

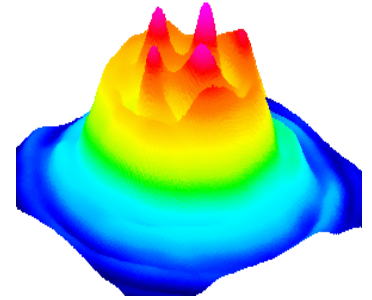
# DataRay Inc.

Advancing the Technology of Laser Analysis

## NOW with M-Squared Option!

## Laser Beam Profilers

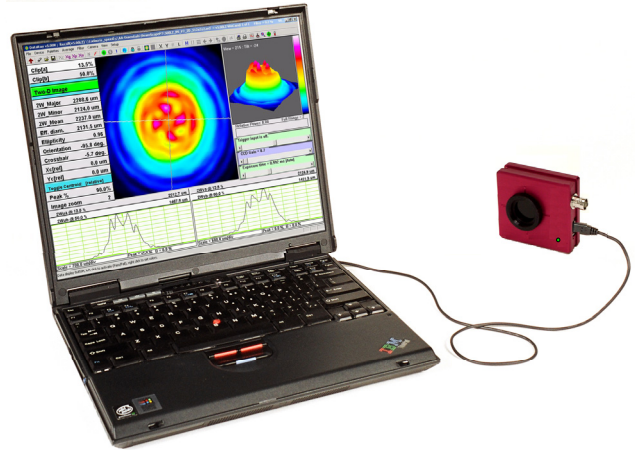
- WinCamD™ -UCD12** 1/2" CCD 14-bit ADC
- WinCamD™ -UCD23** 2/3" CCD 14-bit ADC
- WinCamD™ -UHR** 5.2 μm CMOS
- WinCamD™ -UHS** High Speed-CMOS
- BladeCamD™** 0.65" Ultra-Thin Probe Camera
- WinCamD-FIR™** 8-14 μm



### Compact, Portable, Port-Powered, USB 2.0 Beam Profiling for PC or Intel-Mac

#### Features

- ◇ **USB 2.0 port-powered**; flexible 3 m cable; *no external power supply required.*
- ◇ **0.65" mm Ultra-thin BladeCamD** (includes ND filter) to fit tight beam trains [0.50"/12 mm without filter]
- ◇ 14/10 Bit Digital CMOS/CCD cameras with on-chip 10-bit or external 14-bit ADC
- ◇ 4 MB image buffer & on-board microprocessor
- ◇ Window-free sensors standard for no fringing
- ◇ 20,000:1 electronic auto-shutter, 50 μs –1000 ms
- ◇ 1,000:1 SNR options (30/60 dB Optical/Electrical)
- ◇ Pulsed laser auto-trigger and synchronization
- ◇ Parallel capture on multiple cameras
- ◇ Field-replaceable image sensors
- ◇ Large area TaperCamD options to 20 x 15 mm (p.7)
- ◇ X-Ray, UV, 1310 nm (p.8) & 1475-1680 nm (p.10)

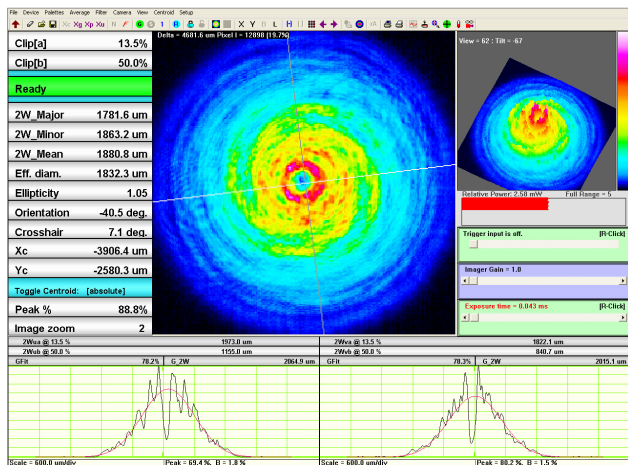


#### Applications

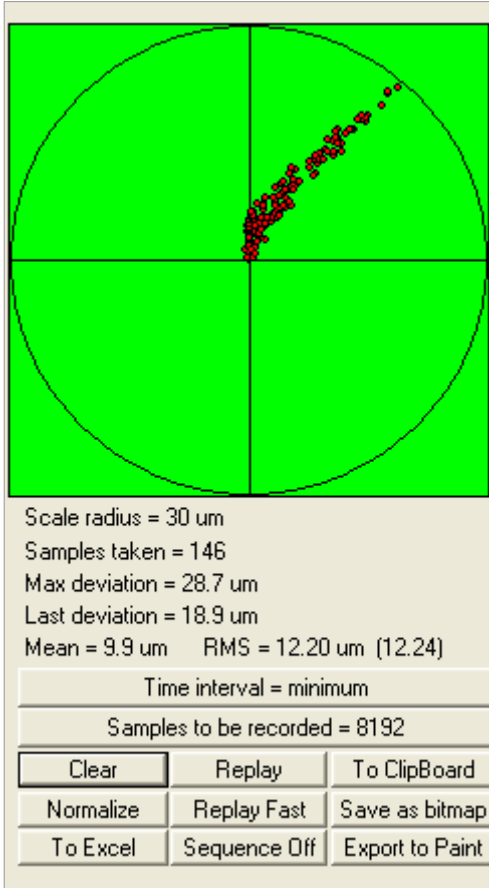
- ◇ **CW & Pulsed** laser profiling
- ◇ Field servicing of lasers and laser-based systems
- ◇ Optical assembly & instrument alignment
- ◇ Beam wander & logging
- ◇ **M-Squared Measurements**



Camera shown actual size  
2.40 x 2.65 x 1.12" (x0.9" without filter) [61 x 67 x 28 mm]



