Direct Coupling Studies

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CALICE Accomplishments

- CALICE collaboration built and beam tested about 10,000 channels AHCAL prototype.
- The CALICE AHCAL prototype utilized scintillator with embedded wave length shifting fiber and SiPM detector as on cell readout. Each SiPM connected to electronics with cable.
- Does such approach 1,000 scalable to ILC detector calorimetry? The design is a calorimetric novelty, but can’t be extrapolated to full detector.

How to Go from Here to There 1

- If we acquire plastic scintillator as an active media, nowadays the primary candidate for the photo sensor is the multi-pixel avalanche photodiode operating in the limited Geiger multiplication mode.The photodiode is insensitive to magnetic fields up to 9.5 T, compact, and has a spectral response range from 270 to 900 nm. The CALICE AHCAL is the first that used such photodiodes in a so large scale.
- Because the scintillator and solid state photomultiplier system isn’t optimized, the direct coupling was radioactive source and cosmic rays tested and results were reported (ITEPh, MEPhI, and DESY).
- The direct coupling studies in current and pulse modes were started at NICADD/NIU in spring 2007 after receiving the Hamamatsu MPPC. The pilot measurement results were reported in May (DESY) and September (Prague) 2007.

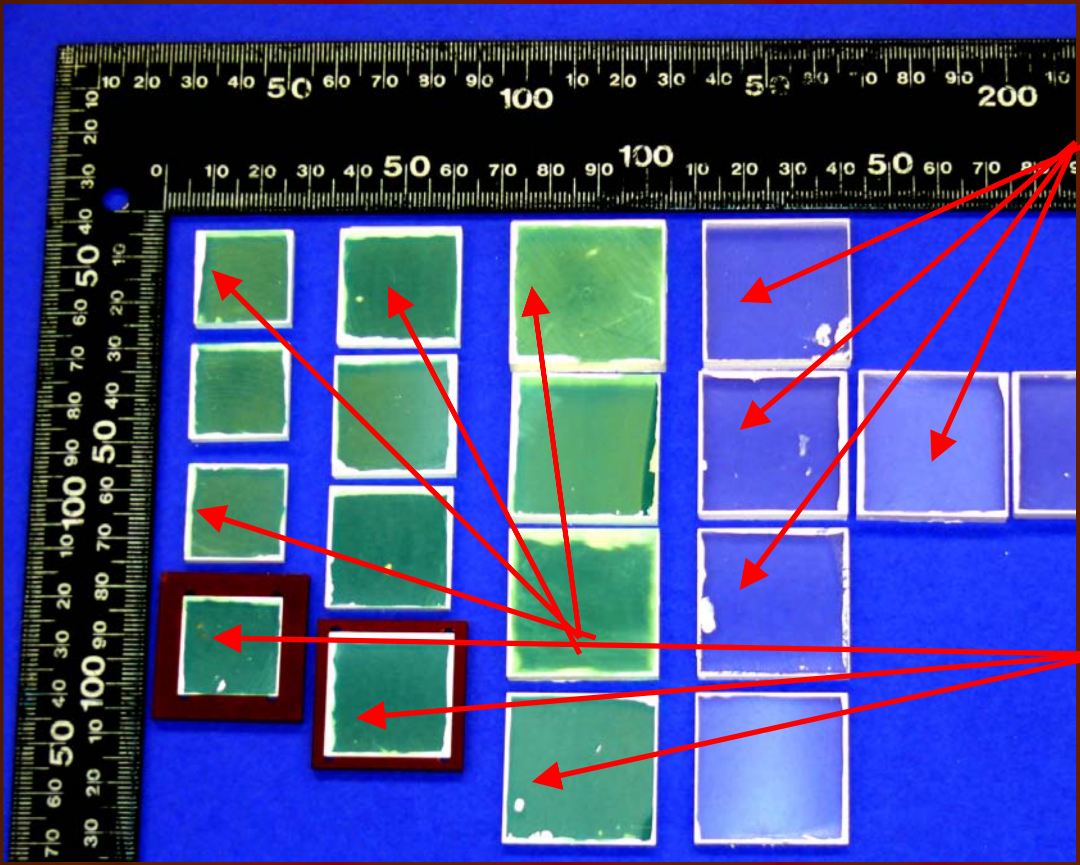
How to Go from Here to There 2

- A layer of active cells that well-match to photo sensors is a module unit for the ILC detector highly segmented calorimeter. The unit can be linear, square, rectangular, or any other mechanically and assembly acceptable shape with hundreds or thousands of cells inside.
- The photo detectors are mounted directly onto the surface of printed circuit boards (PCB). The nowadays photo detector needs to be mechanically redesigned to have small metal tabs that could be directly soldered to the PCB surface solder pads. A numerically controlled pick-and-place machine place them on the PCB with solder paste, for instance. A manual preprototype assembly can be difficult.

How to Go from Here to There 3

- There are a few major questions.
- The first one is a cell light yield that needs to be more than 5 photo electrons.
- The second is a uniform light output response through the cell area.
- The third is a mega cell high speed and cost effective mass production, monitoring, and controls; and finally is the full module design, assembly procedure, final engineering survey, and on board active electronics pass test as well.

