

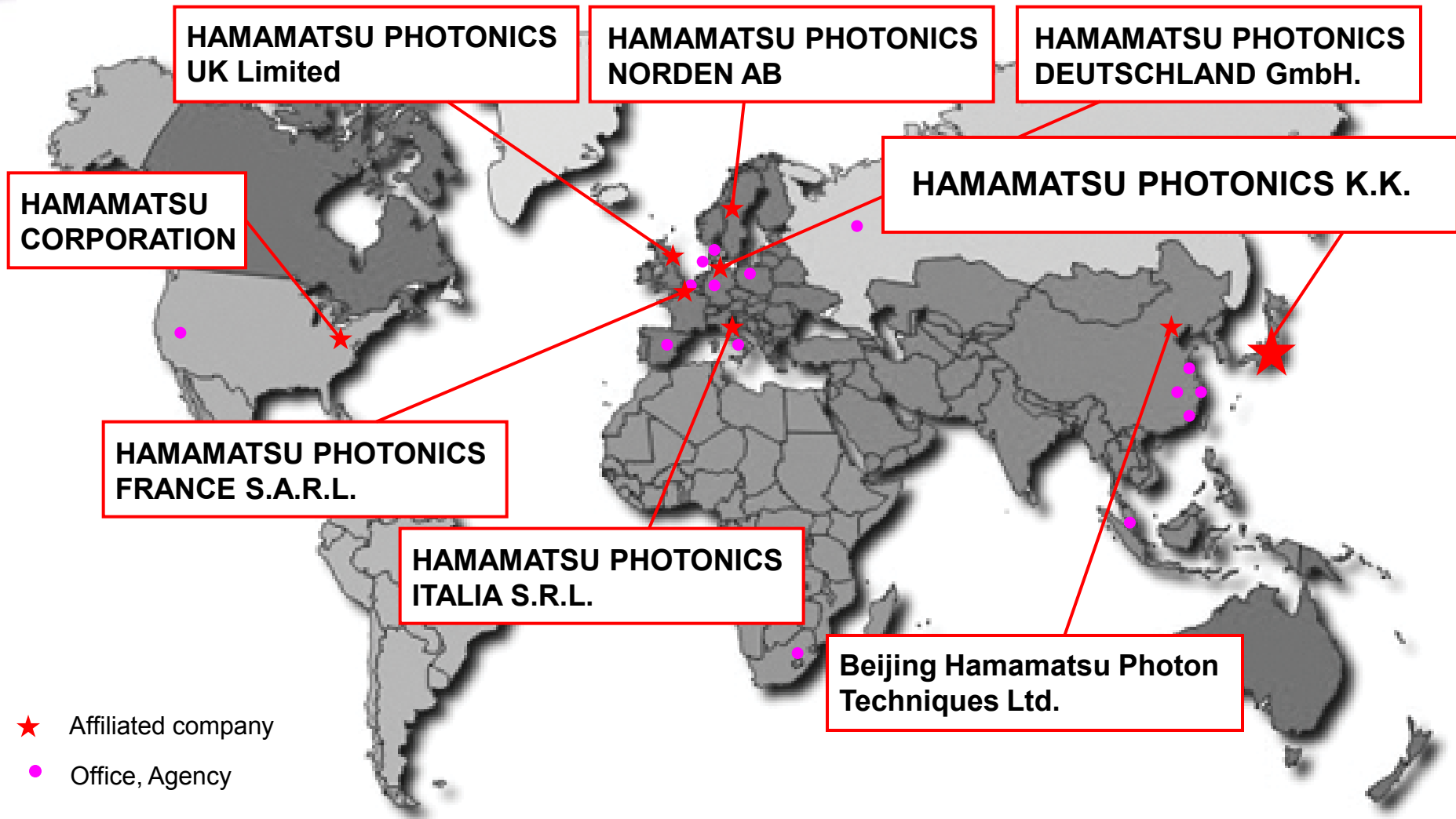
# Multi-Pixel Photon Counter MPPC

by Marius Metzger

17.02.2011

**HAMAMATSU**  
PHOTON IS OUR BUSINESS

# Global network



★ Affiliated company

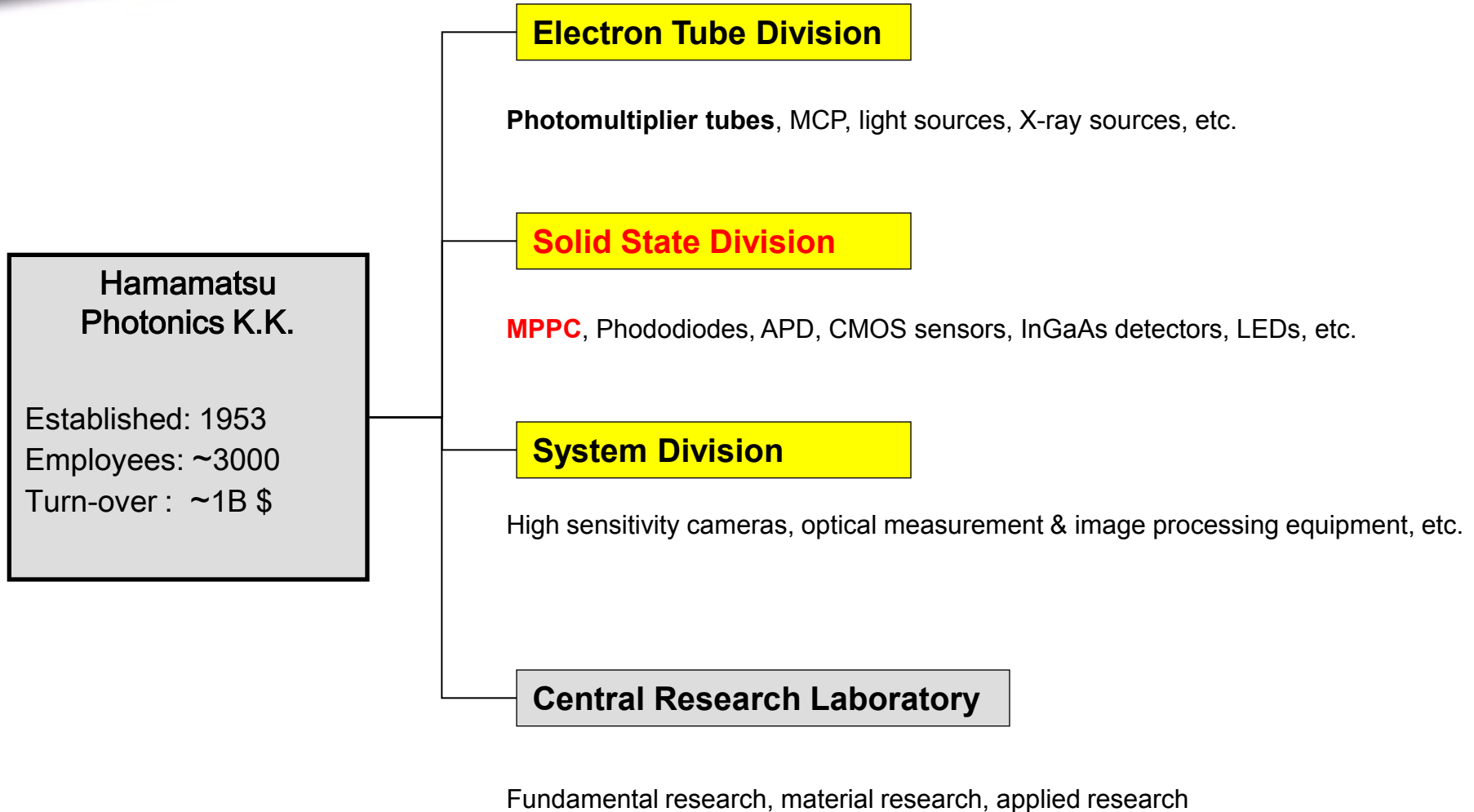
● Office, Agency

16.02.2011

Confidential


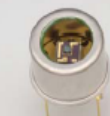
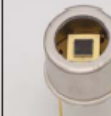

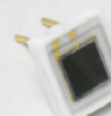
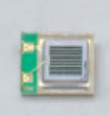
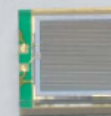
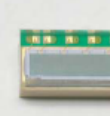
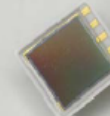
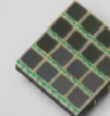
HAMAMATSU PHOTONICS

# Company organization






# Standard MPPC

## ■ MPPC lineup (conventional type)

Type	Metal type			Ceramic type		Plastic package (Surface mount type)			2D array type	
	TE-cooled					Array			Array	Array
Image										
Type no.	S10362-11 (-U series)	S11028 series	Preliminary	S10362-11 (-C series)	S10362-33 (-C series)	S10362-11 (-P series)	S10931 series	S10984 series	S10985 series	S11064 series
Effective active area	1 × 1 mm	1 × 1 mm	3 × 3 mm	1 × 1 mm	3 × 3 mm	1 × 1 mm	3 × 3 mm	1 × 4 mm (1 × 4ch array)	6 × 6 mm (2 × 2ch array)	3 × 3 mm/ch (4 × 4ch array)
Pixel size (μm)	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25	25 × 25
	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50
	100 × 100	100 × 100	100 × 100	100 × 100	100 × 100	100 × 100	100 × 100	100 × 100	100 × 100	50 × 50