## Powerful Beam Analysis Software



### Beam Wander on a drifting Laser

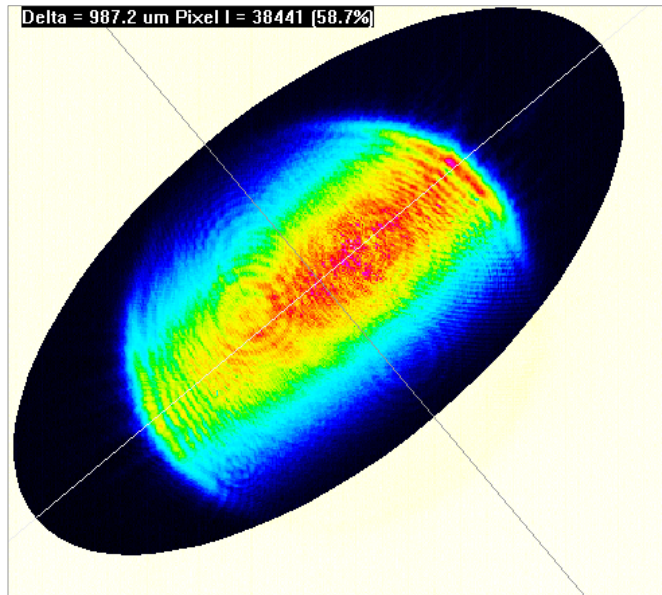
Up to 8192 samples at a User Set interval.  
 Mean, RMS and Max. deviation.

Replay Fast or Slow.

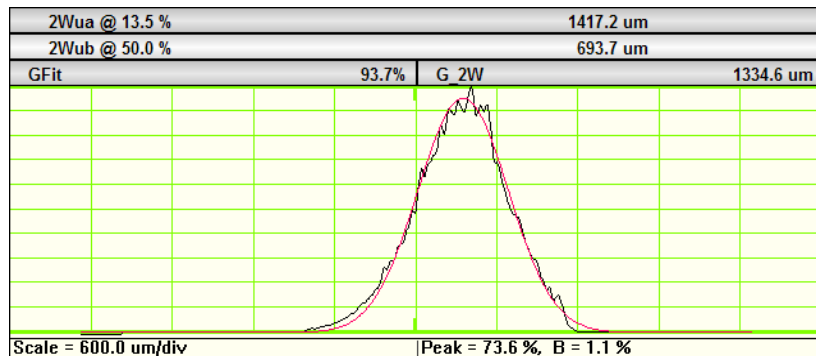
Export to Excel, Paint, Bitmap or Clipboard.

### Auto-Inclusion Region on an Elliptical Beam

Automatically isolates the appropriate analysis region.  
 With user overrides.

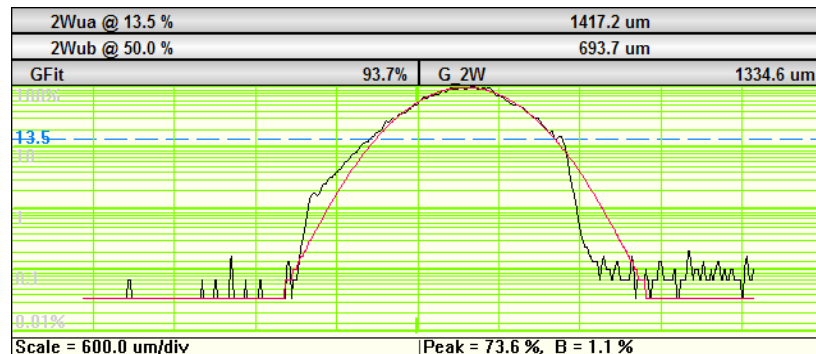


### Standard Linear Profile with Gaussian Fit.



### Logarithmic Profile

The same profile with Averaging & Log 40 dB display reveals structure in the wings of the beam at levels below 1%.



**DataRay Innovation** - The company that brought you the *first* Windows-based CCD beam profiler, the *first* Camera for confined spaces, the *first* software slider exposure and electronic auto-shutter, the *first* standard window-free CCD for no fringing, the *first* auto-orientation on the ellipse & the *first* USB 2.0 beam profiling camera ... has done it again.

**Compact** WinCamD- cameras- *small enough to fit in your shirt pocket-or fit in a space 0.65" thick* offer either the High Speed capability required to capture single pulses to 20 kHz or High Resolution with a pixel size of 4.65 x 4.65 µm.

## Features:

- ◇ Digital serial link for EMI immunity
- ◇ XY profiles and centroids
- ◇ Linear and logarithmic displays
- ◇ Gaussian and Top Hat least squares fits
- ◇ Ellipse Angle, Major, Minor, Mean Diameters
- ◇ Background capture and subtraction
- ◇ Image & Intensity Zoom
- ◇ Linear and area filters
- ◇ Image Averaging, 1 to continuous
- ◇ Compact design 0.65" Probe style for tight applications

## WinCamD-U CCD & CMOS Sensor Specifications:

WinCamD™	-UCD12	-UCD23	-UHR	-UHS High Speed	BladeCamD™
Pixel Count & H x V:	1.4 M Pixel 1360 x1024	1.4 M Pixel 1360 x1024	1.3 MPixel, 1280 x 1024	355 kPixel, 656 x 496	1.3 MPixel, 1280 x 1024
Sensor image area:	6.3 x 4.8 mm	8.8 x 6.6 mm	6.6 x 5.3 mm	6.5 x 4.9 µm	6.6 x 5.3 mm
Pixel dimension:	4.65 x 4.65 µm	6.45 x 6.45 µm	5.2 x 5.2 µm	9.9 x 9.9 µm	5.2 x 5.2 µm
Min. beam (10 pixels):	~47 µm	~65 µm	~52 µm	~100 µm	~52 µm
Shutter type:	Synchronous	Synchronous	Rolling	Synchronous	Rolling
Max. full frame rate:	~10 Hz	~10 Hz	~10 Hz	~10 Hz	~10 Hz
Max. 'every pulse' PRR:	~10 Hz	~10 Hz	~10 Hz	~10 Hz	~10 Hz
Single pulse capture PRR:	20 kHz	20 kHz	20 kHz	~205 kHz	20 kHz
Signal to RMS Noise (Opt./Elec.* dB):	1,000:1 (30/60* dB)	1,000:1 (30/60* dB)	1,000:1 (30/60* dB)	800:1 (29/58* dB)	1,000:1 (30/60* dB)
Electronic Shutter Dynamic Range:	43 dB	43 dB	43 dB	43 dB	43 dB
ND+Shutter+SNR Dynamic Range**:	113** dB; 2.10 <sup>11</sup> :1	113** dB; 2.10 <sup>11</sup> :1	113** dB; 2.10 <sup>11</sup> :1	112** dB; 1.6.10 <sup>11</sup> :1	113** dB; 2.10 <sup>11</sup> :1
TaperCamD pixel size:	10.5 x 10.5 µm	10.5 x 10.5 µm	12 x 12 µm	22 x 22 µm	NA
TaperCamD20-15 pixel size:	14.5 x 14.5 µm	14.5 x 14.5 µm	16 x 16 µm	31 x 31 µm	NA
ADC:	14-bit (16384 levels)	14-bit (16384 levels)	10-bit (1024 levels)	10-bit (1024 levels)	10-bit (1024 levels)

