SiPM Test Facility @ Heidelberg

CALICE Meeting

15.09.2016

Yonathan Munwes

Konrad Briggl

Patrick Eckert

Felix Passenberg

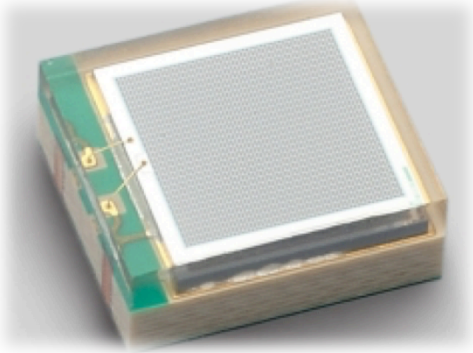
Outline

- HD test setup - reminder
- Results from the first batch of SMD SiPMs
- Conclusion
- Discussion – towards full detector calibration

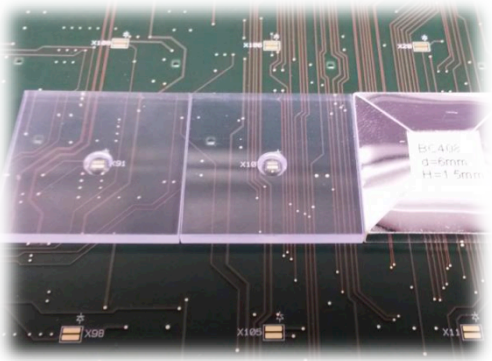
HD tile testing system

- Original system was designed for Tile + SiPM package
  - Can measure up to 220 tiles in ~1 h
  - Used for testing full HBU layer during production of old version layers of the AHCAL prototype
- Upgrade the system for testing SMD SiPMs (new HBU design)
  - QA of SMD SiPMs before equipping the HBUs (~50 SiPMs per tape, 5%)
  - Measure of SiPM properties :gain, V_{br}, $C_{pix,}$ DCR rates, crosstalk rates and temp. coefficients (currently only gain, V_{br}, C_{pix} and temp. Coefficients spreads)

Original system: SiPM + Tile



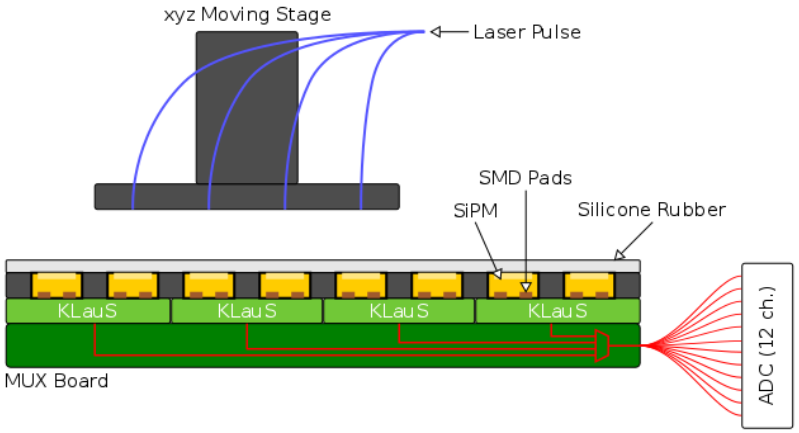
SMD SiPM



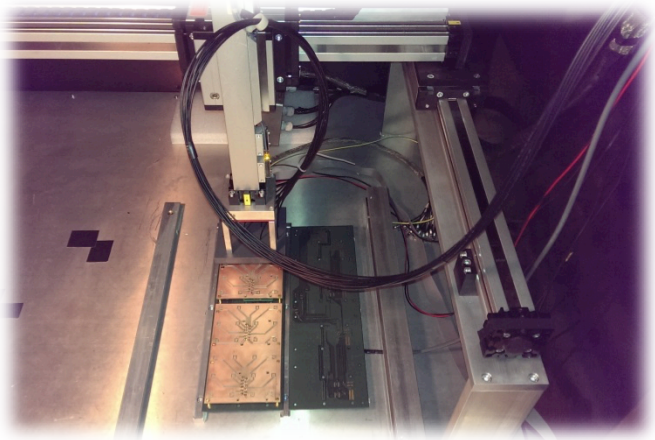
Tiles with SMD SiPMs

Testing setup - SMD SiPM

- System components:
  - Laser head with 12 optical fibers
  - Base plate
    - Up to 144 SMD SiPMs
    - SiPMs spaced with 3 cm x 3 cm (compatible to HBU)
    - RO- 12 KLauS2 chips
    - Multiplexing of Klaus2 output signals to 12 channels ADC
- Advantages:
  - Measure 48 SiPMs in ~8 min
  - Can be use for SMD SiPM QA and also directly on the equipped/semi-equipped HBU (if needed)
- Disadvantage
  - Need to take SiPMs out of the sealed tape (problematic if needed to QA all SiPMs)



