Universal Streak Camera C10910 Series

UV to near-infrared measurement with 1 ps temporal resolution

The streak camera is an ultrahigh-speed detector which captures light emission phenomena occurring in extremely short time periods. In addition to superb temporal resolution, the streak camera can capture spatial (or spectral) data simultaneously.

The C10910 series is a universal streak camera which incorporates all of the specialized technology and expertise that HAMAMATSU acquired over 20 years of research. The streak tubes are manufactured on a regular production schedule at Hamamatsu to provide consistency and reliability. Special requests and custom designs are also available.

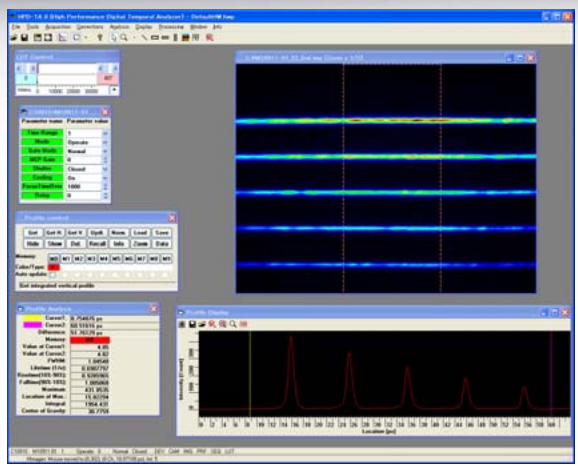
Applications

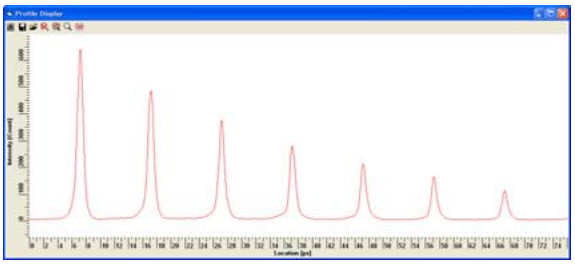
- **Fluorescence lifetime measurement, transient absorption measurement, time-resolved Raman spectroscopy**
- **Optical communications, response measurement of quantum devices**
- **Measurement of electron bunch for synchrotron and LINAC applications**
- **Research involving free electron lasers, and various other types of pulsed lasers**
- **Plasma light emission, radiation, laser ablation, combustion and explosions**
- **Lidar Thomson scattering, laser distance measurement**

HAMAMATSU

PHOTON IS OUR BUSINESS

1 ps temporal resolution





A diverse range of experimental setups from single light emitting phenomena to high-speed repeated phenomena in the GHz domain

UV to near-infrared wavelengths

Optimize the streak camera's performance by selecting the appropriate streak tube (light sensor) for desired spectral range.

USB control

Computer control enables remote operation and advanced measurements with ease of use.

Improved S/N with the internal MCP

Simultaneous measurement of light intensity on temporal and spatial (wavelength) axis

Spectrograph can be placed in front of the streak camera to convert the spatial axis to the wavelength. This enables highly efficient time-resolved spectroscopy measurements.

Ultra-high sensitivity (detection of single photons)

The streak tube converts light into electrons which are then multiplied by an electron multiplier. This enables detection of extremely faint light (at the single-photon level).
(See page 8 "The principle of photon counting integration")

Diverse selection of peripheral equipment

System configuration A full lineup of peripheral devices including spectroscopes, optical trigger heads, and expansion units.

Plug-in unit

Function expansion unit

- Horizontal blanking unit M10914-01
- Shift blanking unit M10914-02
- Synchronous blanking unit M10915-01
- Dual time base extender unit M10916-01
- High repetition dual time base extender unit M10916-02

Peripheral equipment

Spectroscope

A11119-01

A11350-04

A11119-02

A11350-14

Main unit, Optics

Input optics

A1976-01

A1974

Main unit
C10910

C10910
Power supply unit

Output optics

A11695-01

A11695-02

Readout system

Readout camera

ORCA-R2
(Standard type)

IEEE1394b

A11771-01

C9300-508
(High frame rate type)

Camera Link

A11771-02

Data analyzer

Plug-in unit

Sweep unit

- Synchroscan unit M10911-01, -02
- Fast single sweep unit M10912-01
- Slow single sweep unit M10913-01

The C10910 streak camera includes a choice of streak tube detectors and a variety of plug-in options for optimum performance.

