

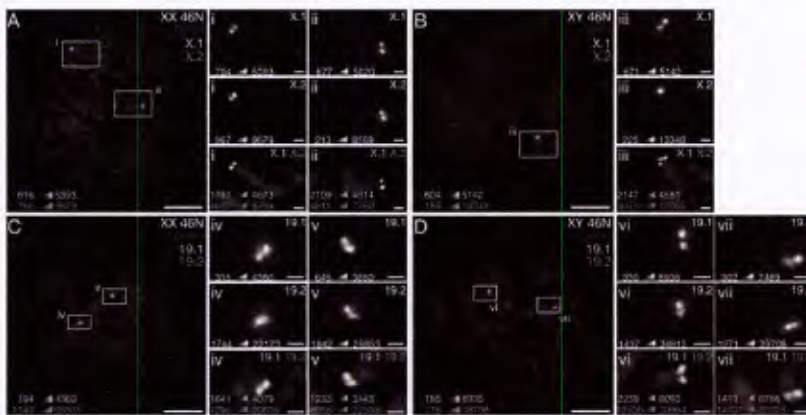
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14. ABSTRACT Super-resolution optical microscopy is a powerful method for visualizing nanostructures and biomolecules in their native, in situ environments. We have constructed a custom super-resolution microscope optimized for the high-throughput, super-resolution structural mapping of nanostructures and biological targets. Our microscope features a large field of view and custom optics that facilitate 3D imaging and enhanced contrast in noisy samples while providing a simple and user-friendly interface. Since recently completing the construction of this instrument, we have begun to optimize its 3D imaging capability, and it has been used to help develop a novel programmable molecular tool for the amplification of fluorescent signals in fixed cells and tissues. In parallel, we have augmented an existing microscope with a high-resolution scanning confocal modality, improving our imaging throughput and opening up high-throughput super-resolution imaging to a broader group of researchers. Collectively, this instrumentation will play a critical role in technology development and materials characterization for the greater Wyss Institute and Harvard Systems Biology community.					
15. SUBJECT TERMS Super-resolution microscopy, DNA nanostructures, DNA origami, systems biology					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Peng Yin
U	U	U	UU	4	19b. TELEPHONE NUMBER (Include area code) 617-432-7731

## Use of Equipment

### Overview.

After the award was granted, we initiated the ordering, purchasing, room refurbishment, and assembly necessary to bring the new instrumentation online. Collectively, this process has taken a considerable amount of time, with the instrumentation only becoming fully operational in late 2017. With the award, we have built the proposed Custom SRM largely as proposed, with one minor difference: we have placed the spinning disc confocal unit (SDC) on a second, pre-existing microscope body and added an adaptive optics (AO) unit to the new microscope chassis. In this way, we have expanded our imaging throughput by creating two microscopy platforms for high-throughput, super-resolution materials characterization, with the AO set-up being ideal for 3D super-resolution of DNA nanostructures and tissue culture samples and the SDC set-up being optimized for samples with very noisy environments such as tissue samples. As the AO set-up was completed first and the SDC set-up only recently has become fully operational, all of the data to date has been collected using the AO set-up and is described below.

