

# Eyepiece Selection Help Sheet

**Magnification = (Telescope Focal Length) / (Eyepiece Focal Length).**

True-Field of View (TFOV) ~ (Apparent Field of View)/(Magnification), -OR-  
TFOV ~ (AFOV x Eyepiece Focal Length) / (Telescope Focal Length)

**NOTE: Both of the above formulas are close approximations.** If you know the eyepiece's field stop,  
TFOV = (Field Stop) \* (57.3) / (Telescope Focal Length)

**Eye Relief**—at least 15mm of eye relief is recommended for eyeglass wearers. Eyeglasses are a necessity if you have astigmatism, especially at low powers. Even without eyeglasses, eye relief under 10mm is a bit tight.

**Exit Pupil = (Eyepiece Focal Length) / (Telescope f-ratio).** Our pupils can dilate up to around 7mm, decreasing to around 5mm as we age. An eyepiece that generates a higher exit pupil than what one's pupil width effectively wastes aperture.

EXAMPLE: Suppose we have an 8" f/6 (focal length = 1,200mm) telescope with 30mm, 20mm, 12mm, and 8mm eyepieces. Our magnifications would be 40X (1,200mm/30mm), 60X (1,200mm/20mm), 100X and 150X. Our exit pupils would be 5.0mm (30mm/6), 3.3mm (20mm/6), 2.0mm, and 1.3mm.

Suggested exit pupils:

5-7mm: Very low power, typically for maxing out true field of view.

3-5mm: Low power, good for all extended objects

2-3mm: Best overall compromise of magnification, sky contrast and image brightness on a variety of deep-sky objects. **Prioritize your eyepiece budget/selection in this range.**

1-2mm: Best for small deep-sky objects (particularly planetary nebulae), resolving clusters and planetary work

<1mm: Best reserved for steady nights with planets and double stars. Image brightness too low for most nebulae and galaxies.

*NOTE: If you have a coma corrector, be aware most have an amplification factor when calculating exit pupils. A Televue Paracorr increases your telescope's effective focal length (and, thus, f-ratio) by 15%. A 10" f/4.7 with a Paracorr is effectively a 10" f/5.4. Likewise, an f/10 Schmidt-Cassegrain with a 0.63X focal-reducer acts as an f/6.3 optical system. Also, be aware most focal reducers will often vignette low-power widefield eyepieces, particularly those > 30mm focal length.*

Focal length selection—this is more of a personal preference, but here are some of the core principles of a good eyepiece line-up: Your “clutch” eyepiece should yield a 2-3mm exit pupil. Buy used to save money. Buy a good barlow lens. Not all nights have steady skies, so let your highest powers (>300X) come via eyepiece + barlow vs. eyepieces alone. A 1.4X ratio between your two most used eyepieces (say, 14mm and 10mm pairing, or a 17mm and 12mm pairing) helps immensely, since a common 2X barlow can extend that ratio two additional focal lengths (14mm, 10mm and 2X barlow = 14mm, 10mm, 7mm and 5mm). Avoid stockpiling low-power eyepieces. FAR more objects are best appreciated with medium/high-powers vs. low-power.

## I. PLOSSL AND ORTHO EYEPIECES:

Televue Plossls—8mm, 11mm, 15mm, 20mm, 25mm, 32mm, 40mm, and 55mm focal lengths. All 1.25", 50°-AFOV except 40mm (43°-AFOV) and 55mm (2"-barrel). World-renowned sharpness and contrast, and very reasonably-priced for Televue eyepieces! Most retail for \$100 or less. The 55mm retails for ~\$200 and best reserved for slow refractors and SCT's. Most used prices are \$70-\$80.

CLONES: Um...everyone. EVERYONE. I'm only half-joking.

Astro-Tech Hi-Grade / Sterling Plossls (recently discontinued)—GREAT bang for the buck. These are 5-element, 1.25"-eyepieces with focal lengths of 4mm, 6mm, 12.5mm, 17mm and 20mm and a 55°-AFOV. A touch soft at the edge (not bad) in fast scopes like 8"+ dobsonians, but very good contrast for the price...which is typically \$30-\$40 new.

