Modular Infinity Microscope (MIM)

Rapid Automated Modular Mounting (RAMM)

And

Video Test Stand (VTS-2100)

Systems

Instruction Manual

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Introduction

The MIM / RAMM /VTS systems consist of a number of modular components that allow rapid assembly of automated optical microscope systems. The Modular Infinity Microscope (MIM) consists of several optics sections, couplers, objective focus devices, beam splitter modules, light sources, etc. that can be constructed into a high performance optical microscope. The Rapid Automated Modular Mounting (RAMM) components are a set of precision machined bars, arches, and mounting parts that can be configured to support ASI automated stages and the MIM hardware in an inverted microscope configuration. The Video Test Stand (VTS-2100) components provide a method of mounting ASI stages and the MIM hardware in an upright microscope configuration. By utilizing these sets of hardware, high quality, customized, automated, optical platforms can be easily constructed at modest cost and with little specialized engineering.

Optical requirements often drive the mechanical ones, so we will begin by describing the MIM system and its possible configuration variants. Then we will discuss the RAMM system components that are required for several sample applications. Finally we will discuss the VTS-2100 system configurations.

Modular Infinity Microscope

The minimum parts required to construct an infinity microscope system are the microscope objective, the tube lens, and a camera mount.

Figure 1: Simplest microscope configuration has C-mount for camera, tube with a tube lens, and an objective lens. Coupling ring connects modules; stop ring can be placed wherever there is a coupling ring. The 2 mm Allen driver is the main assembly tool.

ASI Modular Microscope components consist of tube lenses along with adapters and accessories that either are primarily used in the collimated light space or adapters that are to be used on the image side. Collimated light adapters use the 38mm diameter **C60-RING** system to connect components. Focus-side adapters attached to lens tubes with either a 30mm diameter coupling to the I.D. of the **C60-TUBE**, or with a 50mm coupling on the O.D. of the lens tube.

With infinity microscope systems, the objective can be spaced away from the tube lens without changing the optical magnification. This "infinity space" provides a region where other optical systems can be coupled to the microscope relatively easily. For epi-fluorescent illumination, a filter cube with a dichroic beam splitter can be added to provide the illumination path.

Figure 2: Exploded view of a MIM configured for epi-fluorescent illumination.

The cube module accepts a standard Olympus U-MF2 filter cube and provides coupling to the objective, tube lens assembly, and a fiber illuminator optic.

The MIM system uses as standard 38 mm diameter coupling ring to attach standard modules together. Three or four set screws on each component lock to the coupling ring and provide a simple, accurate, and flexible method of assembly. Each coupling ring also provides a space to include a beam stop. Appropriately placed stops can significantly reduce scattered light in the system.

Basic MIM Specifications

Tube Lenses	**Standard 32 mm dia. × 200 mm f.l. Nikon Also 100, 120, 160, 200, 300 & 400 mm f.l. achromat tube lenses are available.**
Beam Splitters	**Olympus AX/BX/IX series cube U-MF2**
Objectives Supported	**Nikon CFI60 Series Mitutoyo LWD Series *Olympus ∞ corrected**
Camera Ports Supported	**C-mount, T-mount, F-mount, ENG-mount**
Illumination	**Liquid Light Guide Adapter, Lamp Adapters, LED sources available.**
Configurations	**Limitless**

*Olympus objectives will have overall magnification 1.11 × objective marking.

MIM Tube Lenses and Assemblies

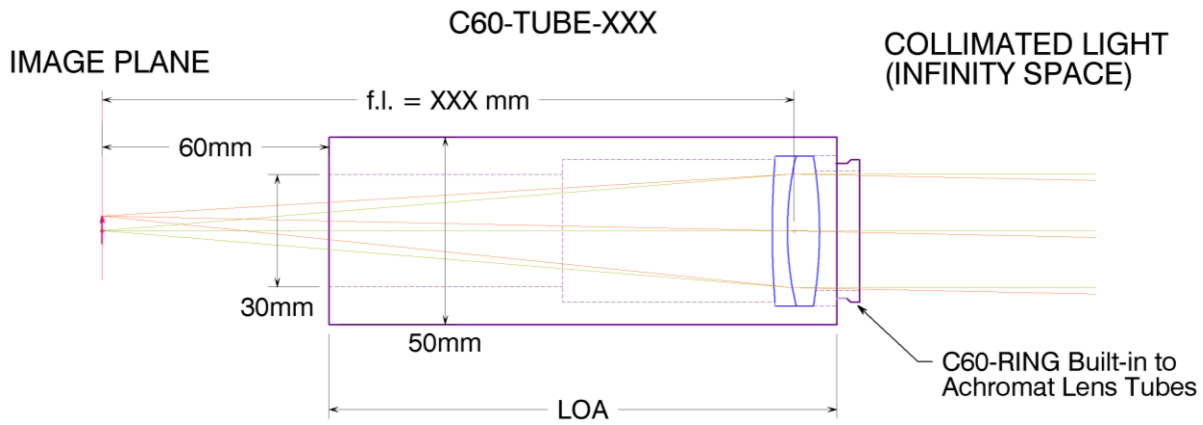


Figure 3: Basic tube lens focuses collimated light into an image.

ASI Modular Microscope components consist of tube lenses along with adapters and accessories that either are primarily used in the collimated light space or adapters that are to be used on the image side. Collimated light adapters use the 38mm diameter C60-RING system to connect components. Focus-side adapters attached to lens tubes with either a 30mm diameter coupling to the I.D. of the C60-TUBE, or with a 50mm coupling on the O.D. of the lens tube.

C60-Tube-B

With infinity microscope systems, the objective can be spaced away from the tube lens without changing the optical magnification. This "infinity space" provides a region where other optical systems can be coupled to the microscope relatively easily. For epi-fluorescent illumination, a filter cube with a dichroic beam splitter can be added to provide the illumination path.

For best imaging performance we recommend the **C60_Tube_B** which uses a Nikon 200mm multi-element tube lens.

Other Tube Lens Assemblies

In addition to the standard **C60-TUBE-B**, there are also several other options for tubes and tube lenses that can be used to obtain different final magnifications. The achromatic lens tubes, **Tube-100**, **Tube-200**, etc., include the male ring end built into the assembly. A coupling **C60-RING** is required for **Tube-B** and **Tube-Z13**.

The distance from the end of the tube to the image plane is 60 mm for all tubes. The tubes have a 50mm O.D. and are terminated with a 30mm I.D. flange.

The table below lists the other options and specifications for the various tube lens assemblies.

Part Number	Lens F.L. (mm)	Magnification for Nikon Objectives	Magnification for Olympus Objectives	Lens type	Length of Assembly (mm)
C60-TUBE-B	200	1.00	1.11	Nikon multi-element tube lens	126.2
C60-TUBE-Z13	164.5	NA	NA	Zeiss multi-element tube lens for 130mm objective-tube distance	121.1
C60-TUBE-100	100	0.50	0.56	Achromat	48.7
C60-TUBE-100D	100	0.50	0.56	Dual Achromat	64.6
C60-TUBE-160	160	0.80	0.89	Achromat	112.3
C60-TUBE-200	200	1.00	1.11	Achromat	152.7
C60-TUBE-300	300	1.50	1.67	Achromat	252.0
C60-TUBE-400	400	2.00	2.22	Achromat	352.0

