Update on the design of SMD SiPM and dimpled tile

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Calorimeter for ILC

Outline

- ## Review
  - Uniformity scan at MPI, Munich (Aug, 2013)

- ## Simulation
  - SMD design: (center) bottom surface coupling
  - Present design: side surface coupling
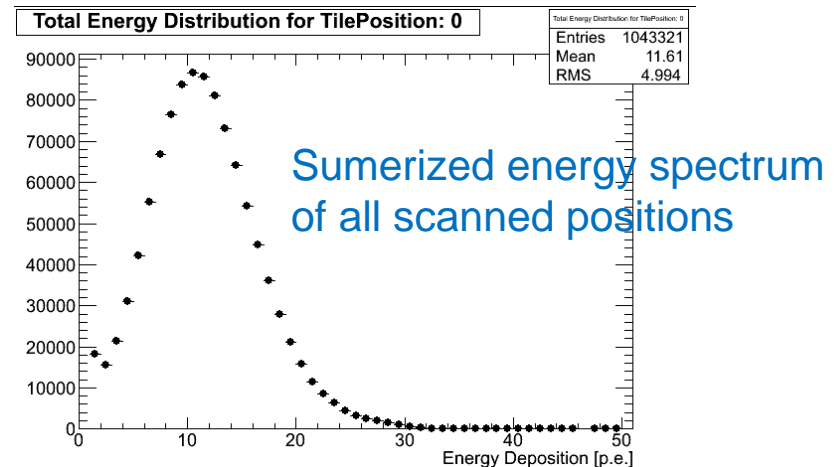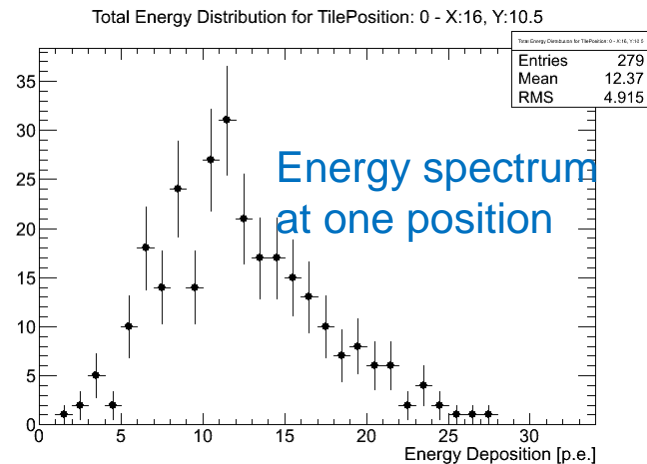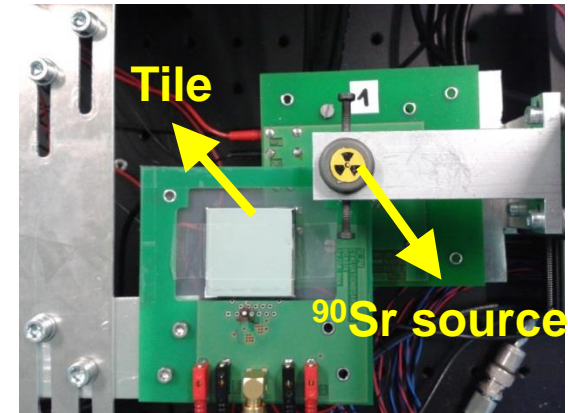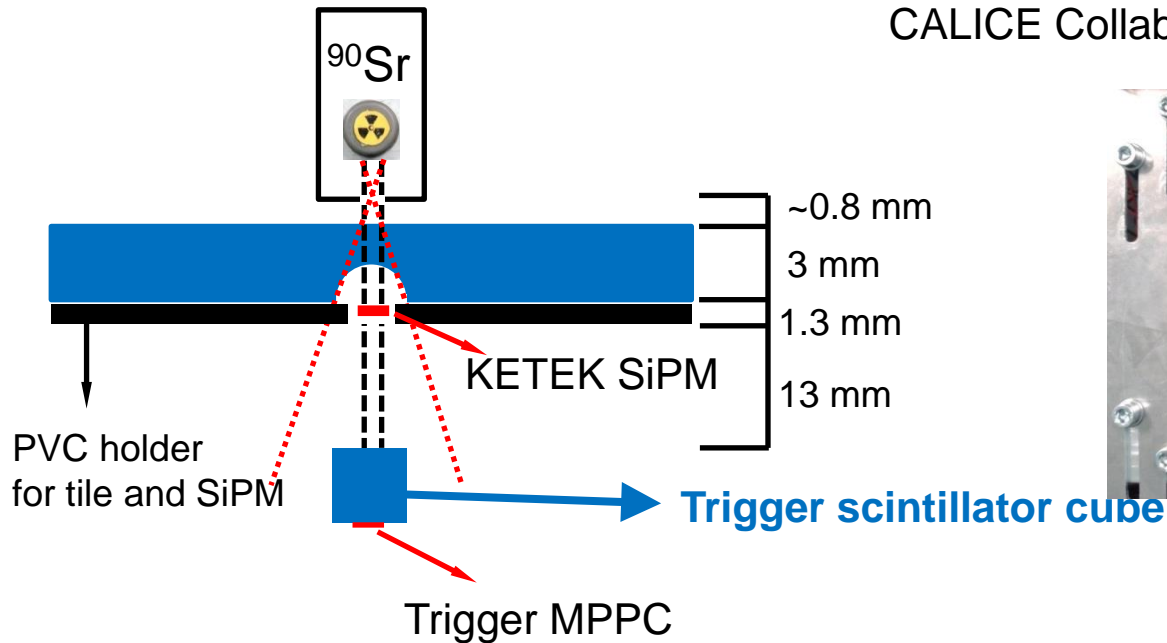
- ## Summary and Plan

