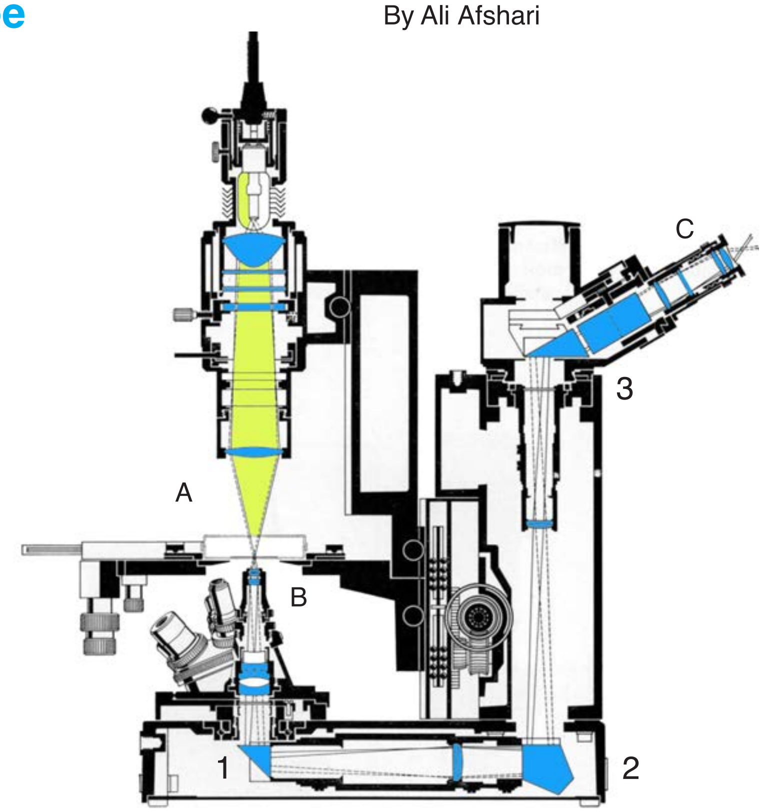
Making of an Inverted Microsocpe

By Ali Afshari

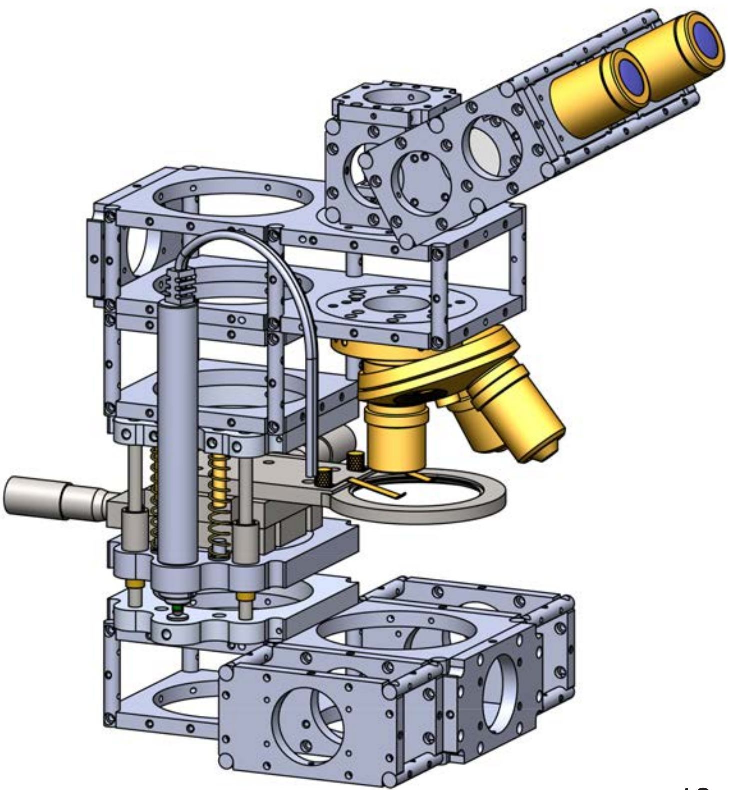
In the last issue, we covered the basics of constructing a biological microscope with new Optoform 40, and 74. The dimensional size of Optoform 40 is to match with Microbench mounts, and Thorlabs' cage system to make switching between them easily. Larger mounts like Optoform 74 follow a geometrical scheme to allow maximum compatibility between the mounts. So in its early days, the basic concept was developed to allow three dimensional beam paths, but it grew both in size, and number of parts to allow construction of 3D structures like microscopes, and various OptoMechaTronics instrumentation. Larger mounts like 142, and 278 are being designed primarily for biomed applications, and will be made available. Now let's construct an inverted microscope.

Let's take a look at what we built last time (below, left), and see what would now be different. To convert that to an inverted microscope, lets look at what modules we could reuse: The Nosepiece turret, the focusing stage, the binocular head, he illumination head, and same raiser plates we built last time. Leitz DIAVERT (right) is an example of a typical inverted microscope. The light source is above the sample platform, usually at a large distance to allow a petri dish to be viewed from below.

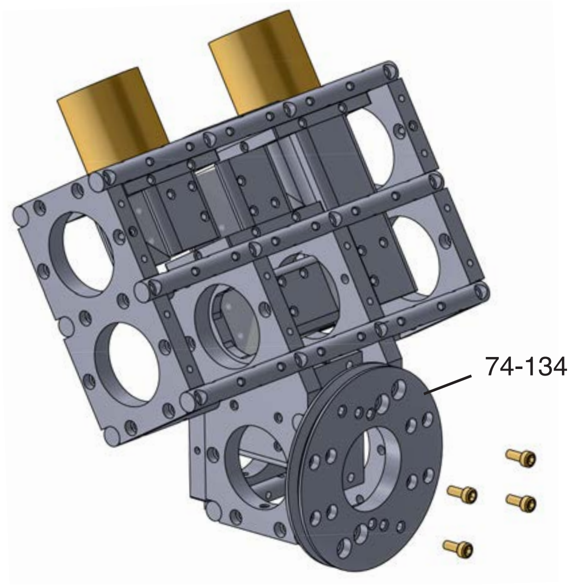
The objective lens in this case goes through three prisms to reach the observation head. There are several relay lenses to transfer the image from the objectives through an elongated beam path to reach the eye. We have a complete description of Leitz DIAVERT in Optomex No 8, Jan-April 2019.



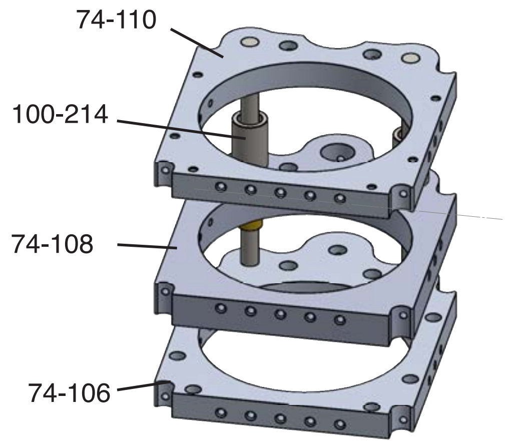
Illimination, and imaging path in Leitz Diavert inverted microscope: A) The light from halogen lap is focused on the sample. B) The objective lens focuses on the sample from below. C) Light from the sample is reflected through prisms 1,2, and 3 to reach the eyepiece. Additional prisms inside the viewfinder are not shown.



