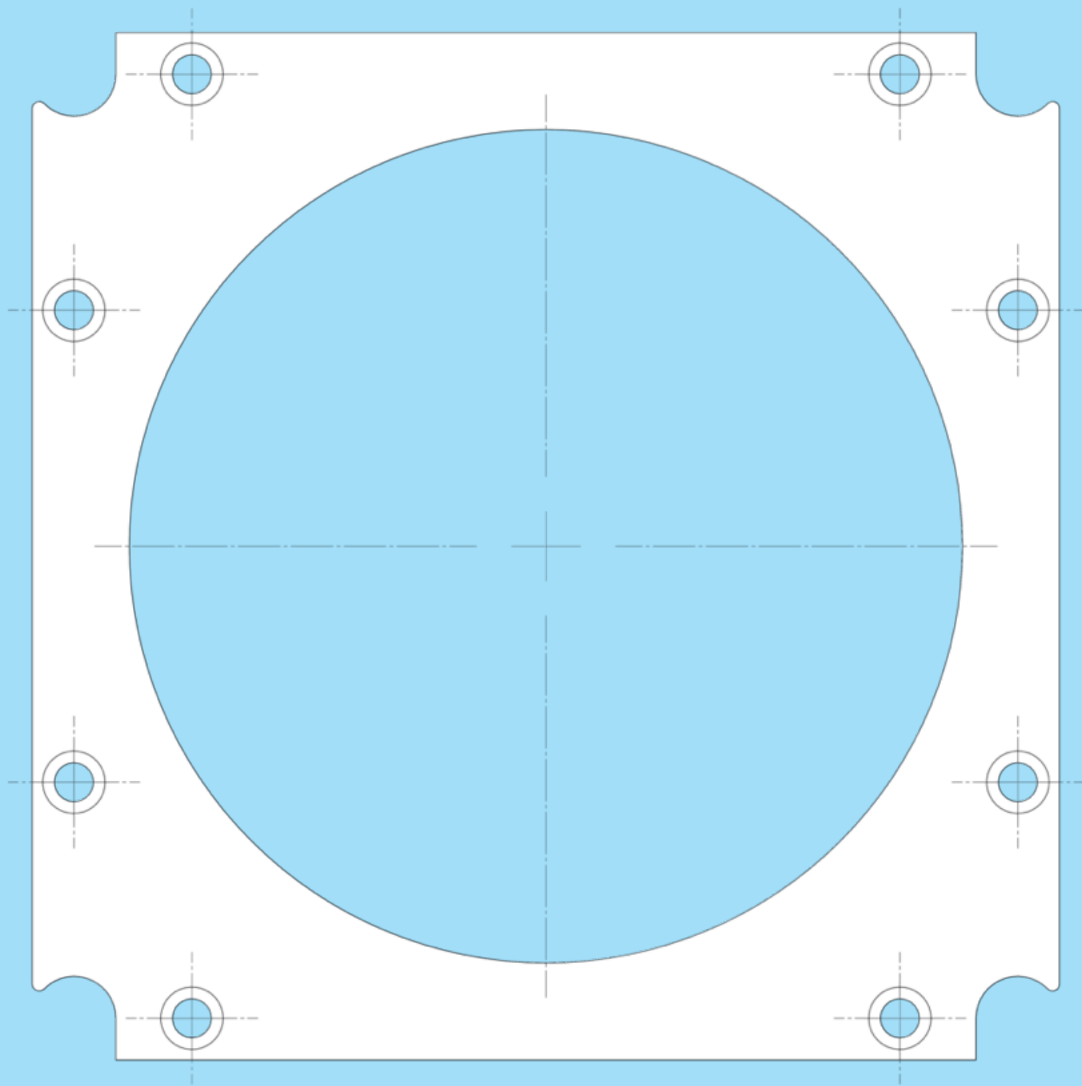


Optomechanix

Optoform 74 User's Guide

www.optoform.com

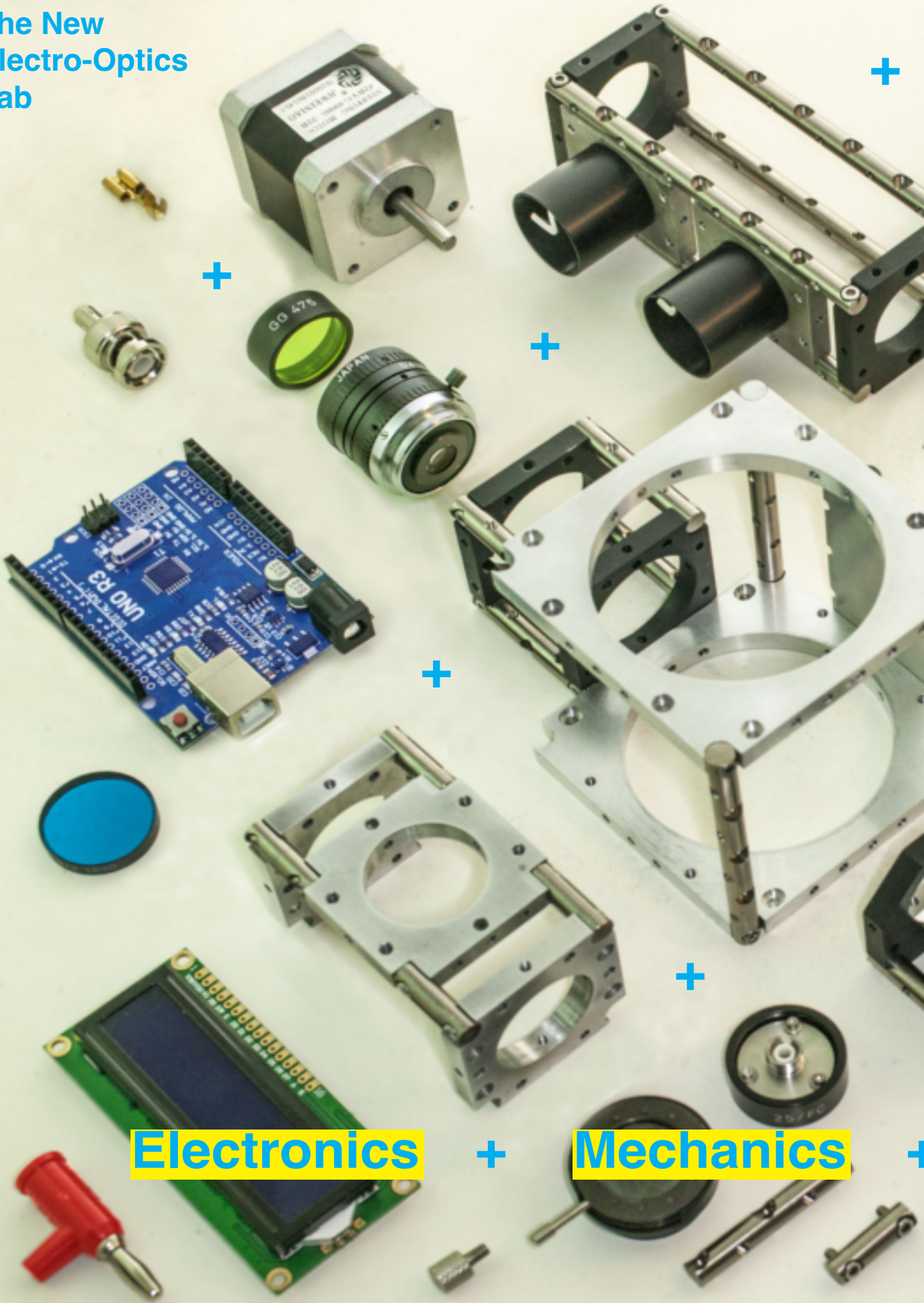
New Optoform II Cage System



PCT Patent Pending US2019/020863
European WO 2020/180307, China 2021

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A bit of History

For me, it all began by purchasing my first Microbench kits in late '80's, and I couldn't take my hands off it. But optical kits have been around since 1920's made by Alfred Carlton Gilbert who is known as the father of Erector Set.

Microbench

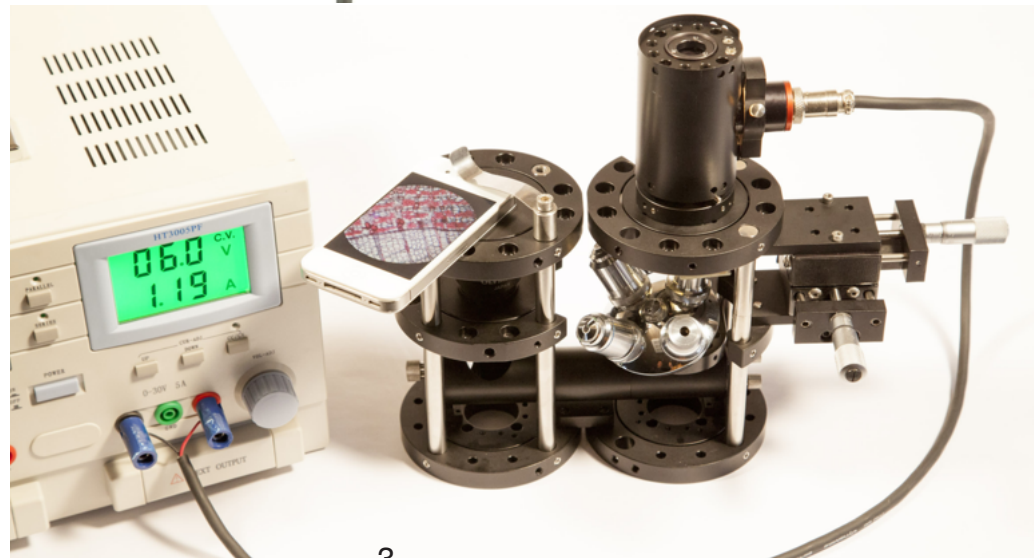
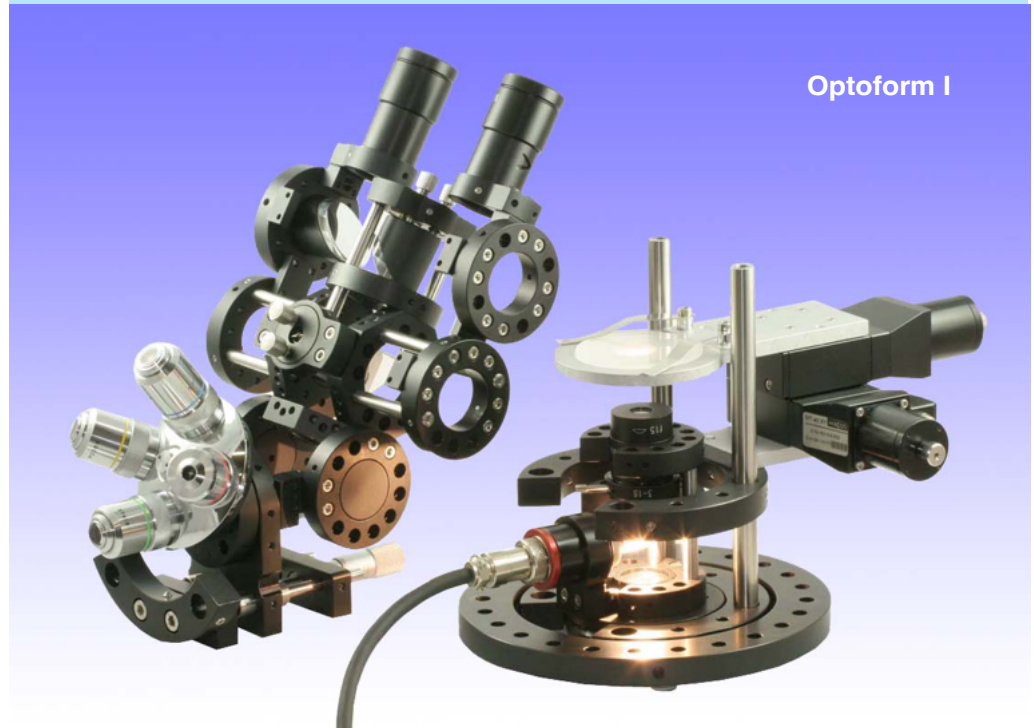
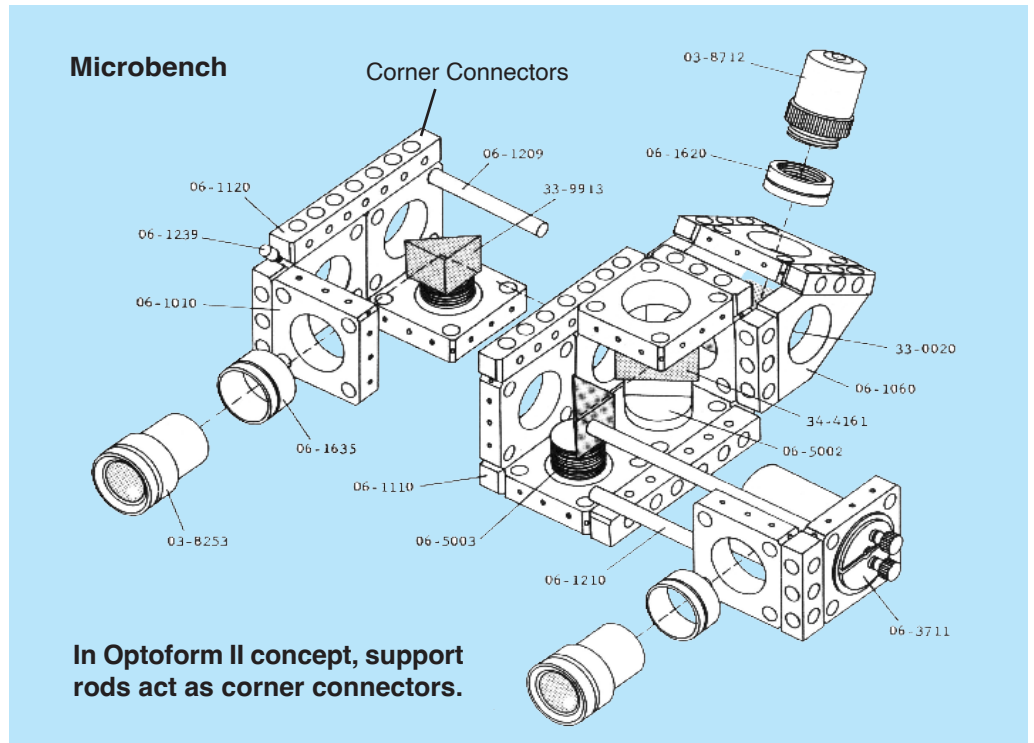
An optimized construction of a binocular head (right) with Microbench system built by author using minimum number of parts. I have always felt Microbench didn't succeed as much as its Thorlabs' counterpart was because it lacked an easy to understand user's manual for its end users. Microbench's use of corner connectors made it capable of solving far more complex problems than its simplified Thorlabs counterpart.

In Optoform II concept, support rods act as corner connectors. We'll build a binocular head with Optoform II to compare its flexibility, and cost.

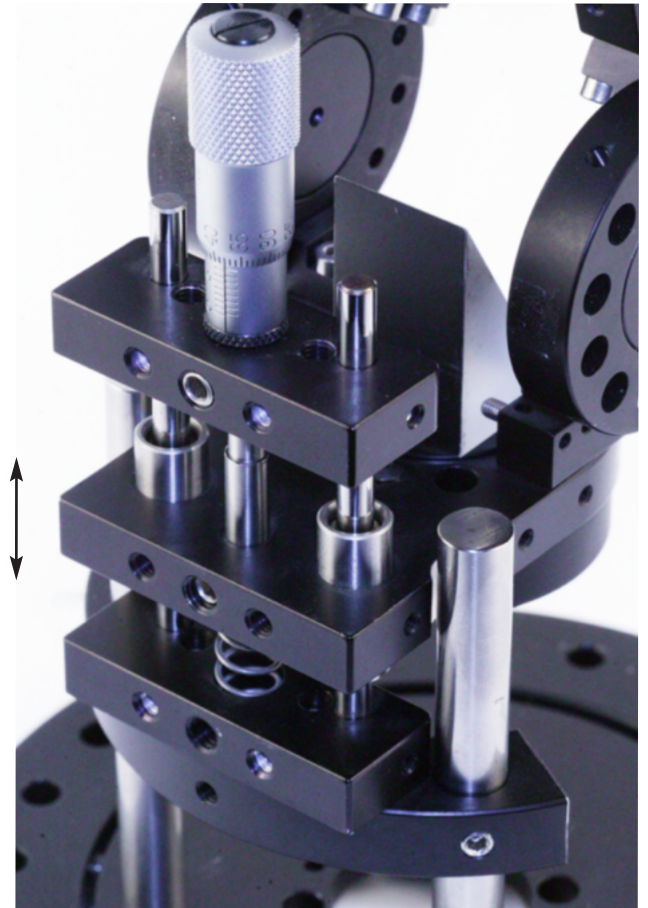
Optoform I

I invented, and filed a PCT patent for Optoform in 1993, hoping to offer a lower cost system than Microbench. Right, a motorized Biological binocular microscope built with original Optoform utilized concentric circular building blocks from 25 to 150 mm in diameter.

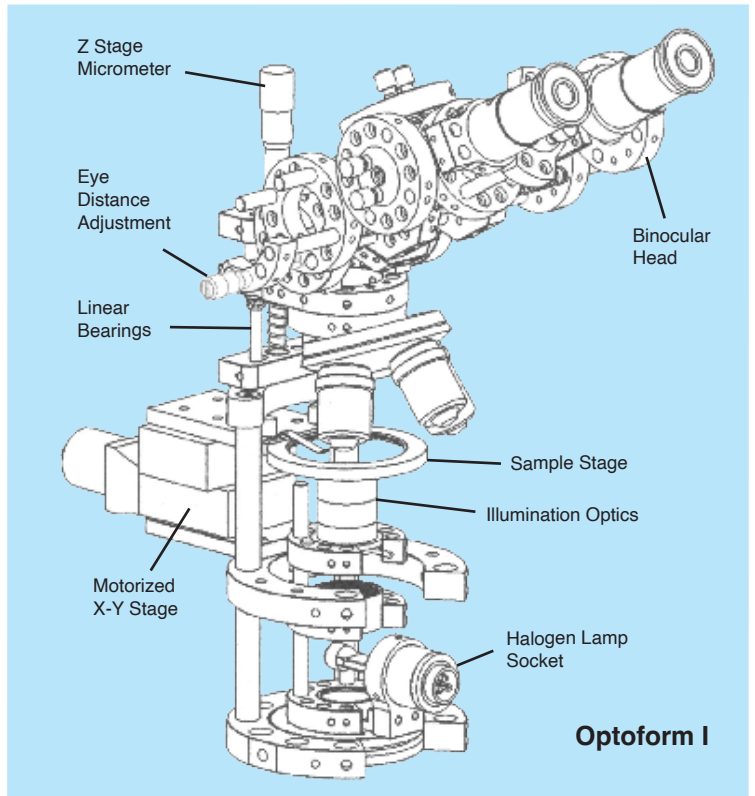
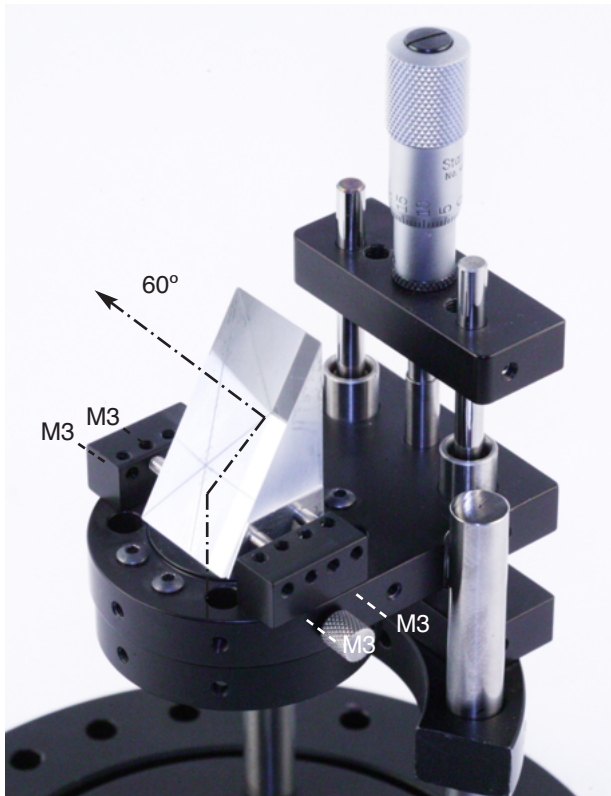
The capabilities of Optoform have been known by many research centers, and universities around the world. Complex optical cage systems are difficult to get started with, but those who do master it, can't live without it. Optoform I is still one of the most versatile erector sets offered to optical engineers, and optics lab technicians alike.



Optoform I is 30 years old



Optoform I introduced linear bearings: It consists of a stationary plate, and a translation plate pushed by micrometer.



It introduced up and down compatibility between the mounts: Close up view of Littrow prism mounting screws (left) utilizing corner connectors . Opto-mechanics is all about details, and Optoform I handled every detail pretty well.



We have come a long way with Optoform II The new generation of optical Cage System

When visiting trade shows, and observing so many new products, I have often offended some sales people by telling them their product isn't genuine. An optical cage system should bring something new, and honest to its end users. If you think you could just take off one rod, or change anodization colors, people will say no to it. Although a one-rod or three rod cage system is not as good as a 4-rod arrangement that's an engineering decision, not an innovative one.

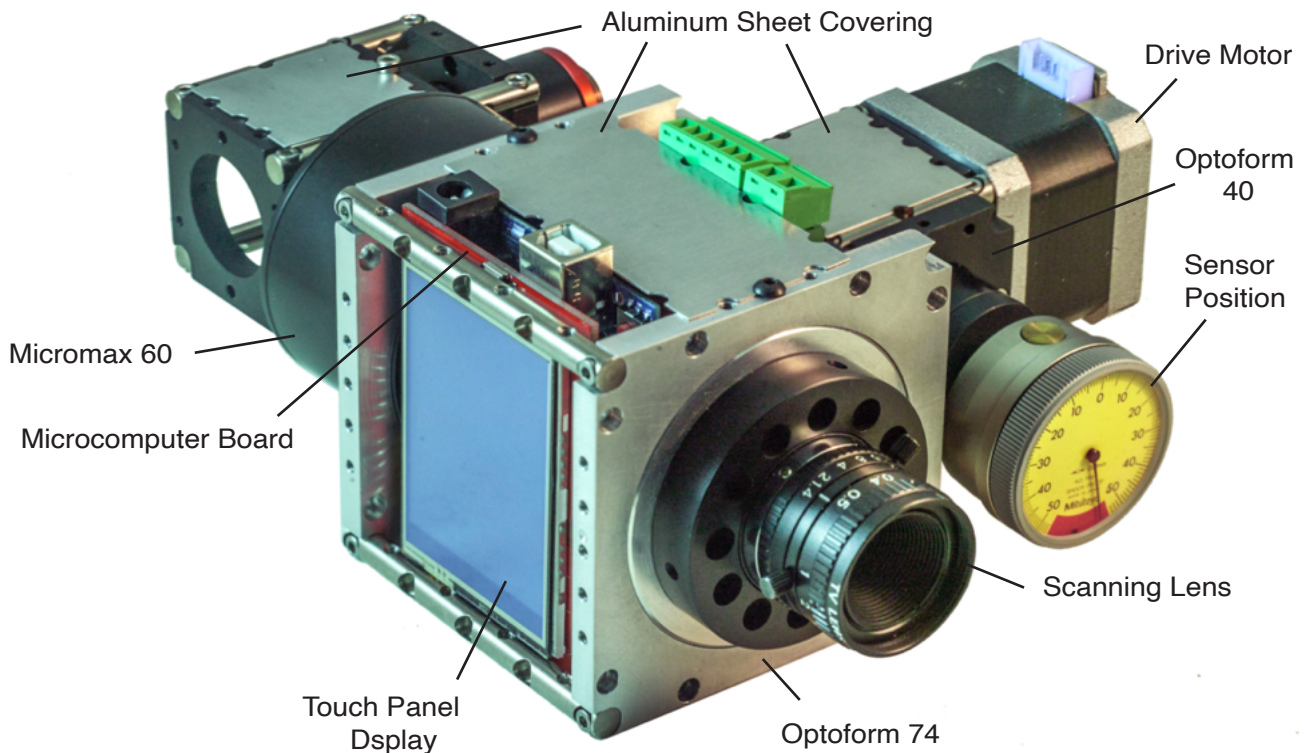
So after nearly 30 years past my original design of Optoform in 1993, I said Optoform II better be something phenomenal or I won't spend time on it. Luckily, the new idea I had about making them cheaper, and more versatile, led me to design a new form that could be produced out of extruded Aluminum - a drastic reduction in manufacturing cost.

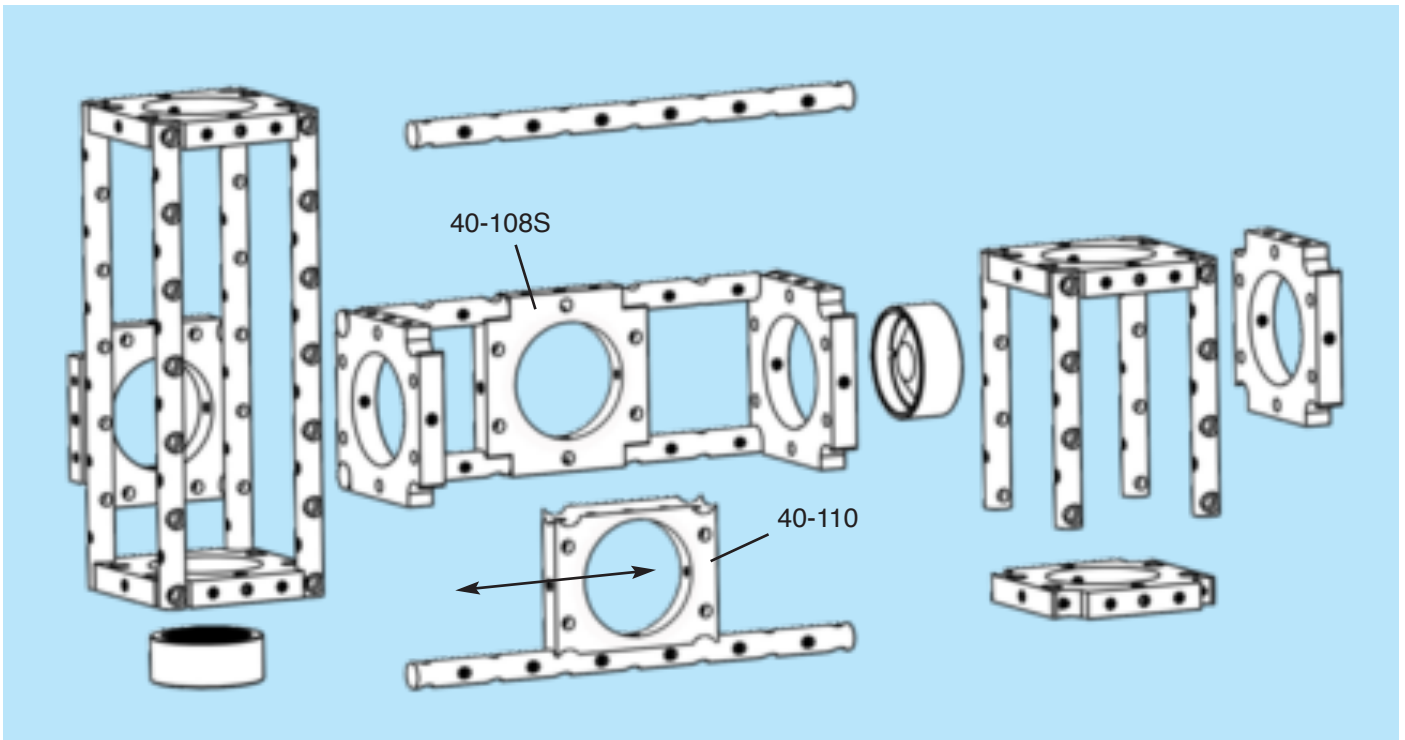
Before signing off an M&A agreement with Edmund Optics to hand over Optoform I, we had been manufacturing it for 18 years. I know it takes a 5-axis CNC machine around 5 minutes to produce each mount. This drives the price to \$30 each. New Optoform II can be produced in about half that time, and half the cost.

Since Optoform II is less expensive, thinner, and lighter, you could divide your setups into sub-assemblies. Optoform II offers space frame components so you could build complete housings, and portable instruments. In upcoming pages, we'll review some real applications, and see how the new Optoform building blocks can be helpful in constructing them. These are culmination of many applications notes previously published in our quarterly magazine at optomechanix.org.

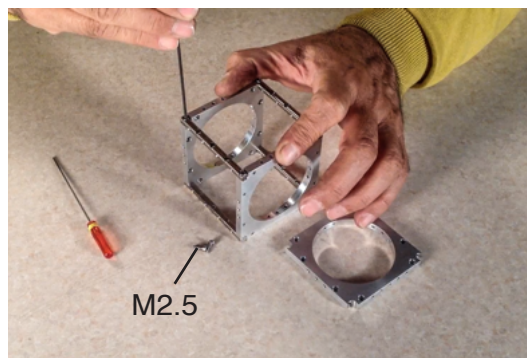
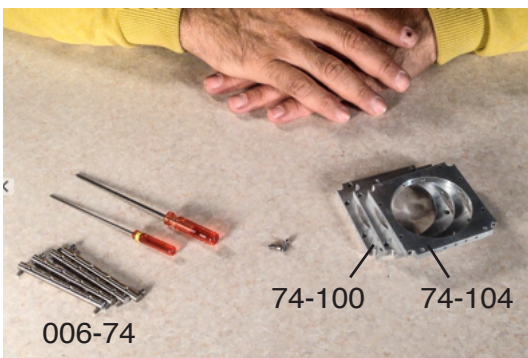
Ali Afshari
CEO, Optomechanix

Approach your final product



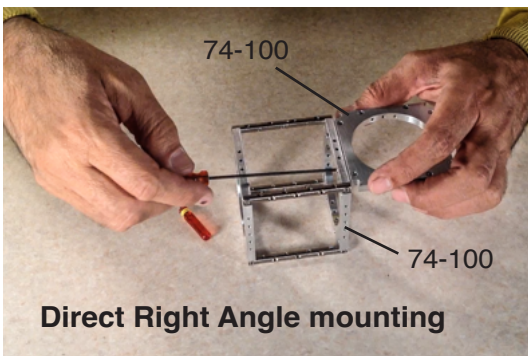


What would happen if you turn support rods to corner connectors? Unlimited mounting possibilities

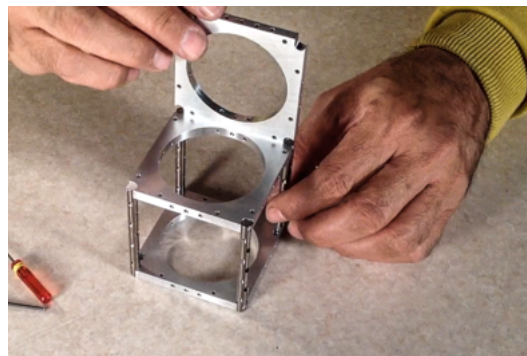


Constructing a cube

Using Optoform 74 mounts: In real practice, you'll only do this once. Cubes are your basic elements to construct 3D structures. The height could range from 12 to 142 in 17 mm increments.

