A Few Degrees Very Wide Field of View Camera for VLT as a Finder for ELT

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The quest for wide field imaging, with some added multi-object spectroscopic capability, immediately evokes the Prime Focus option. On the existing 8 m class telescopes the Subaru [1] and the LBT [2] owns these kind of instruments, while for Gemini some has been planned although none has been actually built.

About VLT, because of its interferometric vocation, little or no efforts have been made in order to provide such an option from the baseline. On the other hand it is well known that, given a certain optical quality, the field of view and the size of the largest optical element of the corrector grows together in an almost linear fashion. Even with options different from the Prime Focus one it is interesting to point out how such a sort of "rule of thumb" still hold with a certain degree of precision. Both the LBT and the Subaru Prime Focus requires a largest optical element (the front lens of the Prime Focus cage) of the order of 0.6–0.8 m, and offer a field of view slightly smaller than half a degree in diameter.

The LSST [3], that is a three mirror telescope with a sort of optical corrector, indeed very similar to a Prime Focus one, does not escape from such a relationship. Its first element after the primary mirror, namely the secondary one, in fact, with a diameter of 3.4 m well match the Field of View of 2.5 degrees [4] that such a facility will encompass. Also, the trapped Cassegrain wide field imager foreseen in the past for LBT, do not escape from such law too.

Making a Prime Focus is, definitively, a risky game, and the overall weight of the Prime Focus cage is, roughly speaking, about one order of magnitude larger than the weight of the largest lens itself. It is definitively illusory to conceive a conventional Prime Focus imager for VLT with a Field of View significantly larger than half a degree with a frontal lens lighter than several hundred of Kgs and with an overall weight of the order of a few metric tons.

Such a facility will have to be positioned away from the current secondary mirror and, even neglecting the constraints imposed by the envelope of the building to avoid interference, this will surely poses some challenges, not necessarily impossible to overcome, to the telescope structure. Moreover it would be very demanding

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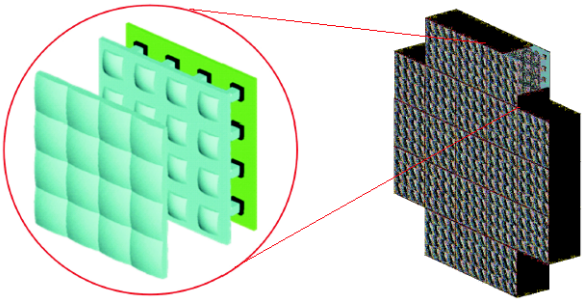

Fig. 1 A conceptual design of the camera idea: a correctors array posed on the VLT focal plane. A colour version of this figure is available at dx.doi.org/10.1007/978-1-4020-9190-2_66

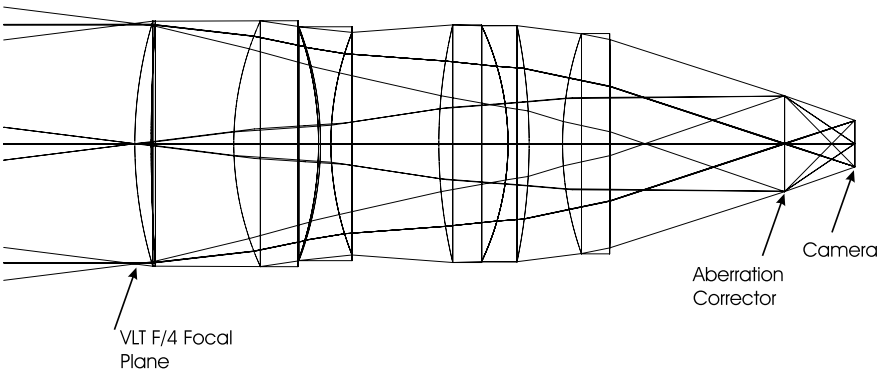

Fig. 2 A collimator composed by 6 elements is posed on the VLT F/4 focal plane. In correspondence of the pupil image there is a corrector plate that convolve light on a CCD. Because of radial distribution of aberration it is possible to split the whole field of view in micro-region within the correction remains roughly the same in a range fixed by the image quality we want to achieve

to imagine this as an option preserving other functionalities of the telescope itself, in particular interferometry, unless with major mechanical workload in the daylight for turning the telescope from a Prime Focus option to the conventional one. Finally, this can maybe achieve a Field of View of the order of one degree, and still this would require a Prime Focus with a front lens rivaling the largest refractive elements ever made in the world (still the famous 1.5 m lens of the Paris Exhibition of 1900 and then lost keep the record, leaving some hopes that in a little more than a century something larger could be one day built on the purpose).

We recently introduced a completely different concept for a very wide field imager. Here we refer, pushing a little to the edge of the feasibility, to a full field of view of 3 degree in diameter. This represent about 36 times the field covered by existing Prime Focus and would surely be in direct competition with LSST.