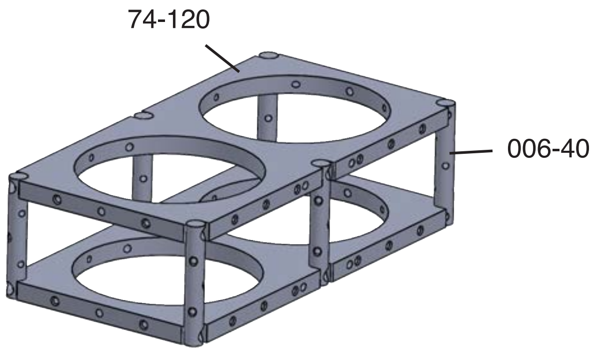
Leitz DIAVERT



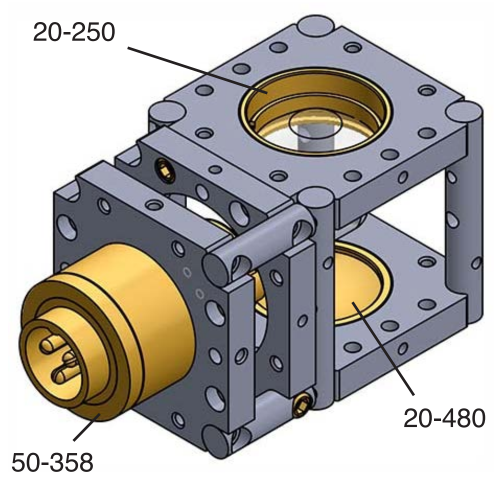
Taking off the mounting ring 74-134 from binocular head to utilize it as the viewing head in inverted microsocpe.



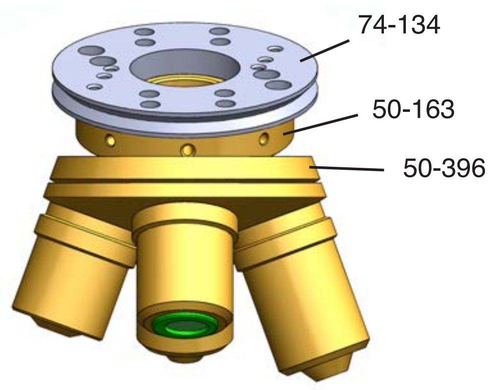
Same focusing Module we built for the biological microscope could be used for the inverted microsocpe.



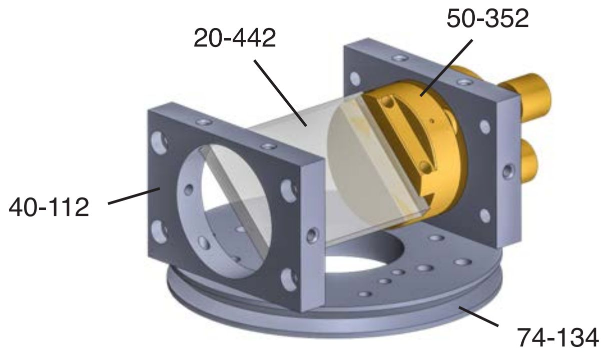
Raiser Platforms could be utilized to build the inverted microsopce.



Same Halogen source that was built for the biological microsocpe could be utilized for the inverted.



Nosepiece Turret that was utiized for biological microscope could be utilized for the inverted microsocpe.

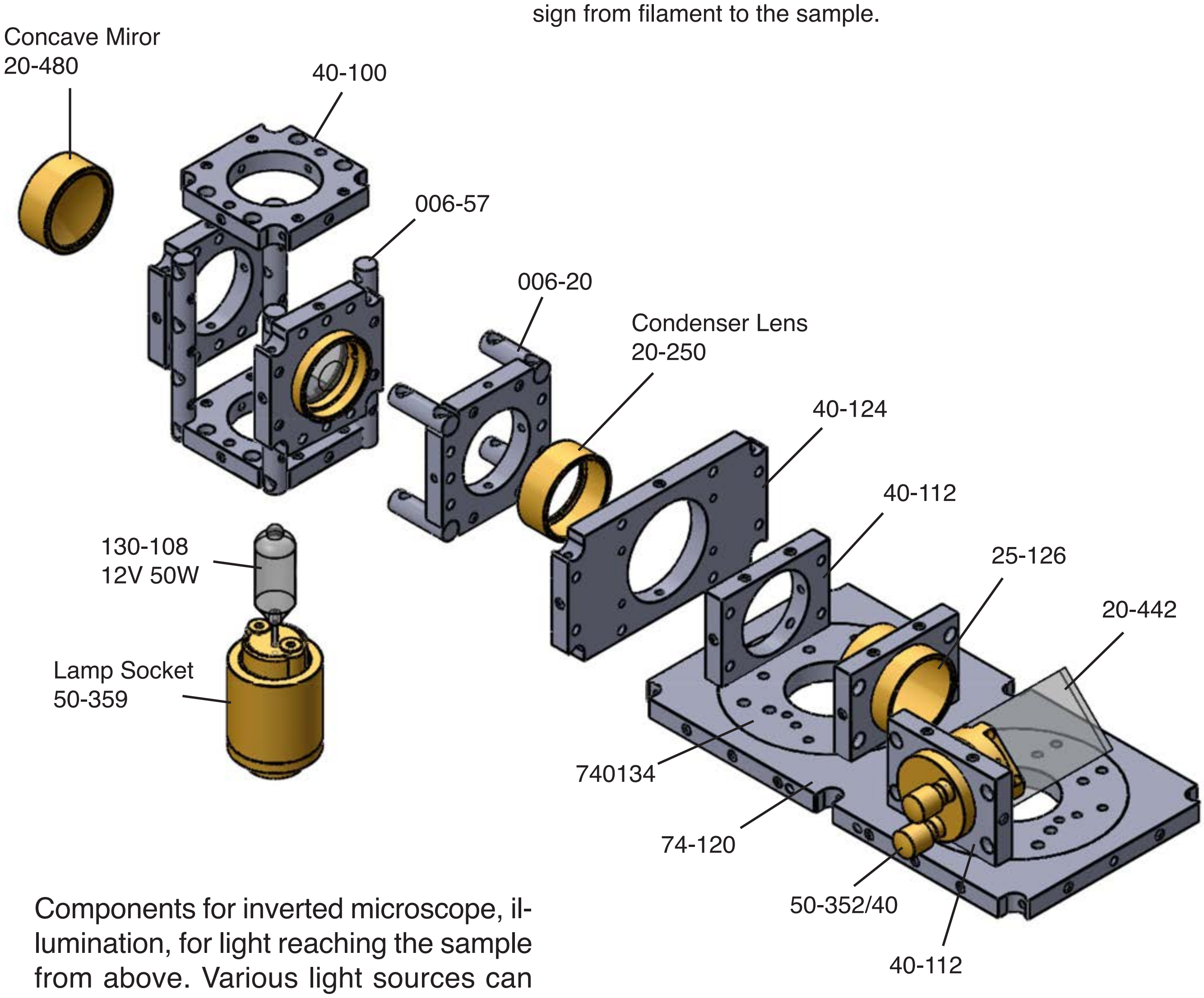


Mirror Holder with tip/tilt mount adjustment can be utilized to construct the illumination, and observation head for the inverted.