C60-Tube-100

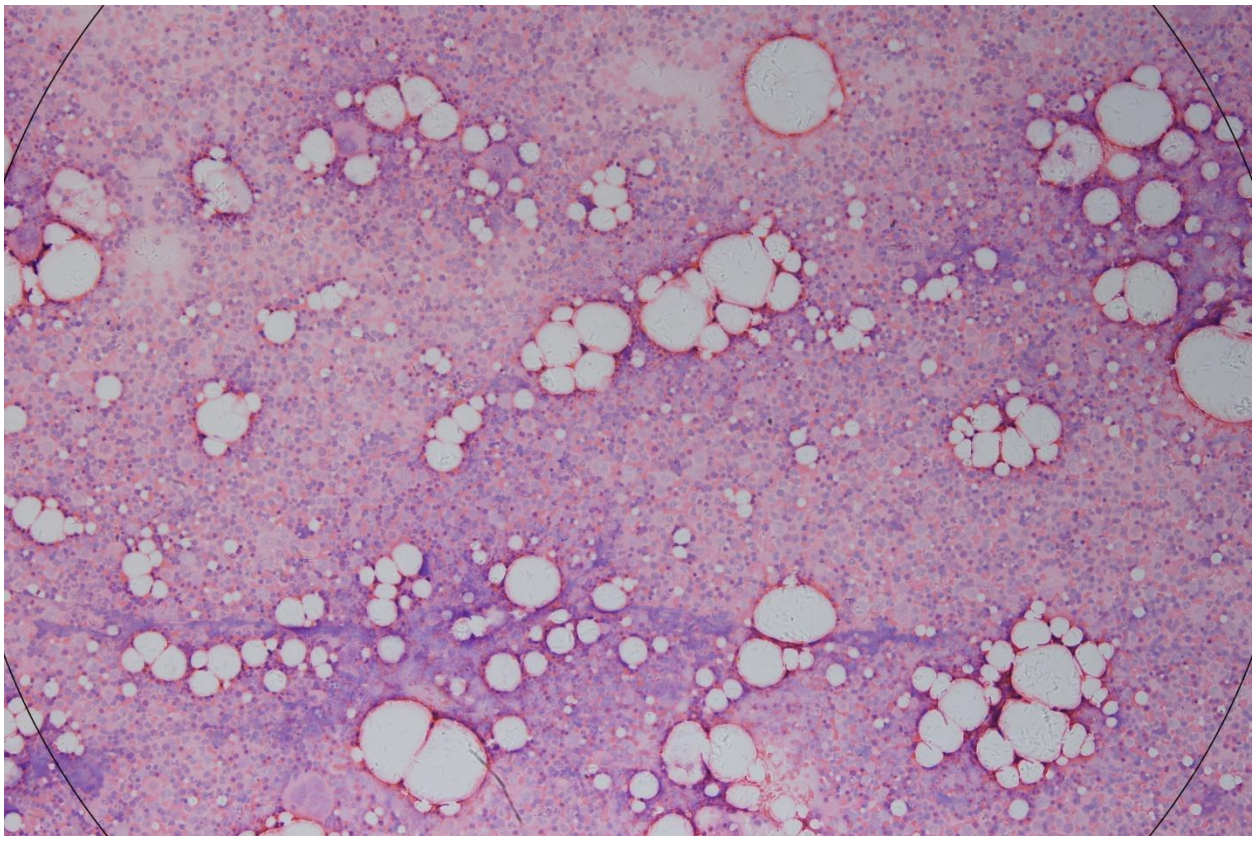
C60-Tube-200

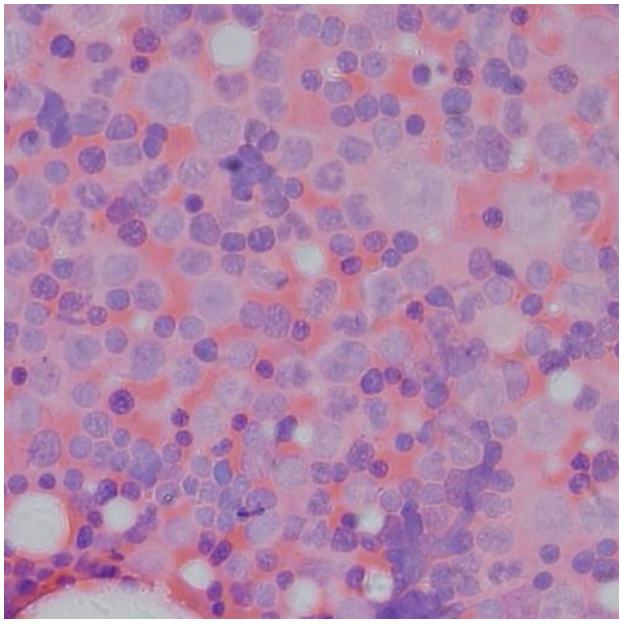
Tube Lens Performance

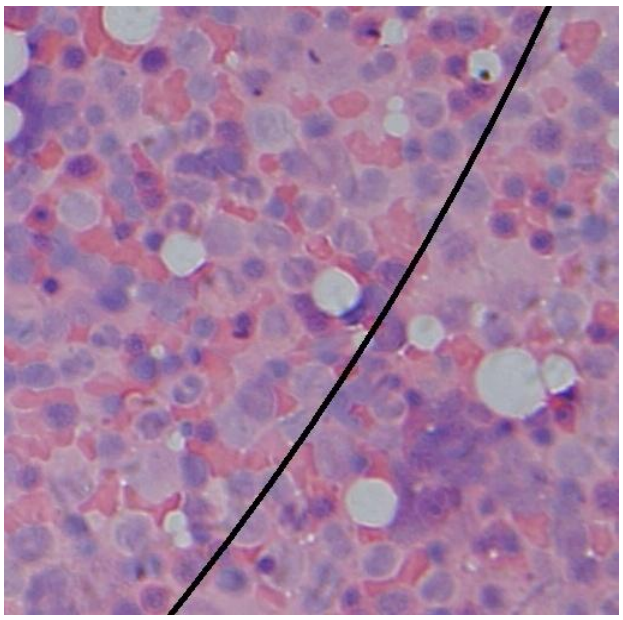
Imaging performance of the tube lens will depend upon the suitable combination of lens and objective, the field of view in the image, and the focal length of the tube lens. In general, longer focal length lenses will have better performance across the field of view. To illustrate this, we show some sample images taken with a variety of tube-lenses using a high quality objectives. All of the images are of a fixed stained bone marrow smear, which provides a nice uniform large area color sample with large spatial dynamic range. The images show a reference circle corresponding to a 25mm field number (FN) for the objective. Magnified sections of the image in the center of the field and near the objective design FN are shown as well. Images were taken using a Sony NEX-3 camera with 23.4 mm x 15.6 mm sensor with 5.1µ pixels. For a more complete set of test images, see the *Tube Lens Performance* document.

C60-Tube_B and Nikon 20X 0.75 Plan Apo Objective

The standard for performance comparison uses a Nikon 20X NA 0.75 PlanApo objective and the Nikon 200mm tube lens in the **C60-Tube_B**.

