SPIRE FTS/Optics meeting QMW Sept. 8, 9 1999

Attendance:

Peter Ade	QMW
Jean-Paul Baluteau	LAS
John Coker (day 2)	MSSL
Pascal Darent	LAS
Kjetil Dohlen	LAS
Didier Ferand	LAS
Matt Griffin	QMW
Peter Hamilton	QMW
Don Jennings	GSFC
Ken King (day 2)	RAL
Jerome Martignac	LAS
Guy Michel	Meudon
Dominique Pouliquen	LAS
Tony Richards	RAL
Sunil Sidher	RAL/QMW
Bruce Swinyard	RAL
Berend Winter (day 2)	MSSL

1. Aims of the meeting

- Agree and close FTS requirements as in the current IRD
- Narrow down on options and make clear plan for deciding on the position measurement scheme
- Clarify requirements for the Warm Electronics
- Formulate an updated development plan at leas up to the DDR

2. Actions from previous meeting

See table at the end of the minutes.

3. Optics

3.1 Presentation by Kjetil Dohlen

- BOLSP460B is the current “official” design. A few tweaks are needed (see viewgraph). 460C is a provisional update (still not optimised).

- Feedback needed from mechanical design/layout team on accommodation (including FTS mechanism) before producing final optimised design.

- Optical design programme now improved - can ray-trace both arms of the FTS at the same time.

- Slight difference in magnification in the two arms as the carriage moves - marginal impact on fringe contrast. At edge of fov, and with maximum travel, displacement is 0.11 mm (vs. diffraction spot size of ~ 2.5 mm).

3.2 Presentation by Tony Richards

- SP460C traced in CODE V (see viewgraph)
- Possible clashes near edges of M11 and M12

- M6 could be tweaked to adjust pupil imaging (see viewgraph - which shows improvement in 460C)
- Viewgraphs show magnifications and movement of pupil near the secondary (for pupil at the centre of movement) - pupil moves quite a bit at the secondary
- Viewgraph showing movement of final pupil (in front of detectors) as carriage moves - shows how much oversizing needed for that stop
- Viewgraphs showing geometric footprints at various mirrors

3.3 Comments on optical design

Fringe Contrast
Analysis is required of the effects of vignetting and diffraction on the reduction in fringe contrast during mirror movement. Any loss of contrast is probably small and only at extremes of fov and resolution – however this should be tested using ASAP. Fringe contrast will dictate the alignment budget and we need a clear requirement on fringe.

Straylight
Best handled by cold stop at entrance to 4-K box between M6 and M7 (doesn’t change with carriage position). Not that concerned about stray light due to beam overspill within the FTS as this won’t be interferometrically modulated.

Retroreflectors
There is an advantage for alignment tolerances in making corners of rooftops coincident This can be accommodated in the optical design. Tolerances are large anyway. It is also suggested that using cube-corner retroreflectors could make system self-correcting in both directions. This would have little impact on the space envelope of the mirror or the optical design. However there is a need to look at whether there is a loss of compensation for aberrations within the optical design

Action: BMS and KD to specify plan for modelling fringe contrast and mirror sizes in the FTS

Action: KD to examine aberration-correcting properties of the cube-corner reflector option.

4. Review of FTS requirements

Review of Bruce Swinyard’s requirements document of 18/8/99

Requirement	Comments
Linear travel	OK
Minimum movement sampling interval	J-PB: Should be “at least the Nyqvist interval” (allows for 5 x oversampling in rapid scan mode)
Sampling step control	Change to 5-25 µm It is not a requiremetn to be able to scan around a region away from the zpd. We do want to be able to start from any specified minus position wrt the zpd
Start and end points of scan	Should be able to start and end data taking at any two arbitrary points within the scan range
Flyback	No requirement
Dead time	Goal of <10% for resolution of 0.4 cm^{-1}

Requirement	Comments
Mirror velocity in operation (taking data)	Max is OK. Goal of higher (0.2) if feasible.
Velocity control	"Selectable" not "variable" Change 0.01 to 0.02 cm s^{-1}
Velocity stability	Requirement = as high as possible Goal = 1% rms at nominal operating speed as measured between 5-200 Hz. Applies for the required resolution of 0.4 cm^{-1}. Applies from scan to scan and within scan. Timescale over which stability required = 1 day
Position measurement	0.1 μm near zpd (±0.3125 cm) 0.3 μm further out (quite conservative) (KD viewgraph shows OK for feedhorns)
Sampling frequency	200 Hz OK
Fringe contrast (modulation efficiency)	See KD's viewgraph Suggested requirement: 80% worst case for any point in the field at 0.4 cm^{-1} but differential vignetting and differential distortion need to be studied. BMS: What is fringe contrast required at? Measurement conditions: monochromatic point source This requirement is on the whole FTS system

4.1 Comments on FTS requirements

200 Hz may be too fast for the CEA detectors
What is the impact of going to 150 um? Accommodation issues rule the use of a third array – it was felt that going to 150 μm with two arrays would compromise the 200-300 μm performance. Peter Ade suggested that we could put slope on SW filter as compromise to get some performance out to 150 μm without big impact on 200-300 um performance.

4.2 Conclusions on FTS requirements

- Idea of tapering the short-wavelength band filter could be looked at
- Baseline FTS wavelength range remains 200 - 670 μm
  Any alternatives will (i) be considered only after detector selection; (ii) may involve extension of wavelength range but not with optimised performance outside the prime 200 - 400 μm band; (iii) have negligible impact on performance within the 200-400 μm range
- Note that the formal requirements are as in the latest issues of the IRD, including the updates discussed at this meeting, not the PDR documentation.

5. Progress on FTS Mechanism

5.1 Presentation by Don Jennings: NASA Goddard carriage mechanism concept

15^0 angle gives travel ~ length of one of the arms
Working on improving the performance wrt up-down motion

- Requirements - see viewgraph - SPIRE requirements should be achievable.
  Getting below 1 kg should be no problem, inc. actuator
  Average dissipation over a scan = 1.7 mW
- GSFC have lots of experience with flex pivots from FIRAS etc.

- SPIRE version has been designed, including actuator
- Actuator diameter is only 26 mm (+ a little bit)
- Design fits within constraints of beams. Limit is width of the dihedral at the front, and there is some margin there.
- Proposing to build prototype by February 2000.

Conclusions on Goddard mechanism:

1. Launch lock (need for it/availability of proven design, etc.) issue needs to be addressed before PDR.
2. Need to discuss flexibility on 20 mm dimension with MSSL
3. Building a prototype is good idea. Parameters for prototype will be fully defined in the next version of the IRD (available soon)
4. Requirement on travel is not a major driver on the FTS
5. Requirements stay, but have a goal of being able to do double-sided interferograms at full resolution.

5.2 Presentation by Pascal Dargent

Viewgraphs showing working on mechanical design of test set-up for position sensor evaluation

5.3 Presentation by Guy Michel: Moiré fringe system evaluation

- Testing Moire fringe system using industrial device with no modification
- Works at 4 K
- Fringe amplitude at 5 K = 100 mV vs 2000 mV at 300 K
- Next steps: investigate mechanical/optical/LED optimisation
- Work towards evaluating concept and proposing a solution
- Also tested LEDs and photodiodes from OPTEK
  This LED also works at 4 K with 0.9 mW LED power
- Also working on capacitative sensor

Comments on Guy’s presentation:

Most of the power is dissipated in the diode substrates rather than in the emitting area.
Getting a special diode could reduce dissipation by factor of ~ 5
Capacitative sensor - best to leave out of the picture - two options is as many as we can study in the time available.

5.4 Presentation by Kjetil Dohlen: LVDT system evaluation at LAS

- Viewgraph showing noise at centre of LVDT travel range of ± 5 mm
- Noise increases with displacement - up by factor of 5 at extremes
- Will repeat measurements with longer travel LVDT

5.5 Presentation by Didier Ferrand: FTS control system

- Option 1:
  Speed control loop + detector position encoder + telemetry
  High bandwidth servo loop for low sensitivity to external disturbances

Need position sensor for step and integrate control
Simple interface with CEA warm electronics

- Option 2:
  Phase lock with incremental encoder
  Incremental encoders for detector sampling and telemetry
  Fully digital system
  Limited velocity stability at low speed
  Not suitable for step-and-integrate control
  Simple DRCU interface and telemetry
  Digital electronics simple
  Correction LVDT non linearity - not easy to do this
  Would need to implement using FPGAs
  Makes DRCU interface tricky

- Option 3:
  See viewgraph

- Conclusions:
  If want a lot of flexibility, may need to combine the two types of position sensors
  Fast scanning easier with Moiré fringe
  Step-and-integrate easier with LVDT but not impossible with encoder (Moire fringe)

Comments on Didier's presentation:

1. Keeping the analogue servo, fully digital control is possible (flexibility on operating parameters such as mirror speed)

2. LVDT correction in flight needed for velocity control. Won't be a problem if it's within the 1% requirement

5.6 Discussion on position measurement system

BMS:	LVDT is still in the running. Advantage that it has been flown. Moiré fringe has disadvantage of having optical source in the box - bad for stray light.
GM:	Cooling LVDT will reduce the sensitivity due to degraded permeability
PARA:	Can specify higher-permeability core
PD:	Effect of non-linearity of guidance on sensor?
PARA:	Moiré fringe system is very insensitive
KD:	Will be testing off-the-shelf long travel LVDT - can be tested cold
PARA:	Specify magnet that can be cooled
KD:	Note that Moiré fringe system was flown on FIRAS (although they used fibres)

5.7 Plan for position sensor development leading up to PDR in March/April

Common requirements and constraints:

Power dissipation	2 mW max; goal a lot less
Volume envelope	Needs to be specified
Redundancy	

Moiré fringe system programme:

Test LEDs at 4 K and identify best option
Measurement of performance at 4 K
Lifetime tests - could just do a lot of cold cycles in the course of the measurement
Thermal cycles - will probably be covered in general testing
Investigation of fringe amplitude degradation
Clarification of effect of fringe amplitude degradation on position resolution (may be OK)
Stray light test - can BACUS be used? - high priority for decision
Stray light suppression by having outer radiation shield - design
Warm vibration
Redundancy - a design with redundancy for LED and photodiode

LVDT system programme:

Performance measurements warm and cold
Performance stability on recycling (especially non-linearity)
Magnetic interference with motor
EMI - same as stray light tests

Conclusions on FTS mechanism/readout development:

1. LAS and CEA to confer on implications for WE of both options (e.g., do we need to decide control system for Nov. PDR, implications for electronics architecture, budgets, schedule, etc.)
2. Moiré system is baseline for Nov. review and FTS PDR
3. LVDT system is to be presented as backup
4. Highest priority tests = stray light tests at QMW

6. Mechanical interfaces and constraints

6.1 Presentation by Berend Winter

- Viewgraphs showing photometer and FTS internal layout
- FTS mechanism envelope assumed so far is as in PDR
- 44.5 mm between OBP and centre of the beam
- OBP is 20 mm thick (TBC)
- Two extra fold mirrors have been added to cope with detector array accommodation problems

6.2 Conclusions on mechanical interfaces

Motor accommodation:
- Motor = cylinder 26 mm diameter; 3.7” = 9 cm
- Could maybe be recessed in OBP but not preferred
- Default: GSFC will redesign with motor on the top. If this is a problem then GSFC can discuss with MSSL.

Dichroic accommodation

- Difficult accommodation problem if 90 mm clear aperture - need to specify the actual requirements

7. FTS development plan

Oct. 99	Breadboard mechanism for control system testing (inc. Moiré fringe tests to be done before PDR)
Nov. 99	Electronics PDR
Feb. 00	GSFC carriage available with commercial motor. Will be available for LAS tests if necessary.
March 00	FTS PDR
Sept. 00	DDR
Mar. 01 ?	AIV of electronics and mechanism (includes qualification)
Jan. 01	Beamsplitters from QMW for optical breadboard model (which will be built up at Saclay)
Feb. 01	DRCU simulator from CEA
June 01	Electronics to CEA
Dec. 01	CQM delivery to RAL
June 03	FM delivery of GSFC carriage to LAS
Dec. 03	FM Delivery to RAL

GSFC already have a unit with similar travel and spring constant. It may be possible for this be used for control system testing.

8. Calibrator

Alternative to calibrator as proposed at PDR:

Point-like source in centre of pupil (80 K; 4% of pupil area)

Surrounded by adjustable temperature black disk (heatable to, say, 15 K) as back-up in case hot calibrator fails and to provide absolute calibration

Advantages: terminates beam on black surface - reduced reflections

Breadboard tests are required to ensure that this method is capable of compensating the telescope background.

Summary of actions

Action	Who	Date	Description	Status	Closed by:
AI-FTS-000300-01	BMS KD	Oct. 15	Specify plan for modelling fringe contrast and mirror sizes in the FTS for PDR purposes	Open	
AI-FTS-000300-02	KD	Oct. 15	Examine aberration-correcting properties of the cube-corner reflector option	Open	
AI-FTS-000300-03	LAS CEA	End Sept.	Confer on implications of various options for warm electronics	Open	
AI-FTS-000300-04	QMW GM	Today	Discuss how to do stray light tests on Moiré system	?	
AI-FTS-000300-05	BW	TBD	Specify volume envelope for FTS mechanism draft ICD	Open	
AI-FTS-000300-06	BMS	Sept. 16	Ask JPL and GSFC if they can reduce the diameter of the FTS detector array modules	Open	
AI-FTS-000300-07	KD	Sept. 16	Specify required clear apertures for dichroics in their nominal positions	Closed	E-mail of 13/9/99 – appended
AI-FTS-000300-08	BW	Sept. 30	Produce preliminary ICD for FTS-structure interface	Open	
AI-FTS-000300-09	DP	cf. Nov. Rev. schedule	Provide Development Plan for FTS for November Electronics Review	Open	
AI-FTS-000300-10	MJG BMS	Sept 26	Review numbers in data rate note to remove errors and include all assumptions explicitly	Open	
AI-FTS-000300-11	PH	End. Oct.	Test feasibility of nulling background using compact source in the pupil	Open	

E-mail Closing Action AI-FTS-0003000-07

Dimensions of photometer dichroics (BOLPHT126B)
KD 13/9/99, in response to action of 9/9/99.

Beam footprints on the dichroics are determined by geometrical raytracing. For both dichroics these are rectangular or slightly trapezoidal with rounded corners. Largest diagonals (Geom. dia.) are measured. The diameter of the component free aperture (Comp. dia.) is calculated by adding 20%.

Code name	Description	Geom. dia.	Comp. dia.
PDIC-1	First dichroic after M9	75 mm	90 mm
PDIC-2	Second " " "	60 mm	72 mm

****
Kjetil DOHLEN, mailto:dohlen@observatoire.cnrs-mrs.fr
Laboratoire d'Optique, Observatoire de Marseille
2, Place Le Verrier, 13248 Marseille Cedex 4, FRANCE
Tel.: (+33) 4 95 04 41 24, Fax.: (+33) 4 91 62 11 90
****

Actions from Previous Meetings:

Most of these are closed or superseded, however some are not and do address important issues – notably the need to define

Action	Who	Due	Description	Status	Closed by:
-AI-FTS-0041-06	MJG	29 Jul 1998	Study the behavior of sensitivity as a function of wavelength for the filled array options	Open?	
-AI-FTS-0056-07	PA	24 Dec 1998	Provide Kjetil with sample filter profile	Open?	
AI-FTS-000164-01	RAL	12/2/99	Translate photometer optical model into CAD compatible format	Closed	IGES file now available direct from optical model
AI-FTS-000164-02	KD	12/2/99	Evaluate spot diagrams and distortion for 4x8 field for flat and curved telescope focal plane.	Closed	PDR presentation
AI-FTS-000164-03	KD	8/3/99	Draw up error budget and alignment tolerances for photometer	Closed	PDR presentation
AI-FTS-000164-04	MC	31/3/99	Analyse diffraction limited performance of new photometer.	Closed	PSF_BPH126.DOC

Action	Who	Due	Description	Status	Closed by:
AI-FTS-000164-05	AR	8/3/99	Input new photometer design into APART and outline first order baffles	Closed	Apart modelling now normal work
AI-FTS-000164-06	BS	12/2/99	Confirm temperatures of optical elements in photometer	Closed	PDR Presentation
AI-FTS-000164-07	BS	8/3/99	Define filtering scheme for photometer	Closed	PDR Presentation
AI-FTS-000164-08	BS	12/2/99	Formally issue shutter specification.	Closed	Now in IRD
AI-FTS-000164-09	PA	1/4/99	Test effect of powered mirrors in breadboard FTS	Closed	No effort available will be done in ASAP model
AI-FTS-000164-10	BS	19/2/99	Issue note outlining different options for sampling FTS mirror positions	Closed	E-mail and discussion this meeting
AI-FTS-000164-11	LR/ GM	8/3/99	Report on use of 4-K LED's and/or lasers for Moire fringe encoder	Closed	Report this meeting
AI-FTS-000164-12	BS/ MG	19/2/99	Evaluate ability to reconstruct redshift of Arp220 like galaxy as function of R.	Delete	Do we still need this? Resolution requirement has been set.
AI-FTS-000164-13	KD	19/2/99	Complete optical model of baseline FTS and provide to RAL.	Closed	Model available in all formats
AI-FTS-000164-14	RAL	23/2/99	Translate into CAD compatible file	Closed	IGES file available directly from optical model
AI-FTS-000164-15	KD	12/4/99	Draw up error budget and alignment tolerances for spectrometer optics	Open	Partially closed at PDR
AI-FTS-000164-16	MC	30/4/99	Analyse diffraction limited performance for spectrometer	Open	Ongoing
AI-FTS-000164-17	AR	12/4/99	Input new spectrometer design into APART and outline first order baffles	Closed	APART model complete now normal work
AI-FTS-000164-18	BS	26/2/99	Confirm temperature of all components in the spectrometer	Closed	PDR Presentation
AI-FTS-000164-19	DP	12/4/99	Identify candidate FTS mirror mechanism consistent with optical design.	Closed	Discussion this meeting – agreement with GSFC
AI-FTS-000164-20	LR/ GM	4/3/99	Finalise requirements on the FTS drive mechanism and position sensor.	Closed	IRD and discussion this meeting
AI-FTS-000164-21	JM/LR	4/3/99	Report on further study into FTS operation.	Closed	Report SAp-SPIRE-MJ-18-99
AI-FTS-000164-22	PA	30/3/99	Measure properties of JPL feedhorns.	Closed	Partially anyway by report to May

Action	Who	Due	Description	Status	Closed by:
					Detector meeting at Caltech
AI-FTS-000164-23	MG/ BS	30/3/99	Finalise number of bands and layout of FTS focal plane using feedhorns	Closed	PDR presentation
AI-FTS-000164-24	JPB	30/3/99	Define requirements on FTS calibration source	Closed	See report from 000164-21
AI-FTS-000164-25	MG/ BS	12/4/99	Write specification for FTS calibration source	Closed	PDR Presentation and IRD
AI-FTS-000164-26	LR	4/3/99	Define draft data rate requirements for the new baseline FTS	Closed	Data Rate Note – to be issued as appendix to Operating Modes Document
AI-FTS-000164-27	LR/PAH	4/3/99	Define draft on-board software requirements for the new baseline FTS.	Open	?

