

Interpretation of Telescope Diagram Reports

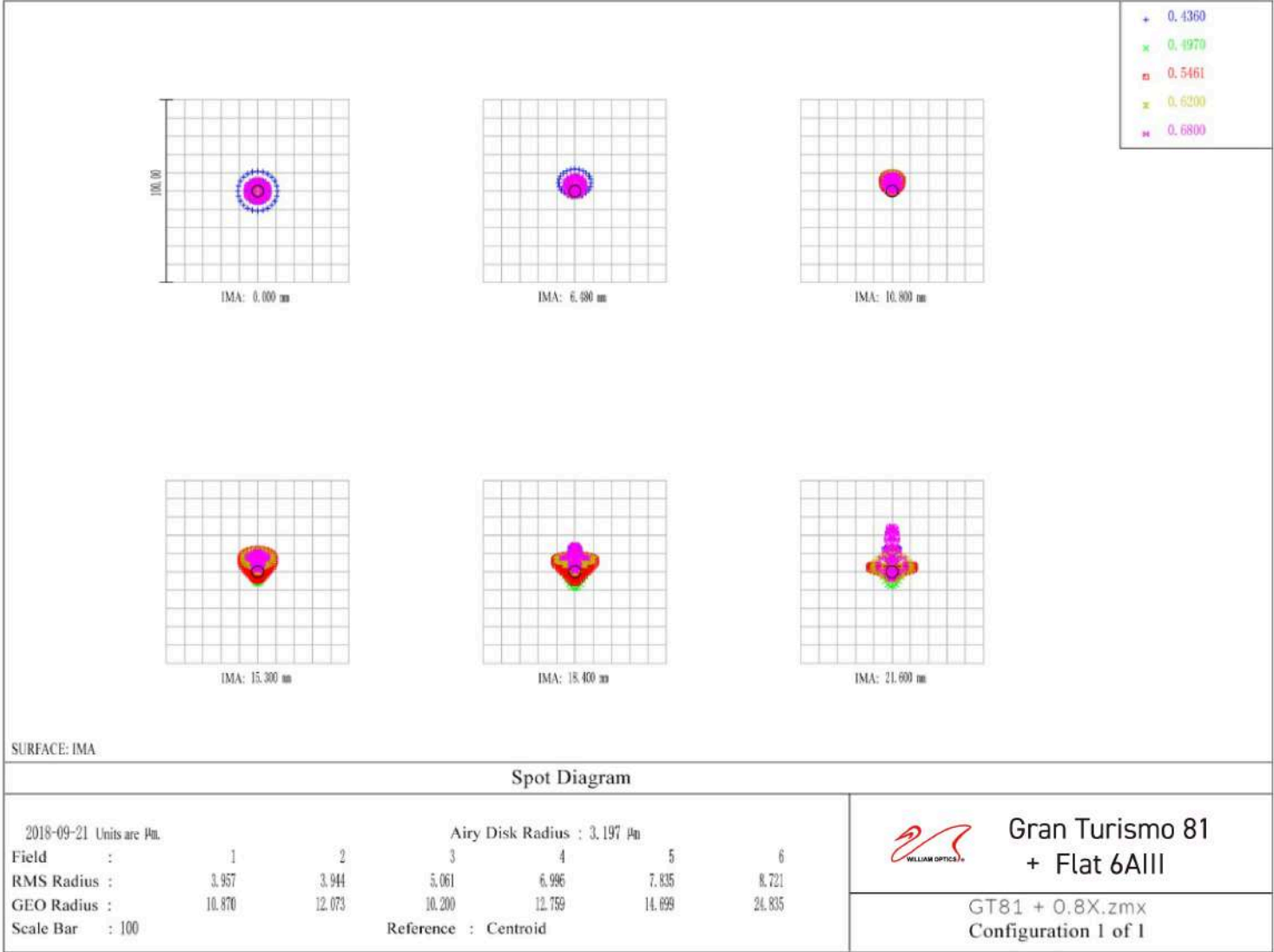
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When purchasing a telescope, you may encounter technical charts and reports that describe the optical performance of the instrument. These reports can feel overwhelming at first, but understanding them will empower you to make an informed decision. This guide will explain four key charts commonly included in telescope performance reports: the **Spot Diagram**, **Longitudinal Chromatic Aberration Report**, and **MTF Chart**.

