LBT PROJECT

TECHNICAL SPECIFICATION

PRIME FOCUS CAMERA – BLUE CHANNEL
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1 - INTRODUCTION

The LBT will be equipped with a prime focus camera over each one of the two primary mirror. Both instruments will work in the visible range, one optimized for shorter wavelength (the Blue channel) and the other for longer ones (the Red channel).

This technical specification concerns the supply of the Blue channel prime focus only. Such instrument will be installed on the LBT at the telescope first light.

The major feature of the LBT prime focus camera is the large FOV and the short focal ratio, a layout that imposes very tight design and construction specification on the prime focus instrument itself.
In particular, one issue is represented by the large diameter (about 800 mm) of the instrument's entrance lens: the support system of such a piece of optics is crucial to achieve the demanded image quality.
On the other hand, the alignment of all the six lenses that make the prime focus instrument requires a very stiff design for the structure where the optics are mounted. Finally, the instrument contains important mechanisms as well, namely the field rotator, two filter wheels and a focus corrector unit, all of which demand smooth and play-free operation capability.
2 - SUPPLY DESCRIPTION

2.1 - Shop Drawings, planning and technical documentation
The Supplier shall produce all the workshop drawings relevant to the supply in object. Such drawings shall be derived from the assembly drawings provided together with the present technical specification. The workshop drawings (“as built” issue) together with the manufacturing and test documentation are considered deliverable items of the present RFQ.

2.2 – Supply limits
This RFQ described in the present document concerns the supply of one Prime Focus unit, namely the Blue channel one.

The limit of the supply is represented by the interface to the swing arm that mounts the prime focus unit and, inside the instrument itself, by the interface to the flange of the cryostat (the feed shutter is excluded from the present specification).

The lenses are excluded from the supply.
The supply does include an Aluminum made dummy of the lens #1.
The Supplier shall also provide and deliver a suitable frame (test bench) to hold the hub during integration.
The unit must be delivered with permanent harness installed: a single interface panel must be provided where all the connectors (power and signal) from the different mechanisms are replicated (feed shutter and camera electronics excluded).

The following sections report a short descriptions of each of the major subsystems to highlight the most relevant fabrication issues.

2.3 - Subsystems

2.3.1 – Hub
This is the structural component of the instrument. It allows connecting the lens mounting frames into a single unit, on which the field rotator is mounted.
The hub is made of steel: the structure must be stress relieved with normal thermal treatments.

The main manufacturing issue of this structure is given by the parallelism, concentricity and planarity among all the interfaces for the lenses mount and between these and the rotator bearing. In this sense it can be considered the possibility to make the final machining of these surfaces with the bearing installed on the piece itself. Another important feature of the structure is the perpendicularity between the interfaces to the spider and the rotator bearing plane.
The hub has eight openings to leave the accessibility needed to install the different components inside it. The supply shall include covers that allow sealing (from dust and stray light) such openings once the system is mounted and aligned.
Inside the hub few minor covers must be installed to shield the rotator motors and the focus corrector drive system from the optical path.

Finally, a ring spacer must be foreseen between each lens mounting frame and its seat onto the hub. The thickness of such spacers will be determined based on the actual shape of the lenses, to be measured once their polishing will be completed.

2.3.2 – Lens frames
All the optical elements (lenses) are out of the scope of the present supply. The optics are made of fused silica.

Each lens is mounted into a frame, which is then connected to the steel hub. The lenses frames are included in the present supply.
On the largest lenses, namely #1 and #2, such a frame is made of INVAR.
These two frames are coupled to the hub by means of a steel flexure (elastic coupling) to relieve the differential thermal deformation between the two metals (INVAR and steel). The mounting frames of the lenses #3-5 are made of stainless steel.

The machining of the frames must comply with the tight alignment tolerances demanded to the optical elements: namely, the tilt of each lens will be adjusted by properly mounting the glass into the frame, while the lateral offset will be adjusted by shifting the frames on their seats in the hub.

A set of plastic pads is foreseen to be interposed between each lens and its frame: on lenses #1 and #2 such pads are made of DELRIN while for the other lenses the pads are made of RTV560 (GE Siliconics). The DELRIN pads must be properly machined to match the lens local curvature. The lenses pads are part of the present supply.

2.3.3 – Focus corrector mechanism
The lens #2 is mounted on a mechanism that allows moving the entire lens frame along the instrument optical axis with a stroke of few millimeters.
Three linear ways are placed 120 deg apart to guide the lens frame which is driven by a linear actuator. An absolute multiturn encoder is directly coupled to the roller screw that drives the lens frame.
The supply does include the procurement of all the mechanism commercial components.
2.3.4 – Derotator

The field rotator is made by a bearing that holds the entire instrument unit together with the filter wheels.