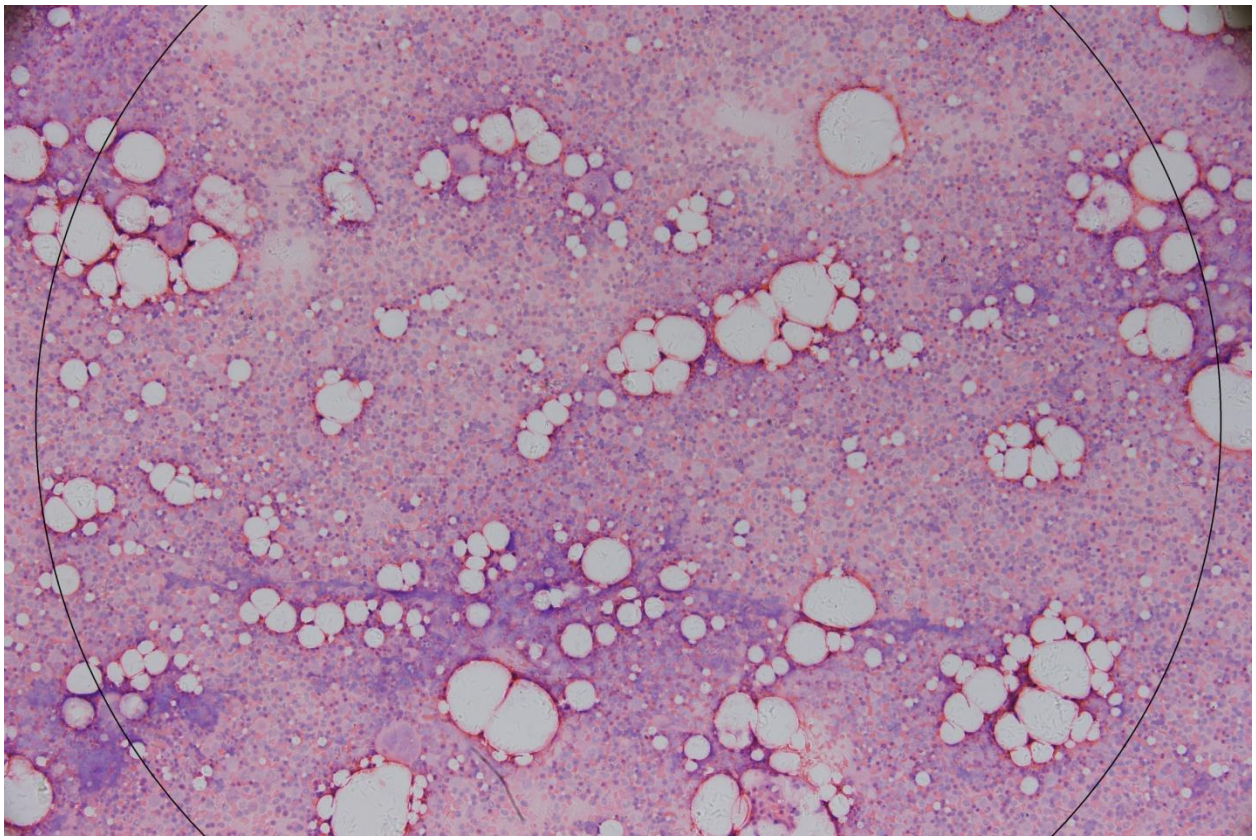


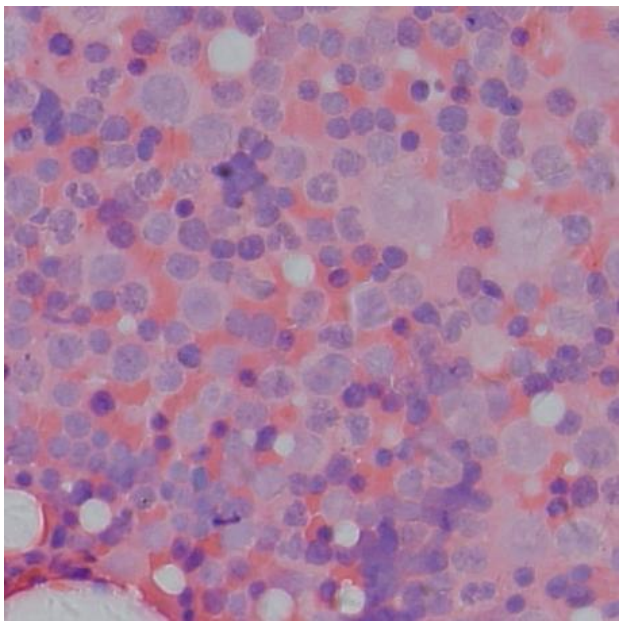


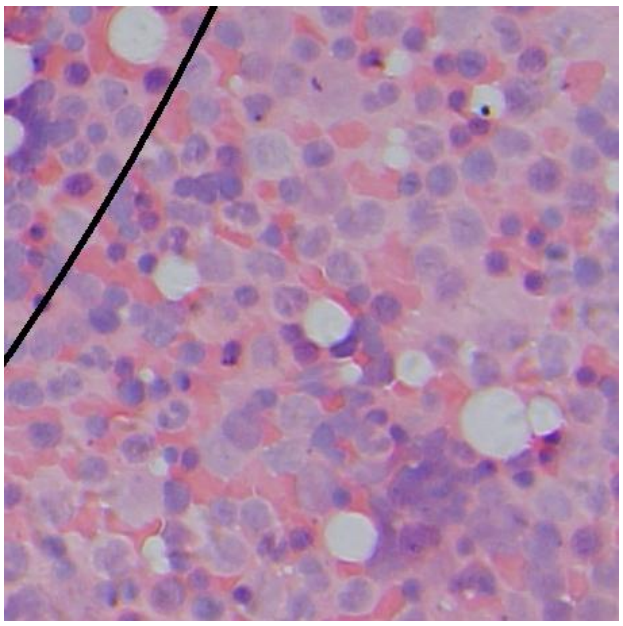


C60-Tube_160 and Olympus 20X 0.75 Plan Apo Objective

The Olympus objective is designed for a 180mm tube lens, so image sizes are slightly bigger than with the Nikon lens. The simple 160mm achromatic lens maintains good sharpness to the edge of the field.







MIM Components: Focus-side Image-plane Adapters for Lens Tubes

All of the tube lens assemblies listed above accept a variety of mounting adapters.

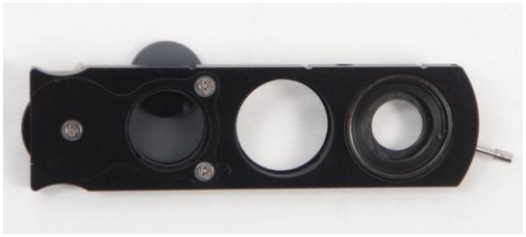
C60-3060-C-Mount

Camera Adapters - C-Mounts

C60-3060-C-Mount
is most the most common method for attaching a camera to a MIM system.

C60-SLDR-C-Mount
is similar to the standard version but also has provision for a filter slider directly in front of the camera. Several sliders can be used with this C-Mount, including the optional POL-SLDR slider that accepts a polarizing filter that may be rotated with a thumb wheel.

C60-SLDR-C-Mount



POL-SLDR rotatable polarizer

DCMS
dual C-mount splitter is optically the same length as the **C60-3060-C-Mount** but allows for a second reflected port. A standard plate beam splitter (25.5 mm × 36 mm × 1.2 mm – "Zeiss size") fits in the device. There is also provision for 25 mm dia. × 3.5mm thick filters directly behind the C-mount flanges. The DCMS is often used with devices for autofocus functions, e.g. CRISP.

DCMS - C-mount Beam Splitter

Camera Adapters - Large Format Mounts

C60-ENG-Mount
provides coupling for cameras using the bayonet Sony ENG mount standard.

C60-ENG-Mount

C60-T-Mount
provides coupling to T-Mount devices and cameras. There are a wide variety of adapters commercially available to adapt interchangeable-lens cameras to T-Mount lenses. Using the C60-T-mount and the appropriate camera adapter, and you can use just about any interchangeable lens digital camera on the MIM.

The **C60-F-Mount** uses the **C60-T-Mount** in conjunction with a T-to-F adapter to provide a coupling for Nikon F-mount cameras.

C60-T-Mount

C60-F-Mount

Other Focus-Side Adapters and Accessories

Light sources can be placed at the image side of a tube lens to generate a collimated illumination source.

C60-LAMP-ADPT -- Universal Lamp Adapter

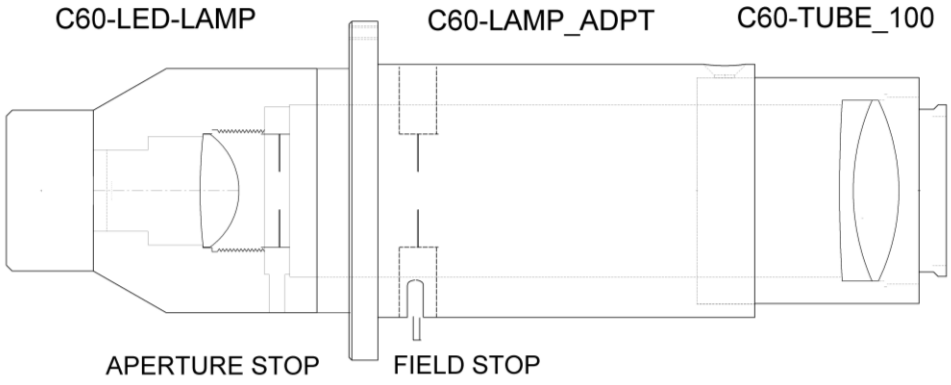
This part allows the **C60-TUBE-xx** lens assemblies to be used as excitation light condensers. The lamp adapter contains a field stop aperture and provides a mating surface for a variety of collimated light sources. Adapters are available for all of the major microscope manufacture's lamp mounts, as well as for the **C60-RING** standard parts such as the **C60-LLG-ILLUM** or **C60-LED-LAMP**.

C60-LAMP-ADPT with C60-RING

C60-LAMP-ADPT with Olympus Lamp-house Mount

Contact ASI for your specific light source coupling requirements.

LAMP CONDENSER SYSTEM



C60-FIBER-LAUNCH

The Fiber Launch is designed for use with TIRF systems, but could also be used to inject laser light for optical trapping or similar applications. The tip of the fiber is designed to be at the focal point of the tube lens to which this part is attached. The micrometer head allows for precise lateral positioning of the fiber tip.

C60-Fiber-Launch

Users may wish to attach MIM components to an existing microscope system. The C-Mount port on a commercial microscope can provide a good coupling location with known optical characteristics associated with the image plane.

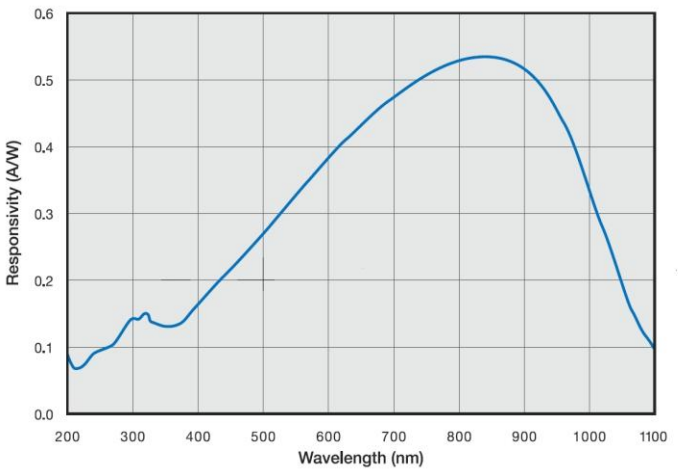
C60-FEMALE-C-MOUNT

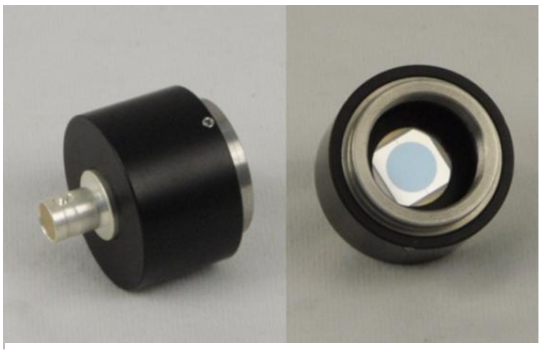
The Female C-mount port adapter places the focus of the microscope at the focus of an associated C60-Tube lens. This can be used to provide a region of collimated light in which filters and beam splitters can be employed effectively.

C60-Female-C-Mount

C60-C-MOUNT-PD

This is a BNC connected C-mount silicon photodiode located at the image plane. The photodiode has 100 mm^2 active area (11.3 mm dia.). Typical response curve is shown below.



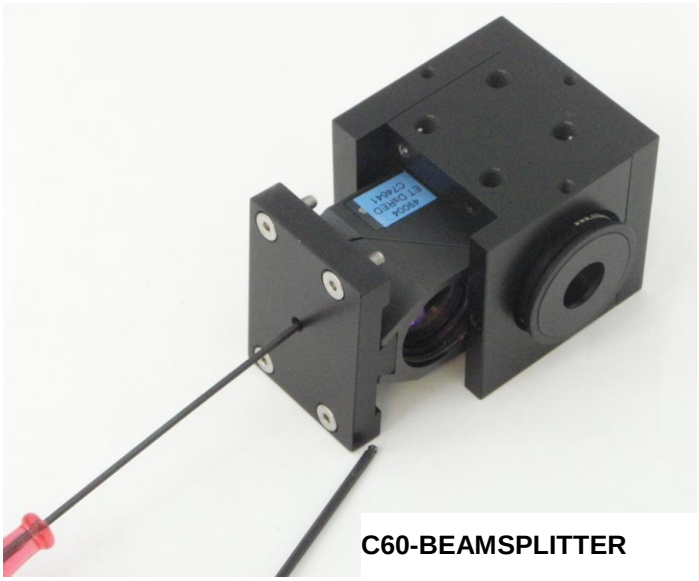


C60-C-Mount-PD

MIM Components: Collimated Light (infinity space) Adapters and Accessories

All of the modular optical assemblies that are designed to work in the collimated light region use a 38 mm diameter **C60-RING** to fasten modules together.

