Minutes of the Third Meeting
of the
HIPPARCOS SCIENCE TEAM
ESTEC, 25-26 March 1982

Attendance

HST:	Dr M.A.C. Perryman (ESA), Chairman
	Dr P. Brosche
	Dr C. Coleman
	Prof. F. Donati
	Dr M. Grenon
	Dr E. Høg
	Prof. J. Kovalevsky
	Dr L. Lindegren
	Mr C.A. Murray
	Mr R.S. Le Poole
	Dr C. Turon
	Prof. C.G. Wynne
ESA:	Mr L. Emiliani
	Mr M. Schuyer
	Mr R. Bonnefoy
	Dr S. Vaghi
	Dr R. Wills
	Mr G. Ratier
ESOC:	Mr H. Laue

1. Adoption of the Agenda

The Agenda as shown in Annex I was adopted.

2. Report by the Project Manager

Emiliani summarised the status of the Phase B activities. The Phase B1 kickoff meeting with the single prime contractor MATRA (leading the MESH Consortium) took place on January 25-27. Progress meetings between MESH and the Project Team were taking place on a monthly basis.

Progress in specific areas is reported below.

The major forthcoming milestones are provisionally as follows:

24 May 1982	SDR data dump
14-18 June 1982	SDR
September 1982	SSDR
October 1982	Release of Phase B2 - C/D ITT
February 1983	Start of Phase B2 - C/D

(SDR = System Design Review; SSDR = Sub System Design Review)

The composition of the ESA HIPPARCOS Project Team was distributed (Annex II)

3. Reprt by the Project Scientist

Perryman reported on the following:

Science Team

The present composition (Annex III) had been modified from that of the meetings held in 1981. The changes ensured that all three scientific consortia (Input Catalogue and the two Data Reduction Consortia) were well represented on the HST, as well as necessary photometric expertise following the inclusion of TYCHO.

The composition had been arrived at following discussions with consortia leaders in Strasbourg at a meeting on 25 February 1982.

TYCHO

Following the recommendations of the Astronomy Working Group and of the Space Science Advisory Committee, the Science Programme Committee approved the inclusion of the TYCHO modification in the baseline design at their meeting of 7 December 1981 (see (10) below).

Selection of Scientific Consortia

Following the release of the Announcement of Opportunity for the Compilation of the Input Catalogue (HIP81/01) and of the Announcement of Opportunity to Participate in the Processing of Scientific Data (HIP81/02), proposals had been received from:

C. Turon - on behalf of a consortium for the Compilation of the Input Catalogue (ICC)

E. Høg - on behalf of the Northern Data Analysis Consortium (NDAC)

J. Kovalevsky - on behalf of the Fundamental Astronomy by Space Techniques Consortium (FAST)

The proposals were reviewed by a Peer Review Group, set up in consultation with the Astronomy Working Group and chaired by Professor A. Blaauw. The composition of this group, its report to the Astronomy Working Group, and its recommendations made to the ESA Science Programme Committee (SPC) are documented in ESA SPC(82)6.

The SPC at its meeting on 18 March 1982 approved the recommendation of the Space Science Advisory Commitee, as set out in Annex IV.

Dr C. Turon, as leader of the ICC, was subsequently invited to join the HST.

In parallel with the activities of the Peer Review Group, the proposals were reviewed by members of the Project Team, ESTEC. The purpose of these assessment activities was:

- to identify potential problem areas;
- to perform a comparison of the proposed data analysis approaches;
- to identify requirements on the industrial contractor, ESA, or the other scientific consortia.

Kick-off meetings between the Project Team and representatives of the consortia had been held immediately prior to the present HST meeting on 24 March (for the 2 data analysis consortia) and on 25 March (for the Input Catalogue Consortium).

Meeting with RAL

Following withdrawl of the COSMOS Industrial Proposal, representatives of the Rutherford & Appleton Laboratories and the Mullard Space Science Laboratory (UK) visited ESTEC on 12 February 1982. The Project Team heard presentations on topics of particular concern to the RAL/MSSL scientists who had been working on aspects of the HIPPARCOS hardware during the preparation of the COSMOS proposal.

Strasbourg Colloquium

The Colloquium on the Scientific Aspects of the HIPPARCOS Mission had been held on 22-23 February 1982 in Strasbourg. 150 participants attended the Colloquium. The Proceedings were being published in ESTEC, and should be distributed on 7 May.

4. Presentation by Consortium Team Leaders

Drs Høg. Kovalesky, and Turon presented outlines of their consortia structure and proposed activities for the benefit of HST members.

Kovalesky described the present status of the FAST work tasks. Activities started included :

- work on raw data treatment (Torino)
- instrumentation modelling (LAS/CERGA)
- link to VLBI (JPL/CERGA)
- matrix inversion (Delft)

Høg distributed an NDAC report (29 Jan 1982) covering the work under way at Copenhagen (on Set Simulations, where a considerable reduction in computing times had been achieved through re-ordering of the normal equations; and work on Database Routines) and Lund (covering work on minor planets, TYCHO data analysis, and double stars).

5. Report on MESH SAG Activities

Le Poole summarized the composition (F. Donati, E. Høg, L. Lindegren R. Le Poole, S. Röser) and activities of the Scientific Advisory Group of MESH.

6. Selection of Optical Configuration

Bonnefoy presented the results of the optical configuration studies performed by MESH. Three configurations have been studied in depth - the All-Reflective Schmidt (ARS), the Dioptric Schmidt (DS) and the Ritchey-Chrétien (RC) configurations. Independent studies of the ARS and DS were being carried out by Prof. Wynne at RGO at the request of the Project Team.

Results were presented in the following areas (Viewgraphs presented are attached as Annex V):

- optical performance of the nominal telescope
- optical tolerances
- photon statistical errors
- straylight
- grid manufacturing
- ghost images
- optics manufacturing and verification
- mass properties

In most areas the ARS had properties superior to those of the DS and to the RC. Wynne nevertheless stressed that the RC configuration, the only solution providing a flat focal surface, should not be fully dismissed until the manufacture of a curved grid could be confirmed.

Lindegren and Wynne urged that if the ARS was selected, further optimization of the design (e.g. pupil masking, or elliptical figuring of the complex mirror) should still be considered.

Apart from these considerations, the support of the HST in the selection of the ARS configuration was given.

7. Report on Grid Studies

Bonnefoy summarized the results, presented at a meeting with CEH and TPD on 24 March, of studies of the manufacture of the grid on a curved surface using electron beam lithography (EBL). A full flat grid had been manufactured by CEH in December 1981. The trial grid manufactured by CEH had been examined independently by TPD and compared with results on grids manufactured by holography. The EBL grids showed sharper edges, but some problems with the 'dark' substrate and stitching errors remained.

Wills presented the preliminary results from his analysis of the periodic structure of the EBL grids.

Høg stressed that the holographic grid should still be studied. It was possible, for example, that the combination of a holographic main grid and an EBL star mapper grid might provide results most amenable to calibration during the mission.

Bonnefoy stated that the studies on the EBL grid had been initiated by the Project, but that the final selection of the most suitable technique would be made by MESH, as a result of their continuing studies.

8. Dynamic Smoothing

Perryman reported on Professor Lacroûte's visit to ESTEC on 8 January 1982 to discuss dynamic smoothing.

MESH were giving attention to the resulting spacecraft dynamics during their selection of the AOCS.

Kovalevsky and Donati provided some preliminary figures for the permissible amplitude jitter as a function of frequency that would permit dynamic smoothing:

< 0.01 Hz	unimportant
0.03-1Hz	20-5 marcsec respectively
1-10 Hz	can be suppressed by correct observing strategy

9. ITT DCN's

The following Document Change Notices (DCN's) had been passed to MESH:

DCN No. 1 (8 Jan 1982) This dealt with the TYCHO experiment. The cover letter providing performance goals to complement the DCN was also distributed. Perryman asked the HST members to provide any comments on this DCN by 30 April. Special attention should be given to the calibration aspects. (see also (10) below).

DCN No. 2 (16 March 1982) This dealt with miscellaneous amendments to the ITT. Perryman drew special attention to the following:

DCN p.3	ITT p.45
" p.3	" p.46
" p.4	" p.49
" p.5	" p.98

These changes were accepted by the HST.

10. TYCHO

Requirements and SOW given to MESH

See DCN No. 1 above. No major comments on the Projects approach to TYCHO were received. In particular the choice of photometric filters would be optimized following the procedure outlined in Perryman's letter to Drs Dickens, Grenon, Heintz & Steinlin (15 Feb 1982) and distributed to HST members before the present meeting:

- maximum separation in wavelength
- maximum bandwidths to allow adequate photon flux
- small filter overlap

Bonnefoy pointed out that the latter might be achieved using a dichroic system, and this approach was considered acceptable. With the expected temperature stability of the payload, significant variations in the long-wavelength response of the photomultipliers was not expected and a long-wavelength cut-off filter may not therefore be required.

Perryman reported Jashek's recommendation made at Strasbourg that the Johnson BV system should be adopted with TYCHO, for homogeneity and calibration reasons.

Grenon agreed with the procedure proposed by the Project and considered that calibration should not be a major problem. Further studies would be made in this area.

Bright Stars

The Project's approach, following the recommendations of the photometrists consulted Drs Grenon, Heintz & Steinlin) was that the bright star limit should be set at the point where coding of the 8-bit samples would be required.

Wills presented the results of his study on the effects of SM coding (19 March 1982). Without coding, the TYCHO bright star limit would lie around B(V)= 4.2 - 6.2 mag depending on star colour, photomultiplier and star mapper configuration. A brighter limiting magnitude could be reached with semi-logarithmic coding, at the expense of some coding induced error.

Grenon argued that omission of stars $B < 6$ mag from TYCHO would not be of great importance. Presently photometry for $B < 6$ mag from ground reached a precision of 0.007 mag in colours, 0.009 mag in magnitudes. Calibration, and homogeneity between ground-observed stars with $B < 6$ mag and fainter TYCHO stars would be achievable. A useful transformation to Johnson BV could also be expected in most cases.

Data Reduction Considerations

At the Data Analysis kick-off meeting held on 24 March both consortia team leaders had confirmed their interest in undertaking the TYCHO analysis, perhaps in collaboration. Perryman would ask the team leaders for a supplement to their proposals to be submitted to ESA before 30 November covering the TYCHO tasks.

11. Calibration

Høg and Kovalevsky provided further clarification on the in-orbit geometrical calibration procedures. Perryman would send a list of specific questions to them. A meeting between ESA, MESH, NDAC and FAST was provisionally arranged for 23 April in case outstanding questions remained.

Le Poole and Høg raised the possibility of reversing the satellite spin direction to identify systematic thermal effects.

12. Invitation for Proposals

The SPC had approved distribution of the Invitation to non-Member State scientists at their meeting on 18 March 1982.

Murray proposed that the 1 October 1982 deadline be postponed for 3 months. Turon was not in favour of this delay; Perryman said that the deadline would remain as set.

Perryman would ask that an Announcement appears in a forthcoming AAS Newsletter. The IAU, and the journals Ap.J., MNRAS, A.&A. would be asked for their institutions distribution list to speed distribution of the Invitation to non-member state institutes.

13. Coordination of Software, Simulations, etc.

Schuyer invited the HST, in particular the consortia leaders, to comment on the desirability of coordination attempts being made by the Project Team to ensure an efficient use and interchange of software and simulation data.

It was agreed that such activities would be valuable, but should not suppress independent work being performed by the different groups.

Schuyer would distribute a questionnare at the end of April, and asked for responses to this at the end of May. The Project Team would act accordingly.

Høg and Kovalevsky asked that the ICC distribute successive versions of their catalogue, starting with a common copy of the CSI as soon as possible.

Kovalevsky asked that the ICC define the format of the Input Catalogue, even though much of the data will be missing from the earliest versions.

14. Any Other Business

Satellite Mothballing

Brosche asked what action was being taken on the proposal (discussed at HST meeting of 1-2 June 1981; also discussed by Dr Schmidt-Kaler at Strasbourg) to shut down the satellite after 2.5 years, starting it up again after a certain time to gain on the proper motions.

Emiliani confirmed that this would not be set as a requirement. The satellite was not designed to sustain such a shut-down period in orbit.

Grid Optimization

Le Poole questioned the Project Team's approach to the problem of grid optimization. Emiliani confirmed that MESH should not undertake extensive investigations into grid configurations.

Lindegren presented some results of his studies on non-periodic grids. These were felt to have important advantages in several areas, especially regarding extraction of the TYCHO data. Non-inclined slits may not be necessary if both SMs are operating simultaneously.

Le Poole expressed concern over the redundancy considerations, and Donati over the achievable accuracies.

Emiliani stated that the Project Team would look at the question of non-periodic grids. Lindegren, as a scientific adviser to MESH, could propose such a design to MESH, and it was MESH's responsibility to decide on the design to be adopted. A non-periodic SM grid was not excluded; but the data handling and on-board software implications would need to be assessed.

15. Next Meeting

Provisionally arranged for 8-9 June. This will follow the SDR Data Dump, and will precede the SDR Review (14-18 June).