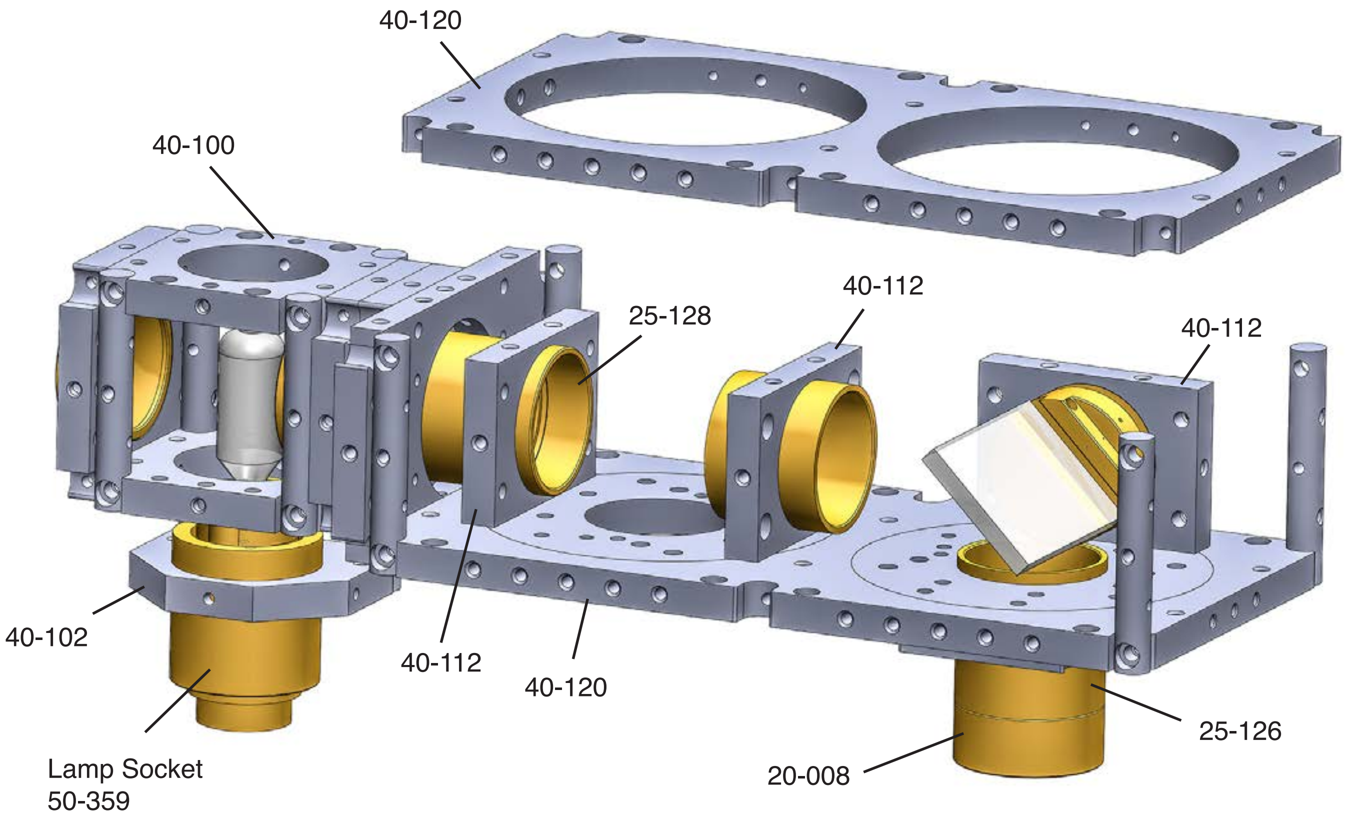
The illumination system

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 the 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.

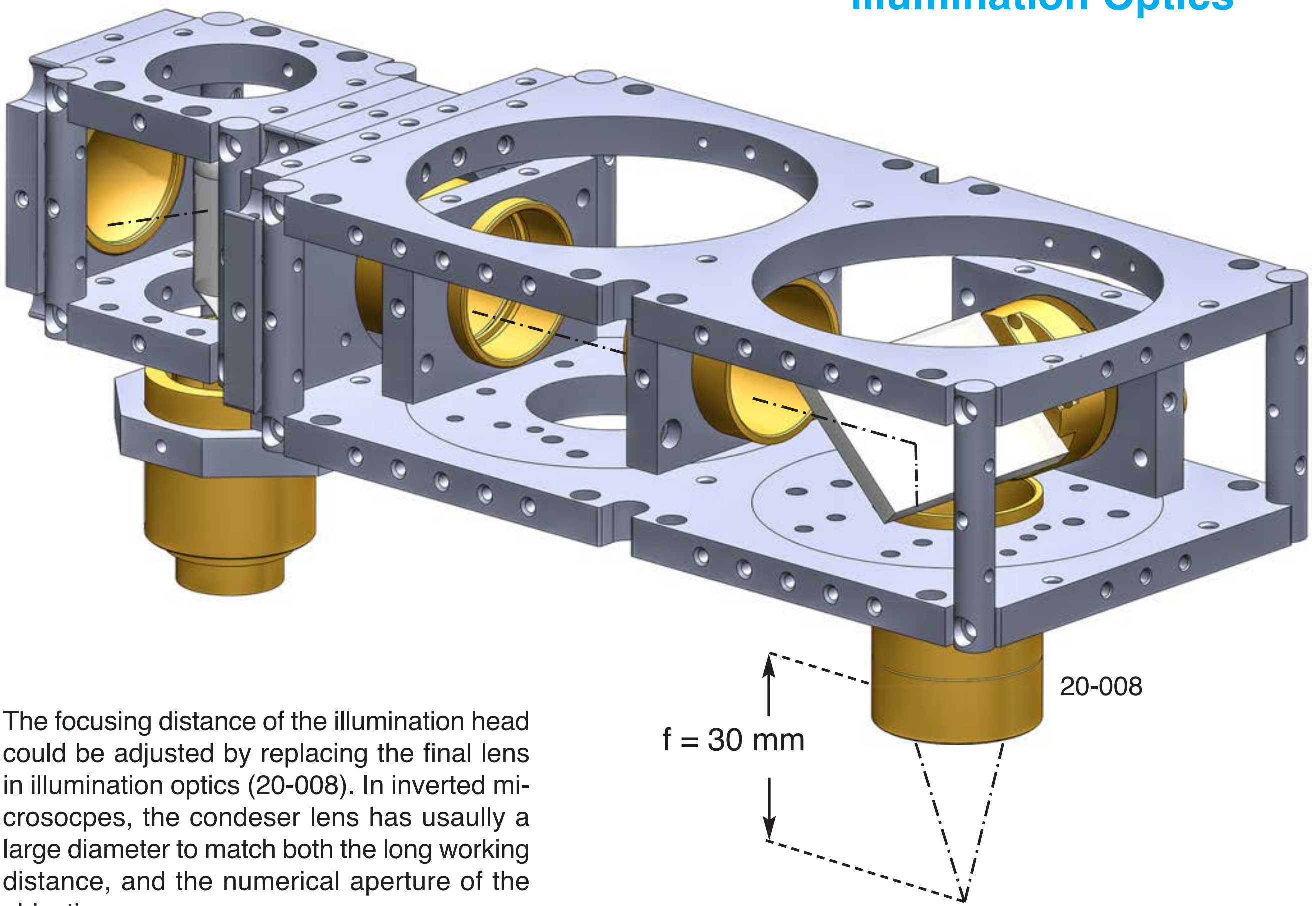
Leitz DIAVERT microscope illumination source with 12V, 20W Halogen lamp (above). DIAVERT uses a srtaight line optical design from filament to the sample.



