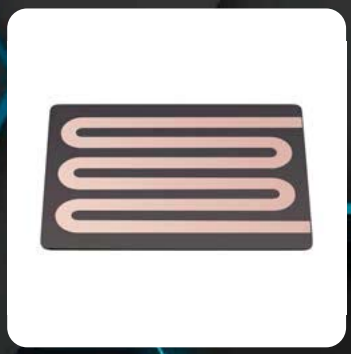
BASPIK
Microchannel technologies



PRODUCT CATALOGUE

MCP for night vision technology

MCP for science and technology

MCP detectors

Secondary electron multipliers

Photomultiplier tubes

ABOUT COMPANY

Vladikavkaz Technology Center BASPIK (VTC BASPIK) is an exclusive leader of the Russian Federation in the field of research, development and manufacturing of microchannel plates and one of the few global large-scale manufacturers in this field.

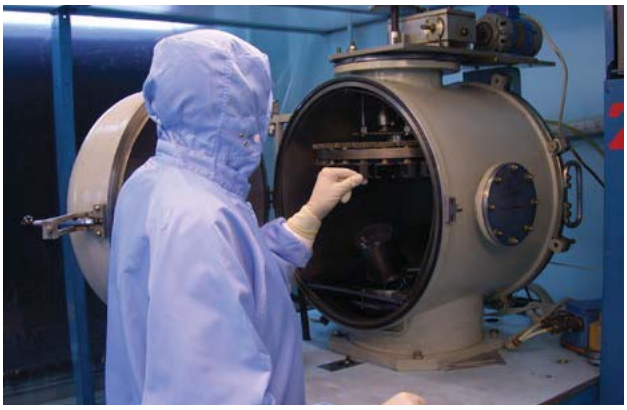
The company produces

- microchannel plates for night vision devices
- microchannel plates for scientific instruments
- Position-sensitive MCP detectors
- secondary electron multipliers
- image intensifier tubes
- photomultiplier tubes (PMT)
- microchannel and microwell structures
- other electro-optical devices

The company has mastered the manufacturing of microchannel plates with 4, 5, 6, 8, 10 μm

channels of different designs: circular, square, rectangular, with a central hole, complex configurations and different dimensions.

Channel diameter spread is no more than 1%.

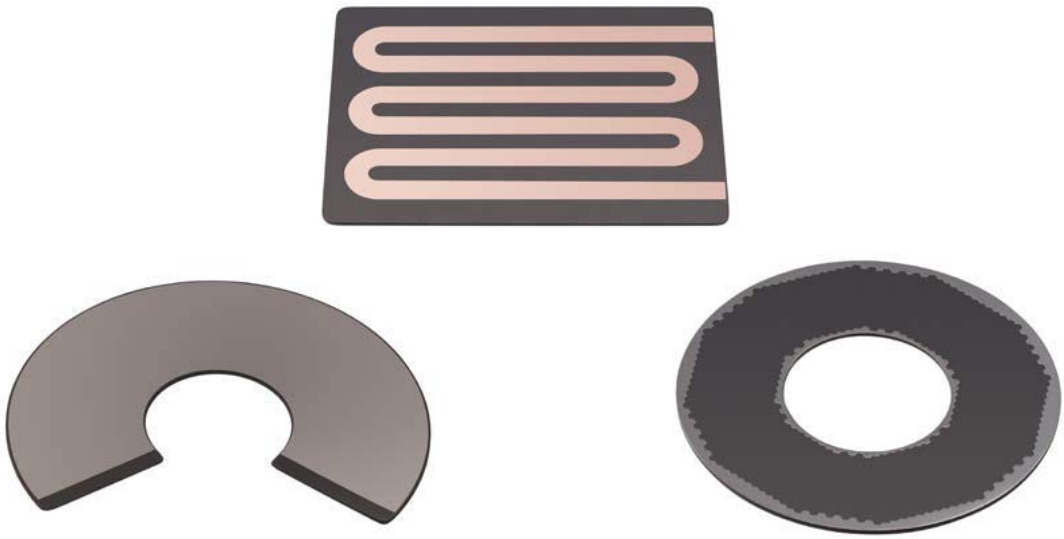


For 25 years VTC BASPIK has been a reliable supplier for several major Russian and foreign manufacturers in various industries.

MICROCHANNEL PLATES (MCP) - A CLASS OF ELECTRONIC PRODUCTS (COMPONENTS)

Each plate consists of millions of ultra-thin conductive glass capillaries, each acting as an independent secondary electron multiplier. Providing two-dimensional electron multiplication capability, MCP is a critical component of image intensifier tubes.

These devices are designed to detect and amplify spatially organized fluxes of charged particles and radiation. Due to their high ion sensitivity, subnanosecond response time, and compact size, MCPs are also widely used in various applications such as time-of-flight mass spectrometry.



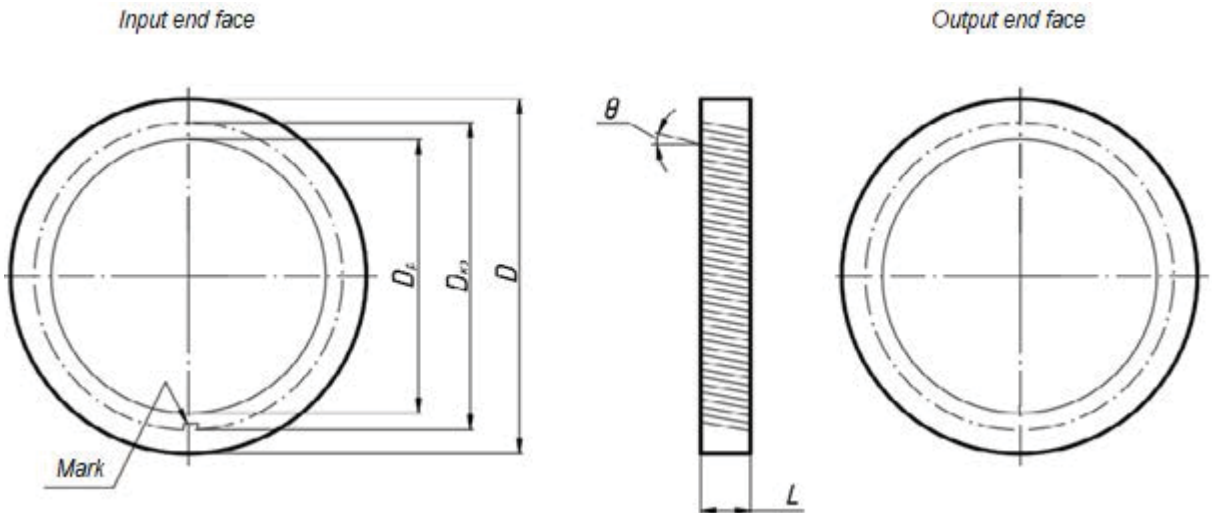
MICROCHANNEL PLATES BEING A PART OF NIGHT VISION DEVICES

The main application of microchannel plates (MCPs) is night vision devices

MCP properties determine parameters of night vision device to a great extent.

Extended Specification

MCP for night vision technology



24.8 mm microchannel plates

Parameter, unit	Microchannel plate type								
	Rimmed MCP 18-3	Rimmed MCP 18-4	Rimmed MCP 18-5	Rimmed MCP 18-6	Rimmed MCP 18-6 A	Rimmed MCP 18-8	Rimmed MCP 18-8 A	Rimmed MCP 18-10	Rimmed MCP 18-10 A
	Номинальное значение								
Geometrics									
Outer diameter D, mm	24.85	24.8	24.75–24.85						
Active area diameter, D_A, mm, min	18.8	18.6							
Contact electrode diameter, $D_{C.E.}$, mm	23.7								
Thickness L, mm	0.2–0.25	0.300±0.015				0.320±0.015		0.41-0.44	
Channel bias angle θ, degrees	8°	5°		5°	12°	5°	12°	5°	12°
End surface flatness tolerance, mm	0.03	0.025	0.02	0.03					
End surface flatness tolerance, mm	0.01								

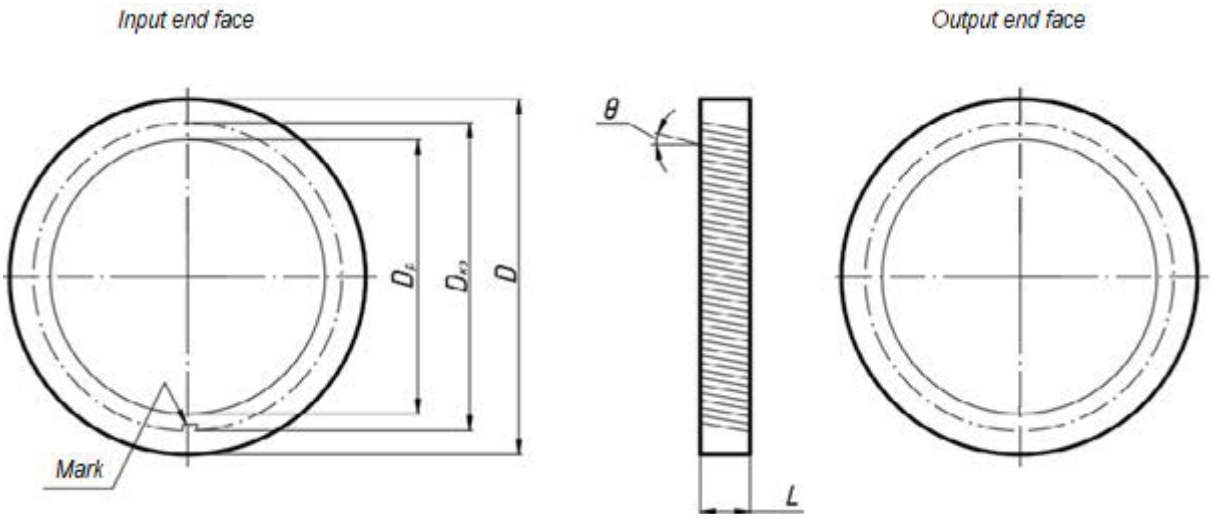
Parameter, unit	Microchannel plate type								
	Rimmed MCP 18-3	Rimmed MCP 18-4	Rimmed MCP 18-5	Rimmed MCP 18-6	Rimmed MCP 18-6 A	Rimmed MCP 18-8	Rimmed MCP 18-8 A	Rimmed MCP 18-10	Rimmed MCP 18-10 A
	Номинальное значение								
Solid rim width, mm, min	1.6								
Rounding width (chamfer), mm	от 0.014 до 0.18 0.18 max								
Structural parameters									
Channel diameter, μm	3.4–3.6	4.4–4.9	5.0–5.5	5.5–6.5		7.0–8.0		9.5–10.5	
Channel pitch, μm, max	5.0	5.0–6.0	7.0	8		9.5		12.4–12.9	
Contact electrode material	Хром								
The mark indicates channel bias direction	Вход								
Electrical ratings									
Operating voltage at 10^3 gain, V, max	1000	950	850	850				800	
Nominal voltage at 10^4 gain, V, max		1250	1100	1150				1100	
MCP resistance $\times 10^8$ Ohm	0.3–1.0	0.5–2.5	0.8–1.5	1–3				1–2.5	
Dark current density, A/cm^2, max	2.2×10^{-13}	1.6×10^{-13}	2.2×10^{-13}	2.2×10^{-13}					
Limiting resolution, lp/mm, min	85			80		60		45	

32.8 mm microchannel plates

P arameter, unit	Microchannel plate type						
	Rimmed MCP 25-3	Rimmed MCP 25-6	Rimmed MCP 25-6 A	Rimmed MCP 25-8	Rimmed MCP 25-8 A	Rimmed MCP 25-10	Rimmed MCP 25-10 A
	Nominal values						
Geometrics							
Outer diameter D, mm	32.75–32.85						
Active area diameter, D_A, mm, min	26						
Contact electrode diameter, $D_{C.E.}$, mm, min	31.7						
Thickness L, mm	0.26	0.285–0.315		0.305–0.335		0.40–0.44	
Channel bias angle θ, degrees	5±1		12±1	5±1	12±1	5±1	12±1
End surface flatness tolerance, mm, max	0.05			0.03	0.05		
End surface parallelism tolerance, mm, max	0.01						
Solid rim width, mm, min	1.6						
Rounding width (chamfer), mm,	0.18 max						
Structural parameters							
Channel diameter, μm	3.4	5.5–6.5		7.0–8.0		9.8–10.8	
Channel pitch, μm, max	4,2	8		9,5		12.9	
Contact electrode material	Хром						
The mark indicates the direction of the channel bias	Вход						
Electrical ratings							
Operating voltage at 10^3 gain, V, max	-	850		800		-	
Nominal voltage at 10^4 gain, V, max	-	1100		1100		-	
Gain at 800 V voltage	-					Не менее 2500	
Gain at 1100 V voltage	1000	-					
MCP resistance, $\times 10^8$ Ohm	1–3	0.8-3.0		0.8–3.0	0.7–2.5	0.75–2.5	
Dark current density, A/cm², max	2.2×10^{-12}	2.2×10^{-13}					
Limiting resolution, lp/mm, min	-	70		60	45		

Specification

Rimmed microchannel plate MCP 18-5



As part of image intensifier tube for night vision technology

Electrical and electro-optical parameters

Parameter	Unit	Value
Gain at 1100 V	-	10^4
MCP resistance	$\times 10^8$ Ohm	0.8–1.5
Dark current density	$\times 10^{-13}$ A/cm^2	2.2
Limiting resolution	lp/mm	86 min

Geometrics

Plate thickness	Unit	Value
Outer diameter	mm	24.85
Active area	mm	18.6
Plate thickness	mm	0.300±0.015
Channel diameter	μm	5.0–5.5
Channel pitch	μm	7
Channel bias angle	degree	5°

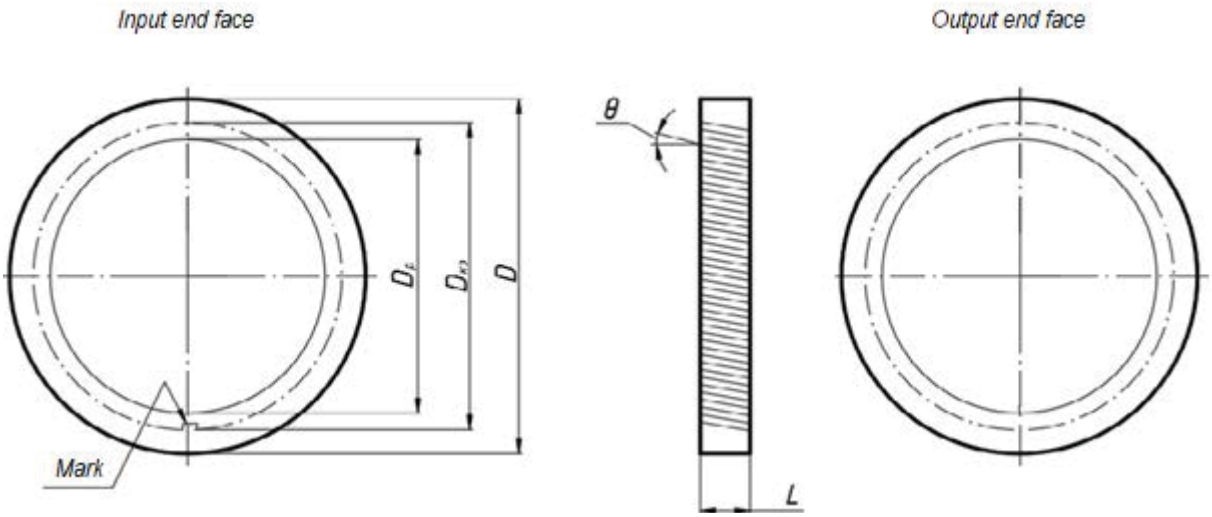
Minimum operating life:

10000 hours minimum as part of the application device

Some items of the specification can be changed according to the customer's requirements

Specification

Rimmed microchannel plate MCP 18-6



As part of image intensifier tube for night vision technology.