Beam Splitter Cubes



C60-BEAMSPLITTER

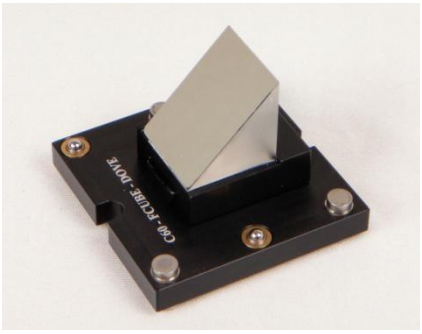
MIM-CUBE-K

One face of the beam splitter cube is removable and has a dovetail that accepts the Olympus U-MF2 filter cube assembly. A set screw in the center of the dovetail locks the filter cube in place. The four M4 flat head screws fasten the dovetail to the cube body. Additional **C60-DOVE** cube mount sections are handy if you wish to swap filter cubes. Three other faces of the cube contain 38 mm diameter ports that accept **C60-RING**s. The remaining two sides have a pattern of four M6 threaded mounting holes on 25mm spacing. The optical length between ports is 60mm.

MIM-CUBE-II-K

This is the same as the basic cube above, but with precision alignment adjusters and quick-change magnetic locks. The cube mount has three ultra-fine pitch adjuster screws and a set of magnetic latch buttons that allow the cube to be adjusted and replaced with repeatable alignment without tools. Additional **C60-DOVE-II** cube mount sections are handy if you wish to quickly swap filter cubes. This cube is very useful for aligning two-camera arrangements, and precision alignment of excitation light sources.

C60-BEAMSPLITTER-II.



C60-25mm_CUBE-HOLDER

is shown here mounted to the **C60-DOVE-II** with a front surface right-angle mirror. Any 25mm optical cube or Right angle mirror can be glued to the **CUBE-HOLDER** for use in the **C60-BEAMSPLITTER** cubes above.

Right Angle Focus Mount – MIM-RA-FOCUS-K

For inverted microscope applications, it works well to fold the objective light path 90º so that the microscope can be kept short. The right angle focus mount achieves this goal while also providing automated focus using the ASI **LS50** actuator. A front surface mirror assembly adds 64 to 75 millimeters to the infinity path, depending upon the focus position. The prism mount can be attached with a **C60-RING** to a beam splitter cube or directly to a main tube.

The focus range is about 15mm before the focus tube extends fully from the prism house body. Longer travel is possible if stray light is not an issue. The LS50 provides focus resolution of less than 50nm when controlled with the MS2000 controller. The right angle focus mount can also be equipped with an automated objective turret.

C60-RA-MIRROR with **LS50** focus actuator.

MIM-RA-FOCUS-K w/ C60-RA-2nd-PORT

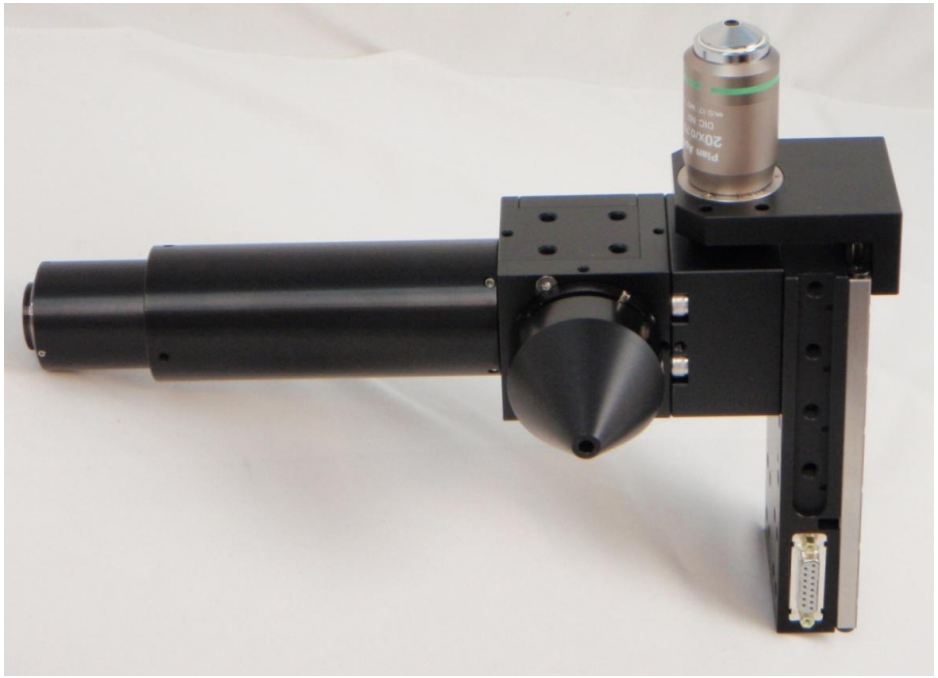
C60-RA-2nd-PORT

This device replaces the front surface mirror in the **C60-RA-MIRROR** with a dichroic beam splitter and provides a downward beam path. The **C60-RA-MIRROR** is attached to the LS-50 below the **C60-RA-2nd-PORT** to provide a lower optical level for additional light path components. The lower port has an optical infinity path length 75 mm longer than the upper port.

Modular Microscope Kits

Examples of Modular Infinity Microscope (MIM) assemblies are shown on the next couple of pages. There are many ways to put the parts together. The following examples show the common configurations.

MIM-INVERTED_BASIC
The most common basic MIM configuration includes the LS-50 focus actuator with the **C60-RA-MIRROR** assembly. A **C60-BEAMSPLITTER** cube with a Liquid Light guide adapter is supplied for fluorescent illumination. A **C60-TUBE_B** lens module and C-mount camera adapter complete the basic kit.



MIM-FC-UPRGHT-MOT

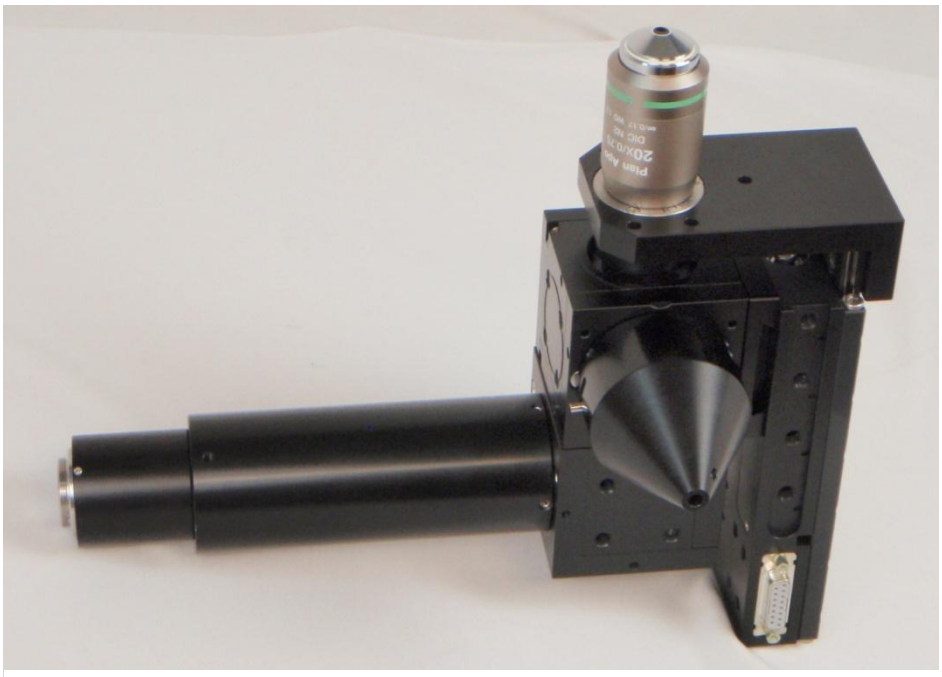
This configuration uses the LS-50 to focus the objective directly in line with the **C60-BEAMSPLITTER** cube. This places the filter cube as close to the objective as possible and works well for upright configurations. The "**FC**" configurations use the **C60-BEAMSPLITTER** cubes, directly mounted to the LS-50 rather than **RA-MIRROR** modules. For inverted applications adding a cube with a mirror directly after the filter cube will allow for a camera to be fitted easily.

MIM-FC-UPRGHT-MOT

MIM-FC-INVERT-MOT

For inverted configurations, it is necessary to add a mirror so that the tube lens and camera can come out horizontally. Another **C60-BEAMSPLITTER** cube is used with a fixed front surface mirror to reflect the image.

In both of these configurations, the objective is as close to the filter cube as possible. This can be advantageous when using low magnification, high NA objectives and trying to look at wide fields of view. Vignetting by the filter cube will is minimized.



MIM-FC_INVERT-MOT

C60-CUBE-SLDR

This is a four-position motorized filter cube slider. The slide holds standard 25mm diameter emission and excitation filters and 25 x 36 x 1.05 mm fluorescent dichroic mirrors. Typical switch time between adjacent positions is less than 250 ms. The slider can be supported by the **C60-RING** mount system between other components, or it can be attached to the LS-50 focus actuator.

