A Large Field F/10 Cassegrain.

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Letter from Christian Huygens to Gallois.

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CHRISTIAAN HUYGENS à GALLOIS.

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Appendice II au No. 1890.

La lettre a été publiée dans le Journal des Sçavants du 13 *juin* 1672 [1]).

Reflexions ſur la deſcription d'une Lunette publiée ſous le nom de Monſieur CASSEGRAIN [2]).

Depuis que M. Newton a inventé ſon nouveau Teleſcope, dont nous avons parlè [3]) dans le Journal du 29 de Fevrier dernier, on en a publié [4]) un autre que l'on pretend eſtre beaucoup plus commode & plus ingenieux. Comme celuy de M. Newton paſſe pour une invention tres-belle, pluſieurs perſonnes ayant entendu dire que cette derniere Lunette eſtoit encore plus parfaite, ont crû qu'il falloit que ce fuſt quelque choſe de tres-excellent, & ont témoigné un grand deſir de ſçavoir au vray ce qui en eſt: C'eſt pourquoy il eſt à propos de l'examiner icy, & de faire voir ce que l'on en doit attendre.

The Newton point of view.

... The advantages of this design are none, drank the disadvantage are so great and so unavoidable, that I fear it will never be put in practise with good effect... I could wish, therefore, Mr. Cassegrain had tried is design before he divulged it. But if, for further satisfaction, I please hereafter to try it. I believe the success will inform him, that such projects are of little moment till they be put in practice.

BORN UNDER SUCH DAMAGING AUSPICES that the undisputed geniuses of the 17th century, Newton and Huygens, negative points of view, it seemed that the invention of the obscure vicar would be vowed to finish in the trash cans of history. This being said, even as that the most brilliant minds of this century believed to have to take party, was already a victory, in particular on behalf of Newton that had to smell something like an imminent danger to the point to pretend to have had the same idea, but preferred to give up! His main objection concerned the difficulty to manufacture the peculiar hyperbolic secondary, inconceivable at this time. But difficulty doesn't mean impossibility! Cassegrain was right too early, in a time where it was not without dangers… A *Timing issue,* as often have the underestimated genius.

As history is ironic (… that I fear it will never be was able to in practice, etc.) and that the facts are headstrong, invention of Cassegrain will reemerge when the techniques will have ripened, to the point of becoming the main type of telescope used particularly in astronomy in his Ritchey-Christian variants, eclipsing the Newton, which will remain until this day, the *darling* of the amateurs.

We presented elsewhere on this site, an easy test for the qualification and measurements of the convex hyperbolic secondary, what gives back interest to this formula because of its modularity and the possibility to use the secondary primary alone in Newton. It being, the Cassegrain presents the same coma that the equivalent Newton, mixed to some astigmatism and especially, field curvature.

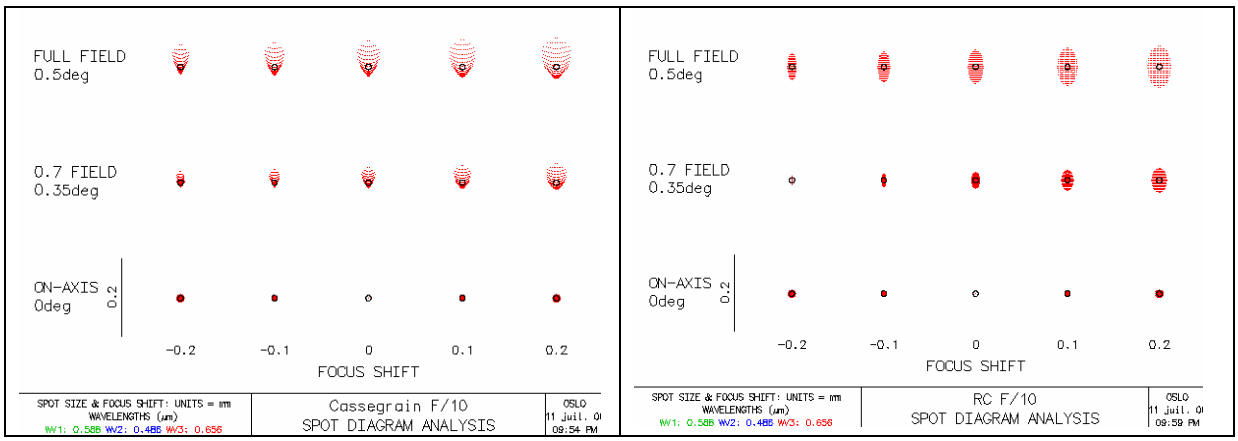
The setting in work of a simplified Ross corrector, as presented elsewhere on this site, will permit to suppress coma and curvature of field, it will decrease astigmatism, and the spherical aberration introduced by the Ross corrector will be annulled by modifying slightly the conical constant of the secondary. The field covered with 1° will have the diagonal 24x36 of the format with a honourable λ/4 in the corner. In the concept, one feels that one is not here very distant to the Rosine telescope, described elsewhere also on this site and of which, the secondary is spherical. Let's start therefore with some useful comparisons that will fix an order of idea.

