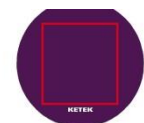




KETEK GmbH Munich - Germany

SiPM Development at KETEK

- A short introduction to KETEK SiPM Products and Status
with focus on small microcell SiPMs -



KETEK

Creative Detector Solutions

KETEK SiPM Devices

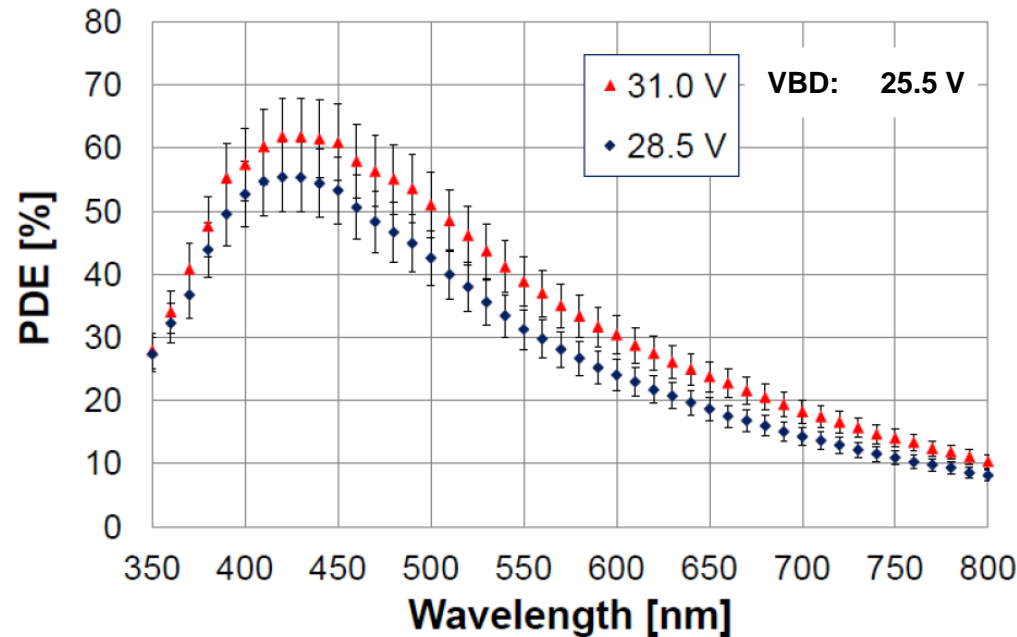
- Technology
- GE of different microcell types
- Projects with small micro pixel sizes
- Ketek standard portfolio
- Status PM1125
- SiPM roadmap



KETEK Silicon Photomultipliers

- Fast Single Photon Counting -

- High PDE
 - up to 60 % for 50 μ m cell type
- Optimized for blue light sensitivity
 - 420 nm peak sensitivity
- Low dark rate
 - below 500 kHz/mm²
- Low cross talk
 - below 25% at 20% OV, dep. on cell- and device type
- Huge bias voltage range of stable operation
 - up to 30% overvoltage
- Extremely low temperature coefficient
 - below 1% above 10% overvoltage



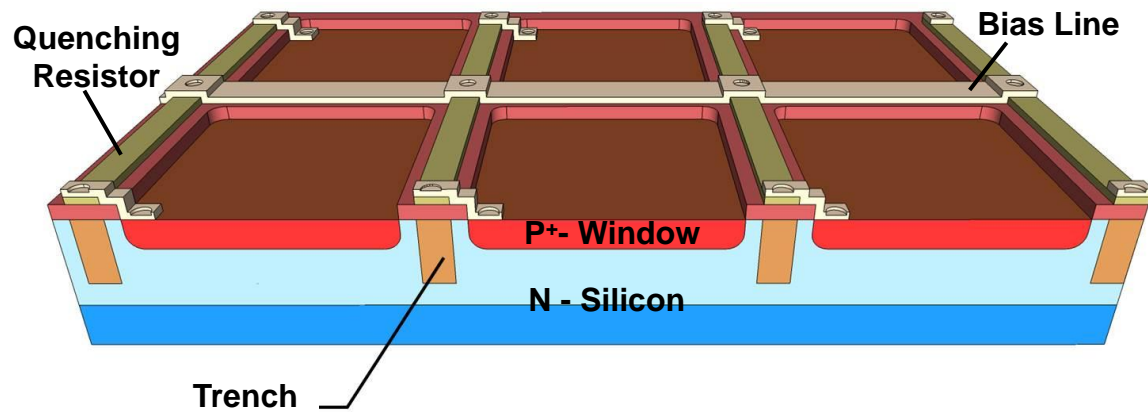
PM1150 - Prototype

Active area: 1.0 x 1.0 mm²
Cell pitch: 50 μ m
Technology: no trench
GE: 70%
Peak sensitivity: 420 nm



Basic Construction of the KETEK Microcell

Section of KETEK SiPM Microcell



- Silicon **P on N** structure with high Geiger efficiency
 - **Shallow entrance window** with high quantum efficiency
 - Optimized **geometrical fill factor**
- ⇒ **High photon detection efficiency**

- Available in two technologies -

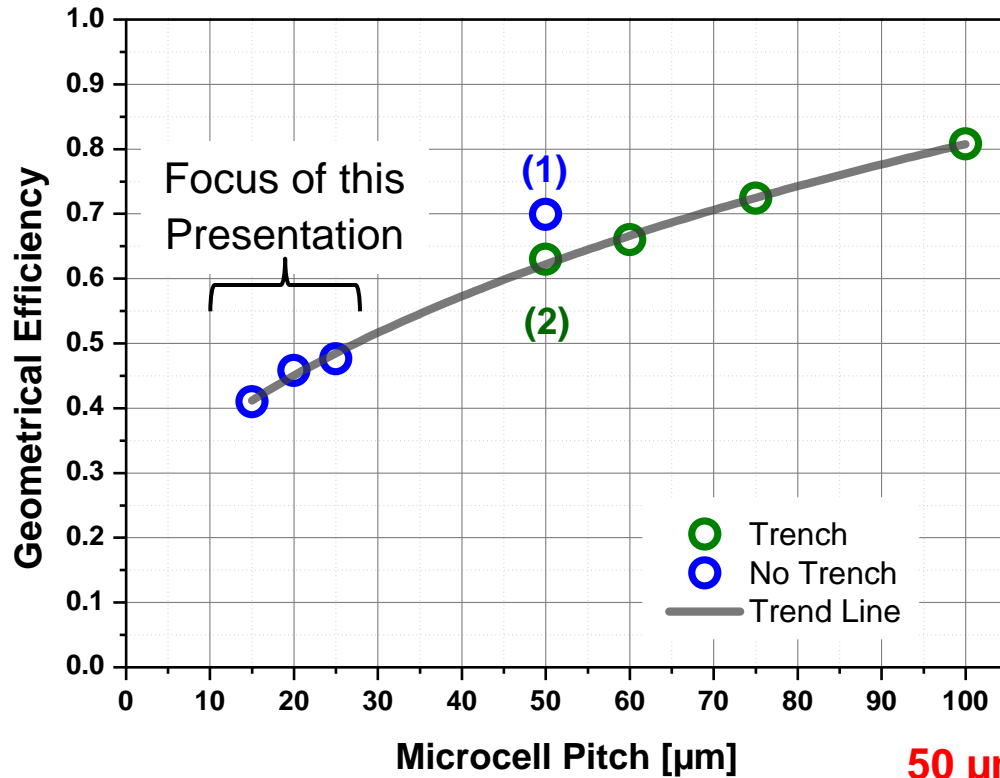
KETEK Standard Technology

- Technology optimized for maximum GE
- Devices with very high PDE
- Particularly suitable for small microcells and small active area

