

## **INGRID Pupilstop report**

By Maarten Blanken

### ***Purpose of this report:***

To give an understanding of the pupilstops in INGRID and to suggest a solution of solving the current problems

### ***Introduction***

INGRID is the ING Red Image Detector that looks at wavelengths of 0.8 to 2.5 micrometers. This end of the spectrum is also called the near-infrared end. Because INGRID looks to the near infrared it is necessary to reduce the thermal radiation entering the instrument. The pupil stop in INGRID is an aperture, which block off any thermal radiation of the telescope structure. This can be the secondary mirror or the structure around the primary mirror.

We find the pupil stop wheel before the filter wheel because you want to block the thermal radiation in the beginning of the light path.

Good positioning of the pupil stop is necessary to give an optimum blocking of thermal radiation.

### ***Problems with the pupilstops:***

The problems with the current pupilstops are the following:

- We are not sure if the K and J/H stops are at the correct distance form the lens barrel.
- The background with the NAOMI K stop is unexpectedly high.
- We are not sure that the positions of the NAOMI stops in the filter wheel are correct.
- The naming of the stops is not really clear; NL and NS for Naomi Long / Short wavelength or Naomi Large / Small pupilstop for the K and J/H stops.

### ***Explanations and suggestions:***

First let me start with some of the specifications of the pupilstops, which Paul Jolley took from the engineering drawings:

Position Outside Diameter	K	J/H
NAOMI	Pos = 6.7 mm OD = $3.895 \pm 0.02$ mm	Pos = 6.7 mm OD = $4.305 \pm 0.02$ mm
CASS F11	Pos = 7.7 mm OD = $24.88 \pm 0.02$ mm	Pos = 6.2 mm OD = $25.25 \pm 0.09$ mm

Taking the Cass F11 K stop as a reference and taking the detector side as positive we find the following position differences:

$\Delta$ Position	K	J/H
NAOMI	-1 mm	-1 mm
Cass F11	0 mm	- 1.5 mm

To check if these differences in position are correct I simulated INGRID in Zemax.

### **Focal position**

The focal position of the pupilstops is as critical as the diameter. The position of a stop will determine how the beam and especially an off axes beam is blocked (Appendix C).

I have simulated INGRID with the J, H and K wavelengths (J = 1.3  $\mu$ m H = 1.6  $\mu$ m and K = 2.2  $\mu$ m) appendix A, B. With the Zemax file (Appendix A, B) I found the following results for focal position:

Position	K	H	J
NAOMI	36.20 mm	36.18 mm	36.20 mm
CASS F11	36.50 mm	37.98	38.69 mm

The position is taken from the stop to the first lens barrel surface.

Taking the Cass F11 K stop as a reference again and the detector on the positive side we find:

$\Delta$ Position	K	H	J
NAOMI	+0.3 mm	+0.32 mm	+0.3 mm
CASS F11	0 mm	-1.48 mm	-2.19 mm

For the Cass F11 stops, the H position difference is about the difference we have now.

The J position difference we have now should be bigger for a good result.

For the NAOMI stop, the K position is out of positioned by 1.3 mm as well as the J and H positions.

**Stop diameter:**

A reminder which diameters we have:

Outside Diameter	K	J/H
NAOMI	OD = $3.895 \pm 0.02$ mm	OD = $4.305 \pm 0.02$ mm
CASS F11	OD = $24.88 \pm 0.02$ mm	OD = $25.25 \pm 0.09$ mm

In Zemax I found the minimum diameter should be the following dimensions:

Minimum Outside Diameter	K	H	J
NAOMI	4.01 mm	4.10 mm	4.09 mm
Cass F11	25.23 mm	25.55 mm	25.74 mm

For the stops to work properly we need a 1.5% smaller diameter. In this case we need the aperture to be smaller to block the thermal radiation of the telescope structure.

Minimum Outside Diameter – 1.5 %	K	H	J
NAOMI	3.97mm	4.06 mm	4.05 mm
Cass F11	24.98 mm	25.29 mm	25.48 mm

Looking at the NAOMI J/H stop we see that this is too big for a good blocking. When observing, this stop will give a lot of background noise.

**Conclusion:**

Concluding to the result of the simulation the position difference and the aperture size are not correct for the NAOMI J/H stop. This stop cannot be used for a good observing. The NAOMI K stop is perfect for the K and the J/H wavelengths and I don't see why there are two NAOMI stops.

The Cass F11 stops have been working correct and also according to the simulation we see that they are well designed. Although the position for J is not exactly what the simulation tells us. We should get a bit of vignetting.

