

# THE BAADER BBHS-SITALL SILVER DIAGONAL

by: William A. Paolini, February 13, 2016



Fig 1: LEFT - Baader 2" BBHS Silver; CENTER - Astro-Physics 2" MaxBright Dielectric; RIGHT - Baader 2" Zeiss Prism.

## 1. OVERVIEW

The new Baader Broadband Hardened Silver (BBHS) diagonal, available as both non-T2 (pictured) and T2-threaded in 2" and as T2 in 1.25" sizes, promises to bring Silver back to the mainstream for diagonal mirrors. Silver has always been an excellent coating for mirroring surfaces, better than aluminum having higher reflectance across the visual spectrum with better transmission in the red color spectrum over aluminum. In addition, both silver and aluminum are easier to maintain a flat wave front since they have less layers compared to full dielectrics (even the tightest coating tolerances can become problematic when 100 or more layers are deposited as with dielectric mirrors). The disadvantage of silver however is that it is subject to tarnishing if not protected very well from moisture; but the new BBHS technology purportedly overcomes the tarnishing issue through the use of a dielectric overcoat to create a durable protective layer for the silvered mirror. With this dielectric overcoat the BBHS silver diagonal is purported to have the same life expectancy as high quality protected aluminum when cleaning is performed with the same care and attention recommended for all precision optical surfaces.

In addition to the use of silver for the mirroring, the Baader BBHS also uses Sitall glass for the mirror's substrate. Sitall is a crystalline glass-ceramic possessing ultra-low thermal expansion properties and a coefficient of thermal expansion of only  $0 \pm 1.5 \times 10^{-7}/^{\circ}\text{C}$  in the temperature range  $-60$  to  $60^{\circ}\text{C}$ . Sitall has been used in the making of primary mirrors for the Russian

Maksutov telescopes, was selected by Lytkarino Optical Glass Factory (LZOS) for the manufacture of the 91 primary mirror segments of the Southern African Large Telescope (SALT), and was used for the primary and secondary mirrors of the VLT Survey Telescope.

Baader claims their BBHS diagonals offer peak reflectivity over a much extended spectrum compared to conventional dielectrics. The typical premium-level dielectrics, like the Astro-Physics MaxBright diagonal and Baader Maxbright star diagonal, claim peak reflectivity in the visual spectrum from approximately 400nm to 700nm. The new BBHS technology claims extending that performance far into the infrared with peak reflectivity extending further into the visual spectrum past 700nm to far outside the visual up to 2000nm.

Diagonal	Size	Type	Reflectivity Claim	Wave Front Claim	Body Build
Baader BBHS	2"	Silver Mirror	Not specified	Not specified	Diecast and CNC Machined Magnesium
Astro-Physics MaxBright	2"	Dielectric	>99%	Inconsistent*	CNC Machined
Baader Zeiss Prism	2"	Zeiss Specification** Prism	Not specified, (Baader Phantom Group Coatings)	Not specified	CNC Machined

*Fig 2: Comparative diagonal features.*

- \* - Marketing on AP website makes no wave front claim. Reference to 1/10 to 1/20 wave over the portion of the mirror in the light path apparently based on forum conversations. No specification in these claims if this is before or after dielectric coating.
- \*\* - Per Baader Planetarium, many production divisions of the former government owned Carl Zeiss Jena have been privatized. The Zeiss core enterprise today concentrates on production of finished ultra-high end optical and medical devices. Many of the thousands of standard components are delivered to Jena "just in time" like any car factory works today. The opticians and skilled people that once made up the company are still alive (and kicking) and as a result many highly capable optical companies have developed in this region, still producing optics in the old Zeiss tradition. Baader has people employed who formerly worked at Zeiss Jena and they still use their contacts to existing optical shops there for the production of their prisms and all optical components for the Mark V binocular, all produced to the original exacting Zeiss specifications and processes.