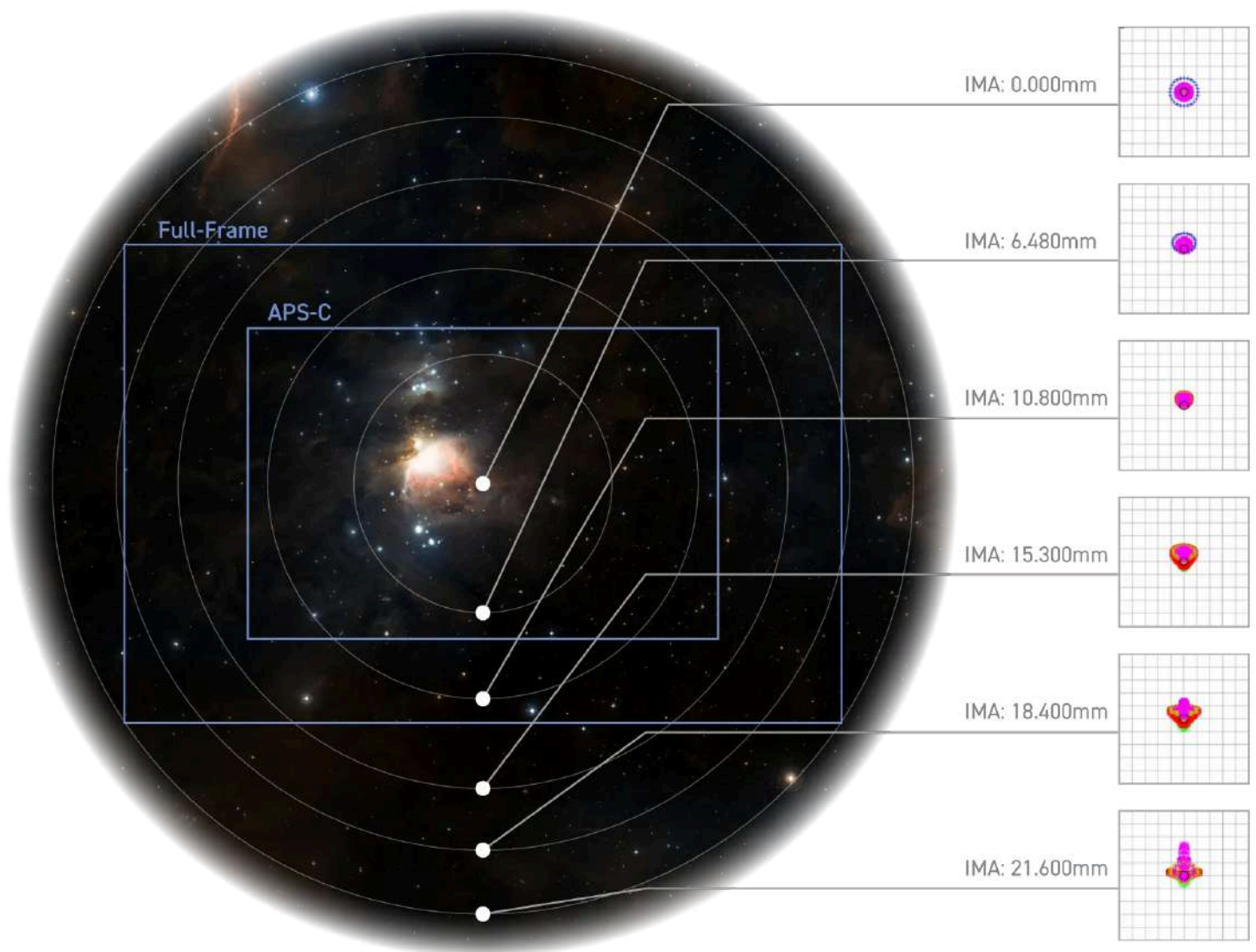
Spot Diagram

The Spot Diagram shows how well a telescope focuses light from different parts of the field of view, offering insights into its optical precision.