SPIRE FTS/Optics Meeting
QMW Sept. 8, 9 1999

AGENDA

Day 1 September 8		
12:00	Aims of the meeting	
12:30	Lunch	
13:15	Actions arising from previous Meetings	
13:30	Review of optical design	
14:30	Review of requirements for the FTS in the light of PDR Board report and SPIRE schedule	
15:10	Summary of FTS requirements	
15:30	Tea	
15:45	Report on activities on FTS mechanism	
17:00	End Day 1	

Day 2 September 9		
9:15	Summary of conclusions from Day 1	
09:45	Discussion on choice of position measurement device	
10:30	Coffee	
10:45	FTS control system	
12:30	Lunch	
13:15	Mechanical interfaces and constraints	
14:15	Schedule	
15:00	Tea	
15:15	Conclusions	
15:30	Review of actions	
15:45	AOB - calibration source ?	
16:00	Meeting ends	

PDR Review Board Comments on the FTS design and developement plan

- "the committee was *somewhat worried about the level of design* of the FTS at this point"
- ". . . the R=1000 goal on the FTS may be driving the design in a different direction than simply meeting the R=100 requirement would do. Although there are obvious scientific advantages in the higher resolution goal, there are clearly tradeoffs in FTS mechanism size, stage design, controller design, and even optics that are being made to achieve the higher resolving power. We *recommend that the SPIRE team re-examine these tradeoffs relative to the science gain afforded by R=1000*. Of course, this also depends strongly on completing the FTS design to the same level as the remainder of SPIRE."
- "FTS Design – For a system that is roughly half of the total SPIRE instrument*, the details of this system are clearly critical to define as soon as possible*, both the mechanical and control system design. This is one of the most important items requiring significant additional effort as soon as possible, since the committee felt that *the current level of design was not at the "PDR" level. Early prototyping of the mechanism will be essential* and should not wait for the design to finalize."

Kjetil Dohlen

Optics

FTS meeting

QMW 8/9/99

OPTICAL DESIGN STATUS

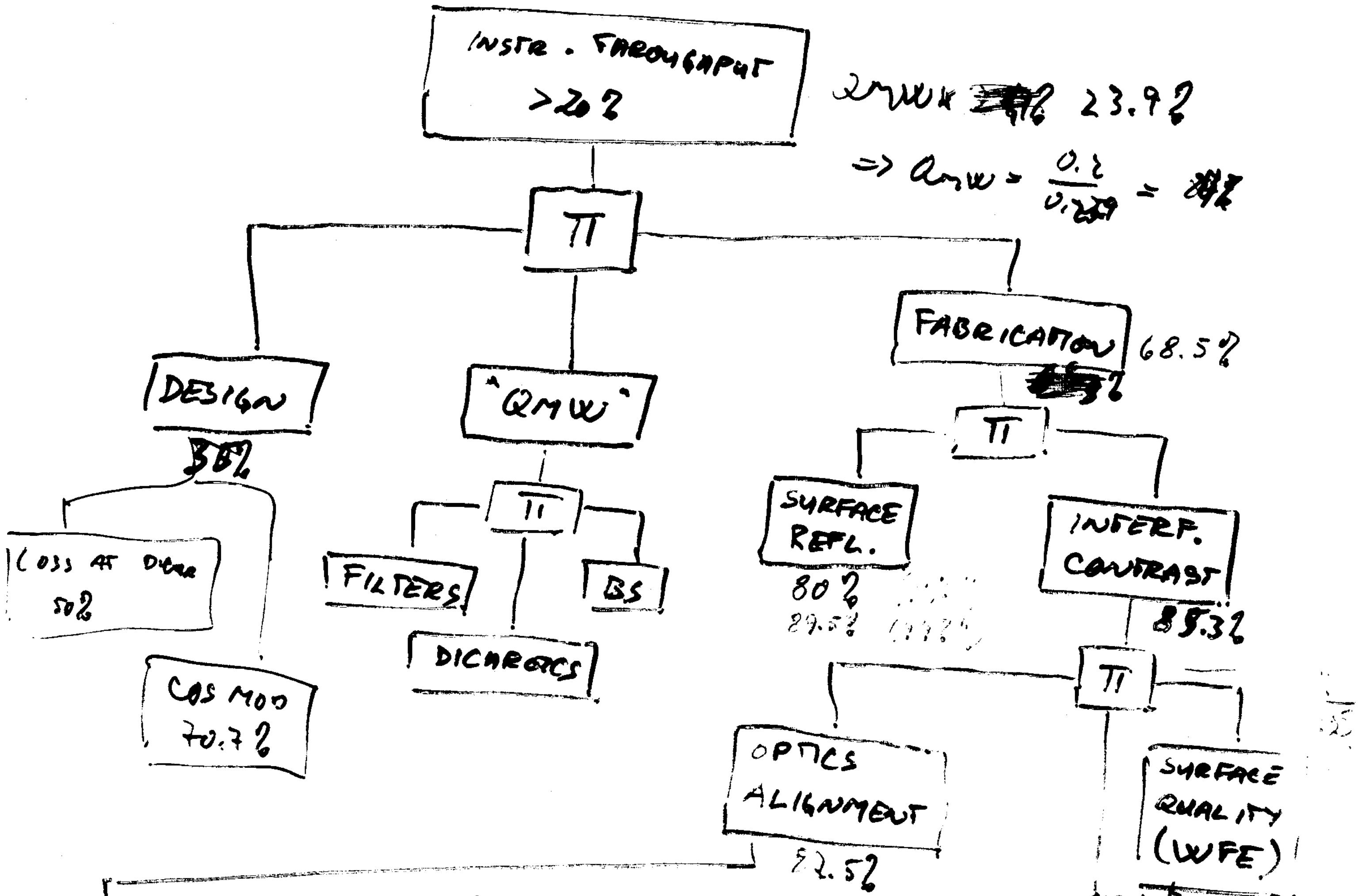
1) Baseline still BOLSP 460 B

- IGS files distributed for mech. design

- Known problems:
  - Tilt error (0.005°) @ M6 leaves FTS axis slightly sqew
  - Poorly optimized M6 toricity leaves pupil image bad
- Tentatively corrected in BOLSP 460C
  → only distributed to Tony for stray-light calculation
- New baseline properly optimized awaits go-ahead from mechanical designer

2) Synopsys has evolved, I can now produce full FTS raypaths

→ BOLSP 472

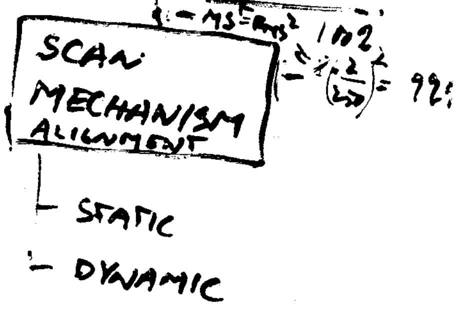


QMW × ~~[illegible]~~ 23.9%

$\Rightarrow a_{QMW} = \frac{0.2}{0.239} = $ ~~[illegible]~~

TILT:

COMP	N	ℓ (mm)	δx FOR δθ = 1'	ℓ
BS	2	40 mm	46 μm	99.8%
Coll	4	150	246	95.2
RT	4	150	246	95.2
			351	90.4%
			↑ RSS	↑ PROD.



$\delta x = 2 \times 2 \times 150 \times \delta\theta$

$= 600\ \delta\theta$

$\delta\theta = 1'$

$\Rightarrow \delta x = 174\ \mu m$

$\Rightarrow \ell = 97.6\%$

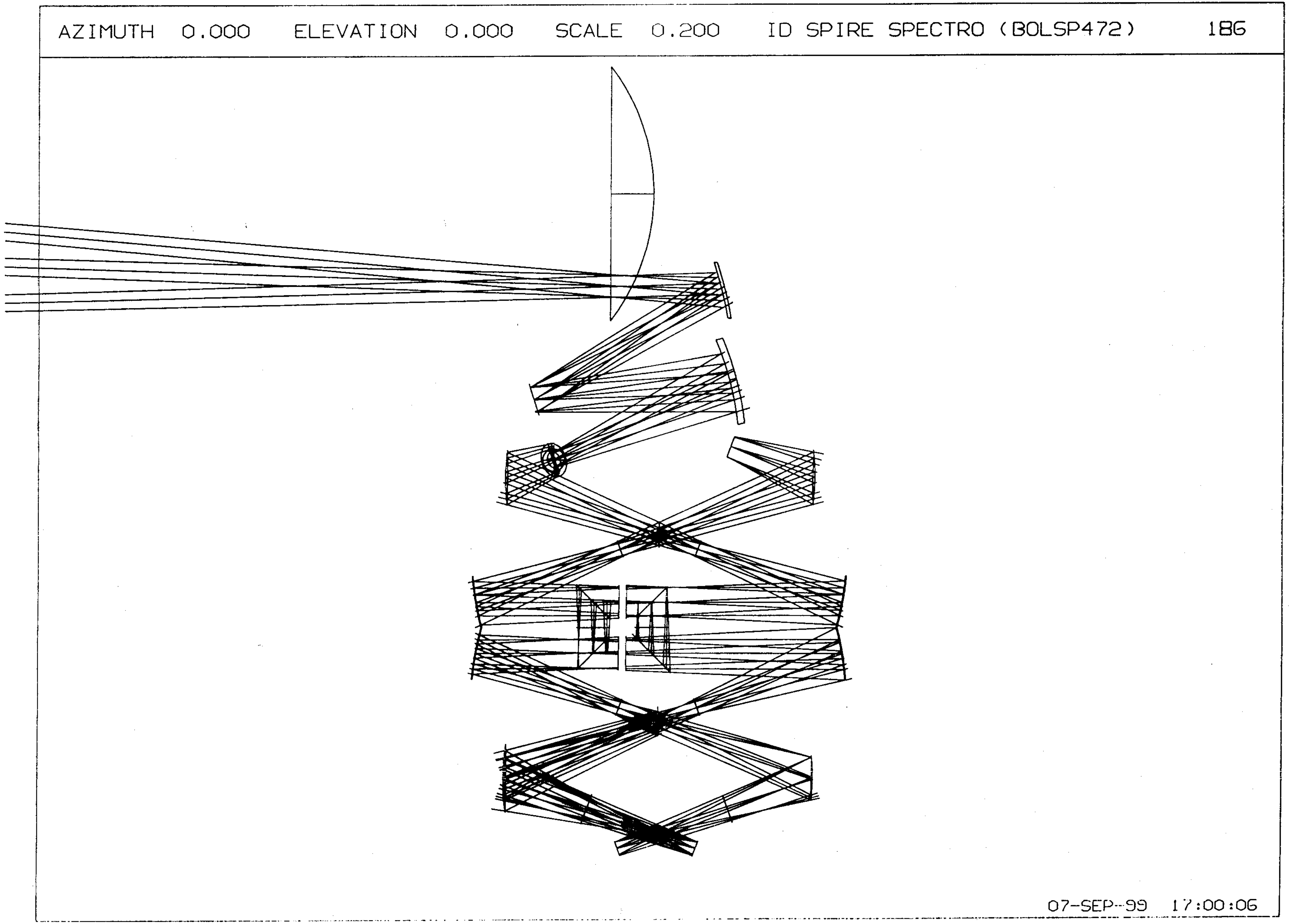
+ DECENTREMENT

· COLLIMATEURS UNIQUEMENT

96.8%

Diagrams for CC.

- Differential vignetting → Avail ASAP analysis } Max OPD
- — " — distortion → $\ell \approx 95\%$ } Edge FOV


AZIMUTH 0.000 ELEVATION 0.000 SCALE 0.200 ID SPIRE SPECTRO (BOLSP472) 186
07-SEP-99 17:00:06

Tony Richards

Optics

Don Jennings

GSFC Carriage

SPIRE Carriage Mechanism
Goddard Concept

Don Jennings

SPIRE FTS PDR
Queen Mary & Westfield College, London
8 & 9 Sept. 1999

- Carriage Requirements:
  - Mass: 1 kg
  - Power: 1 mW
  - Available Volume:
    XxYxZ = 650 x 250 x 420 mm^3 (TBC)
  - Stroke: -3/+32 mm Max.
  - Velocity: 0.01 (TBC) to 0.1 mm/s
  - Velocity Stability: 1%
  - Temperature: 4K

- Carriage Requirements (con’t):
  - Accuracy of moving mirrors :

$\Delta X < 0.1$ mm (TBC)

$\Delta Y < \#$ mm (TBD)

$\Delta \Theta X < 1'$ (TBC)

$\Delta \Theta Y < 1'$ (TBC)

$\Delta \Theta Z <$ (TBD)

- Design Approach:
  - Flexure pivots for low friction and low temperature operation.
  - Double-Parallelogram geometry for long travel and linear motion.
  - Dimensioned to fit within the SPIRE optical beam pattern.
  - Integrated Actuator with minimized power.

- Design Characteristics:
  - Mass:

Mass:		
	Carriage	740 gm
	Actuator	236 gm
	Total	976 gm

  - Power: 1.75 mW (TBC)
  - Dimensions: XxYxZ = 123 x 136 x 105 mm^3
  - Stroke: -3/+32 mm

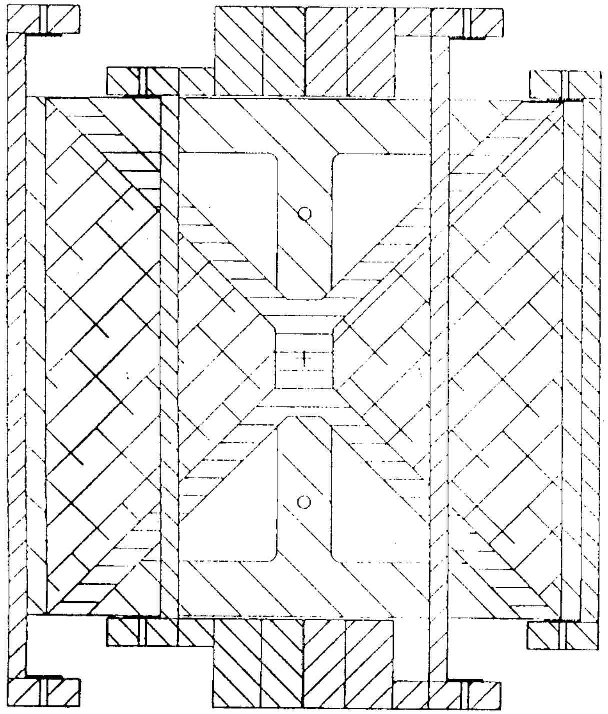
- Design Characteristics (con't):
  - Velocity: 0.01 (TBC) to 0.1 mm/s is achievable.
  - Velocity Stability: 1% is achievable.
  - Temperature: 4 K
  - Optical stability requirements are achievable.

- Status of Carriage:
  - A Larger version (13 cm travel) has been used in a balloon FTS, operating at LN_2.
  - Two small versions have been built with travel of 4 cm.
  - Feeler-gauge tests have been performed on carriage travel.
  - SPIRE version has been designed.
  - Actuator has been designed.

