# Optimization Studies of Scintillator Tiles for the future ILD Hadron Calorimeter

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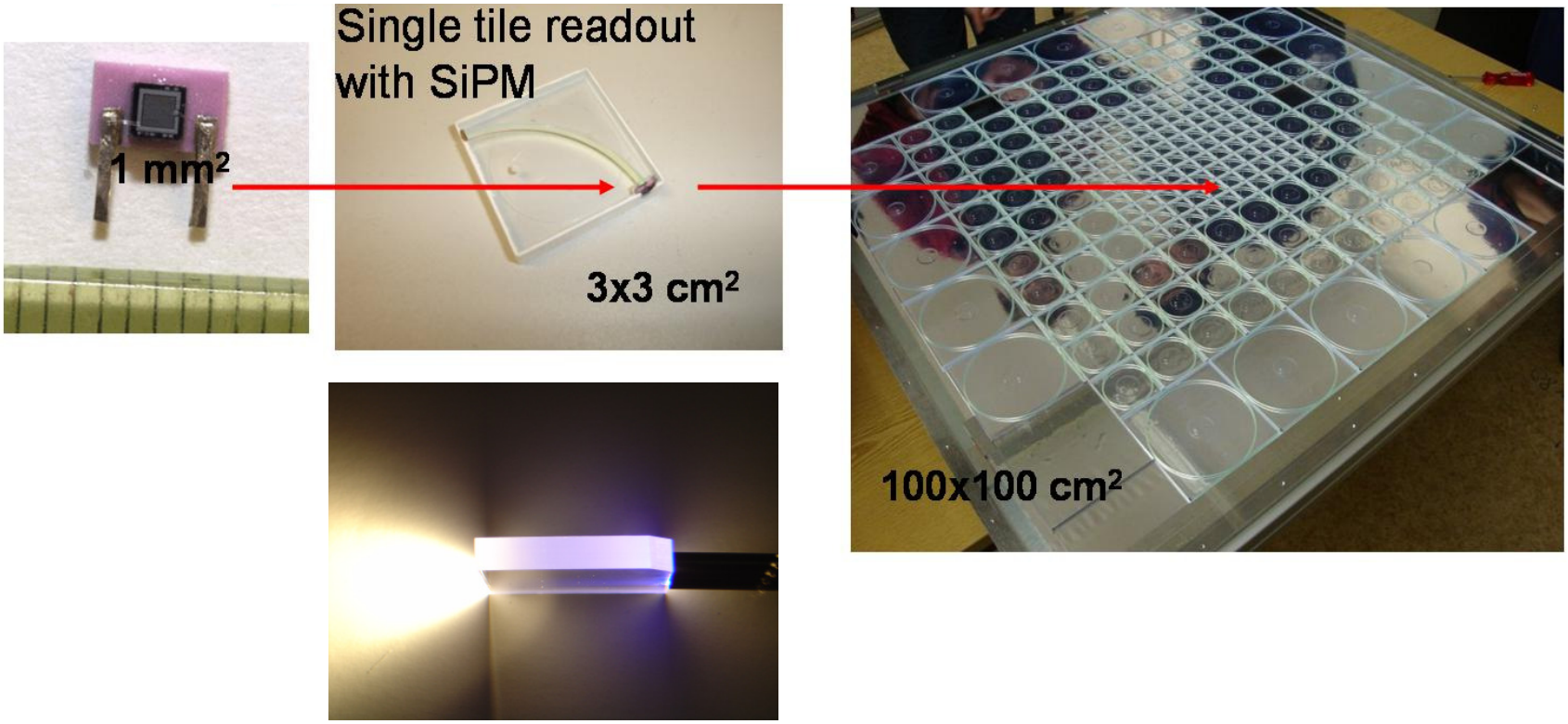
# The Calice Project



