Optically−Athermalized Construction Optical Design for the IMACS Short Camera

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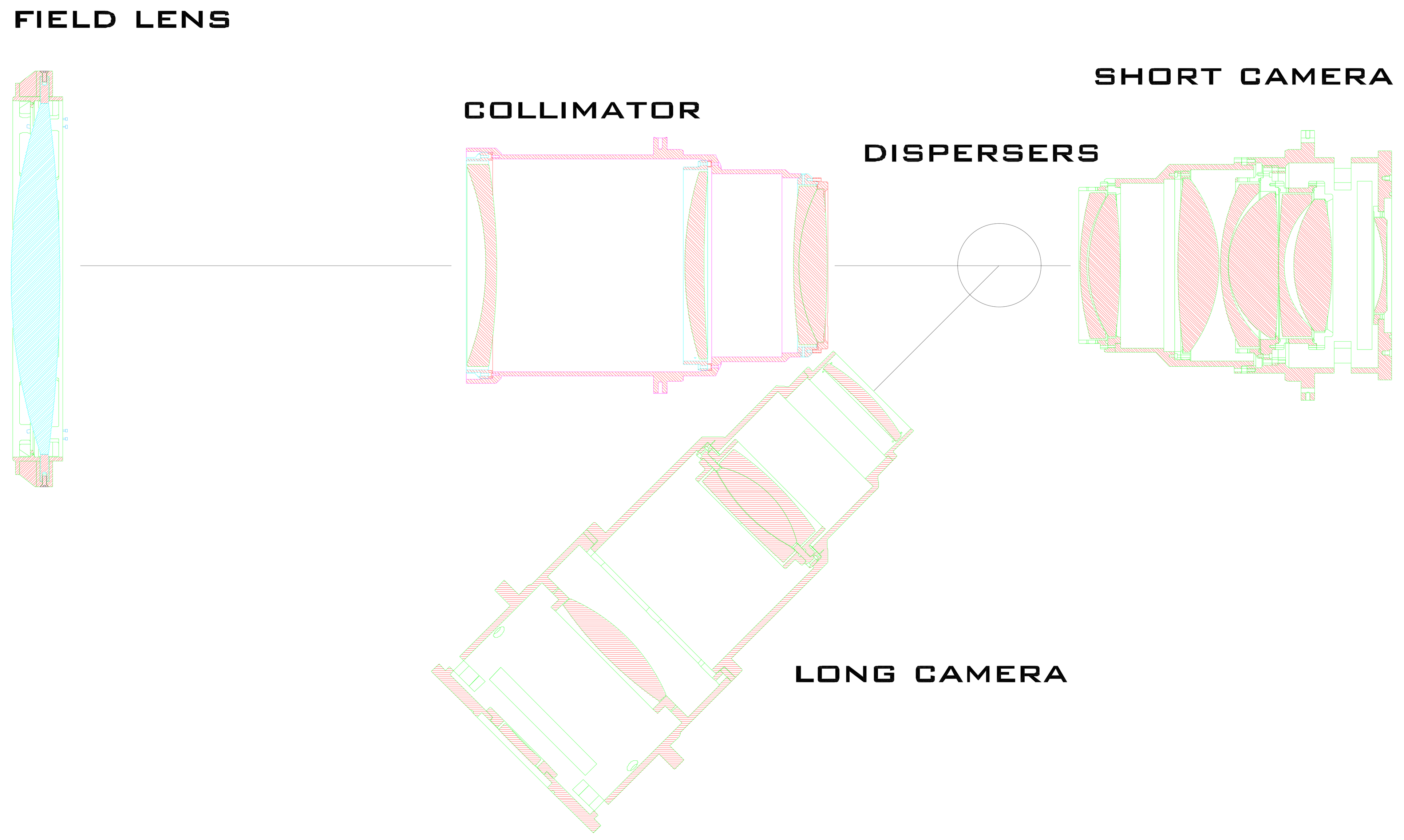
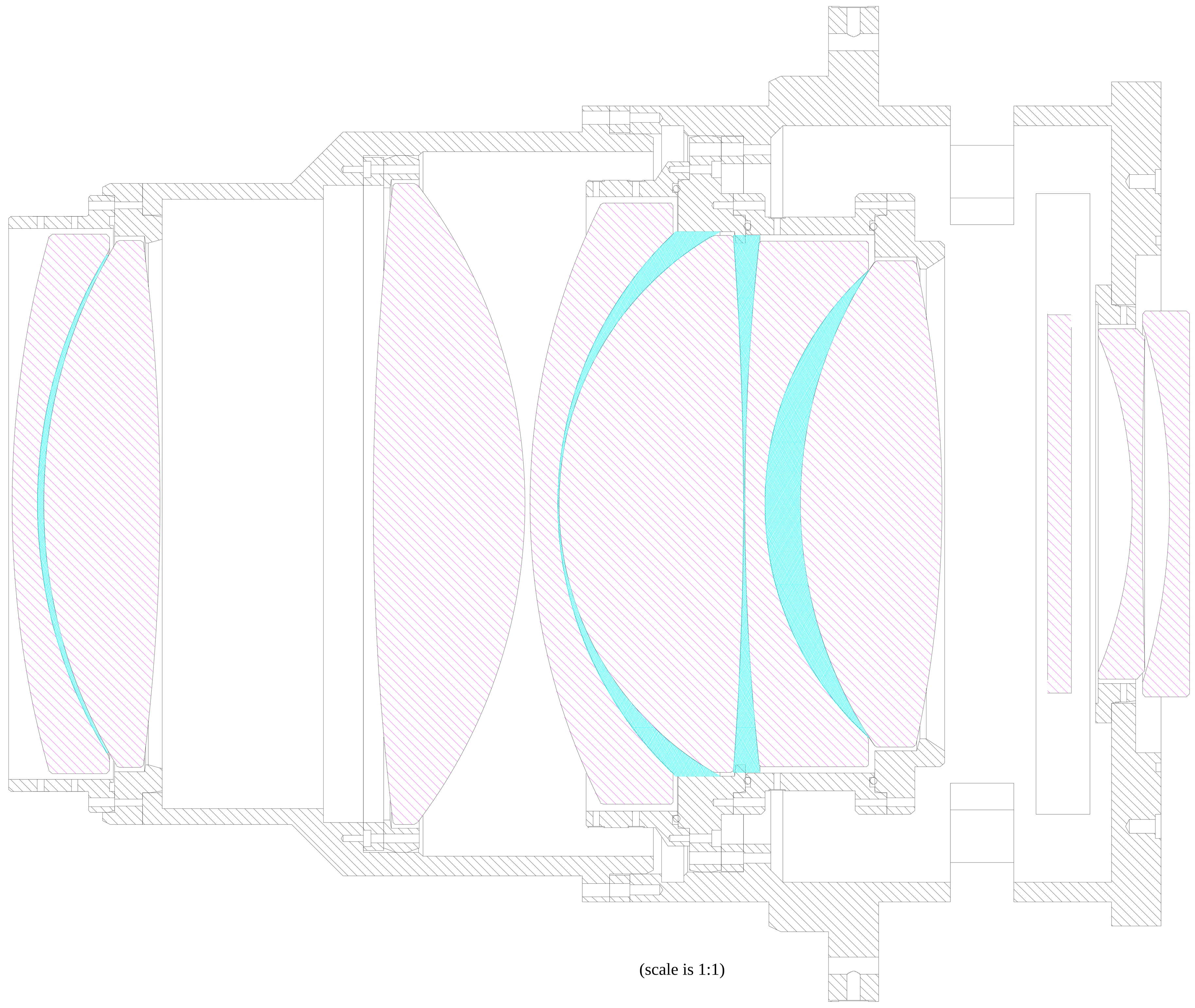
The optical performance of a large, optically fast, all-refracting spectrograph camera is extremely sensitive to potential temperature changes which might occur during an extended single observation, over the duration of an observing run, and/or on seasonal time scales. A small temperature change, even at the level of a few degrees C, will lead to changes in the refractive indices of the glasses and the coupling medium, changes in the lens-element geometries and in the dimensions of the lens cell. These effects combine in a design-specific manner to cause potential changes of focus and magnification within the camera as well as inherent loss of image quality.

