Designing, and Building a Binocular Microscope (Part 2)

In the last issue, I sketched the concept to constructed a biological microscope by combining pre-assembled modules. I also described what modules should be like: Simplified as possible, low cost, and to allow chain connections. What I'll demonstrate in this issue is we have come a long way from building prototypes with discrete components. Building complex opto-mechanical instruments requires preassembled sub-modules, otherwise you'll be spending days designing it with solidworks or catia. Optoform speeds up the process with direct upward/downward compatible modules. If you decide to assemble them in a computer, you'd be also putting together predesigned modules.

In any case, let's get started from where we left off last time by finishing the Binocular viewfinder assembly. You could order this viewfinder, as it will be an available module for the system. To adjust for the eye distance in a binocular head, sliding mounts 40-110 are designed to perform this task. The optical path inside the virwfinder is first bent 30 degrees via a Littrow prism for inclined viewing, and is split into two paths via a beamsplitter. Three additional right angle prisms produce the proper separation between the two beams for binocular viewing. A pair of specially designed 40-120, and 40-126 mounts are utilized to construct this assembly in its bent form. Sliding mounts 40-110 ride on a two 125 mm support rods, that construct this compact 125 x 40 x 114 mm assembly.

While designing this somewhat complex arrangement, two new mounts, and a 125 mm long rod has to be added. This is not a problem. Each module may contain specially designed mounts to perform a specific function. Mounts 40-126 are designed to be reversible, hence reducing the number of necessary parts. Rod spacing in Optoform 40 would become unconventional. Figure 1 shows two mounts 40-100 side mounted to create a combination mount. This arrangement isn't the most efficient way to do it. A better alternative would be to share the inner rods (Fig.2) to create a more compact mount 40-120.

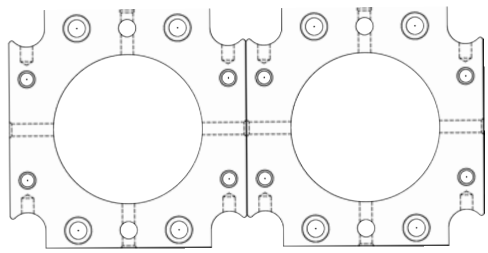
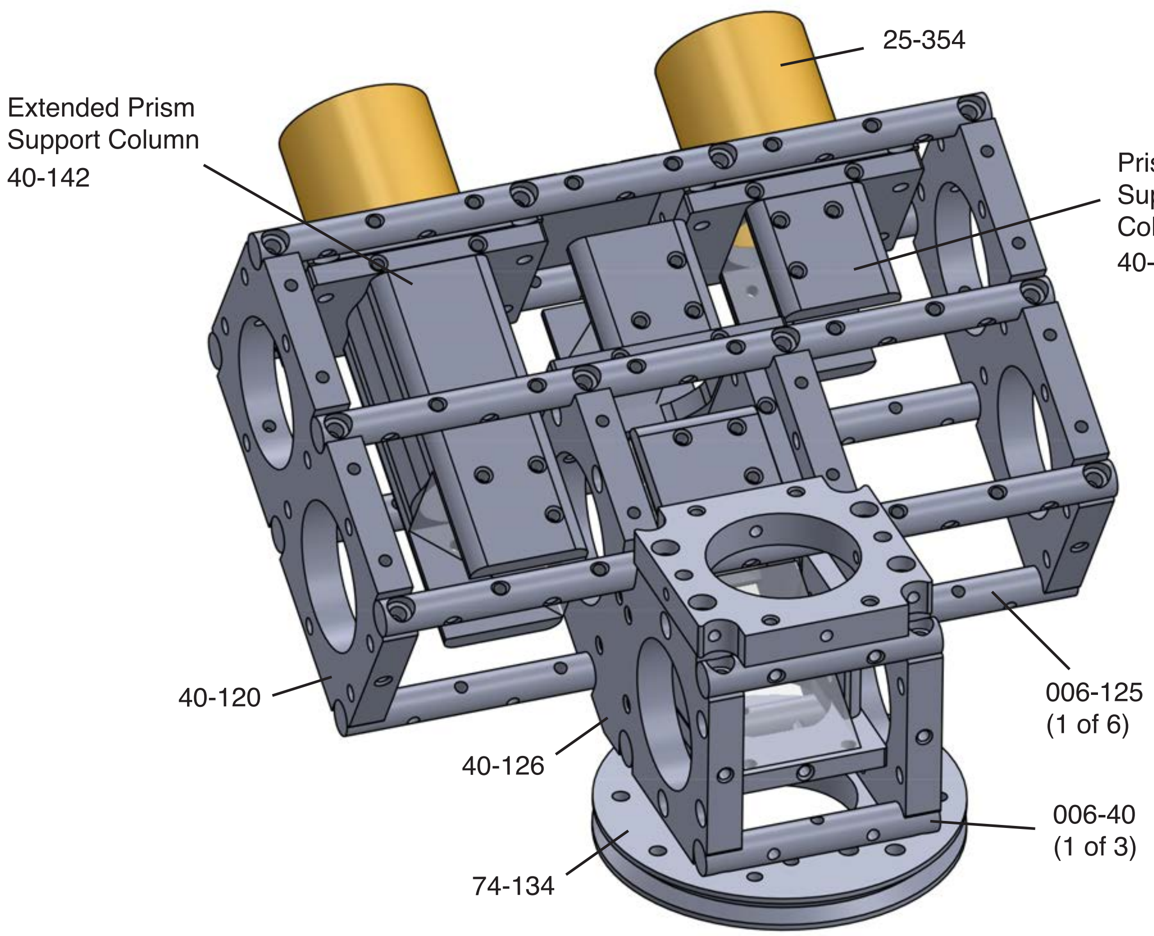


Fig.1 Two side by side mounts 40-100

The same idea would apply when designing mount 40-126. This mount is designed specifically to construct the 30 deg. inclined head (Fig.3). These basic building blocks will be utilized later to construct the rest of the microscopy assembly. The viewing head is now ready to be built.