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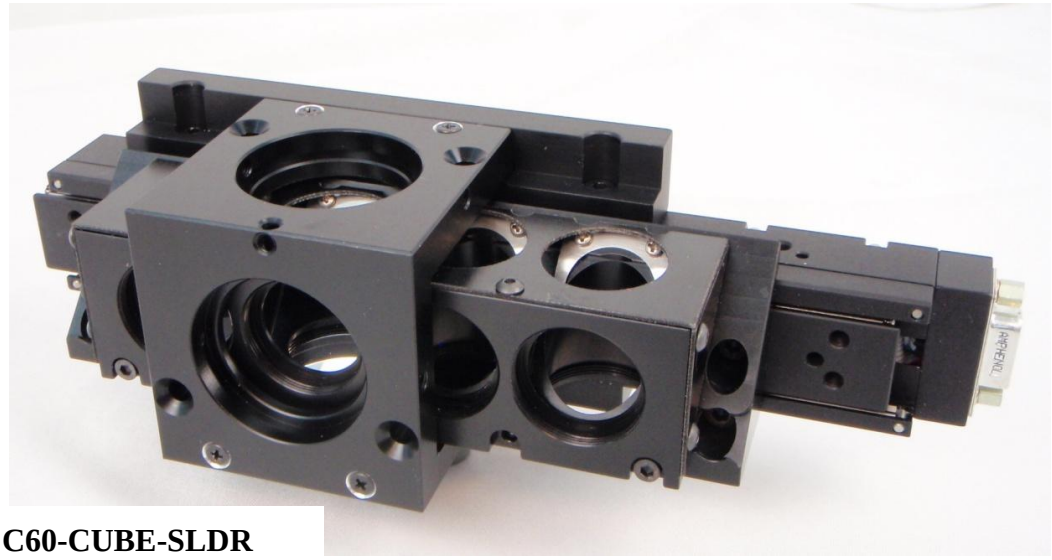
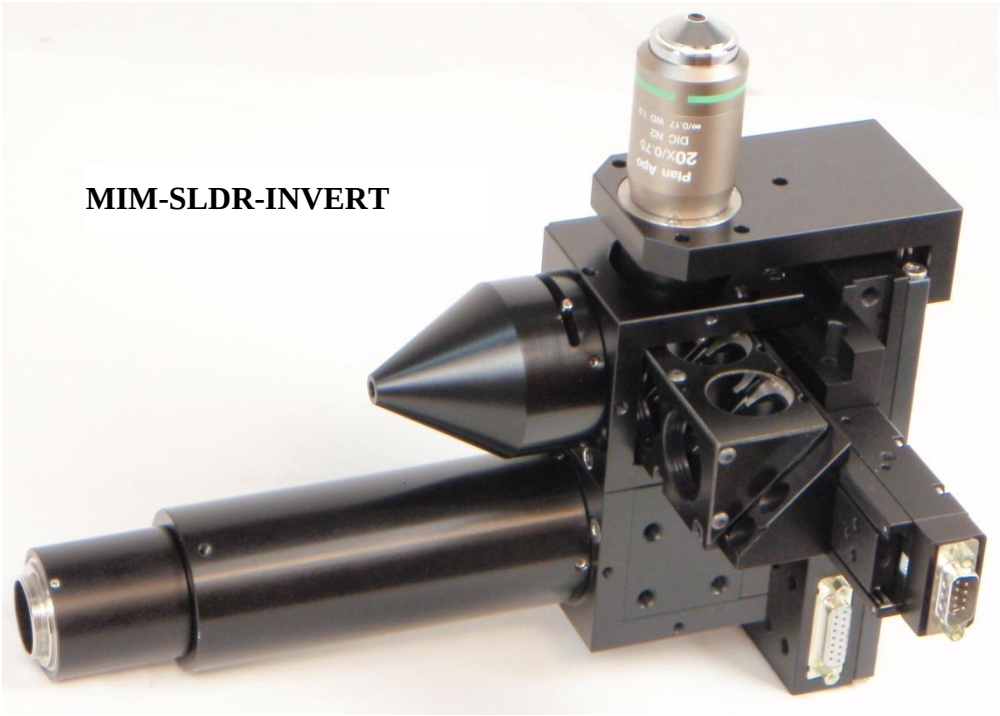


C60-CUBE-SLDR

MIM-SLDR-INVERT

Complete inverted modular microscope based on the LS-50 focus actuator and the **C60-CUBE-SLDR**. This kit includes a lower cube with a right angle mirror, standard tube lens, C-mount adapter and a liquid light guide adapter for fluorescence excitation.



MIM-SLDR-INVERT

Collimated-Space Tubes, Couplers and Adapters

C60-FOCUS_TUBE

allows positioning of a 25mm diameter lens with a focus travel range of 25mm. The tube body attaches to other components with the **C60-RING**. The 25mm optic can be retained with a snap ring or glued in place.

Typical uses include focusing a collimated beam to the back focal plane of a microscope objective lens for TIRF excitation, and adjusting focal position in 4F configurations.

C60-FOCUS_TUBE

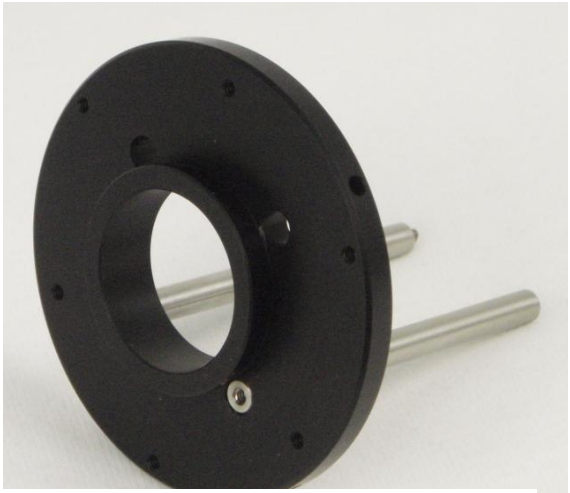
C60-RING & C60-RING-ADJ

The **C60-RING**s are used to join collimated-space components that have the 38mm I.D. x 6mm deep set-screw fitting. The standard **C60-RING** has a close fit to the mating I.D. and 30mm clear aperture. The **C60-RING-ADJ** is close fit on one side and has a 34mm O.D. on the other side to allow +/- 2mm of lateral adjustment between the two joined components. The **C60-RING-ADJ** has a 25mm clear aperture.

C60-RING and C60-RING-ADJ

C60-RING_ADAPTER

This handy coupling adapter can accept several ASI standard microscope lamp or excitation path adapter flanges so you can attach MIM modules directly to your microscope, or attach microscope lamps or similar components to you MIM system. Contact ASI with your requirements. The **C60-RING_ADAPTER** also has provision to attach a standard 30mm square, 6mm diameter "cage system" to the MIM so you can build even more custom systems.



C60-RING_ADAPTER

C60-EXT_TUBE_XX

Extension tubes can be used to space components in collimated space. The tubes come with the male RING fitting on one end and accept a RING on the other end. Presently 25mm, 50mm and 75mm versions are available with male/female fittings and there is a 15mm version with female/female fittings.

C60-Ext_Tube

C60-SLDR-TUBE

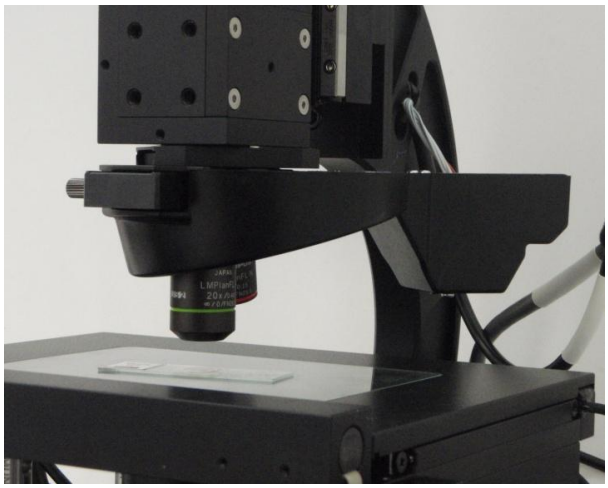
This 20mm long extension tube will accept a filter slider that can also hold an iris diaphragm. This can be used as a simple way to introduce filters into a region of collimated space, or provide an adjustable optical stop.

C60-SLDR_TUBE w/ C60-FILTER_SLIDE

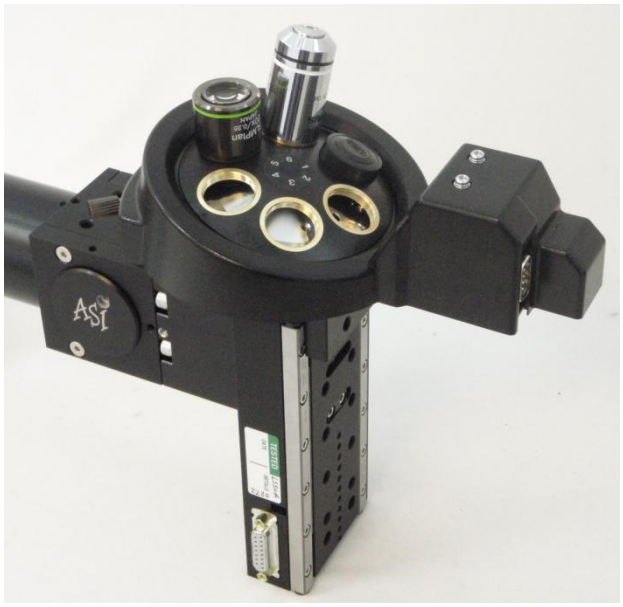
Objective Mounts and Changers

Automated Objective Turret – U-R156M5

A modified Olympus 6-position motorized objective turret may be used with the MIM in either inverted or upright configurations.



