Calibrating with Hadrons

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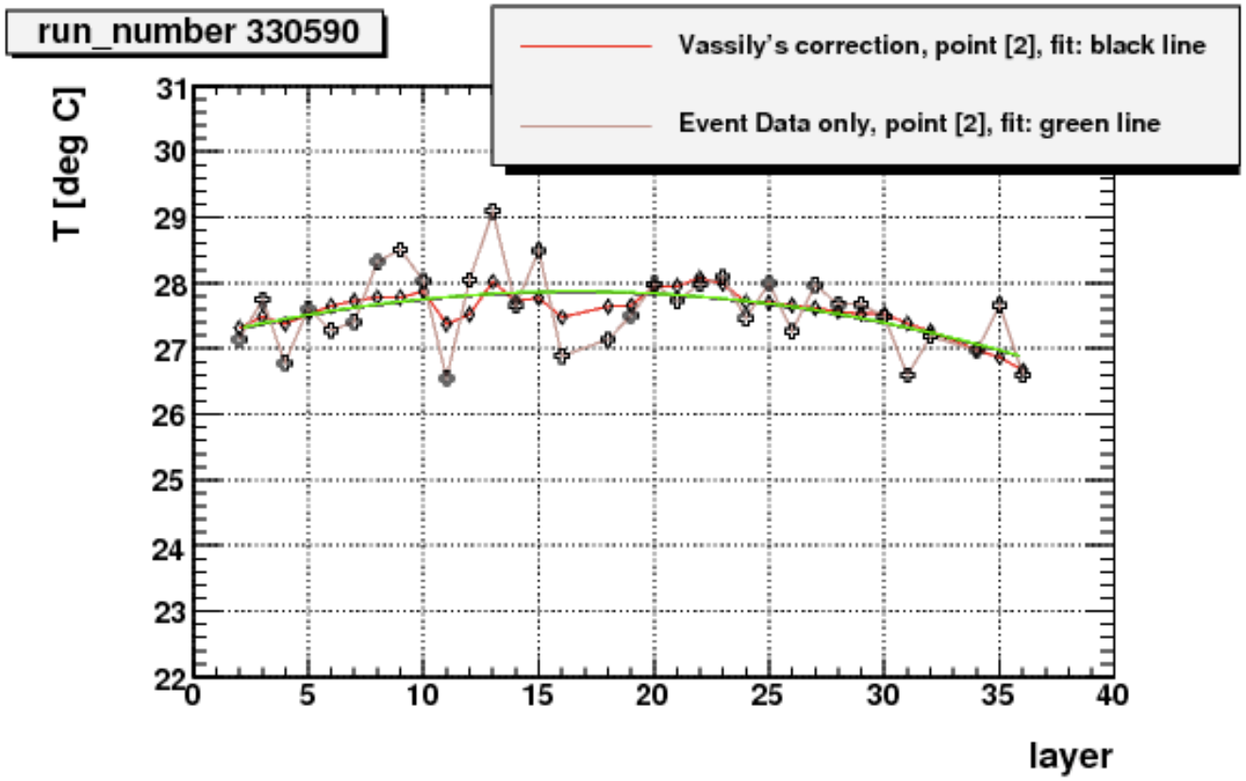
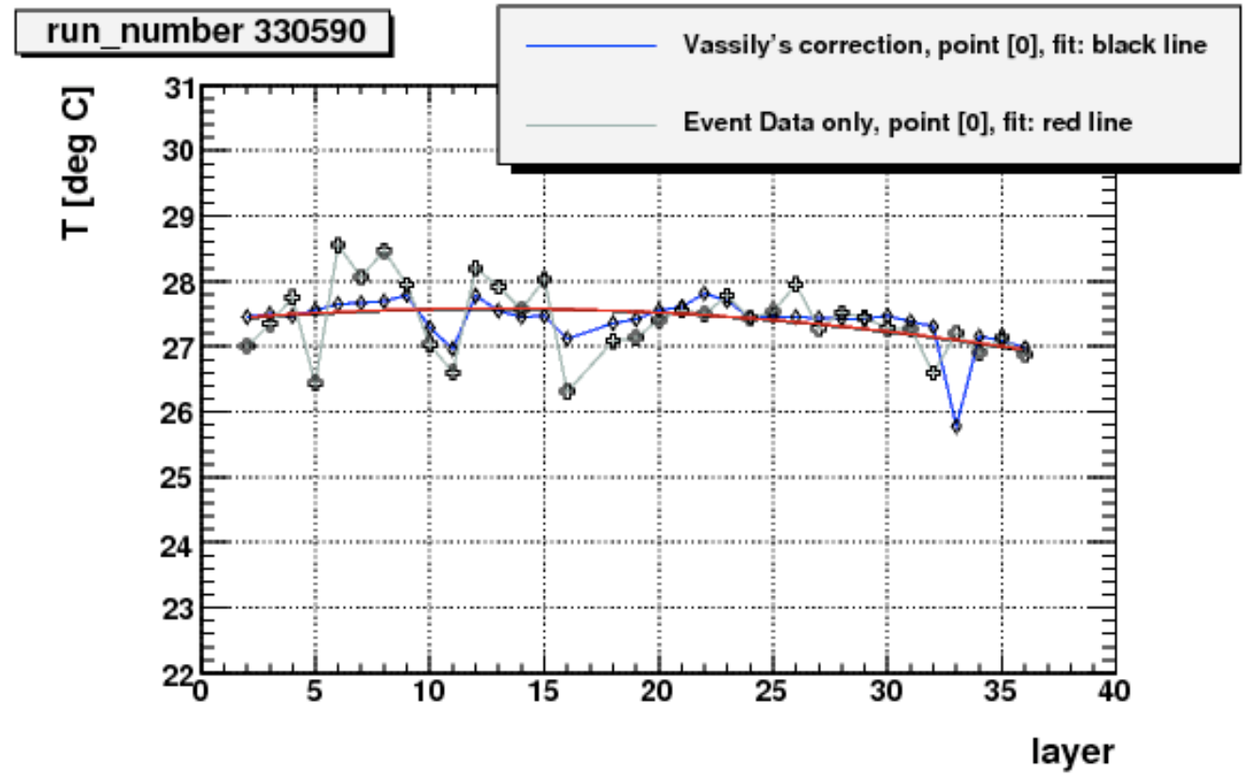
- CALICE Collaboration Meeting, ANL, March 2008 -

Outline:

- Temperature Sensors during CERN Test-Beam
- Temperature Effects on the SiPM Gain
- Possibilities to calibrate an HCAL with Hadrons
- Studying SiPMs at Munich

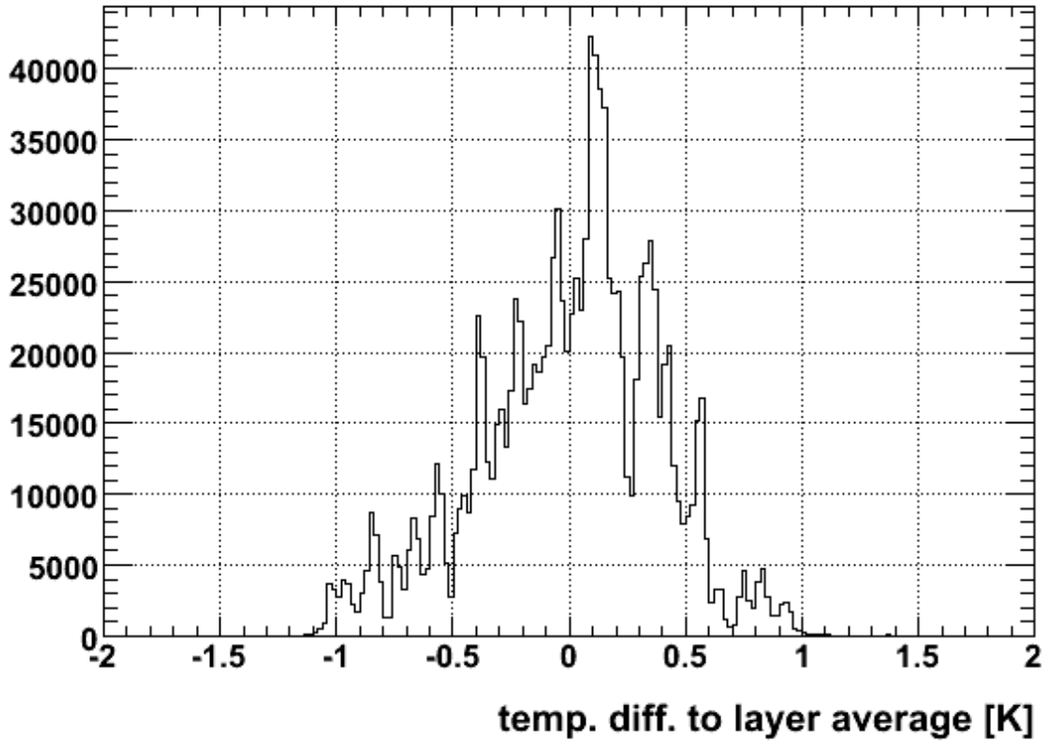
Temperature Measurements

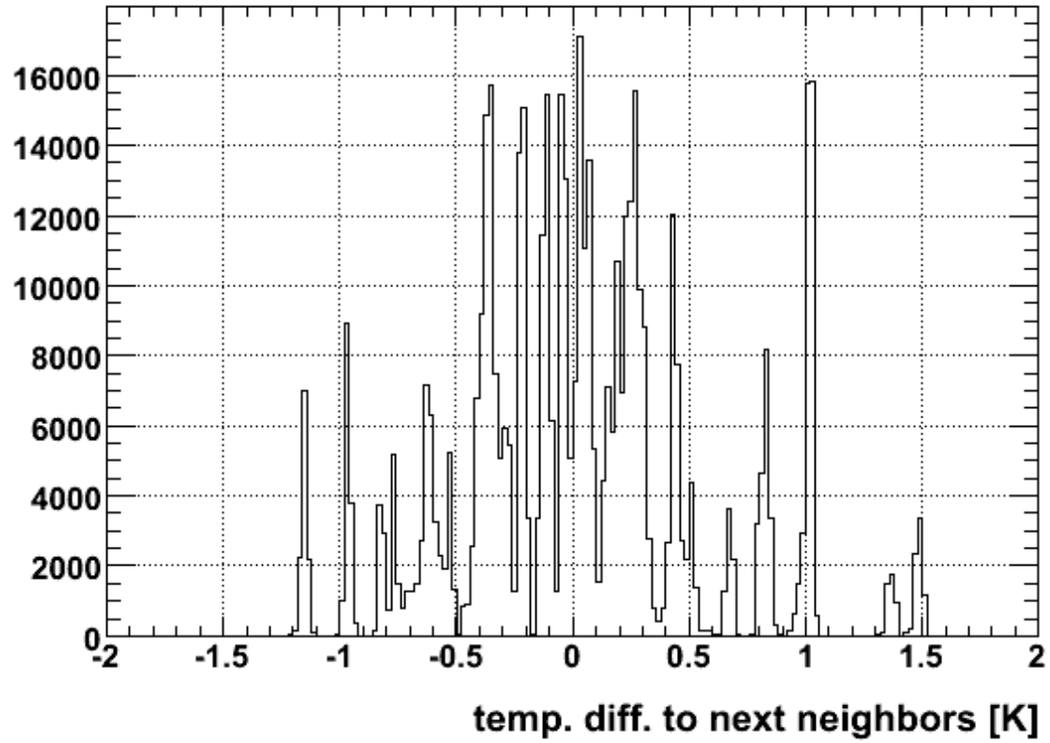




- Temperature monitoring: 5 probes per layer
  - significant variation seen from layer to layer => Not physical
- Correct by assuming temperature distribution in HCAL follows pol2
  - can be used to determine "pedestals" for each channel (V. Morgunov)
  - then fit resulting distribution (with or w/o "pedestal" subtraction), use fit values
  - no big difference whether "pedestal" subtraction used or not