\* OK, we agree that quoting electrical dB for optical SNR is a nonsense, but some suppliers do this, so we offer a comparable specification.

\*\* OK, we agree that Dynamic Range that includes removable ND filters is also nonsense, but some suppliers do this, so we offer comparable specification with ND 4.

## Common WinCamD Series Specifications: [Specifications are subject to change without notice]

Wavelength: WinCamD	~350 to 1150 nm
-1310	~350 to 1330 nm. Residual silicon response. 1290 nm long Pass filter provided.
-NIR	~1480 to 1680 nm. NIR to Visible phosphor, 40 µm FWHM (Erbium response)
-FIR	~8 to 14 µm 23.5 µm pixel pitch, 320 x 240 pixels, 7.5 x 6.6 mm
-UV	~190 to 1150 nm UV converters with wavelength options down to X-ray. <i>UV resolution to 1 µm.</i>
High dynamic range	20,000:1 (43 dB) continuously variable auto electronic shutter, <50 µs to 1.0 s. Additional 10,000:1 ND filter + 5:1 electronic control to give 10 <sup>9</sup> :1.
Pulsed lasers	Auto-trigger sync, TTL input trigger, TTL output trigger – <i>not available on -UHS</i>
Compact- with ND filter	WinCamD-2.40" x 2.65" x 1.12" BladeCamD- 4.5 x 1.8 x 0.65"
Interface	Port Powered USB 2.0 for laptops & desktops. 3 m standard thin cable, 5 m option.
Multiple Heads:	1 – 16 cameras. Parallel capture, serial read.
ISO 11146	Beam profile Second moment processing
Certification	RoHS, WEEE, CE
Measurable Sources	CW beams, Pulsed sources. CW to >20 kHz with single pulse isolation (UHS) User configurable Synchronous, Asynchronous & Variable Delay trigger options. Software programmable trigger input, +ve or -ve edge, 50 Ω or 1 kΩ
Measured Beam Powers	<i>See the Saturation Beam Power/Pulse Energy Graph and Notes, below.</i>
Manual Beam Attenuation:	Provided ND 4.0 (10,000:1) C-mount Neutral Density filters. [ND 4.0 at 546 nm, higher in blue, lower in near IR.] Screw stackable ND 1, 2, 3, 4, 5 available.
Options:	<b>EAM-2:</b> 4-wheel stepped variable attenuator, 0 to 90 dB <b>CUB and CUB-UV</b> 3 to 10 % beam samplers for high power beams 1% and 0.05% Holographic Beam Samplers (by gentec-eo)
Measurement Accuracy	0.1 µm processing resolution for interpolated diameters. Absolute accuracy is beam profile dependent – ~1 µm accuracy is frequently achievable. Centroid accuracy is also beam dependent. It can be as good as ±1 µm since it is arithmetically derived from all pixels above the centroid clip level.

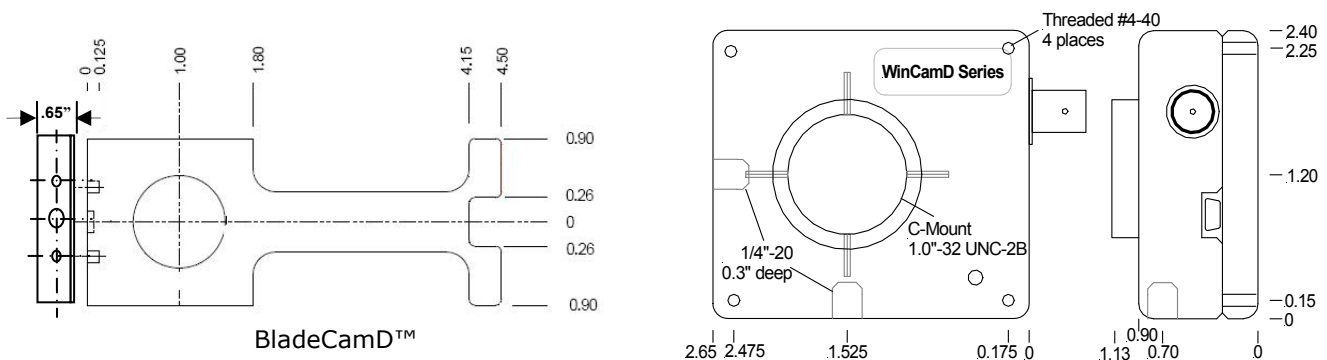


Measured & Displayed Profile Parameters

Beam Diameter: Diameter at two user set Clip levels  
 Gaussian & Second Moment beam diameters  
 Equivalent diameter above a user defined Clip level  
 Equivalent Slit and Knife Edge diameters  
 Beam Fit: Gaussian & Top Hat profile fit & % fit  
 Equivalent Slit profile  
 Ellipticity: Major, Minor & Mean diameters. Auto-orientation of axes.  
 Centroid Position: Relative and absolute  
 Intensity Weighted Centroid and Geometric Center  
 Beam Wander Display and Statistics  
 Smoothing Filter: Triangular running average up to 10% FWHM