Cells Zoography

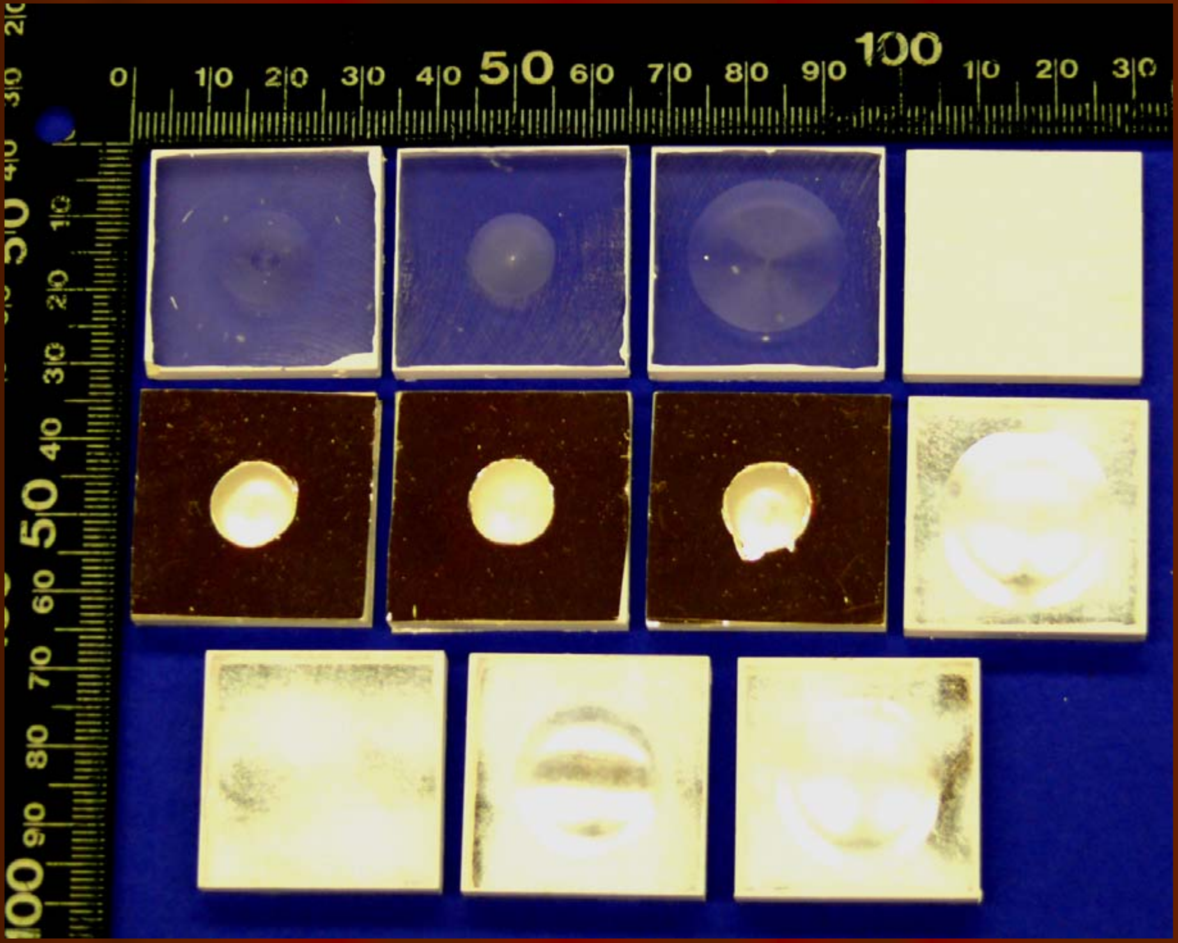


Square 30mm x 30mm EJ-200 6, 5, 4, and 3mm thickness (wavelength of maximum emission is 425nm).

Square 30mm x 30mm; 25mm x 25mm; and 20mm x 20mm with 6, 5, 4, and 3mm thickness EJ-260 (wavelength of maximum emission is 490nm).

Edges are painted in EJ-510 reflective coating.

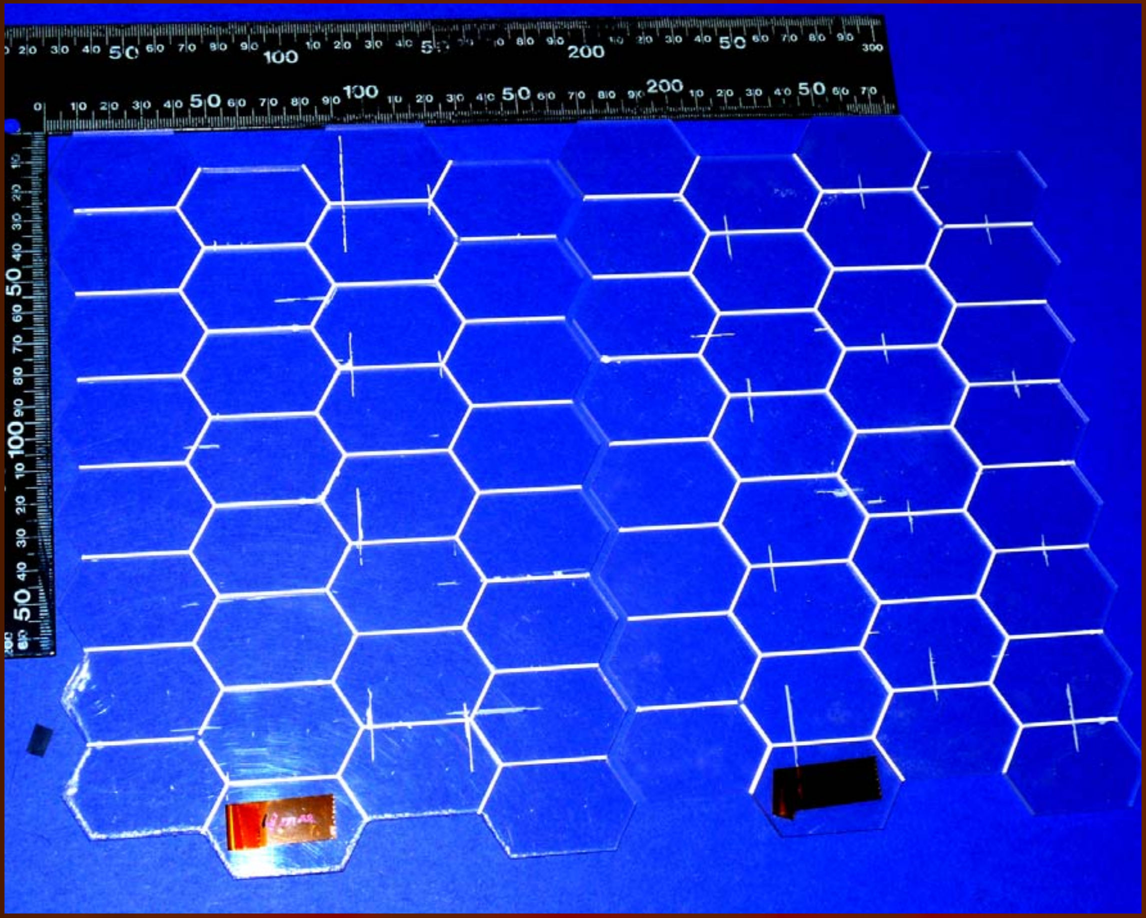
From Modified to Compensated Cells



Square 30mm x 30mm x 5mm EJ-200.

Edges are painted in EJ-510 reflective coating.

From Cells to Mega Cell



64 small hexagonal cells in one mega cell of EJ-200.

