small fixed tilts just give another small fixed optical offset error to the focal plane, to be aligned out later.

4.4.13 Cold Shield

The cold shield will be centered to the focal plane during manufacture. The tolerances maintain the beam clearances.

4.4.14 Detector (focal plane)

The two tilt tolerances (α and γ) form a component of focus error, and will not be aligned out. They apply to the full focal plane assembly. Clocking error is with respect to the mounting flange, and maintains the focal plane clocking within the adjustment range of the dewar assembly.

4.4.15 Dewar Assembly

A second tier of tilts (α and γ) is applied here to account for the total tilt error introduced when the focal plane flange is mounted to the OBA housing. These tilts cannot be aligned away. However, the dewar assembly will be adjustable to focus, center, and clock (4 DOF) the focal plane on the optical axis finally presented to it. There is not enough unambiguous feedback to do this task with just one alignment channel, although it should be very helpful.

4.5 Alignment procedure and tolerances (imager path only)

The alignment procedures described below have been rigorously simulated in the OPTIMA Monte-Carlo exercise. The process does work in that the results of 20 trials all produce acceptable performance.

Any alternatives to the alignment process described below which can be shown to produce optically similar results should be acceptable as long as an adequate review has taken place.

4.5.1 Input collimated alignment beam

A full aperture plane-parallel *reference mirror* is brought into contact with the PDB mounting pads (or the equivalent). The mirror normal now defines the system POA to within .03 degrees (~110 arcsec). A well collimated (better than $\lambda/4$ in the visible) full aperture beam is autocollimated off the flat with less than "a few" fringes of tilt, or within ~5 arcsec. This should probably be done without the scan mirror present. The reference mirror can then be removed.

There is now a high quality POA surrogate entering the HIRDLS telescope.

4.5.2 Primary mirror angular adjustment

The parabola will produce its best focus only if the optical axis is parallel to the collimated input beam (or if the vertex tangent plane is normal to the beam). While observing the quality of the focus, the mirror must be adjusted in tip and tilt until the best observable focus is found. If the figure of the mirror is "in spec", it should be possible to adjust the tilts to within 2/3 of an arc-minute (40 arcsec). See appendix xx.xx.xx Alignability of the Primary Mirror.

4.5.3 Primary mirror offset adjustment

The best focus produced by the previous step will not necessarily be centered in the plane of FS1. The next step is to adjust the primary mirror in x,y,z (without re-introducing a tilt error more than "a few" arcsecs) until the focus is within .1 mm of the center and .05 mm of the plane of FS1. That is, the IRCF X tolerance in adjusting the primary mirror is ± .05 mm.

4.5.4 Secondary mirror adjustment in 5 DOF

Any alignment aids in FS1 can be removed so the secondary can refocus the beam to the vicinity of FS2. It is not obvious whether there is a preferred order to the adjustments of the mirror, but by adjusting 5 DOF of the secondary mirror, its best focus is to be brought within .1 mm of the center, and .05 mm of the plane of FS2. This might not be the best possible focus (equivalent to the theoretical stigmatic focus produced by the unperturbed prescription), but in the presence of figure errors, it should appear to be quite good. Modeling has proceeded with residual tilt errors of .01 degrees in addition to the xyz errors of adjustment.

4.5.5 Centering the ILS

By observing the image of the illuminated edge of the ILS in the plane of the PDB, the ILS is to be adjusted until its image is centered around the physical boundary of the PDB. The granularity (uncertainty) of this adjustment is .1 mm in local X & Y of the ILS.

4.5.6 Angular adjustment of the fold mirror

The fold mirror is adjusted until the image of the ILS is centered on the SAS with angular granularity of .01 degrees. In the simulation, four chief rays are launched from the ± x,y edges through the center of FS2. The intersections of these rays on the SAS plane are balanced by adjusting the fold mirror.

While it was understood at the time the simulation was created that a physical analogue of this approach might not be practical, the flexibility has been given to the vendor to do any equivalent alignment (e.g., with visible optical tooling means) which accomplishes the same goal.

4.5.7 Alignment of the relay section to the Telescope

The relay section is a single structure including FS2 through L2. The ILS and the dewar assembly are not included. In order to align the fold mirror above, the simulation assumed that a surrogate ILS tool is attached to the relay section. (Similarly, a surrogate FS2 was attached to the telescope). To match the relay section to the now aligned telescope, the relay section is to be adjusted as a group until the relay FS2 matches the telescope surrogate FS2 to within .1 mm in x,y,&z. The group is to be tilted about the FS2 location until the relay surrogate ILS matches the telescope ILS with a granularity of .05 degrees in tilt and tip. This granularity or tolerance will produce an uncertainty in matching the surrogate to real ILS of .25 mm. (In the simulation, the surrogate ILS and FS2 apertures were deleted.)

4.5.8 Alignment of FS2 and the Warm Filter Assembly

4.5.9 Alignment of the Dewar Assembly

5.0 Performance analyses (Imager)

Once the simulated alignment process has been done for each perturbed imager, and the prescription stored, various characteristics and performance parameters can be extracted and analyzed. Not only can the formal performance requirements for the imager be checked, but numerous other observations can be made via raytracing which would not be possible or practical on a real instrument. These auxiliary can provide the optical engineer valuable insight to the inner workings of the imager.

The performance data extracted are divided into several categories which follow: Field and Pupil Alignment (5.1), First Order Characteristics (5.2), and Diffraction-based Performance (5.3).

5.1 Field and Pupil Alignment

5.1.1 Alignment of Infinity on FS1

		Geometric Image Quality and Infinity Alignment on FS1								
	---------- ON AXIS ----------				--------LOWER LEFT --------			------- UPPER RIGHT -------		
Lib	RMS	Y-	X-	del-Z	RMS	Y-	X-	RMS	Y-	X-
Nbr	diam.	cntr	cntr	focus	diam	cntr	cntr	diam	cntr	cntr
9	0.0000	0.000	0.000	0.000	0.3860	-4.156	-4.172	0.3875	4.187	-4.171
10	0.0165	0.067	0.069	-0.046	0.3758	-4.082	-4.109	0.3803	4.260	-4.101
11	0.0150	0.064	-0.052	-0.039	0.3880	-4.085	-4.217	0.3873	4.245	-4.222
12	0.0108	-0.085	-0.073	0.033	0.3826	-4.239	-4.249	0.3868	4.108	-4.243
13	0.0143	-0.075	-0.088	-0.046	0.3835	-4.231	-4.265	0.3869	4.118	-4.260
14	0.0158	-0.053	0.081	-0.049	0.3846	-4.209	-4.083	0.3848	4.126	-4.090
15	0.0176	0.094	-0.073	-0.054	0.3719	-4.063	-4.246	0.3887	4.282	-4.251
16	0.0174	0.086	-0.081	-0.037	0.3937	-4.068	-4.255	0.3895	4.277	-4.254
17	0.0184	-0.073	-0.037	0.052	0.3813	-4.230	-4.214	0.3950	4.122	-4.210
18	0.0137	0.037	0.094	0.038	0.3792	-4.127	-4.078	0.3873	4.225	-4.086
19	0.0137	-0.092	0.075	-0.032	0.3765	-4.249	-4.096	0.3933	4.098	-4.101
20	0.0186	0.054	-0.083	0.043	0.3752	-4.109	-4.255	0.3932	4.241	-4.260
21	0.0161	-0.088	0.089	0.038	0.3829	-4.252	-4.083	0.3980	4.102	-4.091
22	0.0168	0.057	-0.075	-0.048	0.3834	-4.103	-4.246	0.3954	4.245	-4.253
23	0.0115	0.086	-0.085	-0.030	0.3888	-4.063	-4.254	0.3826	4.270	-4.251
24	0.0159	0.025	0.046	-0.049	0.3901	-4.132	-4.130	0.3902	4.216	-4.127
25	0.0133	-0.074	-0.091	-0.032	0.3838	-4.221	-4.262	0.3945	4.116	-4.255
26	0.0165	-0.098	-0.098	-0.047	0.3794	-4.242	-4.269	0.3784	4.090	-4.260
27	0.0174	-0.097	-0.080	0.050	0.3890	-4.243	-4.252	0.3945	4.094	-4.243
28	0.0132	-0.086	0.088	0.033	0.3909	-4.232	-4.081	0.3905	4.099	-4.076
29	0.0094	0.086	0.092	-0.030	0.3785	-4.065	-4.087	0.3850	4.284	-4.077
30	0.0184	0.053	-0.067	0.034	0.3953	-4.096	-4.236	0.3738	4.240	-4.231
Averages	0.0153	-0.005	-0.017	-0.010	0.3835	-4.159	-4.189	0.3884	4.184	-4.188
Min	0.0094	-0.098	-0.098	-0.054	0.3719	-4.252	-4.269	0.3738	4.090	-4.260
Max	0.0186	0.094	0.094	0.052	0.3953	-4.063	-4.078	0.3980	4.284	-4.076
Std Dev	0.0026	0.077	0.079	0.041	0.0063	0.077	0.079	0.0062	0.077	0.077

5.1.2 Alignment of the PDB on the ILS

PDB on ILS(T): Geometric Image Quality and Alignment							
	-- From PDB 2:o'clock --			-- From PDB 10:o'clock --			
Lib	to Best	RMS	Edge to	to Best	RMS	Edge to	Min edge
Nbr	focus	diam	Centroid	focus	diam	Centroid	Margin
9	-0.0018	0.0557	0.958	-0.0018	0.0557	0.958	0.383
10	0.1479	0.0574	0.881	0.1465	0.0576	1.059	0.571
11	-0.0179	0.0559	1.034	-0.0431	0.0558	0.848	0.467
12	0.0917	0.0566	1.031	0.0775	0.0566	0.852	0.471
13	0.2535	0.0610	0.774	0.2710	0.0615	0.934	0.442
14	0.0665	0.0562	0.910	0.0337	0.0560	1.015	0.521
15	-0.0256	0.0559	1.043	-0.0556	0.0561	0.873	0.567
16	0.0945	0.0572	0.949	0.1157	0.0573	0.772	0.458
17	0.1444	0.0576	0.914	0.1496	0.0579	0.810	0.472
18	-0.0216	0.0350	0.779	-0.0080	0.0351	0.941	0.480
19	0.0236	0.0552	0.861	0.0051	0.0553	1.038	0.534
20	-0.1424	0.0567	0.770	-0.1459	0.0570	0.934	0.441
21	0.3053	0.0629	1.010	0.3168	0.0632	0.859	0.501
22	0.0883	0.0352	0.992	0.0888	0.0352	0.880	0.526
23	0.1930	0.0376	0.819	0.2180	0.0382	0.962	0.526
24	-0.2619	0.0606	0.784	-0.1941	0.0583	0.910	0.431
25	-0.0549	0.0569	0.855	-0.0648	0.0570	0.995	0.460
26	-0.2353	0.0604	0.931	-0.2611	0.0614	0.830	0.417
27	0.0795	0.0353	0.893	0.0628	0.0352	1.078	0.565
28	-0.0813	0.0571	0.817	-0.0606	0.0569	0.962	0.407
29	-0.1554	0.0573	0.933	-0.1551	0.0574	0.755	0.406
30	-0.1069	0.0363	0.849	-0.0856	0.0360	0.752	0.411
Averages	0.0183	0.0526	0.897	0.0196	0.0526	0.908	0.480
Min	-0.2619	0.0350	0.770	-0.2611	0.0351	0.752	0.406
Max	0.3053	0.0629	1.043	0.3168	0.0632	1.078	0.571
Std Dev	0.1513	0.0098	0.090	0.1518	0.0098	0.097	0.054

5.1.3 Alignment of FS1 on FS2

FS1 on FS2R: Geometric Image Quality and Alignment
(Pupil & ref. surface is ILST)

		------- ON AXIS ---------			--- LOWER LEFT ---			--- UPPER LEFT ---		
Lib Nbr	RMS diam.	Y-cntr	X-cntr	del-Z focus	RMS diam	Y-cntr	X-cntr	RMS diam	Y-cntr	X-cntr
9	0.0000	0.000	0.000	0.000	1.2996	-14.400	-14.138	1.1844	13.889	-14.142
10	0.0303	-0.146	0.701	0.200	1.2813	-14.583	-13.443	1.1722	13.751	-13.480
11	0.0329	-0.105	-0.392	0.253	1.3050	-14.487	-14.513	1.2094	13.757	-14.515
12	0.0824	-0.444	0.061	0.791	1.3242	-14.878	-14.054	1.1759	13.426	-14.101
13	0.0464	-0.781	-0.407	-0.248	1.3535	-15.258	-14.573	1.1874	13.130	-14.600
14	0.0074	0.009	0.039	-0.014	1.2987	-14.413	-14.127	1.1914	13.922	-14.124
15	0.0451	-0.146	-0.569	0.370	1.3236	-14.578	-14.757	1.1936	13.785	-14.730
16	0.0383	-0.002	-0.662	0.123	1.3096	-14.518	-14.876	1.2344	13.942	-14.917
17	0.0872	-0.399	0.367	0.718	1.3358	-14.858	-13.767	1.1525	13.500	-13.818
18	0.0867	-0.391	0.775	0.816	1.3042	-14.744	-13.321	1.1572	13.467	-13.314
19	0.0581	-0.747	0.179	-0.288	1.3282	-15.030	-13.842	1.1451	13.037	-13.827
20	0.0237	0.276	0.163	-0.111	1.3206	-14.100	-13.950	1.1861	14.140	-13.947
21	0.0670	-0.641	0.555	0.114	1.3278	-15.065	-13.586	1.1273	13.273	-13.595
22	0.0532	-0.027	-0.441	-0.510	1.3074	-14.317	-14.490	1.1735	13.776	-14.470
23	0.0451	0.541	0.059	-0.095	1.2703	-13.761	-13.968	1.2182	14.309	-14.002
24	0.0414	-0.279	0.344	-0.335	1.3038	-14.633	-13.758	1.1720	13.583	-13.753
25	0.0533	-0.491	-0.356	0.246	1.3627	-15.023	-14.613	1.1840	13.512	-14.602
26	0.1080	-0.035	0.073	-1.079	1.3357	-14.550	-14.130	1.2267	13.909	-14.176
27	0.0521	0.102	-0.205	0.503	1.3058	-14.219	-14.261	1.1811	13.908	-14.262
28	0.1064	-0.738	0.444	1.003	1.3128	-15.239	-13.794	1.1648	13.258	-13.792
29	0.0884	0.326	0.622	-0.736	1.2601	-14.073	-13.479	1.1784	14.190	-13.541
30	0.0736	0.525	-0.047	0.195	1.2538	-13.832	-14.127	1.2390	14.340	-14.169
Averages	0.0584	-0.171	0.062	0.091	1.3107	-14.579	-14.068	1.1843	13.710	-14.083
Min	0.0074	-0.781	-0.662	-1.079	1.2538	-15.258	-14.876	1.1273	13.037	-14.917
Max	0.1080	0.541	0.775	1.003	1.3627	-13.761	-13.321	1.2390	14.340	-13.314
Std Dev	0.0271	0.397	0.429	0.525	0.0278	0.429	0.445	0.0289	0.373	0.440

