Visible & Infrared Survey Telescope for Astronomy

Data Flow System

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Change Record

Issue	Date	Sections Affected	Description of Change/Change Request Reference/Remarks
1.0	2006-07-21	All	New document
1.1	2006-08-09	All	total reflectance loss, WFCAM Z, atmosphere, overheads, VISTA Ag coating, throughput.
1.2	2007-03-13	front	first official version
1.3 pre 1	2007-12-07	6	Saturation data

Notification List

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ATC	Malcolm Stewart

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1 Introduction

The Visible and Infrared Survey Telescope for Astronomy (VISTA) is a new 4-metre telescope designed specifically for imaging survey work at visible and near-infrared wavelengths. The pawprint of the VISTA infrared camera (VIRCAM) will cover 0.59 degree^2 in ZYJHK$_s$ passbands, using a 4×4 array of 2k×2k non-buttable chips with ~0.34″ pixels.

VISTA will be located in the southern hemisphere, at the European Southern Observatory's (ESO's) Cerro Paranal Observatory.

1.1 Scope of this Document

The VISTA Data-Flow System follows the specifications laid out in [AD1], including the Exposure Time Calculator (ETC). This document describes the Instrument Data, supplied as machine-readable files, used to calculate the system throughput.

1.2 Data Availability

As well as being described and illustrated in this document, the data is available tabulated in plain ascii files at ftp://ftp.ast.cam.ac.uk/pub/psb/VISTA/instrument.

File	Contents
README	explanatory text
m1.tab	M1 (primary mirror) reflectivity 300-3000nm
m2.tab	M2 (secondary mirror) ditto
concave1.tab	digitized reflectivity data for Lens 1 concave surface, tabulated from 750 to 2500 nm every nm
convex1.tab	Lens 1 convex ditto
concave2.tab	Lens 1 concave ditto
convex2.tab	Lens 2 convex ditto
concave2.tab	Lens 2 concave ditto
convex3.tab	Lens 3 convex ditto
concave3.tab	Lens 3 concave ditto
Z.tab	Z filter tabulated in 1nm steps from 500 to 2500nm
Y.tab	Y filter ditto
J.tab	J filter ditto
H.tab	H filter ditto
Ks.tab	K short filter ditto
qe.tab	representative QE curve for the detectors, tabulated from 806-3529nm every nm
atmosphere.tab	Model atmospheric absorption

1.3 Applicable Documents

[AD1] *Data Flow for the VLT/VLTI Instruments Deliverables Specification,* VLT-SPE-ESO-19000-1618, issue 2.0, 2004-05-22.
[AD2] *VISTA Infra Red Camera Exposure Time Calculator Specification,* VIS-SPE-IOA-20000-0009, issue 1.1, 2005-09-01.

1.4 Reference Documents

[RD1] *VISTA Infra Red Camera DFS Calibration Plan*, VIS-SPE-IOA-20000-00002, issue 1.3, 2005-12-25.
[RD2] *VISTA Infra Red Camera DFS Data-Reduction Specifications,* VIS-SPE-IOA-20000-00003, issue 1.0, 2004-12-15.
[RD3] *VISTA Science Requirements Document*, VIS-SPE-VSC-00000-0001, issue 2.0, 2000-10-26
[RD4] *VISTA IR Camera Technical Specification,* VIS-SPE-ATC-06000-0004 Issue 2.0
[RD5] *The UKIRT Infrared Deep Sky Survey* ZYJHK *Photometric System: Passbands and Synthetic Colours,* Hewett P.C., Warren S.J., Legett S.K., Hodgkin S.T., *MNRAS,* ***367,*** *454*, 2006.
[RD6] *NASA Technical Memorandum,103957.* Lord S.D. 1992.

1.5 Abbreviations and Acronyms

ATRAN	Atmospheric Transmission code
DFS	Data Flow System
ETC	Exposure Time Calculator
PSF	Point Spread Function
SRD	Science Requirements Document
VDFS	VISTA Data Flow System
VIRCAM	VISTA Infrared Camera
VISTA	Visible and Infrared Survey Telescope for Astronomy
WFCAM	Wide Field Camera (on UKIRT)

2 Telescope and Instrument Overview

VISTA is an alt-azimuth 2-mirror telescope with a single focal station (quasi Ritchey-Chrétien) which can accommodate one of two possible cameras: an IR Camera or (if funded later) a visible camera. The telescope has a fast focal ratio (f/1 primary, f/3.25 at Cass) hence a compact structure. The telescope uses active optics, with 84 axial force actuators controlling the shape of the primary mirror (M1), and a 5-axis hexapod controlling the position of the secondary mirror (M2).

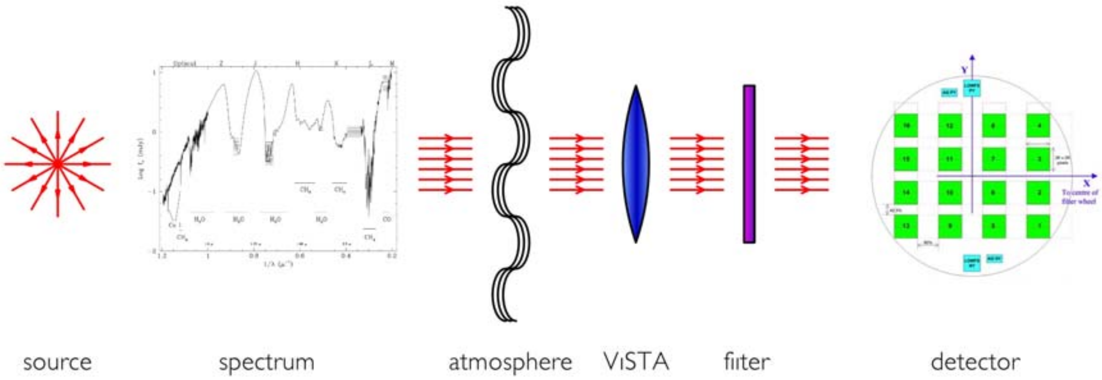

Figure 2-1 Conceptual View of the Light Path from Source to Detector

The infrared camera (details in [RD4]) is a novel design with no cold stop, but instead a long cold baffle extending ~ 2.1m above the focal plane to minimise the detectors' view of warm surfaces. There is a large entrance window (95cm diameter) and 3 corrector lenses, all IR-grade fused silica. There is only one moving part (the filter wheel). The camera also contains fixed autoguiders and wavefront sensors (2 each, using CCDs operating at ~ 800nm wavelength) to control the tracking and active optics. Table 1 gives approximate values for the main system parameters.

Telescope Mount	Alt-Azimuth
Focal Station	Cassegrain
Primary Mirror Diameter	4.1 metre
Entrance Pupil Diameter	3.7 metre
Secondary Mirror Diameter	1.24 metre
Baffle Diameter	1.63 metre
System Focal Length	12.072 metre
Wavelength Range	0.85-2.4μm
Field of View (total)	1.65° diameter
Field of View (detectors)	0.59 deg² (1.5°×1° tiled)
Detectors	4×4 mosaic of 2048×2048 Raytheon VIRGO
Pixel Scale (Infrared)	0.34″ / 20μm
Controllers	ESO IRACE
System Image Quality	≤ 0.5″ (goal: 0.4″).
Readouts	16 per detector (each a “stripe” of 2048×128 pixels).
Readout time	Approx. 1 second
Filters (mounted)	1 dark + 7 science (Z, Y, J, H, K_S, NB1.18 + TBD)

Table 1: VISTA and VIRCAM baseline system parameters

3 VISTA Telescope Mirrors

The two mirrors are silvered for optimal infra red performance, where a fresh Ag coating will give almost complete reflection in the IR.

