STUDY OF PRIME FOCUS CORRECTOR

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Abstract

Four studies for the design of four different prime focus corrector are briefly described.

A three lenses all spherical solution for the F/3 parabolic primary mirror of the 1.82m telescope of Asiago-Padova Observatory is given, starting from an original drawing of Wynne.

Two different solutions, both with three lenses, are given for the prime focus of the Italian *Telescopio Nazionale Galileo* telescope, an F/2.2 Ritchey-Chretien, characterized by a slightly hyperbolical primary mirror of 3.5m: one characterized by all spherical surfaces, the other with two aspherical surfaces.

Finally a solution for the Columbus project (an F/1.2 parabolic primary mirror, 8m in diameter) is also given.

Emphasis is given to the choices made during the optimization runs for each corrector, and to the feasibility of such focal stations with active optic. For some of these corrector analyses for ghost, narciso and optical coupling with a fiber optics spectrograph, are briefly given.

1.Introduction

Wide field coverage with optical performances comparable to the one offered by new generation active optics controlled telescopes is a new task for astronomical optics.

The point concerning prime focus focal station *vs.* focal reducer is not taken into account here, where focus is given to the studied solutions for existing, under construction, planned telescopes where Italy is primarily involved.

Four different solutions are here briefly described. For each one construction parameters can be found in Tab.1 using as a reference Fig.1. Solutions given in this paper (labelled with a number) and solutions found in the literature (labelled by a capital letter, and referring to Tab.2) are plotted in Fig.2 using as coordinates the diameter of the first lens and the distance from the last lens to the detector, normalized to the diameter of the main mirror (that is $\varnothing_1/\varnothing_m$ vs. $d_{3F}/\varnothing_m$). The first figure is roughly proportional to the expensiveness of the focal corrector, while the second is somewhat *proportional* to the easiness of mechanical arrangement of instrumentation at the focal plane. *Best* focal corrector should lies in the bottom-right area of the plot.

2.The 182cm Asiago-Ekar telescope

For this, classical cassegrain telescope, characterized by an F/3 main mirror focal ratio, a straightforward adaptation of a Wynne design (Ref.E) was chosen, after a careful selection of some other solutions available in the literature (#1).

3.The Galileo telescope

This telescope is, almost from the optical point of view, a *replica* of the ESO-NTT. In

Galileo telescope a number of different mechanical features are foreseen in order to permits the exchange of the top unit, like a Prime Focus optical station. A first solution was provided by Officine Galileo (OG,Firenze), see Ref.J (in Fig.2 it is superimposed to solution D), assuming only spherical surfaces. Two further solutions are given in the following.

3.1.An all spherical solution

This solution (#2) was found using as a main requirement a larger distance from the last lens to the detector, retaining the optical performances of the OG solution. This improvement was realized, with some better behaviour off-axis, with only a modes enlargement of the diameter of the first lens. For this corrector a detailed study of ghosts, narciso and compatibility with a fiber-drive spectrograph was performed.

3.2.An improved aspherical solution

A slightly aspherical solution (#3) for the Galileo telescope is here given. The main study developed around this Prime Focus corrector was the feasibility of active-optics. In other word a number of simulation was performed simulating misalignment and miscentering of the optical unit. Wavefront distortions signals provided by a Shack-Hartmann wavefront sensor off-axis coupled to the Prime Focus translates into movement of the whole optical station. Checking of the convergence of this process toward the better optical situation was successful performed.

4.The Columbus 8m class telescope

For this, large diameter and very fast (F/1.1), parabolic primary mirror an aspherical solution is given, characterized by a very small diameter of the first lens, especially if compared to solutions given in the literature for such fast mirrors.

5.Discussion and (preliminary) conclusion

As it can be seen via inspection of Fig.2 a roughly correlation between diameter of first lens and distance from the last lens to the detector can be found. It is also remarkable that, generally, solutions with 4 lenses, or aspheric surfaces (filled circles), are not clearly *better* than the classical 3-lenses all-spherical solutions (open circles), almost from the point of view investigated in the plot given. A more realistic comparison should be performed taking into account field of view coverage, optical performances, throughput, wavelength coverage and ghost analysis.

For the aspherical solutions, it is also to be taken into account how much is the departure from the spherical surface. Another, often discarded, parameter is the set of tolerances for the manufacturing and mounting of the lenses. It is, anyway, remarkable the positive answer given to the feasibility of active-optics in Prime Focus station, even for an aspheric solution.