SMD SiPM schematic view

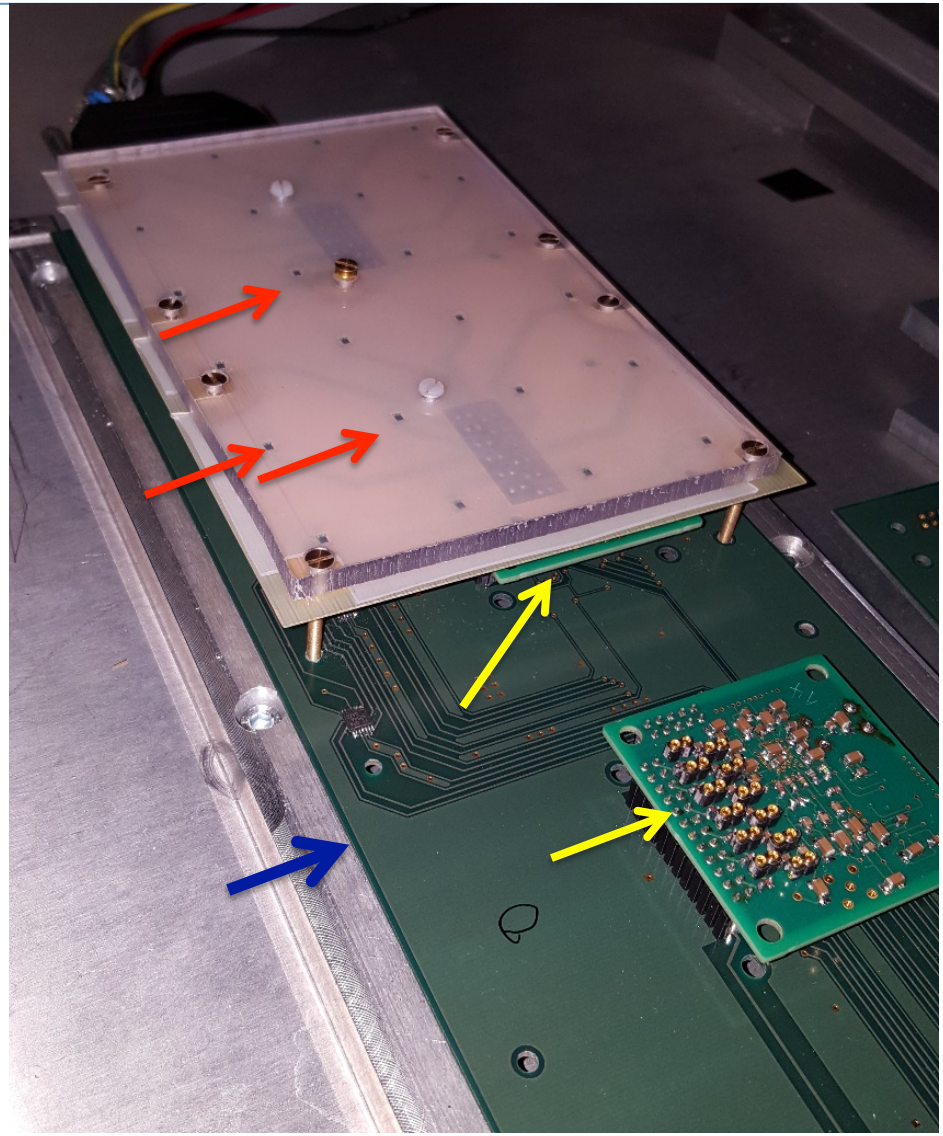


SMD SiPM Setup with fibre fan-out (incomplete)

Testing setup – closer look one module

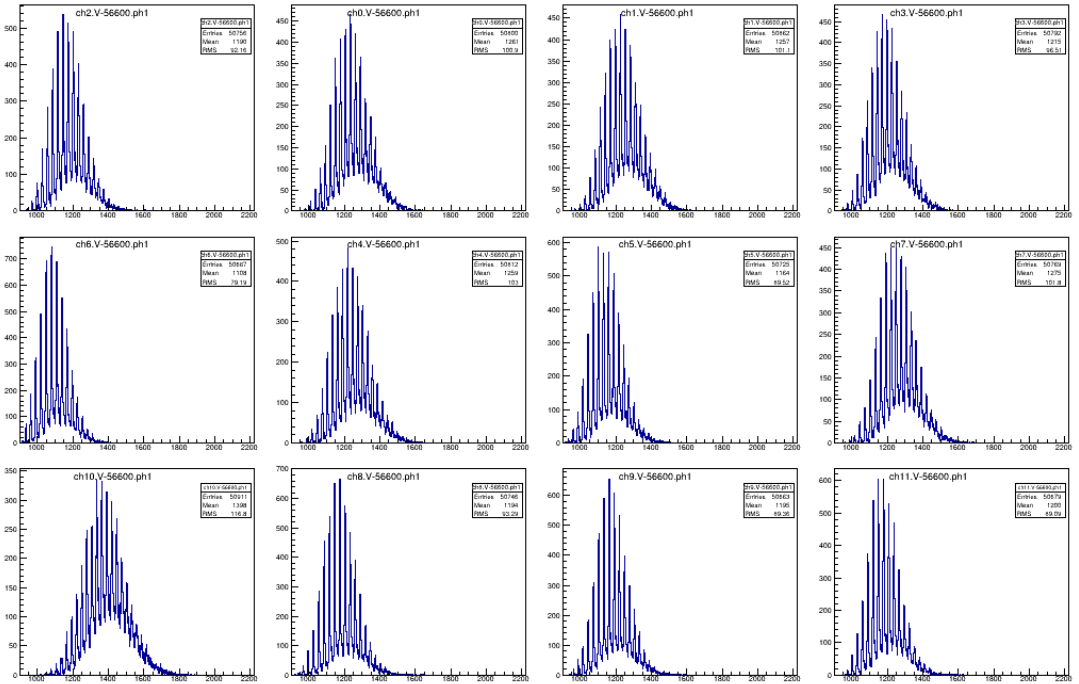
- 24 SiPMs
- 2 Klaus chips
- Multiplex PCB