Package	Metal (TO-18)	Metal (TO-8)	Metal (TO-8)	Ceramic	Ceramic	Plastic	Plastic	Plastic	Ceramic	Plastic

# Standard MPPC modules

## ■ MPPC module lineup (conventional type)

Type	Type no.	Dimension (mm)	Built-in MPPC					
			Package	Effective active area (mm)	Type no.	Number of pixels	Pixel size (mm)	
Standard type		C10507-11 series	80 × 55	Metal	1 × 1	S10362-11 (-U/C series)	1600	25 × 25
				Ceramic			400	50 × 50
	100	100 × 100						
CE compliant		C10751 series	90.7 × 77 × 35	Metal		S10362-11 (-U series)	1600	25 × 25
							400	50 × 50
							100	100 × 100
TE-cooled type		C11208 series	100 × 60 × 35			S11028 series	1600	25 × 25
							400	50 × 50
							100	100 × 100

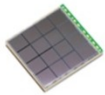
# New MPPC products

**NEW**



**4x4ch monolithic array**  
PWB package  
S11827-3344MG

**NEW**



**4x4ch monolithic array**  
SMD package  
buttable  
S11828-3344M

**NEW**



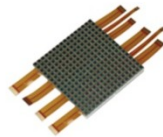
**4x4ch monolithic array**  
with FPC (15 cm)  
buttable  
S11829-3344MF

**NEW**



**4x4ch monolithic array**  
with FPC (5 cm)  
buttable  
S11830-3344MF

**Prototype**



**8x8ch discrete array**  
with FPC  
buttable  
S11834-3388DF

**Prototype**



**4x4ch module**  
C11206-0404FB

**Prototype**



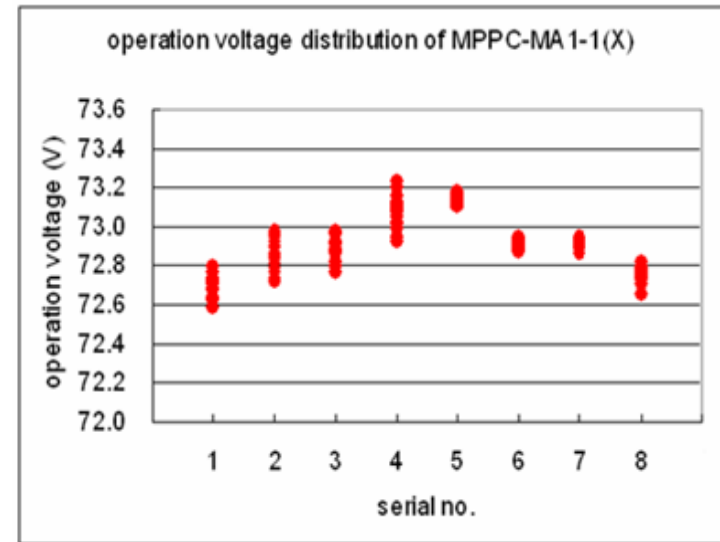
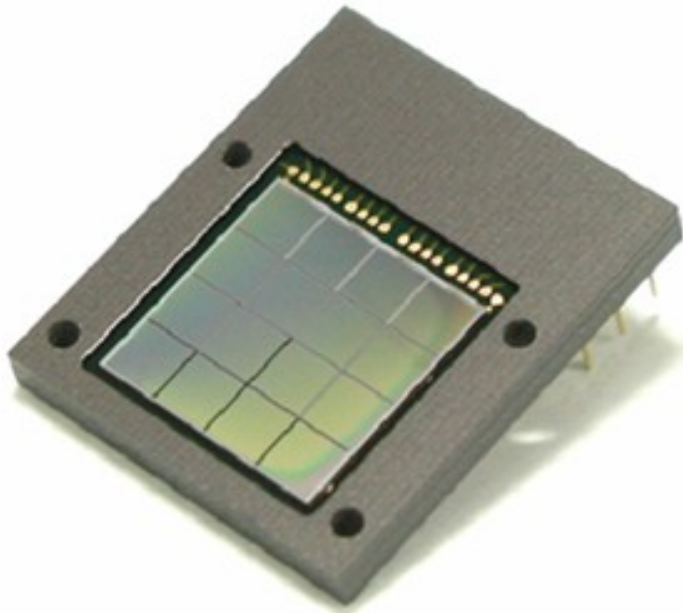
**8x8ch module**  
C11206-0808FA