The seat of the bearing makes the reference for the whole instrument optical axis.

The derotator is moved by a dual drive system, that is one of the two motors always provides a bias torque against the motion direction, thus allowing the compensation of the play between the gear and the driving pinion. Each motor is equipped with a normally closed brake to allow parking the derotator.

A multiturn absolute encoder is coupled to the derotator gear by mean of an anti back-lash pinion, while one incremental encoder is mounted on each motor to provide local feedback.

Both the motors of the derotator must be actively cooled: glycole is available at spider interface, thus a cooling plant made by copper pipes that are in contact with the two motors must be foreseen.

The derotator includes a cable chain which serves all the instruments utility.

The supply does include the procurement of all the derotator commercial components.

2.3.5 – Filter wheels

Two wheels are mounted on the filed rotator, each one carrying up to four filters. The lower wheel is designed to mount permanent filters, while the second one allows replacing the filters without dismounting the instrument.

Each wheel is driven by a DC motor with an absolute multiturn encoder mounted on motor axis. The motor shaft is coupled to the wheel by an anti back-lash pinion that works on a gear mounted on the external circumference of the wheel.

A normally closed brake mounted directly on the wheel shaft.

The filters are actually mounted in a proper frame which holds a magnetic code marker that is read by a sensor head placed on the derotator.

The supply does include the procurement of all the commercial components of the filter wheels, including the filters frames (the filter themselves are excluded as the rest of the optics).
2.4 - Working conditions-
The LBT environmental conditions that apply to the prime focus camera are hereafter listed:

- Operating temperature     \(-20 \div +25 \, ^\circ\text{C}\)
- Operating pressure      \(500 \div 600 \, \text{Torr}\)
- Operating humidity      \(5 \div 95 \, \%\)
- Storage temperature     \(-30 \div +50 \, ^\circ\text{C}\)
- Storage pressure      \(500 \div 700 \, \text{Torr}\)
- Storage humidity      \(5 \div 80 \, \%\)
- Altitude        \(3250 \, \text{m a.s.l.}\)
- Lifetime of the Telescope   exceed 25 years
3 - TECHNICAL DATA AND DRAWINGS

This section reports the most relevant technical information for all subsystems.

3.1 - Technical data

3.1.1 – Hub
Material: steel, FE420 D quality at least
Stress relieve: heat treatment required
Painting: after the stress relieve heat treatment and sand blasting SA 2.5, all the hub structure must be protected with primer (160 µ thickness) before machining; the paint after machining must be epoxy type (70 µ thickness) for all the structure (optical black required for all the surfaces inside the hub); the machined surfaces that must be protected with weather resistant grease

3.2 – Lens frames
Material: INVAR (thermal exp. = 0.9x10^-6 1/K) for frames #1 and #2
       AISI 304 for frames #3-5
       AISI 304 for flexures on both frames #1 and #2
Stress relieve: heat treatment required if welding is adopted
Painting: optical black, on the whole frame except for the machined parts
Pads material: DELRIN for lenses #1 and #2
               RTV560 (GE Siliconics) for lenses #3-5
Astatic levers pads: RTV

3.3 – Focus corrector mechanism
Material: steel, FE420 D quality at least
Stress relieve: heat treatment required
Painting: after the stress relieve heat treatment and sand blasting SA 2.5, all the focus corrector structure must be protected with primer (160 µ thickness) before machining; the paint after machining must be epoxy type (70 µ thickness) for all the structure (optical black required); the machined surfaces that must be protected with weather resistant grease

Linear ways: IKO LWM 1
Roller screw: FAG-UMBRA RVR210/16.1.R6
Bearings unit: STAR 1591-1-1020 NMZ
Planetary gearbox: GSC model PLC 62 (one stage, R=8:1)
DC motor: WAKO RS-60
Encoder: Heidenhain EQN 425
3.4 – Derotator
Material: steel, FE420 D quality at least
Stress relieve: heat treatment required
Painting: after the stress relieve heat treatment and sand blasting SA 2.5, all the structure must be protected with primer (160 μ thickness) before machining; the paint after machining must be epoxy type (70 μ thickness) for all the structure (optical black required); the machined surfaces that must be protected with weather resistant grease
Bearing: Kaydon KF 120 XP4 K
Gear: Dia = 620 mm; m=4; Z=155
Pinion: Dia = 72 mm; m=4; Z=18
Planetary gearbox: GSC model PLC 80 (R=184:1)
DC motor: WAKO RS-60-BE (self braked + encoder)
Encoder: Heidenhain EQN 425
Cable chain: IGUS I-PIST-12 chain 10-7-38