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 microsocpes, the condeser lens has usaully a large diameter to match both the long working distance, and the numerical aperture of the objectives.

Adding Modules Together

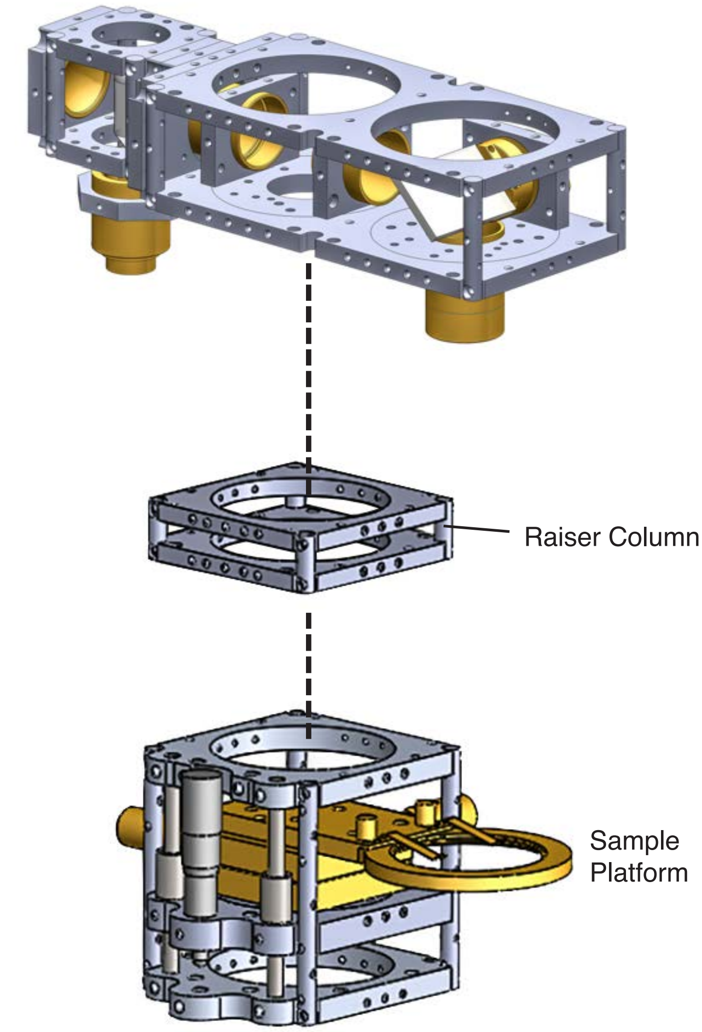
Adding the modules together is trivial in Optoform. The mounting plates that are utilized in making the modules are male/female oriented so every module could be secured to the next, thus erecting the assembly from ground up.

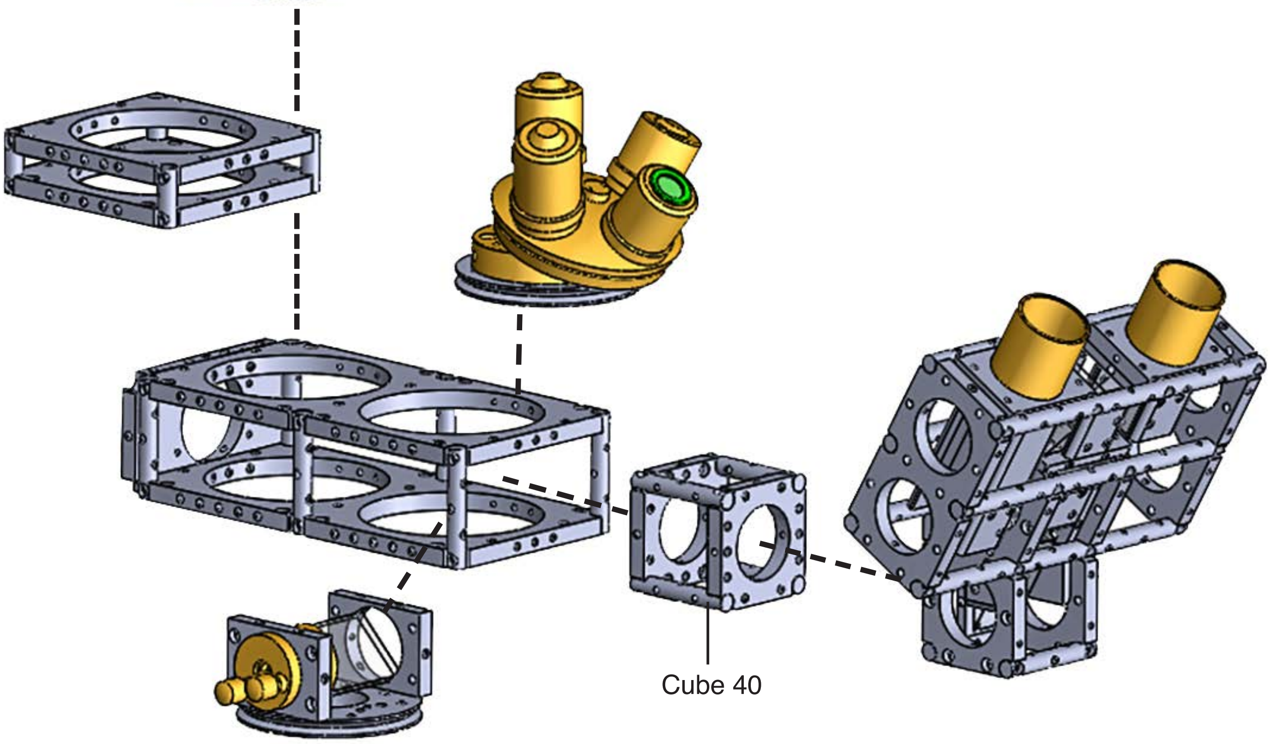
This is where the modularity concept of new Optoform proves to be so useful. The user becomes system designer instead of dealing with bolts and screws. Ball tip hex drivers allow oblique access to connecting screws without obstruction.

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.