MPPC Arrays for PET and HEP

Modules for easy evaluation

# MPPC 4x4 monolithic array

- 3x3mm – 4x4 channel / monolithic chip
- Easy-to-use PWB package

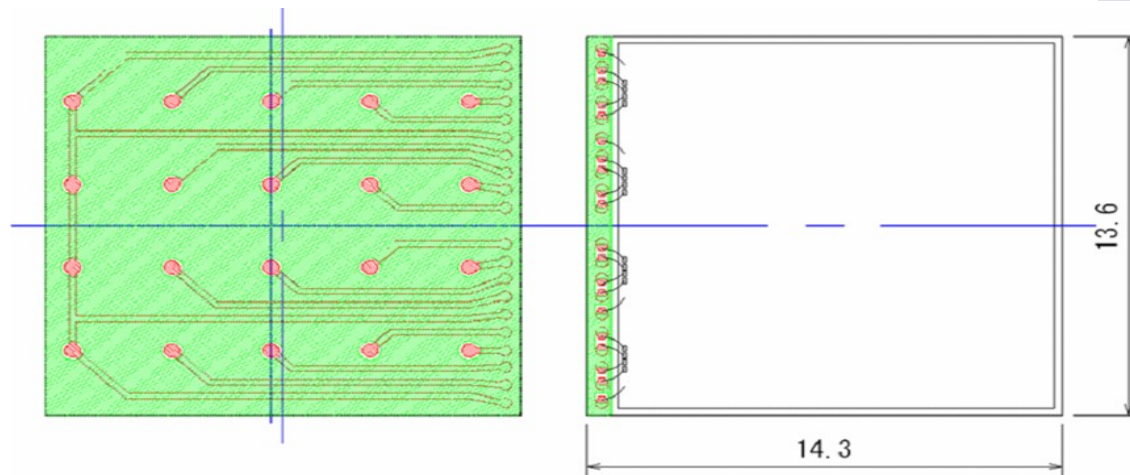
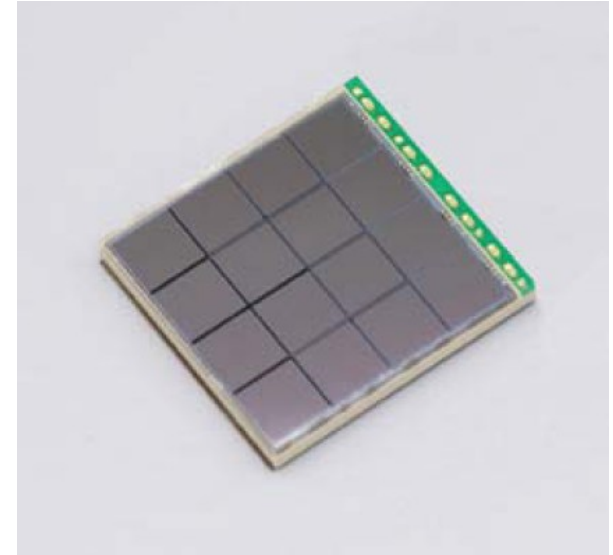


Uniform operation voltage  
16ch for each device (N=8)

Gain uniformity : +/- 10-15%

# MPPC 4x4 monolithic array / buttable

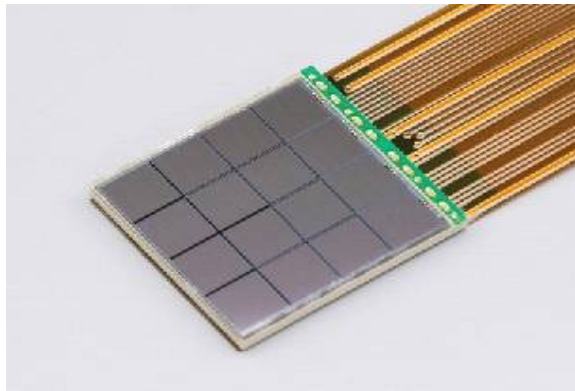
- 3x3mm – 4x4 channel / monolithic chip
- SMD package / buttable
- Non-magnetic



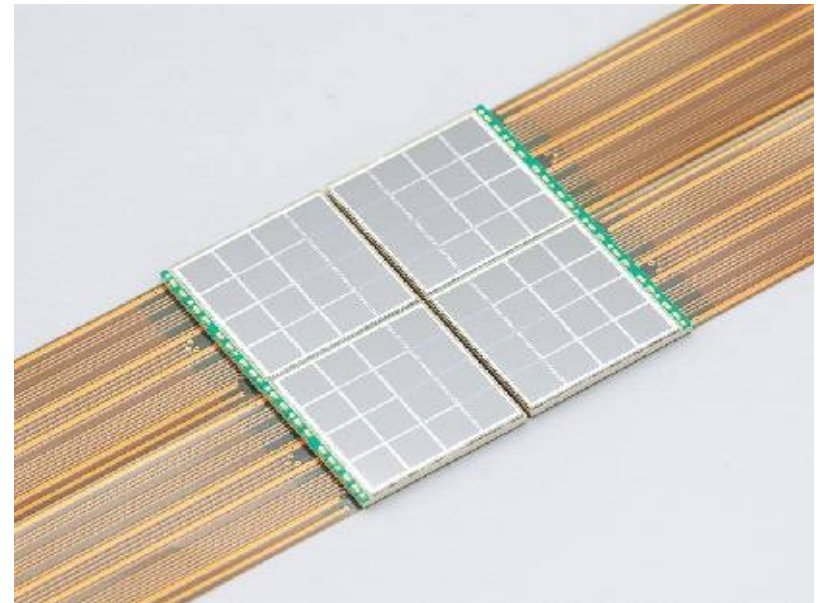


# MPPC 4x4 monolithic array / buttable

- 3x3mm – 4x4 channel / monolithic chip
- SMD package with FPC / buttable
- Non-magnetic