### Mapping oligonucleotide probes on metaphase chromosomes.

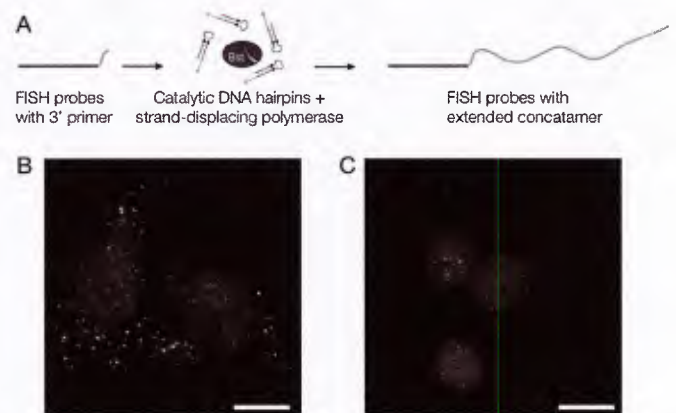


**Fig. 1 Oligo-probes specifically visualize targets on metaphase chromosome.** (A, B) Adjacent FISH probes targeting human chrX hybridized to female (A) or male (B) metaphase spreads. (C, D) Adjacent FISH probes targeting human chr19 hybridized to female (C) or male (D) metaphase spreads. Scale bars: 10  $\mu\text{m}$  in full spread images; 1  $\mu\text{m}$  in inset zoom images. Figure adapted from ref. 2.

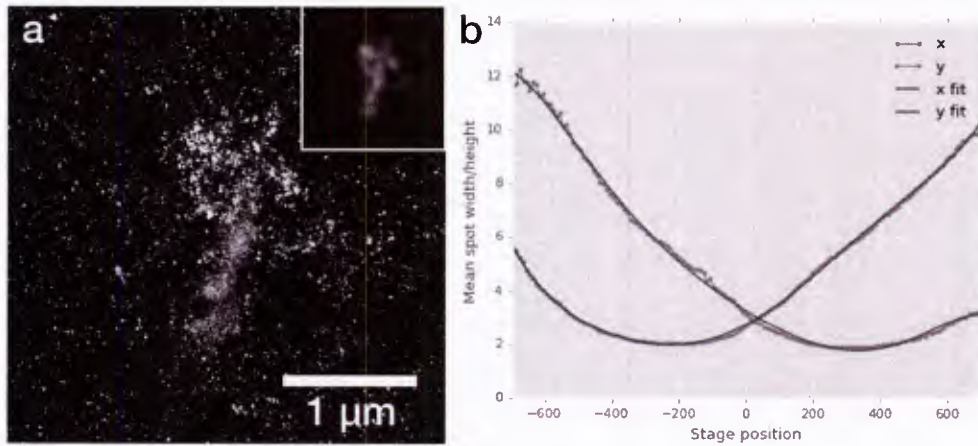
We have recently developed a rapid and robust computational pipeline for the design of programmable oligonucleotide (oligo) probes for fluorescence *in situ* hybridization (FISH)<sup>1,2</sup>. Our new approach improves the rate at which researchers can design oligo FISH probe sets on a genome-wide scale  $\sim 800\text{-fold}^2$  and greatly simplifies the cost and computational complexity of the process, making oligo FISH technologies<sup>1,3-5</sup> more broadly accessible to the general research community. As part of our validation of the new design approach, we performed two-color imaging of pairs of adjacent oligo probes hybridized to spread metaphase chromosomes<sup>2</sup> (**Fig. 1**). This imaging helped confirm the specificity and accuracy of our design software and was an important part of our resulting manuscript in *PNAS*<sup>2</sup>.

### Developing programmable signal amplification technology.

We are developing a novel strategy for the multiplexed amplification of fluorescent signals in fixed cells and tissues based on our recently published Primer Exchange Reaction (PER) technology<sup>6</sup>. In our approach, a short ssDNA sequence is added to an oligo FISH probe (**Fig. 2a**) or a short oligo complementary to a sequence placed on a FISH probe or conjugated to an antibody. A PER reaction is then used to grow a long ssDNA concatamer from the primer seed, which can subsequently be recognized by a complementary fluorescent oligo (**Fig. 2a**). We are using the new microscope to aid us optimizing this method for the visualization of RNA (**Fig. 2b**) and DNA (**Fig. 2c**) targets.



**Fig. 2 PER-mediated signal amplification.** (A) Schematic of PER-mediated signal amplification strategy. (B) PER-amplified RNA FISH targeting CBX5 mRNA in mouse embryonic fibroblasts. (C) PER-amplified DNA FISH targeting the telomeric repeat in human diploid fibroblasts.