- Currently have two module (up to 48 SiPMs)
- The design is modular and can be easily scale up if needed for mass production



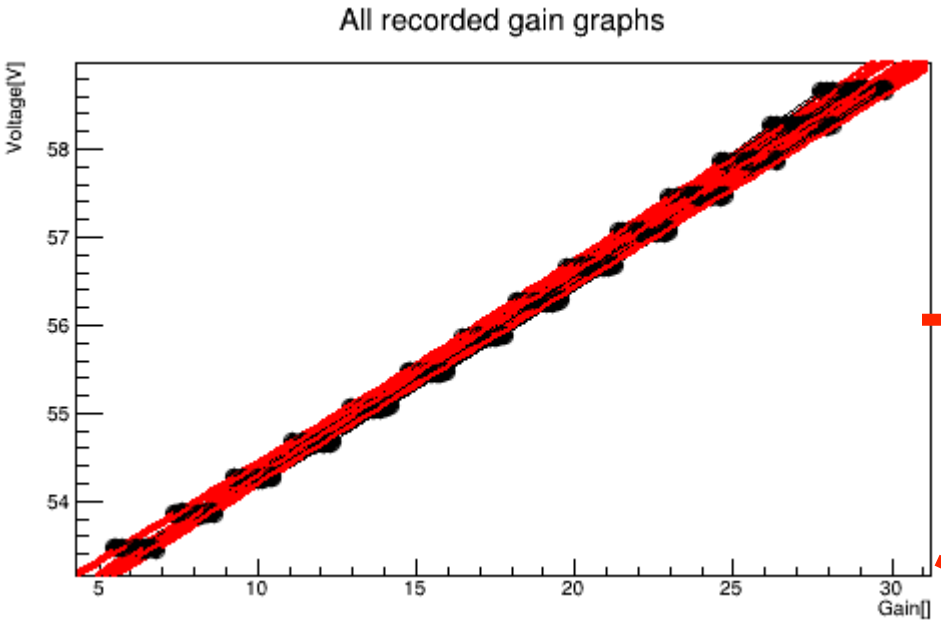
Measurements

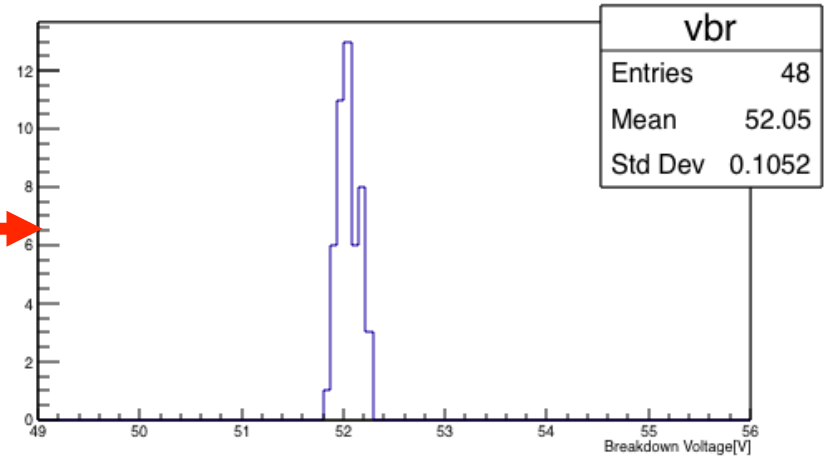
- Voltage scan range 51V-57V, total 15 points
  - 12 fibers coupled to 12 SiPMs
  - Average of ~10 sec/ch (for 15 HV points)
  - Extract from the gain curves the V_{br}, and the pixel capacitance (C_{pix})
- Measure the temp. near the SiPMs
- 12 SiPMs (one board) was measured in control oven for measuring the spread of the temp. coefficients