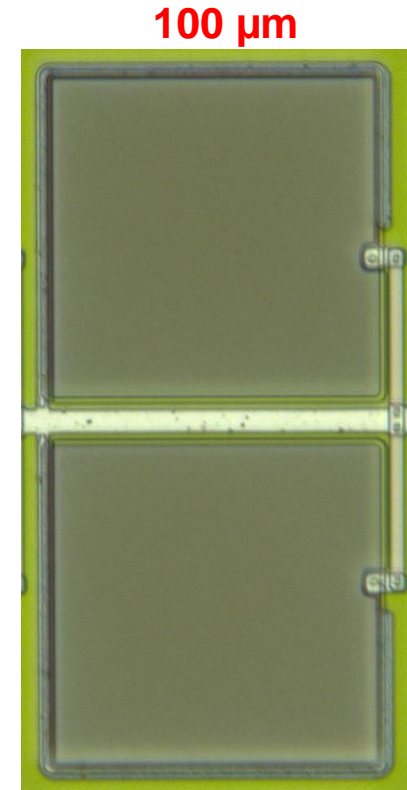
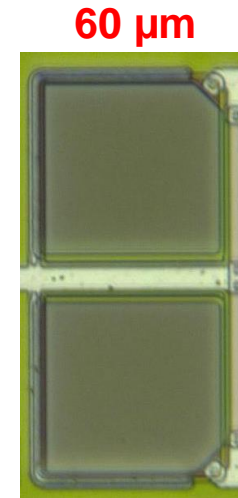
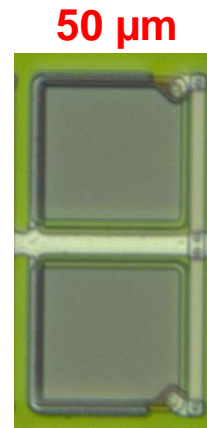
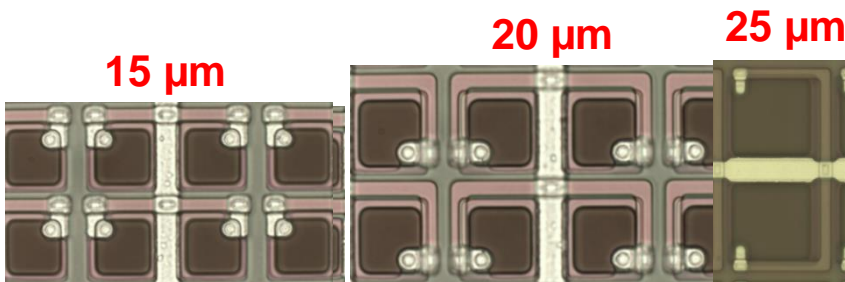
KETEK Trench Technology

- Technology with improved optical barrier and low-RC readout
- Devices with low crosstalk and improved timing
- Particularly suitable for large microcells and large area devices



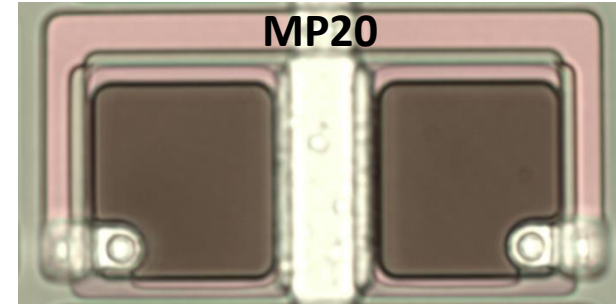


- Microcell sizes from 15μm up to 100μm realized
- Geometrical efficiency up to 70% for 50 μm microcell type



Chip Type A:

- Active area: 4.84 mm²
- 12100 cells with 20 μm pitch
- PDE at 515nm: 20% ... 23%
- PDE at 420 nm: 30% ... 35%



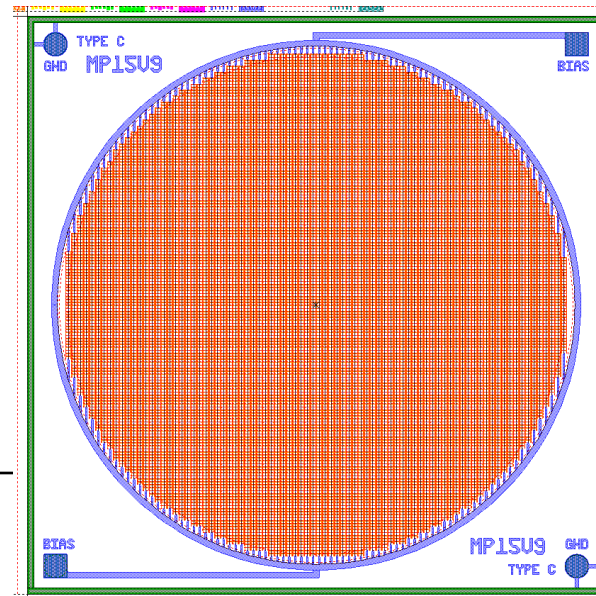
MP20

Chip Type B:

- Active area: 1.0 mm²
- 4384 cells with 15 μm pitch
- PDE at 515nm: 14% ... 15%
- PDE at 420 nm: 20% ... 23%



