Studies of Small Scintillating Cells with Modified Geometries

Alexander Dyshkant for NICADD at NIU

Outline

- LC scintillator based calorimeter with incorporated readout electronics:
 - Electronic circuit board with surface mount Multi_Pixel Photon Counters (MPPC)
 - Array of the concave scintillating cells that is directly coupled to the MPPC on the electronic circuit board
- Current measurements with MPPC
- Concave cell studies:
 - Traditional or flat vs concave cell
 - Response MPPC to different diameter of dimples
 - Distance impact on a MPPC response
 - Response of the adjacent cells and cross talk estimation for the concave cells with MPPC
- Summary and Plans

Electronic Circuit Board with Array of Scintillating Cells



Array of scintillating cells directly coupled to the photo detectors that are surface mounted on a printed circuit board. The front-end electronics and all signal and bias voltage traces for 64 channels are on the same board. Nowadays Fermilab electronics design based on the Minerva FEB 4TriP-t chips 11.17.08 LCWS08 3

Surface Mounted MPPC



View through the spacer opening. The MPPC active area is about 1 mm² (to the right)

11.17.08

LCWS08

Array of Concave Scintillating Cells



Example of 5 x 5 concave scintillating cells that was fabricated as one unit.



Look at V-I



LCWS08

11.17.08

Single Cell Preparation

- For the cells with an area about 9 cm² and thickness about 200 mils scintillator EJ-200 was used
- One side of the cell is flat and the other has a concave dimple in the center of the cell.
- The cell edges were painted using reflective coating EJ-510
- Flat side of the cell was covered with VM2000

Scanner& Scanning

- The photo detector was MPPC-10362-11-050C from Hamamatsu and it was placed under the center of the cell
- The very top surface of the photo detector was even with the bottom surface of the cell
- The following scans were performed from one side to the opposite side through the center of the cell
- A collimated radioactive source Sr90 was used.
- The factory recommended operating voltage was used for MPPC
- The output current was measured with Kiethley 6485 picoammeter.
- During tests the temperature was measured with an accuracy 0.1°F.

Traditional Flat Cell



Concaved Cell



11.17.08

LCWS08



Response of Cell with Different Diameter of Dimple

MPPC-11 Response to Cells



LCWS08

Response of Cell with Different Diameter of Dimple

MPPC-33 Response to Cells



General Considerations

- Direct coupling of a photo detector with an effective active area of about 1 mm² to a concave cell made of plastic scintillator with an about 9 cm² area provides a uniform response across the entire cell without the light yield loss compare to a flat cell (without dimple). This is possible in the case when the top surface of the photo detector is flush with the flat part of the cell concave side. Is such flush position of a photo detector optimal?
- In the case of the surface mount type of photo detector, it will pop out of a printed circuit board into the cell concavity and the cell response can be different.
- So, the vertical position of the photo detector inside the concave cell and its impact on the cell response needs to be clarified. For this test a special stand was designed.

Response Versus MPPC Vertical Position for Concave Cell



Output Current with a Collimated Sr90 on the Top of the Cell Center



LCWS08

Uniformity Measurement Schematic



Cell Response to Sr90 at Two MPPC Vertical Positions



LCWS08

Cross Talk Estimation

- Current response of two concave adjacent cells was measured at the same temperature and the same bias voltage for both MPPC. The MPPCs were install in the center of each concave cell
- The step of scanning was from 0.2 to 3.2 mm. The scans were performed using precision table.
- The goal was to see a gap between the cell boundaries.
- Measurements with one MPPC help estimate amount of light coming from the neighboring cell through the adjacent boundaries

Two Cells and Two MPPC



Impact of Adjacent Cell



Summary

- Concave cell results in uniform response.
- The depth of the sensor within the concavity affects the uniformity of response.
- The uniformity depends on the size of the MPPC.
- The concave scintillating cell indicates a low sensitivity to the diameter of dimple.
- Cross talk between the adjacent concave cells is tolerable.
- An integrated circuit board/scintillator/sensor has been built and under test.

Plans

- Test of single concave scintillating cell produced with injection mold process.
- Test of single concave scintillating cells with a thickness less than 5 mm and an area less and more than 9 cm².
- Test of single concave scintillating cell with less diameter of dimple

Acknowledgment

• The authors would like to thank NIU Sr. Lab. Mechanic Phillip Stone for preparing the scintillating cells; Marcellinus Demarteau for support.