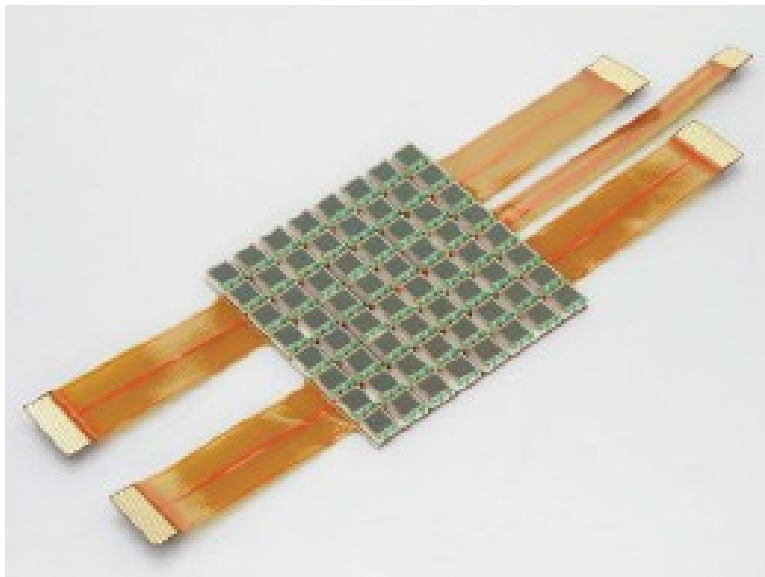
buttable





# MPPC 8x8 discrete array / buttable

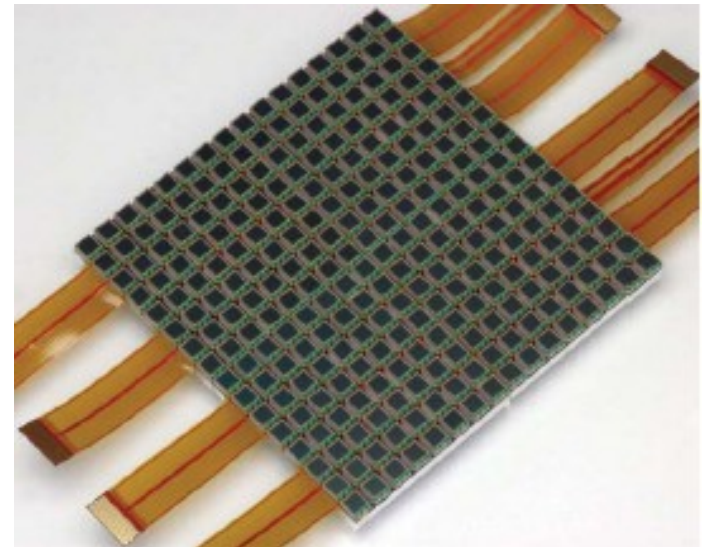
- 3x3mm – 8x8 channel / discrete array
- SMD package with FPC / buttable
- Non-magnetic
- 5mm pitch



buttable



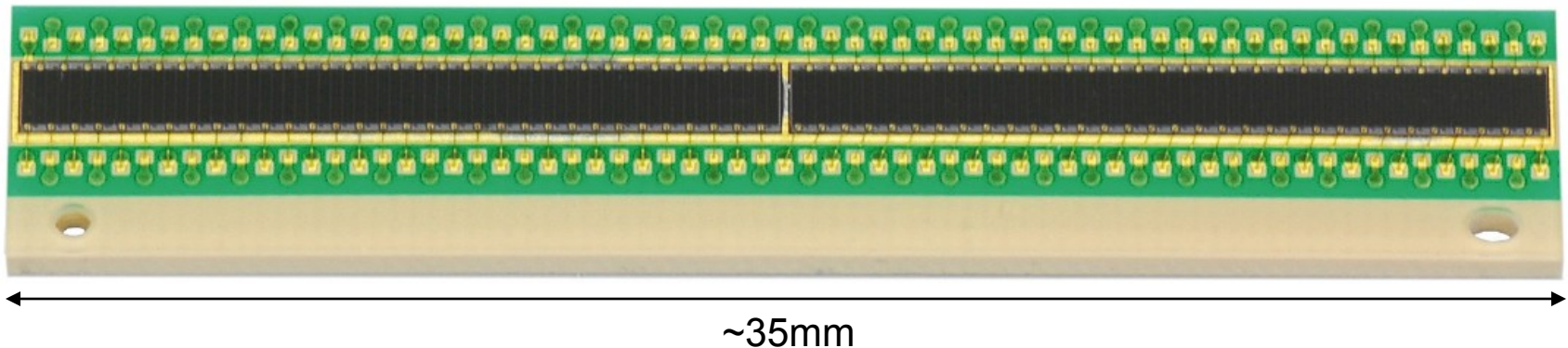
16x16



# Custom-made MPPC example

## MPPC linear array 128ch - developed for fiber tracker

- 2 chips/assembly
- Gap between active area of chips : 250um (= 1ch)
- Buttable device (aimed gap : also 250um)
- Thin epoxy layer: minimize optical cross-talk



