Wide Field Camera (WFC) for the 2.5m Telescope

1. Introduction:

Physical Research Laboratory (PRL) is in the process of commissioning a 2.5m telescope at Mount Abu observatory, India. Wide field camera (WFC) will be the first light instrument for the telescope. It will comprise 4k×4k CCD with physical dimensions of 61.4mm x 61.4mm (15 µm pixel size) covering 17'×17' field-of-view (FOV). The wavelength coverage of WFC is from 380nm to 1000nm with a set of customized SDSS ugriz filters. Figure 1 shows the schematic of WFC. The heart of the camera is its lens Integrated field correcting optics assembly comprising five optical elements (two spherical and three aspheric lenses) shown within the dashed box in Figure 1. It primarily works as a focal reducer to convert an F/8 beam into F/5 one and also as a field corrector to provide flat 17'×17' FOV. The filter wheel assembly and a 4k×4k CCD are not included in this bid requirement.

The primary science goal for the WFC is high precision ugriz photometry and differential photometry at sub-milli-mag accuracy. In order to achieve these goals/objectives imaging must be seeing limited. The median seeing at Gurushikhar observatory site is ~1 arcsec which corresponds to ~62 µm at the F/5 focal plane of the telescope. Thus, in order to have a fully resolved 1 arcsec image we propose for imaging quality with EE80 diameter ~40 µm (~ 0.7 arcsec). WFC optics design shown in figure 1 fulfils these requirements. Figure 2 shows the final spot sizes on the detector image plane. This large box size is required to show the spots of all wavelengths in the same box. The spot sizes of individual wavelengths are well within 40 µm diameter. Thus, it is very important that optical specs mentioned here are adhered to by the VENDOR. Figure 3 shows the Encircled Energy (EE) as a function of radius which ensures the performance of the schematic design meets requirements.

A quotation is requested for WFC Optics (Assembled into the Lens Integrated field correcting optics assembly) as per the design and specifications mentioned in this document.

2. List of deliverables by VENDOR:

1. VENDOR must deliver the Integrated field correcting optics assembly consisting three aspheric lenses and two spherical lenses assembled as lens barrel as per design and specifications given in section 3.
2. All glass-to-air surfaces must be Anti-Reflective (AR) coated as per specification given in this document (see section 3).
3. All the reports mentioned in section 4.
4. The opto-mechanical assembly shall be packed carefully in order to protect it from damage during transit. Each individual package and their intermediate package shall be fixed within the shipping package which shall be resistant to mechanical shocks, humidity and dust. Specific care has to be taken to protect the reflective coating on the optics.
5. The WFC must be delivered within 18months or earlier from the time of accepting the work order.

3. Technical Specifications:

1. The complete camera is to be CGH tested showing the EE80 diameter less than or equal to 40 μm in diameter.
2. Individual lens ROC, thickness, separation and other parameters, tolerances should be within values listed in Table 1 or better subject to Zemax tolerance simulation (as mentioned in section 5).
3. Individual AR coating average transmission between 380nm and 950nm should be greater than 98.5%. The efficiency must be shown as a graph plot.
4. It is preferred that the VENDOR does the job of AR coatings in house on lens surfaces. In the case the VENDOR is outsourcing the AR coatings, they must give PRL the complete details of the coating Vendor including their previous experiences with similar coating (AR) of such large surfaces along with quotation.
5. The Zemax prescription file of the Wide Field Camera will be provided by PRL. VENDOR should optimize for the melt data or equivalent glass. While optimizing the optical distance between the last lens and the detector which is 86.7mm should not be reduced. Approval of the final Zemax design from PRL is must before initiation of manufacturing process.
6. In case of non-availability of H2 quality glass, glass with equivalent properties like transmission, refractive index and Abbe number must be considered and identified and to be checked in Zemax for the overall performance by VENDOR. The variation in merit function (MF) should not be more than 1%. Any such modification / change needs to be approved by PRL before initiation of manufacturing process.
7. The mechanical design shown in Figure 9 is for reference only. VENDOR should produce final design at the time of PDR and CDR. The acceptance from PRL is required before initiation of manufacturing process.
8. The Integrated field correcting optics assembly should be made from 6061 type aluminium and should be black anodized from both inside and outside. It should also be dry Nitrogen purged and sealed. Provision should be there for future dry Nitrogen purging as well. This to avoid any fungal issue on lenses inside the Integrated field correcting optics assembly. Any further details related to protection from fungal issues may be discussed during PDR stage and implemented.

4. Reports to be produced to PRL:

1. Individual lens focal length, curvature, thickness and transmission measurements and CGH reports should be reported to PRL.
2. Final Zemax file after all optimization applied.

3. A report on results from Zemax simulation considering the effects of tolerances/deviations (if any) of various parameters.
4. A report on the efficiency of AR coating including a graph of efficiency vs wavelength.
5. Opto-mechanical design of Integrated field correcting optics assembly.