5.1.4 Alignment of Infinity on FS2

Infinity on FS2R: Geometric Image Quality and Alignment										
(Pupil & ref. surface is ILST)										
	------- ON AXIS ---------				--- LOWER LEFT ---			--- UPPER RIGHT ---		
Lib	RMS	Y-	X-	del-Z	RMS	Y-	X-	RMS	Y-	X-
Nbr	diam.	cntr	cntr	focus	diam	cntr	cntr	diam	cntr	cntr
9	0.0000	0.000	0.000	0.000	0.0935	11.578	11.780	0.0977	-11.986	11.780
10	0.0646	-0.336	0.507	0.549	0.0437	11.228	12.262	0.0903	-12.303	12.275
11	0.0645	-0.287	-0.246	0.578	0.0799	11.294	11.534	0.0542	-12.273	11.540
12	0.0545	-0.205	0.265	0.516	0.0477	11.357	12.014	0.0815	-12.163	12.029
13	0.0234	-0.570	-0.158	0.103	0.0877	11.011	11.605	0.0934	-12.550	11.622
14	0.0413	0.159	-0.190	0.393	0.0692	11.705	11.540	0.0735	-11.770	11.557
15	0.0784	-0.411	-0.363	0.782	0.0604	11.166	11.423	0.0607	-12.410	11.408
16	0.0548	-0.245	-0.432	0.439	0.0927	11.376	11.377	0.0570	-12.262	11.400
17	0.0368	-0.194	0.470	0.319	0.0657	11.394	12.232	0.0823	-12.176	12.255
18	0.0581	-0.495	0.510	0.520	0.0507	11.135	12.319	0.0864	-12.525	12.339
19	0.0342	-0.488	-0.032	-0.018	0.1156	11.077	11.713	0.0871	-12.448	11.725
20	0.0467	0.124	0.397	-0.450	0.1262	11.758	12.214	0.1433	-11.908	12.229
21	0.0269	-0.394	0.304	-0.176	0.1077	11.175	12.047	0.1161	-12.359	12.066
22	0.0293	-0.187	-0.231	-0.141	0.1125	11.383	11.543	0.1043	-12.175	11.538
23	0.0235	0.297	0.299	0.130	0.0802	11.841	12.038	0.0922	-11.641	12.054
24	0.0256	-0.351	0.215	0.049	0.0921	11.254	12.036	0.0992	-12.390	12.026
25	0.0543	-0.282	-0.098	0.490	0.0841	11.316	11.717	0.0556	-12.316	11.698
26	0.0697	0.243	0.349	-0.678	0.1484	11.846	12.151	0.1627	-11.757	12.161
27	0.0300	0.375	0.020	0.121	0.1006	11.898	11.763	0.0813	-11.574	11.746
28	0.0769	-0.494	0.195	0.751	0.0639	11.090	11.999	0.0587	-12.515	11.988
29	0.0588	0.081	0.361	-0.488	0.1311	11.710	12.186	0.1560	-11.955	12.204
30	0.0397	0.375	0.142	-0.091	0.1021	11.953	11.931	0.1261	-11.613	11.948
Averages	0.0472	-0.156	0.109	0.176	0.0887	11.427	11.888	0.0934	-12.147	11.896
Min	0.0234	-0.570	-0.432	-0.678	0.0437	11.011	11.377	0.0542	-12.550	11.400
Max	0.0784	0.375	0.510	0.782	0.1484	11.953	12.319	0.1627	-11.574	12.339
Std Dev	0.0178	0.309	0.297	0.412	0.0286	0.304	0.301	0.0320	0.320	0.305

5.1.5 Alignment of the ILS on the SAS

ILS(T) on SAS: Geometric Alignment and Clearance							
	--------- On Axis ---------			-------- Min Clearance --------			
Lib	to Best	Y	X	Chan	Chan	Chan	Chan
Nbr	Focus	Centroid	Centroid	8	10	17	18
9	0.001	0.000	0.000	0.616	0.605	0.564	0.555
10	5.891	-0.123	0.092	0.880	0.697	0.766	0.802
11	5.996	0.115	-0.204	0.737	0.603	0.593	0.944
12	7.628	0.145	0.081	0.690	0.816	0.983	0.904
13	6.236	-0.157	-0.010	0.978	0.893	0.694	0.682
14	7.023	-0.141	0.107	1.027	0.864	0.696	0.736
15	6.622	-0.094	0.014	0.856	0.938	0.882	0.742
16	5.951	-0.159	0.032	0.867	0.779	0.646	0.667
17	7.549	0.133	-0.117	0.663	0.729	0.788	0.937
18	6.032	-0.095	0.157	0.842	0.718	0.678	0.806
19	6.940	-0.096	-0.069	0.765	0.878	0.883	0.746
20	7.671	-0.060	-0.016	0.759	0.768	0.707	0.705
21	5.215	0.161	-0.095	0.736	0.712	0.672	0.773
22	7.717	-0.077	0.093	0.838	0.827	0.828	0.668
23	5.973	0.157	0.133	0.717	0.704	0.930	0.738
24	5.905	-0.145	0.156	0.991	0.770	0.753	0.707
25	6.072	-0.142	0.013	0.721	0.727	0.567	0.723
26	5.644	0.080	0.042	0.852	0.816	0.946	0.834
27	6.208	-0.128	-0.013	0.793	0.878	0.659	0.669
28	7.812	-0.147	-0.034	0.822	0.854	0.787	0.680
29	7.360	0.127	-0.095	0.751	0.701	0.827	0.931
30	8.359	-0.068	-0.087	0.726	0.805	0.657	0.813
Averages	6.657	-0.034	0.009	0.810	0.785	0.759	0.772
Min	5.215	-0.159	-0.204	0.663	0.603	0.567	0.667
Max	8.359	0.161	0.157	1.027	0.938	0.983	0.944
Std Dev	0.883	0.124	0.098	0.100	0.083	0.118	0.093

5.1.6 Alignment of FS2 on the Detector

FS2R on DET: Geometric Image Quality and Alignment
(Pupil & ref. surface is ILST)

		------- ON AXIS ---------			--- LOWER LEFT ---			--- UPPER LEFT ---		
Lib Nbr	RMS diam.	Y- cntr	X- cntr	del-Z focus	RMS diam	Y- cntr	X- cntr	RMS diam	Y- cntr	X- cntr
9	0.0013	0.000	0.000	0.001	0.0225	-2.526	-2.572	0.0225	2.526	-2.572
10	0.0056	-0.023	0.012	-0.003	0.0191	-2.508	-2.516	0.0190	2.462	-2.523
11	0.0041	-0.102	-0.117	0.004	0.0195	-2.598	-2.672	0.0226	2.406	-2.659
12	0.0052	-0.083	-0.039	-0.004	0.0189	-2.578	-2.587	0.0188	2.417	-2.580
13	0.0069	-0.138	-0.126	-0.012	0.0209	-2.615	-2.656	0.0179	2.348	-2.646
14	0.0108	-0.020	0.016	0.020	0.0196	-2.491	-2.513	0.0235	2.468	-2.504
15	0.0271	-0.127	0.007	0.053	0.0286	-2.594	-2.512	0.0444	2.347	-2.505
16	0.0187	0.004	-0.005	0.035	0.0309	-2.471	-2.543	0.0268	2.496	-2.526
17	0.0197	-0.081	0.016	0.038	0.0424	-2.561	-2.502	0.0315	2.398	-2.515
18	0.0053	-0.141	0.143	0.008	0.0257	-2.641	-2.404	0.0182	2.358	-2.403
19	0.0090	-0.044	0.085	-0.017	0.0267	-2.511	-2.435	0.0191	2.433	-2.429
20	0.0190	-0.002	-0.013	-0.035	0.0249	-2.494	-2.553	0.0243	2.489	-2.549
21	0.0107	-0.032	0.149	-0.019	0.0228	-2.532	-2.400	0.0217	2.470	-2.398
22	0.0097	-0.070	0.035	-0.017	0.0217	-2.568	-2.510	0.0196	2.436	-2.511
23	0.0106	0.008	-0.017	0.018	0.0250	-2.496	-2.562	0.0211	2.505	-2.567
24	0.0082	-0.106	0.132	-0.014	0.0209	-2.621	-2.413	0.0194	2.394	-2.422
25	0.0070	-0.025	0.079	-0.006	0.0268	-2.507	-2.446	0.0224	2.456	-2.445
26	0.0263	0.011	-0.029	-0.052	0.0253	-2.463	-2.544	0.0287	2.484	-2.552
27	0.0116	0.022	-0.036	0.020	0.0206	-2.455	-2.554	0.0178	2.493	-2.561
28	0.0089	-0.046	0.131	0.013	0.0158	-2.555	-2.411	0.0311	2.447	-2.421
29	0.0194	0.055	0.156	-0.037	0.0249	-2.443	-2.385	0.0251	2.547	-2.384
30	0.0057	0.107	-0.032	0.008	0.0197	-2.385	-2.575	0.0245	2.599	-2.566
Averages	0.0119	-0.040	0.026	0.000	0.0238	-2.528	-2.509	0.0237	2.450	-2.508
Min	0.0041	-0.141	-0.126	-0.052	0.0158	-2.641	-2.672	0.0178	2.347	-2.659
Max	0.0271	0.107	0.156	0.053	0.0424	-2.385	-2.385	0.0444	2.599	-2.384
Std Dev	0.0070	0.065	0.083	0.026	0.0057	0.067	0.082	0.0063	0.064	0.079

5.1.7 Alignment of Infinity on the Detector

Infinity on Detector: Geometric Image Quality and Alignment										
(Pupil & ref. surface is SAS)										
	-------- ON AXIS ---------				---- LOWER LEFT ----			--- UPPER RIGHT ---		
Lib	RMS	Y-	X-	del-Z	RMS	Y-	X-	RMS	Y-	X-
Nbr	diam.	cntr	cntr	focus	diam	cntr	cntr	diam	cntr	cntr
9	0.0013	0.000	0.000	0.001	0.0044	-2.161	-2.199	0.0054	2.235	-2.196
10	0.0130	0.040	-0.083	-0.020	0.0094	-2.084	-2.237	0.0056	2.227	-2.238
11	0.0111	-0.048	-0.070	-0.017	0.0078	-2.188	-2.257	0.0083	2.167	-2.241
12	0.0119	-0.044	-0.089	-0.021	0.0064	-2.176	-2.259	0.0095	2.157	-2.251
13	0.0086	-0.031	-0.096	-0.015	0.0050	-2.157	-2.261	0.0041	2.160	-2.245
14	0.0061	-0.050	0.052	0.006	0.0073	-2.158	-2.102	0.0112	2.142	-2.097
15	0.0148	-0.050	0.076	0.027	0.0158	-2.167	-2.085	0.0271	2.138	-2.069
16	0.0127	0.050	0.076	0.020	0.0160	-2.080	-2.105	0.0154	2.258	-2.087
17	0.0153	-0.045	-0.072	0.026	0.0304	-2.168	-2.218	0.0220	2.141	-2.227
18	0.0085	-0.047	0.047	-0.011	0.0072	-2.197	-2.133	0.0122	2.160	-2.125
19	0.0100	0.048	0.091	-0.017	0.0162	-2.066	-2.060	0.0106	2.228	-2.048
20	0.0122	-0.025	-0.089	-0.020	0.0146	-2.163	-2.259	0.0071	2.184	-2.258
21	0.0092	0.042	0.092	-0.014	0.0083	-2.097	-2.081	0.0070	2.245	-2.074
22	0.0082	-0.034	0.079	-0.012	0.0055	-2.174	-2.100	0.0073	2.181	-2.094
23	0.0086	-0.048	-0.074	0.015	0.0173	-2.179	-2.236	0.0126	2.153	-2.245
24	0.0087	-0.039	0.091	-0.015	0.0091	-2.197	-2.092	0.0052	2.176	-2.090
25	0.0137	0.028	0.097	-0.023	0.0068	-2.103	-2.071	0.0091	2.229	-2.060
26	0.0159	-0.035	-0.094	-0.029	0.0090	-2.151	-2.243	0.0158	2.155	-2.251
27	0.0108	-0.048	-0.040	0.016	0.0146	-2.153	-2.182	0.0059	2.134	-2.188
28	0.0110	0.047	0.094	-0.013	0.0134	-2.103	-2.084	0.0138	2.252	-2.081
29	0.0127	0.039	0.088	-0.021	0.0089	-2.102	-2.087	0.0076	2.251	-2.088
30	0.0097	0.037	-0.059	0.012	0.0067	-2.090	-2.230	0.0171	2.244	-2.227
Averages	0.0111	-0.010	0.006	-0.006	0.0112	-2.141	-2.161	0.0112	2.190	-2.156
Min	0.0061	-0.050	-0.096	-0.029	0.0050	-2.197	-2.261	0.0041	2.134	-2.258
Max	0.0159	0.050	0.097	0.027	0.0304	-2.066	-2.060	0.0271	2.258	-2.048
Std Dev	0.0026	0.042	0.082	0.018	0.0059	0.043	0.078	0.0058	0.044	0.081

