

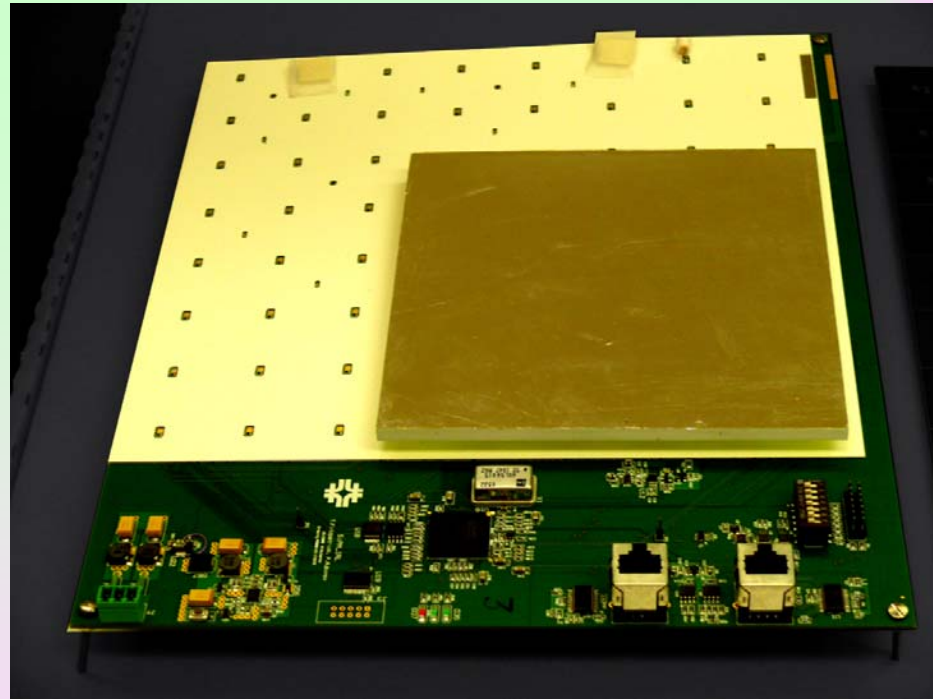
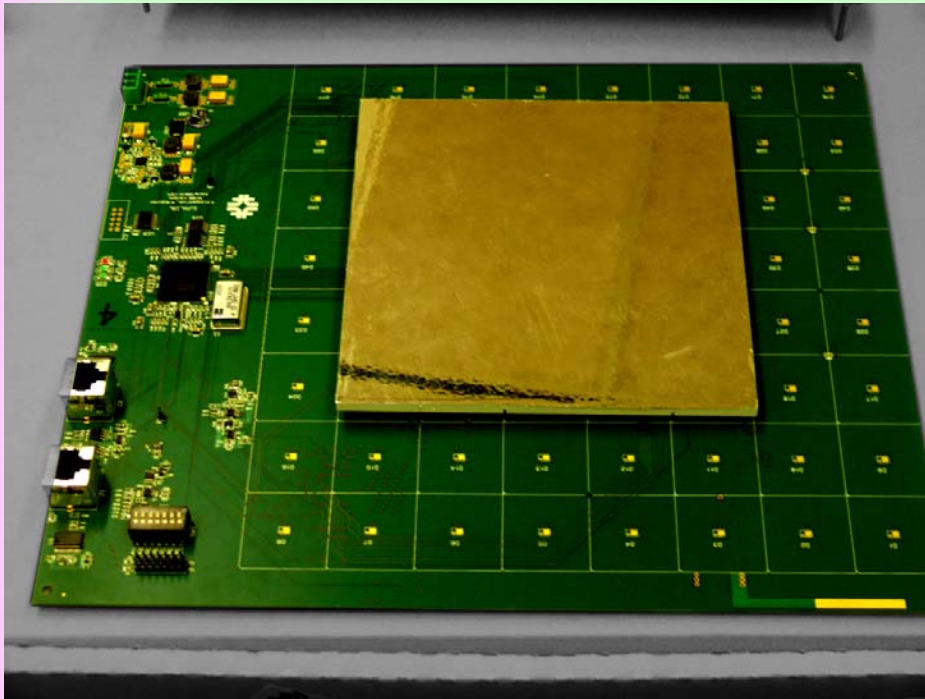
# Studies of Small Scintillating Cells with Modified Geometries

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# Outline

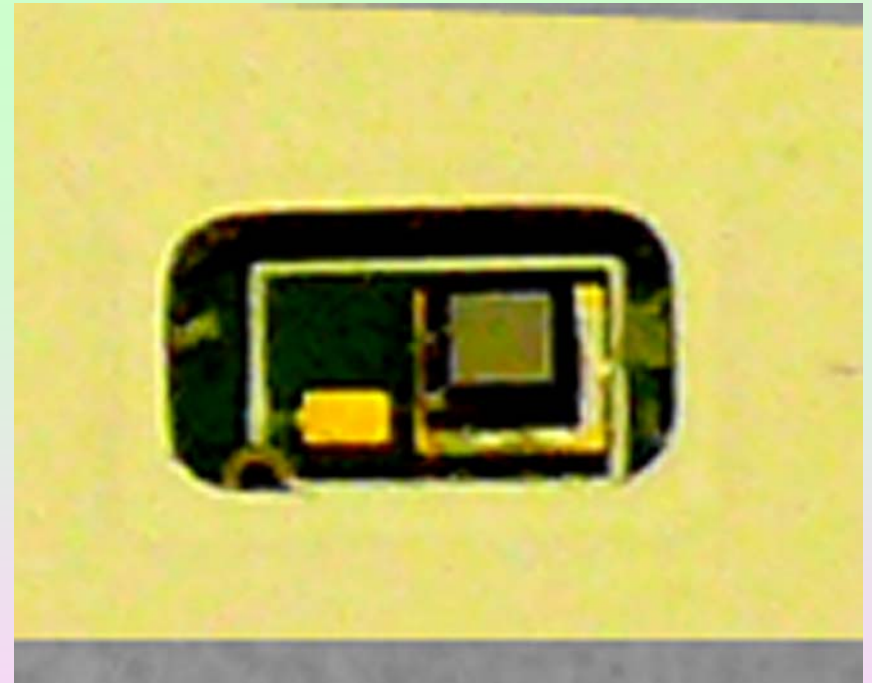
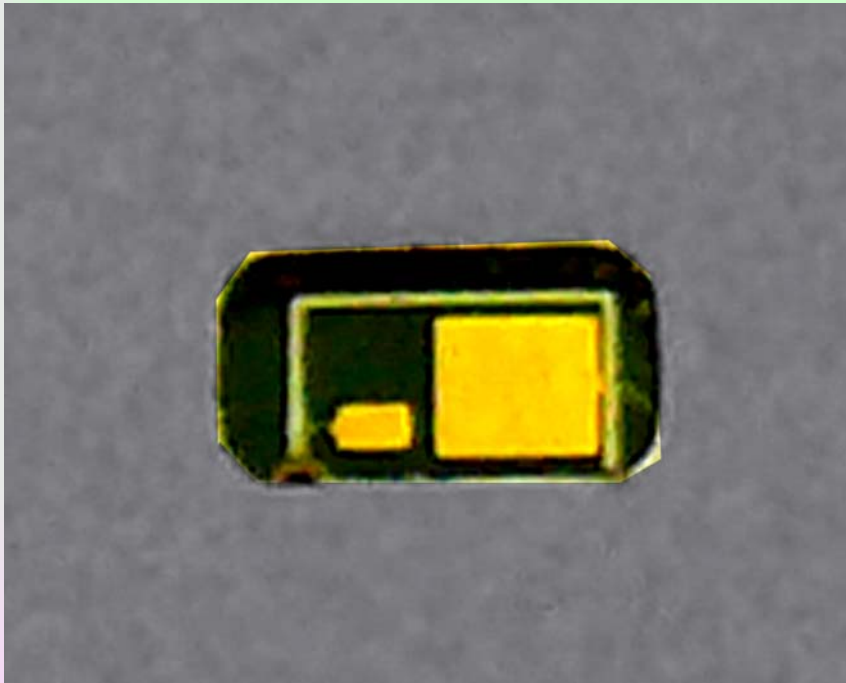
- LC scintillator based calorimeter with incorporated readout electronics:
  - Electronic circuit board with surface mount Multi\_Pixel Photon Counters (MPPC).
  - Array of the concave scintillating cells that is directly coupled to the MPPC on the electronic circuit board.
- Current measurements with 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