5. Tolerance:

Vendor should estimate the effects of manufacturing and mounting tolerances by running a Zemax simulation which includes tolerances mentioned in Table 1. Results of the simulation should be shared with PRL for clearance before initiating manufacturing process.

The requirements are as follows:

1. Co-linearity between optical axis and mechanical axis for the optical elements shall be less than or equal to 50 µm.
2. Flatness at the interfaces shall be within +/- 50 µm.
3. The perpendicularity shall be also less than or equal to +/- 50 µm.
4. The circularity tolerances for the lens elements shall be less than 100 µm.
5. The final EE80 spots produced across the field should be less than 40 µm diameter at the focal plane.
6. The Mount designs for the Optical elements shall be done in such a way that it does not have any stresses on the Optical elements

6. Details of individual optical elements:

Table 2 summarises important parameters of individual lens elements. Figures 4 to 8 shown below highlights the design and technical details of individual optical components. Figure 9 shows the reference mechanical design. Table 1 shows the various parameters of the Lenses.

Note: the final design parameters and corresponding tolerances are subject to change, depending on equivalent glass availability, melt data refractive index, without changing the EE80 diameter of 40 µm spot size at the focal plane.

Table 1: Details of individual lens elements. (Tolerances are as per Table 2).

Lens #	Mechanical Diameter (mm) TBD during PDR**	Radii of Curvature R1 R2 (mm)	Thickness (mm)	Conic constant	Glass	Clear Aperture (mm)	Distance from Previous lens (mm)	Compliance	Remarks
L1	>172	1036.067 338.230	12.000	0 1.188	S-NBM51	172	---		
L2	>172	183.833 -662.218	30.084	0 -6.0	S-FPL55	172	2.0+/-0.02		
L3	>160	118.315 380.137	24.544	0 0	S-FPL55	160	2.0+/-0.02		
L4	>140	902.717 -730.019	10.096	0 -6.0	S-FPL55	140	17.0 +/-0.02		
L5	>130	-605.961 87.313	9.289	0 0	F_SILICA	130 120	6.29 +/-0.02		

** The mechanical diameter should be minimum 10mm more than the clear aperture.

Table 2: Compliance matrix:

Parameter	Result	Compliance	Remarks
Lenses L1 to L5	Dimensions as per Table 1 and tolerances parameters mentioned in section 5		
Transmission & AR coating	Individual Lenses Transmission report with plot must be produced between 380nm and 1000nm with greater than or equal to 98.0% trans mission between 380nm and 950nm after AR coatings on the individual lenses		
Variation in MF	Should not be more than 1% after optimizing with melt data and/or equivalent glass material if necessary		
Tolerances Diameter (mm) of Lenses	+0.00/-0.05		
Tolerances Centre Thickness (mm) of Lenses	± 0.05		

Curvature radii tolerance of Lenses	10 µm for maximum sag deviation at edge		
Tolerances of Radii of Lenses	Better than 0.2 % value of the radius		
Parallelism Tolerances (arcmin)	0.5		
Decentre alignment Tolerances	50 µm		
Scratch-Dig	40/20		
RMS Surface Accuracy in nm	60 or better (60nm or less)		
micro roughness (nm) *rms value*	less than 2nm		
Conic Constant Tolerances	± 0.002		
Surface Decentre (arcsec)	< 60		
Opto-Mechanical alignment Tolerances	± 50 µm or better		

Polishing quality per surface or equivalent RMS value for all air glass surfaces	< 2 fringes over complete polished CA < 0.5 fringes over each sub pupil surface		
Details of individual Lenses & CGH testing of individual lenses	Reports on the final manufacturing of the individual Lenses with measured thickness and Radii and AR coating. CGH transmission wave-front analysis should also be included		
Quality of Glass materials	H2 quality or better along with melt data		
CGH testing of the Lens assembly	Report on the final CGH testing of the Integrated field correcting optics assembly assembly showing the CGH transmission wave-front analysis and they're by showing that the EE80 diameter at the focal plane will 40 µm or better when attached to the 2.5m telescope. Telescope parameters including details of fabricated primary and secondary mirrors (measured interferograms) along with its final wave-front analysis will be provided by PRL		
Mechanical Assembly	The mechanical Lens Assembly detail design and Fabrication must be shared and cleared by PRL during PDR. Figure 9 is for reference only. Material to be used is Aluminium 6061 and all dimensional Tolerances are to be within +/- 25 µm.		
Operating environment	Operation -2C to +35C, Survival -10C to 40C. Air Pressure 1000 mbar (at sea level) to 780 mbar (at 2km height at Observatory); Humidity: Operation from 5% to up to 80% non-condensing, Survival up to 100% non-condensing		
Delivery Period	Kick off meeting: within a month after release of purchase order by PRL, PDR should be within Kick-off + 3 months. CDR should be within PDR + 2 months. Final delivery: 18 months or earlier		

Vendor Experience	Vendor must produce proof of manufacturing similar optics like camera optics or telescope field corrector, particularly larger than 200mm diameter aspheric surfaces and surface quality and tolerances similar to the present requirements.		