Main unit

Main unit C10910

Type number	C10910-01	C10910-02	C10910-04	C10910-05
Photocathode	S-20	S-1	S-25	S-20ER
Interface	USB2.0			
Power supply	AC 100 V to AC 240 V, 50 Hz / 60 Hz			
Power consumption	Approx. 200 VA			
Weight	Approx. 19 kg			

<Photo cathode cooling option>

Type number	M11748
Cooling temperature	approx. 0 ℃

<Streak tube lineup>

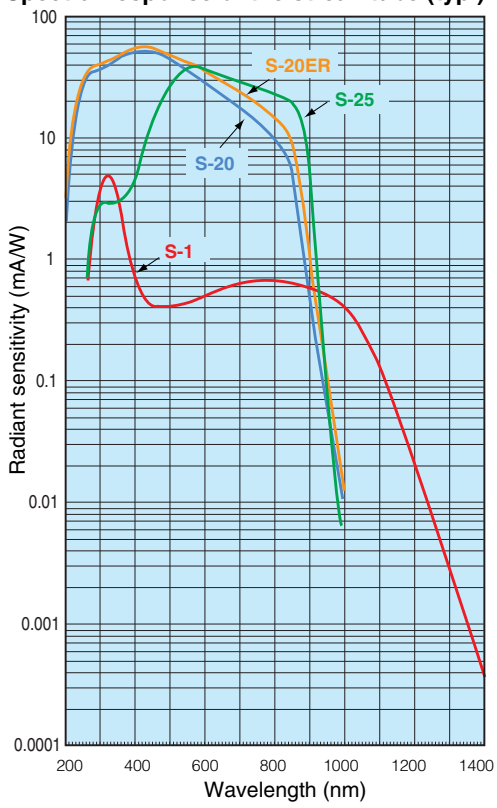
Photocathode	S-20	S-1	S-25	S-20ER
Spectral response characteristic	200 nm to 850 nm	300 nm to 1600 nm	280 nm to 920 nm	200 nm to 900 nm
Effective photocathode size	0.15 mm × 4.42 mm (when coupled with ORCA-R2 CCD camera)			
MCP gain	> 3×10^3			
Phosphor screen	·Phosphor characteristic P-43 ·Fiber-optic output ·Effective phosphorscreen size ϕ18 mm			
Spatial resolution	better than 40 lp/mm (center of photocathode, wavelength 530 nm)			

* Please contact us if you need further information.

<Gate function>

Gating method	MCP + horizontal blanking	MCP + horizontal blanking + photocathode
Gate extinction ratio	1:10^6 min	1:10^8 min
Gate time	50 ns to continuous	
Gate trigger input	TTL / 50 Ω	
Gate trigger delay time	300 ns max.	
Horizontal blanking repetition frequency (Max.)	4 MHz	
MCP gate repetition frequency (Max.)	10 kHz	
Photocathode gate repetition frequency (Max.)	10 kHz	

Spectral response of the streak tube (typ.)

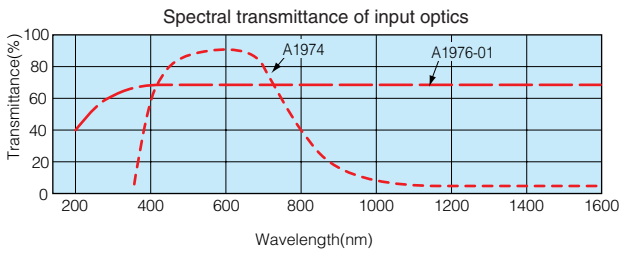


Optics

Input optics

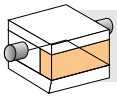
Type number	A1976-01	A1974
Spectral transmission	200 nm to1600 nm	400 nm to 900 nm
Effective F value	5.0	1.2
Image multiplication ratio	1 : 1	
Slit width	0 mm to 5 mm	
Slit width reading precision	5 µm	
Overall length	98.2 mm	159 mm

Spectral transmittance of input optics



Output optics

Type number	A11695-01	A11695-02
Image multiplication ratio	1:0.7 (50 mm:35 mm)	2:1 (105 mm:50 mm)
Effective F value	2.0	2.8
Lens mount	F-mount	F-mount
Corresponding camera	ORCA-R2	C9300-508



Sweep unit
(connected to side panel of main unit)

Synchroscan unit M10911-01, -02

Sweep unit for high-sensitivity and high temporal resolution measurements when synchronized with a high-repetition laser such as a mode-locked Ti-sapphire laser.

