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2nd generation ITM M2

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ABSTRACT

This report describes the study of an alternative optical design for the ITM (International Telescope Maffei) ex-IRAIT telescope installed at Concordia Base in Antarctica¹²³⁴. The goal is to reduce the focal number of the telescope.

Keywords: ITM, IRAIT, Concordia, Infrared

1. INTRODUCTION

ITM (International Telescope Maffei) is the italian telescope installed at Concordia base at DOME C in Antarctica (ex-IRAIT)¹²³⁴. It was designed to operate in such extreme environment for infrared observations, with its first camera AMICA, a dual band camera in near IR (1-5 micron) and medium IR (5-27 micron). The evolution of instrumentation to be installed at the telescope required a dedicated study for a possible change in the focal number from the built $f/21.1651$ to shorter $f/\#$.

2. THE STUDY

In the present technical note we describe few possible scenarios for ITM telescope. The main driver is to provide a choice for a target $f/15$ and an alternative $f/10$. The study has several constraints: from the usual "be cheap", to a more severe "preserve the focal extraction" from the Nasmyth focus (see Figure 1).

The second one enforces a design that modifies the M2 mounting, moving the secondary mirror closer to the M1 position. It has several implications to be taken in account:

- the reduction of M1-M2 distance implies an increase of the M2 size, since it intercepts the optical beam coming from the primary mirror earlier than the original design;
- this increase in size implies an increased central obscuration and a consequent increase of the vignetting;
- this movement can cause a change in the M3 size, or a further vignetting;
- the change in the M2 position implies a change of the mechanical mounting;

Given such considerations, we focus only on the optical properties of the new M2 possibilities, considering the mirror mounting as free as possible.

The mounted M2 has a radius of -920.470 mm, a conic constant of -1.83 , is 130 mm of diameter and is 2005 mm far from M1; the $f/\#$ is 21.1651 . Figure 2 shows the optical quality measured through the spot size. Looking at the central field (number 5) the RMS is 15.942 μm , the GEO radius is 34.357 μm . Another figure of merit proposed is the Zemax plot "Field Curvature and Distortion". Figure 3 shows the two plots for the nominal configuration.

2.1 $f/15$

The first scenario is the $f/15$ focal ratio. We propose two possibilities, one with an hyperbola and the other with aspheric shape. For this scenario the M2 has to be moved at a distance from M1 of 1888 mm; 117 mm shorter than today. The mirror becomes 176 mm of diameter.

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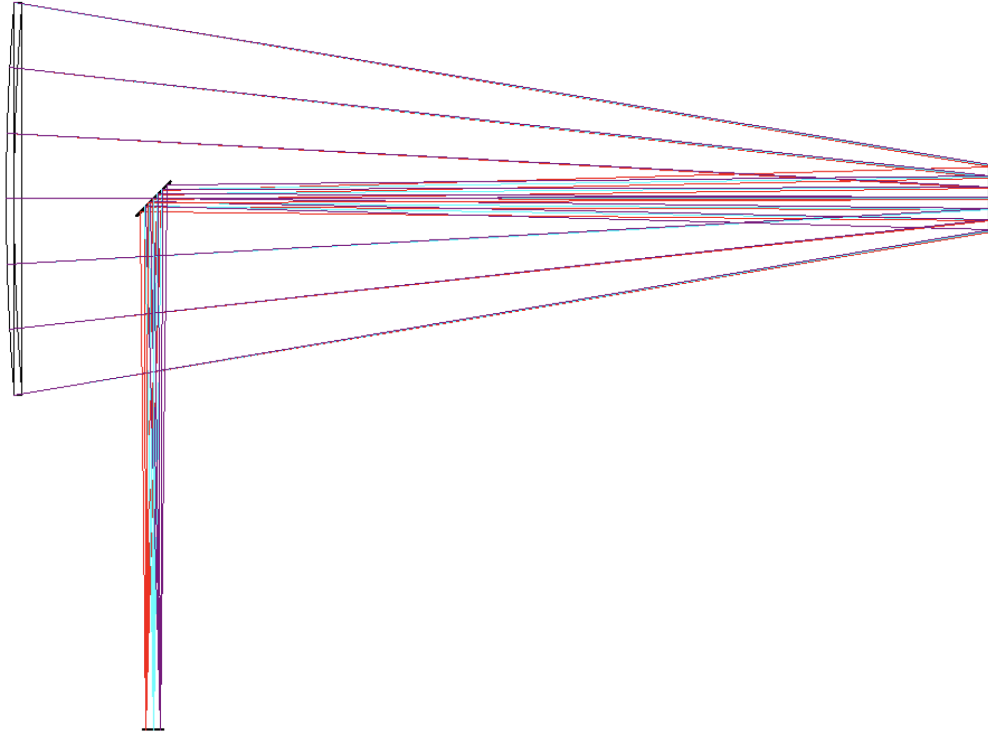