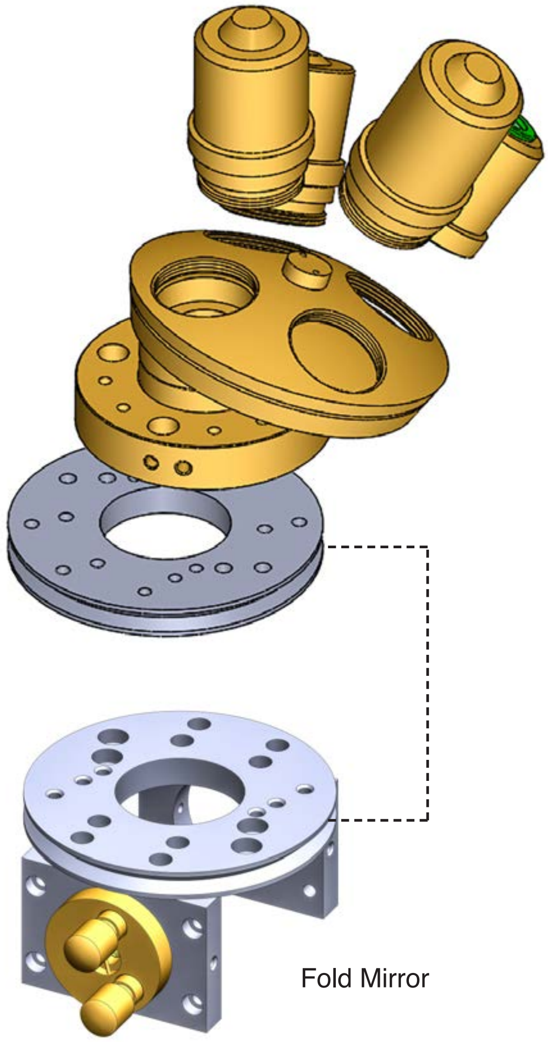


Finishing up the optics Layout

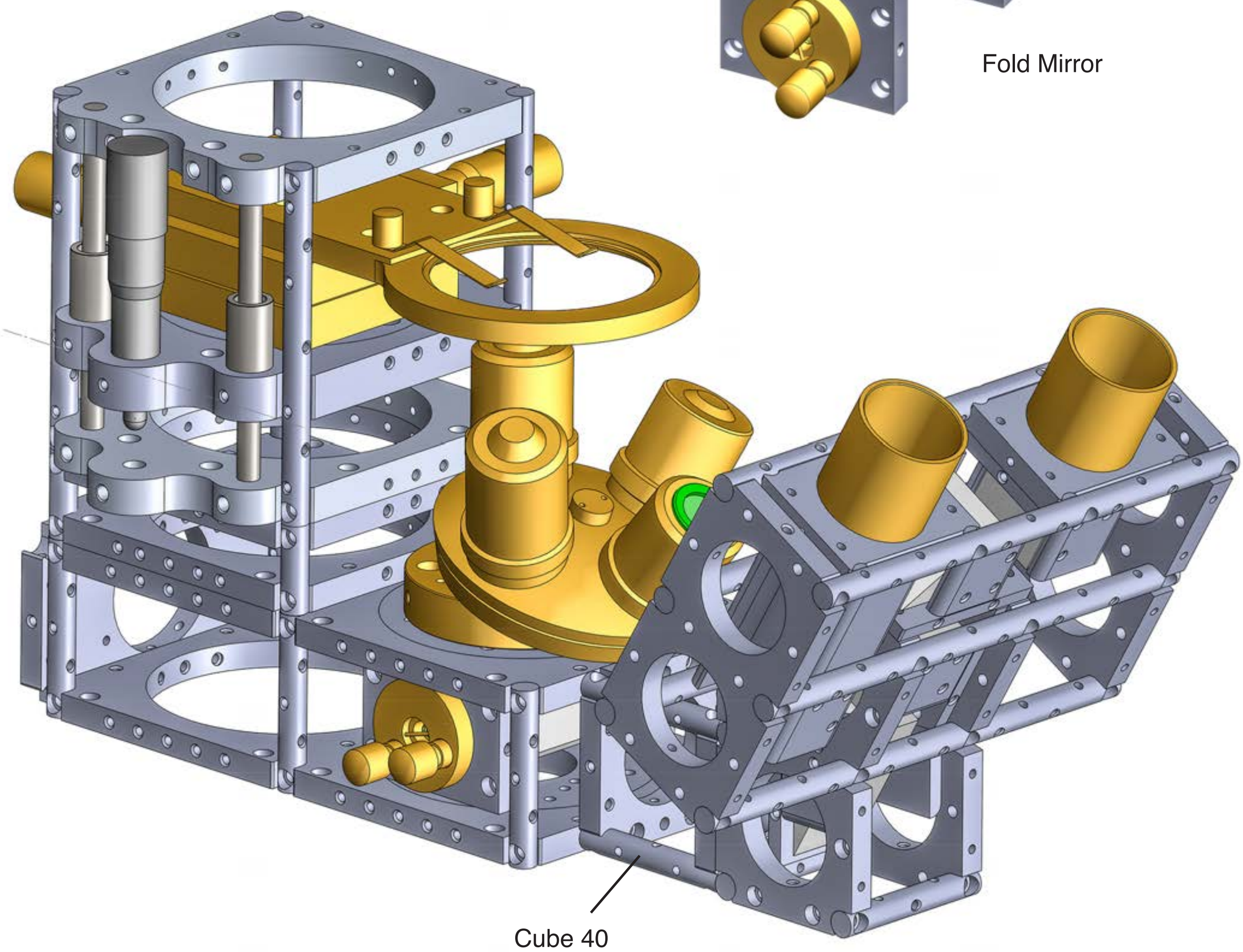
The optical layout of the inverted microscope is pretty much done at this point, and what remains is the illumination system. The binocular observation provides 60 degree inclined viewing, with reasonable height to provide good ergonomics. If higher viewing level is required, raiser platforms, are available 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 new 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 some fresh air.