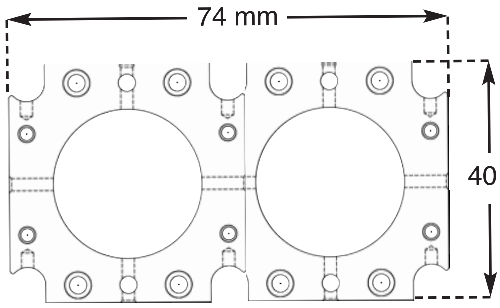


Fig.2 Combination Mount 40 -120

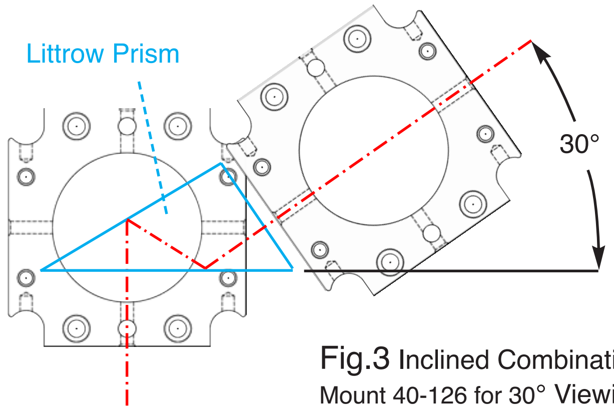
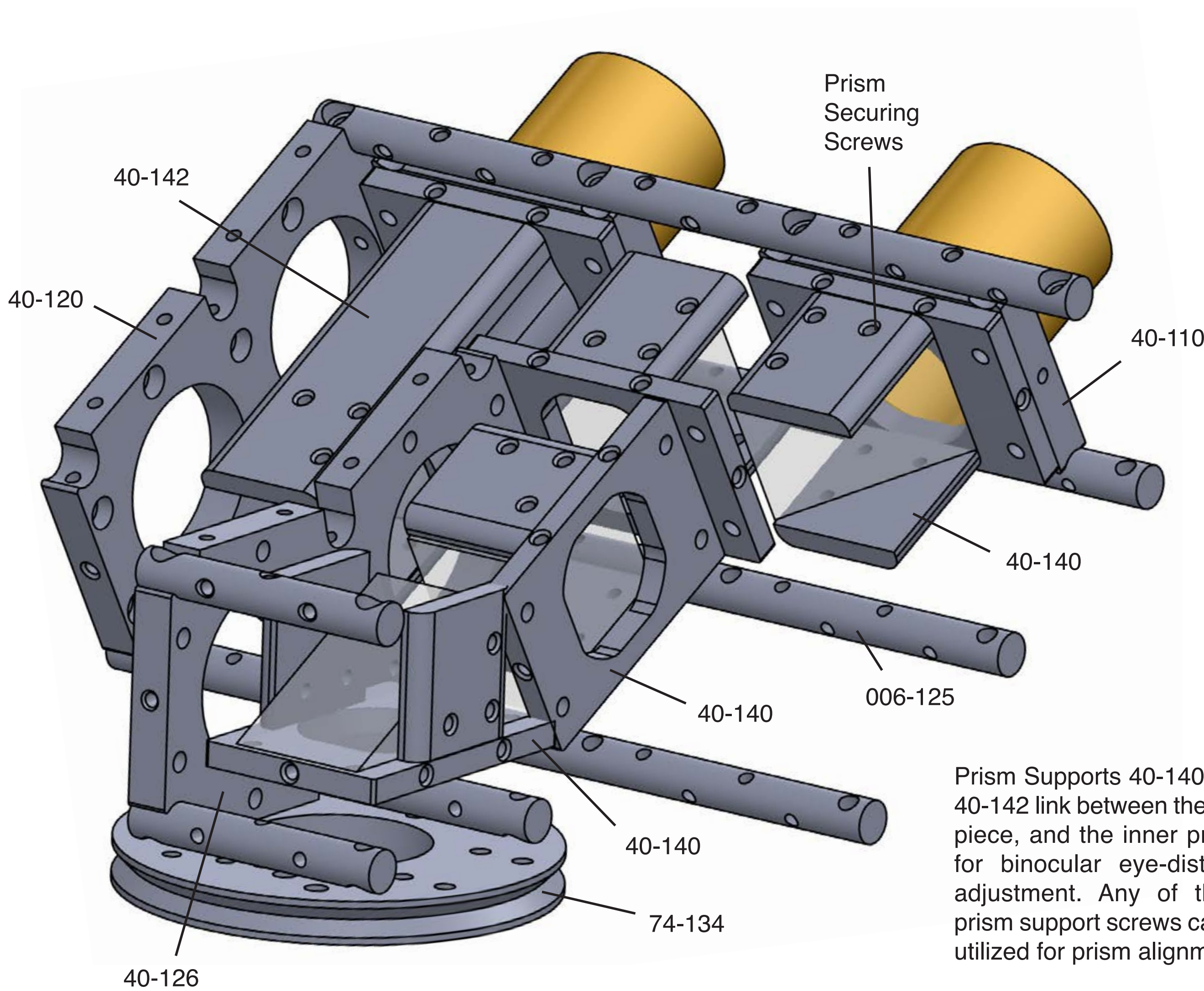


Fig.3 Inclined Combination Mount 40-126 for 30° Viewing

If you are an optics fan, you'd appreciate what we are about to do. We have all used binoculars before but have you ever built one yourself? What it takes is a system capable to constructing it. While we were children, we used the Erector set to make anything we wanted but as we grew up, we were told everything was too complicated. To build a binocular, you'll need to go to Zeiss or Leitz factory, and they'll tell to sit behind an assembly line, or work with machinists to build its already designed parts. With Optoform, you don't have to. If you are able to create form, we'll make it functional. That's really our goal.