Automated turret for upright



Inverted turret configuration

C60-RMS_M25_ADPT

Objective adapter allows RMS threaded objectives to be used with M25-0.75 nosepieces and holders. Adapter is 15mm long so RMS 45mm long objectives come to the same focal point as Nikon CFI-60 objectives.

Illumination Devices

Liquid Light Guide Illuminator – MIM-LLG-ILLUM

A simple way to couple fluorescent excitation light into the MIM is via a high intensity light source with a liquid light guide output. The liquid light guide adapter and be attached to the excitation port on a cube assembly with a coupling ring. The adapter contains a lens that focuses on the end of the light guide and projects the light into infinity space. The illuminator includes an iris to control the light aperture.

MIM-LLG-ILLUM (light guide not included)

LED lamp Illuminator – MIM-LED-LAMP

A high intensity LED lamp source is a simple way to provide transmitted light illumination, or even epi-fluorescent excitation when appropriate LED color is used. For transmitted light a white LED is used. LEDs are available in a range of colors with typically 20-30nm spectral half-widths for fluorescent excitation. The LEDs are rated at 3W and can supply ~100mW of luminous intensity depending on the specific LED wavelength. Using several beam splitter cubes and LED lamps, it is possible to construct a multi-color LED excitation system with these off-the shelf parts.

MIM-LED-LAMP

Trans-illumination Condenser - OLY-TRANS-ILLUM kit

For transmitted light inverted applications this system is based upon the Olympus IX2-LWUCD condenser which combines a long working distance (WD 27mm) and a high numerical aperture (NA 0.55).

Figure 3: Trans-illumination kit

The trans-illumination kit contains the IX2-LWUCD with its 5-position turret and adjustable iris diaphragm. The kit also has a centerable condenser mount, a rack & pinion z-positioner for condenser focusing, and a high brightness LED lamp illuminator with adjustable field iris.

An optional kit (OLY-DIC-OPTION) of Olympus DIC prism and polarizer components is available for high-contrast, high-resolution images with 20X and 40X objectives.

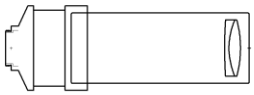
For additional information on DIC microscopy see:
http://www.olympusmicro.com/primer/techniques/dic/discoverview.html
http://www.olympusmicro.com/primer/techniques/dic/dicconfiguration.html`Transmitted`

Configuring MIM Systems

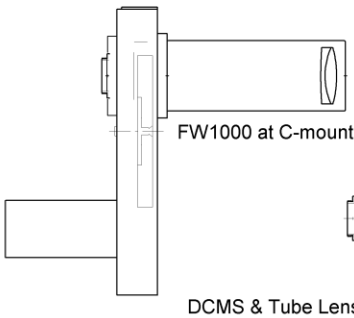
Some of the many ways our modular microscope components can be put together is shown in the configuration sketches on the next page. This is not meant to be exhaustive of the possibilities and doesn't show cases where cubes would be added out of the plane of the paper, which could be useful. Contact ASI for further assistance in configuring a system.

CAMERA MOUNT OPTIONS FOR ALL TUBE LENSES

C60-3060_C-Mount & Tube Lens

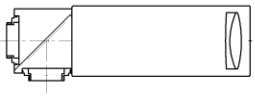


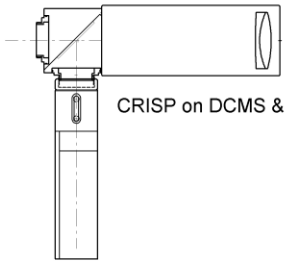
Large Format C-Mount & Tube Lens



FW1000 at C-mount & Tube Lens

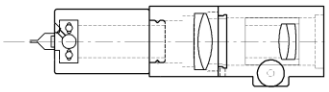
DCMS & Tube Lens



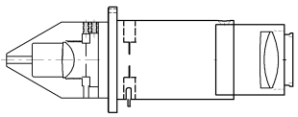


CRISP on DCMS & Tube Lens

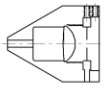
EPI-ILLUMINATION OPTIONS



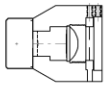
TIRF Fiber Launch Assembly. Focus Tube, 100mm Tube Lens, and Fiber launch. Use with C60-BEAMSPLITTER-II cube with adjustable mirror.



Liquid Light Guide port with Lamp Adapter with field stop for Kohler epi-illumination.



Liquid Light Guide Adapter by itself for critical illumination.

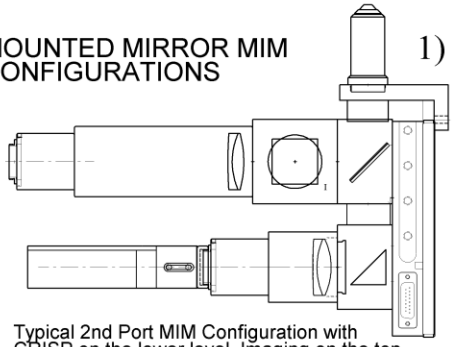


LED Lamp Illuminator

Standard C60-BEAMSPLITTER cubes can be mounted directly to the LS-50 focus actuator using a 10mm dovetail slide assembly. This mounting places the open port either to the front or back, not to the left. The Motorized Cube Slider places the open port to the left. Cubes not directly mounted to the LS-50 on the dovetail slide can face any direction.

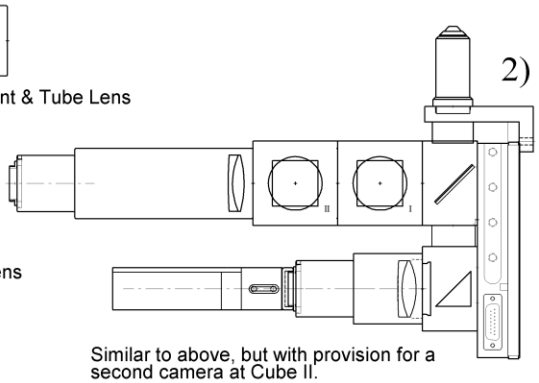
MOUNTED MIRROR MIM CONFIGURATIONS

1)



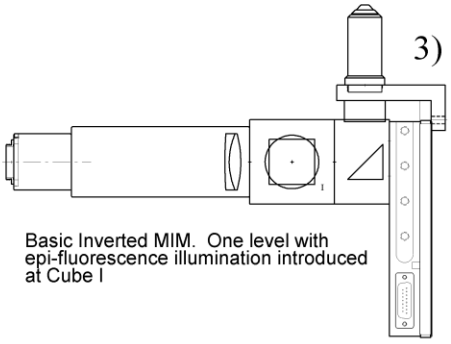
Typical 2nd Port MIM Configuration with CRISP on the lower level, Imaging on the top layer and Epi-illumination introduced at Cube I

2)



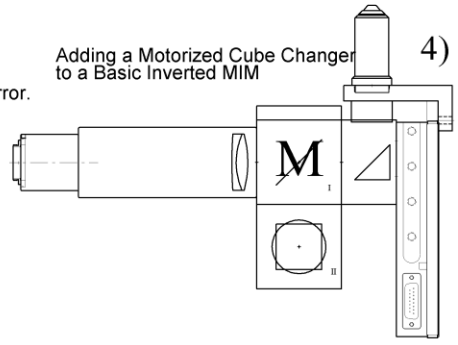
Similar to above, but with provision for a second camera at Cube II.

3)



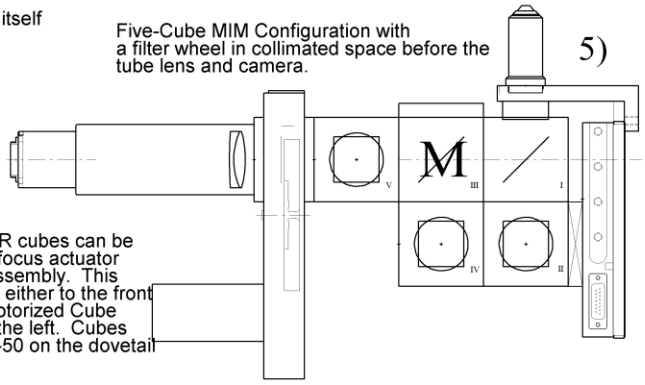
Basic Inverted MIM. One level with epi-fluorescence illumination introduced at Cube I

4)



Adding a Motorized Cube Changer to a Basic Inverted MIM

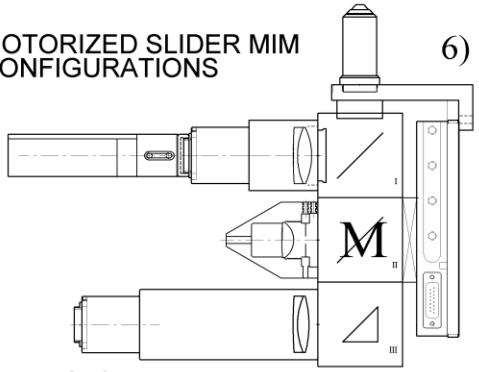
5)



Five-Cube MIM Configuration with a filter wheel in collimated space before the tube lens and camera.