## 2. BUILD, FORM FACTOR AND FEATURES

The Baader BBHS diagonal's all metal construction, which is magnesium for lighter weight and faster thermal acclimation, feels robust with excellent fit and finish. The 2" nose has a very shallow and narrow undercut and at no time did I experience any difficulties when removing it from the focusers on the Takahashi, Vixen, or APM/Lunt telescopes I used for testing. The Baader Clicklock mechanism provided outstanding operation, easily proving to be the most ergonomic method I have ever used to secure eyepieces into a diagonal. With a very short twist of the Clicklock mechanism eyepieces were securely held or effortlessly released.



*Fig 3: Bottom view.*

From a weight perspective, all three diagonals had a similar heft. I did not have a precision scale to do exact weightings, but their feel was very close with the Zeiss prism perhaps being slightly heavier than the other two. Internally, the Baader BBHS diagonal uses flat black micro baffling for light suppression in the nose piece, with side walls in the interior housing smooth and flat blackened.



*Fig 4: Top view of the Baader BBHS diagonal*

The BBHS diagonal I used for this test was not their T-2 version, but what they call the BBHS-Sitall Zenith Mirror diagonal (Baader product # 2456115). It comes standard with the 2" Clicklock mechanism at the eyepiece end and a 2" nosepiece for the focuser. While the nosepiece unscrews and uses threading like their other T-2 diagonals, the 2" Clicklock adapter does not attach using T-2 threads but is held in place by six small hex key set screws that secure themselves to a non-threaded housing.



*Fig 5: Disassembled for cleaning.*

Light path measures reveal the Baader BBHS, as configured, was the longest of the three diagonals (note that its light path length is approximately the same as the Baader Maxbright Dielectric as measured in my 2014 article: "*Mirror vs. Dielectric vs. Prism Diagonal Comparison*"). While longer, observationally I encountered no issue with running out of infocus using any eyepiece or with binoviewers with the optical corrector accessory (OCA) attached.

<b>Diagonal</b>	<b>Measured Light Path (mm)</b>
Baader Zeiss 2" Prism	100
Astro-Physics 2" MaxBright Dielectric	103
Baader 2" BBHS	112

*Fig 6: Diagonal light path measures.*

### 3. OBSERVATIONAL FIELD TESTS



*Fig 7: Baader BBHS diagonal on Lunt 152 ED-Apo with Pentax 30mm XW eyepiece.*

Observational testing was conducted in a suburban location in Northern Virginia, west of Washington, D.C., where the light pollution level varies, depending on the particulates and water vapor in the atmosphere, between light to moderate. Limiting magnitudes at this location vary on Moonless nights from magnitude 4 to magnitude 5.5. For this review the diagonal was tested in three telescopes over the course of several months:

- Lunt152 f/7.9 ED-Apochromat refractor
- Takahashi TSA-102 f/8 Super Apochromat refractor
- Vixen 81S f/7.7 Apochromat refractor

In the above telescopes, the primary eyepieces used for observing were the Pentax XW line and the Baader Morpheus line. The Baader Zeiss prism diagonal and the Astro-Physics MaxBright dielectric diagonal were included for comparison purposes as these two diagonals were used in the original diagonal comparison report in 2014 of twelve different diagonals, *Mirror vs. Dielectric vs. Prism Diagonal Comparison*.

#### 3a. Thermal Acclimation

Since my tests were conducted in the winter, my initial tests were related to thermal acclimation time. In my 2014 comparison of various diagonals, I noted that some diagonals exhibited astigmatism while they were cooling to the ambient outdoor temperatures. With a temperature delta of 28° F (i.e., indoor temp of 74° F and outdoor observing temp of 36° F), the time to acclimate where the on-axis image showed no levels of astigmatism were as follows:

<b>Diagonal</b>	<b>Time to Acclimate (minutes)</b>
Baader 2" BBHS	7.0
Baader 2" Zeiss Prism	9.5
Astro-Physics 2" MaxBright Dielectric	11.5

*Fig 8: Diagonal thermal acclimation times for a 28° F temperature delta.*

When the diagonals showed astigmatism while cooling, stars could not be brought to precise focus and the slightly defocused star showed the characteristic oval that changed orientation by 90° when defocusing between slight in-focus to slight out-focus. With its magnesium construction and virtually zero-expansion Sitall mirror, the BBHS showed the quickest cool down characteristics of the three diagonals. Interestingly, the amount of astigmatism during cool down was also comparatively small in the BBHS and Zeiss prism compared to the Astro-Physics MaxBright dielectric. As a result, both the BBHS and Zeiss prism showed the least amount of star point deformation during cool down. Of course, all scopes were fully acclimated showing perfect star points and airy disk patterns with no diagonals in the train before this test was conducted.