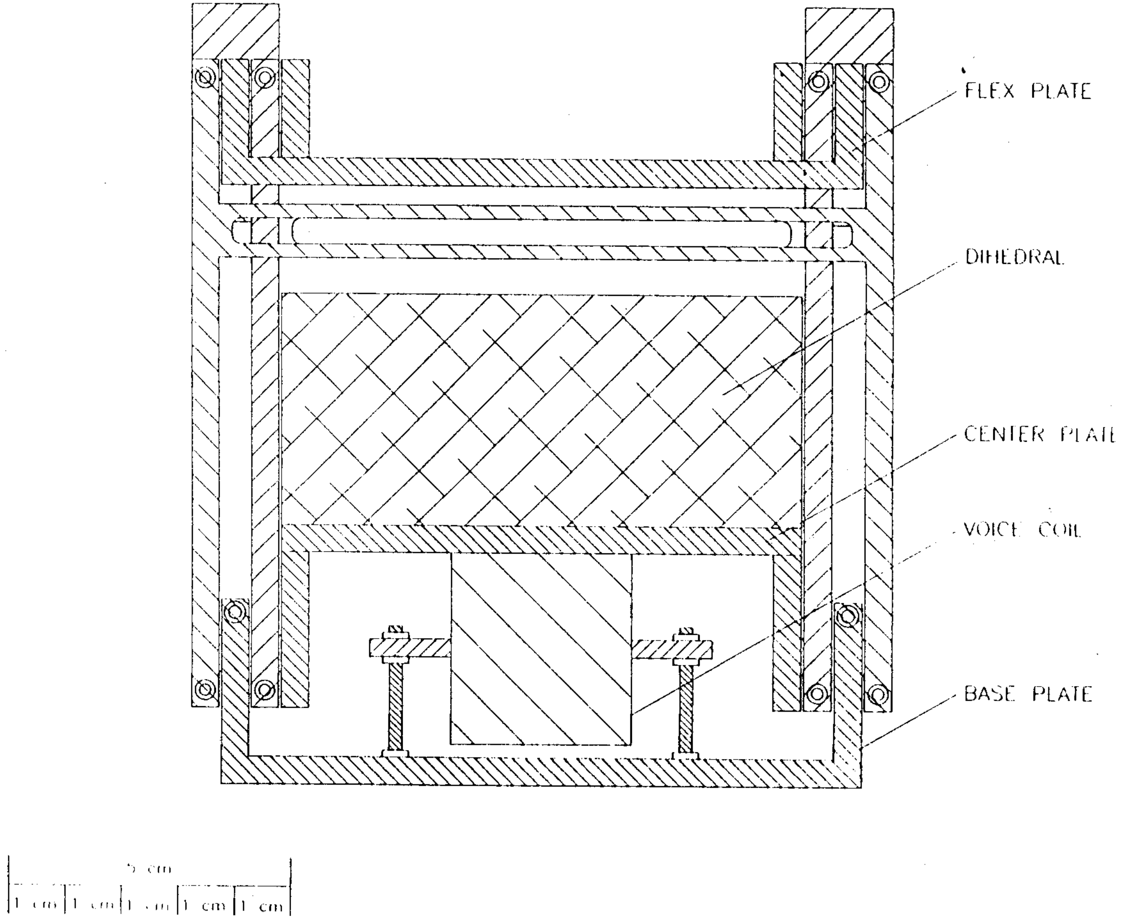
Position 1

Carriage Mechanical Design

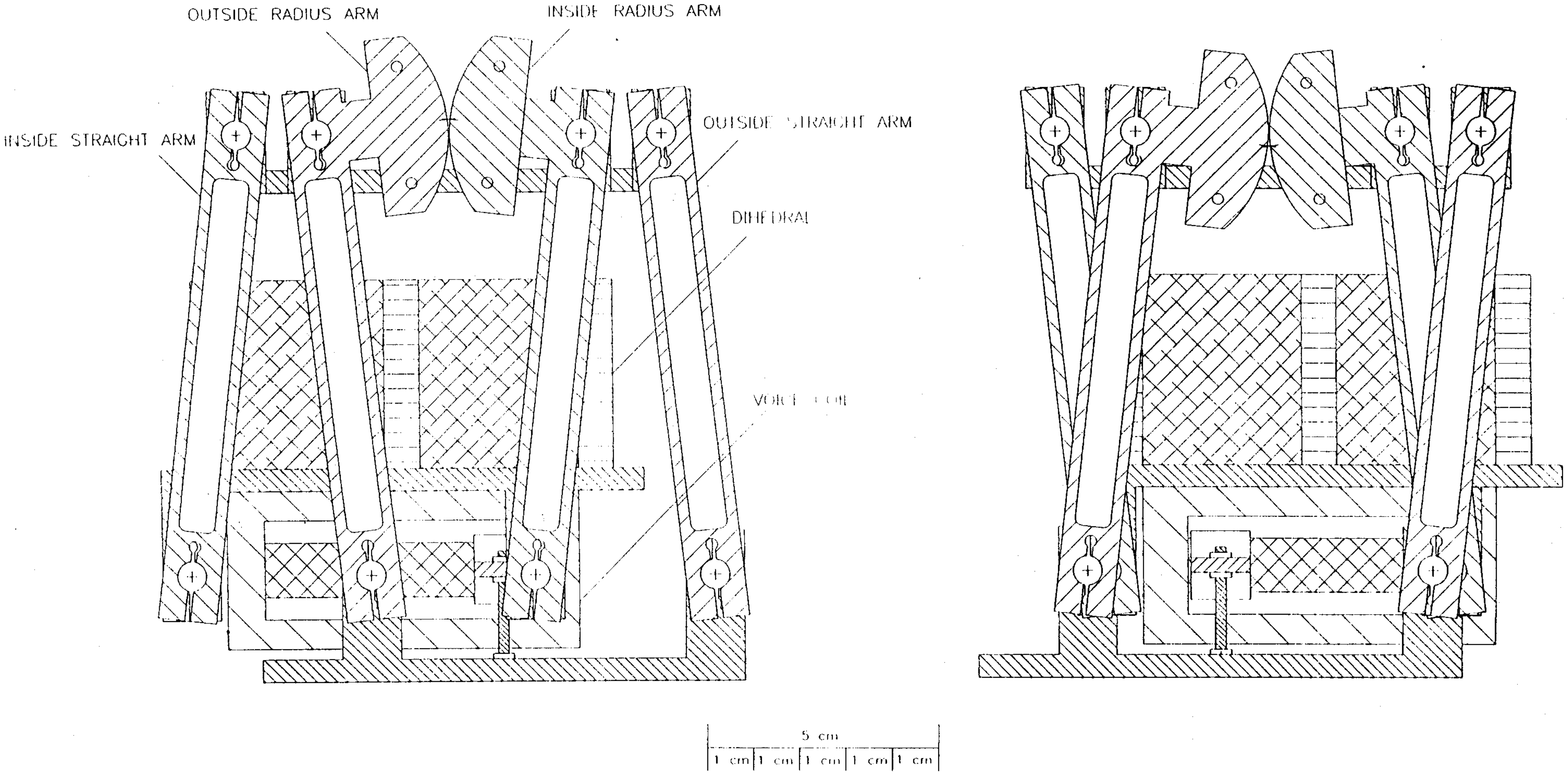
Top View



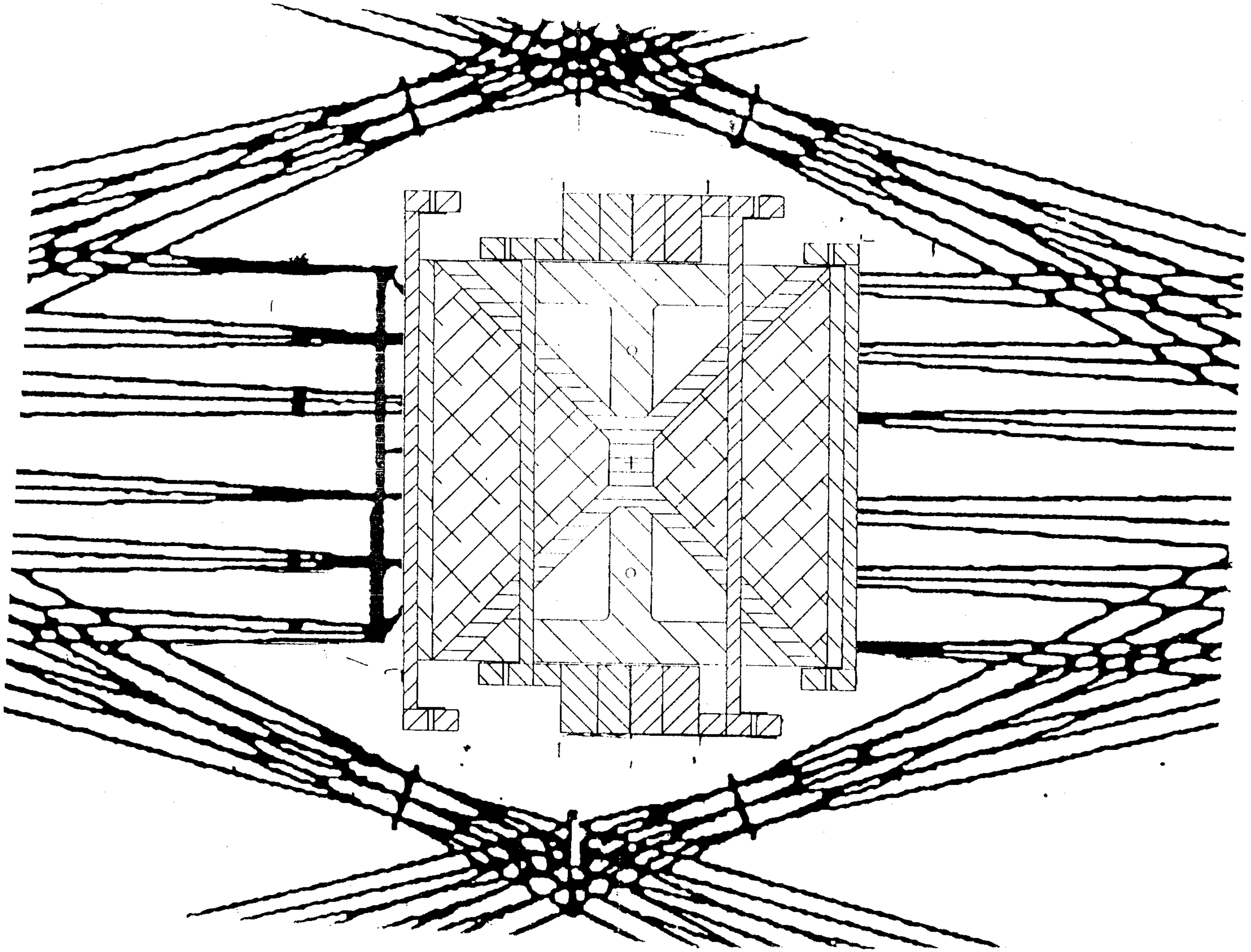
Front View



Carriage Mechanical Design (Side Views)



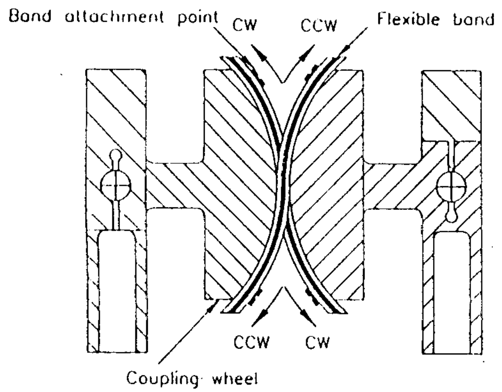
Carriage Fits Within SPIRE Beam Pattern



- Actuator Strawman Design:
  - Stroke: 35 mm
  - Spring constant: 80 N/m
  - Length: 9.6 cm, diameter: 2.6 cm
  - Pure copper windings
  - Power (at 4 K): 1.75 mW (TBC)
  - Mass: magnetic circuit: 165 gm
    bobbin: 71 gm

magnetic circuit:	165 gm
bobbin:	71 gm
total:	236 gm

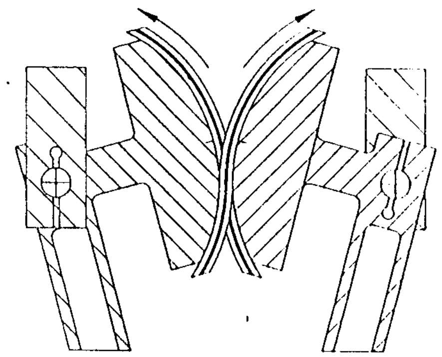
Coupling Between Moving Parallelograms



DOUBLE PORCH SWING
DOUBLE PARALLELOGRAM CARRIAGE

LEFT-TO-RIGHT/RIGHT-TO-LEFT STRAPPING MECHANISM
Figure 2A

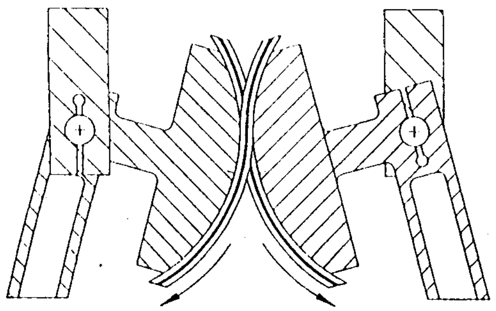
dpg-strx



DOUBLE PORCH SWING
DOUBLE PARALLELOGRAM CARRIAGE

Left Position – CW(CCW)
Figure 2B

dpg-stry



DOUBLE PORCH SWING
DOUBLE PARALLELOGRAM CARRIAGE

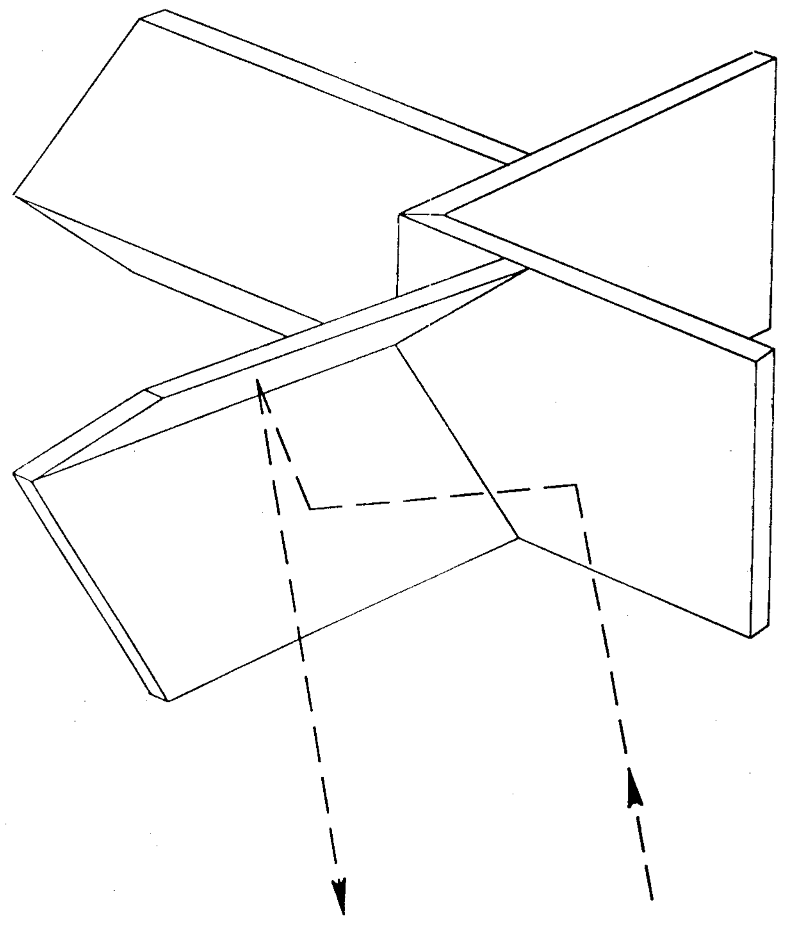
Right Position – CCW(CW)
Figure 2C

dpg-strz

Proposal to use Cube-Corner Retroreflector Instead of Dihedral

- Back-to-back cube-corners with coincident apexes.
- Advantage: Complete tilt and shear. compensation during carriage motion.
- Makes use of symmetry in optical design.
- Assumes reflection symmetry about X-axis.
- Requires one extra facet in each retroreflector.

Cube-Corner Retroreflector



Guy Michel

LED and Photodide Testing

September 6, 1999

J.Martignac CEA
G.Michel DESPA

Low temperature testing of LEDs and Photodiodes

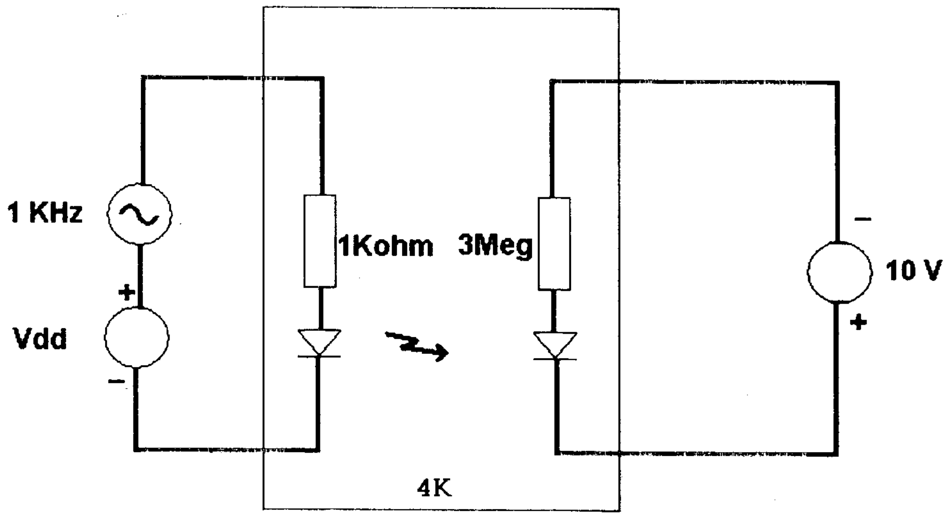
We have tested a couple of LEDs and quad photodiodes produced by OPTEK on a special order from the french company CODECHAMP. These components were to be used on an angular encoder to be operated @ 77K (for a CNES space mission to MARS). The LED has a peak emission at 820nm and a typical DC power of 40mW.
We got from this company a few samples of these components
These Surface Mounted Components HCE 1000-1 /3 are screened to 'S'level of MIL-S-19500H.