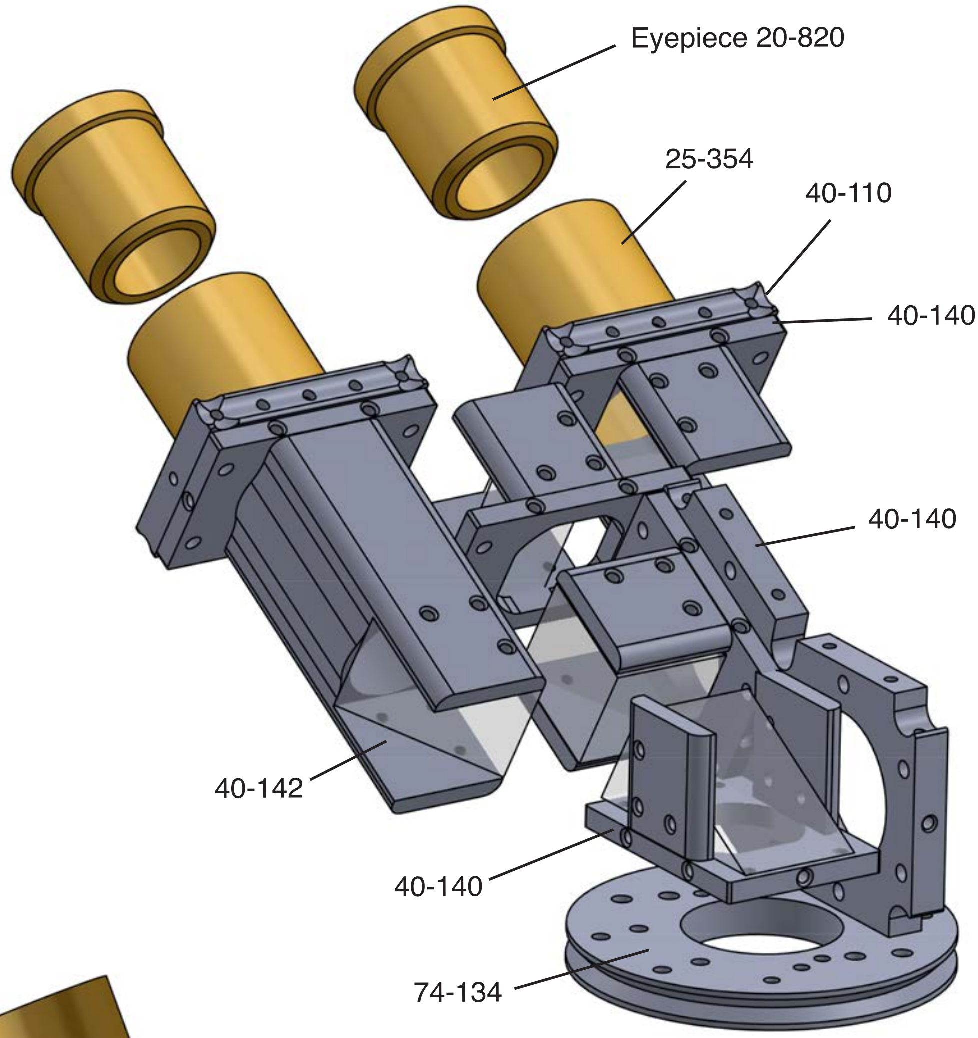


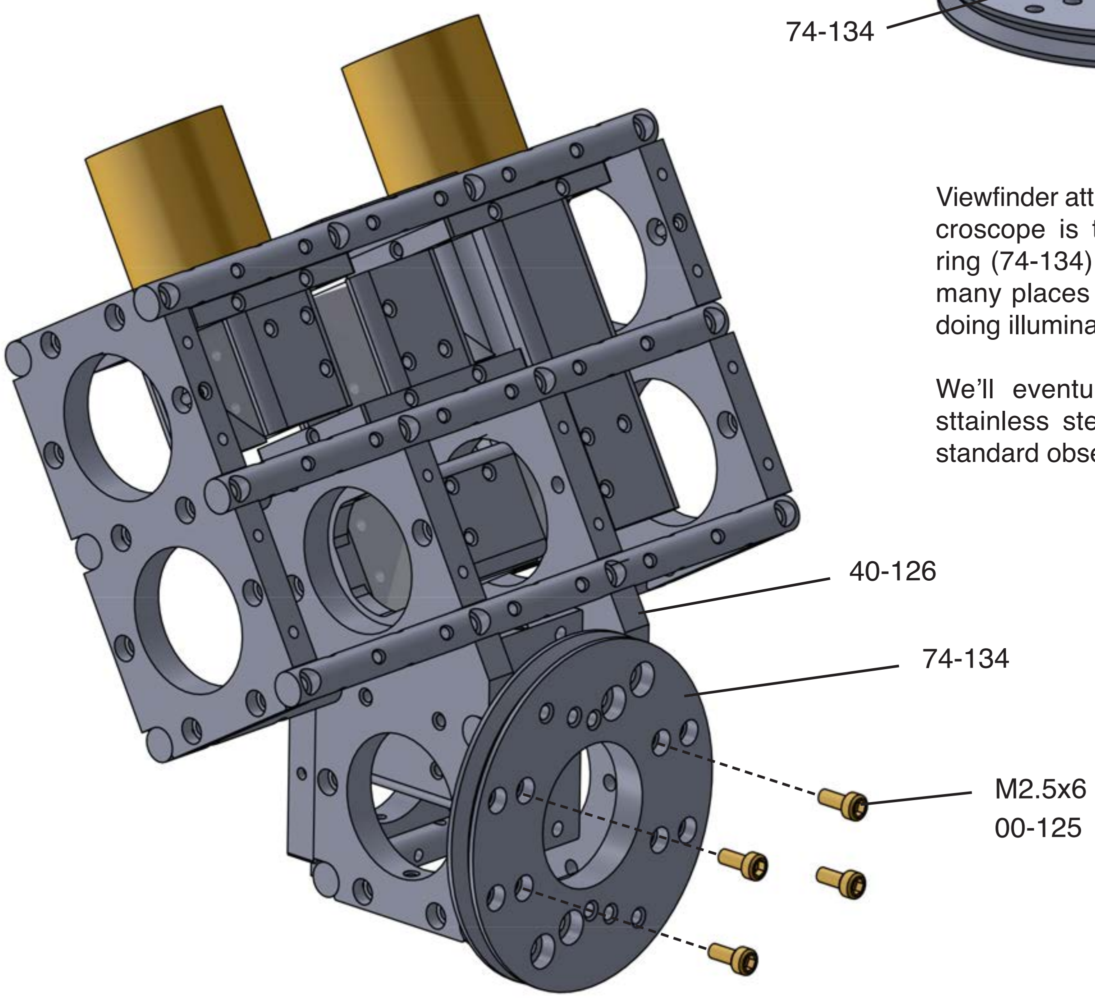
Prism Supports 40-140, and 40-142 link between the eyepiece, and the inner prisms for binocular eye-distance adjustment. Any of the 3 prism support screws can be utilized for prism alignment.

Mounting Prisms

Detail of prism mounts inside the binocular head. What you experience in this assembly is more playful, and more fulfilling than being an assembler who works at Zeiss or Leica microscope factories. They aren't allowed to play, but you can!

Why not use an off the shelf viewfinder? You sure can, but these compact viewfinders have been replaced with large housings that cost too much. You may also have your own idea of adding a CCD camera inside it, or change the design to something that is more suitable for an upright microscope (light coming from above). In either case, Optoform gives you the freedom to implement it.





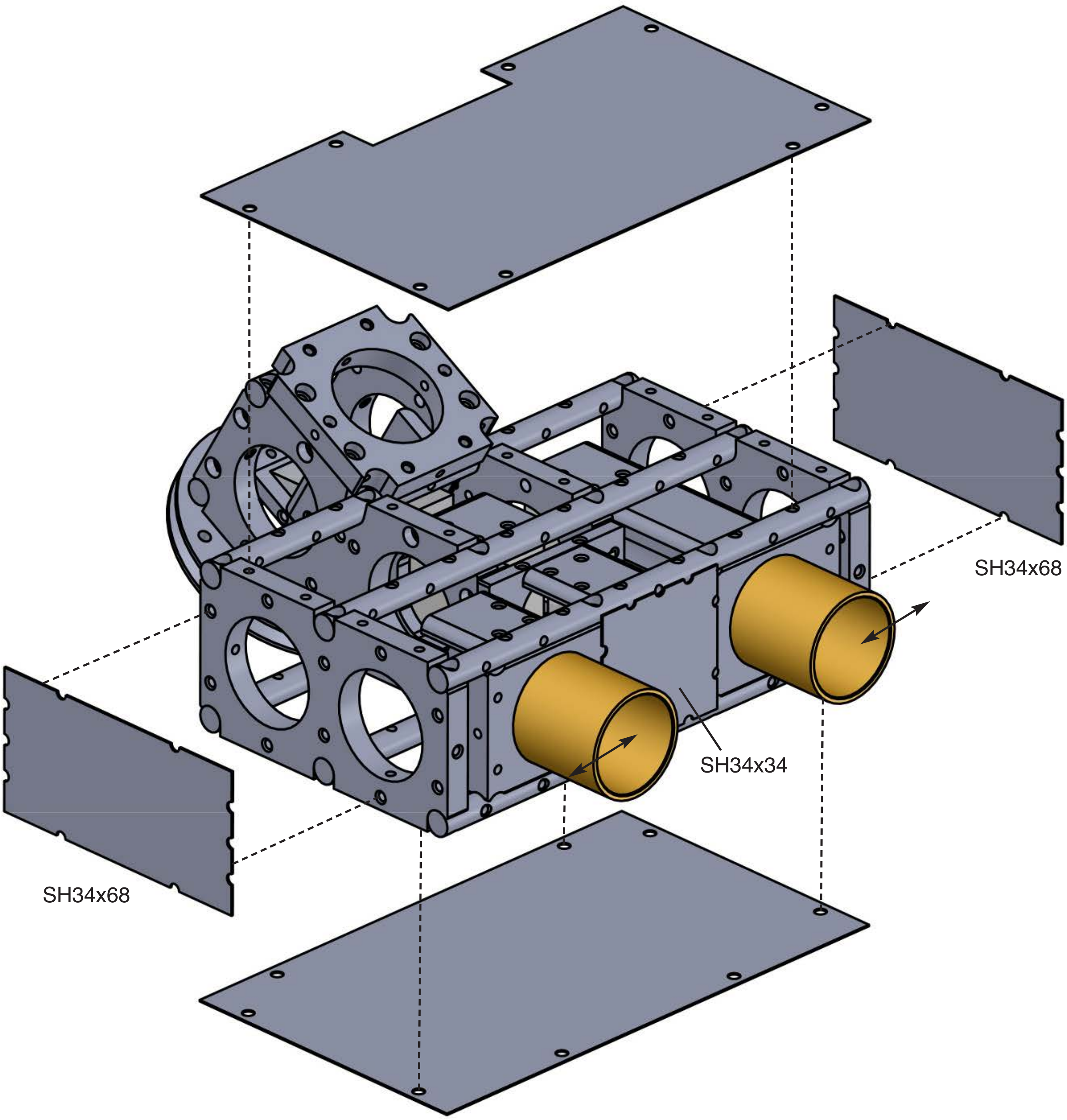
Viewfinder attachement ring to the microscope is this versatile centering ring (74-134). You'll see it utilized in many places to secure mounts, and doing illumination work.