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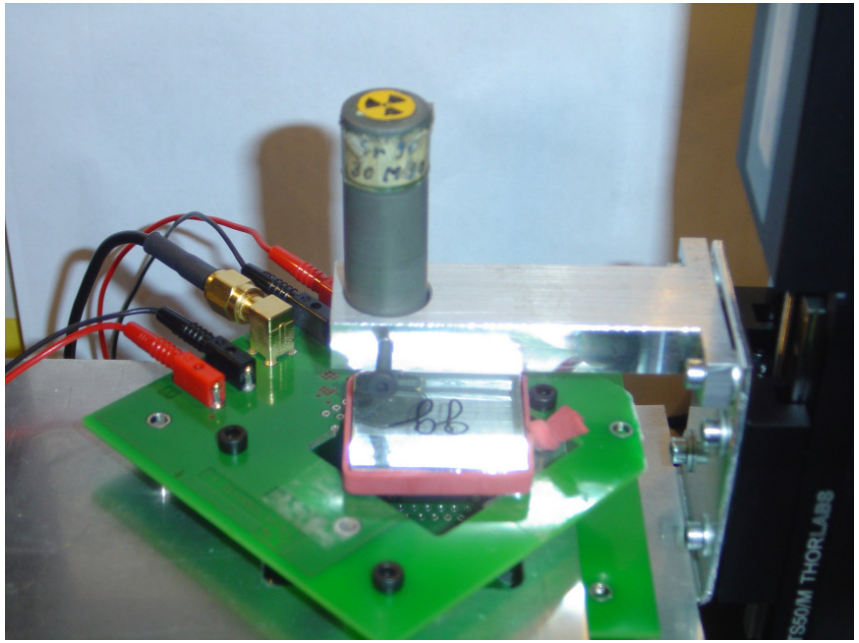
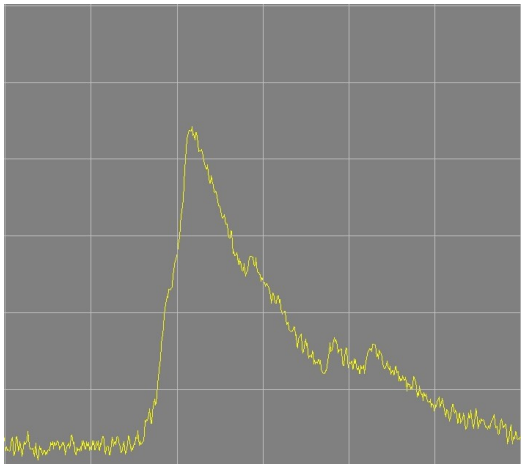
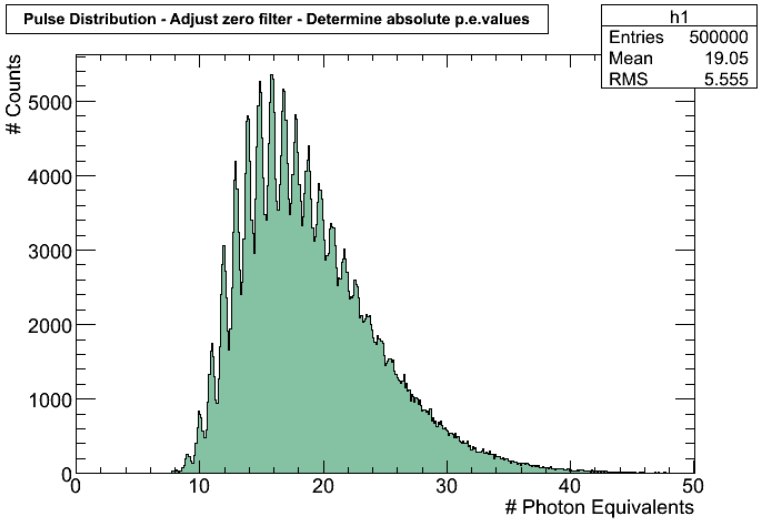
# The Experimental Test Stand



- Sr90 radioactive source
  - Beta decay (2.27MeV)
  - Decay Rate: $1.45 \cdot 10^7 \, Bq$
  - Effective Rate: $3.6 \cdot 10^3 \, \mathrm{sec}^{-1}$
  - Movable in xy-direction
- Mounted on Preamplifier Board (25dB):
  - SiPM P-Type
  - Scintillator Tile: BC-420