Fold Mirror



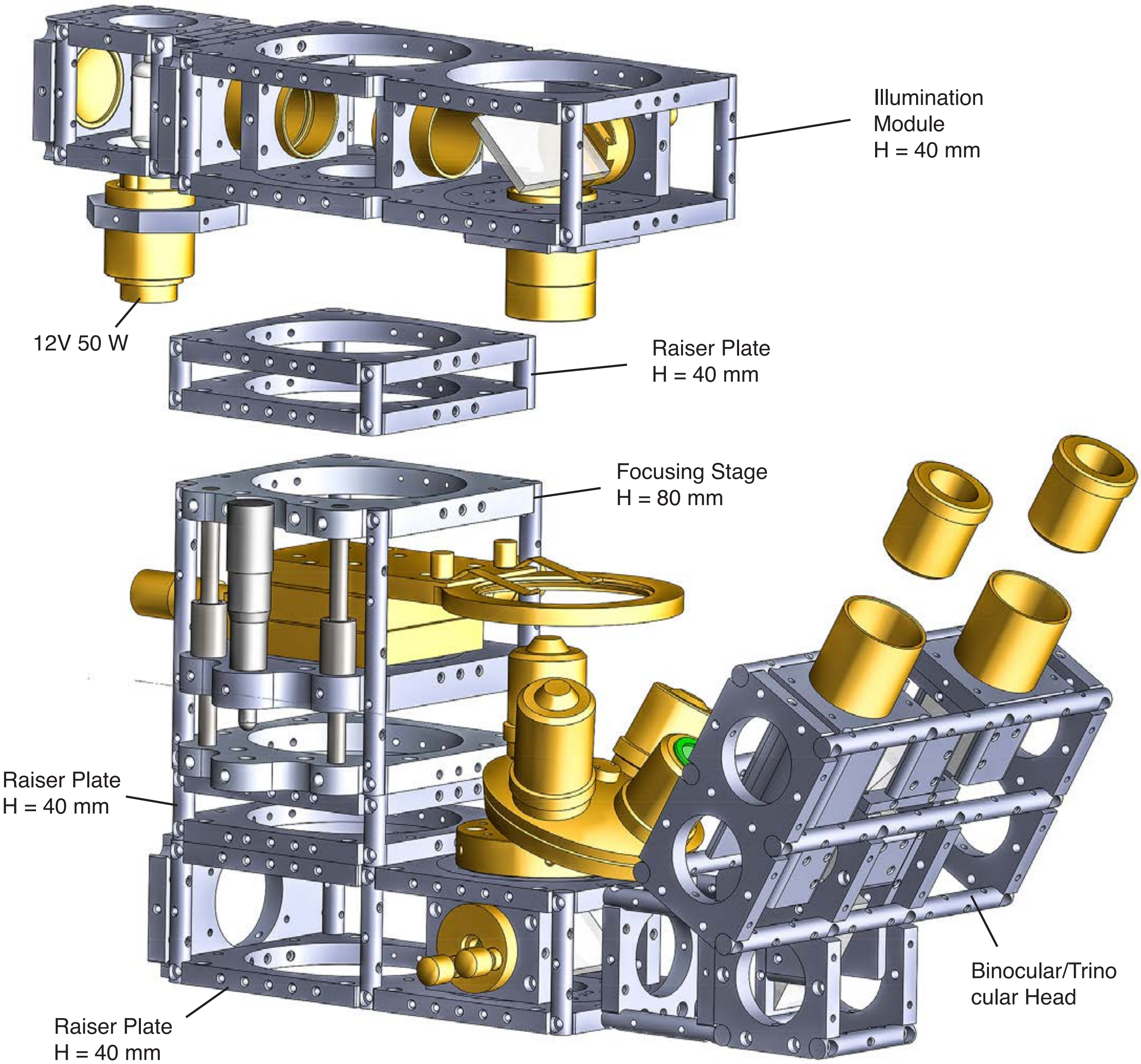
Cube 40

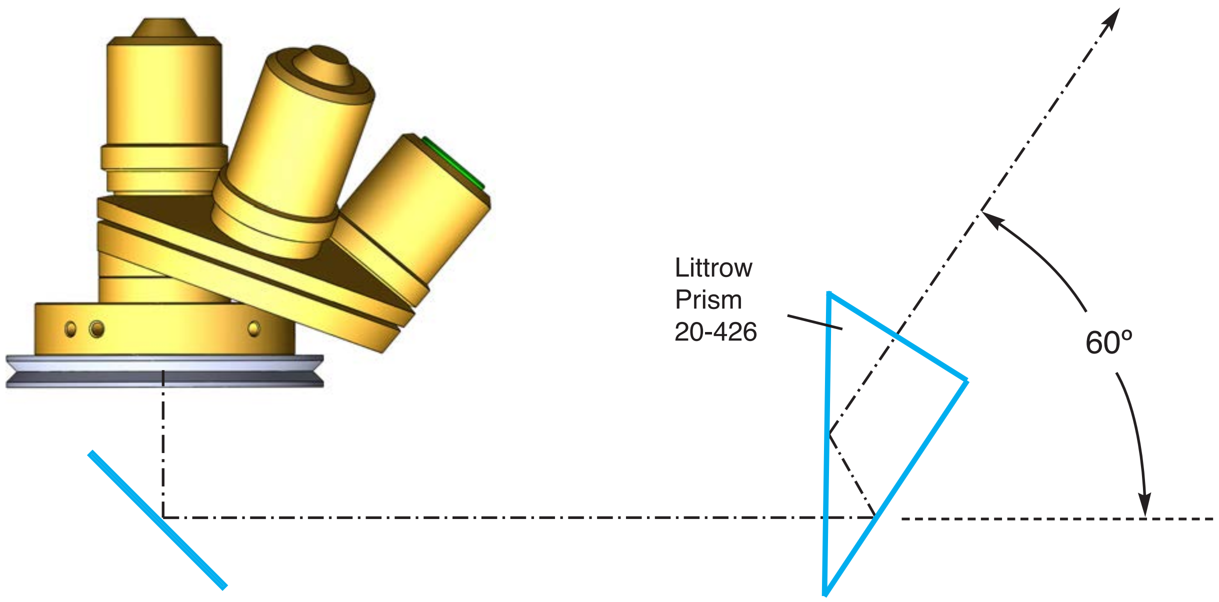
Final Assembly

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 sytem 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).