We'll eventually replace it with a sttainless steel dovetail ring like in standard observation heads.

Sheet Covering

Sheet covers were introduced in the last issue. The idea is to be able to cut off extraneous light, and to prevent dust from entering the optics. For the moving parts sometimes you get lucky. The two eyepiece holders held by sliding mounts 40-110, can slide beneath a single cover sheet (SH-34x34, below) like an off the shelf viewfinder. As you can tell, the part number for sheet metal coverings includes their size information. You could also see the edges in Optoform 40 assemblies are round.

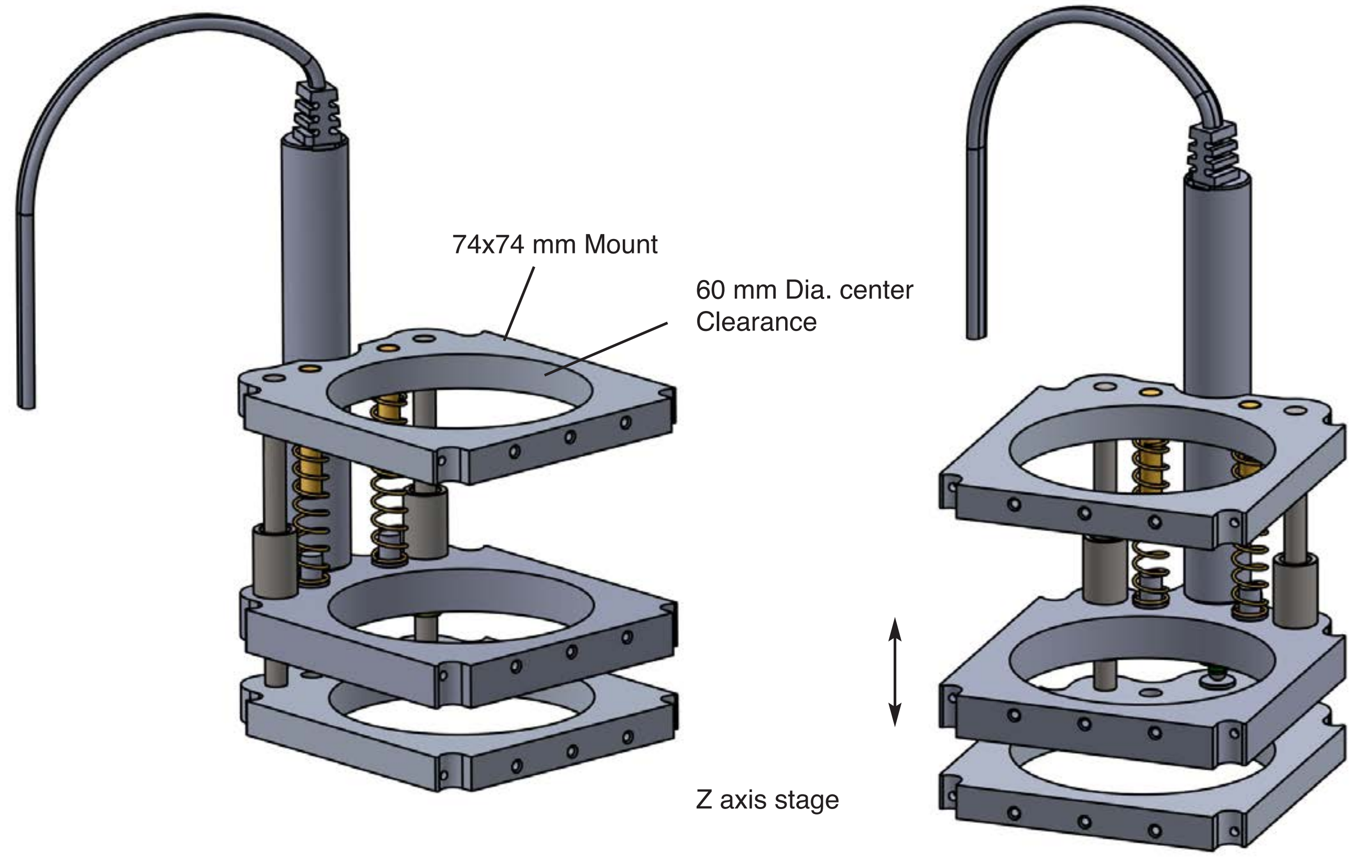
The top, and bottom sheet covers are custom made. We'd offer you the entire unit, and you could either use it as what it is designed for, or disassemble it to make modifications. The prisms are held in place with three set screws which could also be utilized for alignment. There are thin brass sheets to protect the glass, also a thin cardboard packing as cushion.

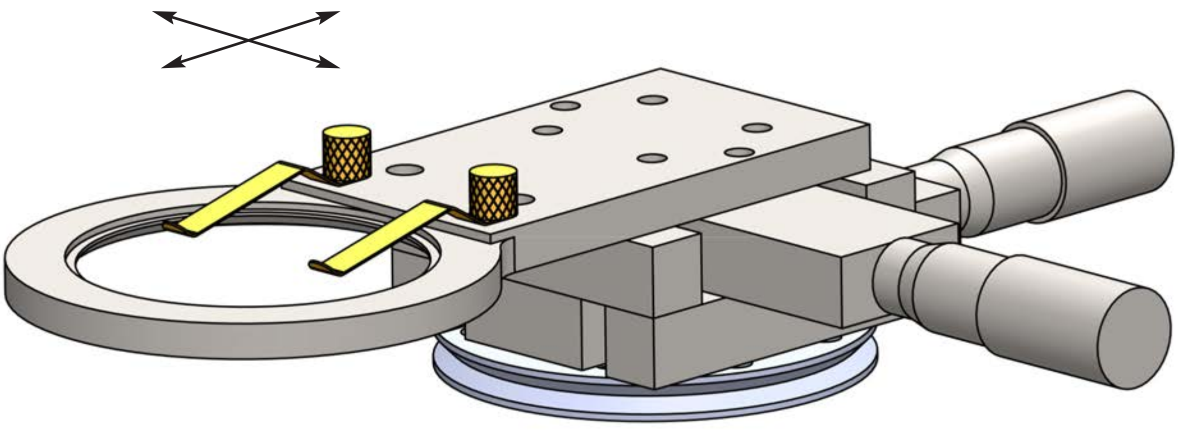


Designing the focusing Module

The focusing module is a tricky one. Under high magnification, it should perform precisely without image drift, while under low magnification, it should have a wide travel range to accommodate objectives that are not necessarily parafocal. We will design an elaborate XYZ stage for the sample but for now, let's design a simple, motorizable system (switchable between manual, and motorized micrometers) utilizing classical Optoform's linear bearing concept.

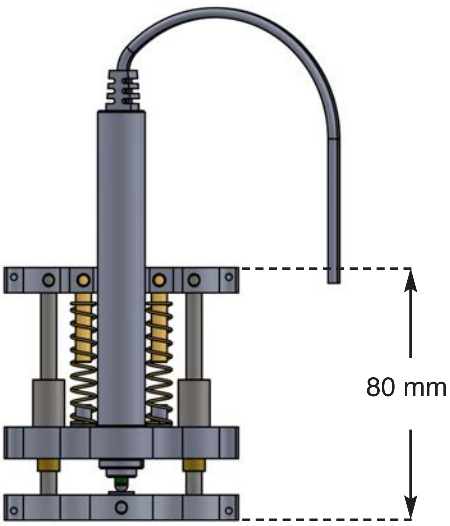
In its classical design, two linear bearings support the sample platform while a combination of a lift micrometer, and a return spring would precisely position the stage. The design is kept symmetrical to provide backlash free Z axis positioning. Four rods, and cover sheets support this 80x95x74 mm module. Because these modules are stackable, and the rods are side mounted, all the mating plates need to be paralleled (identical height on all four corners). With linear bearings, the mounts are already parallel, but for all other assemblies you'll need to adjust for parallelism. I'll show you how how it's done.