5.1.7 LOS error at the PDB

LOS Error of the POA in the PDB Space								
(Ref. surface is SAS, Image surface is DET)								
	---------- ON AXIS ----------				------ ALIGNMENT CHANNEL ------			
Lib	Elevation		Azimuth		Elevation		Azimuth	
Nbr	Angle	Error	Angle	Error	Angle	Error	Angle	Error
	(deg)	(secs)	(deg)	(secs)	(deg)	(secs)	(deg)	(secs)
9	-25.300	-0.9	0.123	444.5	-24.618	0.4	0.000	0.0
10	-25.331	-113.1	0.004	16.1	-24.635	-62.1	0.006	21.5
11	-25.326	-92.9	0.107	384.7	-24.643	-92.3	-0.017	-59.8
12	-25.274	94.1	0.142	512.2	-24.569	175.5	0.040	144.4
13	-25.297	10.6	0.044	158.1	-24.599	68.7	0.043	155.8
14	-25.261	141.4	-0.002	-6.1	-24.562	199.0	-0.003	-9.6
15	-25.323	-82.5	0.110	395.4	-24.611	24.9	-0.033	-119.7
16	-25.333	-120.2	0.007	26.7	-24.640	-81.0	0.006	20.4
17	-25.270	106.6	0.158	568.0	-24.564	192.2	0.054	193.2
18	-25.261	142.0	0.025	91.5	-24.570	172.6	0.025	91.1
19	-25.335	-127.0	-0.060	-215.4	-24.635	-60.7	-0.061	-221.3
20	-25.278	78.1	0.157	566.9	-24.583	125.7	0.055	198.6
21	-25.282	64.3	0.133	479.8	-24.600	63.9	-0.012	-43.6
22	-25.319	-67.6	-0.001	-2.3	-24.629	-40.5	-0.002	-6.2
23	-25.312	-44.5	0.155	559.0	-24.608	34.4	0.050	180.9
24	-25.281	69.8	0.157	566.5	-24.584	123.2	0.012	45.0
25	-25.286	49.6	-0.052	-186.3	-24.592	91.7	-0.053	-189.6
26	-25.320	-71.3	0.094	337.5	-24.615	9.8	-0.006	-21.9
27	-25.263	131.7	-0.012	-43.6	-24.563	195.9	-0.011	-40.1
28	-25.330	-108.4	-0.008	-27.7	-24.641	-82.4	-0.007	-26.3
29	-25.326	-95.3	0.088	316.1	-24.646	-101.7	-0.056	-200.4
30	-25.272	100.4	0.125	450.7	-24.589	103.3	0.016	57.8

5.2 First Order Characteristics

5.2.1 Aperture Area

Entrance Aperture Area and Image F/number				
Lib	--- On-Axis ---		--- Channel 17 ---	
Nbr	Ap.Area	F/nbr	Ap.Area	F/nbr
9	0.0203	1.44	0.0193	1.43
10	0.0195	1.44	0.0185	1.43
11	0.0197	1.45	0.0185	1.43
12	0.0194	1.46	0.0184	1.44
13	0.0196	1.44	0.0184	1.43
14	0.0194	1.44	0.0184	1.43
15	0.0195	1.44	0.0184	1.42
16	0.0200	1.43	0.0188	1.42
17	0.0195	1.45	0.0186	1.43
18	0.0197	1.45	0.0187	1.44
19	0.0194	1.44	0.0183	1.42
20	0.0197	1.45	0.0187	1.44
21	0.0200	1.44	0.0189	1.42
22	0.0195	1.46	0.0184	1.45
23	0.0194	1.46	0.0185	1.44
24	0.0197	1.46	0.0187	1.44
25	0.0200	1.43	0.0189	1.42
26	0.0197	1.44	0.0187	1.42
27	0.0198	1.42	0.0188	1.41
28	0.0195	1.46	0.0184	1.45
29	0.0196	1.46	0.0186	1.44
30	0.0197	1.45	0.0188	1.43
Averages	0.0196	1.45	0.0186	1.43
Min	0.0194	1.42	0.0183	1.41
Max	0.0200	1.46	0.0189	1.45
Std Dev	0.0002	0.01	0.0002	0.01

5.2.2 Focal lengths and Relay magnification

Selected Focal Lengths at 10.6 microns						
Lib	Teles	Relay	Ge L1	Ge L2	On-axis	Ch 17
Nbr	EFL	Mag.	EFL	EFL	EFL	EFL
9	1282	-0.191	140.49	31.679	245.3	237.3
10	1280	-0.188	142.77	31.573	240.9	232.6
11	1282	-0.189	142.56	31.689	242.6	233.5
12	1280	-0.189	143.28	31.798	241.9	233.5
13	1282	-0.188	142.81	31.552	240.9	231.8
14	1277	-0.188	143.04	31.574	239.7	232.1
15	1282	-0.187	143.16	31.494	239.8	230.9
16	1286	-0.188	142.77	31.550	241.9	232.6
17	1282	-0.188	143.21	31.638	241.0	233.6
18	1286	-0.189	142.80	31.771	243.6	235.0
19	1279	-0.187	143.14	31.485	239.5	230.7
20	1287	-0.189	143.27	31.763	243.1	234.9
21	1280	-0.190	142.41	31.714	242.7	234.0
22	1282	-0.190	143.32	31.873	243.2	234.4
23	1278	-0.190	142.77	31.814	242.3	234.7
24	1286	-0.190	142.70	31.828	244.3	235.8
25	1285	-0.188	142.69	31.555	241.8	233.1
26	1284	-0.188	142.68	31.459	240.9	233.1
27	1277	-0.187	142.82	31.445	239.1	231.8
28	1284	-0.190	143.44	31.924	243.6	234.6
29	1288	-0.189	143.40	31.801	243.5	235.3
30	1283	-0.189	143.55	31.779	242.2	234.3
Averages	1282	-0.189	142.87	31.671	241.8	233.4
Min	1277	-0.190	140.49	31.445	239.1	230.7
Max	1288	-0.187	143.55	31.924	244.3	235.8
Std Dev	3	0.001	0.62	0.145	1.5	1.4

5.3 Diffraction-based Performance

5.3.1 Wavefront Error and MTF

Infinity on Detector: Wavefront Quality at 10.6 microns							
RMS WFE and MTF-y @ 6.25 lp/mm, 5 locations, all at 10.6							
(Pupil & ref. surface is PDB)							
(Tracing 4000 rays, 5 field points)							
	----- ON AXIS -----			---- RMS WFE @ FOUR CORNERS ----			
Lib	RMS	del-z	BEST	CH	CH	CH	CH
Nbr	WFE	Best	WFE	10	8	18	17
9	0.0015	-0.001	0.0012	0.0106	0.0106	0.0132	0.0132
10	0.0400	-0.018	0.0293	0.0256	0.0427	0.0194	0.0362
11	0.0406	-0.020	0.0276	0.0302	0.0328	0.0308	0.0376
12	0.0392	-0.024	0.0160	0.0235	0.0292	0.0358	0.0421
13	0.0210	-0.011	0.0120	0.0153	0.0262	0.0123	0.0195
14	0.0186	0.006	0.0167	0.0232	0.0188	0.0345	0.0299
15	0.0513	0.031	0.0192	0.0564	0.0527	0.0883	0.0846
16	0.0408	0.021	0.0260	0.0510	0.0572	0.0482	0.0609
17	0.0413	0.024	0.0214	0.0886	0.0507	0.0652	0.0255
18	0.0327	-0.014	0.0257	0.0241	0.0097	0.0500	0.0436
19	0.0303	-0.016	0.0177	0.0495	0.0262	0.0309	0.0298
20	0.0390	-0.025	0.0140	0.0481	0.0540	0.0156	0.0216
21	0.0326	-0.017	0.0204	0.0257	0.0251	0.0237	0.0433
22	0.0277	-0.015	0.0164	0.0147	0.0200	0.0241	0.0317
23	0.0225	0.013	0.0120	0.0485	0.0315	0.0365	0.0196
24	0.0296	-0.018	0.0143	0.0339	0.0302	0.0187	0.0155
25	0.0360	-0.020	0.0195	0.0155	0.0317	0.0253	0.0510
26	0.0471	-0.026	0.0257	0.0334	0.0396	0.0534	0.0655
27	0.0383	0.019	0.0248	0.0533	0.0706	0.0169	0.0431
28	0.0399	-0.021	0.0255	0.0529	0.0454	0.0392	0.0183
29	0.0442	-0.027	0.0196	0.0296	0.0525	0.0265	0.0471
30	0.0331	0.010	0.0295	0.0202	0.0353	0.0536	0.0551
Averages	0.0355	-0.007	0.0206	0.0363	0.0372	0.0357	0.0391
Min	0.0186	-0.027	0.0120	0.0147	0.0097	0.0123	0.0155
Max	0.0513	0.031	0.0295	0.0886	0.0706	0.0883	0.0846
Std Dev	0.0085	0.019	0.0056	0.0184	0.0151	0.0187	0.0177

5.3.2 Vertical Response (Summaries)

5.3.2.1 Full Width Half Max

Vertical Response: FWHM (km)					
Results of Monte-Carlo Tolerance Budget Test					
Channel	Spec	Nominal	Range		Margin
Number	Value	Value	Min	Max	
1	.9 - 1.05	0.9748	0.9606	1.0322	OK
2	.9 - 1.05	0.9771	0.9508	1.0410	OK
3	.9 - 1.05	0.9776	0.9521	1.0396	OK
4	.9 - 1.05	0.9766	0.9476	1.0469	OK
5	.9 - 1.05	0.9764	0.9513	1.0378	OK
6	.9 - 1.05	0.9768	0.9377	1.0429	OK
7	.9 - 1.05	0.9729	0.9363	**1.0456**	Caution
8	.9 - 1.05	0.9706	0.9373	1.0393	OK
9	.9 - 1.05	0.9737	0.9335	1.0370	OK
10	.9 - 1.05	0.9726	0.9331	**1.0471**	Caution
11	.9 - 1.05	0.9798	0.9427	1.0334	OK
12	.9 - 1.05	0.9738	0.9395	1.0294	OK
13	.9 - 1.05	0.9694	0.9324	1.0378	OK
14	.9 - 1.05	0.9758	0.9280	1.0359	OK
15	.9 - 1.05	0.9746	0.9281	1.0315	OK
16	.9 - 1.05	0.9764	0.9393	1.0375	OK
17	.9 - 1.05	0.9749	0.9328	1.0304	OK
18	.9 - 1.05	0.9785	0.9508	1.0368	OK
19	.9 - 1.05	0.9775	0.9492	**1.0487**	Caution
20	.9 - 1.05	0.9714	0.9471	1.0428	OK
21	.9 - 1.05	0.9754	0.9385	1.0380	OK

5.3.2.2 Integrated Vertical Response under FWHM

Vertical Response: Integrated Vertical Response under FWHM					
Results of Monte-Carlo Tolerance Budget Test					
Channel	Spec	Nominal	Range		Margin
Number	Value	Value	Min	Max	
1	> .80	0.8313	0.8219	0.8353	OK
2	> .80	0.8395	0.8282	0.8420	GOOD
3	> .80	0.8434	0.8304	0.8467	GOOD
4	> .80	0.8460	0.8306	0.8493	GOOD
5	> .80	0.8483	0.8292	0.8515	GOOD
6	> .80	0.8313	0.8458	0.8720	V GOOD
7	> .80	0.8674	0.8404	0.8738	GOOD
8	> .80	0.8679	0.8398	0.8732	GOOD
9	> .80	0.8739	0.8443	0.8792	GOOD
10	> .80	0.8794	0.8519	0.8850	V GOOD
11	> .80	0.8889	0.8659	0.8902	EXCEL
12	> .80	0.8966	0.8709	0.8957	EXCEL
13	> .80	0.8999	0.8739	0.9058	EXCEL
14	> .80	0.9077	0.8758	0.9079	EXCEL
15	> .80	0.9086	0.8756	0.9101	EXCEL
16	> .80	0.9093	0.8719	0.9106	EXCEL
17	> .80	0.9116	0.8702	0.9107	EXCEL
18	> .80	0.9145	0.8773	0.9126	EXCEL
19	> .80	0.9138	0.8898	0.9130	EXCEL
20	> .80	0.9156	0.8981	0.9175	EXCEL
21	> .80	0.9257	0.8870	0.9252	EXCEL

5.3.2.3 Integrated Vertical Response under ± .75 km

Vertical Response: within +/- .75 km						
Results of Monte-Carlo Tolerance Budget Test						
Channel	Spec	Nominal	Range		Margin	
Number	Value	Value	Min	Max	Value	Comment
	>					
1	0.9305	0.9419	0.9351	0.9414	**-0.0046**	Negative!
2	0.9342	0.9455	0.9383	0.9444	**-0.0041**	Negative!
3	0.9360	0.9469	0.9400	0.9463	**-0.0040**	Negative!
4	0.9378	0.9478	0.9409	0.9470	**-0.0031**	Negative!
5	0.9401	0.9486	0.9368	0.9477	0.0033	OK?
6	0.9517	0.9574	0.9508	0.9569	0.0009	V Small
7	0.9526	0.9577	0.9513	0.9573	0.0013	Small
8	0.9547	0.9580	0.9497	0.9587	0.0050	OK
9	0.9567	0.9602	0.9535	0.9598	0.0032	OK?
10	0.9600	0.9628	0.9572	0.9626	0.0028	OK?
11	0.9611	0.9655	0.9602	0.9654	0.0009	V Small
12	0.9646	0.9698	0.9644	0.9695	0.0002	V Small
13	0.9669	0.9719	0.9675	0.9721	**-0.0006**	Negative!
14	0.9679	0.9732	0.9697	0.9732	**-0.0018**	Negative!
15	0.9685	0.9739	0.9700	0.9737	**-0.0015**	Negative!
16	0.9690	0.9741	0.9694	0.9739	**-0.0004**	Negative!
17	0.9703	0.9748	0.9680	0.9742	0.0023	Small
18	0.9716	0.9757	0.9689	0.9752	0.0027	OK?
19	0.9716	0.9763	0.9708	0.9759	0.0008	V Small
20	0.9730	0.9776	0.9743	0.9774	**-0.0013**	Negative!
21	0.9751	0.9794	0.9749	0.9793	0.0002	V Small