Zhumell Z-Series / Orion Edge-On Planetary Series—Another “unsung” series. All 1.25"-barrels, 55°-AFOV, but their 7-element design and 20mm of eye relief sets them apart. Decent performance even in fast scopes. Focal lengths of 3mm, 5mm, 6mm, 9mm, 12.5mm and 14.5mm. Prices very reasonable, all under \$100 new.

“Musayama Clones” (most discontinued, but often pop up in the used markets)--Orion Ultrascopic, Celestron Ultima (not the LX variety), Parks Gold Series, Baader Eudioscopic, Antares Elite, Takahashi LE. 5-element eyepieces with 52°-AFOV with eye-relief on par with similar focal-length plossls, but with better edge correction vs. most plossls. Common focal lengths are 3.5mm, 5mm, 7.5mm, 10mm, 15mm, 20mm, 25mm, 30mm, 35mm (49°-AFOV). Retail ~\$100 new. Used Orion Ultrascopics and Celestron Ultimas go quick on Astromart or Cloudy Nights Classifieds. **The “parent series”--the original Musayama design from mid-1980s Japan--is HIGHLY prized in used markets and often go for \$300+/each.**

Vixen SLV Eyepieces—all 1.25"-eyepieces with a plossl-like 50°-AFOV, but 20mm of eye relief across all focal lengths, which are 2.5mm, 4mm, 5mm, 6mm, 9mm, 12mm, 15mm, 20mm and 25mm. Retail ~ \$170/each. Initial reviews very promising.

Vernoscope Brandons--Very similar to plossl design, ~45°-AFOV. Only single-coated elements vs. multi-coatings by competition, but highly-polished and renowned for planetary and double-star performance. 48mm (2") is a rare bird.

Zeiss Abbe Orthos (I and II)--45° AFOV. The **ultimate** planetary eyepiece and the standard by which all other planetary eyepieces are judged. Both series have unbeatable coatings, contrast, transmission, on-axis sharpness...and cost!! They're legendary, discontinued, come from a prestigious firm, and are thus **EXTREMELY** expensive; selling from \$600 - \$1,000 on used market. The 34mm (ZAO-I only) can net \$2,000 itself. Even the walnut carrying case goes for \$200 on the used market!

Pentax XO and Pentax SMC orthoscopes: very close to ZAO's; insanely sharp on-axis, world-renowned planetary performance...oh, yeah, and PRICE.

Baader Genuine Orthos (~\$85 retail), University Optics Super Abbe (\$60) and H.D. Abbe (\$95), Hutech (discontinued). All are excellent performers on planets, won't swallow your mortgage payment, and are a worthy addition to your eyepiece stable if you have a driven scope.

## **II. 60°-CLASS EYEPIECES:**

Televue DeLite--62°-AFOV, 20mm ER, 1.25"-only barrels. Focal lengths (some new for 2016): 6mm, 7mm, 9mm, 11mm, 15mm and 18.2mm. Retail around \$250 / \$200 used. Outstanding on- and off-axis sharpness. Identical eye relief and barrel size as Televue Radians (60°-AFOV, recently discontinued), but with neutral color-tone. **Aftermarket Radians are good alternatives to DeLites.**

Orion Epic II / AstroTech Paradigms / Celestron X-Cel LX / Meade 5000 HD-60°, to name a few. In the 60° class, there's a *gazillion* Chinese-manufactured eyepieces that appear to be from the same clone batch of 1.25"-eyepieces with focal lengths of 5mm, 8mm, 12mm, 15mm, 18mm and 25mm with around 15mm of eye relief. Most are reasonably-priced around \$65 new and are decent performers even in fast (<f/6) scopes. **One of the better bargains out there, especially if you're looking to upgrade from the plossls supplied with your new telescope, but are on a budget.**

Meade 5000 Super Plossl –These are labeled as plossls, but they are in reality 5-element, 60° eyepieces. The Meade 5K Super Plossls have five elements, vs. the 5000 HD-60's six. These are plossl-like eyepieces stretched too far beyond their customary 50° design, and it unfortunately shows in fast scopes. But they're perfectly acceptable in slow scopes like f/8 refractors and f/10 SCT's.

