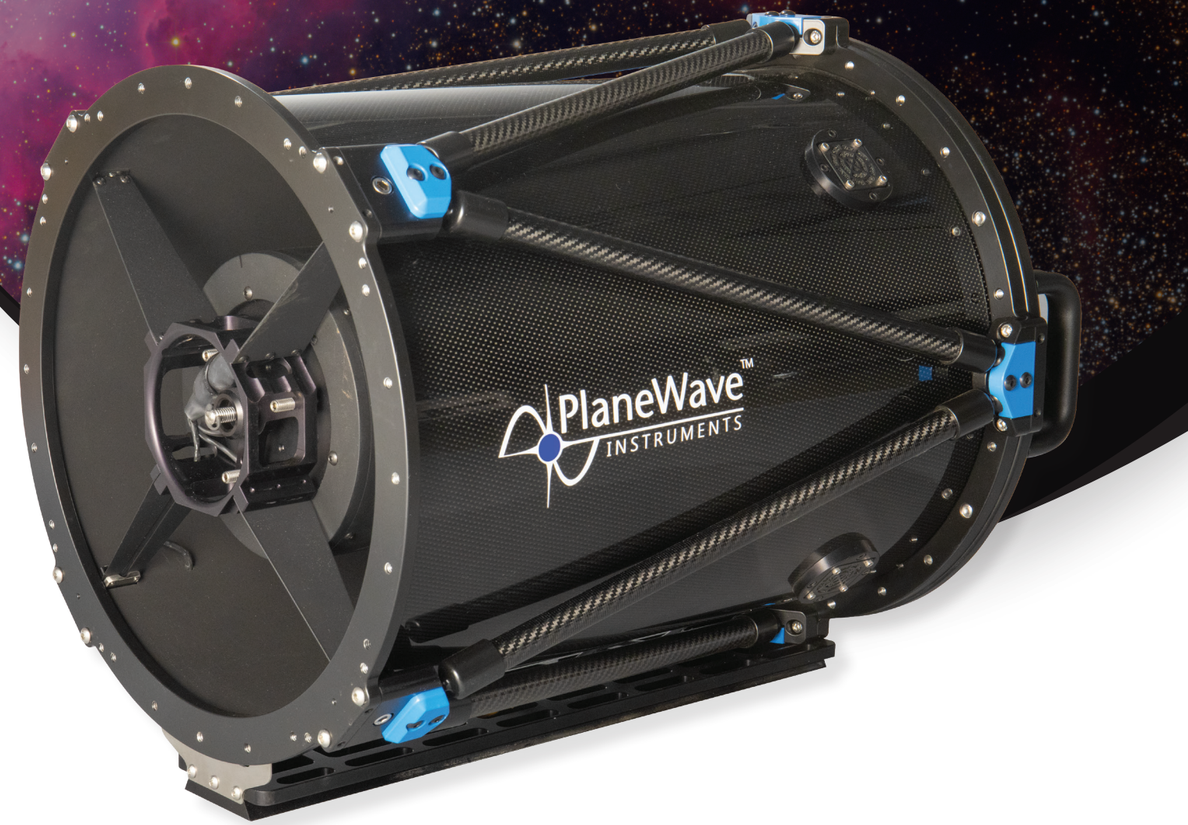
PlaneWave™ INSTRUMENTS

DeltaRho 350

350mm ROWE-ASTROGRAPH



PlaneWave™ INSTRUMENTS

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Advanced imaging applications demand systems that can keep up, and the DeltaRho 350 is designed and made for uncompromising performance as a fast, wide-field optical system. Inspired by the challenges of Space Domain Awareness (SDA), astronomical research surveys, and demanding astrophotographers, PlaneWave's engineers developed an elegant, new optical design that meets PlaneWave standards for imaging performance and ease of use. The DeltaRho 350 offers Cassegrain focus at a focal ratio of f/3. Born from our heritage and insight as one of the world's leading designers and manufacturers of high-performance telescopes, we believe you will find the innovation, resolution, and contrast of the DeltaRho just as amazing as its speed and field of view.