5.3.2.4 Integrated Vertical Response under ± 1.0 km

Vertical Response: within +/- 1.0 km						
Results of Monte-Carlo Tolerance Budget Test						
Channel	Spec	Nominal	Range		Margin	
Number	Value	Value	Min	Max	Value	Comment
	>					
1	0.9566	0.9623	0.9599	0.9620	0.0033	OK?
2	0.9588	0.9644	0.9616	0.9641	0.0028	OK?
3	0.9600	0.9653	0.9630	0.9651	0.0030	OK?
4	0.9611	0.9664	0.9640	0.9661	0.0029	OK?
5	0.9625	0.9667	0.9633	0.9660	0.0008	V Small
6	0.9698	0.9724	0.9705	0.9720	0.0007	V Small
7	0.9704	0.9726	0.9707	0.9723	0.0003	V Small
8	0.9717	0.9725	0.9700	0.9724	**-0.0017**	Negative!
9	0.9729	0.9742	0.9716	0.9738	**-0.0013**	Negative!
10	0.9750	0.9758	0.9739	0.9756	**-0.0011**	Negative!
11	0.9757	0.9777	0.9758	0.9776	0.0001	V Small
12	0.9779	0.9803	0.9787	0.9801	0.0008	V Small
13	0.9793	0.9817	0.9805	0.9817	0.0012	V Small
14	0.9799	0.9826	0.9815	0.9825	0.0016	Small
15	0.9803	0.9830	0.9820	0.9829	0.0017	Small
16	0.9806	0.9832	0.9819	0.9830	0.0013	V Small
17	0.9814	0.9836	0.9817	0.9833	0.0003	V Small
18	0.9823	0.9844	0.9828	0.9842	0.0005	V Small
19	0.9823	0.9848	0.9835	0.9846	0.0012	V Small
20	0.9831	0.9856	0.9847	0.9856	0.0016	Small
21	0.9845	0.9869	0.9855	0.9868	0.0010	V Small

5.3.2.5 Integrated Vertical Response under ± 2.0 km

Vertical Response: within +/- 2.0 km						
Results of Monte-Carlo Tolerance Budget Test						
Channel	Spec	Nominal	Range		Margin	
Number	Value	Value	Min	Max	Value	Comment
1	0.9804	0.9865	0.9861	0.9866	0.0057	Larger
2	0.9815	0.9871	0.9866	0.9870	0.0051	Larger
3	0.9820	0.9873	0.9869	0.9873	0.0049	Larger
4	0.9825	0.9878	0.9874	0.9877	0.0049	Larger
5	0.9831	0.9876	0.9871	0.9874	0.0040	Larger
6	0.9864	0.9897	0.9894	0.9897	0.0030	Med
7	0.9867	0.9897	0.9893	0.9896	0.0026	Med
8	0.9872	0.9895	0.9891	0.9895	0.0019	Small
9	0.9878	0.9902	0.9898	0.9902	0.0020	Small
10	0.9887	0.9907	0.9904	0.9907	0.0017	Small
11	0.9891	0.9917	0.9913	0.9916	0.0022	Small
12	0.9900	0.9928	0.9925	0.9927	0.0025	Med
13	0.9907	0.9933	0.9931	0.9933	0.0024	Small
14	0.9909	0.9937	0.9936	0.9937	0.0027	Med
15	0.9911	0.9939	0.9936	0.9938	0.0025	Med
16	0.9913	0.9939	0.9937	0.9939	0.0024	Small
17	0.9916	0.9940	0.9937	0.9939	0.0021	Small
18	0.9920	0.9944	0.9942	0.9943	0.0022	Small
19	0.9920	0.9946	0.9944	0.9946	0.0024	Small
20	0.9924	0.9949	0.9948	0.9950	0.0024	Small
21	0.9930	0.9956	0.9953	0.9957	0.0023	Small

5.3.2.6 Integrated Vertical Response under ± 3.0 km

Vertical Response: within +/- 3.0 km						
Results of Monte-Carlo Tolerance Budget Test						
Channel	Spec	Nominal	Range		Margin	
Number	Value	Value	Min	Max	Value	Comment
1	0.9877	0.9936	0.9934	0.9936	0.0057	Larger
2	0.9884	0.9937	0.9935	0.9937	0.0051	Larger
3	0.9887	0.9937	0.9935	0.9937	0.0048	Larger
4	0.9890	0.9941	0.9939	0.9940	0.0049	Larger
5	0.9894	0.9938	0.9935	0.9936	0.0041	Larger
6	0.9915	0.9948	0.9946	0.9948	0.0031	Med
7	0.9916	0.9947	0.9945	0.9947	0.0029	Med
8	0.9920	0.9945	0.9943	0.9946	0.0023	Small
9	0.9924	0.9949	0.9947	0.9949	0.0023	Small
10	0.9929	0.9952	0.9949	0.9952	0.0020	Small
11	0.9931	0.9958	0.9956	0.9958	0.0025	Med
12	0.9937	0.9964	0.9963	0.9964	0.0026	Med
13	0.9942	0.9968	0.9966	0.9967	0.0024	Small
14	0.9943	0.9970	0.9969	0.9970	0.0026	Med
15	0.9944	0.9970	0.9969	0.9970	0.0025	Med
16	0.9945	0.9971	0.9970	0.9971	0.0025	Med
17	0.9948	0.9971	0.9969	0.9971	0.0021	Small
18	0.9950	0.9974	0.9972	0.9973	0.0022	Small
19	0.9950	0.9975	0.9974	0.9975	0.0024	Small
20	0.9952	0.9977	0.9976	0.9977	0.0024	Small
21	0.9956	0.9980	0.9979	0.9983	0.0023	Small

5.3.3 Vertical Response (Details)

5.3.3.1 Channel 1

Vertical Response data for Channel 1									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.32	0.9748	0.8313	2.784	0.9419	0.9623	0.9865	0.9936	0.0776
10	12.55	1.0105	0.8260	2.536	0.9353	0.9599	0.9863	0.9936	0.0788
11	12.46	1.0281	0.8353	2.645	0.9389	0.9610	0.9863	0.9935	0.0810
12	12.49	0.9661	0.8231	2.687	0.9386	0.9609	0.9863	0.9935	0.0757
13	12.54	0.9625	0.8270	2.742	0.9409	0.9616	0.9864	0.9935	0.0752
14	12.62	0.9794	0.8285	2.715	0.9402	0.9613	0.9863	0.9935	0.0760
15	12.60	1.0204	0.8321	2.608	0.9377	0.9606	0.9862	0.9935	0.0794
16	12.50	1.0322	0.8350	2.653	0.9381	0.9609	0.9863	0.9935	0.0810
17	12.54	0.9666	0.8254	2.711	0.9398	0.9612	0.9863	0.9935	0.0756
18	12.40	0.9618	0.8279	2.760	0.9414	0.9619	0.9864	0.9935	0.0760
19	12.62	0.9751	0.8271	2.711	0.9399	0.9612	0.9863	0.9935	0.0757
20	12.44	0.9988	0.8261	2.648	0.9369	0.9607	0.9864	0.9936	0.0787
21	12.44	0.9919	0.8298	2.717	0.9395	0.9616	0.9866	0.9936	0.0781
22	12.43	1.0033	0.8311	2.687	0.9390	0.9609	0.9862	0.9934	0.0792
23	12.49	1.0081	0.8283	2.640	0.9370	0.9603	0.9861	0.9934	0.0791
24	12.36	1.0041	0.8298	2.678	0.9382	0.9610	0.9864	0.9935	0.0796
25	12.49	0.9658	0.8265	2.744	0.9403	0.9615	0.9865	0.9935	0.0759
26	12.56	1.0244	0.8327	2.617	0.9376	0.9604	0.9862	0.9934	0.0800
27	12.66	0.9622	0.8235	2.708	0.9392	0.9615	0.9864	0.9935	0.0743
28	12.41	0.9606	0.8219	2.690	0.9387	0.9612	0.9864	0.9935	0.0757
29	12.42	1.0241	0.8282	2.566	0.9351	0.9600	0.9862	0.9934	0.0807
30	12.49	0.9695	0.8274	2.717	0.9411	0.9620	0.9864	0.9936	0.0760
Spec	(none)	.9-1.05	>.80	(none)	0.9305	0.9566	0.9804	0.9877	0.0776
Averages	12.50	0.9912	0.8282	2.675	0.9387	0.9610	0.9863	0.9935	0.0777
Min	12.36	0.9606	0.8219	2.536	0.9351	0.9599	0.9861	0.9934	0.0743
Max	12.66	1.0322	0.8353	2.760	0.9414	0.9620	0.9866	0.9936	0.0810
Std Dev	0.08	0.0258	0.0036	0.0584	0.0017	0.0006	0.0001	0.0001	0.0022

5.3.3.2 Channel 2

Vertical Response data for Channel 2									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.23	0.9771	0.8395	2.954	0.9455	0.9644	0.9871	0.9937	0.0786
10	12.45	1.0410	0.8362	2.749	0.9383	0.9616	0.9866	0.9936	0.0823
11	12.37	1.0107	0.8397	2.873	0.9433	0.9634	0.9869	0.9936	0.0805
12	12.40	0.9802	0.8308	2.823	0.9410	0.9627	0.9867	0.9935	0.0775
13	12.45	1.0389	0.8420	2.839	0.9415	0.9624	0.9867	0.9935	0.0823
14	12.52	0.9820	0.8331	2.848	0.9419	0.9628	0.9867	0.9935	0.0770
15	12.51	0.9711	0.8282	2.804	0.9406	0.9628	0.9867	0.9935	0.0760
16	12.41	0.9687	0.8339	2.881	0.9437	0.9638	0.9869	0.9936	0.0766
17	12.44	1.0063	0.8388	2.883	0.9427	0.9629	0.9868	0.9935	0.0797
18	12.31	1.0229	0.8403	2.867	0.9421	0.9629	0.9868	0.9935	0.0819
19	12.52	1.0236	0.8409	2.863	0.9425	0.9628	0.9867	0.9935	0.0806
20	12.34	0.9660	0.8321	2.861	0.9431	0.9634	0.9869	0.9936	0.0768
21	12.35	0.9508	0.8326	2.878	0.9444	0.9641	0.9870	0.9937	0.0754
22	12.33	1.0267	0.8364	2.802	0.9398	0.9624	0.9867	0.9935	0.0819
23	12.39	1.0302	0.8363	2.792	0.9393	0.9620	0.9866	0.9935	0.0818
24	12.27	0.9808	0.8318	2.846	0.9415	0.9631	0.9869	0.9936	0.0784
25	12.39	0.9741	0.8295	2.838	0.9407	0.9625	0.9869	0.9937	0.0770
26	12.45	1.0277	0.8348	2.785	0.9386	0.9619	0.9867	0.9936	0.0812
27	12.55	0.9832	0.8296	2.804	0.9405	0.9630	0.9868	0.9936	0.0768
28	12.31	1.0111	0.8323	2.795	0.9390	0.9623	0.9868	0.9935	0.0806
29	12.32	0.9666	0.8330	2.861	0.9434	0.9634	0.9868	0.9935	0.0770
30	12.40	1.0062	0.8346	2.821	0.9410	0.9628	0.9868	0.9936	0.0798
Spec	(none)	.9-1.05	>.80	(none)	0.9342	0.9588	0.9815	0.9884	0.0786
Averages	12.40	0.9985	0.8346	2.834	0.9414	0.9628	0.9868	0.9936	0.0791
Min	12.27	0.9508	0.8282	2.749	0.9383	0.9616	0.9866	0.9935	0.0754
Max	12.55	1.0410	0.8420	2.883	0.9444	0.9641	0.9870	0.9937	0.0823
Std Dev	0.08	0.0278	0.0040	0.0373	0.0017	0.0006	0.0001	0.0001	0.0024

5.3.3.3 Channel 3

Vertical Response data for Channel 3									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.19	0.9776	0.8434	3.019	0.9469	0.9653	0.9873	0.9937	0.0790
10	12.41	1.0236	0.8398	2.887	0.9416	0.9633	0.9870	0.9936	0.0812
11	12.33	0.9943	0.8407	2.936	0.9449	0.9644	0.9871	0.9936	0.0794
12	12.36	0.9834	0.8333	2.866	0.9417	0.9635	0.9870	0.9936	0.0780
13	12.42	1.0396	0.8467	2.950	0.9438	0.9639	0.9870	0.9936	0.0826
14	12.47	0.9799	0.8390	2.940	0.9447	0.9642	0.9870	0.9936	0.0773
15	12.47	0.9729	0.8304	2.834	0.9414	0.9636	0.9869	0.9935	0.0765
16	12.37	0.9542	0.8364	2.911	0.9459	0.9650	0.9872	0.9937	0.0757
17	12.40	1.0301	0.8457	2.960	0.9440	0.9639	0.9870	0.9936	0.0820
18	12.28	1.0249	0.8427	2.938	0.9428	0.9639	0.9871	0.9936	0.0823
19	12.49	1.0239	0.8449	2.956	0.9442	0.9640	0.9870	0.9936	0.0809
20	12.29	0.9690	0.8330	2.880	0.9428	0.9641	0.9870	0.9936	0.0773
21	12.33	0.9521	0.8376	2.934	0.9463	0.9651	0.9873	0.9937	0.0759
22	12.29	1.0095	0.8405	2.927	0.9431	0.9639	0.9870	0.9936	0.0809
23	12.35	1.0085	0.8381	2.901	0.9418	0.9634	0.9870	0.9936	0.0803
24	12.24	0.9773	0.8375	2.934	0.9441	0.9644	0.9872	0.9937	0.0784
25	12.36	0.9562	0.8314	2.866	0.9430	0.9639	0.9872	0.9937	0.0758
26	12.41	1.0085	0.8345	2.857	0.9400	0.9630	0.9870	0.9936	0.0799
27	12.50	0.9823	0.8325	2.855	0.9418	0.9638	0.9870	0.9936	0.0771
28	12.28	1.0085	0.8396	2.916	0.9429	0.9640	0.9871	0.9936	0.0808
29	12.29	0.9648	0.8384	2.938	0.9458	0.9648	0.9871	0.9937	0.0772
30	12.35	1.0057	0.8400	2.921	0.9433	0.9640	0.9870	0.9936	0.0801
Spec	(none)	.9-1.05	>.80	(none)	0.9360	0.9600	0.9820	0.9887	0.0790
Averages	12.37	0.9938	0.8382	2.910	0.9433	0.9640	0.9871	0.9936	0.0790
Min	12.24	0.9521	0.8304	2.834	0.9400	0.9630	0.9869	0.9935	0.0757
Max	12.50	1.0396	0.8467	2.960	0.9463	0.9651	0.9873	0.9937	0.0826
Std Dev	0.08	0.0270	0.0046	0.0374	0.0016	0.0005	0.0001	0.0001	0.0023