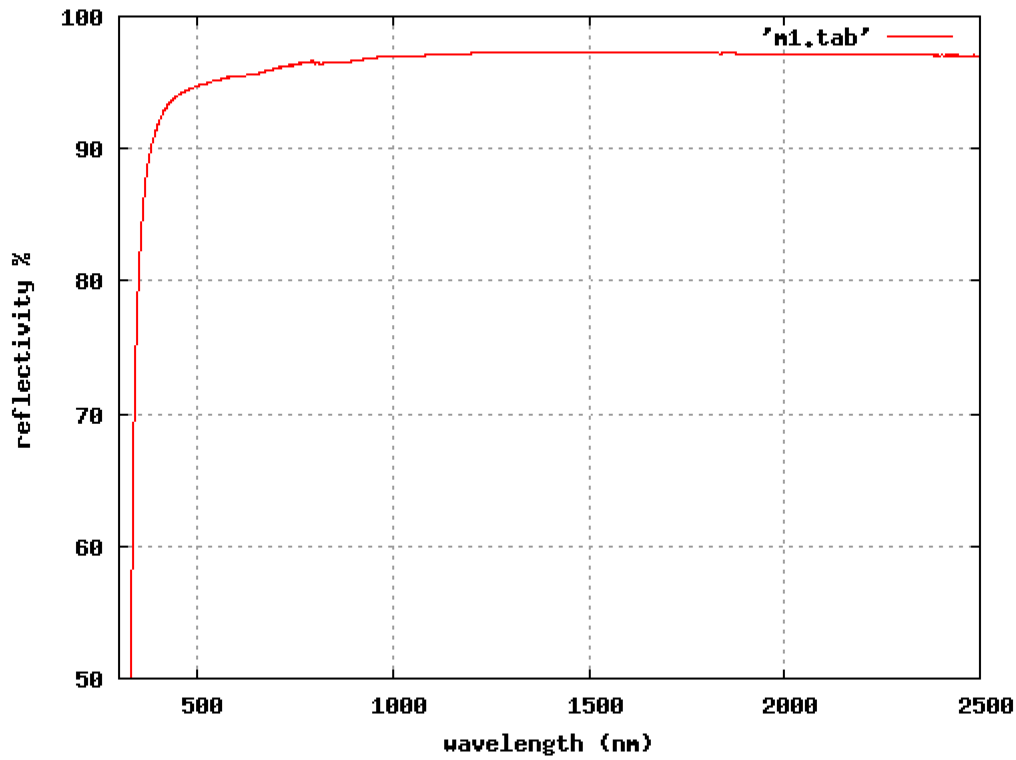

Figure 3-1 Ag coating Reflectivity

At the time of this document release, the actual VISTA mirror reflectivity is unavailable; however the Figure 3-1 shows the performance of matching material which was silver-coated in the VISTA silvering plant. The original un-calibrated data has had a scale factor of 1.0029 applied long ward of 2000nm to put it on a common system. It can be assumed that M1 and M2 will be initially identical.

4 Transmission Optics

Four elements are in this category, the cryostat front window and the set of lenses comprising the correction optics.

4.1 Cryostat Window

The plane window has its outside surface in atmosphere, with the potential to accumulate contamination, with the inside surface in the essentially permanently clean environment of the cryostat.

4.2 Field-Correction Lenses

There are three lenses, each with a concave and convex surface, all reside within the cryostat.

Reflectance data was provided graphically by the manufacturer and has been digitised using “Engauge Digitizer” software (http://digitizer.sourcefourge.net). Note that the very high frequencies are a measurement artefact - for example they go negative on occasion – and so the digitization process smoothed over the curves.