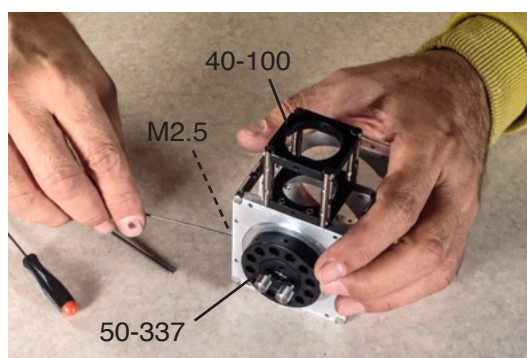
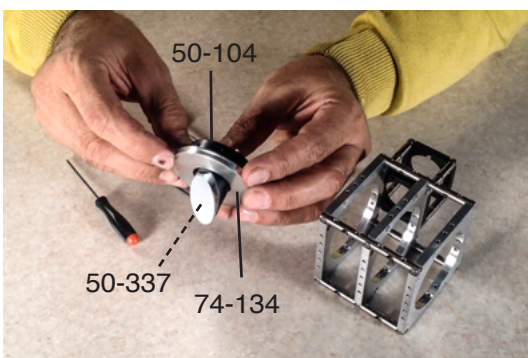


Direct Right Angle mounting



Securing mounting plates at right angles

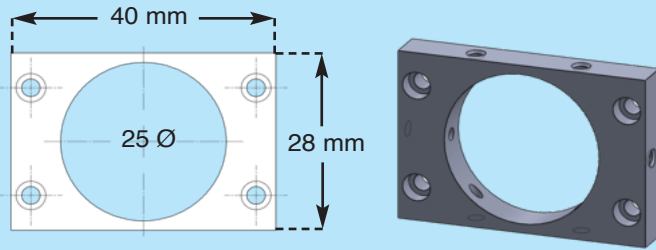
Using counter-bores on the face of 74-100, and equally spaced M2.5 bores on the side of 74-100 or 74-104, two mounts may be joined together at right angles.



Using Optoform Accessories:

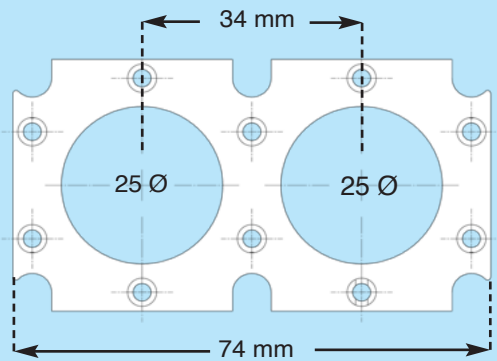
Utilizing 50-104 to secure 45° mirror mount 50-337 on mounting adapter 74-134. This centering disc is held at 3 points via M2.5 set screws (right).

Special Mounts 40



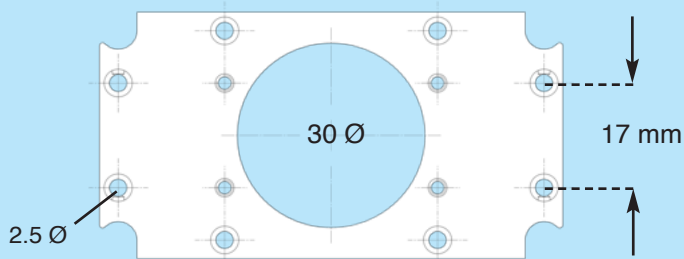
40-112 Compact Mount 40

Secures Optoform accessories on top of 74-134 to secure 25 mm mounted optics, and various Optoform accessories. Designed to secure optics inside 40 mm tall instrument base (above).



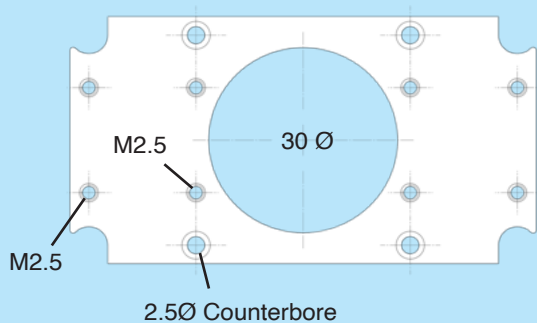
40-120 Combination Mount 25

It is two 40-104 mounts placed side by side, sharing the two middle rods. Supports two parallel optical beam paths, 34 mm apart. For binocular vision systems, and Z-path beam folding to shorten the size of an optical layout.



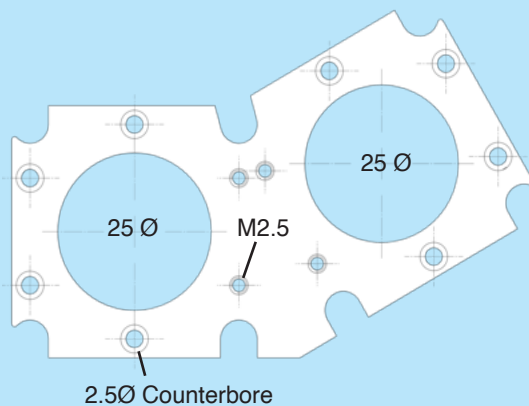
40-124 Side Mount 30, 40/74

For side mounting Optoform 40 mounts to mounts 74. Has four mounting bores to accept mounts 40 at its center. Mates with 40-126. Secures 30 mm mounted optics via M2.5 set screws.



40-126 Side Mount 30, 40/74

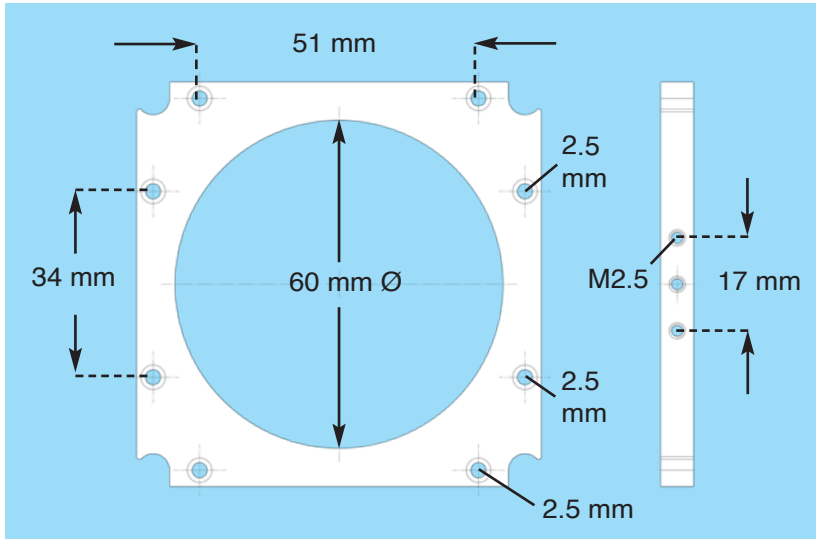
Identical to 40-124 but with mating bores to be secured face to face with 40-124. Allows end to end connection of modules, and mates directly with 74-100 mounts. Secures 30 mm mounted optics via M2.5 set screws.



40-128 Inclined Tilt Platform 25

For constructing a binocular head with 60 degree inclined viewing. Mates with Optoform 40 mounts in both axial and orthogonal directions via support rods. A specially designed rod for constructing the binocular head is available 006-128 with L = 128 mm. This rod has the correct length to work with 40-108. Secures 25 mm mounted optics via M2.5 set screws.

Optoform 74 mounts

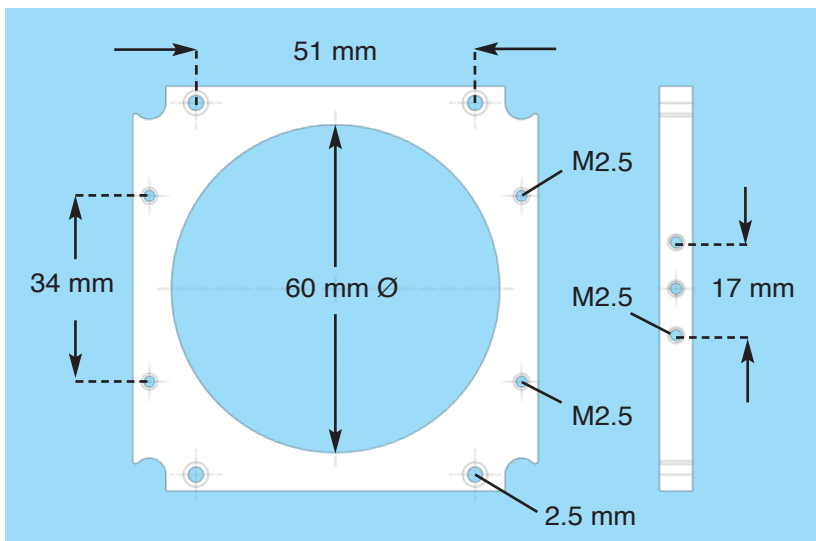


74-100 Standard Mount 74

Mounting plate 74-100, and 74-104 have matching 2.5 mm counter-bores, and tapped bores, 51 mm apart, to allow securing them face to face, i.e., for joining two sub-assemblies.

The 17 mm spaced mounting bores on its side will mate directly with Optoform 40 mounts. The 34 mm spaced mounting bores are to interface to other 74 mounts, or side mounts 40-124, and 40-126.

Will secure 60 mm mounted optics, and centering discs. Accepts Optoform 40 mounts on its M2.5 side bores.

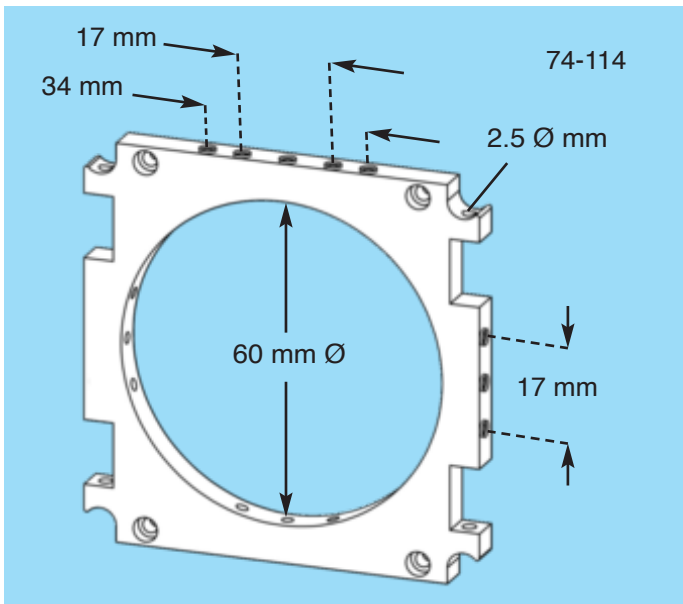


74-104 Mating plate 74

Identical to 74-100 but with 51 mm spaced threaded bore pattern to mate face to face. This orients the rods on the top, and bottom of the mounts for easy assembly. For side bore pattern, please refer to 74-114 description.

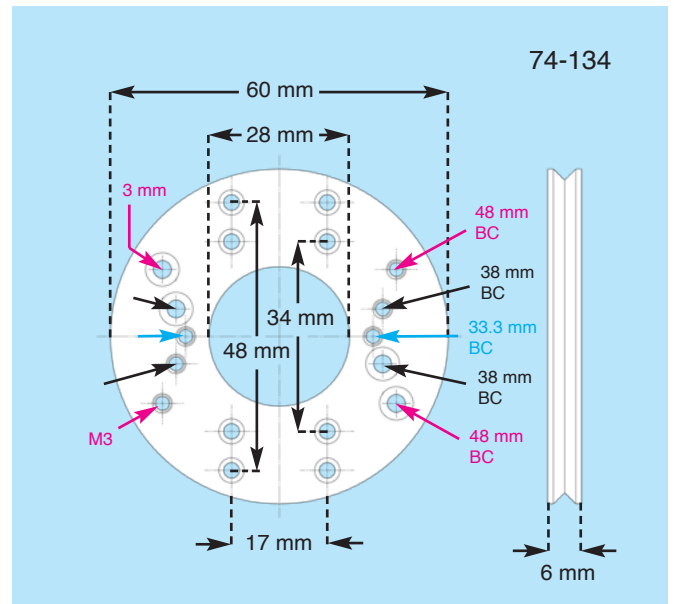
74-114 Side Mount 74

Identical to 74-100, and 74-104, but with portions removed to allow securing it to rods internally rather than externally via M2.5 screws. This mount could be secured anywhere along 2, 3, 4 rods.



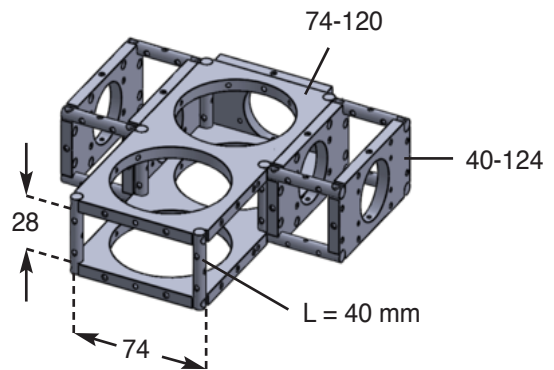
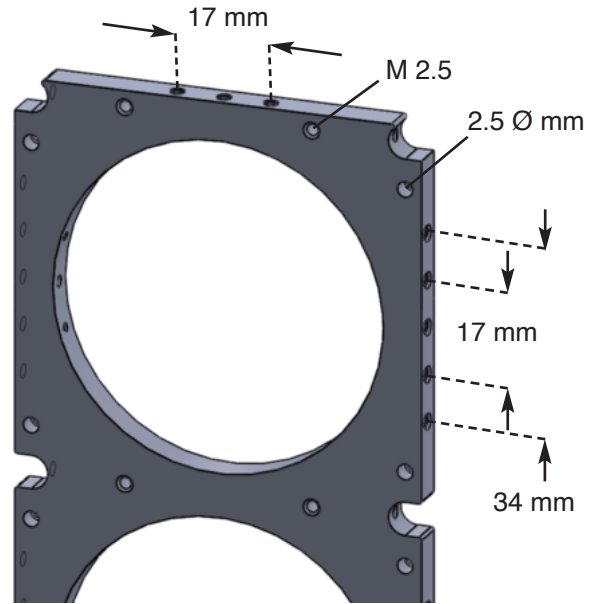
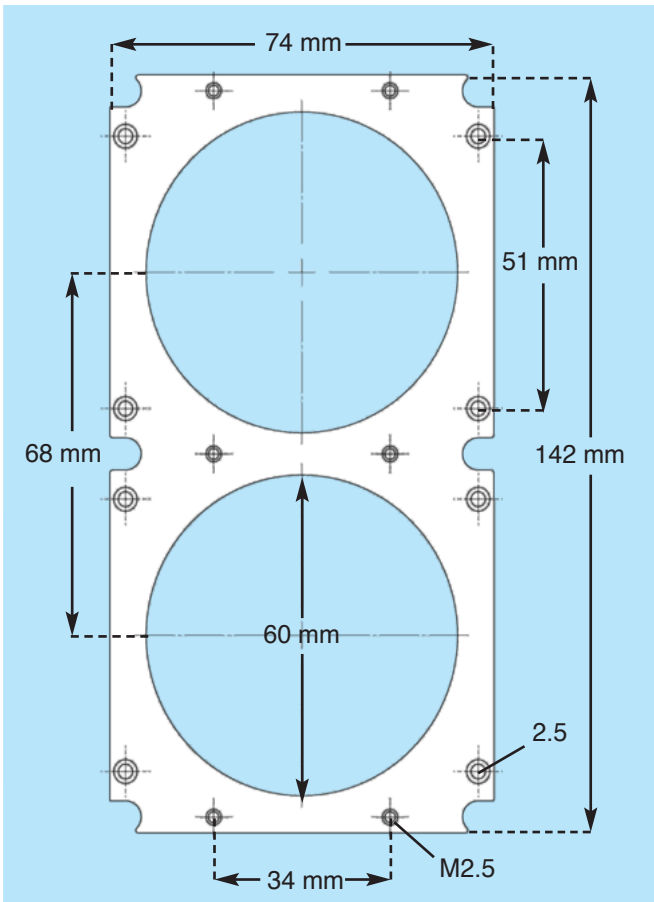
74-134 Mounting Adapter 60

Accepts Optoform 40 mounts, Microptic 50 (38 mm BC), or 2x2 mounts (48 mm BC) to integrate full range of classic Optoform accessories. It is secured in place via four M2.5 screws, 90 degrees apart, and is not intended for centering. The hole pattern is complex but it's much easier during use.



74-120 Combination Mount 74x142

Combines two optical 74 mounts, 68 mm apart. Accepts Optoform 40, and 74 mounts on its sides, i.e. 40-124 to create instrument platforms (below).

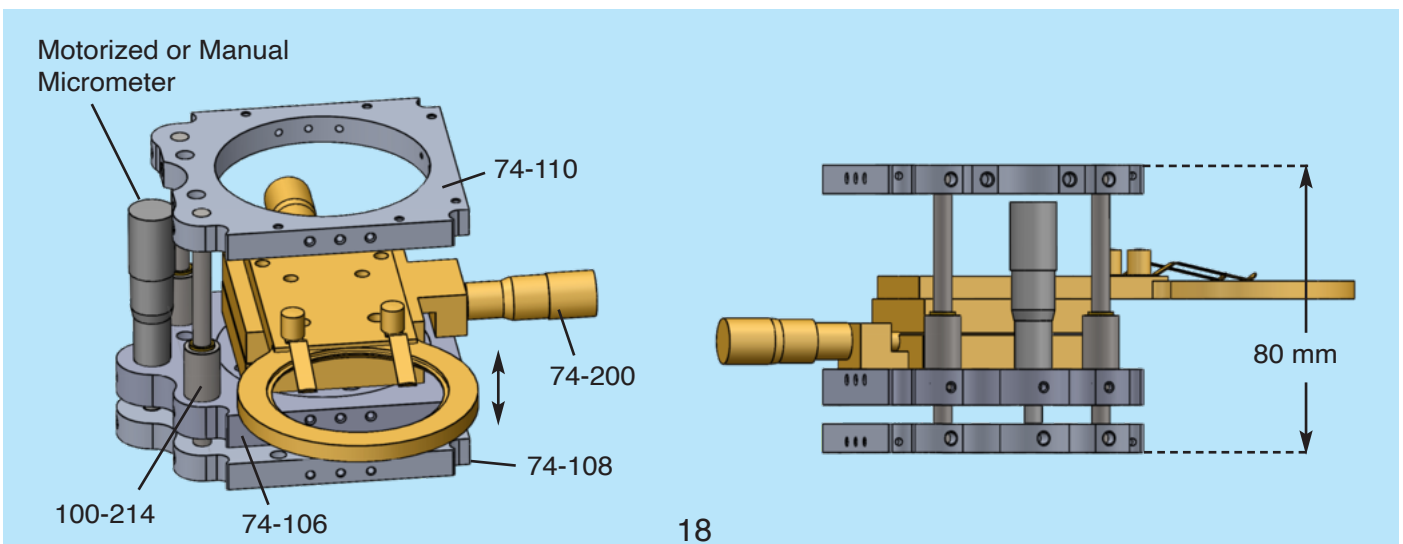


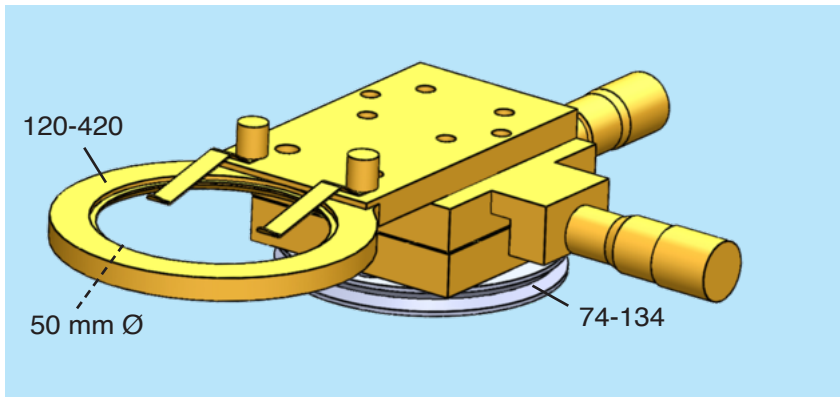
Instrument base constructed with 74-120, 40-124, and 006-40 rods (right). The sides of this assembly may be covered by our Aluminum sheets with hole patterns that match the side bore patterns on the mounts. Aluminum sheets provide structural rigidity, light seal, and dust protection for the inner optics.

74-106M Focusing Module

Focusing module consists of three mounting plates 74-106, -108, and -110. Two linear bearings guide the stage, while a motorized or manual micrometer positions the stage along its 80 mm precision ground guide rails. The focusing stage is put together with four Aluminum rods, and structurally reinforced by thin sheet covering.

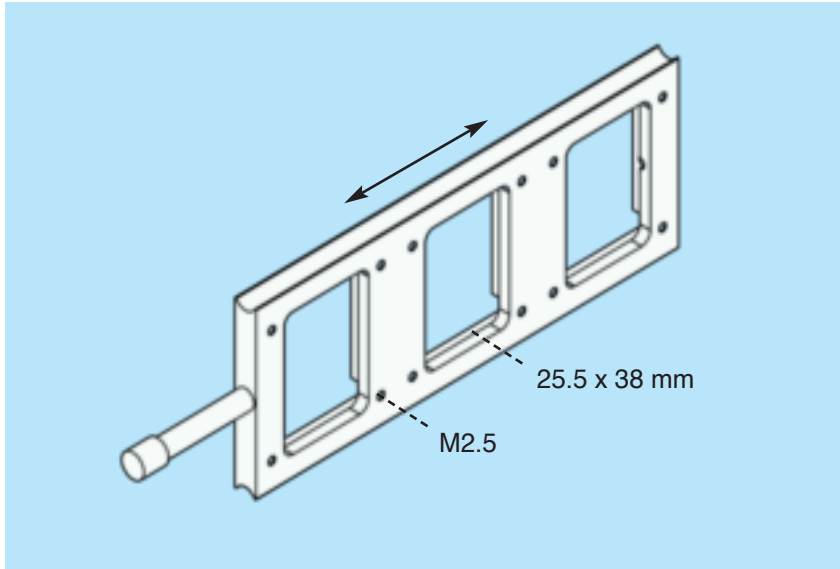
X-Y stage 74-200 may be secured on its translating plate (74-108) to construct a X-Y-Z stage for microscopy applications.





74-200 X-Y Stage with sample holder 120-420, 13 mm Travel

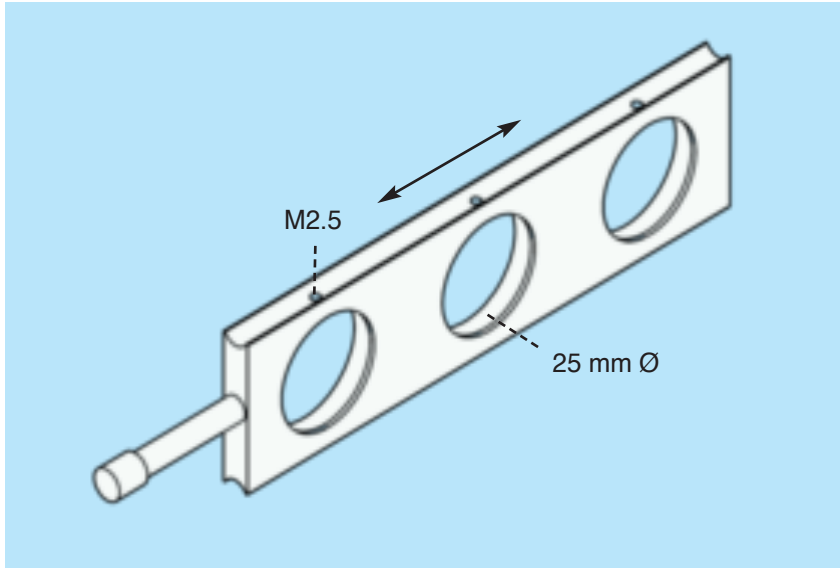
This low profile X-Y stage is designed to secure samples for microscopy applications. It works with focusing stage above to create a manual or motorized X-Y-Z satage. Accepts 50 mm diffused glass, 1 mm thick.



40-148 Dichroic Filter Slider

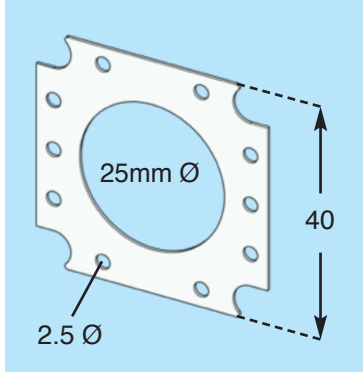
Accepts standard 25.5x38 mm beamsplitters for Zeiss Axiovert microscopes. Filter slots have a lip to prevent filters from falling off, and two M2.5 set screws, and spring washers to secure each filter in place.

This mount provides 24 mm clearance aperture at 45 degree sliding position guided by twelve 6 mm rods arranged together with end connecting adapter 00- (below).



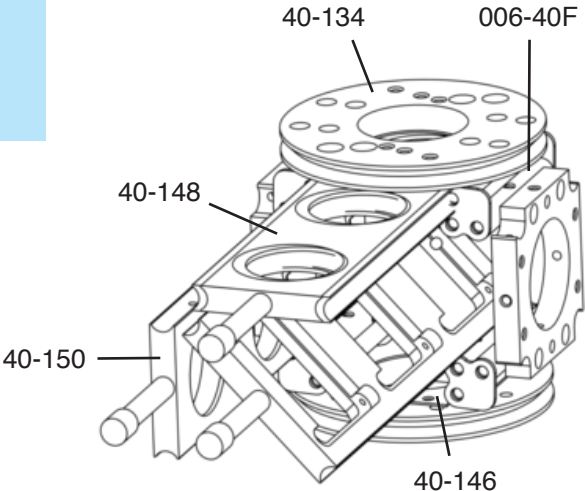
40-150 Filter Holder Slider

Accepts standard 25 mm Ø mounted filters, for Zeiss Axiovert microscopes. Filter slots have a lip to prevent filters from falling off, and M2.5 set screws to secure each filter in place. 24 mm clearance aperture.

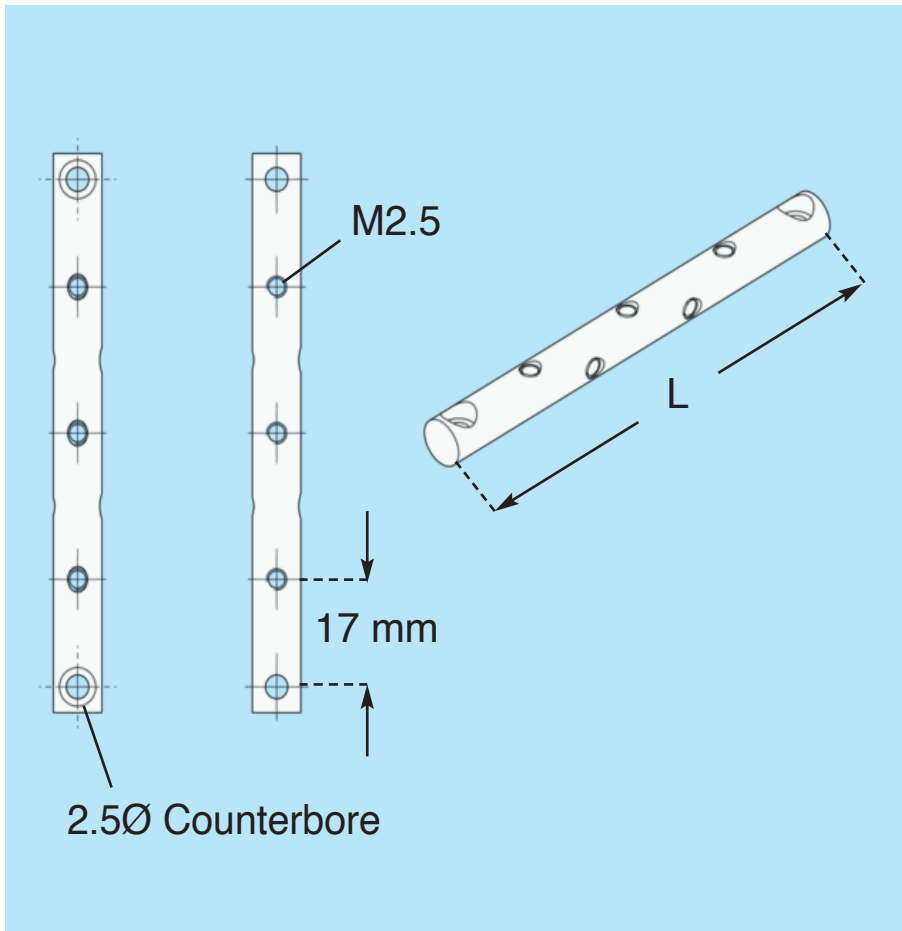


40-146 Spacer Plate 25

Provides clearance space for slider filter assembly. May also be utilized to shield off-axis light coming through, from the edges of open mounts like 40-102, or 40-134.

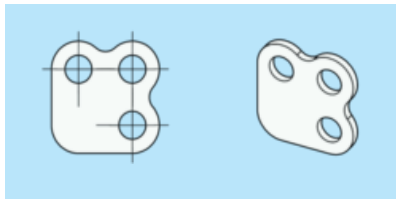


40-148M



Support Rods		
Aluminium Alloy	Stainless S	
006-12, L= 12 mm	Special Order	
006-20, L= 20 mm		
006-23, L= 23 mm		
006-40, L= 40 mm		
006-50, L= 50 mm		
006-57, L= 57 mm		
006-65, L= 65 mm		
006-74, L= 74 mm		006-74S
006-80, L = 80 mm		006-80S
006-108, L= 108 mm		006-108S
006-128, L= 128 mm	006-128S	
006-142, L= 142 mm	006-142S	

Mounting Hardware



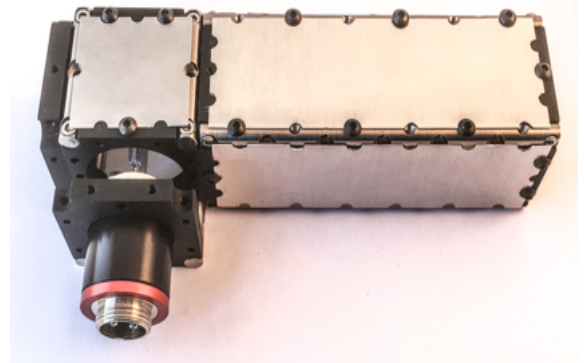
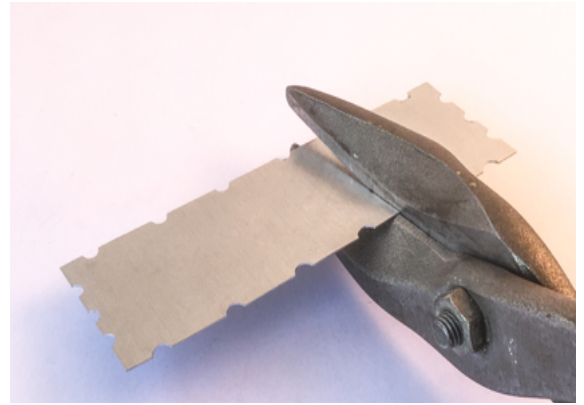
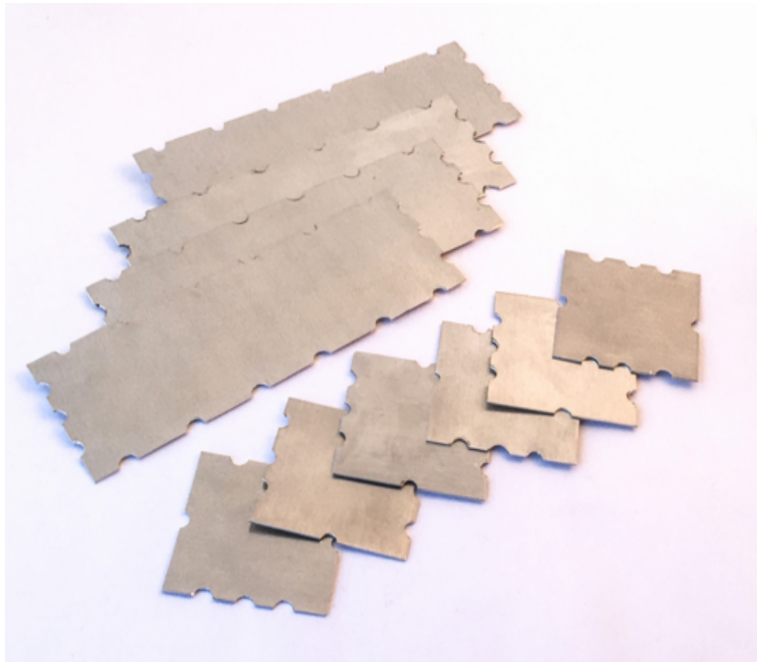
00 - 300 End connecting Adapter for Rods

For end connecting specially made 6 mm rods 006-40F with M2.5 mm threaded ends, to provide linear guides for sliding filter holder 40-150, and sliding beamsplitter holder 50-148.

