THIRTEENTH MEETING OF THE HIPPARCOS SCIENCE TEAM

ESTEC, 20-21 March 1986

Attendance:	HST:	Dr. A.M. Cruise Dr. M. Crézé Prof. M. Grewing Dr. E. Hoeg Prof. J. Kovalevsky Dr. L. Lindegren Mr. C.A. Murray Dr. C. Turon
		(Drs. Donati and Grenon were unable to attend)
ESTEC:		M.A.C. Perryman, M. Schuyer, R.D. Wills, S. Vaghi
		L. Emiliani, K. v. Katwijk, G. Ratier, H. O. Pace, M. Setzke, H. Hassan, K. Clausen (part-time)
ESOC:		J. van der Ha, J. Sternberg
Matra:		E. Zeis (part-time)

AGENDA: The agenda given in Annex I was adopted.

1. PROJECT STATUS REPORT

Emiliani reported on the technical and schedule status of the Project (Annex II). Attention was drawn to the forthcoming System Critical Design Review to which HST members were invited to participate, either through document review at their home institute or at ESTEC. (Availability of documentation: 16 May, Review in ESTEC: 20 May - 9 June).

Emiliani announced that he would be leaving his post as Hipparcos Project Manager in April, moving to the Columbus Project in Paris. Later in the meeting it was announced, by M. Delahais, that H. Hassan would take over as acting Project Manager thereafter.

Cruise, on behalf of the HST, expressed thanks to Emiliani for his significant contribution to the project over the past 6 years, and in particular his receptiveness to the scientific goals and requirements as represented by the HST.

2. SPACECRAFT STATUS

Clausen presented an overview of the spacecraft status. Problems areas were confined mainly to AOCS and EPSS. Part of the presentation was devoted to the on-board timing and datation. Offline, further clarification would be made by the Project (Action 1) in the form of a technical note and/or through clarification of the DDID.

3. PAYLOAD STATUS

van Katwijk presented an overview of the payload status (Annex IV). This report covered the present hardware status, recent test results (payload OSTM thermal balance/thermal vacuum, straylight and FPA EM performance tests), future program, and areas still under analysis (contamination: particles and molecular). Kovalevsky stressed the importance of obtaining detailed information on the IFOV profile measurements - results from the FPA EM performance test would be distributed (Action 2).

Ratier presented an overview of the grid calibration methodology developed in TPD (Annex V). Hoeg requested that a uniform notation is used for the grid. Schuyer/Ratier pointed out that the co-ordinate system definitions are given in the Overall System Specification/Payload System Specification/Refocussing Assembly specifications, but that in any case calibration data will be put in a form understandable to the DRC.

4. SYSTEM ASPECTS

a) Grid Ratio Constraints: Wills distributed figures (Annex VI) showing M_1, M_2 and the Cramer-Rao bound as a function of slit width. In view of the currently poor controllability of the grid writing process with respect to this parameter, HST were asked to comment on the criticality of the present specifications on slit width (3.2 ± 0.05 µm). Lindegren noted that increasing the slit width has a large effect on the double star observability/detectability, but that this effect has not been quantified. If possible Lund would undertake further simulations to assess the effect further (Action 3). ESTEC would review the impact on the accuracy due to the enhanced M_3 at smaller slit widths (Action 4). Meanwhile MATRA/TPD/CSEM would continue to aim for the specifications. Zeis stressed the potential programmatic impact if the writing can not achieve the present specifications, unless the specification value can be relaxed.

In response to a question by Lindegren, Zeis noted that the value of 3.2µm is a diffraction measurement slit width, the EPBG process having been correspondingly biased to yield such an expected value.

b) Star density constraints on INCA: Schuyer noted that current OBC/ESOC considerations lead to a continuous star density limit of 2.3 x mean density per FOV (based on 100000 programme stars) in order to arrive at a minimum length of the PSF duration of 5 min. An 'enhanced' Input Catalogue should not exceed this limit. Turon/Crézé considered that their own internal constraints were, in any case, more stringent.

c) IDT/SM ITF Calibration: Wills noted that the SRD requirements on the IDT ITF is 1%, which is not met for the brightest stars assuming a general ITF model (Annex VII). HST provisionally agreed that the results of the CAPTEC work would be used by Wills to reformulate the specifications accordingly: for the IDT σ_{itf}/Γ_{oo} would be relaxed to 5% in the range B=3 to 1 mag, B-V = 0.5. For the SM, requirements would be placed on the ITF calibration only for stars fainter than B=5 mag, i.e. in the range over which the Tycho specifications extend (See also Action 5).

d) SM Distortion Review: the Project Team's present understanding, which will form the basis of a revision in the appropriate OSS/PLSS specifications, was presented by van Katwijk (Annex VIII).

e) IFOV Profile Calibration: Wills presented some results of the FPA measurements pertaining to 1 star colour, at different radial distances. Next measurements would come at payload level/PFM FPA testing. Colour effects appeared to be of less importance than the dependence within the FOV, due to the fact that the focus coil currents are optimised for one FOV position and that the focus coil current is therefore not optimum at other FOV positions. Wills noted that the present specifications did not permit the calibration of the long-range part of the IFOV profile because of the unavailability of bright star colours. Kovalevsky/Turon pointed out that all bright stars (say 4000 with $H < 6$ mag) will have a precision in (B-V) better than 0.1 mag. Kovalevsky stressed that more positions (and not just a radial profile) and measurements further out in the profile are definitely needed.

Wills noted that 8 radial directions are available in the raw measurement data, and this raw data was requested by Kovalevsky. Wills noted that 8 radial directions would also be measured in orbit, but presently limited to 90 arcsec due to the adopted calibration mode. ESTEC would review the possibility of calibrating the longer range IFOV profile in orbit using a stationary IFOV and moving stars (Action 6). Kovalevsky noted his willingness to give inputs to this discussion, if requested.

f) Payload Test Data Availability: Perryman would request MATRA to make available the raw data resulting from the P/L PFM tests of the IDT modulation/SSR/background. Zeis stressed that the tests would not be fully representative in terms of modulation factors, the tape formats may not be easy to interpret, and that only 3 grid periods would be scanned at payload level, although these measurements could be repeated several times.

g) Fast Commissioning Support: outside of the main meeting, Kovalevsky and Emiliani discussed the status of the calibration task within FAST. Manpower problems within FAST meant that Kovalevsky could not presently commit to carry out tasks identified at SRU, Utrecht. Emiliani would investigate allocation of an ESA external fellowship in exchange for such a commitment.

5. INPUT CATALOGUE ASPECTS

a) Double stars in INCA: After a presentation by Turon and some discussions, Kovalevsky agreed with the the revised Lund criterion for inclusion of double star entries in the Input Catalogue.

Two entries would be retained for stars with $10<\rho<30$ arcsec, $\Delta M < 2.5$ mag. One entry only for $\rho<10$ arcsec. Lindegren noted that, while further simulations were evidently desirable, Lund could not presently undertake to carry these out. To assess whether the SOS worked satisfactorily with this entry concept, Crézé would eventually carry out appropriate simulations.

Murray asked that the choice of cluster stars accounts for the need of a cluster reference frame (e.g. the selected stars should not be distributed linearly). Turon announced that the choice is ongoing, including such a consideration.

b) INCA Contents and Formats: Turon distributed a draft proposal (Annex IX). Lindegren requested a cross-reference to other INCA running numbers related to any given running numbers for each CCDM component. Murray will write to M. Chapront (BdL, Paris) requesting information on major planet ephemerides in same format as for minor planets. Turon will provide a revised proposal, to be reviewed by HST (Action 7).

van der Ha noted that Alain Schütz (ESOC) will start working on the Input Calogue after June. A meeting towards the end of 1986 might be foreseen between INCA/ESOC to discuss detailed implementation of the Catalogue - it was understood (as outlined in the MIP) that ESOC's work would entail inclusion of information on proper motions, minor and major planets ephemerides, variable stars, and conversion of INCA data to PSF parameters. Turon noted that minor planets updates would go to ESOC every 6 months approximately.

c) PSF Preparation: Crézé presented the current status of the catalogue simulations (Annex X). Items discussed included:

- a 90% survey completeness can be achieved, reasonably uniformally over magnitude. Perryman requested that detailed results are made available, and that the survey definition is rediscussed (e.g. completeness versus target accuracy). Crézé would distribute results to HST/ESA about the end of May (Action 8).
- more stars can be forced in the survey, but at the expense of losing flexibility in the modulation procedure;
- a detailed description of the algorithms would be made within the next 3 months, and these would be discussed with ESOC with the aim of achieving agreement on their implementation (Action 9).
- Murray expressed reservations on selecting 'proper motion only' stars for particular types of observation. He would try to formulate his concerns more explicitly. Kovalevsky would discuss the concept with Walter. Crézé noted that he did not feel particularly happy with the concept. At this stage he was simply showing that such manipulation could be achieved.

6. DATA REDUCTION ASPECTS

a) Hoeg presented present plans for TDAC simulation work (Annex XI).

b) Murray reported on the simulated data analysis meeting held in ESTEC on 19 March. Some minor errors in the RGO analysis had been identified (true phase determination, OTF calibration).

Insufficient time had been available to review the CSS results. Lindegren revised the format for IDT data comparison tapes - this was distributed to ESTEC, RGO, CSS and a re-submission of the analysis results on Run 9 was requested by Perryman. The next discussion of the simulated data analysis would be held at the NDAC meeting at RGO (20-21 May).

Cruise distributed a technical note summarising his findings related to the analysis of the FAST SM simulated data.

c) Global Observing Programme: Kovalevsky presented results of continuing work on the GOP carried out by van Daalen et al. at Delft (Annex XIII). Two main conclusions can be drawn:

- with smoothing, errors are degraded more with respect to a geometrical reduction (which itself shows marginal degradation with respect to the nominal GOP) for 1 GC. For one RGC the degradation is not so strong, and a catalogue of 120000 stars should be acceptable in terms of the final achievable accuracy.
- from variable star density experiments, Delft have concluded that local star density enchancements have little effect on the global accuracy at the GCR level, only on the local accuracy.

In view of these results, INCA can proceed in the construction of the catalogue based on a maximum number of 120000 stars, as long as the minimum PSF duration constraint is respected. The finally defined star distribution can then be passed to Delft who could recommend on the global observing time as a function of magnitude for the extreme geometric/smoothing reduction options.

7. ESOC ACTIVITIES (ANNEX XIII)

van der Ha gave an overview of the current ESOC activities, and a short overview of the calibration plans.

van der Ha presented an overview of the proposed Performance Monitoring, and distributed the ESOC Monitoring Software Requirement. HST, and in particular M. Crézé and R. Le Poole, were invited to review this document and provide comments if appropriate (Action 10).

Sternberg presented a status report on the DDID, and a few specific items were clarified. Kite (ESOC) would start working on details of the tape production in the near future. An informal meeting between Sternberg/Kovalevsky would take place to discuss further details at ESOC on 28 April. A future revision of the DDID would include clarification of the timing issues, incorporation of appropriate information from the SICD, and futher details of the housekeeping records.

8. MISCELLANEOUS

a) Agreement: A sixth draft was distributed. It would be discussed between FAST/INCA at the INCA meeting in Paris on 16 April to which Professors Bernacca and Fricke, the respective Steering Committee Chairmen, would also participate.

b) French Translation of Ad Astra: Kovalevsky and Turon had been invited to review the appropriate sections of the translation on the DRC and INCA activities.

Perryman reported on the difficulties experienced on the English version with Dr. Dommanget (Bruxelles). Criticisms had been brought to the SPC on the absence of details of the Belgian participation and the work of the Observatoire Royal de Belgique. Letters of complaint had also been written by Obs. Royal (Professor Melchior) to the ESA Director of Science (Professor Bonnet). HST were not in favour of introducing any institute names in the French version of the brochure.

c) ST Proposal: Perryman noted that the proposal for ST time to continue the Hipparcos/Extragalactic reference link was in the process of finalisation. The deadline for the proposals was now 15 September 1986.

9. NEXT MEETING

The next meeting of the HST will be held in ESTEC on 23-24 September 1986, provisionally preceeded by a half day meeting on simulated data comparison.

M.A.C. Perryman

esa estec

HIPPARCOS

MEETING HIPPARCOS 13th HST

PLACE ESTEC

REF.

DATE 20-21/3/86

PAGE

ACTION No	DESCRIPTION (not more than 4 lines)	CLOSING DATE	ACTIONNEE Person/firm	INITIATOR Person/firm
1	Production of timing tech. note and/or clarification of DD10	Next HST	Project (Schuyer / ESOC)	MAP
2	Distribute results of FPA EM Performance Test measurements of IFOV profile to FAST, NDAC as a function of the 5 positions in FOV	Next HST	K. v. Katwijk	MAP
✓ 3	Lund to perform simulations for double stars at slit widths 2.9 µm and, if possible, 3.05, 3.35 µm.	May 15	L. Lindegren	MAP
✓ 4	ESTEC to review Acc. Report for effects of M3 on phase error, to assess slit width acceptability	May 15	M. Schuyer	MAP
✓ 5	Review proposed new spec^n on SM/IDT ITF given in main minutes, communicate unacceptability to ESTEC; propose alternative calibration method if unacceptable	May 15	HST	MAP
6	Review possibility of long-range IFOV profile calibration	Next HST	M. Schuyer	MAP
10 (9)	HST to review ESOC Monitoring S/W Requirements Document	April 30	HST / Le Poole / Creze	MAP
8	Distribute further results of simulation work to HST/ESA	May 31	M. Crézé	MAP
7 (9)	ESTEC/HST/ESOC to review draft INCA contents/formats	Next HST	ESTEC/HST/ESOC	MACP
9	Creze to propose PSF preparation algorithms for consideration by ESTEC/ESOC	July 31	M. Crézé	MACP

Signatures

ANNEX I

Thirteenth Meeting

of the

HIPPARCOS SCIENCE TEAM

20-21 March 1986

Agenda

Place: Room 32004 Start: 09.30

1. Project Status Report (L. Emiliani, 10 mins)

2. Payload Status Report:
   - mirrors/detector/grid status (K. van Katwijk, 30 min)
   - thermal vacuum tests report (K. van Katwijk, 20 min)
   - grid calibration methodology (L. Fontijn, tbc, 30 min)

3. Spacecraft Status Report (K. Clausen, 30 min)

4. Input Catalogue (120 min):
   - double star status and DRC requirements (C. Turon)
   - INCA contents and formats (C. Turon)
   - PSF preparation/algorithms (M. Creze)

5. Miscellaneous (60 min):
   - Agreement
   - Ad Astra, French translation + publicity plans
   - ST proposal status (delay to 15 September)

6. ESOC Activities (120 min):
   - general status report (J. van der Ha)
   - DDID status, including raw data archive (J. Sternberg)
   - plans for payload monitoring (J. van der Ha)
   - calibration (J. van der Ha)

Friday

7. System Aspects (120 min):
   - star density constraints on INCA (M.Schuyer)
   - SM/IDT ITF calibration (R. Wills)
   - SM distortion review (K. van Katwijk)
   - IFOV profile calibration (R. Wills)
   - grid ratio constraints (E. Zeis, tbc)
   - timing tech. note status (M. Schuyer/J. van der Ha)
   - payload test data availability (E. Zeis, tbc)
   - FAST commissioning support status (S. Vaghi)

8. Data Reduction Aspects (90 min):
   - Simulated data analysis debrief (C. Murray)
   - NDAC processing of FAST SM data (M. Cruise)
   - TDAC planning (E. Hoeg)

9. AOB/Next Meeting

ANNEX II

H I P P A R C O S   S U M M A R Y   S T A T U S

(20.03.1986)

P R E S E N T A T I O N

TO THE

HIPPARCOS SCIENCE TEAM

LE.

ANNEX II

Date

Date ....

SATELLITE STATUS

QUALIFICATION

MAJOR ACHIEVEMENT :

- S/L STRUCTURAL MODEL SUCCESSFULLY QUALIFIED IN STATIC/ACOUSTIC/VIBRATIONS — INTESPACE FEB. 1986

NEXT STEP :

- THERMAL QUALIFICATION BY FOKKER — IABG JUNE 1986

BUDGETS

- MASS — STILL CRITICAL (NEED FOR CERENKOV SHIELDING) - SEEMS UNDER CONTROL.
- POWER — EXTREMELY CRITICAL (NEGATIVE MARGIN SAA 0° ECLIPSE !)
  NOT YET UNDER CONTROL BECAUSE :

  a) Difficult to get freezing of heater power
  b) Difficult to get EOL figures derived from EM measurements and WCA
  c) Difficult to get reliable measurements on certain EM units

MISSION PERFORMANCES

CONFIDENCE THAT THE 2 mas SPEC WILL BE ACHIEVED HAS BEEN GAINED FROM OSTM-EM TEST RESULTS :

MAJOR ACHIEVEMENTS

- P/L MECHANICAL/THERMAL STABILITY SUCCESSFULLY VERIFIED DURING TB/TV TESTS	IAL LIEGE NOV 85
- P/L STRAYLIGHT TESTS SUCCESSFULLY COMPLETED	MATRA DEC 85
- FPA FUNCTIONAL TESTS SUCCESSFULLY PERFORMED (FPA ready to undergo mechanical tests)	MATRA FEB 86

NEXT STEPS

- VERIFICATION OF EM OPTICAL PERFORMANCES OF TELESCOPE (WFE)	Planned April/ May 1986
- End-to-end P/L tests on EM	July to October 86

OTHER ACHIEVEMENT : On orbit calibration fully settled through delivery to ESA of operational software requirements (CAPTEC)

Date ....

Date

SYSTEM DESIGN

THREE MODIFICATIONS :

- HIPPARCOS WILL NOW BE LAUNCHED BY ARIANE IV (JUNE 1988)

  DUA has been agreed between MATRA and ESA and submitted to ARIANESPACE

  One open point : date of updated coupled analysis

- IMPLEMENTATION OF SHIELDING AGAINST PARTICLES (CERENKOV EFFECT) IS ON-GOING

- POTENTIAL OPERATIONAL CHANGE : N2H4 SUN ACQUISITION SEQUENCE
  - 10 RPM deployment implemented
  - Feasibility study completed by MATRA CMT
  - Decision to be taken by ESA mid-March

Date ....

SYSTEM TECHNICAL CONCERNS

. **CONTAMINATION**

Molecular contamination
Particulate contamination

. **ESD**

Grounding of all conductive items not yet guaranteed : detailed review is on-going at MATRA and the point will be discussed with each concerned subcontractor.

. **RADIATION EFFECTS**

On optical transmitting elements (grid, relay optics) are still under detailed assessment.

Date..........

SCHEDULE

. Successfull achievements (with respect to delayed dates agreed in September 1985) :

- P/L OSTM and EM
- On Board software V1
- S/C structure
- S/C Harness
- Data handling S/S
- EGSE and integration preparation at AERITALIA

. Some delays encountered for Telecommunications S/S
Thermal Control S/S

. Most critical areas (EM)

- EPSS } All possible work-around solutions at system level have now been exhausted and
- AOCS } any additional delay wrt dates set in January 1986 directly impact the satellite.

. PFM schedule extremely critical :

. Detection S/S is the most critical
. S/C S/S PFM deliveries not completely secured.

Date ....

HIPPARCOS SYSTEM CDR

- KEY DATES

    AVAILABILITY OF DOCUMENTATION FROM MATRA ...... MAY 16, 1986
    CDR KICK-OFF ...... MAY 22, 1986
    REVIEW IN ESTEC ...... MAY 20 - JUNE 9, 1986
    REVIEW IN MATRA ...... JUNE 16-20, 1986

- REVIEW PANELS (ESTEC REVIEW)

    SYSTEM
    MISSION PERFORMANCE
    AIV
    P.A. & CONF. MGMT.
    SOFTWARE
    THERMO-MECHANICAL
    AVIONICS
    ELECTRICAL
    AOCS
    OPTICS & DETECTION

NOTE : PANELS FOR REVIEW IN MATRA SLIGHTLY DIFFERENT

- SELECTED HST MEMBERS ARE INVITED TO PARTICIPATE IN MISSION PERFORMANCE PANEL

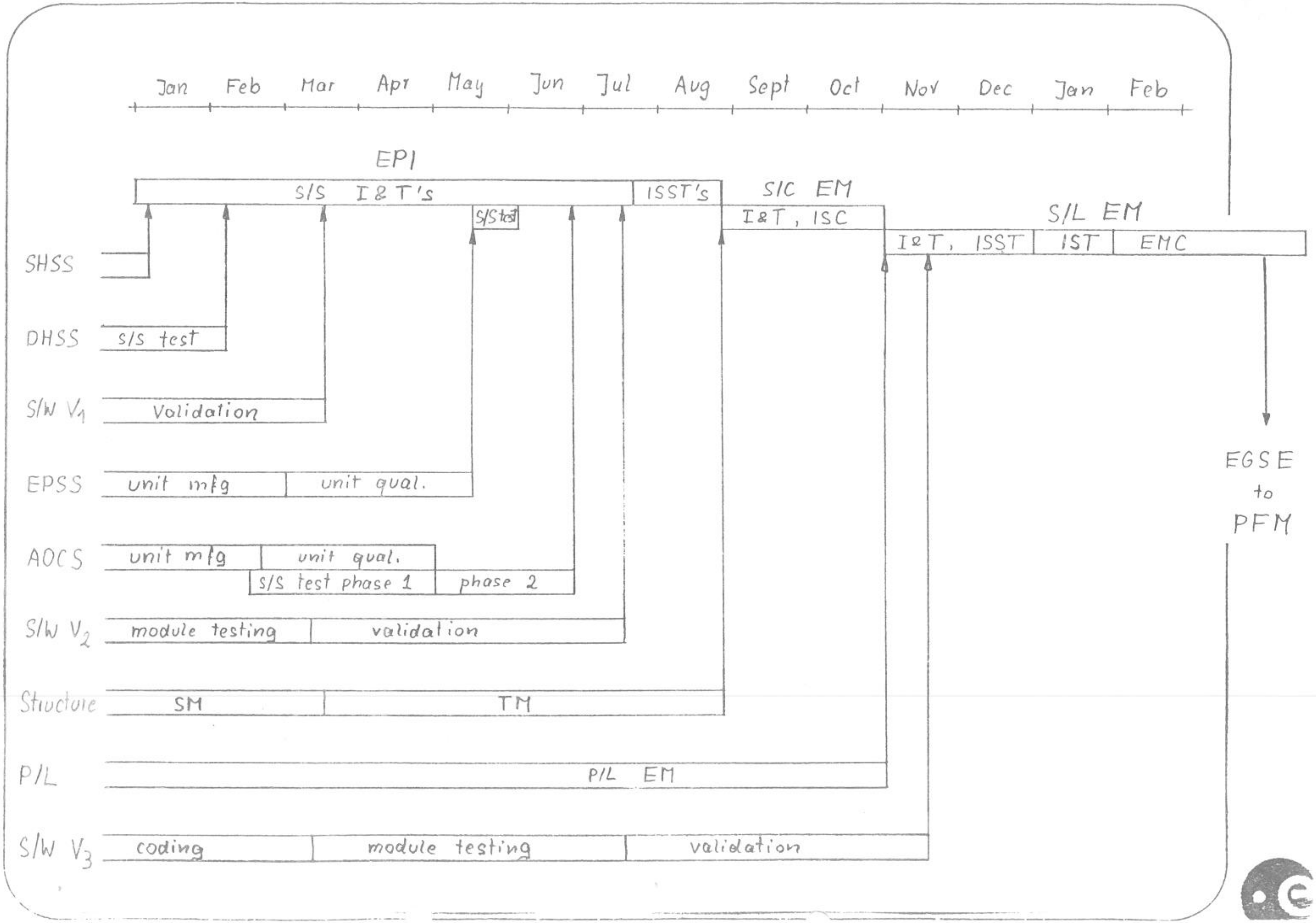
Date K.C. 19.3.86

S/C STATUS

K. CLAUSEN

HST MEETING - MARCH 86

ANNEX III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Feb
Mar
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Jan
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EPI
S/S I&T's
ISST's
S/S test
S/C EM
I&T, ISC
S/L EM
I&T, ISST
IST
EMC
EGSE to PFM
SHSS
DHSS
s/s test
S/W V1
Validation
EPSS
unit mfg
unit qual.
AOCS
unit mfg
unit qual.
S/S test phase 1
phase 2
S/W V2
module testing
validation
Structure
SM
TM
P/L
P/L EM
S/W V3
coding
module testing
validation

Date K.C. 19.3.86

S/C SYSTEM ISSUES:

INITIAL SUN ACQUISITION

CHANGE FROM SLEW WITH COLD GAS RCA AT 1 R.P.M.
TO SLEW WITH HYDRAZINE RCA AT 10 R.P.M.

RTAD INITIALIZATION

TRADE OFF BETWEEN PERFORMANCE OF SUN POINTING ON BOARD
AND COMPLEXITY OF ISPR ALGORITHM ON GROUND

RTAD GROUND SUPPORT FOR OCCULTATION AND ECLIPSE

ASSESSMENT OF GYP - SM THERMAL DISTORTION RATE AND IMPACT ON RTAD
REQUIRED ATTITUDE AND RATE UPDATE FROM GROUND

Date K.C. 19.3.86

TIMING AND DATATION

SCIENTIFIC DATA:

- DATATED WITHIN A TIM FORMAT BY FOLLOWING SYNCHRONIZATION SCHEME (H/W IN FGE)

BCP 1	15/160 Hz	TM FORMAT START
BCP 4	150 Hz	IDT PILOTING
IDT SAMPLE	1200 Hz	IDT, SM SAMPLING

DELTA BETWEEN BCP 1 AND BEGIN OF TIM TRANSMISSION IS IN "DATATION CHANNEL"

- ACCURACY ALLOCATION

S/L:	IDT SAMPLE TO TM FRAME SYNC	± 4 μs ABSOLUTE
		± 3.5 μs STABILITY OVER 1 FRAME
G/S:	TM FRAME SYNC TO UTC	± 1 MS ABSOLUTE
		± 1.5 μs STABILITY OVER 5 MINUTES

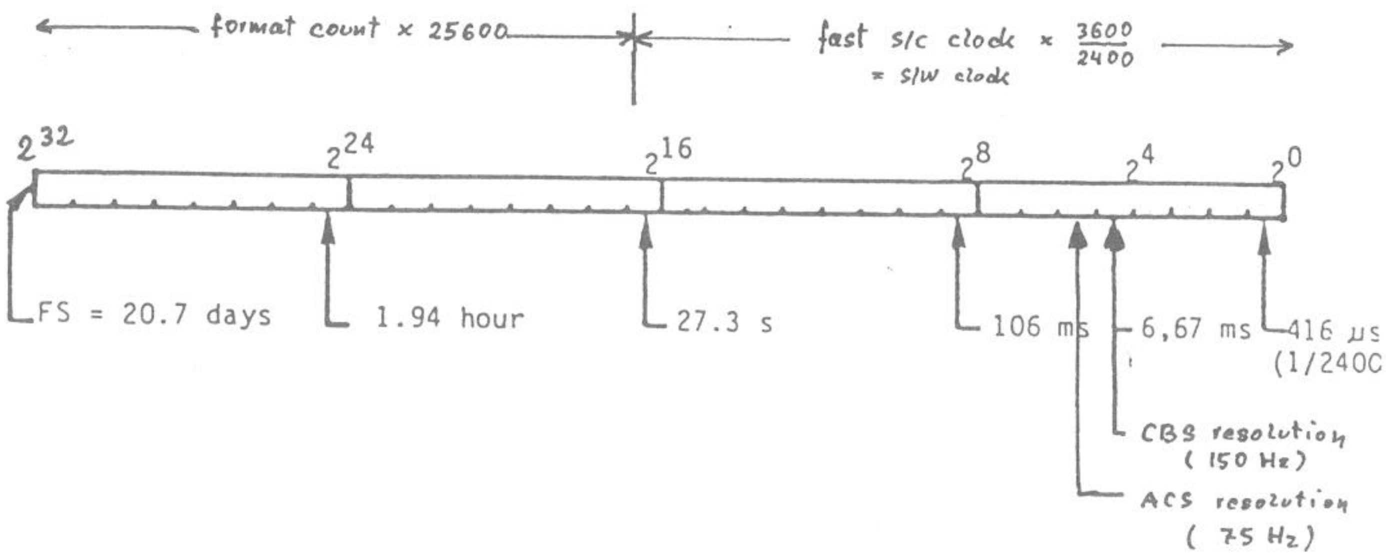
Date K.C. 19.3.86

TIMING AND DATATION

ON BOARD CLOCKS:

- OBC	H/W:	3600 Hz	RESET WITH BCP1	(FAST S/C CLOCK)
	S/W:	2400 Hz	RESET WITH BCP1	(FICTICIOUS)
- CLE	H/W:	9360 Hz	RESET WITH BCP4	(ESS DATATION)
	S/W:	75 Hz	RESET WITH BCP1	(INTERRUPT)

ON BOARD TIME



ANNEX IV

(1) Date 19/3/86

HIPPARCOS SCIENCE TEAM
MEETING 20-21 MARCH 1986

PAYLOAD STATUS REPORT

PREPARED BY
K. VAN KATWYK

(2) Date 19/3/86

CONTENTS

- PRESENT HARDWARE STATUS
- RECENT TEST RESULTS
- NEAR FUTURE PROGRAM
- AREAS STILL UNDER ANALYSIS
- ANNEXES A, B, C

PRESENT HARDWARE STATUS

- MIRRORS

  TECHNOLOGY : PADS REDESIGN INDUCING POLISHING DIFFICULTIES (TRIANGULAR ASTIGMATISM → DIFFERENTIAL DEFOCUS)

	MODEL	WFE	CHROMA	
BEAMCOMBINER*	EM	$\approx \lambda/20$	≈0,8 mas	CUTTING TO BE DONE
	PFM	$\approx \lambda/50$	≈0,6 mas	
	SPARE	$\approx \lambda/60$	≈1,0 mas	
FLATFOLDING MIRROR	EM	$\approx \lambda/96$	≈<1 mas	OLD PADS DESIGN
	PFM	$\approx \lambda/40$	≈ ? mas	NOT READY
SPHERICAL MIRROR	EM	$\approx \lambda/91$	≈<1 mas	OLD PADS DESIGN
	PFM	$\approx \lambda/50$	≈ ? mas	NOT READY