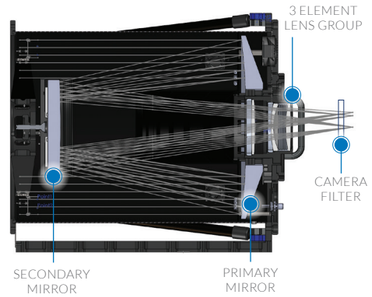
DELTARHO 350 **FEATURES**

Optical Design

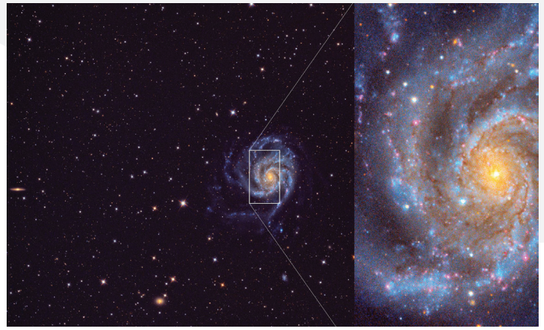
The DeltaRho optical design evolved from the revolutionary Corrected Dahl-Kirkham (CDK) telescope design, created by David Rowe (our CTO) and introduced by PlaneWave in 2006. Both designs include field corrector lens groups near the focal plane, use ellipsoidal (aspheric) primary mirrors, and spherical secondary mirrors. This approach to corrected Cassegrain optics is elegant in its simplicity, and effective in creating flat, well corrected images from competitively priced telescopes.

Due to the much wider field of view, the DeltaRho 350 features a 3-element corrector lens group, compared to the 2-element group seen in the f/6.5 – f/8 CDK optical-tube-assemblies.

Using glasses of three unique refractive indexes achieves correction across an image circle that is larger than most of today's detectors, while limiting chromatic dispersion to less than 1/3 the depth of the critical focus zone.



Stray-light mitigation is important for every telescope and is even more critical for wide-field systems. PlaneWave's engineers designed the DeltaRho optics, mechanics, and baffles with this first-in-mind.



Zoomed in view of the Pinwheel Galaxy core using 5 x 2-minute unguided exposures with a ZWO6200M CMOS camera (3.8 um pixels).

Careful ghost analysis has been conducted to ensure that lens reflections never reach the focal plane, and light baffles have been carefully placed to prevent unwanted reflections from OTA mechanics, maximize image contrast. An f/3 focal ratio telescope can quickly capture faint subjects and details, and one with effective stray-light mitigation will do so even faster.

Field of View and Resolution

You know a wide field of view is exactly what you need, but what about resolution? The DeltaRho 350 boasts a 3.2-degree field of view over its 60 mm image circle. It also produces tightly focused stars across this enormous field. On-axis, the system produces RMS spot sizes smaller than 1 arcsecond (4.95 microns). At the edge of field, the spot size is just under 1.5 arcseconds (7.56 microns). This level of resolution is a great match for many applications and sites around the globe, ensuring DeltaRho 350 images are both widely and sharply detailed.

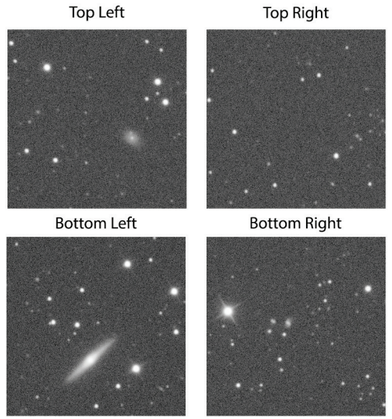
USA-Made Optics

PlaneWave is proud to make and qualify our mirrors in-house, at our optical production facilities in Michigan and California. This ensures that every mirror is tested at every step of the fabrication process and allows us to inspect our optics as both individual elements and as finished telescopes. We know that exceptional system performance is what our users expect, which is why PlaneWave utilizes Computer Numerical Control (CNC) to generate, grind, polish, figure, and mount our own mirrors. We have also created proprietary testing metrology and our own robotic optics machines to be able to deliver exceptional optics at exceptional value, all made in the USA.

