esa

MINUTES OF MEETING

HERSCHEL / Planck Project

SPIRE-RAL-MOM-000609

date	27/03/2001	reference	SCI-PT/	page	1/5
meeting date	idem	meeting place	Rutherford Appleton Laboratory (RAL)		
chairman	D. de Chambure / G. Pilbratt				
participants	See annex 1	copy	7 pages + 9 pages annexe		
subject	Telescope Interface Meeting				

description	action	due date
(1) Agenda		
Introduction		
Clarification on telescope design		
- conical constants for M1 and M2		
- footprint		
- mirror coating		
Stray light analysis		
- status		
- work to be done		
- issues (narcissus effect ...)		
Telescope / Instrument alignment		
End		
(2) Participant list (see annex 1)		

description	action	due date

(3) Herschel telescope prescription

Dominique Doyle presentation

- See attachment (to be sent by e-mail)
- Analysis has been done on the "two" telescope so called JPL design and PACS design from the document given by PACS reference PACS-ME-TN-008.
- No appreciable difference between the two designs.
- JPL design is "sound" for all instruments

Norbert Geis presentation (PACS consortium)

- No appreciable difference between JPL and PACS design

F. Safa presentation (see annex 2)

- Same conclusions as above
- PACS design has been "optimised" to their instrument.
- Richtey-Chretien versus Cassegrain
  The astigmatism is the same for both (can't be removed : third reflective surface is necessary)

description	action	due date
the coma is better removed with the Richtey-Chretien and it is in the "noise" of the overall WFE budget. (coma is 1µm RMS at edge of FOV 0.25°).		
• For manufacturing and testing a Richtey-Chretien, a null lens is necessary whose accuracy of manufacturing could "nullify" the efforts spent in polishing the Primary and the Secondary. Effort shall better be spent on M2 polishing for Cassegrain configuration than on a null lens for a Richtey-Chretien telescope.		
• Explanation of M2 alignment on-ground (~~lateral~~ ± 0.5mm ; vertical ± 1mm) to optimise the complete telescope : Focal length	is adjusted	mainly with radius of M1 and M2.
• General discussion on the SiC technology and on its design		Error tolerances are the same for both concepts

Agreement

All participants (PACS; SPIRE; HIFI) agree that the JPL telescope design is acceptable and good for each of their instrument.

However, the attendees think that a Cassegrain

description	action	due date
telescope (as presented by F. Sofa) could even be more benefitial for their instrument. Each instrument team shall confirm the above and eventually commit to the Cassegrain design within 2 weeks (6/04/01).		

Telescope specification update.

From the IID-A Is 1 (Sept 2000 issue), the following will be updated (for issue 2) and also in the telescope specification

(M1) - addition of conical constants for M1 and M2.

(M1)
- removal of mirror thickness
- central hole diameter has to be verified (wrt straylight effects diffraction and vignetting effect)
- sag value removal.
- vertex to paraxial focal plane (PF) : 1050.16 mm corrected to 1050 mm
- attachment points, radial distance to be reviewed with PLM contractor : ~~1037~~ mm → 875 mm (TBC)

(M2)
- diameter edge : 308.1 mm (± 0.5mm)
- center thickness to be removed
- sag value to be removed

(M2) support structure

(Focal surface)
- diameter
- radius of curvature
- height above optical bench

} to be left (sag to be removed defined by M1 M2 conical constants)

4

description	action	due date

Coating

- Preliminary results on Ni coating reflectivity tests presented by F. Sola.
  Ni resistivity (at 100K) is better than Al (at 20°C)
- The emissivity measurement device at JPL availability has to be confirmed.
- Ni looks as good as Al in terms of reflectivity/emissivity in the 80-670 µm range but will have to be confirmed by tests on proper samples in the course of the telescope development.