**Fig. 3 Super-resolution imaging of chromosome targets.** (a) 9-color 2D DNA-PAINT image of FISH probes targeting a region on human chromosome 19. Inset: diffraction-limited version of same field of view. (b) 3D calibration curve of fluorescent bead samples for 3D astigmatism super-resolution imaging.

### Highly multiplexed super-resolution imaging of chromosome structure.

We are combining 'Oligopaint' oligo FISH probe technology<sup>1</sup> and Exchange-PAINT super-resolution microscopy<sup>7</sup> to generate nanoscale images of chromosome structure with many colors. To date, we have achieved 9 color 2D super-resolution imaging at <10 resolution (**Fig. 3a**). We are now implanting the adaptive optics system to apply optical astigmatism<sup>8,9</sup>

to enable 3D super-resolution imaging (**Fig. 3b**). Going forward, we plan combine the highly multiplexed imaging approach with AO-mediated optical astigmatism to create highly-multiplexed, 3D super-resolution images of chromosome structure in healthy and cancerous cells.

### References.

1. Beliveau, B. J. *et al.* Versatile design and synthesis platform for visualizing genomes with Oligopaint FISH probes. *Proc. Natl. Acad. Sci.* **109**, 21301–21306 (2012).
2. Beliveau, B. J. *et al.* OligoMiner provides a rapid, flexible environment for the design of genome-scale oligonucleotide in situ hybridization probes. 1–10 (2018). doi:10.1073/pnas.1714530115
3. Chen, K. H., Boettiger, A. N., Moffitt, J. R., Wang, S. & Zhuang, X. RNA imaging. Spatially resolved, highly multiplexed RNA profiling in single cells. *Science* **348**, aaa6090 (2015).
4. Shah, S., Lubeck, E., Zhou, W. & Cai, L. In Situ Transcription Profiling of Single Cells Reveals Spatial Organization of Cells in the Mouse Hippocampus. *Neuron* **92**, 342–357 (2016).
5. Eng, C.-H. L., Shah, S., Thomassie, J. & Cai, L. Profiling the transcriptome with RNA SPOTs. *Nat. Methods* (2017). doi:10.1038/nmeth.4500
6. Kishi, J. Y., Schaus, T. E., Gopalkrishnan, N., Xuan, F. & Yin, P. Programmable autonomous synthesis of single-stranded DNA. *Nat. Chem.* (2017). doi:10.1038/nchem.2872
7. Jungmann, R. *et al.* Multiplexed 3D cellular super-resolution imaging with DNA-PAINT and Exchange-PAINT. *Nat. Methods* **11**, 313–8 (2014).
8. Huang, B., Wang, W., Bates, M. & Zhuang, X. Three-dimensional super-resolution imaging by stochastic optical reconstruction microscopy. *Science* (80-. ). **319**, 810–813 (2008).
9. Izeddin, I. *et al.* PSF shaping using adaptive optics for three-dimensional single-molecule super-resolution imaging and tracking. *Opt. Express* **20**, 4957 (2012).

### **Special circumstances surrounding any change from the Grantee's proposal**

In our proposal, we described the design of a microscope containing a spinning disc confocal unit to allow imaging 3D super-resolution imaging in thick and noisy samples. After the grant was awarded, we determined that we could increase our imaging throughput and the breadth of samples we could characterize even further by placing the spinning disc confocal unit on a second microscope body (a shared department resource as well) and adding an adaptive optics unit to the new microscope body, as described in the report.