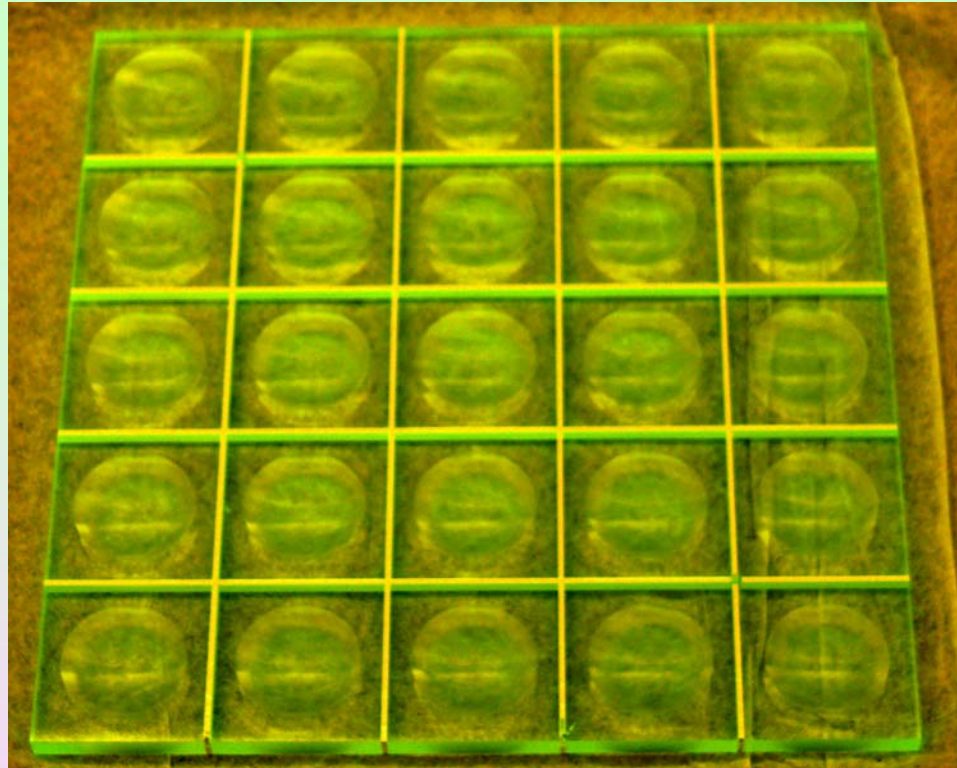
Array of scintillating cells directly coupled to the photo detectors that are surface mounted on a printed circuit board. **The front-end electronics and all signal and bias voltage traces for 64 channels are on the same board.** Nowadays Fermilab electronics design based on the Minerva FEB 4TriP-t chips.

# Surface Mounted MPPC



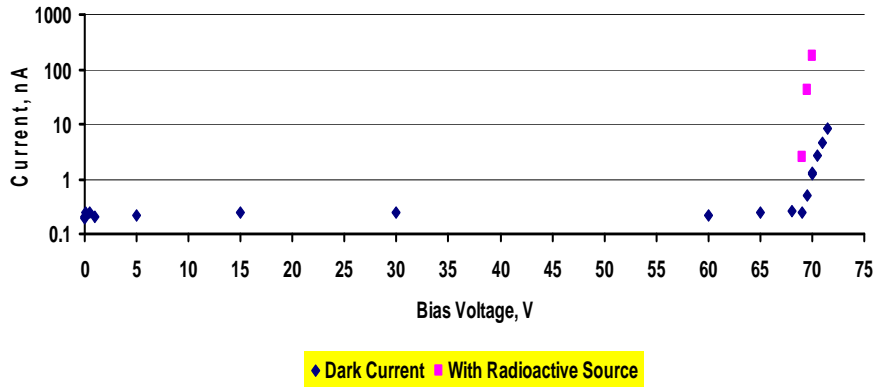
View through the spacer opening. The MPPC active area is about  $1 \text{ mm}^2$  (to the right).

# Array of Concave Scintillating Cells

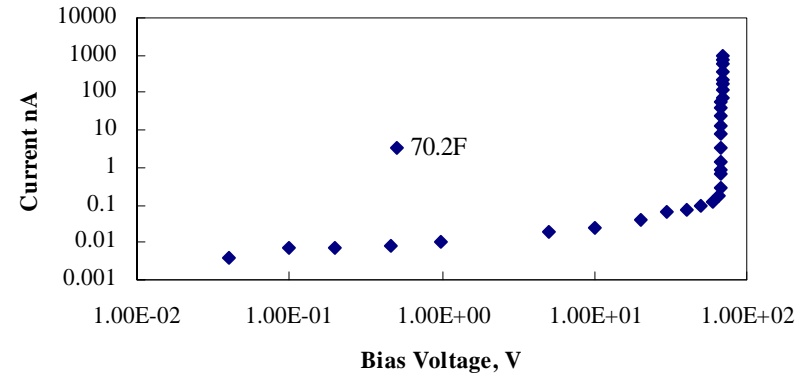


Example of 5 x 5 concave scintillating cells that was fabricated as one unit.