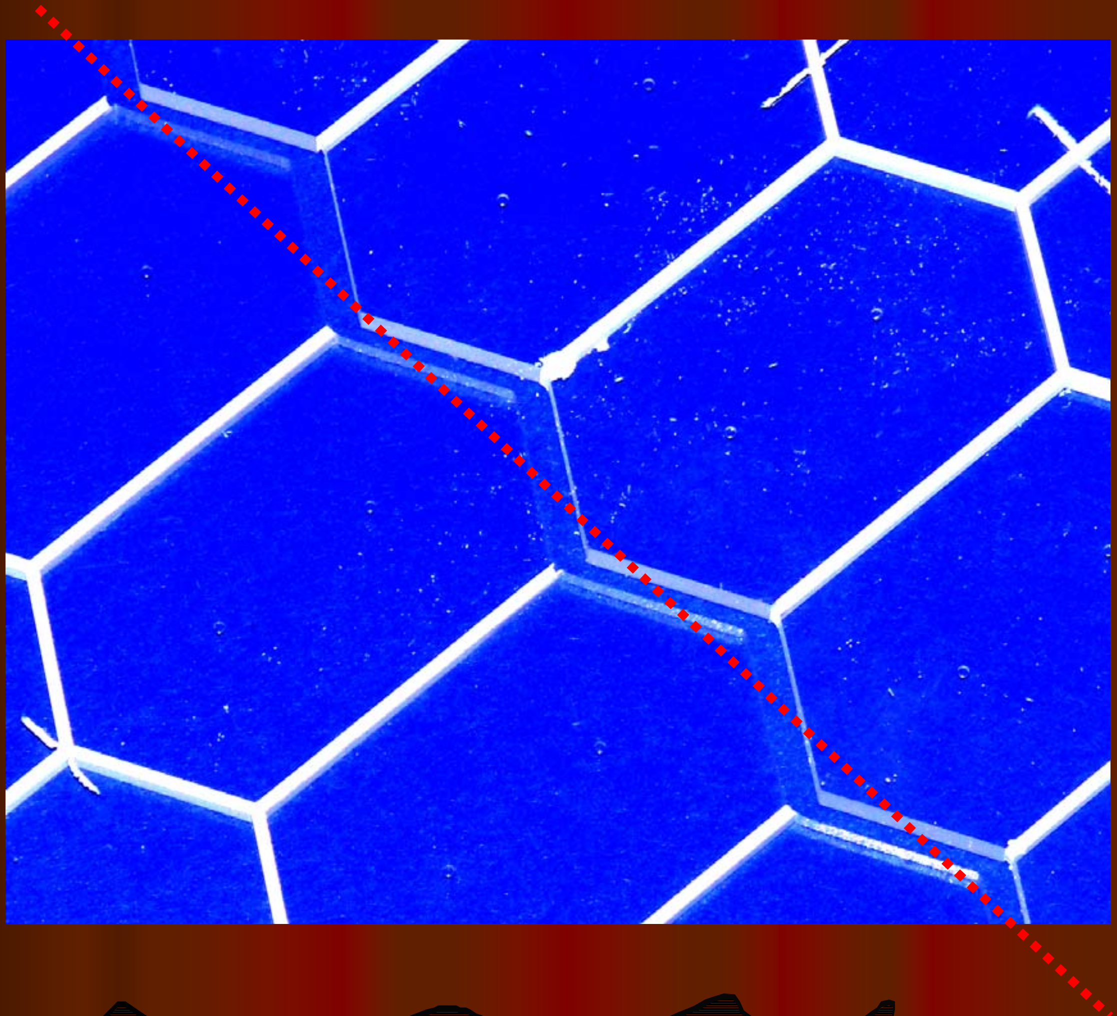
Thickness 3 and 4mm.

Separation between cells 0.9mm.

Two aliment holes per mega cell.

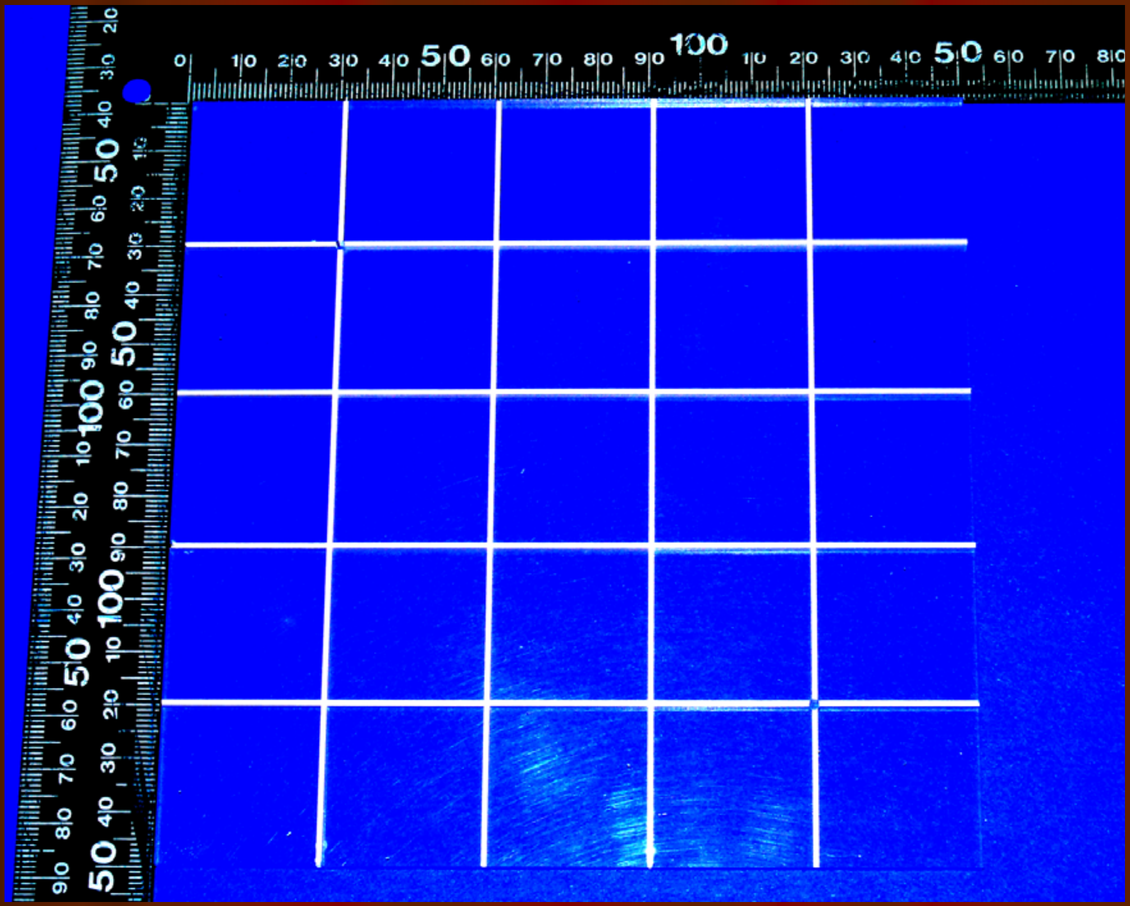
The mega cell fabrication is similar to CALICE TCMT scintillating strip production.

