MANIFEST - a many-instrument fiberpositioning system for GMT

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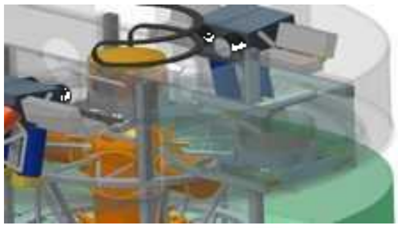

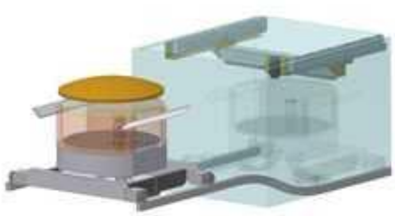

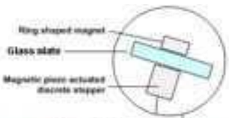

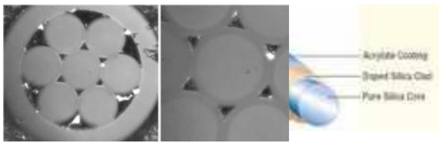

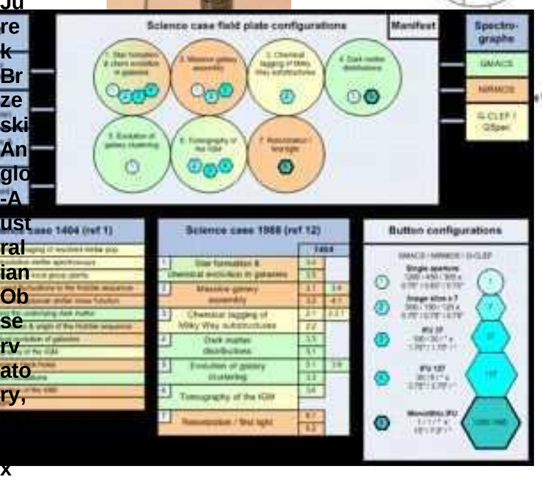

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Corrector lens G-CLEF cable wrap GMACS
MANIFEST retracted volume
MANIFEST
NIRMOS

ABSTRACT MANIFEST is a proposed fiber-positioning facility for the GMT, capable of feeding other instruments as needed. It is a simple, flexible and modular design, based on Starbugs, *Hexabundles*, fiber *tapers*, together with extensive use of standard telecommunications fiber technology. Up to 2000 individually deployable Starbugs are envisaged, with a wide variety of aperture types (single-aperture, image-slicing, IFU). MANIFEST allows (a) full use of the GMT's 20' field-ofview, (b) a multiplexed IFU capability, (c) closely pack spectra on the detectors, (d) greatly increased spectral resolution via image-slicing, (e) simultaneous observing with multiple instruments, (f) OH-suppression in the near-infrared. Together, these gains make GMT the most powerful of the ELT's for wide-field spectroscopy.

INTRODUCTION MANIFEST (the Many Instrument Fiber System) positions fiber apertures over the full 20' GMT focal plane, feeding all of the proposed natural-seeing/GLAO (ground-layer adaptive optics) spectrographs (GMACS, NIRMOS, and G-CLEF), with a wide variety of aperture geometries.

Field Plate Gantry Corrector lens
Starbugs fiber bundles

The design concept for MANIFEST presented an intriguing challenge. The GMT spectrographs can accommodate more targets than can readily be achieved with pick-and-place positioners (like 2dF), which are limited by retractor volumes, fiber crossings of the focal plane, and reconfiguration times. A positioning system based on fixed patrol areas (such as FMOS/Echidna or LAMOST) would not give the desired capabilities to observe clustered targets, or to have a choice of aperture geometries for each target. Our proposed design removes the need for retractors, eliminates fiber crossings of the focal plane, and has short reconfiguration times, while allowing very large numbers of targets, with great flexibility in terms of aperture geometries and target configurations.

Rail

HANGING STARB

UGS Starbugs are autonomous piezo-electric mini-robots, which simultaneously position themselves on a field plate [1]. For MANIFEST, the AAO has recently prototyped a new version, which differs from its predecessors by (a) having a new 'lift-and-step' action, giving an extremely repeatable motion, and (b) hanging below a thin glass dome, with a ring magnet above the plate to provide adhesion. This means no retractors, and no fibers crossing the focal plane. The new prototype is shown below, and is fully discussed in a separate paper [2]. The new design allows very large numbers of Starbugs to be deployed over the 1200mm diameter GMT focal plane, as schematically shown below. The glass dome does not need to be figured to high precision, and can be slumped from commercially available glass sheets.

