

Photonique SA

Presentation for LIGHT 07

Schloss Ringberg - Tegernsee

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Co-founder & CEO

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Overview

- Some words about Photonique
- SSPM technology, products and performance
- Sensor packages and support electronics
- Some nice applications
- Final remarks

Photonique SA – The Company

Founded:

June 2004 in Geneva – Switzerland

Photonique SA & CPTA (V. Golovin):

Formed a joint-venture where:

- Photonique Application analysis, High level design, Characterization
- CPTA Core sensor design, Production & Packaging
- Photonique Commercializes technology, Logistics, Financing

Photonique SA – The Company

Business Model:

- Pure-play developer of SSPMs
- Supplier of associated components (e.g. electronics)

We Offer:

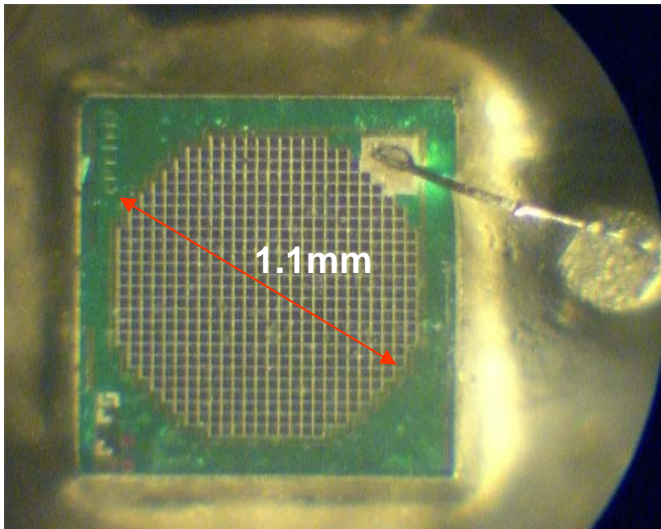
- Turn key products for familiarization & small scale projects
- Customized sensor & package solutions for OEM and large projects
- Advisory services and integration support

Core Sensor Technology (I)

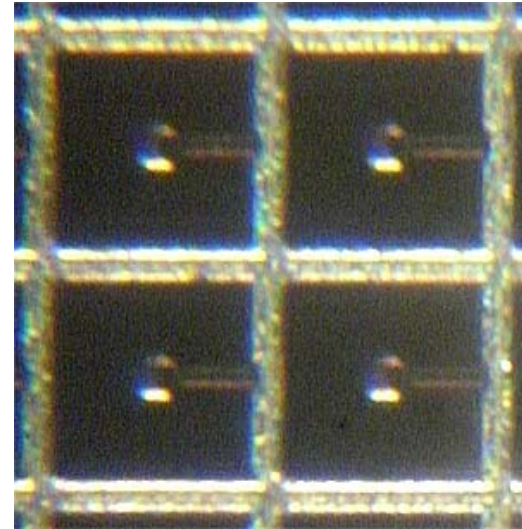
Key Features:

- Mature SSPM implementations using both **p** and **n** doped substrates
- Electro-optical separation of micro-cells using trench architecture
- Unique quenching resistor technology

➔ Low bias; Low cross-talk / ENF ; High temperature stability; Good geometric factor



1mm² on TO-18 can - 556 micro-cells



30μm x 30μm micro-cells
surrounded by aluminized trench

Core Sensor Technology (II)

SSPM Realization – Capabilities Today:

- Overall sensor size 0.25mm ... 3.0mm in both X and Y
- Micro-cell dimensions: 15 μ m ... 100 μ m in both X and Y
- Substrate doping **p** (Blue/Green/red/IR) or **n** (UV – blue)
- Quenching resistor ~ 100kOhm ... 1GOhm
- Gain up to 1.5×10^6 (for integration window of 50ns)
- Rise time <500ps
- Good control After-pulsing; Cross-talk; Temp. stability; Longevity
- Can tune for Spectral response; Bias voltage, Gain