Figure 1. Zemax view of the ITM telescope layout.

2.1.1 Non-aspheric

The first hypothesis is based on a non-aspheric mirror. The radius of the mirror is 1267.195 mm , the conic constant is -2.177 , and the system will have a resulting $f/15.636$. Figure 4 represents the spot size for a $6'$ field of view. Looking at the central field, the RMS is $8.588 \mu\text{m}$, the GEO radius is $22.293 \mu\text{m}$.

2.1.2 Aspheric

The second hypothesis is based on an aspheric mirror. The radius of the mirror is 1267.191 mm , the conic constant is -1.586 , and the system will have a resulting $f/15.635$. Figure 5 represents the spot size for a $6'$ field of view. Looking at the central field, the RMS is $8.600 \mu\text{m}$, the GEO radius is $21.116 \mu\text{m}$. Aspheric terms are:

- 4th: -3.737 E-11 ;
- 6th: 2.697 E-16 ;
- 8th: -1.741 E-20 ;

Figure 6 shows the Field Curvature and Distortion for the two cases of the $f/15$ scenario.

2.2 f/10

The second scenario is the $f/10$ focal ratio. We propose again two possibilities, one with an hyperbola and the other with aspheric shape. For this scenario the M2 has to be moved at a distance from M1 of 1688 mm ; 317 mm shorter than today. The mirror becomes 243 mm of diameter.