Electrical and electro-optical parameters

Parameter	Unit	Value
Gain at 1150 V	-	10^4
MCP resistance	$\times 10^8$ Ohm	1.0–1.5
Dark current density	$\times 10^{-13}$ A/cm^2	2.2
Limiting resolution	lp/mm	80 min

Geometrics

Parameter	Unit	Value
Outer diameter	mm	24.85
Active area	mm	18.6
Plate thickness	mm	0.300±0.015
Channel diameter	μm	5.5–6.5
Channel pitch	μm	8
Channel bias angle	degree	5°

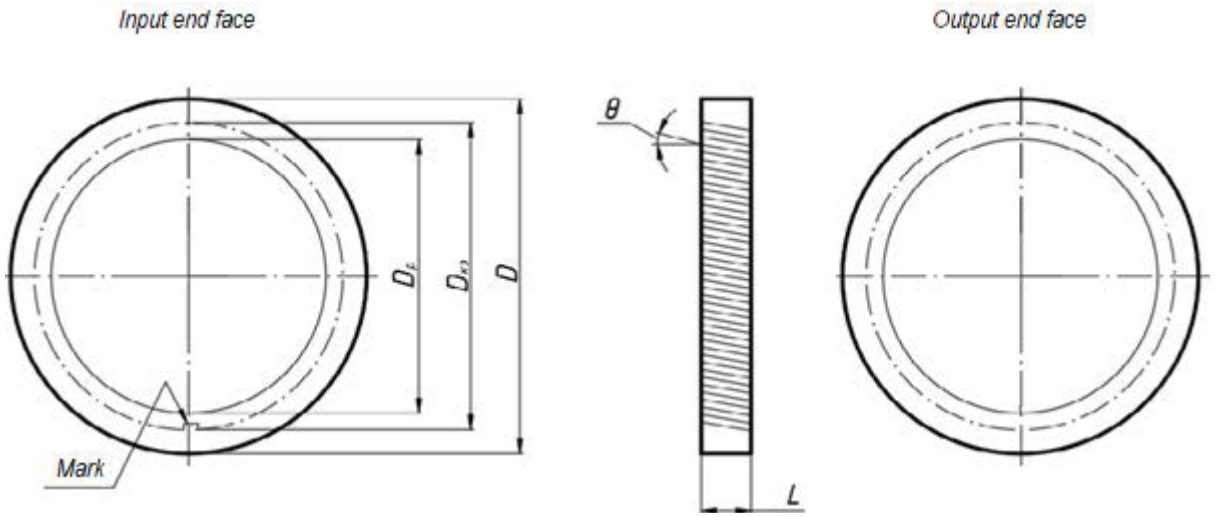
Minimum operating life:

10000 hours minimum as part of the application device

Some items of the specification can be changed according to the customer's requirements

Specification

Rimmed microchannel plate MCP 18-10



As part of image intensifier tube for night vision technology.

Electrical and electro-optical parameters

Parameter	Unit	Value
Gain at 1100 V	-	10^4
MCP resistance	$\times10^8$ Ohm	1.0–2.5
Dark current density	$\times10^{-13}$ A/cm^2	2.2
Limiting resolution	lp/mm	45 min

Geometrics

Parameter	Unit	Value
Outer diameter	mm	24.75–24.85
Active area	mm	18.6
Plate thickness	mm	0.41–0.44
Channel diameter	μm	9.5–10.5
Channel pitch	μm	12.4–12.9
Channel bias angle	degree	5°

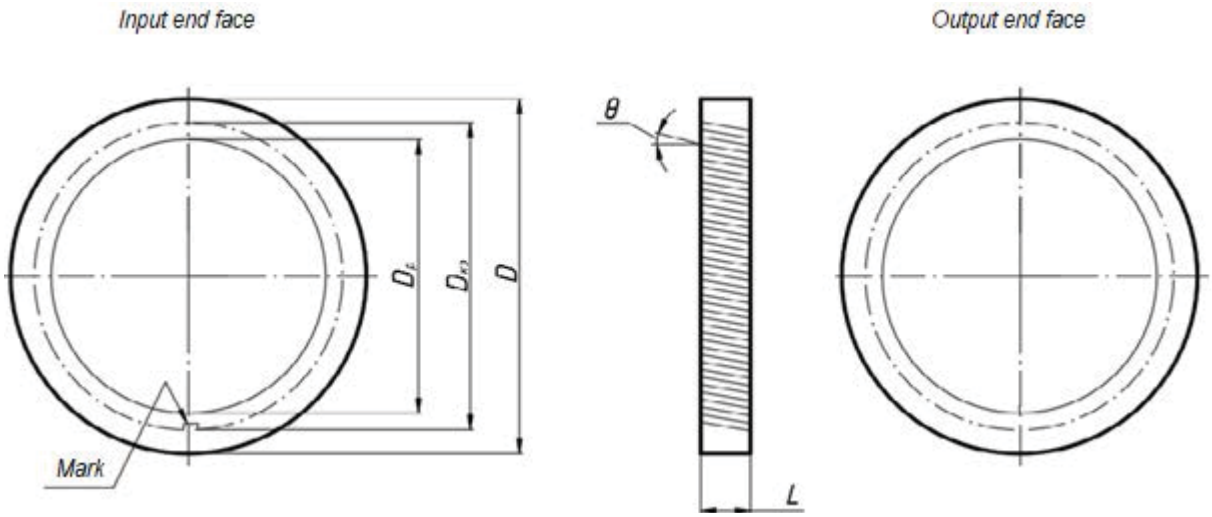
Minimum operating life:

10000 hours minimum as part of the application device

Some items of the specification can be changed according to the customer's requirements

Specification

Rimmed microchannel plate MCP 25-6



As part of image intensifier tube for night vision technology.

Electrical and electro-optical parameters

Parameter	Unit	Value
Gain at 1100 V	-	10^4
MCP resistance	$\times 10^8$ Ohm	0.8–3.0
Dark current density	$\times 10^{-13}$ A/cm^2	2.2
Limiting resolution	lp/mm	70 min

Geometrics

Parameter	Unit	Value
Outer diameter	mm	32.75–32.85
Active area	mm	26
Plate thickness	mm	0.285–0.315
Channel diameter	μm	5.5–6.5
Channel pitch	μm	8
Channel bias angle	degree	5±1°

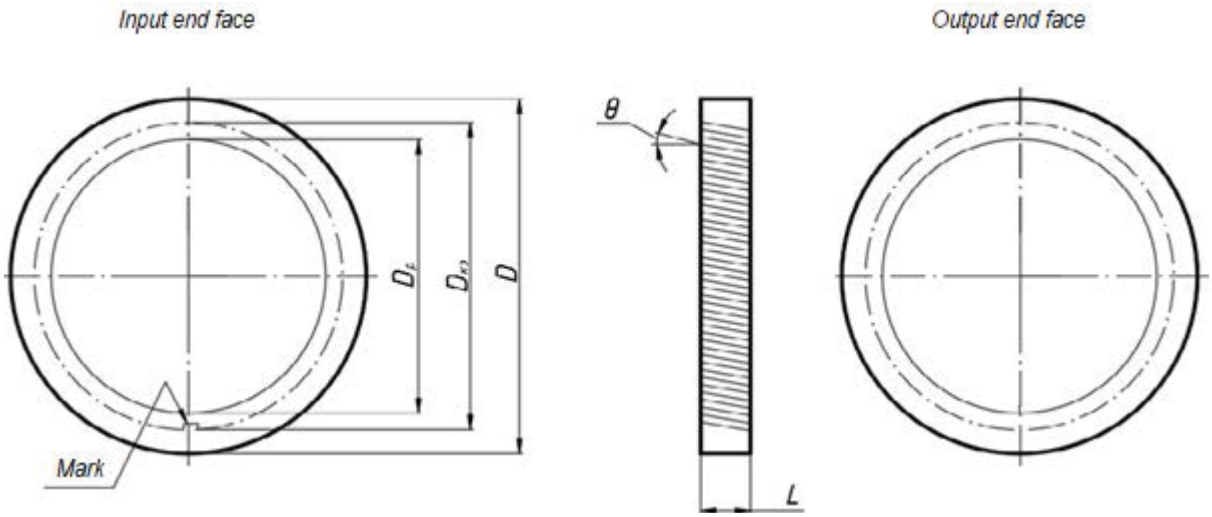
Minimum operating life:

10000 hours minimum as part of the application device

Some items of the specification can be changed according to the customer's requirements

Specification

Rimmed microchannel plate MCP 25-10A



As part of image intensifier tube for night vision technology.

Electrical and electro-optical parameters

Parameter	Unit	Value
Gain at 1100 V	-	10^4
MCP resistance	$\times 10^8$ Ohm	0.75–2.5
Dark current density	$\times 10^{-13}$ A/cm^2	2.2
Limiting resolution	lp/mm	45 min

Geometrics

Parameter	Unit	Value
Outer diameter	mm	32.7–32.85
Active area	mm	26
Plate thickness	mm	0.40–0.44
Channel diameter	μm	9.8–10.8
Channel pitch	μm	12.2–12.9
Channel bias angle	degree	$12^{\pm 1^o}$

Minimum operating life:

10000 hours minimum as part of the application device

Some items of the specification can be changed according to the customer's requirements

MICROCHANNEL PLATES FOR SCIENCE AND TECHNOLOGY

VTC BASPIK manufactures microchannel plates for use as part of various scientific and technical equipment. MCPs are used to amplify weak signals and determine position parameters of particles in a variety of image detectors, as part of photoelectronic and X-ray vacuum devices, field-ion microscopes.

Possible applications for MCPs include:

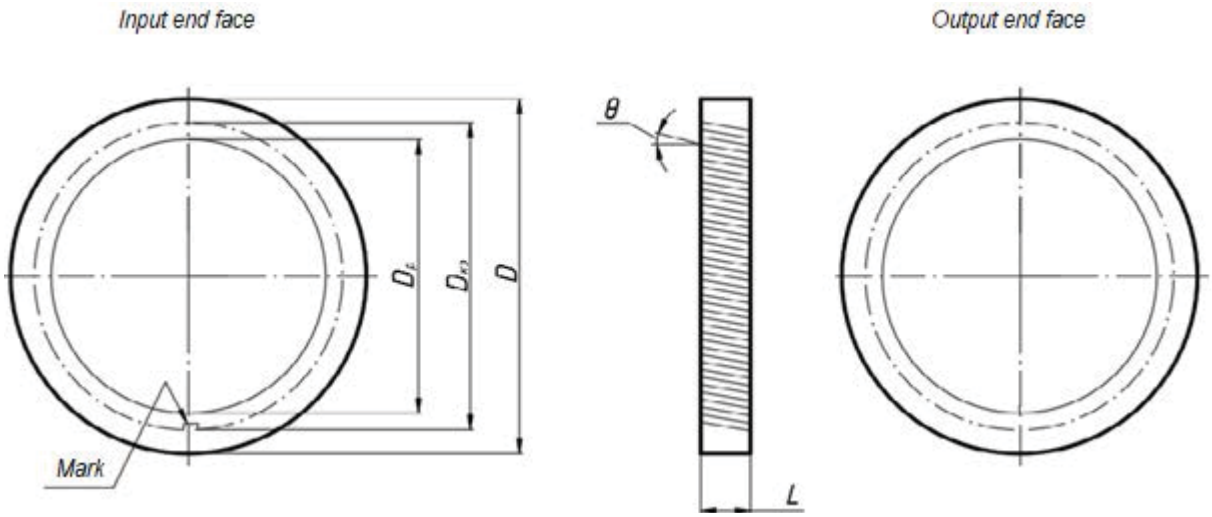
- astronomy
- chemistry
- aerospace engineering
- biology
- machine industry
- medical diagnostics
- experimental physics
- ecology and biosecurity

Research and production capacities of the company allow to complete customized orders for the development of microchannel plates for specific equipment having the required technical parameters in a relatively short time.

Extended Specification

MCP for science and technology

Circular microchannel plates

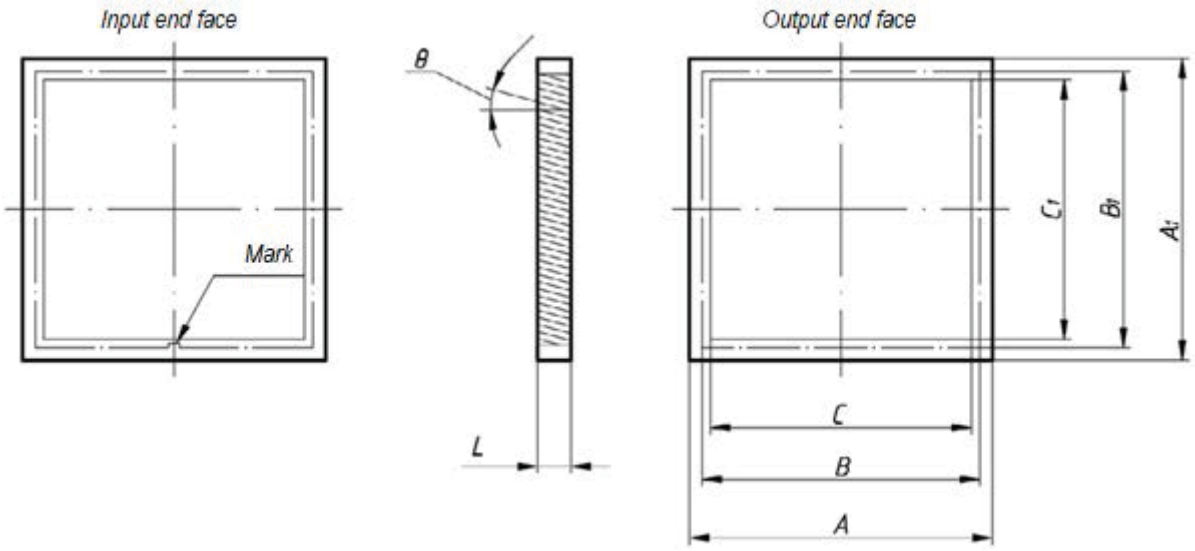


Microchannel plates with 46 mm, 50 mm, 56 mm, 87 mm diameters.

