Proposal for dual-channel Bolometer for FIRST

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1. INTRODUCTION

Following the work-group meeting at RAL 10-11 February 1997, this note describes a proposal for a dual channel bolometer. The FIRST telescope focus is taken to be F/10. Both channels have separate sky-chopping mirrors: M3 forms for each channel a pupil onto wobbling M4 of Dia. 30mm. The photometer channel (PHOT-BOL) produces an F/4 beam onto three arrays separated by dichroics. The spectrometer channel (SPEC-BOL) produces a spectrum of a slit in a F/3 focus. 5 orders are measured simultaneously to cover the range from 200μm to 350μm with a grating movement of ±6.2°.

Fig 1 shows a view of the entire instrument within its envelope, looking down along the telescope axis.

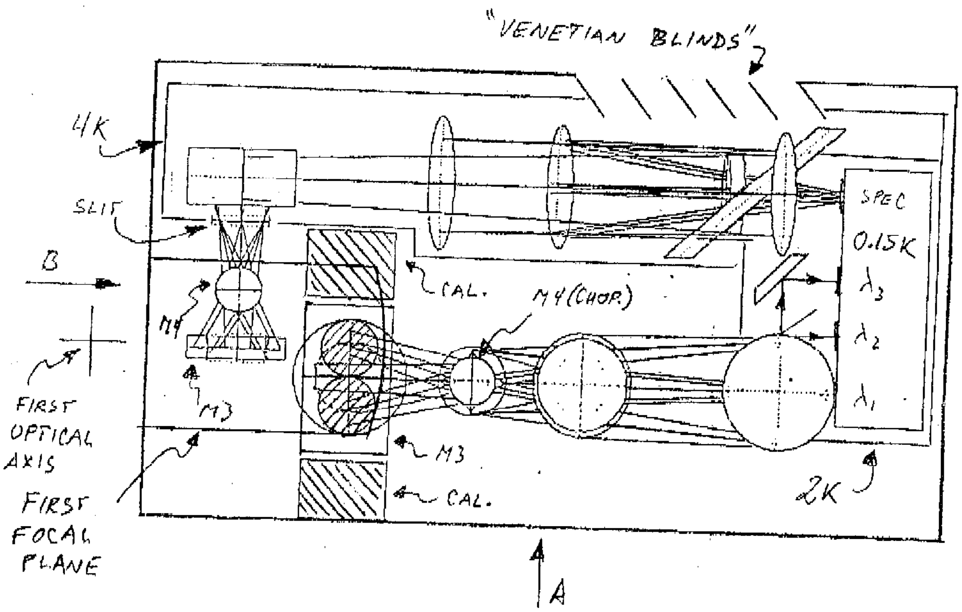


Figure 1.

2. PHOT-BOL

The photometer channel consists of 6 mirrors (M3 to M8) outside of the 2K box, with a pupil on M4 (chopper) and M8 (Lyot). The 2K box has an entrance window and contains two dichroics and three folding flats, directing the F/4 beam onto three separate arrays (cf. Fax from Griffin, 18/02/97). The arrays are co-planar amongst themselves as well as with the spectro array (see Sec. 4). The Lyot stop may possibly moved to the 2K box entrance window if a transmission stop is preferred. Fig. 2 shows a side view of the PHOT channel.

All mirrors are flat or spherical, except M8 which is toroidal. A spherical M8 may be acceptable but the geometrical spots are then slightly larger than the smallest detectors due to astigmatism. With a toroidal M8, the spots are within Ø1.5mm over the entire FOV.