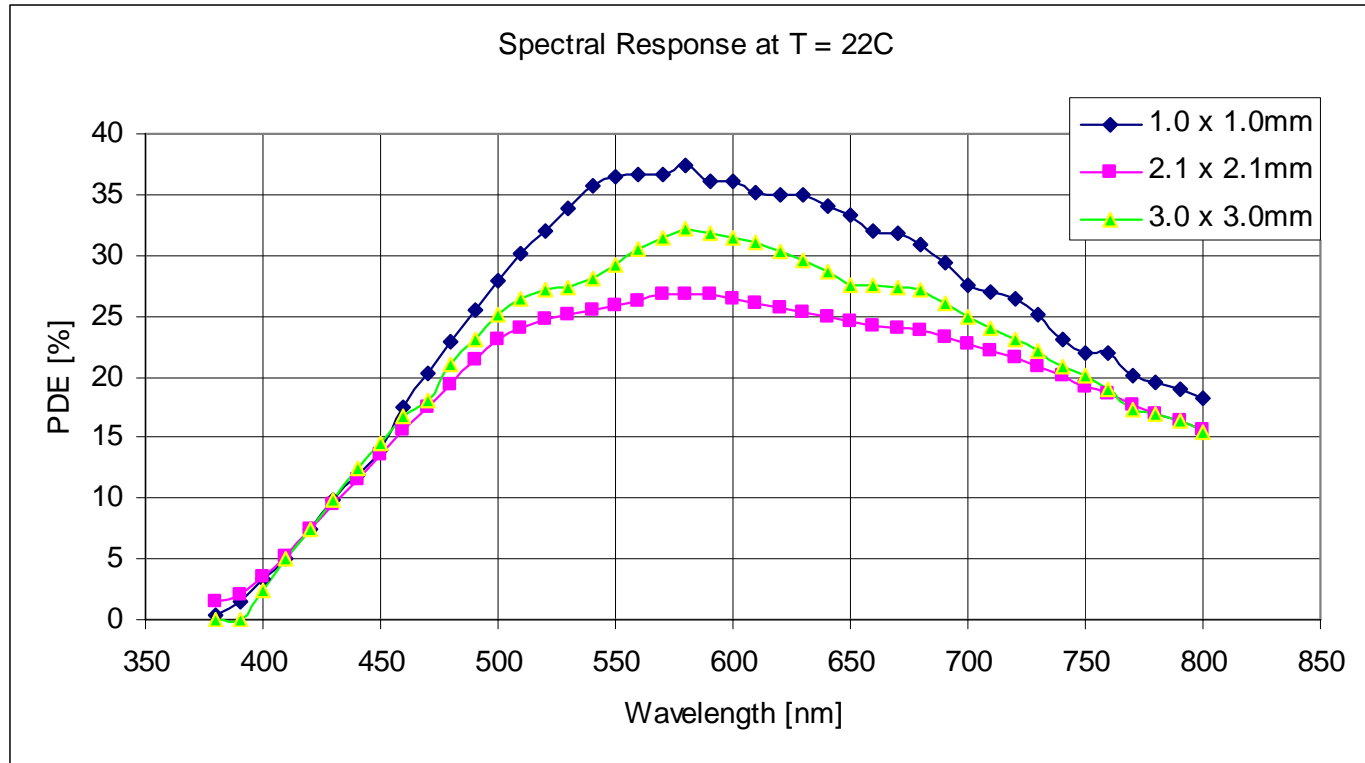
Turn-Key SSPMs

Turn-Key Overview:

Size	Bias	Application	Product Ref.	Techn.
1mm²	20V bias	visible	(0701BG)	p
	30V bias	UV-Blue	(0611B1MM)	n
	40V bias	green-red high gain	(050701GR)	p
4.4mm²	20V bias	visible	(0604BG4MM)	p
	35V bias	UV-Blue (PET)	(0611B4MM)	n
9.0mm²	20V bias	blue-green-red	(<i>0710BG9MM</i>)	p

Turn-Key SSPMs - Performance (I)

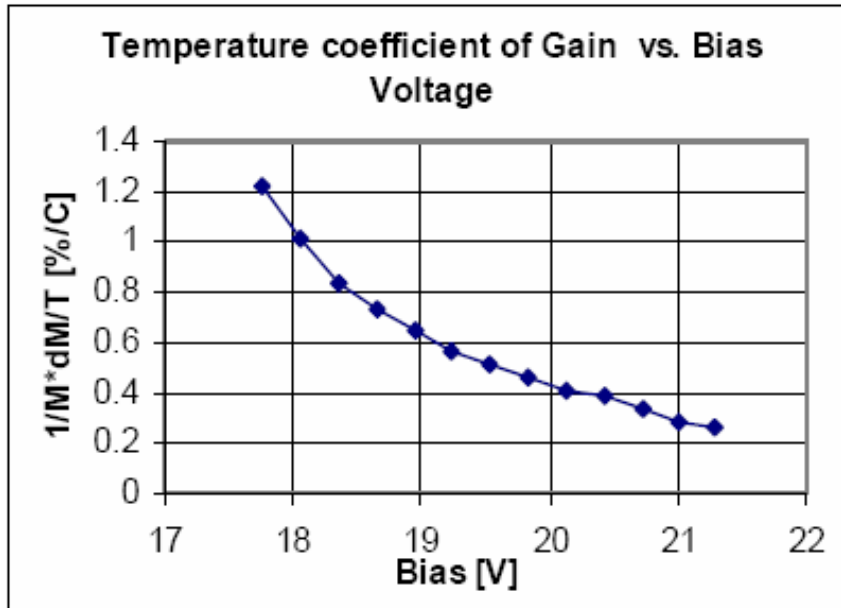
Key Performance Data p doped 20V technology



3 X 3 mm data preliminary

More performance data available at: www.photonique.ch

Turn-Key SSPMs - Performance (II)



Excellent **temperature stability** for 20V technology - 0701BG / 0604BG4MM

(M = Signal Amplitude)

Also:

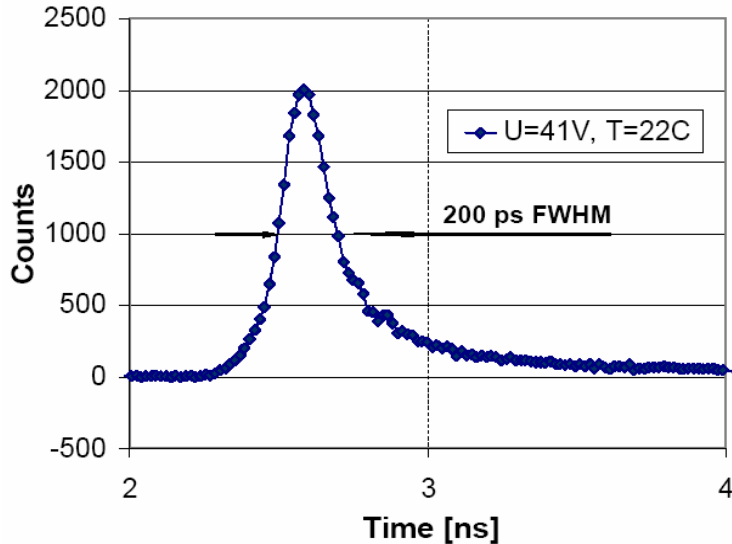
- Excess noise factor < 1.2
- Signal rise time < 700ps
- Bias voltage range $\pm 2.5V$ (at $T=22C^{\circ}$)