5.3.3.4 Channel 4

Vertical Response data for Channel 4									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.22	0.9766	0.8460	3.116	0.9478	0.9664	0.9878	0.9941	0.0788
10	12.46	1.0415	0.8454	2.901	0.9433	0.9644	0.9875	0.9940	0.0825
11	12.37	0.9934	0.8430	2.996	0.9469	0.9657	0.9876	0.9940	0.0792
12	12.41	0.9790	0.8399	3.001	0.9450	0.9652	0.9875	0.9939	0.0776
13	12.47	1.0423	0.8493	2.966	0.9451	0.9648	0.9875	0.9939	0.0826
14	12.49	0.9754	0.8402	3.020	0.9453	0.9651	0.9874	0.9939	0.0769
15	12.50	0.9926	0.8325	2.879	0.9409	0.9646	0.9876	0.9940	0.0780
16	12.41	0.9540	0.8386	3.008	0.9469	0.9661	0.9877	0.9940	0.0756
17	12.43	1.0285	0.8484	2.999	0.9460	0.9653	0.9876	0.9940	0.0817
18	12.33	1.0060	0.8370	2.918	0.9421	0.9645	0.9876	0.9940	0.0803
19	12.53	1.0469	0.8485	2.927	0.9444	0.9647	0.9875	0.9939	0.0825
20	12.34	0.9476	0.8367	2.999	0.9461	0.9659	0.9877	0.9940	0.0754
21	12.38	0.9730	0.8423	3.060	0.9470	0.9657	0.9877	0.9940	0.0774
22	12.33	1.0268	0.8451	2.956	0.9445	0.9649	0.9875	0.9939	0.0822
23	12.37	1.0051	0.8448	3.021	0.9459	0.9653	0.9876	0.9940	0.0801
24	12.29	0.9824	0.8383	2.986	0.9440	0.9652	0.9876	0.9940	0.0787
25	12.41	0.9552	0.8306	2.922	0.9426	0.9646	0.9877	0.9940	0.0755
26	12.44	1.0235	0.8386	2.887	0.9412	0.9640	0.9875	0.9940	0.0811
27	12.52	0.9815	0.8362	2.950	0.9437	0.9653	0.9877	0.9940	0.0771
28	12.33	1.0288	0.8418	2.904	0.9428	0.9648	0.9876	0.9940	0.0823
29	12.33	0.9650	0.8415	3.044	0.9467	0.9657	0.9876	0.9940	0.0770
30	12.39	1.0084	0.8402	2.945	0.9436	0.9647	0.9875	0.9939	0.0802
Spec	(none)	.9-1.05	>.80	(none)	0.9378	0.9611	0.9825	0.9890	0.0788
Averages	12.41	0.9979	0.8409	2.966	0.9445	0.9651	0.9876	0.9940	0.0792
Min	12.29	0.9476	0.8306	2.879	0.9409	0.9640	0.9874	0.9939	0.0754
Max	12.53	1.0469	0.8493	3.060	0.9470	0.9661	0.9877	0.9940	0.0826
Std Dev	0.07	0.0311	0.0050	0.0528	0.0019	0.0005	0.0001	0.0000	0.0025

5.3.3.5 Channel 5

Vertical Response data for Channel 5									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.39	0.9764	0.8483	3.024	0.9486	0.9667	0.9876	0.9938	0.0778
10	12.65	1.0378	0.8475	2.990	0.9434	0.9645	0.9872	0.9935	0.0809
11	12.56	1.0158	0.8470	2.973	0.9458	0.9656	0.9873	0.9936	0.0798
12	12.60	0.9795	0.8363	2.833	0.9432	0.9648	0.9872	0.9936	0.0764
13	12.68	0.9513	0.8414	3.045	0.9477	0.9660	0.9873	0.9936	0.0740
14	12.65	0.9741	0.8449	2.963	0.9472	0.9658	0.9873	0.9936	0.0759
15	12.70	1.0166	0.8302	2.761	0.9368	0.9633	0.9871	0.9935	0.0786
16	12.61	1.0284	0.8508	3.055	0.9460	0.9657	0.9874	0.9936	0.0805
17	12.61	0.9524	0.8402	3.018	0.9472	0.9659	0.9874	0.9936	0.0745
18	12.54	0.9748	0.8292	2.734	0.9405	0.9642	0.9872	0.9935	0.0763
19	12.73	0.9804	0.8434	2.927	0.9460	0.9654	0.9873	0.9936	0.0758
20	12.53	0.9702	0.8415	2.906	0.9461	0.9658	0.9874	0.9936	0.0763
21	12.58	0.9900	0.8406	2.902	0.9441	0.9651	0.9873	0.9936	0.0775
22	12.52	1.0131	0.8409	2.912	0.9424	0.9647	0.9873	0.9936	0.0797
23	12.54	1.0355	0.8515	3.066	0.9455	0.9652	0.9872	0.9936	0.0815
24	12.49	1.0220	0.8490	3.038	0.9453	0.9653	0.9872	0.9935	0.0807
25	12.61	0.9626	0.8393	2.917	0.9464	0.9657	0.9874	0.9936	0.0752
26	12.62	1.0157	0.8435	2.963	0.9432	0.9647	0.9872	0.9936	0.0793
27	12.67	0.9774	0.8400	2.902	0.9454	0.9657	0.9874	0.9936	0.0759
28	12.54	1.0362	0.8466	2.982	0.9431	0.9648	0.9871	0.9935	0.0815
29	12.52	1.0341	0.8441	2.959	0.9419	0.9645	0.9872	0.9936	0.0814
30	12.55	0.9558	0.8351	2.939	0.9451	0.9653	0.9873	0.9936	0.0749
Spec	(none)	.9-1.05	>.80	(none)	0.9401	0.9625	0.9831	0.9894	0.0778
Averages	12.60	0.9964	0.8420	2.942	0.9444	0.9651	0.9873	0.9936	0.0779
Min	12.49	0.9513	0.8292	2.734	0.9368	0.9633	0.9871	0.9935	0.0740
Max	12.73	1.0378	0.8515	3.066	0.9477	0.9660	0.9874	0.9936	0.0815
Std Dev	0.07	0.0306	0.0060	0.0877	0.0026	0.0007	0.0001	0.0000	0.0026

5.3.3.6 Channel 6

Vertical Response data for Channel 6									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.49	0.9768	0.8695	3.569	0.9574	0.9724	0.9897	0.9948	0.0774
10	12.73	1.0153	0.8669	3.547	0.9544	0.9713	0.9895	0.9947	0.0789
11	12.62	1.0171	0.8681	3.593	0.9546	0.9715	0.9896	0.9947	0.0798
12	12.66	1.0332	0.8691	3.615	0.9538	0.9709	0.9894	0.9946	0.0809
13	12.70	0.9682	0.8649	3.459	0.9561	0.9717	0.9895	0.9947	0.0754
14	12.81	1.0376	0.8720	3.661	0.9546	0.9712	0.9894	0.9946	0.0803
15	12.77	1.0408	0.8629	3.468	0.9513	0.9707	0.9894	0.9947	0.0807
16	12.68	0.9489	0.8558	3.436	0.9555	0.9717	0.9896	0.9947	0.0741
17	12.72	1.0228	0.8675	3.595	0.9533	0.9706	0.9894	0.9946	0.0796
18	12.56	0.9961	0.8691	3.601	0.9561	0.9719	0.9896	0.9947	0.0785
19	12.78	0.9758	0.8588	3.358	0.9537	0.9710	0.9894	0.9946	0.0754
20	12.62	0.9649	0.8458	3.096	0.9508	0.9705	0.9895	0.9947	0.0755
21	12.62	0.9634	0.8601	3.360	0.9554	0.9719	0.9897	0.9947	0.0755
22	12.61	0.9377	0.8598	3.575	0.9569	0.9720	0.9895	0.9946	0.0737
23	12.67	0.9638	0.8643	3.410	0.9563	0.9717	0.9895	0.9946	0.0753
24	12.53	1.0278	0.8638	3.511	0.9524	0.9711	0.9896	0.9948	0.0812
25	12.67	0.9539	0.8614	3.458	0.9563	0.9718	0.9896	0.9947	0.0746
26	12.76	1.0429	0.8715	3.642	0.9542	0.9711	0.9894	0.9946	0.0810
27	12.85	0.9739	0.8493	3.146	0.9519	0.9708	0.9895	0.9947	0.0748
28	12.58	0.9799	0.8567	3.328	0.9533	0.9712	0.9895	0.9947	0.0770
29	12.59	0.9617	0.8582	3.293	0.9553	0.9717	0.9895	0.9947	0.0756
30	12.68	0.9435	0.8585	3.487	0.9568	0.9720	0.9895	0.9947	0.0737
Spec	(none)	.9-1.05	>.80	(none)	0.9517	0.9698	0.9864	0.9915	0.0774
Averages	12.68	0.9890	0.8621	3.459	0.9544	0.9713	0.9895	0.9947	0.0772
Min	12.53	0.9377	0.8458	3.096	0.9508	0.9705	0.9894	0.9946	0.0737
Max	12.85	1.0429	0.8720	3.661	0.9569	0.9720	0.9897	0.9948	0.0812
Std Dev	0.09	0.0355	0.0068	0.1545	0.0018	0.0005	0.0001	0.0001	0.0027

5.3.3.7 Channel 7

Vertical Response data for Channel 7									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.61	0.9729	0.8674	3.620	0.9577	0.9726	0.9897	0.9947	0.0765
10	12.84	1.0338	0.8663	3.439	0.9533	0.9710	0.9894	0.9945	0.0796
11	12.75	1.0371	0.8717	3.609	0.9544	0.9715	0.9895	0.9946	0.0805
12	12.78	1.0114	0.8670	3.456	0.9546	0.9715	0.9895	0.9946	0.0783
13	12.82	0.9556	0.8623	3.596	0.9571	0.9721	0.9895	0.9946	0.0740
14	12.93	1.0383	0.8738	3.634	0.9550	0.9714	0.9893	0.9945	0.0795
15	12.89	1.0216	0.8705	3.549	0.9553	0.9717	0.9895	0.9946	0.0784
16	12.81	0.9486	0.8596	3.622	0.9568	0.9723	0.9896	0.9946	0.0735
17	12.83	1.0235	0.8662	3.472	0.9530	0.9707	0.9893	0.9945	0.0789
18	12.66	1.0129	0.8731	3.618	0.9562	0.9719	0.9895	0.9946	0.0792
19	12.90	0.9683	0.8638	3.575	0.9561	0.9717	0.9895	0.9946	0.0744
20	12.74	0.9408	0.8404	3.282	0.9519	0.9709	0.9895	0.9946	0.0729
21	12.72	0.9363	0.8522	3.541	0.9554	0.9720	0.9896	0.9947	0.0728
22	12.74	0.9538	0.8634	3.653	0.9572	0.9722	0.9895	0.9946	0.0743
23	12.78	0.9411	0.8614	3.672	0.9573	0.9722	0.9895	0.9946	0.0730
24	12.64	1.0051	0.8669	3.448	0.9552	0.9718	0.9896	0.9946	0.0787
25	12.78	0.9509	0.8636	3.701	0.9572	0.9722	0.9896	0.9947	0.0738
26	12.88	1.0456	0.8732	3.610	0.9548	0.9714	0.9894	0.9945	0.0804
27	12.97	0.9751	0.8461	3.196	0.9514	0.9709	0.9894	0.9946	0.0743
28	12.68	0.9723	0.8455	3.187	0.9513	0.9709	0.9894	0.9945	0.0758
29	12.71	0.9388	0.8509	3.445	0.9555	0.9719	0.9895	0.9946	0.0731
30	12.81	0.9426	0.8572	3.526	0.9572	0.9722	0.9895	0.9946	0.0729
Spec	(none)	.9-1.05	>.80	(none)	0.9526	0.9704	0.9867	0.9916	0.0765
Averages	12.79	0.9835	0.8617	3.516	0.9551	0.9716	0.9895	0.9946	0.0761
Min	12.64	0.9363	0.8404	3.187	0.9513	0.9707	0.9893	0.9945	0.0728
Max	12.97	1.0456	0.8738	3.701	0.9573	0.9723	0.9896	0.9947	0.0805
Std Dev	0.09	0.0396	0.0097	0.1464	0.0019	0.0005	0.0001	0.0001	0.0029

