SiPM QA test results

Calice Meeting

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QA requirement reminder

- DCR < 500KHz
- Cross-talk < 3%
- PDE (@420nm) >20%
- Gain >3x10^5
- dV/dT < 1% of excess bias voltage (~50mv/k)
- V_{bd} spread min-max within a batch 200 mV

- From each batch of 600 SiPMs 24 are tested
- Batch rejection if fails > 1/24

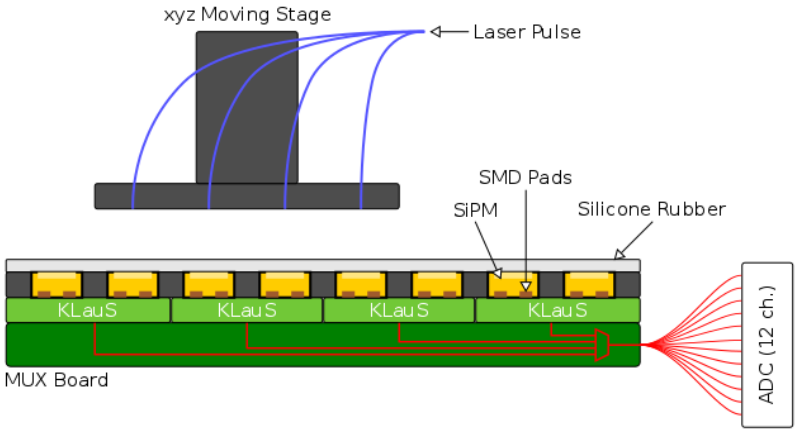
SiPM sample

- first batch result (1000 SiPMs) reported in previous talk
- Received 2 large SiPM delivery
  - 16.5.2017 – 19 batches, each with 16 SiPMs (one batch contain only 12 SiPMs)
  - 23.5.2017 – 19 batches, each with 16 SiPMs:(one batch contain only 15 SiPMs)
- These QA test corresponds to the full order from Hamamatsu of 24K SiPMs

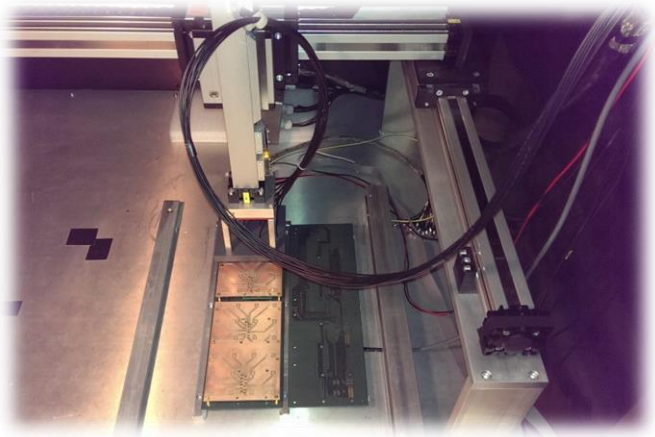
- For each batch the following parameter spreads are measured:
  - SiPM breakdown voltage (vbd) –requirement is on the min-mx
  - Dark count rate (DCR)
  - Crosstalk (CT)
  - Gain
  - dV/dT – only for sub samples

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 24 SiPMs in ~4 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)

Measurement procedure

- The setup is inside an oven with constant temperature of 25^{o}C
- Measure 8 SiPM each time – have place to 12, limited by the no. of fibers
- Measure the SPS spectrum for voltage range of 7 V from 1 V above breakdown (Hamamatsu datasheet) at step size of 0.1 V
- For each sample wait 45 min for temperature stability
- For the sample measured during night re-measure for temperatures (10,15,20,25,30,35,40^{o}C)

Analysis procedure

- Extract for each measurement the gain using FFT
- Extract the breakdown voltage for each temperature and SiPM from linear fit of gain vs. voltage in the range of 1.5-2.5V OV
- Estimate the DCR from SPS using Poisson statistics: $DCR = -\ln(N_0 / N_{tot}) / \Delta t$
- Estimate CT higher limit from the DCR spectrum