Outlook:

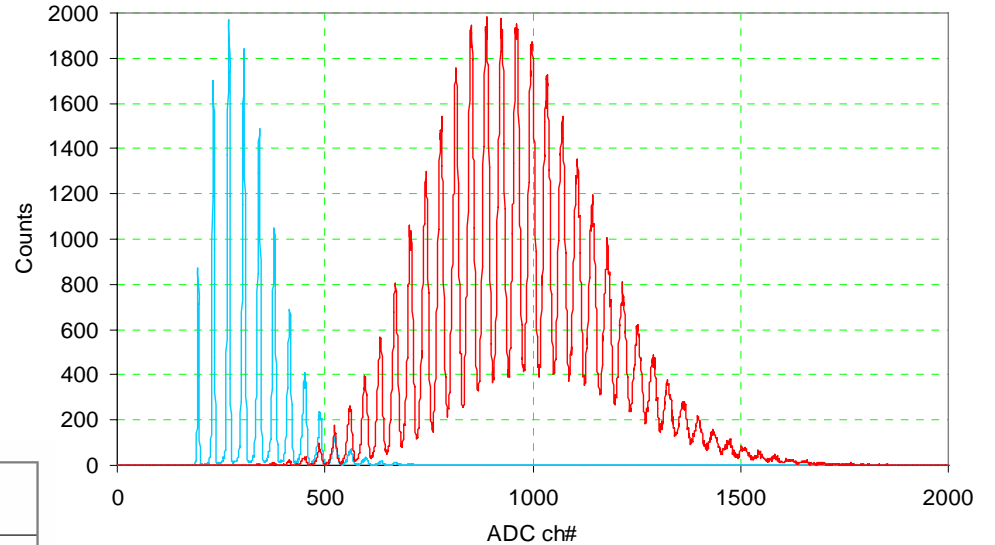
- Improved signal gain up to 1.5×10^6
- Reduced signal tails
- Improved peak PDE to $\sim 50\%$ (at $T=22C^{\circ}$)

Turn-Key SSPMs - Performance (III)

Photon counting



Green-red sensitive APD, low amplitude light signals, U=43V, T=-22 C

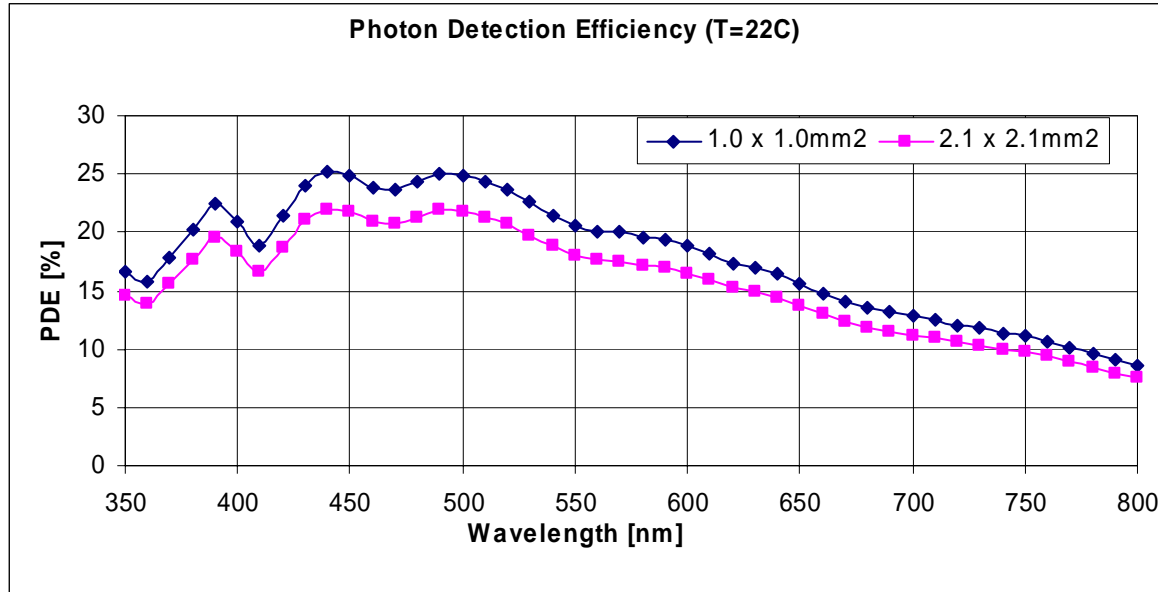


Signal rise time

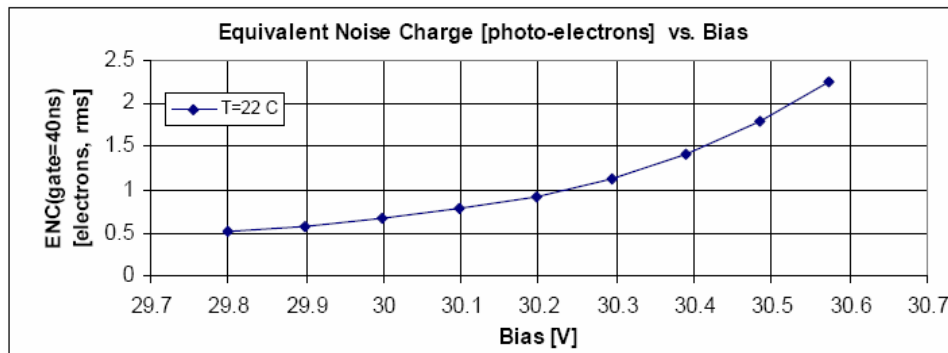
(050701GR)