### III. SUPERWIDE AND ULTRAWIDE EYEPIECES:

Televue Ethos (2"/1.25"-barrel, 100°-AFOV unless otherwise noted):

3.7mm (110°-AFOV), 4.7mm (110°-AFOV), 6mm, 8mm, 10mm, 13mm, 17mm (2"), and 21mm (2"). Mind-blowing AFOV, extremely sharp on- and off-axis, excellent contrast. 21mm is VERY expensive, ~\$900 retail. All others retail around \$600, except \$750 for 17mm.

CLONES: Explore Scientific 100° Series ("ES-100"): all 2"-barrels: 5.5mm, 9mm, 14mm, 20mm, 25mm. Eye relief listed as 12-14.5mm, but eye lens recessed more than Televue Ethos. 14mm is VERY close in performance to 13mm Ethos, all others just a tiny bit short. **Excellent values**, particularly the 14ES-100 and 20ES-100. William Optics 101°-Series and Lunt Engineering--100° eyepieces are essentially the same as the ES-100's.

Televue Naglers (82° Ultrawide)

Type 1 (discontinued): 4.8mm (short eye relief!!), 7mm, 9mm, 11mm (rare!), 13mm.

Type 2 (discontinued): 12mm, 16mm, 20mm (heavy!!).

Type 4: 12mm, 17mm, 22mm. Eye relief is 17-19mm; eyeglass-friendly. 12mm and 17mm are dual 2"/1.25"-barrels; 22mm is 2"-only. Prices \$375 - \$500 new / \$250 - \$400 used

Type 5: 16mm (only 10mm eye relief), 20mm (12mm ER), 26mm (17mm ER), and 31mm (19mm ER). 16mm has 1.25"-barrel; all others 2". Prices \$350 - \$600 new / \$250 - \$500 used

Type 6: 2.5mm, 3.5mm, 5mm, 7mm, 9mm, 11mm, 13mm, all 1.25"-only barrels w/12mm eye relief. All very compact and light, priced in the low-\$300s. The 13T6 is a jack-of-all-trades eyepiece for dogs.

Common Nagler Clones: Explore Scientific 82°-Series / Meade 5000 UWA / Celestron Luminos / Celestron Axiom LX (recently discontinued). Focal lengths: 4.7mm, 5.5mm (Meade only), 6.7mm, 8.8mm, 11mm (ES only), 14mm, 18mm, 24mm (2") and 30mm (2"). Celestron Axiom LX's are probably the same focal lengths from the 6.7mm on up, but marketed as "7mm", "10mm", "15mm", "19mm", "23mm", and "31mm". Axiom LX superior to Luminos series; the latter series has issues with edge-of-field brightening. Most are like having 90% of a Nagler's performance for just 35-50% of their Nagler counterpart. Contrast is good, just not as good as Televue Naglers. Best is the 5.5mm Meade, worst (though not bad) are the 14mm and 18mm ES and Meade versions (15mm and 19mm Celestron Axiom LX's / Luminos), which have noticeable field curvature. Recessed eye lenses on ES-82's reduce usable eye relief below what eyeglass wearers need except for 24mm and 30mm eyepieces.

William Optics UWAN (Ultra-Wide Angle) / Orion Megaview--4mm, 7mm, 16mm, 28mm (2"), all 82°. This was the first serious shot across the bow from Chinese-manufacturers on the Televue ultra-wide ship. Excellent contrast and edge sharpness, but plagued by poorly-ergonomic, flat "face plate". The 28mm UWAN is very impressive in all scopes, but it is heavy and the "face plate" forces user to turn eye to easily see into the eyepiece.

Vixen SSW—Released in 2015, all 1.25", 83°-AFOV with 13mm eye relief. Available in 3.5mm, 5mm, 7mm, 10mm and 14mm focal lengths. Few user reports as of Feb. 2016, but largely favorable. Retail ~ low \$300s/each.

Televue Panoptic (68° Superwides)--eye relief ~2/3 of focal length. The 15mm (1.25") and 22mm (2"/1.25") are discontinued; current line-up are two 1.25"-eyepieces, the 19mm and 24mm, and 27mm, 35mm and 41mm, all 2". All 2"-Panoptics are eyeglass-friendly.