### **3b. Stray Light Control and FOV Illumination**

As noted in my 2014 test of various diagonals, not all diagonals maintain a fully illuminated field of view (FOV) when using a 2" eyepiece that has a field stop that renders the maximum true field of view (TFOV) capability of the 2" barrel. For this test, I used the Pentax 40mm XW with a field stop of 46.5mm. All diagonals presented a visual FOV that appeared well illuminated with no detectable vignette of the FOV or dimming near the field stop. The field stop also showed sharp and distinct with all diagonals. At no time were any stray light artifacts observed during the testing.

### **3c. Scatter**

In my 2014 diagonal comparison, I assessed that the Baader Zeiss prism diagonals tested and the Vernonscope Silver diagonal were the ones that showed a markedly less amount of scatter compared to the dielectrics and aluminized diagonals tested. While the premium dielectrics like the Astro-Physics MaxBright and Baader Maxbright dielectrics were better relative to scatter than other dielectrics, they still showed more scatter than the Baader Zeiss prisms and Vernonscope silver. Using the same Astro-Physics MaxBright diagonal from that test in this current test, the Baader BBHS visually showed a level of scatter that was slightly less. However, the Baader Zeiss 2" prism diagonal still slightly less scatter than the BBHS. As example, scatter halos around stars and planets showed slightly less extent and slightly less brightly in the BBHS

compared to the dielectric. This difference was close, but still visually detectable. And where the scatter difference apparently had more impact was in observing close double stars. Using the 81mm Vixen 81S Apo with a low power eyepiece so the split of Rigel was more difficult, through the dielectric the separation was just observable with a very slim line of gray-black separating the two stars. With the BBHS the visual of the split appeared very different, with the gray-black region between the stars being more fully black and also thicker, making the split observation all the easier. Moving to some closer doubles in Orion, the results were consistently similar. One one double in Orion that was too close to split at the magnification I was using so that it appeared as just a non-descript elongation of a single mass through the dielectric, with the BBHS this same double showed instead as two distinct touching balls. This improved performance was very exciting to see. My presumption is that this performance difference was due to narrow angle scatter differences nearest the stars, but it could very well be other factors that are involved. Regardless of what the main driver for the difference is, scatter or some other attribute, what was important was that the BBHS was more effective at splitting close doubles and provided a more enjoyable observation as a result.

### **3d. Faintest Stars and Nebula**

For this test I approached it two ways: first I observed clusters with faint stars to see if any of the faintest threshold stars showed in one diagonal any better than another, and secondly I observed the greatest extent of nebula that were visible (i.e., did any diagonal show nebula extending to a further extent). Many amateurs in casual discussions usually refer to differences like this as being due to transmission differences. However, although transmission may indeed be a player, it must be realized that other factors can also contribute, such as contrast and scatter. So rather than getting bogged down in trying to determine the optical or manufacturing drivers behind any observation outcome difference, it is best in my opinion to just focus on the observations.

Looking for faintest stars, I observed the Double Cluster, the Orion Nebula, and the open clusters in Auriga. I was not expecting much of any differences relative to seeing faintest stars as all the diagonals were top shelf equipment. To my surprise however, I discovered differences immediately. When observing the Double Cluster, the faintest stars that were at the threshold of vision and only detectable with averted vision in the BBHS and Zeiss prism, were completely invisible in the Astro-Physics dielectric! This performance difference was repeated observing other open clusters and was repeatedly encountered when observing the Trapezium in M42, where the F component remained illusive in the dielectric but was plainly visible in the BBHS and to a slightly lesser extent in the Zeiss prism.