**Suggestions**

For the Cass F11 stops:

- Move the Cass F11 J/H stop to a middle position within the wavelengths (J and H). This means put it at a distance of 1.835 mm from the Cass F11 K stop. This should result in an overall good position of this pupilstop.
- Make a new stop for the Cass F11 J band with the same diameter as the Cass F11 J/H stop. Put this stop on the correct position. The NAOMI J/H stop is not necessary to me. So we can put this new Cass F11 stop on the old NAOMI J/H position.

For the NAOMI stops:

- Do not use the NAOMI J/H stop because this is too big to block any thermal radiation
- Move the NAOMI K stop to the correct position so it will perform better.

### **Other problems:**

- The background with the K stop is unexpectedly high.

Looking at how big the background noise is we can say one of the following is true:

1. The two stops for NAOMI are swapped in position. Therefore when observing with the NAOMI K stops, which is actually the NAOMI J/H stop, you would get a lot of background noise because this stop is too big.
2. If the background noise is small. Then it might be that this is created by the miss positioned stop.

- We are not sure that the positions of the NAOMI stops in the filter wheel are correct.

Like the answer before it might be that the two NAOMI stops are physically in the wrong position. It could also be that the software is moving the pupilstop wheel to the wrong position.

- The naming of the stops are not really clear NL and NS for Naomi Long / Short wavelength or Naomi Large / Small pupilstop for the K and J/H stops.

Why don't we name the stops like above NAOMI K, NAOMI J/H, CASS K and CASS J/H?

### **Appendices:**

A) INGRIDF11NAO Conf 2 (Cass F11 configuration)

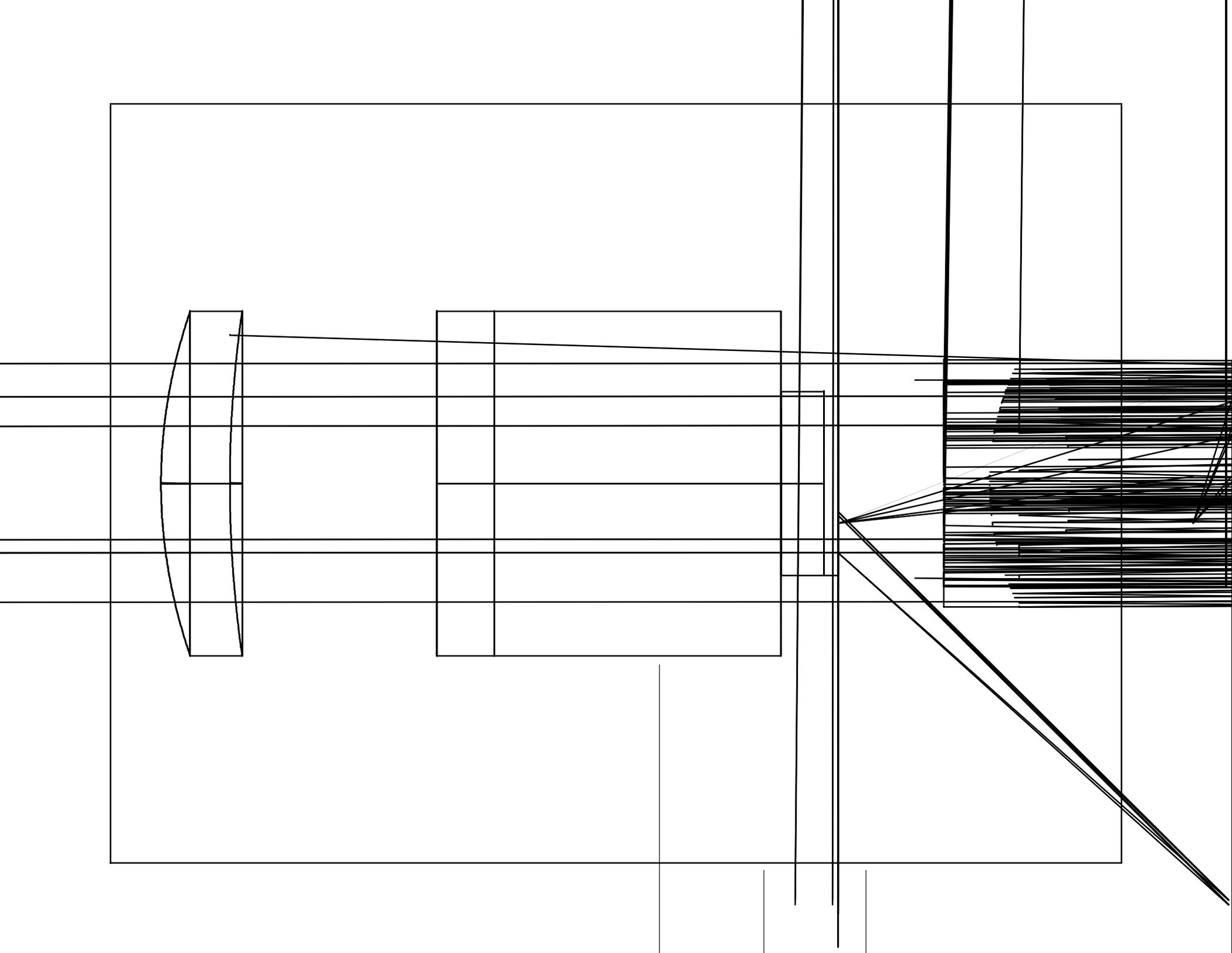
- Optical layout of Cass F11 foreoptics
- Footprint of stop surface for J, H and K wavelengths