Cassegrain versus RC.

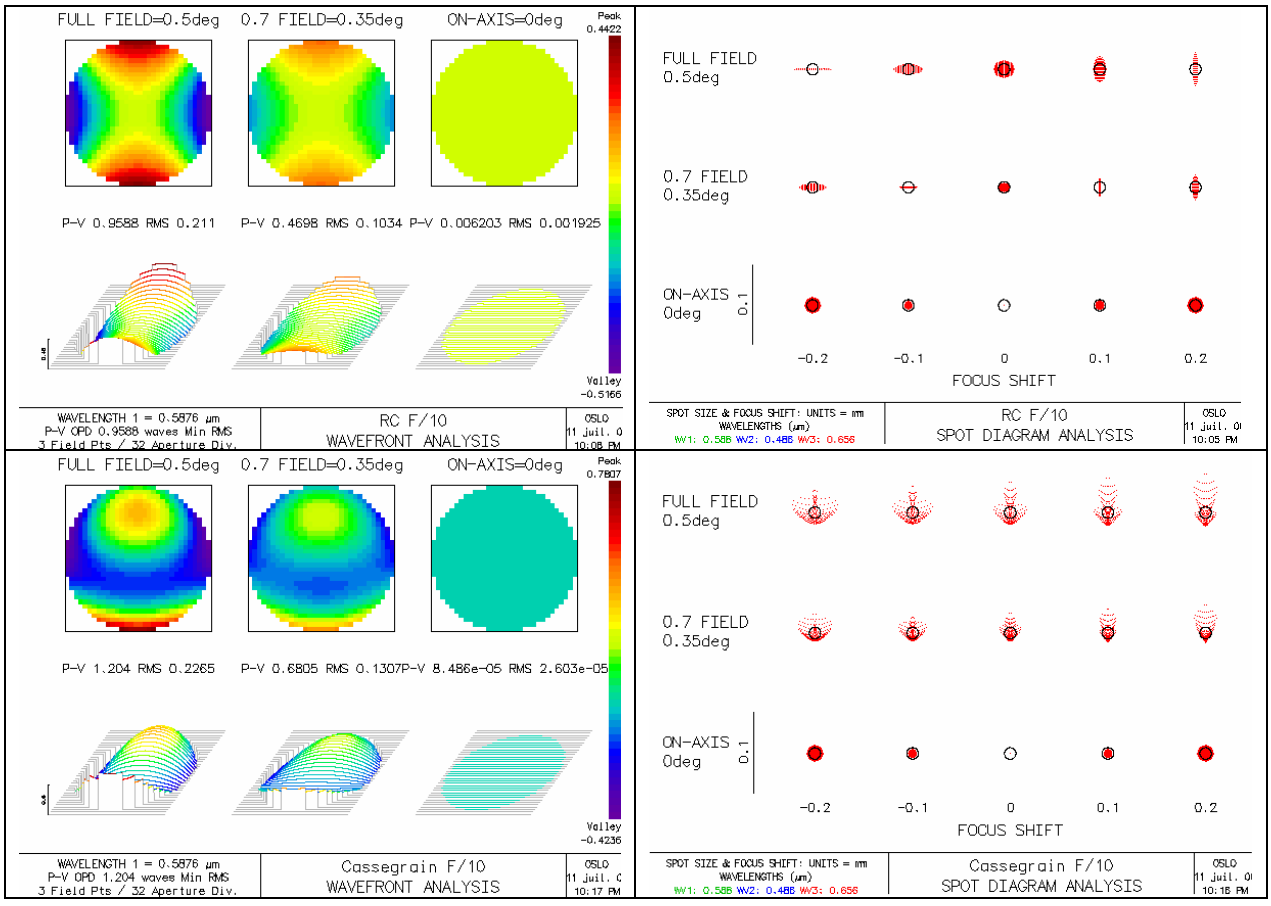
Let's compare two telescopes with a 250 mm diameter, all two at F/10. In both cases, the rear distance is 200 mm, "d" is the distance between the two mirrors. The parameters are the next one:

	Cassegrain	Ritchey-Christian
r1 mm	2000	2000
r2 mm	-1143	-1143
- b1	-1	-1,167
- b2	-5,44	-7,7
D mm	657	657

As we ca see, the conique constant only change. The secondary of the RC will probably be a little more difficult to achieve, for that reason. What about the performance at ½° of the axis for our two telescopes?