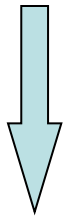
# MPPC modules

standard

1ch type



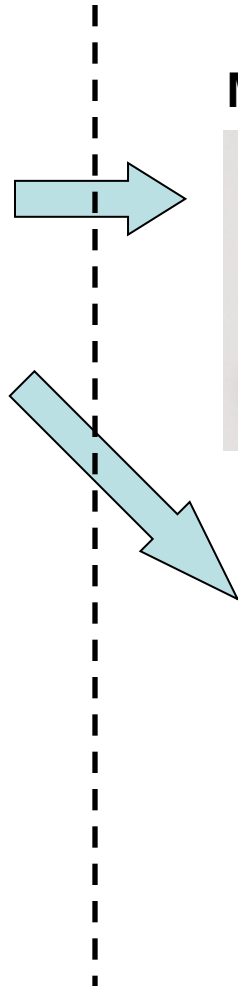
C10507 series



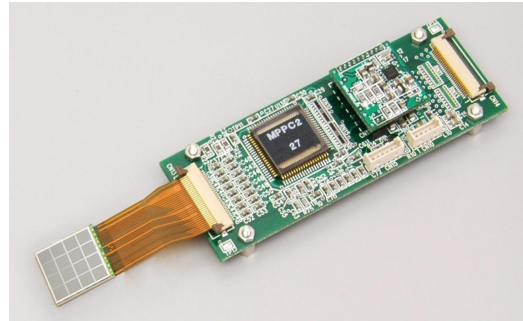
TE Type



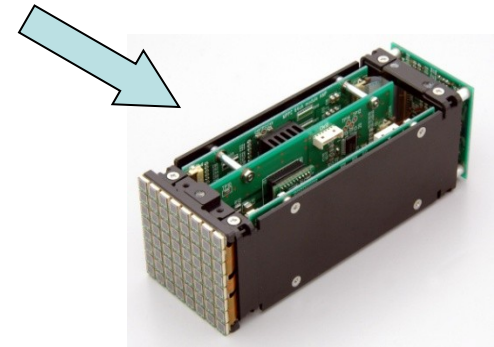
C11208 series



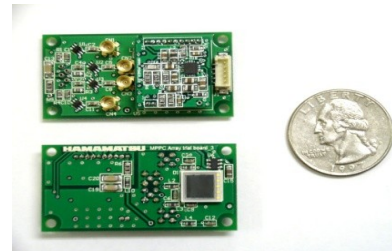
Module 4x4 monolithic



Module 8x8 discrete

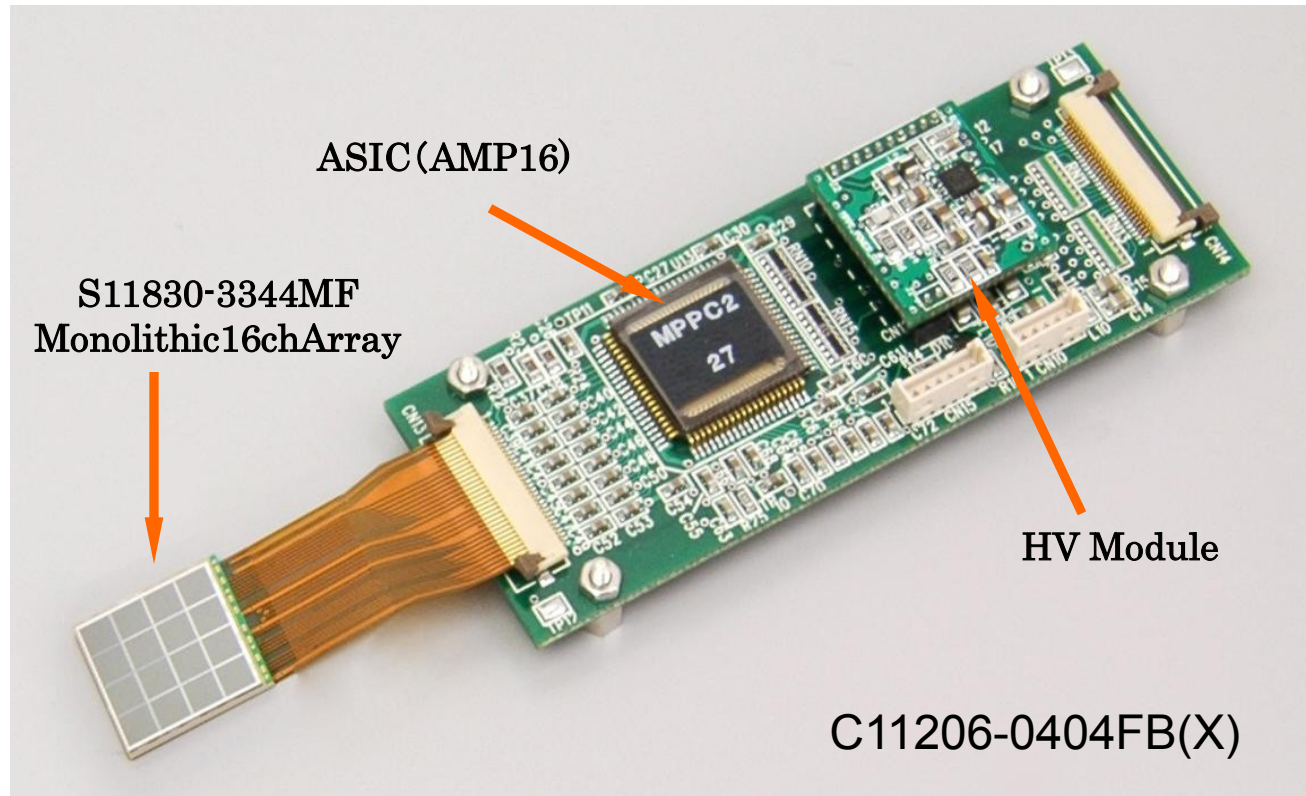


Module 2x2 ; high speed type





# MPPC module 4x4

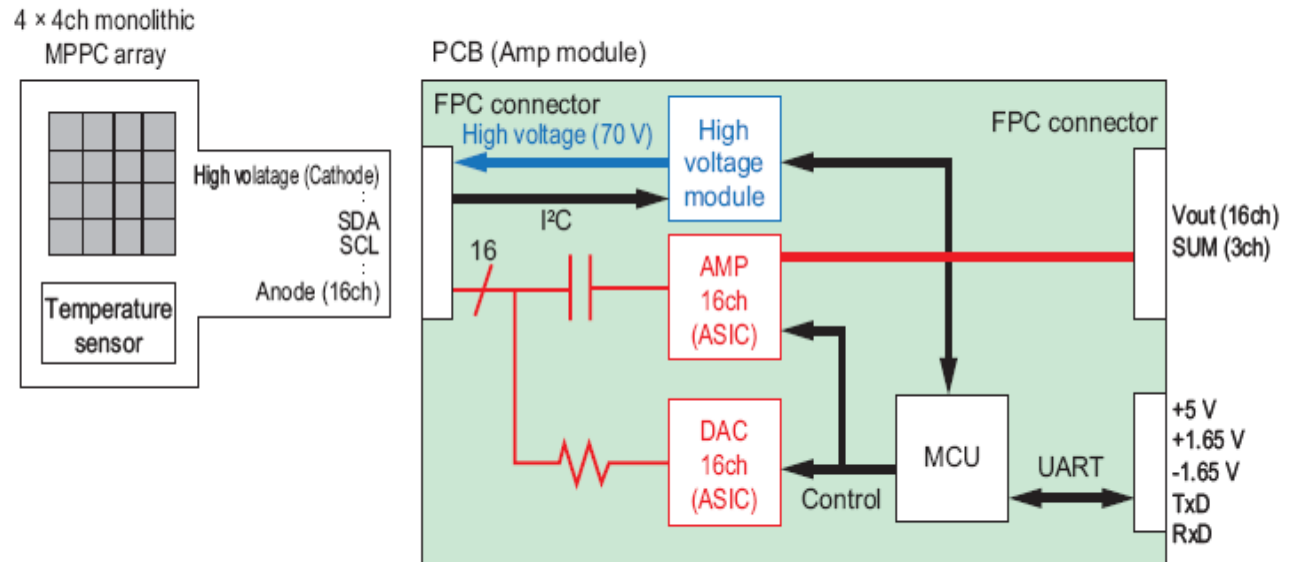


Including preamp and bias circuit for MPPC array

# MPPC module 4x4

## ■ Block diagram

C11206-0404FB (X)