Type number	M10911-01	M10911-02
Temporal resolution *1	< 1 ps FWHM	< 2 ps FWHM
Sweep time *2	Approx. 100 ps to 1/6 fs	Approx. 200 ps to 1/6 fs
Sweep range	5 selectable ranges	3 selectable ranges
Synchroscan frequency	Selectable from 75 MHz to 165 MHz	250 MHz
Synchronous frequency range	fs ±0.2 MHz	
Trigger jitter	Temporal resolution or less	
Trigger signal input	–3 dBm to +17 dBm / 50 Ω	
Trigger delay tuneup	> 360 degree	

*1 At the center of window at 800 nm wavelength
NOTE: The figure does not include phase noise of the light source or temporal broadening by a spectrograph. The time resolution changes as following values when using the C10910-04(S-25).

Type number	M10911-01	M10911-02
Temporal resolution	< 4 ps FWHM	< 4 ps FWHM

*2 fs = synchroscan frequency

Fast single sweep unit M10912-01

High-speed sweep plug-in unit designed for high resolution single-shot measurements, but can also trigger up to 10 kHz at lower resolutions.

Type number	M10912-01
Temporal resolution *1	< 1 ps FWHM
Sweep time	0.1 ns to 50 ns / full (with ORCA-R2)
Trigger jitter	<10 ps rms
Trigger delay	Approx. 10 ns (fastest sweep range)
Sweep repetition frequency (Max.))	10 kHz
Trigger signal input	± 5 V/50 Ω
Monitor out signal	3 Vp-p (typ.)

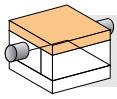
*1 At the center of window at 800 nm wavelength
NOTE: The figure does not include phase noise of the light source or temporal broadening by a spectrograph. The time resolution changes as following values when using the C10910-04(S-25).

Type number	M10912-01
Temporal resolution	< 4 ps FWHM

Slow single sweep unit M10913-01

A sweep unit for randomly triggered or single-shot measurements of slower phenomena.

Type number	M10913-01
Temporal resolution	<20 ps FWHM
Sweep time	1.2 ns to 1 ms / full (with ORCA-R2)
Trigger jitter	Temporal resolution or more
Trigger delay	Approx. 40 ns (fastest sweep range)
Sweep repetition frequency (Max.)	4 MHz (fastest sweep range)
Trigger signal input	± 5 V / 50 Ω
Monitor out signal	3 Vp-p (typ.)



Function expansion unit
(connected to top of main unit)

Horizontal blanking unit M10914-01

The standard unit for return sweep blanking during single-sweep operation. For return sweep blanking in synchroscan operation, refer to M10914-02 or M10915-01.

Type number	M10914-01
Sweep repetition frequency (Max.)	4 MHz

Shift blanking unit M10914-02

For use in combination with synchroscan and pulse picker or regen amplifier, For applications such as fast picosecond risetime or lifetime decay of data which may include residual light extending beyond the synchroscan's return sweep, e.g. nanoseconds to milliseconds.

Type number	M10914-02
Sweep repetition frequency (Max.)	10 kHz
Trigger signal input	± 5 V/50 Ω
Blanking time (Max.)	10 µs

* Patented

Synchronous blanking unit M10915-01
(With M10911-01 Synchroscan unit)

Extends the performance of synchroscan operation by synchronously blanking the return sweep. For applications such as high-repetition light in the GHz range, or for picoseconds risetime and lifetime decay measurements on data which includes residual light beyond a few nanoseconds, but less than the synchroscan's sweep period (e.g. < 10 ns).