Output Current vs Bias Voltage

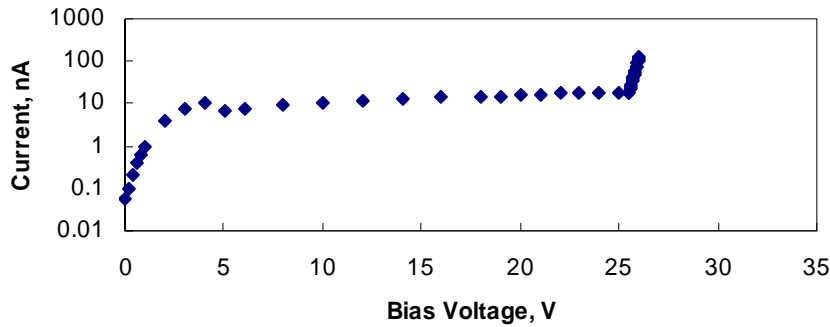


V-I for MPPC-33-100C

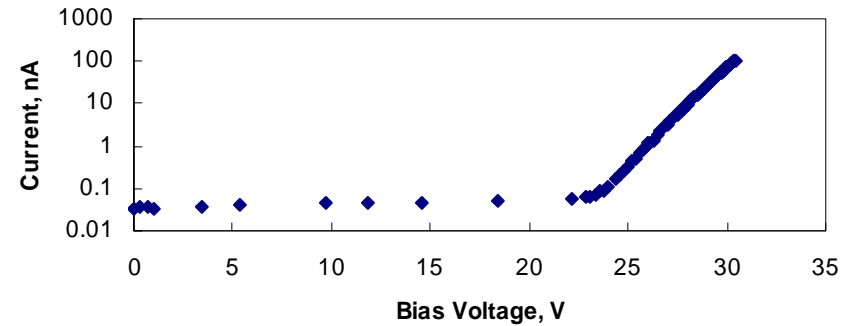


# Look at V-I

I\_V for CPTA SiPM at room



V-I at LN for SiPM from CPTA



With low noise photo detector the current measurements are reasonable.

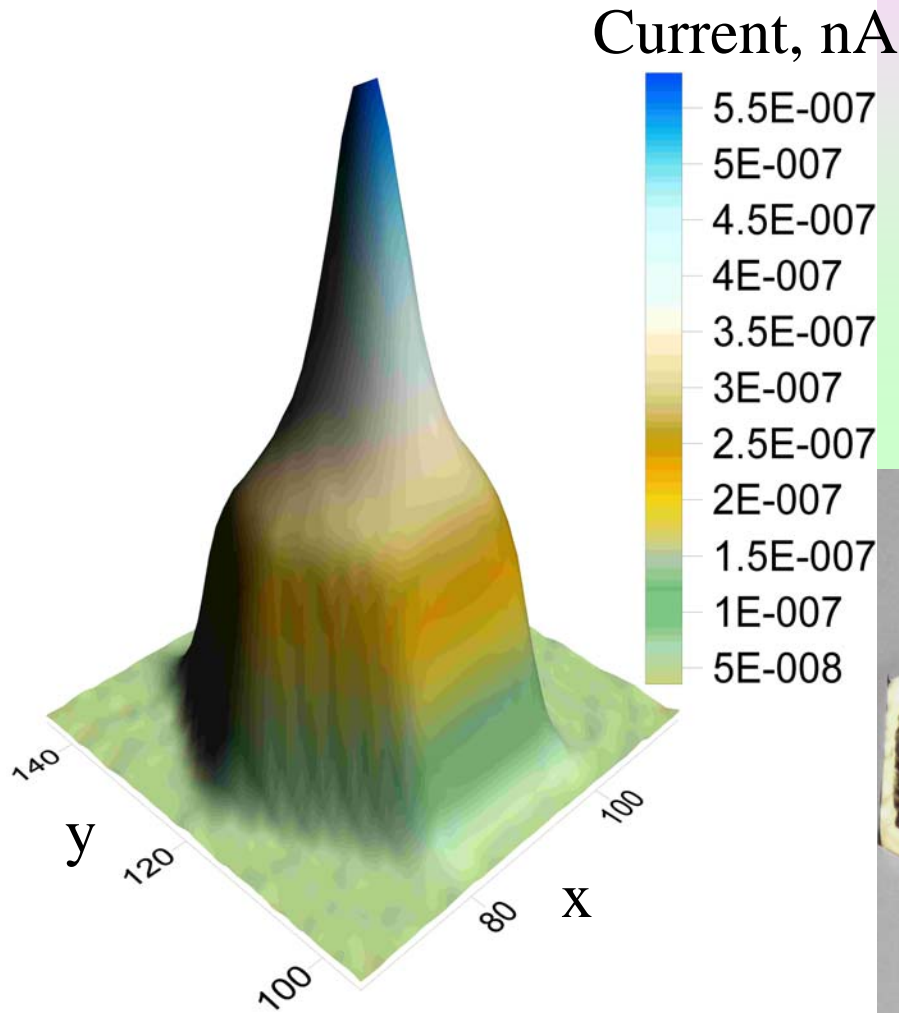
# Single Cell Preparation

- For the cells with an area about 9 cm<sup>2</sup> 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.

