000119_1_0 BOL|CEA|M|0032.10

BOL/TECH. MEETING

Saclay

Nov. 12, 97

FIRST BOL TECHNICAL TEAM MEETIN[illegible]
12 NOV 97 CEA SACLAY / ORME.

Name	Organisation	telephone	fax	E:mail
Wilfred Oliver	MSSL	(+44) 01483 204119	(+44) 01483 278312	wto@mssl.[illegible] .uk.
MATT GRIFFIN	QMW	+44-171-975-5068	+44-181-980-0986	m.j.GRIFFIN@[illegible]
COLIN CUNNINGHAM	ROE	44-131 668 8223	44-131 668 1130	CRC@ROE.[illegible]
JEAN-PAUL BALUTEAU	LAS	33.491 05 59 30	33.491 66 18 55	BALUTEAU@ASTR[illegible]
DOMINIQUE POULIQUEN	L.A.S.	33.491055949	33 491661855	DOMINI@AST -M[illegible]
FRANÇOIS PAJOT	IAS	33 1 69858567	33 1 69858675	pajot@ias
J M Lamarre	IAS	+33 1 69858577	"	lamarre@i[illegible]
Peter A.R. ADE	QMW	44 171 9755032	44 181 9800986	P.A.R.ADE@QM[illegible]
IAN HEPBURN	MSSL.	44 1483 204101	44 1483 278312	IDH@MSSL
Bruno MAFFEI	QMW	44 171 4153760	44 181 980 0986	B.Maffei@qmw[illegible]
Christophe BUZZI	CEA/LETI	0476884973	0476885167	buzzi@[illegible] cea.[illegible]
Martin Caldwell	RAL	+44-1235-446586	+44 1235 446667	m.caldwell rl.ac.uk.
Fraser MORRISON	ROE	44-131-668-8347	44-131-668-1130	gfm@roe.ac.[illegible]
[illegible] SARACENO	IFSI-CNR	39-6-4993-4398	6-4993-4383	[illegible]@ifsi.[illegible]
LEONARDO VANZI	CAISMI-CNR	39-55-2752206	39-55-2752292	VANZI@ARCETRI
ROBERTO MAIOLINO	ARCETRI OBS.	39-55-2752250	" "	MAIOLINO@ARCETRI ASTRO.IT
Jean-Louis AUGUÈRES	CEA/SAp	+33(0)1-69-08-30-58	+33(0)1-69-08-65-77	augueres@cea
Kjetil DOHLEN	OMA	33(0)495 04 41 24	33(0)491 62 11 90	DOHLEN@OBMAE CNES-MRS.
Eli ATAD-ETTEDGUI	ROE	0131-6688202	0131-668-1130	ea@roe.ac.[illegible]
RENATO ORFEI	IFSI-CNR	+396-4993-4393	+396-4993-4383	orfei@ifsi.rm.[illegible]
RICCARDO CERULLI	" "	+396 49934377	" "	cerulli@ifsi.rm[illegible]
Ken King	RAL	+44 1235 446558	+44 1235 6667	kj.king@rl.ac.[illegible]
Bruce Swinyard	RAL	+44 1235 446845	— " —	B.M.Swinyard @RL.AC.[illegible]
Louis RODRIGUEZ	CEA/SAp	33 169 08 6948	33 1 6908 6572	LRODRIGUEZ@cea
Pierre Cox	IAS	33 1 69858737	33 1 69858675	cox@ias.fr

Aims of this meeting

1. **Finalise technical options for AO response preparation.**

2. **Identify work needed for:**

   - Technical Description
   - IID-B

3. **Establish tasks and deadlines for AO preparation**

Important issues:

- ^{3}He cooler base-line specification
- FTS optical design and accommodation
- Photometer stray light analysis
- Thermal model
- Cryo-harness definition
- Definition of operating modes

  + ON BOARD PROCESSING REQUIREMENTS

BOL instrument design

- Significant design changes following
  - Bolometer Arrays Workshop held at QMW 29, 30 Oct.
  - BOL Scientific Case Team Meeting, Nov. 6

1. ^{3}He cooler now base-line instead of dilution cooler
2. Large format bare detector arrays now base-line stead of feed-horn arrays
3. FTS is favoured spectrometer option

Previous baseline (now fall-back)

- Hexagonally close-packed arrays of 2Fλ circular feedhorns with spider-web bolometers
- Photometer

Photometer	250 μm	61 dets.	
	350 μm	37	
	500 μm	19	Total = 117

Spectrometer ~ 40 (either FTS or grating options)

- Total no. of detectors in instrument: Approx. 160

New base-line

- Filled absorber arrays of square 0.5Fλ pixels (full sampling of the image)
- Imaging FTS spectrometer
- Bolometer array technology: to be determined
- Photometer

Photometer	250 μm	32 x 32 = 1024	
	350 μm	24 x 24 = 576	
	500 μm	16 x 16 = 256	Tot. = 1856

- Spectrometer	25-38 cm^{-1}	16 x 16 = 256	
	38-50 cm^{-1}	16 x 16 = 256	Tot. = 512

Min 2 x 2 arcmin fov (goal = 3 x 3 arcmin)

- Total no. of detectors in instrument: 2368

Reasons for changing the base-line

Detector arrays:

- Best possible sensitivity for deep imaging surveys for high-z galaxies ⇒ must have as many detectors as possible.
  - Improvement in mapping speed
  - Factor of 4 ? (being studied)
- Simplified observing modes
- Reduced susceptibility to pointing and tracking errors
- Easier imaging spectroscopy with an FTS
- Easier to implement simultaneous mapping with PHOC
- Feed-horn array option = reliable, conservative design but will be obsolete when BOL flies
- Intention to fly large-format filled arrays if we can ⇒
  - Propose this as base-line for space-craft interfaces and resource requirements and internal requirements
  - Retain the more conservative feed-horn arrays as a fall-back option.

FTS spectrometer:

- Flexible spectral resolution
- Imaging spectroscopy
- Full scan sensitivity comparable to grating
- Known line sensitivity inferior to grating but not science driver
- Lower susceptibility to stray light, spectral leaks

BOL Sensitivity:

- Guarantee figures based on fall-back
- Quote goals based on filled arrays

Array technology options

Base-line:

(a) CEA arrays
  - 2-K multiplexer

(b) Goddard pop-up arrays with TES sensors
  - SQUID multiplexer at 0.3 K or 2 K

(c) Caltech spider webs with TES sensors
  - SQUID multiplexer at 0.3 K or 2 K

Fall-back:

Spider web bolometers with feed-horns
  - JFET module inside instrument box

AO response must:

- describe generic features of array options
- indicate envelope of spacecraft resources consistent with any of the options
- describe back-up option and its resource requirements

Thermal model

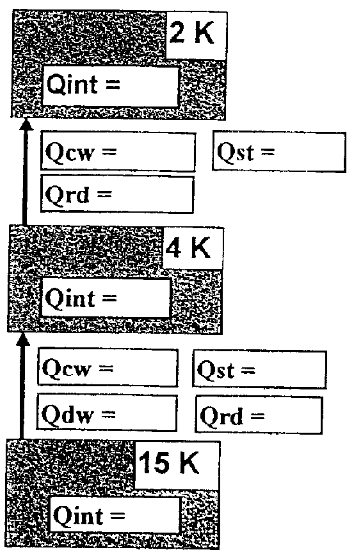
- Internal dissipation
  - Chopper
  - FTS mechanism
  - FTS black body calibrator
  - Array multiplexer
  - FET module (back-up only)

Note: 2-K and 4-K dissipation now much higher than before

- ^{3}He fridge (power profile)
- Conduction by mechanical supports and wires
- Radiation

Stage	"15-K" Temp. (K)	FTS Op. (mW)	PHOT Op. (mW)	Non Op. (mW)
2 K				
4 K	10			
	15			
	20			
15 K *				

* Dissipation only



Qint	Internal dissipation
Qcw	Conduction due to wiring
Qdw	Dissipation due to wiring
Qst	Conduction due to structure
Qrd	Heat load due to radiation

CHOICE OF SPECTROMETER

(i) SCIENTIFIC DRIVERS:

- CASE FOR HI-Z LINE SPECTROSCOPY LOOKS MARGINAL @ $Z \gtrsim 1.0$ WITH EITHER GRATING OR FTS

- GOOD CASE FOR LOW RES. (R~10- HI Z SPECTROSCOPY FOR SED DETERMINATION

* - EXCELLENT CASE FOR GALACTIC ASTRONOMY ON PRE-STELLAR, COLD ISM, PLANETARY NEBULA ETC IF THERE IS AN IMAGING SPECTROMETER (SPATIAL RES $\lesssim 25''$? SPECTRAL "A FEW HUNDR

- ASTRONOMERS PUSHING FOR WIDER λ COVERAGE (DESIRE CII (157) TO CI (609))
  ⇒ AT LEAST H_2O (?) 538 µm (GROUND STATE)
  ⇒ CI(350)/CI(609) ⇒ N_e

CHOICE OF SPECTROMETER

(2) TECHNICAL DRIVERS

- NEITHER FTS NOR GRATING HAS MUCH ADVANTAGE FOR POINT SOURCE SENSITIVITY @ R = 400
- IN ANY PRACTICAL SPECTROMETER THERE DOES NOT APPEAR TO BE AN ISSUE ON THE DETECTION OF WEAK LINES ON A STRONG CONTINUUM. [GSW]
- THE CURRENT (ANY) GRATING DESIGN WILL HAVE LIMITED SPATIAL RESOLUTI AND WILL HAVE TO RASTER TO GIVE FULLY SAMPLED IMAGES
- TO ACHIEVE A COMPARABLE SENSITIVITY THE GRATING PROBABLY REQUIRES DETECT AT < 300mK (NEP 1×10^{-17} W $Hz^{-1/2}$ f ~ 5Hz)
- THE GRATING REQUIRES A* STRAYLIGHT INPUT < 15 fW
- YOU CANNOT CHANGE THE SPECTRAL RESOLUTI ON A GRATING
- FOR A GIVEN GRATING DESIGN IT IS VERY DIFFICULT TO CHANGE THE WAVELEN RANGE.

⇒ IMAGING FTS

BOL FTS

Considered baseline:

- R = 1000 at λ = 250 μm (unapodized!)
- Hence: L = R λ / 2 = 125 mm
- With PARA scheme, physical scan length (single-sided interferogram): ΔL = L/8 = 15.6 mm ($\pm$7.8 mm)
- FOV = 3' = 0.87 mrad
- Entrance pupil, D = 3.3 m
- Beam size, d = 50 mm
- Mirror mechanism: Parallelogram with Bendix joints
- Displacement sensor:
  Electro/magneto/mechanical probably not accurate enough
  Optical measurement probably required
  Moire system simplest but space qualification doubtful (?)
  Diode laser auxiliary interferometer probably safest bet (CIRS, 170 K, 1.78 μm)
  Complexity!

BOL FTS

Approximate opto-mechanical implementation

- BIG
- Difficult to accomodate in space envelope
- Consider effects of reducing beam size:

1) Contrast reduction, valid at max OPD and FOV

- cos θ variations in OPD:
  $R = \sigma/\Delta\sigma = d^2/(\lambda\ D\ FOV) = 1.4\ d^2$
  Hence d > 27 mm (22 mm for 2')

- Beam walk, relative beam displacement = 0.1:
  $R = 4\ (\Delta d/d)\ d^2/(\lambda\ D\ FOV) = 0.56\ d^2$
  Hence d > 42 mm (35 mm for 2')

2) Instrument size

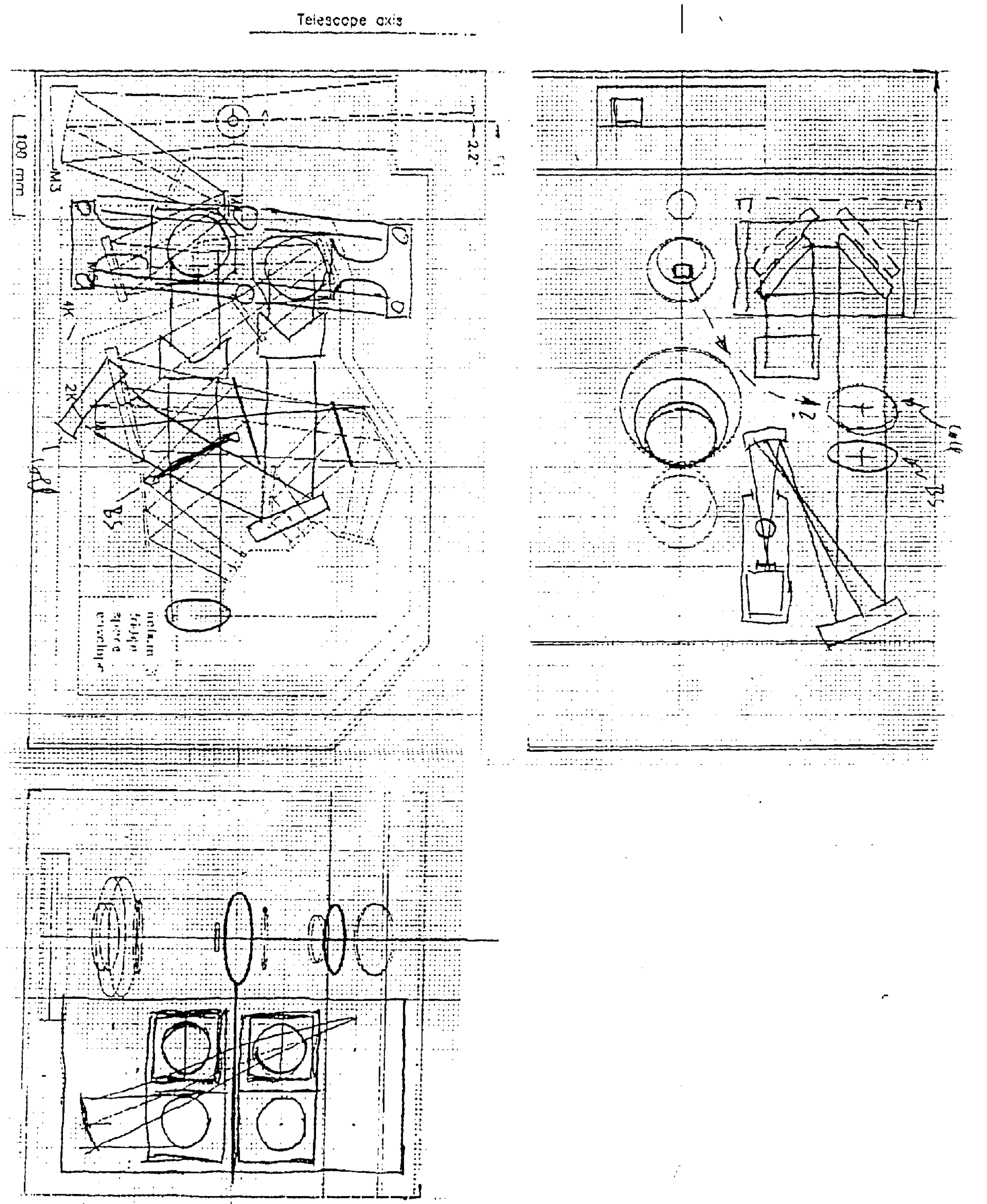
- Overall envelope: approx: (6x3x2.5)d

- Component size:
  $W = d + 2\delta d \approx d + 28$ mm
  since: $\delta d = l\ \Delta\theta$
  $\Delta\theta = FOV\ D/(2\ d)$
  $l \approx 10\ d$

BOL FTS

Conclusion:

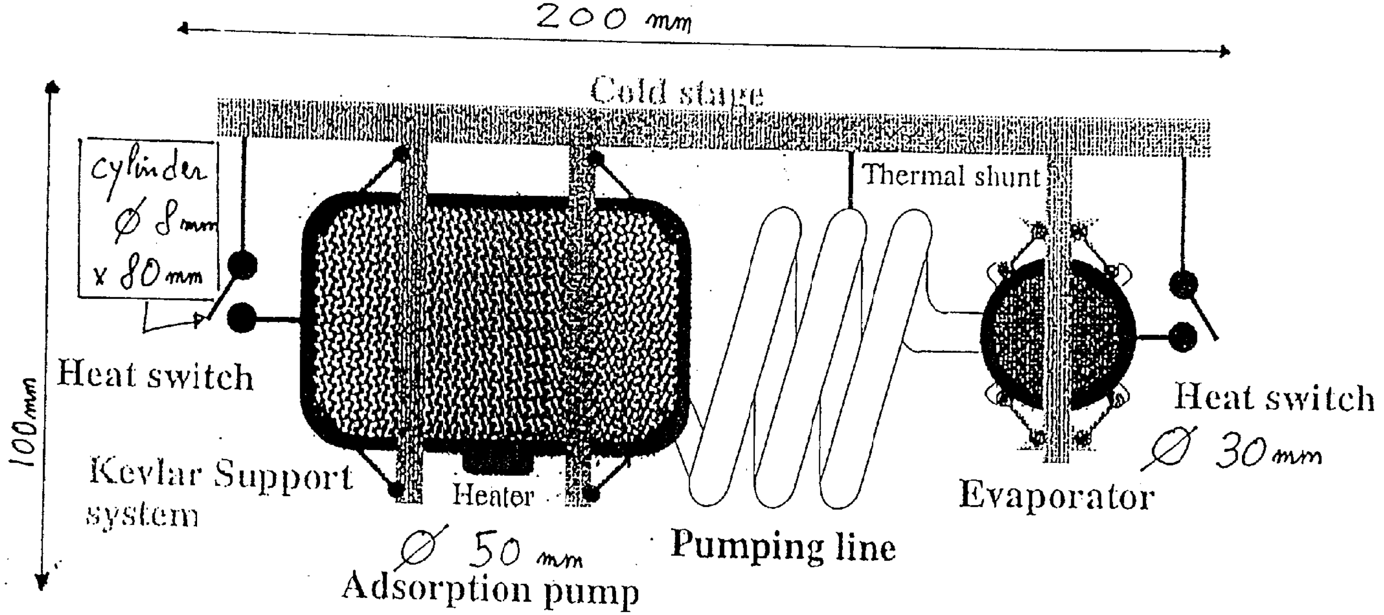
- 50 mm beam size is theoretically well adapted for the baseline FTS
- Difficult to implement in space available however
- May want to reduce beamsize to 20 – 30 mm
  - Accepting reduced performance at edge of field
  - Reducing FOV



Telescope axis
100 mm
M3
4K
2K
2.2'

SPACE SYSTEM

PRINCIPLE OF OPERATION



SIZE: 200 x 100 x 100 mm

Mass ≤ 1 Kg

	Pump heat switch	evaporator heat switch
Condensation phase	OFF	ON
Cooldown phase	ON	OFF
Low temperature phase	ON	OFF

Lionel Duband CEA DSM/D

^{3}He sorption cooler

- Baseline: - The temperature of the ^{4}He stage is 1.8 K
  - The temperature of the ^{3}He stage is 300 mK
  - 48 hours cycle (minimum).