Type number	M10915-01
Synchroscan frequency	Selectable from 75 MHz to 165 MHz
Horizontal shift width	3 mm or 13 mm (at phosphor screen)

Dual time base extender unit M10916-01
(Can be used with all sweep units)

For simultaneous dual-sweep operation and single channel pinhole input. Compatible with all sweep plug-in units, the M10916-01 extender unit provides slower time axis in a perpendicular axis, e.g. simultaneous high-speed vertical sweep and horizontal slower sweep. For applications such as bunch length measurements or phase stability in synchrotrons.

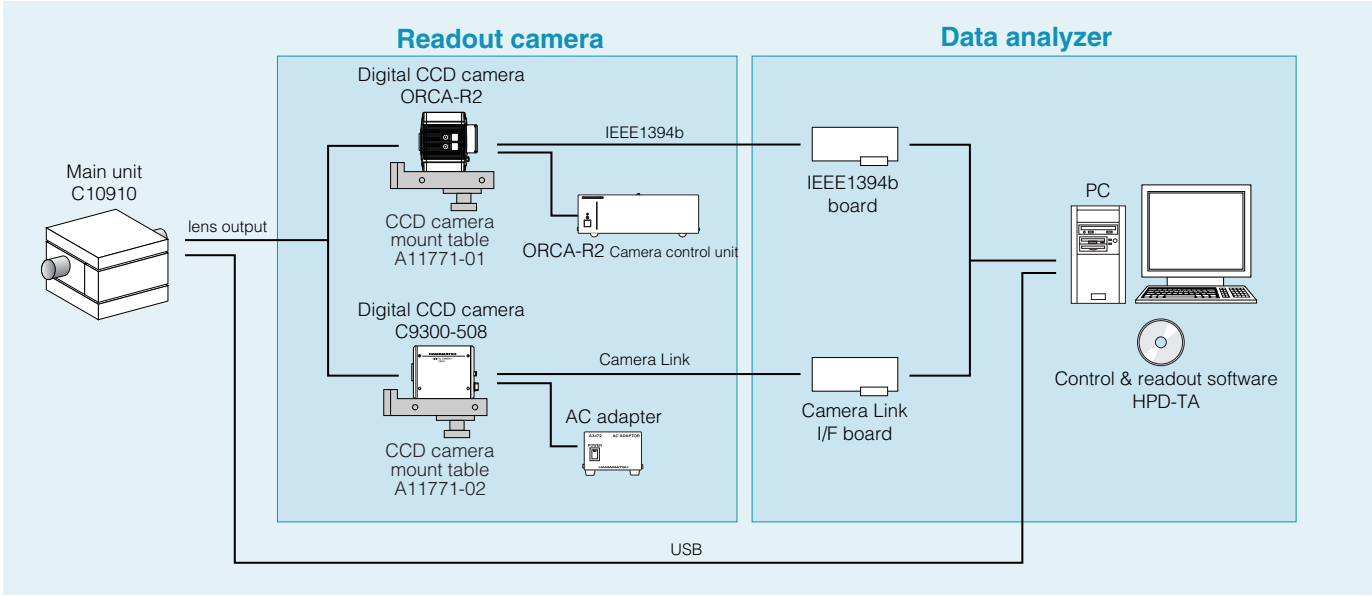
Type number	M10916-01
Sweep time	100 ns to 100 ms / full (with M10911-01, -02, with ORCA-R2) 1 ms to 100 ms / full (with M10912-01, with ORCA-R2) 2 µs to 100 ms / full (with M10913-01, with ORCA-R2)
Sweep repetition frequency (Max.)	10 Hz
Trigger signal input	± 5 V/50 Ω
Monitor out signal	3 Vp-p (typ.)

High repetition dual time base extender unit M10916-02

High repetition version of the M10916-01. Enables higher-repetition frequency measurements for applications such as photon correlation.

Type number	M10916-02
Sweep time	100 ns, 200 ns, 500 ns / full(with ORCA-R2)
Sweep repetition frequency (Max.)	10 kHz
Trigger signal input	± 5 V/50 Ω
Monitor out signal	3 Vp-p (typ.)