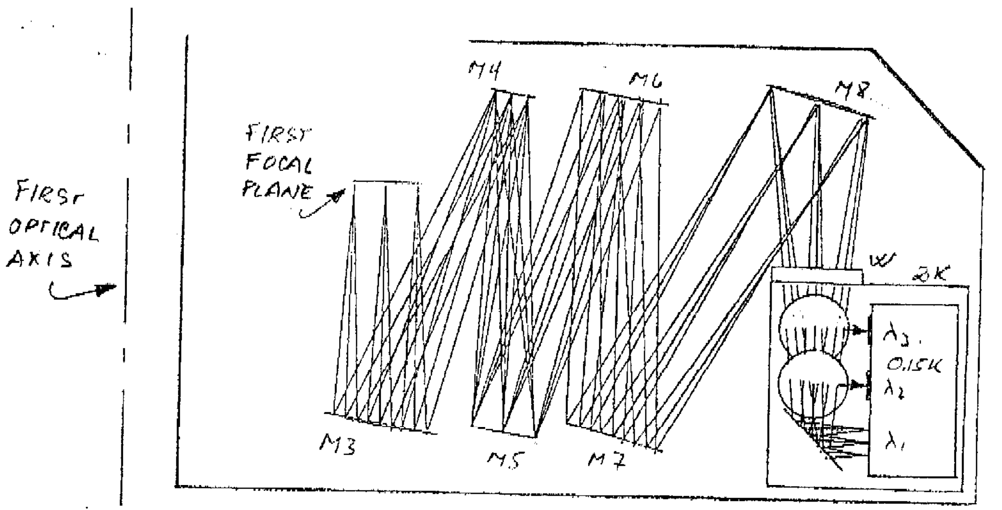


Figure 2.

3. SPEC-BOL

The spectrometer channel consists of 7 mirrors (M3 to M9) and an off-plane Littrow grating (G) outside of the 2K box. The F/3 beam enters the 2K box through a window directly onto the detector array (see Sec 4). A slit is placed between M4 (chopper) and M5. The slit is physically a slot in the 4K enclosure, everything following is thus at 4K. A pupil image is placed close to the grating, but it has been found impractical to produce another pupil image within the 4K enclosure. (Note added in proof: A possibility for a pupil on M7 and on the grating appears to exist, but with very steep beam-angles between M7 and M8 (the collimator). To be looked into.)

The channel is very crowded and it is not entirely clear if all fits in, particularly a collision between grating and 2K box is a worry. A 3D CAD study is required to figure this out.

The spectral range is divided into five orders as shown in Table 1. The resolving power (given by order times number of rulings, nN) is optimized for $R = 1000$ at 250 μm. The resulting grating measures about 85mm by 175mm and tilts through ±6.2° from 48.56° to 61°.

Figure 3 shows two views of the grating instrument, one (a) from the direction marked A in Fig. 1 and one (b) from the direction marked B in Fig.1.

FIRST, SPEC-BOL, grating calculations

K. D., LOOM 6/3/97

Assumptions:

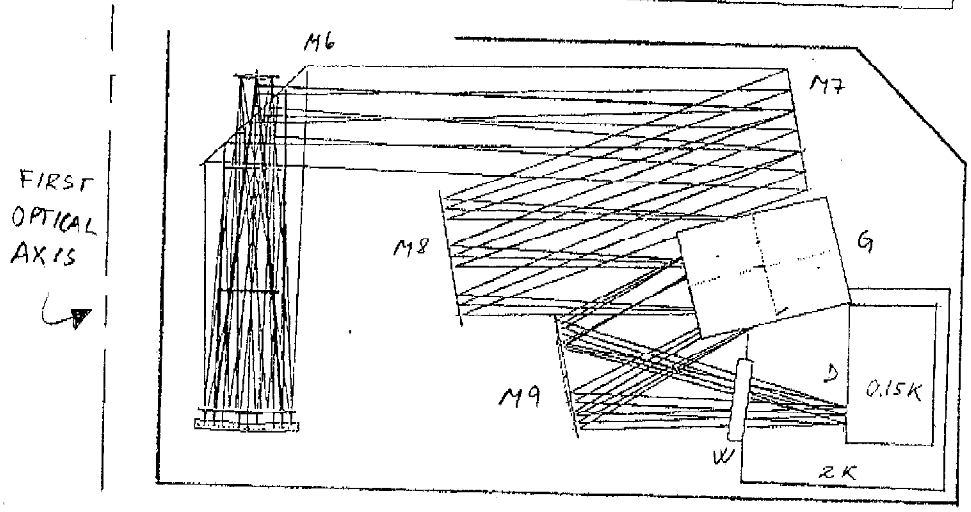
lamMax	350.00	um
thMax	61.00	deg
nMin	6.00	no unit
Diam	83.04	mm
d	1.20	mm
Wgr	171.27	mm