SMD SiPM

- ## Motivations

  - No pins: more tolerance for alignment
  - Easier to solder on HBU boards automatically
  - Massive assembly machine (Phi Chau's talk)

- ## Mega-tiles initiated by NIU

  - Large concave dimple in the bottom of tile
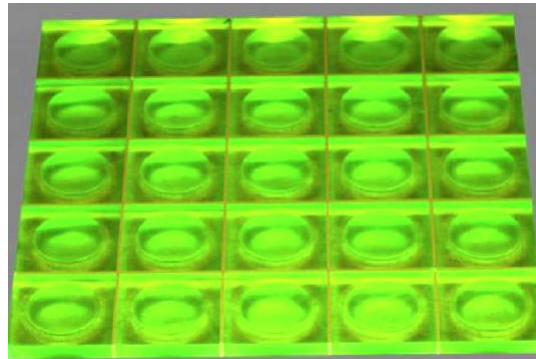
Ref: Nuclear Instruments and Methods in Physics Research A 605 (2009) 277

Review: teststand in MPI Munich
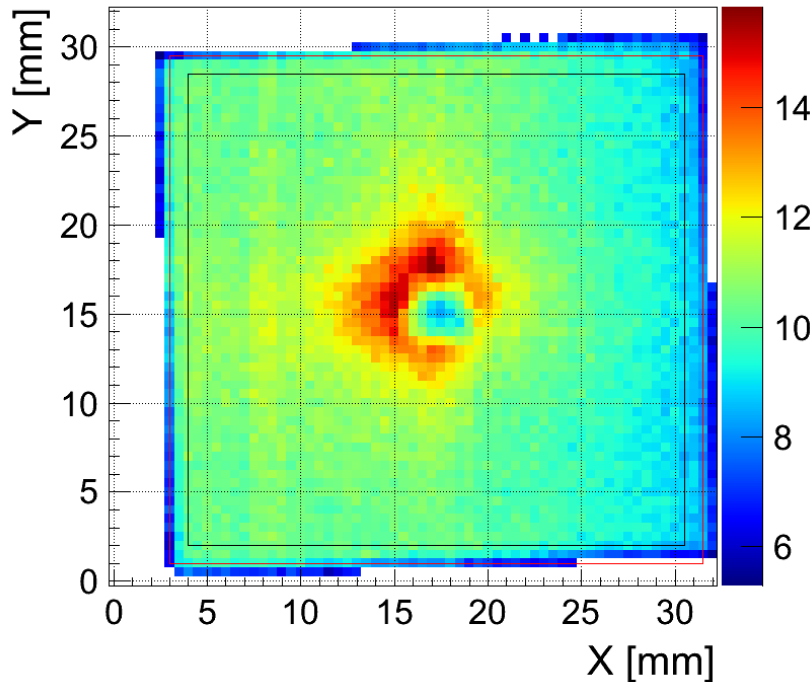
CALICE Collab. Meeting, Annecy, Sep 2013

^{90}Sr

~0.8 mm

3 mm

1.3 mm

13 mm

KETEK SiPM

PVC holder
for tile and SiPM

Trigger scintillator cube

Trigger MPPC

Tile

^{90}Sr source

Total Energy Distribution for TilePosition: 0 - X:16, Y:10.5

Entries	279
Mean	12.37
RMS	4.915

Energy spectrum
at one position

Energy Deposition [p.e.]

Total Energy Distribution for TilePosition: 0

Entries	1043321
Mean	11.61
RMS	4.994

Sumerized energy spectrum
of all scanned positions

Energy Deposition [p.e.]

Review: uniformity of center-dimpled tile

Dome height: 0.5mm; box depth: 1.5 mm

Mean 10.6 p.e. detected

Higher reponse?