ANNEXES

Third Meeting

of the

HIPPARCOS SCIENCE TEAM

25-26 March 1982

AGENDA

Report by the Project Manager

Report by the Project Scientist

Presentation by Consortia Team Leaders

Report by R. Le Poole on MESH SAG activities

Selection of optical configuration

Report on grid studies

Dynamical smoothing

Distribution of ITT DCNs

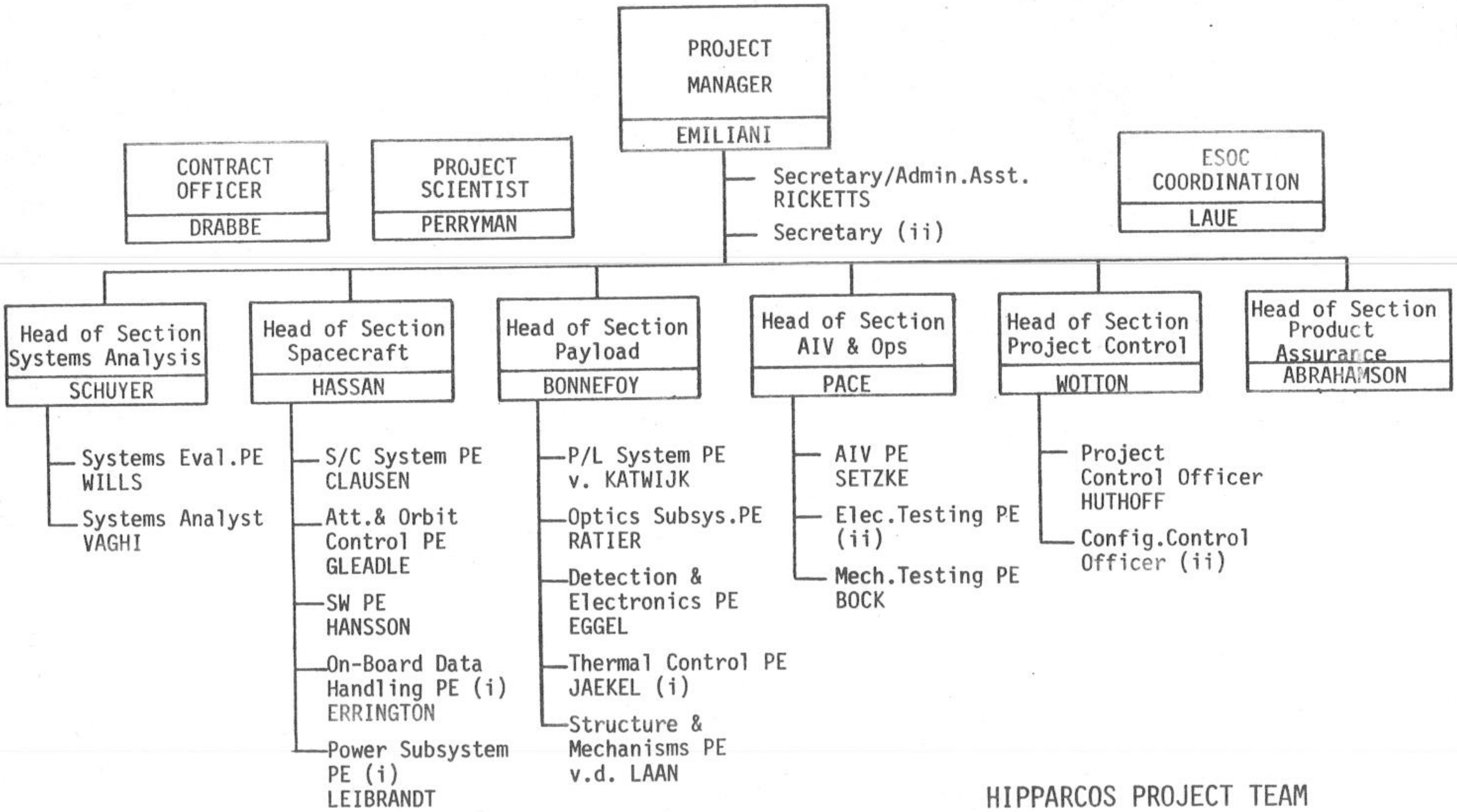
TYCHO:
- Requirements and SOW given to MESH
- Choice of photometric filters (see distributed note)
- Bright stars
- Data reduction considerations

Calibration

Invitation for Proposals - distribution to Non-Member States

Coordination of software, simulations, interfaces, etc.

Any other business



HIPPARCOS PROJECT TEAM

(i) Dedicated to both S/C and P/L
(ii) Position planned to be filled at a later time

HST MEMBERS

Dr. M.A.C. PERRYMAN
Astronomy Division
ESTEC
2200 AG NOORDWIJK, THE NETHERLANDS

Tel.: (0)1719 - 82253/82585
Telex: 39098

Dr. P. BROSCHE
Observatorium Hoher List der
Universitäts Sternwarte Bonn
D-5568 DAUN, Eifel
Fed. Rep. of Germany

Tel.: 09 49 6592 2150
Telex:

Dr. C. COLEMAN
Marconi SDS Ltd.
arren Lane
STANMORE HA7 4LY
England

Tel.: 09 44 1 954 2311
Telex:

Prof. F. DONATI
Istituto Galileo Feraris
Corso Massimo d'Azeglio 42
10125 TORINO, ITALY

Tel.: 09 39 11 680868
Telex: 211553 iengf

Dr. M. GRENON
Observatoire de Genève
CH-1290 SAUVERNY
Switzerland

Tel.: 09 41 22 552611
Telex: 22674

Dr. E. HØG
Copenhagen University Observatory
Øster Voldgade 3
DK-1350 COPENHAGEN K, DENMARK

Tel.: 09 45 1 141790
Telex: 44155 danast dk

Prof. J. KOVALEVSKY
Centre d'Études et de Recherches
Géodynamiques et Astronomiques
CERGA
Avenue Copernic
06130 GRASSE, FRANCE

Tel.: 09 33 93 365849
Telex: 470865

Dr. L. LINDEGREN
Lund Observatory
Box 1107
22104 LUND, SWEDEN

Tel.: 09 46 46 107309
Telex: 33533 luniver

Mr. C.A. MURRAY
Royal Greenwich Observatory
Herstmonceux Castle
HAILSHAM, E. SUSSEX BN27 1RP, ENGLAND

Tel.: 09 44 32 181 3171, ext. 213
Telex: 87451

Mr. R.S. LE POOLE
Huygens Laboratorium
P.O. Box 9513
2300 RA LEIDEN, THE NETHERLANDS

Tel.: (0)71 - 148333, ext. 5874
Telex: 39058 astro nl

Dr. C. TURON
Section d'Astrophysique
Observatoire de Meudon
92190 MEUDON, FRANCE

Tel.: 09 33 1 534 7530, ext. 470
Telex: 270912 obastr

Prof. C.G. WYNNE
Royal Greenwich Observatory
Herstmonceux Castle
HAILSHAM, E. SUSSEX BN27 1RP
Great Britain

Tel.: 09 44 32 181 3171
Telex: 87451

SSAC(82)2
Paris, 3 March 1982

EUROPEAN SPACE AGENCY

SPACE SCIENCE ADVISORY COMMITTEE

HIPPARCOS

Recommendation on the Proposals for the Input Catalogue and the Data Reduction

The Space Science Advisory Committee, at its 28th Meeting held on 3 March 1982:

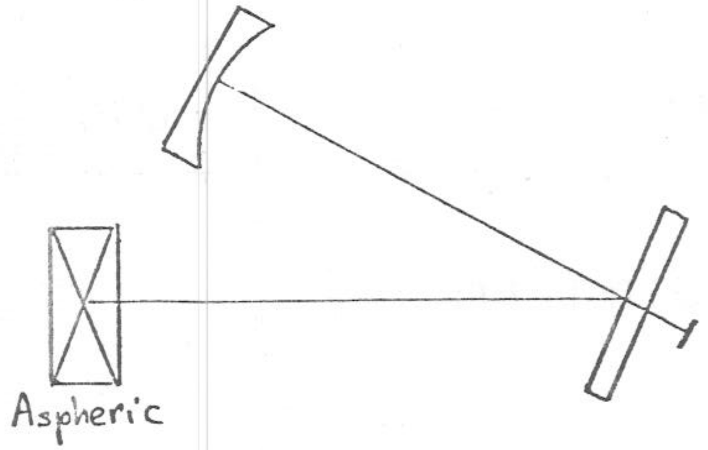
- expressed its appreciation of the thorough evaluation of the Peer Group and unanimously endorses its report;
- recommends acceptance of the 3 proposals received;
- urges the Executive to take all necessary steps to ensure the highest quality of the ultimate Hipparcos Catalogue;
- recommends the Executive to invite the world-wide scientific community to contribute by submitting proposals for the Input Catalogue;
- recommends that data rights for non-Member State scientists contributing to the Input Catalogue should be awarded on the same basis as data rights for Member State scientists, as set down in the Invitation for Proposals;
- in the event of receipt of similar proposals for the Input Catalogue from Member and non-Member State scientists, it is recommended that the former category receives priority.

ANNEX V

SELECTION OF OPTICAL CONFIGURATION

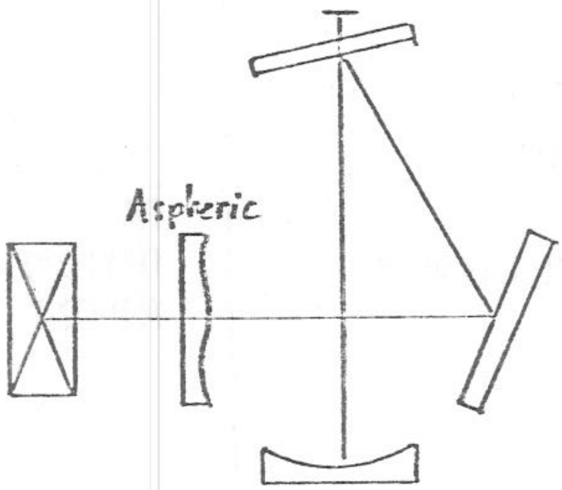
OPTICAL CONFIGURATIONS

ARS



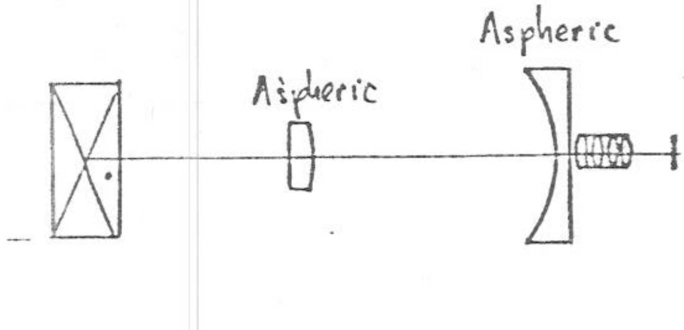
- F = 1550
- ϕ = 320
- curved field
- γ = 58°

D.S



- F = 1550
- ϕ = 320
- curved field
- γ = 68°

RC



- F = 2450
- ϕ = 320
- Flat Field
- γ = 68°

SELECTION CRITERIA	CATEGORY	REF. NOTES MAT-HIP-...
1 - OPTICAL PERFORMANCES OF THE NOMINAL TELESCOPE	P/L AND SYSTEM PERFORMANCES	361
2 - OPTICAL TOLERANCES		364
3 - PHOTON STATISTICAL ERROR		341
4 - STRAYLIGHT		370
5 - GRID MANUFACTURING		317
6 - GHOST IMAGES		318
7 - OPTICS MANUFACTURING AND VERIFICATION		350
8 - INTEGRATION AND TESTS AT TELESCOPE LEVEL	P/L DEVELOPMENT AND COST	316
9 - MASS PROPERTIES		315
10 - SIZE AND LAY-OUT		346
11 - COST AND DEVELOPMENT		369
12 - SYSTEM CRITERION	SATELLITE	373

RELATIVE MERIT PER CATEGORY AND PER CRITERION						CRITERIA WEIGHING FACTOR		FIGURE OF MERIT PER CATEGORY					CATEGORY WEIGHING FACTOR
	CRITERIA	ARS	DS	RC		F_C			CRITERIA	ARS	DS	RC	
1	OPTICAL PERF. (NOMINAL)	2	1	3		x1		1	OPTICAL PERF. (NOMINAL)	2	1	3	
2	OPTICAL TOLERANCES	1	1	2		x1		2	OPTICAL TOLERANCES	1	1	2	
3	PHOTON STAT. ERROR	1,2	1	2,3		x2		3	PHOTON STAT. ERROR	2,4	2	4,6	
4	OPTICS MFG & VERIFIC.	1	2	3	→	x2	→	4	OPTICS MFG & VERIFIC.	2	4	6	
5	STRAYLIGHT	1	1	1		x1		5	STRAYLIGHT	1	1	1	
6	GRID MFG	1,1	1,1	1		x2		6	GRID MFG	2,2	2,2	2	
7	GHOST IMAGES	1	3	2		x0,3		7	GHOST IMAGES	0,3	0,9	0,6	
										10,9	12,1	19,2	x F_1
8	OPTICS MFG & VERIFIC	1	2	3		x1		8	OPTICS MFG & VERIFIC.	1	2	3	
9	TELESCOPE AIT	1	1	3		x1		9	TELESCOPE AIT	1	1	3	
10	MASS PROPERTIES	2	3	1	→	x1	→	10	MASS PROPERTIES	2	3	1	
11	SIZE AND LAY OUT	2	2	1		x1		11	SIZE AND LAY OUT	2	2	1	
12	COST AND DEVELOP.	2	3	1		x2		12	COST AND DEVELOP.	4	6	2	
										10	14	10	x F_2
13	SYSTEM CRITERION	2	3	1	→	x1	→	13	SYSTEM CRITERION	2	3	1	x F_3