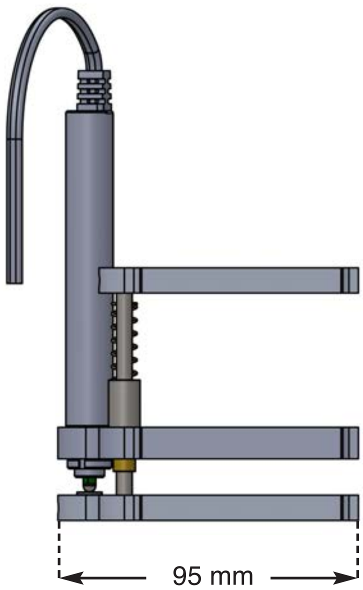


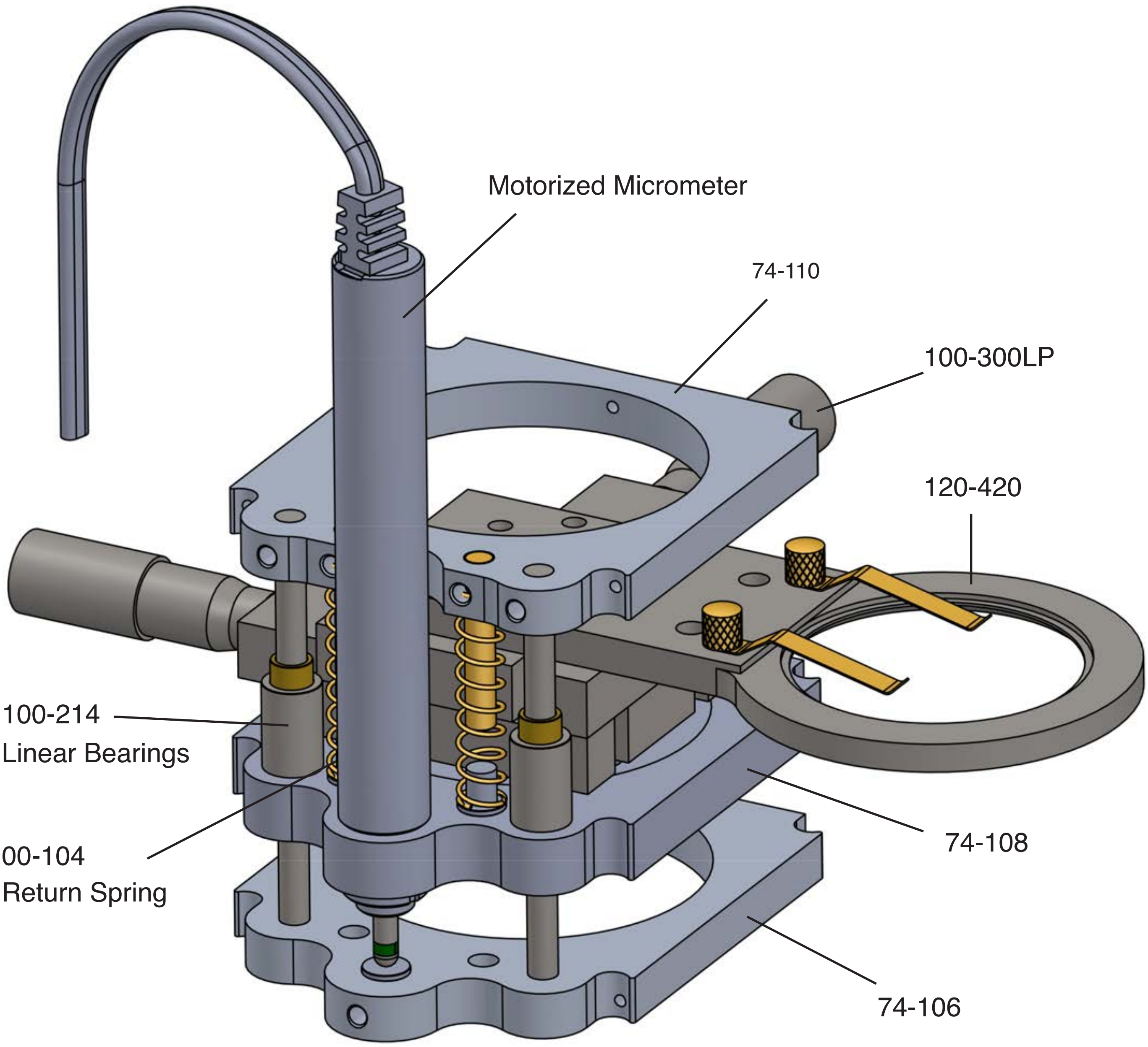


Compact XY stage 100-300LP may be motorized by replacing its micrometers.

The XYZ stage assembly will have sheet covering to protect its inner components. The design of new Optoform modules allows chain connections. You'll see how this piece will fit to the rest of the system without any obstruction. The standard configuration is supplied with 13 mm micrometers which may be replaced with motorized micrometers as shown. Custom 80 mm long rods support the assembly. The rod system is fully compatible with mounts 74.







Expanding Optoform to Larger Mounts

As you see for constructing the rest of the microscope, we'll need more modules. In classic Optoform, we increased size and thickness of mounts, and support rods as the scale got bigger, but in new Optoform, we'll keep them the same! This is unheard of in Optomechanics. The advantage we have is full compatibility between every individual part in the system. What is allowing us to do this in module design is we could utilize sheet covering, and anything else that is necessary to achieve mechanical rigidity. Also in larger mounts, we could utilize as many rods as we need, which could have any shape necessary. This would be impossible to accomplish with prior art.

The next size up is mount 74. This mount is a combination of 4 pieces of mount 40-100 (Fig.4). The combination mount will always share rods between them. You'll see how this idea will allow construction of assemblies with extreme complexity. Again, the end user would just combine modules, while we'll handle the complexity for you. Our goal is to offer you a construction system that you could also use to house your electronics. Optomechanics comes included. Say you want to house the power supply: The stand-off for the electronics board, and the box could be built with Optoform. Every rod is 6 mm in diameter, and every mount is 6 mm thick, ready to be assembled. Your control panel would be one of the sides of the housing, while the box height could range from 20 to 250 mm in height. Optoform mounts, and rods, and cover sheets could be on your electronics parts bin next to your soldering iron. You got the idea.