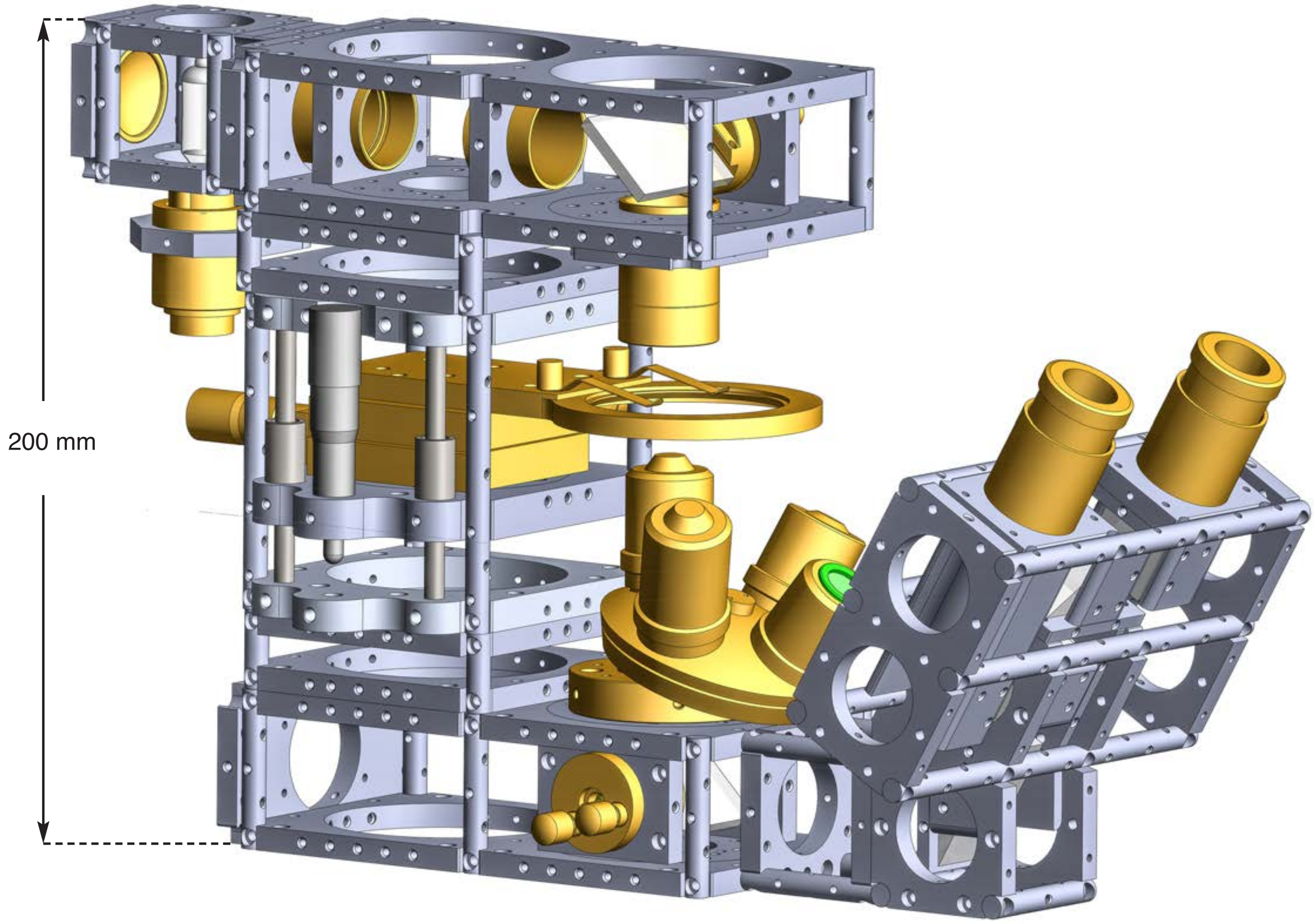
The reason Optoform works so well is because of so many man hours in designing, manufacturing, and putting together its inventory of parts. The end user grabs a lens from a lens kit, and inserts it into the mount, and it's ready to go. You have to be a manufacturer to realize how tight the tolerances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

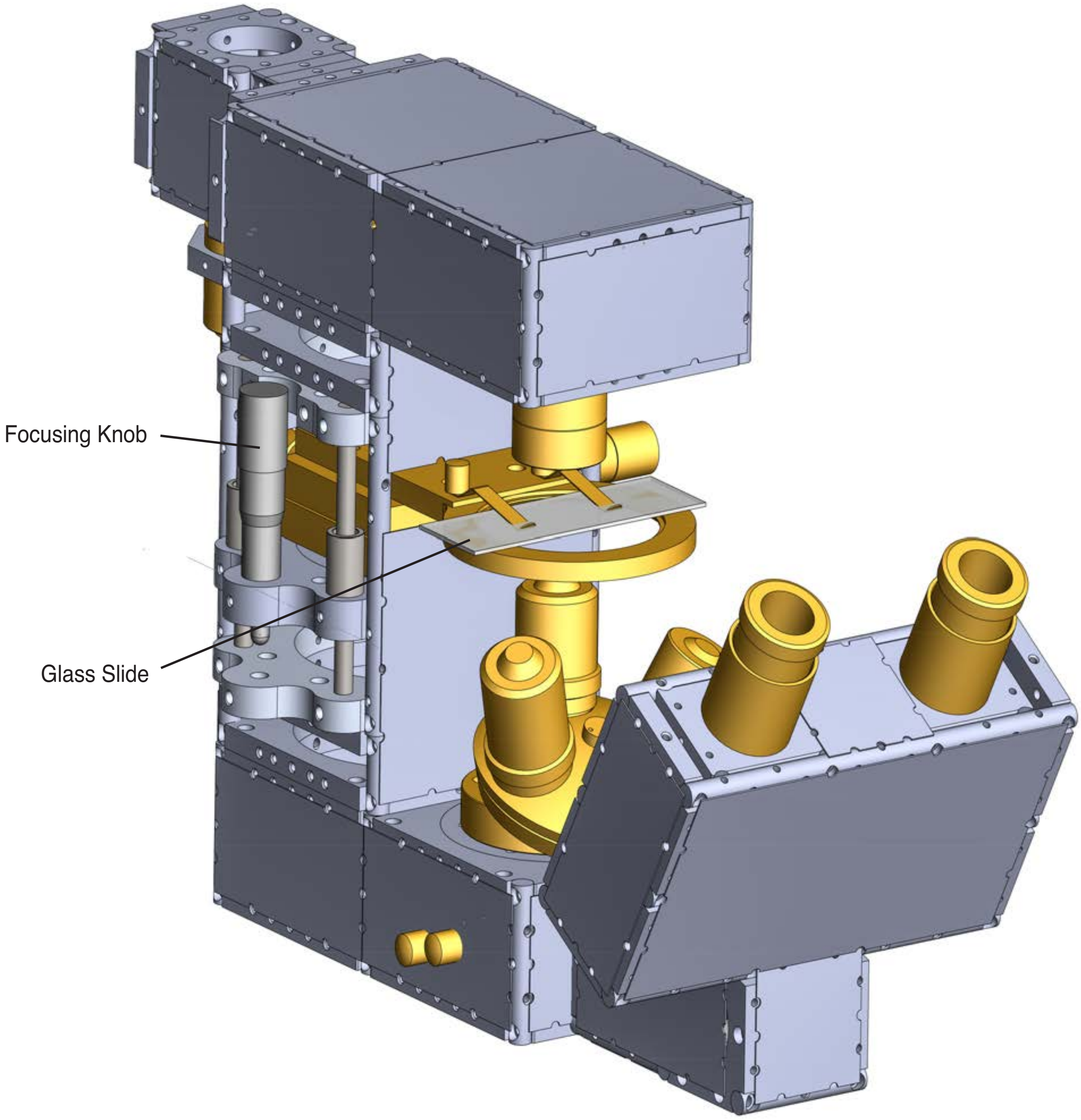
By using, and evaluating this microsocpe, we can prepare it for the next step of construction: To finish it up with pre-cut sheet metal covers for added rigidity, and stability. Sheet metal coverings have a notch pattern to allow securing them on the side of mounting lates via M2.5 button-head mounting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