## ONR Final Equipment List

Award: N00014-16-1-2563

Title: Custom Super-Resolution Microscope for the Structural Analysis of Nanostructures

PI: Peng Yin

Type of Equipment	Manufacturer/Vendor	Model/Item Number	Description	Quantity	Total
Optical laser	MPB COMMUNICATIONS INC	2RU-VFL-P-1000-532-B1	VFL-P-1000-532 in 2RU-255 package	1	\$ 15,800.00
Optical laser	MPB COMMUNICATIONS INC	2RU-VFL-P-1000-642-B1R	2RU-VFL-P-1000-642 in 2RU-255 package	1	\$ 20,000.00
Optical rail system (beam path control)	OPTOSIGMA CORP	CAA-25LS	Carriers for Large Optical Rai	12	\$ 450.00
Optical rail system (beam path control)	OPTOSIGMA CORP		FREIGHT	1	\$ 27.00
Optical rail system (beam path control)	OPTOSIGMA CORP	OBT-800SH	Medium Low-Profile Optical Rai	2	\$ 230.00
Optical rail system (beam path control)	OPTOSIGMA CORP	OBT-500SH	Medium Low-Profile Optical Rai	2	\$ 180.00
Optical rail system (beam path control)	OPTOSIGMA CORP	OBT-300SH	Medium Low-Profile Optical Rai	3	\$ 210.00
Optical rail system (beam path control)	OPTOSIGMA CORP		Freight		\$ 13.00
Optical rail system (beam path control)	OPTOSIGMA CORP	995-0001	OPTO-MECHANICS SPECIAL ORDER: CUSTOM HIGH STABILITY BALL PLUNGER POST HOLDER ALL SPECIFICATIONS SAME AS P/N: BRS-12.7-25.4UU EXCEPT FOR ADAPTER NUT & PIN M16P1 ADAPTER NUT AND PIN FROM BRS-12-XX SERIES POST	12	\$ 282.00
Laser beam shaper	ADLOPTICA OPTICAL SYSTEMS GMBH	1050	Aligner, opto-mechanical component for piShaper	1	\$ 160.00
Laser beam shaper	ADLOPTICA OPTICAL SYSTEMS GMBH	1004	Mount, opto-mechanical component for piShaper	1	\$ 410.00
Laser beam shaper	ADLOPTICA OPTICAL SYSTEMS GMBH	1011	Optical component piShaper_6_6_VIS	1	\$ 4,090.00
Laser beam shaper	ADLOPTICA OPTICAL SYSTEMS GMBH		Freight		\$ 110.00
Optical laser	TOPTICA PHOTONICS	IBEAM SMART-405-S	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	1	\$ 5,330.00
Optical laser	TOPTICA PHOTONICS	IBEAM SMART-488-S	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	1	\$ 6,669.00
Optical laser	TOPTICA PHOTONICS	IBEAM SMART-CLUP-405	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	1	\$ 500.00
Optical laser	TOPTICA PHOTONICS	IBEAM SMART-CLUP-488	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	1	\$ 500.00
Optical laser	TOPTICA PHOTONICS	#ME-022489	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	2	\$ 200.00
Optical laser	TOPTICA PHOTONICS	EK-000692-TPI	IBEAM-SMART-405-S   IBEAM-SMART-CLUP-405   IBEAM-SMART-CLUP-488   #ME-002489   #EK-000692	2	\$ 250.00
Optical laser	TOPTICA PHOTONICS		Transportation & Logistics	1	\$ 316.00
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	D10NLC	1.0x C-Mount F/Nikon 38mm Iso Port	2	\$ 256.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MAK10110	CFI 10x Eyepiece FN 22mm NC	2	\$ 347.80
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MRD01991	CFI Apo 100x/1.49 oil TIRF Obj w/temp correction collar	1	\$ 9,627.48
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MRD01905	CFI PlanApo Lambda 100x oil	1	\$ 5,176.58
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	91032	Chroma Custom Tirf Cube TE/Ti OptiGrid	1	\$ 522.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	CUSTOM-532nm-TIRF	Consisting of ZET532/10x ZT532RDC_UF2 ET542LP ET550LP	1	\$ 1,235.00
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MXA20660	Diaphot System Cond. Dust Cap	4	\$ 41.36