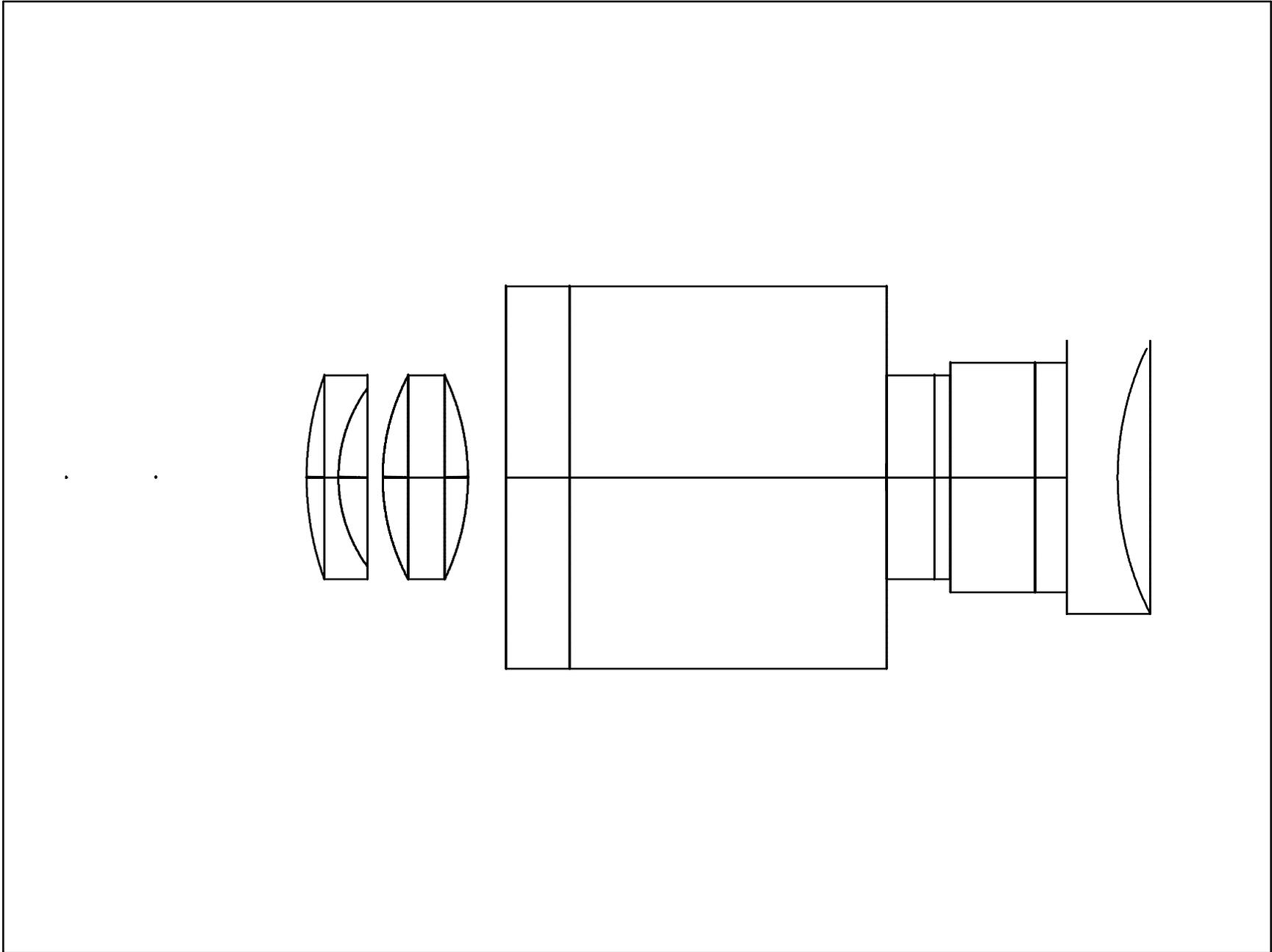
B) INGRIDF11NAO Conf 3 (NAOMI configuration)