Mega Cells Connection



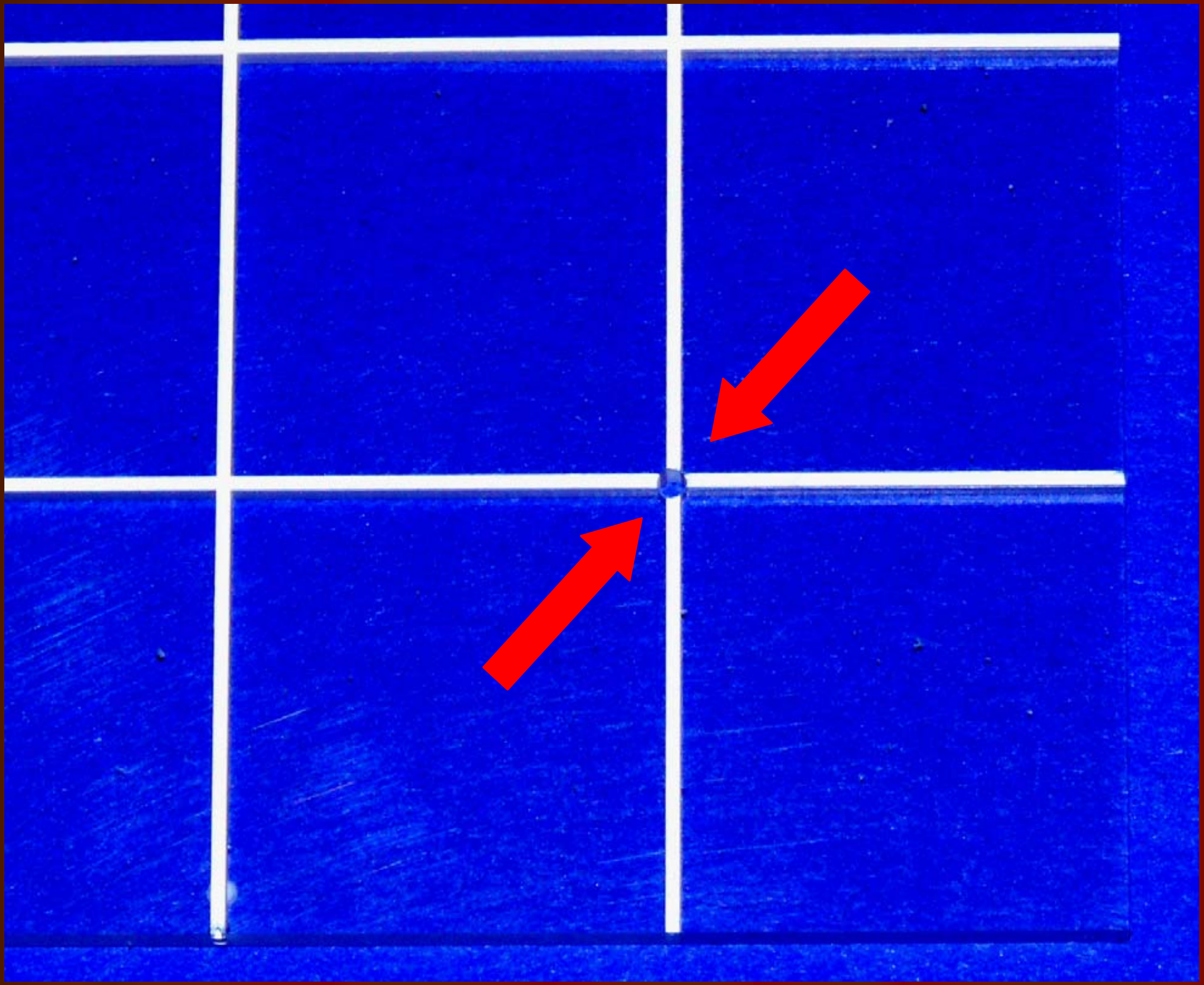
Mega cells have a fine connection along the edges

Square Mega Cell



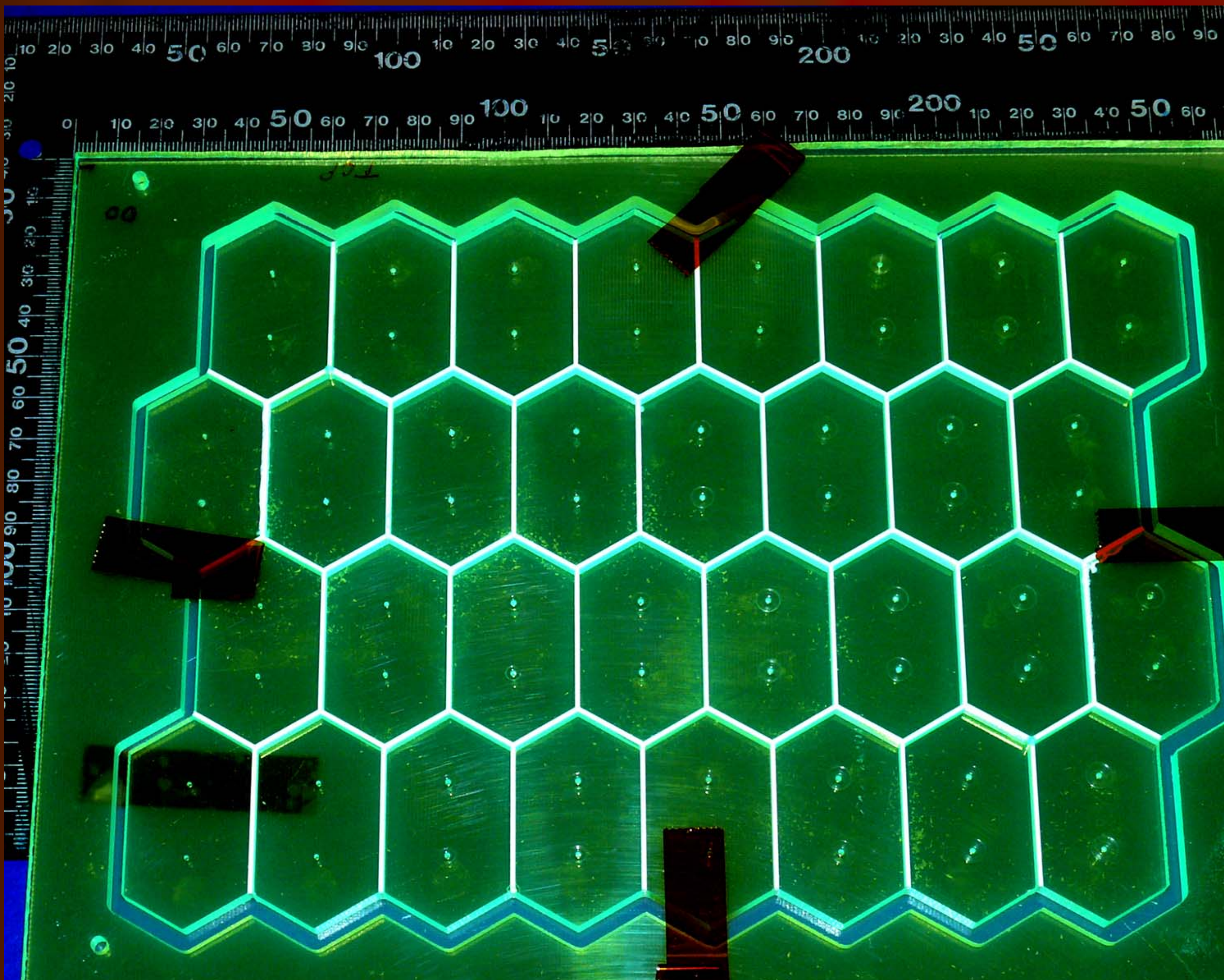
Example of 25 30mm x 30mm square cells of 4mm thickness made of EJ-200 with two aliment holes (next slide)

Mega Cell Aliment Hole



The direct coupling PC board has a few dull pins for exact aliment mega cell holes .