FINAL FIGURES OF MERIT

ARS	DS	RC
23	29	30

$F_{1,2,3} = 1$

TABLE 3,2 A - P/L EVALUATION - PUPIL Ø IDENTICAL 3 SOLUTIONS

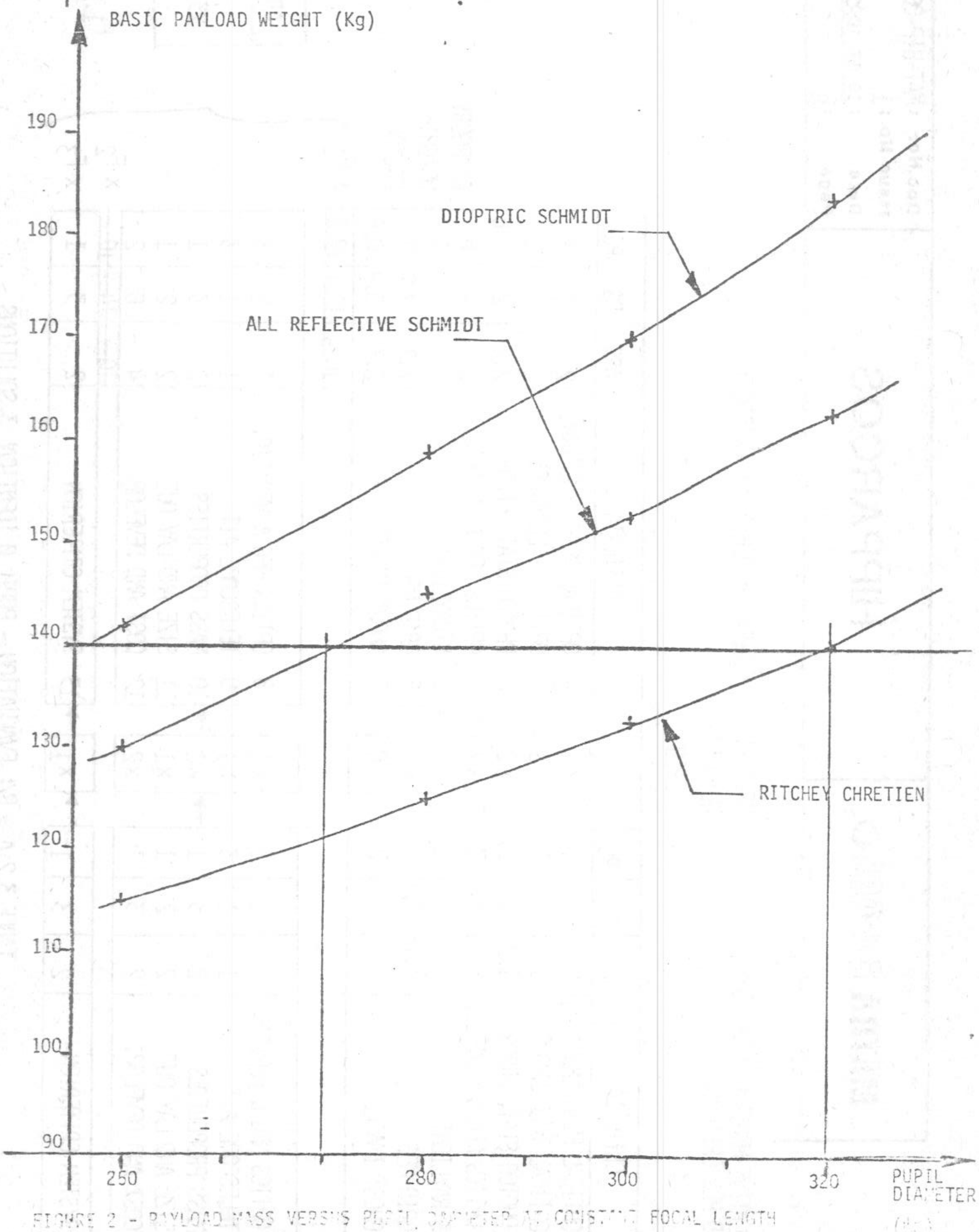


FIGURE 2 - PAYLOAD MASS VERSUS PUPIL DIAMETER AT CONSTANT FOCAL LENGTH

RELATIVE MERIT PER CATEGORY AND PER CRITERION

CRITERIA WEIGHING FACTOR

FIGURE OF MERIT PER CATEGORY

	CRITERIA	ARS	DS	RC	F_C	CRITERIA		ARS	DS	RC	
1	OPTICAL PERF. (NOMINAL)	1,2	1	3	X1	1	"	1,2	1	3	
2	OPTICAL TOLERANCES	1	1	2	X1	2	"	1	1	2	
3	PHOTON STAT. ERROR	1	1,5	1,5	X2	3	"	2	3	3	
4	OPTICS MFG & VERIFIC.	1	2	3	X2	4	"	2	4	6	
5	STRAYLIGHT	1	1	1	X1	5	"	1	1	1	
6	GRID MFG	1,1	1,1	1	X2	6	"	2,2	2,2	2	
7	GHOST IMAGES	1	3	2	$X_{0,3}$	7	"	0,3	0,9	0,6	
								0,7	13,1	17,6	× F_1
8	OPTICS MFG & VERIFIC	1	2	3	X1	8	"	1	2	3	
9	TELESCOPE AIT	1	1	3	X1	9	"	1	1	3	
0	MASS PROPERTIES	1	1	1	X1	10	"	1	1	1	
1	SIZE AND LAY OUT	2	2	1	X1	11	"	2	2	1	
2	COST AND DEVELOP.	1,5	2	1	X2	12	"	3	4	2	
								8	10	10	× F_2
3	SYSTEM CRITERION	2	2	1	X1	13	"	2	2	1	× F_3

CATEGORY WEIGHING FACTOR

FINAL FIGURES OF MERIT

ARS	DS	RC
19,7	25,1	28,6

$F_{1,2,3} = 1$

SUB-SYSTEMS	RITCHEY CHRETIEN + FIELD CORRECTOR		ALL REFLECTIVE SCHMIDT		DIOPTRIC SCHMIDT	
STRUCTURE	57,2	67,5	72,0	84,96	77,3	91,21
BAFFLES	7,5	8,85	7,5	8,85	7,5	8,85
THERMAL	8,0	9,44	8,0	9,44	9,2	10,86
OPTICS	22,7	24,16	31,2	32,99	45,70	48,22
SEDH	16,5	19,53	16,5	19,53	16,5	19,53
DETECTION	13,2	15,76	13,2	15,76	13,2	15,76
MECHANISMS	4,0	4,72	4,0	4,72	4,0	4,72
HARNESS	10,2	13,58	10,2	13,58	10,2	13,58
PAYLOAD BASIC MASS	139,3 KG	+ 23 KG	162,6 KG	+ 21 KG	183,6 KG	
PAYLOAD CURRENT MASS		163,57 KG		189,83 KG		212,73 KG

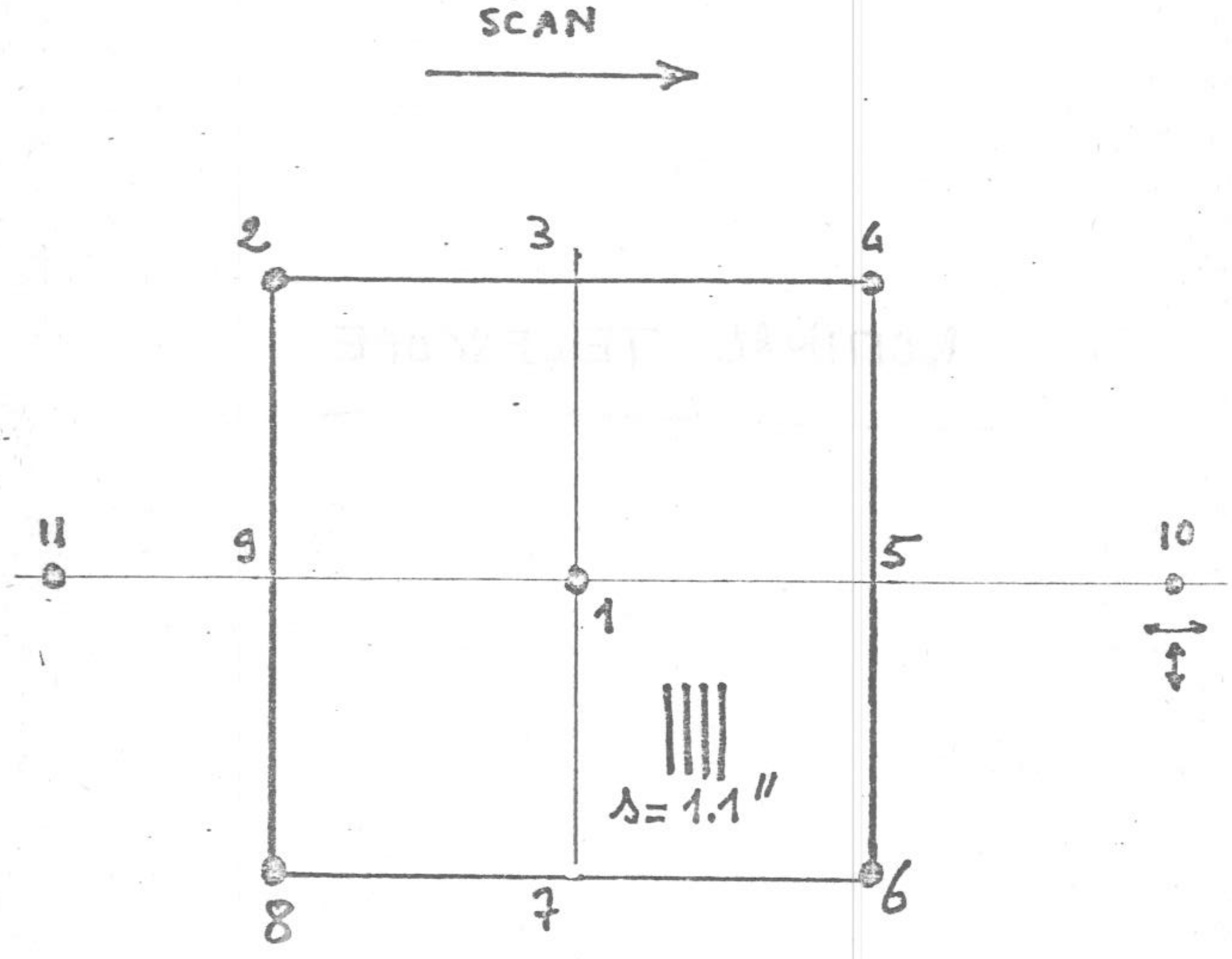
BASIC AND CURRENT MASS OF PAYLOAD CANDIDATE CONFIGURATIONS FOR AN ENTRANCE PUPIL DIAMETER OF 320 MM AND A 70 HZ FREQUENCY

. 20/30KG WEIGHT INCREASE WRT PROPOSAL EXPLAINED BY

- TYCHO ≈ 10 KG
- RE-ESTIMATE OF HARNESS (≈ + 7 KG) AND T/C HW (≈ + 3 KG)
- BETTER ESTIMATE OF MIRROR MOUNTS (≈ + 6 KG)