Preamp

16ch Amp Array

Bias offset

16ch DAC Array

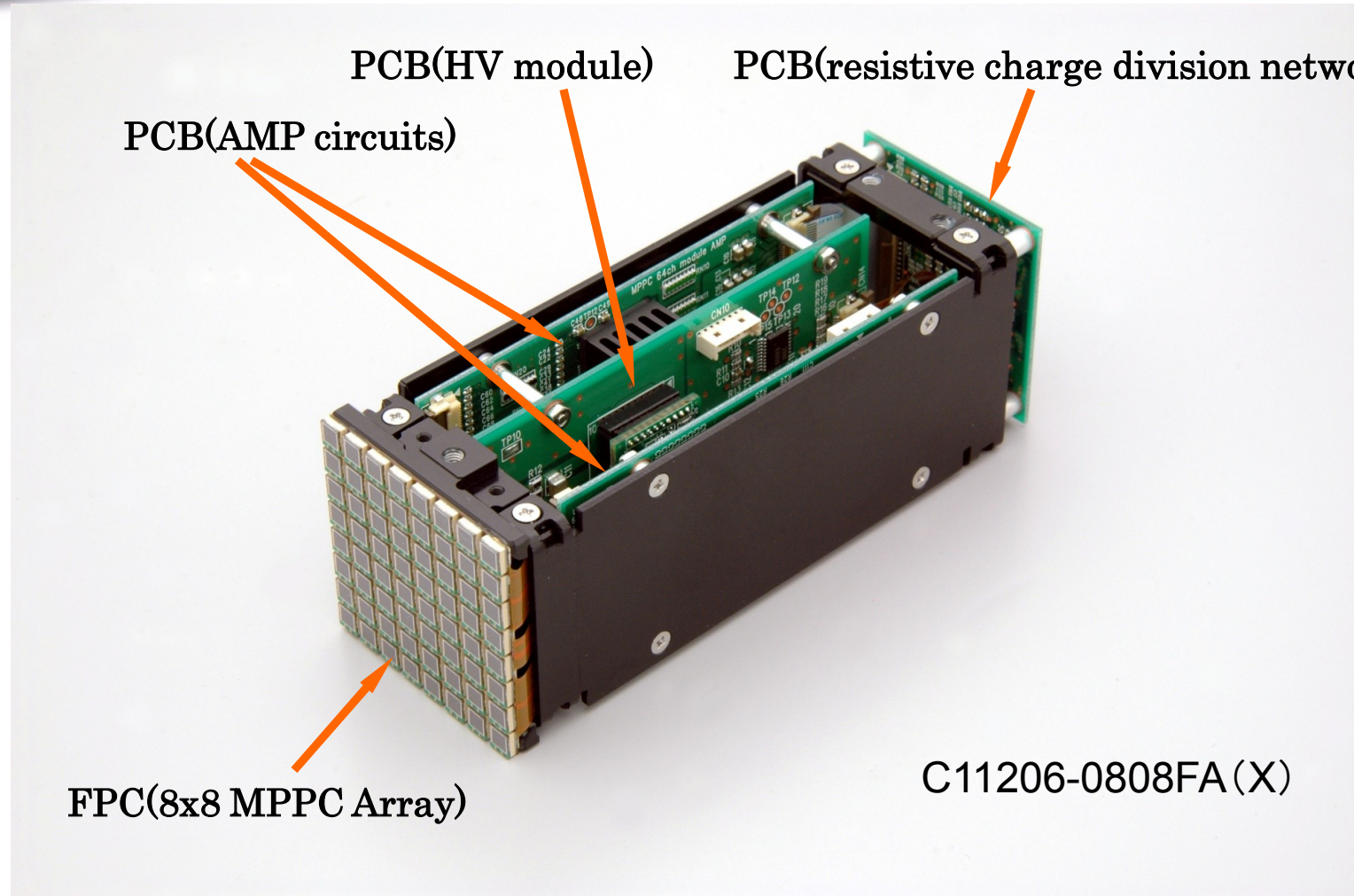
-> Provides gain uniformity

Bias Voltage

70V

-> With temperature compensated circuit

# MPPC module 8x8 (prototype)



Including preamp and bias circuit for MPPC



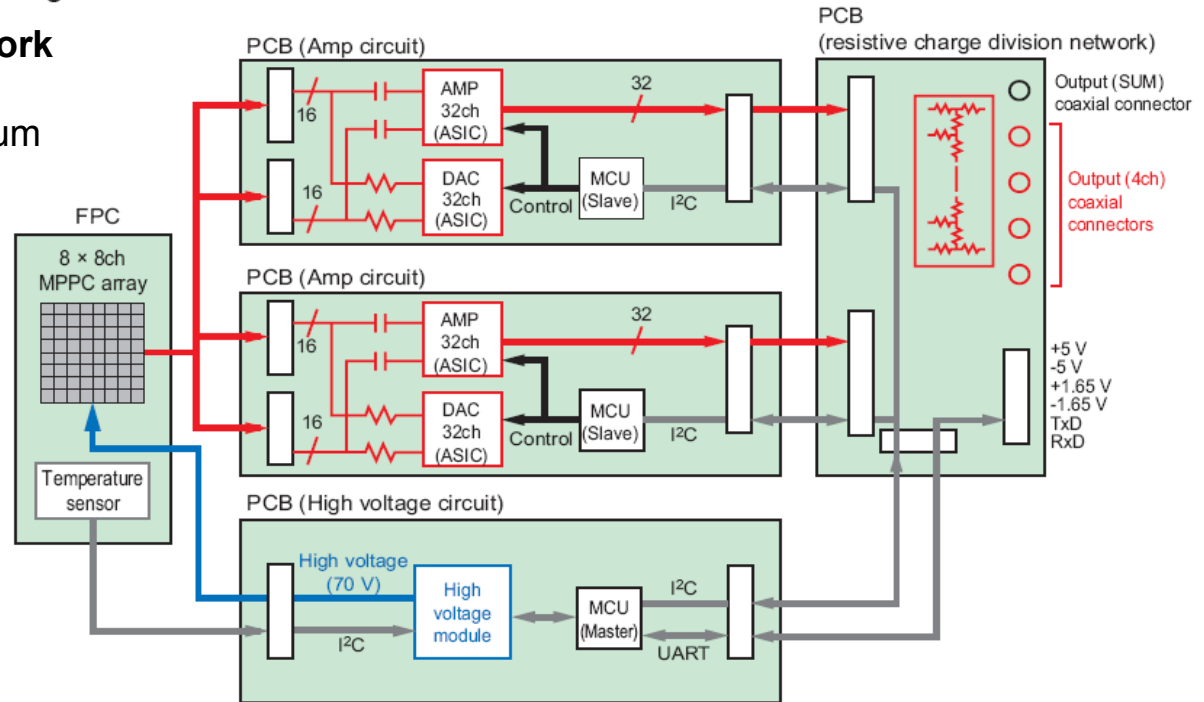
# MPPC module 8x8 (prototype)

## ■ Block diagram

### Resistive charge division network

Buffer Amplifier  