CLONES: Explore Scientific 68°-Series, Meade 5000 SWA (discontinued). Focal lengths: 16mm, 20mm, 24mm, 28mm, 34mm, 40mm. Good contrast and edge performance in fast scopes. Eye relief is ~2/3 of focal length, ranging from uncomfortable for the 16mm to almost rifle-scope for the 40mm.

## IV. LONG EYE-RELIEF ULTRAWIDES / SUPERWIDES:

Explore Scientific 92°-SERIES—New for 2016, these are 2"-eyepieces with about 20mm of eye relief and a 92°-AFOV, the widest available. Current oculars are 12mm and 17mm, retailing for \$499 new.

Televue Delos (72°-AFOV, all 1.25"-barrels):

3.5mm, 4.5mm, 6mm, 8mm, 10mm, 12mm, 14mm, 17.3mm. 3.5mm through 12mm parfocal; 14mm and 17.3mm parfocal with each other. Eye relief adjustable; maxes out at 20mm. VERY high-contrast, sharp images on and off-axis. Outstanding performance on planets for a wide-field eyepiece. ~\$350 retail / \$250-\$275 used.

Pentax XW--70° AFOV, 20mm eye relief

3.5mm, 5mm, 7mm, 10mm, 14mm, 20mm, 30mm (2", discontinued), 40mm (2", discontinued). Adjustable eye relief up to 20mm. VERY high contrast, with more comfortable eye placement vs. Delos. 14mm on up have notable field curvature, though Paracorr cleans them up in fast reflectors. 10mm and below simply outstanding in all scopes. 30mm and 40mm are RARE and sell FAST on used market. 3.5mm through 10mm XW's generally regarded as a tie vs. Delos. ~\$290 to \$350 new, \$220 - \$250 used.

Pentax XL-- Introduced in 1996, discontinued with XW series intro in 2003. Similar performance, focal lengths and accolades to the XW's, only with 65°-AFOV vs. 70°-AFOV. (28mm is 1.25", 58°).

Vixen LVW--3.5mm, 5mm, 8mm, 13mm, 17mm, 22mm, 30mm (2"-barrel) and 42mm (2"). All 65° w/20mm ER. Very comfortable eye placement, good contrast and edge correction. 22mm LVW is particularly renowned for its edge sharpness. Some lateral color. Used prices SUBSTANTIALLY lower than retail pricing, about \$150 used vs. \$250-\$300 retail.

LVW "CLONES": Baader Hyperions / Orion Stratus / Celestron Duo: -68°-AFOV w/20mm ER, Focal lengths = 5mm, 8mm, 10mm, 13mm, 17mm, 21mm, 24mm. All 2"/1.25"-barrels. Good contrast, but soft in fast dobs. The 17mm is generally regarded as the best of the bunch.

*Slightly different 70°-class, LVW "clones", but very similar amongst themselves:*

- (1) *Celestron Ultima LX--3.5mm, 5mm, 8mm, 13mm, 17mm, 22mm (2"-only), 32mm (2"-only)*
- (2) *Astro-Tech AF-70: 3.5mm, 5mm, 8mm, 13mm, 17mm, 22mm (2"-only)*
- (3) *Olivon 70°--3.5mm, 5mm, 8mm, 13mm, 17mm, 22mm (2"-only), 32mm (2"-only)*

Hyperions a little softer than the other three in fast optical systems. In the latter three series, the 22mm is one of the best values in low-power widefield eyepieces. All four retail in the low-\$100s, and \$70-\$100 on the used markets.

Long Perng / Omegon LE / Altair Astro Lightwave Premium LER / Levenhuk-Ra ER20-WA: 3.5mm, 7mm, 9mm, 12mm, 14.5mm, 18mm, all 1.25" w/68°-AFVO and 20mm eye relief. The 12mm and 14.5mm are good performers even in fast scopes; all others better suited for slower scopes. Lateral color an issue in outer half of field of view. ~\$150 new / ~\$100 used.