Instrument foot print

- Current description in IIDB is valid for SPIRE and HIFI.
- PACS foot print has been updated and is attached as info in Annex.
- Final update will be implemented in next issue of the IID-B.

description	action	due date
4) stray light issues		
Design features		
• SPIRE recommends the implementation of spoiler on the tripod of the telescope to decrease stray light reflection coming from the sun shield.		
• Design ~~of~~ central hole → I/F with cryostat to be carefully looked at		
• HIFI wishes to have discussion of the center of M2 (hole or other solution) to avoid narcissus effect. (discussion / cone		
Specifications.		
• Instrument teams to make proposals for stray light requirement for their respective instrument.		
– HIFI requirement are laid down in TWG MoM (June 99).		
– PACS requirements are laid down in a technical note PACS Optical Rqt Specification ~~HIFI~~		
– SPIRE to comment stray light specification for their instrument.		Action 30/4/01

• It is reminded that telescope background level and emissivity ~~level~~ knowledge is important for the SPIRE and the PACS bolometers.

(6)

description	action	due date
Stray light model		
- PACS simplified model is available (ASAP only scattered surfaces)		
- SPIRE stray light model is not complete and will be completed in the coming weeks. (APART model)		
- HIFI model not applicable / not available		
Some		
SPIRE presentation on main stray light paths (based on "old" Dornier studies)		
Next Optical System Working Group Meeting 20-21/6/01 at ESTEC		

LIST OF PARTICIPANTS.

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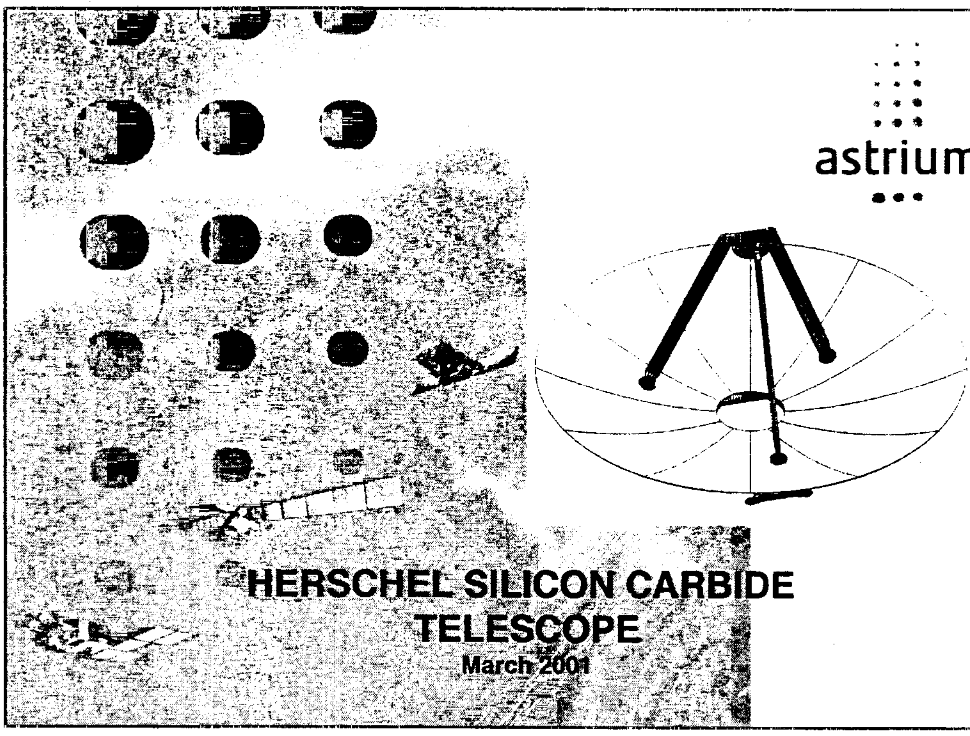
Annex 2



HERSCHEL SILICON CARBIDE TELESCOPE

March 2001

PACS & JPL designs

- Both designs are practically identical and refer to a Ritchey-Chrétien telescope
- Focal surface as defined by PACS leads to a defocus of ~ 3 mm at the field edge
- Focal surface as defined by JPL (parabola) gives negligible defocus error over the whole field

Herschel Telescope optical parameters	PACS	JPL
Entrance pupil diameter (0 deg)	3283 mm	3283 mm
Focal length	28500 mm	28500 mm
f-number	f/8.68	f/8.68
Primary vertex to best focus	1050 mm	1050.16 mm
Aperture stop	on M2	on M2
Field of view	+/- 0.25 deg. circular	+/- 0.25 deg. circular
Primary reflector		
Radius of curvature	3500 mm	3500 mm
Useful diameter	3469 mm	3469 mm
Conic constant	-1.001	-1.00129
Distance to M2	1587.97 mm	1588.969 mm
Secondary reflector		
Radius of curvature	-345.264	-345.264
Conic constant	-1.29218	-1.296
Diameter	308.3 mm	308.3 mm
Image surface		
Radius of curvature	-160	-167.171
Conic constant	-0.8143	-1
Diameter	246 mm	246 mm

