Detekce světla – Co je dnes k dostání

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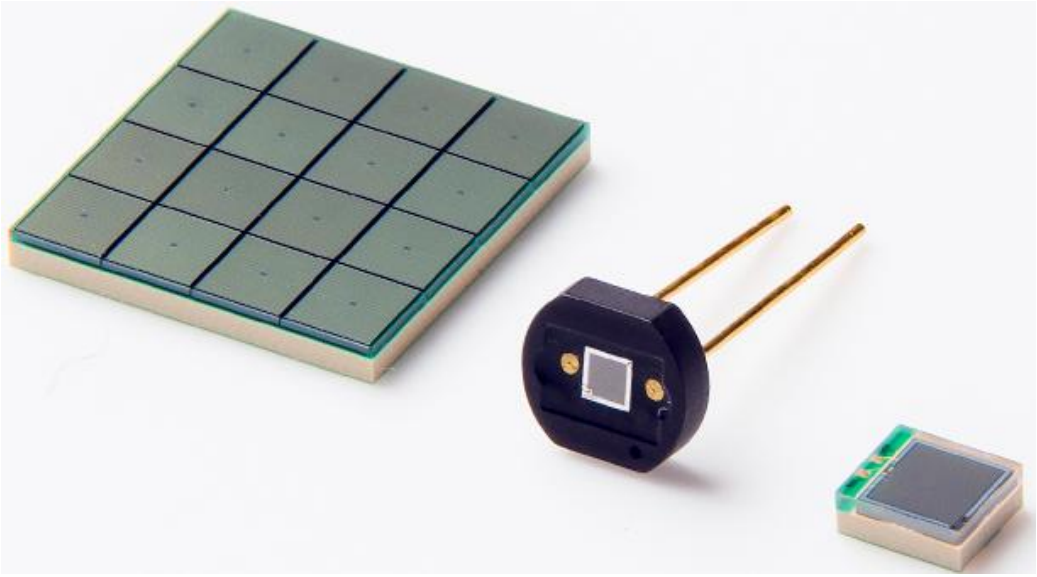