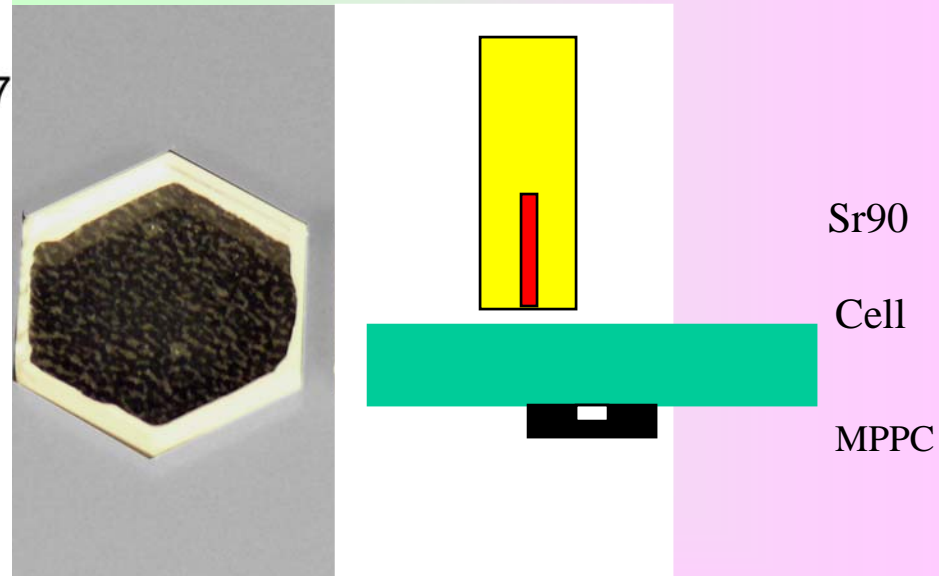
# Scanner & Scanning

- 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



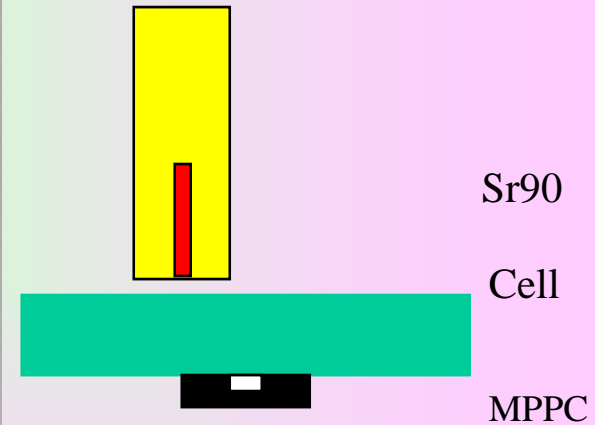
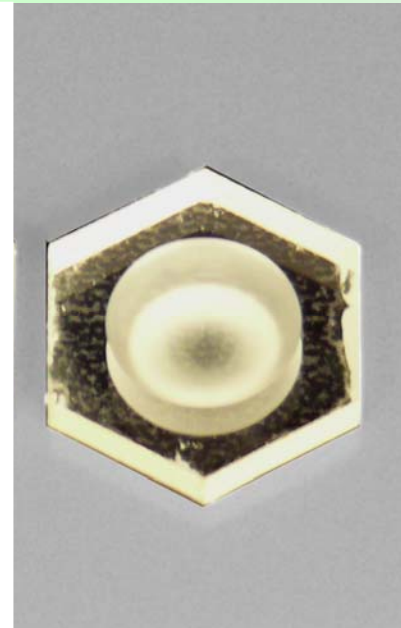
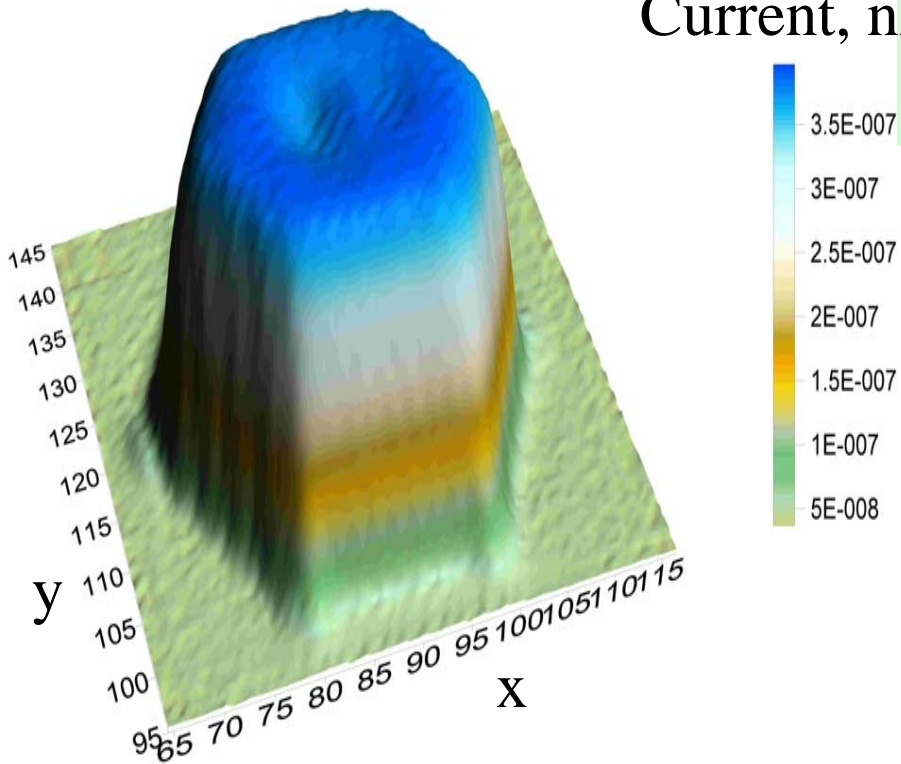
MPPS is directly coupled at the center of the cell.



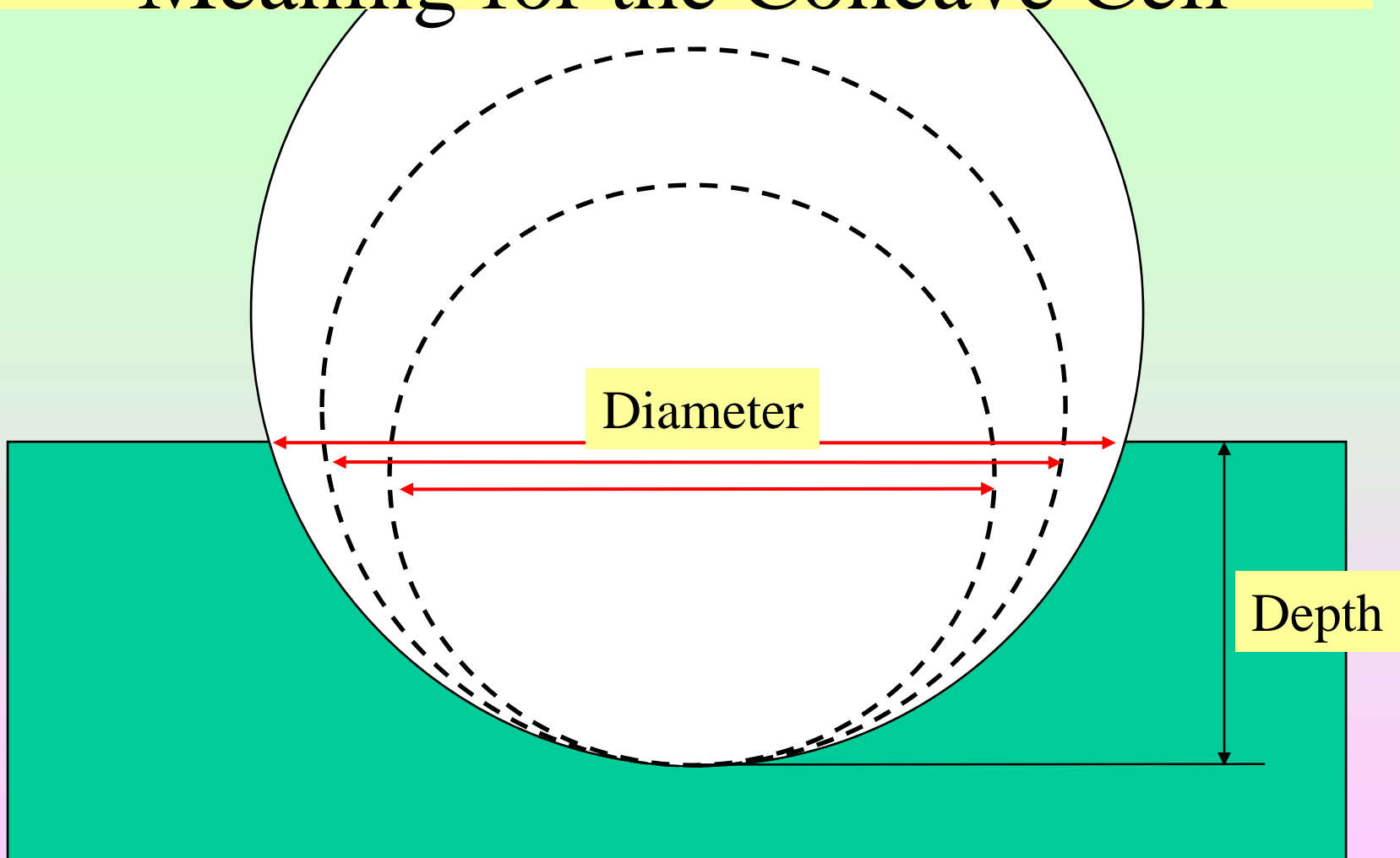
# Concave Cell

MPPS is directly coupled at the center of the cell.