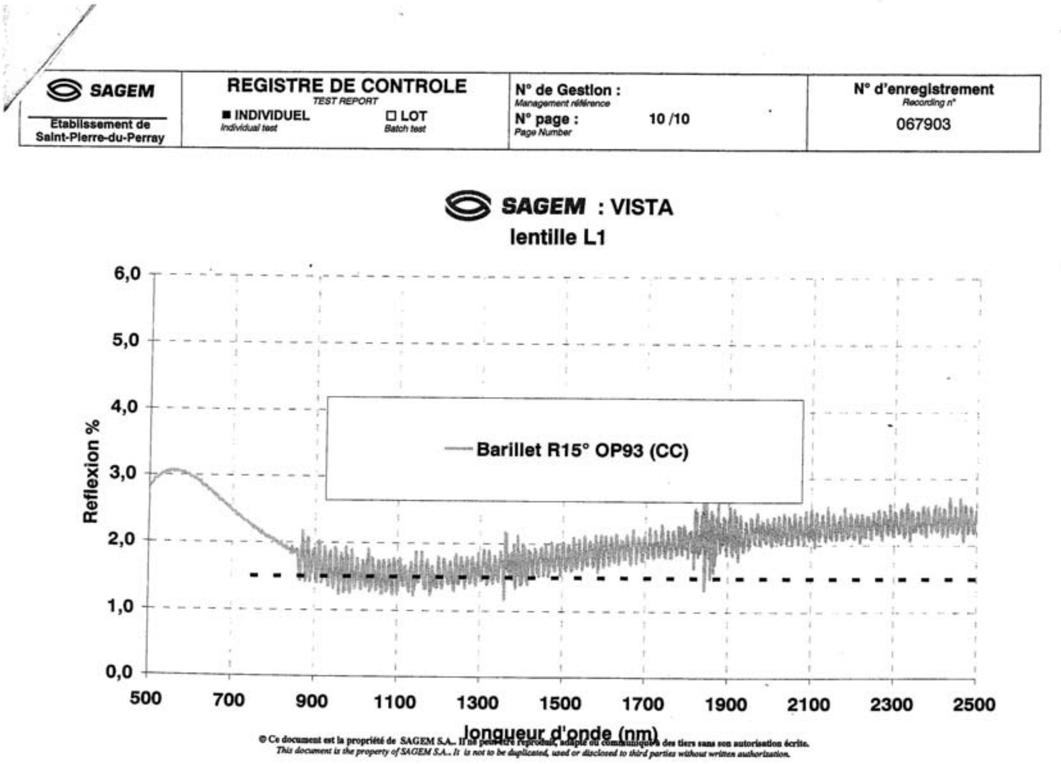

Figure 4-1 Trace of Lens 1 Concave Surface

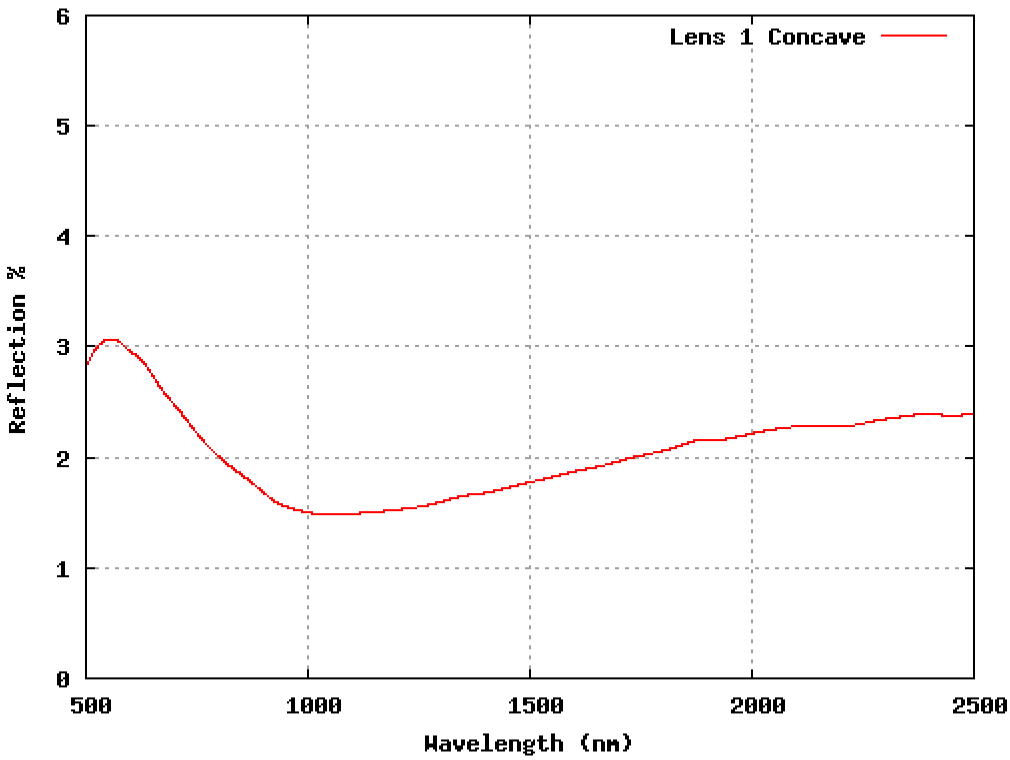

Figure 4-2 Lens 1 Concave Surface Data.