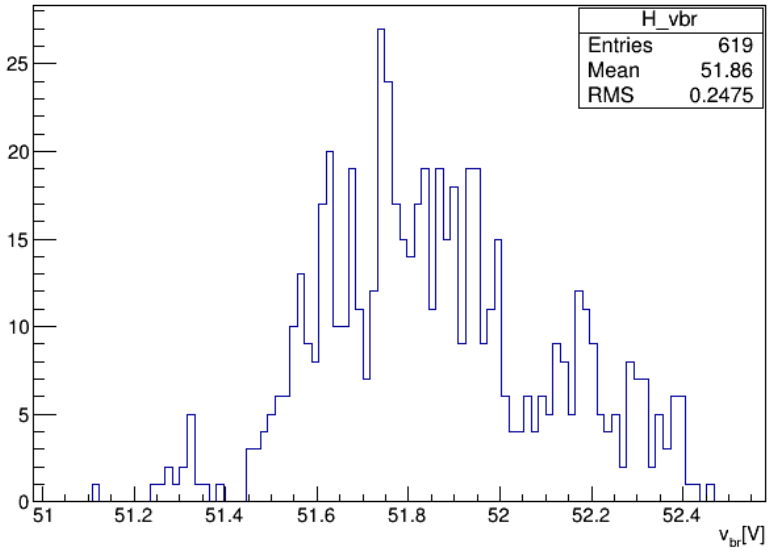
@5V OV

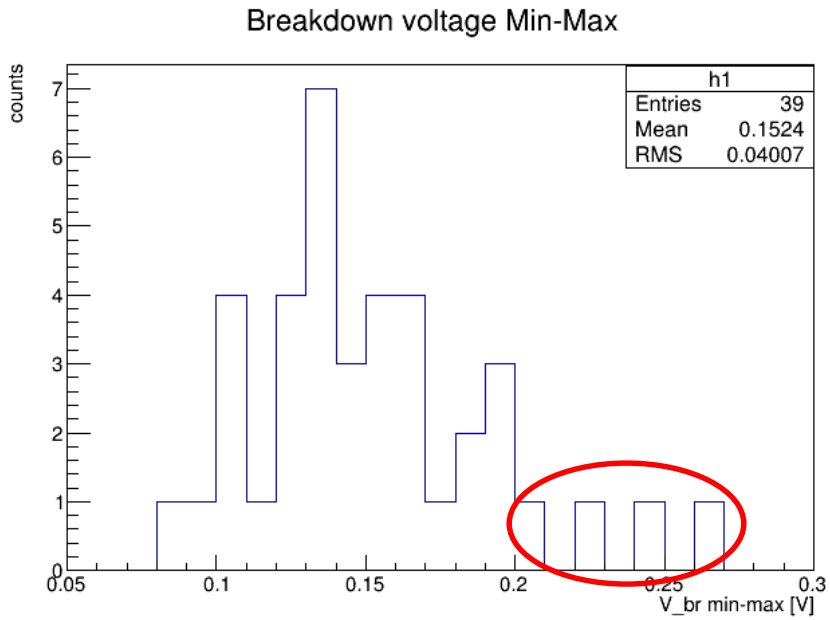
- When available extract for each SiPM the temperature coefficient from linear fit of the breakdown voltage vs. temperature

* the gain is measured in arbitrary units >13 ~>3×10^5 (the requirement)