DELTARHO 350 **FEATURES**

Edge Performance

Single 2-minute unguided exposure, ZWO6200M, 3.8 um pixels.



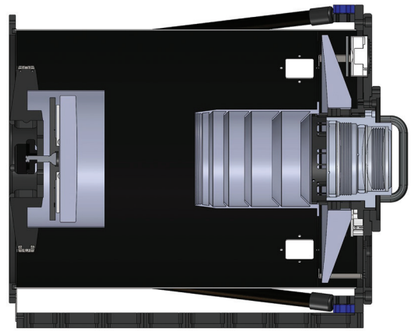
Cassegrain Focus

The DeltaRho 350 is a Cassegrain focus system for one reason: versatility. Some applications call for very simple equipment solutions, while others require much more. Even modest instrument packages or filter wheels can become challenges for prime-focus designs, blocking light from reaching the optics while adding diffraction to the image. We want you to have the flexibility to use the filter wheels and filters needed to illuminate this 60 mm field, or to integrate other large instrumentation that is best to have behind the telescope.

Advanced Light Baffle Design & Fabrication

Optical baffles prevent the focal plane from seeing light which has not been focused by the optical system. However, even the blackest of paints and metal finishes still reflect some amount of light, particularly at grazing angles. More advanced baffle shapes make a significant difference.

PlaneWave's computer-aided and advanced baffle design includes light-trapping features, allowing the capture and mitigation of diffuse reflections from within the optical system. Years of related research and development have led to new approaches to baffle shaping and 3D-printing of complex baffle designs. Traditional fabrication, like machining or molding, cannot economically and precisely produce these structures which is why we print our baffles in-house.



These perspectives and approaches have been beautifully delivered in the DeltaRho 350. Within the primary mirror baffle, there are nine smaller "bafflets". Notice in the cross-sectional drawing that the light-facing surfaces of each feature will bounce light away from the focal plane. With similar treatment applied to baffles within the corrector lens assembly, the results are breathtaking. We have been amazed by the contrast of images taken during prototyping of the DeltaRho 350 and cannot wait to see the beauty you produce with yours.

Mechanical Stability

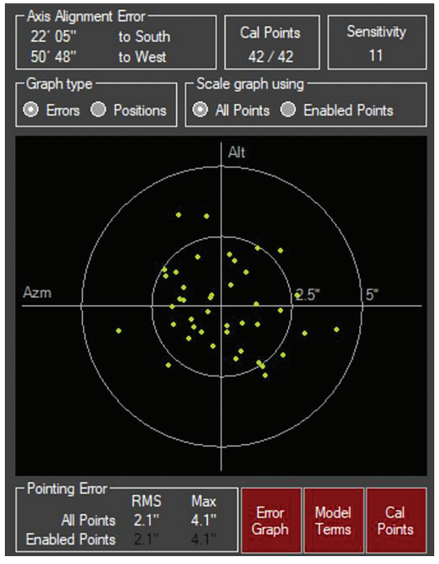
Keeping optics properly aligned is one of the most important jobs of a telescope's mechanics and faster focal ratio systems can make this challenging. In use with the L-350 Direct Drive Mount, DeltaRho 350 telescopes have shown pointing-model accuracy in the range of 1.5 to 3.0 arcseconds RMS.

DELTARHO 350 **FEATURES**

The DeltaRho 350's primary mirror is the heaviest optical element in the system and is fixed in place. This supports the system's performance and requires more work and attention during epoxymounting of the optics and assembly of the telescope. There are two clear advantages:

Rigidity – A fixed primary mirror is an important foundation when measuring angular differences in arcseconds. Our epoxy-bonded primaries do not tip or tilt over time, relative to the backplate or front ring. Consider competing systems – where adjustable mechanics support the primary, and you are expected to use those adjustments. Our method ensures the optical and mechanical axes of the telescope are aligned to eliminate image-plane tilt. Our optional adjustable tilt adapter will help solve any tilt within the camera itself.

Single-Mirror Collimation – Unlike other Cassegrain-style telescopes, the DeltaRho's primary mirror is aligned and rigidly mounted the OTA backplate, requiring only the secondary mirror to be adjusted in collimation. Simplified collimation makes your work in the field more enjoyable and ensures that your optics produce the highest-quality images.