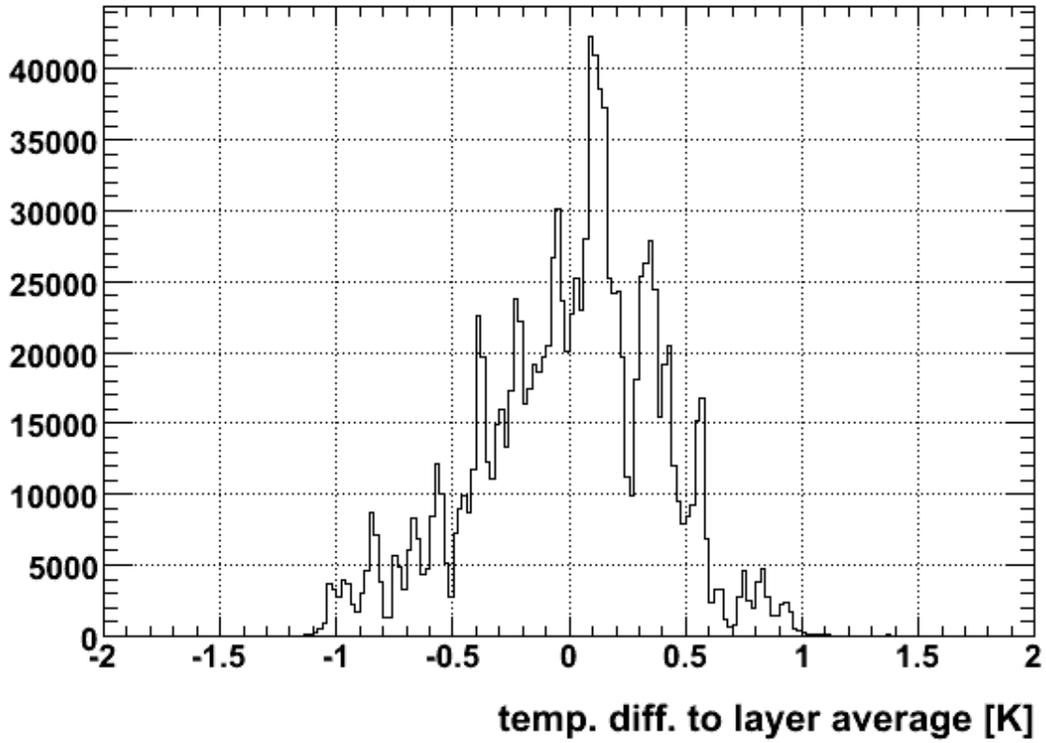
Understanding Temperatures

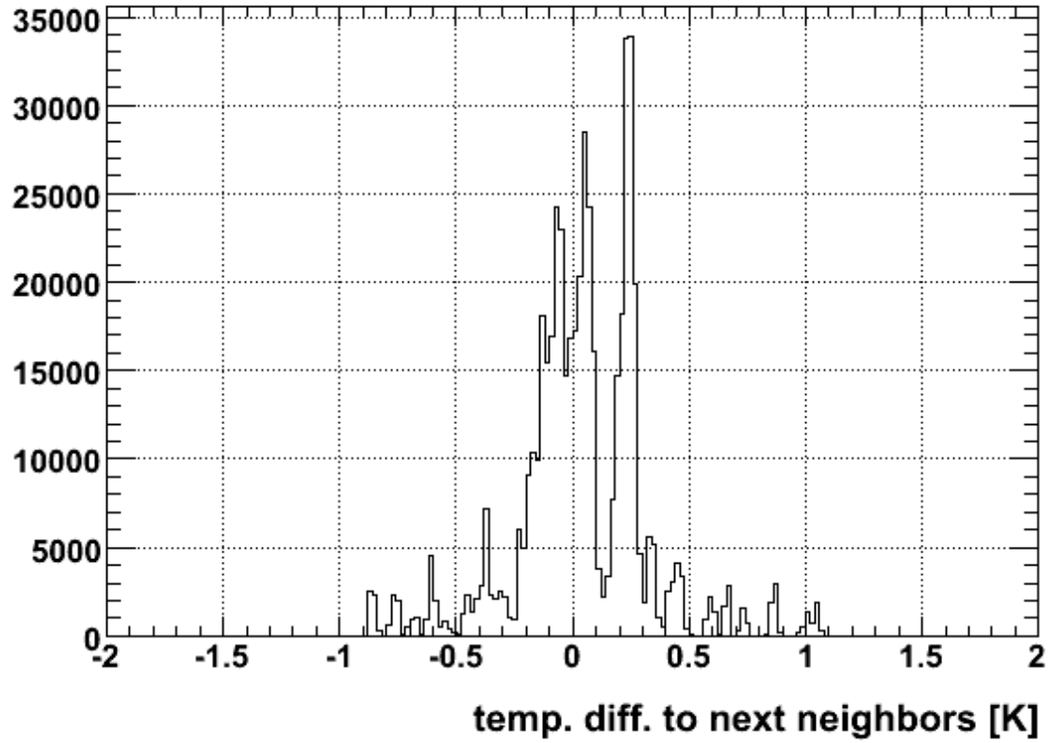




- Test to confirm that the fluctuations seen in the temperature data are not real temperature differences: Compare a temperature sensor with the average of its two next neighbors within a layer, and with the average of all sensors in the layer
- width of distribution should be smaller for the first case if variations are physical, but this is not observed

Understanding Temperatures





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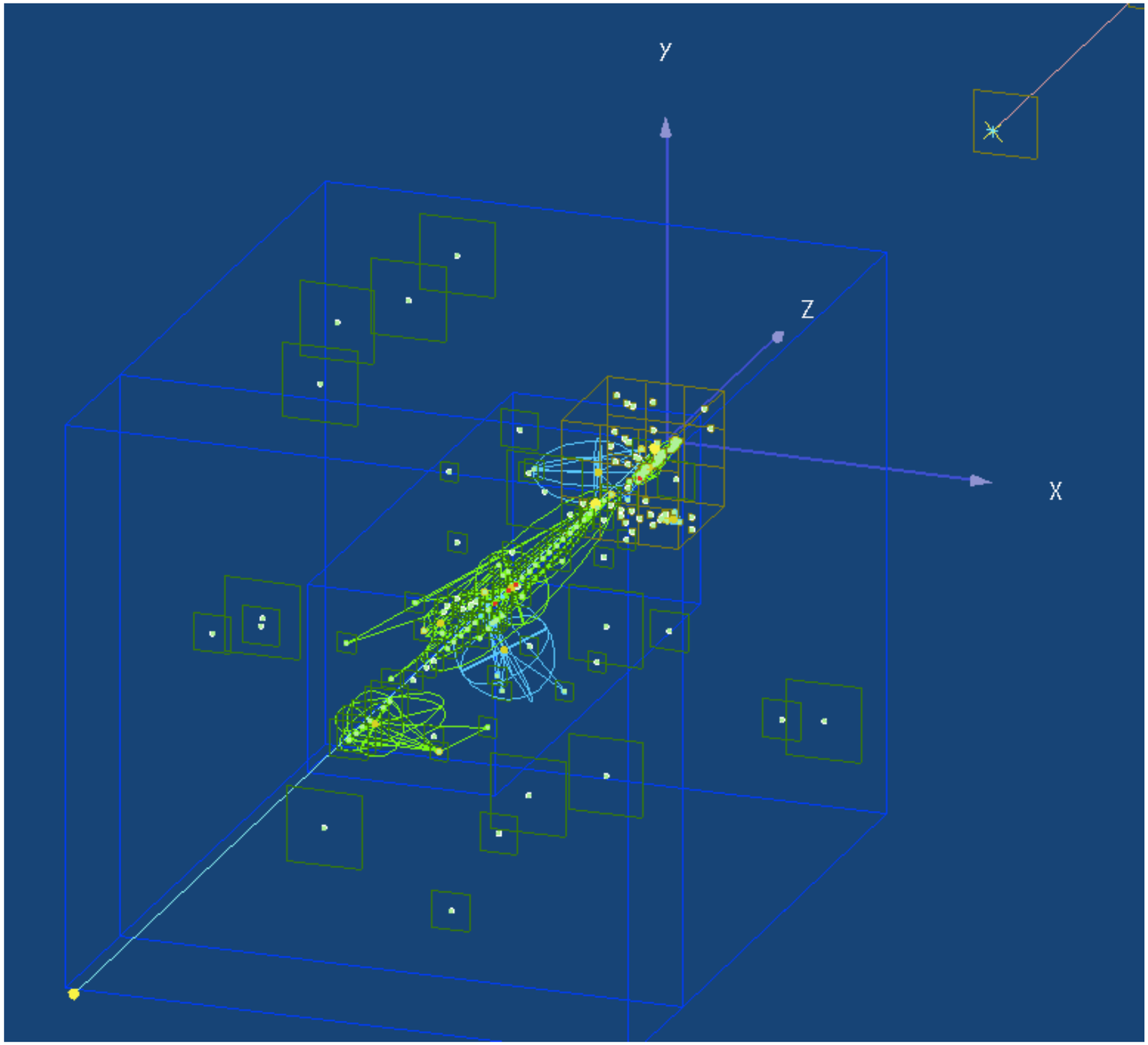
- width of distribution should be smaller for the first case if variations are physical, but this is not observed
- applying correction narrows the distribution considerably

Using Hadrons to Calibrate: Software

- Data extraction from binary files using TreeMaker from V. Morgunov
  - Temperature correction turned on or off
  - Gain calibration (based on muon runs) from V. Morgunov
- Event reconstruction using V. Morgunov's DeepAnalysis:
  - used to identify track-like clusters in the HCAL
- For each tile in a track-like cluster the amplitude is saved in a tree for later analysis