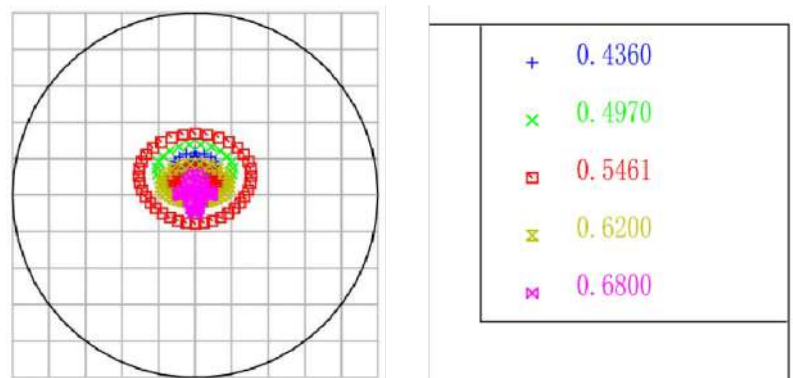
This is a typical Spot Diagram (I have selected a chart where the star point deformation is more noticeable, sourced from the William Optics GT-81 paired with the Flat6AIII):



At first glance, we see six spot diagrams (in cases of larger image circles, there might be more than seven). These diagrams are essentially extracted from six specific positions on the imaging plane. If we arrange them systematically, it becomes clear that:



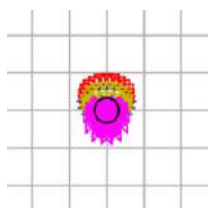
Next, you'll notice that each spot diagram is composed of symbols in various colors, each representing photons of different wavelengths (as indicated by the legend in the top-right corner). Light from different wavelengths passes through the lens system at varying angles, resulting in different degrees of refraction, which collectively form the patterns observed in the focal plane.



▲ Each Color represents a different wavelength

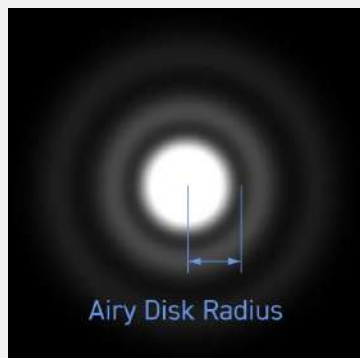
A compact Spot Diagram indicates sharp image quality. If the spots are significantly spread out, it suggests the telescope may suffer from optical issues such as **spherical aberration** or **coma**, which can degrade image clarity.

And the separation of different colors within the diagram reflects **chromatic aberration**.



If there is a black hollow circle at the center, it represents the size of the **ideal star point**. This circle is typically defined by the operator, as its size varies depending on the wavelength and intensity of the light. The value is usually derived from a general approximation of the intensity distribution across a typical wavelength.

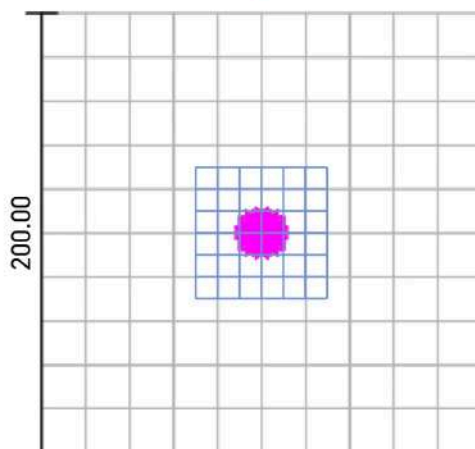
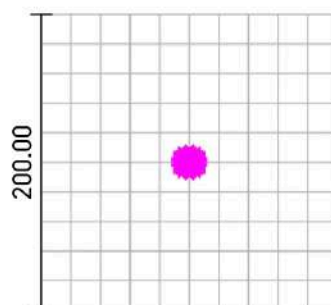
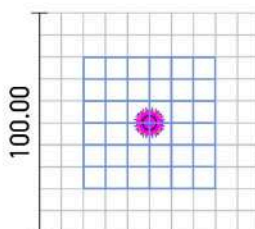
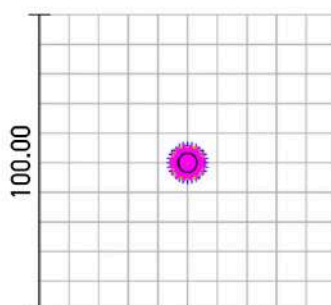
Note: You might wonder why the ideal image of a point light source at infinity has a measurable area. This is due to **diffraction** – parallel light beams passing through any aperture, including the large opening of a telescope tube, produce a concentric ripple pattern known as an **Airy disk**.