The concept rely on a large number of small adiacent cameras mounted on a low focal ratio Cassegrain focus, namely an about F/4 one (Fig. 1 and Fig. 2).

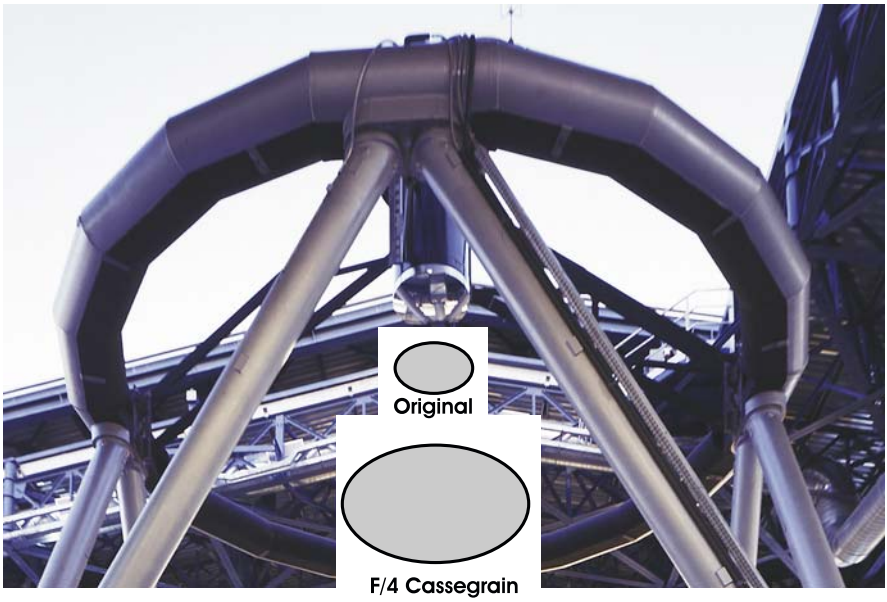

Fig. 3 In figure it can be seen the *upper part* of one of the VLT Unit Telescope. At the *top center* one can see the secondary mirror as it is now, while *just below* one can see a design in scale of the secondary mirror needed to make the UT an F/4 Cassegrain. A colour version of this figure is available at dx.doi.org/10.1007/978-1-4020-9190-2_66

This of course requires the change of the secondary mirror with a larger one (Fig. 3), but positioned closer to the primary mirror, leaving no problem for any possible interference with the existing VLT building and ameliorating the mass and momentum stress to the telescope structure. Also, the existence nevertheless of a Cassegrain foci, although with a different focal ratio and in a position that can be placed with some degree of freedom in some preferred place, shed some hope that, with the proper retrofitting of the VLTI arm related to the Unit Telescope chosen for the conversion to Wide Field imager and spectrograph, the interferometric option can be fully retained. This should be the subject of a specific study, but the tiny Field of View of any interferometric channel makes such a chance a realistic one.

There are different ways this camera can have spectroscopic capability. The one envisaged in the original concept involves a certain number of fiber positioner to be placed in alternative to the detector. Note that these will be in the, mechanically comfortable, condition to requires to move some fibers in an area smaller than the one the mechanical device can occupy. From preliminary discussions on such an option for LBT we found that off-the-shelf components could be, in principle, used for such an option. Alternatively a further intermediate focal plane and pupil plane could be introduced to allow for some multi-slit and grism directly in the camera design. Depending upon the required quality of the intermediate focal plane the golden rule of optical design (requiring more elements for more “tasks” to be achieved from the optical device) could be to some extent dampened.

Surely such an instrument poses a challenge in term of data reduction and data handling. While the second is common to any instrument like the LSST one (who is going to take advantage of Google technology) the first would be rather particular in this camera. Individual distortion and mapping on the sky of the several cameras would be taken into account, with the remarkable problem that a small overlap in the border between adjacent cameras is to be considered, given the (poor) optical quality of the image at the pure Cassegrain F/4 focal plane. On the other hand this will gives a virtually no dead zones in the covered Field of View.

In the spectroscopic option, also operations would require some challenging and demanding approach as the number of slits to be positioned simultaneously to make the instrument effective would becomes huge. On the other hand the instrument is inherently suitable to massive parallelization and one can imagine a dedicated computing unit for a certain small amount of contiguous imaging elements.

As mass production of both optical elements, detectors, and electronics are to be envisaged for this instrument, it is difficult to trace a detailed cost profile using existing instrumentation as a baseline, but the cost will probably be somewhere in the 10 to 20 million Euros range.

Finally, keeping in mind how boring has been the second Prime Focus of LBT, I can imagine a change in the attitude has to happen to handle, test, qualify and adjust the hundreds of camera that one requires for such a wide field camera. A larger involvement of the industry and/or automated procedures for aligning and tuning the optics depending upon the off-axis position of the single cameras will be likely to be required.

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