Larger SiPM sensitive area: e.g. 2x2mm

Dev. from 10.6 p.e.:

30% area: 96.6%
20% area: 91.4%
10% area: 69.5%
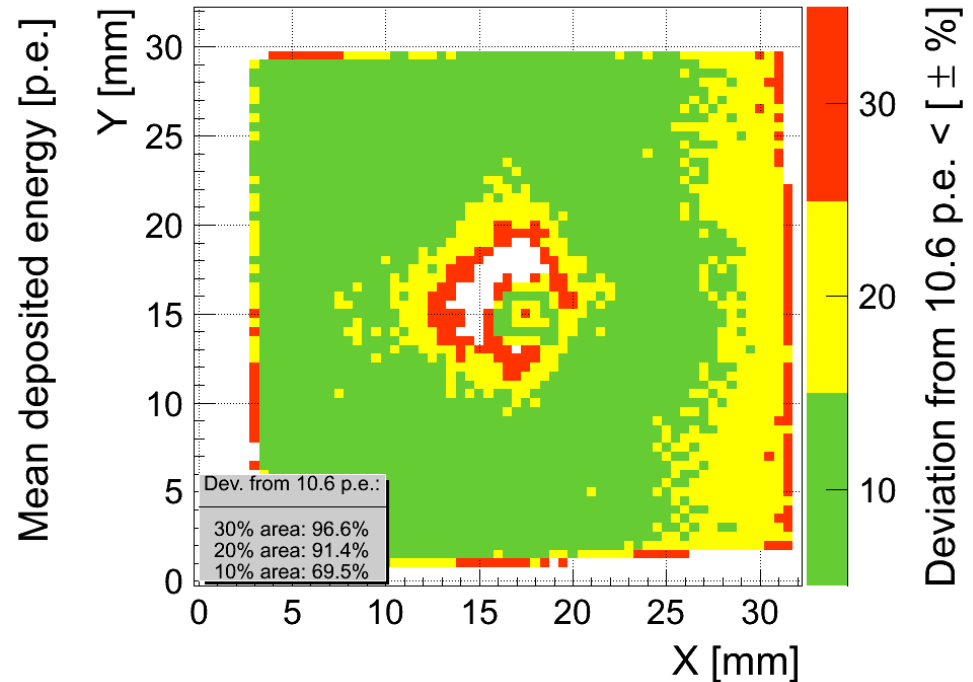
96.6% area: 30% dev.
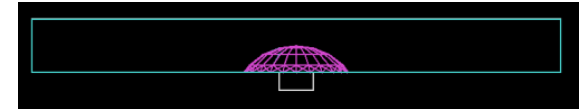91.4% area: 20% dev.
69.5% area: 10% dev.

Better uniformity?

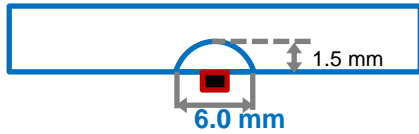Wider and shallower dimple

Simulation: SMD SiPM + dimpled tile

- ## Geometry
  - Dimpled tile: $30 \times 30 \times 3 \ mm$
  - SiPMs (used same PDE curve)
    - KETEK PM11*: $1.2 \times 1.2 \ mm$
    - KETEK PM22*: $2.0 \times 2.0 \ mm$
  - Reflective foil:
    - 3M ESR: curve of reflectivity vs wavelength

- ## Primary particle generator
  - Fixed energy: $2.28 \ MeV$ (Max. in Sr-90 Beta spectrum)

- ## Simulation scan
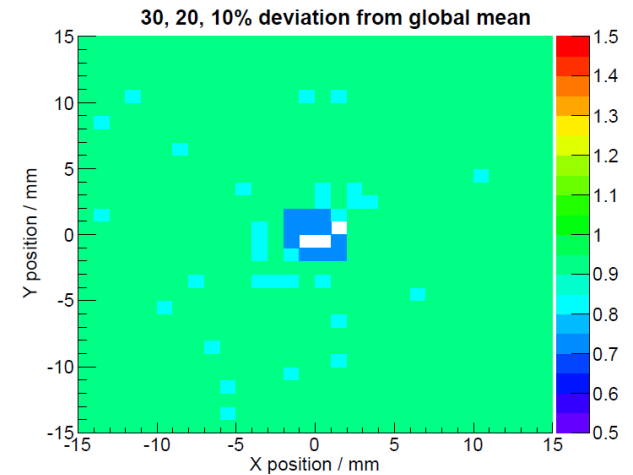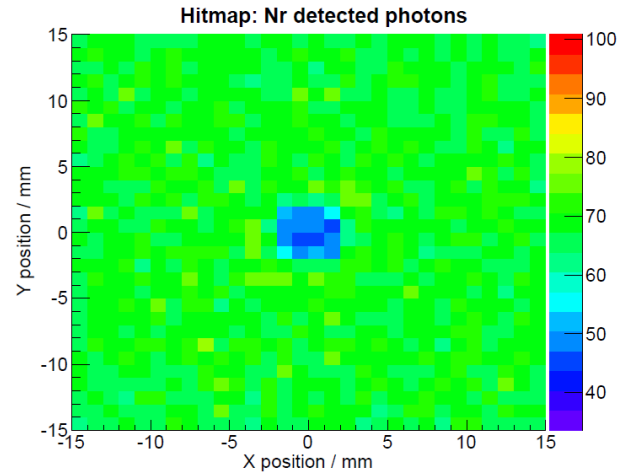 - 30x30bins; 100 events/bin

SiPM flush with bottom surface

$1.2 \times 1.2\ mm$ SiPM
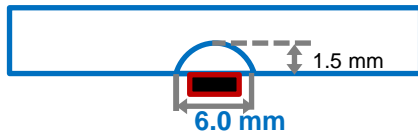
Mean 67 p.e.