Obsah

PIN, PMT, CCD, CMOS a jiná šepleť

výrobců nepočítaně, přeprodejců ještě víc, poměr kvalita/cena

HAMAMATSU
PHOTON IS OUR BUSINESS

Nikon

Kodak
Share Moments. Share Life.™

TDK
Life on Record

Canon

THORLABS
Scientific Imaging

Newport

OLYMPUS

COHERENT®

Hamamatsu Orca-Quest

ORCA®-Quest
Photon Number Resolving

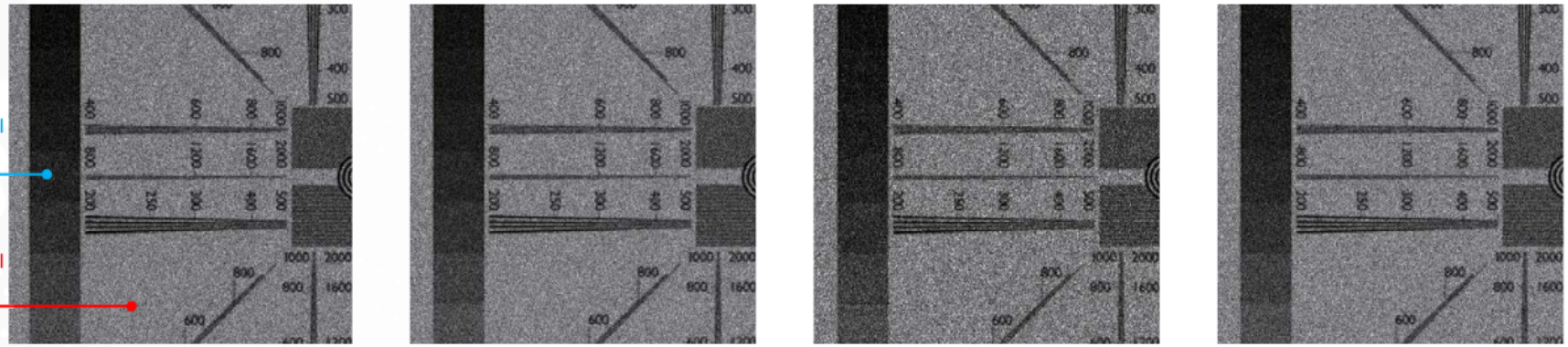
ORCA®-Quest
Ultra-Quiet Scan

EM-CCD camera

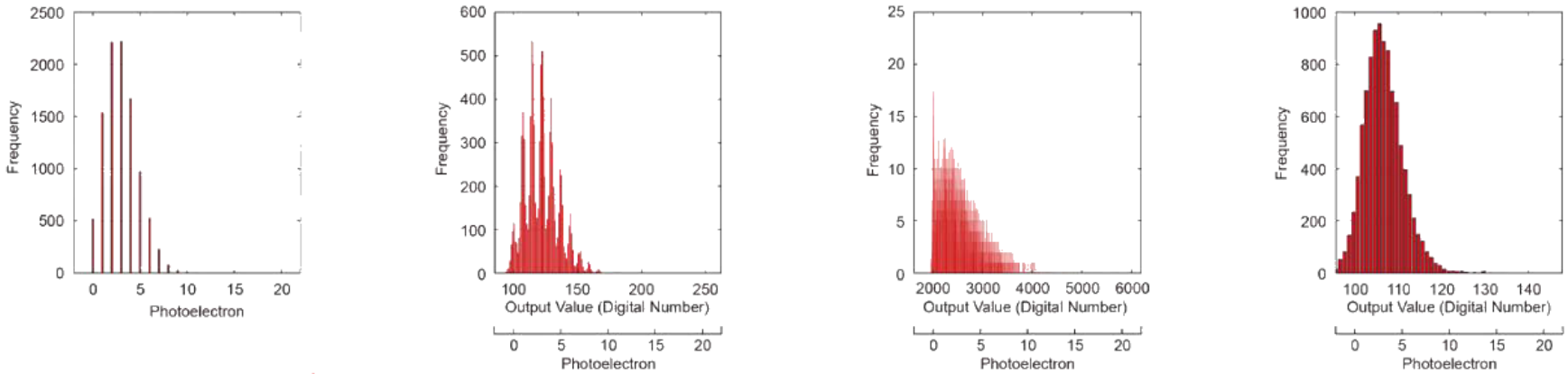
Gen II sCMOS camera

Approx. 3 electrons/pixel

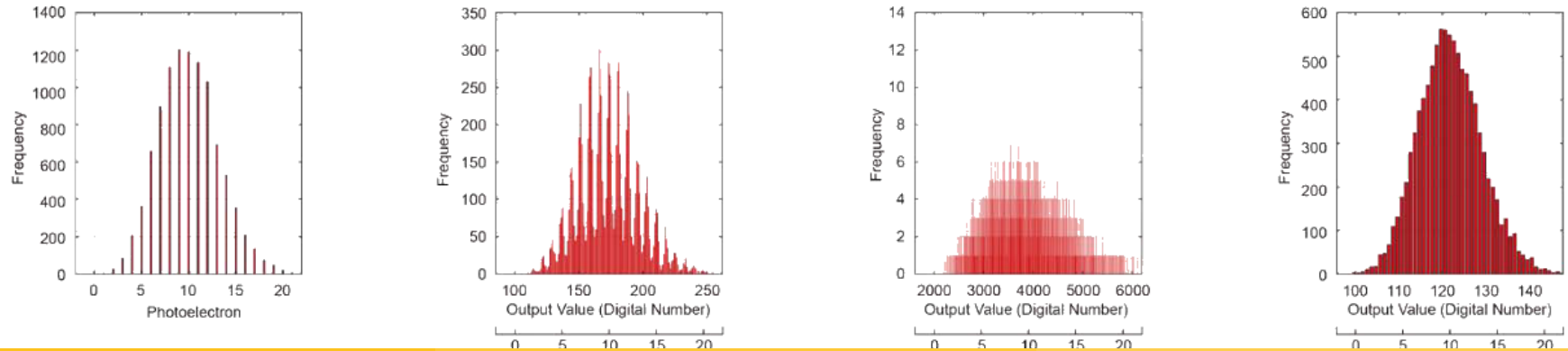
Approx. 10 electrons/pixel



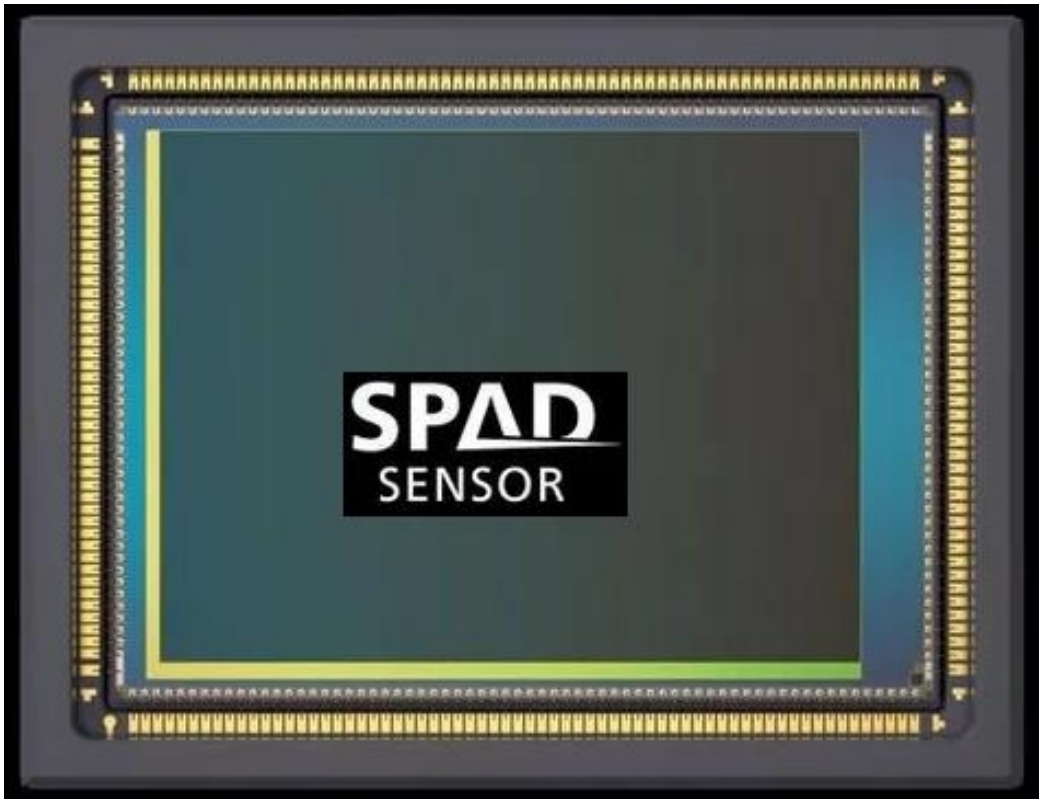
Average number of photoelectrons generated per pixel: 3 electrons



Average number of photoelectrons generated per pixel: 10 electrons



Canon ME20F-SH



- CMOS 35 mm
- 2.26 Mpix (2000 $\times$ 1128)
- min osvětlení 0.0005 lx
- zisk 75 dB

Obsah

EMCCD

iXon Life

ANDOR
an Oxford Instruments company

Princeton Instruments

Raptor photonics


h·nü 1024
BUILT FOR
RESOLUTION
WIDE FIELD OF VIEW
COMBINED WITH PHOTON-
COUNTING CAPABILITIES
h·nü
nüvü
cameras


High-speed readout (ImagEM X2)
70 frames/s
at full resolution
1076 frames/s
at Sub-array 16 pixel, 4×4 binning
High QE
over 90 %
wavelength 500 nm to 650 nm
HAMAMATSU
PHOTON IS OUR BUSINESS

EMCCD – porovnání

výrobce	Andor	Princenton	Raptor	nüvü cam.	Hamamatsu
model	Ultra 888	1KBX3-10 µm	Falcon III	h·nü 1024	C9100-24B
rozlišení	1024×1024				
pixel [µm]	13×13	10×10		13×13	
I_{dark} [e^-/px/s]	0.000 11	0.002	< 0.001	0.000 07	0.001
kap. px [ke^-]	80	30	29		50
nás. reg.	730	150	200	730	400
δ_{ro} [e^-]	130	80	60	3	10
s EM	< 1	< 1	< 1	< 0.1	< 1
EM zisk	1 – 1000		1 – 5000		10 – 1200
fps [Hz]	26	30	31	25	18.5