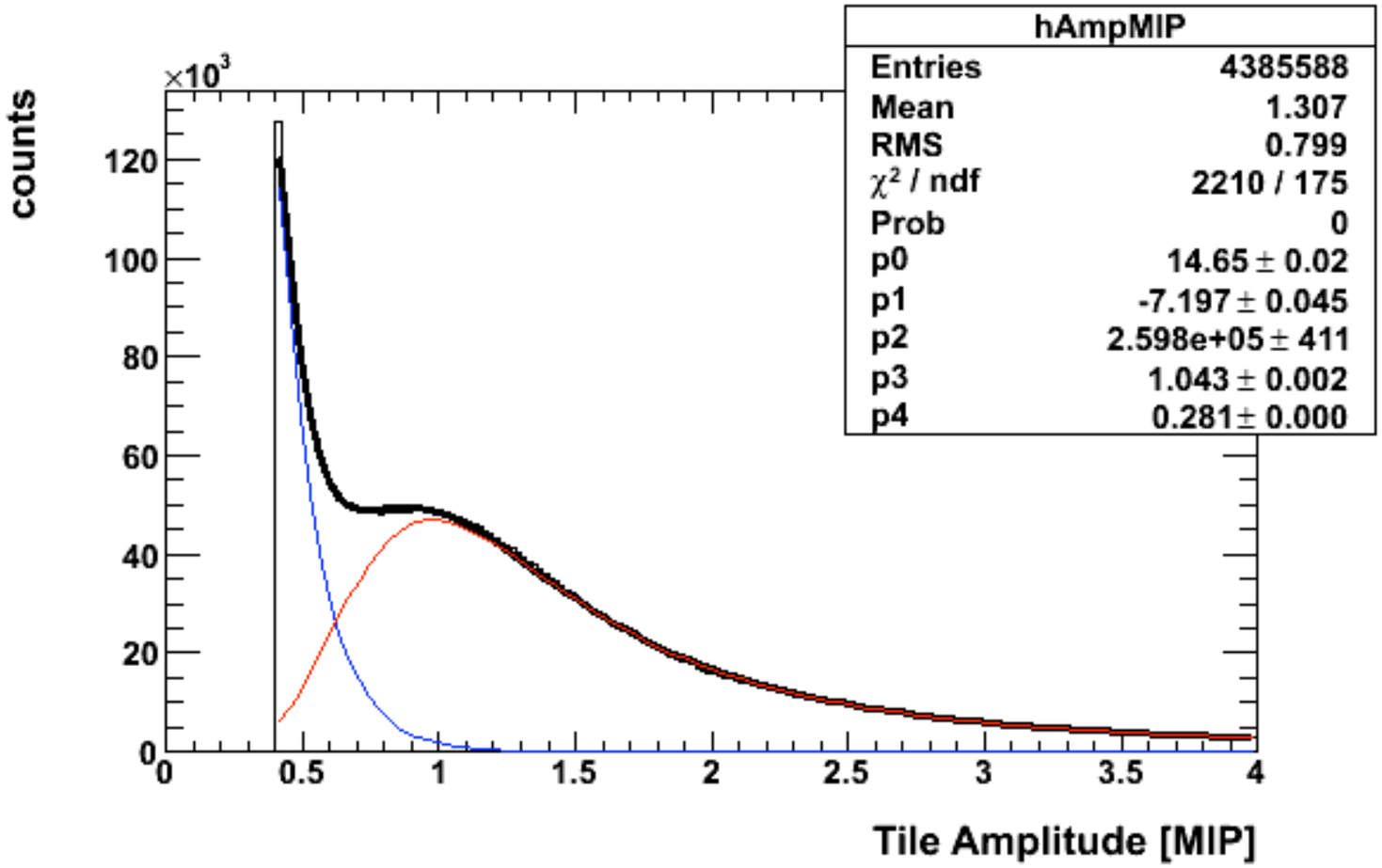
- preparing the migration to the official software framework
- analysis based on V. Morgunov's code intended as a proof of principle

Track-like Clusters in Hadron Showers



- Hadronic interactions are governed by λ_I, ~17 cm in Fe (~ 8 calorimeter layers)
  - long tracks within hadronic showers are quite common
  - can be used as additional MIPs!

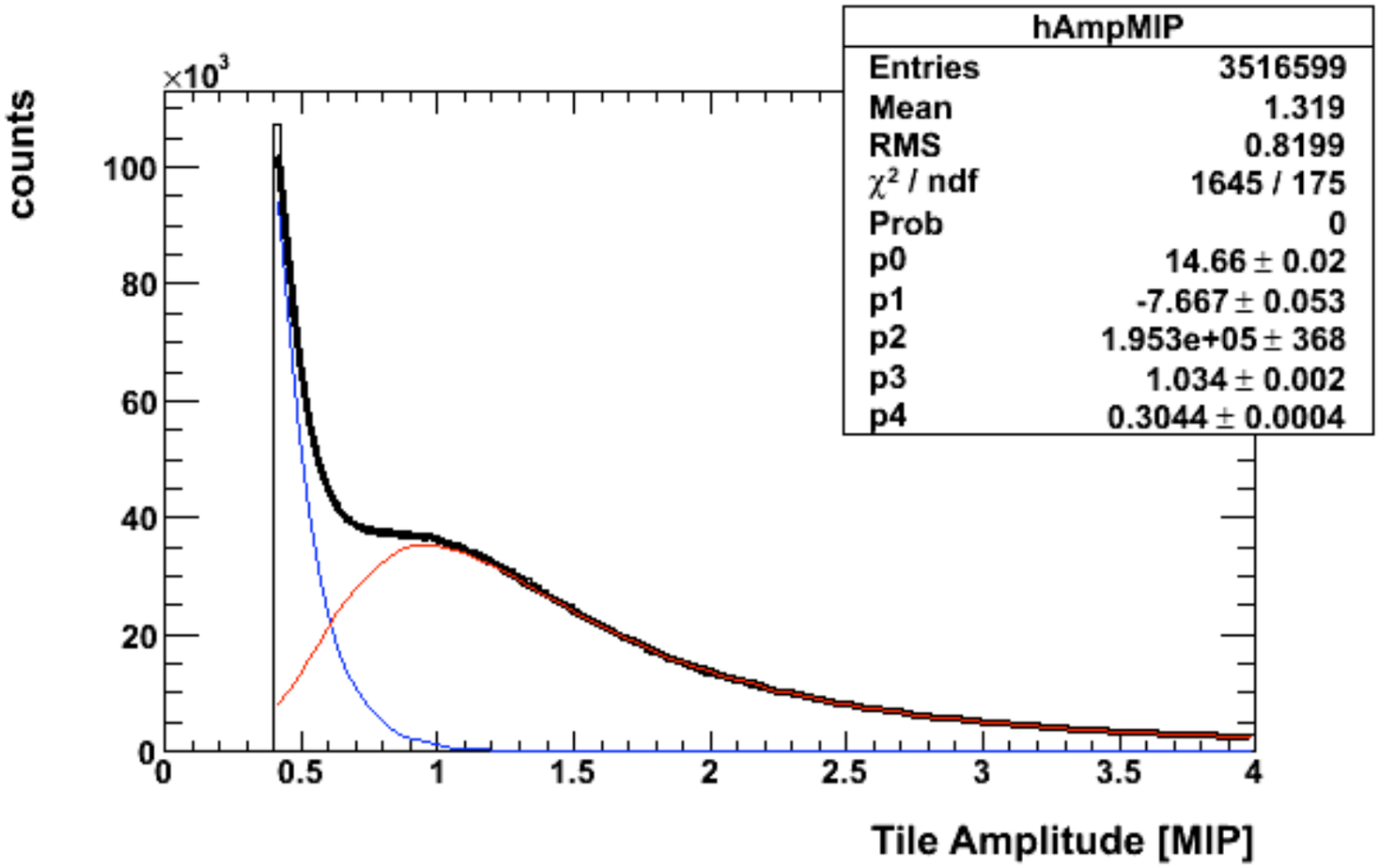
Tile Distribution



- Run number 330590
- no temperature correction
- events with 2 or less track-like clusters
- minimum of 12 tiles in cluster
- maximum of 50 tiles in cluster

- Energy Distribution of Tiles in Track-like showers
- fitted with exponential background (fitted from 0.4 to 0.7) and sum of exponential and Landau

Tile Distribution: No Muons



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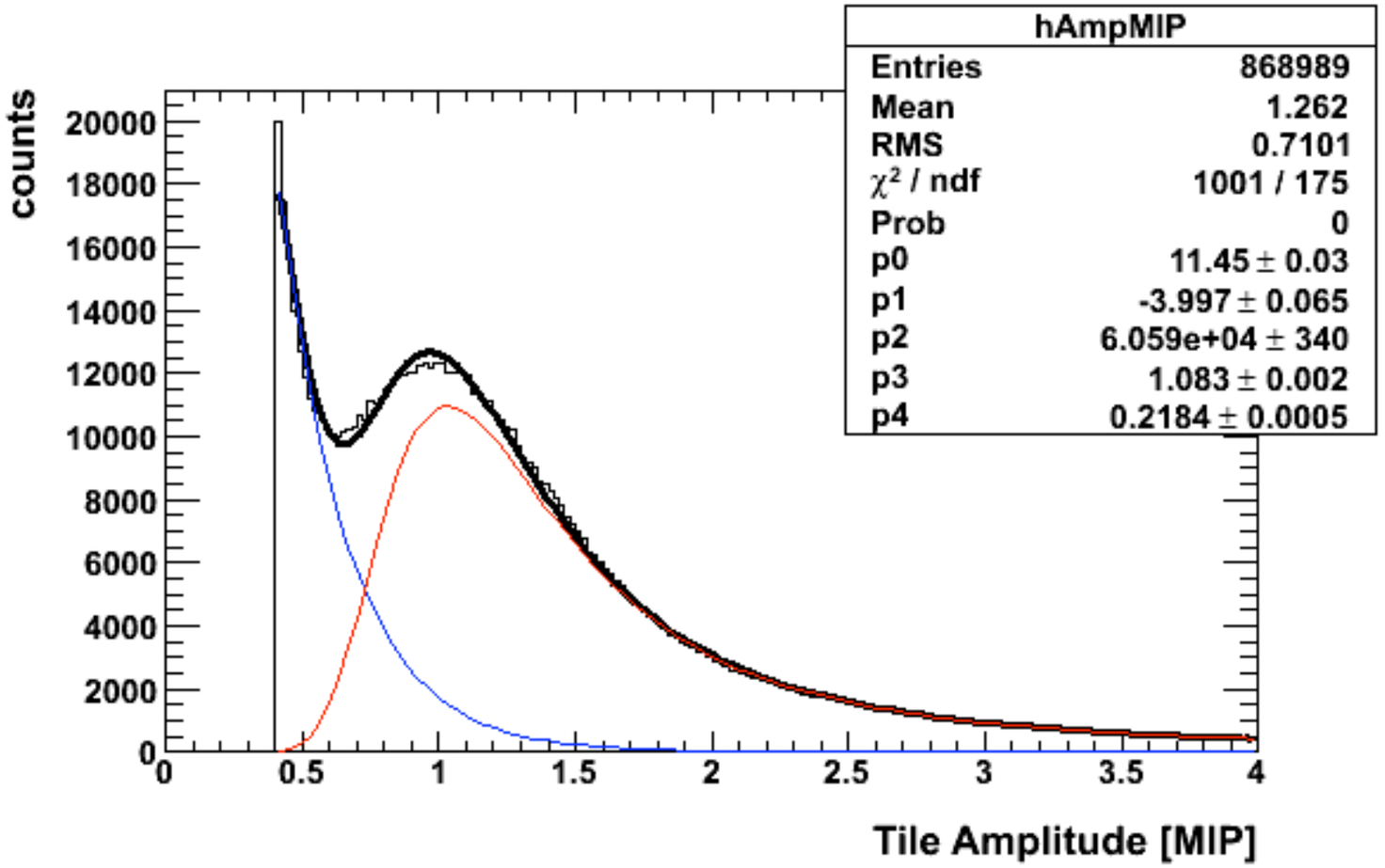
- Muon rejection:
  - Tail catcher: Number of hits not between 15 and 25, energy not between 1.5 GeV and 3.0 GeV