# The Experimental Setup

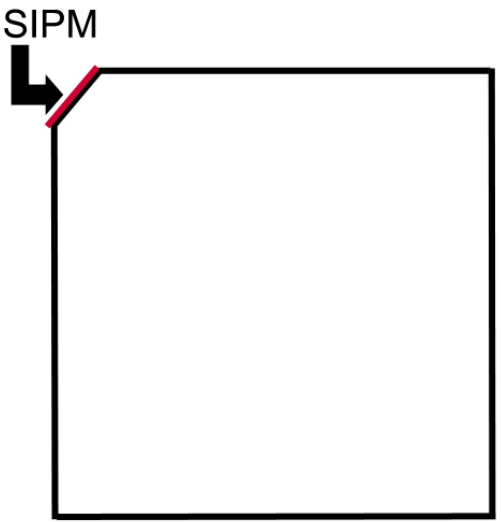


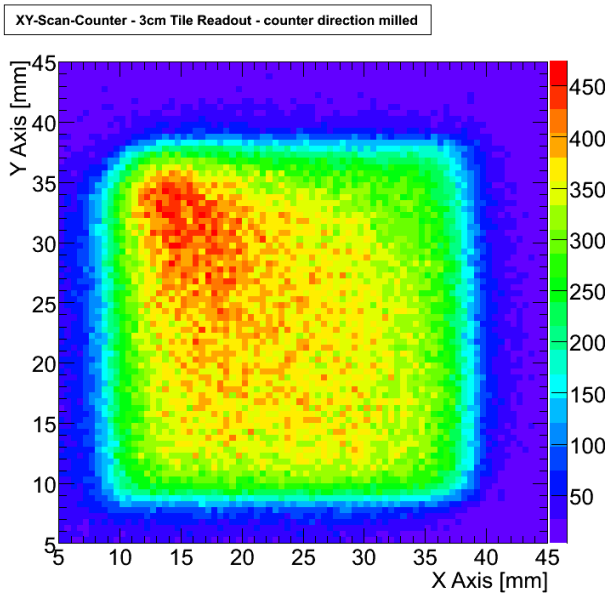


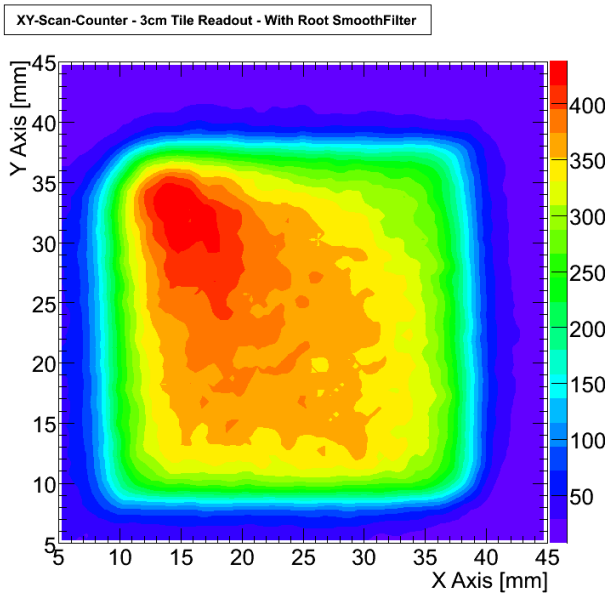

- SiPM readout with 4GHz Oscilloscope
- Waveform Integral equals the Number of fired SiPM pixels
  - Quantized
- Energy deposition of penetrating electrons is Landau distributed

# First Results–The Counter XY Scan

- SiPM readout with 225MHz Counter
- Count the number of signals above the 7pe threshold within the gate time of 5sec
- Plot the number of counted signals vs. XY-Pos.