Key Applications

Quantum imaging, Cold atom & ion research, Fast astronomy, Tomography, Fast spectroscopy, Single molecule detection, Super-resolution, Calcium signaling, Fluorescence imaging, Genome sequencing, Solar cell inspection etc.

iCCD, iCMOS, EMiCCD

ANDOR
an Oxford Instruments company

Princeton Instruments

PI-MAX®4: 1024 EMB

PHOTONIC SCIENCE

Intensified
CCD & CMOS
Camera

Raptor photonics

iCCD, iCMOS, EMiCCD porovnání

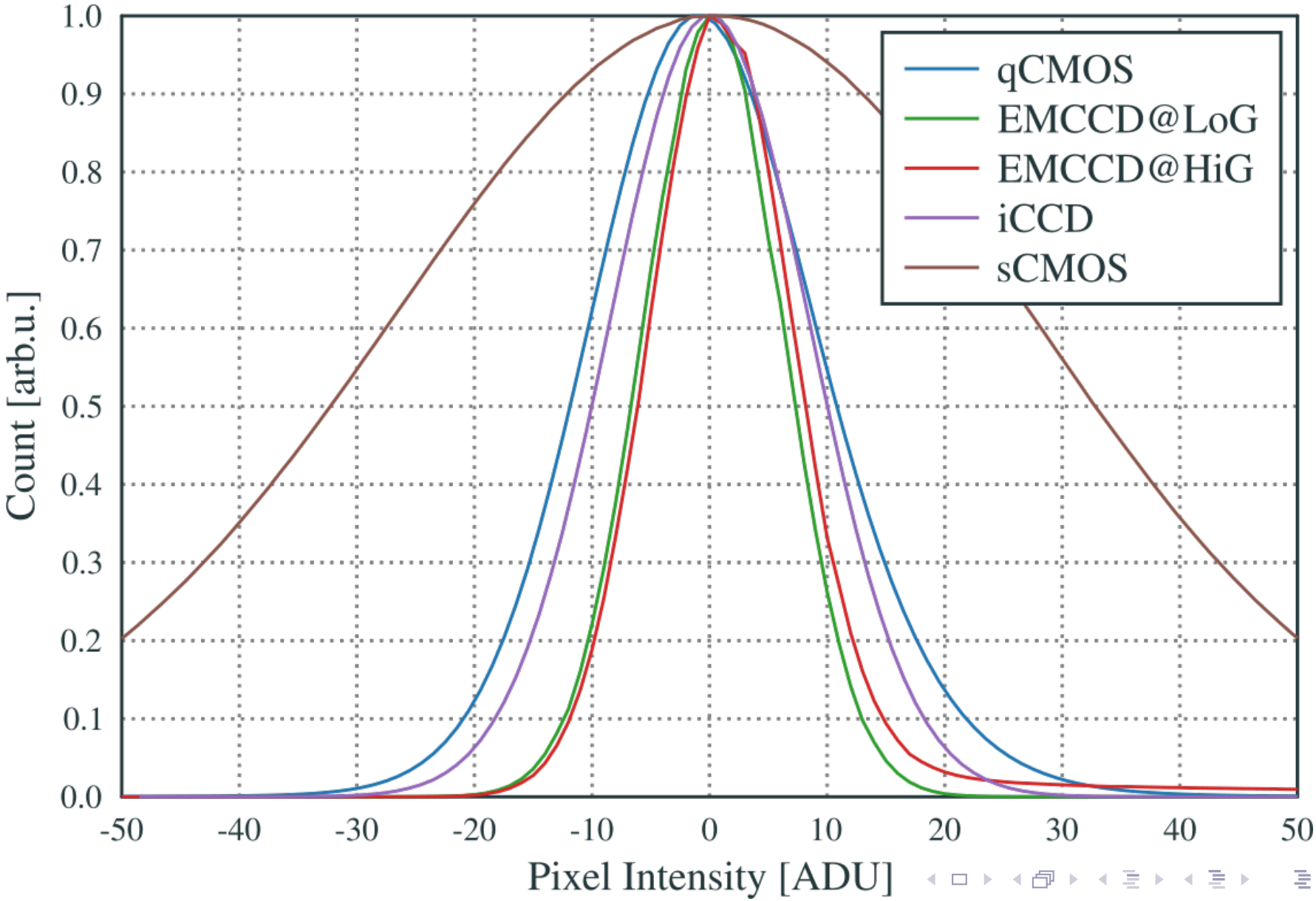
výrobce	SCO	Andor	PI	Photonic	Raptor
typ	iCCD	iCMOS	EMiCCD	iCCD iCMOS	iCCD
rozlišení	1360x1024	2560x2160	1024x1024	1940x1460	1024x1024
pixel [µm]	4.7×4.7		13x13	4.5x4.5	13x13
gate [ns]	0.2	2	0.5	3	40
fotokatoda	gen II	gen II i gen III			gen II
δ_{ro} [e^-]		2.4	90		18
fps [Hz]		50		25	0.9