Readout system



Readout camera

Digital CCD camera ORCA-R2

Recommended readout camera for universal applications, including single-shot, analog and photon counting integration.

Type number	ORCA-R2 (C10600-10B)
Effective number of pixels	1344 (H) × 1024 (V)
Cell size	6.45 µm (H) × 6.45 µm (V)
Effective area	8.67 mm (H) × 6.60 mm (V)
Working area on phosphor screen	12.39 mm (H) × 9.43 mm (V)
Working size of photocathode	Approx. 4.42 mm (H)
Exposure time	10 µs to 4200 s
Readout speed	28.4 frames/s (2×2 binning / fast scan mode)
A/D converter	12 bit /16 bit

CCD camera mount table (for ORCA-R2) A11771-01

Digital CCD camera C9300-508

Readout camera optimized for rapid photon counting operation.

Type number	C9300-508
Effective number of pixels	640 (H) × 480 (V)
Cell size	7.4 µm (H) × 7.4 µm (V)
Effective area	4.74 mm (H) × 3.55 mm (V)
Working area on phosphor screen	9.95 mm (H) × 7.46 mm (V)
Working size of photocathode	Approx. 3.55 mm (H)
Exposure time	33.1 µs to 1 s
Readout speed	150 frames/s (1×1 binning)
A/D converter	12 bit

CCD camera mount table (for C9300-508) A11771-02

Data analyzer

Control & readout software HPD-TA

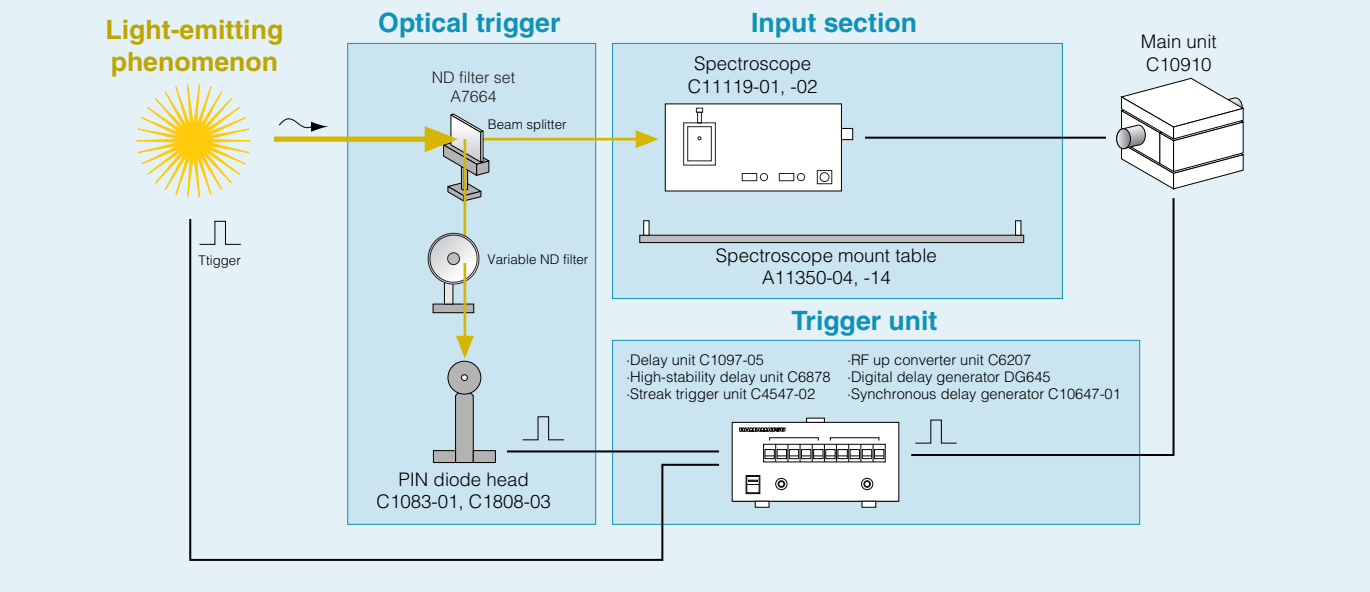
The HPD-TA is a high-performance digital data acquisition and control system specifically designed to read out images from the streak camera's phosphor screen.