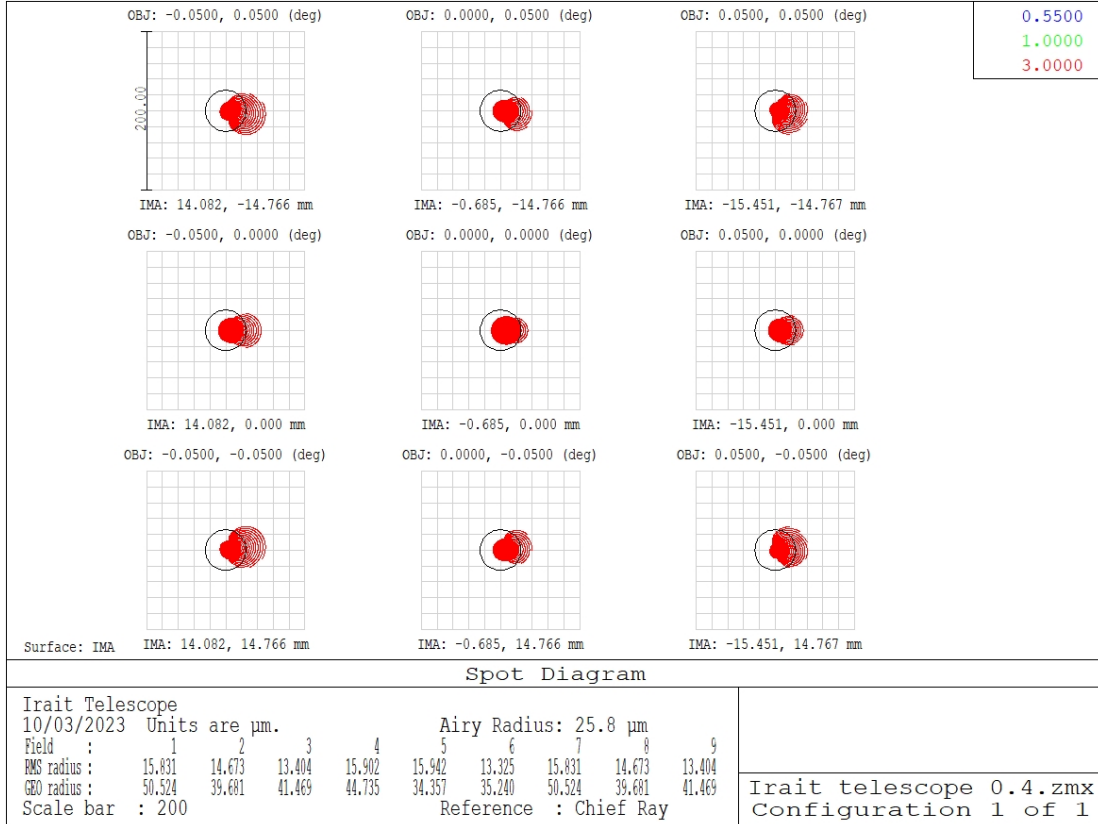


Figure 2. Nominal configuration spot size.

2.2.1 Non-aspheric

The third hypothesis is based on a non-aspheric mirror. The radius of the mirror is 2001.474 mm , the conic constant is -3.283 , and the system will have a resulting $f/10.398$. Figure 7 represents the spot size for a $6'$ field of view. Looking at the central field, the RMS is $5.251 \mu\text{m}$, the GEO radius is $13.093 \mu\text{m}$.

2.2.2 Aspheric

The fourth hypothesis is based on an aspheric mirror. The radius of the mirror is 2001.464 mm , the conic constant is -4.049 , and the system will have a resulting $f/10.404$. Figure 8 represents the spot size for a $6'$ field of view. Looking at the central field, the RMS is $5.275 \mu\text{m}$, the GEO radius is $11.939 \mu\text{m}$. Aspheric terms are:

- 4th: $1.136 \text{ E-}11$;
- 6th: $6.079 \text{ E-}17$;
- 8th: $-2.438 \text{ E-}21$;

Figure 9 shows the Field Curvature and Distortion for the two cases of the $f/10$ scenario.