*PERFO REQU'TS SIMULTANEOUSLY FOR BOTH FOV'S

(4) Date 19/3/86

PRESENT HARDWARE STATUS

- **GRID + DEFLECTORS**

TECHNOLOGY : VARIATION OF SLITWIDTH (GRIDRATIO) SEE DEDICATED PRESENTATION

- "CERENKOV MASKS" ON DEFLECTORS DEFINED

BEST AVAILABLE GRIDS (BOTH OUT OF SPEC):

F9 · SCANFIELD ORIENTATION SLIGHTLY OUT OF SPEC
· SLITWIDTH $3{,}52 \pm 0{,}03\ \mu m$

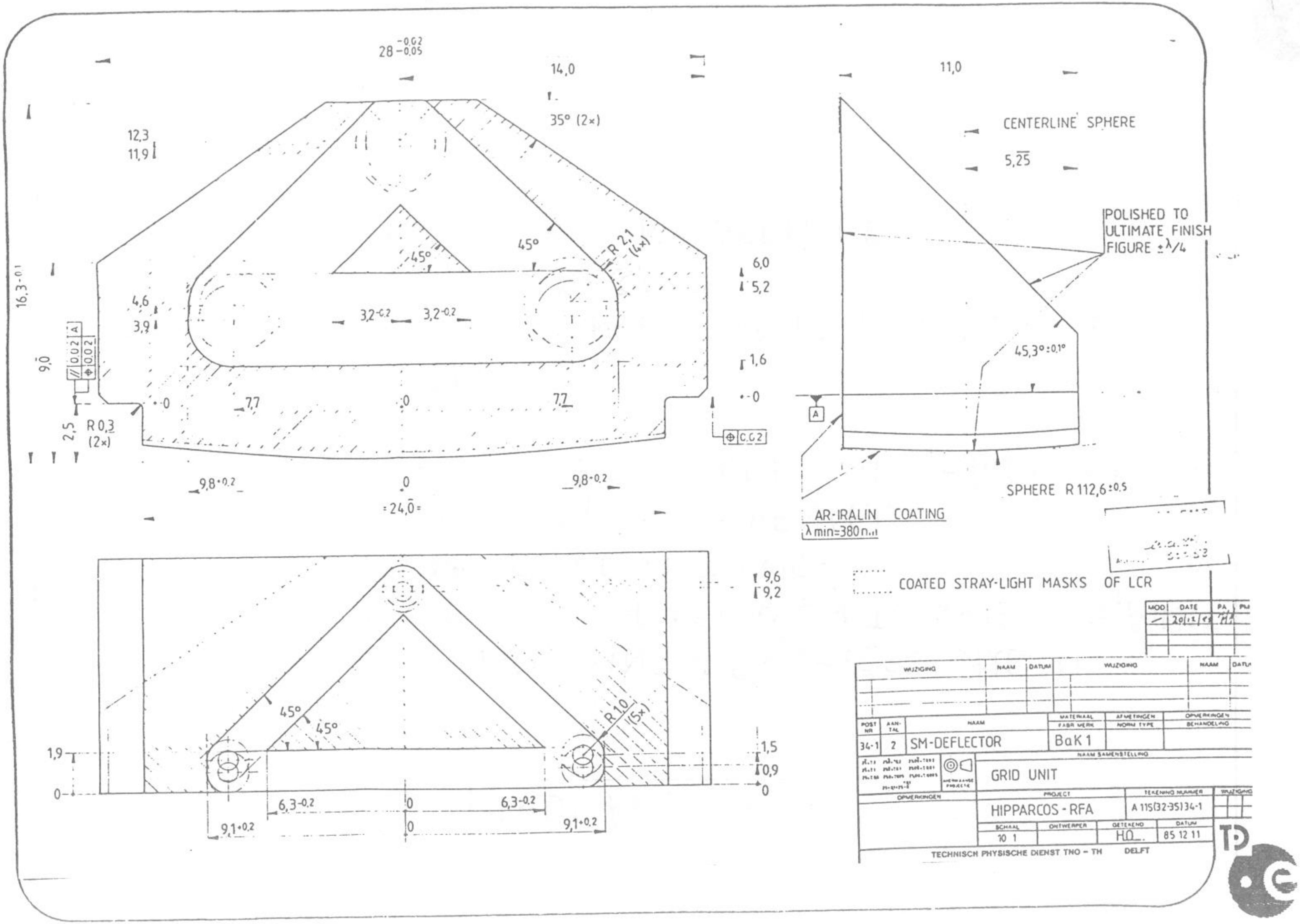
F10 · CHEVRON PATTERN (1,3,2) REVERSED WRT VERTICAL
· SLITWIDTH $3{,}28 \pm 0{,}02\ \mu m$

- **STRUCTURE + THERMAL CONTROL**

SHIELDING AGAINST CERENKOV EFFECT IMPLEMENTED
(BASED ON BACKGROUNDNOISE IBG = 84 + 10% MAINCHAIN
IBG = 2400 + 50% SM-CHAIN

SUBSYSTEMS QUALIFIED, PFM H/W IN PRODUCTION

(5) Date 19/3/86



28 −0,02 −0,05
14,0
11,0
35° (2×)
CENTERLINE SPHERE
5,25
12,3
11,9
POLISHED TO
ULTIMATE FINISH
FIGURE ±λ/4
45°
R 2,1 (4×)
45°
6,0
5,2
16,3-0,1
4,6
3,9
3,2-0,2
3,2-0,2
9,0
// 0,02 A
⊕ 0,02
1,6
45,3°±0,1°
0
7,7
0
7,7
0
A
2,5
R 0,3 (2×)
⊕ C,02
9,8+0,2
0
9,8+0,2
24,0
SPHERE R 112,6±0,5
AR-IRALIN COATING
λ min=380 nm
9,6
9,2
COATED STRAY-LIGHT MASKS OF LCR
45°
45°
R 1,0 (5×)
1,9
1,5
0,9
0
0
6,3-0,2
0
6,3-0,2
9,1+0,2
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20/12/85
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TPD

PRESENT HARDWARE STATUS

- RELAY OPTICS

  TECHNOLOGY : DARKENING OF GLASSES DUE TO IRRADIATION ; DIFFICULTY TO SHIELD AGAINST SOLAR FLARE PROTONS

  CERENKOV SHIELDING IMPLEMENTED

  FILTERS (GG-375) IN BT-CHANNEL IMPLEMENTED

- FOCAL PLANE BAFFLE

  VIGNETTING FOR EXTREME SM POINTS RESOLVED (<1% VS 5% REQU'T)

  MODIFICATION TO BE IMPLEMENTED

(7) Date 19/3/86

PRESENT HARDWARE STATUS

- DETECTION

TECHNOLOGY : HIGH TENSION SUPPLY (TRAFOS) CRITICAL
EM-RESULTS MAIN DETECTOR ASSY : AS EXPECTED
STARMAPPER ASSY : DETECTION EFFICIENCY LOWER THAN EXPECTED ON TUBE, BUT OK
EM EQUIPMENT USED IN FPA-EM TESTING
PFM HARDWARE IN PRODUCTION / UNDER TEST

RECENT TEST RESULTS

- **PAYLOAD OSTM TBTV TEST** (OCT/NOV '85) SEE ANNEX A

- EXTREMELY STABLE SHORT TERM TEMP. CONTROL
- COUPLING BETWEEN EXTERNAL ENVIRONMENT AND PERFO LIKE BASIC ANGLE VARIATION + GRID ROTATION
- HEATER POWER DEMAND OF PAYLOAD TOBE FINALISED
- SPGRID PERFO : RESOLUTION BETTER THAN 5 nm (0,7 mas)
- TEST ASSESSMENT REPORT STILL OUTSTANDING (CONVERSION FROM BC $\gamma = 20'$ TO BC $\gamma = 58°$; INTERPRETATION OF MOISTURE RELEASE EFFECT ON REFOC PRESETTING)

(9) Date 19/3/86

RECENT TEST RESULTS

- STRAYLIGHT TEST (DEC'85) SEE ANNEX B

MEASUREMENT OF ATTENUATION RELATIVE TO POINT SOURCE AT VARIOUS FIELD POSITIONS + EXTRAPOLATION TO EARTH/MOON CONFIGURATIONS

STRONG INFLUENCE OF REFLECTION OF CENTRAL PART OF BEAMCOMBINER (UNPAINTED ZERODUR)

→ IMPROVEMENT WITH BLACK FOIL COVER AT CENTRAL PART (ALSO FOR ESD REASONS)

GOOD CONFIDENCE TO MEET STRAYLIGHT PERFO FOR PFM HARDWARE.

RECENT TEST RESULTS

- FPA EM PERFO TEST (JAN/FEB'86) SEE ANNEX C

PERFO LIMITATIONS DUE TO
- OPTICAL QUALITY OF PROJECTOR
- VIBRATION OF SCANNING SOURCE
- VIBRATION OF TEST ROOM
- LIGHTTIGHTNESS OF TEST SPECIMEN

ACHIEVEMENTS:
- MECHANISM REPRODUCIBILITY
- PILOTING CAPABILITY
- IFOV PROFILE (SLIGHTLY OUT OF SPEC)

- DYNAMIC/INTEGRITY TESTS

SATELLITE STM COUPLED TEST (FEB'86)
PAYLOAD OSTM DELTA QUALIF TEST (MAR'86)

(11) Date 19/3/86

NEAR FUTURE PROGRAM

EM TELESCOPE WFE TEST IN VACUUM (APR/MAY '86)
PAYLOAD PERFO TEST (JULY/SEP '86)

PFM HARDWARE DELIVERY (MAY/JUNE '86)
TELESCOPE WFE TEST IN VACUUM (AUG '86)
FPA PERFO TEST (AUG/SEP '86)

ANNEX V

Date

G R I D   C A L I B R A T I O N   M E T H O D O L O G Y

(DEVELOPED IN T.P.D. BY MR. FONTIJN)

G. RATIER

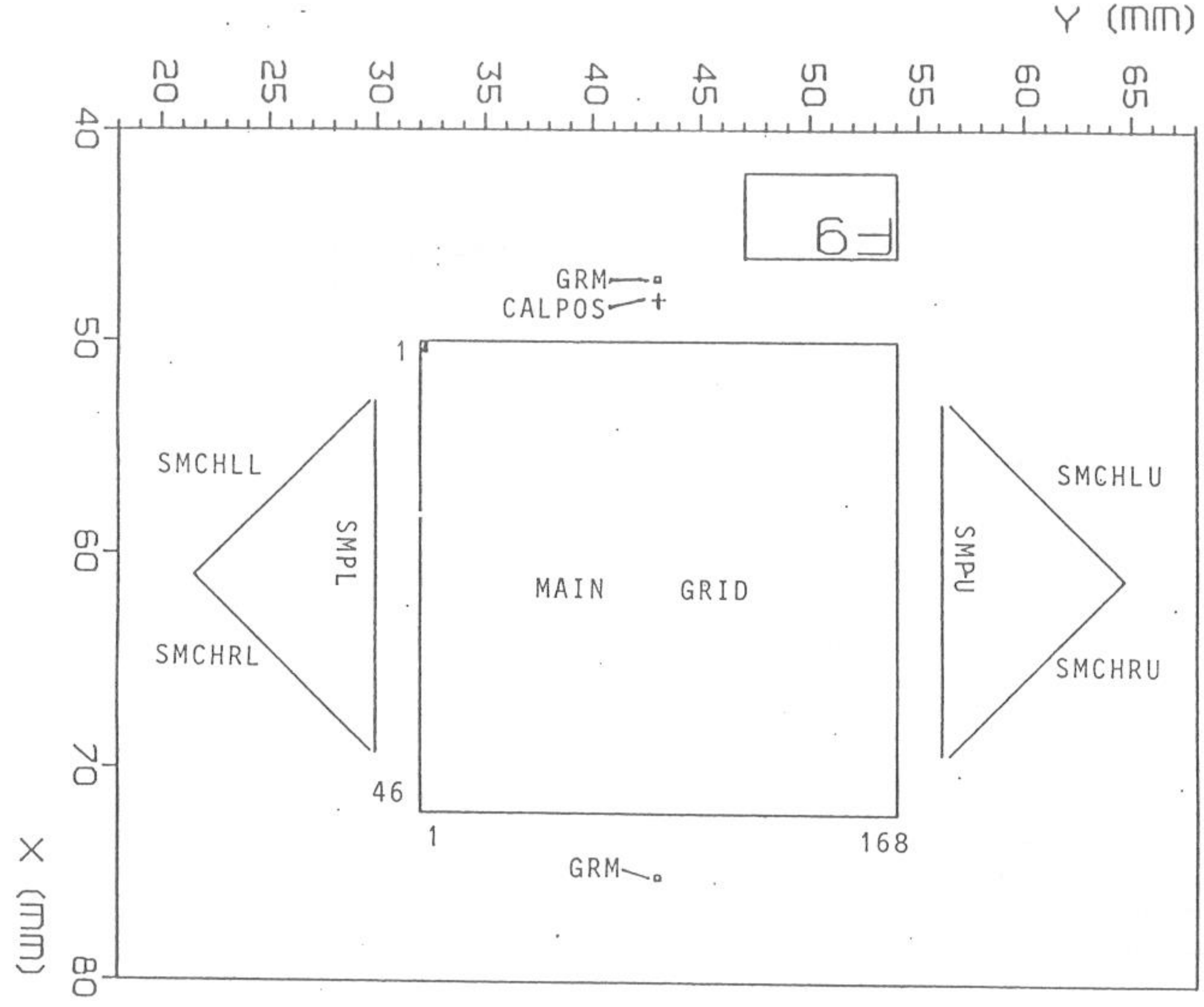
HST 20 MARCH 1986

GRID CALIBRATION SEQUENCES

- MANY SEQUENCES ARE USED FOR CHECKING THE PERFORMANCES/ADJUSTMENT OF THE TPD EBPG MACHINE.
- SOME SEQUENCES ARE USED TO VERIFY THAT THE MANUFACTURING REQUIREMENTS ARE MET (E.G. S.S.I.)
- M.S.I. CALIBRATION IS PERFORMED ON MAIN GRID (MG) AND STAR MAPPER (SM).

Date

Date



ABBREVIATIONS USED IN GRID CALIBRATION

Date..............

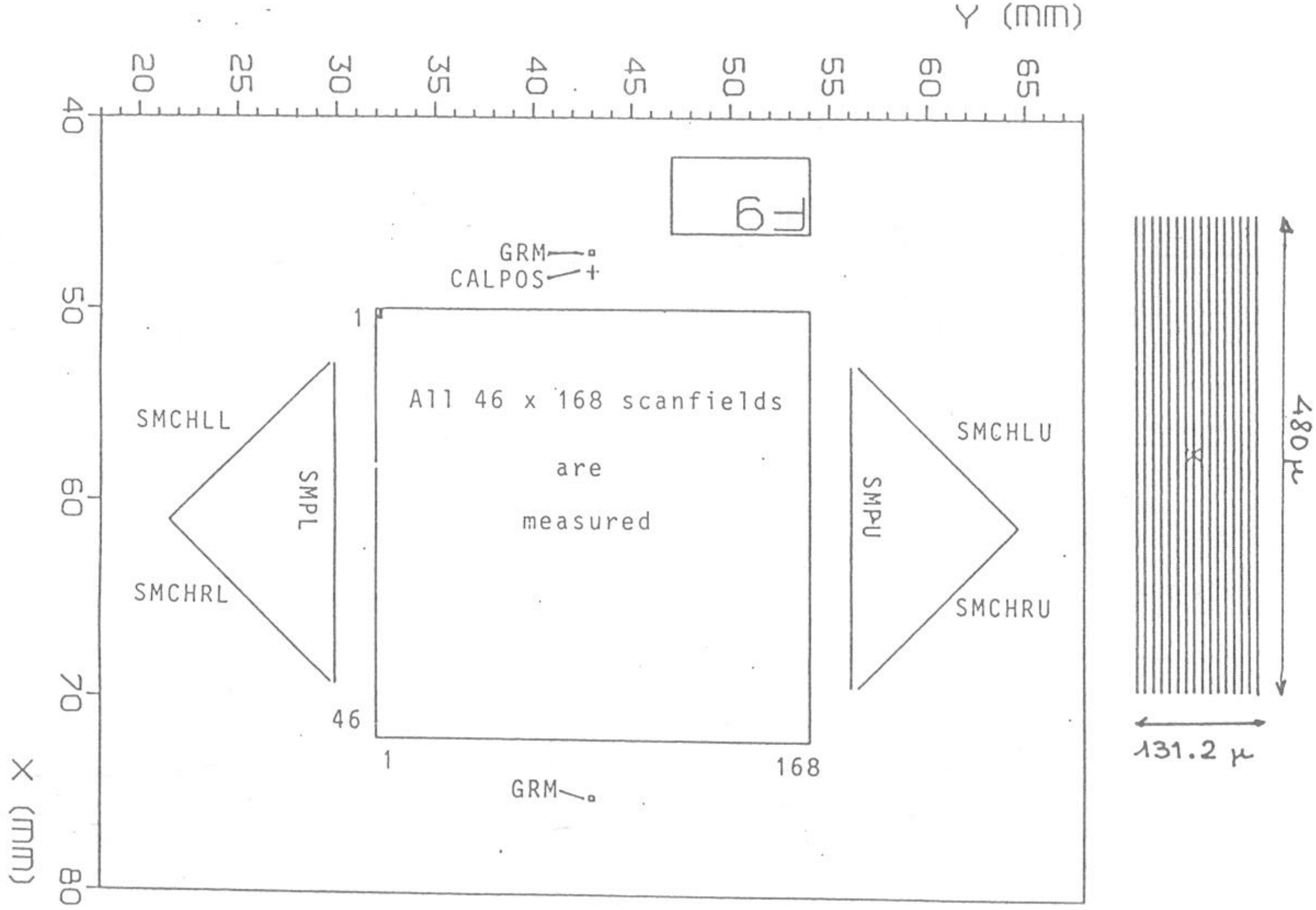
MAIN GRID

SEQUENCE (DURATION)	SUBSEQUENCE (FILE ≠)	≠ OF SCANFIELDS MEASURED	≠ OF SLITS MEASURED PER SCANFIELD	PURPOSE
MG1 (49 mm)	MG1.1 (001)	4	8	Verify the presence of all scanfields & calibration pattern CALPOS. Determine the overall grid gains & rotations.
	MG1.2 (002)	1	1 (10 times)	Test the EBPG measurement accuracy for slit width and position
	MG1.3 (003)	1	8 (10 times)	Test the repeatibility of scanfield measurements
	MG1.4 (004)	1	80 (10 times)	Derive the scanfield distortion and test its repeatibility
	MG1.5 (005)	16	80	Assess the SSI properties and uniformity of the scanfield distortion
	MG1.6 (006)	16 (same as in MG1.5)	8	Test the effect of the number of slit measurements per scanfield
	MG1.7 (007)	16 (same as in MG1.5)	1	Test the MSI determination accuracy with a single measurement at scanfield center
	MG1.8 (008) | MG1.9 (009)	: REPEAT OF MG1.7		
	MG1.10 (010)	4 X 46 (4 rows)	1	Assess the MSI transverse gradient (coarse)

MAIN GRID

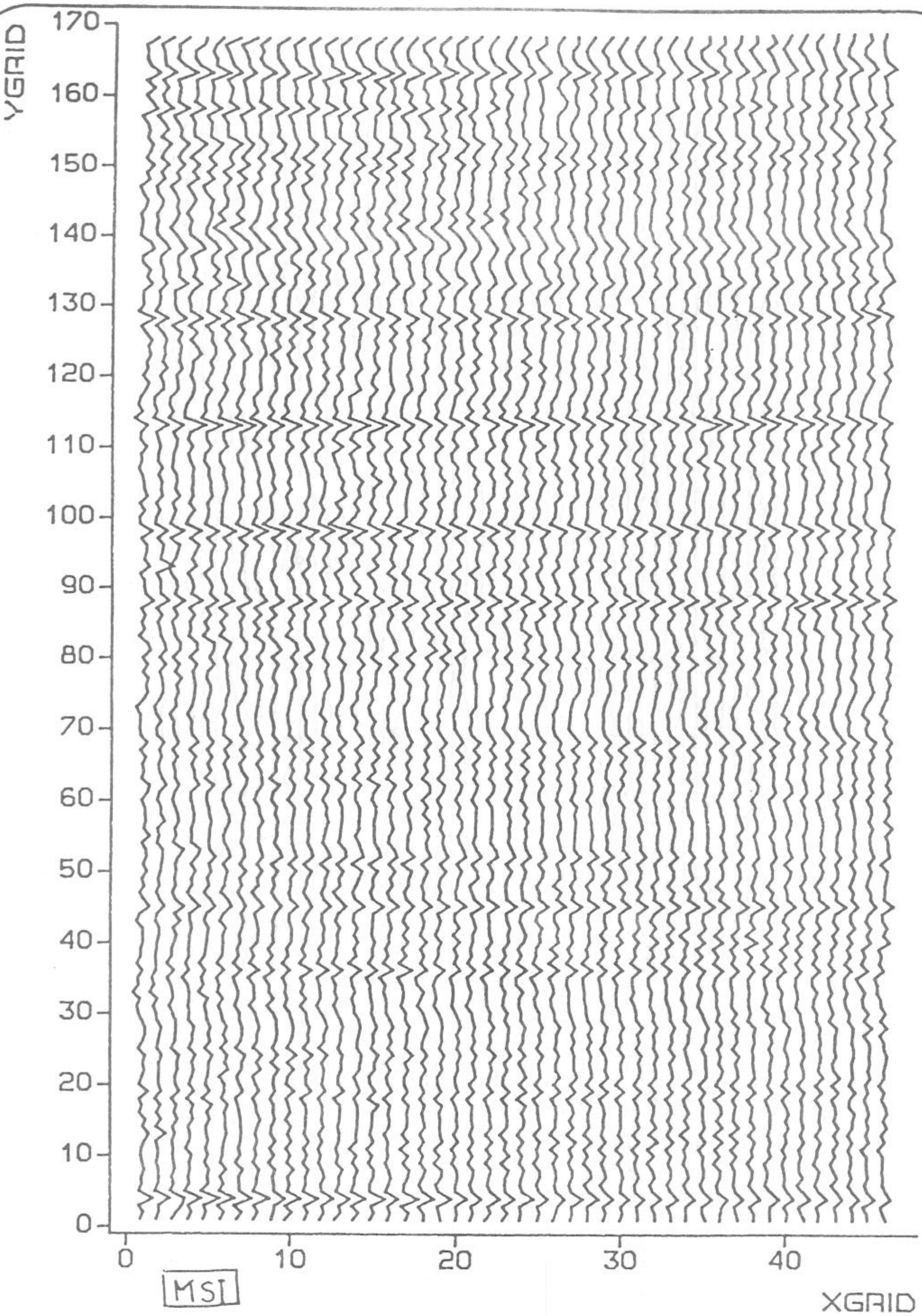
SEQUENCE (DURATION)	SUBSEQUENCE (FILE ≠)	≠ OF SCANFIELDS MEASURED	≠ OF SLITS MEASURED PER SCANFIELD	PURPOSE
MG.CSEM (4 mn)	(011)	46. (1st row)	2	Compare TPD measurements with CSEM optical data on the same slit
MG.DIFFR (6 mn)	(012)	20 (center of MG)	12	Derive a mean slit width for comparison with optical diffraction measurements and derive the corresponding correction factor
MG2 (50 mn)	MG2.1 (013)	4 X 16 (same as MG1.10)	8	Assess the MSI transverse gradiant (fine)
	MG2.2 (014)	4 X 56 (Center part of 4 lines)	8	Determine the scanfield rotation (correlated/uncorrelated parts)
MG3 (2 H 44 mn)	MG3.1 (015)	46 X 168 (all scanfields)	1 (scanfield center)	Derive the MSI matrix

Date..................



MAIN GRID CALIBRATION SEQUENCE

Date



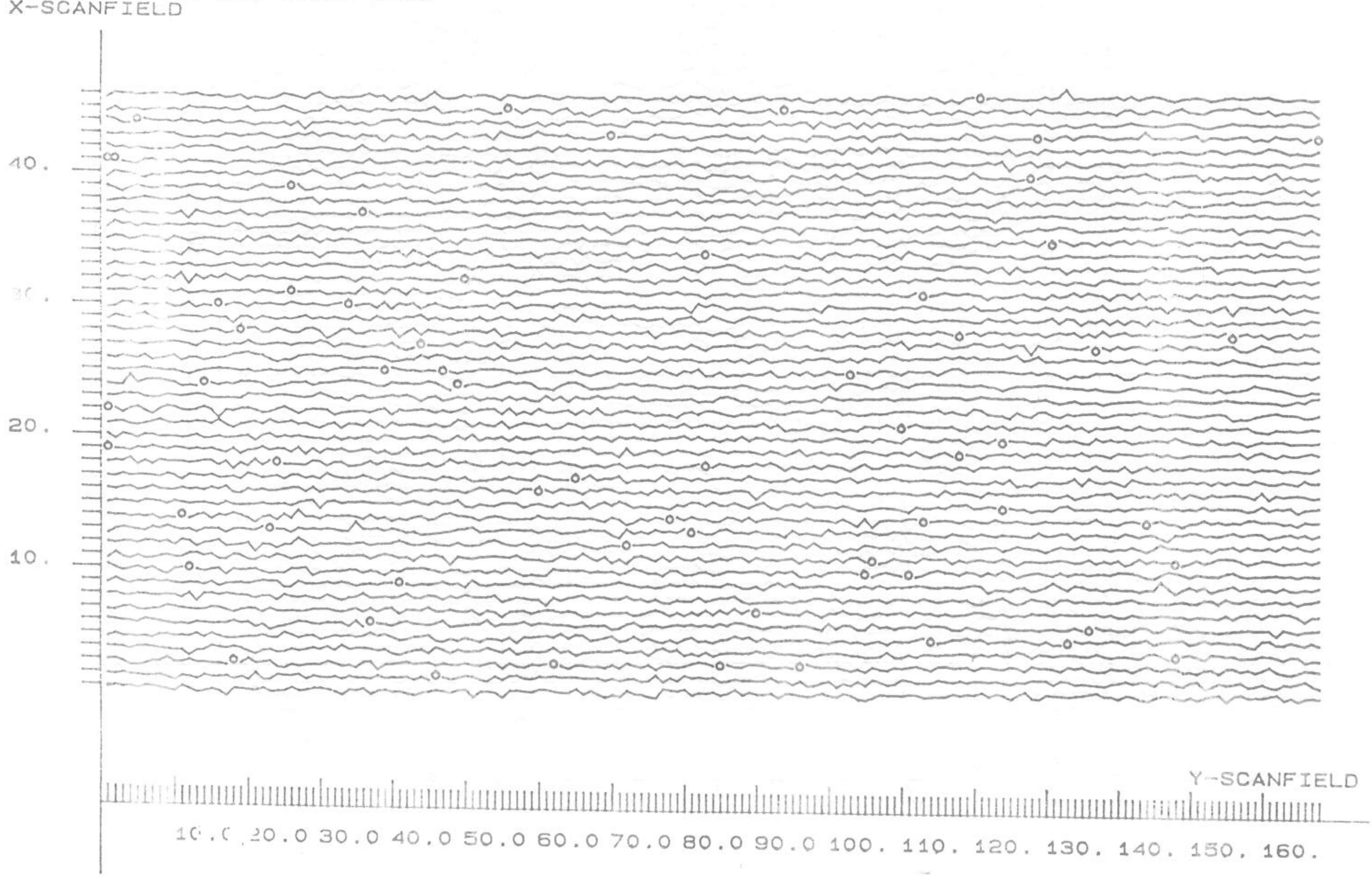
D/P5/218 deviations 100 nm / div

FILE T.TPDP08A015

MEAN SLITWIDTH : 3292.