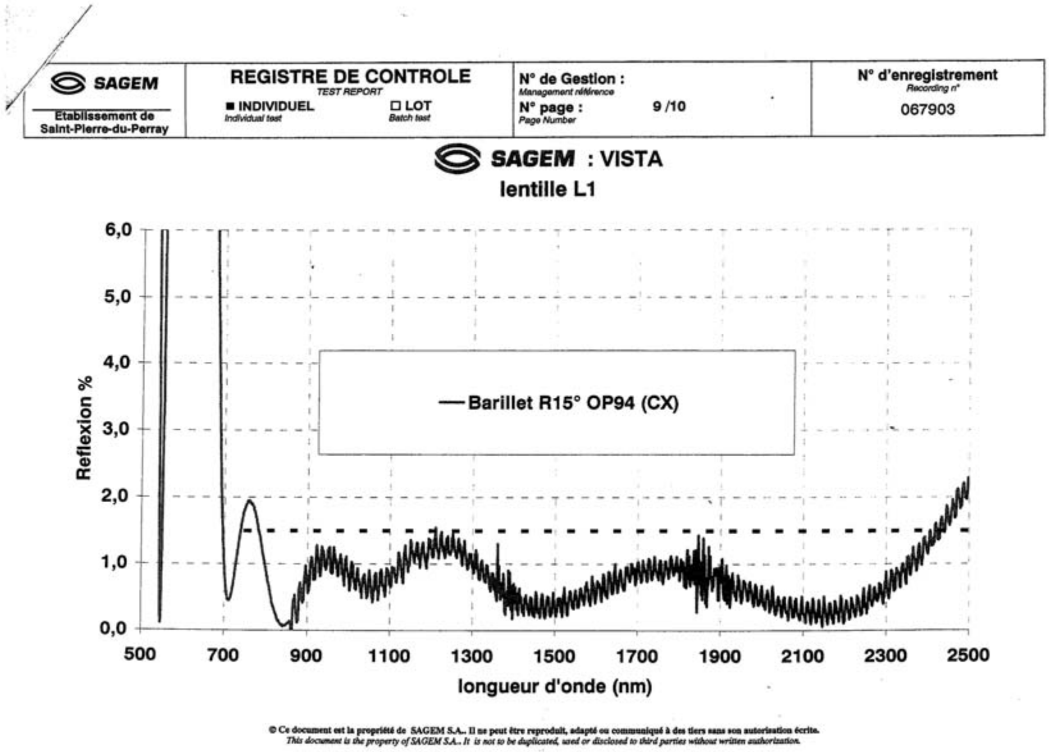

Figure 4-3 Manufacturer's Trace of Lens 1 Convex Surface

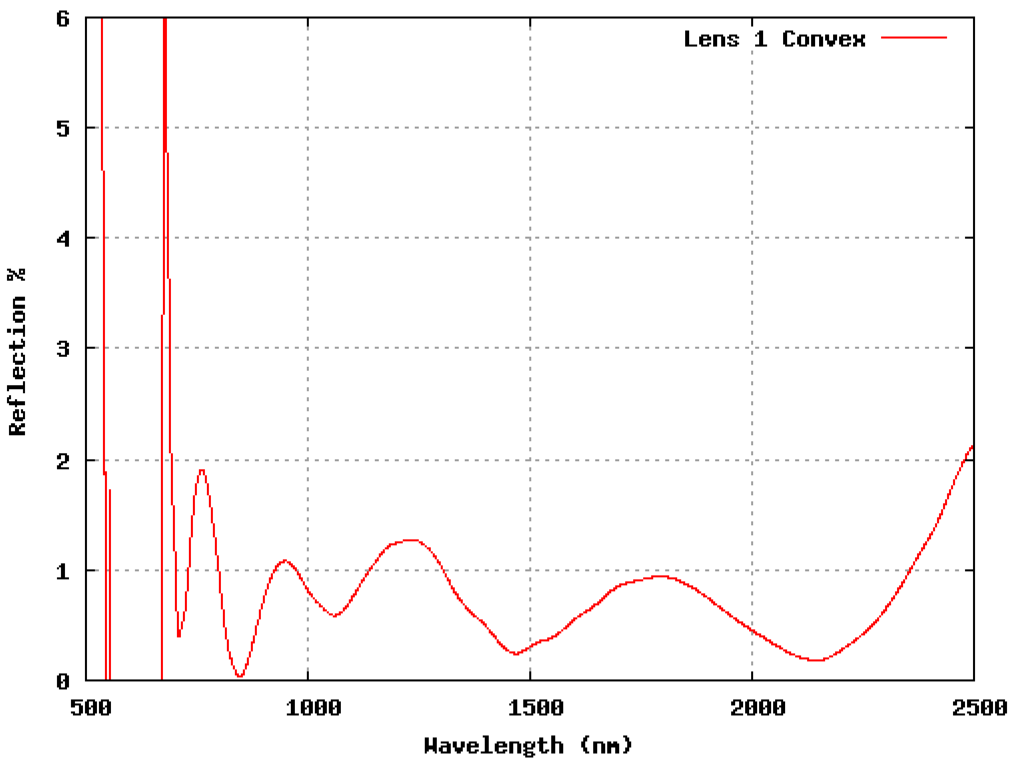

Figure 4-4 Lens 1 Convex Data

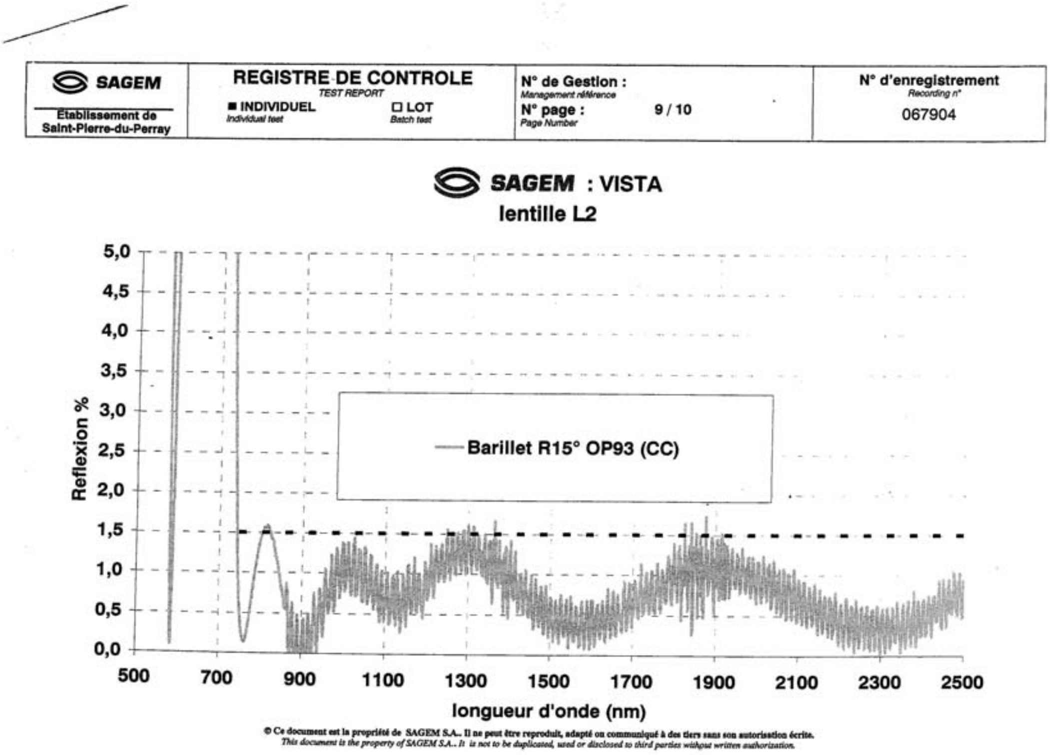

Figure 4-5 Manufacturer's Trace of Lens 2 Concave Surface

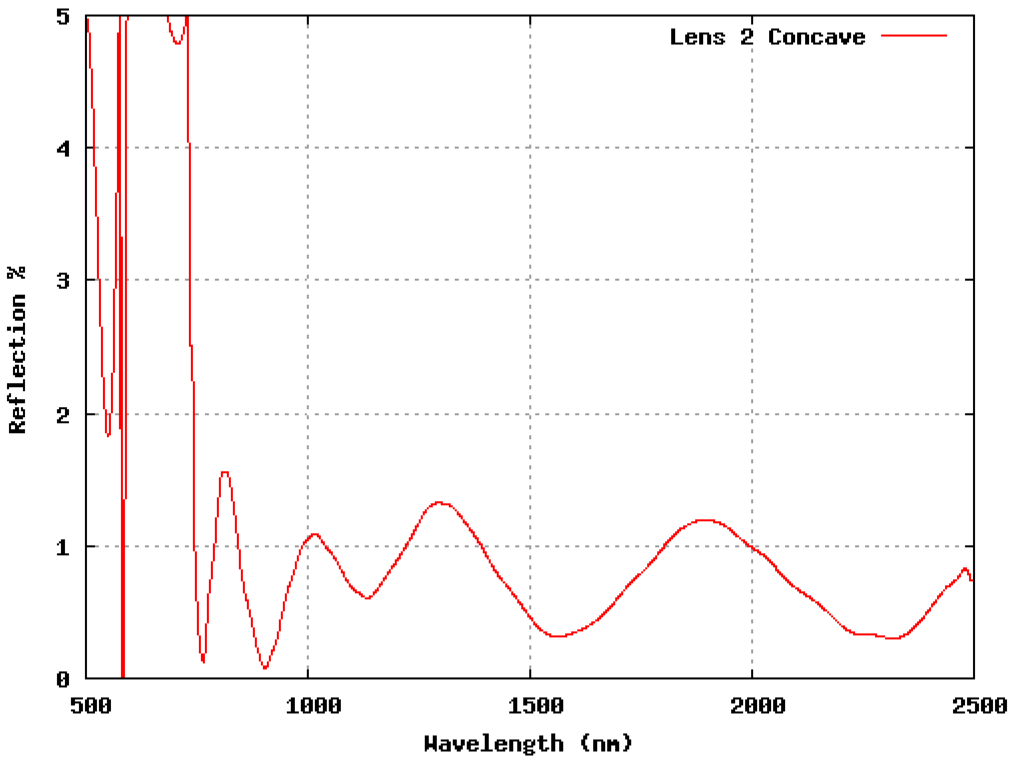

Figure 4-6 Lens 2 Concave Data

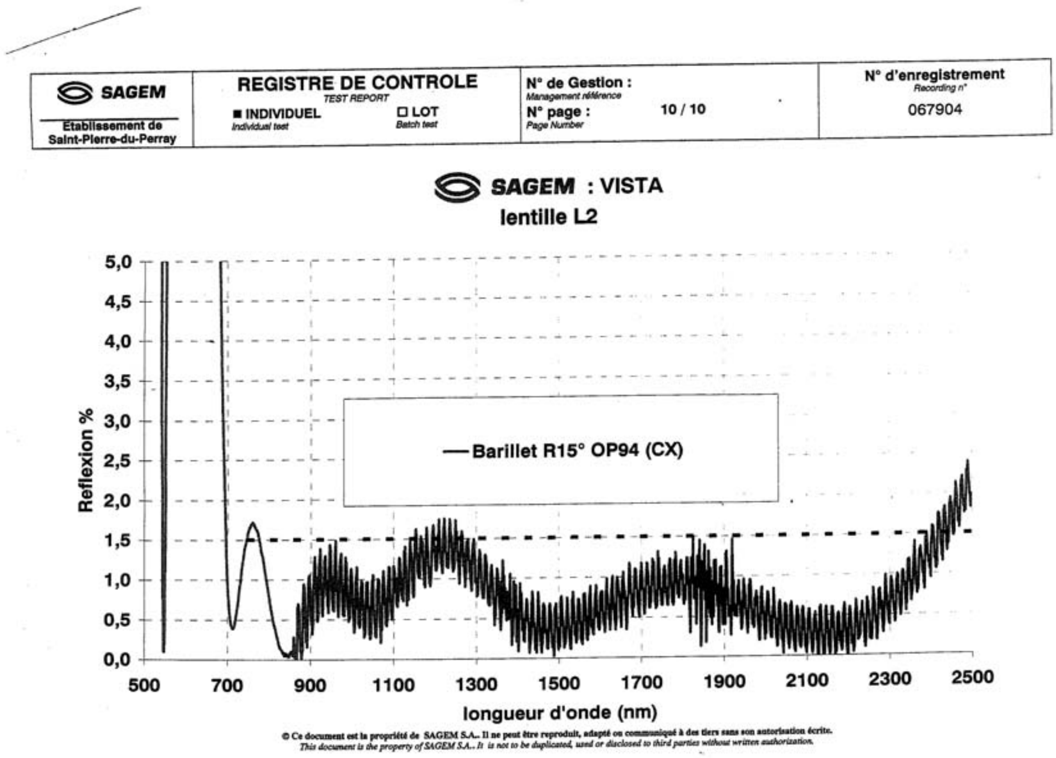

Figure 4-7 Manufacturer's Trace of Lens 2 Convex Surface

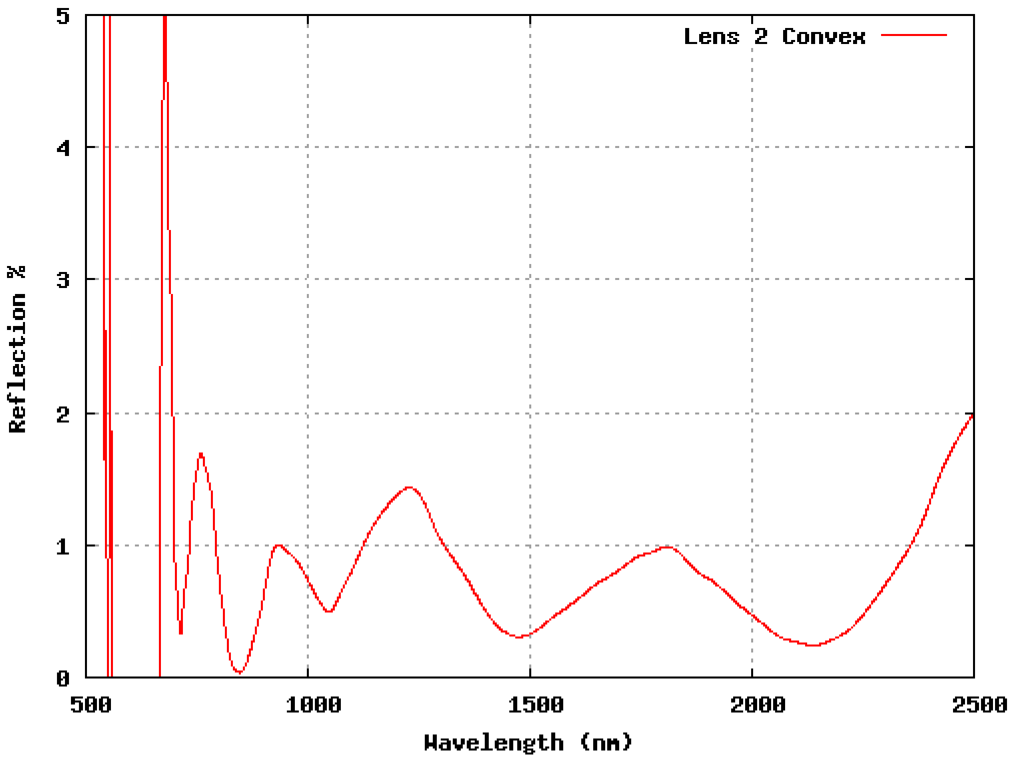

Figure 4-8 Lens 2 Convex Data

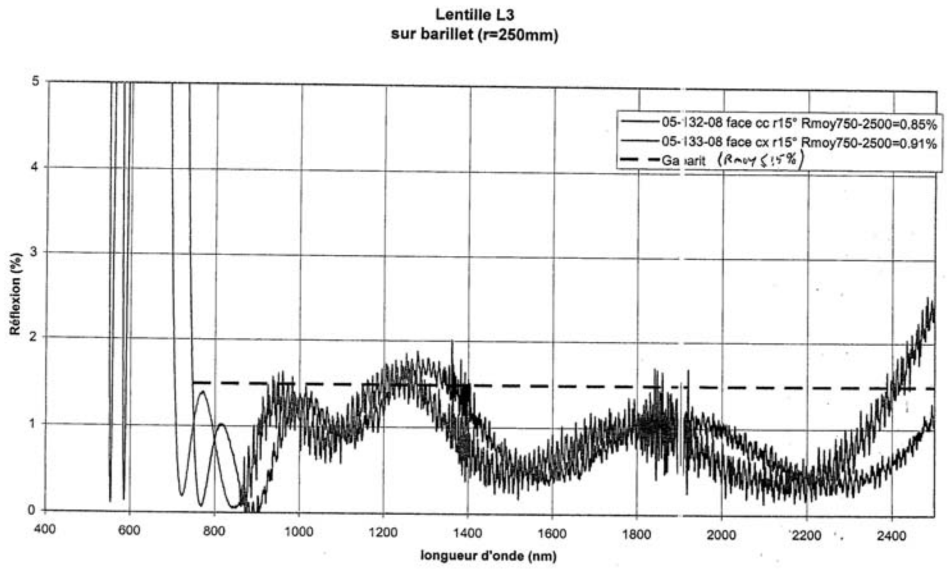

Figure 4-9 Manufacturer's Traces of Lens 3 Both Surfaces

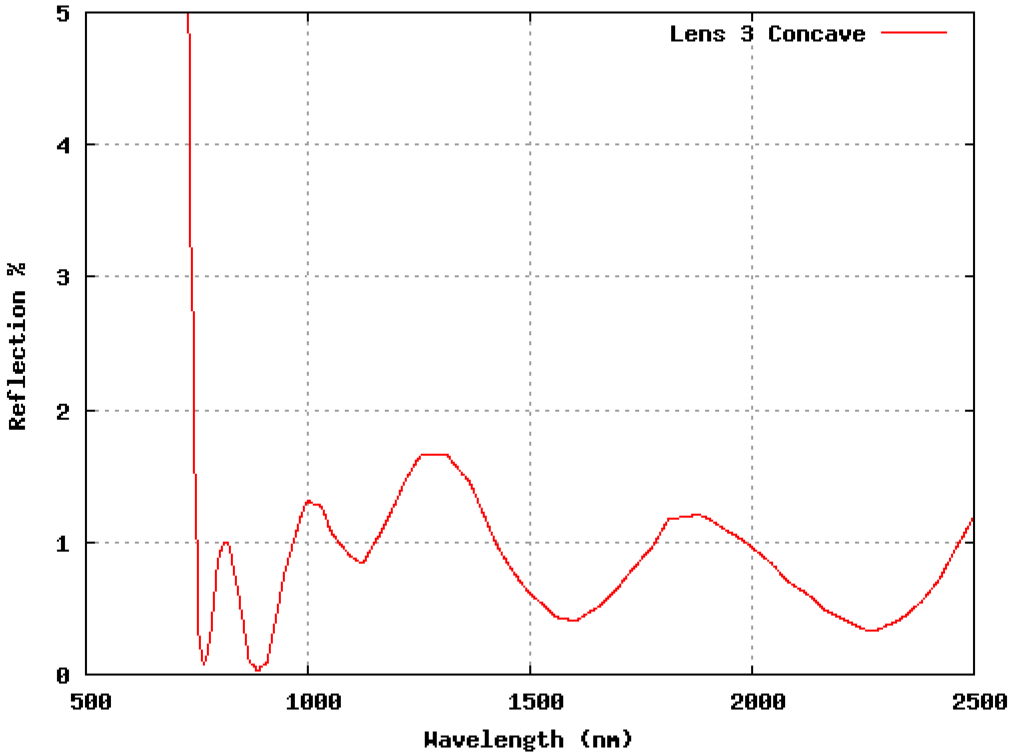