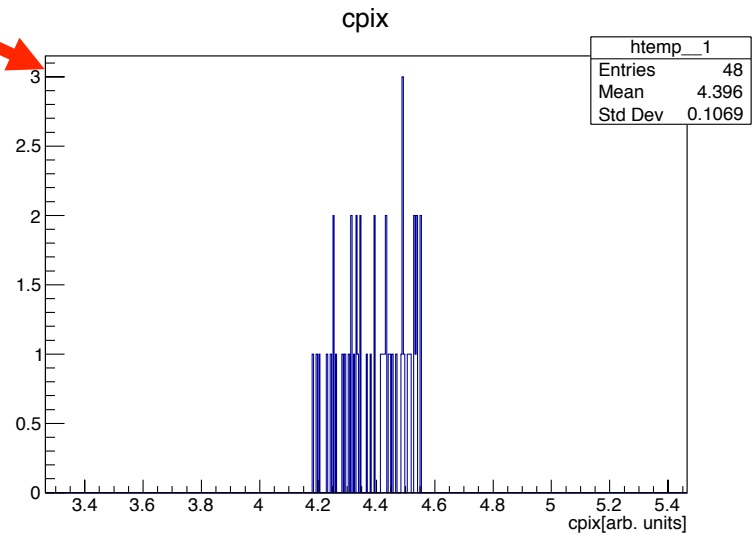


Example SPS from the online monitoring system at 57V

Analysis results – no calibration





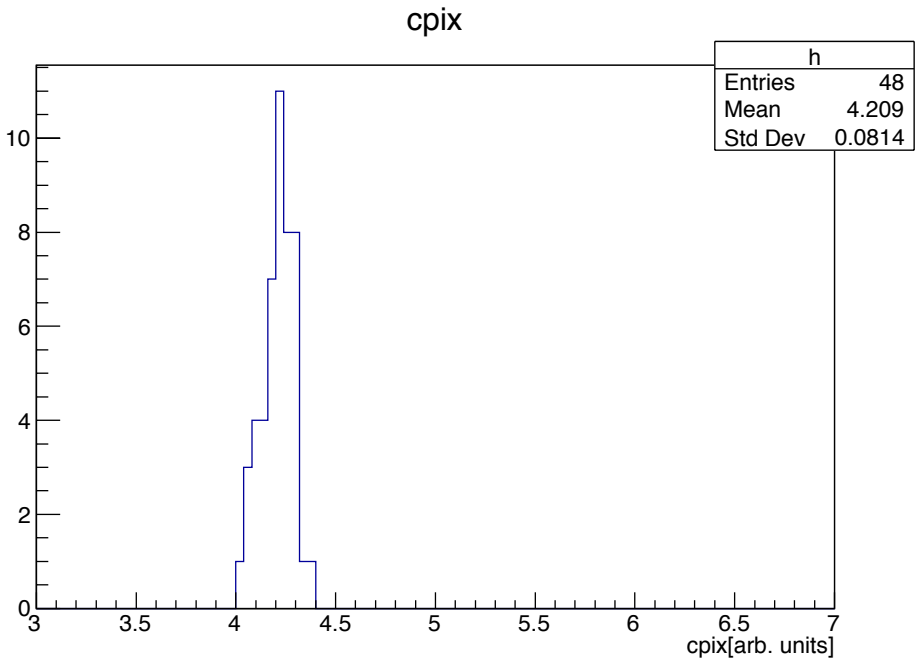


From all 48 SiPMs **– NO CALIBRATION APPLIED**
Breakdown voltage 52.05 +/-0.11 V
Pixel capacitance 4.396 +/- 0.11[arb. units]

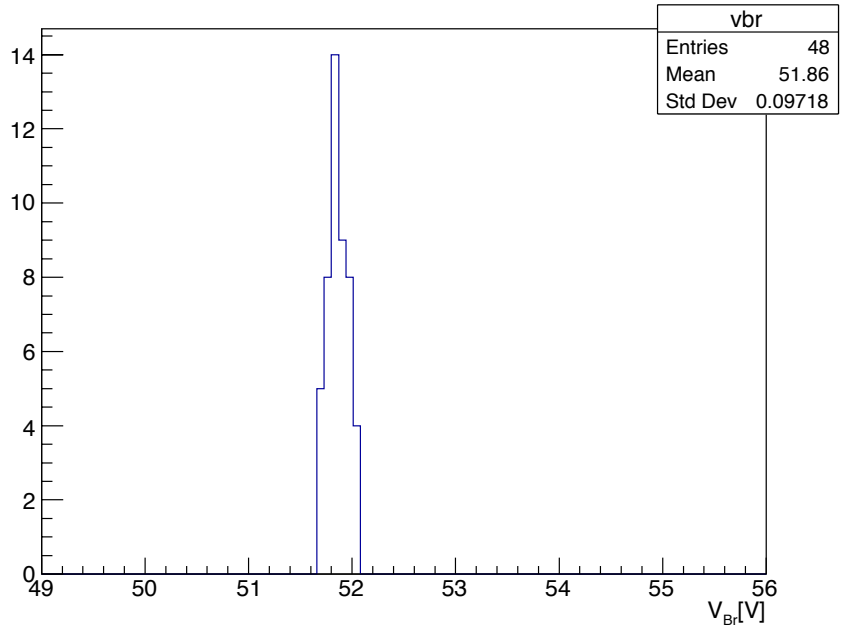
- Systematics correction needed :
  - Non linearity
  - Temp. corrections