- Characteristics: - 4 Litres STP fridge
  - Size of the box : 100 x 100 x 200 mm
  - Mass < 1 kg

- Heat switches (Gaz gap heat switch)
  - 2 thermometers (4 wires) and 2 heaters (2 wires) [redundant]
  - 2 heat switches --> 24 wires
  - With a 400 Ω heater, the maximun current is 2mA

- Pump
  - 2 thermometers (4 wires each) --> 8 wires
  - 1 heater + 1 for redundancy (2 wires each) --> 4 wires
  - Total: 12 wires
  - Heater impedance: 1 k Ω
  - maximum current in the heater : 14 mA (voltage 14 Volts)

- Total energy per cycle = 450 Joules

- Recycling time: - 2 hours with 40 mW
  - 4 hours with 20 mW

- Orientation: For ground operation purpose the sorption pump cannot be below the evaporator

APPENDIX A

DATA

Wiring description

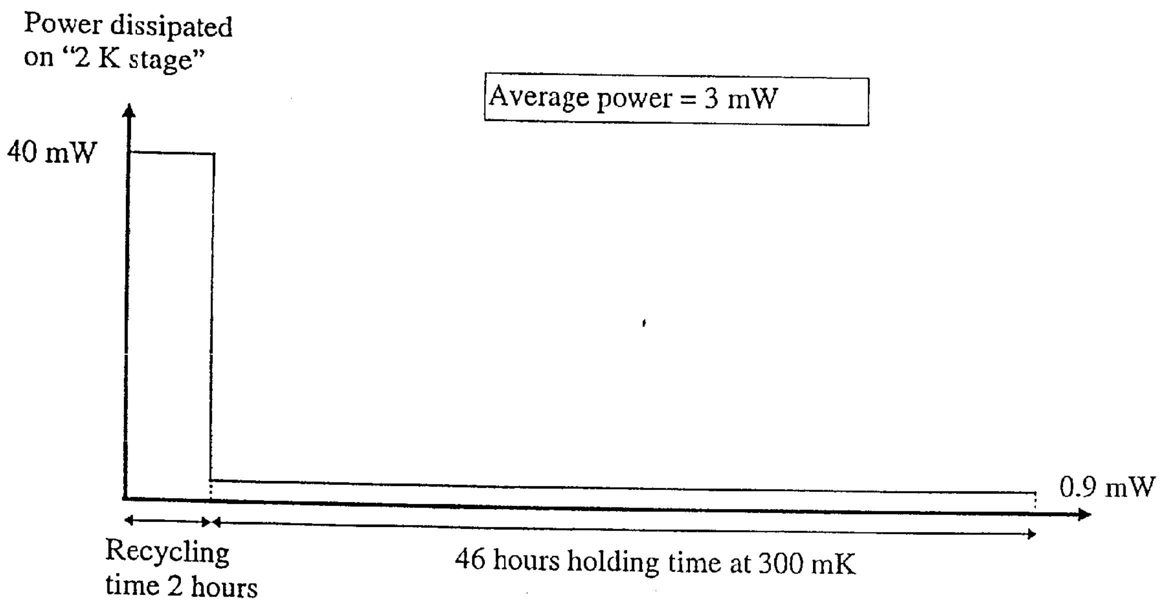
Function:

- 0.3K: 2368 bolometers; Bolometer biases/gnds; 5 thermometers(0.3K)
- 2 K: 2 thermometers(2K)
- 4 K: 4 thermometers(4K)
- 4 K: FTS temp sensors; FTS posn sensors; FTS drive coils (Main); FTS drive coils (Red)
- 2 K: Pump heater (Main); Pump heater (Red); Pump therm. (Main); Pump therm. (Red); Evap. therm. (Main); Evap. therm. (Red); Pump HS heater (Main); Pump HS heater (Red); Evap. HS heater (Main); Evap. HS heater (Red); Pump HS therm (Main); Pump HS therm (Red); Evap. HS therm (Main); Evap. HS therm (Red)
- 15 K: Chop. drive coil (Main); Chop. drive coil (Red); Chop. pick-up coil (Main); Chop. pick-up coil (Red)
- 15 K: 2 thermometers(15K)
- JFET module power; JFET thermometers; JFET heaters

No of wires Nw	No of shields Ns	Fac	Resistivity 1e-8 ohms.m R	Brass(0) or SST(1) Mat	Current Ity (mA)
474	29	2.5	64	1	$1 \cdot 10^{-6}$
58	14	2.5	64	1	$1 \cdot 10^{-6}$
20	5	2.5	64	1	$1 \cdot 10^{-2}$
8	2	2.5	64	1	$1 \cdot 10^{-2}$
8	2	2.5	64	1	$1 \cdot 10^{-2}$
8	2	2.5	64	1	$1 \cdot 10^{-2}$
0	0	0	64	1	0.1
0	0	0	4.5	0	8
0	0	0	4.5	0	0
2	0	0	4.5	0	14
2	0	0	4.5	0	0
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
2	0	0	4.5	0	2
2	0	0	4.5	0	0
2	0	0	4.5	0	2
2	0	0	4.5	0	0
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	64	1	$1 \cdot 10^{-2}$
2	1	2.5	4.5	0	0
2	1	2.5	4.5	0	0
2	1	2.5	4.5	0	0
2	1	2.5	4.5	0	0
8	2	2.5	64	1	$1 \cdot 10^{-2}$
16	0	0	4.5	0	9.81
4	0	0	64	1	$1 \cdot 10^{-2}$
4	0	0	4.5	0	5

$R \equiv R \cdot 10^{-8} \cdot \text{ohm} \cdot \text{m}$ Heat dissipation in wires $Lp \equiv \overrightarrow{\left(\overrightarrow{(Ity \cdot Ity)} \cdot R\right)}$

Power profile



- Parasitic load of 20 μW --> average dissipation on 2K stage: 3 mW , holding time ~ 46 hours

BOL Instrument Cryoharness IIDWIR04.XLS 04/11/97
NEW BASELINE

NBOLS 2368

From BOL FPU

ID	Signal definition	Name	No. of Cond.	No. of shields	Current (A)	Duty Cycle (t*T)	Max. Line Volt (V)	Remarks
1	Det. signals	Bols	?	?	1.00E-09	1		SST AWG38
2	Bolometer biases/gnds	Biases	?	?	1.00E-09	1		SST AWG38
3	0.3-K therms. (5)	TH-300	20	5	1.00E-05	1		SST AWG38
4	2-K therms (2)	TH_2	8	2	1.00E-05	1		SST AWG38
5	4-K therms (2)	TH_4	8	2	1.00E-05	1		SST AWG38
6	15-K therms (2)	TH_15	8	2	1.00E-05	1		SST AWG38
7	FTS temp sensors	F_Temp	8	2	1.00E-05	0.01		SST AWG38
8	FTS posn sensors	F_Posn	?	?	1.00E-04	1		SST AWG38
9	FTS drive coils (main)	F_Drive_M	?	?	8.00E-03	0.5		Brass AWG38
10	FTS drive coils (red.)	F_Drive_R	?	?	0.00E+00	0		Brass AWG38
11	Pump heater (main)	PH_M	2	0	1.40E-02	0.014		Brass AWG38
12	Pump heater (red.)	PH_R	2	0	0.00E+00	0		Brass AWG38
13	Pump therm. (main)	PT_M	4	0	1.00E-05	1		SST AWG38
14	Pump therm. (red.)	PT_R	4	0	1.00E-05	1		SST AWG38
15	Evap. therm. (main)	ET_M	4	0	1.00E-05	1		SST AWG38
16	Evap. therm. (red.)	ET_R	4	0	1.00E-05	1		SST AWG38
17	Pump heat SW heater (main)	PHSWH_M	2	0	2.00E-03	0.96		Brass AWG38
18	Pump heat SW heater (red.)	PHSWH_R	2	0	0.00E+00	0		Brass AWG38
19	Evap. heat SW heater (main)	EHSWH_M	2	0	2.00E-03	0.04		Brass AWG38
20	Evap. heat SW heater (red.)	EHSWH_R	2	0	0.00E+00	0		Brass AWG38
21	Pump heat SW therm. (main)	PHSWT_M	4	0	1.00E-05	1		SST AWG38
22	Pump heat SW therm. (red.)	PHSWT_R	4	0	1.00E-05	1		SST AWG38
23	Evap. heat SW therm. (main)	EHSWT_M	4	0	1.00E-05	1		SST AWG38
24	Evap. heat SW therm. (red.)	EHSWT_R	4	0	1.00E-05	1		SST AWG38
25	Chopper drive coil (main)	CH-DR_M	2	1	?	1		Brass AWG38
26	Chopper drive coil (red.)	CH-DR_R	2	1	?			Brass AWG38
27	Chopper pick-up coil (main)	CH_PU_M	2	1	?	1		Brass AWG38
28	Chopper pick-up coil (red.)	CH_PU_R	2	1	?	1		Brass AWG38

	Total		?	?				

Notes: No specification available as yet for:
Detector multiplexer
FTS drive and position sensor
Exact details of chopper

Summary of thermal model (filled arrays)

2 K:

Conduction:	Structure	6 μW
	Wires	TBD (was 35 μW)
	^{3}He system	3 mW (avg.)
		20/40 mW (peak) (2 hrs/4hrs cycle)
Dissipation:	CEA CMOS MUX	2 mW
	Dissip. by wires	TBD (was negligible)
Radiation:		0.8 μW (from 4 K)
Total 2 K:		~5 mW + ?

4 K:

Conduction:	Structure	0.15 mW
	Wires	TBD (was 0.8 mW)
Dissipation:	Chopper	4 mW (Not simultaneous)
	FTS drive	4 mW (Not simultaneous)
	Wires	TBD (was 0.9 mW)
	FTS BB calibrator	TBD (guess 2 mW)
Radiation:		0.6 mW
Total 4 K:		~8.5 mW ?

(Figures from IID_WIR4.XLS; TH_FIRST18.MCD)
(CF supports; f_o = 150 Hz; $M_{2\text{-}K}$ = 9.7 kg; $M_{4\text{-}K}$ = 24.5 kg; $T_{15\text{-}K}$ = 15 K)

Quick summary on proposed ^{3}He cooler for FIRST

(November 7th 1997) - Lionel Duband CEA - SBT)

To date, a 4 liters STP cooler has been identified to be suitable for FIRST. We summarize below its main geometrical characteristics.

Type : Self-contained unit using a cryogenic adsorption pump
Charge : 4 liters STP (^{3}He)
Pressure at ambiant temperature (≈ 20°C) : 7.1 MPa (71 bars)
Charcoal mass : 13 g
Sorption pump : stainless steel sphere ID 44 mm x OD 46 mm with internal structure
Evaporator : stainless steel sphere ID 24 mm x OD 26 mm with internal structure
Pumping line : stainless steel tube ID 10 mm x OD 10.4 mm - total length ≈ 190 mm
Support structure : titanium brackets associated with Kevlar or Vectran cords
Heat switches : 2 gas gap heat switch required
Overall mass of the above components : of the order of 500 g (not including the box - see below)
Overall dimensions : fit in a box 200 mm x 100 mm x 100 mm
Thermometers and heaters required (double for redundancy purposes) :

	Sorption pump	Heat switches
Thermometer	2	2 x 2 = 4
Heater	2	2 x 2 = 4
number of wires	2 x 4 + 2 x 2 = 12	4 x 4 + 4 x 2 = 24
Total number of wires	36	

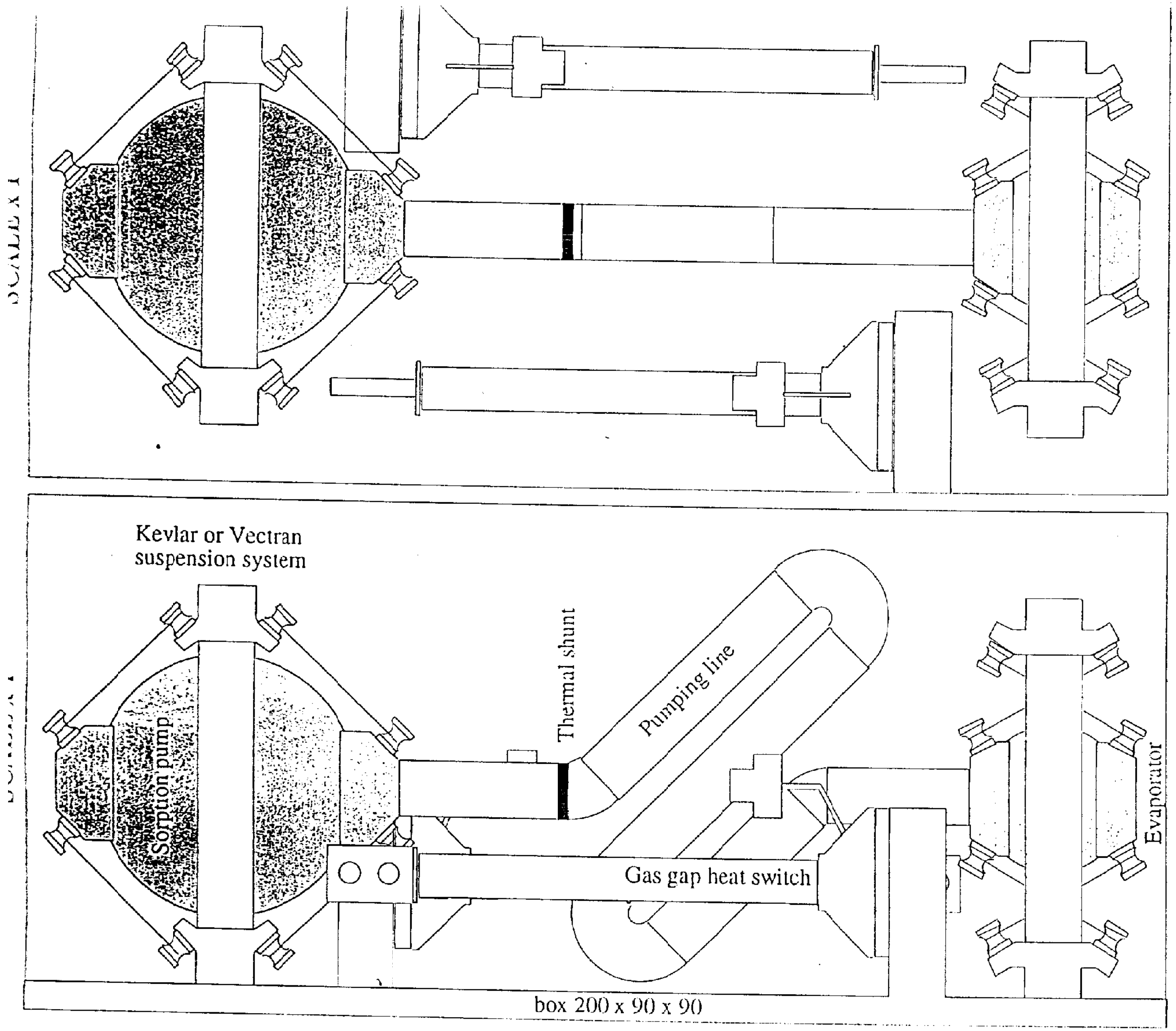
An overal view is given on the following page. This is just an "artist" view of a possible arrangement. I haven't done any detail design on the support structure yet.

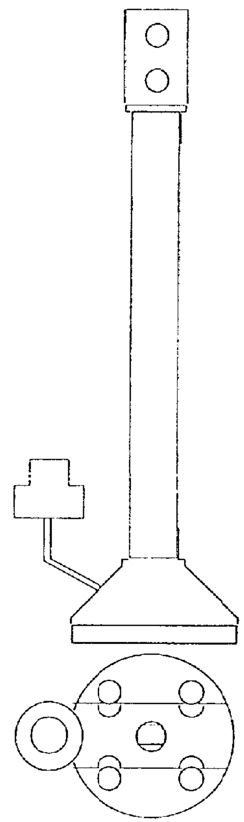
Remarks :

- It might be possible to slightly reduce the overall dimensions if necessary- 190 x 90 x 90 should be OK.
- The evaporator and sorption pump could be made out of titanium, which would save up some mass. In addition in this case it might then be possible to mechanically support the pump with the first straight section of the pumping line (some bracket at this location), thus removing the need for the bracket with pulleys and cords (further saving on the mass of the pump). TBC. (some snubber design may be considered).
- Similarly since I am using in this design straight sections of tubes, and **IF I can confirm** thru measurements that titanium has a much lower thermal conductivity than stainless steel **in this range**, then I could use a Ti alloy for the tube (heat switches too) - that would not only improve the hold time but also affect the average power dissipated, etc...

FIRST
3HE COOLER

WARNING:
- This is an "artist" view of a possible arrangement
- No detail calculations have been performed on the support structure





November 7th, 1997 - Lionel Duband CEA - SBT

Some considerations about the spectroscopic channel of BOL

Paris meeting - November 12, 1997

Roberto Maiolino Osservatorio Astrofisico di Arcetri
Largo E. Fermi 5, 50125 Firenze - Italy
maiolino@arcetri.astro.it

Leonardo Vanzi CAISMI - CNR
Largo E. Fermi 5, 50125 Firenze - Italy
vanzi@arcetri.astro.it

In this document we discuss some of the issues related to the spectroscopic channel of BOL. More specifically, we compare the expected performances of the FTS with the Grating option. We show how the choice of the instrumental setup critically determines the scientific goals that can be achieved. Most of these aspects have already been discussed in detail in several presentations at the meeting in Marseille on September 22-23. The goal of this short report, that is far from being complete, is to review some of the instrumental and scientific issues, and to discuss some technical details that was neglected in former documents.

This report also benefits by discussions and technical inputs from Dr. B. Carli and Dr. P. Saraceno.

1 Sensitivity

We calculated the expected limiting flux of the spectroscopic channel of BOL both in the FTS and grating configuration. In this section we briefly summarize results of our calculation. We have used the characteristics of FIRST described by Swinyard & Griffin (1997, SG97). "Band 1" and "Band 2" correspond to the spectral ranges 200–260μm and 260–400μm respectively.

1.1 NEP of the system.

The main noise sources are the photon noise from the background and the detector noise.

With regard to the background we assume that most of the contribution is due to thermal emission from the primary mirror (T=80K, emissivity=0.04), this contribution can be calculated simply by integrating the Plank function over the suitable band. Results are given in Tab. 1. For the grating configuration we assume a pixel spectral coverage of 0.3μm (band 1) and 0.4μm (band 2), corresponding to a spectral resolution ($2\Delta\lambda$) R=400.