Figure 4-10 Lens 3 Concave Data

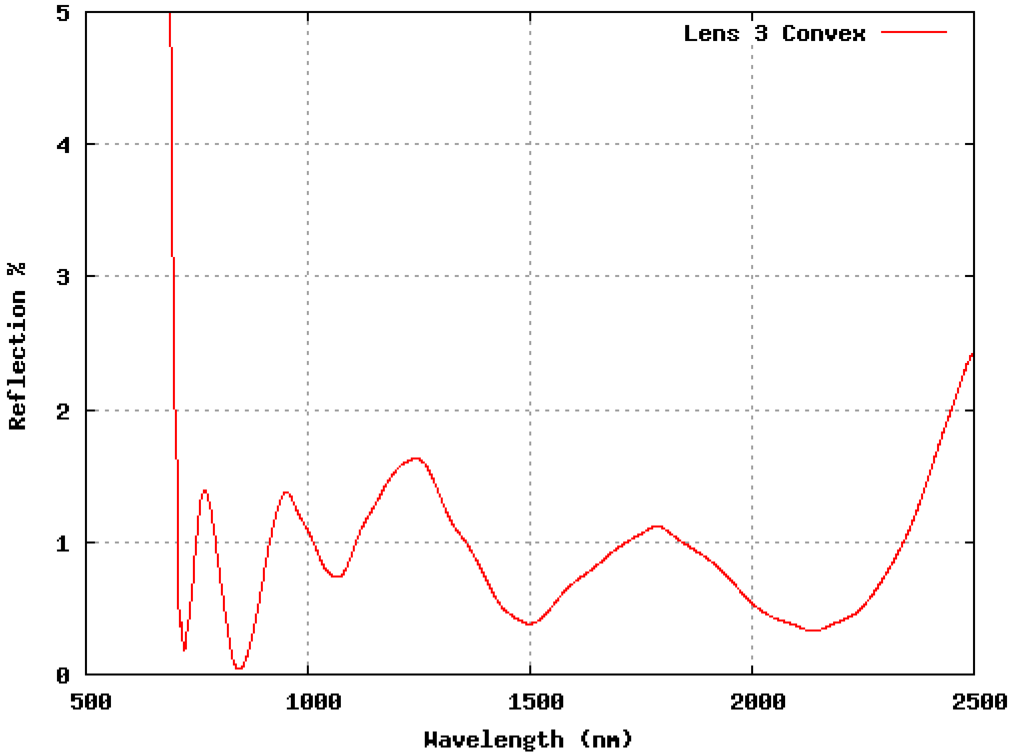

Figure 4-11 Lens 3 Convex Data

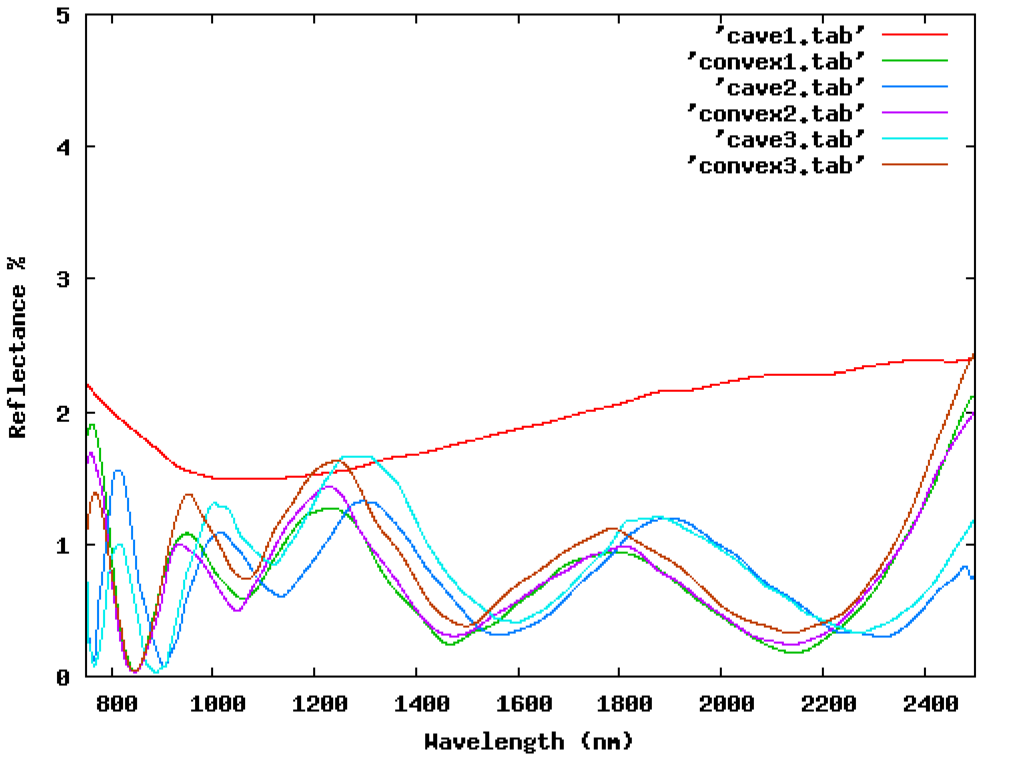

Figure 4-12 All Lens Reflectance data over-plotted

In the over-plot diagram Figure 2-1, the none-valid data below 750nm is omitted. It can be seen that the reflectance of the concave surfaces of lenses 2 & 3 matches rather well, as do all three convex-surface data sets.

4.3 Total Reflectance Losses

Combining all six lens-surface data, and in the absence of actual window data assuming that the window will have the same surface properties as lens 3, the total attenuation due to reflectance in the transmission optics is as shown in Figure 4-13.