SCALE | 200.NM

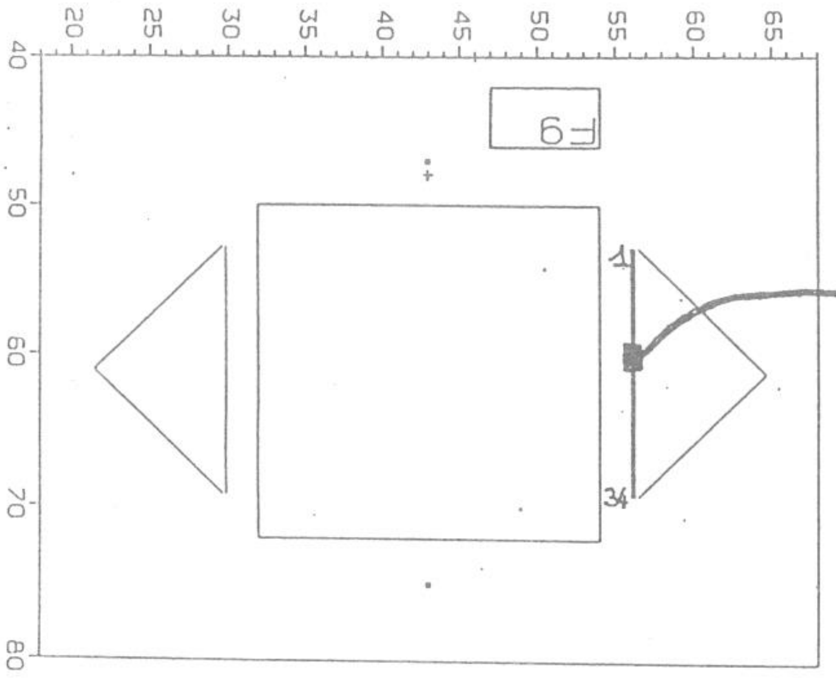
SLITWIDTH ON THE WHOLE GRID

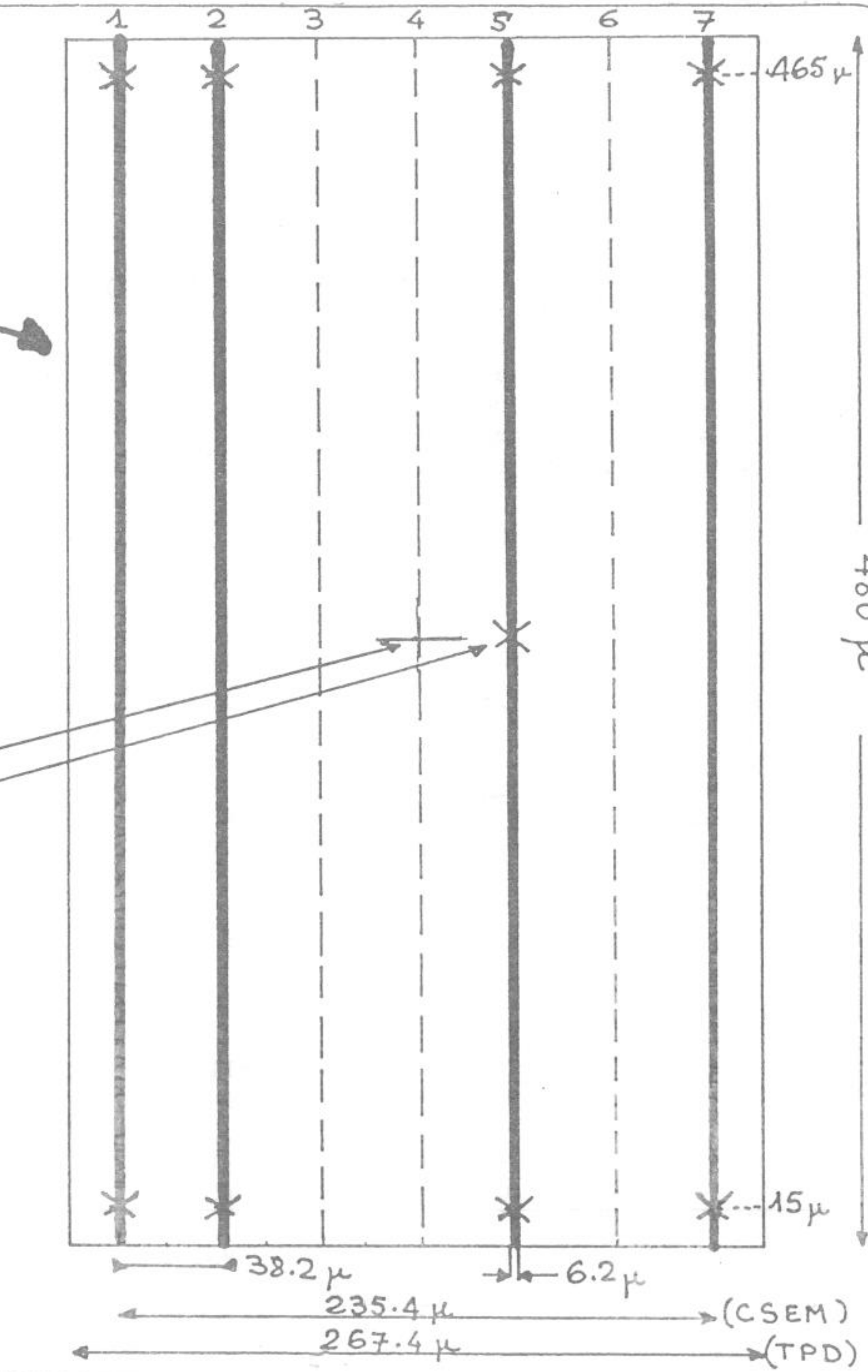


STAR MAPPER GRID

SEQUENCE (DURATION)	SUBSEQUENCE (FILE =)	= OF SCANFIELDS MEASURED	= OF SLITS MEASURED PER SCANFIELD	PURPOSE
SMPU1 (11 mn)	SMPUI.1 (016)	1	20 (5 times)	Determine the scanfield pattern
	SMPUI.2 (017)	1 (same as SMPUI.1)	8 (5 times)	Test the effect of the number of measurements upon scanfield determination
	SMPUI.3 (018)	34 (all scanfields of SMPU)	8	Derive MSI, scanfield gain, rotation and assess SSI
	SMPUI.4 (019)	34	1	Derive MSI for SMPU
SMPL1 (11 mn)	(020 to 023)	Same sequence as above for SMPL		
SMCHLU.1 (14 mn)	SMCHLUI.1 (024)	1	7 X 4	Determine the scanfield pattern
	SMCHLUI.2 (025)	1 (same as in SMCHLUI.1)	2 X 4	Test the effect of the number of measurements upon scanfield determination
	SMCHLUI.3 (026)	1 (same as in SMCHLUI.1)	4 X 4 (moved by 2 m)	Check small scale periodic effect
	SMCHLUI.CO.3 (027 to 029)	same as SMCHLUI.2 for 3 different scanfields		

Date





Scanfield size:

-for writing: 480µ x 235.4µ

-for calibration: 480µ x 267.4µ

Note: For the 34 scanfields,

-8 points are obtained during seq. SMPUI.3

-only the center of slit 5 is obtained for M.S.I. evaluation in seq. SMPUI.4

CALIBRATION OF STAR MAPPER PARALLEL SLITS (SMPU)

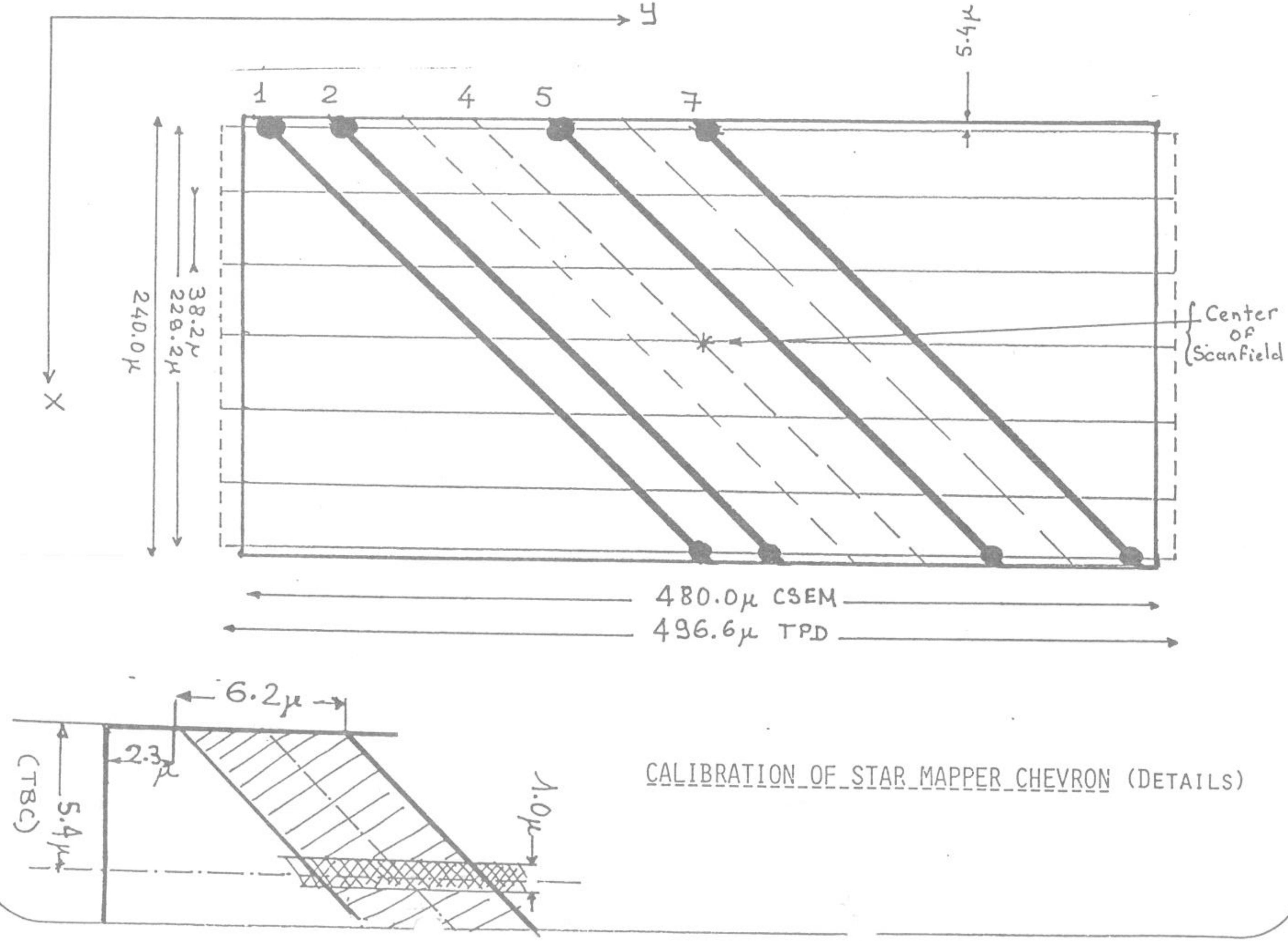
Date..................

STAR MAPPER GRID

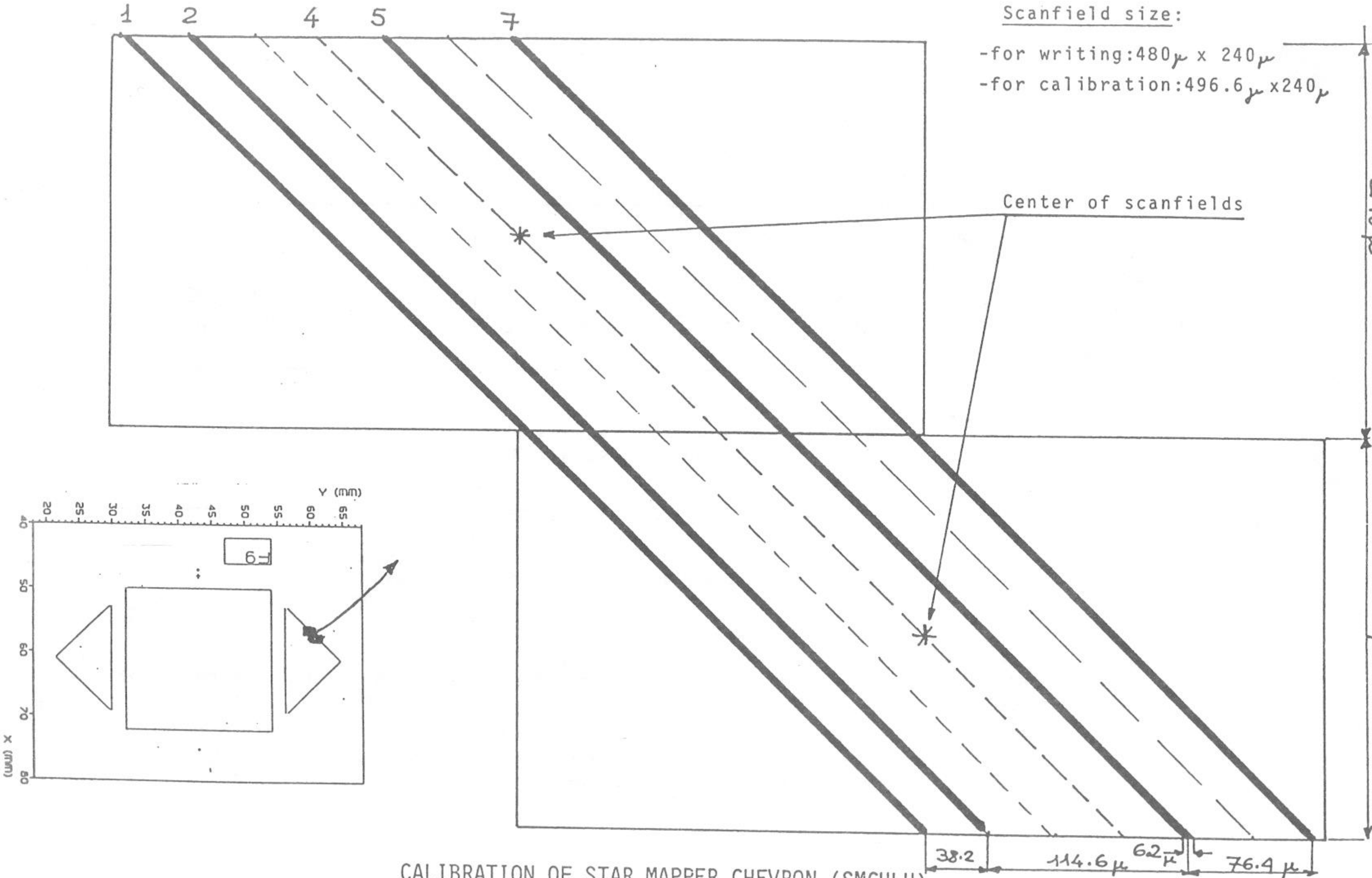
SEQUENCE (DURATION)	SUBSEQUENCE (FILE =)	= OF SCANFIELDS MEASURED	= OF SLITS MEASURED PER SCANFIELD	PURPOSE
SMCHRU.1 (14 mn)	Same as (030 to 035)	SMCHLU1 for	SMCHRU	
SMCHLL1 (14 mn)	(036 to 041)		SMCHLL	
SMCHRL1 (14 m)	(042 to 047)		SMCHRL	
SMCHLU2 (1 H 30 mn)	SMCHLU2.CO.34 (048 to 081)	34 (all scanfields for SMCHLU)	2 X 4	Derive MSI for SMCHLU
SMCHRU2 (1 H 30 mn)	Same as above for SMCHRU (082 to 115)			
SMCHLL2 (1 H 30 mn)	Same as above for SMCHLL (116 to 149)			
SMCHRL2 (1 H 30 mn)	Same as above for SMCHRL (150 to 183)			

Date

Date........................



CALIBRATION OF STAR MAPPER CHEVRON (DETAILS)



CALIBRATION OF STAR MAPPER CHEVRON (SMCHLU)

Date..............

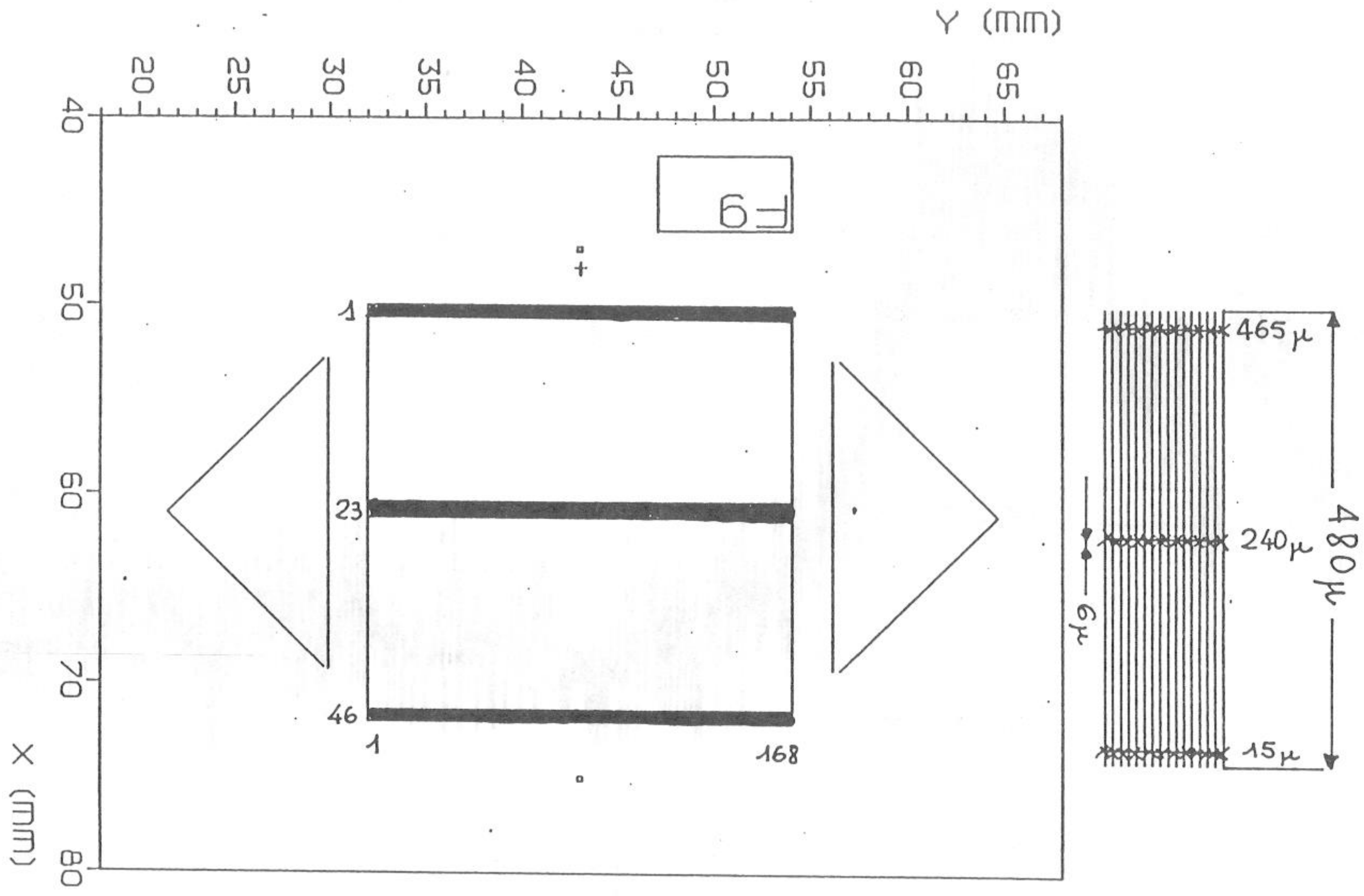
MAIN GRID

SEQUENCE (DURATION)	SUBSEQUENCE (File ≠)	≠ OF SCANFIELDS MEASURED	≠ OF SLITS MEASURED PER SCANFIELD	PURPOSE
MG4 (30 mn)	MG4.1 (184)	4 (same as in MG1.1)	2 X 4	Repeat MG1.1 in order to assess the rotation of the substrate wrt EBG during the whole calibration period
	MG4.2 (185) MG4.3 (186)	Same as MG4.1 (to assess the accuracy of measurement)		

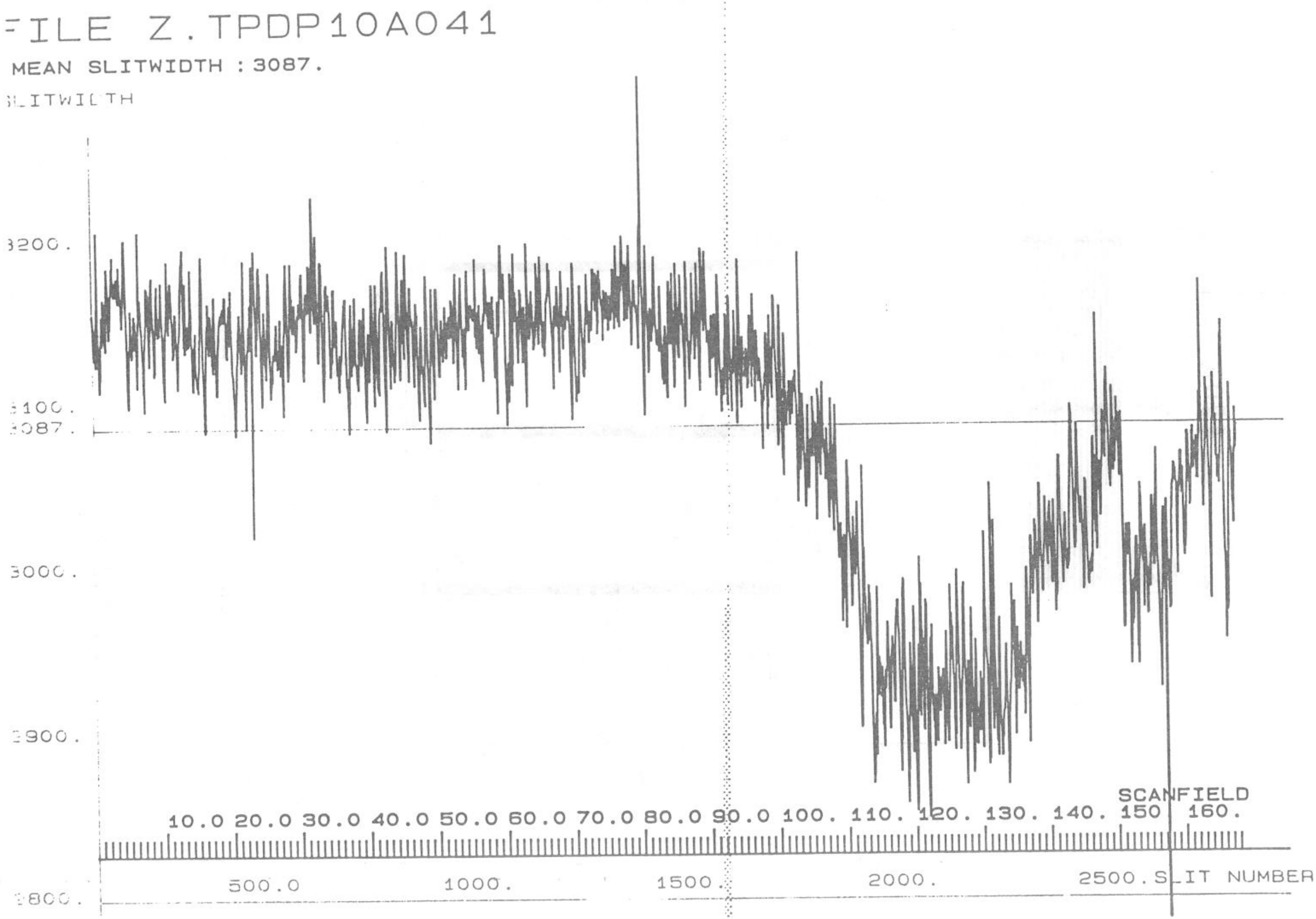
SPECIAL RUNS REQUESTED BY ESA

MG.ESA (4 hours)		3 X 168	3 X 16	Increase knowledge of grid parameters along 9 different scans dealing with all the slits

Date



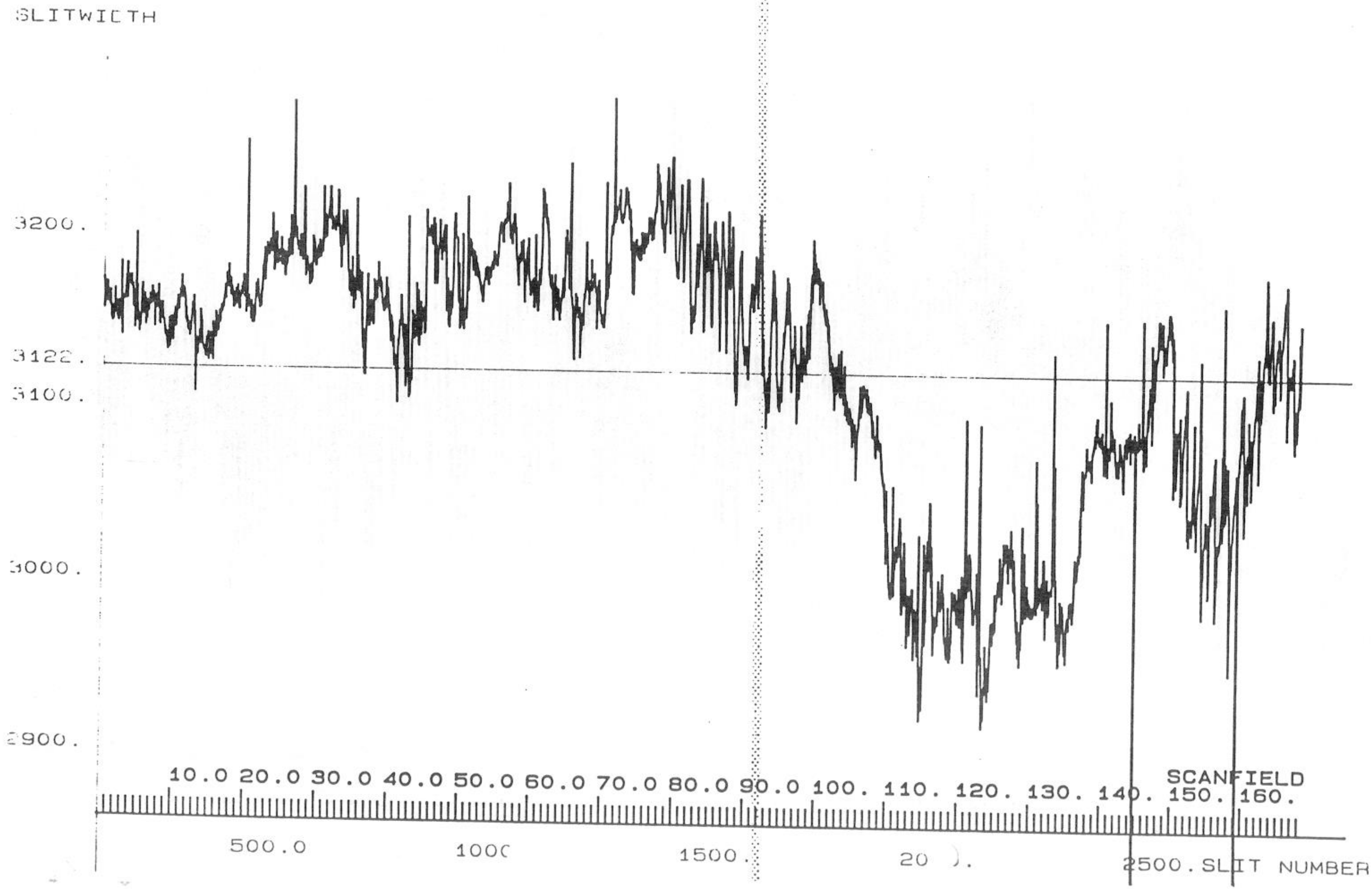
SPECIAL RUNS " MG.ESA "



FILE Z.TPDP10A041
MEAN SLITWIDTH : 3087.
SLITWIDTH
3200.
3100.
3087.
3000.
2900.
2800.
10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100. 110. 120. 130. 140. 150 160.
SCANFIELD
500.0
1000.
1500.
2000.
2500.
SLIT NUMBER

FILE Z.TPDP10A042

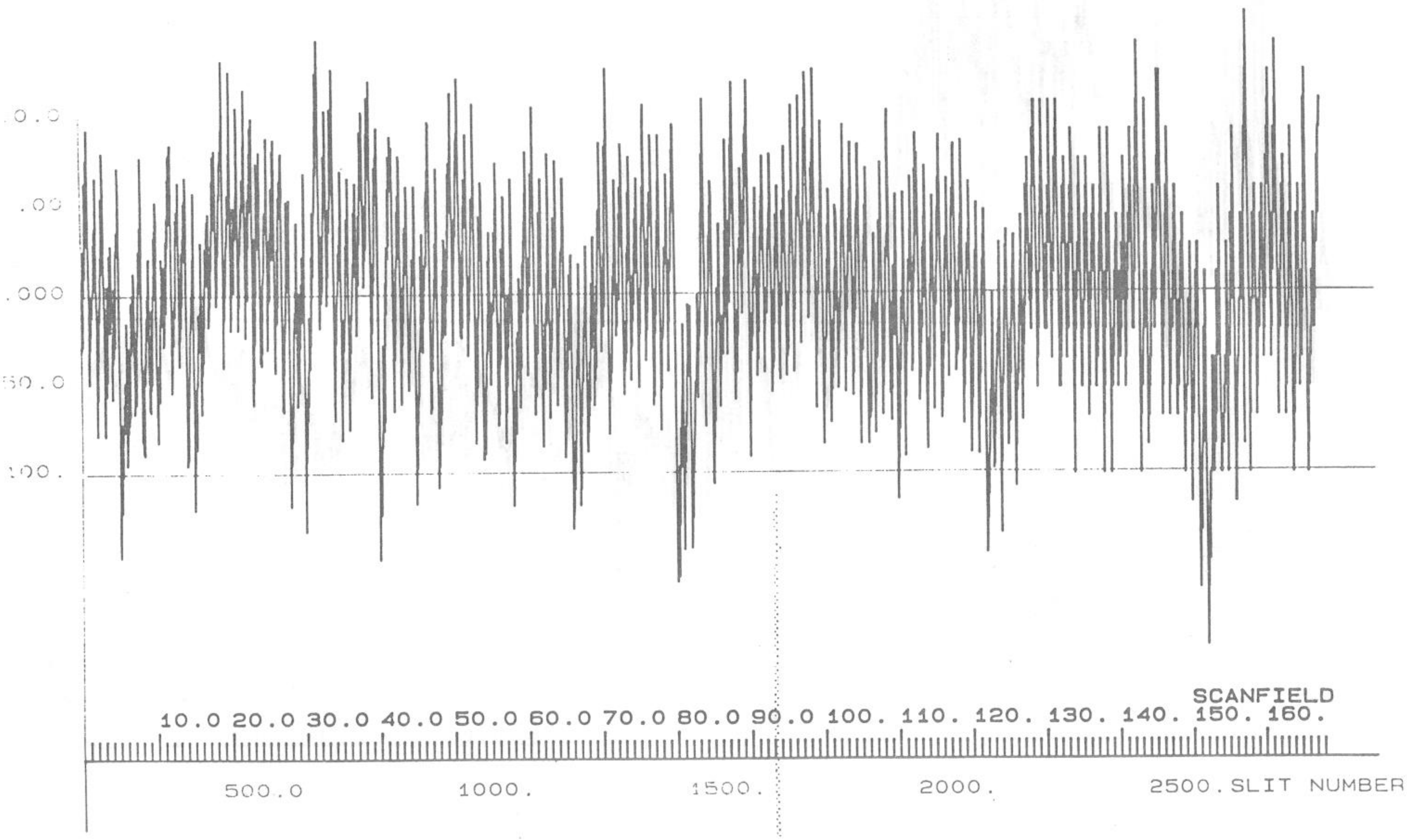
MEAN SLITWIDTH : 3122.