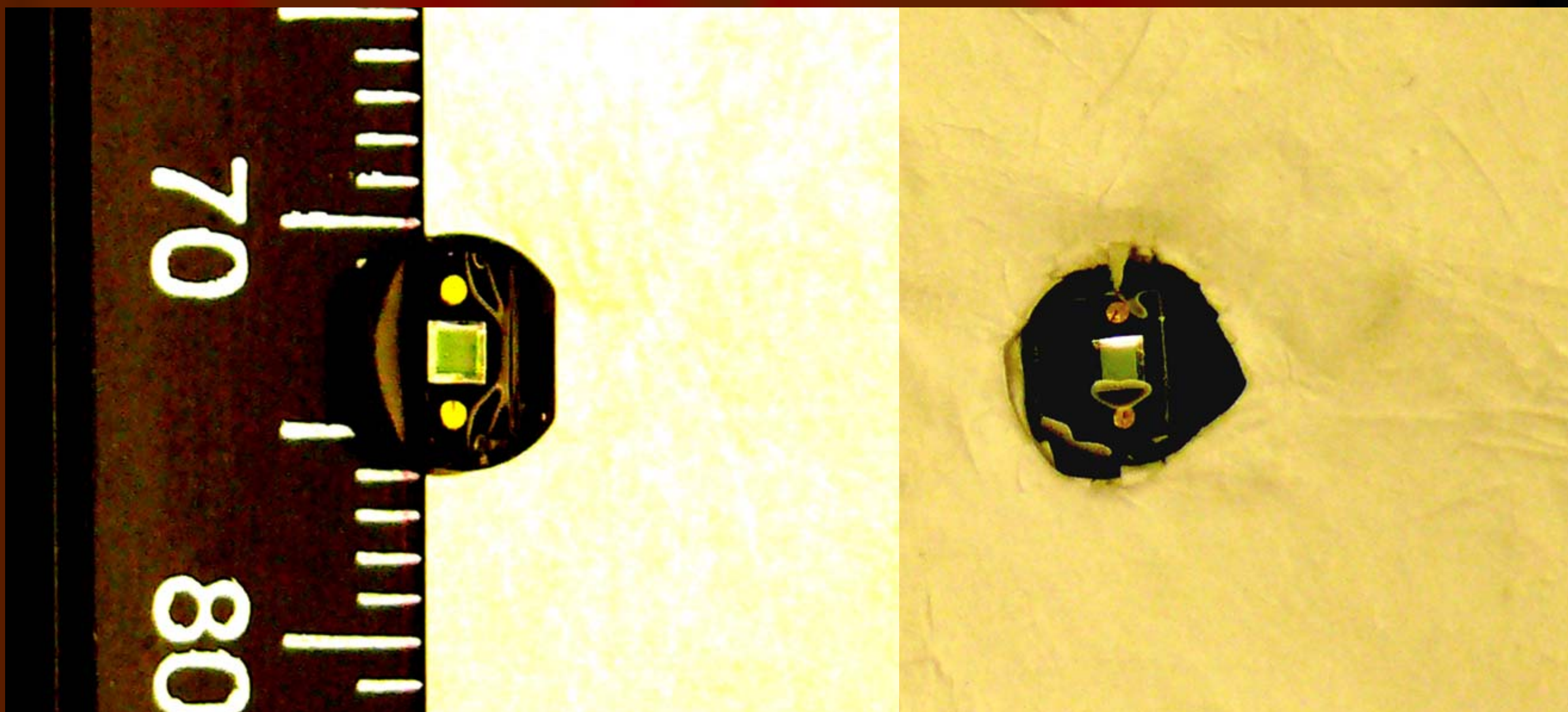
Mega Cell of Hexagonal Cells



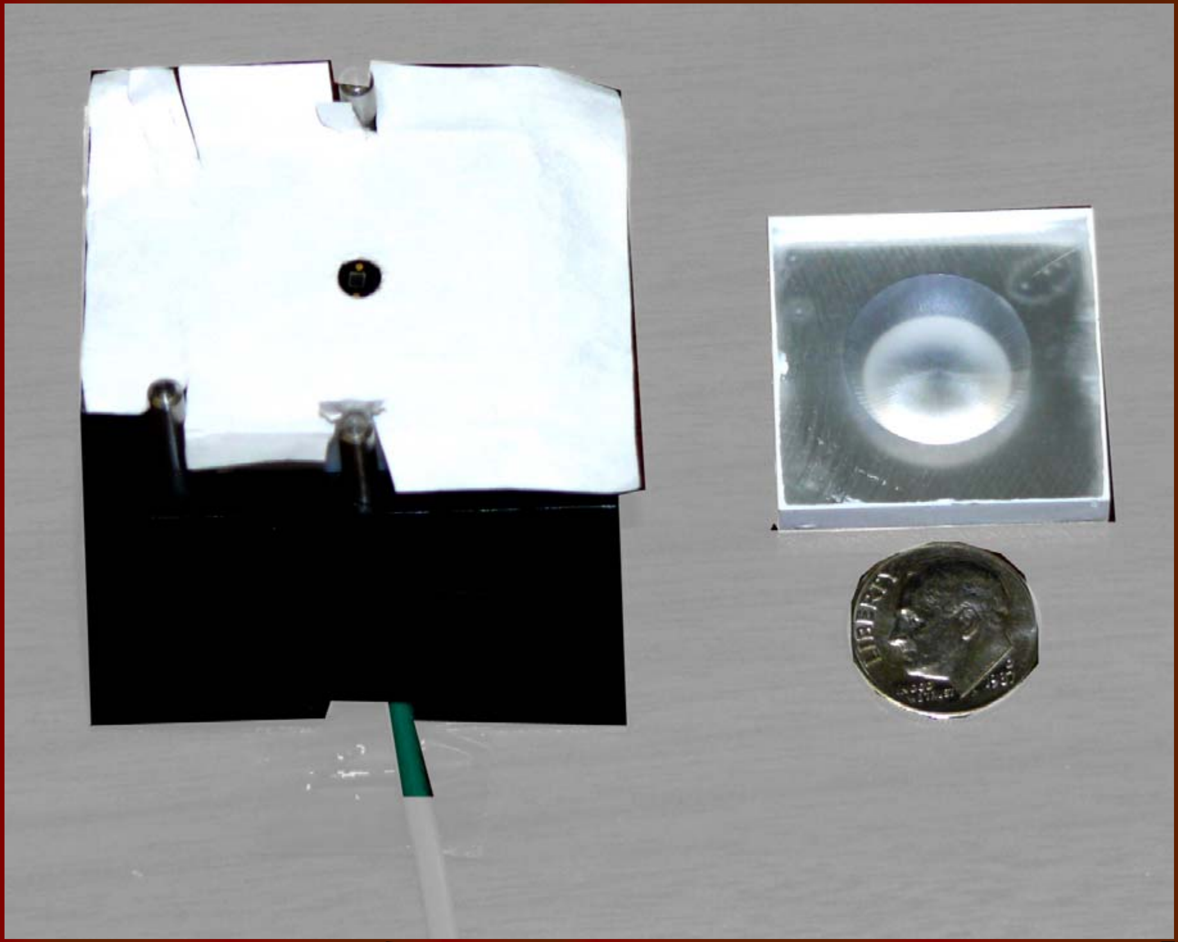
The green emitting plastic scintillator EJ-260 from Eljen Technology with wavelength of max emission at 490 nm