Parameter, unit	Microchannel plate type							
	MCP 46-12	MCP 50-10	Rimmed MCP 50-10	MCP 50-15	MCP 56-15	Rimmed MCP 56-15	MCP 70-15	MCP 87-12
	Nominal value							
Geometrics								
Outer diameter D, mm	45.7–46.0	49.5		49.8–50.0	56		69.5–70.0	86.3–86.8
Active area diameter, D_A, mm, min	44	48,5	41,5	47,5	54	48	68.0	77.5
Contact electrode diameter, $D_{C.E.}$, mm	45	49		48.5	55		-	85

Parameter, unit	Microchannel plate type							
	MCP 46-12	MCP 50-10	Rimmed MCP 50-10	MCP 50-15	MCP 56-15	Rimmed MCP 56-15	MCP 70-15	MCP 87-12
	Nominal value							
Thickness L, mm	0.46–0.50	0.5		0.75–0.80			0.7–0.8	0.69–0.75
Channel bias angle θ, degrees	От 5° до 9°	От 6° до 9° От 11° до 13°		От 7° до 10°			От 9° до 12°	8°
End surface flatness tolerance, mm	0.075							0.05
End surface parallelism tolerance, mm	0.030						0.05	0.03
Solid rim width, mm	-	-	2 min	-	-	2 min	-	-
Rounding width (chamfer), mm	0,35 max							
Structural parameters								
Channel diameter, μm	11.1–12.5	10.0–10.6		14.5–15.5				11.5–12.5
Channel pitch, μm	15 max	от 12.2 до 12.5		19 max				15
Contact electrode material	Хром							
The mark indicates channel bias direction	Вход							
Electrical ratings								
Nominal voltage at 10^4 gain, V, max	1100							1200
MCP resistance, $\times 10^8$ Ohm	0.5–10	0.25–2.5		0.5–10			0.5–2.5	0.05–0.5
Dark current density, A/cm^2, max	1×10^{-12}	1×10^{-13}		1×10^{-12}			3×10^{-13}	-

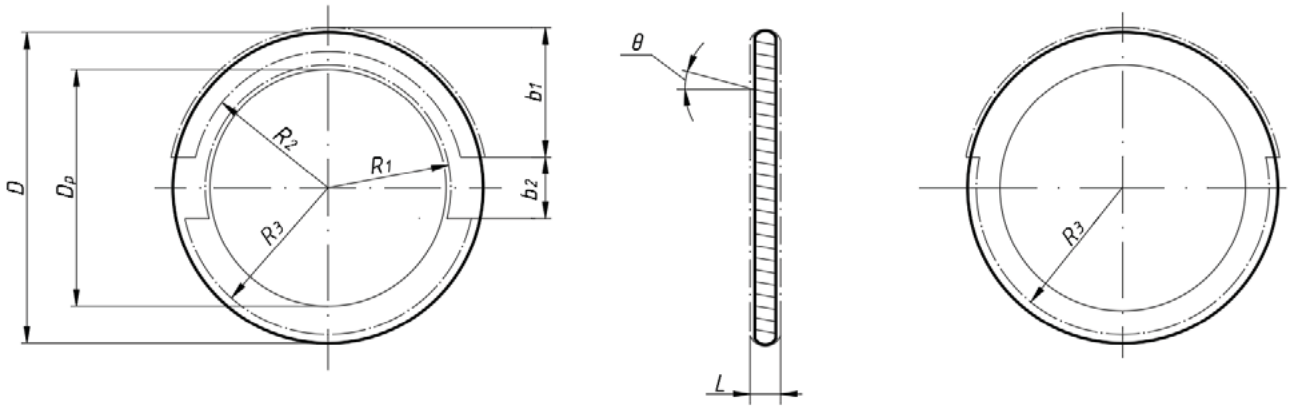
Rectangular microchannel plate



Parameter, unit	Microchannel plate type		
	MCP 36×36	MCP 20×90	MCP 100×100-15
	Nominal value		
Geometrics			
Outer diameter A×A1, mm	36×36	90×20	100×100
Active area size B×B1, mm,	34×34	86×26	96×96
Contact electrode size C×C1, mm	-	88×28	98,4×98,4
Thickness L, mm	0.70±0.1	0.9	1.0–1.2
Channel bias angle θ, degrees	9°±1	7°	8°±2
End surface flatness tolerance, mm, max	0.045	0.05	0.10
End surface parallelism tolerance, mm, max	0.03	0.02	0.02
Chamfer, mm, max	0.3	0.18	0.5
Structural parameters			
Channel diameter, μm	12	15±0.5	
ШаChannel pitch, μm	19 max	19 max	
MCP open area ratio	55 min	0.59 min	
Contact electrode material	Chromium		
The mark indicates channel bias direction	Input		

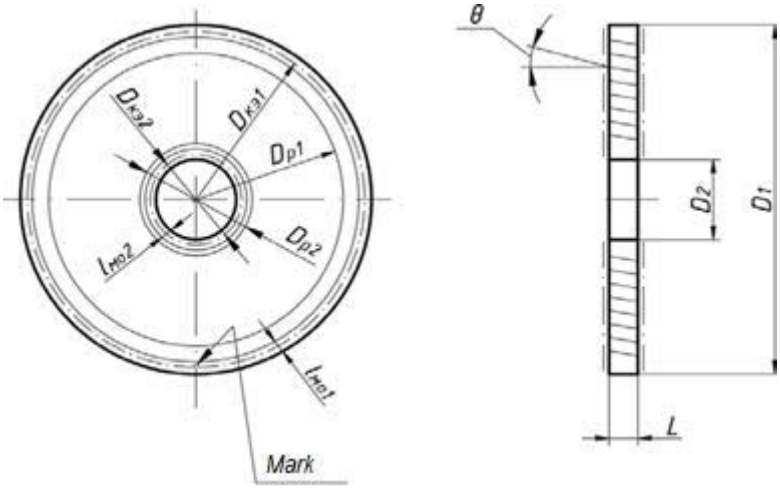
Parameter, unit	Microchannel plate type		
	MCP 36×36	MCP 20×90	MCP 100×100-15
	Nominal value		
Electrical ratings			
Nominal voltage at 10^4 gain, V	1100 max	-	1200 max
Gain at MCP voltage of 800 V, min	-	1000	-
MCP resistance, $\times 10^8$ Ohm	0.5–5	0.5–2.5	0.2–10
Dark current density, A/cm^2, max	1×10^{-12}	-	2×10^{-13}

Microchannel plates with a shaped contact electrode



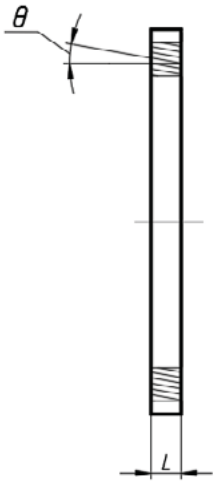
Parameter, unit	Microchannel plate type	
	Rimmed MCP 25-10 S	Rimmed MCP 25-12 S
	Nominal value	
Geometrics		
Outer diameter D, mm	32	
Active area diameter, D_A, mm	25.5	
Contact electrode size, mm:		
R1	13	
R2	14.4	
R3	15.5	
b1	13	
b2	6	
Thickness L, mm	0.38 0.46	0.46
Channel bias angle θ, degrees	8°	
End surface flatness tolerance, mm	0.045	
End surface parallelism tolerance, mm	0.02	
Solid rim width, mm	1.8	
Rounding width (chamfer), mm	от 0.014 до 0.18	
Structural parameters		
Channel diameter, μm	9.5	12
Channel pitch, μm	от 12.1 до 12.9 от 11.5 до 15.6	15
Contact electrode material	Chromium	
The mark indicates channel bias direction	Input	
Electrical ratings		
Operating voltage at 10^3 gain, V, max	850	
Nominal voltage at 10^4 gain, V, max	1200	
MCP resistance, $\times 10^8$ Ohm	1.0–5.0	

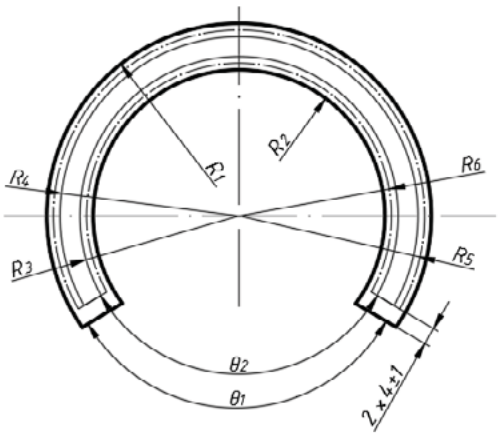
Microchannel plates with central hole



Parameter, unit	Microchannel plate type	
	MCP 35-15 CH	MCP 50-15 CH
	Nominal value	
Geometrics		
Outer diameter D1, mm	32.7	56
Hole diameter D2, mm	7.45	24
Active area ring limited by D_A1-D_A2 diameters, mm	26.7–9	54.2–26.8
Contact electrode ring limited by $D_{C.E.}1$-$D_{C.E.}2$ diameters, mm	31.8–8.1	50–28.5
Thickness L, mm	0.7	0.75
Channel bias angle θ, degrees	От 5° до 9°	7°
End surface flatness tolerance, mm	0.075	
End surface parallelism tolerance, mm	0.02	
Solid rim width, mm		
$l_{sr}1$	1.5	1.8
$l_{sr}2$	0.75	1.8
Rounding width (chamfer), mm	от 0.014 до 0.18	
Structural parameters		
Channel diameter, μm	15	
Channel pitch, μm	19	
Contact electrode material	Chromium	
The mark indicates channel bias direction	Input	
Electrical ratings		
Nominal voltage at 10^4 gain, V, max	1100	
MCP resistance, $\times 10^8$ Ohm	1–10	
Dark current density, A/cm², max	2.2×10^{-13}	

Microchannel plates with annular segment





Parameter, unit	Microchannel plate type	
	MCP 43.5LR	MCP 50LR
	Nominal value	
Geometrics		
Outer radius R1, mm	43.5	50
Hole radius R2, mm	33	17
Active area radius, mm		
R3	40.5	47
R4	36	20
Contact electrode radius, mm		
R5	43.0	49.5
R6	33.5	17.5
Thickness L, mm	1	
Annular segment, degree		
θ1	118°	112°
θ2	118°	112°
Channel bias angle θ, degrees	8°	
End surface flatness tolerance, mm	0.03	
End surface parallelism tolerance, mm	0.03	
Solid rim, mm	None	
Rounding width (chamfer), mm	0.13	
Structural parameters		
Channel diameter, μm	25	
Channel pitch, μm	32	
Contact electrode material	Chromium	
The mark indicates channel bias direction	Input	
Electrical ratings		
Gain at MCP voltage 1000 V, min	10000	
MCP resistance, $\times 10^6$ Ohm	4-6	5-11
Gain uniformity, %	30	

MICROCHANNEL PLATE DETECTORS

MCP detector consists of an assembly of two or more microchannel plates (MCPs). Its operating principle relies on the detection and amplification of the primary flux of charged particles.

VTC BASPIK detectors are manufactured with high quality microchannel plates of different sizes, shapes and technical parameters.

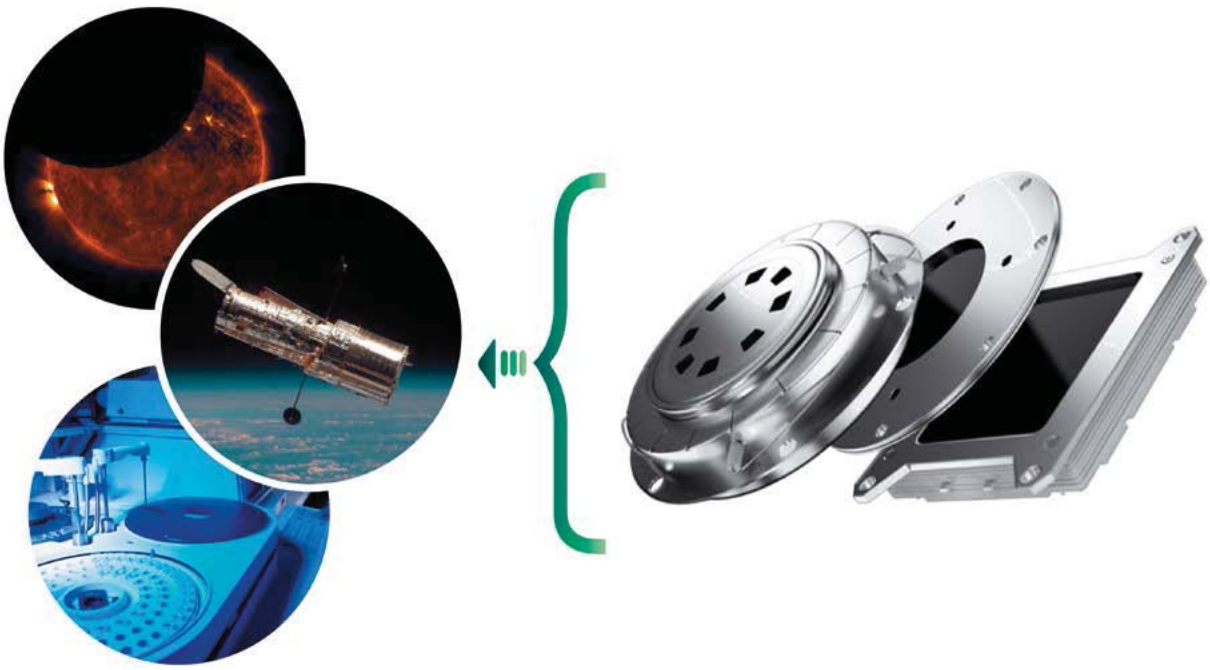
The following versions of the products are available:

- with 18, 25, 42, 48, 50, 78 mm active area diameter;
- single MCP, chevron stack and Z-stack;
- with metal anode, without anode, with phosphor screen;
- with a mesh in front of the MCP;
- assembled on a vacuum flange;
- with different MCP resistance.

The fundamental feature of VTC BASPIK detectors is the possibility of customized design and manufacture in accordance with customer technical requirements.