The power on each pixel due to the background is obtained by multiplying the values of Tab. 1 by the throughput (λ^2) and by the efficiency of the system.

The NEP due to the background is readily obtained as

$$NEP = \sqrt{P\ \omega\ h\nu\ \epsilon} \quad (1)$$

where P is the power emitted by the primary as given in Tab. 1, ω is the throughput (λ^2), ϵ is the total efficiency.

Table 1: Background in $W/m^2/str$ emitted by the primary mirror in the the pixel spectral range

FTS	200-260	260-400	Grating	230.0-230.3	320.0-320.4
	$2.0\ 10^{-11}$	$2.7\ 10^{-11}$		$9.7\ 10^{-14}$	$7.4\ 10^{-14}$

Table 2: Total NEP in $10^{-17} W/m^2$

FTS	200-260	260-400	Grating	230.0-230.3	320.0-320.4
	6.4	6.4		5.0	5.0

At these wavelengths a more accurate estimate of the noise is given by including the factor $(n+1)$, where n is the total number of photons per mode, $n = (exp(h\nu/KT) - 1)^{-1} \approx 1$. In the FTS case the total power is lower by a factor of 2, because only one polarization is used. From the values given by BG97 we get an efficiency of the optics of 0.30 for the grating and 0.11 for the FTS. Since the quantum efficiency of the bolometers is η=0.8, the total efficiency is ϵ(G)=0.24 and ϵ(FTS)=0.09. By assuming a detector NEP of $5 \times 10^{-17}\ W/\sqrt{Hz}$ we obtain the total NEP listed in Tab. 2. The values are just a little lower than those given by SG97 due to our approximation in considering the primary mirror as the only source of background. It is also clear from Tab. 2 that the NEP is completely dominated by the detector noise in the grating configuration while detector and background give comparable contributions in the FTS configuration. The latter fact rules out the multiplex advantage of the FTS as described by Natale & Ventura (1984, NV84).

1.2 Limiting Flux

Limiting fluxes at the level of $k\sigma$ for a point source are given by the following expression:

$$F_l = \frac{k\ NEP}{\sqrt{2T/N}\ \epsilon\ A\ \Delta\nu\ \gamma} \tag{2}$$

where T is the total integration time, N the number of spectral elements, A the collecting area of the telescope, $\Delta\nu$ the resolution element and γ the modulation/demodulation efficiency of the spectrometer. The latter is 1 for the grating and $\sqrt{N/8}$ for the FTS (see NV84). The actual on–source exposure in the Grating option is half of the total integration time because chopping is required. The number of spectral elements is given by the length of the whole spectral band divided by the resolution element, mainly 200 for band1 and 350 for band2. In the grating configuration however 20 spectral elements are measured in each exposure, therefore N is reduced by this factor becomming 10 and about 20 respectively for band1 and band2. Limiting fluxes for T=1h, 1σ are presented in Tab. 3. For the grating we have considered the two possibilities: full scan of the spectrum (f.s.) and observation of a single known line (s.l.) obtained with just one setting of the grating.

Our values are in substantial agreement with those quoted by SG97 for the FTS and for the grating in the f.s. mode. For the s.l. mode we get values that are a factor of 3-4 lower, this is probably due to a different approach to the measure of a single line. We assumed the line observed with only 1 setting of the grating ($\Delta v < 8000 Km/s$).

Note that, since the grating spectrometer is detector noise limited, a reduction of the

Table 3: Limiting fluxes for continuum in mJy and for a line in $10^{-19} W/m^2$ in band 1 and band 2. For the grating there are 2 options: the full scanning of the band (f.s.) and measurement of a single known line (s.l.). Grating limiting fluxes are lower by a factor of $5 \cdot \sqrt{2} \approx 7$ id the detectors NEP is $10^{-17}\ W/\sqrt{Hz}$ and on–on chopping is performed.

	cont.1	cont.2	line1	line2
FTS	145	214	24	23
Grating f.s.	66	140	11	15
Grating s.l.	21	43	3.5	5.0

detector NEP implies a reduction of the limiting fluxes by the same factor. If the detectors NEP is as low as $10^{-17}\ W/\sqrt{Hz}$, as expected at 100 mK or for the new planar arrays, then the limiting flux will be lower by a factor of 5 with respect to what reported in Tab.3. The FTS option, being basically background noise limited, is much less sensitive to the detector noise, as already pointed out by SG97, and not much can be gained improving the detectors performances.

Finally, in the grating case the factor of 2 in time lost for off–source exposure can be gained back if two, or more, parallel linear arrays (or even a rectangular planar array) are used. This would allow on–on chopping and would result in an improvement of a factor of $\sqrt{2}$ in sensitivity.

2 Planar arrays

The use of the new planar arrays in BOL has been recently discussed, both for the photometric and for the spectroscopic channel. In the FTS option these new arrays will provide better imaging capabilities. In the grating option such array would provide a larger spectral coverage per setting (resulting in a sensitivity improvement of 25% for the full scan) and, possibly, could provide a long slit observing mode.

The main problem with planar arrays is that they observe the radiation coming from a viewing angle much larger than horn–fed bolometers. As a consequence, the photon noise due to the cold box where the arrays is located is not neglegible and must be taken into account. To be conservative we will assume that planar arrays can observe the radiation coming from the whole 2π solid angle. This new contribution to the NEP can be evaluated by using the expression (1), the power emitted by a blackbody of emissivity 1 and an efficiency of 0.8, that is the efficiency of the detector. Values are $2\ 10^{-15} W/\sqrt{Hz}$ for T=4K and $3\ 10^{-18} W/\sqrt{Hz}$ for T=2K. This NEP contribution depends very steeply on the temperature. However, planar arrays are a convenient solution, both for FTS and grating, as far as it can be hosted in a shielding 2K box.

3 Imaging capabilities of the FTS

Although the sensitivity of the grating configuration is higher than the FTS option, the latter offers spectroscopic imaging capabilities, widely stressed in former meetings. However, we wish to point out two technical problems that have been neglected in previous discussion.

1. When using the FTS off-axis, as it is the case for an imaging FTS, both beams on– and off–axis have to be aligned. This requirement implies that the instrument must be designed to include 4 degrees of freedom to achieve the beam superimposition. More specifically the instrument should allow to compensate 2 *tilt* and 2 *later shift* offsets. This requires a specific optical design for the FTS (Carli 1989). More specifically, the optical design of an FTS that includes these 4 degree of freedom is significantly more complicate than that presented by SG97.

2. The width of the coherence rings on the focal plane decreases as a function of radius. Since pixels have constant size, this implies that off–axis pixels observe more than one coherence ring. As a consequence the spectral resolution decreases as a function of the distance from the optical axis.

4 Comparison with Scientific Cases

In this section we compare the sensitivities that can be achieved by means of the FTS and grating with some of the scientific goals of the FIRST mission. We restrict our discussion to some extragalactic cases.

Fig.1 compares the limiting fluxes of various space and air–borne instruments for a 5σ detection in 1 hour of total integration time. The grating sensitivities are shown both for the full–scan (FS) and single line setting (sl) modes, and for the case of detectors with a NEP = $10^{-17} W/\sqrt{Hz}$ (e.g. operation at 100 mK or planar arrays), indicated by "low NEP" and with red dashed lines.

In nearby galaxies ($z \simeq 0$) the CO transitions are amongst the brightest lines in the $200 - 400\mu m$ range. The blue dashed line in Fig.1 indicates the intensity of the CO lines in one of the most luminous nearby galaxies: the Ultraluminous IR galaxy Arp220. Both FTS and grating should be able to detect all of the CO lines in this band. However, most of the other lines are fainter by one or two orders of magnitudes.

Detection of lines in high–z objects is much more challenging. The two blue dots in Fig.1 indicate the flux of the intense [CII]$158\mu m$ line for objects at z=1. The upper dot indicates the expected flux for an object Arp220–like, i.e. undergoing to a very high starforming activity, while the lower dot indicates the expected flux for a quiescent object such as our Galaxy. The grating spectrometer should be able to detect the [CII] line of Arp220 at z=1, while the FTS spectrometer does not have enough sensitivity to achieve this goal. We explain better this point in Fig.2, where the expected [CII] flux is shown as a function of redshift. Shaded regions indicate redshifts that move the line out of the BOL spectral range. It is apparent that the FTS would be limited to very luminous objects with $z < 0.5$, while the grating spectrometer will be able to detect the [CII] line up to z=1.3 (or even z=1.5 if the detector NEP is lower) and also in objects whose luminosity is lower with respect to the rare case Arp220. Similar considerations can be done for other bright far-IR lines (e.g. [OIII]88μm) that are shifted in the BOL spectral range in high-z objects.

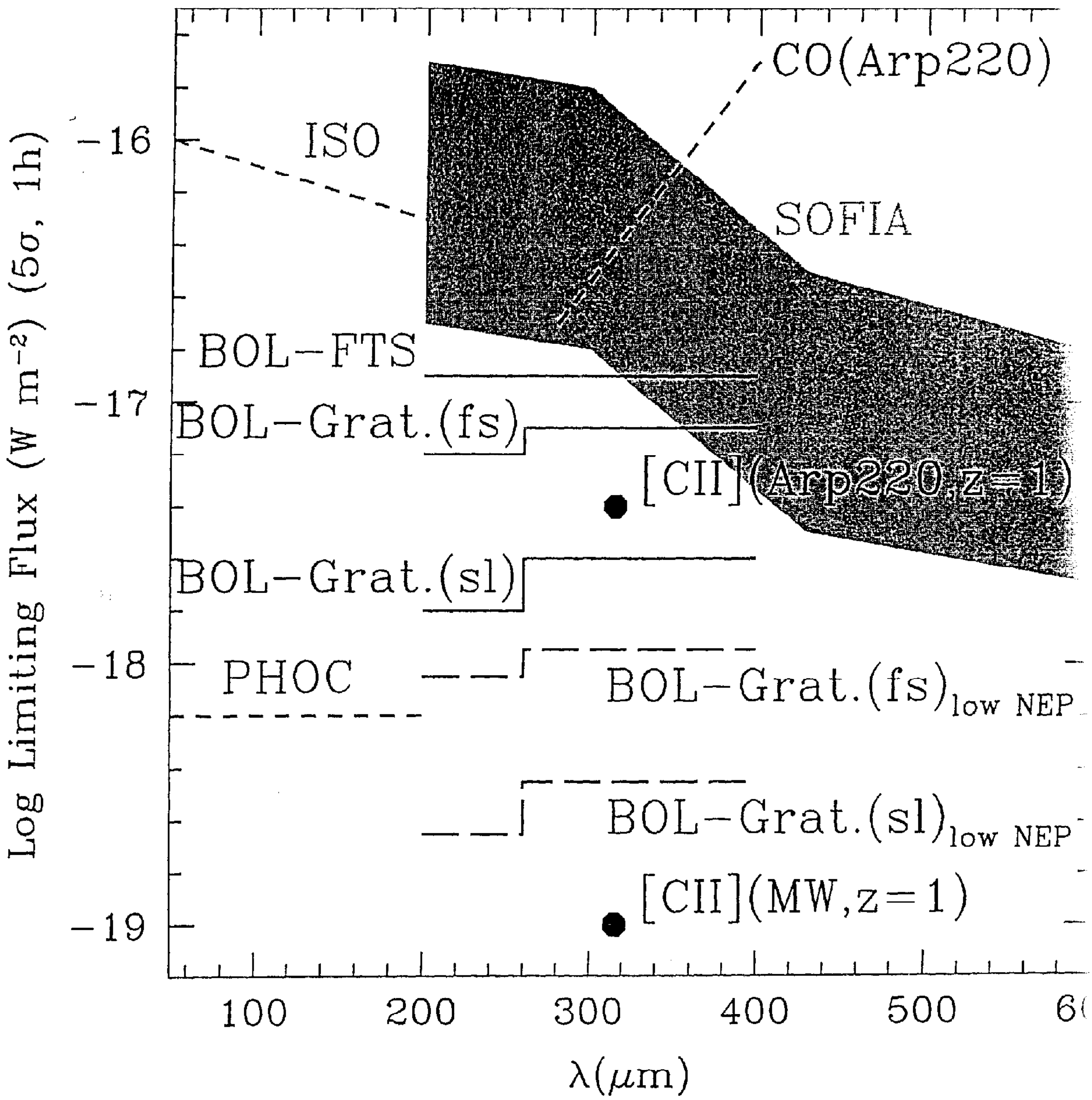
Summarizing, both FTS and grating should be able to detect the brightest molecular lines in nearby objects. However, the FTS option does not appear to be suitable for spectroscopic studies of high-z objects.

5 Bibliography

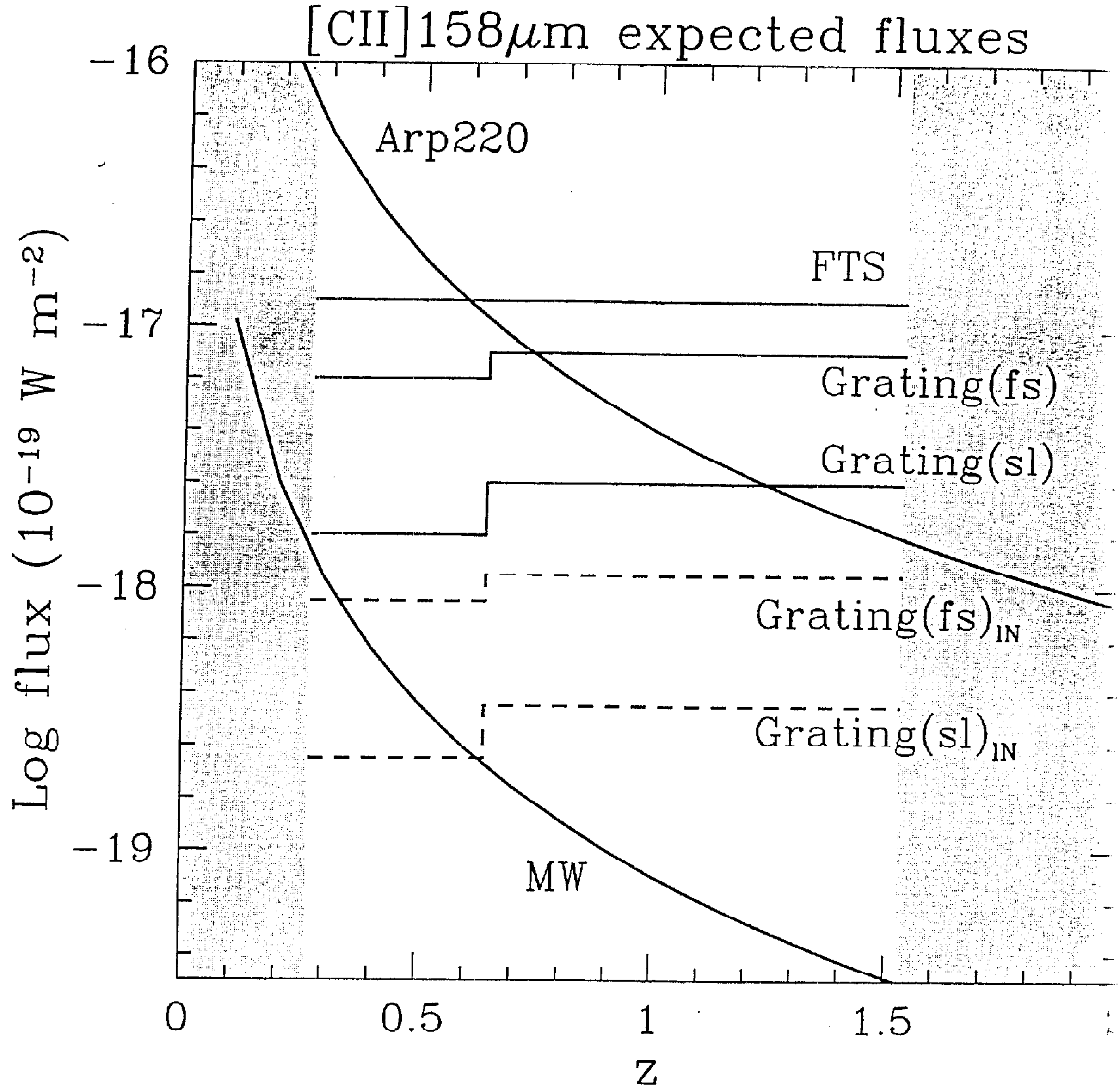
Carli B. 1989, "Fourier Transform Spectroscopy", SPIE, V.1145, 93

Natale V. & Ventura G. 1984, Fourier Spectroscopy in high background noise, Applied Optics 23, 2052

Swinyard B. & Griffin M. 1997, The FTS option for SPEC-BOL, Draft for the BOL Meeting in Marseille September 22-23, 1997



CO(Arp220)
ISO
SOFIA
BOL−FTS
BOL−Grat.(fs)
[CII](Arp220,z=1)
BOL−Grat.(sl)
PHOC
BOL−Grat.(fs)low NEP
BOL−Grat.(sl)low NEP
[CII](MW,z=1)
−16
−17
−18
−19
Log Limiting Flux (W m−2) (5σ, 1h)
100
200
300
400
500
λ(μm)



[CII]158μm expected fluxes
Log flux (10^{-19} W m^{-2})
−16
−17
−18
−19
z
0
0.5
1
1.5
Arp220
FTS
Grating(fs)
Grating(sl)
Grating(fs)$_{IN}$
Grating(sl)$_{IN}$
MW

FIRST BOL STRUCTURE

- Optical layout still fluid
- Size of the 4K, 2K & 300 mK enclosures is not yet defined.
- System level thermal loading study in progress
- Optical mounting & alignment not clear
- Structure design is very immature

FIRST BOL STRUCTURE

- Aluminium base plate/optical bench
- Siffened aluminium or sandwich panel side walls & covers (CFRP or Al face skins)
- Titanium or aluminium mirror mounts
- Struts support enclosures & mirror mounts
- Struts made from CFRP & bonded Titanium fittings

FIRST BOL STRUCTURE

- Design meeting planned for 18th November at ROE (MSSL, ROE, LAS) ?
- Sizable material coupon & component test programme required to establish mechanical & thermal properties at cryogenic temperatures.
- Cost !