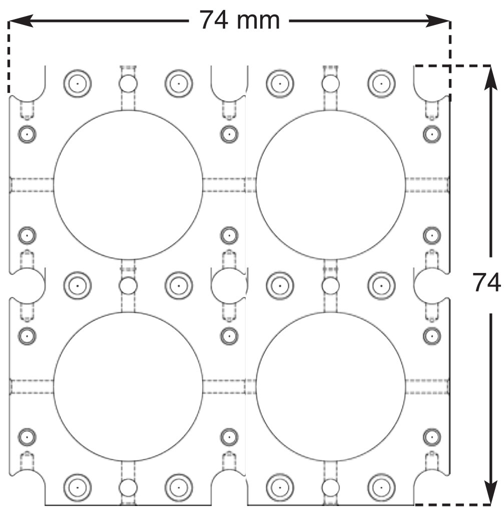


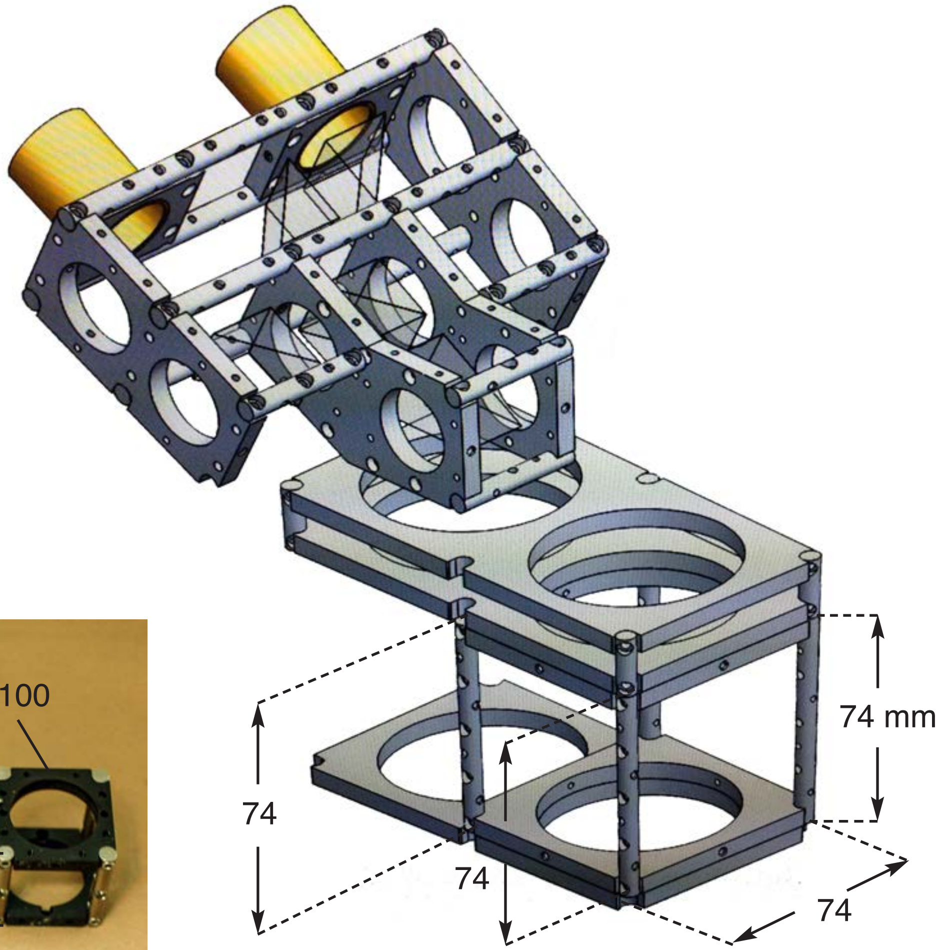
Fig.4 Geometry of Combination Mount 74

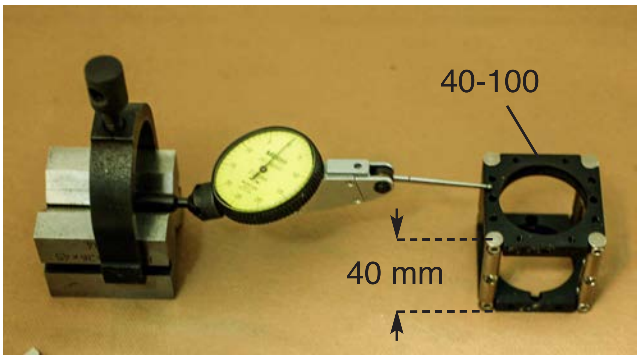
Parallelism

So far, the mechanical geometry of optoform has been 40x40, and now we are adding the next larger size: 74x74 mm. The combination mount for74x74 would naturally be 74x142 mm. Our next size up would be 142x142 mm. How would you make all these sides parallel, and not come up with another eiffel tower?!

You could use a digital caliper to measure each side. Rod lengths are made with 0.01 mm accuracy but you could always press the assembly against a flat surface before tightening the screws, and you'll have good parallelism.

You could also use a height gauge or dial indicator as shown below. All four corners should be within 0.02 mm error. The Aluminum cover sheets would give structural rigidity to the assemblies. Before covering the space frame with sheet covering, the plates could be pressed against a flat surface on every corner before tightening rod securing screws.