Moving to M42 and M43 to observe any differences in the extent of their nebulosity, the BBHS and Zeiss prism both showed more of the wings of M42 extending into the distance, and more pronounced and brighter nebulosity around M43. The caveat relative to nebulosity though is that when the magnification was lower and exit pupils larger, all three diagonals appeared to perform the same. So it was only when more magnification was employed that the performance differences presented themselves. In the case of the Orion observation, the nebula looked visually the same when operating at an exit pupil of 1.25mm using a 10mm XW eyepiece (120x in the Lunt 152 and 82x in the TSA-102). However, when I switched to a 5mm XW with a resulting 0.63mm exit pupil in both refractors, the nebulosity of M42 extended notably further

when observed through the BBHS or Zeiss prism than through the Astro-Physics dielectric. The Zeiss prism showed the furthest extent of the nebulosity, but it was only very slightly more.

### **3e. Rendition of Colors**

Initially I had not planned for any testing of how colors were portrayed by any of the diagonals. My presumption was that they should all be relatively the same so I doubted there would be any notable differences to warrant a test. This all changed when I began my planetary testing observing Jupiter. On my first evening out observing Jupiter, I used the Astro-Physics dielectric diagonal first. The observation was excellent with Jupiter giving up a ton of details through the Lunt 152 Apo. The GRS was also well in view in all its swirling glory. When I switched to the BBHS diagonal, I was shocked as the view was obviously different, and the GRS appeared markedly more saturated displaying a beautifully bright and rich red-pink color! This richer color of the GRS was not slight at all, making it appear surprisingly more contrasted and colorful against its surroundings. In comparison through the dielectric, the GRS looked lackluster and pale in comparison and much less contrasted to its surroundings. I switched diagonals several times, and repeated the observations on other evenings and the difference remained. The BBHS silver mirror was definitely showing colors more vividly than the dielectric, and even a little better than the prism as well. After seeing this performance relative to colors, on other evenings I decided to observe several clusters that contained orange-red stars, like those within M37 as example. Now attuned to look for how vividly colors are shown, it was apparent that the silver diagonal was doing an exceptional job compared to the dielectric as all the clusters I visited showed their orange and red stars much more vividly. Seeing all these star colors so much better then reminded me of a quote from Vincent van Gogh where he said, "*The night is even more richly coloured than the day... If only one pays attention to it, one sees that certain stars are citron yellow, while others have a pink glow or a green, blue and forget-me-not brilliance. And without my expiating on this theme, it should be clear that putting little white dots on a blue-black surface is not enough.*" Sometimes we get so caught up in the details, we forget about the colors. Using the BBHS definitely reminded me just how colorful many targets can be when all components of the optical train are up to the task.

### **3f. Image Crispness**

My final tests were relative to how sharp or crisp the views were between the diagonals, and if there were any differences readily visible between them. For these tests I limited them to lunar and planetary (Jupiter) observing only to make the assessment. Overall, all three diagonals produced what I felt were equally sharp and distinct views with no notable differences. Aside from differences in contrast and color saturation, all diagonals showed sharp and crisp views from low to higher magnifications of approximately 250x.