The HPD-TA allows the remote control of the C10910 via USB interface. The entire system is controlled through a powerful but user friendly software application that runs on a Microsoft Windows platform.

Data acquisition	Live mode, analog integration photon counting, sequence recording
Device control	C10910, CCD camera, spectrograph, delay units
Profile functions	Real-time display, min/max, FWHM, Gauss fit
Data corrections	Background, sensitivity, curvature, jitter
Axis calibration	Channel, time, wavelength
File formats (images)	Binary (up to 32 bits), TIFF, ASCII
File format (profiles)	ASCII

* Computer environment

The HPD-TA requires an industry-standard PC with Microsoft Windows. A high-resolution graphics configuration is recommended. Depending on the streak system configuration, a number of PCI or PCIe slots as well as some USB ports may be required.



Input section

●Spectroscope C11119-01, -02

The combination with streak camera enables to measure wavelength, time and light intensity simultaneously.

The following are needed in order to connect these units to the C10910:

- Spectroscope mounting table
- Light source for wavelength axis calibration (mercury lamp, etc.)

Type number	C11119-01	C11119-02
Optical layout	Czerny-Turner model (with toroidal mirror for aberration correction)	
Focal distance	300 mm (Collimate side) 338 mm (Focus side)	300 mm
F value	3.9	
Incident light slit width	Variable between 10 µm to 3 mm	
Grating	2 (Additional turret/grating available)	3 (Additional turret/grating available)
Reciprocal dispersion	2.20 nm/mm (when using 1200 gr/mm)	2.38 nm/mm (when using1200 gr/mm)
Dimenstions/weight	(W)374 mm x(D)246 mm x(H)208 mm / 13 kg	(W)335 mm x(D)254 mm x(H)203 mm / 15 kg

●Spectroscope mount table A11350-04,-14

A mount table to set up and to fix a streak camera and a spectrograph.

●Fiber-optic input optics (FC Connector) A6368

Fiber-optic input optics can be connected in place of the incident light slit in the C10910.

Optical trigger (PIN diode head)

●PIN diode head C1083-01 (for low repetition)

Used to generate a trigger signal for the streak camera with lasers with low repetition rates.

Type number	C1083-01
Spectral response	400 nm to 1100 nm
Risetime	0.8 ns
Dimensions/ weight	Head: (W)100 mm ×(D)50 mm ×(H)160 mm to 235 mm / 400 g
	Power supply unit: (W)100 mm ×(D)100 mm ×(H)83 mm / 400 g
Power supply	+18 V (battery)

●PIN diode head C1808-03 (for high repetition)

Used to generate a synchronization signal for the streak camera with mode-locked lasers.

Type number	C1808-03
Minimum input level	1 mW (f=80 MHz, λ=800 nm, FWHM<1 ps)
Saturation output level	Approx. 1.5 Vp-p (50 Ω)
Frequency band	<100 MHz
Power supply	AC100 V to AC240 V, 50 Hz / 60 Hz

●ND filter set A7664

The adjustment tool of input light intensity for C1808-03. A variable ND filter and a laser beam splitter are included.

Trigger units

Delay unit C1097-05

A jitter-free delay unit that can be used for single-sweep as well as synchroscan setups.

Type number	C1097-05
Variable delay range	0 ns to 31.96 ns
Delay setting range	30 ps, 60 ps, 120 ps, 250 ps, 500 ps, 1 ns, 2 ns, 4 ns, 8 ns, 16 ns
Minimum delay time	Approx.12 ns
Maximum input voltage	30 V
Interface	USB2.0
Power supply	AC85 V to AC250 V
Power consumption	Approx. 30 VA
Dimensions / weight	(W)215 mm × (D)350 mm × (H)102 mm / 3.4 kg

RF up converter unit C6207

Generates 100 MHz output signal synchronized with 10 MHz input signal. Can be used to stably synchronize a synchroscan unit by inputting the reference output signal of a commercially available frequency synthesizer.