Zesílení mikrokanálkové destičky

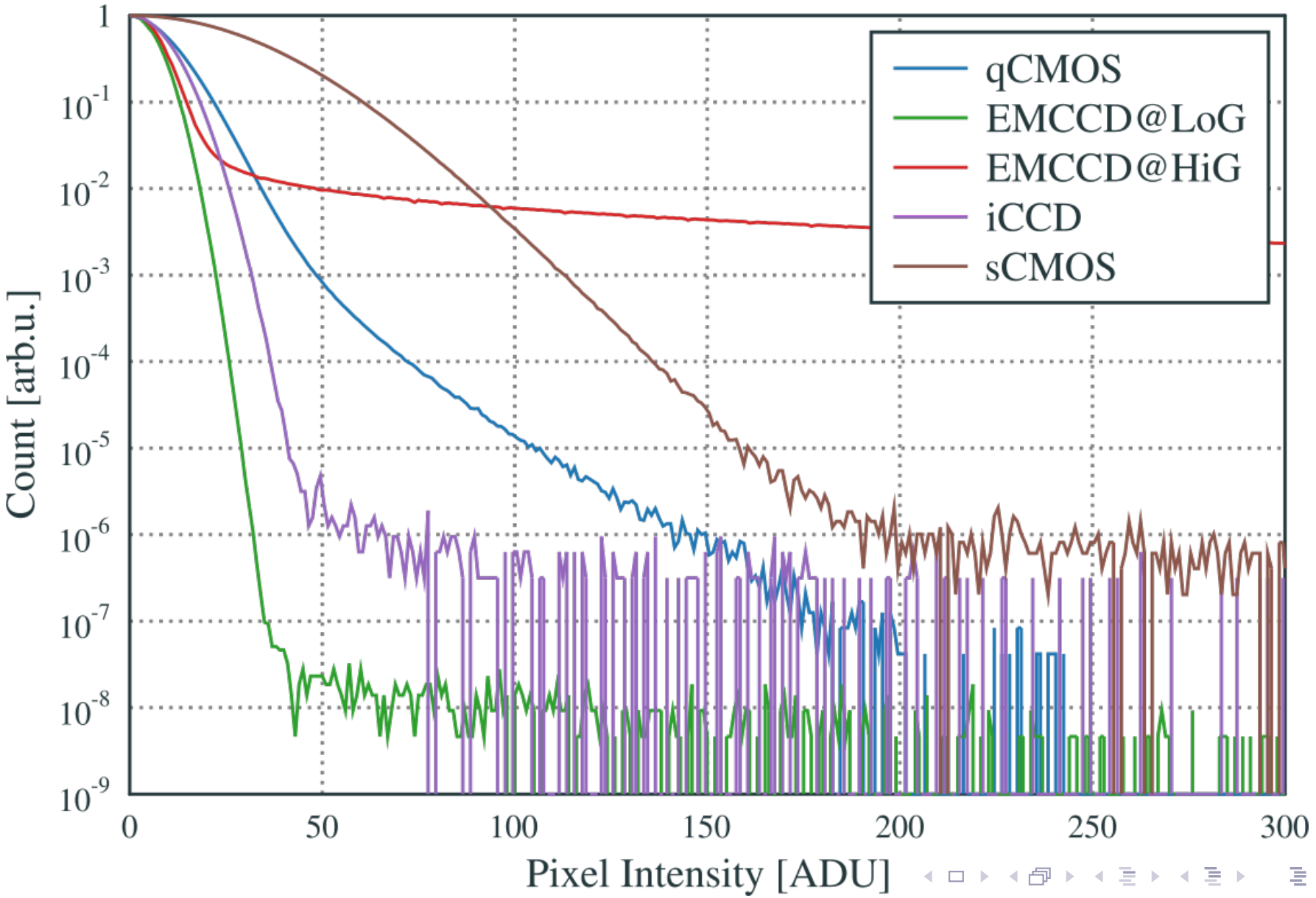
jednoduchá – zisk 10^4, rozlišení 60 čar/mm