MCP detector applications:

- Astrophysics and space research
- Experimental nuclear physics
- Electron and ion microscopy
- Spectrometry
- Medical diagnosis and therapy



Space research

- Global real time monitoring of the Earth's surface from satellites in geostationary and highly elliptical orbits
- Searching of space debris
- Solar wind particle detection
- UV and X-ray detection
- Rare event detection
- Identification of the isotopic composition of solar and galactic particles in telescopic systems

Physical research

- Radiation detection in intensive magnetic fields
- Molecular beam experiments to study the potentials of intermolecular interactions
- Isotope analysis
- Spectroscopy
- Atomic collision physics experiments
- Research on high-energy differential ion and neutral particle scattering
- Nuclear physics research

Medical and pharmaceutical research

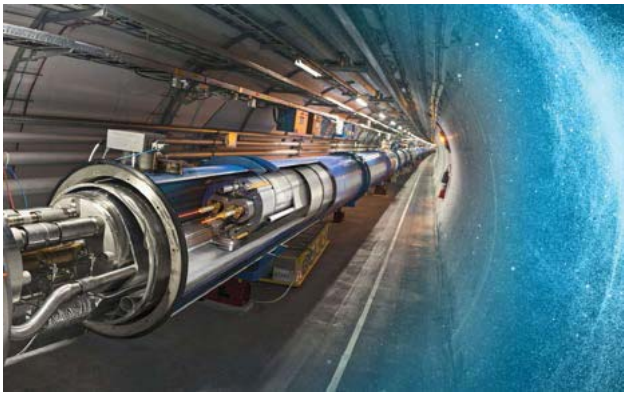
- Low-dose X-ray analysis
- Research of dynamics of visceral organs by obtaining a two-dimensional image of the subject
- Gas analysis for dangerous viral and bacterial infections
- Time-of-flight mass-spectrometry for new drug development and biomolecule recognition
- Ion beam profile control in accelerators in radiation therapy

Industrial applications

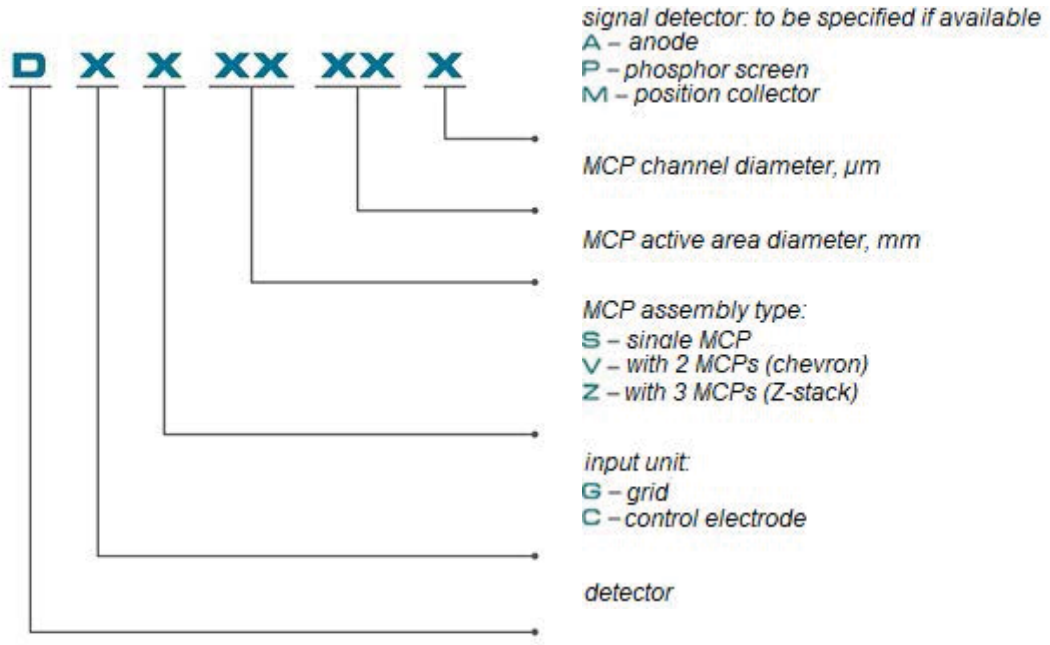
- Nondestructive analysis of three-dimensional compositions for the evaluation of semiconductor and nanostructural devices
- Microscope scanning in semiconductor manufacturing technology
- Surface elementary composition analysis

Application devices

- UV spectrometer
- X-ray telescope
- Cherenkov counter
- Energy analyzer
- Mass spectrometers (quadrupole and magnetic mass analyzers, laser desorption instruments)
- Positron-emission tomography scanner, radiotherapy devices
- Scanning electron microscopes (SEM)



Structure of the detector model notation



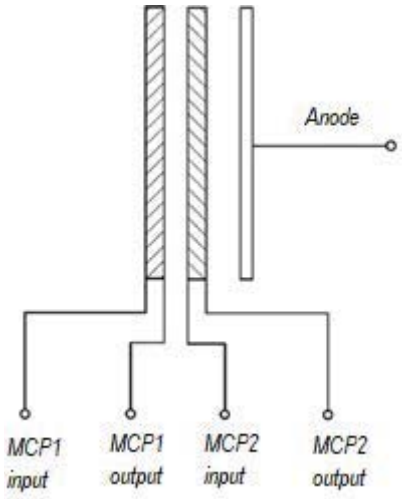
The detector is assembled with gaps between the microchannel plates (with separate power supply), which allows to obtain a gain of more than 1×10^7 (in chevron assemblies) and more than 1×10^9 (in Z-assemblies).

Electrode to lead connection diagram

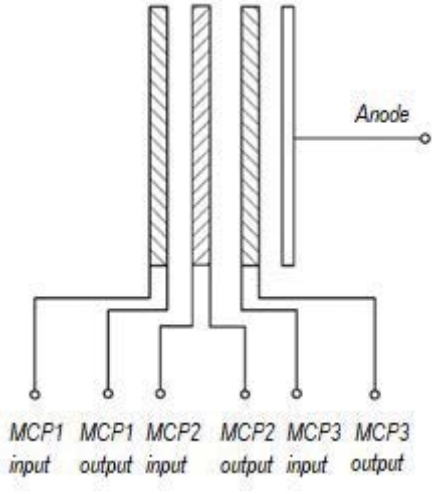
Detector assemblies of two and three MCPs can be assembled:

1. With gaps between the MCPs and separate power supply to each MCP

For chevron stack

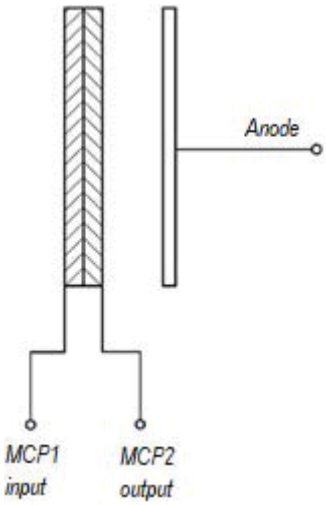


For Z-stack

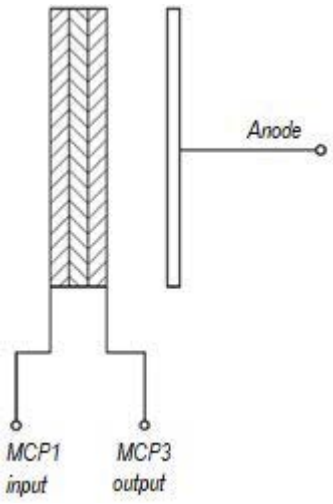


2. With superimposition of one MCP on the other with voltage applied to the input of the first MCP and the output of the last MCP

For chevron stack



For Z-stack



The first case provides a better single-electron pulse height distribution, while the second case simplifies the voltage divider circuit and lowers the overall supply voltage.

Extended Specification

MCP detectors

Assembly type	Units	Single MCP			Chevron stack (with 2 MCPs)			Z-stack (with 3 MCPs)		
Parameter		DS2510	DS5010	DS5615	DV2510 DV256 DV258	DV5010	DV5615	DZ2510 DZ256 DZ258	DZ5010	DZ5615
Active area	mm	25	44	50	25	44	50	25	44	50
Channel diameter	μm	6, 8, 10	10	15	6, 8, 10	10	15	6, 8, 10	10	15
Resistance	Ohm	$5\times10^7 \div 2\times10^8$								
Operating voltage	V	max. 1000			max. 2800			max. 3500		
Height of a detector with anode	mm	12	17		12	17		17		
Height of detector with a phosphor screen	mm	22			22			22		
Detector diameter	mm	max. 54	max. 76	max. 82	max. 54	max. 76	max. 82	max. 54	max. 76	max. 82
Single electron pulse height resolution	%	exponent			max. 70	max. 80	max. 100	max. 30		
Dark count rate density	count/ sec×cm^2	3 max								
Gain		1×10^4 min			1×10^7 min			1×10^8 min		
Versions		with metal anode and phosphor screen						with metal anode		

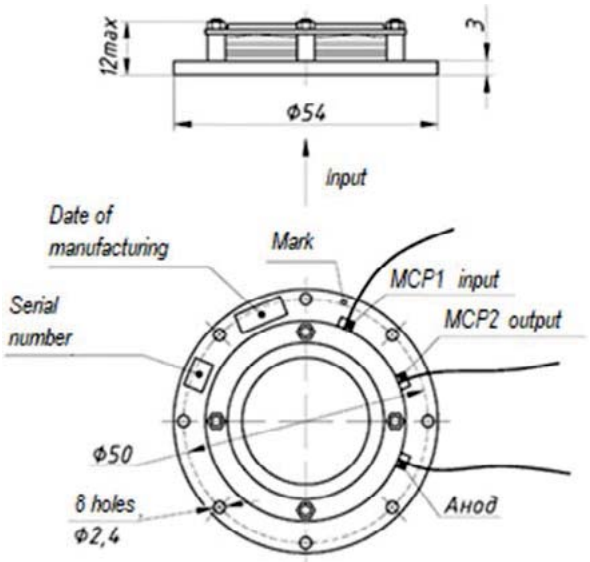
Specification

Open DV2510A detector

The detector is intended for the detection of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, anode and ceramic-to-metal fittings.

Its operating principle relies on the detection and amplification of the primary flux of charged particles.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	mm	10
Channel bias angle	degree	11–13
MCP active area diameter	mm	26
Detector diameter, max	mm	54
Detector height, max	mm	13
MCP qty	pcs..	2

Electrical ratings

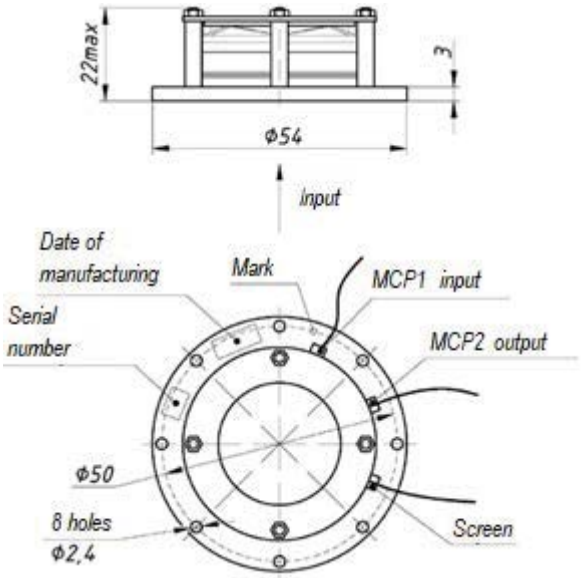
Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm^2	3 max
MCP resistance	MOhm	75–200
MCP voltage at 1×10^7 gain	V	2300 max
Operating pressure, max	Pa (Torr)	1.3×10^{-4} (1×10^{-6})

Specification

Open DV2510P detector with phosphor screen

The detector is intended for the detection and visual observation of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, a phosphor screen and ceramic-to-metal fittings. Its operating principle relies on the detection and amplification of the primary flux of charged particles with subsequent imaging of the amplified flux on the phosphor screen.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	10
Channel bias angle	degree	11–13
MCP active area diameter	mm	26
Detector diameter, max	mm	54
Detector height, max	mm	13
MCP qty	pcs..	2

Electrical ratings

Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm^2	3 max
MCP resistance	MOhm	75–200
MCP voltage at ≥ 1×10^7 gain	V	2300 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})
MCP output-to-screen potential difference	V	3500 max

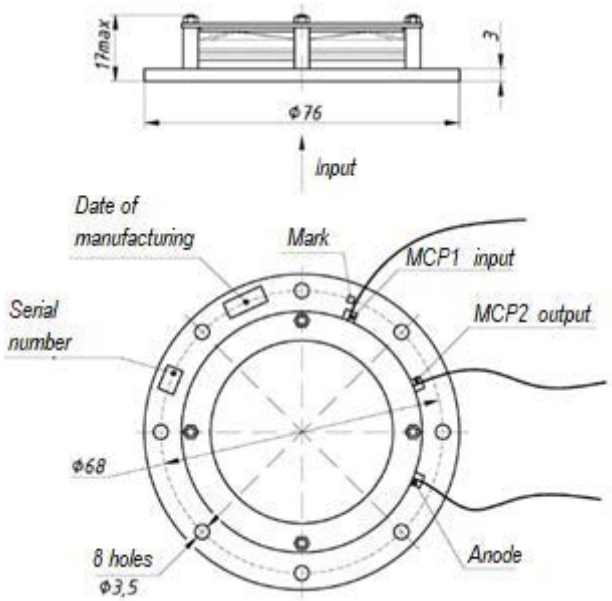
Specification

Open DV5010A detector

The detector is intended for the detection of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, anode and ceramic-to-metal fittings.

Its operating principle relies on the detection and amplification of the primary flux of charged particles.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	10
Channel bias angle	degree	11–13
MCP active area diameter	mm	42
Detector diameter, max	mm	76
Detector height, max	mm	17
MCP qty	pcs..	2

Electrical ratings

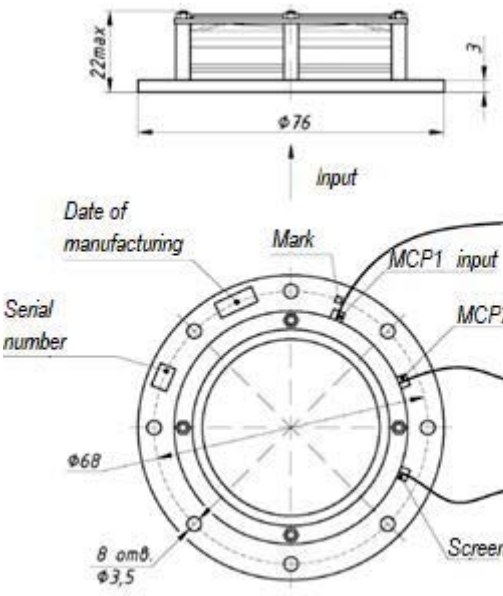
Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm²	3 max
MCP resistance	MOhm	30–200
MCP voltage at ≥ 1×10^7 gain	V	2300 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})

Specification

Open DV5010P detector with phosphor screen

The detector is intended for the detection and visual observation of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, a phosphor screen and ceramic-to-metal fittings. Its operating principle relies on the detection and amplification of the primary flux of charged particles with subsequent imaging of the amplified flux on the phosphor screen.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	10
Channel bias angle	degree	11–13
MCP active area diameter	mm	42
Detector diameter, max	mm	76
Detector height, max	mm	20
MCP qty	pcs..	2

Electrical ratings

Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm^2	3 max
MCP resistance	MOhm	30–200
MCP voltage at ≥ 1×10^7 gain	V	2300 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})
MCP output-to-screen potential difference	V	3500 max

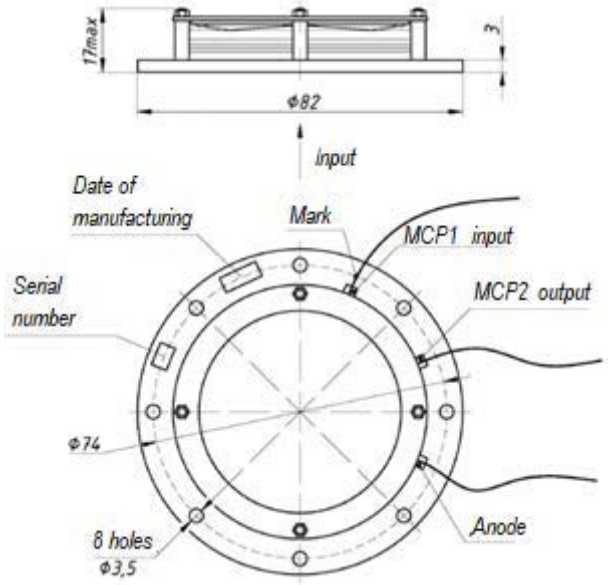
Спецификация

Детектор DV5615A
открытого типа

The detector is intended for the detection of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, anode and ceramic-to-metal fittings.