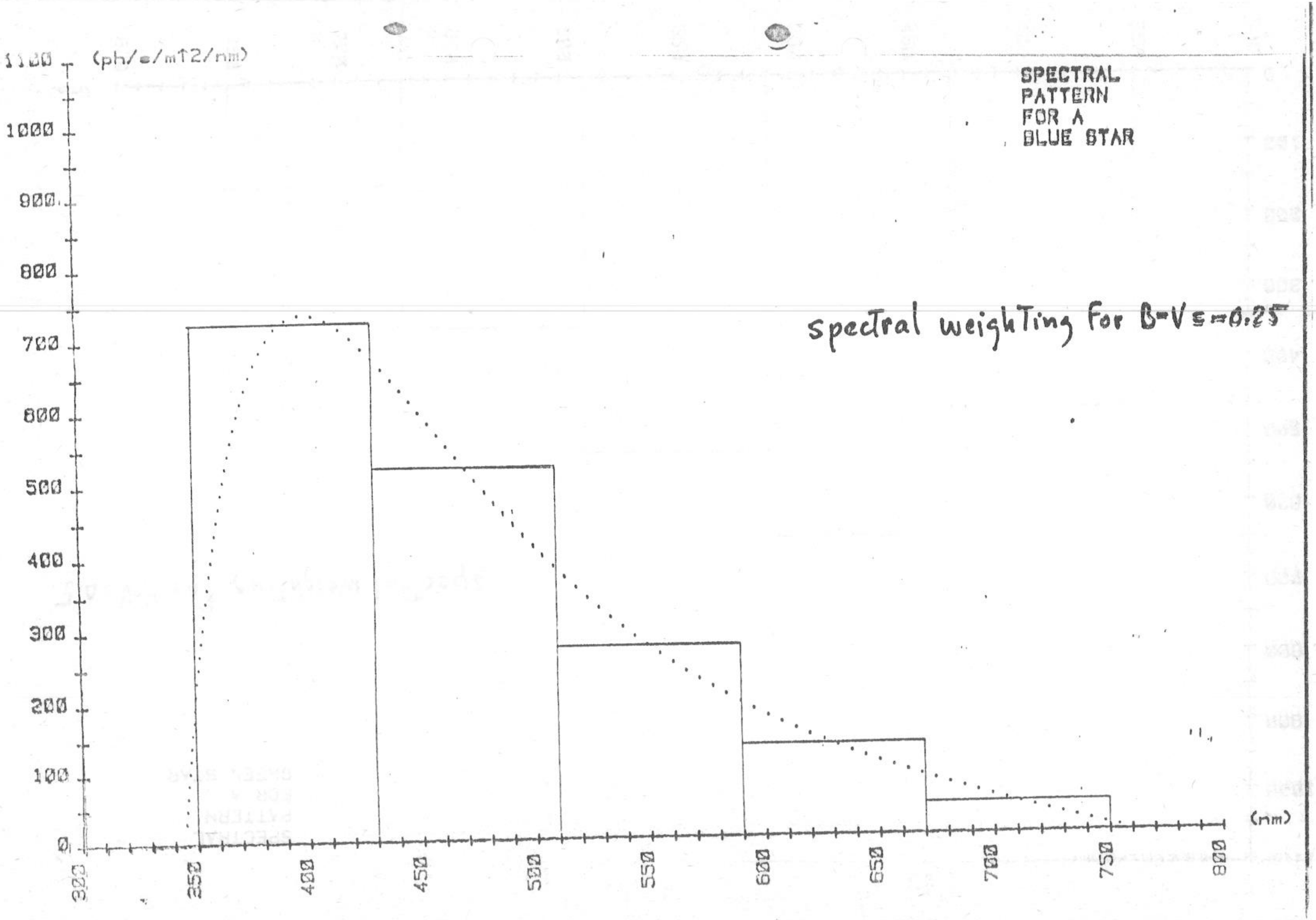
NOMINAL TELESCOPE

FIELD POINTS FOR OTF COMPUTATIONS

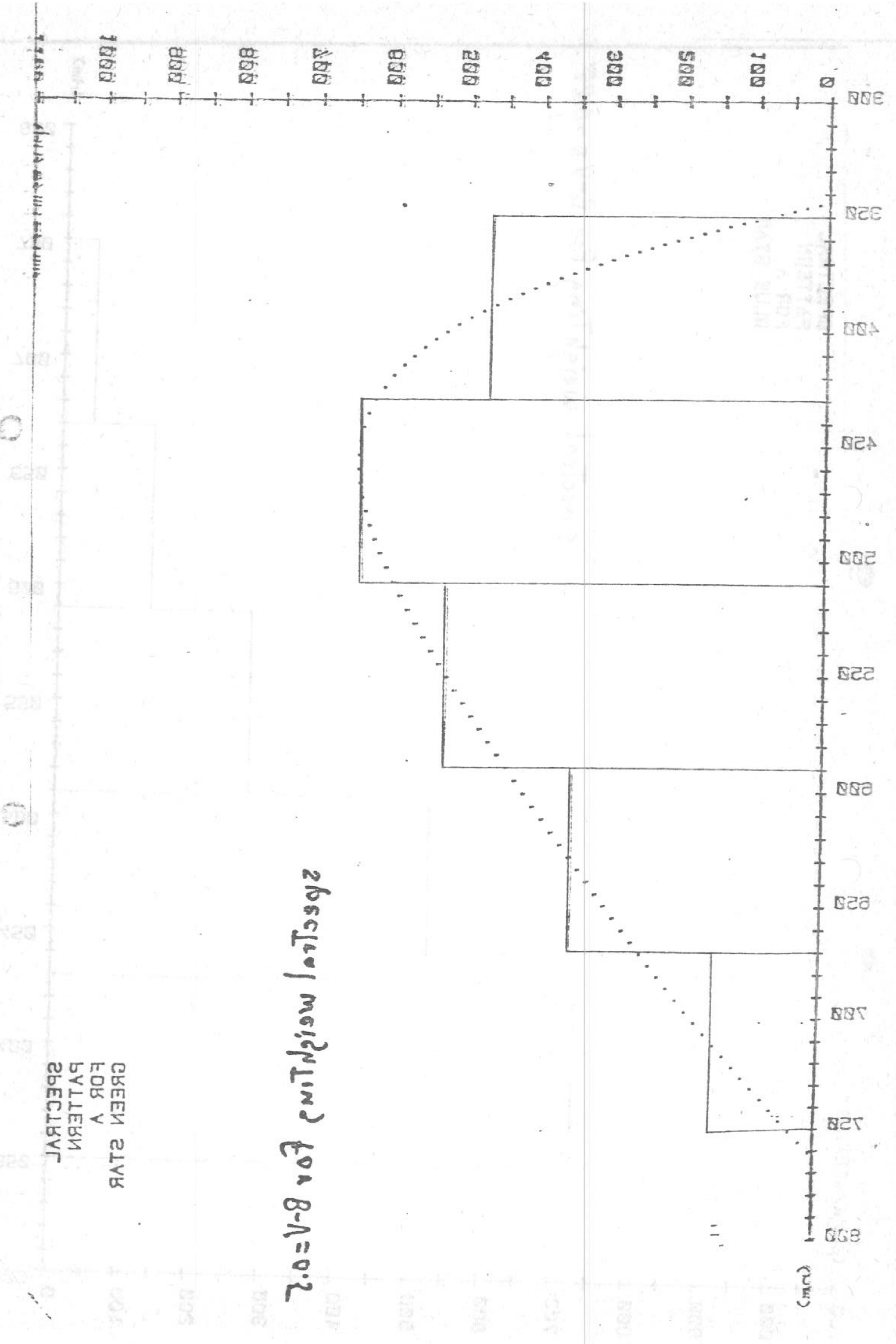


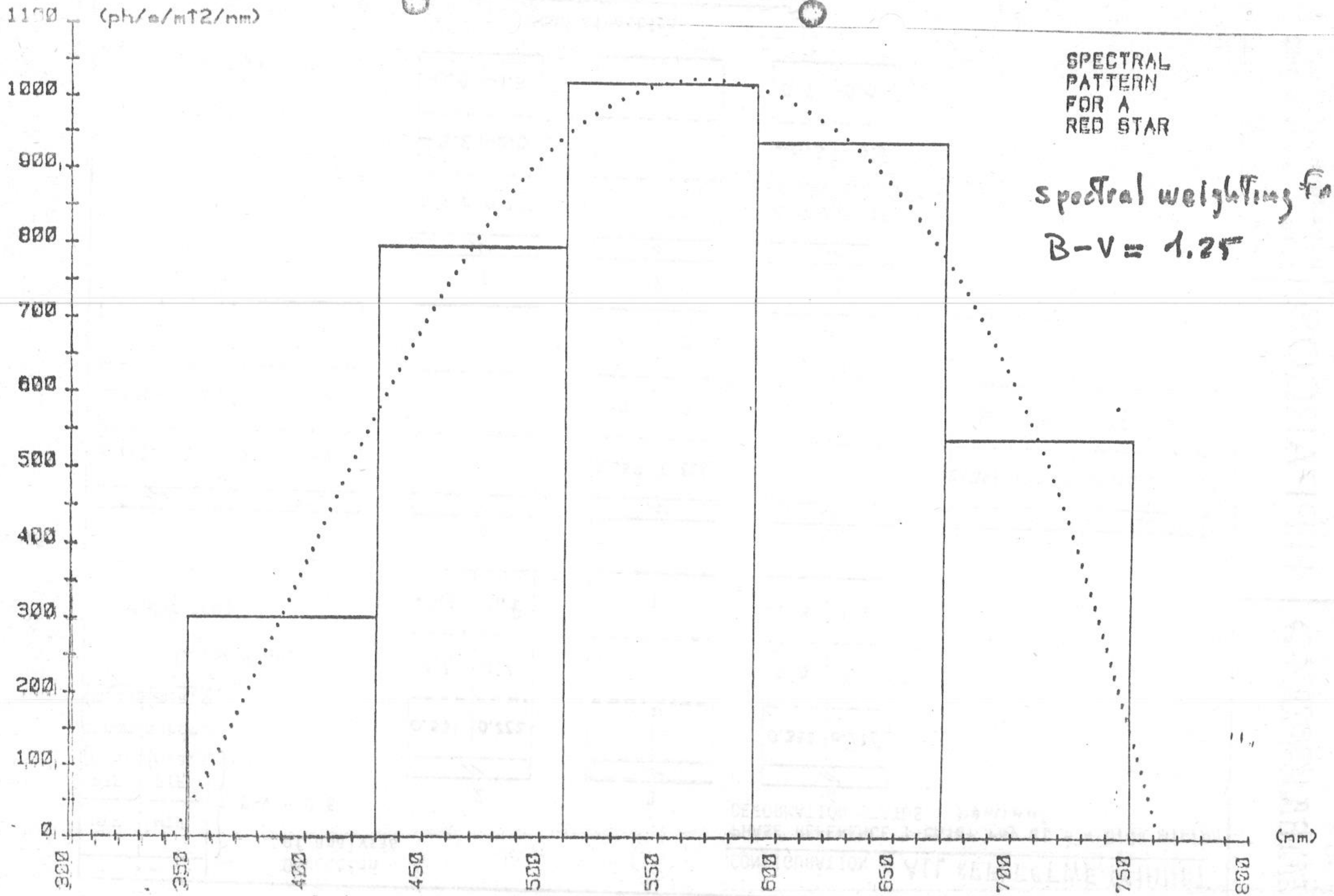
- STAR COLOURS : B-V = 0.5
  B-V = -0.25
  B-V = 1.25

- POLYCHROMATIC OTF COMPUTED WITH LAS SW (5 different wavelengths × spectral weights



Spectral weighTing For B-V = -0.25


SPECTRAL
PATTERN
FOR A
GREEN STAR
spectral weighting for B-V=0.5
0
100
200
300
400
500
600
700
800
900
1000
300
350
400
450
500
550
600
650
700
750
800
(mμ)



spectral weighting for
B-V = 1.25

CONFIGURATION : ALL REFLECTIVE SCHMIDT

PHASE REFERENCE : chief ray at λ = 0,89 micron
DEFORMATION STATUS : Nominal

~~2nd~~ 1st freq.	~~1st~~ 2nd freq.
MTF	MTF
PTF (m.a.s)	PTF (m.a.s)
chrom. (m.a.s)	chrom. (m.a.s)

. Direction of analysis

B-V = 0.5

2

//	
0.331	0.222
1.4	1.4
-0.6	0.8

3

//	

4

//	
0.338	0.228
3.3	3.7
-1.3	1.4

11

//		⊥	
0.327	0.218	0.113	0
-1.9	-1.3	57	-
			-

9

//	

1

//	
0.337	0.226
0	0
0	0

5

//	

10

//		⊥	
0.341	0.230	0.114	0
3.1	2.9	128	-
			-

8

//	
0.332	0.233
-3.2	-2.9
0.9	-1.3

7

//	

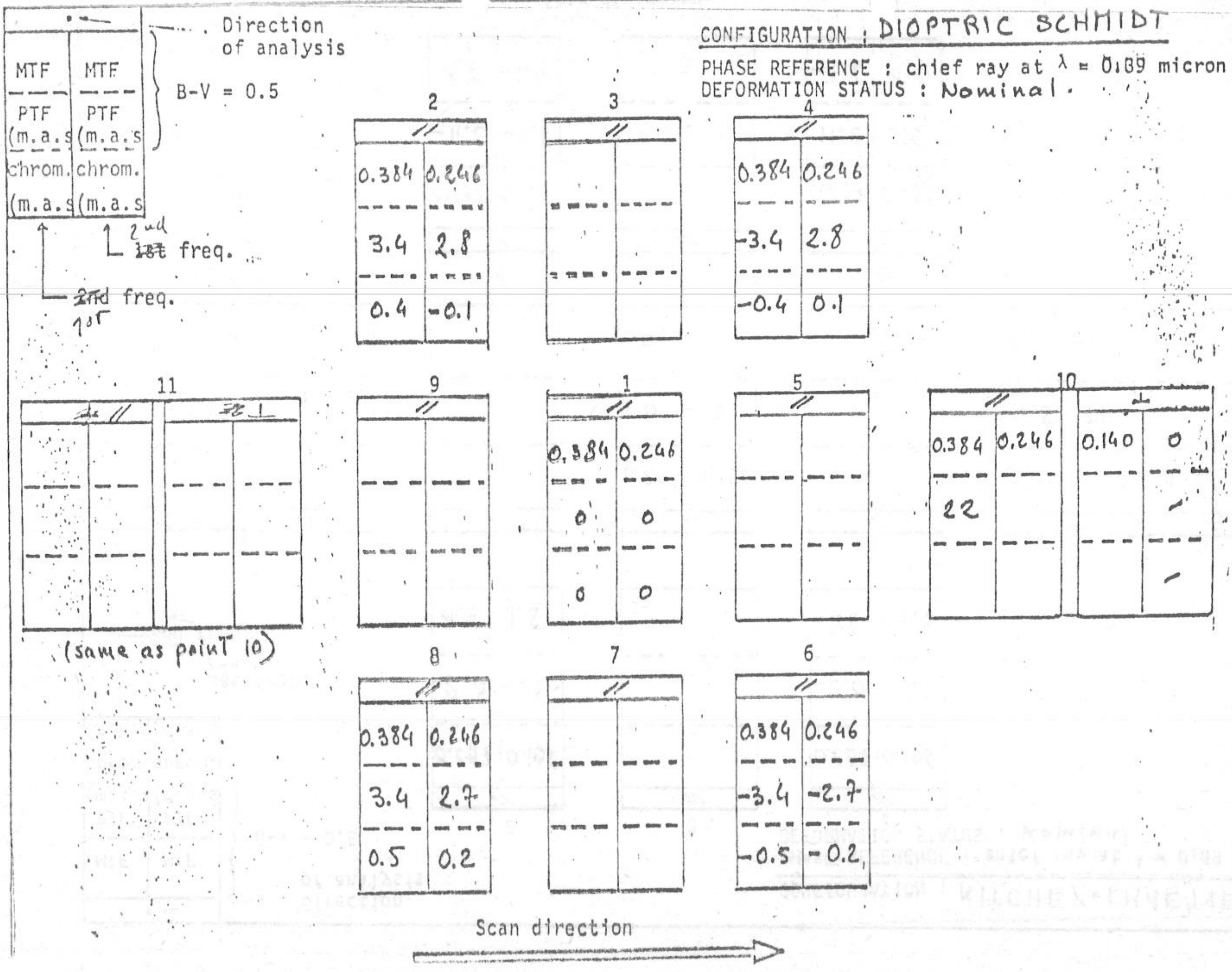
6

//	
0.340	0.228
-0.3	-0.8
0.8	-0.9

Scan direction →

CONFIGURATION : DIOPTRIC SCHMIDT

PHASE REFERENCE : chief ray at λ = 0.89 micron
DEFORMATION STATUS : Nominal.



Point 2 (//)

0.384	0.246
3.4	2.8
0.4	-0.1

Point 4 (//)

0.384	0.246
-3.4	2.8
-0.4	0.1

Point 1 (//)

0.384	0.246
0	0
0	0

Point 10

//		⊥	
0.384	0.246	0.140	0
22			-
			-

Point 8 (//)

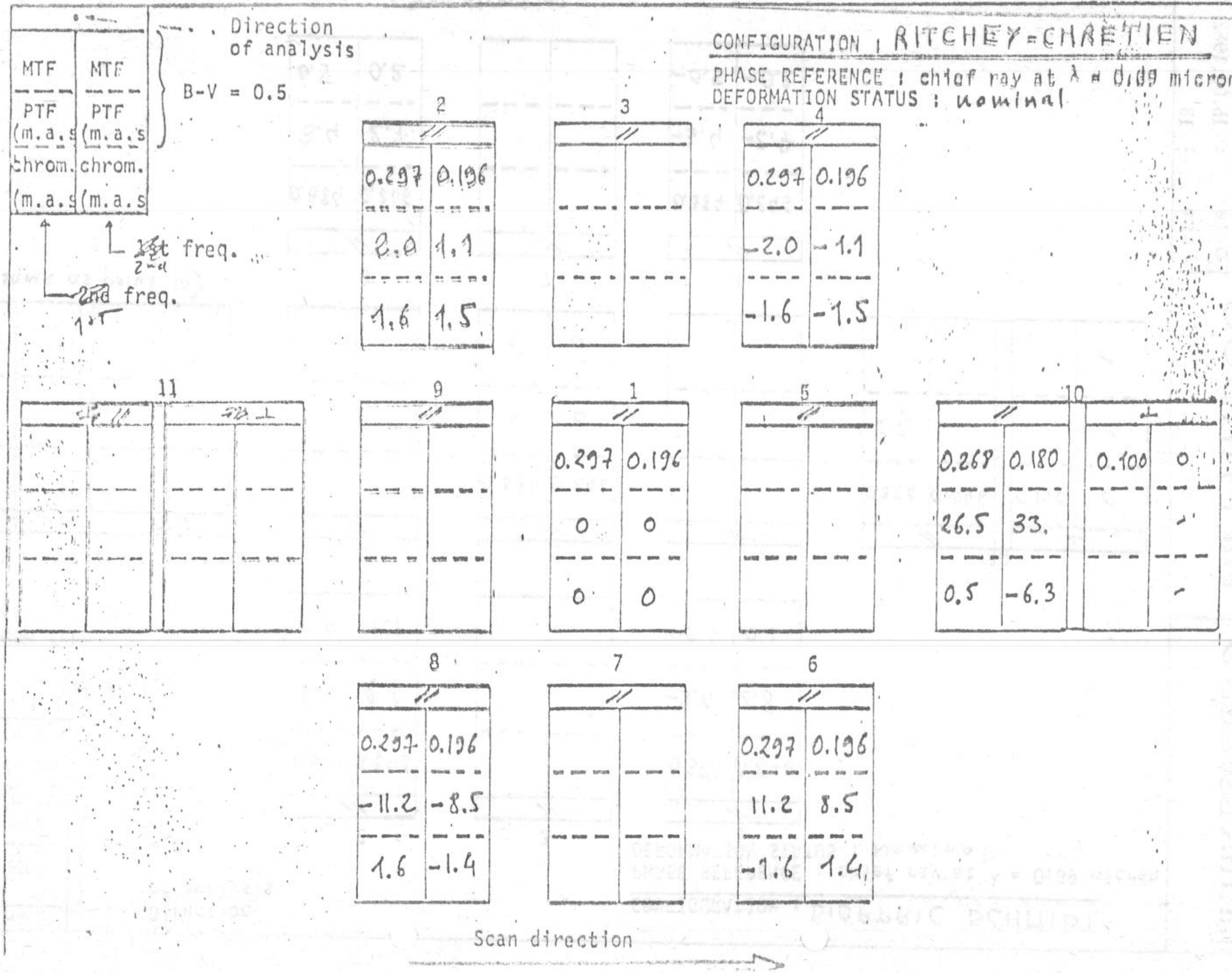
0.384	0.246
3.4	2.7
0.5	0.2

Point 6 (//)