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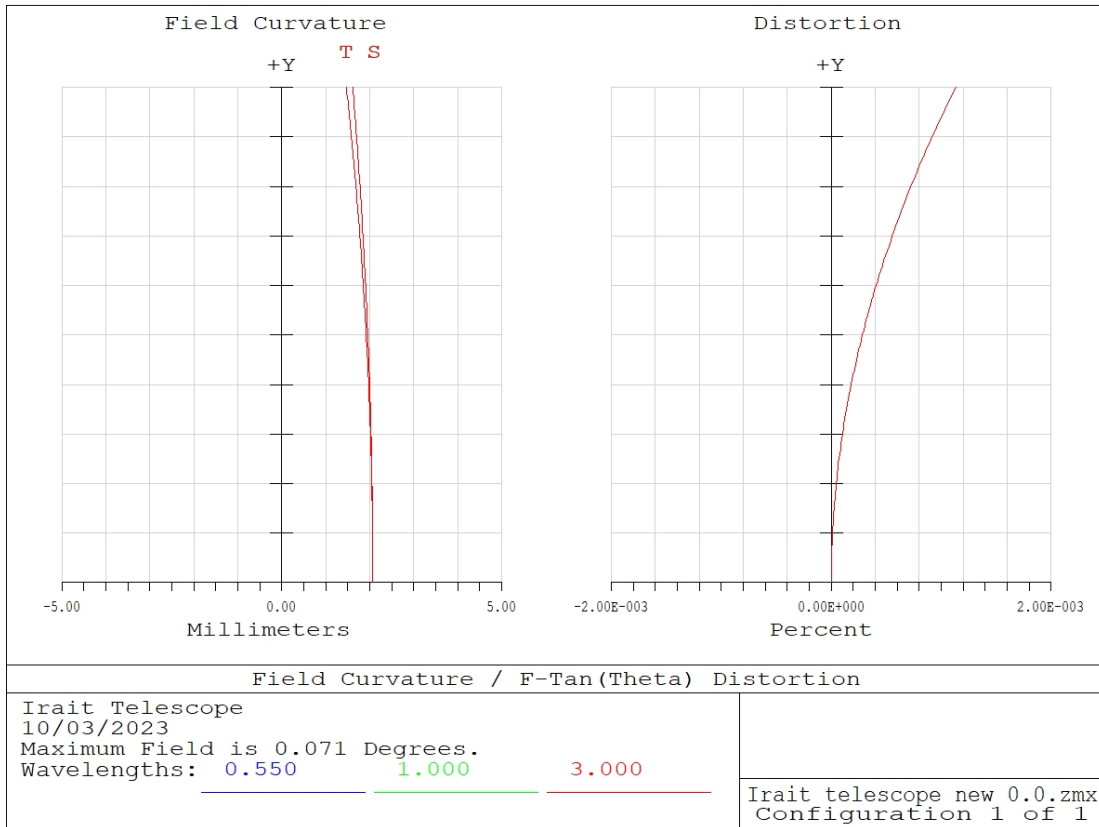


Figure 3. Nominal configuration plot for Field Curvature and Distortion.

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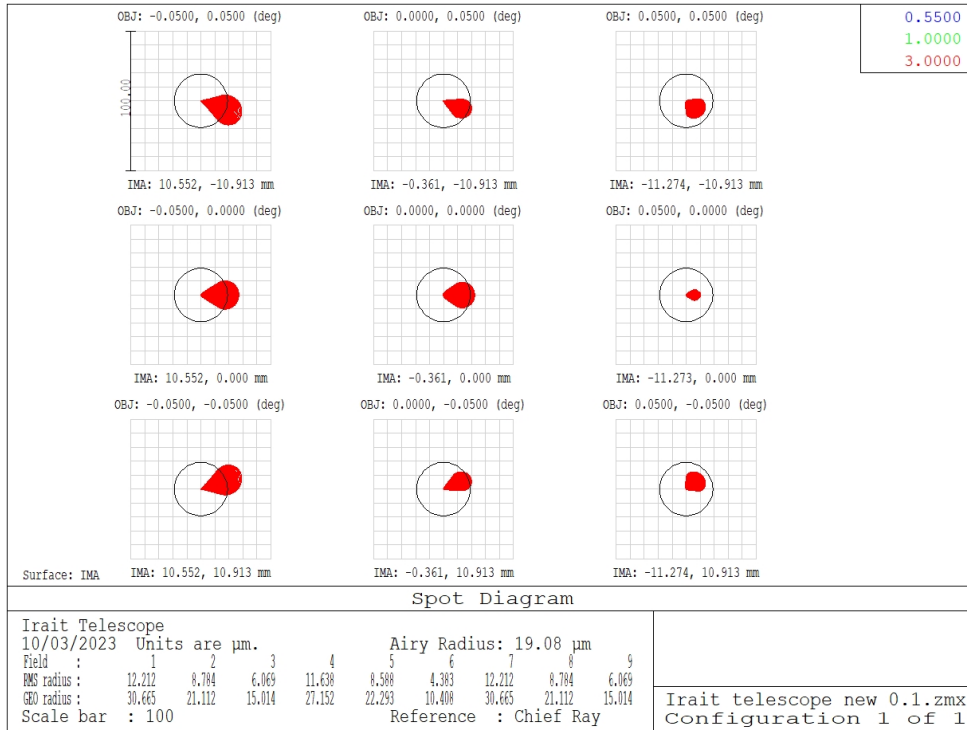


Figure 4. Non-aspheric f/#15 configurations spot size.