Tile Distribution: Only Muons



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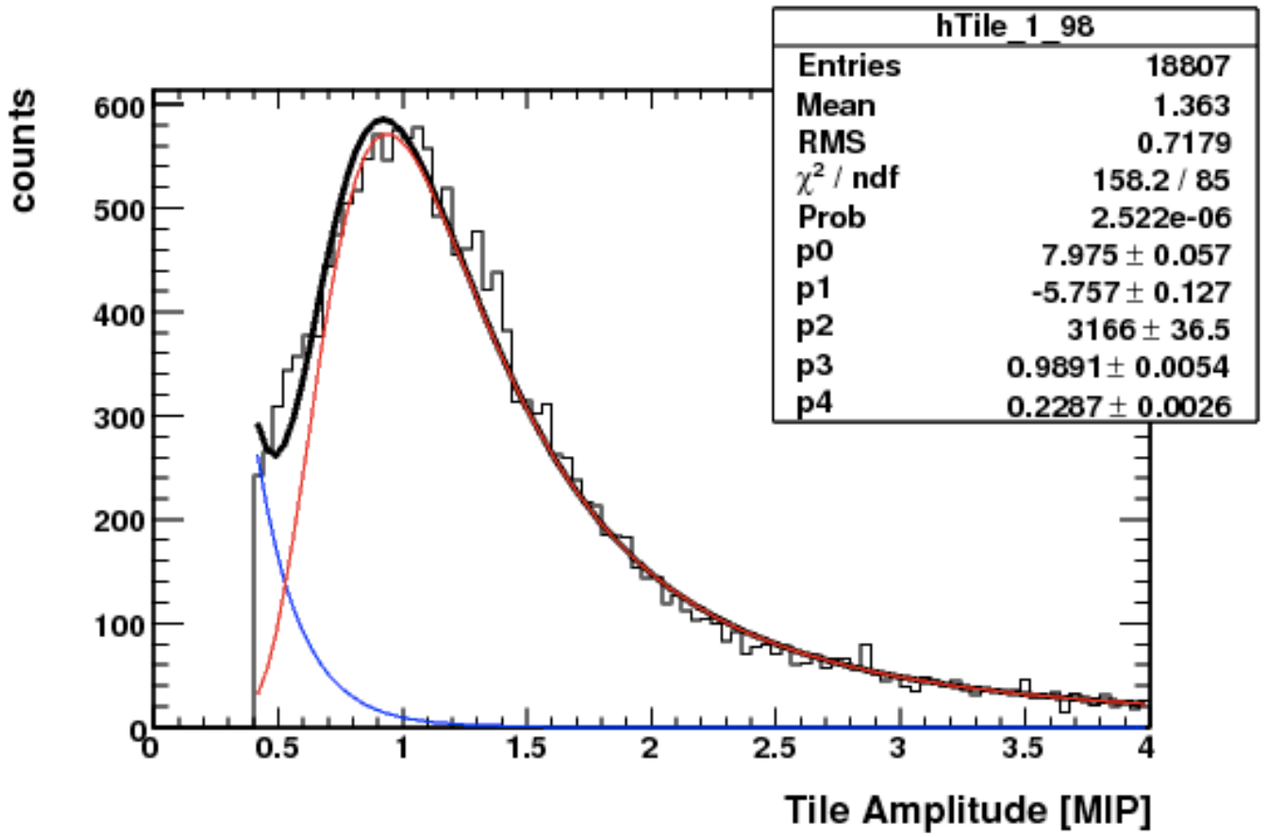
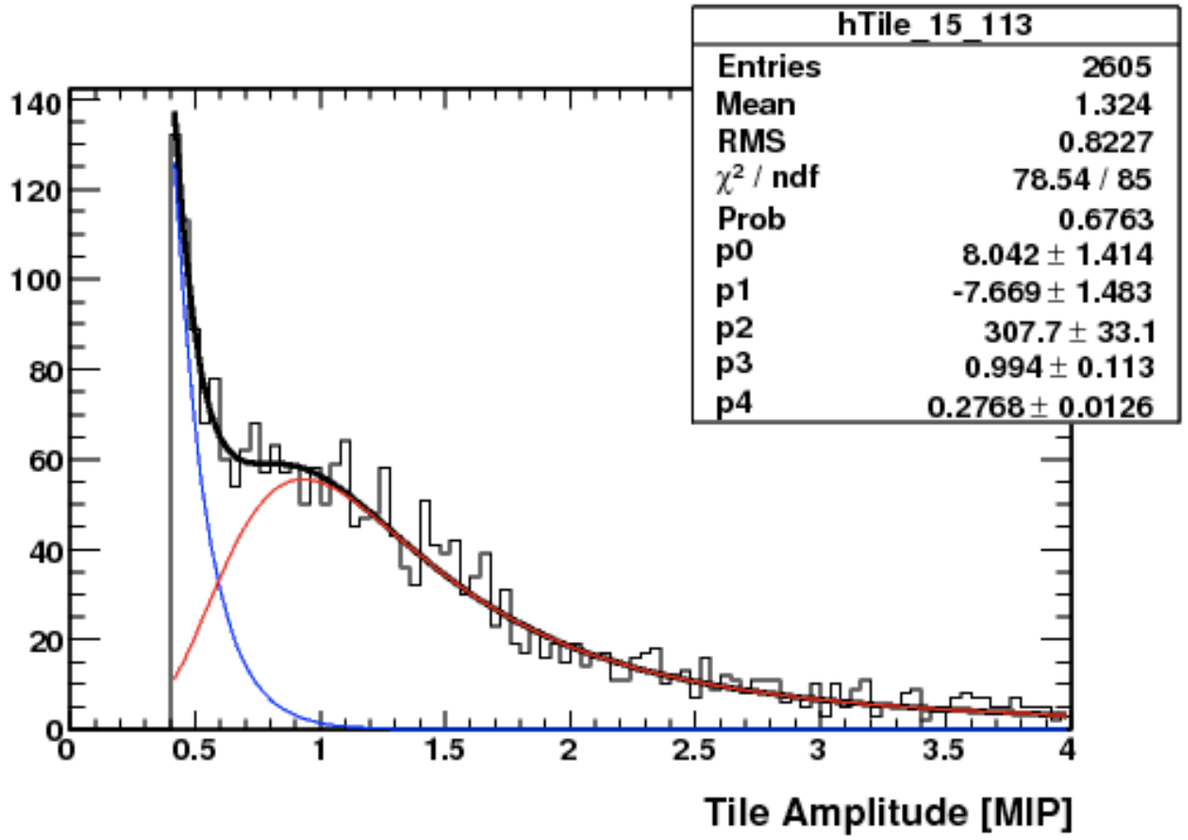
Single Tile Amplitudes

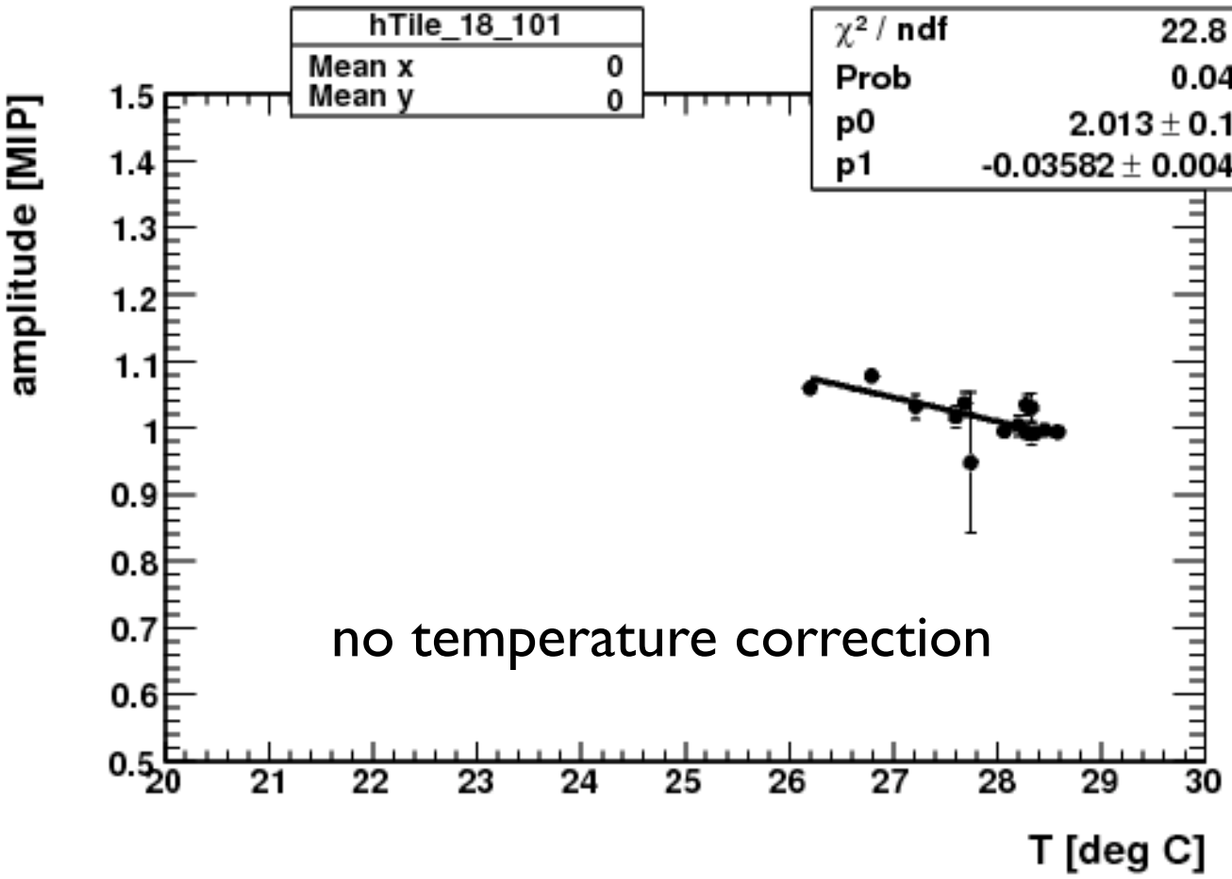


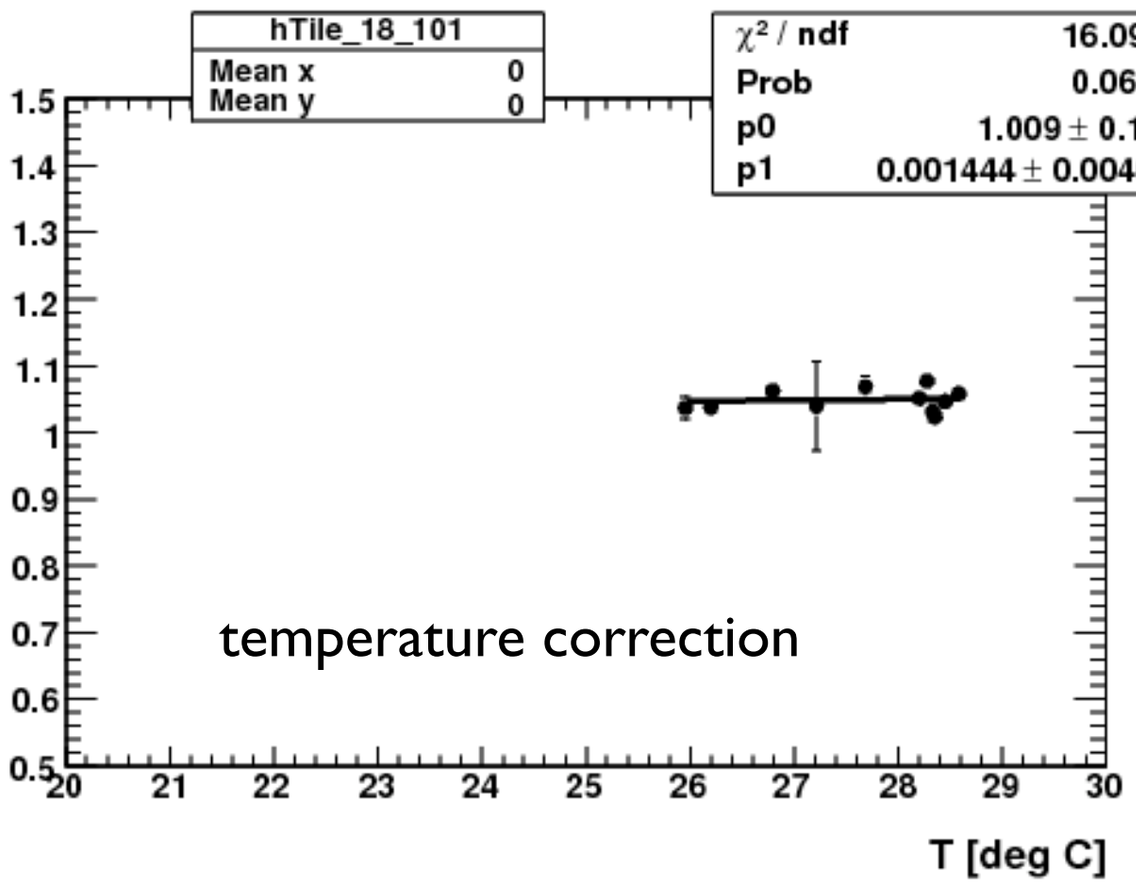


- Energy distribution for two selected tiles, fit with Exponential + Landau
  - 1_98: very close to beam axis, high number of entries, very clear MIP peak
  - 15_113: outside main beam axis, lower overall counts, significant contributions from background (mostly on the side of track-like showers)