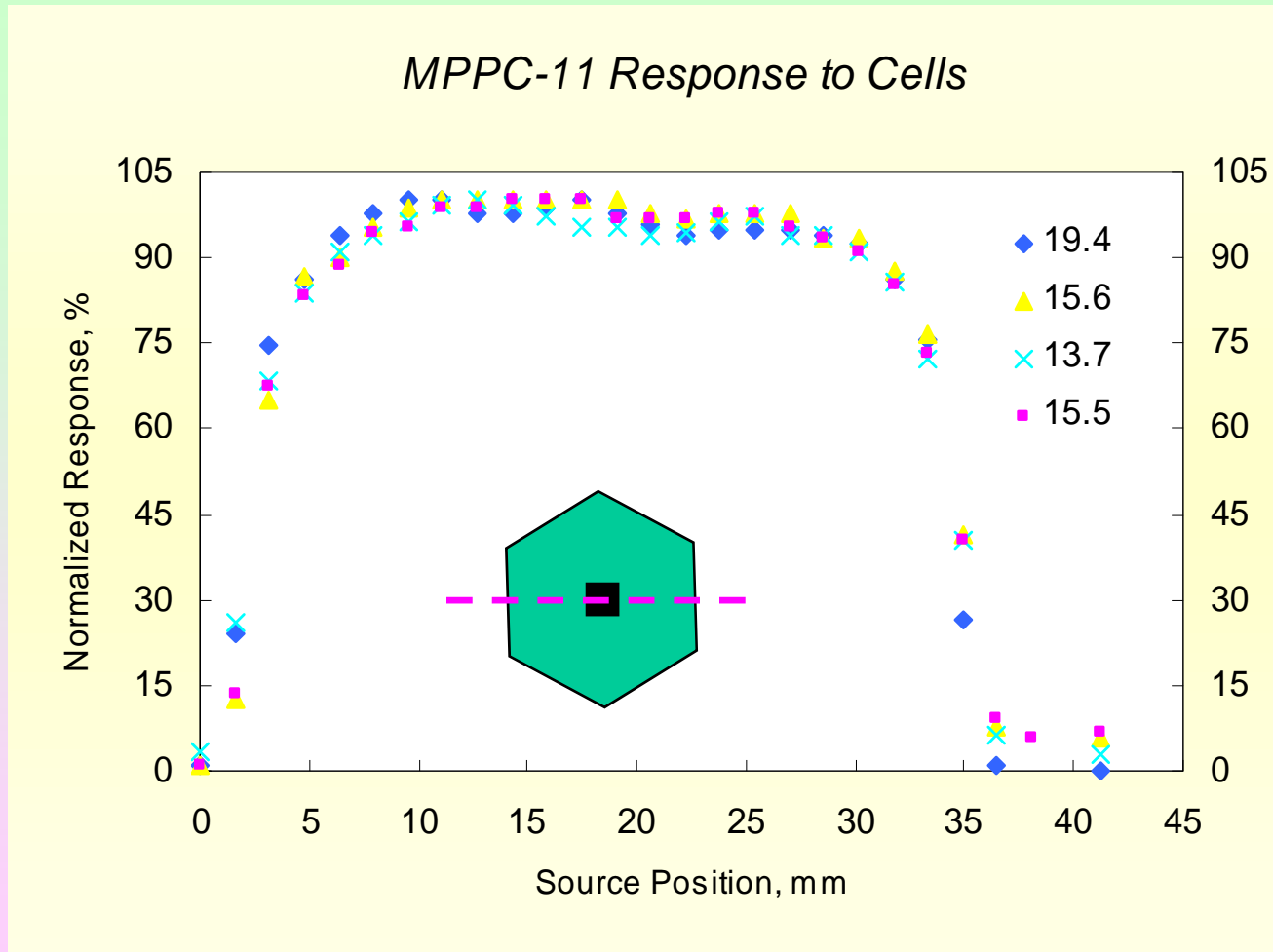
Current, nA



# Dimensions of the Dimple and Their Meaning for the Concave Cell

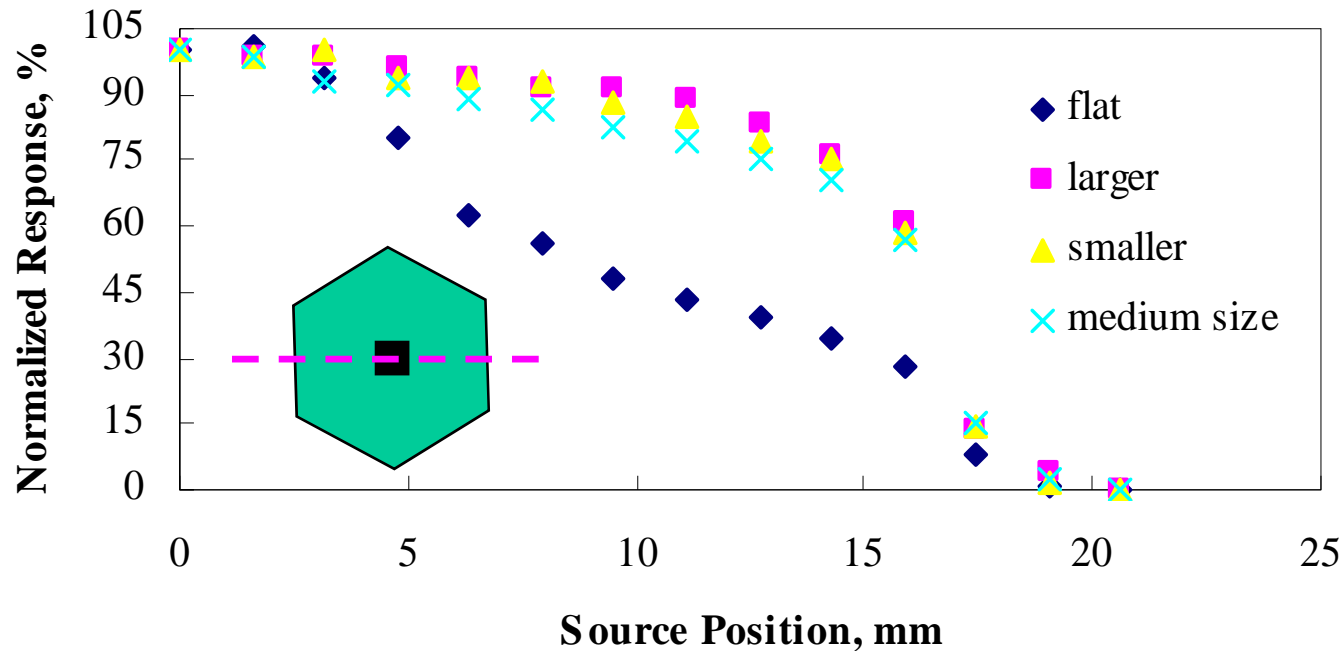


# Response of Cell with Different Diameter of Dimple



# Response of Cell with Different Diameter of Dimple

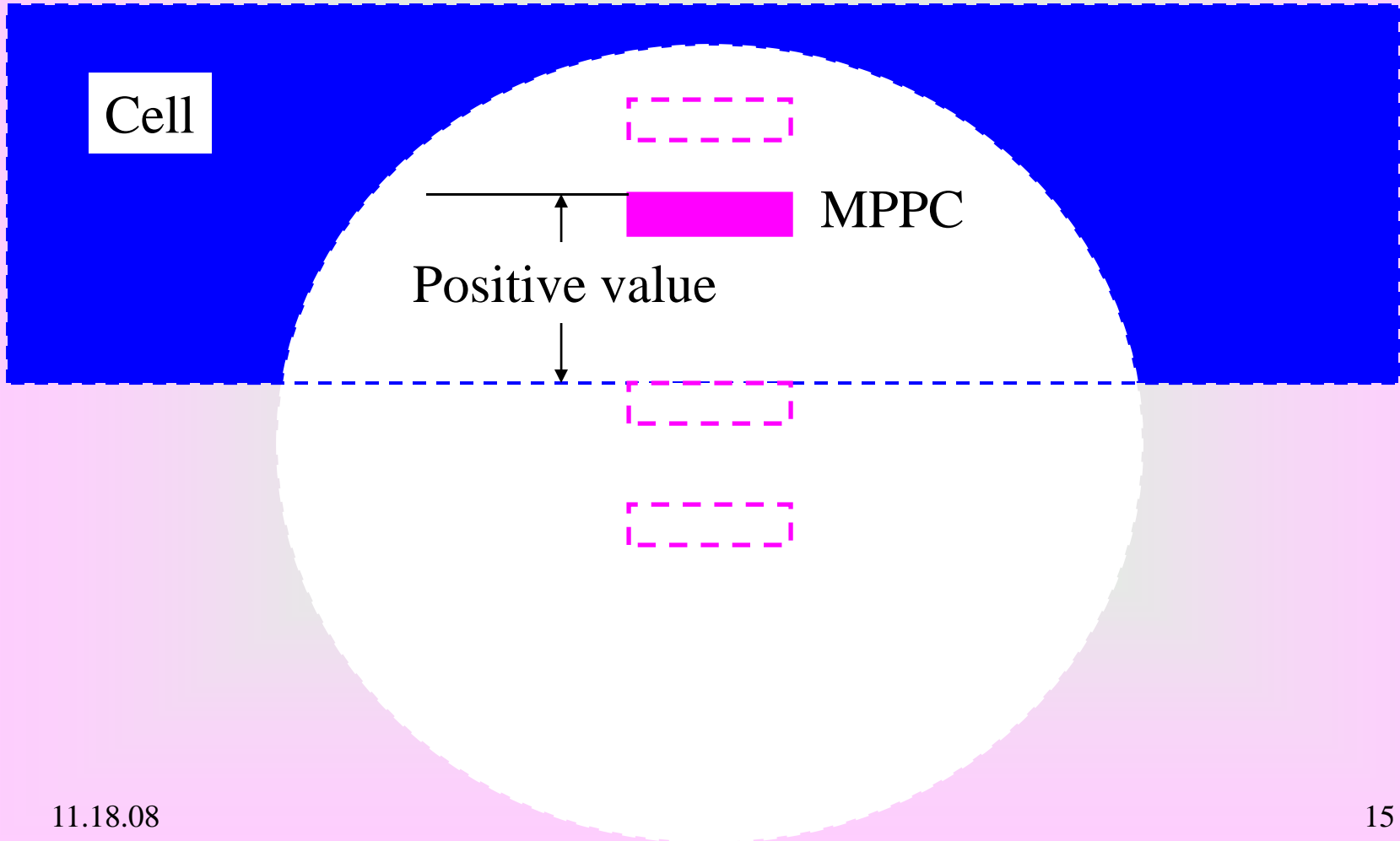