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	TRF49909	ET-561nm Laser bp for TIRF Cube	1	\$ 1,757.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	TRF49914	ET-640-647nm Laser Ip for TIRF Includes Cube	1	\$ 1,757.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	TRF49904-NK	ET488nm Laser bp Includes TIRF Cube	1	\$ 1,757.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MES56100	EI-S-ER Motorized Stage with Encoders	1	\$ 14,277.66
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC		FREIGHT		\$ 464.42
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MBN21816	Filter 45mm Nd 16a	2	\$ 78.96
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	77004	Immersion Oil - 1oz - Type B 29.6cc w/Glass Rod Applicator	3	\$ 28.20
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	500-LDB100FHUB	LED Illuminator with Hub Control	1	\$ 3,249.50
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	P-736.SHN	Microscope Slide Holder for P-736.ZXN	1	\$ 458.81
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	79035	Power Cord - 7'6"	1	\$ 12.22
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	79035	Power Cord - 8ft	1	\$ 12.22
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MBF92200	SU-AC AC Adapter f/Mot Shutter	1	\$ 202.10
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	PD7322RNV	Stage Top Z Piezo	1	\$ 12,513.00
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	90310	Ti Table Mount Bracket Set	1	\$ 239.70
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEL51000	Ti-C System Condenser Turret	1	\$ 517.00
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEL56200	Ti-C-LWD LWD Lens Unit for System Condenser Turret	1	\$ 650.48
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEE59905	Ti-DH Dia Pillar 100w Illum Transmitted Light	1	\$ 1,750.28
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEA53100	Ti-E Inverted Microscope	1	\$ 15,760.98
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEV51110	Ti-FLC-E Motorized Epi-Fluor Filter Turret	1	\$ 1,930.76
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEF55030	Ti-HUB-C/A Hub Controller A	1	\$ 3,609.60
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEP59391	Ti-ND6-PFS Perfect Focus Motorized Nosepiece	1	\$ 16,727.30
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEF55710	Ti-S-C Motorized Stage Controller	1	\$ 3,979.02
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEF55700	Ti-S-EJOY Joystick for Motorized Stage	1	\$ 2,112.18
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MES59110	Ti-SH Universal Holder for Motorized Stage	1	\$ 662.70
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MES59120	Ti-SH Well Plate Holder for Motorized Stage	1	\$ 478.46
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEB55800	Ti-T-B Eyepiece Base Unit	1	\$ 321.48
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	MEB52320	Ti-TD Eyepiece Tube D	1	\$ 1,696.70
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	97050	USB Cable for TIE 15ft Long	1	\$ 13.16
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	P-736.WPN	Well Plate Holder for P-736.ZXN	1	\$ 458.81
Microscope Chassis	MICRO VIDEO INSTRUMENTS INC	ZYLA4.2P-USB3	Zyla 4.2 Plus USB3 Digital Cam	1	\$ 14,065.00
Microscope Control Computer	DELL MARKETING L P	7810 XCTO	Dell Precision Tower 7810;Dell Precision Tower 7810 XCTO Base ; Dell Precision Tower 7810;Dell Precision Tower 7810 XCTO Base	1	\$ 7,935.30