00-116	M2.5x10 Thumb screws, pack of 5	For securing accessories on M2.5 threaded bores
00-120	M2.5x10 Low profile, 25 pcs	For securing two mounts face to face
00-125	M2.5x6 Socket screws, 100 pcs	Standard rod securing screw
00-126	M2.5x3 Set screws, pack of 100	Optics securing screws, L = 3 mm
00-128	M2.5x6 Set screws, pack of 100	Optics securing screws, L = 6 mm
00-129	M2.5x4 low profile, 25 pcs	For sheet covering around Optoform 40 assemblies
00-222	M2.5 Nut, set of 10	For securing accessories along M2.5 set screws
00-248	Ball driver set 1.27, 1.5, 2 mm	For constructing Optoform 40, and 74 assemblies
006-40F	6 mm rod, L = 40 mm, set of 12	Special 6 mm rods with M2.5 threaded ends, with detent

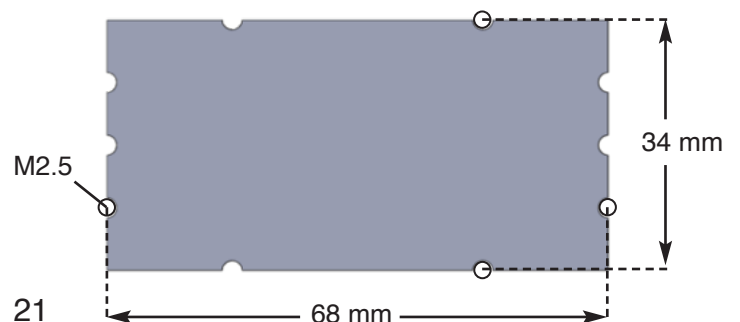
Cover Plates

Sheet covering in Optoform may be easily cut to size by household shears. There are also nibbling tools available to provide clearance notches for mounting screws.



00-500	14 X 34 mm, 0.3 mm Thickness	For covering 20 X 40 space frames
00-502	34 X 34 mm, 0.3 mm Thickness	For covering cube 40 X 40 faces
00-504	34 X 51 mm, 0.3 mm Thickness	For covering 40 X 57 space frames
00-506	34 X 68 mm, 0.3 mm Thickness	For covering 40 X 74 space frames
00-508	34 X 102 mm, 0.3 mm Thickness	For covering 40 X 108 space frames
00-510	34 X 136 mm, 0.3 mm Thickness	For covering 40 X 142 space frames
00-512	68 X 68 mm, 0.3 mm Thickness	For covering cube 74 X 74 space frames
00-514	68 X 102 mm, 0.3 mm Thickness	For covering 74 X 108 space frames
00-516	68 X 136 mm, 0.4 mm Thickness	For covering 74 X 142 space frames
00-518	68 X 120 mm, 0.4 mm Thick, Set of 2	Special 74 X 126 binocular head's top cover
00-520	68 X 102 mm, 0.4 mm Thickness	For covering 74 X 80 linear bearing assembly

Cover plates are cut at the center-line of M2.5 screw bore pattern around their periphery. This allows cover plates to lay side by side around the space constructed by mounting plates, and support rods. In optoelectronics projects, cover plates may be drilled, and nibbled to secure electronics connectors, and switches. The standard color for cover plates is anodized light gray. Unanodized version of cover plates are also available to take any desired color.



Designing, and Building a Binocular Microscope

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 putting together predesigned sub-assemblies.

You can 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 viewfinder is first bent 30 degrees via a Littrow prism for inclined viewing, and is split into two paths via a beamsplitter (Fig. 1). 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 will be utilized to construct this assembly in its bent form. Sliding mounts 40-110 ride on two 128 mm support rods, that construct this compact 128 x 40 x 114 mm assembly.

While designing this somewhat complex arrangement, two new mounts, and a 128 mm long rod must 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. Refer to page 16 for detailed description of these mounts. Figure 1 shows a quick assembly trial to help us conceive its mechanical form.

To create mount 40-126, we'll be folding half of mount 40-120 (Fig. 2) around one of its mid rods. 40-126 is designed specifically to construct the 30 deg. inclined viewing (Fig.3). These basic building blocks will be utilized later to construct the rest of the microscope assembly. The viewing head is now ready to be built.

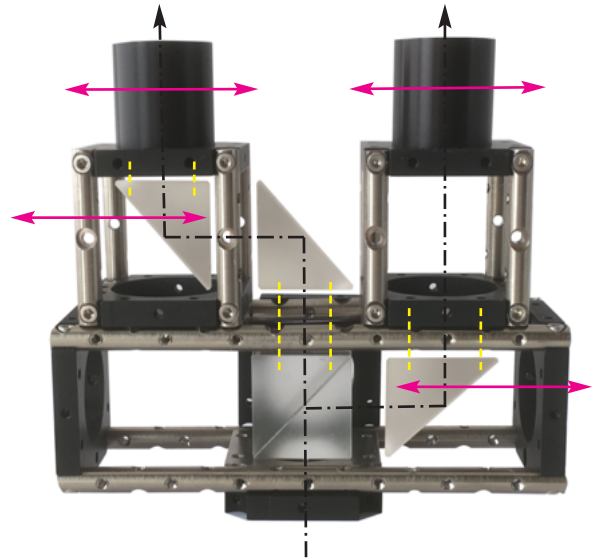
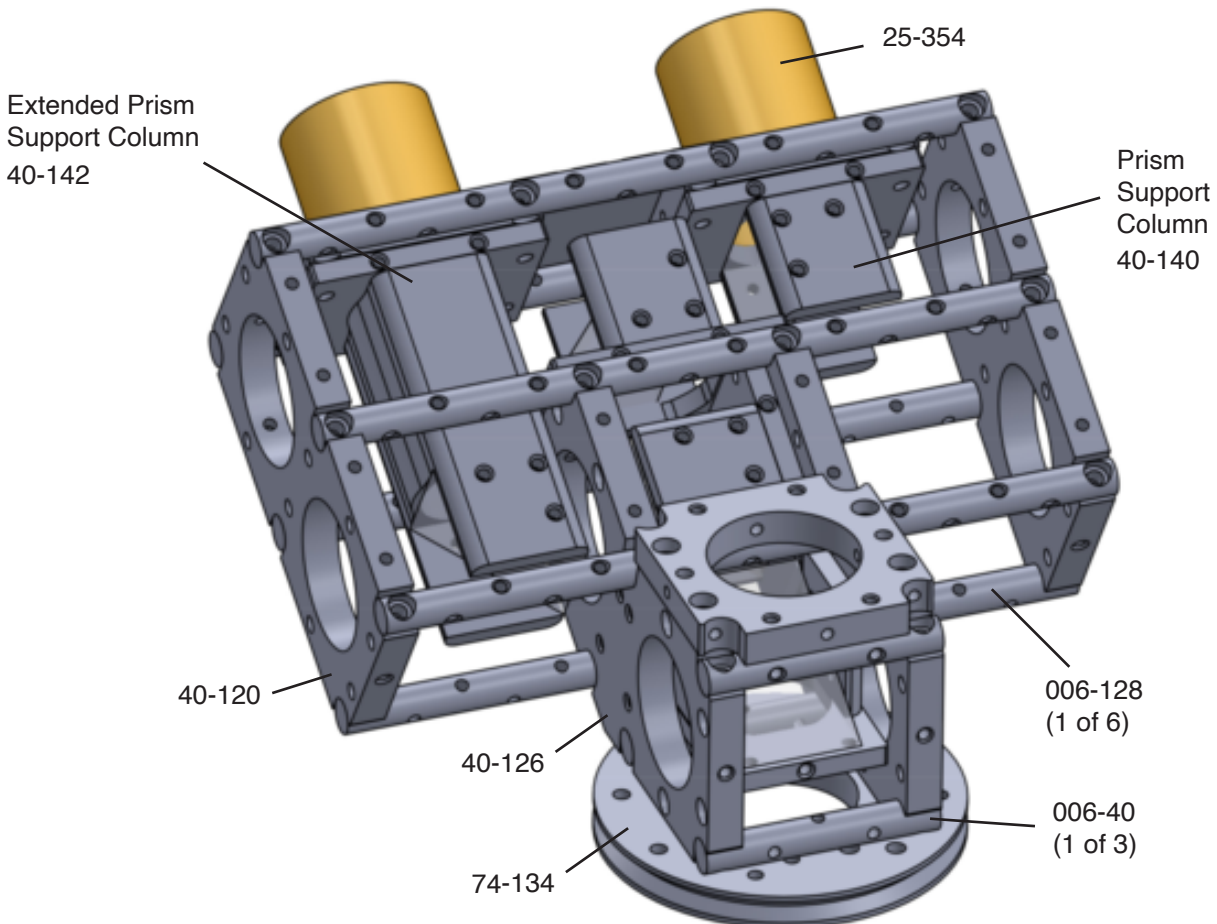


Fig. 1 Preliminary idea of a Binocular Head



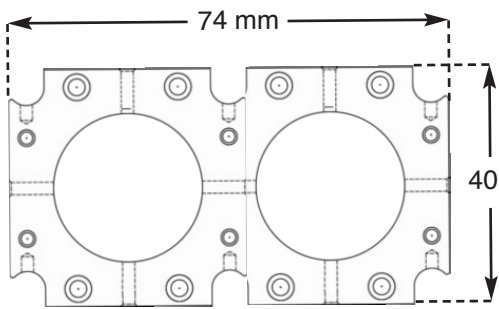


Fig.2 Combination Mount 40-120

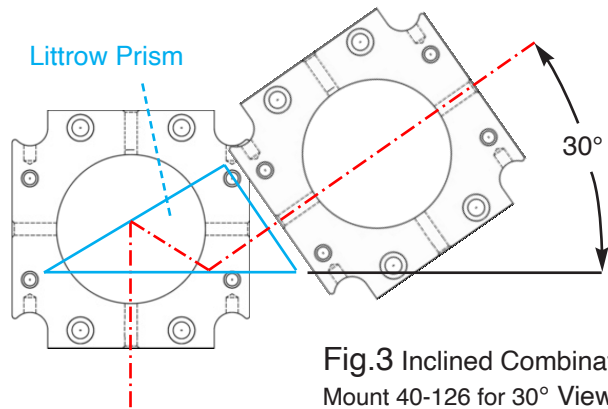
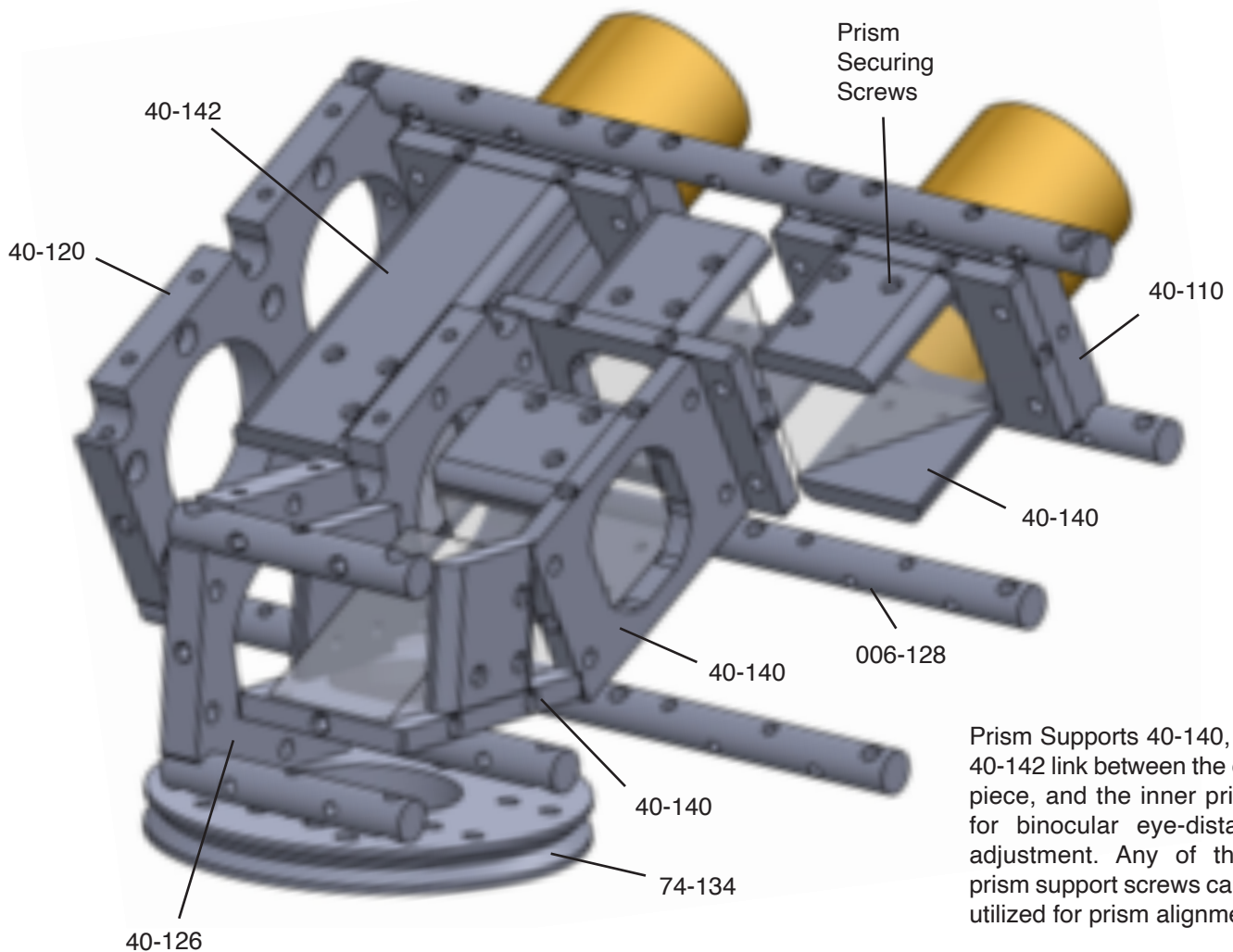


Fig.3 Inclined Combination Mount 40-126 for 30° Viewing

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 of 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.

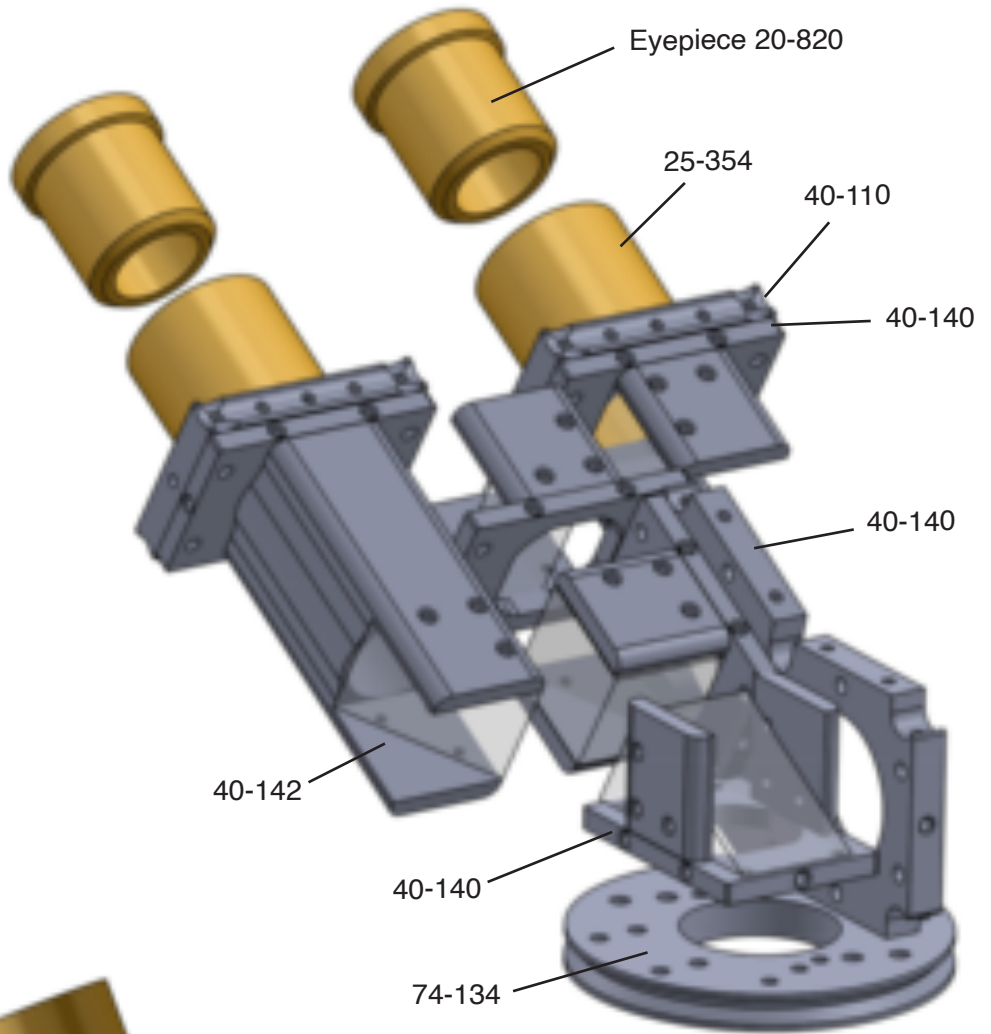


Prism Supports 40-140, and 40-142 link between the eyepiece, and the inner prisms for binocular eye-distance adjustment. Any of the 3 prism support screws can be utilized for prism alignment.

Mounting Prisms

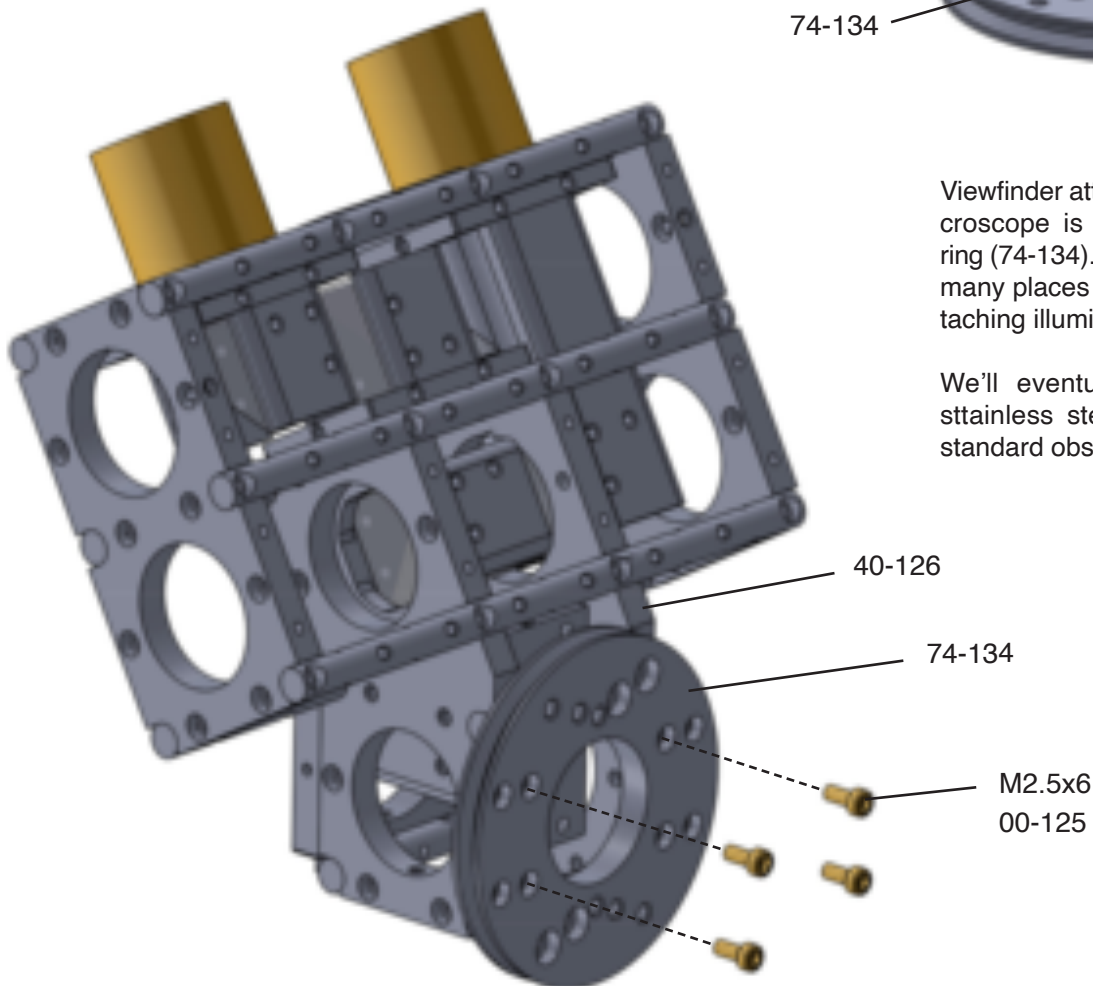
What you experience in this assembly is more playful, and more fulfilling than being an assembler who works at Zeiss or Leica microscope factories. They aren't allowed to play, but you can!

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, Op-toform gives you the freedom to implement it.



Viewfinder attachment ring to the microscope is this versatile centering ring (74-134). You'll see it utilized in so many places to secure mounts, or attaching illumination sources.

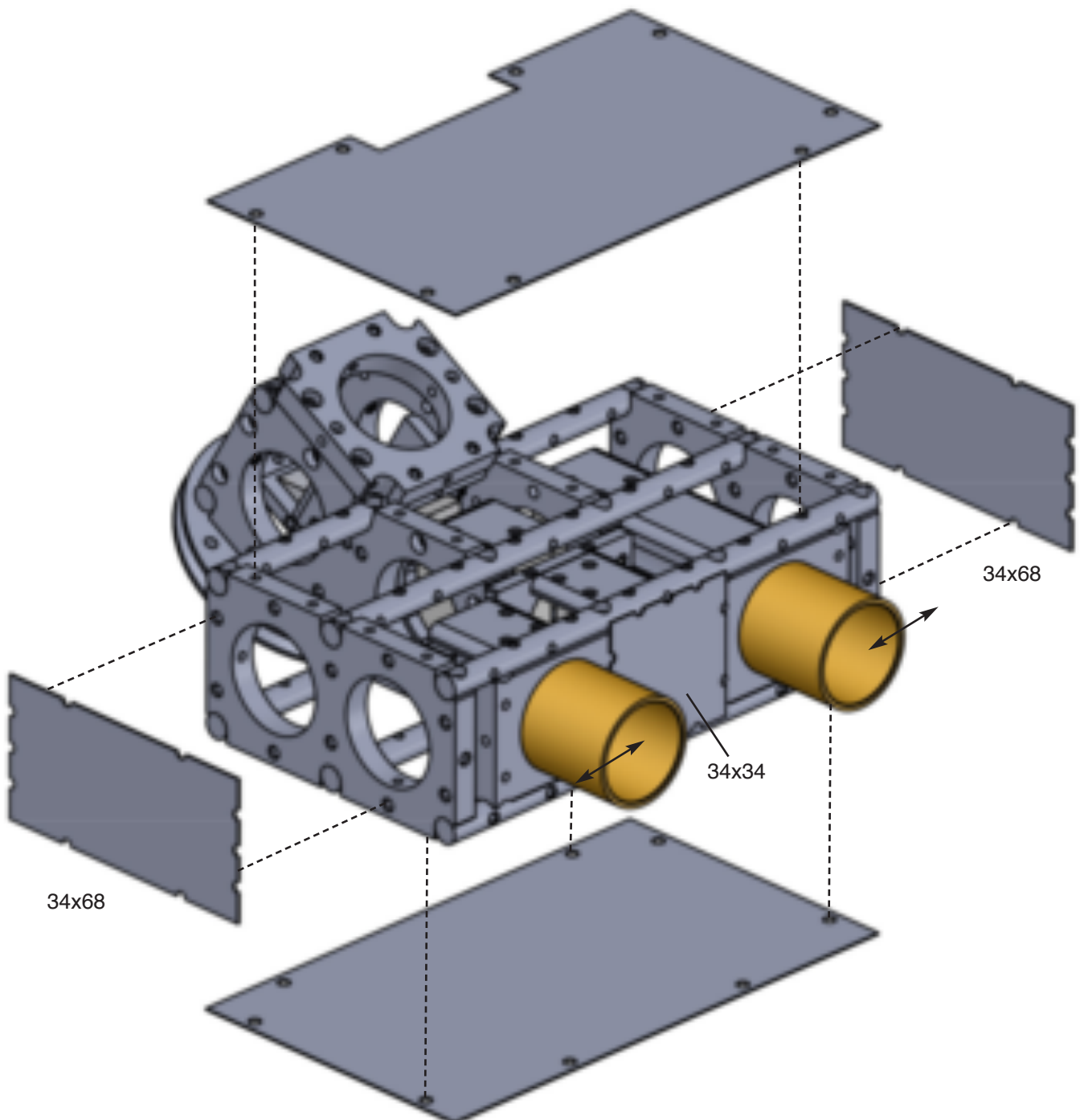
We'll eventually replace it with a stainless steel dovetail ring like in standard observation heads.



Sheet Covering

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 (34x34, below) like an off the shelf viewfinder. You could also see the edges in Optoform 40 assemblies are round. For a list of sheet covering sizes please refer to page 21.

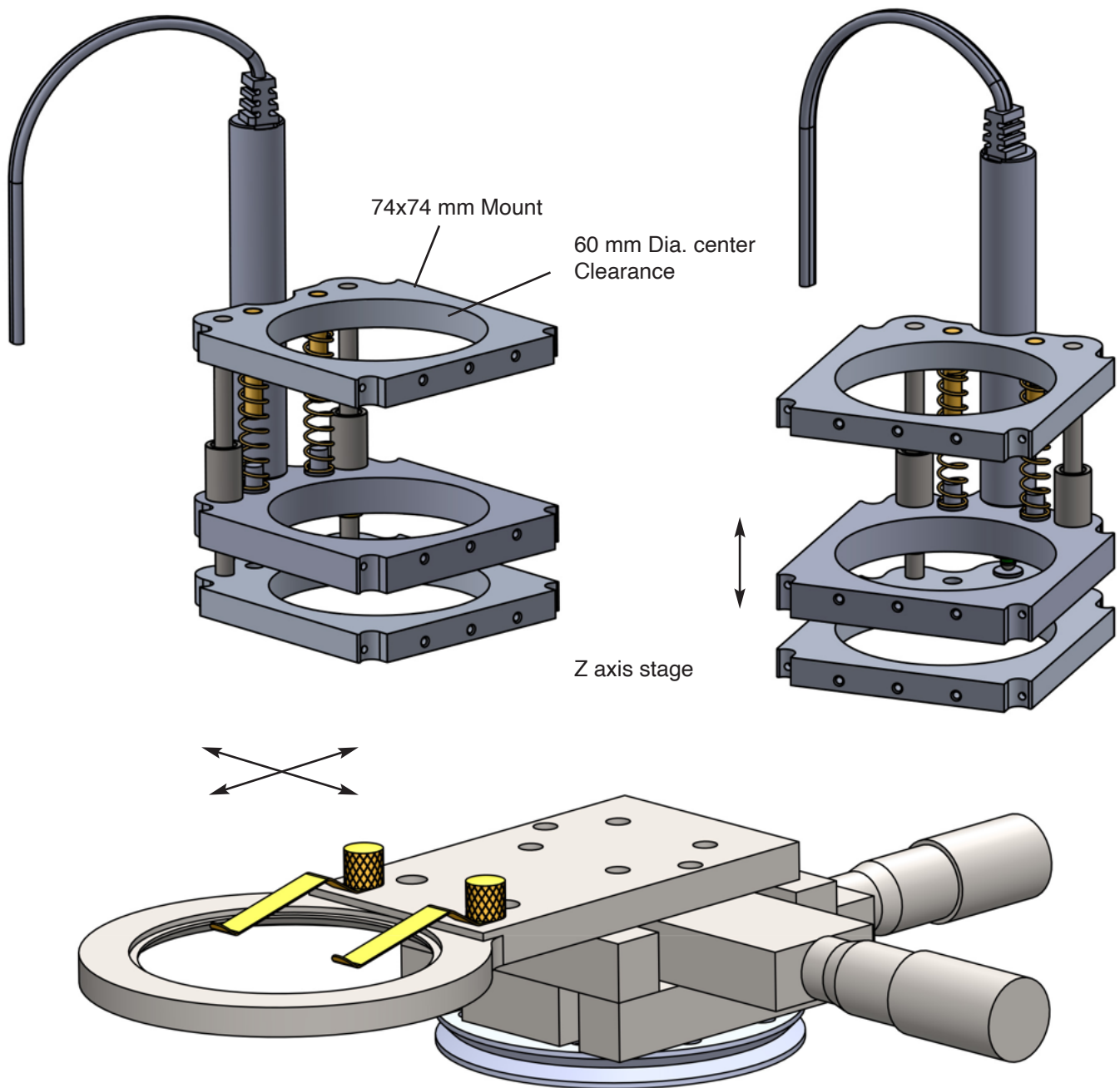
The top, and bottom sheet covers are custom made. We'd offer you the entire unit, and you could either use it as what it is designed for, or disassemble it to make modifications. The prisms are held in place with three set screws which could also be utilized for alignment. There are thin brass sheets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



Designing the focusing Module

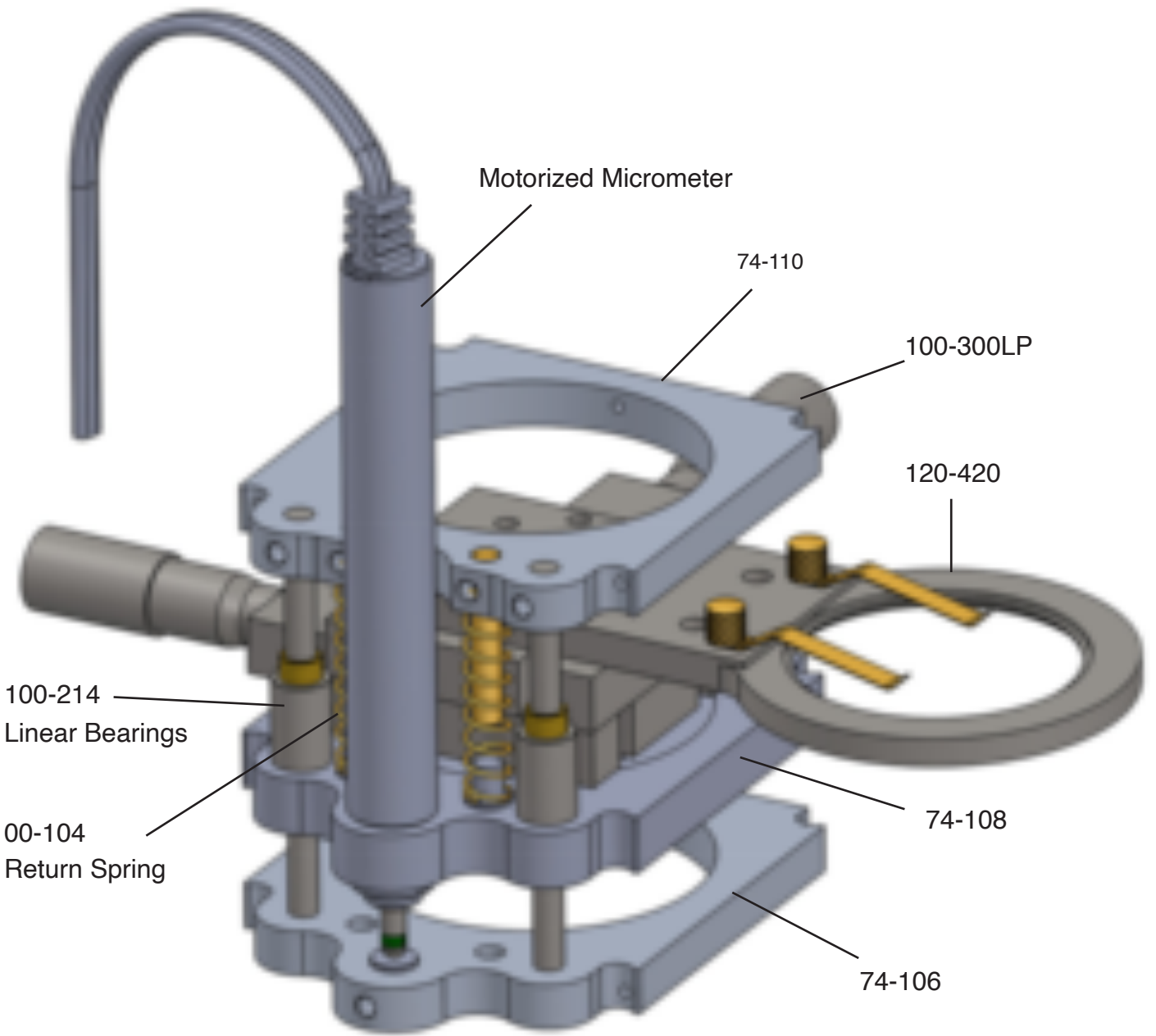
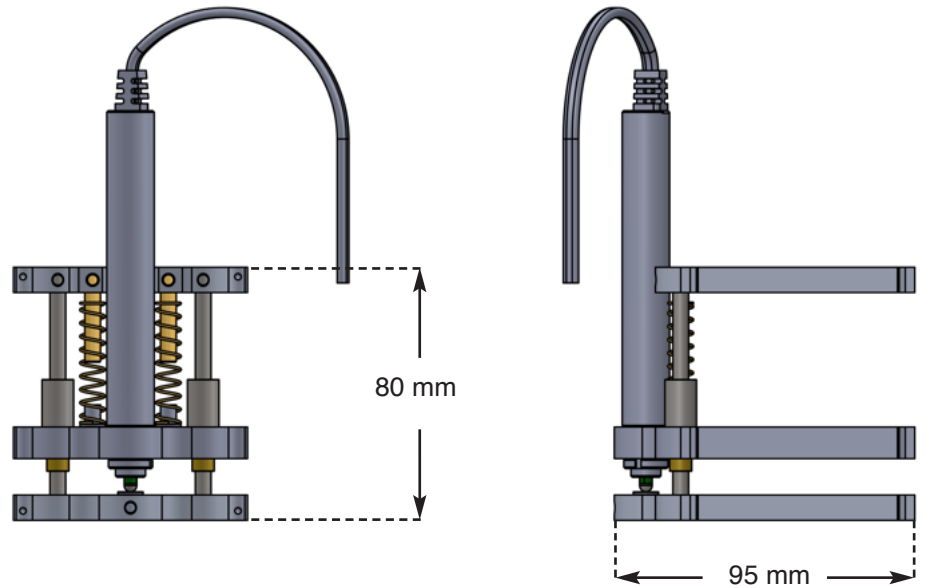
The focusing module is a tricky one. Under high magnification, it should perform precisely without image drift, while under low magnification, it should have a wide travel range to accommodate objectives that are not necessarily parfocal. We will design an elaborate XYZ stage for the sample but for now, let's design a simple, motorizable system (switchable between manual, and motorized micrometers) utilizing classical Optoform's linear bearing concept (see page 4).