MPPC-33 Response to Cells



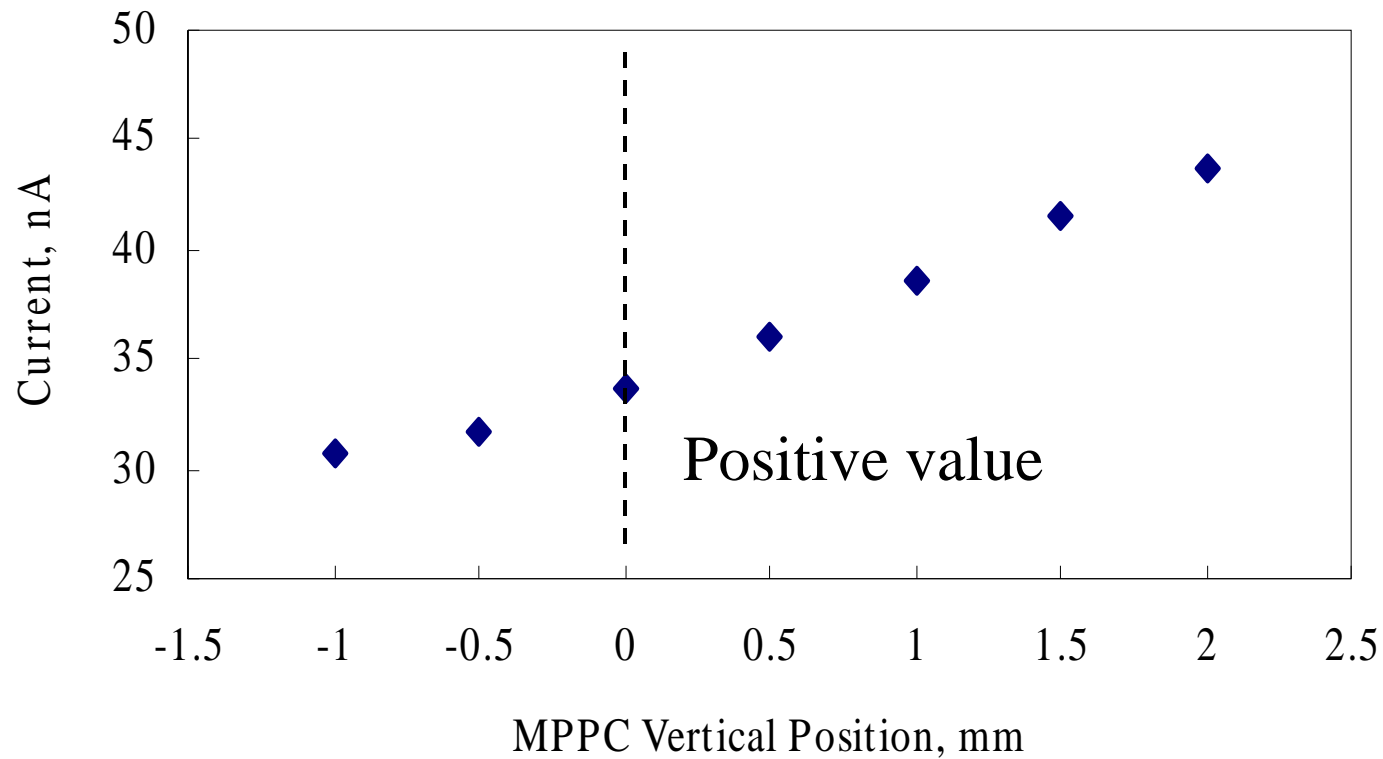
# General Considerations

- Direct coupling of a photo detector with an effective active area of about  $1 \text{ mm}^2$  to a concave cell made of plastic scintillator with an about  $9 \text{ cm}^2$  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.