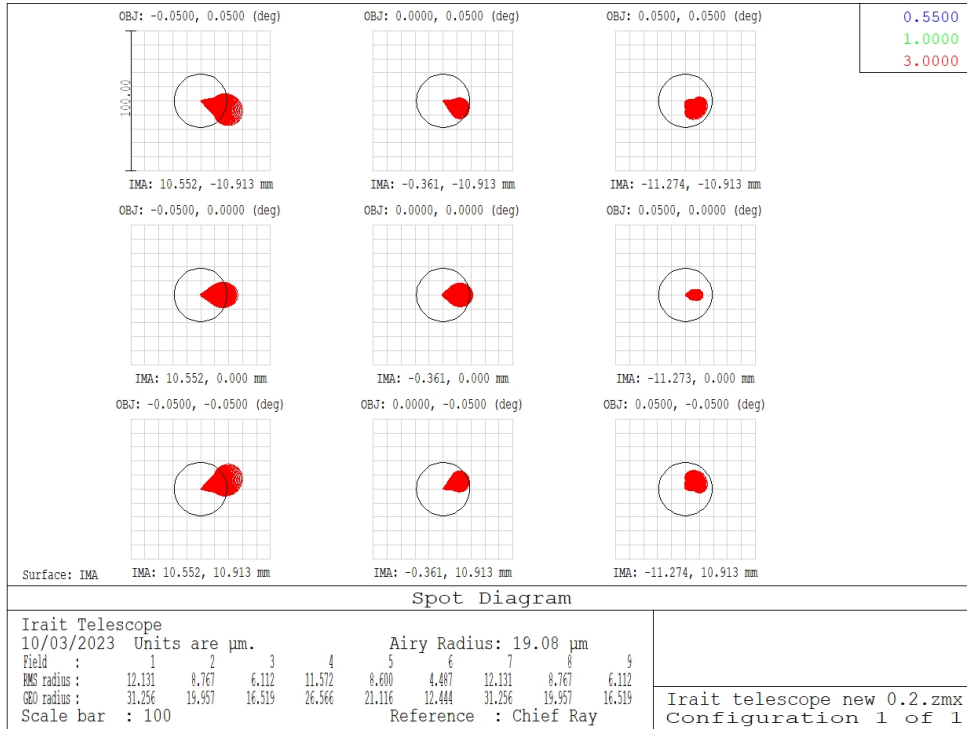


Figure 5. Aspheric f/#15 configurations spot size.