Type number	C6207
Input signal frequency	10 MHz ±10 Hz
Input level	-10 dBm to 0 dBm / 50 Ω
Output frequency	100 MHz
Output signal level (typ.)	3 dBm / 50 Ω
Timing jitter	< 1 ps rms
Power supply	AC100 V to AC240 V, 50 Hz/60 Hz
Power consumption	Approx. 20 VA
Dimensions / weight	(W)262 mm × (D)330 mm × (H)74 mm / 3.2 kg

Synchronous delay generator C10647-01

When using a Ti-Sapphire laser in conjunction with a pulse picker, this unit generates low-jitter trigger signals synchronized with the laser repetition rate.

Type number		C10647-01
Mode-lock IN	Input signal frequency	10 MHz to 200 MHz
	Input signal level	0 dBm to 15 dBm
	Impedance	50 Ω
TRIG.IN	Input signal frequency	0 MHz to 16 MHz
	Input signal level	+0.25 V to +3 V
	Impedance	50 Ω / High Z (10 kΩ)
OUTPUT A	Output signal level	2 V
	Impedance	50 Ω
OUTPUT B, C, D	Output signal level	2.5 V
	Impedance	50 Ω
Operation mode		Internal, External, Dump
Dimensions / weight		(W)333 mm × (D)262 mm × (H)74 mm / 3.2 kg

High stability delay unit C6878

Used in combination with a synchroscan unit M10911-01,-02, the C6878 is used to adjust the phase of the synchronization signal. In addition, the phase can be stabilized, thereby allowing the stable acquisition of streak images over a long period of time.

Type number		C6878
Input signal	Input	Input signal frequency : 75 MHz to100 MHz
		Input level : 0 dBm to +10 dBm
	Ref.in	Input level : -10 dBm to +10 dBm
Output signal level		-3 dBm to +10 dBm
Valuable delay range		Phase angle : 360 °
Power supply		AC100 V to AC240 V, 50 Hz/60 Hz
Power consumption		Approx. 50 VA
Dimensions / weight		(W)261 mm × (D)331 mm × (H)98.5 mm / 4.6 kg

* Patented

Streak trigger unit C4547-02

Convert external trigger signal to gate trigger and streak trigger signal, and provide them to a single sweep unit. Dividing function enables to operate an external trigger that is faster than the sweep frequency of a single sweep unit.

Type number	C4547-02
Input signal frequency	10 MHz to 200 MHz
Input level	0 dBm to 15 dBm / 50 Ω
Output signal level	3 Vp-p/50 Ω
Output frequency	1 Hz to 100 kHz (variable)
Dimensions / weight	(W)262 mm × (D)333 mm × (H)74 mm / 2.5 kg

Digital delay generator DG645

The DG645 is a general-purpose delay generator that matches the streak camera timing with the pulsed laser timing, mainly for slower streak times.

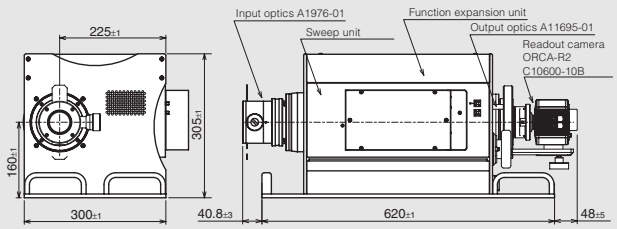
Type number	DG645
Number of output channels	4 ch (AB, CD, EF, GH output terminal)
Output level	0.5 V to 5.0 V / 50 Ω
Variable delay range	0 ps to 2000 s
Delay resolution	5 ps
Internal delay time	85 ns
Repetition rate	Single to 10 MHz
Jitter	< 25 ps rms
Interface	GPIB/RS-232C
Dimensions / weight	(W)216 mm × (D)330 mm × (H)89 mm / 4.1 kg

Other

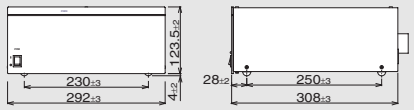
Other peripheral devices may also be available. Please feel free to consult with HAMAMATSU.