5.3.3.8 Channel 8

Vertical Response data for Channel 8									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	13.02	0.9706	0.8679	3.743	0.9580	0.9725	0.9895	0.9945	0.0741
10	13.23	1.0369	0.8566	3.178	0.9497	0.9700	0.9892	0.9944	0.0774
11	13.15	1.0141	0.8714	3.454	0.9563	0.9717	0.9894	0.9945	0.0764
12	13.17	1.0054	0.8659	3.325	0.9559	0.9714	0.9893	0.9944	0.0756
13	13.19	0.9595	0.8596	3.606	0.9556	0.9717	0.9894	0.9945	0.0721
14	13.36	1.0393	0.8732	3.525	0.9554	0.9713	0.9892	0.9944	0.0770
15	13.28	1.0191	0.8690	3.418	0.9556	0.9717	0.9893	0.9944	0.0760
16	13.21	0.9677	0.8555	3.499	0.9547	0.9716	0.9893	0.9945	0.0726
17	13.24	1.0349	0.8698	3.466	0.9544	0.9709	0.9893	0.9944	0.0774
18	13.02	1.0080	0.8729	3.503	0.9565	0.9720	0.9894	0.9945	0.0767
19	13.30	0.9630	0.8571	3.552	0.9556	0.9714	0.9894	0.9945	0.0718
20	13.17	0.9390	0.8436	3.382	0.9525	0.9707	0.9891	0.9943	0.0704
21	13.11	0.9524	0.8529	3.527	0.9547	0.9719	0.9895	0.9945	0.0719
22	13.15	0.9553	0.8638	3.721	0.9572	0.9721	0.9893	0.9944	0.0721
23	13.22	0.9421	0.8595	3.679	0.9565	0.9718	0.9893	0.9944	0.0706
24	13.02	1.0050	0.8605	3.218	0.9538	0.9715	0.9894	0.9945	0.0764
25	13.18	0.9479	0.8648	3.798	0.9587	0.9724	0.9895	0.9946	0.0714
26	13.33	1.0220	0.8707	3.411	0.9557	0.9714	0.9892	0.9943	0.0759
27	13.40	0.9521	0.8487	3.420	0.9539	0.9713	0.9892	0.9943	0.0703
28	13.07	0.9523	0.8398	3.249	0.9512	0.9708	0.9893	0.9945	0.0720
29	13.13	0.9373	0.8489	3.441	0.9551	0.9717	0.9894	0.9945	0.0706
30	13.24	0.9598	0.8596	3.563	0.9566	0.9717	0.9892	0.9943	0.0719
Spec	(none)	.9-1.05	>.80	(none)	0.9547	0.9717	0.9872	0.9920	0.0741
Averages	13.20	0.9816	0.8602	3.473	0.9550	0.9715	0.9893	0.9944	0.0736
Min	13.02	0.9373	0.8398	3.178	0.9497	0.9700	0.9891	0.9943	0.0703
Max	13.40	1.0393	0.8732	3.798	0.9587	0.9724	0.9895	0.9946	0.0774
Std Dev	0.10	0.0363	0.0096	0.1569	0.0020	0.0005	0.0001	0.0001	0.0027

5.3.3.9 Channel 9

Vertical Response data for Channel 9									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.81	0.9737	0.8739	3.779	0.9602	0.9742	0.9902	0.9949	0.0754
10	13.04	1.0370	0.8745	3.732	0.9563	0.9729	0.9900	0.9949	0.0787
11	12.93	1.0330	0.8792	3.865	0.9579	0.9733	0.9901	0.9949	0.0792
12	12.97	1.0327	0.8765	3.797	0.9570	0.9730	0.9900	0.9948	0.0789
13	13.00	0.9401	0.8666	3.852	0.9595	0.9737	0.9901	0.9949	0.0718
14	13.15	1.0360	0.8750	3.742	0.9561	0.9726	0.9899	0.9948	0.0780
15	13.07	1.0197	0.8765	3.783	0.9578	0.9733	0.9900	0.9949	0.0773
16	12.99	0.9451	0.8625	3.738	0.9591	0.9738	0.9902	0.9949	0.0722
17	13.05	1.0192	0.8658	3.534	0.9535	0.9716	0.9898	0.9947	0.0772
18	12.85	1.0111	0.8787	3.825	0.9590	0.9738	0.9902	0.9949	0.0779
19	13.09	0.9655	0.8652	3.644	0.9579	0.9733	0.9901	0.9949	0.0731
20	12.96	0.9632	0.8525	3.426	0.9549	0.9725	0.9899	0.9948	0.0736
21	12.93	0.9590	0.8631	3.659	0.9583	0.9737	0.9901	0.9949	0.0736
22	12.94	0.9609	0.8692	3.769	0.9594	0.9737	0.9900	0.9948	0.0737
23	13.01	0.9613	0.8679	3.755	0.9586	0.9732	0.9898	0.9947	0.0733
24	12.83	1.0290	0.8667	3.567	0.9543	0.9727	0.9900	0.9949	0.0793
25	12.98	0.9756	0.8705	3.625	0.9588	0.9736	0.9901	0.9949	0.0746
26	13.12	1.0285	0.8782	3.788	0.9577	0.9730	0.9899	0.9948	0.0776
27	13.18	0.9541	0.8443	3.291	0.9539	0.9723	0.9899	0.9948	0.0716
28	12.88	0.9549	0.8541	3.488	0.9564	0.9731	0.9900	0.9949	0.0735
29	12.93	0.9335	0.8645	3.829	0.9598	0.9738	0.9900	0.9948	0.0716
30	13.03	0.9609	0.8676	3.709	0.9594	0.9736	0.9900	0.9948	0.0732
Spec	(none)	.9-1.05	>.80	(none)	0.9567	0.9729	0.9878	0.9924	0.0754
Averages	13.00	0.9867	0.8676	3.687	0.9574	0.9732	0.9900	0.9948	0.0752
Min	12.83	0.9335	0.8443	3.291	0.9535	0.9716	0.9898	0.9947	0.0716
Max	13.18	1.0370	0.8792	3.865	0.9598	0.9738	0.9902	0.9949	0.0793
Std Dev	0.09	0.0375	0.0091	0.1513	0.0019	0.0006	0.0001	0.0001	0.0028

5.3.3.10 Channel 10

Vertical Response data for Channel 9									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.81	0.9737	0.8739	3.779	0.9602	0.9742	0.9902	0.9949	0.0754
10	13.04	1.0370	0.8745	3.732	0.9563	0.9729	0.9900	0.9949	0.0787
11	12.93	1.0330	0.8792	3.865	0.9579	0.9733	0.9901	0.9949	0.0792
12	12.97	1.0327	0.8765	3.797	0.9570	0.9730	0.9900	0.9948	0.0789
13	13.00	0.9401	0.8666	3.852	0.9595	0.9737	0.9901	0.9949	0.0718
14	13.15	1.0360	0.8750	3.742	0.9561	0.9726	0.9899	0.9948	0.0780
15	13.07	1.0197	0.8765	3.783	0.9578	0.9733	0.9900	0.9949	0.0773
16	12.99	0.9451	0.8625	3.738	0.9591	0.9738	0.9902	0.9949	0.0722
17	13.05	1.0192	0.8658	3.534	0.9535	0.9716	0.9898	0.9947	0.0772
18	12.85	1.0111	0.8787	3.825	0.9590	0.9738	0.9902	0.9949	0.0779
19	13.09	0.9655	0.8652	3.644	0.9579	0.9733	0.9901	0.9949	0.0731
20	12.96	0.9632	0.8525	3.426	0.9549	0.9725	0.9899	0.9948	0.0736
21	12.93	0.9590	0.8631	3.659	0.9583	0.9737	0.9901	0.9949	0.0736
22	12.94	0.9609	0.8692	3.769	0.9594	0.9737	0.9900	0.9948	0.0737
23	13.01	0.9613	0.8679	3.755	0.9586	0.9732	0.9898	0.9947	0.0733
24	12.83	1.0290	0.8667	3.567	0.9543	0.9727	0.9900	0.9949	0.0793
25	12.98	0.9756	0.8705	3.625	0.9588	0.9736	0.9901	0.9949	0.0746
26	13.12	1.0285	0.8782	3.788	0.9577	0.9730	0.9899	0.9948	0.0776
27	13.18	0.9541	0.8443	3.291	0.9539	0.9723	0.9899	0.9948	0.0716
28	12.88	0.9549	0.8541	3.488	0.9564	0.9731	0.9900	0.9949	0.0735
29	12.93	0.9335	0.8645	3.829	0.9598	0.9738	0.9900	0.9948	0.0716
30	13.03	0.9609	0.8676	3.709	0.9594	0.9736	0.9900	0.9948	0.0732
Spec	(none)	.9-1.05	>.80	(none)	0.9567	0.9729	0.9878	0.9924	0.0754
Averages	13.00	0.9867	0.8676	3.687	0.9574	0.9732	0.9900	0.9948	0.0752
Min	12.83	0.9335	0.8443	3.291	0.9535	0.9716	0.9898	0.9947	0.0716
Max	13.18	1.0370	0.8792	3.865	0.9598	0.9738	0.9902	0.9949	0.0793
Std Dev	0.09	0.0375	0.0091	0.1513	0.0019	0.0006	0.0001	0.0001	0.0028

5.3.3.11 Channel 11

Vertical Response data for Channel 11									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.61	0.9798	0.8889	4.470	0.9655	0.9777	0.9917	0.9958	0.0771
10	12.85	1.0334	0.8813	4.179	0.9607	0.9762	0.9914	0.9956	0.0800
11	12.72	1.0135	0.8824	4.191	0.9633	0.9770	0.9916	0.9957	0.0792
12	12.78	1.0146	0.8873	4.427	0.9633	0.9768	0.9914	0.9957	0.0790
13	12.81	0.9704	0.8860	4.390	0.9646	0.9773	0.9915	0.9957	0.0751
14	12.92	1.0170	0.8824	4.213	0.9625	0.9766	0.9914	0.9957	0.0782
15	12.87	1.0234	0.8808	4.115	0.9624	0.9766	0.9915	0.9957	0.0791
16	12.77	0.9577	0.8685	3.796	0.9630	0.9769	0.9915	0.9957	0.0742
17	12.86	1.0206	0.8794	4.193	0.9605	0.9758	0.9913	0.9956	0.0789
18	12.69	0.9958	0.8873	4.447	0.9644	0.9774	0.9916	0.9957	0.0780
19	12.90	0.9779	0.8666	3.805	0.9602	0.9761	0.9915	0.9957	0.0750
20	12.76	0.9455	0.8659	3.695	0.9625	0.9766	0.9914	0.9957	0.0734
21	12.74	0.9676	0.8853	4.320	0.9653	0.9776	0.9916	0.9958	0.0753
22	12.73	0.9643	0.8843	4.272	0.9649	0.9774	0.9915	0.9957	0.0750
23	12.80	0.9489	0.8826	4.163	0.9649	0.9772	0.9915	0.9957	0.0735
24	12.66	1.0278	0.8838	4.246	0.9626	0.9770	0.9916	0.9957	0.0808
25	12.78	0.9620	0.8844	4.309	0.9649	0.9774	0.9916	0.9958	0.0746
26	12.90	1.0278	0.8902	4.466	0.9636	0.9769	0.9915	0.9957	0.0793
27	12.97	0.9816	0.8742	3.918	0.9635	0.9770	0.9915	0.9957	0.0750
28	12.71	0.9612	0.8687	3.770	0.9632	0.9770	0.9915	0.9957	0.0749
29	12.73	0.9427	0.8828	4.159	0.9654	0.9775	0.9915	0.9957	0.0734
30	12.81	0.9675	0.8834	4.264	0.9643	0.9770	0.9914	0.9956	0.0748
Spec	(none)	.9-1.05	>.80	(none)	0.9611	0.9757	0.9891	0.9931	0.0771
Averages	12.80	0.9867	0.8804	4.159	0.9633	0.9769	0.9915	0.9957	0.0765
Min	12.66	0.9427	0.8659	3.695	0.9602	0.9758	0.9913	0.9956	0.0734
Max	12.97	1.0334	0.8902	4.466	0.9654	0.9776	0.9916	0.9958	0.0808
Std Dev	0.08	0.0311	0.0072	0.2315	0.0015	0.0005	0.0001	0.0000	0.0025

5.3.3.12 Channel 12

Vertical Response data for Channel 12									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.40	0.9738	0.8966	5.038	0.9698	0.9803	0.9928	0.9964	0.0783
10	12.63	0.9679	0.8778	4.392	0.9655	0.9790	0.9925	0.9963	0.0762
11	12.53	0.9395	0.8898	4.737	0.9695	0.9801	0.9927	0.9964	0.0745
12	12.57	1.0294	0.8949	4.307	0.9672	0.9795	0.9926	0.9963	0.0816
13	12.61	0.9513	0.8930	4.965	0.9690	0.9799	0.9926	0.9964	0.0750
14	12.69	0.9843	0.8941	4.847	0.9686	0.9797	0.9926	0.9963	0.0773
15	12.67	0.9619	0.8755	4.226	0.9671	0.9794	0.9925	0.9963	0.0755
16	12.56	1.0152	0.8882	4.319	0.9674	0.9797	0.9927	0.9964	0.0805
17	12.64	0.9730	0.8921	4.897	0.9681	0.9796	0.9926	0.9963	0.0767
18	12.49	1.0068	0.8950	4.704	0.9685	0.9799	0.9926	0.9963	0.0805
19	12.69	0.9652	0.8709	4.145	0.9644	0.9787	0.9925	0.9963	0.0755
20	12.53	0.9660	0.8882	4.737	0.9683	0.9797	0.9926	0.9963	0.0767
21	12.53	0.9924	0.8957	4.874	0.9690	0.9800	0.9927	0.9963	0.0790
22	12.52	1.0048	0.8951	4.725	0.9681	0.9796	0.9926	0.9963	0.0801
23	12.58	0.9613	0.8879	4.742	0.9681	0.9796	0.9926	0.9963	0.0760
24	12.45	0.9508	0.8874	4.736	0.9686	0.9798	0.9926	0.9963	0.0759
25	12.58	1.0292	0.8957	4.333	0.9675	0.9796	0.9927	0.9964	0.0815
26	12.66	0.9765	0.8943	4.916	0.9688	0.9798	0.9926	0.9963	0.0768
27	12.73	1.0175	0.8932	4.441	0.9682	0.9797	0.9926	0.9963	0.0797
28	12.50	1.0118	0.8823	4.131	0.9663	0.9794	0.9926	0.9963	0.0806
29	12.50	0.9395	0.8788	4.412	0.9680	0.9797	0.9926	0.9964	0.0745
30	12.57	0.9663	0.8945	4.964	0.9692	0.9800	0.9926	0.9963	0.0765
Spec	(none)	.9-1.05	>.80	(none)	0.9646	0.9779	0.9900	0.9937	0.0783
Averages	12.58	0.9815	0.8888	4.598	0.9679	0.9796	0.9926	0.9963	0.0776
Min	12.45	0.9395	0.8709	4.131	0.9644	0.9787	0.9925	0.9963	0.0745
Max	12.73	1.0294	0.8957	4.965	0.9695	0.9801	0.9927	0.9964	0.0816
Std Dev	0.08	0.0287	0.0075	0.2828	0.0013	0.0003	0.0001	0.0000	0.0024