Its operating principle relies on the detection and amplification of the primary flux of charged particles.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	15
Channel bias angle	degree	7–10
MCP active area diameter	mm	48
Detector diameter, max	mm	82
Detector height, max	mm	17
MCP qty	pcs..	2

Electrical ratings

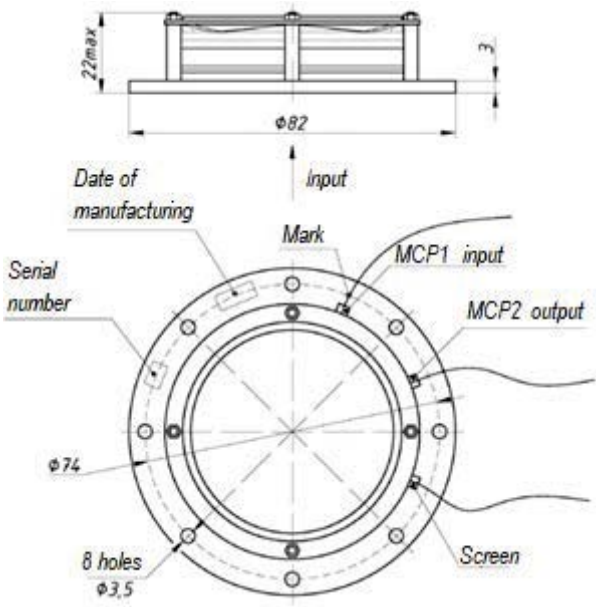
Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm²	3 max
MCP resistance	MOhm	30–200
MCP voltage at ≥ 1×10^7 gain	V	2300 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})

Specification

Open DV5615P detector with phosphor screen

The detector is intended for the detection and visual observation of particulate and electromagnetic radiation as a part of scientific and industrial equipment. The detector consists of a chevron stack of two MCPs, a phosphor screen and ceramic-to-metal fittings. Its operating principle relies on the detection and amplification of the primary flux of charged particles with subsequent imaging of the amplified flux on the phosphor screen.

The detector can be vacuum heated at 300°C. The detector can be operated in any position.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	15
Channel bias angle	degree	7–10
MCP active area diameter	mm	48
Detector diameter, max	mm	82
Detector height, max	mm	21
MCP qty	pcs.	2

Electrical ratings

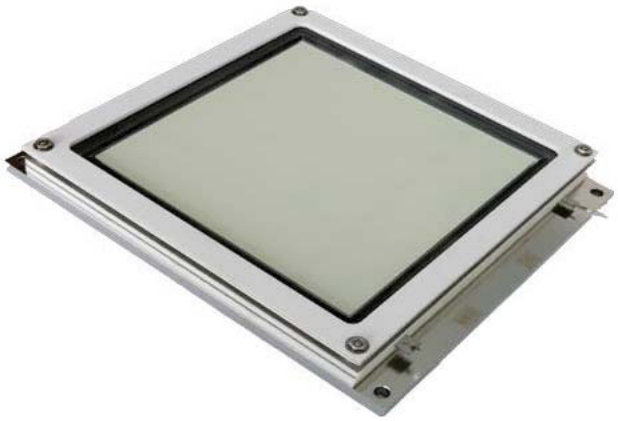
Parameter	Unit	Value
Gain	-	1×10^7
Single electron pulse height resolution, max	%	120
Dark count rate density	count/sec×cm^2	3 max
MCP resistance	MOhm	20–200
MCP voltage at ≥ 1×10^7 gain	V	2300 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})
MCP output-to-screen potential difference	V	3500 max

Specification

DV100X100P detector based on MCP chevron stack and phosphor screen

The detector is intended for charged particle detection and visual observation of fast processes as a part of scientific instruments.

Its operating principle relies on the detection and amplification of the primary flux of charged particles with subsequent excitation of the phosphor screen by the amplified flux of electrons



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	15
Channel bias angle	degree	6–10
Active area dimensions	mm	90×90
Overall dimensions	mm	136×116
Detector height	mm	23 max
MCP qty	pcs..	2

Electrical ratings

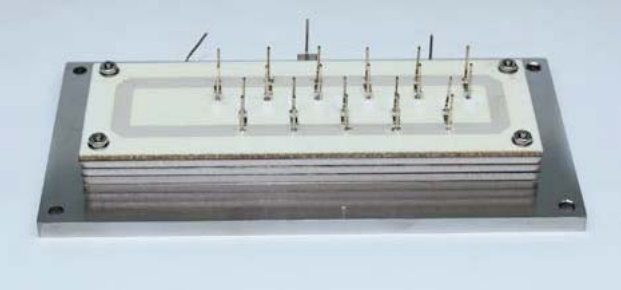
Parameter	Unit	Value
Gain	-	1×10^{7} min
MCP2 output to screen potential difference	V	3500 max
Dark count rate density	count/sec×cm^2	3, max
MCP resistance	MOhm	20–100
MCP assembly operating voltage	V	2300, max
Operating pressure	Pa (Torr)	1.3×10^{-4}, max

Specification

20x90 MCP multianode position-sensitive detector

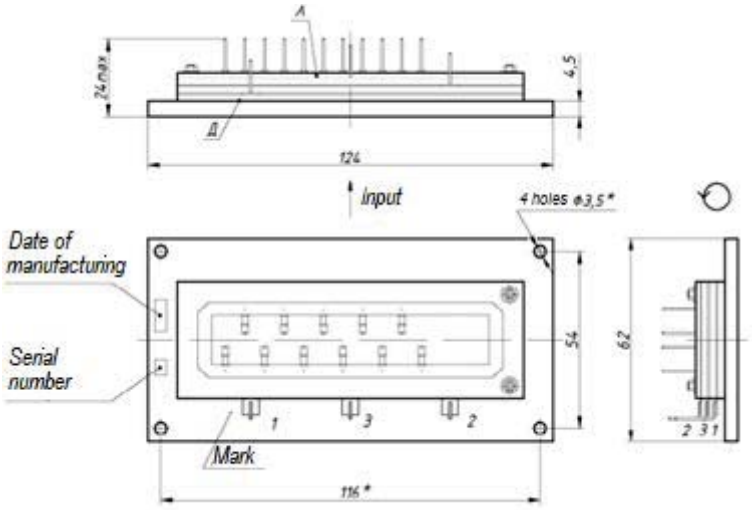
Open ceramic-to-metal detector based on two microchannel plates 20x90-10 MCPs and a multisection anode.

Field of application - in mass-spectrometers for medical diagnostics, pharmaceuticals, biosafety, oil and gas industry, nuclear energetics.



Geometrics

Parameter	Unit	Value
MCP channel diameter	μm	9.5–10.5
Channel bias angle	degree	11–13
MCP working dimensions, min	mm	15.0×85.0
Detector dimensions,max	mm	124×62
Detector height, max	mm	24
MCP qty	pcs.	2



Electrical ratings

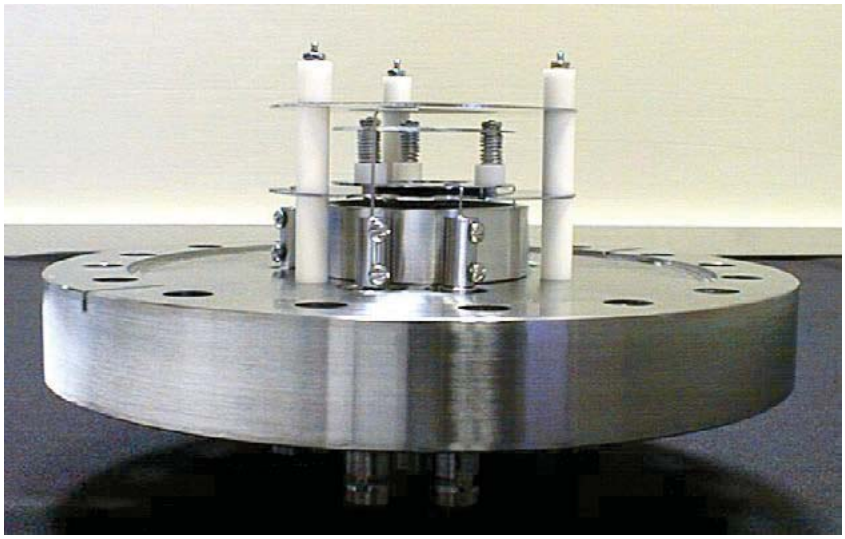
Parameter	Unit	Value
Gain	-	1×10^{7}
Single electron pulse height resolution, max	%	140
Dark count rate density	count/sec×cm^2	3 max
MCP resistance	MOhm	22
MCP voltage at ≥ 1×10^{7} gain	V	2700 max
Operating pressure	Pa (Torr)	1.3×10^{-4} (1×10^{-6})

Specification

Vacuum flange MCP detector

An open-type ceramic-to-metal detector based on microchannel plates and a metal anode mounted on a vacuum flange is designed for the detection of single pulses from low-energy electrons in an electron time-of-flight spectrograph.

The detector is mounted on a vacuum flange and connected to the coaxial vacuum leads so that the MCPs can be operated immediately after applying voltage. Flange type is CF-100 conflat. Wiring cables for voltage supply to the MCP are suitable vacuum-tight SHV/MHV. Cable for the output signal acquisition is BNC/SMA. Vacuum tightness of the flange assembly is not less than 10^{-7} mbar/Torr. A matched load of 50 ohms is used.



SECONDARY ELECTRON MULTIPLIERS:

electronic devices for amplifying (multiplying) the flow of electrons based on secondary electron emission

Open SEMs are vacuum tube devices which are used for direct detection of electromagnetic radiation or particles. The device is used in facilities operating under natural vacuum conditions (in space) and in high-vacuum measuring instruments at pressures which do not normally exceed 10^{-3} Pa.

Depending on their design, SEMs are divided into two main groups: (1) with discrete dynode systems in which electron fluxes are multiplied on separate electrodes which are dynodes, with potentials of dynodes in such SEMs increasing in a stepwise manner, and (2) with distributed (continuous) dynode systems in which electron fluxes are multiplied along the surfaces with a continuous change in potential (channel electron multiplier, microchannel plates).

VTC Baspik produces channel SEMs (SEM-6M and SEM-6G) and SEMs with a chevron stack of two MCPs (SEM-7B in various versions).

New version of a SEM

VTC Baspik has developed a secondary electron multiplier SEM-7B instead of the previously produced SEM-7M. For customer's convenience, SEM-7B is made in the same dimensions as the SEM-7M. A distinctive feature of the SEM-7B is the absence of organic-based glue in the design, which previously did not allow the product to be heated to temperatures above 200 °C negatively affecting the life time of the product. The SEM-7B uses a special soldered ceramic-to-metal housing, into which a chevron MCP assembly is mounted and secured mechanically by a retaining ring. The design allows the product to be heated in vacuum at 300°C, if necessary. The MCPs are end-to-end stacked in a chevron, i.e. the voltage applied to the assembly is common: the input of the first MCP and the output of the second MCP. This reduces the maximum supply voltage of SEM from 2800 V to 2600 V and simplifies the design of the voltage divider. The typical supply voltage is 2200 V.

Specification

SEM-7B secondary electron multiplier

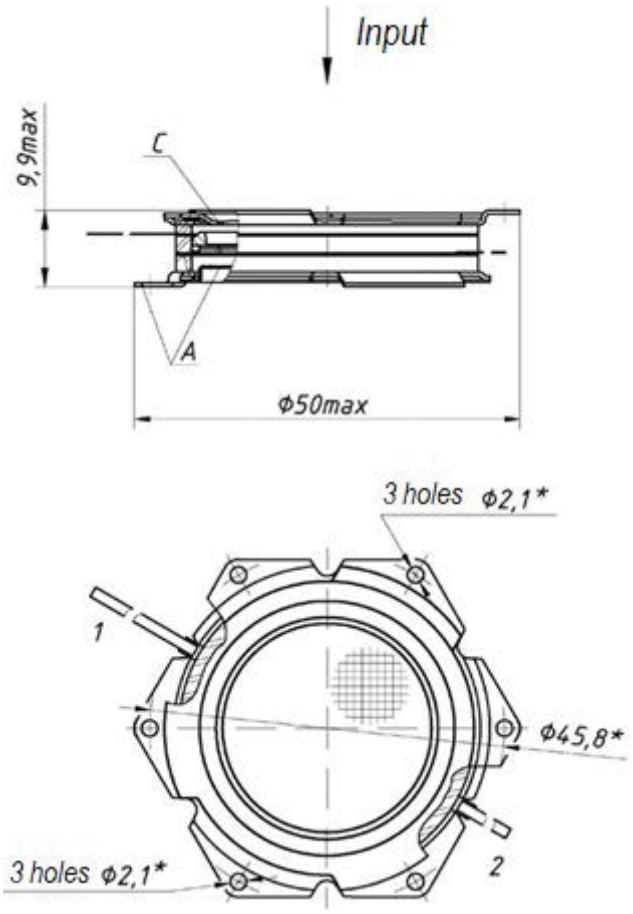
SEM-7B secondary electron multiplier with 25 mm active area diameter is intended for the detection of particulate and other short-wavelength electromagnetic fluxes as part of scientific and industrial equipment, including space instruments.

Rimmed microchannel plates 25-10A MCPs with 33 mm overall diameter, 25 mm active area diameter and 10 μm channel diameter are used in this device.