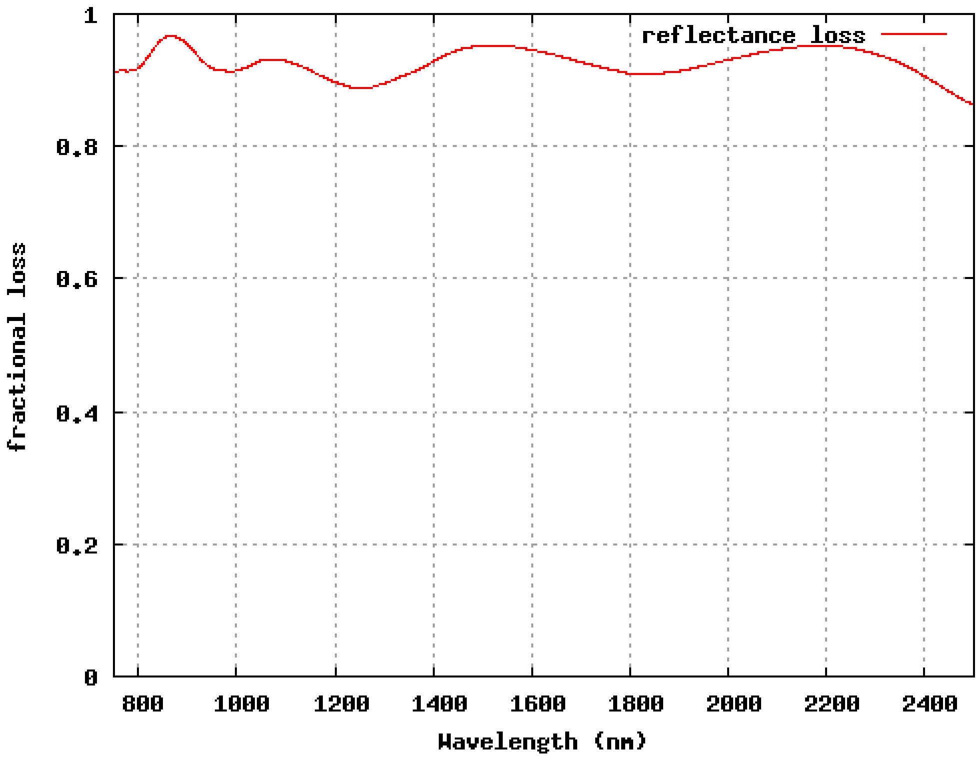

Figure 4-13 Total Attenuation in Transmission Optics

5 Filters

The VIRCAM filters are designed to work at the cryogenic temperatures of the IR detectors. Because the science filters themselves cannot be scanned in such an environment, smaller witness samples are scanned at the correct temperature. The profiles of the four currently supplied filters are shown below in Figure 5-1. The Z filter for VIRCAM has been specified to be as close as practicable to the WFCAM Z filter [RD5], and the latter will be used pending data for the new filter.