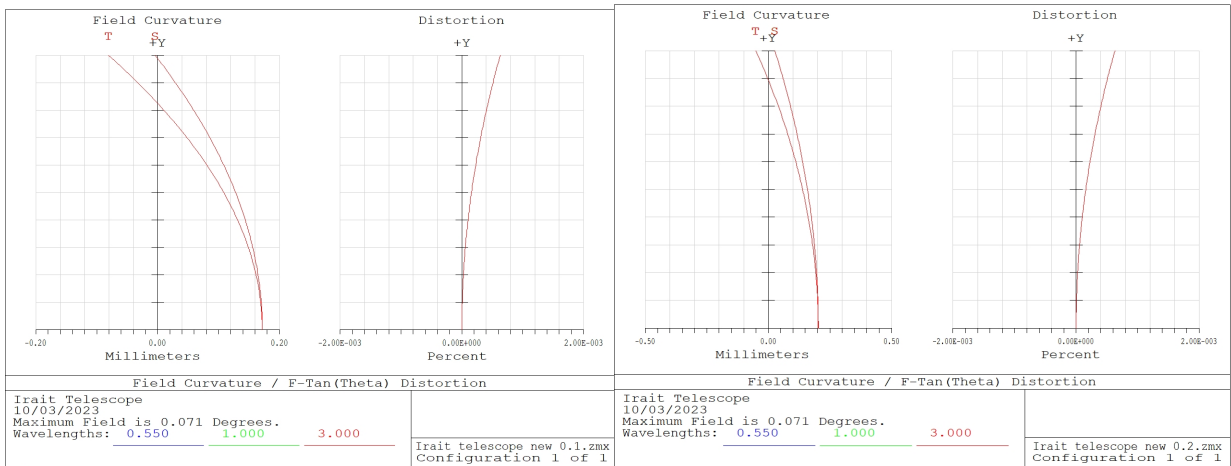


Figure 6. Field Curvature and distortion for the non-aspheric configuration (left panel) and aspheric configuration (right panel) in the f/10 scenario

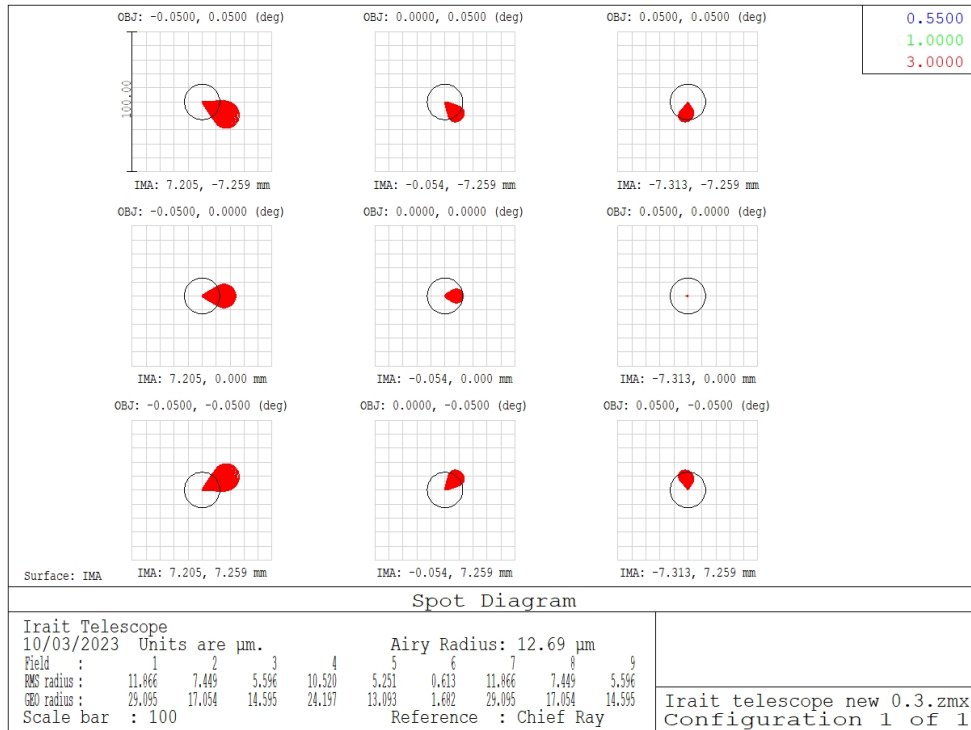


Figure 7. Non-aspheric f/#10 configurations spot size.