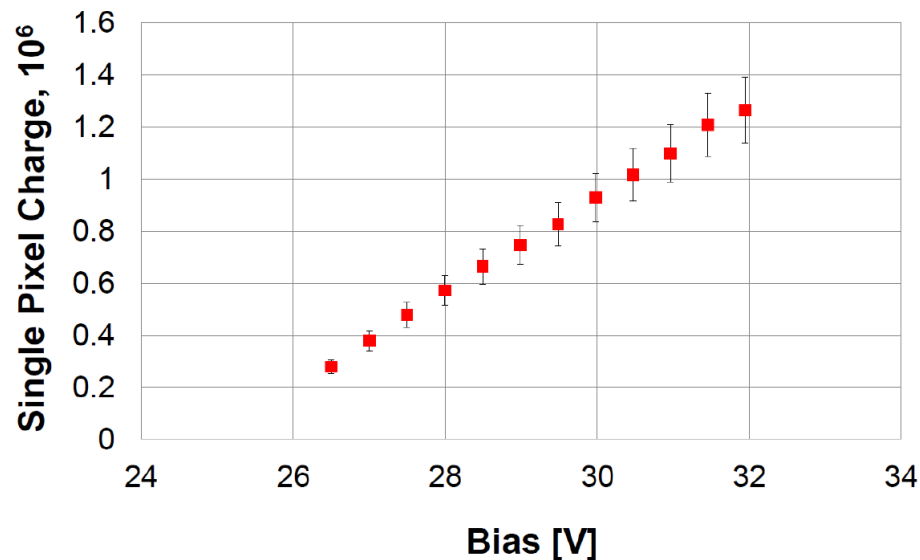
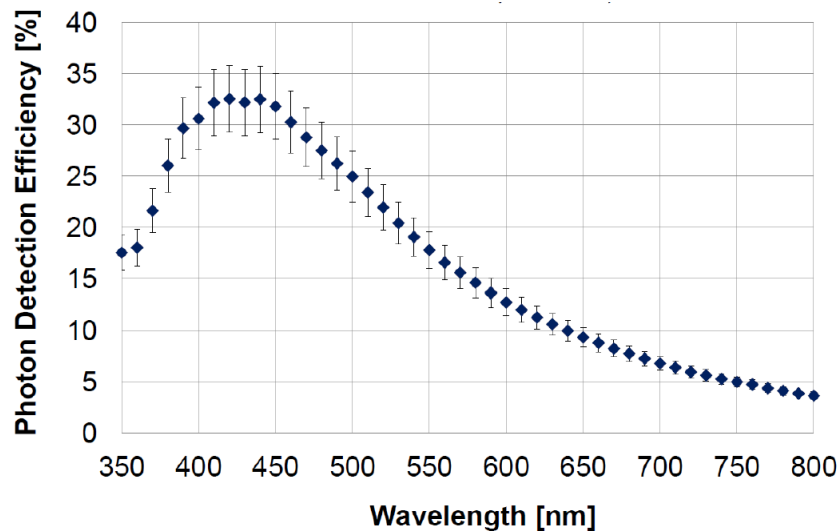
MP15



Chip Type C:

- Active area: 5.0 mm²
- 22376 cells with 15 μm pitch
- PDE at 515nm: 17% ... 20%
- PDE at 420 nm: 22% ... 24%

Characteristic of Chip Type A (4.8 mm²): 20μm Cell Pitch Type



CERN CMS Customized Chip Type A

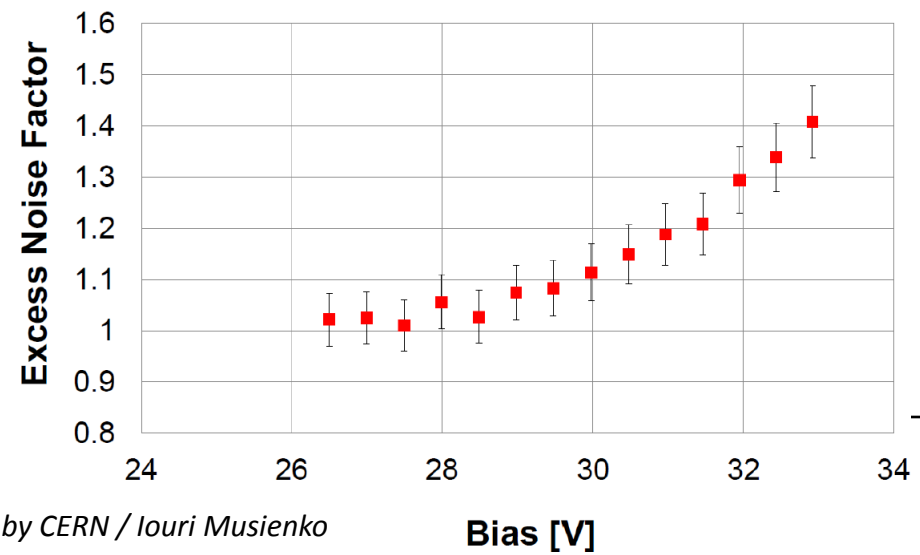
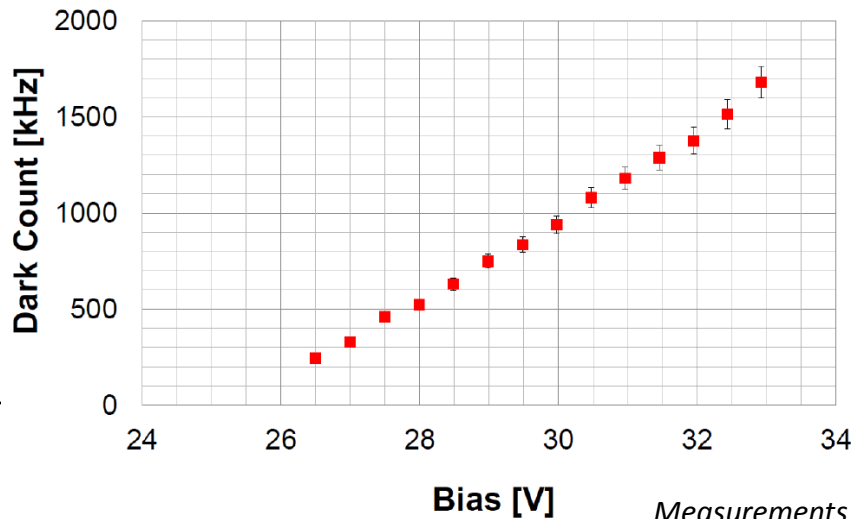
Active Area: 4.8 mm²