3.5 – Filter wheel (2x)
Material: Aluminum
Painting: primer plus optical black required (black anodization to be evaluated)
Gear: Dia = 495 mm; m=1.5; Z=330
Pinion: Dia = 36 mm; m=1.5; Z=24
DC motor: WAKO RSM-25
Brake: ELECTROID EFSB-3 Model “B”
Encoder: Heidenhain EQN 425
Cable chain: IGUS I-PIST-12 chain 10-7-38
ID sensor: BALLUF BIS C-306 + (4x) BIS C-105-02
3.2 – List of drawings

3.2.1 – List of assembly optical drawings

Dwg. 602a002 PFocus Optical Assembly

3.2.2 – List of sub-assembly optical drawings

602a005 – Pfocus optical Lens N.1
602a006 – Pfocus optical Lens N.2
602a007 – PFocus optical Lens N.3
602a008 – PFocus optical Lens N.4
602a009 – PFocus optical Lens N.5
602a010 – PFocus optical Lens N.6
602a011 – PFocus optical Tolerances

3.2.3 – List of assembly mechanical drawings

Dwg. 602a012 PFocus Mechanical Assembly

3.2.4 – List of sub-assembly mechanical drawings

602a013 – PFocus mechanical Hub
602a014 – PFocus mechanical Derotator
602a015 – PFocus mechanical Cable chain
602a016 – PFocus mechanical Lens N.3-4-5
602a017 – PFocus mechanical Lens N.2
602a018 – PFocus mechanical Lens N.1
4. SUPPLY RULES.

The construction of the “LBT Double Prime Focus – Blue channel” must comply to the rules hereafter listed.

4.1 - Planning
The Manufacturer shall submit to the P.O. a detailed planning of construction, highlighting the intermediate tests and verifications foreseen by its Quality Control Service.

4.2 – Procedures
The Manufacturer shall provide all the procedures to execute the critical operations of the manufacturing and integration phases. During all the manufacturing, integration and test operations the Supplier must grant to the Customer full access to the relevant facilities.

4.3 - Surface protection and painting
All the metal parts must be protected against corrosion by suitable surface treatments and/or painting. The surface finishing must anyway be approved by the Customer.

4.4 - Delivery
The unit shall be delivered to “Osservatorio Astronomico di Padova” after the final acceptance test at Supplier’s workshop premises (ref. section 5). The package shall be consistent with ground transportation and temporary outdoor storage.

The unit must be delivered to “Osservatorio Astronomico di Padova” by end of February 2002.
5 – ACCEPTANCE TESTS

The following acceptance tests will be performed at Supplier’s workshop premises:

5.1 – Hub
These tests aim to proof that the bearing axis and the optical elements interfaces fulfil the geometrical specifications. A set of important dimensions will be specified to be checked either by means of a 3D test machine or by setting up a tailored measurement system. Such dimensions are at least the internal diameters of the lens frames and the distances between the different frame seats on the hub and the derotator bearing. Another mandatory check concerns the perpendicularity of the derotator bearing axis and plane with respect to the interfaces of the hub to the spider.

5.2 – Focus corrector mechanism
The Supplier shall run this mechanism and measure with an independent set of instruments (e.g. three dial gauges 120 deg. apart) the movement of the lens frame. In order to make such test representative of the actual functioning of the system, a dummy of the lens #2 should be used (mass and c.o.g. only). This test must be run at least at two elevations, namely Zenith and 45deg.

5.3 – Derotator
The Supplier shall run the derotator full stroke in both directions. Moreover, it must be demonstrated the capability of tracking and motion inversion without play on the instrument axis. This test must be run at Zenith and 45 deg elevation. Cable chain functionality will be proofed by this test as well. It is demanded that the derotator tilt stiffness with respect to the hub structure is measured as well.

5.4 – Filter wheels
The Supplier shall run both filter wheels spanning all the possible configurations and proof the functionality of the filter identification capability. In particular the Supplier shall proof the repeatability in the filters positioning on both wheels.

For all these tests the Supplier shall propose a test procedure to be approved by the Customer. “Osservatorio Astronomico di Padova” could provide, if requested, both instrumentation and personnel to support this test at Supplier’s workshop premises.

The Supplier shall grant to “Osservatorio Astronomico di Padova” personnel access to the workshop to perform independent functional tests for a maximum of two weeks.