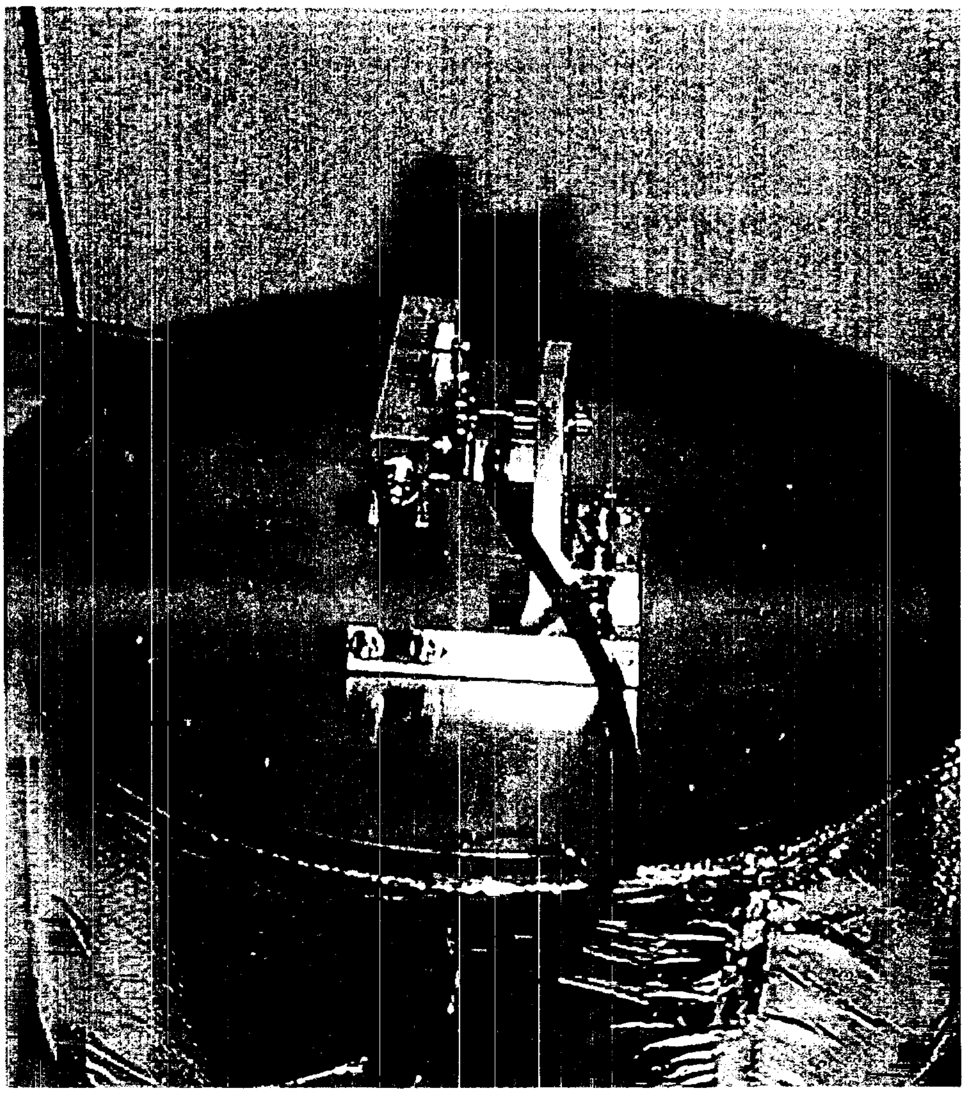
This very first test is to see if the couple LED and photodiodes work at 4K.

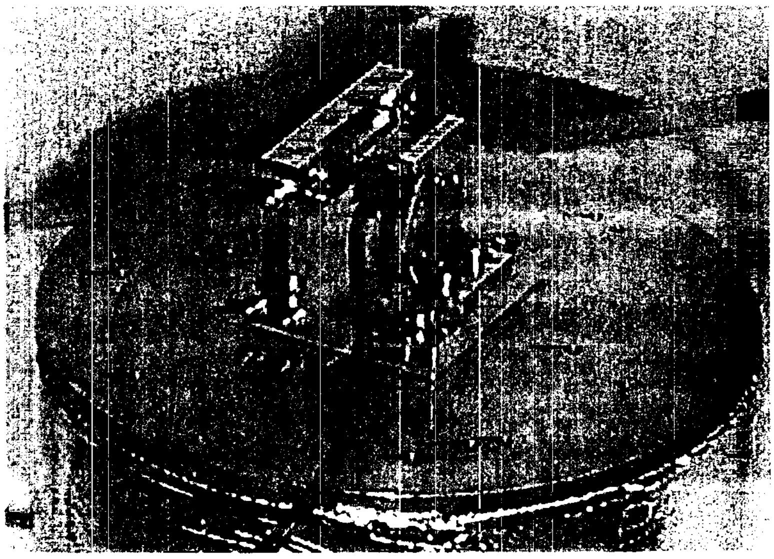
Experimental setup:

The LED and the photodiodes are placed facing each other in the cryostat. The back of their ceramic package is pressed by a copper bar tied to the cryostat bottom plate .

The LED is powered by a DC and an AC generator through a resistor of 1K. The AC introduce a 1 KHz modulation .
The photodiode is working in the photo-conductive mode with a load resistor of 3 Meg and a polarisation of 10 V.
The temperature at the LED is monitored .







Results:

The system works @ 4K.

To produce a 100mV pp output at the photodiode, the power at the LED is .86 mW.

The system starts immediately after a 1 hour power cutoff

The next test planned is to use an optical fiber to carry out of the cryostat the flux emitted by the LED and measure the optical power.

D9/1/99

J.Martignac CEA
G.Michel DESPA

Testing at cold of an industrial grade moiré transducer (Heidenhain LIP 403 A)

The unit tested was evaluated many years ago as a potential backup to the laser interferometer for the CASSINI /CIRS mission.

This system includes a grating and an optical head set-up in the cryostat . A box outside of the cryostat contains the photodiodes preamplifiers and LED driver .

The grating is mounted on a simple flexible mount (parallelogram with copper berylium springs). This allows to see fringes induced by the slight vibrations of the cryostat.

No modifications has been introduced in the device but the wiring to separate the warm electronics and reach inside of the cryostat the critical active components in the optical head 1 LED and 3 photodiodes.

We have carried out a straight test of this system.

The output fringes are the only way to monitor the behaviour . The results are:

Fringe amplitude @ 300 K 2000 mV pp

Fringe amplitude @ 5 K 100 mV

This result is very encouraging and unexpected in the first place.

What next ?

Evaluate the changes due to temperature (300K >> 4K)

mechanical:
- defocusing collimating lens < > detector (thermal contraction of holding structure)

optical
- curvature of collimating lens
- index of refraction
- transmission of this interferential system (1 diffraction grating –1 transmission grating)

light source –LED -
- drop in efficiency

Since this is a device to be operated at room temperature for an industrial operation (0- 50° C) , no special effort has been made to optimize the power. For our application we have to trade the power dissipation v.s. the S/N, eventually use another LED more efficient at 4K with a goal of max 1mW and a S/N of the fringes of 500 – 1000.

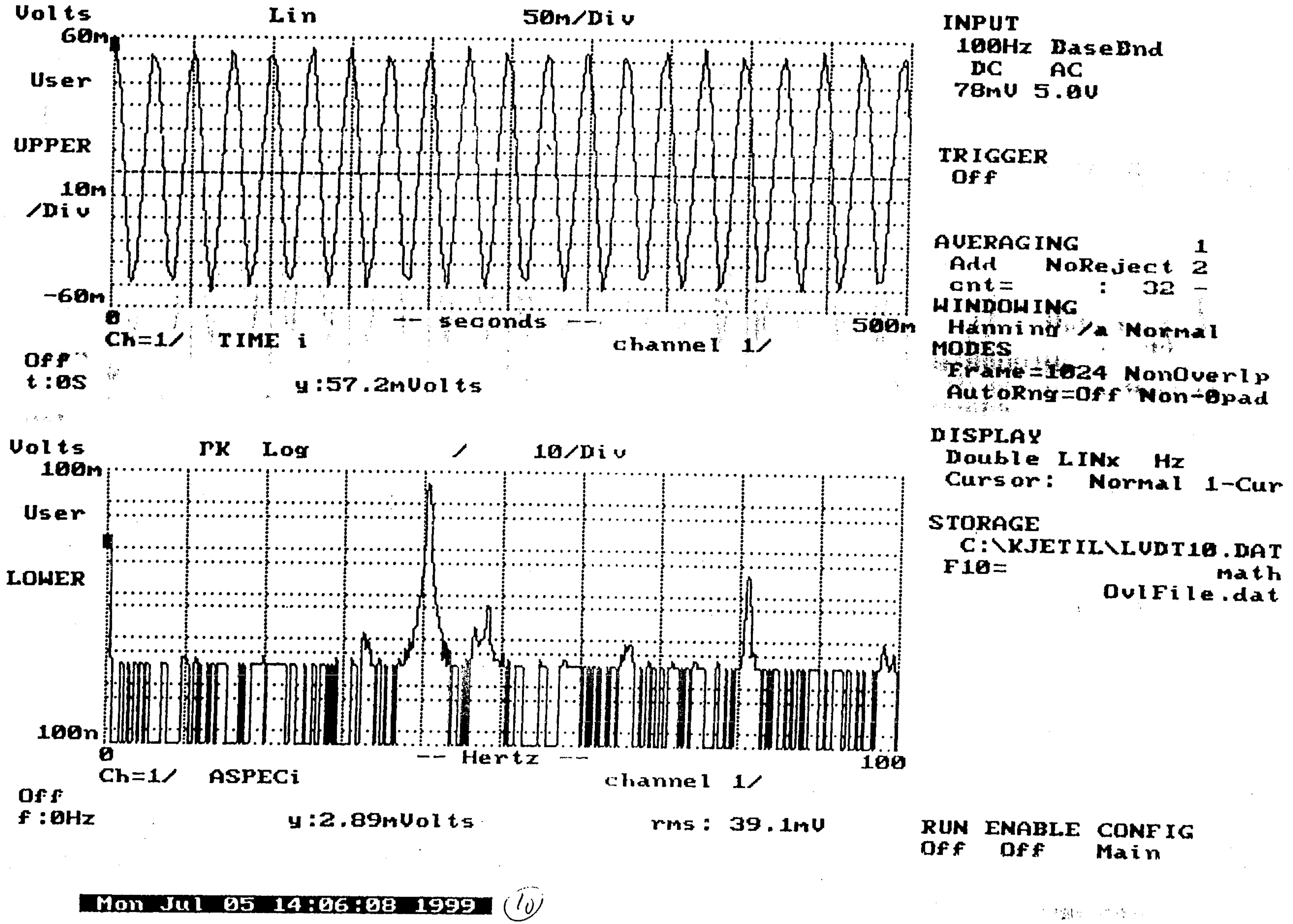
The model we are looking for is a LIP 401 R which includes a fiducial mark.

We can work in this way and get a better idea of the task and propose a solution.
This development can be carried out in Saclay and Meudon.
We do not desesperate in getting some useful informations from Heidenhain to help us.

Kjetil Dohlen

LVDT Testing

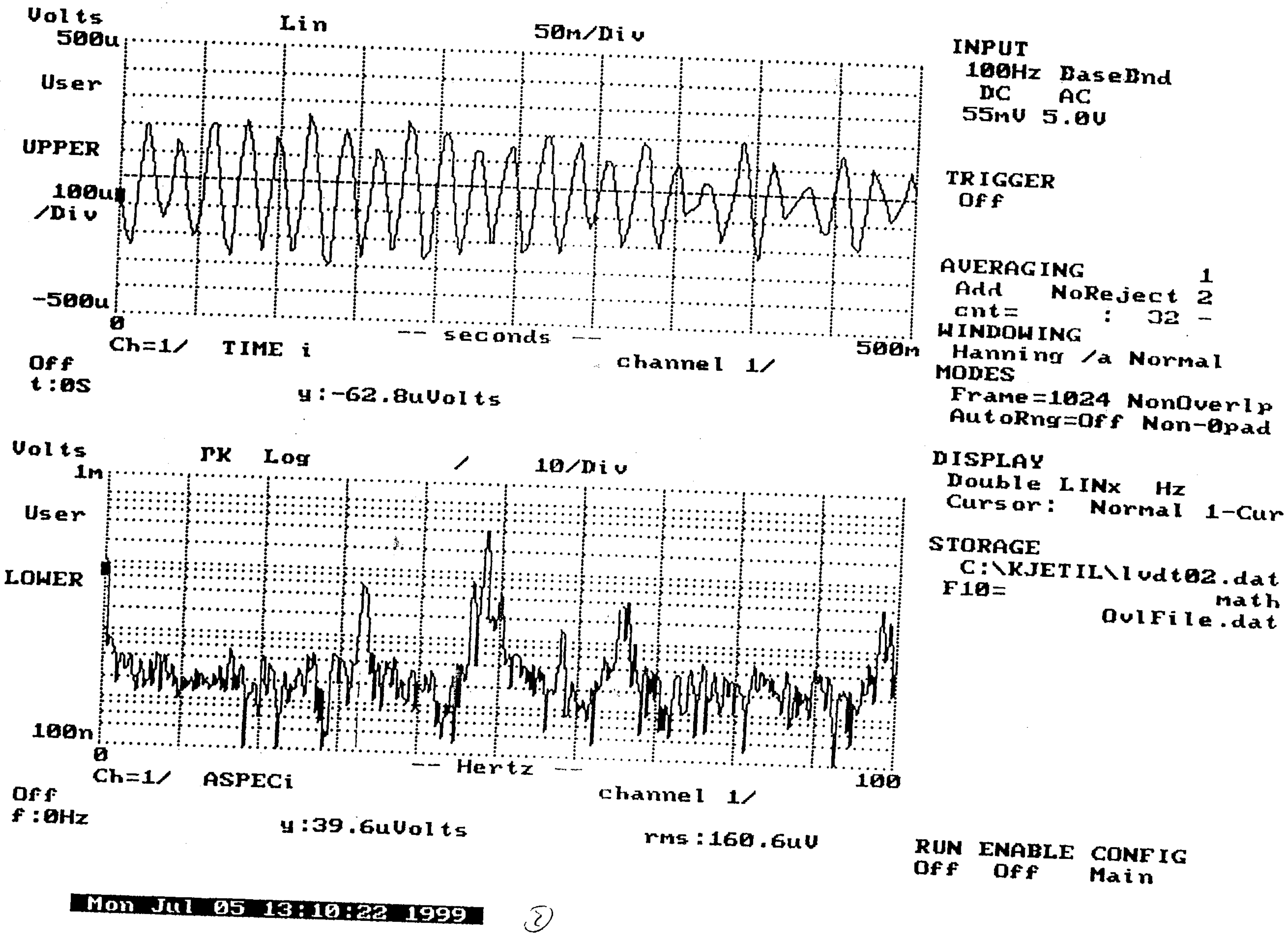
PRINTOUT 8



```
INPUT
 100Hz BaseBnd
  DC    AC
 78mV 5.0V

TRIGGER
 Off

AVERAGING          1
 Add    NoReject 2
 cnt=      :  32 -
WINDOWING
 Hanning /a Normal
MODES
 Frame=1024 NonOverlp
 AutoRng=Off Non-0pad

DISPLAY
 Double LINx  Hz
 Cursor:  Normal 1-Cur

STORAGE
  C:\KJETIL\LVDT10.DAT
 F10=             math
             OvlFile.dat

RUN ENABLE CONFIG
Off  Off    Main
```