July 2000

(9)

PACS & JPL designs (continued)

PACS			
Field (deg) deg)	WFE (µm)	Best focus shift (mm)	WFE at best focus (µm)
0	0.06	-0.07	0.05
0.05	0.1	0.04	0.09
0.015	0.84	0.99	0.69
0.2	1.53	1.85	1.23
0.25	2.46	3.08	1.93

JPL			
Field (deg) deg)	WFE (µm)	Best focus shift (mm)	WFE at best focus (µm)
0	0.07	-0.07	0.06
0.05	0.13	-0.05	0.13
0.015	0.72	0.09	0.71
0.2	1.24	0.08	1.24
0.25	1.92	-0.12	1.92

Note on defocus:
1 µm WFE is equivalent to:
- 2.1 mm shift at telescope focus
- 10 µm shift for M2

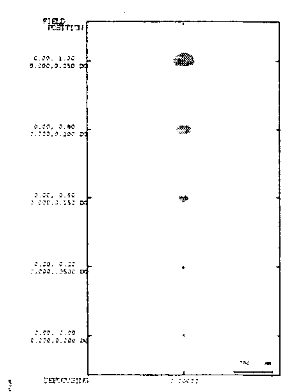
Herschel Telescope Definition (1)

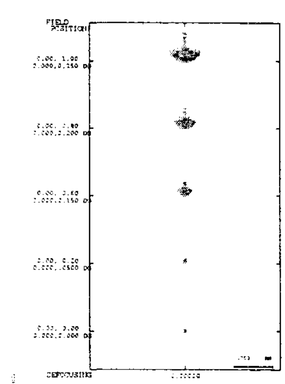
- **One can notice that the conic constant of the primary reflector is very close to -1, i.e. that the primary is practically a parabola**
- **This means that the pure Ritchey-Chrétien is in practice very close to a pure Cassegrain, with a parabolic primary reflector**
  The reason is that the optical WFE performance in the field of view is driven by astigmatism (not by coma aberration) , which is identical for both configurations
- **Astrium recommends a parabolic primary reflector for simplifying its test during polishing (and better mastering its performance)**

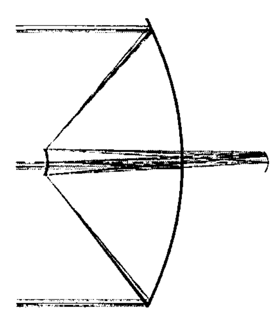
Herschel Telescope Definition (2)

Herschel Telescope optical parameters	M1 Parabola (Astrium proposal)	Ritchey-Chrétien	Typical tolerance or comment
Entrance pupil diameter (0 deg)	3283 mm	3283 mm	specified from f-number and focal length
Focal length	28500 mm	28500 mm	specified with tolerance +/- 50 mm
f-number	f/8.68	f/8.68	specified 8.68; tolerance +/- 0.02
Primary vertex to best focus	1050 mm	1050 mm	specified with tolerance +/- 10 mm
Aperture stop	on M2	on M2	specified
Field of view	+/- 0.25 deg, circular	+/- 0.25 deg, circular	specified
Primary reflector			
Radius of curvature	3500 mm	3500 mm	+/- 2mm
Useful diameter	3469.5 mm	3469 mm	beam motion +/- 93 mm for +/- 0.25 deg
Conic constant	-1	-1.00102	overall WFE 4 µm rms
Distance to M2	1587.998 mm	1588.008 mm	
Secondary reflector			
Radius of curvature	345.2 mm	345.179 mm	+/- 0.4 mm
Conic constant	-1.279	-1.2923	overall WFE 1.5 µm rms
Diameter	308.12 mm	308.44 mm	+/- 0.1 mm (tbc)
Image surface			
Radius of curvature	-165 mm	-165.1 mm	
Conic constant	-1	-1	parabola
Diameter	246 mm	246 mm	corresponds to +/- 0.25 deg

Herschel Telescope Definition (3)