Thickness 1/4´´

HAMAMATSU MPPC S10362-11 Series Were Used



Cell and MPPC Holder for Cosmic Rays Tests

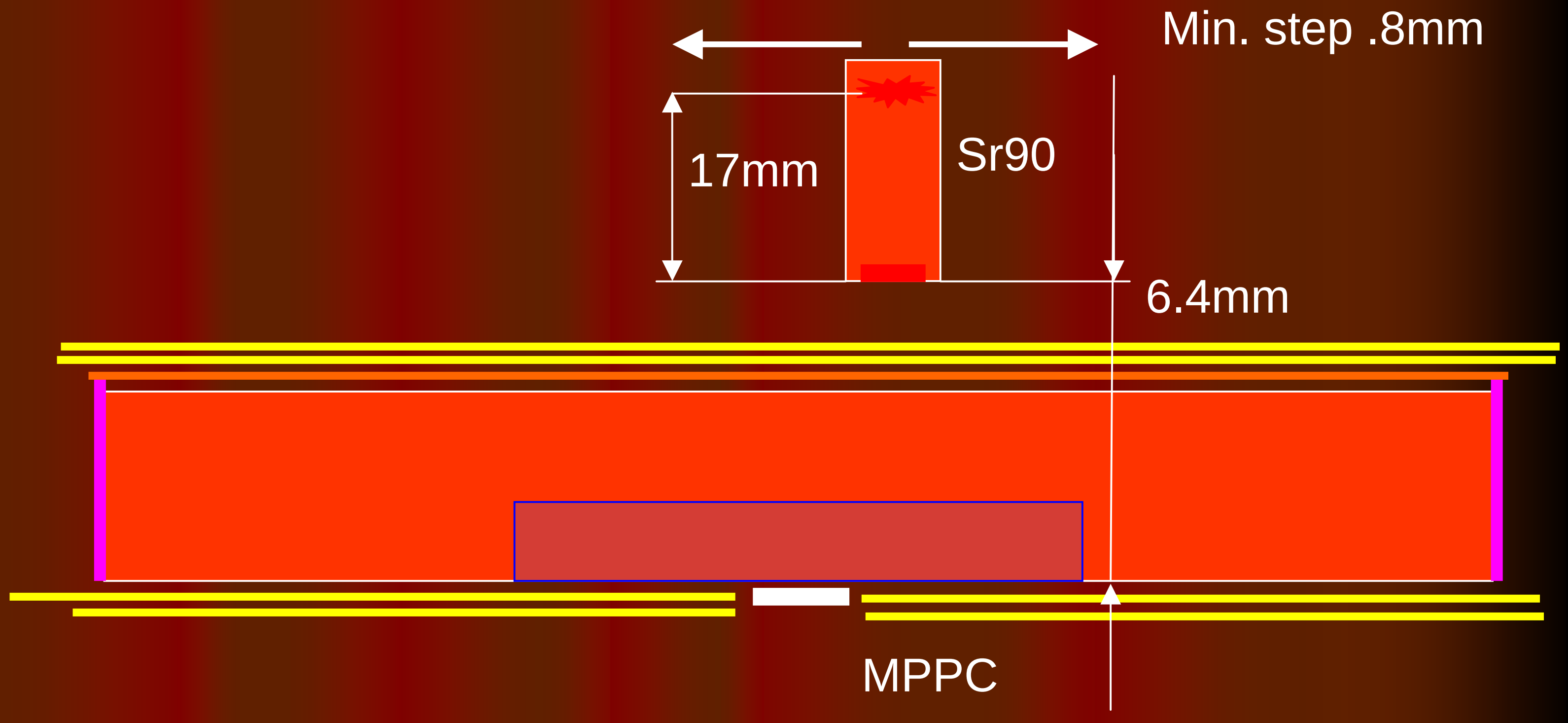


Compensating Cell Light Yield in Cosmic Rays Tests

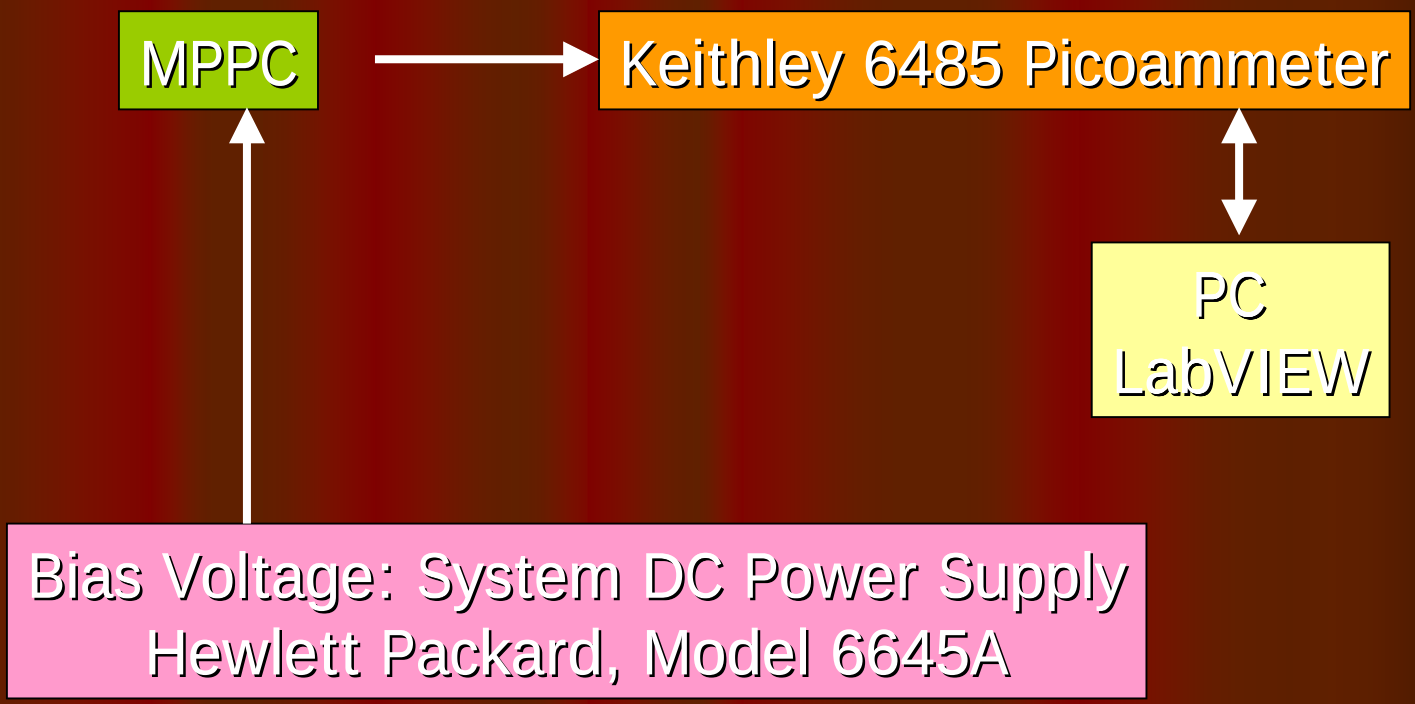
HAMAMATSU MPPC S10362-11	Light Yield, PE	Comments
-100C	~13	Calibrated using SES in physics mode only
-050C	~10	Calibrated using SES in calibration mode
-025C	~7	Estimated value because of low gain