1.5 mm

6.0 mm

99.7% area: 30% dev.
98.4% area: 20% dev.
95.0% area: 10% dev.

Hitmap: Nr detected photons

30, 20, 10% deviation from global mean
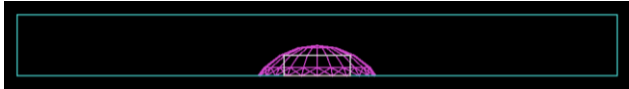
$2.0 \times 2.0\ mm$ SiPM

Mean 185 p.e.

1.5 mm

6.0 mm

99.4% area: 30% dev.
99.0% area: 20% dev.
95.2% area: 10% dev.

Hitmap: Nr detected photons

30, 20, 10% deviation from global mean
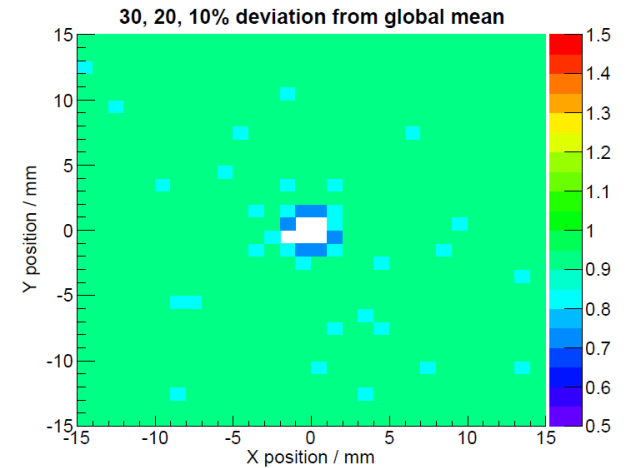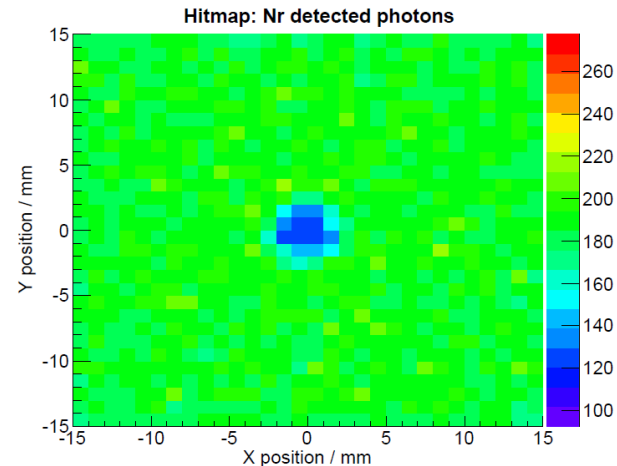
SiPM: 1.0mm inside dimple

$1.2 \times 1.2 \; mm$ SiPM

Mean 47 p.e. ↓

1.5 mm

6.0 mm
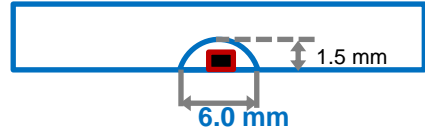
100% area: 30% dev. ↑
100% area: 20% dev. ↑
95.8% area: 10% dev. ↑

Hitmap: Nr detected photons

X position / mm
Y position / mm

30, 20, 10% deviation from global mean

X position / mm
Y position / mm
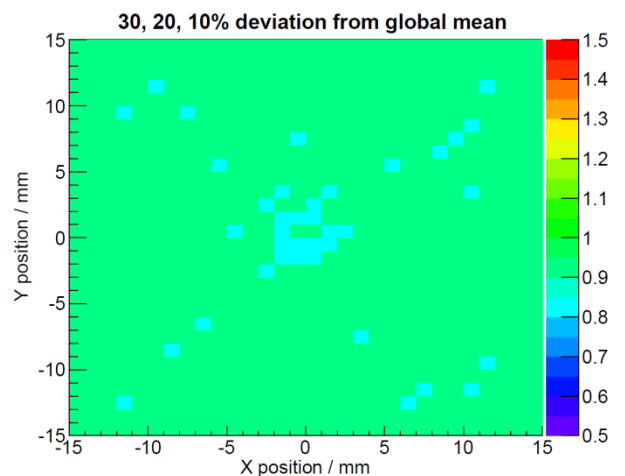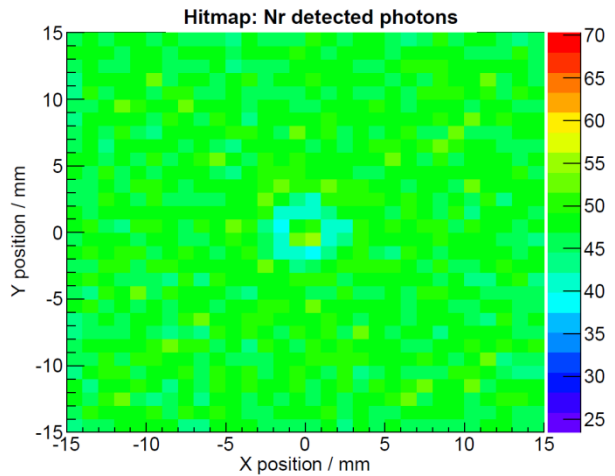
$2.0 \times 2.0 \; mm$ SiPM