5.3.3.13 Channel 13

Vertical Response data for Channel 13									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.40	0.9694	0.8999	5.118	0.9719	0.9817	0.9933	0.9968	0.0780
10	12.63	0.9470	0.8778	4.353	0.9688	0.9808	0.9932	0.9967	0.0746
11	12.55	1.0007	0.8962	4.390	0.9699	0.9810	0.9932	0.9966	0.0794
12	12.58	0.9706	0.8892	4.643	0.9700	0.9810	0.9932	0.9967	0.0769
13	12.62	1.0337	0.9053	4.976	0.9699	0.9810	0.9932	0.9967	0.0814
14	12.71	0.9868	0.8929	4.605	0.9701	0.9809	0.9931	0.9966	0.0774
15	12.69	0.9468	0.8963	5.193	0.9716	0.9814	0.9932	0.9967	0.0744
16	12.59	1.0378	0.9058	5.016	0.9703	0.9812	0.9933	0.9967	0.0819
17	12.61	1.0341	0.9009	4.843	0.9686	0.9805	0.9931	0.9967	0.0815
18	12.47	0.9324	0.8973	5.328	0.9721	0.9817	0.9933	0.9967	0.0745
19	12.70	1.0144	0.8980	4.592	0.9689	0.9807	0.9931	0.9966	0.0794
20	12.52	0.9552	0.8739	4.227	0.9685	0.9808	0.9932	0.9967	0.0760
21	12.52	0.9388	0.8860	4.837	0.9708	0.9815	0.9933	0.9967	0.0747
22	12.52	1.0177	0.9053	4.894	0.9705	0.9811	0.9932	0.9967	0.0808
23	12.57	0.9403	0.8944	5.145	0.9714	0.9813	0.9932	0.9967	0.0746
24	12.44	0.9441	0.8846	4.722	0.9704	0.9813	0.9932	0.9967	0.0756
25	12.57	0.9658	0.8788	4.406	0.9675	0.9805	0.9932	0.9967	0.0765
26	12.65	1.0159	0.8971	4.516	0.9692	0.9808	0.9932	0.9967	0.0798
27	12.74	0.9707	0.8869	4.550	0.9704	0.9812	0.9932	0.9967	0.0760
28	12.48	0.9507	0.8774	4.405	0.9694	0.9810	0.9932	0.9967	0.0758
29	12.50	0.9566	0.8758	4.208	0.9692	0.9810	0.9932	0.9967	0.0762
30	12.59	0.9409	0.8896	4.788	0.9713	0.9814	0.9932	0.9967	0.0745
Spec	(none)	.9-1.05	>.80	(none)	0.9669	0.9793	0.9907	0.9942	0.0780
Averages	12.58	0.9762	0.8909	4.697	0.9699	0.9811	0.9932	0.9967	0.0772
Min	12.44	0.9324	0.8739	4.208	0.9675	0.9805	0.9931	0.9966	0.0744
Max	12.74	1.0378	0.9058	5.328	0.9721	0.9817	0.9933	0.9967	0.0819
Std Dev	0.08	0.0362	0.0101	0.3188	0.0012	0.0003	0.0001	0.0000	0.0026

5.3.3.14 Channel 14

Vertical Response data for Channel 14									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.29	0.9758	0.9077	5.133	0.9732	0.9826	0.9937	0.9970	0.0789
10	12.52	0.9731	0.8862	4.241	0.9697	0.9815	0.9936	0.9969	0.0772
11	12.44	1.0041	0.8920	4.539	0.9706	0.9819	0.9937	0.9970	0.0802
12	12.47	0.9700	0.8827	4.121	0.9697	0.9816	0.9936	0.9969	0.0772
13	12.53	1.0185	0.9079	5.422	0.9714	0.9819	0.9936	0.9969	0.0809
14	12.59	0.9714	0.8981	4.682	0.9719	0.9820	0.9936	0.9969	0.0767
15	12.58	0.9466	0.8968	4.981	0.9730	0.9824	0.9936	0.9969	0.0751
16	12.49	1.0164	0.9071	5.311	0.9721	0.9822	0.9937	0.9970	0.0810
17	12.50	1.0107	0.9050	5.297	0.9710	0.9817	0.9936	0.9969	0.0804
18	12.37	0.9378	0.8931	4.960	0.9727	0.9824	0.9936	0.9970	0.0756
19	12.59	1.0359	0.9055	5.286	0.9707	0.9817	0.9936	0.9969	0.0819
20	12.40	0.9598	0.8882	4.351	0.9715	0.9820	0.9936	0.9970	0.0770
21	12.43	0.9412	0.8891	4.755	0.9723	0.9824	0.9937	0.9970	0.0755
22	12.40	1.0198	0.9014	5.097	0.9711	0.9820	0.9936	0.9970	0.0818
23	12.45	0.9409	0.8987	5.163	0.9729	0.9823	0.9936	0.9970	0.0754
24	12.34	0.9280	0.8958	5.210	0.9732	0.9825	0.9937	0.9970	0.0750
25	12.47	0.9473	0.8897	4.719	0.9712	0.9820	0.9937	0.9970	0.0757
26	12.53	1.0136	0.9046	5.246	0.9712	0.9819	0.9936	0.9970	0.0804
27	12.62	0.9758	0.9034	4.901	0.9728	0.9824	0.9937	0.9970	0.0769
28	12.38	0.9783	0.8925	4.540	0.9713	0.9820	0.9936	0.9969	0.0785
29	12.39	0.9565	0.8758	3.897	0.9701	0.9817	0.9936	0.9969	0.0768
30	12.47	0.9651	0.9009	4.672	0.9727	0.9823	0.9936	0.9970	0.0771
Spec	(none)	.9-1.05	>.80	(none)	0.9679	0.9799	0.9909	0.9943	0.0789
Averages	12.47	0.9767	0.8959	4.828	0.9716	0.9820	0.9936	0.9970	0.0779
Min	12.34	0.9280	0.8758	3.897	0.9697	0.9815	0.9936	0.9969	0.0750
Max	12.62	1.0359	0.9079	5.422	0.9732	0.9825	0.9937	0.9970	0.0819
Std Dev	0.08	0.0325	0.0086	0.4322	0.0011	0.0003	0.0000	0.0001	0.0024

5.3.3.15 Channel 15

Vertical Response data for Channel 15									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.27	0.9746	0.9086	5.064	0.9739	0.9830	0.9939	0.9970	0.0791
10	12.50	0.9676	0.8887	4.347	0.9709	0.9820	0.9937	0.9970	0.0770
11	12.42	1.0052	0.8879	4.217	0.9708	0.9822	0.9937	0.9970	0.0804
12	12.45	0.9533	0.8802	4.305	0.9708	0.9820	0.9936	0.9970	0.0762
13	12.51	1.0135	0.9101	5.464	0.9723	0.9824	0.9937	0.9970	0.0805
14	12.55	0.9909	0.8974	4.706	0.9718	0.9821	0.9936	0.9969	0.0784
15	12.55	0.9458	0.9001	5.232	0.9736	0.9827	0.9937	0.9970	0.0752
16	12.47	1.0183	0.9044	5.066	0.9727	0.9826	0.9938	0.9970	0.0812
17	12.47	1.0315	0.9073	5.433	0.9713	0.9820	0.9937	0.9970	0.0823
18	12.36	0.9602	0.8964	4.792	0.9731	0.9827	0.9938	0.9970	0.0774
19	12.57	1.0207	0.9016	5.019	0.9711	0.9820	0.9937	0.9970	0.0807
20	12.38	0.9759	0.9003	4.753	0.9727	0.9825	0.9937	0.9970	0.0784
21	12.40	0.9634	0.8756	3.936	0.9700	0.9820	0.9937	0.9970	0.0772
22	12.38	1.0208	0.9025	5.084	0.9717	0.9822	0.9937	0.9970	0.0820
23	12.42	0.9629	0.9002	4.935	0.9730	0.9824	0.9936	0.9969	0.0773
24	12.32	0.9281	0.8965	5.296	0.9737	0.9829	0.9938	0.9970	0.0752
25	12.45	0.9485	0.8785	4.276	0.9703	0.9821	0.9937	0.9970	0.0759
26	12.49	1.0141	0.9019	5.118	0.9710	0.9821	0.9937	0.9970	0.0806
27	12.58	0.9746	0.8971	4.513	0.9730	0.9826	0.9937	0.9970	0.0771
28	12.36	0.9772	0.8972	4.627	0.9724	0.9824	0.9937	0.9970	0.0786
29	12.37	0.9602	0.8837	4.320	0.9714	0.9823	0.9937	0.9970	0.0773
30	12.44	0.9427	0.8978	5.149	0.9735	0.9827	0.9937	0.9970	0.0756
Spec	(none)	.9-1.05	>.80	(none)	0.9685	0.9803	0.9911	0.9944	0.0791
Averages	12.45	0.9798	0.8955	4.790	0.9720	0.9823	0.9937	0.9970	0.0783
Min	12.32	0.9281	0.8756	3.936	0.9700	0.9820	0.9936	0.9969	0.0752
Max	12.58	1.0315	0.9101	5.464	0.9737	0.9829	0.9938	0.9970	0.0823
Std Dev	0.08	0.0308	0.0095	0.4403	0.0011	0.0003	0.0001	0.0000	0.0023

5.3.3.16 Channel 16

Vertical Response data for Channel 16									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.34	0.9764	0.9093	5.230	0.9741	0.9832	0.9939	0.9971	0.0787
10	12.58	0.9749	0.8913	4.506	0.9708	0.9821	0.9937	0.9970	0.0770
11	12.51	1.0079	0.8957	4.567	0.9722	0.9825	0.9938	0.9970	0.0801
12	12.53	0.9555	0.8783	3.988	0.9708	0.9822	0.9937	0.9970	0.0758
13	12.61	1.0375	0.9106	5.632	0.9720	0.9824	0.9938	0.9970	0.0820
14	12.61	0.9901	0.9051	5.151	0.9729	0.9826	0.9938	0.9970	0.0780
15	12.65	0.9489	0.8985	5.004	0.9739	0.9829	0.9938	0.9970	0.0748
16	12.56	1.0367	0.9068	5.262	0.9726	0.9827	0.9938	0.9970	0.0822
17	12.54	1.0170	0.9068	5.385	0.9724	0.9826	0.9938	0.9971	0.0807
18	12.45	0.9628	0.8987	4.611	0.9733	0.9829	0.9938	0.9971	0.0770
19	12.66	1.0214	0.9003	5.009	0.9712	0.9822	0.9937	0.9970	0.0802
20	12.46	0.9828	0.9034	5.043	0.9731	0.9827	0.9938	0.9970	0.0784
21	12.50	0.9453	0.8784	4.209	0.9714	0.9824	0.9938	0.9970	0.0753
22	12.46	1.0202	0.9052	5.245	0.9723	0.9825	0.9938	0.9970	0.0815
23	12.49	0.9393	0.8990	5.168	0.9737	0.9829	0.9938	0.9971	0.0751
24	12.41	0.9509	0.8984	4.949	0.9738	0.9830	0.9939	0.9971	0.0764
25	12.53	0.9528	0.8719	3.715	0.9694	0.9819	0.9938	0.9970	0.0755
26	12.56	1.0178	0.9043	5.341	0.9716	0.9824	0.9938	0.9970	0.0806
27	12.64	0.9498	0.8945	4.656	0.9738	0.9830	0.9938	0.9970	0.0749
28	12.46	0.9589	0.8877	4.307	0.9727	0.9827	0.9938	0.9970	0.0766
29	12.45	0.9632	0.8947	4.531	0.9726	0.9826	0.9938	0.9970	0.0770
30	12.51	0.9644	0.8966	4.594	0.9727	0.9826	0.9938	0.9970	0.0767
Spec	(none)	.9-1.05	>.80	(none)	0.9690	0.9806	0.9913	0.9945	0.0787
Averages	12.53	0.9809	0.8965	4.803	0.9723	0.9826	0.9938	0.9970	0.0779
Min	12.41	0.9393	0.8719	3.715	0.9694	0.9819	0.9937	0.9970	0.0748
Max	12.66	1.0375	0.9106	5.632	0.9739	0.9830	0.9939	0.9971	0.0822
Std Dev	0.07	0.0330	0.0102	0.4952	0.0012	0.0003	0.0000	0.0000	0.0025