- Optical layout of NAOMI foreoptics
- Footprint of stop surface for J, H and K wavelengths

C) PSdrawing and PSmatrix

Explanation for the pupilstop focal position





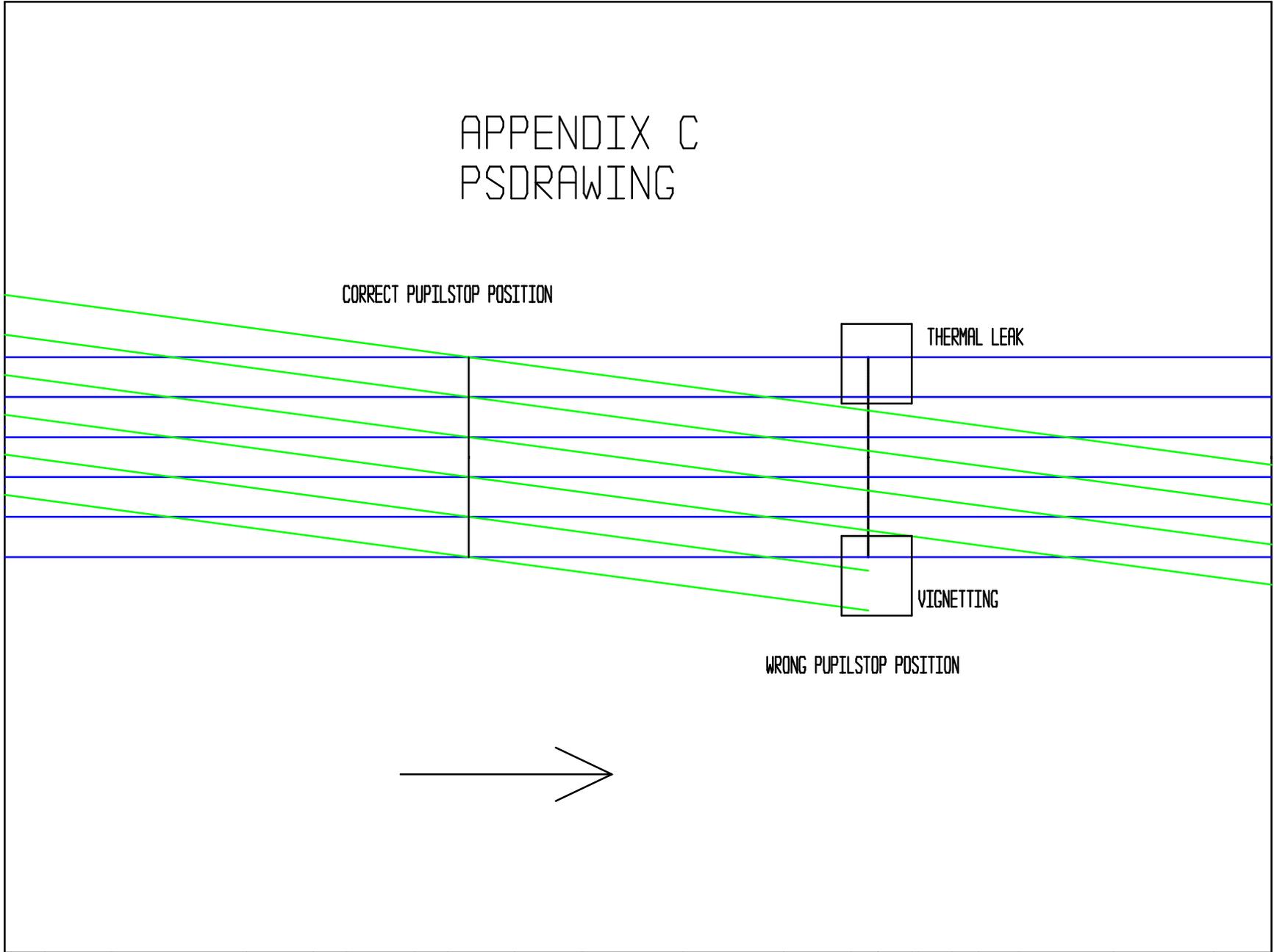
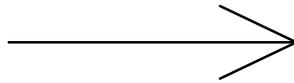
# APPENDIX C PSDRAWING

CORRECT PUPILSTOP POSITION

THERMAL LEAK

VIGNETTING

WRONG PUPILSTOP POSITION



CONFIG 1

0.00 DEG

200.00



SURFACE: IMA