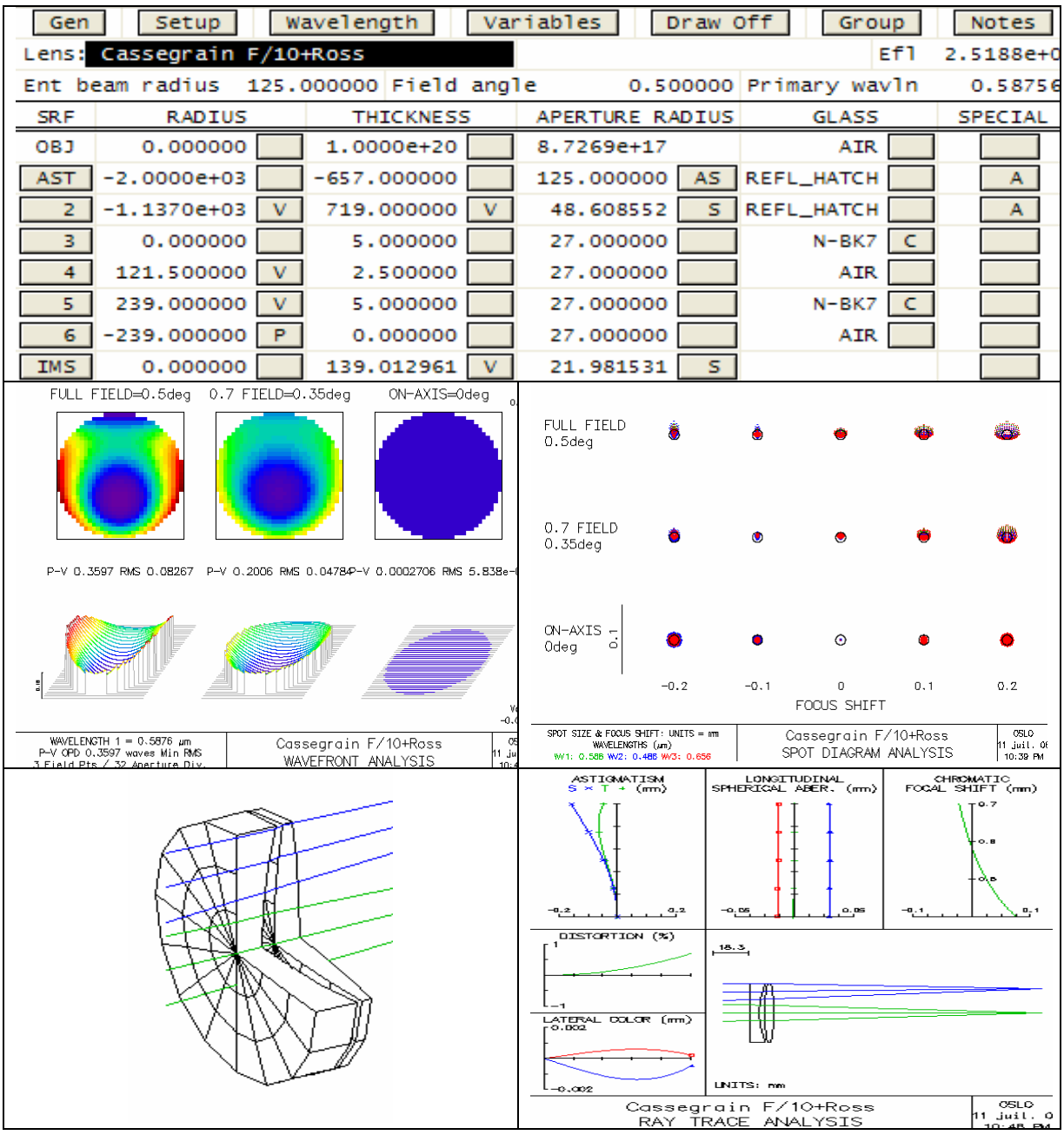
The spot diagram of the RC is symmetrical and elliptic. As introducing a -350 mm field bends, it is possible to win a lot in quality since the spot will become then circular as one can see it below. This practice was current in the past with photographic plates. Otherwise, the spot is not fundamentally different from the one of the Cassegrain, except his symmetry so useful to localize the stars of the Card of the Sky. It is not a generality: F/10 is here the F/D pivot. On this side the -350 mm spot of the RC is weaker than the Cassegrain one, beyond that it is the inverse, this with a F/4 primary.