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 most assemblies it's best to adjust for parallelism. I'll show you 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. 80 mm rods 006-80 support the assembly (see page 20 for rod lengths).



Expanding Optoform to Larger Mounts

As you see for constructing the rest of the microscope, we'll need larger mounts. 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 larger rods within any of the modules, 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). Combination mounts 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 ourselves. Our goal is to offer you a construction system that you could also use to house your electronics. Optomechanics comes already included. Say you want to house a 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 could have any width and height. Optoform mounts, and rods, and cover sheets could be on your electronics parts bin next to your soldering iron. You got the idea.

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 for 74x74 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 could have 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.

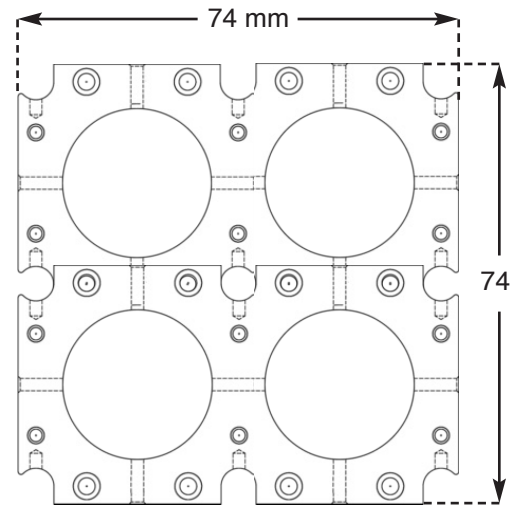
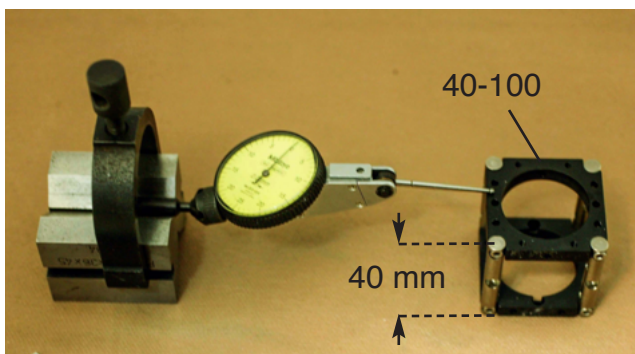
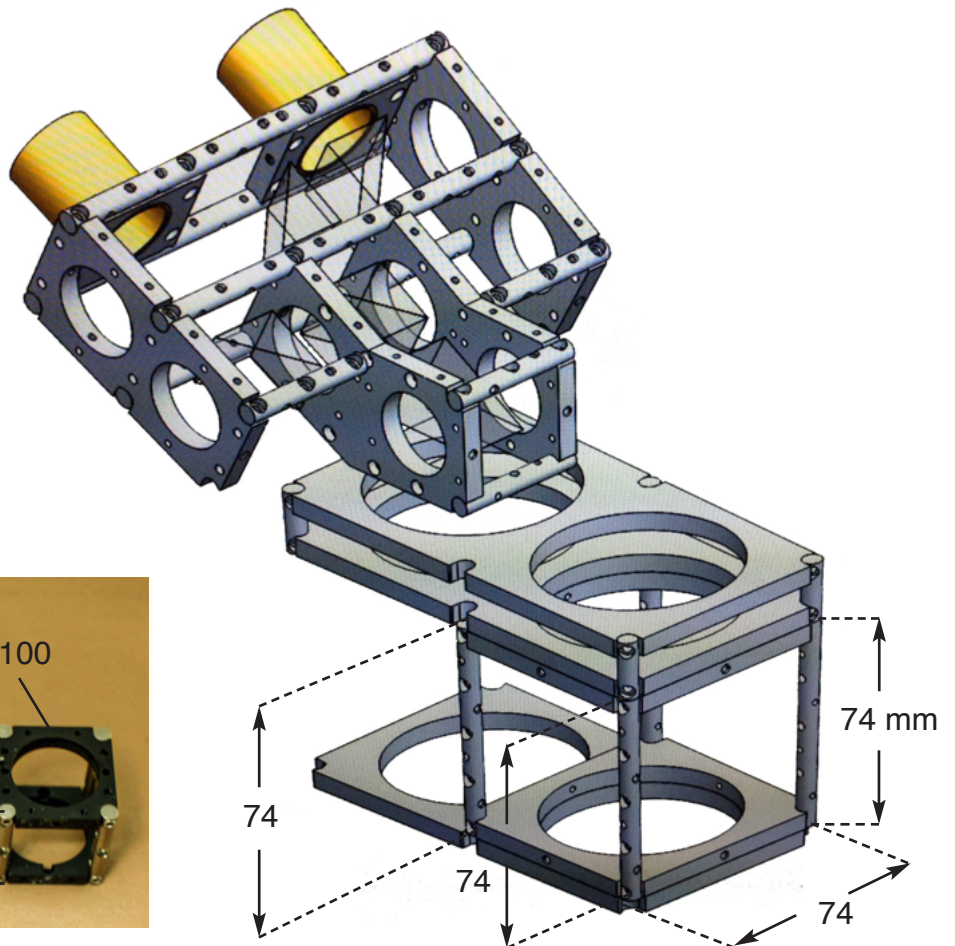


Fig.4 Geometry of Combination Mount 74

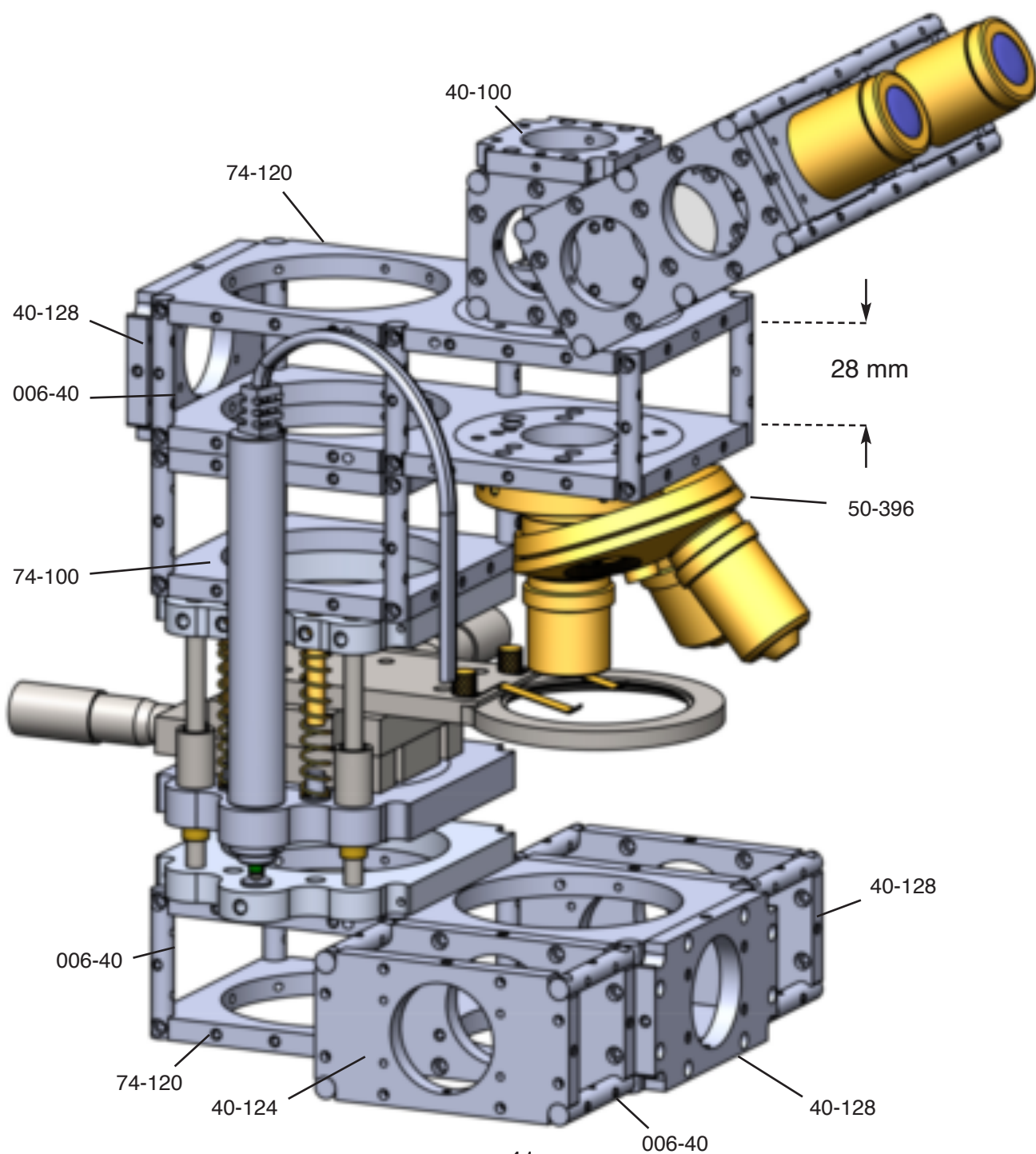


Checking all four sides of a cube with a dial indicator.

Integrating the Modules

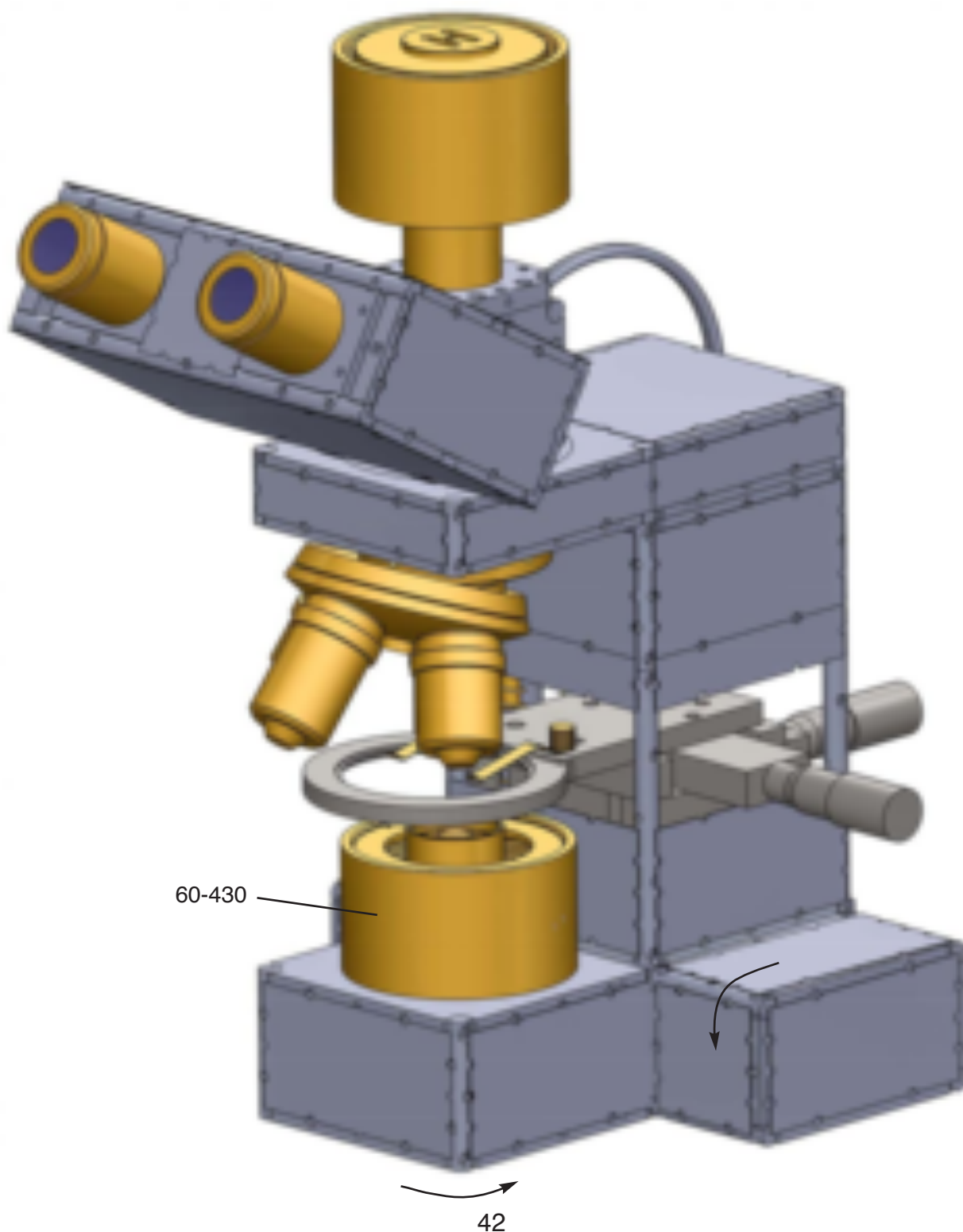
The current configuration allows implementation of both incident, and transmission illumination. The spacing between mounts 74-120 is 28 mm, and a new mount 40-112 is added to fit in between these mounts for securing all the necessary beamsplitters, and optical elements that are utilized in designing a Kohler illumination or an Epi-Luminiscent scheme. Any illumination optics we come up with is a stand alone module that may be taken off from the microscope to be replaced by an alternate design.

The base platform is currently designed in a T-shaped space frame 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 electronics 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 40-128 for this purpose. It is mounted at several places around the microscope to show various light source mounting possibilities.



Adding Sheet Covering

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 covers you could get to cover your design. 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 the excess off with scissors. They do much better cuts on thin Aluminum sheets than heavy duty cutters. In any case, you'd also notice the condenser housing below the sample (60-430) is built with Micromax 60. This is an exact match to the inside clearance aperture of mount 74's.

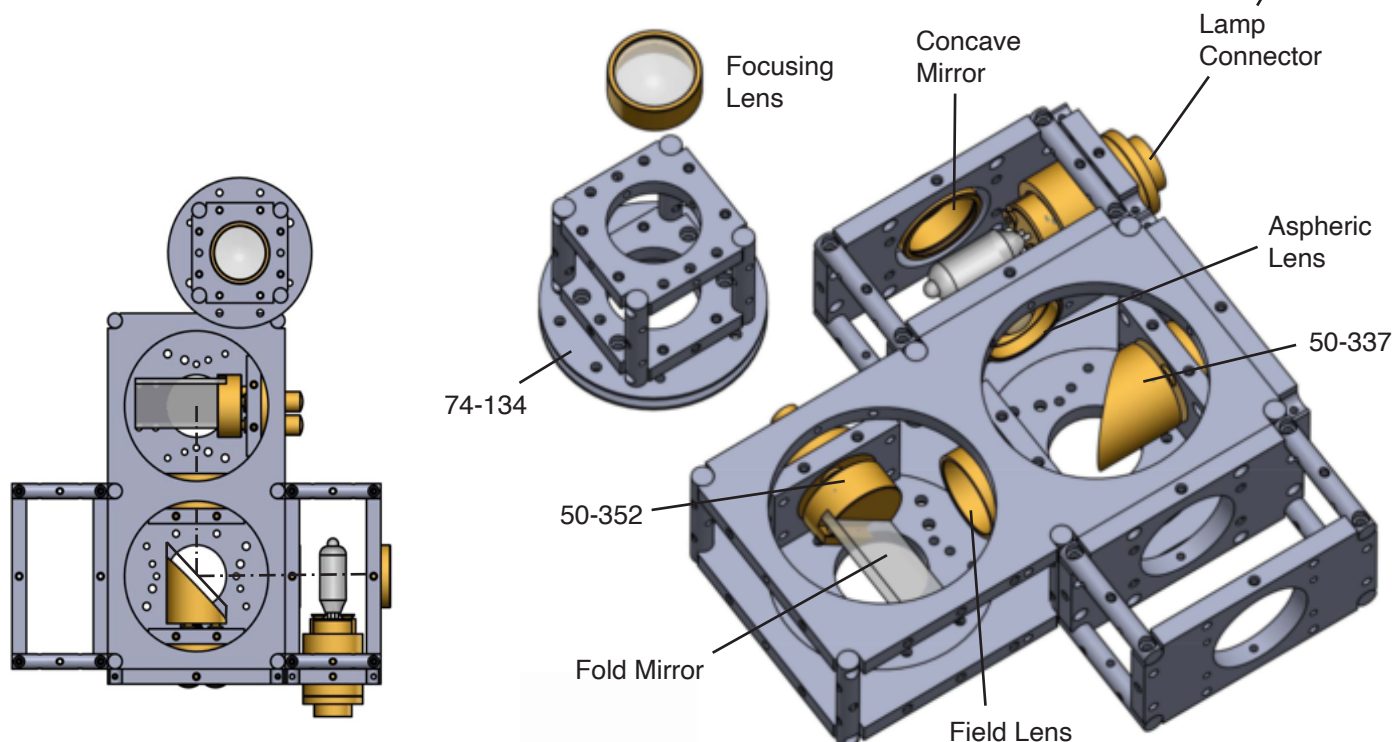
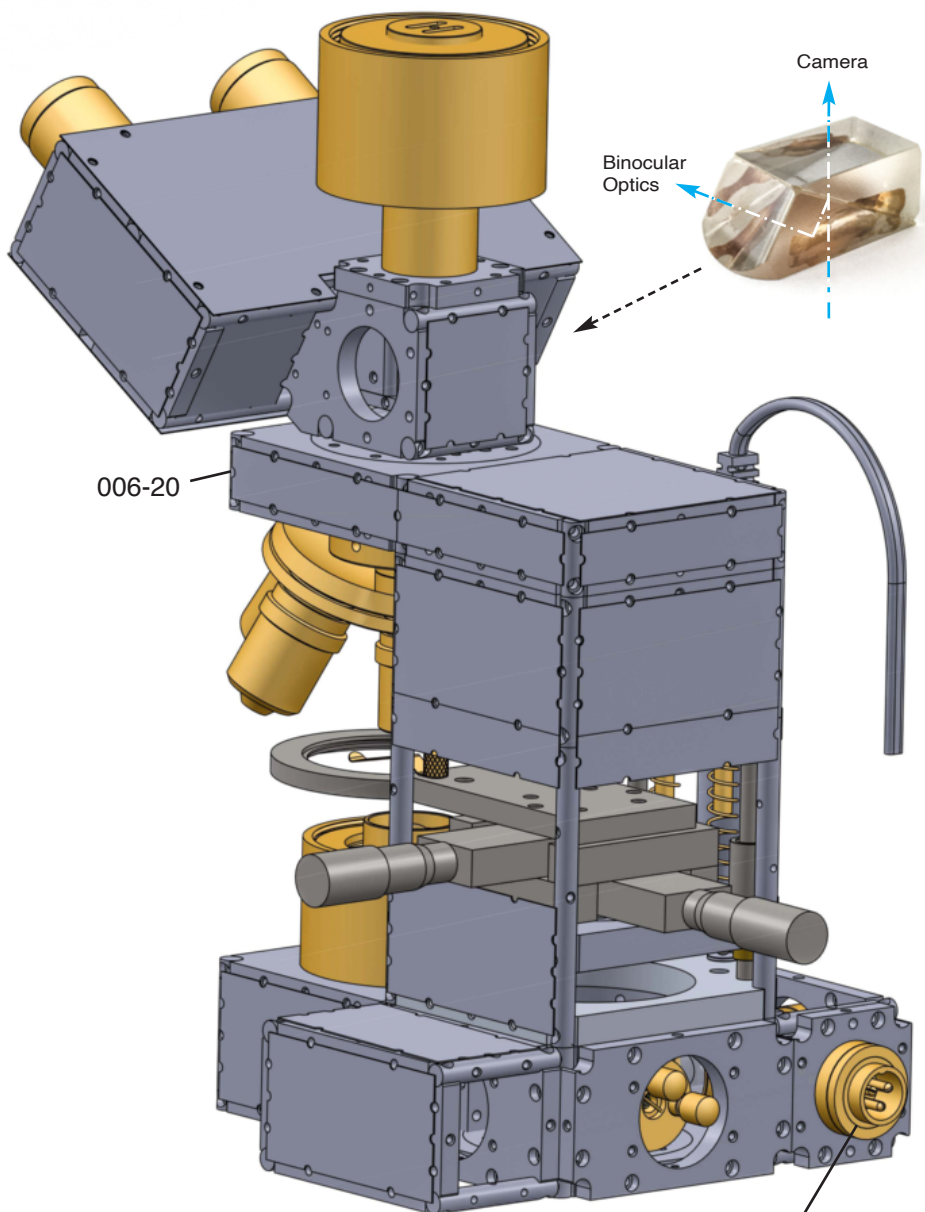


Micromax 60 accommodates much bigger lenses. It is perfect for constructing condenser optics for illumination purposes. The Littrow prism can be replaced with a specially cemented version (right) to convert the binocular head to a trinocular observation head as show in this example.

Back Illumination

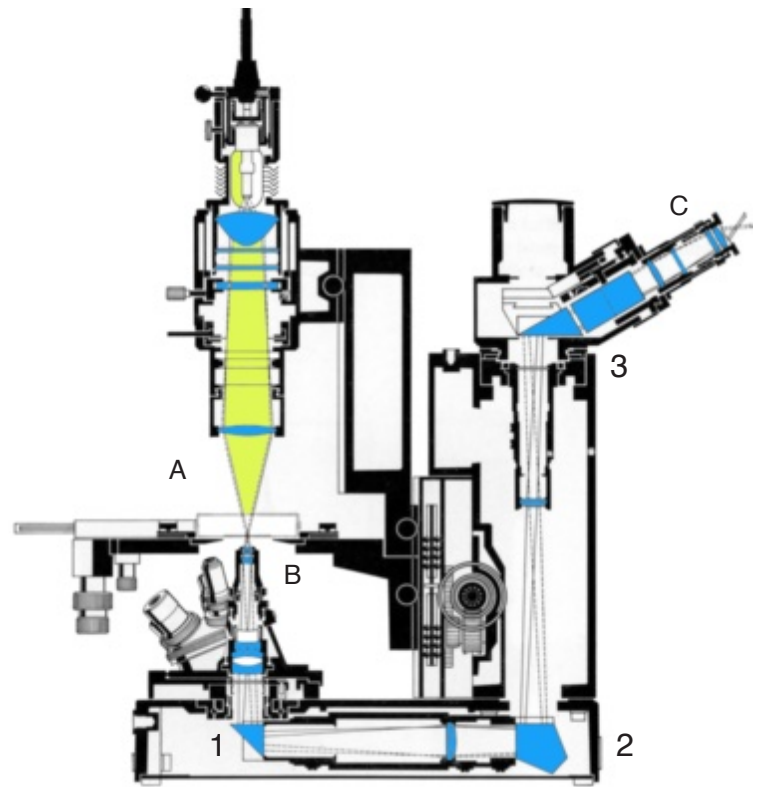
The microscope base in most microscopes are occupied by power supply electronics. This worked well for older generation microscopes because the weight of the power supply with its wire wound transformer would give the microscope a good balance. Today's switching power supplies are so light; they could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

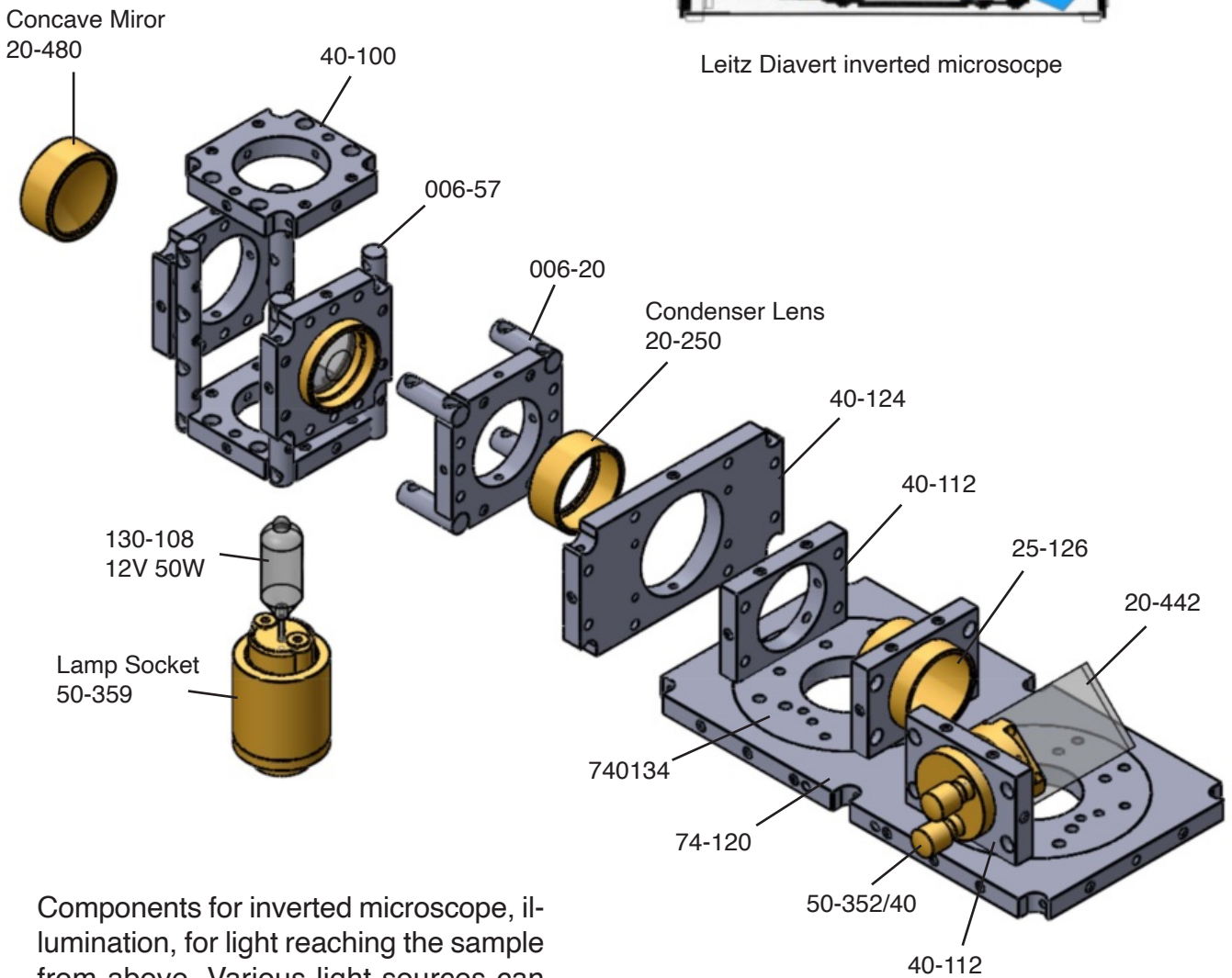


The illumination system

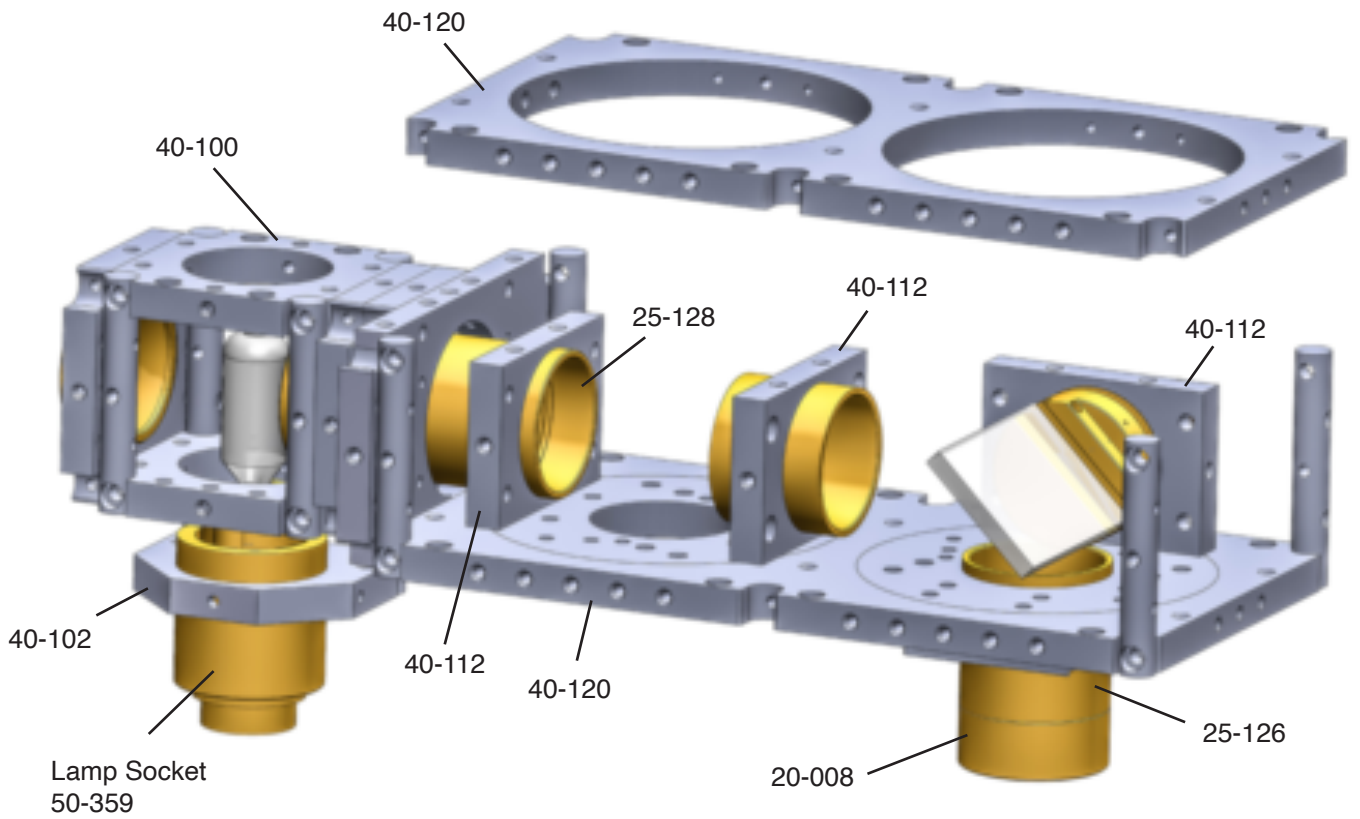
We suggested this illumination system last time as an optional configuration to convert the biological microscope to an epiluminescent or metallurgical system. We could now utilize it for inverted microscope. The core of the illumination system is the Halogen lamp, and as a module, there are several ways to build it below. The condenser optics for inverted microscopy (right) has a large diameter to match the numerical aperture of the objectives. This is not so obvious in upright microscopes because it is hidden beneath the stage.