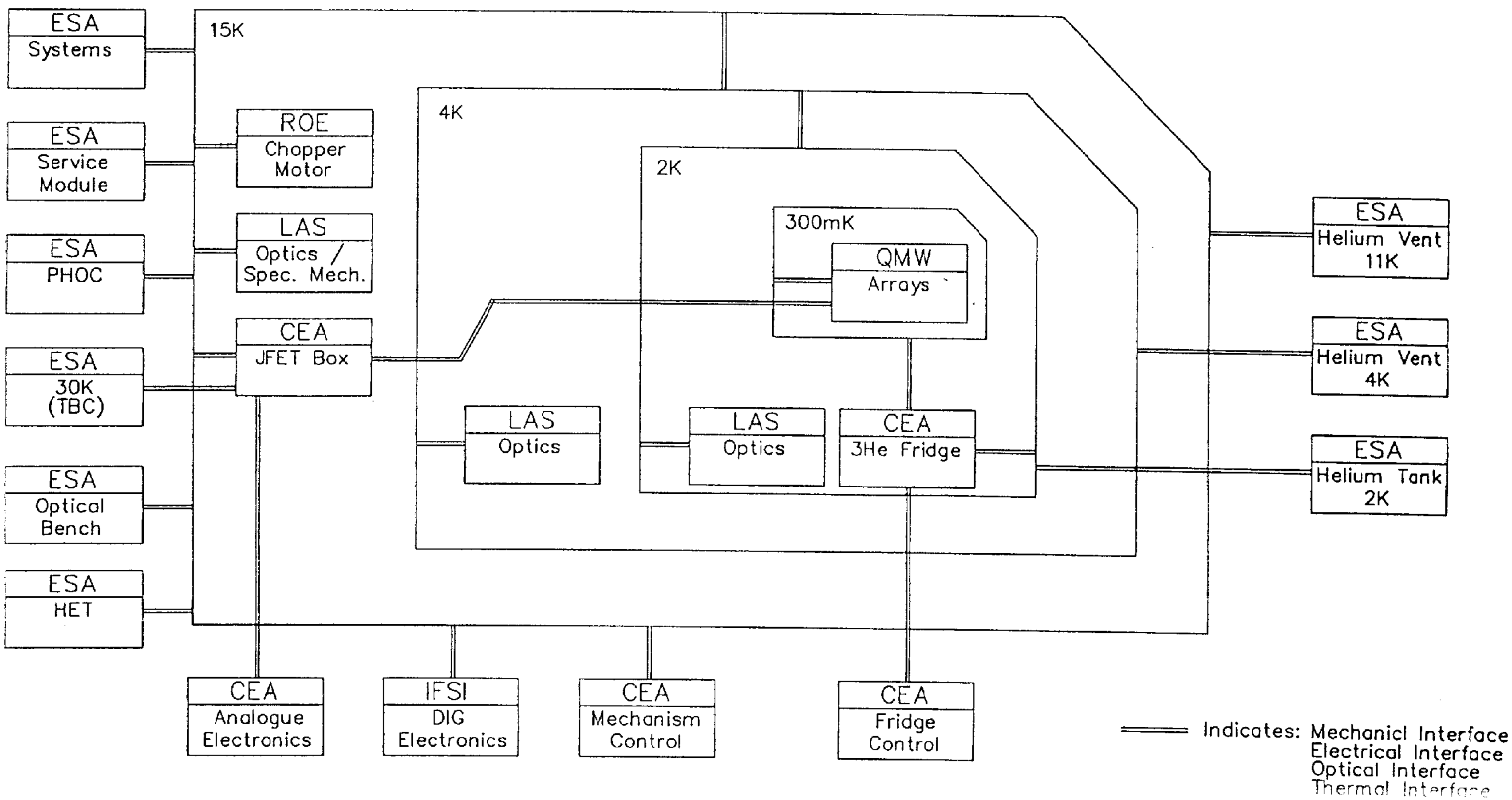
Inside BOL

- Mass = ?
- Size of the box : 100 x 100 x 200 mm
- Adsorption pump diameter : 50 mm
- Evaporator diameter : 30 mm
- Pumping line : Stainless Steel tube wind into an helix
  Diameter : 10 mm
  Overall length : 200 mm
- Suspension system : Kevlar or Vectran
- Gaz gap heat switch : Cylinder of 8 mm diameter and 80 mm height
- 4 Litres STP fridge:
  Holding time 53 hours
  - with a parasitic load of 15.5 µW --> average dissipation on 2K stage: 2.2 mW
  - with a parasitic load of 100 µW --> average dissipation on 2K stage: 16 mW

Rq

- For ground operation purpose the sorption pump cannot be below the evaporator
- In the case of a bolometer array dissipation of 20 µW, using 5 arrays will lead to a dissipation of 100 µW. The holding time with the same fridge will then be 7 hours.

BOL System Block Diagram.



IFSI is proposing to manufacture the 3 DPU for FIRST (1 for Planck as well).

This approach will force some kind of standardisation:

- uP general design and S/C I/F
- OBS: language, overall design, S/C I/F , documentation
- Similar APU I/F. Parallel or serial
- Save some money

Interface proposal

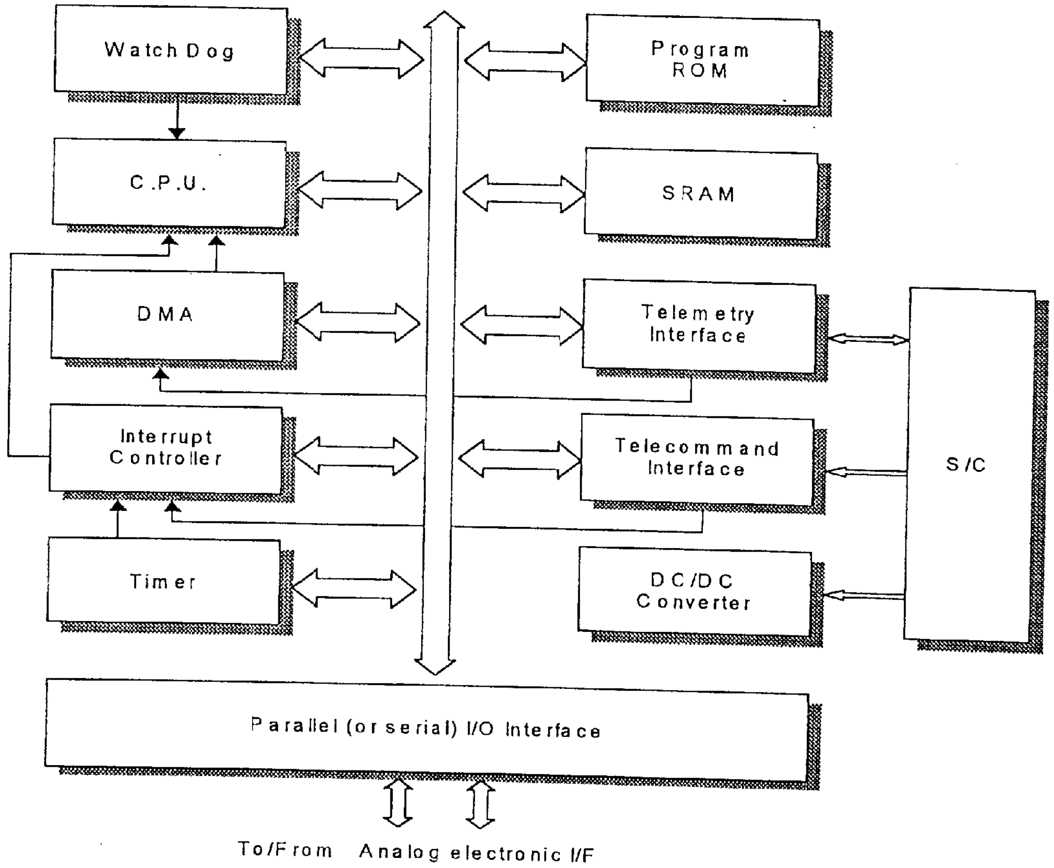
Serial

- 2 Serial 16 bit registers. Can be managed as for (old) ESA telemetry/telecommand standard
- Proposed clock frequency ~ 500KHz (~ 50 uS/word)
- Might foresee up to 8 bit parallel lines

Parallel

- 16 bit parallel port(s) is the alternative to the serial one

DPU block diagram



APU Interfaces

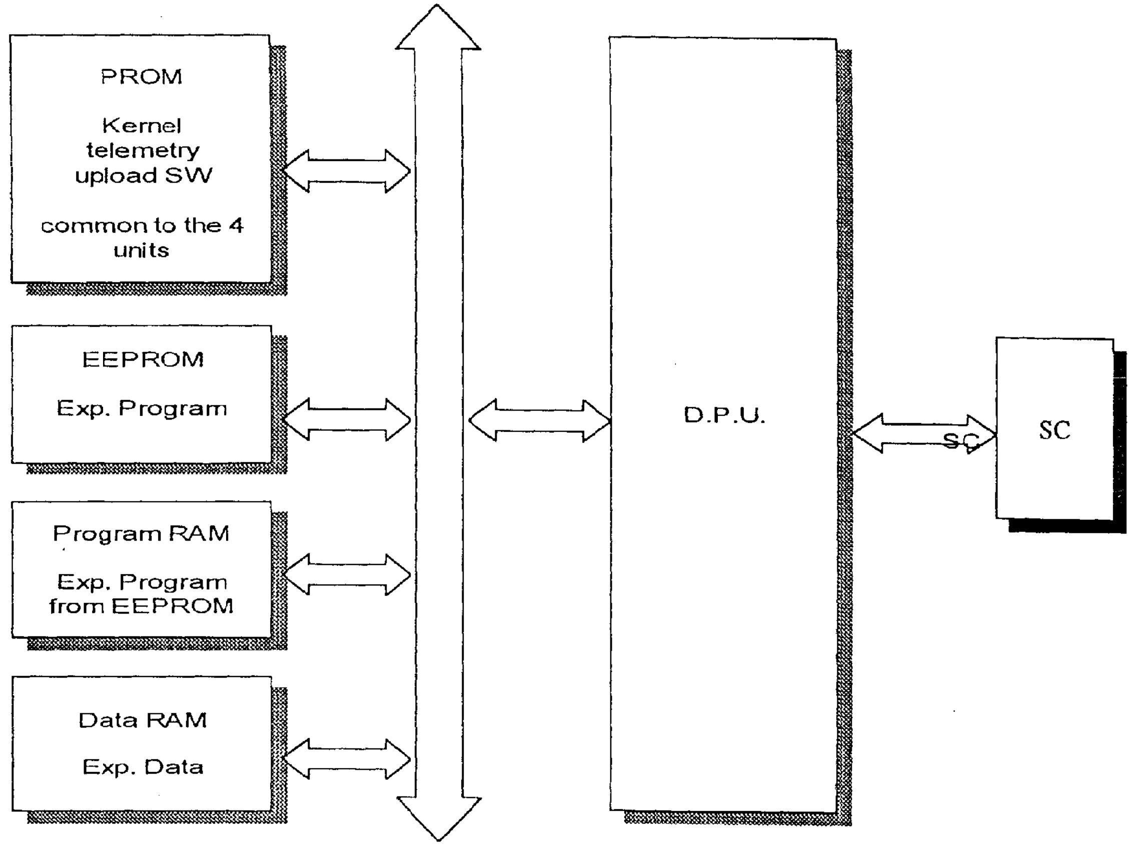
As simple and general as possible in order to replicate for the 3(+1) instruments.

- Parallel I/F exporting data address and direction coded in a 8 or 16 bit word.
  - Easier to implement.
  - Fast
  - More wires
  - Difficult to duplicate (redundancy)
- Serial I/F exporting data address and direction coded in a 8 word.
  - Need some HW also on the APU side
  - Slower (e.g. 500 KHz clock)
  - few wires
  - easy to duplicate

On Board Software design

- Will use C language for main part of OBS (depends on uP family)
- Program stored in PROM and EEPROM, execute both in EEPROM and RAM
- Possibility to upload the instrument program with experiment integrated on S/C
- Upload patches and new parameters during mission
- Upload new instrument program during mission if enough upload telemetry is available

Memory organisation



Redundancy

- Depends on the allowed weight and volume.
- Plan to redound at board level (2 CPU+mem 2 APU I/F 2 DC/DC converter)
- Upload SW patches (or full program)

Test Philosophy

- We do not deliver any test HW
- Spacecraft simulator (PC board) for internal use can be designed in collaboration with experimenters and/or ESA
- EGSE should be ready for instrument level testing
- Availability of experiments simulators is appreciated
- EM like unit will be delivered to every exp. Institution

uP Family

- We will push for Intel (AMD) 80C186.
- We might be “invited” to use the Marconi MA31750

Physical resources

- Might foresee 5 Kg 5Liters 5Watt depending on board redundancy and overall power requirements
- Estimate cost is 10 Glira or 3.6 M pounds (salaries not included) for 4 units

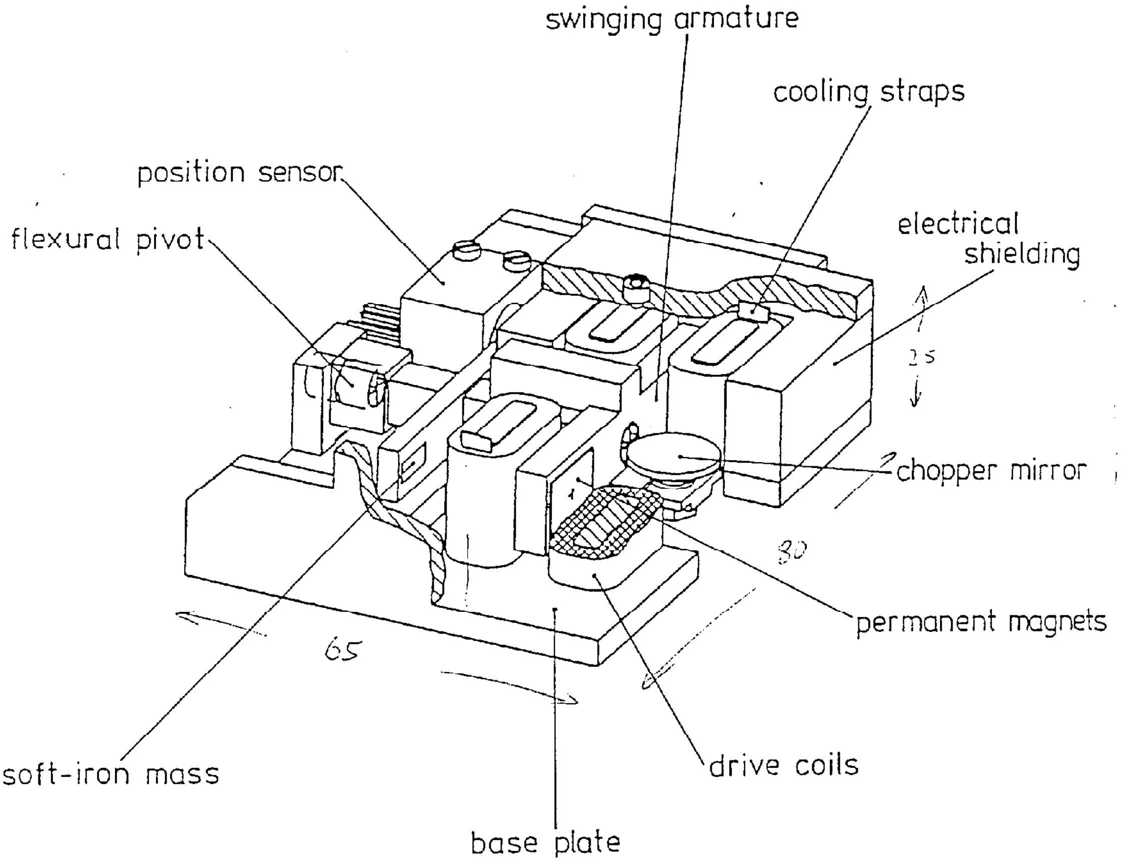


Fig.1 Basic design of the chopper

Optical Design of BOL (version 2)
Eli Atad , ROE , 12 November 1997

TELESCOPE SPECIFICATION

The Bolometer Imager is designed with the telescope using the following parameters:

Focal length: 28500 mm

Fnumber: 8.68

Unvignetted FOV: circular 0.5 degrees diameter

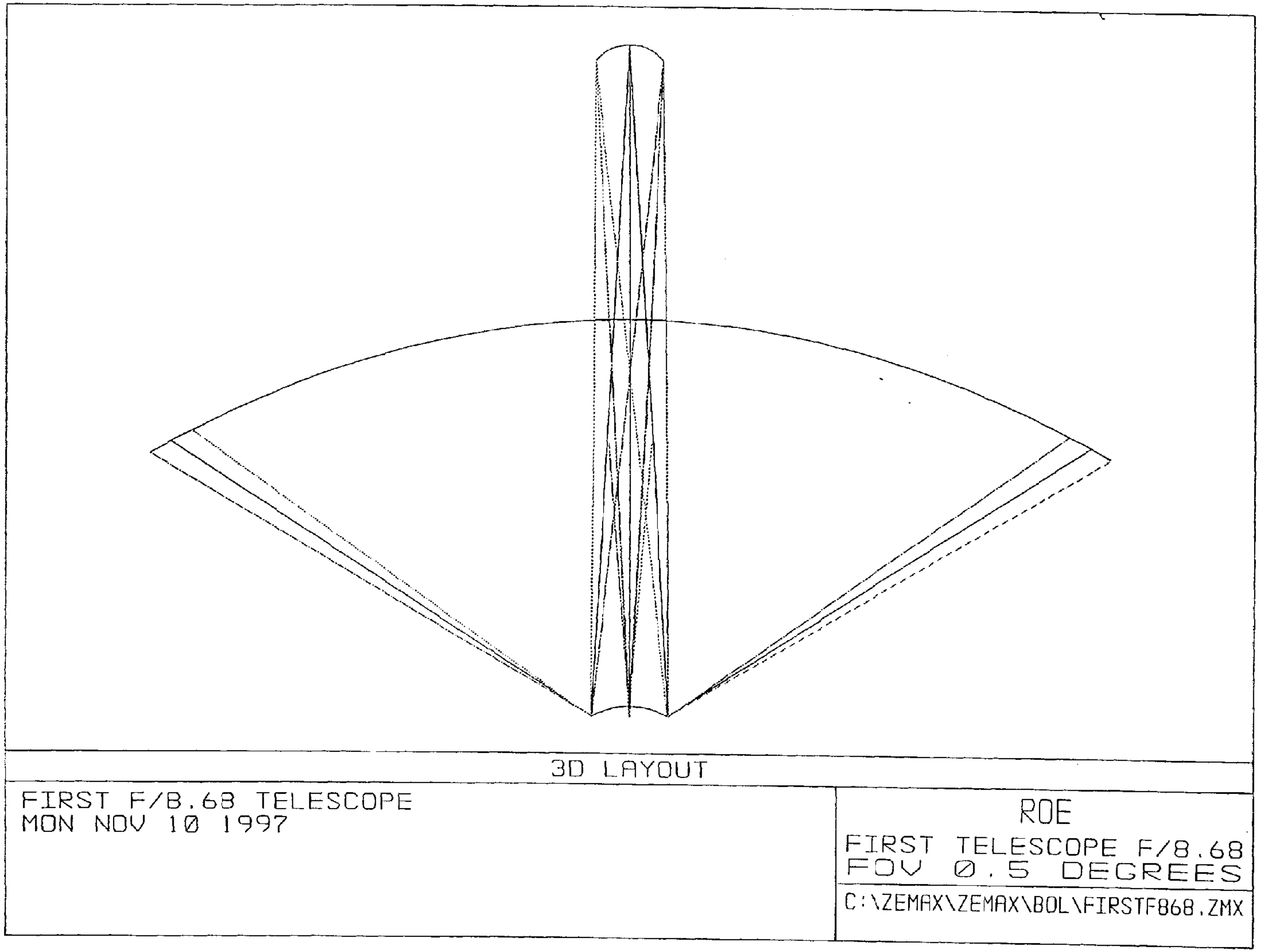
Stop at secondary mirror

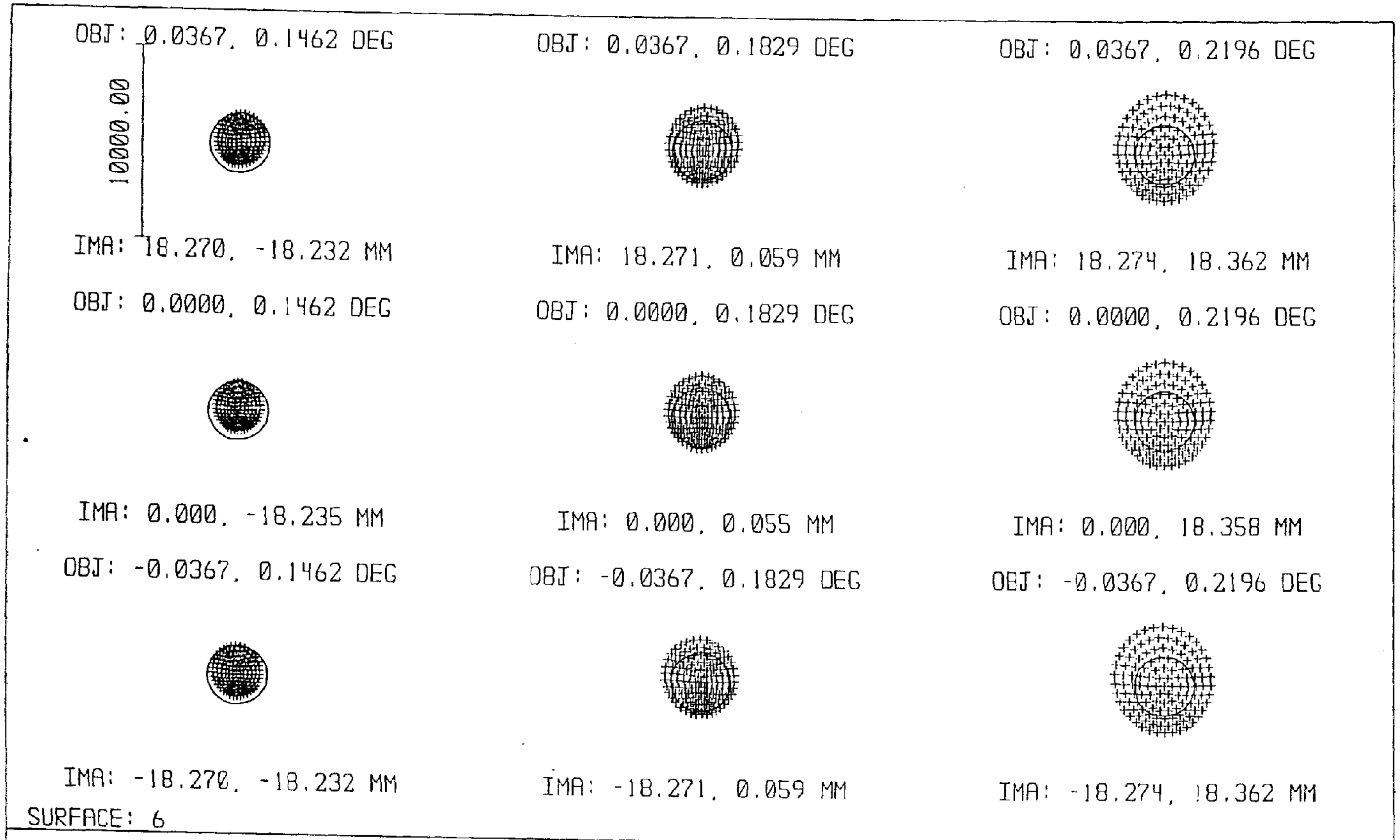
Back focal length: 975 mm (measured from pole of primary mirror); the distance between the focal plane and the pole of BOL M3 is 170 mm and 202 mm from the optical bench.

The optical axis of BOL is tilted by 2.2 degrees relative to the telescope optical axis (corresponds to 91 mm decentered at focal plane) .

TELESCOPE OPTICAL DESIGN /IMAGE QUALITY

The radius of curvature of the telescope focal plane is 158.3 mm which has to be taken into account in the design of Bolphot . A spot diagram at the telescope focal plane is shown below:


3D LAYOUT
FIRST F/8.68 TELESCOPE
MON NOV 10 1997
ROE
FIRST TELESCOPE F/8.68
FOV 0.5 DEGREES
C:\ZEMAX\ZEMAX\BOL\FIRSTF868.ZMX

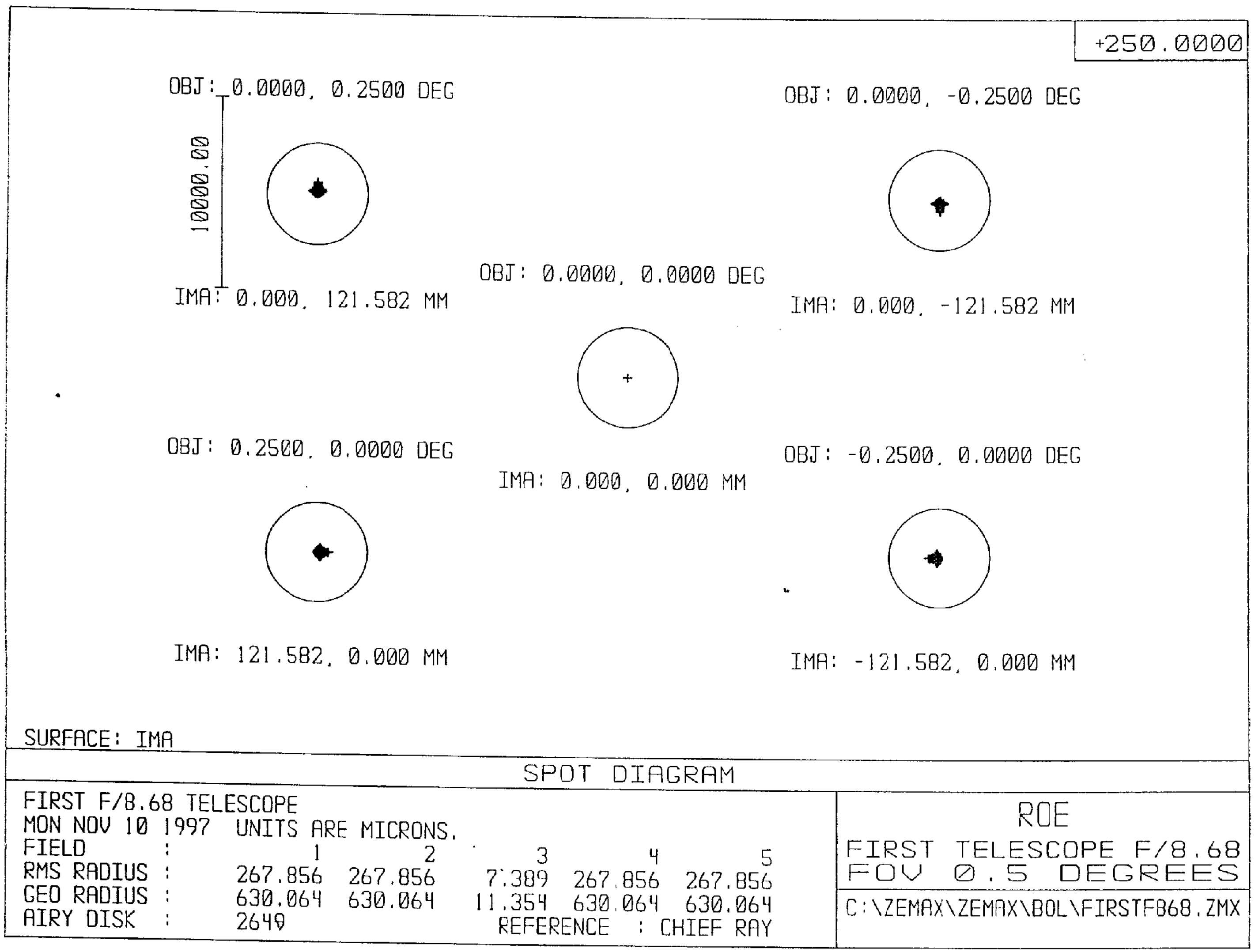


SPOT DIAGRAM

BOL PHOTOMETER WITH F/8.68 TELESCOPE
MON NOV 10 1997 UNITS ARE MICRONS.

FIELD :	1	2	3	4	5	6	7	8	9
RMS RADIUS :	972.895	1.4E+003	2.0E+003	917.344	1.4E+003	2.0E+003	972.895	1.4E+003	2.0E+003
GEO RADIUS :	1.5E+003	2.3E+003	3.1E+003	1.5E+003	2.2E+003	3.1E+003	1.5E+003	2.3E+003	3.1E+003
AIRY DISK :	1556								

REFERENCE : CHIEF RAY

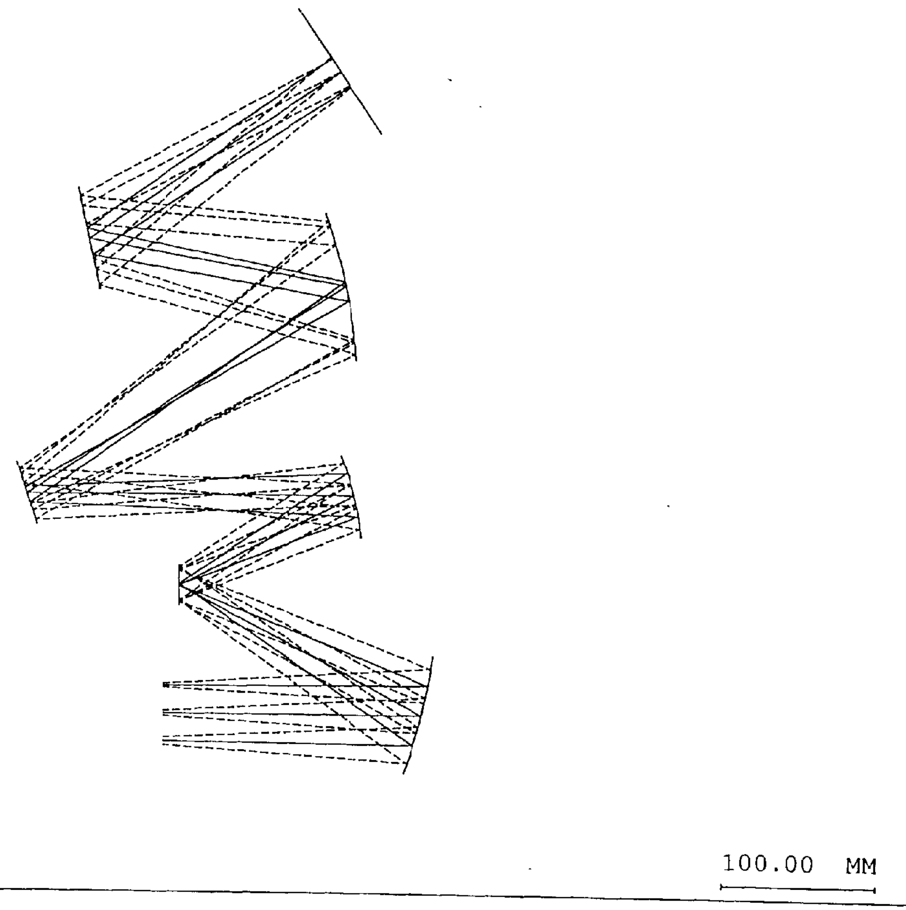

+250.0000
OBJ: 0.0000, 0.2500 DEG
10000.00
IMA: 0.000, 121.582 MM
OBJ: 0.0000, -0.2500 DEG
IMA: 0.000, -121.582 MM
OBJ: 0.0000, 0.0000 DEG
IMA: 0.000, 0.000 MM
OBJ: 0.2500, 0.0000 DEG
IMA: 121.582, 0.000 MM
OBJ: -0.2500, 0.0000 DEG
IMA: -121.582, 0.000 MM
SURFACE: IMA
SPOT DIAGRAM
FIRST F/8.68 TELESCOPE
MON NOV 10 1997 UNITS ARE MICRONS.
FIELD : 1 2 3 4 5
RMS RADIUS : 267.856 267.856 7.389 267.856 267.856
GEO RADIUS : 630.064 630.064 11.354 630.064 630.064
AIRY DISK : 2649
REFERENCE : CHIEF RAY
ROE
FIRST TELESCOPE F/8.68
FOV 0.5 DEGREES
C:\ZEMAX\ZEMAX\BOL\FIRSTF868.ZMX

Photometer / Imager (designed with 3.5 m; F/8.68 FIRST)

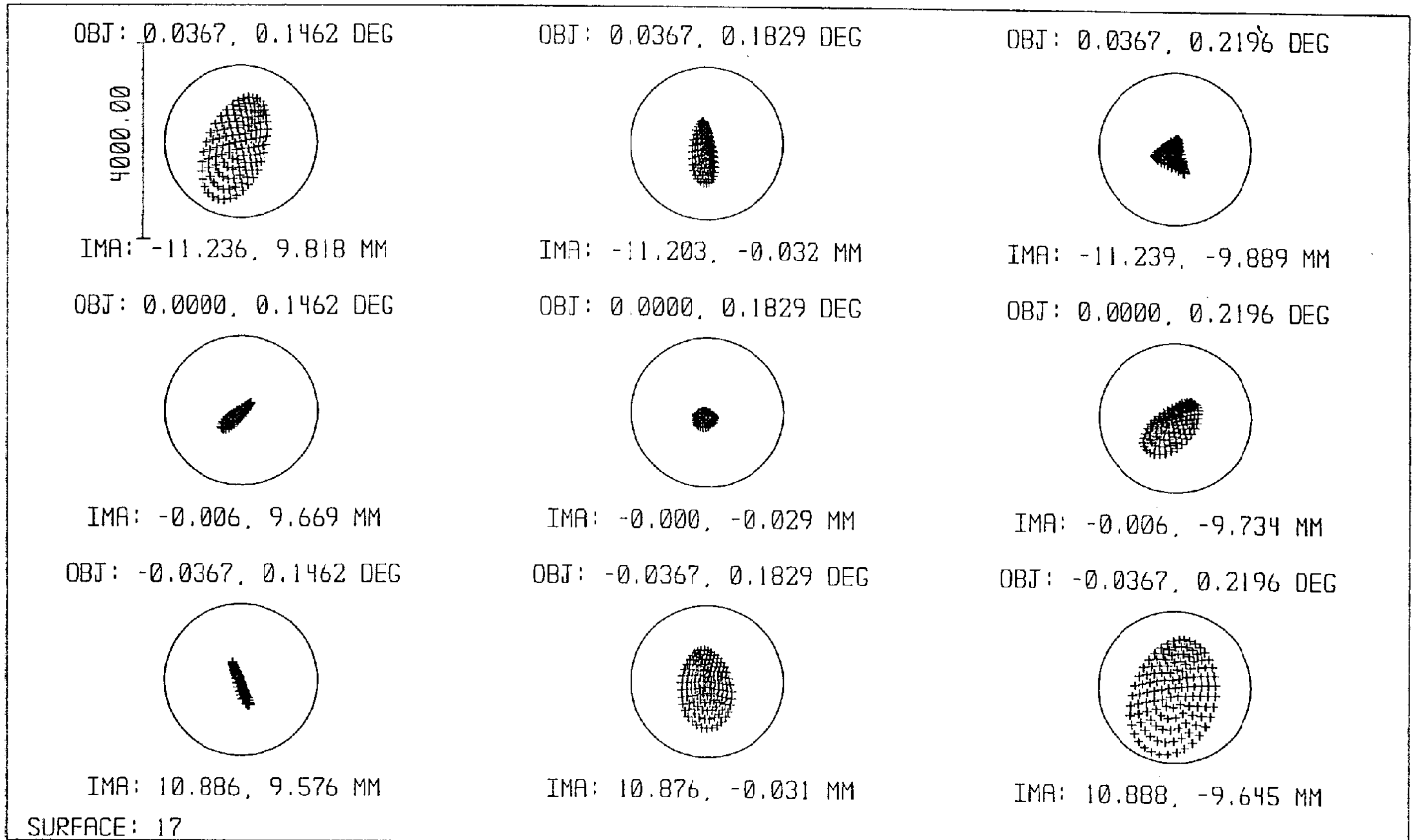
- Working wavelengths: 200-600 microns
- Fnumber: F/5
- Field of View: 4.4 arcmin square
- Chopper in the instrument and placed at the image of FIRST secondary mirror which is the stop of the telescope.
- Has to fit with the spectrometer in the 690*410*410 mm space enveloppe.
- A physical cold stop at 4K to reduce background radiation.
- The photometer will share the same foreoptics as the spectrometer (one chopper only, weight) ,providing an f/4.5 beam for the eventual slit .
- 3 arrays of square detectors optimized for 3 separate wavelengths: 250, 350,480 microns : 32*32 (0.625mm pixel), 24*24 (0.875mm pixel), 16*16 (1.2 mm pixel).
- No Filter wheel .