Cell Pitch: 20 μm

GE (layout): 46%

VBD: 25.5 V

Batch: C1-W12-V4



Measurements performed by CERN / Iouri Musienko

PDE Enhancement of 15 μm Cell Pitch Type

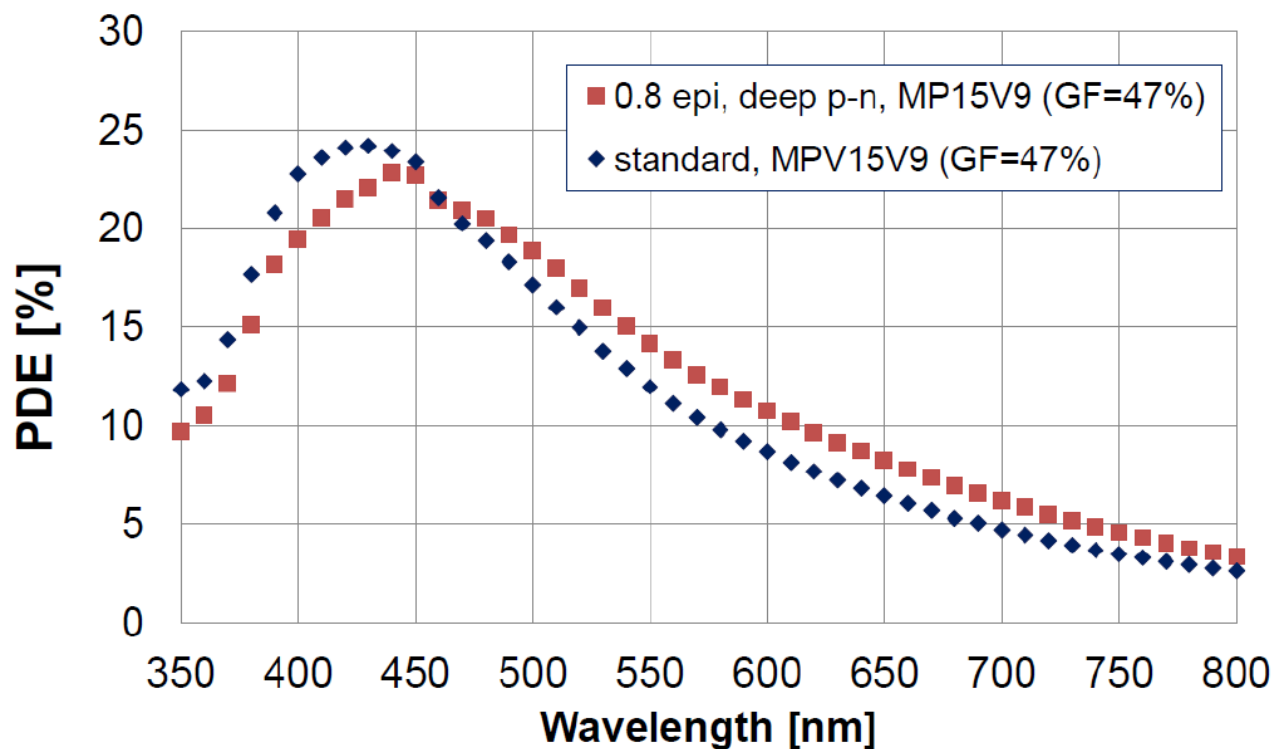
KETEK SiPMs, V-VB=4.0V

CERN CMS Customized Chip (C):

Active Area: 5.0 mm²

Cell Pitch: 15 μm

GE (layout): 47%



- Measurements performed by CERN / Iouri Musienko
- PDE is not affected by crosstalk and afterpulsing
- **22-24%** PDE for blue light



Scheduled Standard Portfolio in Plastic Package

- Four different package sizes



PM11 – PM22 – PM33 – PM66

- Five different micropixel sizes



25 μm – 50 μm – 60 μm – 75 μm – 100 μm

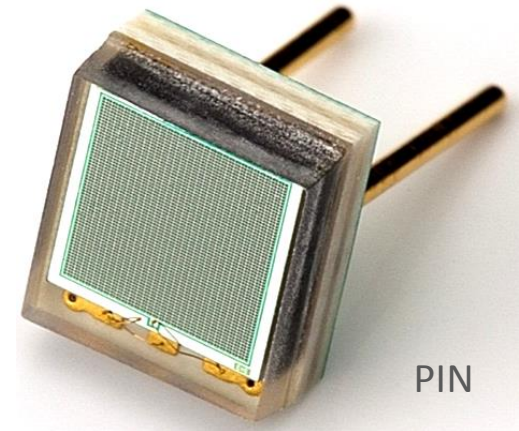
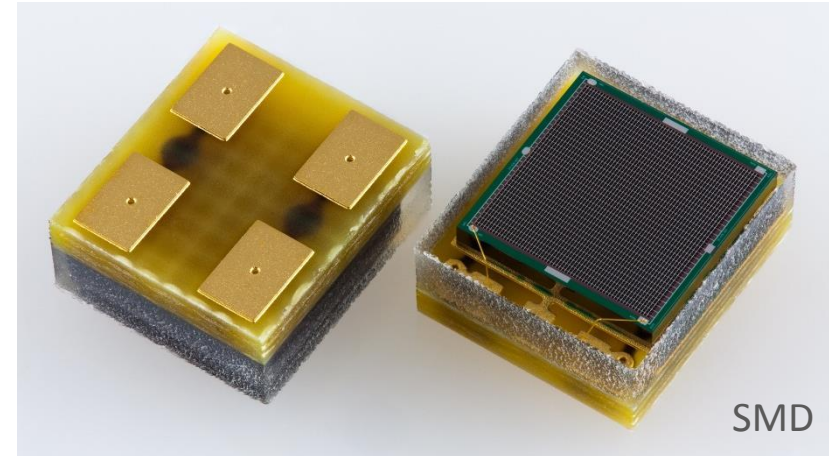
- Standard- and Trench Technology