Note: All measurements were performed using CALICE electronics and software

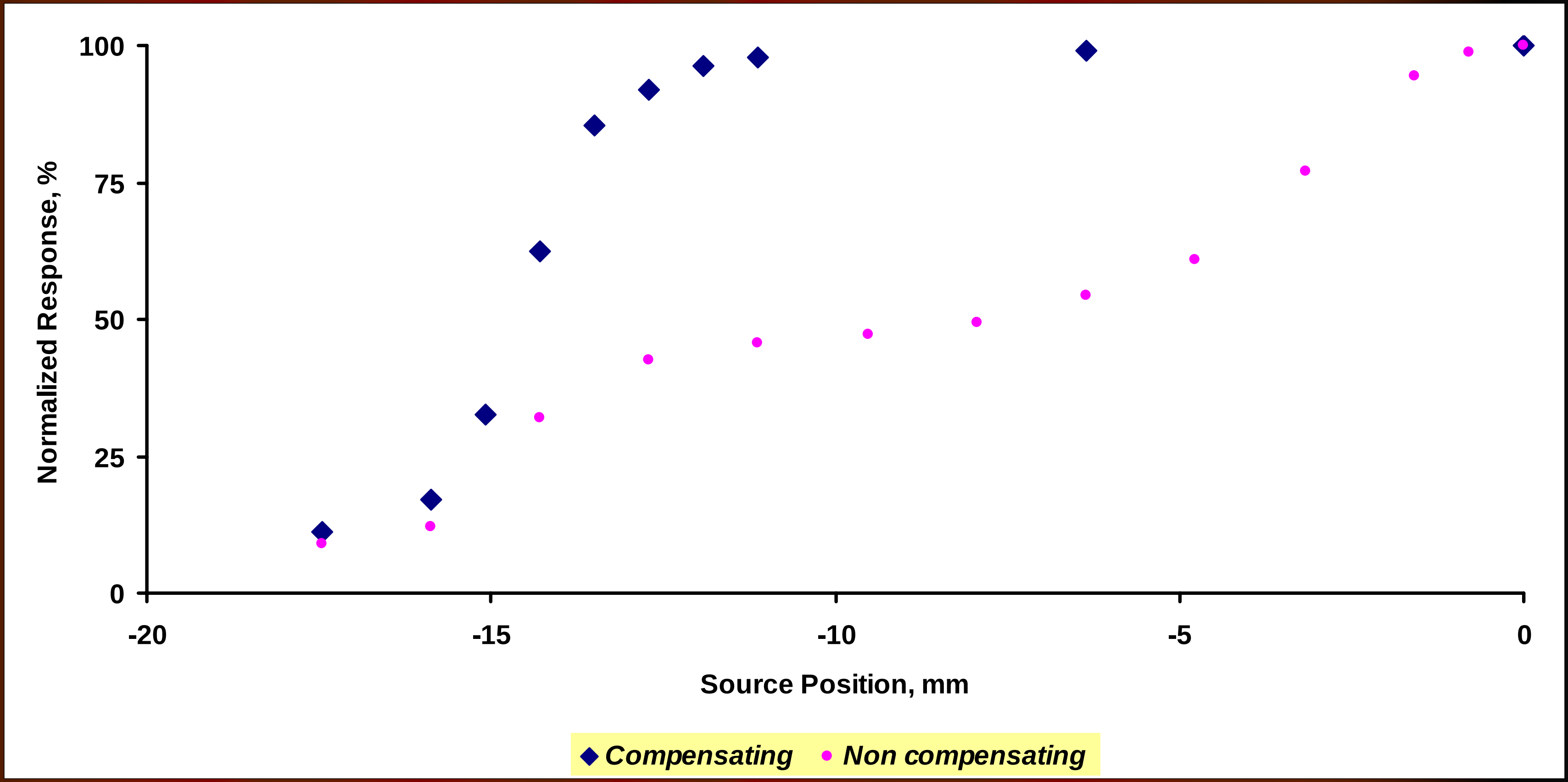
Cell Scan Setup Schematic (not to scale)