FILE Z.TPDP10A041

ESIDUAL ON SLIT POSITION 52.1 NM (RMS)

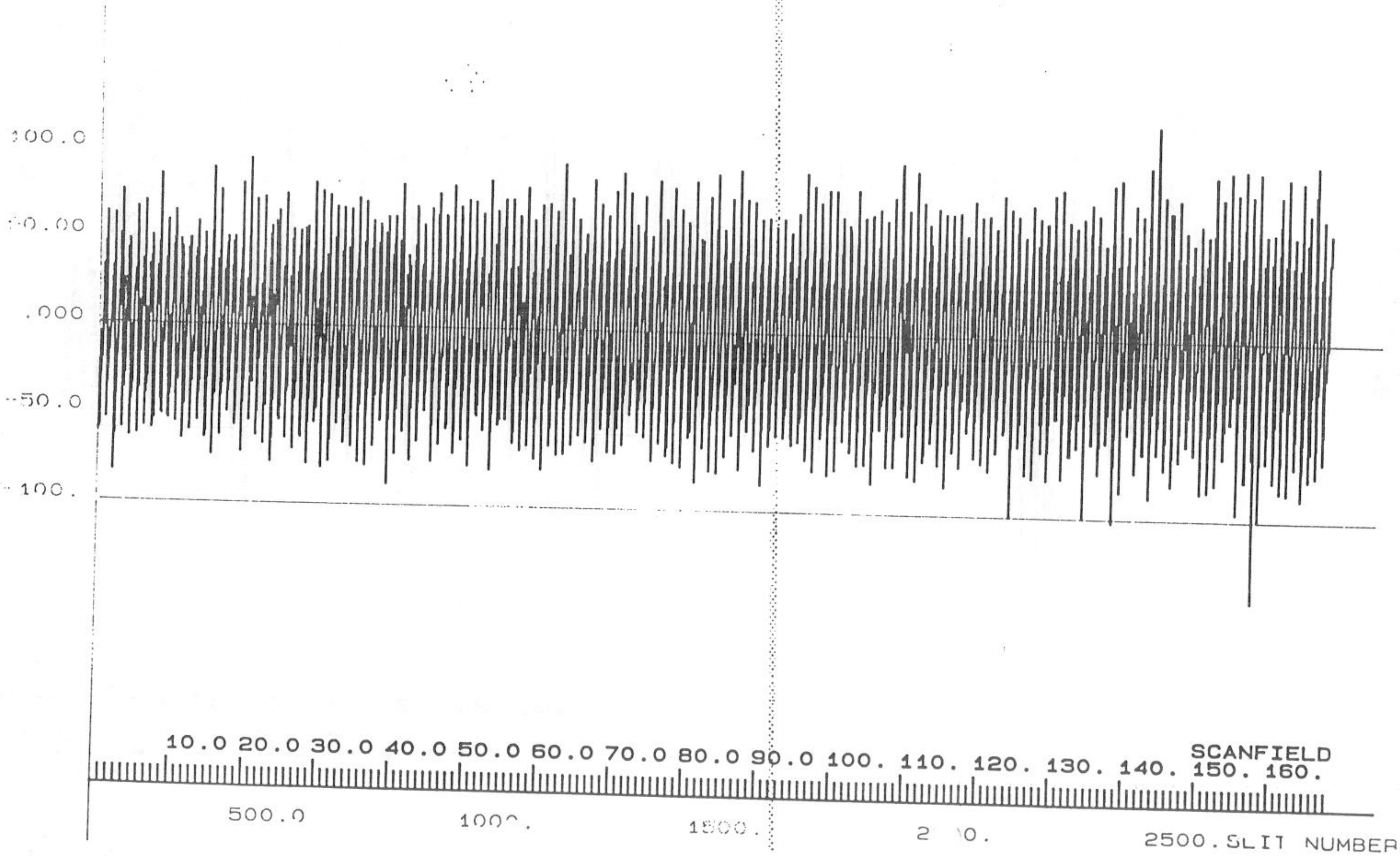
WITH L.S.I. CORRECTION



FILE Z.TPDP10A041

RESIDUAL ON SLIT POSITION 39.9 NM (RMS)

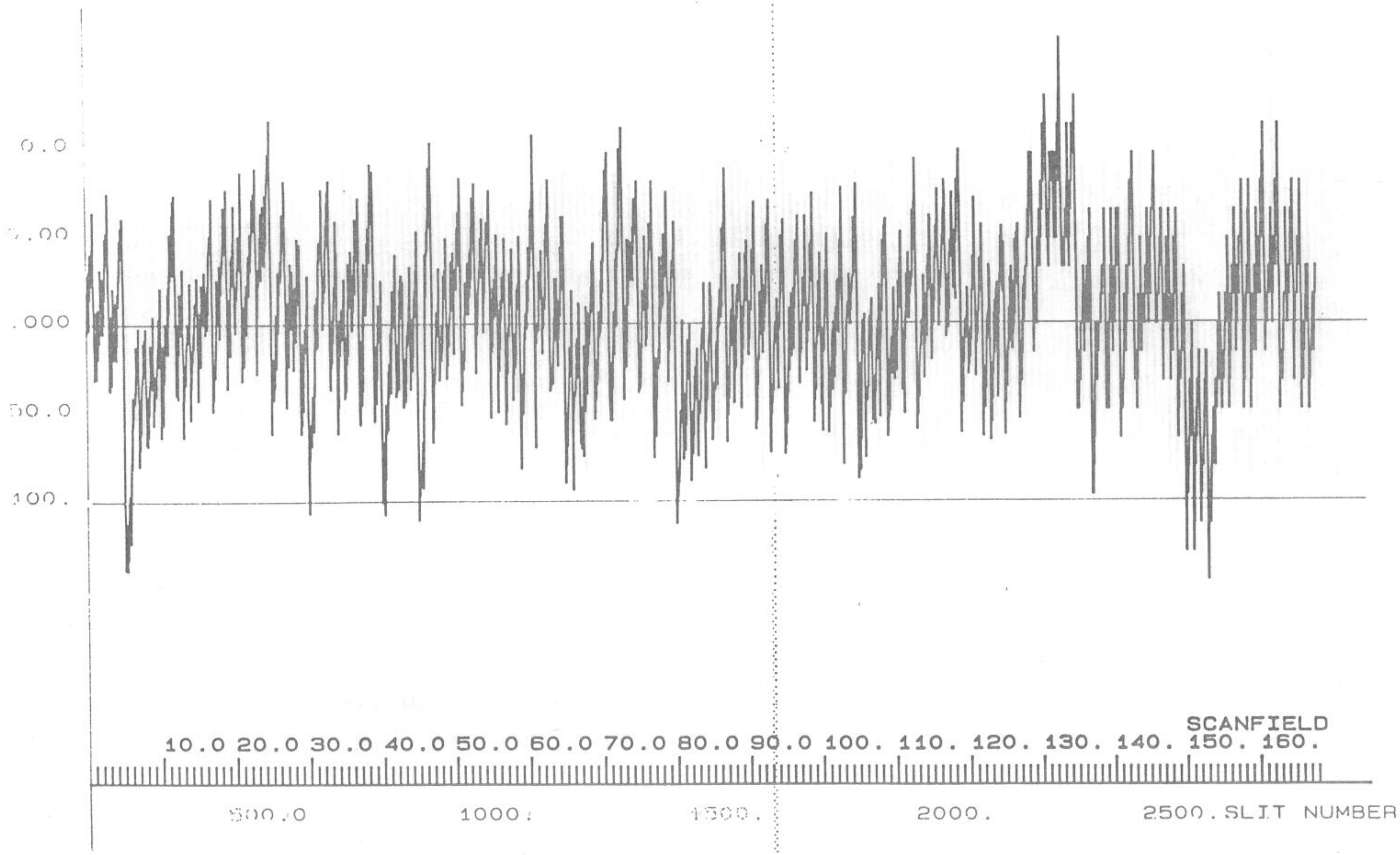
WITH M.S.I. CORRECTION



FILE Z.TPDP10A042

ESIDUAL ON SLIT POSITION 42.0 NM (RMS)

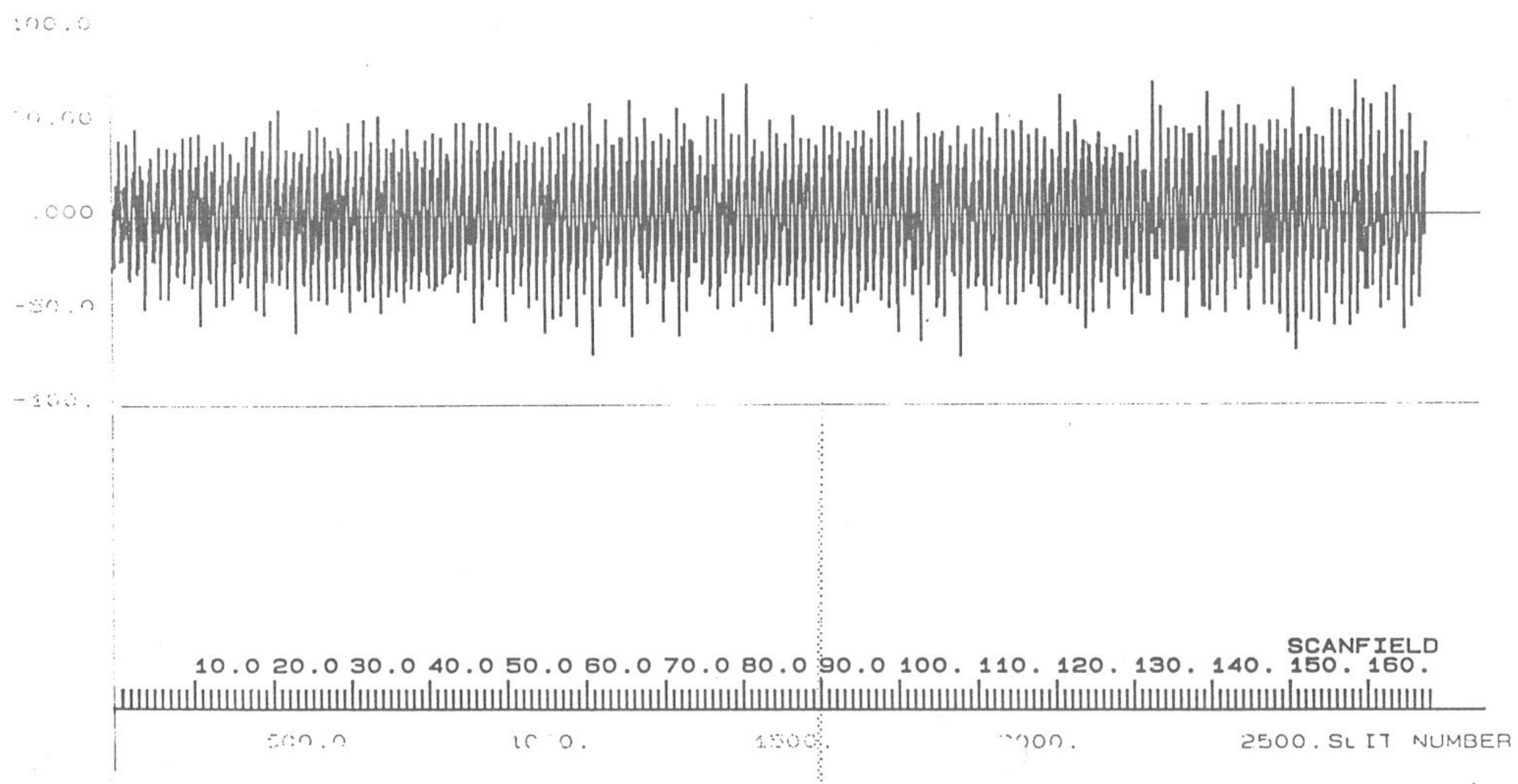
WITH L.S.I. CORRECTION



FILE Z.TPDP10A042

RESIDUAL ON SLIT POSITION 24.6 NM (RMS)

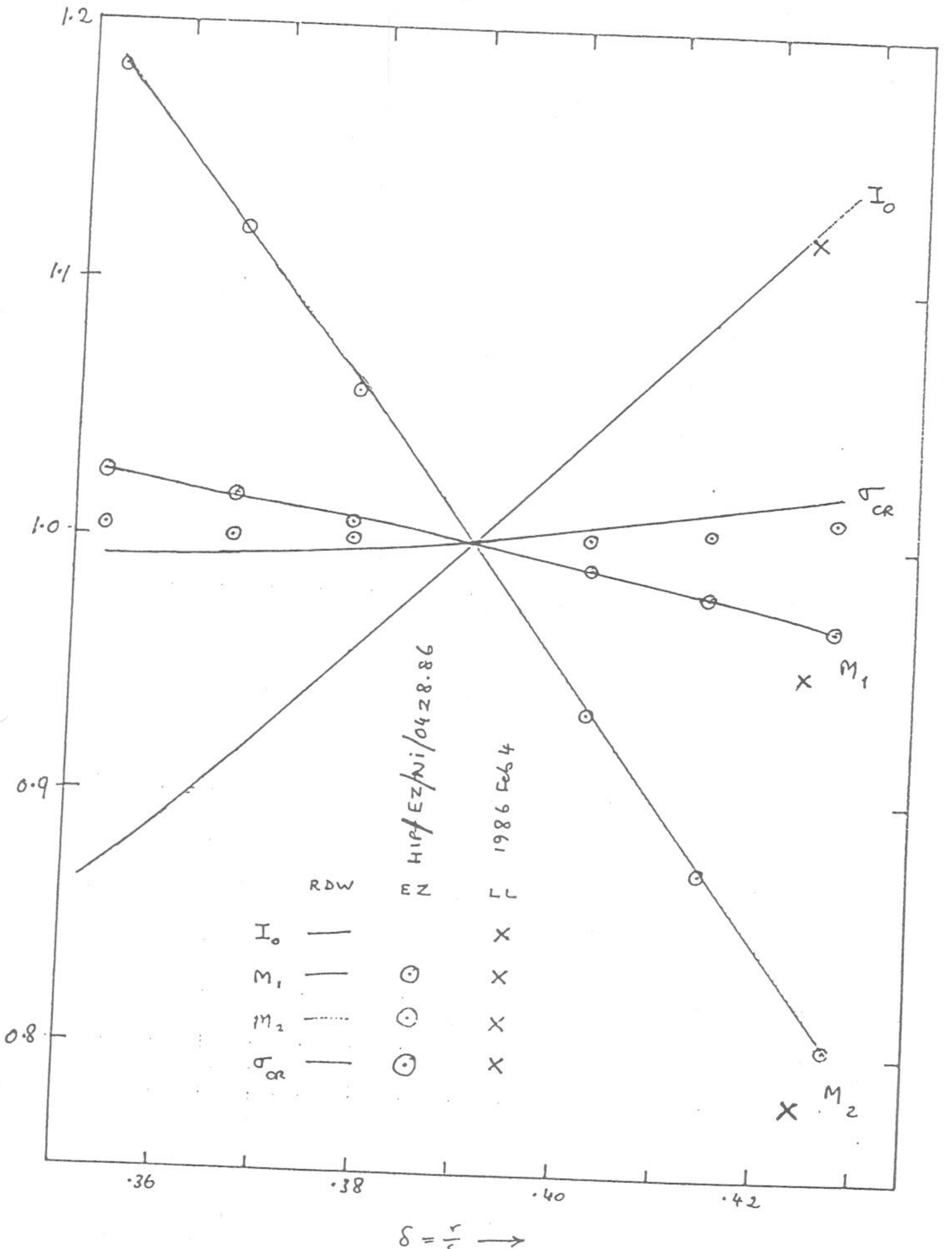
WITH M.S.I. CORRECTION



ANNEX VI
HST

RDW → MS, SV, RB, GR, KvK, MACP

Performance variation with grid slit width
B = 9, B − V = 0.5



MAIN MISSION ITF CALIBRATION

$$I_{obs} = I_{pf} \left(r_{00} + r_{10} \times 10^{-2} I_{obs} + r_{11} \times 10^{-4} \times I_{obs}^{2} + \cdots \right)$$

$$I_{true} = r_{00} I_{pf}$$

$$I_{obs} = I_{true} \left(1 + C_{ITF} / r_{00} \right)$$

$$C_{ITF} = r_{10} \times 10^{-2} I_{obs} + r_{11} \times 10^{-4} I_{obs}^{2}$$

$$\sigma^{2}_{ITF} = E\left[\left(\hat{C}_{ITF} - C_{ITF} \right)^{2} \right]$$

B (mag)	V (mag)	I_{obs} (s^{-1})	C_{ITF}	σ_{ITF}/r_{00} (%)
9.9	9.4	10^3	-1.79×10^{-7}	-
7.4	6.9	10^4	-1.79×10^{-6}	-
4.9	4.4	10^5	-1.77×10^{-5}	0.1
4.2	3.7	2×10^5	-3.4×10^{-5}	0.3
3.2	2.9	5×10^5	-8.3×10^{-5}	0.9
3.0	2.5	6×10^5	-9.9×10^{-5}	1.2
2.4	1.9	10^6	-1.54×10^{-4}	2.7

(B−V = 0.5)

STAR MAPPER ITF CALIBRATION

$$N_0^* = 4\int I_0^* \, SSR(t)\, dt$$

$$C = r_{00}\,(1 + C_{ITF})$$

N_0^* (cts)	σ_{ITF}/C (%)
10^3	0·15
2×10^3	0·30
5×10^3	0·74
6×10^3	0·88
8×10^3	1·17
10^4	1·47
2×10^4	2·9
4×10^4	5·8
8×10^4	11·5

For $B=5$ and $B-V=0$ $\quad N_0^*(B_T) \approx 4000$ cts

For $B=5$ and $B-V=1{\cdot}5$ $\quad N_0^*(V_T) \approx 5000$ cts

ANNEX VIII

TRANSFORMATION/DISTORTION

- REFERENCE FRAMES
- BREAKDOWN OF TRANSFORMATION COMPONENTS
- MIRROR SURFACE APPROXIMATION
- ASTIGMATISM DUE TO BASIC ANGLE
- EFFECT OF GRID MOVEMENT ON DISTORTION
- STARMAPPER DISTORTION

KvK (1) Date 19/3/86

KvK (2) Date 19/3/86

REFERENCE FRAMES

FIELD COORDINATES (η, ζ) IN ARCSEC
GRID COORDINATES (G, H) IN ARCSEC <u>OR</u> NONDIMENSIONAL

OPTICAL REFERENCE FRAME USED FOR GRID ALIGNMENT:
"SCAN PLANE" – PARALLEL TO BEAMCOMBINER NORMALS
– THROUGH SPH. MIRROR CENTER OF CURVATURE
"VERT. PLANE" – PARALLEL TO BEAM COMB. BISSECTRIX OF NORMALS
– THROUGH SPH. MIRROR CENTER OF CURVATURE
$\Rightarrow$ CENTER OF GRID WHERE $\gamma = \text{MAX}$

REMARK: (G, H) DEPEND ON FOCAL LENGTH VIA DIMENSIONS (mm) ON GRID AND NORMALISATION OF FOV SIZE

KvK (3) Date 19/3/86

BREAKDOWN OF TRANSFORMATION COMPONENTS

MAIN FIELD SCAN DIRECTION $G = G_N + G_L + G_M + G_S$

G = STARPOSITION AS SENSED BY PRIMARY DETECTOR, AT B–V = 0,50 ⇒ 6 TRANSFORM. (FOV, GRIDFREQU., DETECTOR)

G_N = NOMINAL DIS~~TOR~~TION TRANSFORMATION, LIMITED TO 3^e DEGREE POLYNOMIAL IN (η, ζ) OF BOTH MAIN AND SM FIELDS

= $F.\eta + D_N$ $\quad D_N = 2^e + 3^e$ DEGREE TERMS ONLY OF G_N

(G_N, D_N) DO NOT DEPEND ON OPTICS, ONLY VIA F

G_L = LARGE SCALE COMPONENT, LIMITED TO 2^e DEGREE POLYNOMIAL IN (η, ζ) OF LEAST SQUARE FIT ON MAIN FIELD

G_M = MEDIUM SCALE COMPONENT, LIMITED TO 168 x 46 DISCRETE SCAN FIELDS

G_S = SMALL SCALE COMPONENT, RESIDUAL OF TRANSFORMATION (TO BE EXPRESSED IN RANDOM, SAWTOOTH DISTORTION, ETC)

KvK (4) Date 19/3/86

BREAKDOWN OF TRANSFORMATION COMPONENTS

SM-FIELD SCAN DIRECTION $G^* = G^*_N + G^*_L + G^*_M + G^*_F + G^*_R$

G^* = STARPOSITION AS SENSED BY SM DETECTOR, BASED ON MAX. CORRELATION OF SRR AND FILTER, AT B-V = 0,50 AFTER AVERAGING OVER BT AND VT CHANNEL

G^*_N = SAME AS FOR MAINFIELD

G^*_L = EXTRAPOLATED FROM MAINFIELD LEAST SQUARE FIT

G^*_M = MEDIUM SCALE COMPONENT, LIMITED TO DISCRETE SCANFIELDS

G^*_F = FOV DEPENDENT "PHASE SHIFT" DUE TO ASTIGMATISM OF OPTICS AND HALFPUPIL OFFSET, ON CHEVRONS ONLY

G^*_R = RESIDUAL OF TRANSFORMATION

MIRROR SURFACE APPROXIMATION

SPHERICAL MIRROR $X = R - \sqrt{R^2 - \rho^2} \approx \rho^2/2R + \rho^4/8R^3$

FOR $\rho \leq 145$ (mm) AND $R = 2800$ (mm)

BEAMCOMBINER $X = \frac{1}{2}\rho^2 CK + \rho^4 AD$ PER MIRROR HALF

AFTER ROTATION (BASIC ANGLE/4) ± 14,5 degr

AND VERT. SHIFT (COMPENSATION) ± 4,0 mm THEN

$$X = \frac{1}{2}\rho^2 CK \left[\{\cos\varphi/\cos(\gamma/4)\}^2 + (\sin\varphi + t/\rho)^2\right] +$$
$$+ \rho^4 AD \left[\{\cos\varphi/\cos(\gamma/4)\}^2 + (\sin\varphi + t/\rho)^2\right]^2$$

FOCAL LENGTH $f_\varphi \approx f/\{\cos^2\varphi/\cos^2(\gamma/4) + \sin^2\varphi\}$

$f = 1437922$ mm, $\gamma = 58$ degr } $f_0 = 1347778$ mm IN SCAN DIRECTION; $f_{90} = 1437922$ mm IN VERT. DIRECTION

KvK (5) Date 19/3/86

KuK ⑥ Date 19/3/86

in red – Lorio-Fili comments 2/5/86

ASTIGMATISM DUE TO BASIC ANGLE

BEAMCOMBINER + SPHERICAL MIRROR COMBINED FOCAL LENGTH

$f^{*} = \frac{f_{BC} - f_{SM}}{f_{BC} - f_{SM} - d}$ ← $d = (bc - sm)$ distance. $f_{BC} < 0$, $f_{SM} > 0$, $d < 0$

$f_0^* = 1/(1/1400 + 1/f_0) \Rightarrow 1398{,}5473$ (mm) IN SCAN DIRECTION 1401.4558

$f_{90}^* = 1/(1/1400 + 1/f_{90}) \Rightarrow 1398{,}6382$ (mm) IN VERT. DIRECTION 1401.3649

DIFFERENTIAL FOCUS 0,0909 (mm) ASTIGMATISM 0.0914

~~BEST~~ Back FOCAL LENGTH FROM LAS ANALYSES $f_0^* = 1398{,}6090$ (mm)

CONTRIBUTION OF BEAMCOMBINER:

$f_0 = 1/(1/f_0^* - 1/1400) \Rightarrow 1407658$ (mm)

APPARENT FOCAL LENGTH IN VERT. DIRECTION:

$f_{90} = f_0 / \cos^2(\gamma/4) \Rightarrow 1501807$ (mm)

$f_{90}^* = 1/(1/1400 + 1/f_{90}) \Rightarrow 1398{,}6961$ (mm)

DIFFERENTIAL FOCUS 0,0871 (mm) ASTIGMATISM

BOTH METHODS ⇒ ASTIGMATISM ≈ 90 μm

KvK (7) Date 19/3/86

EFFECT OF GRIDMOVEMENT ON DISTORTION

DISPLACEMENT COMPONENTS OF GRIDSURFACE $x=(y^2+z^2)/2R$

$u = u_0 - \gamma y + \beta z$ IN OPTICAL DIRECTION (x)

$v = v_0 - \alpha z + \gamma x$ IN SCAN DIRECTION (y)

$w = w_0 - \beta x + \alpha y$ IN VERT. DIRECTION (z)

(u_0, v_0, w_0) TRANSLATION

(α, β, γ) ROTATION

APPARENT IMAGE DISPLACEMENT COMPONENTS

$$\delta = \{u_0(\langle y\rangle - y)/f + v_0 - \alpha z + \beta(\langle y\rangle - y)z/f - \gamma(\langle y\rangle - y)y/f\}/f$$

$$\varepsilon = \{u_0(\langle z\rangle - z)/f + w_0 + \alpha y + \beta(\langle z\rangle - z)z/f - \gamma(\langle z\rangle - z)y/f\}/f$$

$\langle y\rangle, \langle z\rangle$ PUPIL CENTROID COORDINATES

f = FOCAL LENGTH

$$\rightarrow \begin{cases} DG = 147{,}34\,\Delta x - 1{,}1576\,x\Delta z - 7{,}8571\,y\Delta\theta z + 0{,}061735(x^2\Delta\theta y - xy\Delta\theta x) \\ DH = \underbrace{147{,}34\,\Delta y}_{\text{SHIFT}} - \underbrace{1{,}1576\,y^*\Delta z}_{\text{SCALE}} + \underbrace{7{,}8571\,x\Delta\theta z}_{\text{ROTATION}} + \underbrace{0{,}061735(xy^*\Delta\theta y - yy^*\Delta\theta x)}_{\text{QUADRATIC}} \end{cases}$$

SHIFT + SCALE + ROTATION + QUADRATIC

WITH $y^* = y \pm 63{,}9/11$ DEPENDENT ON FOV

(DG, DH) mas, $(\Delta x, \Delta y, \Delta z)$ μm, $(\Delta\theta x, \Delta\theta y, \Delta\theta z)$ as, (x, y, z) mm

KuK (8) Date 19/3/86

STARMAPPER DISTORTION

G_F^* = FOV DEPENDENT "PHASE SHIFT", ON CHEVRONS ONLY

WITH PUPIL CENTROID AT 63,9 (mm)
ASTIGMATISM OF 90 (µm)
FOCAL LENGTH OF 1400 (mm)
NOMINAL, KNOWN AND CONSTANT SHIFT IS $G_F^* = \pm 605{,}2$ (mas)

IN ADDITION CROSS EFFECTS DUE TO OPTICS DISTORTION AND GRID ROTATION NEED TO BE ADDED.

SM DISTORTION SPECIFICATION UNDER REVIEW

ANNEX IX

cc. ROW
MS
ESOC JvdH
J.S.

DRAFT

WHAT WILL BE AVAILABLE IN THE "INPUT CATALOGUE" ?

C. Turon

10/03/86

****

Make a clear distinction between :

I. - The "INCA" Data Base which includes all available data and cross-identifications on all proposed stars (210 000 stars).

II. - A subset of this base (100 - 120 000 stars) that will be observable by Hipparcos.
For these stars, any desirable subset of data may be taken from the INCA Data Base.

I - Data in the "INCA" Data Base" (210 000 stars).

1. all known cross-identifications (from which any subset may be extracted in answer to specific requests) ;

2. so-called "fundamental" data : position, proper motion if available, B (or H) and/or V magnitude, a code for variability, the spectral type.
The positions and magnitudes given here are those used within INCA simulations.

3. "measurements". These include the measurements available within SIMBAD, and specific INCA "measurements" described in detail underneath (taken from INCA report N° 11 to ESA, January 1986, pp.37-38).

   a) : pH (Hipparcos photometry).
   - H magnitude
   - σ H
   - code for source (from 0 to 99)
   - S if standard stars for Hipparcos
   - V magnitude
   - σ V
   - code for source (from 0 to 99)
   - (B-V)
   - σ(B-V)

. code for source (from 0 to 99)
. code for reference

b) vH (Hipparcos variable stars).
. magnitude at maximum luminosity
. type of magnitudes
. magnitude at minimum luminosity
. magnitude adopted for simulation
. percentage of the period when the star is brighter than the Hipparcos limiting magnitude
. code for reference

c) sH (Hipparcos simulation).
. number of the version
. pressure
. observability parameter
. code for reference

d) CCDM (specific data for multiple stars).
. letter for the component
. $\Delta\alpha$ with respect to the α given in the CCDM
. $\Delta\delta$ with respect to the δ given in the CCDM
. code for reference
. magnitude
. position angle θ in degrees
. separation ρ in arcseconds
. 0 if there is an orbit in an annex catalogue
. letter of the associated component if ρ < 10"
. coded spectral type
. code for reference

e) pos (position of the star).
. right ascension
. σ_α
. declination
. σ_δ
. Equinox
. Mean epoch of the observations
. code for reference

f) pm (proper motion).
. $\mu_\alpha \cos\delta$
. $\sigma_{\mu_\alpha} \cos\delta$
. μ_δ
. σ_{μ_δ}
. code for reference

II - <u>Data in the Input Catalogue</u> (100 - 120 000 selected stars).
One "main catalogue". Four annex catalogues".

MAIN CATALOGUE.

1. <u>Running number</u>.

All selected stars will be numbered once sorted out by increasing right ascension. In this context, "star" is used for "separate entry" to be taken into account for the preparation of the PSF (either single star or components with a separation larger than 10").

In addition :

1) a 2-digit code will indicate :
   . the number of entries for the considered system,
   . the number of components considered in this entry, in case of joint system (ρ < 10") ;

2) in case of double or multiple stars, the CCDM number (Catalogue of Double or Multiple Stars), allowing us to enter the annex catalogue N°1, dedicated to detailed information on these stars.

Examples :

type of star	running number	code	CCDM number	considered components
simple star	581	11	-	-
double star ρ < 10"	582	12	00012+23/15	AB
double star $\rho \geq$ 10"	583 586	21 21	00123-10,20 00123-10/20	A B
triple star ρ AB < 10" ρ AB,C < 10"	590	13	12567+01/02	ABC
triple star ρ AB < 10" ρ AB,C $\geq$ 10"	591 595	22 21	01465-51/03 01465-51/03	AB C

2. <u>Data necessary for ESOC</u>.

- position + rms   Equinox 2000, Epoch 1990
- H magnitude + rms + flag for standard stars
- flag for variable star = code for variation amplitude. Indicates an entry in Annex Catalogue N°3, dedicated to detailed information on variable stars
- parameter resulting from mission simulation.