At lambda = 250 um:

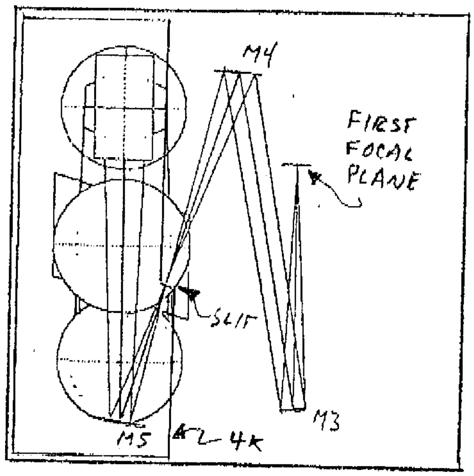
n_250	8.00
th_250	56.41
R_250	1000.02

Order	*Wavelength range*		*Angular range*		*Resolving powers*	
n	lamMax	lamMin	thMax	thMin	Rmax	Rmin
6.00	350.00	300.00	61.00	48.56	855.99	627.06
7.00	300.00	262.50	61.00	49.93	998.66	752.17
8.00	262.50	233.33	61.00	51.03	1141.33	879.75
9.00	233.33	210.00	61.00	51.92	1283.99	1009.31
10.00	210.00	190.91	61.00	52.67	1426.66	1140.47

Table 1.



(a)



(b)

Figure 3.

All mirrors are flat or spherical except M9 (camera) which is toroidal. The resulting geometrical spots are within Ø3mm. There is certainly room for improvement by deforming other mirrors.

Due to the off-plane arrangement of the Littrow grating, the slit image is tilted by about 30° in the focal plane. The 5x5 detector array should therefore be laid out as shown in Fig. 4.

Stray light rejection has not been treated in detail, but it seems that the major problem is to eliminate the parts of the spectrum diffracted off the grating which is not imaged onto the detector array. One solution may be to place Venetian blinds in the side wall of the instrument as indicated in Fig. 1, allowing unwanted flux to exit from the instrument altogether, possibly into free space...

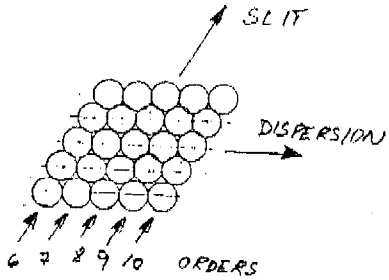


Figure 4.

4. COLD (2K) BOX

The 2K box has two entrance windows allowing the two beams to enter. The PHOT beam enters in a direction parallel to the FIRST optical axis, the SPEC beam enters perpendicular to this axis. The detectors are mounted on the face of the 0.15K box, enclosed within the 2K box. The detector plane is perpendicular to the SPEC beam. The PHOT beam is initially parallel to the detector plane. Two successive dichroics split the beam into three beams which are directed onto the detector arrays via folding flats. Fig. 5 shows a view of the 2K box from the direction marked A in Fig. 1.

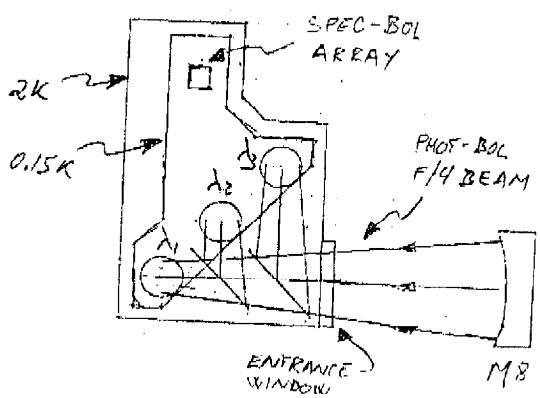


Figure 5. View of the cold box looking down at the detectors. The three PHOT arrays are hidden below the folding flats.