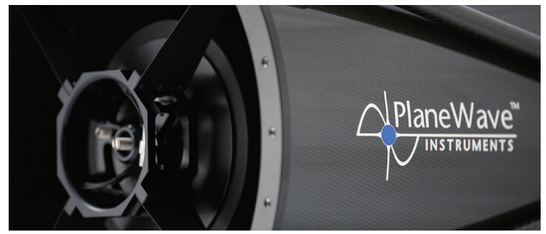


PWI4 software pointing model results with the DeltaRho 350 & L-350 mount. Pointing error for the 42-point model was 2.1 arcsecond RMS error.

Thermal Control and Stability

From the materials used in fabrication, to the integration of dew heaters and temperature sensors, to the placement of seven fans on the DeltaRho 350 incorporates a variety of features designed to control and withstand the changing environment in the field.

Fused Silica Mirrors – Like all other current PlaneWave telescopes, the DeltaRho 350 includes mirrors produced from fused silica (quartz). With a very low coefficient of thermal expansion, use of quartz optics ensures that changing temperatures do not result in mirrors changing shape.



Carbon Fiber Truss – Carbon fiber is lightweight and incredibly strong, but it can also be manufactured to not change length over temperature. Combined with careful attention to fittings, geometry, and mechanical strain relief, supporting the major length of the optical axis with carbon fiber has allowed our engineers to create a thermally-stable structure.

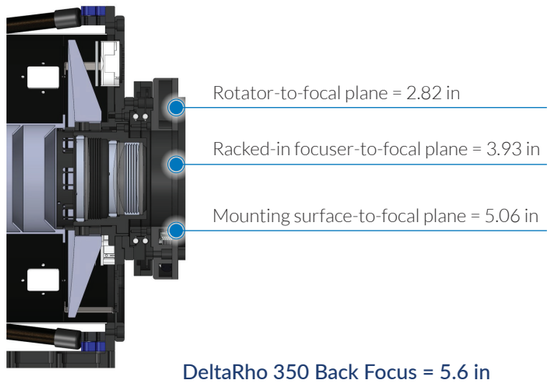
Dew Heating System – The DeltaRho 350 is pre-wired and ready for connection to the Series-5 Controller. Within the OTA, polyimide heating pads are carefully placed to offer heating of the primary and secondary mirrors, when ambient temperature and dew point are too close for comfort. Additionally, multiple temperature sensors allow the system to adjust the heat of each optic and are controllable through PlaneWave Instruments (PWI) software.

Fans for Cooling and Tube-Seeing – Atmospheric scintillation, commonly called "seeing", occurs within air on optical surfaces just as it does in the larger environment. The only requirement is for the optic to be different in temperature than the air. Traditionally, fans are used to cool the primary mirror toward the ambient temperature, but equilibration is not reached until after the environmental ceases cooling. This means that there will be a boundary layer of boiling air sitting between the sky and the mirror for most of the night. PlaneWave has proven that well-placed side fans will significantly reduce mirrorsurface seeing effects, while further assisting in cooling. This is why the DeltaRho 350 features a total of seven fans, with three in the backplate and four at the perimeter of the primary mirror.

DELTARHO 350 **FEATURES**

Rotator and Focuser

Our new rotator and focuser designs add more flexibility to our systems. The goal was to create a faster, stronger, focuser and rotator system that had a thinner profile than the IRF90. Our new Series-5 stackable focuser and rotator have achieved this for users of our CDK700 and smaller telescopes. Both the focuser and rotator offer a clear aperture of 5 inches and are designed to stack for users that require de-rotation. For those only needing focusing capabilities, the new focuser also occupies less back focus, which means more room for imaging train components. In addition, we have designed a new 5-wire bus communication box that controls the rotator and focuser, which includes M12 circular 5-wire threaded connector heads for environmental sealing.