3. Additional data useful to DRC, given if available.

- V magnitude + rms
- B-V + rms
- HD spectral type
- trigonometric parallax + rms
- annual proper motion + rms
- radial velocity + rms
- flag for type of binarity
- flag for veiling glare due to programme stars
- flag for veiling glare due to bright non-programme stars

4. Additional information (if available).

- best ESA priority
- bidimensional MK spectral type
- code indicating that the star is included in some catalogues (uvby photometry, Geneva photometry, ...)

5. Identifications.

- HD number
- DM number
- } other identifications
-

For ESA :

- identification of proposals asking for this star, running numbers in each proposal, ESA priority in this proposal.

6. Sources and references.

- for positions
- for proper motions
- for B magnitude
- for V magnitude
- for trigonometric parallax
- for radial velocity
- for MK spectral type

7. Double stars.

Adopted rule : . 1 entry if $\rho < 10''$ AB
. 2 entries if $\rho \geq 10''$ A, B

a) for close double stars ($\rho < 10''$)

In the main catalogue, the position and magnitude of the photo-center are given. Positions and magnitudes of both components (if available) are given in Annex Catalogue N°1.

b) for wide double stars ($\rho \geq 10''$)

. If the two components are requested separately by proposers, the information on both components will be found in the main catalogue, under two separate entries.

. If only one of the two components is requested by proposers :

either

this component only appears in the main catalogue ; information on the second one may be found in Annex Catalogue N°1 ;

or

both components appear in the main catalogue with two separate entries.

. In both cases, within which limits in ρ and Δm the second component should be included in the main catalogue ? (if its position and magnitude are known).

8. Multiple systems.

Adopted rule :

. 1 entry for any subset of components such that $\rho < 10''$;

. additional entry for any component at a distance $\rho \geq 10''$ from each of the other components.

9. Variable stars.

The adopted rule for the H magnitude depends on the type of variability.

It may be :

- the magnitude at minimum luminosity (for eruptive variables),
- the magnitude at maximum luminosity (for eclipsing variables),
- a mean (or weighted mean) magnitude, depending on the type of light curve.

Detailed information on variability is given in Annex Catalogue N°3.

Ephemerides for large amplitude variable stars are given in Annex Catalogue N°4.

ANNEX CATALOGUE N°1 : Detailed information on double and multiple stars.

- Input Catalogue running number
- CCDM number
- considered component
- delta α } with respect to α, δ as given in the CCDM number
- delta δ }
- source of position
- magnitude
- position angle : θ } with respect to the reference component
- separation : ρ }
- reference
- O if orbital double star, orbital elements given in Annex Catalogue N°2
- if the above data are joint information on a close binary, identification letter of the second component
- spectral type

ANNEX CATALOGUE N°2 : Orbital elements for orbital double stars.

- Input Catalogue running number
- CCDM number
- orbital elements

ANNEX CATALOGUE N°3 : Detailed information on variable stars.

- Input Catalogue running number
- name of the variable star
- type of variability
- magnitude at maximum luminosity
- type of magnitude
- magnitude at minimum luminosity
- period of variation (in days)
- epoch (in Julian days)
  . of last minimum for eclipsing variables and T Tauri type stars,
  . of last maximum for all other types of variable stars
- percentage of the period when the variable star is observable by Hipparcos
- reference

ANNEX CATALOGUE N°4 : Ephemerides for large amplitude variable stars.

- Input Catalogue running number
- name of the variable star
- epoch
- magnitude

DRAFT

WHAT WILL BE AVAILABLE IN THE "INPUT CATALOGUE" ?

for Minor Planets

C. Turon

10/03/86

****

Here again, there may be a distinction between the Data Base on Hipparcos minor planets and the data necessary for satellite operation or data reduction.

I - CONTENT OF THE MINOR PLANETS DATA BASE.

Chebychev coefficients for the various parameters describing each minor planet are given at successive epochs, every 30 days. The coefficients are valid over overlapping intervals of 34 days. 8 coefficients are presently given. This number may be modified according to the results of further tests.

For each epoch, are given :

- a running number for the Hipparcos minor planets
- the number of the minor planet
- Chebychev coefficients for the right ascension (J2000)
- Chebychev coefficients for the declination
- Chebychev coefficients for the ecliptic longitude
- Chebychev coefficients for the ecliptic latitude
- Chebychev coefficients for the distance
- Chebychev coefficients for the phase angle
- Chebychev coefficients for the magnitude

Any subset of this Data Base may be selected for ESA or DRC.

Remark for ESOC :

The data on minor planets should be updated during the year prior the launch but also during the mission itself, every 6 (TBC) months.

Geocentric, J2000, (i.e. only need to correct for satellite orbit.)

ANNEX V

PROGRAM STAR FILE PREPARATION

1 Observing Strategy Distortions and possible actions at PSF level.

2 Modulation of Observing strategy parameters :

- parameters
- control of data acquisition
- modulation scheme.

3 Cost/Quality considerations :

- simulation results with and without modulation
- additionnal ressource requirements
  - . updates of the covariance matrix
  - . observing calendar
  - . frequency of updates
- special processing
  - . "proper motion stars" in dense fields
  - . alternate observations in very dense fields

4 Observability

5 Dates

observing strategy effects

- Pressure dominates

1°: if PR is such that
$\Sigma x_0 \geq 20$
y_0 does not work

2°: when 1 high Pressure + 1 Medium pressure

Even Frame		odd frame	
HP field	MP field	HP	MP
1	1	7	3
2	2	6	2
3	3	5	1
4		4	
5		3	
6		2	
7		1	

$\Sigma x_0 = 20$ (line drawn after row 4)

A.P. favours stars in MP fields

3°: Stars with $k x_0 << y_0$ are unfavoured in dense fields

Control of Data Acquisition (1)

1 <u>Basic Tool:</u>

The Covariance Matrix of Astrometric Unkn

$$B = A^{-1}$$

$$A = [a_{jk}] , \quad a_{jk} = \sum_i \alpha_{ij} \alpha_{ik} P_i \qquad (1)$$

$P_i = P(m)\,\tau_i$

τ_i : observing time dedicated to the star under consideration during field crossing i

2 <u>Standard observing history</u> (Target)

- field crossings are predicted on the basis of a strict Nominal Scanning Law (= Nominal Observing Calendar = NOC)

- $\tau_i = \bar{\tau}$ = target observing time per field crossing

$$\longrightarrow \bar{A} \rightarrow \bar{B} = \bar{A}^{-1}$$

INCA can provide either

$\bar{\tau}$ and $\bar{B}$ once the starting point of observations is known

or

produce the code

3 State of observations at time t

It is derived from $\overline{B}$ by substituting progressively actual observations to standard ones in (1)

$$\tilde{B}(t_i) = \tilde{A}^{-1}(t_i) \qquad \tilde{A}(t_i) = [\tilde{a}_{jk}(t_i)]$$

$$\tilde{a}_{jk}(t_i) = \tilde{a}_{jk}(t_{i-1}) + \alpha_{ij}\,\alpha_{ik}\,P(m)\,(\tau_i - \overline{\tau})$$

at $t = 0 \quad \tilde{B}(0) = \overline{B}$

A few terms in $\tilde{B}$ will be compared to identical term in $\overline{B}$ indicating Under or Over observations

$b_{33},\ b_{55},\ ?,\ \ldots \qquad \vec{r}(t) = \left(\frac{\overline{b_{33}}}{\tilde{b}_{33}(t)},\ \frac{\overline{b_{55}}}{\tilde{b}_{55}(t)}\right)$

4 Expected yield

the efficiency of the next observation to come is measured by comparing $\overline{B}$ (or $\tilde{B}$) to a matrix B^* from which this observation has been excluded

See example

$$B^*(t_i) = A^{*-1}(t_i) \qquad A^*(t) = [a^*_{jk}(t_i)]$$

$$a^*_{jk} = a_{jk} - \alpha_{ij}\,\alpha_{ik}\,P(m)\,\overline{\tau}$$

Expected yield (Efficiency) $\quad \vec{s}(t) = \left(\frac{b^*_{33}(t)}{b_{33}},\ \ldots\right)$

once per day, for each star expected to be observed during day D+1

compute

1 THE STATE OF OBSERVATIONS :

$r_1(\pi)$, $r_2(\mu_\lambda)$, $r_3(\mu_\beta)$

IF $r_1 < (1-\varepsilon_1)$ OR $r_2 < (1-\varepsilon_2)$ OR $r_3 < (1-\varepsilon_3)$ THEN UNDEROBSERVED

$\varepsilon = 0.02$

IF $r_1 > (1+\varepsilon'_1)$ AND $r_2 > (1+\varepsilon'_2)$ AND $r_3 > (1+\varepsilon'_3)$ THEN OVEROBSERVED

$\varepsilon' = 0.002$

ELSE NORMAL

2 THE EXPECTED EFFICIENCY :

$s_1(\pi)$, $s_2(\mu_\lambda)$, $s_3(\mu_\lambda)$

IF $s_1 \geq (1+\varepsilon''_1)$ OR $s_2 \geq (1+\varepsilon''_2)$ OR $s_3 \geq (1+\varepsilon''_3)$ THEN EFFICIENT

$\varepsilon'' = 0.002$

ELSE NOT EFFICIENT

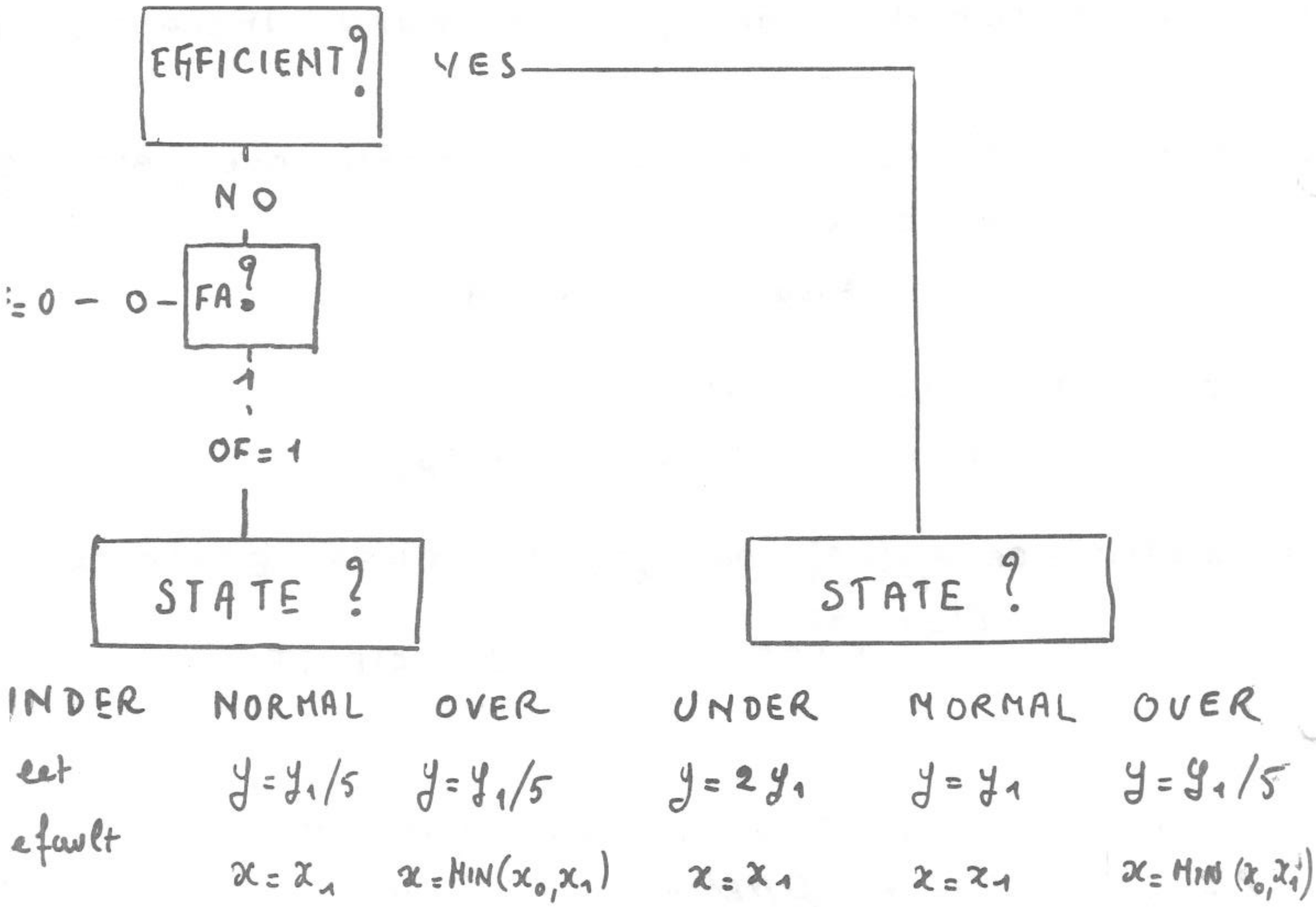
Assuming that parallaxes are not requested for some stars (PMO *)

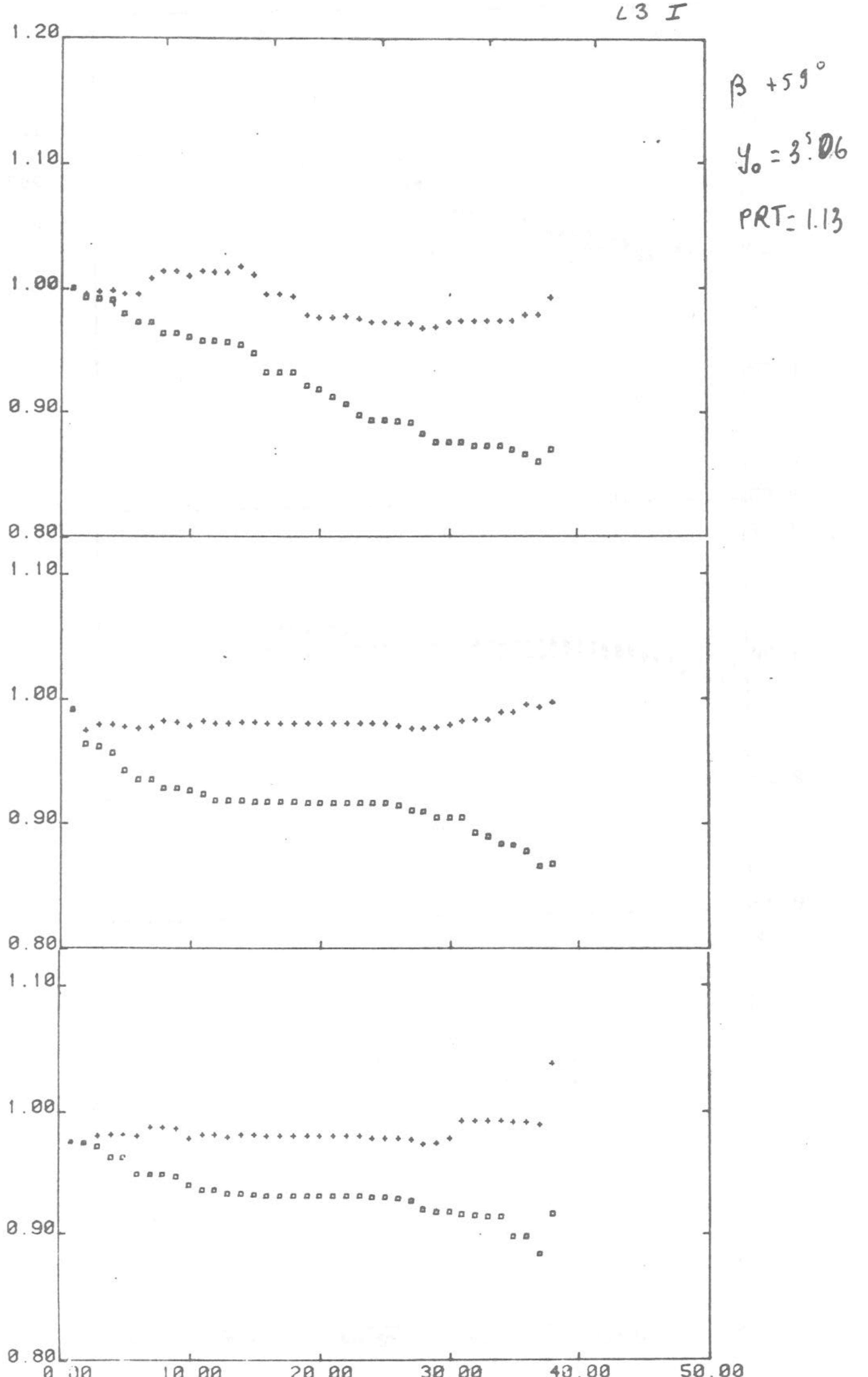
ε'_1 and ε''_1 are set to arbitrarily large values so that $r_1 > 1 + \varepsilon'_1$ and $s_1 < 1 + \varepsilon''_1$ systematicaly

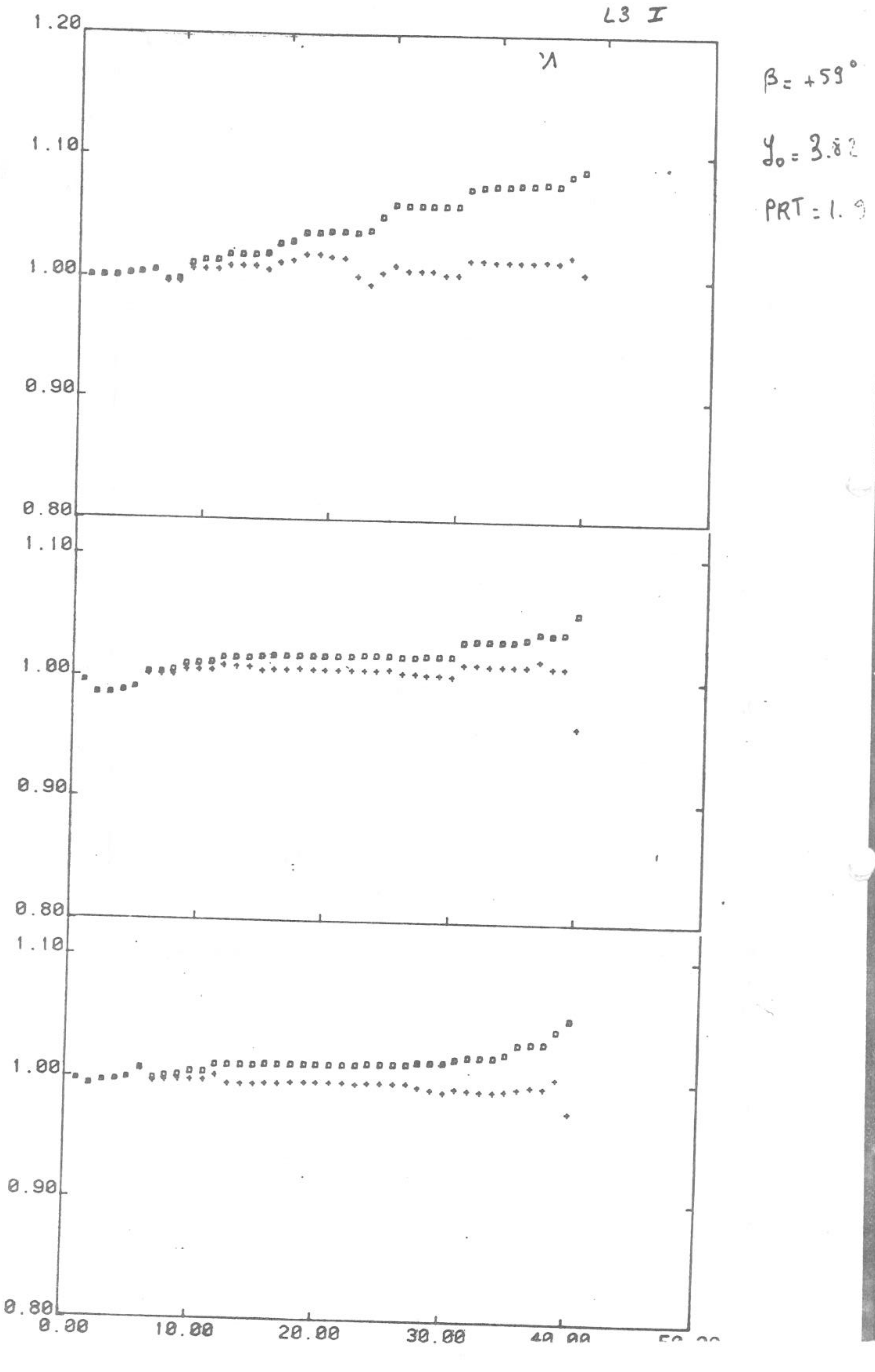
OBSERVING DECISIONS

Default values

minimum time (number of slots)	$x_1 = Max(x_0, INT(y_0/2))$
target time	$y_1 = y_0 / G_0$ $(y_0 = Tcib / N(p)(1-O_c))$
observing flag	OF = 1

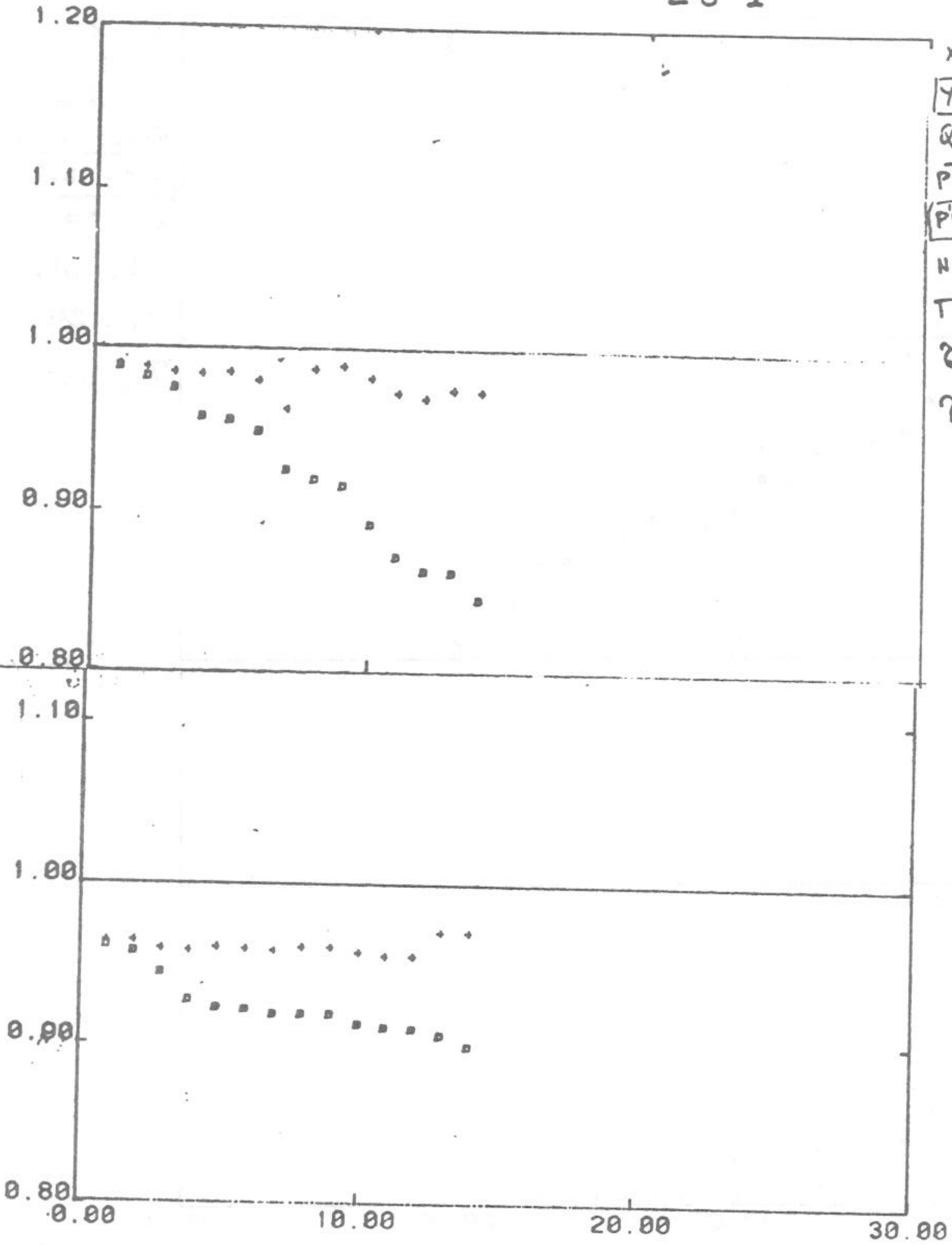



L3 I
β +59°
y_o = 3ˢ.06
PRT = 1.13
1.20
1.10
1.00
0.90
0.80
1.10
1.00
0.90
0.80
1.10
1.00
0.90
0.80
0.00
10.00
20.00
30.00
40.00
50.00


L3 I
β = +59°
y_0 = 3.82
PRT = 1.9
1.20
1.10
1.00
0.90
0.80
1.10
1.00
0.90
0.80
1.10
1.00
0.90
0.80
0.00
10.00
20.00
30.00
40.00

P = 0

L3 I



$X_0 = 1.$

$Y_0 = 6.27$

$Q_0 = 1.17$

$\overline{PR}Y_0 = 357$

$\overline{PR}T = 1.69$

N = 82

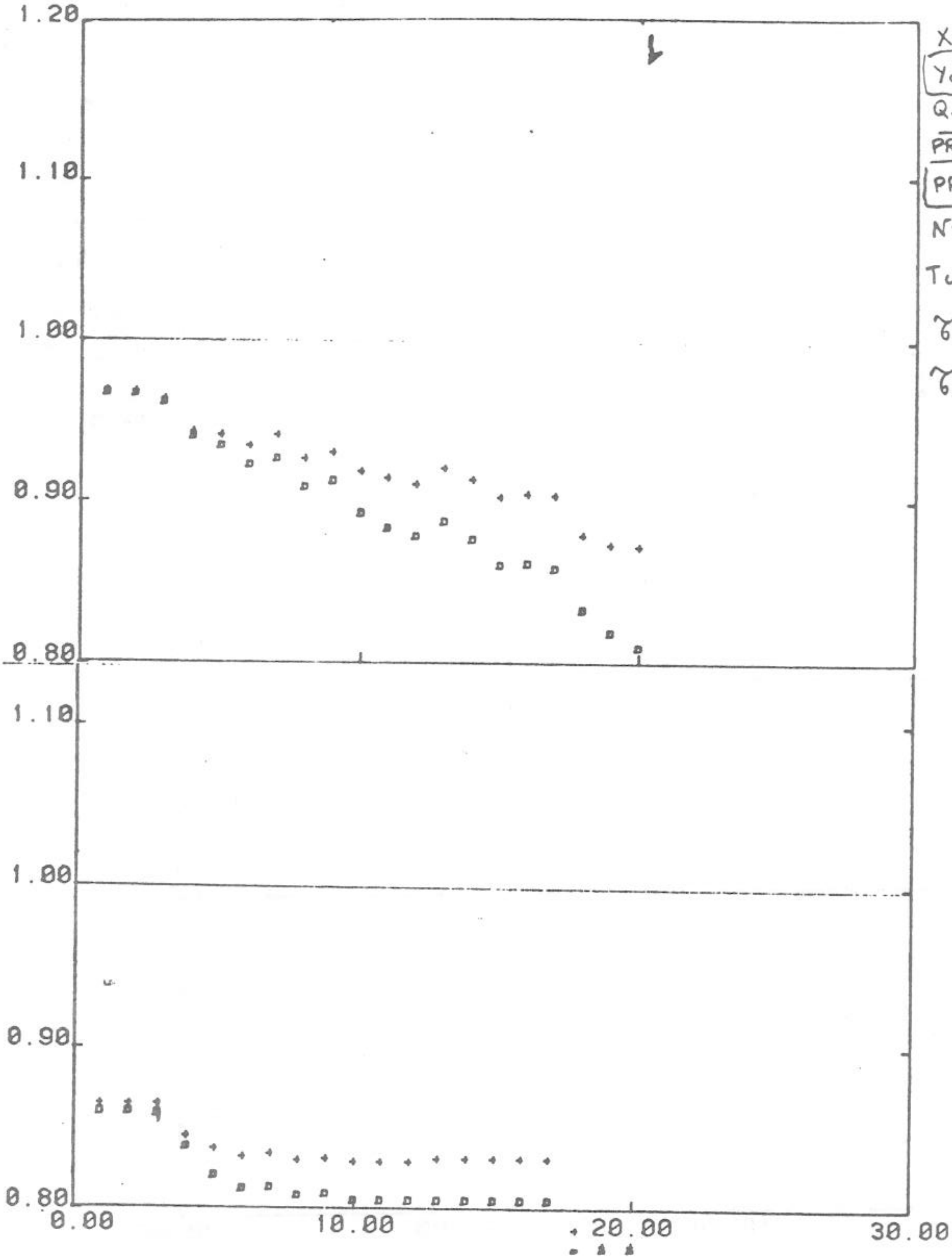
Tub = 511.