Optical Stability Table	NEWPORT CORP		FREIGHT		\$ 990.00
Optical Stability Table	NEWPORT CORP	M-RS4000-46-12	RS4000 Series Optical Table, 1200 x 1800 x 305 mm, M6 Holes	1	\$ 5,899.00
Optical Stability Table	NEWPORT CORP	S-2000A-423.5	Set of four S-2000 Series 23.5 in. tall standard isolators with automatic leveling	1	\$ 3,155.20
Optical rail system (beam path control)	OPTOSIGMA CORP	SOM-BCA5	Extension Cable for OptMike	1	\$ 95.00
Optical rail system (beam path control)	OPTOSIGMA CORP		Freight		\$ 17.00
Optical rail system (beam path control)	OPTOSIGMA CORP	MHAN-50.8M	Gimballed Mirror Holder	1	\$ 266.00
Optical rail system (beam path control)	OPTOSIGMA CORP	BRS-20-60	High Stability Ball Plunger Po	1	\$ 25.65
Optical rail system (beam path control)	OPTOSIGMA CORP	SOM-C13E	OptMike with Encoder	1	\$ 522.50
Optical rail system (beam path control)	OPTOSIGMA CORP	OMEC-2BG	OptMike-E (B type) Controllers	1	\$ 1,757.50
Optical rail system (beam path control)	OPTOSIGMA CORP	RS232C/STR-1.8	RS232C Cable	1	\$ 38.00
Optical rail system (beam path control)	OPTOSIGMA CORP	561-2751	USB-SERIAL ADAPTER US232R-10	1	\$ 28.50
Adaptive Optics Unit	IMAGINE OPTIC	MICAOv1.2MICAO INST	Calibration with WF Imager / Microscope BFP conjugation 1-day Engineer installation service 1-day Engineer user training Travel cost & lodging Included	1	\$ 2,400.00
Adaptive Optics Unit	IMAGINE OPTIC	MICAOv1.2	Deformable mirror calibration Aberration correction using wavefront sensor Sensorless aberration correction algorithms (Genetic and 3N)	1	\$ 13,400.00
Adaptive Optics Unit	IMAGINE OPTIC	WF IMAGER	HASO wavefront sensor Conjugation lens for MicAO pupil conjugation For C mount camera port USB3.0 PCIe board + USB3.0 cable	1	\$ 19,950.00
Adaptive Optics Unit	IMAGINE OPTIC	MICAO 3DSR	Real 3D imaging for PALM/STORM microscopy Plug and Play device Contains MirAO 52EP deformable mirror, silver coating Microscope compatibility: Standard inverted frames Optimized	1	\$ 46,800.00
Optical Stability Table	NEWPORT CORP		Freight		\$ 159.00
Optical Stability Table	FEDEX CORP		Shipping for parts from ADLOPTICA OPTICAL SYSTEMS GMBH		\$ 32.00
Optical Stability Table	NEWPORT CORP	ATS-6	Overhead Table Shelf With Electrical Outlets, 6 ft. Table Length		\$ 2,137.50
Optical rail system (beam path control)	OPTOSIGMA CORP		Freight		\$ 36.00
Optical rail system (beam path control)	OPTOSIGMA CORP	CAA-25LS	Carriers for Large Optical Rai	6	\$ 213.78
Optical rail system (beam path control)	OPTOSIGMA CORP	CAA-40LS	Carriers for Large Optical Rai	3	\$ 114.00
Optical rail system (beam path control)	OPTOSIGMA CORP	CAA-60LS	Carriers for Large Optical Rai	4	\$ 170.00
Optical rail system (beam path control)	OPTOSIGMA CORP	BRS-20-80	High Stability Ball Plunger Po	3	\$ 76.95
Optical rail system (beam path control)	OPTOSIGMA CORP	DLB-50-450PM	LENS, ACHR DBLT D50.00/FL450/B	1	\$ 130.15
