Date: 21/03/2001
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Ref.: memo0103.

Subject: **Areas of ING interest in the development of a fibre fed, cryogenic camera for astronomical observations.**

0. Introduction.

Following the experience built up with *S-Cam 1 - S-Cam 2* and aiming to larger resolving power and extended wavelength band-pass, we have started looking at the possibility to build a new generation camera with the focal plane illuminated via optic fibres. A fibre-fed approach (UV-grade, pure silica fibre, with a core diameter of 200 ? *m*) has been routinely used in our lab for the characterisation of single pixel and array detectors, demonstrating an excellent suppression of the IR background and a typical bandwidth ranging between 220 and almost 2000 *nm*. The suppression of IR is related to the length of the fibre and to the fact that it is heat sunk at several locations within the cryostat. The IR radiation emitted by the warm portion of the fibre is effectively absorbed by the cold part of it, which in turn does not contribute to any significant thermal emission. In the case of the experimental set-up mentioned above, a large chip area is illuminated, thus avoiding any serious alignment issue between the fibre and the individual detector elements on the detector chip.

1. Technical issues.

In the case of a fibre-fed cryogenic camera, more fibres (of order 10) would reach different zones of the focal plane area, thus requiring a precise alignment of each fibre with respect to the active elements of the array. In addition, the area illuminated by each fibre should be minimised in order to avoid any cross-talk effect between photons transmitted by different fibres on the respective detecting elements. A number of technical difficulties are associated with these requirements, with the interface between the fibre and detector surface clearly representing the most critical issue. The main requirements to be kept in consideration are the following:

?? The small dimensions of the illuminated area forces to use small core diameter fibres ($d_c < 50$?m) and to place them very close to the detector surface.
?? An efficient exploitation of the array area also requires the different fibres to be close to each other. This implies the utilisation of fibres with a small external diameter ($d_o < 100$?m).
?? The terminal portion of the fibres has to be located inside the cryostat and properly thermalised, at several intermediate temperatures, for a length of order 0.5-1.0 m).
?? Silica fibres with a polyamide coating are best indicated for cryogenic applications, with a bandwidth of order 250 – 2000 nm.
?? Vacuum feed-throughs are required on the cryostat hull. It could be conceivable to have a portion of fibre (1 m) continuing outside the cryostat, but we would prefer to have a number of vacuum-tight fibre connectors located directly on the cryostat hull.
?? While transmission losses must be minimised, some level of fibre connectivity is desired to ensure flexibility during operations, installation and storage of the camera.

A number of additional issues apply to the interface between the fibres and the detector surface, but they are best tackled at ESA, in conjunction with the STJ detector programme.

2. Possible areas of interest at ING.

This memo aims to provide a list of technical issues related to the development of fibre-fed instrument and which are linked to the development activities undertaken at the Isaac Newton Group (ING) and to the interface between an ESA cryogenic camera and the AutoFib 2 assembly. The list includes areas which are of interest to ESA, and it should be considered as a first attempt to describe possible collaboration areas between ESA and ING. On this basis, it is proposed that ING would then look at the technical issues listed in the table below and provide information to ESA in the form of technical report / documentation.

Summary table.

Issue #	Topic description.	Relevant output.
1	The astronomical case. (Instrument baseline: E/?E 2x *S-Cam* 2, 10x fibre, 250-2000 nm)	Assessment of the science which could be produced by a fibre-fed instrument in combination with AF2, or installed at an alternative focus (e.g. Nasmyth).
2	Trade-off analysis: science output Vs. number of fibres.	Expanding on the assessment performed above, we discuss the dependence between science output and number of fibres.
3	AF2: characteristics, installation and operational constraints.	A description of the key features, of the typical installation and operation procedures related to the utilisation of AF2.
4	Fibre-to-fibre connectors.	Utilisation of low-loss, high-reproducibility fibre connectors. Typical performance, products available, past experience built up at ING. Connection of fibres with a different core diameter. Alternative techniques (e.g. *SELFOC*).
5	Small core diameter fibres.	Characteristics and availability of optic fibres with a core diameter ? 50 mm and with a small NA. Multi-mode Vs. Single-mode, step-index Vs. graded index, termination techniques.
6	Installation / logistics.	Preliminary assessment of the location and of the installation procedure a future generation cryogenic camera (related to focus choice, see Issue 1).

3. Schedule considerations.

The present goal at ESA is to complete a technical feasibility assessment by the end of this year. Activities in ESTEC focus on the interface between fibres and focal plane array, with a number of alternative solutions presently being studied. On this basis we would need input on the issues listed above by the end of July 2001. This deadline would leave sufficient slack for iterations on specific issues and allow to include the input provided into the design solutions under assessment, in view of issuing a feasibility assessment report in the late fall of 2001.

4. Conclusions.

The development of a fibre-fed cryogenic camera offers major advantages in comparison with a traditional focal plane approach: a better rejection of the IR flux, an increased resolving power, the possibility to enlarge the bandwidth and, last but not least, much lower thermal loads on the cryogenic stages. When properly implemented, a fibre-fed approach can also allow a more efficient exploitation of the detector area, allowing multi-object performance on small size arrays. Such a fibre-fed instrument could make use of the *AutoFib 2* facilities (prime focus) or be installed at a Nasmyth focus of the WHT (ING).
This memo presents a list of technical areas in which the support of the ING would allow to proceed further with the development work carried out at ESTEC, allowing a better assessment of the proposed techniques and favouring the future integration of such an instrument.
It is hoped that, on the basis of this document and thanks to a constructive collaboration between ESA and ING, it will be possible to complete a feasibility study by the end of 2001.