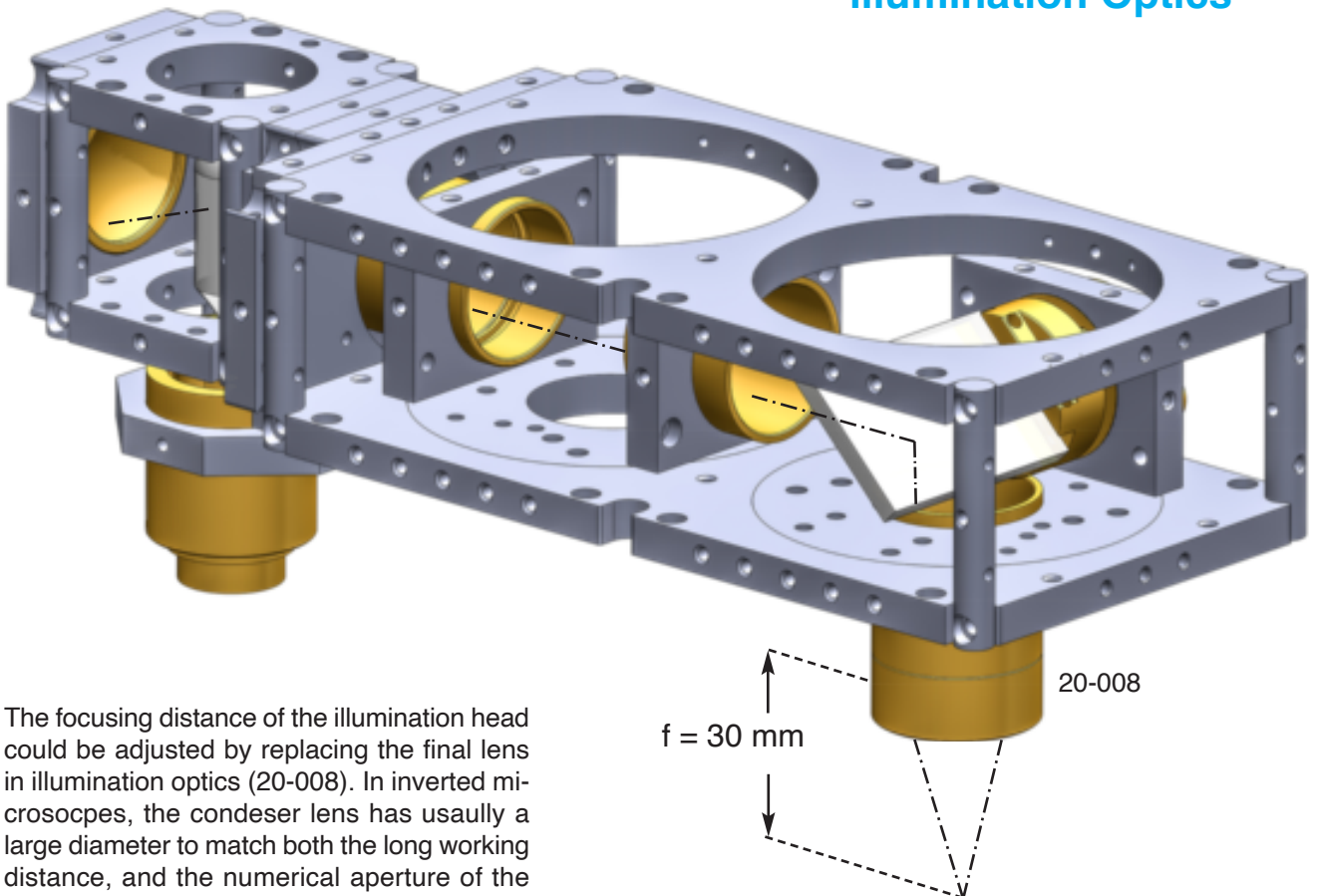
Leitz Diavert inverted microscope



Components for inverted microscope, illumination, for light reaching the sample from above. Various light sources can be integrated inside optoform, including this 12V, 50W Halogen lamp.



illumination Optics



The focusing distance of the illumination head could be adjusted by replacing the final lens in illumination optics (20-008). In inverted microscopes, the condenser lens has usually a large diameter to match both the long working distance, and the numerical aperture of the objectives.

Adding Modules Together

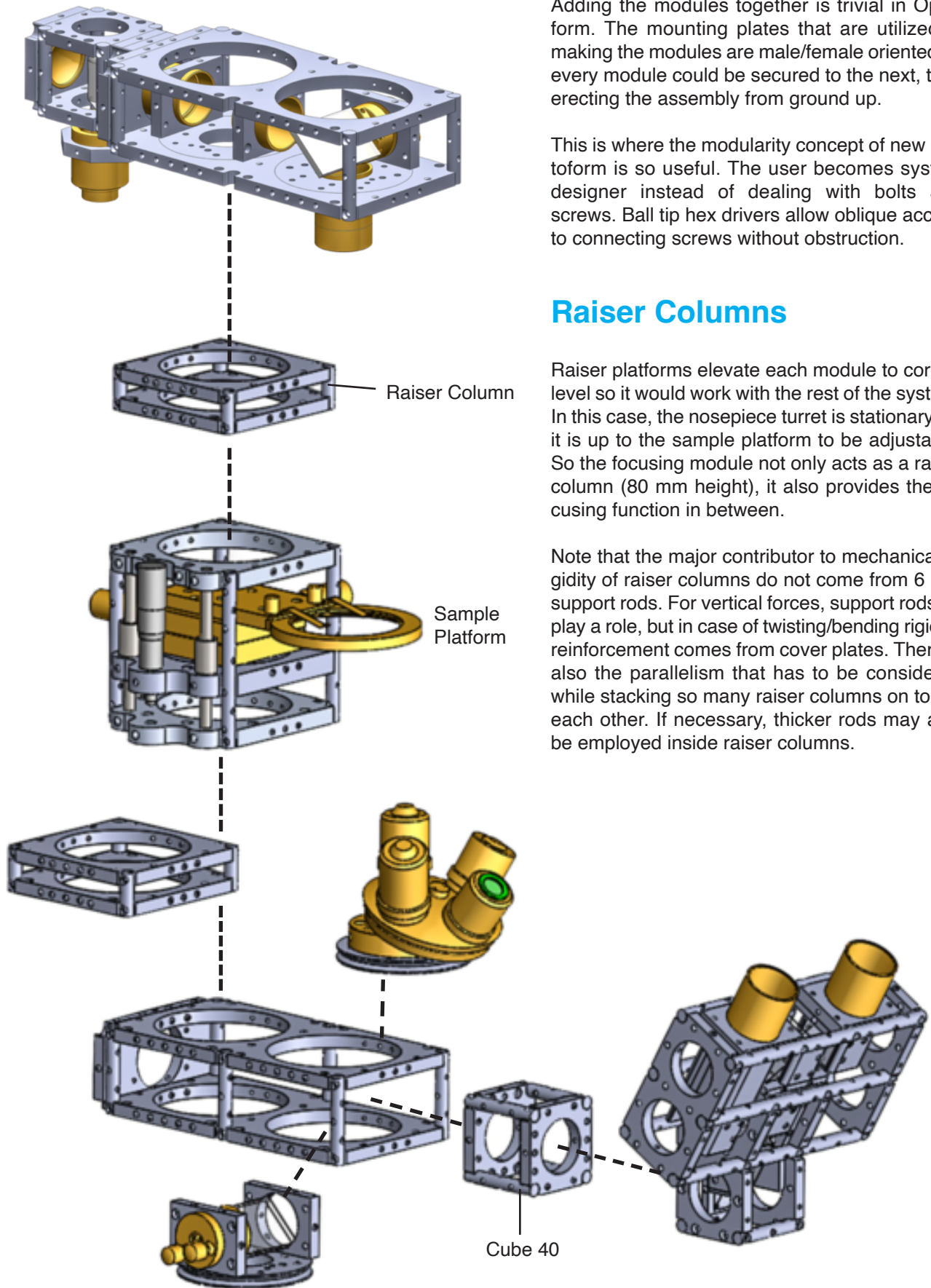
Adding the modules together is trivial in Optoform. The mounting plates that are utilized in making the modules are male/female oriented so every module could be secured to the next, thus erecting the assembly from ground up.

This is where the modularity concept of new Optoform is so useful. The user becomes system designer instead of dealing with bolts and screws. Ball tip hex drivers allow oblique access to connecting screws without obstruction.

Raiser Columns

Raiser platforms elevate each module to correct level so it would work with the rest of the system. In this case, the nosepiece turret is stationary, so it is up to the sample platform to be adjustable. So the focusing module not only acts as a raiser column (80 mm height), it also provides the focusing function in between.

Note that the major contributor to mechanical rigidity of raiser columns do not come from 6 mm support rods. For vertical forces, support rods do play a role, but in case of twisting/bending rigidity, reinforcement comes from cover plates. There is also the parallelism that has to be considered while stacking so many raiser columns on top of each other. If necessary, thicker rods may also be employed inside raiser columns.

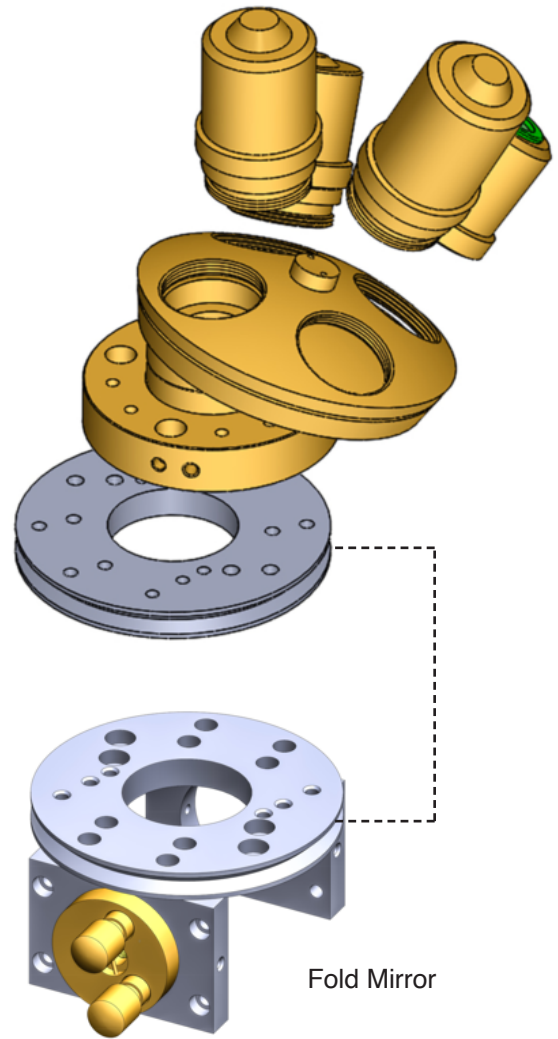


Finishing up the optics Layout

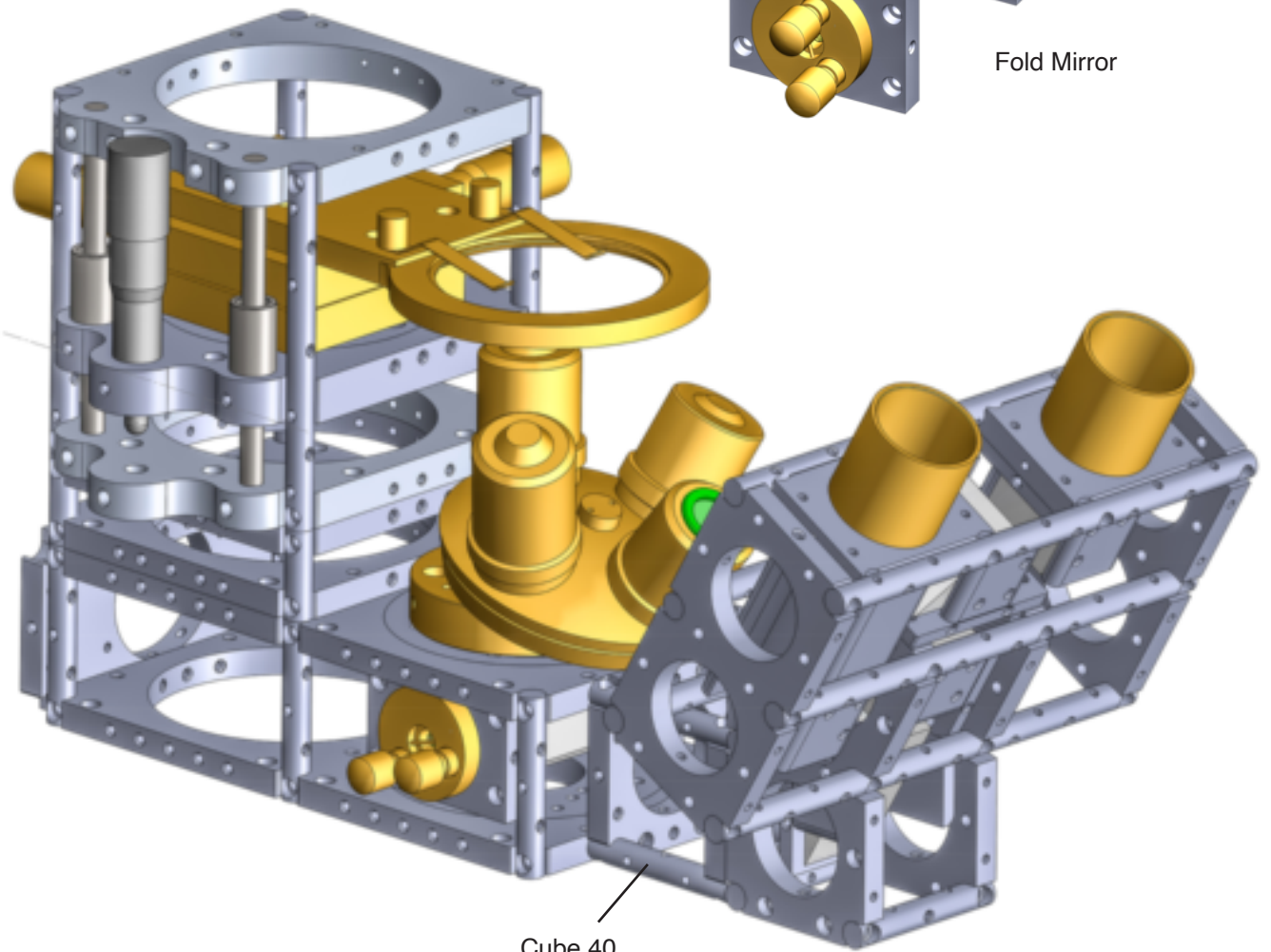
The optical layout of the inverted microscope is pretty much done at this point, and what remains is the illumination system. The binocular observation provides 60 degree inclined viewing, with reasonable height to provide good ergonomics. If higher viewing level is required, raiser platforms, are available in both Optoform 40, and 74 to accomplish it.

An inverted microscope lets you pay more attention to your objective lenses, and the illumination optics because they are more visible, and easier to see. The tilted nosepiece turret is facing toward the operator (to prevent its collision with focusing module on the back wall). A cube 40 is utilized to extend the position n of binocular head, allowing the nosepiece turret to rotate without obstruction.

Note how the modularity scheme of Optoform has liberated it from the “through the rods” optical path to “outside of the rods” optical path. The nosepiece turret has always been a dilemma for the cage system construction but as you see in this assembly, it’s out of the cage, enjoying fresh air.



Fold Mirror



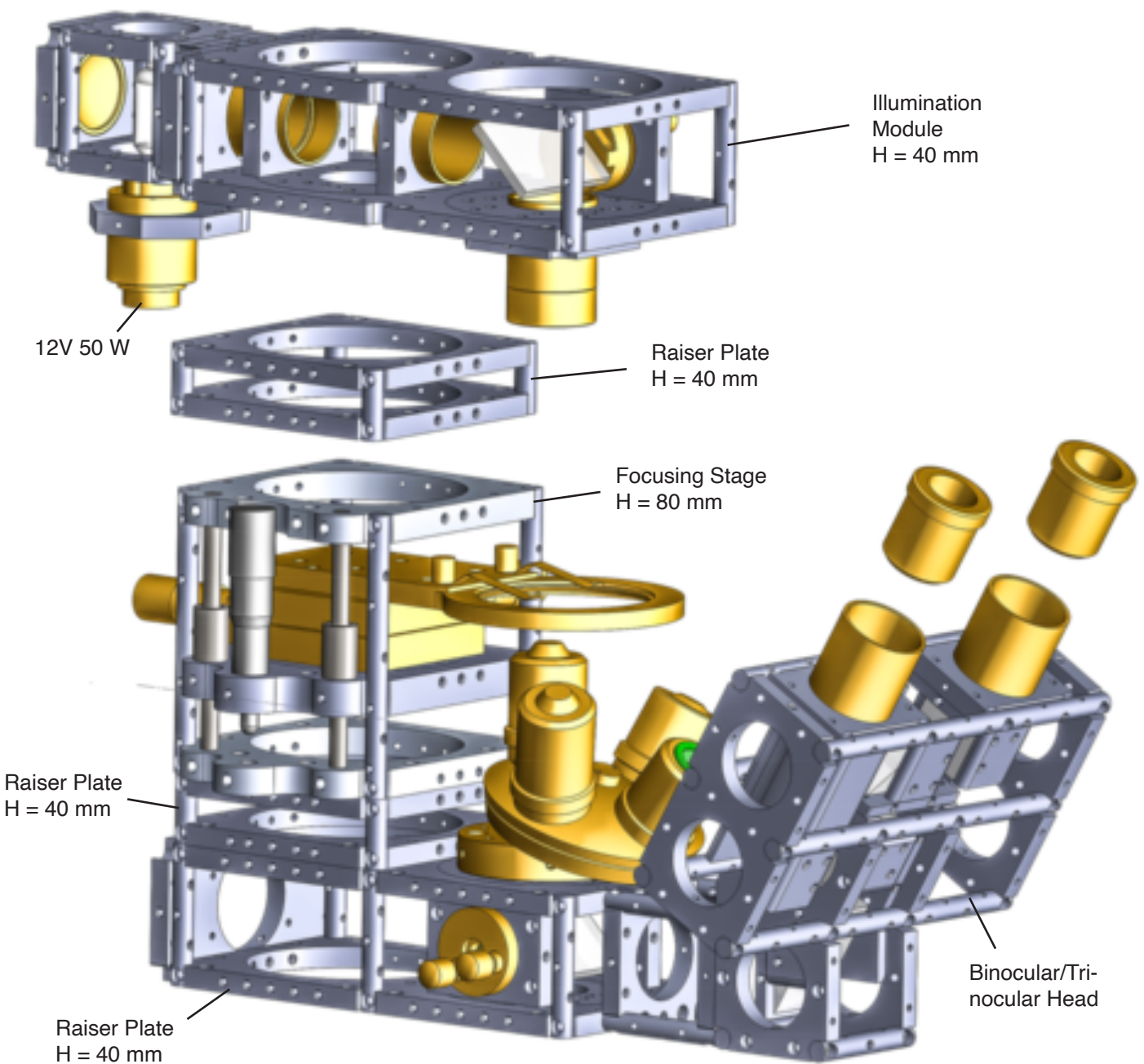
Cube 40

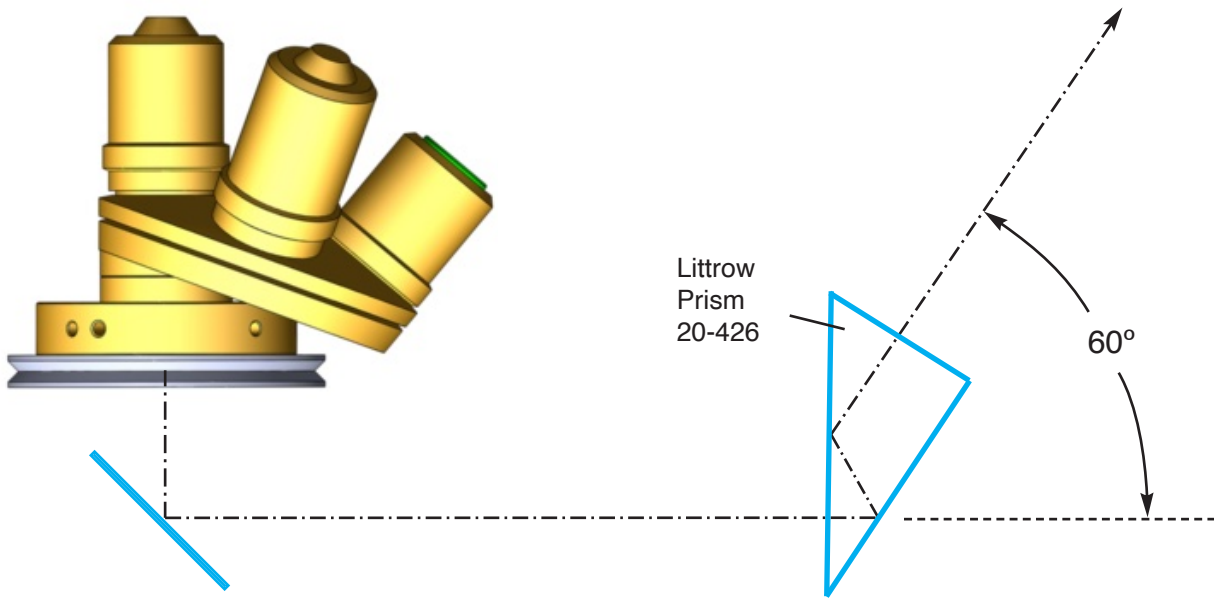
Final Assembly

well, here is the entire system we built, and it measures only 200 mm in height. I just received an email from an optics student, asking me if I had a DIY guide to make this system so everybody could use. My answer was unfortunately no. The reality is only grownups could afford these optical kits, and its mechanical components to experiment with. Optical toys for children did have reasonable quality back in the 30's but with the introduction of plastics, children toys, telescopes, and microscopes have become so cheap that they don't play a great role model for optical engineering. Owning this system was my own dream when I was a child. The price difference is approximately 100 to 1 (\$75 to \$7,500).

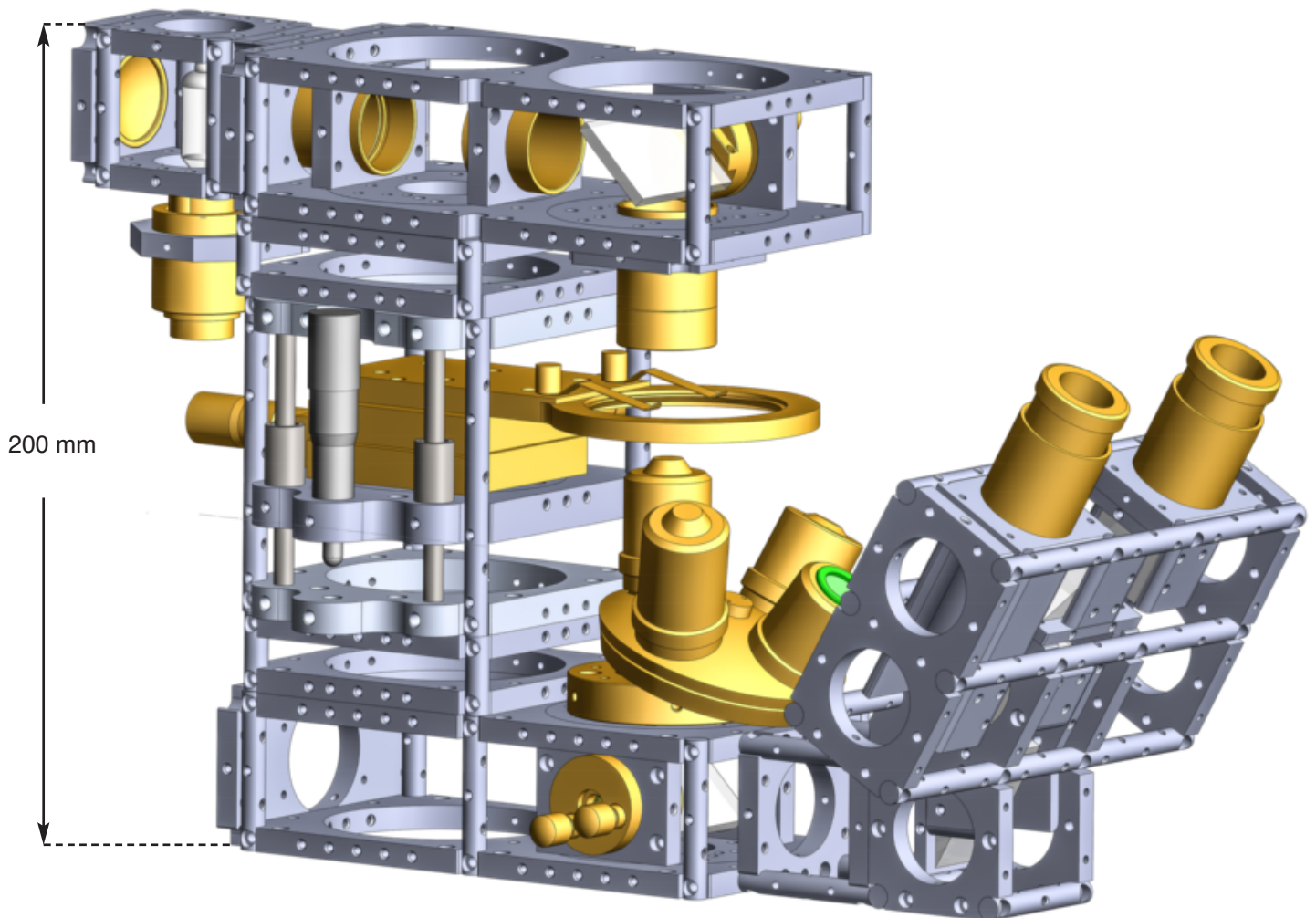
The reason Optoform works so well is because of so many man hours in designing, manufacturing, and putting together its inventory of parts. The end user grabs a lens from a lens kit, and inserts it into the mount, and it's ready to go. You have to be a manufacturer to realize how tight the tolerances are for each, and every piece, and how many parameters, and mounting possibilities are considered before a new piece is added to the system.

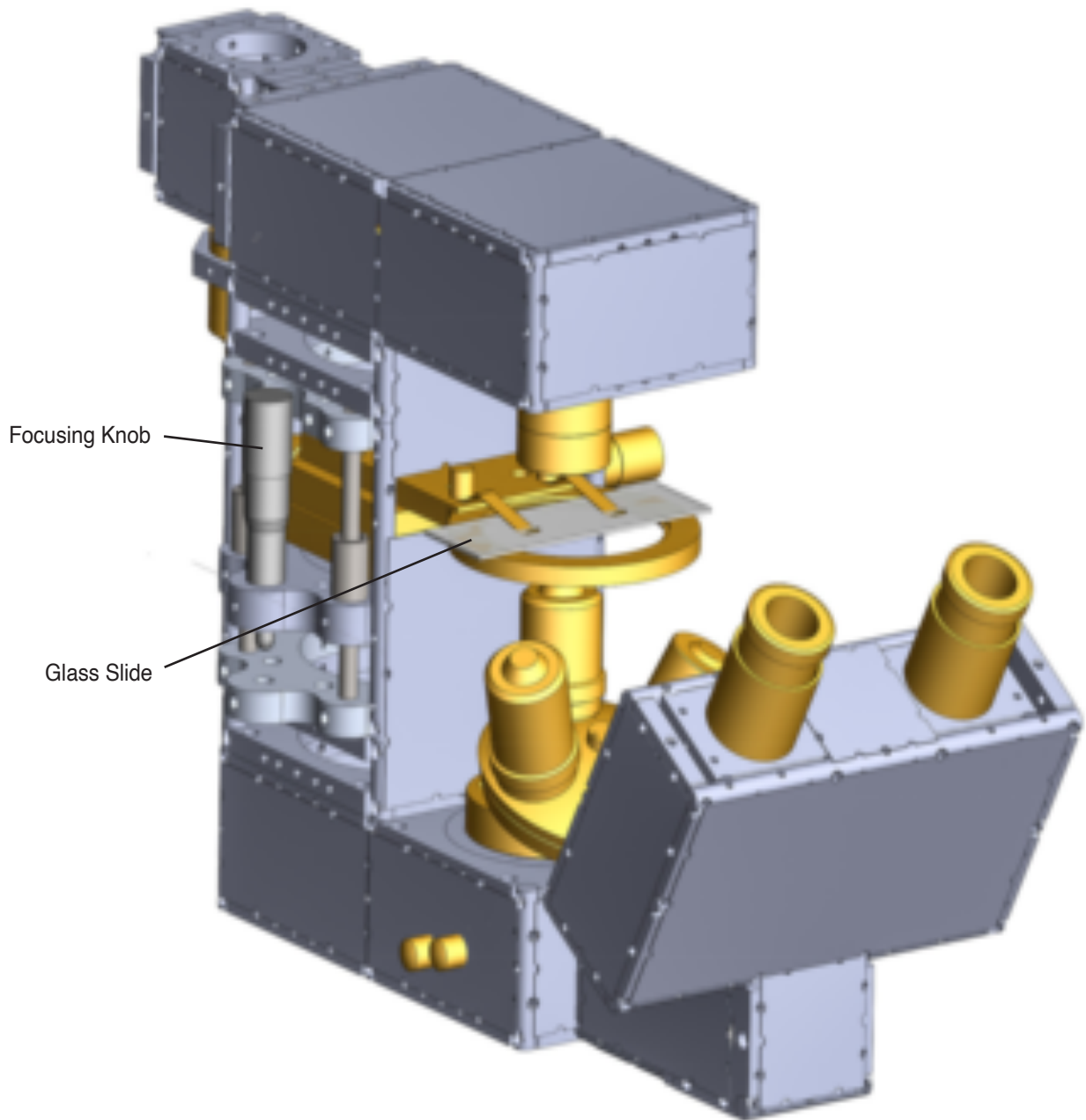
By using, and evaluating this microscope, we can prepare it for the next step of construction: To finish it up with pre-cut sheet metal covers for added rigidity, and stability. Sheet metal coverings have a notch pattern to allow securing them on the side of mounting plates via M2.5 low profile mounting screws. Not all the open threaded bores has to be utilized, but just enough to secure the cover plates at critical points.