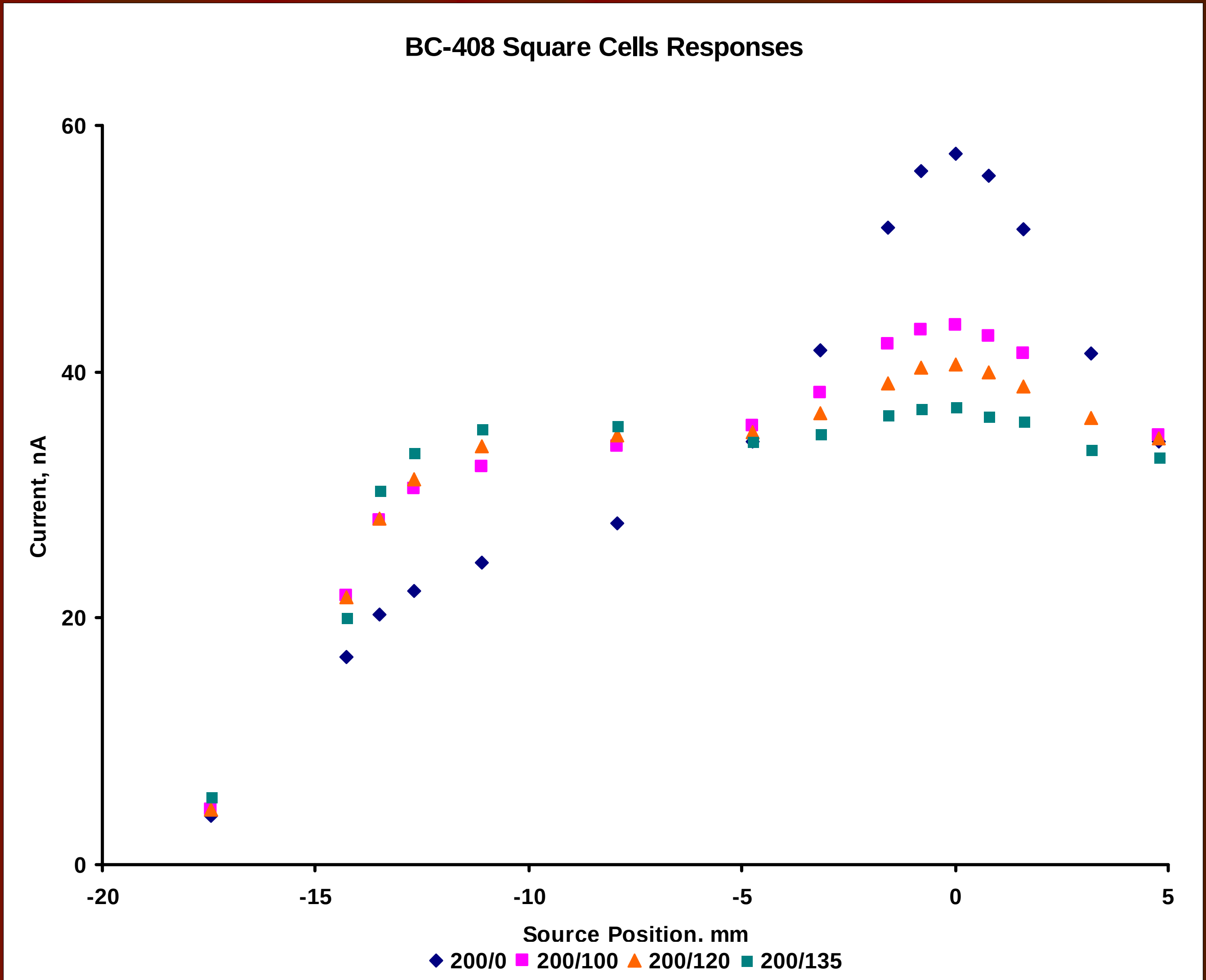
Measurement Setup



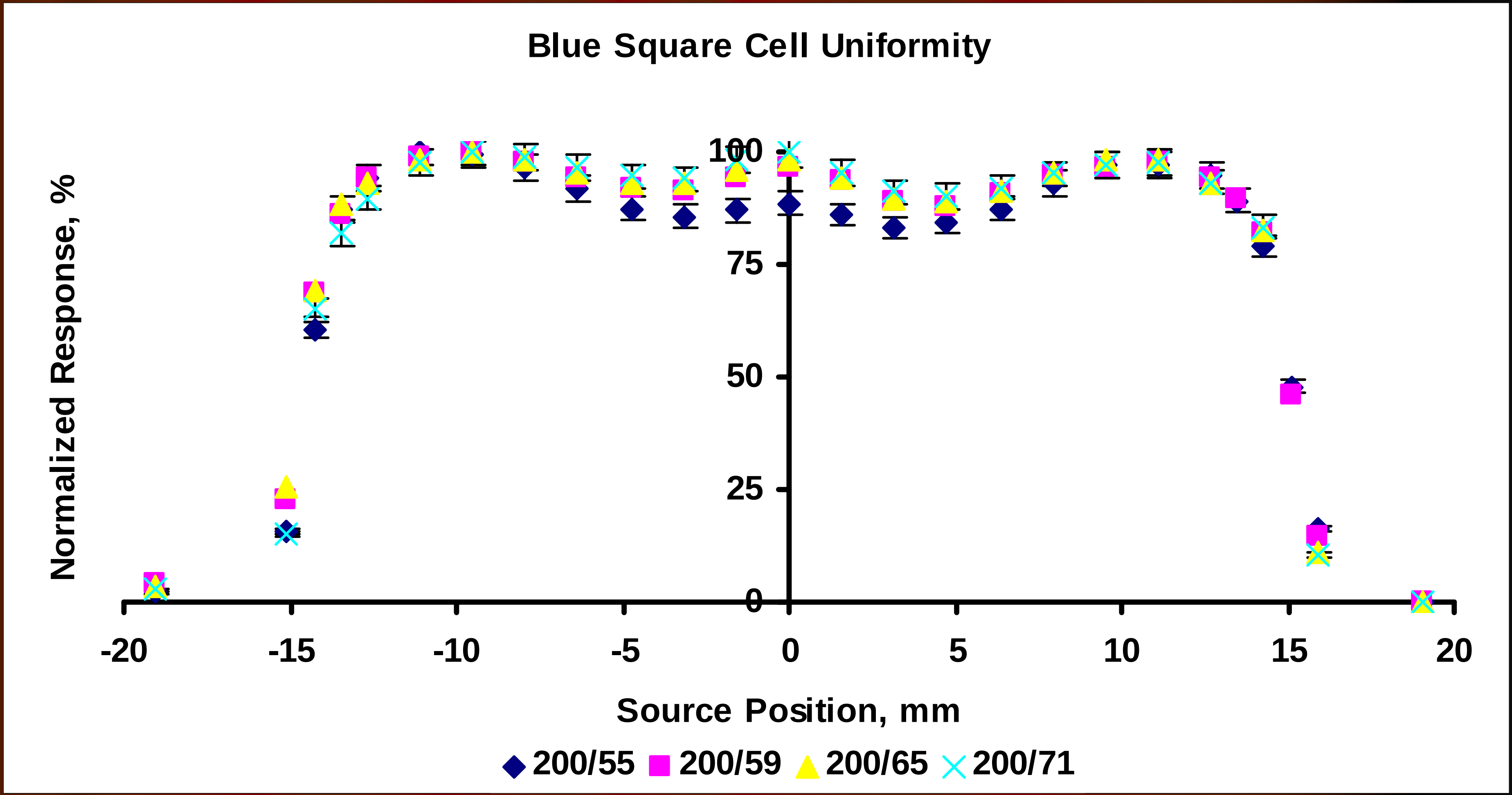
Improvements in Scintillating Cell Uniformity Using Compensating Cell and Direct Coupling



Compensating cells fabricated at NIU were highly uniform.



Compensating cell fabricated at FNAL using tools that match to mega cell production.



Compensating cell fabricated at FNAL Axxiom for mega cell production.

Compensating Cell Lay Out

1. *Individual compensating cell fabrication at NIU.*
2. *Individual compensating cell fabrication using tool acceptable for mega cell production at FNAL.*
3. *Mega cell of compensating cells production at FNAL.*
4. *Individual compensating cell fabrication using injection mold process at Dynasty Mold Inc..*
5. *Mega cell of compensating cells production using injection mold process at Dynasty Mold Inc..*

Summary

- In cosmic rays tests a 5 mm thick, 9 cm^2 area, square compensating scintillating (EJ-200) cell in direct coupling with HAMAMATSU MPPC provides 7-13 PE.
- A square compensating scintillating cell with uniformity response across the area within 10% can be fabricated in a regular machine shop using market available tools .
- Mega cells of 25-64 compensating scintillating cells production are in progress at Fermilab.
- Fully instrumented PCB with integrated photo sensors coupled to scintillating mega cell is a new option that can simplified active layer design and assembly.

Note

- This NICADD at NIU research was performed in part in collaboration with Adam Para (Fermilab).

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