# HAPI Narrowband filter specification

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## DOCUMENT CHANGE DETAILS

| Issue | Date | Page | Description Of Change | Comment |
|---|---|---|---|---|
| 1 | 12/5/2016 | All | Initial Issue | |
| 2 | 14/7/2016 | | Update to reflect resizing of camera aperture | |
| 3 | 05/8/2016 | | Updated to include substrate drawing and test requirement | |

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## 1 INTRODUCTION

This document provides the specifications for the narrowband filters to be used in the HAPI instrument.

The instrument consists of 10 cameras which are designed to image a swath of 200km from a satellite at an altitude of 700km, the entrance aperture is circular with a diameter of 12mm and the detector is 10.85mm across. Each of the cameras works at a different wavelength in the range 407-485nm.

This is achieved with the design in Figure 1

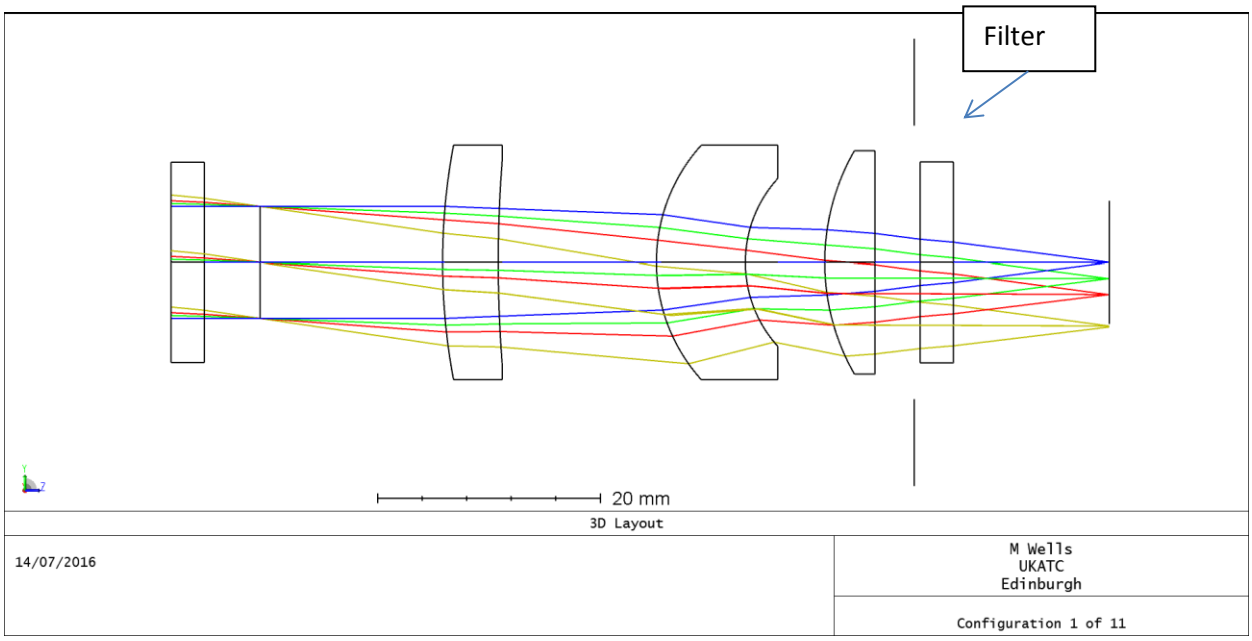


**Figure 1 HAPI optical layout showing location of filter**

The each of the lenses is the same across all 10 channels, residual chromatic aberrations are minimised by changing the spacings between them. The image space of the cameras is nearly telecentric and the filter is placed between the last lens and the detector. The filter substrate is 18mm in diameter and 3mm thick.

## 2 FILTER SPECIFICATIONS

For overall dimensions refer to substrate drawing ref HAPI_003 Issue A. The filter specifications are detailed in Table 1:

| | Item | Value | |
|---|---|---|---|
| 1. | Number of filters | 10 | |
| 2. | Effective centre wavelengths After shift due to non-collimated beam | Ch1 407.0nm, Ch2 413.4nm, Ch3 416.2nm, Ch4 426.3nm, Ch5 435.1nm, Ch6 448.0nm, Ch7 463.3nm, Ch8 477.1nm, Ch9 479.9nm, Ch10 485.0 | nm |
| 3. | Image NA at location of the filters | 0.126 | |
| 4. | Tolerance on centre wavelengths | ±0.25nm | nm |
| 5. | Filter bandwidth (FWHM) After broadening due to non-collimated beam | 1.8 | nm |
| 6. | Tolerance on bandwidth | -0.0nm +0.20nm | nm |
| 7. | Transmission | >80% at peak | For collimated beam |
| 8. | Blocking requirements | $<2\ 10^{-4}$ in the wavelength range 350-1000nm | |
| 9. | Filter substrate diameter | 18 +/- 0.05 | mm |
| 10. | Clear aperture | 16 | mm |
| 11. | Filter thickness<br>Filter substrate | 3.0 +/-0.05<br>Not critical, please use your standard material | mm |
| 12. | Transmitted wavefront | <100nm RMS | nm |
| 13. | Operating temperature | 15 | C |
| 14. | Temperature coeffifient | $d\lambda/dT$ | To be provided by manufacturer |

**Table 1 Design Requirements**

### 2.1 WAVELENGTH SHIFT AND PROFILE BROADENING

As can be seen from the optical layout the filter is placed in a converging beam in front of the detector, the numerical aperture (NA) of the beam at the detector is in Item 3 of Table 1 . This results in a broadening of the filter profile and a shift of the central wavelength to shorter wavelengths.

The magnitude of the shift and broadening of the filter profile depend on the following parameters

1) NA of the beam at the position of the filter.
2) The telecentricity of the beam across the field.
3) The nominal central wavelength of the filter when used in a collimated on-axis beam.
4) The effective refractive index of the materials used in filter layers.
5) The shape of the filter passband

In designing the filter the first 3 items in this list come from the optical model and the central wavelength requirements for each of the 10 cameras as listed in Item 2 of Table 1. The effective refractive index and the shape of the passband in collimated light will be a manufacturer supplied values.

The manufacturer shall design and make the filters such that, for a converging beam with an NA=0.126 and whose chief ray is perpendicular to the filter, the passbands are as listed in item 2 of Table 1 and the FWHM =1.8nm within the tolerances in Items 4 and 6 of Table 2 respectively.

### 2.2 FILTER SUBSTRATE

The substrate (ref drawing HAPI_003 Issue A) has a diameter of 18mm and a clear aperture of 16mm and a thickness of 3mm. The material for the substrate is not critical and can N-BK7 or fused silica or other standard glass that you use for filters. The WFE for the transmitted beam should be <100nm RMS.

### 2.3 FILTER TEST

As an option a cost for providing a spectral scan of each filter should be included as outlined below:

a) a spectral scan using a collimated beam + calculation showing shift for a NA=0.126 beam

or

b) a spectral scan using a NA=0.126 beam