Scale Issue

When comparing spot diagrams, the most critical aspect is the scale of the chart. Similar to maps, each spot diagram includes a scale, typically indicated near the *IMA: 0.000 mm* position, with units often in micrometers (μm).

For example, in a diagram with a $100\ \mu\text{m}$ scale bar, the spots will appear twice as large as those in a diagram with a $200\ \mu\text{m}$ scale bar. Therefore, to ensure an accurate evaluation, diagrams must be resized proportionally when making comparisons.

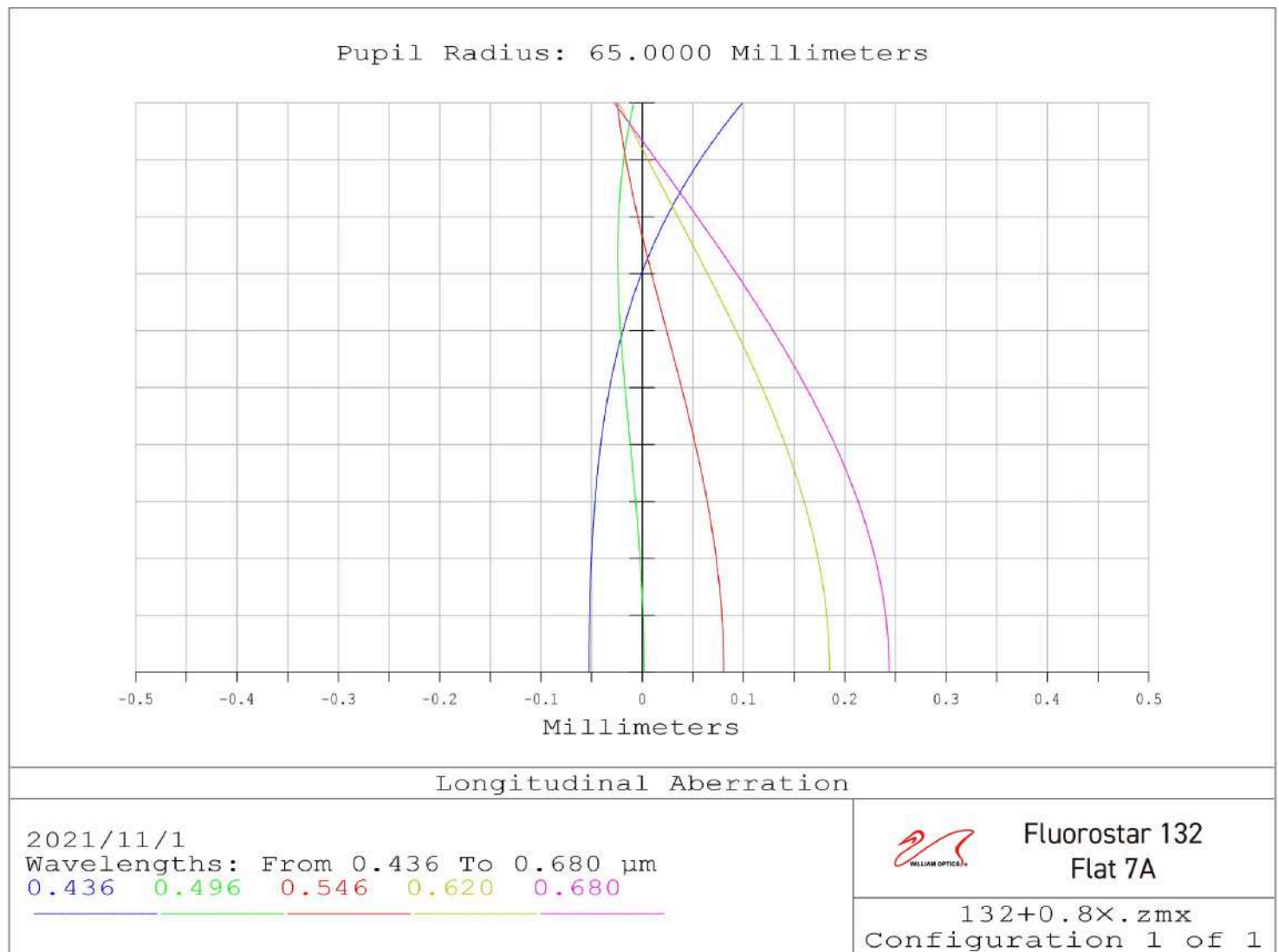


Longitudinal Aberration Report