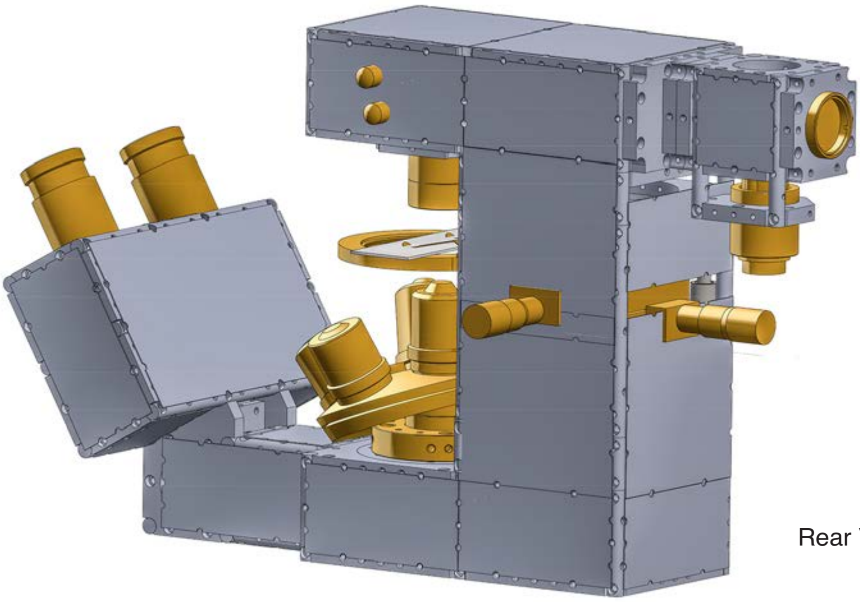
Above, utilizing the Littrow prism is not so trivial. In this case, the angle gets complex, if you have doubt about it, try constructing it in your lab. In optics, always have your feet on the ground, meaning to always use a line of reference. The nature of the cage system mechanics, with its 4 rod system, 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.



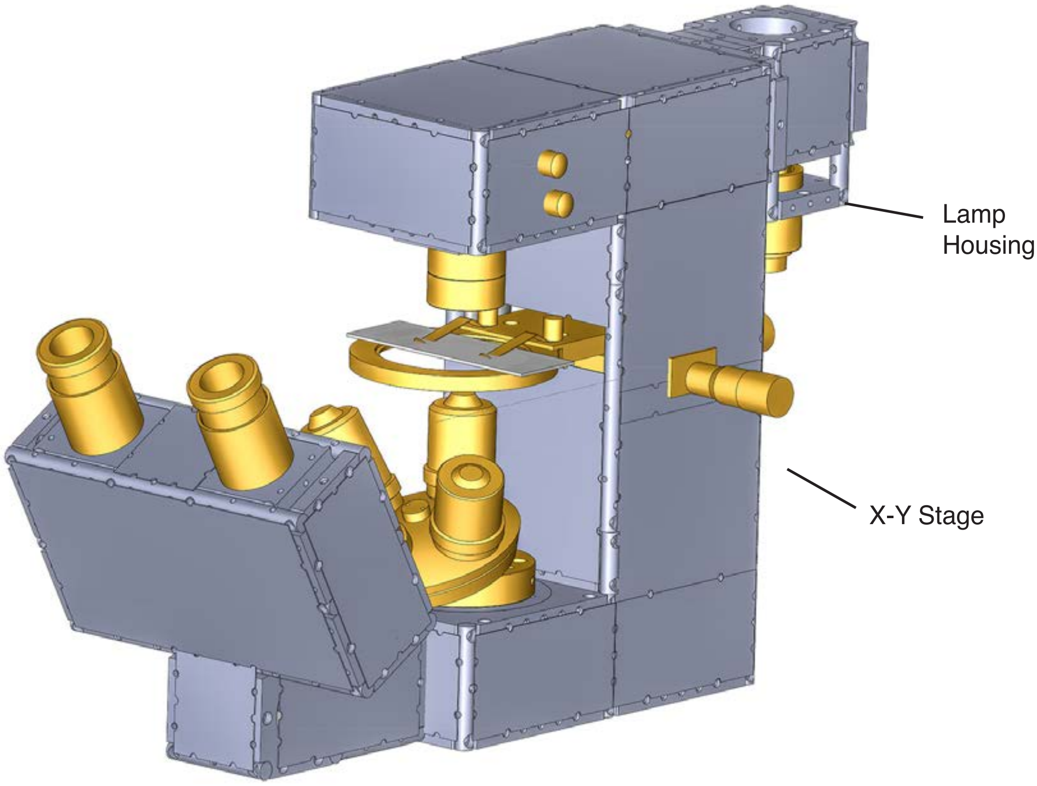


Sheet Metal Covering

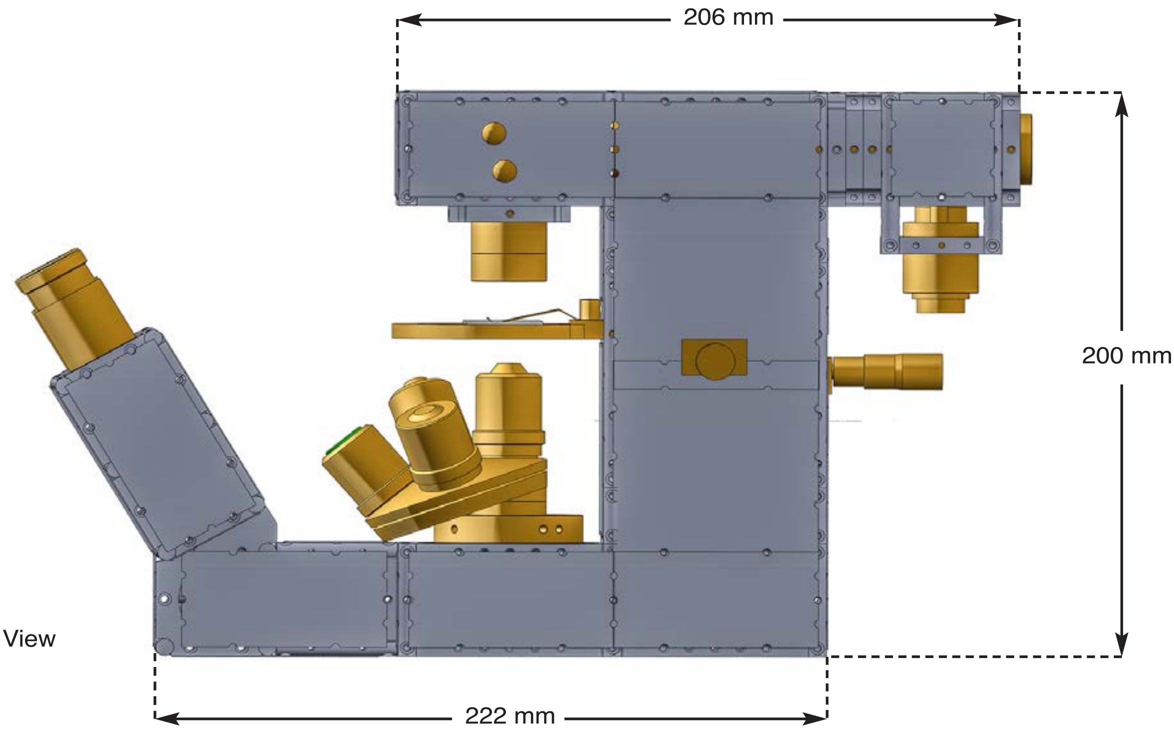
Cover sheets has been added to light seal, and dust seal the optics. The microscope is quite compact, and when the entire assembly is packed inside cover sheets, then the end user would think that it would also needs to add rubber legs. When you deal with a complete instrument, then usability, and durability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



Rear View



For more on the sheet metal covering please refer to two past issues. An imaging microscope with trinocular head may be easily constructed identical to biological microscope shown in our last issue. In that arrangement, the CCD camera would be situated in front of the microscope.



Side View