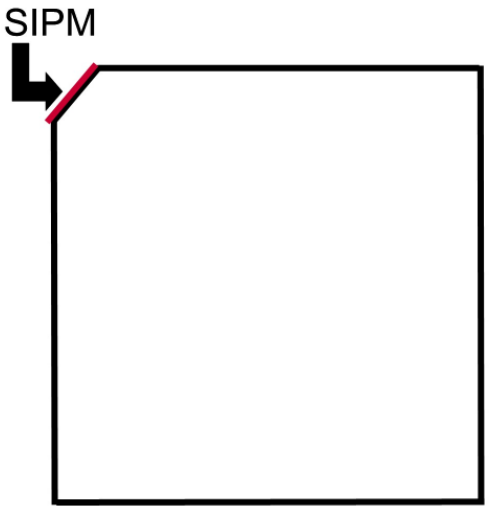


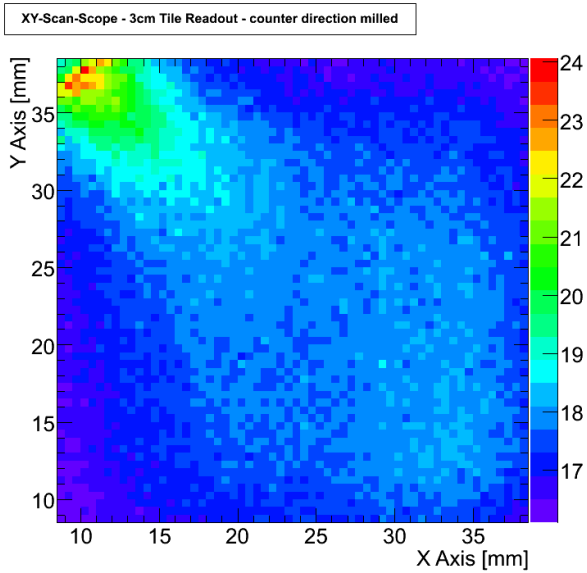



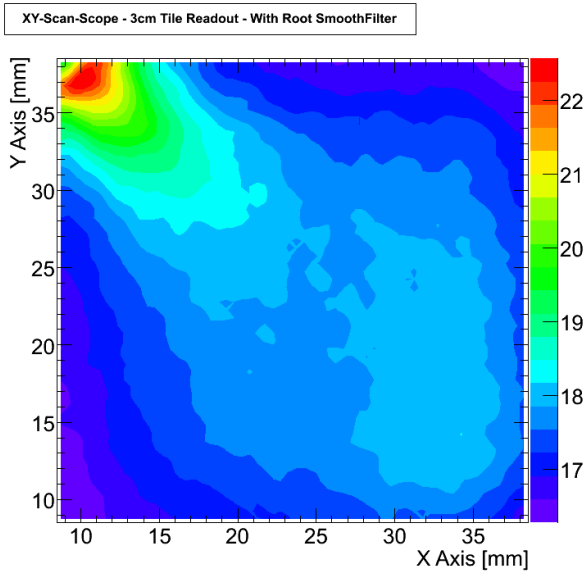



# First Results – The Scope XY Scan

- SiPM coupled to the corner of a 3x3cm Tile
- Record 1000 Waveforms at each XY-Position
  - Resolution: 5x5mm -> 60x60 positions on the Tile
- Plot the mean measured energy deposition vs. XY-Pos.



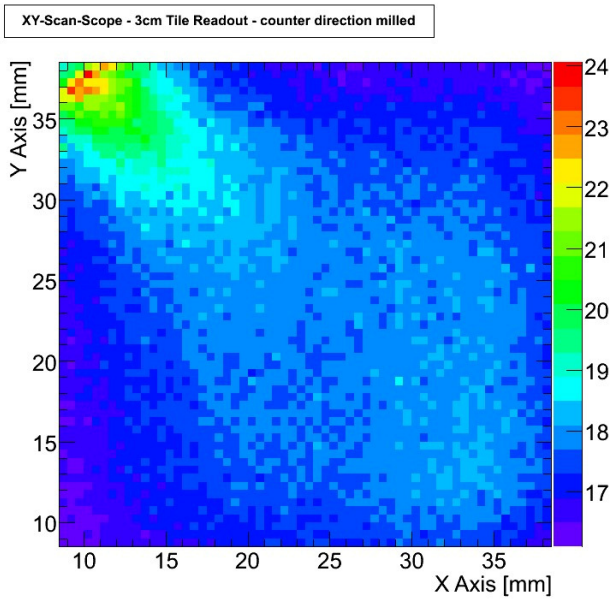



# The need for a uniform PDE

- Mean Energy Deposition of penetrating electrons is independent of the XY-Pos.