Output

>100MHz  
4point, 1sum



Preamp

32ch Amp Array (x 2) -> Bandwidth 100Mhz

Bias offset

32ch DAC Array -> Provides gain uniformity

Bias Voltage

70V

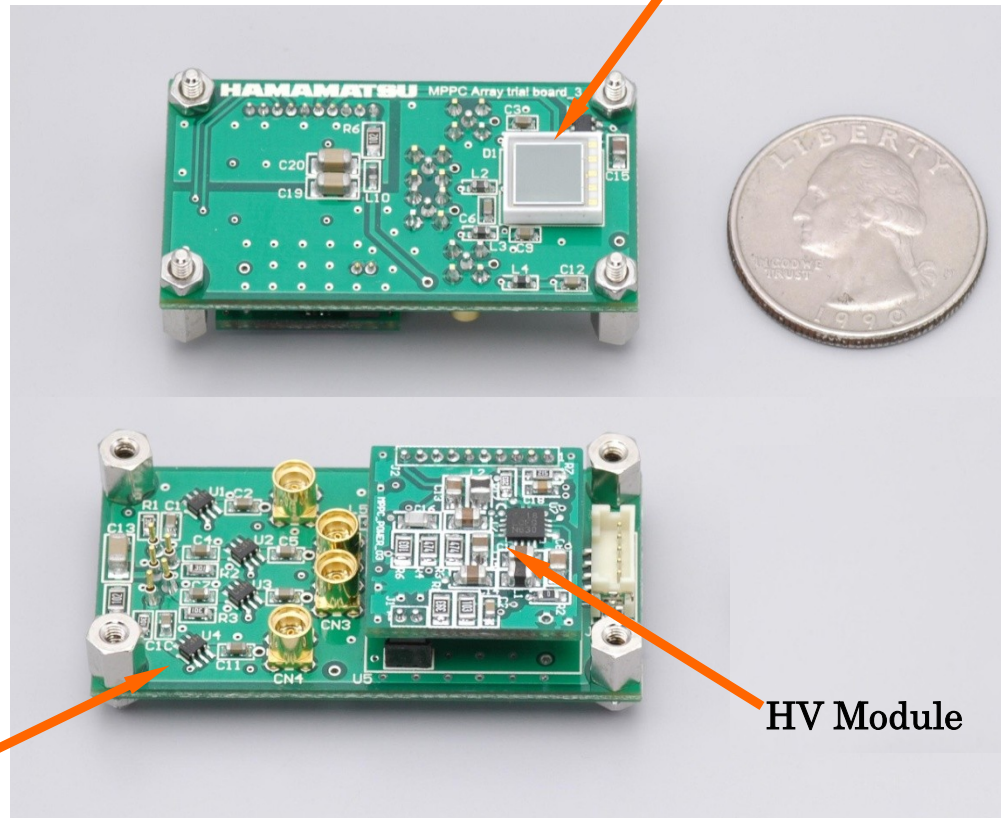
-> With temperature compensated circuit

Temperature sensor 0.03°C/LSB

# MPPC module 2x2 / high speed

C11207-0202FA (X)