- Pin- and SMD Version

- Most variants available until Mai 2013

PM3350 - SMD

3 x 3mm² active area; 50 μm cell type;
peak wavelength 420 nm; plastic package

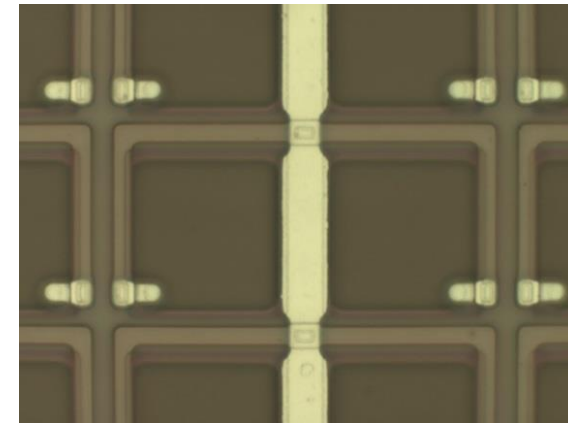
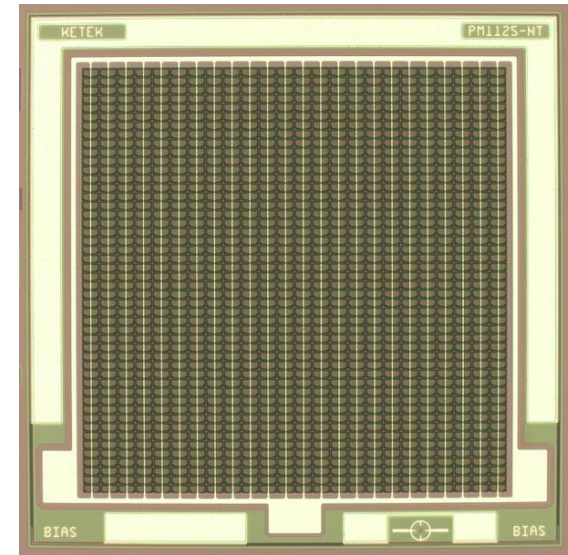
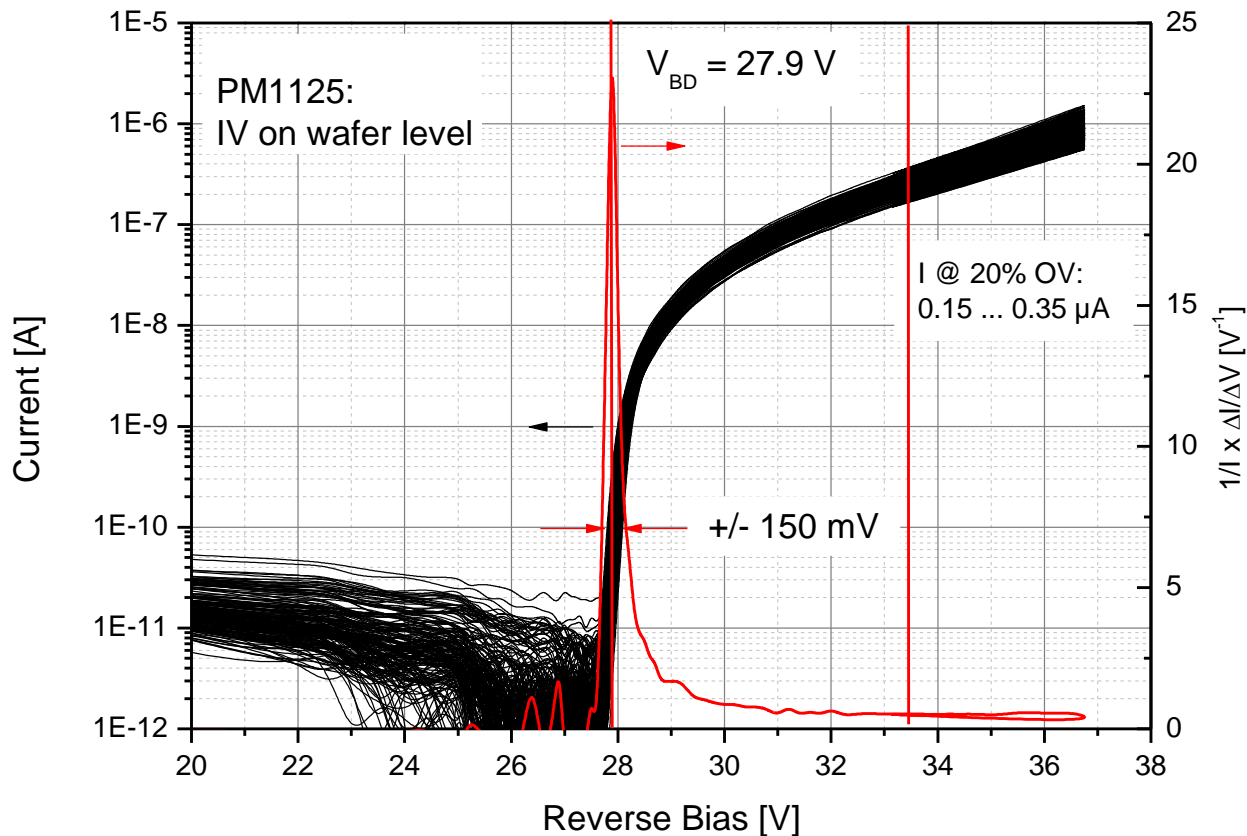


First Results from PM1125

- Active area: 1.2 mm x 1.2 mm
- Number of cells: 2304
- Geometrical fill factor (according to design): 47%
- Dark current at 20% OV (and RT): $< 0.5 \mu\text{A}$

PM1125 - SMD

1.2 x 1.2 mm² active area; 25 μm cell type; peak wavelength 420 nm;



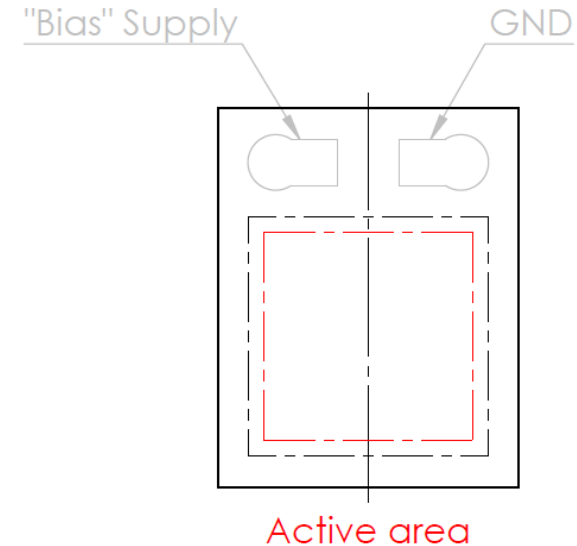
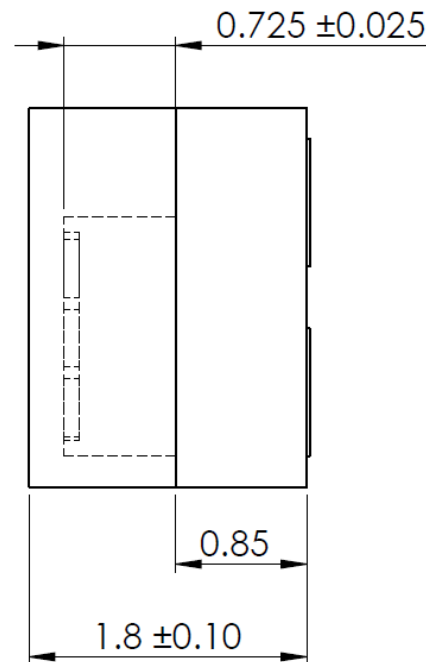
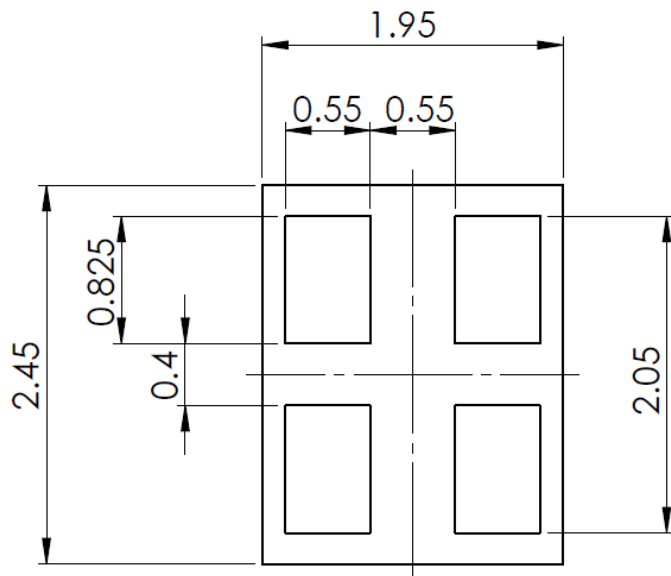
First Results from PM1125

PM1125 Production Schedule

Testing of devices:	CW 12
Dicing:	CW 13
Packaging:	CW 18
Testing and shipping:	CW 19 (until 10 th of May)