Turn-Key SSPMs - Performance (IV)

Key Performance Data n doped 35V technology



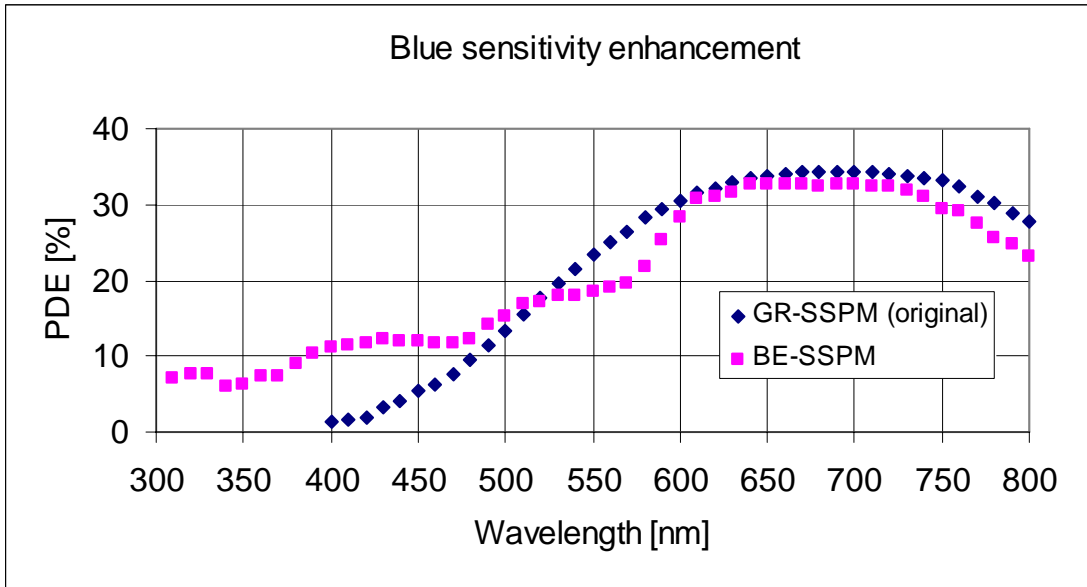
1.0 and 4.4mm²:
Excess noise < 1.1
Rise time < 0.7ps



1mm² Noise characteristics

Turn-Key SSPMs - Performance (V)

Sensitivity enhancement with wavelength shifter



Enhanced UV/blue sensitivity
for a 3 x 3mm red-green
sensitive SSPM



Coating applied to 4x1mm² array

Sensor Packaging (I)

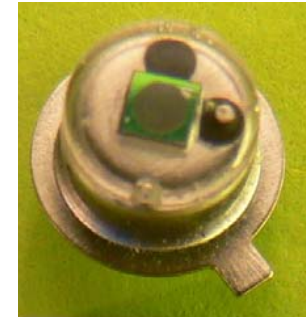
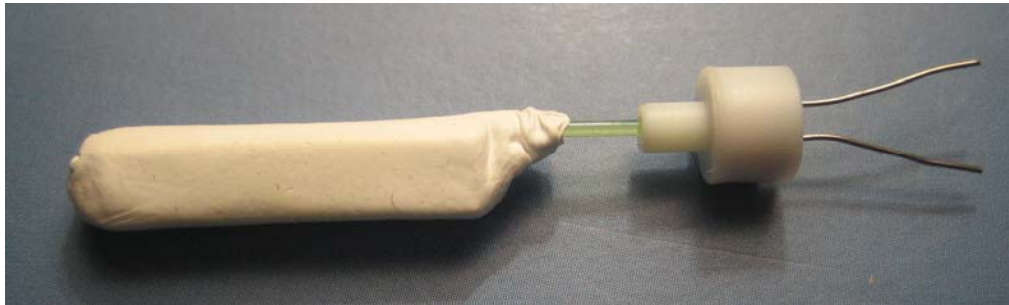
The Issues:

- Uniformity
- Sensor assessment & characterization takes place in multiple steps
- Yield
 - single die matrices not (yet) feasible
- Bonding wire(s)

The Requirements:

- Good coupling to light source
- Robustness
- Foot print
- Handling

Coupling to Fibers - Sensor Packaging (II)



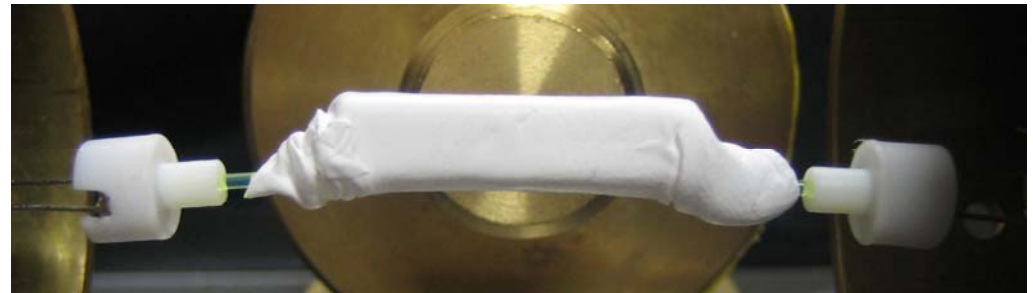
Crystal: 4 x 4 x 20mm LYSO

Source: Cs137 (662keV)

Fibre: Kurray Y11

SSPMs:

- 1x1 40V 560nm
- 3x3 Blue enhanced

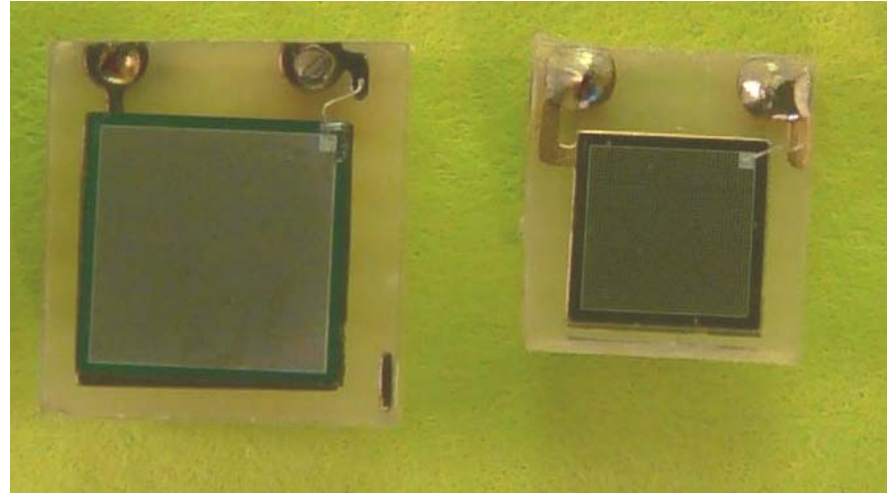


SSPM	Coupling	dE/E (FWHM)
• 3x3mm	direct: optical grease	16.0%
• 1x1mm	fibre: single ended	16.7%
• 1x1mm	fibre: double ended	14.1%

Coupling to Scintillators - Sensor Packaging (III)

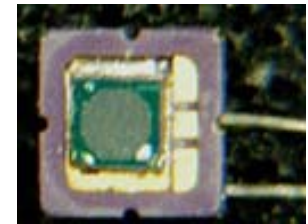
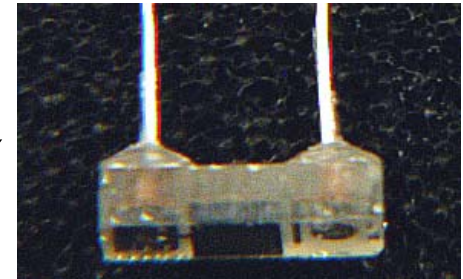
PCB mounted - Epoxy encasted discrete sensor packages

- Non-magnetic pins
- Standard pin pitch
- Epoxy coating ~50µm thick

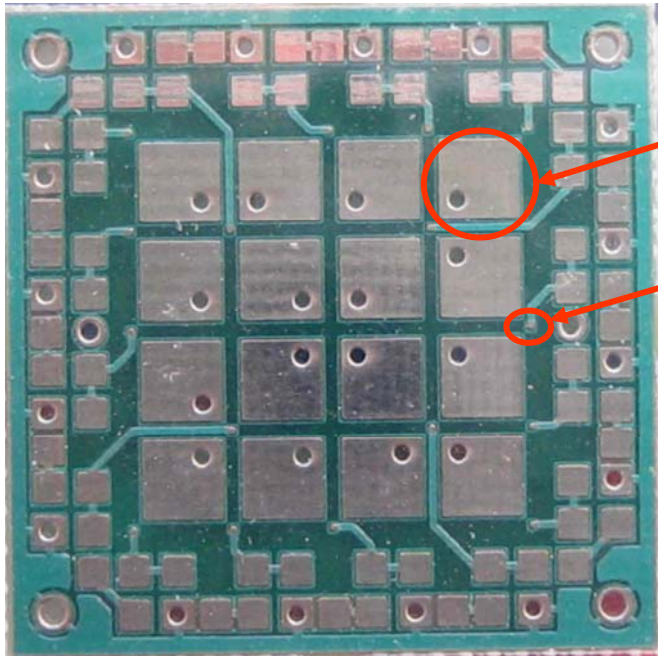


Package foot print

Sensor Size	X	Y
• 2.1 x 2.1	4.0	4.0
• 3.0 x 3.0	5.0	5.0
• 2.1 x 2.1	2.8	7.5
• 1.0 x 1.0	3.0	3.0



4 x 4 PET Module - Sensor Packaging (IV)