Mean 130 p.e. ↓

1.5 mm

6.0 mm

100% area: 30% dev. ↑
99.9% area: 20% dev. ↑
96.4% area: 10% dev. ↑

Hitmap: Nr detected photons

X position / mm
Y position / mm

30, 20, 10% deviation from global mean

X position / mm
Y position / mm
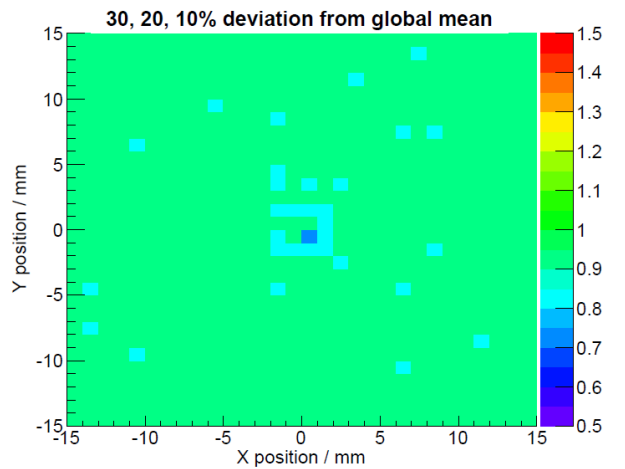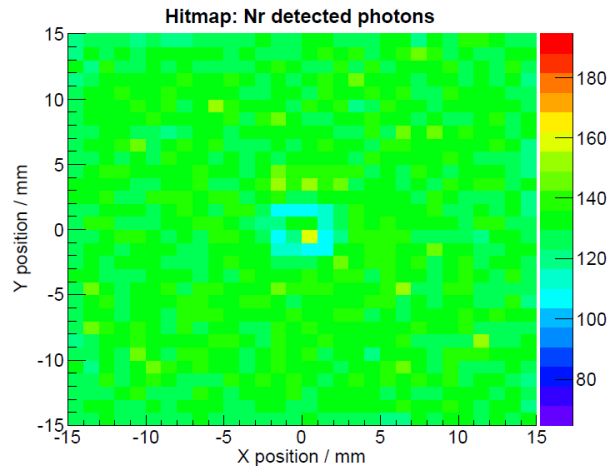
Side surface coupling: MC vs measurement

Tile: $30 \times 30 \times 3\ mm$; **no dimple**
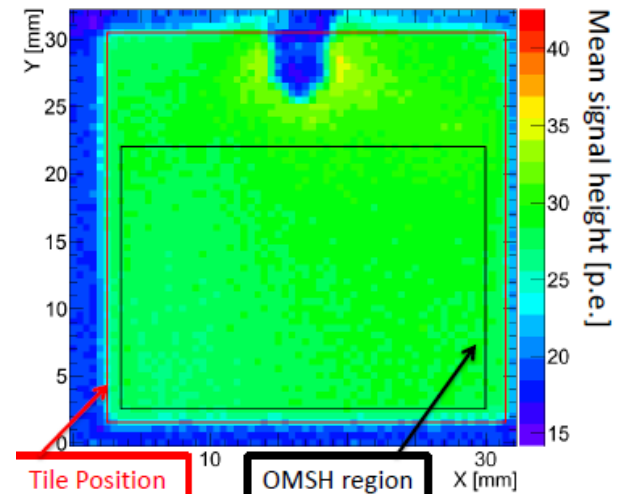

Simulation
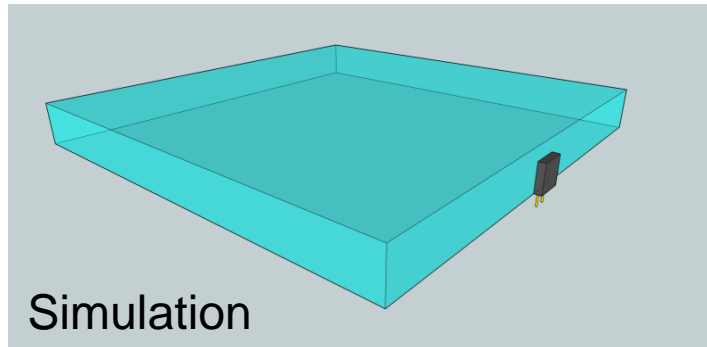
KETEK SiPM $1.2 \times 1.2\ mm$: mean 42 p.e.