PM1125 - SMD

1.2 x 1.2 mm² active area; 25 μm cell type;
peak wavelength 420 nm;

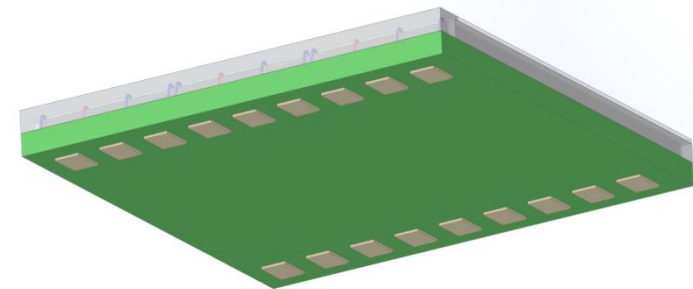
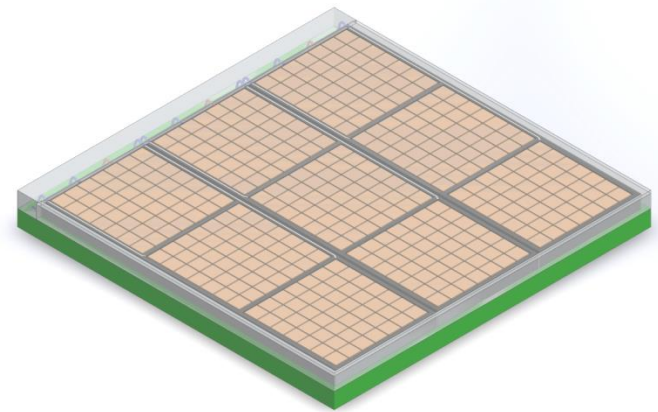


Qualification Test Results – Environmental Stress Test

Test	Test Conditions	Qty	Target	Specification	Results
PC	Pre-conditioning / MSL classification	≥ 10	MSL3	Bake: 24h at 125°C Soak: 192h at 30°C/60%R.H. Reflow: 3 x Peak 255°C – 260°C	33/33 OK
HTS	High Temperature Storage (1000h @ 125°C)	≥ 10	0 failed parts	MSL3 Preconditioning 300h at 125° C + 170h at 125° C (470h) + 330h at 125° C (800h) + 200h at 125° C (1000h)	11/11 OK 11/11 OK 11/11 OK 11/11 OK
H ³ TS	High Humidity High Temperature Storage (1000h @ 85°C/85 % rH)	≥ 10	0 failed parts	MSL3 Preconditioning 300h at 85° C/85rH + 170h at 125° (470h) + 330h at 125° (800h) + 200h at 125° (1000h)	11/11 OK 11/11 OK 11/11 OK 11/11 OK
ESD*	ANSI/ESDA/JEDEC JS-001-2012– Human Body Model (HBM) – Component Level	≥ 10	0 failed parts	± 1kV ± 2kV	10/10 OK 10/10 OK

- Reflow soldering has to be performed under N2 atmosphere

- Completion of portfolio until Q2 / 2013
- Further noise reduction (DR, X-Talk) by enhancing the KETEK trench technology
- Devices with reduced capacitance and enhanced green light sensitivity
- Through silicon via technology
- Chip size package
- Arrays on package level



9-Channel SiPM-Array

WELCOME TO **KETEK**

SILICON DETECTORS FOR X-RAY AND OPTICAL SPECTROSCOPY



KETEK

Creative Detector Solutions

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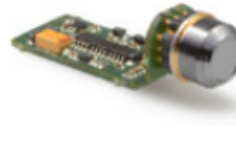
VITUS SDD

Silicon Drift Detectors with 7 mm² to 100 mm² active area for X-ray spectroscopy
[read more](#)



AXAS

Analytical X-ray Acquisition Systems complete with SDD, preamplifier and pulse processor
[read more](#)



VIAMP

OEM solution combines Silicon Drift Detector with preamplifier in optional housing
[read more](#)



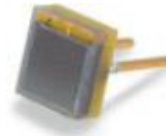
VICO

Electronic components for optimised use of VITUS SDDs in OEM devices
[read more](#)



Accessories

Additional equipment for Silicon Drift Detectors, e. g. preamps, DPP etc.
[read more](#)



SiPM

Silicon Photo-multipliers with 1.4 mm² to 36 mm² active area for low-level light detection
[read more](#)

NEWS

FOUNDATION OF...

Fraunhofer-Einrichtung für Modulare Festkörper-Technologien (EMFT), Siemens AG, LFoundry GmbH, KETEK...
[...read more](#)

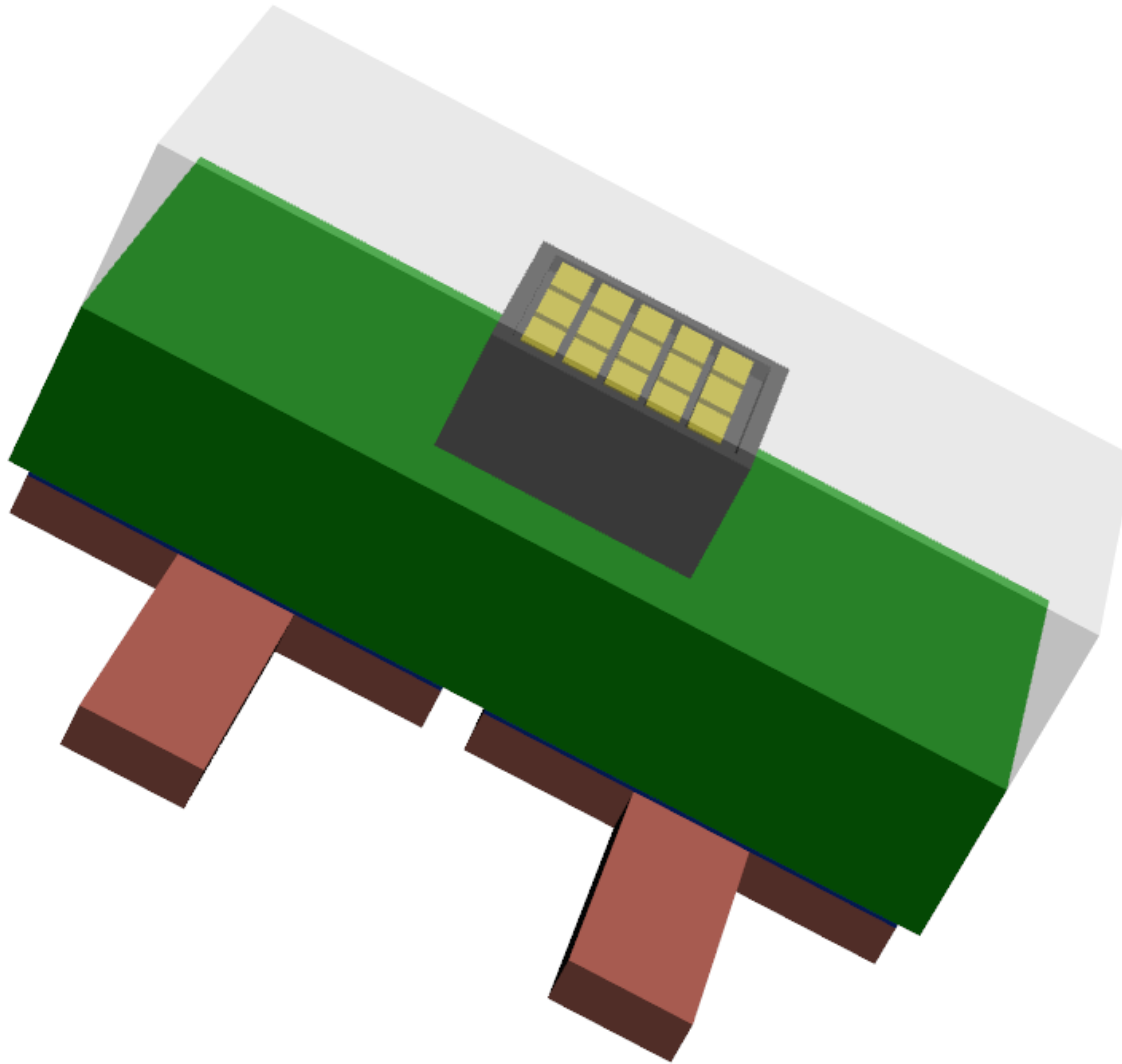
NEW 50MM² HIGH-END...