Mon Jul 05 14:06:08 1999 ⑩

PRINTOUT 2

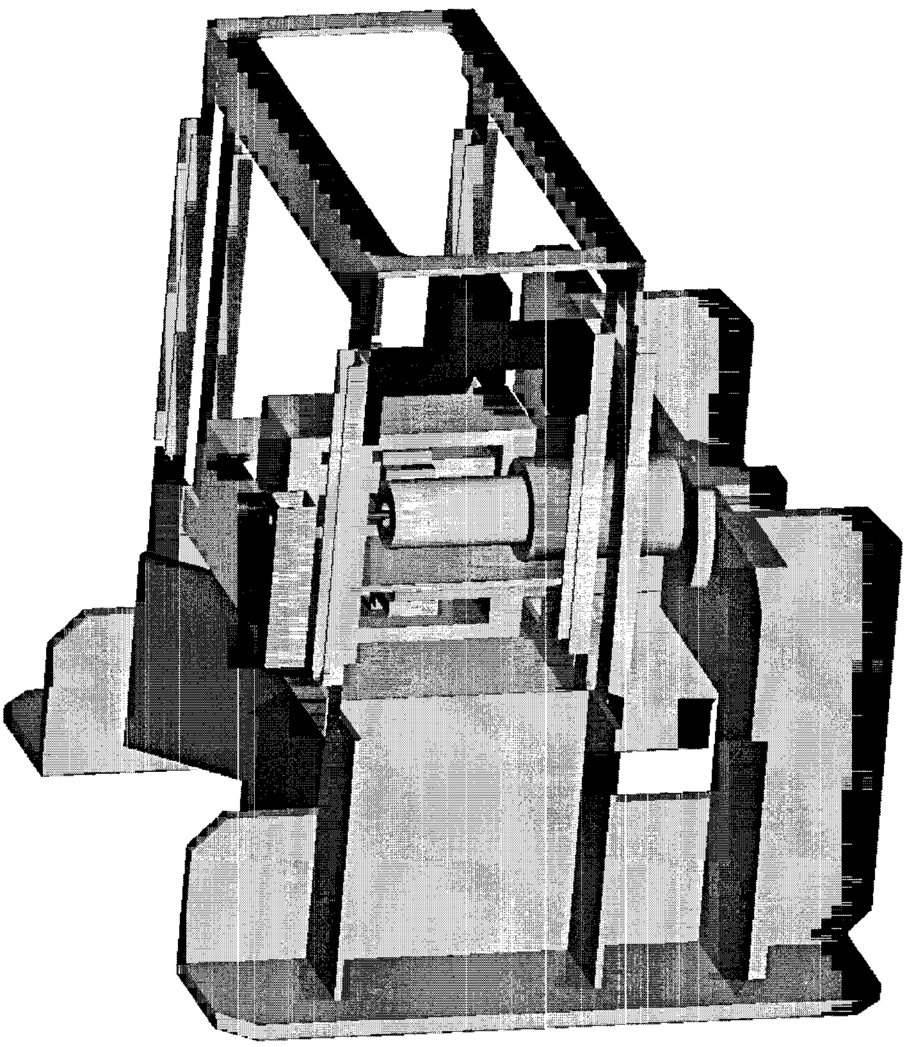


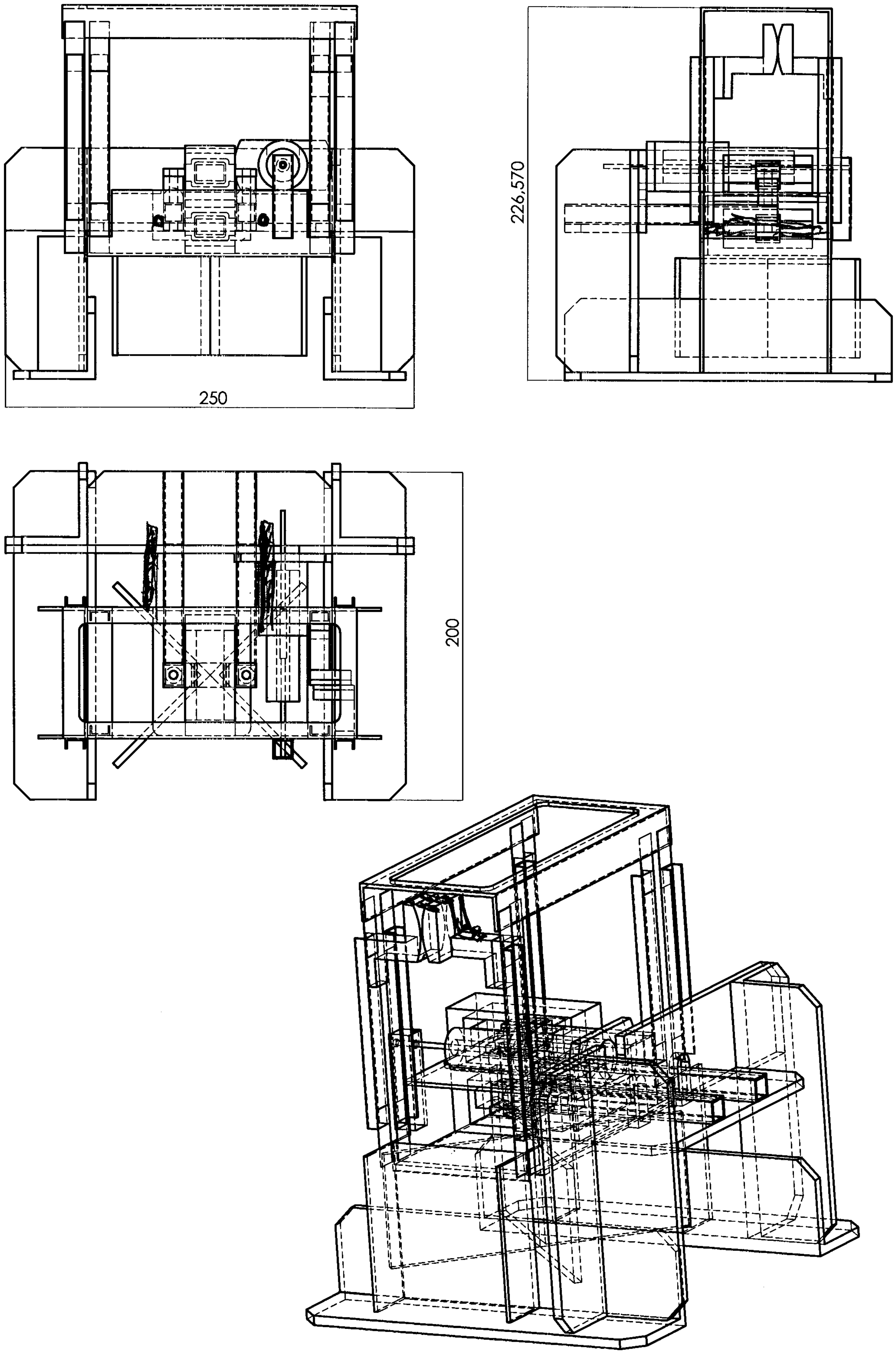
```
Ch=1/   TIME i                    channel 1/
Off
t:0S
              y:-62.8uVolts

Ch=1/   ASPECi                    channel 1/
Off
f:0Hz
              y:39.6uVolts            rms:160.6uV

INPUT
 100Hz BaseBnd
  DC    AC
 55mV 5.0V

TRIGGER
 Off

AVERAGING               1
 Add     NoReject 2
 cnt=        :  32 -
WINDOWING
 Hanning /a Normal
MODES
 Frame=1024 NonOverlp
 AutoRng=Off Non-0pad

DISPLAY
 Double LINx  Hz
 Cursor:  Normal 1-Cur

STORAGE
  C:\KJETIL\lvdt02.dat
 F10=                math
              OvlFile.dat

RUN  ENABLE  CONFIG
Off   Off     Main

Mon Jul 05 13:10:22 1999
```

②

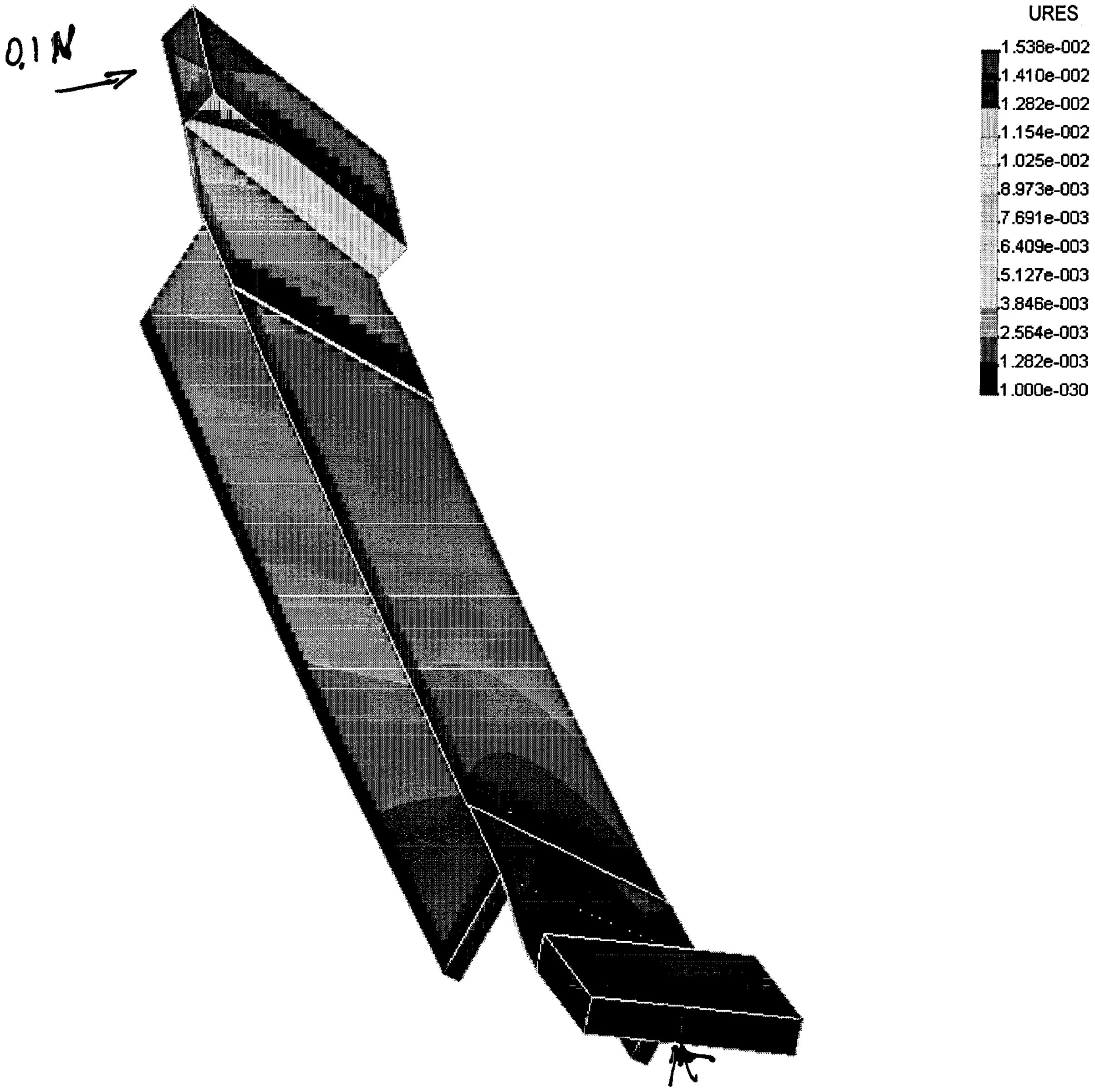
Pascal Dargent

FTS Carriage Mechanical Breadboard

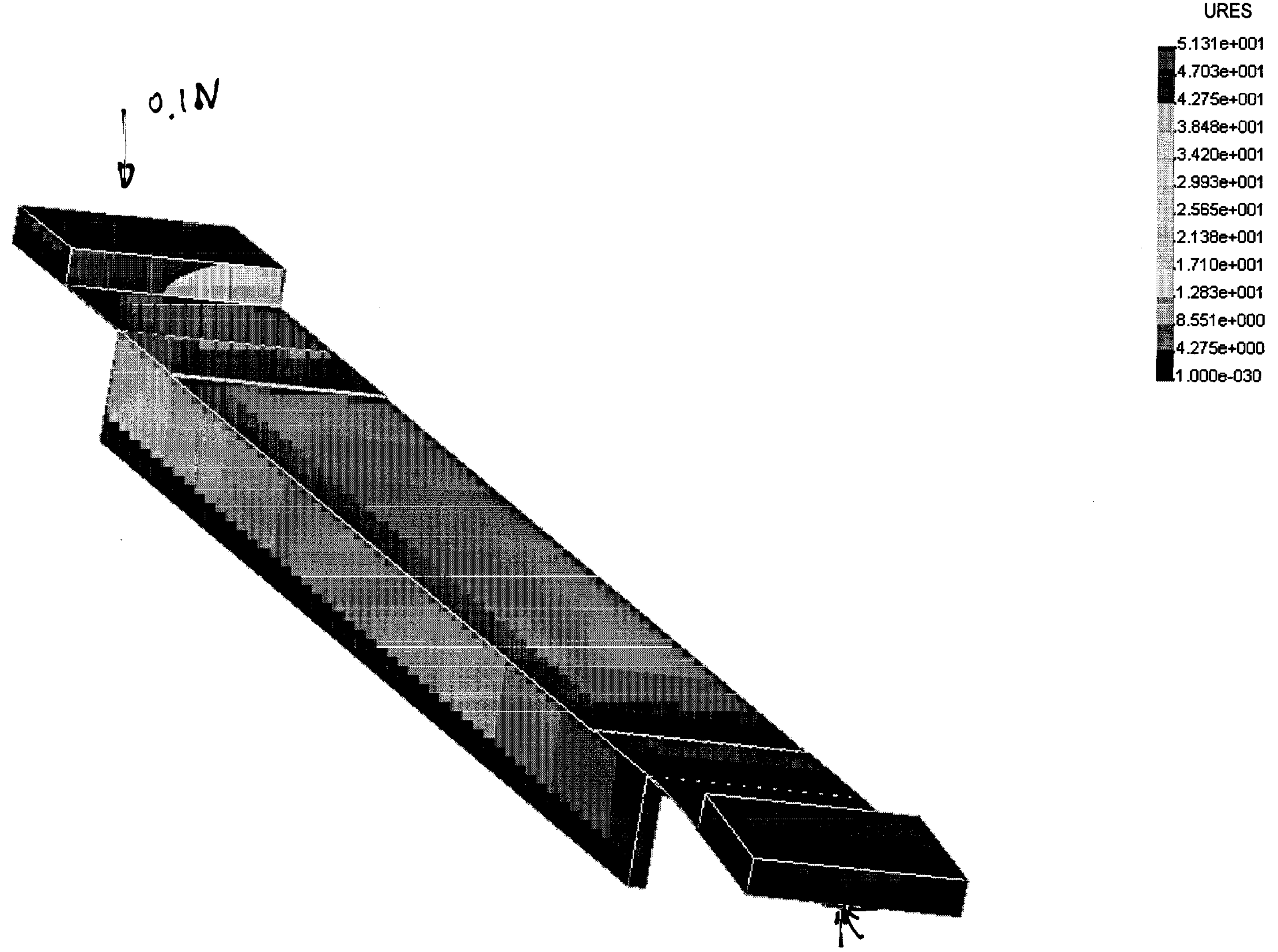


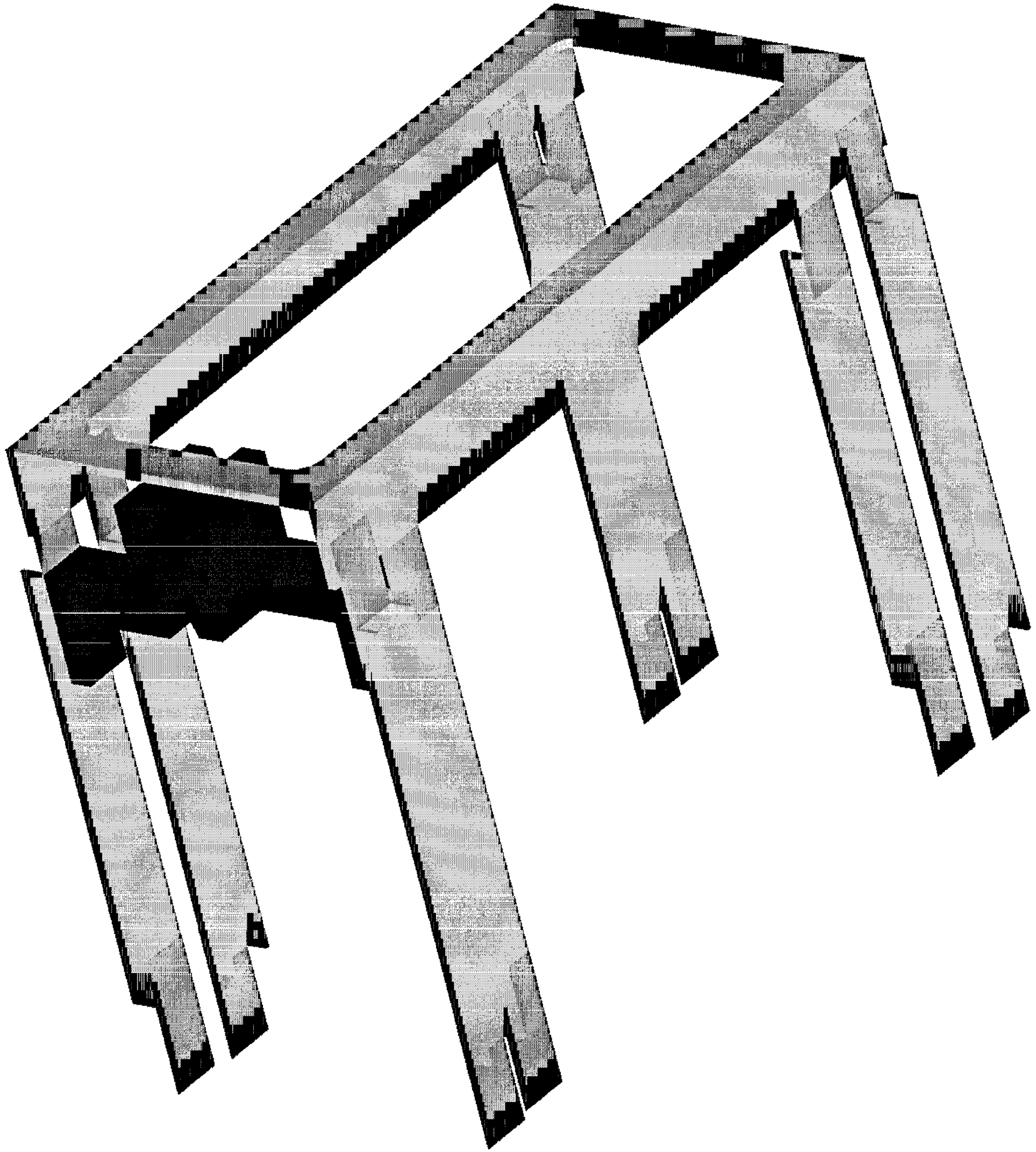

250
226,570
200

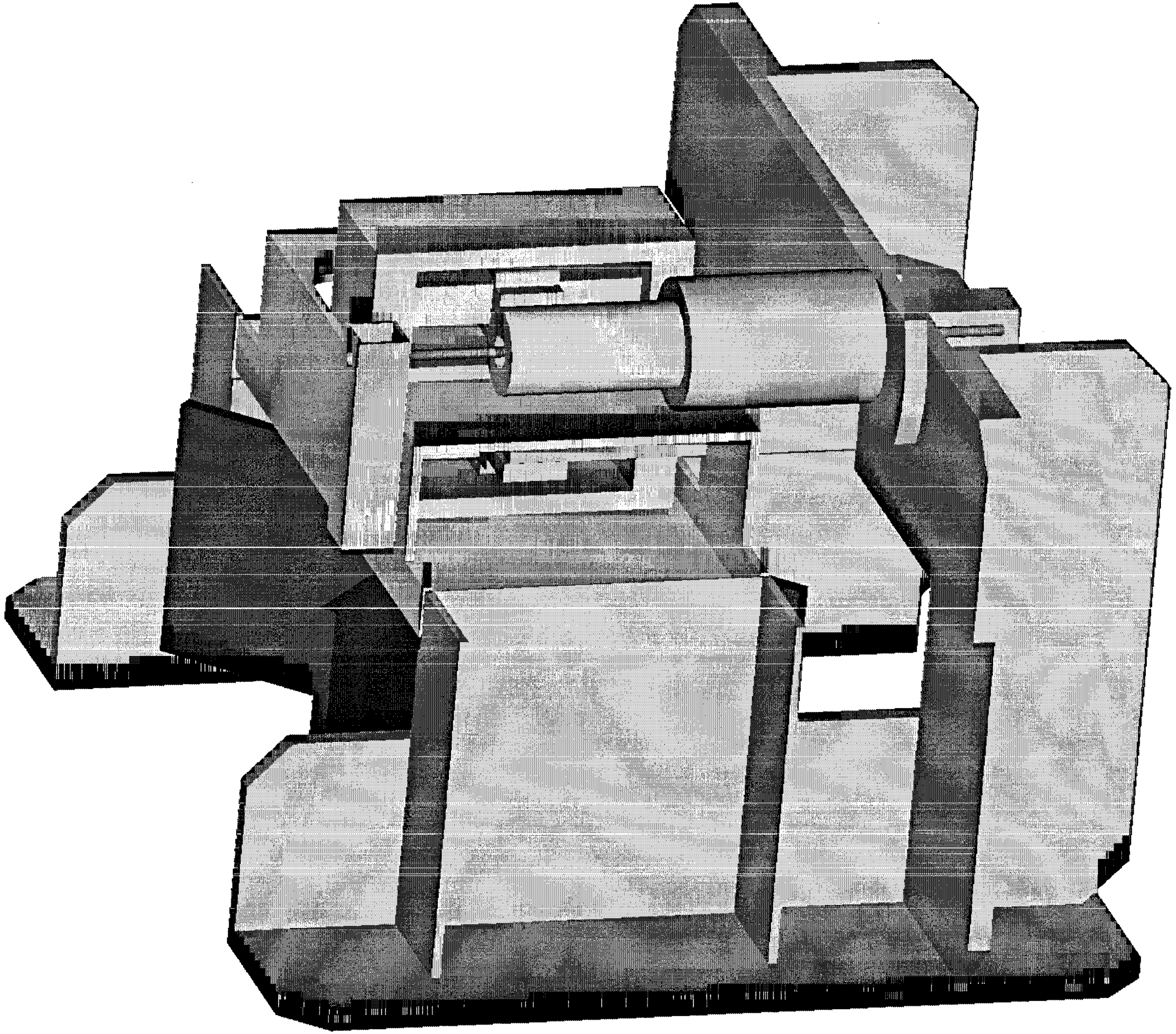
TestRaideur-Transverse :: Déplacement Statique
Unités: mm