mean **29.2 p.e./mm²** can be foreseen
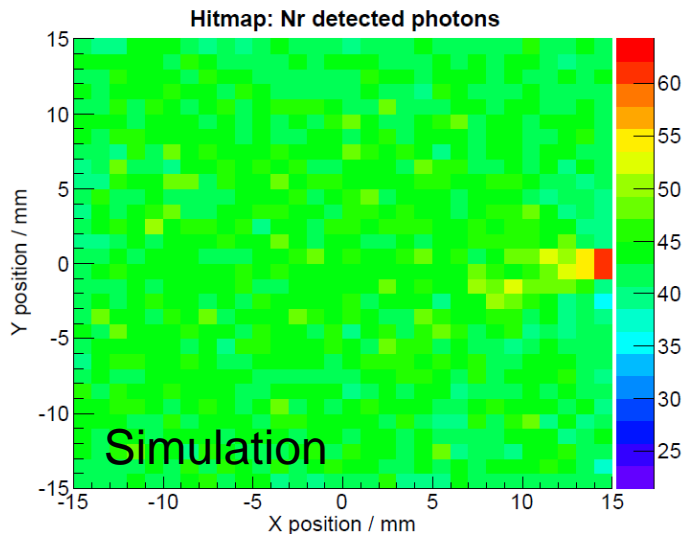
Uniformity measurement of DESY tile at MPI

**MPPC 1x1 mm:
Mean 28.4 p.e.**

**Ref: Christian Soldner, CALICE Collab. Meeting,
Shinshu Japan, Mar. 2012**

Summary

- ## Present design (side-surface coupling)
  - Simulation can be compared with measurement

- ## Simulation for SMD design
  - More p.e.s by larger SiPM sensitive area (roughly proportional)
  - SMD SiPM (sensitive surface)
    - Flush: more p.e. but less uniformity
    - 1mm inside dimple: better uniformity; less p.e.

Plan

- ## Updated SMD design
  - Uniformity measurement
  - Compare with simulation

- ## SMD design for HBU boards
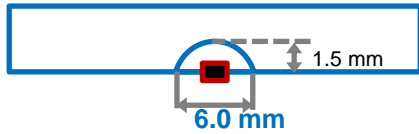 - Collaboration-wide efforts
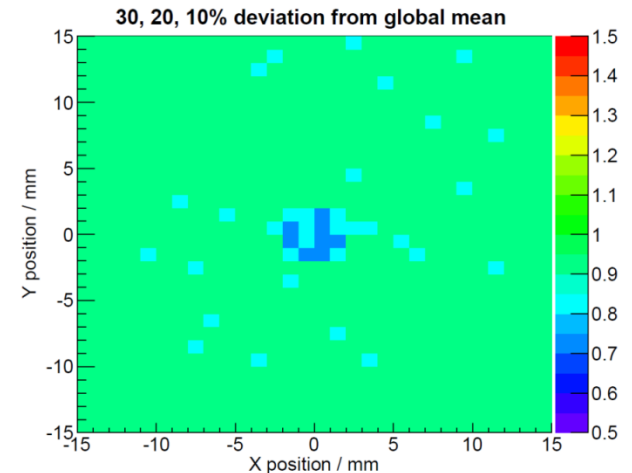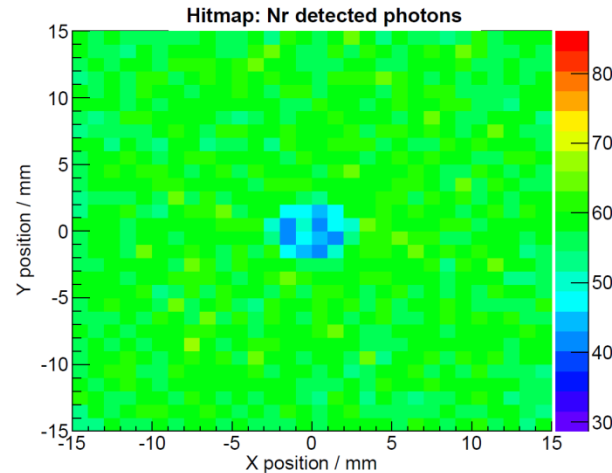
Thank you!

SiPM 0.5mm inside dimple

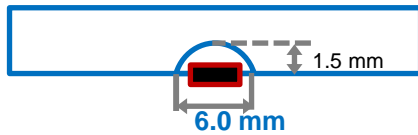## $1.2 \times 1.2 \; mm$ SiPM

Mean 57 p.e.

1.5 mm

6.0 mm

100% area: 30% dev.
99.1% area: 20% dev.
95.4% area: 10% dev.

$2.0 \times 2.0 \; mm$ SiPM

Mean 158 p.e.