Basic parameters

Parameter, unit	Value	
	min	max
Supply voltage at ≥ 1×10^7 gain, V		2300
Single electron pulse height resolution, %		120
Dark count rate density, count/sec× см^2		3
Strip current of MCP assembly at MCP supply voltage of 2000 V, μA	5	25
Mass, g		22

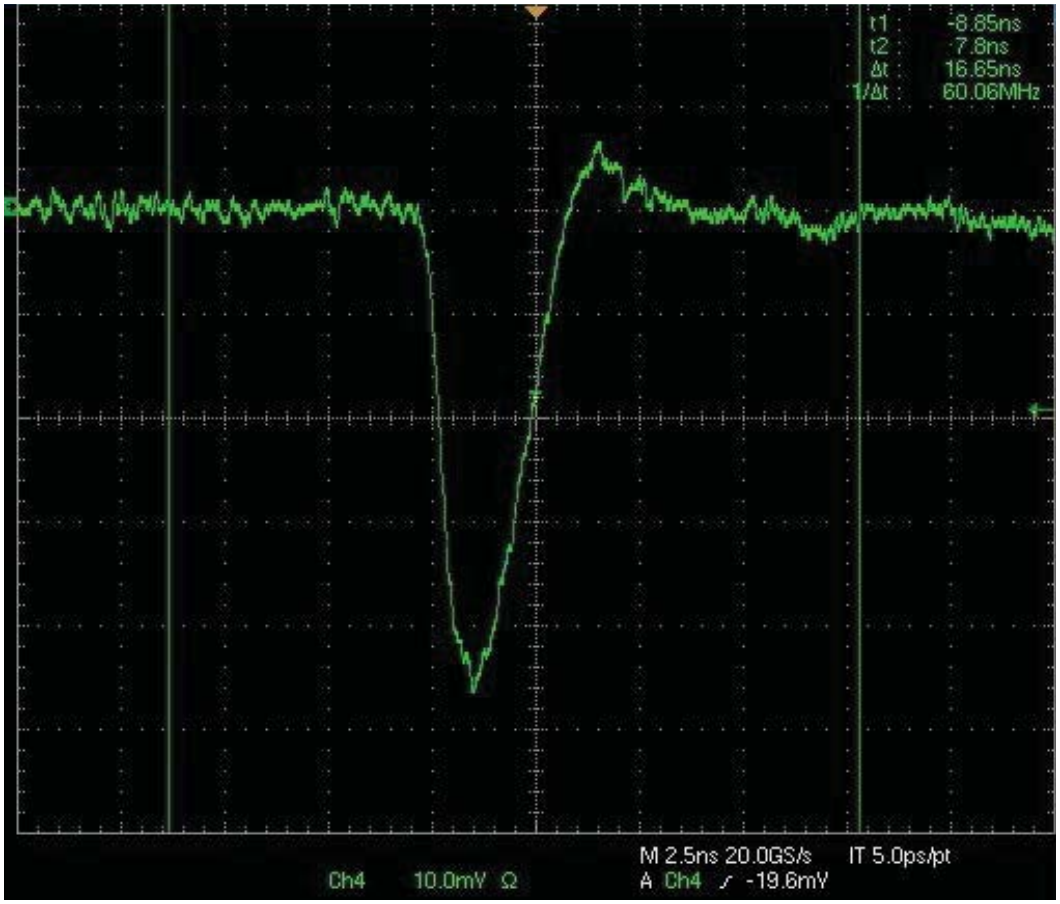
Electrode to lead connection diagram



Overall dimensions

Parameter	Unit	Value
Maximum diameter	mm	50
Height	mm	9.9
Input window area	cm^2	5

SEM-7B detector pulse type



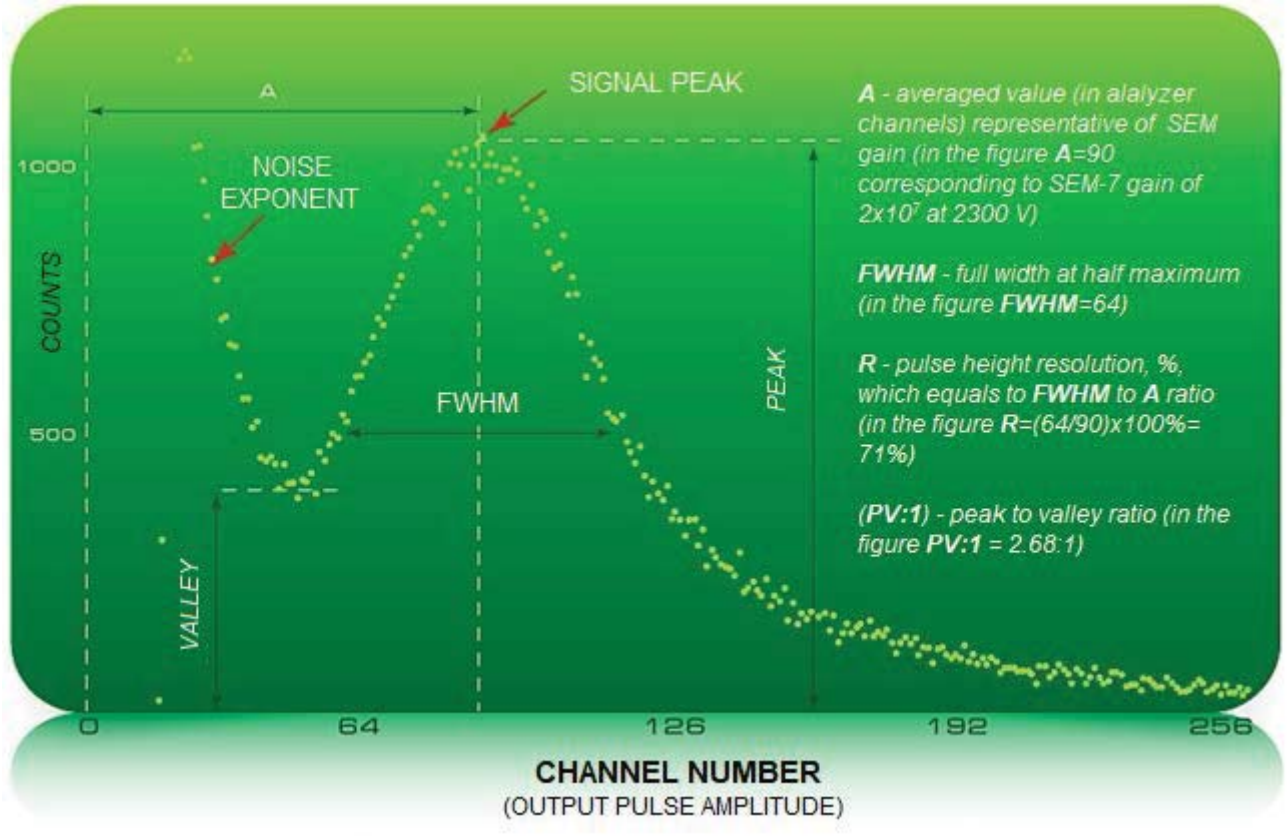
Reference data

Parameter	Unit	Value
Pulse leading edge rise time	ns	0.6–0.7
Full width at half maximum (FWHM)	ns	1.5–2

Resistance to environmental conditions

Parameter	Value
Sinusoidal vibration	acceleration amplitude of 200 m×sec^{-2} (20g) in 100÷3000 Hz range
Linear acceleration	acceleration amplitude of 200 m×sec^{-2} (20g)
Operating temperature	± 50 °C
Transportation temperature	+ 60, - 60 °C
Maximum temperature of vacuum heating	300 °C
Reliability: operating life	10 000 hours

Typical single-electron pulse height distribution of SEM-7B with two MCPs



Parameters of the applied MCP

Parameter	Unit	Value
MCP active area diameter	mm	25
Channel diameter	µm	10
Channel bias angle	degree	11÷13

Available versions of SEM-7B

- With a grid in the control electrode and a metal anode
- With a control electrode and a metal anode
- With a grid in the control electrode (without an anode)
- With a control electrode (without an anode)

Specification

SEM-6 secondary electron multiplier

SEM-6 channel-type secondary electron multiplier with electrostatic electron focusing and open input is intended for the detection of charged and neutral particles, UV and soft X-rays.

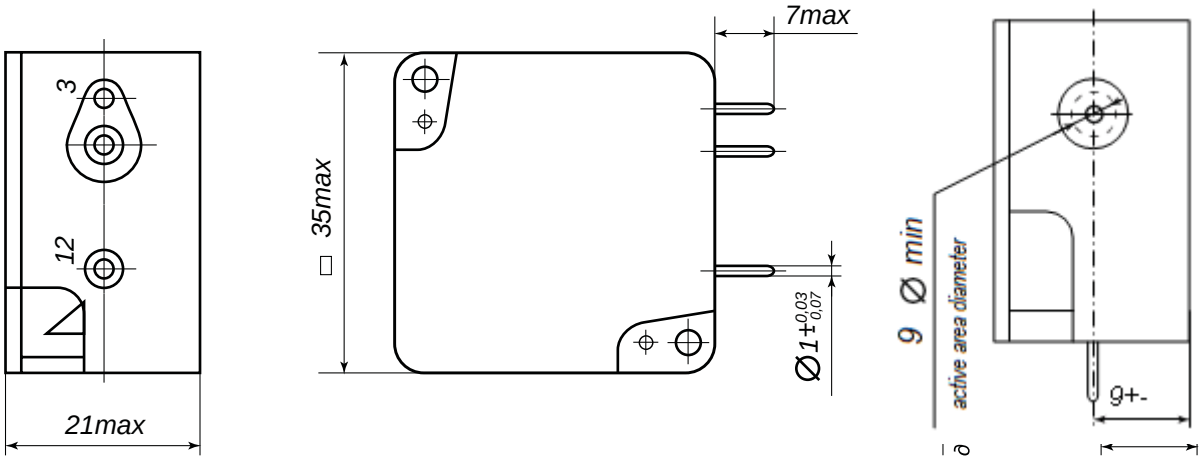
Its design features are the following: open input, 9 mm input window.

One dynode is used.

SEM-6 channel is a thin tube with inner diameter of about 1.5 mm bent at a radius of 5 mm. The channel expands with a 65° cone to a diameter of 10 mm at the input end.

It is available in two versions - with adhesive or mechanical attachment of the multiplier and leads to the housing. SEM-6G version has an input grid.

Electrode to lead connection diagram



1 – SEM input
2 – Anode
3 – SEM output

Lead numbering is arbitrary

Electrical ratings

Parameter, unit	Value	
	min	max
Gain at ≤ 300 V	1×10^8	–
Pulse height resolution at count rate of up to 1×10^4 counts/sec and U corresponding to 1×10^8 gain	–	0.5
Dark count rate, count/sec	–	0.5
Channel supply current at 4000 V, μA	5	20

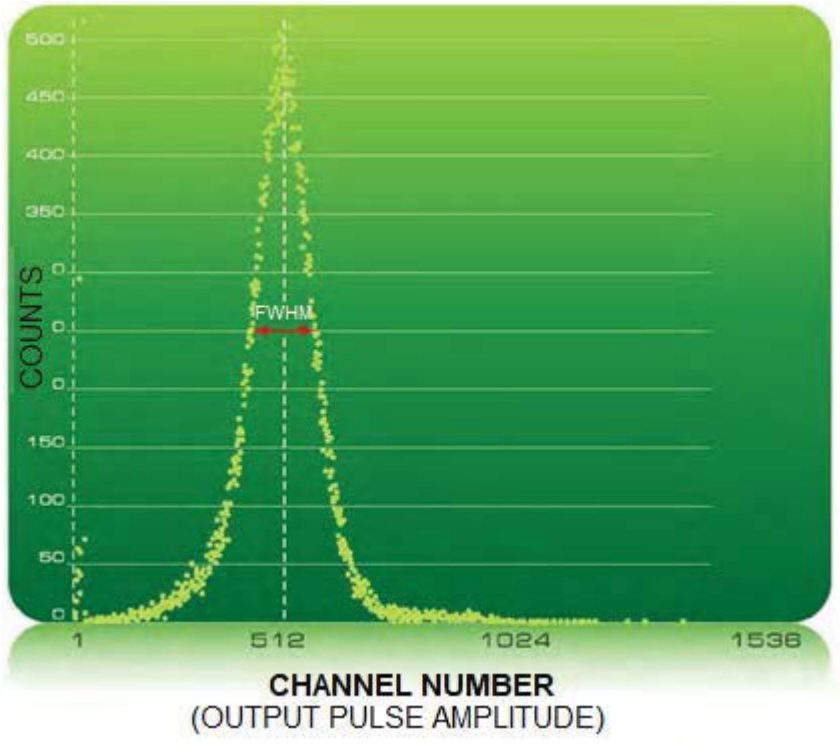
Electrical ratings changing during operation

Parameter, unit	Value, max
Pulse height resolution at count rate of up to 1×10^4 counts/sec and U ≤ 3300 V	0,8
Increase of supply voltage at 1×10^8 gain, %	15

Absolute maximum ratings

Parameter, unit	Value, max
Gain	7×10^8
Supply voltage, V	4000
Average output current, μA	1
Count rate, count/sec	10^5

Typical single-electron pulse height distribution of SEM-7B with two MCPs



A – the average value (in analyzer channels), which characterizes the gain of SEM (in the figure **A**=445, which corresponds to the gain of SEM-6 of 1×10^8 at a voltage of 2200 V)

FWHM – full width at half maximum (in the figure FWHM = 139).

R – pulse height resolution (%) which equals to the ratio of **FWHM** to **A** (in the figure **R**=(445/139) × 100%=31,2%)

PHOTOMULTIPLIER TUBES (PMT)

Photomultiplier tube (PMT) is a vacuum tube device in which light flux ranging from infrared to ultraviolet spectrum is converted into a flux of electrons with further amplification.

For the detection of very weak light signals the photon counting method is used to acquire maximum information. Discrete dynode PMTs, MCP-PMTs, avalanche diodes, hybride PMTs are typically used as photon counting detectors. Among these types of detectors MCP-PMTs from VTC Baspik have the advantage of fast response, low dark count rate, increased surface area, low power consumption, and stable operation under the exposure to magnetic fields.

Typical applications

- In nuclear physics as a scintillation counter component
- In laser and television devices
- In optical instruments
- For low-level radiation detection
- In nondestructive inspection aids as a detector in scanners for X-ray film digitization

PMT with a built-in voltage divider

PMTs with a built-in voltage divider are in some cases more convenient for operation. A resistive voltage divider is mounted on the PMT vacuum unit, which provides the necessary electrode potentials of the device.

MCP-PMT which are photon counting devices with a built-in voltage divider are available in two versions:

- Sapphire-2AM for UV spectrum
- Topaz-M for visible light

PMTs can be supplied as vacuum units or with a voltage divider built into the same housing as the vacuum unit.

Specification

Topaz-M photon counting MCP-PMT

Topaz-M MCP-PMT with a built-in voltage divider is designed for the detection and amplification of optical signals in the visible light spectrum and provides operation in photon counting mode.

PMT vacuum unit has a bialkali antimony-potassium-sodium photocathode, a chevron stack of two MCPs and a metal anode. Its construction parts form an immersion lens that focuses photoelectrons to the first MCP input. A resistive voltage divider is mounted on the vacuum unit, providing the necessary PMT electrode potentials. The entire device is housed and sealed with a compound. Attached to the output end of the envelope is a 50-Ohm SMA output connector for signal acquisition and a high voltage SHV connector for power supply.