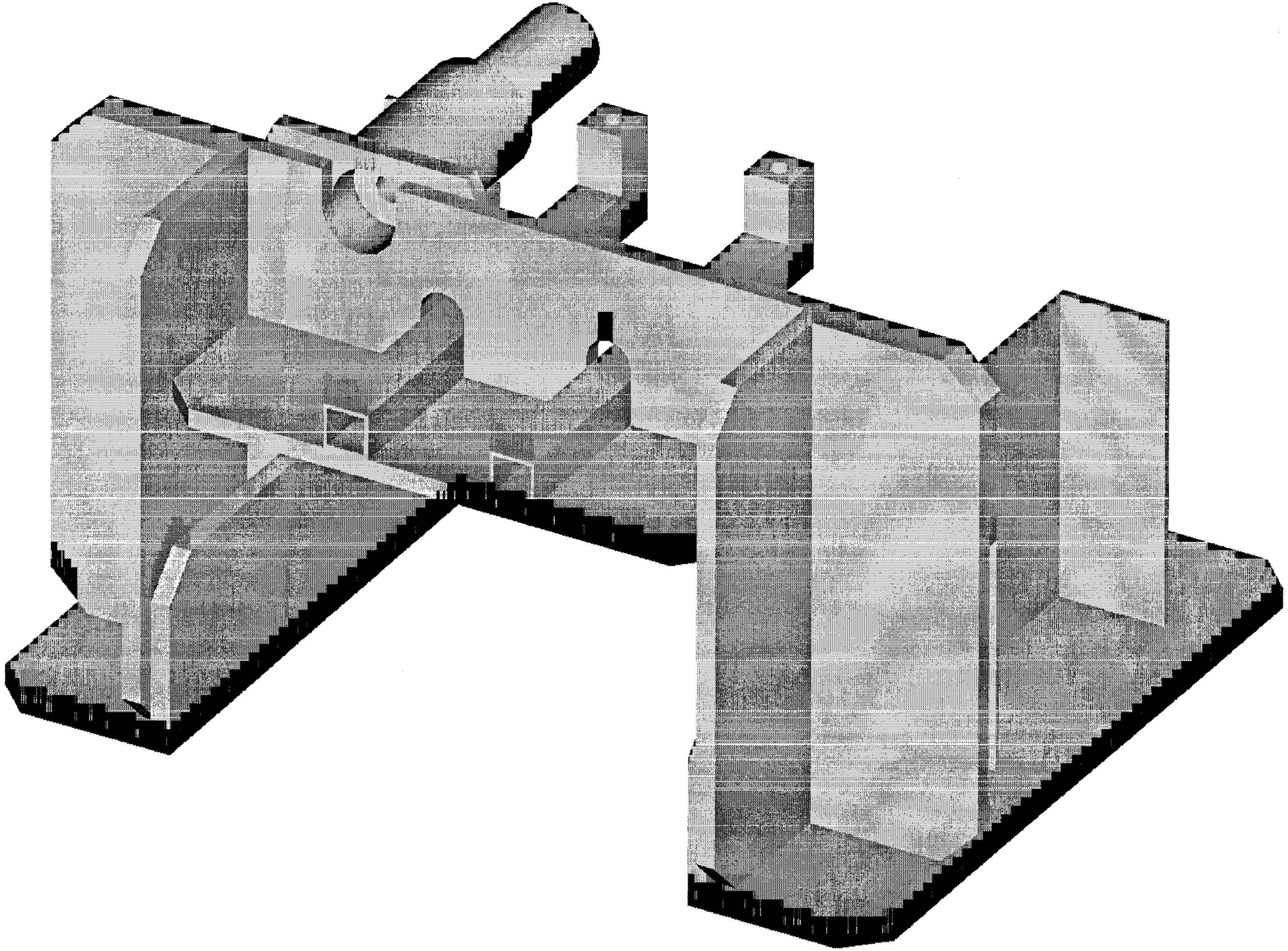


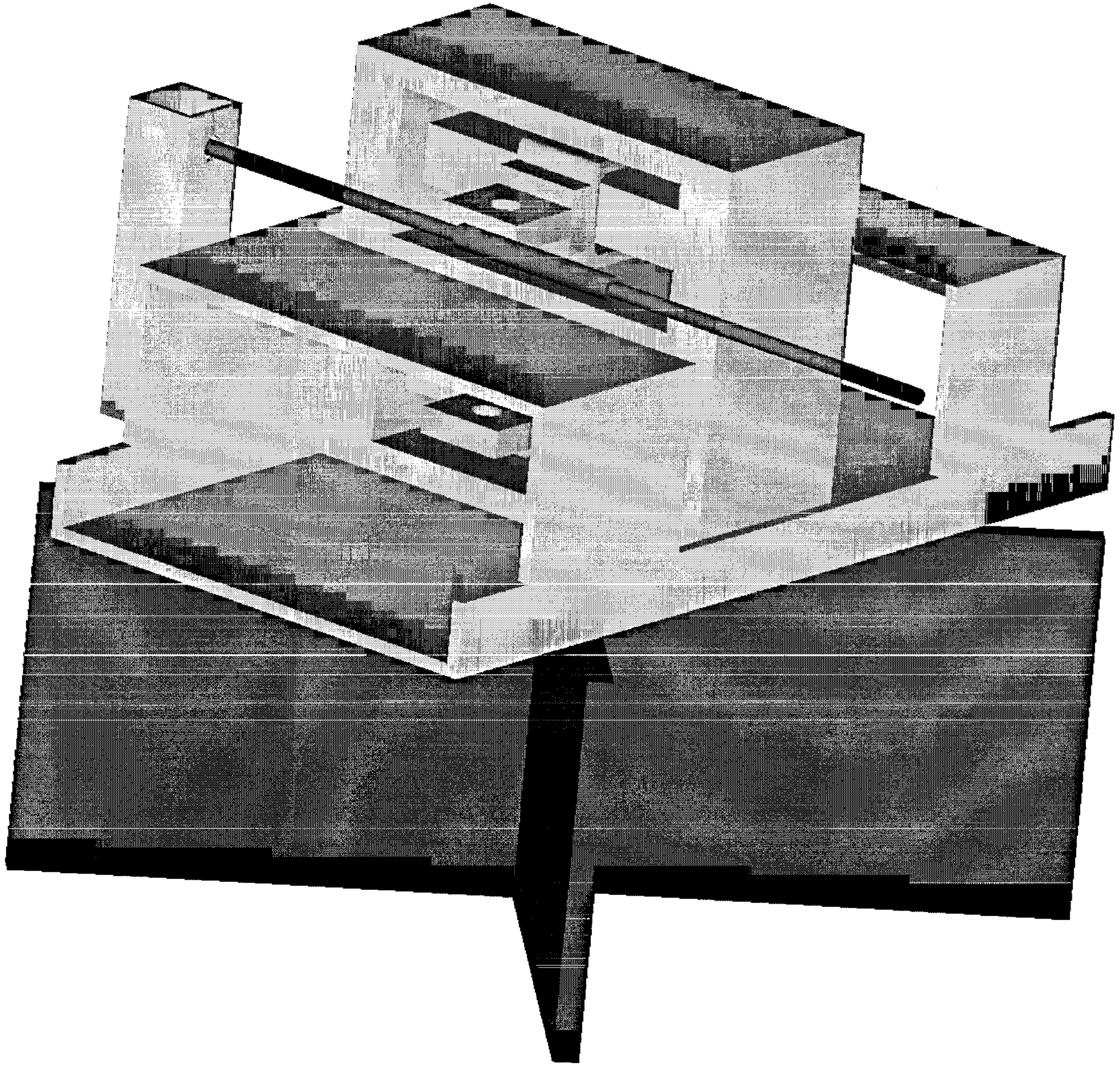
TestRaideur-Test1 :: Déplacement Statique
Unités: mm



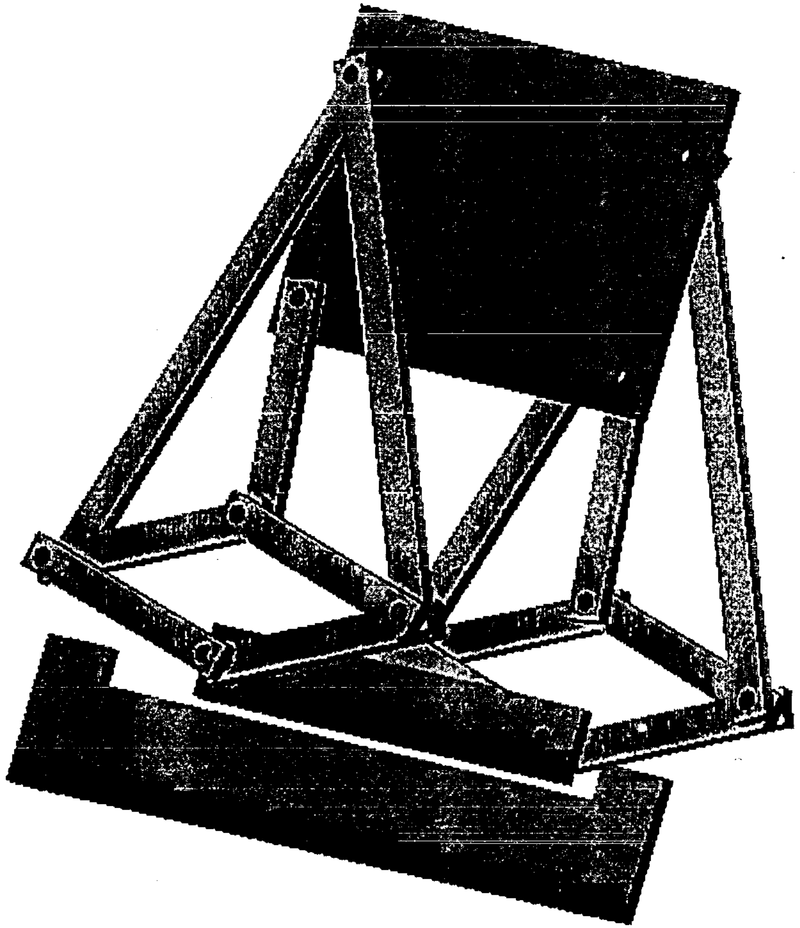








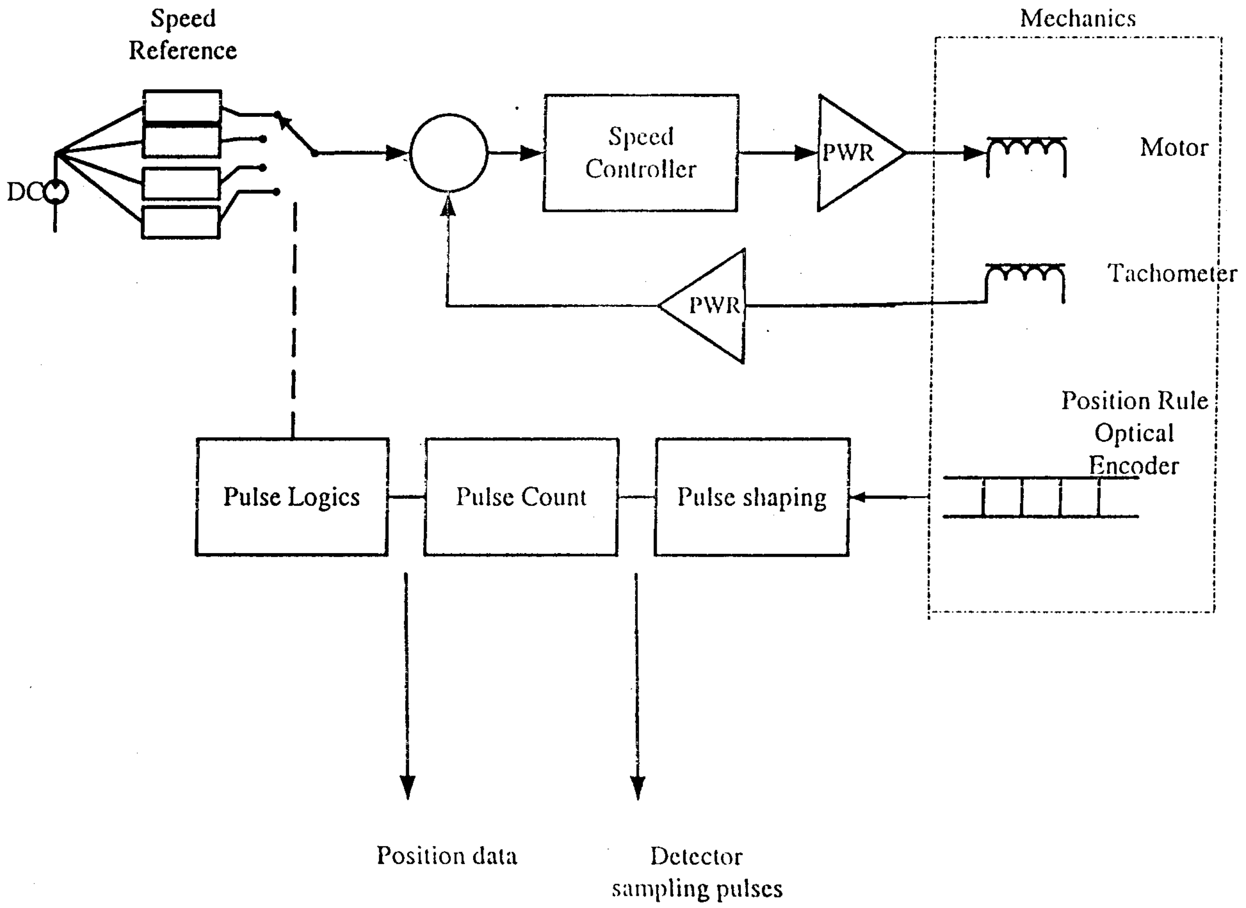
Designs (7) :
Peaucellier link (1864)



Didier Ferrand

FTS Control System

#1: Control type: Speed servo loop
Detector sampling: Incremental encoder
Telemetry: incremental +counter