Re-analyzed in linear range

- The gain distribution suffer from non-linearity in low and high regions (see example in the BK slides)
  - Low from ADC non-linearity
  - High from Klaus2 saturation
- From residual distribution this effect is within one ADC bin



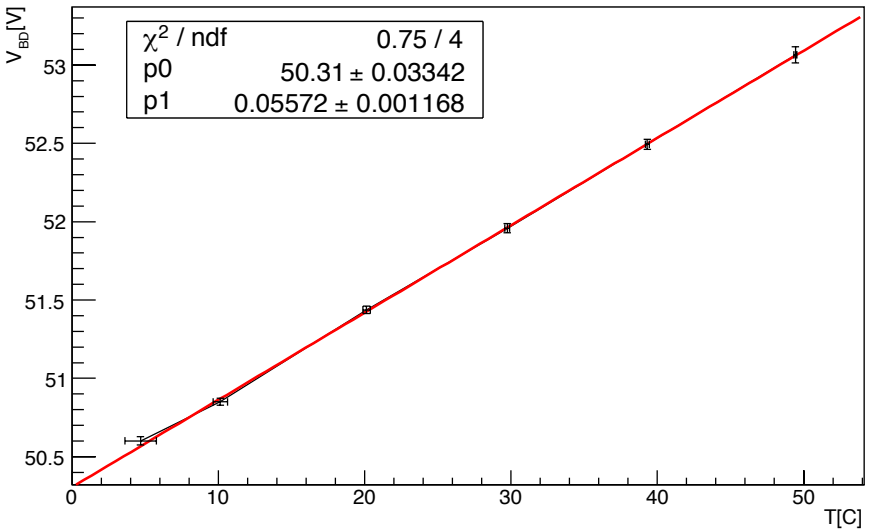
C_{pix} spread after non-linearity correction



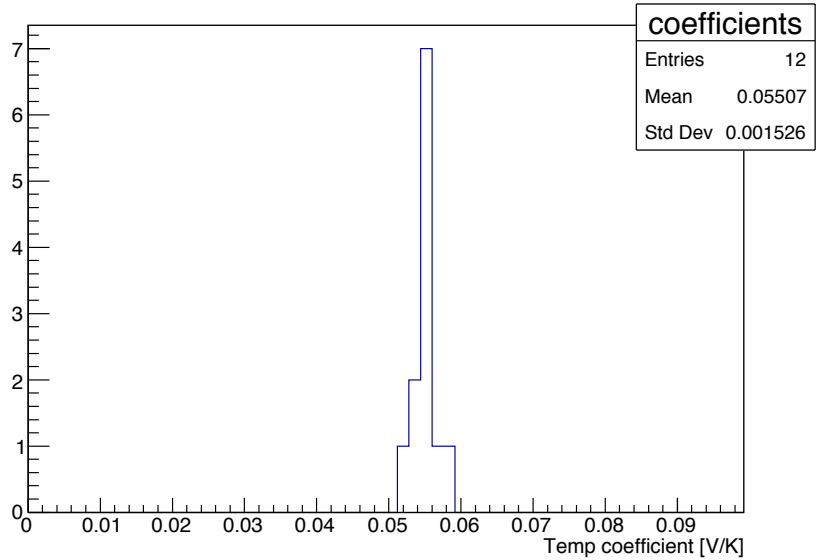
Breakdown voltage spread after non-linearity correction

Temperature scan

- Measure the breakdown voltage of 12 SiPMs for different temperature (4-50 ^{O}C)
  - This is not in the standard test bench -> take the module+laser head into an oven)
- Extract the temperature coefficient spread