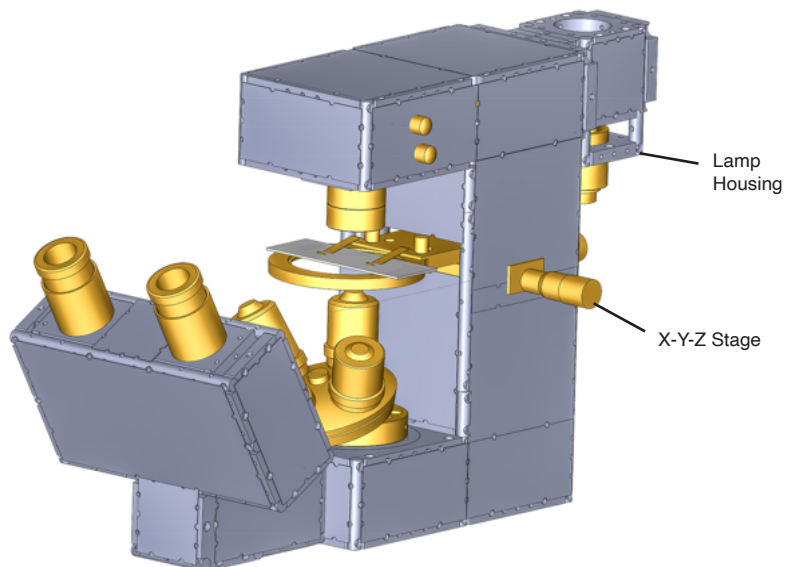
Above, utilizing the Littrow prism is not so trivial. In this case, the angle gets complex, if you have doubt about it, try constructing it in your lab. In optics, always have your feet on the ground, meaning to always use a line of reference. The nature of the cage system mechanics, with its 4 rod system, looks to be an impediment in optomechanical design because one would have a tough time with angles. Once that is resolved, the cage system becomes far more practical in doing prism work than table top experimentation. The reason is once you construct a self holding assembly like Optoform, you could easily rotate it but you can't do that with breadboards, and optical tables. In this case, all you have to do is build the binocular head assembly, and rotate it by 90 degrees.





Sheet Metal Covering

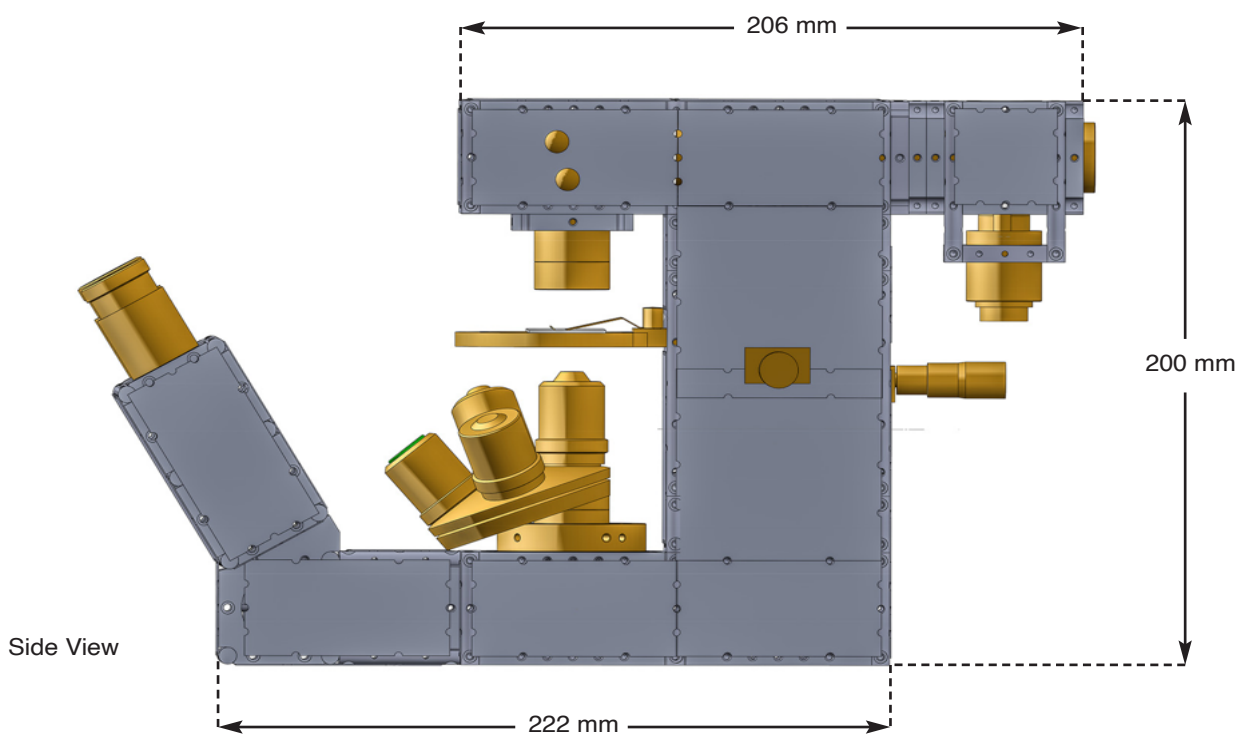
Cover sheets has been added to light seal, and dust seal the optics. The microscope is quite compact, and when the entire assembly is packed inside cover sheets, then the end user would think that it would also need to add rubber legs. When you deal with a complete instrument, then usability, and durability becomes a concern. Issues like strain relief for cabling, and usability to be easily operated by others come to play that would change the outlook of the microscope.





The Imaging System

An imaging microscope may be easily constructed with trinocular head, identical to the biological microscope we built earlier. In that arrangement, the CCD camera would be situated in front of the microscope. Optoform setups could be re-configured to accommodate a variety of design options.



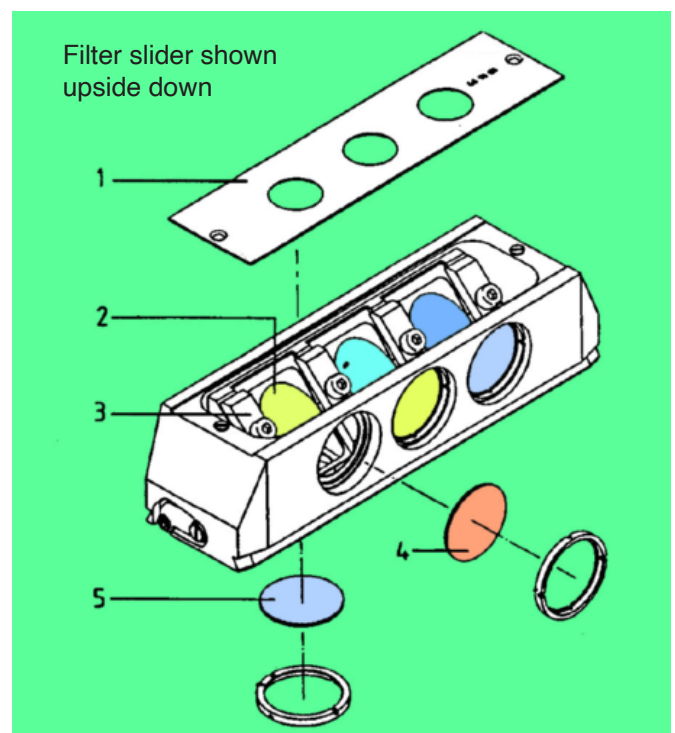
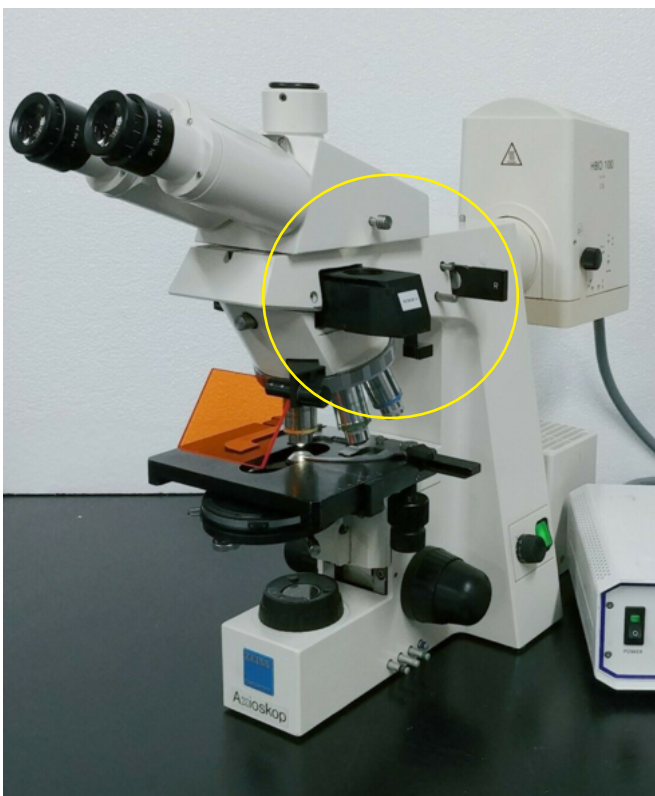
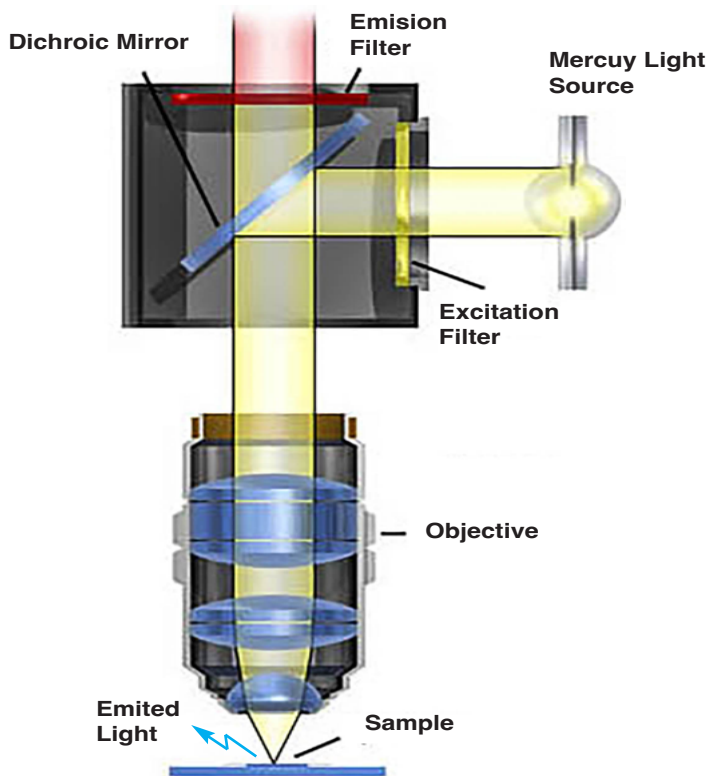
Fluorescent Microscopy

Basic concept of Fluorescence microscopy consisting of a UV light source, Excitation filter, Dichroic mirror, and a Barrier filter is implemented with Optoform, and in the next chapter, we'll explore scanning fluorescent microscopy.

Several filter/beamsplitter combinations must be offered to work with specific sample types. We'll be utilizing circular bandpass filters for now but will eventually use standard Zeiss filters.

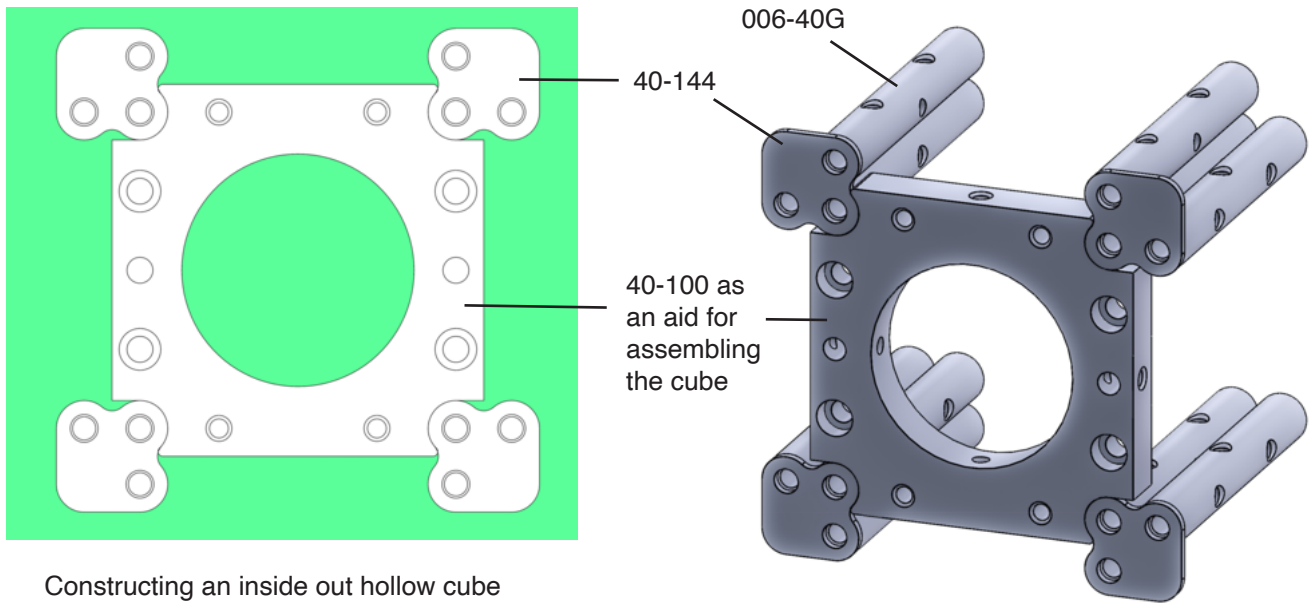
Designing the new mounts

A new mount will be needed to implement the beamsplitter slider so it will be built using Optoform's frame structure. We'll need to compete with existing microscopes on cost, and versatility. Once we implement it with Optoform, it will exceed in flexibility among other microscopes because it will provide a completely open architecture design.



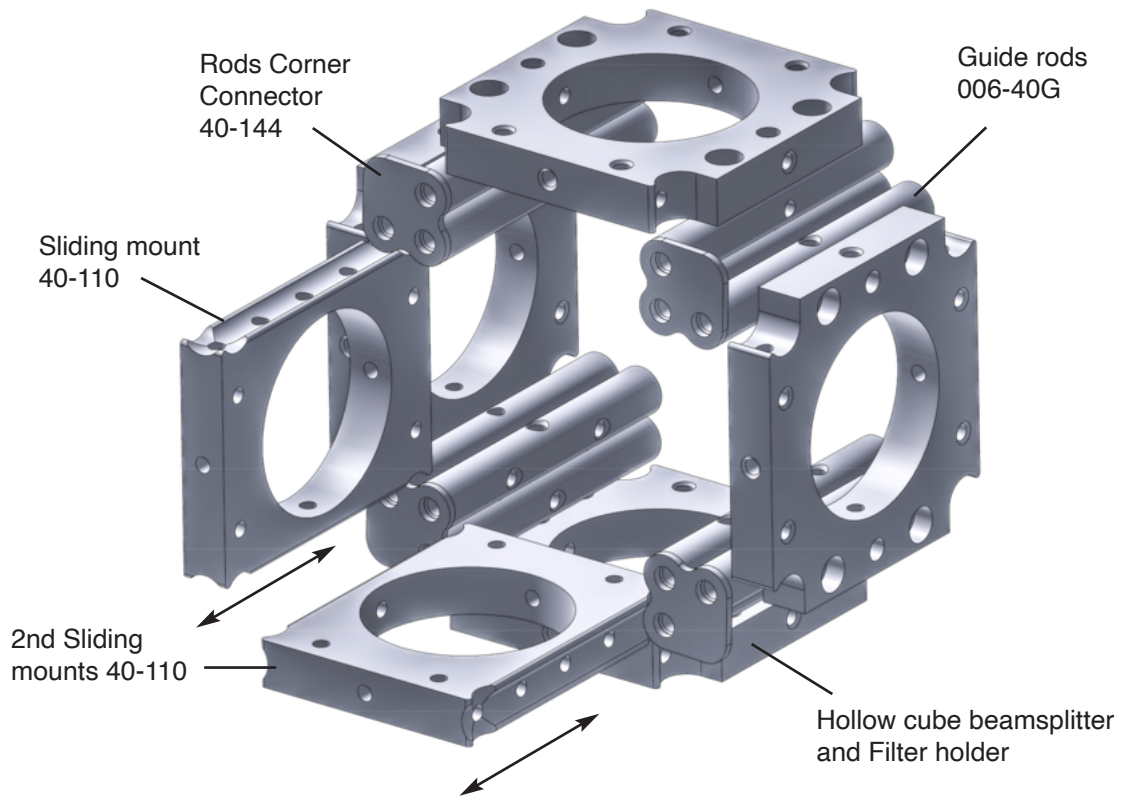
Zeiss Axioskop Fluorescent filter slider consists of Emission filter (5), Excitation filter (4), and Dichroic beamsplitter (2). The filter block is identical to slider in Axiovert

Designing the beamsplitter housing for Fluorescent filters

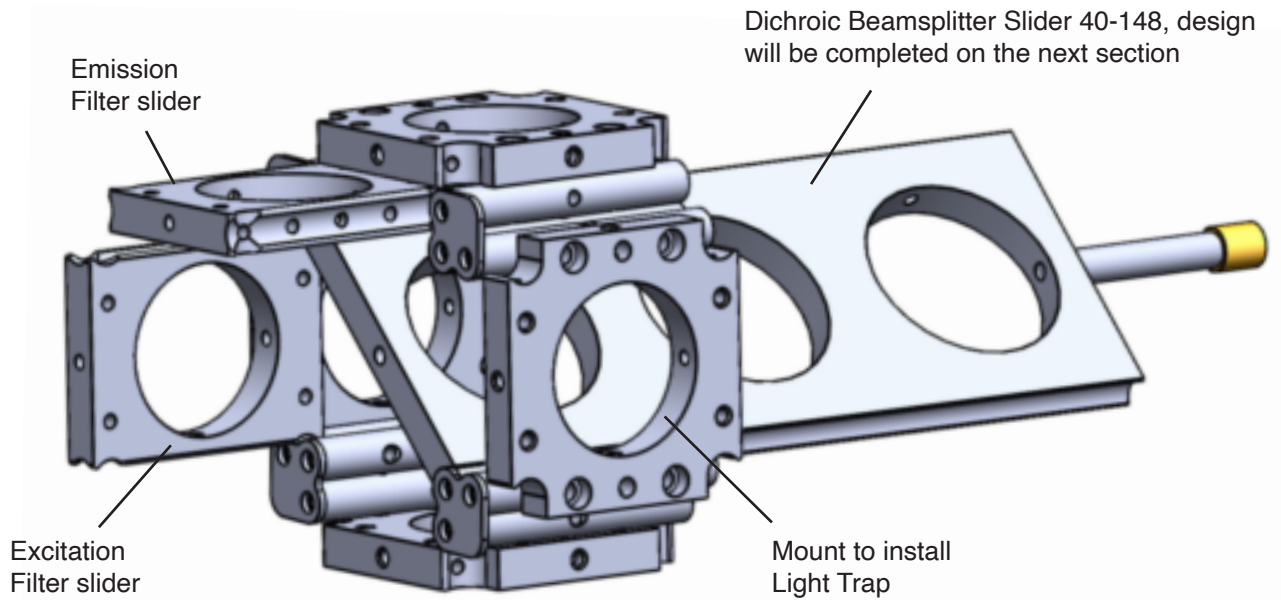


Constructing an inside out hollow cube

The idea would be to have a means to form a cube that is hollowed from inside out so it would allow mounts to slide in and out without obstruction. Let me show you what I mean: What we need to build is a beamsplitter housing that would



accept any number of filters on its four faces around a central beamsplitter (above). This is accomplished by side mounting the rods by a corner connector 40-144 that basically secures three rods side by side to provide clearance for sliding mounts 40-110 to be inserted without collision with the neighboring mounts. It would therefore allow inserting a multiplicity of beamsplitters, and filters without any obstruction. We could either side connect the sliding mount 40-110 to insert various filters or to switch between filters very rapidly, we could make an extended version. We'll also need to design a diagonal sliding mount to secure various beamsplitters, mounted in 30 mm lens cells. The 30 mm lens cell provides a 28 mm clearance aperture to provide the necessary beam path clearance when mounted at 45°.

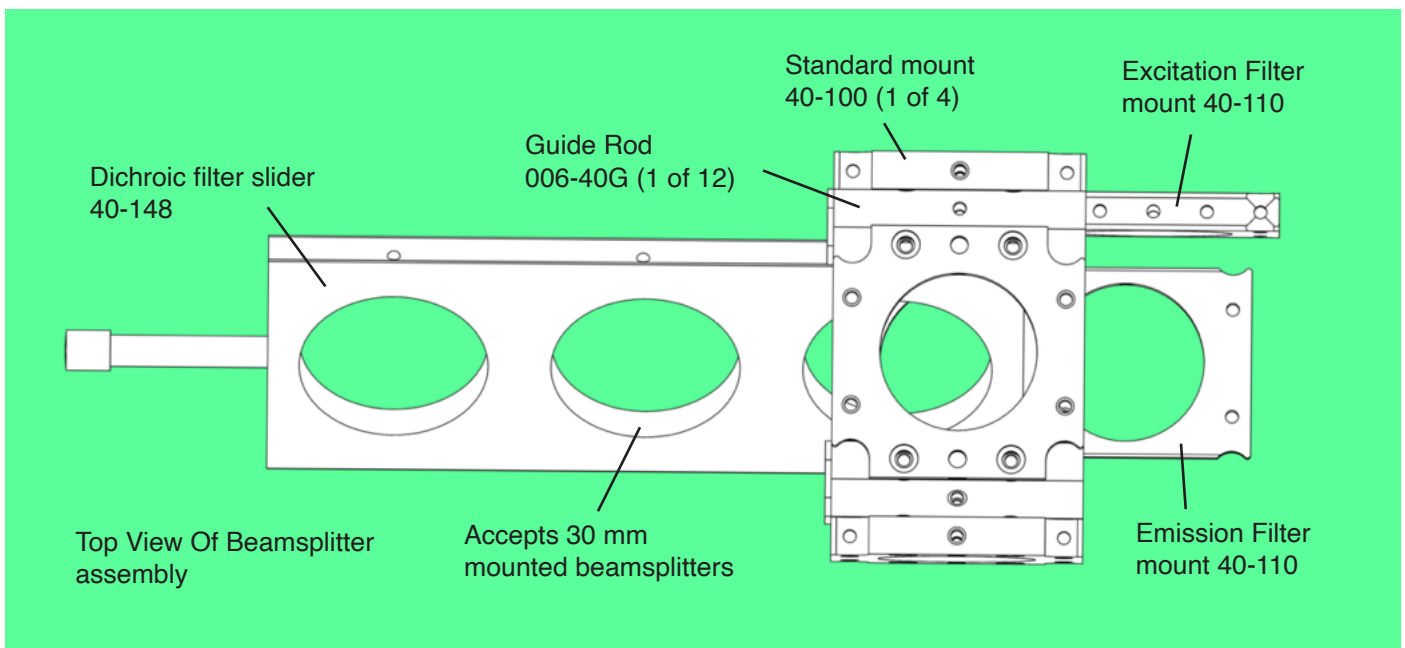
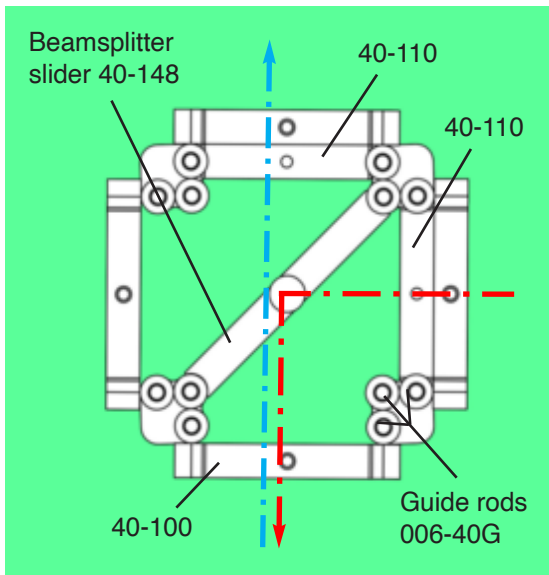


Sliding Beamsplitter 40-148

I think we are there now to start constructing our beamsplitter assembly. Let's view the assembly constructed above. It takes 8 Rod Corner Connectors 40-144 to construct this cube.

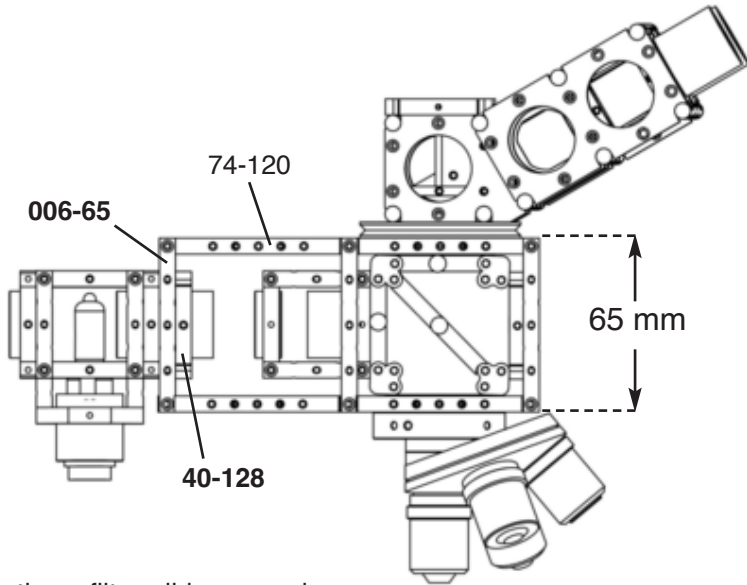
Several sliding mounts 40-110 could be side connected to add as many filters one would wish to have, or a 3-position filter holder could be designed for securing a set of 3 filters for Emission, and another set to secure Excitation filters. If you notice there are four sides to the beamsplitter cube, securing the emission, transmission and the objective lens. What could we use the 4th aperture for?

The fourth side is utilized to secure a light trap. The light trap is the most crucial part of the beamsplitter assembly. It would influence the image contrast. Several designs are offered for light traps. One simple example would be a small can, painted dull black on the inside, filled with black anti static sponge.



Building our very own Fat Microscope

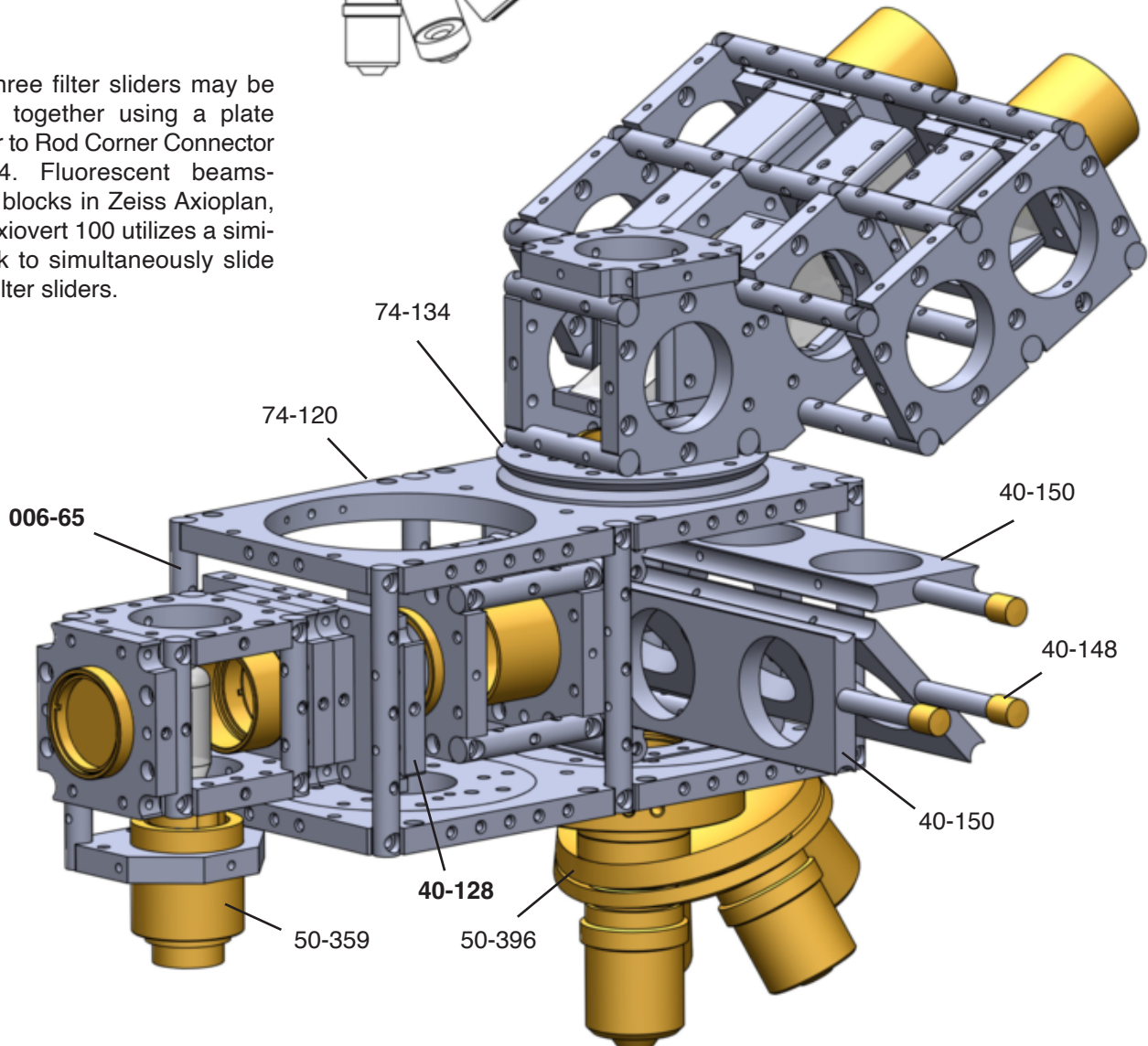
Lets now integrate our beamsplitter assembly with other sub assemblies we had constructed in past issues. The filter sliders are also shown. The light source could be Halogen but a high intensity Mercury or Xenon lamp is recommended. We'll be making one later. We now have to decide where we'll mount the beamsplitter assembly. The best option would be to mount it inside a larger housing to light seal the beam path. So we'll remove the upper, and lower 40-100 mounts,



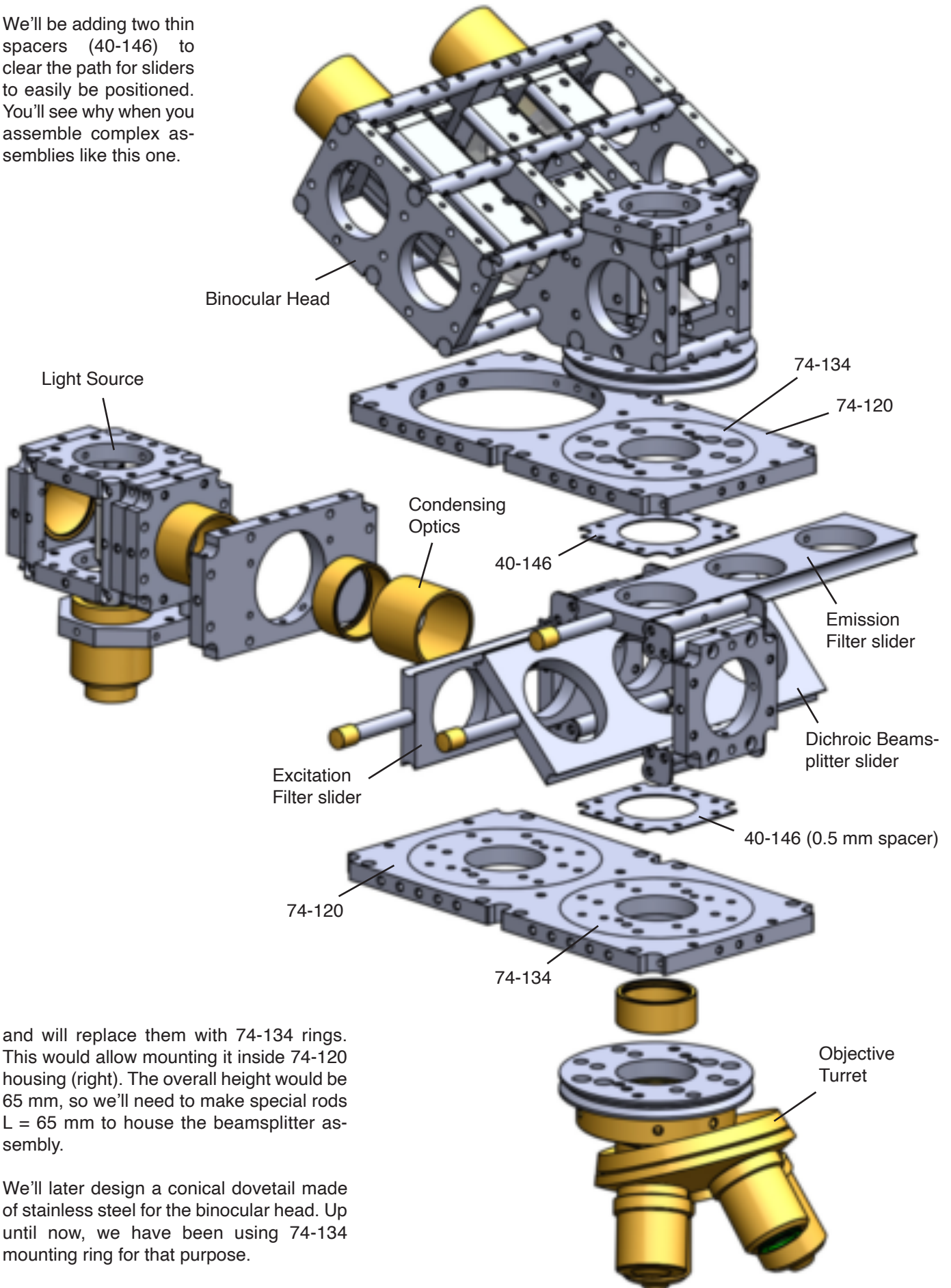
Note in spite of the height difference in this illumination assembly with standard 40, and 74 mounts, mount **40-128** is mounted at the center of rod pair **006-65**.