KETEK is introducing its new 50mm² silicon drift detector with unprecedented guaranteed energy...
[...read more](#)

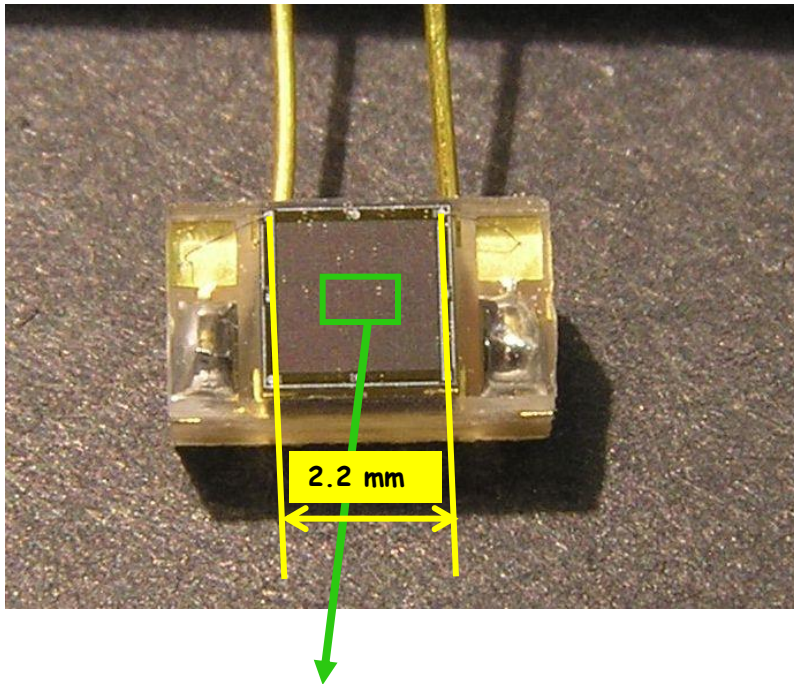
Thank you for your attention!