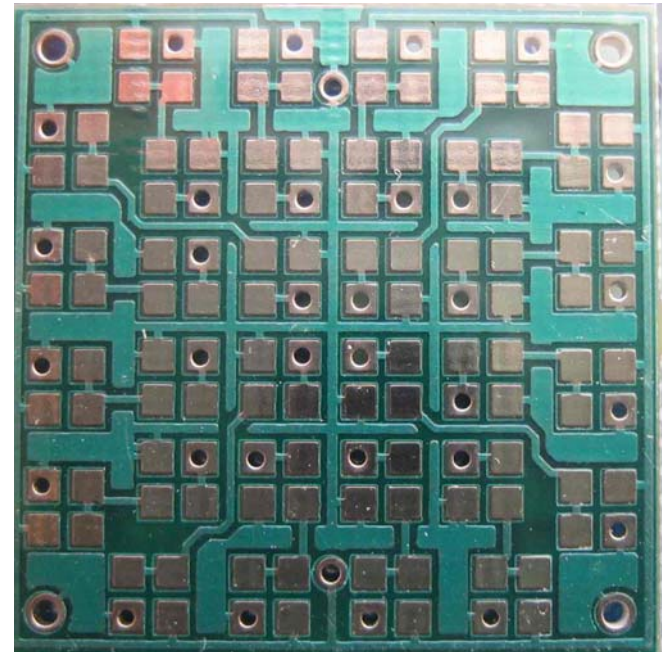


4x4mm pad for SSPM placement

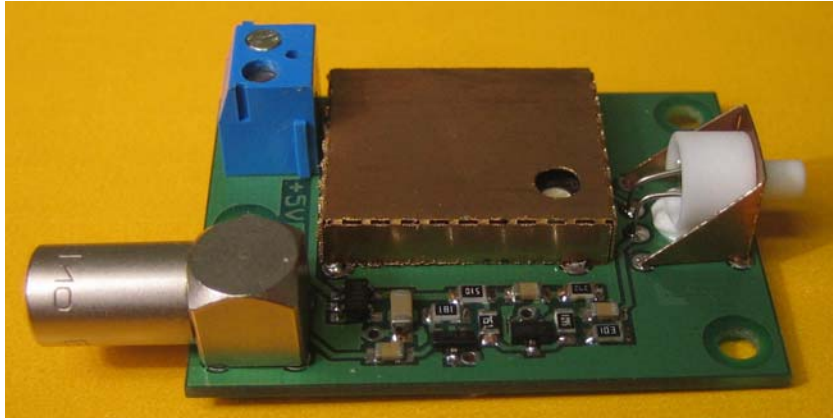
Bonding point

Crystals with face size larger equal 4mm x 4mm.
Single bias voltage supply.
Accommodates 4.4mm² SSPMs.

Back side circuitry accommodates resistor chain realizing bias corrections for individual sensors.



Electronics (I)



Photon detector module

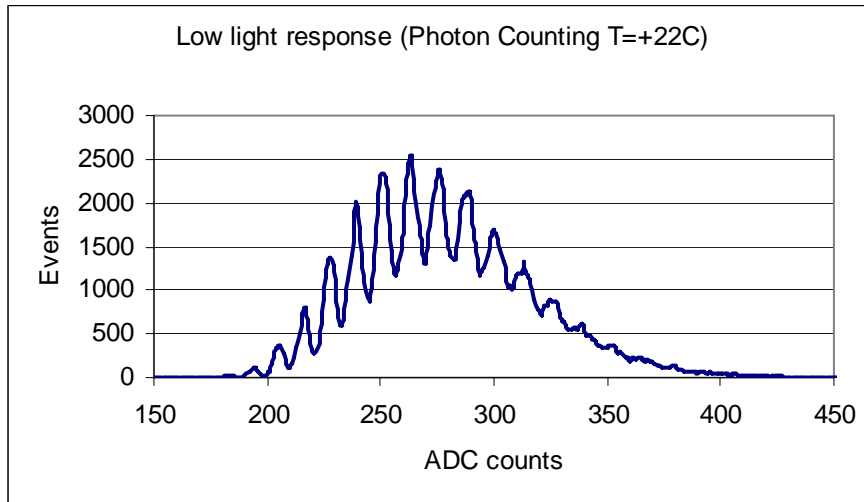
Gain response is temperature stabilized to within 10% between -10C and +30C

Operating voltage 5V ... 9V

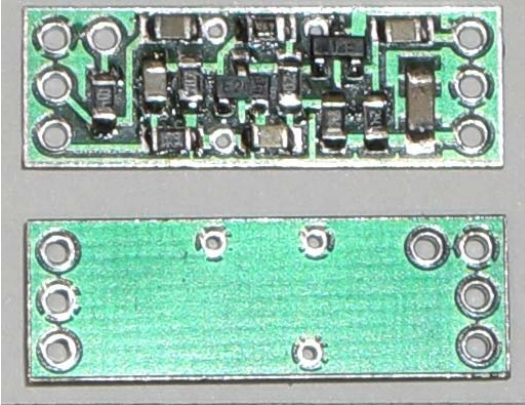
50 Ohm output impedance

EUR 650.-

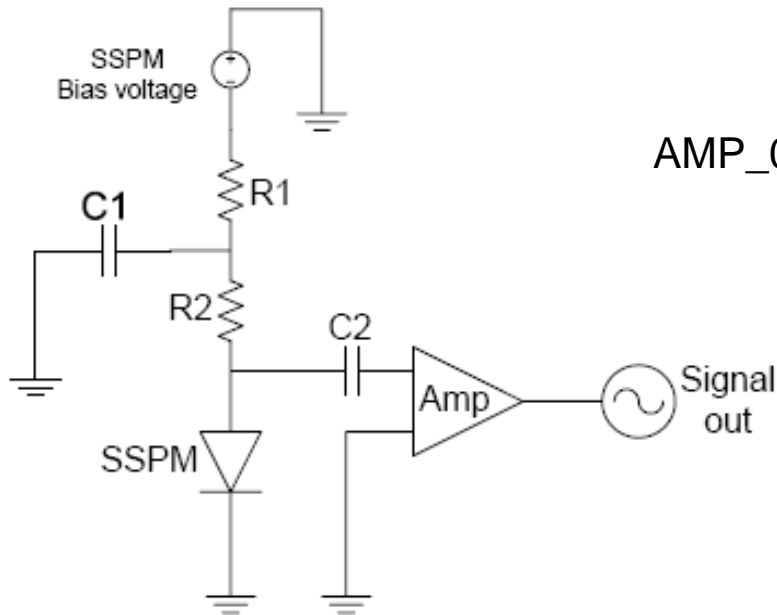
MOD-0604 FIB/CER



Electronics (II)

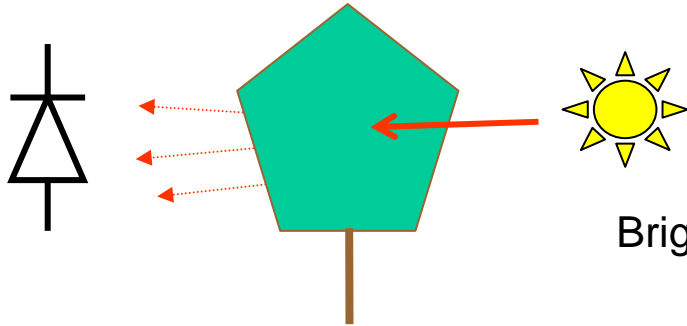


Bias circuit combined with a transimpedance amplifier
on a small form factor PCB board.