Optical rail system (beam path control)	OPTOSIGMA CORP	DLB-50-300PM	LENS, ACHR DBLT D50/FL299.50 B	1	\$ 130.15
Optical rail system (beam path control)	OPTOSIGMA CORP	DLB-50-350PM	LENS, ACHR DBLT D50/FL350.2 BM	1	\$ 130.15
Optical rail system (beam path control)	OPTOSIGMA CORP	DLB-50-400PM	LENS, ACHR DBLT D50/FL400.00 B	1	\$ 130.15
Optical rail system (beam path control)	OPTOSIGMA CORP	OBT-300SH	Medium Low-Profile Optical Rai	5	\$ 332.50
Optical rail system (beam path control)	OPTOSIGMA CORP	955-0001	OPTO-MECHANICS SPECIAL ORDER : Custom High Stability Ball Plunger Post Holders PN: BRS-12.7-101.6(M16) Specifications; All specifications are same as BRS-12.7-101.6UU but changing the male adapter nut from 1/4-20UNC to M16.	18	\$ 508.50
Optical rail system (beam path control)	OPTOSIGMA CORP	955-0001	OPTO-MECHANICS SPECIAL ORDER :Custom High Stability Ball Plunger Post Holders PN: BRS-12.7-76.2(M16) Specifications; All specifications are same as BRS-12.7-76.2UU but changing the male adapter nut from 1/4-20UNC to M16.	4	\$ 113.00
Optical rail system (beam path control)	OPTOSIGMA CORP	995-0001	OPTO-MECHANICS SPECIAL ORDER:Custom High Stability Ball Plunger Post Holders PN: BRS-12.7-63.5(M16) Specifications; All specifications are same as BRS-12.7-63.5UU but changing the male adapter nut from 1/4-20UNC to M16.	2	\$ 48.50
Optical rail system (beam path control)	OPTOSIGMA CORP	RO-20-80	Posts	4	\$ 28.52
Optical rail system (beam path control)	OPTOSIGMA CORP	LHCM-50	Two-axis Lens Holder	3	\$ 641.25
Optical rail system (beam path control)	OPTOSIGMA CORP	TSD-601S	X axis Steel Extended Contact	4	\$ 1,064.00
Optical rail system (beam path control)	OPTOSIGMA CORP	TSD-302S	XY axis Steel Extended Contact	1	\$ 560.00
Dichroic mirror (beam path control)	MICRO VIDEO INSTRUMENTS INC	Zzt405rdc-uf3	405 Longpass Laser Mirror 3mm thick Ultra-Flat 25 X36mm	1	\$ 427.50
Dichroic mirror (beam path control)	MICRO VIDEO INSTRUMENTS INC	zt488RDC-UF3	488 Longpass Laser Mirror 3mm thick Ultra-Flat 25 X36mm	1	\$ 427.50
Dichroic mirror (beam path control)	MICRO VIDEO INSTRUMENTS INC	zt532RDC-UF3	532 Longpass Laser Mirror 3mm thick Ultra-Flat 25 X36mm	1	\$ 427.50
Dichroic mirror (beam path control)	MICRO VIDEO INSTRUMENTS INC		FREIGHT		\$ 15.00
Confocal scanhead	READCOOR INC	Confocal scanhead	Confocal scanhead - Wide space pinholes between 200 and 600 um sCMOS sensor compatible Single fixed dichroic to split high/low 488/589 FITC, TXR 532/640 CY3, CY5 Dual band emission filters set for FITC, CY3, TXR, CY5 optimized for specifi	1	\$ 124,278.71
Tabletop optical unit (beam path control)	THORLABS INC		FREIGHTHex Drive Ultra Stable Mirror Mount For 1 inch Optics		\$ 1.00
Tabletop optical unit (beam path control)	THORLABS INC	POLARIS-K1-H	Hex Drive Ultra Stable Mirror Mount For 1 inch Optics	2	\$ 266.56