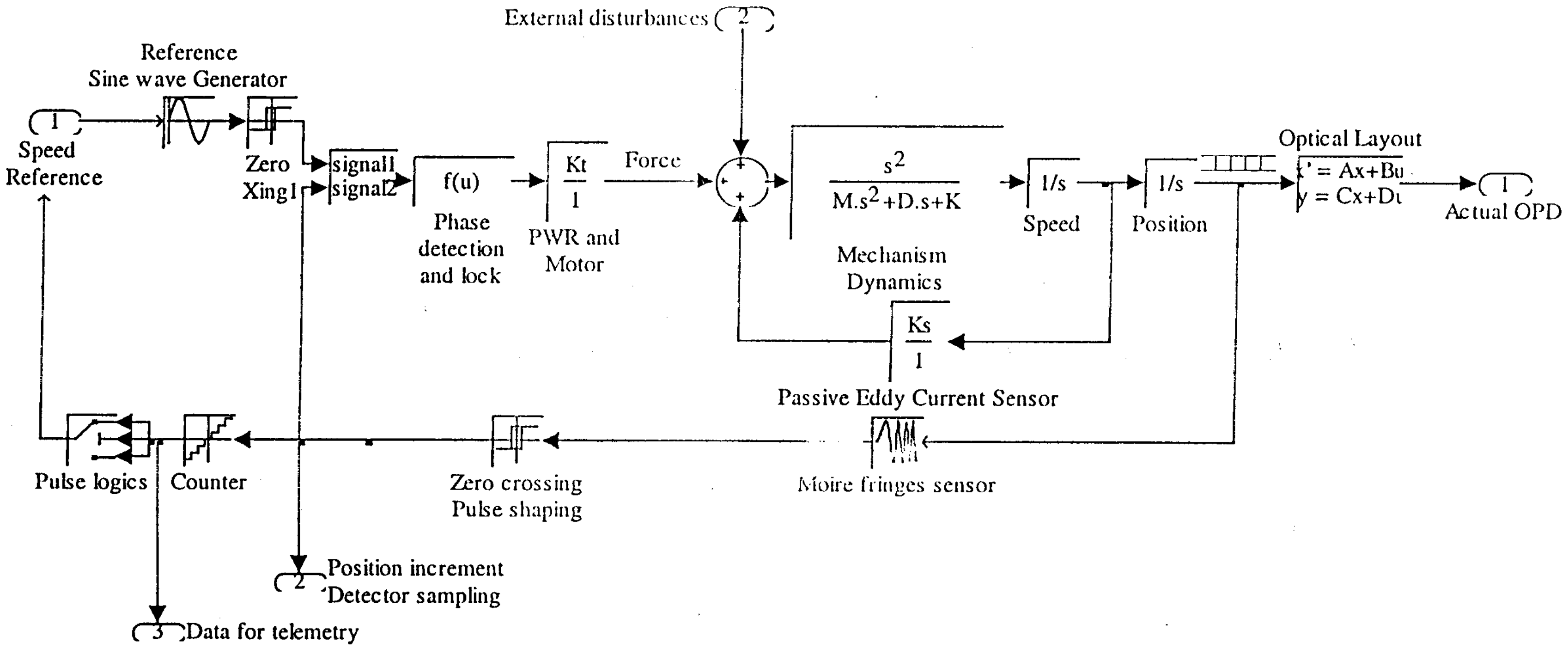


#1: Control type: Speed servo loop
Detector samping: Incremental encoder
Telemetry: incremental +counter

- **Servo Loop**:
  - good scan performances. High bandwidth for external disturbance rejection (phase lag between actuator force input and speed measurement allows high gain).
  - cancellation of speed static error by a dedicated integral effect

  BUT:
  - cumulative errors in position (to avoid position divergence: low bandpass position control ?).
  - Not adequate for step control -> need a Position sensor
- **Interface with DRCU**: very simple
- **Telemetry**: a simple counter instead of a ADC
- **Detector sampling**: deliver naturally pulses according to opd
- **Complexity/risks**: digital electronics simple to realize
- **Heritage**: FIRAS

#2: Servo Control type: Phase lock on an incremental encoder
Detector sampling: incremental encoder
Telemetry: incremental encoder



FTS Control System Block Diagram: Phase Lock with Moire Fringes Solution

#2: Servo Control type: Phase lock on an incremental encoder
Detector sampling: incremental encoder
Telemetry: incremental encoder

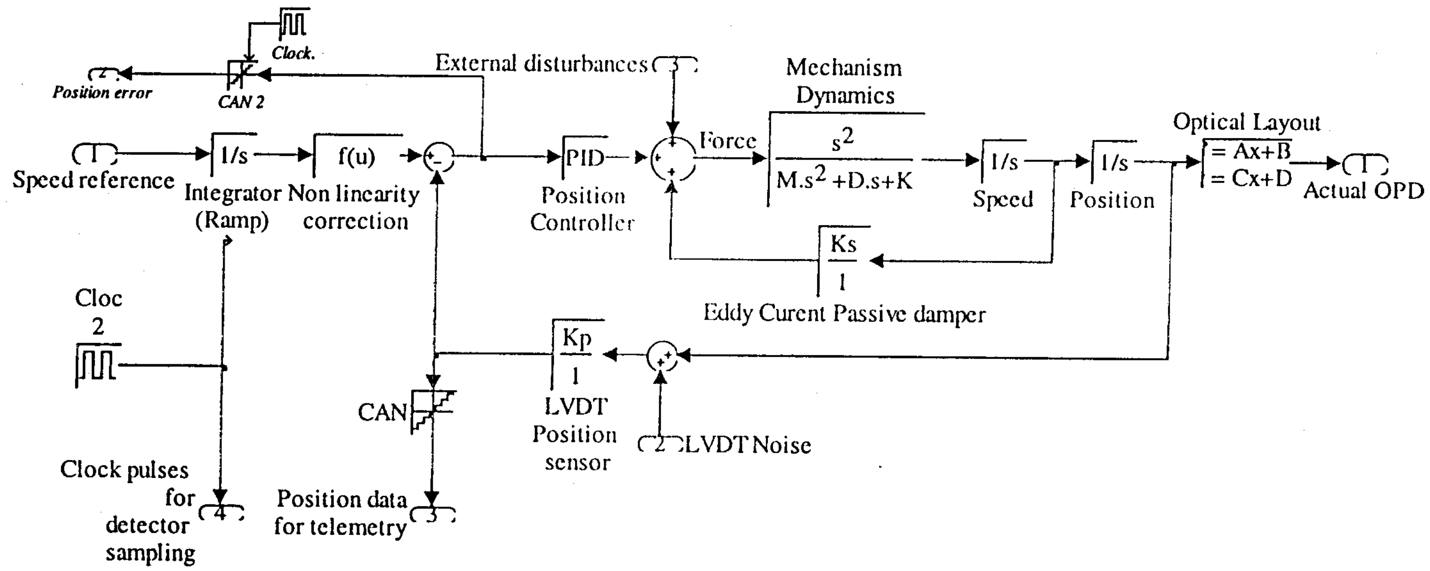
- Servo control:
  - Suitable for tracking application.

BUT:

  - Limited velocity stability performances for low speed motion.
  - Not suitable for step control. (For a 100 Hz bandwidth, need of a 1 kHZ sampling rate)

- Interface with DRCU: simple interface
- Telemetry: a simple counter instead of a ADC
- Detector sampling: deliver naturally pulses according to opd
- Complexity/risks: digital electronics simple to realize

#3: Servo Control loop type:position using a LVDT Detector sampling: Clock ;Telemetry data: LVDT



FTS Control System Block Diagram: Position Control Loop with LVDT

#3: Servo Control loop type:position using a LVDT Detector sampling: Clock ;Telemetry data: LVDT

- **Servo control**:In case of a step control functionality, a position loop is needed and a LVDT is adapted.

  BUT:

    - not suitable for opd tracking. Need of a ramp generation + a correction for non-linearity.

- **Detector sampling**: trigger done by a dedicated clock generated in the FTS Control Electronics, providind a time comb and not an OPD comb. **With time sampling, the position tops are irregularly spaced** and one has to reconstruct each spectrum through amplitude interpolation. If the telemetry rate is suffisant this process could be done on the ground. One has to notice that the amplitude normalisation is compulsary for both sensors if the speed stability is not reached
- **Telemetry**: need of a high resolution ADC .Position data quantized by a ADC (at least 16 bits if the absolute position needed on the full range).
- **Electronics Complexity**: a LVDT resolution is limited by electronics noise. The very high resolution of **0.1 microns** needs a **low noise conditionning electronics**. The elctronics is more complex to calibrate.
- **Heritage**: ISO-LWS + **LVDT 'S have been space qualified**.

FTS Servo Development model

The FTS Control System performance shall be verified on a dedicated bench monitored by a PC equipped with MATLAB/DSpace Fast Prototyping Set with the implementation of:

  - one linear motor
  - one additional motor for speed control loop
  - 1 or 2 LVDTs (short/long strokes)
  - an incremental encoder (option)
  - various stiffness

- **The main performances to be checked shall be :**
  - Position tracking accuracy
  - Speed motion stability
  - External disturbances rejection level-Bandwidth-Settling time
  - Robustness of the control system v.s. process parameters drift (in particular the stiffness)

Conclusions

Ideally from a control point of view, the goal is to perform:

- a stable scan by mean of a a velocity control loop. Need of a velocity sensor investigation as the core of the servo control. Need a velocity sensor with a good linearity.
- A triggering of the detector representative of the OPD
- telemetry data without the need of a high resolution ADC
- Easy interface, Digital electronics easy to implement

- **=>The solution including a velocity sensor + an incremental encoder is more suitable**
  -> Cf FIRAS configuration

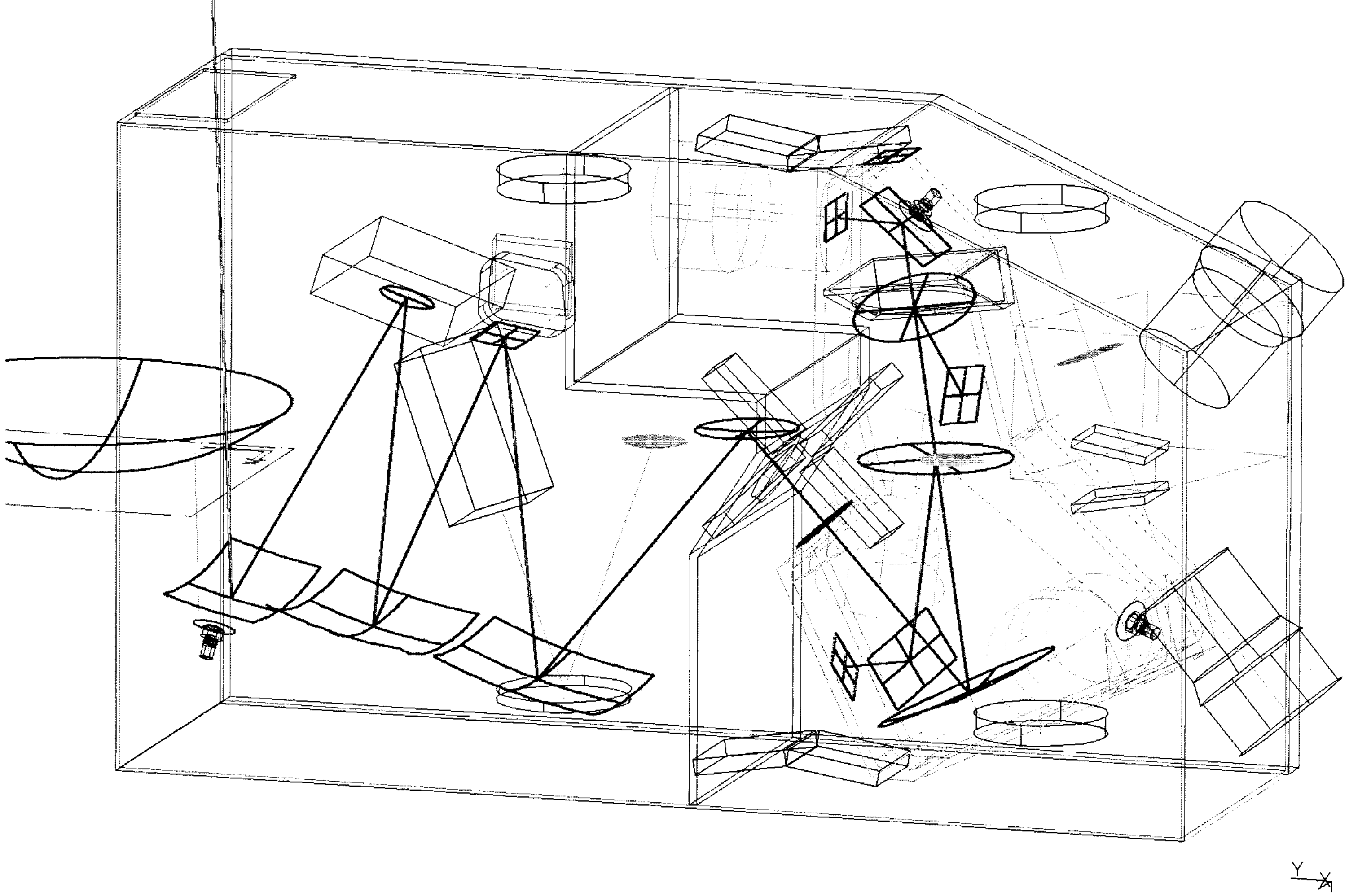
- In case of Step control: a position sensor needed. Use of a LVDT for position control mode (cf FIRAS)

- The redundancy and degraded mode aspects have to be investigated since the begining to make decision of combining 2 type of sensors or the combination of 2 LVDTs of different strokes