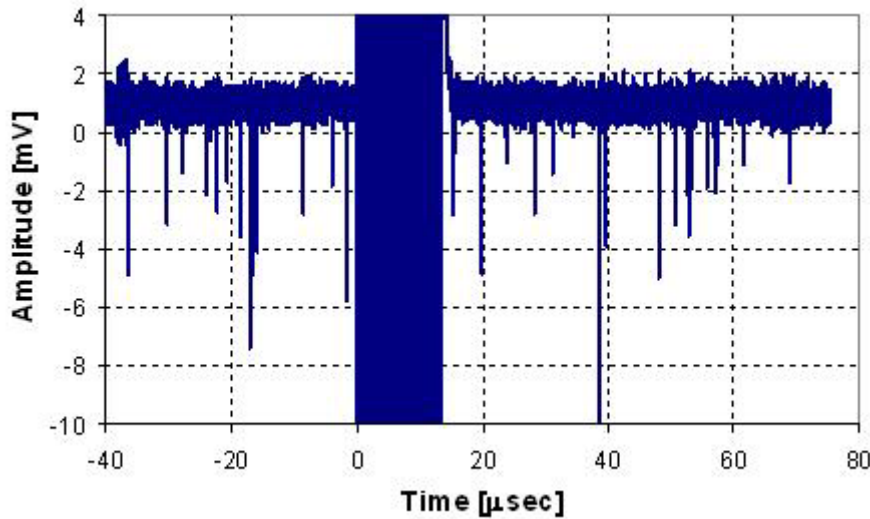


	V_{op}	Gain	Rise time
AMP_0604	4V ~ 10V	20x ~ 60x	5ns
AMP_0611	4V ~ 10V	10x ~ 20x	700ps

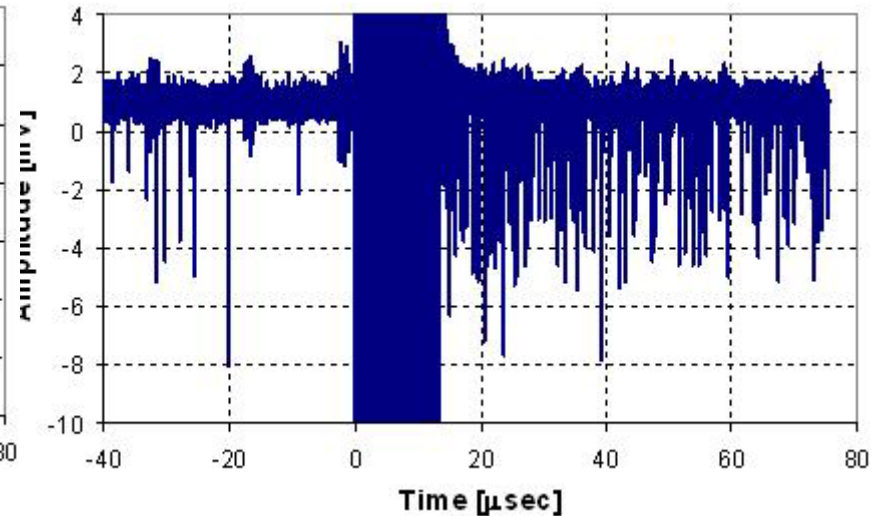
Nice Applications - Biophotons



• No specimen



• With specimen



Nice Applications – Intraoperative Beta Camera

Prototype Solid State Photomultiplier Based Intra-Operative Beta Camera

Elena Heckathorne, *Student Member, IEEE*, Robert Silverman, *Senior Member IEEE*,
Farhad Daghighian, *Member IEEE*, and Magnus Dahlbom, *Senior Member, IEEE*

