Status of scintillator and SiPM tests at CERN

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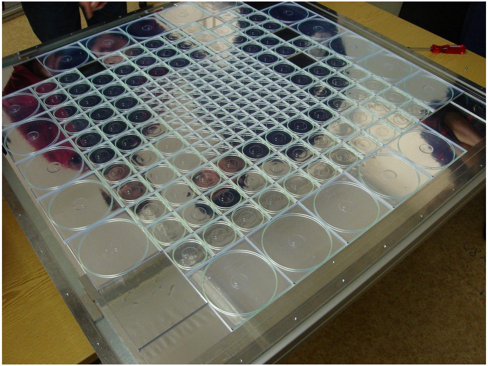
CLIC Detector and Physics
Collaboration Meeting

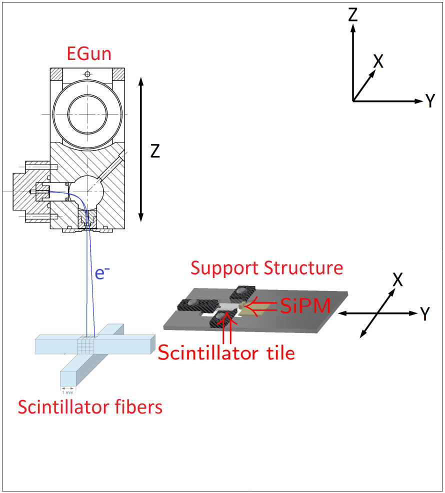
Motivation

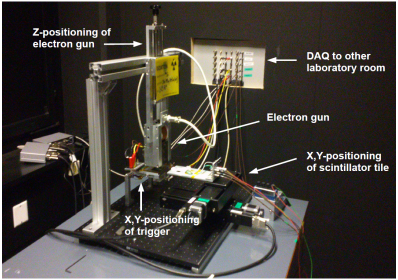
- Improve understanding of scintillators and SiPMs and related systematic effects in CALICE AHCAL test beam experiments
- Characterize new generation of SiPMs
- Characterize impact of scintillator wrappings and tile size on measured light yield

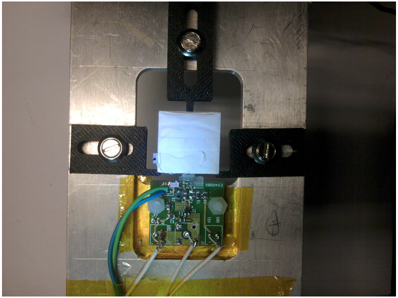


Sensitive layer of the CALICE AHCAL

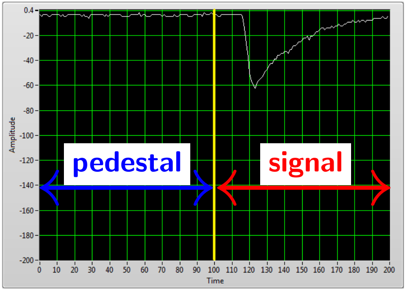
The setup at CERN



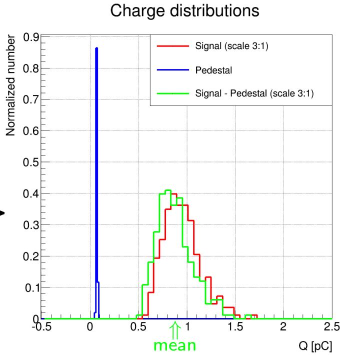




The method of the charge measurement

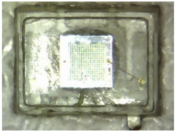


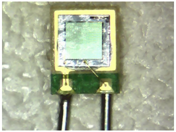
$\int dt$ $\Rightarrow$



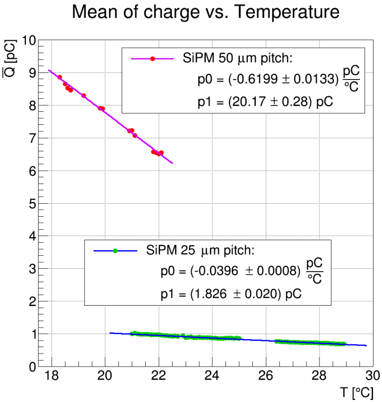
- Two time windows for pedestal and signal measurement
- Convert signal and pedestal response to charge by time integration
- Subtract pedestal from signal event-by-event
- Get the mean of the Signal-Pedestal distribution