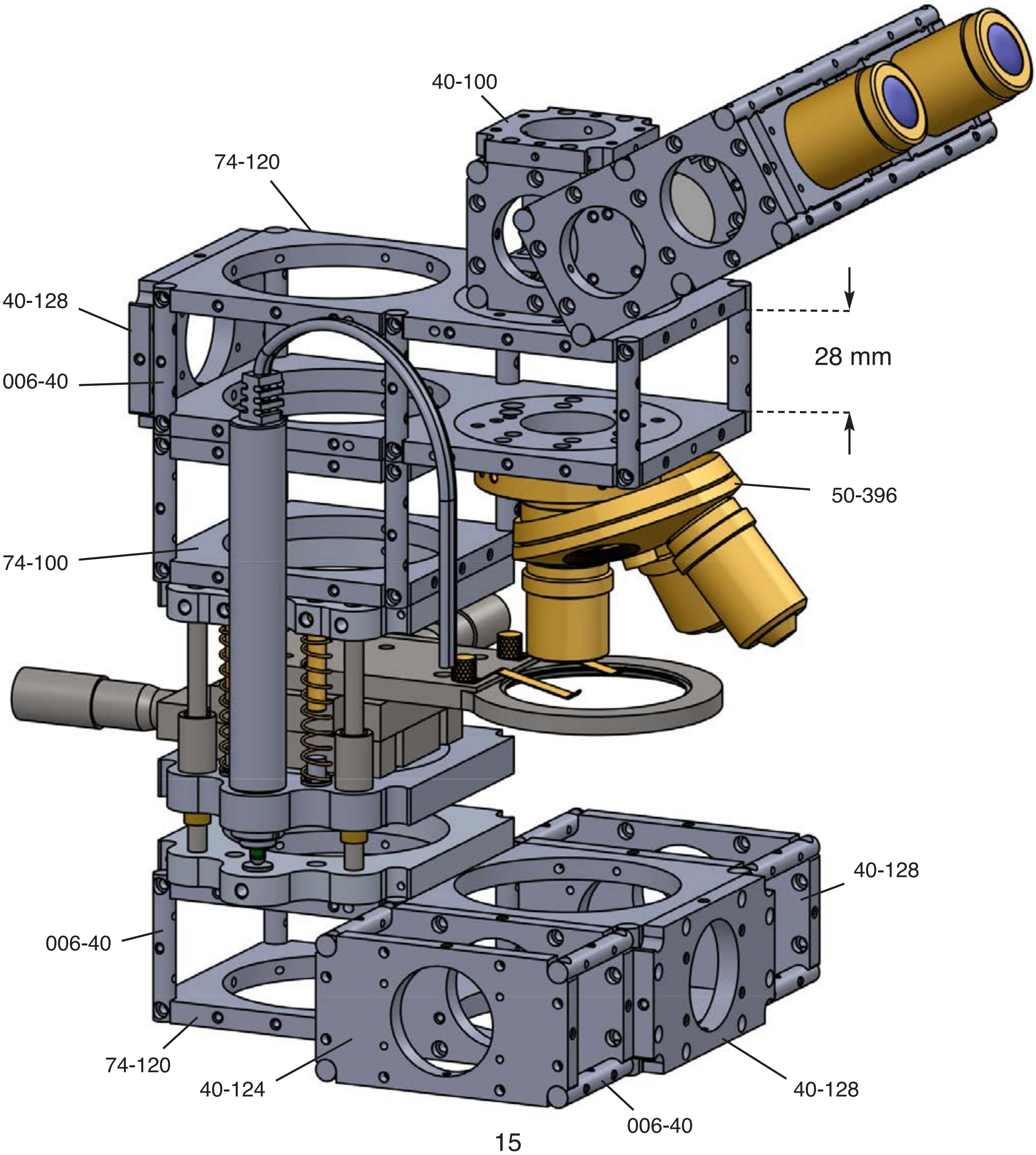


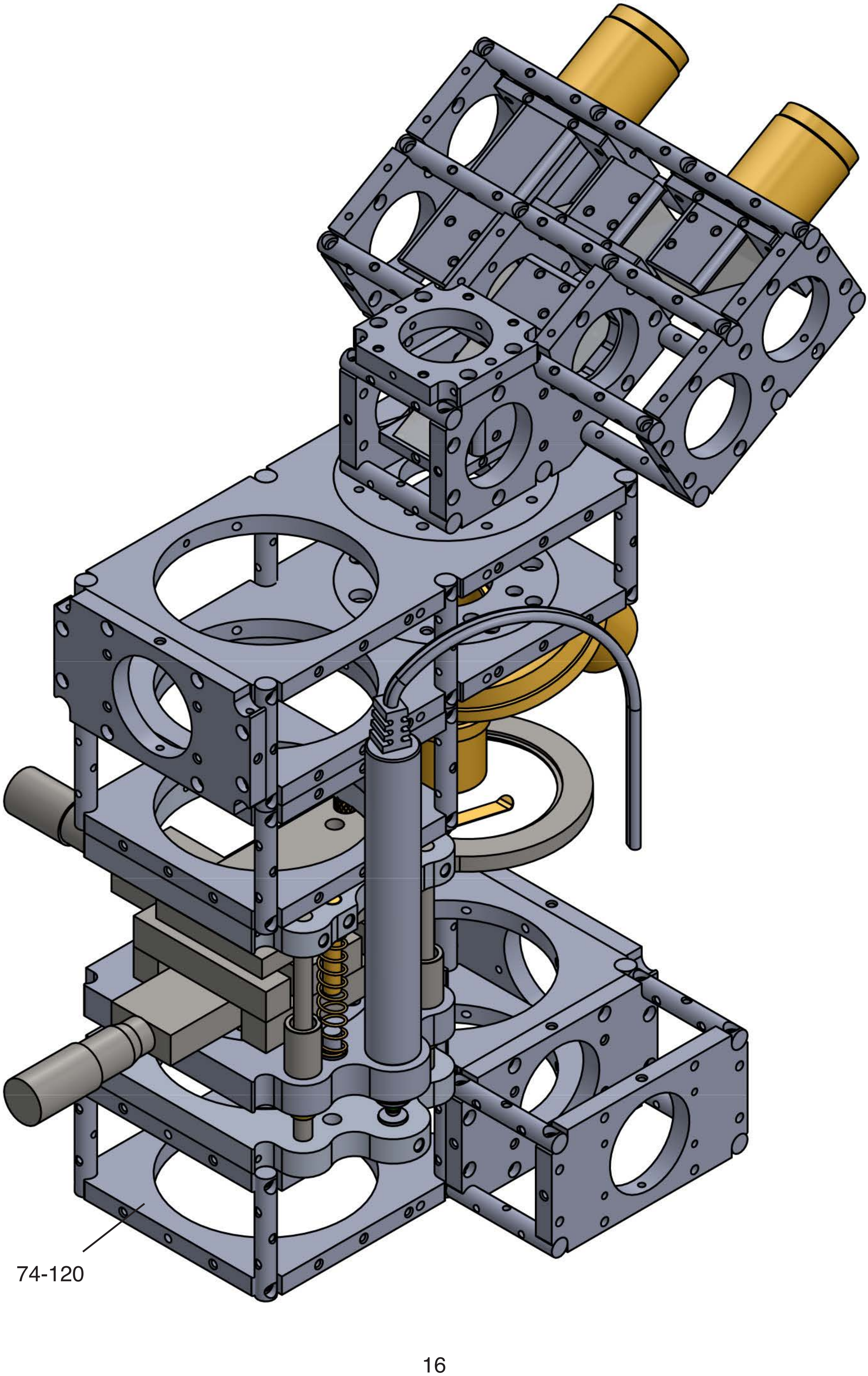


Integrating the Modules

The current configuration allows implementation of both incident, and transmission illumination. The spacing between mounts 74-120 is 28 mm, and a new mount is added to fit in between these mounts for securing all the necessary beam-splitters, and optical elements that are utilized in designing a Kohler illumination or an Epi-Luminiscent scheme. Again, the illumination optics is a stand alone module that could be separated from the microscope to be replaced by an alternate design.

The base platform is currently designed in a T-shaped space that could hold some electronics. As the mounts get larger, their size to thickness ratio increases, and in larger mounts, they are not any thicker than elctronics enclosures with good heat dissipation. I will have to give you a few examples till you see what I mean by this. But for now, take my word for it: The new Optoform assemblies are perfect for wire routing, and electronic parts integration into the optics housing. I guess the easiest example would be housing a large CCD camera, mounted on 40-100 plate on top of the microscope. We'll construct one later. But what's missing in this microscope is the illumination optics. I'll explain that next. We have designed a special mount for this purpose (40-128). It is mounted at several places around the microscope to show various light source mounting possibilities.




74-120

Support Base

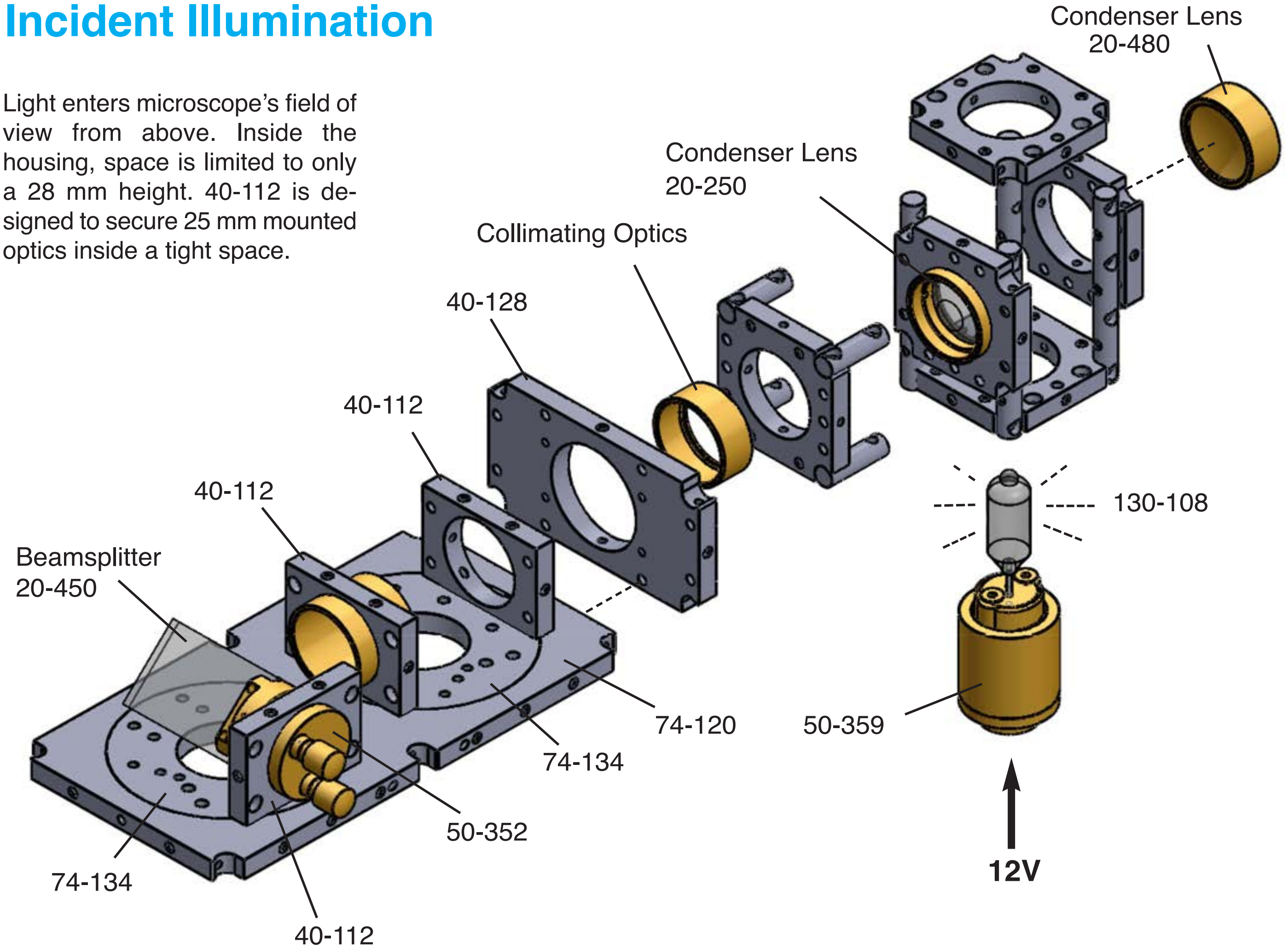
The microscope base is desired to have as low profile as possible, but it has to be thick enough to house the illumination optics if the light comes from below the sample. In this example, we'll utilize 40 mm rods to minimize the height. If we decide not to have the base to house the optics, we could house a switching power supply board there.