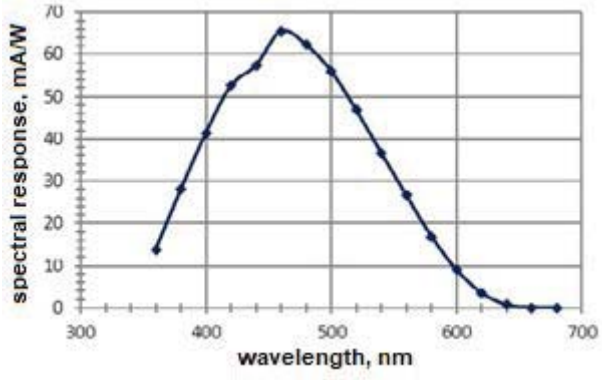
Basic technical characteristics

Parameter, unit	Value
Spectral response range, nm	300– 650
Integral sensitivity, μA/lm	35 min
Spectral response at λ = 420 nm, mA/W	45 min
Photocathode active area diameter, mm	17
Gain at MCP voltage of 3300 V max	10^6 min
Single electron pulse height resolution, %	110 max
Peak-to-valley ratio	10 min
Dark count rate density (at 25°C), count/sec×см^2	40 max
Anode current pulse duration (FWHM), ns	1.2 max
Anode current pulse rise time, ns	0.8 max
Mass, g	50 max

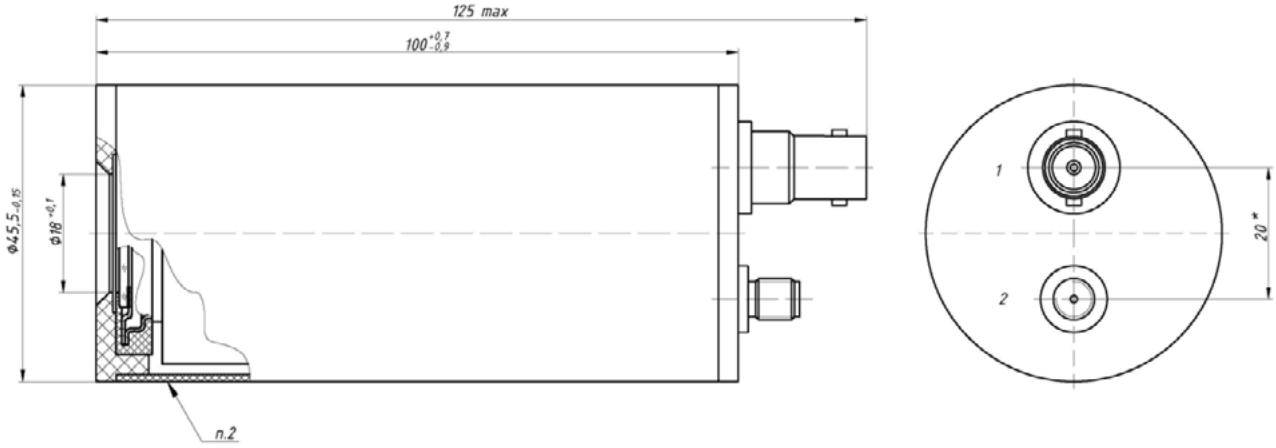
Absolute maximum ratings

Parameter, unit	Normal value, max
Supply voltage, V	3400
Count rate, kHz:	
– Long-term – 7000 hours	300
– Short-term – 1 hour	15 000

Typical spectral response of Topaz-M photocathode



Electrode voltage supply layout



Lead designation

1. Power-supply voltage from 2400 to 3300 V.
2. Signal output

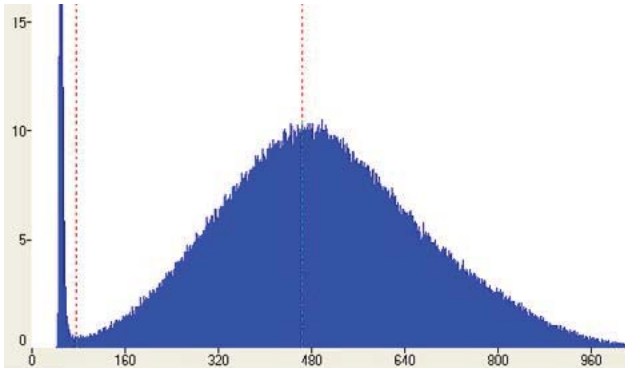
Notes:

1. Reference dimensions.

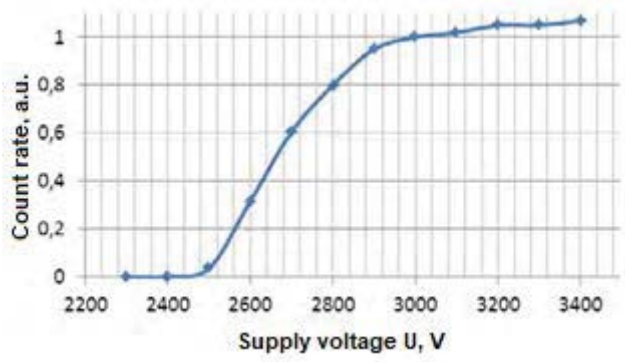
2. Marking position:
– In the first line - the product name;
– In the second line - date of manufacture (the last two digits of the year and two digits of the month) and the product number.

3. Lead numbering is arbitrary.

Single-electron output pulse height distribution



Topaz-M PMT counting response



Admissible environmental conditions

Parameter, unit	Value
Sinusoidal vibration:	
– frequency range, Hz	10-80
– acceleration amplitude, m×sec^{-2} (g)	50 (5)
High ambient temperature:	
– operating, °C	50
– limiting, °C	60
Low ambient temperature:	
– operating, °C	- 50
– limiting, °C	- 60
Temperature variation, °C	- 50 to 50

Specification

Topaz photon counting MCP-PMT Sapphire-2AM

Sapphire-2AM MCP-PMT with a built-in voltage divider is designed for the detection and amplification of optical signals in the UV spectrum and provides operation in photon counting mode.

PMT vacuum unit has a cesium-telluride photocathode, a chevron stack of two MCPs and a metal anode. Its construction parts form an immersion lens that focuses photoelectrons to the first MCP input. A resistive voltage divider is mounted on the vacuum unit, providing the necessary PMT electrode potentials. The entire device is housed and sealed with a compound. Attached to the output end of the envelope is a 50-Ohm SMA output connector for output signal acquisition and a high-voltage SHV connector for the power supply.

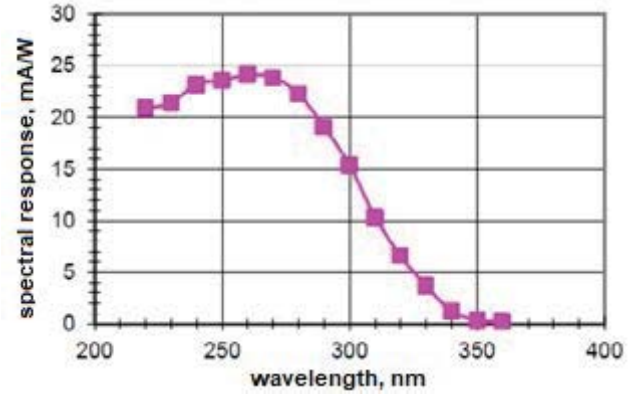
Basic technical characteristics

Parameter, unit	Value
Spectral response range, nm	115– 360
Spectral response at λ = 250 nm, mA/W	20 min
Photocathode active area diameter, mm	15
Gain at MCP voltage of 3300 V max	10^6 min
Single electron pulse height resolution, %	110 max
Peak-to-valley ratio	10 min
Dark count rate density, count/sec×см^2	10 max
Anode current pulse duration (FWHM), ns	1.2 max
Anode current pulse rise time, ns	0.8 max
Mass, g	50 max

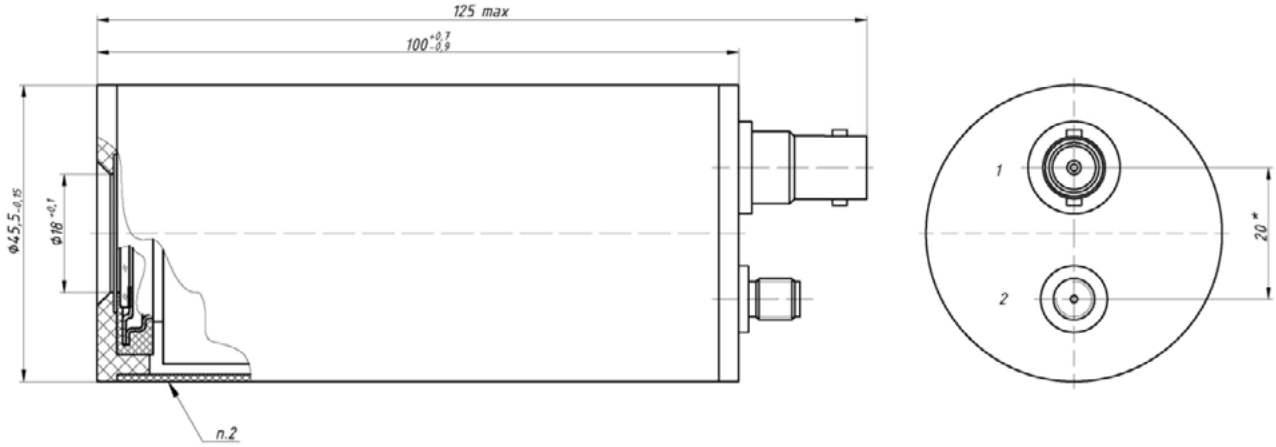
Absolute maximum ratings

Parameter, unit	Normal value, max
Supply voltage, V	3400
Count rate, kHz: – Long-term – 15000 hours – Short-term – 1 hour	 300 40 000

Typical spectral response of a cesium-telluride photocathode



Electrode voltage supply layout



Lead designation

1. Power-supply voltage from 2400 to 3300 V.
2. Signal output

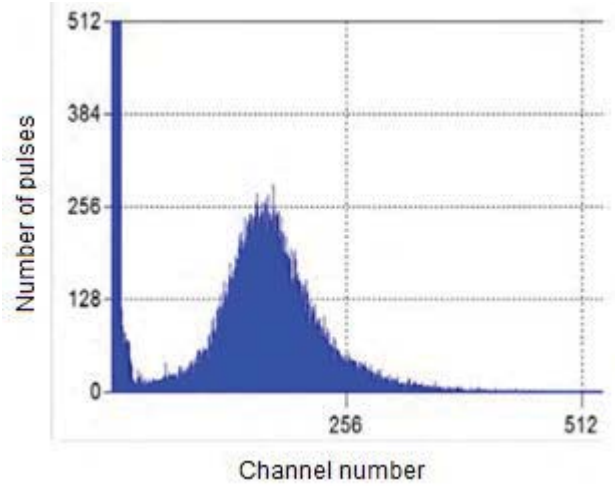
Notes:

1. Reference dimensions.

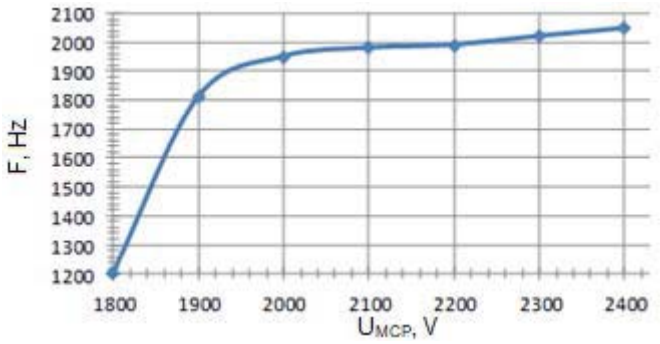
2. Marking position:
– In the first line - the product name;
– In the second line - date of manufacture (the last two digits of the year and two digits of the month) and the product number.

3. Lead numbering is arbitrary.

Single-electron output pulse height distribution



Sapphire-2AM PMT counting response



Admissible environmental conditions

Parameter, unit	Value
Sinusoidal vibration:	
– frequency range, Hz	10–80
– acceleration amplitude, m×sec^{-2} (g)	50 (5)
High ambient temperature:	
– operating, °C	50
– limiting, °C	60
Low ambient temperature:	
– operating, °C	- 50
– limiting, °C	-60
Temperature variation, °C	-50 to 50

Specification

Topaz photon counting MCP-PMT

MCP photomultiplier tube (MCP-PMT) Topaz is designed for the detection and amplification of visible light in 300-650 nm wavelength range and enables operation in photon counting mode. Structurally, Topaz MCP-PMT is a metal-glass vacuum unit with an insulating coating, containing a bi-alkali antimony-potassium-sodium photocathode, a chevron stack of two micro-channel plates, and a metal anode. The electrons are focused from the photocathode to the MCP input by the electrostatic lens field.

It can be used as a Cherenkov detector. Since PMT is thermally stable up to 150 °C, it can be used in devices operating under high climatic loads.

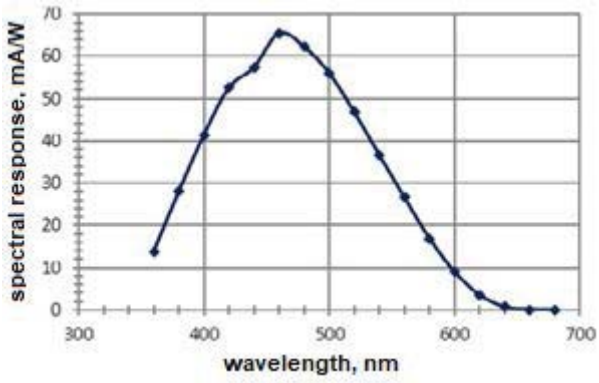
Basic technical characteristics

Parameter, unit	Value
Spectral response range, nm	300– 650
Integral sensitivity, μA/lm	35 min
Spectral response at λ = 420 nm, mA/W	45 min
Photocathode active area diameter, mm	17
Gain at MCP voltage of 2400 V max	10^6 min
Single electron pulse height resolution, %	110 max
Dark count rate density, count/sec×см^2	40 max
Peak-to-valley ratio	10 min
Anode current pulse duration (FWHM), ns	1.2 max
Anode current pulse rise time, ns	0.8 max
Mass, g	50 max

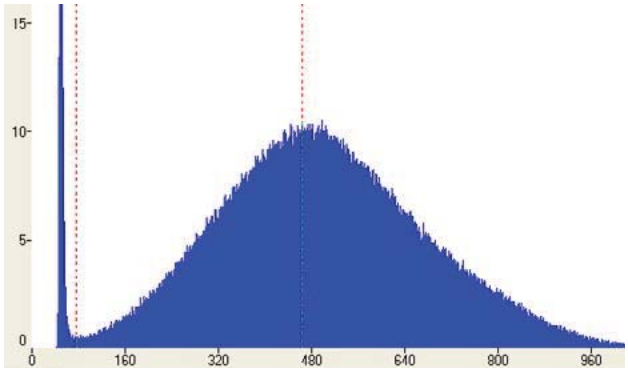
Absolute maximum ratings

Parameter, unit	Normal value, max
Supply voltage, V	3400
Count rate, kHz: – Long-term – 7000 hours – Short-term – 1 hour	 300 15 000

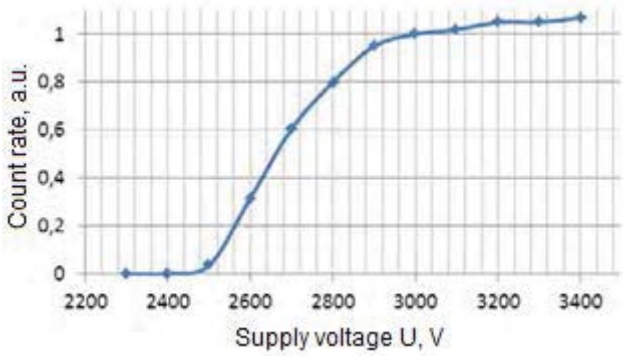
Typical spectral response of Topaz PMT photocathode



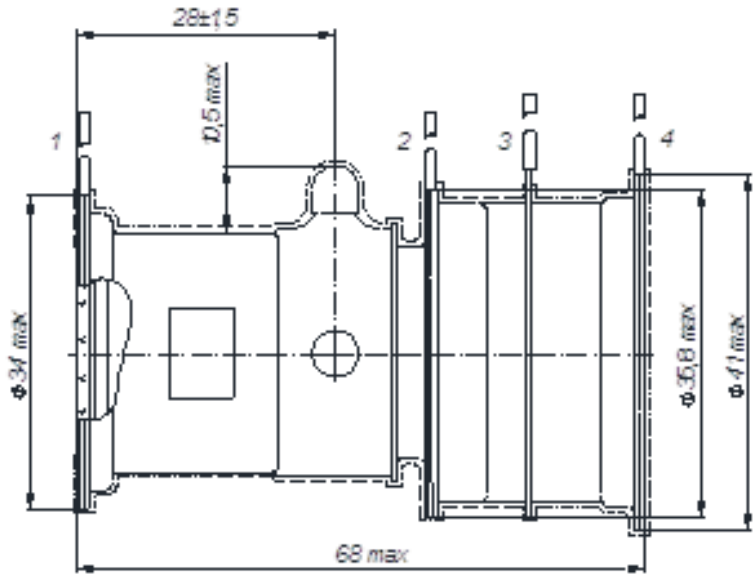
Single-electron output pulse height distribution