As we can see, the error on the wave is bigger for the Cassegrain and especially the shape of the spot is more unfavourable. Even while correcting the curvature of field of the Cassegrain, the account is not there, the field of the RC is corrected much better in these conditions. Is the situation a desperate one? Absolutely not.

An extremely flexible combination.

We can keep the advantages of the Cassegrain, that reside in the interchange ability of the secondary, with an excellent correction at F/10, if one uses *a Ross corrector*, here in a simple shape, a plano-concave lens and biconvex one. The conical constant of the secondary will be -5,15 instead of -5,44 so that to compensate the spherical aberration introduced by the aforesaid corrector. Notice that the primary remains parabolic.

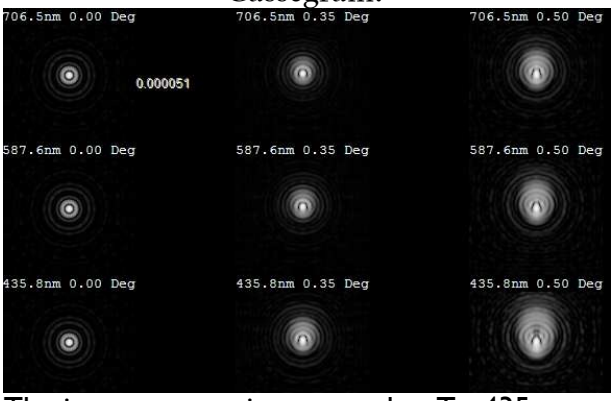


The depth of field is -+ 100 µ. One can see that the spot is of smaller size that the one of the RC on a field bends and corrected by a plano-concave lens. The field is practically planed. Besides one is a superlative P/V λ/3 *at the corner* of the 24x36 mm field. The chroma introduced by the corrector is negligible too. For the Cassegrainian with elevated F/D, just suppress the Ross and change the secondary.

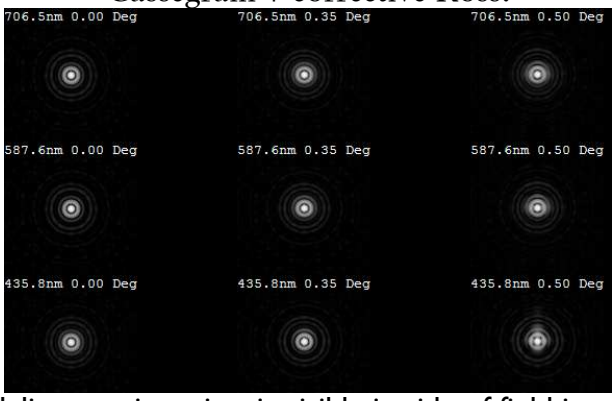
One compares the spot of the Cassegrain below and the one of the version corrected to 0,5° out of axis for 706 nm, 587 nm and 435 nm. The spot is composed of coma, field

curvature and astigmatism, having about 50µ at ½ ° out of the axis with the Cassegrain. While adding the Ross, the spot remains constant on the whole field and close to the diffraction limit on the whole band of wavelength.

Cassegrain.