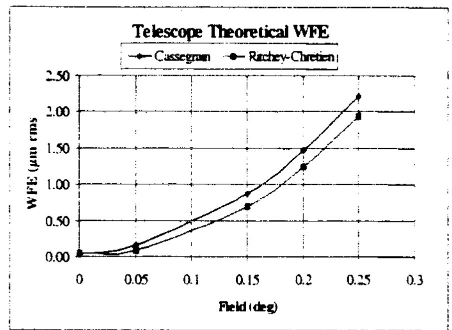






Telescope theoretical WFE: comparison between a pure Ritchey-Chrétien and the proposed Cassegrain configuration

- The focal surface is well represented by a parabola over the whole FOV
- Both theoretical WFE are extremely close, and are equivalent with respect to the overall telescope WFE budget (goal 6 μm , spec 10 μm)



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Nickel coating as candidate for Herschel

- Coating reflectivity performance in the far infrared is driven by the electrical resistivity of the coating metal.
- Ni coating may be interesting for its better cleanability in comparison to Al
- Ni reflectivity is satisfactory in the far infrared and should be > 0.99. This will be confirmed by emissivity measurements on samples.
- Ni resistivity drops down with temperature faster than Al: comparable performance expected in cold.

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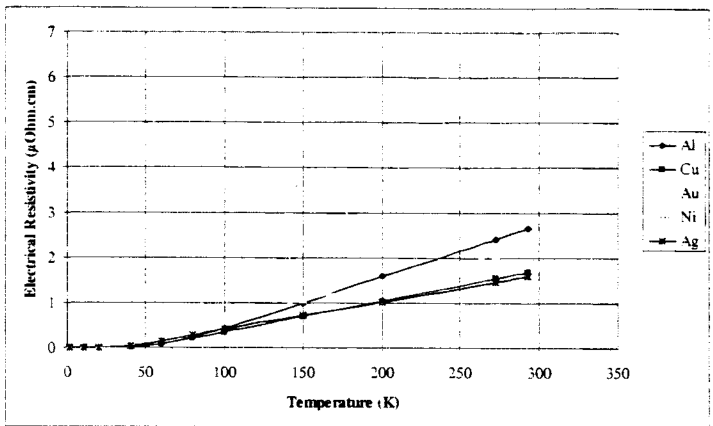
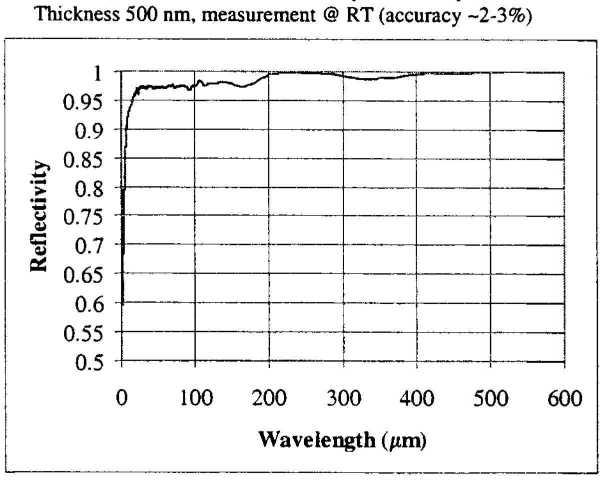
Ni Electrical Resistivity vs Temperature



Ni reflectivity measurement

LEMTA reflectivity measurements on SiC sample with evaporated Ni coating.
Thickness 500 nm, measurement @ RT (accuracy ~2-3%)



RAL, 27/3/2001

PACS Beam Footprints above FPU

We show the PACS beam footprint geometry at various heights above the paraxial focal plane of FIRST, as well as a graph with formulas for interpolation of the geometry parameters to any height.

The telescope prescription is that from Sep 1999, *FIRST Telescope Optical and Optomechanical Report by A B Hull* from JPL. For the purposes of this document, the telescope prescription is functionally identical to the one used internally for the design of PACS. The co-ordinate system used has as its origin the telescope paraxial focus, and is parallel to the satellite system (X= toward telescope, Y= away from HIFI, Z= toward PACS).