Displayed Profiles	2-D & 3-D plots
Displayed Plots	10, 16, 256 or max. colors or gray. Contoured display at 10 and 16 color. X-Y Profiles, 2D, 3D Plots. Zoom to x10
Processing Options	Image & profile averaging, 1, 5, 10, 20, Continuous Background Capture and Subtraction User set rectangular or elliptical Capture region <b>*.job</b> files save all WinCamD custom settings for particular test configurations
Pass/Fail display	On-screen, in selectable <b>Pass/Fail</b> colors. Ideal for QA & Production.
Averaging	Beam dimension running average up to 50 samples
Log data and statistics	Min., Max., Mean, Standard Deviation. Up to 4096 samples
Relative Power Measurement	Rolling histogram based on user's initial input. Units of <b>mW, μJ, dBm, %</b> or user choice (relative to a reference measurement input)
Fluence	Fluence, within user defined area
Chip depth from front of case /filter ring all ±~0.5 mm	-UCD12 7.3/15.1 mm -UHR, -UHS 8.7/16.5 mm -UCD23 7.5/15.3 mm -BladeCamD 5.0/ 8.8 mm
Outline and Mounting L x W x D	WinCamD-Series 2.65 x 2.4 x 0.9/1.13" Without/With ND4 filter See Drawing below 67 x 61 x 23/29 mm BladeCamD 4.5 x 1.8 x 0.5/0.65" Without/With ND4 filter 11.43 x 45.72 x 12.7 mm
Weight, Camera Head	155 gm (5.5 oz)
Minimum Computer Requirements:	1 GHz Pentium IV or higher running Windows XP/Vista; 512/1024 MB RAM; 10 MB Hard Drive space; 1024 x 768 monitor, USB 2.0 hi-power (500 mA) port.
	<b>PC or Intel-Mac</b>

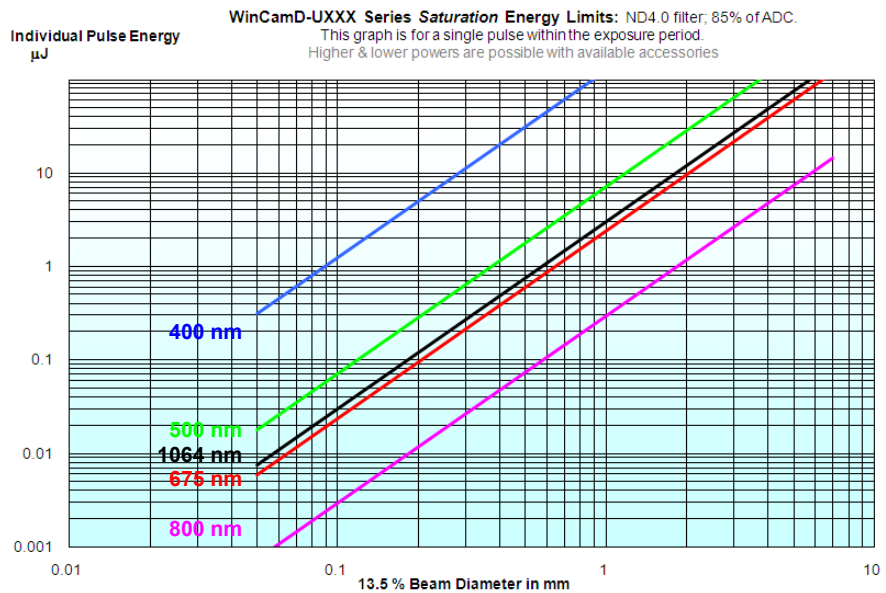
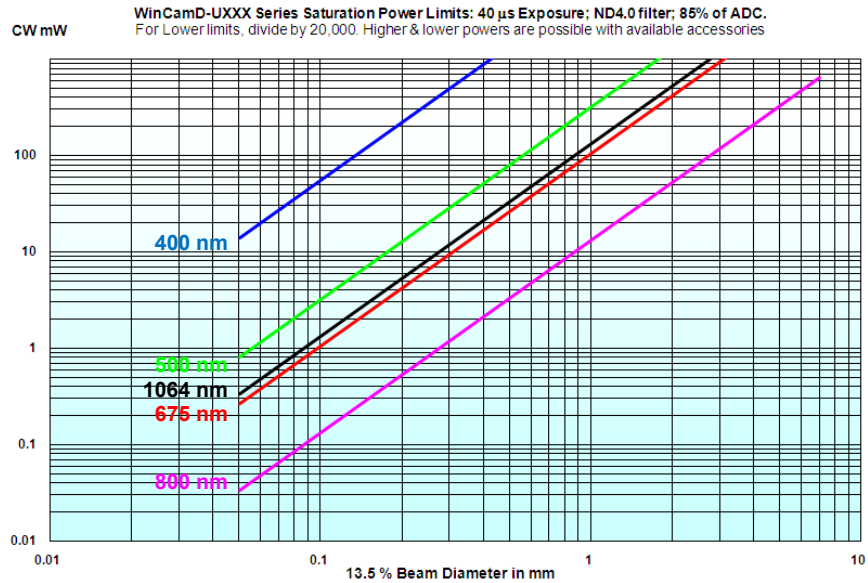
**Outline and Mounting** (not to scale)



## Saturation Beam Power/ Pulse Energy Graphs

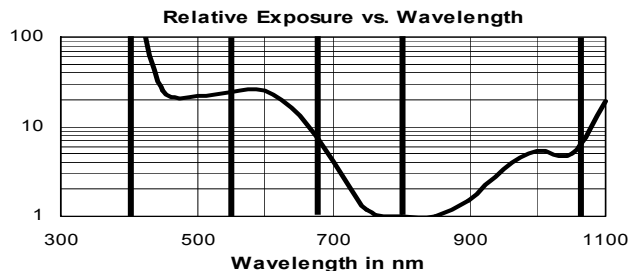
These two graphs allow you to simply determine the approximate maximum CW optical power (above) or pulse energy (below) that the standard WinCamD-U configuration can measure for your beam diameter and wavelength *without additional attenuation*. The **Saturation Limit** assumes:

- The provided ND 4.0 filter in place
- The electronic shutter set at 40  $\mu\text{s}$ , its lowest value
- The ADC gain set at 1, its lowest value
- **The beam onto the ND filter must not exceed 5 W total power or 100 mW/per  $\text{mm}^2$ . [10 W/per  $\text{cm}^2$ ]**



The lower limit in the standard configuration is  $\sim 10^{-5}$  x the Saturation Limit.