S10985  
Monolithic  
4ch Array

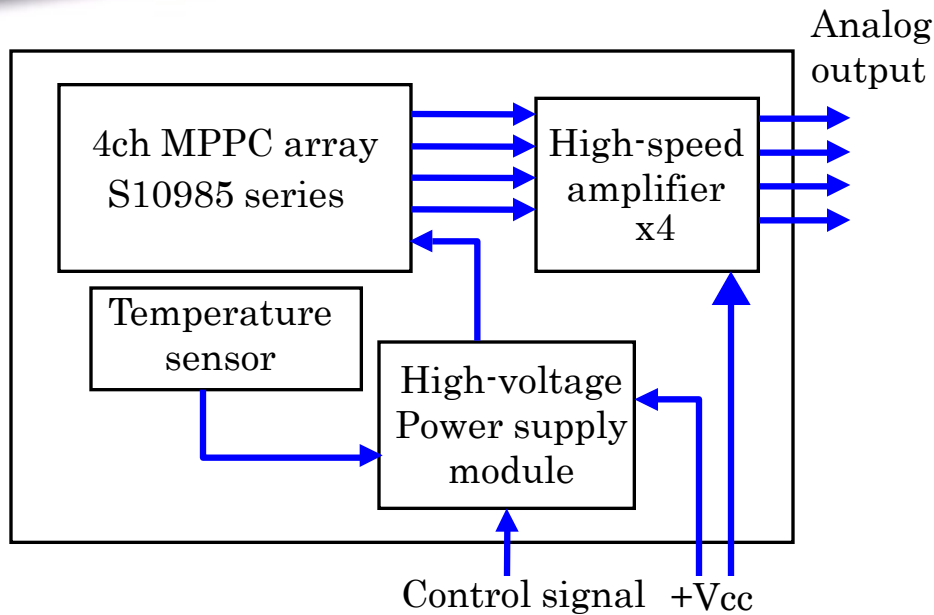


High-speed amp

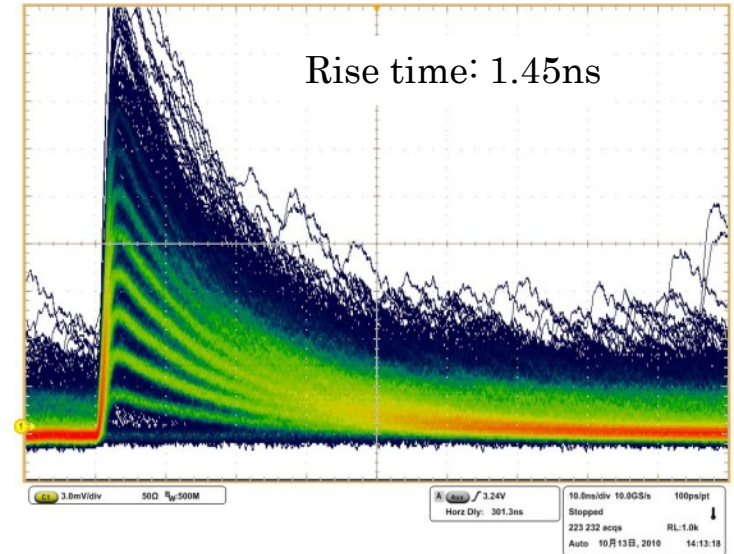
HV Module

Including high-speed amp and bias circuit for MPPC

# MPPC module 2x2 / high speed



## Analog Output



Amp bandwidth **1GHz** 4ch parallel analog out

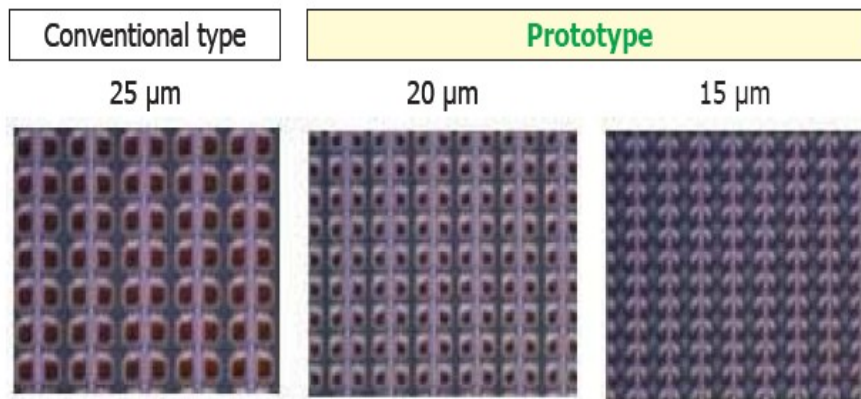
# Further efforts in progress / improvements

- **Low dark count** (e.g. 3x3mm<sup>2</sup>, 50um pixel)  
10Mcps (2007)  
--> 5Mcps (2009)  
--> 1Mcps (2010 – best run) --> consolidate
- **UV sensitivity (300-400nm)** (e.g. 50um type, incl. crosstalk and afterpulse)  
PDE 30% --> 45% @ 350nm  
Continuous improvement of A.R. and G.F.
- **High time resolution (jitter)** (e.g. 1x1mm, 1 p.e. level)  
aro 250ps (2009)  
--> Lower than 130ps (2010)
- **Gain Uniformity improvement**  
For large multi-channel arrays
- **Package development**  
Buttable with very small gap

# R&D : smaller pixel & higher pixel number

## Small pixel MPPC (Active area: 1×1 mm)

HAMAMATSU is trying to develop small pixel MPPC.

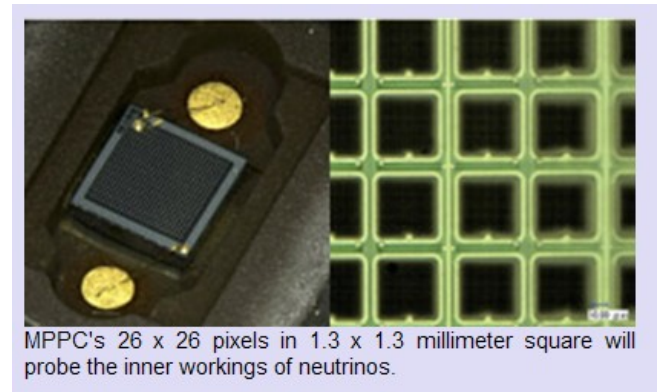


Pixel size (μm)	Number of pixels	Fill factor (%)	Gain
25	1600	30.8	$2.75 \times 10^5$
20	2500	22	$\approx 2 \times 10^5$
15	4489	20	(Preliminary)

- fast recovery time ( few ns)
- high dynamic range and high count rate

# MPPC mass-production for T2K (example)

- The Tokai-to-Kamioka second generation long-baseline neutrino oscillation experiment is underway
- The world's first large-scale implementation of new innovative photon detector:
- 60'000pcs of MPPC 1.3x1.3mm , 50um
- Delivered: 2008-2010



# Summary

- Large family of standard MPPC products
- Lots of custom-made MPPC developments on-going
- Continuous effort to improve standard MPPC specifications
- New MPPC devices with multichannels / large active area, and evaluation modules
- Good customer support by established sales network
- Good know-how & experience of stable & large volume production
- Capability to ramp-up to even higher production capacity in short time





THANKS

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