1.5 mm

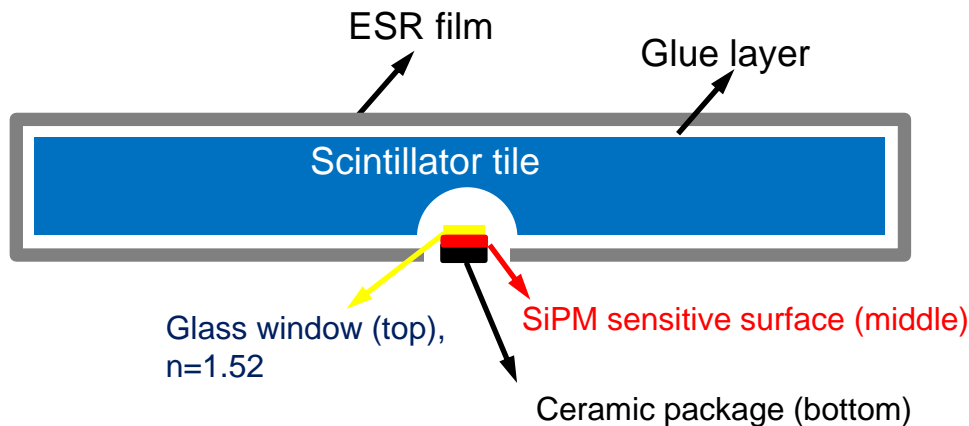**6.0 mm**

100% area: 30% dev.
98.8% area: 20% dev.
93.6% area: 10% dev.

Hitmap: Nr detected photons

30, 20, 10% deviation from global mean

Hitmap: Nr detected photons

30, 20, 10% deviation from global mean
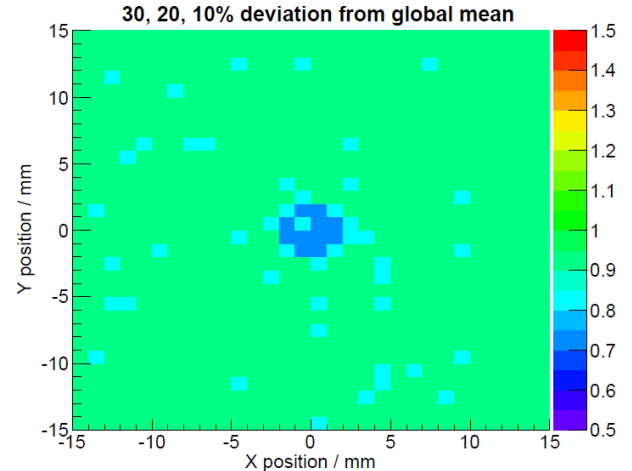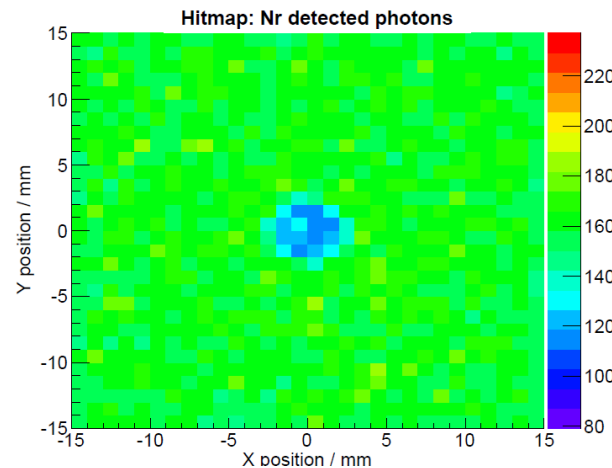
Simulation: setup for uniformity scan

ESR film

Glue layer

Scintillator tile

Glass window (top), n=1.52

SiPM sensitive surface (middle)

Ceramic package (bottom)

Scintillator tile: 30x30x3 mm³
KETEK SiPM: 1.2x1.2 mm²
Geant4 9.6.0.p01

Optical boundary model:
polished or ground (UNIFIED Model)

^{90}Sr

0.8 mm

3 mm

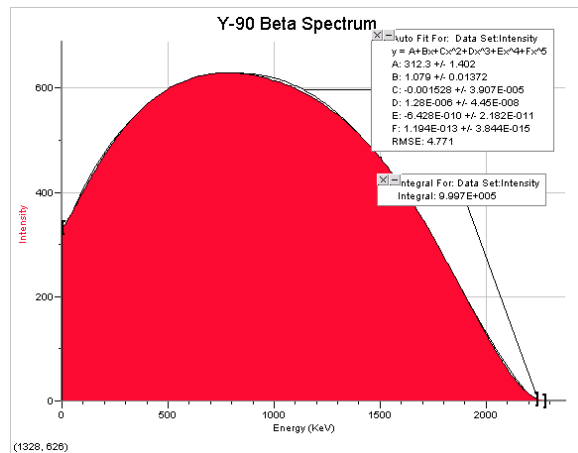Electron as primary particle (perpendicular incidence)
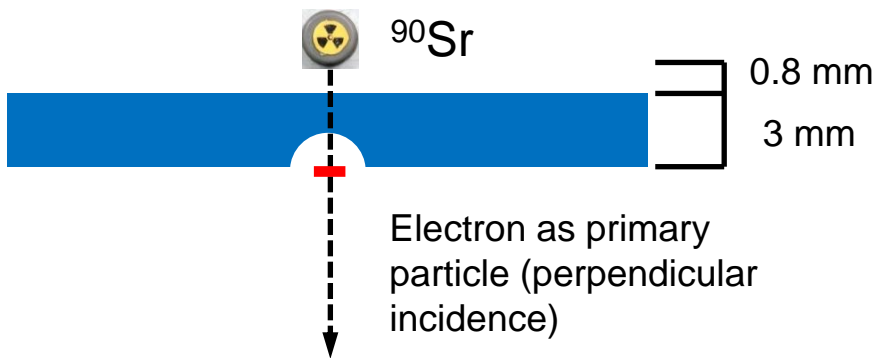
Scan step size: 1 mm
1 run: simulate 50 events at each position
30x30 positions to cover the whole tile area