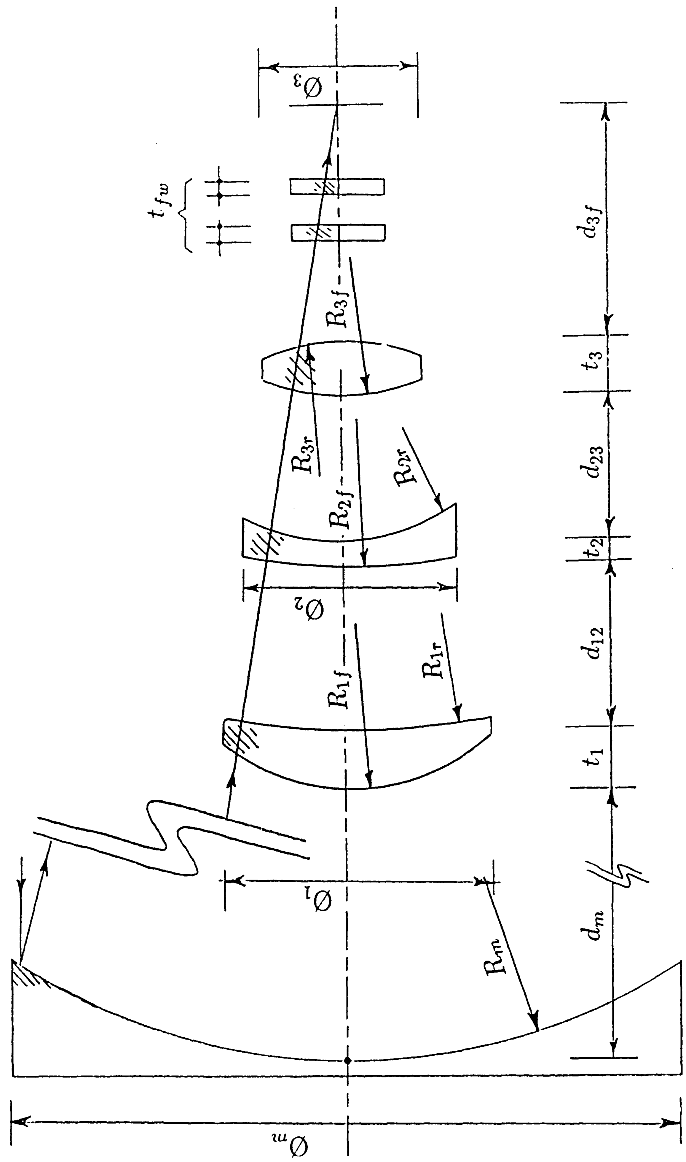
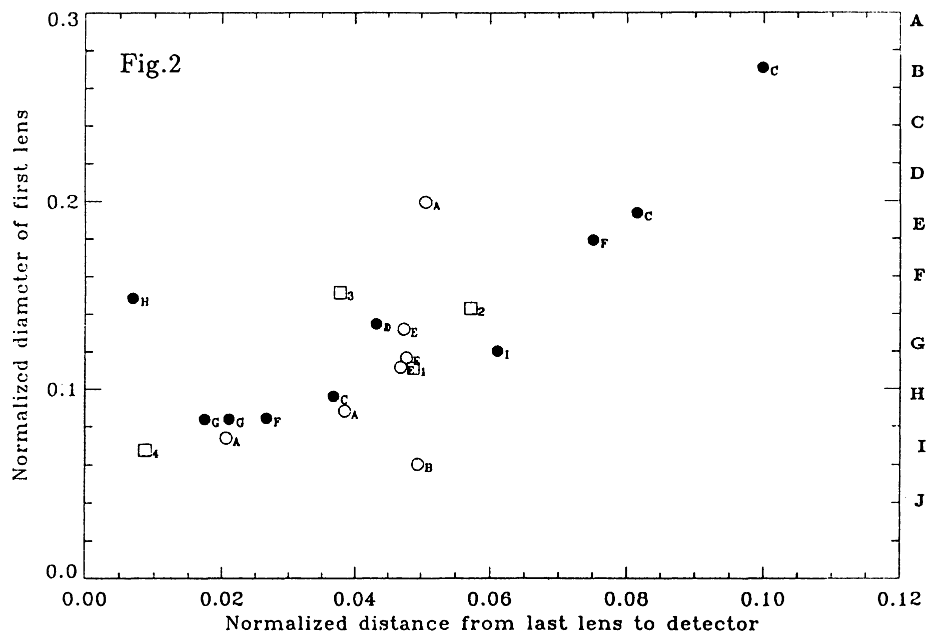


Figure 1: Parameters of the Prime Focus corrector used in Tab.1.

#	R_m	K_m	d_m	$Ø_m$	R_{1f}	R_{1r}	t_1	$Ø_1$	d_{12}	R_{2f}	R_{2r}	t_2	$Ø_2$	d_{23}	R_{3f}	R_{3r}	t_3	$Ø_3$	d_{3F}	t_{fw}	Notes
1	10786	−1.0	4936.8	1820	194.74	225.86	18.67	202	161.87	389.43	137.13	4.23	130	208.36	240.78	−1708	14.74	105	88.72	13.0	Schott UBK7
2	15400	−1.0238	6759.5	3500	462.76	489.47	55.0	500	401.26	816.67	265.84	25.0	300	272.29	499.30	−1000	44	250	200.0	13.0	Schott UBK7
3	15400	−1.0238	6716.1	3500	500.46	539.17	85.56	530	355.07	795.18	301.83$^{(1)}$	17.2	310	388.17	403.45$^{(2)}$	∞	55.0	200	131.8	17.1	Fused Silica
4	19200	−1.0	8930.4	8000	334.42	328.15	80.0	540	252.26	616.89	168.78$^{(3)}$	45.5	270	215.22	213.39$^{(4)}$	−1262	20.0	150	69.0	9.0	Fused Silica

Table 1: Aspheric surfaces: (1): $A_4 = 7.88\cdot10^{-10}$, $A_6 = 1.22\cdot10^{-14}$; (2): $A_4 = 2.97\cdot10^{-9}$, $A_6 = 3.66\cdot10^{-14}$; (3): $A_4 = -4.608\cdot10^{-6}$, $A_6 = -3.782\cdot10^{-9}$, $A_8 = -9.609\cdot10^{-11}$; (4): $A_4 = -9.123\cdot10^{-6}$, $A_6 = -4.228\cdot10^{-8}$, $A_8 = 8.391\cdot10^{-10}$.



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E C.G.Wynne "A new wide-field triple lens paraboloid field corrector", *M.N.R.a.S.* (1974) **167** 189;

F E.H.Richardson, C.F.W.Harmer and W.A.Grundman "Better but bigger prime focus corrector lenses for Ritchey-Chretien telescopes", *M.N.R.a.S.* (1984) **206** 47;

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Table 2: References used in Fig.2 for the Prime Focus correctors found in the literature.