A Longitudinal Aberration Report illustrates how well the telescope handles chromatic aberration, a common issue where light of different colors focuses at slightly different points.

Unlike the Spot Diagram, which analyzes the imaging of light sources from multiple directions, the Longitudinal Aberration Report focuses specifically on paraxial light. It examines the focal position distribution of different wavelengths on the lens, from the optical axis to the edge.

Below is a typical Longitudinal Aberration Report (sourced from the William Optics FLT-132 paired with the Flat7A):

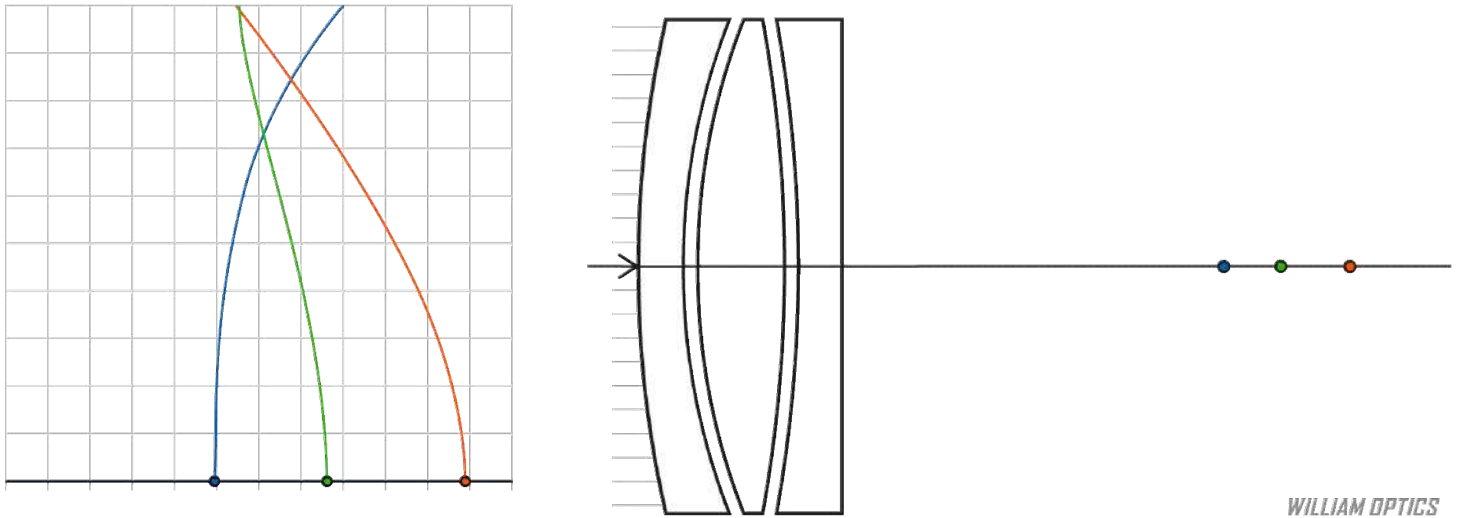


Each color in the diagram represents a different wavelength of light (with the legend located in the bottom left corner).