We have used an optical design technique originally developed for the SAO's BINOSPEC instrument in order to produce a construction optical design for the Carnegie IMACS Short camera. This design combines temperature-dependent parameter variations in such a way that their net effect upon focus and magnification is passively reduced to negligible residuals, without the use of high-expansion plastics, "negative-c.t.e." mechanisms or active control within the lens cell.

The seasonal temperature variations at the Magellan telescopes on Las Companas, Chile, are largely limited to (-4 to +20)-C, over which the spectrograph is required to operate without a significant change of plate scale at the detector. the IMACS Short camera is passively athermalized by using the dn/dT of the liquid optical couplant between the lenses.



Shown at the left are the IMACS optics, which mount at the Nasmyth focus. The telescope focal surface is just to the left of the field lens. The field lens funnels the light from the telescope's 30-arcmin field of view into the collimator, which forms a pupil at the circle. A large wheel with six positions may hold mirrors, gratings, grisms, Fabry-Perot etalons, and so on. IMACS has two cameras available, one with a grating dispersion and and one with grism dispersion. A dewar with an (8192 x 8192)-pixel CCD detector array and an XYZ flexure-control stage may be swapped between the two cameras, which share the same dewar window/field flattener as the last optical element. The grism-dispersed Short camera, toward the right of the figure, has a (27 x 27)-arcmin field of view on the sky (The corners of the field are lopped off by the telescope field of view.), with an imaging scale of 5 pixels per arcsec.



(scale is 1:1)

The original pre-construction design of the Short camera, before athermization was considered, was a 10-element camera with three aspheric surfaces and twelve air-glass surfaces. However, before fabrication commenced, the concept of using the optical couplant to thermally passivate a spectrograph camera had been developed for BINOSPEC by H. W. Epps and D. G. Fabricant. Applying this new method to the Short camera resulted in the current design which is not only thermally compensated, but delivers better images and eliminates one element, one aspheric surface, and two air-glass surfaces from the design.

A full-scale drawing of the IMACS Short camera is shown at the left. The blue regions are the couplant fluid. The monochromatic image diameters (using the larger elliptical pupil), are 24.2 +/- 6.7 microns, average over all field angles and wavelengths, without refocus. The maximum lateral color is 20.5 microns. Over the (-4 to +20)-C temperature range, the focus varies +/-12 microns, and the scale varies by +/-0.014%.

A thermal analysis of the camera gives a maximum thermal time constant of about 1 hour for the central region of the last fluid lens in the quartet. Rapid changes in temperature will be mitigated by wrapping the camera with a few inches of insulation.

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