0.384	0.246
-3.4	-2.7
-0.5	-0.2

CONFIGURATION : RITCHEY-CHRETIEN

PHASE REFERENCE : chief ray at λ = 0,69 micron
DEFORMATION STATUS : nominal



2

//	
0.297	0.196
2.0	1.1
1.6	1.5

3

//	

4

//	
0.297	0.196
-2.0	-1.1
-1.6	-1.5

11

//		⊥	

9

//	

1

//	
0.297	0.196
0	0
0	0

5

//	

10

//		⊥	
0.268	0.180	0.100	0
26.5	33.		-
0.5	-6.3		-

8

//	
0.297	0.196
-11.2	-8.5
1.6	-1.4

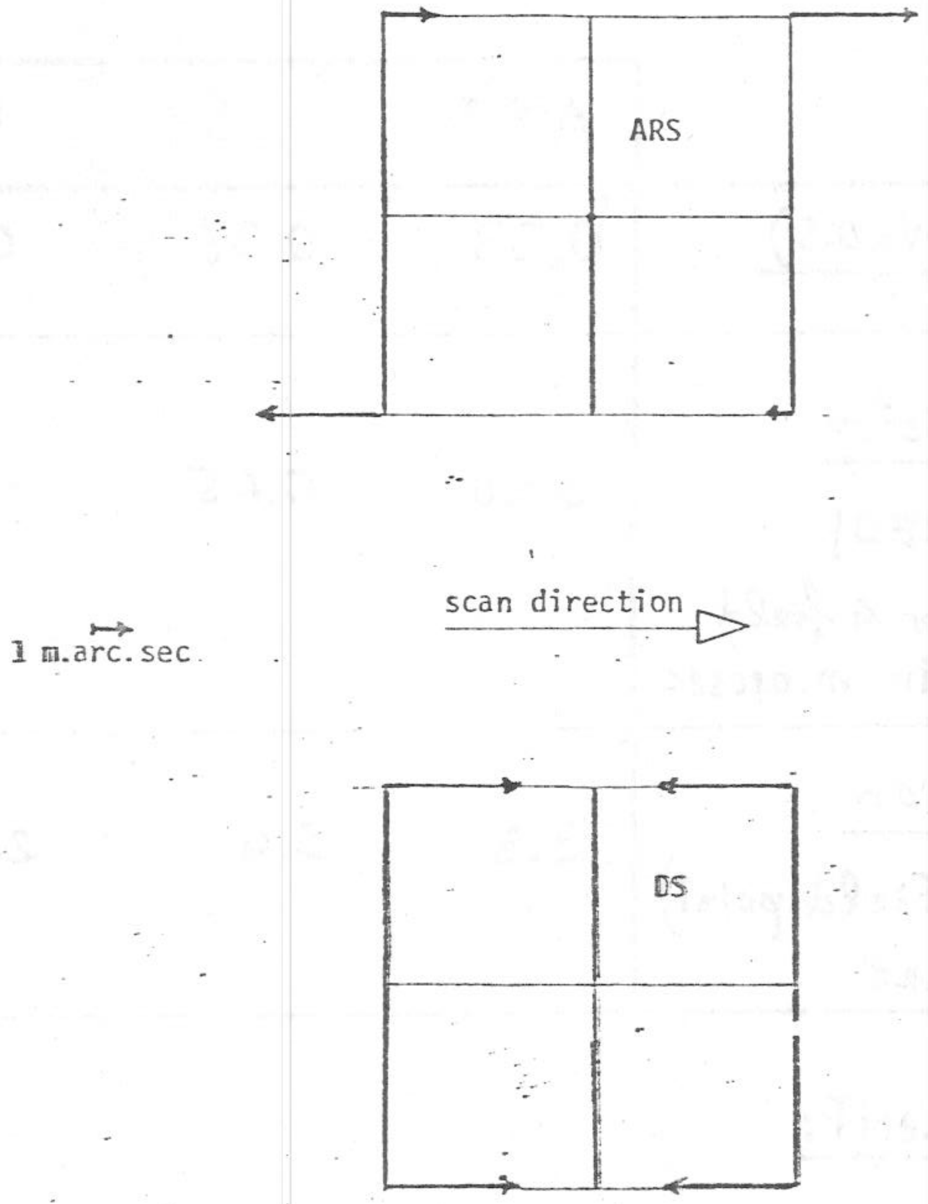
7

//	

6

//	
0.297	0.196
11.2	8.5
-1.6	1.4

Scan direction



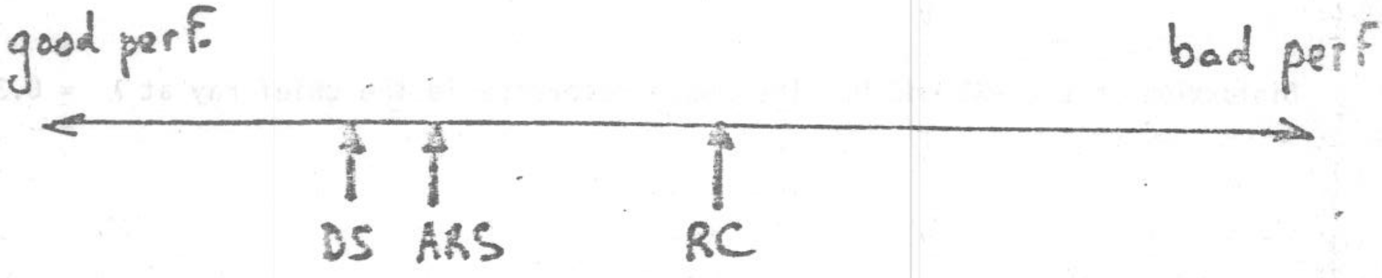
Distorsion of the ARS and DS. The phase reference is the chief ray at λ = 0.39 mi

NOMINAL TELESCOPE

PERFORMANCE SUMMARY

	ARS	DS	RC
1) MTF (B-V=0.5)	0.33	0.38	0.30
2) chromaticity |BLUE – RED| (average over 4 field corners in m.arcsec	0.90	0.45	1.6
3) Distorsion (at worst field point) m.arc sec	3.3	3.4	2000

Relative merit:



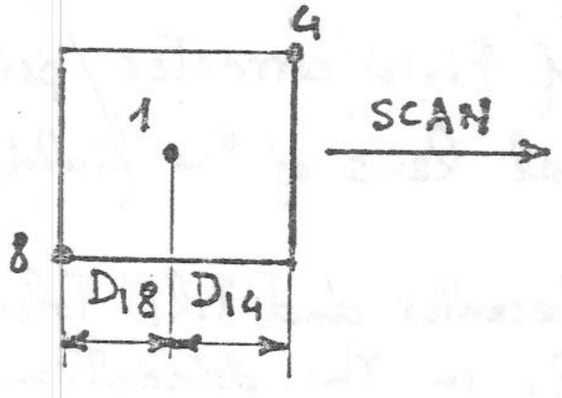
OPTICAL TOLERANCES (1)

CRITERIA

1) MTF : - 10% loss with respect to nominal telescope
→ (long term tolerances, except for defocus)

2) chromaticity :
- 1 m.a.s. increase WRT nominal telescope
→ long term tolerances

3) Distorsion :
- variation of 1 m.a.s. of distance D_{14} or D_{18} WRT nominal telescope
→ short term tolerances (24 hours)

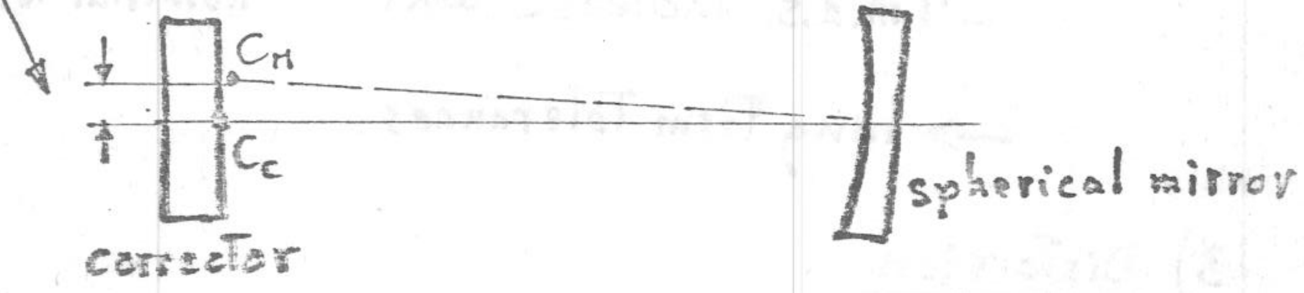


OPTICAL TOLERANCES (2)

MISALIGNMENT PARAMETERS

SCHMIDT (ARS OR DS) :

- "Mis match" between the curvature center of the spherical mirror and the symetry center of the corrector.
- position of grid / spherical mirror (decenter, tilt, defocus)



RC

- relative position of secondary mirror / primary
- position of field corrector / primary
- individual lens of the field corrector

Remark The decenter and tilt tolerances have been analysed only in the direction which affects the WFE symetry in the sensible direction. with respect to chromaticity.

PTICAL .OLERANCES : CHROMATICITY

RITERION : δ (B-R) = 10^{-3} arc sec (variation with respect to nominal telescope)

- displacements in mm, tilts in degree
- X not critical

DEFORMATION TYPE		D S		A R S		R C	
	field point	1	4	1	4	1	4
SCHMIDT CORRECTOR DECENTER	Δx	0.07		0.12			
SECONDARY MIRROR DECENTER	Δx					0.01	0.01
SECONDARY MIRROR TILT	Θ_y					0.003	0.003
FIELD CORRECTOR DECENTER	Δx						0.36
FIELD CORRECTOR TILT	Θ_y						0.14
FIELD CORRECTOR - SINGLE LENS DECENTER	Δx						0.18
GRID DEFOCUS	Δz		-0.022 +0.056		-0.004 +0.015		0.53
GRID DECENTER	Δx		X		1.8		
GRID TILT	Θ_y		1.8		0.15		3.2

OPTICAL OLERANCES : MTF

CRITERION : 10 % loss with respect to nominal telescope

- displacement in mm, rotations in degree
- ✶ : not critical, compared to chromaticity or distorsion tolerance

DEFORMATION TYPE		D S		A R S		R C	
	field point	1	4	1	4	1	4
SCHMIDT CORRECTOR DECENTER	Δx	3.8	3.8	4.2	4.2		
SECONDARY MIRROR DECENTER	Δx					✶	✶
SECONDARY MIRROR TILT	θ_y					✶	✶
FIELD CORRECTOR DECENTER	Δx					✶	✶
FIELD CORRECTOR TILT	θ_y					✶	✶
FIELD CORRECTOR - SINGLE LENS DECENTER	Δx					✶	✶
GRID DEFOCUS	Δz	-0.008 +0.009		-0.008 +0.012		0.05	0.06
GRID DECENTER	Δx	✶	✶	✶	✶	✶	✶
GRID TILT	θ_y		0.1		0.1		0.3

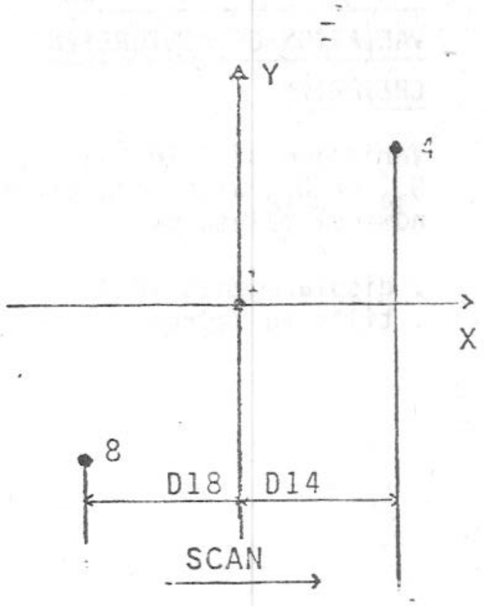
CONFIGURATION : ARS

VARIATION OF DISTORSION

CRITERION

variation of 1.10^{-3} arc sec of D_{14} or D_{18} with respect to the nominal telescope

- . displacements in mm
- . tilts in degree



NOMINAL	D_{14}	D_{18}
DEFORMATION STATUS	Δ (D_{14})	Δ (D_{18})
PUPIL CORRECTOR DECENTER : Δx =	0.046	0.227
SECONDARY DECENTER : Δx =		
TILT : θ_y =		
FIELD CORRECTOR DECENTER : Δx =		
TILT : θ_y =		
LENS DECENTER : Δx =		
GRID DEFOCUS : Δz =	0.0010	0.0010
DECENTER : Δx =	0.135	0.119
TILT : θ_y =	0.05	0.06

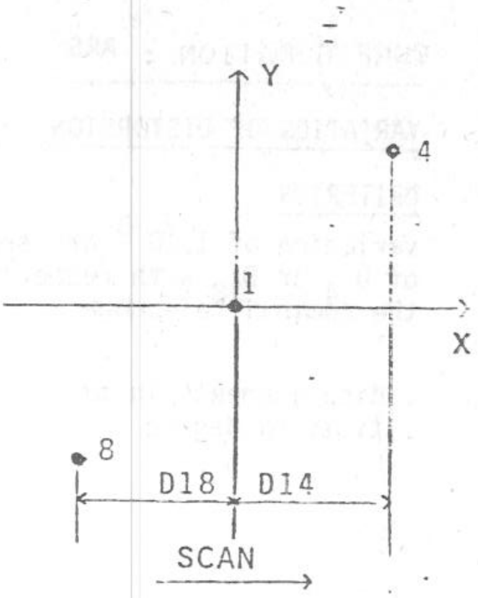
CONFIGURATION : DS

VARIATION OF DISTORSION

CRITERION

Variation of 1.10^{-3} arc sec of D_{14} or D_{18} with respect to the nominal telescope.