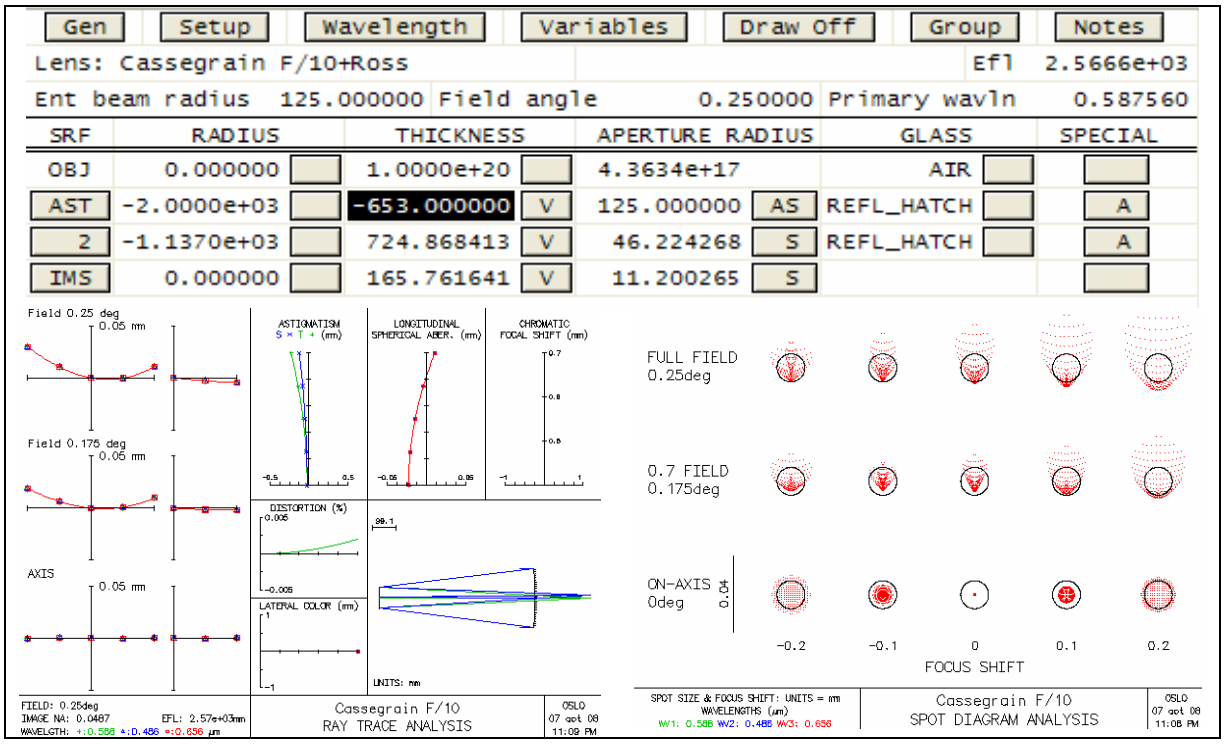


Cassegrain + corrective Ross.



The improvement is spectacular. To 435 nm, a delicate astigmatism is visible in side of field in ½° for this version.

If one wishes to use the system at F/10 without the corrector but with a conical constant of -5.15, what avoids having two secondary slightly different in terms of conical constants, one is going to introduce spherical aberration, the one precisely that was supposed to compensate the aberration due to the Ross. Another way exists to compensate the spherical aberration: it consists in modifying slightly *the position of the secondary mirror*. Of the sort, one will have optimized the combination in big field with the Ross and one will have a Cassegrain without corrector and usable directly with a Barlow. Let's have a look at our Cassegrain with the conical constant of -5.15.



The secondary is at 653 mm of the focal plane instead 657 mm previously, either a shift of 4 mm only to annul the spherical aberration. The focal plan is also shifted a bit. This being said, one has an extremely flexible combination here, at the same time a Newtonian, Cassegrainian and a wide field astrographe.

To note that it would have been possible to make the inverse choice, that means to leave the secondary with a conic constant of -5.44 and to move away the secondary, probably 4 mm, so that to annul the spherical aberration generated by the Ross in the context of its use for the wide field. But I am not sure that the field will be so wide. A new survey imposes itself.

Incidentally, one also sees that if one is not 100% motivated about the accurateness of the BFL, it will always be possible to manage with an approximate conical constant…

To Conclude

Cassegrain or Ritchey-Chrétien? We showed that the wide field was not necessarily a monopoly of the Ritchey-Chrétien, in particular if the primary is not a very open one. The performances are excellent, but ask for serious mechanics so that to guarantee the collimation of the components, that is still the case for all combinations, the Dall-Kirkham remaining the most tolerant in collimation because of its spherical secondary. About the Wynne-Rosin, it appears like a particular case of the one that is treated here. As Deng Siao Ping said: *It do not care if the cat is black or white, if it catches the mice, it is a good cat.*

The planetary performances associated or not to a Barlow, are also guaranteed with this combination of which the secondary will be less deformed than the one of the RC. Finally, those having a Newtonian will be able to make evolve it without changing the primary mirror. It is there an interesting possibility.

What about the RC? It should be interesting if the primary is smaller than F/4 and if we leave from scratch. It is in this context that the professional telescopes are all of RC types even the fact that one doesn't necessarily avoid a big field corrector. The realization for the amateur will be slightly more difficult because of the secondary that will especially be more distorted when the primary will be more open. Associated to a corrector, it will evidently give outstanding results. With regard to the test of the secondary, it is clarified elsewhere on this site. One will also read with profit in the same place, the articles dedicated to the Ross corrector.

09/08/2008