The footprint geometry is given explicitly at the heights above the paraxial focal point mentioned at the FIRST Instrument I/F Study Progress Meeting, 20 Oct 1999:
X= 244
X= 385
X= 771
X= 850 (back surface of primary mirror)
X= 1050 (front surface of primary mirror)

The PACS beam profile is simply a rectangle with rounded corners. The starting size at the focal plane is given by the extreme positions attainable by the PACS built-in chopper and our combined spectrometer and photometer fields-of-view. The footprints are symmetrical with respect to the Z-axis.

The net full width along Y, **dY** and along Z, **dZ,** the centre Z-co-ordinate, **Zo** of this rectangle and the maximum allowed radii, **R** of the corners are given in the following table (+/- 1mm).

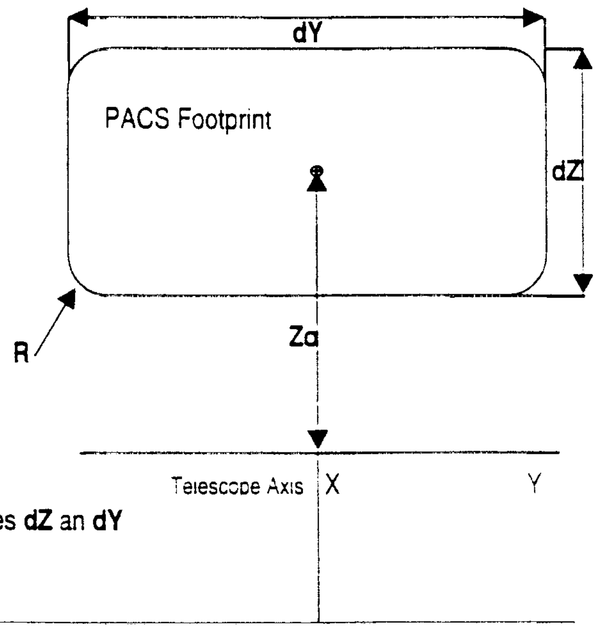
X (from focal plane)	dY	dZ	Zo	R
0	66	28	80	0
244	84	50	72.5	15
385	97	66	68	23
771	133	107	57	45
850	140	115	54	50
1050	160	137	48	61