## V. BUDGET WIDEFIELDS:

As Phil Harrington said, these are worthy of consideration if your budget is low and your f-ratio is high. Almost all of these retail less than \$100.

Orion Q70 / Astro-Tech Titan / Garrett Optical SWA – 26mm, 32mm and 38mm, all 2"-barrels and around 70°-AFOV.

Meade QX—15mm, 20mm, 26mm, 30mm, 36mm, 70°. 15mm and 20mm are 1.25"-barrels, others 2".

GSO Superviews (most 68°-AFOV)—15mm (1.25"), 20mm (1.25"), 30mm (2"), 42mm (2", 65°) and 50mm (2", 60°).

Agena Ultrawide / Astrobuffet 1-rpd / BW-Optik / Moonfish Ultrawide / Olivon 80° Ultrawide—11mm (1.25"), 15mm (1.25"), 16mm (2"), 20mm (2") and 30mm (2"), all 80°. Eye relief short on 11mm and 15mm versions. Many of the 20mm are actually 30mm with a Smythe / Barlow element to sharpen the view somewhat. The 30mm version is often thought of as a "Poor Man's 31mm Nagler". Decent in slow scopes, soft across much of the field at f/5...and hideous at f/4.

University Optics MK-70 König (discontinued)--25mm and 40mm most common version, w/70°-AFOV. Decent in slow scopes, and better coatings than Chinese counterparts. Occasionally pop up in used markets. The 40MK-70 is prized among refractor and SCT owners. Used prices ~\$150 - \$200.

## VI. ZOOM EYEPIECES:

Baader Hyperion 8-24mm Mark III (or II) Zoom—Probably the best overall value in zoom eyepieces. Though marketed as having 50°-68° AFOV, various Cloudy Nights posts put the AFOV around 45° at 24mm to 72° at 8mm. Retail around \$250 / \$150-\$180 used. **HIGHLY RECOMMENDED** if looking for a zoom eyepiece.

Leica ASPH 17.8mm – 8.9mm. Very, VERY high-contrast views, AFOV starts around 60° at 17.8mm setting and hits 80° at 8.9mm. Good (not perfect, but close) edge sharpness in fast scopes and essentially perfect > f/6. God-awful expensive at \$900 new, but replaces multiple widefield focal lengths.

Nagler 3-6mm zoom—despite the name, it's only 50°-AFOV vs. 82°, but the field of view is maintained through the focal length range. Eye relief is tight at 10mm, but far superior to similar focal length orthos or plossls.

## VII. BARLOW LENSES:

A barlow lens is an essential part of any eyepiece collection, particularly if you're trying to stretch your dollars. Most are inexpensive and well-made.

Televue 2X and 3X barlows—Televue makes a 2" Big Barlow, but the 1.25" 2X and 3X barlows are more common. They work well, and considering we're talking about Televue, very reasonably priced in the low-\$100s new and in the \$70-\$80 range used.

Orion Shorty 2X Barlow / Celestron Ultima 2X Barlow—These have been around in one form or another for decades. Prices reasonable; around \$40 new.

GSO 2"/1.25" 2X ED Barlow—Easily the best bang for the buck. It's a 2"-barlow that comes with a 1.25"-adapter and acts as a 2X barlow in normal use for either 1.25" or 2" eyepieces. The barlow lens doublet unscrews from the main body and could be attached directly to a 2" eyepiece, acting as a 1.5X barlow. Or, you can put the barlow before the diagonal in a refractor or Schmidt-Cassegrain, and effectively have a 3X barlow. Best part--it's only \$70 new and \$50 used.

Televue Powermates—A different beast altogether. These are 4-element telecentric barlows, unlike the more customary 2- and 3-element barlow lens. Some barlows cause vignetting with longer-focal length eyepieces. That is not an issue with the Powermates. 2.5X and 5X Powermates are 1.25"-only; 2X and 4X are 2" w/1.25"-adapter. Prices range from \$170 - \$300 new, \$125 - \$240 used.

Explore Scientific Focal Extenders—Similar to Powermates; 1.25"-barrels for 2X, 3X and 5X models, and a 2"-version of the 2X. Prices \$100-\$200 new, \$70 - \$150 used.