Tabletop optical unit (beam path control)	THORLABS INC	RSP1X15/M	15 Indexing Rotation Mount	1	\$ 128.38
Tabletop optical unit (beam path control)	THORLABS INC	P15S	15um MOUNTED PINHOLE	1	\$ 73.01
Tabletop optical unit (beam path control)	THORLABS INC	P250/M	38mm Solid Post 250mm Length	4	\$ 272.44
Tabletop optical unit (beam path control)	THORLABS INC	VA100/M	Adjustable Mechanical Slit	1	\$ 247.94
Tabletop optical unit (beam path control)	THORLABS INC		FREIGHT		\$ 16.31
Tabletop optical unit (beam path control)	THORLABS INC	LJ1558L2-A	H=30.0 L=60.0 f=300.0 NBK7 A Coat Plano Convex Cyl Lens	1	\$ 137.20
Tabletop optical unit (beam path control)	THORLABS INC	LMR01/M-P5	Metric Lens mounting ring for 0.5" dia optic, 5 pack	1	\$ 71.70
Tabletop optical unit (beam path control)	THORLABS INC	CFS1ND/M	MetricCage Filter Slider with 1.0, 2.0, 3.0 & 4.0 ND Filters	1	\$ 264.60
Tabletop optical unit (beam path control)	THORLABS INC	C220TMD-A	Mounted $\phi=7.22\text{mm}$ , $f=11.00\text{mm}$ , $NA=0.25$ DZK3 Asphere,-A	1	\$ 69.58
Tabletop optical unit (beam path control)	THORLABS INC	PS908L-A	N-BK7 RA Prism, 20mm, - A Coated on legs	1	\$ 85.00
Tabletop optical unit (beam path control)	THORLABS INC	PF175	P-Series Clamping Fork	4	\$ 70.17
Tabletop optical unit (beam path control)	THORLABS INC	PB4/M	P-Series Pedestal Base Adapter	4	\$ 49.78
Tabletop optical unit (beam path control)	THORLABS INC	KT310/M	Spatial Filter, Mechanical Assembly	1	\$ 879.06
Tabletop optical unit (beam path control)	THORLABS INC	POLARIS-K1	Ultra Stable Mirror Mount For 1 Inch Optics	1	\$ 136.22
Tabletop optical unit (beam path control)	THORLABS INC	BB1-E02	$\phi$ 25.4 mm Mirror, Broadband -E02 Coated	3	\$ 220.79
Tabletop optical unit (beam path control)	THORLABS INC	LA1422-A	$\phi$ 25.4 F=40.0 N-BK7 A Coated Plano Convex Lens	1	\$ 32.10
Tabletop optical unit (beam path control)	THORLABS INC	ACY254-200-A	$\phi$ 25.4mm, F=200mm, Cylindrical Achromat, -A Coated	1	\$ 368.48
Tabletop optical unit (beam path control)	THORLABS INC	MY10X-803	10X Mitutoyo Plan- Apochromat Objective, 0.28 NA, 34.0 mm WD	1	\$ 855.54
Laser intensity modulator	QUANTA TECH INC	AOTFnC-400.650.TN	AOTFnC-400.650-TN Polychromatic Modulator 400-650 nm, Aperture 3 mm, including high accuracy, Temperature Stabilization Download Data Sheet	1	\$ 2,780.00
Laser intensity modulator	QUANTA TECH INC	CBL-SAM200SAM-RG223	CBL-SAM200SAM-RG223 Coaxial cable SMAm/RG223/SMAm, Length 2m	1	\$ 19.00
Laser intensity modulator	QUANTA TECH INC	CBL-SCF200SCF-RG316	CBL-SCF200SCF-RG316 Coaxial cable SMCf/RG316/SMCF, Length 2 m	1	\$ 31.00
Laser intensity modulator	QUANTA TECH INC	MPDS8C-D65-22-74.158-RS	MPDS8C-D65-22-74.158-RS Multi Purpose Digital Synthesizer 74-158MHz, 110-230 VAC, MOD IN: 0-5V or 0-10V, BLANKING : TTL, Extinction >80dB, RS 232 Download Data Sheet	1	\$ 3,755.00
Motorized mirror (beam path control)	NEWPORT CORP	8742-4-KIT	8742-4-KIT: Four-Axis 8742 Picomotor Controller/Driver Kit	1	\$ 1,030.14
Motorized mirror (beam path control)	NEWPORT CORP		FREIGHT		\$ 14.55
Motorized mirror (beam path control)	NEWPORT CORP	M-BKL-4	Kinematic Base, Locking, 88.9 x 101.6 mm, Metric	1	\$ 238.00
Motorized mirror (beam path control)	NEWPORT CORP	M-460P-XYZ	Peg-Joining Linear Stage, 25.4 mm XYZ-Travel, Metric	1	\$ 898.70
Motorized mirror (beam path control)	NEWPORT CORP	8821	PicomotorPiezo Clear Edge Center Mount, 1.0 in. Diameter, 2-Axis	1	\$ 1,055.36
				<b>TOTAL</b>	<b>\$ 424,157.99</b>