$\tau_0 = 270.$

$\tau_m = 356.$

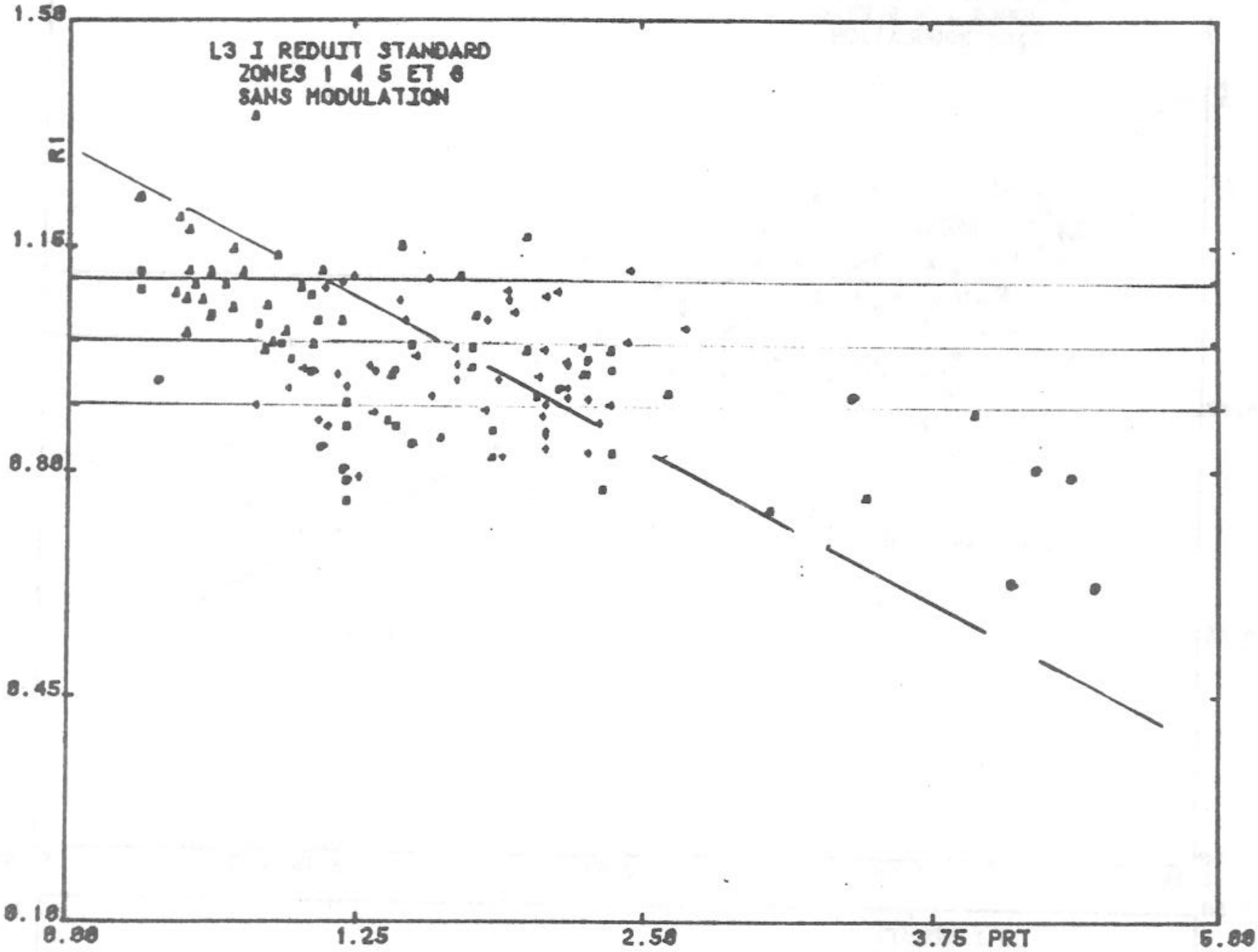
L3 I

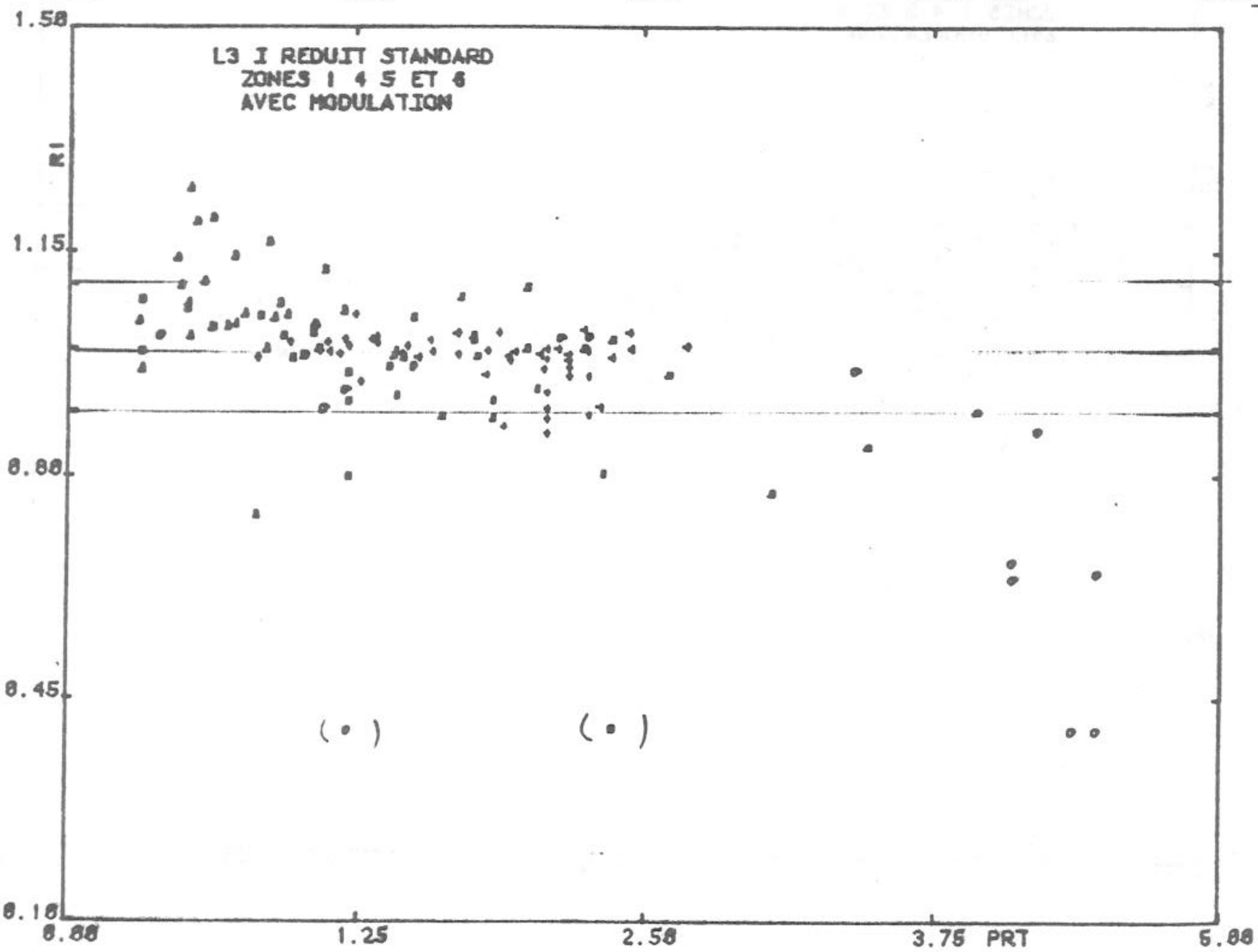
β ~ 0

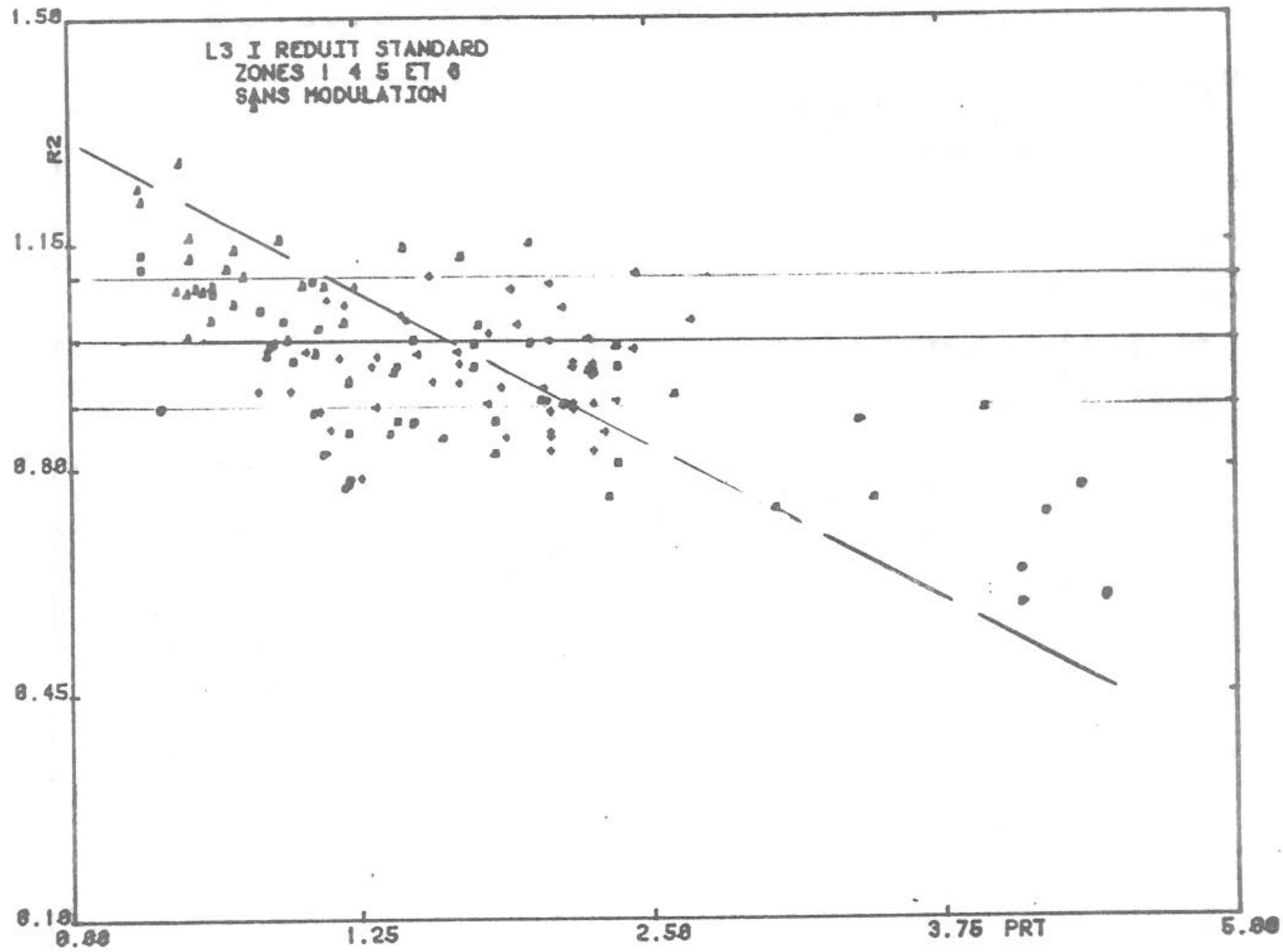


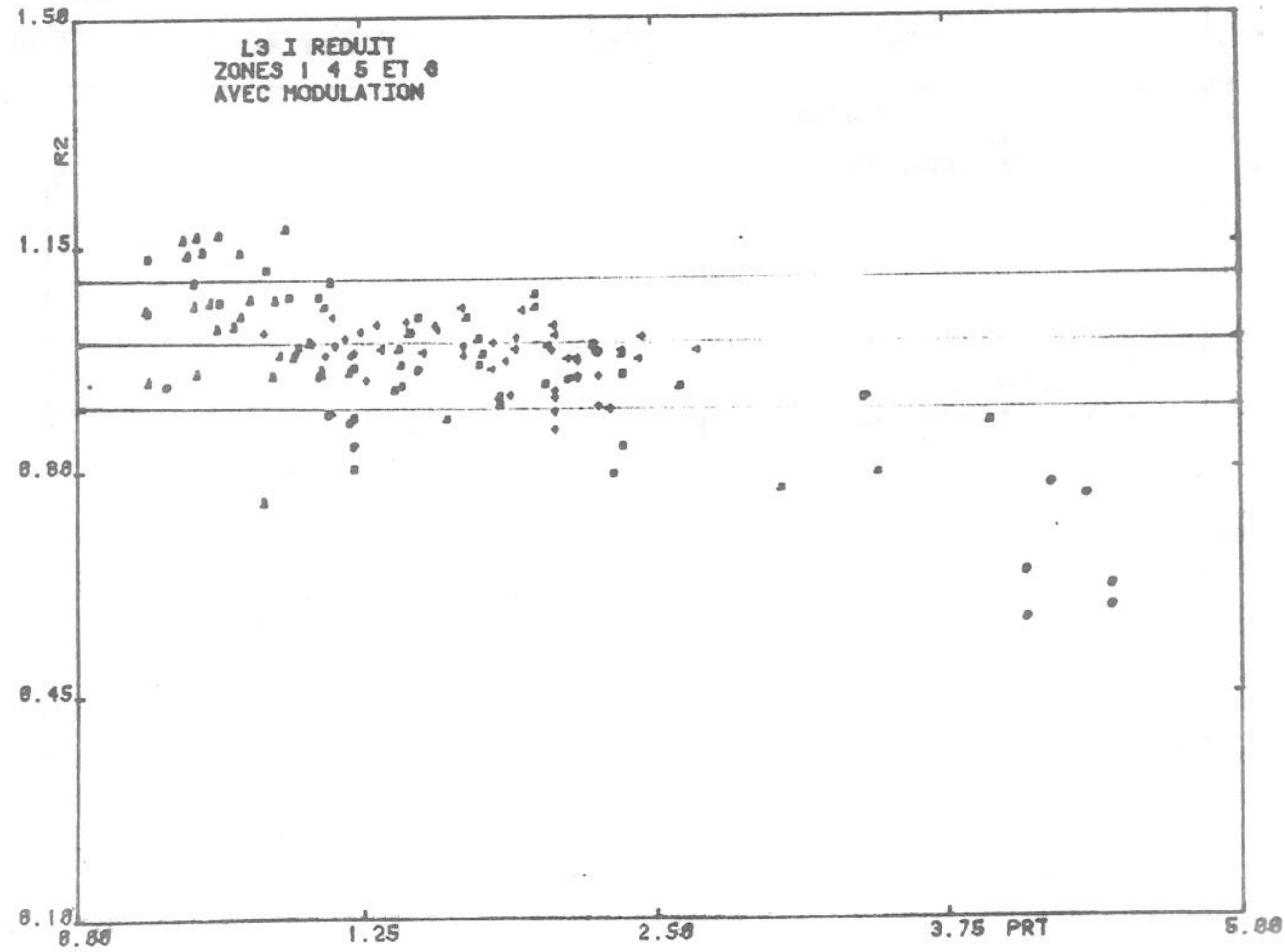
X_0 = 1.
Y_0 = 3.89
Q_0 = .67
$\overline{PRY_0}$ = 4.20
PRT = 4.20
N = 79
Tub = 465.
τ_1 = 210.
τ_m = 248.

Parallaxe Target Accuracy / Achieved / Total Pressure
in red: initial distorted response



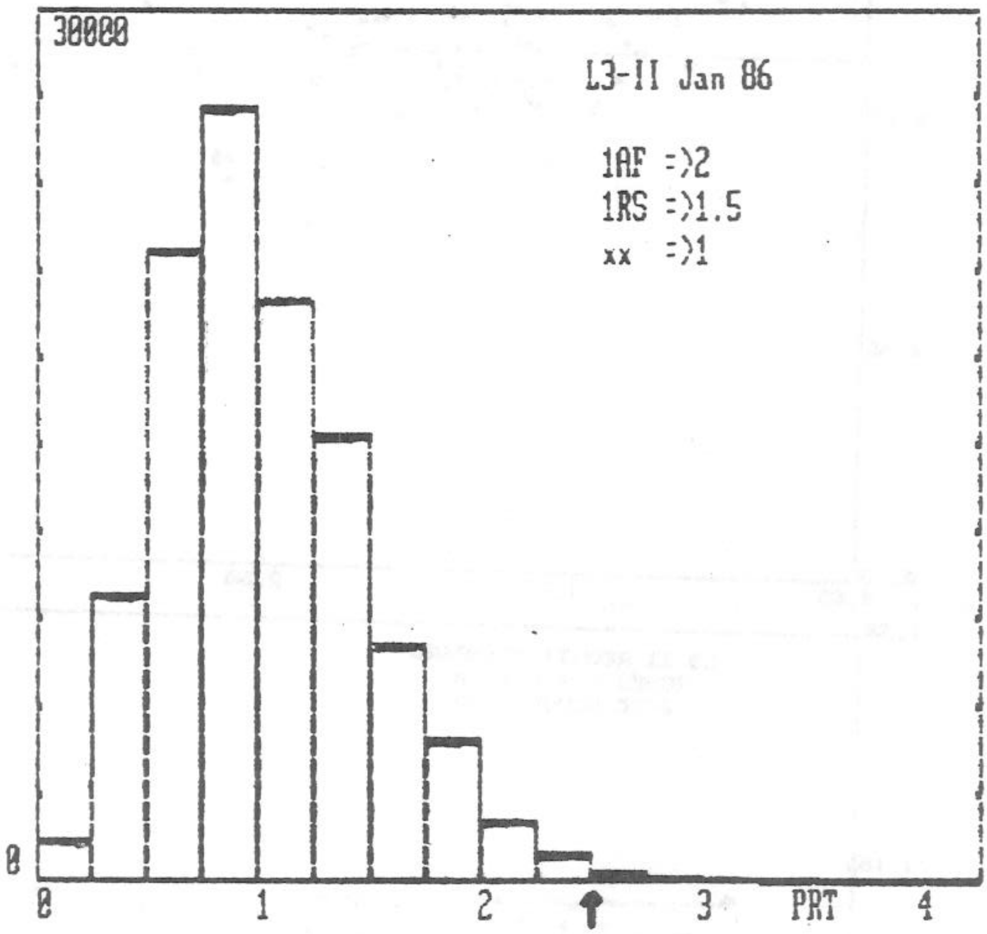



L3 I REDUIT STANDARD
ZONES 1 4 5 ET 6
SANS MODULATION
R2
1.50
1.15
0.80
0.45
0.10
0.00
1.25
2.50
3.75
PRT
5.00

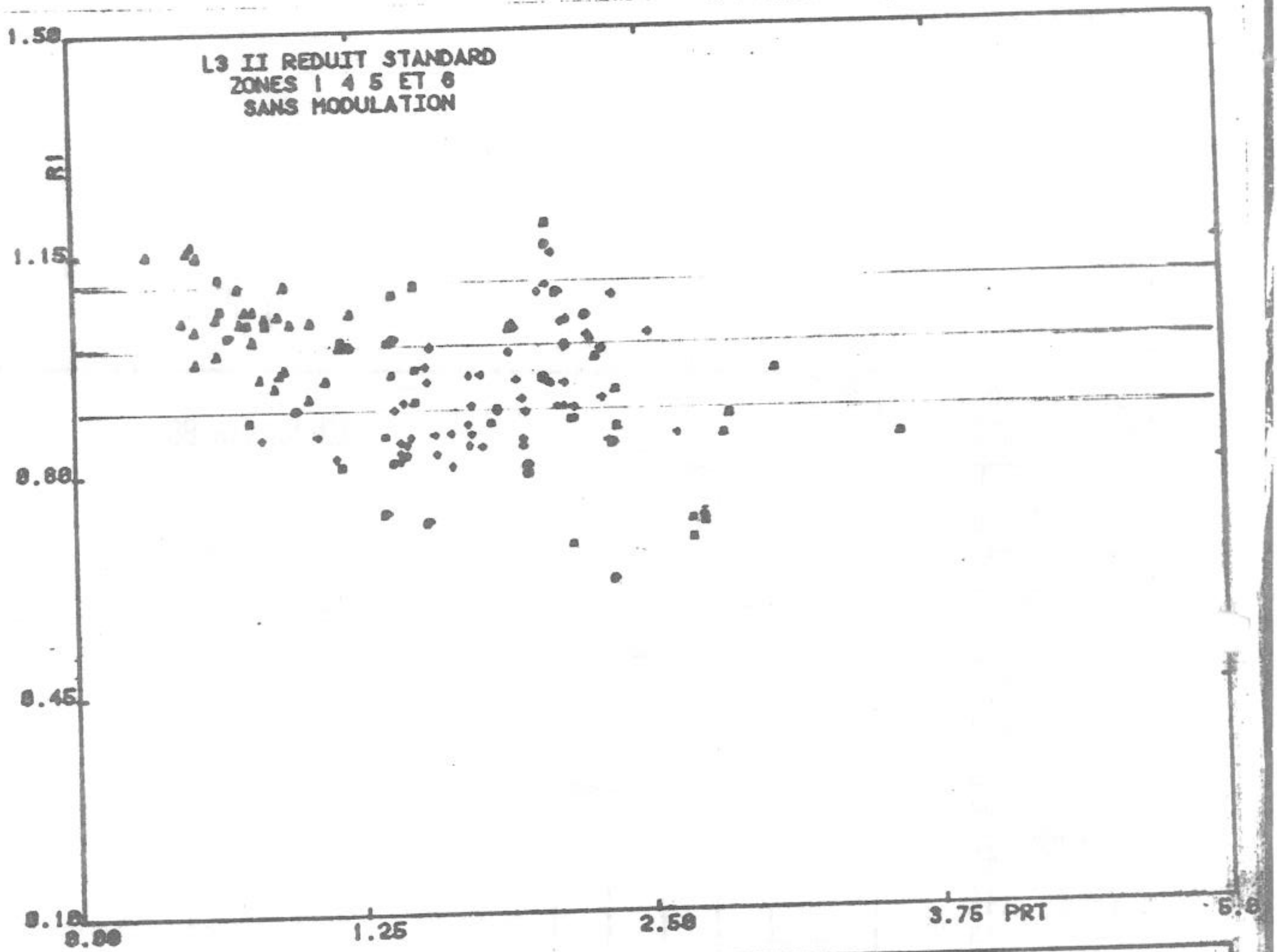

L3 I REDUIT
ZONES 1 4 5 ET 6
AVEC MODULATION
R2
1.50
1.15
0.80
0.45
0.10
0.00
1.25
2.50
3.75
PRT
5.00

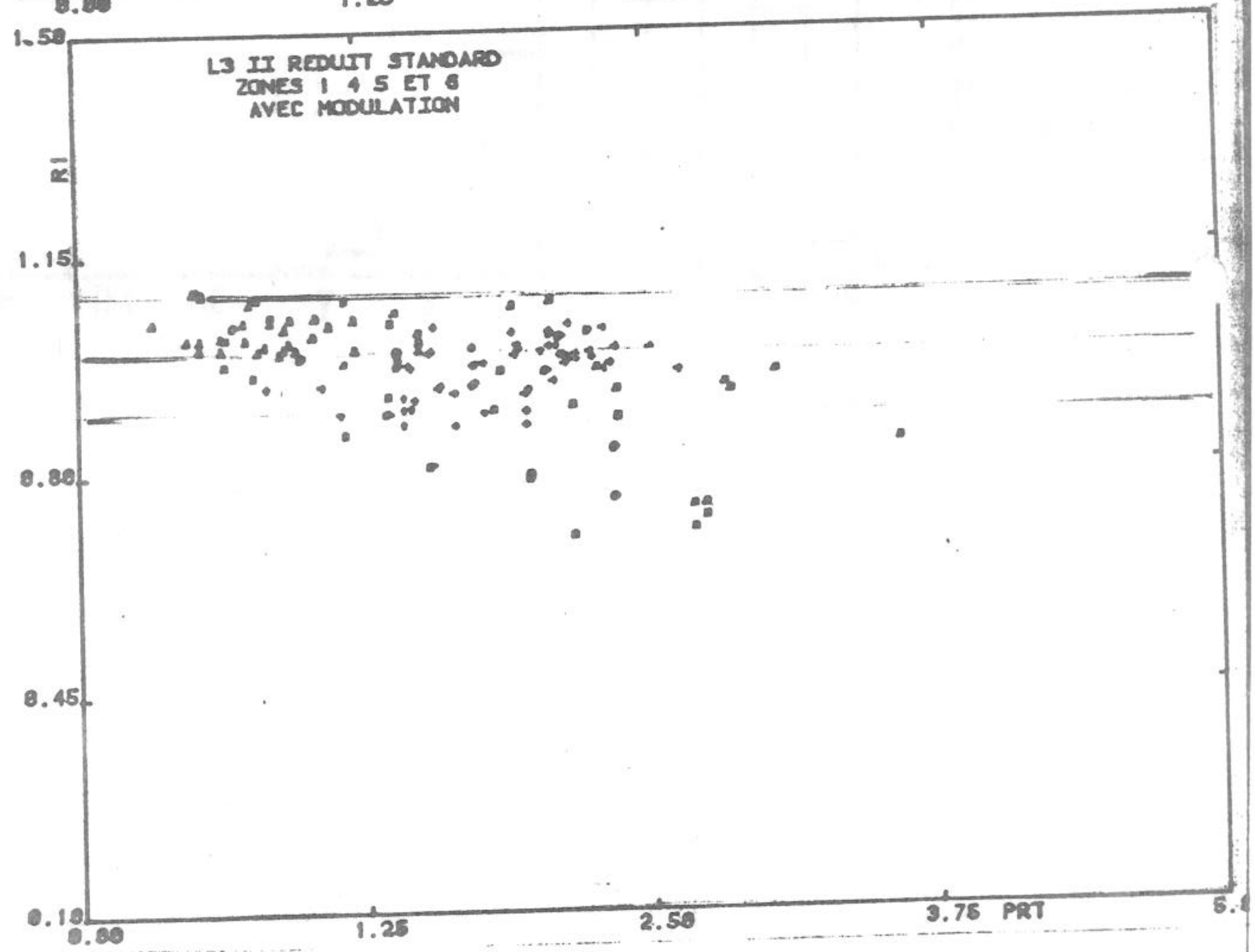
Ntot = 111976

PRT	N
<.25	1470
	9878
	21718
.75-1	26622
	20083
	15366
	8113
1.75-2	4977
	2166
	990
→	341
2.75-3	141
	63
	28
	11
3.75-4	2
	7