In this case, 40-128 is secured to 006-65 from the inside. This allows cover plates to cover the illumination housing without any mechanical conflict with its lamp housing.

The three filter sliders may be linked together using a plate similar to Rod Corner Connector 40-144. Fluorescent beamsplitter blocks in Zeiss Axioplan, and Axiovert 100 utilizes a similar link to simultaneously slide their filter sliders.

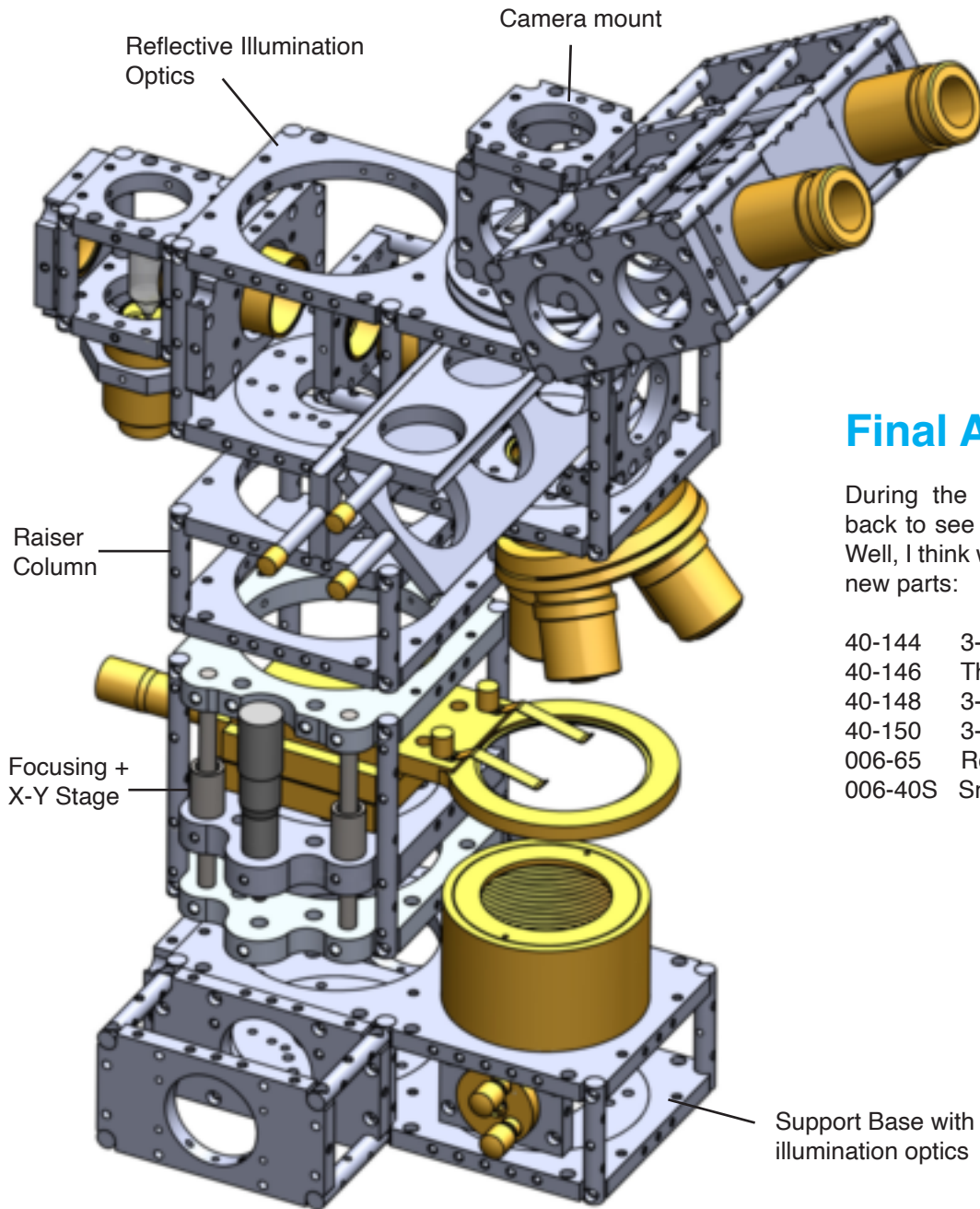


We'll be adding two thin spacers (40-146) to clear the path for sliders to easily be positioned. You'll see why when you assemble complex assemblies like this one.



and will replace them with 74-134 rings. This would allow mounting it inside 74-120 housing (right). The overall height would be 65 mm, so we'll need to make special rods $L = 65$ mm to house the beamsplitter assembly.

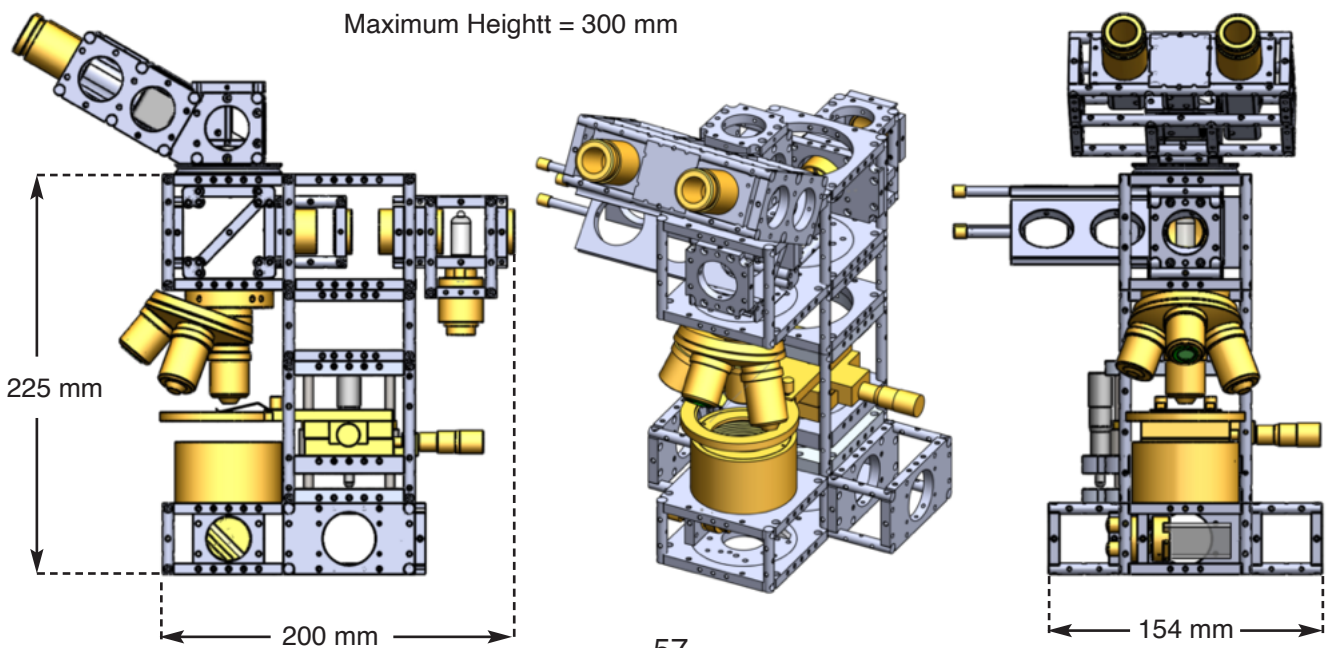
We'll later design a conical dovetail made of stainless steel for the binocular head. Up until now, we have been using 74-134 mounting ring for that purpose.



Final Assembly

During the final assembly we'll look back to see how we did in our design. Well, I think we did ok by just adding six new parts:

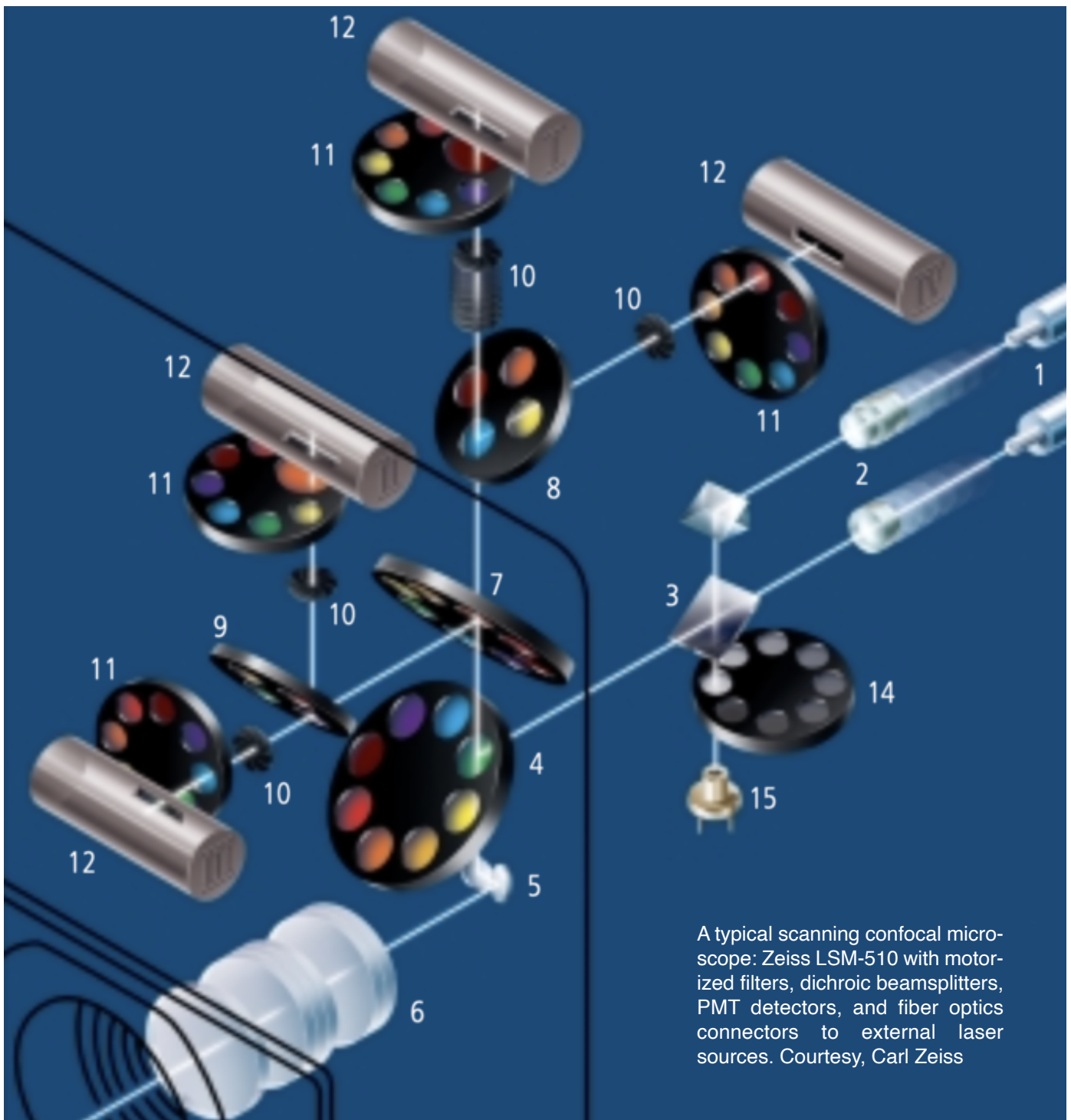
- | | |
|---------|----------------------------|
| 40-144 | 3-Rod Corner Connector |
| 40-146 | Thin Plate 0.5 mm thick |
| 40-148 | 3-Position Diagonal Slider |
| 40-150 | 3-Position Filter Slider |
| 006-65 | Rod L = 65 mm |
| 006-40S | Smooth Guide Rods |



Designing the Confocal Head for Optoform Microscope

In last section, we developed the central beamsplitter slider for Fluorescent microscope. Although Zeiss utilizes this scheme, their slider is a solid block which has to be pre-assembled before its insertion into the microscope. In our design, there are three sliders, that could be independently selected to get the desired emission/excitation/absorption effect. The standard filter size for Ziess is 25 mm, and the bemsplitter size is 25.5 x 36 mm. A high quality 3-filter/beamsplitter set will cost around \$1,200 each, adding up to \$3,600 just for filters.

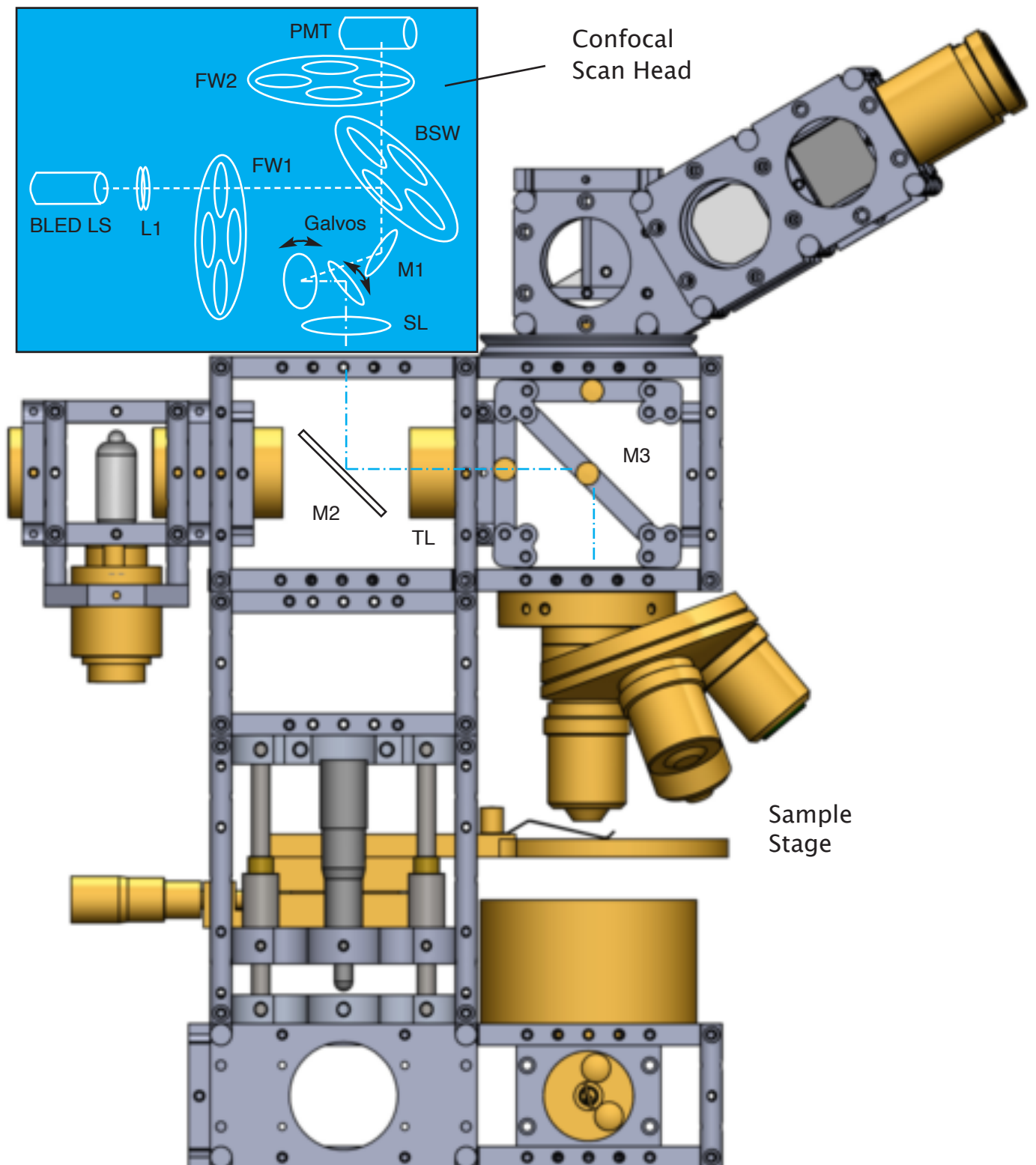
Typical combinations that are available are: **546/ 580/ 590**, **485/ 510/ 515**, and **385/ 395/ 397** for Ex-citation/ Dichroic/ Emission filters respectively. As we see in LSM 510 (below), all the internal filters of Axiovert 2 microscope are bypassed, and the scan head has its own sets of filters, and beamsplitters. Looking back at our Optoform microscope, the placement of the Confocal head could be on the back side of 74-120 mount, behind the trinocular observation head we built in previous section.

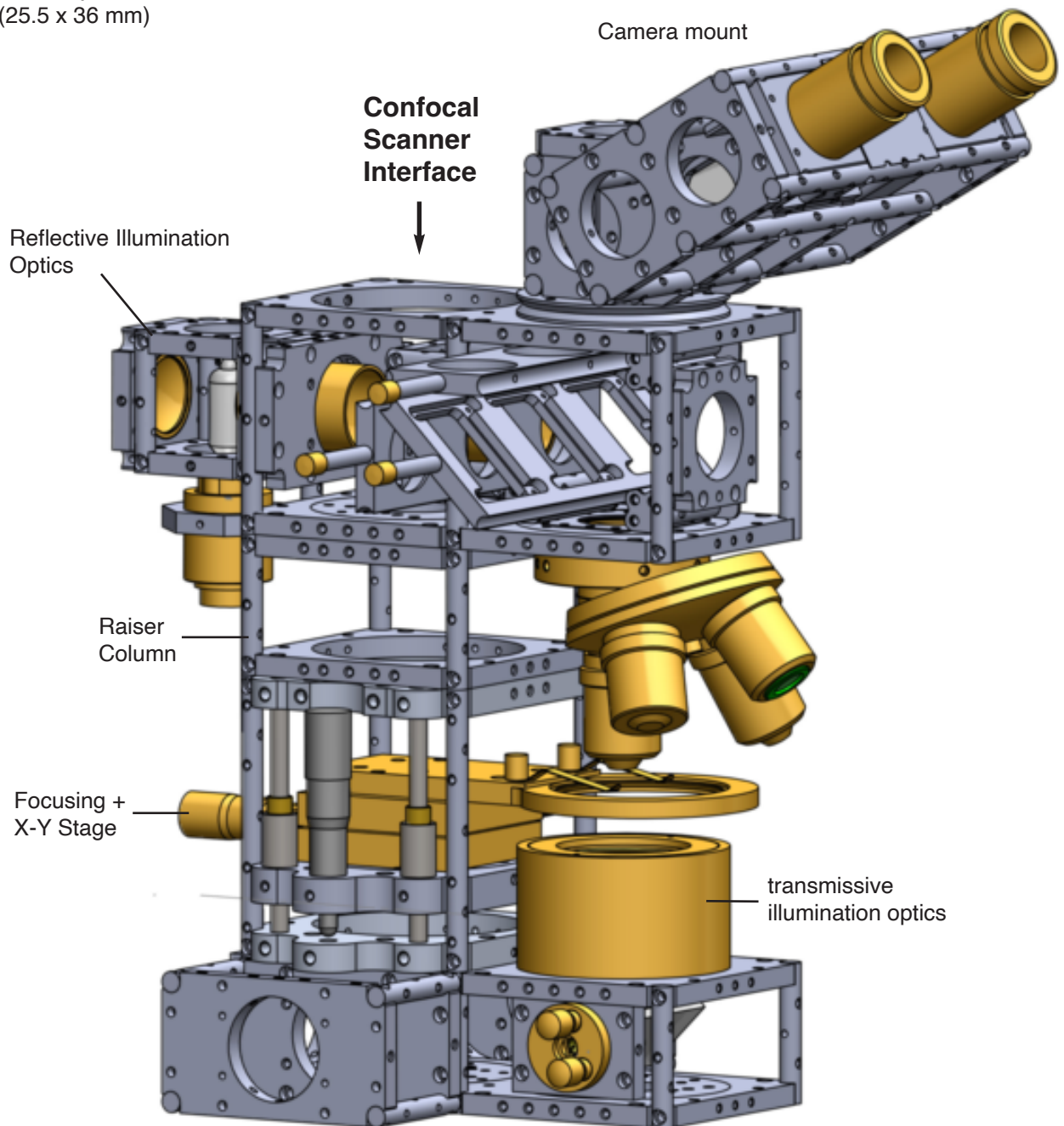
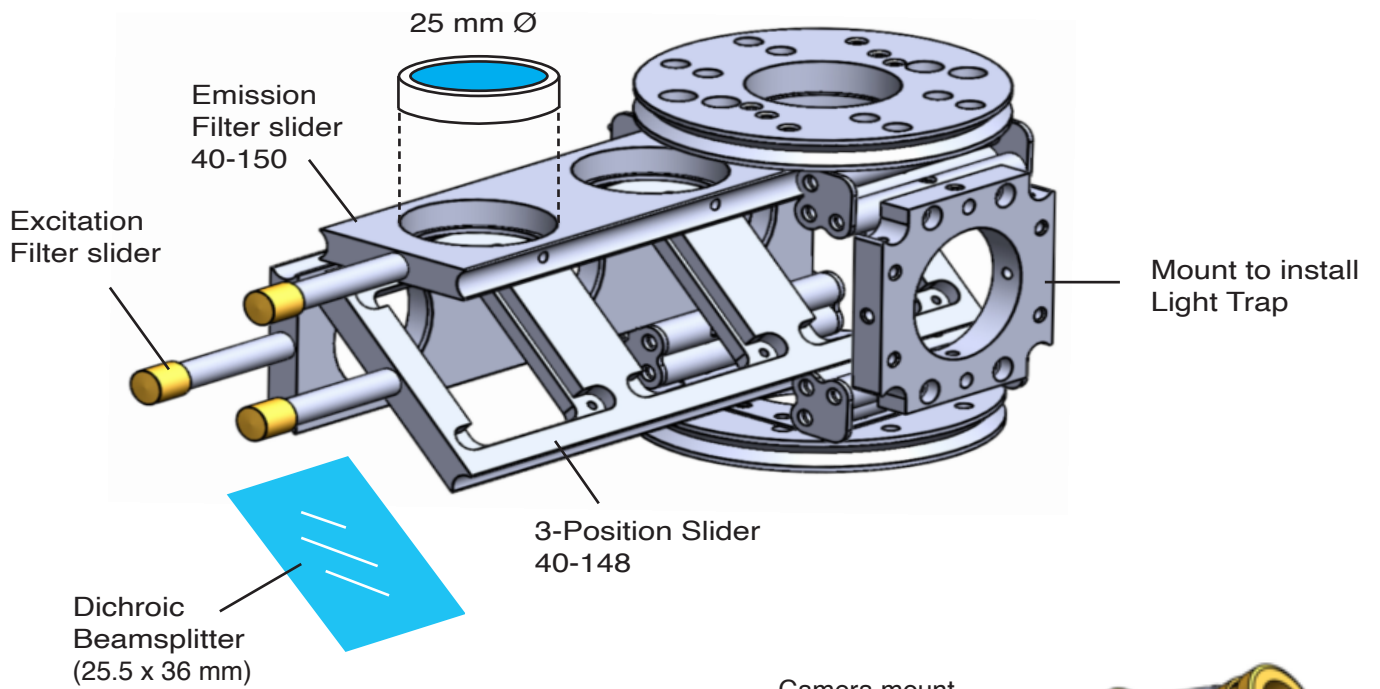


A typical scanning confocal microscope: Zeiss LSM-510 with motorized filters, dichroic beamsplitters, PMT detectors, and fiber optics connectors to external laser sources. Courtesy, Carl Zeiss

Optoform Version of Confocal Scan Head

Lets now begin designing a Confocal Scan Head with Optoform. The basic design would be a combination of individually designed Optoform modules. But for now, let's see how a side view of the microscope would look like. At system level, if we were to copy Zeiss LSM 510 Confocal scanner, we'll have the simplified arrangement below: Light originates from a bright LED light source and collimation optics L1, goes through excitation filter set FW1, reflects off of beamsplitter wheel BSW, reflects off of X-Y galvos, then through scan lens SL, and enters the light path of microscope through mirror M2, and M3, finally focused by an objective on the sample. The fluorescent light emitted from the sample goes through the objective lens, then reflects off of mirror M3, then M2, and goes through the galvos, passes through dichroic beamsplitter BSW, emission filter set FW2, and to the PMT detector. To start with, the filter wheels could be replaced with a particular filter set, and a dichroic beamsplitter. We don't know yet where to find the elliptical dichroic beamsplitters (Like those found in LSM 150). There is a better approach we could take to avoid Zeiss' spaghetti optical design, and this is how:

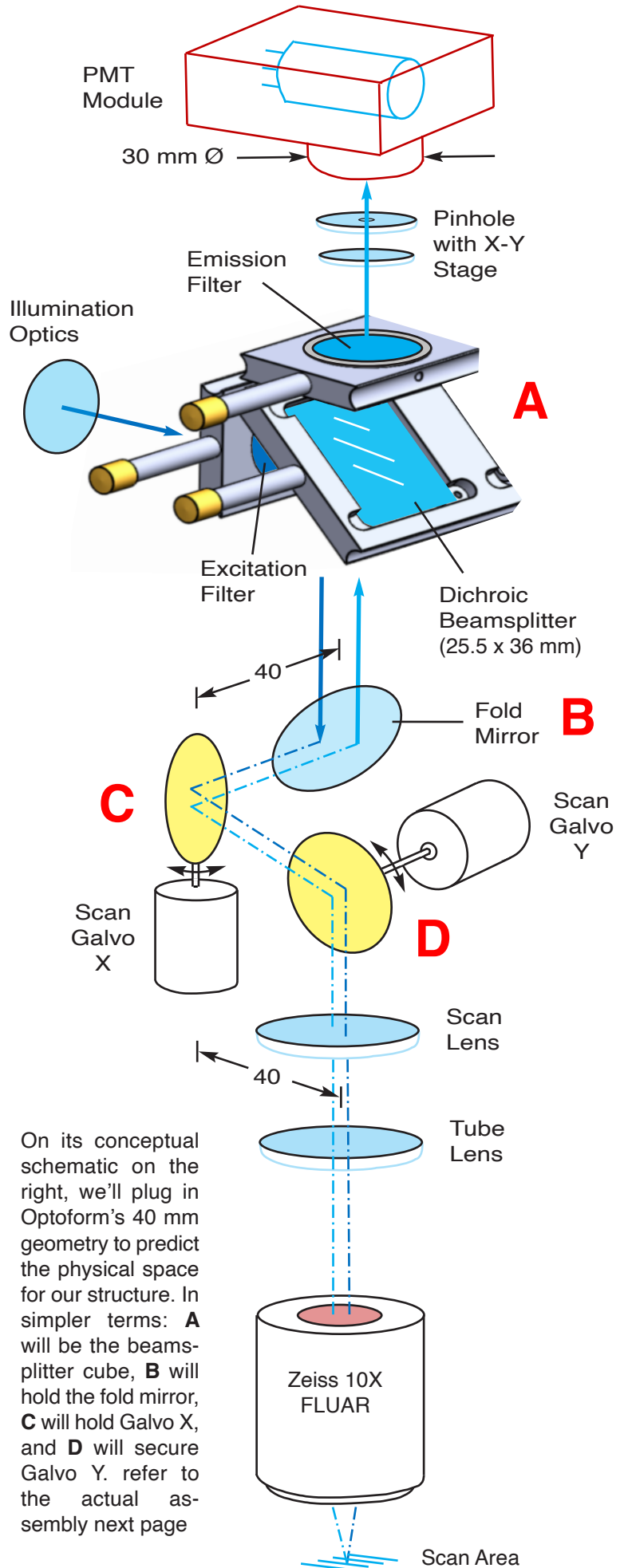




The Simplified Layout

Instead of filter wheels, why not utilize the same assembly we built for fluorescent microscopy? If we decided to motorize the system, we could devise linear actuators instead of a rotary filter wheel drive. So here is a basic design for the system. For PMT housing we could utilize the same module we developed for Strategene and was made available in classical Optoform catalog. It is made of black Deryln, and has a rectangular lens mount on its front face for mounting cylindrical optics.

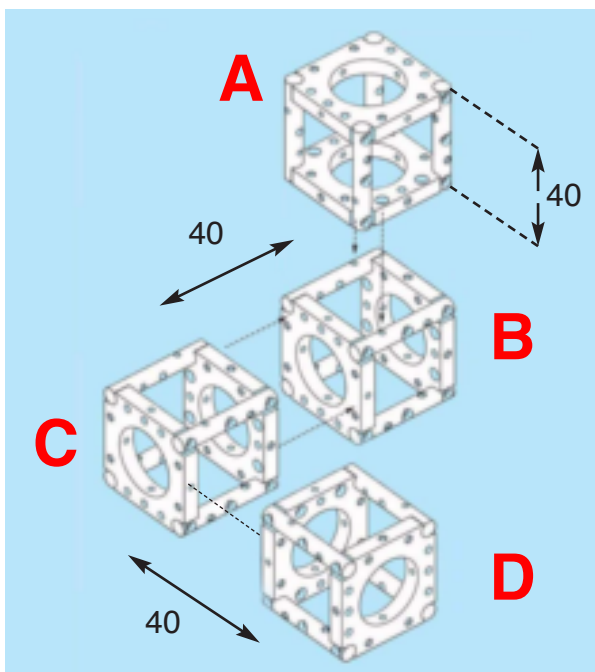
The detection side needs more work because the scan area is supposed to be a pinhole. So we'll need to have an X-Y stage like we saw in Zeiss LSM 510 to align the beam from the spot on the sample onto the PMT. In Zeiss design, there had to be compensation for a shift by the scan head laying on top of microscope. We'll also have the same challenge if this design is intended to be an add on module.