Tile Positions

Effects of Temperature Correction

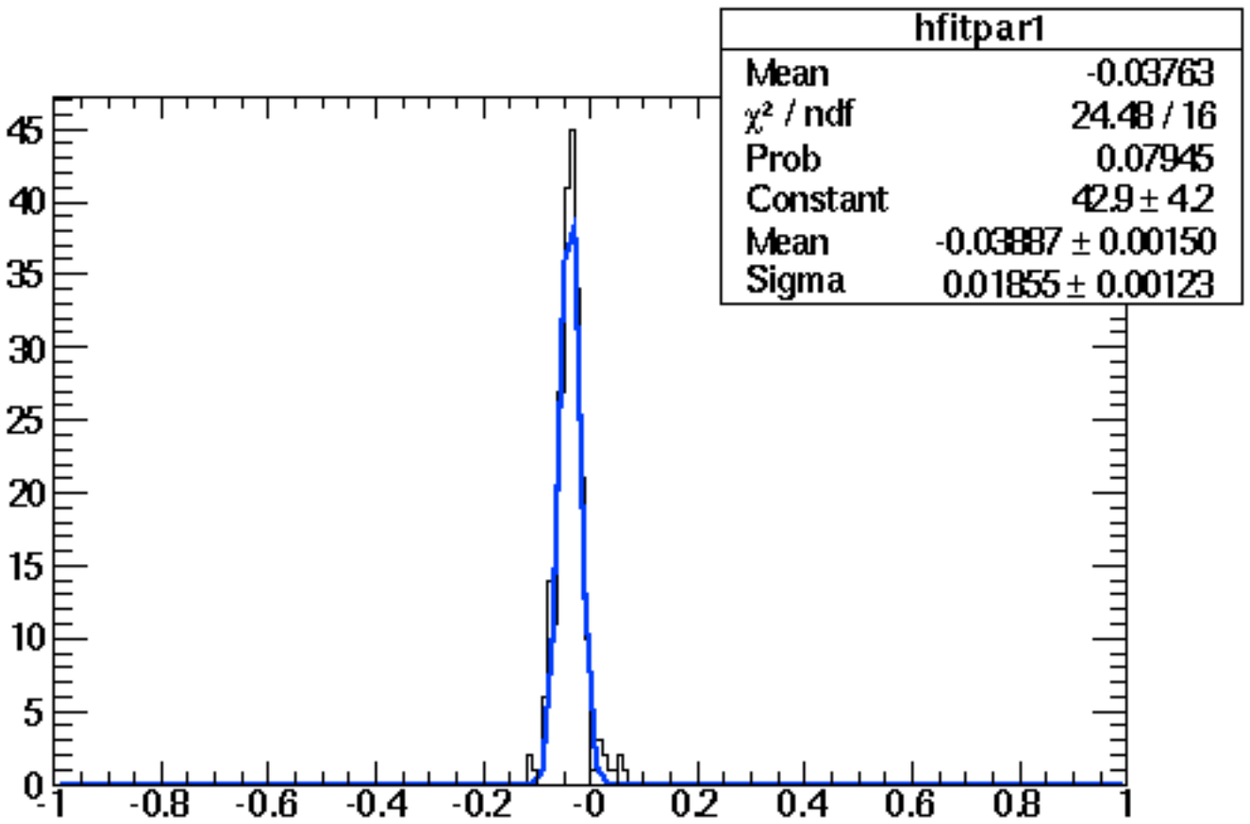




- temperature effect determined from slope of several points taken at different temperature
  - slope consistent with zero for applied temperature correction
  - MIP peak systematically high by a few percent, this is due to the method of calibration used by V. Morgunov