Topaz PMT counting response

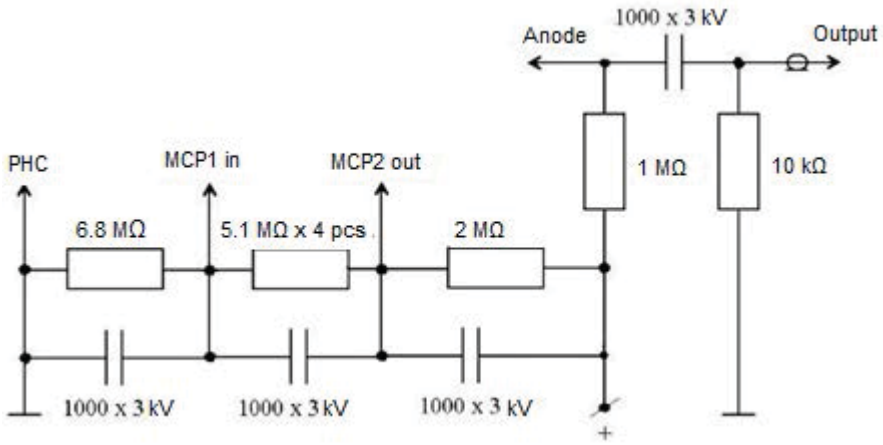


Electrode voltage supply layout



Lead number	Electrode	Electrode voltage, V
1	Photocathode	0
2	Multiplier input	700
3	Multiplier output	2800
4	Anod	2900

Recommended voltage divider circuit



Admissible environmental conditions

Parameter, unit	Value
Sinusoidal vibration:	
– frequency range, Hz	10–500
– acceleration amplitude, m×sec^{-2} (g)	50 (5)
Repeated mechanical shock:	
– shock acceleration peak value, m×sec^{-2} (g)	150 (15)
– duration, ms	6±2
– number of shocks	5000
Single-action mechanical shock:	
– shock acceleration peak value, m×sec^{-2} (g)	2943 (300)
– duration, ms	1–3
– number of shocks	6
High ambient temperature:	
– operating, °C	50
– limiting, °C	60
Low ambient temperature:	
– operating, °C	- 50
– limiting, °C	- 60
Temperature variation, °C	- 50 to 150
High air humidity at 25° C, %	98

Specification

Sapphire-2AM photon counting MCP-PMT

MCP photomultiplier tube (MCP-PMT) Sapphire-2A photomultiplier tube is designed for the detection and amplification of UV light in 115-360 nm wavelength range and enables operation in photon counting mode.

Structurally, Sapphire-2A MCP-PMT is a metal-glass vacuum unit with an electroinsulating coating, containing a cesium-telluride photocathode on a magnesium fluoride substrate, a chevron stack of two microchannel plates, and a metal anode. The electrons are focused from the photocathode to the MCP input by the electrostatic lens field. It can be used as a Cherenkov detector.

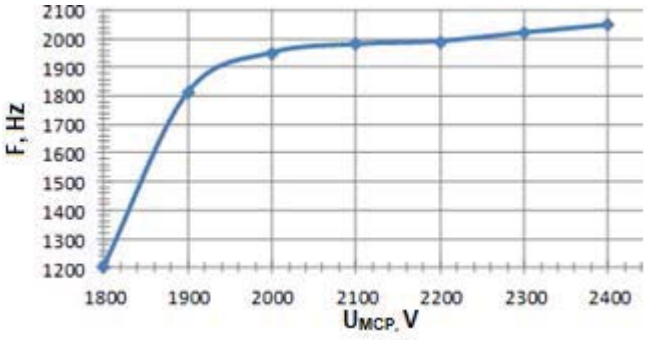
Basic technical characteristics

Parameter, unit	Value
Spectral response range, nm	115– 360
Spectral response at λ = 250 nm, mA/W	20 min
Photocathode active area diameter, mm	15
Gain at MCP voltage of 2400 V max	10^6 min
Single electron pulse height resolution, %	100 max
Peak-to-valley ratio	10 min
Dark count rate density, count/sec×см^2	5 max
Anode current pulse duration (FWHM), ns	1.1 max
Anode current pulse rise time, ns	0.8 max
Mass, g	50 max

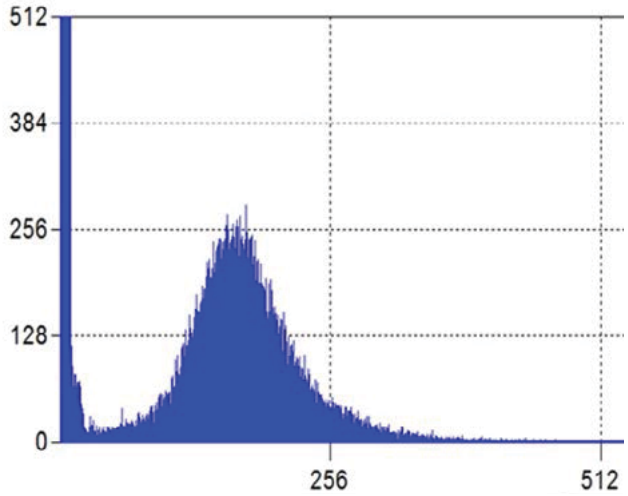
Absolute maximum ratings

Parameter, unit	Normal value, max
Supply voltage, V	3400
Count rate, kHz: – Long-term – 15 000 hours – Short-term – 1 hour	 300 40 000

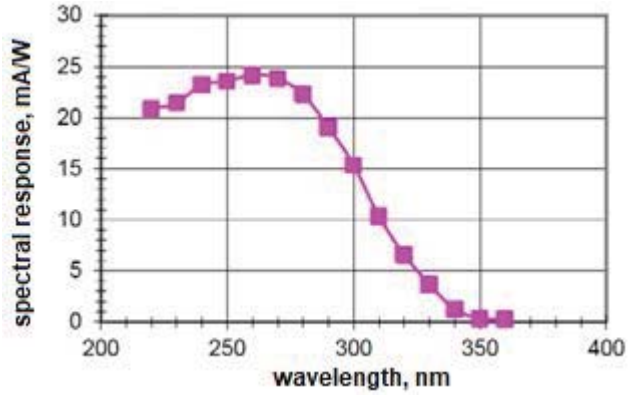
Sapphire-2AM PMT counting response



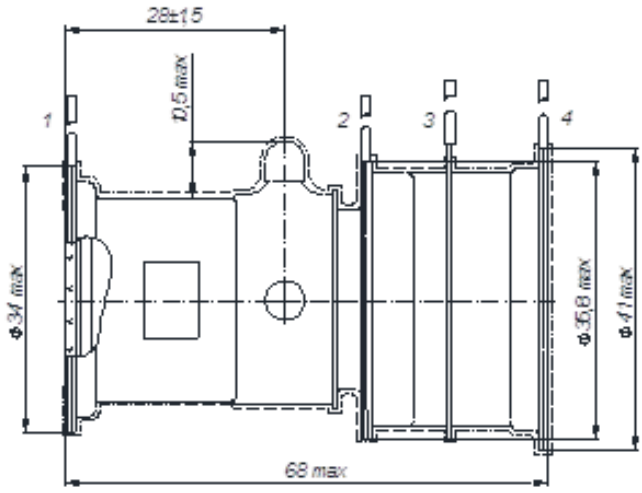
Single-electron output pulse height distribution



Typical spectral response of a cesium-telluride photocathode

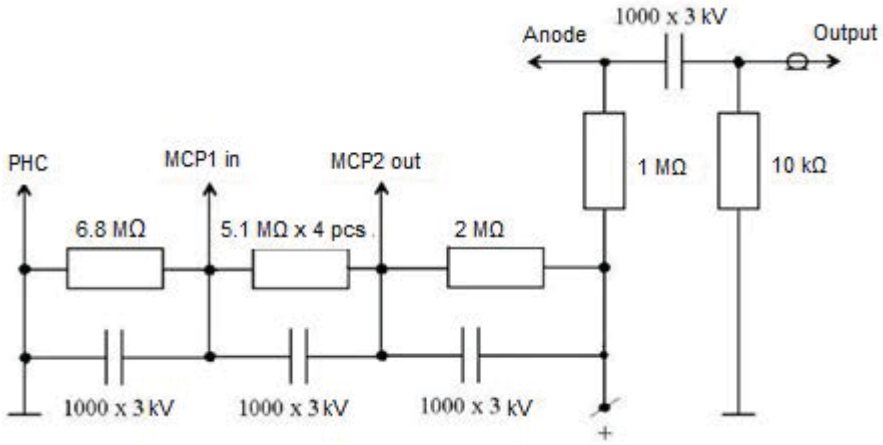


Electrode voltage supply layout



Lead number	Electrode	Electrode voltage, V
1	Photocathode	0
2	Multiplier input	700
3	Multiplier output	2800
4	Anod	2900

Recommended voltage divider circuit



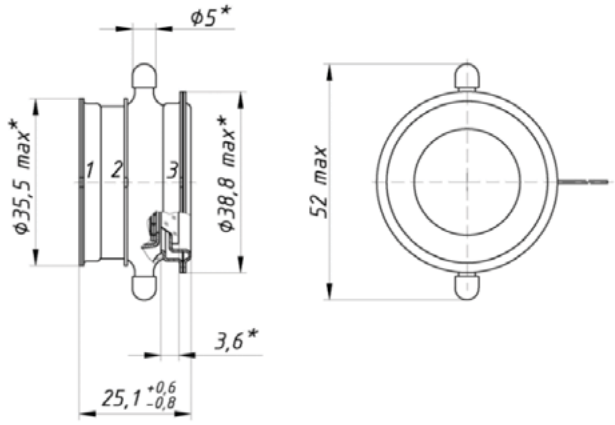
Admissible environmental conditions

Parameter, unit	Value
Sinusoidal vibration:	
– frequency range, Hz	10–500
– acceleration amplitude, m×sec^{-2} (g)	50 (5)
Repeated mechanical shock:	
– shock acceleration peak value, m×sec^{-2} (g)	150 (15)
– duration, ms	6±2
– number of shocks	5000
Single-action mechanical shock:	
– shock acceleration peak value, m×sec^{-2} (g)	2943 (300)
– duration, ms	1–3
– number of shocks	6
High ambient temperature:	
– operating, °C	50
– limiting, °C	60
Low ambient temperature:	
– operating, °C	- 50
– limiting, °C	- 60
Temperature variation, °C	- 50 to 50
High air humidity at 25° C, %	98

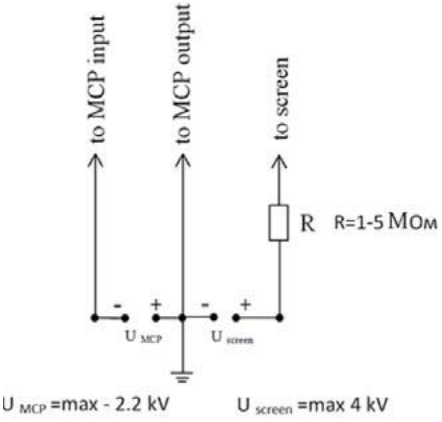
Specification

Zircon-R soft X-ray detector

The detector is a glass-to-metal vacuum unit coated with an electrically insulating composition. The assembly includes a 0.15 mm thick beryllium foil input window, a chevron stack of two MCPs (enabling operation in the single photon counting mode), a CsI photocathode applied to the input surface of the first MCP, a yellow-green light emitting screen on a glass disk, and a getter. Vacuum X-ray detector is intended for the detection, amplification and imaging in soft X-ray range. It can be used in X-ray spectrometry and microscopy.



Recommended power supply circuit



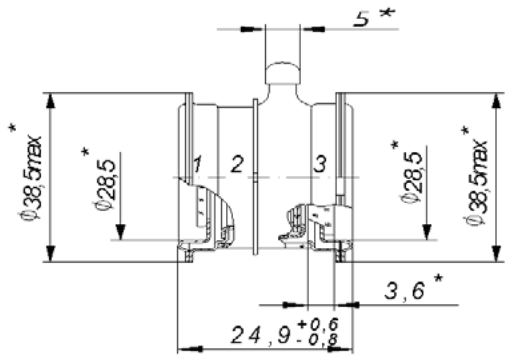
Basic technical characteristics

Parameter, unit	Value
Photocathode active area diameter, mm	18
Gain at MCP voltage of 2200 V max	10^6 min
Dark count rate density, count/sec×см$^{-2}$	10 max
Minimum energy of the detected X-ray photons, keV	1,5*
MCP assembly output-to-screen voltage, V	300** min
MCP assembly output-to-screen voltage, V voltage, V	2500 min 4000 max

Notes:
* Provided by the product design.
** 300V voltage is applied to determine X-ray radiation characteristics by counting pulses without imaging.

Specification

Vacuum UV detector Zircon

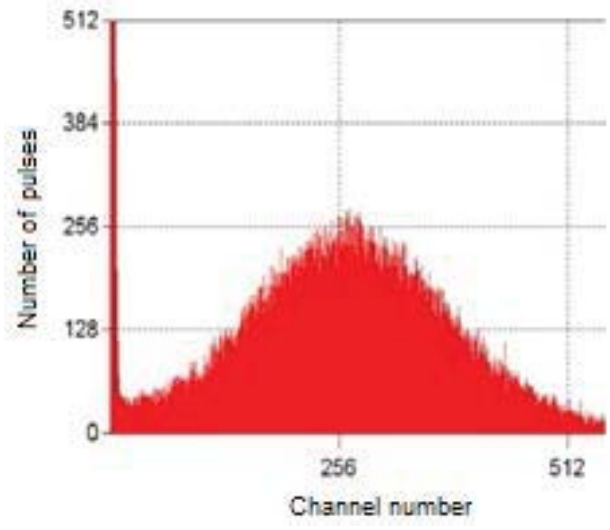


MCP-based vacuum detector with a magnesium fluoride input window and a yellow-green emitting phosphor screen on glass. The detector consists of two chevron MCPs providing operation in photon counting mode. A cesium iodide photocathode is deposited on the input surface of the first MCP to increase the UV sensitivity. The detector is intended for detection, intensity measurement and, if necessary, imaging of far ultraviolet radiation.

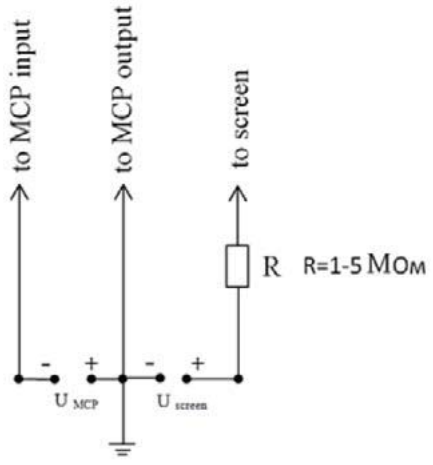
Basic technical characteristics

Parameter, unit	Value
Spectral response range, nm	115–210
Photocathode active area diameter, mm	18 min
Pulse height resolution, %	100 max
Gain (at MCP voltage 2200 V max)	10^6 min
Dark count rate, $sec^{-1}cm^{-2}$	10 max
Mass, g	30 max

Single-electron pulse height distribution



Recommended power supply circuit



U MCP =max - 2.2 kV U screen =max 4 kV

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