Photometer/Imager Optical Data:

Component	Radius of Curv (mm)	Separation (mm)	y- Tilt (degrees)	CA Diameter (mm)
telescope FP f/8.68 (20K) (7.237"/mm)	Plano	170		61.0
M3 (sphere)	340.00	180.00	14.0	84.5
M4 (chopper)	Plano	128.83	28.0	24.0
M5 (toroid)	176.416 195.718	84.467	14.0	58.5
Cold reimaged Focal plane f/4.5 (4K)	Plano	129.18		34.0
M6	Plano	100.34	17.0	42.5
cold stop (2K)	Plano	150.00		40.0
M7 (toroid)	347.126 403.739	170.00	22.0	94.0
M8 (dichroic)	Plano	198.00	22.0	62.0
Detector/f/5				Square 21mm side Dst:21*26
(12.56"/mm)				



BOL PHOT f/8.68 telescope/square array   Scale: 0.25   10-Nov-97



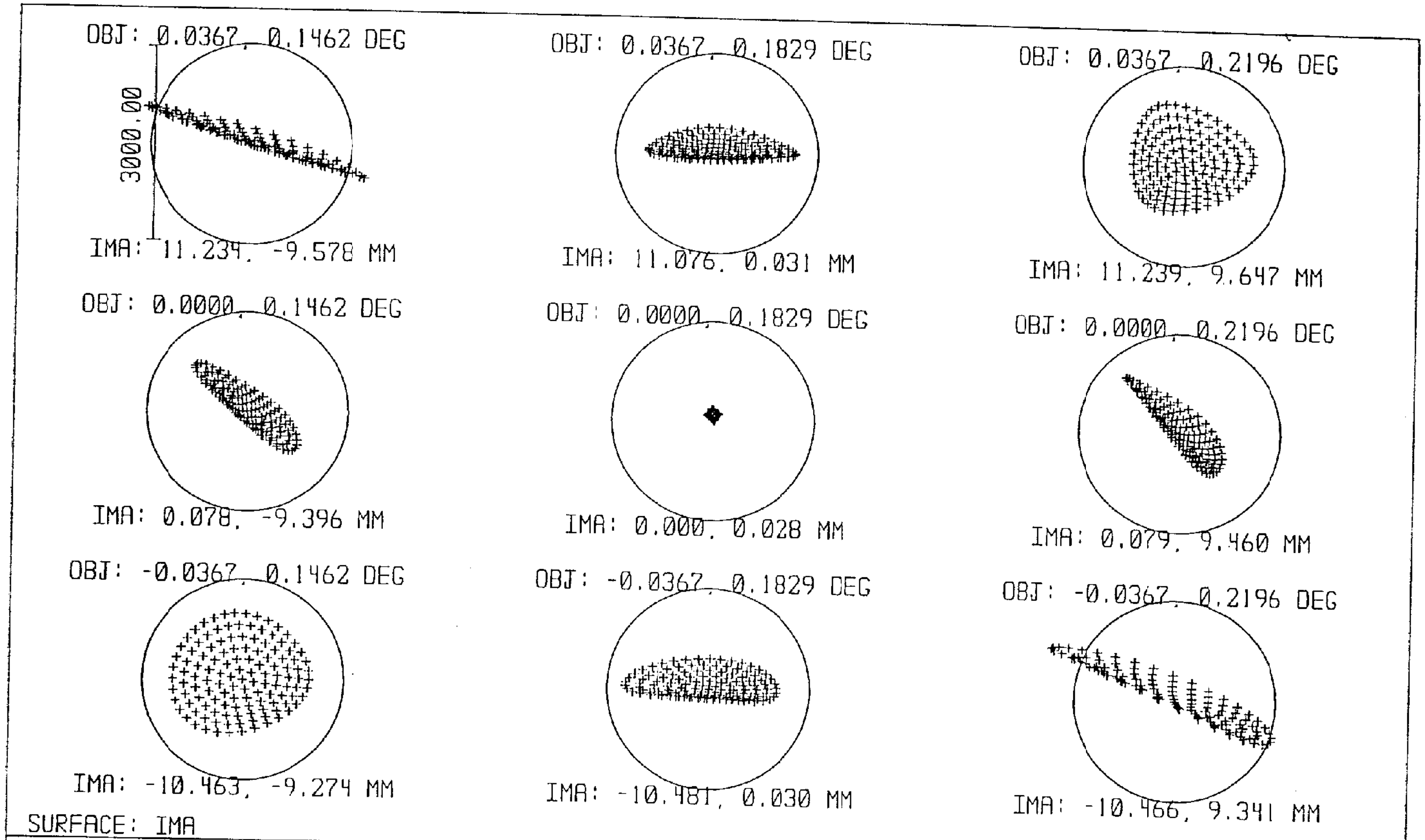
SPOT DIAGRAM

BOL PHOTOMETER WITH F/8.68 TELESCOPE
MON NOV 10 1997 UNITS ARE MICRONS.

FIELD :	1	2	3	4	5	6	7	8	9
RMS RADIUS :	677.978	372.300	266.675	237.492	151.434	429.982	256.132	509.028	782.975
GEO RADIUS :	1.3E+003	806.901	538.177	551.116	342.551	890.189	546.522	947.050	1.4E+003
AIRY DISK :	1556								

REFERENCE : CHIEF RAY

IMAGES AT [illegible] REIMAGED [illegible] PLANE [illegible]



SPOT DIAGRAM

BOL PHOTOMETER WITH F/8.68 TELESCOPE
FRI NOV 7 1997 UNITS ARE MICRONS.

FIELD :	1	2	3	4	5	6	7	8	9
RMS RADIUS :	948.203	622.939	667.561	556.353	83.100	570.247	756.094	657.827	1.0E+003
GEO RADIUS :	1.8E+003	1.2E+003	1.1E+003	1.1E+003	191.136	1.2E+003	1.1E+003	1.3E+003	2.1E+003
AIRY DISK :	1556								

REFERENCE : CHIEF RAY

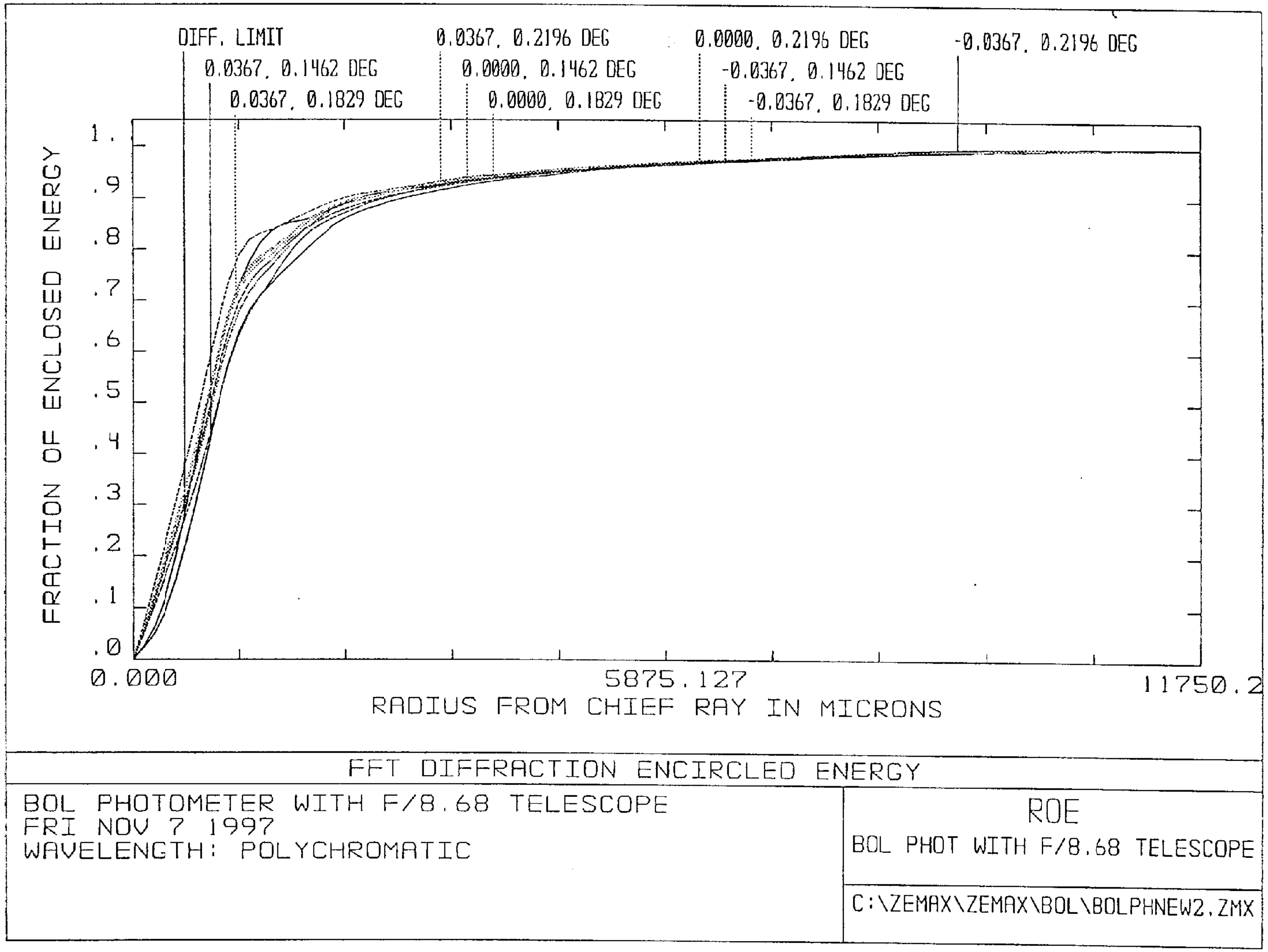

DIFF. LIMIT
0.0367, 0.1462 DEG
0.0367, 0.1829 DEG
0.0367, 0.2196 DEG
0.0000, 0.1462 DEG
0.0000, 0.1829 DEG
0.0000, 0.2196 DEG
-0.0367, 0.1462 DEG
-0.0367, 0.1829 DEG
-0.0367, 0.2196 DEG
FRACTION OF ENCLOSED ENERGY
1.
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
0.000
5875.127
11750.2
RADIUS FROM CHIEF RAY IN MICRONS
FFT DIFFRACTION ENCIRCLED ENERGY
BOL PHOTOMETER WITH F/8.68 TELESCOPE
FRI NOV 7 1997
WAVELENGTH: POLYCHROMATIC
ROE
BOL PHOT WITH F/8.68 TELESCOPE
C:\ZEMAX\ZEMAX\BOL\BOLPHNEW2.ZMX

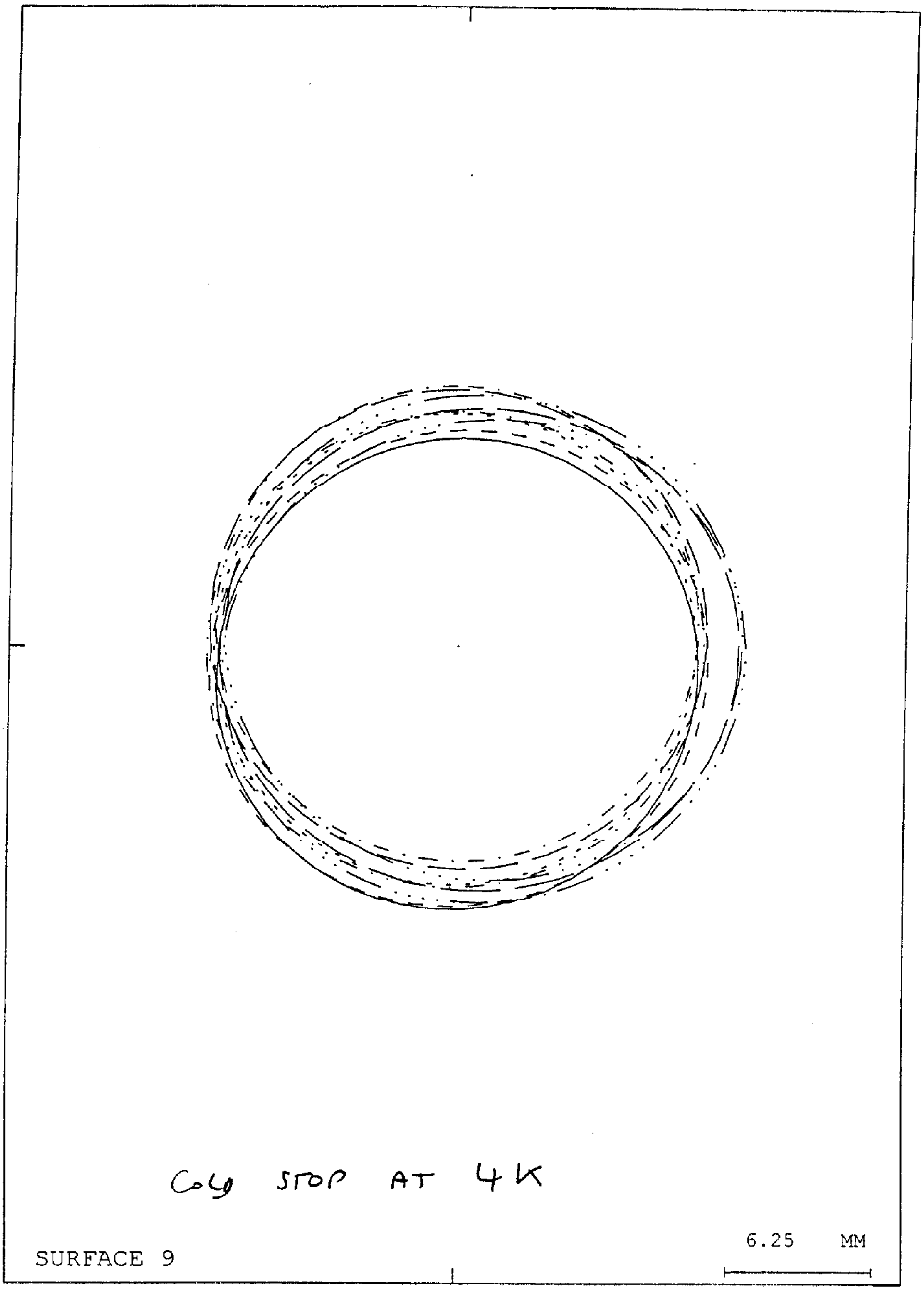
IMAGE QUALITY

Encircled Energy Diameters (mm) and Strehl ratios:

Wavelength (µm)	250	350	480
Airy disk (80%) (mm)	2.5	3.5	4.8
Geometrical spots (mm)			
80% on-axis	0.85	0.85	0.85
off-axis	1.50/2.50	1.50/2.50	1.50/2.50
Strehl ratios			
on-axis	1.00	1.00	1.00
off-axis	0.70/0.90	0.83/0.95	0.91/1.00

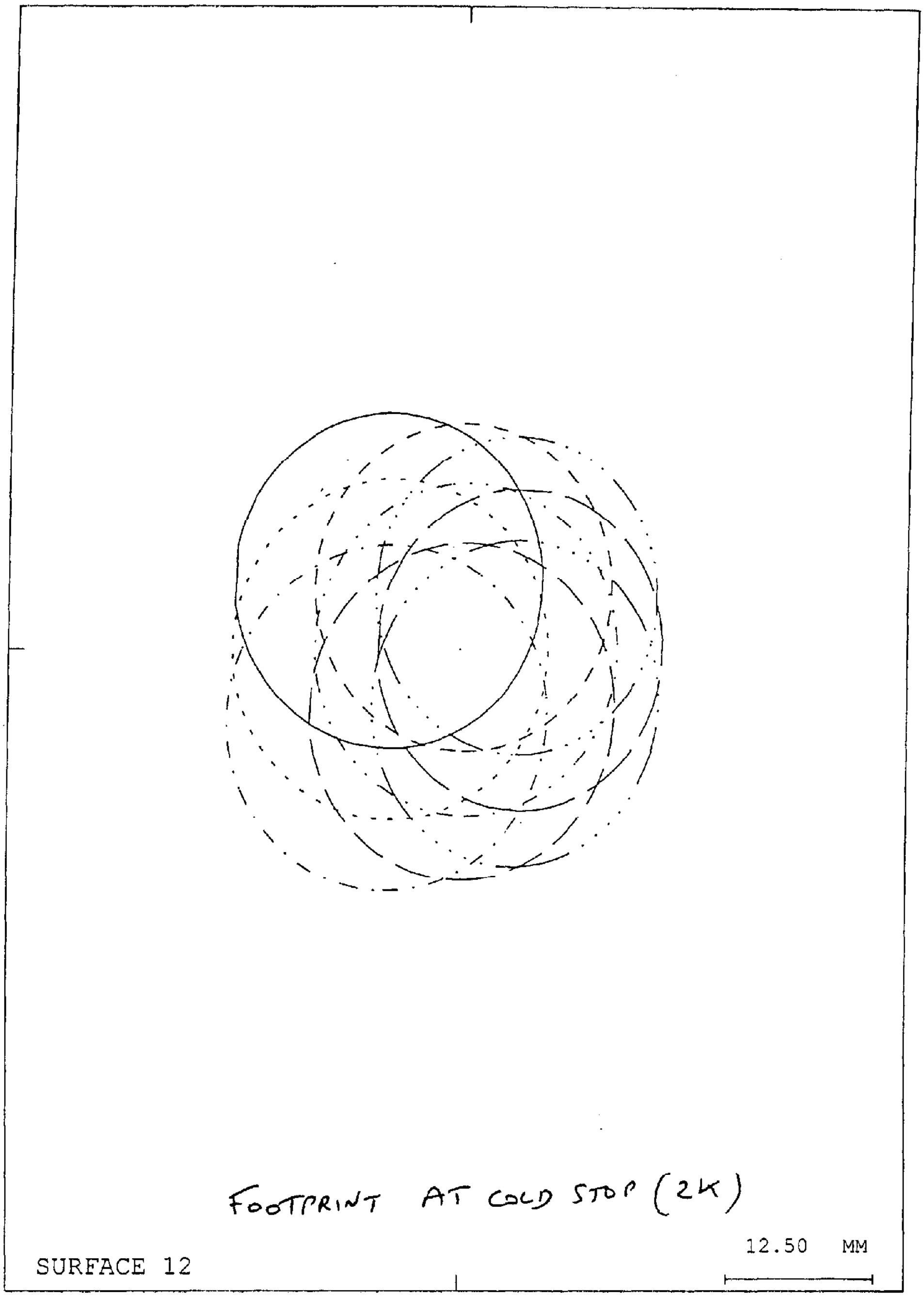
THROUGHPUT : 0.89 (without filters)

(assuming 0.98 reflectivity per mirror)