5.3.3.17 Channel 17

Vertical Response data for Channel 17									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.59	0.9749	0.9116	5.286	0.9748	0.9836	0.9940	0.9971	0.0770
10	12.86	0.9760	0.8912	4.413	0.9713	0.9824	0.9938	0.9970	0.0754
11	12.79	1.0304	0.8994	4.792	0.9722	0.9827	0.9938	0.9970	0.0802
12	12.81	0.9789	0.8901	4.396	0.9717	0.9826	0.9938	0.9970	0.0759
13	12.91	1.0191	0.9093	5.512	0.9722	0.9825	0.9937	0.9969	0.0785
14	12.85	0.9659	0.9053	4.955	0.9739	0.9830	0.9938	0.9970	0.0748
15	12.93	0.9752	0.8937	4.458	0.9728	0.9827	0.9938	0.9970	0.0750
16	12.84	1.0192	0.9082	5.358	0.9734	0.9830	0.9938	0.9970	0.0789
17	12.80	1.0117	0.9084	5.455	0.9728	0.9827	0.9938	0.9970	0.0786
18	12.74	0.9624	0.8853	4.210	0.9724	0.9828	0.9938	0.9970	0.0752
19	12.96	1.0272	0.9107	5.557	0.9728	0.9826	0.9938	0.9970	0.0789
20	12.73	0.9550	0.8911	4.649	0.9734	0.9831	0.9939	0.9970	0.0748
21	12.79	0.9703	0.8842	4.044	0.9714	0.9826	0.9938	0.9970	0.0754
22	12.74	1.0173	0.9078	5.366	0.9731	0.9828	0.9938	0.9970	0.0794
23	12.74	0.9362	0.9011	5.382	0.9742	0.9831	0.9938	0.9970	0.0734
24	12.70	0.9328	0.8902	4.966	0.9736	0.9831	0.9939	0.9970	0.0733
25	12.83	0.9608	0.8702	3.586	0.9691	0.9821	0.9938	0.9970	0.0744
26	12.81	1.0296	0.8843	4.389	0.9680	0.9817	0.9938	0.9970	0.0799
27	12.87	0.9702	0.9055	4.970	0.9741	0.9833	0.9939	0.9971	0.0750
28	12.76	0.9835	0.9062	5.084	0.9734	0.9828	0.9938	0.9970	0.0766
29	12.71	0.9395	0.8725	4.117	0.9713	0.9826	0.9938	0.9970	0.0736
30	12.76	0.9406	0.8910	4.858	0.9733	0.9830	0.9939	0.9971	0.0735
Spec	(none)	.9-1.05	>.80	(none)	0.9703	0.9814	0.9916	0.9948	0.0770
Averages	12.81	0.9810	0.8955	4.787	0.9724	0.9827	0.9938	0.9970	0.0762
Min	12.70	0.9328	0.8702	3.586	0.9680	0.9817	0.9937	0.9969	0.0733
Max	12.96	1.0304	0.9107	5.557	0.9742	0.9833	0.9939	0.9971	0.0802
Std Dev	0.07	0.0330	0.0120	0.5533	0.0016	0.0004	0.0000	0.0000	0.0023

5.3.3.18 Channel 18

Vertical Response data for Channel 18									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.59	0.9785	0.9145	6.114	0.9757	0.9844	0.9944	0.9974	0.0774
10	12.89	1.0229	0.9092	5.535	0.9740	0.9836	0.9942	0.9972	0.0793
11	12.74	0.9746	0.9014	5.314	0.9744	0.9840	0.9943	0.9973	0.0761
12	12.82	1.0198	0.9028	5.186	0.9735	0.9836	0.9942	0.9972	0.0794
13	12.89	0.9596	0.9001	5.212	0.9732	0.9835	0.9942	0.9972	0.0739
14	12.84	1.0196	0.9083	5.554	0.9742	0.9838	0.9943	0.9973	0.0793
15	12.89	0.9786	0.8856	4.535	0.9724	0.9834	0.9942	0.9973	0.0754
16	12.80	0.9739	0.9126	5.991	0.9752	0.9842	0.9943	0.9973	0.0757
17	12.85	1.0309	0.9033	5.311	0.9722	0.9832	0.9942	0.9973	0.0801
18	12.79	0.9770	0.8935	4.810	0.9733	0.9836	0.9942	0.9972	0.0759
19	12.96	0.9881	0.9048	5.562	0.9736	0.9836	0.9942	0.9973	0.0759
20	12.76	0.9508	0.8994	5.103	0.9746	0.9840	0.9943	0.9973	0.0740
21	12.82	1.0353	0.9049	5.311	0.9730	0.9835	0.9942	0.9973	0.0807
22	12.73	1.0333	0.9112	5.596	0.9742	0.9838	0.9943	0.9973	0.0811
23	12.76	0.9676	0.9079	5.636	0.9747	0.9839	0.9943	0.9973	0.0754
24	12.73	1.0102	0.9125	5.938	0.9747	0.9839	0.9942	0.9973	0.0792
25	12.83	1.0274	0.9001	5.167	0.9719	0.9833	0.9942	0.9973	0.0799
26	12.84	1.0208	0.8773	3.823	0.9689	0.9828	0.9942	0.9973	0.0791
27	12.86	1.0297	0.9113	5.650	0.9740	0.9838	0.9943	0.9973	0.0800
28	12.79	0.9971	0.9060	5.577	0.9741	0.9837	0.9942	0.9973	0.0777
29	12.75	0.9706	0.9054	5.456	0.9746	0.9839	0.9943	0.9973	0.0757
30	12.76	1.0368	0.9072	5.142	0.9740	0.9838	0.9943	0.9973	0.0812
Spec	(none)	.9-1.05	>.80	(none)	0.9716	0.9823	0.9920	0.9950	0.0774
Averages	12.81	1.0012	0.9031	5.305	0.9736	0.9837	0.9942	0.9973	0.0779
Min	12.73	0.9508	0.8773	3.823	0.9689	0.9828	0.9942	0.9972	0.0739
Max	12.96	1.0368	0.9126	5.991	0.9752	0.9842	0.9943	0.9973	0.0812
Std Dev	0.06	0.0288	0.0088	0.4799	0.0014	0.0003	0.0001	0.0000	0.0024

5.3.3.19 Channel 19

Vertical Response data for Channel 19									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.34	0.9775	0.9138	6.173	0.9763	0.9848	0.9946	0.9975	0.0790
10	12.60	1.0487	0.9109	4.869	0.9740	0.9840	0.9945	0.9974	0.0829
11	12.48	0.9692	0.8990	5.347	0.9748	0.9843	0.9945	0.9974	0.0773
12	12.54	1.0220	0.9036	4.983	0.9744	0.9841	0.9944	0.9974	0.0814
13	12.60	0.9745	0.9014	5.469	0.9739	0.9840	0.9944	0.9974	0.0770
14	12.60	1.0209	0.9091	5.392	0.9749	0.9842	0.9945	0.9975	0.0809
15	12.62	0.9740	0.9059	5.722	0.9756	0.9844	0.9945	0.9975	0.0769
16	12.52	0.9724	0.9125	6.177	0.9759	0.9846	0.9945	0.9975	0.0774
17	12.58	1.0094	0.8991	5.146	0.9731	0.9837	0.9944	0.9974	0.0801
18	12.48	0.9565	0.8954	4.948	0.9750	0.9844	0.9945	0.9975	0.0762
19	12.66	0.9897	0.9031	5.517	0.9742	0.9841	0.9945	0.9974	0.0780
20	12.48	0.9701	0.9072	5.807	0.9756	0.9845	0.9945	0.9975	0.0775
21	12.52	1.0330	0.9066	5.148	0.9741	0.9841	0.9945	0.9974	0.0824
22	12.46	1.0350	0.9115	5.300	0.9747	0.9842	0.9945	0.9974	0.0829
23	12.51	0.9701	0.9093	5.848	0.9755	0.9844	0.9945	0.9974	0.0773
24	12.43	1.0237	0.9114	5.511	0.9753	0.9844	0.9945	0.9975	0.0823
25	12.54	1.0260	0.9025	5.082	0.9731	0.9840	0.9945	0.9975	0.0817
26	12.58	1.0454	0.8898	3.852	0.9708	0.9835	0.9945	0.9974	0.0827
27	12.63	1.0116	0.9130	5.829	0.9753	0.9844	0.9946	0.9975	0.0801
28	12.48	0.9927	0.9069	5.705	0.9753	0.9844	0.9945	0.9974	0.0794
29	12.47	0.9492	0.9008	5.262	0.9755	0.9845	0.9945	0.9975	0.0757
30	12.51	1.0394	0.9078	4.848	0.9746	0.9842	0.9945	0.9974	0.0829
Spec	(none)	.9-1.05	>.80	(none)	0.9716	0.9823	0.9920	0.9950	0.0790
Averages	12.54	1.0016	0.9051	5.322	0.9746	0.9842	0.9945	0.9974	0.0797
Min	12.43	0.9492	0.8898	3.852	0.9708	0.9835	0.9944	0.9974	0.0757
Max	12.66	1.0487	0.9130	6.177	0.9759	0.9846	0.9946	0.9975	0.0829
Std Dev	0.06	0.0317	0.0060	0.4938	0.0012	0.0003	0.0000	0.0001	0.0026

5.3.3.20 Channel 20

Vertical Response data for Channel 20									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.27	0.9714	0.9156	6.368	0.9776	0.9856	0.9949	0.9977	0.0792
10	12.50	1.0428	0.9123	5.354	0.9751	0.9848	0.9948	0.9977	0.0830
11	12.40	0.9647	0.8981	5.329	0.9761	0.9852	0.9948	0.9976	0.0777
12	12.45	0.9929	0.9067	5.333	0.9764	0.9852	0.9949	0.9976	0.0797
13	12.50	0.9673	0.9008	5.531	0.9752	0.9849	0.9949	0.9977	0.0772
14	12.54	1.0238	0.9170	5.545	0.9763	0.9851	0.9949	0.9977	0.0813
15	12.54	0.9669	0.9091	5.983	0.9771	0.9853	0.9949	0.9976	0.0771
16	12.43	0.9607	0.9133	6.373	0.9774	0.9856	0.9950	0.9977	0.0772
17	12.50	1.0286	0.9139	5.428	0.9754	0.9848	0.9948	0.9976	0.0819
18	12.38	0.9471	0.9027	5.557	0.9769	0.9854	0.9949	0.9977	0.0762
19	12.57	0.9608	0.9044	5.820	0.9760	0.9850	0.9948	0.9976	0.0763
20	12.40	0.9623	0.9066	5.914	0.9769	0.9854	0.9949	0.9977	0.0775
21	12.42	1.0032	0.9061	5.238	0.9760	0.9852	0.9949	0.9977	0.0806
22	12.38	1.0319	0.9133	5.440	0.9758	0.9850	0.9949	0.9977	0.0829
23	12.43	0.9495	0.9112	6.205	0.9770	0.9853	0.9948	0.9977	0.0762
24	12.34	0.9969	0.9083	5.439	0.9766	0.9853	0.9949	0.9977	0.0807
25	12.45	1.0015	0.9039	5.196	0.9751	0.9850	0.9949	0.9977	0.0803
26	12.50	1.0176	0.8983	4.385	0.9743	0.9847	0.9949	0.9977	0.0810
27	12.57	1.0101	0.9147	5.427	0.9769	0.9853	0.9949	0.9977	0.0801
28	12.38	1.0056	0.9110	5.415	0.9767	0.9852	0.9948	0.9976	0.0811
29	12.38	0.9582	0.9098	6.015	0.9771	0.9854	0.9949	0.9976	0.0772
30	12.44	1.0367	0.9175	5.541	0.9764	0.9852	0.9949	0.9977	0.0829
Spec	(none)	.9-1.05	>.80	(none)	0.9730	0.9831	0.9924	0.9952	0.0792
Averages	12.45	0.9919	0.9085	5.546	0.9762	0.9852	0.9949	0.9977	0.0794
Min	12.34	0.9471	0.8981	4.385	0.9743	0.9847	0.9948	0.9976	0.0762
Max	12.57	1.0428	0.9175	6.373	0.9774	0.9856	0.9950	0.9977	0.0830
Std Dev	0.07	0.0314	0.0057	0.4185	0.0008	0.0002	0.0001	0.0000	0.0024

5.3.3.21 Channel 21

Vertical Response data for Channel 21									
Lib	Plt.Sc.	FWHM	IVR*	SLOPE*	IVR	IVR	IVR	IVR	Detec.Ht.
Nbr	(km/mm)	(km)	FWHM	(@50%)	.75km	1.0km	2.0km	3.0km	(mm)
9	12.30	0.9754	0.9257	6.452	0.9794	0.9869	0.9956	0.9980	0.0789
10	12.53	1.0179	0.9166	6.220	0.9773	0.9862	0.9955	0.9981	0.0810
11	12.42	0.9427	0.8970	5.053	0.9782	0.9866	0.9954	0.9980	0.0757
12	12.48	1.0182	0.9231	6.727	0.9782	0.9864	0.9955	0.9981	0.0814
13	12.52	0.9474	0.9068	5.697	0.9779	0.9864	0.9953	0.9980	0.0755
14	12.58	1.0380	0.9243	6.864	0.9779	0.9862	0.9955	0.9981	0.0824
15	12.57	0.9696	0.9092	5.313	0.9784	0.9865	0.9954	0.9980	0.0768
16	12.46	0.9438	0.9108	5.918	0.9792	0.9868	0.9954	0.9980	0.0757
17	12.53	1.0261	0.9038	5.454	0.9749	0.9855	0.9954	0.9981	0.0816
18	12.39	0.9667	0.9124	5.409	0.9788	0.9867	0.9955	0.9980	0.0777
19	12.60	0.9862	0.9219	6.398	0.9783	0.9864	0.9954	0.9979	0.0779
20	12.42	0.9419	0.8870	4.615	0.9770	0.9862	0.9953	0.9980	0.0757
21	12.44	1.0065	0.9252	6.849	0.9787	0.9866	0.9957	0.9982	0.0806
22	12.41	1.0076	0.9196	6.456	0.9780	0.9863	0.9955	0.9981	0.0808
23	12.47	0.9660	0.9197	5.918	0.9786	0.9865	0.9954	0.9980	0.0772
24	12.36	1.0020	0.9237	6.683	0.9786	0.9865	0.9956	0.9982	0.0807
25	12.48	1.0240	0.9215	6.749	0.9776	0.9863	0.9957	0.9983	0.0819
26	12.54	1.0163	0.9114	5.790	0.9769	0.9861	0.9956	0.9982	0.0807
27	12.62	1.0319	0.9226	6.655	0.9781	0.9863	0.9956	0.9982	0.0817
28	12.41	0.9879	0.9169	5.968	0.9784	0.9865	0.9954	0.9980	0.0792
29	12.40	0.9385	0.9133	6.200	0.9793	0.9867	0.9954	0.9980	0.0756
30	12.47	1.0156	0.9213	6.482	0.9783	0.9864	0.9956	0.9982	0.0812
Spec	(none)	.9-1.05	>.80	(none)	0.9751	0.9845	0.9930	0.9956	0.0789
Averages	12.48	0.9902	0.9147	6.068	0.9780	0.9864	0.9955	0.9981	0.0791
Min	12.36	0.9385	0.8870	4.615	0.9749	0.9855	0.9953	0.9979	0.0755
Max	12.62	1.0380	0.9252	6.864	0.9793	0.9868	0.9957	0.9983	0.0824
Std Dev	0.07	0.0338	0.0099	0.6375	0.0009	0.0003	0.0001	0.0001	0.0025