Use the graph right to estimate for other wavelengths.



## ORDERING INFORMATION

◇ **3 Year Warranty**      ◇ **Free Software Upgrades**      ◇ **30 Day Sale or Return Evaluation PO**

A Complete System comprises: Camera, ND 4.0 filter, Software, 3 m (10 ft) Cable, User Manual.

Generate the Part Number based upon the component descriptions, and limitations, in the table.

Your CCD or CMOS chip choice does *not* affect the system price except for the 2/3" CCD chip which is higher.

<b>Part Number</b>	=	<b>Camera type</b>	+	<b>CCD/ CMOS chip</b>	+	<b>Suffix</b> (if required)
		WinCamD		-UCD12/UHS, UHR		-UV
		TaperCamD		-UCD12		-1310
		TaperCamD20-15		-UCD23		-NIR

e.g. **WinCamD-UHR** is a complete working system with a High Resolution CMOS with 5.2 μm pixels.

**TaperCamD-1310** is a complete working system with a 14.4 x 10.8 mm FO Taper for 1310 nm.

Part Number component descriptions	
WinCamD	Complete working USB 2.0 camera system. Add CMOS chip extension to generate Part #.
TaperCamD	WinCamD-UCD12 with 14.4 x 10.8 mm 1.6:1 FO taper on the sensor
TaperCamD20-15	WinCamD-UCD23 with 20 x 15 mm 2.27:1 FO taper on the sensor – <i>only</i> with –UCD23 chip.
-UCD12	1/2" CCD sensor for CW and pulsed, 1360 x 1024 pixels 4.65 x 4.65 μm
-UCD23	2/3" CCD sensor for CW and pulsed, 1360 x 1024 pixels 6.45 x 6.45 μm
-UHR	1/2" CMOS sensor for CW and low PRR, 1280 x 1024 pixels 5.2 x 5.2 μm
-UHS	1/2" CMOS sensor for CW and pulsed, 656 x 496 pixels 9.9 x 9.9 μm
-1310	Adds 50 mm C-mount tube and long-pass filter for 1290 to 1350 nm work.
-UV	Camera with 3 mm UG11 filter instead of ND 4.0. Works at 260 through 380 nm.
-NIR	On-chip IR to visible phosphor converter for 1480 to 1600 nm.

**Extra Cameras**, priced lower than systems, programmed to **only** work as *additional* cameras on the same PC.

**Extra cameras**, come with Cable, Mount and ND filter, but no Software or User Manual. Confirm with factory.

Add additional suffix **-X** to the system Part #. E.g.: **WinCamD-UHS** becomes **WinCamD-UHS-X**

Accessories	
EAM-2	Variable Attenuator, 93 dB optical dynamic range. Max.: 1 W/cm <sup>2</sup> /100 mJ/cm <sup>2</sup> .
CUB & CUB-UV	Vis & UV Beamsplitters, 3% to 10% (polarization dependent) C-mount to camera.
ND1.0, ND2.0, ND3.0, ND4.0, ND5.0	Additional Neutral Density filters in ND 1 steps in stackable C-mount threaded holders. (ND4.0 filter comes as standard with the system.). See User Manual for curves. (Add <b>L</b> after <b>ND</b> for use with large TaperCamD- NDL1.0, NDL2.0, NDL3.0, NDL4.0, NDL5.0)

M-Squared Option for WinCamD – USB 2.0	
M2DU-WC-LNZ-UV-100 185-450 nm	WinCamD-Series USB 2.0 M <sup>2</sup> Scan Stage with lens & adaptor plates: 2.5 μm steps, 44 mm travel + Mounted 100 mm focal length fused silica singlet lens (17.5 mm aperture) for 185 to 450 nm + 3 m (10 ft) cable Contact factory for lens assemblies for other focal lengths
M2DU-WC-LNZ-VIS-100 400- 700 nm	WinCamD-Series USB 2.0 M <sup>2</sup> Scan Stage with lens & adaptor plates: 2.5 μm steps, 44 mm travel + Mounted 100 mm focal length achromat lens (17.5 mm aperture) for 400 to 700 nm + 3 m (10 ft) cable Contact factory for lens assemblies for other focal lengths
M2DU-WC-LNZ-NIR-100 630 - 1100 nm	WinCamD-Series USB 2.0 M <sup>2</sup> Scan Stage with lens & adaptor plates: 2.5 μm steps, 44 mm travel + Mounted 100 mm focal length achromat lens (17.5 mm aperture) for 630 to 1100 nm + 3 m (10 ft) cable Contact factory for lens assemblies for other focal lengths
M2DU-WC-LNZ-TEL-100 1030- 1800 nm	WinCamD-Series USB 2.0 M <sup>2</sup> Scan Stage with lens & adaptor plates: 2.5 μm steps, 44 mm travel + Mounted 100 mm focal length achromat lens (17.5 mm aperture) for 1030 to 1800 nm + 3 m (10 ft) cable Contact factory for lens assemblies for other focal lengths

Other DataRay Profiling Instruments	
BeamMap2	Real Time M-Squared Multi-plane profiler 0.1 μm resolution on CW lasers Centroid, Alignment, Divergence, M <sup>2</sup> : Visible and Telecom wavelengths.
Beam'R2	0.1 micron resolution on CW lasers, 0.5 μm to 4 mm beam dimensions
BeamScope-P8	3.0 μm to 23 mm, M <sup>2</sup> accessory option, ISO 11146 Standard Linear scanning slit, CW or Pulsed (prf >5 kHz) lasers, up to 23 x 45 mm scanned area
WinCamD-UFIR	8-14 μm Imager IR Profiler 320 x 240, 23.5 μm pitch pixels 14 bit USB 2.0