dvojitá – zisk 10^6, rozlišení 30 čar/mm

NEVĚŘTE REKLAMĚ !!! Všechny kamery jsou stejný



Využití pro fotonovou detekci



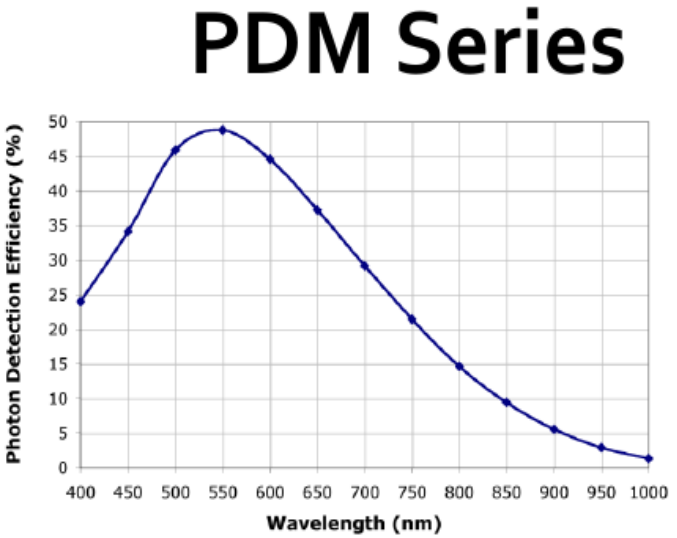
Obsah

APD – lůzři

Micro Photon Devices

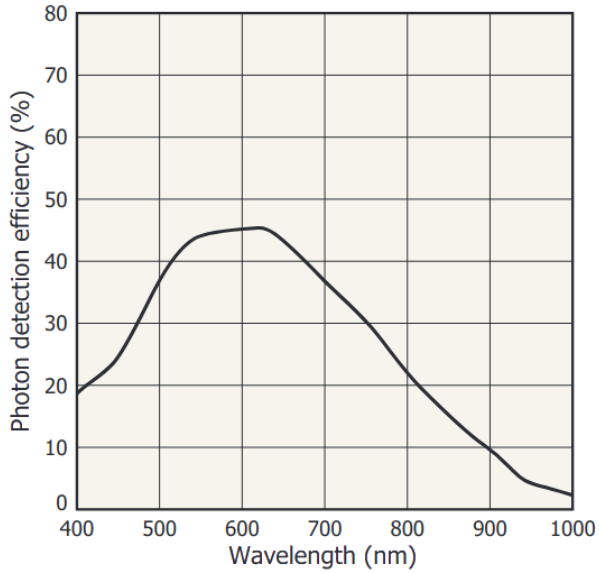
$\tau_D = 77\,\text{ns}$

$\Delta t = 35\,\text{ps}$



Hamamatsu C16533

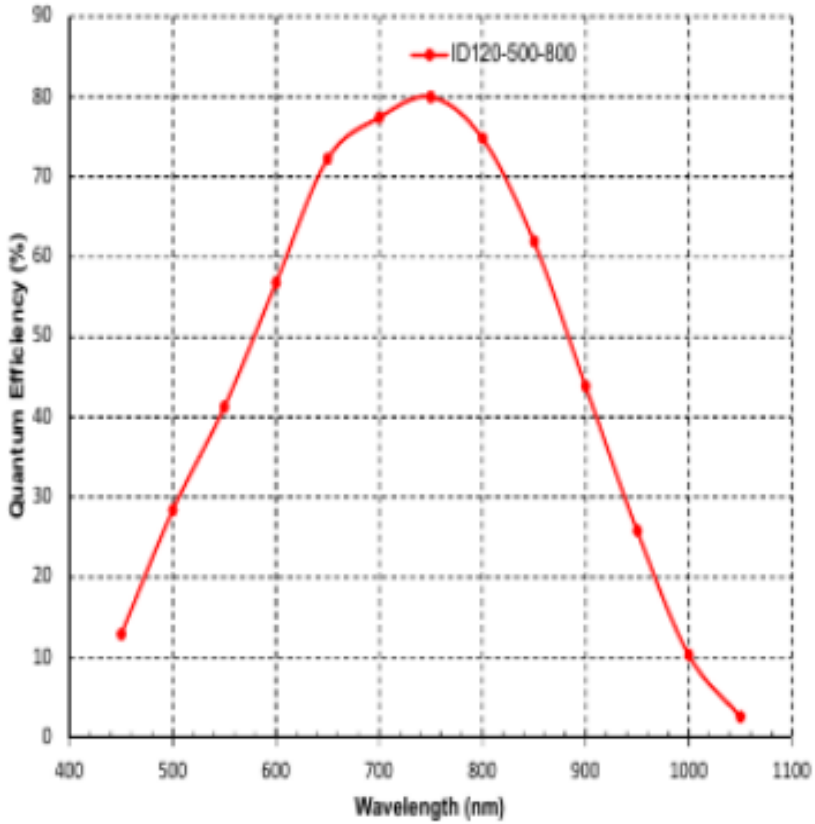
$D = 20\,\text{Hz}$



APD ID Quantique

Jednofotonový detektor pro kvantovou kryptografii

- $\tau_D = 1\,\mu s$ (pasivně zhášený)
- $D < 200\,Hz$
- $\Delta t \sim 400\,ps$
- možnost nastavit předpětí a teplotu



IR APD ID Quantique

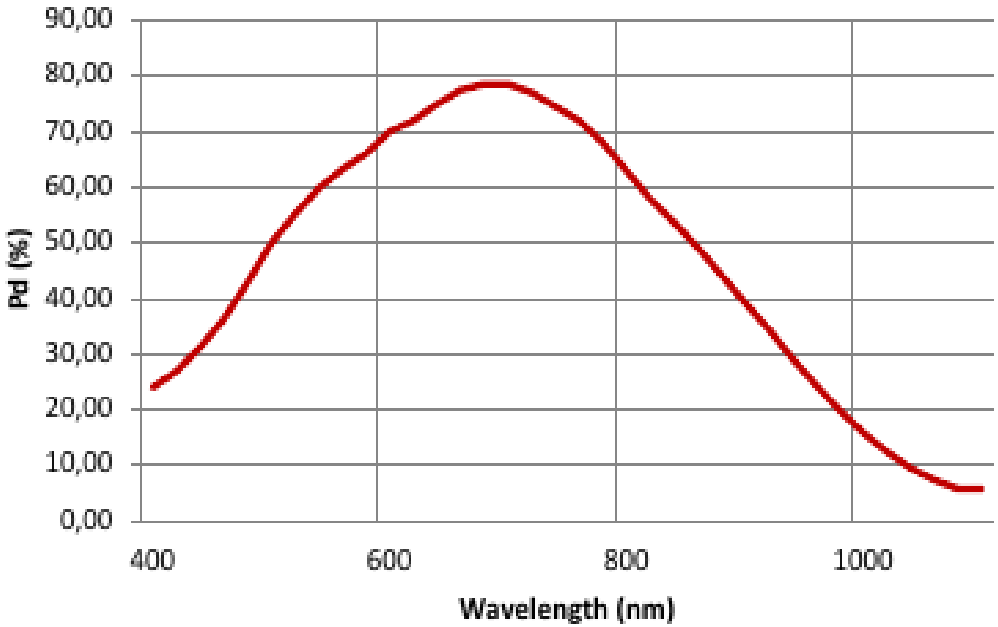
- 900 – 1700 nm
- $\tau_D = 2 - 100\,\mu s$
- η až 25 %
- $D < 50$ Hz při $-90°$
- $\Delta t \sim 400$ ps
- váha 30 kg

SWISS MADE

APD Laser Components

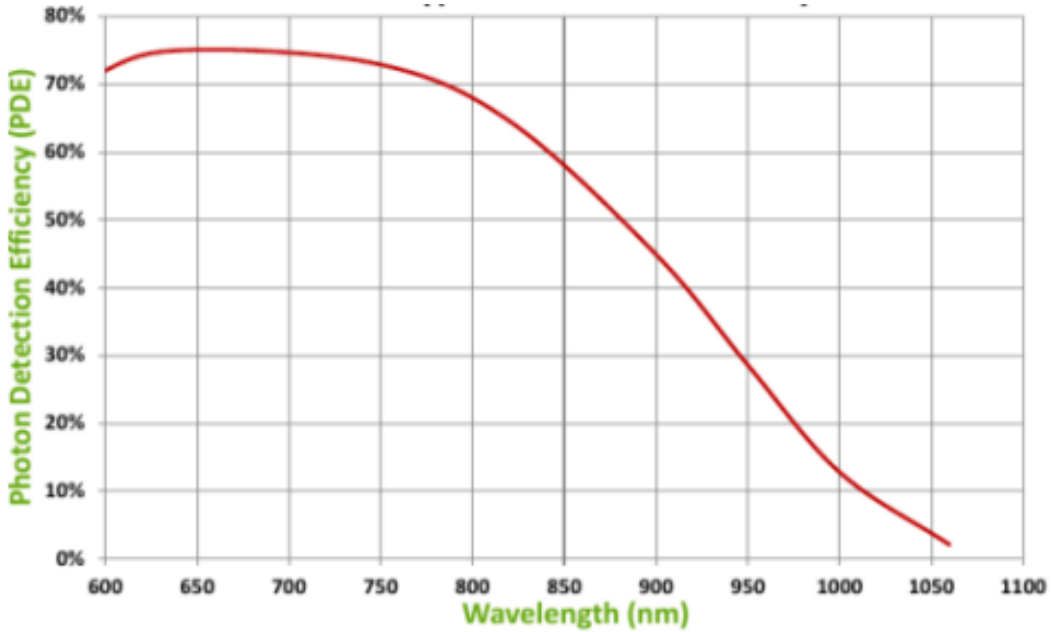
- $\tau_D = 45\,\text{ns}$
- $D < 50, 100, 250, 500\,\text{Hz}$
- $\Delta t = 1000\,\text{ps}$