Illumination Optics

There are several optical paths the illumination optics could take form. It could be an inverted arrangement or in this example, the standard upright design. For epiluminescence illumination, let's utilize our Halogern lamp module connected to microscope's rear end. To accomplish this, we would populate the 74-120 mount with an assortment of optical elements to collimate, and focus the beam onto the sample (below). There are two 74-134 centering rings mounted on combination mount 74-120: One secures the beamsplitter holder below the binocular head while the other secures the illumination optics of the lamp housing side the microscope.

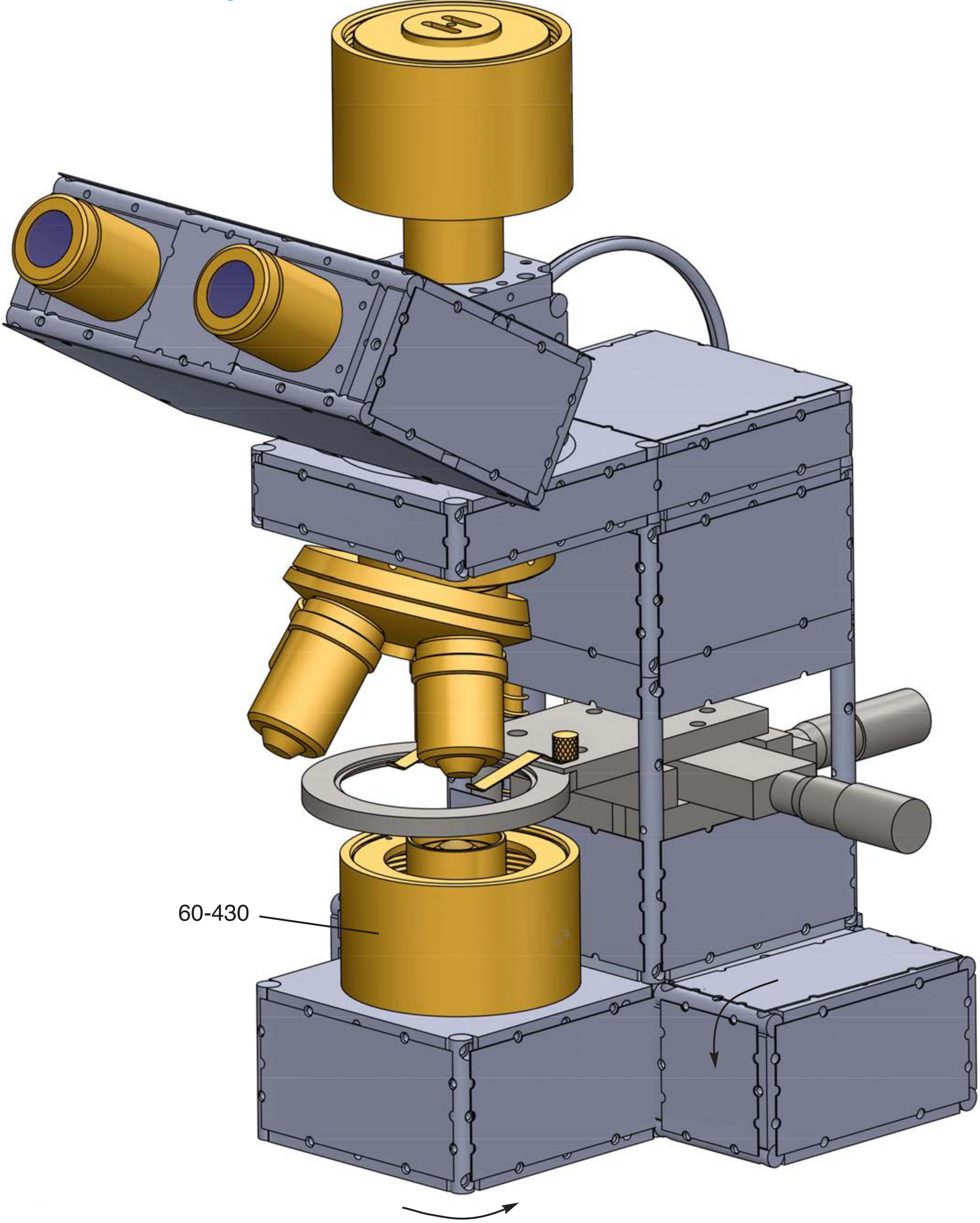
Incident Illumination

Light enters microscope's field of view from above. Inside the housing, space is limited to only a 28 mm height. 40-112 is designed to secure 25 mm mounted optics inside a tight space.



Various illumination schemes could be implemented in between two 74-120 mounts. Although discrete components are shown, the illumination assembly actually consists of two modules: The lamp housing (right), and the illumination optics housing sitting below the binocular head. Note the illumination path is shown from right to left for clarity (opposite of its orientation inside the microscope on the previous page).

Final Assembly



The final assembly is to cover the instrument with sheet metal shell. With new Optoform this is easy because there are plenty of inexpensive pre-cut anodized Aluminum cover shell you could get to cover it. Note where there are vertical rods, there are vertical curves around the body, and horizontal rods would result in horizontal curves on the housing contour. If you have conflict between two cover sheets, just cut them with scissors. Office scissors do much better cuts on thin Aluminum sheets than heavy duty cutters. In any case, you'd also notice the focusing barrel below the sample (60-430) is built with Micromax 60. This is an exact match to the inside clearance aperture of mount 74's.

Micromax 60 accommodates much bigger lenses. It is perfect for constructing condenser optics for illumination purposes. The Littrow prism can be replaced with a specially cemented version to convert the binocular head to a trinocular observation head as show in this example.

Back Illumination

The microscope base in most microscopes are occupied by power supply electronics. This worked well for older generation microscopes because the weight of the power supply with its wire wound transformer would give the microscope a good balance. Today's switching power supplies are so light; they could be housed anywhere.

We haven't reached the electronics part yet, so it's pure optics for now. Most of the components like the lamp housing, mirrors, and tilt stages are borrowed from our classic Optoform parts catalog. Several views of the illumination optics housed inside the microscope's base is shown here. The upper platform securing the trinocular head, and objective turret is built with shorter rods (20 mm) to provide structural rigidity.