Result – breakdown voltage

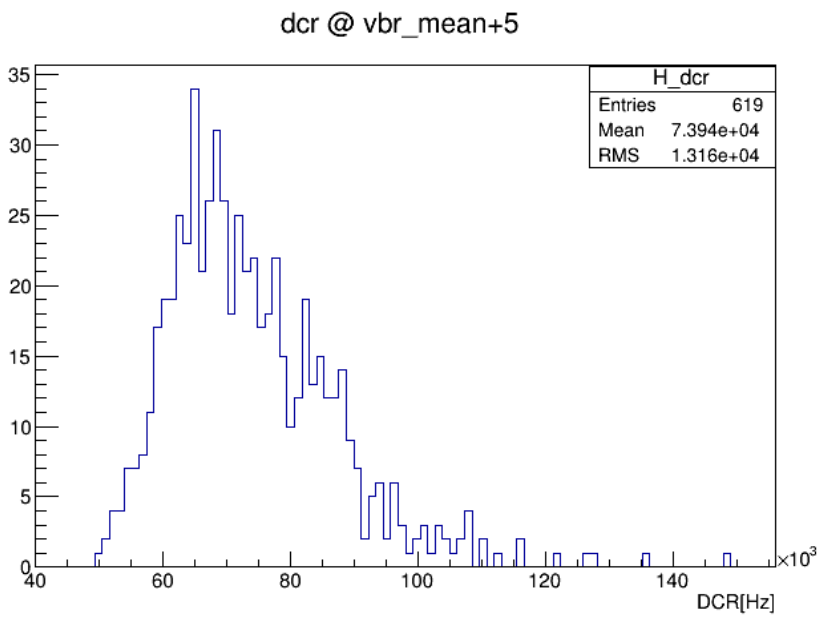
- In total 619 SiPMs were measured

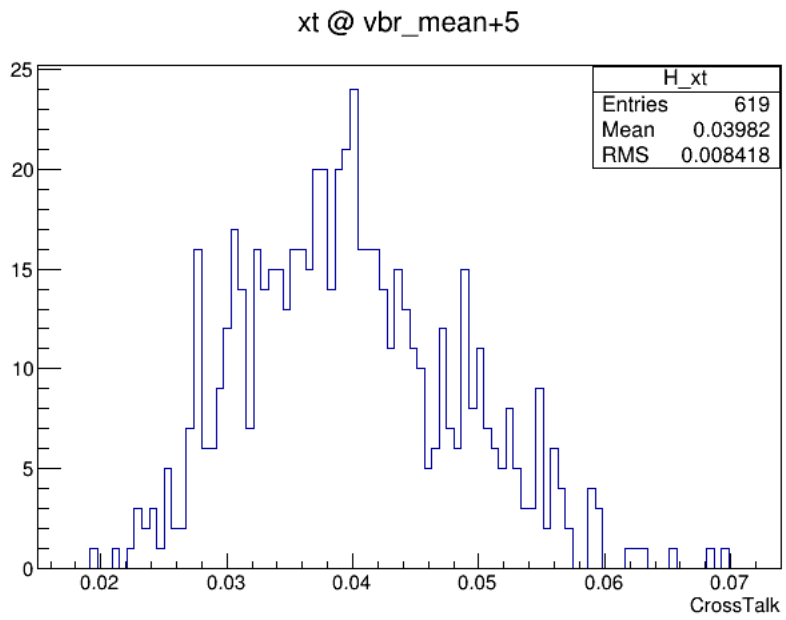




- In 4 batches there was 1 outlier in the min-max breakdown voltage (excluding this one the min-max was well below 200 mv)

Result – DCR @ CT

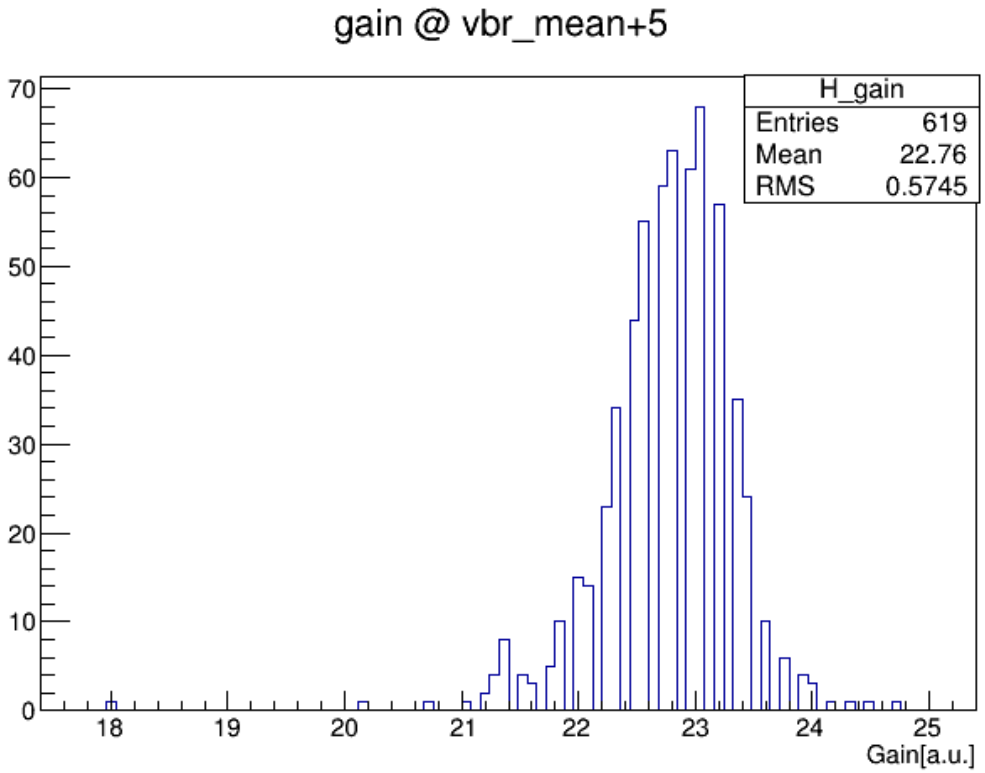




- DCR well below the requirement
- CT – mean value slightly higher but can reach up to 7%
  - This result include some of the after pulses due to the integration window