Calibration of the SiPM - Temperature dependence





- SiPMs from Hamamatsu:
  - $\Rightarrow$ Type No.: S10943-8584(X), Serial No.: 11770, 50μm pitch, Number of pixels: 400
  - $\Rightarrow$ Type No.: S10362-11-025P, Serial No.: 225, 25μm pitch, Number of pixels: 1600



- Used the EGun and the wrapped □20x2 tile
- Fit $\overline{Q}$ vs T dependence with linear fit function:

$$\Rightarrow \boxed{\overline{Q} = p0 \cdot T + p1}$$

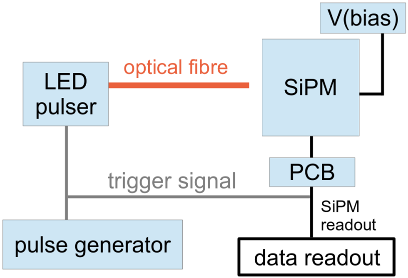
- SiPM with 50μm pitch: $\Delta\overline{Q}_{T=19℃} \approx 7.4\frac{\%}{℃}$

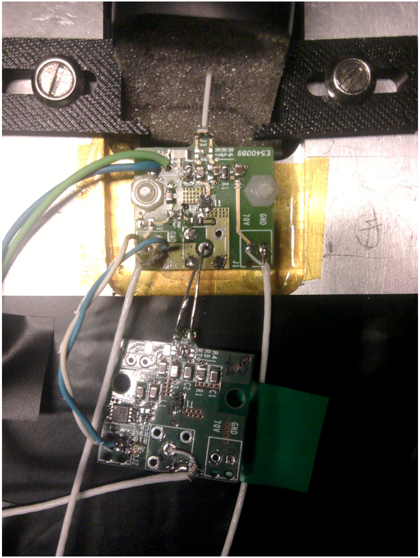
  SiPM with 25μm pitch: $\Delta\overline{Q}_{T=19℃} \approx 3.7\frac{\%}{℃}$
- $\left.\frac{\overline{Q}_{25\mu m}}{\overline{Q}_{50\mu m}}\right|_{(T=22\ ℃)} < 1, \quad \left.\frac{\mathrm{Gain}_{25\mu m}}{\mathrm{Gain}_{50\mu m}}\right|_{(T=22\ ℃)} < 1$
- In order to cope with the reduced gain in the 25μm SiPM, a 2nd amplification stage was installed

Calibration of the SiPM - Gain

- Replace scintillator tile by optical fiber, which is connected to an LED pulser
- Measure signal from individual photons for gain calibration

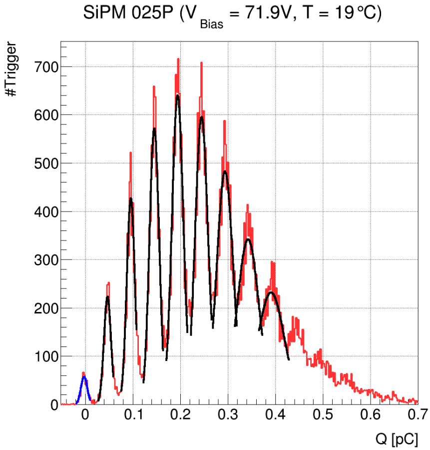
Simplified schematic of the setup for the characterization of the SiPM:



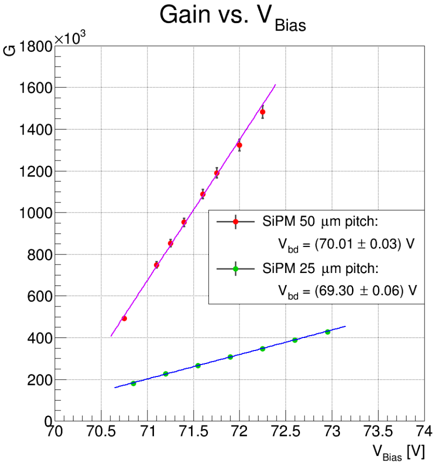


Calibration of the SiPM - Gain

- Measure the charge of single photons
- Measure T simultaneously
  $\Rightarrow$ Temperature correction of $Q^{measured}$ for each measurement
- Fit separate Gaussian functions to the first n peaks (here n=9)
  - $\Rightarrow$ The first peak is the noise peak (i=1)
  - $\Rightarrow$ $i >= 2$ photoelectron peak
- Calculate $\overline{\Delta Q}$ $\Rightarrow$ Gain (=G)
- Repeat the method for different V_{Bias} values
  - $\Rightarrow$ $G - V_{Bias}$ dependence