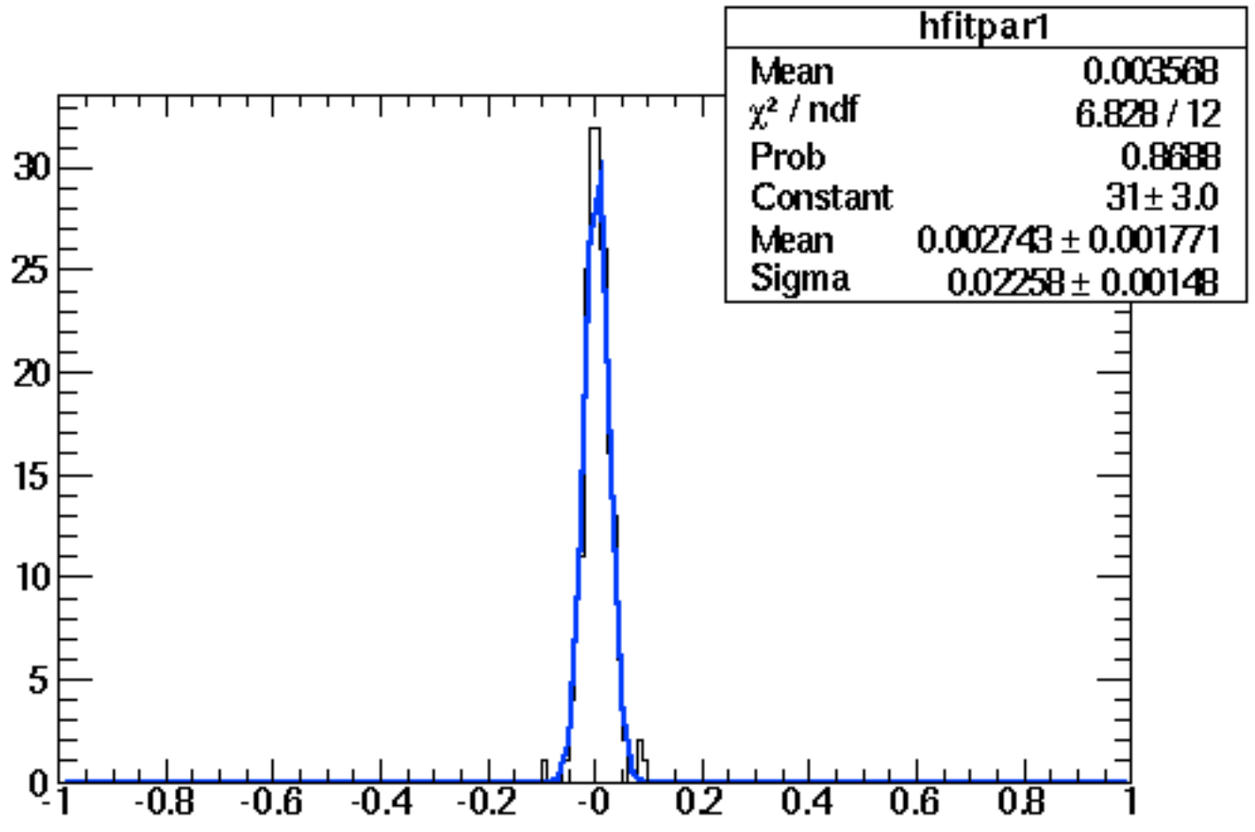
Temperature Effects on Gain

no temperature correction



slope of gain vs temperature

temperature correction



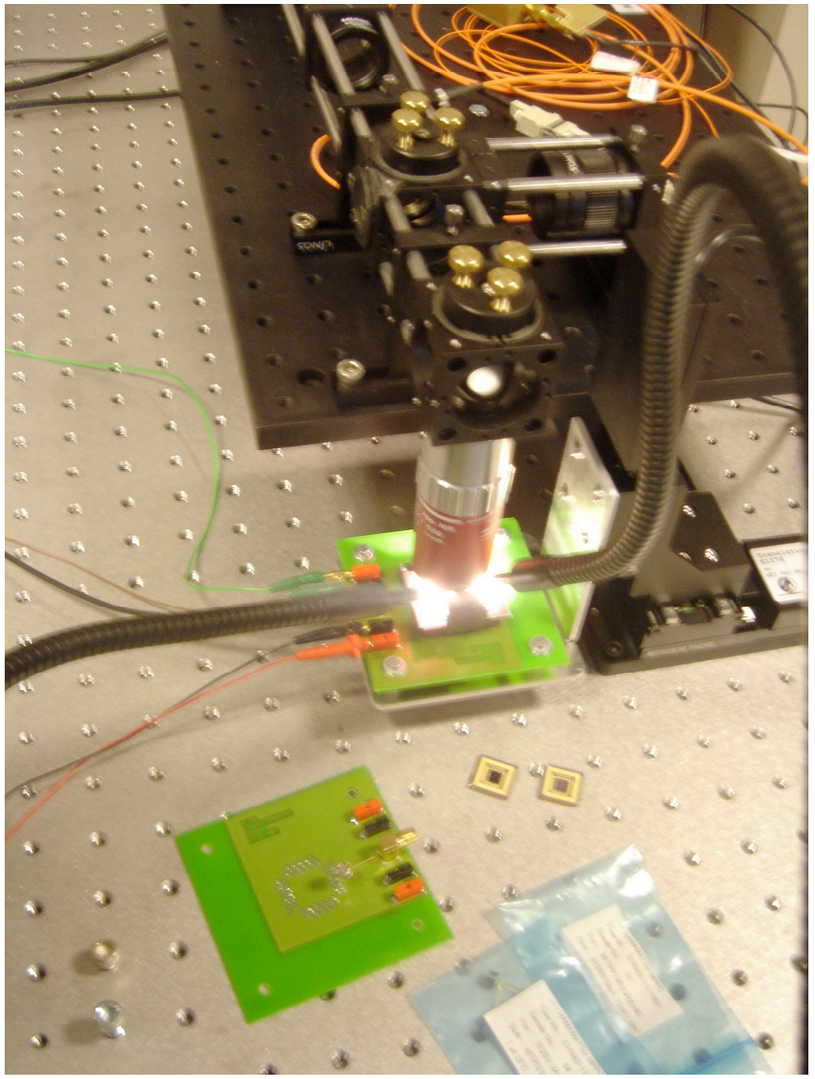
slope of gain vs temperature

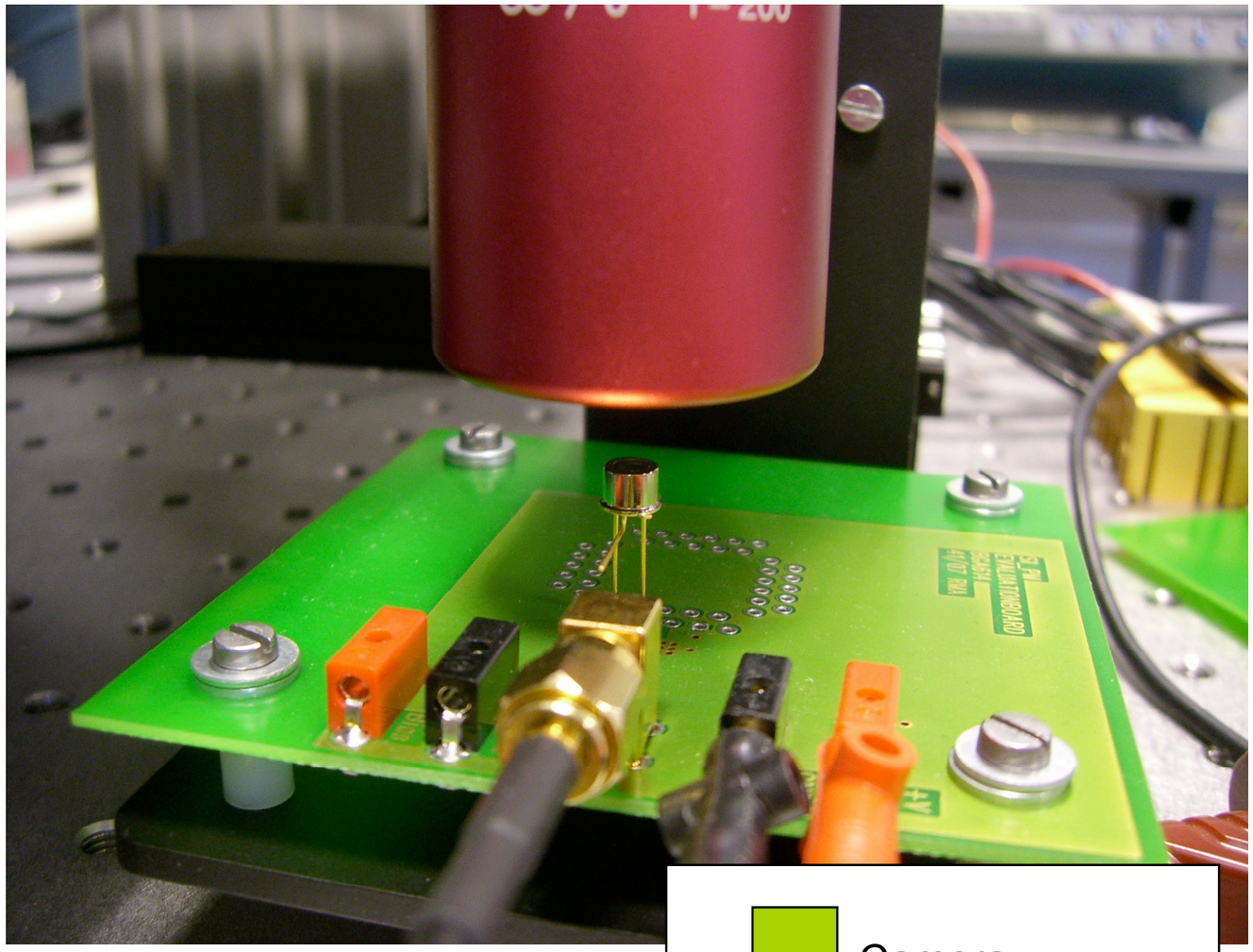
- clear effect of temperature correction visible
  - temperature correction reduces gain change with temperature to zero within errors
    - temperature correction derived from muon runs: independent dataset
  - w/o correction: ~4% gain change per degree K

Using Hadrons to calibrate

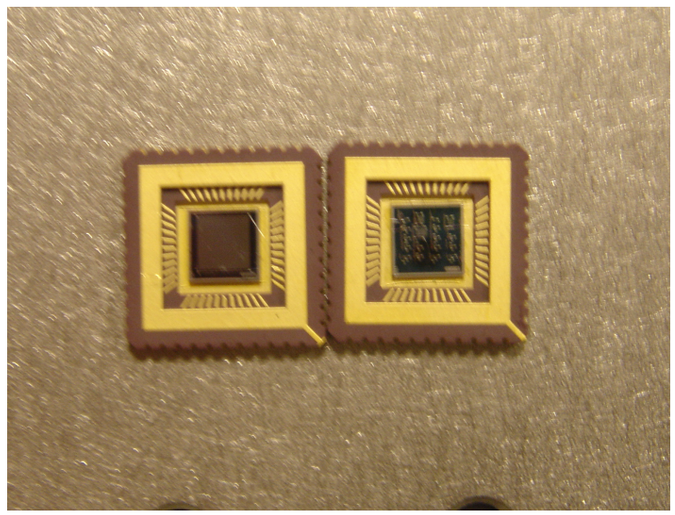
- In an experiment muons might not be very abundant
- Explore the possibility to use hadrons to calibrate the HCAL
- Typical CERN run:
  - 150 k hadrons (with muon rejection)
  - good fits for ~ 100 tiles (however with wildly varying stats, very good on beam axis, not so good elsewhere)
  - ~1k hadrons to calibrate a tile

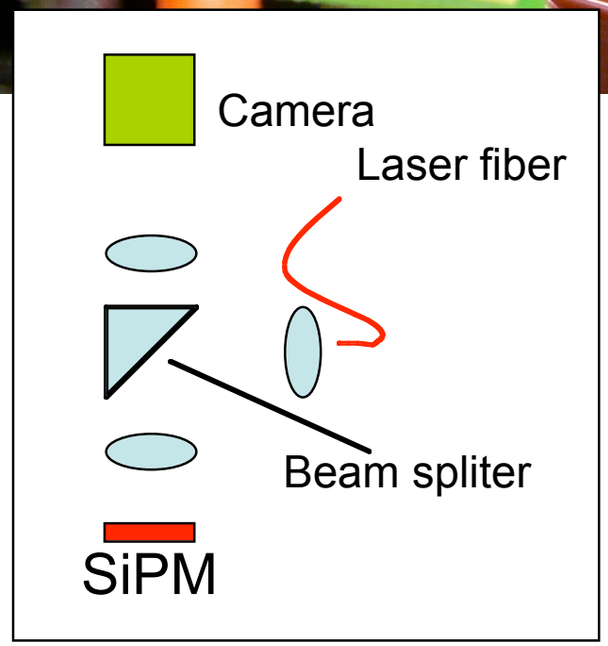
Study of SiPMs @ MPI



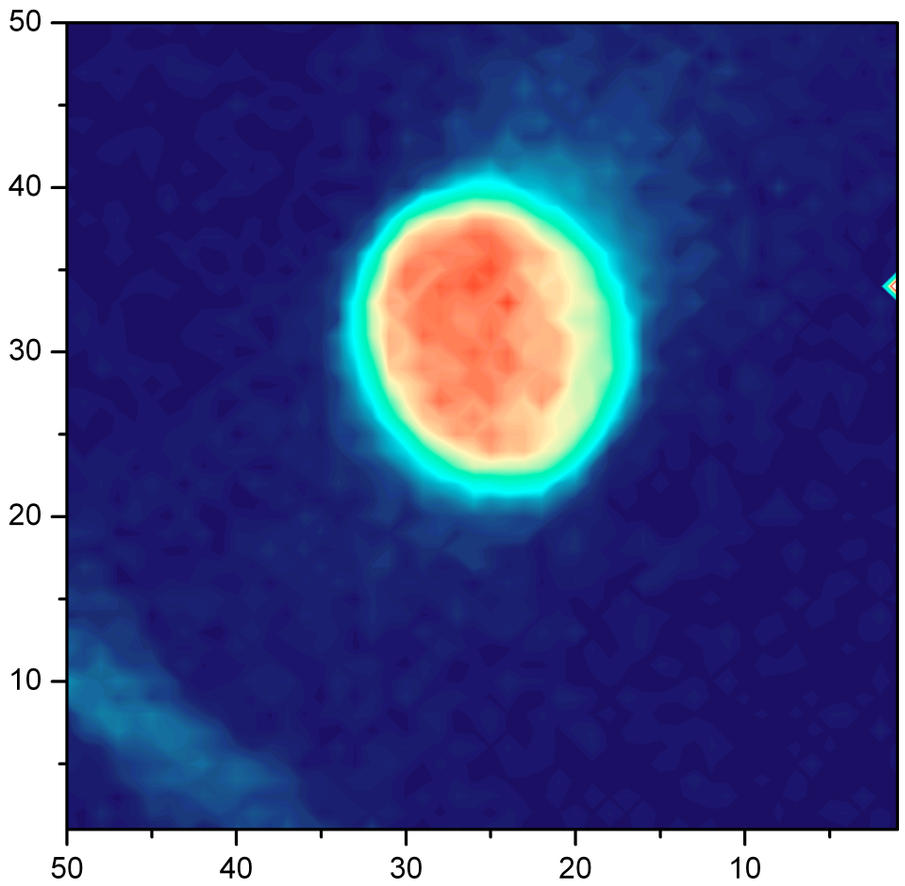


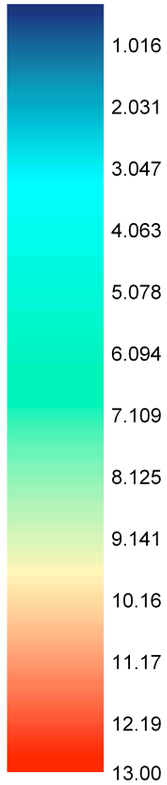
- XYZ Stage
- Visible to NIR Microscope Optics
- Laser and Fiber Collimator