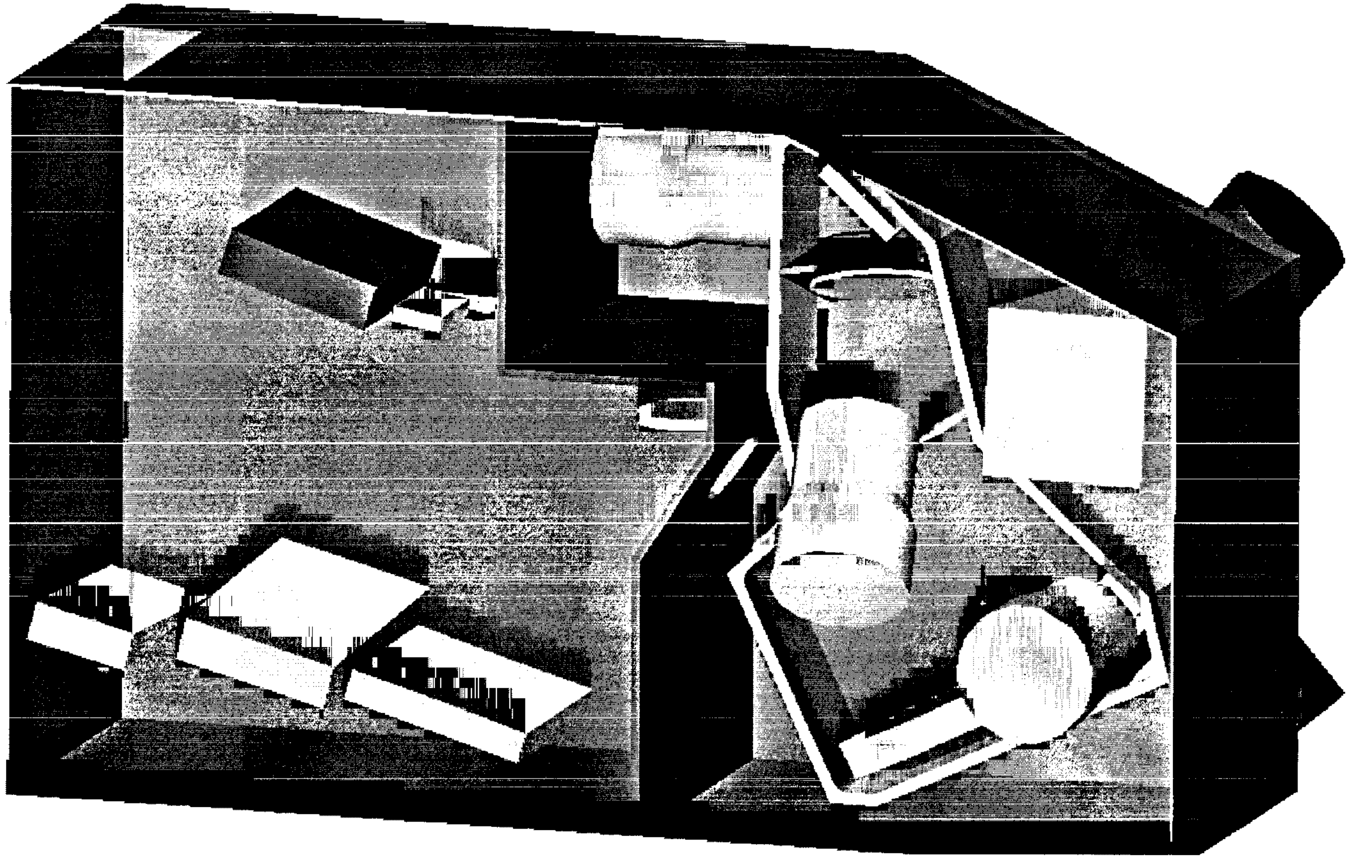
Berend Winter

Mechanical
Accommodation

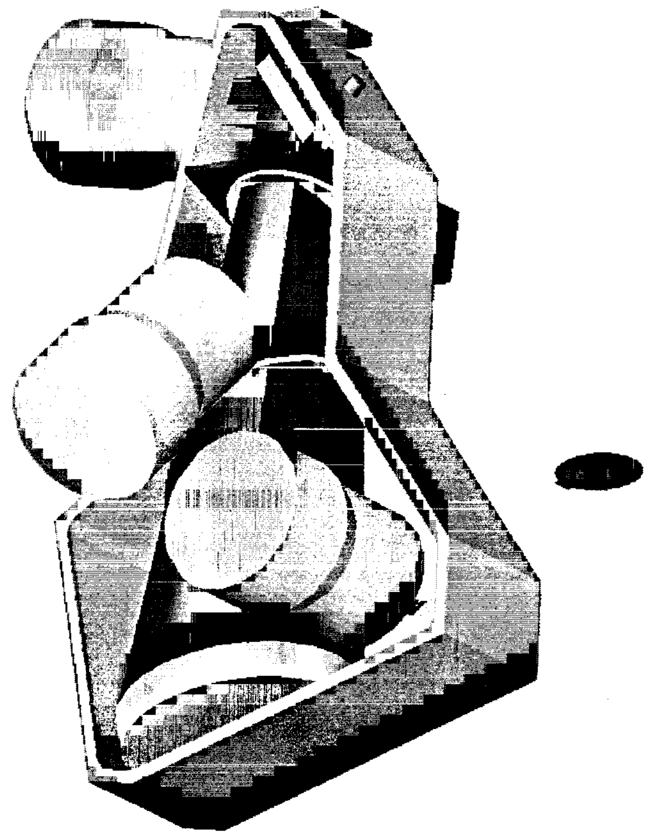
SPIRE ray diagram overview



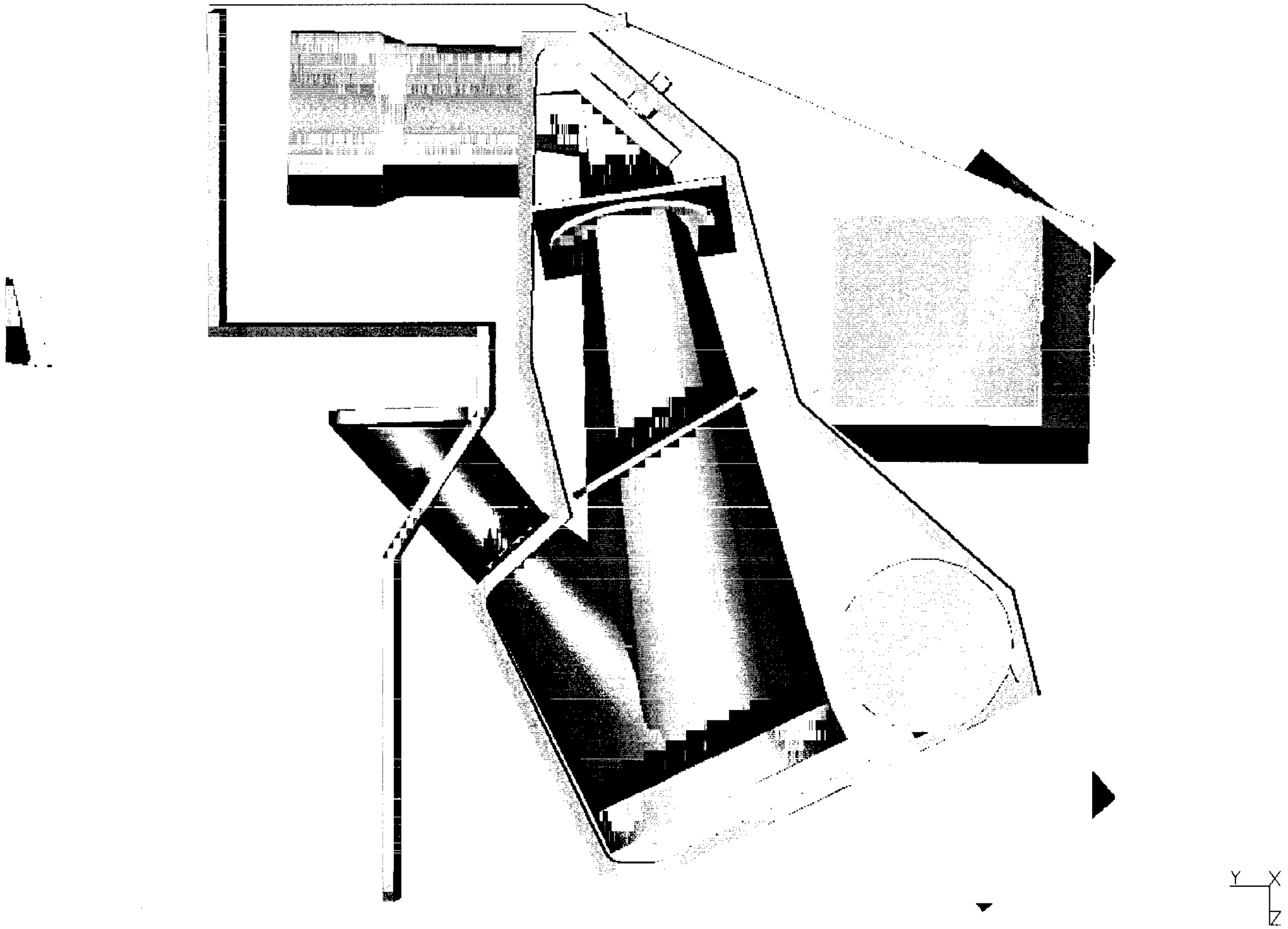
Shaded view photometer



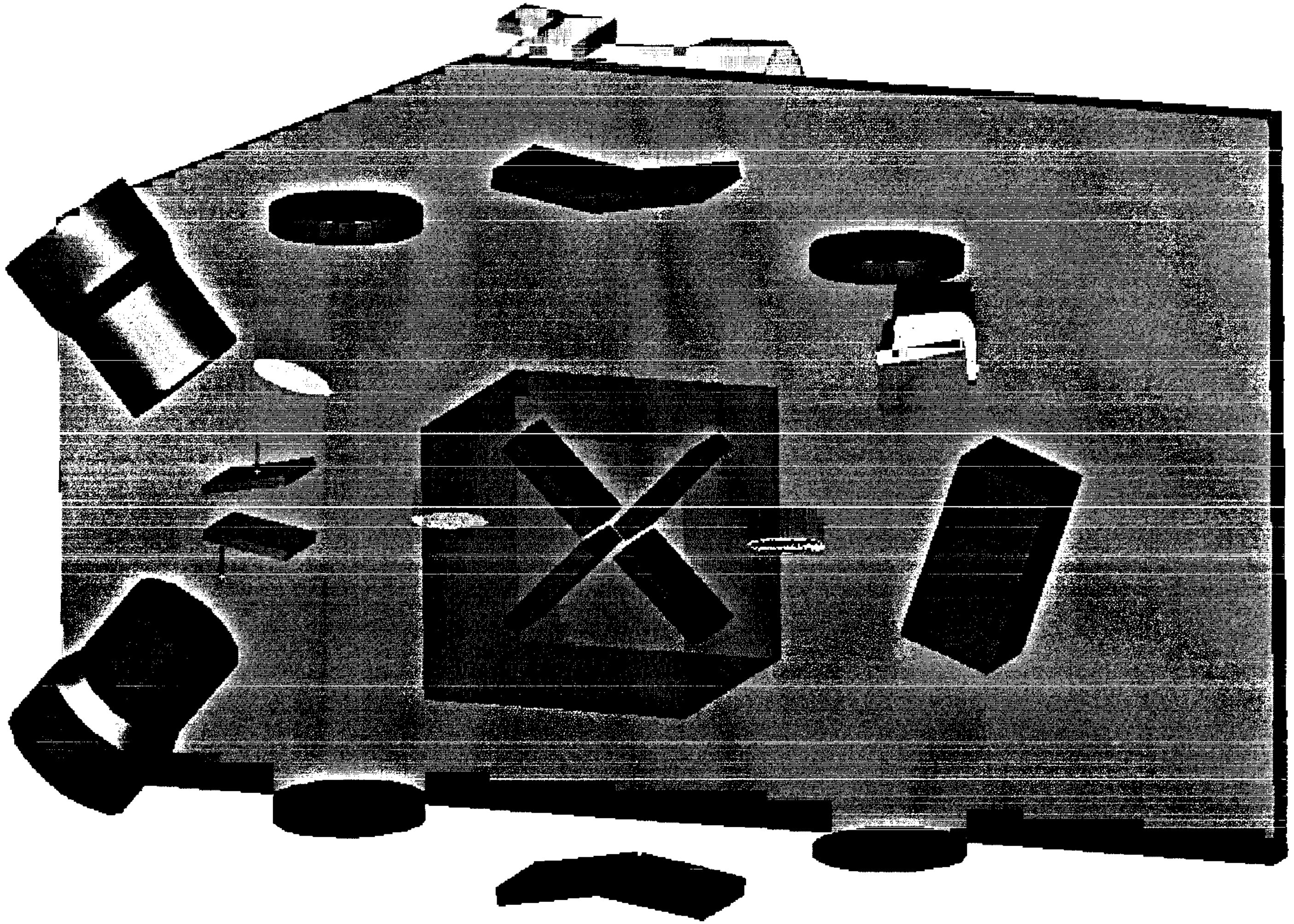
Photometer detector box



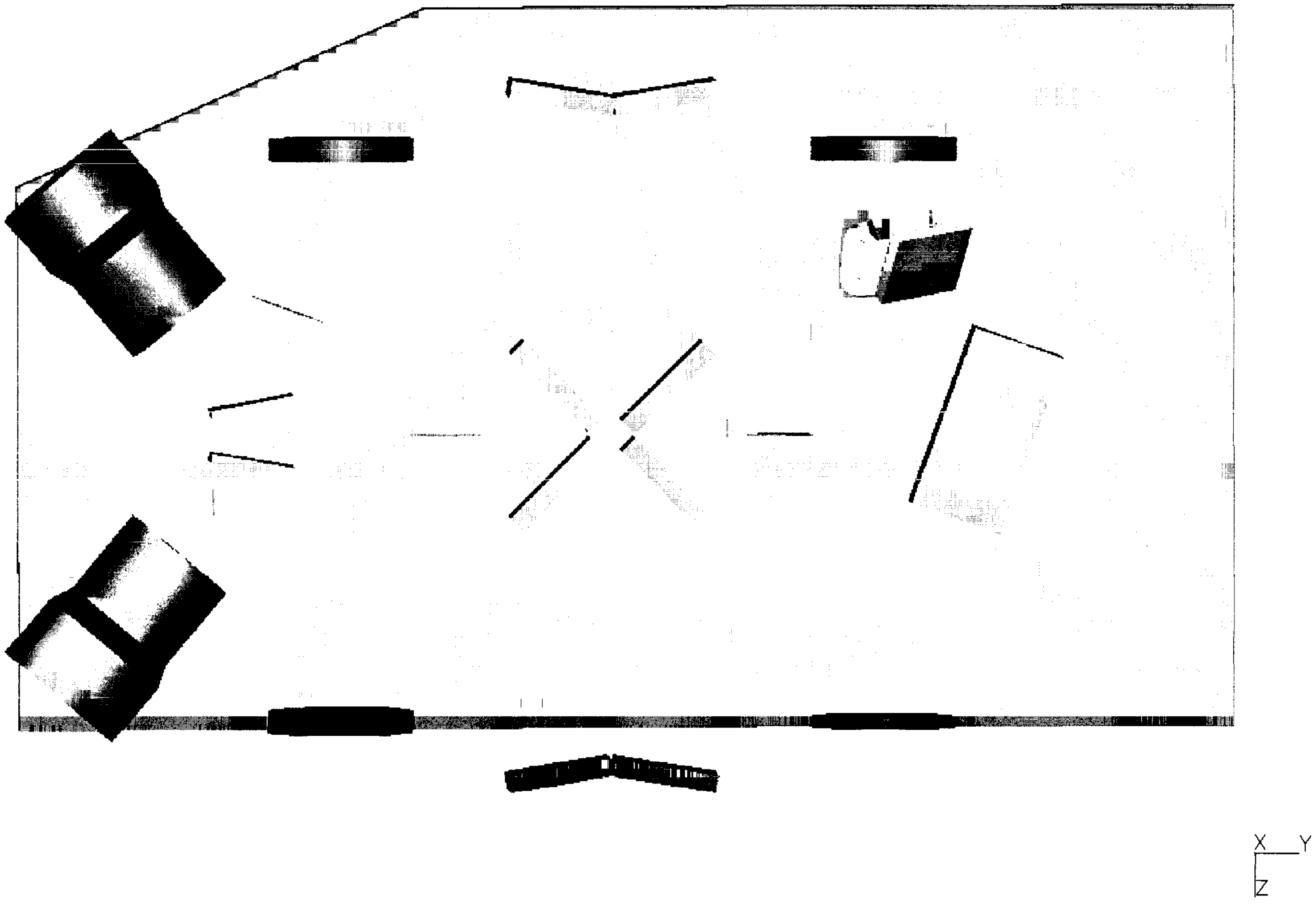
Photometer detector box



FTS overview



FTS ray diagram



Bruce Swinyard

Development Plan and Schedule

POSITION SENSOR

MOIRÉ

- FIND GOOD LED FOR HIGH AMPLITUDE FRINGES
- PERFORMANCE MEASUREMENT COLD
- LIFETIME / ~~[illegible]~~ THERMAL CYCLING TESTS.
- * - STRAYLIGHT TEST *
- WARM VIBRATION TEST
- REDUNDANCY

LVDT

- * - PERFORMANCE MEASUREMENT WARM/COLD. *
- PERFORMANCE STABILITY ON ~~[illegible]~~ THERMAL CYCLING.
  - ESPECIALLY NON-LINEARITY
- POWER CONSUMPTION. < 2 [illegible]
- REDUNDANCY
- MAGNETIC INTERFERENCE WITH MOTOR
- EMI. → SAME AS STRAYLIGHT TEST.

⇒ DECIDE CONTROL SYSTEM ⇒ IN TIME FOR NOVEMBER.

⇒ IDENTIFY INTERFACES WITH WE FOR CONTROL OPTIONS.

\# MEETING WITH CERN END SEPT

→ PRESENT BOTH OPTIONS.

BASELINE MOIRÉ FRINGE

DATE

NOV '99

ELECTRONICS
PDR

OCT '99
NON-REP
BREADBOARD
FOR CONTROL
TESTING
INCL.
MOIRÉ FRINGE

[illegible]

MARCH '00 SEPT '00

ΔPDR

CDR

FEB '00
CARRIAGE
PROTOTYPE
WITH COMM
MOTOR

FEB '00
MOIRÉ DEVICE
TESTED.
INCL STRAYLIGHT

FEB '00
OPTICS MODELLING

FEB '00
FIRST DRAFT
ICD.

JAN '01

OPTICAL
BREADBOARD

BEAM
SPLITTERS
QMW.

[illegible] DEC '01

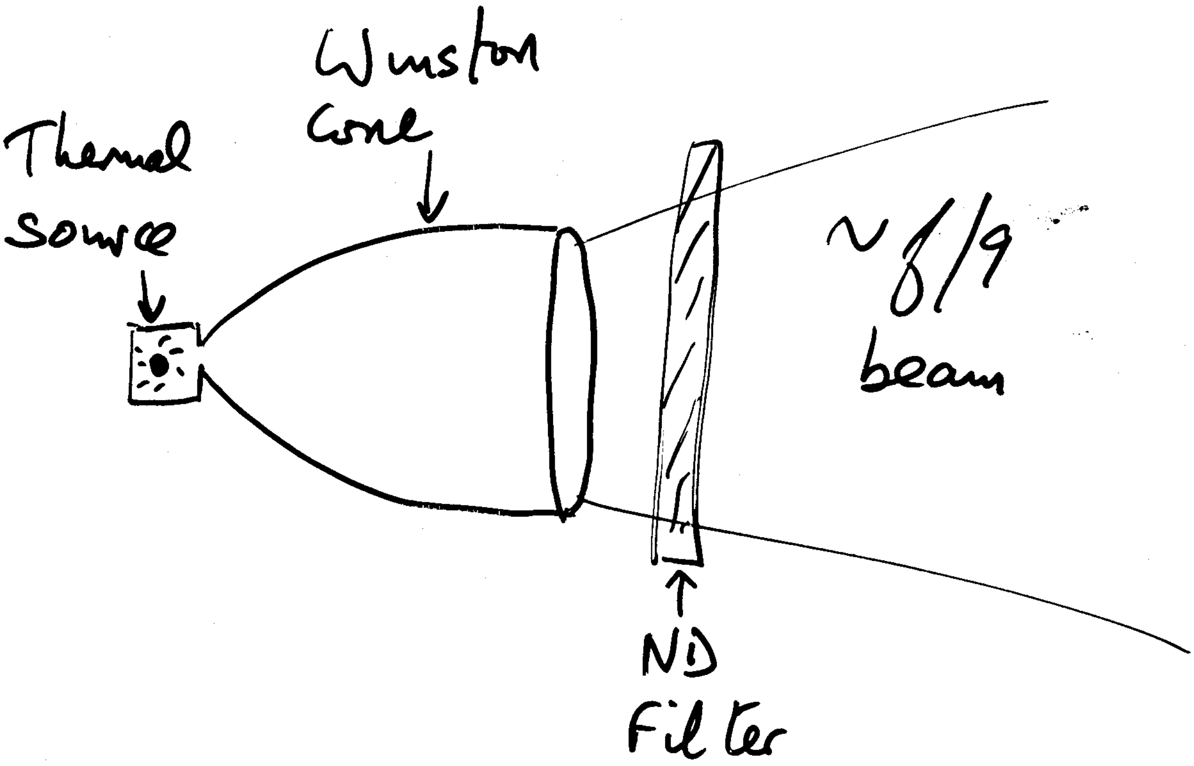
~~FEB~~'01 JUNE '01

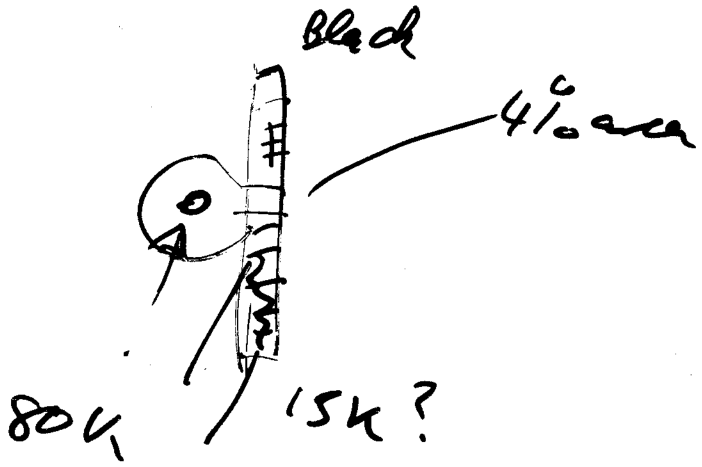
DELIVERY
TO RAL

ELECTRONICS
TO CEA

AIV/QUAL
OF ELEC
+ MECH.

DRC SIM
FROM CEA


Thermal source
Winston cone
~f/9 beam
ND Filter


Black
4% area
80K
15K?