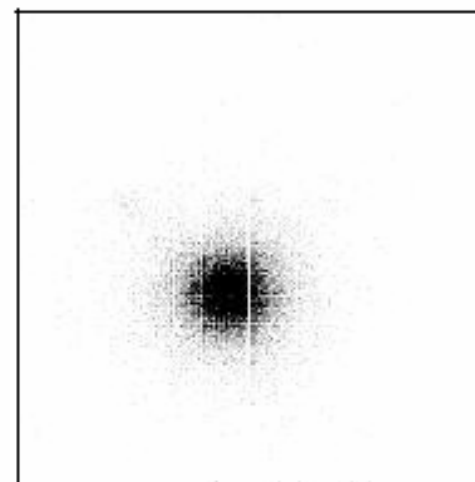
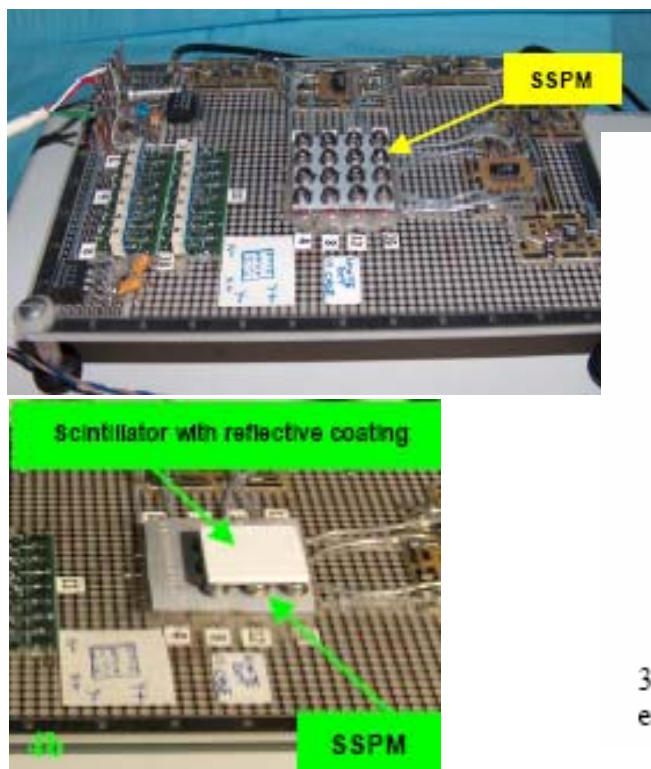
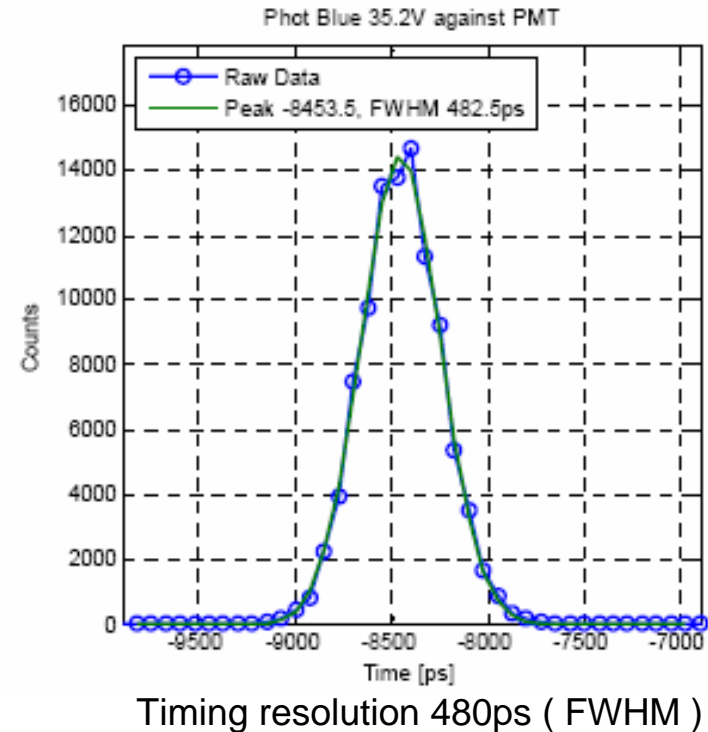
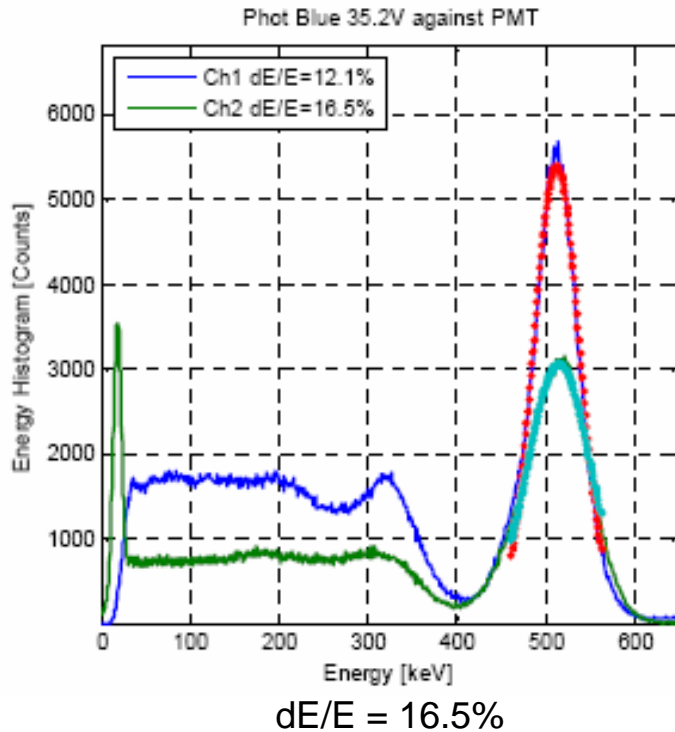


Fig. 10. Typical image of 1 mm collimated beta source acquired using a 3x3 sub-array of SSPMs coupled to a 19 mm x 19 mm x 2 mm sheet of red-emitting plastic scintillator.

Nice Applications - TOF-PET Study

- Source: Na22
- 2 x 2 x 20mm LYSO crystal glued to SSPM
- Reference: XP2020



Philips Research – Aachen (T. Solf)

Final remarks

Why are SSPMs (still) so expensive?

- Technology mature but not at industrial production level
- Creating “exotic conditions” in silicon
- QC / Characterization are “manual” tasks
- Volumes today are insufficient to push pricing down significantly
- Need order sizes of 10k (1mm²) and 100k (>>1mm²)

When are we getting (single die) matrices?

- 2008 - 2009

How else can we enlarge sensor area at affordable cost?

- Micro optics
- Hybrid systems
- New ideas...?!