- displacements in mm
- tilts in degree



NOMINAL	D_{14}	D_{18}
DEFORMATION STATUS	$\Delta\ (D_{14})$	$\Delta\ (D_{18})$
PUPIL CORRECTOR DECENTER : Δx =	0.027	0.027
SECONDARY DECENTER : Δx =		
TILT : Θ_y =		
FIELD CORRECTOR DECENTER : Δx =		
TILT : Θ_y =		
LENS DECENTER : Δx =		
GRID DEFOCUS : Δz =	0.0010	0.0010
DECENTER : Δx =	0.119	0.142
TILT : Θ_y =	0.04	0.05

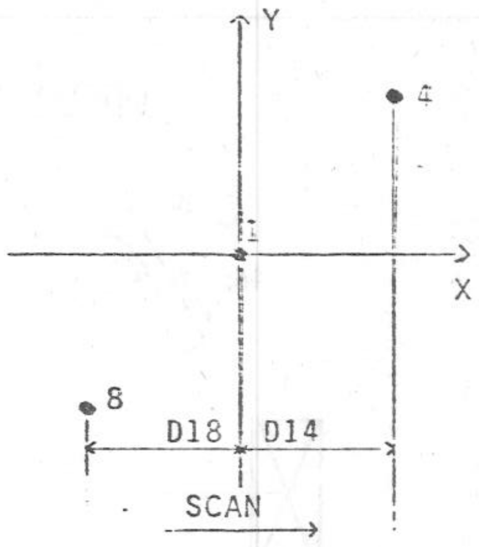
CONFIGURATION : RC

VARIATION OF DISTORSION

CRITERION :

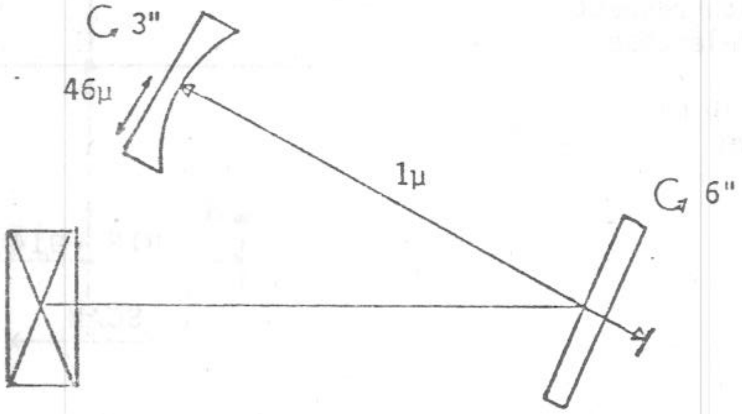
Variation of 1.10^{-3} arc sec of D_{14} or D_{18} with respect to the nominal telescope

. displacements in mm
. tilts in degree

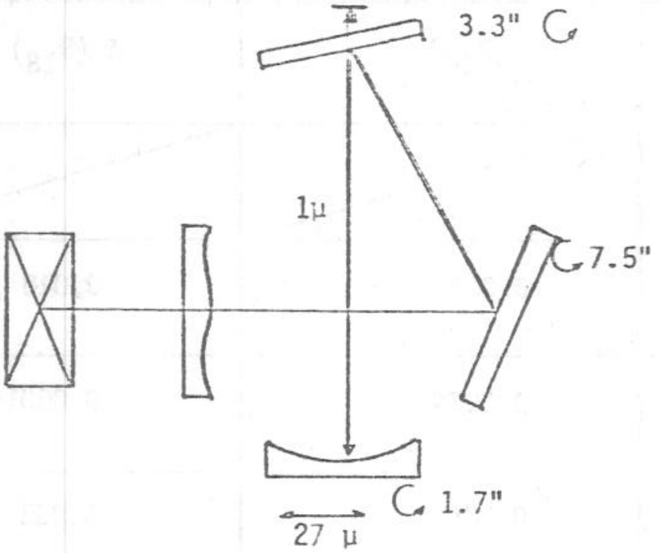


NOMINAL	D_{14}	D_{18}
DEFORMATION STATUS	$\Delta(D_{14})$	$\Delta(D_{18})$
PUPIL CORRECTOR DECENTER : Δx =		
SECONDARY DECENTER : Δx =	0.006	0.018
TILT : Θ_y =	0.0024	0.00016 (?)
FIELD CORRECTOR DECENTER : Δx =	0.005	0.003
TILT : Θ_y =	0.0005	0.0005
LENS DECENTER : Δx =	0.003	0.0014
GRID DEFOCUS : Δz =	0.277	0.277
DECENTER : Δx =		
TILT : Θ_y =	0.83	0.56

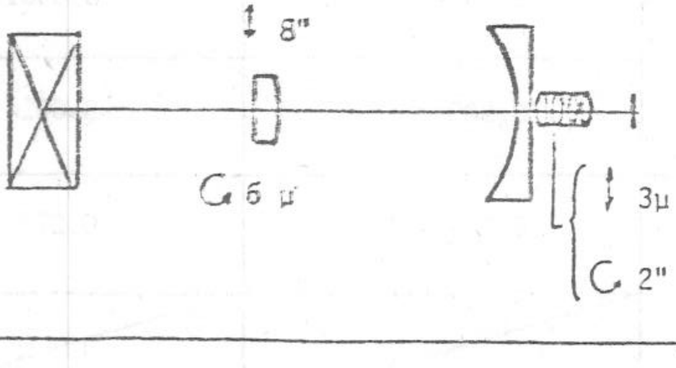
CRITICAL SHORT TERM TOLERANCES (DISTORSION)



ARS

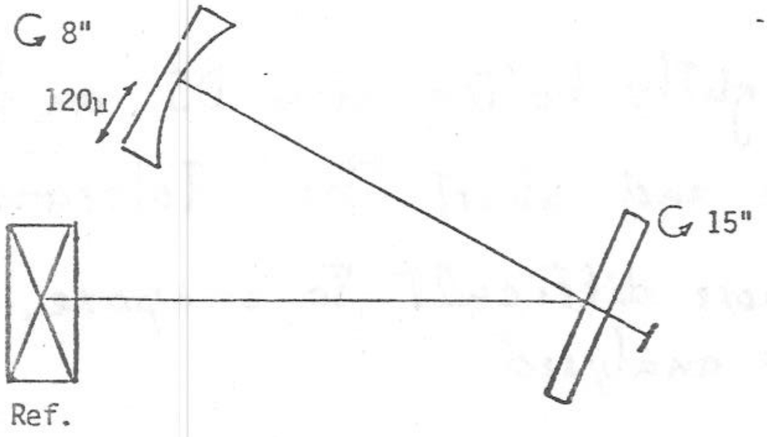


DS

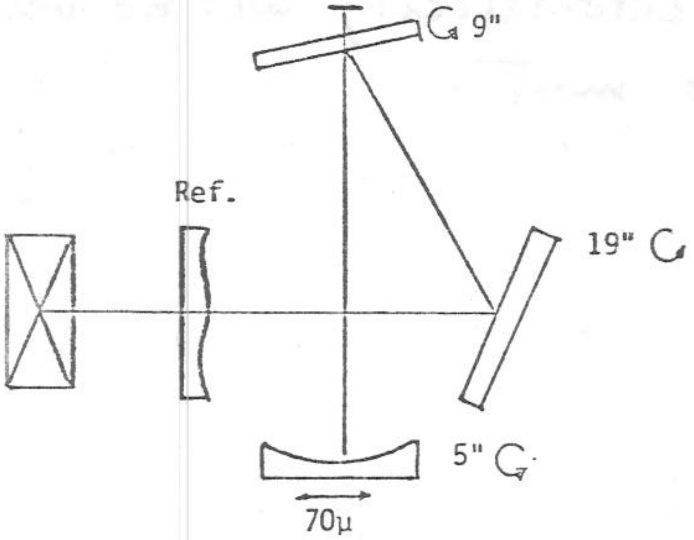


RC

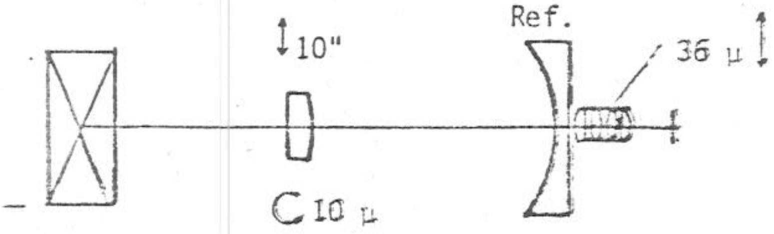
CRITICAL LONG TERM TOLERANCES (CHROMATICITY)



ARS



DS



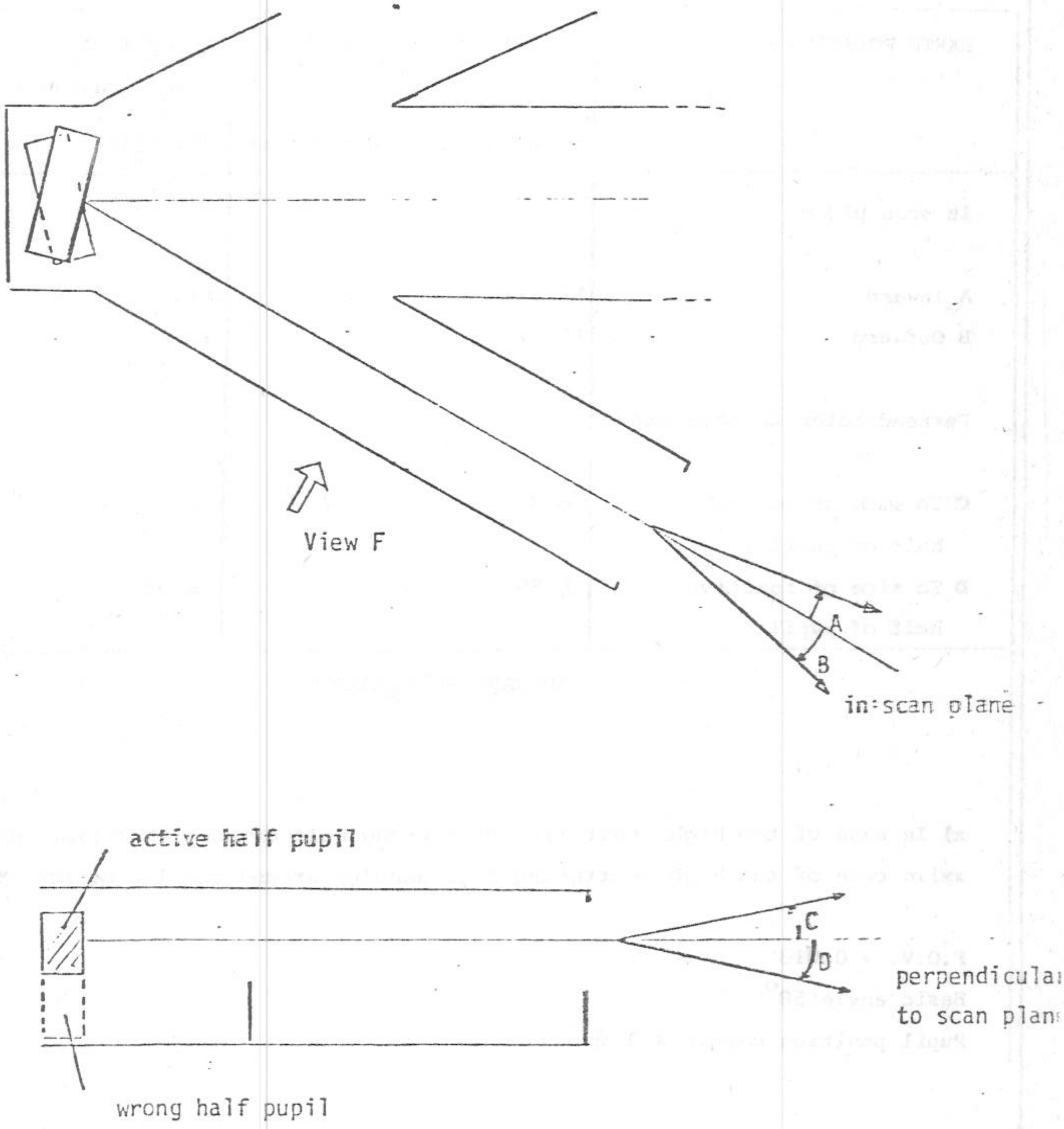
RC

CONCLUSION ON TOLERANCES

- ARS slightly better than DS on both long term and short term tolerances
- RC is more difficult to compare, and not yet fully analysed.

- in all cases the long term tolerances related to chromaticity will be very difficult to meet

STRAY LIGHT



Unprotected angles

EARTH POSITION	MINIMUM EARTH ANGLES (DEGREES)			
	Dioptric Schmidt		Other configuration	
	Probable	Worst case	Probable	Worst cas
In scan plane				
A Inward	11.8		11.8	
B Outward	11.27		11.27	
Perpendicular to scan plane				
C To side of active half of pupil	6.39	8.7 x)	6.39	8.7 x)
D To side of inactive half of pupil	6.39		6.39	7.07 xx)

SUMMARY PERFORMANCE

x) In case of too high scattering from wrong half of complex mirror. Margin

xx) In case of too high scattering from annulus around complex mirror. Margin .3

F.O.V. ± 0.013
Basic angle 58°
Pupil position margin ± 1 mm

TABLE 1 - UNPROTECTED ANGLES

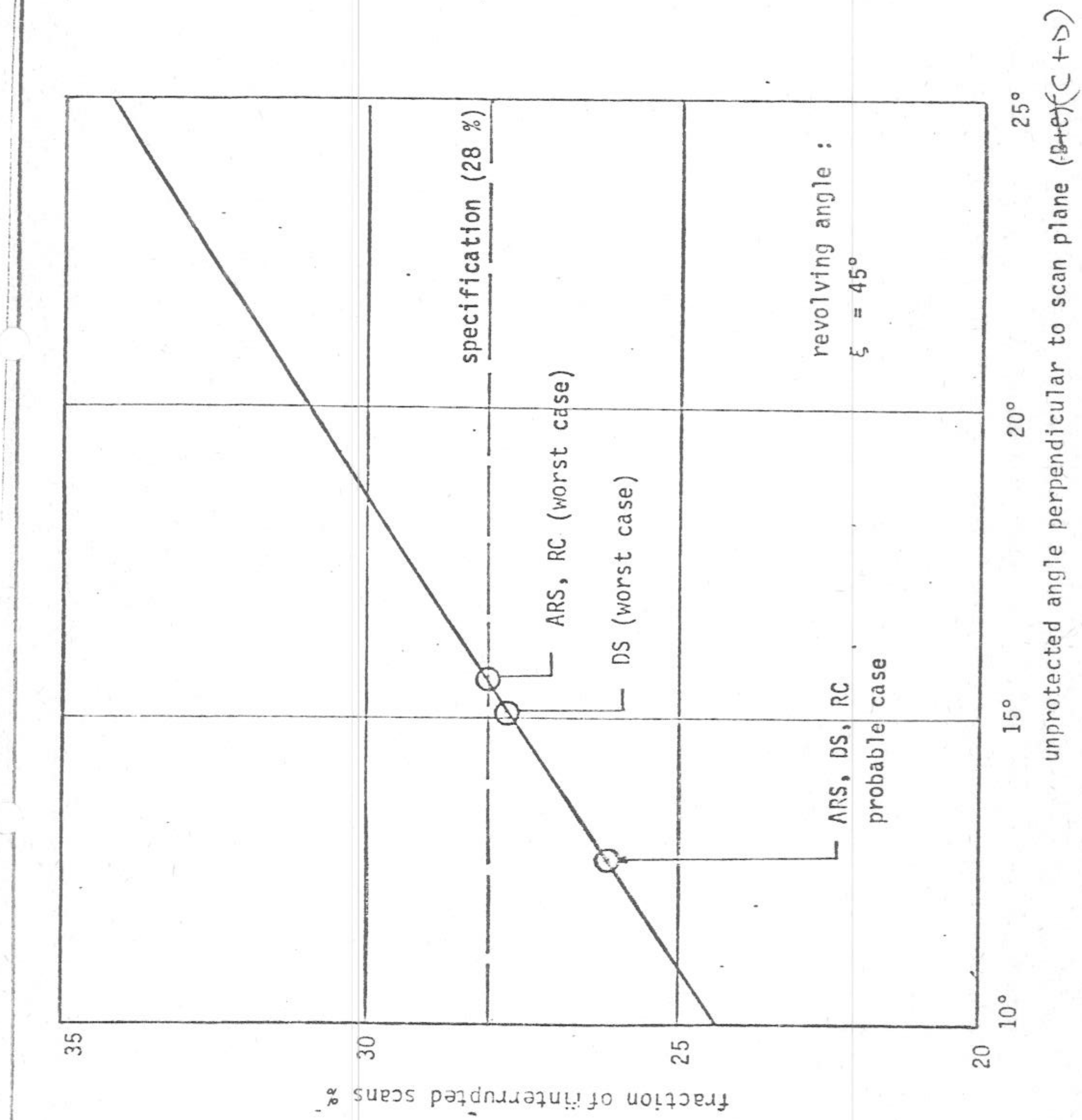


Fig 2 - FRACTION OF INTERRUPTED SCANS VS UNPROTECTED TRANSVERSE FOV

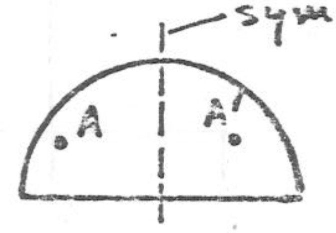
OPTICS MANUFACTURING

OPTICS MANUFACTURING 1)