- průměr aktivní plochy 100 µm
- cena $\sim$ 140 000 Kč



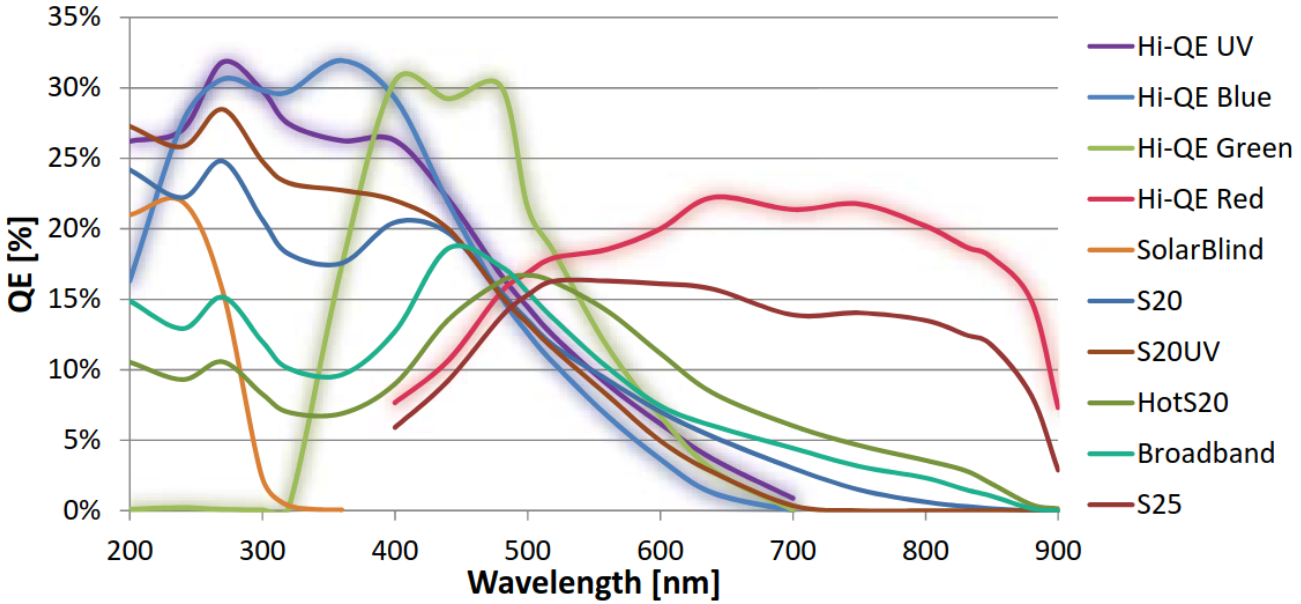
APD Excelitas

- $\tau_D = 24\,\text{ns}$
- $D < 100, 250, 500, 1000, 1500\,\text{Hz}$
- $\Delta t = 350\,\text{ps}$
- průměr aktivní plochy 180 µm
- cena 5 618 $