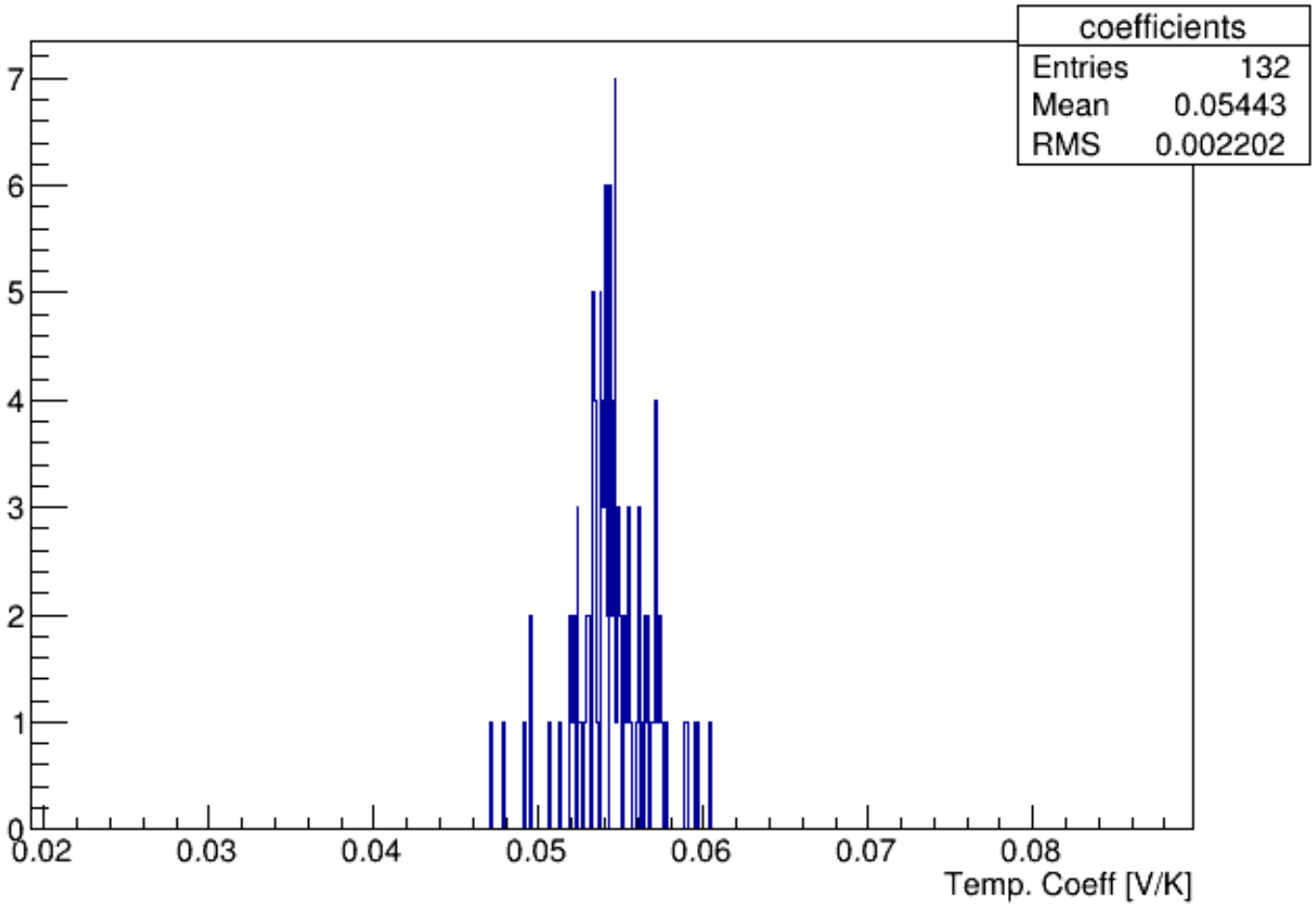
Result- Gain

- All result are way above the requirement
- ~~6-7x10^5
- Will be calibrated soon



Result temperature coefficients

- min-max <15 mV/K => can use mean value for correcting all SiPMs OV



QA summary for both big samples

- Results from first delivery (16.5.2017) showed good results, where all the parameters satisfied the requirements (total 19 batches):
  - Vbd(min-max) = 151+/-32 mv @5V OV
  - DCR 72+\-12 KHz @5V OV
  - CT 4.1+\-0.9% @5V OV
  - Gain 22.6+0.6 [a.u] @5V OV (above 13 >$3x10^5$, full calibration ongoing)
  - dV/dT 54.5 mv/K

- The second delivery, also meet the requirements (total 20 batches)
  - Vbd (min-max) = 154+/-46 mv @5V OV
  - DCR 75+\-14 KHz @5V OV
  - CT 3.8+\-0.7% @5V OV
  - Gain 22.8+0.5 [a.u] @5V OV (above 13 >$3x10^5$, full calibration ongoing)
  - dV/dT 54.7 mv/K

Summary

- All SiPMs sample meet the requirements and we have a green light for production
- The CT values might be slightly higher than expected but considering the very low DCR it is not a problem
- The temperature coefficient meet the requirement and the total spread is low enough for voltage correction using the mean value coefficient