DeltaRho 350 Back Focus = 5.6 in

- Series-5 Focuser thickness = 1.675 in
- Series-5 Rotator thickness = 1.105 in
- Series-5 Focuser travel = 0.65 in
- Remaining back focus of rotator and focuser halfway racked-out = 2.495 in

SERIES-5 ROTATOR

- Back focus path length: 1.105 in
- Rotates up to 700 degrees between mechanical hard stops (+ or – 350 degrees from the center of travel)
- Speed: up to 15 degrees/second
- Clear aperture: 5 in
- Weight capacity: 40 lbs
- Weight: 5.5 lbs

SERIES-5 FOCUSER

- Back focus path length: 1.675 in
- Focuser travel range of 0.65 in
- Clear aperture: 5 in
- Weight capacity: 40 lbs
- Weight: 6.5 lbs

DELTARHO 350
ASTROPHOTOGRAPHY

Crescent Nebula (NGC6888)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt-az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures per channel (Gain 100 and Offset 75)

Trifid Nebula (M20)

Imaging location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt-az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures per channel (Gain 100 and Offset 75)

DELTARHO 350 **ASTROPHOTOGRAPHY**

Eagle Nebula (M16)

Imaging Location
McDonald Observatory

Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in Alt-az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
10 x 2-minute Luminance and
5 x 2-minute exposures RGB
(Gain 100 and Offset 75)

Markarian's Chain (NGC4435)

Imaging Location
McDonald Observatory

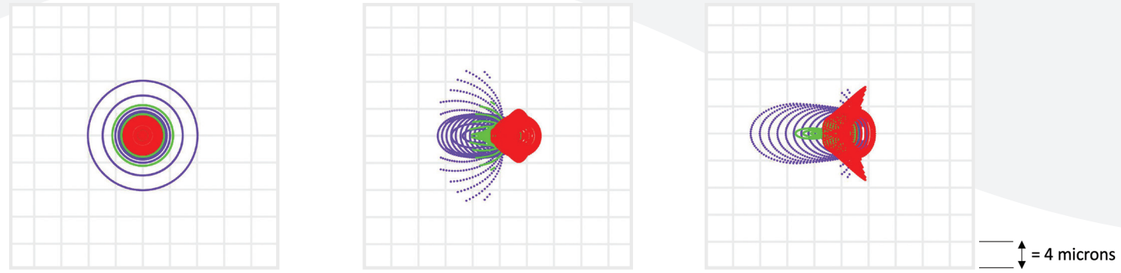
Telescope
PlaneWave Instruments DeltaRho 350

Mount
PlaneWave Instruments L-350 in alt-az orientation (IRF90 for field de-rotation)

Camera
ZWO ASI6200M, EFW-7, and Chroma Filters

LRGB
5 x 2-minute exposures for L and
3 x 2-minue exposures for RGB
(Gain 100 and Offset 75)

DELTARHO 350 **SPECIFICATIONS**



Distance Off-Axis = 0 mm
RMS Spot Size (radius) = 2.386 microns

Distance Off-Axis = 23.051 mm
RMS Spot Size (radius) = 2.830 microns

Distance Off-Axis = 29.630 mm
RMS Spot Size (radius) = 3.225 microns

OPTICAL DESIGN

Optical Design	Corrected Cassegrain
Aperture	350 mm (13.78 in)
Focal Length	1050 mm (41.34 in)
Focal Ratio	f/3
Central Obstruction	56% by diameter
Back Focus from Mounting Surface	5.6 in (142.24 mm)
Weight	46 lbs (21 kg)
OTA Length	23 in (584 mm)
Optical Performance (Spot Diameter)	4.8-micron RMS on-axis 5.6-micron RMS at 23 mm off-axis 6.4-micron RMS at 30 mm off-axis
Telescope Cage	Carbon fiber truss poles with carbon fiber shroud
Optimal Field of View	60 mm image circle

SECONDARY MIRROR

Diameter	190 mm (7.48 in)
Material	Fused silica (quartz)
Shape	Spherical
Coating	Enhanced aluminum - 96%

PRIMARY MIRROR

Optical Diameter	13.78 in (350 mm)
Outer Diameter	14.5 in (468.3 mm)
Shape	Prolate ellipsoid
Material	Fused silica (quartz)
Coating	Enhanced aluminum - 96%
Alignment	Permanently aligned at factory