- Measured Mean Energy Deposition is not:
  - Reflectivity of Mirror Foil < 100%
  - Photon Absorption of the Scintillator material
    - Decay time: 1.5ns

# The need for a uniform PDE




Assume:

- *Ideal:* Mean Number of detected Photons per Tile and penetrating particle for perfectly uniform Tiles: 20pe
- *Experiment:* Max. Deviation from that value (depending on the XY-Position):

$$error = \pm 4\,pe = 20\%$$

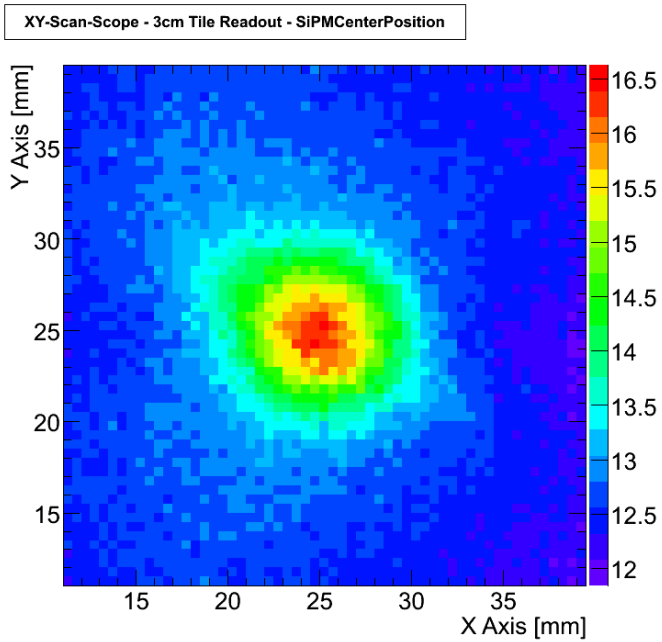
XY-Dependence of the measured mean Energy deposition is expected to degrade the Energy resolution of the HCAL

- A Simulation is planned to quantify this effect

# Optimization Plans

- Finding the optimal
  - SiPM coupling position
  - Tile Shape
  - Modified reflective Foil


- For the application in a future HCAL a compromise between realizability and perfect uniformity has to be made



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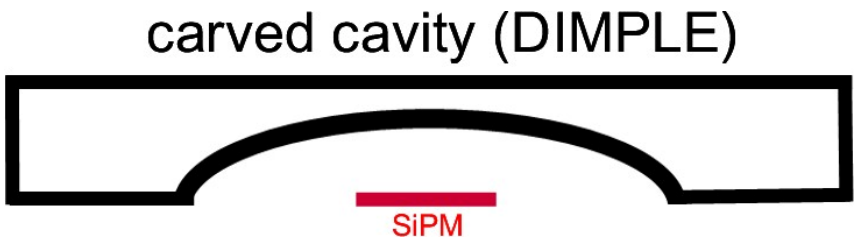