The **vertical axis** indicates the **off-axis distance**, where the bottom corresponds to the center of the lens, and the top represents the edge. This particular diagram illustrates the range from the optical axis (0 mm) to an off-axis distance of 65 mm for a telescope with a 132 mm aperture.

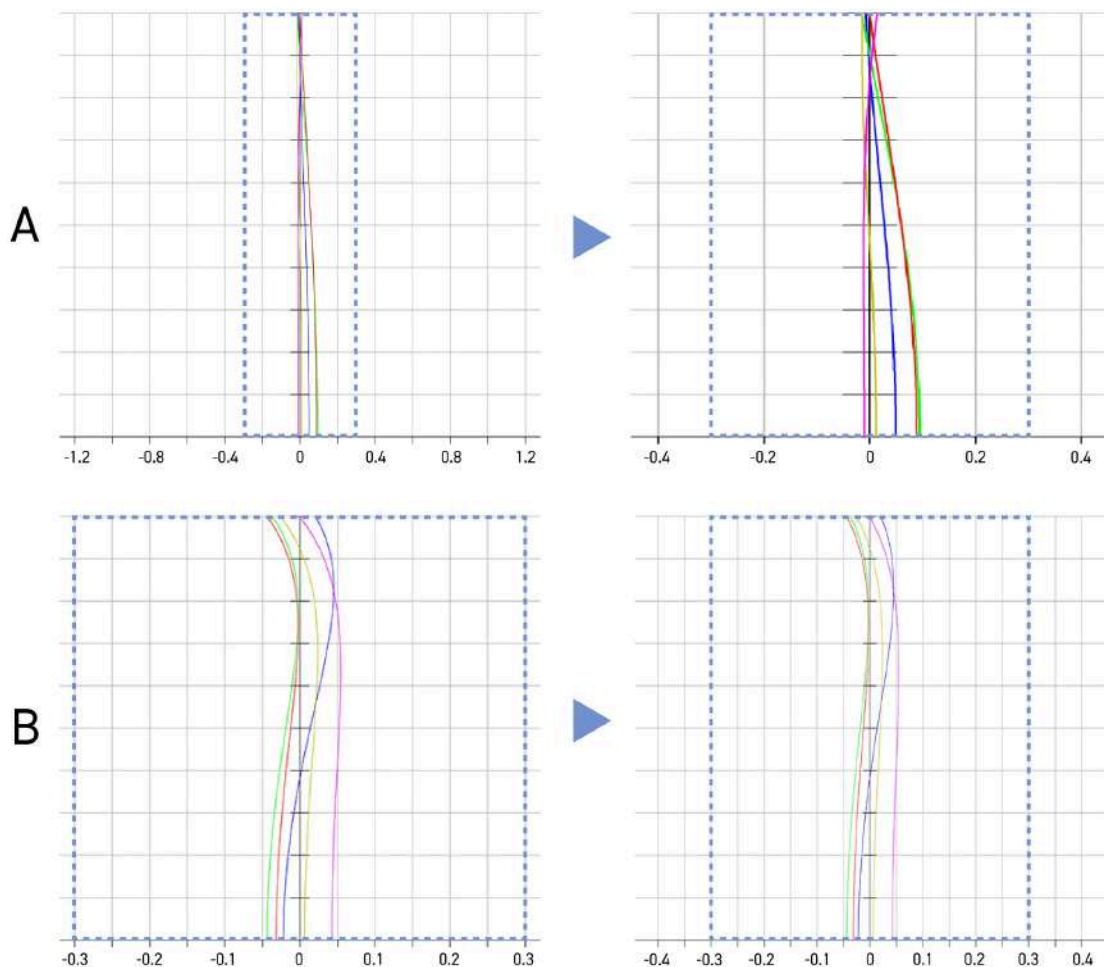
The **horizontal axis** represents the **relative distance of the focal point**, measured in millimeters. The origin (0) holds no specific significance in this context.