π



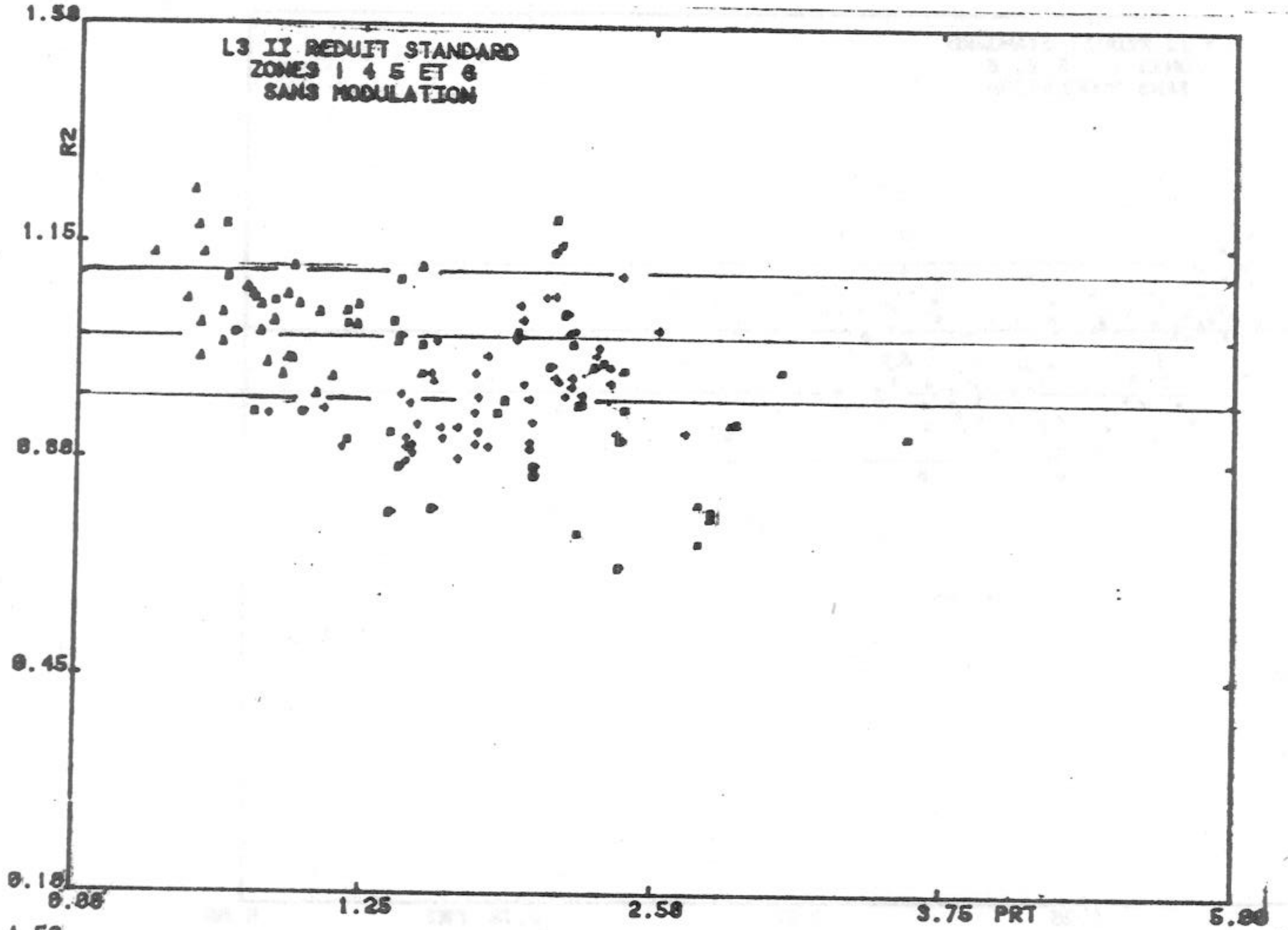


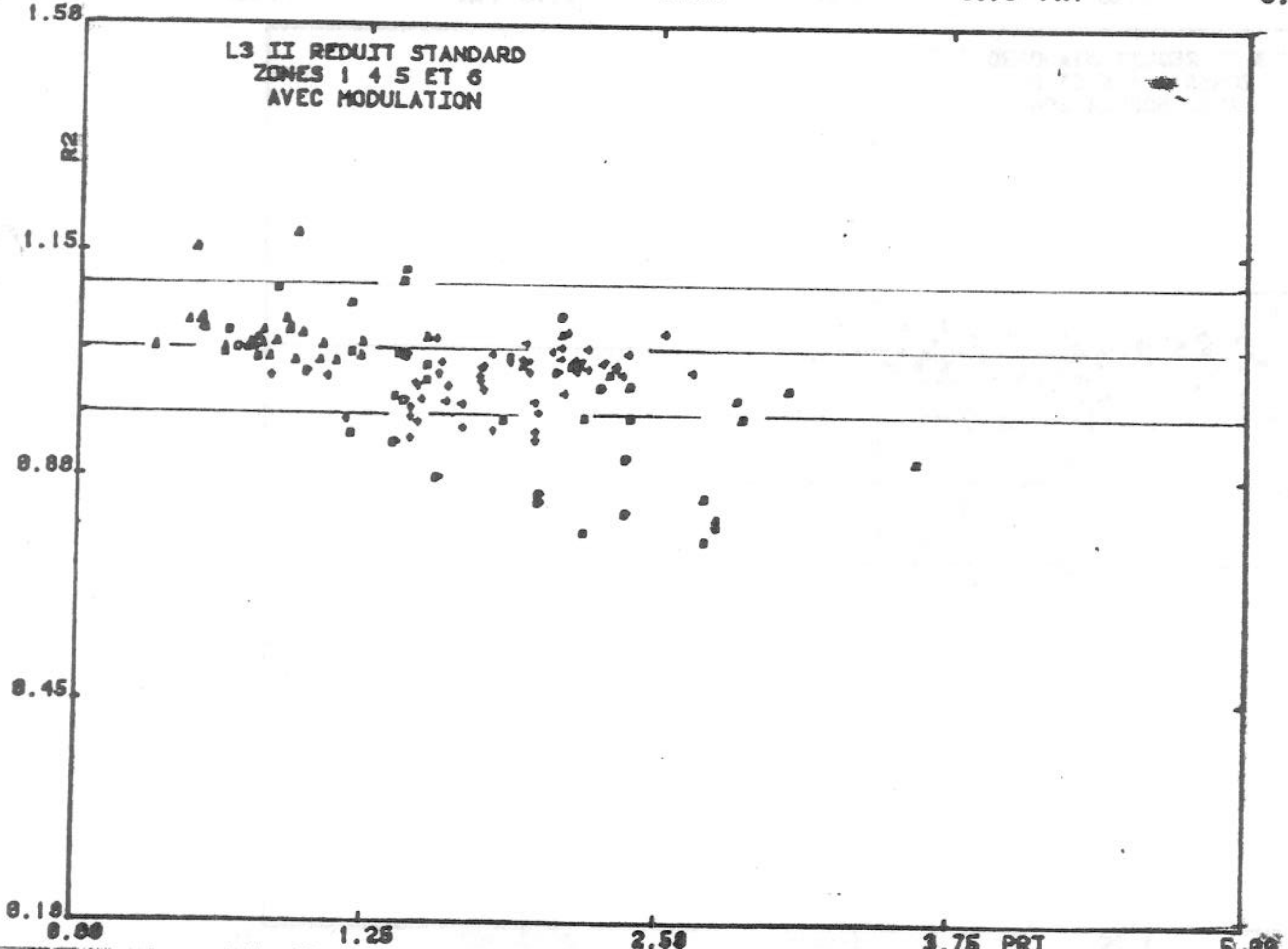
FOLD

TEKTRONIX,INC.
PA 10.006-2410-00

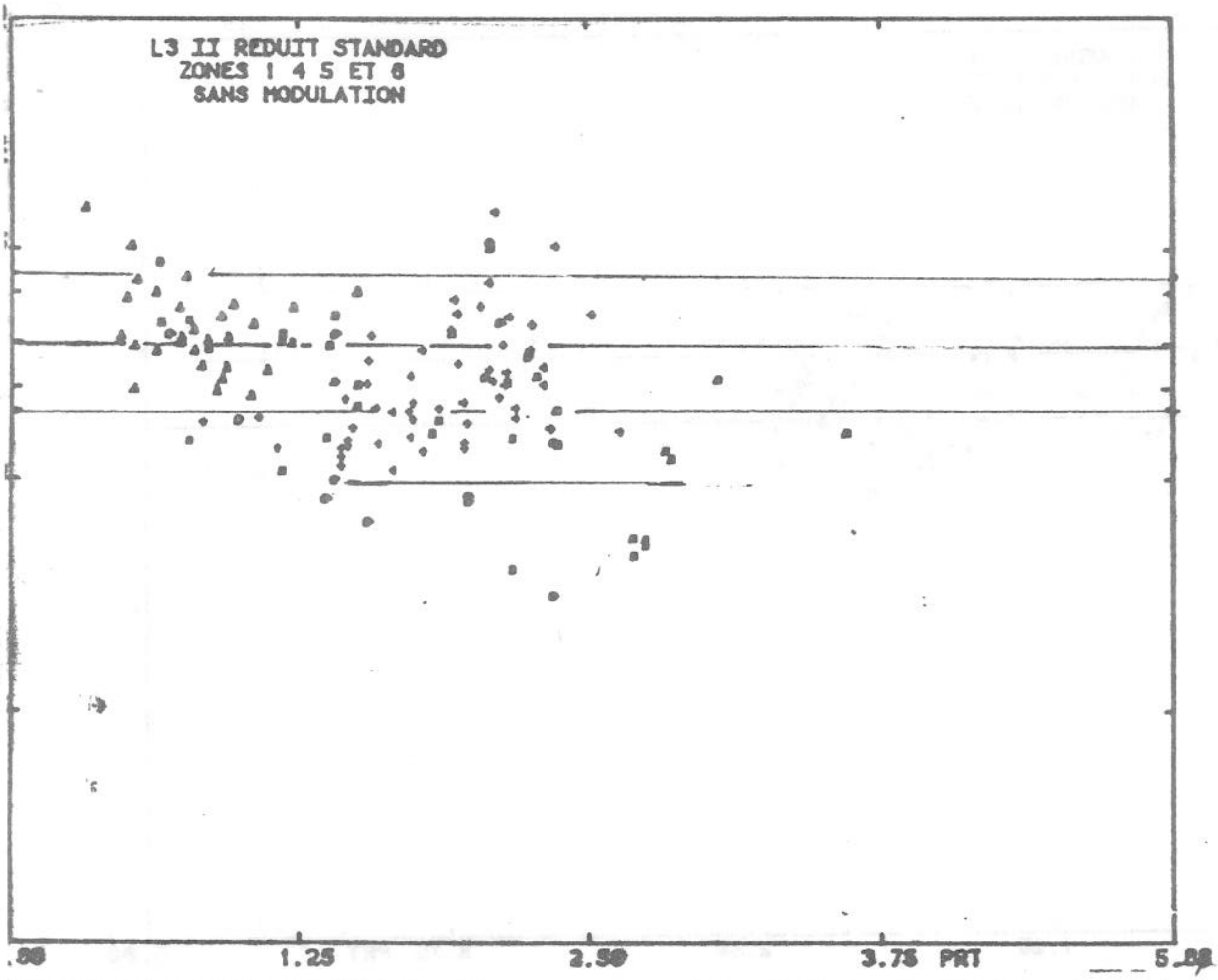
FOLD

μ_λ

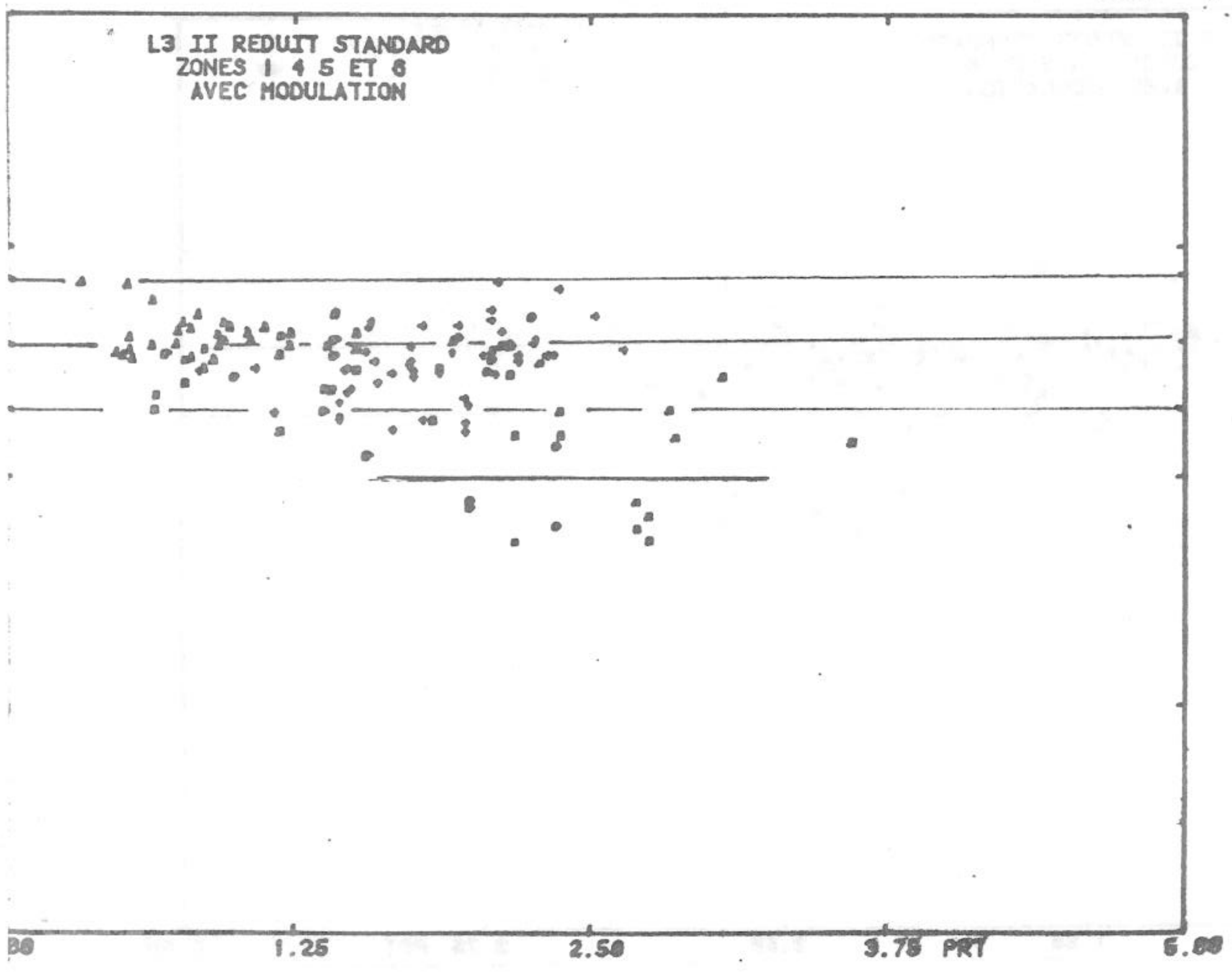

L3 II REDUIT STANDARD
ZONES 1 4 5 ET 6
SANS MODULATION
R2
1.58
1.15
0.88
0.45
0.18
0.00
1.25
2.50
3.75 PRT
5.00


L3 II REDUIT STANDARD
ZONES 1 4 5 ET 6
AVEC MODULATION
R2
1.58
1.15
0.88
0.45
0.18
0.00
1.25
2.50
3.75 PRT
5.00

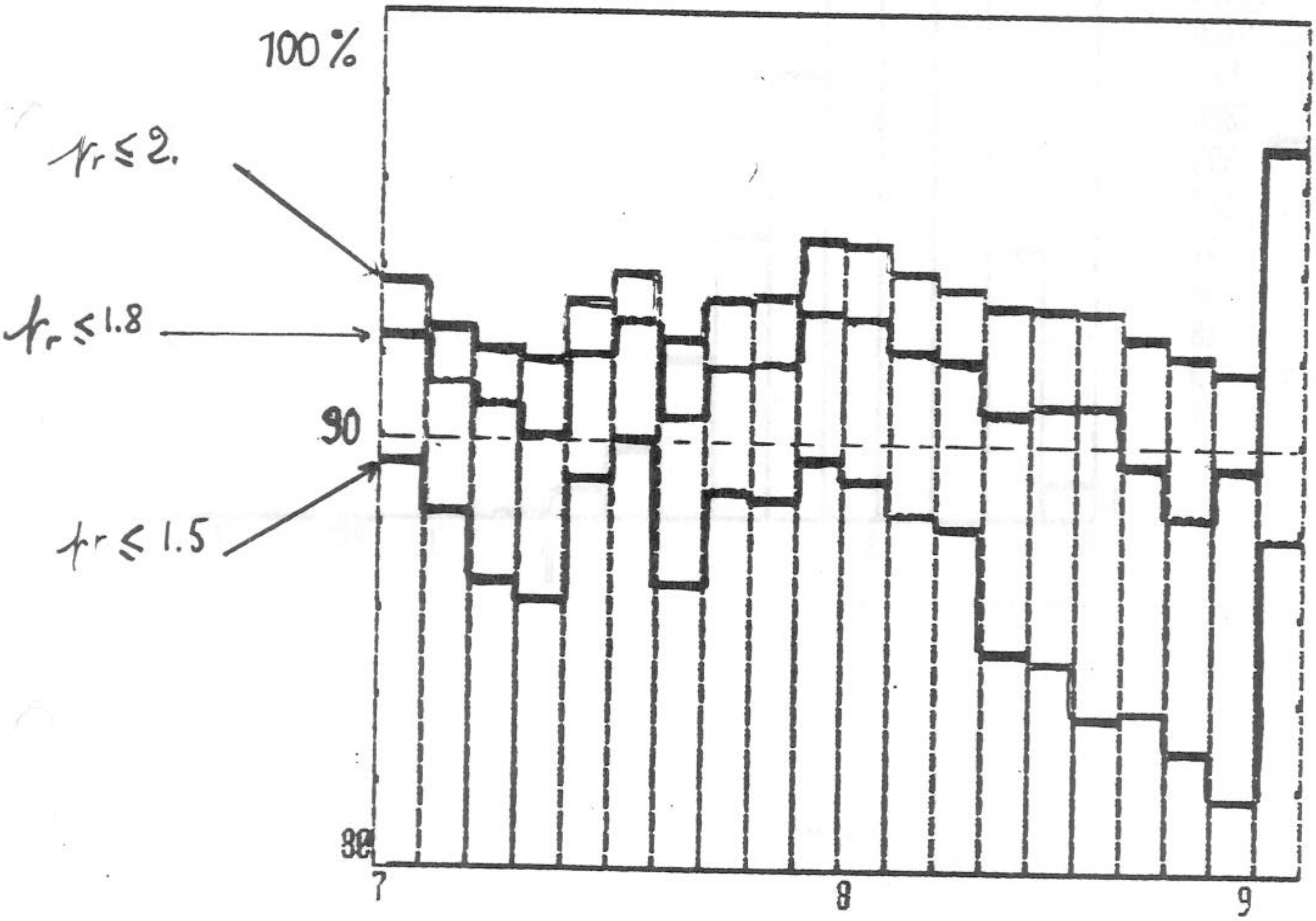
μ_β



L3 II REDUIT STANDARD
ZONES 1 4 5 ET 6
SANS MODULATION
.00
1.25
2.50
3.75 PRT
5.00



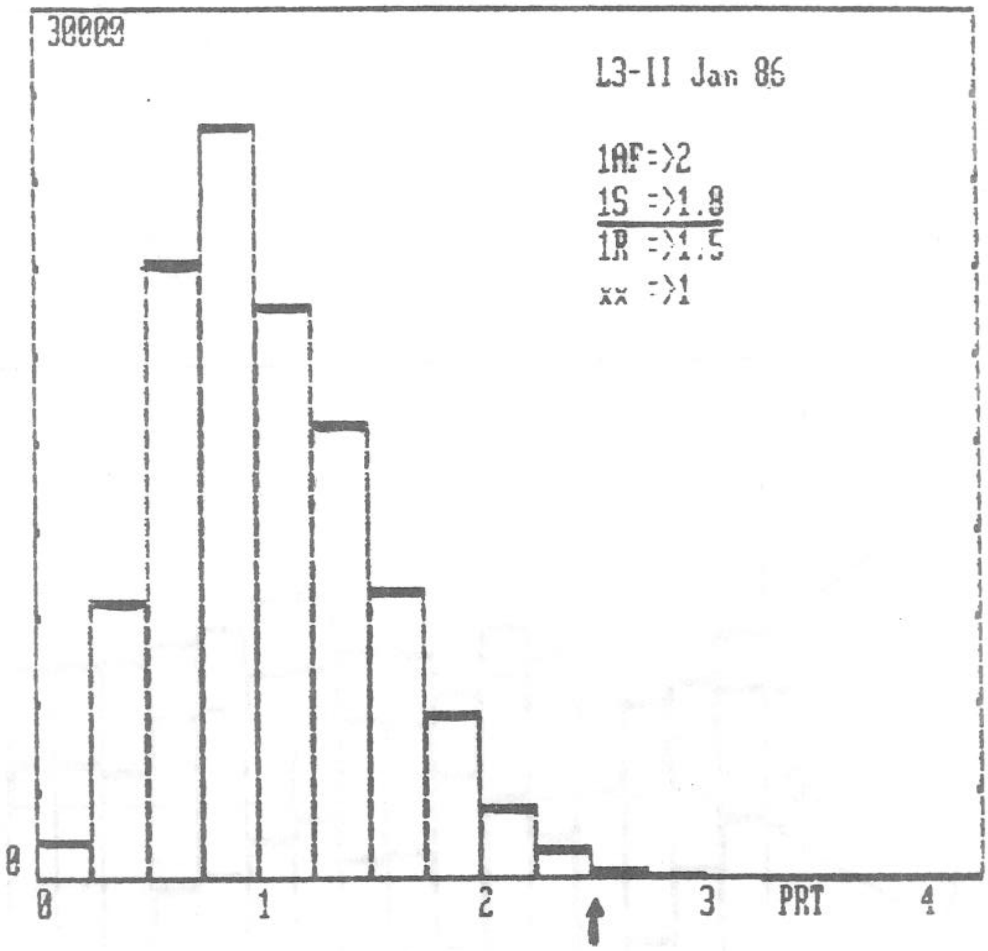
L3 II REDUIT STANDARD
ZONES 1 4 5 ET 6
AVEC MODULATION
.00
1.25
2.50
3.75 PRT
5.00



survey completness

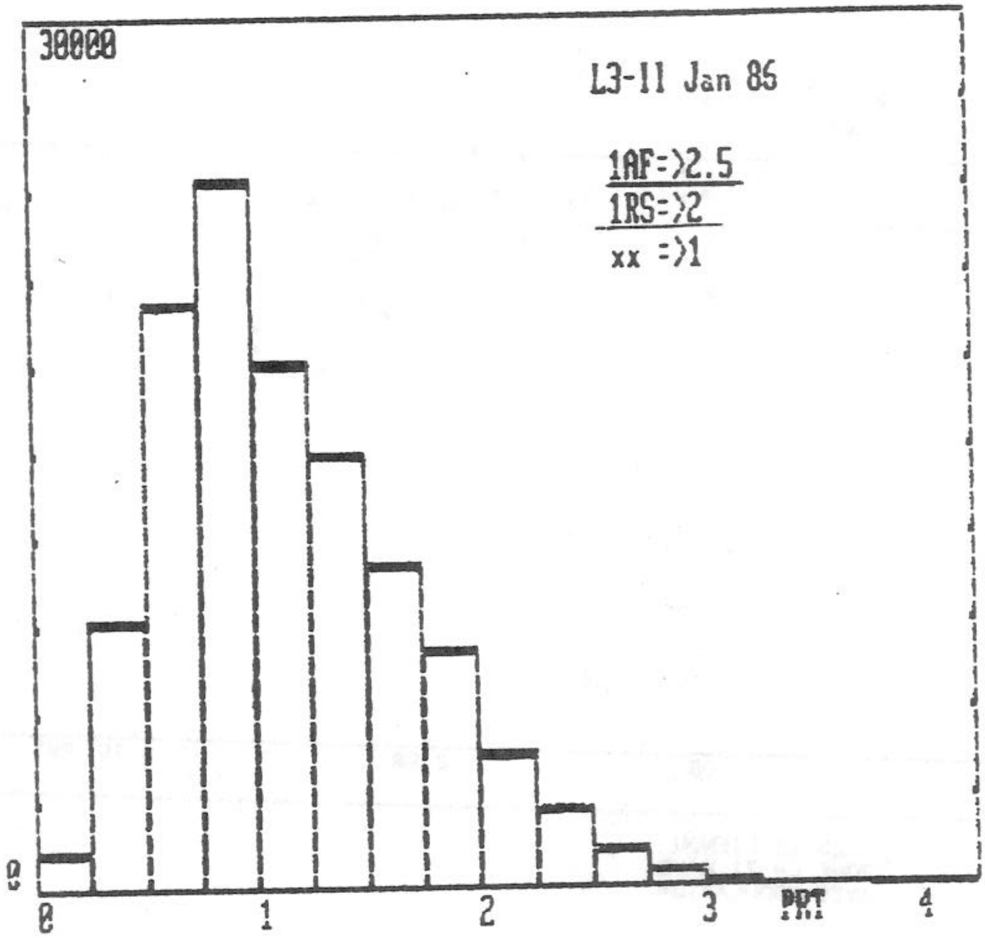
Ntot = 113956

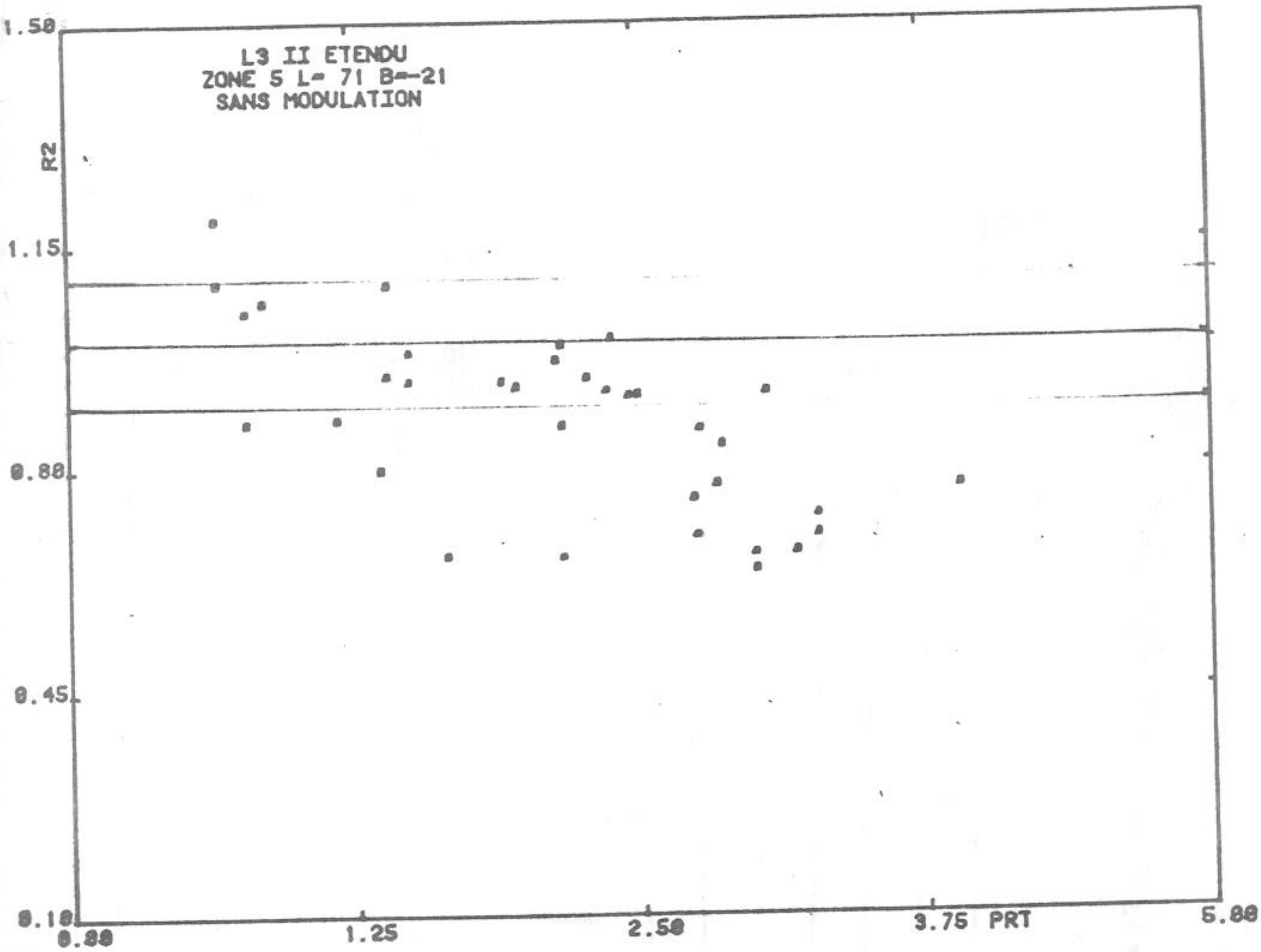
PRT	N
<.25	1446
	9622
	21248
.75-1	26003
	19799
	15777
	10012
1.75-2	5720
	2565
	1086
→	393
2.75-3	162
	67
	36
	10
3.75-4	3
	7

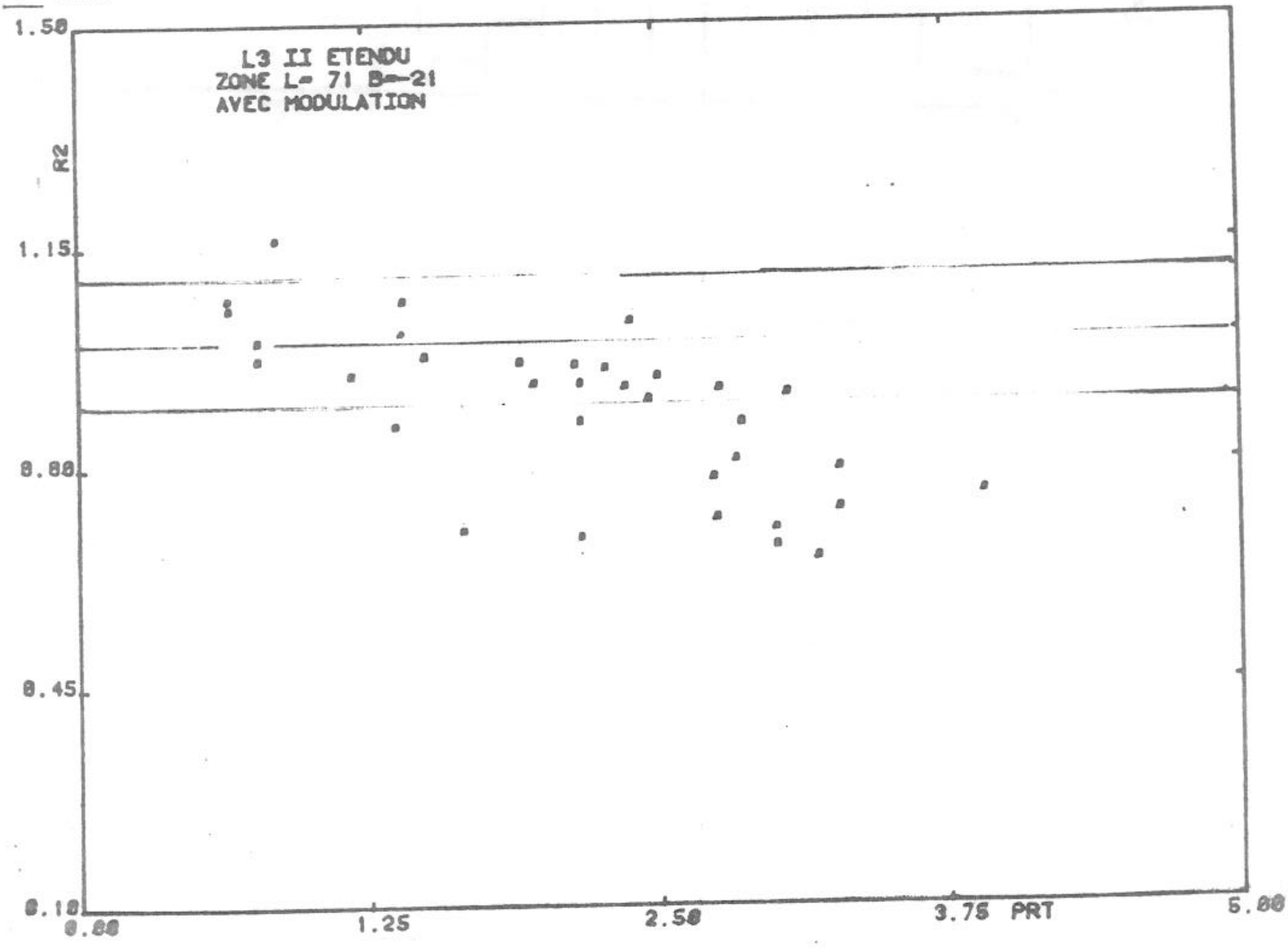


Ntot = 118119

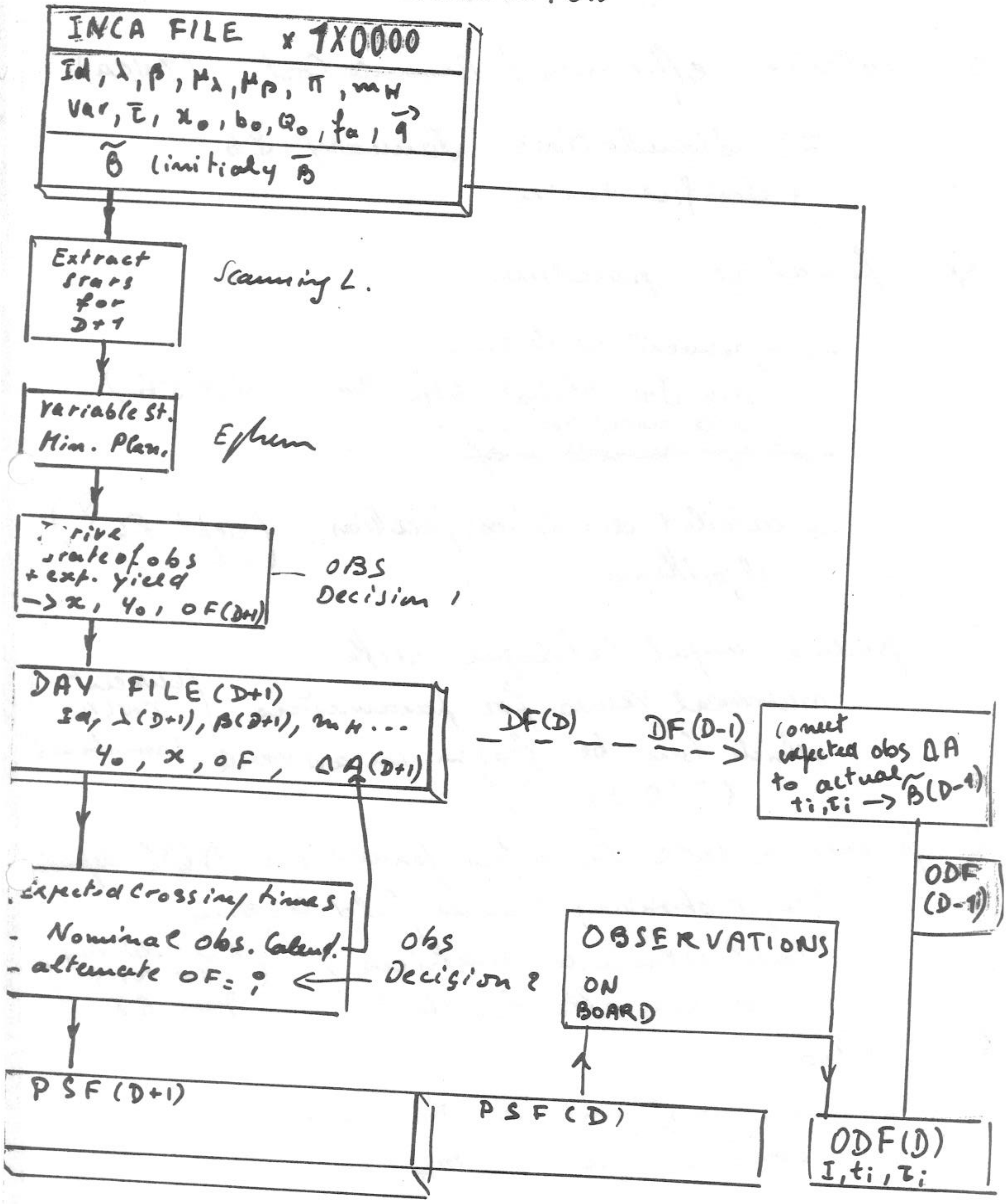
PRT	N
<.25	1401
	9240
	20240
.75-1	24484
	18175
	15825
	11136
1.75-2	8258
	4715
	2791
	1380
2.75-3	687
	319
	139
	66
3.75-4	28
	35




L3 II ETENDU
ZONE 5 L= 71 B=-21
SANS MODULATION
R2
1.50
1.15
0.80
0.45
0.10
0.00
1.25
2.50
3.75 PRT
5.00


L3 II ETENDU
ZONE L= 71 B=-21
AVEC MODULATION
R2
1.50
1.15
0.80
0.45
0.10
0.00
1.25
2.50
3.75 PRT
5.00

PSF PRODUCTION



.. Deliver a clarified version of reference document (UCC 03)

NEXT STEPS

1/ balance efficiency / Ressource Cost (INCA)

=> Simulations January 86
+ Clarified version

2/ finalize procedure

-> agreement with ESOC
and on global Algorithm (Mid 86)
file description ...
~~-> rough description of~~

-> detailed description peculiar algorithms (Sept. 86 ?)