10-Nov-97

BOL PHOT f/8.68 telescope/square array

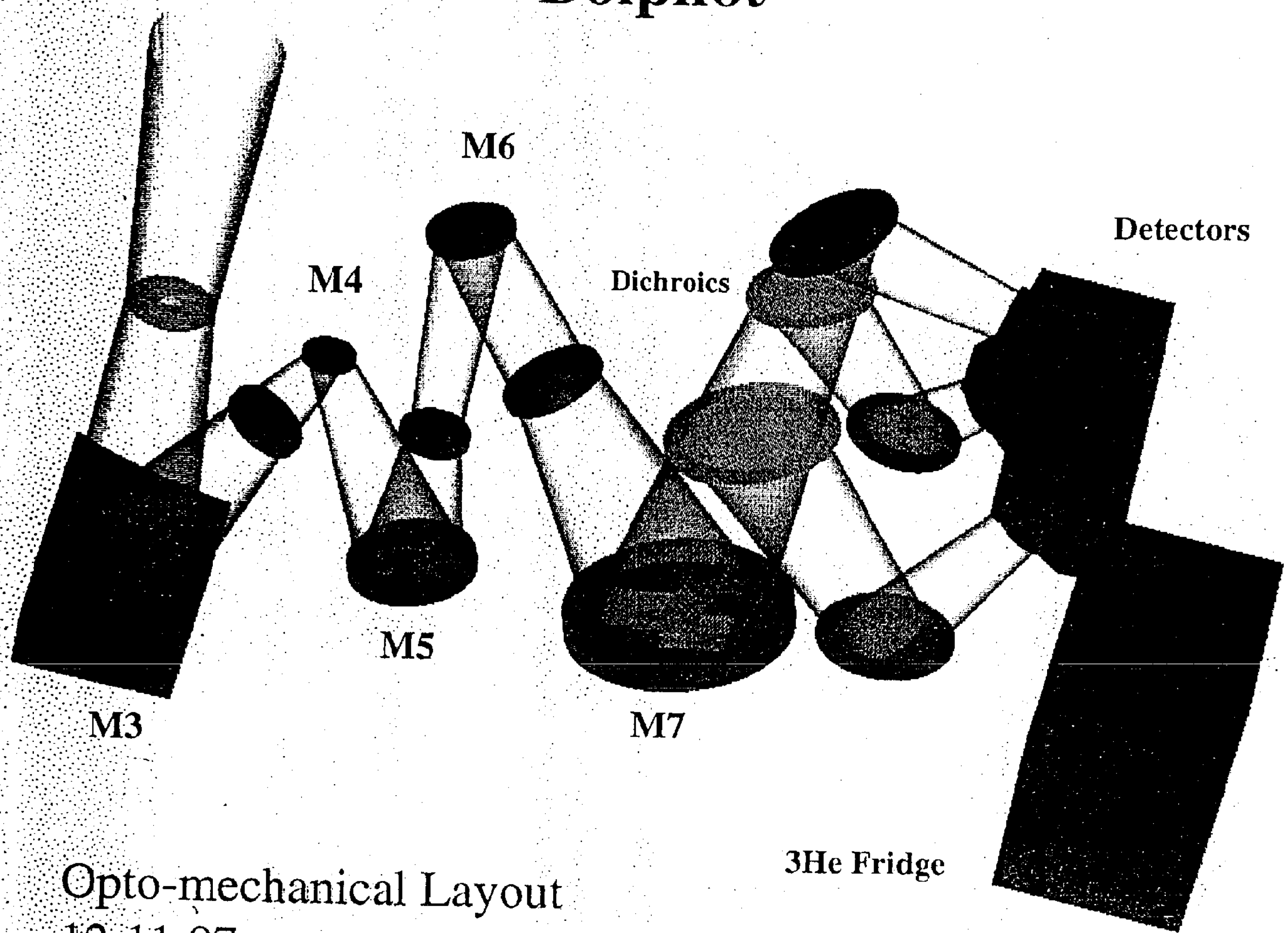


10-Nov-97

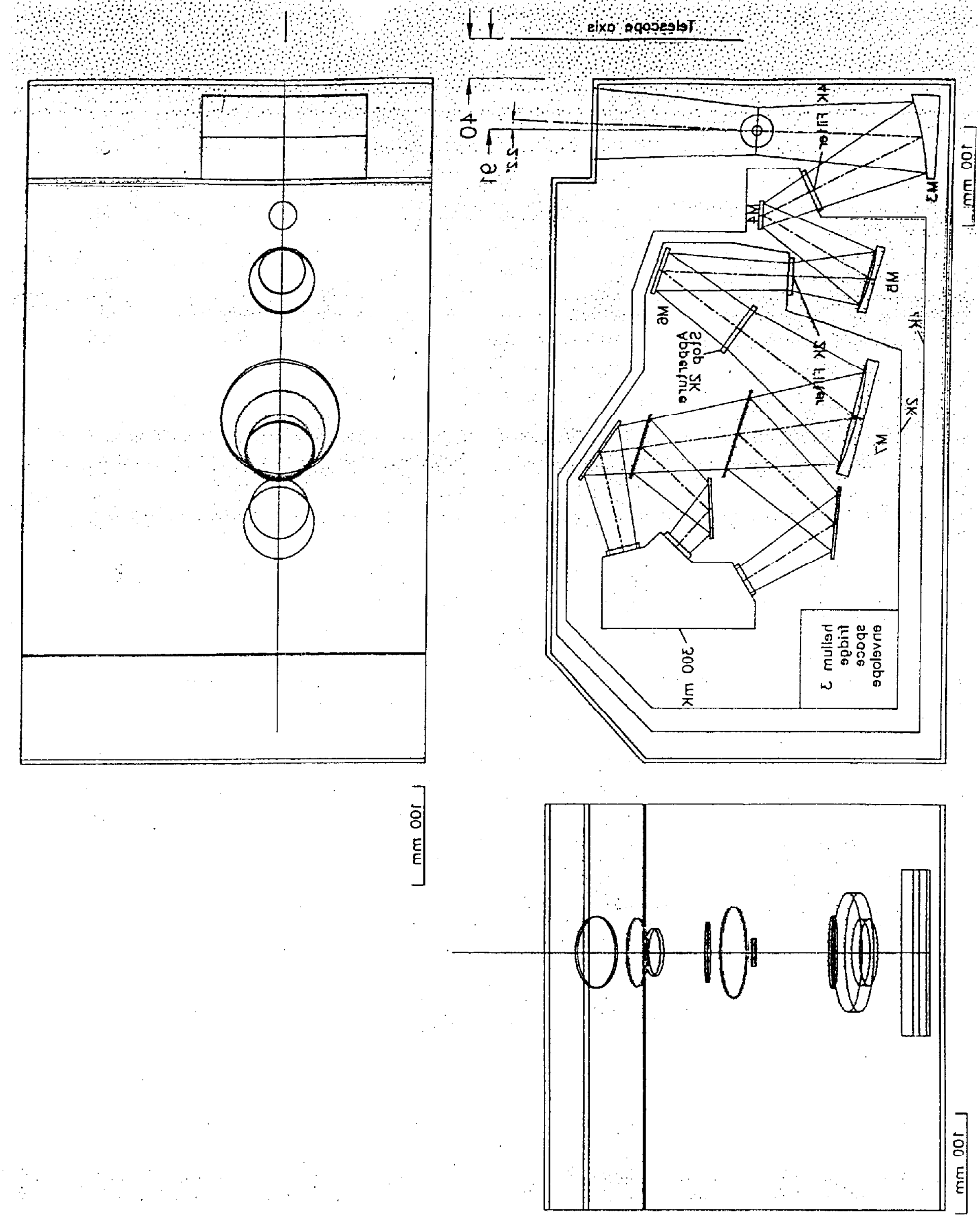
BOL PHOT f/8.68 telescope/square array

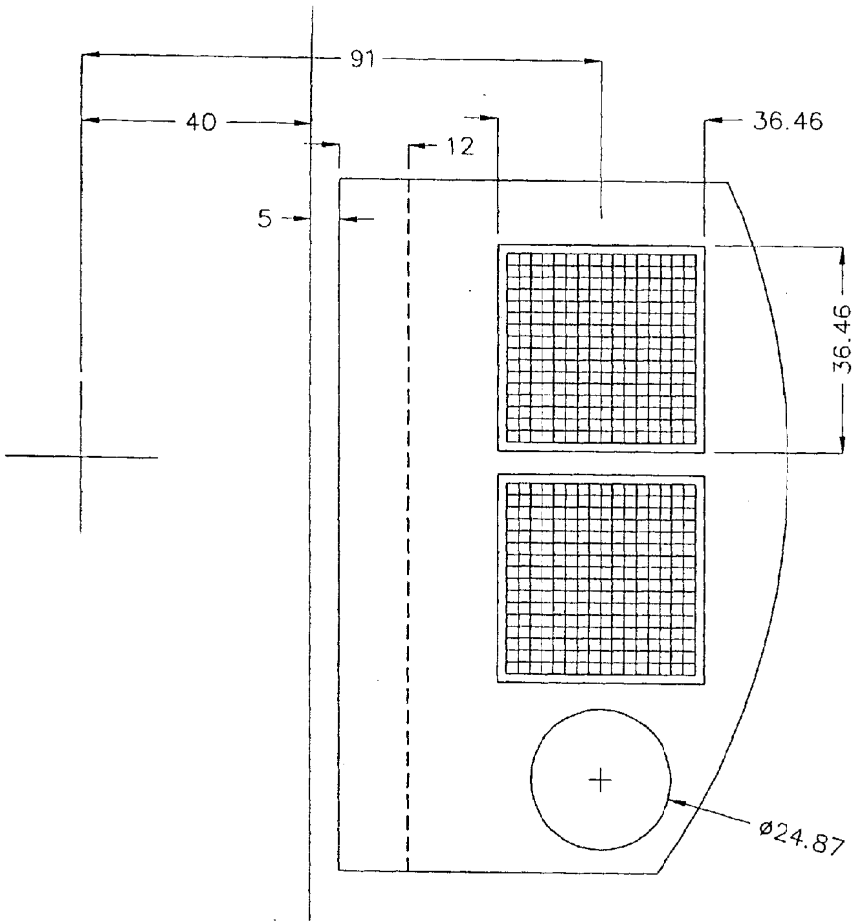
ϕ 40 mm

Bolphot

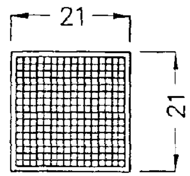


Opto-mechanical Layout
12:11:97


Telescope axis
40
16
2.2
100 mm
M3
4K Filter
M4
M5
2K Filter
M6
Stop 2K
Apperture
M7
4K
2K
helium 3
fridge
space
envelope
300 mK
100 mm
100 mm



Detector Mapped to Telescope Focal Plane.
Incuding 3 arcmin FOV for FTS.
12th Nov.' 1997



Actual Size of Detector

Martin Caldwell, RAL.

SUMMARY.

- ASAP© model based on 3-D ray-trace, of current PHOT design & component sizes.
- Propagates detector sensitivity function outwards through system, from detector to sky (= FOV response).
- At each component, determines flux on optics surround, to find contributions to background level, mainly :

  Cold stop, M3 surround, M1 rear-side, M2 surround.

- Propagates beam as-clipped by last component, so that effect on subsequent components and net FOV can be arrived at.
- Most important issue is BOL pupil's undersize required with respect to telescope.

Example beam patterns at each end of system (detector & sky).

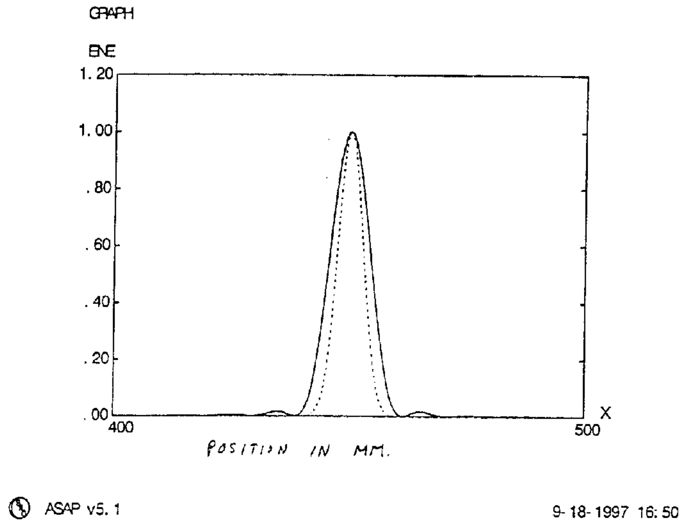
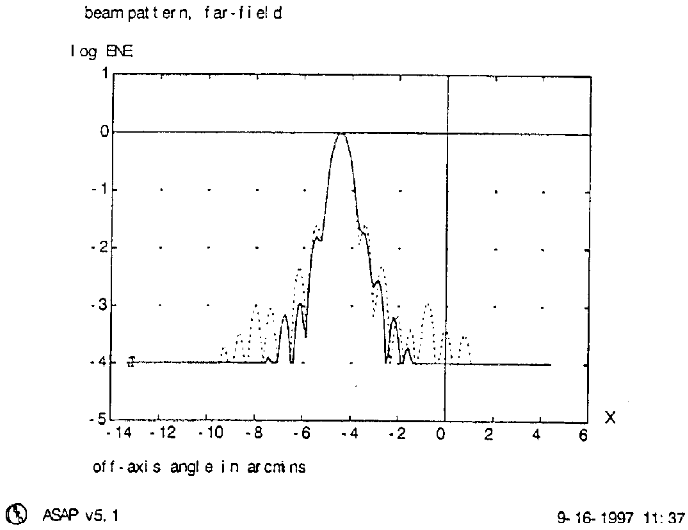


Fig.2 Beam patterns at detector plane, for gaussian (dotted line, waist=$(2/\pi)F\lambda$, $1/e^2$ intensity clipping) and top-hat (solid line, 1st min=$1.22F\lambda$), λ=0.64mm.



Instrument response on sky: point source transmittance (PST).

CLRC

Martin Caldwell, RAL.

SUMMARY.

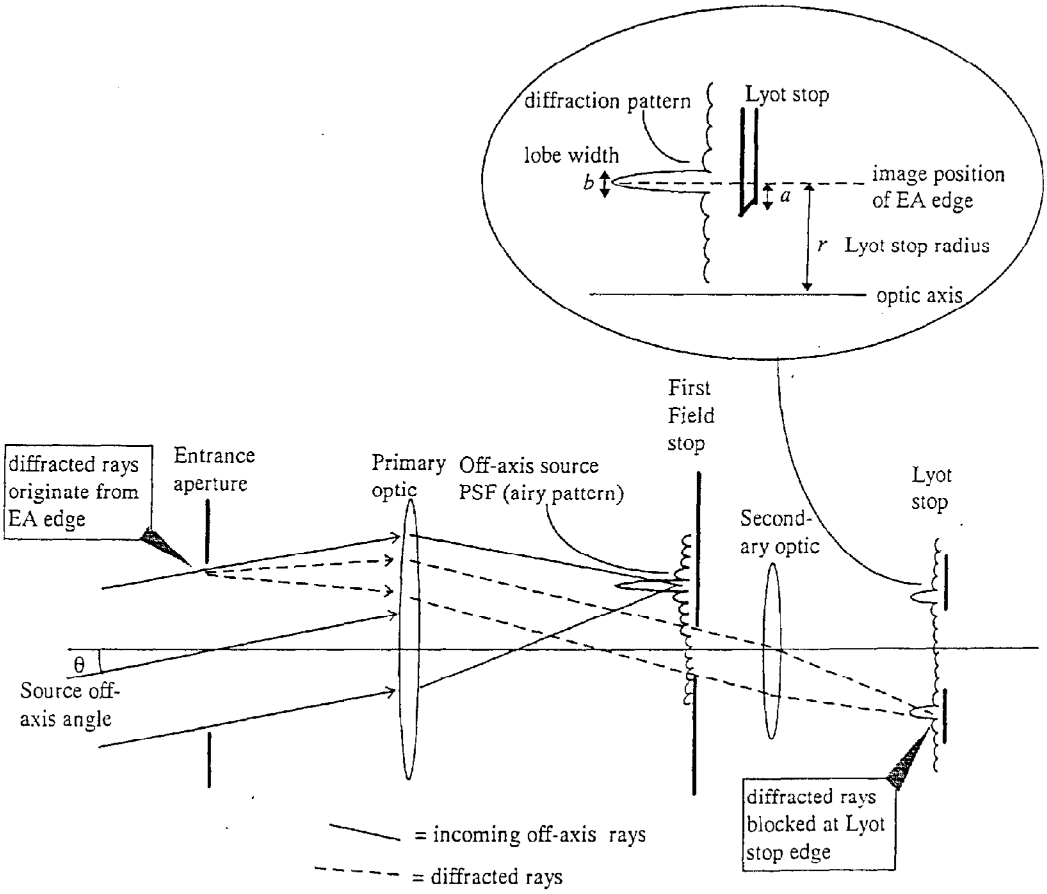
- ASAP© model based on 3-D ray-trace, of current PHOT design & component sizes.
- Propagates detector sensitivity function outwards through system, from detector to sky (= FOV response).
- At each component, determines flux on optics surround, to find contributions to background level, mainly :

  Cold stop, M3 surround, M1 rear-side, M2 surround.

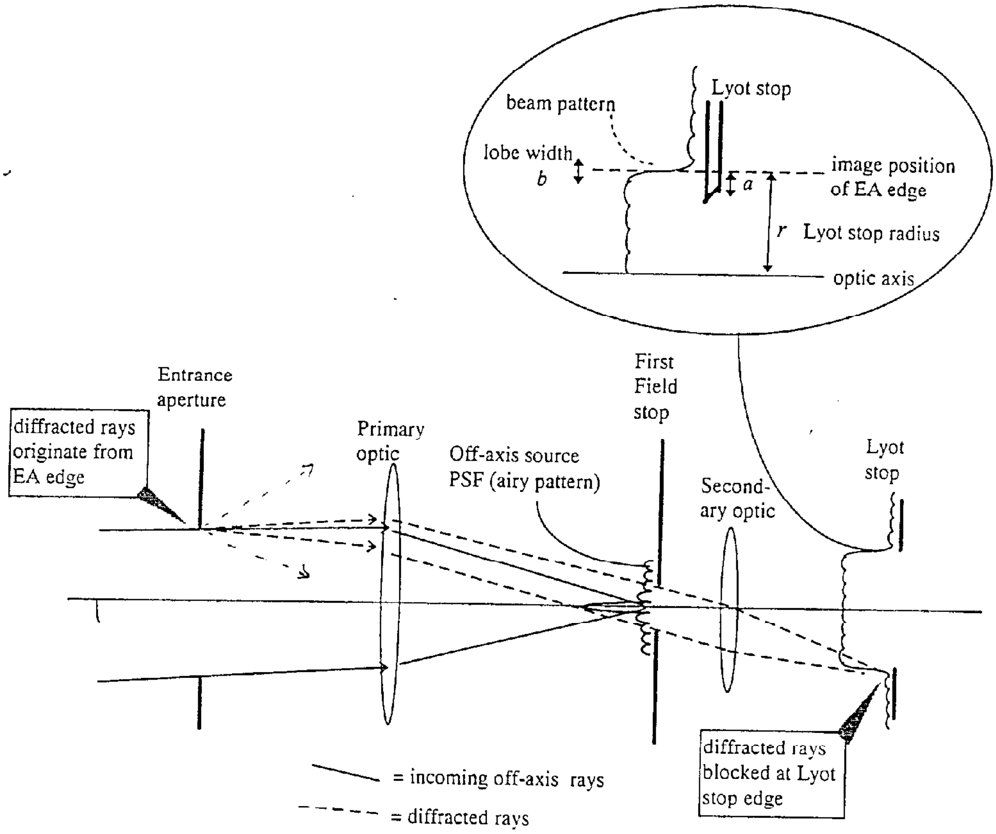
- Propagates beam as-clipped by last component, so that effect on subsequent components and net FOV effect can be arrived at.
- Most important issue is BOL pupil's undersize required with respect to telescope.

