000158

SPIRE	Ref: SPIRE/RAL/N/0036.10
A Re-scoped FTS for SPIRE	**Issue:**
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INTRODUCTION

In the likely event that the ESA evaluation committee will require us to reduce the resolving of the spectrometer to 100; make a large cut in the degree of data compression required and look for increased sensitivity, I set out here an outline for a re-scoped FTS and its baseline operating parameters.

OUTLINE DESIGN

The original design for the spectroscopy channel of the FIRST bolometer instrument was an imaging FTS with a field of view of at least 2x2' and a resolution 1000. If instead a resolution of 100 is used with a field of view of 1x1 arcmin, then the required maximum OPD reduces to 1.4 cm and the beam size through the instrument can be reduced from 30 to 20 mm. In fact the analysis laid out in Kjetil's note (BOL/LOOM/N/0031.10) shows that we only require a beam diameter of 6 mm but this feels too small for comfort at these wavelengths! We can now consider moving just one of the mirrors (x2 folding) and a linear motion of a maximum of 0.7 cm. With a limited movement and reduced FOV we also perhaps start to consider a dual beam instrument to recover the lost polarisation. Independent of that question I have recalculated the operating parameters for an FTS with R=100 and either 2x2 or 1x1 arcmin FOV.

OPERATING PARAMETERS AND SYSTEM REQUIREMENTS FOR THE REDUCED FTS

Wavelength coverage	λ = 200 - 667 μm or 15 - 50 cm^{-1} Optimised for operation in 200-400 μm band
Bands	Band 1 - 200-299 centred at 240 (33 - 50 cm^{-1}) Band 2 - 299-667 centred at 412 (15 - 33 cm^{-1})
Required resolution	$\lambda/\Delta\lambda$ = 100 at 250 μm (40 cm^{-1}) $\Rightarrow \Delta\sigma$ = 0.4 cm^{-1}
Optical path difference	$\sigma = 1/(2L) \Rightarrow L = 1.25$ cm assume 1.4 cm for scan length to allow for measure of zero path difference
Linear travel	(1.4 cm)/2 = 0.7 cm
Nyqvist sampling rate:	$\Delta x_{max} = 1/(2\sigma_{max})$ $\Rightarrow \Delta x_{max} = 1/(2 \times 33) = 0.015$ cm for band 2 $\Rightarrow \Delta x_{max} = 1/(2 \times 50) = 0.010$ cm for band 1
Over-sampling factor	5 $\Rightarrow \Delta x$ = 30 μm band 2 $\Rightarrow \Delta x$ = 20 μm band 1

No. of samples per interferogram	N_{samp} = (1.4 cm)/(30 μm) = 467 band 2 N_{samp} = (1.4 cm)/(20 μm) = 700 band 1
Audio frequencies	$f = v_{opd}\sigma$ where v_{opd} is the rate of change of the optical path difference.
Max. allowed audio freq.	20 Hz (from assumed detector response) $\Rightarrow v_{opd} = 20/50 = 0.4$ cm s^{-1} $\Rightarrow v_{mirrors} = v_{opd}/2 = 0.2$ cm s^{-1}
Audio freq. band	15 - 33 $cm^{-1} \rightarrow$ 6 - 13 Hz 33 - 50 $cm^{-1} \rightarrow$ 13 - 20 Hz
Time per scan	t_{scan} = (1.4 cm)/(0.4 cm s^{-1}) = 3.5 s
Sampling rate	(467 samples)/(3.5 s) = 133 samples s^{-1} - band 2 (700 samples)/(3.5 s) = 200 samples s^{-1} - band 1
Number of detectors	400 (16x16 + 12x12) 2x2 arcmin FOV 100 (8x8 + 6x6) 1x1 arcmin FOV
Position measurement:	OPD accuracy required = 1/50 of step minimum = 20/50 = 0.4 μm Actual position measurement = 0.4/2 = 0.2 μm Sampling required = same as single detector in band 1
Internal read-out rate:	2x2 Field Band 2: 133 Hz x 144 dets = 19.152 kHz Band 1: 200 Hz x 256 dets = 51.200 kHz Position measurement = 0.2 kHz Total = 70.3522 kHz 1x1 Field Band 2: 133 Hz x 36 dets = 4.788 kHz Band 1: 200 Hz x 64 dets = 12.800 kHz Position measurement = 0.2 kHz Total = 70.3522 kHz
No. bits required to sample signal	Max signal = twice that from telescope background $\Rightarrow 6\mathrm{x}10^{-12}$ W

	Background limited NEP = 7×10^{-17} W $Hz^{-1/2}$ Detection bandwidth = 20 Hz Dynamic range required = $6 \times 10^{-12}/(7 \times 10^{-17}\sqrt{20})$ = 19166 14 bits = 16384 (near enough) - or a couple of gain stages and 12 bits would also do if we can't get a fast 14 bit ADC. Call it 16 bits to allow for encoding timing and gain.
Bit rate per frame	2x2 field 306 kbits/s - band 2 819 kbits/s - band 1 1126 kbits/s total 1x1 field 76.6 kbits/s - band 2 204.8 kbits/s - band 1 281.4 kbits/s total
Total bits per scan	2x2 field - 39410 kbit 1x1 field - 985 kbit
Integration time required to fit this into telemetry (lossless compression of factor 5 'cos of oversampling)	2x2 field - 39410/(5x40) = 197 secs 3-4 minutes (5-6 scans) 1x1 field - 985/(5x40) = 4.9 secs 2 scans (if that)