Example plot for single SiPM V_{br} with respect to the temperature

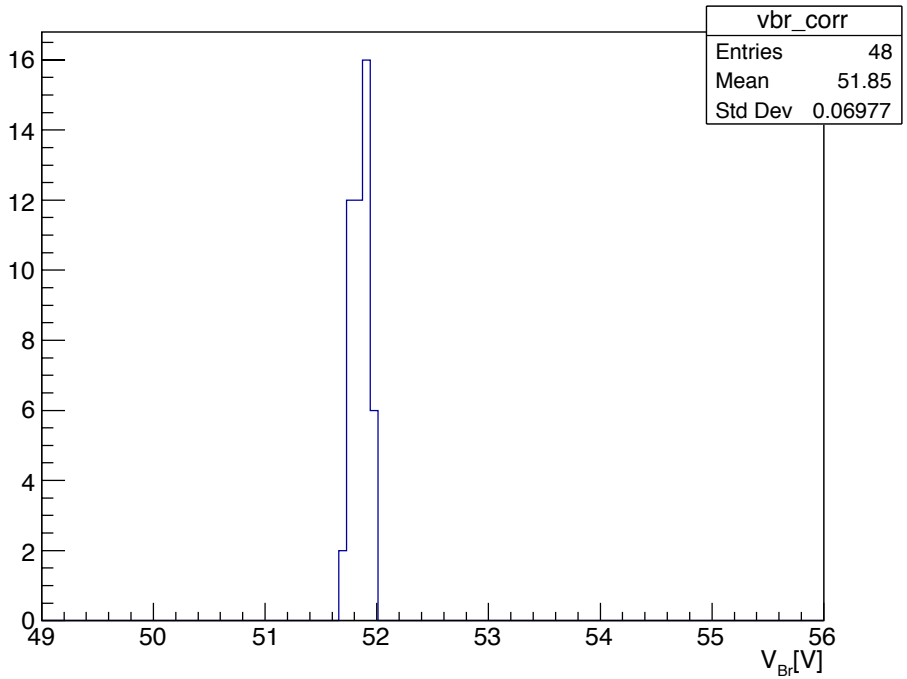


Temperature coefficient spread of 12 SiPMs

Temperature coefficient speard 55.07+/-1.5 [mV/^{O}C] (2.7%)

Temperature corrected spreads

- Applying the **average** temperature coefficient to correct all 48 SiPMs to a fixed temperature of 25 ^{O}C



- Breakdown voltage 51.85 +/-0.07 V
- Spread of breakdown voltage is 1.4-%2.3% (assuming 3 to 5 OV)

Summary

- Upgraded our tile test bench for measuring SMD SiPMs (new HBU design)
- Can measure spread of SiPMs properties for QA needed for future mass production
- The design is scalable
- Can be used for testing equipped HBUs
- Main results:
  - Breakdown voltage spread results (assuming OV range 3-5V):
    - 2.2%-3.4% - no correction applied
    - 1.4%-2.3% - temperature and using the linear range
  - Temperature coefficient spread of 2.7% (will measure all 48 SiPM spread for better statistics)
- Is this sufficient for mass production QA? (discussion next slide)

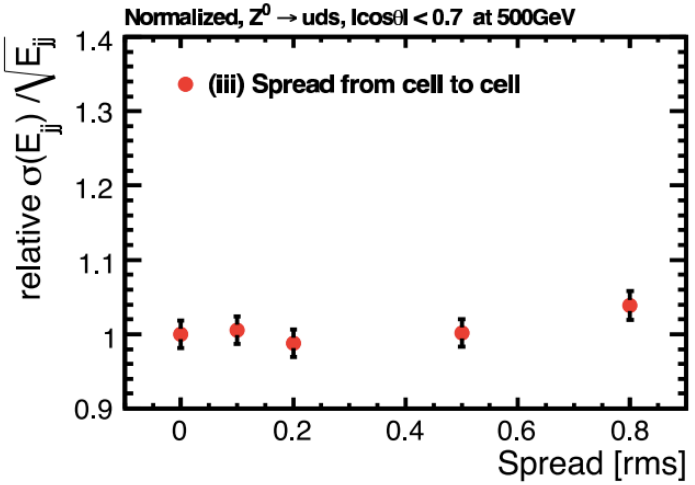
- Currently implementing DCR and crosstalk rates in the analysis
  - Have some difficulties with the DCR measurement

Discussion

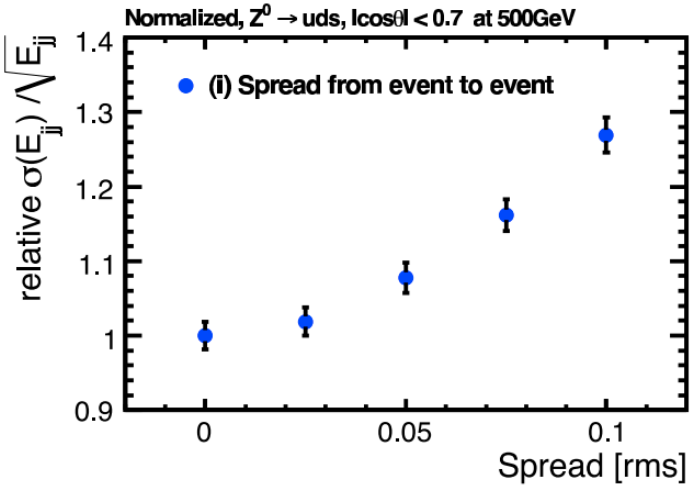
- Looking towards system calibration…
- From “Calibration of the Scintillator Hadron Calorimeter of ILD” ILC and CALICE Internal Note for IDAG 2009

- channel to channel variations:
  - not relevant for energy resolution (only for fluctuations of > 50%)
  - in situ calibration schemes (rely on MIP reconstruction) require cell to cell variation of <10% (no reference given)
  - can in principle be measured for every channel with cosmics (Mainz)

- Saturation correction -> needed for the MIP calibration
  - Needed for every channel
  - Idea: check if we can use global saturation function-> requires small spread from channel to channel (we are measuring)



“Corresponds to an imperfect inter-calibration of individual detector cell”