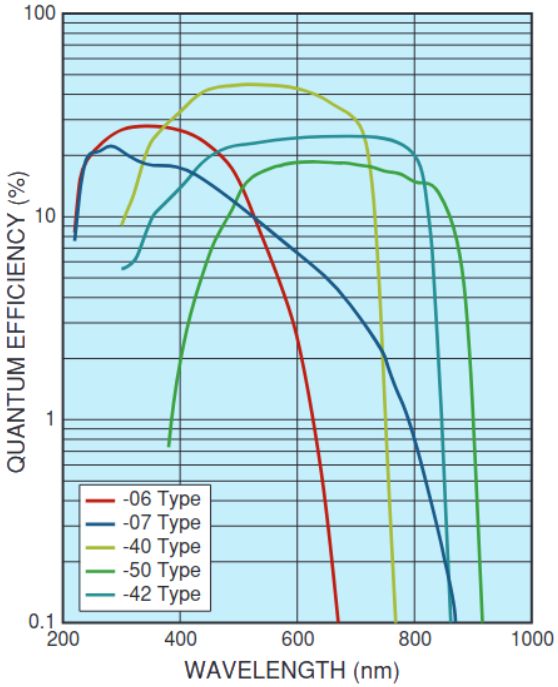


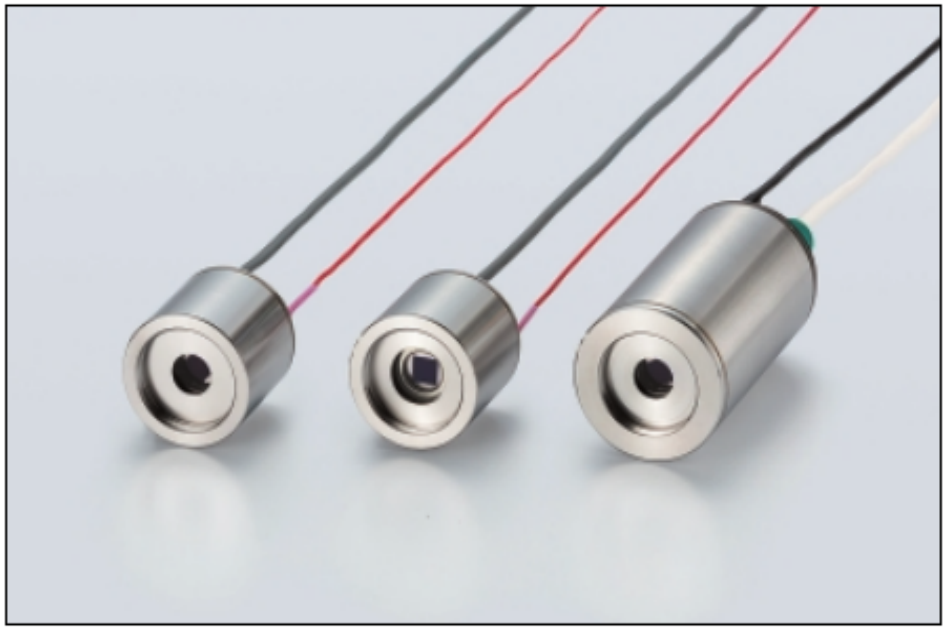
Obsah

HPD – Photonis



HPD – Hamamatsu



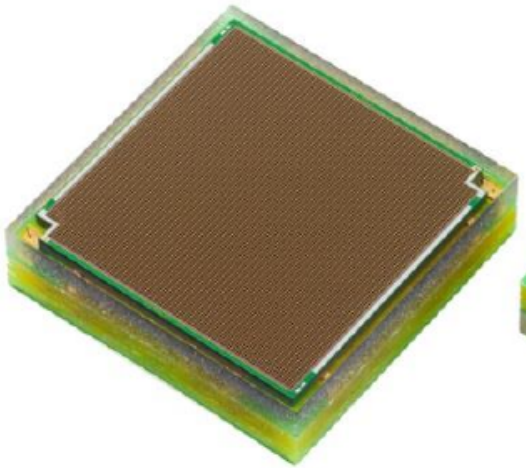


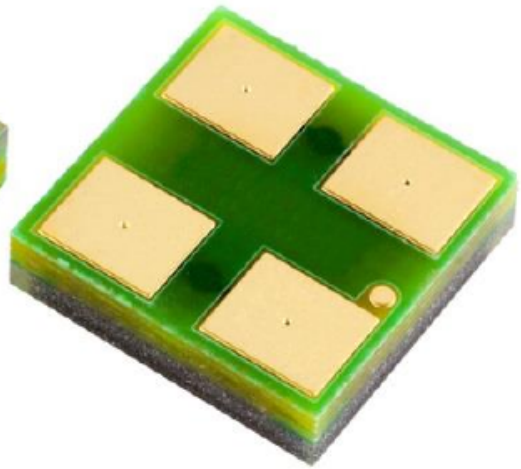
Left: R10467U-40, Center: R11322U-40, Right: H13223-40

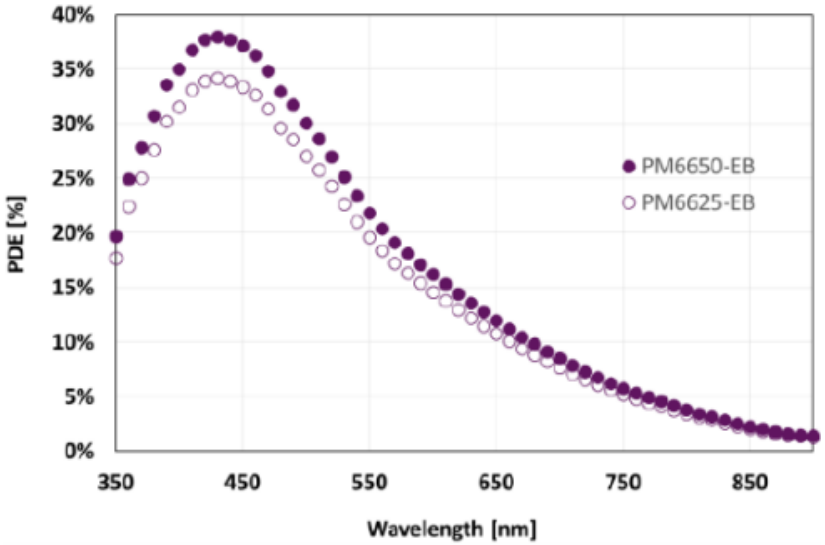
Parameter		R10467U-06	R11322U-40	R10467U-40 H13223-40	R10467U-50	Unit
Spectral response		220 to 650	300 to 720	300 to 720	380 to 890	nm
Photocathode	Material	Bialkali	GaAsP	GaAsP	GaAs	—
	Effective area	ϕ6	ϕ5	ϕ3	ϕ3	mm
Window material		Synthetic silica	Borosilicate glass			—
Window type		Plano-concave	Flat			—
Operating ambient temperature		+15 to +35				°C
Storage temperature		0 to +40				°C
Quantum efficiency		28 *4	45 *5	45 *5	14 *6	%
Gain *2		1.2×10^5				—

Obsah

KeteK – Silicon Photomultiplier (55 a 14 kpx)