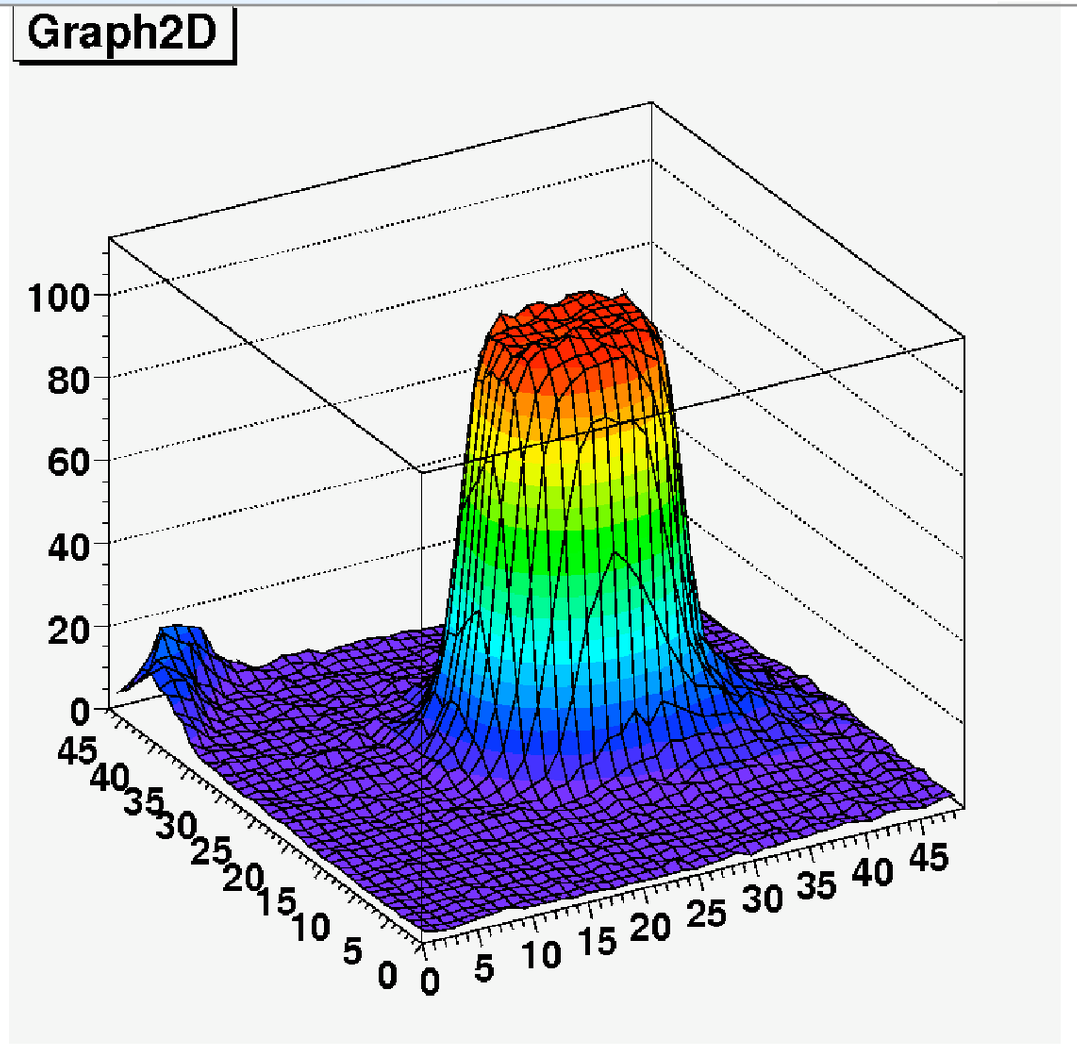


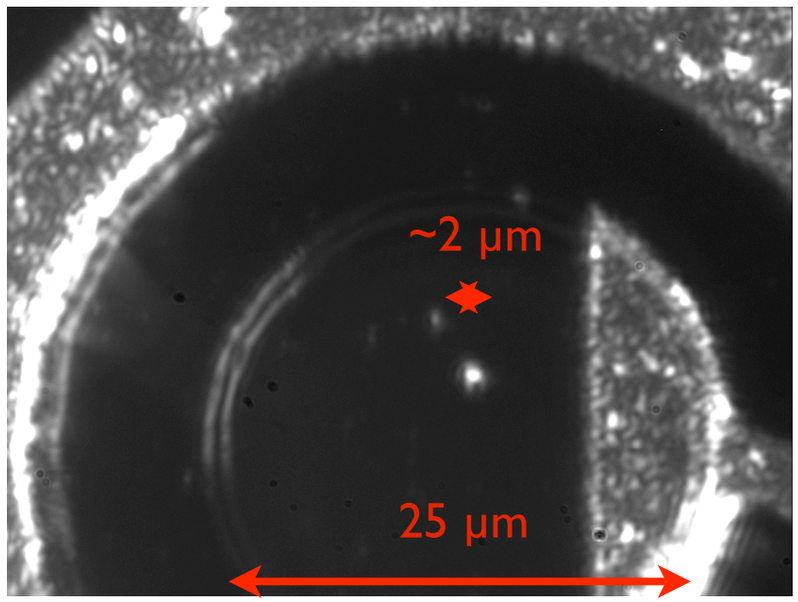


Sensitivity of Pixel Surface





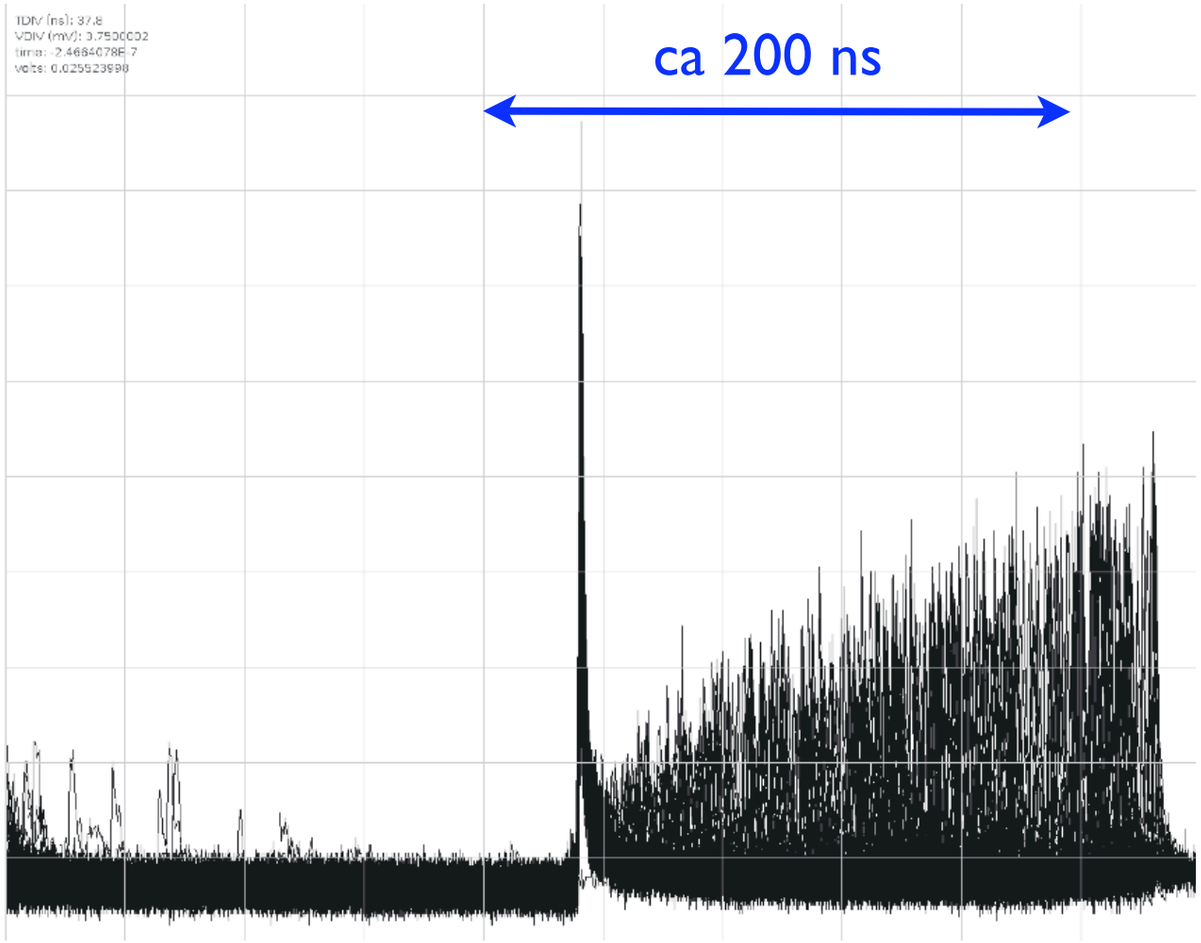


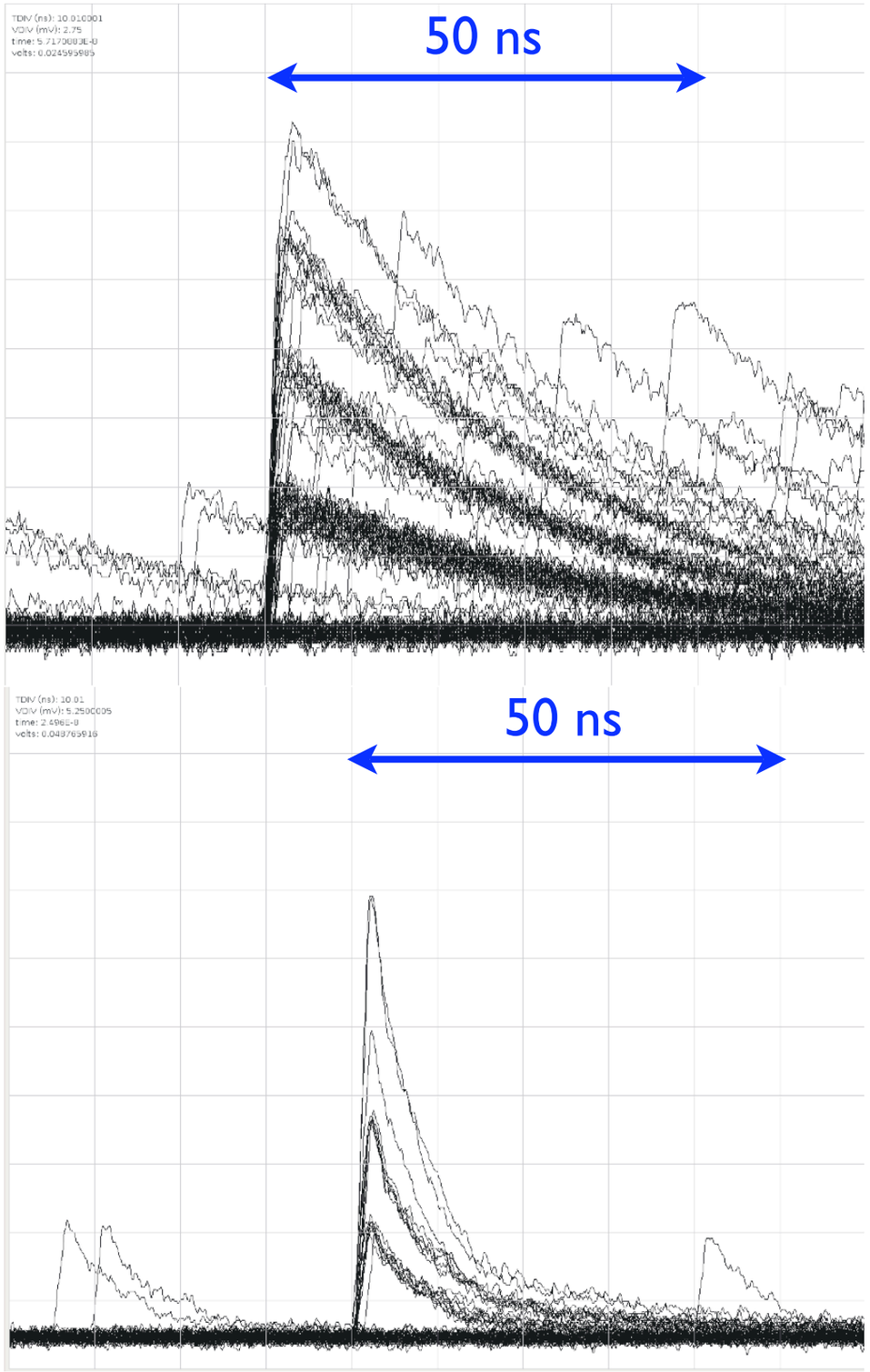


- Studies of a Prototype SiPM (HLL Munich)
- Single circular pixel, 25 µm diameter
- 850 nm laser, spot size ~ 2 µm

SiPM Response to short Laser Pulse

Amplitude dependence on time between pulses (recovery time)