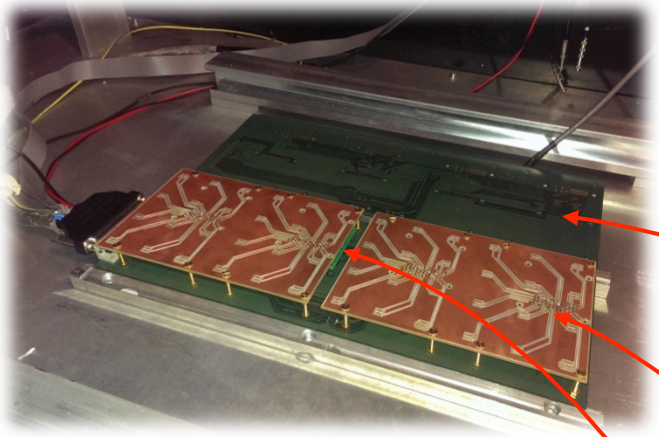


“Corresponds to an imperfect correction for temperature variations or voltage fluctuations”

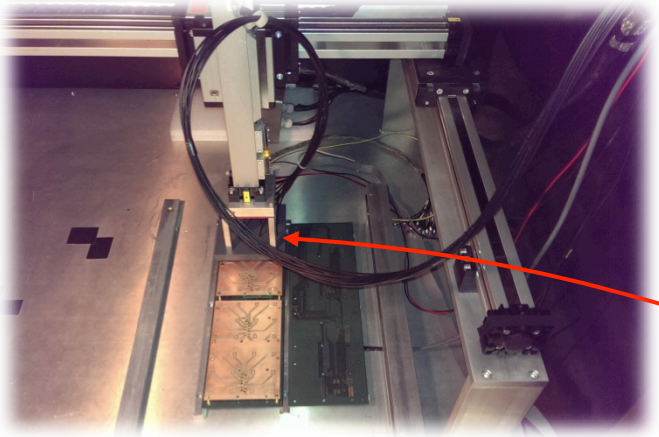
Backup slides

SMD SiPM Setup

SMD SiPM Setup (incomplete)



SMD SiPM Setup with fibre fan-out (incomplete)



144 SiPMs with 3 cm x 3 cm spacing (compatible to HBU)

Multiplexing PCB (3x)

- Connects Klaus chips to ADC

Connection PCB (6x)

- SiPM to KLauS connection

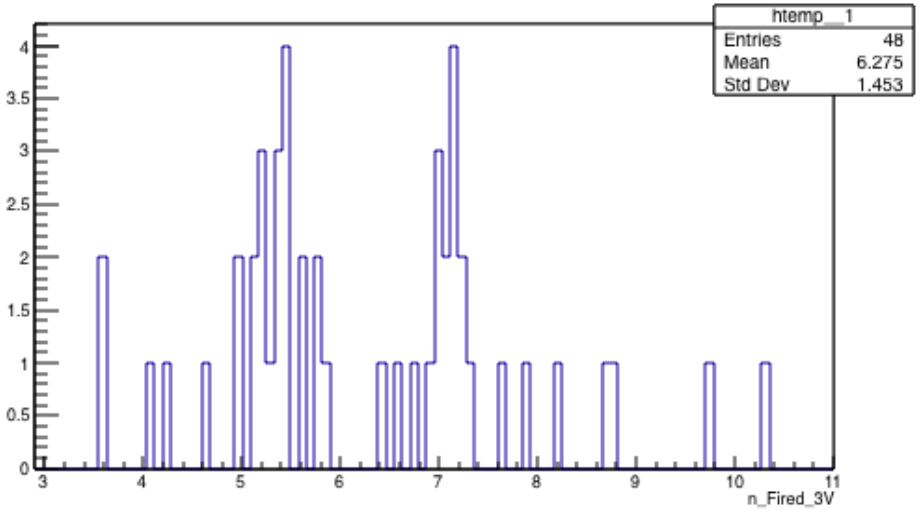
KLauS Board (12x)

Fibre Fan-out (12 fibres)

Average fired pixels for all fibers vs. single fiber

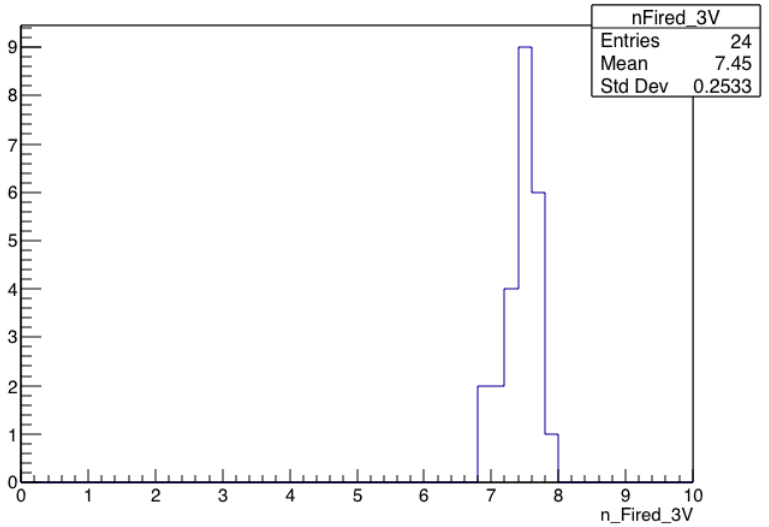
- large spread between the channels
- Expected to be much better after proper calibration