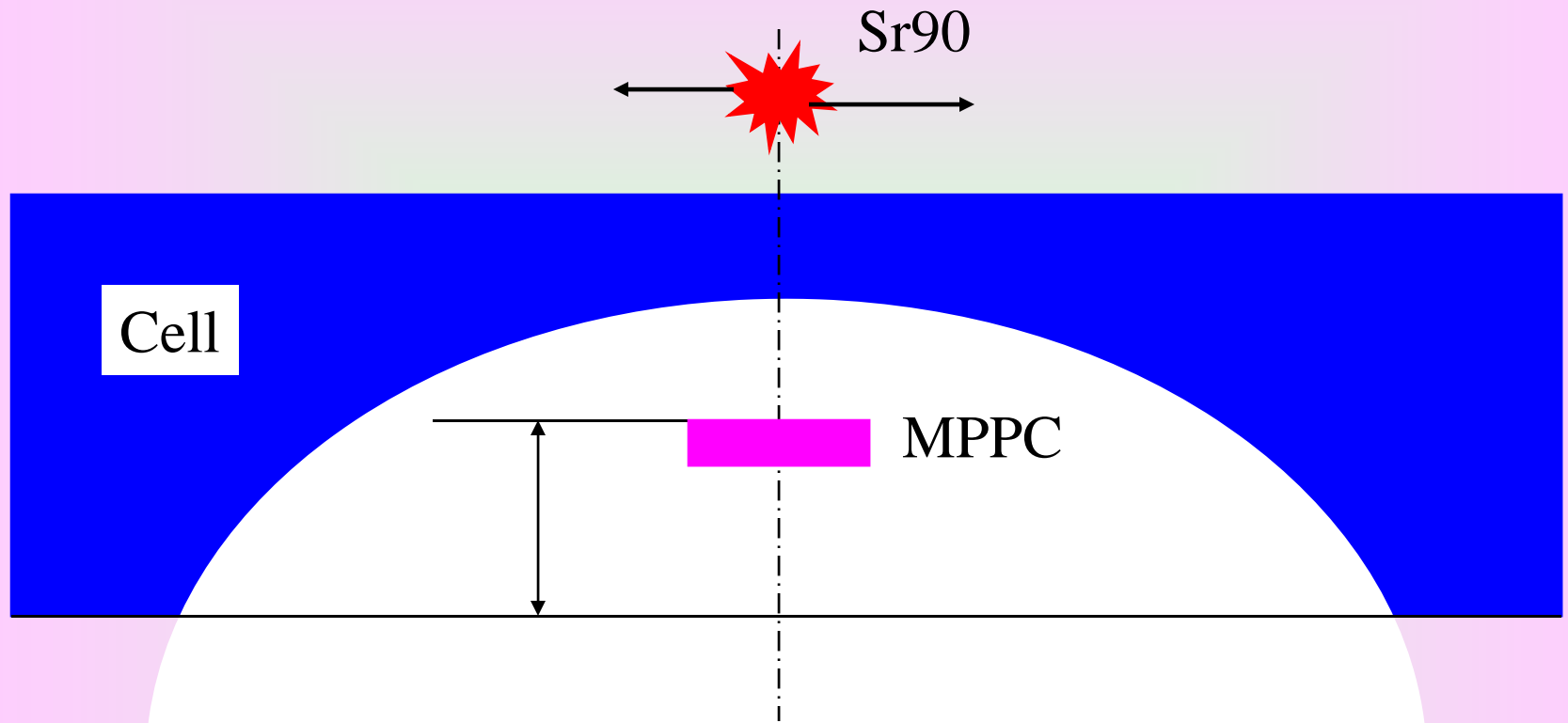
# Response Versus MPPC Vertical Position for Concave Cell



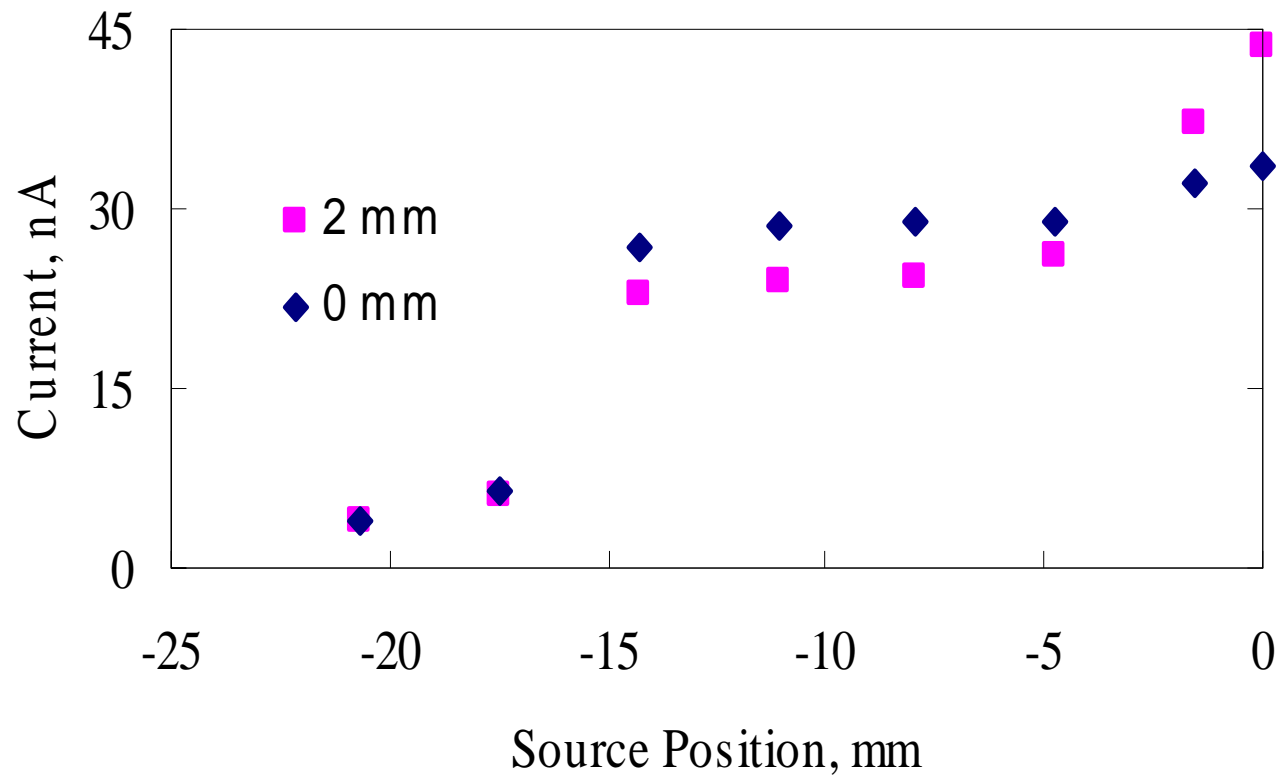
# Output Current with a Collimated Sr90 on the Top of the Cell Center