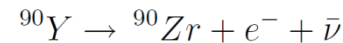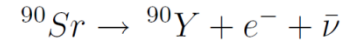Measured curve:
ESR reflectivity vs wavelength

CRESST experiment
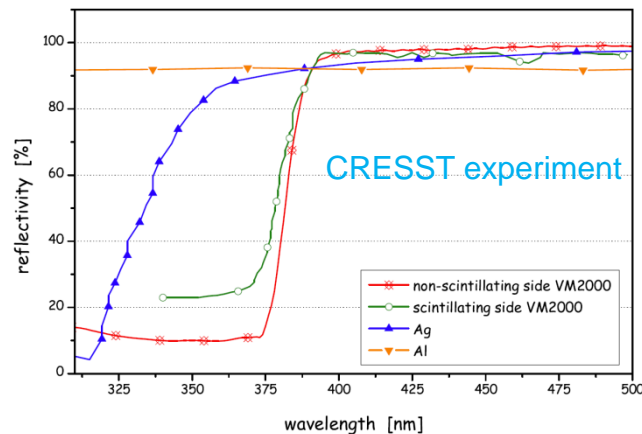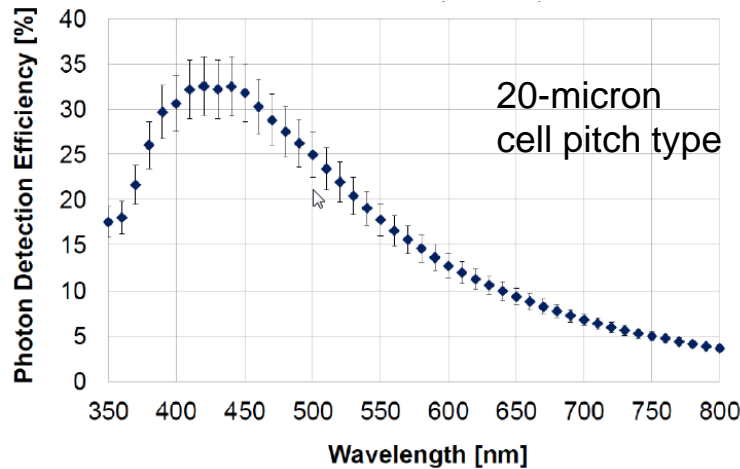
Plot courtesy of Frank Simon

Simulation: details

Y-90 Beta Spectrum

^{90}Sr energy spectrum:
use normalized polymial fitting as p.d.f. to sample

$$^{90}Sr \rightarrow\ ^{90}Y + e^- + \bar{\nu}$$
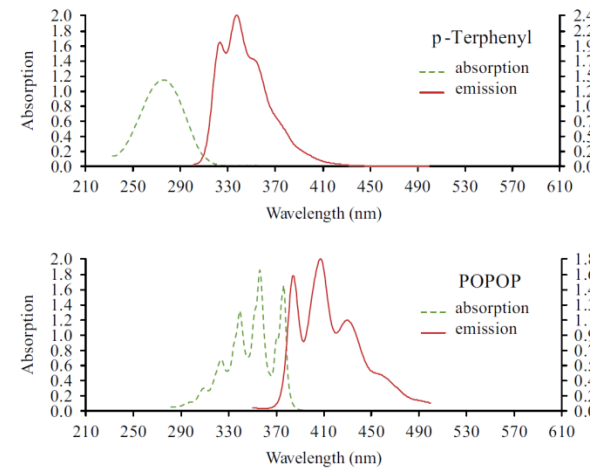
$$^{90}Y \rightarrow\ ^{90}Zr + e^- + \bar{\nu}$$

Ref 1: Silicon Strips and Pixel Technologies, Excellence in Detectors and Instrumentation Technologies 2011, CERN

KETEK PDE curve

20-micron cell pitch type

Scintillator emission spectra

Scintillator from NA62, produced by IHEP (Protvino, Russia)

Ref 2: SiPM Development at KETEK, CALICE Collaboration Meeting, March 2013 Hamburg

Ref 3: Nuclear Instruments and Methods in Physics Research A 577 (2007) 523