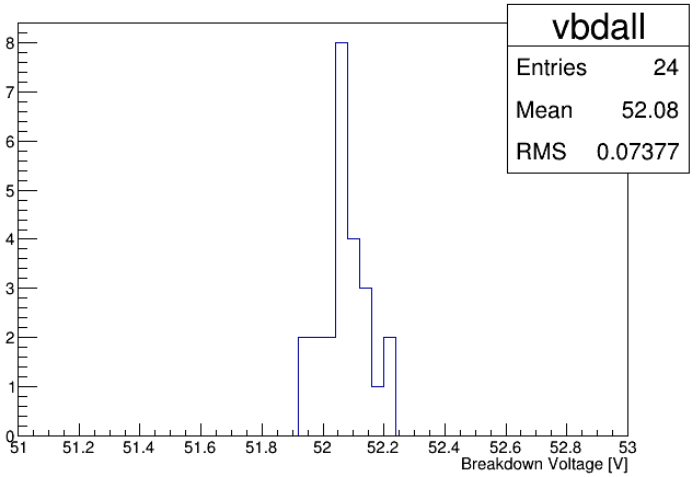
All 48 channels with 12 fibers



- Bigger spread than the 3x3 SiPM (smaller surface more sensitive to fiber alignment)
- After calibration can expect sigma <0.3
- Single fiber scan much longer, temp. correction might improve the results

Same fiber 24 channels

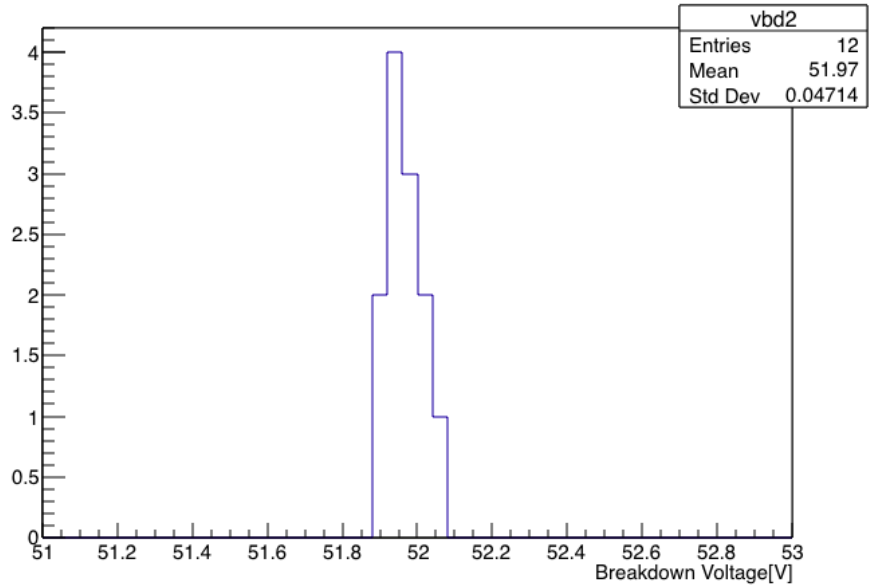




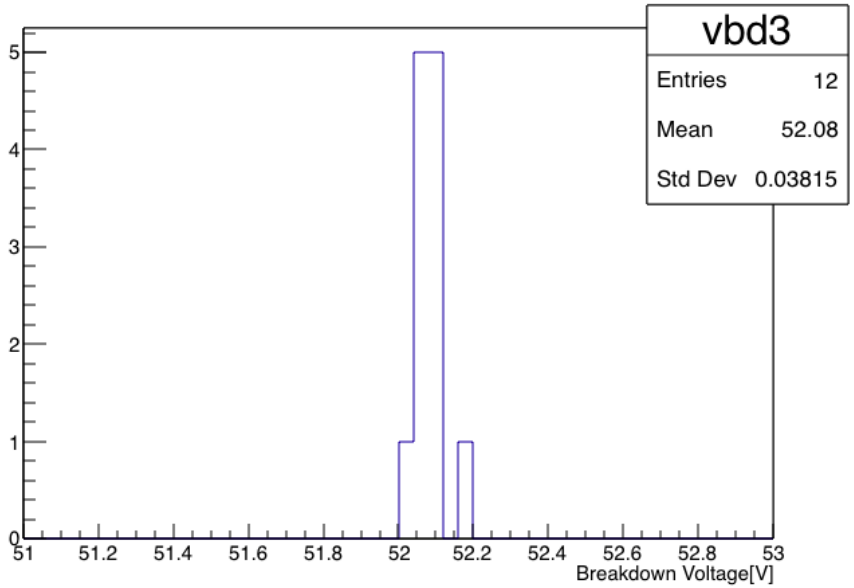
Single channel all fibers

- Same channel measurements with all the fibers
- Sigma of 0.038-0.047 V
- Temperature correction is needed

Klaus chip2



Klaus chip3



Gain fit non-linearity example