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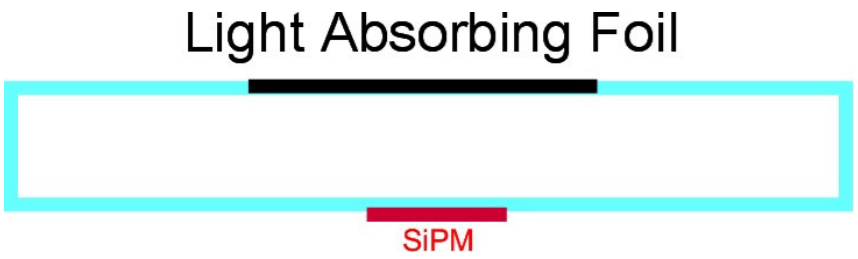
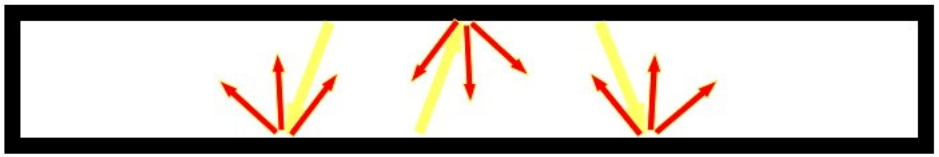
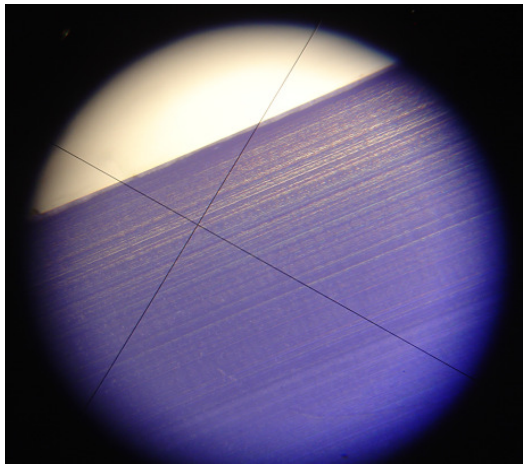


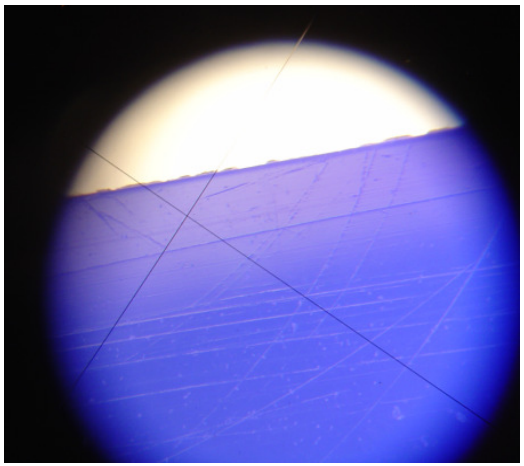
# Optimization Plans

- Maximize the Tile Response by:
  - Finding the optimal surface structure

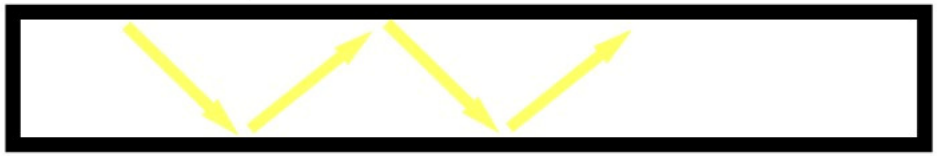
milled surface





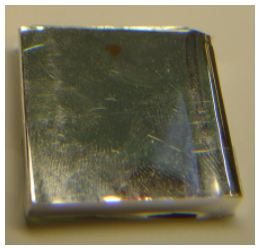


polished surface



# Optimization Plans

- Maximize the Tile Response by:
  - Finding the optimal reflective material:



  - Currently used: Reflective Foil
    - Problems: -Light absorbing Airgaps hard to avoid
      -Difficult to handle in Mass production
  - Planned: Reflective Lacquer
    - Advantage: -uniform reflectivity
    - Problems: -reliable technique for spreading the lacquer over the Tile necessary (avoid formation of drops)

# The need for coincidence

- Current cut at 7pe due to Dark Rate of the SiPM

  -> Landau Distribution is cut

  -> Values for the measured Mean energy depositon preliminary
- Solution: Coincidence
  - Select physical signals from darkrate by simultaneously firing two tiles