Dimensional outlines (Unit : mm)

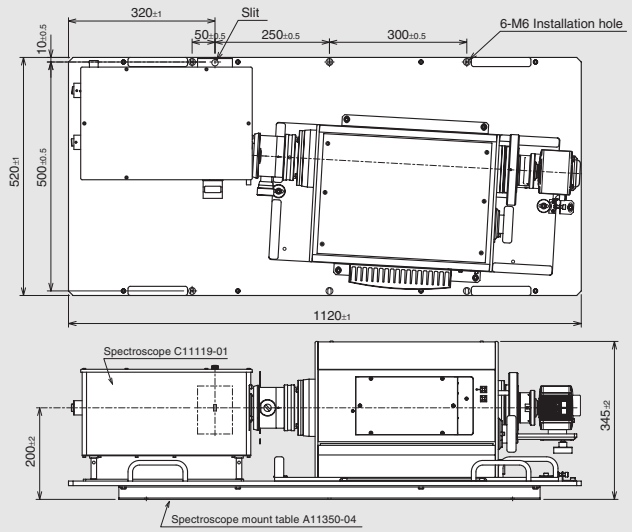
Main unit C10910 (Approx.19.0 kg)



Power supply unit C10910 (Approx. 5.9 kg)

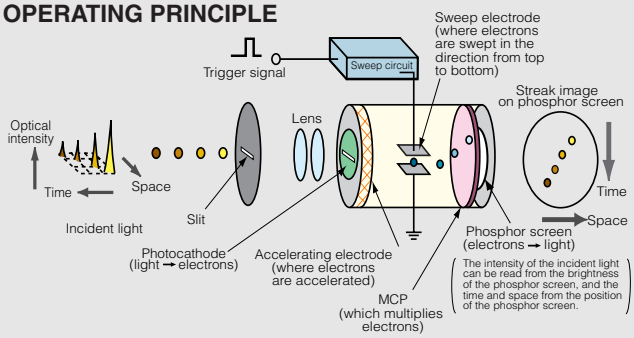


Main unit C10910 + Spectroscope + Mount table



Operating principle

OPERATING PRINCIPLE



The light pulse to be measured is projected onto the slit and is focused by the lens into an optical image on the photocathode of the streak tube. Changing the temporal and spatial offset slightly each time, four light pulses, each with a different light itensity, are introduced through the slit and conducted to the photocathode.

Here, the photons are converted into a number of electrons proportional to the intensity of the incident light. The four light pulses are converted sequentially to electrons which are then accelerated and conducted towards the phosphor screen.

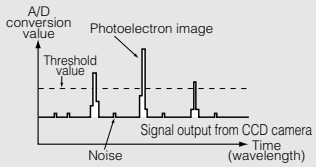
As the group of electrons created from the four light pulses passes between a pair of sweep electrodes, a high voltage is applied (see above), resulting in a high-speed sweep (the electrons are swept in the direction from top to bottom). The electrons are deflected at different times, and at slightly different angles in the perpendicular direction, and are then conducted to the MCP (micro-channel plate).

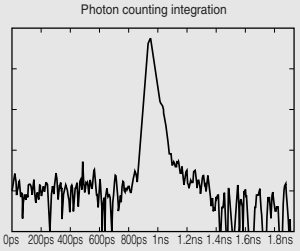
As the electrons pass the MCP, they are multiplied several thousands of times and are then bombarded against the phosphor screen, where they are converted back into light.The fluorescence image corresponding to the first incident light pulse is positioned at the top of the phosphor screen, followed by the others, with images proceeding in descending order; in other words, the axis in the perpendicular direction on the phosphor screen serves as the temporal axis. The brightnesses of the various fluorescence images are proportional to the intensities of the corresponding incident light pulses. The positions in the horizontal direction on the phosphor screen correspond to the positions of the incident light in the horizontal direction.

THE PRINCIPLE OF PHOTON COUNTING INTEGRATION

Photoelectrons given off from the photocathode of the streaktube are multiplied at a high integration rate by the MCP, and one photoelectron is counted as one intensity point on the phosphor screen. A threshold value is then used with this photoelectron image to clearly separate out noise.

Separation of photoelectron image and noise





Light source: PLP (λ =800 nm)
Integration time: 1 min

Positions in the photoelectron image which are above the threshold value are detected and are integrated in the memory, enabling noise to be eliminated completely. This makes it possible to achieve data measurements with a high dynamic range and high S/N.

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