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A Tale of Three Lenses: How Alignment Turning Creates Accurate Imaging Systems for Less

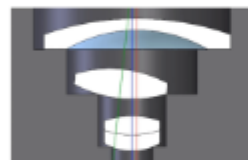
White by Will Rusin
Principal Optical Engineer, Optikos Corporation

I've spent a good deal of my nearly 20-year career here at Optikos working on high performance imaging projects. I've collaborated with our mechanical engineers exploring the trade space between the stiffness we'd like and the compliance we need. We've modeled the optical and mechanical tolerances on massive computer monitors with infinite axes and all the best engineers. They've processed from reliable vendors and inspected and tested extensively, and finally, the day comes to put that all behind us and just build the first one.

I go in as usual into the clean room where I spend a surprising amount of time aligning the lens barrel on the center station. Then, I start stacking lenses, turning things set screws, and arguing with myself about the merits of chasing the last 2 microns of runout in an element. I stack a few more elements—everything is looking surprisingly good. Inevitably I hit that one element that just can't get into place. Maybe it's because there's a hair too much wedge in the element. Maybe the lens barrel has a defect that's pushing the lens off center. Maybe it's all of the above and more, because when you're looking for lens to lens alignment of 5 - 10µm everything matters and no imperfection is too small.

Eventually I'm able to scrape and shim and deliver the high performing lens my customer needs. I got there, but it wasn't efficient, and it sure wasn't pleasant. And I think to myself "there has to be a better way!"

As it turns out, there is.



View this article online on the [Anywhere Light Goes™](#) blog to see the animations and video content of alignment turning methods at Optikos.

Use the QR code or visit [optikos.com/anywhere-light-gets-here](https://www.optikos.com/anywhere-light-gets-here)

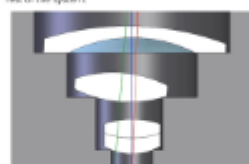


Traditional Lens Barrel

In a traditional, high-performance lens assembly, elements are stacked in a barrel with glass-to-metal interfaces that vary based on lens geometry. Alignment is performed on a lens centering station where each lens is either pushed laterally for centeration or rolled about a surface for tilt using set screws. Each lens has a unique optical axis defined by the line joining its surface centers of curvature. The goal is to minimize the misalignment of each lens relative to a global datum.

The animation below demonstrates how to achieve perfect alignment of a lens assembly when you have perfect parts.

Let's first consider a biconvex singlet in an edge centered spot in a lens barrel. If we assume all seats in the lens barrel are perfectly concentric then we can roll the lens about one surface until both are aligned. For a meniscus or negative lens, let's assume the addition of an annulus. If the annulus is ground perfectly to the optical axis of the lens then we can push the element laterally until its axis is aligned to the rest of the system.



Now let's get real and throw in some concentricity tolerance in the seat for our biconvex lens and a wedge of the ground annulus in our meniscus lens. The second animation demonstrates that when we have real parts with non-zero tolerances you can null tilt or centeration of a lens.

Learn more at optikos.com/anywhere-light-gets-here

A Tale of Three Lenses: How Alignment Turning Creates Accurate Imaging Systems for Less

Optikos Principal Optical Engineer Will Rusin explains how alignment turning can be used to create extremely accurate optical systems, at scale, for lower cost.

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