

SiPM Saturation Study with UV Pulse Laser

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Saturation of SiPMs

Standard SiPM for ILD AHCAL : Hamamatsu MPPC S13360-1325PE

- \blacktriangleright Active area : 1.3 × 1.3 mm²
- Pixel pitch : $25 \,\mu m$
- 2668 pixels
- MPPC saturation was already measured in the previous studies using fast ps pulse laser with 467 nm wavelength (S. Krause, ICASiPM2018)
- Time constant of emission of scintillation light (few ns) is not negligible compared to recovery time of SiPM cell (17 ns) Ref: JINST 10 (2015) P10031
 - Expected smaller saturation
- Our idea is to measure the SiPM saturation with scintillation light
 - It can be directly used for saturation correction



S. Krause ICASiPM2018

Saturation Study with UV Laser

- Excite scintillator with fast fsec UV pulse laser
 - Standard 30 × 30 mm² scintillator tile used for large prototype (provided by a courtesy of E. Garutti)
 - 190 nm wavelength -> invisible to MPPC
 - Different attenuations (10 40 dB) applied depending on the light intensity
 - MPPC S13360-1325PE with over voltage of +5 V
 - Same reflector as in large prototype (3M Vikuiti)







Experiment Setup

Cut off contamination of other wavelength light

Incident light intensity controlled with three ND filters



Analysis

- Digitized waveform is integrated to estimate charge
- The charge is then converted into number of photoelectrons being divided by single photoelectron charge

htemp

Entries

Std Dev

Mean

0.4

charge

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54420

0.1674

0.0556



Laser Intensity

- Incident light intensity is measured with photodiode
 - Measured separately from saturation measurement due to a lack of splitter for UV light
- Relation between Npe and diode current is calibrated at small Npe (e.g. linear) region
- Effect of crosstalk and after-pulse not subtracted



MPPC Saturation

Saturation still has uncertainties of attenuation factor and photodiode calibration

► The uncertainties will be resolved through next measurements



Comparison with Previous Study

- Comparing the measured saturation with the previous study
- Very large saturation recovery observed even at minimum of the band
- Still a few things to be checked
 - Resolve the uncertainty of the curve
 - Possible excitation of scintillation light in surrounding materials?





To Do

- Stabler monitoring of laser light intensity
- Fine calibration of attenuator and photodiode
- Measurement with tile without reflector
 - ► To see effect of scintillation light excitation in reflector
- Measurement with 400nm laser incident in scintillator tile
 - ▶ To check the reproducibility of previous saturation curve
- Comparison with theoretical model of saturation
- Over-voltage dependence of saturation curve
- Measurement with different scintillator materials
- Try saturation correction using the observed curve on the AHCAL testbeam data

Summary

- SiPM saturation could be lower for the scintillation light due to the SiPM cell recovery
- We measured the SiPM saturation with fs UV pulse laser incident on standard scintillator tile for AHCAL
- Large saturation recovery observed
- Still the measured curve have big uncertainty to be resolved
- Further studies such as theoretical modeling and material dependence

Backups

11

Saturation Curve without Correction



12