3 produce input Catalogue with numerical values for parameters which can be frozen in advance (PMO stars ?) (Current INCA Commitment)

4 produce a code for other parameters NDC dependent
(target observing time per field crossing
target covariance matrices) (first delivery for tests Jan 87)
(to be run after launch).

5 Expected
- final constraints on minimum observing times $x_0(m_H)$
- Comments, questions about proposed procedure
- check of possible interactions with
other ...

ANNEX XI

(Plan issued Feb. 28, Høg/Grewing)

Distribution: Egret, Kovalevsky, Bastian, Maluck, Scales, Perryman, Stewart

TDAC Simulati[on]

1986: March | April | May | June | July | August | September | October | November | Dec

next TDAC meeting 07.10/11 (July)

LEGEND:
PS = Prototype Software
PD = Prototype Data/Catalogue
FS = Final Software
FD = Final Data

DATA STREAM 3 (TBD) to include larger intervals of photon counts, real attitude, etc. using TBD

DATA STREAM 1

FAST SM counts, (20 hours)
Input Catalogue + attitude (from FAST) — 03.01 FAST Catalogue (with PGCs) to AIT

Detection/Estimation (Scales/Maluck) AIT
- prepare CUO s/w to read FAST data tape, etc. — 04.01 I/O
- derive raw transits/improve s/w using FAST data — 07.01 PS PD raw transits in EH format + Report (including timing/resources)

Photometry (Scales) AIT
- validate/prepare CUO Calib, s/w with present observation eqns or modified eqns
- derive calibration parameters/identify 10% standard stars
  + photometric catalogue
  + comparison with input Catalogue

— 10.01 PS; PD Photometry + report (including timing/resources)

Identification + Astrometry (TBD)

DATA STREAM 2

STGSSS Catalogue test area (Egret CDS)
- SIMBAD link
- redundancy elimination
- statistics of star density

— 06.01 PD

- Simulation at higher star density (i.e. real), linear attitude motion (Kovalevsky?) — 06.01 TO ARI

Preparation of Prediction s/w (Bastian, ARI) — PS

PGC generation (using linear attitude motion)
Preliminary assessment of timing/tape handling — 1 month; 07.01 PD PGC predictions to AIT + report

Detection/Estimation to determine raw transits — 10.01 PD

Photometry (Cal. Parameters + photom. cat. + comparison with INCA). — 12.01 PD Photometry + Report

ANNEX XII

…erwaal, va[illegible], v Daalen
(Delft)

19.03.86-1

ACCURACY OF STAR ABSCISSAE

(Simulation studies Reduction on Circles)

A. INCREASING NUMBER OF STARS

B. VARIABLE STAR DENSITY

A. Distinguish : increase

- at all magnitudes proportionally

<u>code : P</u>

- at magnitude 9 exclusively

<u>code : 9</u>

A&B. Distinguish :

- geometrical attitude

<u>code : G</u>

- smoothed attitude

<u>code : S</u>

19.6.86-2

SUMMARY EARLIER RESULTS (Copenhaguen)

1 SCANNING CIRCLE 800 ** /circle
= 100,000 /sphere

+ 50% = 1200 ** /circle
150,000/sphere

GEOMETRIC MODE ONLY

(mas)		800	1200 (+ mag 9)	1200 (prop.)
overall	σ	7.00	7.39	8.01
	$\sigma_{mag\ 9}$	6.22	6.64	6.97
	rigidity	2.6	2.4	2.3

(mas)	800	1200 (+9)	1200 (P)
mag 8	6	6	7
9	6	7	7
10	7	7	8
11	8	9	9
12	11	12	13

CONCLUSION: INCREASING THE CATALOGUE DOES LITTLE HARM (GEOMETRIC MODE)

19.3.86.3

SUMMARY EARLIER RESULTS

(Copenhaguen) (Dwingeloo)

1 SCANNING CIRCLE

	sphere:	100000	120,000	150000	200000
	code	OVERALL ACCURACY (σ (mas))			
		800	960	1200	1600
geom	GP	7.	7.2	8	8.3
smooth	SP	5.5	6.1	6.9	7.4
	Gg	7.	6.9	7.4	7.4
	Sg	5.5	5.9	6.3	6.4

code: Sg (smooth + mag.g)

σ (mas)		800	960	1200	1600
mag	9	4.5	4.8	5.2	5.6
	10	5.3	5.9	6.4	6.8
	11	6.9	7.9	8.4	8.8
	12	9.8	11.0	12.3	12.8

CONCLUSION: WITH SMOOTHING OF ATTITUDE INCREASING THE CATALOGUE DOES MORE HARM THAN WITHOUT SMOOTHING

19.3.86.4

NEW RESULTS :

5 SCANNING CIRCLES

2400 SIMULATED STARS =
1600 OBSERVED STARS = 87%
87,000 ** /sphere

2880 STARS — 104,000 /sphere 104%
3600 STARS — 130,500 /sphere 130%

OVERALL σ (MAS)

	87%	104%	130,5%	
GP	5,0	5.0	5.2	+4%
SP	4.0	4.2	4.7	+12%
Gg	5.0	4.7	4.7	(!) -6%
Sg	4.0	4.0	4.2	+5%

GEOMETRIC P/g

(MAS)	87%	104%	130.5%	
8	3.7	3.6/3.5	3.5/3.5	-5%
9	4.2	4.0/3.9	[illegible]/3.9	-4%
10	4.7	4.6/4.6	4.7/4.7	0
11	5.9	6.1/5.9	6.3/6.2	+5%
12	8.4	8.6/8.5	8.9/8.6	+6%

SMOOTHING P/g

(MAS)	87	104	130	+%
8	2.2	2.4/2.3	2.4/2.4	9
9	2.8	2.9/2.9	3.2/3.1	14
10	3.6	3.8/3.8	4.1/4.1	14
11	5.2	5.4/5.2	6.2/6.2	19
12	8.0	8.2/8.2	8.9/8.6	10

CONCLUSION : WITH MORE CIRCLES THE RESULTS LOOK BETTER AGAIN

WORK LOAD WITH HIGHER DENSITIES

	87 %	104 %	130 %
NORMAL EQU.	14	17	21
CHOLESKI	8	17	33
SOLUTION	2	2	3
VARIANCES	23	49	96
SMOOTHING	21	22	25
TOTAL	69	108	179

CPU-seconds on IBM 3083

179 seconds ~ 6 minutes on CDC 750

CONCLUSION : CHOLESKI & VARIANCES
INCREASE RAPIDLY
BUT ARE ONLY A PART
OF THE REDUCTION

HIGHER DENSITIES LEAD TO BETTER RIGIDITY
SO, QUESTION: COULD WE TAKE LESS REVOLUTIONS IN ONE RGC, AND STILL GET GOOD RIGIDITY (AND LESS CPU-TIME)?

TYPICAL RIGIDITY, 5 CIRCLES, GEOM. V = 1.7
AND, 1 CIRCLE : 800 960 1200 1600
V = 2.6 2.5 2.4 2.1

ANSWER : NO (similar with smoothing)

B. VARIABLE DENSITY

- NOT ALL ECLIPTIC LATITUDES β ARE SCANNED AS OFTEN
- DEFINE $N(\beta)$ = NUMBER OF SCANS
- <u>IDEA</u> : TO COMPENSATE THIS BY INCLUDING MORE STARS AT β's WITH LARGER $N(\beta)$
- DENSITY : $D(\beta) \sim 1/N(\beta)$

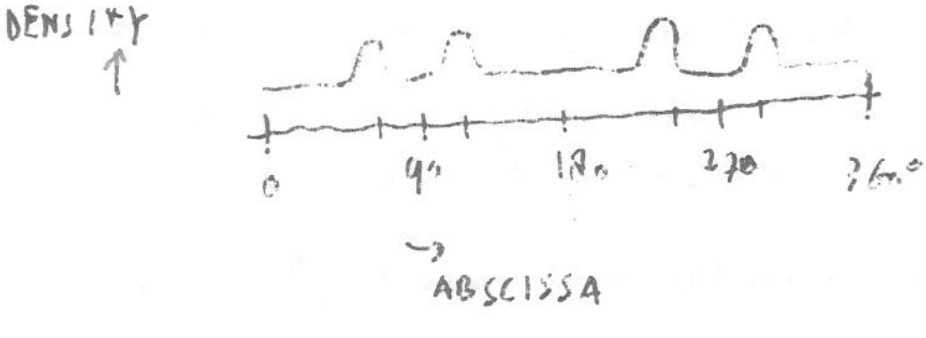
QUESTION : EFFECT OF THIS ON OVERALL ACCURACY

" " " " RIGIDITY

EXPERIMENTS : 1 CIRCLE
800 **
G̲EOMETRIC &
S̲MOOTHING

MAGNITUDE 9
STARS ONLY

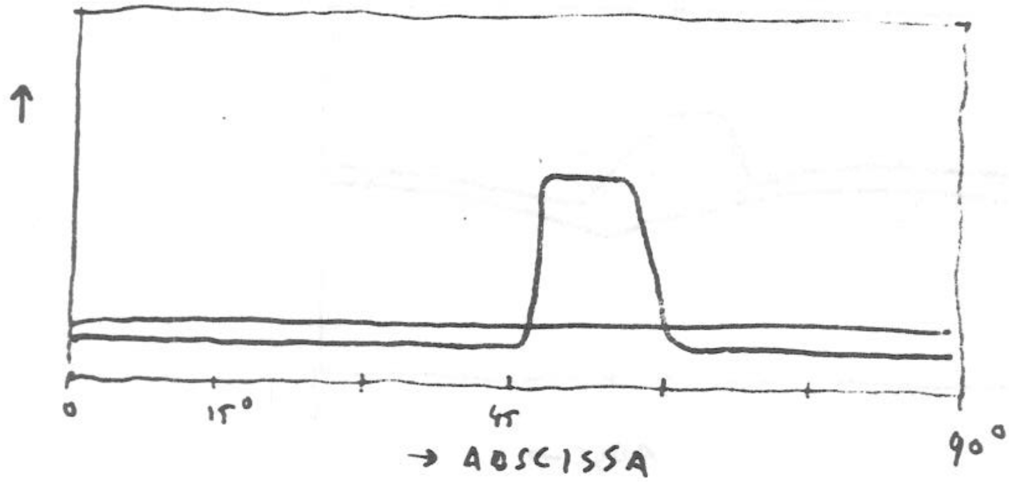
DENSITY PEAK AT 55° (ABSCISSA ON CIRCLE)
2 TIMES HIGHER THAN AVERAGE
PEAK WIDTH ~10°



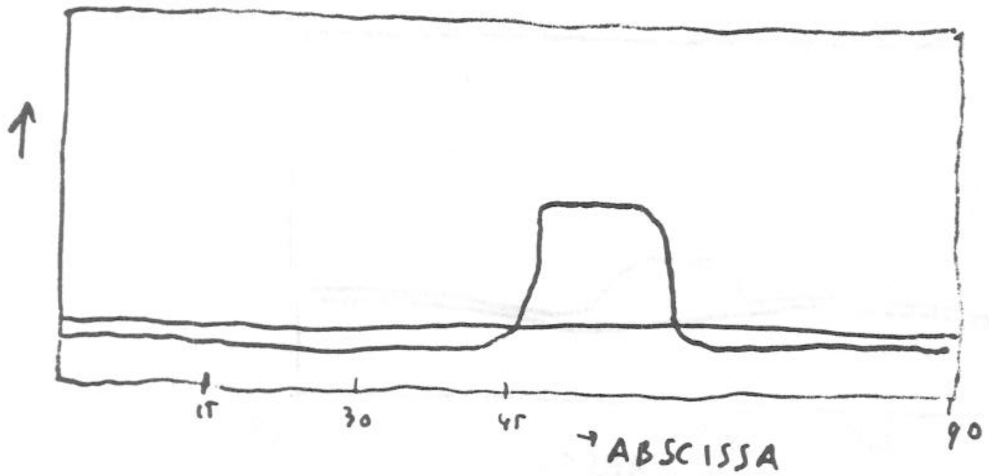
PEAK AT 55°

19.3.86.7

STARDENSITY

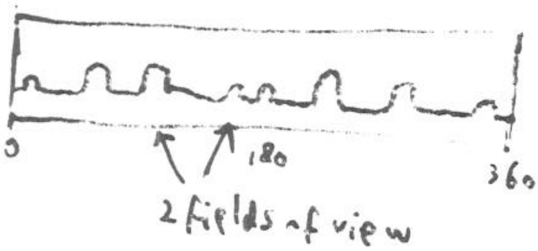


1/OBS. WEIGHT (*)



—— = constant density
▬▬ = variable density

(*) OVER THE WHOLE CIRCLE
1/OBS. WEIGHT IS
LIKE THIS



OVERALL RESULTS

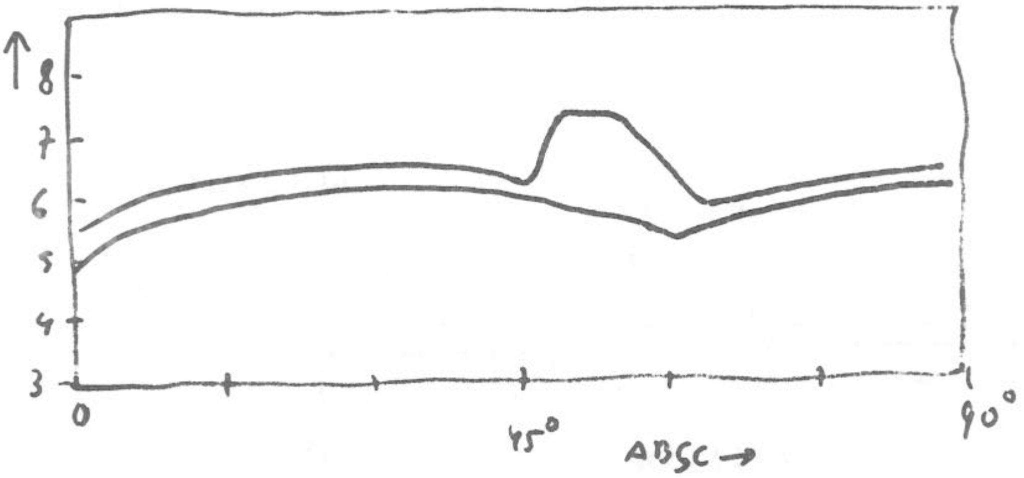
GEOM	σ (mas)	rigidity
const	5.8	4.4
var	6.4	4.2 (!)

SMOOTH	σ (mas)	rigidity
const	4.5	2.6
var	4.9	2.4 (!)

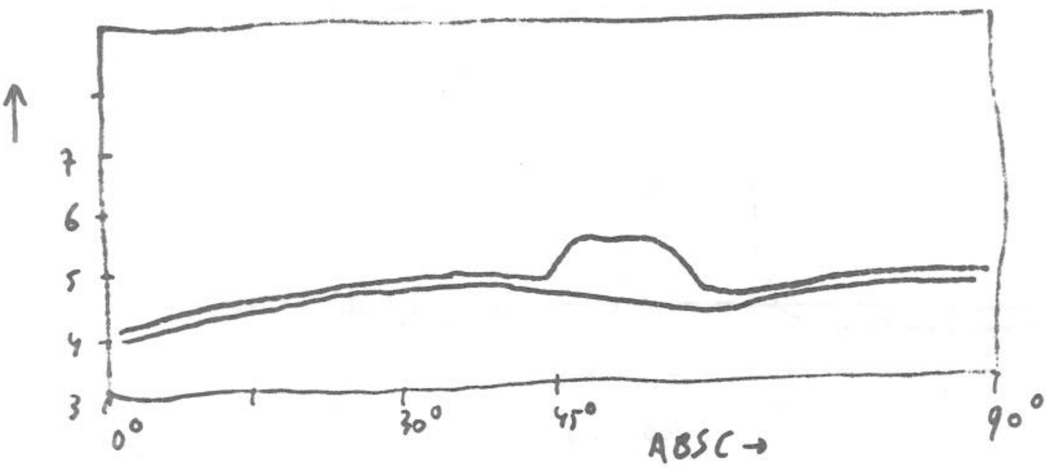
19.3.86.8

PEAK AT 55°

σ GEOM.



σ SMOOTH



— = const. dens. — = var. dens.

CONCLUSION: ① THE EFFECT REMAINS ALMOST LOCAL, IN PARTICULAR IN CASE OF SMOOTHING

② THE RIGIDITY REMAINS GOOD

ANNEX XIII

ESA ESOC

ESOC - HIPPARCOS STATUS

PRINCIPAL RECENT MILESTONES:

- MISSION IMPLEMENTATION PLAN FINALISED
- SOFTWARE REQUIREMENTS REVIEW COMPLETED
- COMPUTER CONFIGURATION DEFINED

PRESENT ACTIVITIES:

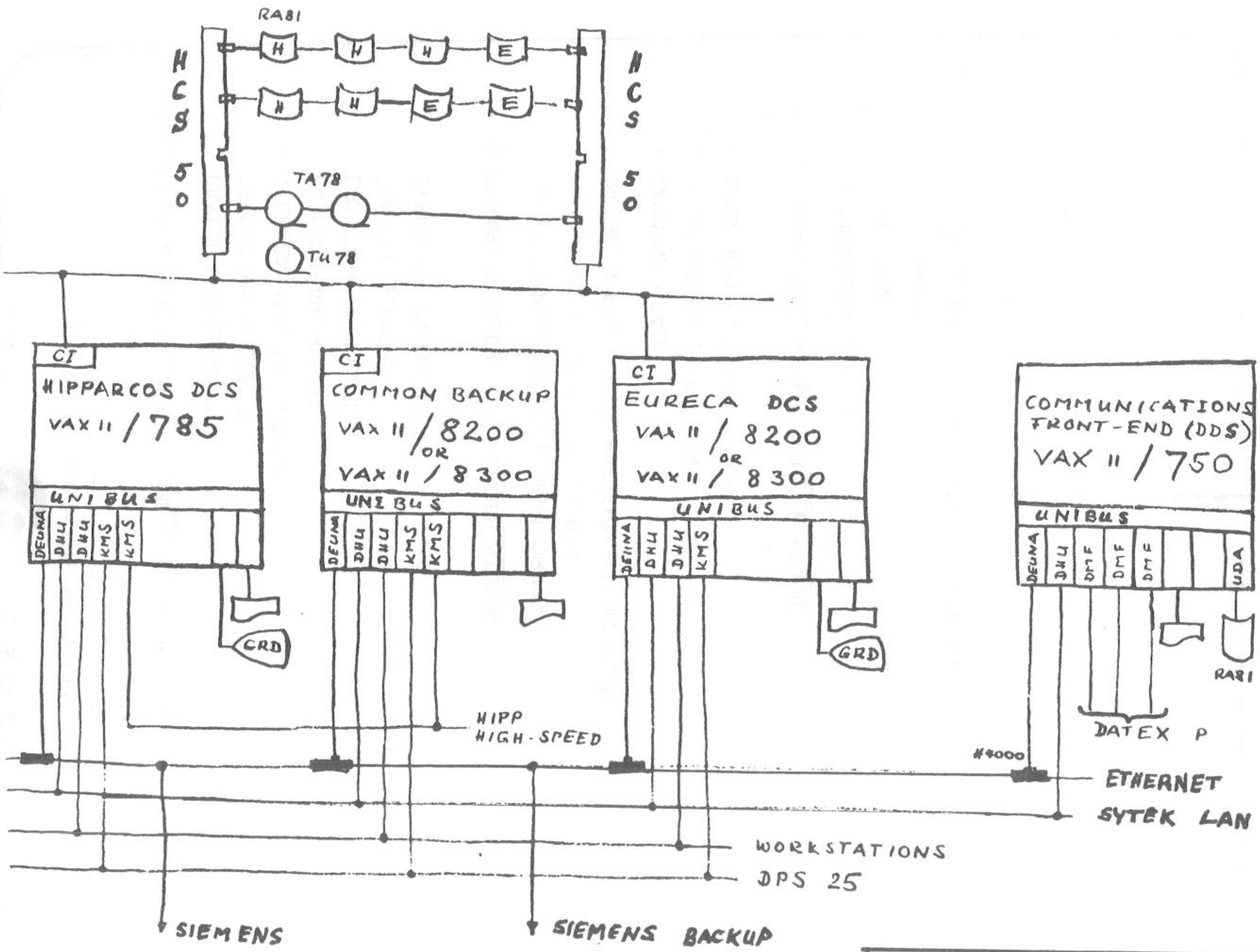
- SOFTWARE ARCHITECTURAL DESIGN HAS STARTED
- SOFTWARE REQUIREMENTS BEING FINALISED
- HIPPARCOS USER MANUAL BEING ANALYSED FOR DEFINITION OF OPERATIONS PLAN
- STUDIES ON INITIALISATION BEING PERFORMED

COMPUTER CONFIGURATION

* VAX CLUSTER CONFIGURATION:

  - VAX 11/785 DEDICATED TO HIPPARCOS
  - VAX 11/8200 (or 8300) FOR EURECA
  - VAX 11/8200 (or 8300) AS BACKUP FOR EITHER HIPPARCOS OR EURECA
  - TWO (REDUNDANT) HIERARCHICAL STORAGE CONTROLLERS (HSC 50)
  - DUAL-PORTED DISC AND TAPE DRIVES
  - 3 ONLINE AND 2 BACKUP DISCS OF 456 MBYTES EACH
  - 8 MBYTE PHYSICAL MEMORY NEEDED

ESA ESOC



Overall Cluster Configuration

STATUS OF SOFTWARE ACTIVITIES

* SOFTWARE REQUIREMENTS COMPLETED IN AREAS:
  - PAYLOAD CALIBRATIONS
  - TELEMETRY PROCESSING
  - TELECOMMANDING SUPPORT
  - FILING & ARCHIVING
  - DRC TAPE PRODUCTION
  - OBC/CLE SUPPORT
  - OPERATOR INTERFACES

* SOFTWARE REQUIREMENTS UNDER STUDY:
  - PAYLOAD PERFORMANCE MONITORING
  - REAL-TIME ATTITUDE MONITORING
  - INITIAL & FINAL STAR PATTERN RECOGNITION
  - GROUND RTAD
  - ATTITUDE INITIALISATION
  - EMERGENCY REACQUISITION

* SOFTWARE REQUIREMENTS TO BE STUDIED:
  - PSF PREPARATION
  - INCA UPDATES
  - LEOP SUPPORT
  - ORBIT DETERMINATION & STATIONKEEPING

INITIALISATION PHASE STUDIES:

* SUN POINTING ACCURACY ASSESSMENT:

  - ROUGH CALIBRATION OF:

    . SAS POINTING BIASES

    . X, Y GYROS DRIFT RATES

  - SIMULATION OF SUN POINTING CONTROL

* STAR PATTERN RECOGNITION:

  - SIMULATIONS OF ALGORITHM ON BASIS OF:

    . STAR MAPPER MEASUREMENTS

    . Z GYRO RATE READINGS

  - EXTERNAL MATRA CONTRACT:

    . ALTERNATIVE APPROACHES

    . FINAL STAR PATTERN RECOGNITION

PERFORMANCE MONITORING

OBJECTIVES:

i) QUICK IDENTIFICATION OF PERFORMANCE DEGRADATION DUE TO ONBOARD ANOMALY

ii) COMPILATION OF PERFORMANCE PARAMETERS OVER THE MISSION

CONSEQUENCES:

i) INITIATION OF DIAGNOSTIC AND REMEDIAL ACTIVITIES

ii) BASIS FOR DECISION ON CALIBRATIONS, USE OF REDUNDANT ELEMENTS OR ANALYSIS

IDT PERFORMANCE MONITORING TASKS

i) EXTRACTION OF IDT SAMPLES FOR SELECTED STARS

ii) ESTIMATION OF COUNT RATE I_0 AND MODULATION COEFFICIENT M_1

iii) CALCULATION OF EXPECTED I_0 AND M_1

iv) DETERMINATION OF BACKGROUND COUNT RATES

v) COMPILATION OF EXPECTED AND OBSERVED COUNT RATES AND MODULATION COEFFICIENT

EXTRACTION OF IDT SAMPLES

* Reference stars with $6 \leq B \leq 9$ are selected at random with separation of at least one minute

* Downlinked IDT observation reports are scanned for selected stars

* Dwell periods over one observation frame are identified

* Relevant IDT samples are retrieved from telemetry

LEAST SQUARE FIT OF OBSERVED IDT COUNTS

* Algorithm produces estimates for:

  $I_o' = I_o + I_{BK}$: total (observed + background) count rate

  $I_o' M_1'$, $I_o' M_2'$ } contain first two modulation coefficients

  ψ_o : phase w.r.t. grid reference

* On the basis of a priori value of M_1 :

  $I_{BK} = (1 - M_1'/M_1)\, I_o'$

  $I_o = I_o' - I_{BK}$

  $M_1' = (I_o' M_1')/I_o'$

CALCULATION OF EXPECTED COUNT RATE

* Expected count rate I_0 modelled as function of:
  - star's magnitude
  - star's colour
  - position in FOV

* Expected reference values for M_1' and I_{BK} may not be needed

COMPILATION OF OBSERVED AND EXPECTED COUNT RATES

* Collected data are analysed in batches of about 15 minutes for feedback to operator
* Data are categorised according to star magnitude and colour classes
* Averages are calculated for batches of 10 stars in each category. If discrepancies exceed preset limits alarms are raised.
* Long-term statistics are compiled using daily averages for each star category

STAR MAPPER PERFORMANCE MONITORING TASKS

i) RETRIEVAL OF B_T AND V_T SAMPLES FOR SELECTED STARS

ii) CALCULATION OF B_T AND V_T COUNTS FROM SAMPLES

iii) CALCULATION OF EXPECTED B_T AND V_T COUNTS

iv) DETERMINATION OF BACKGROUND COUNTS

v) COMPILATION OF PREDICTED AND OBSERVED SM COUNTS

CALCULATION OF EXPECTED COUNTS

* EXPECTED COUNT RATE IS MODELLED AS FUNCTION OF STAR MAGNITUDE, COLOUR AND SSR'S (FOR EACH OF B_T, V_T CHANNELS)

COMPILATION OF OBSERVED AND EXPECTED COUNTS

* AVERAGES OF OBSERVED COUNT RATES AND BACKGROUND COUNT RATES ARE COMPILED FOR EACH BATCH OF STARS
* RESULTS ARE CATEGORISED ACCORDING TO B_T OR V_T; INCLINED OR VERTICAL SLITS; MAGNITUDE
* IF DISCREPANCIES EXCEED PRESET THRESHOLDS ALARMS ARE RAISED
* LONG-TERM STATISTICS ARE COMPILED BY COLLECTING DAILY AVERAGES FOR EACH CATEGORY

CALIBRATION STATUS

* FIRST ISSUE OF SOFTWARE REQUIREMENTS COMPLETED
* ARCHITECTURAL DESIGN UNTIL SEPTEMBER 86
* START OF SINGLE TESTS: JAN 87
* START OF INTEGRATED TESTS: JAN 88

UNDER STUDY

* EXACT TASK DISTRIBUTION

  DRC'S - ESOC
* DATA INTERFACES

  DRC'S - ESOC