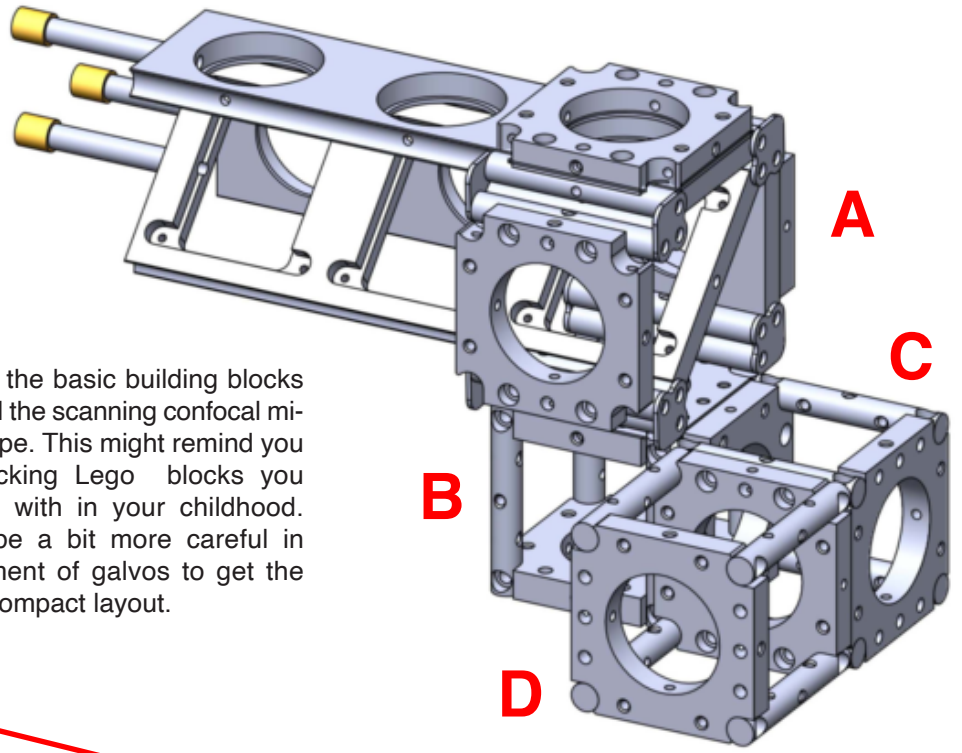
Integrating the Modules

So here it is, put together by connecting cubes A, B, C, and D (right), and after the installation of the necessary hardware: The galvo cubes, the beamsplitters, and filters, fold mirror, PMT tube, the pinhole, and the light source.

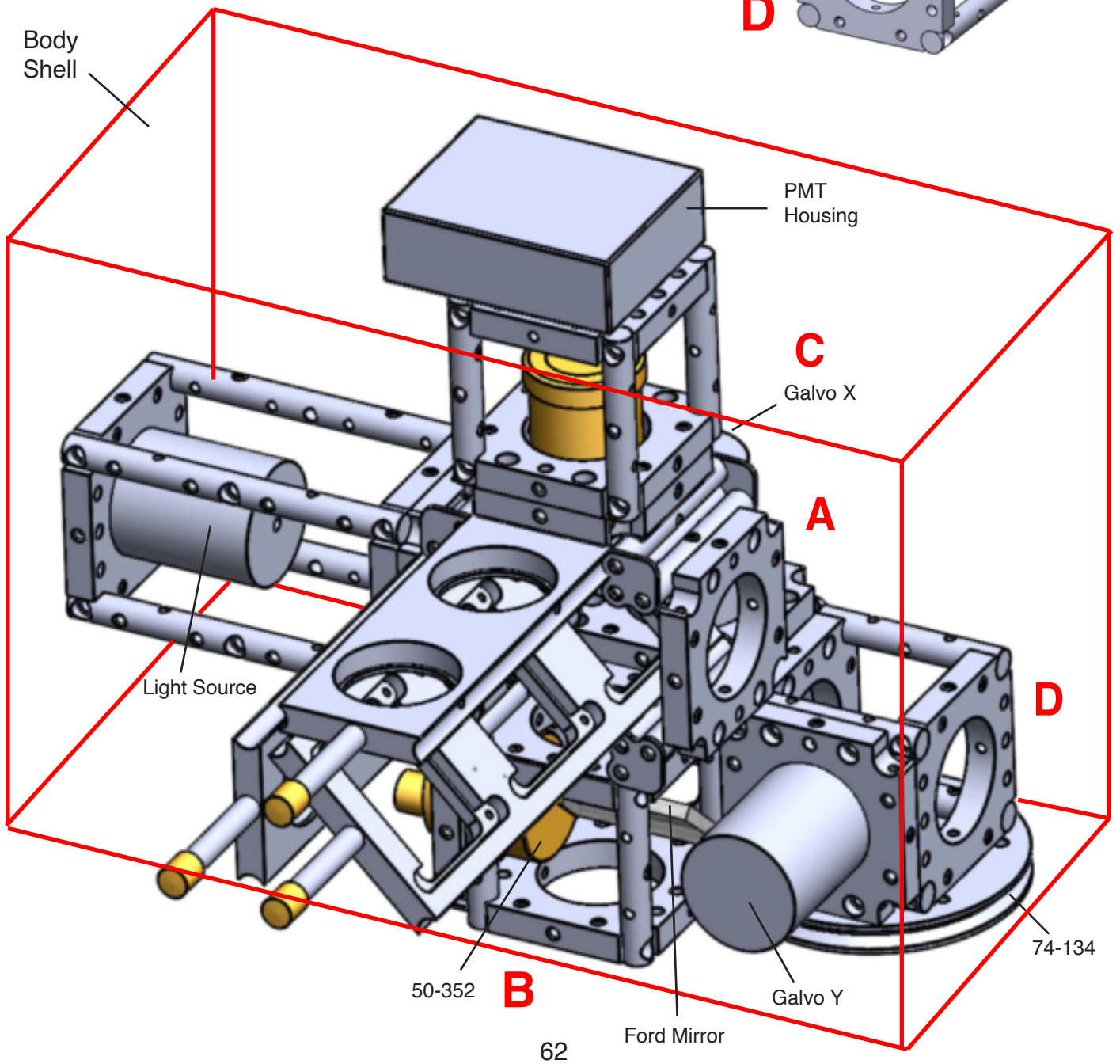
Let's now go back to the discussion we had about the chassis. We have the option of fitting this assembly inside a symmetrical housing (with the scan lens centered in the middle of the box, or



On its conceptual schematic on the right, we'll plug in Optoform's 40 mm geometry to predict the physical space for our structure. In simpler terms: **A** will be the beamsplitter cube, **B** will hold the fold mirror, **C** will hold Galvo X, and **D** will secure Galvo Y. refer to the actual assembly next page

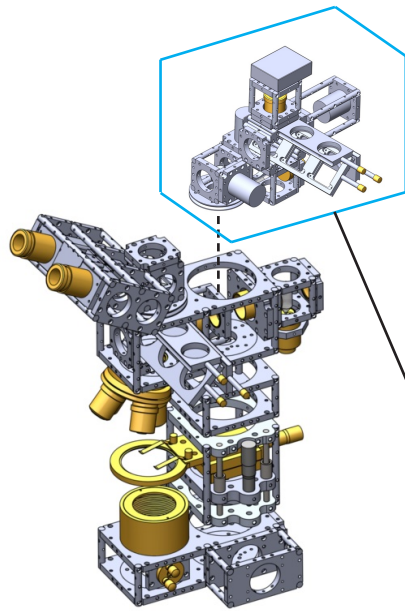


Here's the basic building blocks to build the scanning confocal microscope. This might remind you of stacking Lego blocks you played with in your childhood. We'll be a bit more careful in placement of galvos to get the most compact layout.

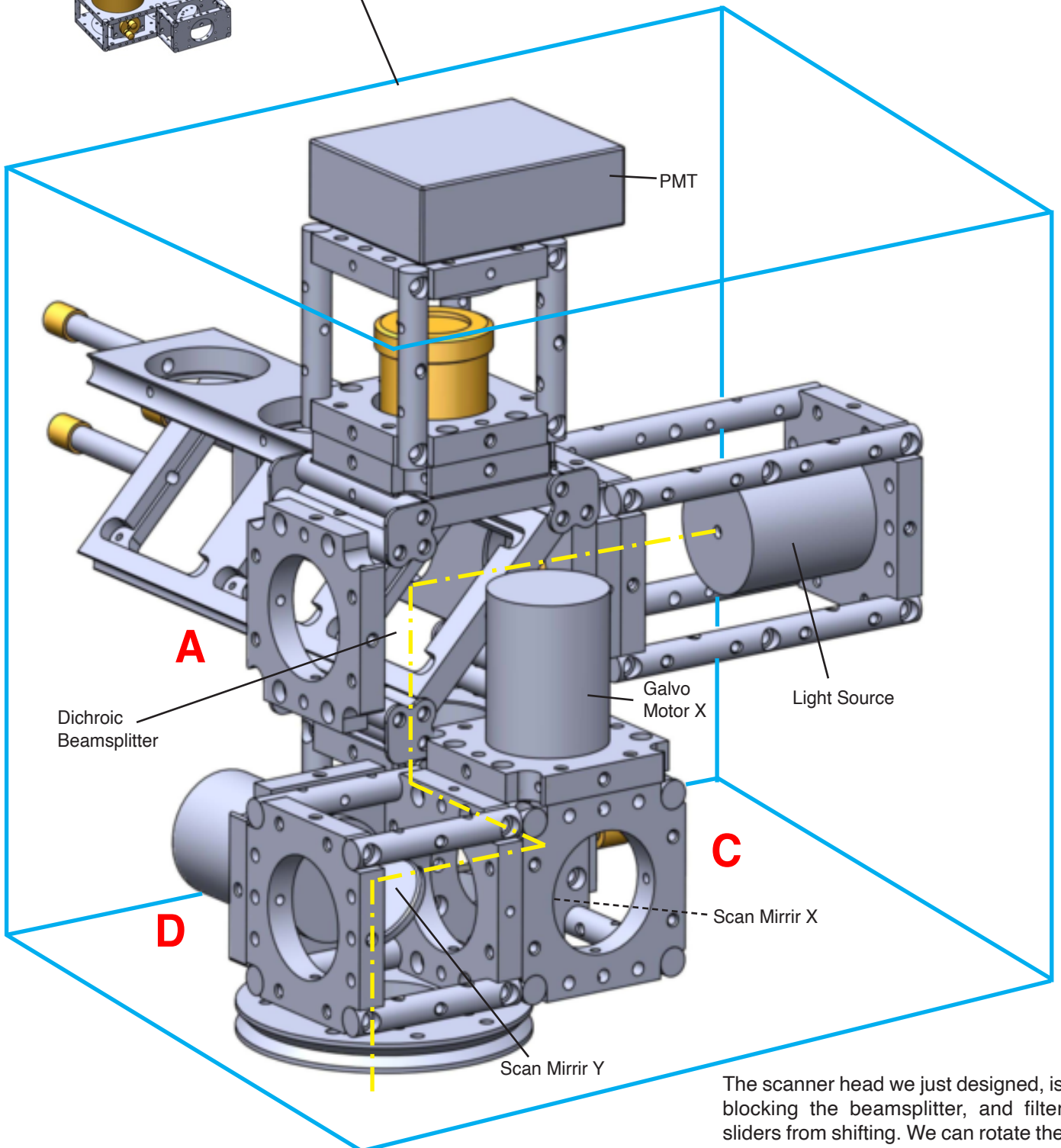


Designing the Chassis

Designing the housing requires two parallel walls that could be connected by rods, and would also accept standard mounts 40, and 74 to house the inner modules (below). Optoform II is good at this because its support rods are secured on the outer edges of the mounts. So, the two walls could be any shape, and form. Like any other Optoform assembly, the chassis would turn out to be a light weight skeleton structure to gain its structural rigidity from thin Aluminum covering. Being light tight is also crucial in this application because the PMT may work under extremely dim lighting conditions. I hope by now, we have a better understanding of Optoform's design philosophy.



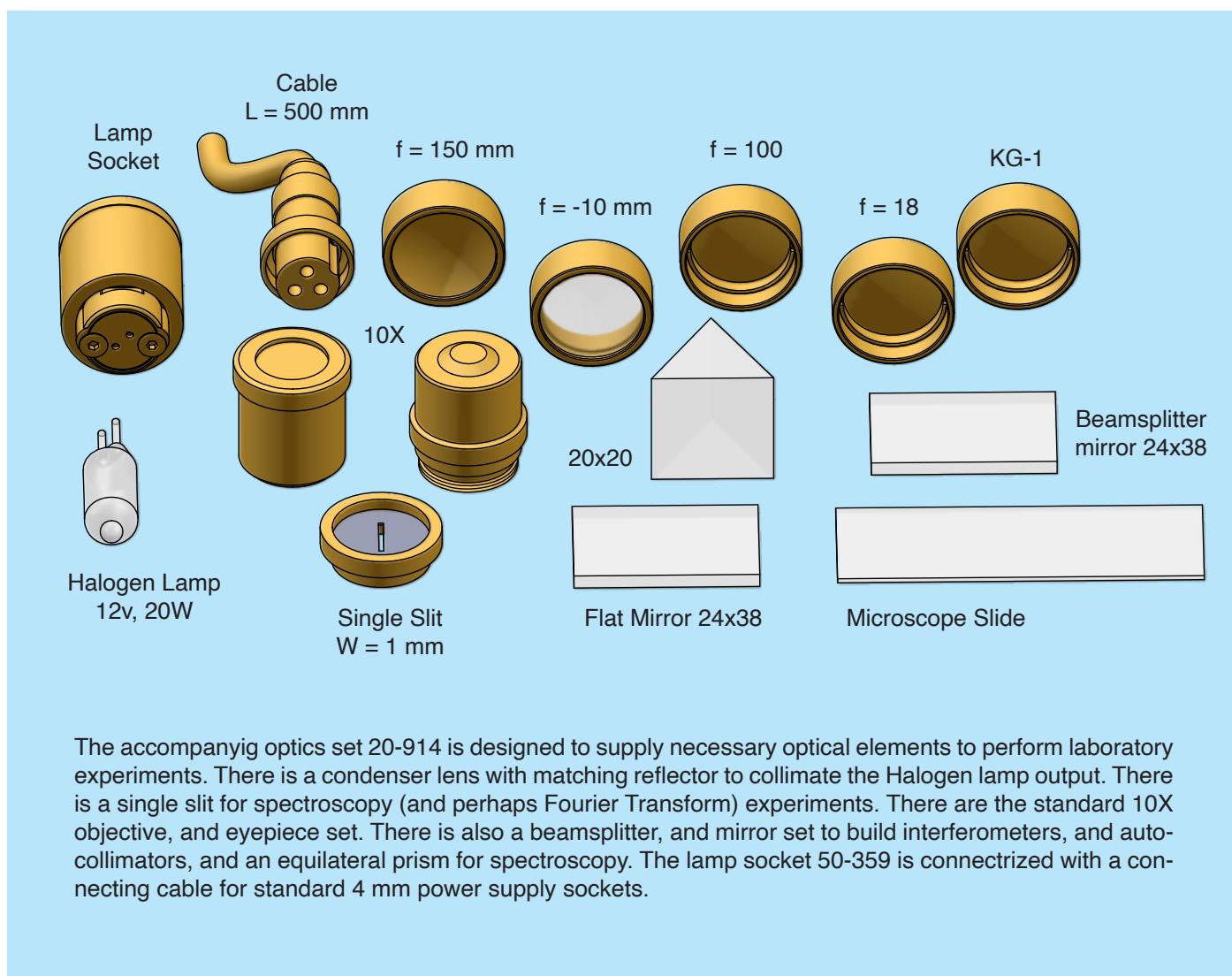
Confocal Scanner Module



The scanner head we just designed, is blocking the beamsplitter, and filter sliders from shifting. We can rotate the position of galvos 90° to clear the path.

Small Optics Set 20-914

Part No	Description	Price	Quantity	Total
50-359	Lamp Socket 20/50W	105	1	105
130-102	Halogen Lamp 12v/50W	14	1	14
20-761	Slit, 1 mm	30	1	30
20-823	Eyepiece 10X	50	1	50
20-812	Microscope Objective 10X	120	1	120
20-442	Flat Mirror 25x38x3	30	1	30
20-450	Beamsplitter Mirror 25x38x2	34	1	34
20-412	Equilateral Prism 20x20x20	52	1	52
20-250	Condenser Lens $f = 18$	65	1	65
20-020	Plano Convex Lens $f = 100$	53	1	53
20-022	Plano Convex Lens $f = 150$	58	1	58
20-480	Concave Mirror $f = -10$	83	1	83
20-640	KG-1 Heat Absorbing Filter	44	1	44
20-SP	Kit Box	25	1	25
			Total Price	\$763



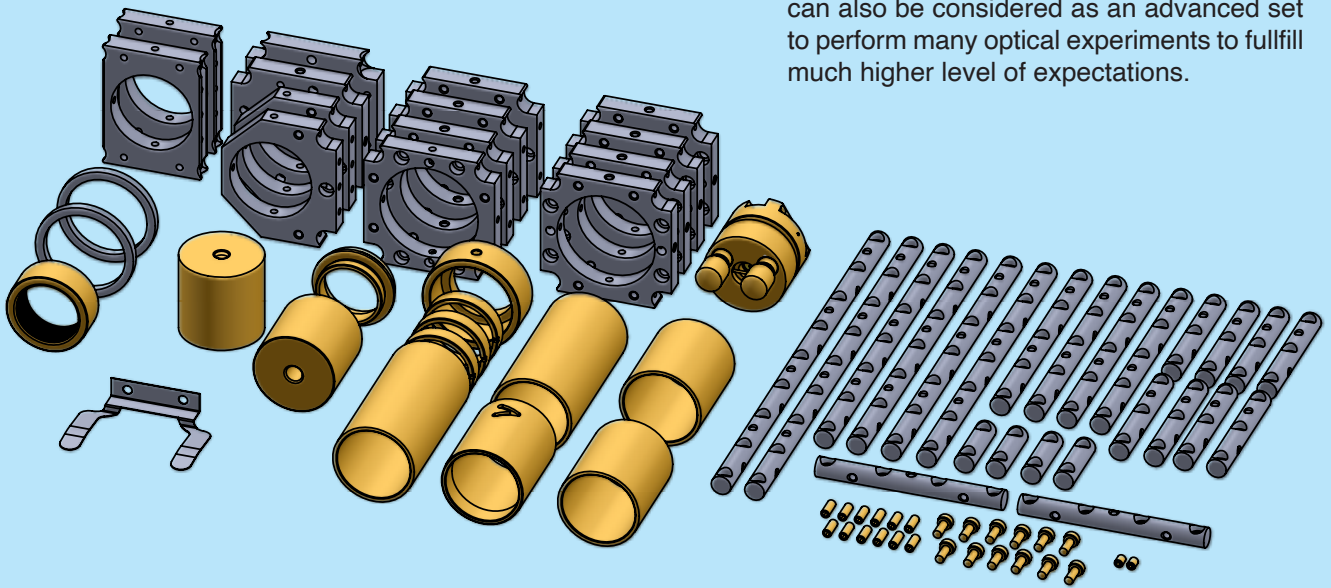
Optoform II Introductory Kit 40-706

The new Optoform Basic kit is designed to allow the end user to setup a multiplicity of optical experiments. The kit allows hands-on assembly of several optical instruments so its opto-mechanical capabilities could be studied. The rest is up to the user's own imagination, and creativity to build their own projects. First lets examine what's in this introductory kit, and then we'll start constructing from basic experiments such as a telescope, and we'll do more complex setups such as an autocollimator, and a spectroscope.

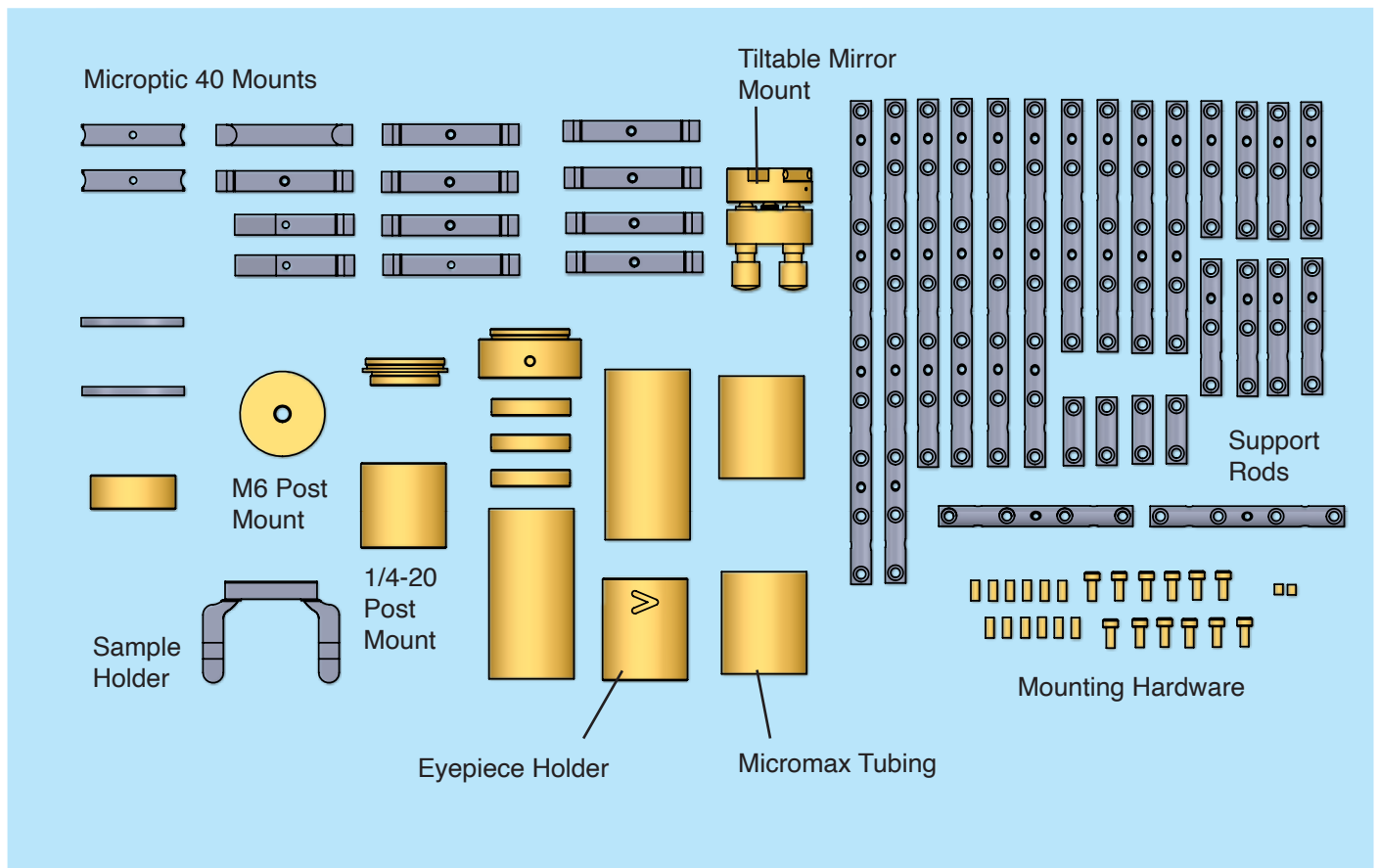
This kit is a mixture of parts from the Micromax system, some of Microptiic 50 accessories, and the new Optoform 40 mounting plates. There are plenty of rods to do many complex setups. Micromax tubing is utilized mainly for focusing of optical elements or to extend the optical path.

Part No	Description	Price	Quantity	Total
40-100	Standard Mount 25	\$20	4	80
40-102	Compact Mount 25	\$20	2	40
40-104	Angle Mount 25	\$20	4	80
40-106	Mating Plate 25	\$20	4	80
40-108	Intermediate Mount 25	\$23	1	23
40-110	Sliding Mount 25	\$25	1	25
40-130	Microbench Adapter 25	\$20	1	20
40-134	Side Mount 25	\$20	2	40
40-136	Side mount 25C	\$20	1	20
50-352	Titable Mirror Mount 25	84	1	84
50-331	Microscope Objective Mount 25	19	1	19
25-128	Tube 25, L = 30	25	2	50
25-130	Tube 25, L = 50	28	1	28
25-332	Microscope tube adapter	26	1	26
25-354	Eyepiece Holder 25	23	1	23
25-306	Extended Retaining Ring	9	3	27
25-198	Lens Cell Adapter	25	1	25
50-333	Post mount adapter M6	21	1	21
50-341	Post mount adapter 1/4-20	21	1	21
00-852	Sample Securing Spring Plate	25	1	25
006-20	Support Rod, L = 20	5	4	16
006-23	Support Rod, L = 23	5	2	10
006-40	Support Rod, L = 40	5	8	40
006-56	Support Rod, L = 56	6	2	12
006-74	Support Rod, L = 74	7	4	28
006-108	Support Rod, L = 108	8	4	32
006-142	Support Rod, L = 142	10	2	20
00-502	Cover Plate 34X34 mm	4	4	16
00-125	M2.5x6 Socket Head pack Of 100	25	1	22
00-126	M2.5x3 Set Screws pack Of 50	16	1	16
00-128	M2.5x6 Set Screws pack Of 50	16	1	16
00-129	M2.5x4 Cover Screws set of 20	10	1	10
00-248	Ball Driver set 1.25, 1.5, 2 mm	12	1	12
40-128	Spacer set 25/30x2.5 mm	12	1	12
20-SP2	Kit Case	35	1	35
			Total Price	\$1,076

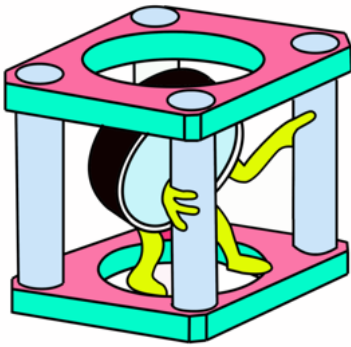
New Optoform Kit is moderately arranged to allow performing various optical experiments. This kit is not only a starter kit but it can also be considered as an advanced set to perform many optical experiments to fulfill much higher level of expectations.



40-706 Optoform Starter kit contains 60 parts. Various lab setups can be performed such as building simple telescopes, or an autocollimator, and other applications such as microscopy, spectroscopy, etc.



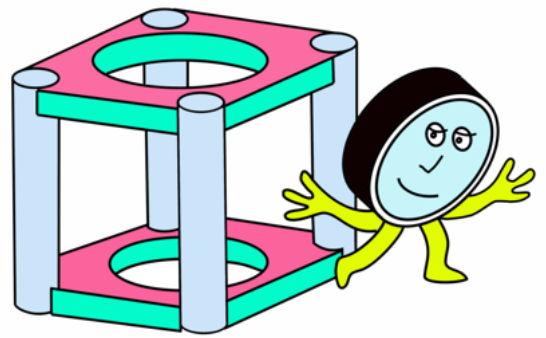
In the next pages, and the following issue, we will show how to set up these experiments, but the main goal is to prepare you to setup your own ideas, and be able to do problem solving in your own lab.



Other Cage Systems

Out of the cage system:

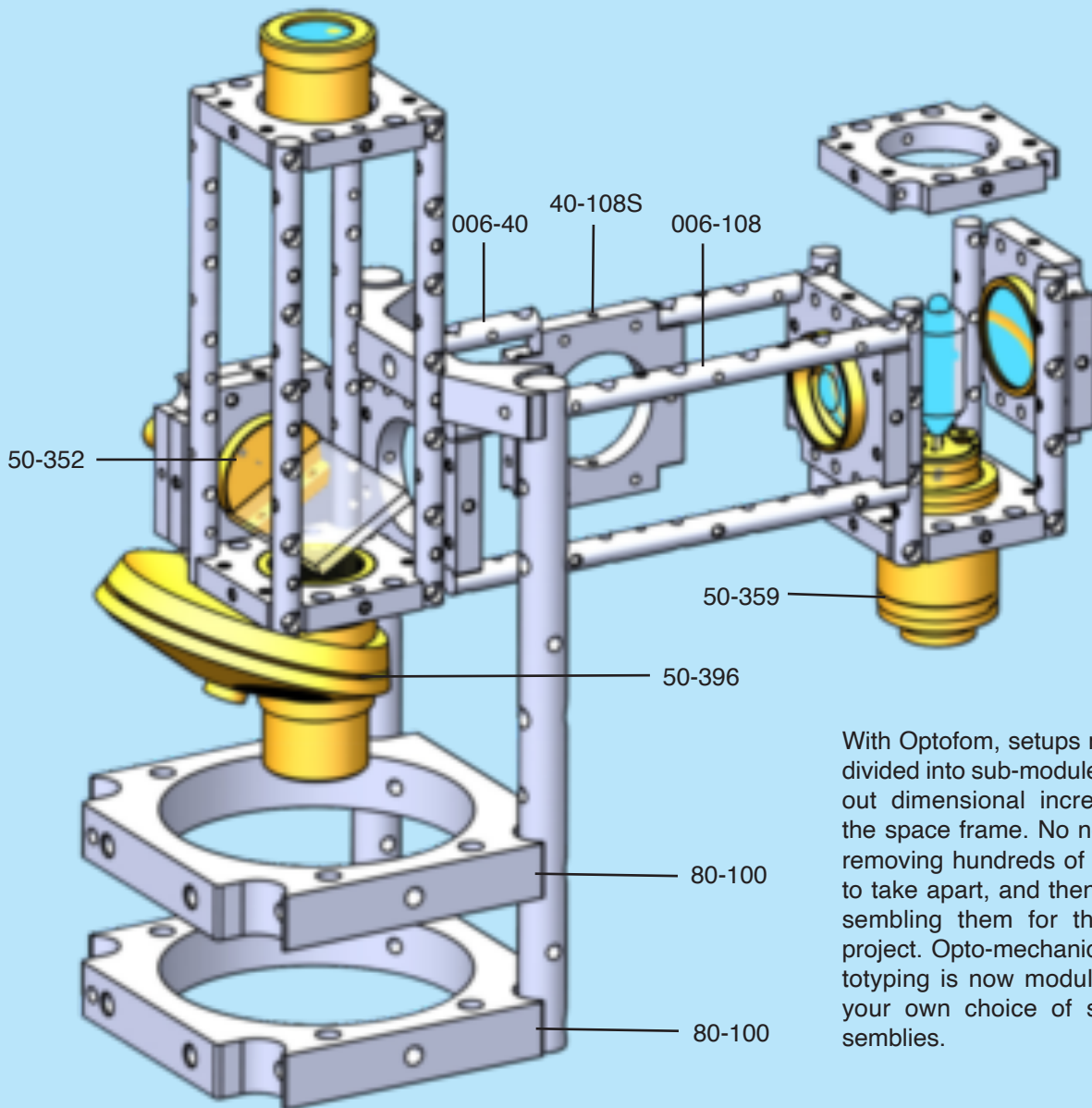
You can now use larger optics



New Optoform

Placing support rods on the outside corners of Optoform mounts allows 25/30 mm mounted optics to be easily inserted, and taken out without obstruction. Up to 40 mm optics may now be fitted in between the rods.

Take apart, and reconfigure your designs with no limits



With Optoform, setups may be divided into sub-modules without dimensional increase of the space frame. No need for removing hundreds of screws to take apart, and then re-assembling them for the next project. Opto-mechanical prototyping is now modular with your own choice of sub-assemblies.