These footprints were arrived at using *purely geometrical optics.*

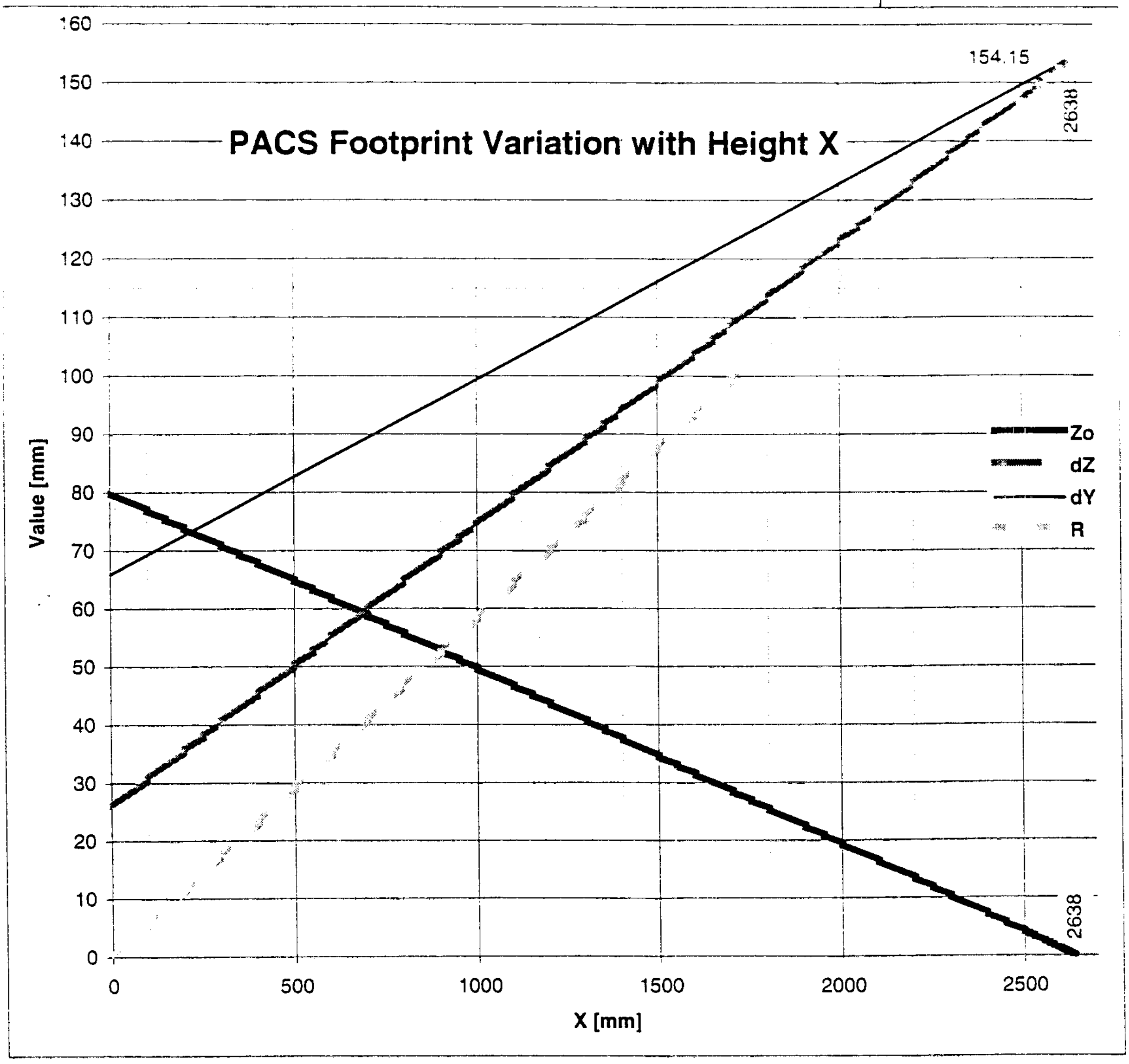
To avoid diffraction losses, oversized apertures are required. A combined 20mm (TBC) full-width oversize is adequate to prevent both, diffraction losses for beams near the edge of the field, and diffractive scattering of stray light into the beam, and to allow for the relative alignment margin between FPU and telescope (2-5 mm?).

The PACS Footprint is a rectangle at Zo=80, dZ=26, dY=66 in the focal plane of the Herschel Telescope. Above the focus, the footprint becomes a rounded rectangle.
All Geometrical Parameters vary linearly with height X above Focus.
They can be determined by evaluating **Quantity = a X + b**

Quantity	a	b
Zo	-0.030326	80
dZ	0.048578	26
dY	0.033415	66
R	0.058434	0



After finding the net beam geometry we then need to add 20 mm (10 mm radial "zone of avoidance") to quantities **dZ** an **dY** to allow for diffraction and alignment margins.



Reflectivity of Telescope Coatings

A HIGH PRECISION REFLECTOMETER FOR SUBMILLIMETER WAVELENGTHS

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Submillimeter Technology Laboratory
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Table III
Results of Reflectivity Measurements at $\lambda = 513.01\ \mu m$

metal	Reflectivity at 513.01 μm	uncertainty	Hagen-Rubens Eqn. (3)	H-R w/ corr. Eqn. (4)	conductivity $10^{17}\ sec^{-1}$	relaxation time 10^{-14} sec
Copper	0.997	0.001	0.9979	0.9978	5.36	2.70
Silver	0.996	0.001	0.9980	0.9978	5.67	4.00
Gold	0.994	0.001	0.9976	0.9975	4.07	3.00
Aluminum	0.995	0.001	0.9974	0.9973	3.40	0.80
Nickel	0.994	0.001	0.9960	0.9960	1.49	0.32
Chromium	0.993	0.001	0.9942	0.9942	0.70	0.33

Annex 4

Table IV
Reflectivity of Commercially Available Front Surface Mirrors

Metal	Reflectivity at 513.01 μm	uncertainty	Hagen-Rubens Eqn. (3)	H-R w/ corr. Eqn. (4)	conductivity 10^{17} sec 1	relaxation time 10 ^{14} sec
Enhanced Al	0.992	0.001	0.9974	0.9973	3.40	0.80
Protected Al	0.985	0.001	0.9974	0.9973	3.40	0.80
"Edmund" Gold	0.995	0.001	0.9976	0.9975	4.07	3.00