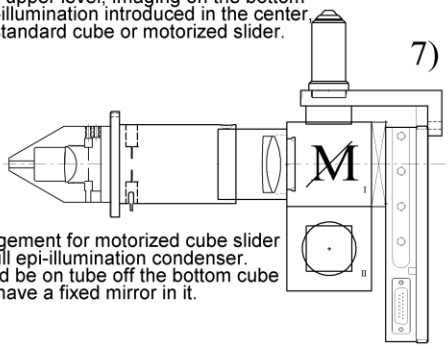
MOTORIZED SLIDER MIM CONFIGURATIONS

6)



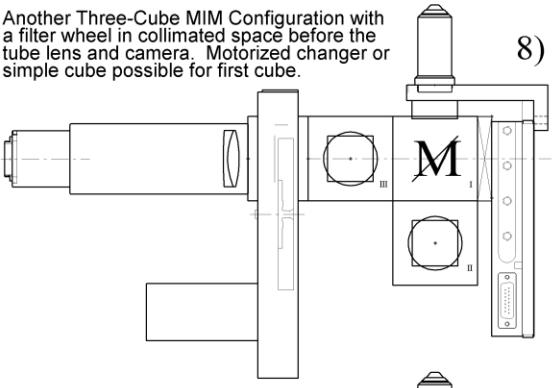
Three-Cube MIM Configuration with CRISP on the upper level, Imaging on the bottom layer and Epi-illumination introduced in the center, either with a standard cube or motorized slider.

7)



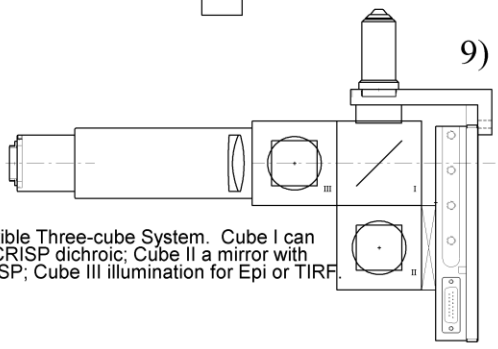
Typical arrangement for motorized cube slider shown with full epi-illumination condenser. Camera would be on tube off the bottom cube which would have a fixed mirror in it.

8)



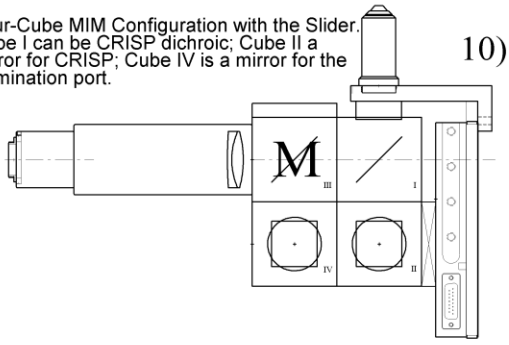
Another Three-Cube MIM Configuration with a filter wheel in collimated space before the tube lens and camera. Motorized changer or simple cube possible for first cube.

9)



Flexible Three-cube System. Cube I can be CRISP dichroic; Cube II a mirror with CRISP; Cube III illumination for Epi or TIRF.

10)



Four-Cube MIM Configuration with the Slider. Cube I can be CRISP dichroic; Cube II a mirror for CRISP; Cube IV is a mirror for the illumination port.

Infinity Space Limitations

The flexibility afforded by the infinity corrected microscope allows one to assemble an optical train with several beam splitters, mirrors, or focus devices in the infinity space region without substantially changing the optical characteristics of the system. However, there are limits to how far you can spread the distance from the objective to the tube lens before vignetting of the image will occur. The length of the infinity space, $L_{Infinity,}$ must be kept less than

$$L_{Infinity} \leq (D_{Tube} - D_{OBJ}) \times F_{Tube} / D_{Sensor}$$

where D_{Tube} is the diameter of the tube lens, D_{OBJ} is the diameter of the objective pupil, D_{Sensor} is the diagonal length of the sensor, and F_{Tube} is the focal length of the tube lens. We can use values for the MIM tube lens and consider a few examples for various objectives and sensor formats.

$$D_{Tube} = 32 \text{ mm} \quad F_{Tube} = 200 \text{ mm}$$

$$L_{Infinity} \leq (32 \text{ mm} - D_{OBJ}) \times 200 \text{ mm} / D_{Sensor}$$

Approximate pupil diameter for a few objectives and the size of a few CCD sensors:

20X N.A. 0.5	10mm	1" CCD	16mm
20X N.A. 0.75	15mm	2/3" CCD	11mm
10X N.A. 0.25	10mm	½" CCD	8 mm
40X N.A. 0.75	7.5mm		
60X N.A. 1.4	9.7mm		

So if we consider nominal objectives with 12mm pupil and a 2/3" CC camera, we find

$$L_{Infinity} \leq (32 \text{ mm} - 12 \text{ mm}) \times 200 \text{ mm} / 11 \text{ mm} = 363 \text{ mm}$$

For a fast objective and a 1" CCD camera, we find

$$L_{Infinity} \leq (32 \text{ mm} - 20 \text{ mm}) \times 200 \text{ mm} / 16 \text{ mm} = 150 \text{ mm}$$

So in general, large camera sensors with N.A. objectives impose the limit on how many beam splitter cubes you can stack up before running into problems. The minimum-length epi-fluorescent inverted configuration, with one C60-BEAMSPLITTER cube is about 130 mm long. The exact length of the infinity region can be determined from the tables below that list the infinity space length of various MIM components and can be used to determine if a particular configuration will result in collimated-space vignetting or not.

Table 1: Infinity-Space Length of MIM Components

Part Number	Description	Infinity-Space Length (mm)
C60-BEAMSPLITTER	Beam splitter cube mount	60
C60-RA_MIRROR	Right Angle mirror focus section	52
C60-RA_OBJ_MNT	Objective holder – variable focus	12 + focus range
C60-OBJ_MNT	Objective holder – fixed	18
C60_TUBE_B	Tube lens assembly 200 mm f.l.	6
U-R156M5	Automated 6-position objective turret	35
C60-RA_DOVE	Dovetail mount for automated turret	12 + focus range
C60-RA-2nd-PORT	Added distance to lower tier port	75
FW-1000 w/ Adapters	Filter-wheel with infinity path mounts	43

		12.5mm Radius FN 25		**15.2mm square chip FN 22**		**13.3mm square chip - FN 19**		**One inch chip FN 16**		**2/3 inch chip FN 11**	
Objective Example	**Objective Beam Diameter (mm)**	22mm aperture Free Length (mm)	29 mm aperture Free Length (mm)	22mm aperture Free Length (mm)	29 mm aperture Free Length (mm)	22mm aperture Free Length (mm)	29 mm aperture Free Length (mm)	22mm aperture Free Length (mm)	29 mm aperture Free Length (mm)	22mm aperture Free Length (mm)	29 mm aperture Free Length (mm)
60X NA 1.42	6	143	197	165	232	188	265	212	301	306	433
20X NA 0.6	12	95	149	108	176	122	200	138	227	197	324
10X NA 0.45	18	47	101	52	120	58	136	64	153	88	215

Collimated-Space MIM Configuration	**Name**	**Single Objective**	**C60-Duplex Objective**	**Olympus Turret**
C60-CUBE	MIM FC Mot	77	124	112
C60-CUBE; RA-Mirror	MIM Inv. Basic	129	176	164
C60-CUBE; FW1000		120	167	155
(2) C60-CUBES		137	189	180
(2) C60-CUBES; FW1000		180	227	215
(3) C60-CUBES		197	249	240
(3) C60-CUBES; FW1000		240	287	275

Avoid vignetting in collimated space be ensuring your configurations does not exceed the Free Length allowed by the camera chip size and objective beam diameter. Critical apertures are assumed to be near the tube lens and have either 22mm or 29mm clear aperture, as would be typical of 25 or 32 mm filters. When possible, place 25mm filters as close to the objective as possible. Mild collimated-space vignetting will appear as dimming in the corners of the image

Rapid Automated Modular Mounts (RAMM parts)

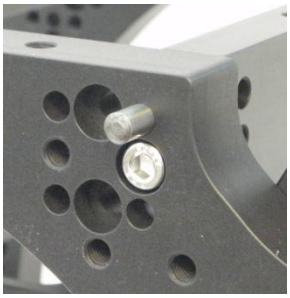
The RAMM components are engineered to provide a means to quickly put together an inverted microscope and automated microscope stage configuration for dedicated automated applications. The basic components are built around metric standard dimensions and complete assemblies are best used with metric breadboards.

RAMM-BASIC framework.

The basic RAMM frame work provides a mounting platform 400 mm wide by 450 mm deep by 250 mm tall. The arches contain a series of counter-bored holes for M8 bolts as well as holes for 8 mm dowel pins. Cross bars, which accept the M8 bolts and dowel pins, can be attached in several locations. The cross bars include mounting holes for several ASI stage models to mount to the RAMM when the bars are used on the top outside positions. The recommended stages to use with the RAMM hardware are the IX71/81 inverted stages, in either normal, piezo-Z or flat-top configurations. These stages are designed for travel centered about an optical axis in the center of the RAMM assembly.

RAMM-FULL, with top-side riser.

Frequently equipment needs to be mounted above the stage, so a riser assembly is available that allows the mounting of top-side equipment without reducing normal stage travel. There are several hole sets for mounting the cross bar in various positions. Like the basic framework, the connections are pinned with 8mm dowels.



The RAMM has evolved to include a more flexible mounting system for the drop arms. These stands are called the RAMM-DV series which have a sliding dovetail attachment for the support arms so the supports are not restricted to only positions where there are mounting holes.

RAMM-BASIC-DV framework

Any number of special mounting bars and fixtures can be bolted to the RAMM structure. One worth mentioning is the mounting system for the MIM. Pairs of special hangers are designed to hold the MIM centered within the RAMM framework, and also allow for substantial vertical adjustment. The hangers either attached directly to the LS-50 focus actuator, or to the collars that can be used to support MIM tube lenses.