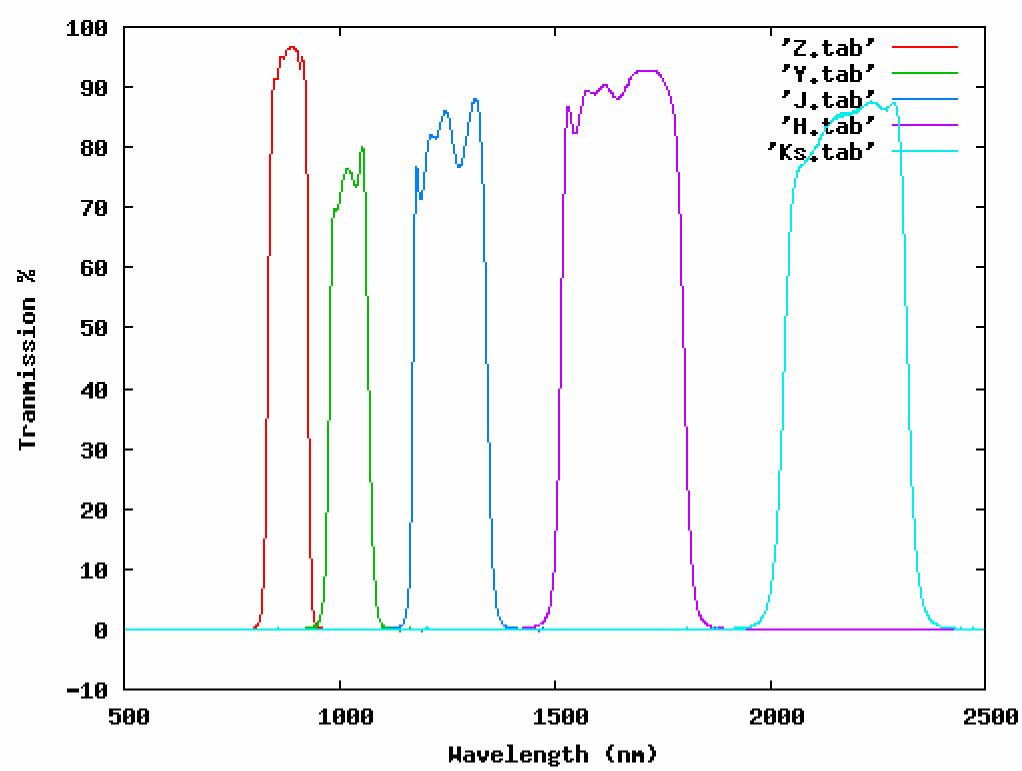

Figure 5-1 VIRCAM filter Witness-Sample transmissions

6 Detectors

6.1 Quantum-Efficiency

The Quantum-Efficiency curve was supplied as a representative, relative scan:

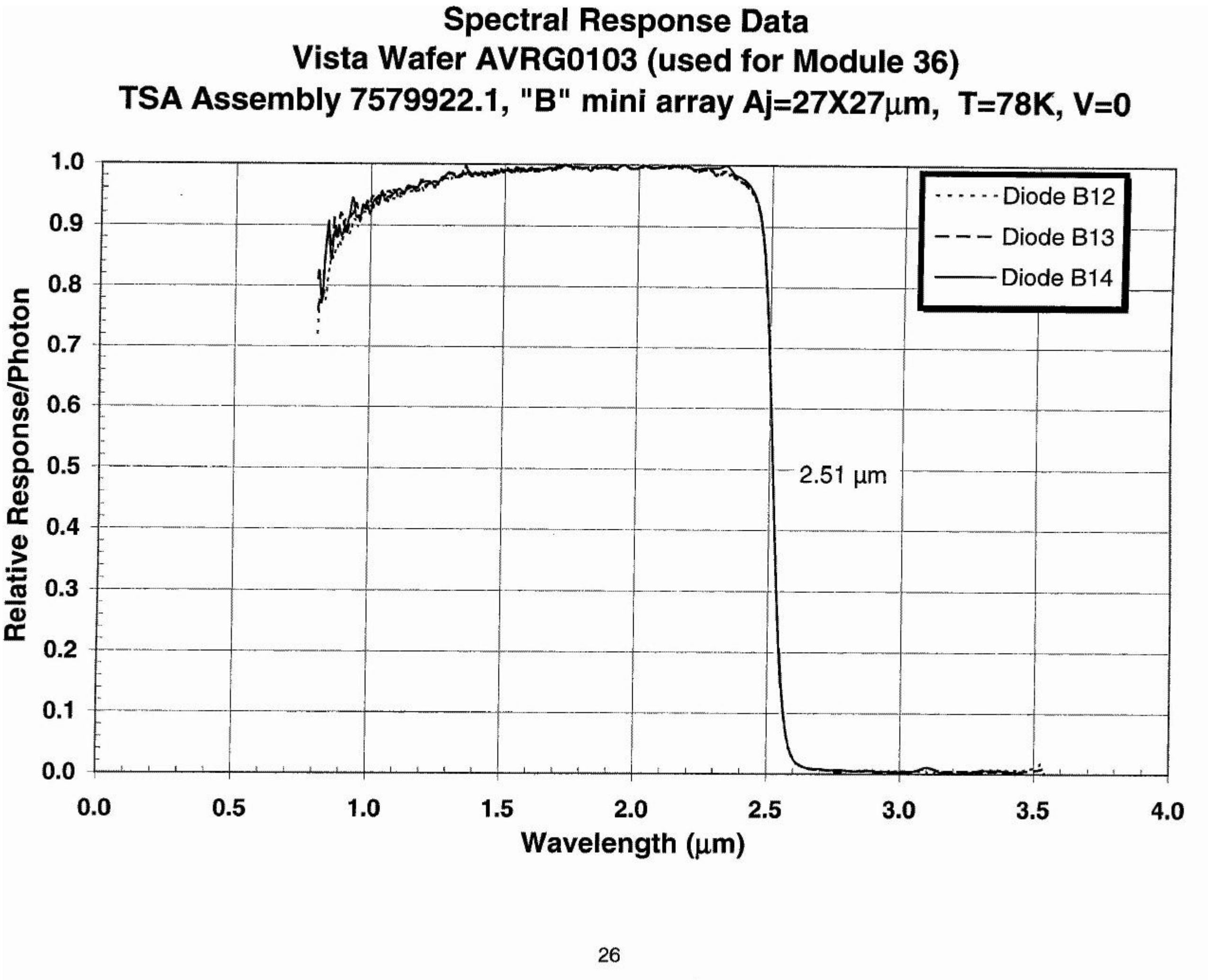

Figure 6-1 Manufacturer's Quantum-Efficiency Curve

When digitized in similar fashion to the lenses, and scaled to a typical good science-grade chip, the data is as follows:

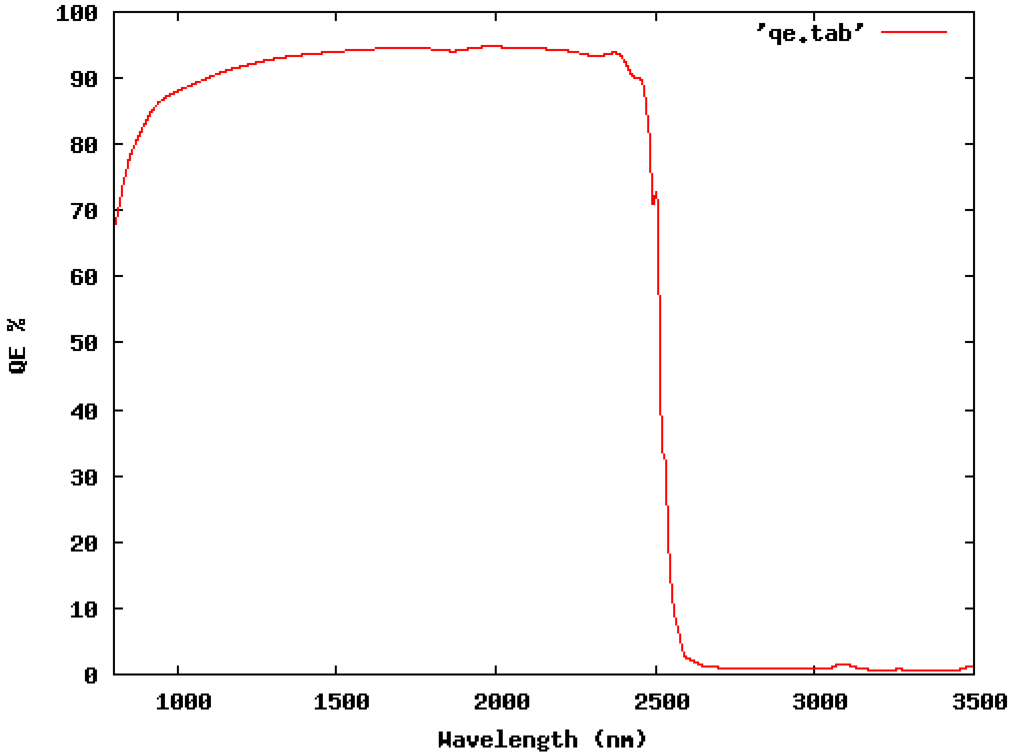

Figure 6-2 QE Data scaled to detector

6.2 Saturation Levels

Interim values for the saturation levels in ADUs for each chip has been determined from AIT data taken at RAL during 2006:

Chip	Saturation/ADU
1	34300
2	38000
3	37800
4	37000
5	31200
6	38800
7	36500
8	38400
9	39400
10	36900
11	39300
12	36500
13	40500
14	39600
15	37200
16	40600

Table 2 Detector Saturation Levels

Note that these are interim values (as of 2007-12) pending a targeted investigation of saturation characteristics.

7 Atmosphere

While not part of the instrument as such, the atmosphere is a key element in the

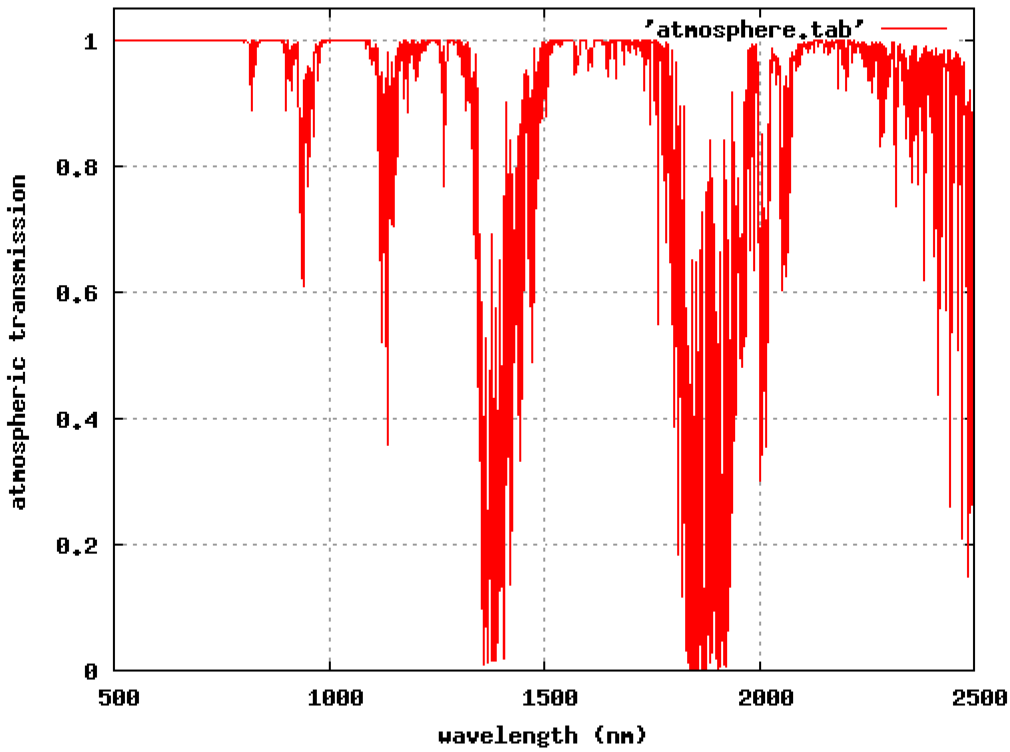

Figure 7-1 Adopted Atmospheric absorption at VISTA

exposure-time calculation. The model, shown in Figure 7-1 above, is the atmospheric absorption computed with ATRAN ([RD6]) for an airmass of 1.0 and precipitable water vapour of 2.0mm. It has been binned to 1nm to match all of the optics data.

8 Total System Throughput

Combining all of the above information, we can now derive the total system throughput from above the atmosphere, through the telescope, window, lenses, filter and detector. Using the QE for the best detector, Figure 8-1 illustrates the calculated throughput for Z, Y, J, H and K_S.

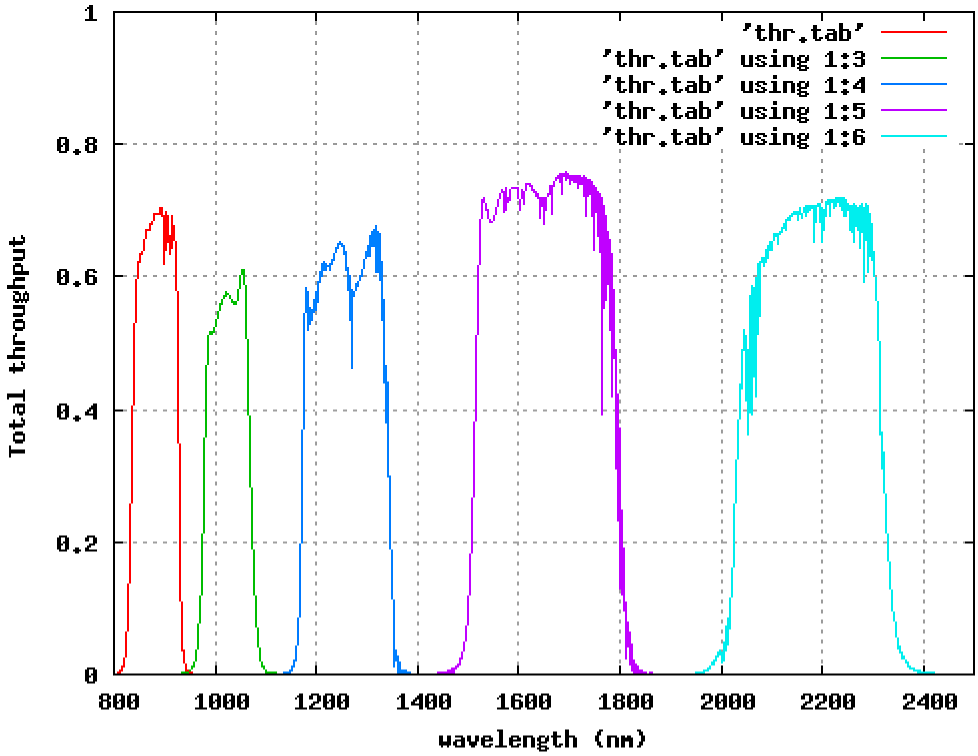

Figure 8-1 Total Throughput at an Airmass of 1.0

9 Overheads

The calculation of elapsed time for a tile, for a given set of exposure parameters, as described in section 7.2 of the ETC specification [AD2], will use the following overhead elements:

Overhead	Time/s
O_{DIT}	1.0
O_{jitter}	6.0
O_{micro}	4.0
O_{paw}	10.0
O_{read}	1.0
$O_{read/reset}$	1.0
O_{reset}	1.0
O_{save}	3.66

Table 3 Exposure Overhead Values

__oOo__