SPECIFICATION ON WFE

- overall regularity : $\mathrm{WFE} \lesssim \lambda/30$ RMS (1

- WAVE FRONT SYMETRY :

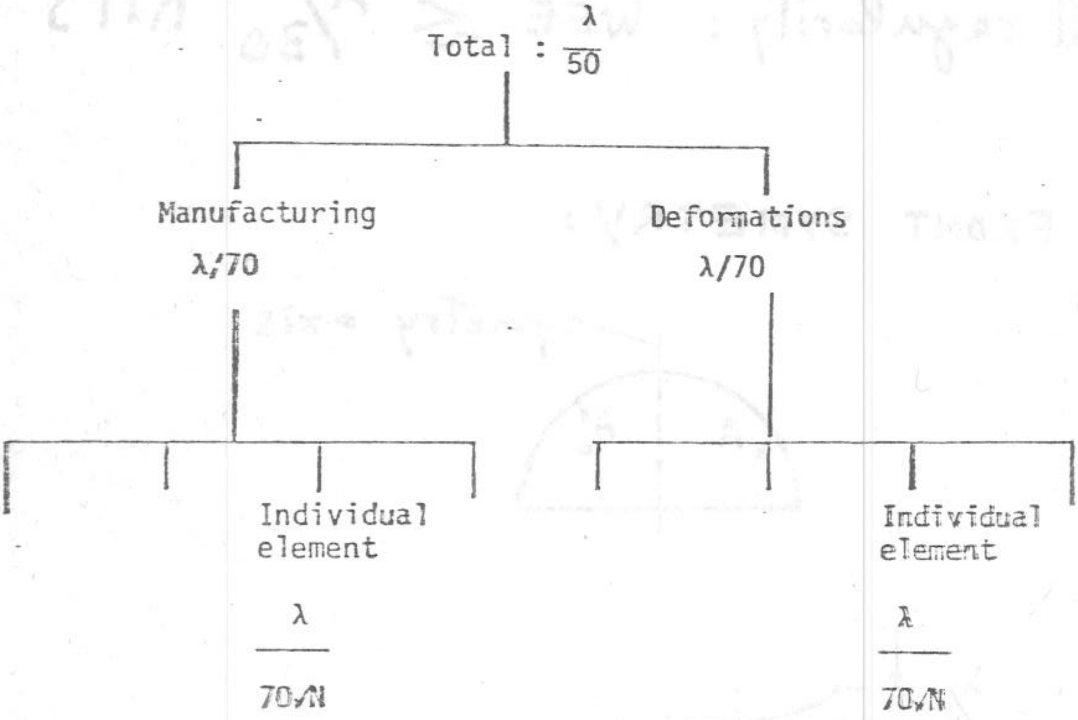


$$\left| \mathrm{WFE}_A - \mathrm{WFE}_{A'} \right| \lesssim \lambda/50 \qquad (2)$$

These tolerances refer to the whole Telescope. They shall be shared between all optical elements, and between polishing and Thermo-mechanical stress on mirrors.

3 - WFE APPORTIONEMENT BETWEEN MANUFACTURING AND THERMO MECHANICAL DEFORMATIONS

The following WFE apportionnement can be made for a configuration including N optical elements ; (we consider only the odd component of the WFE) :

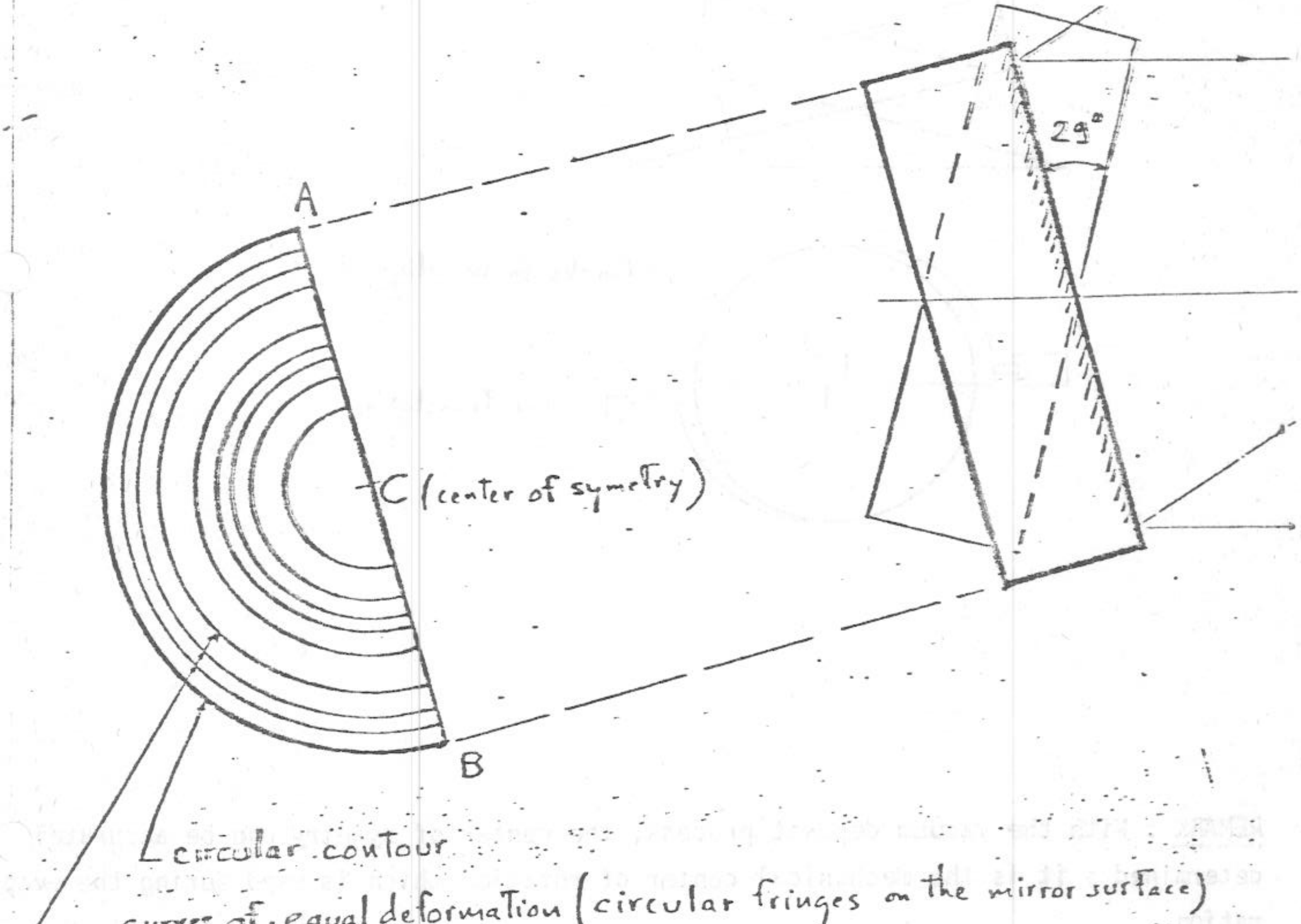


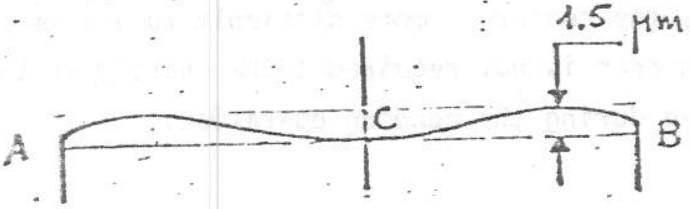
Therefore the ~~figuring~~ WFE accuracy on each optical component is :

- for the DS (5 components) : $\frac{\lambda}{156}$
- for the ARS (3 components) : $\frac{\lambda}{121}$
- for the RC (4 components) : $\frac{\lambda}{140}$

BEAM COMBINER

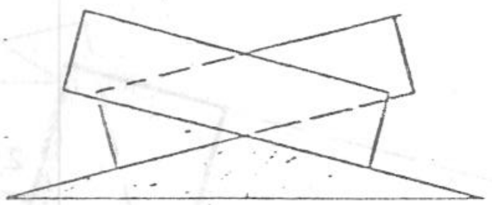
ARS

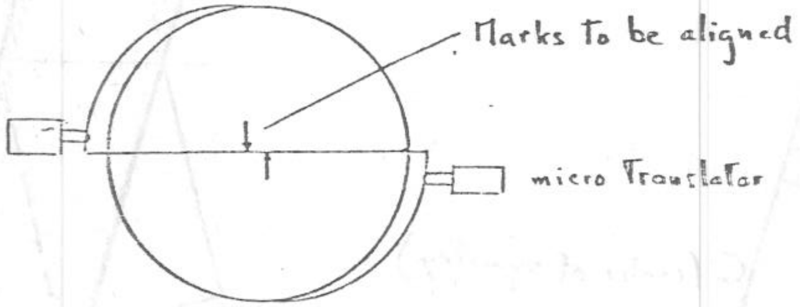




DS or RC : same as ARS but flat profile

CENTERING THE 2 HALVES OF ARS Beam Combiner BEFORE BONDING :

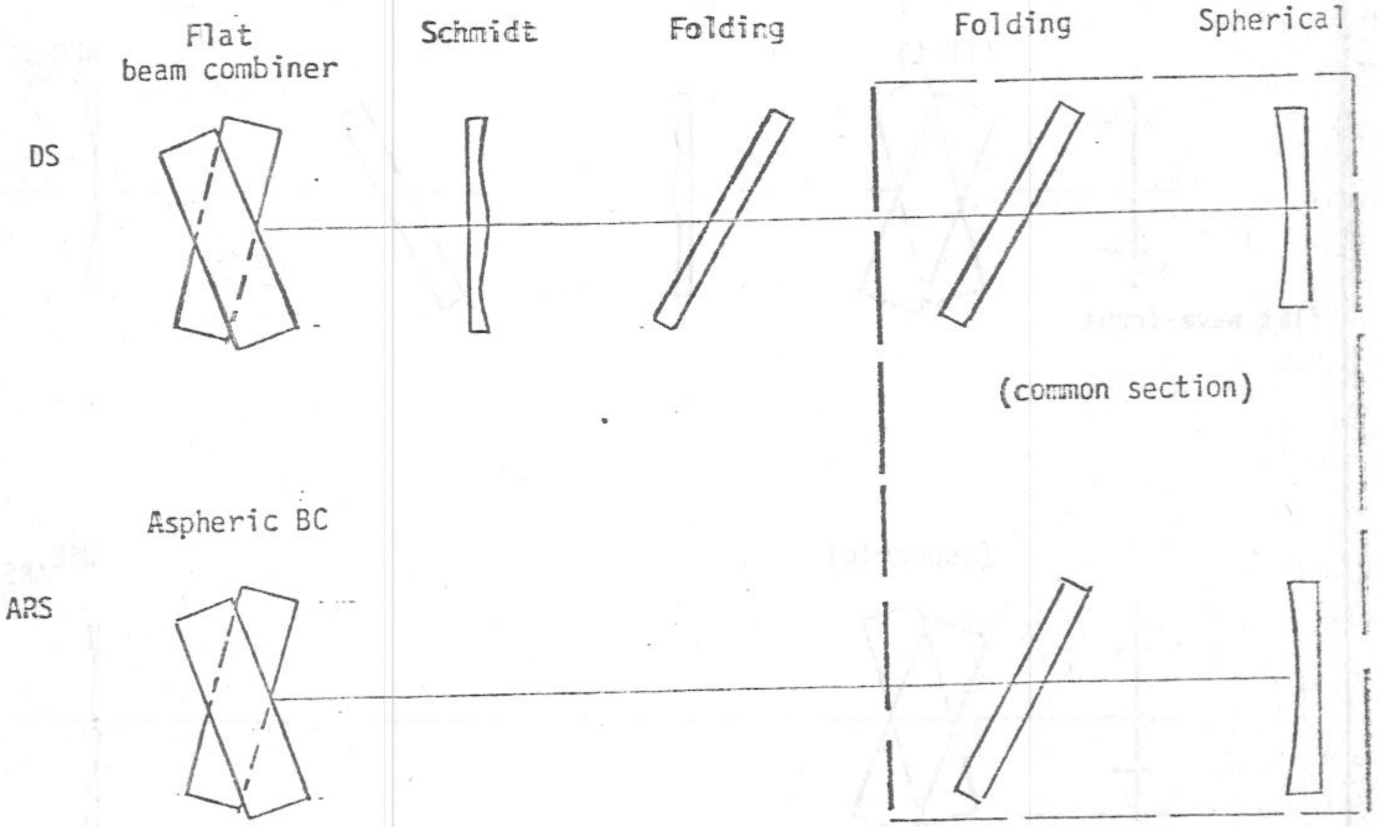




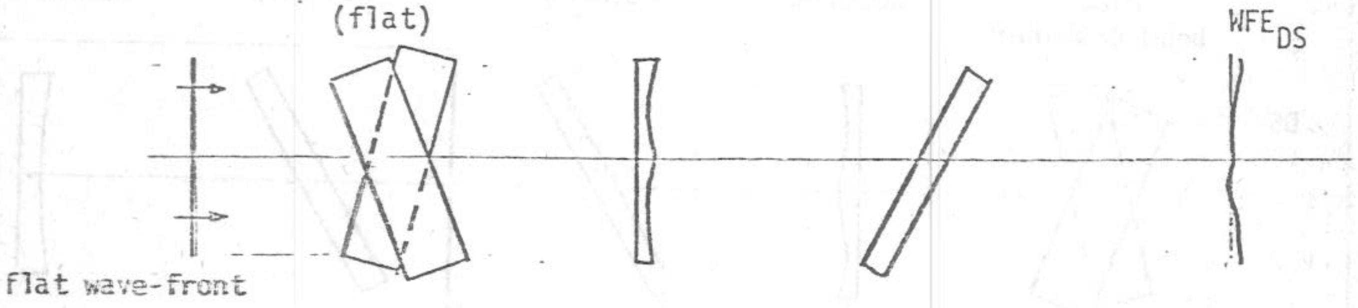
REMARK : With the vacuum deposit process, the center of symetry can be accuratel determined : it is the mechanical center of rotation which is used during the evap ration.