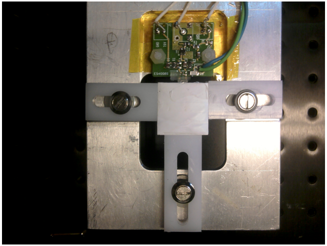
Calibration of the SiPM - Gain



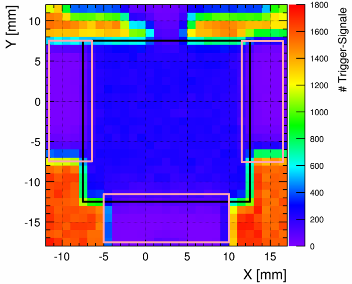
- Fit $G - V_{Bias}$ with linear function
- $\boxed{G \propto (V_{Bias} - V_{bd})}$
- $Slope_{50\mu m}(T_{ref}) \approx 6 \cdot Slope_{25\mu m}(T_{ref})$
  $\Rightarrow$ SiPM with $25\mu m$ has less V_{Bias} dependence
- $G_{25\mu m}(V_{op}, T_{ref}) \approx 4 \cdot G_{50\mu m}(V_{op}, T_{ref})$

Improvement of the experimental setup

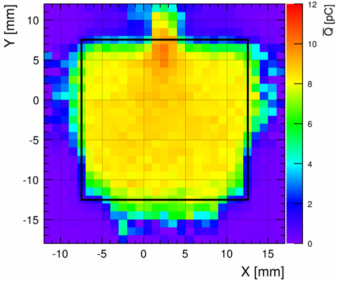
- At the beginning:
  use "high-material" tile holders to hold the scintillator in place
- The #Trigger map shows the transparency of the support structure
- Even if the electron beam does not hit the scintillator, stray particles produced in the tile holders leak into scintillator resulting in a measurable signal



#Trigger map of a tilescan

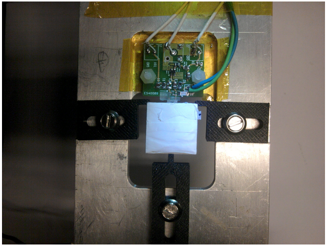


$\overline{Q}$ map of a scintillator tile

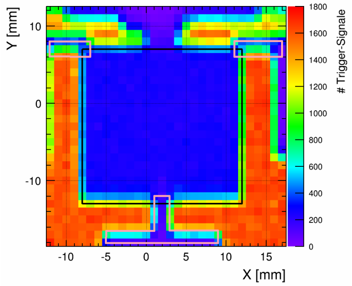


Improvement of the experimental setup

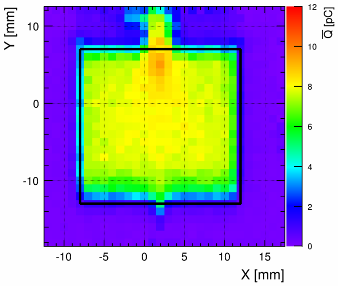
- Reduce material in tile holders close to the tile as much as possible
  - ⇒ The signal from stray particles disappeared on the $\overline{Q}$ map



#Trigger map of a tilescan

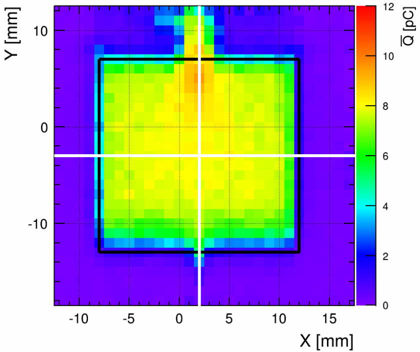


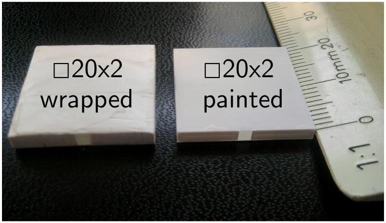
$\overline{Q}$ map of a scintillator tile