Out-of-field diffraction defence with Lyot Stop.

Opt. Eng. Vol.36 No.10 p.2793 (Oct.'97)



In-field equivalent.



- Imaging from one pupil plane to the next, with spatial resolution limited by field stop relative aperture F' (fourier optics) :

$$b/2 \approx F'.\lambda$$

- Consequence is that without undersizing, the beam as defined by clipping at one stop partly 'sees' a border region around the edge of the next stop, of width ~ b/2 (applies equally to reverse ray-trace).

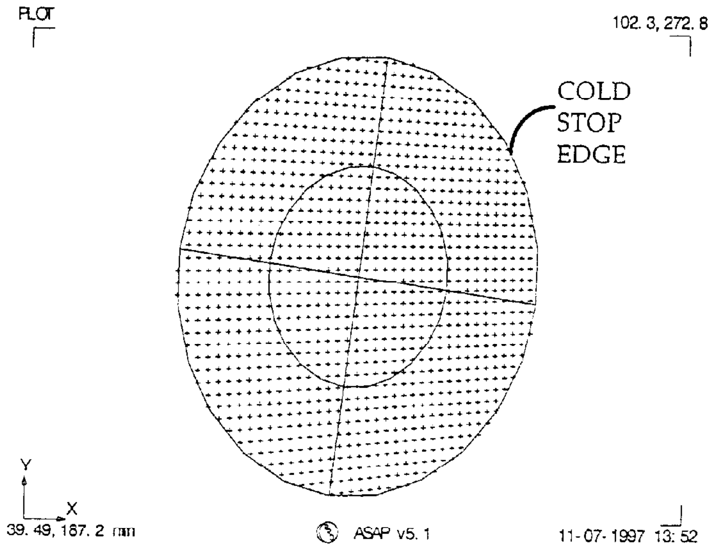
- Ideal undersize is by dimension a > b/2.

if designed for longest BOL wavelength, would give a/r~ 10%, throughput loss ~ 20%

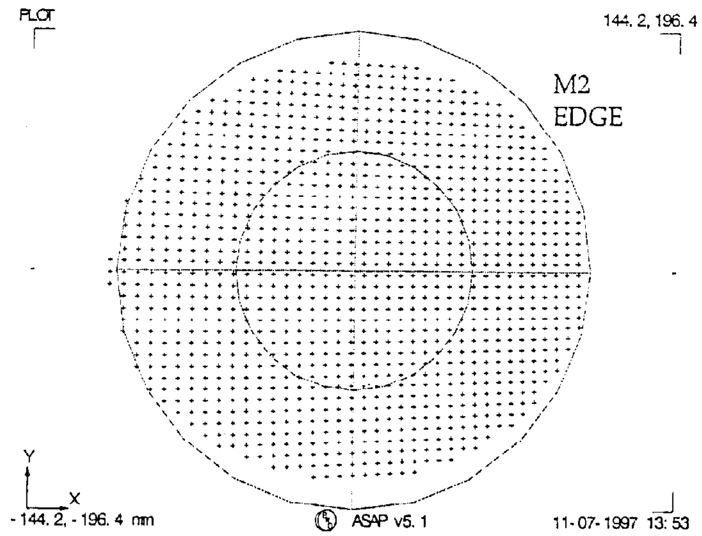
Defining of clipping edge. For modelling patterns beyond field stop, definition of initial beam to < b, is adequate.

Undersizing to avoid clipping at M2, latest PHOT-BOL design, 0.5μm wavelength.

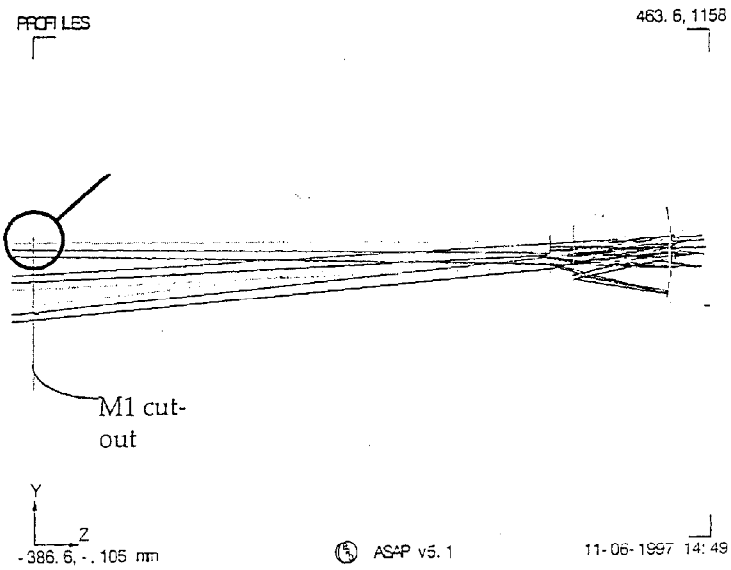
Geometric beam on cold stop

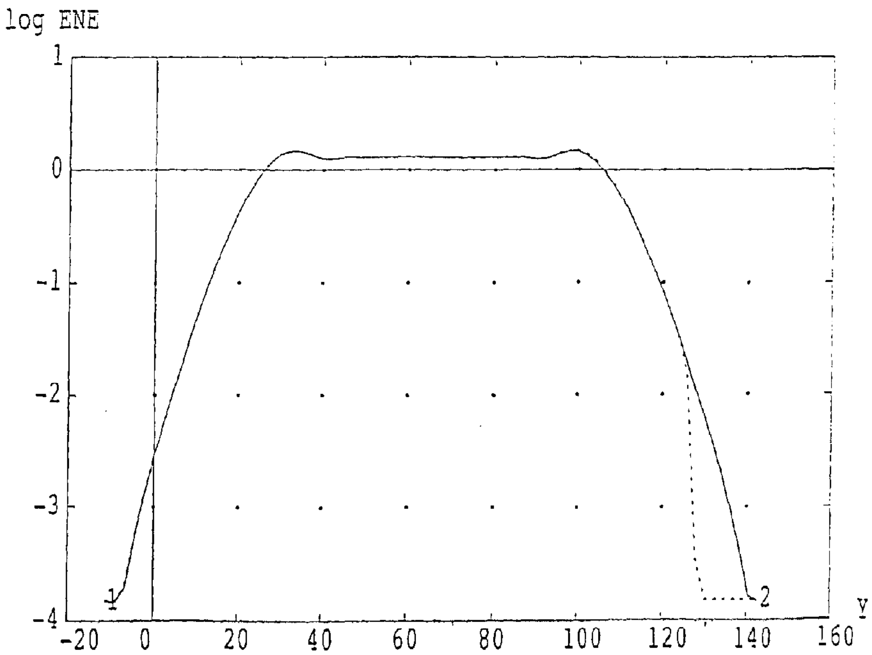


Geometric footprint on M2, field (x,y)=(0,1)

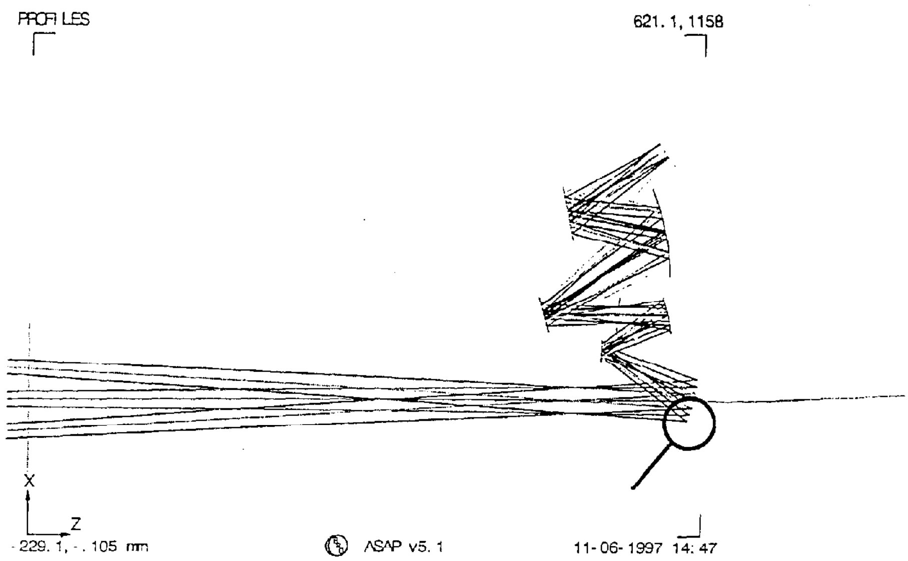


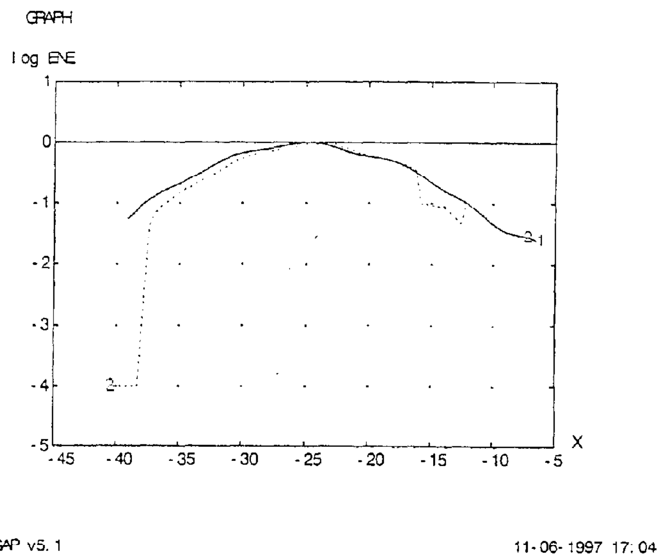
Clipping at M1 rear-side.





clipping at M3, for outermost detector





- Model does not include propagation of this near-field clipping.

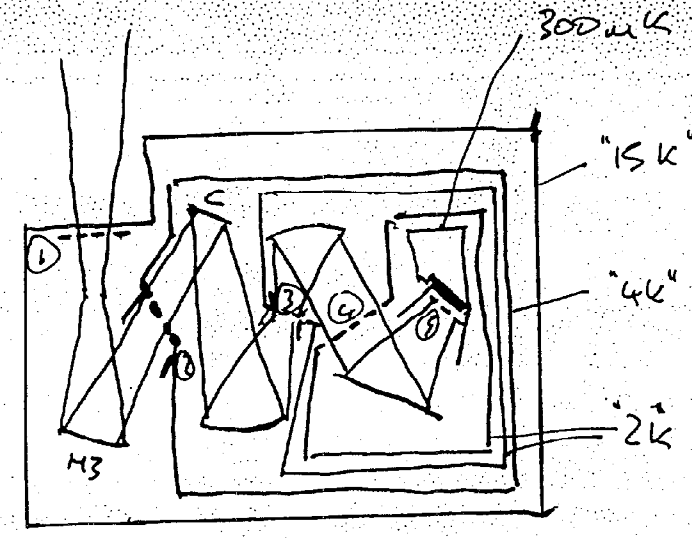
Background levels due to beam clipping, as fractions of telescope background.

Component	fraction of flux lost		Surround emissivity	Temp	Fractional background, band 3		
	centre det.	edge det.			in-field, centre	in-field, edge	Out-of-field OOF (wide-angle)
Cold stop	0.006 gaus'n 128 lamb'n	0.006 gaus'n 128 lamb'n	1.0	2	1e-7 gaus'n 0.0026 lamb'n	1e-7 gaus 0.0026 lamb'n	not applicable
M3 surround	0	0.04	0.15	15	~ 0	4e-4	0.21 at 80k Ref.1
rear-side of M1	0	0.0145	0.15	80	~ 0	0.11	tbd
M2 surround	<0.02	0.02	0.15	80	<0.15	0.15	tbd

Ref.1 "Level of photometer background signal from optics" A Richards BOL/RAL/N007.1

SACLAY 12/4/97

STRAYLIGHT CONTROL STRATEGY FOR PHOTOMETER



- MAKE AS MUCH OF THE OPTICS AS POSSIBLE @ ≤ 4K ⇒ INCLUDING THE CHOPPER MIRROR + MECHANISM?
- HAVE TWO "2K" BOXES SEPARATED AT SYSTEM COLD STOP
- THERMAL FILTERS PLACED AT ① + ② AND POSSIBLY AT ③
- PASS BAND FILTERS AT ④ AND ⑤
- BAFFLES AT ②, ③ AND ⑤ AND POSSIBLY AT ④.
- INTERNAL WALLS + ABSORBERS AT CRITICAL POINTS.
- FEEDTHROUGHS FOR TAKING OUT WIRING + BAFFLES THERMAL I/F.

IID B DRAFT 1ST DEC LORC

INSTRUMENT DESCRIPTION — BRUCE/MJG

THERMAL DESIGN
HEAT LOADS — BRUNO

MASS — WILF/FRASER

MECHANICAL INTERFACE → OB — WILF
THERMAL INTERFACE — COLIN

WIRING — BRUNO/LAURENT

EMC — COLIN/LAURENT

DATA RATE — COLIN/LAURENT

MORE DETAIL NEEDED:

CHOPPER — FRASER

CALIBRATOR(S) — BRUCE

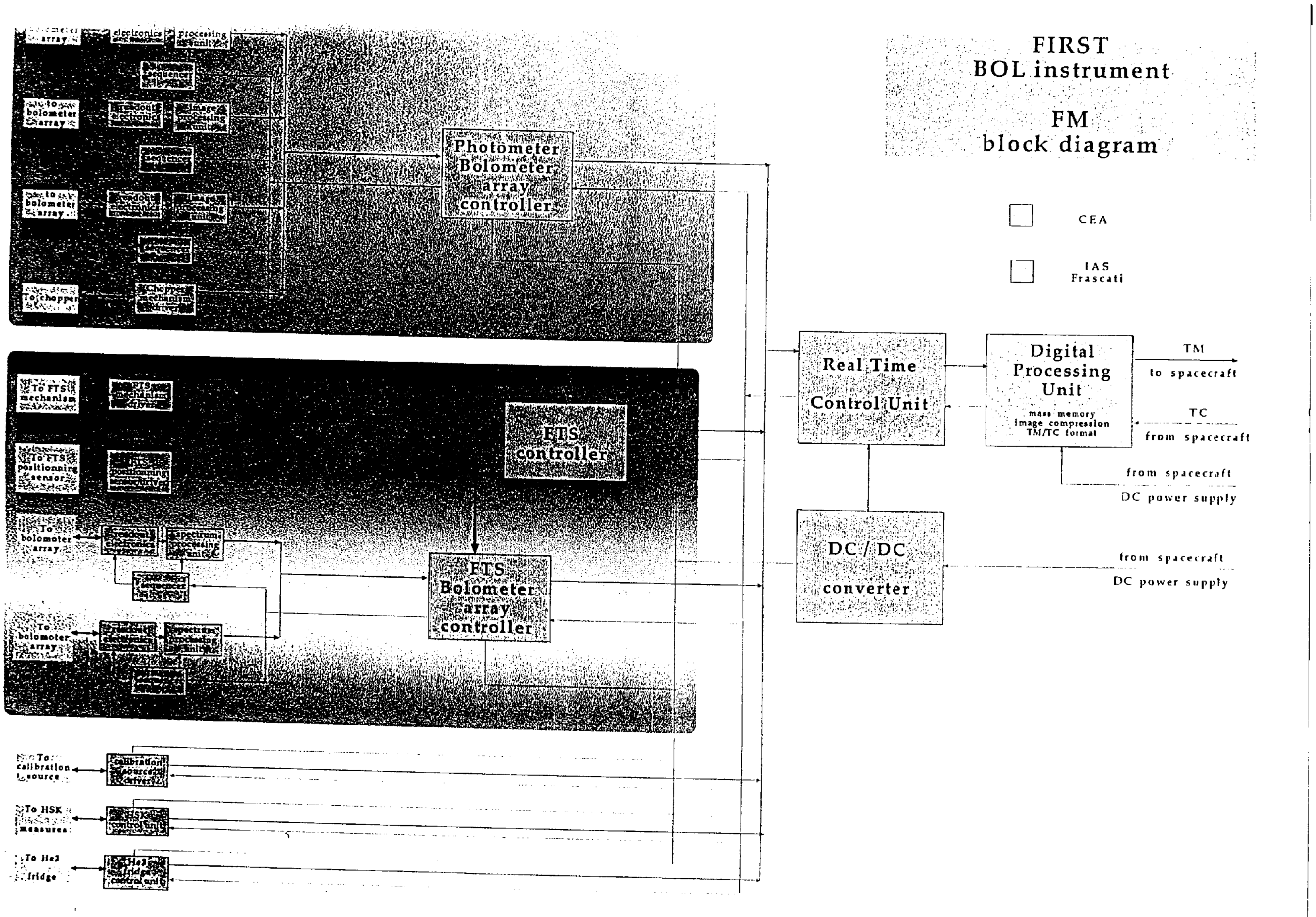
~~FET~~ COLD READOUT — COLIN, LAURENT, SAM HARVEY

EGSE/MGSE/OGSE — BRUCE

TEST PLAN — BRUCE

FTS MECHANISM / POWER etc — DOMINIC

POWER BUDGET — ~~[illegible]~~ RENATO


FIRST
BOL instrument
FM
block diagram
CEA
IAS
Frascati
Photometer Bolometer array controller
FTS controller
FTS Bolometer array controller
Real Time Control Unit
Digital Processing Unit
mass memory
image compression
TM/TC format
TM
to spacecraft
TC
from spacecraft
from spacecraft
DC power supply
DC/DC converter
from spacecraft
DC power supply
To FTS mechanism
To FTS positionning sensor
To bolometer array
To bolometer array
To chopper
To calibration source
To HSK measures
To He3 fridge