LENS GROUP

Diameter	110 mm (4.33 in)
Number of Lenses	Three
Coating	Broadband AR Coatings (less than .5% reflected from 400 to 700 nm)

PlaneWave™ INSTRUMENTS

DELTARHO 350 **SPECIFICATIONS**

STANDARD FEATURES

Corrected Cassegrain	Yields a flat field optimized for astrophotography.
Carbon Fiber Truss Design	Minimizes thermal expansion to limit focus shift due to changes in temperature.
Dovetail Expansion Joint	Allows for the difference in thermal expansion between carbon fiber and aluminum. The expansion joint allows the aluminum dovetail to expand and contract without stressing the carbon fiber truss.
Cooling Fans	Reaches thermal equilibrium quickly with three fans at the backplate and four on the side to help cool the telescope to ambient temperature. The fans are controlled by a computer if the optional Electronic Focus Accessory (EFA Kit) is purchased.
Dew Prevention Ready	Prevents dew through internally-wired polyimide film heater pads and temperature sensors, which can be controlled with the optional Series-5 Controller.

SHIPPING

Crated Shipping Weight	225 lbs
Crate Width	31 in
Crate Height	26 in
Crate Length	53 in

INCLUDED ACCESSORIES

OTA Cover	Protects the telescope optics.
PlaneWave Thumb Drive	Contains software and instructions for collimation and spacing the primary to secondary mirror.
24VDC Power Supply	Provides power for the fans (not included for European orders).
Wrench Set (5812A35)	Standard hex wrenches (European orders only).

WHY **PLANEWAVE**

Founded in 2006 with the goal of creating the perfect telescope, PlaneWave Instruments designs and manufactures observatory-class instruments for clients around the world right here in the United States. These include commercial off-the-shelf (COTS) 300 mm, 350 mm, 400 mm, 500 mm, 600 mm, 700 mm, 1,000 mm, and 1,500 mm ground-based telescopes, and tracking systems.

Many of our telescopes have evolved from the revolutionary Corrected Dall-Kirkham (CDK) optical design developed by CTO, Dave Rowe. The CDK is coma-free, has no off-axis astigmatism, and has a flat field. In addition to the CDK, PlaneWave offers the DeltaRho astrograph series and classic Ritchey-Chrétien (RC) designs. With a strong understanding of our customers' diverse needs, our team of industry experts are dedicated to finding the right optical design for your unique application.

Our telescope mounts are agile direct-drive tracking systems that are highly reliable and allow slew speeds of more than 50 degrees per second. Our mounts are capable of >1,000,000 slews per year to track orbital or deep space objects without failure.

These telescopes and mounts are tested throughout every step of the assembly process to ensure the only thing standing between you and flawless observation is a cloudy sky. They have also been designed for remote use, making them ideal for autonomous observatories.

We believe in specialization, which is why we work with a variety of commercial integrators and prime contractors. Through collaboration, we create complete solutions for research observatories, laser communication and SSA ground stations, and other advanced applications. Whether you need minimal assistance or full turn-key solutions, our team will be there to support you.

Core Capabilities

- PlaneWave management is experienced and has a proven track record of delivering on time and on budget.
- PlaneWave is a leader in developing products that are innovative, high quality, and are designed in such a fashion that they are scalable to volume manufacturing.
- Our facilities utilize SolidWorks and custom software tools, state of the art CNC, as well as 3D printing to design and realize our products.
- PlaneWave employs a pool of very talented young innovative mechanical, electrical and software engineers. Our reputation allows us to pick from the best.

Key Technologies

- PlaneWave has developed state-of-the-art optical manufacturing and testing facilities. From individual mirrors to complete optical systems, we ensure that each of our products is of the highest quality.
- We have developed extensive motion control algorithms, astrometric analysis software, pointing analysis and correction software, and control system architectures that significantly enhance the performance of our gimbal systems.
- PlaneWave's vertical integration includes in-house design and manufacturing of our gimbals, motors, optics, and OTAs. This allows for minimized cost and maximized performance through design optimization of each system component.