# Uniformity Measurement Schematic



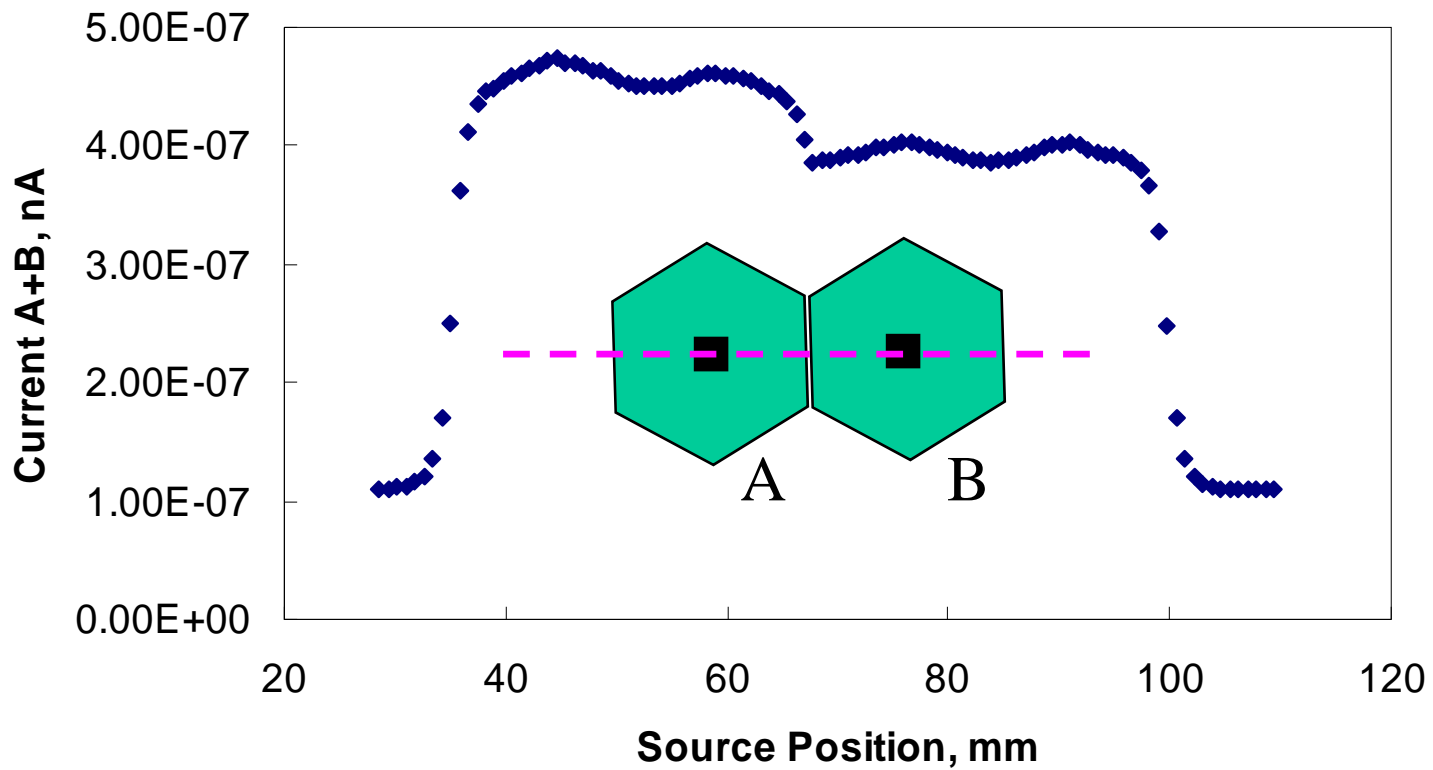
# Cell Response to Sr90 at Two MPPC Vertical Positions



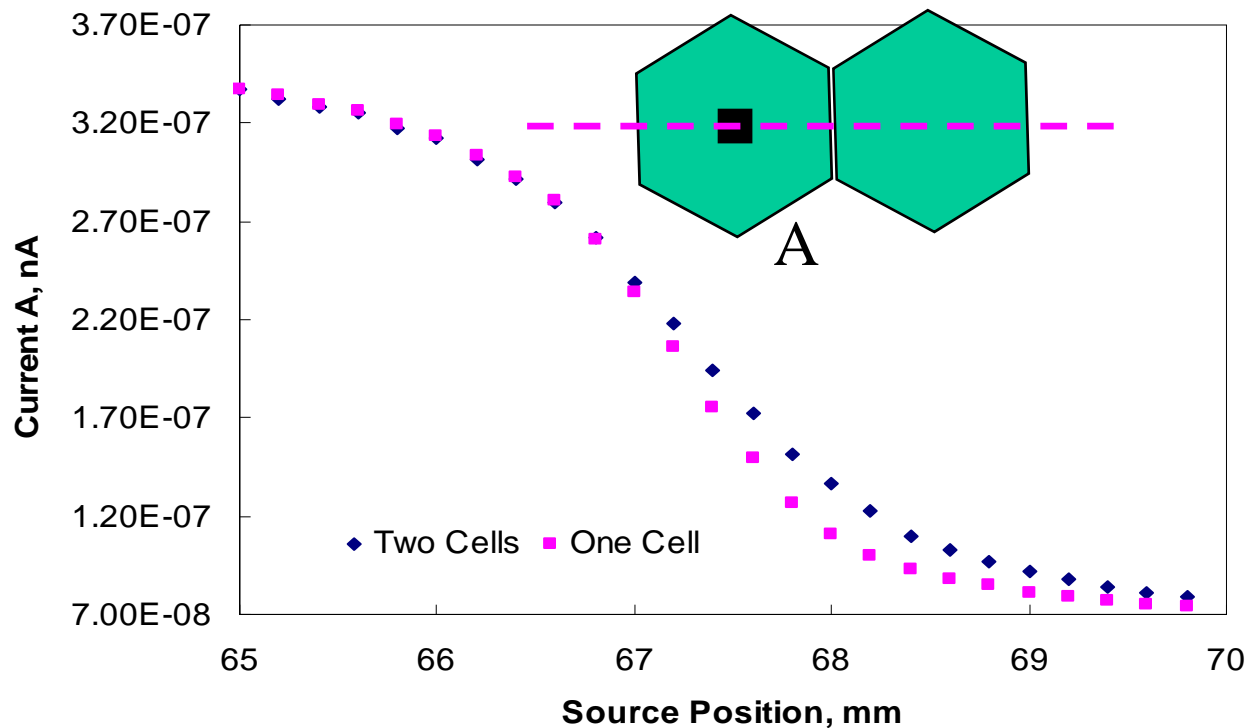
# Cross Talk Estimation

- 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 cm<sup>2</sup>.
- 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.