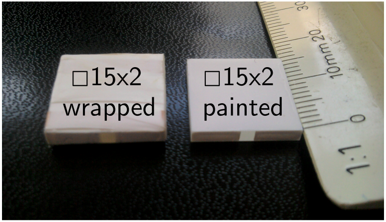


Comparison of different tiles

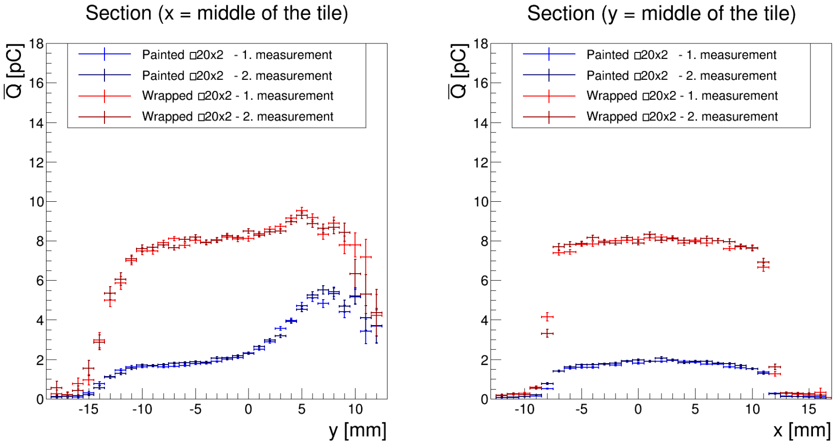
- Tested scintillator tiles:
  - ⇒ coating:
    - wrapping (3M foil)
    - reflection paint
  - ⇒ size:
    - □20x2 mm^3
    - □15x2 mm^3





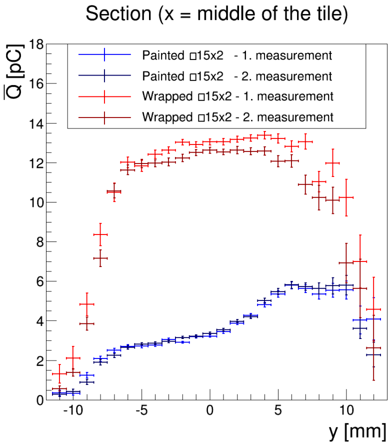


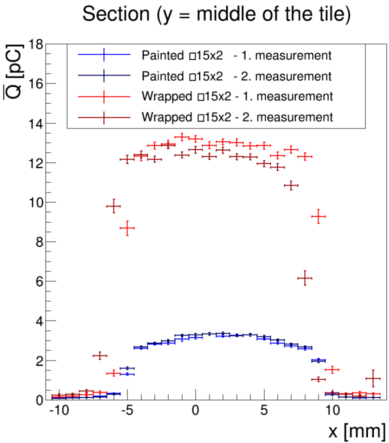
Slices of the □20mm tiles



- The light yield of the wrapped tile is ~ 4 times higher than for the painted tile
- $Y\overline{Q}$ section: peak at the SiPM; $X\overline{Q}$ section: uniformity
- The measurements agree within uncertainties

Slices of the □15mm tiles





- Same light yield difference regarding the coating as observed for the □20mm tiles
- The light yield of the □15mm tiles is ~ 1.5 times higher than for the □20mm tiles. This effect is understandable due the aspect ratio of the tiles with different sizes

Summary and Outlook

- Comparison of the SiPMs:
  - ⇒ SiPM with 25μm pitch has less Temperature dependence compared to the SiPM with 50μm
  - ⇒ SiPM with 25μm pitch has less V_{Bias} dependence compared to the SiPM with 50μm
- Comparison of the tiles:
  - ⇒ The light yield of the wrapped tile is ~ 4 times higher than for the painted tile independent of the size
  - ⇒ The light yield of the □15mm tiles is ~ 1.5 times higher than for the □20mm tiles independent of the coating
- Next steps:
  - ⇒ Study smaller scintillator tiles (eg. □10mm)
  - ⇒ Detailed test of the reproducibility of the tile scans
  - ⇒ Temperature measurements with a Peltier-element chamber
  - ⇒ Tile scan with several tiles next to each other to understand cross-talk between the tiles