Hamamatsu
100UI

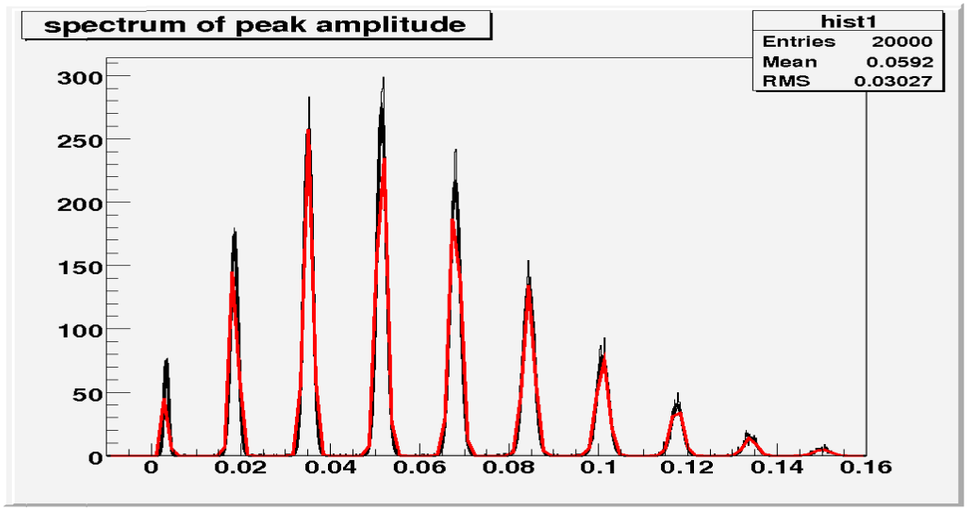
100 Events

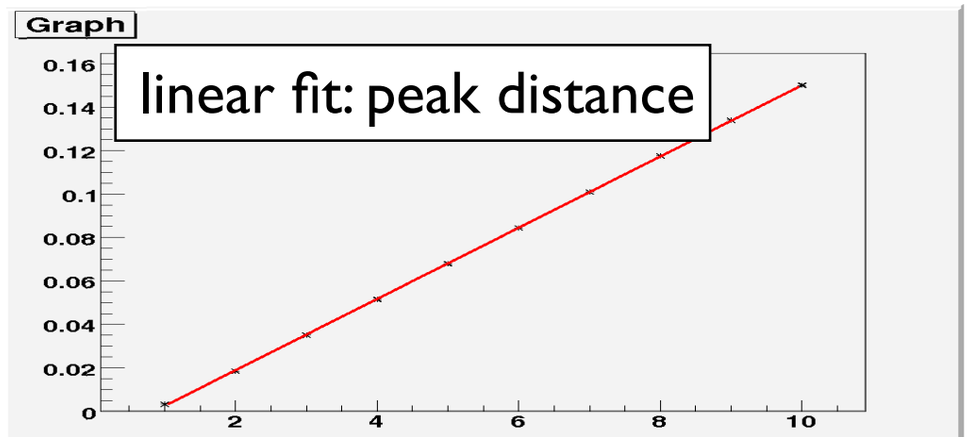
HLL Test array

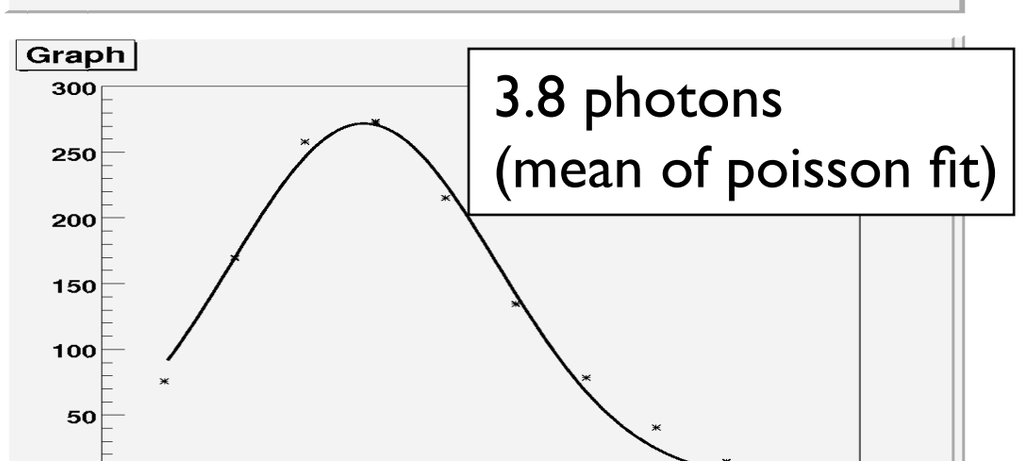
100 Events

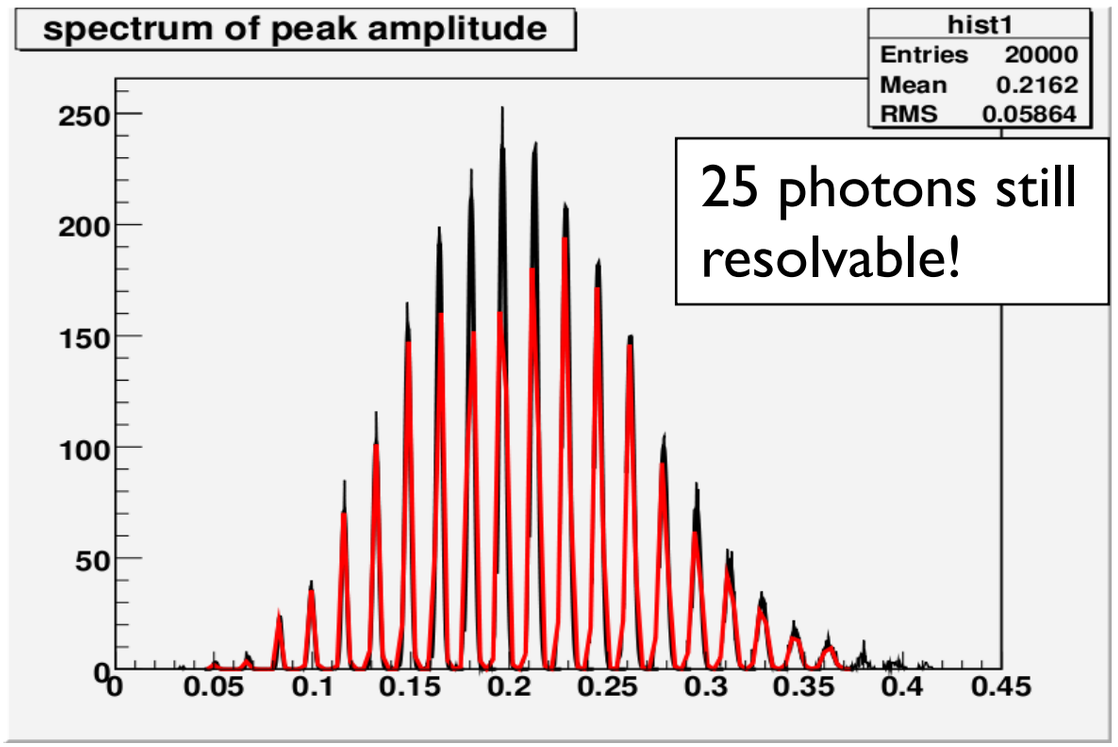
- different SiPMs:
  - different pixel size
  - different quenching resistor

Multi-Photon Response



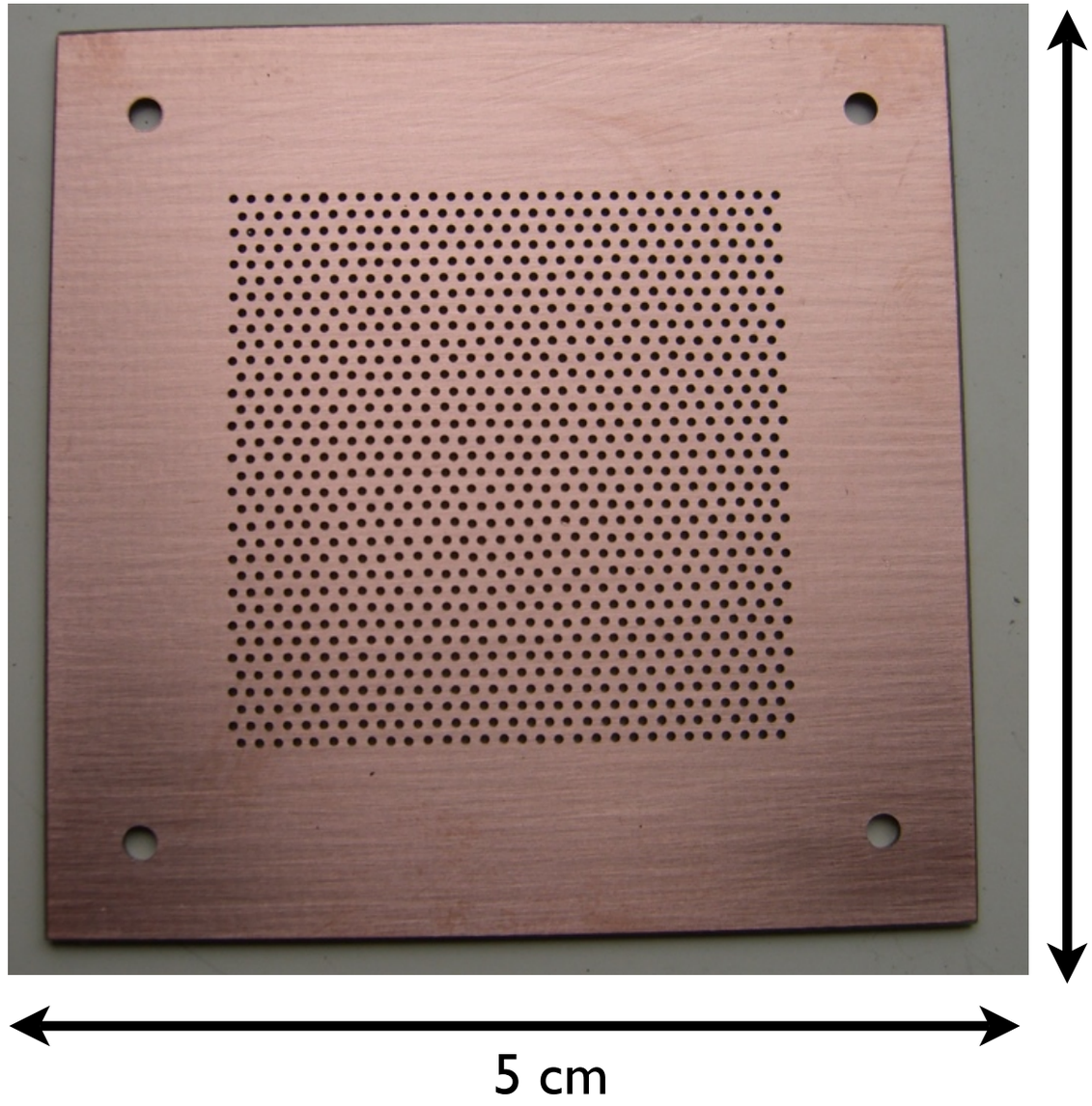






- HLL SiPM test device
  - 500 pixels, 5 mm x 5 mm
  - spectrum shows peak amplitude, not integral, gives better resolution, but all photons have to arrive at the same time

Other Projects: ThickGEMs



- Planning to study ThickGEMs as an option for DHCAL
- First ThickGEM prototype (3 cm x 3cm active area, 1k holes) produced at MPI Munich

Summary

- Hadrons can be used for calibration purposes by exploiting track-like clusters in showers
- A temperature correction based on a 2nd order polynomial fit to temperature readings shows good results
- The temperature dependence of the SiPM gain is clearly observed in hadron runs

- At Munich, we have started a variety of activities within CALICE:
  - Test beam data analysis and calibration
  - SiPM development
  - Study of gaseous detectors
  - Stack Mechanics starting 2009