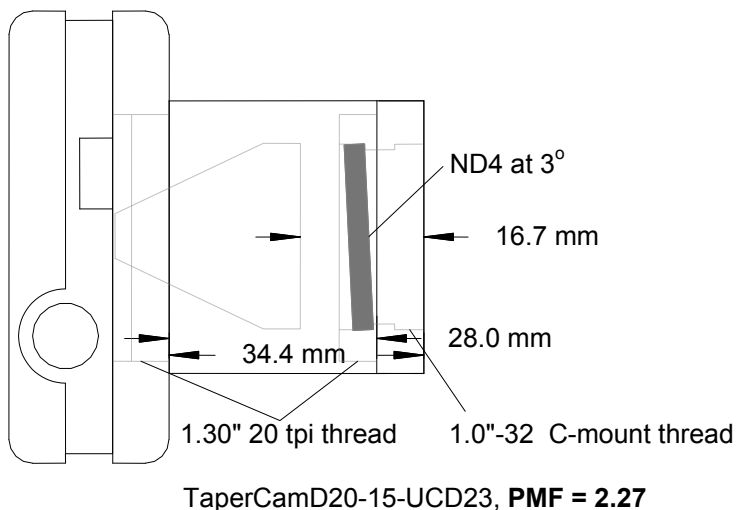
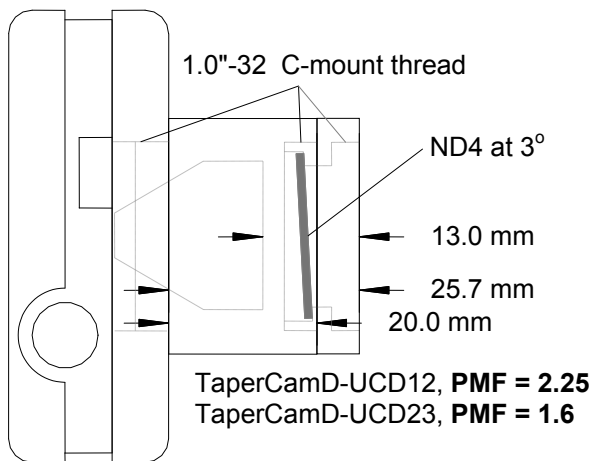
## TaperCamD for Direct Imaging of Larger Beams

**TaperCamD-UCD12** and **TaperCamD20-15-UCD23** series beam profiling cameras are unique to DataRay and offer a larger effective imager area. TaperCamD series cameras offer direct imaging of the beam without any of the Gaussian beam near-field/far-field issues that arise with the use of beam expansion telescopes.

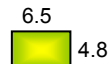
They are available in standard, -1310 and -NIR versions.

Fiber optic tapers are fused coherent fiber bundles, heated, drawn and polished to give an output end the size of the imager chip. The image is **demagnified** ( $M < 1$ ) from the faceplate input to the imager chip end. The taper ends are bonded to the surface of the imager chip using a proprietary DataRay process which eliminates both surface reflections and thermal cycling stress.

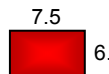
- The PMF (Pixel Multiply Factor) shown below and on the camera label is entered into the software in order to provide correct diameter readings.
- NA at the imager end is 1.0. NA at the input faceplate is a factor of M smaller.
- The individual fibers at the input end are 6  $\mu\text{m}$  pitch with a 50% core/cladding area ratio.
- Refractive index is 1.81, leading to a front surface reflectivity of 8.3%.
- Empty filter holders are available for both TaperCamD sizes.
- A 0.25" deep extension ring is available with male and female 1.30"-20 tpi threads.
- Residual distortion is specified by the manufacturer at  $\pm 3\%$  barrel/pin-cushion distortion. In our experience this distortion is concentrated towards the edges of the field.
- Residual non-uniformity in optical response is generally small and requires no correction, but the ability to do so is available in the software.



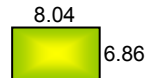
Imager area is shown **actual size in mm** for:



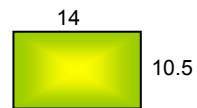
WinCamD-UCD12, -UHR, -UHS



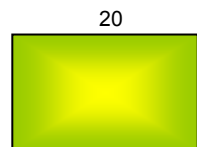
WinCamD-FIR 8-14  $\mu\text{m}$



WinCamD-UCD23



TaperCamD-UCD12



TaperCamD20-15-UCD23

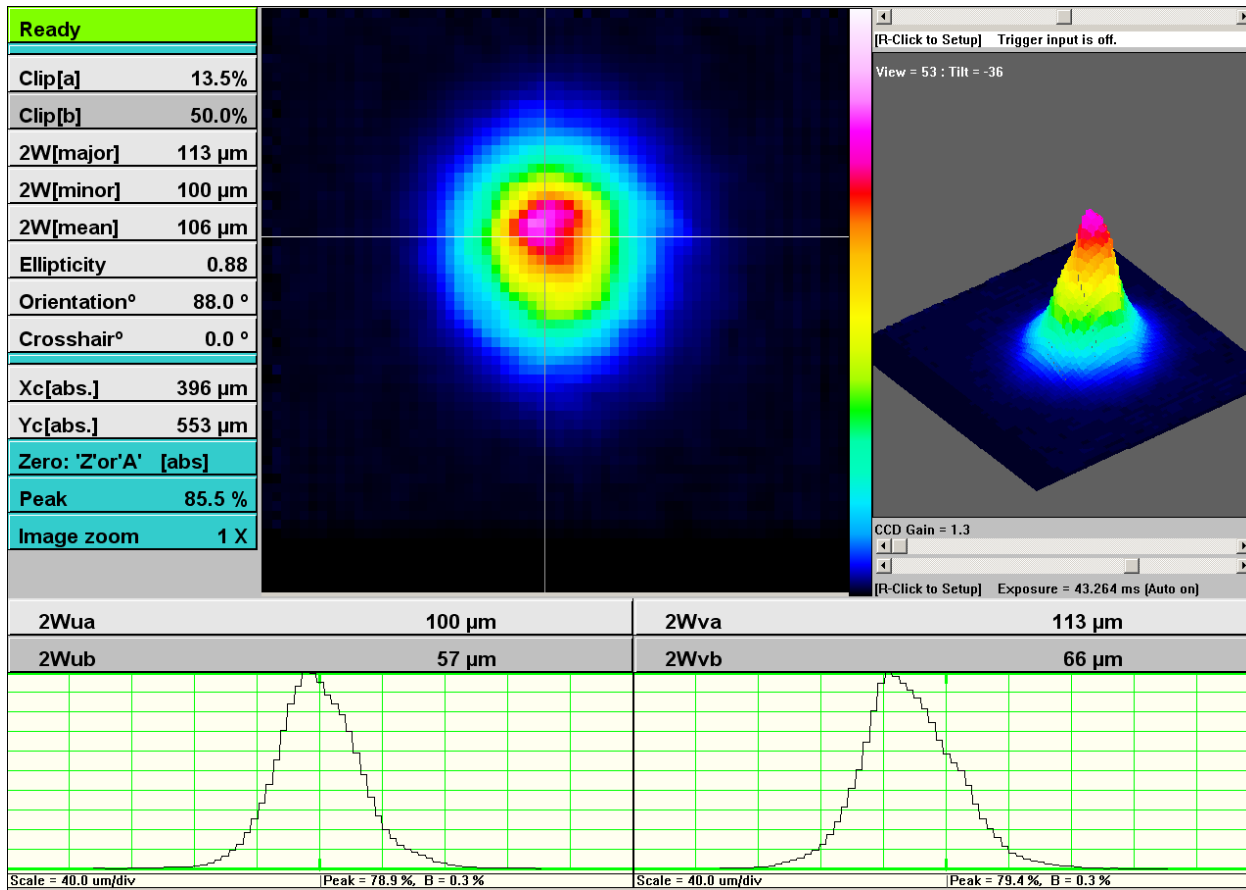


BladeCamD with UHR chip



## WinCamD-UCD12-1310: High Resolution beam profiling to 1350 nm.

**Image of a 1310 nm beam, 100 µm diameter, 1.5 mW.** [43 ms Shutter. No ND filter]  
The high resolution advantage of 4.65 micron square pixels is clearly seen.



### Summary:

- 1) **Technology.** WinCamD-UCD12-1310 uses proprietary software and electronics in conjunction with factory selected CCDs that exhibit residual sensitivity at 1310 nm. This is a tailing silicon response, and has been observed out to at least 1340 nm. The effective Quantum Efficiency (QE) in this tailing response is around 0.01%, i.e. a factor of around  $\sim 10^4$  down on the visible response.
- 2) **Features.** Despite the low QE, WinCamD-UCD12-1310 cameras can be very attractive for 1310 nm region use if the source irradiance is adequate (see later). The 4.65 micron square pixels give much higher resolution than standard NIR cameras. The WinCamD shutter exposure of up to 1047 ms is 25 to 30 times greater than that of standard cameras, partially compensating the low 1310 nm sensitivity.
- 3) **Operational Issues.** ND filters are not normally used with WinCamD-UCD12-1310, unless the beam power is very high, meaning that normal laboratory background can dominate the 1310 nm signal. Options are:
  - Use no filter and work in a darkened room, or with black screening
  - Use a long pass filter which blocks radiation below the wavelength(s) of interest.
 DataRay supports both options.
  - **No Filter Operation.** With no shading or filtering, a typical room background level is equivalent to an exposure time of  $\sim 3$  ms. i.e. the background is  $\sim 10\%$  of the signal when the exposure time with signal is  $\sim 0.3$  ms. This emphasizes the need to suppress the ambient light as far as is possible. Working in a darkened lab is the best solution.





A 50 mm long, 30 mm outer diameter, black-anodized C-mount tube, provided, will reduce the ambient lab background by a factor of around 4.

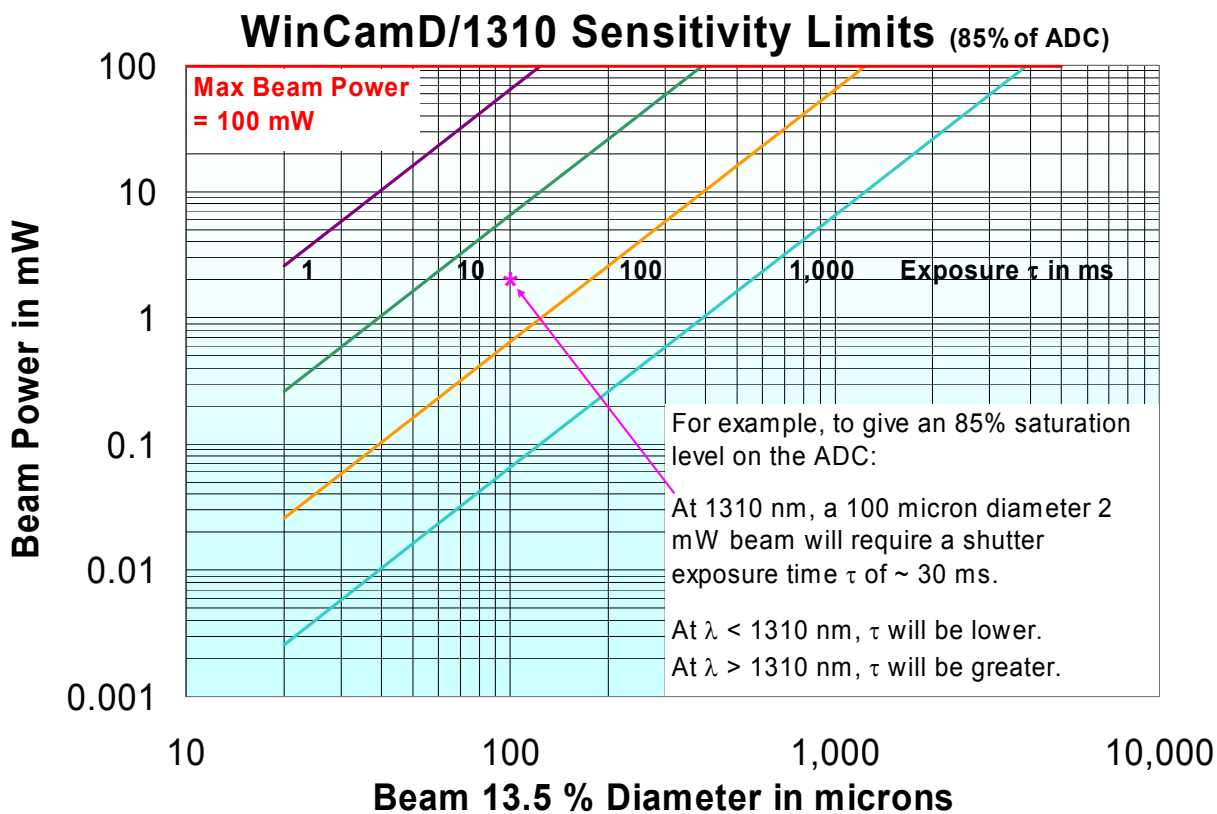
A 100 mm long tube will reduce the ambient lab background by a factor of around 8.