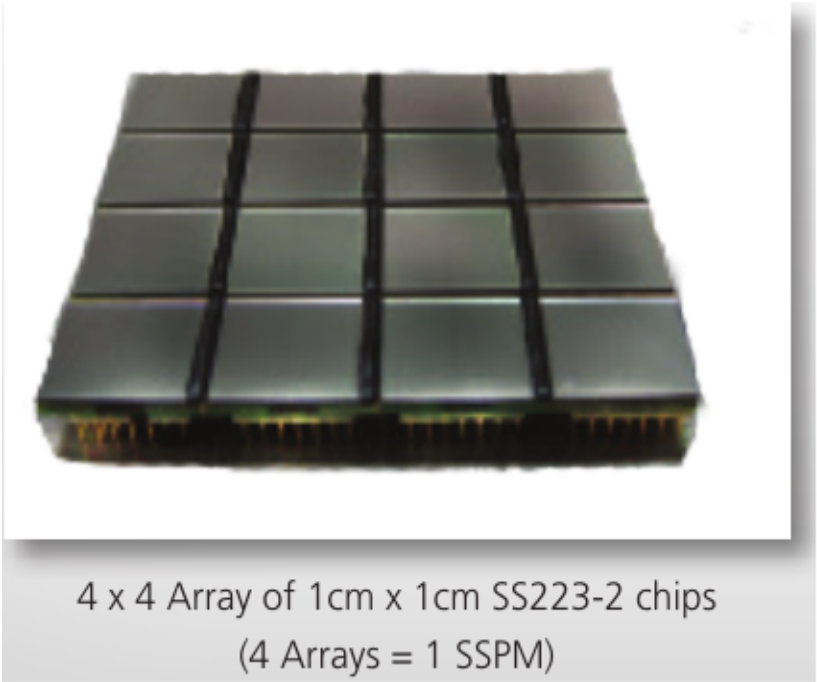




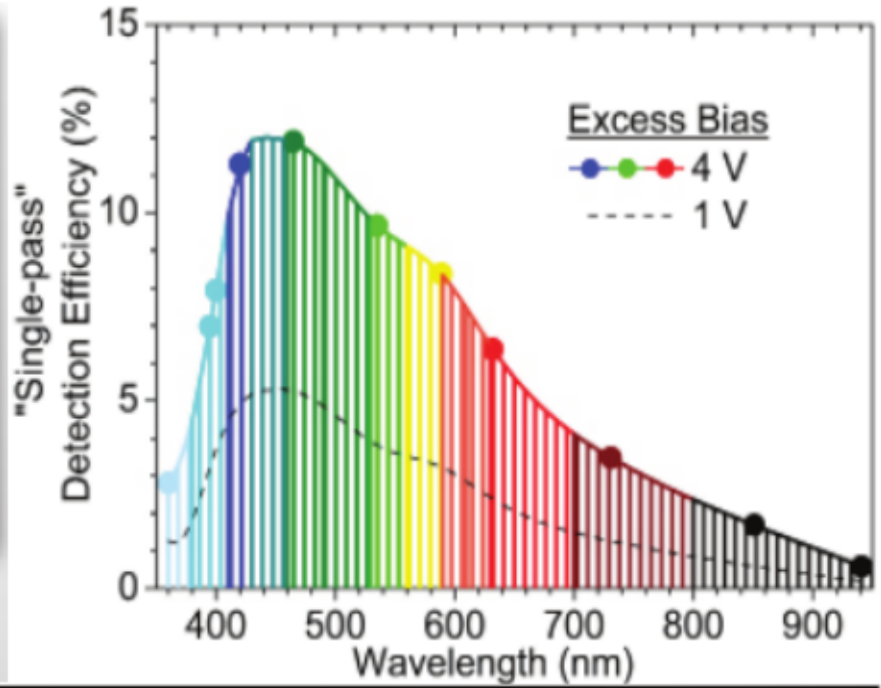
Parameter	Type	Microcell Size [µm]	Typ. @ 2.5 V_{OV}	Typ. @ 5.0 V_{OV}	Unit
Photo Detection Efficiency @ 430 nm	PM66	25	26	34	%
		50	28	38	
Dark Count Rate	PM66	25	250	500	kHz/mm²
		50	250	500	
Crosstalk Probability	PM66	25	16	35	%
		50	16	35	
Afterpulse Probability	PM66	25	1	3	%
		50			
Gain	PM66	25	0.9	1.7	x 10^6
		50	3.6	7.2	

Breakdown voltage 26.5 V, recommended overvoltage 2–5 V,
Recovery time 40 (70) ns, Price 122 €

RMD – Solid State Photomultiplier (CMOS)



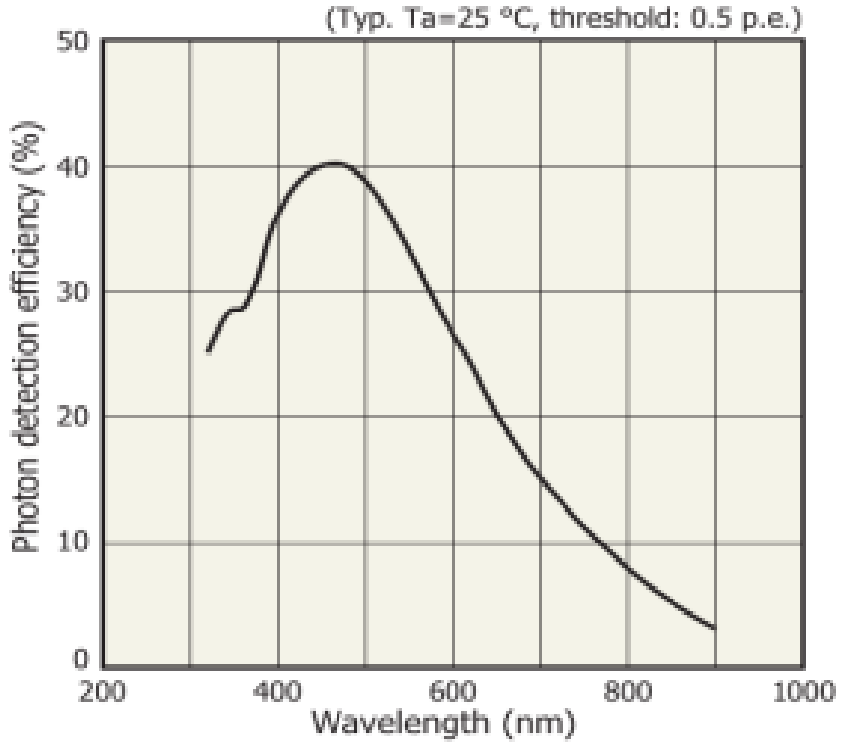
4 x 4 Array of 1cm x 1cm SS223-2 chips
(4 Arrays = 1 SSPM)



Design	SS223-1CS12	SS223-2CS12	SS223-3CS12	SS223-6SQ4
Pixel Size	30 µm × 30 µm			
Array Format	6 × 6	2 × 2	1 × 1	1 × 1
Number of Pixels per Array	1156	12882	38416	1024
Array Fill Factor, FF	46%	46%	33%	46%
Array Area	1.5 mm × 1.5 mm	5.0 mm × 5.0 mm	10 mm × 10 mm	1.5 mm × 1.5 mm

Breakdown voltage 27.2 V, Operation voltage 27.5–32.5 V,
Recharge time 30 ns, Gain 3×10^6, $D \sim 16$ kHz/px

Hamamatsu – MPPC (667 a 3600 px)



Parameter	Symbol	Condition	C13366-1350GD			C13366-3050GD			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range	λ			320 to 900			320 to 900		nm
Peak sensitivity wavelength	λp		-	450	-	-	450	-	nm
Element temperature (setting temperature)	Td		-	-20	-	-	-20	-	°C
Photon detection efficiency	PDE	Threshold: 0.5 p.e.	-	40	-	-	40	-	%
Dark count	CD	Threshold: 0.5 p.e.	-	2.5	7	-	12	36	kcps
Comparator output	-			TTL compatible					-
Afterpulse probability	-	100 ns to 500 ns	-	0.1	-	-	0.1	-	%
Crosstalk probability	-		-	1	-	-	3	-	%
Comparator threshold level	-			adjustable in 9 steps from 0.5 to 8.5					p.e.