## 4. CONCLUSION

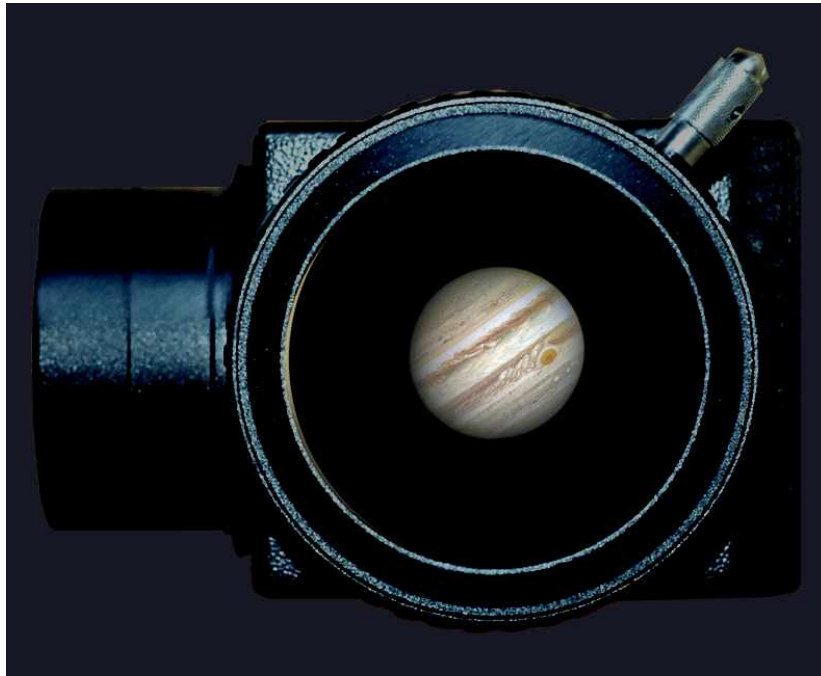


Fig 9: Image inset: Jupiter; NASA, ESA, and A. Simon (Goddard Space Flight Center)

The purpose of this evaluation was to test the performance of this latest offering from Baader relative to the diagonals I previously tested in my 2014 report, *Mirror vs. Dielectric vs. Prism Diagonal Comparison*. In that previous comparison there was a silver diagonal that proved to be exceptional, but with a prohibitive cost, the Vernonscope 1/20th wave quartz star diagonal. The new Baader BBHS technology was therefore intriguing as it promised the performance of silver without the purported longevity worries and at a price commensurate with the non-silver competition.

Overall, all three diagonals provided superlative results with earned reputations. However, the Baader BBHS dielectric protected silver diagonal distinguished itself by pulling in fainter stars, showing minimal scatter, and presenting colorful stars and planetary features more richly colored, with its silver technology besting the defacto standard for high performance dielectric diagonals. Its Clicklock mechanism provided a level of ergonomic ease far surpassing other locking technologies I have used. It clearly demonstrated low levels of perceived scatter, the ability to bring into view the dimmer of stars in clusters than the other diagonals, the ability to make more authoritative double star splits, and the ability to show the faintest extents of nebula. All these attributes were highly welcomed and they clearly enhanced my observations. Most surprising however, was how brightly and vividly the BBHS technology portrayed the colors of stars and of planetary features, showing colors more richly saturated and more beautifully bright than even the best dielectric technology diagonal could muster. The views through the BBHS of brightly colored stars accentuated in familiar clusters, and of a richly colored GRS coursing its way across Jupiter were nothing less than truly memorable.

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## About the Author



**William "Bill" Paolini has been actively involved in optics and amateur astronomy for 45 years, is author of the desk reference on astronomical eyepieces: *Choosing and Using Astronomical Eyepieces* which is part of the Patrick Moore Practical Astronomy Series published by Springer of New York, has published numerous product reviews on major online amateur astronomy boards, and volunteers with public tours at a famous vintage Clark refractor site.**

**Bill's professional background is as an officer in the U.S. Air Force and as a computer scientist, holding a Bachelor's degree in Computer Science and a Master of Science in Education. He has worked for the U.S. Department of Defense, the U.S. Department of Commerce, the Federal Trade Commission, the Federal Reserve, the World Bank, and a variety of commercial corporations in the information technology, information technology security, and telecommunications industries.**

**Bill has been observing as an amateur astronomer since the mid-1960's, grinding mirrors for homemade Newtonian telescopes during the 1970's and eventually owning, using, and testing several hundreds of eyepieces in a wide variety of telescopes from Achromatic and Apochromat refractors to Newtonian, Maksutov-Cassegrain, and Schmidt-Cassegrain designs. Today he enjoys observing and testing new equipment from his suburban home west of Washington, D.C., where his primary amateur astronomy pursuits are lunar, planetary, bright nebula, open cluster, and globular cluster observing.**

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