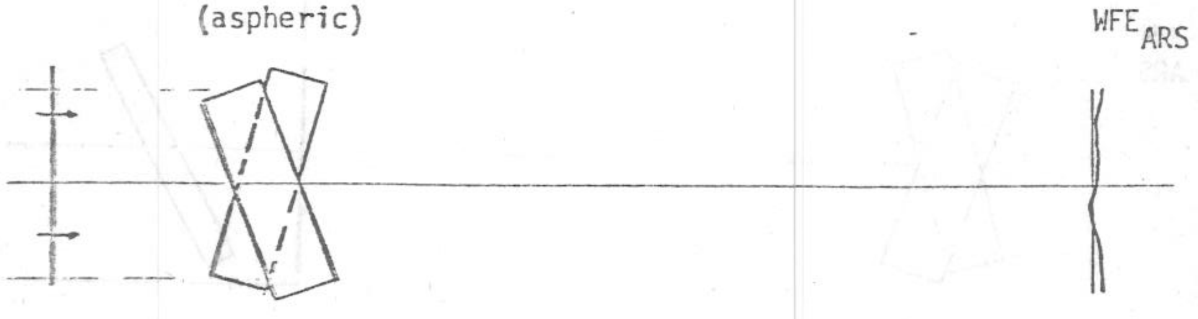
For conventional polishing, the center is more difficult to locate ; however, the mark to be printed on the mirror is not required to be exactly at the center, as f as it is correctly realigned during the bonding operation.

COMPARISON ARS/DS 1



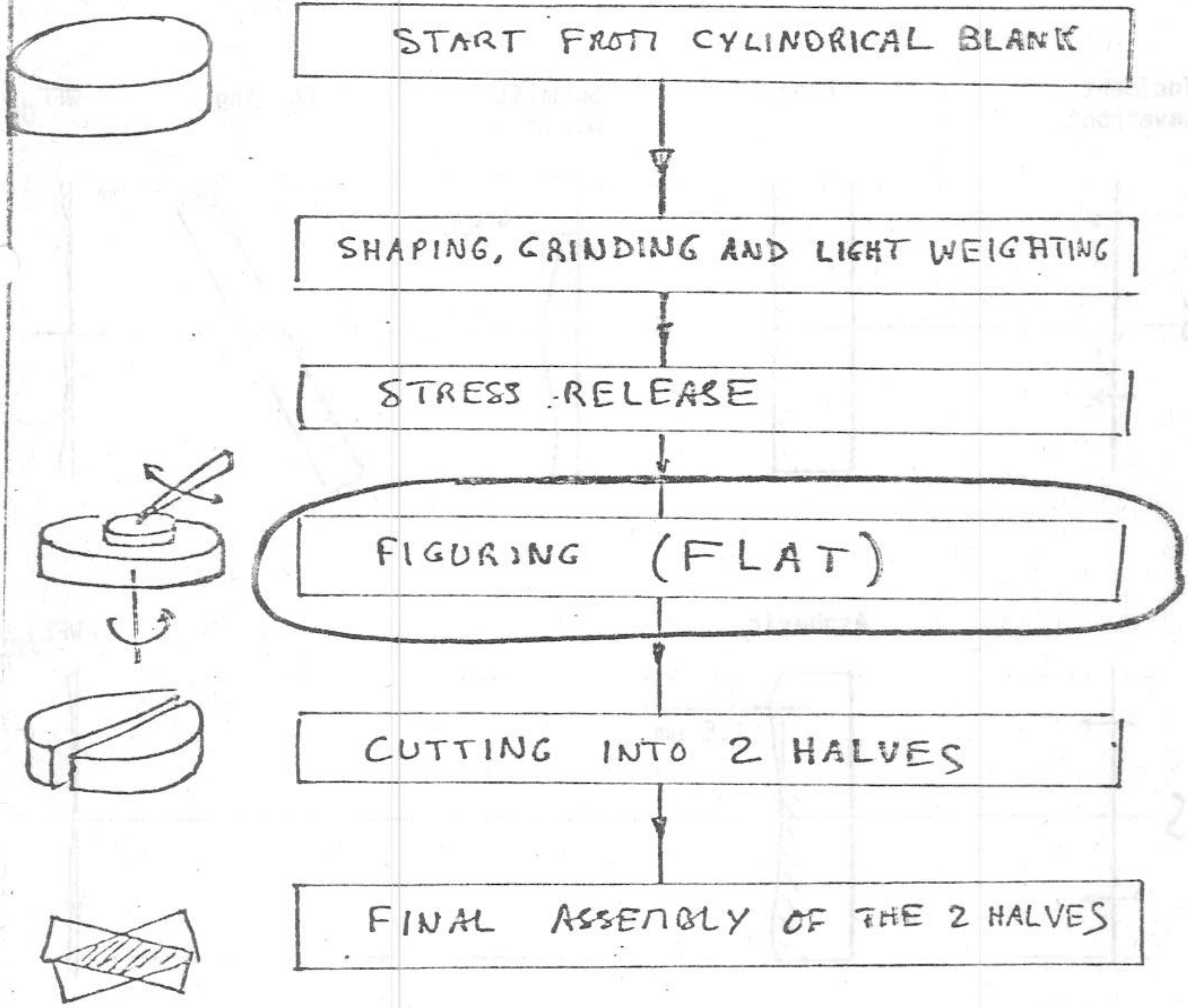
COMPARISON ARS/DS (2)





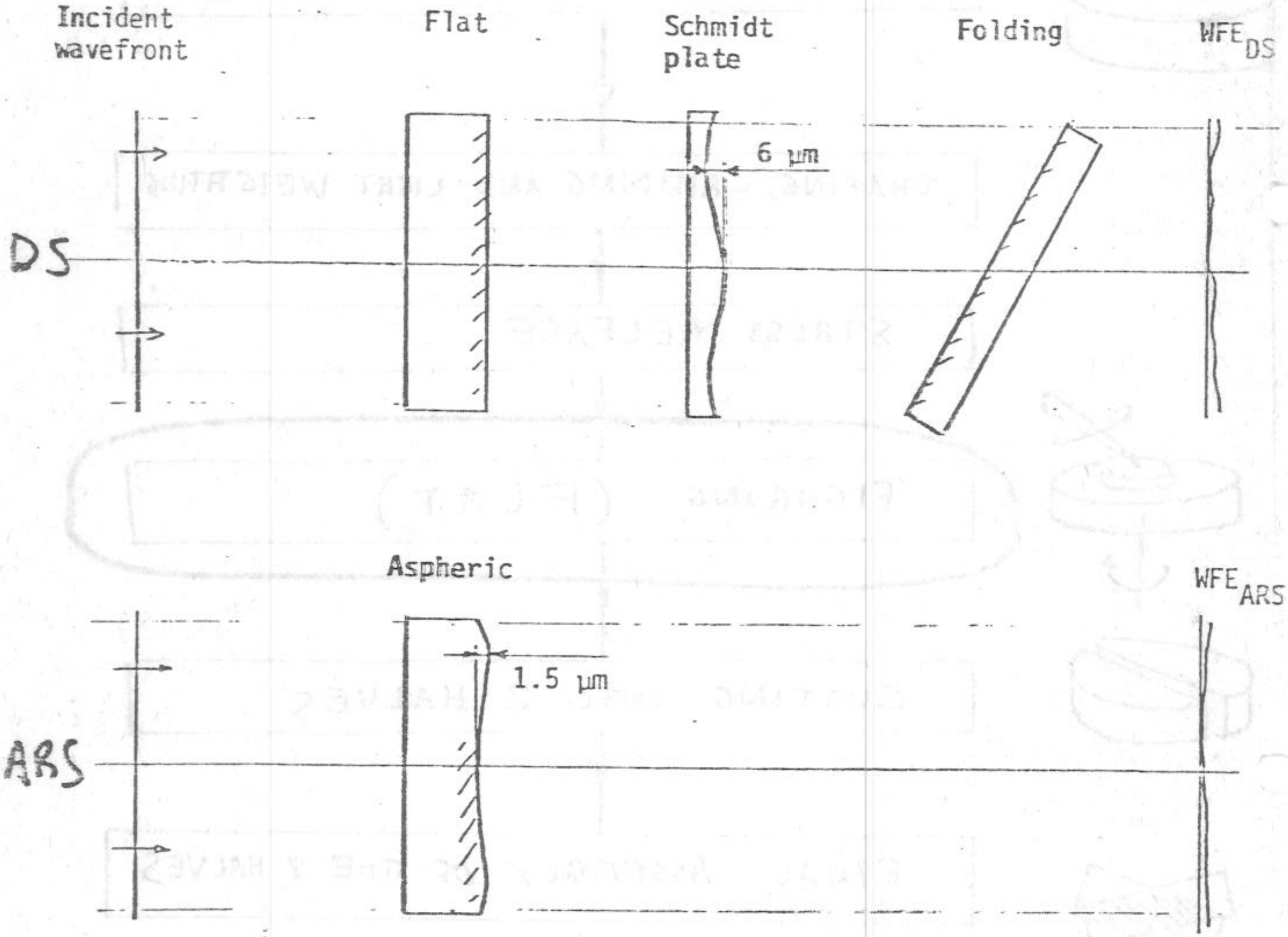
B.C. manufacturing procedure

(RC or DS)



COMPARISON DS/ARS (3)

final comparison diagram:



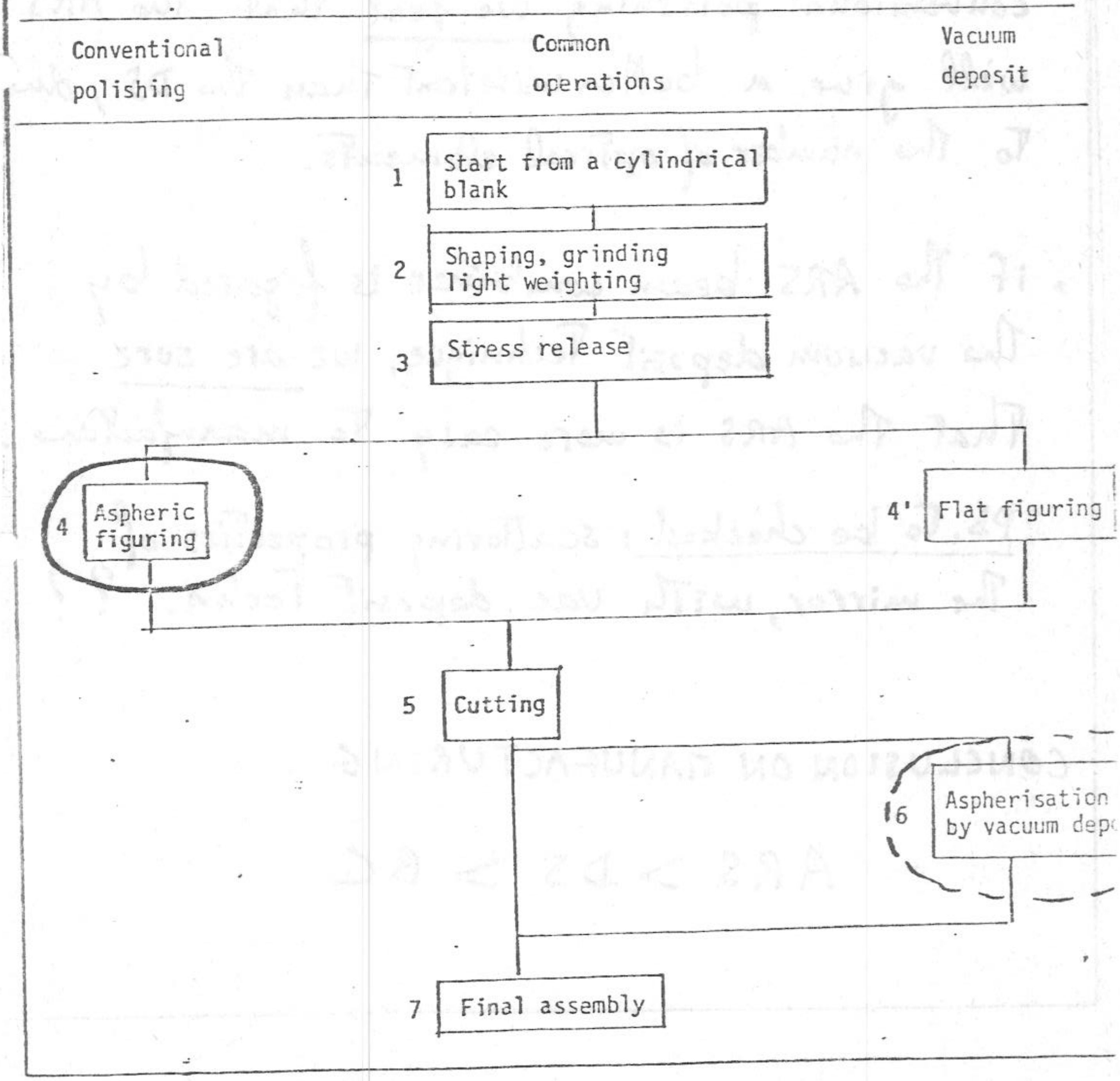
which configuration will give the best symetrical wavefront after manufacturing?

PROBLEM : NO MANUFACTURER CAN COMMIT HIMSELF ON THE $\lambda/50$ spec. on WFE symetry

B.C. Manufacturing procedure (ARS)

Two methods are a priori possible :

- conventional polishing
- aspherisation by vacuum deposit.



COMPARISON ARS/DS (4)

MATRA "ENGINEERING JUGEMENT" :

- if the ARS beam combiner is figured by conventional polishing <u>we feel</u> that the ARS will give a better wavefront than the DS, due to the number of optical elements.

- if the ARS beam combiner is figured by the vacuum deposit technique, we <u>are sure</u> that the ARS is more easy to manufacture.

<u>Pb. To be checked</u> : scattering properties of the mirror, with vac. deposit techn. ??

CONCLUSION ON MANUFACTURING :

ARS > DS > RC