With thin black card and tape, you can mount your own custom tube off the provided 50 mm C-mount extension, and customize the ambient suppression shading to your application.

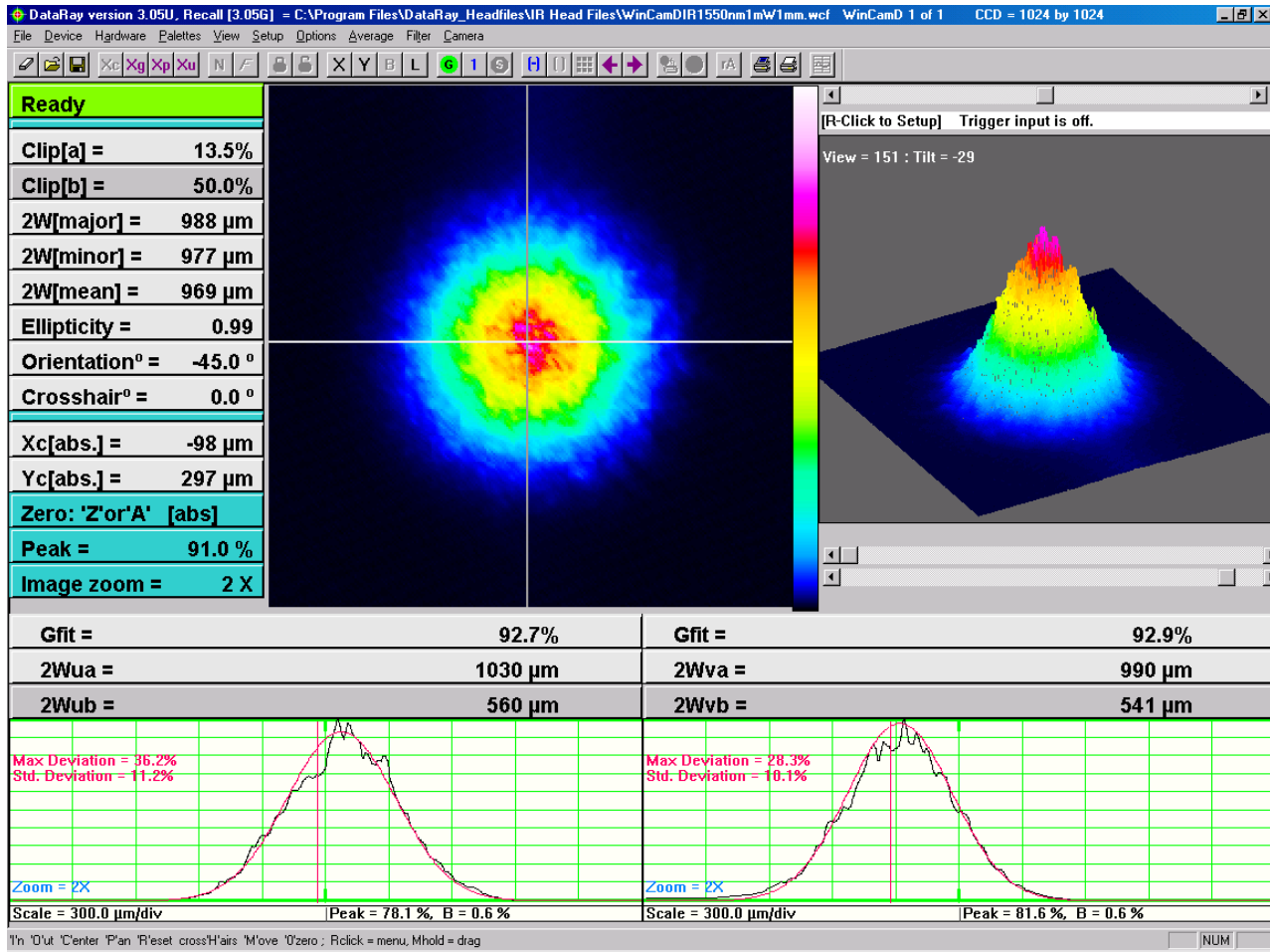
- **Long-Pass Filter Option.** DataRay provides the WinCamD-UCD12-1310 camera with an angle-mounted, C-mount WCD-LPF1290 custom long pass filter, with  $\geq 80\%$  transmission above 1295 nm, 50 % transmission at 1290 nm, 1% transmission at 1285 nm, fully blocked below 1250 nm.

This filter provides very effective blocking of visible light, e.g. ambient light or laser pump signal. It has a custom construction to minimize fringing effects, but can still lead to some fringing due to internal reflections in the filter sandwich and between the filter rear surface and the CCD. Filters with lower cut-on wavelengths can be obtained to special order.

- **Exposure Time.** Use the graph below to estimate the required exposure time for your beam.
- **Maximum Beam Power.** Note the red line indicating to the maximum power of 100 mW allowed on the CCD. Above this level, you must use sampling or attenuation to reduce the beam power.



## WinCamD-NIR: Economical Telecom beam profiling, 1475 to 1600 nm



### WinCamD-NIR & TaperCamD-NIR for Telecom C & L bands

- 1475 - 1600 nm, IR phosphor-on-Silicon CCD
- 25 μm FWHM point spread function due to phosphor
- ±10% spatial response non-uniformity due to phosphor
- ~20 μW to 100 mW, for 1 mm diam. @1550 nm. (With 0.02% transmission (1550 nm) ND filter)  
e.g. 10 ms exposure on 1 mW, 1 mm diameter beam at 1550 nm.
- **Gamma:** Signal = (Incident Irradiance)<sup>γ</sup> where γ = 1.414. Gamma (γ) correction is included in the software.