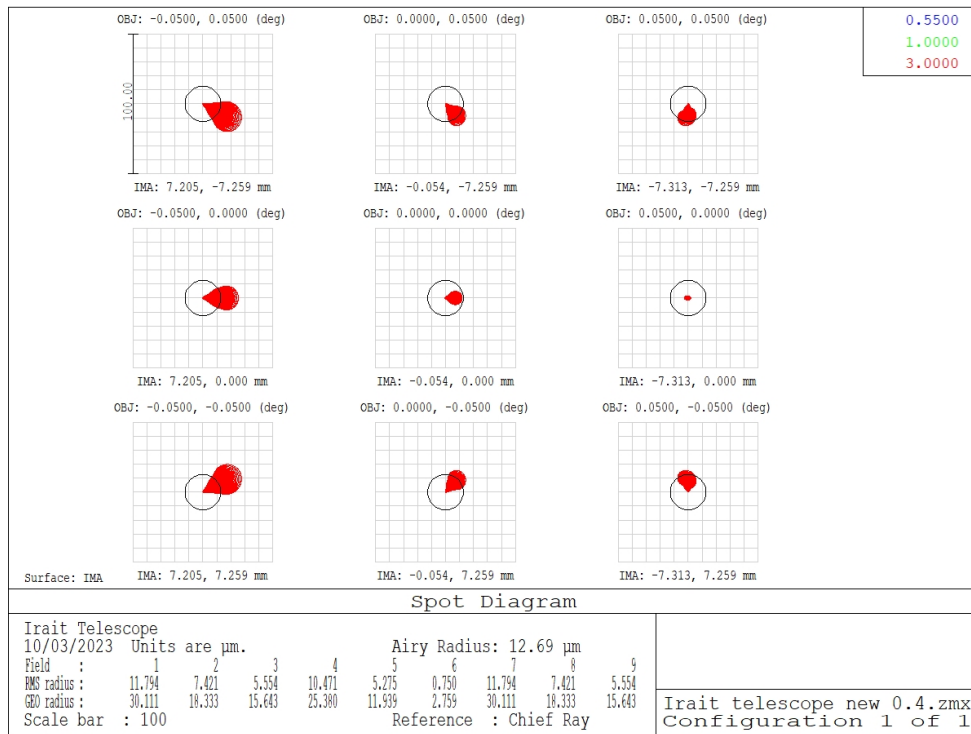


Figure 8. Aspheric f/#10 configurations spot size.

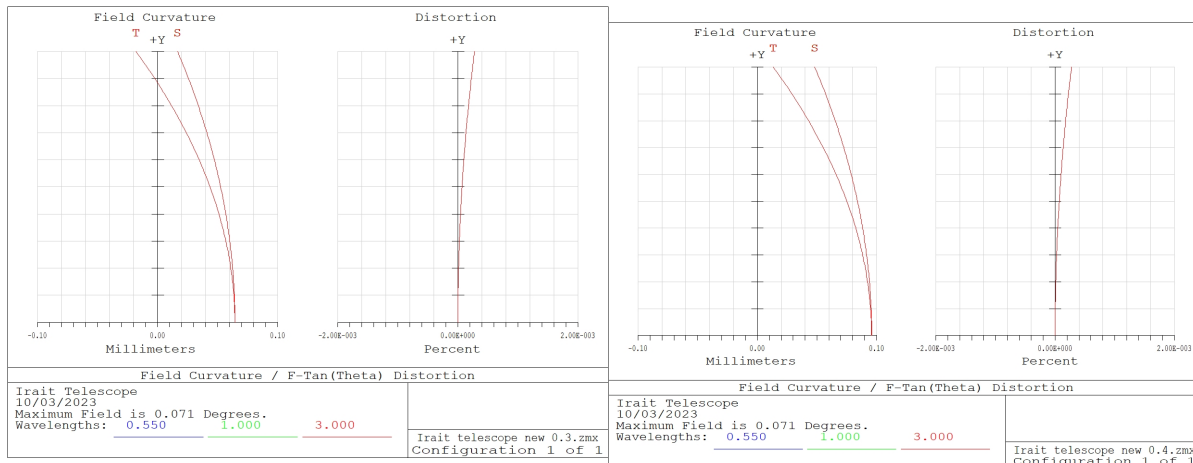


Figure 9. Field Curvature and distortion for the non-aspheric configuration (left panel) and aspheric configuration (right panel) in the f/10 scenario