Let's visualize the complex description, which results in the following illustration (using red, green, and blue wavelengths as examples, with the lens configuration and scale shown for illustration purposes only and not representing the actual situation):



Thus, we can observe that **more concentrated lines indicate less chromatic dispersion**, resulting in a more perfect star point.

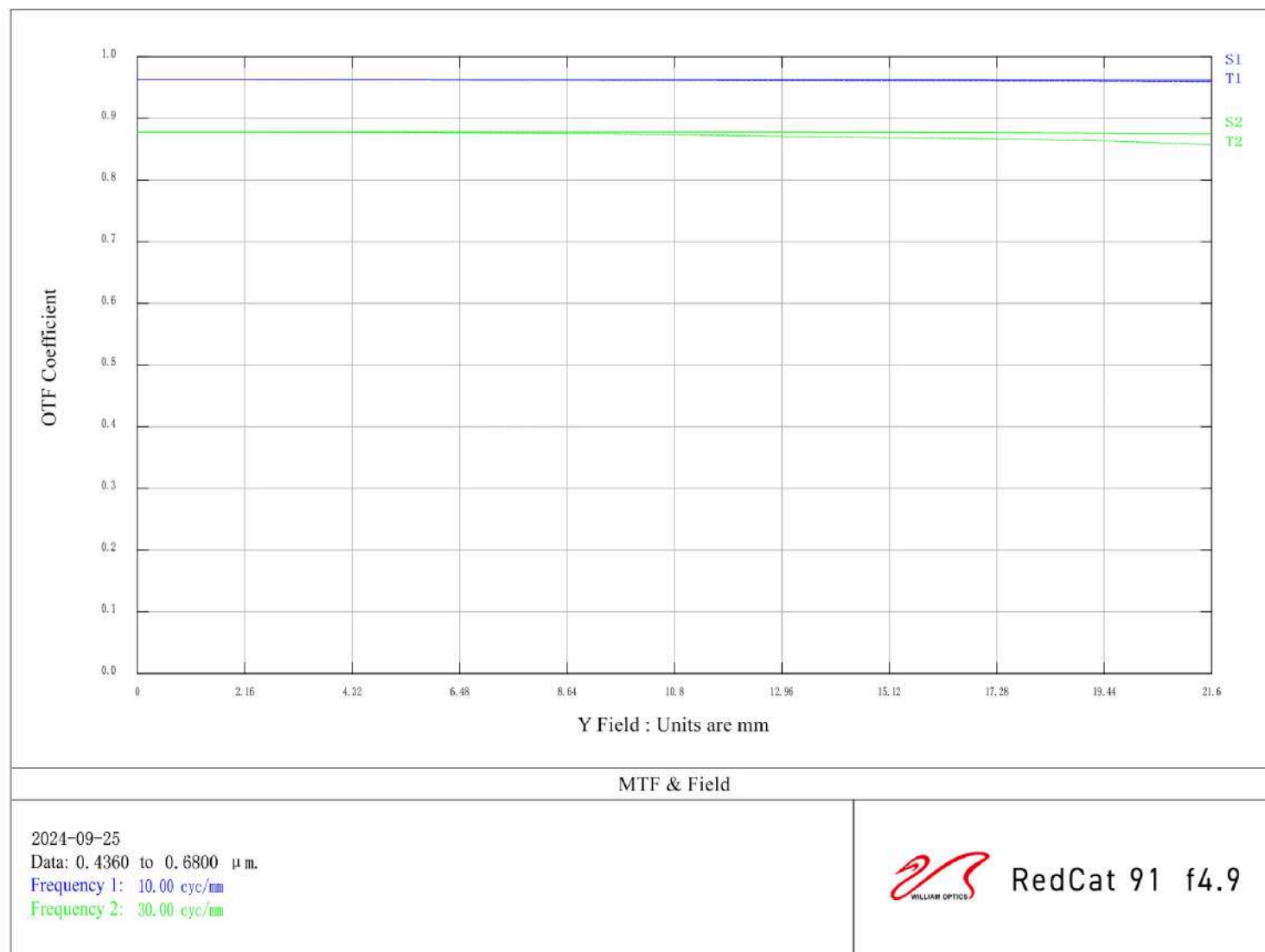
Of course, when comparing the diagrams, it is also essential to pay attention to the **scale** of the horizontal axis.