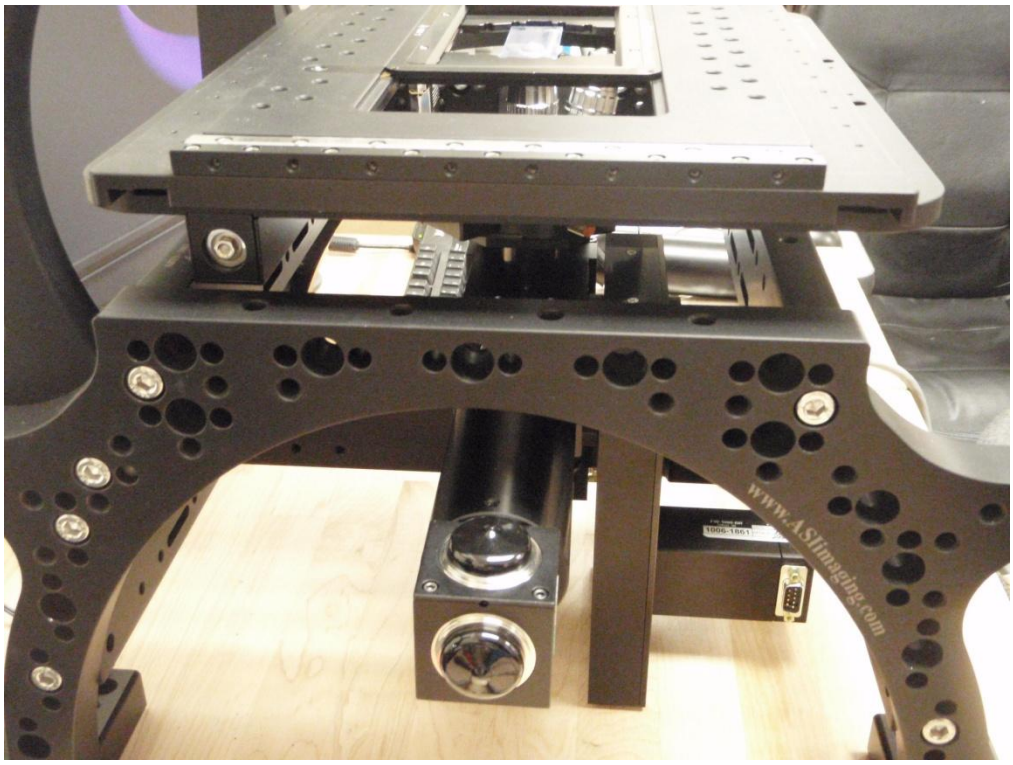
When large assemblies are built below the stage level, RAMM-SILTS can provide more room for optical components underneath.

Another set of RAMM main mounting bars may be attached to the BASIC frame with a set of top-side bar supports. This allows secure mounting of a top-side modular microscope which can be arranged directly above the one below.

A complex modular microscope system that uses both of these frame options is shown in the photo at the left.

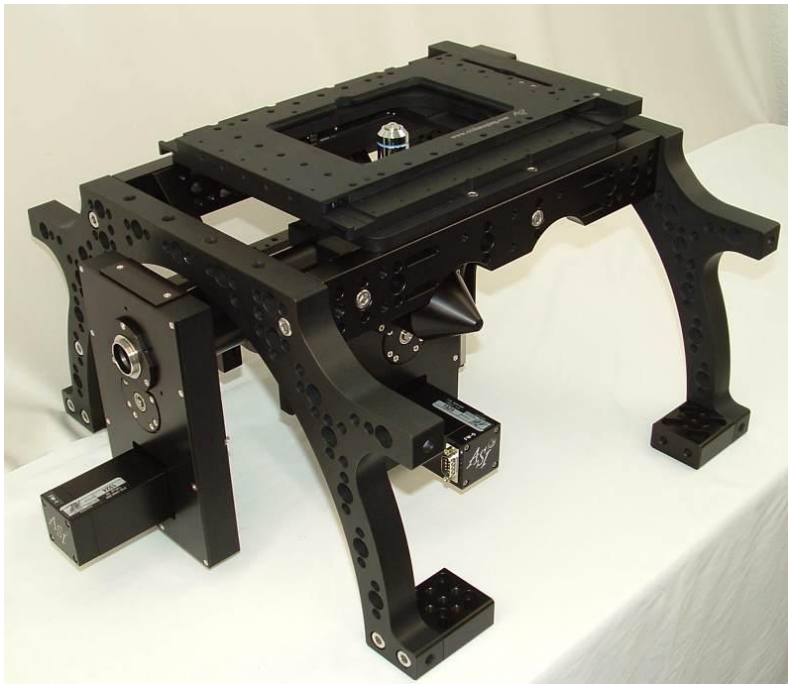
RAMM & MIM Assemblies

Here are a few example photos of RAMM/MIM systems that can be assembled with these components.

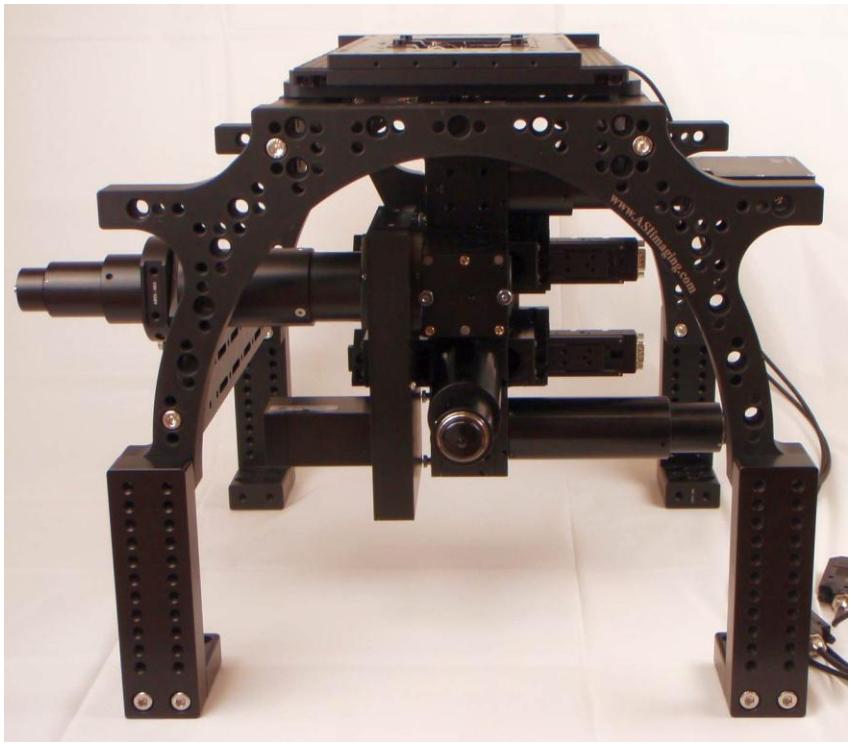


Complete system with large stage, filter wheel, and motorized objective turret and a C-mount Splitter for two cameras.

A Basic RAMM/MIM system with XYZ stage system and two filterwheels for fluorescent imaging is shown, right.



The Olympus condenser transmitted light option on a RAMM frame.



Multi-cube, multi-port fluorescent imaging system.

Video Test Stands

The VTS-2100 and VTS-2300 video test stands are simple platforms on which to build motorized video microscope systems in an upright configuration. The solid base has an array of mounting holes for attaching ASI stages or other equipment. A built-in high brightness LED in the center of the base provides a light source. The upright arm will accept a dovetail slide for coarse position adjustment, and typically, an LS-50 linear stage is mounted to the slide for motorized fine focus adjustment.

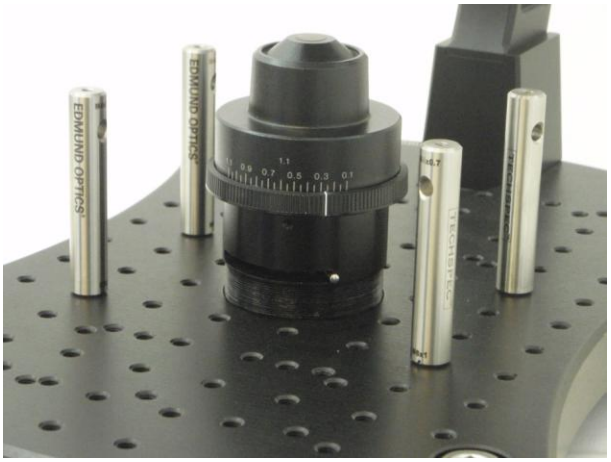
The newer VTS-2300 stand has a heavy-duty post mount with an adjustable mount that allows for flexible positioning of the top-side microscope.

VTS-2100 with locking dovetail slide.

An Abbe condenser can be fitted over the LED source. Various collimating lenses or diffusers can be used in front of the LED lamp to improve the uniformity or intensity of the light. When a condenser is used, longer stage mounting posts and an upright arm riser are used to move everything higher.

A small amount of adjustment is provided in the dovetail mount of the condenser for centering. Obtain basic centering when bolting the upright members to the base. Some trial and error adjustment may be necessary.

VTS-2300 stand



Optional under-stage condenser and stage mounting posts.

VTS-2300 Example Systems

Complete upright MIM system with automated XYZ stage, objective turret, and C-mount camera, and epi-fluorescent LED illuminator on a VTS-2300 stand.