Additional Slides

Discussion: KETEK Leadframe Solution for DESY / Uni Hamburg



KETEK SiPM

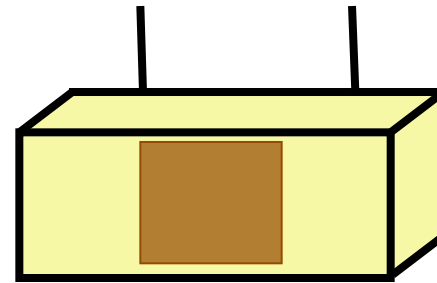


Sensitive area - $2.2 \times 2.2 \text{ mm}^2$

Package size (LxHxD) - $5.4 \times 2.9 \times 2.0 \text{ mm}^3$

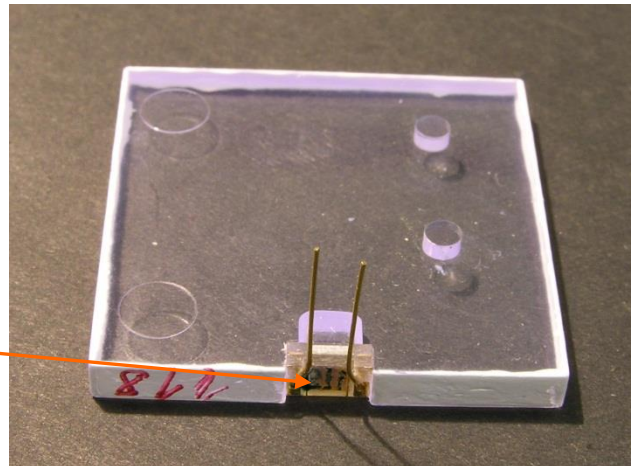
Pins go up

Distance between the pins 2.54 mm

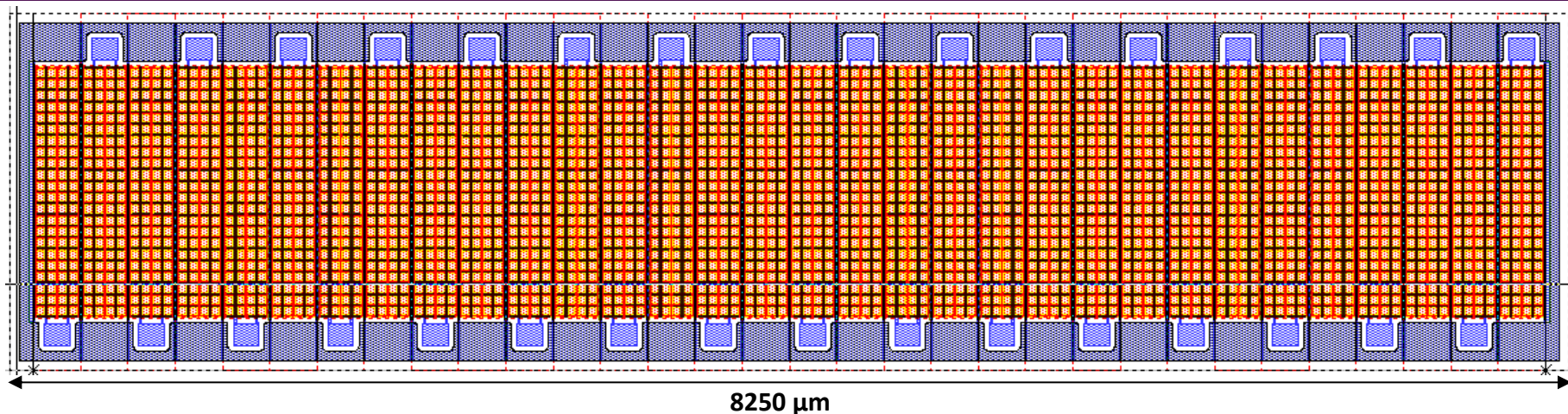


Picture of a tile with SiPM

Grooves for flexible pins



Projects: CERN LHCb Fiber Tracker Upgrade



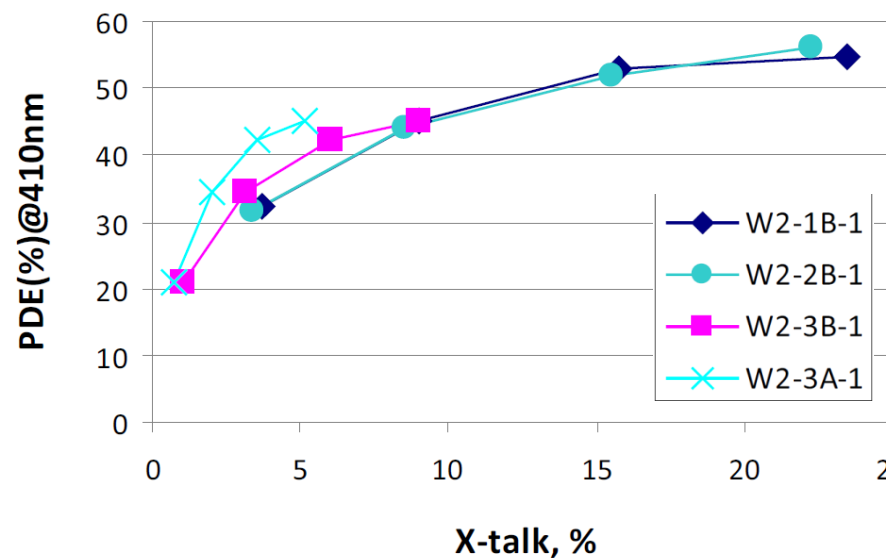
8250 μm

Geometry of device:

- 32 Bias Bondpads (“Bias”) with GND Bond Frame
- Cell Pitch: 60 μm x 57.5 μm
- Quantity of cells: 88 per channel // 2816 per chip

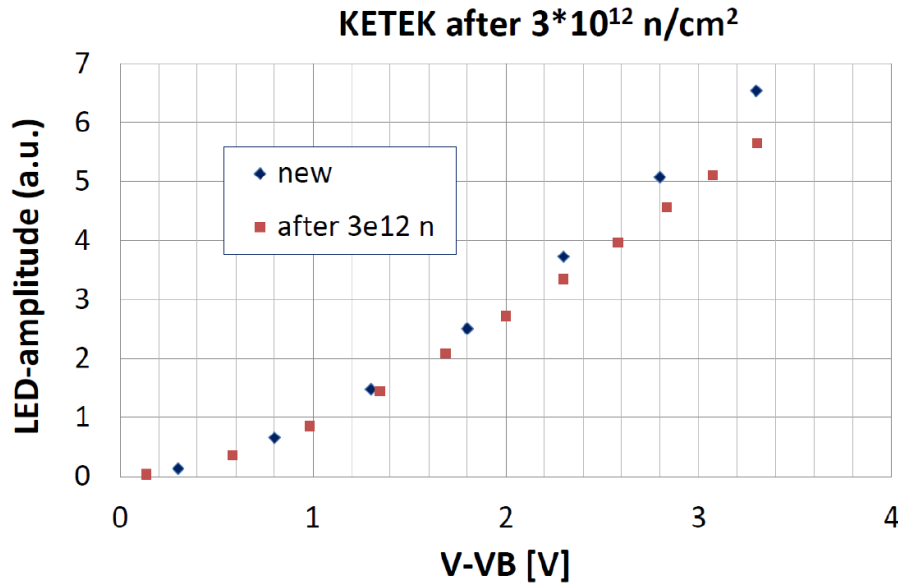
First Spectroscopic results:

- PDE(410 nm) ~ 45% and XT ~ 5% for Trench-Version (“3A”)!

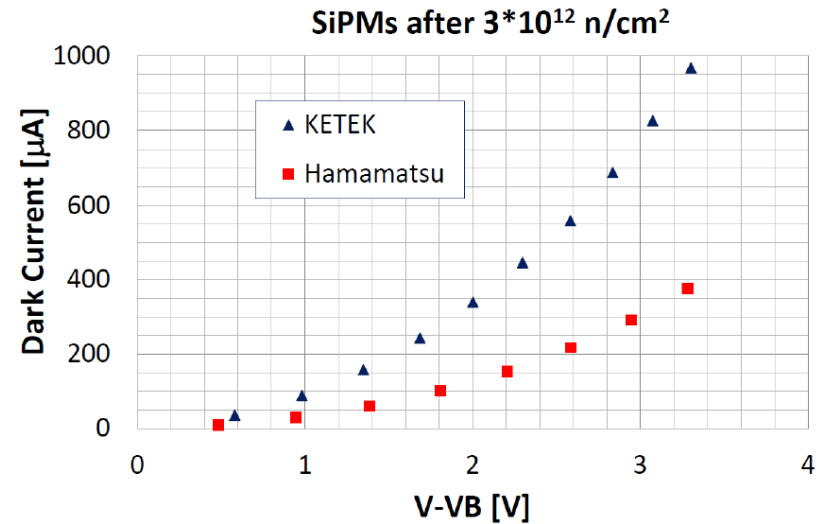


Radiation Hardness measured at CERN CMS

KETEK: LED amplitude vs. dVB

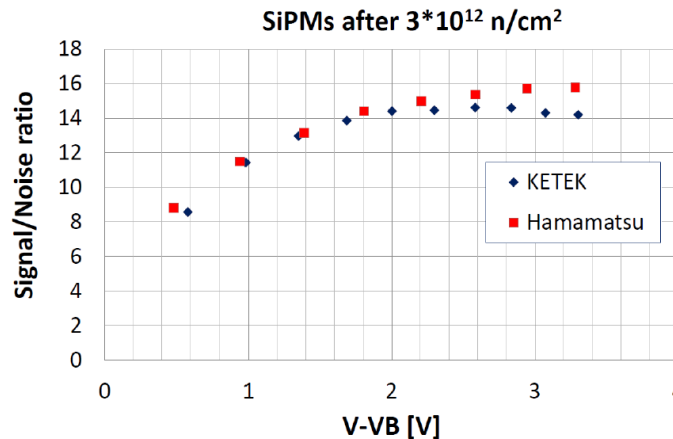


MPPC&KETEK: Dark Current vs. dV



Dark current is higher for the KETEK SiPM mainly due to larger gain and better GF

MPPC&KETEK: S/N ratio vs. dV



Signal to Noise ratio in p.e. (which is proportional to the HCAL Noise in GeV) is the same for both SiPMs