MTF Chart (Modulation Transfer Function)

The MTF chart evaluates how effectively a telescope preserves contrast and resolution at various levels of detail (spatial frequencies) across the image frame, from the center to the edges.

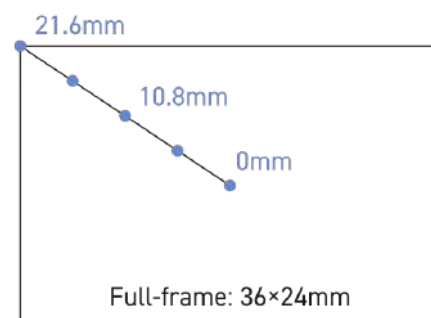
Below is a typical MTF Chart (sourced from the William Optics Cat-91):



The **vertical axis** represents the intensity of the Optical Transfer Function (OTF), ranging from 0 to 1 (or expressed as a percentage). A higher value indicates better **preservation of contrast** in the image.

The **horizontal axis** represents the **distance from the center of the sensor**, with the leftmost point (0) corresponding to the center of the sensor, and the rightmost point marking the sensor's edge.

In this example, the chart uses a Full Frame sample, so the maximum value is half of the diagonal length, which is 21.6 mm (half of the 43.3 mm diagonal).



The curves on the chart are represented by various colors and line styles, each signifying different aspects.

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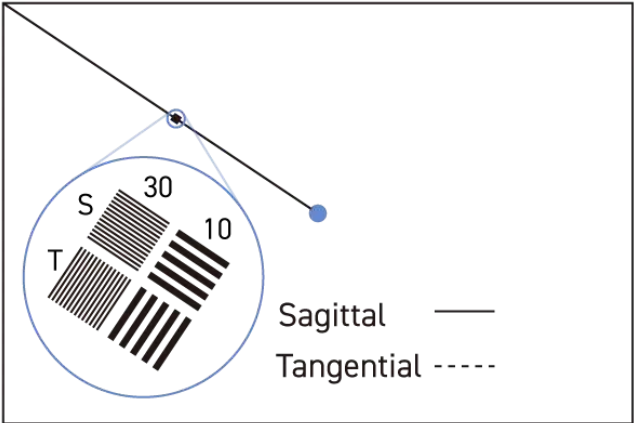
Data: 0.4360 to 0.6800 μm .

Frequency 1: 10.00 cyc/mm

Frequency 2: 30.00 cyc/mm

Different colors represent different **spatial frequencies**, measured in cycles per millimeter (cyc/mm), which indicate the number of complete light-dark cycles per millimeter. This can be thought of as **the density of image details**. Typically, 10 cyc/mm and 30 cyc/mm frequencies are analyzed. Low frequencies represent large-scale image contrast, while high frequencies represent fine detail resolution. Generally, lenses perform better at low frequencies than at high frequencies.

Within each color, there are **solid and dashed lines**, representing different orientations of light-dark regions. The solid line corresponds to the sagittal direction, and the dashed line corresponds to the tangential direction. **The better these two align, the smoother the image will appear.**



Thus, we can summarize some simple tips for reading MTF charts:

Feature	Meaning	What to Look For
Sagittal vs. Tangential	Radial vs. circular direction	Closer = better aberration control
10 cyc/mm	Low spatial frequency (contrast)	High values = excellent contrast
30 cyc/mm	High spatial frequency (sharpness)	High values = detailed sharpness
On-axis vs. Off-axis	Center vs. edges of the image	Smaller drop-off = better edges

Note

- In zoom or adjustable aperture lenses, the **MTF performance will vary due to changes in focal length or aperture**. This explanation is intended as a basic introduction focused on prime astronomical telescopes.
- **MTF ≠ Real-World Image Quality**: MTF is measured under controlled conditions and may not fully reflect real-world use. Factors like sensor resolution, focus accuracy, and post-processing also affect image quality.

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