Field plate assembl

APERTURE TYPES AND NUMBERS

MANIFEST provides a wide variety of aperture geometries. These include single apertures of around 0.75", and several IFU/image-slicing modes with individual apertures size about 0.25". Other modes, e.g. extreme image-slicing, or pupil imaging, are possible and will be considered as part of the feasibility study.

use *Hexabundles* [3]. A Hexabundle is a fused set of 7 or more fibers, with very thin cladding between them, which open out after a few millimetres into separate fibers. Filling factors of 85-90% can be achieved.

The f/8 native speed of GMT is too slow to use directly with fibers. We propose to use fiber tapers [4] to change the speed of the beam, both on input and output. Fiber tapers have a gradual transition from a larger to smaller diameter, causing an adiabatic change in beam speed, without loss of etendue. Both tapers and Hexabundles are otherwise lossless and achromatic, so they offer great simplicity and efficiency to the design.

FROM STARBUG TO SPECTROGRAPH All fibers will have 250µ m outer diameters (including cladding and buffer), to allow commercial ribboning and connectorisation techniques to be used. Each sets of Starbugs and fibers sufficient to fill a single spectrograph form a single module, which terminates in a connectorised plug. The spectrographs are fed via fiber slits, each with its own connectorised socket. The modules are then interchangeable between the spectrographs, and vice versa. Modules can also be added, upgraded or replaced as desired. GMACS will be fed via fold mirrors. For NIRMOS, it is proposed that the fibers will run into the fore-dewar, which will be evacuated and cooled to -50°C, to allow use over the full *H*-band (to 1.81µ m). For G-CLEF, the fibers will run back up to the G-CLEF front end on the instrument platform via a cable wrap.

Full *J*+*H*-band OH-suppression [5], for sufficient apertures to fill NIRMOS, is a goal for MANIFEST.

PERFORMANCE **Resolution**: Image-slicing improves spectral resolution by a factor ~3 over a seeing-limited slit, for all proposed spectrographs. Larger gains, up to a factor ~7, would be straightforward to achieve for GMACS and G-CLEF.

Field-of-view: All spectrographs can make use of the full 20' GMT FOV. MANIFEST can be used with the GLAO system, over the full GLAO FOV.

Efficiency: The proposed design minimises fiber length and 4 air/glass surfaces. There is a compensating gain from feeding VPH spectrographs at their superblaze angle, and this makes MANIFEST effectively 'throughput neutral' for most survey work.

MANIFEST SCIENCE GAINS

MANIFEST gives multiple scientific gains to the instruments it feeds. These include:

- Access to the full 20' field-of-view
- Efficient spectra packing onto detectors
- Increased resolution, by factors 3-8
- Multiplexed, deployable IFU's in various sizes
- Simultaneous use of multiple instruments

Survey speeds are increased by an order of magnitude for many of GMT's main science drivers (Ly-**a**tomography, galaxy assembly, Galactic archeology). OH suppression would give another order of magnitude sensitivity improvement in *J*+*H* bands. Overall, MANIFEST gives GMT the largest A**O** of any of the ELT's, and hence makes it the most powerful ELT for survey work.

THE MANIFEST FEASIBILTY STUDY In January 2010, the GMTO Board announced that y GMACS fold mirror fiber conduit guide GMACS slits Manifest space envelope

HEXABUNDLES AND TAPERS For image-slicing aperture geometries, we propose to

Enough apertures will be provided to fill each spectrograph in each of the geometries of interest. A total of up to 2000 separately deployable Starbugs are envisaged, as laid out below:

Aperture Geometry	Overall Diameter	Fiber Diameter	# Fibers	GMACS capacity	G-CLEF capacity	NIRMOS capacity	**MANIFEST complement**
Single aperture	~0.75"	~0.75"	1	1200	50	45 0	**1200 Vis/NIR**
Image - sliced	~0.75 "	~0.2 5"	7	5 00	20	150	**5 00 Vis + 150 NIR**
IFU 37	~2"	~ 0.2 5"	37	10 0	4	3 0	**100 Vis + 30 NIR**
IFU127	~4"	~ 0.2 5"	127	25	1	9	**25 Vis + 9 NIR**
IFU 900	~ 10"	~0.2 5"	900	4	−	1	**4 Vis + 1 NIR**

'MANIFEST is likely to be a very high priority second generation instrument' and supported a feasibility study, starting in July 2010, to develop MANIFEST as a telescope facility for GMT.

The feasibility study will establish the interfaces between MANIFEST and the other instruments and the telescope itself. It will also seek to retire the risks associated with the various novel technologies (Starbugs, Hexabundles, tapers, cooled fibers, glass fieldplate) through prototyping and testing.

The amount of OH-suppres be implemented depends p which is

as yet uncertain. We will design for both full-OHsuppression, and also a demonstrator capability.

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